

# Status of Hall B

Volker D. Burkert

CLAS Collaboration Meeting  
October 3 - 6, 2017

- Overview
- HPS & PRad update
- CLAS physics highlight
- CLAS12 status
- Preparation for engineering & physics run
- PAC45
- Summary



*CLAS12 Complete*

*The message from  
DOE for CD4B*

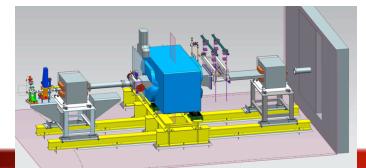
# Hall B Overview

The 12 GeV upgrade project is complete, CD4B granted by DOE

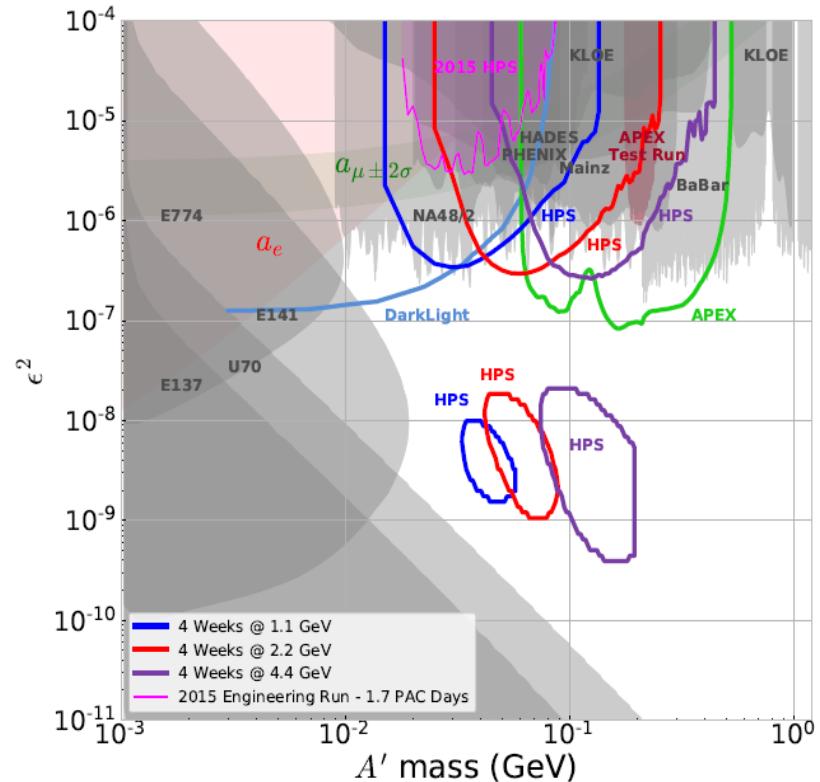
- **CLAS12 upgrades with collaboration driven equipment**
  - Forward Tagger installed, Central Neutron Detector installed, Barrel and Forward MM integrated with SVT, RICH Detector in final assembly stage
- **Continued flow of publications in refereed journals and conference talks**
  - 193 science papers + 39 technical papers published in refereed journals
  - > 2,150 talks at conference (> 1,300 invited)
  - >175 PhD theses completed on CLAS results [30 in progress]
  - 2017 JSA Thesis Price: Priyashree Roy (FSU) - Polarization observables in vectormeson photoproduction with FROST and polarized photons
  - 10 PhD theses in progress on CLAS12
- **Other Hall B experiments**
  - Proton Radius experiment – 2 PhD theses in process
  - Heavy Photon Search – 4 PhD theses completed, 1 in progress, 1<sup>st</sup> publication in preparation
- **CLAS12 engineering & physics runs**
  - Scheduled for December 2017 – March 2018,
- **Ready for Science**
  - Review 9/25-26 – implementation of results in preparation for upcoming run



# Heavy Photon Search

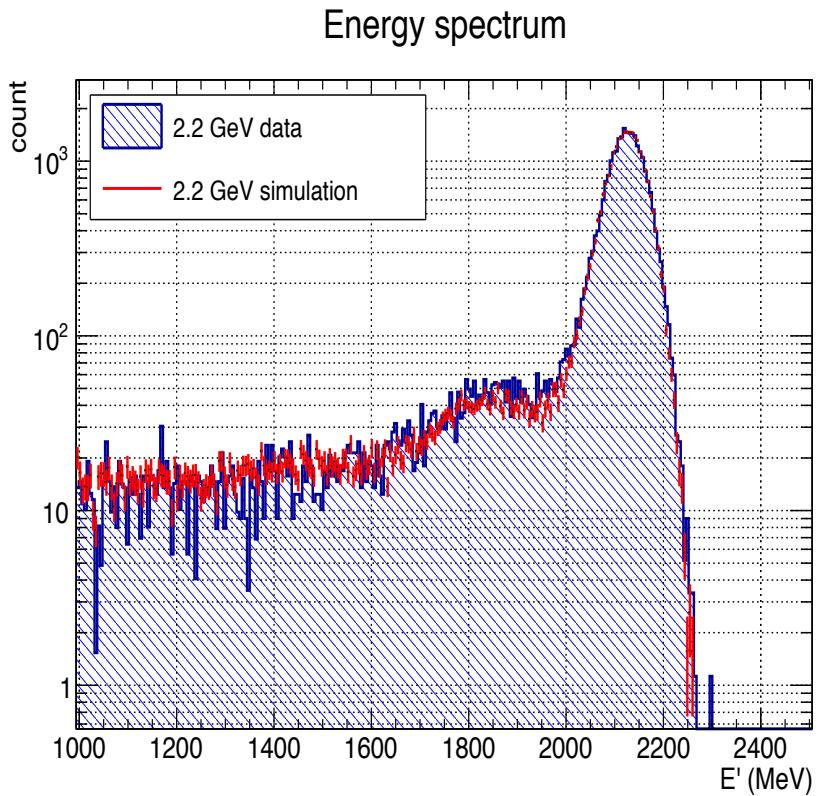


- First Vertexing Results presented in two theses
  - \* Sho Uemura , 10% 2015 (Stanford, 12/16)
  - \* Holly Vance, 100% 2015 (Old Dominion, 9/17)
- Reach roughly a factor of 6 worse than projected, so 2015 running has no sensitivity to A's.
- New SVT Layer closer to target and new positron trigger recover HPS reach.
  - \* Upgrades passed ERR in June
  - \* Construction underway; complete late 2018
- HPS will resume A' search in well-motivated, unexplored parameter space in 2019.



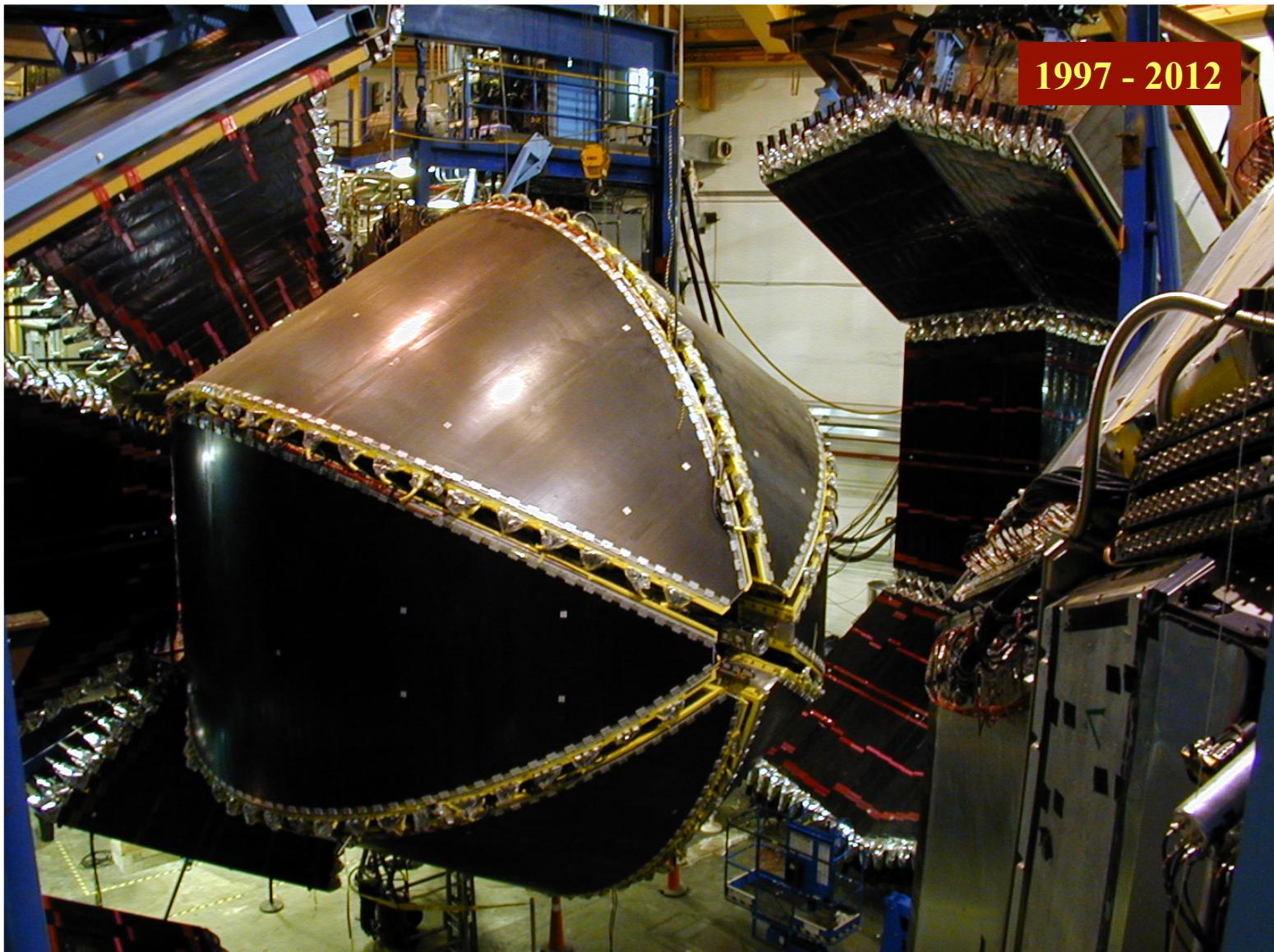
# Proton Radius Experiment

- All 2.2 GeV beam energy data have been analyzed
- A small contribution from the inelastic processes at 2.2 GeV (<2% at highest angles) has been identified:
  - ✓ simulated and subtracted with a sub percent precision from the physics distributions
- Extraction of the  $\text{ep} \rightarrow \text{ep}$  differential cross sections is expected in October, 2017.



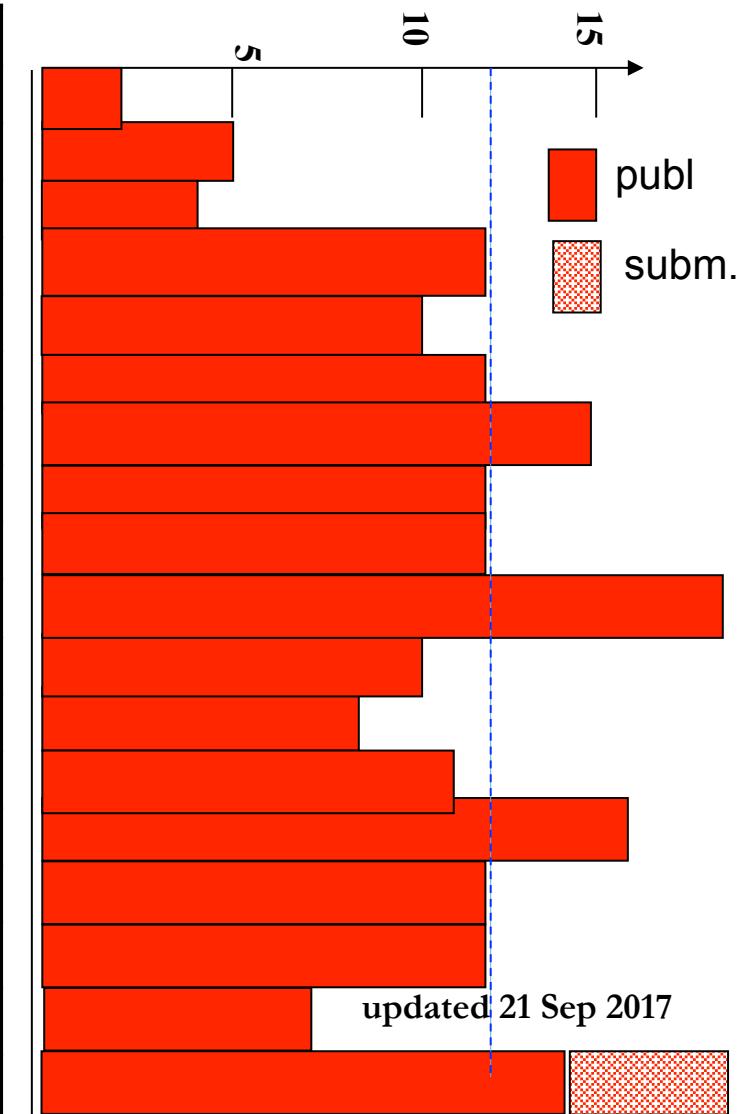
Scattered electron energy distribution from the data (black) and simulation (red) including inelastic processes.

# CEBAF Large Acceptance Spectrometer (CLAS)

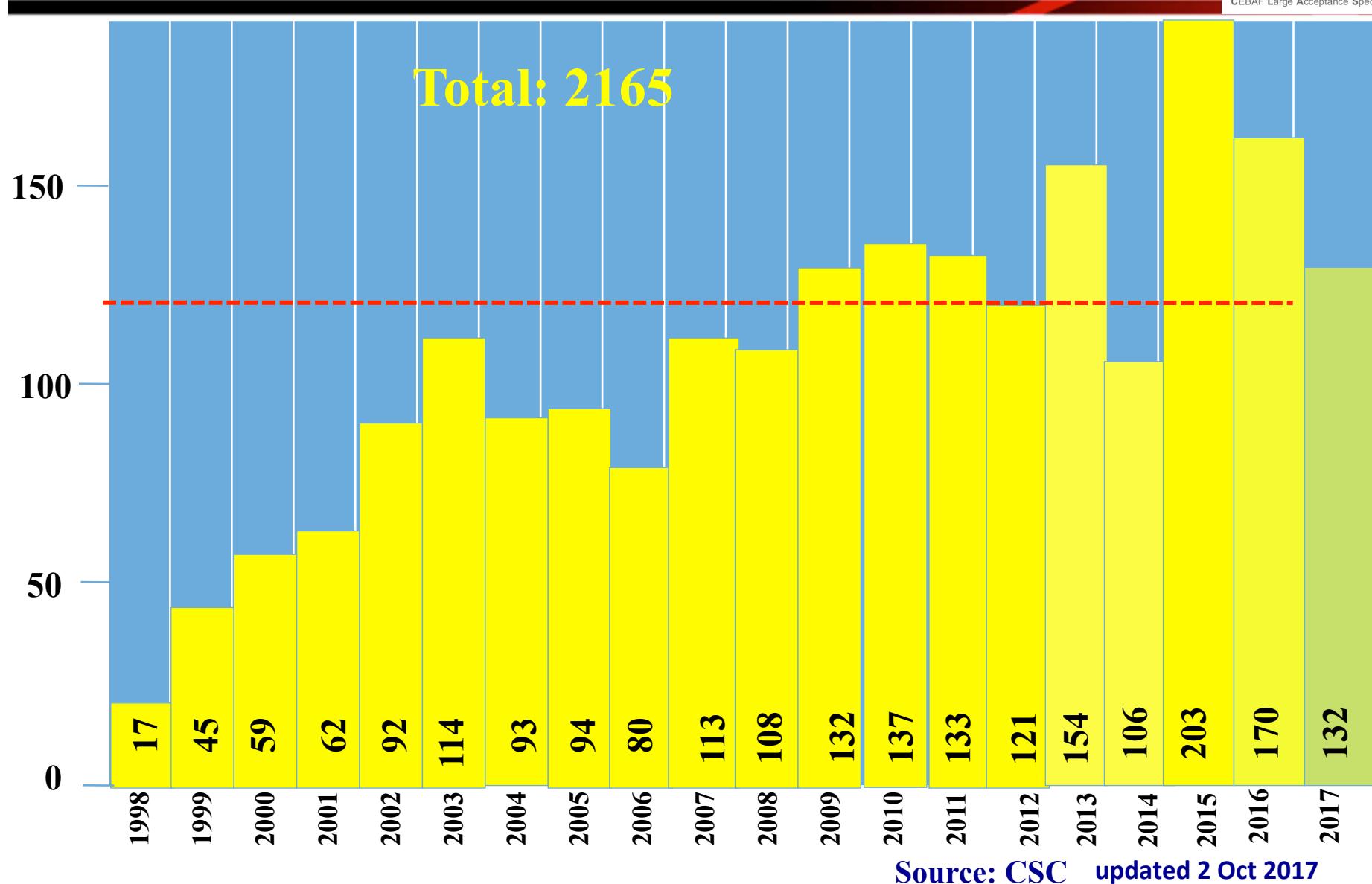


# Hall B Physics Publications in refereed Journals

	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	5	3	12
2016	7	-	-	7
2017	8+1	6+3	+1	14+5
SUM	94+1	62+3	37+1	193+5



# Conference Presentations



Source: CSC updated 2 Oct 2017

# Total Solar Eclipse on August 21, 2017

Columbia, SC, USA, local time : UT - 4



13:20



14:04



14:35



14:42:54



14:42:54



14:52



15:22



16:04

*NSTAR 2017*



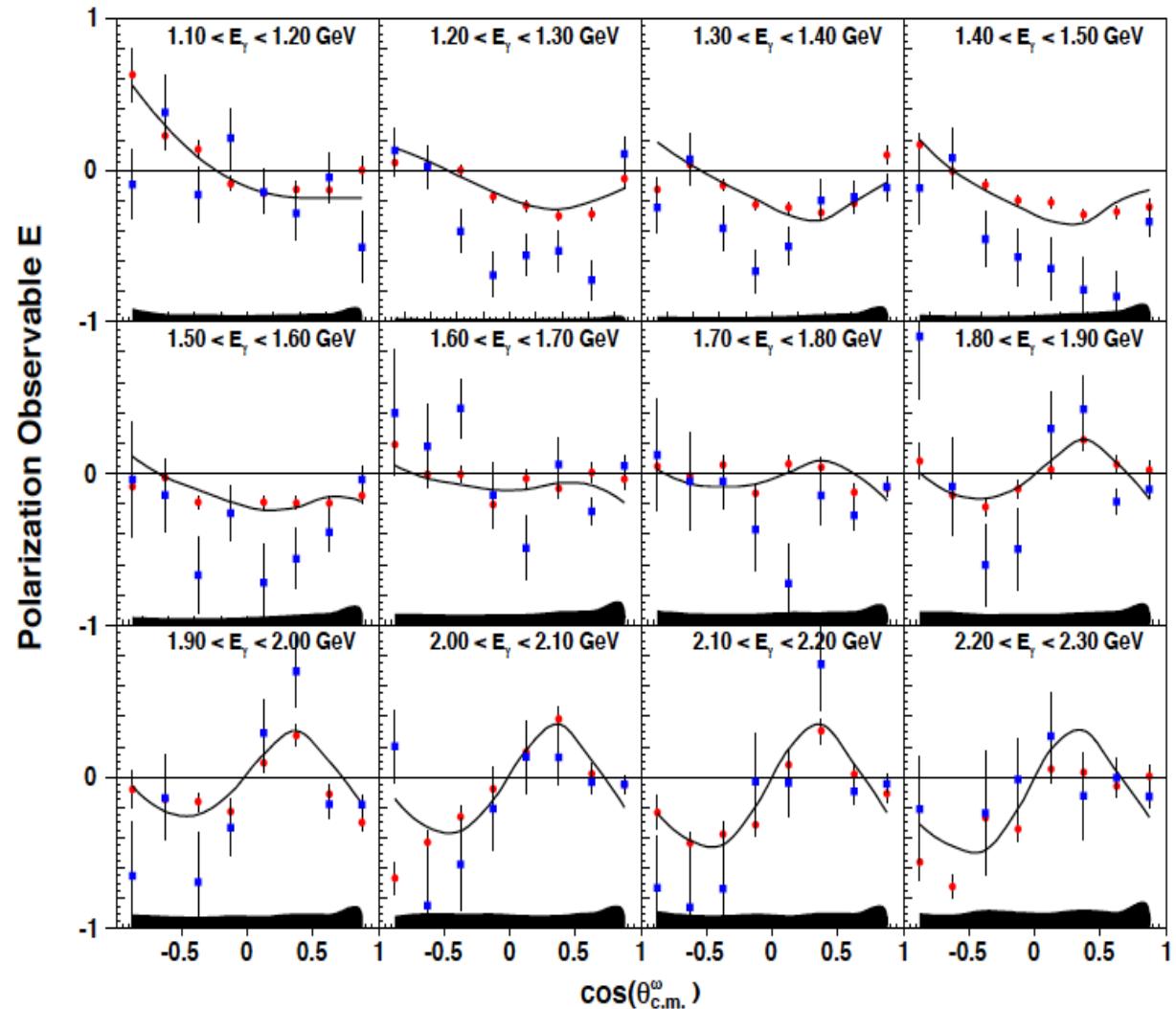
# Polarization asymmetry E in $\gamma p \rightarrow p\omega(\pi^+\pi^-\pi^0)$

Z. Akbar et al., arXiv:1708.02608 (2017)

- CLAS-FROST
- CB-ELSA

In the Bonn-Gatchina multi-channel partial-wave analysis the CLAS data show strong evidence for “missing” **N(2000)5/2<sup>+</sup>**.

State was previously seen in 2009 CLAS paper on p $\omega$  partial wave analysis on SDME.



# 2017 CLAS data in evidence for new N\*'s

Paper	Reference	N*'s
Strong evidence for N*'s near 1900 MeV	A.V. Anisovich et al., PRL 119 (2017), 062004	N(1895)1/2- N((1880)1/2+ N(1900)3/2+
Helicity asymmetry E in $\gamma p \rightarrow p\omega(\pi^+\pi^-\pi^0)$	Z. Akbar et al., arXiv:1708.02608 (2017)	N(2000)5/2+ N(2120)3/2-
Beam-Target Helicity Asymmetry for $\gamma n \rightarrow \pi p$ in the N* Resonance Region	D. Ho et al., Phys.Rev.Lett. 118 (2017) no.24, 24200	N(2040)3/2+
$N^* \rightarrow N\eta'$ decays from photoproduction of $\eta'$ mesons off protons (E)	A.V. Anisovich et al., Phys.Lett. B772 (2017) 247	N(1895)1/2- N(1900)3/2+ N(2100)1/2+ N(2120)3/2-
Photon beam asymmetry $\Sigma$ In the reaction $\gamma p \rightarrow p\omega$	P. Collins et al., Phys.Lett. B773 (2017) 112-120	$J^P=3/2^+$
Differential cross sections and polarization observables from CLAS K* photo-production and the search for new N* states	A.V. Anisovich et al., Phys.Lett. B771 (2017) 142	N(1895)1/2-, N(2100)1/2+
Photon beam asymmetry $\Sigma$ for $\eta$ and $\eta'$ photoproduction from the proton	P. Collins et al., Phys.Lett. B771 (2017) 213-221	N(1895)1/2- N(1900)3/2+ N(2100)1/2+ N(2120)3/2-
Evidence for $\Delta(2200)7/2^-$ from photo-production and consequence for chiral-symmetry restoration at high mass	A.V. Anisovich et al, Phys.Lett. B766 (2017) 357-361	$\Delta(2200)7/2^-$

# Progress in Nucleon Spectroscopy

Star ratings of PDG before 2012 and projections for 2018, most of the data from CLAS experiments.

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\*

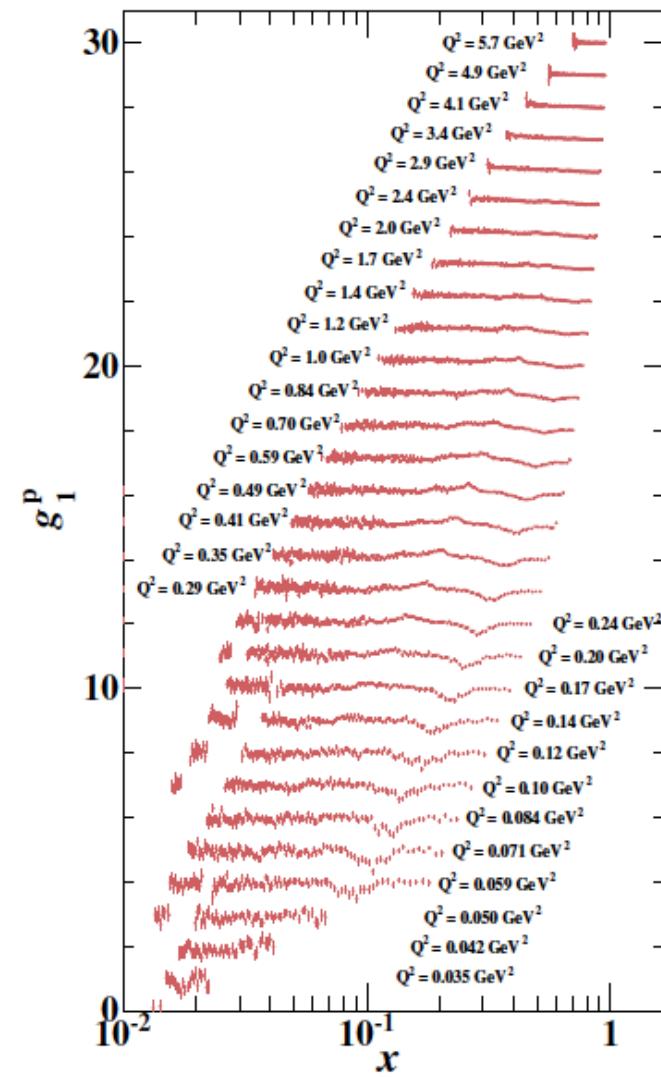
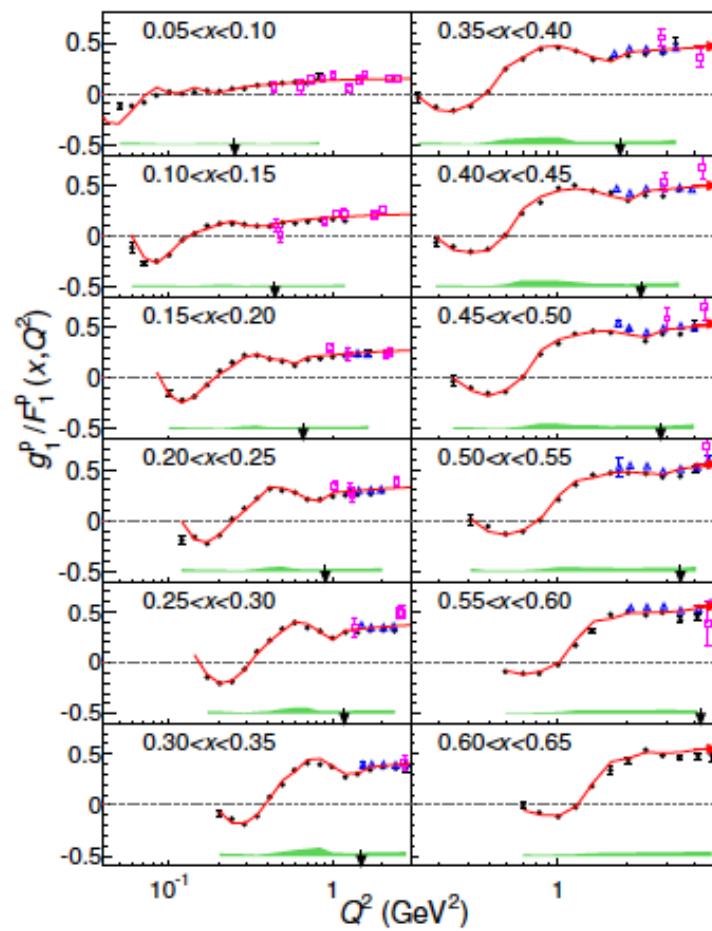
Existence is certain  
Existence is very likely  
Evidence of existence is fair  
Evidence of existence is poor

State $N(\text{mass})J^P$	PDG pre 2012	PDG 2018*
$N(1710)1/2^+$	***	****
$N(1880)1/2^+$		***
$N(1895)1/2^-$		****
$N(1900)3/2^+$	**	****
$N(1875)3/2^-$		***
$N(2120)3/2^-$		**
$N(2000)5/2^+$	*	**
$N(2060)5/2^-$		**
$\Delta(2200)7/2^-$	*	***

\*) projected

# Inclusive beam-target polarization data

EG1: R.G. Fersch et al., arXiv:1706.10289



**Forward Detector (FD)**

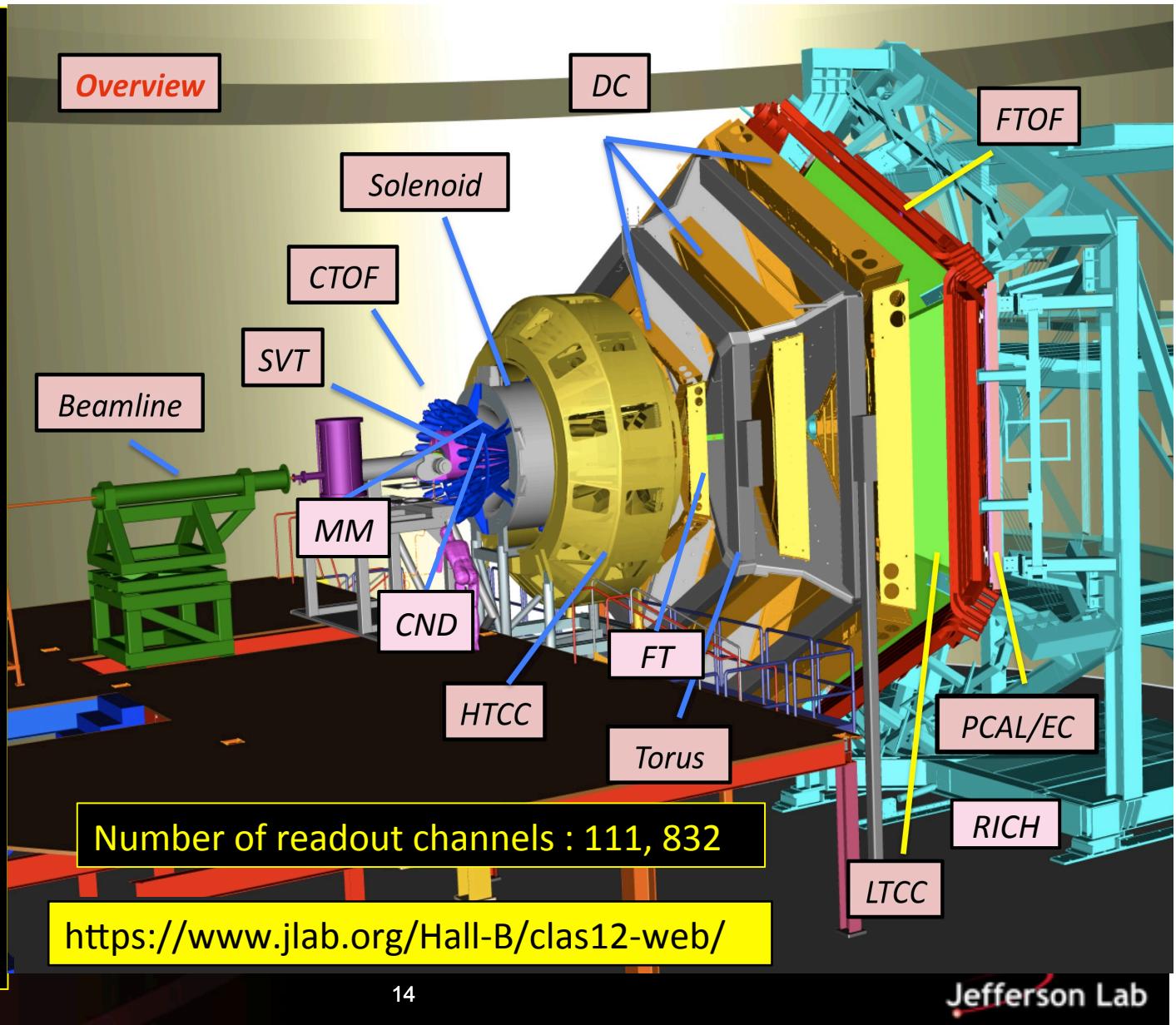
- TORUS magnet
- HT Cherenkov Counter
- Drift chamber system
- LT Cherenkov Counter
- Forward ToF System
- Pre-shower calorimeter
- E.M. calorimeter
- Forward Tagger
- RICH detector

**Central Detector (CD)**

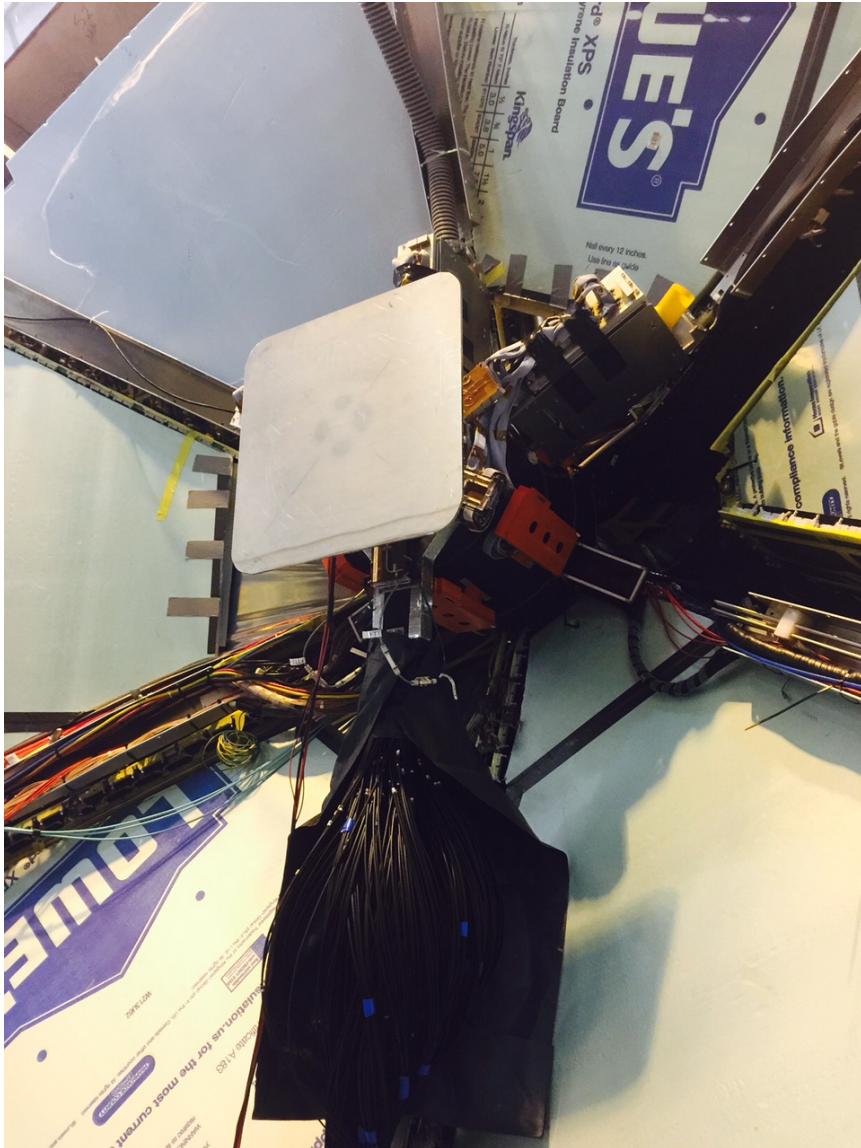
- Solenoid magnet
- Silicon Vertex Tracker
- Central Time-of-Flight
- Central Neutron Detector
- MicroMegas

**Beamline**

- Photon Tagger
- Shielding
- Targets
- Polarimeter
- Farady Cup



# Forward Tagger Installed



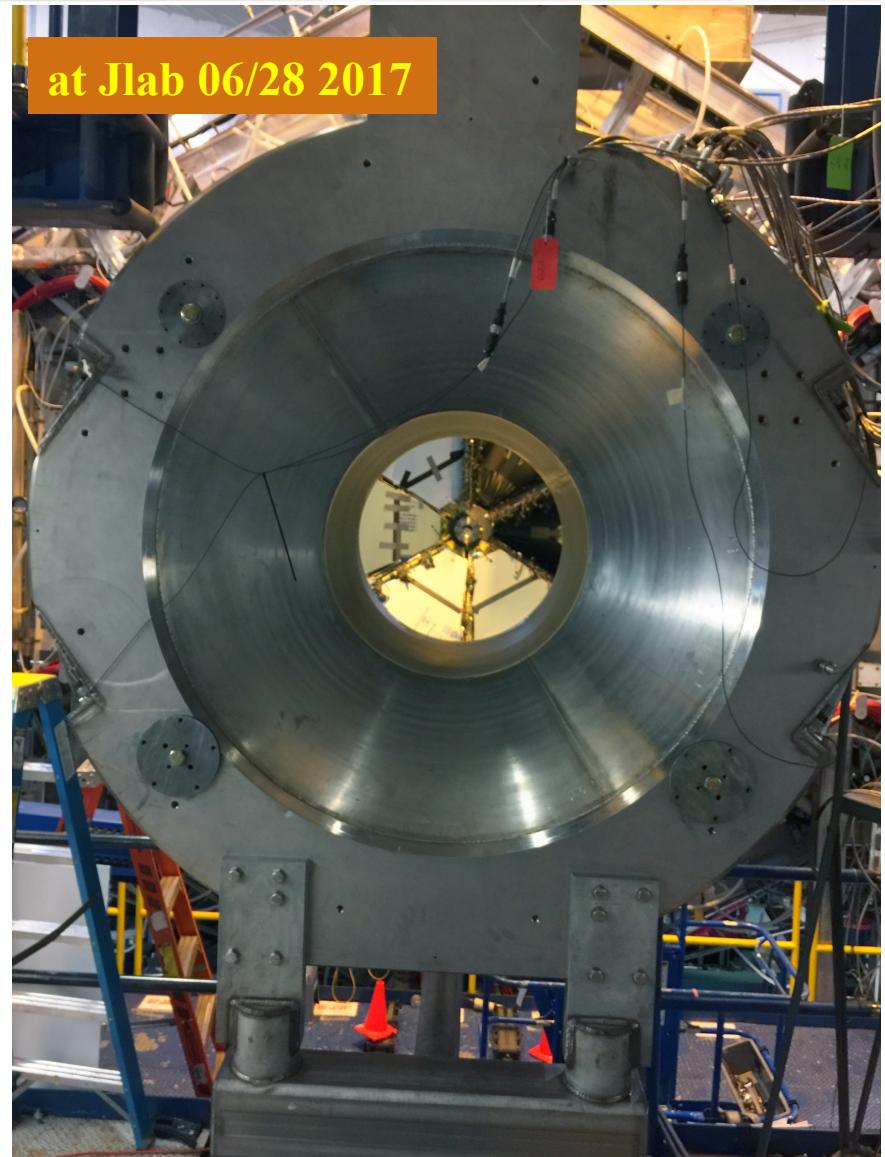


# Solenoid Magnet from ETI to Hall B

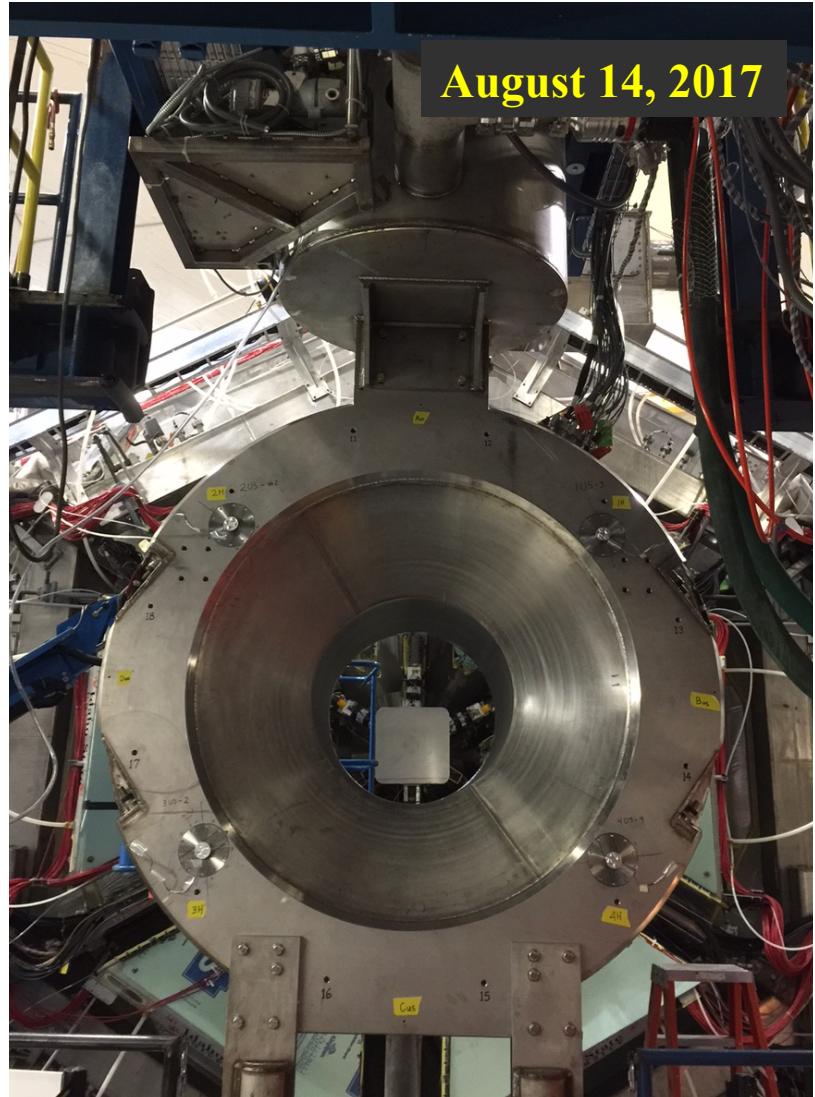
At ETI 06/24 2017



at Jlab 06/28 2017

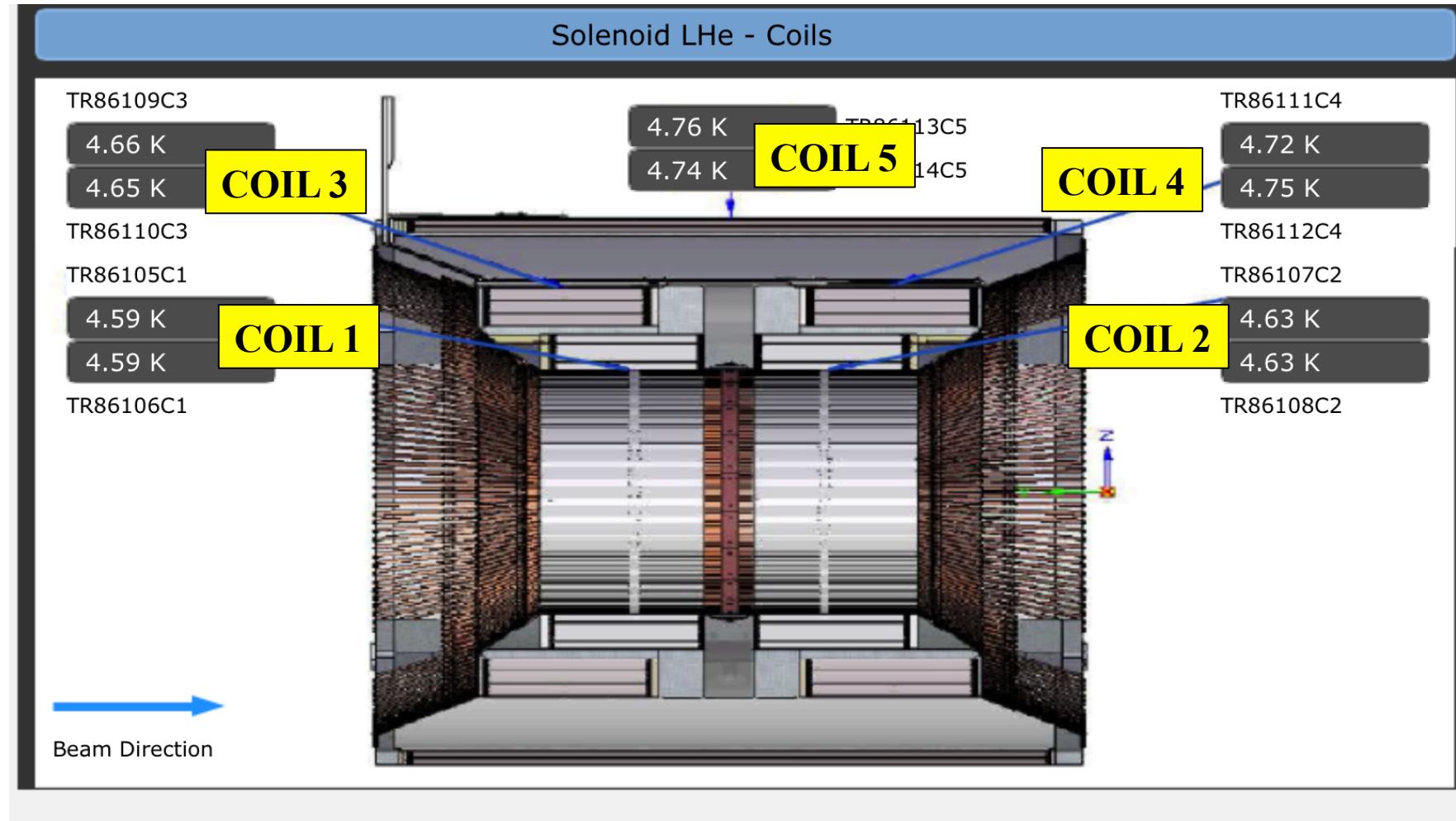


# Solenoid on Service Tower – Start of cooldown



# Solenoid Coils @ 4.6K

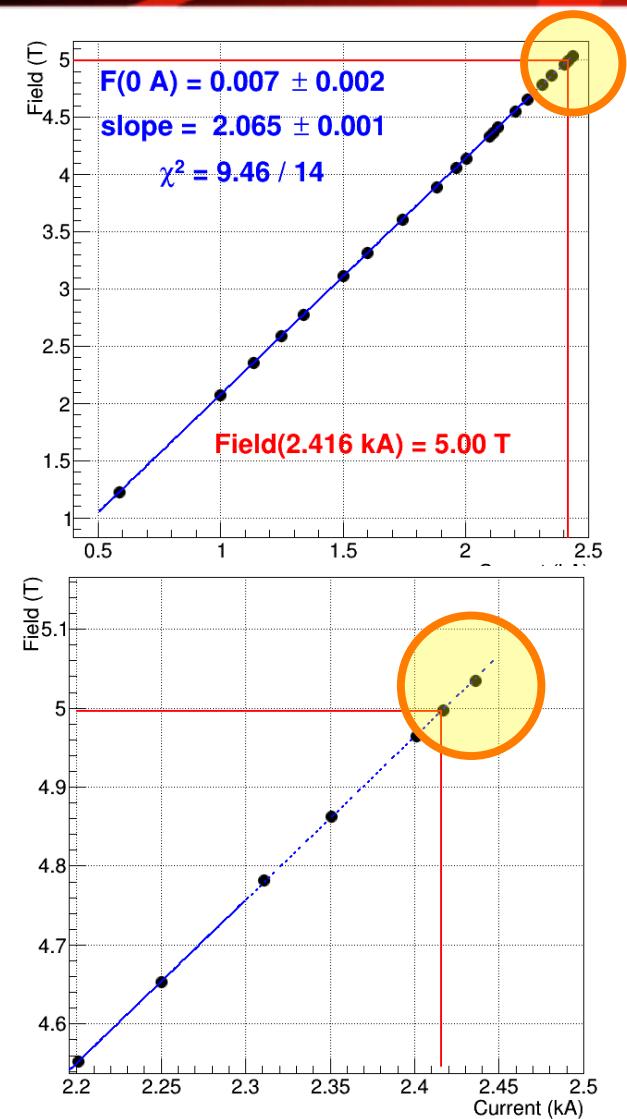
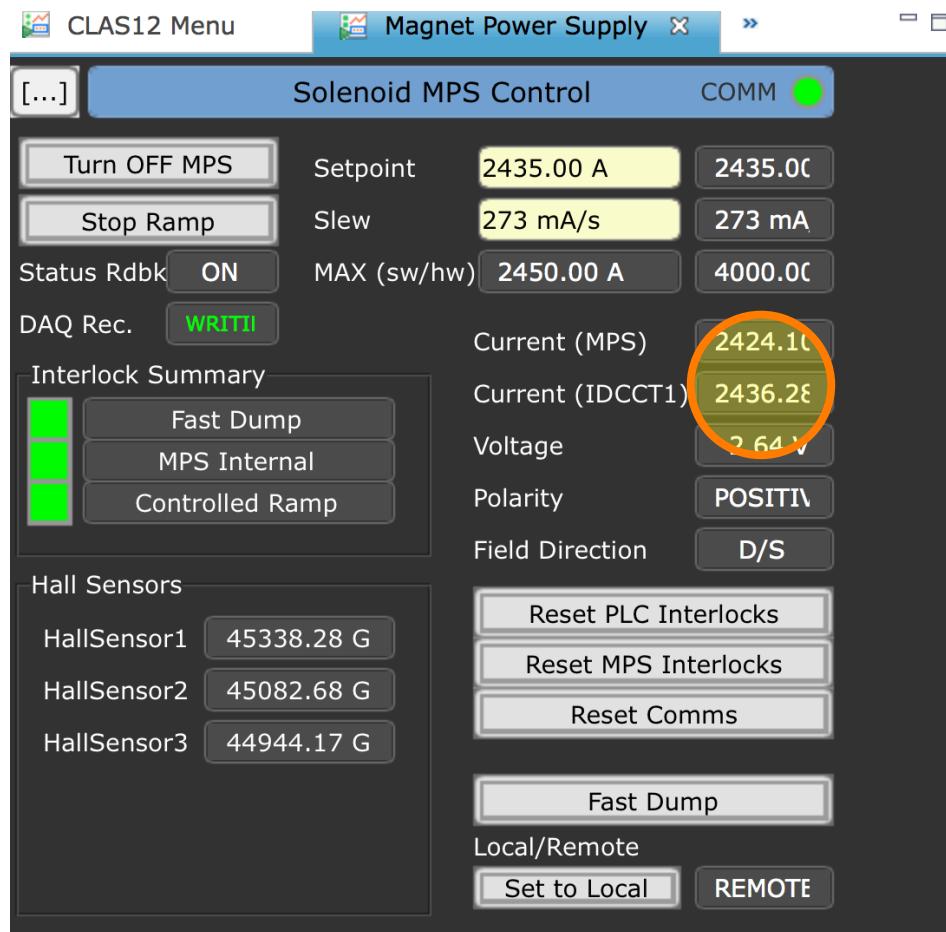
09/07/2017



# Solenoid reaches full current

Design Current:  $2416 \text{ A} \Rightarrow 5 \text{ Tesla central field}$

Monday 9/18/2017, 11:07 hrs

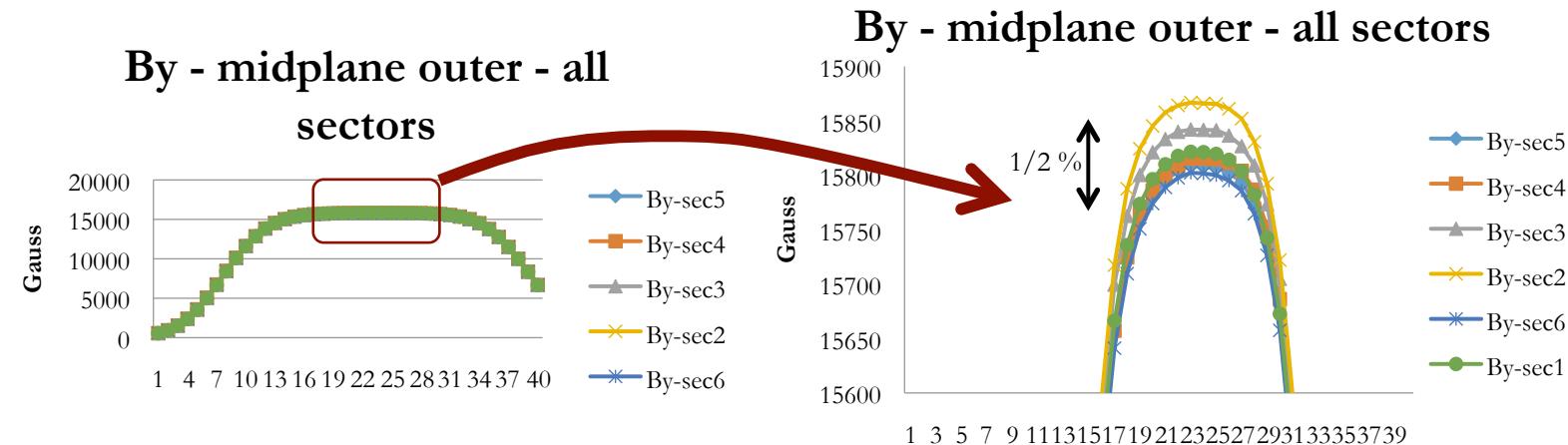




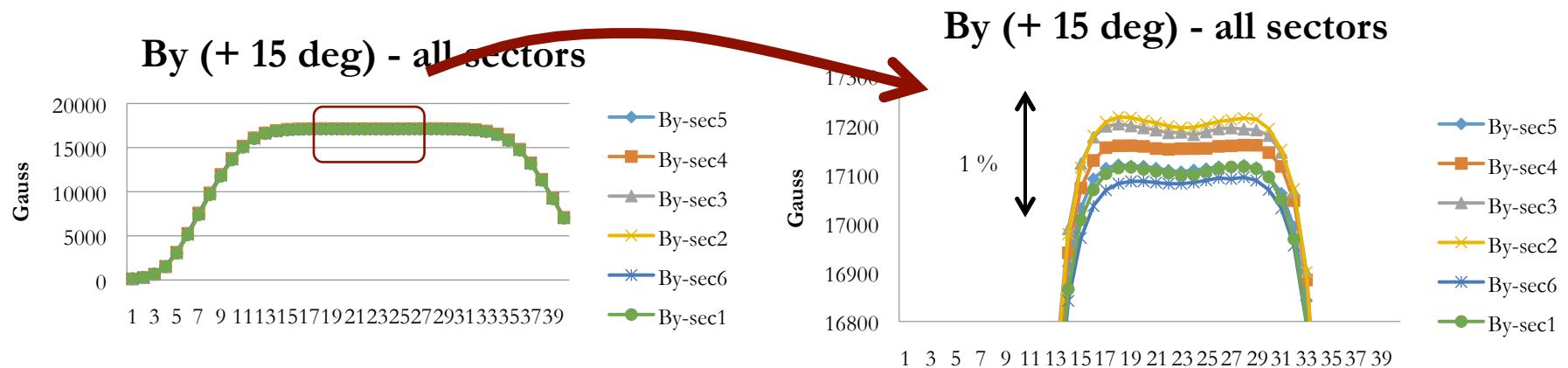
*CLAS12 Complete*

*The message from  
DOE for CD4B*

# Torus Magnetic Field Distribution



→ Midplane B-fields vary by ~1/2% Sector to Sector



→ +/- 15 Deg. B-fields Vary by < 1% Sector to Sector

# Solenoid Magnetic Fringe Field

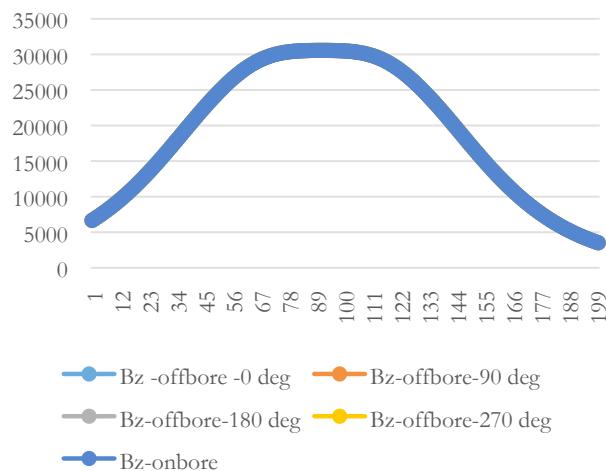
Location	Bx (G)	By (G)	Bz (G)	Bmod (G)	Bmod (G) sum of individual component
HTCC-01	5.00	0.00	-3.33	5.00	6.0
HTCC-02	0.00	0.00	-5.00	5.00	5.0
HTCC-03	3.33	-1.67	13.33	13.33	13.8
HTCC-04	-5.00	0.00	21.66	21.66	22.2

	MEAst	MEASa	MAG	COMPt	COMPa	MAG
CTOF	(G)	(G)	(G)	(G)	(G)	(G)
Dnst far	38	-20	43			
Dnst near	102	395	408			
Upst HI far	245	-220	329	261	227	346
Upst HI near	773	-600	979	776	630	1000
Upst LO far	207	-307	370	245	308	394
Upst LO near	757	-715	1041	702	815	1076

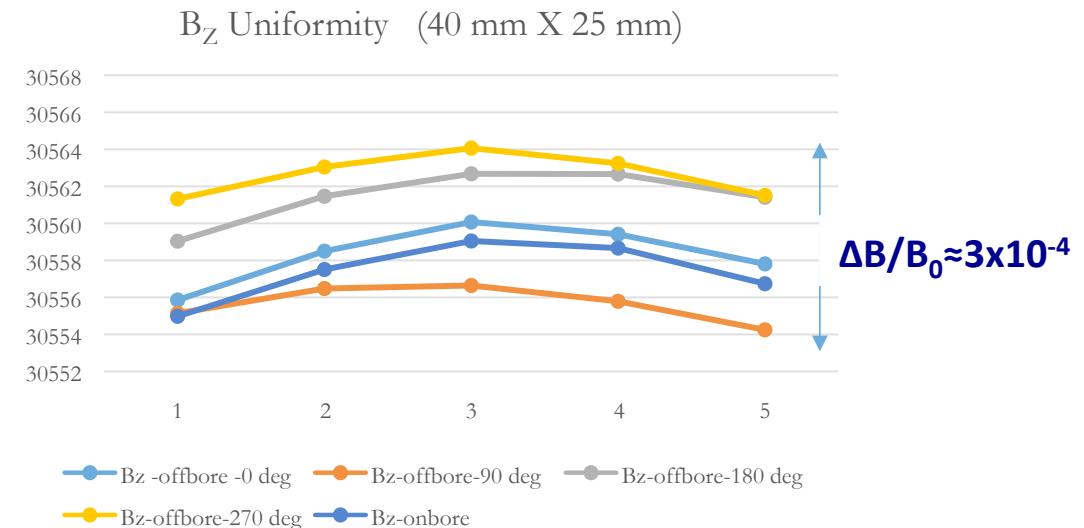
Shield coil #5 works as expected, field values are within specs

# Solenoid Magnetic Main Field

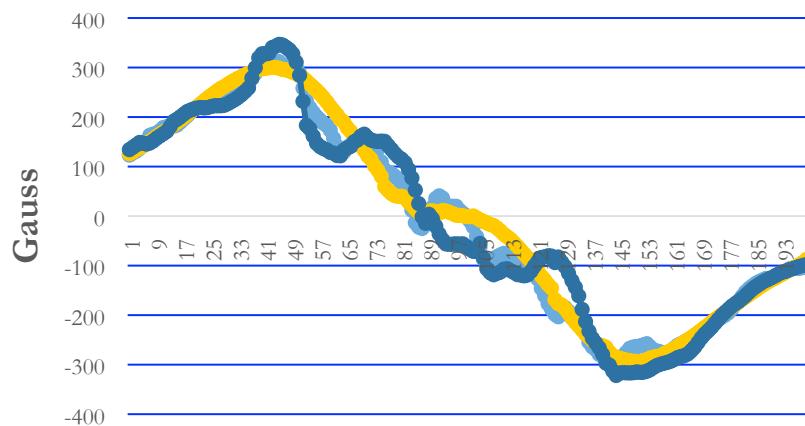
Bz vs. Z



Azimuthal variation off-bore (12.5 mm)



Bradial(corrected) vs. Z - 0, 90, 180 deg



Equality of the off-axis radial components to +/- 30 Gauss  
 → Survey axis agrees with magnetic axis within 2 mm (preliminary).

# Torus Magnet and Solenoid Magnet at full current

Screen Shot 2017-09-27 at 10.28.24 PM

[...]

**Torus MPS Control**      COMM [ ]

Turn OFF MPS	Setpoint	3775.00 A	3775.00
Stop Ramp	Slew	401 mA	
Status Rdbk	ON	MAX (sw/hw)	3800.00 A
DAQ Rec.	WRITING	Current (MPS)	3767.32
Interlock Summary		Current (IDCCT1)	3770.45
<span style="color: green;">[ ]</span> Fast Dump		Voltage	1.38 V
<span style="color: green;">[ ]</span> MPS Internal		Polarity	POSITIV
<span style="color: green;">[ ]</span> Controlled Ramp		Field Direction	CCW
Hall Sensors			
CCM A	20014.36 G	Reset PLC Interlocks	
CCM B	19913.35 G	Reset MPS Interlocks	
CCM C	20109.99 G	Reset Comms	
CCM D	20684.18 G	Fast Dump	
CCM E	19734.42 G	Local/Remote	
CCM F	20705.79 G	Set to Local	REMOTE

We have a complete magnetic spectrometer !

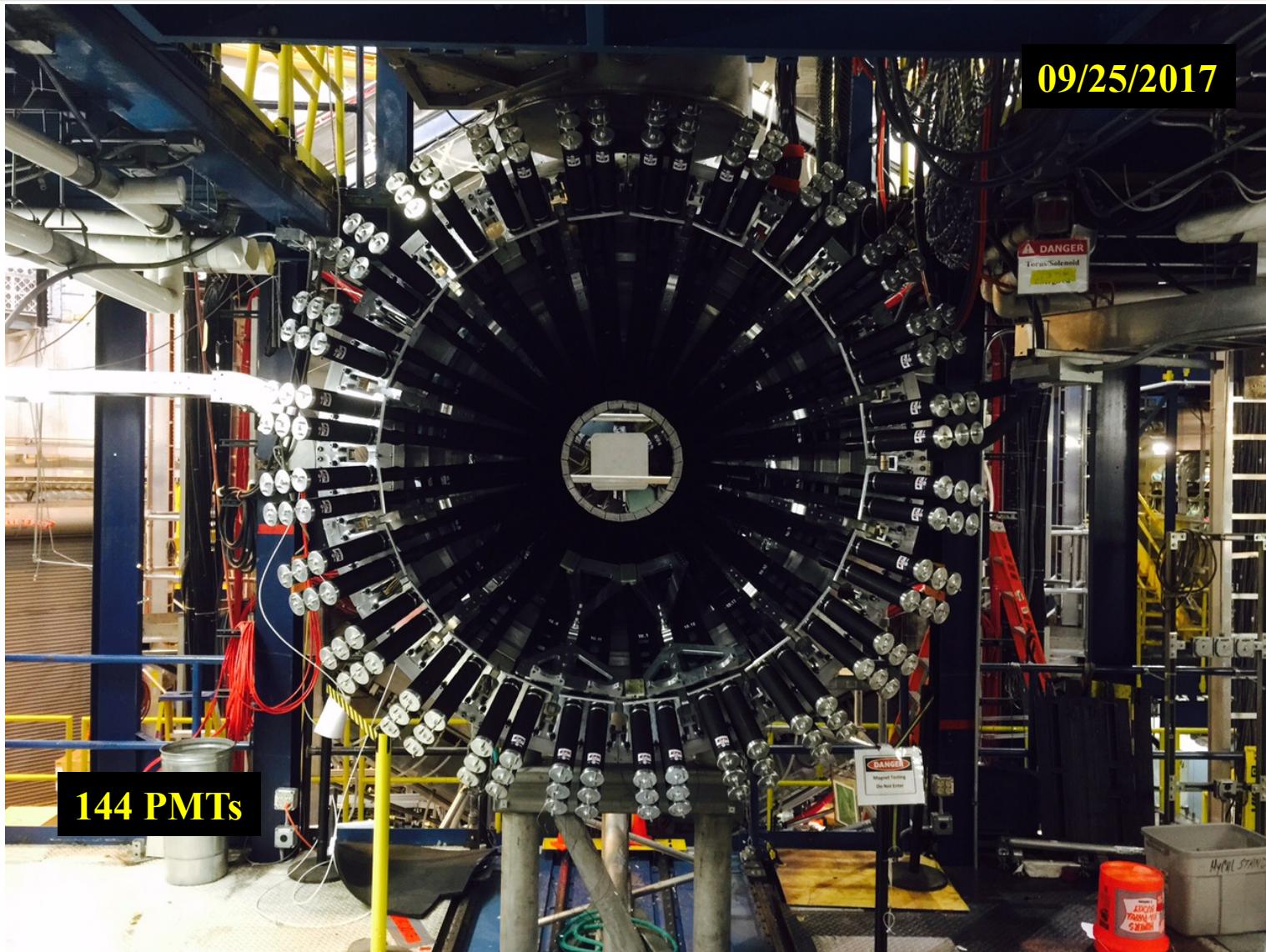
[...]

**Solenoid MPS Control**      COMM [ ]

Turn OFF MPS	Setpoint	2416.00 A	
Stop Ramp	Slew	324 mA	
DAQ Record	WRITING	MAX (sw)	
Interlock Summary		Current (MPS)	
<span style="color: green;">[ ]</span> Fast Dump		Current (IDCCT1)	
<span style="color: green;">[ ]</span> MPS Internal		Voltage	
<span style="color: green;">[ ]</span> Controlled Ramp		Polarity	
Hall Sensors (DS bore edge)			
HallSensor1	44999.01 G	Reset PLC Interlocks	
HallSensor2	44736.38 G	Reset MPS Interlocks	
HallSensor3	44601.20 G	Reset Comms	
Central Field (calc)	5.09 T	Fast Dump...	
Local/Remote		Set to Local	REMOTE

Both Torus magnet field polarities + and - were tested

# CND installed in Solenoid



# CLAS12



HALL B

## Mechanical structure

- Mechanical structure ready
- Installation tools in preparation

## Aerogel

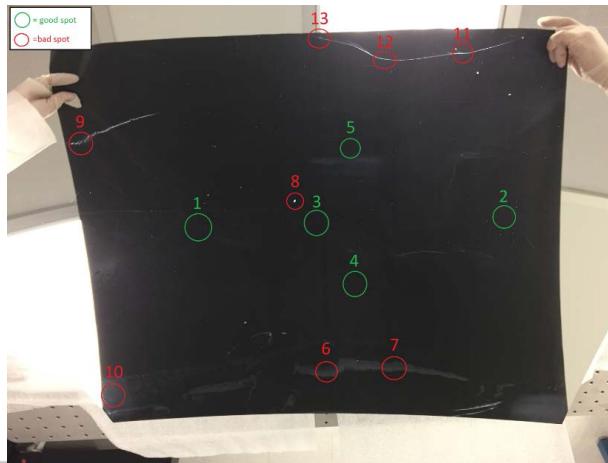
- Baseline production done
- Working on additional spares

## Mirrors

- Spherical reveal defects after coating
- Resurface done, coating ongoing
- Lateral mirrors at JLab
- Front mirrors being delivered

## PMT + Electronics

- Being assembled



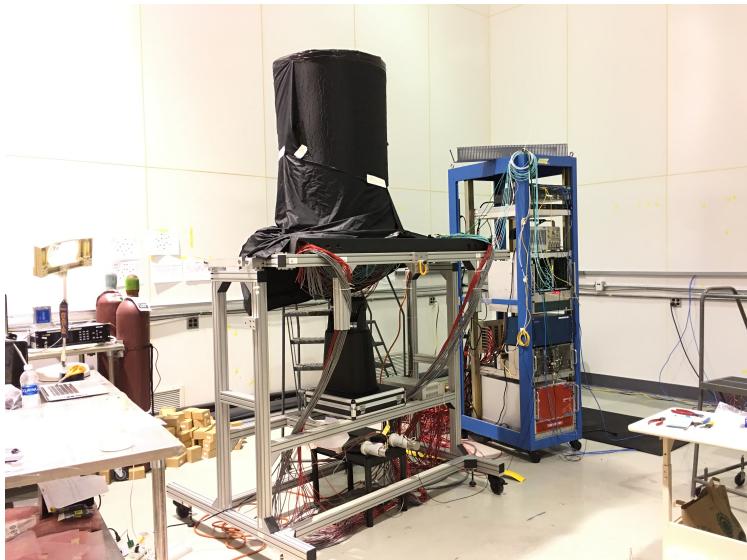
RICH assembly on track for installation mid November



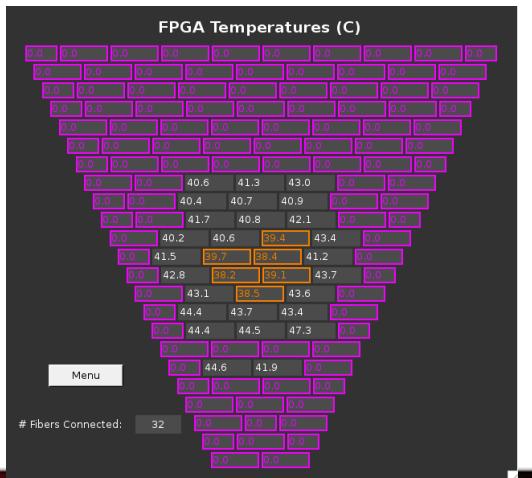
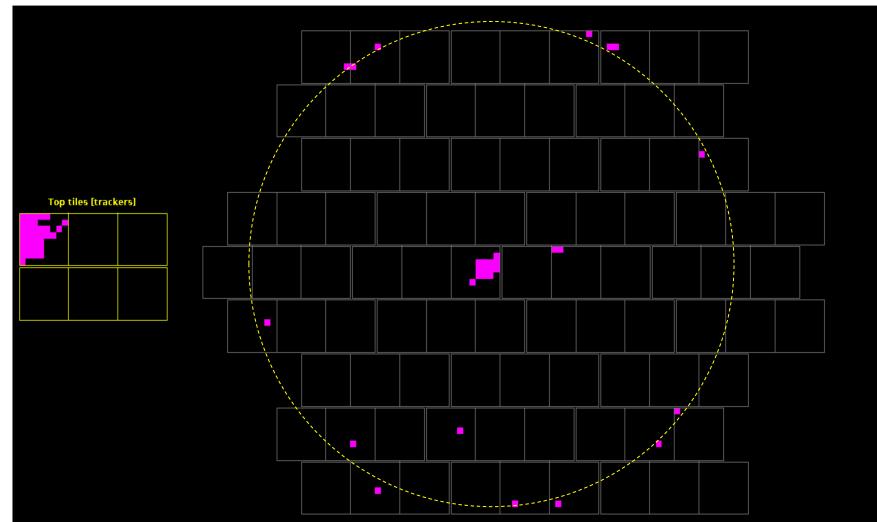
# **CLAS12**



# HALL B



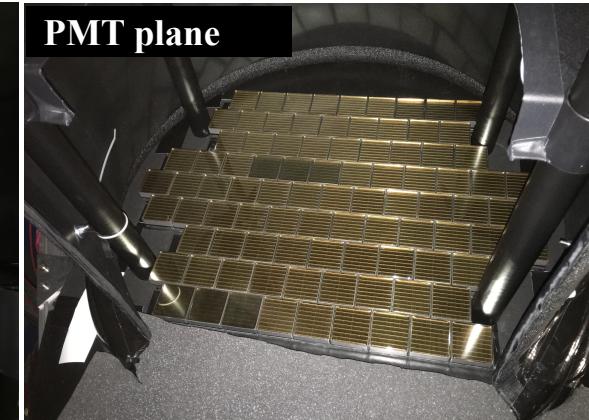
## First stage cosmic run successfully completed



## Trigger and tracking station



## PMT plane



# Readiness for Science Review

In preparation for the upcoming engineering run and the following CLAS12 1<sup>st</sup> Experiment a review of the preparedness of the Hall B/ CLAS team was performed.

Review Committee: K. Giffioen, B. Hess, K. Joo, D. Lawrence, Elton Smith (co-chair), S. Stepanyan (co-chair), B. Zihlmann.

Eight individual charge items covering aspects of commissioning plan, production triggers, monitoring & software tools, on/offline shift staffing, computing resources, documentation, simulations?

⇒ The Recommendation of the committee are now are being addressed.

=> Latifa to say more this afternoon.

# Basic Installation and Experiment Schedule

Date	Activity
10/04/2017	CTOF Installation start
10/26/2017	CTOF Installation complete
11/10/2017	Readiness for Engineering run
11/15/2017	Close Forward Carriage
11/17/2017	Cosmic Ray Run with all detectors and magnets
12/04/2017	Engineering run I starts (10.6 GeV)
12/17/2017	Engineering run I ends
01/12/2018	Engineering run II starts (10.6 / 6.4/4.3/2.1 GeV)
01/28/2018	Engineering run II ends
02/05/2018	Physics Run begins (10.6 GeV)
03/23/2018	Physics Run ends (46 days)

# PAC45 – Hall B approved experiments

<u>Proposals</u>		<u>Contact</u>	<u>Days</u>
<b>New RG Proposal RG-L</b>			
E12-17-012	Partonic Structure of Light Nuclei	Meziani	35
E12-17-012A	Tagged EMC measurements on Light Nuclei	Dupre	45
E12-17-012B	Spectator-Tagged DVCS on Light Nuclei	Armstrong	45
E12-17-012C	Other Physics Opportunities w/ ALERT	Hafidi	55
Total Beam Time Requested			55

## RG Experiment RG-A

E12-12-001A Near threshold J/ψ production – LHCb pentaquark Stepanyan

New beam time for Hall B Proposals: **55**

## Total number of Hall B approved experiments

Experiment Count	Experiment Days	Run Groups	RG days	Compression
42	3243	12	1091	0.34

# Conclusion/Outlook

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**The CD4B approval by DOE was a huge accomplishment**

**Now we need to channel the energy to launch a successful 12 GeV science program**

**The effort of the entire CLAS collaboration is needed!**



# Run Groups

HALL B

Proposal	Physics	Contact	Rating	Days	Group	Equipment	Energy	Run Group	Target
E12-06-108	Hard exclusive electro-production of $\pi^0, \eta$	Stoler	B	80	139	RICH (1 sector) Forward tagger	11	A F. Sabatié	liquid H <sub>2</sub>
E12-06-108A	Exclusive N*→KY Studies with CLAS12	Carman		(60)					
E12-06-108B	Transition Form Factor of the $\eta'$ Meson with CLAS12	Kunkel		(80)					
E12-06-112	Proton's quark dynamics in SIDIS pion production	Avakian	A	60					
E12-06-112A	SIDIS Λ production in target fragmentation region	Mirazita		(60)					
E12-06-112B	Colinear nucleon structure at twist-3	Pisano		(60)					
E12-06-119(a)	Deeply Virtual Compton Scattering	Sabatie	A	80					
E12-09-003	Excitation of nucleon resonances at high Q <sup>2</sup>	Gothe	B+	40					
E12-11-005	Hadron spectroscopy with forward tagger	Battaglieri	A-	119					
E12-11-005A	Photoproduction of the very strangest baryon	Guo		(120)					
E12-12-001	Timelike Compton Scatt. & J/ψ production in e+e-	Nadel-Turonski	A-	120					
E12-12-001A	J/ψ Photoproduction & study of LHCb pentaquarks	Stepanyan		(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 <sub>2</sub> 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		(60)					
E12-09-008B	Colinear nucleon structure at twist-3	Pisano		(60)					
E12-11-003	DVCS on neutron target	Nicolai	A	90					
E12-11-003A	In medium structure functions, SRC, and the EMC effect	Hen		(90)					
<b>Beam time partial sum</b>				<b>765 (1475)</b>	<b>229</b>				

# Run Groups

HALL B

E12-06-109	Longitudinal Spin Structure of the Nucleon	Kuhn	A	80	185	Polarized target RICH (1 sector) Forward tagger	11	C	NH <sub>3</sub> ND <sub>3</sub>
E12-06-109A	DVCS on the neutron with polarized deuterium target	Niccolai		(60)					
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	Buelzman	A	42	42	Radial TPC	11	F	Gas D <sub>2</sub>
E12-14-001	EMC effect in spin structure functions	Brooks	B+	55	55	Pol. LiH target	11	G	LiH
<b>TOTAL CLAS12 run time (approved experiments)</b>				<b>1466 (2118)</b>	<b>631</b>				

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	H	HD
C12-12-009	Transversity w/ di-hadron on transvere target	Avakian	A	110					
C12-12-010	DVCS with transverse polarized target in CLAS12	Elouadrhriri	A	110					
<b>All CLAS12 transverse target proposals</b>				330	110				
E12-11-006	Heavy Photon Search at Jefferson Lab (HPS)	Jaros	A	180	180	Setup in alcove	2.2, 6.6	I	Nuclear
E12-11-106	High Precision Measurement of the Proton Charge Radius	Gasparian	A	15	15	Primex	1.1, 2.2	J	H2 gas
<b>Beam time request from CLAS12 C1 experiments + non-CLAS12 experiments</b>				525	305				
<b>Beam time from approved CLAS12 experiments (from previous table)</b>				<b>1466 (2118)</b>	<b>631</b>				
<b>Beam time for Hall B experiments table 1 + table 2 (incl. 110 days of C1 approved exp.)</b>				<b>1991 (2643)</b>	<b>936</b>				

# Run Groups

HALL B

Proposal	Physics	Contact	Rating	Days	Group	Equipment	Energy	Group	Target
E12-16-010	A search for Hybrid Baryons in Hall B with CLAS12	D'Angelo	A-	100	100	Forward Tagger	6.6, 8.8	K Confinement & Strong QCD	IH2
E12-16-010A	Nucleon Resonances in exc. KY electroproduction	Carman	A-	(100)					
E12-16-010B	DVCS with CLAS12 at 6.6 and 8.8 GeV	Elouadrhiri	A-	(100)					
<b>Total Beam time of Run Group K</b>					<b>100 (300)</b>	<b>100</b>			
E12-17-012	Partonic Structure of Light Nuclei	Meziani	A-	(35)	55	ALERT detector	2.2, 11	L	$D_2, {}^4He$
E12-17-012A	Tagged EMC measurements on Light Nuclei	Dupre	A-	(45)					
E12-17-012B	Spectator-Tagged DVCS on Light Nuclei	Armstrong	A-	(45)					
E12-17-012C	Other Physics Opportunities w/ ALERT	Hafidi	A-	55					
<b>Total Beam time Run Group L</b>					<b>55 (180)</b>	<b>55</b>			
<b>Beam time of approved &amp; C1 approved CLAS12 experiments from table 1 + table 2</b>					<b>1991 (2763)</b>	<b>936</b>			
<b>Beam time for Hall B experiments table 1 + table 2 + table 3</b>					<b>2146 (3243)</b>	<b>1091</b>			

Proposal Count	Experiment Days	Run Groups	RG days	Compression
42	3243	12	1091	0.34

# Conclusions

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