

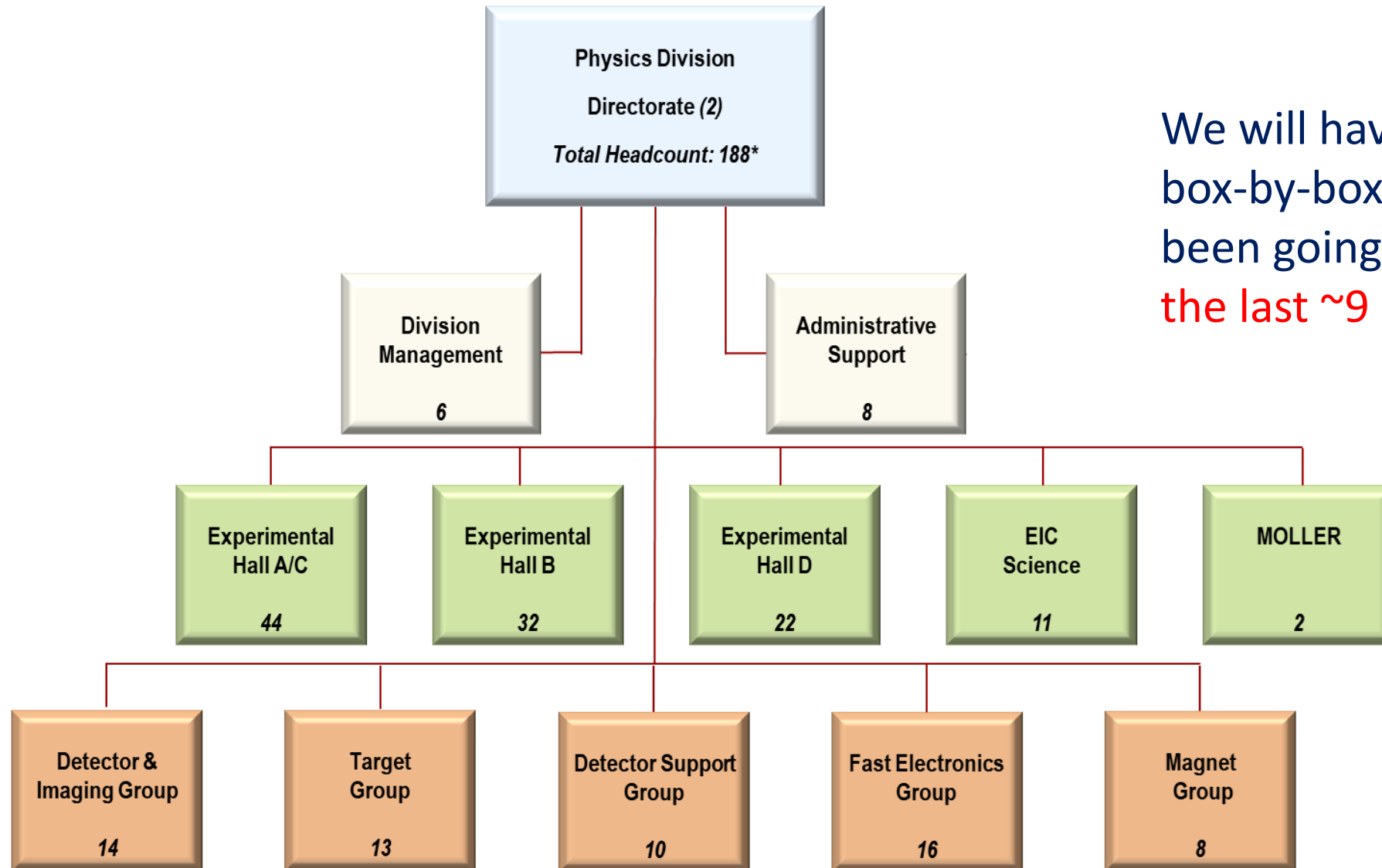


Input from Jlab Physics Division

Cynthia Keppel, Associate Director for Experimental Physics

SoLID Collaboration Meeting
Argonne National Laboratory
June 21, 2024

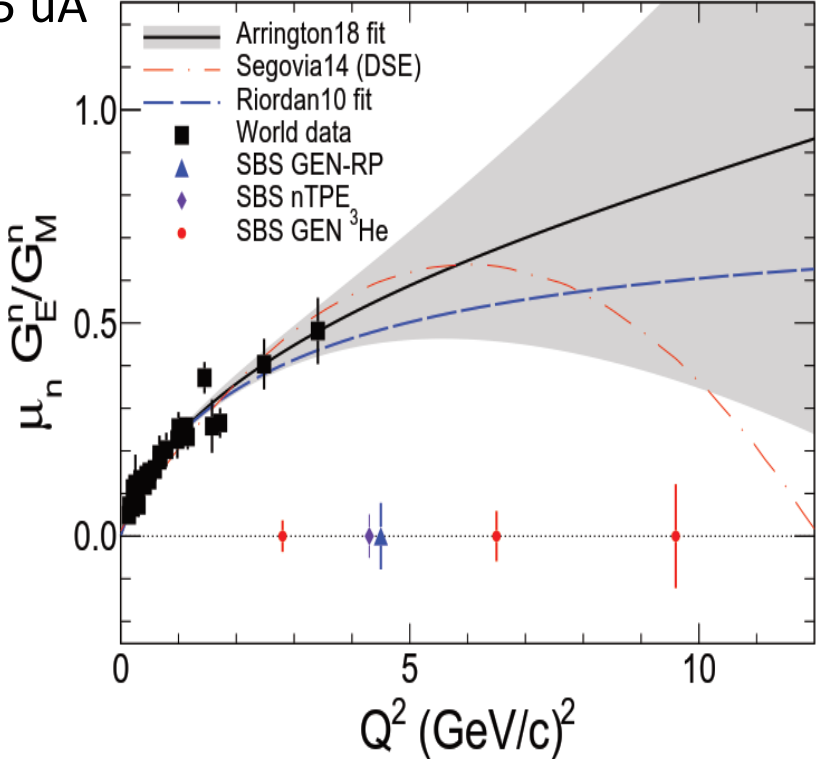
Organization: Experimental Physics Division



We will have a look box-by-box what's been going on over the last ~9 months

Hall A: Completed Neutron Electric Form Factor Experiments

- 60cm long polarized helium cell at 50% polarization at 45 uA
- Highest Figure-of-merit ever achieved!
- 6 graduate students on the experiment.



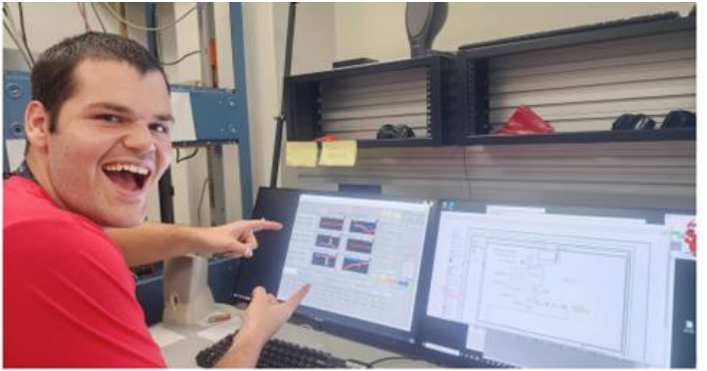
These experiments will clearly differentiate between fundamental approaches to QCD.



Gary is installing target oven



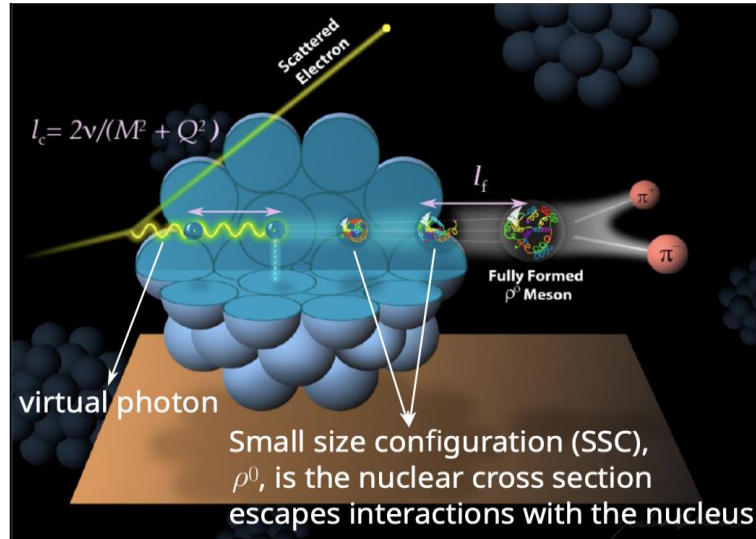
Kate with the 3He target cell



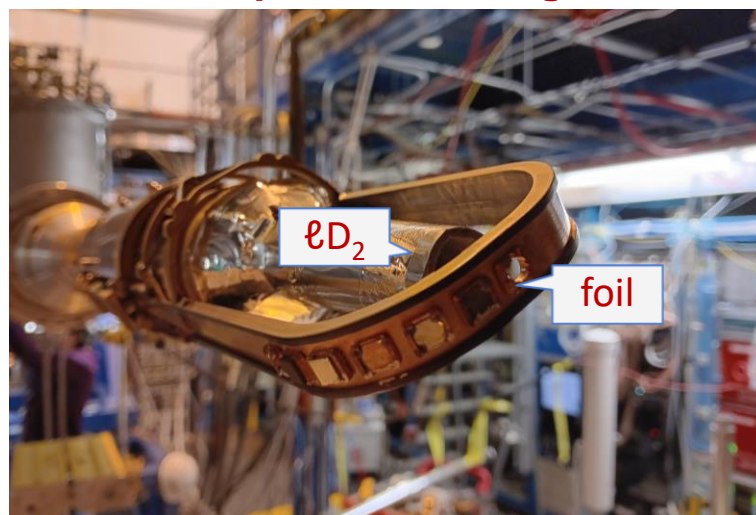
Hunter is excited about the first NMR measurement

Highlights from Hall B

Run Group D physics concept

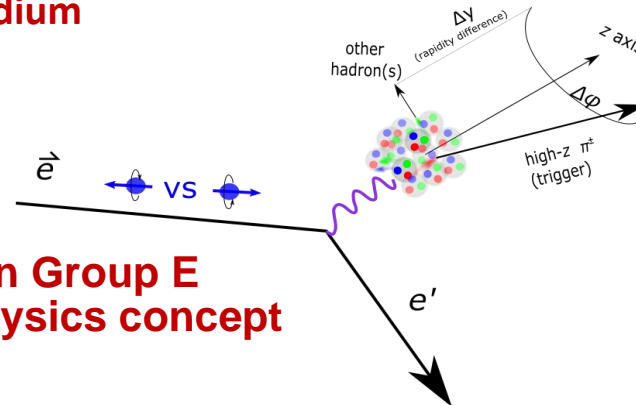


Run Group E double target



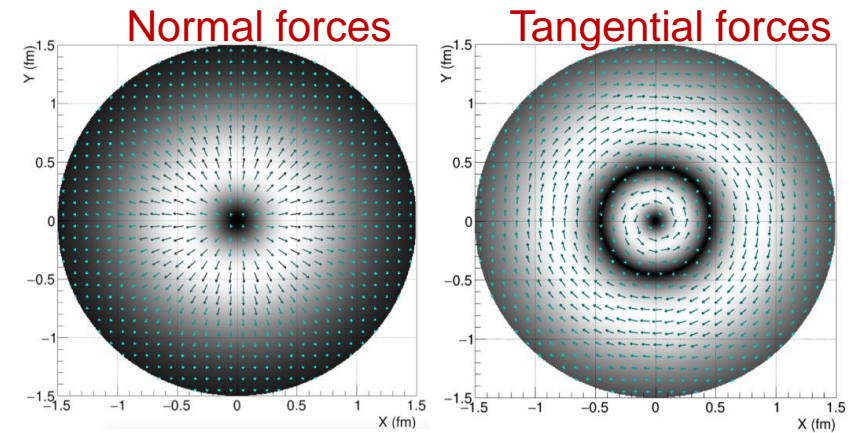
- Run Group D took data for two months with ℓD_2 and nuclear target foil assembly to measure ρ^0 -meson production for a study of **color transparency**
- Run Group K took data for two months with ℓH_2 at lower beam energies and reaching the **highest momentum resolutions** in CLAS12 for **baryon spectroscopy**
- Run Group E taking data with ℓD_2 and nuclear targets *simultaneously* to allow cancellation of systematic uncertainties in study of **quark hadronization in nuclear medium**

Run Group E physics concept



Recent publications:

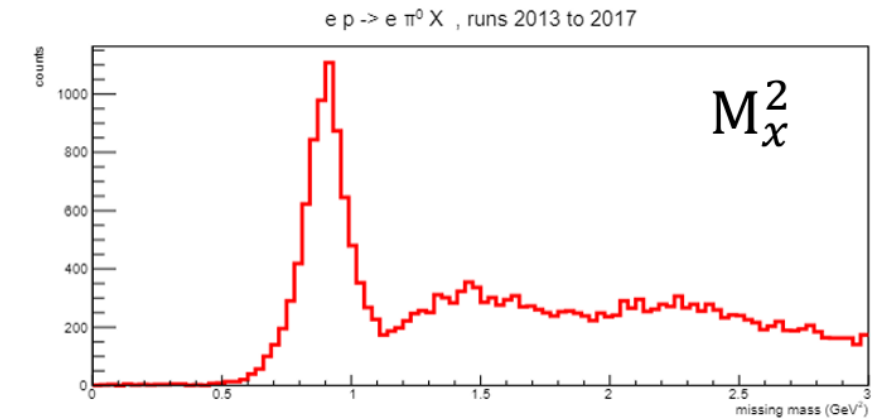
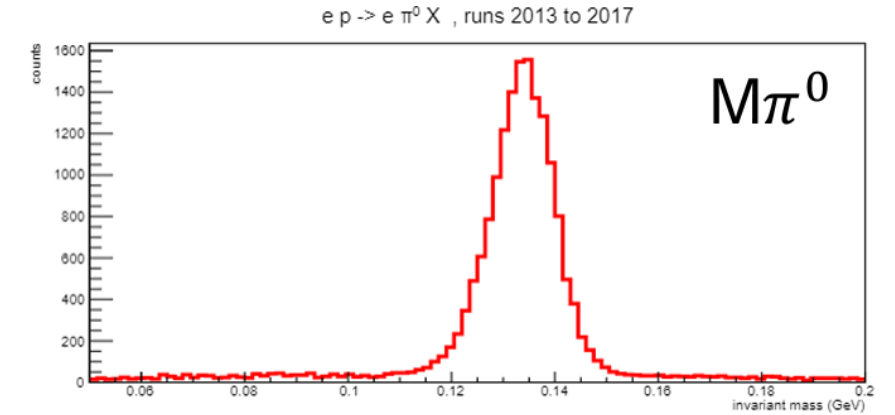
- V. D. Burkert et al., “Colloquium: Gravitational form factors of the proton”, Rev. Mod. Phys. 95, 041002 (22 Dec 2023), news release “Gravity Helps Show Strong Force Strength in the Proton”.



- Andrey Kim et al. (CLAS Collaboration), “Beam spin asymmetry measurements of deeply virtual π^0 production with CLAS12”, Phys. Lett. B 849, 138459 (Feb. 2024).
- Iu. A. Skorodumina et al. (CLAS Collab), “Double-pion electroproduction off protons in deuterium: Quasifree cross sections and final state interactions”, arXiv:2308.13962, accepted in Phys. Rev. C.

Hall C: Ran 4 experiments with the new Neutral Particle Spectrometer (NPS)

- NPS is calorimeter of 1080 PbWO4 crystals behind a 0.6 Tm sweeping magnet on platform attached to SHMS
- NPS detects photons and π^0 . In coincidence with HMS simultaneously measure DVCS and π^0 production.



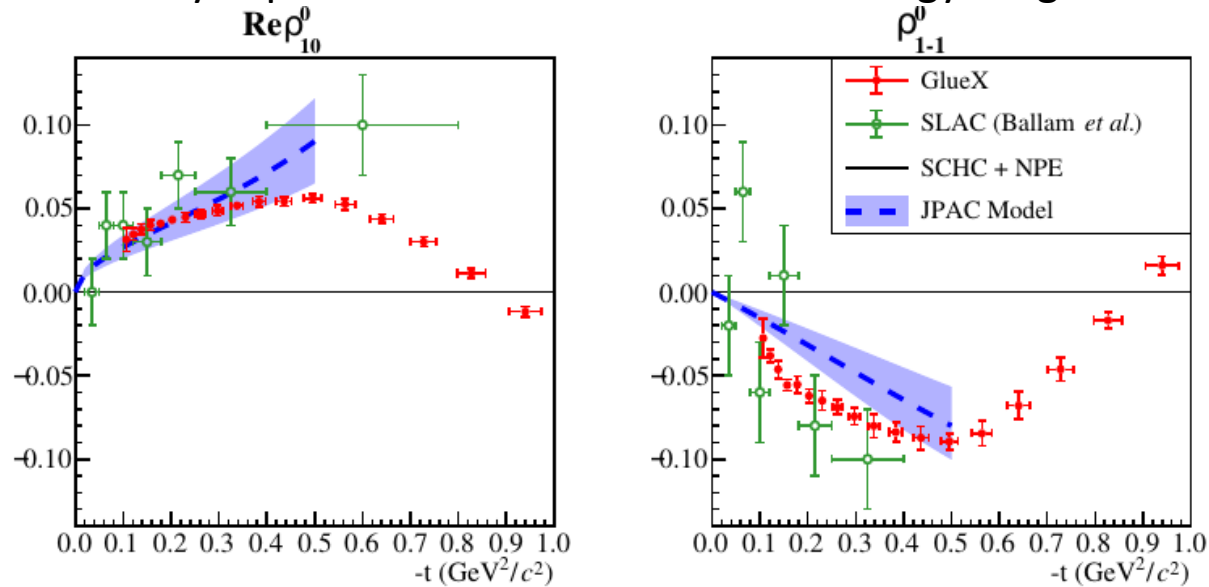
Highlights from Hall D

GlueX Collaboration, PRC 108, 055204 (Nov 2023)

Measurement of SDME in $\rho(770)$ production by linearly polarized photons at 8.2-8.8 GeV

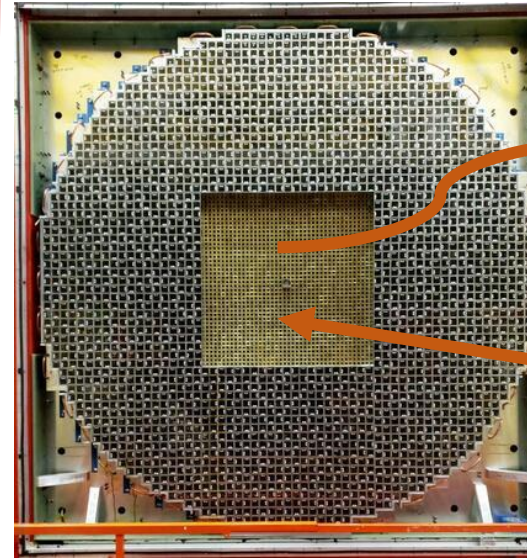
$$\gamma p \rightarrow \rho^0 p$$

- Enables modeling of resonances production at ≈ 9 GeV
- Lays the foundation for hybrid meson search: good comparison of the SDME analysis results with the amplitude analysis results
- Greatly supersedes the old data in this energy range



GlueX: 5 PhD dissertations have been defended in 2024 Jan-Apr

FCAL upgrade for GlueX-II+JEF



Removed
400 lead glass
modules

Inserted
1600 PbWO₄
modules

PbWO₄ crystals:
- Twice better resolution than lead glass
- Radiation hardness

A year-long, major upgrade
Could restart of running in Fall 2024

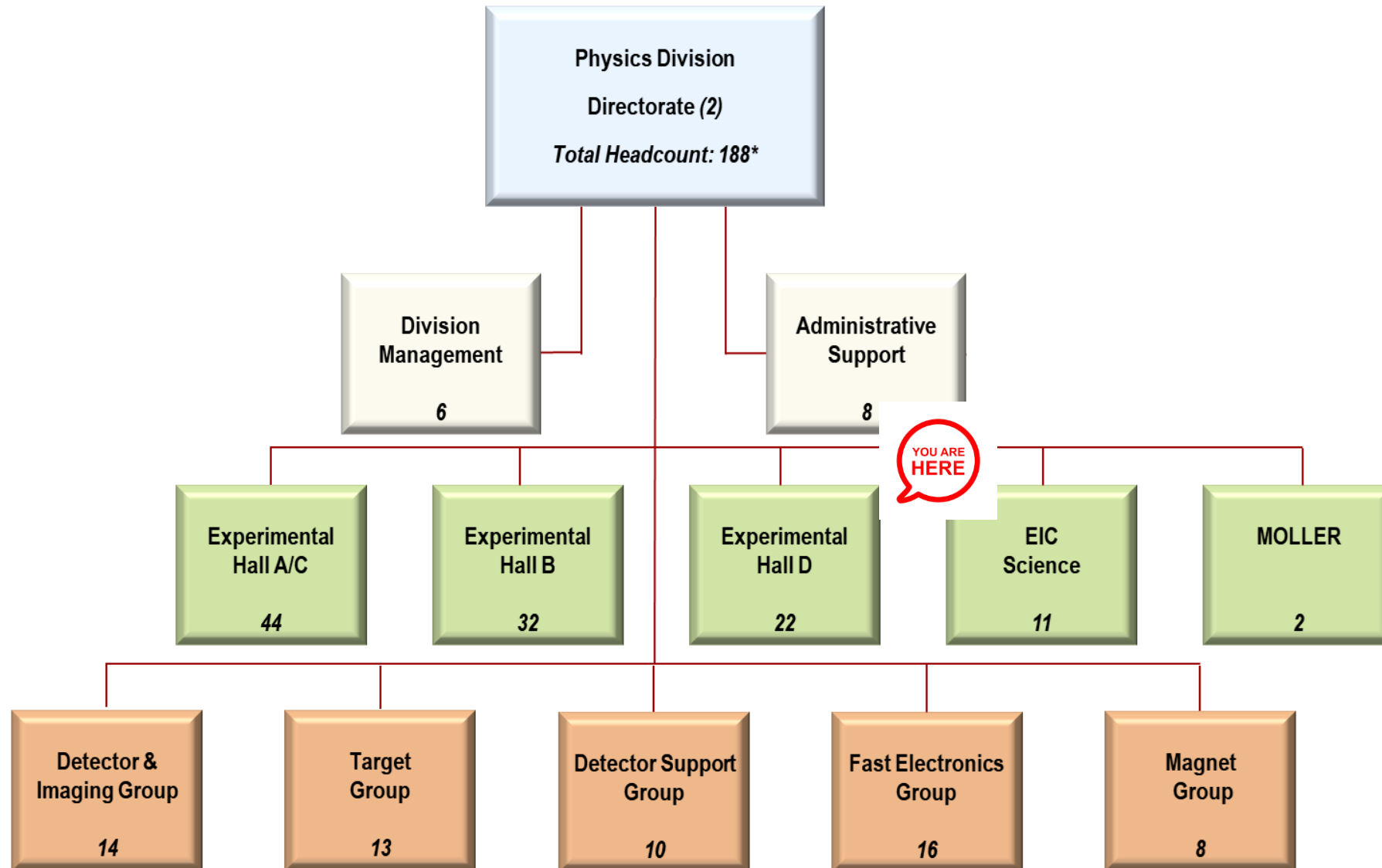
4 days opportunistic Hall D run in March, 2024



Using Pair Spectrometer for detector testing

Beam restoration to Hall D after a year break
Testing GEM-TRD prototype
Goal: better PID for charmonia studies

Organization: Physics Division

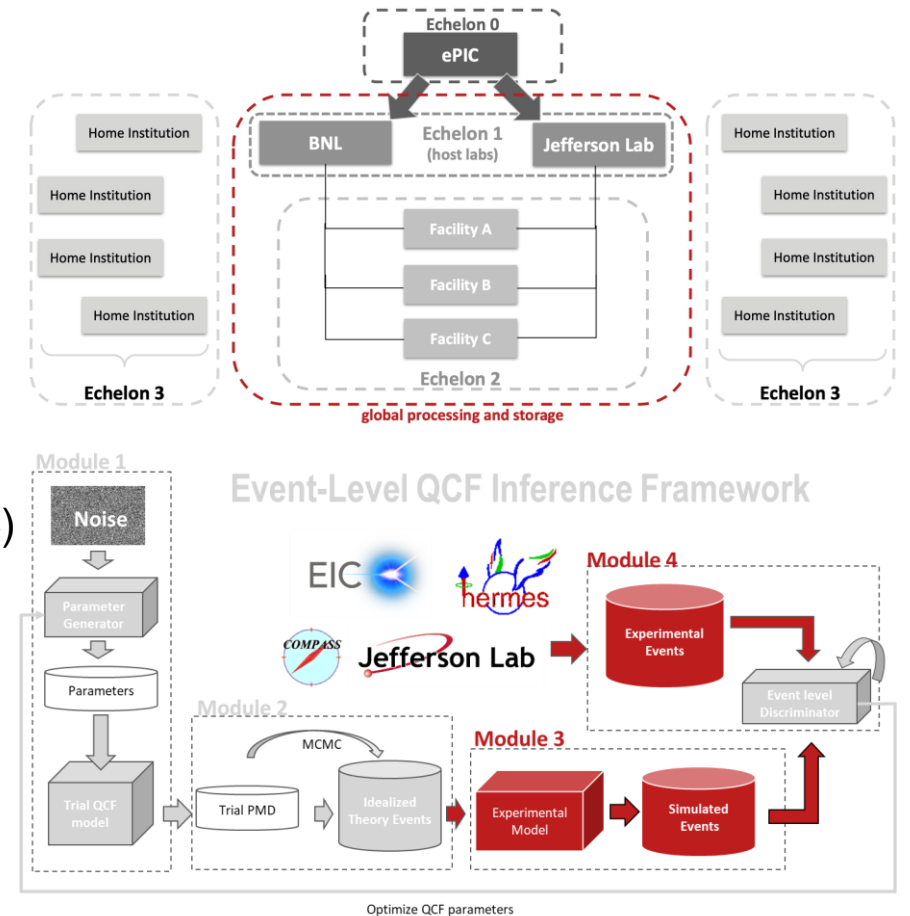


EIC Science Group

The mission of Jefferson Lab's Electron-Ion Collider (EIC) Group is to **advance the science program of the EIC**, to **support the EIC project**, and to **provide a regional hub for analyzing future EIC data**.

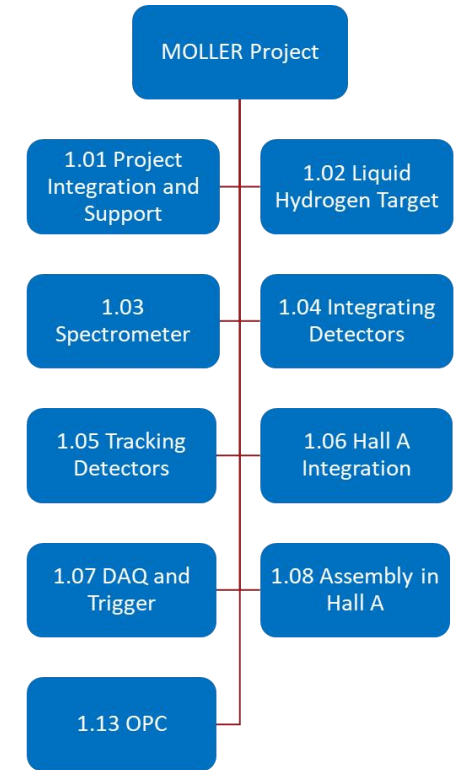
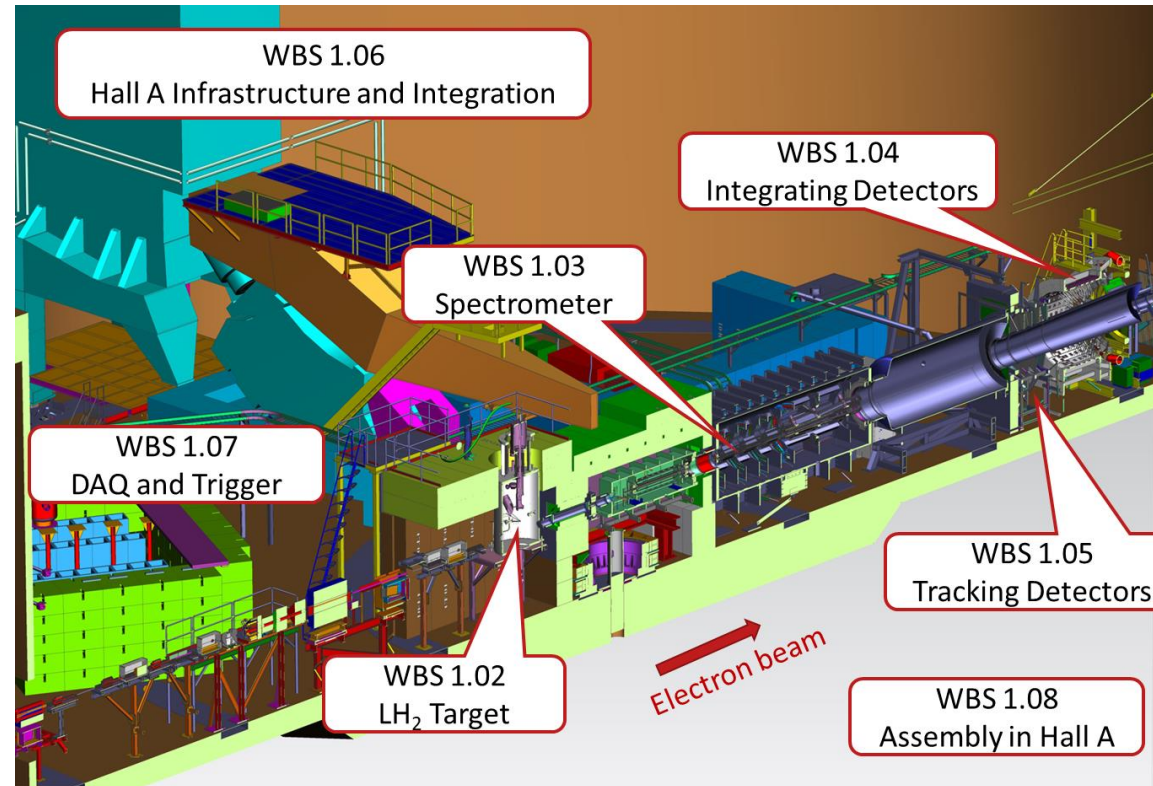
- **Support the EIC project = EIC detector**; scientific guidance; international outreach; ePIC collaboration roles and responsibilities.

- JLab leads the EIC detector and international engagement to success
 - CAMs of tracking, particle id, magnet, electronics, DAQ, IR/auxiliary detectors.
 - External peer reviews have uniformly praised detector progress.
 - Magnet construction will be in-kind. Successful start of RRBs.
 - Synergy with JLab advanced computing vision (streaming, AI, HPDF).
- JLab leads the computing and software efforts in EIC
 - JLab (Physics, CST) introduced ePIC computing model for rapid data processing.
 - Defined milestones for implementation, featuring streaming readout, AI, and heterogeneous computing. Started development of streaming computing prototype.
 - Synergy with SoLID.
- QuantOm: 3D Imaging of Quarks and Gluons using AI and Exascale (SciDAC)
 - Advance multidimensional data challenge of 3D Imaging in joint experimental-theoretical workflow at the event level.
 - Synergy with ANL and JLab Theory Group; EIC Group leads experimental aspects.
 - First physics publication in preparation that describes QuantOm workflow in detail.
 - Next step: Test and validate workflow with existing Hall C DIS measurements.
- Leads development of novel GEM-based Transition Radiation Detector
 - Synergy with Hall D.
 - Successful beam tests at JLab/Hall D, FNAL and CERN.
 - Interest at CERN for forward PID instrumentation and with MPGD community.



MOLLER Experiment: Precision Standard Model Test

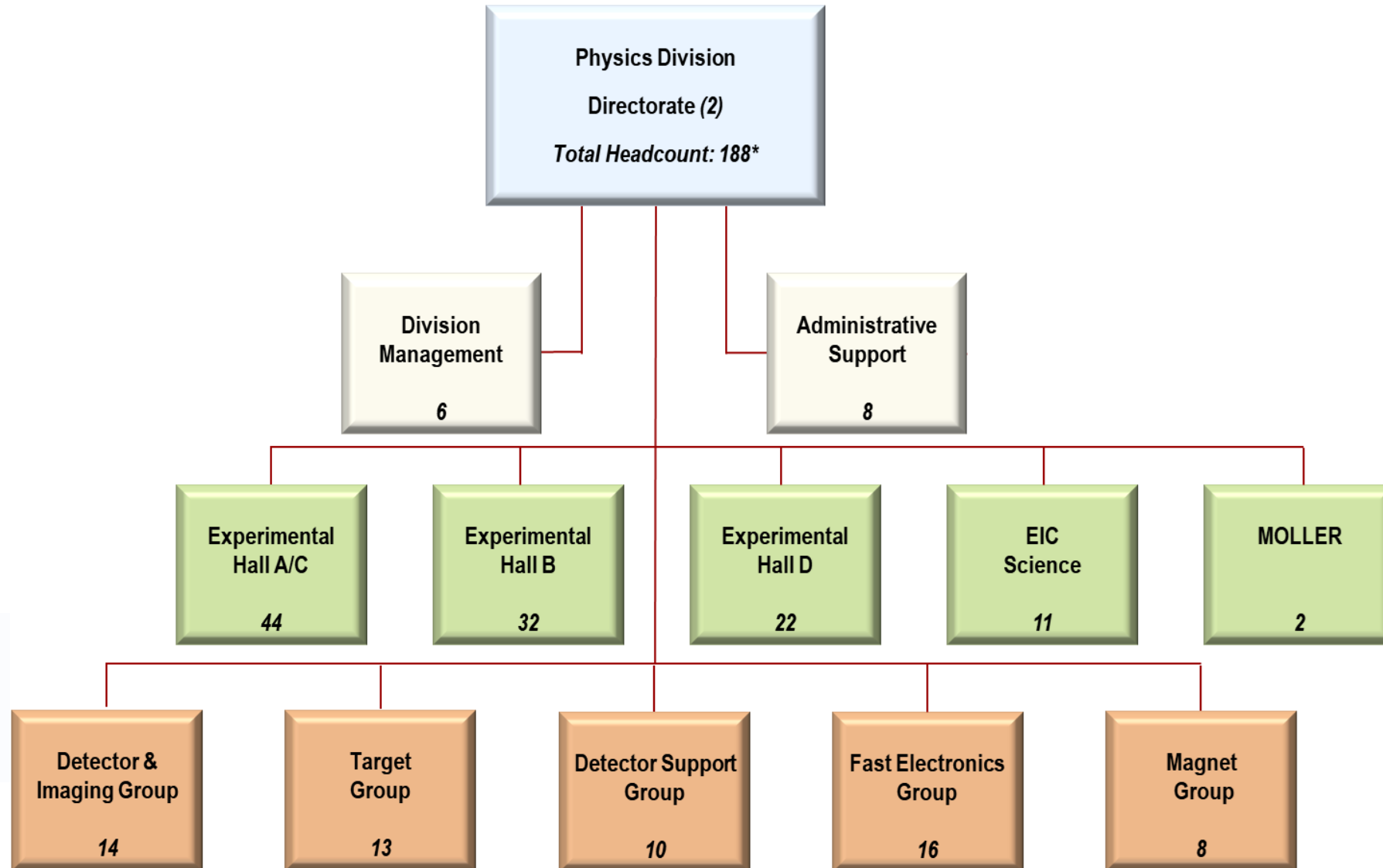
Measurement of parity violating asymmetry, A_{PV} , in electron-electron scattering, and thus the weak charge of the electron, Q_W^e



Level 1 Milestone	Schedule
CD-0, Approve Mission Need	11/18/2016 (actual)
CD-1, Approve Alternative Selection and Cost Range	12/15/2020 (actual)
CD-3A, Approve Long Lead Procurements	03/28/2023 (actual)
CD-2/CD-3, Approve Performance Baseline/Start of Construction	Q3 FY24
CD-4, Approve Project Completion	Q2 FY28

MOLLER CD-2/3
ESAAB Review
May 28, 2024

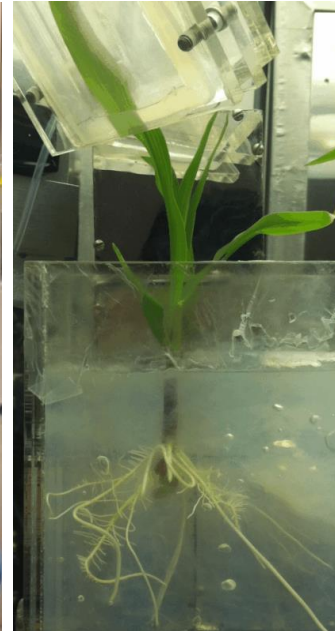
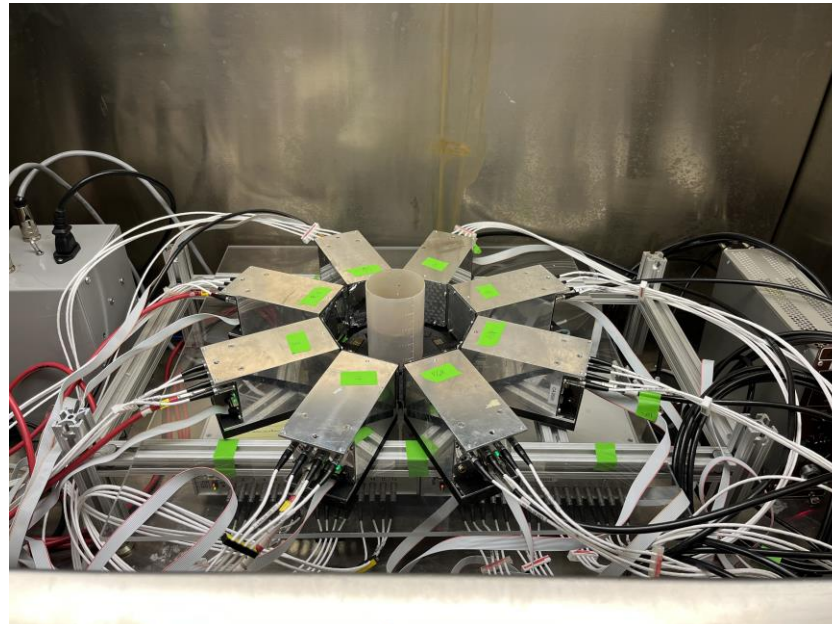
Organization: Physics Division



YOU
ARE HERE

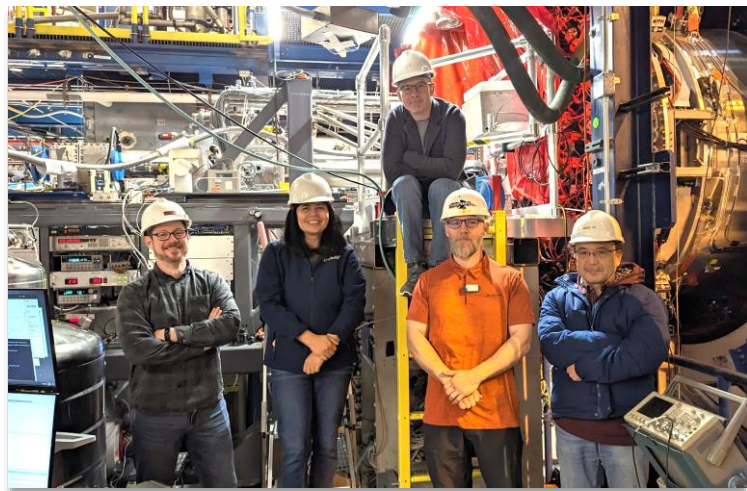
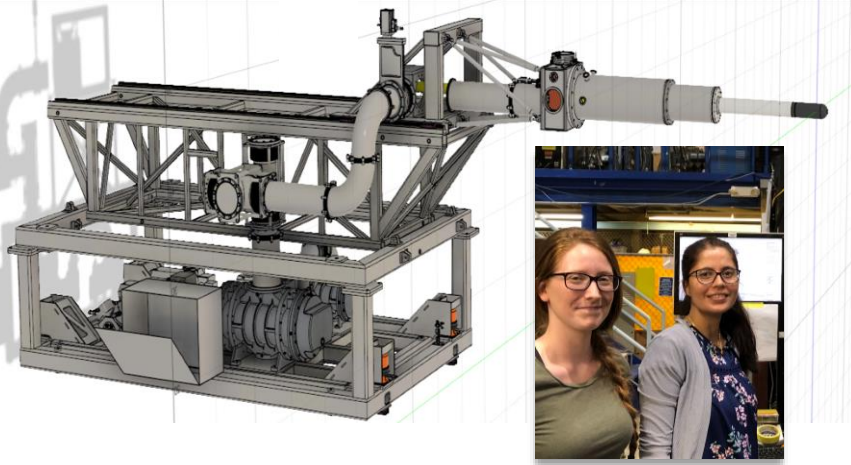
Detector and Imaging Group

“Phyto” PET Instrumentation Project UC Santa Cruz: *Department of Electrical & Computer Engineer*, Stanford University: *Stanford Center for Innovation in In Vivo Imaging* and Jefferson Lab



Dr. Shiva Abbaszadeh's team and Jefferson Lab collaborators at Stanford's Radiochemistry Lab

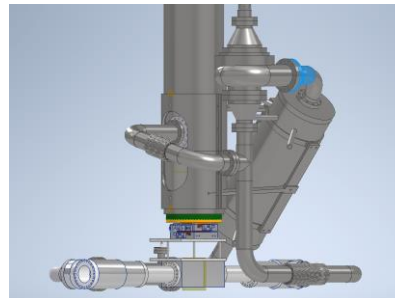
Target Group



CLAS12 Dynamically Polarized Target

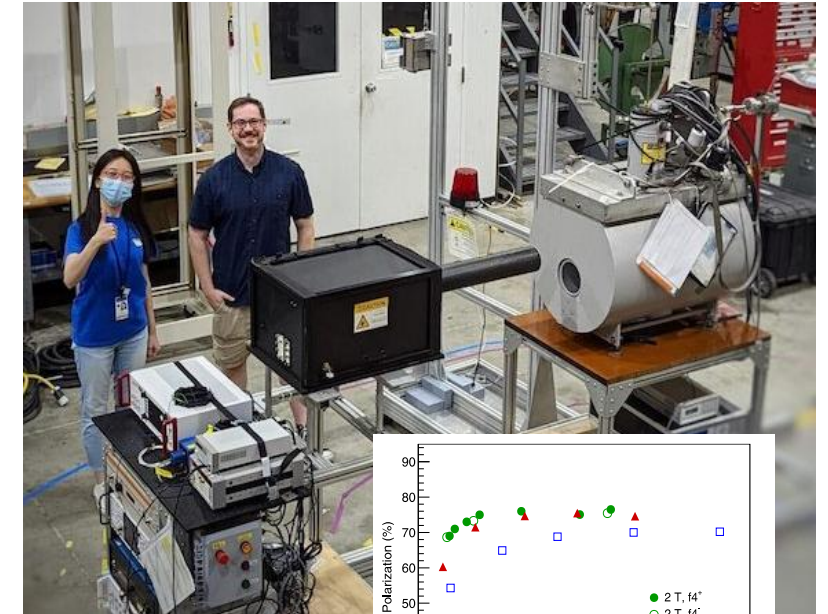
- Proton polarization → 90%
- Deuteron polarization → 55*%
- 132 days of continuous operation
- **Only 4 days of maintenance**
- Two PhD theses

*A record for electron beam experiments



Liquid Hydrogen Target for MOLLER

- **The most powerful LH2 target ever built**
- Design and CD2 procurements complete
- Construction to commence upon CD2 approval



High Field Polarized ^3He Target

- Developing the first polarized ^3He target for high-field spectrometers (CLAS, Hall D)
- Metastability Exchange Optical Pumping
- **75% polarization demonstrated at 3 Tesla**



Detector Support Group



Amrit Yegneswaran
– Group Leader



Aaron Brown
NPS controls



Marc McMullen & Pablo Campero
LAPPD Test Stand



Mindy Leffel
CLEO-III
Instrumentation



Brian Eng & George Jacobs
EIC beampipe Test stand



Tyler Lemon
DIRC bar testing



Peter Bonneau
EPICS Phoebus Alarm



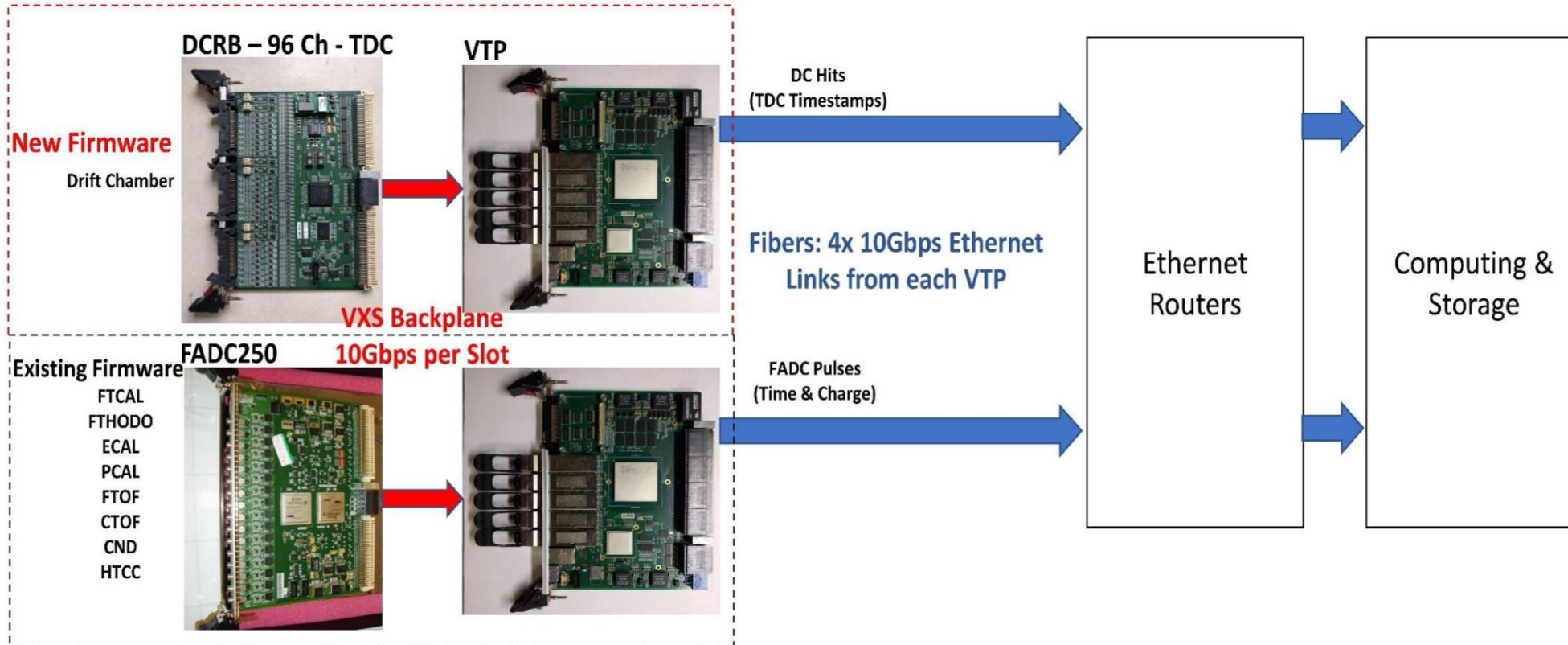
Mary Ann Antonioli
NPS controls

Recent Contributions: NPS controls, LAPPD test stand, EIC-Beampipe test stand, EIC-DIRC quartz bar QA, EPIC Phoebus alarm handler, ECAL controls, CLEO-II magnet instrumentation, GEM detector controls, and Moller magnet instrumentation

Notes and Talks posted on the [DSG website](#)

VXS Trigger Processor – Streaming ReadOut Adding 96 Channel Drift Chamber Readout Board TDC

Front-end Crates



- FADC250 streaming support (pulse charge & time) already supported
- DCRB streaming support expected ready soon (1 or 2 weeks out) for CLAS12 beam test
- Will be first streaming test in CLAS12 with calorimeters, Cherenkov, and Drift Chambers for large triggerless DAQ

MOLLER

1st out of 5 Magnet Power Supply



The MPS successfully commissioned and tested with the prototype SC4 coil. This was the first high power test of MOLLER coil(s). The coil was run at the MPS maximum output 3900A this is 116% of nominal design .

MPS Commissioning team



MOLLER Space in Test Lab (April 2024)

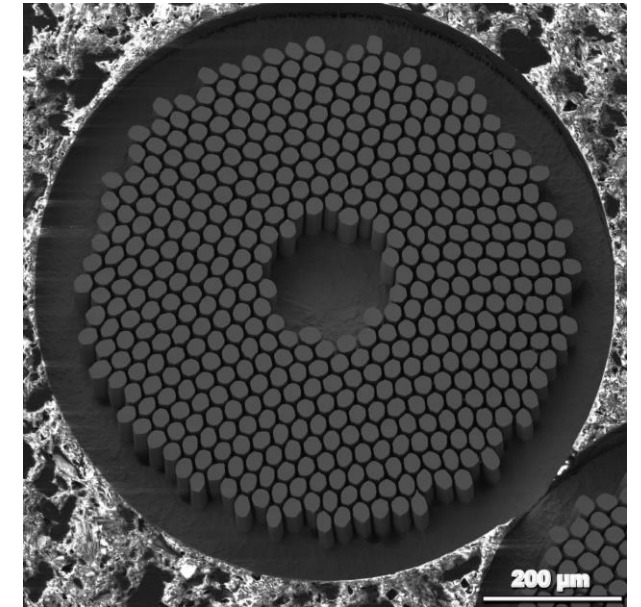


5x SC1-SC3 production Coils and 3 prototypes



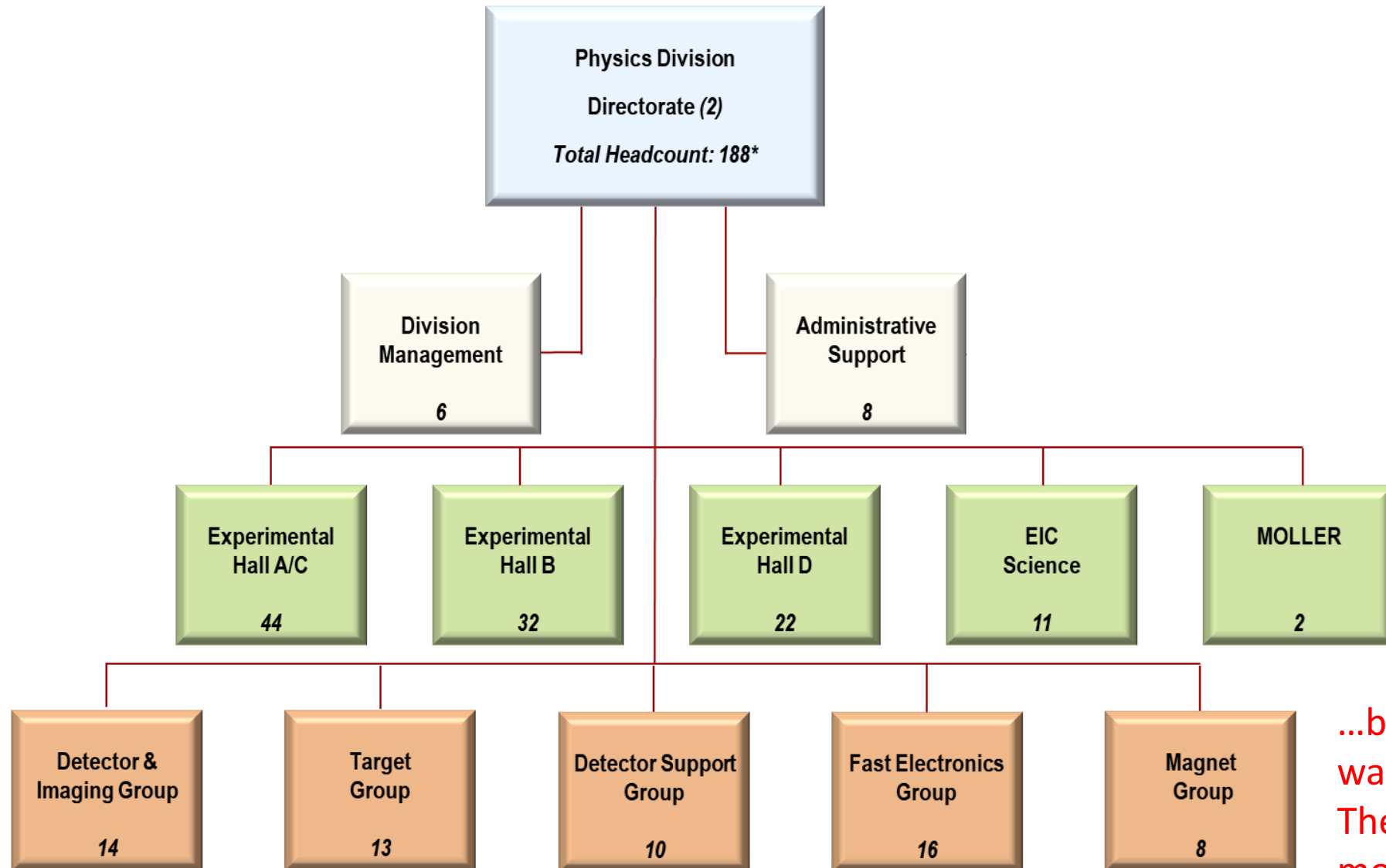
EIC – Detector Solenoid (Conductor)

Solenoid conductor finalized using Rutherford cable made of 22 strands of 0.847mm diameter, soldered in copper channel. Scanning Electron Microscopy (SEM) shows high quality filament



Cu/Sc = 1.31049
Filament diameter = $24.6 \pm 1 \mu\text{m}$
Strand diameter = $843.8 \mu\text{m}$

Organization: Physics Division

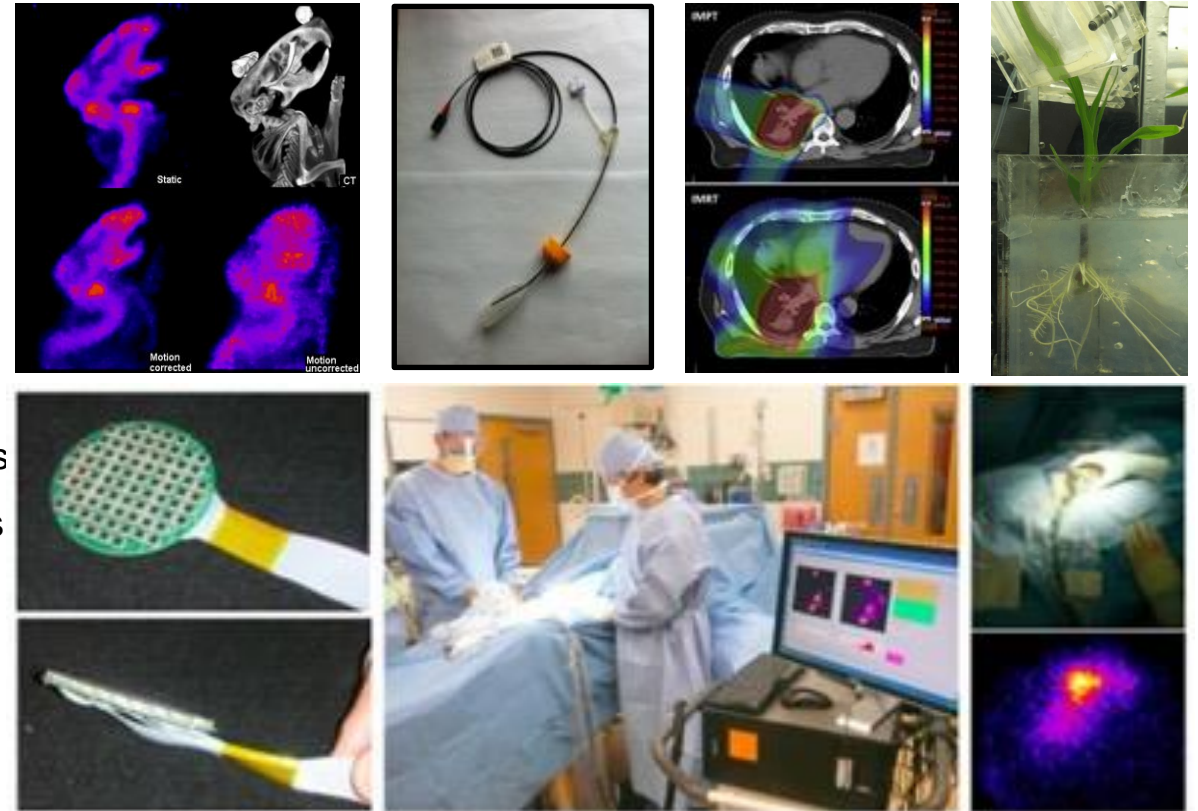


...but
wait!
There's
more!....

Detector R&D (NP Applications)

US-based MicroPattern Gaseous Detector Facility - A Community User Resource

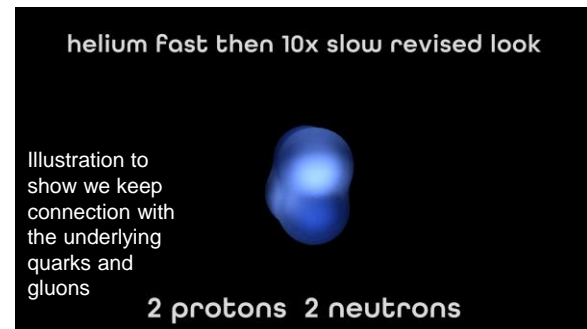
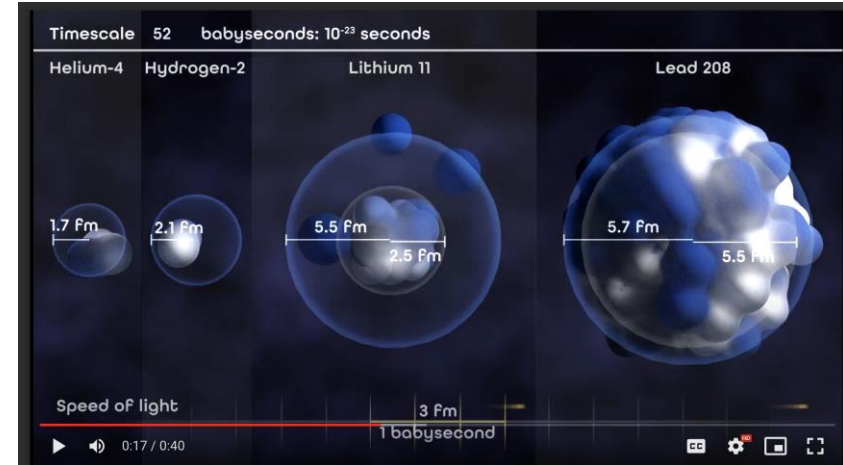
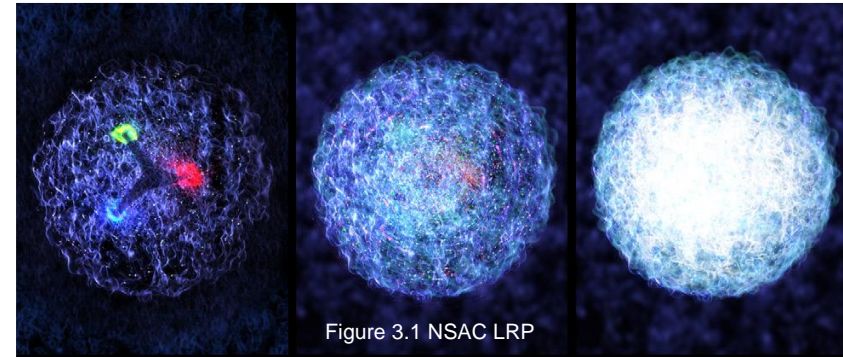
- Large number of US institutions engaged in MPGD activities
 - Limited inter-disciplinary interaction between the institutions
- The community needs a dedicated US-based MPGD User Facility with a:
 - Production workshop like to the SiDet Facility for at FNAL
 - Detector R&D Lab like the RD51 / GDD Lab at CERN
- US-MPGD center will be greatly beneficial for EIC detector development
- Jefferson Lab is an excellent place for an MPGD center in the US
 - At the forefront in the deployment of large MPGDs in NP experiments
 - In-house MPGD expertise and beam test capabilities for MPGD tests



**Leveraging nuclear science
capabilities for biomedical applications**

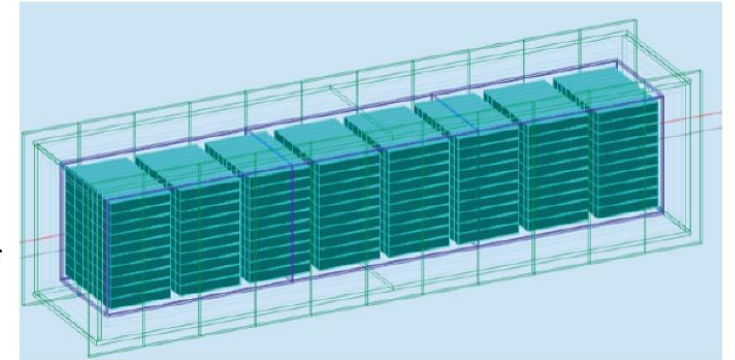
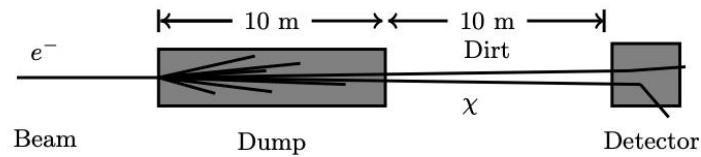
Visualization of Proton and Nucleus Structure

- Led by Jefferson Lab and MIT
- Charting the inner structure of the proton
 - <https://www.youtube.com/watch?v=G-9l0buDi4s>
 - 46K views to date
 - Graphics widely used, e.g. by PBS Space Time with 2M views
 - Graphics highlighted in 2023 NSAC LRP
- Visualizing the proton – a documentary
 - <https://www.youtube.com/watch?v=e2FrALuacZ4&t=5s>
 - 10K views to date
- Ongoing: visualizing the nucleus
 - Motion and binding animations complete, defined length and time reference
 - Various nuclei animated, can zoom in to see underlying quark-gluon structure
 - Next steps: neutron skins, halo nuclei, rotational and vibrational collective motion
 - Further ongoing: 9 posters on Modeling the Structure of Matter Throughout History
 - Goal is to release at 2024 Fall Division of Nuclear Physics meeting @ MIT

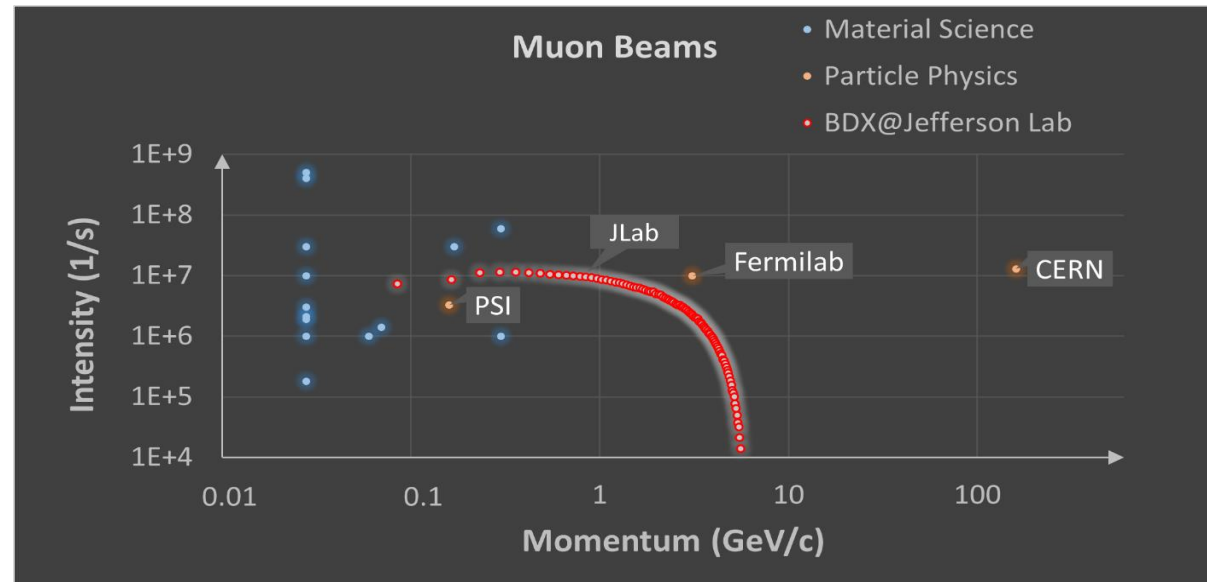


BDX and Secondary Beam Capability Behind Hall A

The Beam Dump Experiment (BDX) at Jefferson Laboratory (JLab) is an electron-beam thick-target experiment to search for Light Dark Matter (LDM) particles in the MeV-GeV mass range



Muons and neutrinos that penetrate the shielding form high-intensity secondary beams. Monte Carlo simulations of muons produced have been performed (M. Battaglieri et al., *Secondary Beams at High-Intensity Electron Accelerator Facilities*, Instruments 8, 1 (2024), <https://doi.org/10.3390/instruments8010001>.)



Is this a new JLab (HEP) Physics program? Look for 'BDX and Beyond' workshop being planned at JLab for this Fall/Winter!

We are also planning for the long-term future of Jefferson Lab.

- CEBAF @ 22 GeV**
- Program developed through a series of workshops in 2022-2023
 - Next one at LNF-INFN (Italy) December 9-13, 2024



arXiv > nucl-ex > arXiv:2306.09360

Accepted for publication in EPJA

Nuclear Experiment

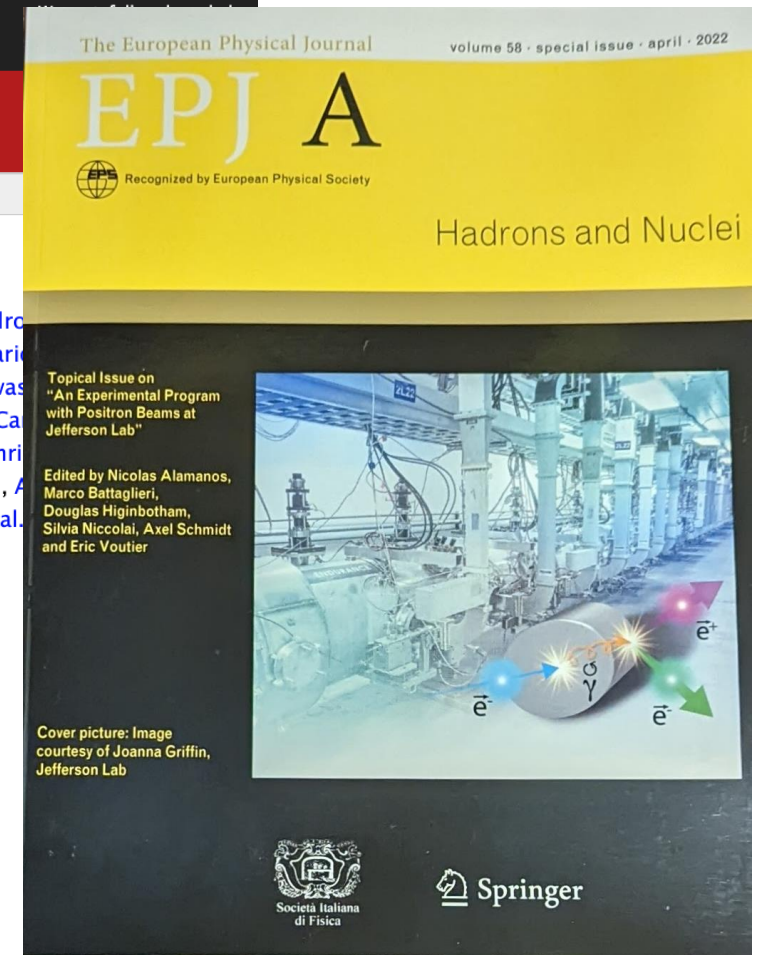
[Submitted on 13 Jun 2023 (v1), last revised 24 Aug 2023 (this version, v2)]

Strong Interaction Physics at the Luminosity Frontier with 22 GeV Electrons at Jefferson Lab

A. Accardi, P. Achenbach, D. Adhikari, A. Afanasev, C.S. Akondi, N. Akopov, M. Albaladejo, H. Albataineh, M. Albrecht, B. Almeida-Zamora, M. Amarian, D. Andre...
D.S. Armstrong, M. Arratia, J. Arrington, A. Asaturyan, A. Austregesilo, H. Avagyan, T. Averett, C. Ayerbe Gayoso, A. Bacchetta, A.B. Balantekin, N. Baltzell, L. Bari...
Bashir, M. Battaglieri, V. Bellini, I. Belov, O. Benhar, B. Benkel, F. Benmokhtar, W. Bentz, V. Bertone, H. Bhatt, A. Bianconi, L. Bibrzycki, R. Bijker, D. Binosi, D. Biswas...
S.A. Bogacz, M. Boggione, M. Bondí, E.E. Boos, P. Bosted, G. Bozzi, E.J. Brash, R. A. Briceño, P.D. Brindza, W.J. Briscoe, S.J. Brodsky, W.K. Brooks, V.D. Burkert, A. Ca...
Cardman, D.S. Carman, M. Carpinelli, G.D. Cates, J. Caylor, A. Celentano, F.G. Celiberto, M. Cerutti, Lei Chang, P. Chatagnon, C. Chen, J-P Chen, T. Chetry, A. Chri...
Chudakov, E. Cisbani, I. C. Cloët, J.J. Cobos-Martinez, E. O. Cohen, P. Colangelo, P.L. Cole, M. Constantinou, M. Contalbrigo, G. Costantini, W. Cosyn, C. Cotton, A...
Dusa, V. Crede, Z.-F. Cui, A. D'Angelo, M. Döring, M. M. Dalton, I. Daniilkin, M. Davydov, D. Day, F. De Fazio, M. De Napoli, R. De Vita, D.J. Dean, M. Defurne et al...
authors not shown)

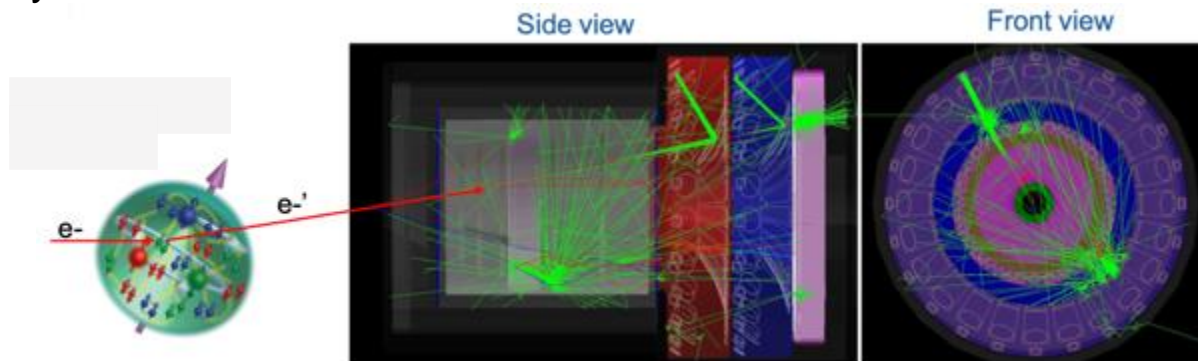
[2306.09360](https://arxiv.org/abs/2306.09360) [nucl-ex] 444 authors

**CEBAF @ 12 GeV
With a Positron Beam**

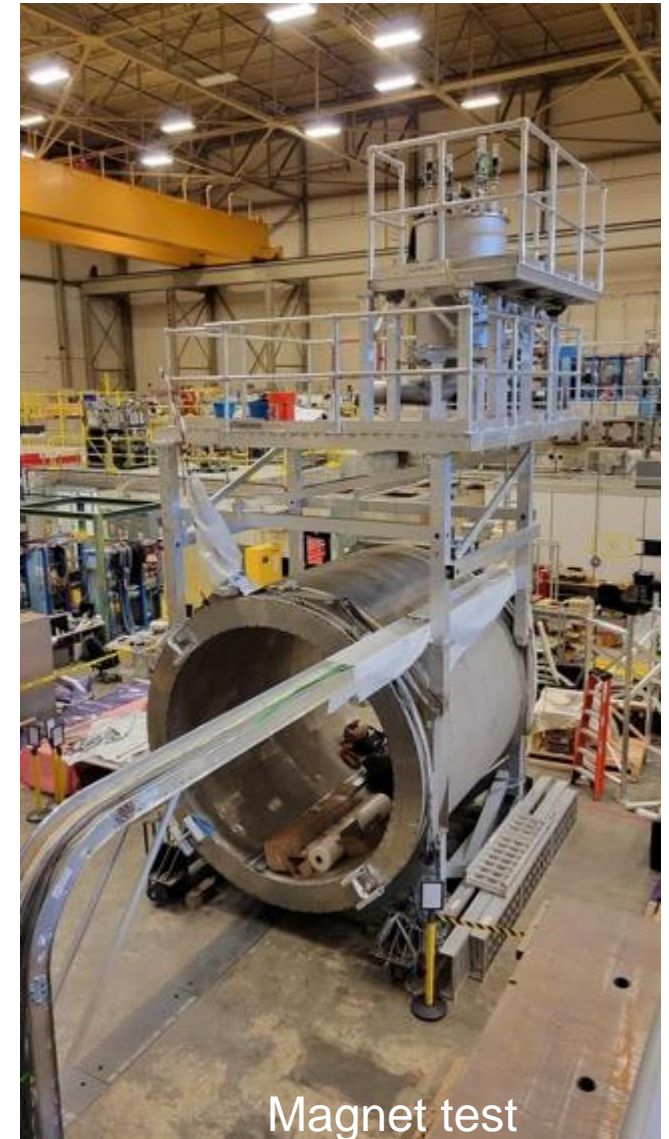


The best for last! SoLID fully enables CEBAF 12 GeV at the intensity frontier

- Nucleon spin, proton mass, BSM experiments require precision measurements of small cross sections and asymmetries, combined with multiple particle detection
- There is a critical need for a high luminosity 10^{37} - 10^{39} $\text{cm}^{-2}\text{s}^{-1}$ **and** large acceptance working in tandem
- Science reach
 - Precision 3D momentum imaging in the valence quark region
 - Exploring the origin of the proton mass and gluonic force in the non-perturbative regime
 - Beyond Standard Model searches in tandem with Moller



Awaiting Science Review Report



What's happening for SoLID at the lab now...

- Proposed ~\$30M “redirect” to support SoLID project (JLab Operations to take on more dependencies – magnet, some infrastructure,...)
 - Hoping for some feedback next week
- Two Capital Equipment projects already in place
 - Magnet refurbishment and testing
 - Data acquisition
- Working with DOE to identify preR&D opportunities
- Staff continuing to assist in development

- This completes your Division tour....



- Just 1-2 highlights per group/Hall, just for last ~9 months
- Plus some glimpse into future-thinking work
- SoLID is a priority