

Hall B Report

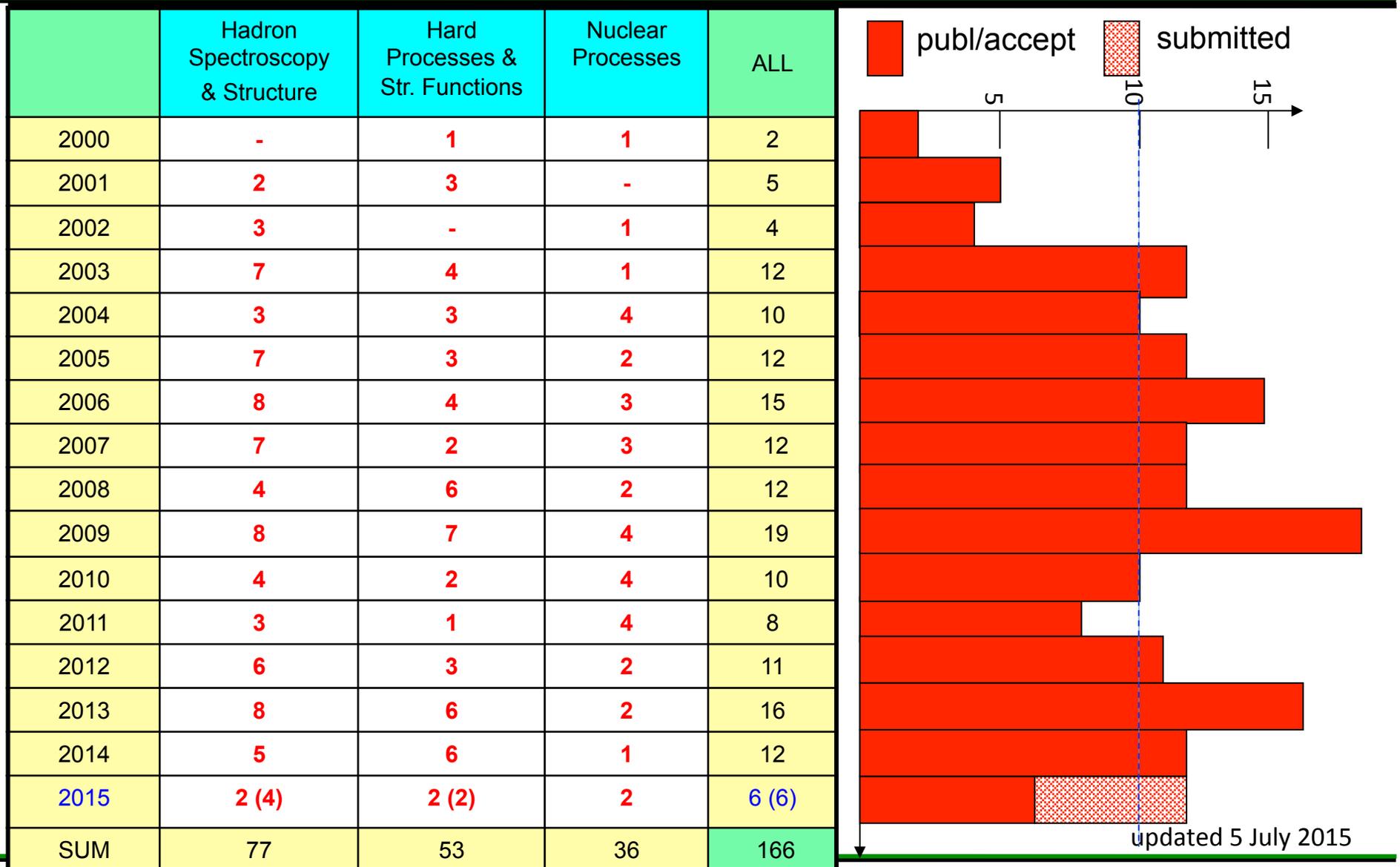
Volker D. Burkert

PAC43 Meeting
7 July 2015

- Hall B 2015 publications
- PRad & HPS status
- CLAS12 status
- Commissioning plan
- Summary



Hall B Physics Publications in refereed Journals



I. Senderovich et al., First measurement of the helicity asymmetry E in η photoproduction on the proton, arXiv:1507.00325.

H.S. Jo et al., Cross sections for the exclusive photon electro-production on the proton and GPDs, arXiv:1504.02009, subm. PRL

A.V. Anisovich et al., Existence of $\Delta(2200)7/2^-$ precludes restoration of chiral symmetry, arXiv:1503.05774, (w/ BnGa group) subm. PRL

S. Strauch et al., First Measurement of the Polarization Observable E in the $p(\gamma, \pi^+)n$ Reaction up to 2.25 GeV, arXiv:1503.05163, subm. PLB

I.G. Aznauryan and V.D. Burkert, Extracting meson-baryon contributions to the $N(1675)5/2^-$ resonance, Phys. Rev. C, in print, 2015.

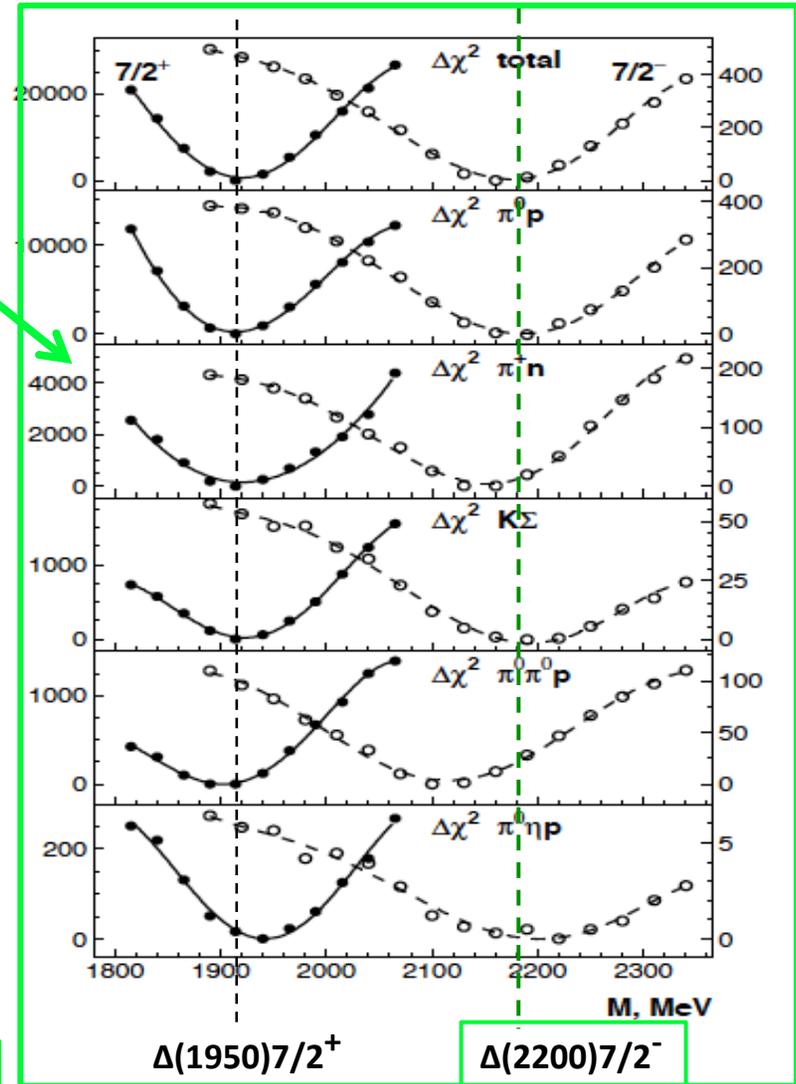
N. Zachariou et al, Determination of the Beam-Spin Asymmetry of Deuteron Photodisintegration in the Energy Region $E_\gamma = 1.1-2.3\text{GeV}$, Phys.Rev. C91, 055202 (2015)

S. Pisano, et al., Single and double spin asymmetries for deeply virtual Compton scattering measured with CLAS and a longitudinally polarized proton target, Phys.Rev. D91 (2015) 5, 052014

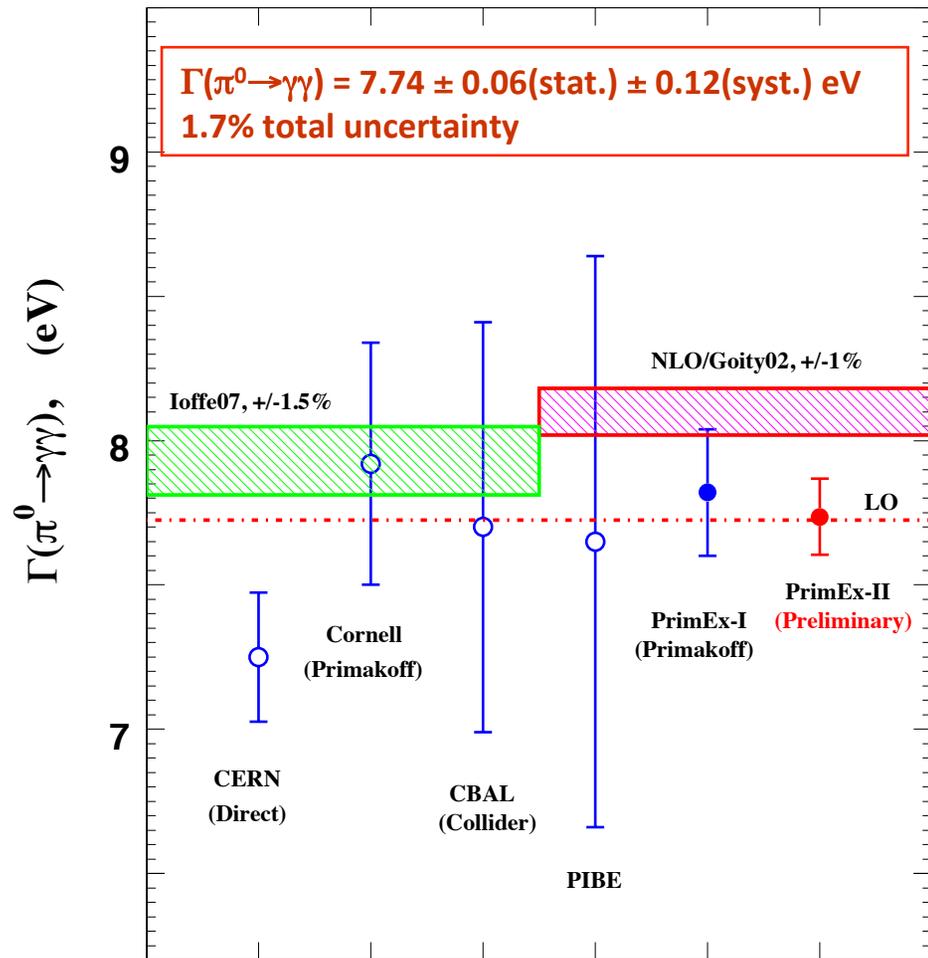
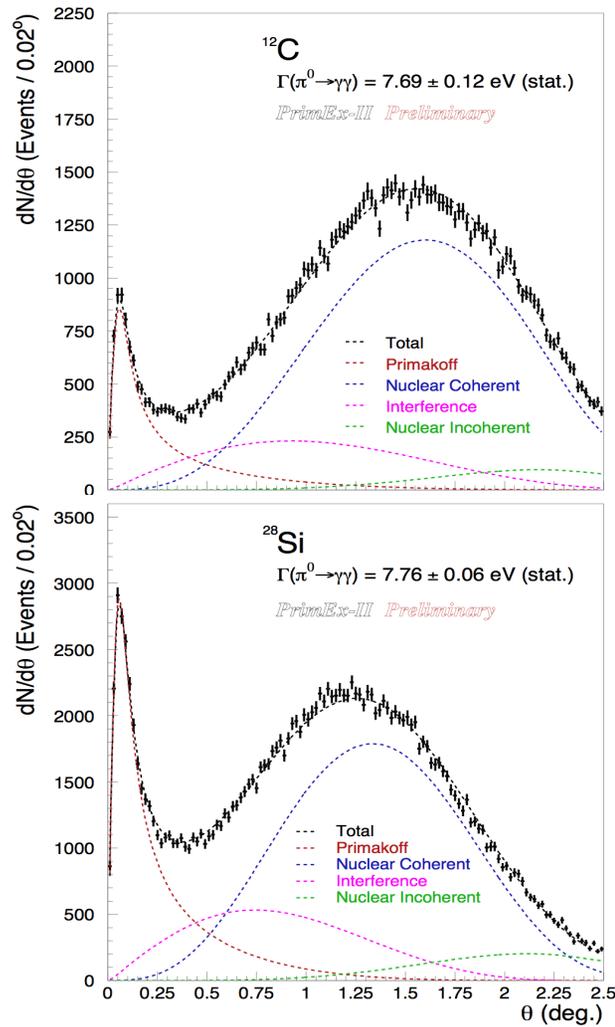
E. Seder et al., Longitudinal Target-Spin Asymmetries for Deeply Virtual Compton Scattering, Phys. Rev. Lett. 114, 089901 (2015)

K. Park et al., Measurements of $ep \rightarrow e\pi^+n$ at $W = 1.6 - 2.0$ GeV and extraction of nucleon resonance electro-couplings at CLAS, Phys.Rev. C91 (2015) 045203

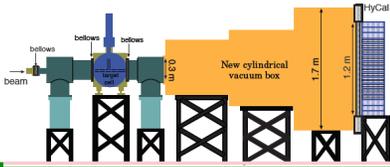
D. Adikaram et al., Towards a resolution of the proton form factor problem: new electron and positron scattering data, Phys. Rev. Lett. 114 (2015) 6, 062003



Strong signal of $\Delta(2200)7/2^- (*)$



Another independent analysis is on the way.



PRad status



Goal: Measure the proton radius with higher precision in electron scattering.

NSF/MRI: Duke U., MSU, NC A&T, NSU (ISU)

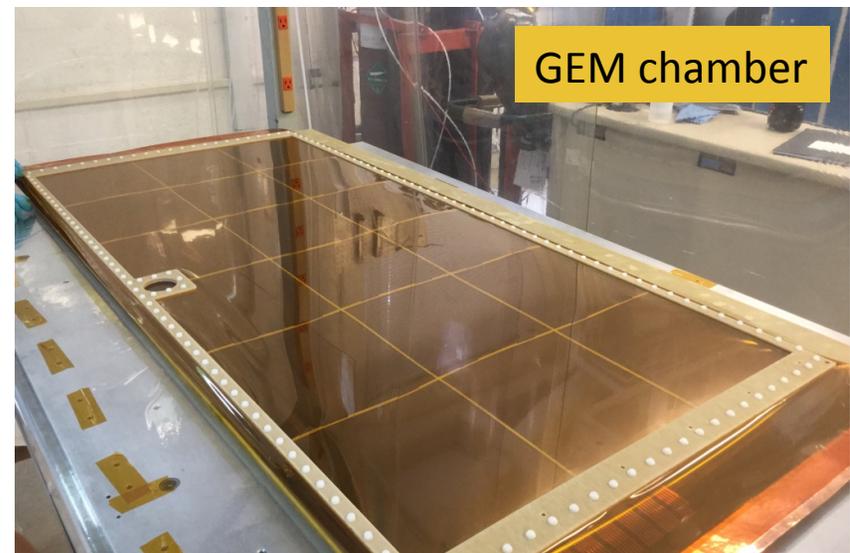
Completed

- HyCal and its infrastructure and DAQ are ready
- Large vacuum chamber (2 pieces) delivered. It was vacuum and pressure tested at the vendor.
- Large thin windows are made
- Windowless gas target is essentially ready
 - tested by running continuously for a week with Helium gas
- First GEM chamber is assembled and being tested at UVA

Remains to be done

- Assemble the second GEM chamber
- Design the beam line and fabricate its parts

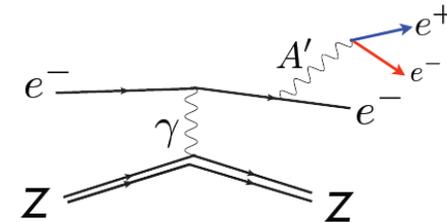
Aiming to have all pieces ready for installation by December. Beam time request submitted.





Search for a massive, vector gauge boson, A'

- radiated by electron beam, decaying to e^+e^-
- a portal to Dark Matter, coupling to SM via mixing with γ



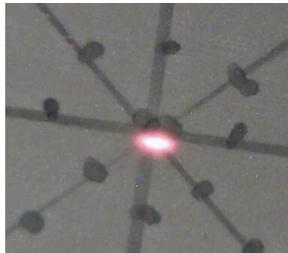
Successful Commissioning in 2014 & 2015

- Full Hall-B beamline and HPS dipole chicane
- "Ribbon" beam on target: $\sigma_y \sim 30 \mu\text{m}$, $\sigma_x \sim 150 \mu\text{m}$
- Si Tracker, PbWO₄ Calorimeter & Trigger, DAQ
- Tracker gradually moved to 0.5 mm from beam

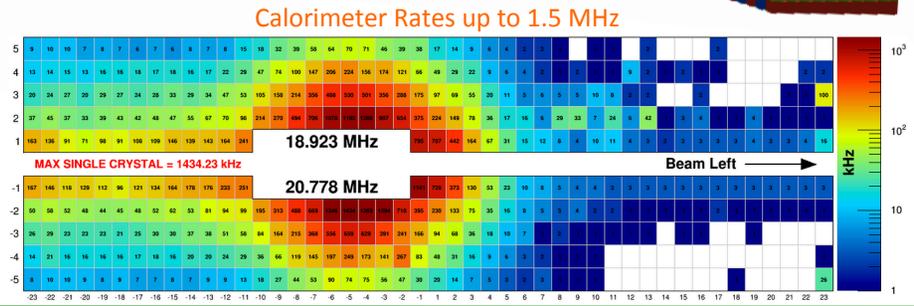
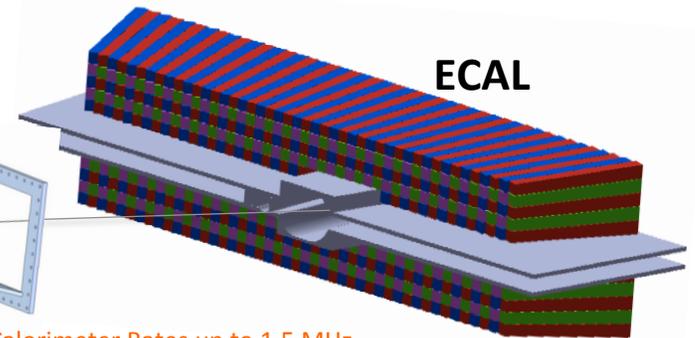
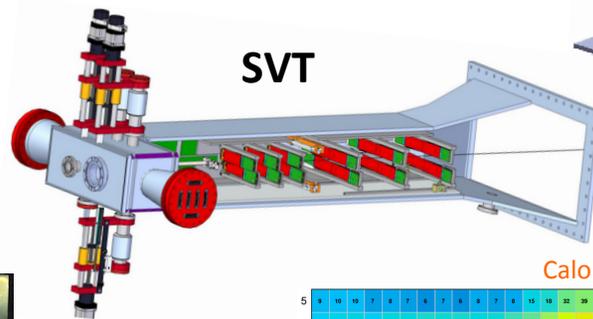
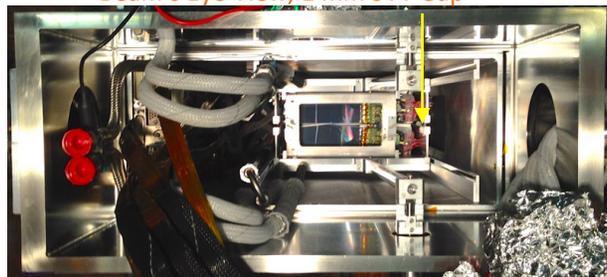
Successful 2015 Engineering Run

- 1-pass 1.05 GeV, 50 nA on 4 μm W target
- Conditions & Performance as Expected
- Analysis & Calibration in Progress

Beam Profile at HPS



Beam's Eye View, 1 mm SVT Gap

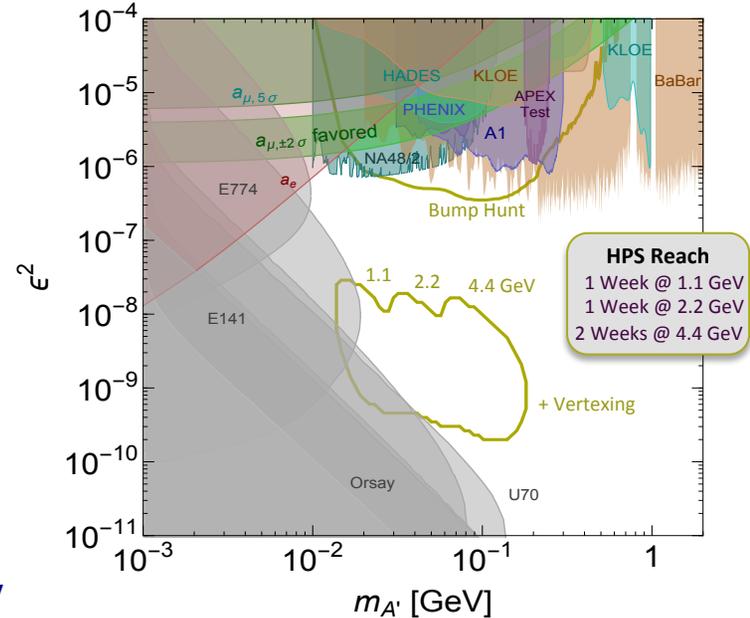




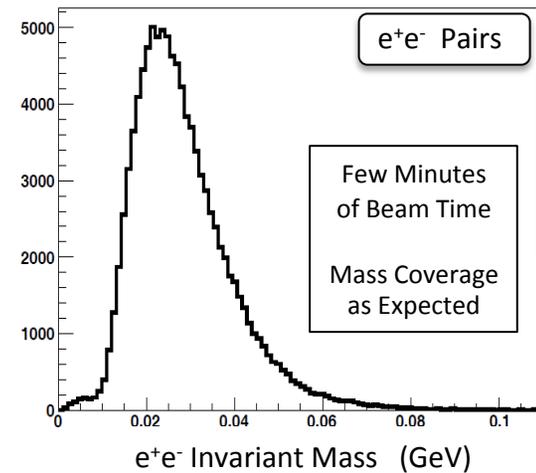
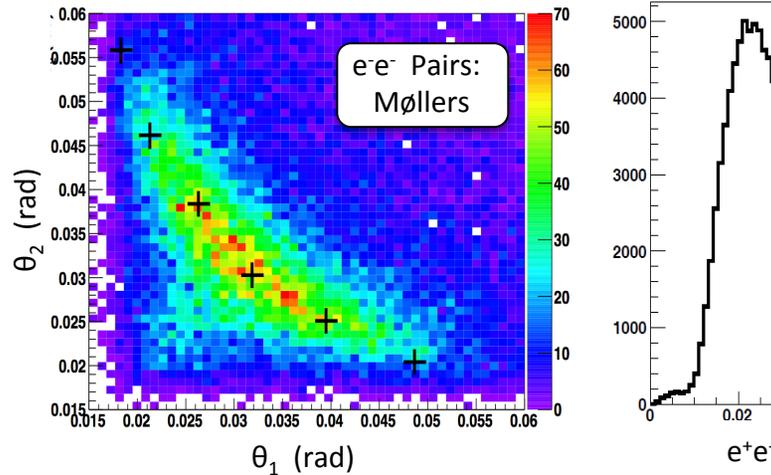
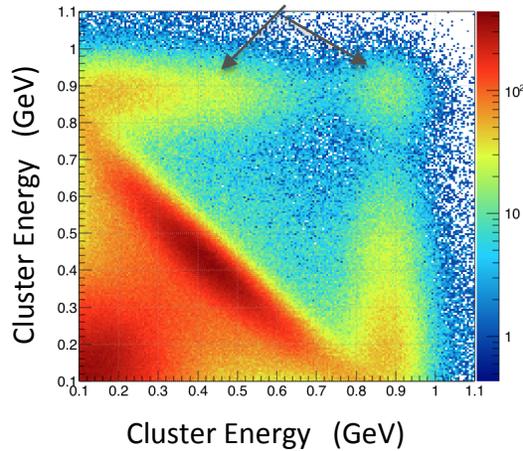
Expected Performance Achieved

- Angular coverage down to 15 mrad
- 50 nA @ 1.05 GeV on 4 μm W target
- DAQ @ 18 kHz, 10% deadtime, 160 MB/s
- Detector Rates & Occupancies as Expected

- 10 mC (2 PAC-days) of physics data at nominal settings
- Calibrations and Analysis In Progress
 - Coulomb and Møller scattering benchmarks available
 - ECAL energy and SVT alignment calibrations underway
 - Checking rates, mass and vertexing resolution
 - Studying inefficiencies
- Working to confirm HPS Physics Capability this summer
- Preparing for running in FY2015/2016 at 2.2 and 4.4 GeV



Coulomb Scattered, Random Coincidences



Base equipment

Forward Detector (FD)

- TORUS magnet (6 coils)
- HT Cherenkov Counter
- Drift chamber system
- LT Cherenkov Counter
- Forward ToF System
- Pre-shower calorimeter
- E.M. calorimeter

Central Detector (CD)

- SOLENOID magnet
- Barrel Silicon Tracker
- Central Time-of-Flight

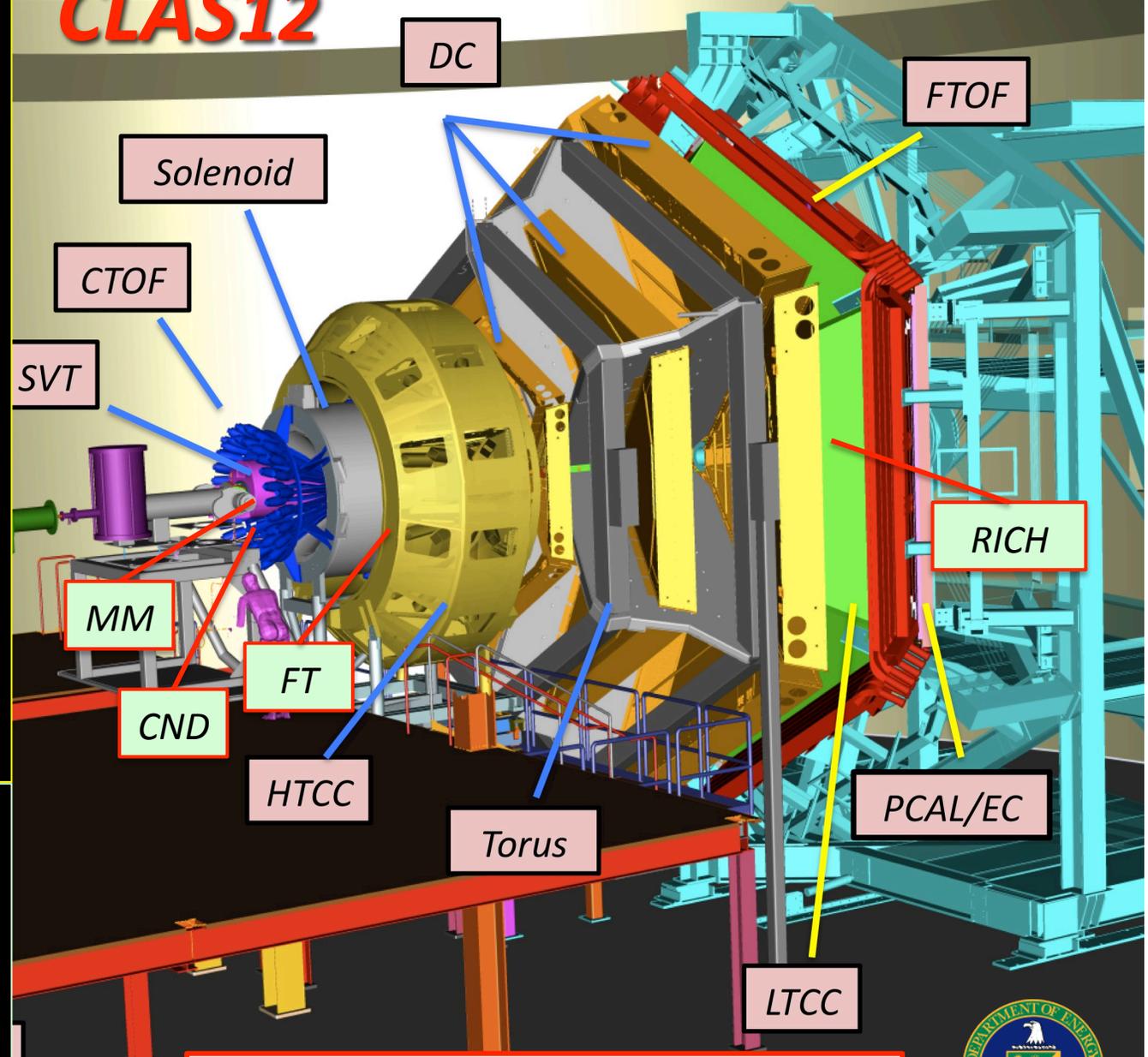
Beamline

- Targets
- Moller polarimeter
- Photon Tagger

Upgrade to base equipment

- MicroMegas
- Central Neutron Detector
- Forward Tagger
- RICH detector (1 sector)
- Polarized target (long.)

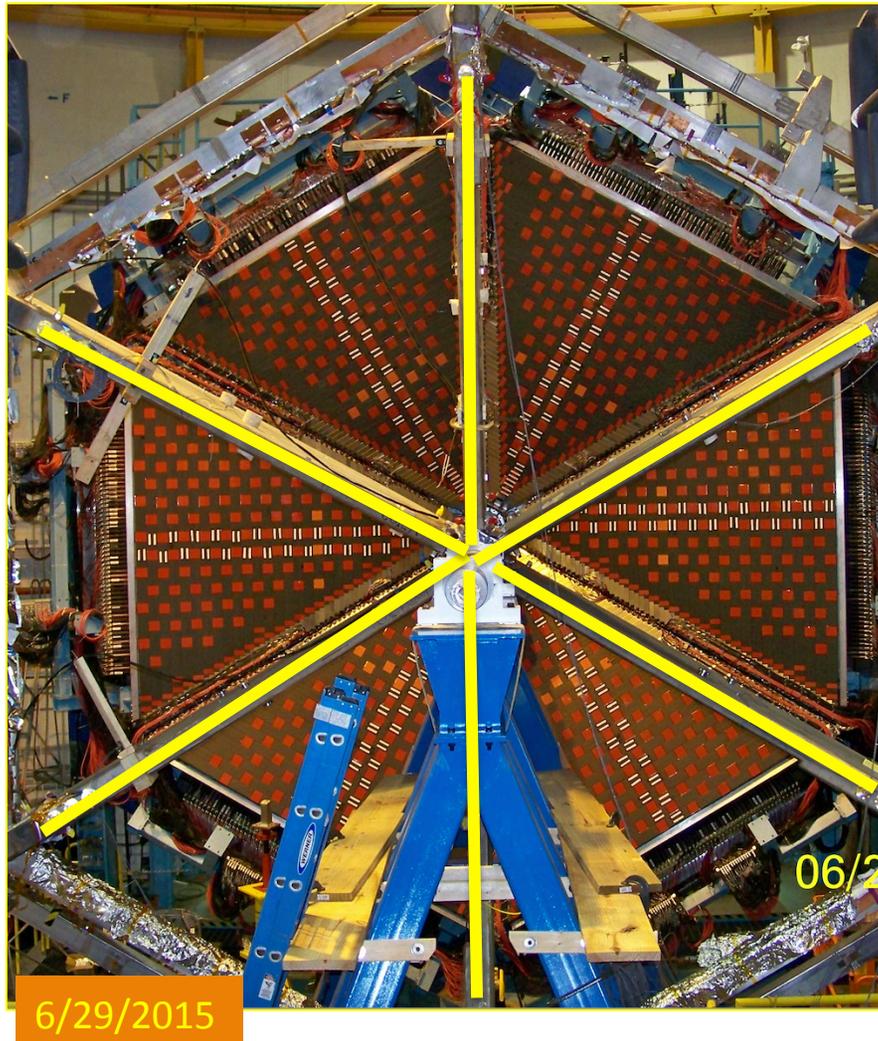
CLAS12



<http://www.jlab.org/Hall-B/clas12-web/>

PAC43 meeting 7 July 2015





TORUS Magnet Installation

6 coils installed in Hall B

Full Torus commissioned and field mapped 7/2016.

SOLENOID Magnet

2nd of 5 coils completed, 3rd processing

Delivery of Magnet to JLab ~5/2016

Expected to be operational ~9/2016

Beam Line Instrumentation

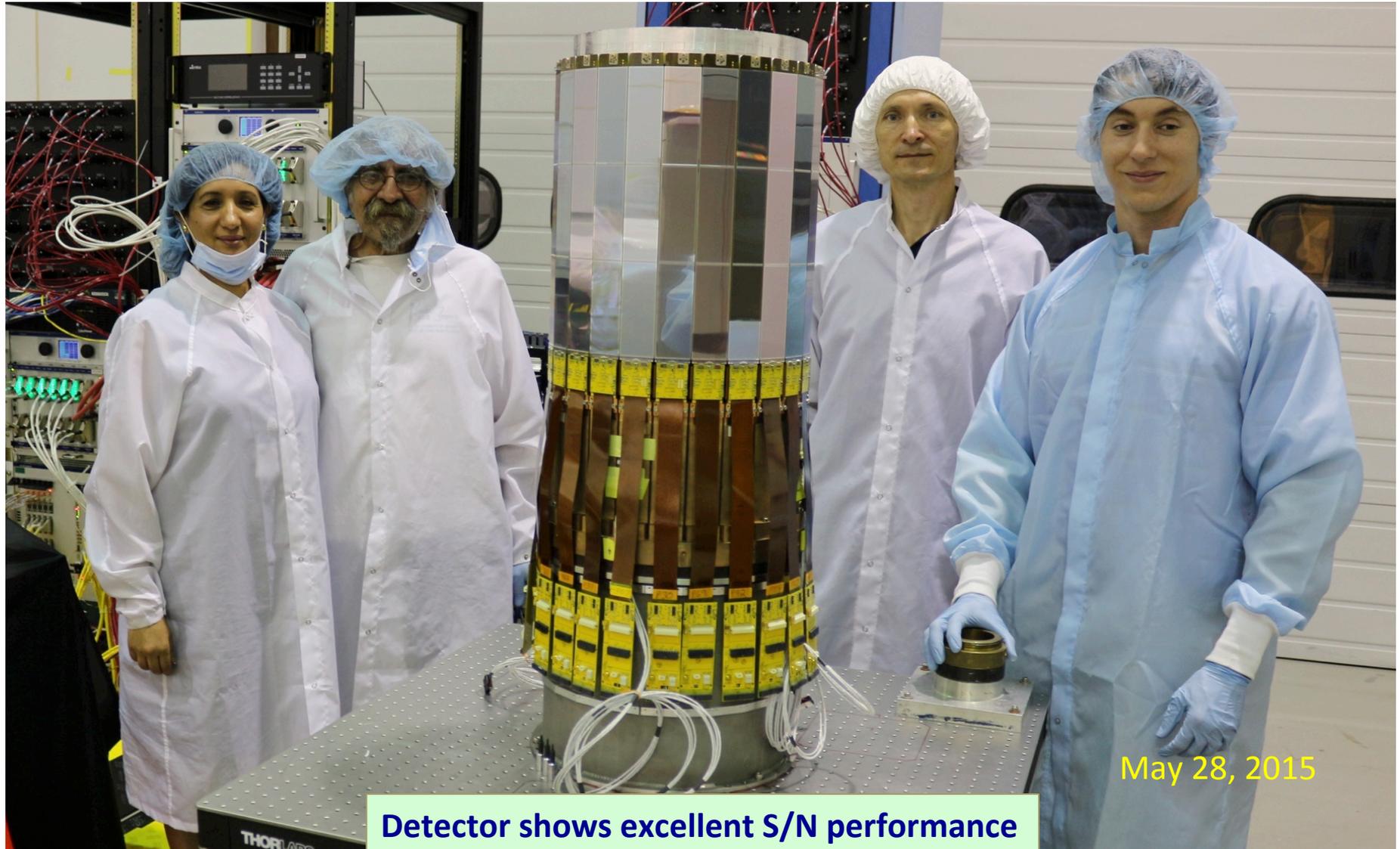
Commissioned during HPS run up to Faraday cup, BPMs, harps, halo counters.

Additional beam line components to be installed beginning 10/2015

Forward Carriage

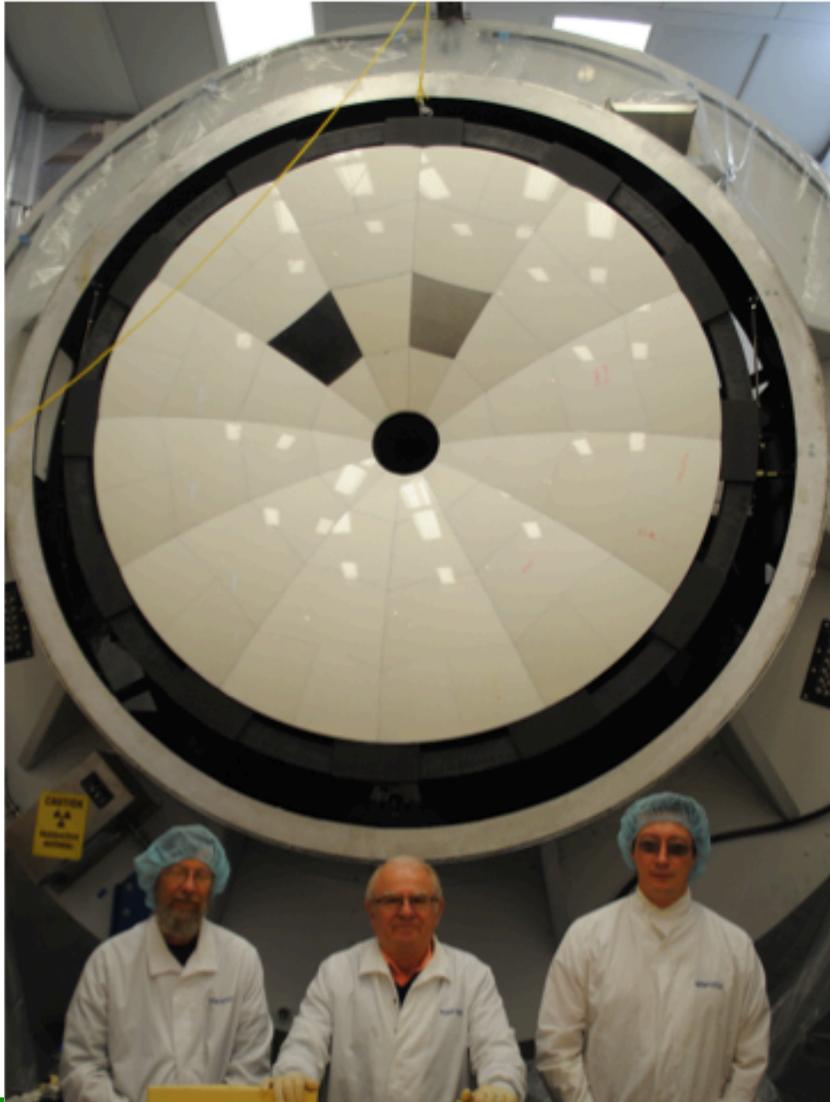
FTOF1a, FTOF1b, PCAL and EC essentially operational 2+ years prior to scheduled beam commissioning.

Hall B SVT – Region 1-3 & 4 *CLAS12*



May 28, 2015

Detector shows excellent S/N performance



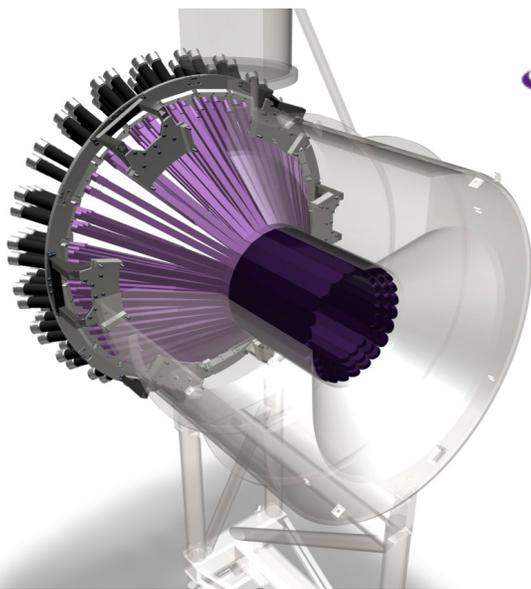
The mirror as seen from the downstream end with the backing structure exposed.

Mirror consists of 60 mirror facets arranged in 12 segments that focus Cerenkov light into 48 5" PMTs distributed azimuthally in 360 degrees.

Essential feature is the low material budget of 135 mg/cm^2 , allowing for the installation in front of the tracking chambers.

Project to be completed July 2015

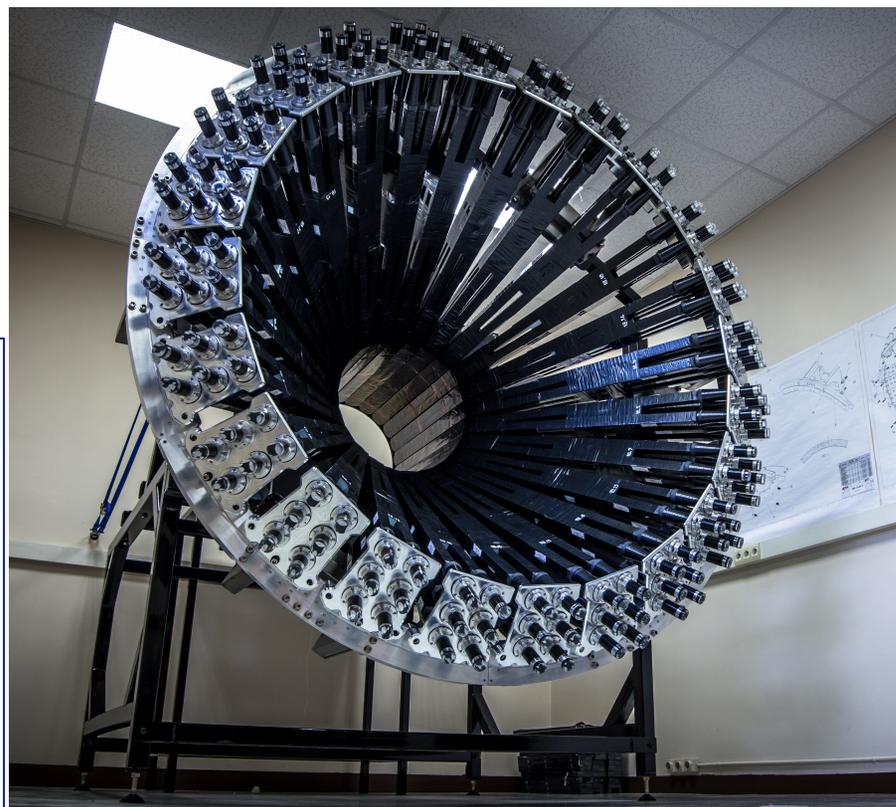
Hall B Central Neutron Detector *CLAS12*



All detector components
arrived at JLab June 2.

Detect neutrons in range $0.2 < p < 1.0 \text{ GeV}/c$
at $\theta = 40^\circ - 120^\circ$, $\Delta\phi = 360^\circ$

- 48 segments in azimuth, 3 radial layers
- 72 u-turn shaped light guides connect neighboring segments for light readout
- 144 PMTs Hamamatsu R10533 with triple layers of magnetic shielding
- Time resolution $\delta T = 150 \text{ ps}$.



Hall B CLAS12 experiments – run groups

Proposal	Physics	Contact	Rating	Days	Group	New equipment	Energy	Run Group	Target
E12-06-108	Hard exclusive electro-production of π^0, η	Stoler	B	80	139	RICH (1 sector) Forward tagger	11	A F. Sabatié	liquid H ₂
E12-06-108A	Exclusive N*->KY Studies with CLAS12	Carman	NR	(60)					
E12-06-112	Proton's quark dynamics in SIDIS pion production	Avakian	A	60					
E12-06-112A	Semi-inclusive Λ production in target fragmentation region	Mirazita	NR	(60)					
E12-06-112B	Collinear nucleon structure at twist-3	Pisano	NR	(60)					
E12-06-119(a)	Deeply Virtual Compton Scattering	Sabatie	A	80					
E12-09-003	Excitation of nucleon resonances at high Q ²	Gothe	B+	40					
E12-11-005	Hadron spectroscopy with forward tagger	Battaglieri	A-	119					
E12-11-005A	Photoproduction of the very strangest baryon	Guo	NR	(120)					
E12-12-001	Timelike Compton Scatt. & J/ ψ production in e+e-	Nadel-Turonski	A-	120					
E12-12-007	Exclusive ϕ meson electroproduction with CLAS12	Stoler, Weiss	B+	60					
E12-07-104	Neutron magnetic form factor	Gilfoyle	A-	30	90	Neutron detector RICH (1 sector) Forward tagger	11	B K. Hafidi	liquid D ₂ target
E12-09-007(a)	Study of partonic distributions in SIDIS kaon production	Hafidi	A-	30					
E12-09-008	Boer-Mulders asymmetry in K SIDIS w/ H and D targets	Contalbrigo	A-	56					
E12-09-008A	Hadron production in target fragmentation region	Mirazita	NR	(60)					
E12-09-008B	Collinear nucleon structure at twist-3	Pisano	NR	(60)					
E12-11-003	DVCS on neutron target	Niccolai	A	90					
E12-11-003A	In medium structure functions, SRC, and the EMC effect	Hen	NR	(90)					
Beam time partial sum				765 (1275)	229				

Note: Experiment ending with A or B are run group experiments approved by the CLAS collaboration. They are running parallel to the experiments with same experiment number. Their requested time is listed in () as no new beam time is required.

CLAS12 approved & C1 & non-CLAS12

E12-06-109	Longitudinal Spin Structure of the Nucleon	Kuhn	A	80	185	Polarized target RICH (1 sector) Forward tagger	11	C	NH ₃ ND ₃ S. Kuhn
E12-06-119(b)	DVCS on longitudinally polarized proton target	Sabatie	A	120					
E12-07-107	Spin-Orbit Correl. with Longitudinally polarized target	Avakian	A-	103					
E12-09-007(b)	Study of partonic distributions using SIDIS K production	Hafidi	A-	80					
E12-09-009	Spin-Orbit correlations in K production w/ pol. targets	Avakian	B+	103					
E12-06-106	Color transparency in exclusive vector meson production	Hafidi	B+	60	60		11	D	
E12-06-117	Quark propagation and hadron formation	Brooks	A-	60	60		11	E	Nuclear
E12-06-113	Free Neutron structure at large x	Bueltman	A	40	42	Radial TPC	11	F	Gas D ₂
E12-14-001	EMC effect in spin structure functions	Brooks	B+	55	55	Pol. LiH target	11	G	LiH
TOTAL CLAS12 run time (approved experiments)				1466 (1976)	631				

Proposal	Physics	Contact	Rating	Days	Group	Equipment	Energy	Group	Target
C12-11-111	SIDIS on transverse polarized target	Contalbrigo	A	110	110	Transverse target	11	G	HD
C12-12-009	Transversity w/ di-hadron on transverse target	Avakian	A	110					
C12-12-010	DVCS with transverse polarized target in CLAS12	Elouadrhiri	A	110					
All CLAS12 transverse target proposals				330	110				
C12-11-006	Heavy Photon Search at Jefferson Lab (HPS)	Jaros	A	180	180	Setup in alcove	2.2, 6.6	H	Nuclear
E12-11-106	High Precision Measurement of the Proton Charge Radius	Gasparian	A	15	15	Primex	1.1, 2.2	I	H ₂ gas
Beam time request from CLAS12 C1 experiments + non-CLAS12 experiments				525	305				
Beam time from approved CLAS12 experiments (from previous table)				1466 (1976)	631				
TOTAL Beam time for all Hall B experiments				1991 (2501)	936				

Hall B Run Schedule – Tentative 7/2015

Run Group	Days	2015	2016	2017	2018	2019	2020	2021	Remain
All Run Groups	936		CND MM FT	BONUS RICH	Long. PT		Trans. PT	468	468
HPS	180*	3 5?	7.5 ?	20					145
PRad	15*		7.5 ?	15					---
CLAS12 KPP			15						
RG-A (proton)	139*			20 40					79*
RG-B (deut.)	90*				40				50*
RG-F (BoNuS)	42*				40				2
RG-C (NH ₃)	120				20 40				60
RG-C-b (ND ₃)	65					35			30
RG-E (Hadr.)	60					25 10			25
RG-G (TT)	110*						55		55
RG-D (CT)	60						35		25
RG-K (LID)	55							55	---



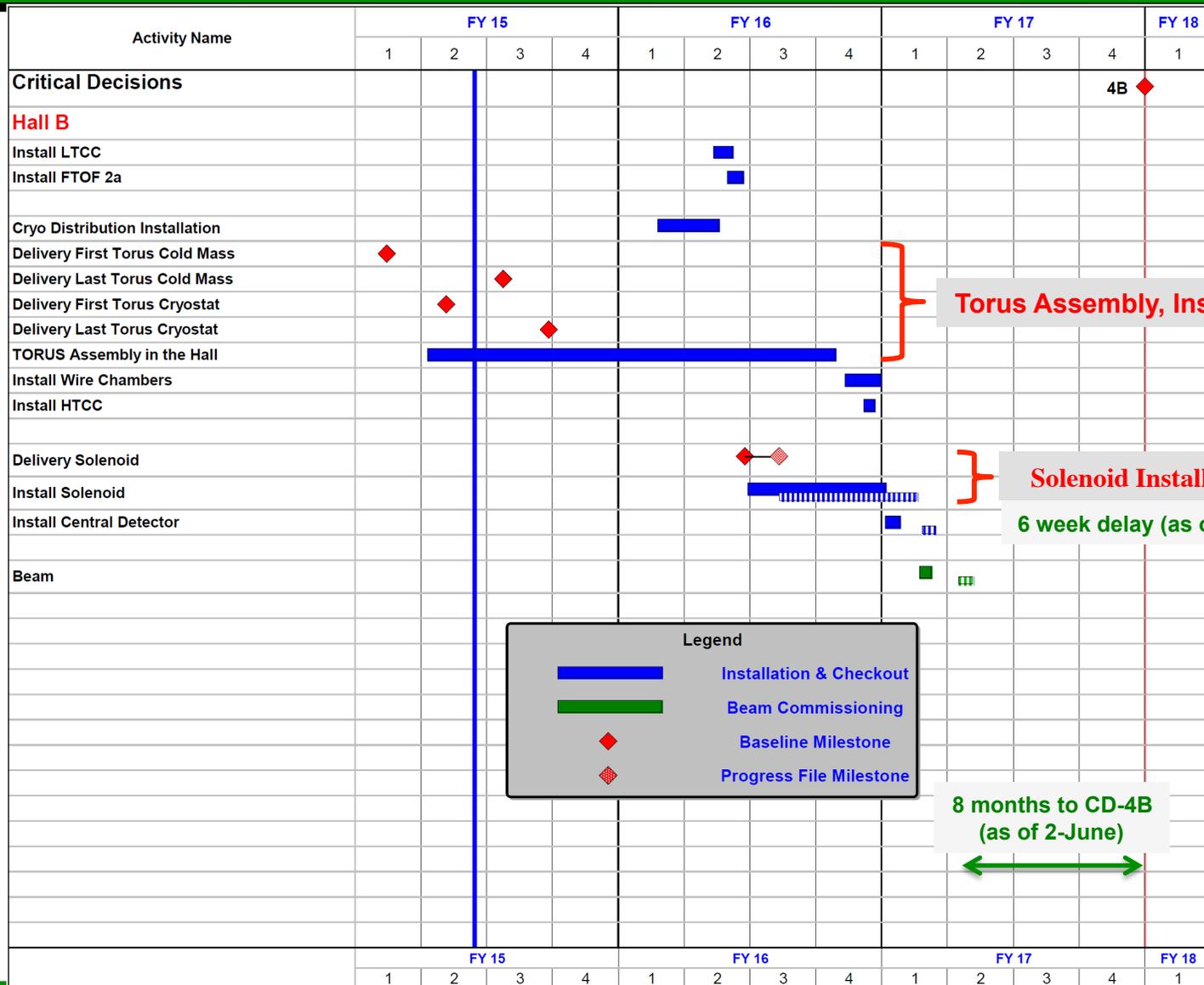
Hall B Commissioning experiment *CLAS12*

- **Established CLAS12 commissioning group effort**
 - Offline software focus on event reconstruction and with simulated Geant4 data using full luminosity, including e.m. and hadronic background
 - CLAS collaborators involved in software validation process and stress tests on simulated data for different physics reactions
 - Detector calibrations procedures being incorporated into CLAS12 software framework
- **Software projected ready by 6/2016 for event reconstruction in full CLAS12**
- **First commissioning experiment from run group RG-A (liquid H₂ target) with initial physics focus on Deeply Virtual Compton Scattering**
- **Workshop scheduled for 10/19-20 2015 with focus on commissioning experiments.**

Conclusions

- **Hall B continues to produce high quality science in many areas of hadron physics**
 - CLAS collaboration has steady flow of papers from 6 GeV era
 - PRIMEX-II run producing precision data on π^0 live time
 - HPS successful engineering run - ready for physics in 2015/2016
 - Proton radius experiment (PRad) in preparation
- **CLAS12 is on track for commissioning in the Fall 2016**
 - Strong science program with high impact experiments for 12 GeV era
 - Organization and tools in place for efficient data taking for high impact experiments beginning 2017.

Additional slides



Legend

- Installation & Checkout
- Beam Commissioning
- Baseline Milestone
- Progress File Milestone

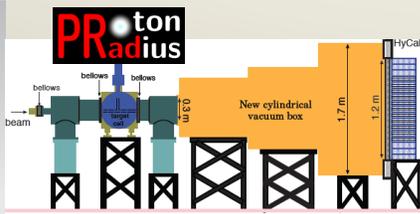
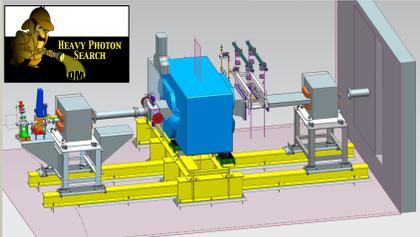
Torus Assembly, Install + Test

Solenoid Install + Test

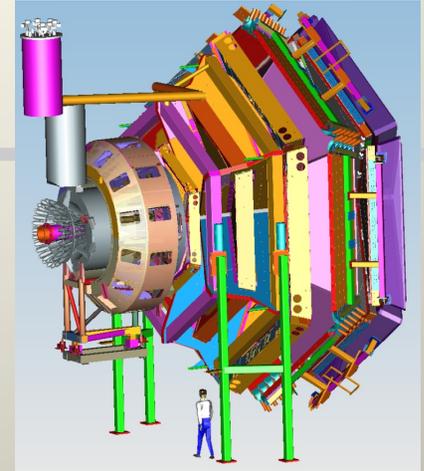
6 week delay (as of 27-Feb)

8 months to CD-4B (as of 2-June)

Plans for first years of Beam in Hall B



6 A-rated experiments in first 5 years: HPS, PRad, pDVCS, nDVCS, pSIDIS, g_1^p/g_1^n

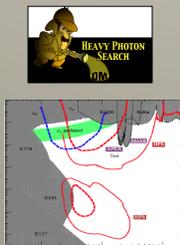


Construction & Installation

Commissioning & early 11 GeV Experiments

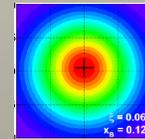
< 6 GeV beam

Installation



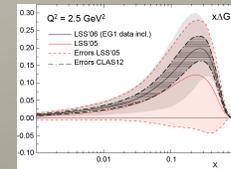
11 GeV

pDVCS & GPDs
pSIDIS & TMDs
neutron F2



nDVCS & GPDs
nSIDIS & TMDs

g_1^p, g_1^n - large x spin structure



QCD in nuclei

CY 2015

CY 2016

CY 2017

CY 2018

CY 2019