U.S. DEPARTMENT OF ENERGY | Office of Science

Accelerator R&D Stewardship

Office of High Energy Physics
Office of Science
U. S. Department of Energy

Eric R. Colby

Program update given to HEPAP
September 6, 2013

Program Contacts: Eric.Colby@Science.DOE.GOV , Michael.Zisman@Science.DOE.GOV

2009: Accelerators for America's Future Workshop

U.S. DEPARTMENT OF ENERGY
Office of Science

Welcome to All!

Accelerators for America's Future Symposium and Workshop

October 26-28, 2009
Washington, D.C.

Dennis Kovar
Associate Director of the Office of Science
for High Energy Physics

U.S. DEPARTMENT OF ENERGY
Office of Science

The Charge

- **The Office of High Energy Physics asked Walter Henning and Charles Shank (co-chairs) to propose a mechanism for collecting the information and generating a report that**
  - **identify current and future needs of stakeholders**
  - **seek out crosscutting challenges—technical, cost, policy—whose solutions may have transformative impacts on opportunities for the future**
  - **identify the areas of accelerator R&D that hold greatest promise**
  - **provide guidance to bridge the gap between basic accelerator research and technology deployment**

Across all areas that utilize particle accelerators:

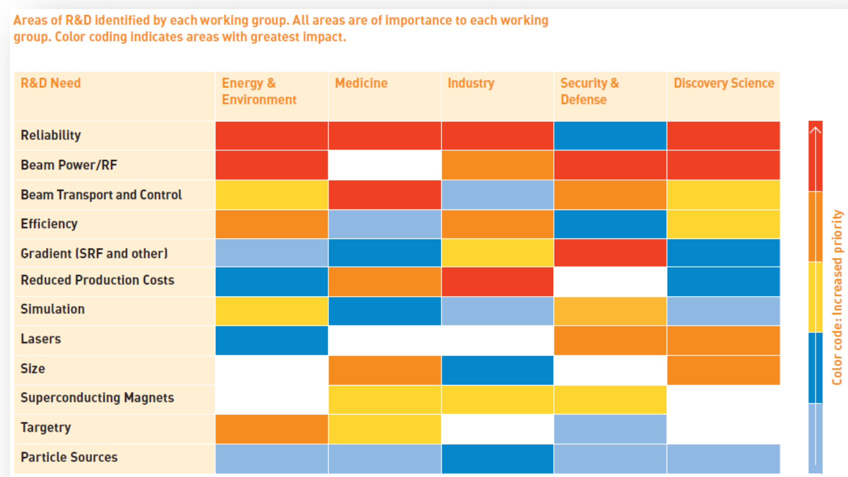
- **Discovery Science**
- **Medicine and Biology**
- **Energy and Environment**
- **National Security**
- **Industrial Applications and Production**

3

2010: Accelerators for America's Future Report

Identified the importance of accelerator technologies to sectors of the US economy

- "…advocated [for] the creation of large-scale **demonstration and development facilities to help bridge the gap** between development and deployment of accelerator technologies"
- "…called for **greatly improved** interagency, interprogram, and industry-agency **coordination**."
- "…strongly highlighted the value of expanded **training and education** of accelerator scientists and engineers…"



http://science.energy.gov/~/media/hep/pdf/accelerator-rd-stewardship/Report.pdf

2011: Senate Requests 10-Year Plan for Accelerator R&D Stewardship

Accelerators for America's Future
Workshop: October 2009
Report: June 2010

http://science.energy.gov/~/media/hep/pdf/accelerator-rd-stewardship/Report.pdf

"The Committee directs the Department to submit a …

10-year strategic plan … for accelerator technology research and development to advance accelerator applications in energy and the environment, medicine, industry, national security, and discovery science.

The strategic plan should be based on the results of the Department's 2010 workshop study, Accelerators for America's Future, …"

Senate Report 112-075, p. 93. (Ordered to be printed September 7, 2011)

Strategic Stewardship Plan

- **HEP currently leading development of a strategic plan for accelerator stewardship to respo… national needs**
  - *Accelerators for America's Future* …) identified needs
    - also identified potential re… the various constituencies
  - recent actions
    - additional … program manager (Fed position) hired
    - HEP … for stewardship planning is on-board and currently … mulate strategic plan
    - … orce set up to provide community input o… ible strategy (Holtkamp's talk)
      - DOE will carefully consider th… at its plan
- **Formal plan will be coor… HEP in close consultation with … SC program offices**
  - response … submitted at SC level
    - … vities likely require partnerships with other programs … the right people will reside in HEP

Completed

Completed

Evolution of Program …

- Accelerator Task Force has pr… on how HEP might effectively broad… …ange accelerator R&D portfolio to explic… needs beyond HEP
  - and beyon… Science (SC)

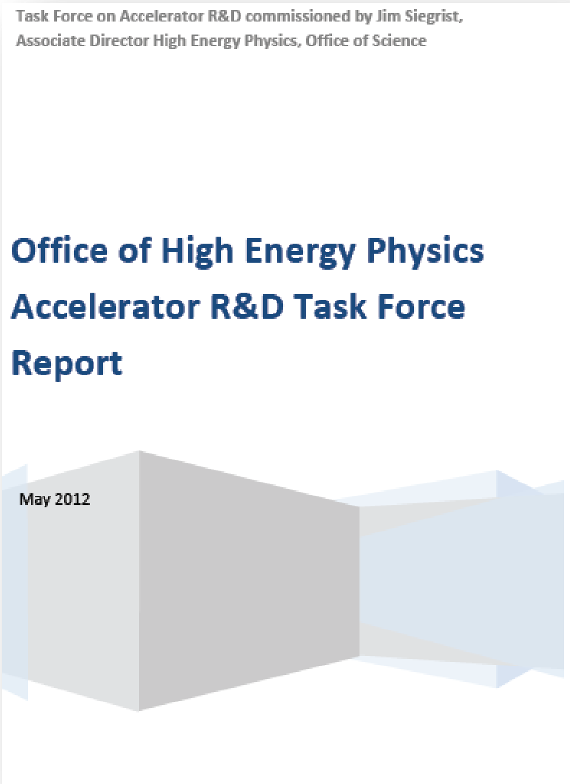
Completed

- Possible …
  - designa…e representatives from the various stakeholders to meet regularly and advise/evaluate the accelerator stewardship program
    - other SC programs
    - other agencies (NSF, NIH, ONR,…)
    - medical community
    - national security/defense community
    - industrial users
      - need both large and small companies; perspectives are different
  - targeted community workshops could be used to assess progress and solicit future needs
    - decision-making process must be seen as transparent and fair

Note: both programmatic and end-user perspectives needed

2012: Holtkamp Accelerator R&D Task Force Report

The follow-on to *Accelerators for America's Future*


Task Force on Accelerator R&D commissioned by Jim Siegrist, Associate Director High Energy Physics, Office of Science

Office of High Energy Physics Accelerator R&D Task Force Report

May 2012

Accelerator R&D Task Force Report
May 2012

http://science.energy.gov/~/media/hep/pdf/accelerator-rd-stewardship/Accelerator_Task_Force_Report.pdf

To prepare for creating an accelerator R&D stewardship strategic plan, Dr. Jim Siegrist, Associate Director of Science for High Energy Physics, in consultation with other SC Associate Directors, asked SLAC National Accelerator Laboratory to convene a community task force, chaired by Dr. Norbert Holtkamp from SLAC, to provide information that would:

1. **Identify research opportunities** that might have strong potential for broad national benefits
2. **Summarize the status** of key research and technology areas identified
3. **Identify possible impediments** (both technical and otherwise) to successful accelerator R&D stewardship activities for the broad user base envisioned

Elements of Accelerator R&D Stewardship

- **Accelerator R&D develops basic science and technologies needed to design, build, and operate state-of-the-art accelerators**
  - accelerators are essential for making new discoveries in HEP
  - **and** for serving a broader community
    - discovery science
    - industry
    - medicine
    - defense and security
    - energy and environment

  } ⇒ Stewardship

- **There is already a strong connection between current R&D thrusts and stewardship program needs**

Connecting Accelerator R&D to Science and to End-User Needs

Science Goal "Push"					Application "Pull"				
Particle Beam Quality	Photon Beam Quality	Beam Intensity	Compact or High Energy	DOE R&D Program Thrust	Industry	Medicine	Energy and Environment	Defense and Security	Discovery Science
●	●	●	●	Superconducting RF	●		●	●	●
●	●	●	●	Accelerator, Beam, Computation		●	●	●	●
●	●	●	●	Particle Sources	●		●	●	●
		●	●	RF Sources	●		●	●	●
●	●	●	●	Beam Inst. & Controls		●	●	●	●
●	●		●	NC High-gradient Accel. Structures	●	●		●	●
			●	New Accelerator Concepts		●		●	●
●	●	●	●	Superconducting Magnets	●	●			●

2012: Mission of Accelerator Stewardship

- **Mission: to support fundamental accelerator science and technology development of relevance to many fields and to disseminate accelerator knowledge and training to the broad community of accelerator users and providers.**

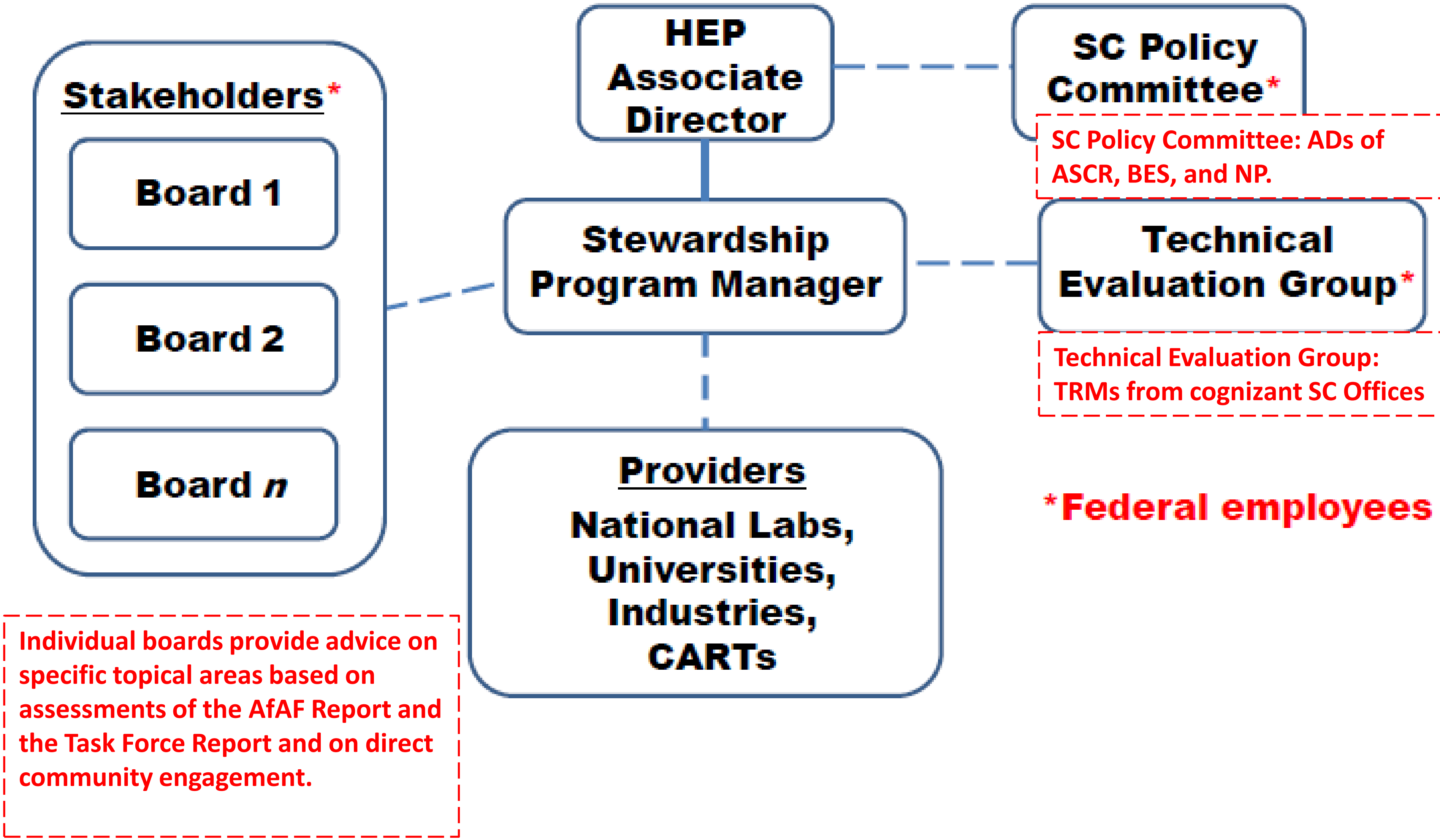
- **Carrying out this new mission (in addition to carrying out the present HEP programmatic R&D effort) will be accomplished through:**

  - **Facilitating access to** national laboratory accelerator **facilities** and infrastructure for **both industrial and other U.S. government agency users/developers** of accelerators and related technology

  - Working with accelerator user communities and industrial accelerator providers to **develop innovative solutions to critical problems**, to the benefit of **both the broader user communities and the DOE discovery science community**

  - Serving as a catalyst **to broaden and strengthen the community** that relies on accelerators and accelerator technology

Schematic of Proposed Program Organization



Programmatic Elements of Stewardship

- Immediately augment existing programs to provide opportunities for industrial and other federally funded users at DOE facilities by increasing support staff and funding for test facilities.
  - 2012: Completed survey of available national lab infrastructure and capabilities
  - 2013-14: Follow-on Meeting on Accelerator R&D Stewardship Activities at test facilities
- In the mid-term (2–5 years), identify a few topical areas with high impact for focused work. Anticipated areas are: (1) improved particle beam delivery and control for cancer therapy facilities; and (2) laser development addressing the needs of the accelerator community, i.e., high peak power, high average power, and high electrical efficiency; and (3) topics in energy and environment. Each topical area will have a stakeholder board.
- In the longer term (5–10 years), select additional topical areas for focused work. New stakeholder boards will be created as topics are identified.
- In steady state, SC/HEP goal is to support at least three topical areas at any given time.

2012: Facility Survey Results

- **In addition to broad expertise in accelerator and component design, specialized infrastructure exists**
- **Lab infrastructure falls mainly into these categories:**
  - Beam test facilities
    - electrons, neutrons, protons, light and heavy ions
    - includes particle sources, transport lines, diagnostics, laser-driven accelerators
  - Superconducting cable/strand and cavity preparation and testing facilities
    - cabling equipment, heat treatment ovens, clean rooms
    - Cavity polishing, chemistry, test dewars, etc.
  - Magnet test facilities
    - power supplies, cryogenic test stands, field mapping
  - RF test facilities
    - RF power sources, cryogenic test stands, processing capabilities, clean rooms
  - High-performance computing expertise
    - includes finite-element calculations, general accelerator design, nonlinear beam dynamics and beam transport, radiation shielding, electromagnetic modeling
  - Fabrication and materials characterization facilities
    - high accuracy NC machine tools, CMMs, e-beam welders, wire EDM, chemical cleaning, electro-polishing, SEMs, laser trackers, coating systems, remote handling,…

Initial Topical Area Workshops

- **Workshops organized to assess needs in two identified target areas**
  - Ion Beam Therapy Workshop (co-sponsored by NIH/NCI)
    - January 9-11, 2013 in Bethesda, MD
      - organized by DOE
  - Laser Technology for Accelerators Workshop
    - January 23-25, 2013 in Napa, CA
      - organized by LBNL
  - Both meetings were small and tightly focused
    - attendance by invitation only; included stakeholder agencies
      - limited number of industrial "observers" accommodated
- **Motivated by power efficiency and sustainability considerations across the SC complex, a 3rd topic area is under consideration:**
  - Energy and environment topics (e.g. energy efficient accelerator power sources)

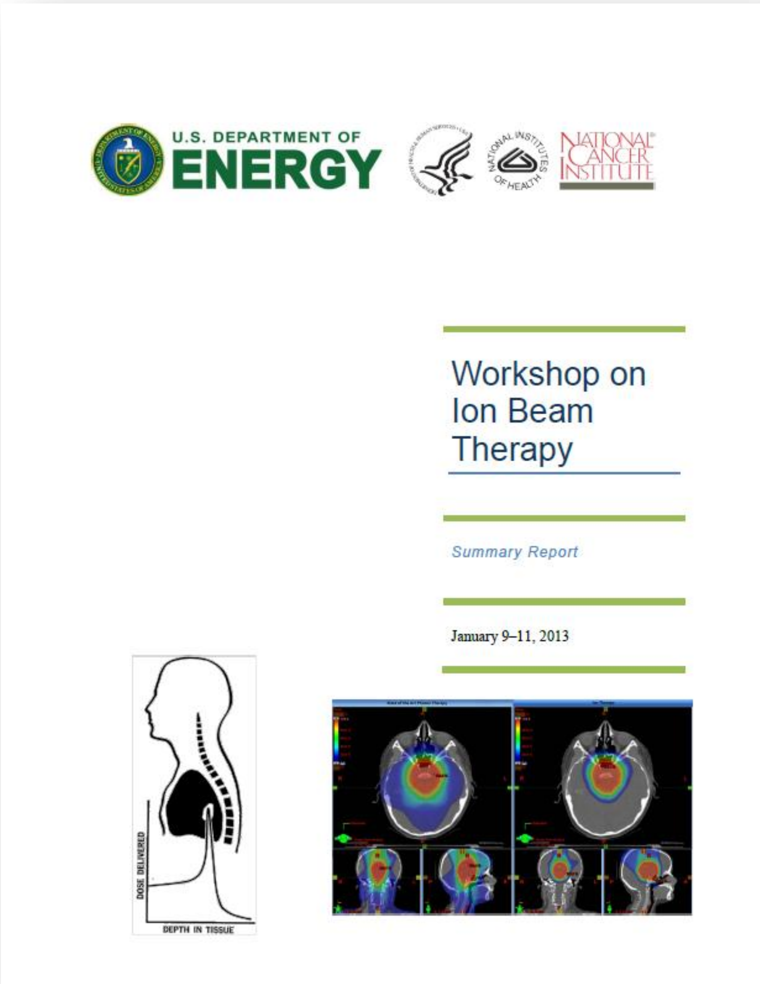
DOE/NIH Ion Beam Therapy Workshop Charge

January 9-11, 2013, Bethesda, MD

- **Prepared jointly by DOE-HEP and NIH-NCI**
  - **Identify a set of representative clinical applications** that span the range of expected future therapy requirements. These need to include capabilities for performing radiobiological experiments as well as human treatment protocols in order to explore the scientific principles underlying observed clinical results and point the way to promising protocol designs.
  - **Assess the corresponding beam requirements** (e.g., energy range and energy spread, intensity range and pulse-to-pulse intensity jitter, spot size and pulse-to-pulse position jitter, repetition rate, ion species) for future treatment facilities and compare these with today's state-of-the-art.
  - **Assess the corresponding beam delivery system requirements** (e.g., energy and position adjustability, time scale for adjustments, size of footprint, component mass, transverse and longitudinal acceptance) for future treatment facilities and compare these with today's state-of-the-art.
  - **Identify R&D activities needed to bridge the gap between current capabilities and future requirements**; include an assessment of which R&D investments are likely to have the highest near-term performance gains.

DOE/NIH Ion Beam Therapy Workshop Report

January 9-11, 2013, Bethesda, MD



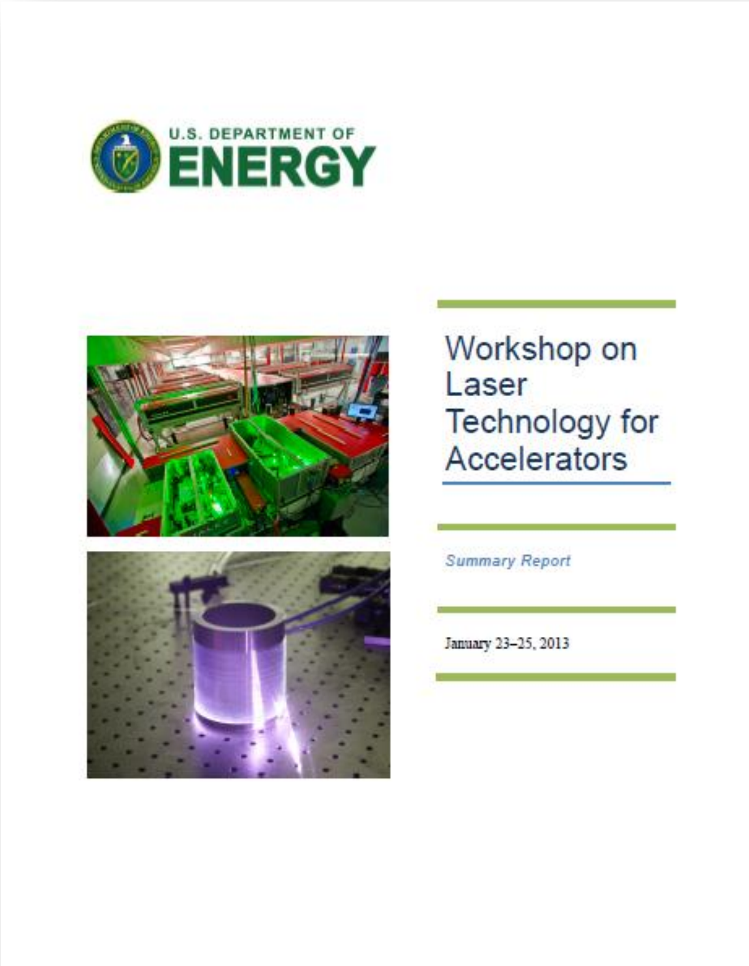
http://science.energy.gov/~/media/hep/pdf/accelerator-rd-stewardship/Workshop_on_Ion_Beam_Therapy_Report_Final_R1.pdf

The Report highlighted 8 themes:

- **Further studies of radiobiology and clinical efficacy are needed**
- **Machine R&D leading to**
  - **Cost and size reduction**
  - **Faster beam control and diagnostics**
  - **Faster 3D scanning**
  - **Smaller, less costly gantries**
  - **Real-time range and dose verification**
- **Future facilities will need multiple ion species**
- **International operational & clinical experience should be leveraged**

DOE Workshop on Laser Technology for Accelerators

January 23-25, 2013 Napa, CA.



http://science.energy.gov/~/media/hep/pdf/accelerator-rd-stewardship/Lasers_for_Accelerators_Report_Final.pdf

- Charge:
  - Identify laser-based accelerator applications
  - Assess laser specifications for each
  - Identify technical gaps
  - Specify R&D activities needed to bridge gaps
  - Compare U.S. R&D activities global laser R&D efforts

- Identified a high-impact, underfunded area central to laser technology for accelerators:
  - Ultrafast lasers (<1 ps) operating at high peak power (>10 TW) and **high average power (>1 kW),** and highest power efficiency (>20%)

Energy & Environmental Applications of Accelerators

- **Energy**
  - Accelerator energy efficiency
    - EO13514 mandates 28% GHG reduction from FY08 to FY20; current DOE SC complex accelerator energy usage is ~1000 GW-h/yr
    - Initiative to increase accelerator efficiency will have broad impact across SC labs, and in industrial uses of accelerators
  - Use of accelerators to deliver heat more precisely and controllably than conventional thermal processes
- **Environment**
  - Pollution reduction NOX, SOX reduction by flue gas treatment
  - Waste treatment
  - Pesticide and pharmaceutical reduction in domestic water supplies
- **Preparing a Request for Information**

Five Criteria for "Good" Accelerator R&D Stewardship Activities

1. **The application must involve accelerators or accelerator-related technologies either as:**
   1. Accelerator Research that has synergy with and benefits the primary HEP mission
   2. Accelerator Development (but often this will be WFO)
2. **There must be non-trivial intellectual involvement of the lab.**
   Good: Build an accelerator technology component (NB: usually WFO)
   Better: Design an accelerator technology component (WFO?)
   Best: Design, build, and test an accelerator technology component (Stewardship)
3. **The activity must be reasonably consistent with the mission of the lab, and minimally impact the primary SC program.**
   Good: Activity **maintains** a (again, this is usually WFO)
   Better: Activity **expands** a **core skill or facility needed for the mission**
   Best: Activity **develops a new**
4. **The lab must arguably be the best provider* of the capability or service.**
   Good: Lab's capability is not unique, but lab is close to customer
   Better: Lab's capability is leading, and lab is close to customer
   Best: Lab is the only possible provider
5. **The customer benefiting from the stewardship activity must endorse the goals.**
   Good: Customer participates in discussion of task definition, writes letter of support
   Better: Customer and lab partner on research, some cost sharing from customer (e.g. 1:10)
   Best: Customer and lab partner on research, significant cost sharing from customer (e.g. 1:1)

*and must not compete with an existing business
WFO = Work For Others

What would success look like?

- **Opening Access to Test Facilities**
  - Co-investment from the customer (OFA or industry)
  - Publications, patents, new products/processes, positive feedback
  - Facility quality and utilization improve; new intellectual connections formed
- **Ion Beam Therapy**
  - New components tested, industry partnerships formed, devices commercialized
  - TFs enable radiobiology experiments to be realized
  - Patient outcomes improved, treatment costs reduced
  - Beam capability and technology of HEP programs improved generally
- **Laser Technology R&D**
  - High power ultrafast laser technologies advanced
  - 1 kW test facility built, OFAs invest in science center based on the test facility
  - 10 kW test facility built, OFAs invest in 2nd science center based on the TF
  - GeV-demonstrator built for potential HEP application
- **Energy-Efficient Accelerator Power Systems**
  - High voltage modulator and high power rf technologies become more efficient
  - Industry adopts and produces new designs, HEP and OFAs buy new components
  - Significant impact on GHG emissions in SC accelerator applications

FY2014 Energy and Water Development Appropriations Bill S. 1245, (June 27, 2013)

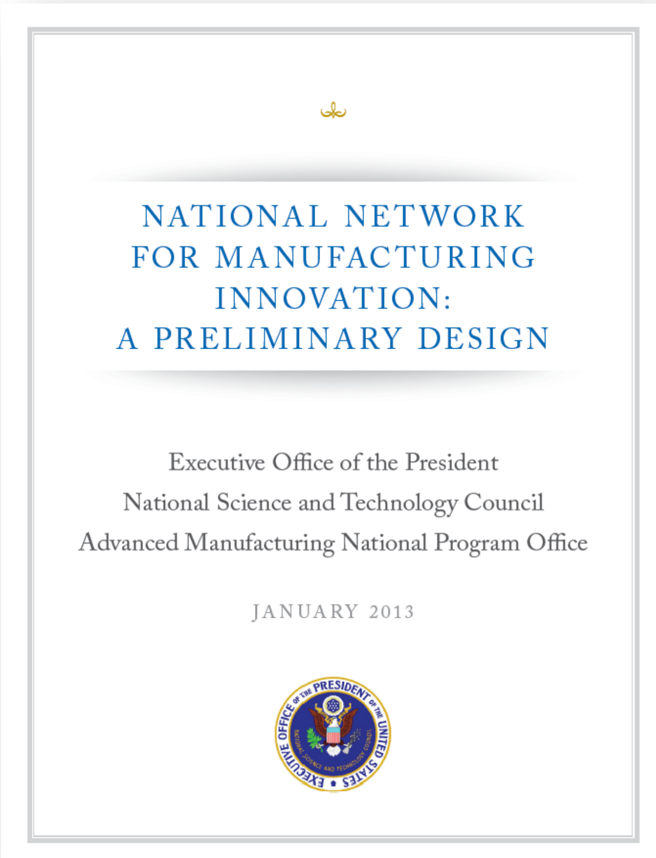
mates, and encourage international collaborators to make financial contributions. Within the funds for High Energy Physics, the Committee recommends $15,000,000 to support minimal, sustaining operations at the Homestake Mine in South Dakota.

Within the funds for High Energy Physics, the Committee also recommends $20,000,000 for Accelerator Stewardship. The Committee recognizes the critical role accelerator technology can play in addressing many of the economic and societal issues confronting the country. The Committee supports the Office of Science's efforts to make unique test facilities available to U.S. industry to accelerate applications of accelerator technology. Testing accelerator technology, such as at beam facilities, is the only, unambiguous way to demonstrate the operational efficacy of a new technology and represents the final step in validating a design concept.

NUCLEAR PHYSICS

The Committee recommends $569,938,000 as requested for Nuclear Physics. Within these funds, the Committee recommends

Accelerator Stewardship Seen in a Broader Context


NATIONAL NETWORK FOR MANUFACTURING INNOVATION: A PRELIMINARY DESIGN

Executive Office of the President
National Science and Technology Council
Advanced Manufacturing National Program Office

JANUARY 2013

http://manufacturing.gov/nnmi.html

- **President Obama has announced a 1B$ initiative to promote American manufacturing capability**
  - **National Network for Manufacturing Innovation** (NNMI)
  - Composed of ≤15 **Institutes for Manufacturing Innovation** (IMIs)
  - Managed through Commerce (NIST)
  - Each IMI funded at 70-120M$ / 5-7 years, to be matched 1:1 by the proposing non-profit
- **1+3 IMIs have been started or proposed:**
  - NAMII (funded, operating)
  - Wide Bandgap Materials (DOE-AMO)
  - LM3I and DMDI (DoD)

Accelerator Stewardship Seen in a Broader Context

- For a majority of Accelerator R&D Stewardship activities, the intent is to carry the R&D forward to first prototype testing under relevant conditions. (ie to TRL 5-6)
- NNMI intends to fund both the technology development and the manufacturing development up to TRL 7/MRL 7.

Accelerator R&D Stewardship

DOC's National Network for Manufacturing Innovation

Work For Others

NATIONAL NETWORK FOR MANUFACTURING INNOVATION: A PRELIMINARY DESIGN

Table 1. Technology Readiness Levels and Manufacturing Readiness Levels, after [21]

	TRL 1:	Basic principles observed and reported	MRL 1:	Manufacturing feasibility assessed
	TRL 2:	Technology concept and/or application formulated	MRL 2:	Manufacturing concepts defined
	TRL 3:	Analytical and experimental critical function and/or characteristic proof of concept	MRL 3:	Manufacturing concepts developed
NNMI Target	TRL 4:	Component and/or breadboard validation in a laboratory environment	MRL 4:	Capability to produce the technology in a laboratory environment
NNMI Target	TRL 5:	Component or breadboard validation in a relevant environment	MRL 5:	Capability to produce prototype components in a production relevant environment
NNMI Target	TRL 6:	System/subsystem model or prototype demonstration in a relevant environment	MRL 6:	Capability to produce prototype system or subsystem in a production relevant environment
NNMI Target	TRL 7:	System prototype demonstration in an operational environment	MRL 7:	Capability to produce systems, subsystems or components in a production relevant environment
	TRL 8:	Actual system completed and qualified through test and demonstrated	MRL 8:	Pilot line capability demonstrated; Ready to begin Low Rate Initial Production
	TRL 9:	Actual system proven through successful mission operations	MRL 9:	Low rate production demonstrated; Capability in place to begin Full Rate Production

3.3 IMI Funding, Revenue, and Sustainability

Each Institute should be of sufficient size and scope to have major national and regional economic impacts and to address the multidimensional challenges associated with the Institute's focus area. The

National Network for Manufacturing Innovation: A Preliminary Design

Stewardship, SBIR/STTR, and WFO

	Accelerator Stewardship	SBIR/STTR & TTO	WFO
Mission	• Open Lab Facilities • Apply accelerators to solve challenging problems	• Move technology towards market • Stimulate small businesses	• Customer-defined, as consistent with lab's mission per DOE O 481.1
Technical & Manufacturing Readiness	TRL 1-6 MRL none	Phase I: TRL 2-3 Phase II: TRL 3-4/MRL 1-4	TRL ~2 to 9 MRL 1 to ~8
Time Horizon	Up to ~10 years	9 mos/24 mos	Customer-defined
Topic Selection	Stakeholder Boards	Lab input, DOE selects	Lab Selects
Progress Review	Community Workshops Grant Reports Contact with users (UECs)	Grant Reports	Customer-defined metrics
Funding Mechanism	FOAs, peer-review	FOAs, peer-review	WFOA/CRADA
Intellectual Involvement of Program	Significant	(no requirement)	(no requirement)

Take-Home Message

- **Accelerator Stewardship is leveraging, not diversion**
  - Mission still comes first
  - Activities selected for their synergy with the primary program and impact on important non-HEP problems
- **Stewardship will not diminish HEP's historic role as guardian of high-risk/high-payoff accelerator R&D**
  - Long view and corporate memory of HEP are unique and essential for technology R&D that often spans decades
  - NSF initiative in accelerator science is highly welcome
- **Stewardship is outreach that yields new interdisciplinary connections**
  - Strengthening HEP's connections with other science funding agencies
  - Spawning new directions of collaborative research
  - Creating broader awareness of the value of HEP science and technology
- **Stewardship will enable nearer-term societal contributions from our research**
  - Critical in an age of increasing pragmatism
  - Done on our own initiative and on terms we define