U.S. Department of Energy

Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs

Topics

FY 2013
Phase I
Release 1

Amended August 15, 2012 (page 2)

Participating DOE Research Programs

- Office of Advanced Scientific Computing Research
- Office of Basic Energy Sciences
- Office of Biological and Environmental Research
- Office of Defense Nuclear Nonproliferation
- Office of Fusion Energy Sciences
- Office of High Energy Physics
- Office of Nuclear Physics

Schedule

Event	Dates
• Topics Released:	Monday, July 16, 2012
• Funding Opportunity Announcement Issued:	Monday, August 13, 2012
• Letter of Intent Due Date:	Tuesday, September 04, 2012
• Application Due Date:	Tuesday, October 16, 2012
• Award Notification Date:	Early January 2013*
• Start of Grant Budget Period:	February 2013*

*Preliminary Dates Subject to Change

Change Control Table	
Date	Change
08-15-12	Topic 21 (page 68): Only Fast-Track applications will be accepted for this topic. Please refer to FOA for details on preparing Fast-Track applications.

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Selected topic and subtopics contained in this document are designated as Technology Transfer Opportunities (TTOs). The questions and answers below will assist you in understanding how TTO topics and subtopics differ from our regular topics.

What is a Technology Transfer Opportunity?

A Technology Transfer Opportunity (TTO) is an opportunity to leverage technology that has been developed at a DOE National Laboratory. Each TTO will be described in a particular subtopic and additional information may be obtained by using the link in the subtopic to the DOE National Laboratory that has developed the technology. Typically the technology was developed with DOE funding of either basic or applied research at a DOE National Laboratory and is available for transfer to the private sector. The level of technology maturity will vary and applicants are encouraged to contact the appropriate Laboratory prior to submitting an application.

How would I draft an appropriate project description for a TTO?

For Phase I, you would write a project plan that describes the research or development that you would perform to establish the feasibility of the TTO for a commercial application. The major difference from a regular subtopic is that you will be able to leverage the prior R&D carried out by the National Lab and your project plan should reflect this.

Am I required to have a subcontract to the National Lab in my grant application?

No. Your project plan should reflect the most fruitful path forward for developing the technology. In some cases, leveraging expertise or facilities of the National Lab via a subcontract may help to accelerate the research or development effort. In those cases, the small business may wish to negotiate with the National Lab to become a subcontractor on the application.

Is the National Lab required to become a subcontractor if requested by the applicant?

No. Collaborations with National Labs must be negotiated between the applicant small business and the National Lab. The ability of a National Lab to act as a subcontractor may be affected by existing or anticipated commitments of the National Lab research staff and its facilities.

Are there patents associated with the TTO?

The TTO will be associated with one or in some cases multiple patent applications or issued patents.

If selected for award, what rights will I receive to the technology?

Those selected for award under a TTO subtopic, will be assigned rights to perform research and development of the technology during their Phase I or Phase II grants. Please note that these are NOT commercial rights which allow you to license, manufacture, or sell, but only rights to perform research and development.

In addition, an awardee will be provided, at the start of its Phase I grant, with a no-cost, six month option to license the technology. It will be the responsibility of the small business to demonstrate adequate progress towards commercialization and negotiate an extension to the option or convert the option to a license. A copy of an option agreement template will be available at the National Laboratory which owns the TTO.

How many awards will be made to a TTO subtopic?

Initially we anticipate making a maximum of one award per TTO subtopic. This will insure that an awardee is able to sign an option agreement that includes exclusive rights in its intended field of use.   If we receive applications to a TTO that address different fields of use, it is possible that more than one award will be made per TTO.

How will applying for an SBIR or STTR grant associated with a TTO benefit me?

By leveraging prior research and patents from a National Lab you will have a significant "head start" on bringing a new technology to market. To make greatest use of this advantage it will help for you to have prior knowledge of the application or market for the TTO.

Is the review and selection process for TTO topics different from other topics?

No. Your application will undergo the same review and selection process as other applications.

PROGRAM AREA OVERVIEW: OFFICE OF ADVANCED SCIENTIFIC COMPUTING RESEARCH

1. ADVANCED NETWORK TECHNOLOGIES AND SERVICES (PHASE I, $150,000/PHASE II, $1,000,000)

Network operators face a growing need for advanced tools and services to better manage their infrastructure. Network users also need better tools and services to 1) deal with the increasing amounts of data being generated, moved, and archived; and 2) help in reporting real problems that impact their ability to use the network. Hardening existing tools and services that manage the explosive growth in data will make it easier for users to use the network.

Developing new technologies, tools, or high-level services that promote a modular use of measurement and monitoring data will make it easier for network operators to manage their infrastructure. These new modular tools and services should provide multiple levels of detail to authorized personnel with decisions on the level of detail to release under the control of the infrastructure owner. Applications should also be permitted to retrieve summary information to assist users in reporting problems. This will allow network operators to receive the detailed information needed to fix a problem while simplifying the users' ability to report a problem. Meeting both types of needs using a single measurement and monitoring infrastructure would greatly improve the network experience for a large number of users.

This topic solicits proposals that address issues related to building, operating, and maintaining large network infrastructures, developing tools and services that report performance problems in a manner suitable for network engineers or application users, or hardening existing tools and services that deal with Big Data.

Grant applications are sought in the following subtopics:

a. Management tools for Network Operators

Network infrastructure must be actively managed to ensure that the infrastructure itself does not become a performance bottleneck. This management requires an understanding of how traffic is currently flowing, making predictions about how traffic flows will change in the future, and, increasingly, how much energy this infrastructure is using. Network operations staff need tools and services to make real-time decisions regarding the current performance of the network. Operators also need tools and services that handle longer term capacity planning activities which balance multiple parameters e.g. cost, performance, and energy usage.

perfSONAR (http://www.perfsonar.net) is an architecture developed by the Research and Education Network community for developing multi-domain measurement and monitoring services. This architecture separates the collection of measurement and monitoring data from the analysis of this data. Using this architecture tools and services that collect unique data values can be developed and deployed by operators and/or users who find these tools useful. Tools and services that analyze data can draw from a wide collection of data sources without needing to deploy boxes in hundreds to thousands of locations.

Grant applications are sought to develop advanced tools and services suitable for managing large distributed network infrastructures. Issues include, but are not limited to: hardening of existing research tools that leverage a modular architecture to generate or consume data; tools that collect data from unique devices or services; data analysis tools that simplify a network operator's task of running a network; data analysis tools that inform network users where performance bottlenecks exist; intuitive displays of performance or operational data tailored to network operators or network users; capacity planning tools that allow operators to determine how to effectively grow the network to meet future demands; or tools that allow operators to optimize the network balancing performance, cost, and energy consumption.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Advanced Materials Optical Network Support Services

Optical networks have revolutionized wide-area network infrastructure deployments, providing ever-increasing amounts of bandwidth at ever-decreasing costs. As costs have dropped, optical network components moved out of the wide area and into the metro area, and now the residential distribution environment. This expansion requires a shift away from small numbers of very expensive optical test gear to a world with large numbers of inexpensive gear that operates over a wide range of speeds and distances. It also requires the mass production of support tools and services to aid in the installation, testing, operations, and growth of this optical infrastructure. Grant applications are sought that address the emerging need for massive deployment of optical network infrastructure. Issues include, but are not limited to: tools that decrease the cost of terminating or splicing optical cables, components to test optical signal quality, components that operate at 100+ Gigabit per sec line rates.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Video Collaboration Services

Scientific and commercial users increasingly rely on videoconferencing as a foundational tool. Supporting distributed science and research requires ubiquitous, seamless collaboration tools with the capability to incorporate unique visualization and instrumentation views. At the same time, this seamless collaboration must occur across multiple vendor video solutions. The increasing importance of video collaboration in supporting virtual organizations presents an opportunity to develop tools and/or services that close some of the technology gaps which hinders today's collaboration experience., These advanced tools and services should permit users to add any device in the network into a collaborative environment, including scientific instruments and visualization tools. Grant applications are sought that address issues related to video interoperability across multiple protocols and vendor products and demonstrate integration of scientific virtualization networked devices. Issues include, but are not limited to: multi-vendor interoperation, multi-platform browser-based access, endpoint software with increased usability, support for mobile devices, and scientific device API development for visualization. Service performance measurement and diagnostic functions should be integrated.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Big Data-Aware Middleware and Networking

The growing ubiquity, volume, and velocity of data is having a transformative impact on many sectors of modern society including, energy, science, and defense. DOE operates a broad assortment of scientific facilities such as light sources, observatories, and supercomputing facilities that generate vast amounts of data. Over the years DOE has invested in the development of tools, services, visualization systems, data analytic technologies, and network capabilities to manage the massive science data sets being generated by these facilities. These capabilities, originally developed for data-intensive science, represent state–of-art solutions to some aspects of the emerging Big Data challenges. Grant applications are sought to engage and expose the small business communities working with Big Data to leverage DOE's vast portfolio of scientific data management capabilities, adapting them for commercial and industry use. Issues include, but are not limited to: hardening tools and services developed for scientific data management; development of turnkey systems, middleware, and network tools to support Big Data centers, data clouds, or large storage systems; and development of value-added services and tools to enhance the capabilities of existing enterprise data management software or hardware sub-systems.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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3. Randal E. Brian, "Data-intensive Scalable Computing for Scientific Applications," *IEEE Computing Science and Engineering*, Vol., 13, No. 6, pp 25-33. November 2011 (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=5953577)

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6. FastBit: An Efficient Compressed Bitmap Index Technology (https://www.globusonline.org/)

7. OSCARS - End-to-end bandwidth reservation systems: (http://www.lbl.gov/cs/Archive/news073109.html)

8. Nimbus - an open source toolkit for Infrastructure-as-a-Service for clouds (http://www.mcs.anl.gov/research/project_detail.php?id=88)

9. The Visualization and Analytics Center for Enabling Technologies (VACET) (http://www.vacet.org/about.html)

10. SciDAC Visualization projects (http://www.scidac.gov/viz/viz.html)

11. Hadoop – (http://hadoop.apache.org/)

12. eCenter – End-to-end enterprise network monitoring (http://code.google.com/p/ecenter/)]

2. INCREASING ADOPTION OF HPC MODELING AND SIMULATION IN THE ADVANCED MANUFACTURING AND ENGINEERING INDUSTRIES (PHASE I, $150,000/PHASE II, $1,000,000)

Over the past 30 years, The Department of Energy's (DOE) supercomputing program has played an increasingly important role in the scientific discovery process by allowing scientists to create more accurate models of complex systems, simulate problems once thought to be impossible, and analyze the increasing amount of data generated by experiments. Computational Science has become the third pillar of science, along with theory and experimentation. However despite the great potential of modeling and simulation to increase understanding of a variety of important engineering and manufacturing challenges, High Performance Computing (HPC) has been underutilized due to application complexity, the need for substantial in-house expertise, and perceived high capital costs. This topic is specifically focused on bringing HPC solutions and capabilities to the advanced manufacturing and engineering market sectors.

Grant applications are sought in the following subtopics:

a. Turnkey HPC Solutions for Manufacturing and Engineering

HPC modeling and simulation applications are utilized by many industries in their product development cycle, but hurdles remain for wider adoption especially for small and medium sized manufacturing and engineering firms. Some of the hurdles are: overly complex applications, lack of hardware resources, inability to run proof of concept simulations on desktop workstations, solutions that have well developed user interfaces, but are difficult to scale to higher end systems, solutions that are scalable but have poorly developed user interfaces, etc. While many advances have been made in making HPC applications easier to use they are still mostly written with an expert level user in mind.

Grant applications that focus on HPC applications that could be utilized in the advanced manufacturing supply chain and additive manufacturing processes are strongly encouraged as well as applications that address the need to have solutions that are easier to learn, test and integrate into the product development cycle by a more general user (one with computational experience, but not necessarily an expert). Issues to be addressed include, but are not limited to: Developing turn-key HPC application solutions, porting HPC software to platforms that have a more reasonable cost vs. current high end systems (this could also include porting to high performance workstations (CPU/GPU) which would provide justification for the procurement of HPC assets or small scale clusters, or to a “cloud” type environment or service), HPC software as a service, etc.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. HPC Support Tools and Services

Many tools and services have been developed over the years to support the HPC user and development community. These tools (debuggers, profilers, workflow engines, low-level libraries, etc), although very powerful, take a good deal of time and effort to learn and use. For a company to utilize HPC in the development of their product or service they need to invest a substantial amount in learning these tools and services. This presents an insurmountable barrier for many organizations. If the tools were easier to use and more intuitive they could be more widely utilized. Grant applications are sought that will help make HPC tools and services easier to use for the experienced (not expert) user, through enhanced or simplified user interfaces, consolidation of tools into a common environment, common frameworks, etc. Grant applications must establish how the proposed tools and services can greatly increase the ease of use for a less-experienced HPC user or developer.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Hardening of R&D Code for Industry Use
The Office of Science (SC) Office of Advanced Scientific Computing (ASCR) has invested millions of dollars in the development of HPC software in the areas of modeling and simulation, solvers, and tools. Many of these tools are open source, but are complex "expert" level tools. The expertise required to install, utilize and run these assets poses a significant barrier to many organizations due to the levels of complexity built into them to facilitate scientific discovery and research, but such complexity may not necessarily be required for industrial applications. Grant applications are specifically sought that will take a component or components of codes developed via the Scientific Discovery through Advanced Computing (SciDAC) program, or other ASCR programs, and "shrink wrap" them into tools that require a lower level of expertise to utilize. This may include Graphical User Interface Designs (GUIs), simplification of user input, decreasing complexity of a code by stripping out components, user support tools/services, or other ways that make the code more widely useable. Applicants may also choose to harden the codes developed by other projects provided that the potential industrial uses support the DOE mission.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Other
In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

Note: In addition to local, cluster, or cloud computing resources, applicants may consider using DOE's Open Science (DOE-SC) Computing facilities, the National Energy Research Scientific Computing Center (NERSC), the Argonne Leadership Computing Facility (ALCF), or the Oak Ridge Leadership Computing Facility (OLCF). Applicants wishing to run at the NERSC (http://www.nersc.gov) facility should send email to "consult@nersc.gov" and inquire about the Education/Startup allocation program. Descriptions of the allocation programs available at the ALCF can be found at http://www.alcf.anl.gov/resource-guides/getting-time-alcf-systems. Questions concerning allocations on the ALCF can be sent to Mike Papka, the ALCF center director at "papka@anl.gov". Descriptions of the allocation programs available at the OLCF are available at http://www.olcf.ornl.gov/support/getting-started/. Questions concerning allocations on the OLCF can be sent to Jim Hack, the OLCF center director at "jhack@ornl.gov". Proprietary work may be done at the ALCF and OLCF facilities using a cost recovery model.

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1. “Minding the Missing Middle”, HPCC Conference Summary, Newport RI. March 31 2011 (http://www.hpcwire.com/hpcwire/2011-03-31/minding_the_missing_middle.html)

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2. “US Manufacturing-Global Leadership Through Modeling and Simulation” White Paper, Council on Competitiveness. March 2009. (http://www.compete.org/images/uploads/File/PDF%20Files/HPC%20Global%20Leadership%20030509.pdf)

PROGRAM AREA OVERVIEW: OFFICE OF BASIC ENERGY SCIENCES

The Office of Basic Energy Sciences (BES) supports fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels in order to provide the foundations for new energy technologies and to support DOE missions in energy, environment, and national security. The results of BES-supported research are routinely published in the open literature.

A key function of the program is to plan, construct, and operate premier scientific user facilities for the development of novel nano-materials and for materials characterization through x-ray, neutron, and electron beam scattering; the former is accomplished through five Nanoscale Science Research Centers and the latter is accomplished through the world's largest suite of synchrotron radiation light source facilities, neutron scattering facilities, and electron-beam microcharacterization centers. These national resources are available free of charge to all researchers based on the quality and importance of proposed nonproprietary experiments.

A major objective of the BES program is to promote the transfer of the results of our basic research to advance and create technologies important to Department of Energy (DOE) missions in areas of energy efficiency, renewable energy resources, improved use of fossil fuels, the mitigation of the adverse impacts of energy production and use, and future nuclear energy sources. The following set of technical topics represents one important mechanism by which the BES program augments its system of university and laboratory research programs and integrates basic science, applied research, and development activities within the DOE.

For additional information regarding the Office of Basic Energy Sciences priorities, click here.

3. TECHNOLOGY TO SUPPORT BES USER FACILITIES (PHASE I, $150,000/PHASE II, $1,000,000)

   The Office of Basic Energy Sciences (BES), within the DOE's Office of Science, is responsible for current and future user facilities including synchrotron radiation, free electron lasers, and the Spallation Neutron Source (SNS). This topic seeks the development of technology to support these user facilities.

   Grant applications are sought in the following subtopics:

   a. Synchrotron Radiation Facilities and Neutron Scattering Facilities
   As synchrotron radiation and neutron scattering have become important tools across a broad area of forefront science, the DOE supports collaborative research centers for synchrotron radiation and neutron scattering science. Research is needed for advanced detectors. With advances in the brightness of synchrotron radiation sources, wide gap has developed between the ability of these sources to deliver high photon fluxes and the ability of detectors to measure the resulting photon, electron, or ion signals. At the same time, advances in microelectronics engineering should make it possible to increase data rates by orders of magnitude, and to increase energy and spatial resolution. With the development of fourth-generation x-ray sources with femtosecond pulse durations, there will be a need for detectors with sub-picosecond time resolution. Grant applications are sought to develop new detectors for

synchrotron radiation science across a broad range of applications. Areas of interest include: (1) area detectors for diffraction experiments; (2) area detectors for readout of electron and ion signals; (3) detectors capable of ultra-high temporal resolution; (4) high resolution and/or high frame rate imaging detectors; (5) detectors for high rate fluorescence spectroscopy; (6) detectors for high energy fluorescence spectroscopy; (7) development of high atomic weight semiconductor wafers of sufficient quality and size for bump-bonded high energy (> 20 keV) x-ray detectors; (8) high efficiency, imaging area x-ray detectors capable of micron or smaller spatial resolution for x-rays in the 20 keV to 100 keV range; and (9) low-noise high dynamic-range charged coupled device (CCD) detector for coherent scattering experiments in the soft x-ray spectral regime. The detector should have a high-repetition read-out of >120 Hz and pixel sizes on the order of 50 microns[2]. A detector targeting soft X-ray applications should have single-photon sensitivity for photons from 100 - 2000 eV. A similar detector is also needed for hard X-ray applications, with photon energies on the scale of 10 keV. Often, detector concepts or prototypes already exist in the community, and the primary hurdle is commercialization. Proposed approaches that emphasize engineering for commercialization are of interest.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Instrumentation for Ultrafast X-Ray Science

The Department of Energy seeks to advance ultrafast science dealing with physical phenomena that occur in the range of one-trillionth of a second (one picosecond) to less than one-quadrillionth of a second (one femtosecond). The physical phenomena motivating this subtopic include the direct observation of the formation and breaking of chemical bonds, and structural rearrangements in both isolated molecules and the condensed phase. These phenomena are typically probed using extremely short pulses of laser light. Ultrafast technology also would be applicable in other fields, including atomic and molecular physics, chemistry, and chemical biology, coherent control of chemical reactions, materials sciences, magnetic- and electric field phenomena, optics, and laser engineering.

Grant applications are sought to develop and improve laser-driven, table-top x-ray sources and critical component technologies suitable for ultrafast characterization of transient structures of energized molecules undergoing dissociation, isomerization, or intramolecular energy redistribution. The x-ray sources may be based on, for example, high-harmonic generation to create bursts of x-rays on subfemtosecond time scales, laser-driven Thomson scattering and betatron emission, and laser-driven K-shell emission. Approaches of interest include: (1) high-average-power ultrafast sources that achieve the state-of-the-art in short-pulse duration, phase stabilization and coherence, and high duty cycle; (2) driving lasers that operate at wavelengths longer than typical in current CPA titanium sapphire laser systems; and (3) characterization and control technologies capable of measuring and controlling the intensity, temporal, spectral, and phase characteristics of these ultra short x-ray pulses.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Superconducting Technology for Light Sources and Neutron-spallation Sources

Superconducting Radio-Frequency (SRF) systems for particle accelerators have become essential tools for light sources and for spallation neutron sources. Many ring-based light sources use superconducting cavities to store electron beams of large currents. These cavities complete in their cryostat and with electronic operation system have been commercialized and are available from industry. However, further developments will be needed, e.g. on couplers with changed coupling, on couplers with reduced breakdown, and on new construction techniques. The SNS build and operated by BES shows that SRF Linacs have become essential for neutron spallation. The ESS will be based on similar technology, will have 5 times more beam power, and therefore opens opportunities for SRF R&D and commercialization. Light sources will likely be based on SRF linacs. Research topics for SRF linacs are therefore timely, including (a) high-Q cavity production, (b) HOM absorbers for high-current operation, (c) CW cryomodule design, (d) high-power CW couplers, (e) new SRF materials, particularly Nb3Sn.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Other

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2. “PSD 6-The Sixth International Conference on Position Sensitive Detectors,”, Leicester, UK. September 9-13, 2002. (http://cdsweb.cern.ch/record/574446)

3. “Section A–Accelerators, Spectrometers, Detectors and Associated Equipment”, *Nuclear Instruments & Methods in Physics Research*. Vol. 477(1-3). January 21, 2002. (http://www.sciencedirect.com/science/journal/01689002)

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6. "7th International Workshop on Radiation Imaging Detectors (IWORID-7)", European Synchrotron Radiation Facility (ESRF) Workshop , Grenoble, France. July 4-7, 2005. (http://www.esrf.eu/events/conferences/IWORID7/FinalProgramme)

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1. "Directing Matter and Energy: Five Challenges for Science and the Imagination," Basic Energy Sciences Advisory Council, US Department of Energy. December, 2007. (http://science.energy.gov/bes/news-and-resources/reports/abstracts/#GC)

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4. Phuoc, K. T., et al., "Laser-Based Synchrotron Radiation," *Physics of Plasmas 12*. January 2005 (http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1007&context=physicsumstadter)

5. Jiang, Y., et al., "Generation of Ultrashort Hard-X-ray Pulses with Tabletop Laser Systems at a 2-kHz Repetition Rate," *Journal of the Optical Society of America*, Vol. 20, Issue 1, pp. 229 – 237. 2003. (http://josab.osa.org/abstract.cfm?id=70903)

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7. Zhang , X. et al, "Quasi-Phase-Matching and Quantum-Path Control of High-Harmonic Generation Using Counterpropagating Light," *Nature Physics*, Vol. 3, pp. 270 – 275. 2007. (http://www.nature.com/nphys/journal/v3/n4/abs/nphys541.html)

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4. RADIO FREQUENCY (RF) DEVICES AND COMPONENTS FOR ACCELERATOR FACILITIES (PHASE I, $150,000/PHASE II, $1,000,000)

The Office of Basic Energy Sciences, within the DOE’s Office of Science, is responsible for current and future synchrotron radiation light sources, free electron lasers, and spallation neutron source user facilities. This topic seeks the development of radio frequency devices and components to support these user facilities.

Grant applications are sought in the following subtopics:

a. RF Power Devices and Accessories
Grant applications are sought to develop: (1) a very high power (100-400 kW) 350-500 MHz solid state power amplifier to replace klystron amplifiers in synchrotron light sources; (2) high repetition rate (1 kHz or more) high performance normal conducting linear accelerators to be used for driving free electron lasers (FELs) operating with electron energies up to the order of 20 GeV. This accelerator technology would provide a lower cost option than superconducting accelerators for high repetition rate FELs. Integrated modules combining power source and accelerating structure deserve consideration; (3) medium power phase locked sources: Develop low cost pulsed power sources in the S, C or X-band frequency range with ~1 us pulse length, and peak powers from 1-100KW and < 0.1 degree RMS phase noise relative to their drive pulse (narrowband OK). These sources would be less expensive than TWTs; and (4) compact high efficiency RF sources in the range of 10-20 kW CW at 1.3 to 1.5 GHz for future linac based light sources, with size, cost and performance better than existing small klystrons.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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5. ADVANCED SOURCES FOR ACCELERATOR FACILITIES (PHASE I, $150,000/PHASE II, $1,000,000)

The Office of Basic Energy Sciences, within the DOE's Office of Science, is responsible for current and future synchrotron radiation light sources, free electron laser, and spallation neutron source user facilities. This topic seeks the development of technology to support the particle and radiation sources needed for these user facilities.

Grant applications are sought in the following subtopics to develop novel electron gun features including:

a. Electron Gun Technology

(1) (a) Robust high quantum efficiency photocathodes with high quantum yield in the visible spectral range (e.g. quantum efficiency of more than several % in the green), capable of delivering thousands of Coulombs of charge from a single mm-diameter laser spot in a real life accelerator environment; (b) material engineering of new photocathode materials with ultra-low thermal emittance (0.1 mm-mrad per 1 mm rms laser spot size) and simultaneous fast response time (<1 picosecond); (c) tool development for calculation of photocathode performance such as thermal emittance and response time from basic material properties and its bench marking with experimental data.

(2) Accelerating structures supporting electric fields of 10-100 MVm^{-1} at a cathode surface, allowing laser excitation of the cathode material and rapid acceleration of the emitted electrons, with minimal emittance growth and an electron bunch repetition rate of 1 MHz or greater. Combined with suitable cathode materials and a photocathode laser, the system should be capable of producing low emittance (less than 1 mm-mrad normalized) electron bunches at a minimum 1 MHz repetition rate, with up to 1 nC charge per bunch.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Other

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6. ANCILLARY TECHNOLOGIES FOR ACCELERATOR FACILITIES (PHASE I, $150,000/PHASE II, $1,000,000)

The Office of Basic Energy Sciences, within the DOE's Office of Science, is responsible for current and future synchrotron radiation light sources, free electron laser, and spallation neutron source user facilities. This topic seeks the development of computational, control, and superconducting technologies to support these user facilities.

Grant applications are sought in the following subtopics:

a. Beam Dynamics for Ultra-bright Electron and X-ray Beams

Advanced light sources of the future will push the envelope of small emittances, high currents, and short bunch lengths and low energy spread. Codes that simulate the beam dynamics, the halo creation, and beam/matter interaction will therefore be important. Code development in the following topics is required: (1) Scattering within the beam of advanced light sources, (2) space-charge dominated electron beams, (3) creation of the X-ray field in advanced light sources, (4) halo formation and radiation-background simulations, (4) collimation and interaction of beam and vacuum chamber.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Other
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Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

References Subtopic a:

1. Bisognano, J. J. and Mondelli, A. A., eds., "Computational Accelerator Physics", Proceedings of the American Institute of Physics (AIP) Conference, Williamsburg, VA, September 24-27, 1996. May 1997. (http://www.amazon.com/Computational-Accelerator-Physics-Conference-Proceedings/dp/1563966719)

2. Qiang, J. and Ryne, R., "Parallel Beam Dynamics Simulation of Linear Accelerators," Proceedings of the: 18th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA. March 18-22, 2002. (http://www.osti.gov/energycitations/servlets/purl/792968-2qDC1P/native/792968.pdf)

3. Ko, K., "High Performance Computing in Accelerator Physics," Proceedings of the 18th Annual Review of Progress in Applied Computational Electromagnetics, Monterey, CA. March 18-22, 2002. (http://www-group.slac.stanford.edu/acd/Computers2.html#)

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5. "Proceedings of the International Computational Accelerator Physics Conference, St. Petersburg, Russia" *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment.* Vol 558, No. 1. March 2006. (http://www.sciencedirect.com/science/journal/01689002; search for year and vol. number)

7. INSTRUMENTATION FOR ADVANCED CHEMICAL IMAGING (PHASE I, $150,000/PHASE II, $1,000,000)

The Department of Energy seeks to advance chemical imaging technologies that facilitate fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels. The Department is particularly interested in forefront advances in imaging techniques that combine molecular-scale spatial resolution and ultrafast temporal resolution to explore energy flow, molecular dynamics, breakage, or formation of chemical bonds, or conformational changes in nanoscale systems.

Grant applications are sought only in the following subtopics:

a. High Spatial Resolution Ultrafast Spectroscopy

Chemical information associated with molecular-scale processes is often available from optical spectroscopies involving interactions with electromagnetic radiation ranging from the infrared spectrum to x-rays. Ultrafast laser technologies can provide temporally resolved chemical information via optical spectroscopy or laser-assisted mass sampling techniques. These approaches provide time resolution ranging from the breakage or formation of chemical bonds to conformational changes in nanoscale systems but generally lack the simultaneous spatial resolution required to analyze individual molecules. Grant applications are sought that make significant advancements in spatial resolution towards the molecular scale for ultrafast spectroscopic imaging instrumentation available to the research scientist. The nature of the advancement may span a range of approaches including sub-diffraction limit illumination or detection, selective sampling, and coherent or holographic signal analysis.

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b. Time-Resolved Chemical Information From Hybrid Probe Microscopy's

Probe microscopy instruments (including AFM and STM) have been developed that offer spatial resolution of molecules and even chemical bonds. While probe-based measurements alone do not typically offer the desired chemical information on molecular timescales, methods that take advantage of electromagnetic interactions or sampling with probe tips have been demonstrated. Grant applications are sought that would make available to scientists new hybrid probe instrumentation with significant advancements in chemical and temporal resolution towards that required for molecular scale chemical interactions. The nature of the advancement may span a range of approaches and probe techniques, from tip-enhanced or plasmonic enhancement of electromagnetic spectroscopy's to probe-induced sample interactions that localize spectroscopic methods to the molecular scale.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

References:

1. FY 2006 BES Chemical Imaging Research Solicitation (http://science.doe.gov/grants/pdf/DE-FG01-05ER05-30.pdf)

2. "Visualizing Chemistry, The progress and Promise of Advanced Chemical Imaging, National Academies Press," 2006. (http://www.nap.edu/catalog.php?record_id=11663 ; http://science.doe.gov/grants/pdf/DE-FG01-05ER05-30.pdf)

8. INSTRUMENTATION FOR ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY (PHASE I, $150,000/PHASE II, $1,000,000)

The Department of Energy supports research and facilities in electron and scanning probe microscopy for the characterization of materials. Performance improvements for environmentally acceptable energy generation, transmission, storage, and conversion technologies depend on a detailed understanding of the structural and property characteristics of advanced materials. The enabling feature of nanoscience, as recognized in workshop reports sponsored by the Department of Energy and by the National Nanotechnology Initiative, is the capability to image, manipulate, and control matter and energy on nanometer, molecular, and ultimately atomic scales. These fundamental research areas are strongly tied to the energy mission of the Department, ranging from solar energy, energy storage and conversion technologies, and carbon sequestration. Electron and scanning probe microscopies are some of the primary tools and widely used for characterizing materials. Innovative instrumentation developments offer the promise of radically improving these capabilities, thereby stimulating new innovations in materials science and energy technologies. Major advances are being sought for capability to characterize and understand materials, especially nanoscale materials, in their natural environment at high resolutions typical of electron and scanning probe microscopy and with good temporal resolution. To support this research, grant applications are sought to develop instrumentation capabilities beyond the present state-of-the-art in (a) electron microscopy and microcharacterization, (b) scanning probe microscopy and (c) areas relevant to (a) and (b), such as integrated electron and scanning probe microscopy capabilities.

Grant applications are sought only in the following subtopics:

a. Electron Microscopy and Microcharacterization
Electron microscopy and microcharacterization capabilities are important in the materials sciences and are used in numerous research projects funded by the Department. Grant applications are sought to develop components and accessories of electron microscopes that will significantly enhance the capabilities of the electron-based microcharacterization, including improved spatial and temporal resolution in imaging, diffraction and spectroscopy with and without applied stimuli (e.g., temperature, stress, electromagnetic field, and gaseous or liquid environment):

Stages and holders that provide new capabilities for in situ transmission electron microscopy experiments in liquid, gaseous, optoelectronic and/or other extreme environments that also provide capability for simultaneous spectroscopy.

New electron sources that can operate in pulsed modes to femtosecond frequencies. Of particular interest are laser-assisted field emission guns for application to pulsed mode operation as a single purpose apparatus for time-resolved diffraction experiment, or incorporated into a conventional electron microscope to achieve more versatile capabilities. Proposed solutions must demonstrate point-source-emitter capability.

Ultra-high energy resolution and collection efficiency x-ray, electron loss, and/or optical spectrometers compatible with transmission electron microscopy. Analytical electron energy loss spectroscopy approaches include systems able to achieve high energy resolution (10 meV or better), high energy dispersion (>25mm/eV), efficient trapping of the zero-loss-peak (ZLP) so that spectra at energies <1eV will not be dominated by the ZLP "tail". Energy dispersive spectroscopy approach of interest should include efficient detector materials and improved geometry for maximum signal collection. Single electron detector arrays facilitating ultra high speed counting for electron spectroscopy (~ nanosecond) are of particular interest.

High efficiency and high sensitivity electron detectors. Approaches of interest include CMOS-based electron detectors for high-resolution imaging, detectors with a wide dynamic range (16-20bit) for electron diffraction, and secondary electron detectors for surface imaging.

Systems for automated data collection, processing, and quantification in TEM and/or STEM. Approaches of interest should include (1) hardware and platform-independent software for data collection and visualization, (2) automated measurement and mapping of crystallography, internal magnetic or electric field, or strain, and (3) multi-spectral analysis. Proposed solutions must be demonstrated in TEM or STEM mode.

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b. Scanning Probe Microscopy (SPM)

Scanning probe microscopy is vital to the advancement of nanoscale and energy science, and is used in numerous materials research projects and facilities funded by the Department. Grant applications are sought to develop:

New generations of SPM platforms capable of operation in the functional gas atmospheres and broad temperature/pressure ranges, functional SPM probes, sample holders/cells (including electrochemical and photoelectrochemical cells), and controller/software support for ultrafast, environmental and functional detection. Areas of interest include: (1) SPM platforms capable of imaging in the controlled and reactive gas environments and elevated temperatures for fuel cell, and catalysis research, (2) variable pressure systems with capabilities for surface cleaning and preparation bridging the gap between ambient and ultra-high vacuum platforms, (3) insulated and shielded probes and electrochemical cells for high-resolution electrical imaging in conductive solutions; (4) heated probes combined with dynamic thermal measurements including thermomechanical, temperature, and integrated with Raman and mass-spectrometry systems, and (5) probes integrated with electrical, thermal, and magnetic field sensors for probing dynamic electrical and magnetic phenomena in the 10 MHz - 100 GHz regime, and (6) SPM platforms and probes for other functional imaging modes (including but not limited to microwave, pump-probe, etc). Probes and probe/holder assemblies should be compatible with existing commercial hardware platforms, or bundled with adaptation kits. Complementary to this effort is the development of reliable hardware, software, and calibration methods for the vertical, lateral, and longitudinal spring constants of the levers, sensitivities, and frequency-dependent transfer functions of the probes.

SPM platforms designed for SPM combined with other high-resolution structural and chemical characterization modes. Examples include but are not limited to (a) SPM platforms integrated with high-resolution electron beam imaging in transmission and scanning transmission electron microscopy environments, (b) SPM platforms integratable with focused X-ray, (c) imaging modalities providing local chemical information including mass-spectrometry and nano-optical detection.

A new generation of optical and other cantilever detectors for beam-deflection-based force microscopies. Areas of interest include: (1) low-noise laser sources and detectors approaching the thermomechanical noise limit, (2) high bandwidth optical detectors operating in the 10-100 MHz regime, and (3) small-spot (sub-3 micron) laser sources for video-rate Atomic Force Microscopy (AFM) measurements. Piezoresistive and tuning-fork force detectors compatible with existing low-temperature high-magnetic field environments are also of interest.

Systems for next-generation controllers and stand-alone modules for data acquisition and analysis. Areas of interest include: (1) multiple-frequency and fast detection schemes for mapping energy dissipation, as well as mechanical and other functional properties; (2) active control of tip trajectory, grid, and spectral acquisition; and (3) interactive SPMs incorporating decision making process on the single-pixel level. Proposed systems should include provisions for rapid data collection (beyond the ~1kHz bandwidth of feedback/image acquisition of a standard SPM), processing, and quantification; and hardware and platform-independent software for data collection and visualization, including multispectral and multidimensional image analysis (i.e., for force volume imaging or other spectroscopic imaging techniques generating 3D or 4D data arrays). For rapid data acquisition systems, software and data processing algorithms for data interpretation are strongly encouraged.

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c. Other

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References Subtopic a:

1. A BES-Sponsored workshop report "Future Science Needs and Opportunities for Electron Scattering: Next-Generation Instrumentation and Beyond" that outlines many of the important future directions for electron microscopy and scattering is available on the web. (http://science.energy.gov/bes/news-and-resources/reports/workshop-reports/)

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5. "Aberration Correction in Electron Microscopy: Materials Research in an Aberration-Free Environment", Workshop Report, U.S. DOE Argonne National Laboratory Argonne National Laboratory, July 18-20, 2000. Published Oct. 2001. (http://ncem.lbl.gov/team/TEAM%20Report%202000.pdf)

References Subtopic b:

1. BES-Sponsored workshop reports that address the current status and possible future directions of some important research areas are available on the web. (http://science.energy.gov/bes/news-and-resources/reports/basic-research-needs/)

2. Paul Alivisatos, et al. "Nanoscience Research for Energy Needs", Report of the National Nanotechnology Initiative Grand Challenge Workshop. March 16-18, 2004. (http://science.energy.gov/~/media/bes/pdf/reports/files/nren_rpt.pdf)

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4. Kalinin, S.V. Scanning Probe Microscopy (2 vol. set): Electrical and Electromechanical Phenomena at the Nanoscale, Springer, Dec. 2006. (ISBN: 978-0387286679; http://www.amazon.com/Scanning-Probe-Microscopy-vol-Electromechanical/dp/0387286675/ref=sr_1_1?ie=UTF8&s=books&qid=1252006052&sr=1-1)

5. Li, Mo et al. "Ultra-sensitive NEMS-based cantilevers for sensing, scanned probe and very high-frequency applications", *Nature*, Vol. 2, pp. 114-120. Jan. 2007. (http://www.nature.com/nnano/journal/v2/n2/abs/nnano.2006.208.html)

9. INSTRUMENTATION AND TOOLS FOR MATERIALS RESEARCH USING NEUTRON SCATTERING (PHASE I, $150,000/PHASE II, $1,000,000)

As a unique and increasingly utilized research tool, neutron scattering makes invaluable contributions to the physical, chemical, and nanostructured materials sciences. The Department of

Energy supports neutron scattering and spectroscopy facilities at neutron sources where users conduct state-of-the-art materials research. Their experiments are enabled by the convergence of a range of instrumentation technologies. The Department of Energy is committed to enhancing the operation and instrumentation of its present and future neutron scattering facilities (References 1-3) so that their full potential is realized.

This topic seeks to develop advanced instrumentation that will enhance materials research employing neutron scattering. Grant applications should define the instrumentation need and outline the research that will enable innovation beyond the current state-of-the-art. Applicants are strongly encouraged to demonstrate applicability and proper context through collaboration with a successful user of neutron sources. To this end, the STTR program would be an appropriate vehicle for proposal submission. Alternatively, applicants are encouraged to demonstrate applicability by providing a letter of support from a successful user. Priority will be given to those grant applications that include such collaborations or letters of support.

A successful user is defined as someone at a research institution who has recently performed neutron scattering experiments and published results in peer reviewed archival journals. Such researchers are the early adopters of new instrumentation and are often involved in conceptualizing, fabricating, and testing new devices. A starting point for developing collaborations would be to examine the annual activity reports from neutron scattering facilities with links at: http://www.ncnr.nist.gov/nsources.html and http://www.ncnr.nist.gov/.

Grant applications are sought in the following subtopics:

a. Advanced Detectors

Develop advanced detectors with high efficiency and high resolution position sensitive neutron detectors for neutron scattering and imaging. With the severe shortage of 3He innovative alternative detector technologies with similar or better performance are required for the current and future neutron scattering facilities.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Advanced Optical Components

Develop novel or improved optical components for use in neutron scattering instruments (References 4-6). Such components include, neutron guides, neutron lenses and focusing mirrors, neutron monochromators, neutron polarization devices including ^{3}He polarizing filters, radio-frequency flippers, and Meissner shields.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Advanced Sample Environment

Develop instrumentation and techniques for advanced sample environment (Reference 7, 8) for neutron scattering studies, with an emphasis on controlled chemical and gaseous environment. These environments should simulate conditions relevant to energy-related materials and should provide a novel means of achieving extreme sample conditions of temperature, pressure, electric and magnetic fields (or combinations thereof).

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d. Other

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Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

References:

1. Anderson, I. S. and Guerard, B., eds., "Advances in Neutron Scattering Instrumentation," Proceedings of the SPIE (International Society for Optical Engineering), Vol. 4785, San Diego, CA, July 7-8, 2002, (ISBN: 0819445525; http://spie.org/x648.html?product_id=457266)

2. "Needs for nanoscience application of neutron optics/techniques": (http://www.nano.gov/node/68)

3. Anderson, K. "Neutron Optical Devices" *Neutron Imaging and Applications* (http://www.springerlink.com/content/978-0-387-78692-6)

4. Majkrzak C. F. and Wood, J. L., eds., "Neutron Optical Devices and Applications," Proceedings of the SPIE, Vol. 1738, San Diego, CA. July 22-24, 1992. (ISBN: 0819409111)

5. Mezei, F., et al., eds., "Neutron Spin Echo Spectroscopy," *Lecture Notes in Physics*, *Vol. 601*, New York, Springer Verlag: 2003. (ISBN: 3540442936).

6. Klose, et al., eds., "Proceedings of the Fifth International Workshop on Polarized Neutrons in Condensed Matter Investigations," Washington, D.C., June 1-4, 2004, Physica B: Condensed Matter, Vol. 356, Elsevier, 2004. (ISSN: 0921-4526; http://www.sciencedirect.com/science/journal/09214526/356/1-4)

7. Crow, J., et al., "SENSE: Sample Environments for Neutron Scattering Experiments," Tallahassee, FL, September 24-26, 2003, Workshop Report. 2004. (http://neutrons.ornl.gov/workshops/tallahassee_workshops_2003/SENSE_report_1-14-04.pdf.)

8. Rix, J.E. et al., "Automated sample exchange and tracking system for neutron research at cryogenic temperatures", *The Review of Scientific Instruments*. Vol 78, 013907. 2007. (http://www.ncbi.nlm.nih.gov/pubmed/17503933)

10. CATALYSIS (PHASE I, $150,000/PHASE II, $1,000,000)

The U.S. Department of Energy recognizes catalysis as an essential technology for accelerating and directing chemical transformation. In particular, catalysis is key to developing technologies for converting alternative feedstocks, such as biomass, natural gas carbon dioxide, and water to commodity fuels and chemical products.

Grant applications are solicited only in the following subtopics:

a. Catalysis for the Production of Hydrocarbon Fuels or Chemicals from Mixed-Oxygenates

The chemical catalysis of petroleum naphtha and natural gas liquids to final products that contain oxygen are among the most energy intensive conversion processes of industrial chemistry. However, oxygenates from biomass, such as syngas or mixed alcohols, contain significant amounts of oxygen by weight and are good starting materials to make a range of products, including hydrocarbon fuels or polymeric monomers. In this subtopic, new catalytic conversion routes that begin with feedstocks derived from cellulosic origin are solicited (for example, new synthetic routes to chemicals starting with succinic acid or furan). Any final fuel product must be a drop-in, hydrocarbon fuel and cellulosic ethanol production will not be considered responsive to the solicitation. The application should also address the robustness and resistance to degradation of the synthesis catalysts in the presence of the oxygenated feed.

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b. Chemical Catalysis of Lignin

Lignin is present in a wide variety of lignocellulosic biomass feedstocks and can make up greater than 50% of the weight. Chemical conversion of lignin to other products, however, has been so difficult that lignin separated from cellulose in industrial processes, such as paper production process, is often just burned as fuel. This subtopic solicits new catalytic conversion routes of either raw or processed lignin to chemicals or hydrocarbon fuels, with a preference for non-aromatic products. Process economics will have to be considered, and for a commercially commercial viable process, lignin catalytic conversions would have to be on a par with existing conversion processes.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Innovative Approaches Toward Discovery and/or Development of Ultra-low- and Non-PGM Catalysts for PEMFCs and Non-PGM Catalysts for AFCs

DOE is seeking novel transformative research demonstrating potential to lead to the development of next generation low- or non-precious group metal (PGM) oxygen reduction reaction (ORR) catalysts for polymer electrolyte membrane fuel cells (PEMFCs), as well as hydrogen oxidation reaction (HOR) and ORR catalysts for anion-exchange membrane (alkaline) fuel cells (AFCs). For PEMFCs, the DOE has targeted PGM total content for both electrodes at < 0.125 g PGM/kW and PGM total loading < 0.125 mg PGM/cm2 (electrode area) by 2017. DOE has targeted 300 A/cm3 at 800 mVIR-free by 2017 for non-PGM catalysts*. A better understanding of the active site in non-PGM catalysts is needed and any known catalytic activity should be included. The work plan should include a discussion of the catalytic activity testing required to show viability and should demonstrate a pathway toward scientific advancement.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Photo- and Electrochemical Conversions in Especially High Heat Transfer Chemical Contacting Schemes

This subtopic solicits new conversion processes involving photo and electrochemical catalysis that use a liquid or vapor contacting scheme that provides extremely high heat and mass transfer rates, such as "microchannel" chemical reactors. The strategy behind such contacting schemes is the conversion efficiencies possible with heat transfer rates high enough to limit hazardous potential of chemical and oxygen contacting within inflammability mixture limits, for example. These chemical reactor contacting schemes have not been extended to involve photo- or electrochemical conversions, which might improve conversion efficiencies even more. The investigation of such new catalytic processes involves long term R&D, which will be a factor considered in the evaluation of grant applications responsive to this subtopic solicitation.

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e. Alternative Approaches for Natural and Gas Liquefaction

The traditional process for transforming natural gas to liquid fuels with sufficiently high octane and quality for transportation—involving steam reforming of methane and with further catalysis and reforming—is wasteful and polluting. Alternatives (e.g. cracking natural gas condensate (C4, C5 in particular) to olefin and reacted with acid to yield reformulated gasoline) have been considered but have not been proven at commercial scale. This sub topic solicits R&D proposals in such new areas with a goal (assuming continued low natural gas prices (e.g. $2/MMBTu and H2 lower than $4/MMBTu) of a synfuel that would compete with petroleum gasoline.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

f. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

References:

1. "Basic Research Needs: Catalysis for Energy," Report from the U.S. Department of Energy Basic Energy Sciences Workshop. Aug. 6-8, 2007. (http://science.energy.gov/bes/news-and-resources/reports/basic-research-needs/)

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11. WIDE BANDGAP SEMICONDUCTORS FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY (PHASE I, $150,000/PHASE II, $1,000,000)

Wide bandgap (WBG) semiconductors – with bandgaps significantly greater than 1.7 eV — include silicon carbide (SiC), gallium nitride (GaN), zinc oxide (ZnO) and diamond (C). They offer the opportunity for dramatic improvement in a variety of applications such as power electronics, solid-state lighting, fuel cells, photovoltaics, and sensing in harsh environments. Compared to today's Si based technologies, devices using WBGs can operate at higher temperatures (e.g. function at ambient temperatures higher than 150^{o}C without external cooling), withstand greater voltages (>10's of kV) over time, and switch at much higher frequencies (10's of kHz to 10's of GHz). While devices employing these materials in bulk or thin film form have started to gain traction in areas such as switch-mode power supplies and solar inverters, widespread adoption in critical energy relevant markets such as various types of electric vehicles and grid power conversion will require significant improvements in substrate and epitaxial layer quality as well as substantial cost reductions at commercial scales. Given their tremendous potential contribution to improving overall U.S. energy efficiency, the integration of renewables at multiple scales into the grid, and the acceleration of the deployment of distributed energy technologies such as electric vehicles and fuel cells, overcoming these barriers is a national priority[1].

Grant applications are sought only in the following subtopics:

a. Bulk GaN Substrates and Novel Architectures

The vast majority of GaN-based devices available today are based on semiconducting films deposited onto non-native substrates. While LEDs and lasers based on such mixed approaches do dominate the (still relatively small) solid-state lighting field and other specialty applications, excessive capital costs have limited their penetration into the much larger lighting market to date. These mixed approaches also present obstacles to the consistent production of reliable devices for power electronics. Current challenges to large-scale manufacturing processes include low processing yield due to lattice constant and thermal expansion coefficient mismatch between the semiconducting thin film material and substrate. Heteroepitaxial growth is also vulnerable to wafer curvature and strain-related defects that can degrade the electrical performance of the semiconductor resulting in poor device performance and reduced device yield. "GaN on GaN" approaches offers the potential to overcome many of these obstacles[2] and could enable the development of vertical device architectures for high-power applications. Economically competitive methods of producing high-quality GaN substrates at requisite scales have not, however, achieved critical mass in the market. This subtopic solicits applications that offer cost-effective, practical, and scalable solutions to the problem of native GaN substrate production:

1. In the long term, methods that scale to the production of 150-200 mm diameter GaN wafers with dislocation defect density below $10^4/cm^2$ at costs no more than 2-3X those of Si would likely enable significant market penetration. Competitive applications should demonstrate a plausible path towards such goals after phase III, and articulate appropriate intermediate metrics for phase I and II.

2. Additionally, novel technological approaches that rely on nanoscale[3, 4] or other unique architectures are strongly encouraged, as long as they illustrate a clear path to commercial-scale device production for power electronics applications. Included in this category are options such as photoconductive switches that may or may not incorporate standard p-n junctions[5] and could enable the commercial utilization of materials such as diamond. Competitive applications should clearly specify a long-term path towards marketplace viability after phase III, and articulate appropriate intermediate objectives for phase I and II.

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b. Advances in Epitaxial Growth

The relatively low cost of substrates such as Si and sapphire makes them potentially attractive for cost-sensitive applications requiring bias voltages in the range 600-1200V, such as hybrid vehicles. GaN-on-Si devices, however, have the shortcoming of relatively high defect density (10^9-$10^{10}/cm^2$), as do sapphire, as well as SiC. Therefore, substantial improvements to the epitaxial deposition processes on these non-native substrates are needed, including approaches that incorporate diamond layers to enhance thermal conductivity. This subtopic solicits applications with the potential to reduce defect densities by an order of magnitude or more for: (a) GaN on one or more of Si, sapphire and SiC, or; (b) SiC on SiC.

Competitive applications will describe the state-of-the-art in defect densities for the material system(s) of interest, as well as the potential of their proposed process or method to achieve the required improvements above this baseline. Candidate techniques include the integration of in-situ metrology into real-time production processes, semi- and non-polar approaches to GaN device development[9, 10] and innovative epitaxial strategies.[11, 12] Similar to subtopic a, cost will also be an important factor under this subtopic. Competitive proposals should exhibit a feasible path-to-market plan to enable significant penetration with costs no more than 2-3X those of Si and competitive with existing Si-based alternatives. Furthermore, phases II and III should illustrate the credible possibility of achieving such solutions from a system perspective by the completion of phase III.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Device Redesign and Passive Components

Transistors based on WBGs such as SiC and GaN (with the possible exception of Schottky diodes) may require device redesign to take advantage of their extended capabilities. Improvements in passive components such as capacitors, inductors, and transformers capable of operating at 10-1000 kHz, 600-20kV, and 0.1-10kA are necessary, with specific requirements varying by end-use application. This subtopic solicits applications that target the design of devices appropriate to systems that fall into one or more of the following categories:

1. Microgrids and traction motors at 10-15 kV, in competition primarily with Si-based IGCTs, and other gate-controllable thyristors, although Si-based IGBTs are also relevant.

2. Vehicles and other distributed two-way power devices at 600-1200V, competing with existing Si IGBTs and MOSFETs

3. Household and small-scale commercial operations at 110-480V, both single and three-phase.

Proposals based on novel device designs that take advantage of the operating characteristics of WBG materials (e.g. higher temperatures, greater operating voltages, and higher switching frequencies than Si), such as JFETs, are encouraged. In addition to primary device operation, issues such as alternative surface passivation materials and techniques[13] and investigation of novel gate dielectrics[14] may also be relevant. Novel ohmic and Schottky contact deposition strategies are also candidates. Proposals that adopt a co-design approach that includes collaboration among multiple levels of the WBG manufacturing value chain are particularly invited. Proposals should emphasize their value proposition to the particular application they are targeting, including a price/performance comparison with relevant Si-based alternatives, and must demonstrate a clear path to market viability after phase III, with clearly articulated milestones and intermediate metrics for phase I and II.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Other

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12. ADVANCED FOSSIL ENERGY TECHNOLOGY RESEARCH (PHASE I, $150,000/PHASE II, $1,000,000)

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from hydrocarbon fuels. In supplying this energy need, however, the Nation must address growing global and regional environmental concerns, supply issues, and energy prices. Maintaining low-cost energy in the face of growing demand, diminishing supply, and increasing environmental pressure requires new technologies and diversified energy supplies. These technologies must allow the Nation to use its indigenous fossil energy resources more wisely, cleanly, and efficiently. This topic addresses grant applications for the development of innovative, cost-effective technologies for improving the efficiency and environmental performance of advanced large scale industrial and utility fossil energy power systems. Small scale applications, such as residential, commercial and transportation will not be considered. The topic serves as a bridge between basic science and the fabrication and testing of new technologies.

Grant applications are sought in the following subtopics:

a. Carbon Dioxide (CO_2) Conversion to Fuels and Chemicals

Utilization of carbon dioxide (CO_2) has become an important global issue due to the significant and continuous rise in atmospheric CO_2 concentrations, accelerated growth in the consumption of carbon-based energy worldwide, depletion of carbon-based energy resources, and low efficiency in current energy systems.

Proposals are sought to develop novel and advanced concepts for conversion of $CO_2$from large (> 100MW) industrial and utility power generation facilities based on advanced catalysts for CO_2conversion to produce value-added fuels and industrial chemicals.

Proposals must be novel and innovative and show clear economic advantages over the existing state of the art. Processes must incorporate chemical versus physical transformation, not use hydrogen as a feedstock, and provide a net positive CO_2 life-cycle benefit.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Chemical Looping Combustion for CO_2 Capture

Chemical looping has the potential to generate electricity using a process that produces a concentrated stream of CO2, which could reduce power consumption and make carbon capture, utilization and storage more economical.

Prior Chemical Looping Combustion processes in the power industry have employed dual circulating fluidized bed reactors with the oxygen carrier remaining in the solid phase. Novel concepts are sought that will advance the state-of-the-art.

Grant applications are sought to develop a novel chemical looping combustion process that is able to capture at least 90% of the CO2 emitted by a megawatt-scale coal-fired power plant, at a 25% or less increase in the cost of energy services compared to a similar plant without CO2 capture.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Advanced Nickel Based Alloy Architecture for Single Crystal Gas Turbine Components

Nickel based superalloys are used for hot gas path components in gas turbines because of their excellent creep resistance properties. To achieve their maximum mechanical capability these materials must be cast as single crystals. Although casting yields have improved, they have not improved sufficiently to enable the wide-spread use of single crystal superalloys in industrial gas turbines. Grant applications are sought for research and development to explore compositional adjustments to the alloy system in order to increase the yield rates of single crystal castings for high-temperature gas turbine applications. Development of models correlating casting defects to composition variables is encouraged.

Grant applications must provide details regarding material compositions, process parameters, and technical capabilities for assessing feasibility. A clear path to an improvement in casting yield should be demonstrated. Costs of capital equipment, process consumables, and casting materials should be discussed relative to the state of the art. Technical requirements for gas turbine applications should be addressed, such as component geometry tolerances, the ability to fabricate serpentine internal cooling passages, and weldability.

The included advanced substrates must (1) have high strength at elevated temperatures; (2) withstand the high thermal, creep, and fatigue loads resulting from spallation and/or debonding of the accompanying coating system; (3) provide an adequate level of internal cooling for future high-temperature, high-hydrogen-fired turbine applications; and (4) demonstrate viable extended life (i.e., 8,000-30,000 hrs) in oxidizing environments containing as much as 15-20% H_2O, where surface temperatures range between 1,100-1,500ºC.

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d. Advanced Evaporative, Dry or Non-Aqueous Industrial or Utility Cooling Systems

Improvements are sought to narrow the cost advantage of evaporative cooling or significantly improve upon the cost of commercially available dry cooling or non-aqueous options. A more efficient innovation is sought that eliminates cooling water consumption in an ultra supercritical steam power plant condenser cooler for an industrial or utility sized plant. This effort to eliminate cooling water loss is motivated by the desire to alleviate water permitting constraints on power plants that arise from competing demands on water from agriculture, other water uses and general population growth trends. Historically, power plants with ease of accessing water were cooled by evaporative cooling means. Recently, some power plants especially if in an arid desert location with limited access to water can have dry cooling systems installed with increases in cost and increased footprints and system size. Promising technologies exist in different stages of commercial readiness especially in other analogous industries with earlier adoption schedules at smaller sizes or in other parts of the world with different constraints with respect to water and different rules. Any sub-combination of surface treatments can be considered from the non-limiting group of nano-textured surfaces, micro-grooved surfaces, ablation, coatings, self-similar geometric modifications, fractal fins, fluidic interface treatments, micro-structural modifications to cooling surfaces, or chemical compositions. Historically, non-aqueous methods of direct cooling steam power plants (including but not limited to air, carbon dioxide, helium, argon, liquid sodium, subterranean soil, and other chemical compositions) remain a challenge to show competitive relative to conventional evaporative cooling baselines and existing dry cooling technologies. Appropriately detailed simulation or mathematical modeling is needed to show reliable operation scaling above 600 MW heat dissipation and downstream operating temperatures in an ultra supercritical steam plant using annualized levelized cost of electricity (LCOE) per megawatt*hour to show economic merit. Proposals need to convincingly show at least a twenty-five percent effectiveness advantage relative to any commercially available dry cooling baseline. Selection criteria will be cost of implementation, effectiveness as determined by water loss avoidance relative to evaporative baseline, heat dissipation, and reliability. Any claims of performance, reliability or commercial power plant suitability, must be supported by written endorsements from relevant subject matter experts, experimental results, accredited means, market analyses, or identification of commercial test sites.

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e. Other

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2. Novel Carbon Sequestration Concepts, U.S. Dept. of Energy, Office of Fossil Energy, Office of Sequestration, Hydrogen & ClEAN COAL FUELS, AVAILABLE AT (http://www.fe.doe.gov/programs/sequestration/novelconcepts/index.html)

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13. ADVANCED FOSSIL ENERGY SEPARATIONS AND ANALYSIS RESEARCH (PHASE I, $150,000/PHASE II, $1,000,000)

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from hydrocarbon fuels. This topic addresses grant applications for the development of innovative, cost-effective technologies for improving the efficiency and environmental performance of advanced large scale industrial and utility fossil energy power systems. Small scale applications, such as residential, commercial and transportation will not be considered. The topic serves as a bridge between basic science and the fabrication and testing of new technologies. The Instrumentation, Sensors & Control element focuses on the development of novel sensors critical to the implementation and optimization of advanced fossil fuel-based power generation systems, including new classes of sensors capable of monitoring key parameters (temperature, pressure, and gases) and operating in harsh environments. This involves development of innovative analytical techniques for on-line industrial use, along with technologies that meet the immediate high-priority measurement need.

Grant applications are sought in the following subtopics:

a. Offshore CO_2 Sequestration Monitoring
The sudden expansion of a pressurized fluid (gas or liquid) passing through a leak and subsequent turbulence generates a signal. The SBIR Program seeks to further develop monitoring capabilities which can detect gaseous or multi-phase releases from subsea bed geological formations as used for CO_2 sequestration. As part of this, it is critical that the system be able to adequately filter ambient noise or signal structures from the signal generated

by the target plume. This can be accomplished either by development or further refinement of advanced sensors, or entire telemetry packages for fixed or mobile detection systems.

Additionally, this is not restricted to hardware. The construction of robust software packages, which allow evaluation in real time of the signal and its development, and therefore of the component(s) associated with the leakage are also encouraged. The above tools could support project development as part of a monitoring, verification and assessment requirement in the unlikely scenario of a breach to containment as well as fulfilling requirement of a final report as part of progression to a Phase II. Finally, the development of testing devices or monitoring techniques is also encouraged in the broad arena of non-destructive testing in an ocean or offshore environment. Such devices should be used to detect micro -scale weaknesses to engineering subsystems prior to failure

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b. Subsurface CO_2 Sequestration Monitoring

It will be necessary to improve existing monitoring technologies and develop novel technologies, as well as novel application of technology systems and supporting protocols, in order to decrease the cost and decrease the uncertainty in measurements needed to satisfy regulations for tracking the fate of subsurface CO_2 and quantifying any emissions from geologic reservoirs. MVAA tools are needed that are broadly applicable in different geologic storage classes and that have high accuracy. Innovative 2nd and 3rd generation tools are needed that can provide assurance of 99 percent permanence of geologic CO_2 storage. Grant applications are sought to develop innovative subsurface MVAA tools that can be applied in a systematic approach to address monitoring requirements across the range of storage formation(s), depth(s), porosities, permeabilities, temperature(s), pressure(s), and associated confining formation properties likely to be encountered in geologic carbon storage. These tools should have the potential to reduce the cost of permanent geologic storage of CO_2. Increased capabilities of these MVAA tools should also yield the ability to differentiate between natural and anthropogenic CO_2 and account for the location of injected CO_2 and any potential release, thus ensuring the protection of human health and the environment.

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c. Power Plant Mercury Emissions Monitoring

In December 2011, the Environmental Protection Agency (EPA) announced the Mercury and Air Toxics Standards (MATS) for power plants. This rule requires existing and new coal-fired power plants to meet stringent mercury reduction levels. Specifically, the rule applies to new and existing electric generating units (EGUs) that burn coal or oil to generate greater than 25 megawatts (MW) of electricity for sale and distribution through the national electric grid to the public. These new standards limit mercury emissions on the order of tenths to ten-thousandths of a pound/gigawatt-hour of gross electrical output (lb/GWh) depending upon the coal type, whether the plant is existing or new, and the power plant technology.

Grant applications are sought for robust, novel sensor technologies that can accurately, precisely, and continuously monitor and measure mercury emissions levels to determine compliance with these standards and monitoring requirements for coal- and oil-fired EGUs.

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d. Solid Oxide Fuel Cell (SOFC) Chrome Species Contaminant Monitoring and Removal
Research has shown that chrome species can react with some SOFC cell components causing degradation. The chrome is thought to volatilize from hot metallic components and react with cell and stack components. A potentially cost-effective solution would be to getter the volatile chrome species through the use of a sorbent.

Phase I should focus on the identification and evaluation of novel approaches to achieve concentrations of chrome to ppb levels in the cathode-side air stream. The air is initially ambient containing a finite amount of humidity; therefore, testing should simulate this through the use of humidified air rather than dried air. Phase I should also initially evaluate the economic and performance of the sorbent with respect to regeneration or disposal requirements and cycle performance requirements. Proposed technologies should demonstrate commercial economic potential and have commercial applicability for megawatt scale systems.

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e. Other
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3. Specific guidelines for the assessment of carbon dioxide streams for disposal into sub-seabed geological formations

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1. "Development of a 1 x N Fiber Optic Sensor Array for Carbon Monitoring", Montana State University. (http://www.netl.doe.gov/publications/factsheets/project/FE0001858.pdf)

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1. EPA Mercury and Air Toxics Standards webpage and final rule information source (http://epa.gov/mats/actions.html)

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3. National Energy Technology Laboratory Mercury Emissions Control/Regulatory webpage (http://www.netl.doe.gov/technologies/coalpower/ewr/mercury/regs.html)

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14. HIGH PERFORMANCE MATERIALS FOR NUCLEAR APPLICATION (PHASE I, $150,000/PHASE II, $1,000,000)

To achieve energy security and greenhouse gas (GHG) emission reduction objectives, the United States must develop and deploy clean, affordable, domestic energy sources as quickly as possible. Nuclear power will continue to be a key component of a portfolio of technologies that meets our energy goals. Nuclear Energy R&D activities are organized along four main R&D objectives that address challenges to expanding the use of nuclear power: (1) develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors; (2) develop improvements in the affordability of new reactors to enable nuclear energy to help meet the Administration's energy security and climate change goals; (3) develop sustainable nuclear fuel cycles; and (4) understanding and minimization of risks of nuclear proliferation and terrorism.

To support these objectives, the Department of Energy is seeking to advance engineering materials for service in nuclear reactors.

a. Specialty Steels and Alloys

Grant applications are sought to develop radiation resistant steels, ferriticmartensitic (FM) steels, oxide dispersion strengthened (ODS) steels, and high alloys that can be used in liquid cooled reactors at 400-800°C, which have improved creep strength, can be formed and joined, and are compatible with one or more high-temperature reactor coolants. Grant applications also are sought to improve the weldability and formability of FM and ODS steels, develop methods to monitor in situ irradiation performance in these materials, and develop improved non-destructive evaluation techniques.

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b. Refractory, Ceramic, Ceramic Composite, Graphitic, or Coated Materials
Grant applications are sought to develop refractory, ceramic, ceramic composite, graphitic, or coated materials that can be used in the Generation IV Advanced Gas Cooled Reactors Next Generation Nuclear Plant (NGNP) at temperatures to 800°C and the Fluoride Salt High Temperature Reactor at temperatures to 700°C, in a thermal neutron spectrum environment during normal operations and accidents. These ceramics, graphitic, or coated materials should have the following characteristics: (1) low thermal expansion coefficients, (2) excellent high-temperature strength, (3) excellent high-temperature creep resistance, (4) good thermal conductivity, (5) ability to endure a high-neutron-fluence environment, (6) ability to be easily fabricated, (7) capable of being joined, (8) low erosion properties in flowing helium (for NGNP applications), and (9) ability to survive air and/or water ingress accidents. Because high temperature strength and corrosion resistance may be difficult to achieve with a single material, composite or coated systems may be required.

In addition, grant applications are sought to develop methods for real-time in situ monitoring of the irradiation performance of these refractory, ceramic, graphitic, and coated composite materials. Approaches of interest include the development of sensors that can monitor the mechanical properties of these materials during their service lifetime and during large temperature changes.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Assessment and Mitigation of Materials Degradation
Grant applications are sought to develop technologies for the assessment and mitigation of materials degradation in Light Water Reactor systems and components, in order to extend the service life of current light water reactors. Approaches of interest include (1) advanced in situ techniques for the monitoring of swelling in stainless steel, hardening of reactor pressure vessels, and the degradation of concrete;
(2) new techniques for component repair; (3) methods that can mitigate or predict irradiation and aging effects in reactors and components, and (4) improved nuclear fuel cladding materials.

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d. Other
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5. “Light Waster Reactor Sustainability,” U.S. DOE Office of Nuclear Energy (http://www.nuclear.gov/LWRSP/overview.html)

15. LOW COST, OPTIMIZED REDOX FLOW BATTERY ELECTROLYTES, NOVEL SOLID IONIC CONDUCTING MEMBRANES, AND RECHARGEABLE AIR-BREATHING CATHODES FOR BATTERIES FOR STATIONARY STORAGE (PHASE I, $150,000/PHASE II, $1,000,000)

The projected doubling of world energy consumption within the next 50 years, along with resource constraints and environmental concerns about using fossil fuels , have spurred great interest in generating electrical energy from renewable sources such as wind and solar. The variable and stochastic nature of renewable sources, however, makes solar and wind power difficult to manage, especially at high levels of penetration. To effectively use the intermittent renewable energy and enable its delivery demand electrical energy storage (EES). For example, storage operating near an intermittent, renewable wind energy source can smooth out wind variability, lessen the slope on ramp rates, and, at sufficient scale, can store off peak wind energy. EES is also an effective tool to improve the reliability, stability, and efficiency of the future electrical grid, i.e. smart grid that enables real-time, two-way communication to balance demand and generation and supports plug-in electrical vehicles. Electrical energy storage can shave peaks from a user or utility load profile, increase asset utilization by improving duty factor and delaying utility upgrades, decrease fossil fuel use for ancillary services, provide high levels of power quality, and increase grid stability. Distributed energy storage near load centers can reduce congestion on both the distribution and transmission systems.

Among the most promising electrical storage technologies are redox flow batteries (RFBs) and sodium (Na) batteries. RFBs have the advantage of allowing separation of power and energy. The power (kW) of the system is determined by the size of the electrodes and the number of cells in a stack, whereas the energy storage capacity (kWh) by the concentration and volume of the electrolyte. Varied RFBs have been developed, including the all vanadium redox flow batteries (VRBs) that have recently demonstrated operation at multi-MWs with unlimited cycle life. The use of abundant, low cost Na makes the Na-batteries attractive to further cost reduction for the grid applications. Sodium batteries typically come with either a polysulfide or metal halide cathode. Both deliver good performance but at high capital and levelized costs (>$3,000/kW and >30¢/kWh, respectively). One of the major cost drivers for sodium batteries is the solid-state electrolyte membrane, while for VRBs the cost is attributed to the electrolyte. Finally, the ultimate in low-cost, high energy density energy storage are the metal-air systems, which have been demonstrated in the laboratory but suffer from drastically limited cycle life and low efficiency at the discharge and recharge cathode half-reactions.

Particularly sought this year are research efforts related to novel, high performance and low-cost electrolytes in RFBs, high conductivity solid-state electrolyte membranes either for sodium or for other abundantly available lightweight multivalent cation systems (e.g., aluminum or magnesium), and technologies with promise to extend the life of metal-air cathodes to thousands of cycles at low cost and high cycle efficiencies.

Grant applications are sought only in the following sub-topics:

a. Cost Effective, Optimized Vanadium Based Aqueous Electrolytes

Liquid electrolyte in RFB serves as a "fuel" to store electricity via redox reactions when flowing through electrodes. The liquid electrolyte determines the energy capacity and is a main component to the overall capital cost and technical performance. This is particular true for the all-vanadium RFBs or VRBs. The current electrolytes in vanadyl sulfate systems account for nearly 40% of the total cost of a 1MW/8MWh all vanadium system. The high cost comes from vanadium and preparation of high purity of the vanadium aqueous electrolytes. There is also a stability issue in the current sulfate electrolytes. When the vanadium concentration is over 2 M, the electrolytes will become super saturated, resulting in formation of precipitation for V^{5+} at the temperatures above 40°C and for V^{2+}, V^{3+}, V^{4+} at the temperatures below 10°C. Accordingly, current VRBs are limited to around 1.7 M and operated in 10-35^{o}C, with heat management required. As such grant applications are sought to develop cost-effective, optimized aqueous vanadium base electrolytes that can demonstrate: 1) high solubility of active components and stability over broad operating conditions, 2) excellent electrochemical reversibility, 3) good chemical compatibility to adjacent components such as electrodes, tubes, etc. 4) acceptance to environment, and 5) most of all, low cost by reduction of vanadium use and simplification of electrolyte preparation.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Cost Effective, Optimized Na^+ and Multi-Valent Ion Conducting Membranes

Na-batteries, including both NSBs and NMBs, are built upon a Na^+ conducting solid state membrane. The most widely used is doped β -Al_2O_3, a structure of alternating closely-packed slabs and loosely-packed layers that allows for facile transport of Na^+ in elevated temperatures. For a satisfactory performance, the Na-batteries are built upon a thick solid electrolyte (≥1.0 mm) and operated at 300-350^{o}C. The solid oxide membranes are prepared via sophisticated ceramic processing, including extruding/casting and varied stages of heating or sintering. Alternatively NaSICON has been reported lately for Na-batteries that can operate at lower temperatures than that required for NSBs and NMBs. There however remain challenges for this type of membranes in conductivity, long term stability, etc. In addition to sodium, other membrane chemistries are of interest to enable the usage of other low-cost, multivalent materials (magnesium or aluminum as examples) that would increase energy density and improve cost. Lithium-based chemistries are specifically discouraged from this call. Applications are sought to develop low cost, robust solid state membranes that can allow for satisfactory operation of Na- and other multivalent cation-based batteries at temperatures <250^{o}C. An ideal membrane should exhibit: 1) high cation conductivity, 2) excellent structural and mechanical stability, 3) good chemical stability to adjacent components during operation at elevated temperatures, and 4) low cost in raw materials and manufacturing.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Low Cost, Robust, Rechargeable Oxygen Cathode for Metal-Air Systems

Metal-air chemistry has the highest theoretical energy density due to the use of an inexhaustible supply of low-cost O_2 discharging 4 electrons per molecule as a cathode. For example, lithium-air yields 13 kWh/kg versus the anemic 0.42 kWh/kg for lithium-ion[6], highlighting the tremendous advantage in energy density of metal-air over existing technology, and important for reducing the overall cost of large scale stationary storage. Historically, technical limiting factors that vary based on the chosen anode material-electrolyte system have prevented the realization of a specific rechargeable chemistry. Current technology is limited by the high over potentials of the oxygen reduction reaction (ORR) and its reverse reaction, the oxygen evolution reaction (OER), poor cycle life, and high cost of electrodes using platinum electrocatalysts. Applications are sought to develop a rechargeable oxygen cathode for a chosen battery chemistry that (1) is electrically efficient (roundtrip efficiency >75%), (2) is cost-effective, (3) is mechanically and chemically robust in the intended metal-air battery environment, (4) demonstrates good cycle characteristics (thousands of cycles), and (5) is viable for use with the selected metal-air system.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

References:

1. "Bottling Electricity: Storage as a Strategic Tool for Managing Variability and Capacity Concerns in the Modern Grid," Electricity Advisory Committee, The US Department of Energy. 2008. (http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/final-energy-storage_12-16-08.pdf)

2. "Advanced Materials and Devices for Stationary Electrical Energy Storage Applications," TMS and NEXIGHT for US DOE. 2011. (http://energy.tms.org/docs/pdfs/Advanced_Materials_for_SEES_2010.pdf)

3. *Handbook of Energy Storage for Transmission and Distribution Applications*., Electrical Power Research Institute, Palo Alto, CA, and Department of Energy, Washington, D.C., 2003. (http://www.sandia.gov/ess/publications/ESHB%201001834%20reduced%20size.pdf)

4. Yang, Z. et al., "Electrochemical Energy Storage for The Green Grid", *Chemical Reviews*, Vol. 115, pp. 3577. 2011. (http://www.ncbi.nlm.nih.gov/pubmed/21375330)

5. Lu, X et al., "Advanced Materials for Sodium-Beta Alumina Batteries: Status, Challenges and Perspectives," *Journal of Power Sources*, Vol. 195, pp. 2431. 2009. (http://www.sciencedirect.com/science/article/pii/S0378775309021284)

6. Linden, D. and Reddy, T. eds., *Handbook of Batteries (3rd Edition).* New York: McGraw-Hill, 2002.

16. TECHNOLOGY TRANSFER OPPORTUNITIES: BASIC ENERGY SCIENCES (PHASE I, $150,000/PHASE II, $1,000,000)

Applicants to Technology Transfer Opportunities should review the section describing Technology Transfer Opportunities on page 1 of this document prior to submitting applications.

Grant applications are sought only in the following sub-topics:

a. Process for Epoxy Foam Production

Epoxy foams are often used as encapsulents and in structures such as wind generator blades, windsurfing boards, and automotive spoilers due to their rigidity, adhesive strength, moisture resistance, and toughness. These foams allow for highly reliable strength to be added to a material through a relatively inexpensive process. However, these foams often require the use of hazardous chemicals such as physical blowing agents (PBA's) or freons in order to achieve adequate foaming of the epoxy material. Sandia National Laboratories have developed a novel method for producing epoxy foams that does not require the use of PBA's or freons, while still maintaining the extent of foaming. This method uses maleic anhydride as a curing agent for the production of foamed epoxies with a large range of physical densities, depending on the concentration of maleic anhydride, initiators, surfactants, and reaction temperatures used. Another benefit afforded by this method is relatively low curing temperatures (below 100°C) and the ability to produce numerous foamed hybrid materials dependent on the types of additives used.

Potential Applications: Aircraft and Aerospace, Electronics, and Construction/ HVAC
Benefits: No PBA's or freons required making it safer; large range of densities; low curing temperatures; cohesive with other additives; Technology Readiness Level: 4

Sandia National Laboratory Information
TTO tracking number: SD 10311.0
Contact: Elizabeth Kistin Keller, 505-844-1017, ejkisti@sandia.gov
Website: https://ip.sandia.gov/

Please submit all topic and subtopic questions through FedConnect at
https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Ternary Compound Nanocrystals for Photovoltaic Devices

Solar cells based on highly confined nanocrystals of the ternary compound PbSxSe1-x. The crystalline, monodisperse alloyed nanocrystals are obtained using a one-pot, hot injection reaction. Photovoltaic devices made using these ternary nanoparticles are more efficient than either pure PbS- or pure PbSe-based nanocrystal devices

Although little research has focused on ternary compositions of nanoparticles for solar cells, thin film solar cell studies indicate that such compositional tuning can yield significant improvements in performance. PbSe nanocrystal solar cells generate larger short circuit photocurrents while PbS nanocrystal devices with similar bandgap have shown a larger open circuit voltage. By creating ternary PbSxSe1-x, both carrier transport and voltage are optimized.

Nanocrystals are an excellent potential choice for photovoltaic device applications due to their high photoactivity, solution processability and low cost of production. A challenge for any nanoparticle-based solar cell, however, is taking advantage of quantum confinement effects to improve the optical absorption process without overly hindering the subsequent transport of charge electrodes. Various binary semiconductor nanoparticles, such as CdSe, CdTe, Cu2S, InP and InAs, have been explored for photovoltaic devices, but the reported efficiencies remain low, mostly limited by poor charge transport between the nanocrystals. The Berkeley Lab ternary compound nanocrystals, however, show promise for more efficient photovoltaic devices.

Lawrence Berkeley National Laboratory information:
TTO information: http://www.lbl.gov/Tech-Transfer/techs/lbnl2740.html
Patent Status: U.S. Regular Application filed; http://ip.com/patapp/US20110277838
TTO tracking number: IB - 2740
Contact: Shanshan Li, ttd@lbl.gov , 510-486-6457

Please submit all topic and subtopic questions through FedConnect at
https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Catalyst for Selective Acid Transesterfication

The ability to separate functionalized mesoporous silica nanoparticles (MSNs) for recycling has enabled application of these materials as heterogeneous catalysts in many chemical transformations. However, the sensitivity to hydrolysis and subsequent loss of catalytic performance has reduced the economic benefit potential of MSN catalyst. Ames Laboratory researchers have developed an efficient bifunctional MSN catalyst for the esterification reaction. They achieved superior reactivity by supplementing the catalytic groups with the secondary functionality designed to expel the resulting aqueous by-products thereby preventing hydrolysis of the silica surface and plugging of the nano-environment. The principle employed in the architecture of this new catalyst makes it suitable for reactions involving dehydration and yields compounds of high purity.

Advantages include a robust structure which enables multiple recycling, high purity yields which are achieved by efficiently expelling by-products of reaction, and enhanced reactivity compared to existing commercial catalysts. Laboratory trials have been successful.

Ames Laboratory information:
TTO:www.techtransfer.iastate.edu/en/for_industry/technology_search/search.cfm?fuseaction=technology.details&id=3881
Patent Status: Utility Patent Filed:
TTO tracking number: 03881/AL583
Contact: Stacy Joiner, joiner@ameslab.gov , 515-294-5932
Ames Laboratory website: www.ameslab.gov/techtransfer

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Palladium-Cobalt Particles As Oxygen-Reduction Electrocatalysts

Oxygen reduction electrocatalysts are made of palladium-cobalt alloys, reducing cost by eliminating platinum. Palladium-cobalt alloys offer a less expensive alternative to platinum catalysts with similar activity for oxygen reduction. Opportunity 1: Demonstrate performance in a PEM fuel cell. Opportunity 2: Demonstrate application to heterogeneous catalysis.

The immediate application is to PEM fuel cells, in which the oxygen reduction reaction is the performance-limiting step. Here the addition of cobalt to the platinum catalyst reduces cost without sacrificing catalytic activity. The catalysts may also be effective in replacing platinum for heterogeneous catalysis.

Brookhaven National Laboratory information:
Patent Status: U.S. Patent 7,632,601
TTO tracking number: BSA 05-02
Contact: Kimberley Elcess; elcess@bnl.gov ; 631-344-4151
Brookhaven National Lab website: http://www.bnl.gov/techtransfer/

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

PROGRAM AREA OVERVIEW: OFFICE OF BIOLOGICAL AND ENVIRONMENTAL RESEARCH

The Biological and Environmental Research (BER) Program supports fundamental, peer-reviewed research on complex systems in climate change, subsurface biogeochemistry, genomics, systems biology, radiation biology, radiochemistry, and instrumentation. BER funds research at public and private research institutions and at DOE laboratories. BER also supports leading edge research facilities used by public and private sector scientists across a range of disciplines: structural biology, DNA sequencing, functional genomics, climate science, the global carbon cycle, and environmental molecular science.

BER has interests in the following areas:

(1) Systems biology is the multidisciplinary study of complex interactions specifying the function of entire biological systems—from single cells to multi cellular organisms—rather than the study of individual components. The Biological Systems Science subprogram focuses on understanding the functional principles that drive living systems, from microbes and microbial communities to plants and other whole organisms. Questions include: What information is in the genome sequence? How is information coordinated between different sub cellular constituents? What molecular interactions regulate the response of living systems and how can those interactions be understood dynamically and predicatively? The approaches employed include genome sequencing, proteomics, metabolomics, structural biology, high-resolution imaging and characterization, and integration of information into predictive computational models of biological systems that can be tested and validated.

The subprogram supports operation of a scientific user facility, the DOE Joint Genome Institute (JGI), and access to structural biology facilities. Support is also provided for research at the interface of the biological and physical sciences and in radiochemistry and instrumentation to develop new methods for real-time, high-resolution imaging of dynamic biological processes.

(2) The Climate and Environmental Sciences subprogram focuses on a predictive, systems-level understanding of the fundamental science associated with climate change and DOE's environmental challenges—both key to supporting the DOE mission. The subprogram supports an integrated portfolio of research from molecular-level to field-scale studies with emphasis on multidisciplinary experimentation and use of advanced computer models. The science and research capabilities enable DOE leadership in climate-relevant atmospheric-process research and modeling, including clouds, aerosols, and the terrestrial carbon cycle; large-scale climate change modeling; experimental research on the effects of climate change on ecosystems; integrated analysis of climate change impacts; and advancing fundamental understanding of coupled physical, chemical, and biological processes controlling contaminant mobility in the environment.

The subprogram supports three primary research activities and two national scientific user facilities.

- Atmospheric System Research seeks to resolve the two major areas of uncertainty in climate change model projections: the role of clouds and the effects of aerosols on the atmospheric radiation balance.
- Environmental System Science supports research that provides scientific understanding of the effects of climate change on terrestrial ecosystems, the role of terrestrial ecosystems in global carbon cycling, and the role of subsurface biogeochemical processes on the fate and transport of DOE-relevant contaminants.

- Climate and Earth System Modeling focuses on development, evaluation, and use of large scale climate change models to determine the impacts of climate change and mitigation options.
- Two scientific user facilities—the Atmospheric Radiation Measurement (ARM) Climate Research Facility and the Environmental Molecular Sciences Laboratory (EMSL)—provide the broad scientific community with technical capabilities, scientific expertise, and unique information to facilitate science in areas integral to the BER mission and of importance to DOE.

For additional information regarding the Office of Biological and Environmental Research priorities, click here.

17. ATMOSPHERIC MEASUREMENT TECHNOLOGY (PHASE I, $150,000/PHASE II, $1,000,000)

World-wide energy production is modifying the chemical composition of the atmosphere. Such modifications are linked not only with environmental degradation and human health problems but also with changes in the most sensitive parts of the physical climate system – namely, clouds and aerosols. The Intergovernmental Panel on Climate Change (IPCC) is making progress toward its next major report, the Fifth Assessment Report (AR5), which will be released in 2013 and 2014. The Fourth Assessment Report of the IPCC examined the effect of changes in clouds and aerosols on the Earth's energy balance. It was determined that innovative measurement technologies are needed to provide both input and comparison data for models used to assess the energetic impacts of clouds and aerosols. These technologies will require high accuracy and time stability, in order to support a strategy of sustainable and pollution-free energy development for the future. When the last IPCC report was published in 2007, there was a lack of data on the Arctic. The latest scientific data on the rate of Arctic warming show dramatic levels of melting and sea level rise occurring far faster than previous climate model estimates. The U.S. Arctic continues to be one of the most difficult places on Earth for year-round scientific observations and research. One of the major recommendations of an Arctic Research Consortium of the U.S. (ARCUS), 1997 report, "Logistics Recommendations for an Improved U.S. Arctic Research Capability" (www.arcus.org/logistics/index.html), was to increase use of robotic aircraft to meet the growing need for environmental observing in the Arctic. Therefore the DOE Atmospheric Radiation Measurement (ARM) program (http://www.arm.gov/) continues to advance its mission and vision by expanding its footprint in the North Slope of Alaska (NSA). Thus we are seeking opportunities to expand measurements in the Arctic to obtain statistically significant data for climate models by providing routine measurements. Subtopics (a) and (b) are requesting these measurements to be conducted on small UAV platforms.

Additionally, the DOE Atmospheric Systems Research program (http://asr.science.energy.gov/) continues to make inroads to improved measurements of its science through subtopics (c) through (f). Grant applications that respond to this topic must propose Phase I bench tests of critical technologies. ("Critical technologies" refers to components, materials, equipment, or processes that overcome significant limitations to current capabilities.) In addition, grant applications should (1) describe the purpose and benefits of any proposed teaming arrangements with government laboratories or universities, and (2) support claims of commercial potential for proposed technologies (e.g., endorsements from relevant industrial sectors, market analysis, or identification of potential spin-offs). Grant applications proposing only computer modeling without physical testing will be considered non-responsive.

Grant applications are sought in the following subtopics:

a. Instrument Package for Characterization of Aerosols, Turbulence, and Surface Characteristics in the Arctic

Measurements in the Arctic are needed to provide data regarding atmospheric characterization of clouds, aerosols, and boundary layer diurnal evolution in the vicinity of ARM's (Atmospheric Radiation Measurement) North Slope of Alaska (NSA) scientific user facility (http://www.arm.gov/sites/nsa/). Measurements of the vertical distribution of aerosol properties provide essential information for generating more accurate model estimates of radiative forcing and atmospheric heating rates compared with employing remotely sensed column averaged properties. Therefore, we are seeking miniaturization of airborne instrumentation for light aircraft platforms in the Manta, ScanEagle, or Raven classes of unpiloted aerial vehicles (UAVs) that adhere to Federal Aviation Administration manufacturing specifications. We expect the instruments to fit the payload capacities of light UAVs, ranging up to approximately 5 kg. Available operating power for these instruments will be up to 50 watts.

Instrument packages are sought, including:

- measurement capabilities for aerosol size distributions in the 10nm to 10 micron range
- a sonic anemometer for turbulence measurements
- a cloud condensation nuclei counter (CCN)
- surface characterization capabilities using lidar, synthetic aperture radar (SAR), and/or camera (downward) imaging capability that would acquire multi-temporal imagery of snow cover and surface water extent during the melt season.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Greenhouse Gas and Carbon Isotope Measurements from UAVs

Stable isotopologues of methane and carbon dioxide can be powerful tracers for identifying the sources of greenhouse gases. Airborne surveys of isotopologues of these greenhouse gases made at sufficiently high precision and speed will be an invaluable tool in the studies of Arctic climate change and the terrestrial carbon cycle. Instruments capable of operating on light-weight airborne platforms such as UAV's with little or no temperature or pressure controls are needed. Therefore, we are seeking miniaturization of airborne instrumentation for light aircraft platforms in the Manta, ScanEagle, or Raven classes of unpiloted aerial vehicles (UAVs) that adhere to Federal Aviation Administration manufacturing specifications. We expect the instruments ranging up to approximately 5 kg, to fit the payload capacities of light UAVs. Available operating power for these instruments will be up to 50 watts.

Measurements must be made with high precision for either methane (CH_4) or carbon dioxide (CO_2) at rates of 1 Hz. or better. We seek an instrument to examine climate issues related to vegetation properties (possibly via lidar), presumably multi-temporal, through the growing season. It is preferable to measure both land surface CO_2 fluxes, near-surface CO_2 concentration in the atmosphere, other land surface (e.g., surface temperature) and atmospheric states (e.g., temperature, humidity, wind), and atmospheric radiation measurements. This would allow for the development of land models of the carbon cycle and atmospheric models involving prognostic CO_2. This information is needed to address issues related to adaptive grids in DOE's modeling endeavors in the Arctic utilizing the Regional Arctic System Model (RASM).

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Measurements of the Chemical Composition of Atmospheric Aerosols

Enhanced measurement methods are needed for the real-time characterization of the bulk and the size-resolved chemical composition of ambient aerosols, particularly carbonaceous aerosols. Such improved measurements would be used to facilitate the identification of the origin of aerosols, (i.e., primary versus secondary and fossil fuel versus biogenic). Also, these measurements could help elucidate how the particles of an aerosol are processed in the atmosphere by chemical reactions and by clouds, and how their hygroscopic properties change as they age. This information is important because relatively little is known about organic and absorbing particles which are abundant in many locations in the atmosphere. In particular, there is a need for instruments capable of real-time measurements of the composition of these particles at the molecular level. Although recent advances have led to the development of new instruments, such as particle mass spectrometers and single particle analyzers, these instruments have important limitations in their ability to quantify black carbon vs. organic carbon, provide speciation of refractory and volatile organic compounds, and calibrate both organic and inorganic components. Furthermore, instruments that otherwise would be suitable for ground-based operation often have limitations (size, weight, power, stability, etc.) that restrict their application for *in situ* measurements, where critical atmospheric processes actually occur (e.g., in or near clouds using aircraft or balloons).

In order to better understand the chemical composition of atmospheric aerosols, grant applications are sought to develop improved instruments, or entirely new measurement methods, that provide: (1) speciation of individual organics, including those containing oxygen, nitrogen, and sulfur; (2) identification of elemental carbon and other carbonaceous material, so that the makeup of the absorbing fraction is known; (3) identification of source markers, such as isotopic abundances in aerosols; and (4) the ability to probe the chemical composition of aerosol surfaces.

In order to address the deficiencies associated with current techniques, proposed approaches should seek to provide: (1) quantifiable results over a wide range of compounds, which is a deficiency of laser ablation aerosol mass spectrometer methods; (2) measurements over a range of volatility so that dust, carbon, and salt are detectable, which is a deficiency of thermal decomposition aerosol mass spectrometers; and (3) measurements with high time resolution, which is a deficiency of filter techniques. Proposed approaches that can measure aerosol chemical composition from airborne platforms would be of particular interest.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Measurements of the Chemical Composition of Atmospheric Aerosol Precursors

In order to better understand the evolution of aerosols in the open air, grant applications are sought to develop instruments that can make fast measurements of gas phase organics or other substances that might either condense or dissolve into aerosols or cloud droplets. Of special interest are volatile organic compounds (VOC) and intermediate volatility organic compounds (IVOC). Although VOCs and IVOCs partition primarily into the gas phase, they may react with gaseous oxidants or with existing aerosol particles and droplets to form a secondary organic aerosol (SOA) mass. Current methods for predicting SOA production rates, based only on precursor organic compounds that have been quantified (both VOCs and oxygenates), underestimate SOA production by factors of 3 or more. One problem is that many gaseous organic compounds are not detected by commonly-used techniques, such as gas chromatographic or chemical ionization-mass spectrometric methods.

Grant applications also are sought to develop instruments to determine the total amount of carbon in these organic compounds. The data provided by these instruments would allow scientific insights to be gained regarding the reason for the underestimation of SOA production. (That is, is the underestimation due to key precursors that are not measured? Or, is it due to the use of extrapolations – from laboratory kinetic and equilibrium data – that were not appropriate for ambient conditions?)

Finally, grant applications are sought to develop improved measurements of inorganic aerosol precursors. Examples of compounds of interest (with desirable detection limits and response rates listed in parenthesis) include gaseous HNO_3 (0.1 ppbv, 1 Hz), O_3 (2-3 ppbv, 10 Hz), and SO_2 (5 pptv, 1 Hz). In addition to the free-air measurements described above, grant applications are sought to develop instruments or instrument systems for measuring aerosol precursors in cloud droplets. Such systems must address (1) methods for the efficient sampling of droplets; and (2) a mechanism for transferring the sample to the appropriate analytical instrumentation, in which the organic or inorganic target analytes are measured. Of particular interest are systems that can separate or discriminate between interstitial compounds and compounds that occur dissolved or suspended within cloud droplets. Proposed instruments that are suitable for sampling from airborne platforms (that is, with reduced weight and power requirements, high sensitivity, and fast response time) are of particular interest.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

e. Aerosol Size Distributions

Knowledge of particle size distribution is essential for describing both direct and indirect radiative forcing by aerosols. However, current techniques for determining these distributions are often ambiguous because of the assumption that the particles are spherical. In particular, the optical techniques most often used in the 0.5-10 µm size range have inherent problems.

Therefore, grant applications are sought for techniques for which the size determination is not based on optical properties, to determine the size distribution of ambient aerosols in the 0.1 – 10 μm size ranges. Proposed approaches must address the influence of relative humidity and must be integrated with the simultaneous measurement of such properties as mass concentration, area (extinction), and particle number.

Grant applications also are sought to develop fast (~ 1 sec) and lightweight (suitable for sampling from airborne platforms) instruments for (1) particle size spectrum measurements in the 10- 600 nm size range, and (2) for cloud droplet/drizzle measurements (10–1000 μm size range). Related airborne measurements of great interest are (3) a fast spectrometer for measurement of cloud condensation nuclei number concentrations over supersaturation ranges of the order 0.02% – 1% and (4) a spectrometer/counter for ice nuclei (IN) number concentrations over effective local temperatures down to -38 °C.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

f. Aerosol Scattering and Absorption (in situ)

The aerosol absorption coefficient, together with the aerosol scattering coefficient, determines the single-scattering albedo. This key aerosol property, along with the factors that contribute to it, are critical for determining heating rates and climate forcing by aerosols. Therefore, grant applications are sought to develop reliable instruments for the *in situ* measurement (using aircraft or balloons) of the single-scattering albedo for particles containing black and organic carbon, dust, and minerals. The measurements must cover the solar wavelengths (UV, visible, and near infrared), must not alter aerosol properties, and must address the influence of relative humidity.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

g. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

References Subtopics a-b:

1. The Arctic Research Consortium of the U.S. (ARCUS) (http://www.arcus.org/arcus/index.html)

2. Curry, J.A., Maslanik, J., Holland, G., and Pinto, J., “Applications of Aerosondes in the Arctic”, *Bulletin of the American Meteorological Society (BAMS).* December 2004. (http://curry.eas.gatech.edu/currydoc/Curry_BAMS85A.pdf)

3. Corrigan, C.E., Roberts, G.C., Ramana M.V., Kim and Ramanathan, V. "Capturing Vertical Properties of Aerosols and Black Carbon over the Indian Ocean Using Autonomous Unmanned Aerial Vehicles", *Atmospheric Chemistry and Physics*. Volume 8, Issue 3. 2008. (http://www.atmos-chem-phys.org/8/737/2008/acp-8-737-2008.html).

References Subtopics c-f:

1. "A Reconfigured Atmospheric Science Program", *U.S. Department of Energy Biological and Environmental Research Advisory Committee.* April 2004. Pages 18-21. http://science.energy.gov/~/media/ber/berac/pdf/Asp.pdf)

2. "Atmospheric System Research Science and Research Plan", January, 2010. (See http://science.energy.gov/~/media/ber/pdf/Atmospheric_system_research_science_plan.pdf)

18. CARBON CYCLE MEASUREMENTS OF PROCESSES IN THE ATMOSPHERE AND BIOSPHERE (PHASE I, $150,000/PHASE II, $1,000,000)

Eighty-five percent of our nation's energy results from the burning of fossil fuels from vast reservoirs of coal, oil, and natural gas. These processes add carbon to the atmosphere, principally in the form of carbon dioxide (CO_2). It is important to understand the fate of this excess CO_2 in the global carbon cycle in order to assess contemporary terrestrial carbon sinks, the sensitivity of climate to atmospheric CO_2, and future potentials for sequestration of carbon in terrestrial systems. Therefore, improved measurement approaches are needed to quantify the change of CO_2 in atmospheric components of the global carbon cycle. There is also interest in innovative approaches for flux and concentration measurements of methane and other greenhouse gas constituents associated with terrestrial systems as well as quantifying root associated belowground processes relevant to carbon cycling.

The "First State of the Carbon Cycle Report (SOCCR)" (Reference 1) and the "Carbon Cycling and Biosequestration Report: (Reference 2) provides rough estimates of terrestrial carbon sinks for North America. A DOE working paper on carbon sequestration science and technology (Reference 3) also describes research needs and technology requirements for sequestering carbon by terrestrial systems. Both documents call for advanced sensor technology and measurement approaches for detecting changes of atmospheric CO_2 properties and of carbon quantities of terrestrial systems (including biotic, microbial, and soil components). Such measurement technology would improve the quantification of CO_2, as well as carbon stock and flux, in the major sinks identified by the SOCCR report (see Figure ES.1 in Reference 1). Furthermore, the "U.S. Carbon Cycle Science Plan" (Reference 4) provides additional background on critical, overarching research needs related to carbon cycling in terrestrial ecosystems.

Grant applications submitted to this topic should (1) demonstrate performance characteristics of proposed measurement systems, and (2) show a capability for deployment at field scales ranging from experimental plot size (meters to hectares of land) to nominal dimensions of ecosystems (hectares to square kilometers). Phase I projects must perform feasibility and/or field tests of proposed measurement systems to assure a high degree of reliability and robustness. Combinations of stationary remote and *in situ* approaches will be considered, and priority will be given to ideas/approaches for verifying biosphere carbon changes. Measurements using aircraft or balloon platforms must be explicitly linked to real-time ground-based measurements. Grant applications based on satellite remote sensing platforms are beyond the scope of this topic, and will be declined.

Grant applications are sought in the following subtopics:

a. Novel Measurements of Carbon, CO_2, and Trace Greenhouse Gas Constituents of Terrestrial and Atmospheric Media

Improved measurement technology is needed to better characterize processes involving carbon transformations of soil, vegetation, and associated ecosystem components and exchanges with the atmosphere. Particular areas of interest include high resolution measurements of soil carbon/organic matter – i.e., the carbon content of biological tissues in various components (e.g., phytomass, detritus) of terrestrial ecosystems; improved measurement technology for atmospheric CO_2 and its isotopes; and high accuracy and precision measurement of other trace greenhouse gases. Requests for specific grant applications are described in items (1) to (4) below:

1) For determining the carbon content of biota and soil, grant applications are sought to develop and demonstrate measurement technology for estimating changes of carbon quantities and/or fluxes involving major components of ecosystems, with accuracy on the order of 10 grams per square meter or less. Quantification of spatially resolved aggregate estimates of terrestrial carbon changes should have an accuracy of 10 to 25 $g/m^2/yr$ (or approximately 0.25 tonnes of carbon per hectare per year), with less than 25 percent uncertainty.
2) Grant applications are sought to design and demonstrate a new CO_2 analyzer that (a) can determine the mole fraction of CO_2 in dry ambient air to a relative precision of 1 part in 3000 or better, in one minute or less; (b) operates with small amounts of gas (30 cc/min or less) to minimize problems due to water vapor and to minimize consumption of reference gases, if employed; (c) is robust enough for unattended field deployment for periods of half a year or longer; (d) costs less than $5000 when manufactured in quantity; and (e) is not sensitive to motion.
3) Grant applications are sought to develop lightweight sensors (approximately 100 grams) for measuring atmospheric CO_2. The sensors must be capable of measuring fluctuations of CO_2 in air of the order of plus or minus 1 ppm, in a background of 370 ppm. The devices must be suitable for launch on ballonsondes or similar platforms, and therefore must be insensitive to large changes in ambient temperature and pressure. The devices also must be able to operate on low power (e.g., 9v battery) and have a response time of less than 30 seconds.
4) Grant applications are sought to develop new technology platforms that can be used to measure fluxes and/or concentrations of important trace greenhouse gas constituents, as well as the isotopes of carbon, methane, CO, and other trace species. Instrument designs should (a) place emphasis on determining the sources and sinks of carbon, CO, and trace species, and (b) ensure long-term and robust field deployment. Grant applications dealing with the remote measurement of vascular plant properties and processes will be considered, provided that they meet the requirements described below.

In general, new technology for measuring terrestrial biota and soil must be accomplished by *in situ* and/or non-invasive means, across a range of temporal scales (from seconds to days) and spatial scales (from millimeters to kilometers), depending on the system properties being observed. The remote sensing of organic carbon is also of interest – the term "remote sensing" means that the observation method is physically separated from the object of interest. All instruments must be portable and deployable in remote locations, and must not adversely impact the site of deployment. Two other approaches are also of interest: (1) the development of unique surface-based observations that are used for the calibration/interpretation of other remotely derived data; and (2) potential applications of CO_2 sensors via balloon sonde. NOTE – remote sensing data acquisition by airborne or satellite platforms will not be considered.

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b. Portable Technologies for Fast and Precise Measurements of Atmospheric Nitrogen, Argon, or Oxygen

Fast and precise measurements of atmospheric nitrogen (N_2), Argon (Ar), and oxygen (O_2) have the potential to become the foundation of the next generation of eddy covariance technologies and revolutionize the real-time observations of fluxes of atmospheric greenhouse gases between the earth surface and the atmosphere (Reference 20). Measuring such fluxes is crucial in the research fields of climate change, global change biology, and ecology. Measurements of N_2, Ar, and O_2 also have direct applications in agriculture, medicine, and industrial processes. However, it is challenging to measure these gases precisely with fast response due to their high ambient abundance. Innovative technologies are sought with the following specifications:

Nitrogen (N_2) – The response time must be less than 100 ms. The N_2 can be measured directly in the unit of molar density within the range of 20 to 60 mol/m^3 with a precision of 0.2%. An acceptable alternative would be the measurement of the ratio of an atmospheric greenhouse gas (e.g. carbon dioxide, water vapor, or methane) to N_2 with a precision of 1%.

Argon (Ar) – The response time must be less than 100 ms. The Ar can be measured directly in the unit of molar density within the range of 150 to 650 mmol/m^3 with a precision of 0.2%. An acceptable alternative would be the measurement of the ratio of an atmospheric greenhouse gas (e.g. carbon dioxide, water vapor, or methane) to Ar with a precision of 1%.

Oxygen (O_2) – The response time must be less than 100 ms. The O_2 should only be measured directly in the unit of molar density within the range of 5 to 15 mol/m^3 with a precision of 0.001%.

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c. Innovation and Improvement for *In Situ* Fine Root Measurements

Fine roots (generally < 2 mm in diameter) play a critical role in the carbon and nutrient cycles of ecosystems. Their production, distribution within the soil, and turnover must be measured to have a full understanding of how an ecosystem is responding to perturbations such as climate change. Currently, the best method available for quantifying fine roots is minirhizotrons (Reference 21), which are used to periodically collect images of intact roots with a camera inserted in a transparent tube installed in the soil. Current analysis of the collected images is difficult, labor-intensive, and subject to operator biases. Quantification and analysis is a particular challenge in certain environments such as rocky soils and wetland ecosystems (Reference 22).

Grant applications are sought for technology innovation to improve current minirhizotron technologies and produce rapid assessments and measurements of in situ fine root measurements. Improvements should be aimed at developing an integrated high-throughput system that captures and processes images in real time and produces an automated replicable and artifact-free analysis of the images. Key capabilities should include state-of-the-art analytical operations, immediate detection and extraction of features (see item 2 below), and use of image-processing filters for comparing images while keeping pace with the rate of image capture. Specific technology developments should include one or more of the following criteria:

1) Advanced Image Collection System – New, low-cost imaging/camera designs and automated acquisition systems with increased versatility in soil imaging and field conditions. Device flexibility of usage and portability are also sought.
2) Automated Image Analysis – Software improvements to develop new image-processing algorithms and automated solutions that can reduce the amount of manual intervention required for each image analysis. A reliable, automated minirhizotron image analysis system would make possible more consistency and greater data intensity. An example of a minirhizotron analysis system is RootFly (http://www.ces.clemson.edu/~stb/rootfly/), but this program has proven inadequate for truly automated analysis, especially in systems where there is little contrast between roots and the background soil matrix. Specific high resolution root parameters that should be captured by automated analysis include, but are not limited to, root length, root diameter, color, turnover rates and fungal presence. Innovative methods for automated analysis of fine root and fungal dynamics (i.e., production, mortality, and turnover calculate between sampling dates) are also highly desired.
3) Three-dimensional Scaling Image of Image Analysis – Current analysis methods cannot adequately scale 2-dimensional minirhizotron images to three-dimensional data. There is potential for automated analysis of root edge resolution in order to quantify the image depth of field, or whether a particular root was "in focus" and therefore within a given depth of field (Reference 22).
4) Multispectral Image Analysis – There have been suggestions that multispectral signatures may also lead to better quantification of minirhizotron images (Reference 23). Proposers should consider use of multispectral capabilities.
5) Physical and Chemical Assessment of Soil Matrix – Temporal resolution of temperature, moisture content and nutrient availability at the site of the minirhizotrons images is a critical missing component that limits linking fine root behavior with concurrent physical conditions. Innovations that provide corresponding physical and chemical conditions within the soil at or adjacent to the image collection location is highly desired.
6) Other Non-Destructive Belowground Assessment Tools – Additionally, desired measurement characteristics could include other non-destructive, remote quantification or visualizations of

fine roots in soil such as ground penetrating radar (Reference 24) microscopic or high-resolution X-ray imaging of roots (Reference 25), and portable X-ray tomography (i.e., http://www.emsl.pnl.gov/capabilities/viewInstrument.jsp?id=34132). Such a system could be deployed using the minirhizotron tubes that have been installed in many experimental sites, or newer, miniaturized approaches that are minimally invasive to the experimental system (e.g. soil environment) could be developed.

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d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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19. ENHANCED AVAILABILITY OF CLIMATE MODEL OUTPUT (PHASE I, $150,000/PHASE II, $1,000,000)

Much of the nearly $2 billion annual research budget for the U.S. Global Change Research Program supports research from the Department of Energy, National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and National Science Foundation (NSF). Studies supported by this research, include modeling and simulation of long-term climate change. Model output resulting from climate change projections is a valuable resource and the DOE has played a crucial role in providing such datasets to the research community. For example, the Program for Climate Model Diagnosis and Intercomparison (PCMDI) (http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php) makes available a subset of multi-model output from the Intergovernmental Panel for Climate Change (IPCC) Fourth Assessment Report to researchers for non-commercial purposes only. However, other users, particularly non-researchers that intend to use the data for commercial purposes, have been requesting access to the multi-model output. As the temporal and spatial resolution of models increase, vast amount of climate model output are generated; access and analysis of such data by non-researchers is a daunting challenge.

Grant applications are sought only in the following subtopics:

a. Accessibility of Climate Model Data to Non-Researchers

The purpose of this subtopic is to broaden the usage of federally-funded, long-term climate change simulations of high-end climate models, such as the Community Climate System Model, the NOAA Geophysical Fluid Dynamics Laboratory model, and the NASA Goddard Institute for Space Studies model.

Therefore, grant applications are sought to develop technology for making the output of these models more accessible to a variety of users. Approaches of interest include the development of (1) preferred data formats for users of climate model output in particular applications (e.g., agriculture, water resources, energy); (2) methods for converting the data from existing data formats to formats required by users in the application communities; and (3) improved software frameworks and prototypes for data access by distinct application communities. Applicants are expected to document lessons learned in the experience of providing climate model output data to the non-research community.

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b. Develop Modeling Capabilities and Tools that will Facilitate a Better Linkage Between Global and Regional Climate Model Output and Wind-Energy Stakeholders

There are a wide range of uncertainties in general circulation and regional climate models that make them unsuitable for direct use in the design and planning of wind-energy systems. In addition, the global climate model output resolution is much too coarse for use by wind energy planners. Modeling tools that are capable of converting the output of global models to local scales and enable better understanding of the interaction between wind farms and regional climate are invited as part of this grant application request. Model output can also be used in conjunction with observations to enable a better characterization of the interaction between wind plants and local/regional/global climate. Applications that can identify and reduce the largest sources of uncertainty to enable an efficient use of future wind predictions are invited. An assessment of the nature and likelihood of extreme wind events in the current and future climate should help protect national investments in wind energy resources. To summarize, the effect of climatology, climate change, and extremes on wind farms and/or the effect of wind farms on regional climate is an important part of this solicitation.

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c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

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20. TECHNOLOGIES FOR SUBSURFACE CHARACTERIZATION AND MONITORING (PHASE I, $150,000/PHASE II, $1,000,000)

In support of the Department of Energy's (DOE's) secure and sustainable energy mission the Office of Biological and Environmental Research seeks to advance fundamental understanding of coupled biogeochemical processes in complex subsurface environments to enable systems-level prediction and decision support. This basic scientific understanding is applicable to a wide range of DOE relevant energy and environmental challenges including:

- Cleanup of contaminants and stewardship of former weapons production sites
- Underground storage of spent nuclear fuel
- Carbon cycling and sequestration in the environment
- Nutrient cycling in the environment in support of sustainable biofuel development
- Fossil fuel processing and recovery from the deep subsurface.

Science-based understanding and solutions to these challenges are constrained by:

- The inherent complexity and inaccessibility of subsurface environments and the strong coupling of biological, chemical and physical processes across vast spatial and temporal scales.
- Lack of well established, holistic approaches for understanding, predicting and controlling biogeochemical and hydrodynamic processes in realistically complex subsurface environments.

The development of new measurement and monitoring tools for interrogating physical, chemical, and biological processes in subsurface environments are needed to develop and test predictive models of subsurface systems and enable quantitative and robust decision support.

Grant applications submitted to this topic must describe why and how proposed *in situ* fieldable technologies will substantially improve the state-of-the-art, include bench and/or field tests to demonstrate the technology, and clearly state the projected dates for likely operational deployment. New or advanced technologies, which can be demonstrated to operate under field conditions and can be deployed in 2-3 years, will receive selection priority. Claims of relevance to DOE sites, or of commercial potential for proposed technologies, must be supported by endorsements from relevant site managers, market analyses, or the identification of commercial spin-offs. Grant applications that propose incremental improvements to existing technologies are not of interest and will be declined.

For the following subtopics, collaboration with government laboratories or universities, either during or after the SBIR/STTR project, may speed the development and field evaluation of the measurement or monitoring technology. In addition, some of these organizations operate user facilities that may be of value to proposed projects. These facilities include: Integrated Field Research Challenge (IFRC) research sites in Oak Ridge, TN (http://www.esd.ornl.gov/orifrc/index.html); Old Rifle, CO (http://ifcrifle.pnl.gov/); and Hanford, WA (http://ifchanford.pnl.gov/). At IFRC research sites, scientists can conduct field-scale research and obtain DOE-relevant samples of soils, sediments, and ground waters for laboratory research.

The Environmental Molecular Science Laboratory (EMSL) at the Pacific Northwest National Laboratory (http://www.emsl.pnl.gov). EMSL is a national scientific user facility with state-of-the-art instrumentation in environmental spectroscopy, high field magnetic resonance, high performance mass spectroscopy, high resolution electron microscopy, x-ray diffraction, and high performance computing.

Grant applications must describe, in the technical approach or work plan, the purpose and specific benefits of any proposed teaming arrangements.

Grant applications are sought in the following subtopics:

a. Mapping and Monitoring of Hydrogeologic Processes
While subsurface characterization methods are improving and yielding higher-resolution data, they are still not routinely used to describe flow and transport processes, to test and validate reactive transport models, or to guide decision support. Grant applications are sought to develop high-resolution geophysical, geochemical, or hydrogeological methods to: (1) characterize subsurface properties that control the transport and dispersion of contaminants and nutrients in groundwater, the unsaturated zone, and soil systems; or (2) monitor dynamic processes such as fluid flow, contaminant and nutrient transport, and geochemical and microbial activity in these subsurface environments. Approaches of interest include the development of:

- Integrated approaches where geophysical data are combined with other types of data (e.g., core analyses, well logs, hydrogeologic and geochemical information) to better constrain and evaluate flow and transport models;
- Improved tools and methods for hydrogeologic characterization using cone-penetrometers and conventional well logging systems;
- Innovative advances of temperature sensing technologies and approaches for hydrological characterization and monitoring from subsurface, surface, or airborne platforms; and
- Improved methods for the long-term monitoring (for one year, ten year, and one hundred year time frames) of subsurface systems, using integrated sensor networks.
- Improved characterization and monitoring approaches (to support conceptual and numerical model development) for:
    - fractured-rock and karst systems
    - systems with significant underground infrastructure, both known and unknown (pipes, filled areas of variable permeability, basements, tanks)
    - source zones with contaminants having unique properties (e.g., elemental mercury, DNAPL)

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b. Real-Time, In Situ Measurements of Geochemical, Biogeochemical and Microbial Processes in the Subsurface

Sensitive, accurate, and real-time monitoring of geochemical, biogeochemical, and microbial conditions are needed in subsurface environments, including groundwater, sediments, and biofilms. In particular, highly selective, sensitive, and rugged in situ devices are needed for low-cost field deployment in remote locations, in order to enhance our ability to monitor processes at finer levels of resolution and over broader areas. Therefore, grant applications are sought to develop innovative sensors and systems to detect and monitor subsurface geochemical and biogeochemical processes that control the chemical speciation or transport of radionuclides, metals and organic contaminants of concern at contaminated DOE sites (e.g., technetium, chromium, strontium-90, mercury, uranium, iodine-129, plutonium, americium, cesium-137, cobalt, carbon tetrachloride, TCE, PCE, VC, DCE and emerging organic contaminants). The ability to distinguish between the relevant oxidation states of the radionuclide and metal contaminants is of particular concern. Innovative approaches for monitoring multi-component biogeochemical signatures of subsurface systems including nutrients are also of interest. As is the development of robust field instruments for multi-isotope and quasi-real time analyses of suites of isotopes (e.g. CH4, CO2, nitrogen compounds, and water isotopes). Grant applications must provide convincing documentation (experimental data, calculations, etc.) to show that the sensing method is both highly sensitive (i.e., low detection limit), precise, and highly selective to the target analyte, microbe, or microbial association (i.e., free of anticipated physical/chemical/biological interferences). Approaches that leave significant doubt regarding sensor functionality in realistic multi-component samples and realistic field conditions will not be considered.

Grant applications also are sought to develop integrated sensing systems for autonomous or unattended applications of the above measurement needs. The integrated system should include all of the components necessary for a complete sensor package (such as micro-machined pumps, valves, micro-sensors, solar power cells, etc.) for field applications in the subsurface. Approaches of interest include: (1) automated sample collection and monitoring of subsurface biogeochemistry and microbiology community structure, (2) fiber optic, solid-state, chemical, or silicon micro-machined sensors; and (3) biosensors (devices employing biological molecules or systems in the sensing elements) that can be used in the field – biosensor systems may incorporate, but are not limited to, whole cell biosensors (i.e., chemiluminescent or bioluminescent systems), enzyme or immunology-linked detection systems (e.g., enzyme-linked immunosensors incorporating colorimetric or fluorescent portable detectors), lipid characterization systems, or DNA/RNA probe technology with amplification and hybridization. Grant applications that propose minor adaptations of readily available materials/hardware, and/or cannot demonstrate substantial improvements over the current state-of-the-art are not of interest and will be declined.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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21. TECHNOLOGY TRANSFER OPPORTUNITIES: GENOMIC SCIENCE AND RELATED TECHNOLOGIES (PHASE I, $225,000/PHASE II, $1,500,000)

ONLY FAST-TRACK APPLICATIONS WILL BE ACCEPTED FOR THIS TOPIC.

Applicants to Technology Transfer Opportunities should review the section describing Technology Transfer Opportunities on page 1 of this document prior to submitting applications.

DOE's Office of Biological and Environmental Research (BER) supports DOE mission-driven fundamental research aimed at identifying the foundational principles that drive biological systems. Development of innovative approaches for sustainable bioenergy production will be accelerated by systems biology understanding of non-food plants that can serve as dedicated cellulosic biomass feedstocks and microbes capable of deconstructing biomass into their sugar subunits and synthesizing next generation biofuels from cellulosic biomass. The Genomic Science Program research also brings the -omics driven tools of modern system biology to bear on analyzing interactions among organisms that form biological communities and between organisms and their surrounding environments.

DOE's Office of Biological and Environmental Research established three Bioenergy Research Centers (BRCs) in 2007 to pursue the basic research underlying a range of high-risk, high-return biological solutions for bioenergy applications. Advances resulting from the BRCs are providing the knowledge needed to develop new biobased products, methods, and tools that the emerging biofuel industry can use. The three Centers are based in the Southeast, the Midwest, and the West Coast, with partners across the nation. DOE's Lawrence Berkeley national Laboratory leads the DOE Joint BioEnergy Institute (JBEI) in California, DOE's Oak Ridge national laboratory leads the BioEnergy Science Center (BESC) in Tennessee, and the University of Wisconsin-Madison leads the Great Lakes Bioenergy Research Center (GLBRC).

The goal for the three BRCs is to understand better the biological mechanisms underlying biofuel production so that these mechanisms can be redesigned, improved, and used to develop novel, efficient bioenergy strategies that can be replicated on a mass scale. Many of these new mechanisms form the foundation for each BRC's inventions and tech-transfer opportunities, which enable the development of technologies that are critical to the growth of a biofuels sector. The BRC intellectual property (IP) is available through licensing to the public, and this SBIR Topic is intended to facilitate a bridge between the BRCs and small businesses.

This Topic solicits the development of technologies based on specific progress made by the BioEnergy Science Center and the Joint Bioenergy Institute.

Applications should address potential risks such as biocontainment challenges as well as strategies to mitigate those risks.

Grant applications are sought to further develop the following technologies with potential use for the development of biofuels:

Joint Bioenergy Institute (JBEI)

a. Engineered Biosynthesis of Alternative Biodiesel Fuel in E. Coli and Yeast - A method has been developed for producing biofuel molecules that are an alternative to ethanol. The method produces isoprenyl alkanoates that can be hydrogenated and blended into gasoline or diesel fuel. In addition, the invention includes the design and manipulation of biosynthetic pathways to increase flux for enhanced production of fuel molecules. With additional testing, this technology may be applicable for biogasoline as well. (http://www.lbl.gov/Tech-Transfer/techs/lbnl2391.html)

b. Energy Crops Engineered for Increased Sugar Extraction through Inhibition of snl6 Expression - Engineered plants have been developed with inhibited expression of snl6, a cinnamoyl-CoA reductase-like (CCR-like) gene. As a result, the JBEI plants have reduced lignin or phenolic compounds compared to wild type plants and yield an increase of up to 10 percent of sugar extracted. The modification can be applied to a wide range of plants including rice, Miscanthus, switchgrass, sugarcane, sugar beet, and sorghum and corn, among others. (http://www.lbl.gov/Tech-Transfer/techs/lbnl2763.html)

c. Irreversible, Low Load Genetic Switches - This system enables multiple genes to be turned on or off at different states of an organism's lifecycle, which has both research and industrial applications. It offers improved reliability over other approaches by ensuring that circuits proceed to completion rather than equilibrating. Potentially, these devices could be used to construct an expression system with low load on the cell, a very low level of basal expression, and an extremely high level of expression after induction. This could be useful in industry and medicine where a growth phase and a production/manipulation phase need to be kept distinct. Using this sort of toggle, many changes can be made at once to cell physiology. (http://www.lbl.gov/tt/techs/lbnl2593.html)

d. Directed Evolution of Microbe Producing Biofuels Using In Vivo Transcription Factor Based Biosensors - A method of using transcription factors expressed in vivo to evolve, screen, and select for microorganisms producing an intracellular small molecule of interest, such as a short chain alcohol. Biosensors composed of transcription factors and their cognate promoters are designed and constructed to be capable of binding the particular molecule of interest. This technology improves screening throughput over current methods by several orders of magnitude. In addition, it exhibits greater sensitivity as compared to high-throughput colorimetric screens. Downstream application of the invention as a selection method could allow for direct, dynamic evolution of strains without the need for screening. (http://www.lbl.gov/tt/techs/lbnl2710.html)

e. Versatile Antibody for Analyzing and Purifying Proteins - A new, versatile antibody has been developed that can be used to localize, quantify, and purify proteins that have been expressed using Gateway® compatible vectors. These vectors can then be used for *in vitro* transcription-translation or transformed into cells of archaea, bacteria, plants, and animals. The new antibody labels proteins over the same range of applications with much greater efficiency than conventional techniques that use tags, such as GFP. Until now, methods for labeling proteins have required that scientists develop antibodies to their individual proteins of interest or use specific vectors to affix existing tags to these proteins. These methods can be labor intensive, relatively inefficient, and sometimes applicable with only certain cells types and proteins. This new antibody overcomes these limitations. (http://www.lbl.gov/tt/techs/lbnl2600.html)

Bioenergy Science Center (BESC)

f. Scanning Probe Microscopy with Spectroscopic Molecular Recognition - ORNL researchers developed an innovative imaging method that possesses the imaging capability of scanning near-field ultrasound holography and the chemical specificity of reverse photoacoustic spectroscopy. Initially developed for plant cell wall imaging, this imaging method can achieve chemical differentiation with nanometer resolution. Atomic force microscopy is a well established technique for imaging surface features of a nanometer or less. In conventional methods, a cantilever has a tip capable of making a nanometer sized contact. However, any small variation in distance between the probe and the sample surface can result in a large change in the contact force between the probe's tip and the sample. To address this challenge, the invention includes two independent oscillators and is able to distinguish the frequencies of the two acoustic waves applied to the probe. In addition, electromagnetic energy is applied to the sample, causing a change in phase of the second acoustic wave. The device can also be used for determining chemical characteristics of a sample by applying different acoustic waves. (http://www.ornl.gov/adm/partnerships/factsheets/10-G00983_ID2174.pdf)

g. Mode Synthesizing Atomic Force Microscopy and Mode-Synthesizing Sensing - In a single run and without damaging the sample, ORNL's mode-synthesizing atomic force microscopy (MSAFM), along with mode-synthesizing sensing, acquires a variety of information and allows for new sensing modalities. Initially developed for plant cell wall imaging, ORNL's invention uses nonlinear nanomechanical interactions at ultrasonic frequencies to noninvasively and nondestructively detect multiple surface and subsurface properties of materials at the nanoscale. A microscope capable of nondestructively characterizing nanoscale features, or inhomogeneities, at high resolution is critical to understanding biological processes that lead to cell signaling, protein folding, and gene expression. Using MSAFM, nanoscale properties such as porosity, granularity, elasticity, density, and morphology can all be acquired simultaneously. A major innovation in bioscience research, MSAFM is equally important for solid-state devices. The characterization of nanoscale subsurface features poses a challenge for the microelectronics industry, and the ability to access and detail buried nanostructures holds great promise in applications such as detecting dopants and defects in silicon chips. (http://www.ornl.gov/adm/partnerships/factsheets/10-G00623_ID2253.pdf)

h. Transformation of Gram Positive Bacteria by Sonoporation - A genetic engineering technology invented at ORNL facilitates DNA delivery to a cell by using ultrasound to permeate the cell's plasma membrane. DNA delivery using this technology is simple, quick, inexpensive, and offers a universal method for gene transfer. Existing methods for DNA delivery all have significant drawbacks, including causing significant damage to the membrane of a cell. These conventional methods require repeated rounds of washing and other treatments, prior to DNA transformation, making the protocol complex and difficult. The ORNL invention provides a sonoporation-based method that uses ultrasonic frequencies to effectively modify the permeability of the cell plasma membrane prior to inserting a chosen compound. The method can be universally applied to deliver nucleic acids, proteins, lipids, carbohydrates, viruses, small organic and inorganic molecules, and nanoparticles to Gram positive bacteria, including Bacillus, Streptococcus, Acetobacterium, and Clostridium. (http://www.ornl.gov/adm/partnerships/factsheets/11-G00255_ID2139_rev.pdf)

i. Nucleic Acid Molecules Conferring Enhanced Ethanol Tolerance and Microorganisms Having Enhanced Tolerance to Ethanol - Researchers at ORNL developed microorganisms that can quickly overcome the resistance of biomass to breakdown, and improved both the cost and efficiency of the biofuel conversion process. Conventional biomass pretreatment methods release sugars, weak acids, and metabolic by-products that slow down or even stop fermentation, resulting in slower biofuel production. ORNL researchers use information from the acetaldehyde-CoA/alcohol dehydrogenase gene, and its mutations, to synthesize a microorganism that is more tolerant of ethanol and consequently avoids the inhibitory by-products of conventional pretreatment. The researchers also developed a method for enhancing the resistance of the microorganism and producing alcohol from cellulosic biomass material. (http://www.ornl.gov/adm/partnerships/factsheets/11-G00203_ID2408.pdf)

j. Cofermentation with Cooperative Microorganisms for More Efficient Biomass Conversion - It is well known that biomass has primarily two sources of fermentable carbohydrates, cellulose and hemicelluloses. Research has been underway for decades aimed at both depolymerizing these complex carbohydrates and fermenting them to products of interest such as fuels and chemicals. Common approaches are the addition of enzyme to carry out the hydrolysis (depolymerization) and include a microorganism that can ferment some or all the resulting simple sugars. Various microorganisms have different capacities to breakdown these complex carbohydrates and ferment the resulting sugars to fuels and chemicals. Here we have shown that two microorganisms that normally would not co-exist due to differences in temperature optimums can be grown with one at suboptimal temperature, and together, they uniquely convert biomass to fermentation chemicals more rapidly and efficiently than either microorganism could accomplish alone. Additionally the two microorganisms provide different depolymerizing enzymes, so they act synergistically to more efficiently breakdown the biomass carbohydrates, while leaving lignin intact. Also, these microorganisms can provide initial biological "pretreatment" at one temperature and a more complete fermentation with the second microorganism at the other temperature. (http://www.ornl.gov/adm/partnerships/factsheets/11-G00205_ID2454.pdf)

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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PROGRAM AREA OVERVIEW: OFFICE OF DEFENSE NUCLEAR NONPROLIFERATION

The Office of Defense Nuclear Nonproliferation (DNN) mission is to provide policy and technical leadership to limit or prevent the spread of materials, technology, and expertise relating to weapons of mass destruction; advance the technologies to detect the proliferation of weapons of mass destruction worldwide; and eliminate or secure inventories of surplus materials and infrastructure usable for nuclear weapons. It is the organization within the Department of Energy's National Nuclear Security Administration (NNSA) responsible for preventing the spread of materials, technology, and expertise relating to weapons of mass destruction (WMD).

Within DNN, the Office of Research and Development, reduces the threat to national security posed by nuclear weapons proliferation and detonation or the illicit trafficking of nuclear materials through the long-term development of new and novel technology. Using the unique facilities and scientific skills of NNSA and DOE national laboratories and plants, in partnership with industry and academia, the program conducts research and development that supports nonproliferation mission requirements necessary to close technology gaps identified through close interaction with NNSA and other U.S government agencies and programs. This program meets unique challenges and plays an important role in the federal government by driving basic science discoveries and developing new technologies applicable to nonproliferation, homeland security, and national security needs. The Research & Development Office is comprised of two programs: Proliferation Detection and Nuclear Detonation Detection.

The Proliferation Detection program advances basic and applied technologies for the nonproliferation community. Specifically, the program develops the tools, technologies, techniques, and expertise for the identification, location, and analysis of the facilities, materials, and processes of undeclared and proliferant nuclear weapons programs and to prevent the diversion of special nuclear materials, including use by terrorists.

The Nuclear Detonation Detection program builds the nation's operational sensors that monitor the entire planet from space to detect and report surface, atmospheric, or space nuclear detonations; and produces and updates the regional geophysical datasets enabling operation of the nation's ground-based seismic monitoring networks to detect and report underground detonations. This program also conducts research and development on nuclear detonation forensics, improvements in satellite operational systems to meet future requirements and size and weight constraints, and radionuclide sampling techniques for detection of worldwide nuclear detonations.

For additional information regarding NNSA's overall nuclear nonproliferation activities, including, research and development, click here.

22. RADIATION DETECTION (PHASE I, $150,000/PHASE II, $1,000,000)

The Office of Defense Nuclear Nonproliferation Research and Development (NA-22) is focused on enabling the development of next generation technical capabilities for radiation detection of nuclear proliferation activities. As such, the office is interested in the development of radiation detection techniques and sensors, and advanced detection materials, that address the detection and isotope identification of unshielded and shielded special nuclear materials, and other radioactive materials in all environments. In responding to these challenging requirements, recent research and development has resulted in the emergence of radiation detection materials that have good energy resolution. From these materials, the developments of radiation detectors that are rugged, reliable, low power and capable of high-confidence radioisotope identification are sought. Currently, the program is focused on the development of improved capabilities for both scintillator and semiconductor-based radiation detectors. The objective of this topic is to gain insight into a mechanistic understanding of material performance as the base component of radiation detectors. That is, the program is interested in moving beyond the largely empirical approach of discovering and improving detector materials to one based on a clear understanding of basic materials properties.

Grant applications are sought only in the following subtopics:

a. Scintillators for Gamma Spectroscopy

We would like to support research on materials that will lead to practical high-brightness scintillators with energy resolution significantly better than the currently available sodium iodide-based gamma spectrometers. Several new and promising formulations have been discovered and synthesized in small quantities, but there is a need for industrial crystal-growth facilities to find ways to produce practical sizes of high-quality scintillators at a reasonable cost. As an alternative to crystal growth, techniques that produce high quality, large volume scintillators with good spectroscopic performance from the consolidation of powders are highly desirable. Moreover, a scintillator thick enough to absorb high energy gamma rays must also be very transparent to its own emitted light. A laboratory demonstration is expected in Phase I, while Phase II should lead to the development of a commercial process with a significant advantage over current crystal growth techniques.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Semiconductors for Gamma Spectroscopy

We are interested in promoting the industrial capacity to develop large volume, high quality radiation detector materials based on semiconductors that operate at ambient temperature. Approaches of interest must address growth issues involving such semiconductor materials, so that reliable, high yield, rapid and large volume growth is readily achievable at a reasonable cost. It should be recognized that good electronic transport properties are essential, such as electron and hole mobilities and lifetimes, which as a rule require extremely low concentrations of deleterious impurities and careful control of deliberate dopants. Phase I should result in the identification of new materials or of a clear path to improving upon existing growth techniques. Phase II should include a demonstration of a material fabrication process that is free from dislocations, cracking, chemical heterogeneities, and minor crystalline phases, including precipitates.

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c. Advanced Organic Materials

New organic solid materials capable of detecting fast neutrons and distinguishing them from gamma rays are of interest to the program. Important criteria for fast neutron detection devices are intrinsic efficiency for fission spectrum neutrons and pulse timing precision, as well as good gamma rejection ratio. These materials would replace liquid scintillators in a number of applications important to nonproliferation. Phase 1 would establish a pathway to production of significant quantities of detector material, while making use of materials supplied by NNSA laboratories. Phase 2 would expand the technology beyond the scale of individual exploratory experiments to the stage of employing kilogram quantities of high quality neutron detecting material in large detectors or arrays of modules.

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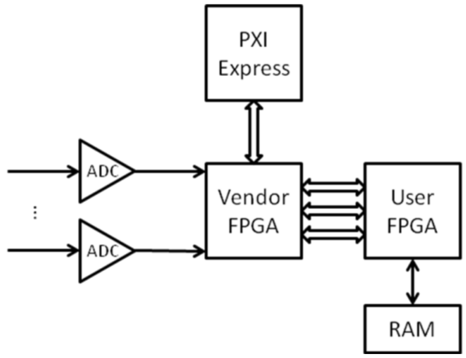
d. Multichannel Data Acquisition System with User FPGA

The deployment of devices using High Purity Germanium (HPGe) has highlighted the need for improved ruggedized electronics. Of particular interest is a multi-channel PXI Express data acquisition board capable of applying user FPGA algorithms at near-acquisition rates. Target is 4-8 channels of 14-bit data at 400MHz in a 3U form factor.

Desirable characteristics include:
Hardware Requirements

- 14-bit, 400MHz
- 4/6/8 channels
- 3U PXI Express (PXIe)
- Vendor FPGA(s) to handle ADCs and PXIe
- User FPGA clocked at acquisition rate
- Dedicated serial transceiver(s) between each vendor FPGA and user FPGA Data Streaming Requirements
- Stream 2 channels of raw data @ 400MHz over PXIe bus (3+ channels at reduced rates)
- Stream all channel data @ acquisition rates into user FPGA
- Stream ~100-byte packets at 1MHz event rates from user FPGA to PXIe bus User FPGA Requirements
- Serial transceiver link between user FPGA and each vendor FPGA
- Perform simple algorithms (i.e. trapezoid filter) simultaneously on all channels at acquisition rates



Block diagram of data acquisition system.

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e. Other
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Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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23. TECHNOLOGY TO FACILITATE MONITORING FOR NUCLEAR EXPLOSIONS (PHASE I, $150,000/PHASE II, $1,000,000)

The Ground-based Nuclear Explosion Monitoring Research and Development (GNEM R&D) Program is sponsored by the U.S. Department of Energy's National Nuclear Security Administration's Office of Defense Nuclear Nonproliferation Research and Development (NA-22). This program is responsible for the research and development necessary to provide the U.S. Government with capabilities for monitoring nuclear explosions. The mission of the GNEM R&D Program is to develop, demonstrate, and deliver advanced ground-based seismic, radionuclide, hydro acoustic, and infrasound technologies and systems to operational agencies to fulfill U.S. monitoring requirements and policies for detecting, locating, and identifying nuclear explosions (see Reference 1). Proposals that enhance U.S. capabilities that also benefit the international monitoring capabilities in the context of preparations for a Comprehensive Nuclear-Test-Ban Treaty (CTBT) may be submitted.

Research is sought to move toward commercialization of algorithms, hardware, and software that advance the state-of-the-art for event detection, location, and identification. Superior technologies will help improve the Air Force Technical Applications Center's (Reference 2) ability to monitor for nuclear explosions, which are banned by several treaties and moratoria. Annual research progress of the GNEM R&D program is available in proceedings posted on-line (see Reference 3). Grant applications responding to this topic must state (1) the current state-of-the-art, in terms of relevant specifications such as sensitivity, reliability, maintainability, etc., as well as the performance goal of the proposed advance in terms of those same specifications; and (2) address the commercialization path of any instruments or components developed. Due to the small market potential of treaty monitoring technologies, this call is focused toward already existing or emerging commercial products for other applications that could be modified/enhanced for treaty monitoring applications. The resulting "treaty monitoring edition" of the product(s) would hopefully provide a performance advantage that would also benefit the original market and thereby leverage existing markets.

Grant applications are sought in the following subtopics:

a. Technologies and capabilities, associated with the US Atomic Energy Detection System (USAEDS) and CTBTO International Monitoring System (IMS) and International Data Centre (IDC), for network monitoring of seismic, infrasound, hydro-acoustic and radionuclide signatures.

Grant applications are sought to improve monitoring station network performance.

Examples of useful improvements that impact network performance:

- Seismic Instrumentation: less expensive and/or more robust instrumentation (to decrease the cost of deploying and maintaining a network). We seek development of self-calibrating instrumentation that logs recording parameters (gain, sample rate, filters, sensor location, sensor orientation, sensor and recording system serial numbers, etc.) and instrument and recording system responses. The goal is to improve the efficiency of field deployments by reducing/eliminating the need for human field notes, which will reduce meta-data errors and reduce the time/cost of field deployments. The system should be supported by software that converts to common seismic formats, especially archival formats.
- Infrasound Instrumentation: less expensive and/or more robust instrumentation (to decrease the cost of deploying and maintaining a network); improved, small-footprint wind noise reduction (to enhance signals). We seek systems that reduce/eliminate the need for human field notes (see section on seismic instrumentation).
- Radionuclide Instrumentation: innovative variable speed high-volume whole air collection systems capable of flow rates down to 1 liter/min and pressures up to 4000 psig.
- Geophysical data digitizers/recording units: low-power robust field deployable systems with on-board programmable capabilities for in-situ processing that seamlessly connect to commercially available geophysical sensors (e.g., seismic, acoustic/infrasonic).
- Data Processing: data-mining/machine-learning techniques that exploit the growing archive of labeled monitoring results from past years to improve detection, location, and/or identification of new events (e.g., adaptation of image recognition methods). Open source algorithm and graphical user interface development for multi-technology (multi-phenomenology) detection and location of waveform events.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Technologies and capabilities for CTBT On-Site Inspections and other related international technical cooperation.

Grant applications are sought to facilitate on-site inspections for treaty monitoring by adapting to treaty use existing commercially available products. As stated in the Comprehensive Nuclear-Test-Ban Treaty (Protocol Part II, E, paragraph 69; see treaty text http://www.ctbto.org/the-treaty/treaty-text/) the permitted activities are:

- Position finding from the air and at the surface to confirm the boundaries of the inspection area and establish coordinates of locations therein, in support of the inspection activities;
- Visual observation, video and still photography and multi-spectral imaging, including infrared measurements, at and below the surface, and from the air, to search for anomalies or artifacts;
- Measurement of levels of radioactivity above, at and below the surface, using gamma radiation monitoring and energy resolution analysis from the air, and at or under the surface to search for and identify radiation anomalies;
- Environmental sampling and analysis of solids, liquids, and gases from above, at and below the surface to detect anomalies’

- Passive seismometry and active seismic surveys to search for and locate underground anomalies, including cavities and rubble zones;
- Magnetic and gravitational field mapping, ground penetrating radar and electrical conductivity measurements at the surface and from the air, as appropriate, to detect anomalies or artifacts; and
- Drilling to obtain radioactive samples.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Other
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Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

References Subtopics a-b:

1. "Nuclear Explosion Monitoring Research and Engineering Program Strategic Plan, National Nuclear Security Administration," September 2004. (Document No. DOE/NNSA/NA-22-NEMRE-2004) (https://na22.nnsa.doe.gov/cgi-bin/prod/nemre/index.cgi?Page=Strategic+Plan)

2. U.S. National Data Center, Air Force Technical Applications Center (http://www.tt.aftac.gov/wrt)

3. Monitoring Research Review(s) for Ground-Based Nuclear Explosion Monitoring Research and Development. (http://www.monitoringresearchreview.com/previousproceedings.html)

24. NUCLEAR FORENSICS (PHASE I, $150,000/PHASE II, $1,000,000)

In nuclear forensics operations, solid and liquid samples of interest are packaged in polyethylene bags and in a variety of plastic, pyrex, and/or glass containers. After the initial packaging, it is important to trace and track the identity of the sample (and related items) in subsequent over packaging, repackaging, sample splitting, and laboratory analysis activities, due to stringent sample inventory and chain-of-custody requirements. Technology that is better than currently available commercial products could help improve upon the ability to associate a unique identifier with each sample container.

Grant applications are sought only in the following subtopics:

a. Durable Scannable Labels on Plastics - Robust and Versatile Labeling in Support of Sample Management
Grant applications are sought to develop a technique to put a scannable alphanumeric barcode (or equivalent) on plastic surfaces of polyethylene bags, pyrex and glass containers (e.g., test

tubes and vials), and the surfaces of other plastic containers used to contain samples of liquids, powders, or small bulk solids (less than 0.1 ft^3 in size).
The barcode (or equivalent) could be embossed, pressed, stamped, affixed with adhesive, or otherwise attached, so that it does not fall off of any of these surfaces during handling. The barcode should be capable of being put on the container before or after a sample item is already in it, without touching the sample. The barcode should be readable from a standard optical laser scanner.

The life cycle of a nuclear forensics sample (from field collection through final disposition) has many operational constraints that currently available sample inventory and management systems are not able to meet. These constraints are of the following three types:

1) Organizational – sample collection may be performed by more than one organization each with its own sample management plans for subsequent analyses that could be performed at one or more of several different laboratories. In outdoor field environments, personnel need to be able to reliably assign unique sample identifiers with no chance of duplicates throughout the entire system. Common laboratory tasks include sample splitting and identification of wastes generated during sample analysis – all residues need to be traceable to the original sample for regulatory purposes.
2) Radiological Requirements – radiological safety, packaging, and transportation requirements require the use of multiple layers of packaging and containment during transportation and storage. In practice, multiple individual samples may be conglomerated in the outer layer(s) of packaging. Most samples of interest can be handled by hand and do not require additional shielding materials for radiological protection.
3) Security – the sensitive nature of evidentiary samples requires a sample management system that is capable of identifying and tracking a sample in a variety of environments ranging from tactical outdoor settings to special compartmentalized information facilities (SCIFs). In some of these environments, radiofrequency-based transmission (e.g., via RFID tags) is prohibited.
Phase I: Demonstrate the proof of concept for developing a barcode method (or equivalent) that is compatible with the plastic surfaces identified above. Figures of merit include the degree to which it can be affixed to the plastic surface without contact with the sample inside the container, how well the barcode survives in harsh environments and in handling operations over time, and the accuracy with which its alphanumerics can be scanned and read (even on curved surfaces of test tubes, vials, or bags) by an optical barcode reader (or equivalent).

Phase II: Advance the technology to a workable prototype that can be tested on a variety of plastic surfaces and in a variety of environmental settings and handling conditions.
Phase III: Commercialize the technology, either as a stand-alone component of a system or as part of a larger inventory system for sample identification and tracking.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

References Subtopics a-b:

1. 10 CFR 835, Occupational Radiation Protection (http://www.hss.doe.gov/HealthSafety/WSHP/il/10cfr835/10_151.html)

2. 10 CFR 71, Packaging and Transportation of Nuclear Material (http://www.nrc.gov/reading-rm/doc-collections/cfr/)

3. DOE O 460.1C, Packaging and Transportation Safety (http://www.hss.energy.gov/nuclearsafety/nfsp/facrep/Order-Modules/O-460-1C_O-460-2A_ssm.pdf)

4. Moody, K.J., Hutcheon, I.D., and Grant, P.M., "Nuclear Forensic Analysis" CRC Press, Boca Raton, Fla: 2005. (ISBN 978-0-8493-1513-8)

5. Nuclear Forensics Support, International Atomic Energy Agency Nuclear Security Series No. 2 Technical Guidance Reference Manual (2006), ISBN 92-0-100306-4 (http://www-pub.iaea.org/MTCD/publications/PDF/Pub1241_web.pdf)

25. GLOBAL SAFEGUARDS (PHASE I, $150,000/PHASE II, $1,000,000)

The Global Safeguards Program supports NNSA's nuclear nonproliferation mission by developing innovative safeguards technologies to verify the correctness and completeness of declarations regarding nuclear materials. The program develops technologies to detect diversion of nuclear material from declared facilities; to detect undeclared nuclear material and activities; and to verify compliance with safeguards agreements related to the control, production, or processing of nuclear material. This includes the verification that declared facilities have been constructed and remain as declared, and the verification that undeclared facilities do not exist. The program includes R&D in nuclear (and relevant nonnuclear) measurements, information integration and management, advanced tools for systems analysis, authentication, and containment and surveillance technology.

Grant applications are sought only in the following subtopics:

a. Design Information Verification
Grant applications are sought for the development of tools to identify changes in monitored facilities; determination of safeguards relevance of changes; verification of declared design and operation, methods to deal with information overload; protection of operator's sensitive information; and creation of a 3-D plant layout (fast, inexpensive, and acceptable to the operator).

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b. Other
In addition to the specific subtopics listed above, the Department invites grant applications in other areas relevant to this Topic.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

References Subtopic a:

1. "Safeguards to Prevent Nuclear Proliferation." March 2009. (http://www.world-nuclear.org/info/inf12.html).

2. "The US Support Program to IAEA Safeguards." Modified June 5, 2008. (http://www.bnl.gov/ispo/ussp/).

3. "Safeguards R&D Program in the United States." Presented at the 50th Anniversary meeting of Institute for Nuclear Materials Management, July 2008. (http://www.inmm.org//AM/Template.cfm?Section=Home)

26. REMOTE SENSING (PHASE I, $150,000/PHASE II, $1,000,000)

For decades, the Remote Sensing Program has been a cornerstone in the national capability for the detection of facilities and activities related to the proliferation of foreign nuclear programs. The Remote Sensing Program research projects encompass a wide variety of potential capabilities to detect signatures associated with the development of nuclear weapons. The research areas in the Remote Sensing program include sensor development, image processing, and digital signal processing techniques for characterization of observed phenomena.

Grant applications are sought only in the following subtopics:

a. Electrically-triggered pump-probe carrier lifetime measuring apparatus for LWIR
A design of a commercial, inexpensive electrically-triggered pump-probe carrier lifetime measuring apparatus for LWIR is sought. This could be used by researchers to characterize InAs/InAsSb material). Carrier lifetime is the key parameter that dictates detector performance, and such a product could significantly enhance the ability of contractors to develop and offer high performance III-V LWIR FPAs. While some laboratories have developed home-grown carrier-lifetime measurement capability, the complexity and cost of these devices has impeded growth in the area of nBn detector technologies.

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b. High-Speed Photon Counting Devices and Enabling Technologies
Megapixel-class imaging systems with single-photon sensitivity, high time resolution (sub-ns) of each detected photon, and the capability to detect and process high photon rates (above

108 detected photons per second) are highly desirable for a number of application areas. The NA-22 remote sensing program seeks research and development on full sensor systems with these capabilities or on enabling technologies for such systems. Examples of enabling technologies are multi-channel (~100) readout electronics including high-density, high-speed (pulse widths ~1 to < 100 ns), low-noise (noise equivalent charge of < 1000 electrons) analog preamplifiers and low-power, high-density, continuously sampling, multichannel ADCs well matched to such amplifiers.

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c. Remote Portable Sensor for CTBT/OSI

Applications are desired to develop portable gas-phase sensors which would be appropriate for eventual use in On-Site Inspections (OSI) under the Comprehensive Nuclear Test-Ban Treaty (CTBT). In particular, sensors which can rapidly detect combustion gases such as carbon monoxide likely to be released after an underground explosion are desired. Sensors should have low detection limits (sub-ppm), high sampling throughput (one second response time), ability to measure stable isotope ratios of carbon and oxygen (1 percent precision), and be portable for rapid screening of large areas remotely. Of particular interest are infrared spectroscopic sensors using quantum cascade or interband cascade lasers, and sensor architectures with small sample volume requirements.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Temperature-Emissivity-Separation (TES) with Combined Fluid Flow-Hyperspectral Radiation Simulations

Temperature-emissivity-separation (TES) for a target object relies on accurate data for computation of thermal radiation fluxes being emitted by the sky and by adjacent objects. In cluttered scenes, TES is made more difficult by the contributions of adjacent objects to the thermal radiation received by a target object, which reduces the target object's characteristic spectral features. Simulations of the target object using hydrodynamic - hyperspectral simulators are an alternative to traditional TES. The combined hydrodynamic - hyperspectral simulations require best available scene geometry, meteorology and target characteristics. Target temperature and material could be determined by running a series of simulations with different target spectra until best matches between measured and simulated apparent target temperature and spectra are found. Proposals are solicited to assess the ability of combined hydrodynamic – hyperspectral simulators (HHS) to reproduce target object temperatures and spectra in geometrically complex environments. Part of the project would be blind tests of the ability of the HHS to identify target materials, using hyperspectral images of target objects and other data collected by Department of Energy remote sensing program. One or more DOE national laboratories would supply the successful applicant with the necessary experimental data for model validation. The collaborating DOE laboratory would evaluate the successful applicant's comparisons of simulation to measurement, material identification and the improvement afforded by the HHS relative to simpler codes that do not include realistic fluid flow to drive convective heat transfer in the simulations.

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e. Remote Detection of Extremely Small Vibration

In order to further the goal of nuclear nonproliferation, it is important to be able to detect remotely signs of clandestine nuclear activities, such as, but not limited to, operation of dynamic machinery in hidden, subterranean facilities. In principle, such an operation can be identified by detection of small vibrations at characteristic frequencies. However, these signals are expected to be extremely small if the machinery is hidden deep under a mountain, for example. Conventional vibration detectors have typical sensitivities of 1 micro-g per root Hertz (where g is the acceleration due to Earth's gravity), and would not be able to detect these signals from a significant distance. Recent developments have shown that new types of detectors, such as those based on the use of the fast-light effect induced by anomalous dispersion, can enhance the sensitivity to vibration by nearly six orders of magnitude. Devices based on these technologies may be configured for ultrasensitive sensing of many effects, including rotation and vibration. Therefore, grant applications are sought for the development of technology for remote detection of extremely small vibration signatures, with a sensitivity of at least 1 pico-g per root Hertz, representing a six orders of magnitude enhancement over the typical capability of current technologies. A proposed vibrometer must be able to detect vibrations in three orthogonal directions, should also be extremely compact, have a high dynamic range, be very robust against environmental disturbances, and consume very low power.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

f. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas relevant to this Topic.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

References Subtopic a:

1. Grein, C.H. and M. E. Flatté, "Optimization of MWIR Type-II Superlattices for infrared detection", *Proc. SPIE* 7660, 76601L. 2010 . (http://spie.org/x10.xml?WT.svl=tn7)

2. Flatté, M.E. and C. E. Pryor, "Defect states in type-II strained-layer superlattices", *Proc.SPIE* 7608, 7608-76. 2010. (http://spiedigitallibrary.org/proceedings/resource/2/psisdg/7608/1/760824_1?isAuthorized=no)

3. Youngdale, E.R. et al., "Auger lifetime enhancement in InAs/GaInSb superlattices," *App. Phys. Lett.*, Vol. 64, pp. 3160–3162. 1994. (http://apl.aip.org/resource/1/applab/v64/i23/p3160_s1)

4. Grein, C.H, et al. "Long wavelength InAs/InGaSbInfrared detectors: Optimization of carrier lifetimes," *J. Appl. Phys*.., Vol. 78, pp. 7143-7152. 1995. (http://jap.aip.org/resource/1/japiau/v78)

References Subtopic b:

1. L.C. Stonehill et al, Cross-Strip Anodes for High-Rate Single-Photon Imaging, 2009 IEEE Nuclear Science Symposium Conference Record, pp 1417 - 1421. (http://ieeexplore.ieee.org/xpl/conferences.jsp)

2. O.H.W. Siegmund et al, High Performance Cross-Strip Detectors for Space Astrophysics, 2007 IEEE Nuclear Science Symposium Conference Record, pp 2246 - 2251. (http://ieeexplore.ieee.org/xpl/conferences.jsp)

References Subtopic c:

1. Kosterev, A., "Application of quantum cascade lasers to trace gas analysis," *Applied Physics B-Lasers and Optics*, Vol. 90, Iss. 165. 2008. (http://www.springerlink.com/content/vj732t0002842k75/?MUD=MP)

2. Kelly, J.F. et al. "A capillary absorption spectrometer for stable carbon isotope ratio ($^{13}C/^{12}C$) analysis in very small samples," Rev. Sci. Instrum. 83, 023101. 2012. (http://rsi.aip.org/resource/1/rsinak/v83/i2/p023101_s1)

References Subtopic e:

1. H.N. Yum, M. Salit, J. Yablon, K. Salit, Y. Wang, and M.S. Shahriar, "Superluminal ring laser for hypersensitive sensing," Optics Express, Vol. 18, Issue 17, pp. 17658-17665. 2010. (http://www.opticsinfobase.org/oe/abstract.cfm?uri=oe-18-17-17658; including references)

2. Smith, D.D et al. "Enhanced sensitivity of a passive optical cavity by an intracavity dispersive medium," Phys. Rev. A 80, 011809. 2009. (http://pra.aps.org/abstract/PRA/v80/i1/e011809)

3. Chen, C. et al., "Broadband Michelson fiber-optic accelerometer," Applied Optics, Vol. 38, No. 4, pp. 628. 1999. (http://www.opticsinfobase.org/ao/abstract.cfm?uri=ao-38-4-628)

4. M.S. Shahriar, S. Tseng, J. Yablon, and H. Yum, "An Ultra-sensitive DC and AC Accelerometer Using Dual Superluminal Zero-Area L-shaped Ring Lasers." presented at the Conference on Lasers and Electro-Optics, Baltimore, MD (2011) (http://www.opticsinfobase.org/abstract.cfm?URI=CLEO:%20A%20and%20T-2011-ATuE1)

PROGRAM AREA OVERVIEW: OFFICE OF FUSION ENERGY SCIENCES

The Department of Energy sponsors fusion science and technology research as a valuable investment in the clean energy future of the nation and the world, as well as to sustain a field of scientific research - plasma physics - that is important in its own right and has produced insights and techniques applicable in other fields of science and industry. The Fusion Energy Sciences (FES) mission is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. This is accomplished by studying plasma and its interactions with its surroundings across wide ranges of temperature and density, developing advanced diagnostics to make detailed measurements of its properties and dynamics, and creating theoretical and computational models to resolve the essential physics principles. FES has four strategic goals:

- Advance the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source;
- Support the development of the scientific understanding required to design and deploy the materials needed to support a burning plasma environment;
- Pursue scientific opportunities and grand challenges in high energy density plasma science to explore the feasibility of the inertial confinement approach as a fusion energy source, to better understand our universe, and to enhance national security and economic competitiveness, and;
- Increase the fundamental understanding of basic plasma science, including both burning plasma and low temperature plasma science and engineering, to enhance economic competiveness and to create opportunities for a broader range of science-based applications.

This is a time of important progress and discovery in fusion research. The U.S. has joined an international consortium (consisting of the European Union, Japan, China, Russia, Korea, and India) to fabricate and operate the next major step in the fusion energy sciences research program, a facility called “ITER.” ITER will be designed to demonstrate burning plasma.

The FES program is making great progress in understanding turbulent losses of particles and energy across magnetic field lines used to confine fusion fuels, identifying and exploring innovative approaches to fusion power that may lead to more economical power plants and encouraging private sector interests to apply concepts developed in the fusion research program. The following topics are restricted to advanced technologies and materials for fusion energy systems, fusion science and technology relevant to magnetically confined plasmas, high energy density plasmas and inertial fusion energy, and low-temperature plasmas, as described below.

For additional information regarding the Office of Fusion Energy Sciences priorities, click here.

27. ADVANCED TECHNOLOGIES AND MATERIALS FOR FUSION ENERGY SYSTEMS (PHASE I, $150,000/PHASE II, $1,000,000)

An attractive fusion energy source will require the development of superconducting magnets and materials as well as technologies that can withstand the high levels of surface heat flux and neutron wall loads expected for the in-vessel components of future fusion energy systems. These technologies and materials will need to be substantially advanced relative to today's capabilities in order to achieve safe, reliable, economic, and environmentally-benign operation of fusion energy systems. Further information about research funded by the Office of Fusion Energy Sciences (FES) can be found at the FES Website (URL: www.science.energy.gov/fes/).

Grant applications are sought in the following subtopics:

a. Plasma Facing Components

The plasma facing components (PFCs) in energy producing fusion devices will experience 5-15 MW/m2 surface heat flux under normal operation (steady-state) and off-normal energy deposition up to 1 MJ/m2 within 0.1 to 1.0 ms. Refractory solid surfaces represent one type of PFC option. These PFCs are envisioned to have a refractory metal heat sink, cooled by helium gas, and a plasma facing surface, consisting of an engineered refractory metal surface or a thin coating of refractory material that minimizes thermal stresses. The materials being considered include tungsten and molybdenum alloys. Grant applications are sought to develop: (1) innovative refractory alloys having good thermal conductivity (similar to Mo, at a minimum), resistance to recrystallization and grain growth, good mechanical properties (e.g., strength and ductility), and resistance to thermal fatigue; (2) coatings or specialized low-Z surface treatments of refractory alloy armor for improved plasma performance; (3) innovative refractory-metal heat sink designs for enhanced helium gas cooling; (4) efficient fabrication methods for engineered surfaces that mitigate the stresses due to high heat flux; and (5) joining methods, for attaching the plasma facing material to the heat sink, that are reliable, efficient to manufacture, and capable of high heat transfer – these new joining techniques may be applicable to either advanced, helium-cooled, refractory heat sinks or present-day, water-cooled, copper-alloy heat sinks.

In addition, grant applications are sought to develop new or improved *in situ* diagnostic techniques to monitor the health and performance of operating PFCs and plasma edge conditions. A carefully selected combination of microelectromechanical (MEMS)-like, robust diagnostics could create an instrumented PFC that monitors important characteristics (such as the temperature and stress gradients) within the PFC or provides real-time information on erosion/deposition rates or tritium uptake during operation. Measurements of current, B-field, plasma edge temperature and density, spectral emissions, and heat flux also would be of interest. Such diagnostics must be an integral part of the PFC, be self-powered, operate at elevated temperatures in the presence of high magnetic fields and neutron fluence, be immune to RF noise, provide for wireless data transmission with high signal to noise ratio, and be compatible with high performance plasma operation.

Another PFC option is to use a flowing liquid metal surface as a plasma facing component, an approach which will require the production and control of thin, fast flowing, renewable films of liquid lithium, gallium, or tin for particle control at diverters. Grant applications are sought to develop: (1) techniques for the production, control, and removal of flowing (velocity 0.01 to 10 m/s) liquid metal films (0.5-5 mm thick) over a temperature controlled substrate; (2) advances in materials that are wet by liquid metals at temperatures near the respective metal melting point and that are conducive to the production of uniform well-adhered films; (3) techniques for active control of liquid metal flow and stabilization in the presence of plasma instabilities (time and space varying magnetic field); and (4) computational tools that model the flow and magnetohydrodynamic response of flowing liquid metals.

Grant applications also are sought to develop and demonstrate innovative computational techniques directly related to modeling surface material properties and/or plasma surface/interactions, for the purpose designing and assessing PFC surface materials. Finally grant applications are sought to develop cost-effective experimental techniques that integrate multiple approaches, listed in the paragraphs above, in order to allow advanced plasma-material-interaction testing and simulation.

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b. Blanket Materials and Systems

Blanket systems including an integrated first wall facing the plasma are complex, multi-function, multi-material components that capture neutrons emitted from the burning plasma to both produce tritium via nuclear reactions with lithium, and extract the energy for efficient power conversion. Associated with the blanket are coolant and tritium processing systems, all of which have scientific and technological issues in need of resolution. Proposals that address these issues in areas such as:

- Thermofluid and thermomechanical simulation of coolant flows and structural responses under surface and volumetric heat loads;
- Mass transport (corrosion and tritium) modeling development and simulations;
- Ceramic breeder and beryllium pebbles material fabrication, characterization, and thermo mechanics;
- SiC or alternate insulators for electric current and thermal heat;
- Tritium permeation barriers and permeator windows, corrosion barriers, etc.;
- Chemistry and impurity control in coolants (helium, liquid metals, etc.);
- Flow and other diagnostic sensors compatible with fusion environment; or any blanket and tritium system relevant development issue.

Several areas of particular interest are described in more detail below.

There is a strong need to understand and predict in greater detail both the corrosion, transport and redeposition of materials, and the generation, bubble formation, transport and permeation of tritium in the fusion relevant coolant and breeder material Pb-15.7Li alloy. Both numerical predictive tools and increased database from experimental studies are needed to better characterize the corrosion and tritium transport behavior in Pb-Li alloy under fusion relevant conditions that include operation at 400-700C and the presences of strong magnetic fields in contact with various materials such as ferritic steels, silicon-carbide, and other proposed tritium or corrosion barrier or permeator materials for tritium extraction.

The pebble-bed solid breeder configuration introduces several operational limits: thermo-mechanical uncertainties caused by pebble-bed wall interaction, potential sintering and subsequent macro-cracking, and a low pebble-bed thermal conductivity – all of which result in small characteristic bed dimensions and limit windows of operation. A new form of solid breeder morphology is required that holds the promise for increased breeding ratios – dictated by increased breeder material density; long term structural reliability; and enhanced operational control – compared to packed beds. Grant applications are sought for new solid breeder material concepts that include: (1) increased breeder material densities (~80%); (2) higher thermal conductivities (provided by a fully interconnected structure, as opposed to point contacts between pebbles); (3) better thermal contact, such as reliable bonded contact, with cooling structures (instead of point contacts between pebbles and wall); (4) the absence of major geometry changes between beginning-of-life and end-of life (such as sintering in pebble beds) in the presence of high neutron fluence; and (5) structural integrity in freestanding and self-supporting structures with significant thermo-mechanical flexibility.

Flow channel inserts (FCIs) act as magnetohydrodynamic and thermal insulators in ferritic steel channels containing, for example, a slowly flowing tritium breeder such as molten Pb-15.7Li alloy. The insert geometry is approximately box-channel-shaped in straight channels, with more complex shapes possible, for insertion in manifolds and other complex-geometry elements in the flow path. Although SiC/SiC composite is a candidate FCI material, its use would differ from its potential application as a structural material in that high thermal and electrical conductivity would not be desirable. In fact, the electrical conductivity should be low, with a target maximum around 1 to 50 $\Omega^{-1}m^{-1}$. In addition, the strength requirements for a SiC/SiC FCI are reduced compared to the composite's application as a structural material, because the primary stresses and pressure loads will be very low. On the other hand, the insert must be able to withstand thermal stresses from through-surface temperature differences in the range of 150-300K, over a thickness of 3 to 15 mm depending on designs. Grant applications are sought to develop manufacturing techniques for radiation resistant, low thermal/electrical conductivity SiC/SiC composites or other suitable, compatible materials that would make for effective FCIs. One approach that has been envisioned is the use of a final "sealing" layer of SiC matrix material, which would be near theoretical density and cover any porosity or exposed fibers in the main body of the insert. Two-dimensional weaves are also thought to be satisfactory, as well as an effective way to reduce electrical conductivity normal to the interface between the insert and the Pb-15.7Li (the more important of the directions). In addition, grant applications are sought to develop experimental techniques for determining: (1) the compatibility between the SiC/SiC composite and such breeder materials as Pb-15.7Li alloy, and (2) the insert integrity under cyclic thermal loading and other in-service conditions.

One of the missions of the ITER project is the integrated testing of fusion blanket modules in a true integrated fusion environment. This ITER fusion environment includes radiation and magnetic fields, along with surface and volumetric heating, under pulsed and/or steady-state plasma operation. The testing of first wall/blanket components will be performed in ITER by inserting "test blanket modules" (TBMs) that will be complicated systems of different functional materials (breeder, multiplier, coolant, structure, insulator, etc.) in various configurations with many responses and interacting phenomena (e.g., thermomechanical, thermofluid, nuclear). As part of the design and validation process an overall simulation of a "virtual" TBM, integrating all of the individual computational modeling simulations at the system level, is essential to define meaningful experiments. Such a simulation would be inherently multi-scale and multi-physics and will require careful code and algorithm design. Therefore, grant applications are sought to develop a TBM and general power reactor relevant simulation code that can provide detailed predictions of: (1) fluid flow and thermal hydraulic characteristics; (2) the thermal response of all materials (structure, breeder, multiplier, coolant, insulator, etc); (3) structural responses such as stress and deformation magnitudes with respect to different loadings, including both steady-state surface heat flux and dynamic loadings; (4) mass transfer characteristics including both corrosion and tritium transport phenomena, and (5) other important performance characteristics of the TBM or blanket system. The overall code framework/structure must effectively link all of the simulation components of the virtual TBM and serve as an efficient, useful, and user-friendly tool that is extendable from ITER to demonstration power reactor conditions.

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c. Superconducting Magnets and Materials

New or advanced superconducting magnet concepts are needed for plasma fusion confinement systems. Of particular interest are magnet components, superconducting, structural and insulating materials, or diagnostic systems that lead to magnetic confinement devices which operate at higher magnetic fields (14T-20T), in higher nuclear irradiation environments, provide improved access/maintenance or allow for wider operating ranges in temperature or pulsed magnetic fields.

Grant applications are sought for:

(1) Innovative and advanced superconducting materials and manufacturing processes that have a high potential for improved conductor performance and low fabrication costs. Of specific interest are materials such as YBCO conductors that are easily adaptable to bundling into high current cables carrying 30 - 60 kA. Desirable characteristics include high critical currents at temperatures from 4.5 K to 50 K, magnetic fields in the range 5 T to 20 T, higher copper fractions, low transient losses, low sensitivity to strain degradation effects, high radiation resistance, and improved methods for cabling tape conductors taking into account twisting and other methods of transposition to ensure uniform current distribution.

(2) Novel methods for joining coil sections for manufacture of demountable magnets that allow for highly reliable, re-makeable joints that exhibit excellent structural integrity, low electrical resistance, low ac losses, and high stability in high magnetic field and in pulsed applications. These include conventional lap and butt joints, as well as very high current plate-to-plate joints. Reliable sliding joints can be considered.

(3) Innovative structural support methods and materials, and magnet cooling and quench protection methods suitable for operation in a fusion radiation environment that results in high overall current density magnets.

(4) Novel, advanced sensors and instrumentation for monitoring magnet and helium parameters (e.g., pressure, temperature, voltage, mass flow, quench, etc.); of specific interest are fiber optic based devices and systems that allow for electromagnetic noise-immune interrogation of these parameters as well as positional information of the measured parameter within the coil winding pack. A specific use of fiber sensors is for rapid and redundant quench detection. Novel fiber optic sensors may also be used for precision measurement of distributed

and local temperature or strain for diagnostic and scientific studies of conductor behavior and code calibration.

(5) Radiation-resistant electrical insulators, e.g., wrap able inorganic insulators and low viscosity organic insulators that exhibit low gas generation under irradiation, less expensive resins and higher pot life; and insulation systems with high bond and higher strength and flexibility in shear.

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d. Structural Materials and Coatings

Fusion materials and structures must function for a long time in a uniquely hostile environment that includes combinations of high temperatures, reactive chemicals, high stresses, and intense damaging radiation. The goal is to establish the feasibility of designing, constructing and operating a fusion power plant with materials and components that meet demanding objectives for safety, performance and minimal environmental impact. Pursuant to this goal grant applications are sought for:

(1) Development of innovative methods for joining beryllium (~2 mm thick layer) to RAFM steels. The resulting bonds must be resistant to the effects of neutron irradiation, exhibit sufficient thermal fatigue resistance, and minimize or prevent the formation of brittle intermetallic phases that could result in coating debonding.

(2) Development of fabrication techniques for typical component geometries envisioned for use in test blanket modules for operation in ITER using current generation RAFM steels. Such fabrication techniques could include but are not limited to appropriate welding, hot-isostatic pressing, hydroforming, and investment casting methods as well as effective post joining heat treatment techniques and procedures. Appropriate fabrication technologies must produce components within dimensional tolerances, while meeting minimum requirements on mechanical and physical properties.

(3) Development of oxide dispersion strengthened (ODS) ferritic steels. Approaches of interest include the development of low cost production techniques, improved isotropy of mechanical properties, development of joining methods that maintain the properties of the ODS steel, and development of improved ODS steels with the capability of operating up to ~800˚C, while maintaining adequate fracture toughness at room temperature and above.

(4) Development of high ductility, high-fracture toughness tungsten alloys with isotropic properties. Areas of interest include improvements in the grain boundary strength and fracture toughness, and joining techniques. In addition, development of engineered tungsten/PFC materials to control or eliminate blistering associated with the interaction of tungsten with He and H isotopes from the plasma by providing high diffusivity paths to release He and H and decrease retention of these gases is of interest.

(5) Development of functional coatings for the RAFM/Pb-Li blanket concept. Coatings are needed for functions that include (1) compatibility: minimizing dissolution of RAFM in Pb-Li at 700°C, (2) permeation: reducing tritium permeation (hydrogen for demonstration) by a factor of >100 and (3) electrically insulating: reducing the pressure drop due to the magneto-hydrodynamic (MHD) effect. Proposed approaches must: (1) account for compatibility with both the coated structural alloy and liquid metal coolant for long-time operation at 500-700˚C (2) address the potential application of candidate coatings on large-scale system components; and (3) demonstrate that the permeation and MHD coatings are functional during or after exposure to Pb-Li.

(6) Development of failure assessment and lifetime prediction methodologies of structural materials in the fusion environment, including physics-based methods to determine damage accumulation, residual life, and reliability of structural components under combinations of steady and cyclic loading, high-temperature, and neutron irradiation.

(7) Development of innovative modeling tools for the above joining methods, materials, and coatings. Modeling approaches may range from atomistic and molecular dynamics simulations of atomic collision and defect migration events to improved finite element analysis or thermodynamic stability methods.

Priority will be given to innovative methods or experimental approaches that enhance the ability to obtain key mechanical or physical property data on miniaturized specimens, and to the micromechanics evaluation of deformation and fracture processes.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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28. FUSION SCIENCE AND TECHNOLOGY (PHASE I, $150,000/PHASE II, $1,000,000)

The Fusion Energy Sciences program currently supports several fusion-related experiments with many common objectives. These include expanding the scientific understanding of plasma behavior and improving the performance of high temperature plasma for eventual energy production. The goals of this topic are to develop and demonstrate innovative techniques, instrumentation, and concepts for (a) measuring magnetized-plasma parameters, (b) for low-temperature and multi-phase plasmas, (c) for magnetized-plasma simulation, control, and data analysis, and (d) for overcoming deleterious plasma effects during discharges. It is also intended that concepts developed as part of the fusion research program will have application to industries in the private sector. Further information about research funded by the Office of Fusion Energy Sciences (FES) can be found in the FES Website (URL: http://www.science.doe.gov/ofes/).

Grant applications are sought only in the following subtopics:

a. Diagnostics

Diagnostic systems are critical to the success of any experimental campaign. In order to ensure continued progress in plasma experiments in pursuit of magnetic fusion energy, applications are sought for the development of diagnostic techniques to measure plasma parameters not previously accessible, or at a level of detail greater than previously possible, or at a substantially reduced cost or complexity. Preference will be given to research and development of advanced and innovative diagnostics that will advance our scientific understanding and predictive capability of magnetic fusion devices. Proposals addressing diagnostic needs of research on long-pulse facilities are also encouraged. Proposals addressing a specific milestone or a critical step towards the development of a major advanced and innovative diagnostic are welcome, including the development of subsystems, components, or methodologies for extending the capability of an advanced diagnostic technique being developed in the regular FES advanced Diagnostics program. Requests seeking funding for the application of proven and matured diagnostic techniques to major fusion experimental facilities (DIII-D, NSTX, Alcator C-Mod, ITER) will not be considered under this subtopic. Such diagnostic applications are typically funded via separate solicitations as part of experimental facilities, based on their own research program priorities.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Components for Heating and Fueling of Fusion Plasmas

Grant applications are sought to develop components related to the generation, transmission, and launching of high power electromagnetic waves in the frequency ranges of Ion Cyclotron Resonance Heating (ICRH, 50 to 300 MHz), Lower Hybrid Heating (LHH, 2 to 10 GHz), and Electron Cyclotron Resonance (or Electron Bernstein Wave) Heating (ECRH / EBW, 28 to 300 GHz). These improved components are sought for the microwave heating systems of the current large facilities in the United States (Alcator C-Mod, DIII-D and NSTX), facilities under construction (including ITER), and smaller machines exploring innovative and alternate concepts. Components of interest include power supplies, high power microwave sources or generators, fault protection devices, transmission line components, and antenna and launching systems. Specific examples of some of the components that are needed include tuning and matching systems, unidirectional couplers, circulators, mode convertors, windows, output couplers, loads, energy extraction systems from spent electron beams and particle accelerators, and diagnostics to evaluate the performance of these components. Of particular interest are components that can safely handle a range of frequencies and increased power levels.

For the ITER project, the United States will be supplying the transmission lines for both the ECRH (2 MW/line) system, at a frequency of 170 GHz, and for the ICRH system (6 MW/line), operating in the range of 40 – 60 MHz.. For this project, grant applications are needed for advanced components that are capable of improving the efficiency and power handling capability of the transmission lines, in order to reduce losses and protect the system from overheating, arcing, damage or failure during the required long pulse operation (~3000s). Examples of components needed for the ECRH transmission line include high power loads, low loss miter bends, polarizers, power samplers, windows, switches, and dielectric breaks. Examples of components needed for the ICRH transmission line include high power loads, tuning stubs, phaseshifters, switches, arc localization methods, and in line dielectric breaks. For the ECRH and ICRH ITER transmission lines, improved techniques are needed for the mass production of components, in order to reduce cost. Lastly, advanced computer codes are needed to simulate the radiofrequency, microwave, thermal, and mechanical components of the transmission lines.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Simulation and Data Analysis Tools for Magnetically Confined Plasmas

The predictive simulation of magnetically confined fusion plasmas is important for the design and evaluation of plasma discharge feedback and control systems; the design, operation, and performance assessment of existing and proposed fusion experiments; the planning of experiments on existing devices; and the interpretation of the experimental data obtained from these experiments. Developing a predictive simulation capability for magnetically confined fusion plasmas is very challenging because of the enormous range of overlapping temporal and spatial scales; the multitude of strongly coupled physical processes governing the behavior of these plasmas; and the extreme anisotropies, high dimensionalities, complex geometries, and magnetic topologies characterizing most magnetic confinement configurations.

Although considerable progress has been made in recent years toward the understanding of these processes in isolation, there remains a critical need to integrate them in order to develop an experimentally validated integrated predictive simulation capability for magnetically confined plasmas. In addition, the increase in the fidelity and level of integration of fusion simulations enabled by advances in high performance computing hardware and associated progress in computational algorithms has been accompanied by orders of magnitude increases in the volume of generated data. In parallel, the volume of experimental data is also expected to increase considerably, as U.S. scientists plan to collaborate on a new generation of overseas long-pulse superconducting fusion experiments. Accordingly, a critical need exists for developing data analysis tools addressing big data challenges associated with computational and experimental research in fusion energy science.

Grant applications are sought to develop simulation and data analysis tools for magnetic fusion energy science addressing the challenges described above. Areas of interest include, but are not limited to: (1) algorithms incorporating advanced mathematical techniques; (2) algorithms targeting novel computing architectures, including Graphics Processing Unit (GPU), manycore, and heterogeneous computing platforms; (3) verification and validation tools, including efficient methods for facilitating comparison of simulation results with experimental data; (4) data management, visualization, and analysis tools for local and remote multi-dimensional time-dependent datasets resulting from large scale simulations or experiments; (5) techniques for coupling simulation codes, including coupling across different computer platforms and through high speed networks; (6) methodologies for building highly configurable and modular scientific codes and flexible user-friendly interfaces; and (7) remote collaboration tools that enhance the ability of geographically distributed groups of scientists to interact and collaborate in real-time.

The simulation and data analysis tools should be developed using modern software techniques, should be capable of exploiting the potential of next generation high performance computational systems, and should be based on high fidelity physics models. The applications submitted in response to this call should have a strong potential for commercialization and should not propose work that is normally funded by program funds. Although applications submitted to this topical area should primarily address the simulation and data analysis needs of magnetic fusion energy science, applications proposing the development of tools and methodologies which have a broader applicability, and hence increased commercialization potential, are encouraged.

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d. Components and Modeling Support for Validation Platforms for Fusion Science

The FES Validation Platforms program has the long-term performance measure of demonstrating enhanced fundamental understanding of magnetic confinement and improving the basis for future burning plasma experiments. This can be accomplished through investigations and validations of the linkage between prediction and measurement for scientific leverage in testing the theories and scaling the phenomena that are relevant to future burning plasma systems. This research includes investigations in a variety of concepts such as stellarators, spherical tori, and reversed field pinches. Key program issues include initiation and increase of plasma current; dissipation of plasma exhaust power; symmetric-torus confinement prediction; stability, continuity, and profile control of low-aspect-ratio symmetric tori; quasi-symmetric and three-dimensional shaping benefits to toroidal confinement performance; divertor design for three-dimensional magnetic confinement configurations, and the plasma-materials interface. Grant applications are sought for scientific and engineering developments, including computational modeling, in support of current experiments in these research activities, in particular for the small-scale concept exploration experiments. The proposed work should have a strong potential for commercialization. Overall, support of research that can best help deepen the scientific foundations of understanding and improve the tokamak concept is an important focus area for grant applications.

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e. Other

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Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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29. HIGH ENERGY DENSITY PLASMAS AND INERTIAL FUSION ENERGY (PHASE I, $150,000/PHASE II, $1,000,000)

High-energy-density laboratory plasma (HEDLP) physics is the study of ionized matter at extremely high density and temperature, specifically when matter is heated and compressed to a point that the stored energy in the matter reaches approximately 100 billion Joules per cubic meter (the energy density of a hydrogen molecule). This corresponds to a pressure of approximately 1 million atmospheres or 1 Mbar. Research in HEDLP forms the scientific foundation for developing scenarios that could facilitate the transition from laboratory inertial confinement fusion (ICF) to inertial fusion energy (IFE).

While substantial scientific and technical progress in inertial confinement fusion has been made during the past decade, many of the technologies required for an integrated inertial fusion energy system are still at an early stage of technological maturity. This relative immaturity ensures that commercially viable IFE remains a long-term (>15 years) objective. Research and development activities are sought which address specific technology needs (specified below), necessary to both assess and advance IFE. Given the long-term prospects for IFE, applications submitted under this topical area must also clearly describe their potential/plans for short-term *(2-10 years)* commercialization in other commercial industries such as telecommunications, biomedical, etc.

Grant applications are sought only in the following subtopics:

a. Driver Technologies

Inertial fusion energy hinges on the ability to compress an ICF target in tens of nanoseconds and repeat this process tens of times per second. Thus, the development of technologies is needed to build a driver (e.g., lasers, heavy-ions, pulsed power) that can meet the IFE requirements for energy on target, efficiency, repetition rate, durability, and cost. Specific areas of interest include but are not limited to: wavelength and beam quality for lasers, brightness for lasers and heavy ions, and pulse shaping and power.

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b. Driver Delivery Systems

The development of final focusing elements capable of focusing the driver energy onto target with the required precision fidelity, damage threshold, and repetition rate is sought. These elements should be resistant to damage from both the target emissions and the driver energy. Specific examples include but are not limited to: optics, magnets, and electrical transmission lines.

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c. Ultrafast Diagnostics

The development of ultrafast diagnostics is needed to assess driver and plasma conditions on sub-picosecond time scales. This technology has the potential to enable the development and deployment of feedback systems capable of ensuring the necessary reliability required for commercially viable IFE. Specific areas of interest include but are not limited to: the generation, detection, and control of nonlinear optical processes in plasmas.

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d. Other
In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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1. "Advancing the Science of High Energy Density Laboratory Plasmas," Report of the HEDLP Panel of the Fusion Energy Sciences Advisory Committee. January 2009. (http://science.energy.gov/~/media/fes/fesac/pdf/2009/Fesac_hed_lp_report.pdf)

30. LOW TEMPERATURE PLASMAS (PHASE I, $150,000/PHASE II, $1,000,000)

Low-temperature plasma science and engineering addresses research and development in partially ionized gases with electron temperatures typically below 10 eV. The richness of the field comes from the intimate contact between energetic plasmas and ordinary matter in all its phases: gas, liquid, and solid making it a highly complicated, coupled, nonlinear and non-equilibrium system. The focus of this topic continues to be on fundamental issues and applications of low-temperature plasma science and engineering in which improved understanding of the plasma state is needed leading to new spin-offs and impact in other areas or disciplines. Current challenges have been identified in the areas of biological and medical applications of low-temperature plasmas, plasma-assisted synthesis and microelectronics, and development of new low-temperature plasma diagnostics and modeling. Increased scientific understanding in these areas will be crucial for developing new marketable products and technologies.

a. Science Enabling Low Temperature Plasma Engineering and Technology
A weakly to partially ionized gas is often characterized by strong non-equilibrium in the velocity and energy distributions of its neutral and charged constituents. Topics being encouraged include:
(1) Fundamental plasma science leading to the development of microelectronics and plasma-enabled technologies,
(2) Low-temperature plasma science and technology for biological and medical research, and
(3) Development of new diagnostic tools and/or computer codes for measuring/predicting essential low-temperature plasma properties, three-dimensional structures, etc.

All research proposals must have a strong commercialization potential.

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b. Other
In addition to the specific subtopics listed above, the Department invites grant applications in

other areas relevant to this Topic.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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PROGRAM AREA OVERVIEW: OFFICE OF HIGH ENERGY PHYSICS

Through fundamental research, scientists have found that all observed matter is composed of apparently point-like particles, called leptons and quarks. These constituents of matter were created following the "big-bang" that originated our universe, and they are components of every object that exists today. We also understand a great deal about the four basic forces of nature: electromagnetism, the strong nuclear force, the weak nuclear force, and gravity. For example, in the past we have learned that the electromagnetic and weak forces are two components of a single force, called the electro-weak force. This unification of forces is analogous to the unification in the mid-nineteenth century of electric and magnetic forces into electromagnetism. History shows that, over a period of many years, the understanding of electromagnetism has led to many practical applications that form the technical basis of modern society.

The goal of the Department of Energy's (DOE) Office of High Energy Physics (HEP) is to provide mankind with new insights into the fundamental nature of energy and matter and the forces that control them. This program is a major component of the Department's fundamental research mission. Such fundamental research provides the necessary foundation that enables the nation to advance its scientific knowledge and technological capabilities, to advance its industrial competitiveness, and possibly to discover new and innovative approaches to its energy future.

The DOE HEP program supports research in three discovery frontiers, namely, the energy frontier, the intensity frontier, and the cosmic frontier. Experimental research in HEP is largely performed by university and national laboratory scientists, usually using particle accelerators located at major laboratories in the U.S. and abroad. Under the HEP program, the Department operates the Fermi National Accelerator Laboratory (Fermilab) near Chicago, IL. The Department also has a significant role in the Large Hadron Collider (LHC) at the CERN laboratory in Switzerland. The Tevatron Collider at Fermilab was the world's highest energy accelerator for over a decade, until the startup of the LHC. The Fermilab complex also includes the Main Injector, which is used independently of the Tevatron to create high- energy particle beams for physics experiments, including the world's most intense neutrino beam. The SLAC National Accelerator Laboratory and the Lawrence Berkeley National Laboratory are involved in the design of state-of-the-art accelerators and related facilities for use in high-energy physics, condensed matter research, and related fields. SLAC facilities include the 3 kilometer long Stanford Linear Accelerator capable of generating high energy, high intensity electron and positron beams. The first 2 kilometers of the linear accelerator is currently being used for the Facility for Advanced Accelerator Experimental Tests (FACET). While much progress has been made during the past five decades in our understanding of particle physics, future progress depends on a great degree of availability of new state-of-the-art technology for accelerators, colliders, and detectors operating at the high energy and/or high intensity frontiers.

Within HEP, the Advanced Technology subprogram supports the research and development required to extend relevant areas of technology in order to support the operations of highly specialized accelerators, colliding beam facilities, and detector facilities which are essential to the goals of the overall HEP program. As stewards of accelerator technology for the nation, HEP also supports development of new concepts and capabilities that further scientific and commercial needs beyond the discovery science mission. The DOE SBIR program provides a focused opportunity and mechanism for small businesses to contribute new ideas and new technologies to the pool of knowledge and technical capabilities required for continued progress in HEP research, and to turn these novel ideas and technologies into new business ventures.

For additional information regarding the Office of High Energy Physics priorities, click here.

31. HIGH ENERGY PHYSICS COMPUTATIONAL TECHNOLOGY (PHASE I, $150,000/PHASE II, $1,000,000)

The DOE supports the development of computational technologies essential for success of the experimental, theoretical, and R&D programs in the Office of High Energy Physics (HEP). HEP funded research is aimed at understanding how our universe works at its most fundamental level through Energy, Intensity and Cosmic Frontiers [1]. Experiments for HEP science are data intensive, and rely heavily on scientific computing for planning, operations, software, data taking and data analysis. State of the art modeling and simulation are integral to the planning, development, and success of science at the three frontiers.

Although particle physics computer systems and software development typically occur in large collaborative efforts at national particle accelerator centers, there are opportunities for small businesses to make innovative and creative contributions that can be commercialized. Applicants interested to apply for the SBIR/STTR projects in the HEP Computational Technology area are encouraged to collaborate with active high energy particle physicists at universities or national laboratories to establish mutually beneficial goals. National Laboratories that support HEP research can be found at [2] and on-line directories of appropriate researchers are available by institution at [3]. Prospective applicants are also advised to consult with the SBIR commercialization department and their collaborator's university or laboratory small business offices for appropriate presentation of commercialization plans.

Although some aspects of HEP computing technology may have similarities with other disciplines applicants should consult with their HEP supported collaborators and focus on proposals that enhance HEP research interests. Areas of present interest are outlined below in the sub topics.

All grant applications must clearly and specifically indicate their relevance to present or future HEP programmatic activities as described in the Energy, Intensity, and Cosmic frontiers.

Grant applications are sought in the following subtopics:

a. Collaboration Software for Distributed Computing

The international nature of HEP experiments and their large computing resource requirements drive the current HEP paradigm of handling and analyzing experimental data in a highly distributed fashion. By aggregating world-wide computing resources from HEP and other disciplines, initiatives like the Open Science Grid [4] aim to enable a federated computing model for HEP and other participating disciplines. Grant applications are sought to develop advanced infrastructure technologies to strengthen the ability of dispersed particle physics researchers to collaborate. Examples include client-server frameworks, remote data selection techniques, distributed data management and analysis frameworks, and project management software. Grant applications are also sought that support the design, implementation, and operation of distributed computing systems comprising distributed Petaflops of CPU power and distributed petabytes of data, middleware development for grid-enabled systems, security assurance tools a distributed environment, and other related technology relevant for high energy physics.

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b. Frameworks and Database Development

Grant applications also are sought in areas of large data including frameworks for the management, configuration, custody, and dissemination of large data sets (experimental or simulation data), development of data storage, management reliability, and preservation systems and related tools for large data needs of the HEP community.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Parallelization of Software and Simulation Tools

Grant applications are sought that facilitate parallelizing HEP community codes on multi core computer systems including clusters, and/or GPU systems that address specific or broad HEP research areas and/or complement use of supercomputers.

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d. Enhancing the Geant4 Simulation Toolkit

Grant applications are sought for enhancements or additions to the Geant4 simulation toolkit [5] that would be beneficial to its use in high energy physics while widening its applicability outside high energy physics. Examples might include: a) enhanced simulation of radiation effects in semiconductors to aid in the design of radiation-hard electronics; b) simulation of material activation in high radiation environments; c) improved interface to Computer Aided Design systems enabling tasks such as efficient exploration of shielding configurations; d) improvements to the precision and speed of the Geant4 electromagnetic physics modeling benefiting both high energy physics and other uses.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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3. "Open Science Grid," a partnership between the National Science Foundation and the U.S. Department of Energy's Office of Science (http://computing.fnal.gov/xms/Science_%26_Computing/Scientific_Facilities/Open_Science_Grid)

4. Geant4 (http://geant4.cern.ch/)

32. ADVANCE CONCEPTS AND TECHNOLOGY FOR HIGH INTENSITY ACCELERATORS (PHASE I, $150,000/PHASE II, $1,000,000)

The DOE High Energy Physics (HEP) program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. The strategic plan for HEP includes initiatives on the intensity frontier, relying on accelerators capable of delivering very high average beam intensity at multi-GeV energies, i.e. beam powers measured in megawatts. Beams are typically composed of protons or ions. The DOE HEP program seeks to develop advanced technologies that can be used to support MW-class facilities in a cost effective manner, and also to develop new concepts and capabilities that further scientific and commercial needs beyond HEP's discovery science mission.

Grant applications are sought only in the following subtopics:

a. Accelerator Development and Modeling of Advanced Concepts
Grant applications are sought to develop new or improved accelerator designs and supporting modeling that can provide efficient acceleration of intense particle beams in either linacs or synchrotrons. Efficient acceleration refers to beam losses of less than 1 W/m. Topics of interest include: (1) linac configurations, either pulsed or CW, capable of delivering >1 MW beams at energies between 1-10 GeV; (2) halo formation in pulsed or CW linacs; (3) concepts for high intensity rapid cycling synchrotrons; (4) space-charge mitigation techniques; (5) new methods for multi-turn H^- injection, including laser stripping techniques; and (6) higher order mode generation, propagation, and suppression in acceleration cavities, including the photonic band gap structures.

The HEP application of interest is for a high intensity proton source to support intensity frontier programs including long baseline neutrino beams and rare processes experiments. Other possible applications include high-intensity proton drivers for neutron production, waste transmutation, energy production in sub-critical nuclear reactors, medical proton therapy, and radioisotope production.

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b. Superconducting Radiofrequency Cavities

Grant applications are sought for the development of superconducting radiofrequency cavities for acceleration of proton and ion beams, with relativistic betas ranging from 0.1 to 1.0. Frequencies of current interest include 325, 650, and 1300 MHz. Continuous wave (CW) cavities are of the greater interest, although pulsed cavities could also be supported. Accelerating gradients above 15 MV/m, at Q_0 in excess of 2×10^{10} (CW), and above 25 MV/m at Q_0 in excess of 1×10^{10} (pulsed) are desirable. Topics of interest include: (1) cavity designs; (2) cavity fabrication alternatives to electron beam welding, including for example hydroforming and automatic TIG or laser welding of cavity endgroups; (3) other cavity and cryomodule cost reduction methods; (4) cw power couplers at >50kW; (5) fast tuners for microphonics control; (6) higher order mode suppressors, including extraction of HOM power via the main power coupler and with photonic band gap cavities; (7) ecologically friendly or alternative cavity surface processing methods; (8) alternatives to high pressure rinsing that would allow in-situ cleaning of cavities to control field emission; and (8) high resolution tomographic x-rays of electron beam welds in cavities. (For SCRF applications involving muon accelerators see section 29a.)

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Radio Frequency Power Sources and Components

Grant applications are sought for the development of power sources for cavities operating with 1-10 mA of average beam current in linacs capable of accelerating protons and ions to several GeV. Frequencies of interest include 325, 650, and 1300 MHz. Continuous wave (CW) applications are the primary interest. Examples of systems of interest include, but are not limited to: klystrons, solid state, inductive output, and phase locking magnetron devices; and the associated power supplies/modulators. Pulsed applications of interest include sources capable of delivering high peak power (multi-MW) with pulse lengths in the range 6-30 msec at 10 Hz. Of particular interest are the high efficiency solid state CW rf sources (30 kW at 650 MHz and 10 kW at 325 MHz) for the FNAL Project X linac.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. High Gradient Tunable RF Cavities for Rapid Cycling Synchrotrons

Grant applications are sought to develop high gradient cavities that can be utilized in synchrotrons with repetition rates in the range of 5-50 Hz, with frequency swings corresponding to beta variations from 0.9-1.0. Cavity gradients in excess of 20 MV/m are desirable. Topics of interest include: (1) cavity (including tuner) designs; (2) cavity fabrication techniques; and (3) power sources.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

e. High Reliability Ion Sources

Grant applications are sought for the design, and possibly demonstration units, of CW proton and H^- sources capable of operating at up to 10 mA. The primary interest is in sources that can be fabricated with high reliability, meaning source lifetime of greater than one month.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

f. Beam Choppers, Bunchers, and Transverse Deflectors

Grant applications are sought for beam deflecting devices that can be used to remove or deflect proton or ion bunches for the purpose of forming variable bunch patterns of use in high intensity proton accelerators. Topics of particular interest include: (1) wideband beam choppers capable of removing beam from a dc source at energies in the 2-3 MeV range; specifically with capabilities of providing arbitrary chopping patters with a bandwidth of >300 MHz; and (2) narrowband transverse deflecting cavities capable of CW operation at a few hundred MHz, with deflecting fields of ~25 MV/m.

In addition grant applications are sought for buncher cavities that can be utilized in the initial acceleration stages of proton or ion accelerators.

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g. Cryogenic and Refrigeration Technology Systems

Many new accelerators are based on the cold (superconducting) technology requiring large cryogenic systems. Grant applications are sought for research and development leading to the design and fabrication of improved cryomodules for superconducting cavity strings. Each cryomodule typically contains four to eight cavities in helium vessels and include couplers, tuners, quadrupoles, 2K helium distribution system, and instrumentation to measure temperatures and pressures in the cryomodule during cool down and operation. Improvements in cryomodule components, cryomodule design and fabrication techniques which result in lower costs, improved control of cavity alignment, better understanding of cavity temperatures, and lower heat leaks are of particular interest. Other areas of interest include optimized methods for current leads for magnets operation at 2K where the helium pressures are sub atmospheric.

Grant applications also are sought to increase the technical refrigeration efficiency – from 20% Carnot to 30% Carnot – for large systems (e.g. 10 kW at 2K), while maintaining higher efficiency over a capacity turndown of up to 50%. This might be done, for example, by reducing the number of compression stages or by improving the efficiency of stages. Grant applications also are sought to develop improved and highly efficient liquid helium distribution systems."

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h. Other
In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

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33. ADVANCED CONCEPTS AND TECHNOLOGY FOR HIGH ENERGY ACCELERATORS (PHASE I, $150,000/PHASE II, $1,000,000)

The DOE High Energy Physics (HEP) program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. As high energy physics facilities get bigger and more costly, the DOE HEP program seeks to develop advanced technologies that can be used to reduce the overall machine size and cost, and also to develop new concepts and capabilities that further scientific and commercial needs beyond HEP's discovery science mission.

Grant applications are sought only in the following subtopics:

a. Advanced Accelerator Concepts and Modeling
Grant applications are sought to develop new or improved accelerator designs that can provide very high gradient (>200 MV/m for electrons or >10 MV/m for protons) acceleration of intense bunches of particles, or efficient acceleration of intense (>50 mA) low energy (of order <20 MeV) proton beams. Approaches of interest include: (1) the fabrication of accelerator structures from materials such as Si, SiO_2 or GaAs, using integrated circuit technology, where the realization might include photonic bandgap structures or gratings powered by lasers in the wavelength range 1 to 2.5 µm; (2) the development of micro-capillary arrays with arbitrary thickness-to-diameter ratios, with capillary diameters down to 5 µm, and with different diameters and materials in the same plate (which might also incorporate defect structures such as lines and holes); and (3) the development of high-efficiency, high-power, lasers at 1.5-4.5 µm, providing >10 µJ per pulse at repetition rates >10 MHz, excellent mode quality M^2<1.2, and the long-term potential for both carrier-envelope- phase stabilization and excellent wall-plug efficiency (>30%). For all proposed concepts, stageability, beam stability, manufacturability, and high-wall plug-to-beam power efficiency should be considered.

Grant applications are also sought to demonstrate technologies that support the production of high-peak current (> 5 kA), low-emittance (< 0.15 micrometer) electron bunches (> 100 pC). Novel emittance partitioning concepts are of particular interest, including developing high compression ratio (>20) bunch compressors based on coupled emittance exchangers that suppress effects from coherent synchrotron radiation and multi-stage emittance partitioning schemes where excess transverse emittance is efficiently transferred into the longitudinal dimension.

Grant applications also are sought to demonstrate efficient low-loss proton acceleration in the energy range of 5-25 GeV using non-scaling, fixed-field alternating-gradient (FFAG) accelerators and integrable optics accelerators. This demonstration may require an electron model to directly simulate operation in a space-charge limited regime and fast RF modulation for high repetition rate and ultra-wide tune range operation. The HEP application of interest is for a proton driver injector for muon colliders and/or neutrino factories. Other possible applications include high-intensity proton drivers for neutron production, waste transmutation, energy production in sub-critical nuclear reactors, medical proton therapy (250 MeV), and radioisotope production.

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b. Concepts and Technology for Muon Colliders and Muon Beams

Grant applications are sought for the development of novel devices and instrumentation for use in producing intense low energy muon beams suitable for precision muon experiments, and intense high energy muon beams suitable for neutrino factories and/or muon colliders. Areas of interest include: (1) Analysis of the importance of physics processes that are not presently simulated by existing cooling codes, including plasma effects in absorbers, effects of very strong magnetic fields on multiple scattering, effects of intense muon beams on ionization energy loss, wakefields in RF cavities closed with metal windows, and other phenomena; (2) design of an injection system for an Accumulator Ring in the proton driver, including foil heating, beam painting, and other phenomena; (3) Development of advanced beam-current monitors that can measure beam current with 0.1% accuracy and polarimeters for measuring the polarization of stored muon beams; (4) concepts and prototyping elements for cost effective rapid acceleration, e.g., 1 T/s pulsed magnets.

Grant applications are also sought to develop: (1) new concepts for the generation, capture, manipulation, cooling, acceleration and colliding of intense muon beams; (2) large aperture kickers for injection and extraction in muon cooling rings; (3) instrumentation for muon channels with intensities ~10^{12} muons/pulse; (4) design of Fixed Field Alternating Gradient (FFAG) rings; (5) design of Recirculating Linear Accelerators (RLAs); (6) new concepts for RF amplifiers or pulse compression schemes for use with non-superconducting RF cavities in the cooling channel of muon colliders.

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c. Novel Device and Instrumentation Development

Grant applications are sought for the development of electromagnetic, permanent magnet, silicon microcircuit, or electron-beam- based charged particle optical elements for particle beam focusing. Examples include, but are not limited to, (1) dipoles, quadrupoles, higher order multipole correctors for use in electron linear accelerators; and (2) solenoids for use in electron-beam or ion-beam sources, or for klystron or other radio frequency amplifier tubes operating at wavelengths from 0.7 to 10 cm. In these optical elements, permanent magnets or hybrid magnets incorporating magnetic materials that have very high residual magnetization, radiation resistance, and thermal stability (low variation of field strength with temperature) are of particular interest.

Grant applications also are sought to develop (1) undulators for bunching high energy electron beams, needed for phased injection in high frequency accelerating structures and for generating coherent transition radiation; (2) electron lenses for compensation of space-charge and beam- beam effects and for particle collimation; (3) novel charged particle beam monitors to measure the transverse or longitudinal charge distribution, emittance, or phase-space distributions of small radius (0.1 μm to 5 mm diameter), short length (10 μm to 10 mm) relativistic electron or ion beams; and (4) devices capable of measuring and recording the Schottky or transition radiation spectrum of these beams (proposed techniques should be nondestructive, or minimally perturbative, to the beams monitored and have computer-compatible readouts).

Grant applications also are sought to develop achromatic, isochronous compact focusing systems with broad energy acceptance and compact broadband (10-100 MeV) spectrometers, suitable for use in laser acceleration experiments.

Lastly, grant applications are sought to develop high density (range of 10^{18}-10^{20} cm^{-3}), high repetition rate (≥10 Hz) pulsed gas jets, capable of producing longitudinally tailored density profiles with long lengths (centimeter scale) and narrow widths (few hundred microns) for use in laser wakefield accelerators. The gas jet should have sharp entrance gradients, with a transition region/length on the order of 500 μm. The pulse duration of the jets should be less than 500 μs to minimize the amount of gas loading in vacuum chambers. Cluster gas jets, i.e., jets that are cooled and produce atomic clusters, are also of interest.

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d. Laser Technology for Accelerators

Lasers are used in many areas of accelerator applications, ranging from plasma channel formation to laser wakefield acceleration. Grant applications are sought to develop lasers for laser-accelerator applications that provide substantial improvements over currently available lasers in one or more of the following parameters: (1) longer wavelengths (up to 2 to 2.5 μm for use with Si transmissive optics), (2) very short wavelengths (< 200 nm) with low mode numbers ($M^2 < 100$) and high pulse energy (> 0.1 J) for photo-ionized plasma sources, (3) higher power, (4) higher repetition rates, and (5) shorter pulse widths.

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e. Inexpensive High Quality Electron Sources

Grant applications are sought for the design and prototype fabrication of small, inexpensive electron sources for use in advanced accelerator R&D laboratory experiments. The following parameters are target values for accelerator research experiments: (1) energy range of 5 to 35 MeV providing, at a minimum, on the order of 10^9 electrons in a bunch less than 5 picoseconds long; (2) normalized transverse beam emittance $<5\pi$ mm-mrad; and (3) pulse repetition rate >10 Hz. Grant applications also are sought for sources with significantly lower bunch charges, energies, and emittances from a matrix cathode, but at comparable or greater peak currents and significantly higher repetition rates. In addition, grant applications are sought to develop a bright direct-current/radio-frequency (DC/RF) photocathode electron source that combines a pulsed high-electric-field DC gun and a high field RF accelerator, operates at a repetition rate of several kHz, and has electron bunch specifications similar to those listed above.

Grant applications also are sought to develop: (1) robust RF photocathodes (quantum efficiencies >0.1 percent) or other novel RF gun technologies operating at output electron beam energies >3 MeV; (2) laser or electron driven systems for such guns; and (3) electron beam sources, such as sheet or multiple beams, relevant to the abovementioned high power RF applications.

Novel electron sources suited for injection into laser-driven structure-based accelerators are also sought. Sources such as the laser-assisted field emission "super-tip" sources are sought, with the capability of providing up to 1 fC/optical cycle bunch charge, normalized transverse emittance of <0.001 mm-mrad, and MHz repetition rates.

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f. Precision Corrector Magnet Driver

The present generation of multi-channel correction magnet drivers (e.g. MCOR) is approaching obsolescence and new high availability designs are needed for high energy accelerator systems. Grant applications are sought for systems incorporating 16 channels or more in a 19 inch rack mounted crate with a height of 6U or less. Bi-polar driver cards of up to ±20 A output current should be developed. High accuracy current and voltage regulation and stability are required, <10 ppm/°C, with RMS current noise <0.01%. Digital regulation, with sufficient speed to support a 4 kHz feedback rate, should be employed. Excellent reliability is essential with a target MTBF of 150,000 hours. Additionally, high availability features such as redundancy, hot-swap, embedded diagnostics/prognostics to enhance system availability. Each crate should incorporate an EPICS IOC and support external communication via IP protocol over Gigabit Ethernet.

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g. Hardware and Software Solutions for Accelerator Control

Grant applications are sought to develop: (1) improved software systems for command and control functions, real time database management, real-time or off-line modeling of the accelerator system and beam, and status display systems encountered in state-of-the-art approaches to accelerator control and optimization; and (2) improved decision and database management tools, specifically for use in planning and controlling the integrated cost, schedule, and resources in large HEP R&D and construction projects.

Grant applications are sought for designing a next generation precision digital controller capable of controlling and monitoring power supplies with ~kA output current. The precision controller should have support for two current transductors [primary and secondary], magnet interlocks, GND-current monitoring, remote monitoring of all internal voltages and switchable digital and analog control of the current loop. The controller should have better than 10 ppm regulation along with temperature stability of 1-2 ppm/^{o}C. The controller should employ hardware based [FPGA] magnet interlocks and power supply protection. Each Controller chassis should also have an EPICS IOC running Linux_RT/RTEMS and support external communication via IP protocol over Gigabit Ethernet and be compatible with the EVR/EVG Timing or the SLAC time stamp synchronization system and Fast Feedback system at SLAC-LCLS. Additionally, high availability features such as redundancy, embedded diagnostics/prognostics to enhance system availability should be incorporated.

Grant applications also are sought to develop real-time optical networks for pulsed-accelerator control. These networks require timing information to be combined with data-communication functions on a single optical fiber connected to pulsed device-controllers. The single fiber should provide each controller with an RF-synchronized clock that has the following features: (1) an arrival time that is phase-locked to the temperature-stabilized RF reference phase, (2) a phase- locked machine pulse fiducial point, (3) digital data for machine pulse-type selection and specific pulse identification, and (4) real-time-streaming pulsed waveform data-acquisition capabilities. The controllers serve as interfaces to systems that provide such functions as low-level RF signal generation, modulator control, beam position monitors, and machine protection system sensing. The network should provide real-time, fast-feedback loop closure and TCP/IP connectivity for slow control functions such as database access, device configuration, and code downloading and debugging.

Finally, grant applications are sought to develop real-time processors and software for pulsed accelerator control and monitoring. The software should be based on a multiprocessor architecture that can be deeply embedded within pulsed device-controllers, which employ system-on-a-chip, field-programmable gate-array, or application-specific integrated circuit technologies. The architectures should feature distinct processors for real-time pulse-to-pulse functions, and conventional slow control functions. Architectural provisions for supporting machine protection functions via an additional processor or dedicated hardware also should be included.

For the preceding two paragraphs, proposed solutions should be engineered to include: (1) resistance to electromagnetic interference generated by nearby, large pulsed-power systems; and (2) maximum availability in remote deployment locations.

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h. Computational Tools and Simulation of Accelerator Systems

Grant applications are sought to develop new or improved computational tools for the design, study, or operation of charged-particle-beam optical systems, accelerator systems, or accelerator components. These tools should incorporate innovative user-friendly interfaces, with emphasis on graphical user interfaces and windows. Grant applications also are sought for the conversion of existing codes for the incorporation of these interfaces (provided that existing copyrights are protected and that applications include the authors' statements of permission where appropriate).

Grant applications also are sought to develop improved simulation packages for injectors or photoinjectors. Areas of interest include: (1) improved space-charge algorithms; (2) improved algorithms for the self-consistent computation of the effects of wakefields and coherent synchrotron radiation on the detailed beam dynamics; (3) improved fully-three-dimensional algorithms for the modeling of transversely asymmetric beams; and (4) explicit end-to-end simulations that provide for more accurate beam-quality calculations in full injector systems.

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i. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

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34. RADIO FREQUENCY ACCELERATOR TECHNOLOGY FOR HIGH ENERGY ACCELERATORS AND COLLIDERS (PHASE I, $150,000/PHASE II, $1,000,000)

Radio frequency (RF) technology is a key technology common to all high energy accelerators. RF sources with improved efficiency and accelerating structures with increased accelerating gradient are important for keeping the cost down for future machines. DOE-HEP seeks advances directly relevant to HEP applications, and also new concepts and capabilities that further scientific and commercial needs beyond HEP's discovery science mission.

Grant applications are sought only in the following subtopics:

a. New Concepts and Modeling Techniques for Radio Frequency Acceleration Structures
Grant applications are sought for research on very high gradient RF accelerating structures, normal or superconducting, for use in accelerators and storage rings. Gradients >150 MV/m for electrons and >10 MV/m for protons in normal cavities are of particular interest, as are means for suppressing unwanted higher-order modes and reducing costs. In muon

accelerator R&D, structures for capture and acceleration of large emittance muon beams and techniques for achieving gradients of 5-20 MV/m in cavities with frequencies between 5 and 1300 MHz (including superconducting cavities whose resonant frequencies can be rapidly modulated) are of interest. Methods for reducing surface breakdown and multipactoring (such as spark-resistant materials or surface coatings, or special geometries) and for suppressing unwanted higher order modes also are of interest, as are studies of surface breakdown and its dependence on magnetic field. Grant applications should be applicable to devices operating at frequencies from 1 to 40 GHz, or between 5 and 1300 MHz for muon accelerators. Grant applications also are sought to develop simulation tools for modeling high-gradient structures, in order to predict such experimental phenomena as the onset of breakdown, post breakdown phenomena, and the damage threshold. Specific areas of interest include the modeling of: (1) surface emission, (2) material heating due to electron and ion bombardment, (3) multipactoring, and (4) ionization of atomic and molecular species. Approaches that include an ability to import/export CAD descriptions, a friendly graphical user interface, and good data visualization will be a plus.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Materials and Fabrication Technologies for SRF Cavities

Material properties, surface features, processing procedures, and cavity geometry can have significant impact on the performance of superconducting radio-frequency (SRF) accelerator cavities. Grant applications are sought to develop (1) new raw materials streams, such as those utilizing large-grain Nb ingot slices; (2) new or improved SRF cavity fabrication techniques, such as seamless and weld-free approaches; (3) SRF cavity fabrication techniques that reduce use of expensive metals such as niobium while achieving equivalent performance as bulk niobium cavities; (4) new or improved bulk processing technologies, such as mechanical or plasma polishing; (5) new or improved final surface preparation and protection technologies; and (6) new cavity ideas aimed at breakthroughs in understanding and performance of SRF cavities.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Radio Frequency Power Sources and Components

Grant applications are sought to develop high efficiency, high peak power, narrow-band, low-duty-cycle, low pulse rate (~100 Hz), pulsed S, C and X-band RF amplifiers. In particular, 25 MW and 50 MW S-band (2.8175 GHz) and X-band (11.424 GHz) klystrons are sought that produce 3 microsecond (S-band) and 2 microsecond (X-band) long pulses at 120 Hz. Periodic permanent magnet focused sheet beam and annular beam klystrons or alternatively cryogen-free superconducting solenoid magnets, which would increase overall efficiency, are of particular interest. Of particular interest are solid state low noise S-band and X-band klystron drivers. Requirements at X-band are 2 kW, 2 μs, 360 Hz, 100 MHz bandwidth, 50 dB gain, and low noise (<0.1 degree). S-band requirements are: peak output power +60dBm at 0.2% duty, 37 dB gain, 5 μsec, 360 Hz, pulse to pulse added noise jitter (10Hz to 2MHz BW) less than 30 fs rms. Amplifiers should be designed for installation in a 19 inch rack mount chassis and weigh less than 30 pounds.

High gradient X-band linacs may require some RF power handling components which have not been fully developed. Grant applications are sought to develop active RF pulse compression systems capable of handling high peak powers (for example, greater than 300 MW) and pulse widths of approximately 300 nanoseconds at X- band. Grant applications also are sought for RF components such as circulators, isolators and switches. Finally, X-band loads (50 MW/5 kW average, and 5 MW/25 kW average) are needed.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Modulators for Pulsed Radio Frequency Systems

Most RF power sources for high gradient linacs for future linear colliders require high peak-power pulse modulators of considerably higher efficiency than presently available. Grant applications are sought for new types of modulators in the 100 kV – 1 MV range for driving currents of 0.1 – 1 kA, with pulse lengths of 0.2 – 5.0 μs, and with rise- and fall-times that are ~10% of the pulse length or less. Grant applications also are sought for the development of a 2 μs, 420 kV, 420 A, 120 Hz induction modulator that could be used to drive a variety of high power klystrons (from S-band to X-band).

Grant applications also are sought for the development of modulators with improved voltage control for RF phase stability in some alternate RF power systems, as well as cathode modulators that are compact and cost competitive compared to present cathode pulse modulator schemes. Grant applications should address issues related to cost saving, manufacturability, and electrical efficiency in modulators.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

e. Switching Technology for Pulsed Power Applications

Grant applications are sought to develop improved high power solid-state switches for pulsed power. Applications of interest include thyratron replacement in line-type klystron modulators, switches/switch modules for modern klystron modulator topologies (e.g. hard-switch array, Marx, resonant converter, inductive adder …), and switches for drivers of ultra-fast beam deflectors. Switch parameters are application specific, but in aggregate cover a broad range: voltage from 1 kV to 50 kV; pulse current from 0.1 kA to 10 kA; pulse lengths from nanosecond to millisecond range; duty cycle from <0.1% to 1% (typical). In general, there is an emphasis on very fast switching (compared to typical power conversion applications) to minimize losses and enable high bandwidth performance (ns – sub-μs), and high di/dt (up to 100 kA/μs). Proposals should address applications of specific interest to DOE-HEP.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

f. Energy Storage for Pulsed Power Systems

High reliability, high-energy-density energy storage capacitors are a key component for the development of reliable solid state pulsed power systems. Grant applications are sought to develop and optimize storage capacitors that can: (1) deliver high peak pulse current (0.1-10 kA) in the partial discharge region (less than 30 percent voltage droop during pulse); (2) be designed with very low inductance connections to allow fast rise and fall time discharge without ringing (di/dt ~20 kA/μs); (3) be packaged to meet the requirements of high power solid state board layouts and have minimum production cost; and (4) have an accurately known lifetime of tens of thousands of hours.

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g. Deflecting Cavities (AKA "crab cavities")

High luminosity colliders can benefit from the use of a crossing angle between the colliding beams. The crossing angle will provide larger luminosity gains if the particle bunches are tilted, resulting in what is called a "crab crossing." Grant applications are sought for the development of crab cavities for the LHC and other applications. Approaches of interest, which may include new cavity geometries, should include the demonstration of high-performance prototype superconducting crab cavities. Grant applications also are sought for ancillary technology for use with crab cavities, including the development of (1) fundamental power couplers; (2) high-order, same-order, and low-order mode damping couplers, including design, analysis, and low-power testing; and (3) conceptual and detailed designs for low-cost crab cavity cryomodules and tuners.

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h. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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8. Muon Collider Workshop 2011: Physics-Detectors-Accelerators, Telluride, Colorado. June 27 – July 1, 2011. (http://conferences.fnal.gov/muon11/)

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10. The First International Particle Accelerator Conference, IPAC'10, Kyoto, Japan. May 23 – 28, 2010. (http://epaper.kek.jp/IPAC10/)

11. "Twelfth International Workshop on Neutrino Factories, Superbeams and Betabeams, NuFact10," Mumbai, India, October 20–25, 2010. (NuFact10 AIP Conference Proceedings October 2011, Volume 1382; ISBN: 978-0-7354-0942-2)*

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*Abstracts and ordering information available at: http://proceedings.aip.org/proceedings/

35. HIGH-FIELD SUPERCONDUCTOR AND SUPERCONDUCTING MAGNET TECHNOLOGIES FOR HIGH ENERGY PARTICLE COLLIDERS (PHASE I, $150,000/PHASE II, $1,000,000)

The Department of Energy High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this research in high-field superconductor and superconducting magnet technologies. This topic addresses only those superconducting magnet development technologies that support dipoles, quadrupoles, and higher order multipole corrector magnets for use in accelerators, storage rings, and charged particle beam transport systems, and only those superconductor technologies that support long strand lengths suitable for winding magnets without splices.

Grant applications are sought only in the following subtopics:

a. High-Field Superconducting Wire Technologies for Magnets
 Grant applications are sought to develop new or improved superconducting wire for magnets that operate at a minimum of 12 Tesla (T) field, with preference for production scale (> 3 km continuous lengths) wire technologies at 15 to 25 T and demonstration scale (>1 km lengths) wire technologies at 25 to 50 T. Current densities should be at least 400 amperes per square millimeter of strand cross-section (often called the engineering current density) at the target field of operation and 4.2 K temperature. Tooling and handling requirements restrict wire cross-sectional area from 0.4 to 2.0 square millimeters, with any transverse dimension being not less than 0.25 mm. Vacuum requirements in accelerators and storage rings favor operating temperatures below 20 K, so high-temperature superconducting wire technologies will be evaluated only in this temperature range. Primary materials of interest are Nb_3Sn, $Bi_2Sr_2CaCu_2O_8$ (Bi-2212), and $YBa_2Cu_3O_7$ (ReBCO); other materials may be considered if high field performance, length, and cost equivalent to these primary materials can be demonstrated. All grant applications must result in wire technology that will be acceptable for accelerator magnets, including not only the operating conditions mentioned above, but also delivery of a sufficient amount of material (1 km minimum continuous length) for winding and testing small magnets. New or improved wire technologies must demonstrate at least one of the following criteria *in comparison to present art*: (1) property improvement, such as higher current densities and higher operating fields; (2) improved management of property degradation as a function of applied strain; (3) reduced transverse dimensions of the superconducting filaments (sometimes called the effective filament diameter), in particular to less than 30 micrometers at 1 mm wire diameter, with minimal concomitant reduction of the thermal conductivity of the stabilizer or strand critical current density; (4) innovative geometry for ReBCO materials that leads to lower magnet inductance (cables) and lower losses under changing transverse magnetic fields; (5) correction of specific processing flaws (*not* general improvements in processing), to achieve properties in wires of more than 1 km length that are presently restricted to wire lengths of 100 m or less; (6) significant cost reduction for equal performance in all regards, especially current density and length.

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b. Superconducting Magnet Technology
Grant applications are sought to develop: (1) improved instrumentation to measure properties (such as local strain, temperature, and magnetic field) which are directly applicable to the testing of superconducting magnets; (2) improved current lead and current distribution systems,

based on high-temperature superconductors, for application to superconducting accelerator magnets – requirements include an operating current level of 5 kA or greater, stability, low heat leak, and good quench performance; (3) alternative designs – to traditional "cosine theta" dipole and "cosine two-theta" quadrupole magnets – that may be more compatible with the more fragile Nb_3Sn and HTS/high-field superconductors (including open midplane magnets that may be needed in a Muon Collider design); (4) designs for bent solenoids for muon collider applications; (5) improved industrial fabrication methods for magnets such as welding and forming; (6) improved cryostat and cryogenic techniques; (7) fast cycling HTS magnets capable of operation at or above 4T/s; (8) quench protection in HTS magnets; (9) reduction in magnetization induced harmonics in HTS magnets; (10) very high field (>20 T) dipoles.

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c. Starting Raw Materials and Basic Superconducting Materials

Grant applications are sought for raw materials that result in improved performance and can be incorporated into existing wire technologies under subtopic (a) with minimal disruption. (1) Nb_3Sn and other wire technologies rely upon various pure metal and metal-alloy raw materials containing niobium, tantalum, titanium, tin, and copper. Likewise, REBCO wire technologies depend on textured metal substrates, while Bi-2212 technologies depend on silver alloys. Grant applications are sought to develop improved starting metals and alloys, especially those which improve fabrication of the subsequent superconducting composite wire, reduce requirements for heat treatment and reaction, and reduce cost. (2) Bi-2212 and other wire technologies rely upon the fabrication of high-quality powders of the superconducting material. Grant applications are sought to develop powder fabrication facilities, improved quality control measures and better characterization tools.

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d. Ancillary Technologies for Superconductors

Grant applications also are sought to develop innovative cable designs and wire processing technologies. Approaches of interest include methods to use stranded conductors with high aspect ratio to make efficient magnet cables, methods to adapt tape geometries to particle accelerator applications; and technologies to increase wire piece length and billet mass.

Grant applications also are sought for innovative insulating materials with reduced thickness to increase block current density in a coil while maintaining or increasing dielectric breakdown strength. Insulating systems must be compatible with the targeted superconductor and magnet processing cycle, (e.g. high temperature reactions in the 750-900 ºC range in the case of Nb_3Sn or BSCCO), be capable of supporting high mechanical loads at both room and cryogenic temperatures, have a high coefficient of thermal conductivity, be resistant to radiation damage, and exhibit low creep and low out-gassing rates when irradiated.

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e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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* Abstracts and ordering information available at: http://proceedings.aip.org/proceedings/

36. HIGH-SPEED ELECTRONIC INSTRUMENTATION FOR DATA ACQUISITION AND PROCESSING (PHASE I, $150,000/PHASE II, $1,000,000)

The DOE supports the development of advanced electronics and systems for the recording, processing, storage, distribution, and analysis of experimental data that is essential to experiments and particle accelerators used for High Energy Physics (HEP) research. Areas of present interest include signal processing, event triggering, data acquisition, high speed logic arrays, and fiber optic links useful to HEP experiments and particle accelerators. Grant applications must clearly and specifically indicate their relevance to present or future HEP programmatic activities.

Although particle physics detector and data processing instrumentation typically are developed in large collaborative efforts involving national laboratories, there are efforts where small businesses can make innovative and creative contributions. Applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals.

Proposed devices must be explicitly related to future high-energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators. Relevant potential improvements over existing devices and techniques must be discussed explicitly. Areas of possible improvement include radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, compactness, cost, etc.

Grant applications are sought in the following subtopics:

a. Special Purpose Chips and Devices for Large Particle Detectors
Grant applications are sought to develop special purpose chips and devices for use in the

internal circuitry employed in large particle detectors. Desirable features include low noise, low power consumption, high packing density, radiation resistance, very high response speed, low-overhead calibration, stability, and/or high adaptability to situations requiring multiple parallel channels. Desirable functions include amplifiers, counters, analog pulse storage devices, decoders, encoders, analog-to-digital converters, analog waveform sampling, picosecond-resolution time-to-digital converters, controllers, and communications interface devices.

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b. Circuits and Systems for Processing Data from Particle Detectors

Grant applications are sought to develop circuits and systems for rapidly processing data from particle detectors such as proportional wire chambers, scintillation counters, silicon microstrip detectors, pixilated imaging sensors, particle calorimeters, large-area photodetector arrays, cryogenic detectors, and Cerenkov counters. Representative processing functions and circuits include low noise pulse amplifiers and preamplifiers, high speed counters, time-to-amplitude converters, and local time, charge, and signal shape extraction. Compatibility with one of the widely used or evolving module interconnection standards is highly desirable, as would be low power consumption, high component density, and/or adaptability to large numbers of multiple channels.

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c. Systems for Data Analysis and Transmission

Grant applications are sought to develop advanced high-speed logic arrays and microprocessor systems for fast event identification, event trigger generation, low front-end data reduction, and data processing with very high throughput capability. Such systems should be compatible with or implemented in one of the widely used or evolving module interconnection standards. Grant applications also are sought for the innovative use of fiber optic links, electro-optic modulators, and/or commodity high-bandwidth networks for high-rate transmission of collected data between particle detectors and data recording or control systems. Approaches of interest should demonstrate technologies that feature one or more of the following characteristics: low bit-error rate, radiation tolerance, low failure rate, low power consumption, high packing density, and the ability to handle a large number of channels at very high rates.

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d. Enhancements to Standard Interconnection Systems

Much of the electronics instrumentation in use in HEP is packaged in one of the international module inter-connection standards. Grant applications are sought to develop (1) new modules that will provide capabilities not previously available; (2) technology to substantially enhance the performance of existing types of modules; and (3) components, devices, or systems that will enhance or significantly extend the capability or functionality of one of the standard systems in HEP applications. Examples include large and/or fast buffer memories, single module computer systems (either general purpose or special purpose), display modules, interconnection systems, communication modules and systems, and disk-drive interface modules.

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e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas relevant to this Topic

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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4. "PCI Express: Performance Scalability for the Next Decade", PCI Special Interest Group. (http://www.pcisig.com/specifications/pciexpress)

5. Advanced Telecommunications Computing Architecture (ATCA), PICMG Consortium. (http://www.picmg.org/v2internal/specifications2.cfm?thetype=One&thebusid=2)

6. "SciDAC:HENP" (Scientific Discovery Through Advanced Computing Programs in High Energy and Nuclear Physics), U.S. DOE Website. (URL: http://www.scidac.gov/)

7. "DOE UltraScience Net: Experimental Ultra-Scale Network Research Testbed [Ultranet] for Large-Scale Science," U.S. DOE Website. (URL: http://www.csm.ornl.gov/ultranet/)

8. Circuit oriented high performance networking (http://www.perfsonar.net/)

9. International Linear Collider Communication Website, International Linear Collider Communication Group. (http://www.linearcollider.org/)

10. Open Science Grid Website. (http://opensciencegrid.org)

11. "CHEP-2012 [Computing in High Energy Physics Conference]," New York, NY. May 21-25,

2012 (http://www.chep2012.org/)

12. 12th Pisa Meeting on Advanced Detectors. La Biodola, Isola d'Elba, Italy , May 20-26 2012: (http://www.pi.infn.it/pm/)

13. 2nd International Conference on Technology and Instrumentation in Particle Physics 2011: TIPP 2011, Chicago, Illinois. June 9-14, 2011. (http://conferences.fnal.gov/tipp11/)

14. 18th Real-Time Conference, Berkeley CA. June 11-15, 2012. (http://rt2012.lbl.gov)

37. HIGH ENERGY PHYSICS DETECTORS AND INSTRUMENTATION ($150,000 PHASE I/ $1,000,000 PHASE II)

The DOE supports research and development in a wide range of technologies essential to experiments in High Energy Physics (HEP) and to the accelerators at DOE high energy accelerator laboratories. The development of advanced technologies for particle detection and identification for use in HEP experiments or particle accelerators is desired. Broadly, the areas of interest are improvements in the sensitivity, robustness, and cost effectiveness of particle detectors. Principal areas of interest include particle detectors based on new techniques and technological developments, or detectors that can be used in novel ways as a consequence of associated technological developments in electronics (e.g., sensitivity or bandwidth). Also of interest are novel experimental systems that use new detectors, or use old ones in new ways, with significant improvement in performance, to extend basic HEP experimental research capabilities or result in less costly and less complex apparatus. Devices which exhibit insensitivity to very high radiation levels have recently become extremely important. Grant applications must clearly and specifically indicate their particular relevance to HEP programmatic activities.

Although particle physics detector development is often concentrated at major national particle accelerator centers, there are many developmental endeavors, especially in collaborative efforts, where small businesses can make creative and innovative contributions that further develop the required advanced technologies. Applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals.

Proposed devices must be explicitly related to future high-energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators. Relevant potential improvements over existing devices and techniques must be discussed explicitly. Areas of possible improvement include radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, compactness, cost, etc.

Grant applications are sought in the following subtopics:

a. Particle Detection and Identification Devices
Grant applications are sought for novel ideas in the areas of charged and neutral particle detection and identification that could lead to improvements in the sensitivity, robustness, or cost effectiveness of particle detectors. These include ideas to advance the utility of detectors for the Energy Frontier such as at an upgraded or future collider; at the Intensity Frontier such

as at a future long baseline neutrino experiment; and at the Cosmic Frontier such as a new Dark Matter detector. Examples include, but are not limited to, semiconductor particle detectors (silicon, CVD diamond, or other semiconductors), light-emitting particle detectors (scintillating materials including fibers, liquids, and crystals or Cherenkov radiators), low radioactivity detectors and associated components, large-area systems used for particle identification and multiple vertex separation, and gas or liquid-filled chambers (used for particle tracking, in calorimeters, and in Cherenkov or transition radiation detectors).

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b. Photon Detectors

The detection of photons is fundamental for many detector applications. Applications include the following: 1) High quantum efficiency visible light photon detectors. 2) Development of lower cost photo-detection technology and production methods scalable to large detectors. 3) Photo-sensors for extreme environments including cryogenic temperatures, corrosive conditions, high and low pressures, electric and magnetic fields, and radiation relevant for future HEP applications. 4) Large-area photo-sensors with significantly improved space resolution and time resolution. 5) Photosensors with improved sensitivity in new regions of wavelength including improvements in windows and coatings. 6) New sensors for light detection. 7) Vacuum technology-based photo detection techniques. 8) Solid state technology-based photo detection techniques. 9) High quantum efficiency X-ray photo-sensors.

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c. Ultra-low Background Detectors

Many experiments conducting a direct search for dark matter require that the detector elements and the surrounding support materials exhibit extreme radiological stability. The presence of trace amounts of radioactivity in or near a detector induces unwanted effects. These elements could include: 1) Ultra-low-background neutron and alpha-particle detectors. 2) Development of ultra-radio-pure material for use in detectors. 3) Manufacturing methods of ultra-low- background materials.

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d. Radiation Hard Devices

Many experiments must locate detectors within extreme radiation areas, e.g., at high luminosity LHC, or at a Muon Collider with muon beam decay background. For these applications radiation hardened devices are required. Applications include the following: 1) Radiation hardened/resistant optical links. 2) Radiation hardened/resistant power supplies or voltage converters, e.g. point of load converters. 3) Development of ultra radiation hard material for use as detector elements. 4) Other radiation sensors for extreme environments.

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e. Cryogenic

Many detectors utilize cryogenic conditions and require cryogenic systems and devices which operate within a cryogenic environment. Applications include the following: 1) Development of the use, production and purification of cryogenic noble gases. 2) Cryogenic Liquid and Gas Particle Detectors. 3) Cryogenic Solid State Detectors.

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f. Mechanical and Materials

HEP experiments frequently require high performance detector support that will not compromise the precision of the detectors. Therefore, grant applications are sought for components used to support or integrate detectors into HEP experiments. The support components must be well matched to the detectors. For many experiments the presence of excess material is detrimental. These applications typically require low-mass and extremely rigid materials. Applications include the following: 1) Development of low mass detector support materials. 2) Novel low-mass materials with high thermal conductivity and stiffness. 3) Very high thermal conductivity, radiation tolerant adhesives. 4) Conventional detectors with substantially improved performance through the use of novel material science developments. 5) Improvements to manufacturing processes for radiation sensors and photosensors relevant for high energy physics. 6) 3D printing technology for rapid prototyping of detector components. The improvements should yield better performance, cost, faster production methods, or entirely new methods that make more efficient use of equipment.

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g. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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38. TECHNOLOGY TRANSFER OPPORTUNITY: DETECTORS ($450,000 PHASE I/ $3,000,000 PHASE II)

Applicants to Technology Transfer Opportunities should review the section describing Technology Transfer Opportunities on page 1 of this document prior to submitting applications.

Grant applications are sought in the following subtopics:

a. **Large Area Fast Photodetectors for Particle Detection** (LAPPD)
Patent Status: Two pending and unpublished patent applications and one published patent application

The LAPPD Collaboration, based at ANL, has been developing an innovative large-area (8” by 8”) photodetector for use in particle physics experiments. The detectors represent an alternative to multi-channel PMTs, possibly at lower cost and with several advanced features.

The detectors use low-cost glass borosilicate capillary plates functionalized with Atomic Layer Deposition, a thin film deposition technique that utilizes alternating, self-limiting chemical reactions between gaseous precursors and a solid surface to grow films in an atomic-layer-by-atomic-layer fashion. This capability has been exploited to deposit resistive and electron-emissive coatings for electron multiplication in the pores of the capillary plates. The economical mechanical design utilizes inexpensive plate glass packaging and an internal voltage divider. An anode design of high-bandwidth strip-lines allows excellent time (~nanoseconds) and space resolution (~mm), multiple-hit capability, and economical coverage of large areas with a small number of electronics channels. The signals are digitized by waveform-sampling chips; the digital signals are processed locally and sparsified data is collected via Gigabit fibers to a PC. Possible applications are non-cryogenic tracking neutrino detectors, and precision Time-of-Flight measurements of particles at colliders and in rare kaon experiments. The current R&D program has established proof-of-principle of the basic technological components.

Possible markets include particle detection within Scientific Applications, neutrino detection in reactor monitoring, neutron detection for transportation security and medical imaging applications.

Argonne National Laboratory information:
http://www.es.anl.gov/Energy_systems/Research/atomic_layer_deposition/Research.html
Contact: Terry Maynard, 630-252-9771, tmaynard@anl.gov
Website: http://www.anl.gov/technology

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PROGRAM AREA OVERVIEW: OFFICE OF NUCLEAR PHYSICS

The Office of Nuclear physics (NP) research seeks to understand the structure and interactions of atomic nuclei and the fundamental forces and particles of nature as manifested in nuclear matter. Nuclear processes are responsible for the nature and abundance of all matter, which in turn determines the essential physical characteristics of the universe. The primary mission of the Nuclear Physics (NP) program is to develop and support the scientists, techniques, and facilities that are needed for basic nuclear physics research and isotope development and production. Attendant upon this core mission are responsibilities to enlarge and diversify the Nation's pool of technically trained talent and to facilitate transfer of technology and knowledge to support the Nation's economic base.

Nuclear physics research is carried out at national laboratories and accelerator facilities, and at universities. The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF) allows detailed studies of how quarks and gluons bind together to make protons and neutrons. In an upgrade currently underway, the CEBAF electron beam energy will be doubled from 6 to 12 GeV. The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) is forming new states of matter, which have not existed since the first moments after the birth of the Universe; a beam luminosity upgrade is currently underway. NP is supporting the development of a next generation rare isotope beam accelerator facility (FRIB). The NP community is also exploring opportunities with a proposed electron-ion collider.

The NP program also supports research and facility operations directed toward understanding the properties of nuclei at their limits of stability, and of the fundamental properties of nucleons and neutrinos. This research is made possible with the Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL) which provides stable and radioactive beams as well as a variety of species and energies; a local program of basic and applied research at the 88-Inch Cyclotron of the Lawrence Berkeley National Laboratory (LBNL); the operations of accelerators for in-house research programs at two universities (Texas A&M University and the Triangle Universities Nuclear Laboratory (TUNL) at Duke University), which provide unique instrumentation with a special emphasis on the training of students; non-accelerator experiments, such as large stand alone detectors and observatories for rare events. Of interest is R&D related to future experiments in fundamental symmetries such as neutrinoless double-beta decay experiments and measurement of the electric dipole moment of the neutron, where extremely low background and low count rate particle detections are essential. Another area of R&D is rare isotope beam capabilities, which could lead to a set of accelerator technologies and instrumentation developments targeted to explore the limits of nuclear existence. By producing and studying highly unstable nuclei that are now formed only in stars, scientists could better understand stellar evolution and the origin of the elements.

Our ability to continue making a scientific impact on the general community relies heavily on the availability of cutting edge technology and advances in detector instrumentation, electronics, software, accelerator design, and isotope production. The technical topics that follow describe research and development opportunities in the equipment, techniques, and facilities needed to conduct and advance nuclear physics research at existing and future facilities.

For additional information regarding the Office of Nuclear Physics priorities, click here.

39. NUCLEAR PHYSICS SOFTWARE AND DATA MANAGEMENT (PHASE I, $150,000/PHASE II, $1,000,000)

Large scale data storage and processing systems are needed to store, access, retrieve, distribute, and process data from experiments conducted at large facilities, such as Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) and the Thomas Jefferson National Accelerator Facility (TJNAF). In addition, data acquisition for the Facility for Rare Isotope Beams (FRIB) requires unprecedented speed and flexibility in collecting data from new flash ADC based detectors. The experiments at such facilities are extremely complex, involving thousands of detector elements that produce raw experimental data at rates up to a GB/sec, resulting in the annual production of data sets containing hundreds of Terabytes (TB) to Petabytes (PB). Many 10s to 100s of TB of data per year are distributed to institutions around the U.S. and other countries for analysis. Research on large scale data management systems and high speed, distributed data acquisition is required to support these large nuclear physics experiments. All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Large Scale Data Storage

The cost of data storage on magnetic disk media is becoming competitive with magnetic tape for storing large volumes of data (ignoring all costs of servers and of I/O performance). Integrated tape libraries have much lower cost per stored byte than current disk systems, but much higher latency to access an arbitrary file. The infrastructure costs of operating lower latency many-petabyte-scale disk storage systems can be significant. One important characteristic of nuclear physics datasets is that most of the data is accessed infrequently. Therefore, grant applications are sought for new techniques for multi-petabyte-scale systems that are optimized for infrequent data access, emphasizing lower cost per byte than current disk systems, lower power usage than most disk systems, and lower access latency to data than current tape systems.

Also, many DOE labs have existing investments in large-scale tape robot technologies, which are at this point the most cost-effective way to store petabyte-sized datasets. Grant applications are sought for (1) the development of innovative storage technologies that not only can use existing cartridge and tape formats but also will significantly increase the storage density and capacity, increase data read and write speeds, or decrease costs; and (2) innovative software technologies to allow file-system-based user access to petabyte-scale data on tape.

The volume of data now being generated in these facilities has reached the point at which bit error rates in hardware are no longer low enough to ensure the integrity of data. Cost-effective software and hardware systems potentially spanning disk and tape storage systems are needed which transparently ensure the integrity of data such that silent error rates are many orders of magnitude below what current tape and disk systems deliver, but without the high cost of integrity that is found in high end RAID disk systems today.

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b. Large Scale Data Processing and Distribution

A recent trend in nuclear physics is to construct data handling and distribution systems using web services or data grid infrastructure software – such as Globus, Condor, SRB, and xrootd – for large scale data processing and distribution. Grant applications are sought for (1) hardware and/or software techniques to improve the effectiveness and reduce the costs of storing, retrieving, and moving such large volumes of data, including, but not limited to, automated data replication coupled with application-level knowledge of data usage, data transfers to Tier 2 and Tier 3 centers from multiple data provenance – with an aim for least wait-time and maximal coordination (coordination of otherwise chaotic transfers), distributed storage systems of commercial off-the-shelf (COTS) hardware, storage buffers coupled to 10 Gbps (or greater) networks, and end-to-end monitoring and diagnostics of WAN file transport; (2) hardware and/or software techniques to improve the effectiveness of computational and data grids for nuclear physics – examples include integrating storage and data management services with scalable distributed data repositories such as xrootd, and developing application-level monitoring services for status and error diagnosis; (3) effective new approaches to data mining, automatic structuring of data and information, and facilitated information retrieval; (4) new tools for configuring and scheduling compute and storage resources for data-intensive high performance computing tasks such as in user analyses where repeated passes over large datasets requiring fast turnaround times are needed; and (5) distributed authorization and identity management systems, enabling single sign-on access to data distributed across many sites. Proposed infrastructure software solutions should consider and address the advantages of integrating closely with relevant components of Grid middleware, such as the Virtual Data Toolkit (VDT), as the foundation used by nuclear physics and other science communities. Applicants that propose data distribution and processing projects are encouraged to determine relevance and possible future migration strategies into existing infrastructures.

Grant applications also are sought (1) to provide redundancy and increased reliability for servers employing parallel architecture, so that they are capable of handling large numbers of simultaneous requests by multiple users; (2) for hardware and software to improve remote user access to computer facilities at nuclear physics research centers, while at the same time providing adequate security to protect the servers from unauthorized access; and (3) for hardware and software to significantly improve the energy efficiency and reduce the operating costs of computer facilities at nuclear physics research centers.

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c. Grid and Cloud Computing

Grid deployments such as the Open Science Grid (OSG) in the U.S. and the Worldwide Large Hadron Collider (LHC) Computing Grid (WLCG) in Europe provide standardized infrastructures for scientific computing across large numbers of distributed facilities. To support these infrastructures, computing paradigms have emerged: (1) Grid Computing, sometimes called "computing on demand," supports highly distributed and intensive scientific computing for nuclear physics (and other sciences); and (2) Cloud Computing, often referred to as "elastic computing", can offer a fast turn-around resource provisioning solution to experiments via virtual machine containing an application-specific computing environment, services and software stack. Accordingly, there is a need for compatible software distribution and installation mechanisms that can be automated and scaled to the large numbers (100s) of computing facilities distributed around the country and the globe including platform independent applications as well as solution supporting the provisioning of resources to multiple experiments at a given site. Grant applications are sought to (a) develop mechanisms and tools that enable efficient and rapid packaging, distribution, and installation of nuclear physics application software on distributed computing facilities such as the OSG and WLCG (b) design innovative solutions for the apportion of resources and achieve resource sharing between many experiments and groups in a Cloud environment (c) seek to leverage industry standards such as the Hadoop file system or MapReduce paradigm to enhance the capabilities of Cloud stacks. Software solutions should enable rapid access to computing resources as they become available to users that do not have the necessary application software environment installed.

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d. Software-driven Network Architectures for Data Acquisition

Modern data acquisition systems are becoming more heterogenous and distributed. This presents new challenges in synchronization of the different elements of this event-driven architecture. The building blocks of the data acquisition system are digitizers, either flash digitizers or integrating digitizers of time, pulse height or charge. These elements respond in real-time to convert electrical signals from detectors into digital form. The data from each detector element is labeled with a precisely synchronized time and transmitted to buffers. The total charge, the number of coincident elements or other information summaries are used to determine if something interesting has happened, that is, forming a trigger. If the trigger justifies it, the data from the elements are assembled together into a time-correlated event for later analysis, a process called Event Building. At present the elements tend to be connected by buses (VME, cPCI), custom interconnects or serial connections (USB).

A concept of the next generation data acquisition system is that it will be ultimately composed of separate ADC's for each detector element, connected by commercial network or serial technology, is envisioned. Development is required to implement the elements of this distributed data acquisition over commercially available network technologies such as 10 Gb Ethernet or Advanced Telecommunications Computing Architecture (ATC). The initial work needed is to develop a software architecture for a system that works efficiently in the available network bandwidth and latencies. The elements desired in the architecture are to (1) synchronize time to a sufficient precision, as good as 10ns or better to support Flash Analog-to-Digital Converter (FADC) clock synchronization, 100ns or better to support trigger formation and event building, (2) determine a global trigger from information transmitted by the individual components (3) notify the elements of a successful trigger, in order to locally store the current information, (4) collect event data from the individual elements to be assembled into events and (5) software tools to validate the function of the synchronization, triggering and event building during normal operation. The synchronization of time is critical to the success of this architecture, as is the constant validation of the synchronization.

The software architecture would specify a functional model for the individual elements of the system, the high level network protocols, and requirements on the communications fabric for given data rates and system latencies. In certain types of experiments at FRIB, low event rates of 1 to 10 kevents/s are anticipated, with large data streams from FADC-based detector systems. The large latencies possible in highly buffered flash ADC architectures can be used to advantage in the design of the architecture. A portable software implementation of the elements would be the next step in the development.

Such an architecture and its implementation could form the basis of a standard for next generation data acquisition in nuclear physics, particularly at the FRIB.

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e. Heterogeneous Computing

Computationally demanding theory calculations as well as detector simulations and data analysis tasks can be significantly accelerated by the use of general purpose Graphics Processing Units (GPUs). The ability to exploit these accelerators is constrained by the effort required to port the software to the GPU environment. More capable cross compilation or source to source translation tools are needed that are able to injest very complicated templatized C++ code and produce high performance GPU code.

Early work by the USQCD (US Quantum Chromo Dynamics) collaboration has demonstrated the power of clusters of GPUs in Lattice QCD calculations. This early work was manpower intensive but yielded a large return on investment through the hand optimization of critical numerical kernels, achieving performance gains of up to 60x with 4 GPUs. However, realizing the full potential of accelerators on the full code base can only be achieved through a capable and performant automated tool chain.

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f. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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4. National Computational Infrastructure for Lattice Quantum Chromodynamics. (www.usqcd.org/)

5. Scientific Discover Through Advanced Computing, SciDAC, U.S. Department of Energy. (www.scidac.gov/physics/quarks.html)

6. The Globus Alliance Website, University of Chicago and Argonne National Laboratory. (http://www.globus.org/)

7. Condor: High Throughput Computing Website, University of Wisconsin. (www.cs.wisc.edu/condor/)

8. Cloud computing and virtual workspaces. (http://workspace.globus.org/)

9. CERN VM Software Appliance webpage. (http://cernvm.cern.ch/cernvm/).

10. Web Services Description Language Website, World Wide Web Consortium. (http://www.w3.org/TR/wsdl)

11. Open Science Grid and the Open Science Grid Consortium Web site, National Science Foundation and U.S. Department of Energy. (http://www.opensciencegrid.org/)

12. The Virtual Data Toolkit (VDT). (http://vdt.cs.wisc.edu/index.html/).

13. Worldwide LHC [Large Hadron Collider] Computing Grid (WLCG) (http://lcg.web.cern.ch/LCG/)

14. European Grid Infrastructure (EGI) (http://www.egi.eu/)

15. U.S. National Nuclear Data Center (http://www.nndc.bnl.gov/)

16. SRB – The SDSC Storage Resource Broker (http://www.sdsc.edu/srb/index.php/Main_Page)

17. Event Driven Architectures (http://en.wikipedia.org/wiki/Event-driven_architecture)

18. IEEE 1588 - Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems (http://ieee1588.nist.gov/)

19. Xrootd scalable distributed data repository (http://xrootd.slac.stanford.edu/)

20. Parallel Analysis Facilities (http://root.cern.ch/drupal/content/proof)

40. NUCLEAR PHYSICS ELECTRONICS DESIGN AND FABRICATION (PHASE I, $150,000/PHASE II, $1,000,000)

The DOE Nuclear Physics program seeks developments in detector instrumentation electronics with improved energy, position, timing resolution, sensitivity, rate capability, stability, dynamic range, durability, pulse-shape discrimination capability, and background suppression. Of particular interest are innovative readout electronics for use with the nuclear physics detectors described in Topic 42 (Nuclear Instrumentation, Detection Systems, and Techniques). All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Advances in Digital Electronics
Digital signal processing electronics are needed to replace analog signal processing in nuclear physics applications. Grant applications are sought to develop: fast digital processing electronics that improve the accuracy of the analog electronics, such as in determining the position of interaction points (of particles or photons) to an accuracy smaller than the size of the detector segments(example: Solenoidal Tracker at RHIC (STAR) decision time ~500 ns with a resolution of < 100ps) . Emphasis should be on circuit technologies with low power dissipation.

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b. Circuits
Grant applications are sought to develop application-specific integrated circuits (ASICs), as well as circuits (including firmware) and systems, for rapidly processing data from highly-segmented, position-sensitive germanium detectors (pixel sizes in the range of 1 mm^2 to 1 cm^2) and from particle detectors (e.g., gas detectors, scintillation counters, silicon drift chambers, silicon pixel and strip detectors, particle calorimeters, and Cherenkov counters) used in nuclear physics experiments. Areas of specific interest include (1) representative circuits such as low-noise preamplifiers, amplifiers, peak sensors, timing sensors, analog storage devices, analog-to-digital and time-to-digital converters, transient digitizers, and time-to-amplitude converters; (2) front-end and multiplexing circuits operating in cryogenic environment, to allow for reduction of noise, power, and number of feedthroughs in highly segmented germanium detectors; (3) multiple-sampling circuits , to allow for pulse-shape analysis; (4) readout electronics for solid-state pixilated detectors, including interconnection technologies, charge sharing processing and correction circuits (pixel pitch below 250 μm), and amplifier/sample-and-hold circuits; (5) systems with exceedingly large dynamic range (> 5000) employing, for example, either dynamic charge sensitive amplifier (CSA) gain changing or combinations of a standard linear CSA with a time-over-threshold (TOT) that works well into CSA saturation; and (6) constant-fraction discriminators with uniform response for low- and

high energy gamma rays. These circuits should be fast; low-cost; high-density; configurable in software for thresholds, gains, etc.; easy to use with commercial auxiliary electronics; low power; compact; and efficiently packaged for multi-channel devices.

In addition, planned luminosity upgrades at RHIC will require fine-grained vertex and tracking detectors (both silicon and gas) for high particle multiplicity environments. Therefore, grant applications are sought for advances in microelectronics that are specifically designed for low-noise amplification (see reference on "First Test Results of MIMOSA-26") and processing of detector signals, and that are suitable for these next generation detectors. The microelectronics and associated interconnections must be lightweight and have low power dissipation. Of particular interest are designs that minimize higher-gate leakage currents due to tunneling and maintain dynamic range.

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c. Advanced Devices and Systems

Grant applications are sought for improved or advanced devices and systems used in conjunction with the electronic circuits and systems described in subtopics a and b:

- Areas of interest regarding devices include (1) wide-bandgap semiconductors (i.e., semiconductor materials with bandgaps greater than 2.0 electron volts, including Silicon Carbide (SiC), Gallium Nitride (GaN), and any III-Nitride alloys); (2) inhomogeneous semiconductors such as SiGe; and (3) device processes such as silicon-on-insulator (SOI) or silicon-on-sapphire (SOS).
- Areas of interest regarding systems include (1) bus systems, data links, event handlers, multiple processors, trigger logics, and fast buffered time and analog digitizers. For detectors that generate extremely high data volumes (e.g., >500 GB/s), (2) advanced high-bandwidth data links are of interest.

Grant applications also are sought for generalized software and hardware packages, with improved graphic and visualization capabilities, for the acquisition and analysis of nuclear physics research data.

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d. Active Pixel Sensors

Active Pixel Sensors in CMOS (complementary metal-oxide semiconductor) technology are replacing Charge Coupled Devices as imaging devices and cameras for visible light. Several laboratories are exploring the possibility of using such devices as direct conversion particle detectors. The charge produced by an ionizing particle in the epitaxial layer is collected by diffusion on a sensing electrode in each pixel. The charge is amplified by a relatively-simple low-noise circuit in each pixel and read out in a matrix arrangement. If successful, this approach would make possible high-resolution, position-sensitive particle detectors with very low mass (approximately 50 microns of silicon in a single layer). This approach would be superior to the present technology that uses a separate silicon detector layer, which is bump-bonded to a CMOS readout circuit. Grant applications are sought to advance the development of integrated detector-electronics technology, using CMOS monolithic circuits as particle detectors. The new active pixel detector with its integrated electronic readout should be based on a standard CMOS process. The challenge is to design a sensor with low noise readout (S/N ~ 30:1 for mid-resistivity silicon designs, also see reference on "First Test Results of MIMOSA-26") circuits that have sufficiently high sensitivity and low power dissipation, in order to detect a minimum ionizing particle in a thin "epitaxial-like" or equivalent layer (~10-30 microns).

Grant applications also are sought for the next generation of active pixel sensors, or even strip sensors, which use the bulk silicon substrate as the active volume. This more advanced approach would have the advantage of developing relatively larger signals and allowing sensitivity to non-minimum ionizing particles, such as MeV-range gamma rays.

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e. Manufacturing and Advanced Interconnection Techniques

Grant applications are sought to develop (1) manufacturing techniques for large, thin, multiple-layer printed circuit boards (PCBs) with plated-through holes, dimensions from 2m x 2m to 5m x 5m, and thicknesses from 100 to 200 microns (these PCBs would have use in cathode pad chambers, cathode strip chambers, time projection chamber cathode boards, etc); (2) techniques to add plated-through holes, in a reliable robust way, to large rolls of metallized mylar or kapton (which would have applications in detectors such as time expansion chambers or large cathode strip chambers); and (3) miniaturization techniques for connectors and cables with 5 times to 10 times the density of standard interdensity connectors.

In addition, many next-generation detectors will have highly segmented electrode geometries with 5-5000 channels per square centimeter, covering areas up to several square meters. Conventional packaging and assembly technology cannot be used at these high densities. Grant applications are sought to develop (1) advanced microchip module interconnect technologies that address the issues of high-density area-array connections – including modularity, reliability, repair/rework, and electrical parasitics; (2) technology for aggregating and transporting the signals (analog and digital) generated by the front-end electronics, and for distributing and conditioning power and common signals (clock, reset, etc.); (3) low-cost methods for efficient cooling of on-detector electronics; (4) low-cost and low-mass methods for grounding and shielding; and (5) standards for interconnecting ASICs (which may have been developed by diverse groups in different organizations) into a single system for a given experiment – these standards should address the combination of different technologies, which utilize different voltage levels and signal types, with the goal of reusing the developed circuits in future experiments.

Lastly, highly-segmented detectors with pixels smaller than 100 microns present a significant challenge for integration with frontend electronics. New monolithic techniques based on vertical integration and through-silicon vias have potential advantages over the current bump-bonded approach. Grant applications are sought to demonstrate reliable, readily-manufacturable technologies to interconnect silicon pixel detectors with CMOS front-end integrated circuits. Of highest long term interest are high-density high-functionality 3D circuits with direct bonding of high resistivity silicon detector layer of an appropriate thickness (50 to 500 microns) to a 3D stack of thin CMOS layers. The high resistivity detector layer would be fully depleted to enable fast charge collection with very low diffusion. The thickness of this layer would be optimized for the photon energy of interest or to obtain sufficient signal from minimum ionizing particles.

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f. Other
In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

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41. NUCLEAR PHYSICS ACCELERATOR TECHNOLOGY (PHASE I, $150,000/PHASE II, $1,000,000)

The Nuclear Physics program supports a broad range of activities aimed at research and development related to the science, engineering, and technology of heavy-ion, electron, and proton accelerators and associated systems. Research and development is desired that will advance fundamental accelerator technology and its applications to nuclear physics scientific research. Areas of interest include the basic technologies of the Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC), with heavy ion beam energies up to 100 GeV/amu and polarized proton beam energies up to 250 GeV; technologies associated with RHIC luminosity upgrades; the development of an electron-ion collider; linear accelerators such as the Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF); and development of devices and/or methods that would be useful in the generation of intense rare isotope beams for the rare isotope beam accelerator facility (FRIB). A major focus in all of the above areas is superconducting radio frequency (RF) acceleration and its related technologies. Relevance of applications to nuclear physics must be explicitly described. Grant applications that propose using the resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Materials and Components for Radio Frequency Devices
   Grant applications are sought to improve or advance superconducting and room-temperature materials or components for RF devices used in particle accelerators. Areas of interest include (1) peripheral components, for both room temperature and superconducting structures, such as ultra high vacuum seals, terminations, high reliability radio frequency windows using alternative materials (e.g., sapphire), RF power couplers, and magnetostrictive or piezoelectric cavity-tuning mechanisms; (2) fast ferroelectric microwave components that control reactive power for fast tuning of cavities or fast control of input power coupling; (3) materials that efficiently absorb microwaves from 2 to 90 GHz and are compatible with ultra-high vacuum, particulate-free environments at 2 to 4 K; (4) innovative designs for hermetically sealed helium

refrigerators and other cryogenic equipment, which simplify procedures and reduce costs associated with repair and modification; (5) more cost effective, kW-to-multiple-kW level, liquid helium refrigerators; (6) simple, low-cost mechanical techniques for damping length oscillations in accelerating structures, effective in the 10-300 Hz range at 2 and/or 4.5 K; (7) alternative cavity fabrication techniques, such as hydro forming or spinning of seamless SRF cavities; and (8) novel SRF linac mechanical support structures with low thermal conductivity and high vibration isolation and strength.

Grant applications also are sought to develop (1) methods for manufacturing superconducting radio frequency (SRF) accelerating structures with $Q_0>10^{10}$ at 2.0 K, or with correspondingly lower Q's at higher temperatures such as 4.5 K; and (2) advanced fabrication methods for SRF cavities of various geometries (including elliptical, quarter and half wave resonators) to reduce production costs. Industrial metal forming techniques, especially with large grain or ingot material, have the potential for significant cost reductions by simplifying sub-assemblies – e.g., dumbbells and beam tube – and reducing the number of electron beam welds.

Grant applications also are sought to develop (1) improved superconducting materials that have lower RF losses, operate at higher temperatures, and/or have higher RF critical fields than sheet niobium; and (2) techniques to create a layer of niobium on the interior of a copper elliptical cavity, such as by energetic ion deposition, so that the resulting 700-1500 MHz structures have $Q_0>8 \times 10^9$ at 2 K. Approaches of interest involving atomic layer deposition (ALD) synthesis should identify appropriate precursors and create high quality Nb, NbN, Nb_3Sn, or MgB_2 films with anti-diffusion dielectric overlayers.

Grant applications also are sought for laser or electron beam surface glazing of niobium for surface purification and annealing in vacuum.

Finally, grant applications are sought to develop advanced techniques for surface processing of superconducting resonators, including methods for electropolishing, high temperature treatments, and surface coatings that enhance or stabilize performance parameters. Methods which avoid use of hydrofluoric acid are desirable. Surface conditioning processes of interest should (1) yield microscopically smooth (R_q< 10 nm / 10µm^2), crystallographically clean bulk niobium surfaces; and/or (2) reliably remove essentially all surface particulate contaminates (> 0.1 µm) from interior surfaces of typical RF accelerating structures. Grant applications aimed at design solutions that enable integrated cavity processing with tight process quality control are highly sought.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Radio Frequency Power Sources

Grant applications are sought to develop designs, computer-modeling, and hardware for 5-20 kW continuous wave (cw) power sources at distinct frequencies in the range of 50-1500 MHz, and for 1 MW cw RF power sources at 704 MHz. Examples of candidate technologies include: solid-state devices, multi-cavity klystrons, Inductive-Output Tubes (IOTs), or hybrids of those technologies. Grant applications also are sought to develop computer software for the design or modeling of any of these devices; such software should be able to faithfully model the complex shapes with full self-consistency. Software that integrates multiple effects, such as electromagnetic and wall heating is of particular interest.

Grant applications also are sought for a microwave power device, klystron, IOT or tunable/phase stabilized magnetron, offering improved efficiency (>55-60%) while delivering up to 8 kW CW at 1497 MHz. The device must provide a high degree of backwards compatibility, both in size and voltage requirements, to allow its use as a replacement for the klystron (model VKL7811) presently used at Thomas Jefferson Laboratory, while providing significant energy savings.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

c. Design and Operation of Radio Frequency Beam Acceleration Systems

Grant applications are sought for the design, fabrication, and operation of radio frequency accelerating structures and systems for electrons, protons, and light- and heavy-ion particle accelerators. Areas of interest include (1) continuous wave (cw) structures, both superconducting and non-superconducting, for the acceleration of beams in the velocity regime between 0.001 and 0.03 times the velocity of light, and with charge-to-mass ratios between 1/6 and 1/240; (2) superconducting RF accelerating structures appropriate for rare isotope beam accelerator drivers, for particles with speeds in the range of 0.02-0.8 times the speed of light; (3) innovative techniques for field control of ion acceleration structures (1° or less of phase and 0.1% amplitude) and electron acceleration structures (0.1° of phase and 0.01% amplitude) in the presence of 10-100 Hz variations of the structures' resonant frequencies (0.1-1.5 GHz); (4) multi-cell, superconducting, 0.5-1.5 GHz accelerating structures that have sufficient higher-order mode damping, for use in energy-recovering linac-based devices with ~1 A of electron beam; (5) methods for preserving beam quality by damping beam-break-up effects in the presence of otherwise unacceptably-large, higher-order cavity modes – one example of which would be a very high bandwidth feedback system; (6) development of tunable superconducting RF cavities for acceleration and/or storage of relativistic heavy ions; and (7) development of rapidly tunable RF systems for applications such as non-scaling fixed-field alternating gradient accelerators (FFAG) and rapid cycling synchrotrons, either for providing high power proton beams or for proton therapy.

RF cavities with high gain in voltage >30 kV and fast frequency switching are of interest for applications in fast acceleration of non-relativistic protons or ions with 0.1 <
create higher Q cavities where the frequency between two cavities can vary up to 25%. This will allow very fast acceleration to be applied for proton driven sub-critical Thorium nuclear reactors and for proton or carbon ion therapy.

Grant applications also are sought to develop software for the design and modeling of the above systems. Desired modeling capabilities include (1) charged particle dynamics in complex shapes, including energy recovery analysis; (2) the incorporation of complex fine structures, such as higher order mode dampers; (3) the computation of particle- and field-induced heat loads on walls; (4) the incorporation of experimentally measured 3-D charge and bunch distributions; and (5) and the simulation of the electron cloud effect and its suppression.

A high-integrated-voltage SRF cw crab crossing cavity is also of interest. Therefore, grant applications are sought for (1) designs, computer-modeling, and hardware development for an SRF crab crossing cavity with 0.5 to 1.5 GHz frequency and 20 to 50 MV integrated voltage; and (2) beam dynamics simulations of an interaction region with crab crossing. One example of candidate technologies would be a multi-cell SRF deflecting cavity.

Finally, grant applications also are sought to develop and demonstrate low level RF system control algorithms or control hardware that provide a robust and adaptive environment suitable for any accelerator RF system. Of special interest are approaches that address the particular challenges of superconducting RF systems, but room temperature systems are of interest as well.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

d. Particle Beam Sources and Techniques

Grant applications are sought to develop (1) particle beam ion sources with improved intensity, emittance, and range of species; (2) methods and/or devices for reducing the emittance of relativistic ion beams – such as coherent electron cooling, and electron or optical-stochastic cooling; (3) methods and devices to increase the charge state of ion beams (e.g., by the use of special electron-cyclotron-resonance ionizers, electron-beam ionizers, or special stripping techniques); (4) techniques for *in situ* beam pipe surface coating to reduce the ohmic resistance and/or secondary electron yield; (5) high brightness electron beam sources utilizing continuous wave (cw) superconducting RF cavities with integral photocathodes operating at high acceleration gradients; (6) techniques and devices for measuring RF resistivity of cryogenically cooled coated tubes..

Accelerator techniques for an energy recovery linac (ERL) and a circulator ring (CR) based electron cooling facility for cooling medium to high energy bunched proton or ion beams are of high interest for next generation colliders for nuclear physics experiments. Therefore, grant applications are sought for (1) design, modeling and proto-type development for a magnetized electron source/injector with a high bunch charge (up to 2 nC) and high average current (above 100 mA) and high bunch repetition rate (up to 75 MHz); (2) designs, modeling, and hardware development for a fast beam-switching kicker with 0.5 ns duration and 10 to 20 kW power in the range of 5-50 MHz repetition rate; and (3) optics designs and tracking simulations of beam systems for ERLs and CRs, with energy range from 5 to 130 MeV, and transporting and matching magnetized beams with superconducting solenoids in cooling channels. Examples of candidate technologies include photo- or thermionic-cathode electron guns with a DC or RF accelerating structure; SRF deflecting cavity, pulse compression techniques, and beam-based kicker. Grant applications also are sought to develop computer software for the design, modeling and simulating any of these devices and beam transport systems.

A full utilization of the discovery potential of a next-generation electron-ion collider requires a full-acceptance detection system that can provide detection of reaction products scattered at small angles with respect to the incident beams over a wide momentum range. Grant applications are sought for design, modeling and hardware development of the special magnets for such a detection system. Magnets of interest include (1) radiation-resistant superconducting (≥ 2 T pole-tip field) septum dipole with electronically adjustable field orientation (+/- 100 mrad); (2) radiation-resistant high-field (≥ 9 T pole-tip field), large-aperture (≥ 20 cm radius) quadrupole; (3) radiation-resistant superconducting (≥ 6 T pole-tip field) large-aperture (≥ 20 cm radius) small-yoke-thickness (≤ 14 cm OD-ID) quadrupole; (4) radiation-resistant super-conducting (≥ 6 T pole-tip field, ~3 cm IR) combined-function magnet with quadrupole and independently adjustable horizontal and vertical dipole field components.

Lastly, grant applications are sought to develop software that adds significantly to the state-of-the-art in the simulation of beam physics. Areas of interest include (1) electron cooling, (2) intra-beam and interbeam scattering, (3) spin dynamics, (4) polarized beam generation including modeling of cathode geometries for high current polarized electron sources, (5) generating and transporting polarized electron beam, (6)beam dynamics, transport and instabilities; and (7) electron or plasma discharge in vacuum under the influence of charged beams. The software should use modern best practices for software design, should run on multiple platforms, and should run in both serial and parallel configurations. Grant applications also are sought to develop graphical user interfaces for problem definition and setup.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

e. Polarized Beam Sources and Polarimeters

With respect to polarizing sources, grant applications are sought to develop (1) polarized hydrogen and deuterium (H-/D-) ^{3}He sources with polarization above 90%; (2) cw polarized electron sources delivering beams of ~10 mA, with longitudinal polarization greater than 80%; (3) ~28 MHz cw polarized sources delivering beams of ~500 mA, with polarization greater than 80%; and (4) devices, systems, and sub-systems for producing high current (>200µA), variable-helicity beams of electrons with polarizations greater than 80%, and which have very small helicity-correlated changes in beam intensity, position, angle, and emittance.

Grant applications also are sought to develop (1) methods to improve high voltage stand-off and reduce field emission from high voltage electrodes, compatible with ultra-high-vacuum environments; (2) wavelength-tunable (700 to 850 nm) mode-locked lasers, with pulse repetition rate between 0.5 and 3 GHz and average output power >10 W; (3) a high-average-power (~100 W), green laser light source, with a RF-pulse repetition rate in the range of 0.5 to 3 GHz, for synchronous photoinjection of GaAs photoemission guns; and (4) a cost-effective means to obtain and measure vacuum below 10^{-12} Torre.

Grant applications also are sought for (1) advanced software and hardware to facilitate the manipulation and optimized control of the spin of polarized beams; (2) advanced beam diagnostic concepts, including new beam polarimeters and polarimeter targets and fast reversal of the spin of stored, polarized beams; (3) absolute polarimeters for spin polarized ^{3}He beams with energies up to 160 GeV/nucleon (4) novel concepts for producing polarizing particles of interest to nuclear physics research, including electrons, positrons, protons, deuterons, and ^{3}He; and (5) credible sophisticated computer software for tracking the spin of polarized particles in storage rings and colliders.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

f. Rare Isotope Beam Production Technology

Grant applications are sought to develop (1) ion sources for radioactive beams, (2) techniques for secondary radioactive beam collection, charge equilibration, and cooling; (3) technology for stopping energetic radioactive ions in helium gas and extracting them efficiently as high-quality low-energy ion beams; and (4) advanced parallel-computing simulation techniques for the optimization of both normal- and super-conducting accelerating structures for the future rare isotope facility.

Grant applications also are sought to develop radiofrequency devices for ion transport along surfaces. The transport of ions along walls of gas-filled vacuum chambers by means of a series of electrodes, to which radiofrequency voltages are applied, has gained significant importance, not only in nuclear physics for the stopping and thermalization of rare isotope beams but also in ion chemistry. Ultra-high vacuum compatible large-size printed circuit boards, or similar approaches, together with tailored RF circuitry, are considered most promising for providing low-maintenance reliable performance.

Grant applications also are sought to develop fast-release solid catcher materials. The stopping of high-energy (>MeV/u) heavy-ion reaction products in solid catchers is interesting for realizing high-intensity low-energy beams of certain elements and for the parasitic use of rare isotopes produced by projectile fragmentation.

Grant applications also are sought to develop techniques for efficient rare isotope extraction from water. Water-filled beam dumps or reaction product catchers, considered in the context of high-power rare isotope beam production, could provide a source for the harvesting heavy-ion reaction products stopped in the water.

Grant applications also are sought to develop techniques for the charge breeding of rare isotopes in Electron Beam Ion Sources or Traps (EBIS/T) prior to reacceleration. High breeding efficiencies in single charge states and short breeding times are required. In order to be able to optimize these values, simulations tools will be needed that realistically describe electron-ion interaction and ion cooling mechanisms and use accurate electric and magnetic field models. Also high performance electron guns with well-behaved beam compression into the magnetic field of the EBIS/T will be required. The electron guns will have to be optimized for high perveance and multi-Ampere electron current output in order to optimize ion capacity, ion beam acceptance and breeding times.

Grant applications are sought for development of radiation tolerant or radiation resistant multipole inserts in large-aperture superconducting quadrupoles used in fragment separators.

Sextupole and octupole coils with multipole fields of up to 0.4 T are required to operate in a 2-T quadrupole field. Minimum cold mass and all-inorganic constructions are requirements that may be partially met with High Temperature Superconducting (HTS) coils or conventional superconductors with non-standard insulation.

Grant applications are sought for development of radiation resistant thermal isolation systems for superconducting magnets. Support links connecting room temperature with the liquid helium structure have to support large magnetic forces, but at the same time have low thermal conductivities to limit heat input. Typically, all-metal links have ten to twenty times higher heat leaks than composite structures. Composites are, however, hundreds or thousands of times more sensitive to radiation damage than metals and so cannot be used in the high-radiation environment surrounding the production target or beam dump areas of high-power heavy ion accelerators. Given the high cost of cryogenic refrigeration, development of radiation resistant, high-performance support links is very desirable. Interested parties could contact Dr. Al Zeller, FRIB/MSU (zeller@frib.msu.edu).

Lastly, grant applications are sought to develop advanced and innovative approaches to the construction of large aperture superconducting and/or room temperature magnets, for use in fragment separators and magnetic spectrographs at rare isotope beam accelerator facilities. Grant applications also are sought for special designs that are applicable for use in high radiation areas.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

g. Accelerator Control and Diagnostics

Grant applications are sought to develop (1) advanced beam diagnostics concepts and devices that provide high speed computer-compatible measurement and monitoring of particle beam intensity, position, emittance, polarization, luminosity, momentum profile, time of arrival, and energy (including such advanced methods as neural networks or expert systems, and techniques that are nondestructive to the beams being monitored); (2) beam diagnostic devices that have increased sensitivities through the use of superconducting components (for example, filters based on high T_c superconducting technology or Superconducting Quantum Interference Devices); (3) measurement devices/systems for cw beam currents in the range 0.1 to 100 μA, with very high precision ($<10^{-4}$) and short integration times; (4) beam diagnostics for ion beams with intensities less than 10^7 nuclei/second; (5) non-destructive beam diagnostics for stored proton/ion beams, such as at the RHIC, and/or for 100 mA class electron beams; (6) devices/systems that measure the emittance of intense (>100kW) cw ion beams, such as those expected at a future rare isotope beam facility; (7) beam halo monitor systems for ion beams; and (8) instrumentation for electron cloud effect diagnostics and suppression.

Grant applications are sought for the development of triggerable, high speed optical and/or IR cameras, with associated MByte-scale digital frame grabbers for investigating time dependent phenomena in accelerator beams. Image capture equipment needs to operate in a high-radiation environment and have a frame capture rate of up to 1 MHz. Imaging system needs to have memory capacity at the level of 1000 frames (10 GByte or higher total memory capacity). The cameras will be used for high-speed analysis of optical transition or optical diffraction radiation data.

Grant applications also are sought for "intelligent" software and hardware to facilitate the improved control and optimization of charged particle accelerators and associated components for nuclear physics research. Areas of interest include the development of (1) generic solutions to problems with respect to the initial choice of operation parameters and the optimization of selected beam parameters with automatic tuning; (2) systems for predicting insipient failure of accelerator components, through the monitoring/cataloging/scanning of real-time or logged signals; and (3) devices that can perform direct 12-14 bit digitization of signals at 0.5-2 GHz and that have bandwidths of 100+ kHz.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

h. Novel acceleration methods for ions

Grant applications are sought to develop laser radiation pressure driven proton and ion beams sources and accelerators of high-brightness and good repetition rate.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

i. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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42. NUCLEAR PHYSICS INSTRUMENTATION, DETECTION SYSTEMS AND TECHNIQUES (PHASE I, $150,000/PHASE II, $1,000,000)

The Office of Nuclear Physics is interested in supporting projects that may lead to advances in detection systems, instrumentation, and techniques for nuclear physics experiments. Opportunities exist for developing equipment beyond the present state-of-the-art at universities and national user facilities, including the Argonne Tandem Linac System (ATLAS) at Argonne National Laboratory. In addition, a new suite of next-generation detectors will be needed for the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) Upgrade of at the Thomas Jefferson National Accelerator Facility (TJNAF), a future facility for rare isotope beams (FRIB) at Michigan State University, detector and luminosity upgrades at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Lab, and a possible future electron-ion collider. Also of interest is technology related to future experiments in fundamental symmetries, such as neutrinoless double-beta decay experiments and the measurement of the electric dipole moment of the neutron, where extremely low background and low count rate particle detections are essential. This topic seeks state-of-the-art targets for applications ranging from spin polarized and unpolarized nuclear physics experiments to stripper and production targets required at high-power, advanced, rare isotope beam facilities. Lastly, this topic seeks new and improved techniques and instrumentation to cope with the anticipated high radiation environment for FRIB. All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Advances in Detector and Spectrometer Technology

Nuclear physics research has a need for devices to detect, analyze, and track charged particles, and neutral particles such as neutrons, neutrinos, photons, and single atoms. Grant applications are sought to develop (1) photosensitive devices such as avalanche photodiodes, hybrid photomultiplier devices, single and multiple anode photomultiplier tubes, silicon-based photomultipliers, high-intensity (~10^{20} γ/s) gamma-ray current-readout detectors (e.g., Compton Diodes), photodiodes for operation at liquid helium temperatures with a signal-to-noise ratio comparable to a photomultiplier tube, photomultiplier tubes designed to work in a liquid helium environment, and other novel photon detectors; (2) detectors utilizing photocathodes for Cherenkov, visible and ultra-violet (UV) light detection, and new types of large-area photo-emissive materials such as solid, liquid, or gas photocathodes; (3) liquid argon and xenon ionization chambers and other cryogenic detectors; (4) single-atom detectors using laser techniques and electromagnetic traps; (5) particle polarization detectors; (6) electromagnetic and hadronic calorimeters, including high energy neutron detectors; and (7) systems for detecting the magnetization of polarized nuclei in a magnetic field (e.g., Superconducting Quantum Interference Devices (SQUIDs) or cells with paramagnetic atoms that employ large pickup loops to surround the sample).

With respect to particle identification detectors, grant applications are sought for the development of: (1) cost-effective, large-area, high-quality Cherenkov materials; (2) cost-effective, position sensitive, large-sized photon detection devices for Cherenkov counters; (3) high resolution time-of-flight detectors, such as Microchannel Plates (MCPs), Multigap Resistive Plate Chambers (MRPCs), and Geiger Avalanche Photodiodes (GAPDs), with the goal of attaining a time resolution of < 10 ps over large areas, typically 10x10 mm2; (4) affordable methods for the production of large volumes of xenon and krypton gas (which would contribute to the development of transition radiation detectors and also would have many applications in X-ray detectors); (5) very high resolution (few tenth of micrometers spatial resolution and tenth of eV energy resolution) particle detectors or bolometers (including the required thermistors) based on semiconductor materials and cryogenic, and radio-frequency techniques. Of particular interest are detector technologies capable of measuring energies of alpha particles and protons with less than 5 keV resolution, thereby allowing spectroscopy experiments using light charged particles to be performed in the same way as spectroscopy experiments using gammas.

In addition, grant applications are sought to develop devices designed to perform precision calibration of the detectors listed above. Such devices include novel, controllable calibration sources for electrons, gammas, alphas, and neutrons; pulsed calibration sources for neutrons, gammas, and electrons; precision charged particle beams; and pulsed UV optical sources.

Grant applications also are sought for the development of tilted solenoids for spectrometers. In high field devices, iron has the undesirable property that saturation effects change the field characteristics as a function of induction. However, without iron, the stray fields are very often unacceptably high. For superconducting solenoids this problem can be solved by active shielding. The development of magnet systems with tilted crossed solenoid windings and active shielding could provide a solution for a broad variety of ironless superconducting dipoles, which, for example, could be used in high-acceptance spectrometers.

Finally, grant applications are sought for innovative designs of high-resolution particle separators and spectrometers for research programs associated with next-generation rare isotope beam and intense stable beam facilities. Developments of interest include both air-core and iron dominated superconducting magnets that use either conventional low-temperature conductor or new medium to high temperature conductors. Such magnets are needed for magnetic spectrometers, fragment separators, and beam transport systems. Innovative designs such as elliptical aperture multipoles and other combined function magnets are of interest. Also, there is a need for cryogenics systems in the mid-capacity range for use with superconducting spectrometers for nuclear physics. The emphasis is on cryogenic systems with higher capacity, improved efficiency, and reduced maintenance requirements at both low (4-20 K) and intermediate temperatures (50-77 K) relative to the present generation of cryocoolers.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

b. Position Sensitive Charge Particle and Gamma Ray Tracking Devices

Nuclear physics research has a need for devices to track charged particles, and neutral particles such as neutrons, neutrinos, photons, and single atoms. Grant applications are sought to develop advancements in the technology of solid-state tracking devices such as highly-segmented coaxial and planar germanium detectors; silicon drift, strip, and pixel detectors; and silicon 3D devices. With respect to solid state tracking devices, approaches of interest include (1) manufacturing techniques, including interconnection technologies for high granularity, high resolution, light-weight, and radiation-hard solid state devices; (2) highly arrayed solid state detectors for neutron detection, with integrated electronics to read-out pulse height; (3) thicker (more than 1.5 mm) segmented silicon charged-particle and x-ray detectors and associated high density, high resolution electronics; (4) cost-effective production of n-type and p-type silicon drift chambers with active areas greater than 16 cm^2; (5) novel, low-noise cooling devices for efficiently operating these silicon drift chambers; (6) and other solid state detectors described in (2)-(4); and (7) techniques for substantial cost reduction of large-mass Ge detectors.

Grant applications also are sought to develop micro-channel plates; and gas-filled tracking detectors such as proportional, drift, streamer, microstrip, Gas Electron Multipliers (GEMs), Micromegas and other types of micropattern detectors, straw drift tube detectors.

Grant applications also are sought to develop position-sensitive charged particle and photon tracking devices, as well as associated technology for these devices, including (1) position-sensitive, high-resolution germanium detectors capable of determining the position (to within a few millimeters utilizing pulse shape analysis) and energy of individual interactions of gamma-rays (with energies up to several MeV), hence allowing for the reconstruction of the energy and path of individual gamma-rays using tracking techniques; (2) hardware and software needed for digital signal processing and gamma-ray tracking – of particular interest is the development of efficient and fast algorithms for signal decomposition and improved tracking programs; High speed triggers using FPGA's capable of decision making in less than 1 us; (3) alternative materials, with comparable resolution to germanium, but with significantly higher efficiency and relatively higher temperature operation (in order to overcome the costly and bulky requirement to cool germanium detectors to liquid nitrogen temperatures); (4) improvements and new developments in micropattern detectors – this would specifically include commercial and cost effective production of GEM foils and other types of micropattern structures, such as fine meshes used in Micromegas, as well as novel approaches that could provide high-resolution multidimensional readout; (5) advances in more conventional charged-particle tracking detector systems, such as drift chambers, pad chambers, time expansion chambers, and time projection chambers (areas of interest include improved gases or gas additives that resist aging, improve detector resolution, decrease flammability, and offer larger/more uniform drift velocity); (6) high-resolution, gas-filled, time-projection chambers employing CCD cameras to perform an optical readout; (7) gamma-ray detectors capable of making accurate measurements of high intensities ($>10^{11}$ /s) with a precision of 1-2 %, as well as economical gamma-ray beam-profile monitors; (8) for rare isotope beams, next-generation, high-spatial-resolution focal plane detectors for magnetic spectrographs and recoil separators, for use with heavy ions in the energy range from less than 1 MeV/u to over 100 MeV/u; (9) a bolometer with high-Z material (e.g., W, Ta, Pb) for gamma ray detection with segmentation, capable of handling 100 -1000 gamma rays per second; (10) detectors made of more conventional materials (silicon or scintillator), capable of reconstructing multiple-Compton gamma-ray scattering with mm resolution; and (11) advances in CCD technology, particularly in areas of fast parallel, low-power readout, and cross-talk control. In the context of (4) we are developing large area imaging devices using the Micromegas technology associated with the read-out of a high number of channels (typically ~10,000) we will need to develop PCB boards that have an extremely good surface finish (in the sub-micron domain), in order to get minimize gain fluctuations and sparking.

Finally, grant applications are sought to develop high-rate, position sensitive particle tracking detectors and timing detectors for high-energy heavy-ions, (for example diamond detectors). Future rare isotope beam facilities like FRIB will provide beams with unprecedented intensity, creating a challenge for single particle tracking and beam profile measurements, and time-of-flight measurements. The development of position sensitive fast particle detectors for particle tracking/timing and with a rate capability of up to 10^7 particles per second would be desirable. Ideally these detectors would provide both position (resolution better than 10 mm) and timing measurements (resolution better than 0.25 ns) maintain performance over extended periods of operation at particle rates of 10^7/s, and have minimal thickness variations (< 0.1 – 0.5 mg/cm^2, depending on the type of beam) over the active area.

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c. Technology for Rare Particle Detection

Grant applications are sought for particle detectors and techniques that are capable of measuring very weak, very rare event signals in the presence of significant backgrounds. Such detector technologies and analysis techniques are required in searches for rare events (such as double beta decay) and for applications in extending our knowledge of new nuclear isotopes produced at radioactive beam facilities. Rare decay and rare phenomenon detectors require large quantities of very clean materials, such as clean shielding materials and clean target materials. For example, neutrino detectors need very large quantities of ultra-clean water.

Grant applications are sought to develop (1) ultra-low background techniques of contacting, supporting, cooling, cabling, and connecting high-density arrays of detectors – ultrapure materials must be used in order to keep the generated background rates as low as possible (goal is 1 micro-Becquerel per kg); (2) advanced detector cooling techniques and associated infrastructure components (high-density signal cabling, signal and high voltage interconnects, vacuum feedthroughs, front-end amplifier FET assemblies), in order to assure ultra-low levels of radioactive contaminants; (3) measurement methods for the contaminant level of the ultra-clean materials; (4) novel methods capable of distinguishing between gammas and charged particles; and (5) methods by which the backgrounds to rare searches, such as those induced by cosmogenic neutrons, can be tagged, reduced, or removed entirely.

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d. Large Band Gap Semiconductors, New Bright Scintillators, Calorimeters, and Optical Elements

Nuclear physics research has a need for developing cost effective new detector and scintillation material with high light outputs and shorter decay times compared to NaI and CsI, for manufacturing practical devices to detect charge particles and gamma rays. Therefore, grant applications are sought to develop new materials or advancements for photon detection, including (1) large band gap semiconductors such as CdZnTe, HgI_2, AlSb, etc.; (2) bright, fast scintillator materials (such as LSO, LYSO, $LaHA_3$:Ce, where HA=Halide and other related compounds), and scintillators with pulse-shape discrimination (PSD) (n/gamma and charged particle); (3) selenium based detectors (perhaps using GaSe, CdSe or ZnSe); (4) plastic scintillators, fibers, and wavelength shifters; (5) cryogenic scintillation detectors (LXe); (6) Cherenkov radiator materials, such as Aerogel, with indices of refraction up to 1.10 or greater, and with good optical transparency; and (7) new and innovative calorimeter concepts, including new materials, higher packing densities, or innovative fiber and absorber packing schemes to achieve a small Moliere radius and short radiation length.

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e. Specialized Targets for Nuclear Physics Research

Grant applications are sought to develop specialized targets for the nuclear physics program, including (1) polarized (with nuclear spins aligned) high-density gas or solid targets; (2) frozen-spin active (scintillating) targets; (3) windowless gas targets and supersonic jet targets for use with very low energy charged particle beams; (4) liquid, gaseous, and solid targets capable of high power dissipation when high intensity, low-emittance charged-particle beams are used; and (7) very thin windows (<100 micrograms/cm^2 and/or 50% transmission at 500 eV X-ray energy) for gaseous detectors, in order to allow the measurement of low energy ions.

Grant applications also are sought to develop the technologies and sub-systems for the targets required at high-power, rare isotope beam facilities that use heavy ion drivers for rare isotope production. Targets for heavy ion fragmentation and in-flight separation are required that are made of low-Z materials and that can withstand very high power densities and are tolerant to radiation.

Also required are targets that would be used with high-power light ion beams for the production of exotic isotopes by spallation reactions.

Finally, grant applications are sought to develop techniques for (1) the production of ultra-thin films needed for targets, strippers, and detector windows – regarding next generation rare isotope beam facility, there is a need for stripper foils or films (in the thickness range from a few micrograms per cm^2 to over 10 milligrams per cm^2) for use in the driver linac, with very high power densities; and (2) the preparation of targets of radioisotopes, with half-lives in the range of hours, to be used off-line in both neutron-induced and charged-particle-induced experiments.

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f. Technology for High Radiation environment of Rare Isotope Beam Facility

The establishment of next generation rare isotope beam facilities requires new and improved techniques, instrumentations, and strategies to deal with the anticipated high radiation environment in the production, stripping, and transport of ion beams. Therefore grant applications are sought to develop:

(1) Rotating vacuum seals for application in high-radiation environment: Vacuum rotary feed-throughs for high rotational speeds, which have a long lifetime under a high-radiation environment, are highly desirable for the realization of rotating targets and beam dumps for rare isotope beam production and beam strippers in high-power heavy-ion accelerators.

(2) Radiation resistant multiple-use vacuum seals: Elastomer-based multi-use vacuum seals have a limited lifetime due to radiation damage in the high-radiation environment found in the target facility of FRIB and other high-power target facilities. Alternative solutions that provide extended lifetimes and are suitable for remote-handling applications are needed.

(3) Radiation resistant magnetic field probes based on new technologies: An issue in all high-power target facilities and accelerators is the limited lifetime of conventional nuclear magnetic resonance probes in high-radiation environments. The development of radiation-resistant magnetic field probes for 0.2-5 Tesla and a precision of $dB/B<1E-4$ would be highly desirable.

(4) Techniques to study radiation transport in beam production systems: The use of energetic and high-power heavy ion beams at future research facilities will create significant radiation fields. Radiation transport studies are needed to design and operate facilities efficiently and safely. Advances of radiation transport codes for inclusion of charge state distributions of initial and produced ions including distribution changes when passing through material and magnetic fields, for efficient thick-shield, heat deposition and gas production studies, for implementation of new models of heavy ion radiation damage, and for validation against experimental data are desired.

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g. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

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h. Technology Transfer Opportunity:_Cross-strip CdZnTe detector with shared electrodes for medical imaging applications

Applicants to Technology Transfer Opportunities should review the section describing Technology Transfer Opportunities on page 1 of this document prior to submitting applications.

This technology is based on the high energy resolution, room-temperature semiconducting radiation detector material - Cadmium Zinc Telluride (CZT). In particular, this technology uses multi-layer radiation detectors based on a cross-strip detector design. The thin layers of individual detectors provide better timing resolution to resolve the single radiation event, which is required in the positron emission tomography (PET) imaging. In addition, the detector module allows the adjacent layers share the electrodes, thus reducing the total number of readout channels by 50%, simplifying the detector system design and reducing losses through dissipation of power and heat. Potentially, commercialization of this technology will generate a new PET imaging system that has better performance than those commercially available and based on scintillator detectors. Researchers at BNL have made a few prototype modules and have done some preliminary tests. Timing resolution of 2 ns has been achieved. Applications are sought to develop the readout electronics, full-size detector module, and image acquisition system. In addition to PET imaging, the detector module can be configured for single photon emission computerized tomography (SPECT) imaging as well. Applications for this Technology Transfer opportunity are sought to optimize prototype design and develop an integrated system demonstrating the feasibility for use of this detector in PET and/or SPECT.

Brookhaven National Laboratory information:
Contact: Steven Wood, (swood@bnl.gov).
Website: http://www.bnl.gov/techtransfer/

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

i. Technology Transfer Opportunity: Boron-Based Nano-proportional Counting System for Neutron Detection

Applicants to Technology Transfer Opportunities should review the section describing Technology Transfer Opportunities on page 1 of this document prior to submitting applications.

This invention relates to a redesign of the anodes in gas proportional counting systems for neutron detection. The new design is comprised of conductive boron doped silica and nanowires results in higher detection efficiencies. The nano-sized anodes when present within an anode array can allow for: significantly higher detection efficiencies due to a higher electric field, system miniaturization, and have low power requirements. This system also eliminates the need for Helium-3 which is in short supply. Applications for this Technology Transfer opportunity are sought to optimize prototype design and develop an integrated system demonstrating the feasibility for use of this detector.

Savannah River National Laboratory information:
Contact: Eric Frickey (eric.frickey@srnl.doe.gov).
Website: http://srnl.doe.gov/tech_transfer/tech_transfer.htm

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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43. NUCLEAR PHYSICS ISOTOPE SCIENCE AND TECHNOLOGY (PHASE I, $150,000/PHASE II, $1,000,000)

Stable and radioactive isotopes are critical to serve the broad needs of modern society and are critical to scientific research in chemistry, physics, energy, environment, material sciences and for a variety of applications in industry and national security. A primary goal of the Department of Energy's Isotope Development and Production for Research and Applications Program (Isotope Program) within the Office of Nuclear Physics (NP) is to support research and development of methods and technologies in support of the production of isotopes used for research and applications that fall within the Isotope Program portfolio. The Isotope Program produces isotopes that are in short supply in the U.S. and of which there exists no or insufficient domestic commercial production capability; some exceptions include special nuclear materials and molybdenum-99, for which the National Nuclear Security

Administration has responsibility. The benefit of a viable research and development program includes an increased portfolio of isotope products, more cost-effective and efficient production/processing technologies, a more reliable supply of isotopes year-round and the reduced dependence on foreign supplies. Additional guidance for research isotope priorities is provided in the Nuclear Science Advisory Committee Isotopes (NSACI) report available at (http://science.energy.gov/np/nsac/) which will serve to guide production plans of the Isotope Program.

All entities submitting proposals to SBIR/STTR Isotope Science and Technology topic must recognize the moral and legal obligation to comply with export controls and policies that relate to the transfer of knowledge that has relevance to the production of special nuclear materials (SNM). Please see 10 C.F.R. PART 810—ASSISTANCE TO FOREIGN ATOMIC ENERGY ACTIVITIES for further information.

a. Novel or improved production techniques for radioisotopes or stable isotopes
Research should focus on the development of advanced, cost-effective, and efficient technologies for producing isotopes that are in short supply and that are needed by the research and applied communities. This includes advanced accelerator and beam transport technologies such as the application of high-gradient accelerating structures, high-energy/high-current cyclotrons, or other topologies that could lead to compact sources as well as novel beam-delivery/rastering and target approaches needed to optimize isotope production . The successful research grants should lead to breakthroughs that will facilitate an increased supply of isotopes that complement the existing portfolio of isotopes produced and distributed by the Isotope Program. Research that will advance the state of the art in high current, high power density accelerator targets for radioisotope production is also of interest.

The development of innovative technologies that will lead to new or advanced methods for production of radioisotopes that align with the priorities of the NSACI report is encouraged. Examples of such high priority isotopes include the alpha emitters ^{225}Ac and ^{211}At that continue to gain importance in targeted alpha therapy applications as well as radioisotope pairs with simultaneous diagnostic and therapeutic capabilities. The new technologies must have the potential to ensure a cost-effective and stable supply of such isotopes.

Grant applications are also sought for new technologies to produce large quantities of separated isotopes – such as kg quantities of germanium-76 (^{76}Ge), selenum-82 (^{82}Se), tellurium-130 (^{130}Te), xenon-136 (^{136}Xe) and transuranium elements such as californium-249 (^{249}Cf), berkelium-249 (^{249}Bk), einsteinium-253 (^{253}Es), and fermium-257 (^{257}Fm) – and other materials that are needed for rare particle and rare decay experiments and heavy element creation in nuclear physics research. Further guidance for research isotope priorities is provided in the Nuclear Science Advisory Committee Isotopes (NSACI) report available at (http://science.energy.gov/np/nsac/).

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b. Improved radiochemical separation methods for preparing high-purity radioisotopes
Separation of isotopes from contaminants and bulk material and the purification of the isotope to customer specifications is a critical process in the production cycle of an isotope. Traditional strategies and techniques rely on old technologies and still require an extensive workforce to operate specialized equipment, such as manipulators for remote handling in hot cell environments. Conventional separation methods may include liquid-liquid extraction, column extraction, distillation or precipitation and are used to separate radioactive and non-radioactive trace metals from target materials, lanthanides, alkaline and alkaline earth metals, halogens, or organic materials. High-purity isotope products are essential for high-yield protein radiolabeling, for radiopharmaceutical use, or to replace materials with undesirable radioactive emissions. Improved radiochemical separation methods can be achieved and costs of isotope production can be reduced by a) improvements in separations chemistry methods, and b) implementing automated systems and robotics. Of particular interest are developments that automate routine separation processes in order to reduce operator labor hours and worker radiation dose, including semi-automation modules for separations or automated, micro-processor controlled systems for elution, radiolabeling, purification, and dispensing. Such automated assemblies should be easily adaptable to different processes and hot cell use at multiple sites, including the DOE laboratories currently producing radioisotopes.

Applications are sought for innovative developments and advances in separation technologies to reduce processing time, to improve separations efficiencies, to automate separation systems, to minimize waste streams, and to develop advanced materials for high-purity radiochemical separations. In particular, the Department seeks improvements in (1) lanthanide and actinide separations, (2) in the development of higher binding capacity resins and adsorbents for radioisotope separations to decrease void volume and to increase activity concentrations, (3) the scale-up of separation methods demonstrated on a small scale to large-volume production level, and (4) new resin and adsorbent materials with increased resistance to radiation, and with greater specificity for the various elements.

The following are some new strategies for radioisotope processing and separation technologies. In lanthanide radiochemistry, improvements are sought to a) prepare high-purity samarium-153 by removing contaminant promethium and europium; or b) to prepare high-purity gadolinium-148 and gadolinium-153 by ultra-pure separation from europium, samarium, and promethium contaminants. Sn-117m has gotten a lot of interest in the last few years. It has favorable nuclear properties for both imaging and therapy (Srivastava, Ref # 3). However, sufficient amounts of the no-carrier-added (NCA) isotope are currently not available. Supply of multi-curie quantities of NCA Sn-117m would be required t to continue ongoing clinical trials or for initiating new ones, and eventually for routine use in patients if some of these trials are successful as expected. Re-186 has favorable nuclear properties for therapy and is chemically similar to Tc-99m which is widely used for diagnostic imaging. Therefore, Re-186 could be used as a therapeutic matched pair for currently available diagnostic imaging agents. However, high specific activity Re-186 is not available either. So, alternative methods of production or mass separation to remove stable Re isotopes, which can provide commercial quantities of high specific activity Re-186 is highly desirable. In actinide radiochemistry, innovative methods are sought a) to improve radiochemical separations of or lower-cost approaches for producing high-purity actinium-225 and actinium-227 from contaminant metals, including thorium, radium, lead, and/or bismuth; or b) to improve ion-exchange column materials needed for generating lead-212 from radium-224, and bismuth-213 from actinium-225 or radium-225. The new technologies must be applicable in extreme radiation fields that are characteristic of chemical processing involving high levels of alpha-and/or beta-/gamma-emitting radionuclides.

The following are some new strategies for radioisotope processing and separation technologies. In lanthanide radiochemistry, improvements are sought to a) prepare high-purity samarium-153 by removing contaminant promethium and europium; or b) to prepare high-purity gadolinium-148 and gadolinium-153 by ultra-pure separation from europium, samarium, and promethium contaminants. Sn-117m has gotten a lot of interest in the last few years. It has favorable nuclear properties for both imaging and therapy. However commercial quantities of the isotope at high specific activity is not available. Supply of commercial quantities of high specific activity Sn-117m would be of high interest. Re-186 has excellent nuclear properties for therapy and is chemically similar to Tc-99m which is widely used for diagnostic imaging. Therefore, Re-186 could be used as a therapeutic matched pair for currently available diagnostic imaging agents. However, high specific activity Re-186 is not available. So, alternative methods of production or mass separation to remove stable Re isotopes, which can provide commercial quantities of high specific activity Re-186 is highly desirable. In actinide radiochemistry, innovative methods are sought a) to improve radiochemical separations of or lower-cost approaches for producing high-purity actinium-225 and actinium-227 from contaminant metals, including thorium, radium, lead, and/or bismuth; or b) to improve ion-exchange column materials needed for generating lead-212 from radium-224, and bismuth-213 from actinium-225 or radium-225. The new technologies must be applicable in extreme radiation fields that are characteristic of chemical processing involving high levels of alpha-and/or beta-/gamma-emitting radionuclides.

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c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Please submit all topic and subtopic questions through FedConnect at https://www.fedconnect.net/FedConnect/PublicPages/FedConnect_Ready_Set_Go.pdf.

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