Jefferson Lab Status

Hugh Montgomery

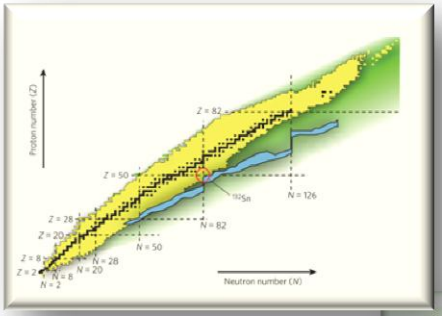
Jefferson Lab PAC 40, June 2013

Jefferson Lab
Thomas Jefferson National Accelerator Facility

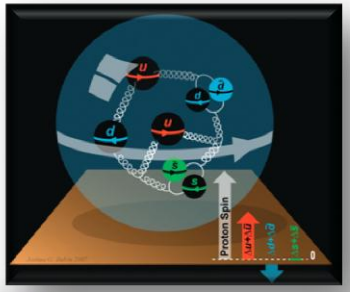
Outline

- Introduction
- Budgets
- NSAC
  - Implementation Subcommittee
  - Facilities Committee
- Upgrade Progress/Rebaselining
- Summary

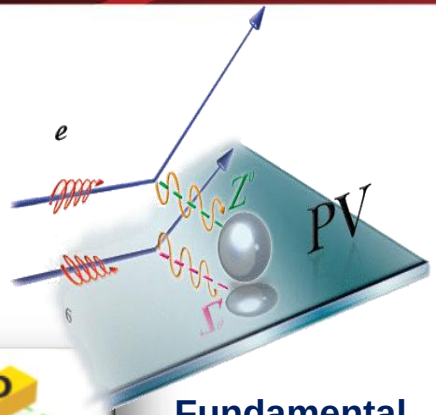
JLab: A Laboratory for Nuclear Science



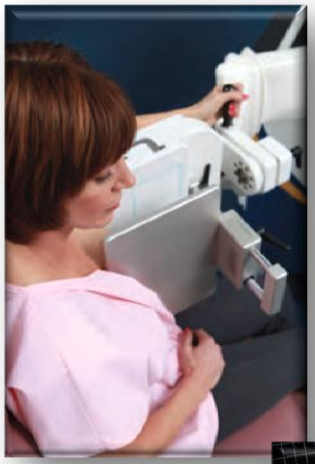
Nuclear Structure



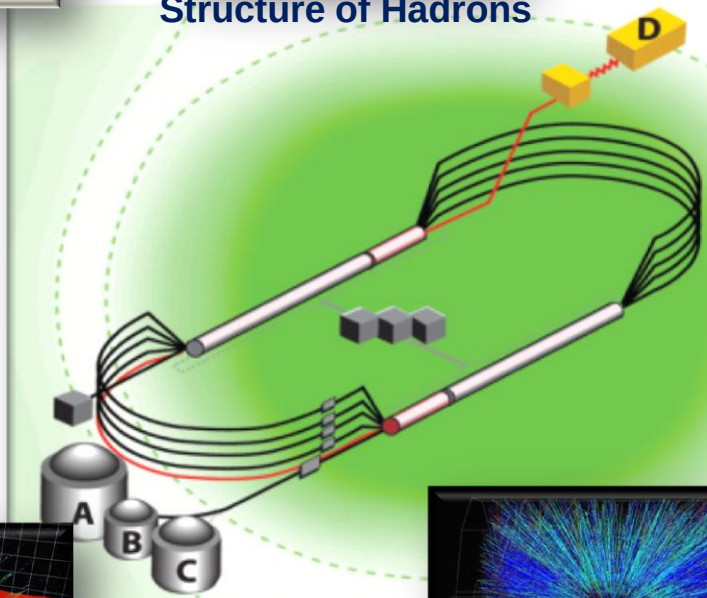
Structure of Hadrons



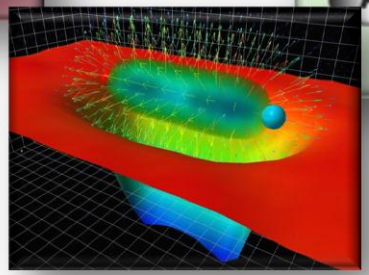
Fundamental
Forces & Symmetries



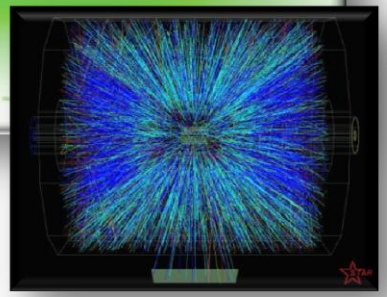
Medical Imaging



Accelerator S&T



Quark Confinement

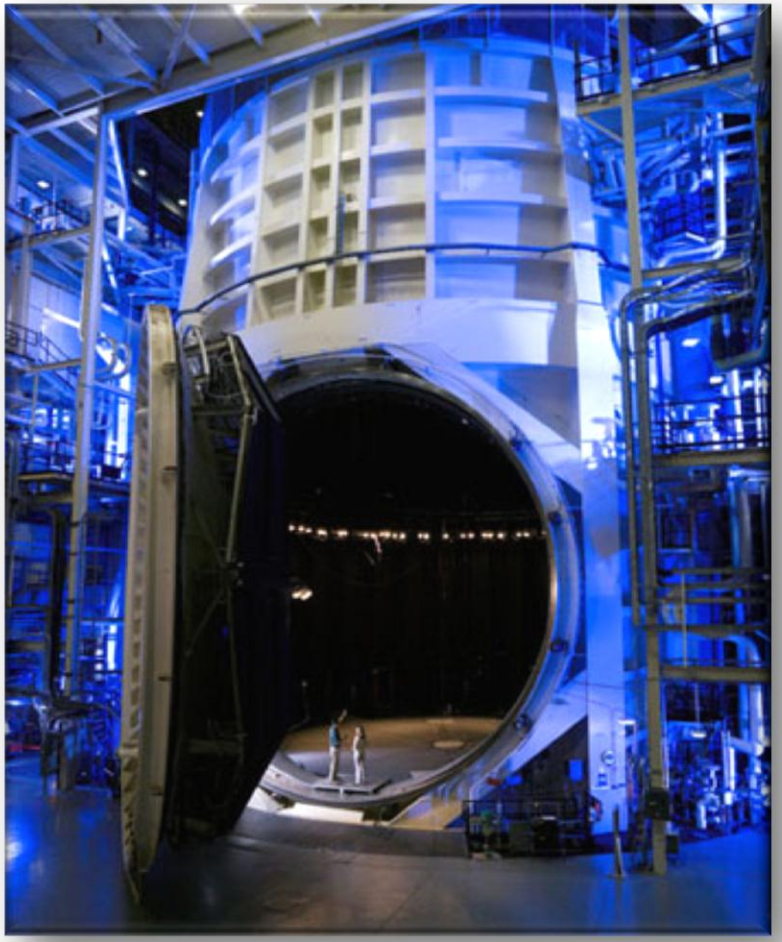


Hadrons from quarks

Theory and
Computation

Technology Transfer:
NASA Cryo Systems Exhibit Unprecedented Efficiency

- **Jefferson Lab's cryogenics group helped NASA scientists design and commission a cryogenics system for the James Webb Space Telescope to ensure that the telescope is fit for its mission:**
  - Cools the telescope's components to temperatures its instruments will experience in space, to within 30 degrees Fahrenheit of absolute zero.
  - Triples refrigeration system capacity of the current system and was the first built using the award-winning, energy-saving floating pressure Ganni Cycle technology, developed at Jefferson Lab.
  - Demonstrates an unprecedented range of load temperature and capacity while maintaining peak efficiency and temperature stability during commissioning.



NASA Johnson Space Center's Space Environment Simulation Lab Chamber
A Photo: NASA

Technology Transfer: Nuclear Medicine Imaging
Clear 3D Brain Scans of Moving Mice

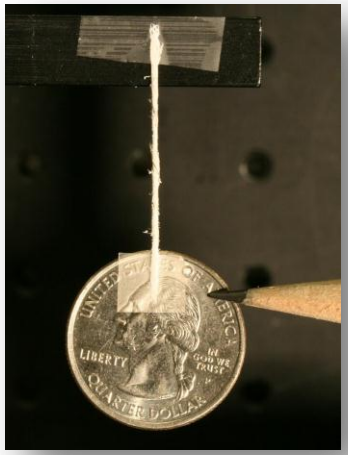
- **AwakeSPECT System** is based on technology developed by Jefferson Lab, with contributions from ORNL, Johns Hopkins University and University of Maryland:
  - Utilizes custom-built gamma cameras, image processing system, infrared camera system and commercial CT system.
  - Acquires functional brain images of conscious, unrestrained, and un-anesthetized mice.
  - Documents for the first time the effects of anesthesia on the action of dopamine transporter imaging compound, and shows the drug was absorbed less than half as well in awake mice than in anesthetized mice.
  - Can aid research into Alzheimer's, dementia, Parkinson's, brain cancers and drug addiction.

Three markers attached to the head of a mouse enable the AwakeSPECT system to obtain detailed, functional images of the brain of a conscious mouse as it moves around inside a clear burrow.

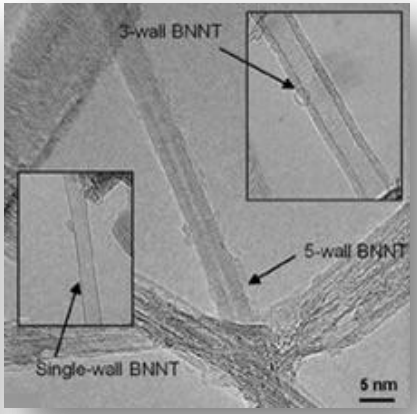
Technology Transfer: Boron Nitride Nanotubes (BNNT)

- **BNNT**:
  - Lightweight, very strong, electrically insulating, thermally conductive, likely not cytotoxic
  - Maintains strength to > 900°C vs. carbon at 400°C
  - Fibril; few defects, NO metal catalyst impurities vs. carbon (not fibril)
  - Possible applications: biomedical - scaffolding for living tissue; chemical -aircraft, aerospace, jet engine parts, fire retardant cabling, electrical insulation, athletic equipment and more.

- BNNT Intellectual Property (IP) developed from research conducted at JLab's FEL in collaboration with NASA Langley Research Center (LaRC) and National Institute of Aerospace (NIA).
- BNNT IP disclosed for patent application and captured in joint ownership agreement by JSA/JLab, NIA and LaRC.
- Adopted DOE-approved JLab Entrepreneurial Leave Program for JSA/JLab employees to advance technology to commercialization.
- BNNT, LLC factory construction began May 1, 2013 in Newport News, Virginia.



Raw BNNT Yarn



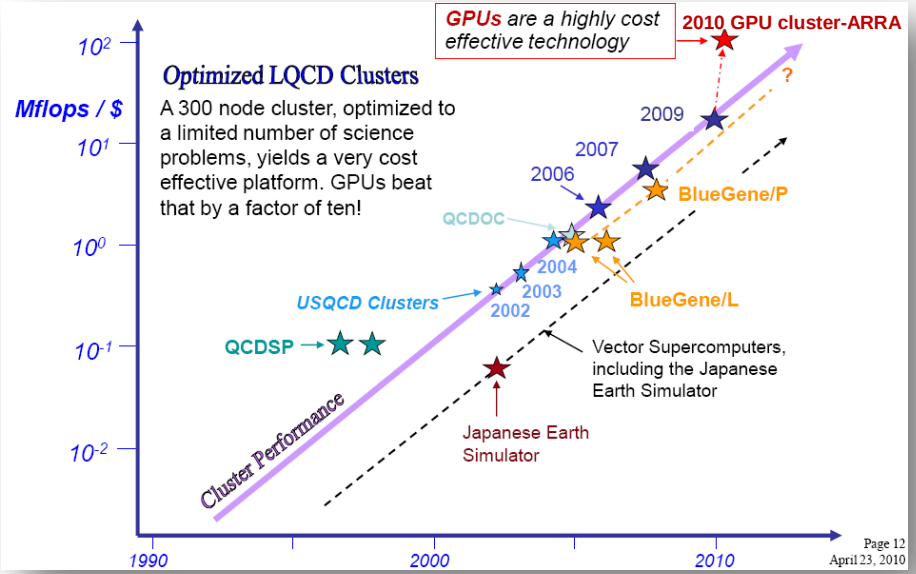
Blowup of BNNT showing few wall structures

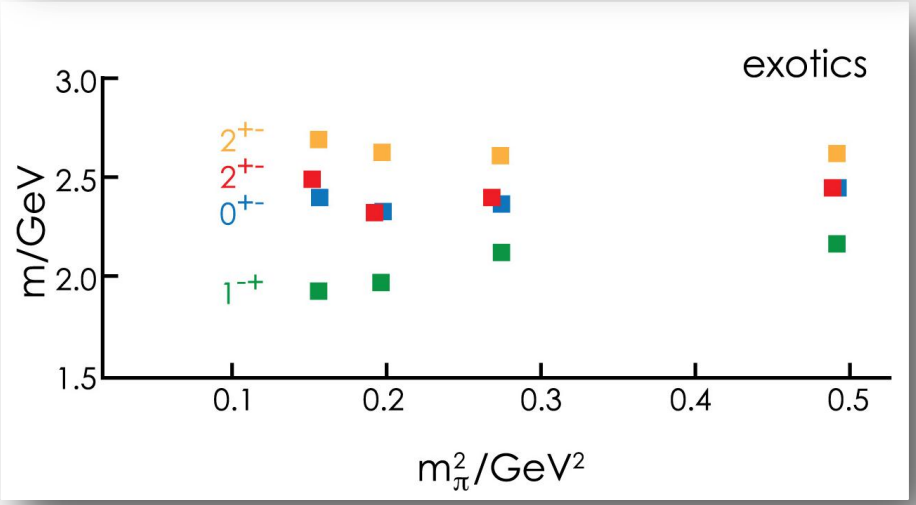
BNNT Fibril Mass

BNNT is Jefferson Lab's current success story in- progress, employing technology transfer tools made available by the DOE

Theory and Computation

- Nuclear Physics Phenomenology
  - Often related to JLab expt. Program
  - JLab Physics Analysis Center (JPAC)
  - New world-wide initiative
  - Adam Sczepaniak to lead (Jlab/I.U.)
- Lattice QCD computation
  - Meson/baryon spectroscopy
  - JLab experiments
  - GPU implementation (Chroma)





Lattice QCD

USQCD

Jefferson Lab Leadership

- David Richards, Executive Committee Member
- Robert Edwards, Program Committee Chair
- Balint Joo, Chair, Users Community ORNL

Infrastructure

Clusters & GPUs

Chroma

SciDAC
Scientific Discovery through Advanced Computing

ARRA & NP
Facilities Project

SciDAC
Scientific Discovery through Advanced Computing

SUPER
INSTITUTE FOR SUSTAINED PERFORMANCE, ENERGY, AND RESILIENCE

- Domain specific language
- Optimize codes for leadership & accelerated architectures
- Implement multi-grid & domain decomposed inverters
- Prepare for new technologies

Budgets/Sequestration

	FY09	FY10	FY11	FY12 Approp Reallocated	FY13 Proposed Reallocation	FY14 Guidance Reallocated
Accelerator Operations	47,420	46,080	44,426	45,140	39,916	51,383
SRF R&D	1,635	1,365	2,421	2,100	2,050	2,141
Accelerator Facility Capital	130	200	200			725
Accelerator Improvement Projects	650	1,050	1,050	622	2,600	2,145
Experimental Facility Operations	24,559	25,967	27,150	27,920	27,500	27,970
Experimental Facility Capital	4,500	6,605	5,250	250	2,400	4,480
GPP	1,800	2,000	2,516	2,000	2,500	2,000
Subtotal NP Facility Ops	**80,694**	**83,267**	**83,013**	**78,032**	**76,966**	**90,844**
ME Research	6,150	6,200	6,495	7,050	7,330	6,852
Theory Research	3,400	3,699	4,000	3,900	4,000	3,873
12 GeV	28,623	20,000	35,928	50,000	43,072	30,000
LQCD & SciDAC	751	638	1,149	1,244	-100	300
Total NP Base and 12 GeV	**119,618**	**113,804**	**130,585**	**140,225**	**131,268**	**131,869**

Sequestration so far $1M reduction from FY2013

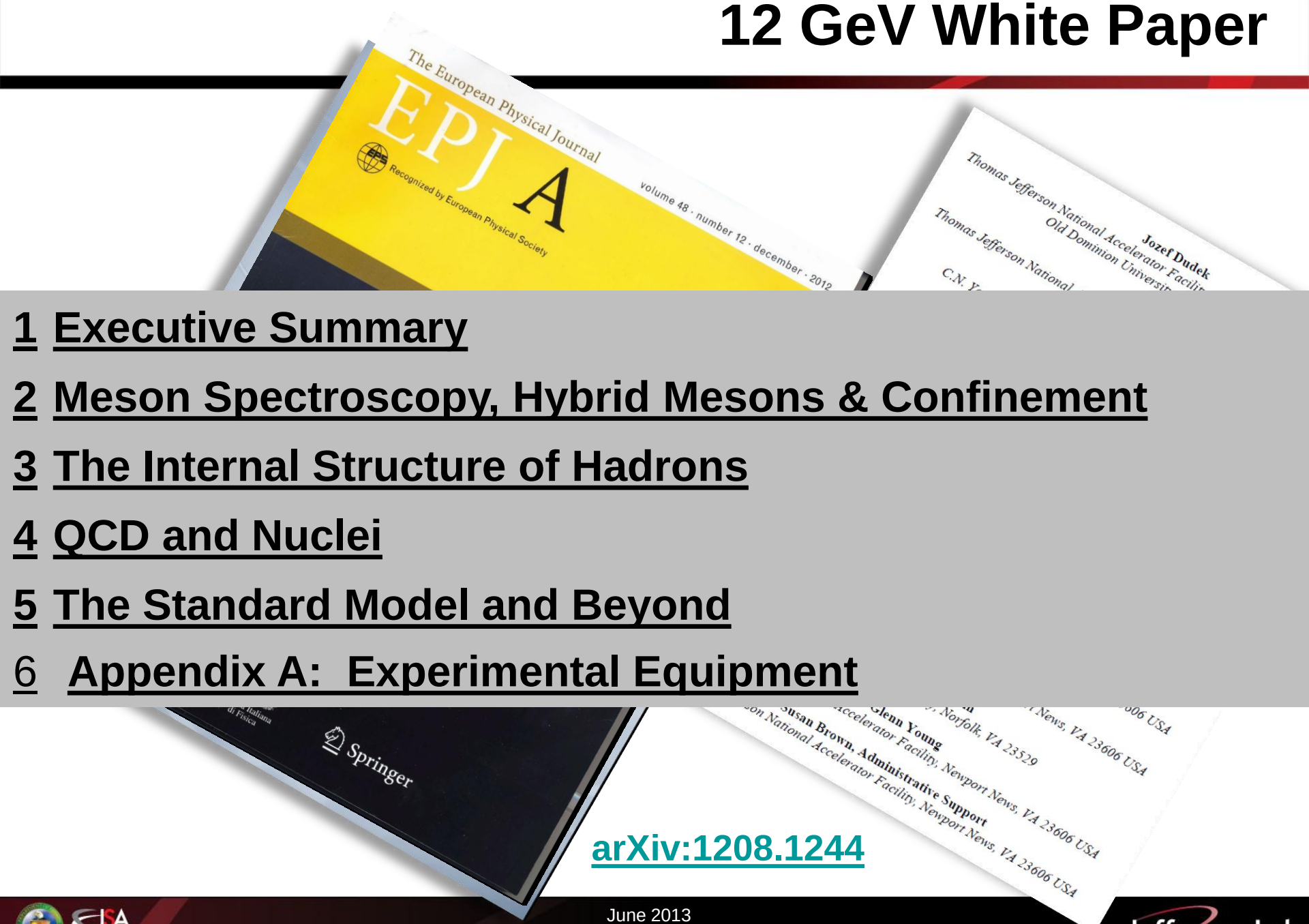
Charge to NSAC (4-5-2012)

We seek advice from NSAC on implementing the priorities and recommendations of the 2007 Long Range Plan in light of projected budgetary constraints and for guidance on developing a plan to implement the highest priority science in the context of likely available funding and world-wide capabilities. We request that NSAC examine the existing research capabilities and scientific efforts, assess their role and potential for scientific advancements, and advise the two agencies regarding the time and resources needed to achieve the planned programs. Your report should describe how to optimize the overall nuclear science program over the next five years (FY 2014-2018), under at least the following funding scenarios for the nuclear science budgets at the two agencies: (1) flat funding at the FY 2013 request level, and (2) modest increases over the next five years.

Based on the priorities and opportunities identified and recommended in the 2007 Long Range Plan, the report should discuss what scientific opportunities will be addressed, and what existing and future facilities and instrumentation capabilities would be needed by the Federal nuclear science program to mount a productive, forefront program for each of the funding scenarios.

NSAC should submit the report by January 2013. We are aware that this is a difficult task. However, the involvement and input of the research community is essential to inform the Department's decisions regarding the strategy for implementing a world-leading U.S. Nuclear Physics program in times of fiscal constraint.

12 GeV White Paper



arXiv:1208.1244

NSAC Implementation Recommendations

- "……..was **unanimous in endorsing the modest-growth budget scenario** as the minimum level of support that is needed to maintain a viable long-term U.S. nuclear science program that encompasses the vision of the LRP (Long Range Plan)."
- "……, the subcommittee has considered the impact on the U.S. nuclear science program under three different budget scenarios. Two of them provide no growth. …….. recommendations that were made for these different scenarios must be viewed as a snapshot in time that reflects the state of the field today. ……. **under all scenarios we must capitalize on the investment that has been made to upgrade CEBAF**."

Office of Science Future Facilities

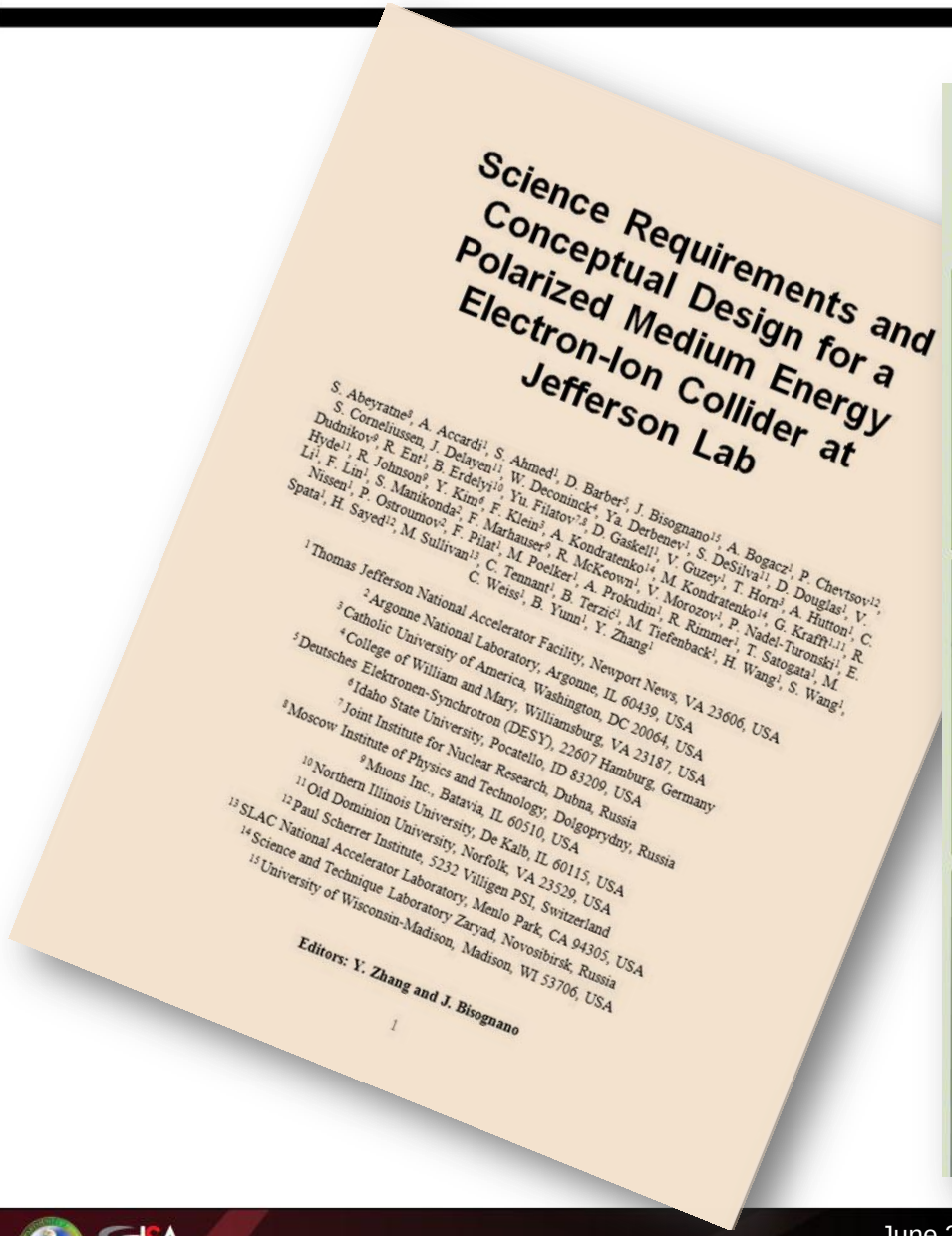
- Charge to all science Federal Advisory Committee Act committees, including NSAC
- Start with Program Office list of existing and future facilities (physics in next ten years as horizon)
- FACAs to add, subtract, rate
  - Physics: Abs. Central, important, lower priority, don't know enough
  - Readiness for construction:
    - Ready to initiate construction,
    - Significant scientific/engineering challengesto resolve before initiating construction
    - Mission and technical requirements not fully defined

NSAC Facilities Recommendations: Input to SC!!

- Existing Facilities:
  - ATLAS at ANL, RHIC at BNL, CEBAF 12 GeV at Jefferson Lab

  All considered to be absolutely central to the physics of the next decade
- Future facilities:
  - FRIB at NSCL
  - 1 tonne-scale neutrinoless $\beta\beta$ decay
  - Electron Ion Collider
  - FRIB considered central and ready to build, others considered central but with significant R&D and/or engineering before ready for construction.
- **DOE/SC will prioritize ……**

Medium Energy EIC@JLab



Science Requirements and Conceptual Design for a Polarized Medium Energy Electron-Ion Collider at Jefferson Lab

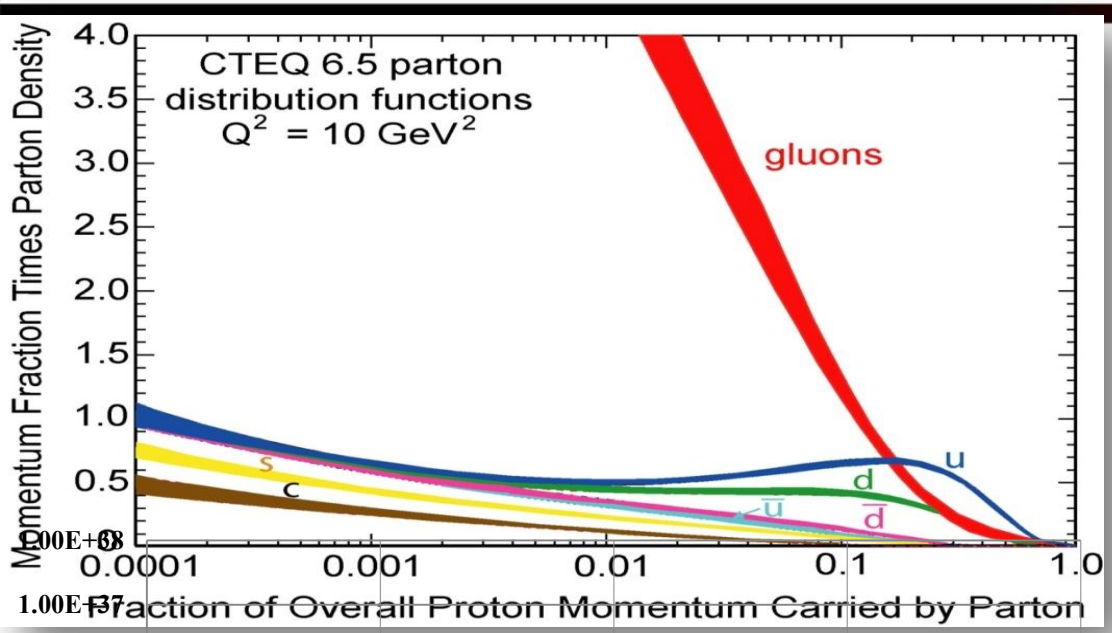
S. Abeyratne[2], A. Accardi[1], S. Ahmed[1], D. Barber[5], J. Bisognano[15], A. Bogacz[1], P. Chevtsov[12], S. Corneliussen[1], J. Delayen[11], W. Deconinck[4], Ya. Derbenev[1], S. DeSilva[11], D. Douglas[1], V. Dudnikov[9], R. Ent[1], B. Erdelyi[10], Yu. Filatov[7,8], D. Gaskell[1], V. Guzey[1], T. Horn[3], A. Hutton[1], C. Hyde[11], R. Johnson[9], Y. Kim[6], F. Klein[3], A. Kondratenko[14], V. Kondratenko[14], G. Krafft[1,11], R. Li[1], F. Lin[1], S. Manikonda[2], F. Marhauser[9], R. McKeown[1], V. Morozov[1], P. Nadel-Turonski[1], E. Nissen[1], P. Ostroumov[2], F. Pilat[1], M. Poelker[1], A. Prokudin[1], R. Rimmer[1], T. Satogata[1], M. Spata[1], H. Sayed[12], M. Sullivan[13], C. Tennant[1], B. Terzić[1], M. Tiefenback[1], H. Wang[1], S. Wang[1], C. Weiss[1], B. Yunn[1], Y. Zhang[1]

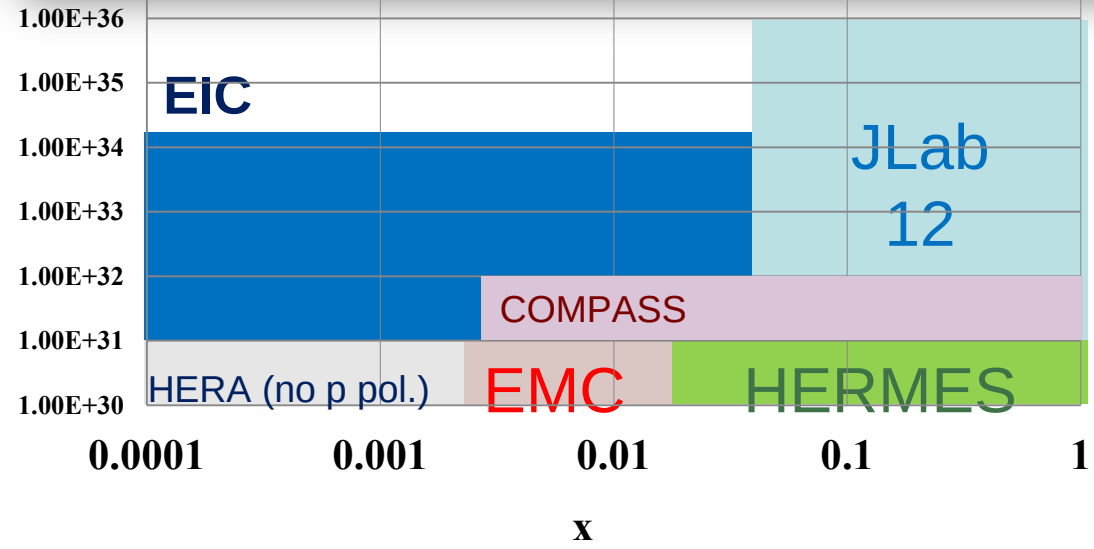
[1] Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA
[2] Argonne National Laboratory, Argonne, IL 60439, USA
[3] Catholic University of America, Washington, DC 20064, USA
[4] College of William and Mary, Williamsburg, VA 23187, USA
[5] Deutsches Elektronen-Synchrotron (DESY), 22607 Hamburg, Germany
[6] Idaho State University, Pocatello, ID 83209, USA
[7] Joint Institute for Nuclear Research, Dubna, Russia
[8] Moscow Institute of Physics and Technology, Dolgoprydny, Russia
[9] Muons Inc., Batavia, IL 60510, USA
[10] Northern Illinois University, De Kalb, IL 60115, USA
[11] Old Dominion University, Norfolk, VA 23529, USA
[12] Paul Scherrer Institute, 5232 Villigen PSI, Switzerland
[13] SLAC National Accelerator Laboratory, Menlo Park, CA 94305, USA
[14] Science and Technique Laboratory Zaryad, Novosibirsk, Russia
[15] University of Wisconsin-Madison, Madison, WI 53706, USA

Editors: Y. Zhang and J. Bisognano

1

The Reach of EIC





- **High Luminosity**
  → 10^{34} cm^{-2}s^{-1}
- **Low x regime**
  x → 0.0001
- **High Polarization**
  → 70%

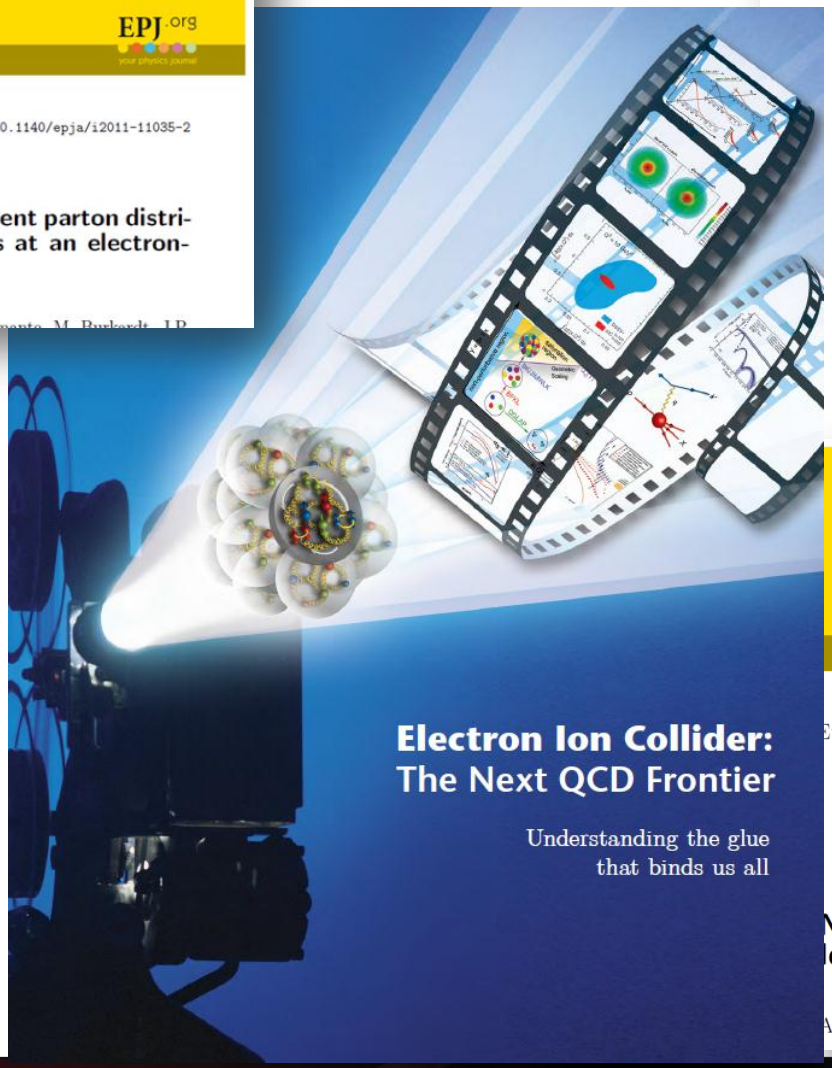
Discovery Potential!

Recent Documents

EPJ A
Hadrons and Nuclei
EPJ.org
your physics journal

Eur. Phys. J. A (2011) 47: 35 DOI: 10.1140/epja/i2011-11035-2

Transverse-momentum–dependent parton distribution/fragmentation functions at an electron-ion collider



The EIC Science case: a report on the joint BNL/INT/JLab program

Gluons and the quark sea at high energies: distributions, polarization, tomography

Institute for Nuclear Theory, University of Washington, USA
September 13 to November 19, 2010

Editors:
D. Boer, Universiteit Groningen, The Netherlands
M. Diehl, Deutsches Elektronen-Synchroton DESY, Germany
R. Milner, Massachusetts Institute of Technology, USA
R. Venugopalan, Brookhaven National Laboratory, USA
W. Vogelsang, Universität Tübingen, Germany

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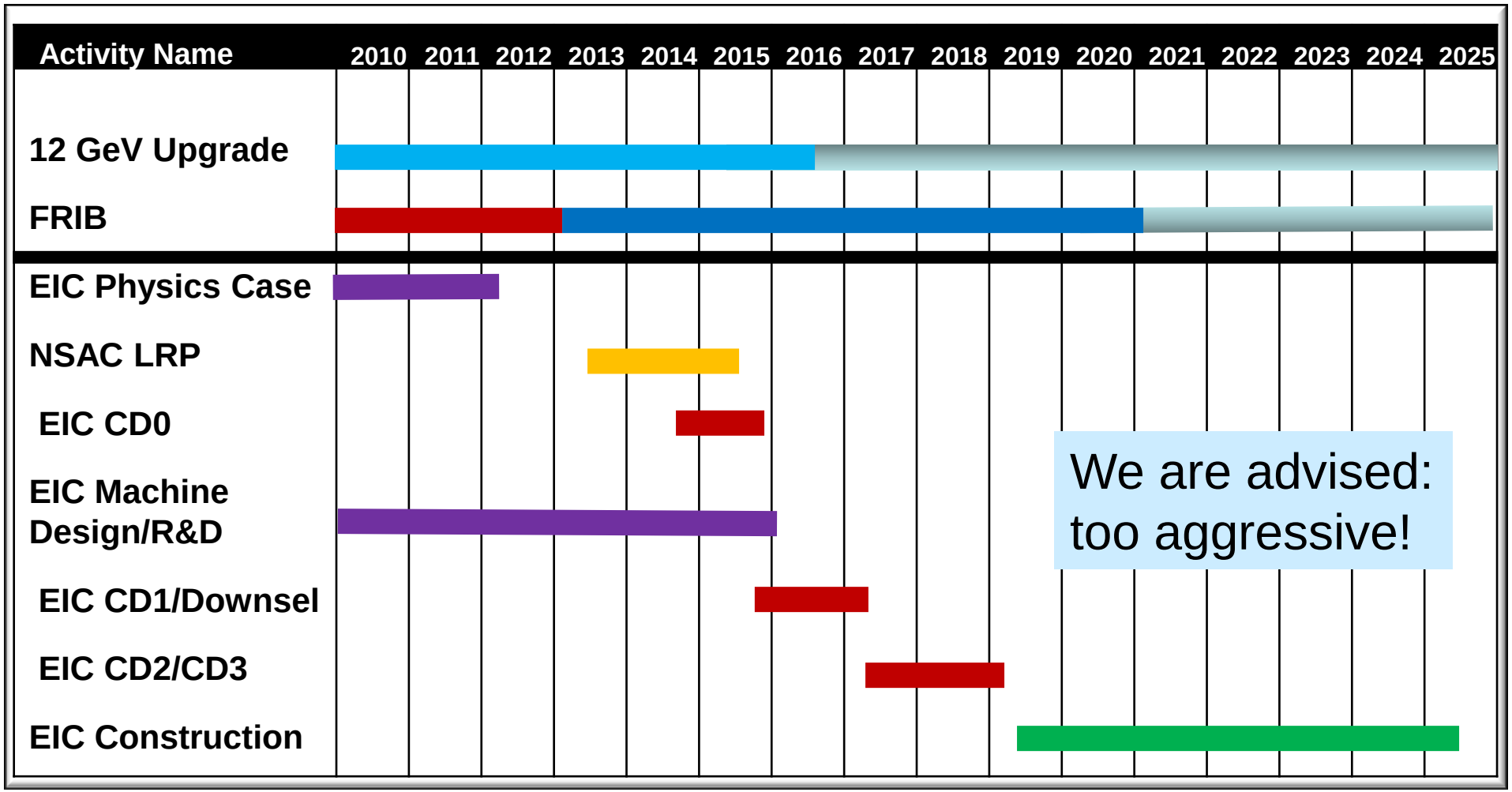
Hadrons and Nuclei
EPJ.org
your physics journal

Eur. Phys. J. A (2012) 48: 92 DOI 10.1140/epja/i2012-12092-7

Nuclear physics with a medium-energy Electron-Ion Collider

A. Accardi, V. Guzey, A. Prokudin and C. Weiss

EIC Realization Imagined



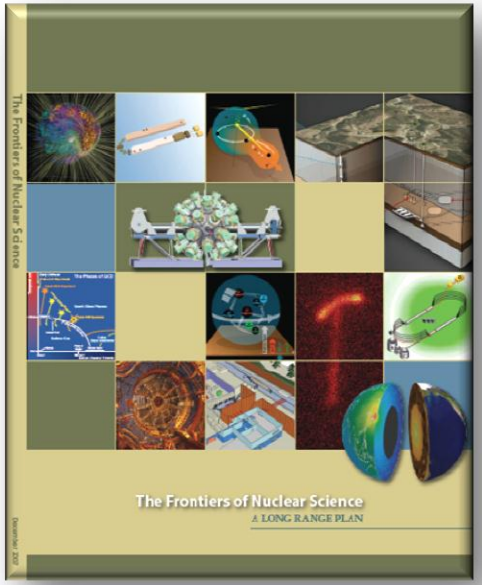
Assumes endorsement for an EIC at the next NSAC Long Range Plan

Assumes relevant accelerator R&D for down-select process done around 2016

DOE – NP Comparative Research Reviews

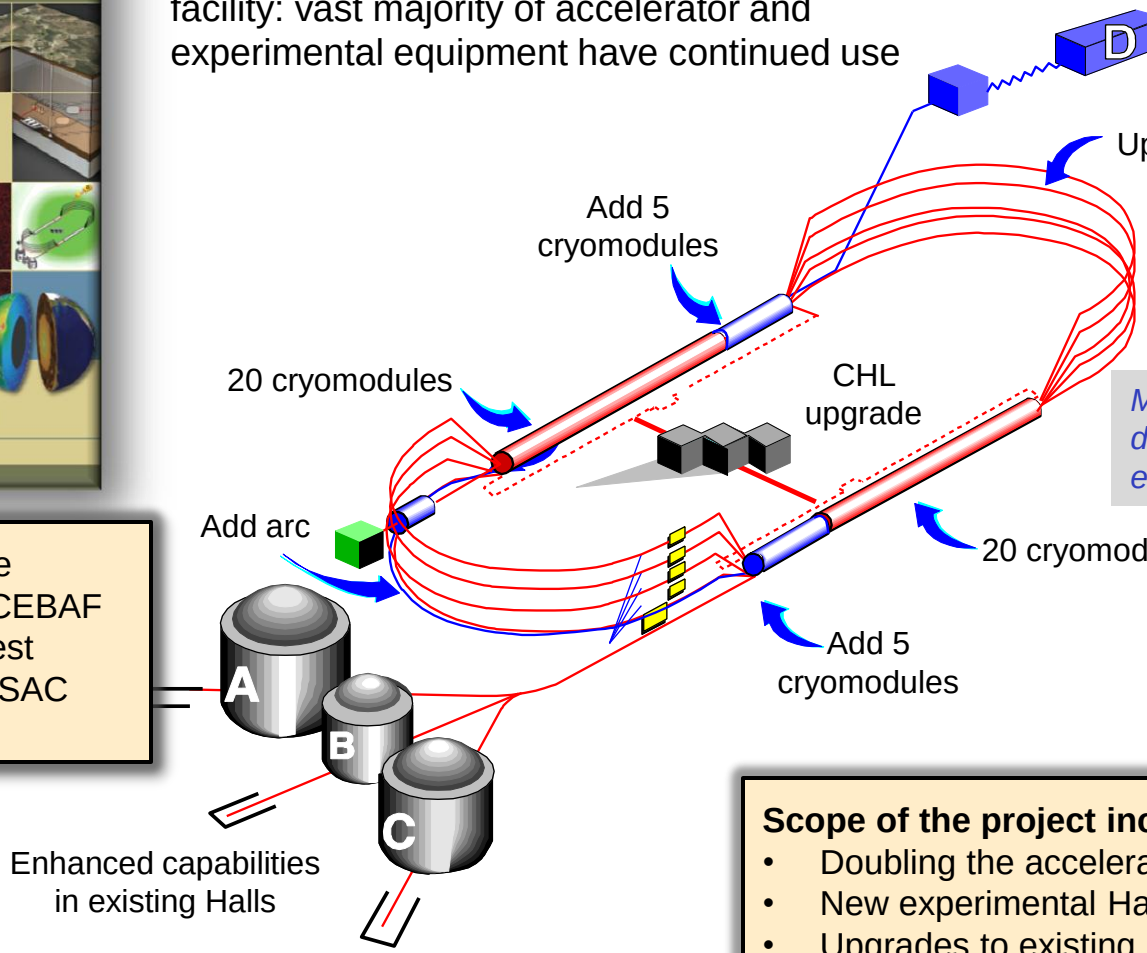
- Applied to all DOE Research Grants, Universities and Labs
  - Documentation 90% past, 10% future
- Jefferson Lab Medium Energy experimental physics presentations 1 week ago
  - Ent, Rossi, Higinbotham, Carlini
- Jefferson Lab Theory presentations next week
  - Pennington, Richards, Pennington
- Comments within weeks, action (cuts?) later.

12 GeV Upgrade Project



The completion of the 12 GeV Upgrade of CEBAF was ranked the highest priority in the 2007 NSAC Long Range Plan.

Upgrade is designed to build on existing facility: vast majority of accelerator and experimental equipment have continued use

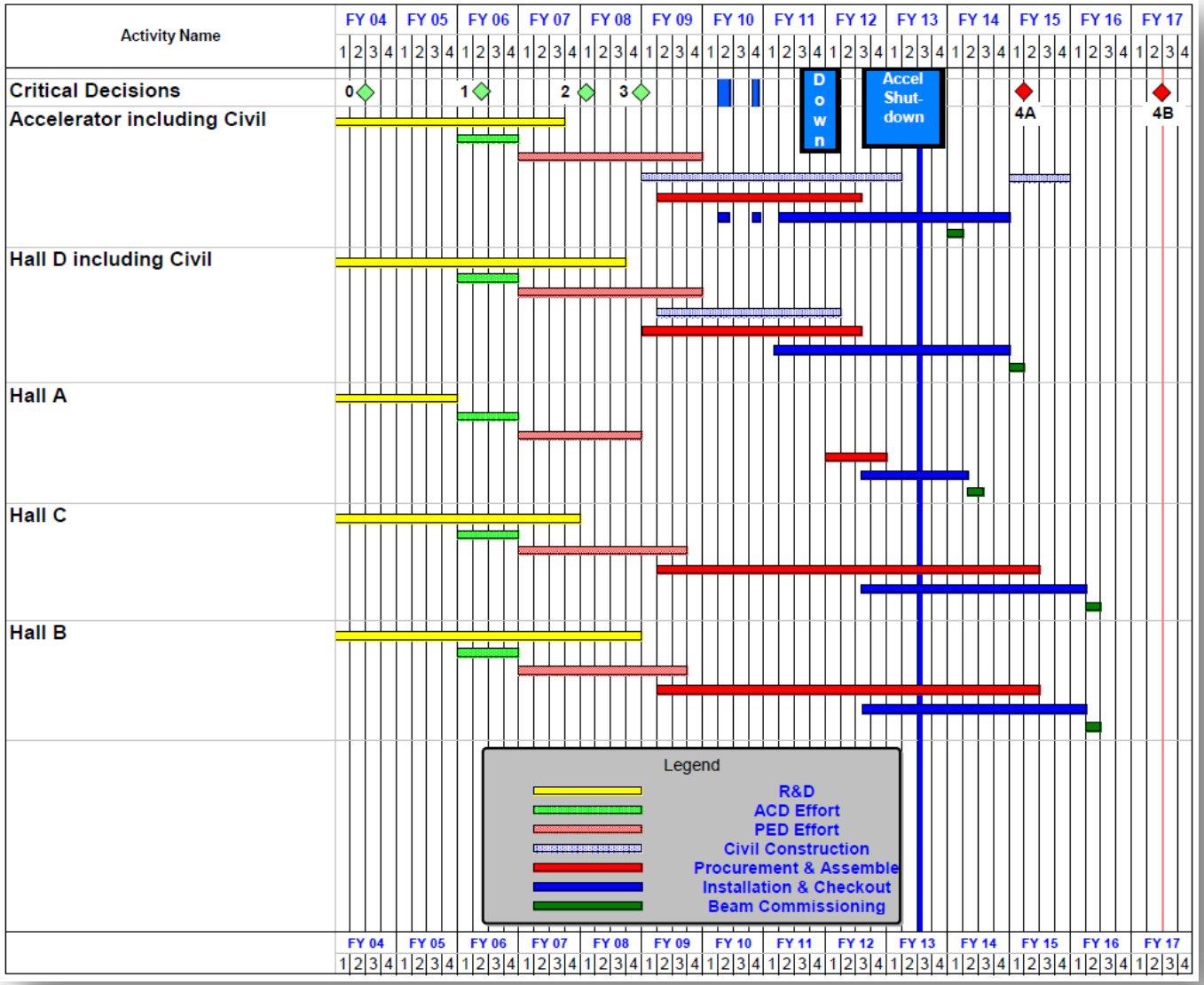


*Maintain capability to deliver lower pass beam energies: **2.2, 4.4, 6.6….***

Scope of the project includes:

- Doubling the accelerator beam energy
- New experimental Hall and beamline
- Upgrades to existing Experimental Halls

12 GeV Upgrade Project Schedule



FY12: reduction of $16M
FY13: Pres Request – no restoration

Present expectation (subject to rebaseline approval in August):

16-month installation
May 2012 - Sept 2013

Accelerator commissioning start
Oct 2013

Hall A commissioning start
Feb 2014

Hall D commissioning start
Oct 2014

Halls B & C commissioning start
Jan/Feb 2016

Project Completion
March 2017

Information based on DOE Project Review May 7-9, 2013

12 GeV Upgrade Project Status

Hall D & Counting House

Project 77% Complete, 91% Obligated

- Civil (92%); Accelerator (91%); Physics Equip (~62%)

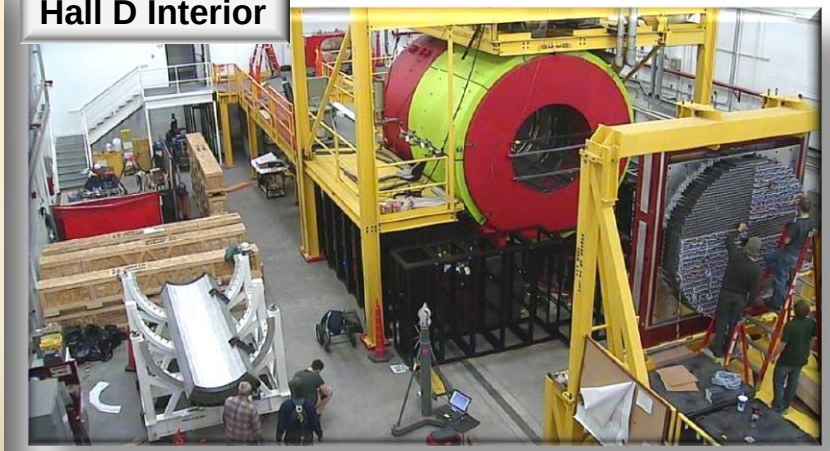
Challenges with spectrometer superconducting magnets

- All 7 new magnets under contract
- Refurbished Hall D Solenoid; further testing in progress

Rebaseline meeting scheduled for August 9, 2013

- Implementation date September 1, 2013
- TPC = $338M; CD-4B March 2017

Hall D Interior

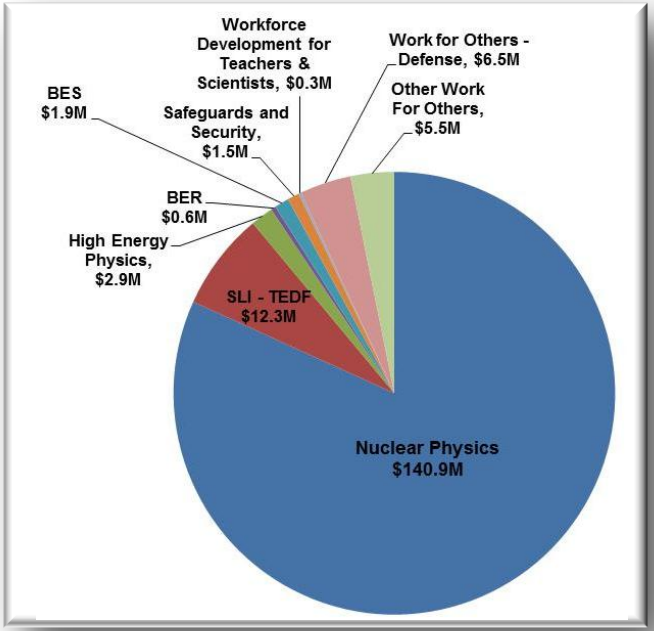


Summary

- **Budget has been a challenge.**
- **Long Range Implementation Report from NSAC**
  - **Supported modest growth scenario for Nuclear Physics**
  - **Recommended completing and exploiting CEBAF Upgrade under any budget scenario**
- **NSAC Future Facilities Report for input to Office of Science**
  - **Viewed Electron Ion Collider as central with significant R&D needed this is input to DOE/SC & likely needs a new SC1**
- **Upgrade Project is moving forward**
  - **Rebaselining review May 2013**
  - **Path forward defined**
  - **Accelerator Commissioning Fall 2013**
- **Working on a bright and exciting future at Jefferson Lab**

Jefferson Lab At-A-Glance

- **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 photon science and related research
  - In operation since 1995
  - 1,385 Active Users
  - 178 Completed Experiments to date; 4 remaining in 6 GeV program
  - Produces ~1/3 of US PhDs in Nuclear Physics (444 PhDs granted, 186 more in progress)
- **Managed for DOE by Jefferson Science Associates, LLC (JSA)**
- **Human Capital:**
  - 759 FTEs
  - 22 Joint faculty, 25 Post docs, 10 Undergraduate; 33 Graduate students
- **K-12 Science Education program serves as national model**
- **Site is 169 Acres, and includes:**
  - 88 SC Buildings & Trailers; 899K SF
  - Replacement Plant Value: $384M

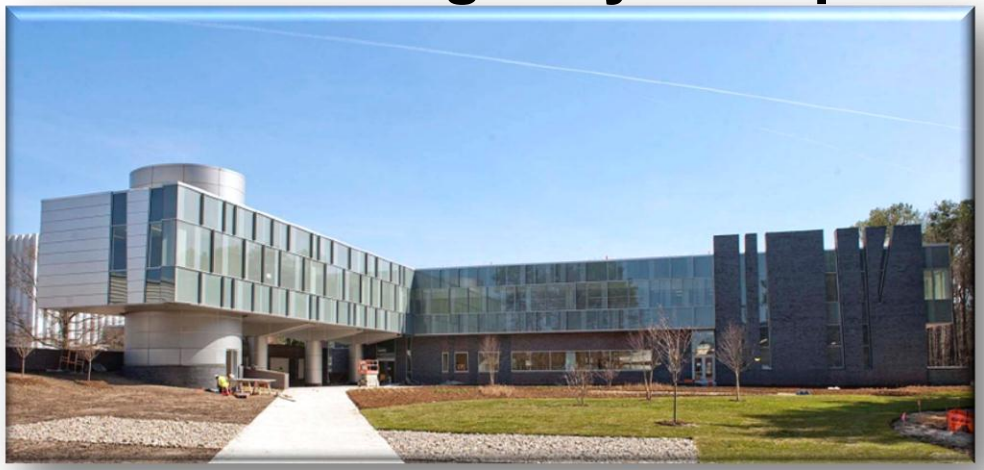


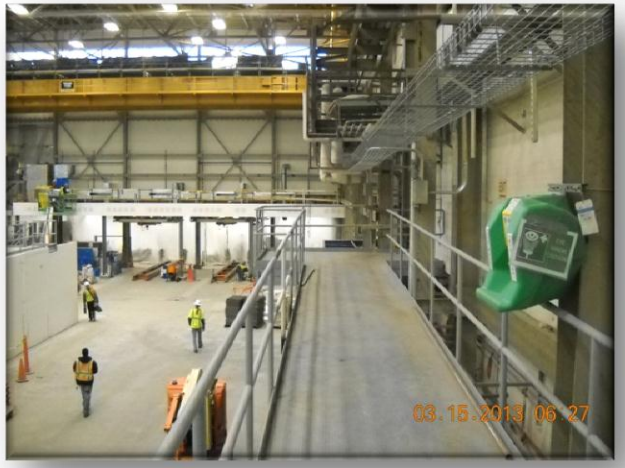
FY 2012:

Total Lab Operating Budget: $98.0M
Total Lab Construction Budget: $62.3M
Total Non-DOE Budget: $12.0M
TOTAL: $172.3M

Technology Engineering and Design Facility

TEDF building fully occupied





Test Lab Renovation on-track for completion 6 months ahead of schedule

Infrastructure – UIM (SLI)

- Project TEC $29.2M
  - Funding FY14-15

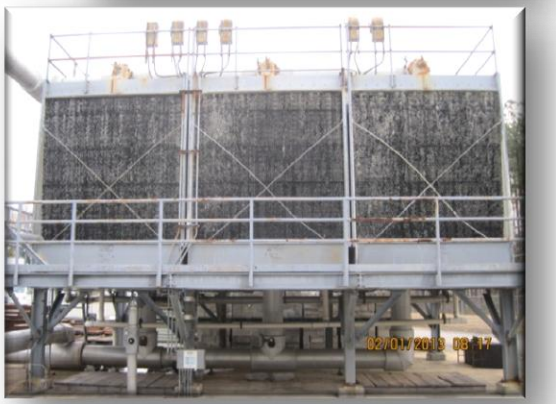
- Accelerator Site Electric Distribution Replacement
  - Critical Elements Planned start 3rd Qtr FY14
  - Remaining Elements Planned start 2nd Qtr FY15

- Accelerator Site Cooling Towers
  - Critical Elements Planned start 3rd Qtr FY14
  - Planned start 2rd Qtr FY15

- Cryogenic Test Facility Upgrade
  - Planned Start 1st Qtr FY15

- Computer center cooling and uninterruptable power supply upgrade
  - Planned Start 2nd Qtr FY15

- Communications Infrastructure Upgrade
  - Planned Start 2nd Qtr FY15



Mission Statement

Jefferson Laboratory, a forefront U.S. Department of Energy Nuclear Physics research facility, provides world-class, unique research capabilities and innovative technologies to serve an international scientific user community. Specifically, the laboratory's mission is to:

- *Deliver discovery-caliber research by exploring the atomic nucleus and its fundamental constituents, including precise tests of their interactions*
- *Apply advanced particle accelerator and detector technologies to address challenges of modern society*
- *Advance knowledge of science and technology through education and public outreach, and*
- *Provide responsible and effective stewardship of resources*

Theory Directions

- Strong Nuclear Physics Theory in multiple areas
  - Effective Field Theories, Baryons, Nuclei
  - Parton Phenomenology, Strong Coupling

- Strong phenomenological component to support experimental program
  - Jlab Physics Analysis Center
    - Baryon analyses
    - Meson Partial Wave Analyses
    - GPD and TMD phenomenology/calculation
    - Adam Sczepaniak (IU/Jefferson Lab) as leader

- Computational Physics
  - Strong national program in Lattice Gauge calculations
  - Encouragement for initiatives with local collaborations, which broaden this aspect, joint Theory IT initiatives

Accelerator Directions

- CEBAF accelerator operations continued to be excellent
  - Polarization, parity quality beams and energy reach are CEBAF hallmarks
  - Now started12 GeV commissioning, beam in Fall 2013
- Preparing for the next machine at Jefferson Lab – **MEIC**
  - **Expanding program including R&D**
- Accelerator R&D is vibrant
  - High Q_0 SRF cavity, best performance for ILC gradient
  - Collaborating on SRF with FRIB, APS SPX, Project X
  - Collaborating with LBNL on NGLS
  - Large number of international collaborations
- Education activities are broad-based and effective

Free Electron Laser Directions

- Funding from Commonwealth of Virginia to strengthen the base FEL capabilities
  - R100 cryomodule ++
- FEL User experiment tests
  - Atom Trap Trace Analysis (ATTA). Lu Zheng-Tian (ANL)
  - Combustion dynamics. David Osborn (Sandia)
  - Electronic structure of correlated materials. Peter Johnson (BNL), Z.-X. Shen (Stanford)
- Particle and Nuclear Physics
  - Tests for Darklight, A' Search
  - Interception 3.2 PPM in 2 mm aperture at 450 kW
  - 8 hour stability run delivering 120 C though 2 mm aperture

Technologies

- Cryogenics
  - NASA James Webb Telescope test chamber
  - FRIB
  - NGLS
- (Medical) Imaging
  - Demonstration of impact of awake/sedated animal response
- Encouraging/Supporting initiatives

LDRD FY2014

Title	Lead Division(s)	Year 1 Budget	Year 2 Budget	Year 3 Budget	Total Budget
Niobium metallurgy investigations for reliable and efficient production of high performance srf cavi	Accelerator	$91,085.00	$91,905.00	$92,751.00	$275,741.00
Pre-conceptual design of a cw positron source for Jlab	Accelerator	$203,074.00	$201,509.00	$0.00	$404,583.00
Fel-srf_semiconductor photocathode performance in a high gradient superconducting rf gun	Accelerator	$235,365.00	$224,984.00	$208,545.00	$668,894.00
A proof-of-principle experiment for a magnetized photo-cathode srf electron gun	Accelerator	$140,700.00	$0.00	$0.00	$140,700.00
Construction of a very large area and low mass triple-gem prototype for future experiments at JLab	Physics	$109,453.00	$0.00	$0.00	$109,453.00
Vacuum uv program development at the JLab fel	FEL	$136,001.00	$162,861.00	$0.00	$298,862.00
Physics potential of polarized light ions with eic@jlab	Physics/Theory	$163,683.00	$166,968.00	$0.00	$330,651.00
Model independent flavor decomposition of partonic transverse momentum distributions	Physics/Theory	$64,500.00	$66,600.00	$68,904.00	$200,004.00
A high signal fidelity external-modulated electro-optically coupled detector for nuclear physics	Physics	$106,617.00	$0.00	$0.00	$106,617.00
Testing fusion fuel polarization survival in a tokamak	Physics	$199,764.00	$199,920.00	$0.00	$399,684.00
Development of a prototype for a fast RF kicker for the MEIC electron cooler	Accelerator	$146,275.00	$0.00	$0.00	$146,275.00
A mach-zehnder interferometer for advanced thz spectroscopy	FEL	$131,832.00	$150,356.00	$0.00	$282,188.00
Ultra-high resolution awake animal pet instrumentation for preclinical imaging	Physics	$173,352.00	$220,395.00	$173,771.00	$567,518.00
Physics, wireless, hand-held data acquisition system for imaging detector	Physics	$62,870.00	$62,220.00	$0.00	$125,090.00
Study and development of photo-detectors for particle identification using micro-channel plates	Physics	$191,080.00	$195,247.00	$192,282.00	$578,609.00
CHEX - chameleon experiment	Physics, FEL	$126,060.00	$69,317.00	$0.00	$195,377.00
High efficiency magnetron rf source for srf accelerators	Accelerator	$199,668.00	$137,157.00	$162,809.00	$499,634.00
Modeling and Design Study on Producing Flux x-ray and Gamma-Ray at JLab FEL Facility	FEL	$58,310.00	$0.00	$0.00	$58,310.00
	Grand Totals for Budget Numbers	**$2,539,689.00**	**$1,949,439.00**	**$899,062.00**	**$5,388,190.00**

2010 NRC Decadal Study

BOARD ON
PHYSICS AND ASTRONOMY

Building the foundation for the future

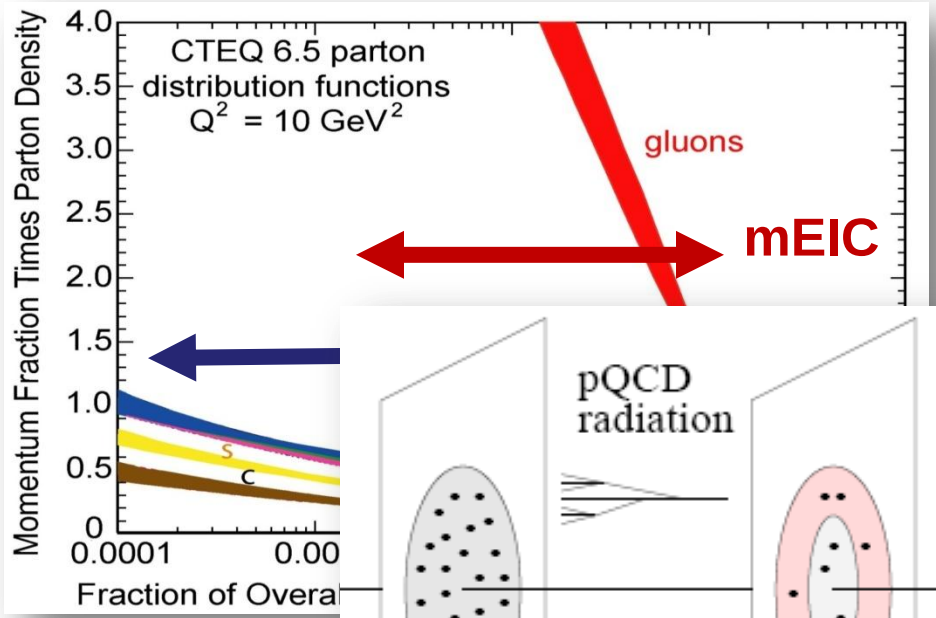
The prospects of an electron-ion collider

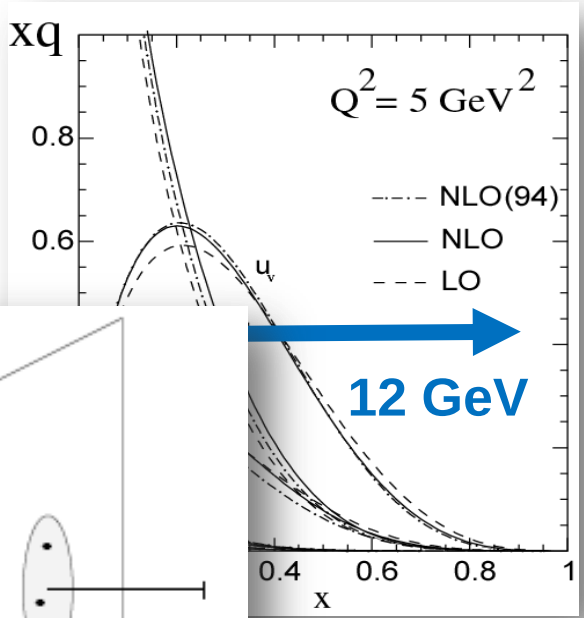
Finding: An upgrade to an existing accelerator facility providing the capability of colliding nuclei and electrons at forefront energies would be unique for studying new aspects of quantum chromodynamics and, in particular, would yield new information on the role of gluons in protons and nuclei. An electron-ion collider is currently a subject of study as a possible future facility

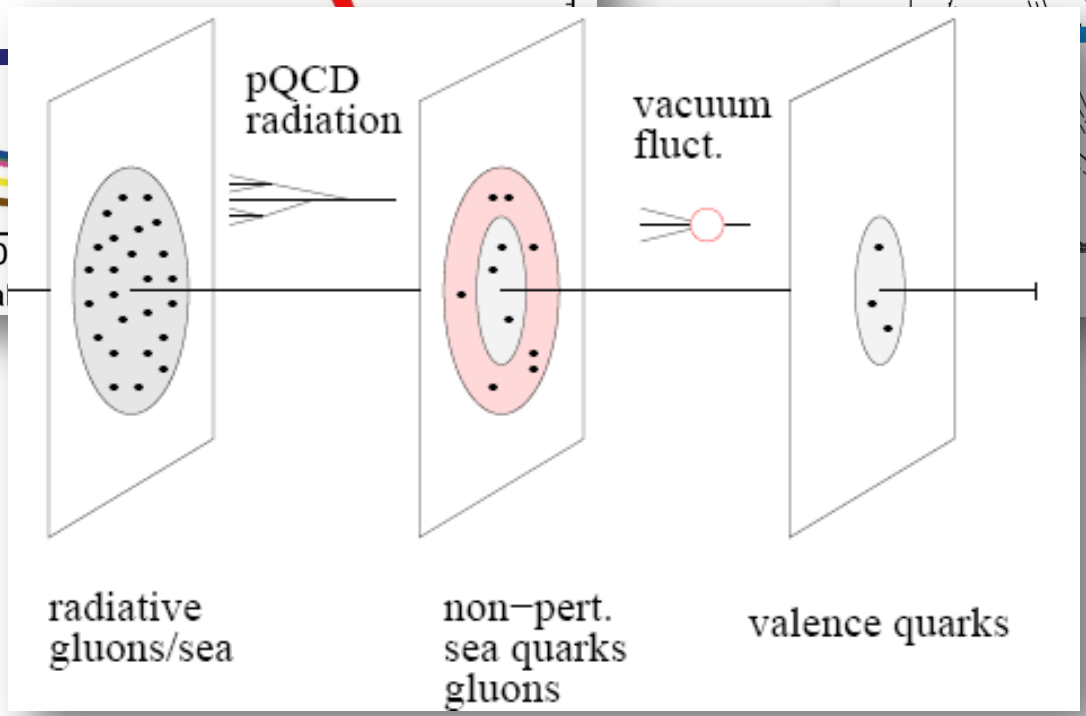
Recommendation: Investment in accelerator and detector research and development for an electron-ion collider should continue. The science opportunities and the requirements for such a facility should be carefully evaluated in the next Nuclear Science Long Range Plan.

The Landscape of EIC

- An EIC aims to study gluon dominated matter.
- With 12 GeV we study mostly the valence quark component







12 GeV Upgrade CHL Components

12 GeV Upgrade

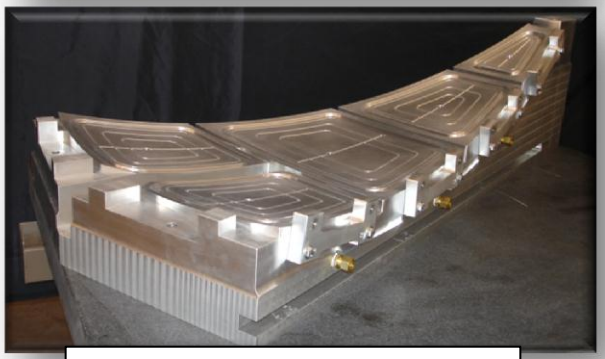
12 GeV Upgrade New Cryomodules

12 GeV Upgrade Accelerator

12 GeV Upgrade Hall B

Sub-System Processor **SSP**

PCAL - cosmic ray testing



HTCC - tooling for mirror assembly

R3 DC – Two crew stringing

FTOF – Testing refurbished CLAS detectors

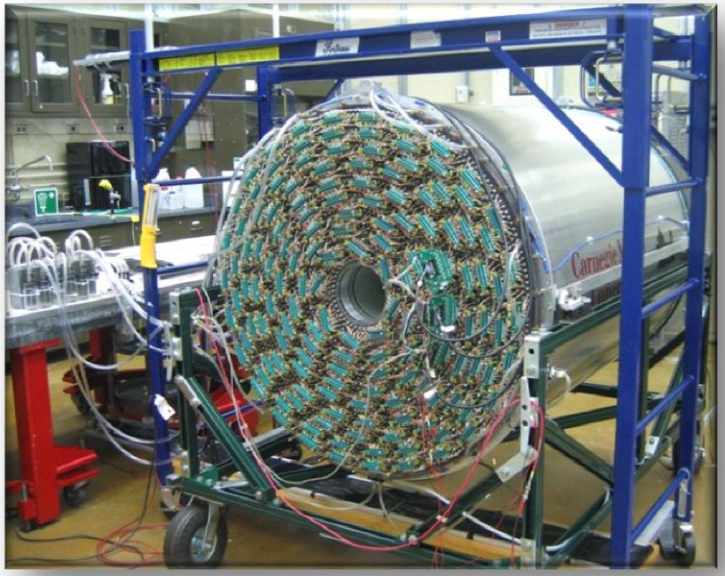
CTOF–Testing the fast scintillators

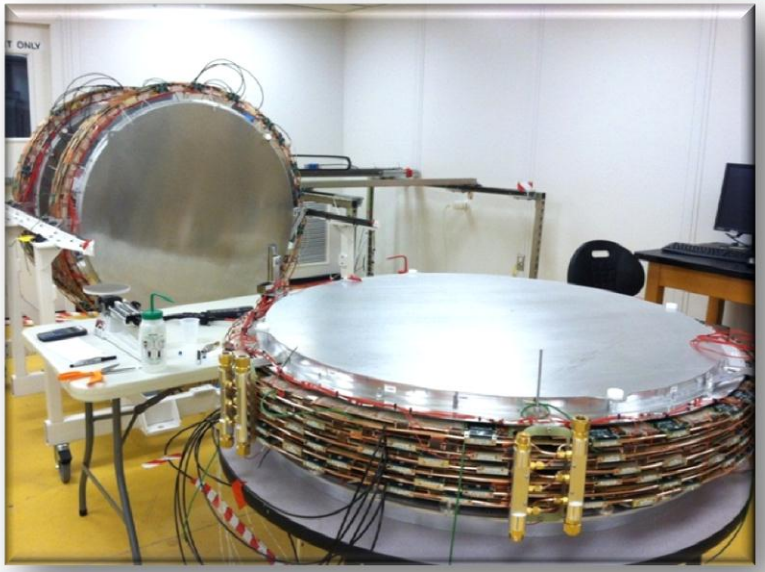
SVT – First pre-production module at FNAL

Space Frame

12 GeV Upgrade Hall C

12 GeV Upgrade Hall D





12 GeV Upgrade Magnets