Jefferson Lab and the NP SBIR/STTR Program

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Hall A and C Leader

Physics Division

DOE-NP SBIR/STTR Exchange Meeting
August 13-14, 2019

Jefferson Lab

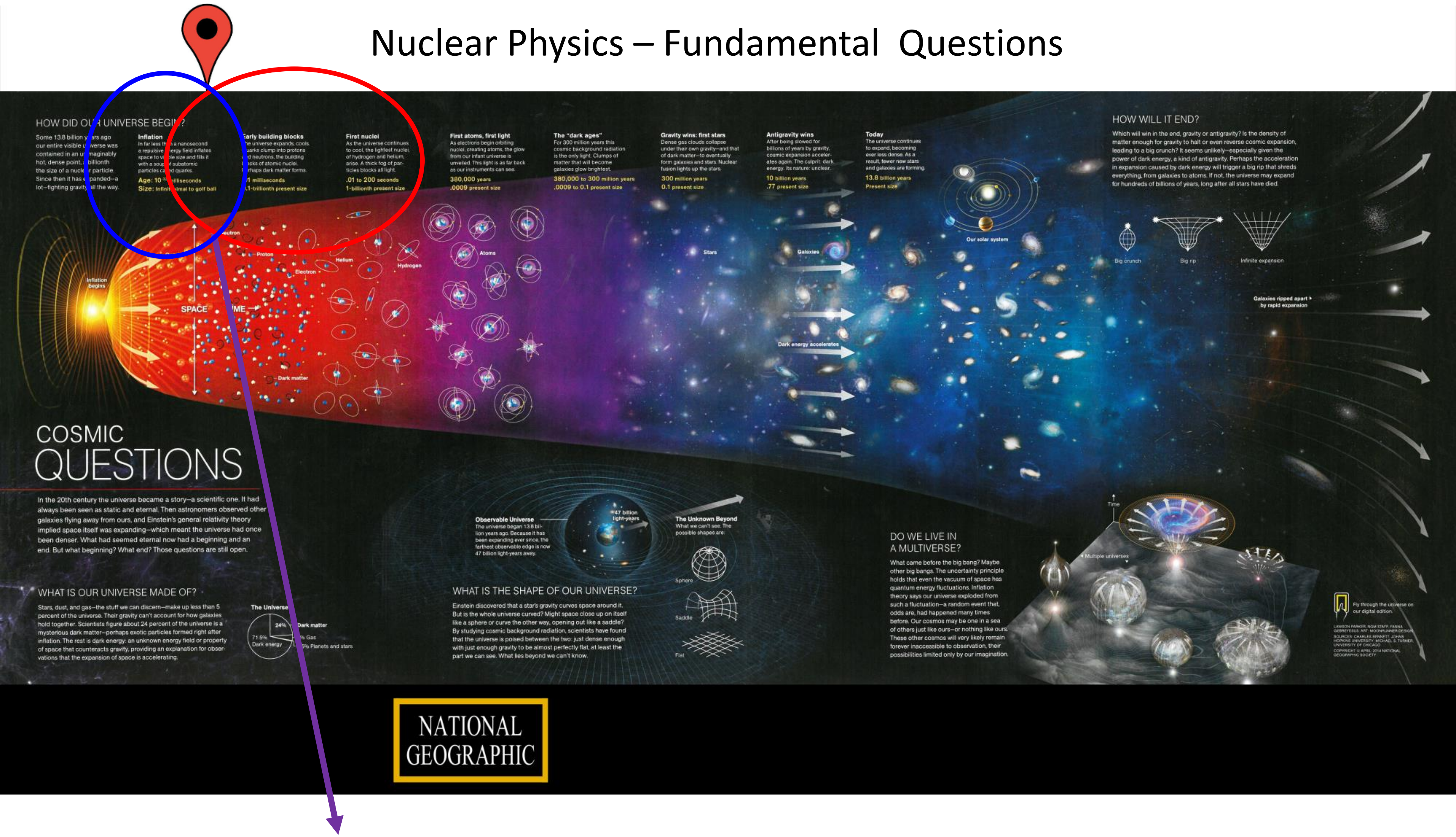
U.S. DEPARTMENT OF ENERGY | Office of Science

JSA

Outline

- **Jefferson Lab Overview and Mission**
- **Accelerator and Experimental Facilities**
- **Scientific and Technical Capabilities**
    - *SBIR Examples and Opportunities*
- **SBIR Engagement**
- **Summary**

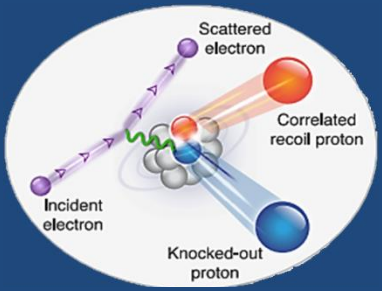
Nuclear Physics – Fundamental Questions



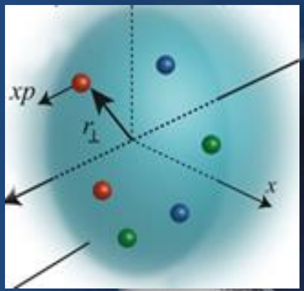
"Medium Energy" Nuclear Physics at Jefferson Lab Seeks to:

- Understand the fundamental structure of visible matter (quarks, gluons,..)
- Understand how hadrons (mesons, nucleons,..) and nuclei are formed

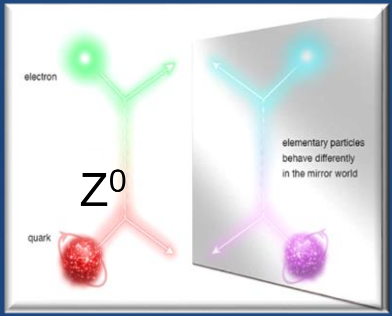
JLab: A Laboratory for Medium Energy Nuclear Science



Nuclear Structure



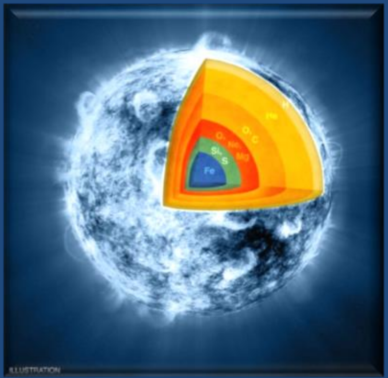
Structure of Hadrons



Fundamental Forces & Symmetries


Medical Imaging

Jefferson Lab has significant research activity in all 5 science chapters of the most recent NSAC LRP.


Nuclear Astrophysics


Cryogenics


Accelerator S&T


Theory & Computation

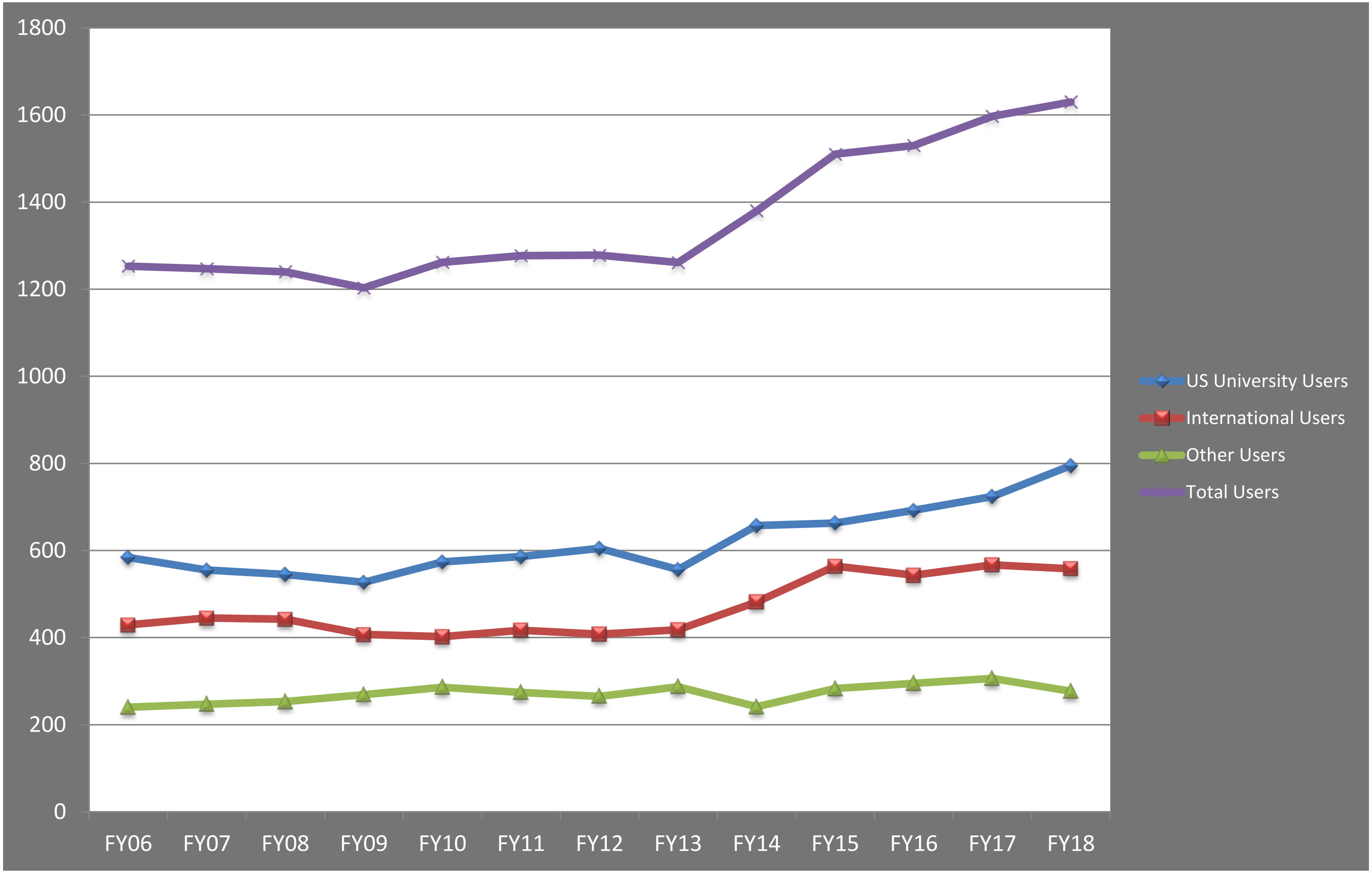
Jefferson Lab Overview

- DOE Office of Science Laboratory with a single program focused on Nuclear Physics.
  - In operation since 1995
- Created to build and operate the Continuous Electron Beam Accelerator Facility (CEBAF), world-unique user facility for Nuclear Physics.
- Mission is to gain a deeper understanding of the structure of matter:
  - Through advances in fundamental research in nuclear physics
  - Through advances in accelerator and nuclear science and technology
- Largest Nuclear Physics user community in the world…*and growing*.

Jefferson Lab by the numbers:

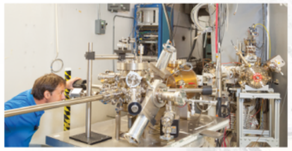
- 700 employees, 27 Joint faculty
- 169 acre site
- 1,630 Active Users
- 630 PhDs granted to-date (212 in progress)
- K-12 programs serve more than 12,000 students and 950 teachers annually
- Scientific users from 39 countries, 278 institutes (124 institutions in 34 states)

Jefferson Lab's user community continues to grow



CEBAF AT JEFFERSON LAB

Jefferson Lab's Continuous Electron Beam Accelerator Facility (CEBAF) enables world-class fundamental research of the atom's nucleus. Like a giant microscope, it allows scientists to "see" things a million times smaller than an atom.



1 INJECTOR

The injector produces electron beams for experiments.

2 LINEAR ACCELERATOR

The straight portions of CEBAF, the linacs, each have 25 sections of accelerator called cryomodules. Electrons travel up to 5.5 passes through the linacs to reach 12 GeV.

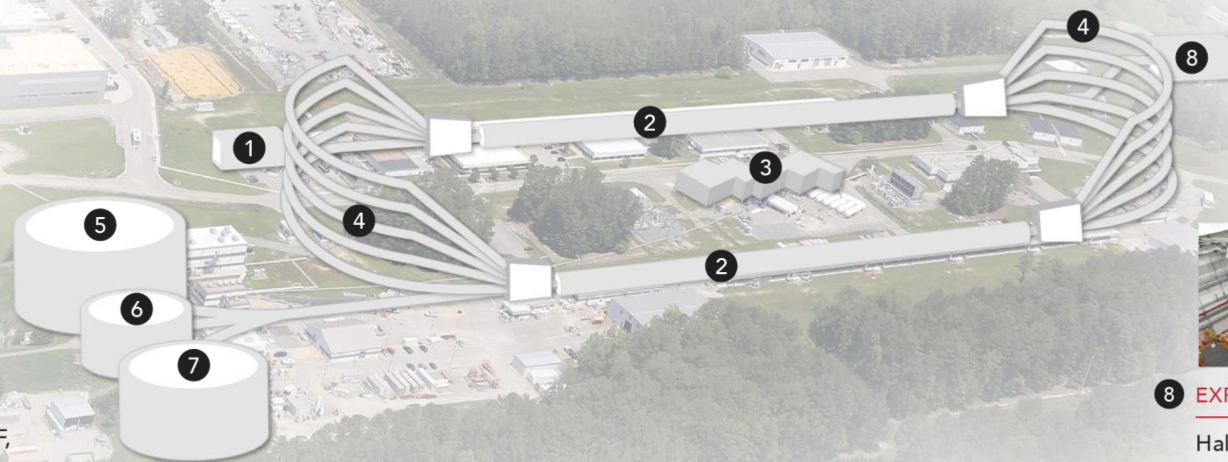


Diagram representational of below ground structure

8 EXPERIMENTAL HALL D

Hall D is configured with a superconducting solenoid magnet and associated detector systems that are used to study the strong force that binds quarks together.

3 CENTRAL HELIUM LIQUEFIER

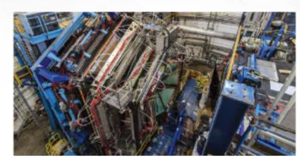
The Central Helium Liquefier keeps the accelerator cavities at -456 degrees Fahrenheit.

4 RECIRCULATION MAGNETS

Quadrupole and dipole magnets in the tunnel focus and steer the beam as it passes through each arc.

5 EXPERIMENTAL HALL A

Hall A is configured with two High Resolution Spectrometers for precise measurements of the inner structure of nuclei. The hall is also used for one-of-a-kind, large-installation experiments.



6 EXPERIMENTAL HALL B

The CEBAF Large Acceptance Spectrometer surrounds the target, permitting researchers to measure simultaneously many different reactions over a broad range of angles.

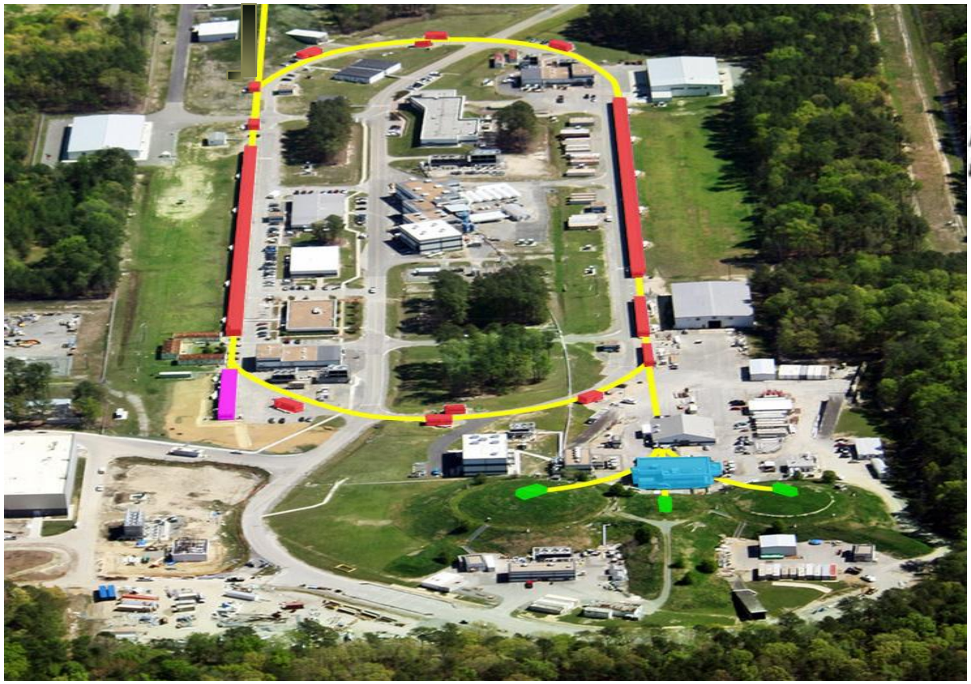
7 EXPERIMENTAL HALL C

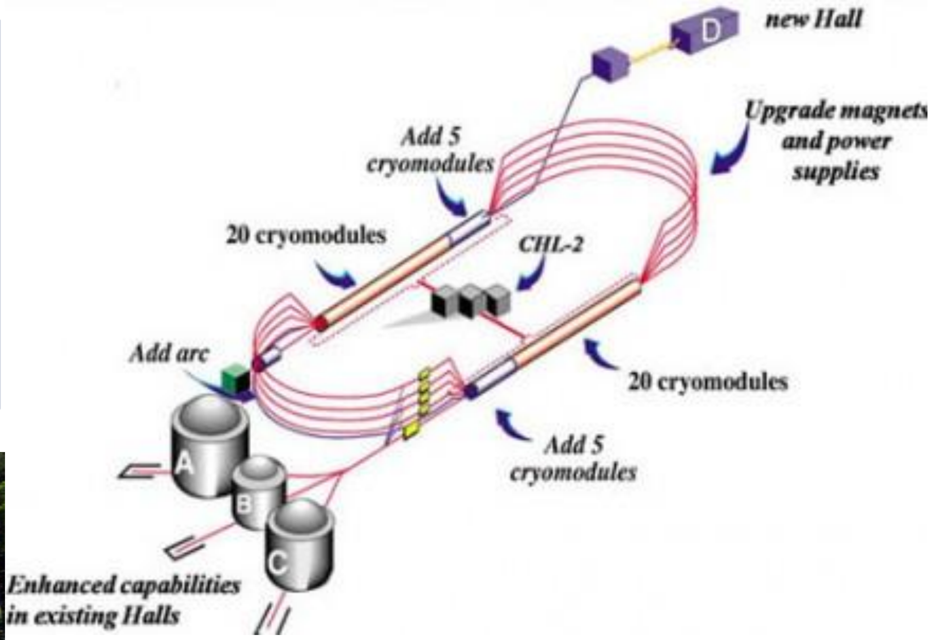
The Super High Momentum Spectrometer and the High Momentum Spectrometer make precise measurements of the inner structure of protons and nuclei at high beam energy and current.

RECENTLY COMPLETED UPGRADE AT JEFFERSON LAB

(as of September 27, 2017)

- **12 GeV Upgrade Project Complete:**
  - Total Project Cost of $338M
  - Double maximum accelerator energy to 12 GeV
  - Add 4th experimental Hall D
  - New experimental equipment in Halls B, C, D
- **In full operation now with simultaneously beam deliver to all 4 experimental halls**

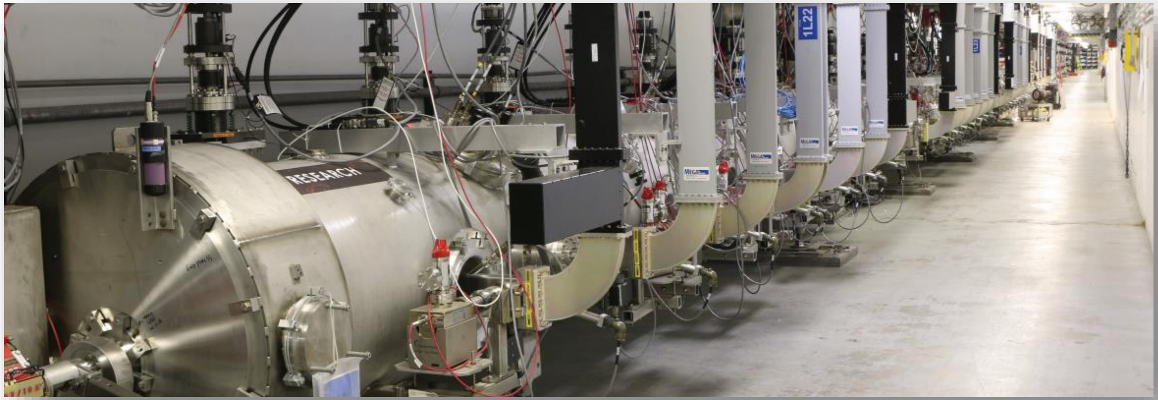




Secures a forefront scientific program for the next 10 or more years

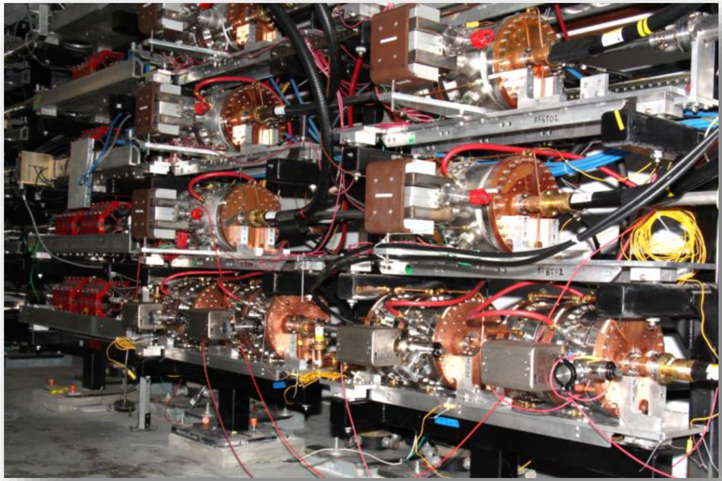
Jefferson Lab

Continuous Electron Beam Accelerator Facility

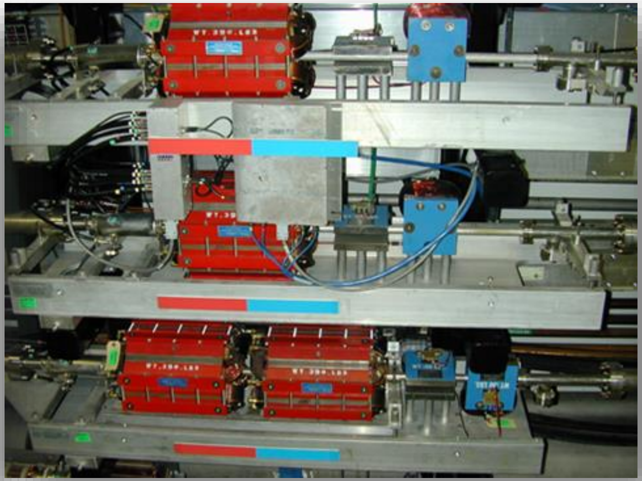


52-1/4 Cryomodules with 418 SRF Cavities to Accelerate Electrons in CEBAF

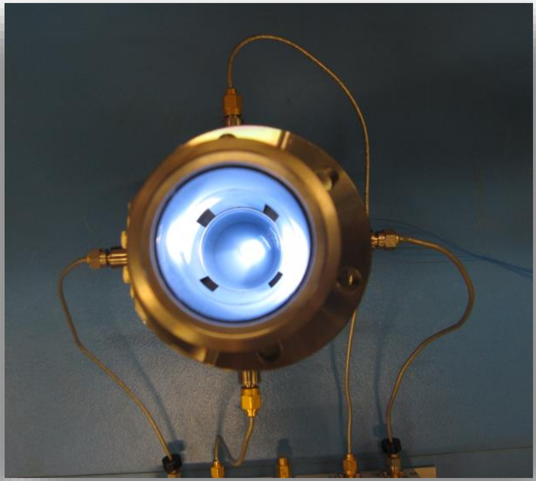
~500 Large Dipoles powered by >40 HVPS



16 RF Deflectors for Extracting Beams



>2800 Magnets to Focus and Steer Beam



>800 Beam Position Monitors

Jefferson Lab Plays a Vital Stewardship Role for "Big Science" Projects Within the Department Of Energy

Jefferson Lab is a world-leader in Superconducting Radiofrequency particle accelerators and cryogenic technologies

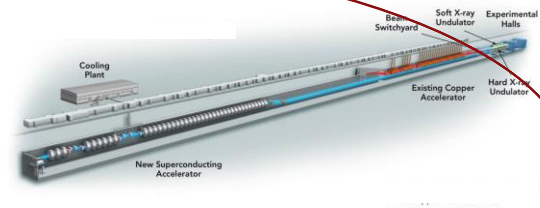
CEBAF - 1994
12 GeV Upgrade - 2017

Spallation Neutron Source (ORNL) - 2006

Facility for Rare Isotope Beams (MSU) - 2021

Linac Coherent Light Source II (SLAC) 2021

SNS Proton Power Upgrade

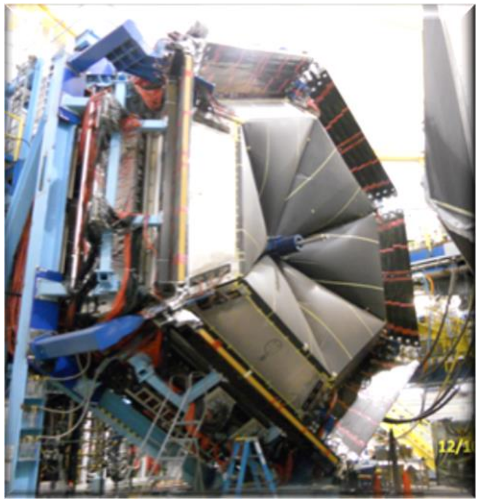


LCLS-II High Energy Upgrade

Jefferson Lab is partnering on two new DOE Projects

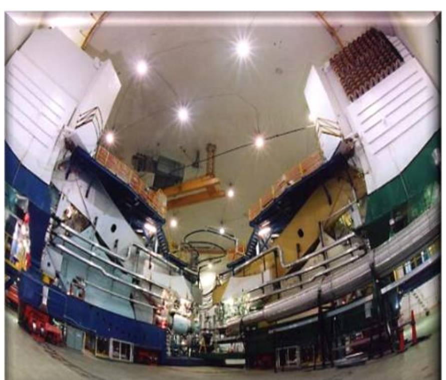
4 Experimental Halls

Hall D – exploring origin of confinement by studying exotic mesons



Hall B – understanding nucleon structure via generalized parton distributions and transverse momentum distributions

Hall C – precision determination of valence quark properties in nucleons and nuclei



Hall A – short range correlations, form factors, hyper-nuclear physics, future new experiments (e.g., MOLLER and SoLID)

Jefferson Lab Scientific Computing

<u>JLAB Hardware</u>
HPC Cluster for Lattice QCD
- 17,152 Xeon Phi KNL cores +
- 12,500 Xeon Phi cores
- LQCD-Ext (2019) GPUs

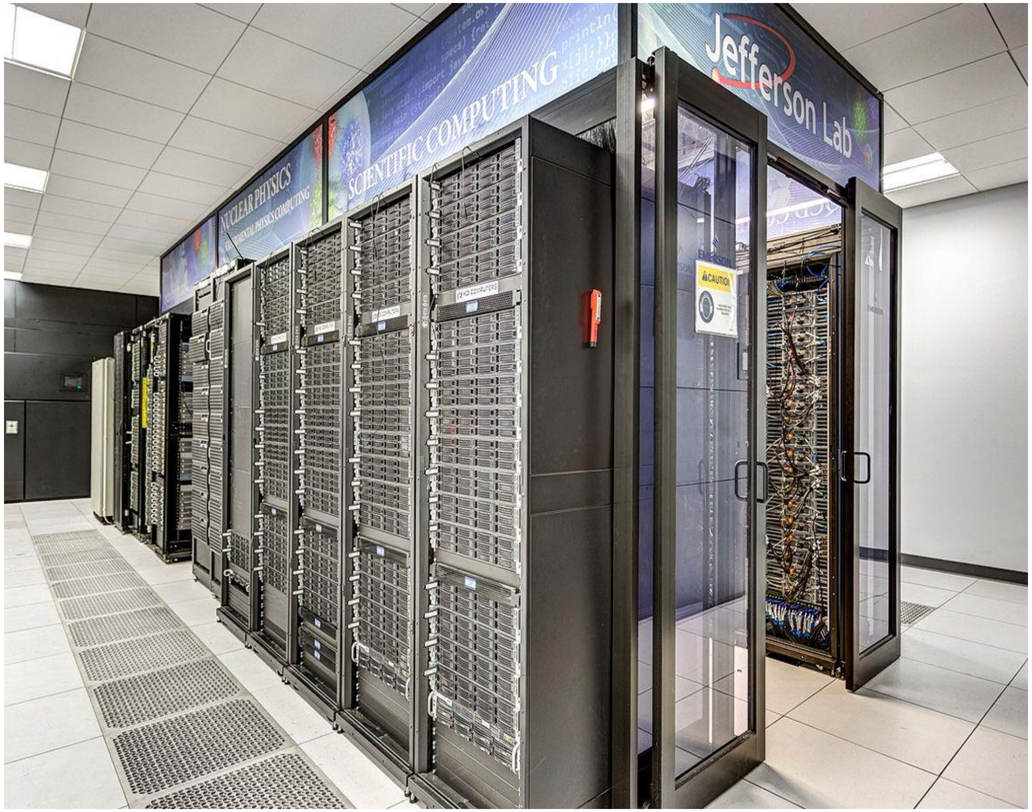
Physics Farm:
14,520 conventional Intel cores
AMD won recent procurement

Heavily Tiered Storage System
With Tape as a warm tier
7 PB disk & SSD storage

<u>Distributed Computing</u>
Open Science Grid 7.2B MC events

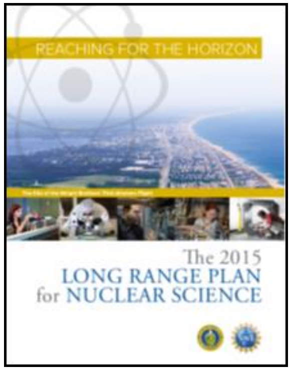
Processing Experimental data at NERSC; Lattice QCD on leadership facilities

Going International: UK & Italian resources in testing phase



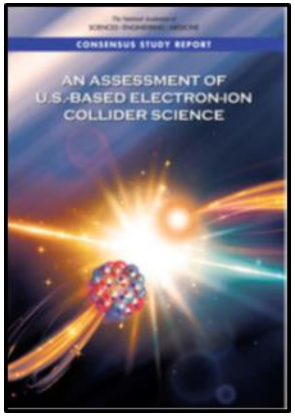
Supports the experimental, computational theoretical and accelerator science communities.

Electron-Ion Collider Planning



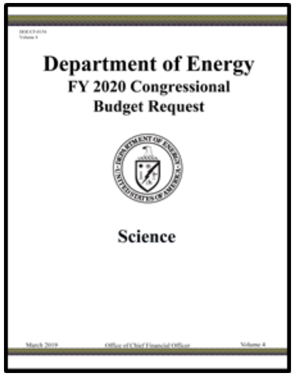
Federal Nuclear Science Advisory Cmte 2015 Long Range Plan

"We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB."



National Academy of Sciences – Assessment of U.S. Based Electron-Ion Collider Science (2018)

"…the committee finds a compelling scientific case for such a facility. The science questions that an EIC will answer are central to completing an understanding of atoms as well as being integral to the agenda of nuclear physics today."



President's FY 2020 Budget Request to Congress (2019)

"Critical Decision-0, Approve Mission Need, is planned for FY 2019"

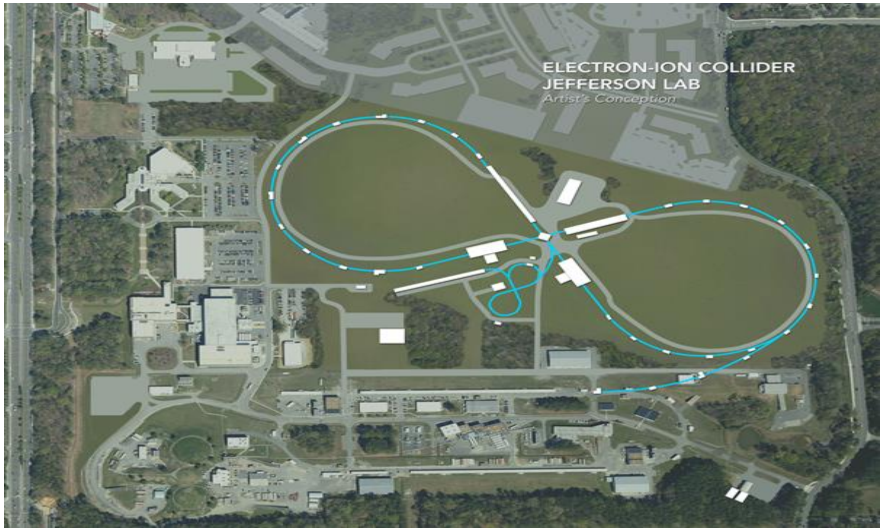
"The FY2020 Request will provide for the first year of Other Project Costs for the Electron Ion Collider, aimed at research to reduce technical risk and the development of a conceptual design."

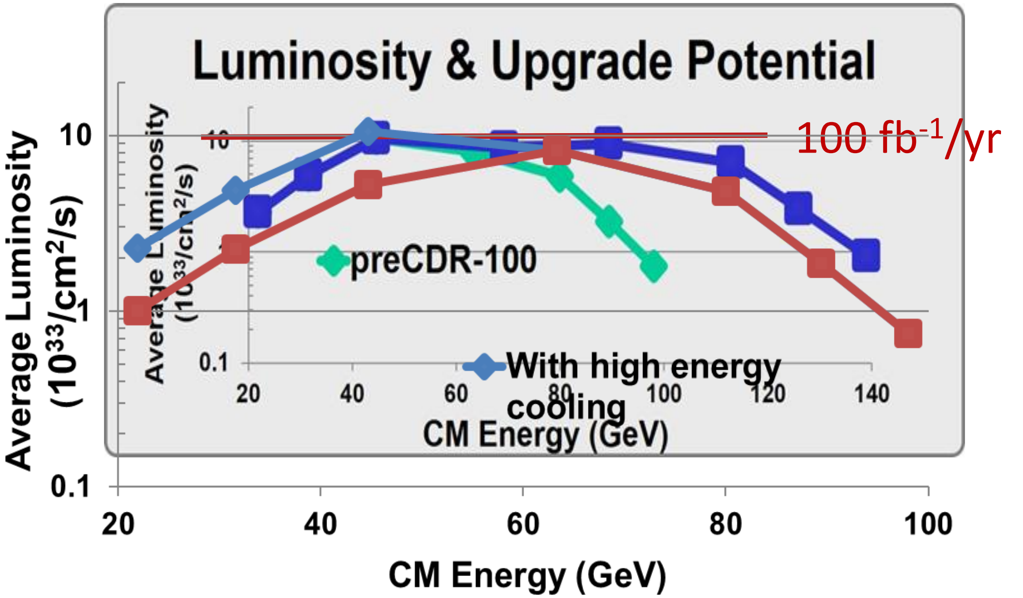
Jefferson Lab Electron Ion Collider

JLab EIC Figure 8 Concept

- High Luminosity of 10^{34} /cm^2/sec well-matched to requirements
- High Polarization (including deuterons)
- Energy Range: $\sqrt{s}$: 20 to 100-140 GeV (magnet technology choice)
- Appropriately balances performance and risk
- Flexible timeframe for construction consistent w/running 12 GeV CEBAF
- Cost effective operations

➢ Fulfills White Paper, NAS Requirements





- PreCDR complete E_{CM} 65➔100GeV
- Independent Cost Review June 2019

Mission and Strategic Plan

MISSION	We support the DOE Office of Science and serve the Nuclear Physics User Community as a world-leading center for fundamental nuclear science and associated technologies		

SCIENCE & TECHNOLOGY

STRATEGIC OUTCOMES	Enable scientific discoveries by the Nuclear Physics User Community through our unique, world leading facilities and capabilities	Plan for future facilities and capabilities to realize the long-term scientific goals in Nuclear Physics research	Provide technology solutions that support the NP community, the larger DOE mission and societal needs
MAJOR INITIATIVES	1 Operate CEBAF accelerator and experimental facilities to execute the FY18 experimental nuclear physics program 2 Prepare CEBAF accelerator and experimental equipment for future 3-5 year experimental physics program 3 Perform R&D to enable enhanced performance and future new capabilities for CEBAF and experimental halls 4 Perform theoretical research in support of the CEBAF 12 GeV program 5 Perform theoretical and experimental research in support of the broader NP research community 6 Provide software and computational resources for theoretical and experimental nuclear physics research	1 Continue to develop the MOLLER and SoLID initiatives 2 Perform Accelerator R&D towards an Electron Ion Collider 3 Perform Detector R&D towards an Electron Ion Collider 4 Pre-project design and planning for an Electron Ion Collider 5 Engage with the EIC user community and further develop the anticipated scientific program for a future Electron Ion Collider 6 Develop and expand expertise in Scientific Computation and Data Science	1 Execute LCLS-II activities to produce project deliverables 2 Perform R&D to enable other future (non-CEBAF, non-EIC) accelerator capabilities and enhance the reputation of JLab in SRF and large-scale cryogenics 3 Perform R&D on topics with potential commercial applications to facilitate transfer of the Lab's technology beyond nuclear physics

OPERATIONS

STRATEGIC OUTCOMES	Provide, protect, and improve the human, physical and information resources that enable world class science		
MAJOR INITIATIVES	1 Business Process Streamlining 2 IT Service Modernization 3 Cyber Operations Laboratory	4 Facilities Engineering and Reliability Enhancement 5 Alternate Work Schedule 6 Website Redesign and Upgrade	7 ISMS Performance Enhancement 8 Enhanced Self-Assessment 9 Reduced Material and Supply Cost Through Improved Commodity Sourcing 10 Total Time Accounting

(https://www.jlab.org/media_relations/JLAB_10_year_plan_public.pdf)

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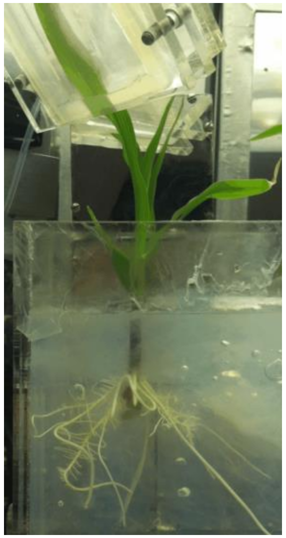
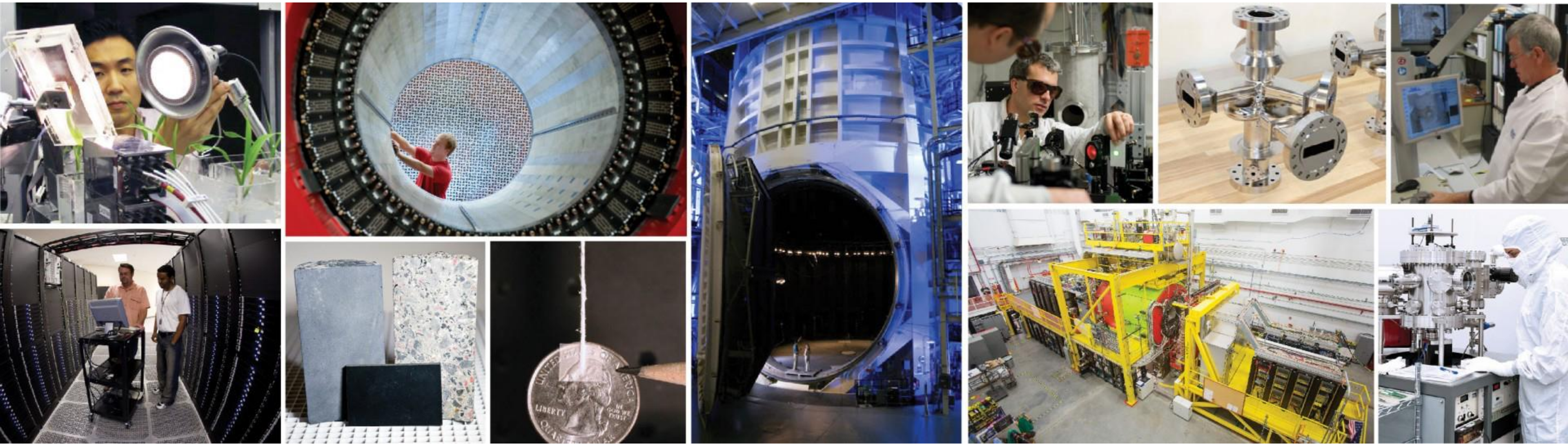
JLab & the NP SBIR/STTR Program

Synergistic involvement

- Accelerator Technology
- Computing, Software and Data Management
- Instrumentation, Detection Systems & Techniques





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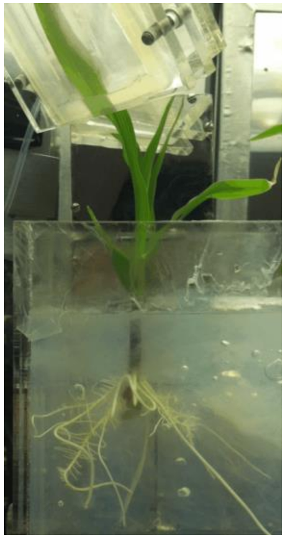
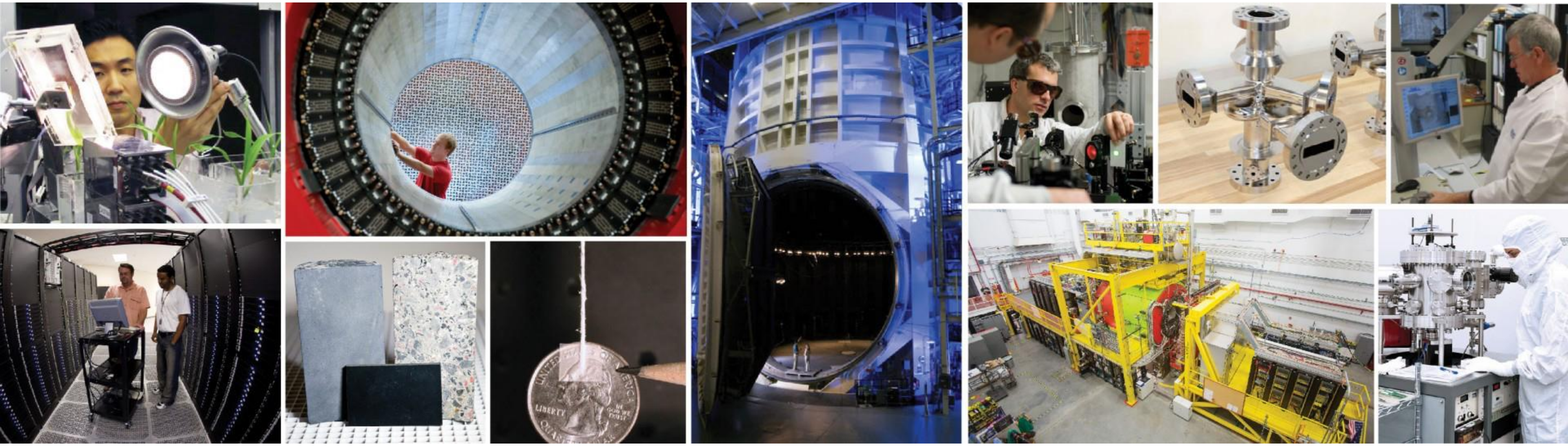
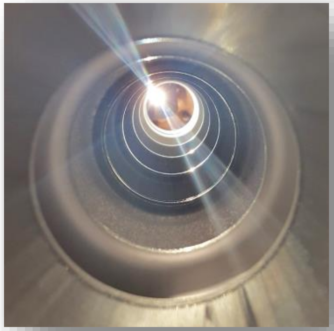




JLAB Accelerator R&D Major Directions

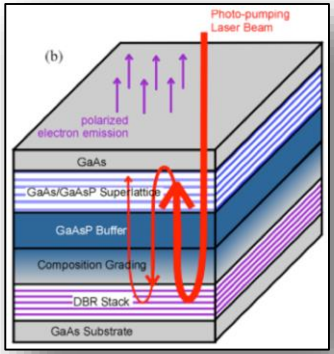
- Superconducting RF R&D
  - Improving SRF performance of CEBAF
  - New SRF technologies for an EIC
  - Next-generation SRF for high quality factor, high-gradient, higher temperature
  - New materials and processes for higher efficiency, lower cost, safer operations
- Electron Source R&D
  - Extend state-of-art for world record quantum efficiency for high polarization photocathodes
  - Parity quality beam program - CEBAF Injector Full-Energy Upgrade to 200 kV gun
  - Magnetized source for JLEIC cooler
  - Advanced cathode materials
- JLEIC R&D activities
  - Pre-conceptual R&D
  - R&D on high-priority topics identified by Jones panel

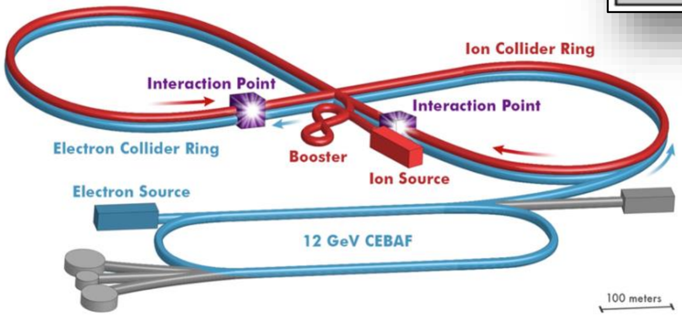
C75 cavity



Nb_3Sn coated 5-cell cavity

World Record High Polarization Photocathode

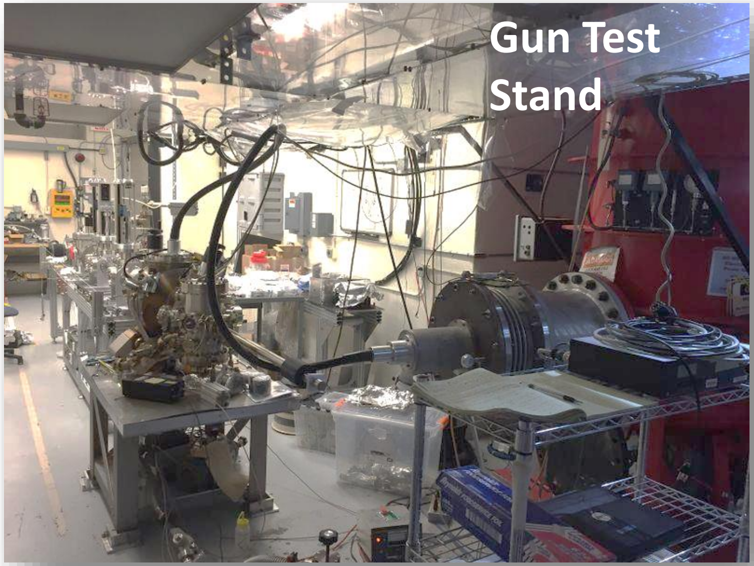


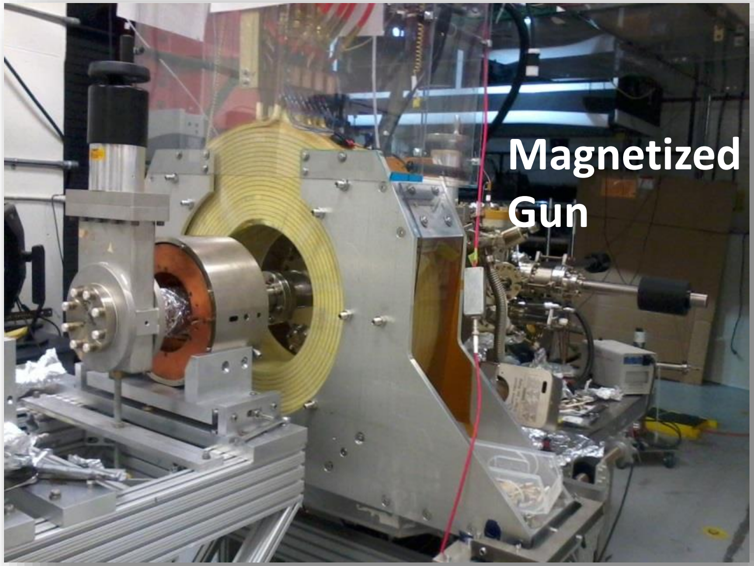


These activities are essential for forming the technological base for future Nuclear Physics research as well as the broader DOE mission

Source Group R&D

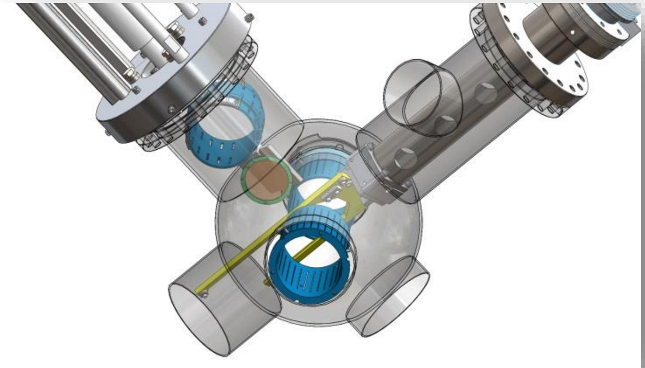
- Magnetized beam transport (LDRD, JLEIC, SBIR)
- Bunchlength monitor and fast kicker using harmonically-resonant cavity, harmonic arbitrary waveform generator and amplifier (SBIR)
- Non-invasive electron beam polarimeter, RF-cavity to detect polarization (SBIR)
- High Polarization and High QE Photocathodes (SBIR)
- Improving vacuum to 10^{-13} Torr (funded via *Research and Development for Next Generation Nuclear Physics Accelerator Facilities*)
- Thermionic gun with RF time structure, for generating magnetized beam (SBIR, JLEIC)
- Powerful drive laser for photoguns, wavelength near 532 and/or 780 nm, with variable repetition rate, ~ 50ps laser pulses via gain-switching (SBIR)



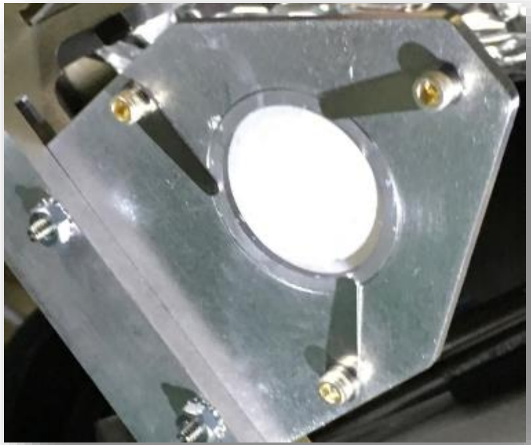


Beam Diagnostics Development

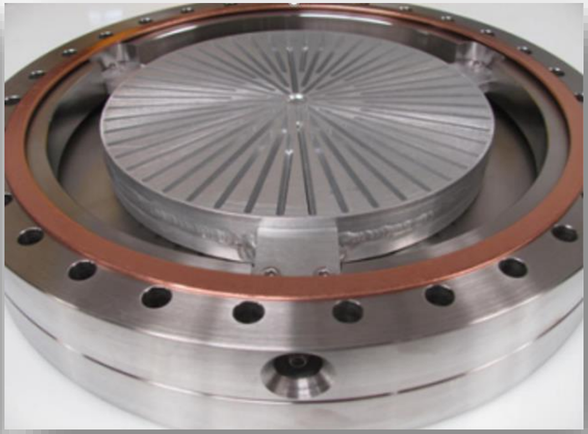
- Boron Nitride Nanotube (BNNT) Diagnostic Development
- Laser Wire Scanner
- Large Dynamic Range Transverse Diagnostics
- Large Dynamic Range Longitudinal Diagnostics
- Non-invasive Polarimetry



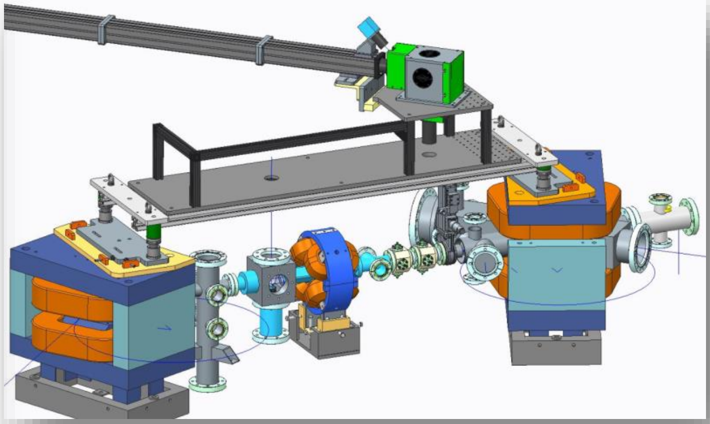
Large Dynamic Range Transverse Diagnostics



40 mm BNNT Viewer Flag



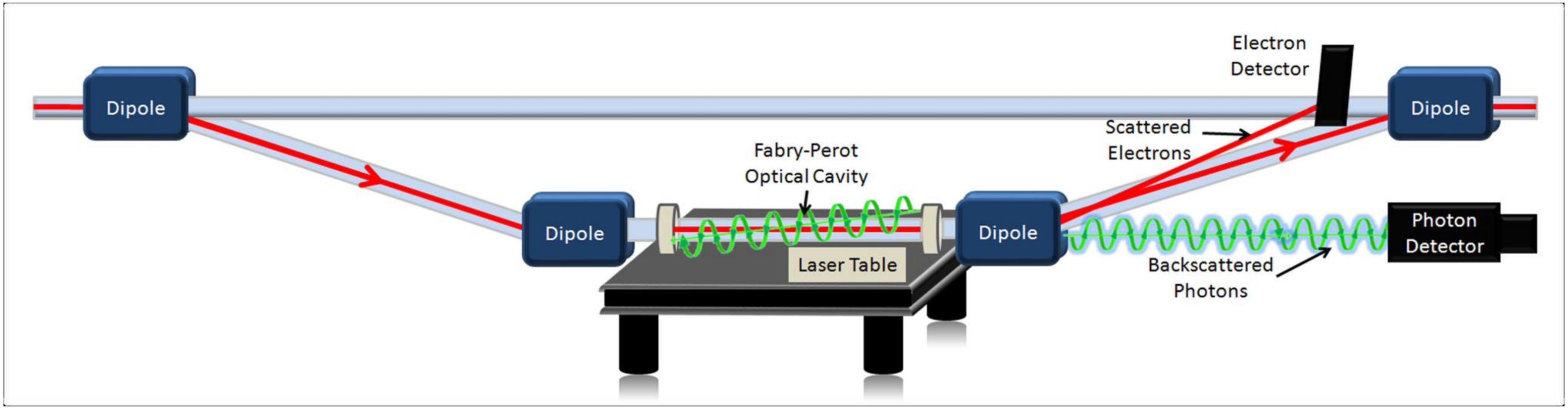
Polarimeter Cavity



Laser Wire Scanner Beam Diagnostic

BNNT PIONEERING REVOLUTIONARY MATERIALS
U.S. DEPARTMENT OF ENERGY Office of Science
HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF
CORNELL UNIVERSITY FOUNDED A.D. 1865
LHeC
Muons, Inc. Innovation in Research
OLD DOMINION UNIVERSITY IDEA FUSION
NIOWAVE Accelerating Your Particles
SLAC NATIONAL ACCELERATOR LABORATORY
radiabeam TECHNOLOGIES
BTG Brookhaven Technology Group
ALPHACORE ANALOG & RF ELECTRONICS

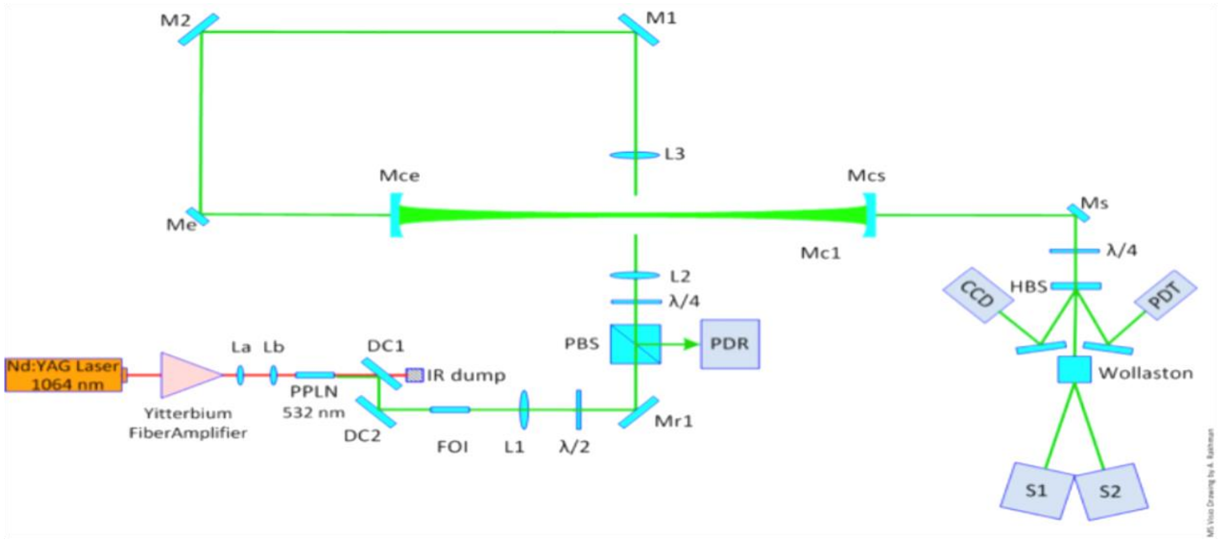
Example: Compton Polarimetry at JLab



1. Laser system: Few kW stored power in FP cavity, with precise knowledge of circular polarization
2. Photon detector: PbWO4 (high energy) or GSO (low energy) crystal(s) operated in integrating mode (need crystal appropriate for high energies) → LED pulser system to monitor/measure linearity
3. Electron detector: Segmented (strip) detector → ~ 200 µm pitch, 192 strips/plane

Two nearly identical systems in Hall A and Hall C

Compton Laser System



System uses high Finesse Fabry-Perot cavity, pumped by narrow linewidth (<5 KHz) green laser

→ Laser system components: 1064 nm seed + 5-10 W fiber amplifier + PPLN doubling system → generates ~1 W green power

→ Would prefer simpler, integrated, turn-key system for deployment in experimental area

- A "turn-key" laser system that provides ~1 W green power with very narrow linewidth (5 kHz) instead of the 3 component system we have now

→ Lower power commercial systems exist (~100 mW), but not 1 W level

Polarimeter Electron Detector

Experimental Hall C made use of a diamond strip electron detector installed in 2009-2010

→ Achieved high precision measurements with no detectable performance degradation

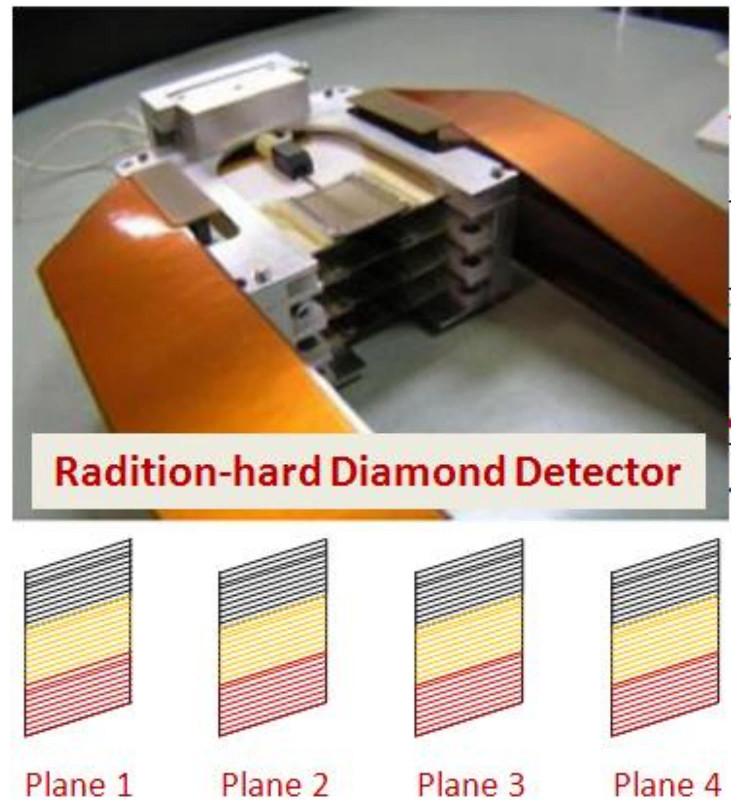
→ Up to 100 kGy environment

Would like to build similar system in Hall A

→ No longer any commercial vendors that provide integrated detector board: Diamond strips, carrier board, connectors, etc.

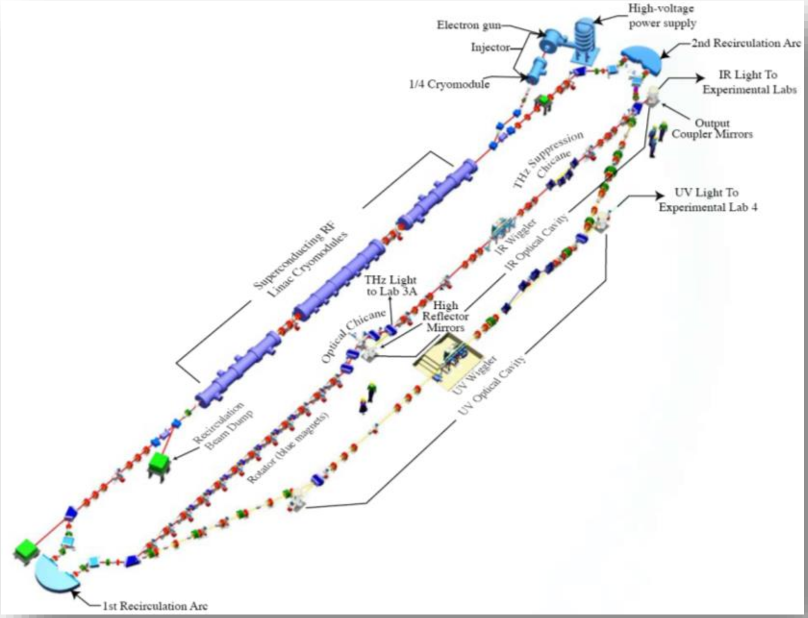
→ SBIR (Applied Diamond) project to develop the capability to build such integrated detectors

→ Another area of R&D would be a very fast diamond strip detector/integrated electronics that would allow us to resolve the individual bunches in an EIC.



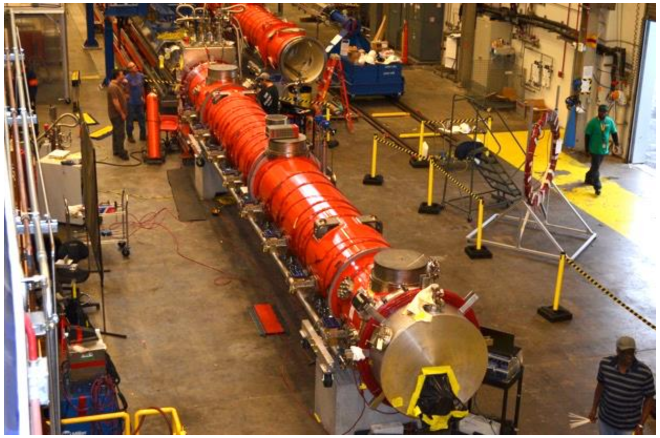
Low Energy Accelerator Facility (LERF)

LERF facility supporting two programs in the near term:



Parameter	Value
Max. Energy	170 MeV
Bunch Charge	150 pC
Bunch Frequency	75 MHz
Current (Fixed Target)	0.5 mA
Current (ERL)	8 mA
Long Axis Length	64 meters

- LCLS-II cryomodule testing – DOE/BES funded effort to gain schedule contingency for cryomodule qualification
- Two LCLS-II cryomodules will be tested at a time on a ~2 month cycle and will repeat ~4 times.
- Sixteen Solid State Amplifiers, LLRF and Cryo controls on loan from SLAC to commission the cryomodules



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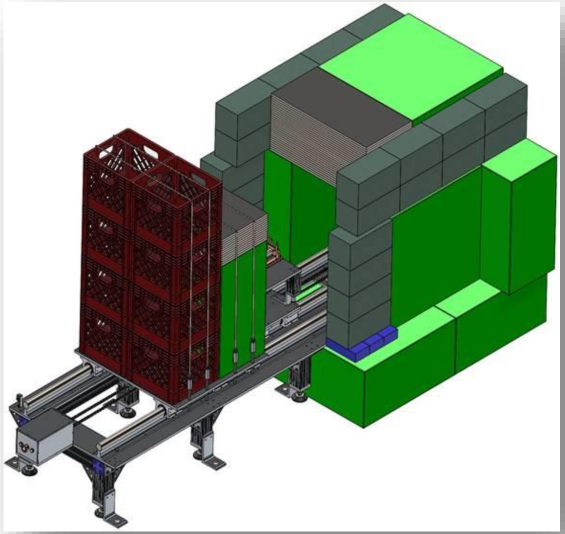
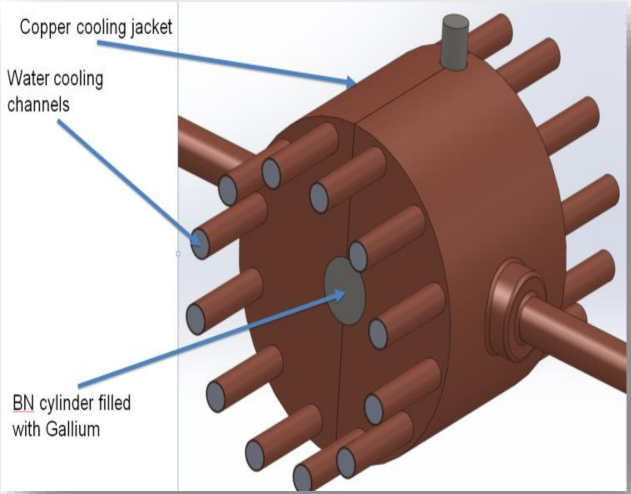
Isotope R&D at JLab-LERF

- DOE/NP Isotope program funded two year R&D plan to address national need for high-priority research isotopes
- Studying the feasibility of producing Cu-67 via photo-production using bremsstrahlung photons from the LERF in Gallium
- Cu-67 potential as a high specific activity theranostic radionuclide. Therapy from 141 keV beta-emitter. Diagnostic from 185 keV photons for imaging.
- Collaboration with New Mexico Tech and Virginia Commonwealth University
- Challenges:
  - High power (50 kW) target system development
  - Remote handling systems development
  - Yield modeling
- *First target irradiation scheduled for Fall 2019*

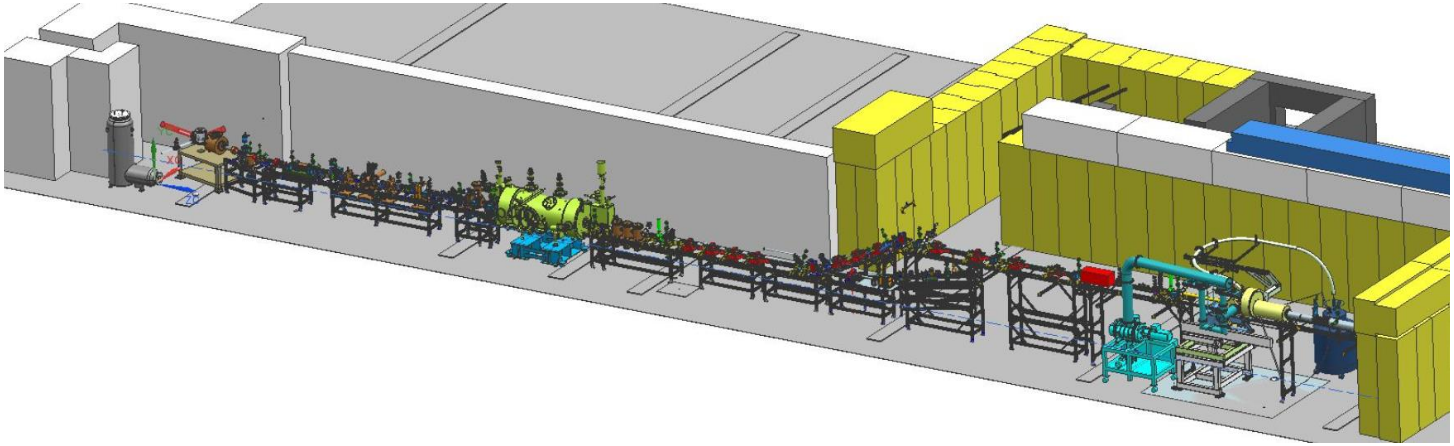


Isotope Target Hot Cell and Shielding



Upgraded Injector Test Facility (UITF)

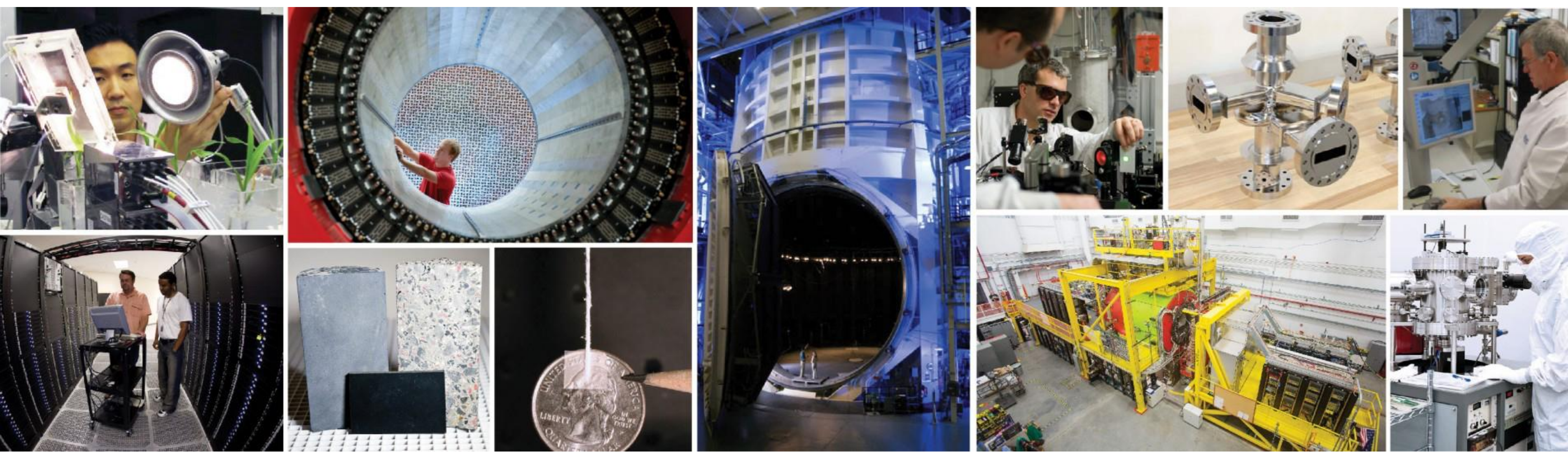
- The Injector Test Facility was established in the very early days of Jefferson Lab to build and commission the CEBAF warm injector while tunnel construction was underway. The facility was recently upgraded with cryogenics capabilities.
- Ongoing and planned R&D include:
  - Full Injector Upgrade: 200 kV gun, Wien filters, new Quarter Cryomodule
  - Polarize solid targets for the Physics Program and commissioning the HDIce target system for a future experiment in Hall B
  - Magnetized beam tests for EIC
  - Polarized positron source development for CEBAF and EIC
  - R&D in support of Environmental Applications of Accelerators



JLab & the NP SBIR/STTR Program

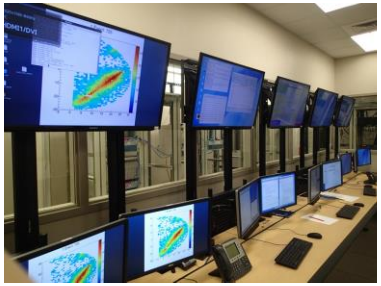
Synergistic involvement

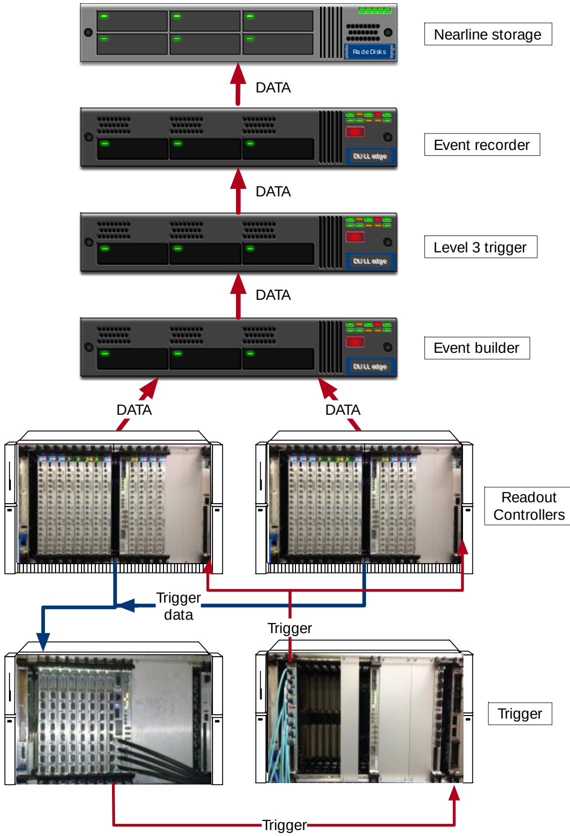
- Accelerator Technology
- Computing, Software and Data Management
- Instrumentation, Detection Systems & Techniques



Data Acquisition

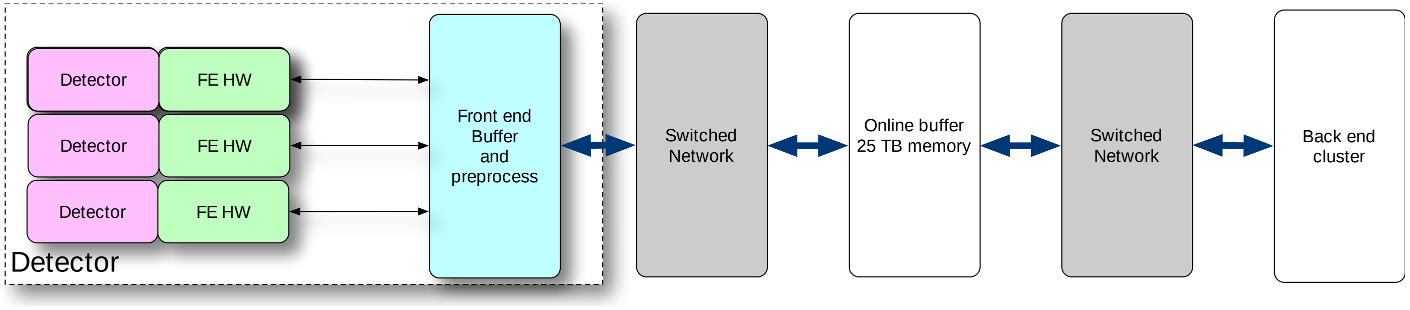
- JLab has a data acquisition support group (DAQ group) to assist researchers with the development, implementation and operation of the systems gather and store the experimental data.
- Currently all major experiments at JLab use CODA which is a suite of software, custom hardware and CotS recommendations developed by the DAQ group.
  - A typical CODA system is shown in the diagram --->
- Largest CODA based system is in use by Hall B CLAS12
  - About 100 VME crates of electronics, 400 MB/s continuous data rate.
- Highest rate CODA based system is in use by Hall D GLUEX
  - About 50 VME crates of electronics, 1.5 GB/s continuous data rate.
- NP data is a stream of “events” which each represent an nuclear interaction of some kind.
  - Events are independent of each other and can be trivially processed in parallel.
  - Events are sensitive to detector conditions and configuration so time order is still important.





Looking to the future

- The 12 GeV program at JLab is just beginning but new experiments and upgrades to existing systems are being proposed.
  - In particular the proposal to develop and build the new EIC and associated detectors.
- This is an ideal time to look at where we are and where we want to go.
- For many reasons, switching away from event-by-event readout solves a lot of upcoming challenges.
  - The leading alternative is "streaming readout". In this model merging data from different detectors into an event is delayed as long as possible.
  - This removes the need to synchronize readout in real time in hardware.
  - Instead data streams in independent parallel channels to a large and fast online store and is merged in software as required in nearline or offline computing systems.



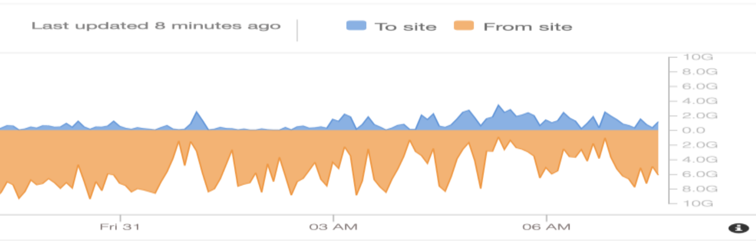
Where we are, link to this meeting

- To move things along we have taken several projects at JLab and grouped them as the “Streaming Readout Grand Challenge”.
  - *To develop a proof of concept integrated readout and analysis based on modern and forward looking techniques in disciplines such as electronics, computing, AI, algorithms and data science.*
- This is a multi-year program but has near term impact for several relatively upcoming 12 GeV experiments.
- Areas of investigation that may be of interest :
  - Low cost streaming capable detector mounted electronics.
  - Protocol and technology for accurately timestamping data.
  - Efficient real time data transport and management.
    - Example, rapidly retrieve or delete data within timestamp ranges.
  - Efficient real time data manipulation
    - Example zero-suppression, pattern finding, reformatting

Computing: the only constant is change

- Must adapt hardware model and services
  - Computing has an increasingly heterogenous look
    - Challenging for physicist-programmers
    - Interested in anything that simplifies the programming model
  - FY 20 focal area: Data storage, data management, data movement
- Must enable new technologies
  - Machine Learning & AI for science
- Many underlying applications and tools in current use started out as SBIR/STTR (batch system, data transport JupyterHub,..)
  - Time is ripe for a New Generation

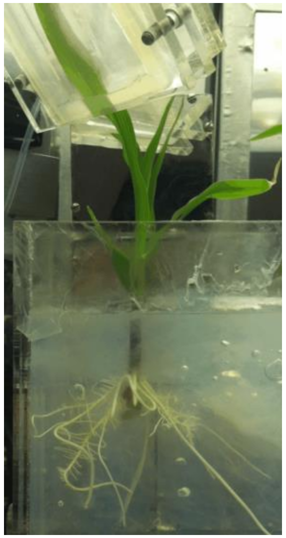
Wide Area Data transfer turns on….

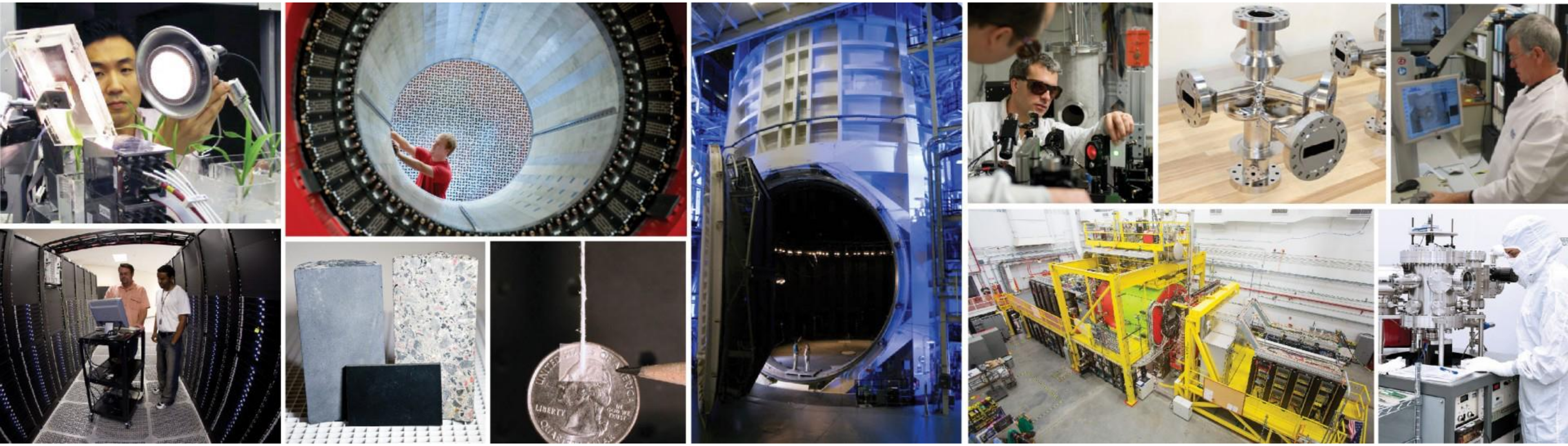


JLab & the NP SBIR/STTR Program

Synergistic involvement

- Accelerator Technology
- Computing, Software and Data Management
- Instrumentation, Detection Systems & Techniques

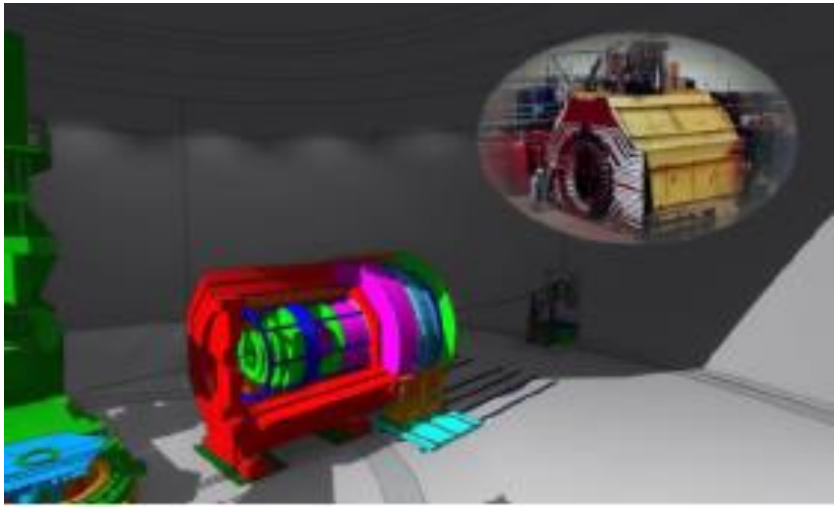




Solenoidal **L**arge **I**ntensity **D**evice (SoLID)

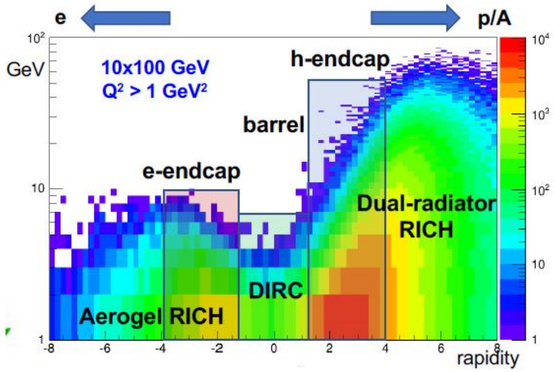
- Full exploitation of JLab 12 GeV Upgrade
  - A Large Acceptance Detector That Can *Also* Handle High Luminosity (10^{37}-10^{39})
  - *Take advantage of latest developments in detectors, data acquisition and simulations*
  - Test bed for EIC detector technology
- EM Calorimeter: particle identification, mainly electron PID
  - Photon detection requires optical fiber with high efficiency
- GEM detectors: tracking
  - High rate readout in high radiation environment
- TOF for hadron (pion) PID
  - Fast readout electronics
- Gas Cherenkov: electron and hadron PID
  - Photon sensors in high background environment

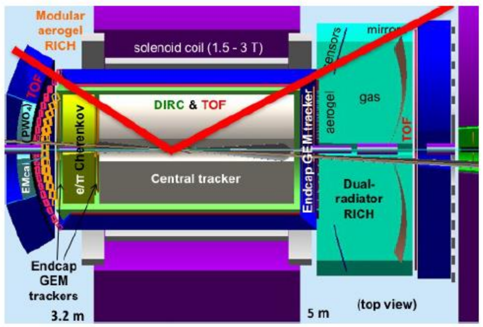
An example: One of many large installation experiments planned for the laboratory



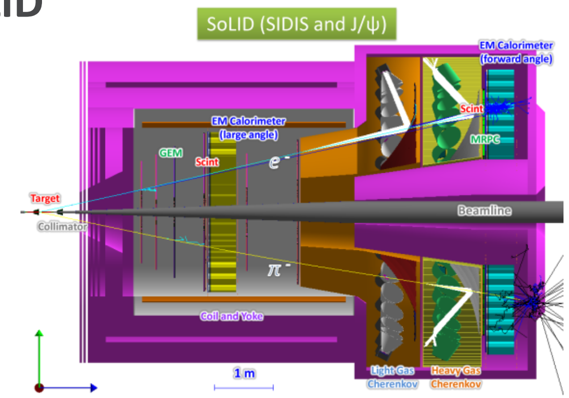
Particle Identification based on Cherenkov detection

EIC-PID





SoLID



SoLID: Extremely high luminosity: ($10^{36\sim39}$ $cm^{-2}s^{-1}$)

§ **Light gas Cherenkov**: Electron/pion separation. *Momentum range: 1.0 - 7.0 GeV/c*

§ **Heavy gas Cherenkov**: Pion identification. *Momentum range: 2.5 - 7.5 GeV.*

Hamamatsu 12700 **MaPMT** is of SoLID consideration. Cons: Expensive, won't work in magnetic field, needs shielding.

EIC-PID: Imaging Cherenkov detectors are the primary technology

§ **h-endcap**: A RICH with two radiators (gas + aerogel): *p/K separation up to ~50 GeV/c*

§ **e-endcap**: A compact aerogel RICH: *p/K separation up to ~10 GeV/c*

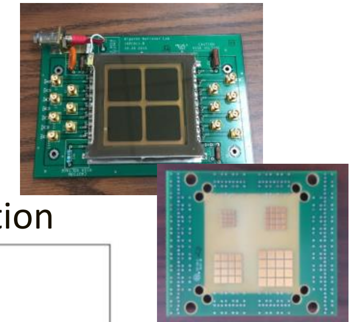
§ **barrel**: A high-performance DIRC: *p/K separation up to ~6-7 GeV/c*

Photonis **Planacon** is available to EIC-PID. Cons: Very expensive.

Low-cost, reliable highly-pixelated (3x3 mm^2) photodetector with **high magnetic field tolerance** (>1.5 Tesla, 2~3 T), **high rate capability** (≥200 kHz/cm^2) and **radiation hardness** (10 Mrad with 10^{15} n/cm^2) is needed for **Cherenkov detectors** for **Particle Identification** at NP programs.

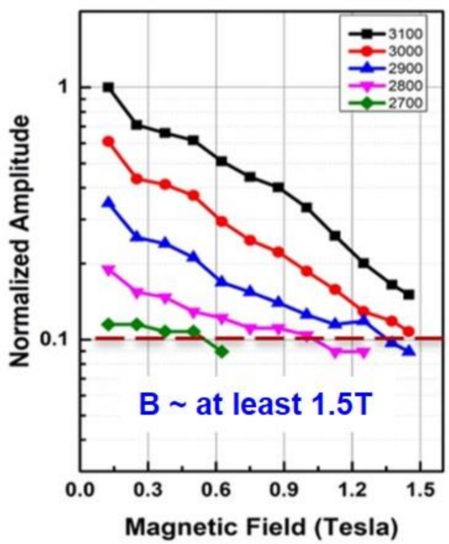
Efforts to address NP needs

Develop MCP-PMTs with whole glass designs specifically for NP-PID:
Mature and low-cost fabrication technique, high yield



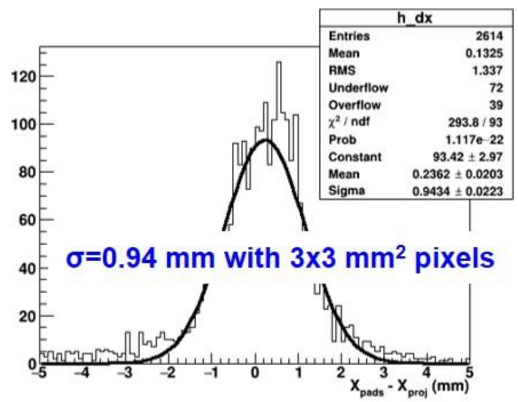
Magnetic field tolerance

ANL version-4 design

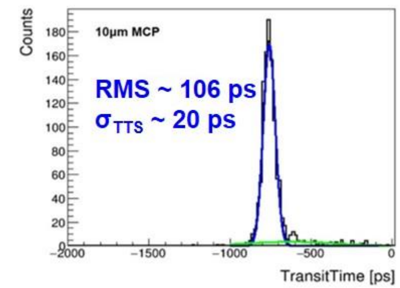


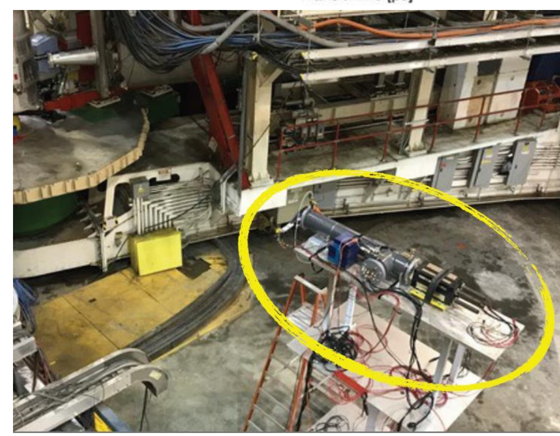
Fine pixel size (2~5x mm^2)

Pixel size	X res (mm)	Y res (mm)
2x2 mm^2	1.4	1.7
3x3 mm^2	0.94	0.95
4x4 mm^2	0.81	0.76
5x5 mm^2	1.1	0.97



Time resolution





Demonstrated specifications (magnetic field, pixel size, time resolution) at Argonne whole glass, low-cost MCP-PMT design, encouraging results for Cherenkov detector prototype.

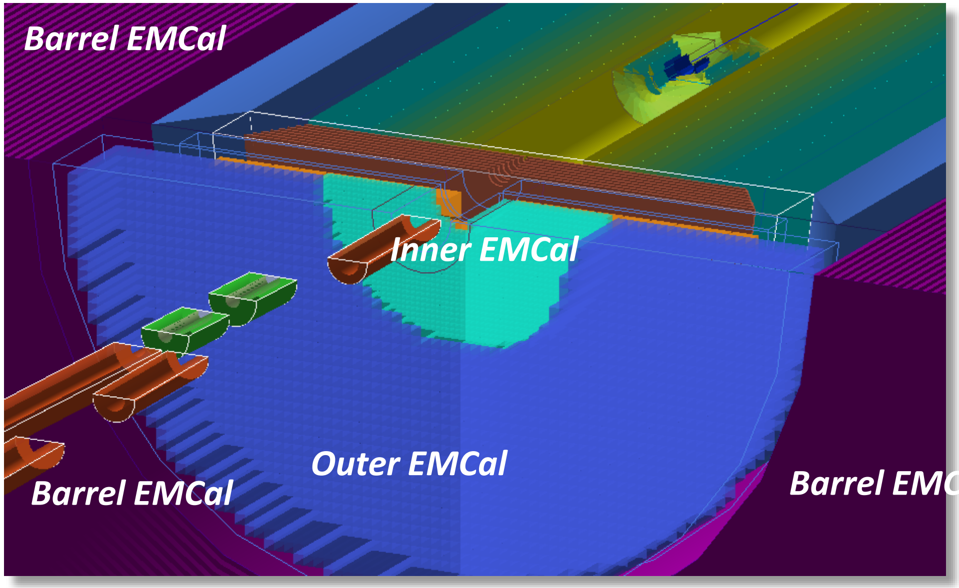
Validating rate capability in JLab high luminosity environment, needs radiation hardness study.

Investing in the future of this technology: A new effort of ANL PHY/MEP collaboration with HEP is underway to extend the whole glass design to 10x10 cm^2, applicable for Cherenkov detector prototyping.

JLab and EIC requirements on Electromagnetic calorimetry

- ❑ JLab 12 GeV requires EMCal for standalone detectors for photon and neutral pion detection
- ❑ EIC requires EMCal for endcaps, large volume barrel, and auxiliary detectors
- ❑ $PbWO_4$ crystals are ideal for precision, but also have limitations and are expensive ($15-25/$cm^3$) – large volume detectors are unaffordable
- ❑ ***Glass-based scintillators are cost-effective alternative to crystals***

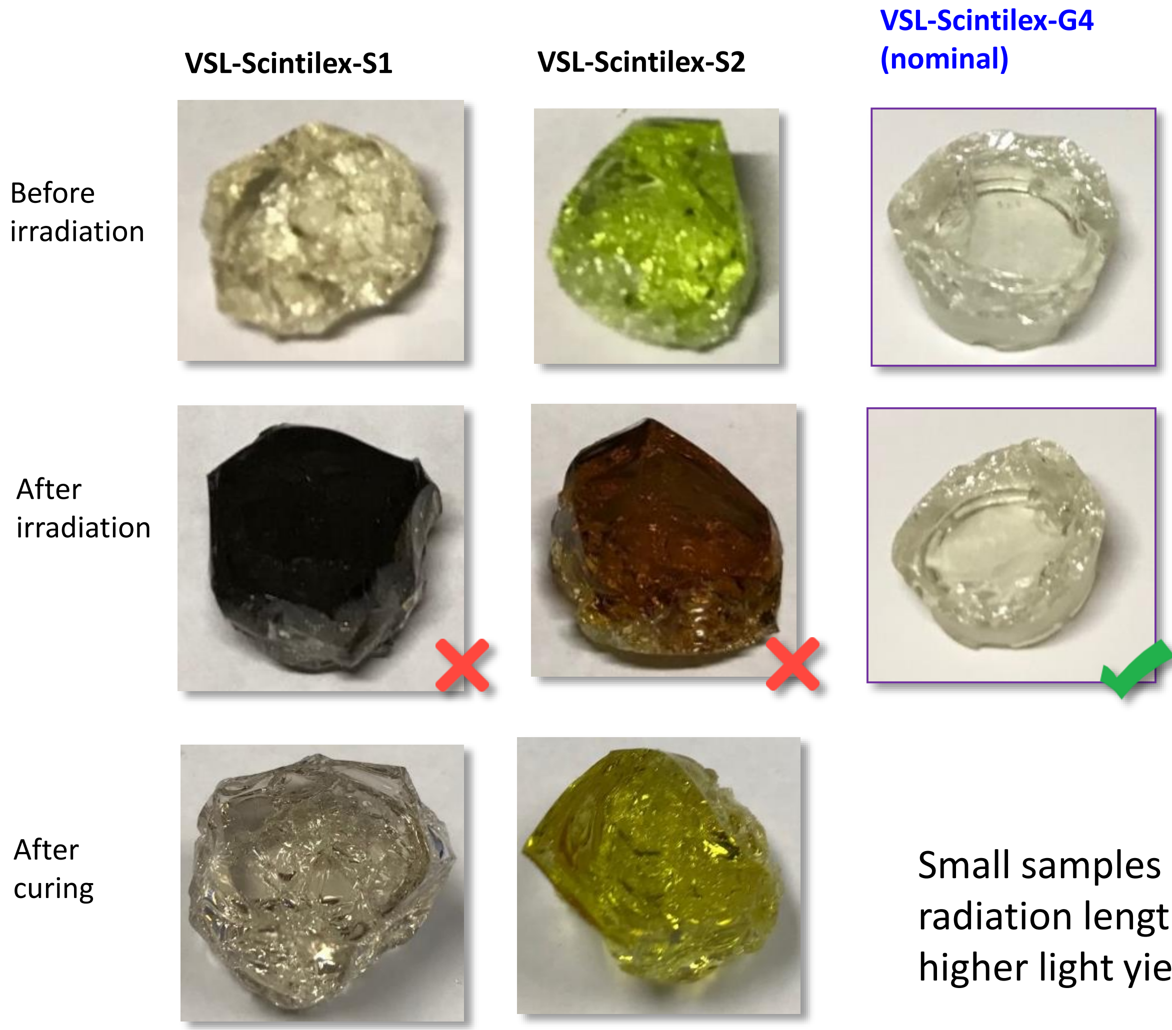
JLab 12 GeV Hall A/C EMCal

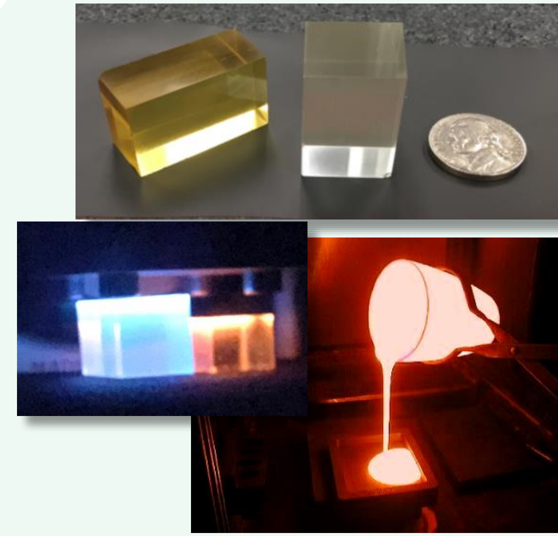


EIC endcap and barrel calorimeters

Glass Scintillator for EM Calorimeters

Large expertise with glass at CUA/VSL/Scintilex

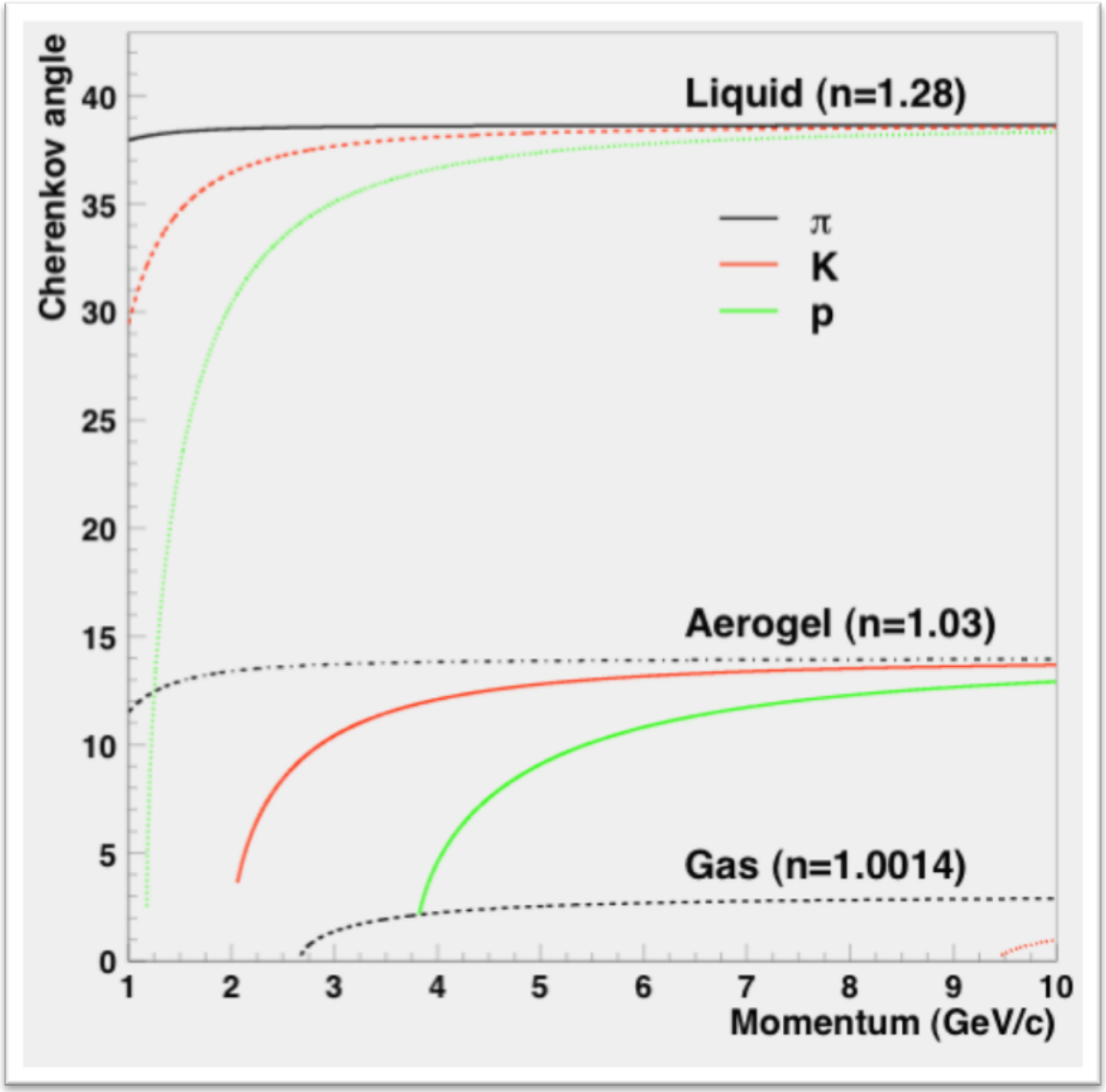




SCINTILEX

Small samples are radiation hard, have good radiation length, timing, and a factor of ten or higher light yield as compared to $PbWO_4$

JLab and EIC requirements on Radiators for Cherenkov Light



- ❑ Aerogel is mandatory to separate hadrons in the 2-8 GeV/c momentum range for threshold and ring-imaging Cherenkov detectors at Jlab 12 GeV and EIC
- ❑ Rayleigh scattering is the dominant cause of aerogel image degradation
- ❑ Rayleigh scattering increases as λ^{-4}
  ➔ collection of visible Cherenkov light
- ❑ Cherenkov Light is a WEAK source of radiation
  ➔ Aerogel should be as transparent as possible

Aerogel for threshold and focusing detectors

SCINTILEX

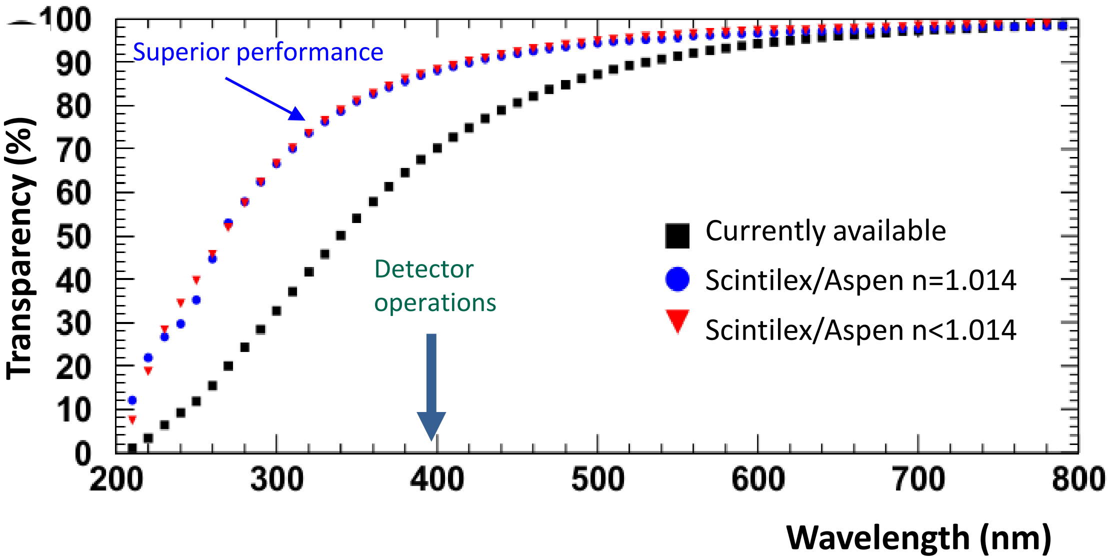
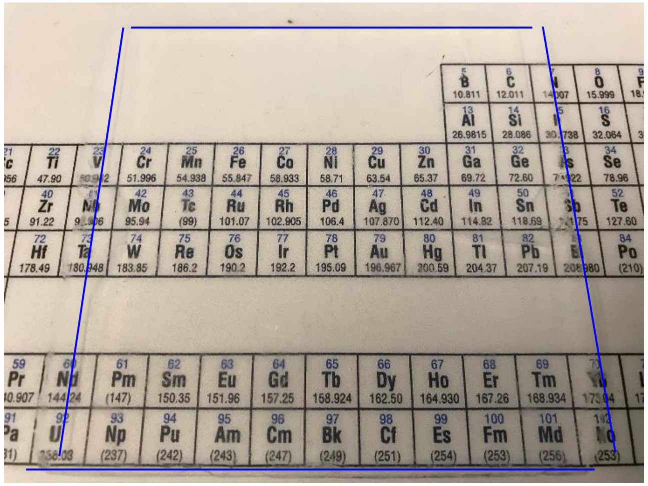
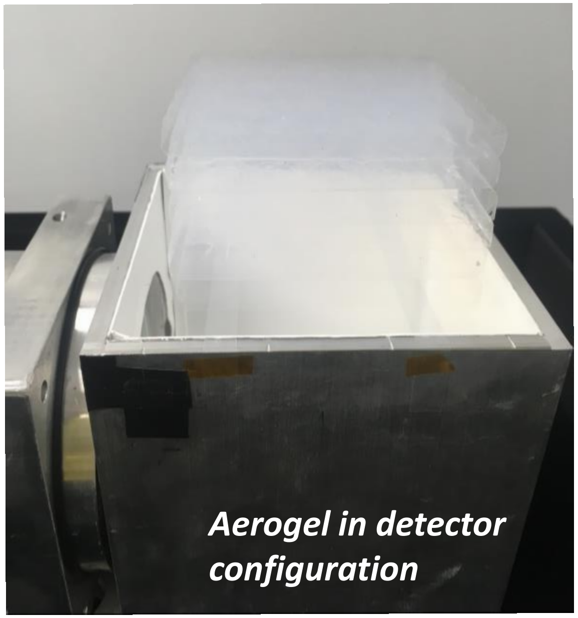


Illustration of aerogel transparency

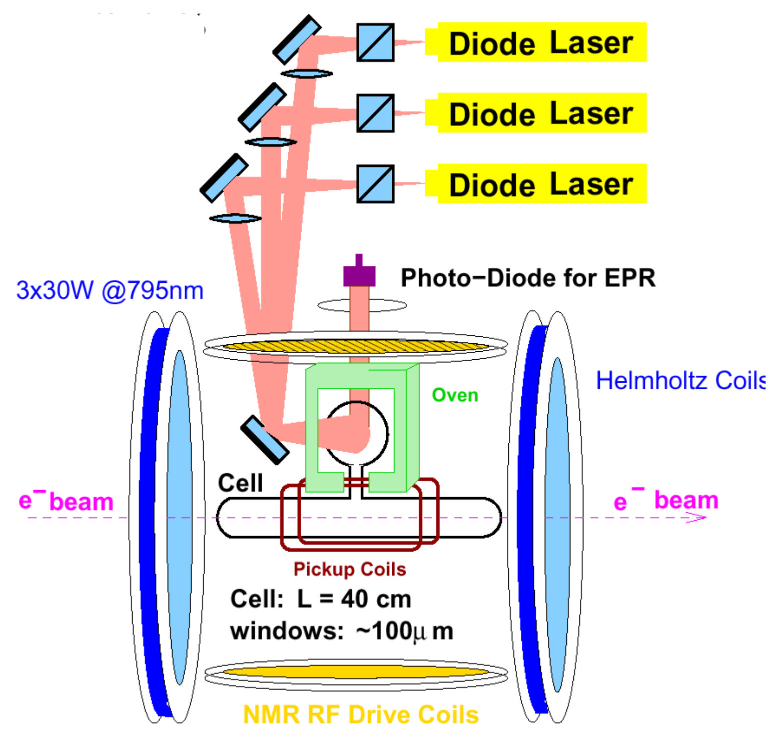




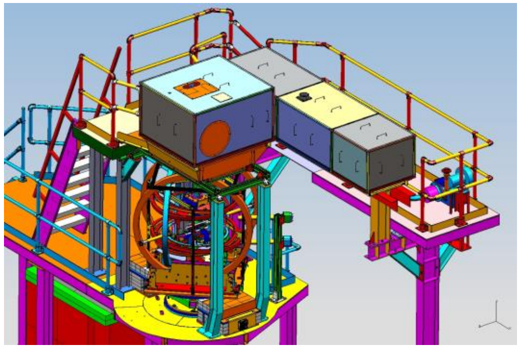
- ❑ Transparency, optical properties, and light yield of samples are superior to existing aerogel
- ❑ Investigating novel method to reinforce optical aerogels to facilitate manufacturing and use in nuclear physics detectors

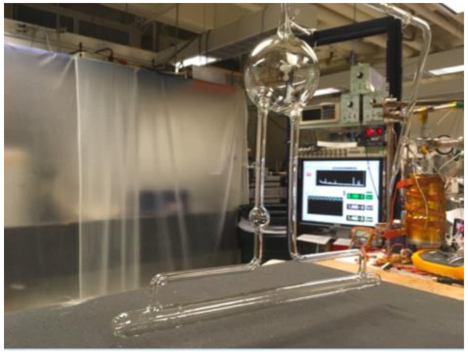
Not just detectors: polarized ^3He target

30 uA on 40 cm , ~10 atm, L ~ 2.2x10^{36} cm^{-2}s^{-1}
In-beam polarization ~ 55-60%,
Polarization measurement precision ~ 3%



- ✓Effective polarized
  neutron target
- ✓13 completed experiments
  8 approved with 12 GeV (A/C)
- ✓longitudinal,
  transverse and vertical
- ✓ Luminosity=10^{36} (1/s)
  (highest in the world)
  upgrade on the way to 10^{37}
- ✓ High in-beam polarization
  60% (>70% no beam)

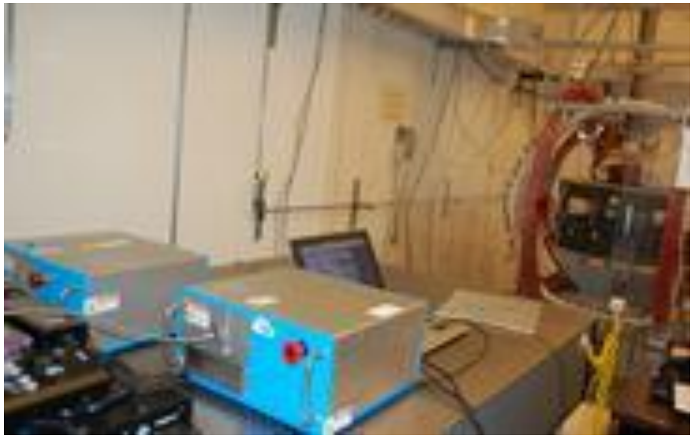




Polarized ^{3}He and SBIR

- Requires high-power, narrow wave-length, high quality, stable long-term operation condition laser system
  - RAYTUM Photonics SBIR phase I and II

- RAYTUM has also helped with a number other issues:
  - Software control of laser multi-sets with interface to standard JLab control system (EPCIS)
  - Optical fiber system, multifibers-to-1 combiner, long-distance transmission
  - Coupling of weak electron paramagnetic resonance (EPR) optical signal into fiber for long distance transmission



JLAB SBIR Program Overview

- Jefferson Lab actively seeks opportunities with **Industrial Partners** to conduct research that is aligned with our Laboratory Agenda
- Laboratory staff work with the **SBIR Program Manager** to edit topical areas for the different Funding Opportunity Announcements
- Solicitations received from Industry cover a broad spectrum of potential opportunities
- We monitor awards for potential synergies with our Strategic Plan
- Interested in growing the program along R&D tracks consistent with the Laboratory Agenda
- Shoring up internal processes to streamline industry engagement with Jefferson Lab
- Held an Industry Day Event in December of 2018 – Accelerators: Driving Applications for Society: https://www.jlab.org/indico/event/297/
- In FY19 16 of 38 supported proposals received an award

FY19 SBIR R&D at Jefferson Lab

Topic	Title	Industrial Partner	Phase
SRF	High Force Spring Clamp System	George H. Biallas P.E	I
SRF	Cold Spray Technology Applications for SRF Cavity Thermal and Mechanical Stabilization	Euclid TechLabs LLC	I
SRF	Stand-alone accelerator system based on SRF quarter-wave resonators	RadiaBeam Systems, LLC	I
SRF	A Method for “in Situ” Measurements of the Unloaded High-Quality Factor of an SRF Resonator Installed at a Cryomodule	Euclid Beamlabs LLC	I
Source	Ultrafast High Voltage Hardware for Ion Clearing Gap	RadiaBeam Systems, LLC	I
Source	"Black Gun" Technologies for DC Photoinjectors	Euclid Beamlabs LLC	I
Source	Vacuum Barriers for XHV Operation of DC Electron Guns	Xelera Research LLC	I
Source	Nanostructured GaAs Photocathodes for Light Trapping and Ion Damage Tolerance	Euclid Beamlabs LLC	I
Controls	A browser based toolkit for improved particle accelerator controls	RadiaSoft LLC	I
Diagnostics	Electron Beam Halo Monitor using BNNT flag	RadiaBeam Systems, LLC	I
Magnets	6 T Large-Aperture Dipole for a 200 GeV Ion Ring for JLEIC	Accelerator Technology Corporation	I
Detectors	High Performance Glass Ceramic Scintillators for Particle Detection in Nuclear Physics Experiments	Scintilex	I
Detectors	Low-cost and Efficient Cooling of on-Detector Electronics Using Conformal Thermoelectric Modules	Nanohmics, Inc	I
Detectors	High Performance Scintillator and Beam Monitoring System	Integrated Sensors, LLC	I
Electron Cooling	Dynamic friction in magnetized electron coolers for relativistic beams	RadiaSoft LLC	II
Source	Precise and ultra-stable laser polarization control for polarized electron beam generation	Raytum Photonics	II

New Tech Center Adjacent to Jefferson Lab

- 80,000 square feet available
- Entrance to the park located at the intersection of Jefferson Avenue & Hogan Drive
- Situated next to Marketplace at Tech Center featuring over 250,000 SF of retail, restaurants, and Crunch Fitness, and the Venture Apartments [iN] Tech Center
- Walking and biking trails
- Access to VT KnowledgeWorks, a business acceleration program at Virginia Tech Corporate Research Center
- Access to videoconferencing and conference rooms
- World leading research grade internet speeds available
- Co-working space available in the building
- Plus, career boards; U.S. mail pick up; personal housekeeping in suites; Newport News Enterprise Zone; networking events, maintenance and after hours assistance

AERIAL MAP

TECH CENTER is adjacent to the Jefferson Lab and minutes from NASA's Langley Research Center. Tech Center is a partnership between W. M. Jordan Development Company, Virginia Tech Corporate Research Center, retail developer S. J. Collins Enterprises, and residential apartment developer Venture Realty, and the City of Newport News. The current development includes 250,000 SF of retail and restaurants, over 250 upscale apartment homes, and at completion, nearly 1 million square feet of research and office space.

- **Located on 50 acres adjacent to Jefferson Lab**
- **Follows the proven business model at Virginia Tech Corporate Research Center (VTCRC)**
- **1 million square feet of research and office space**

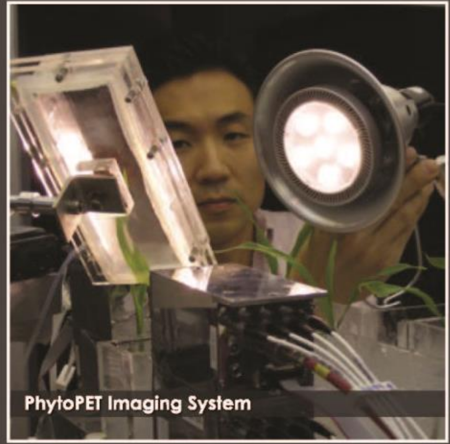
Summary

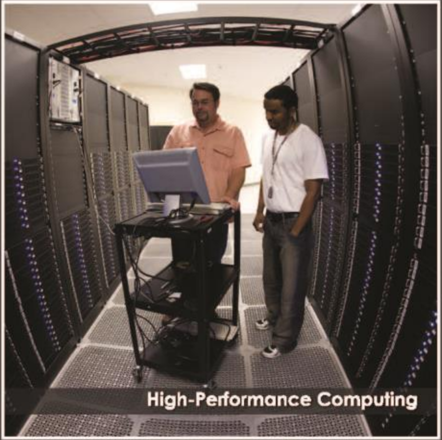
- Jefferson Lab has multiple facilities spanning a broad range of expertise that can be used to support R&D activities

- The SBIR/STTR program at JLab has been growing over the last few years and covers a wide range of R&D topics
- The Laboratory is seeking to continue to grow the SBIR/STTR R&D program along topics that are consistent with the Lab Agenda and our Strategic Vision

Thank you!

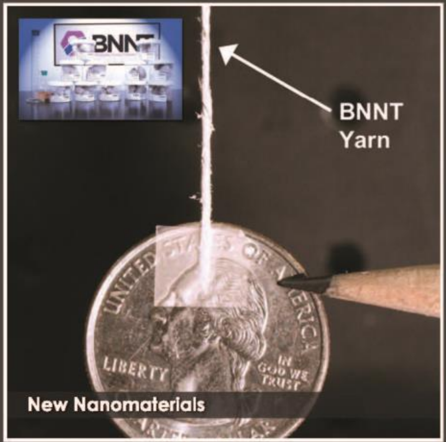
Jefferson Lab FACILITIES EXPERTISE & EQUIPMENT FUEL INNOVATION, FEED BUSINESS


PhytoPET Imaging System

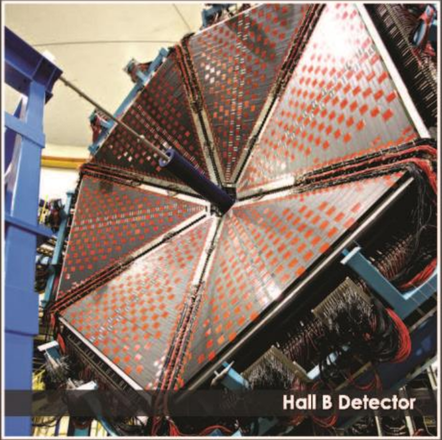

High-Performance Computing

EXPERTISE

- Cryogenics
- High-Performance Computing
- High-Power RF
- Radiation Testing of Materials
- Ultra-High Vacuum
- Radiation Shielding
- Industrial-Scale Control Systems
- Sophisticated Simulation Capabilities
- Safety Systems
- Biological and Medical Imaging



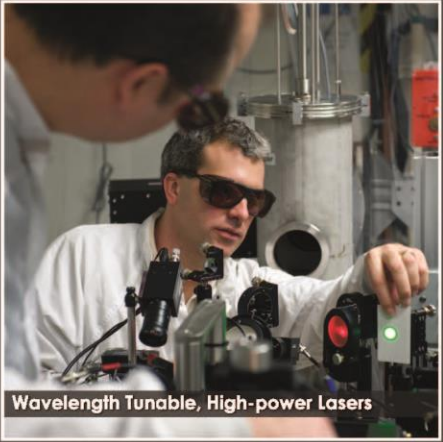
New Nanomaterials


Hall B Detector

FACILITIES AND EQUIPMENT

- Cleanrooms
- Magnetically Shielded Room
- Electron Accelerators
- Wavelength Tunable, High-power Lasers
- Electron Beam Welder
- < 4 Kelvin Dewars
- Nuclear Radiation Detectors
- Surface Analysis Equipment
- CW Free Electron Laser *(world record power)*
- TeraHertz beam *(world record power)*


Crab Cavity


Wavelength Tunable, High-power Lasers


Medical Imaging for Treatment and Diagnostics


Cleanrooms