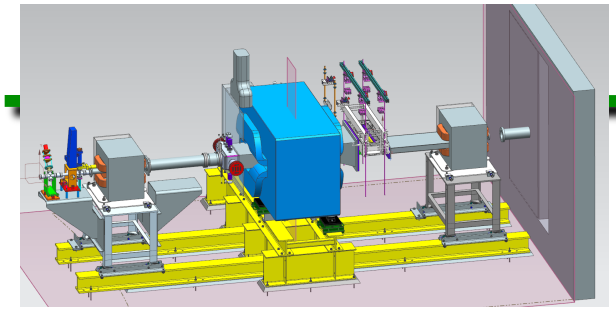
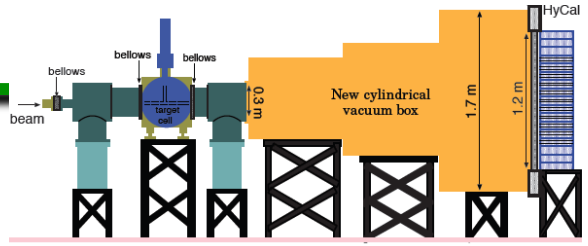
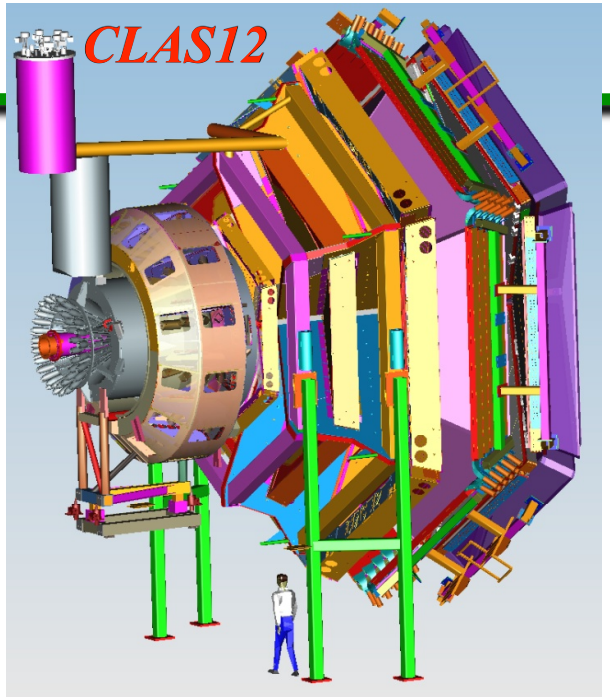






Status of Hall B

Volker D. Burkert

CLAS Collaboration Meeting
October 20-23, 2015

Jefferson Lab
Exploring the Nature of Matter

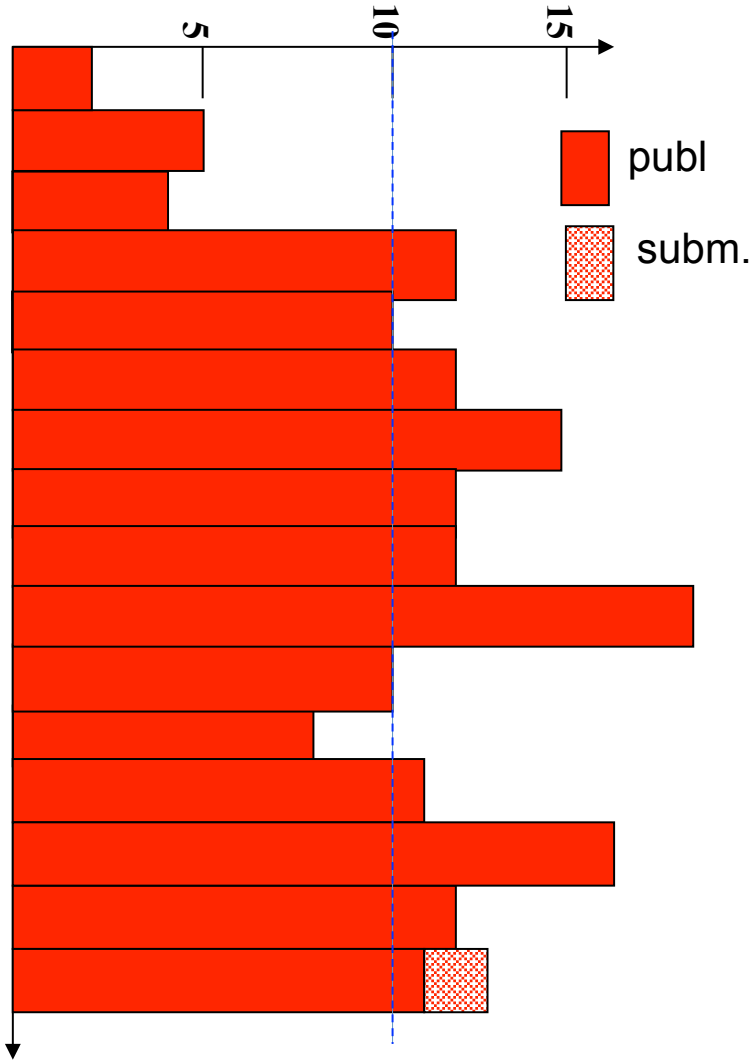
clas
CEBAF Large Acceptance Spectrometer

Hall B Overview

- **Solid flow of PhD theses, publications in refereed journals and conference talks**
  - **148** PhD theses completed on CLAS results (**39** in progress)
  - **171** physics papers published/accepted in refereed journals (incl. higher level analysis papers based on CLAS data)
  - **38** technical papers published in NIM (**25** CLAS, **12** CLAS12, **1** HPS)
  - **> 1,850** talks at conferences (**11** talks for every published physics paper)
- **Non-CLAS12 experiments**
  - **HPS** – Analysis of data from engineering run, plan to run spring/2016
  - **PRad** – Preparations ongoing – ERR scheduled for Nov 12, possible run early summer/2016
- **12 GeV upgrade project**
  - Excellent detector progress: **SVT, HTCC** construction completed
  - All **Torus coils** mounted to spit and connected through hex beams.
  - Solenoid coil #3 winding completed – on critical pass.
- **12 GeV user contributed equipment & software development**
  - CLAS12 upgrade detectors**: CND** received**, FT** in transfer**, MM -** First barrel and forward trackers to arrive at JLab in Nov/Dec**, RICH** detector passed review with few recommendations
  - Offline software released, validation of reconstruction code using cosmic rays.
- **1st Workshop on preparation of first CLAS12 physics experiment**

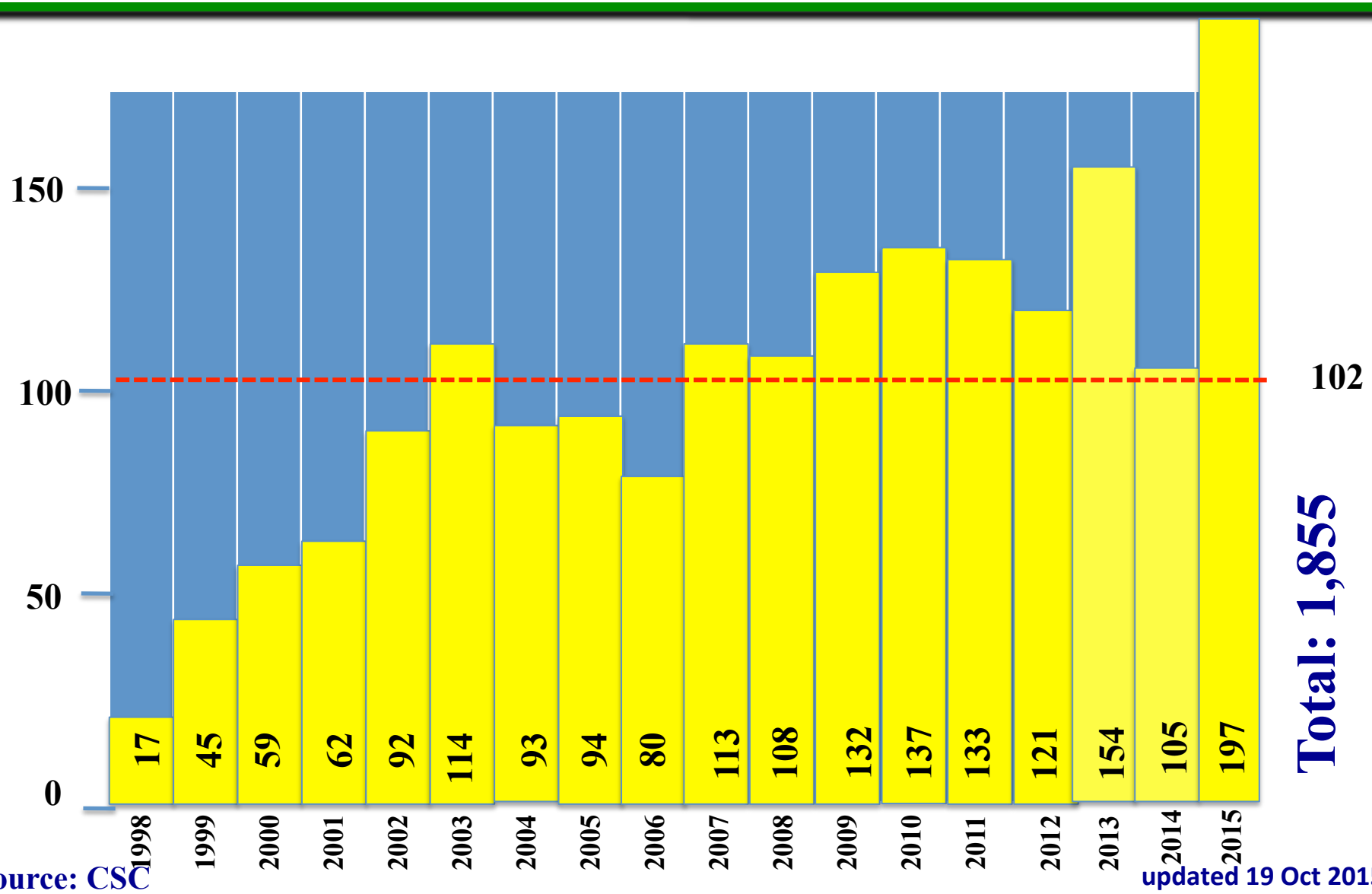
Hall B Physics Publications in refereed Journals

	HSWG	DPWG	NPWG	ALL
2000	-	1	1	2
2001	2	3	-	5
2002	3	-	1	4
2003	7	4	1	12
2004	3	3	4	10
2005	7	3	2	12
2006	8	4	3	15
2007	7	2	3	12
2008	4	6	2	12
2009	8	7	4	19
2010	4	2	4	10
2011	3	1	4	8
2012	6	3	2	11
2013	8	6	2	16
2014	5	6	1	12
2015	4 (2)	4	3	11 (2)
SUM	79	55	37	171

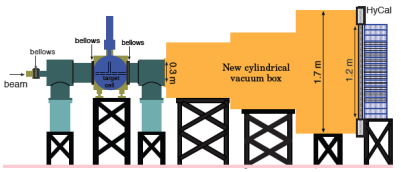


updated 18 Oct 2015

Conference Presentations

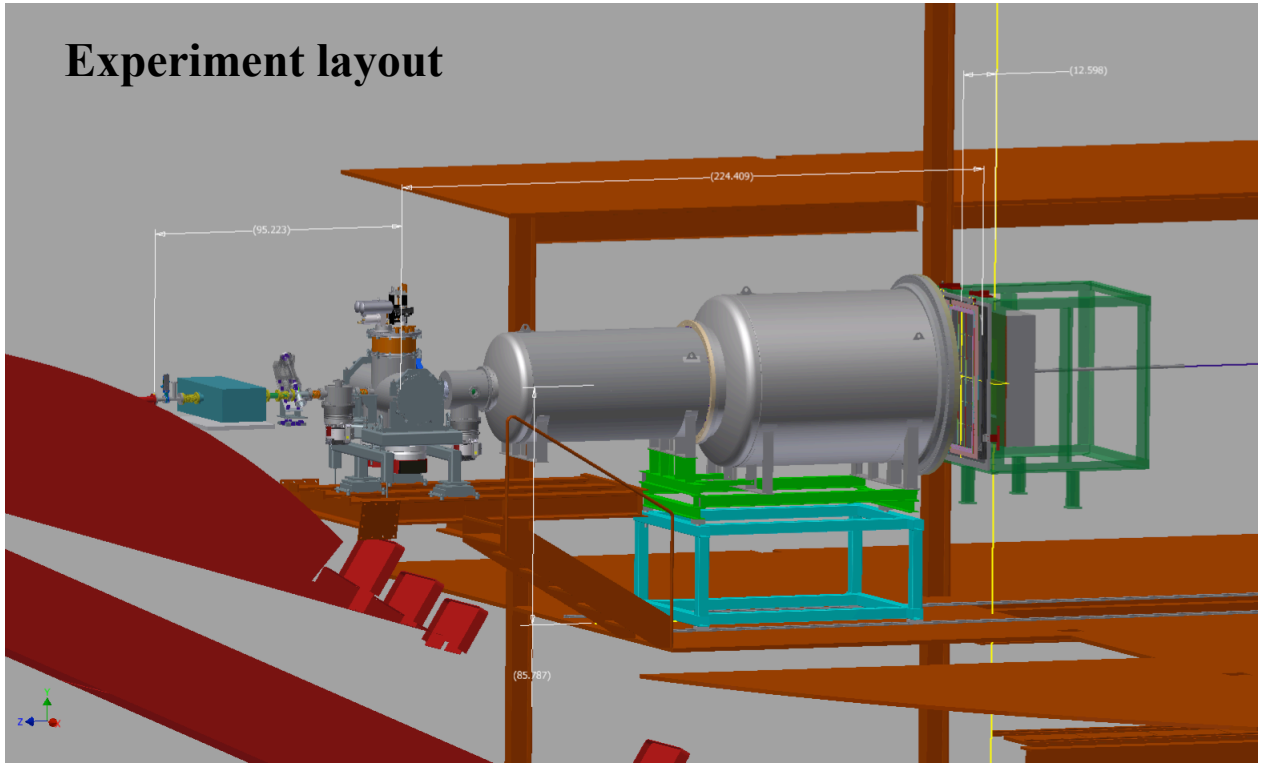


PRad Status

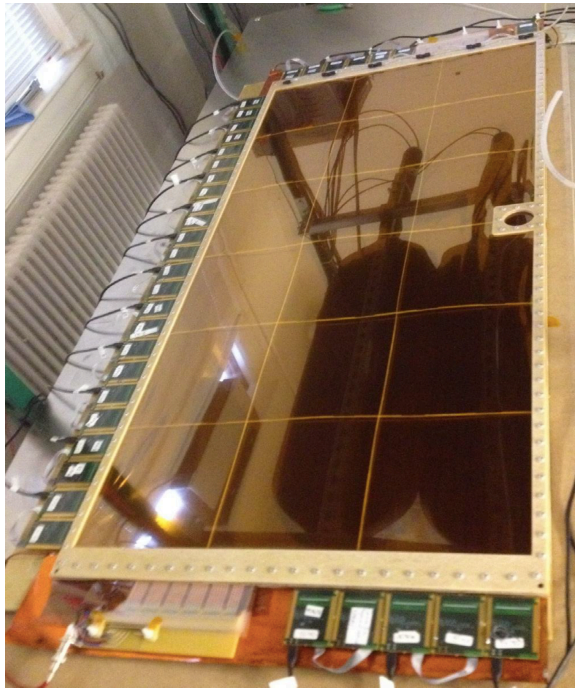


- **Conceptual design of the experiment layout is done. Working on final beam line design and fabrication drawings.**
- **One GEM chamber is assembled and tested, 2nd in preparation**
- **Experiment readiness review scheduled for 11/12.**

Experiment layout

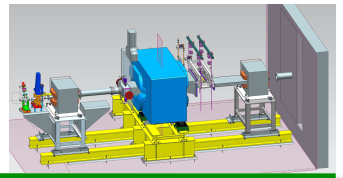


GEM chamber

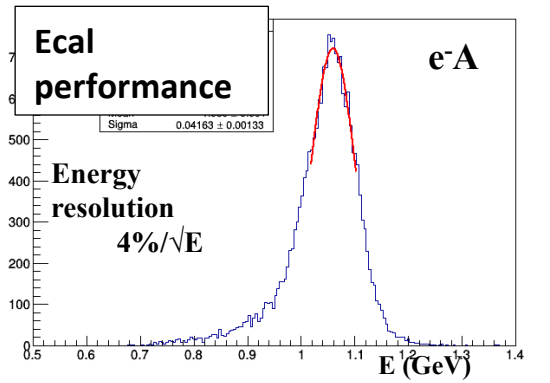


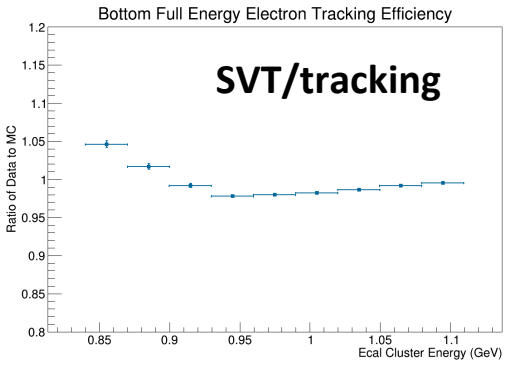
→ **talk by A. Gasparian**

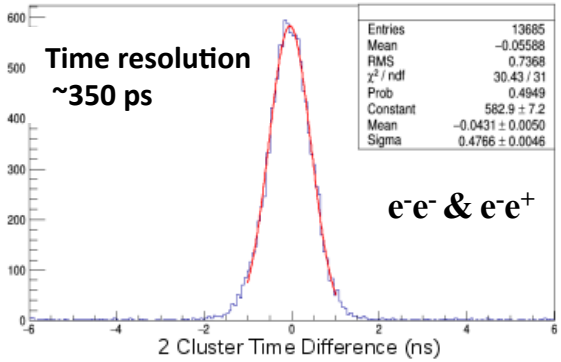
Progress in data analysis

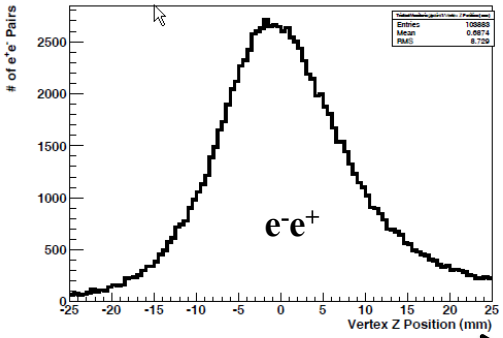


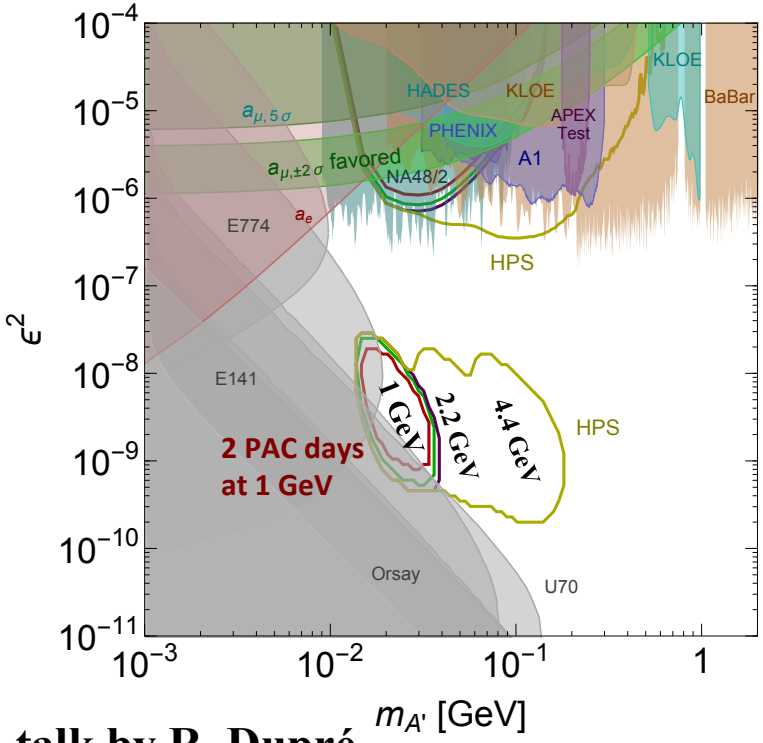
- Acquired 2 PAC-days of physics data at nominal settings – electron beam 1.05 GeV, 50 nA, target 4 μm W, SVT Layer 1 at 0.5 mm from the beam plane
- Only 10% of data are open (unblinded) for calibration and for initial analysis
- The first round of calibrations and alignment of Ecal and SVT is done, pass2 processing of unblinded sample is complete
- Analysis of various benchmark reactions is in progress (e^-e^-, $e^-\gamma$, e^-e^+, e^-A)











→ talk by R. Dupré

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)

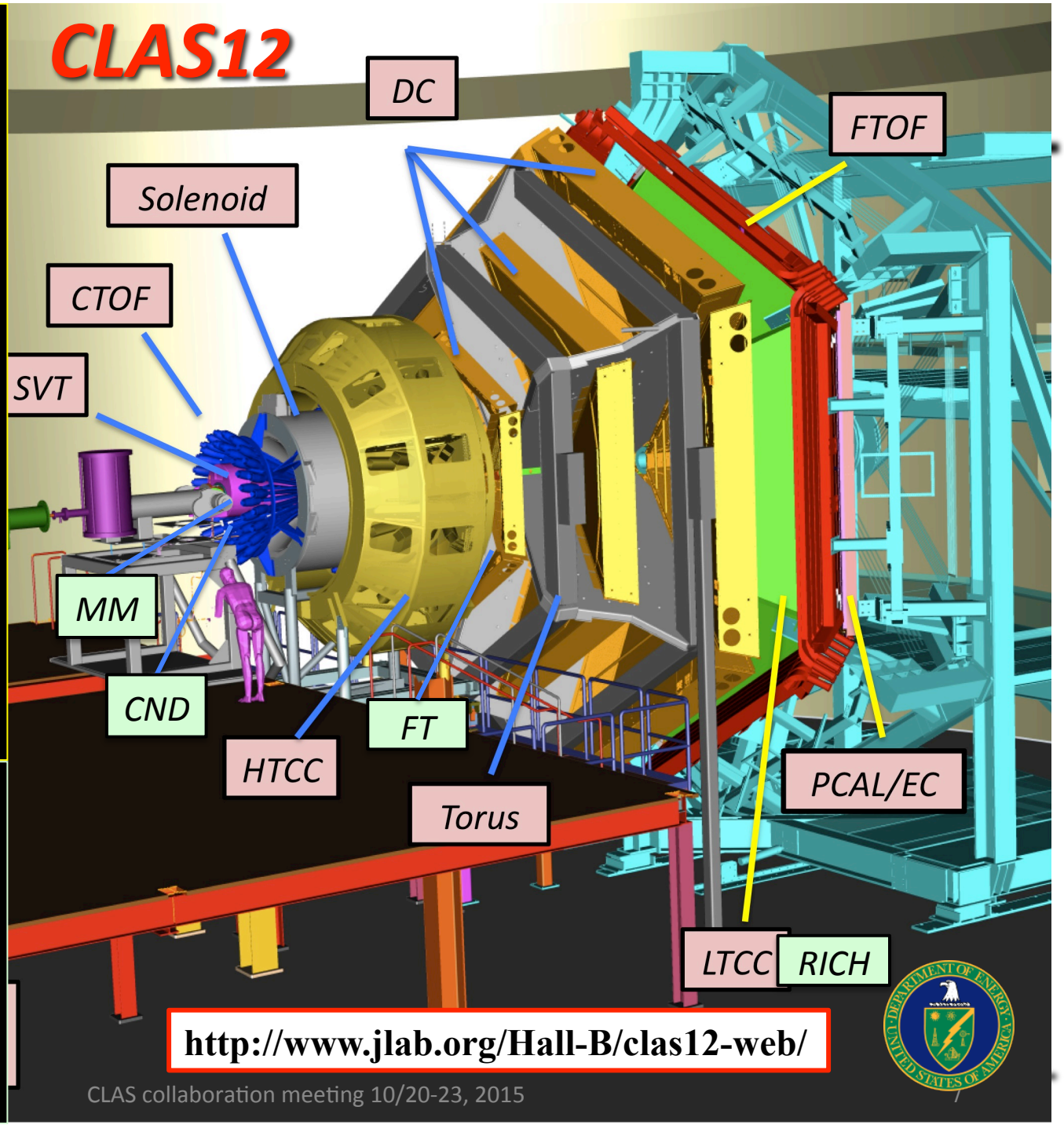
- SOLENOID magnet
- Barrel Silicon Tracker
- Central Time-of-Flight

Beamline

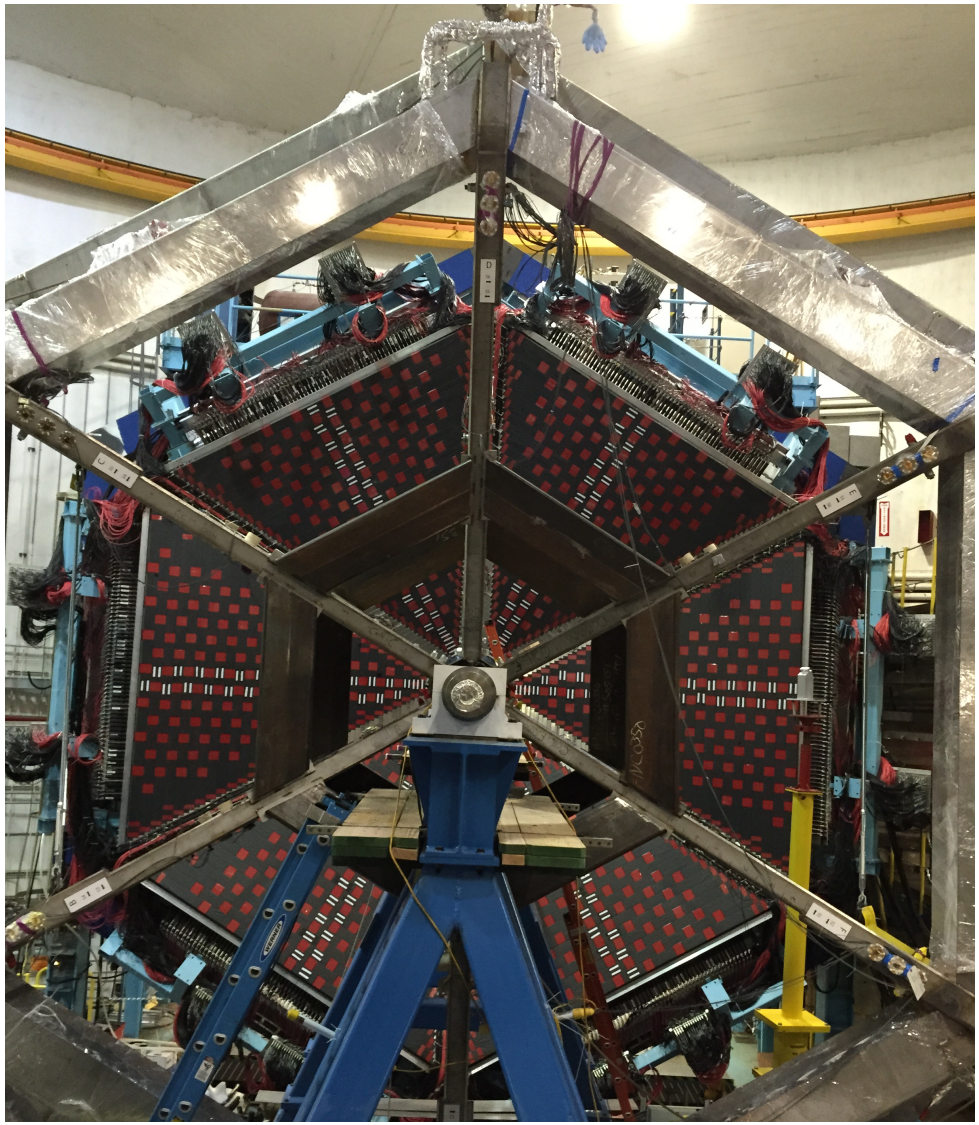
- Targets
- Moller polarimeter
- Photon Tagger

Upgrade to base equipment

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



Status of Hall B



TORUS Magnet Installation

All coils installed in Hall B
All cold and electrical connections done
All N2 shields and vacuum jackets installed
Welding underway

Pump down	March 2016
Cool down expected	April 2016
Magnet ramp up	May 2016
Field mapping	June 2016

SOLENOID Magnet

3 of 5 coils winding complete

Delivery of Magnet to JLab now ~	07 2016
Expected to be operational	10/11 2016

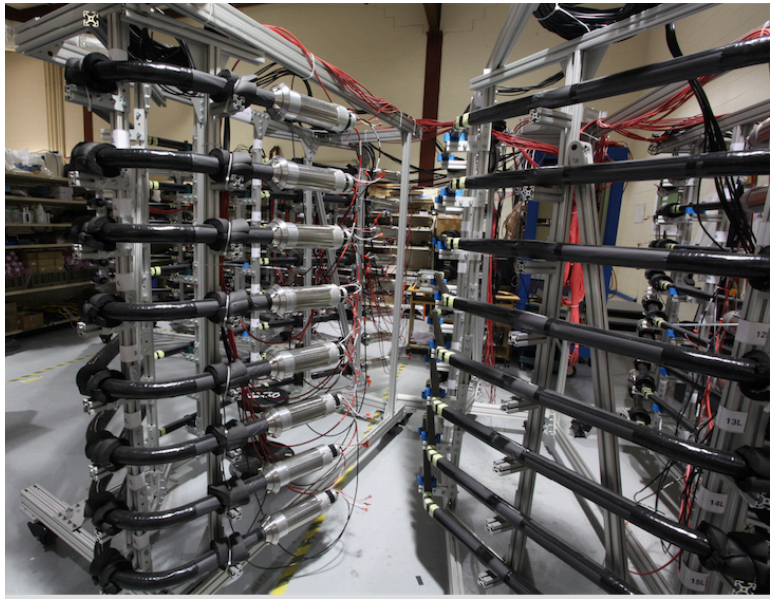
Beam Line Instrumentation

Commissioned during HPS run up to Faraday cup, BPMs, harps, halo counters.
Moeller quad moved for 12GeV operation

Forward Carriage

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

CTOF Status



Design and Procurements:

- Upstream support structure procured; Downstream structure being designed
- Installation tooling/fixtures – conceptual design completed
- LMS fiber optic array procurement in progress

Counter Assembly:

- All counters assembled on storage carts
- Surface "crazing" discovered during testing
  - *7 counters re-surfaced and re-wrapped*
- Now installing fiber mounting blocks for Light Monitoring System (LMS)

Calibration and Testing Status:

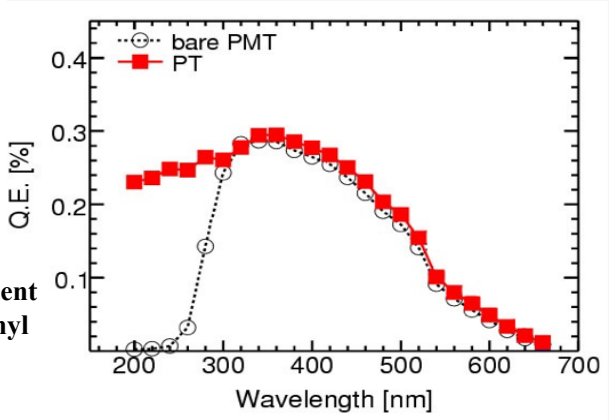
- Tests of shields in realistic B-field completed
- Cosmic ray testing in progress since June
- HV gain matching completed
- Time resolutions measured (70 → 75 ps)
- Calibration suite under development
- Optimization, controls, and calibration of the LMS to be completed this winter

CLAS12 High Threshold CC

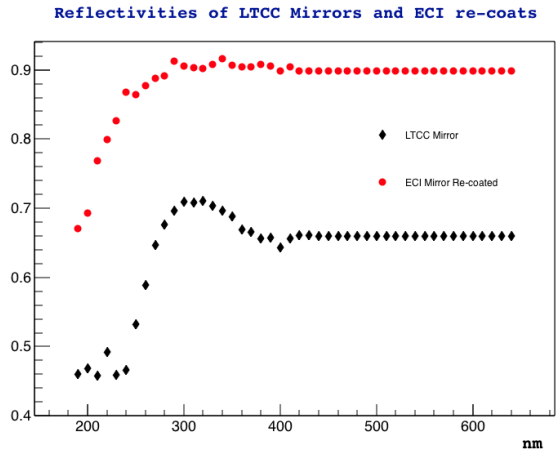
Detector construction complete

CLAS12 Low Threshold CC Status

- **Hardware:**
  - **All mirrors coating completed.**
  - **All PMTs refurbished.**
  - **150 WC re-coated.**
  - **New spine, new window, new patch panel.**
  - **New in-base divider + amplifier.**

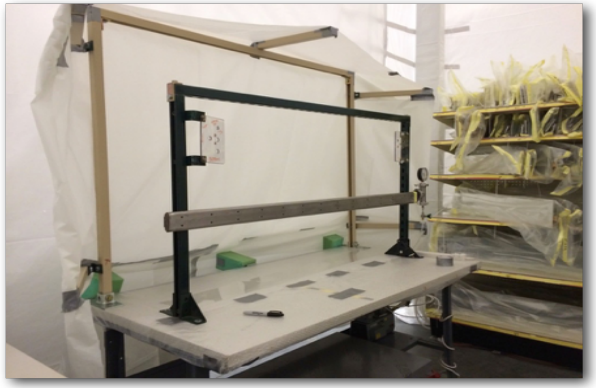


q.e. improvement with p-terphenyl

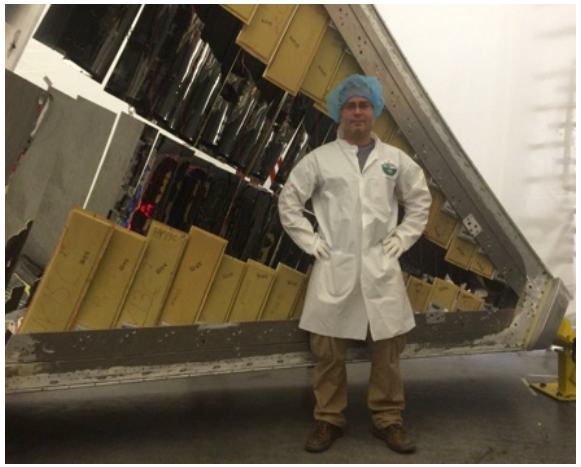


Typical before / after reflectivity of mirrors, WC

- **LTCC sectors:**
  - **3 (of 6) boxes completed**
  - **4th box mirrors alignment in progress**
  - **Project estimate to completion: Nov. 2015**



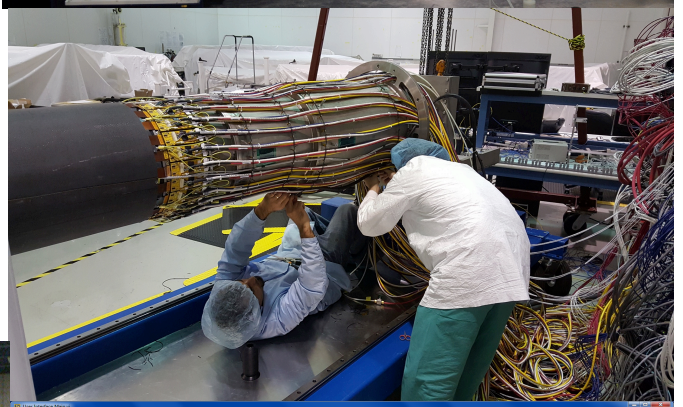
Our mirrors refurbishment facility

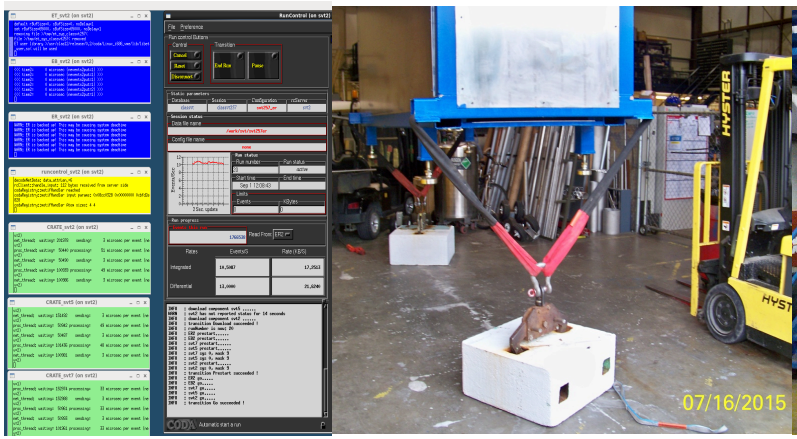


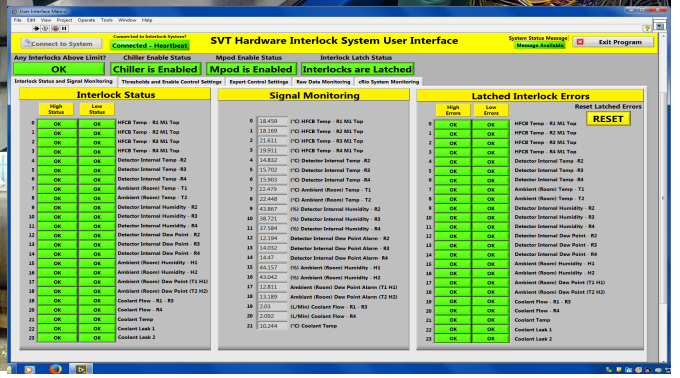
Mirror alignment in progress

CLAS12 SVT Status

- **SVT assembling and integration complete**
  - SVT mechanical survey performed
  - SVT Cabling complete
  - EPICS control and monitoring implemented
  - Hardware interlock system operational
  - SVT calibrated, no extra coherent noise seen
  - Standalone trigger using SD and TI in service
  - Taking cosmic data 24/7 with full DAQ
  - Insertion cart delivered
  - Transportation box load test done

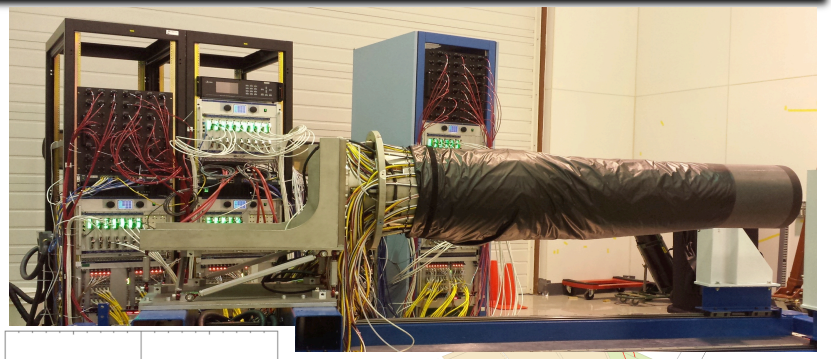




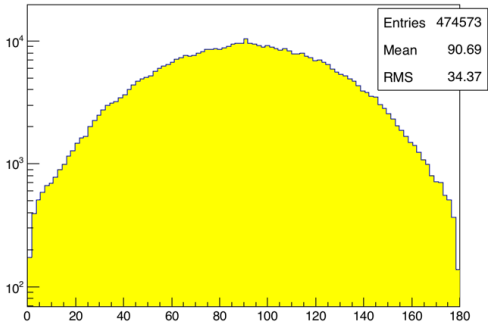


CLAS12 SVT Commissioning with Cosmic Rays

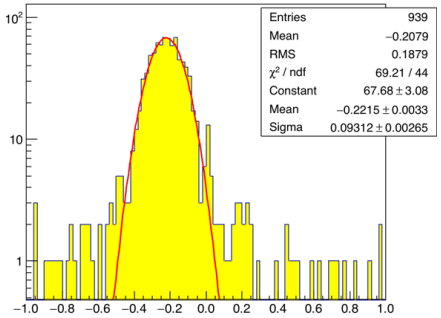
- All three SVT VXS crates are in sync
- Trigger window and latency are set
- SVT 2D and 3D event displays functional
- Reconstruction chain validated
- Data monitoring and validation ongoing
- Monte Carlo tuning on data in progress
- Alignment studies started

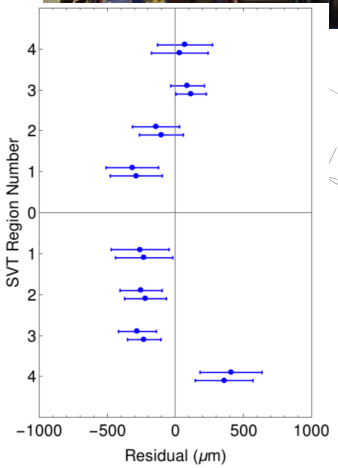


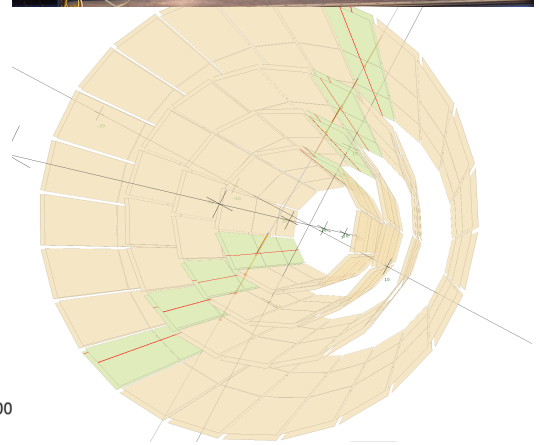
phi

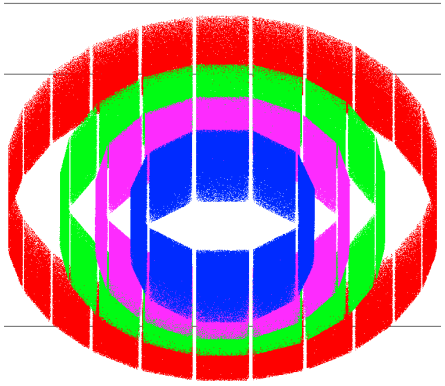


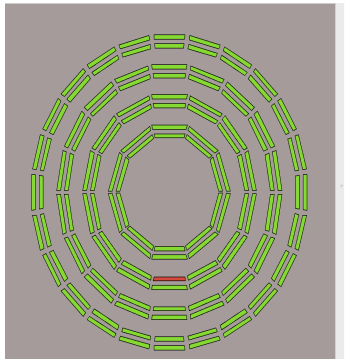
Residual, Layer 5, Sector 13

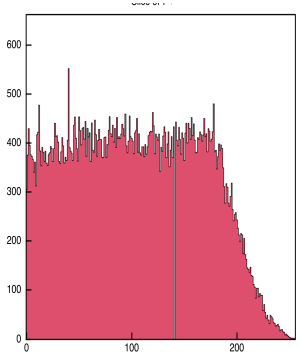


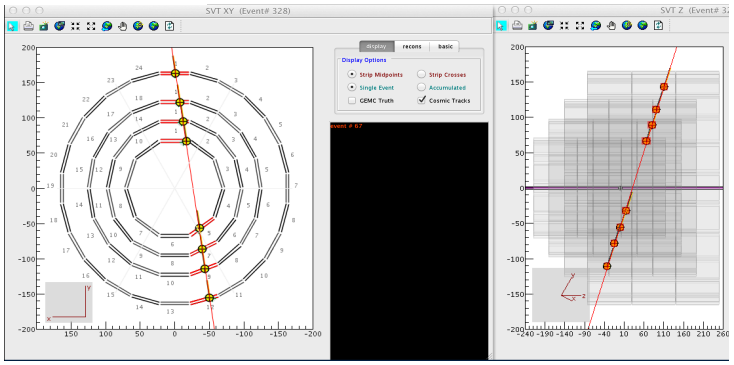








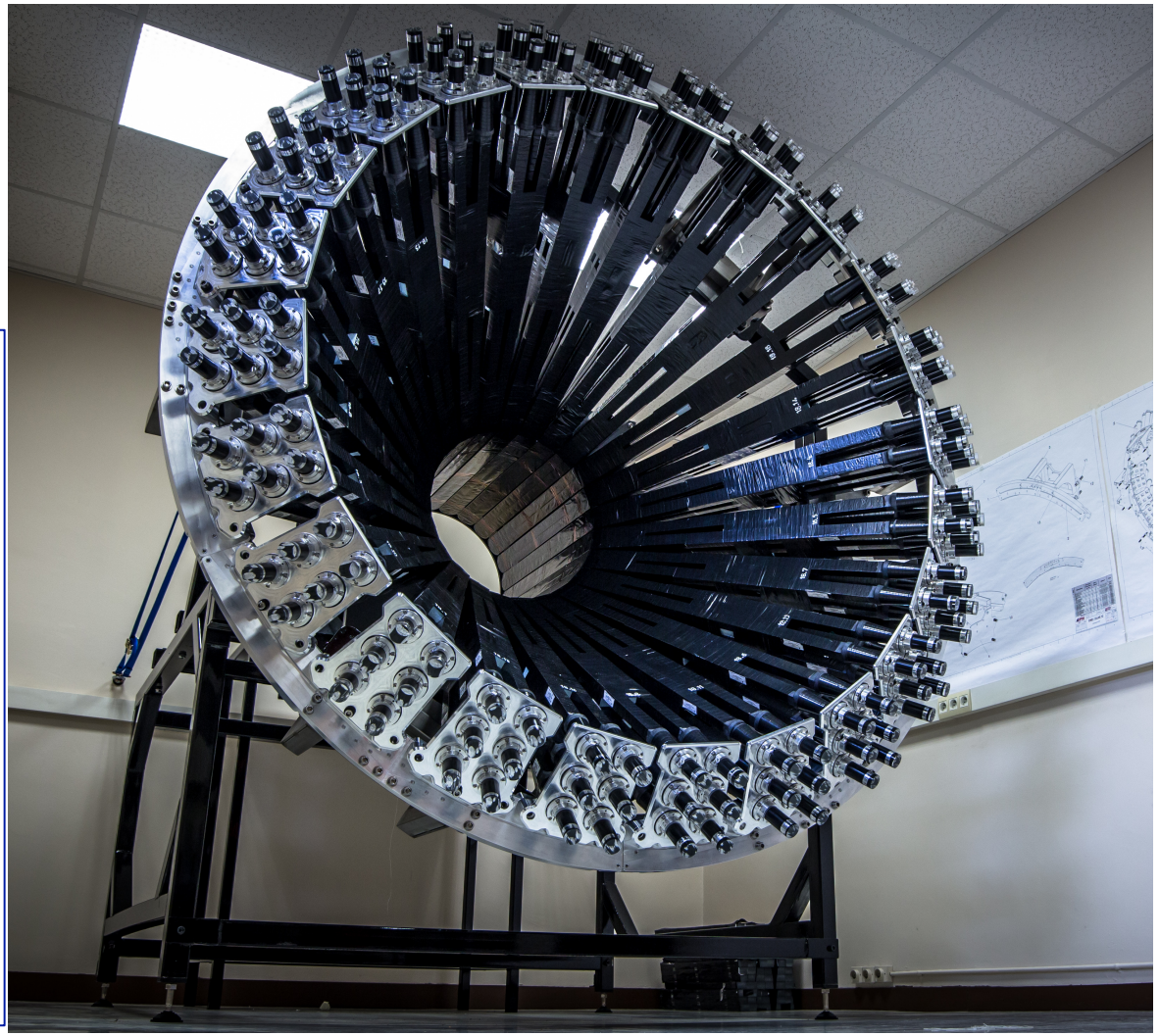




CLAS12 Central Neutron Detector

All detector parts arrived at JLab 6/2/15.

- Detect neutrons in range 0.2< p < 1.0GeV/c at $\theta = 40^o - 120^o$, $\Delta\varphi = 360^o$
- 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 $\delta T = 130$ps.



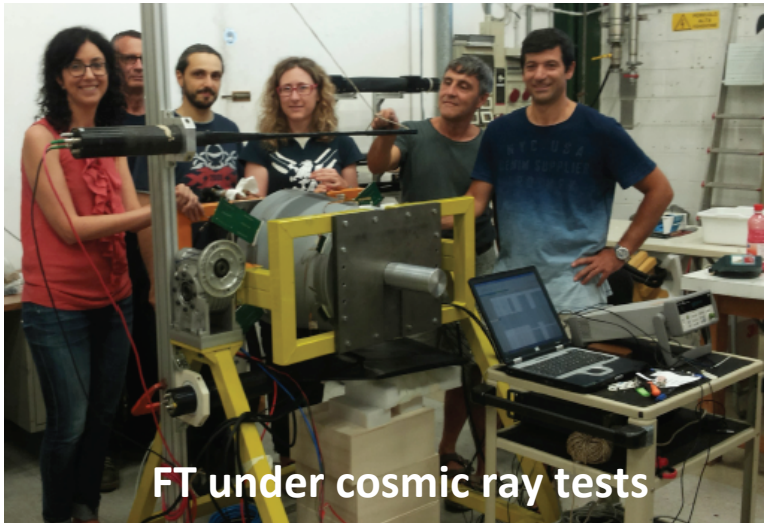
CLAS12 Forward Tagger (FT)

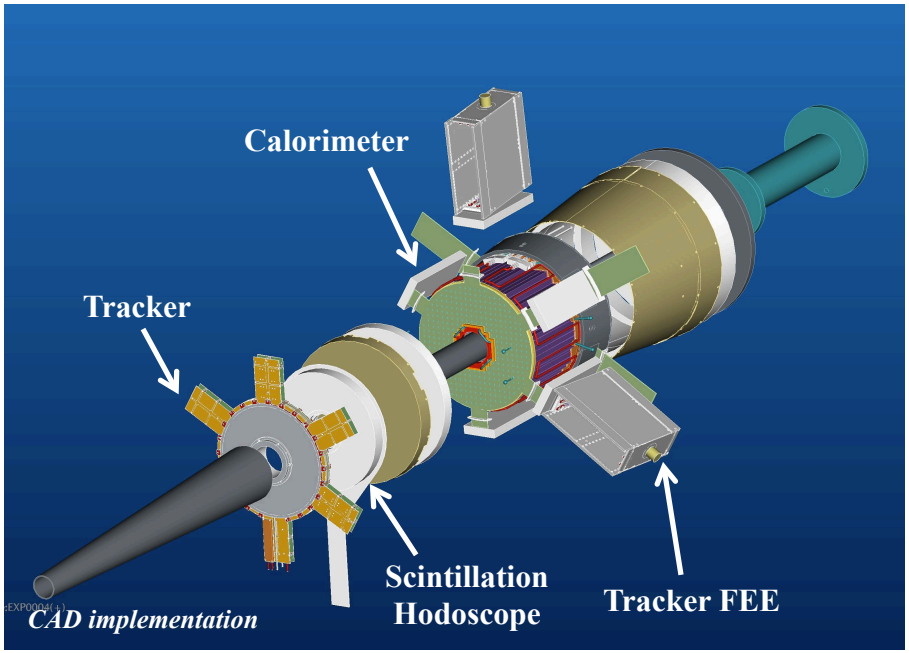
Detect electrons at small angle to perform quasi-real photo-production experiments.

Calorimeter: electron energy/momentum
Photon energy (ν=E-E')
Polarization $\varepsilon^{-1} \approx 1 + \nu^2/2EE'$
$PbWO_4$ crystals with APD/SiPM readout

Scintillation Hodoscope: veto for photons
Scintillator tiles with WLS readout

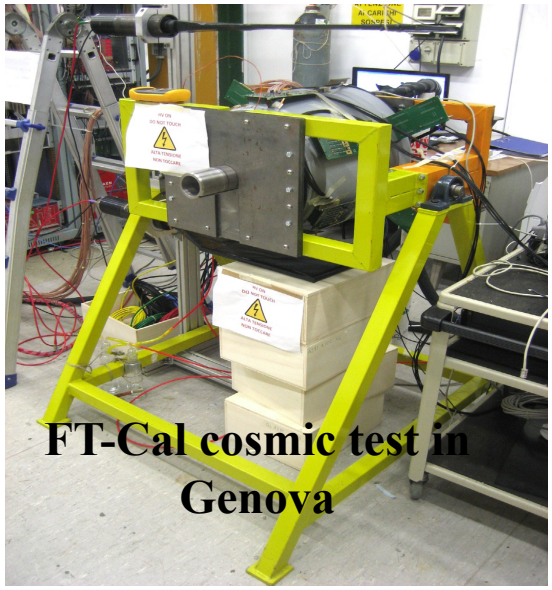
Tracker: electron angles, polarization plane
MicroMegas detectors

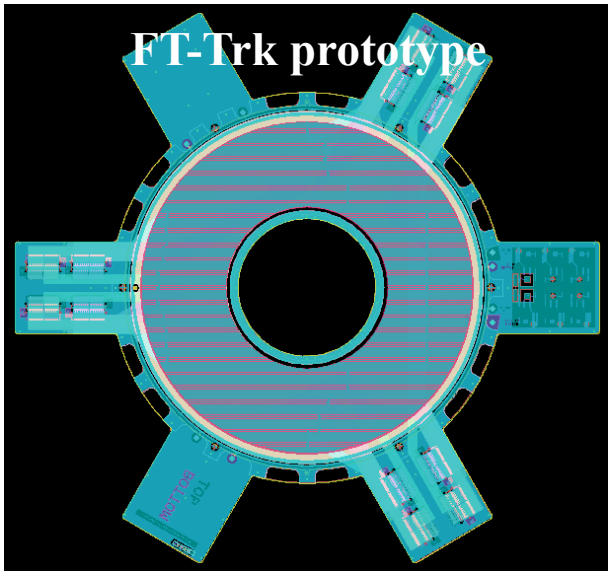


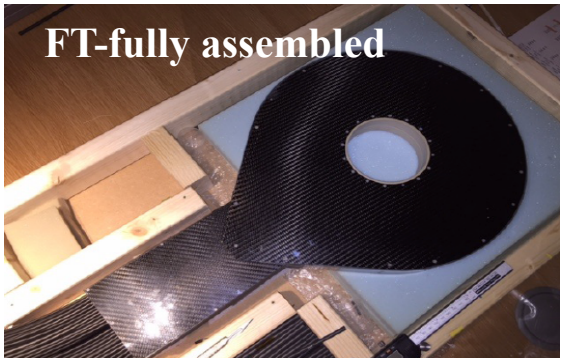


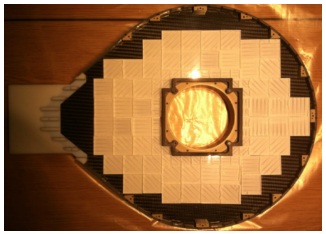
- FT-Cal assembled and tested in Genova
- FT-Hodo assembled in Edinburgh
- FT-Trk expected in Saclay in November
- FT-Cal cosmic tests in Genova
- FT sub-detectors being shipped to Jlab
- FT assembly in EEL building starting in Nov/Dec 2015
- FT commissioning with cosmic expected in Jan 2016
- FT implemented in the CLAS12 rec framework

CLAS12 Forward Tagger Highlights

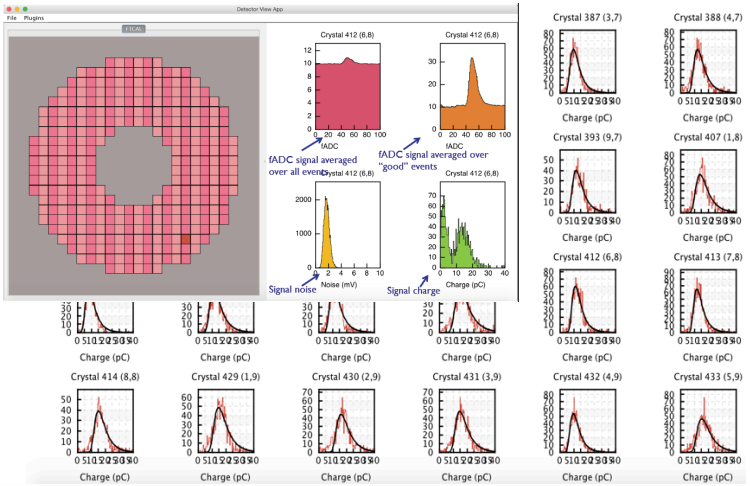


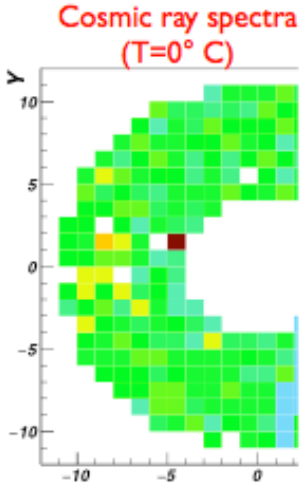


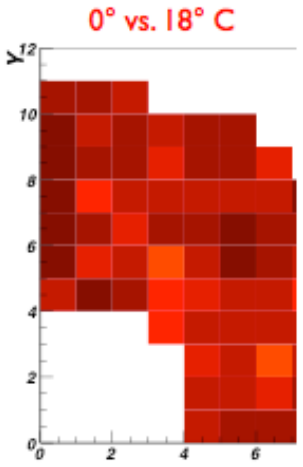




FT-Cal Cosmic ray calibration



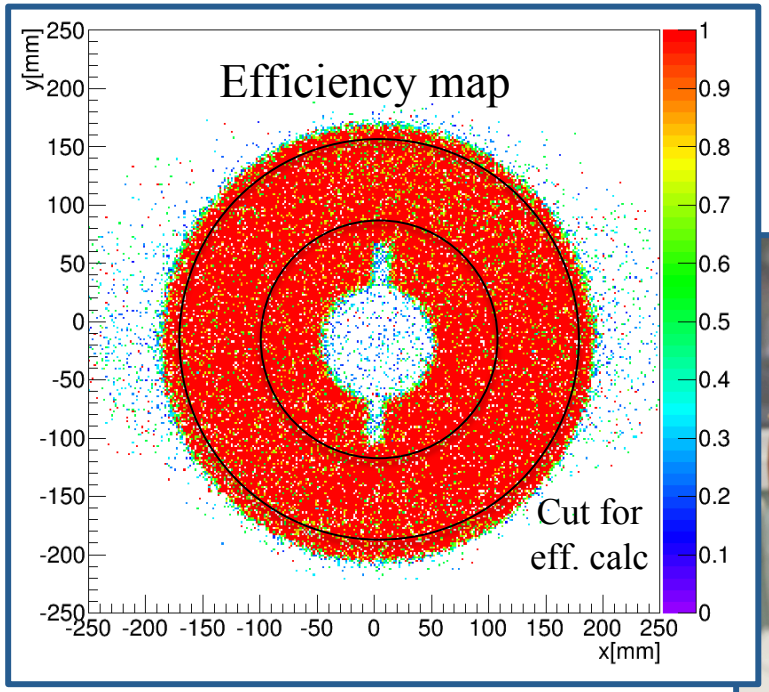


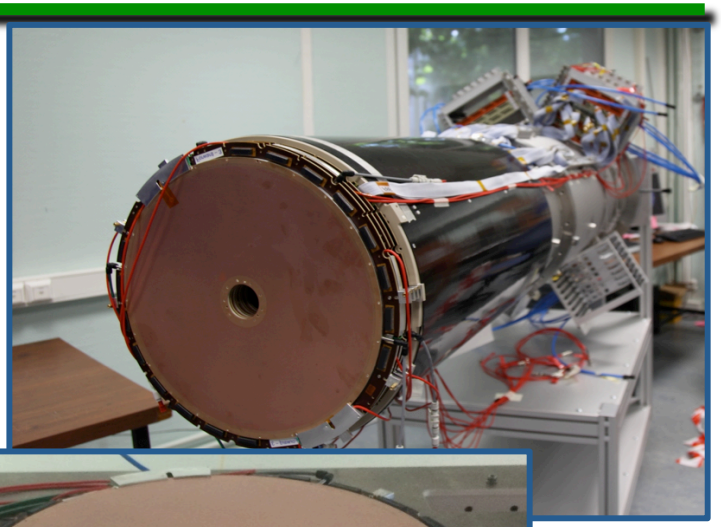


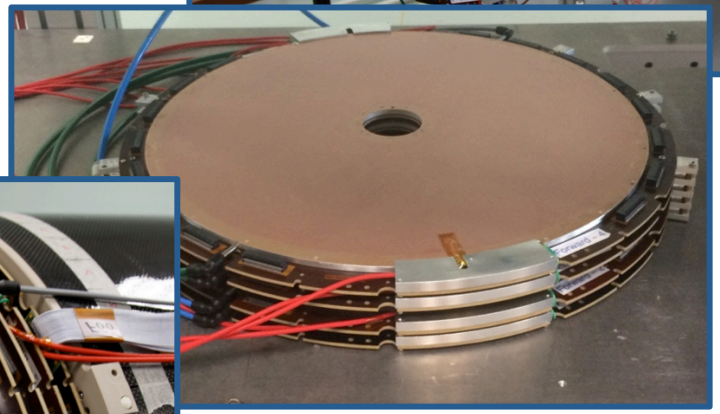
- **Cosmic rays FT-Cal energy calibration**
- **Uniform response**
- **Increase of LY at low T**

Forward Vertex Tracker

- ✓ 4 out of 6 final detectors tested/operational
- ✓ Excellent performances : 2D-efficiency >97%
  ~160µm resolution
- ✓ Integration test in December 2015 (with SVT)
- ✓ 2 remaining detectors coming from CERN in 2015



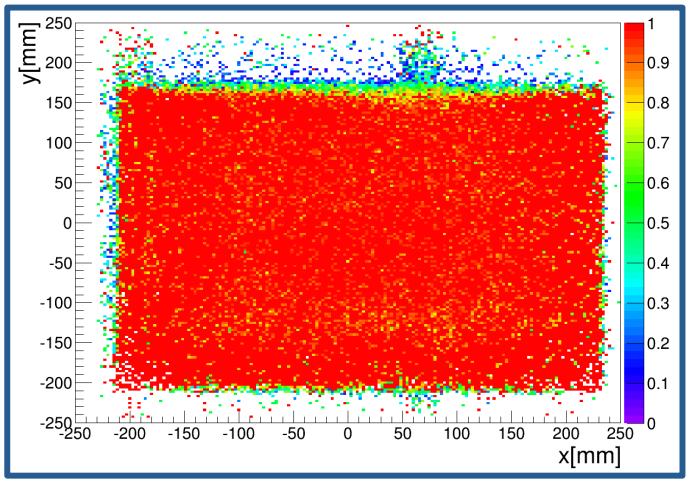


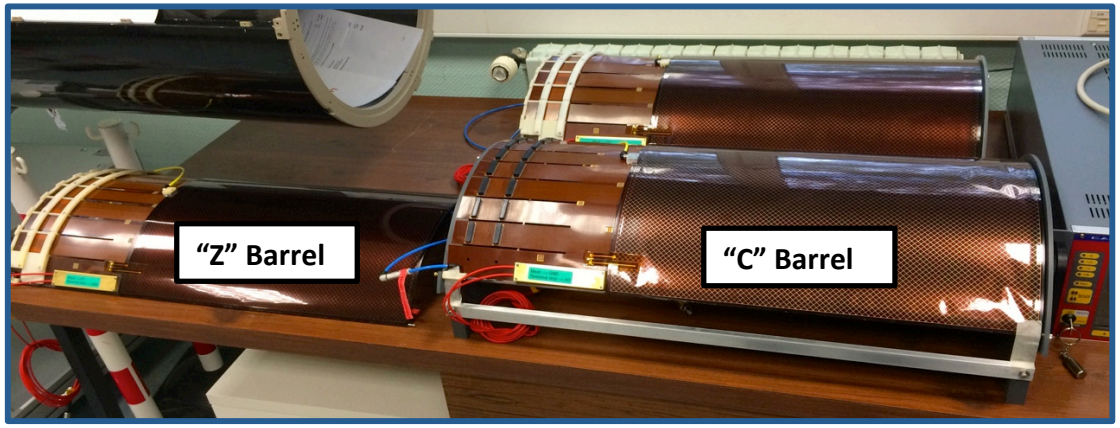


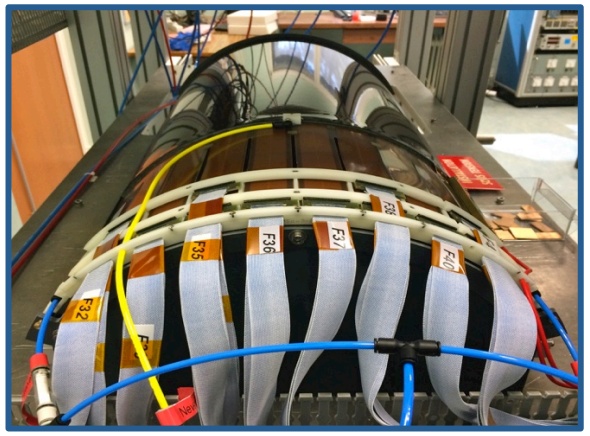
Mock assembly at Saclay started 10/11

Barrel Vertex Tracker

- ✓ 6 out of 6 final detectors tested/operational
- ✓ Excellent performances : 2D-efficiency >98%
  ~200mm resolution
- ✓ Integration test in December 2015 (with SVT)
- ✓ Production of full 6-layer barrel to start this fall







- ❑ Still recovering from drift electrode production issue at CERN (= delays + replacement needed)
- ❑ Non-optimal detectors will be shipped to JLab in November for integration tests, but good enough for tests without magnetic field.

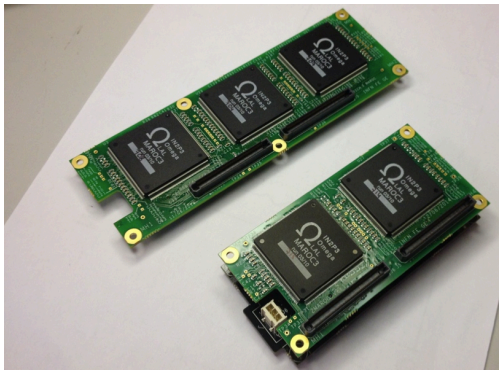
CLAS12 RICH Detector

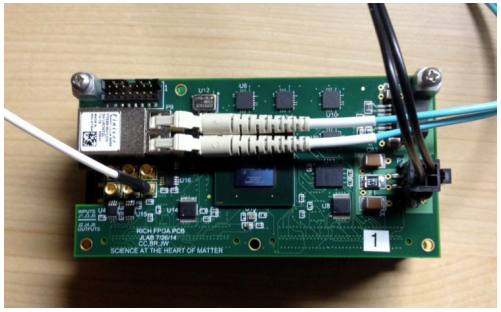
Project Mid-term Review with DOE on 10/14
- very positive response from the committee

Goal: ready for installation in summer 2017

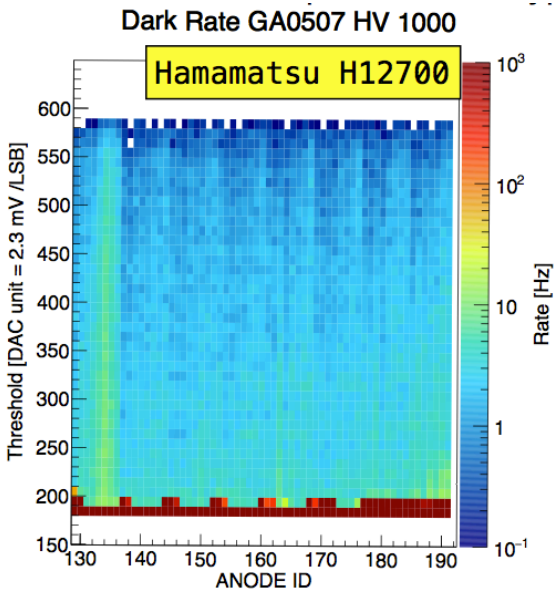
80 H8500 + 260 H12700 MAPMTs received, no defect found. Procurement to be done by end of the year

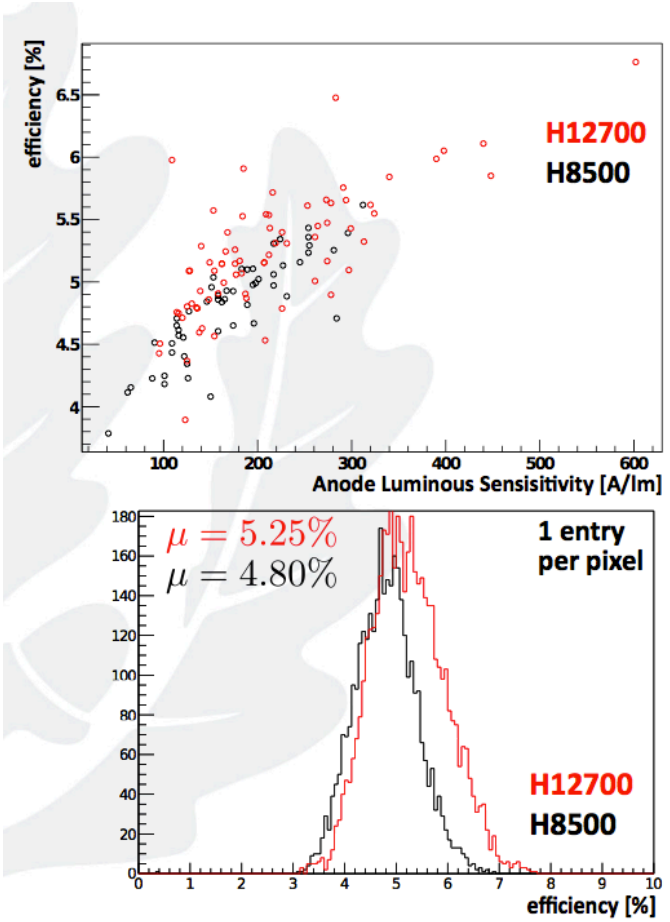
Flexible and compact electronics passing all the functionality tests, interest of Hall-D DIRC, Hall-A SoLID and Detector group.





Mapping MAPMTs dark counts per channel (~15 Hz)

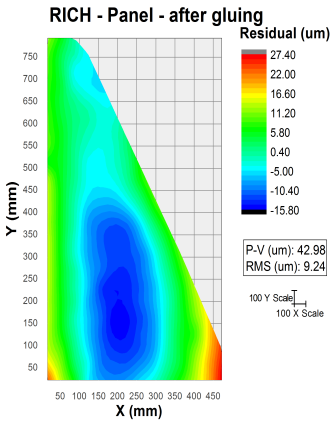




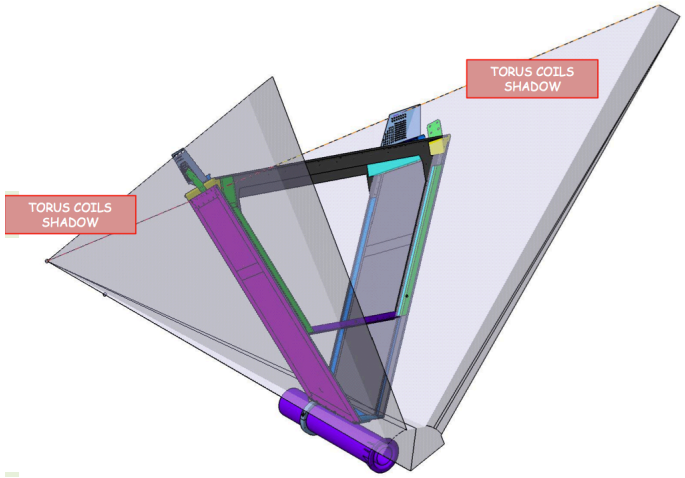
CLAS12 RICH Detector

Mirror under construction meet specs

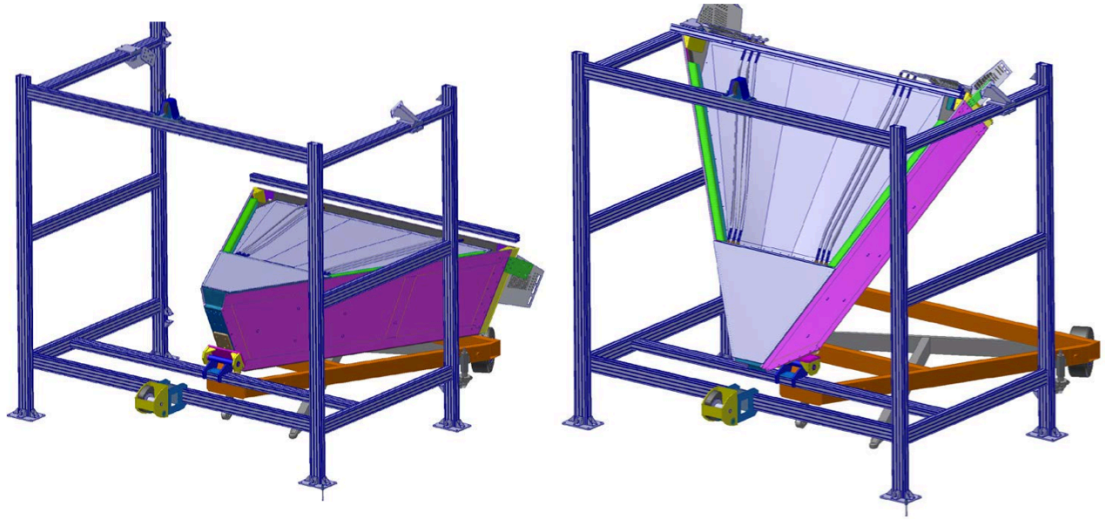
First aerogel delivery at JLab expected this week



CFRP external frame under construction



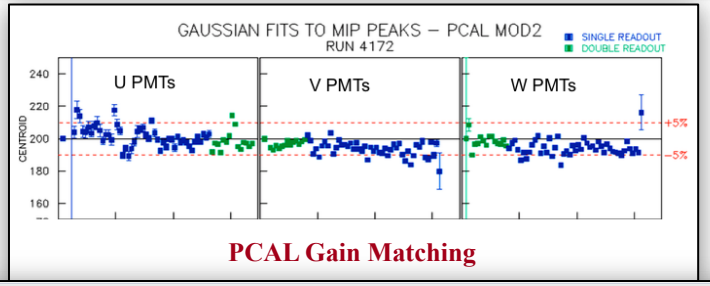
Refining assemble and installation procedure



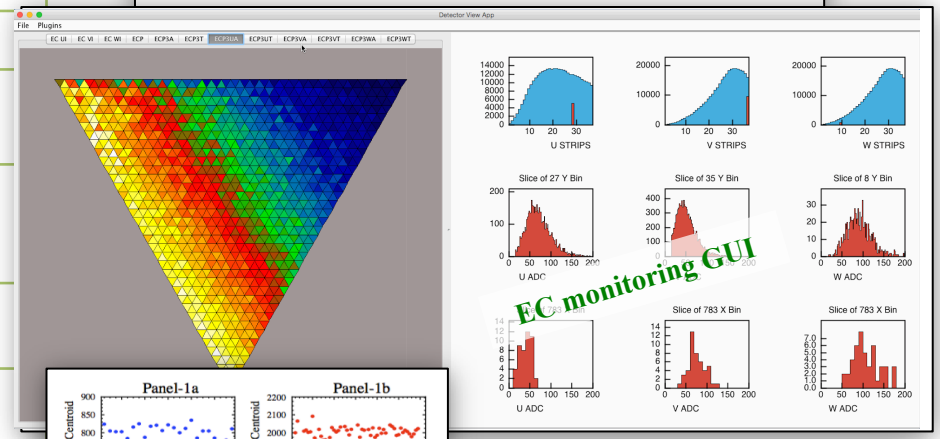
CLAS12 Calibration & Commissioning

- Commissioning and calibration of CLAS12 subsystems in progress:

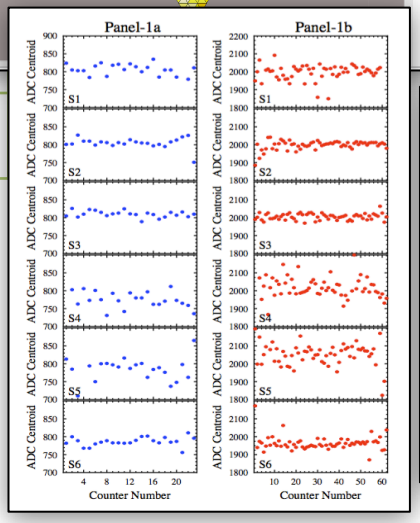
FTOF **EC** **PCAL**	–Advanced commissioning/calibration based on cosmics –DAQ and FADC debugging in progress –Algorithms porting to CLAS12 framework in progress
DC	–cosmic ray calibration in progress
HTCC **LTCC**	–PMT single-photoelectron calibration in progress –Development of calibration suite started
SVT	–Advanced commissioning/calibration stage –Cosmic data analysis for alignment in progress –Calibration software development within CLAS12 framework
CTOF	–Cosmic ray calibration started –Software development based on FTOF calibration suite
CND	–Initial cosmic ray calibration completed –Development of calibration suite started
FT	–Initial cosmic ray calibration of FT-Cal completed –Calibration suite development within CLAS12 framework

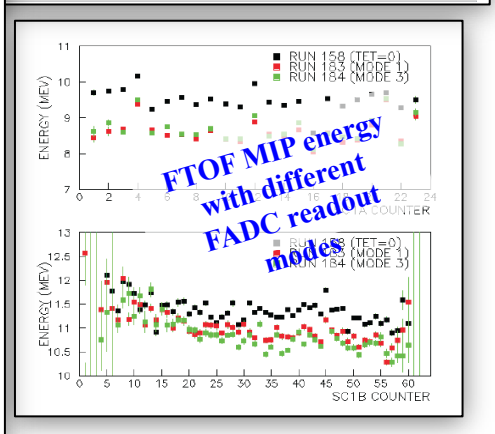


PCAL Gain Matching



EC monitoring GUI





FTOF MIP energy with different FADC readout modes

- Commissioning With Beam (CWB)
  - In progress:
    - Revision of CWB plan
    - Evaluation of particle rates at 11 and 6 GeV
    - Simulation of detector backgrounds
  - Focus of next months:
    - Documentation and training
    - Accurate testing of calibration software
    - Detailed planning of online/offline shifts

CLAS12 Calibration & Commissioning

- Commissioning and calibration of CLAS12 subsystems in progress:

FTOF **EC** **PCAL**	–Advanced commissioning/calibration based on cosmics –DAQ and FADC debugging in progress –Algorithms porting to CLAS12 framework in progress
DC	–cosmic ray calibration in progress
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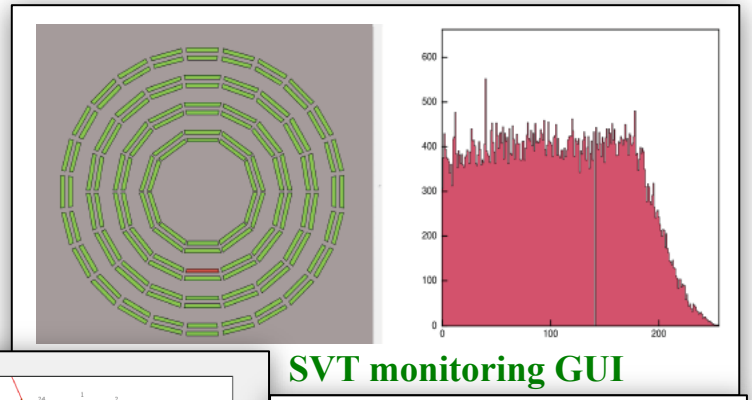
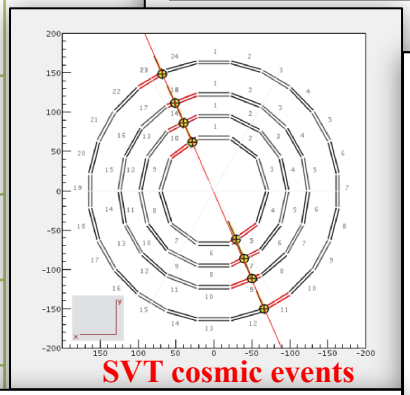
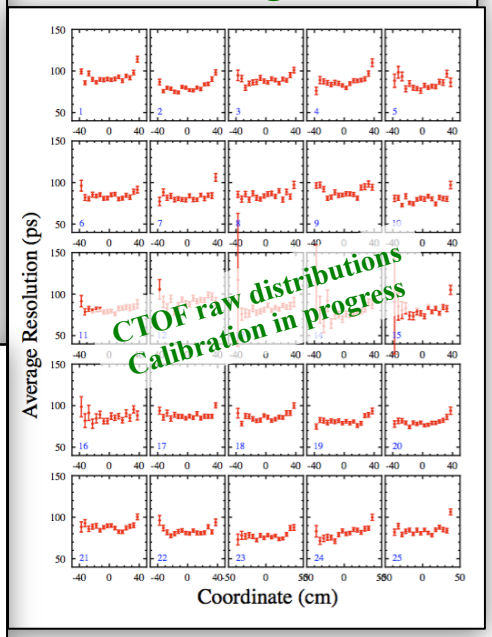
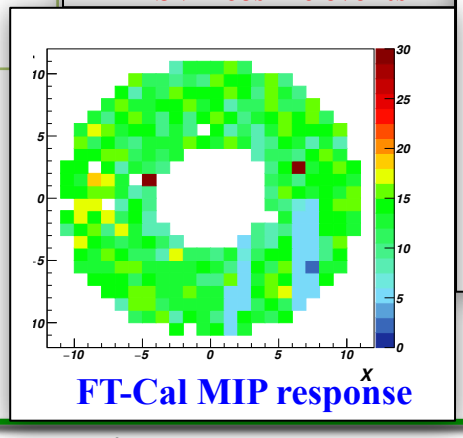

SVT monitoring GUI


SVT cosmic events

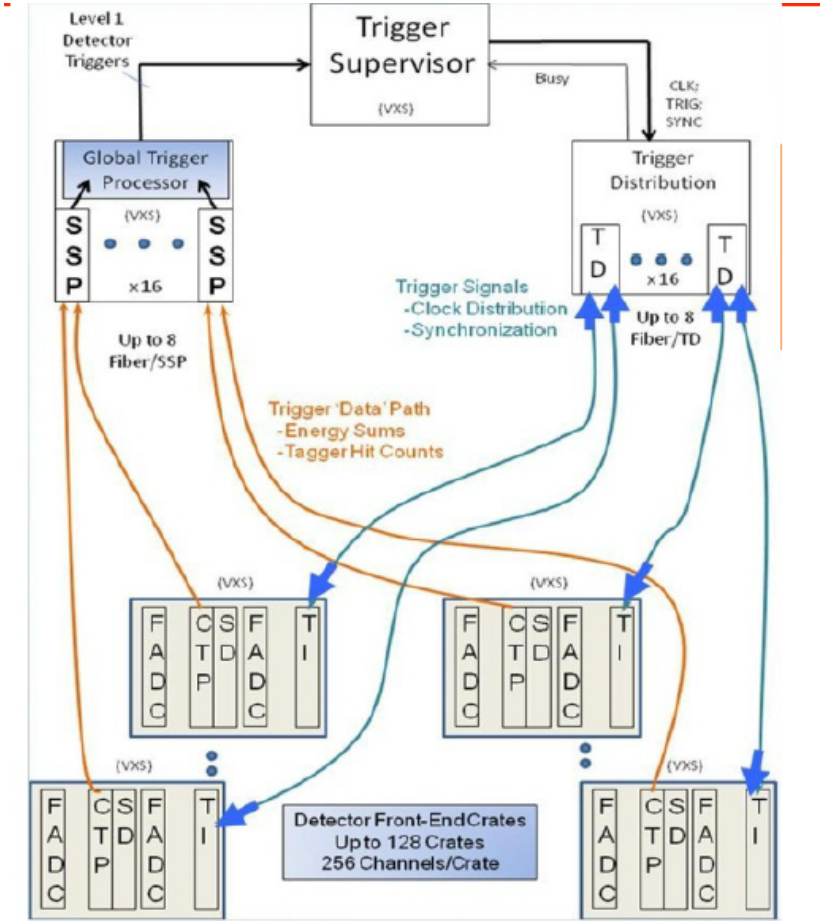



FT-Cal MIP response

- Commissioning With Beam (CWB)
  - In progress:
    - Revision of CWB plan
    - Evaluation of particle rates at 11 and 6 GeV
    - Simulation of detector backgrounds
  - Focus of next months:
    - Documentation and training
    - Accurate testing of calibration software
    - Detailed planning of online/offline shifts

→ R. De Vita

CLAS12 DAQ & Trigger

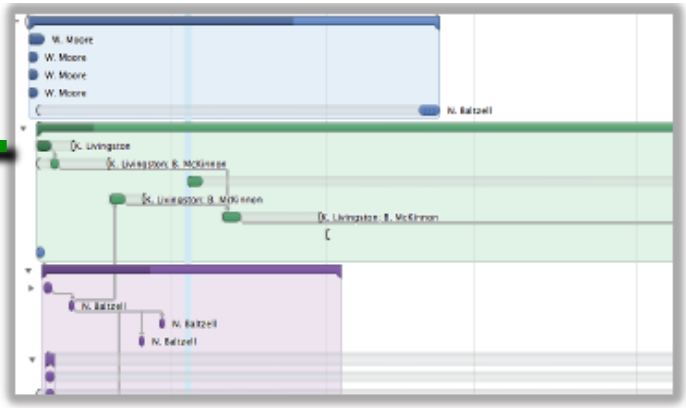


PARAMETER	DESIGN VALUE
Module Format/Bus	VITA 41 - VME64x and VXS (High Speed Serial Extensions)
Number of Readout Crates	50
Number of L1 Crates	30
Serial Interface Technology	2.5 Gbps and 5 Gbps
Serial Interface Transmission	Backplane and Multi-Fiber Optic
VME64x Data Bus Transfer	200 MB/sec
Trigger Distribution Method	High Speed Serial over Fiber Optic
Full L1 System Latency	< 3.7 μs
Trigger Rate Capability	200 kHz
Trigger Resolution	4 ns
Trigger Types	32
Front End Acquisition Clock	250 MHz
Synchronicity (All crates)	4 ns
Bit Error Rate	TBD

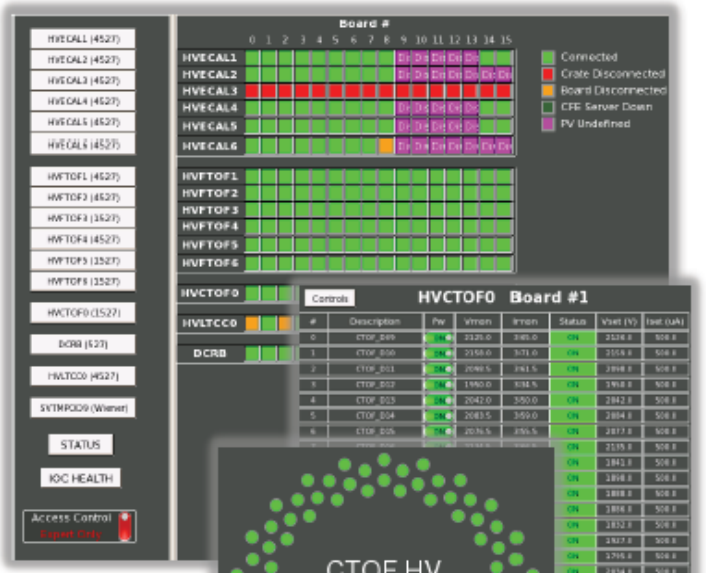
- Forward Carriage DQA crates installed
- CLAS12 Trigger Fiber-Optic cabling installed in FWCR and Pie Tower
- Subway rack installation for DCs completed
- All DC boards received and all boards pass acceptance testing
- 20 VXS crates received

CLAS12 SLOW CONTROLS

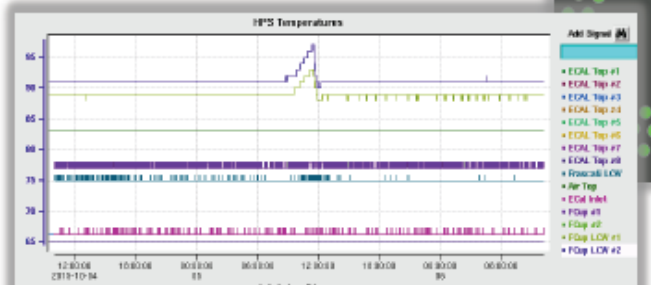
- Organization
  - Main team: N.Baltzell, K.Livingston, B.McKinnon, W.Moore
    - and lots of advice from Hovanes, Sergey, Stepan, etc
  - Wiki page: https://clasweb.jlab.org/wiki/index.php/CLAS12_Slow_Controls
  - Biweekly meetings since July (Fridays @ 9:00 in F228)
  - Progress charts with timeline and FTE
  - Using github for online software, with submodules for epics/coda/...
    - https://github.com/JeffersonLab/clas12-online



- Overview
  - Aiming for more unified & user-friendly system than what CLAS6 had
  - New UI framework: *Control-System Studio*
    - adopted by by numerous labs (e.g. SNS, DESY) and Hall-D
    - dropping CLAS6's old and restrictive *medm/alh*
    - Alarm Handler (*BEAST*) as a server, with clients in *CS-Studio*
    - Provides web access too (read-only without 2-factor already approved)
  - Using JLab's MYA archiver and related supported software (e.g. strip charts)
  - Subsystems: cryo target (Saclay) and Hall-B magnets, cryo, gas (JLab)



- Progress examples
  - Upgraded to modern EPICS release and 64-bit RHEL7
  - Started with clean software tree
    - importing/converting only necessities from CLAS6 (>50% done)
  - High-Voltage EPICS backend and expert GUIs in *CS-Studio*
    - FTOF, PCAL, ECAL, CTOF (already in use by detector experts)
    - DC, LTCC (ready to fully test once detectors installed)



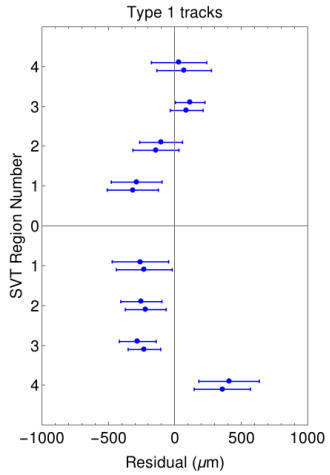
- Plenty still to be done
  - Specialized detector and subsystem screens
    - with help/guidance from subsystem experts
  - This Fall: DC HV/LV constrols test after install
  - Møller polarimeter to new EPICS
  - and more ...

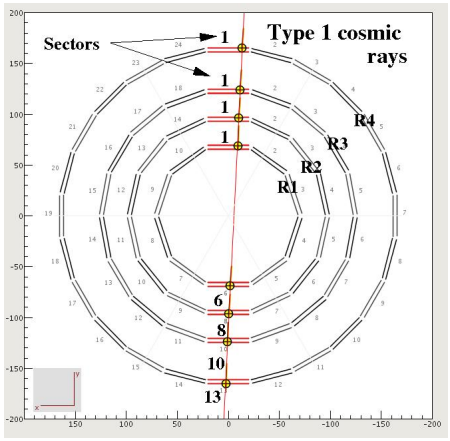
CLAS12 Tracking Status

- **Reconstruction & Simulation**
  - GEMC 2.3 to be released with detector signal model & more realistic digitization
  - Ongoing analysis of SVT cosmic ray data
  - Improved central tracking
  - Alignment studies of SVT with cosmic rays ongoing
  - Reconstruction used for DC calibration
  - HTCC code for e- ID in next release.
  - Development of non-baseline detectors reconstruction ongoing.

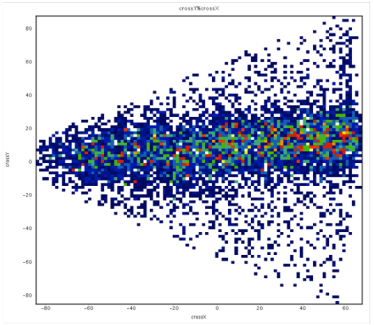
→ **talk by V. Ziegler**

Alignment Study of the SVT

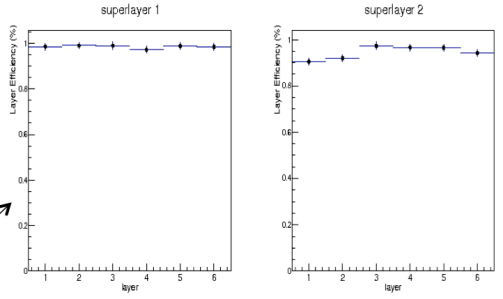




DC12 Cosmic Studies: Efficiency

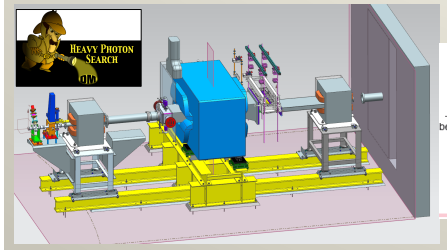


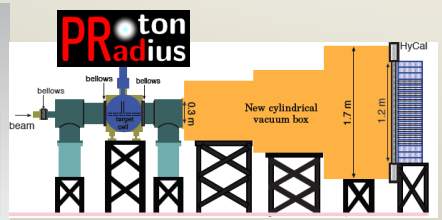
Location of 2-superlayer 'crosses'
→image of scintillator paddle
→reg.1 chamber



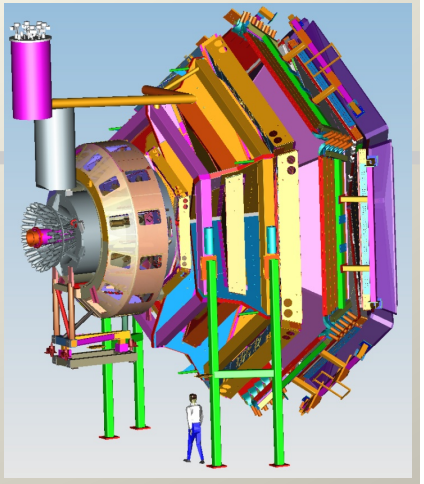
Layer efficiencies at 2250 V

Plans for first years of Beam in Hall B





5 A-rated experiments in early running: HPS, PRad, pDVCS, nDVCS, pSIDIS, g_1^p/g_1^n



Construction & Installation — **Commissioning & early 11 GeV Experiments**

< 6 GeV beam — Installation

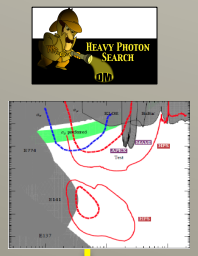
pDVCS & GPDs
pSIDIS &TMDs
neutron F2

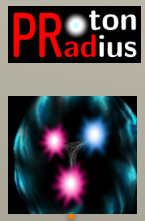
g_1^p, g_1^n - large x
spin structure

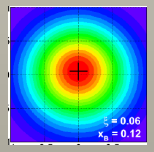
QCD in nuclei

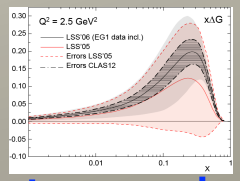
nDVCS & GPDs
nSIDIS & TMDs

11 GeV









CY 2015 | CY 2016 | CY 2017 | CY 2018 | CY 2019

Run Group Schedule – Tentative 6/2015

Run Group	Days	2015	2016	2017	2018	2019	2020	2021	Remain
All Run Groups	**936**		CND MM FT	BONUS RICH	Long. PT		Trans. PT	**525**	**411**
HPS	180*	3	15+						**135**
PRad	15*		15						---
CLAS12 KPP				**15**					
RG-A (proton)	139*			**20 50**					69*
RG-F (BoNuS)	42*				**40**				2
RG-B (deut.)	90*				**45**				45*
RG-C (NH_3)	120				**15**	**45**			60
RG-C-b (ND_3)	65					**35**			30
RG-E (Hadr.)	60					**20**	**15**		25
RG-G (TT)	110*						**55**		55
RG-D (CT)	60						**30**		30
RG-K (LiD)	55							**55**	---

NSAC Long Range Plan 2015

4 recommendations

RECOMMENDATION I

The progress achieved under the guidance of the 2007 Long Range Plan has reinforced U.S. world leadership in nuclear science. The highest priority in this 2015 Plan is to capitalize on the investments made.

- *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.*
- *Expeditiously completing the Facility for Rare Isotope Beams (FRIB) construction is essential. Initiating its scientific program will revolutionize our understanding of nuclei and their role in the cosmos.*
- *The targeted program of fundamental symmetries and neutrino research that opens new doors to physics beyond the Standard Model must be sustained.*
- *The upgraded RHIC facility provides unique capabilities that must be utilized to explore the properties and phases of quark and gluon matter in the high temperatures of the early universe and to explore the spin structure of the proton.*

Concluding Remarks

- CLAS collaboration is generating exciting science as CLAS12 is nearing its completion.
- CLAS12 detectors are complete or in final phase of construction.
- Torus magnet construction in Hall B nearly complete, the Solenoid coils are in production (3 of 5 coils wound).
- CLAS12 event reconstruction software is maturing – testing/ verification ongoing .
- Request for beam time in 2017 for first physics run has been submitted.
- First workshop in preparation for physics run completed
- PAC43 - Any proposals for new beam time must be submitted as run group proposal, i.e. include physics beyond the primary topic.

The CLAS collaboration has contributed in many ways to CLAS12, now is the time to focus our efforts on a successful first physics run in 2017.