



Bob McKeown

NSAC, June 2017

Laboratory Director

Stuart Henderson:

- Accelerator Scientist
- During last tenure served as Director of the Advanced Photon Source Upgrade Project at Argonne National Lab
- Prior: Assoc. Lab Director for Accelerators at FermiLab
- Prior: ORNL, SNS, Director of Research Accelerator Division
- Started Monday, April 3rd



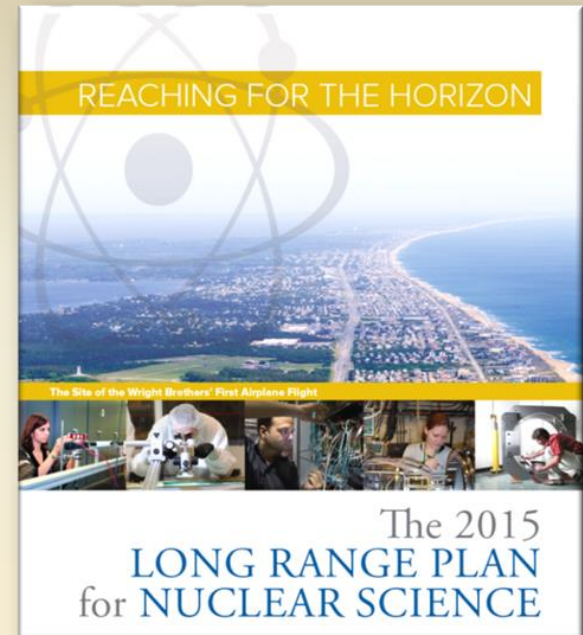
Hugh Montgomery:

- Jefferson Lab Director, September 2008 – April 2017
- Received Secretary's Distinguished Service Award in January 2017
- Thanks for 8 years of effective leadership of Jefferson Lab, and for successfully shepherding the Lab during construction of the 12 GeV upgrade of CEBAF.

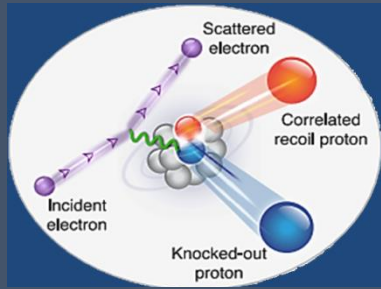


The Basic Message

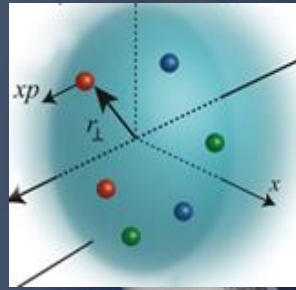
- Realizing science potential of 12 GeV CEBAF is top priority in the 2015 NSAC Long Range Plan
- Construction is essentially complete and we are ready for full scale operations
- Operations budget is presently not sufficient to realize the science program



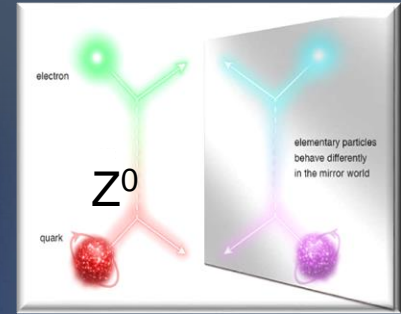
JLab: A Laboratory for Nuclear Science



Nuclear Structure



Structure of Hadrons

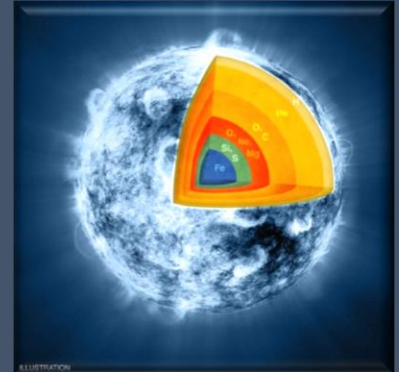


Fundamental Forces & Symmetries



Medical Imaging

Jefferson Lab has significant research activity in all 5 science chapters of the 2015 NSAC LRP!



Nuclear Astrophysics



Cryogenics



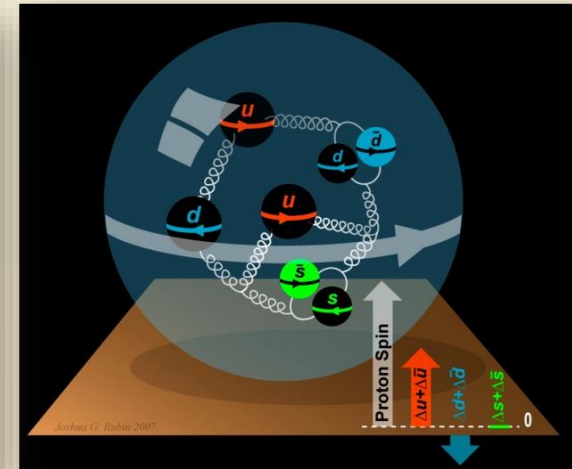
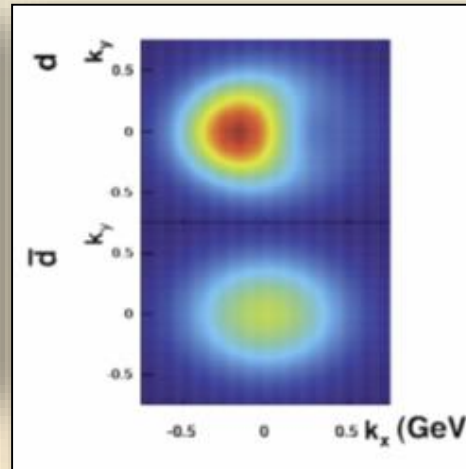
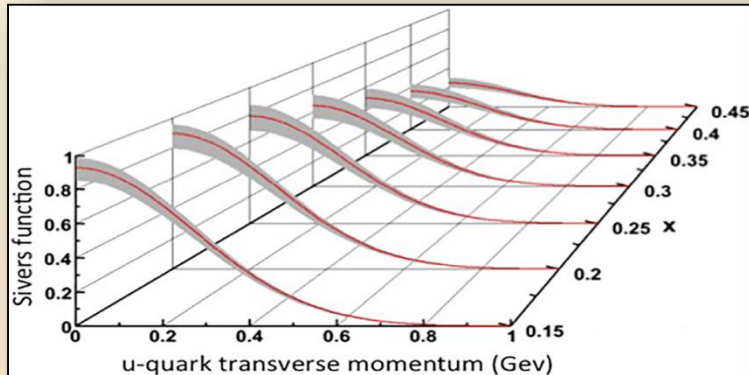
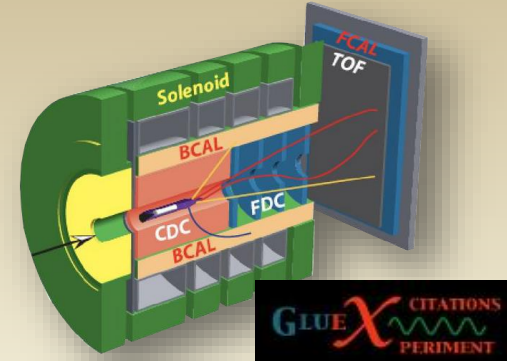
Accelerator S&T



Theory & Computation

Chapter 2: Quark Structure of Hadrons

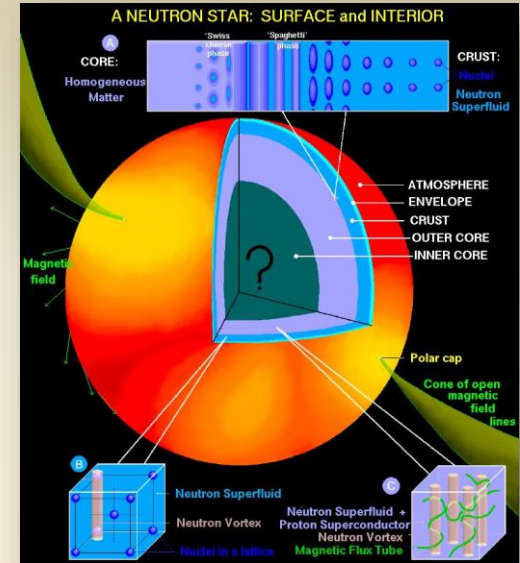
- Search for valence glue in light mesons
- Where is the missing spin in the nucleon? Role of orbital angular momentum?
- Nucleon tomography: the dawn of a new era



Beyond QCD

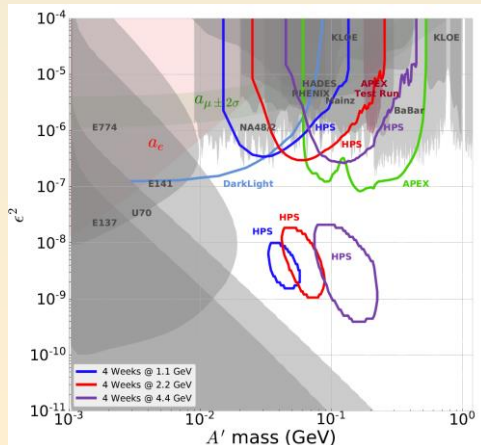
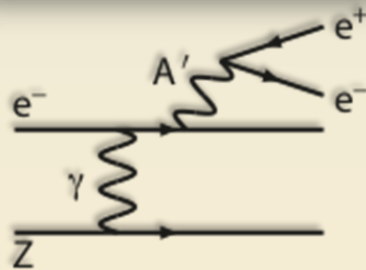
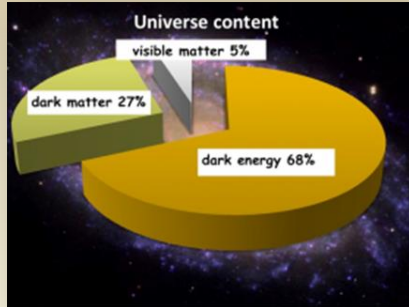
- Chapter 3: Nuclear Structure and Reactions
 - Future CEBAF data will determine the thickness of the neutron skin in a Pb nucleus which is related to the radius of a neutron star.
 - Future CEBAF data on hypernuclei should test explanations of why neutron stars with masses twice that of our sun exist.

- Chapter 4: Nuclear Astrophysics
 - Future CEBAF injector data on $\gamma + {}^{16}\text{O} \rightarrow {}^{12}\text{C} + \alpha$ will provide new information constraining the Carbon/Oxygen ratio in our universe.

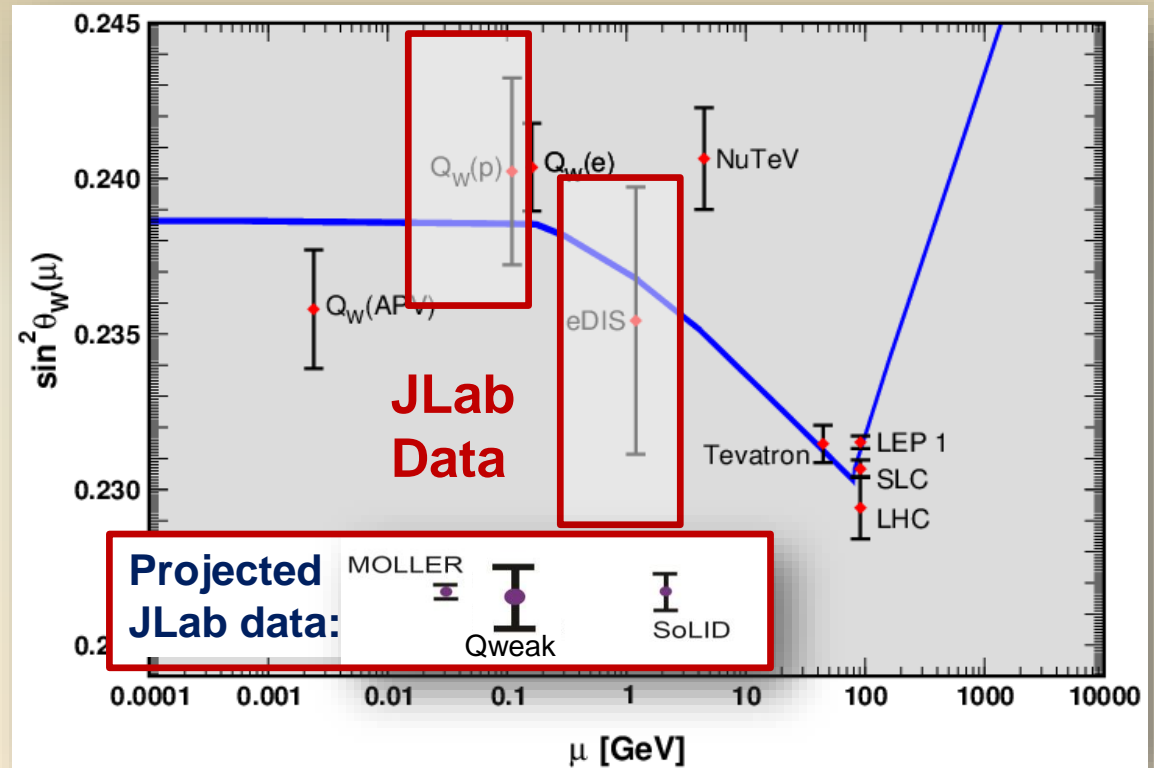


Chapter 5: Fundamental Symmetries and Neutrinos

Search for Dark Photons



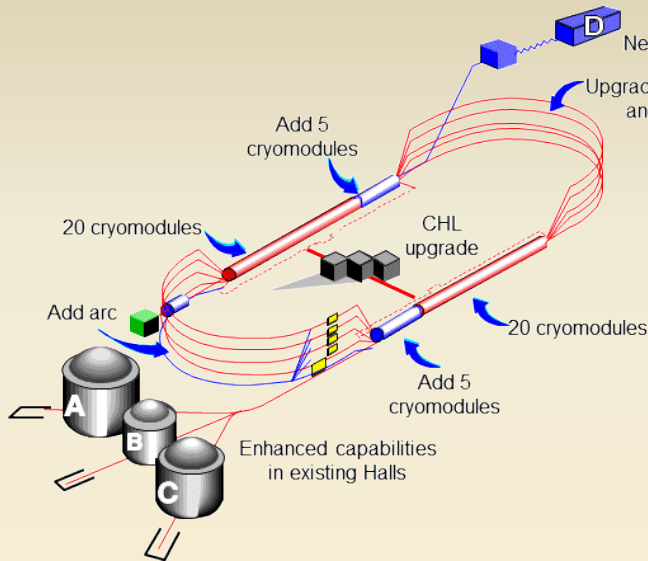
Precision Tests of the Standard Model



- Parity violating electron scattering provides a high precision test of the standard model.
- Complementary to measurements at CERN's Large Hadron Collider

12 GeV CEBAF Upgrade

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



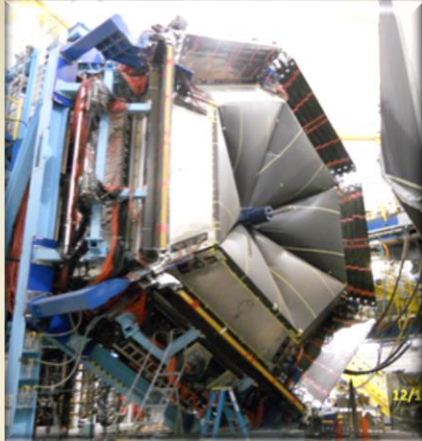
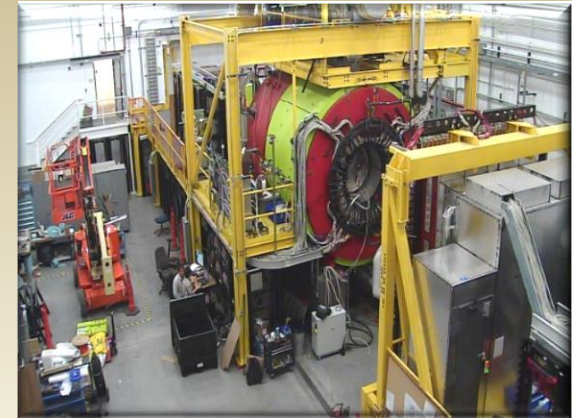
Total Project Cost = \$338M
Estimate to Complete = \$1.2M

Project (99.7% complete):

- Doubling the accelerator beam energy – **DONE**
- Civil construction including utilities – **DONE**
- New experimental **Hall D** and beam line – **DONE**
- Upgrade to Experimental **Hall C** – **DONE**
- Upgrade to Experimental **Hall B** – **99%**
 - **Solenoid magnet only remaining scope**

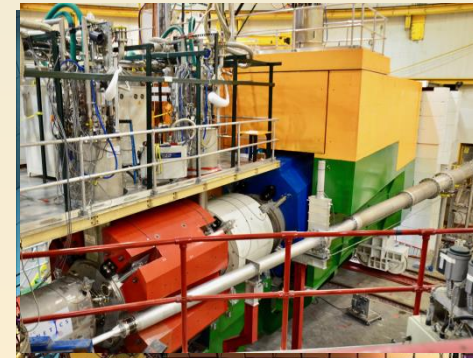
12 GeV Scientific Capabilities

Hall D – exploring origin of **confinement** by studying **exotic mesons**

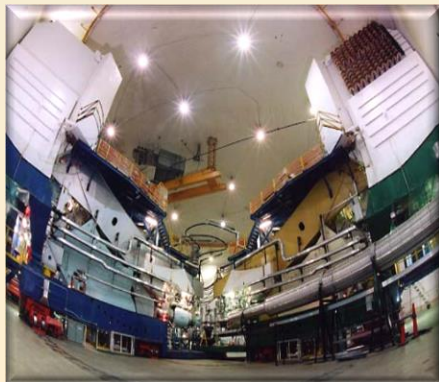


Hall B – understanding **nucleon structure** via **generalized parton distributions** and **transverse momentum distributions**

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., SoLID and MOLLER)**



12 GeV Project: University Detector Work

Hall	University	Activity	Status
B	Idaho State U	Drift Chamber	Complete
B	Old Dominion U	Drift Chamber	Complete
B	U South Carolina	TOF Counters	Complete
B	Moscow State U (RU)	SVT Testing	Complete
C	Michigan State U	HB Magnet	Complete
C	U Virginia	Noble Gas Cerenkov	Complete
D	U Athens (GR)	Monitoring BCAL, FCAL	Complete
D	Carnegie Mellon U	Central Drift Chamber	Complete
D	Catholic U	Tagger Hodoscope	Complete
D	U Connecticut	Tagger Microscope	Complete
D	Florida Internat'l U	Start Counter	Complete
D	Florida State U	TOF Counters	Complete
D	Indiana U	Forward Calorimeter	Complete
D	U Regina (CA)	Barrel Calorimeter	Complete
D	U Santa Maria (CH)	SiPM, Lightguides for BCAL	Complete
B, C, D	U Massachusetts	Electronics Testing	Complete

- NSF-MRI funded (Hall B):
- PCAL Detector
 - Long. Polarized Target

- NSF-MRI funded (Hall C):
- Drift Chambers
 - Trigger Hodoscopes
 - Aerogel

Internat'l contributions for detectors beyond base equipment.

12 GeV Upgrade – Path to Completion

- **Accelerator**
 - Full 12 GeV energy achieved
 - Full luminosity demonstrated
 - Simultaneous multi-hall beam delivery achieved
- **Hall C** – Key Performance Parameter demonstrated
 - SHMS installed, commissioned with beam
 - March 2017
- **Hall B** – Key Performance Parameter demonstrated
 - CLAS12 installed, commissioned with beam
 - February 2017
- **Remaining Scope** = Solenoid Magnet for Hall B
 - Final phase of assembly at vendor, ETI
 - June delivery to Jefferson Lab
 - Installation and commissioning through August



Project Completion September 2017

Equipment Beyond 12 GeV Upgrade

Hall	Item	Users	Status
A	DVCS Calorimeter	France/Orsay	Used/de-installed
A	SBS GEMs	INFN (Italy), UK	Ongoing
A	SBS Hadron Calorimeter	Carnegie Mellon , INFN (Italy)	Ongoing
A	MOLLER magnet pre-R&D	MIT	Ongoing
A	SoLID	Temple , Duke , Argonne , China	Ongoing
A	APEX Septum	Stony Brook , Canada	Complete
B	Longitudinally Polarized Target	Old Dominion	Ongoing
B	Radial TPC	ODU , William & Mary , Hampton Univ	Ongoing
B	Forward Tagger	INFN (Italy)	Complete
B	RICH Sector(s)	Chile, INFN (Italy)	Near-Complete (1)
B	MicroMegas	France/Saclay	Near-Complete
B	Central Neutron Detector	France/Orsay	Complete
B	Heavy Photon Search	DOE-HEP, France, INFN (Italy)	Complete
C	Kaon Detection System	Catholic Univ	Installed
C	Backward Nucleon Detection	Old Dominion , MIT , Israel	Ongoing
C	Neutral Particle Spectrometer	Catholic Univ , France, UK, Armenia	Ongoing
D	DIRC-based Cherenkov	Indiana Univ , MIT	Ongoing
LERF	DarkLight Phase-I	MIT	Ongoing

Note: list is not comprehensive but generally includes contributions >\$0.5M and international efforts.

Hall A: Super BigBite Spectrometer

Construction Complete: Oct 2012 – Feb 2017

Physics – new capability for study of nucleon structure

University collaborators:

Carnegie Mellon (Hadron Detector), **UVA** (polarized ^3He target)

College of William & Mary (GRINCH Detector), **Stony Brook Univ** (Calorimeter)



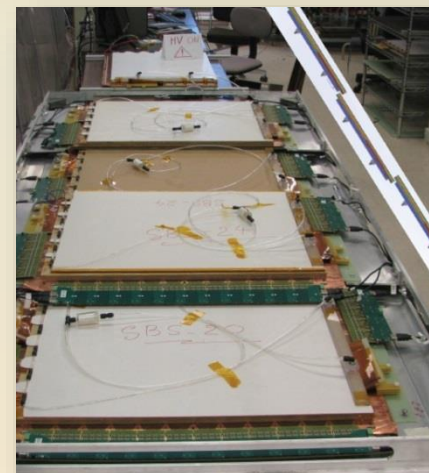
Magnet and Infrastructure:

- existing dipole magnet from BNL, moved to Jlab, modified and refurbished
- infrastructure consists of platform, power supply, beam line, Hall LCW and power upgrades.



Coordinate Detector (CDET):

- **Idaho State Univ** – Scintillating fiber polishing
- **Christopher Newport Univ** – Plane assembly and testing



GEM Detector:

- **UVA** production

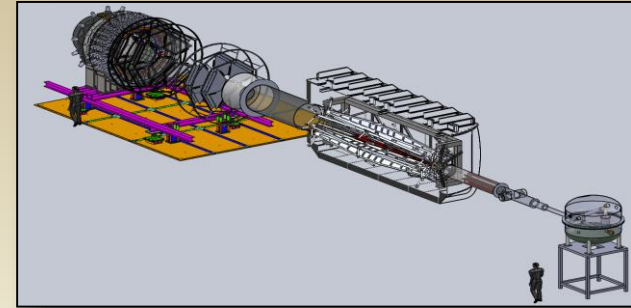
GEM Electronics:

- **INFN** (Italy) production
- **UVA** testing and QA

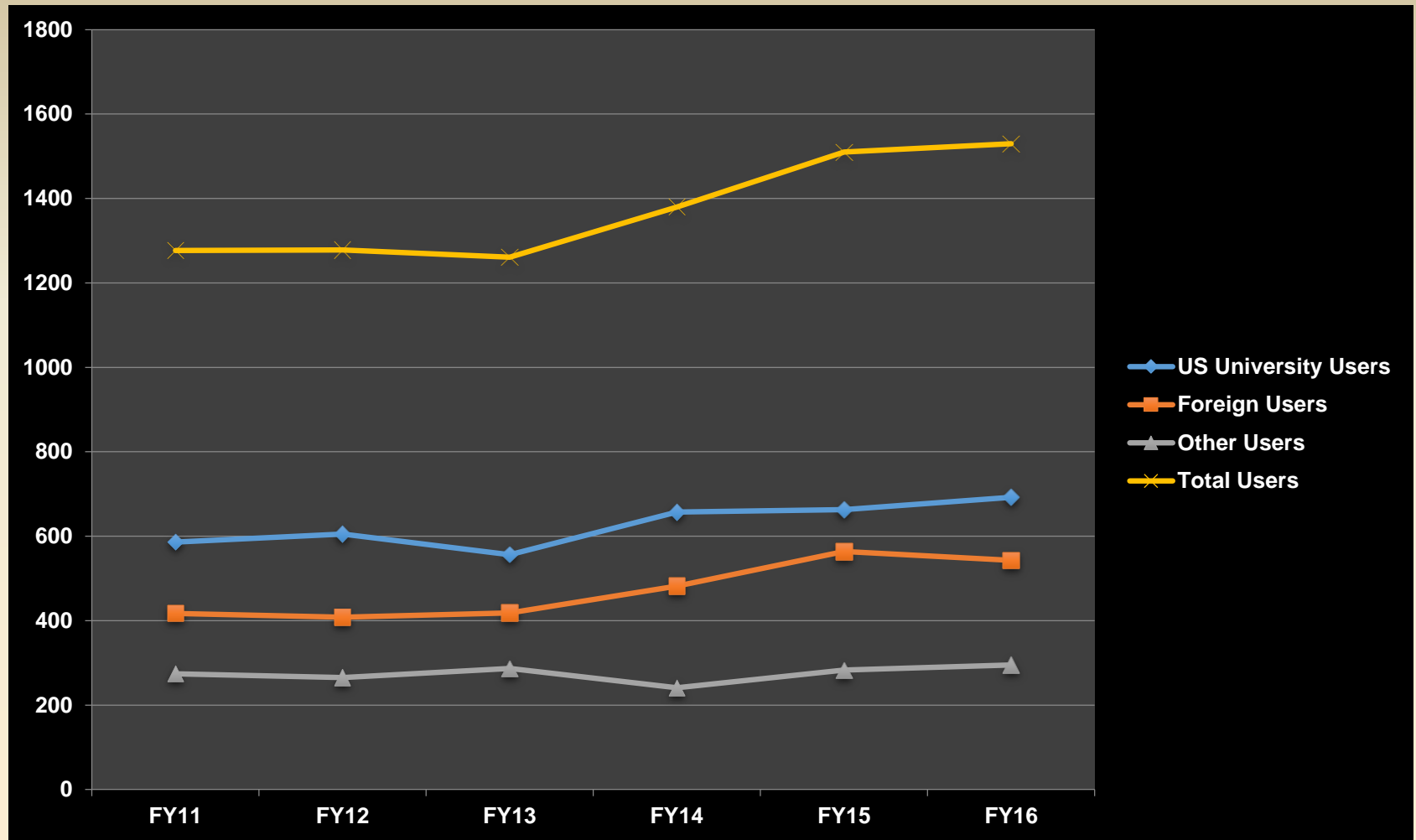
Future Projects

- MOLLER experiment
(Possible MIE – FY19-23)
 - CD-0 approved
(project paused due to budget uncertainty)
 - Standard Model Test
 - DOE science review (September 2014) – strong endorsement
 - Director’s review held December 15-16, 2016
Technical, cost & schedule

- SoLID
 - SIDIS and PVDIS
 - CLEO Solenoid ✓
 - International collaboration
 - Director’s review (Feb. 2015)
→ new pre-CDR almost complete



JLab User Growth

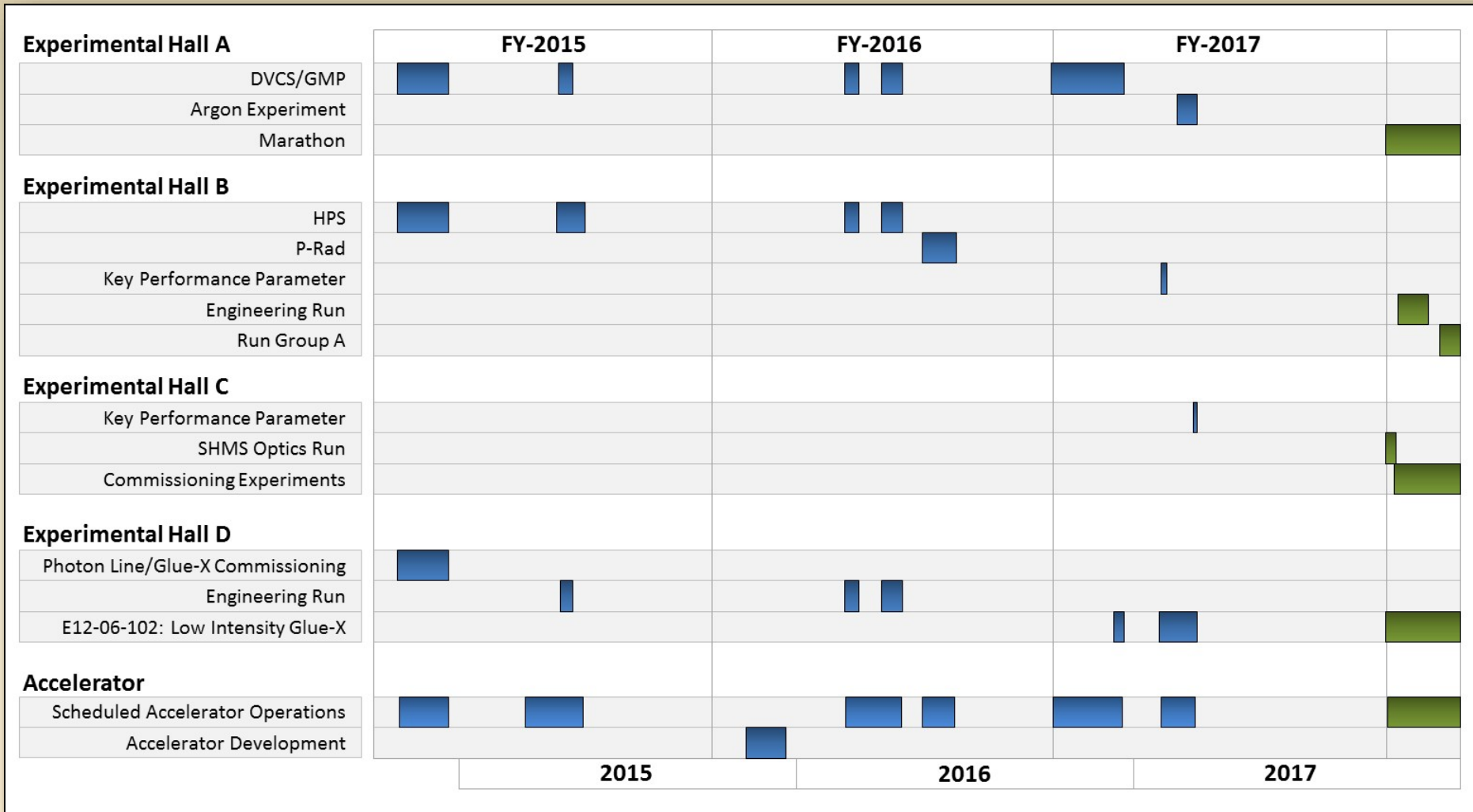


“Other Users” includes US National Labs and Industry

12 GeV Approved Experiments by Physics Topics

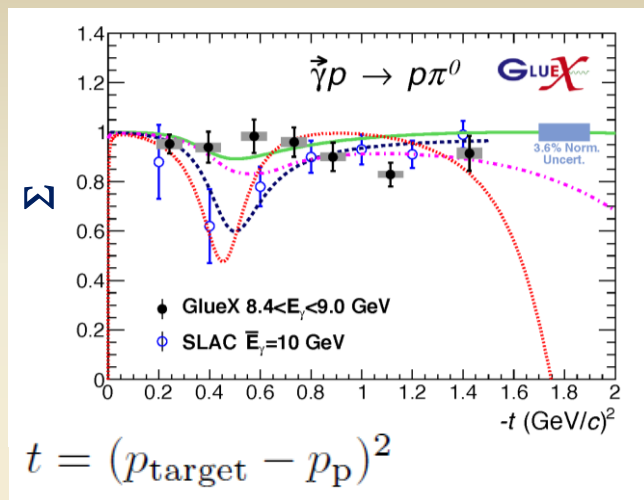
Topic	Hall A	Hall B	Hall C	Hall D	Other	Total
Hadron spectra as probes of QCD	0	3	1	3	0	7
Transverse structure of the hadrons	5	4	3	1	0	13
Longitudinal structure of the hadrons	2	3	6	0	0	11
3D structure of the hadrons	5	9	7	0	0	21
Hadrons and cold nuclear matter	7	3	7	0	1	18
Low-energy tests of the Standard Model and Fundamental Symmetries	3	1	0	1	1	6
Total	22	23	24	5	2	76
Total Experiments Completed	2.5	1.1	0	0.4	0	4.0
Total Experiments Remaining	19.5	22	24	4.6	2	72.0

CEBAF Program FY15-17



First Published Results from 12 GeV CEBAF

The first experimental results, from data collected in the GlueX engineering run, have been published in Phys. Rev. C.



The new GlueX results show:

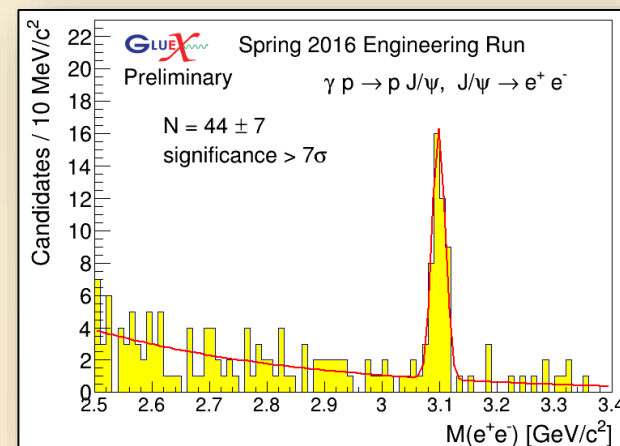
- For neutral pions, the reaction mechanism is dominated by pure vector coupling.
- The first data for beam asymmetry for η production >3 GeV.
- **The GlueX experiment in Hall D can produce timely results.**

GlueX will search for hybrid mesons, particles in which the strong gluonic field contributes directly to their properties. From the spectrum of these particles, we can learn about the gluonic field in QCD.

Bonus:



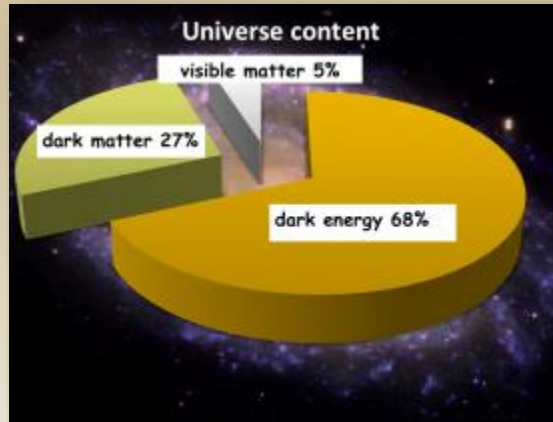
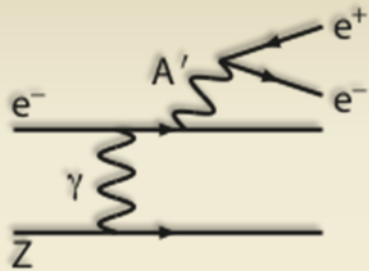
First observation of charmonium at JLab!



Heavy Photon Search – First Results

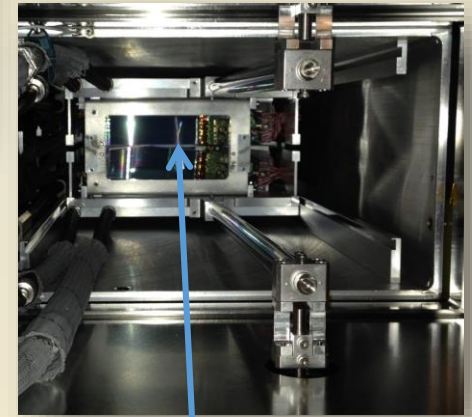
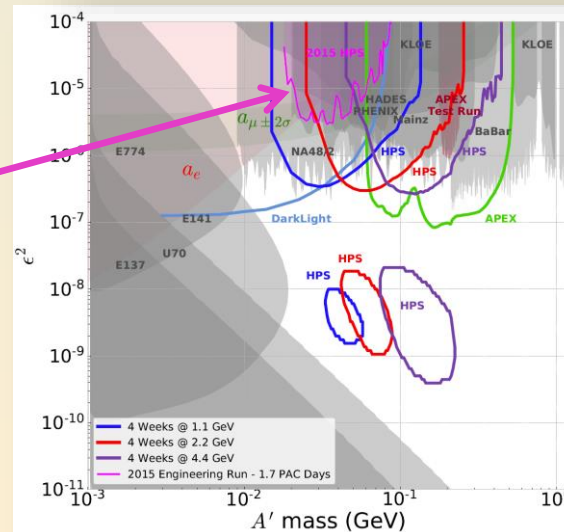


- NP-HEP Collaboration



2015 Engineering Run
1.7 PAC days @ 1.05 GeV

2 GeV data taken in 2016,
under analysis

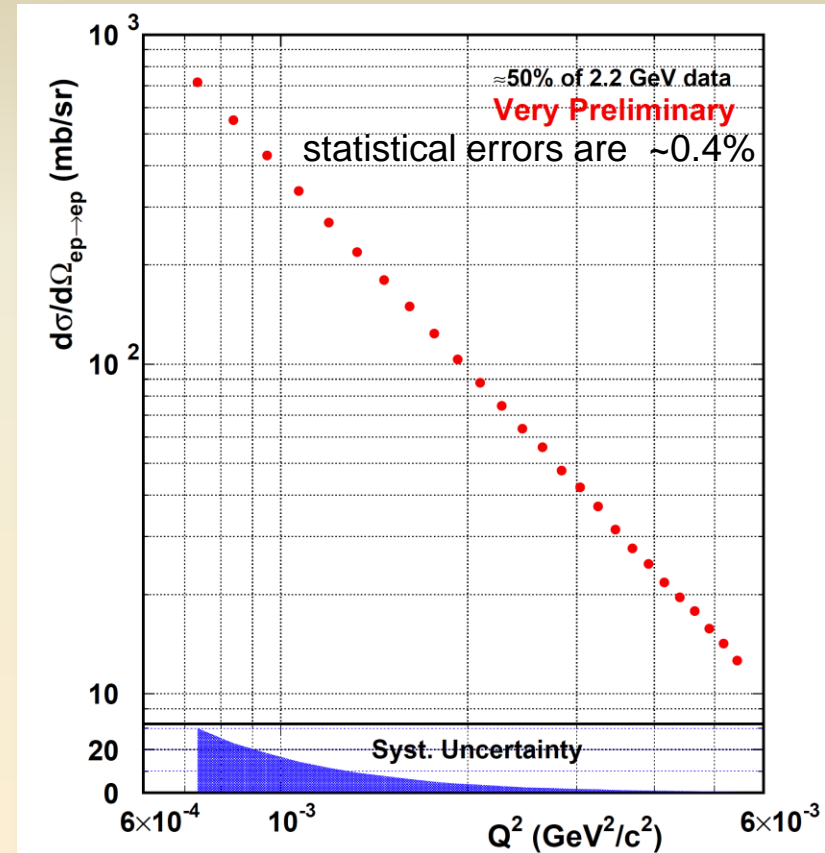
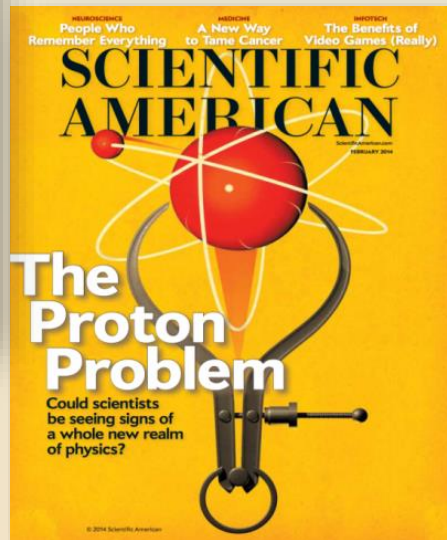


1 mm gap between Si tracker detectors for passage of electron beam

Future Program: more HPS, APEX, DarkLIGHT

PRad

- PRad: new experiment to address proton radius @ JLab
- NSF MRI: H₂ gas target
- DOE GEM tracking detectors
- Successful run in summer 2016

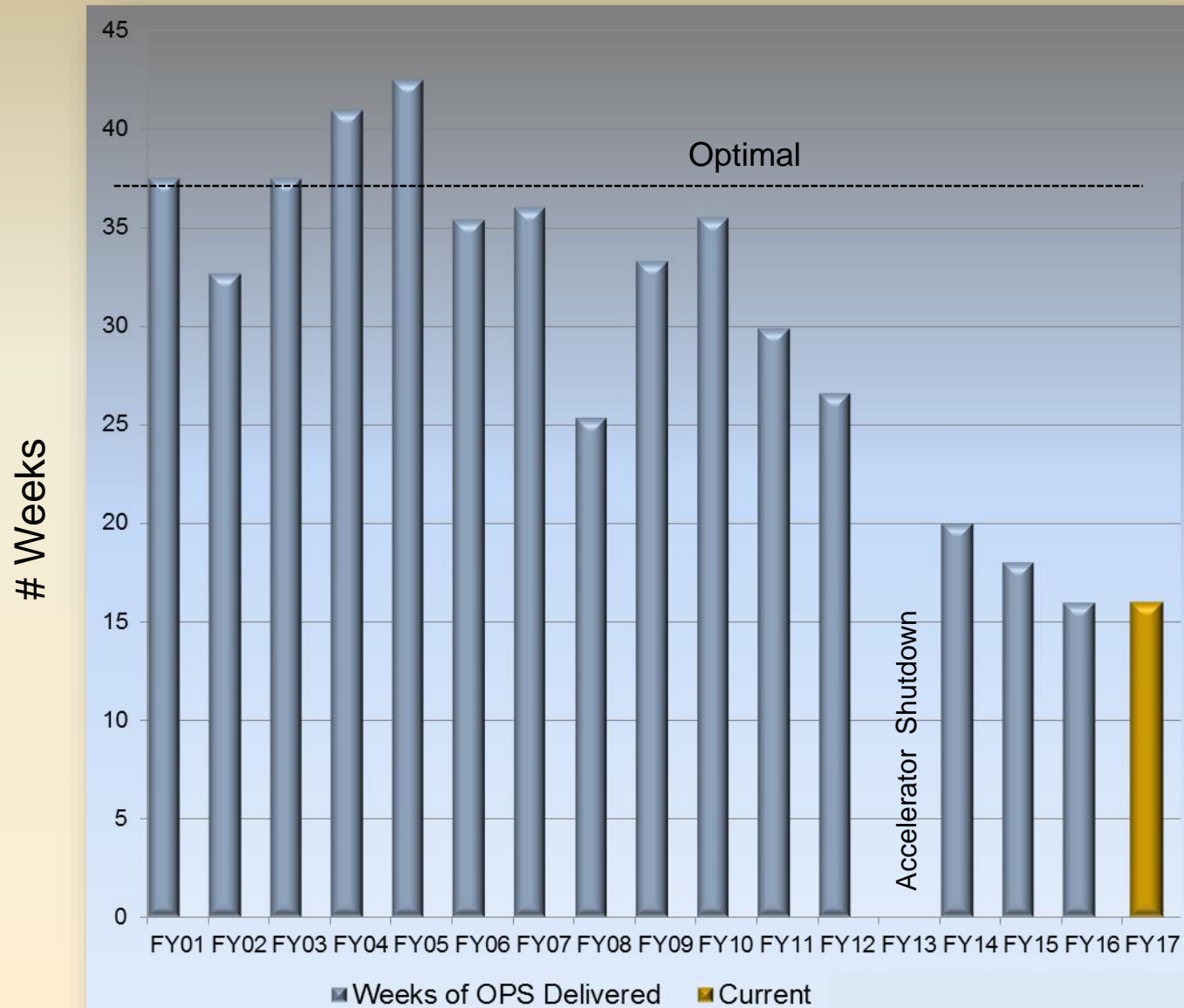


1 GeV data extends to $Q^2 \sim 2 \times 10^{-4}$ GeV²

Realizing the Potential

- NSAC 2015 LRP: “With the imminent completion of the CEBAF 12-GeV Upgrade, its forefront program of using electrons to unfold the quark and gluon structure of hadrons and nuclei and to probe the Standard Model **must** be realized”
- Sufficient operating funds must be provided to enable execution of the scientific program (the FY17 budget figure presented to NSAC on November 17, 2014 for LRP input was \$20M higher than our current budget).
- This is the key challenge for JLab

CEBAF Weeks of Operation Delivered



Outlook

- **12 GeV Upgrade at JLab is a **major** investment**
 - DOE: NP and Office of Science
 - NSF
 - Commonwealth of Virginia
 - US Nuclear Physics community and international partners
 - Jefferson Lab
 - User community (US and international)
- **The large and growing user community is anxious to realize the science program**
- **We are ready to start the 12 GeV science program at JLab**
 - Construction is essentially complete
 - Accelerator is fully operational for multi-hall beam delivery
 - A broad program of 72 approved experiments with many opportunities for discovery is planned
 - Initial science results are already being reported
 - Increased operations funding required
- **Important to remember that MOLLER, SoLID and other smaller projects are also essential to realizing the full potential of CEBAF at 12 GeV**