Hall B Status Report – *We're Back In Business! YES!*

- News and Communication from Jefferson Lab and Hall B
- PAC and Other Proposals
- Hall and Experimental Setup
- RG-D and Run Schedule Update

Latest Publications in the Back-Up

Patrick Achenbach

Nov. 2o23

News from Jefferson Lab and Hall B

THE 2023 LONG RANGE PLAN FOR NUCLEAR SCIENCE

"… recommendation addresses both increasing the research budget to advance the science program and its discovery potential and continuing effective operation of the national user facilities, including CEBAF at Jefferson Lab, …"

"The plan describes possible future upgrades to CEBAF that would open new vistas of research into the structure and dynamics of quarks …"

[Nuclear Science Advisory Committee Hails a New Era of Discovery with Release of Long Range Plan, Jefferson Lab Press Release (Oct. 2023)]

Nuclear Physics Highlights Featuring Hall B

THE 2023 LONG RANGE PLAN FOR NUCLEAR SCIENCE

Sidebar 3.3 Connecting the World of QCD to the Visible World

Because of confinement, we never observe the color-charged particles of QCD—quarks and gluons—in isolation; they are confined to color-neutral hadrons. Thus, every time a high-energy collision breaks up a proton, the energy of the collision allows the creation of more quark–antiquark pairs by converting energy into mass (E = mc2), and the new quarks and antiquarks rapidly bind to the various constituents of the broken-up proton, "snapping" into mesons and baryons, the QCD bound states, which can be detected.

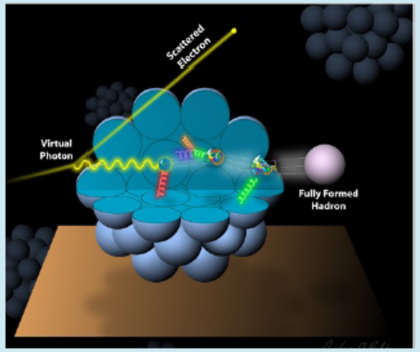


Figure 1. Representation of a high energy collision [S12]

Like blowing soap bubbles from the film with a bubble wand, when every free-streaming bubble must have closed off to become a whole bubble, every free-streaming product of a high-energy collision must have somehow become a "whole" color-neutral particle (Fig 1). Each time you blow on the soap film, a different number of bubbles of varying sizes may be produced. Likewise, each time a high-energy collision involving a proton occurs, a different number of hadrons of varying masses and quantum numbers may be produced.

To date, most efforts have focused on studying the production of a single hadron at a time along the same direction as the outgoing parton. However, in recent years, we have started to study hadronization in more sophisticated ways. Highlights since the 2015 Long Range Plan include spin–momentum correlation measurements in hadronization by the STAR experiment at RHIC, multivariable measurements of identified hadron production in jets by the LHCb experiment at CERN, an investigation by the CLAS experiment at Jefferson Lab of how hadron-pair production is modified in cold nuclear matter, and the modifications to hadrons in jets induced by interactions with the quark–gluon plasma, observed at both RHIC and the LHC.

These exciting results naturally point to more questions.

- What are the timescales of color neutralization and hadron formation?
- What are the differences in hadronization of quarks versus gluons and of light quarks versus heavy quarks?
- How are the various hadrons produced in a single scattering process correlated with one another, and how does hadronization change in a dense partonic environment?

The upcoming decade holds great promise for advancements, both in how we think about hadronization theoretically and in our ability to experimentally untangle the various mechanisms that contribute to this phenomenon. Theoretically, recent developments in quantum computing provide unique opportunities to explore the inherent dynamic nature of hadronization as a process unfolding in time. Experimentally, hadron identification capabilities at the STAR experiment at RHIC, CLAS12 experiment at Jefferson Lab, LHCb and ALICE experiments at CERN, Belle II experiment in Japan, and the ePIC experiment at the future EIC will allow us to measure and compare a wide range of traditional and novel observables related to hadronization.

[Related to T. Chetry et al. (CLAS Collab.), Phys. Rev. Lett. 130, 142301 (2023)]

Sidebar 3.2 The Pressure Inside the Proton

In the history of the universe, protons were formed microseconds after the Big Bang, when the universe expanded and cooled sufficiently for the binding forces to become strong enough to freeze quarks and gluons together into protons and neutrons, the building blocks of the atom's nucleus.

The internal structure of the proton has been studied in great detail using the electromagnetic interaction as a probe. The elastic form factors, its internal distribution of charge and magnetism, have been studied for the past 70 years. Its quark structure has been studied for over 55 years, and its helicity, or spin structure, for over 40 years. In contrast, we know very little about the proton's mechanical properties: its internal mass distribution, angular momentum, pressure and shear stress. These properties are encoded in gravitational form factors, which can be probed directly only in the proton's interaction with gravity- a practical impossibility due to the extreme weakness of the gravitational force. Thus, the mechanical properties were completely unknown until recently.

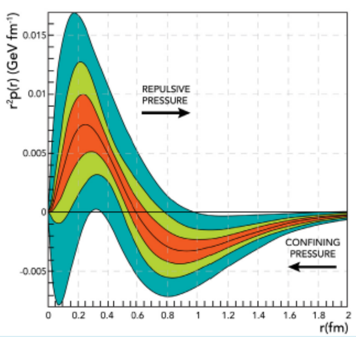


Figure 1: Pressure distribution in the proton weighted as r2 p(r). The peak pressure at r = 0 corresponds to 1035 Pascal. The green shaded bands represent uncertainties if only initial world data (dark) or more recent high statistics data (light) are included. The red band represent projections of future experiments [S10].

A theoretical breakthrough enabled the first experimental extraction of one of the gravitational form factors, D(t), and the determination of the pressure distribution inside the proton shown in Fig. 1 obtained in 2018 by scientists from Jefferson Lab. These results were based on the analysis of deeply virtual Compton scattering (DVCS) data, measured with the CEBAF Large Acceptance Spectrometer CLAS, and combined with information provided by generalized parton distributions (GPDs), a theoretical framework for mapping out the internal structure of protons.

The comparison of peak pressure measured in various regions and objects on Earth, in the solar system, and in the universe are displayed in Fig. 2. The tiny proton with a peak pressure of 1035 Pascal beats them all, including the most densely packed known macroscopic objects in the universe -the cores of neutron stars.

With current and planned state-of-the-art experimental facilities, further development and breakthroughs in theory and in lattice QCD, we will be able to reveal more of the mystery of the strong force, the most powerful force in nature, that binds quarks together to form the fundamental building blocks of the atomic nuclei.

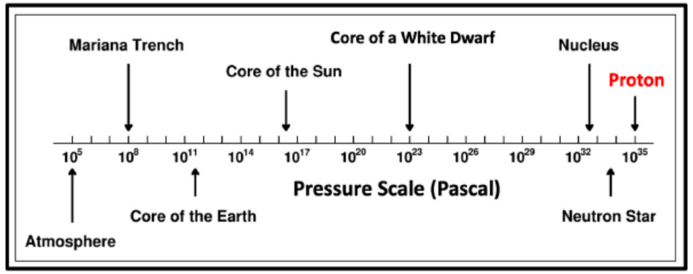


Figure 2: Peak pressure of objects in the universe, including the peak pressure inside the proton [S11].

CLAS prominently mentioned for their past achievements

[V.D. Burkert, L. Elouadrhiri & F.X. Girod,, Nature 557, 396–399 (2018)]

Snapshots from the 2023 LRP

THE 2023 LONG RANGE PLAN FOR NUCLEAR SCIENCE

CLAS12 and CLAS12+ expected to achieve more in the near to distant future

E. Voutier (Contact person) et al., “Beam Charge Asymmetries for Deeply Virtual Compton Scattering on the Proton at CLAS12”, Proposal PR12+23-002 to PAC51 (2023)

Spatial imaging. Spatial imaging techniques and GPDs not only provide information on the position distributions of quarks and gluons within the nucleon but also can provide information related to properties of the nucleon such as mass, angular momentum, pressure, and force distributions inside the nucleon (Sidebar 3.2). Pioneering measurements have been made since the last Long Range Plan, and a dedicated program has been launched at Jefferson Lab, including in Hall B with the CEBAF Large-Acceptance Spectrometer (CLAS)12 and in Hall C with the existing spectrometer and the new Neutral Particle Spectrometer), to study three complementary scattering processes in unprecedented detail and in coordination with theory. The possible addition of a polarized positron beam to CEBAF would enable precise separation of signal and background for one of the relevant processes to access GPDs. The future EIC will enable a complementary program to perform spatial imaging for quarks and gluons carrying smaller momentum fractions of the nucleon.

G. Christiaens et al. (CLAS Collab.), “First CLAS12 Measurement of Deeply Virtual Compton Scattering Beam-Spin Asymmetries in the Extended Valence Region”, Phys. Rev. Lett. 130, 211902 (2023).

S. Diehl et al. (CLAS Collab.), "First Measurement of Hard Exclusive π Δ++ Electroproduction Beam Spin Asymmetries off the Proton", Phys. Rev. Lett. 131, 021901 (2023).

S. Diehl et al. (CLAS Collab.), "A Multidimensional Study of the Structure Function Ratio σLT′/σ0 from Hard Exclusive π+ Electroproduction off Protons in the GPD Regime", Phys. Lett. B 839, 137761 (2023).

A. Kim et al. (CLAS Collab.), "Beam Spin Asymmetry Measurements of Deeply Virtual π0 Production with CLAS12", arXiv:2307.07874, subm. to Phys. Lett. B (2023).

Snapshots from the 2023 LRP

THE 2023 LONG RANGE PLAN FOR NUCLEAR SCIENCE

Non-CLAS12 and non-Collaboration work expected to achieve more in the near to distant future

W. Xiong et al. (PRad Coll.), Nature 575, 147 (2019)

A.Gasparian (Contact person) et al., “PRad-II: A New Upgraded High Precision Measurement of the Proton Charge Radius”, Proposal PR12-20-004 to PAC48 (2023)

3.2.5. SPECTRUM OF EXCITED HADRONS

The GlueX and CLAS12 detectors at Jefferson Lab provide powerful tools for studying the spectrum of hadrons built from light quarks and gluons. A robust experimental program with CLAS12 has focused on measurements of the transitions between the ground and excited baryon states for a range of energy and momentum transfer Q^2, which will enable us to study how hadron structure emerges from QCD.

3.2.1. HOW BIG IS THE PROTON?

According to the Standard Model of particle physics, muons are particles that should behave exactly like heavy electrons, so any discrepancy may indicate the possibility of brand new physics. Since the last Long Range Plan, the PRad electron–proton scattering experiment at Jefferson Lab implemented several innovations to obtain a new r_p value that agreed with the muonic hydrogen results. A follow-up experiment, PRad-II, is being planned, aiming for a factor of four improvement in precision, addressing the question of whether the electron and the muon experience the proton charge radius differently. International exper-

V.D. Burkert and C.D. Roberts, Rev. Mod. Phys. 91, 011003 (2019)

D.S. Carman, R.W. Gothe, V.I. Mokeev, and C.D. Roberts, Particles 6, 416 (2023)

A.N. Hiller Blin and V.I. Mokeev, Few Body Syst. 64, 21 (Apr. 2023)

A.N. Hiller Blin, V.I. Mokeev, W. Melnitchouk, Phys. Rev. C 107, 035202 (2023)

V.D. Burkert, "Nucleon Resonances and Transition Form Factors", Eur. Phys. J, in press (2023)

V.I. Mokeev et al., Phys. Rev. C 108, 025204 (2023)

and many more …

The Workforce Issue Discussed in the 2023 LRP

THE 2023 LONG RANGE PLAN FOR NUCLEAR SCIENCE

RECOMMENDATION 1

The highest priority of the nuclear science community is to capitalize on the extraordinary opportunities for scientific discovery made possible by the substantial and sustained investments of the United States. We must draw on the talents of all in the nation to achieve this goal.

This recommendation requires

- Increasing the research budget that advances the science program through support of theoretical and experimental research across the country, thereby expanding discovery potential, technological innovation, and workforce development to the benefit of society.
- Continuing effective operation of the national user facilities ATLAS, CEBAF, and FRIB, and completing the RHIC science program, pushing the frontiers of human knowledge.
- Raising the compensation of graduate researchers to levels commensurate with their cost of living—without contraction of the workforce—lowering barriers and expanding opportunities in STEM for all, and so boosting national competitiveness.

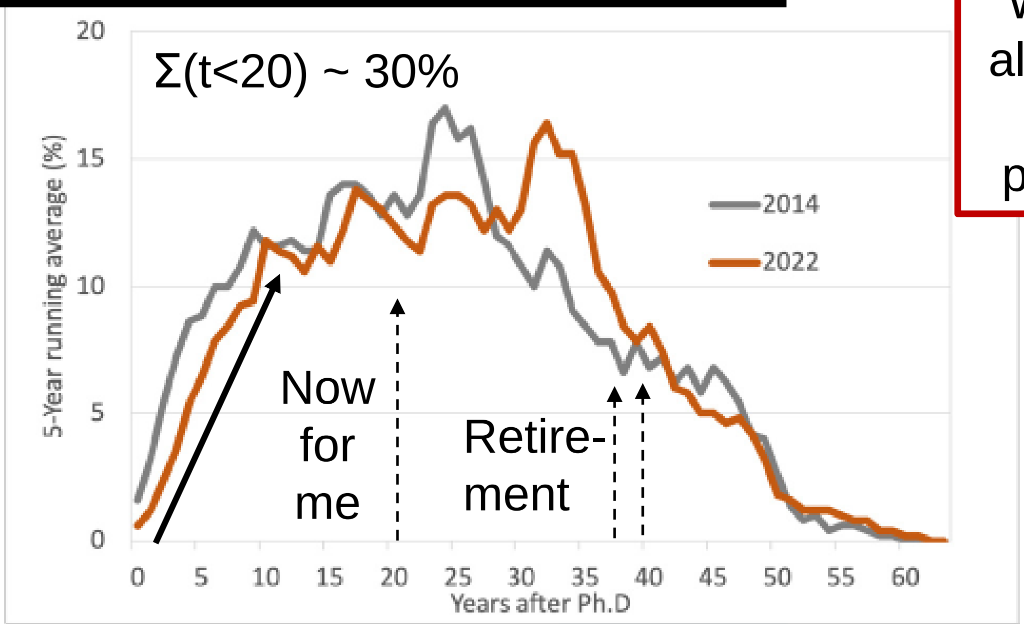


Figure 8.2. Percentages of nuclear physics faculty for a given time since PhD, compiled for the current and previous Long Range Plan. The y-axis is a 5-year average. A shift upward in the average years past PhD indicates an aging workforce [32].

Where are all the early-career physicists?

… the drop in early career faculty recruitment of those qualified to teach nuclear science […] leads to a reduction in available expertise, a decrease in research output, difficulty attracting and retaining students, and a decrease in the quality of nuclear education.

New Hires in Hall B Group in 2023

- Mechanical Designer **Chris Guthrie** June 2023
- Staff Scientist **Chris Dilks** July 2023
- Postdoc **Richard Tyson** Nov 2023
- Staff Scientist **Raffaella De Vita** Nov 2023
- New postdoc position 80/20% LDRD/Hall-B open:

https://misportal.jlab.org/hr/recruiting/postings/13260

Posting Date: 10/05/2023

Salary Range: $61,100 - $91,700 (PD)

Work Location Type: Dedicated On-Site (working 100% on-site)

What your job will be like:

As a postdoctoral fellow in Hall B, you will develop a new high-rate micropattern gaseous detector (MPGD) for application in future nuclear physics experiments at high-luminosities. You will join a team of experienced scientists to contribute in the design, construction and characterization of MPGD detector prototypes. Furthermore, you will conduct an original research program within the Hall B physics program which consists of the three-dimensional imaging of the nucleon, meson and baryon spectroscopy, quark-gluon interactions in nuclei, and the search for physics beyond the Standard Model such as Heavy Photons.

- New engineer position Fusion/Hall-B open

Today, Nov. 7, is Election Day in the U.S.

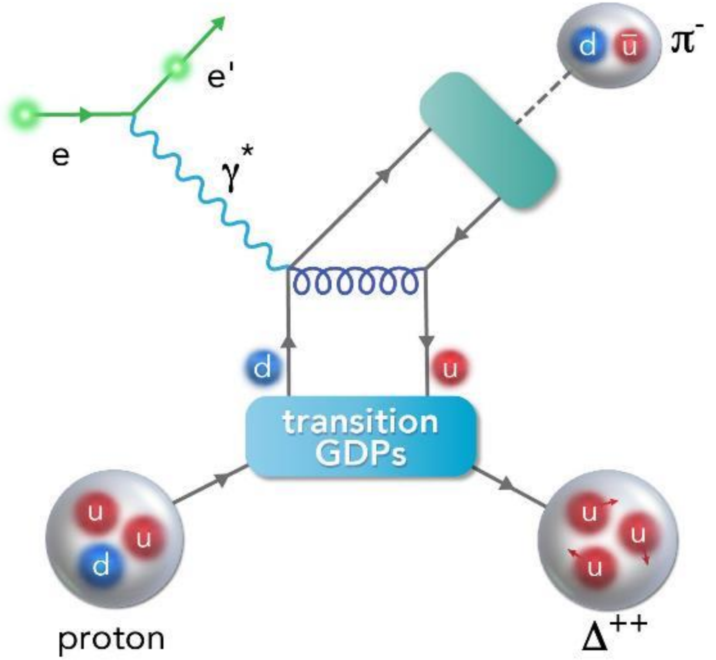
- Please vote for the vacant position of a Students & Postdocs Representative!
  Please form a team to support and deputy the representative, they should not be alone!
- Students & Postdocs play an imperative role in ensuring that the Collaboration is successful:
  We want to strengthen their visibility, feedback, training, … *We* advocate software tutorials, application & career planning support, inclusion, invitations to CCC Meetings, …
- On Wednesday, Nov. 8 from 5:30 to 7pm, the first CLAS collaboration SLAM event will be held at the Tradition Brewery in Newport News. Students and postdocs will be challenged to present their work in only 3 minutes with at most 1 slide and 180 second. Please join!

Communication from Jefferson Lab and Hall B

First Access to Transition GPDs in $\pi^-\Delta^{++}$ Electro-Production

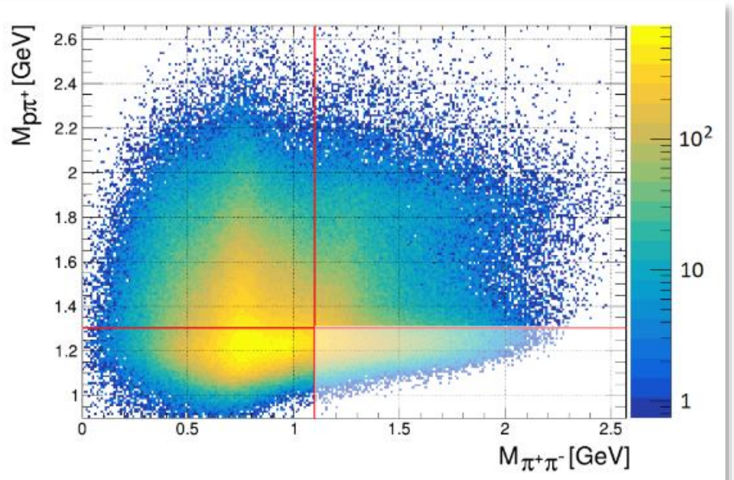
Transition GPDs as a generalization of GPDs to N → Δ processes

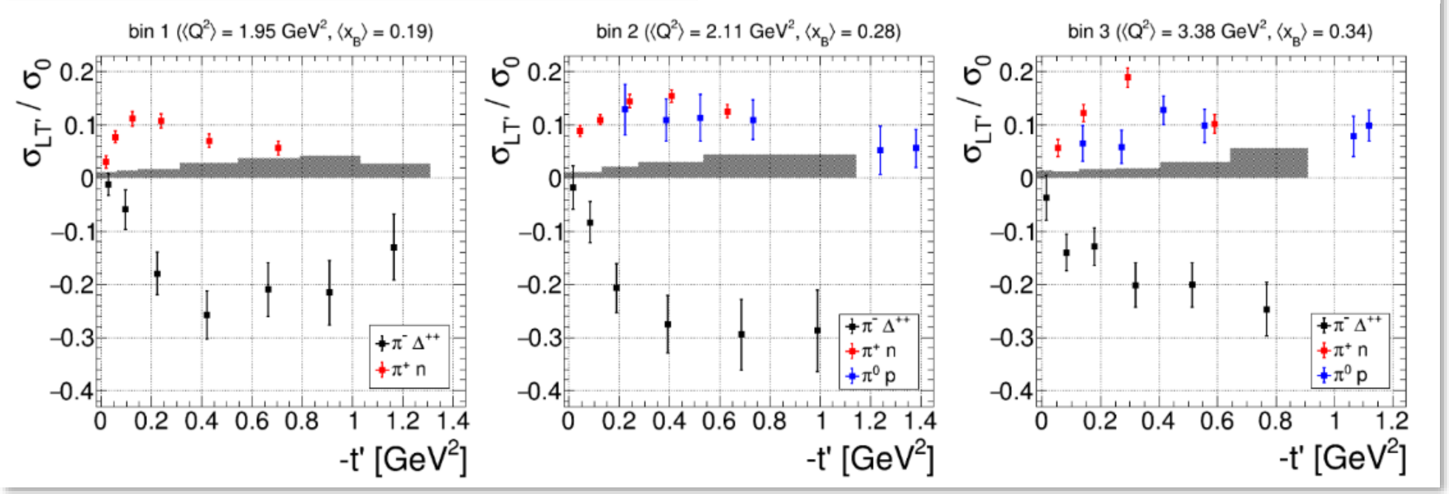
$$ep \rightarrow e' p\, \pi^- (\pi^+)$$



$$BSA = \frac{\sqrt{2\epsilon(1-\epsilon)}\frac{\sigma_{LT'}}{\sigma_0}\sin\phi}{1+\sqrt{2\epsilon(1+\epsilon)}\frac{\sigma_{LT}}{\sigma_0}\cos\phi+\epsilon\frac{\sigma_{TT}}{\sigma_0}\cos 2\phi}$$

- Exploratory measurement
- 3D structure on resonances
- Access to *d*-quark content





[S. Diehl et al. (CLAS Collab.), Phys. Rev. Lett. 131, 021901,11 July 2023]

Reception Latest CLAS News Release

Daily Press

NEWS > SCIENCE

Science

Experiment at Newport News's Jefferson Lab gives insight into building blocks of the universe

It is important not only to communicate to your highly-educated peers, but also to the interested public and policy makers!

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3D Structure of Resonating Proton Offers Insight Into the Chaotic, Nascent Universe

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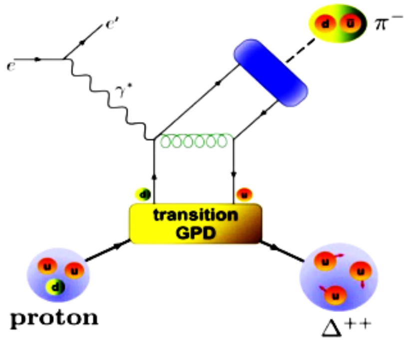
Science 22 AUG 2023 6:32 AM AEST Share

Proton Ringing Sheds Light on Universe's Early Days

RINGING PROTONS GIVE INSIGHT INTO EARLY UNIVERSE



A new study sheds light on the 3D structure of nucleon resonances

NEWPORT NEWS, VA – In the middle of the last century, physicists found that protons can resonate, much like a ringing bell. Advances over the last three decades have led to 3D pictures of the proton and significant insight into its structure in its ground state. But little is known about the 3D structure of the resonating proton.

Now, an experiment to explore the 3D structures of resonances of protons and neutrons at the U.S. Department of Energy's Thomas Jefferson National Accelerator Facility has added one more puzzle piece to the vast picture of the chaotic, nascent universe that existed just after the Big Bang.

New experiment explores 3D structure of resonating protons

August 22, 2023 by News Staff

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Excited protons give clues to building blocks of matter

[Based on S. Diehl et al. (CLAS Collab.), Phys. Rev. Lett. 131, 021901,11 July 2023]

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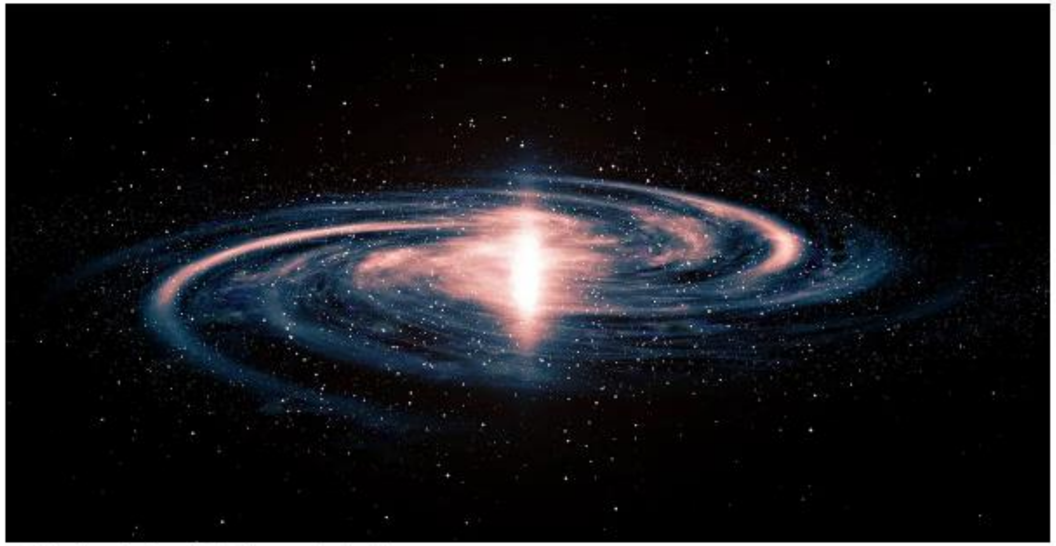
DEEP DIVE

Music of the spheres: Scientists uncover ancient particle hymn from the birth of the universe

Each experiment like this allows physicists to tease out the properties of the early cosmos after the Big Bang

By **RAE HODGE**
Staff Reporter

PUBLISHED SEPTEMBER 1, 2023 5:40AM (EDT)



Spinning Galaxy (Getty Images/cokada)

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Resonating protons could shed light on early universe

This is the first time such a measurement has been achieved and future experiments could shed insights on matter in the nascent phase of the cosmos.

Ameya Paleja
Created: Aug 22, 2023 01:33 PM EST

SCIENCE

Artist's representation of the Big Bang

CLAS is cited by space news journals next to travel to Mars and is connected to spinning galaxies …

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SCIENCE AND EXPLORATION

Ringing Protons Give Insight Into The Early Universe

PAC and Other Proposals

Physics Advisory Committee Meeting 2023

PAC51: https://indico.jlab.org/event/723/contributions/13329/attachments/10143/15123/closeout.pdf

- **CLAS Collaboration proposals:**
  - PR12-23-013 “Measuring Short-Range Correlations with ALERT”
  A rated approved
  - E12-16-010C “Separation of the σL and σT contributions to the production of hadrons in electroproduction”
  RG-K addition endorsed

- **With Positron Working Group:**
  - PR12+23-002 “Beam Charge Asymmetries for Deeply Virtual Compton Scattering on the Proton at CLAS12”
  A- rated approved with C1 condition on positron beam availability
  - PR12+23-008 “A Direct Measurement of Hard Two-Photon Exchange with Electrons and Positrons at CLAS12”
  A rated with C1 condition on positron beam availability

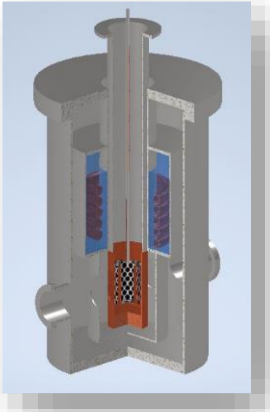
- **“PRad” setup proposals:**
  - PR12+23-005 “A Dark Photon Search with a JLab positron beam” **deferred**
  - PR12-23-011 “Precision Deuteron Charge Radius Measurement with Elastic Electron-Deuteron Scattering”
  deferred

Successful DOE Fusion Science Proposal

Xiangdong Wei and co-applicants received a multi-lab and multi-M$ grant from DOE on “Spin Polarized Nuclei for Injection into DIII-D” in response to call on “INNOVATIVE FUSION TECHNOLOGY AND COLLABORATIVE FUSION ENERGY RESEARCH IN THE DIII -D NATIONAL PROGRAM”, a first step for testing polarization survivability of LiD in plasma

JLab’s Roles and Benefits

- Bringing manpower for building, testing and running a cryostat to irradiate polarized targets
- Building a device to produce LiD pellets
- Irradiating LiD/LiH material coordinated with Accelerator Division



Congratulations to Xiangdong!

Successful Jefferson Lab Laboratory Directed Research and Development (LDRD) Proposals

Sponsoring several projects with participation from Hall B Group or CLAS Collaboration users:

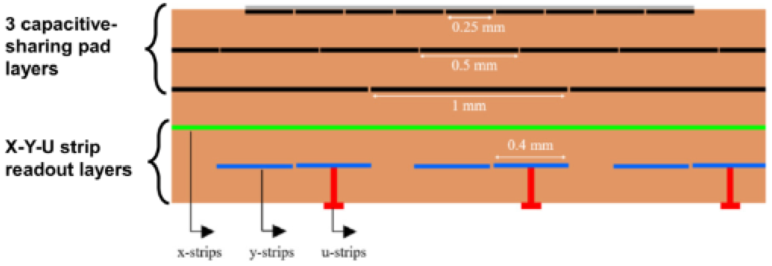
- **"Low-Mass uRWELL detector for high luminosity (~10^{37} cm^{-2} sec^{-1}) experiments**",
  PI: Florian Hauenstein; Rafayel Paremuzyan; Kondo Gnanvo; Stepan Stepanyan
- **"Streaming Readout Real-Time Development and Testing Platform"**,
  PI: David Lawrence; Markus Diefenthaler; Marco Battaglieri
- **“Extraction of Gravitational Form Factors”**,
  PI: Alexandre Camsonne; Volker Burkert; David Richard; Pierre Chatagnon

Congratulations to the proponents!

LDRD Proposal

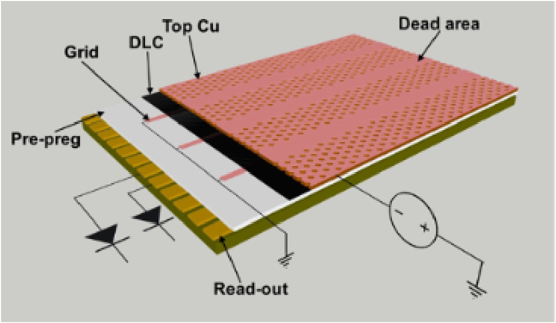
Low-mass µRWELL detector for high luminosity (~10^{37} cm^{-2} s^{-1}) experiments

- **LDRD Proposal FY2024-2026**
- **Background:** Experiments at JLab with luminosities of 10^{36} -10^{37} $cm^{-2}s^{-1}$ for future physics channel of interest like Double Deeply Virtual Compton Scattering measurements —> tracking detectors with high particle rates
- **Goal: Develop µRWELL tracking detector capable of running under high-rate at high luminosities**
- **Methods:**
  - Prototype testing for high-rate, high-luminosity capabilities
    - Various resistive layer layouts
    - Capacitive sharing X-Y-U strip readout
    - Thin gap
  - Software development
    - Implementation in GEMC
    - Hit and track reconstruction algorithm in a high-rate environment
    - Validation with test measurements
- **Personnel:**
  - 1 Postdocs (80% FTE)
  - Florian Hauenstein, Rafayel Paremuzyan, Kondo Gnanvo
- **Investment:**
  - Total of $450k in 2 years
  - Equipment cost ~$120k for prototypes, read-out, detector supports and small GEM trackers for test stand



Cross section view of 3-coordinates X-Y-U strips capacitive-sharing readout

High rate resistive layer design

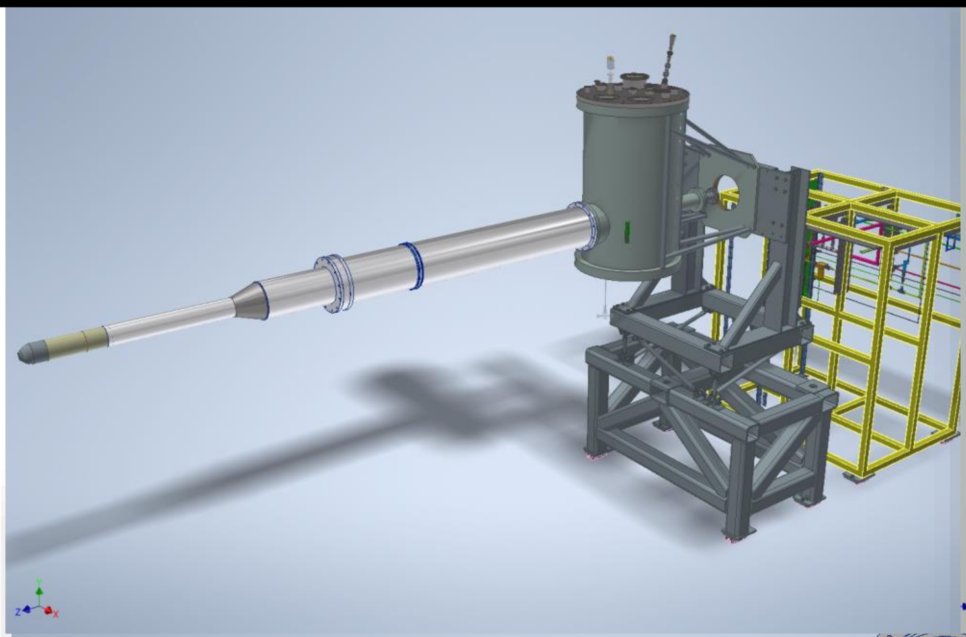


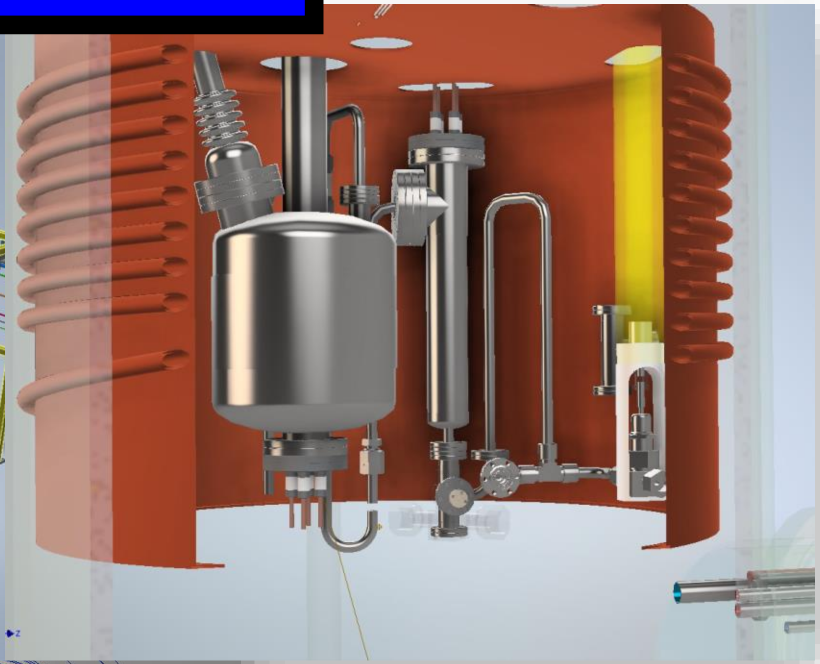
Hall and Experimental Setup

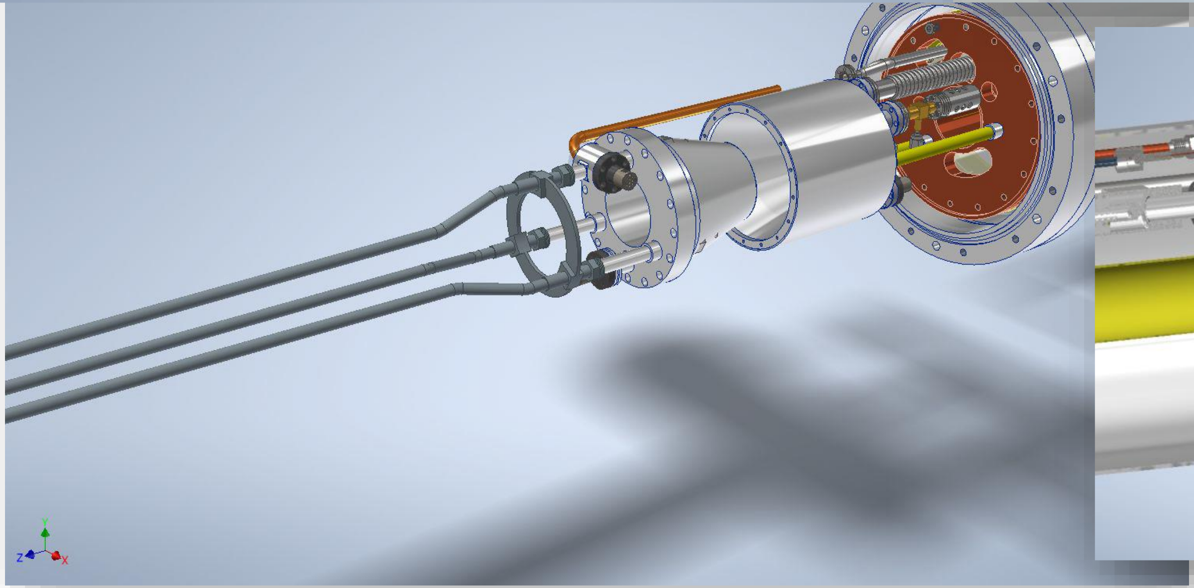
Unpolarized Cryo-Target for Next Runs

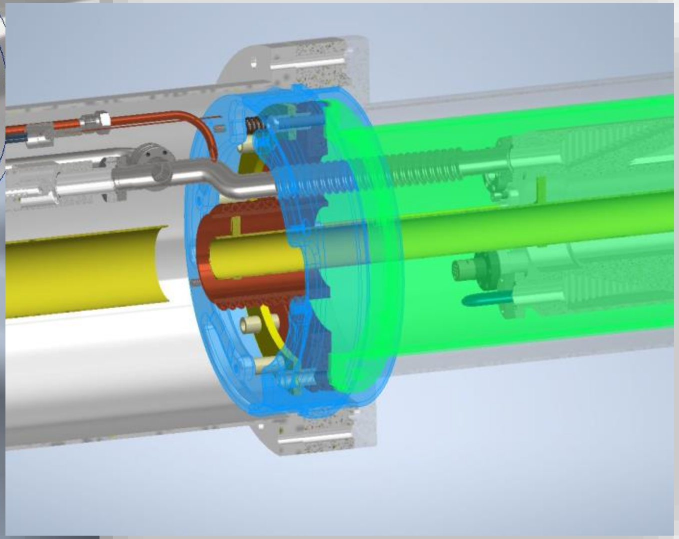
New Modular Design

- Conventional 1 K refrigerator
- Compatibility with existing cells and RG-D/E foil targets
- Solid targets cooling decoupled from cryo-target and cooled by heat shield







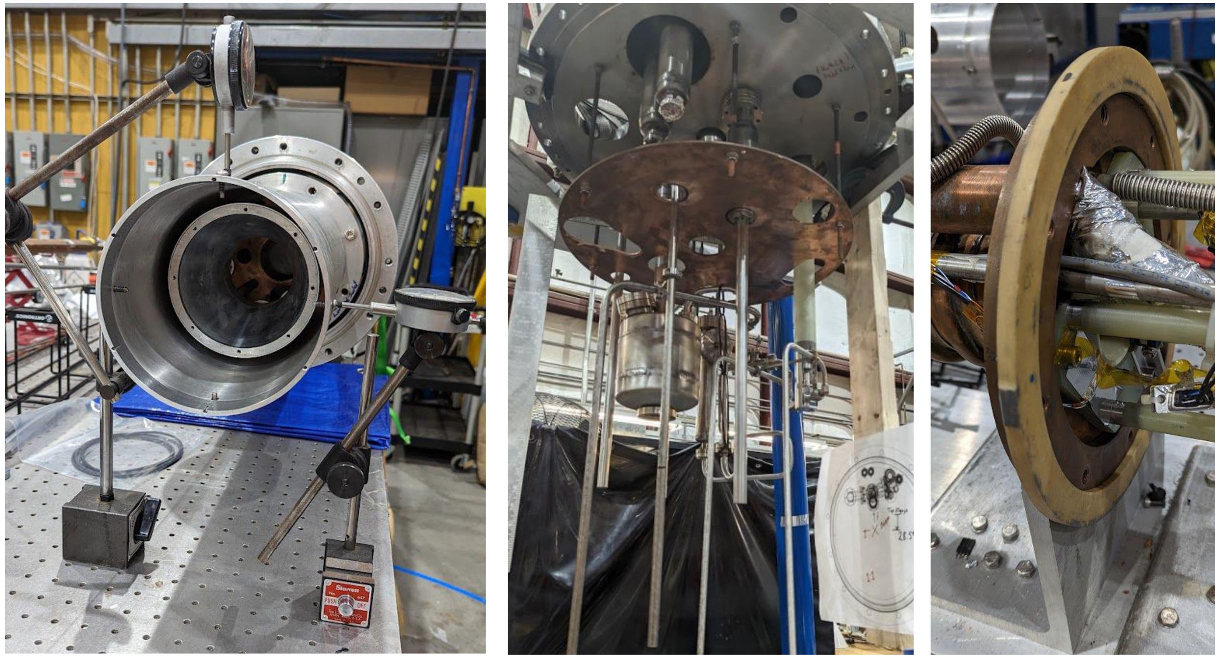


- Nesting conical mount of condenser to He coolant evaporator: Target cell easily removable

Cryo-Target Work During SAD 2023

- Engineering design work by Hall B
- Pressure systems, gas racks, controls, panels by Hall B
- All internal components done by Target Group

Was ready by end of Sept, after a short delay



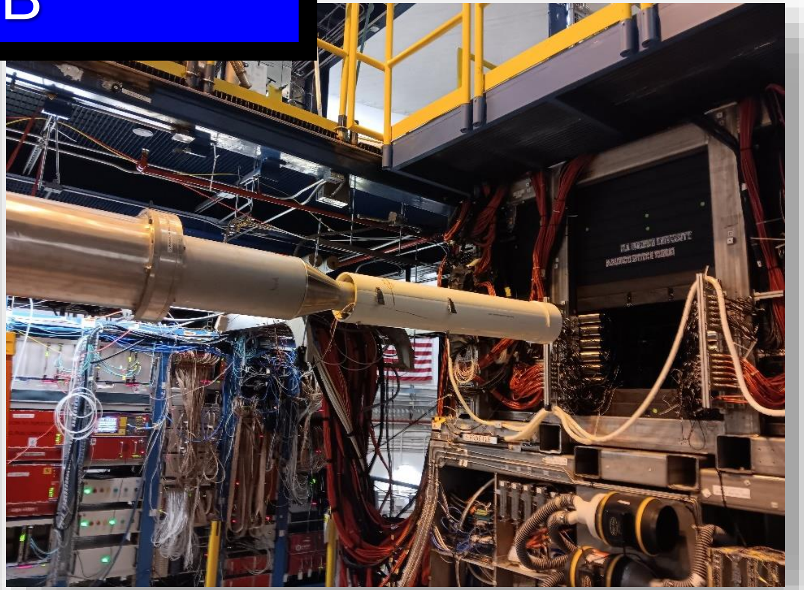
The Finished Hall B Cryo-Target

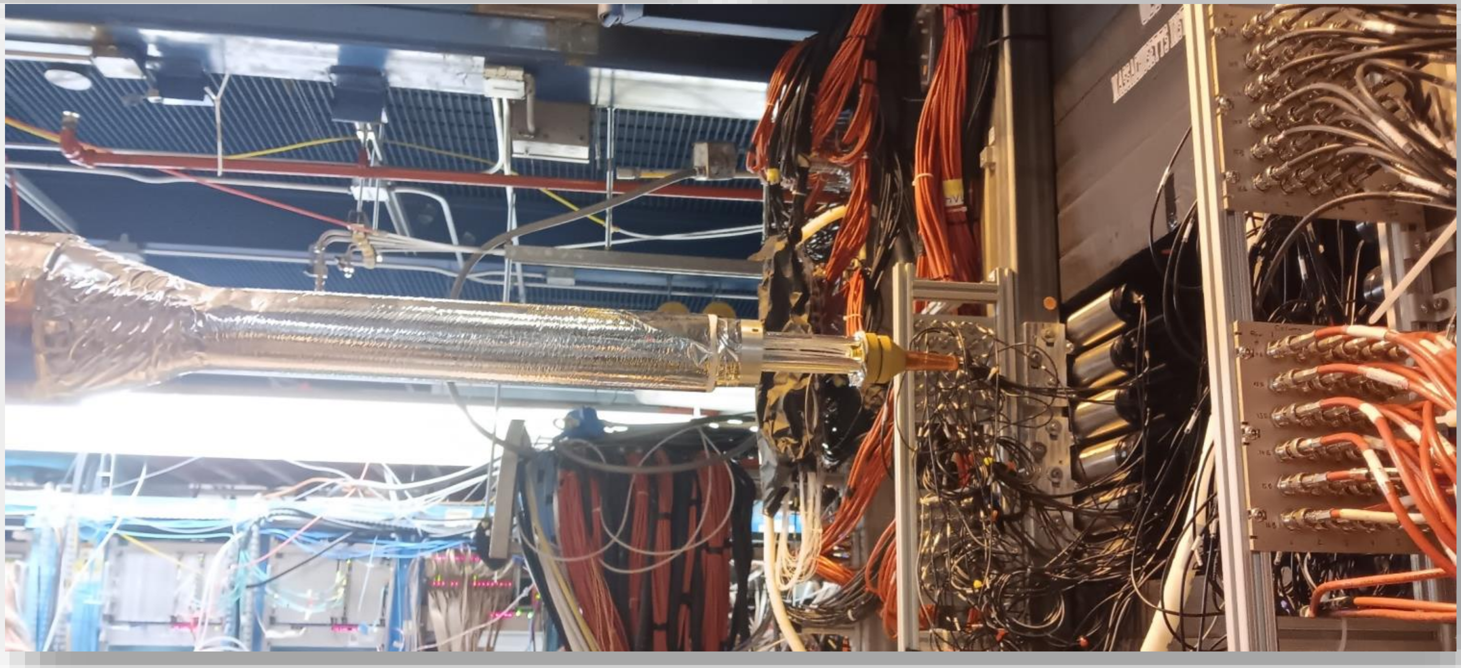
Target Group
James Brock (lead)
Gary Dezern
Dave Griffith
Mark Hoegerl
Paul Hood
Chris Keith
Stan Madlock
James Maxwell

Hall B
Nathan Baltzell
Morgan Cook
Steve Docherty
Denny Insley
Bob Miller (lead)

Thanks to all!

Cryo-Target Check-Out in Hall B

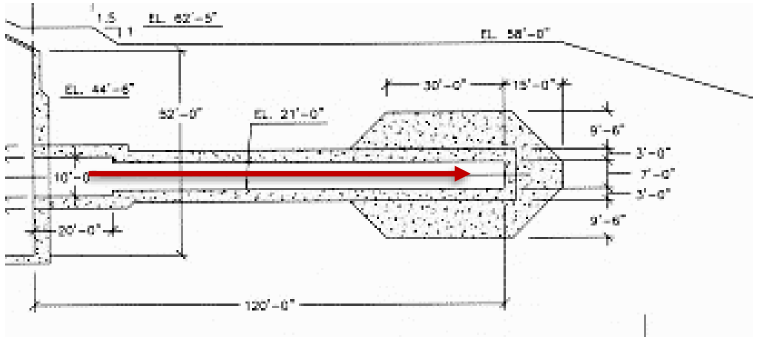




Target works flawless!

Beam-Dump Upgrade During SAD 2023

- Faraday cup was moved down towards the end of the tunnel
- Piping, re-cabling, and installation of new ion pump
- Faraday cup with beam blocker has been approved for 17 kW corresponding to currents of ~ 1.6 µA



This upgrade (‘Phase 1’) is completed except for pump failure

Ensuring a Safe Work Environment in Hall B

- **Safety Pause has ended**

The pause effectively led to a loss of two months of running in Hall B

- **NEW After-Hours High-Hazard Work Policy**

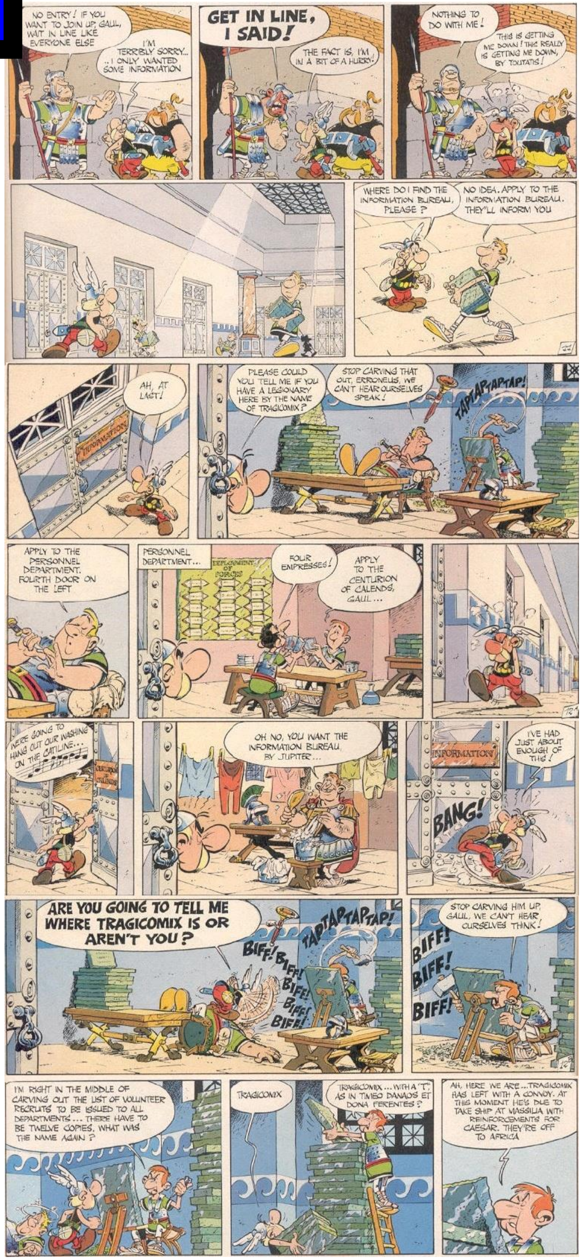
Effective Sept. 15, 2023, a new JLab policy for “High-Risk/High-Consequence Work Performed in Off-Normal Hours” is in effect

The new policy has a list of seven high-risk/high-consequence activities and the approval process that will need to be followed to execute these activities after hours

- **NEW Permit to Work Software ePAS**

Next year, work planning in Hall B will need additional formal permission, control, and authorization processes using a new and complex software

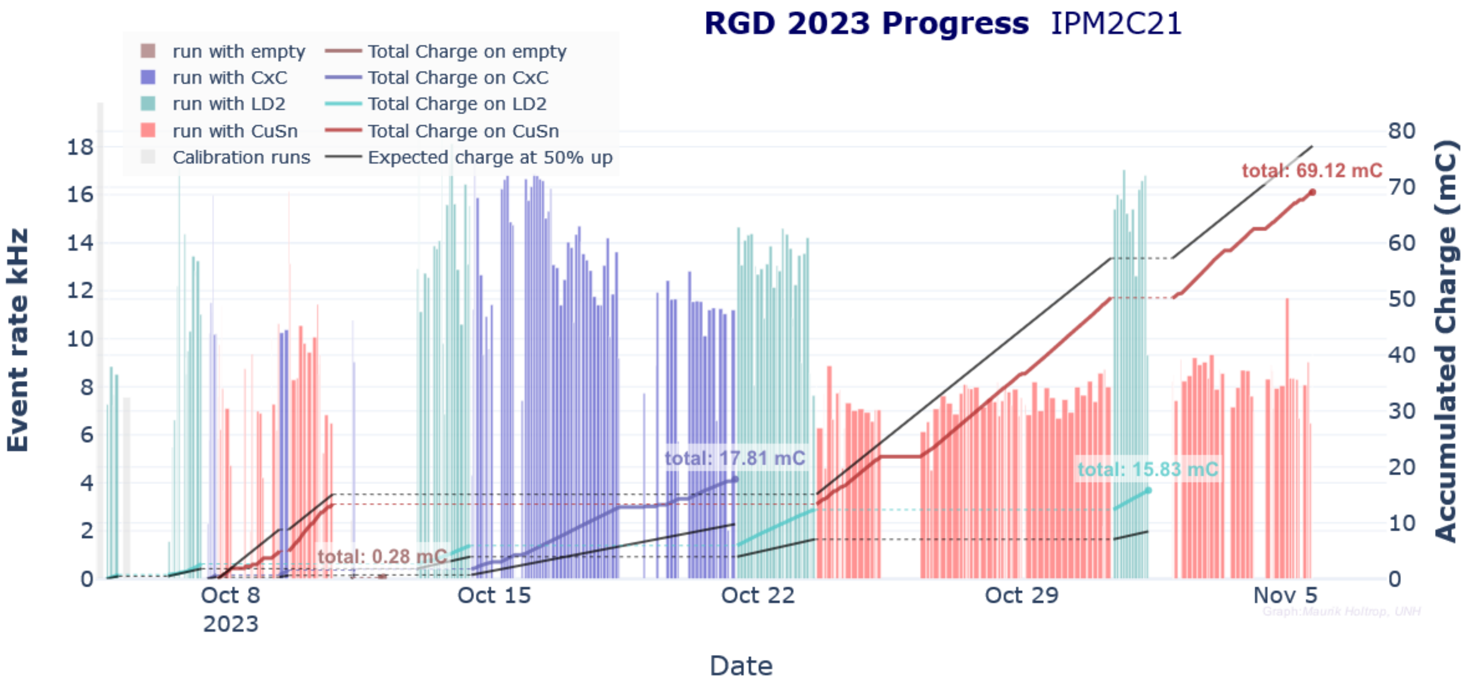
Hall B staff, engineers, and technicians will learn, but work is expected to slow down

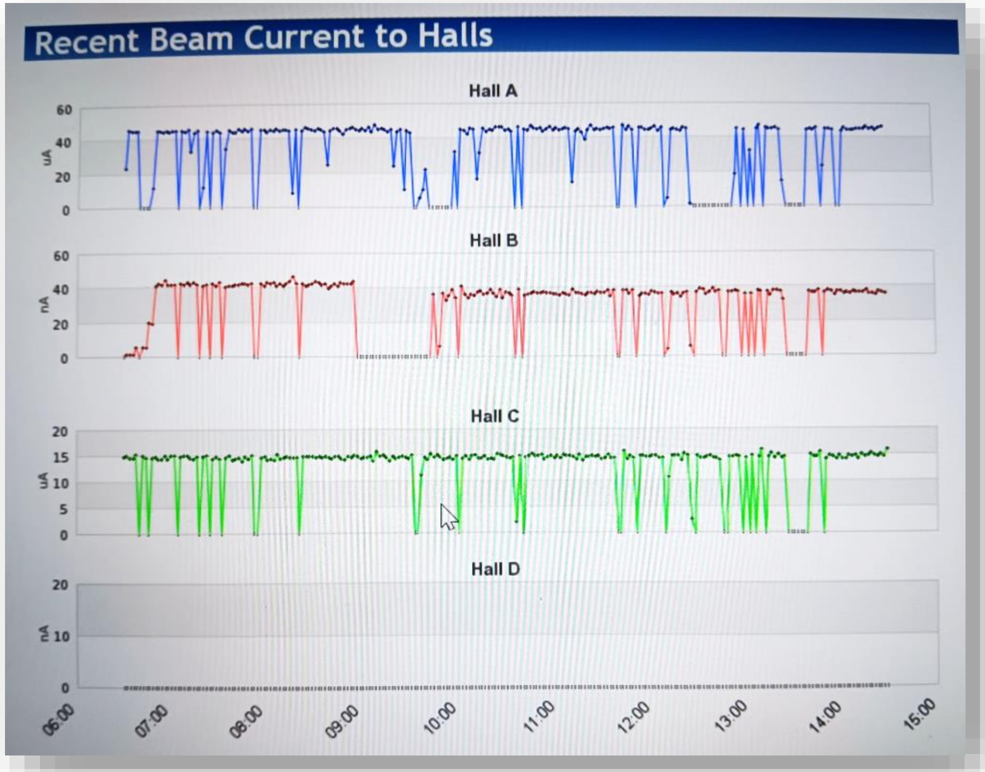


RG-D Run and Run Schedule Update

RG-D Running

RG-D finished 6 weeks of its running at about 50 % of scheduled time





Accelerator runs extremely stable, and RG-D can enjoy efficient data collection

Recent Changes of Run Schedule

Causes for necessary changes:

- ALERT Run-Group got PAC51 approval for additional 17 PAC days
- RG-D started 10 days later due to delays in cryotarget installation and tests
- CVT/MVT needs to get protected from enhanced radiation from Cu&Sn target, limiting RG-D beam currents to values significantly below design luminosity
- Replacement/Repair of ion pump at Faraday cup necessary during winter break, but RG-K needs Faraday cup readout for precise beam charge measurement

New Hall B schedule to accommodate to the new situation:

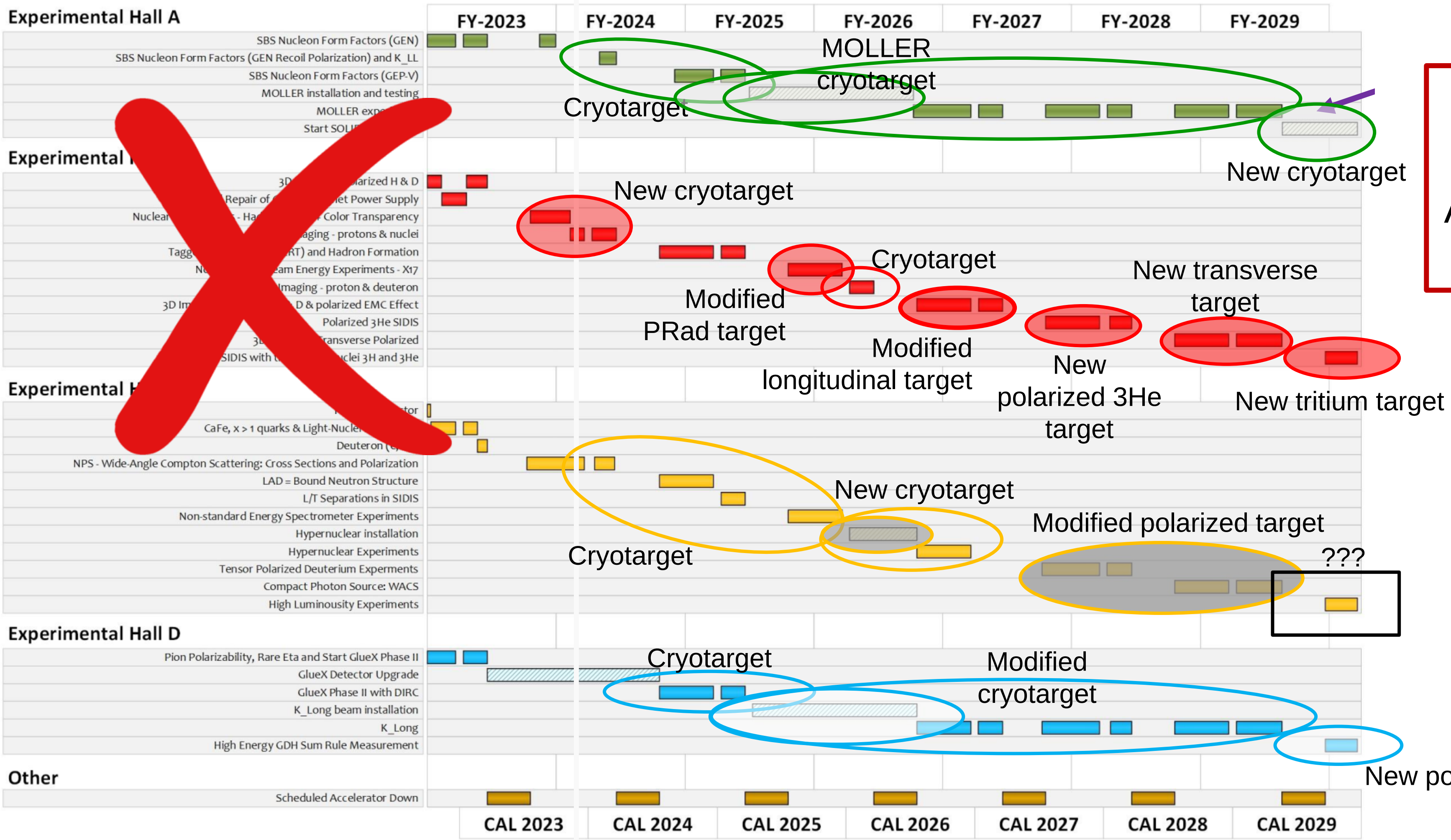
- RG-D will run longer on Cu&Sn target with lower beam current of only 90 – 95 nA
- Dec. 15: change to third-pass beam energy for RG-K
- Dec. 16 – 19: RG-K luminosity scans and other studies
- ALERT will run longer to include time for new proposal

Updated Run Group Schedule

2023-2024								Sceduled PAC days = cal. days/2	Remaining PAC days after end date
START DATE	END DATE	Calendar Days	Remaining PAC Days	Setup/Exp.	Target	Beam Energy	Run Group		
2022-06-14	2022-11-11	143	120		long. polarized NH3/ND3	11	**RG-C**	71.5	49
2022-11-12	2022-12-19	37	downtime	magnet power supply failure					
2022-12-20	2023-01-12	23				Winter break			
2023-01-23	2023-03-19	55	49		long. polarized NH3/ND3	11	**RG-C**	27.5	21
2023-03-20	2023-07-23	125		setup change	target change	SAD 2023			
2023-07-23	2023-09-14	53	downtime	safety pause					
2023-10-01	2023-12-15	75	38		liq. D2 & nucl. (JLab)	11	**RG-D**	38	0
2023-12-15	2023-12-15	0			target change				
2023-12-15	2023-12-19	4	88		liq. H2	8,8	**RG-K**	2	86
2023-12-19	2024-01-10	22			setup change	Winter break			
2024-01-10	2024-03-08	58	86		liq. H2	8,8	**RG-K**	29	57
2024-03-11	2024-03-15	4			target change				
2024-03-19	2024-05-19	61	60		liq. D2 & nucl. (Chile)	11	**RG-E**	31	30
2024-05-18	2024-09-18	123		setup change	target change	SAD 2024			
2024-09-19	2024-12-21	93	55	ALERT	high pressure gas	11	**RG-L**	46.5	8.5

Long-Term Run Schedule

Ovals indicate approved experiments that will utilize systems owned by the Target Group.
FILLED Ovals indicate periods or experiments requiring substantial (> 6 months) new construction or modification of an existing target system.



This scenario should not circulate!

A realistic schedule will get worked out

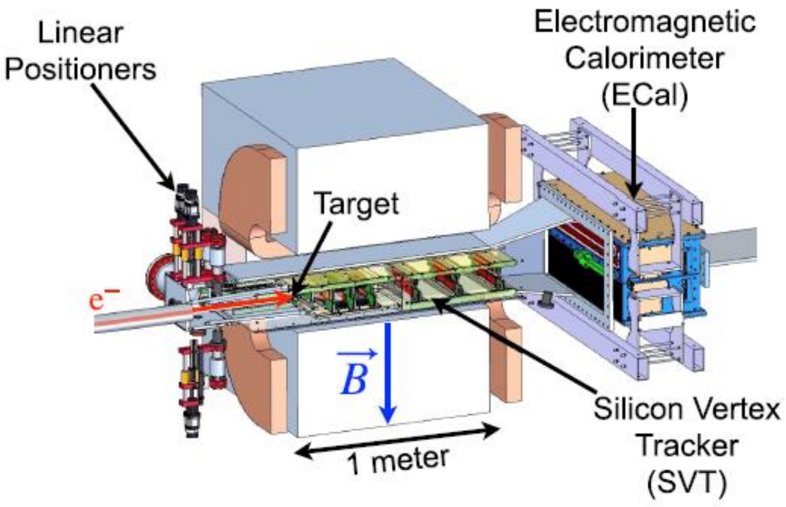
This schedule is highly unrealistic and not achievable by the Target Group

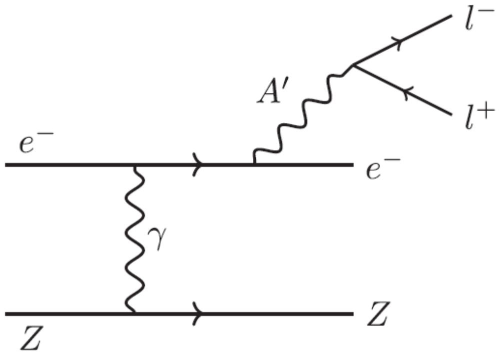
Thank you!

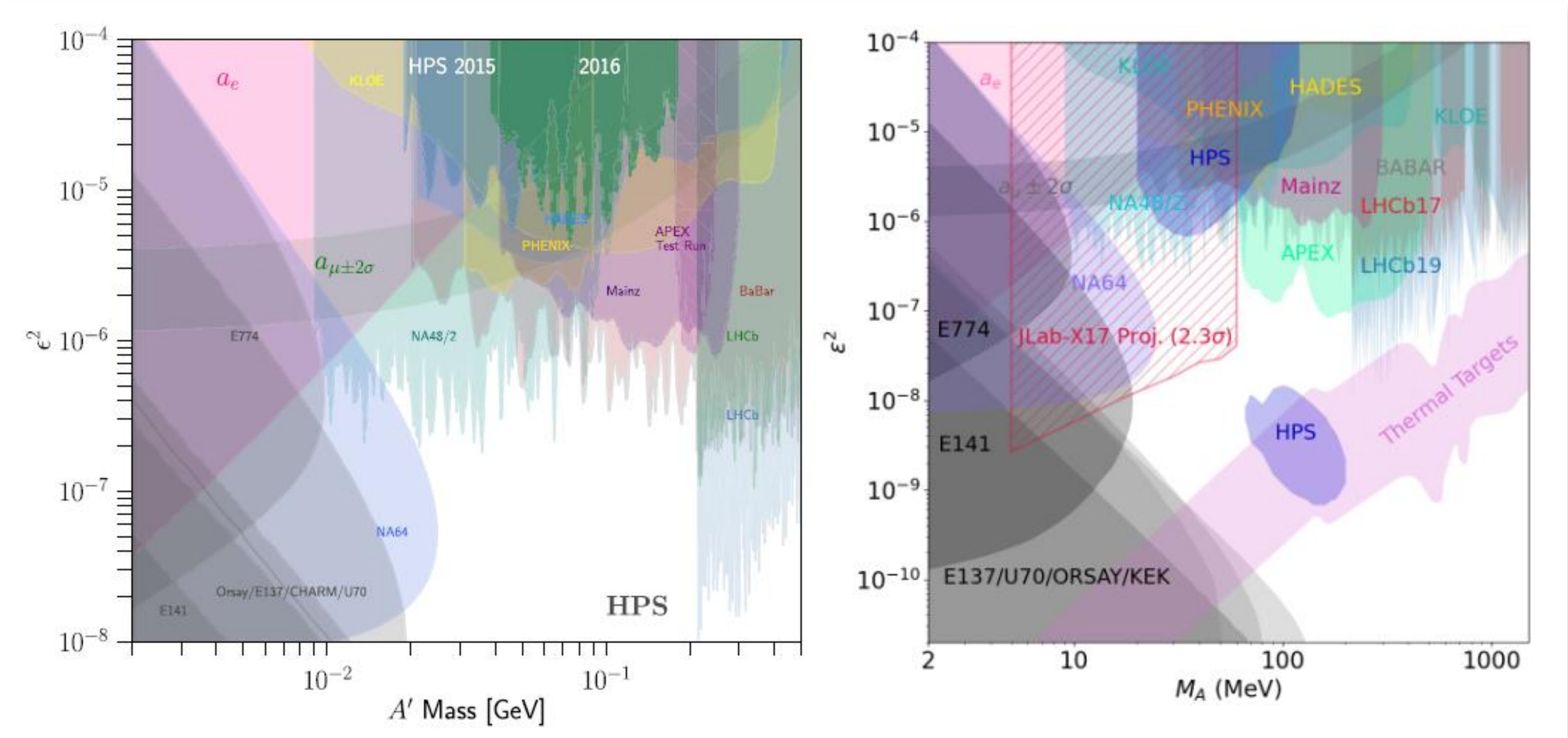
Have a good time in Newport News during this colorful and beautiful Fall days!

Latest Publications

First Displaced Vertex Analysis in Heavy Photon Search







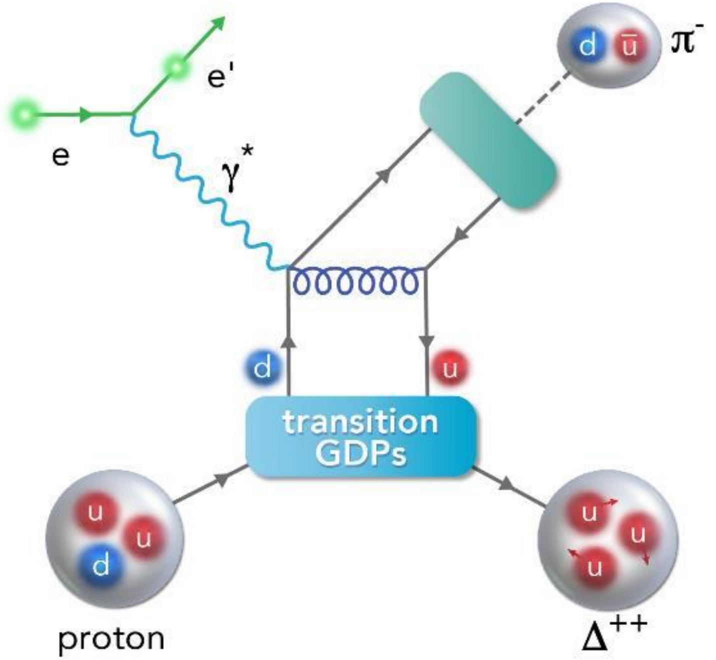
- Including both, bump hunt and displaced vertex search
- Results from 2.3 GeV 2016 engineering run
- Excludes *A'* production over mass range 40 – 180 MeV down to $\epsilon^2 = 10^{-5}$

[P. H. Adrian et al. (HPS Collab.), Phys. Rev. D 108, 012015, 21 July 2023]

First Access to Transition GPDs in $\pi^- \Delta^{++}$ Electro-Production

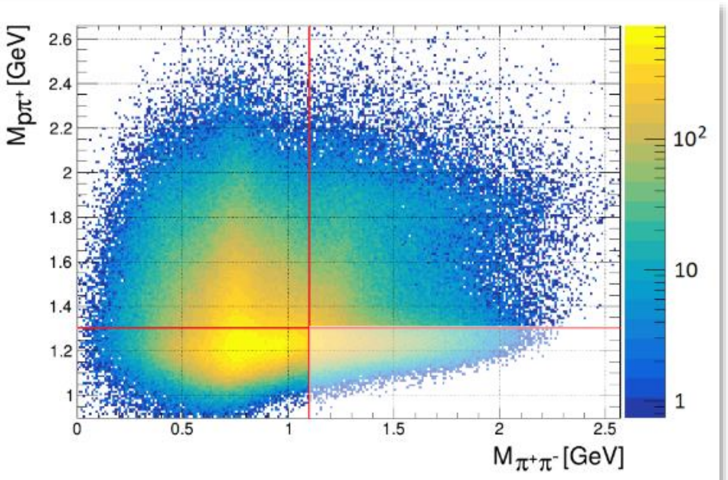
Transition GPDs as a generalization of GPDs to N → Δ processes

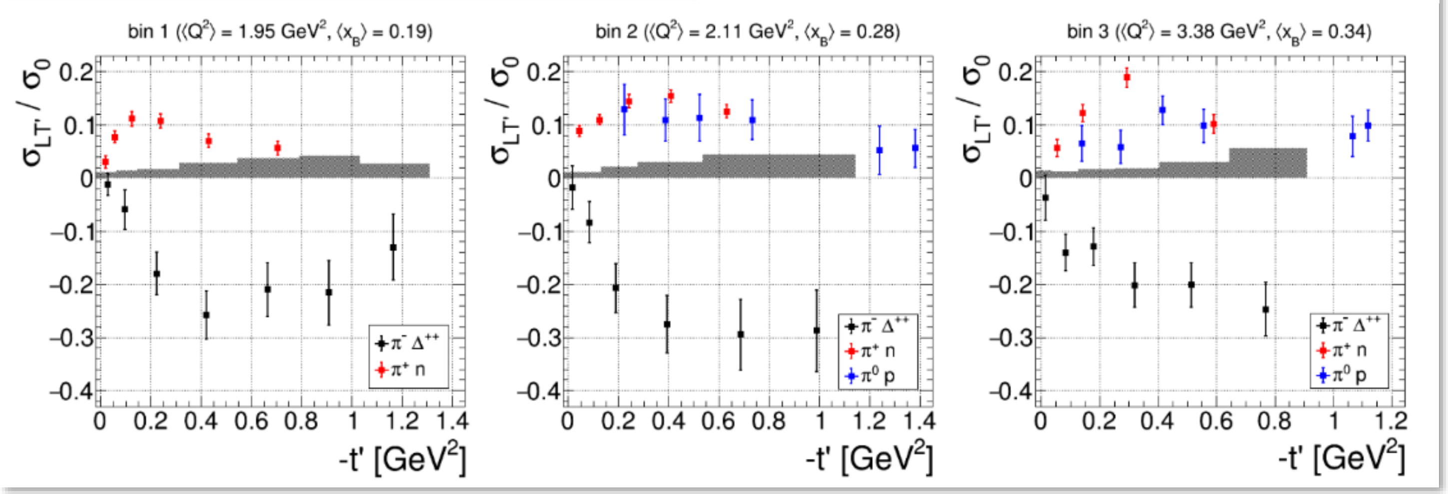
$ep \rightarrow e' p\, \pi^-(\pi^+)$



$$BSA = \frac{\sqrt{2\epsilon(1-\epsilon)}\frac{\sigma_{LT'}}{\sigma_0}\sin\phi}{1+\sqrt{2\epsilon(1+\epsilon)}\frac{\sigma_{LT}}{\sigma_0}\cos\phi+\epsilon\frac{\sigma_{TT}}{\sigma_0}\cos 2\phi}$$

- Exploratory measurement
- 3D structure on resonances
- Access to *d*-quark content

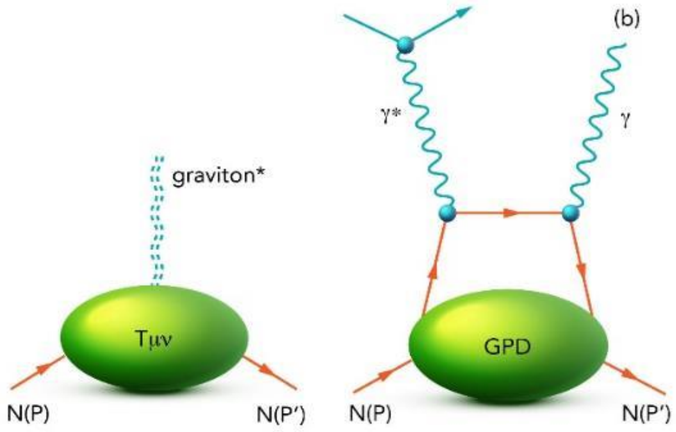




[S. Diehl et al. (CLAS Collab.), Phys. Rev. Lett. 131, 021901,11 July 2023]

First Determination of Distribution of Forces in the Proton

$$\langle p_2|\hat{T}^q_{\mu\nu}|p_1\rangle = \bar{U}(p_2)\left[M_2^q(t)\frac{P_\mu P_\nu}{M} + J^q(t)\frac{\imath(P_\mu\sigma_{\nu\rho}+P_\nu\sigma_{\mu\rho})\Delta^\rho}{2M} + d_1^q(t)\frac{\Delta_\mu\Delta_\nu - g_{\mu\nu}\Delta^2}{5M}\right]U(p_1)$$



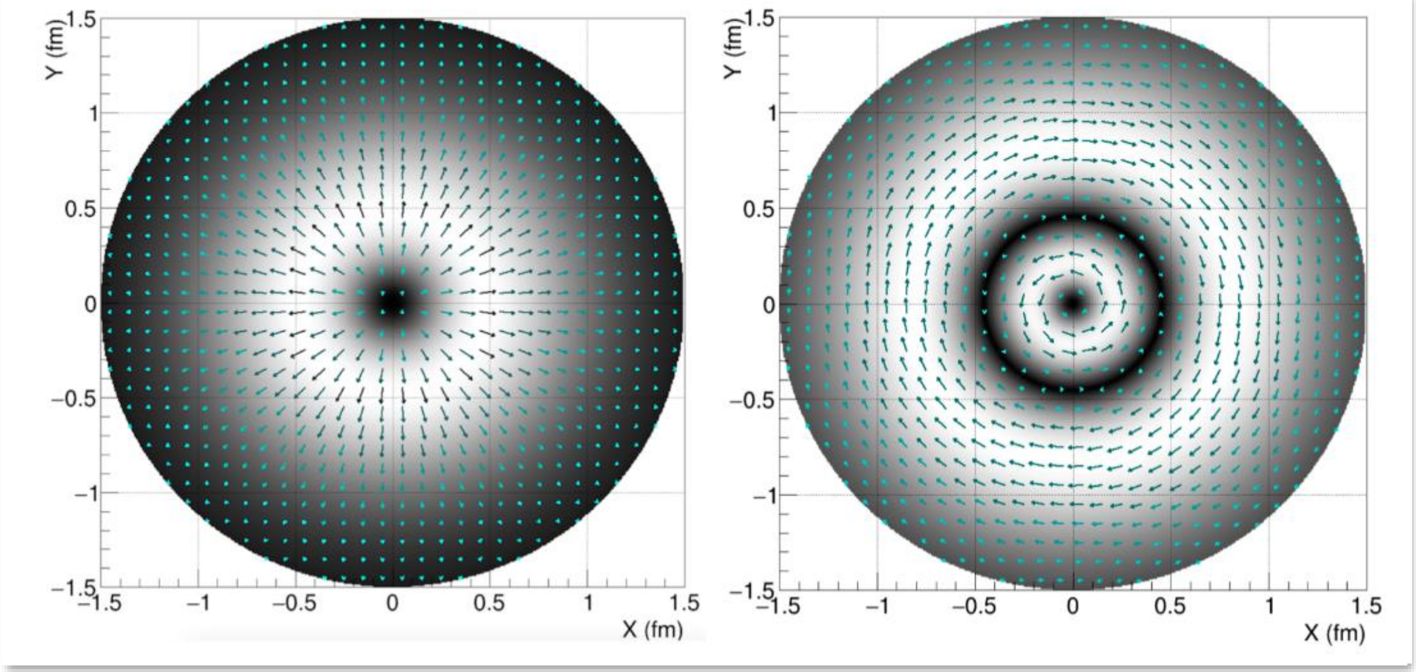
Graviton coupling to the proton

Deeply Virtual Compton Scattering (DVCS)

$$\int dx\, x\, [H(x,\xi,t) + E(x,\xi,t)] = 2J(t)$$

$$\int dx\, x H(x,\xi,t) = M_2(t) + \frac{4}{5}\xi^2 d_1(t),$$

Distribution of forces as function of distance from proton center

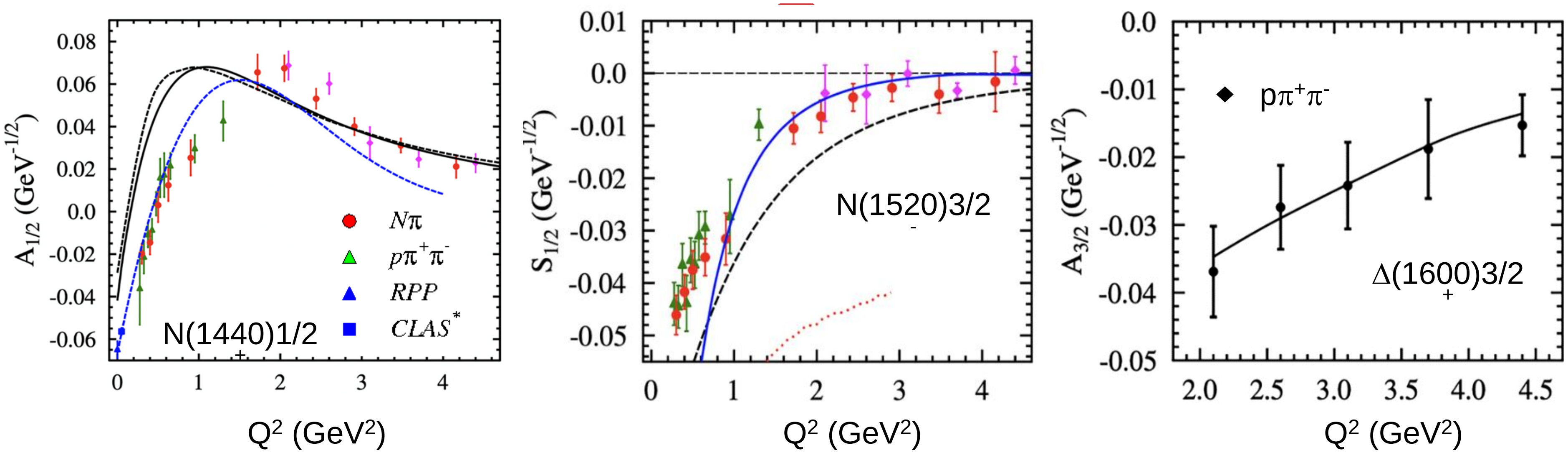


Normal forces

Tangential forces

[V. D. Burkert et al., Rev. Mod. Phys. (accepted 28 July 2023)]

N* Structure from π⁺π⁻p Electroproduction with CLAS



CSM predictions

QM: core of three dressed quarks of running mass

QM: core of three dressed quarks of frozen mass and meson-baryon cloud

QM: core of three dressed quarks of running mass and meson-baryon cloud

QM: core of three dressed quarks of frozen mass

QM: three dressed quarks of leading SU(6) configuration with frozen mass

CSM predictions

QM stands for quark models

Electrocouplings of the N(1440)1/2⁺, N(1520)3/2⁻, and D(1600)3/2⁺ were obtained for Q^2 from 2.0-5.0 GeV² from nine differential cross sections and analyzed within the JLab-Moscow State University meson-baryon reaction model

[V.I. Mokeev, P. Achenbach, V.D. Burkert, D.S. Carman *et al.*, Phys. Rev. C 108, 025204 (25 Aug 2023)]