Jefferson Lab
12 GeV UPGRADE

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NSAC Meeting
Washington, DC
February 26, 2010

OUTLINE

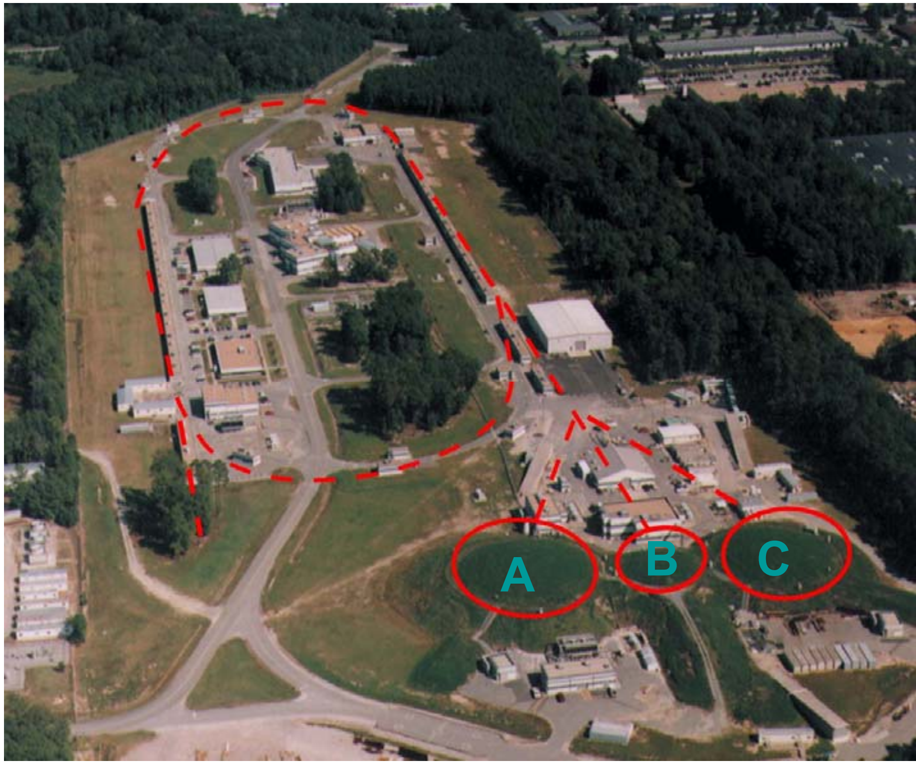
- Existing Jefferson Lab Facility
- Scientific Opportunities
- Jefferson Lab in 12 GeV Era
- Project – Cost & Schedule
- Construction Highlights & Status
- Summary

JEFFERSON LAB TODAY

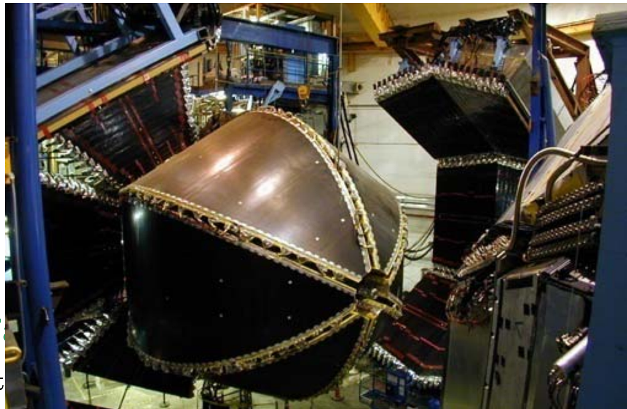
>1300 active member international user community engaged in exploring quark-gluon structure of matter.

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

Newport News, VA



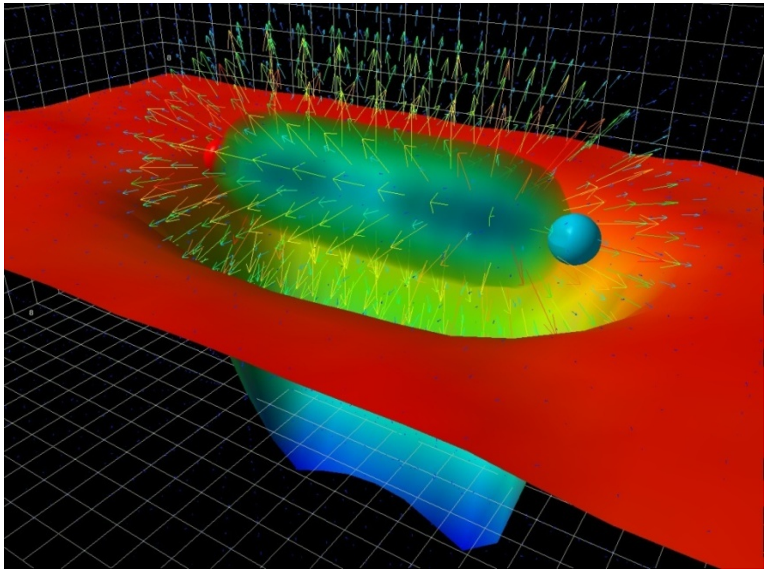
CEBAF's delivery of beam with unique properties to three experimental halls simultaneously. Each hall offers complementary capabilities.



Highlights of the 12 GeV Science Program

- **Explore the physical origins of quark confinement (GlueX)**
- **New and revolutionary 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**

Gluonic Excitations and the Origin of Confinement

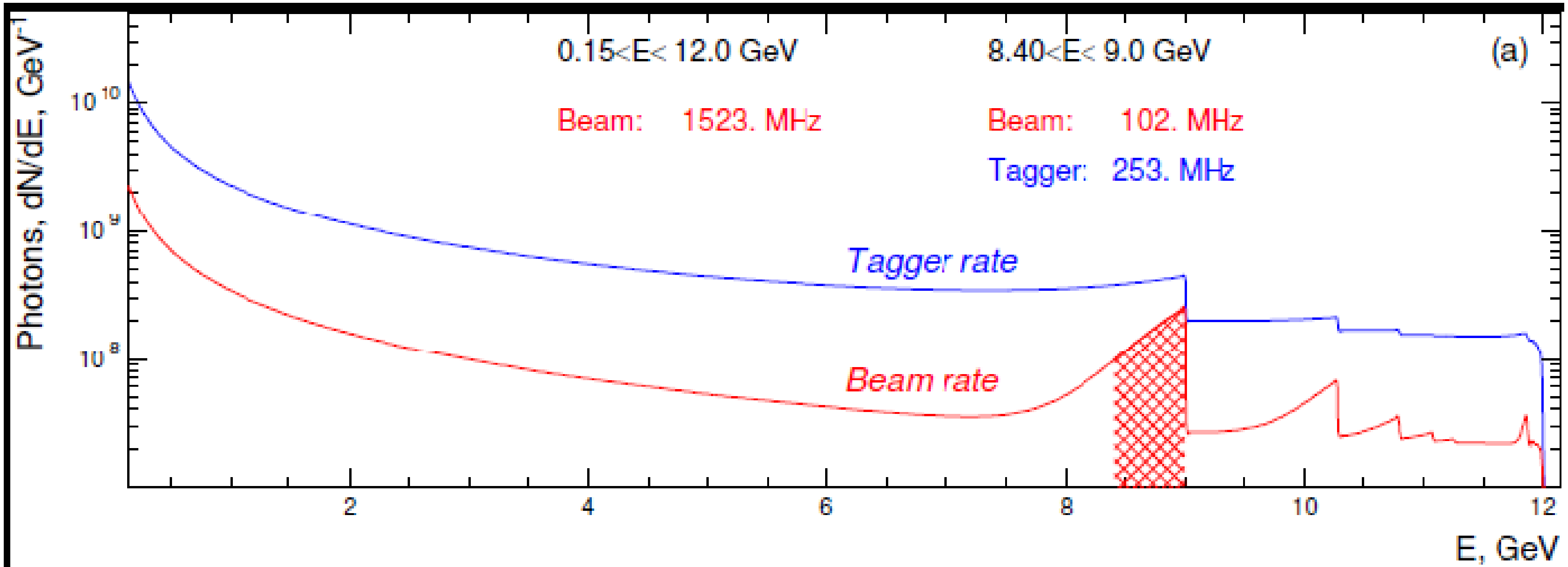


Does confinement occur through formation of string-like flux tubes between quarks? Test this via spectrum of gluonic excitations of exotic mesons.

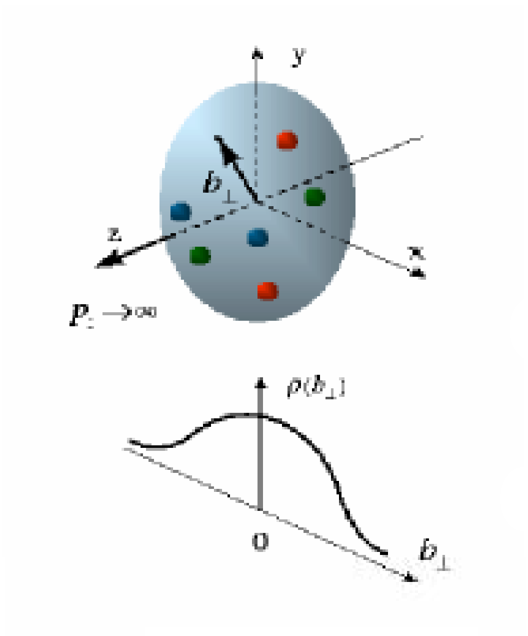
With the 12 GeV CEBAF, a linearly polarized photon beam, and the GlueX detector, JLab will be uniquely poised to:

- **discover these states,**
- **map out their spectrum, and**
- **measure their properties**

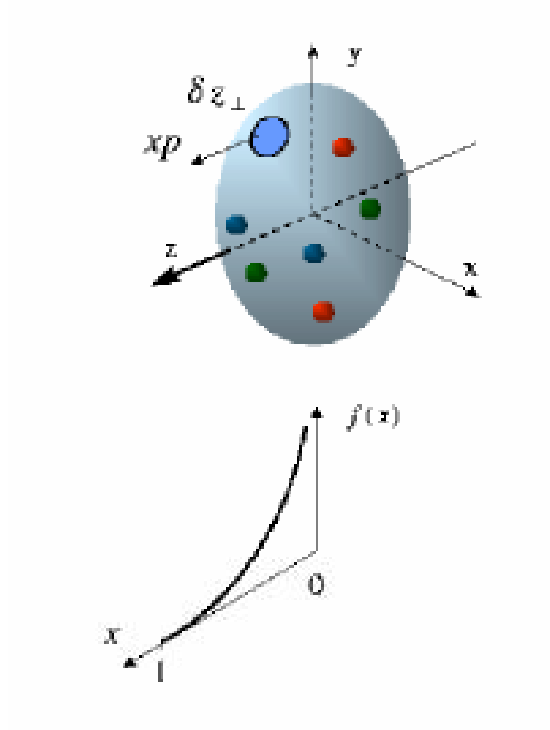
FOM (P^2 Nγ) peaks for M=2.5 GeV and E_0=12 GeV



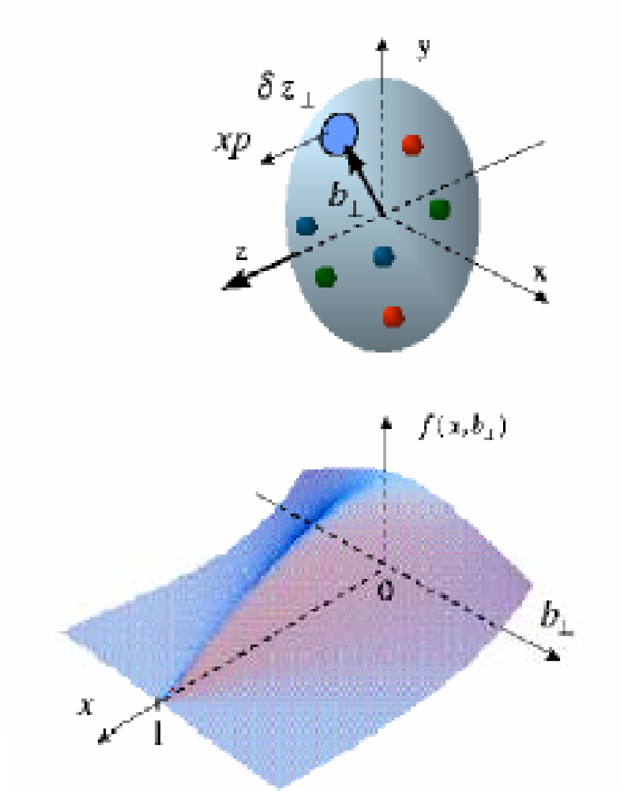
New, comprehensive view of hadronic structure



Elastic Scattering
transverse quark distribution in Coordinate space



DIS
longitudinal quark distribution in momentum space



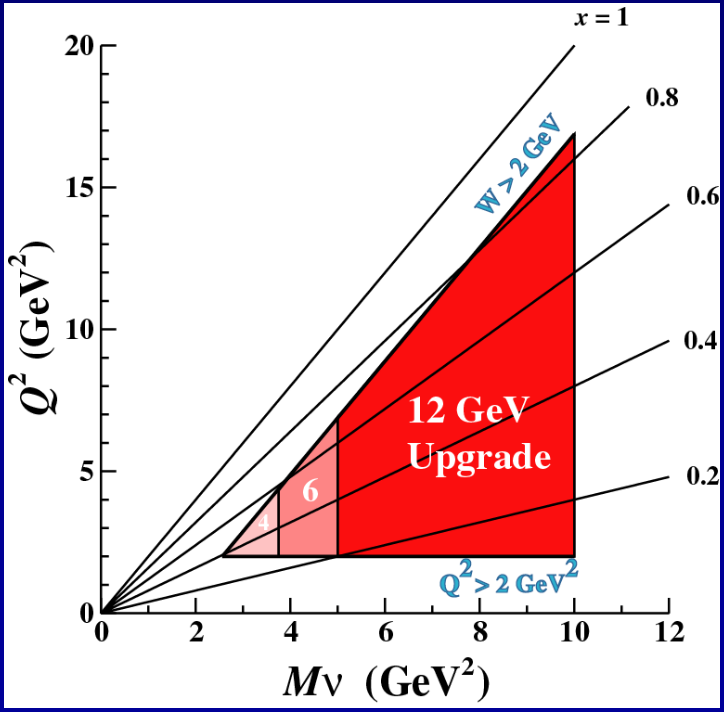
GPDs
The fully-correlated Quark distribution in both coordinate and momentum space

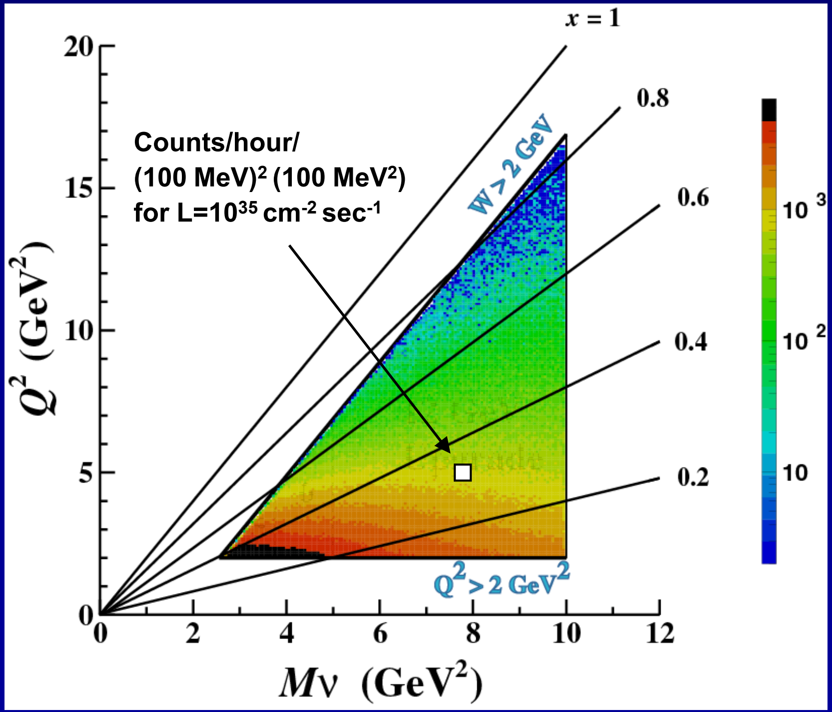
GPDs connect the charge and parton distribution

Quark Structure of Nuclei

- (Nucleons and Pions) or (Quarks and Gluons)?
- Not a simple convolution of free nucleon structure with Fermi motion
- In nuclear deep-inelastic scattering, we look directly at the quark structure of nuclei

12 GeV Upgrade Provides Substantially Enhanced Access to the DIS Regime with enough luminosity to reach the high-Q^2, high-x region!



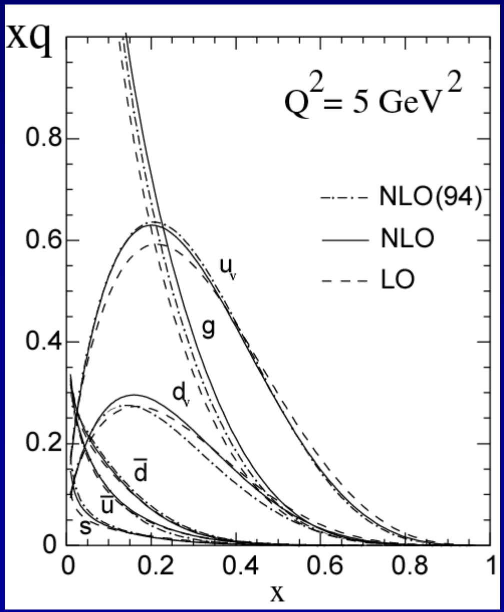


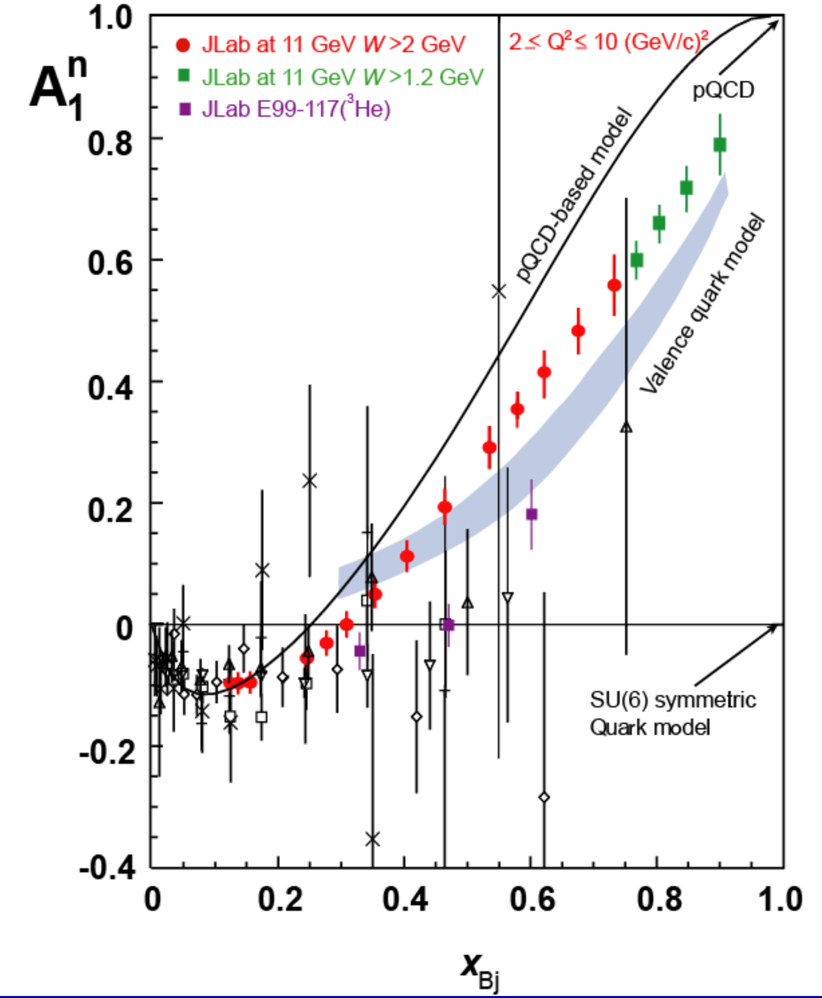
Measuring High-x Structure Functions

REQUIRES:

- High beam polarization
- High electron current
- High target polarization
- Large solid angle spectrometers

Neutron polarization asymmetry





12 GeV will access the regime (x > 0.3), where valence quarks dominate

Does $A_1^n \to 1$ as $x \to 1$?

Defining 12 GeV PHYSICS Program

Four Reviews: **Program Advisory Committees (PAC) 30, 32, 34, 35**

- **2006 through 2010**
- **Recent Charge:**
  - Review proposals that will use base equipment for 12 GeV Upgrade
    - in ***top half*** of priority list for first 5 years of 12 GeV Operations
  - Review proposals that will require major new apparatus
- **Results**:
  - **32 experiments approved**
  - **13 conditionally approved**

Exciting slate of experiments for 4 Halls planned for initial five years of operation!

- **Future Plans:**
  - **12 GeV PACs (a) Proposals, (b) Ranking)**

12 GeV SCIENCE CATEGORIES

- **The Hadron spectra as probes of QCD**
  (GlueX and heavy baryon and meson spectroscopy)

- **The transverse structure of the hadrons**
  (Elastic and transition Form Factors)

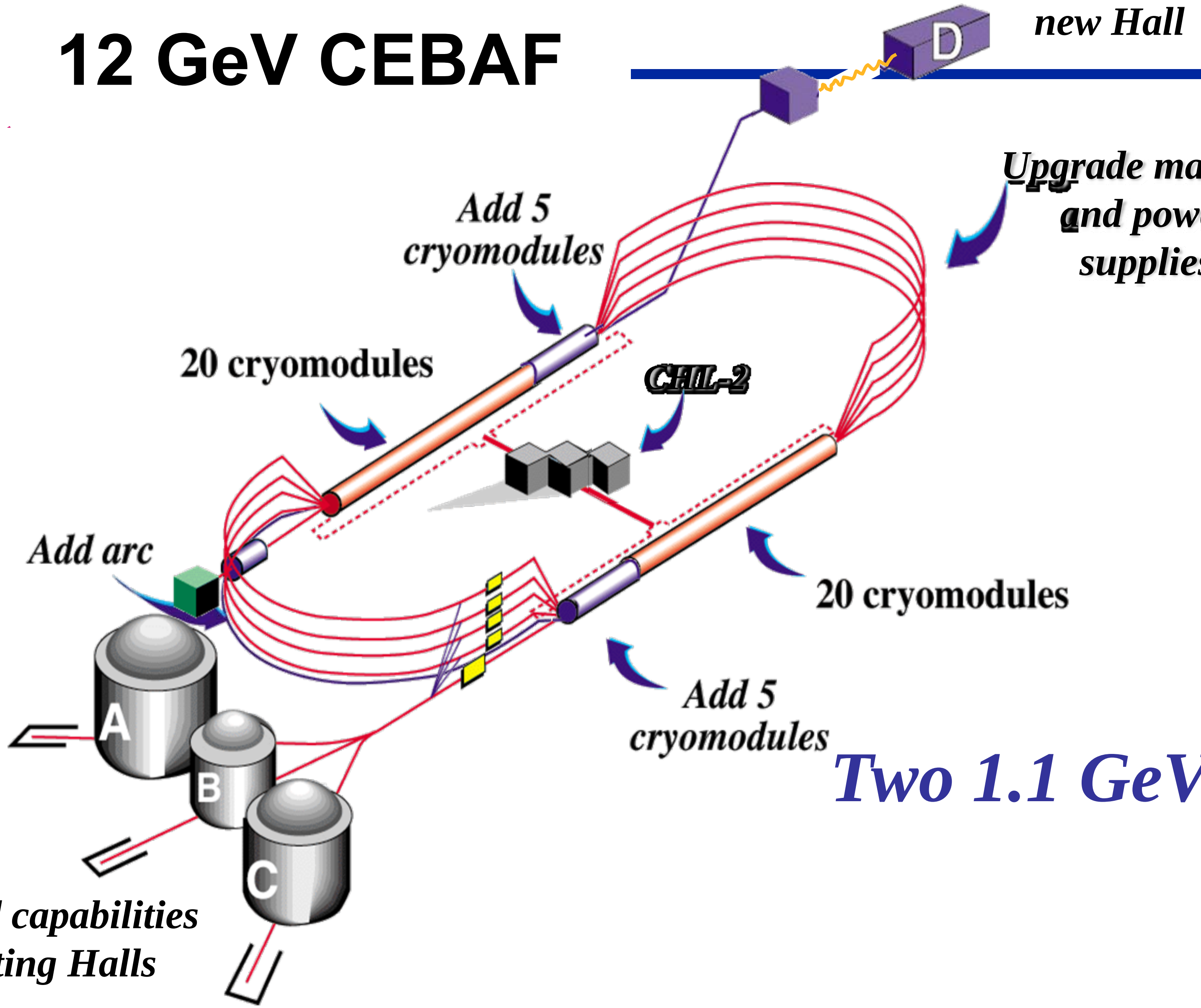
- **The longitudinal structure of the hadrons**
  (Unpolarized and polarized parton distribution functions)

- **The 3-D structure of the hadrons**
  (Generalized Parton Distributions and Transverse Momentum Distributions)

- **Hadrons and cold nuclear matter**
  (Medium modification of the nucleons, quark hadronization, N-N correlations, hypernuclear spectroscopy, few-body experiments)

- **Low-energy tests of the Standard Model and Fundamental Symmetries**
  (Møller, PVDIS, PRIMEX, …..)

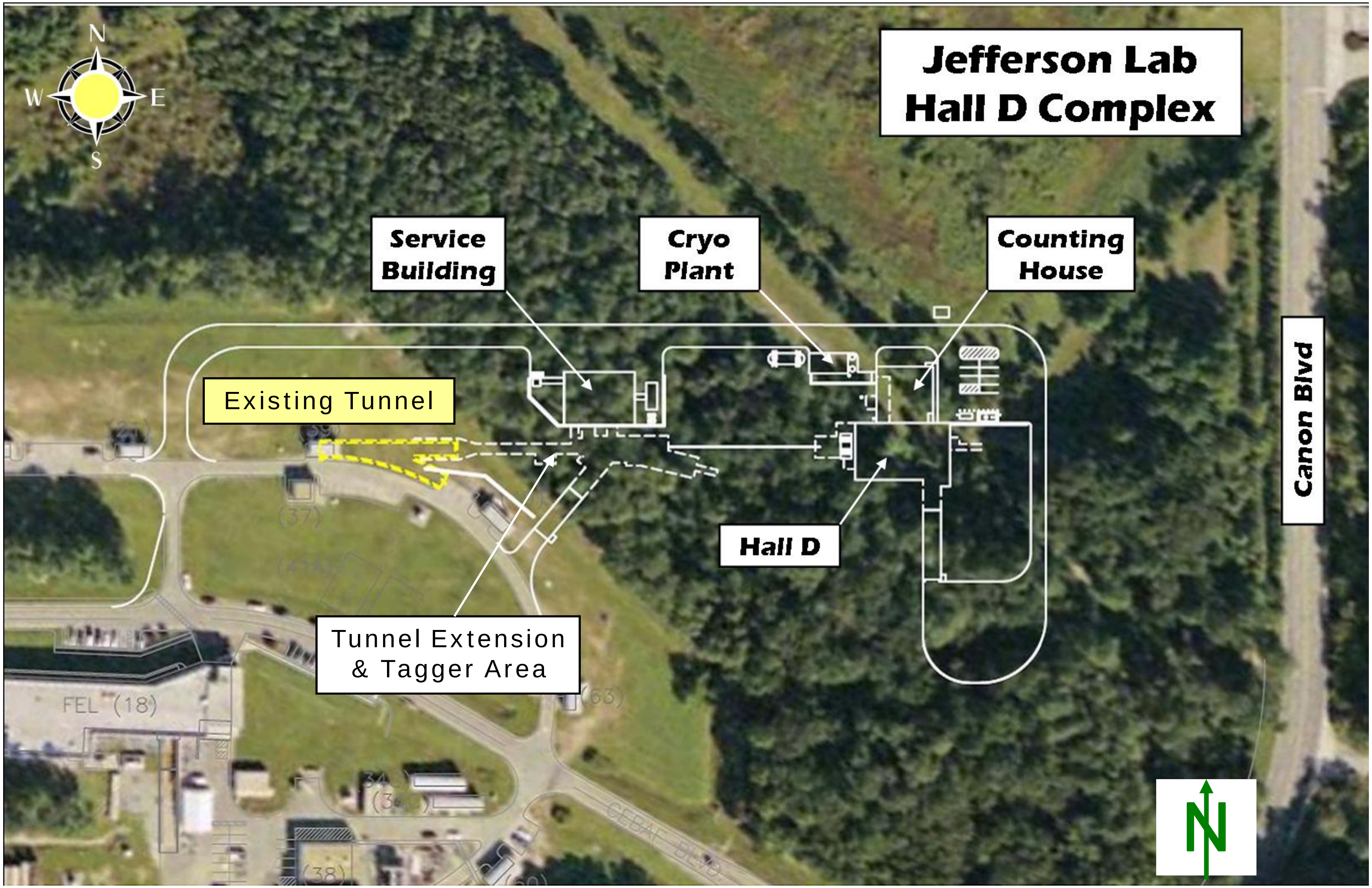
12 GeV CEBAF



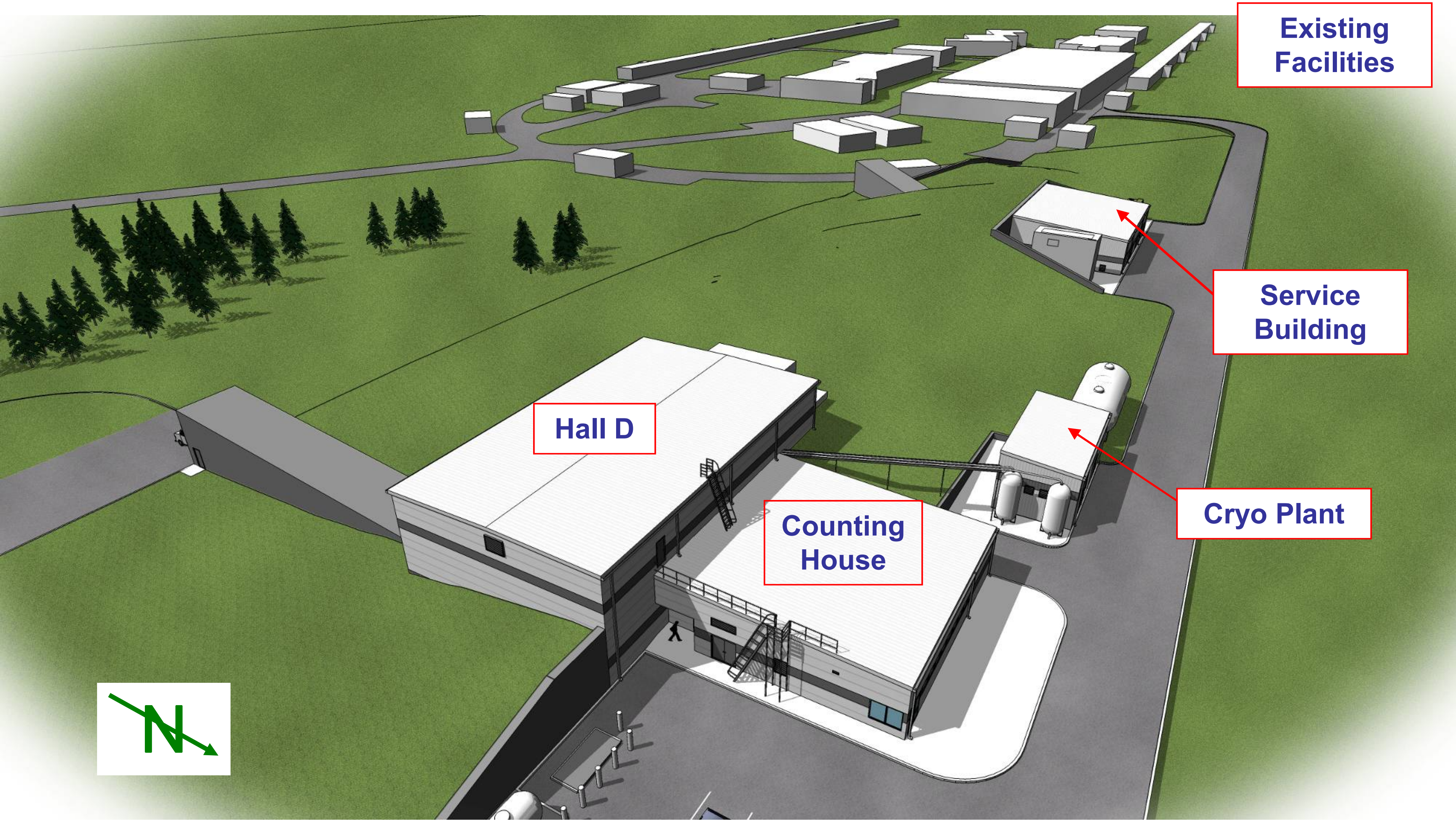
Two 1.1 GeV linacs

Enhanced capabilities in existing Halls

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

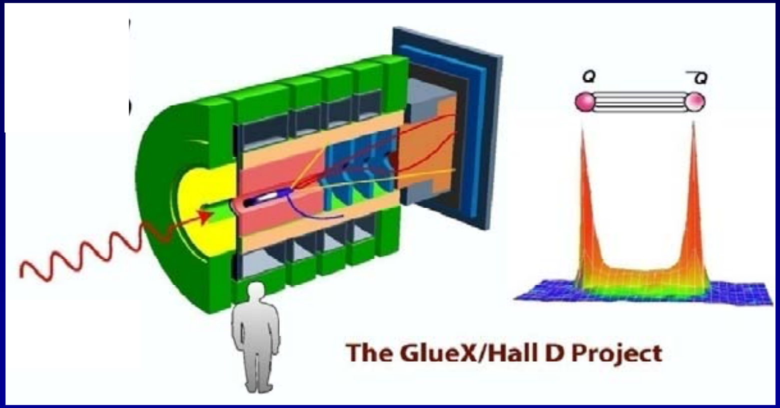
New

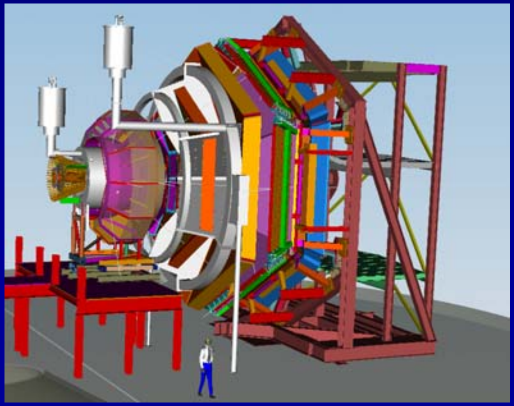
- Arc 10
  - 32 major dipoles (4m long)
  - 40 quads (35x30x30cm)
  - 81 power supplies
  - 32 beam diagnostics
  - 0.3 km of vacuum line

Office of Nuclear Physics
Exploring Nuclear Matter - Quarks to Stars

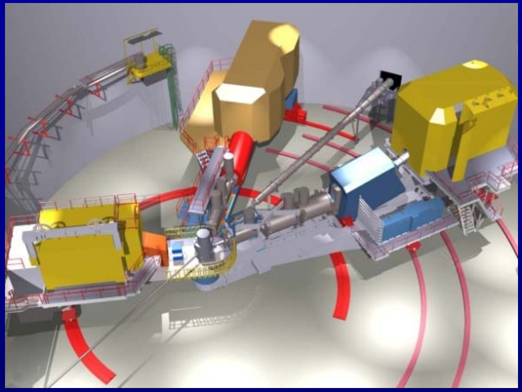
12 GeV Scientific Capabilities

Hall D – exploring origin of confinement by studying exotic mesons

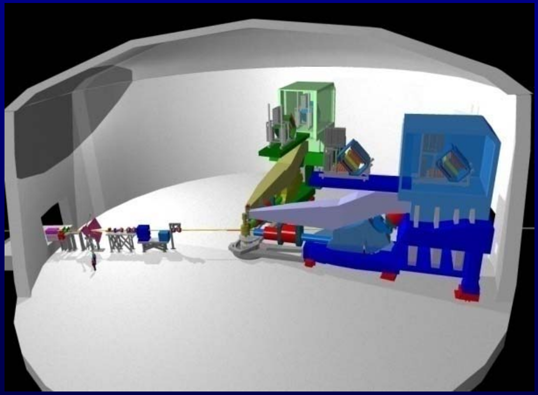




Hall B – understanding nucleon structure via generalized parton distributions



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. PV and Moller)

SCOPE OF 12 GeV UPGRADE

Parameter	Present JLab	Upgraded JLab
Number of Halls	3	4
Number of passes Halls A/B/C	5 (for max energy)	5 (for max energy)
Max Energy to Halls A/B/C	up to ~6 GeV	up to ~11 GeV
Number of passes to Hall D	New Hall	5.5
Energy to Hall D	New Hall	12 GeV
Current – Hall A & C	max ~180 μA combined	max ~85 μA combined (higher at lower energy)
Current – Hall B & D	(B) Up to 5 μA max	(B, D) Up to ~5 μA max each
Central Helium Liquefier (CHL)	4.5 kW	9 kW
# of cryomodules in LINACS	40	50
Accelerator energy per pass	1.2 GeV	2.2 GeV

Routinely provide beam polarization of ~85% now, same in 12 GeV era

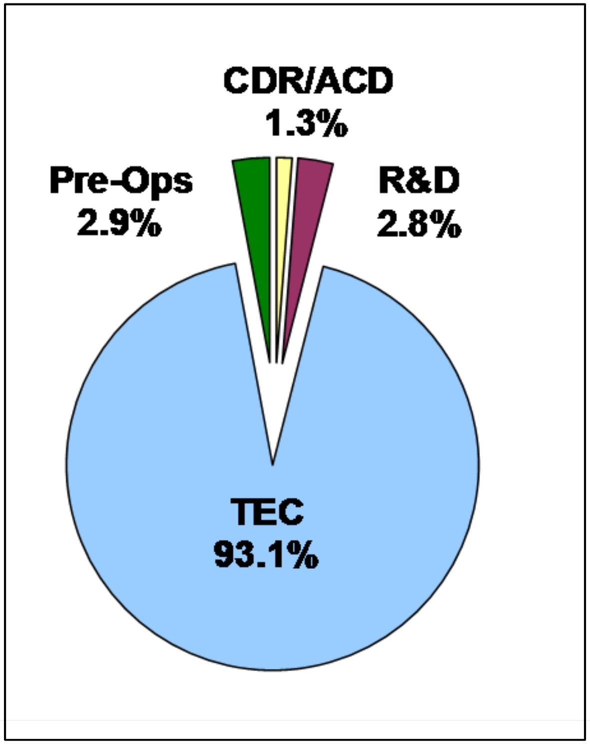
DOE CRITICAL DECISION SCHEDULE

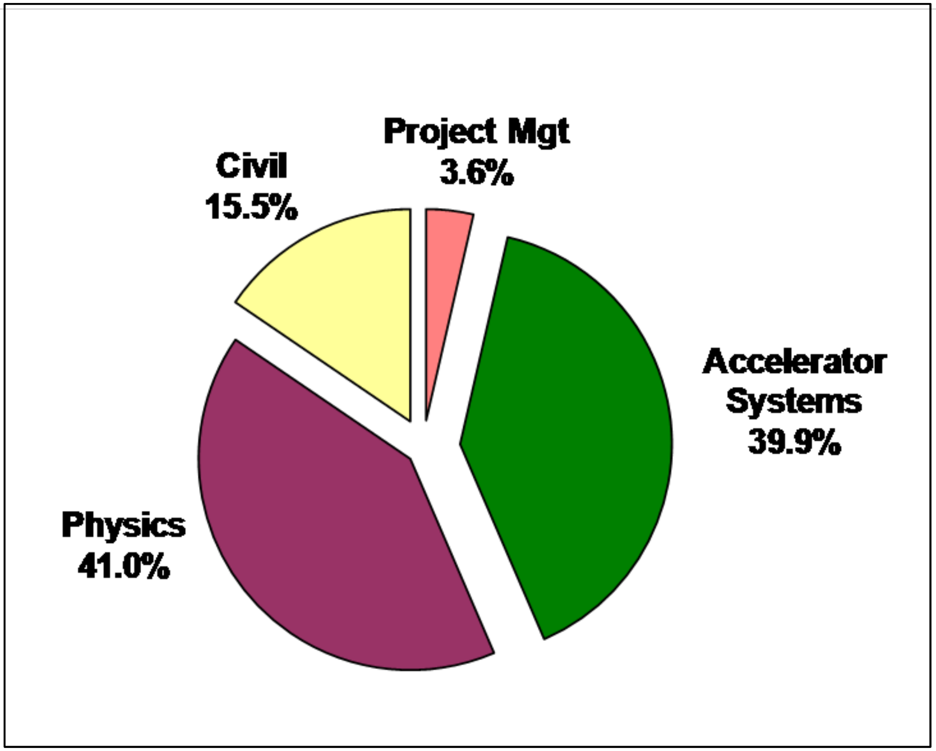
CD-0 Mission Need	MAR-2004 (A)
CD-1 Preliminary Baseline Range	FEB-2006 (A)
CD-2 Performance Baseline	NOV-2007 (A)
CD-3 Start of Construction	SEP-2008 (A)
CD-4A Accelerator Project Completion and Start of Operations	DEC-2014
CD-4B Experimental Equipment Project Completion and Start of Operations	JUN-2015

~15 months into 5.5 year construction period

CD-4 split to ease transition into operations phase

12 GeV TPC and Construction



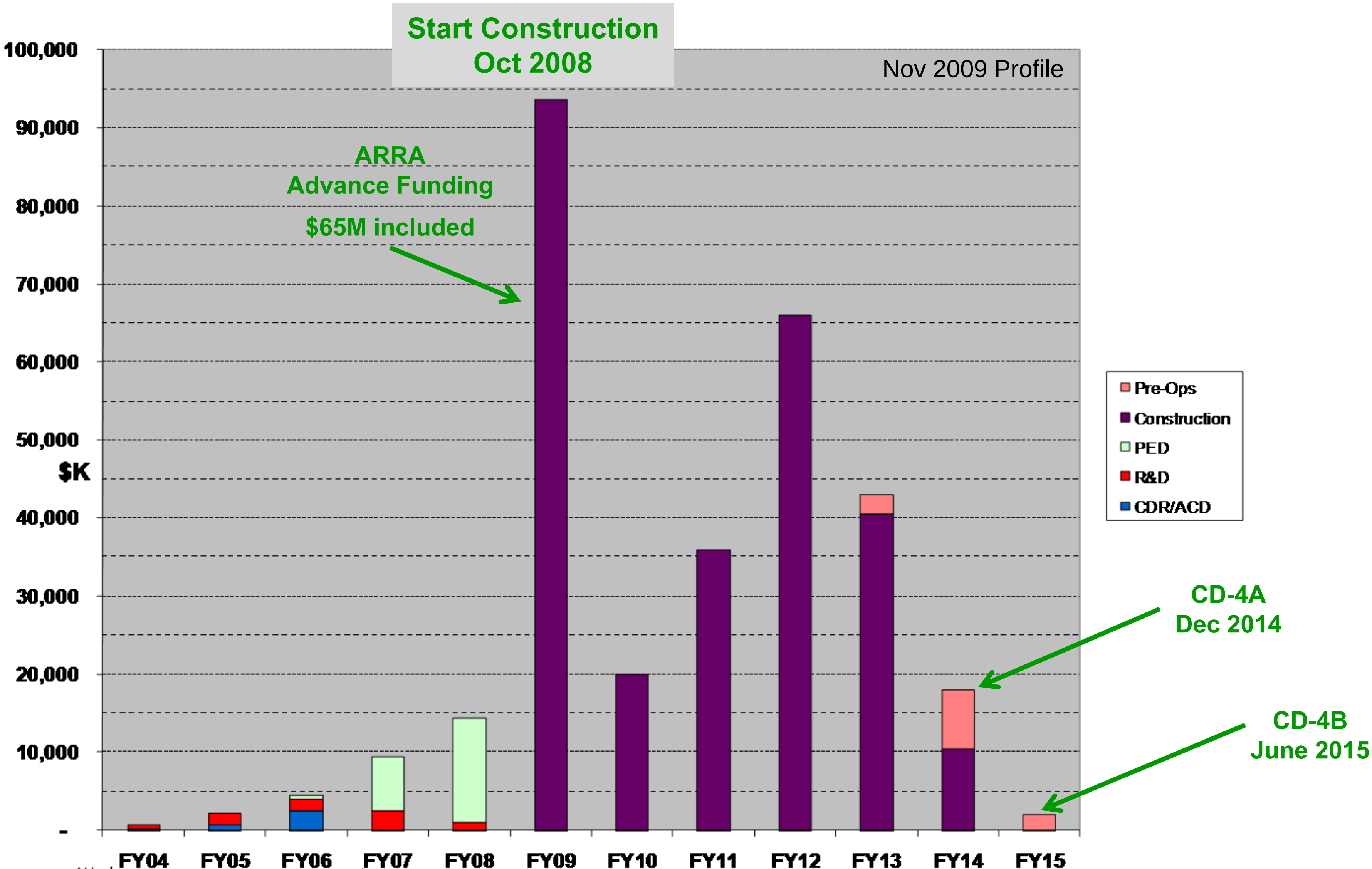


Construction

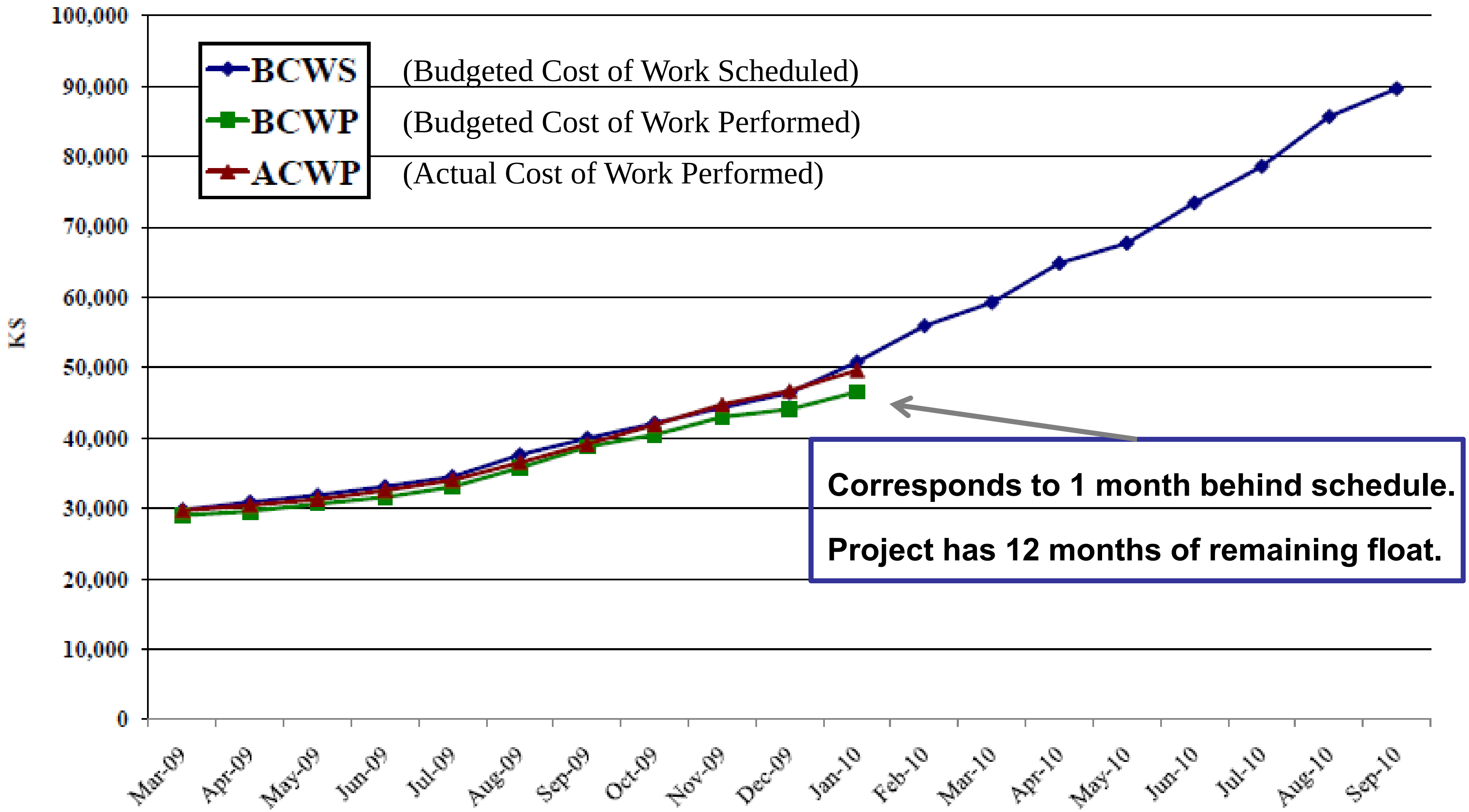
Total Project Cost= $310M

Total Equipment Cost=$287.5M

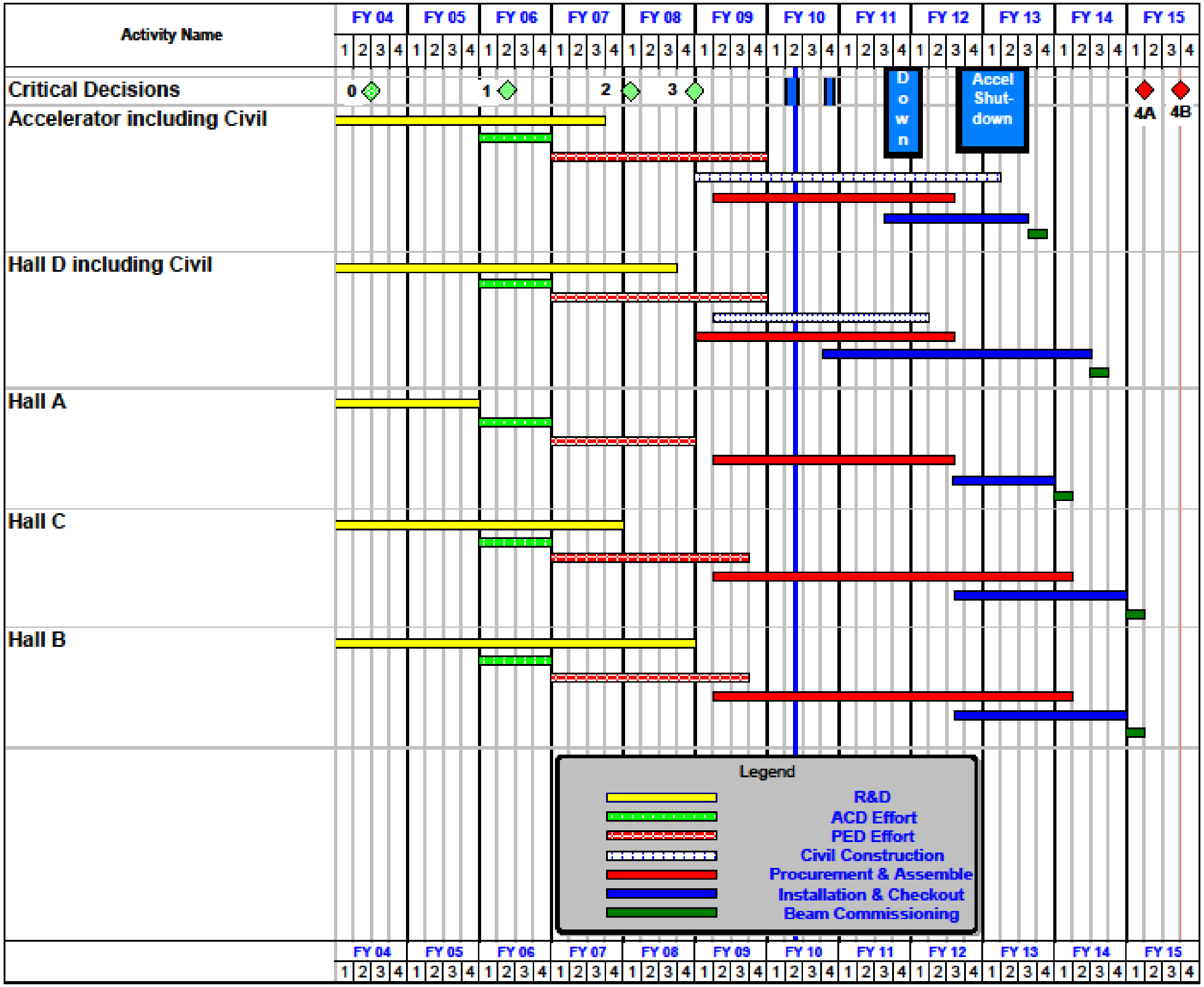
12 GeV - $310M Total Project Cost



12 GeV Total Project Performance



12 GeV UPGRADE SCHEDULE



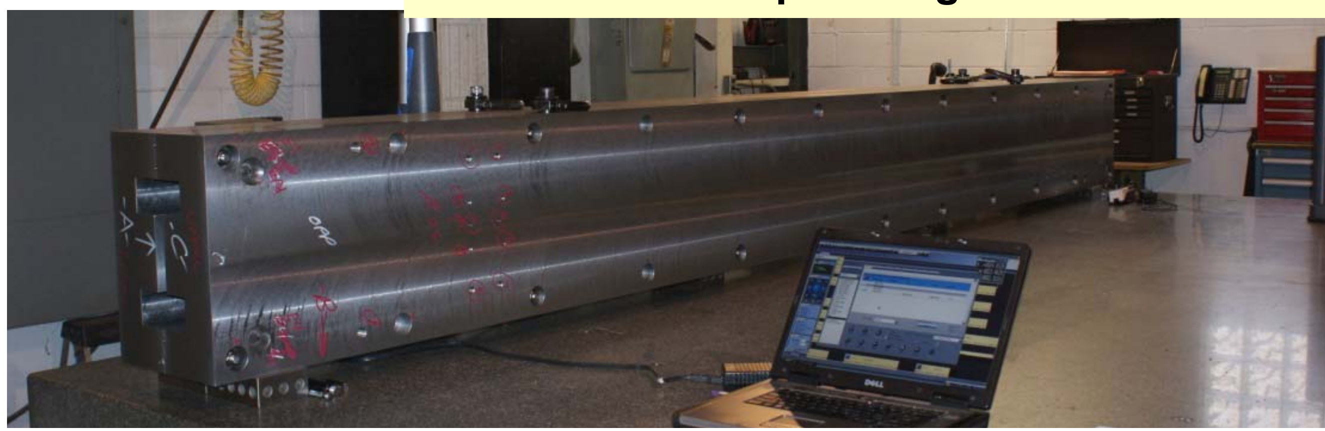
- 6-month installation May-Oct 2011
- 12-month installation May 2012-May 2013
- Hall A commissioning start October 2013
- Hall D commissioning start April 2014
- Halls B and C commissioning start October 2014
- Project Completion June 2015

CONSTRUCTION HIGHLIGHTS

- **<u>Accelerator Major Procurements:</u>**
  - **cryomodule cavities ; beam transport magnets ; helium refrigerator**

- **<u>Accelerator Installation Start: Dec ‘09 to Jan ‘10</u>**
  - **<u>Prep work</u>:**
    - **RF zones**
    - **baseplates**
    - **stands**
    - **alignment**

Core of 4m Dipole Magnet at Vendor



Beam Transport Quadrupole Magnets at JLab

CONSTRUCTION HIGHLIGHTS

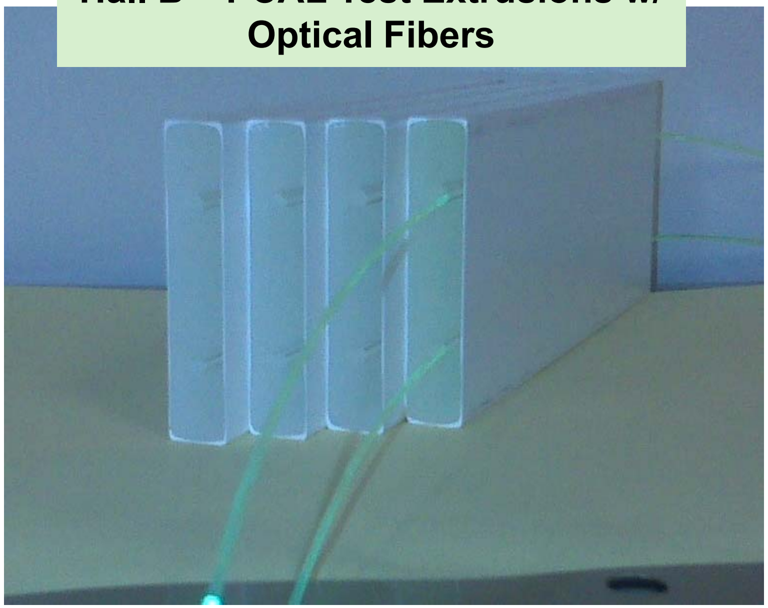
PHYSICS EQUIPMENT

- **Major contracts awarded:**
  - ***3 superconducting spectrometer magnets***
  - ***Hall D Barrel Calorimeter detector construction (Univ of Regina)***

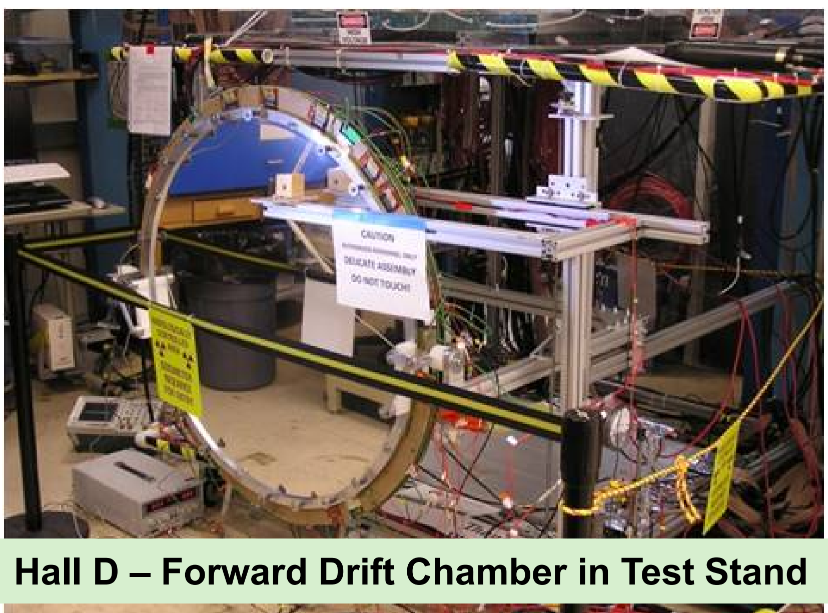
- **Major contracts in progress**
  - ***Hall C Horizontal Bend spectrometer magnet (MSU NSCL)***
  - ***Hall D Central Drift Chamber (Carnegie Mellon)***
  - ***Hall D Forward Calorimeter (Indiana University)***
  - ***Hall B Drift Chambers (Old Dominion; Idaho State)***

PHYSICS EQUIPMENT CONSTRUCTION

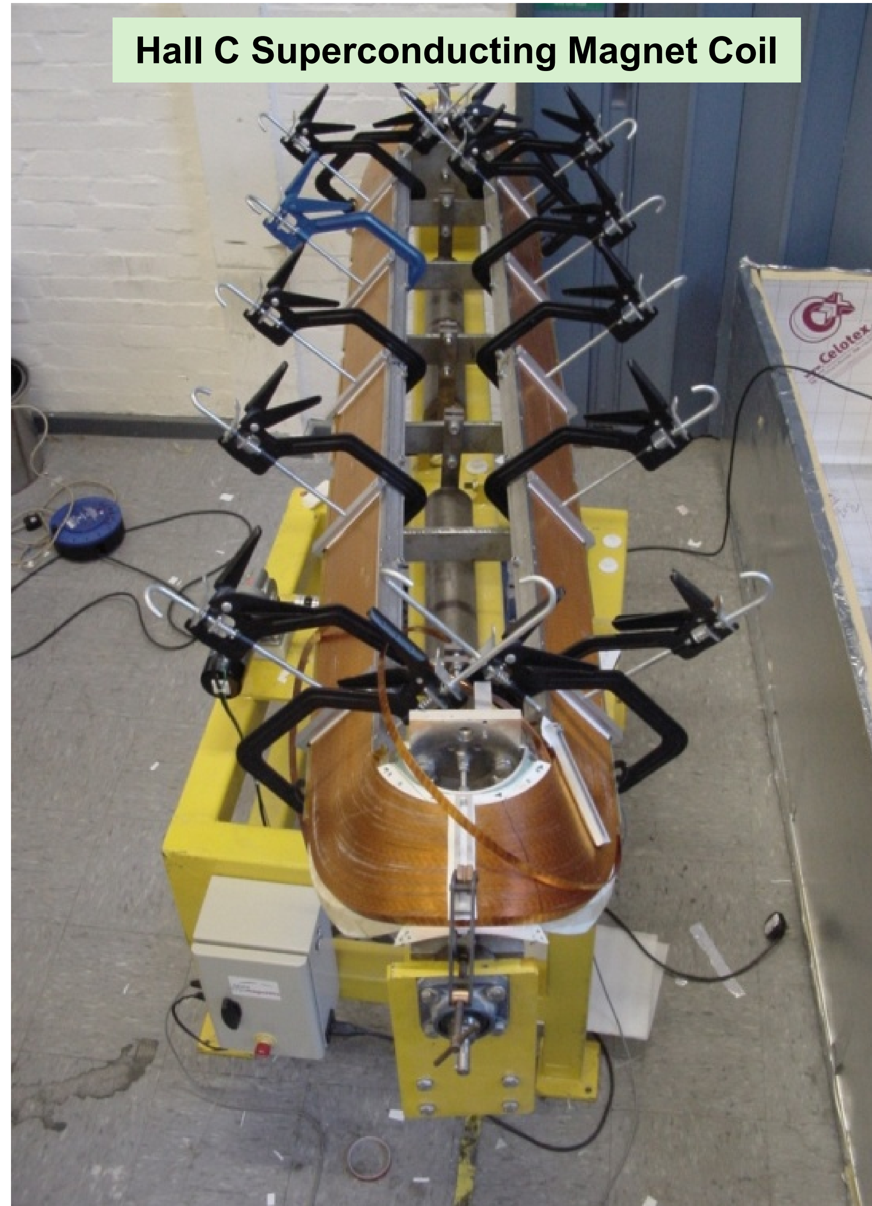
Hall B – PCAL Test Extrusions w/ Optical Fibers



Hall D – Forward Drift Chamber in Test Stand



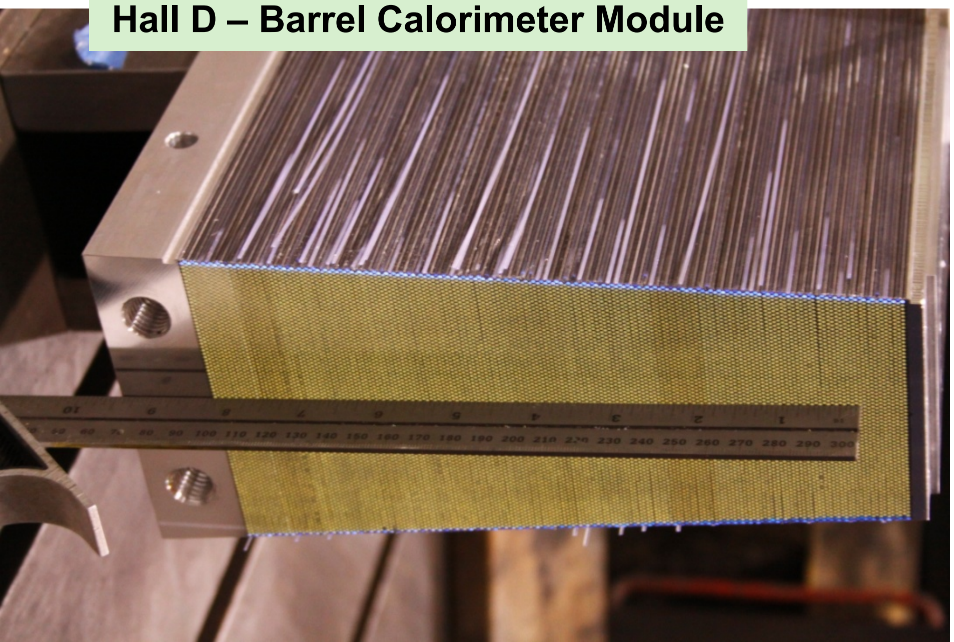
Hall C Superconducting Magnet Coil



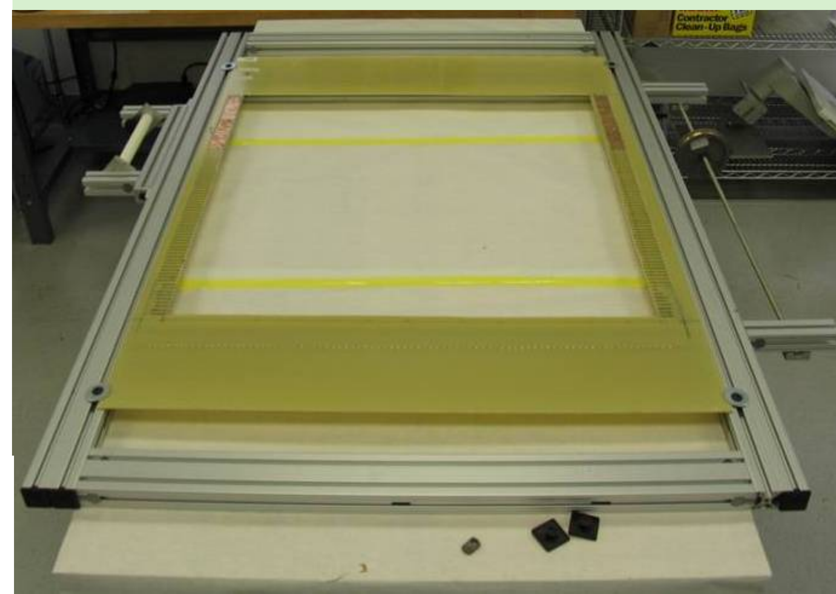
PHYSICS EQUIPMENT CONSTRUCTION

Hall B – Region II Drift Chamber Frame Assembly

Hall D – Barrel Calorimeter Module



Hall C – Wire Stringing Jig for Drift Chamber



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)***

Hall B CLAS12 International Collaborators

COUNTRY	INSTITUTION	FOCUS
UK	Edinburgh Univ	Software
UK	Glasgow Univ	Central Detector
France	Grenoble Univ	Central Detector
France	Orsay – IN2P3	Central n Detector
France	CEA Saclay	Central Tracker
Italy	Bari	Future RICH
Italy	Catania	tbd
Italy	Frascati & Fermi Ctr	Central n Detector
Italy	Genoa	Central n Detector
Italy	ISS/Rome	Future RICH
Italy	Rome Tor Vergata	Central n Detector
Russia	ITEP	Magnets
Russia	Moscow State HEP & SINP	Silicon Tracker
Korea	Kyungpook Nat'l Univ	CD TOF
Armenia	Yerevan Physics Institute	Central Tracker

as of September 2009

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