Jefferson Lab Status

SURA Board of Trustees

Hugh Montgomery

March 11, 2010

Outline of Talk

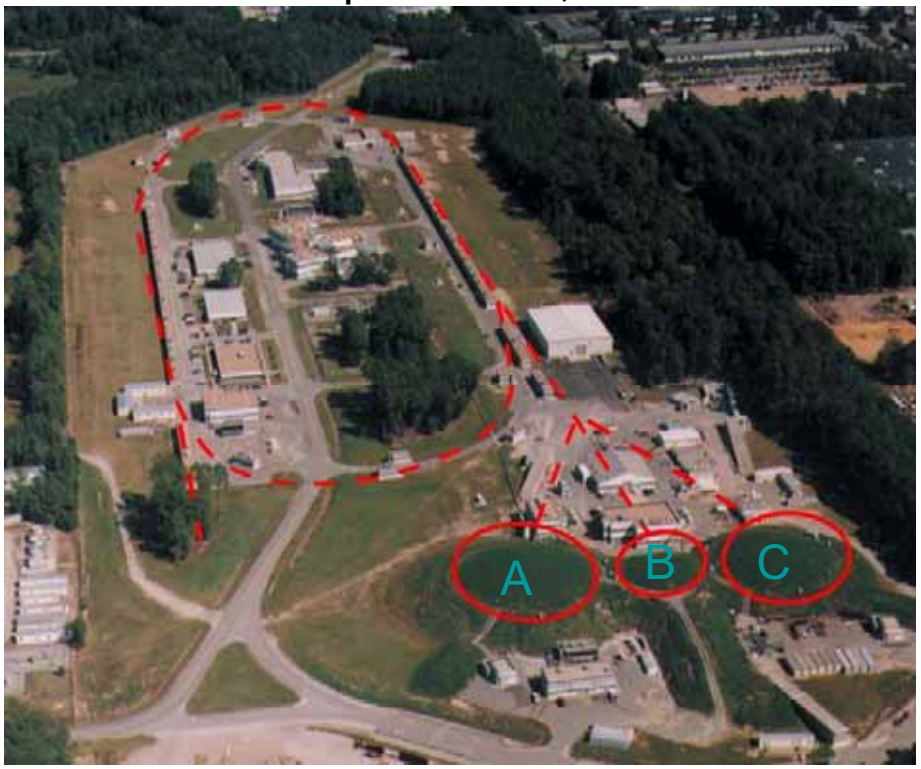
- **Jefferson Lab a strategic view**
- **2009 Performance**
- **2010 as it happens, and 2011 prospects**

JEFFERSON LAB TODAY

>1300 active member international user community engaged in exploring quark-gluon structure of matter.

Superconducting electron accelerator provides 100% duty factor beams of unprecedented quality, with high polarization at energies up to 6 GeV.

Newport News, VA



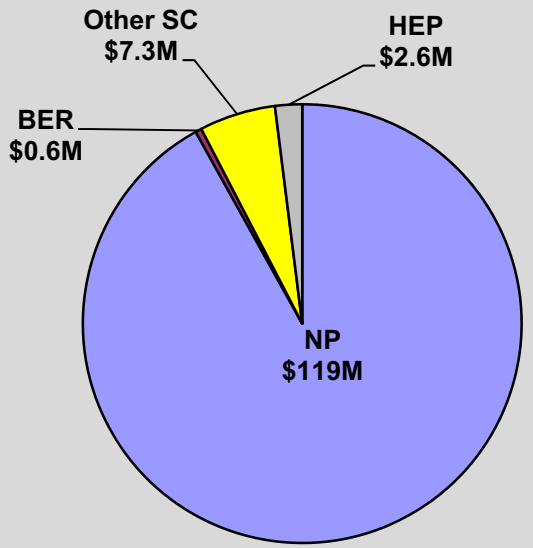
CEBAF's delivery of beam with unique properties to three experimental halls simultaneously. Each hall offers complementary capabilities.

Jefferson Lab At-A-Glance

Celebrated our 25th year in 2009

- **Created to build and Operate the Continuous Electron Beam Accelerator Facility (CEBAF), world-unique user facility for Nuclear Physics**
  - In operation since 1995
  - Over 1,300 Active Users (World's largest Nuclear Physics User Community)
  - 148 Completed Experiments to date; ~21 remaining in 6 GeV program
  - Produces ~1/3 of US PhD's in Nuclear Physics (248 PhD's granted, 192 more in progress)
- **Managed for DOE by Jefferson Science Associates, LLC (JSA)**
  - **JSA is 60% SURA, 40% CSC**
  - **Seminal partnership**
- **Staff of ~650 Full Time Equivalent (FTEs)**
- **K-12 Science Education program serves as national model**
- **Site is 169 Acres, and includes:**
  - 63 Buildings; 684K SF in DOE Buildings
  - Replacement Plant Value: $331M

FY2009
Total DOE funding: $215.9M
Non-DOE funding: $15.9M
ARRA: $86.5M
12 GeV: $65.0M
GPP: $10.0M
LQCD: $4.9M
Accelerator R&D: $6.5M



Core Capability – Nuclear Physics
Experimental, Theoretical and Computational

In Support of Our Primary Mission: Experimental Nuclear Physics

Experimental:

- Operate CEBAF, a world unique, 6 GeV continuous beam electron accelerator for studies of the quark structure of matter
- State-of-the-art detector and data acquisition systems, together with high-energy, high-intensity, polarized, continuous electron beams, provide the highest luminosity (10^{39}/eN/cm^2/s) available for its experiments
- The scientific program aims for excellence and pre-eminence in a number of key areas of nuclear physics:
  - the structure of hadrons;
  - the structure of nuclei; and
  - Standard Model tests via high precision at low energy

Theoretical:

- Broad theoretical support for the interpretation and understanding of JLab data
- Excited Baryon Analysis Center (EBAC) supports the phenomenological analysis of:
  - World (and especially JLab) data on baryon excited states; and
  - Data on meson excited states anticipated from the 12 GeV Upgrade

Computational (Lattice QCD):

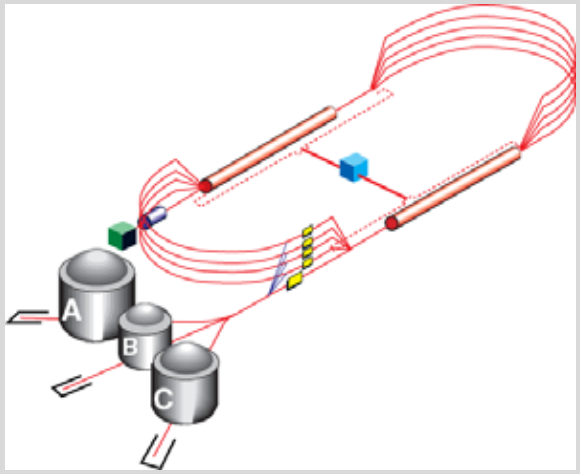
- LQCD is the only known way to solve the strong interaction rigorously
- JLab LQCD program focused on key issues confronted by experiments at 6 and 12 GeV:
  - Generalized parton distributions; structure functions; and meson and baryon excited state spectra

Core Capability
Large-Scale User Facilities

JLab was founded as a large-scale user facility for nuclear physics

Experimental Nuclear Physics

- CEBAF is a world-wide unique user facility for studies of the quark structure of matter.
- Constructed by SURA and operated by SURA and now JSA for nearly 15 years with high productivity and recognized world-leadership in hadronic physics.



- The expertise developed at JLab has led to the design of an upgrade that will double the energy (to 12 GeV) and provide a unique new facility for nuclear physics research that will ensure continued world leadership in this field for more than a decade.
- TJNAF scientists and engineers, in partnership with BNL and others world-wide, are developing the conceptual design of a powerful electron-ion collider that many believe will be needed in the future to advance the field beyond the capabilities of the 12 GeV Upgrade.

Core Capability
Accelerator Science and Technology

State-of-the-art CW superconducting multi-pass linear electron accelerators

Superconducting RF

- Developed SRF technology expertise and experience
- > 35% of the integrated operational experience in the world
- 77 tests carried out on 15 ILC 9-cell cavities processed at JLab, Cornell and FNAL
  - 6 cavities exceeded 35 MV/m, (ILC spec for vertical test); all 6 were processed at JLab
  - The highest cavity gradient achieved (42 MV/m) was also processed at JLab
- Developed cavities with damping of higher order modes for beam currents up to 1 ampere

Cryogenics

- Designed and commissioned the cryogenics plant for SNS
- Reduced the power consumption of the BNL-RHIC cryogenics plant from 9.2 MW to 5.0 MW while increasing the output (President's Closing the Circle Award in 2007)
- JLab-patented Ganni cycle licensed by commercial supplier (LINDE) for worldwide use on cryogenic plants

Energy Recovering Linacs

- Research and Development of the first high power superconducting energy recovery linac, the JLab FEL, with beam currents up to 9 mA
- Exploration of energy recovery mode at >1 GeV in CEBAF

Major Activity
Superconducting RF Technology

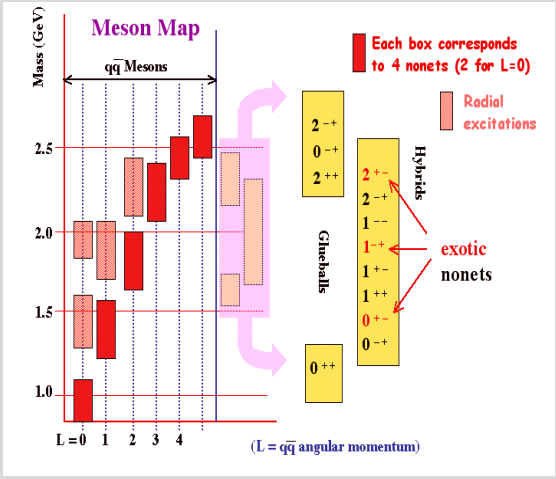
World leading center for accelerator technology

- Current activities include:
  - Building upgrade cryounits for CEBAF@12 GeV (with 3 times the original CEBAF cryomodule performance)
  - Refurbishing existing CEBAF cryomodules for improved performance
  - Carrying out R&D aimed at reaching fundamental limits of SRF performance (e.g., large grain/ single crystal Nb)
  - Leading the ILC global 9-cell high-gradient cavity processing program (a Jlab physicist is the new Group Leader)
- Our aim is to continue as SRF center of expertise for the Office of Science
- We are collaborating with every project in DOE 20 year plan that needs SRF, including FRIB, SNS-PUP, Project X, and the 4th Generation Light Source
  - We have the capacity to participate in R&D for all of them
  - We could handle cavity production for all projects, but not simultaneously
- **Superconducting RF is (only) one of the accelerator core competencies which underpin much of the Office of Science program. These activities need a vibrant and coordinated R&D program aimed at development for the medium term (10 years) (as well as the very long term).**

Major Activity
12 GeV Upgrade

Exciting new scientific opportunities – continue world leadership

- Discover the spectrum and properties of exotic mesons in mass range 1.5-2.6 GeV in order to explore the physical origins of quark confinement

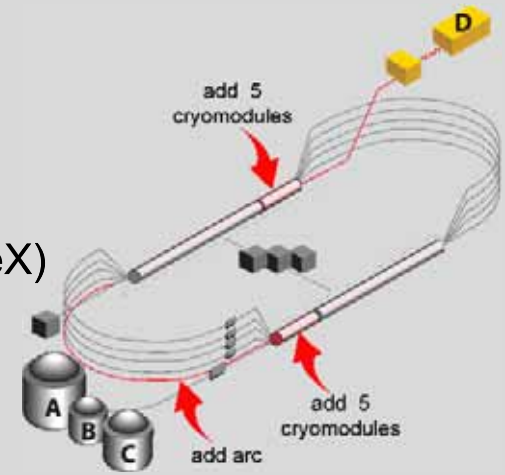


- Define the spin and flavor structure of the nucleon in the valence region, hence test theories of di-quarks, pQCD….
- Determine the orbital angular momentum carried by up and down quarks and explore potential of Generalized Parton Distributions for tomographic imaging
- Exploit the unique capabilities of CEBAF at 12 GeV to explore the structure of nuclei at the level of quarks and gluons – understand the EMC effect
- Probe potential new physics (beyond the Standard Model) through precise test of evolution of $\sin^2 \theta_W$ from Z-pole

Major Activity
12 GeV Upgrade

Project execution proceeding apace

- Total Project Cost $310M
- Upgrade accelerator and infrastructure to allow delivery of 11 GeV to three existing experimental halls and 12 GeV to a new hall
- Construct new hall and completely new, large scale experiment (GlueX)
- Upgrade equipment in other halls to permit exploitation of new energy range



- CD3, ready for construction, granted in September 2008, construction initiated in October 2008
- FY2009 funding $28M, ARRA advancement of funding in 2009 of $65M
- Initial large procurements have already been awarded, including two large civil packages for the Central Helium Liquefier extension and for the Hall D construction
- Accelerator shutdowns 6 months in 2011 and 12 months in 2012, commissioning starts in 2013, CD4 in 2015

Major Activity:
ELectron Ion Collider Physics (ELIC)

Further extension of electron – nucleus scattering physics

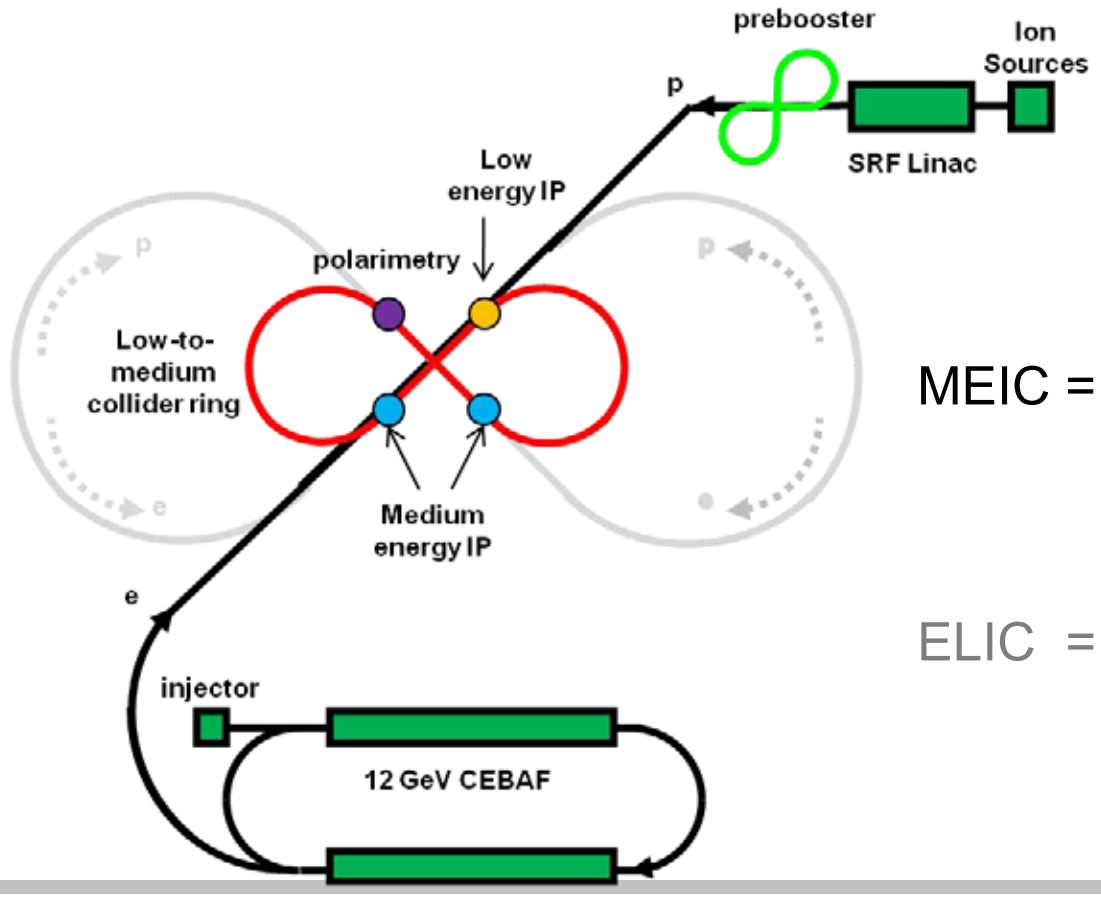
- Define the gluonic and quark spin-flavor structure of the nucleon sea – as 12 GeV will have done for the valence region
- Explore the nature of the very high density, universal gluon field at small Bjorken x
- Common effort to refine the science driving the plans for the facility with BNL, proponents of the CERN LHeC, and an international user community
- International efforts (OECD GSF Report/IUPAP WG.9) concerning funding mechanism
- ELIC design concept promises two orders of magnitude higher luminosity than eRHIC and LHeC designs
- R&D is essential if this is to be a truly world-leading facility

Medium Energy Electron Ion Collider

Map the spin and 3D quark-gluon structure of protons

Discover the role of gluons in atomic nuclei

Understand the creation of the quark-gluon matter around us



MEIC = EIC@JLab
1 low-energy IR (s ~ 200)
3 medium-energy IRs
(s < 2600)

ELIC = high-energy EIC@JLab
(s = 11000)
(limited by JLab site)

Major Activity
Light Source

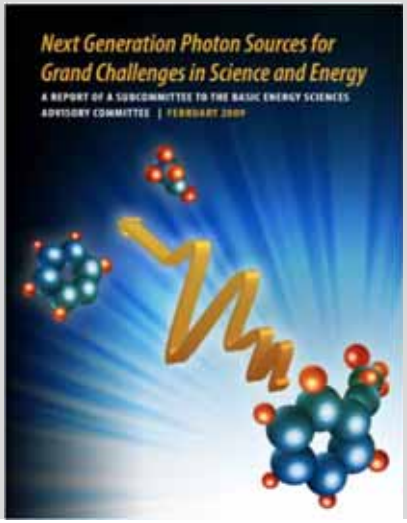
Towards a Next Generation Photon Science Facility at Jefferson Lab

- JLab operates one of two 4GLS in the US
  - In the IR now (14 kW CW power and 150 fs pulse length)
  - In the UV w/ planned CY2009 extensions

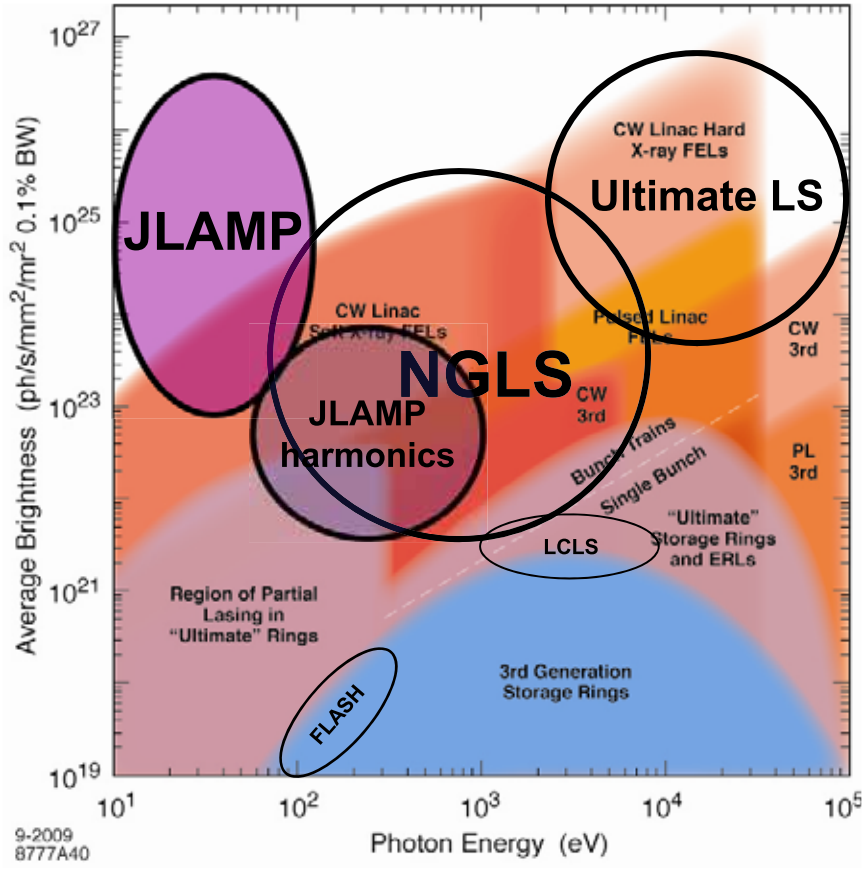
- A proposal JLAMP to BES documented a plan to leverage our technology base and dramatically improve US capability in VUV/soft X-ray generation for a modest investment, extending the JLab 4GLS FEL to high average brightness VUV/soft X-ray and mounting a serious user program:

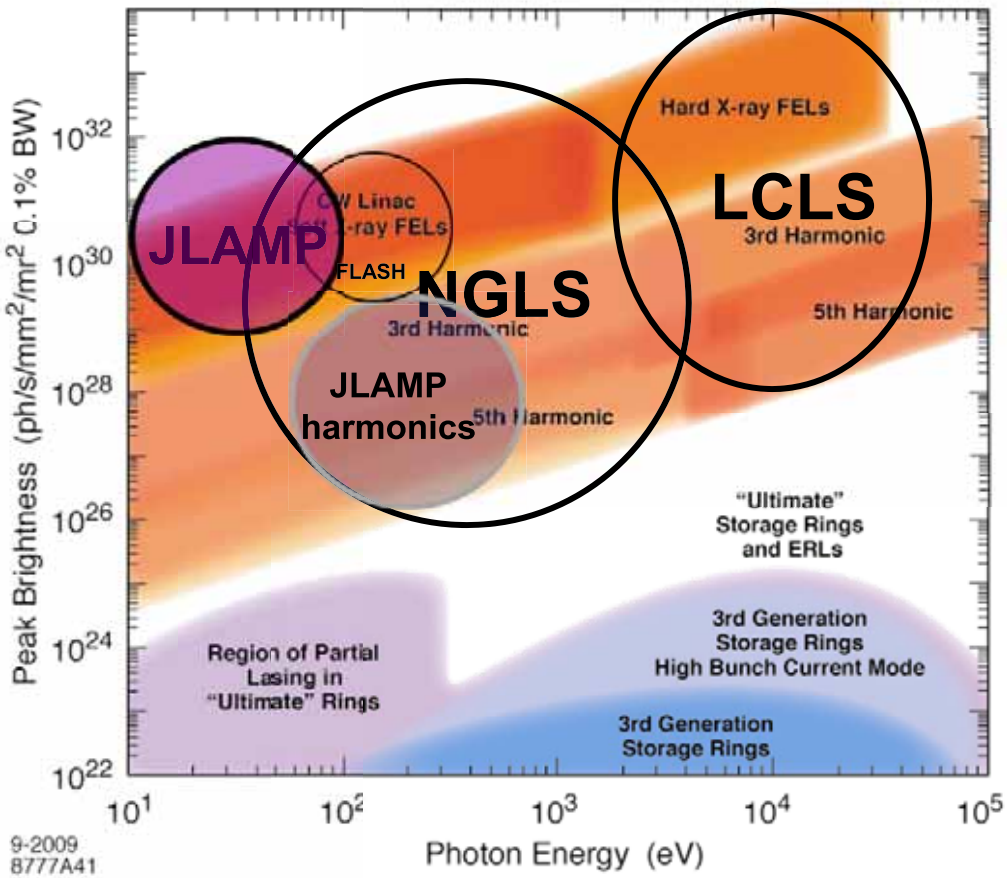
  1. 3rd harmonic of the UV FEL will soon achieve VUV 100nm photons at an average brightness exceeding FLASH (& any other source in the world) and provide user capability
  2. An energy upgrade (to 300 MeV) by replacing cryomodules would reach 60nm in the fundamental and soft X-rays in the 3rd harmonic
     (Intensity would be many orders of magnitude higher than FLASH and pulse lengths would be <100 fs)
  3. Adding energy recirculation to reach 600 MeV would provide a 10nm fundamental with brightness exceeding any available source in the world

- This project would:
  - Cost ~$100M over 5 years
  - Establish User program and address source and detection technology
  - Address R&D goals identified in BESAC Report "*Next Generation Photon Sources for Grand Challenges in Science and Energy*"



JLAMP in the Light Source Landscape





JLAMP delivers important parameter space un-addressed in hard X-ray proposals, with chemical selectivity to measure atomic structure at the nano-scale, measurement of dynamics on the attosecond timescale of electron motion, and imaging

Laboratory Program
Core Capabilities and Activities Summary

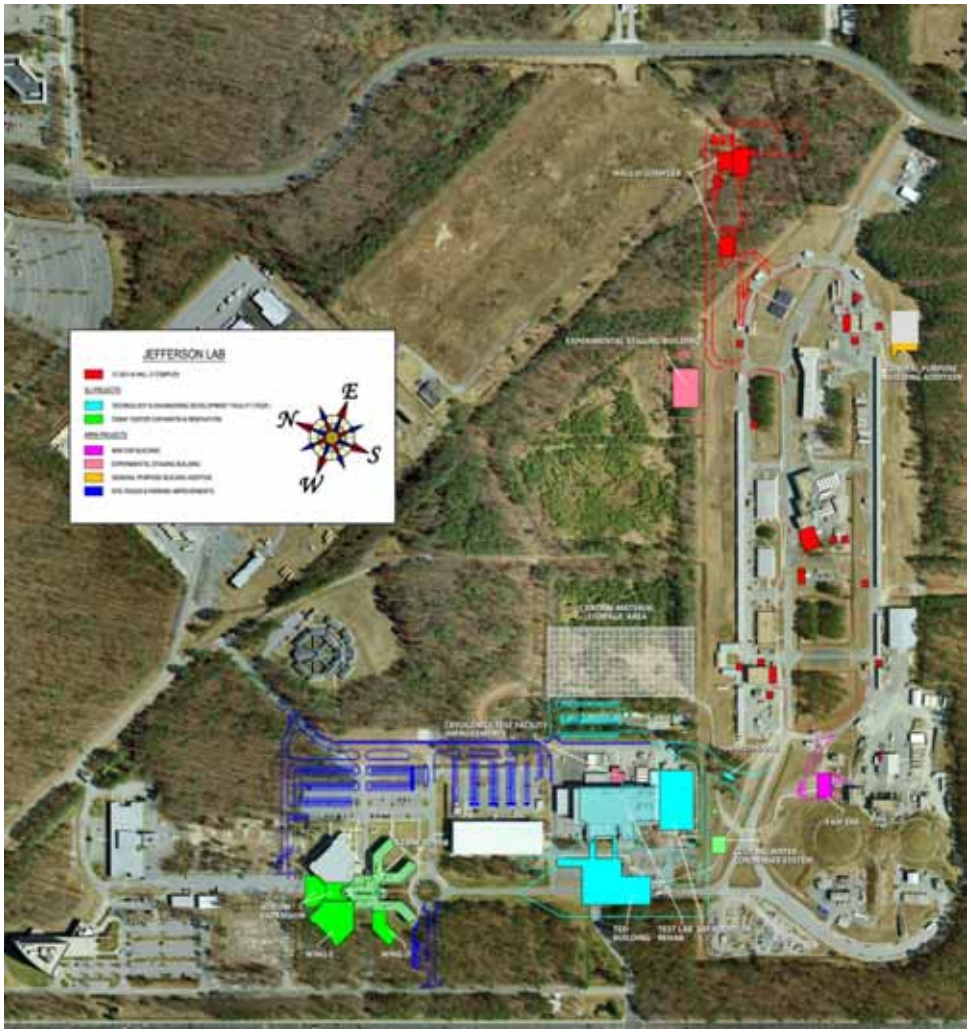
Science and technology directions well defined and understood

- Nuclear Science is the primary Jefferson Laboratory Mission
- The laboratory operates a renowned user facility with a large international user community
- The laboratory core competencies in accelerator science, particularly superconducting radiofrequency technology, energy recirculating linacs, and free electron lasers, make it a broadly sought partner in office of science projects
- Its technology has been widely applied
- Based on its technology, a strong photon science potential and a path to the next generation of X-ray source has emerged

Infrastructure in place and planned to support these directions fully

- Physical Infrastructure
- Systems Infrastructure

Infrastructure Improvements



Funding Sources

Science Lab Infrastructure (SLI)

TEDF - $72.2M (CD-2)
UIM - $29.2M (CD-0)
CC Add & Rehab - $75- 92M
Concept

Stimulus Funding

$10M (one time)

GPP

~$2M (per year)

Technology and Engineering Development Facility

- Addition to Test Lab for SRF
- TED Bldg for Engineering & Shops
- Rehab Test Lab
- Eliminate Unsuitable Space

Test Lab Rehab

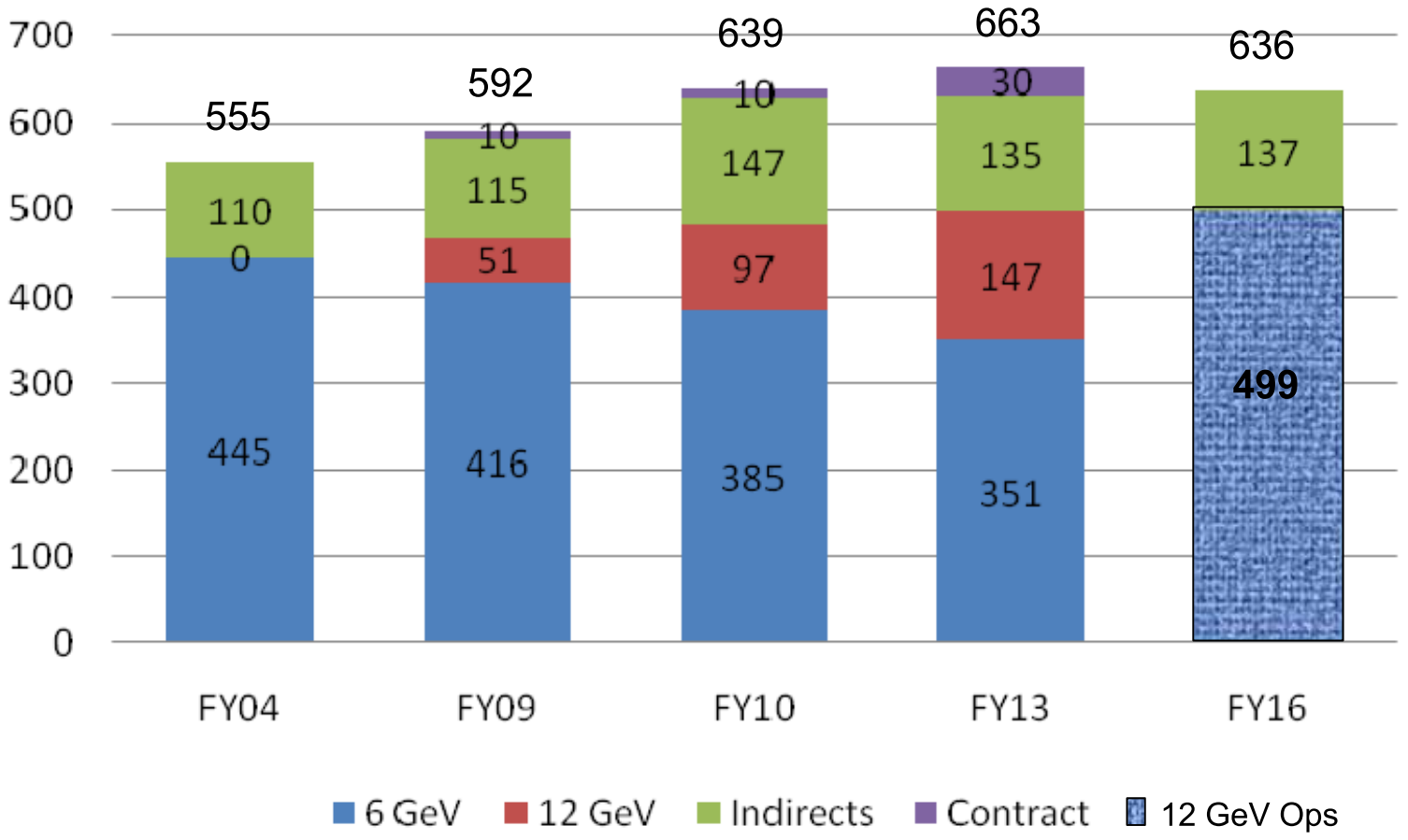
TED Building

SRF Addition

Utilities Infrastructure Modernization

- **Electrical Distribution**
  - Replace primary and secondary feeders to up to 26 substations
  - Increase site alternate power feed from 400 Amps to 1200 Amps
- **Process Cooling**
  - Replace up to 9 cooling towers that are 20-40 years old
  - Provide additional electrical power and cooling to support mission driven computing capacity
- **Cryogenics**
  - Modernize the Test Lab Cryogenic Test Facility. Double cryogenics capacity with no resultant increase in energy
- **Communications:**
  - Replace 20 to 40 year old underground communications and data cabling and switches

Staffing Requirements (FTEs) to Support Operations - NP Funded



Note: Does not include WFO

Bottoms Up Review by Activity

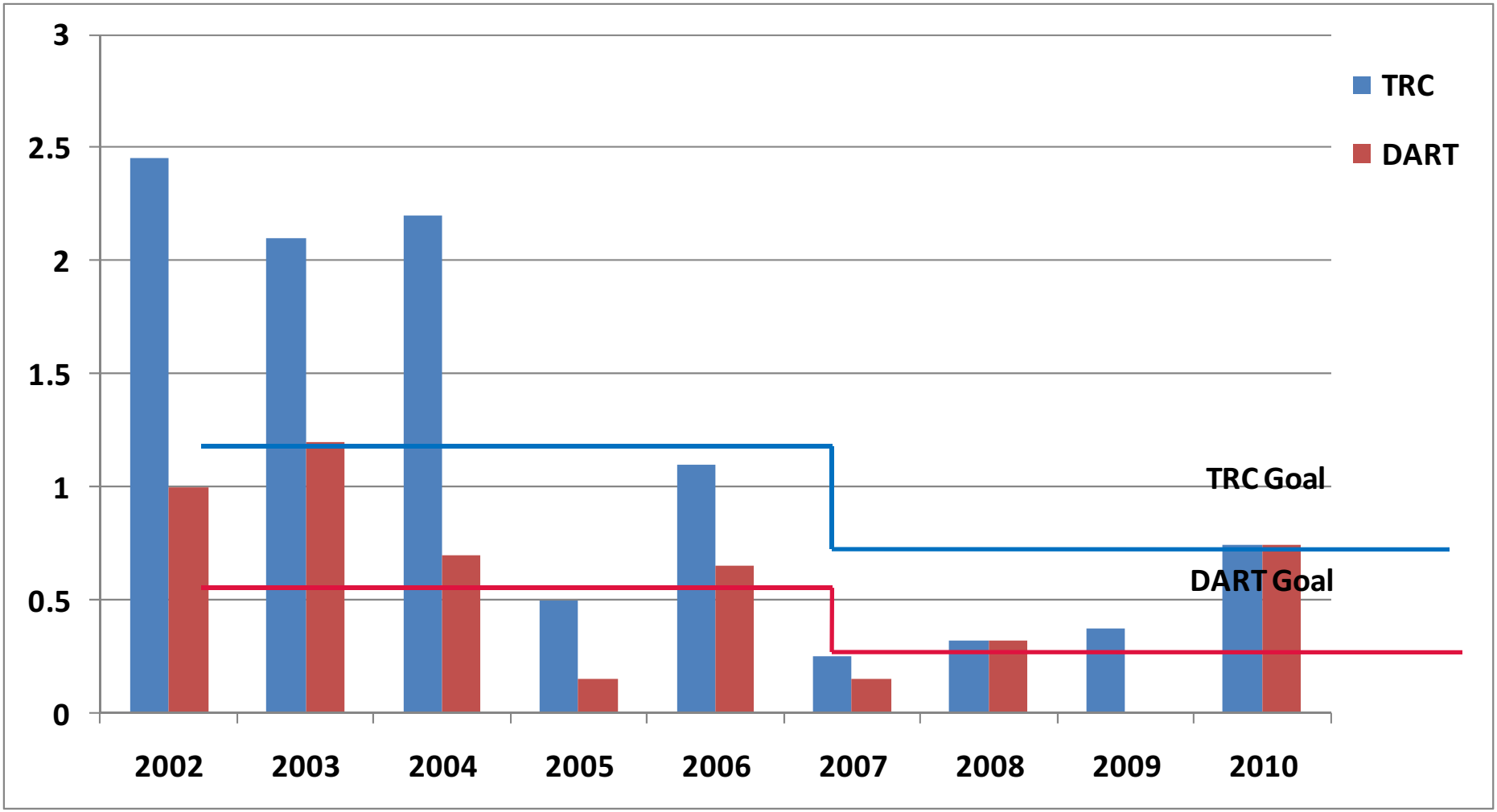
JSA PEMP Grade Summary FY07 – FY09

S&T Performance Goals	FY07	FY08	FY09
1.0 Accomplishment	A−	A	A−
2.0 Construction and Operations of User Research Facilities and Equipment	A	A	B+
3.0 Science and Technology Research Project/Program Management	A	A	A−
M&O Performance Goals	**FY07**	**FY08**	**FY09**
4.0 Leadership and Stewardship of the Laboratory	A−	A−	B+
5.0 Integrated Safety, Health, and Environmental Protection	A−	A−	A−
6.0 Business Systems Integrated Safety, Health, and Environmental Protection	A−	A−	B+
7.0 Operating, Maintaining, and Renewing Facility and Infrastructure Portfolio	A−	A−	A−
8.0 Integrated Safeguards and Security Management and Emergency Management Systems	A−	A−	B+

Late 2009 Jefferson Lab Events

• 4-year Theory Review	September 17
• 12 GeV Lehman Review,	September 22-24
• TEDF Lehman Review,	September 29
• 25th Anniversary,	September 29
• JSA Board Meeting	September 30
• House Science and Technology Testimony,	October 1
• All Hands Meeting	October 9
• Jefferson Lab Users Meeting, Hawaii,	October 15
• Director Brinkman visit,	October 28
• EIC AC at Jefferson Lab,	November 2,3
• Invitation from Basic Energy Sciences to submit JLAMP Proposal,	November 6
• Women in Science and Technology Workshop,	November 16,17
• Presentation of Jefferson Lab staffing plan through 2016,	November 24
• Strategic Planning Jamboree,	December 1
• JSA Science Council,	December 4
• Meeting Office of Science (Brinkman , Dehmer, Malosh) 2009 Performance	December 7
• Undersecretary Koonin visit	December 14
• JSA Operations Committees	December 18

JLab Injury History



Jefferson Lab Personnel

- 12 GeV Project Associate Project Manager for Physics
  Glenn Young (ex ORNL and RHIC Program)
- Hall D Leader
  - Eugene Chudakov (ex Hall A)
- Accelerator Division Deputy
  - Fulvia Pilat (ex RHIC) joining in next few months
- Physics Division
  - Dennis Skopik → Half Retirement, Summer 2009
  - Kees de Jager → Retirement, Summer 2010

  Major contributions to Jefferson Lab Physics are much appreciated
- Theory Director
  - Mike Pennington from Durham U., UK will start July 1.

- Lab Deputy Director – Science – discussions active

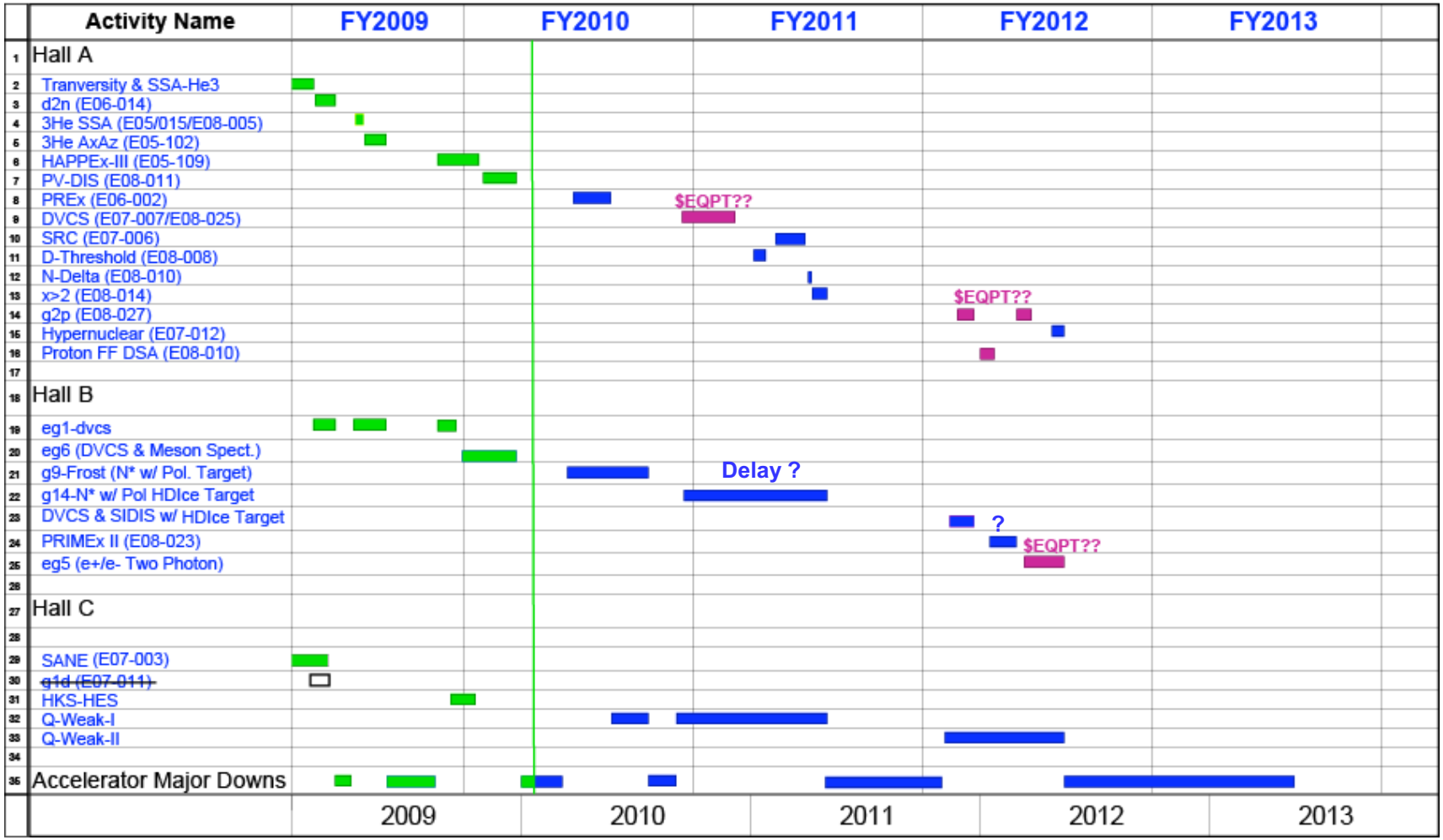
Experimental Nuclear Physics Program FY2010

- Fall 2009 Running is going well
  - Hall A, HAPPEX — completed
  - Hall A, PVDIS — running
  - Hall B eg1 DVCS (GPDs) completed
  - Hall B eg6 DVCS & Meson Spec. — Running
  - Hall C Hypernuclear Experiment completed
  - Hall C QWeak installation underway

FY11 Proposed (@ guidance) Funding Compared to FY10 Appropriation ($K)

Funding	FY10 PB	FY10 Approp	FY11 Guidance	FY11 Proposed (@ guidance)	% Change FY11 Proposed (@ guidance) FY10 Approp	Summary Comments
ME Research	6,200	6,200	6,695	6,265	1.1%	• Favorable FY11 budget request • $1.6M increase over 2010. Less than cost of living • ~$2M pressure
Theory Research	4,037	3,599	3,953	4,150	15.3%	
Accel Ops	49,000	47,140	47,869	49,328	4.6%	
Accel Capital Equipment	840	200	200	200	0%	
SRF R&D	1,500	1,365	1,556	1,400	2.6%	
Accel AIP	1,200	1,050	1,050	1,050	0%	
Exp Sup Ops	25,567	25,567	25,870	24,800	-3.0%	
Exp Support Capital Equipment	4,700	5,200	4,700	4,700	-9.6%	
GPP	2,000	2,000	2,000	2,000	0%	
Subtotal NP Base	**95,044**	**92,321**	**93,893**	**93,893**	**1.7%**	
12 GeV	22,000	20,000	36,000	36,000	80.0%	
Subtotal NP Base & 12 GeV	**117,044**	**112,321**	**129,893**	**129,893**	**15.6%**	
National LQCD Ops & CE	223	223	231	231	3.6%	
SciDAC	299	299	309	309	3.3%	
Total NP	**117,566**	**112,843**	**130,433**	**130,433**	**15.6%**	

Status as of Today



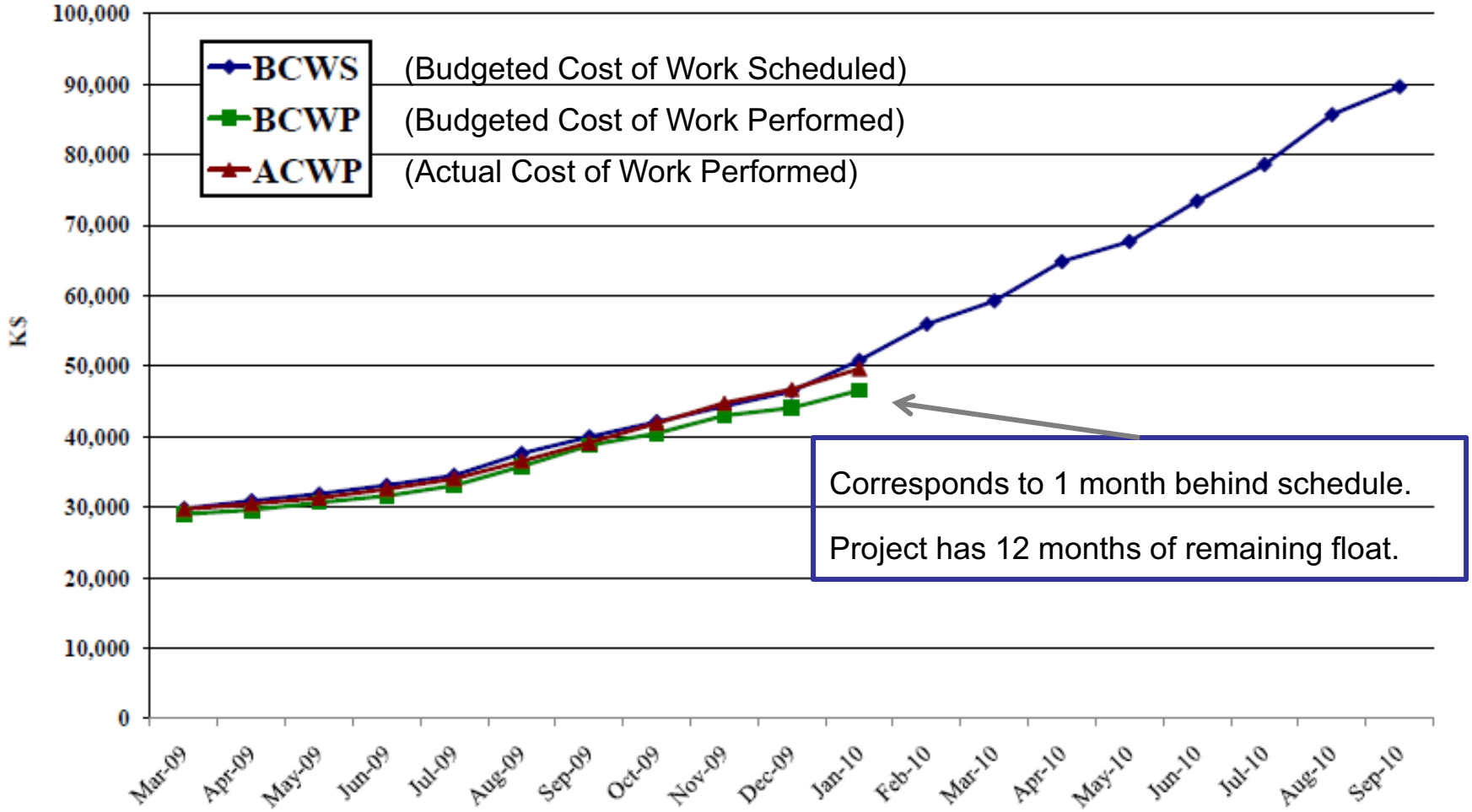
■ = FY09 runs; successful except for g_1^d(polarized target failure), also a number of runs (eg1-dvcs, eg6, HAPPEx-III, PVDIS, HKS) were limited to ~3/4 of planned data

■ = Equipment funding uncertainties remain for FY10-FY12

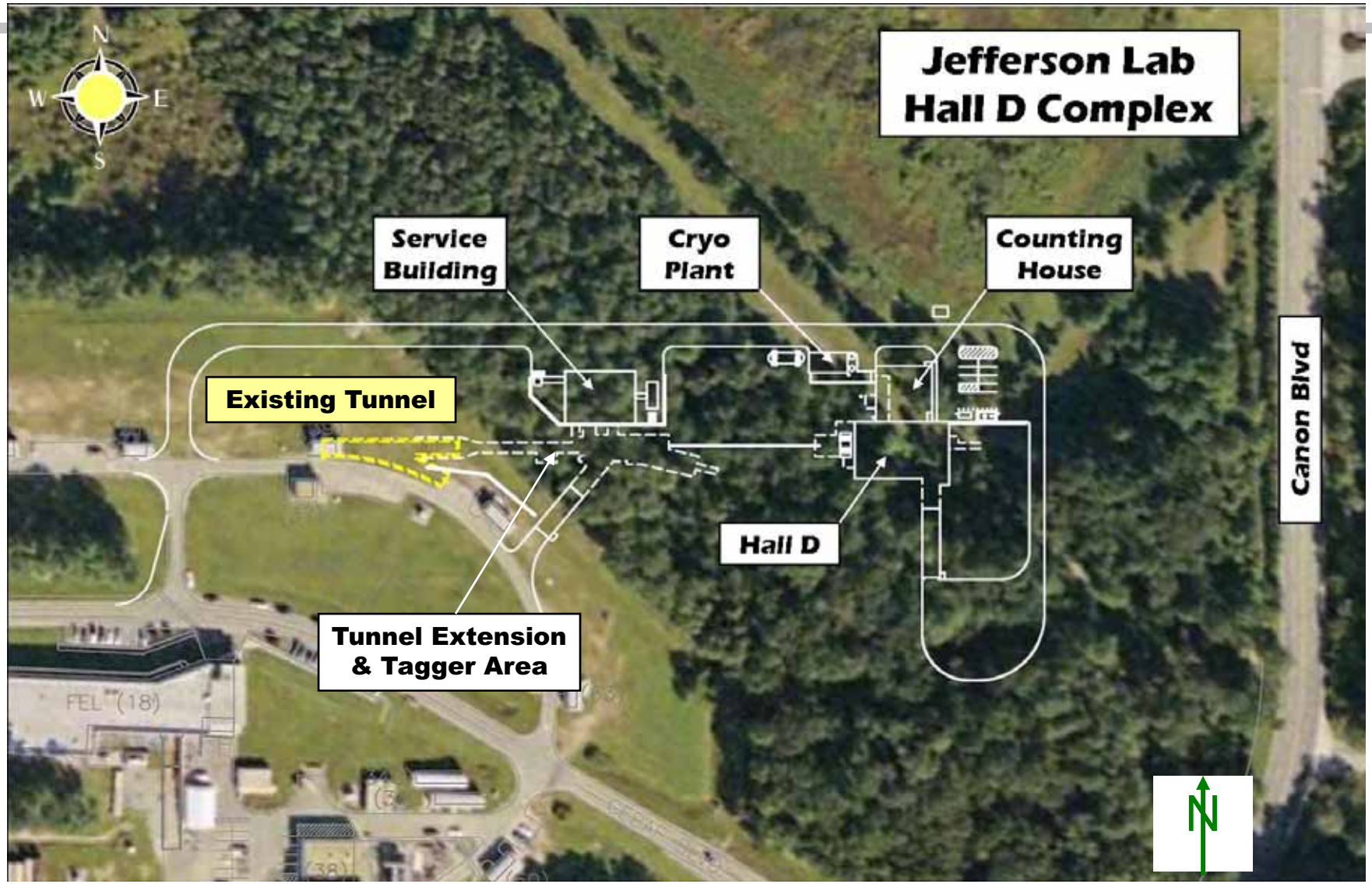
FY11 Issues/Concerns @ Guidance

- The guidance for FY2011 is at less than cost of living and it appears as though we would be about $2M short with respect to need.
- We illustrate consequence with impact on 2012 experiment preparation
- Eventual shortfall will depend on FY2010 actual performance. Any help would be appreciated
- Currently, the candidates to absorb the shortfall are:
  - **$0.75 - 1.0M GPP** – currently we are showing $2M in GPP; given the $10M in 2009, this must be a candidate.
  - **$1.0M BIA** – currently we show in excess of $1M in Klystron work; recent history encourages us to continue the “risk management” approach.
  - **$0.50M Experimental Program** – this will compromise the program beyond QWeak (see following physics slides). The users have been warned. However, management of any actual cut is tricky. We would like to see where we are late in FY2010; it is not clear that the users would be comfortable with that.
- The conclusion here is that we have a tight but manageable situation.

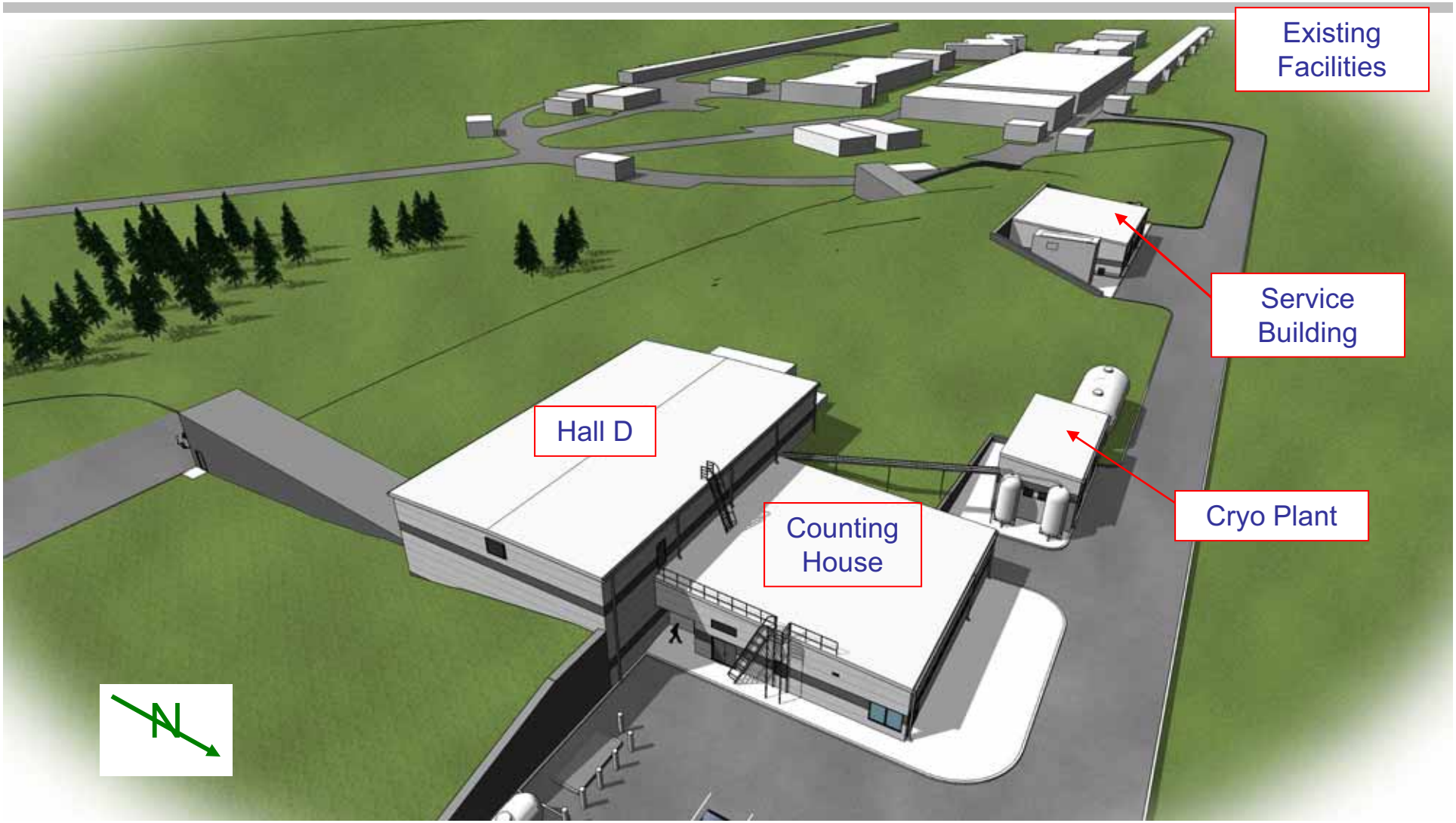
12 GeV Total Project Performance



Hall D Complex – Civil Site Plan



Rendering of Hall D Complex – Overhead View



Acceleration & Beam Transport

- Eight cavities are packaged into each cryomodule
  - 42 cryomodules in CEBAF today
  - 10 new ones will be added
    - high-performance, quadruple the gradient
- Each cavity has dedicated microwave source
  - 338 in CEBAF today
  - 80 new ones will be added
- Duplicate the existing cryogenics plant

Re-use almost all

- Upgrade or replace existing recirculation & transport elements
  - 357 major Dipoles (1-3m long)
  - 730 Quads (30x30x30cm)
  - >2000 power supplies
  - >700 beam diagnostics
  - >5 km of vacuum line

New

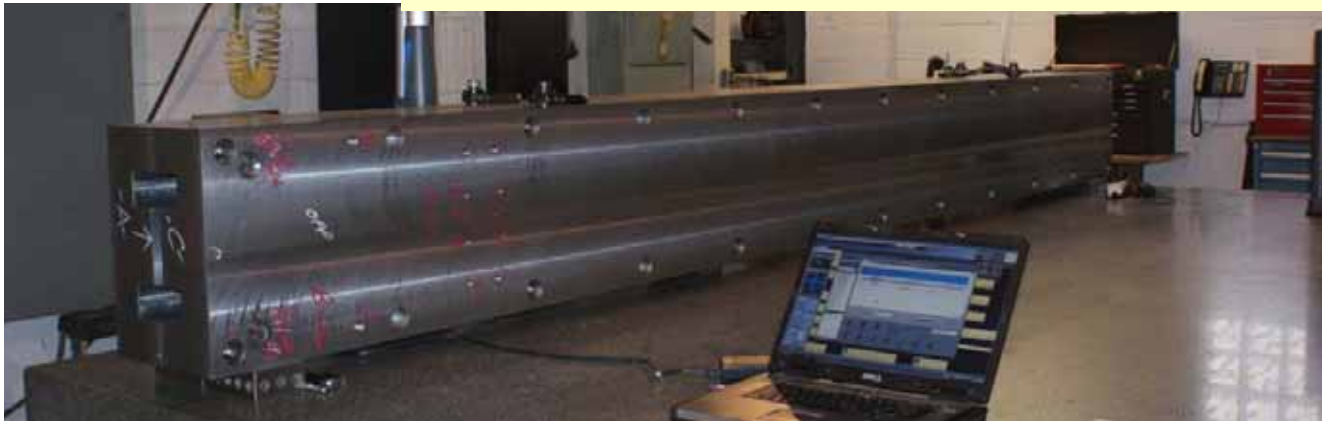
- Arc 10
  - 32 major dipoles (4m long)
  - 40 quads (35x30x30cm)
  - 81 power supplies
  - 32 beam diagnostics
  - 0.3 km of vacuum line

CONSTRUCTION HIGHLIGHTS

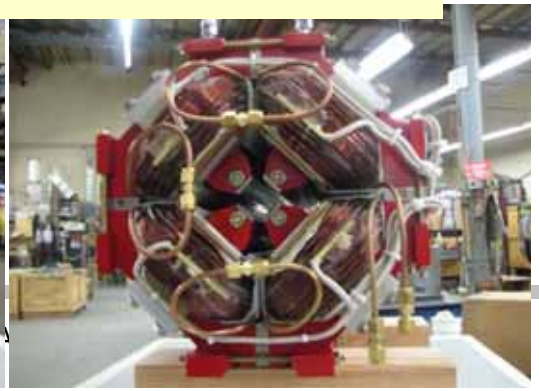
- Accelerator Major Procurements:
  - cryomodule cavities ; beam transport magnets ; helium refrigerator

- Accelerator Installation Start: Dec '09 to Jan '10
  - Prep work:
  - RF zones
  - baseplates
  - stands
  - alignment

Core of 4m Dipole Magnet at Vendor



Beam Transport Quadrupole Magnets at JLab



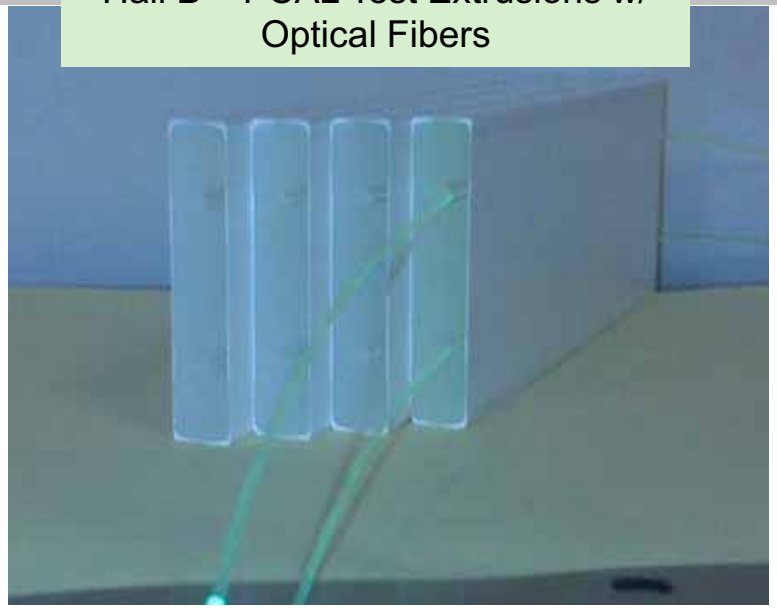
CONSTRUCTION HIGHLIGHTS

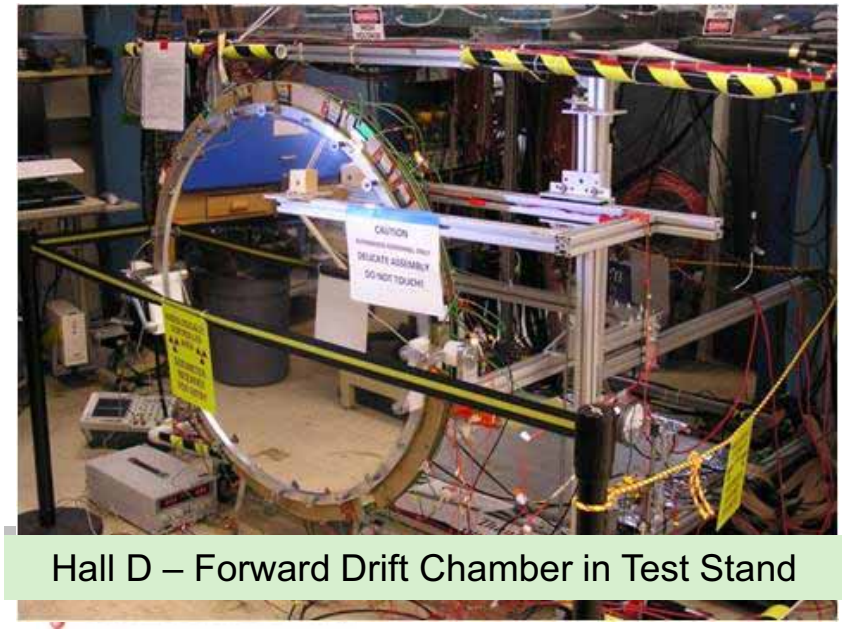
PHYSICS EQUIPMENT

- Major contracts awarded:
  - *3 superconducting spectrometer magnets*
  - *Hall D Barrel Calorimeter detector construction (Univ of Regina)*
- Major contracts in progress
  - *Hall C Horizontal Bend spectrometer magnet (MSU NSCL)*
  - *Hall D Central Drift Chamber (Carnegie Mellon)*
  - *Hall D Forward Calorimeter (Indiana University)*
  - *Hall B Drift Chambers (Old Dominion; Idaho State)*

PHYSICS EQUIPMENT CONSTRUCTION

Hall B – PCAL Test Extrusions w/ Optical Fibers





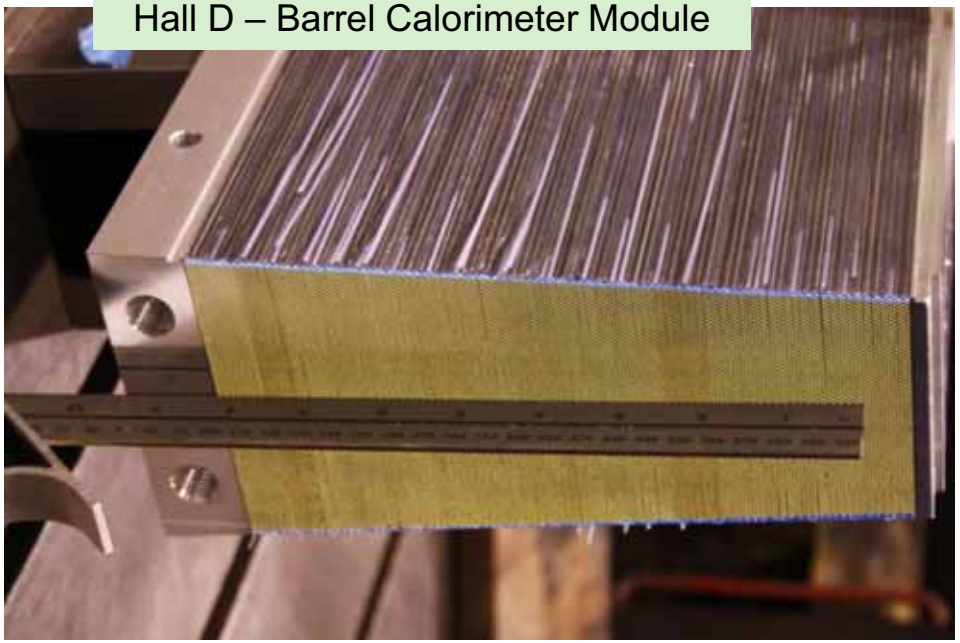
Hall D – Forward Drift Chamber in Test Stand

Hall C Superconducting Magnet Coil

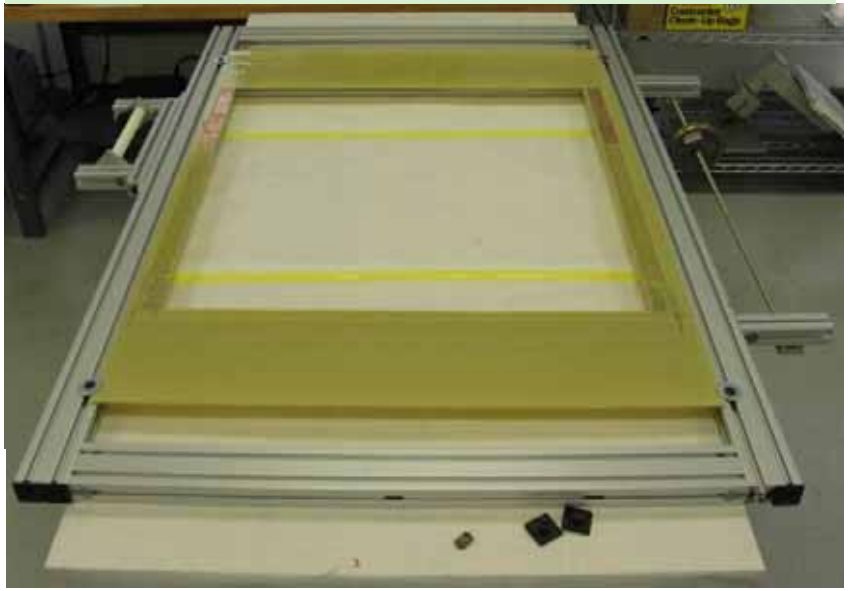
PHYSICS EQUIPMENT CONSTRUCTION

Hall B – Region II Drift Chamber Frame Assembly

Hall D – Barrel Calorimeter Module



Hall C – Wire Stringing Jig for Drift Chamber



CONSTRUCTION HIGHLIGHTS

PHYSICS EQUIPMENT

Strong university User involvement

Two NSF MRI grants

- *Hall B pre-shower calorimeter detector*
  - *William&Mary, James Madison, Norfolk State, Ohio Univ*
- *Hall C detectors*
  - *William&Mary, James Madison, Hampton Univ, NCA&T*

International contributions/collaborators

- *Hall C lead glass: NIKHEF and Yerevan*
- *Hall D: Univ of Regina (Canada); Santa Maria (Chile)*


Groundbreaking


Excavation

Civil Construction: Hall D Complex 2009-2010

12 GeV Upgrade

- An exciting scientific opportunity
  - Explore the physical origins of quark confinement (GlueX)
  - New access to the spin and flavor structure of the proton and neutron
  - Discovering the quark structure of nuclei
  - Probe potential new physics through high precision tests of the Standard Model
- Cost effective plan re-uses most of existing facility
- Strong User community involvement
  - NSF MRI funding to universities for detector elements
  - Strong international collaborations
- Project performance within DOE thresholds
- Construction is well underway !
  - Accelerator commissioning will start May 2013
  - Hall commissioning starts Oct 2013 through Oct 2014
  - Project completion by June 2015

Jefferson Laboratory

Realistic goals

- **World Leading Nuclear Science Program based on 6 GeV then 12 GeV Continuous Electron Beam Accelerator**
  - The nature of Quantum Chromo Dynamics confinement
  - Transformative understanding of nuclear and nucleon structure
  - Precision measurements which challenge and test the standard model of particle and nuclear physics
  - Top class theoretical elucidation

- **World Leadership in Superconducting Radiofrequency Acceleration**
  - Research and development advancing the technology
  - Supporting technologies
  - Support for accelerator construction across the Office of Science

- **A top class longer term future program**
  - Electron Ion Collider
  - Photon science program based on SC Free Electron Laser with next generation light source techniques

- **Excellence in Management and Stewardship**
  - Modern infrastructure