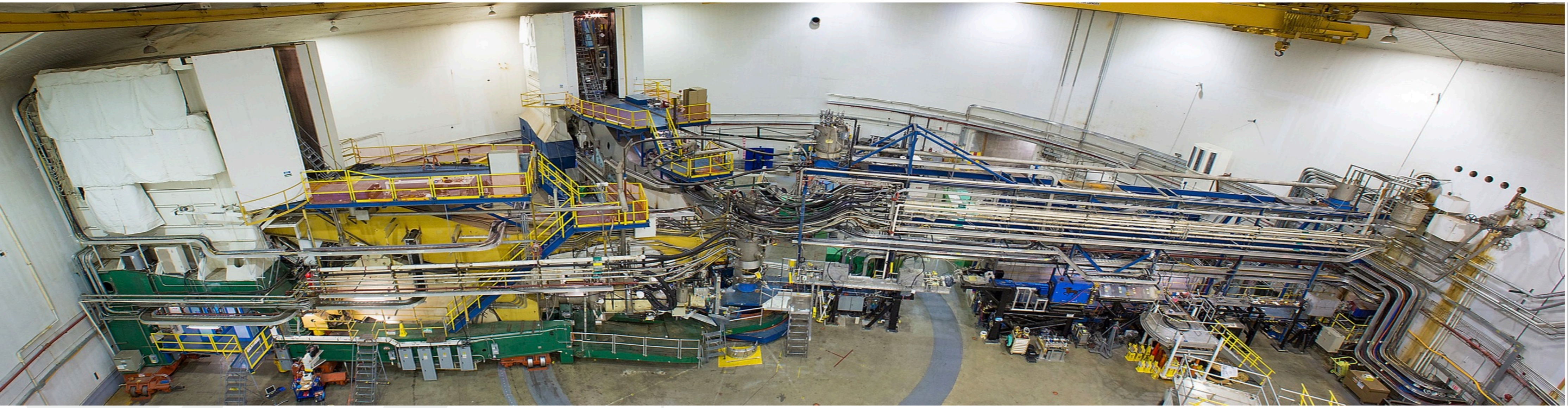
Hall A Status

Program Advisory Committee 48 Update
August 10-15, 2020



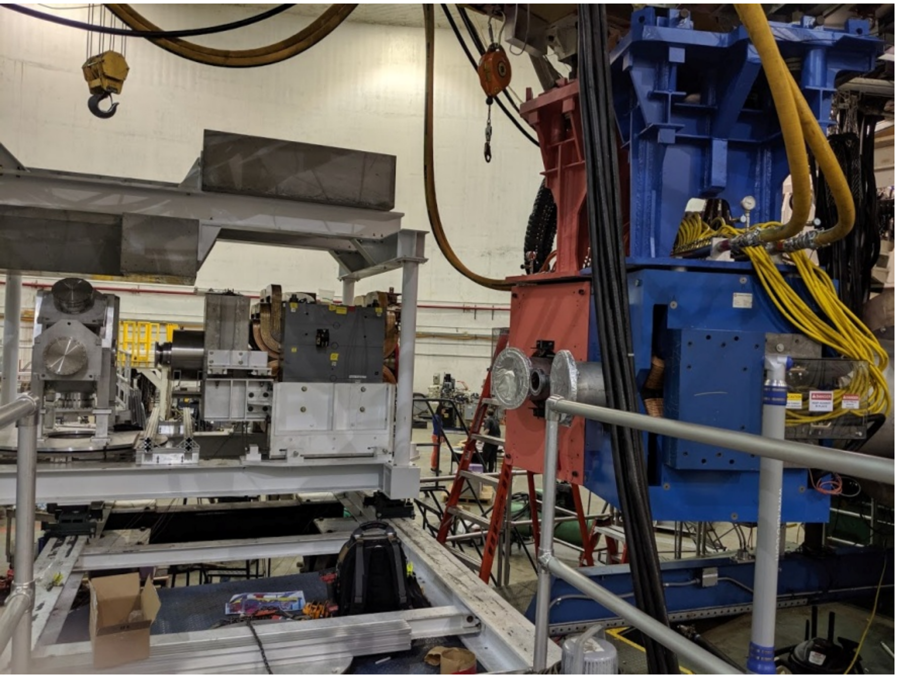
Thia Keppel

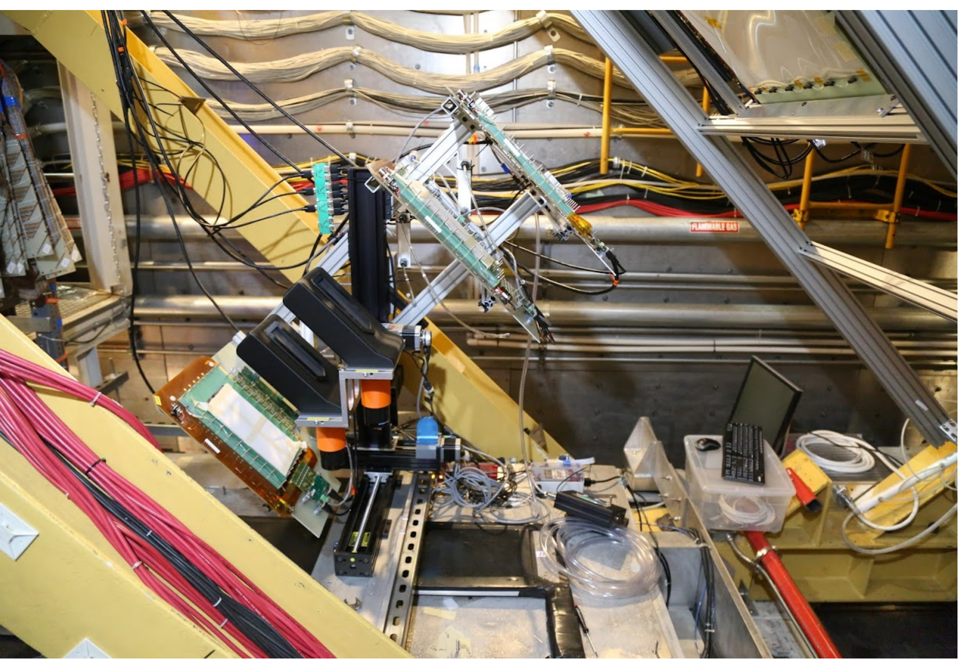
CREX

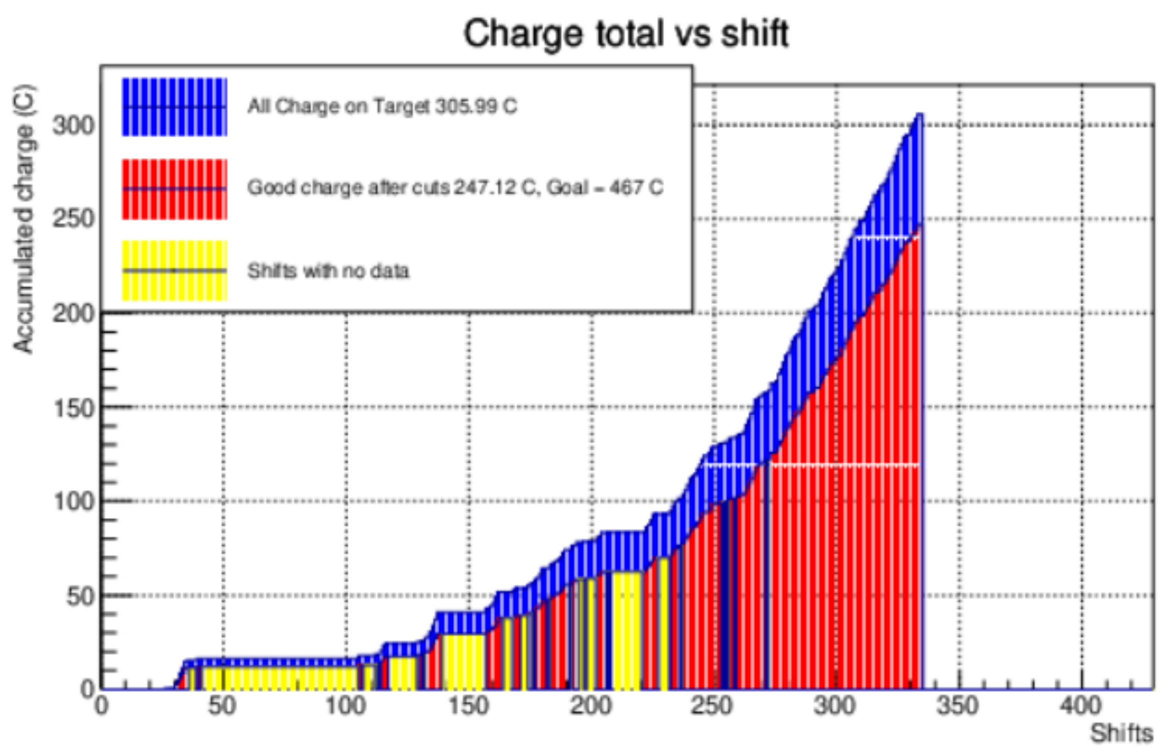
Electroweak asymmetry on ^{48}Ca to measure the weak charge

<u>Getting ready to resume!</u>

- Spectrometer magnets
- VDC swap to spare
- Polarimeter fixes







Large installations on the horizon!

SBS, Hypernuclear, MOLLER, and SoLID…

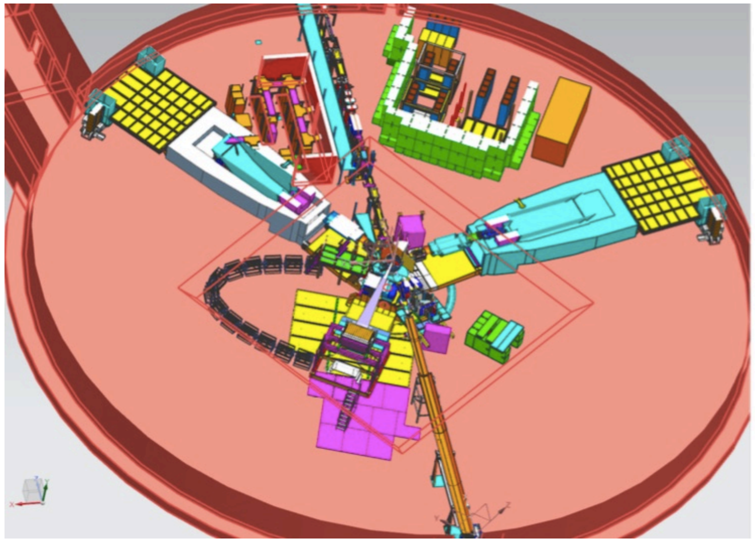
- The right equipment to fully leverage the unique Jefferson Lab accelerator capabilities (intensity, polarization, resolution, parity quality)
- Enable high impact science

5.

Planning for SAD 2020 (i.e. SBS installation!)

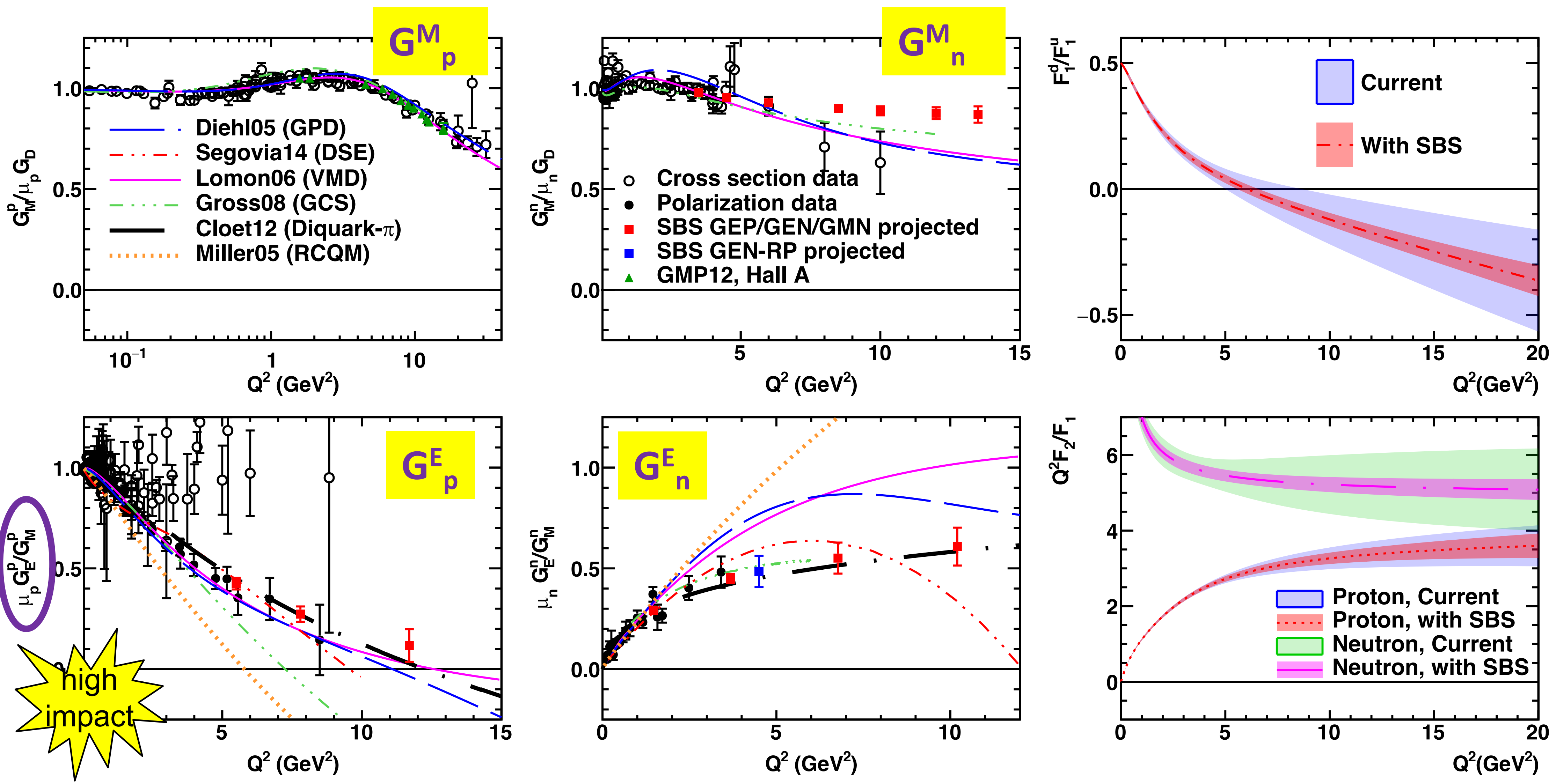
- Remove PREX2/CREX Equipment
- Upgrade LCW System
- Assemble SBS Equipment
  - Install SBS Magnet & Detector Systems
  - Install Big Bite Magnet & Detector Systems
  - Install Target Chamber, Exit Beamline, and Tower Assembly
  - Install Electronics Bunkers
  - Equipment Commissioning and Testing
- Decommission HRS-R
  - Warmup Cryogenic system.
  - Rotate HRS-R pass rollup door
  - Cool down and cleanup HRS-L cryogenic system
- Facilities Work List
  - Hall power upgrade *(contract in place for upgrade to 2MVA)*
  - Move small AHU, replace main (overhead) AHU
  - Move various electrical connections along the wall
  - *Changeout overhead lights*
  - Repair ground water leak near Compton

9-12 months!



Example: Long-standing water leaks near Compton polarimeter

SBS Physics: Extending Q^2 Range of Nucleon Form Factors



- Map transition to perturbative regime—running of dressed quark mass function
- Imaging of the nucleon charge and magnetization densities in impact-parameter space in the infinite momentum frame
- Precision high Q^2 form factors have impact on GPD extractions from DVCS
- Combined data allows flavor separation for large range of Q^2

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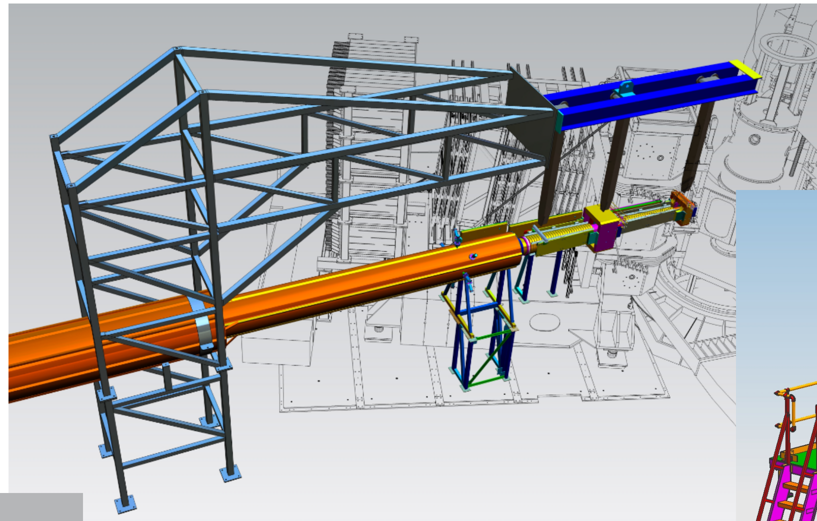
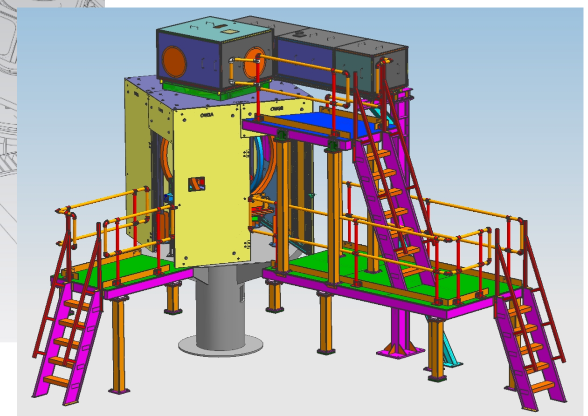
Continued E&D Emphasis: SUPER BIG Efforts for *SUPER BIGBITE SPECTROMETER* Installation

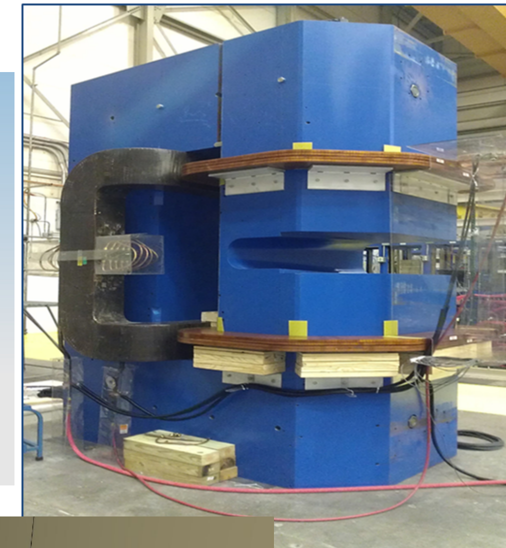


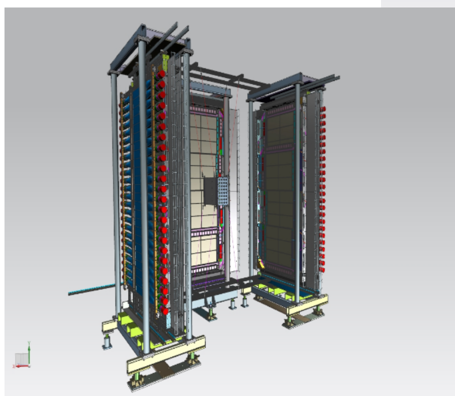
Shielded beamline

Polarized 3He Target

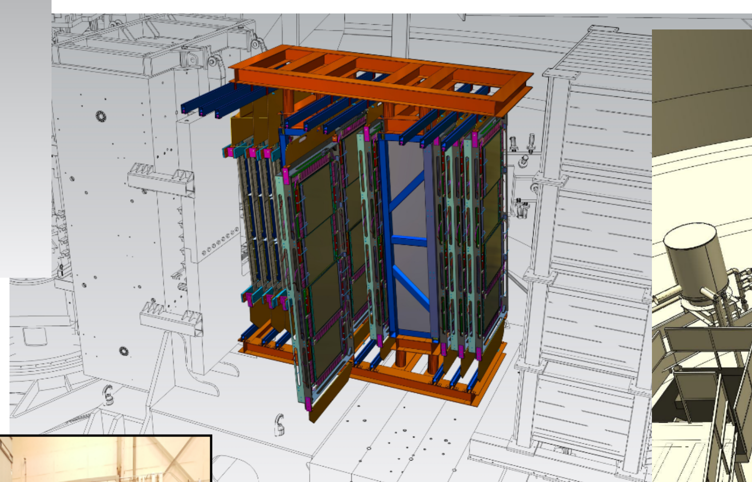


Dipole magnet

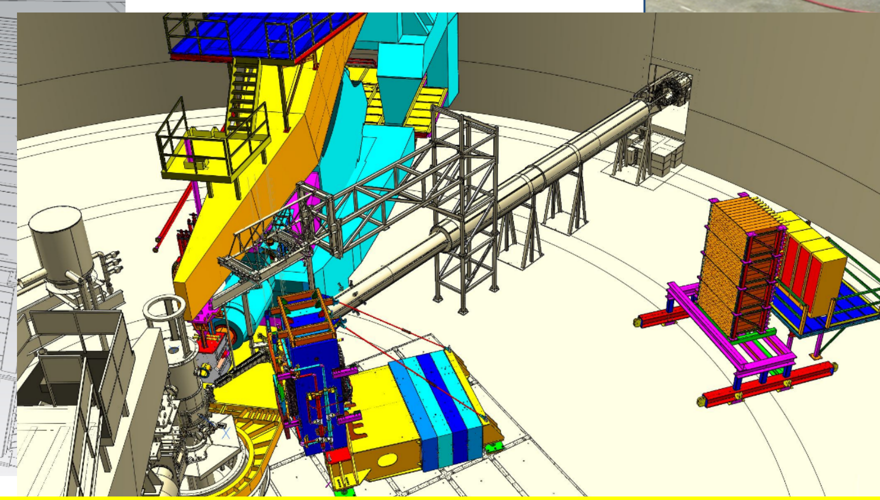




Gen-RP detectors



GEM detectors

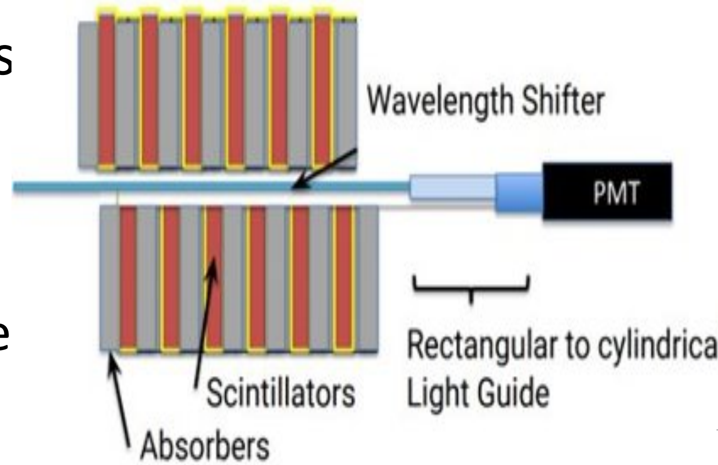


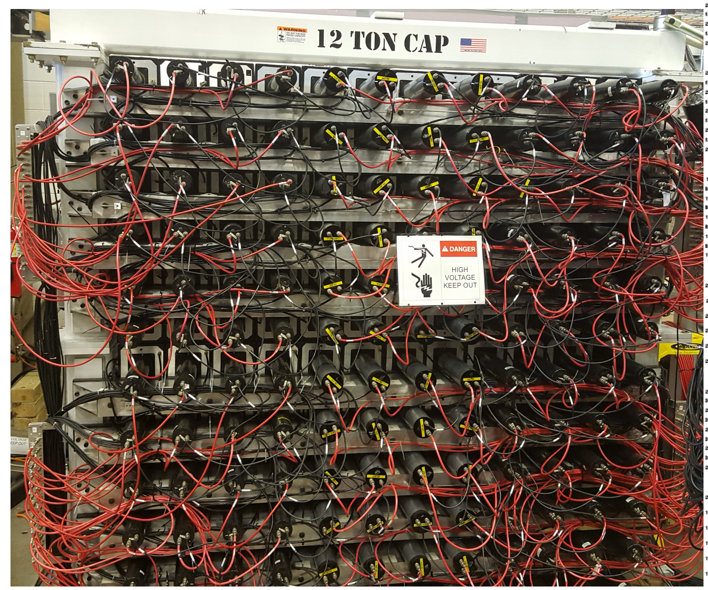
Counterweight support

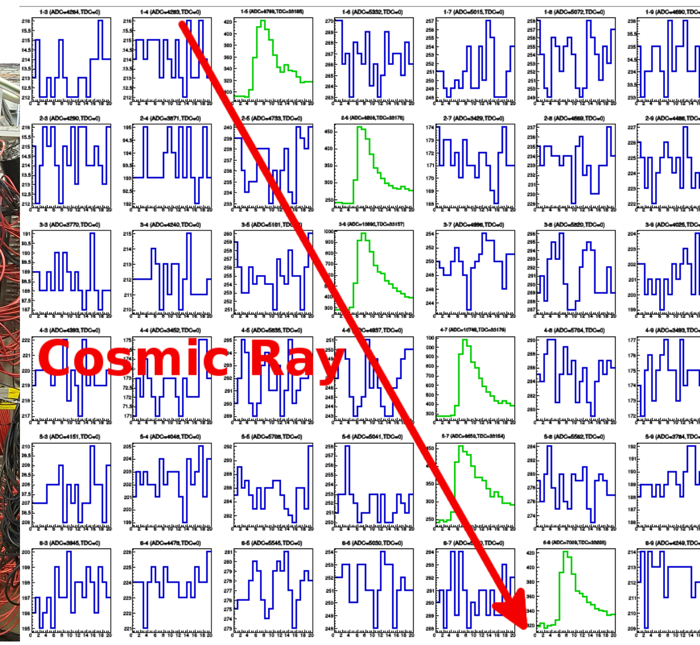
- Layout of equipment for **14 different configurations**
- Installation planning - *assuming COVID restrictions!*
- Preparation for multiple experiments utilizing SBS (Gen-RP, GMn, GEn, GEp, SIDIS, TDIS……..)

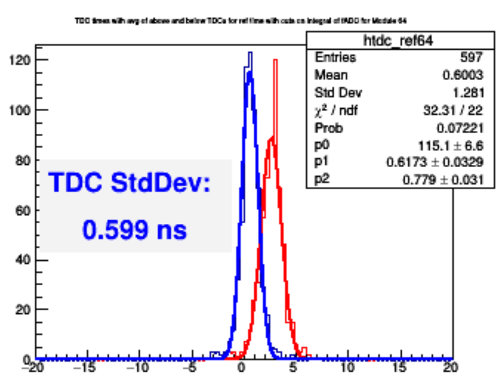
Hadron Calorimeter (JLab, CMU, INFN Catania)

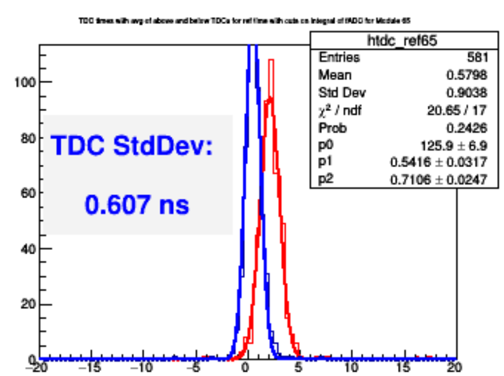
- Detects multiple GeV protons and neutrons.
    - 40 iron layers (absorbers) create particle showers.
    - 40 scintillator layers sample energy.
- 288 modules over 4 subassemblies.
    - Fully assembled and cabled.
    - Data acquisition system operational.
- Cosmic ray tests underway.
- Approaching 0.5 ns timing resolution goal

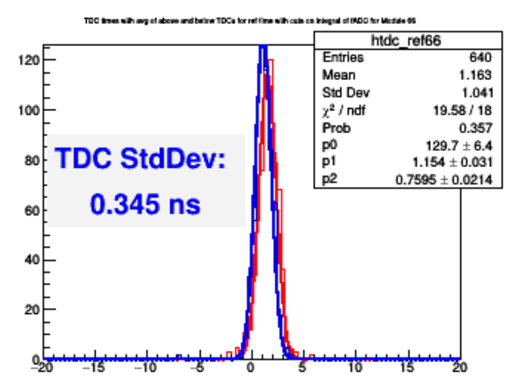


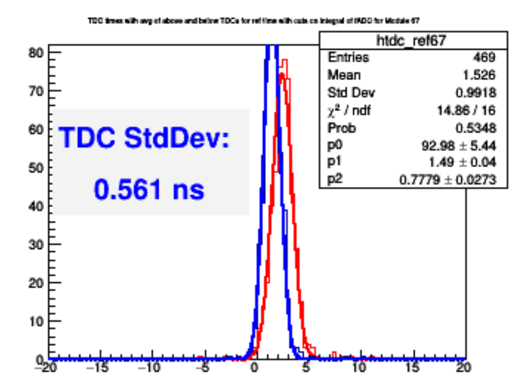










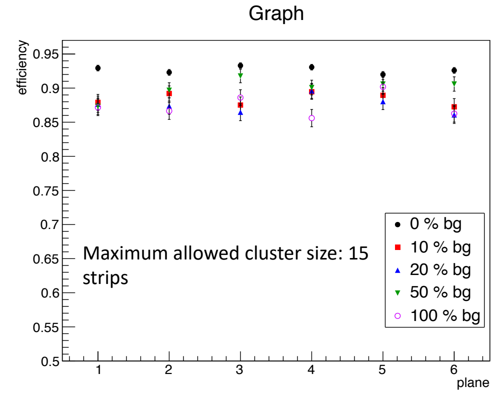


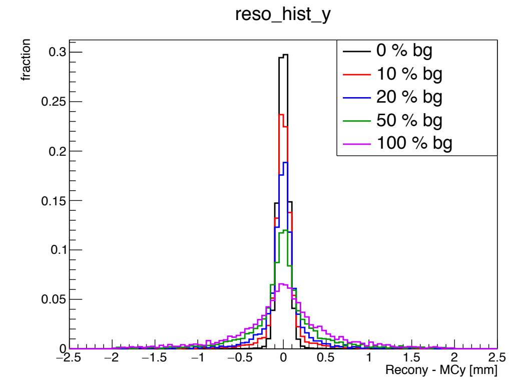
SBS GEM-based tracking (UVA, INFN Rome, HU, Uconn, JLab)

- Assembly of five ***50x60cm²*** modules into one chamber
- Five chambers assembled. Schedule to complete remaining six chambers is six months
- A testing "factory" with large scale DAQ setup
- Have engaged Physics Division Detector and Imaging group for general GEM development and support (also CLAS12, SoLID, TDIS,..)

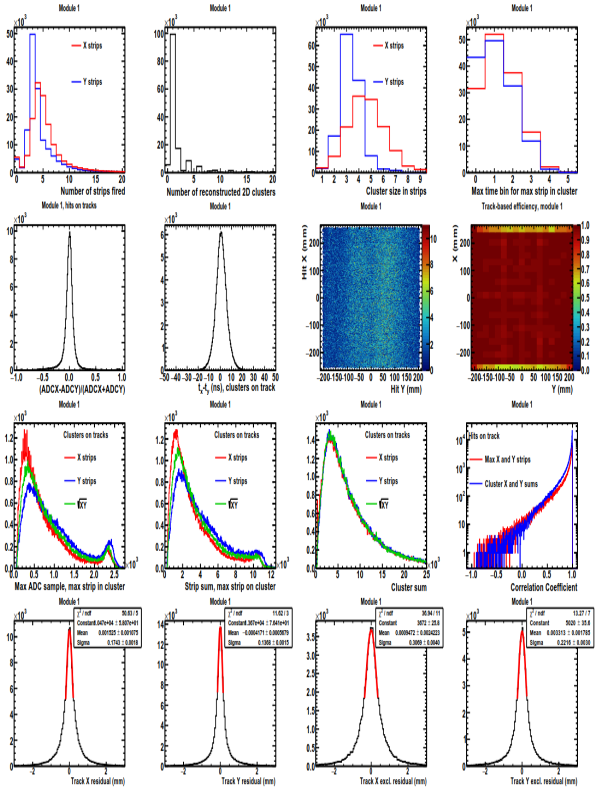
GEM efficiency and resolution

- GEM efficiency and resolution with the current algorithm
- GEM is counted as efficient if there is a reconstructed hit within +/- 5 strips (2mm) around the MC hit
- GEM resolution: the difference between the MC hit and its closest reconstructed hit within the +/- 5 strips range





Simulation



Cosmic ray test stand

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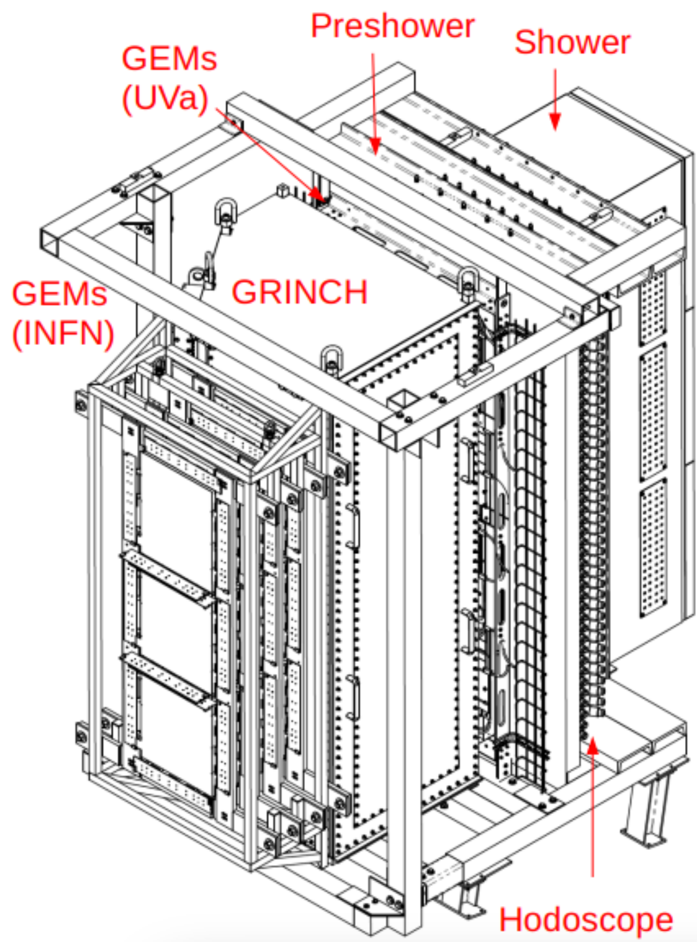
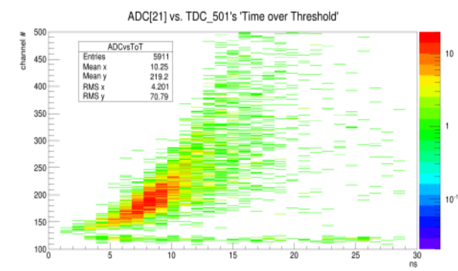
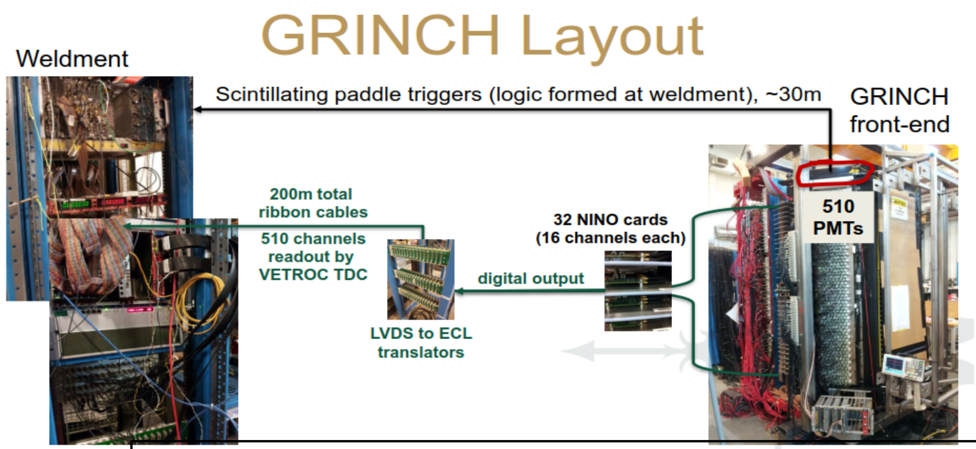
BigBite Detector Package

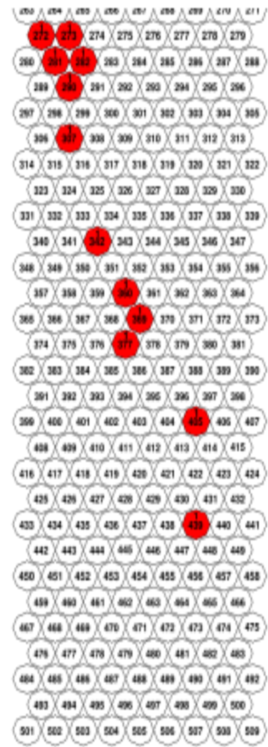


Gas Cherenkov (W&M, JMU, NCA&T)

- 510 PMT are being calibrated using cosmic data by comparing ADC to TDC Time-over-Threshold.







Hodoscope (Glasgow U, JLab)

- Counter holding method was improved.
- Rigidity of individual counters is improving.
- Front-end electronics was installed
- DAQ is under commissioning

Preshower & Shower (JLab, Uconn, Yerevan)

- Cosmic testing done to measure each block's gain versus HV
- Lower performing blocks were replaced in the Shower.
- Preshower blocks were replaced with radiation hard from HERMES
- Magnetic shielding on shower and preshower upgraded to meet field conditions during GMn experiment.

GEM chambers (UVa, INFN/Sanita)

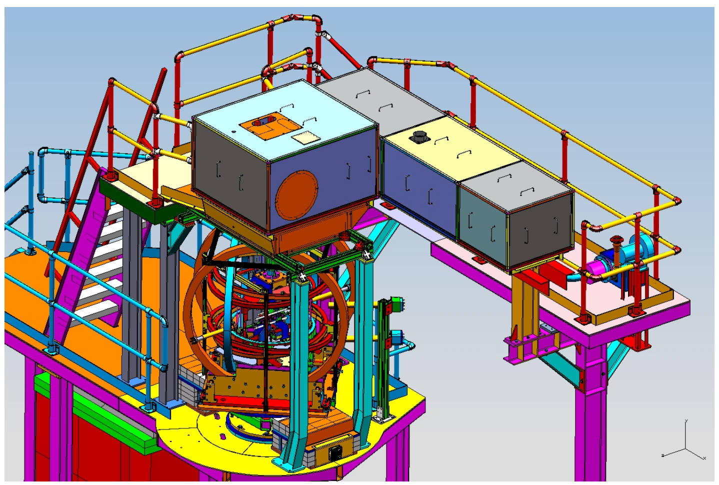
- Rear chamber was test installed
- Front holding frame was optimized for operation
- Two extra chambers with UV strip orientation are under construction

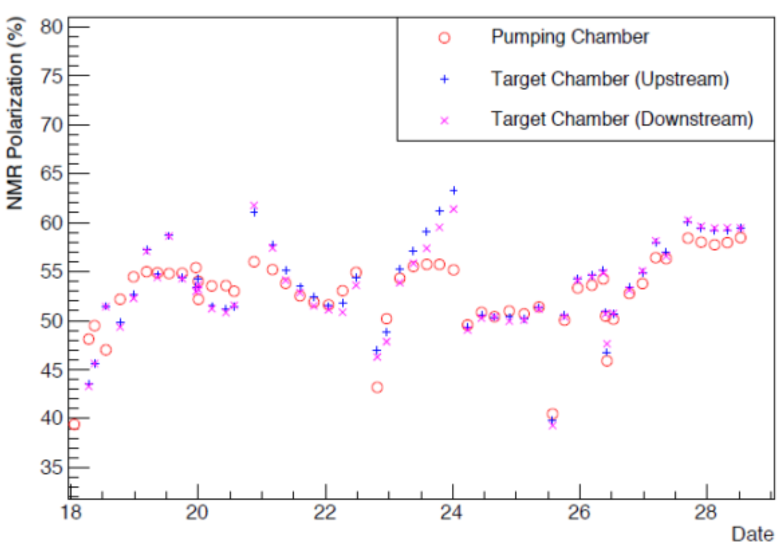
POLARIZED ^{3}HE TARGET DEVELOPMENT

Polarized ^{3}He for A1n/d2n experiment in Hall C

- ✓ 30 μA on 40 cm, ~10 atm ^{3}He gas
- L ~ 2.2×10^{36} cm^{-2}s^{-1} – x2 previous highest L
- ✓ In-beam polarization ~ 55%
- Polarimetry precision ~ 3%

Main challenge was to resume cell production

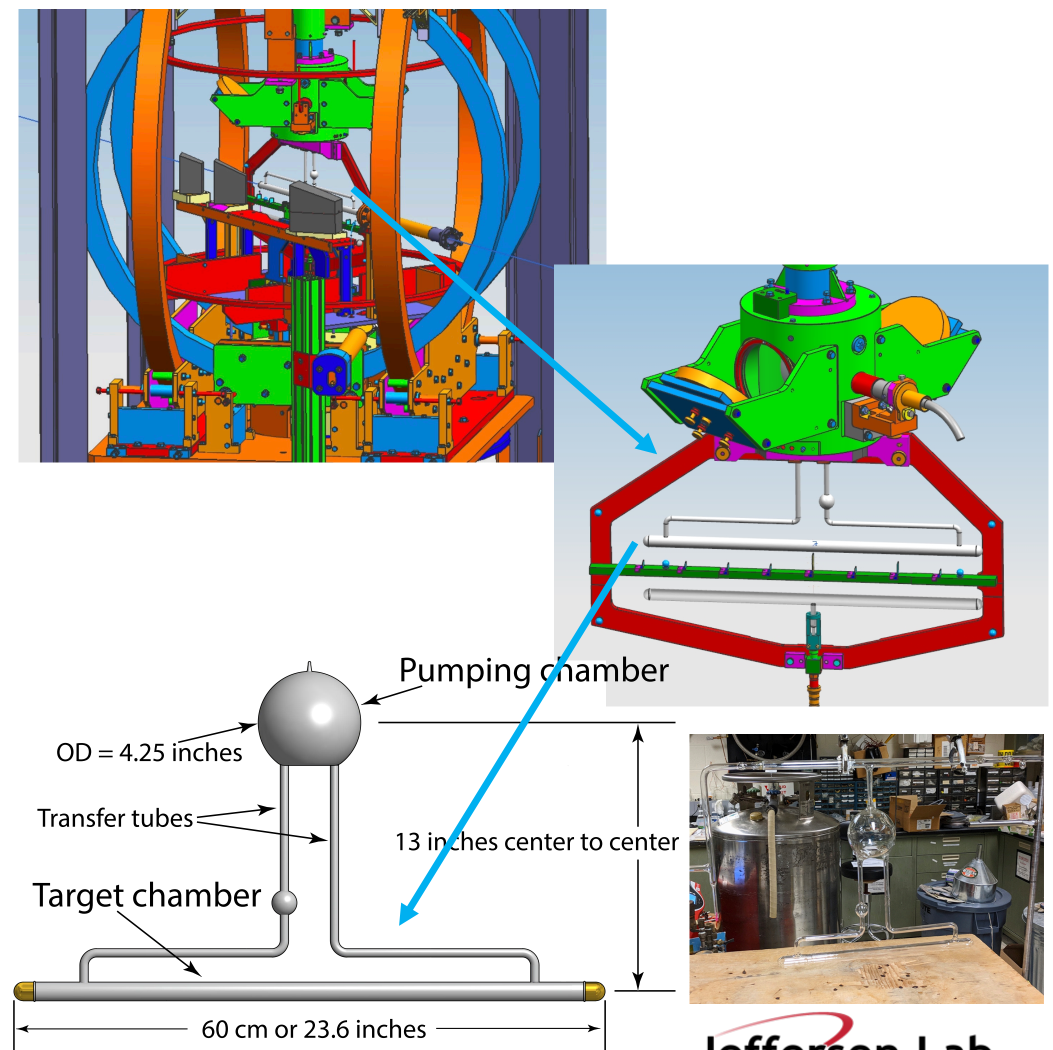




Polarized ^{3}He for GEn experiment in Hall A

- 60 μA on 60 cm, ~10 atm ^{3}He gas
- L ~ 6.6×10^{36} cm^{-2}s^{-1} – x3 higher L
- In-beam polarization ~ 55-60%
- Polarimetry precision ~ 3%

Main challenge: glass/metal end window of cell



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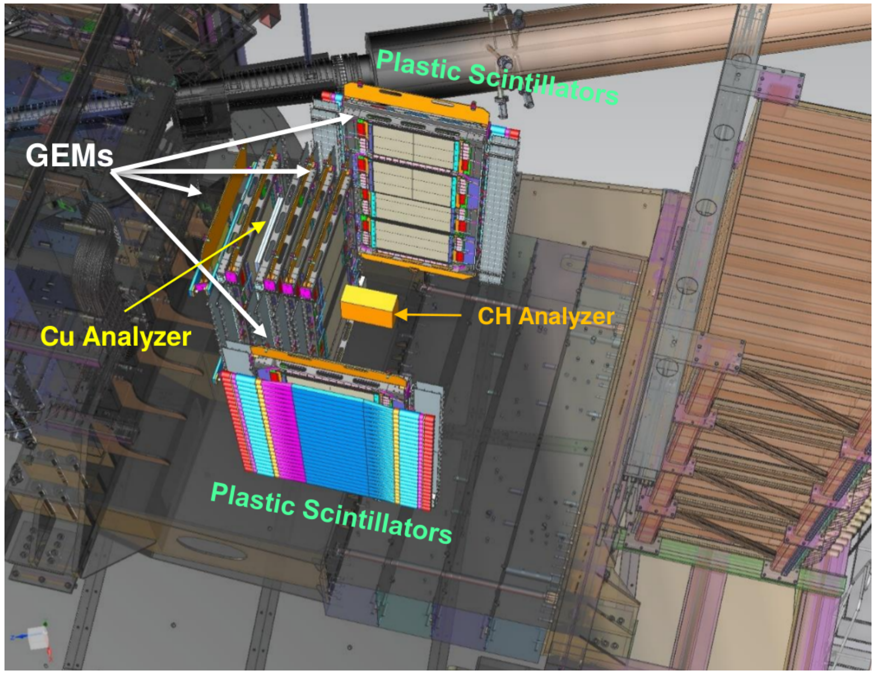
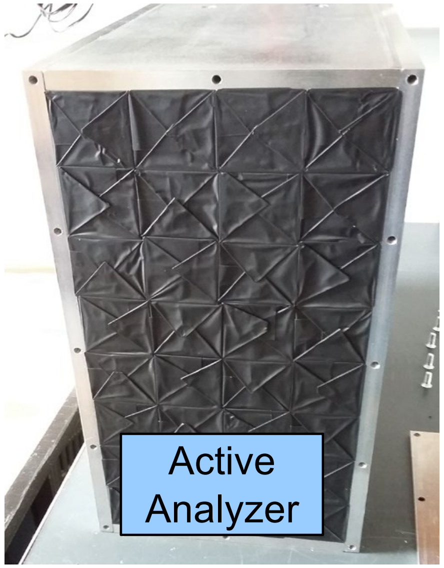
Readying Additional Hardware for G_e^n-RP / E12-17-004

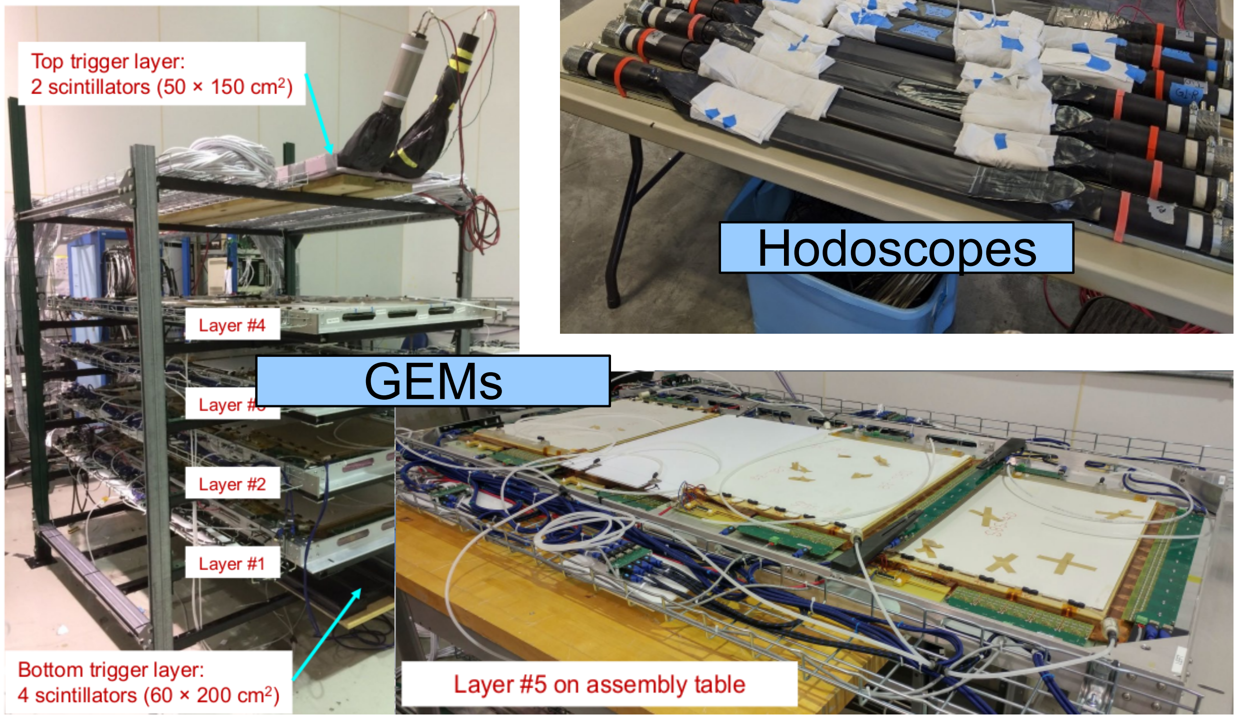
- Active Analyzer (RP)
  - → segmented plastic scint. array
  - → np recoil vertex identification
- Recoil proton detectors (RP)
  - → 2 packages total:
    - » One on SBS Left
    - » One on SBS Right
  - → Each package contains
    - » 1x Hodoscope array
      - – timing, coarse location
    - » 2x UVa GEM planes
      - – proton tracking
- Inline GEMs (R + ChEx)
  - → 2x INFN + 6x UVa GEMs
  - → charged particle veto
  - → large angle proton tracking (RP)
- Steel Analyzer (ChEx)



G_E^n-RP Status

- ERR
  - → Some ongoing questions from the ERR Committee regarding GEM status need resolution
    - Significant benefit to entire SBS program – accelerates GEM schedule
  - → **October 15 deadline allows for scheduling**
- E&D work continues
- Adds substantially to installation





PREX2/CREX as (one) GEM testing ground

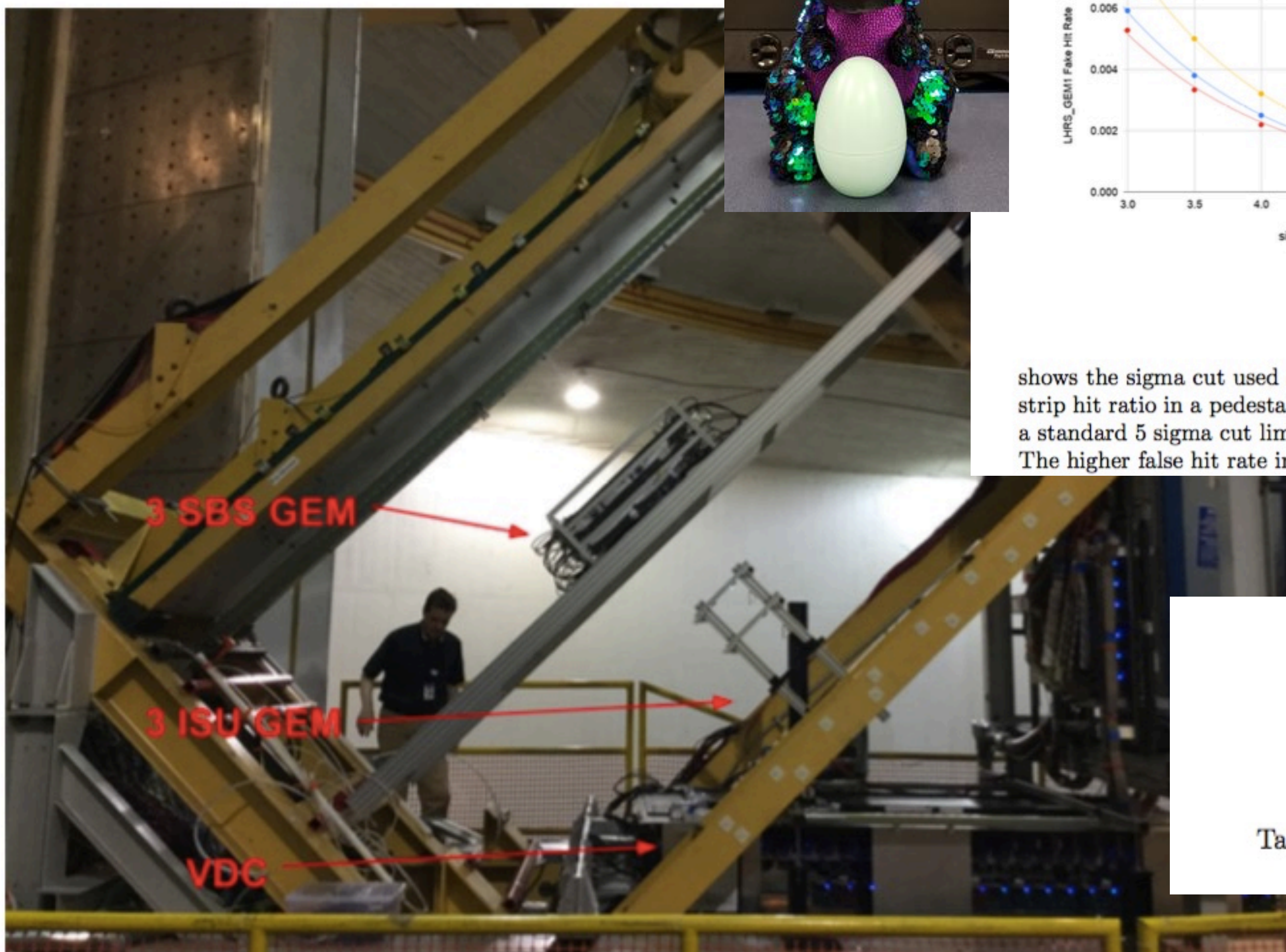


Figure 16: PRex Experiment GEM detectors Layout

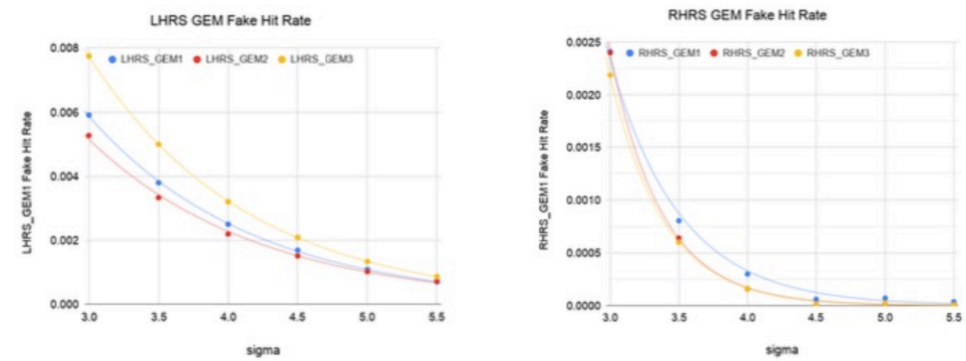


Figure 19: PRex GEM Fake Hit Rate

shows the sigma cut used as a threshold to identify the effective signals. The Y-axis is the false single strip hit ratio in a pedestal run. As expected the increasing threshold reduces the false hit probability; a standard 5 sigma cut limiting the false hit possibility to $1 * 10^{-4}$ for RHRS and $1.5 * 10^{-3}$ for LHRS. The higher false hit rate in the LHRS is due to the higher LHRS pedestal noise levels shown in fig 17.

Figure 18: GEM Efficiency Map

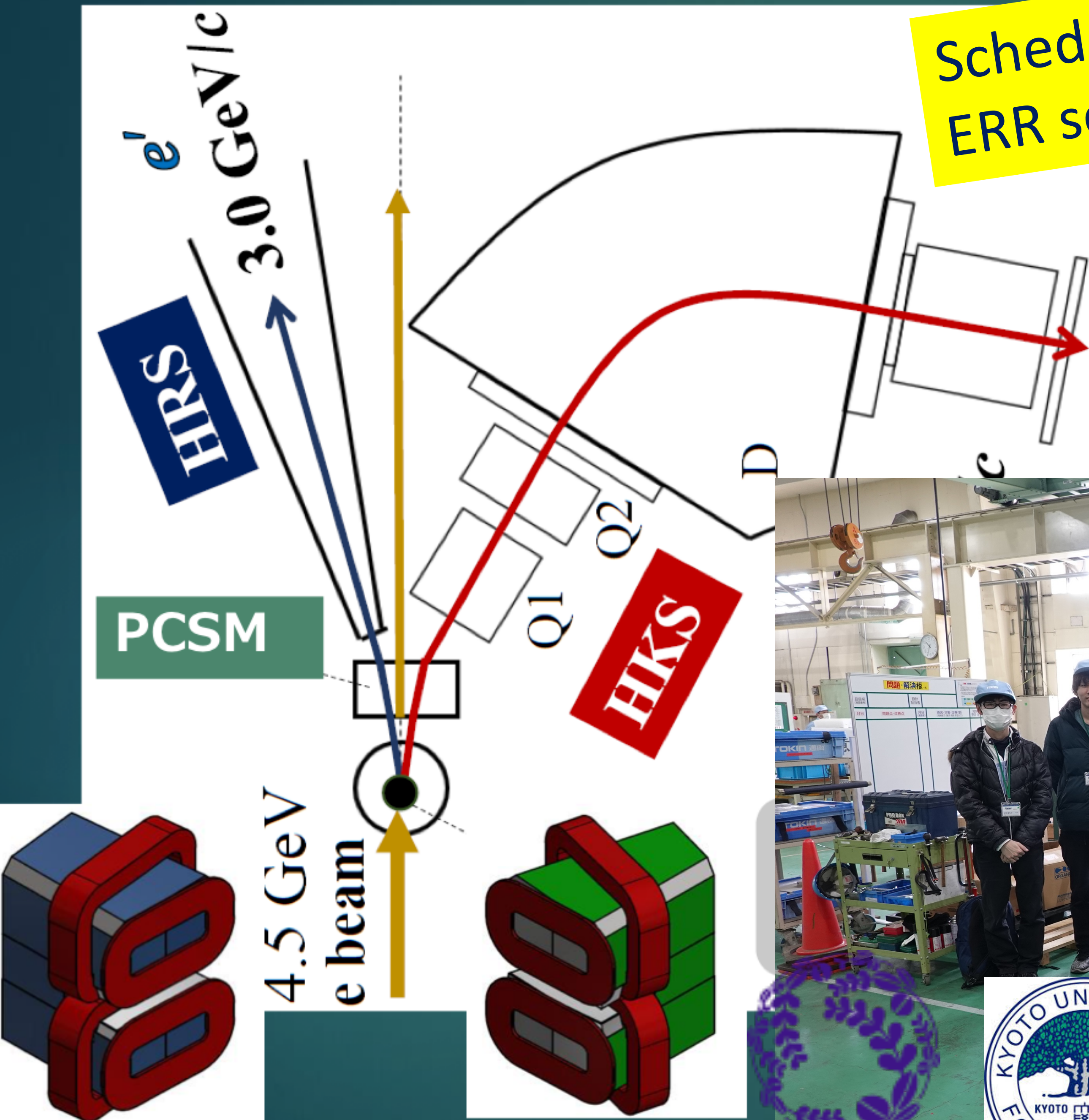
HRS	LHRS			RHRS		
Module	1	2	3	1	2	3
Efficiency	88%	76%	92%	88%	93%	94%

Table 2: PRex GEM Detector hits near (projected) VDC track

SBS Status

- All SBS equipment and dependencies are at the lab and on track for planned installation(s) to run in Hall A
  - First experiments to be G_M^n and G_E^n-RP (after current CREX experiment)
  - No technical showstoppers
- G_M^n Physics Division ERR on May 2017 and G_E^n-RP on May 2019
  - Both experiments have responded to the ERR committee recommendations
- Internal Hall A preparedness reviews
  - Joint G_M^n and G_E^n-RP reviews in Oct 2018 and August 2019
  - Review committee was Hall Leader and two senior Hall A/C staff
  - Produced list of action items
- Bi-weekly SBS management meetings
  - Track action items from the preparedness reviews
  - Monitor progress and coordinate activities between users and Hall A designers/engineers/technicians
- Weekly SBS collaboration meetings

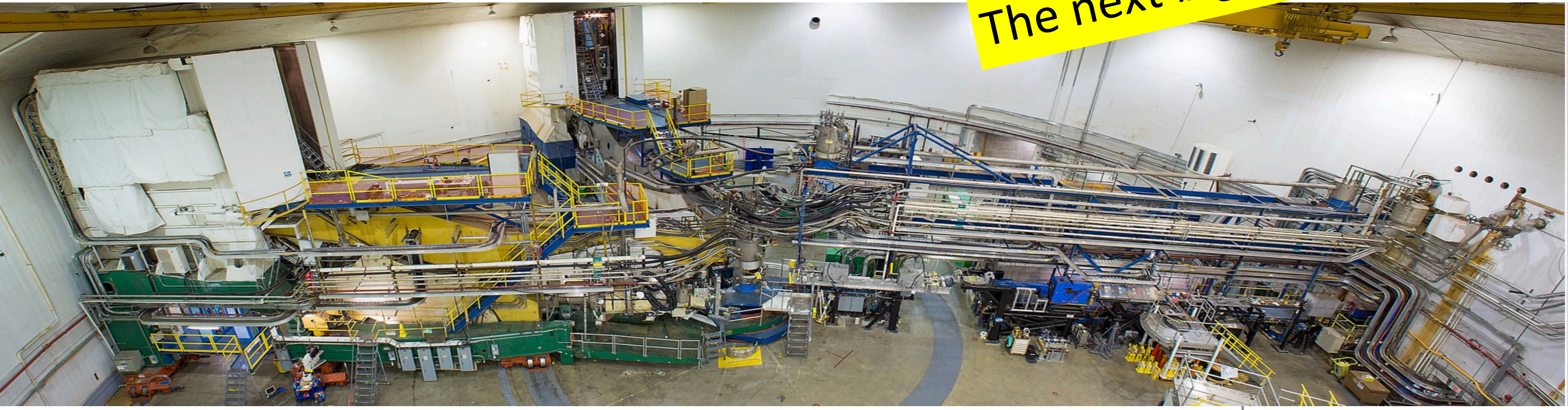
New setup for E12-15-008

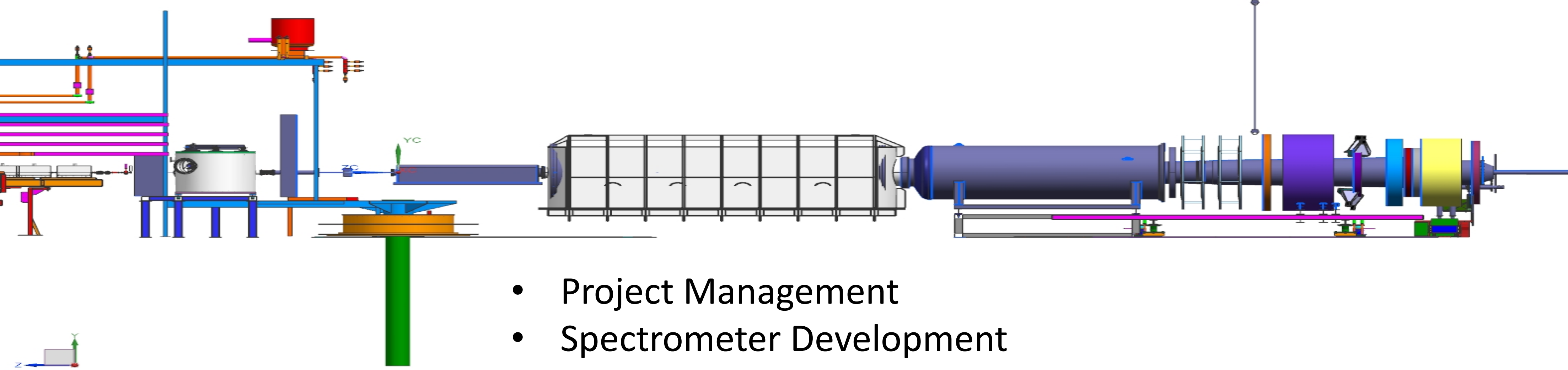


Scheduling ERR soon!

MOLLER

The next big E&D push



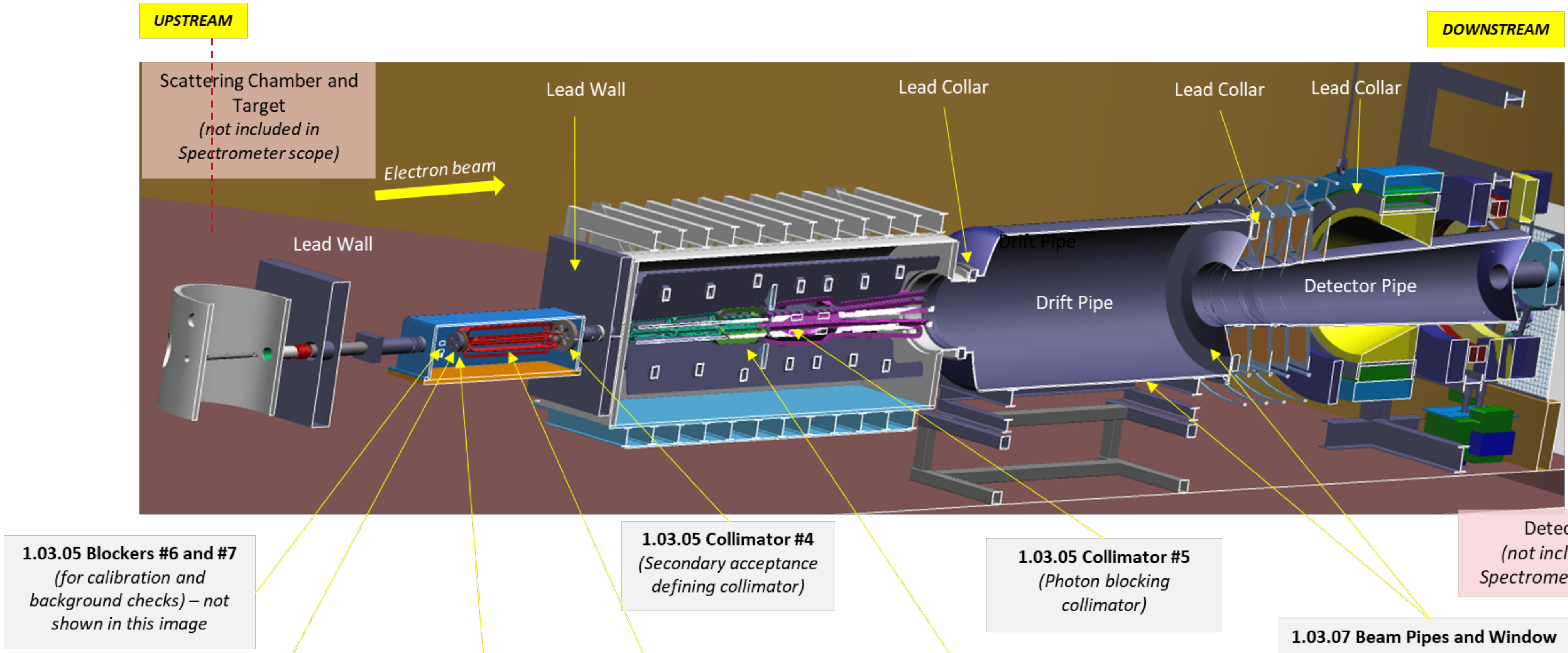


- Project Management
- Spectrometer Development (Physics Division Magnet Group)
- Detector and Integration (Hall A)

MOLLER Timeline

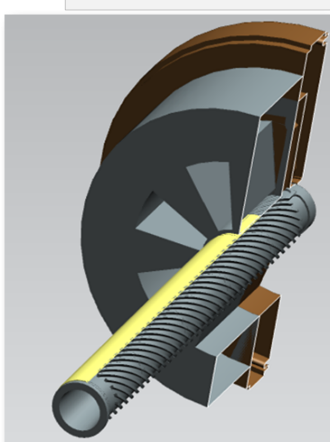
- 2009: Approved by PAC
- 2010: Assigned A rating and awarded full beam time request of 344 PAC days
- 2014: DOE Science Review, Strong Endorsement
- December 2016: Director's Technical Cost and Schedule Review
- ***CD-0 achieved on Dec. 21, 2016*** *with caveat that project is "paused"*
- 2015-2018: Work continues on physics design and simulation of apparatus
- ***2019: Project restarted*** and OPC funding provided for preconceptual design and planning
    - Ongoing Computational Fluid Dynamics calculations for 4 kW LH_2 target
    - Spectrometer magnet – hybrid vs segmented coil design
    - Evaluated vacuum vs inert gas in spectrometer – decision to use vacuum
    - Optimized quartz detector geometry and acceptance
    - Ongoing conceptual design for support structures and shielding requirement evaluations
- April 2019: Director's Technical Cost and Schedule Review
- November 2019: Cost Review
- December 2019: Conceptual Design Review
- January 2020: Director's Technical Cost and Schedule Review
- May 2020: New Project Manager Jim Fast starts
- **August 18-21 2020: CD-1 Director's Review scheduled** ready
- ***September 22-24 2020: CD-1 Independent Project Review (OPA review) scheduled***
- Design and prototyping in FY21-22; construction FY23-25; start of operations late FY25

Spectrometer Design (JLab, Manitoba)



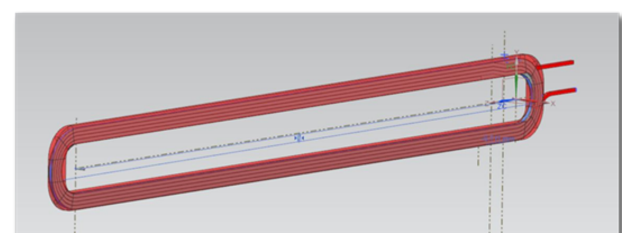
Not shown here:
- 1.03.04 Field measurement system
- 1.03.06 Water chiller
- 1.03.08 Shielding supports

[Note: There is no Collimator #3]



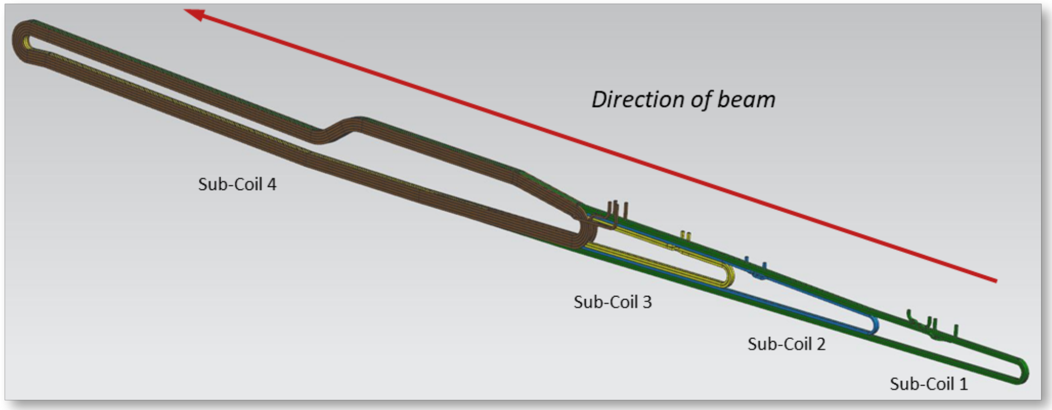
A. Combined Collimator #1 & #2

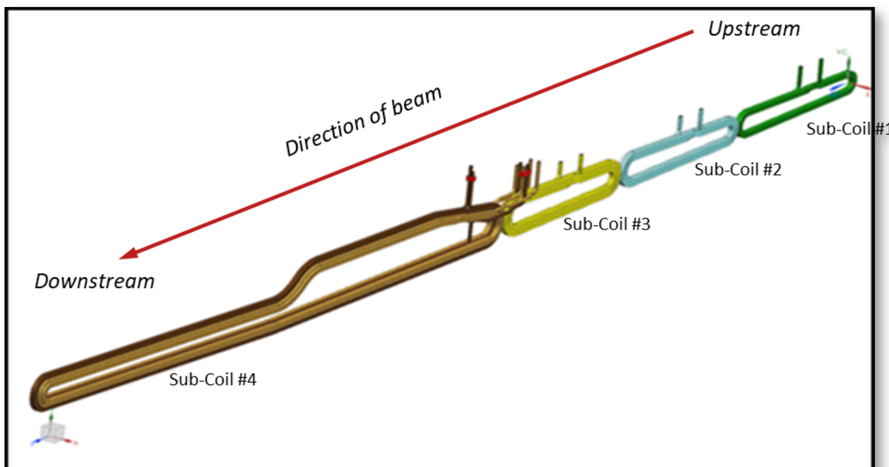
B. Upstream coil – 7 off – simple pancake



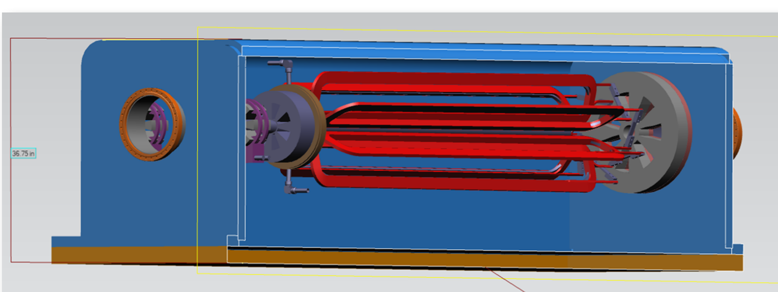
Spectrometer Design (JLab, Manitoba)

C. Downstream coils – 7 off (2 possible designs)

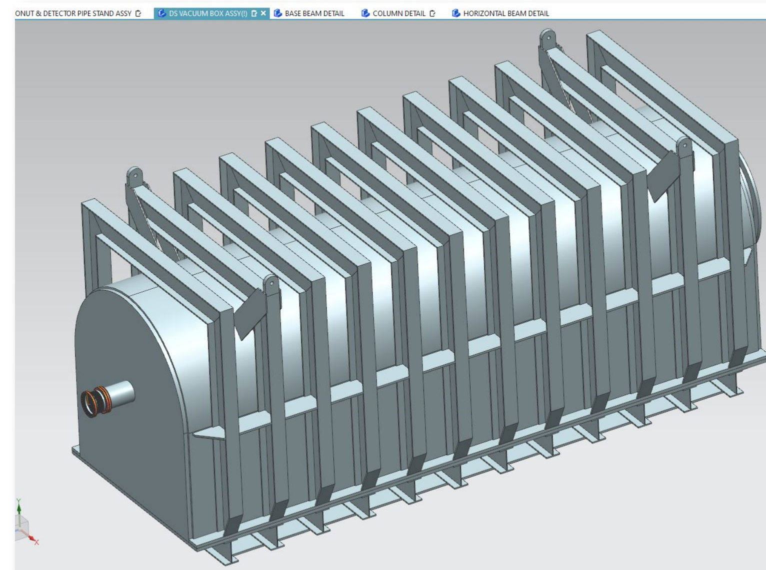




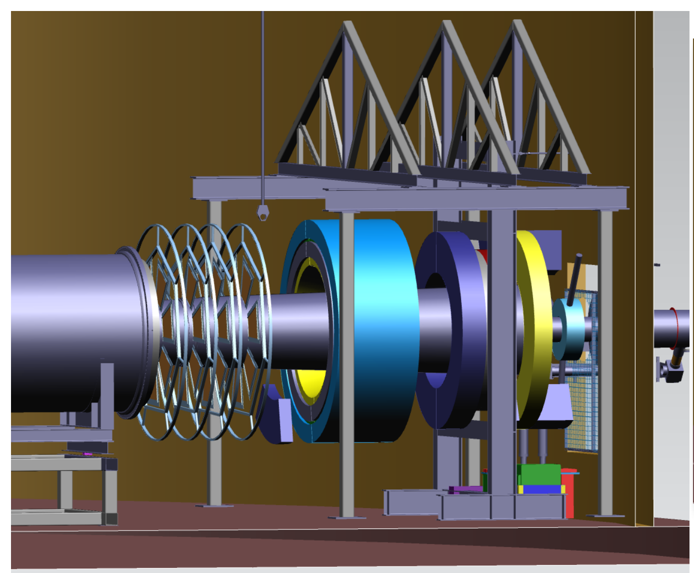
D. Upstream magnet vacuum enclosure

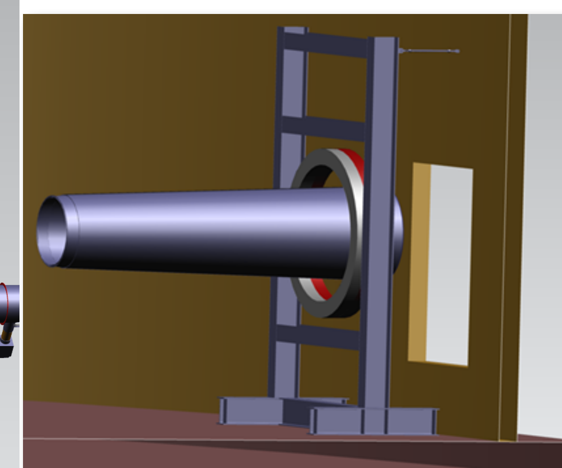


E. Downstream magnet vacuum enclosure



F. Detector Frames

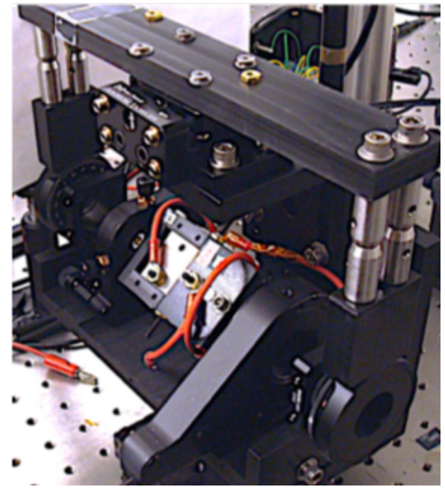


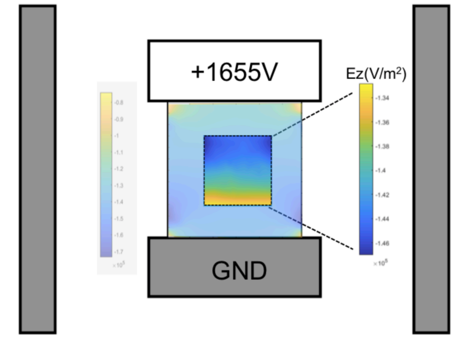


Asymmetries in the Polarized Beam – Lessons from PREX-2

PREX-2 demonstrated new RTP Pockels cell technology, with fast flip and <30 nm in injector

- Good control of beam asymmetries
- Used during 2019/2020, including all of PREX-2 and CREX



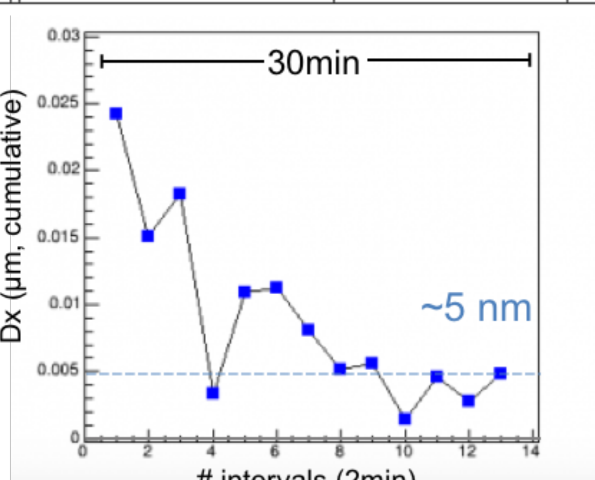


Voltage gradient steering tuned to control position changes

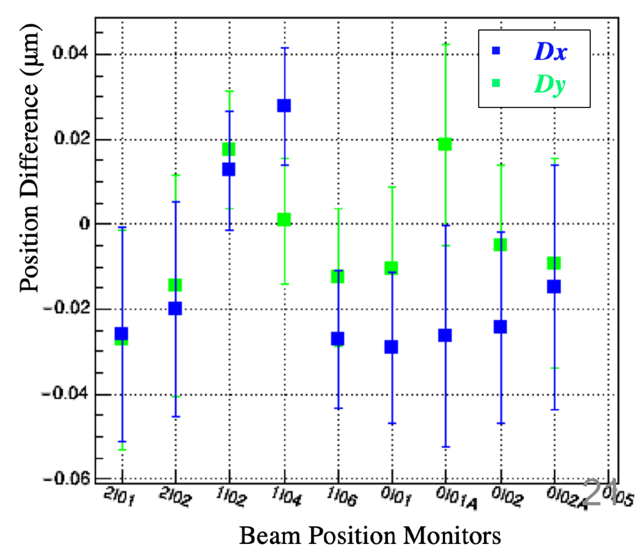
	HAPPEX-II [29] (achieved)	Qweak [63] (achieved)	PREX-2 (achieved)	MOLLER (required)
Intensity asymmetry	400 ppb	30 ppb	25 ppb	10 ppb
Energy asymmetry	0.2 ppb	0.4 ppb	1 ± 0.6 ppb	< 0.7 ppb
position differences	1.7 nm	2.5 nm	$< 2 \pm 2$ nm	1.2 nm
angle differences	0.2 nrad	0.1 nrad	$< 0.2 \pm 0.4$ nrad	0.12 nrad
size asymmetry (quoted)	–	$< 10^{-4}$	$< 10^{-5}$	$< 10^{-5}$

Control sufficient to achieve MOLLER goals.

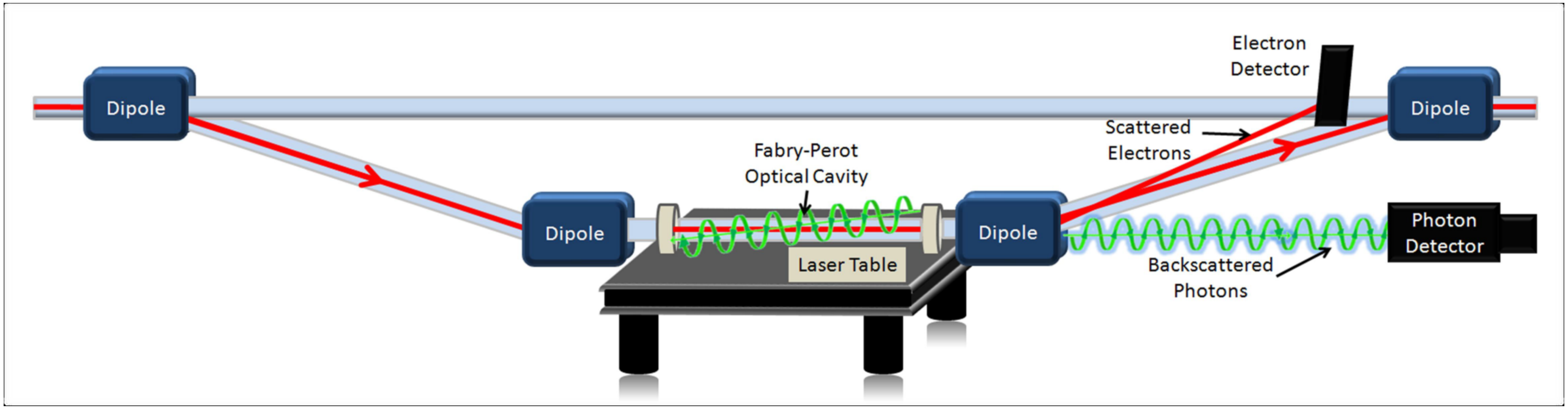
During configuration: tune Pockels cell to zero position differences



PREX position differences average to be consistent with convergence of beam noise.

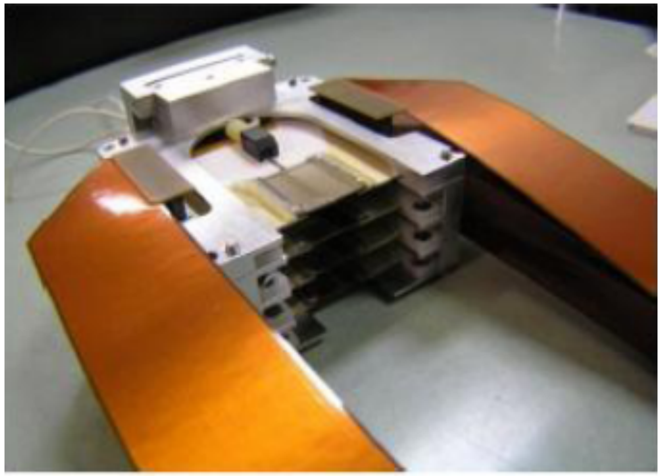


Compton Polarimetry



Precision Compton polarimetry for MOLLER being addressed as part of HIPPOL capital project

- Improved laser system, electron detector DAQ for Hall C
- Larger electron detector for Hall C
- *New electron detector system for Hall A*



Nominal detector technology → diamond

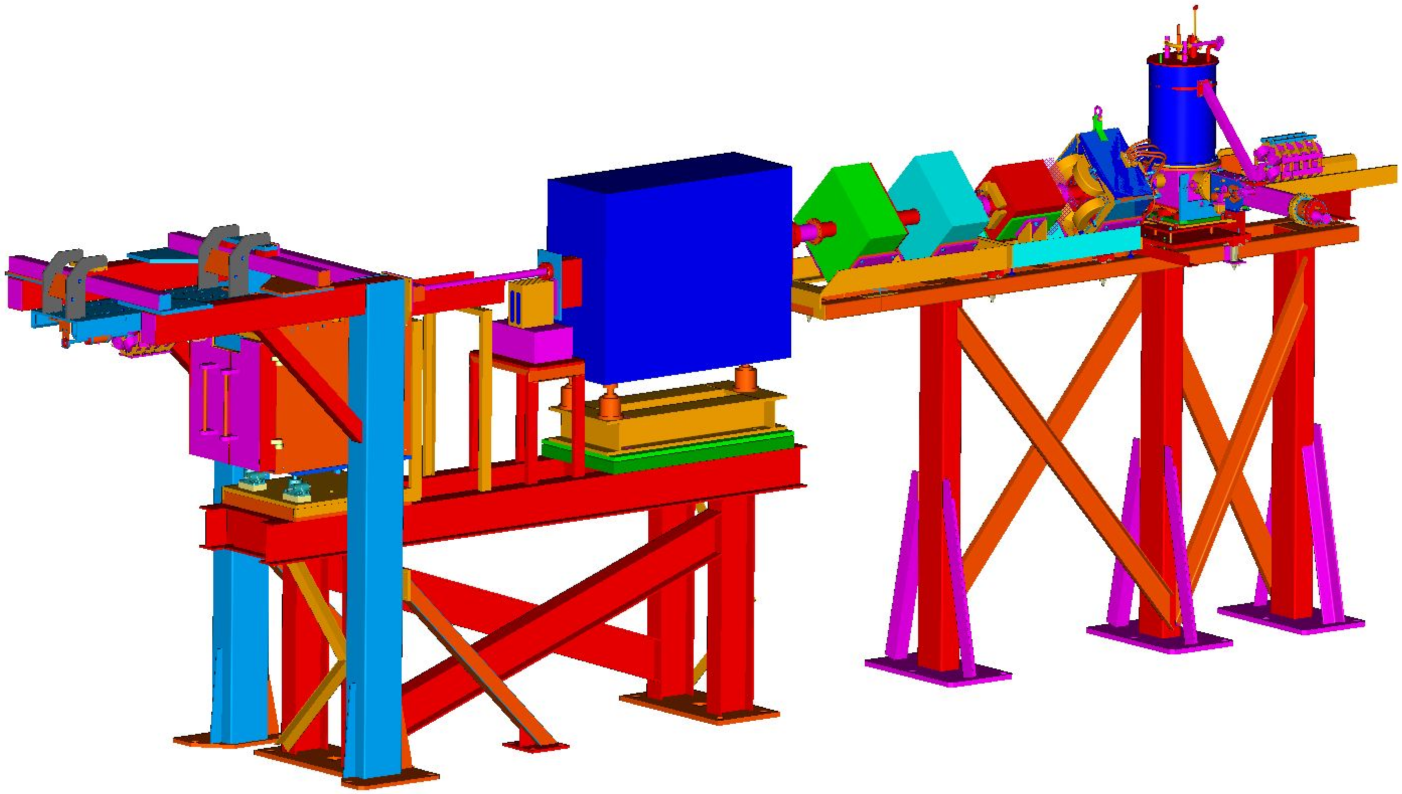
→ New vacuum can needed

→ Additional amplification of analog signal in vacuum desired – or amplification + discrimination at detector?

→ JLab support likely required for new amplifier/discriminators"

→ HVMAPS also being developed at Manitoba

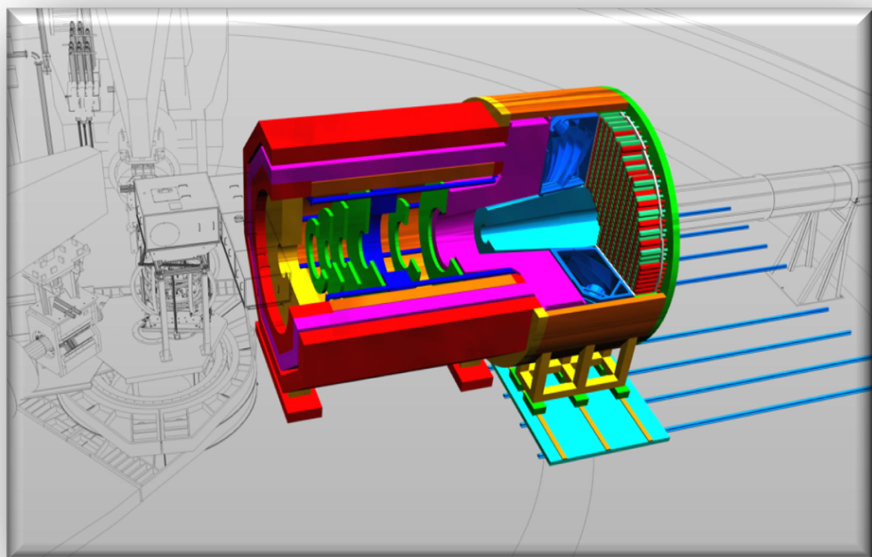
Møller Polarimeter

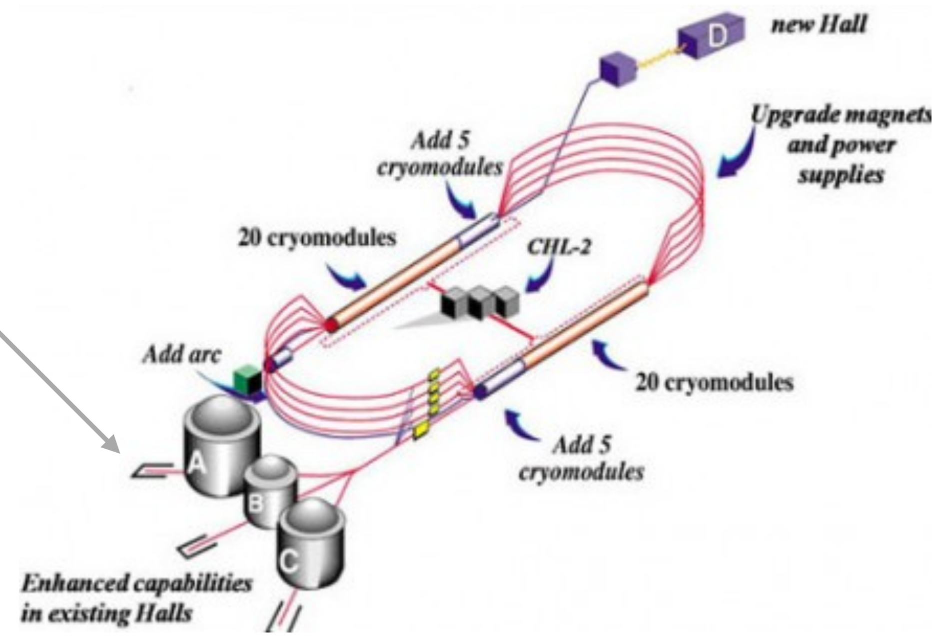


- Developing new, common A/C target design (capital project)
- New suoerconducting magnet for Hall C
- Some improvements to Hall A Møller polarimeter will be accomplished as part of MOLLER project
  - New tracking detector (GEMs) to better understand spectrometer optics and acceptance
  - Additional collimation to more robustly define the acceptance

SoLID: *QCD at the intensity frontier*

SoLID provides *unique* capability combining high luminosity ($10^{37\text{-}39}$ /cm^2/s) (more than 1000 times the EIC) and **large acceptance,** with full ϕ coverage to maximize the science return of the 12-GeV CEBAF upgrade



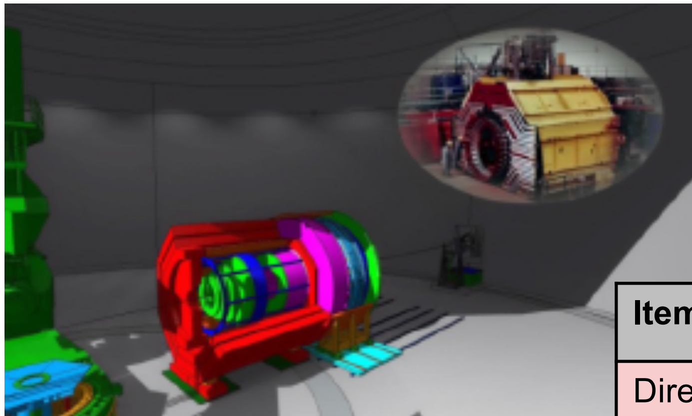


SoLID with unique capability for rich physics programs

- ✓ Pushing the phase space in the search of new physics and of hadronic physics
- ✓ 3D momentum imaging of a relativistic strongly interacting confined system (nucleon spin)
- ✓ Superior sensitivity to the differential electro- and photo- production cross section of J/ψ near threshold (proton mass)

SoLID physics complementary and synergistic with the EIC science (proton spin and mass, two important EIC science questions) – high-luminosity SoLID unique for valence quark tomography (separation of structure from collision) and precision J/ψ production near the threshold

SoLID Timeline Overview
Proposed QCD & Fundamental Symmetries MIE



Unique Capability:

- ✓ High luminosity (10^{37-39})
- ✓ Large acceptance detector with full ϕ coverage

Science Review – March 8-10, 2021

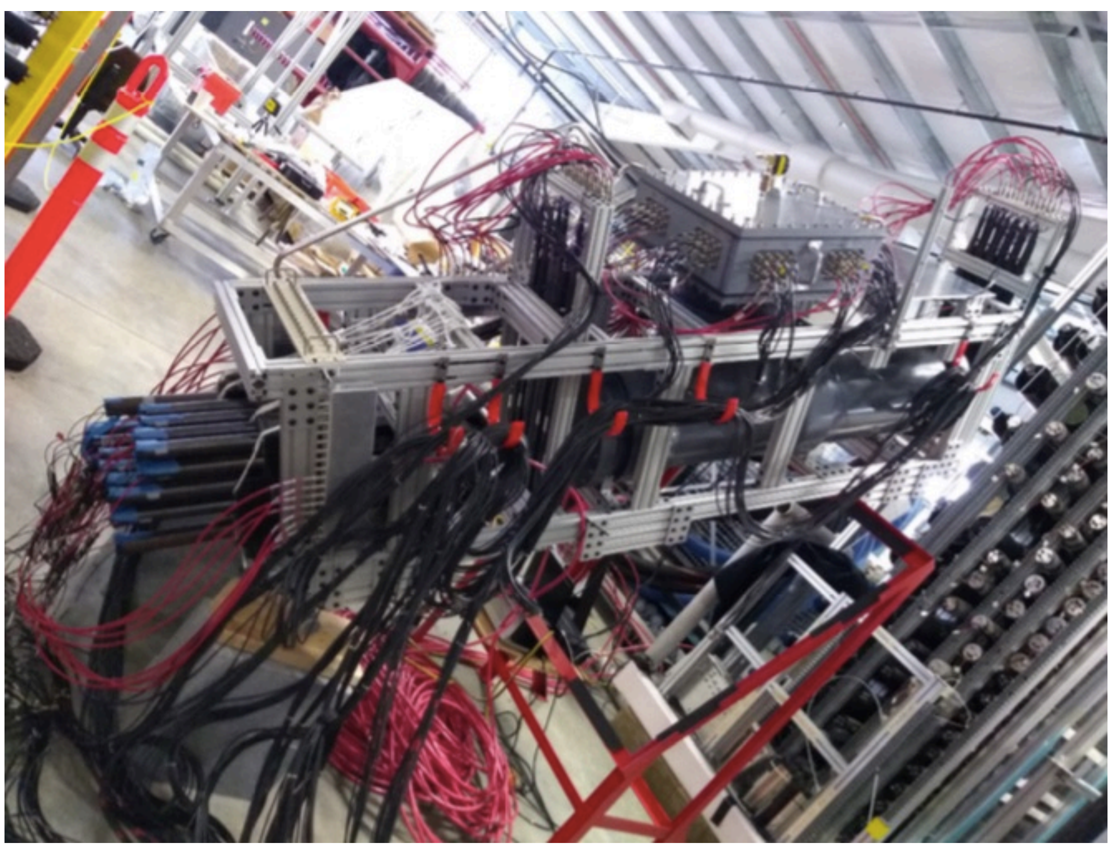
CD0 – proposed 2Q FY21

CD1 – proposed 1Q FY22

Item	Date
Director's Review	February 2015
SoLID User Meeting with DOE/NP	November 2015
Director's Review	February 2016
Follow-Up to Director's Review	Late 2017
SoLID User and JLab Management Meeting with DOE/NP	Mid 2018
Pre-R&D Plan Submission - Updated Cost, Scheduled and Assessed Technical Risks	Summer 2019
Director's Review	September 2019
Follow-Up to Director's Review	End of 2019
SoLID MIE Submission to DOE	**February 2020**

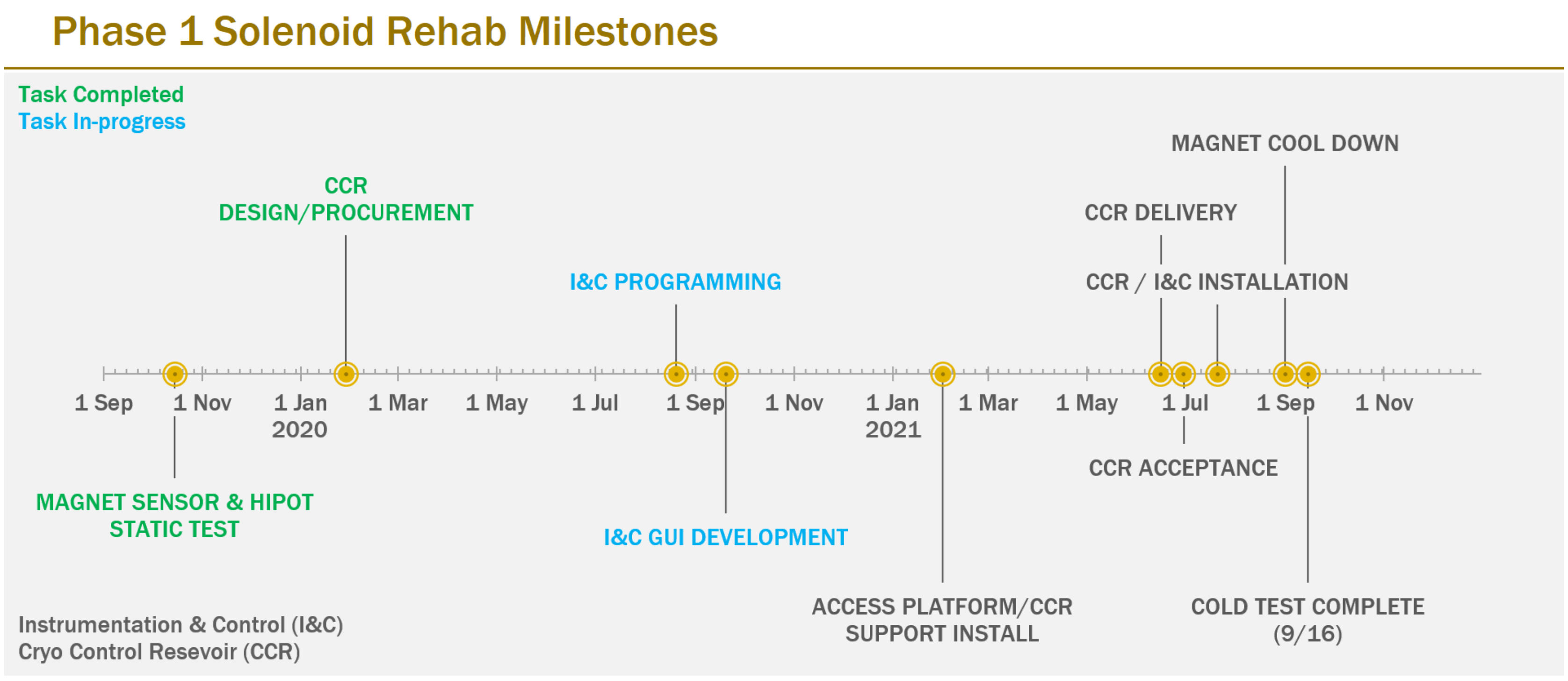
SoLID PreR&D – *retiring the few risks*

- Funding started this year
- DAQ: GEM readout and DAQ testing for high rates
- Cherenkov test for high rates/high background
  - data acquired during A1n/d2n in Hall C
- CLEOII magnet static tests
- *Successful preR&D review August 7*

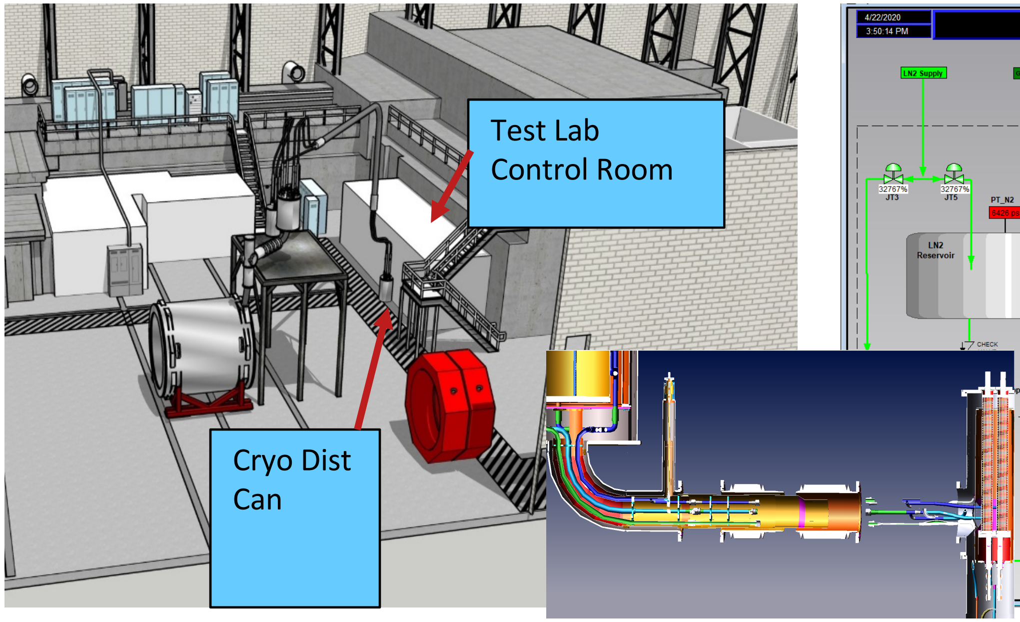


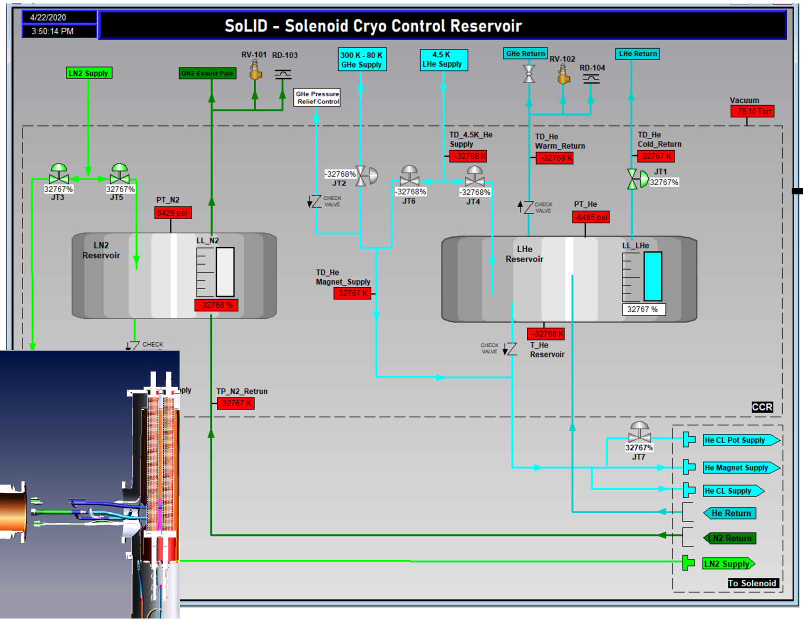
Low rate configuration (~300 kHz rate on maPMTs) at ~ 105 deg, 17 feet away from the target

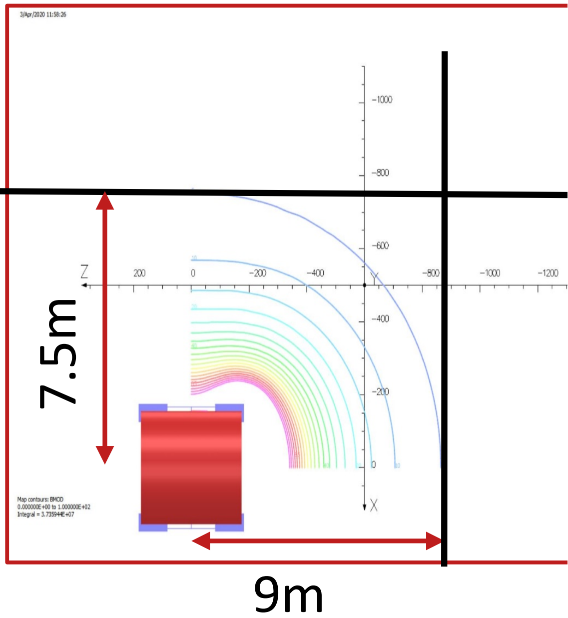
CLEOII Solenoid Rehab – Static and Cold Test



- Solenoid rehab will confirm magnet condition
- Provide project risk reduction
- Refine magnet planning
- Estimated completion Sept 2021

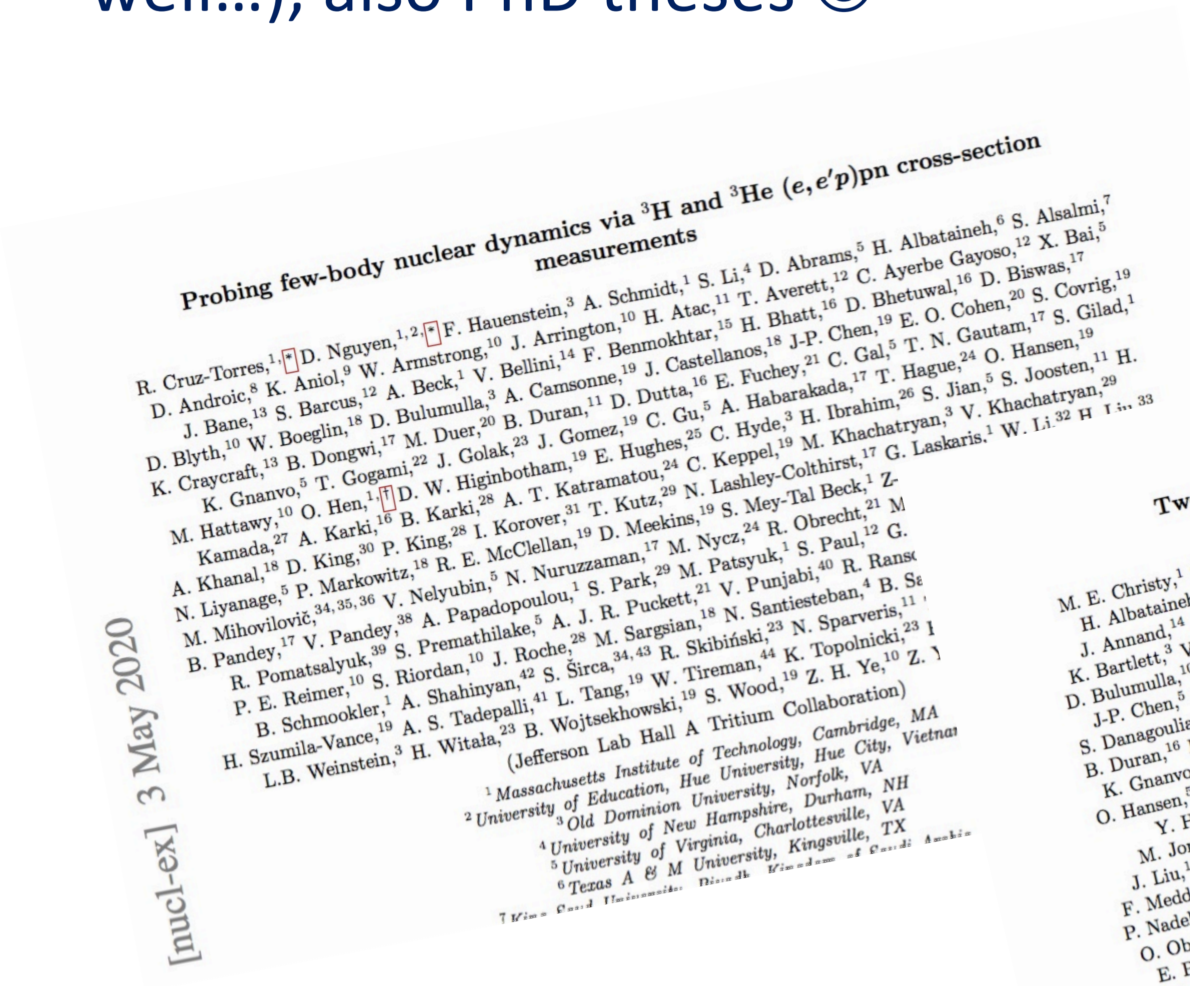






Other News…

12 GeV era publications coming out (some 6 GeV continuing as well…), also PhD theses ☺



Probing few-body nuclear dynamics via ^{3}H and ^{3}He $(e,e'p)pn$ cross-section measurements

R. Cruz-Torres,[1] D. Nguyen,[1,2] F. Hauenstein,[3] A. Schmidt,[1] S. Li,[4] D. Abrams,[5] H. Albataineh,[6] S. Alsalmi,[7] D. Androic,[8] K. Aniol,[9] W. Armstrong,[10] J. Arrington,[10] H. Atac,[11] T. Averett,[12] C. Ayerbe Gayoso,[12] X. Bai,[5] J. Bane,[13] S. Barcus,[12] A. Beck,[1] V. Bellini,[14] F. Benmokhtar,[15] H. Bhatt,[16] D. Bhetuwal,[16] D. Biswas,[17] D. Blyth,[10] W. Boeglin,[18] D. Bulumulla,[3] A. Camsonne,[19] J. Castellanos,[18] J-P. Chen,[19] E. O. Cohen,[20] S. Covrig,[19] K. Craycraft,[13] B. Dongwi,[17] M. Duer,[20] B. Duran,[11] D. Dutta,[16] E. Fuchey,[21] C. Gal,[5] T. N. Gautam,[17] S. Gilad,[1] K. Gnanvo,[5] T. Gogami,[22] J. Golak,[23] J. Gomez,[19] C. Gu,[5] A. Habarakada,[17] T. Hague,[24] O. Hansen,[19] M. Hattawy,[10] O. Hen,[1] D. W. Higinbotham,[19] E. Hughes,[25] C. Hyde,[3] H. Ibrahim,[26] S. Jian,[5] S. Joosten,[11] H. Kamada,[27] A. Karki,[16] B. Karki,[28] A. T. Katramatou,[24] C. Keppel,[19] M. Khachatryan,[3] V. Khachatryan,[29] A. Khanal,[18] D. King,[30] P. King,[28] I. Korover,[31] T. Kutz,[29] N. Lashley-Colthirst,[17] G. Laskaris,[1] W. Li,[32] H. Liu,[33] N. Liyanage,[5] P. Markowitz,[18] R. E. McClellan,[19] D. Meekins,[19] S. Mey-Tal Beck,[1] Z. M. Mihovilovič,[34,35,36] V. Nelyubin,[5] N. Nuruzzaman,[17] M. Nycz,[24] R. Obrecht,[21] M. B. Pandey,[17] V. Pandey,[38] A. Papadopoulou,[1] S. Park,[29] M. Patsyuk,[1] S. Paul,[12] G. R. Pomatsalyuk,[39] S. Premathilake,[5] A. J. R. Puckett,[21] V. Punjabi,[40] R. Ransome, P. E. Reimer,[10] S. Riordan,[10] J. Roche,[28] M. Sargsian,[18] N. Santiesteban,[4] B. S. B. Schmookler,[1] A. Shahinyan,[42] S. Širca,[34,43] R. Skibiński,[23] N. Sparveris,[11] H. Szumila-Vance,[19] A. S. Tadepalli,[41] L. Tang,[19] W. Tireman,[44] K. Topolnicki,[23] L.B. Weinstein,[3] H. Witała,[23] B. Wojtsekhowski,[19] S. Wood,[19] Z. H. Ye,[10] Z. Y.

(Jefferson Lab Hall A Tritium Collaboration)

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[4] University of New Hampshire, Durham, NH
[5] University of Virginia, Charlottesville, VA
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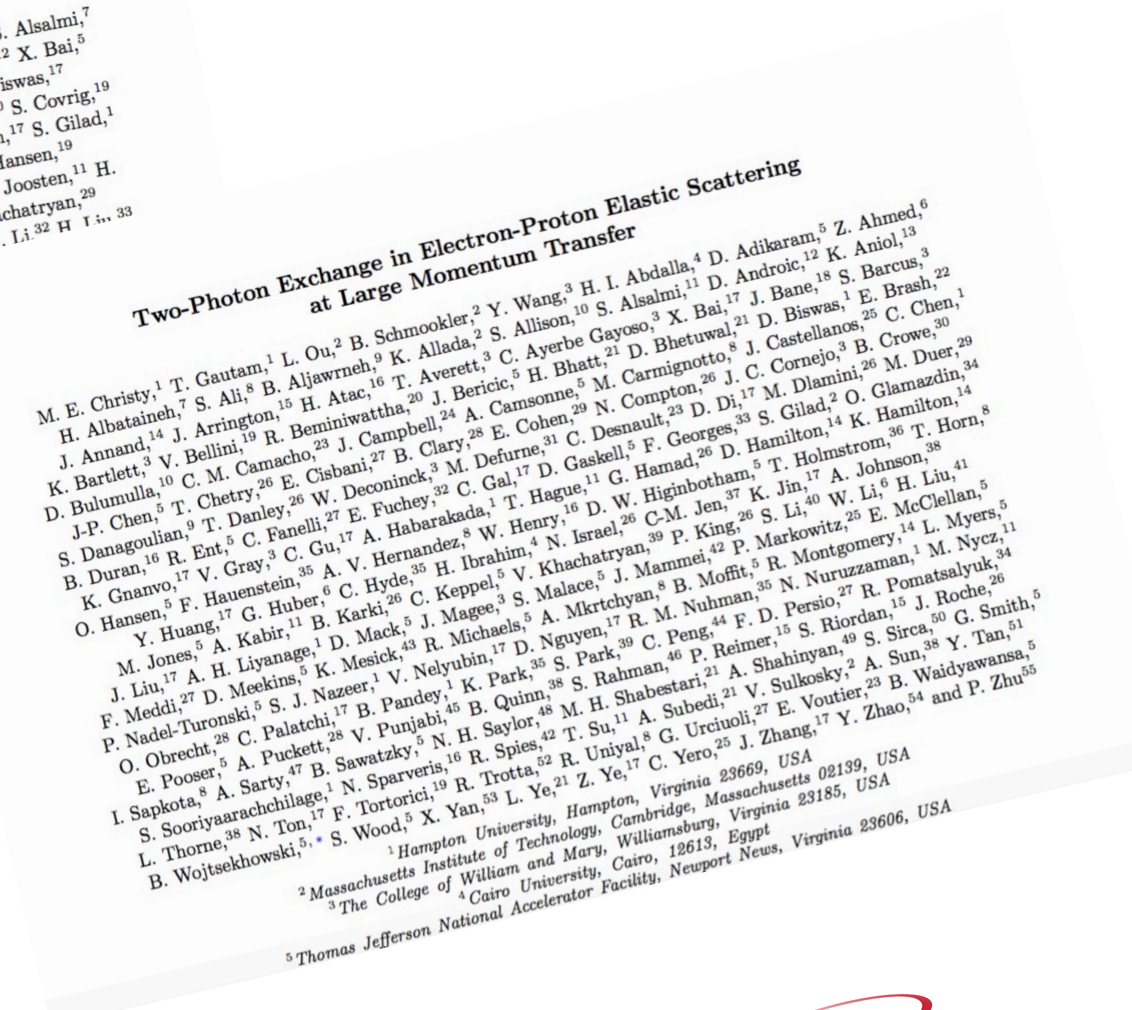
[nucl-ex] 3 May 2020



Two-Photon Exchange in Electron-Proton Elastic Scattering at Large Momentum Transfer

M. E. Christy,[1] T. Gautam,[1] L. Ou,[2] B. Schmookler,[2] Y. Wang,[3] H. I. Abdalla,[4] D. Adikaram,[5] Z. Ahmed,[6] H. Albataineh,[7] S. Ali,[8] B. Aljawrneh,[9] K. Allada,[2] S. Allison,[10] S. Alsalmi,[11] D. Androic,[12] K. Aniol,[13] J. Annand,[14] J. Arrington,[15] H. Atac,[16] T. Averett,[3] C. Ayerbe Gayoso,[3] X. Bai,[17] J. Bane,[18] S. Barcus,[3] K. Bartlett,[3] V. Bellini,[19] R. Beminiwattha,[20] J. Bericic,[5] H. Bhatt,[21] D. Bhetuwal,[21] D. Biswas,[1] E. Brash,[22] D. Bulumulla,[10] C. M. Camacho,[23] J. Campbell,[24] A. Camsonne,[5] M. Carmignotto,[8] J. Castellanos,[25] C. Chen,[1] J-P. Chen,[5] T. Chetry,[26] E. Cisbani,[27] B. Clary,[28] E. Cohen,[29] N. Compton,[26] J. C. Cornejo,[3] B. Crowe,[30] S. Danagoulian,[9] T. Danley,[26] W. Deconinck,[3] M. Defurne,[31] C. Desnault,[23] D. Di,[17] M. Dlamini,[26] M. Duer,[29] B. Duran,[16] R. Ent,[5] C. Fanelli,[27] E. Fuchey,[32] C. Gal,[17] D. Gaskell,[5] F. Georges,[33] S. Gilad,[2] O. Glamazdin,[34] K. Gnanvo,[17] V. Gray,[3] C. Gu,[17] A. Habarakada,[1] T. Hague,[11] G. Hamad,[26] D. Hamilton,[14] K. Hamilton,[14] O. Hansen,[5] F. Hauenstein,[35] A. V. Hernandez,[8] W. Henry,[16] D. W. Higinbotham,[5] T. Holmstrom,[36] T. Horn,[8] Y. Huang,[17] G. Huber,[6] C. Hyde,[35] H. Ibrahim,[4] N. Israel,[26] C-M. Jen,[37] K. Jin,[17] A. Johnson,[38] M. Jones,[5] A. Kabir,[11] B. Karki,[26] C. Keppel,[5] V. Khachatryan,[39] P. King,[26] S. Li,[40] W. Li,[6] H. Liu,[41] J. Liu,[17] A. H. Liyanage,[1] D. Mack,[5] J. Magee,[3] S. Malace,[5] J. Mammei,[42] P. Markowitz,[25] E. McClellan,[5] F. Meddi,[27] D. Meekins,[5] K. Mesick,[43] R. Michaels,[5] A. Mkrtchyan,[8] B. Moffit,[5] R. Montgomery,[14] L. Myers,[5] P. Nadel-Turonski,[5] S. J. Nazeer,[1] V. Nelyubin,[17] D. Nguyen,[17] R. M. Nuhman,[35] N. Nuruzzaman,[1] M. Nycz,[11] O. Obrecht,[28] C. Palatchi,[17] B. Pandey,[1] K. Park,[35] S. Park,[39] C. Peng,[44] F. D. Persio,[27] R. Pomatsalyuk,[34] E. Pooser,[5] A. Puckett,[28] V. Punjabi,[45] B. Quinn,[38] S. Rahman,[46] P. Reimer,[15] S. Riordan,[15] J. Roche,[26] I. Sapkota,[8] A. Sarty,[47] B. Sawatzky,[5] N. H. Saylor,[48] M. H. Shabestari,[21] A. Shahinyan,[49] S. Sirca,[50] G. Smith,[5] S. Sooriyaarachchilage,[1] N. Sparveris,[16] R. Spies,[42] T. Su,[11] A. Subedi,[21] V. Sulkosky,[2] A. Sun,[38] Y. Tan,[51] L. Thorne,[38] N. Ton,[17] F. Tortorici,[19] R. Trotta,[52] R. Uniyal,[8] G. Urciuoli,[27] E. Voutier,[23] B. Waidyawansa,[5] B. Wojtsekhowski,[5,*] S. Wood,[5] X. Yan,[53] L. Ye,[21] Z. Ye,[17] C. Yero,[25] J. Zhang,[17] Y. Zhao,[54] and P. Zhu[55]

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