# Hall-B Status Report

*Welcome everyone to Jefferson Lab!*

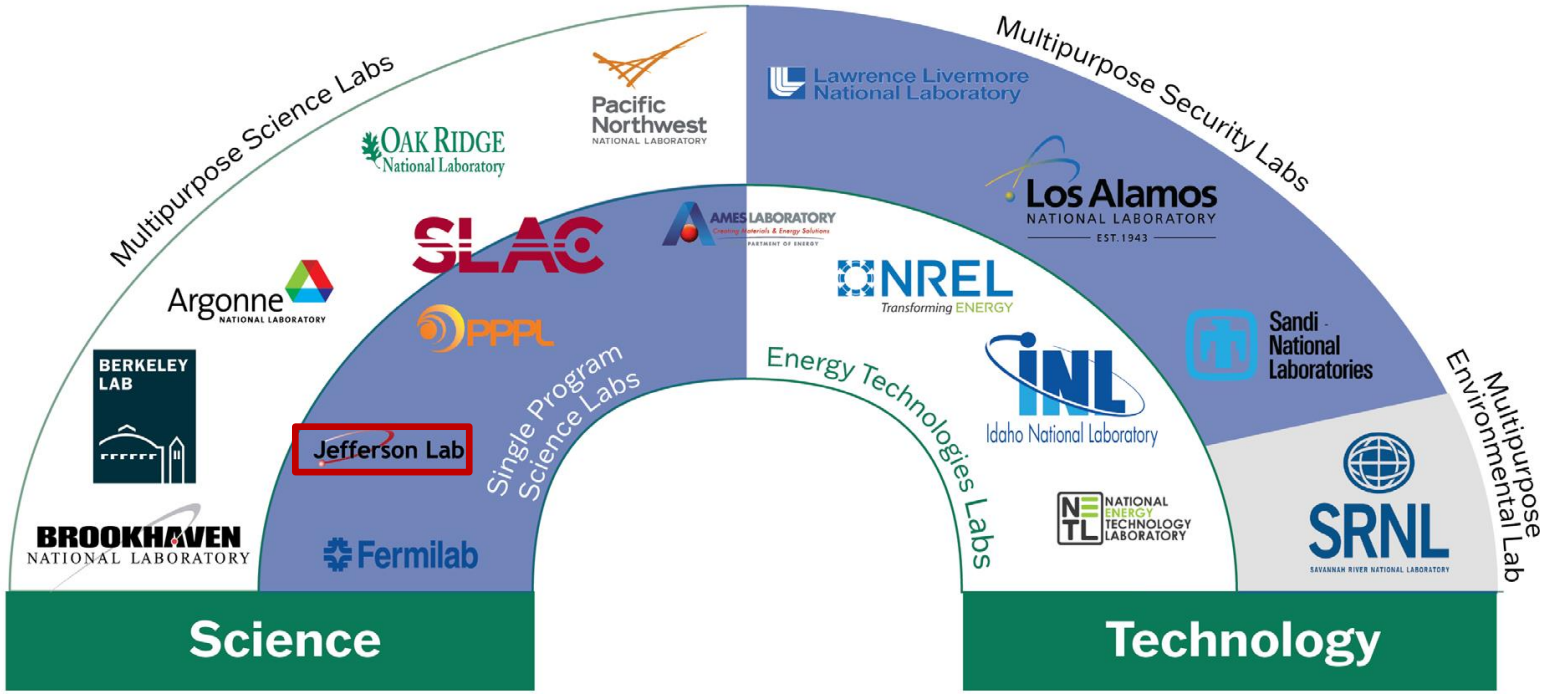
- Budget Issues
- Safety Issues
- Hall-B:
  - Status of Experiments
  - Schedule of Experiments

Patrick Achenbach

*3 June 2024*

# Budget Issues

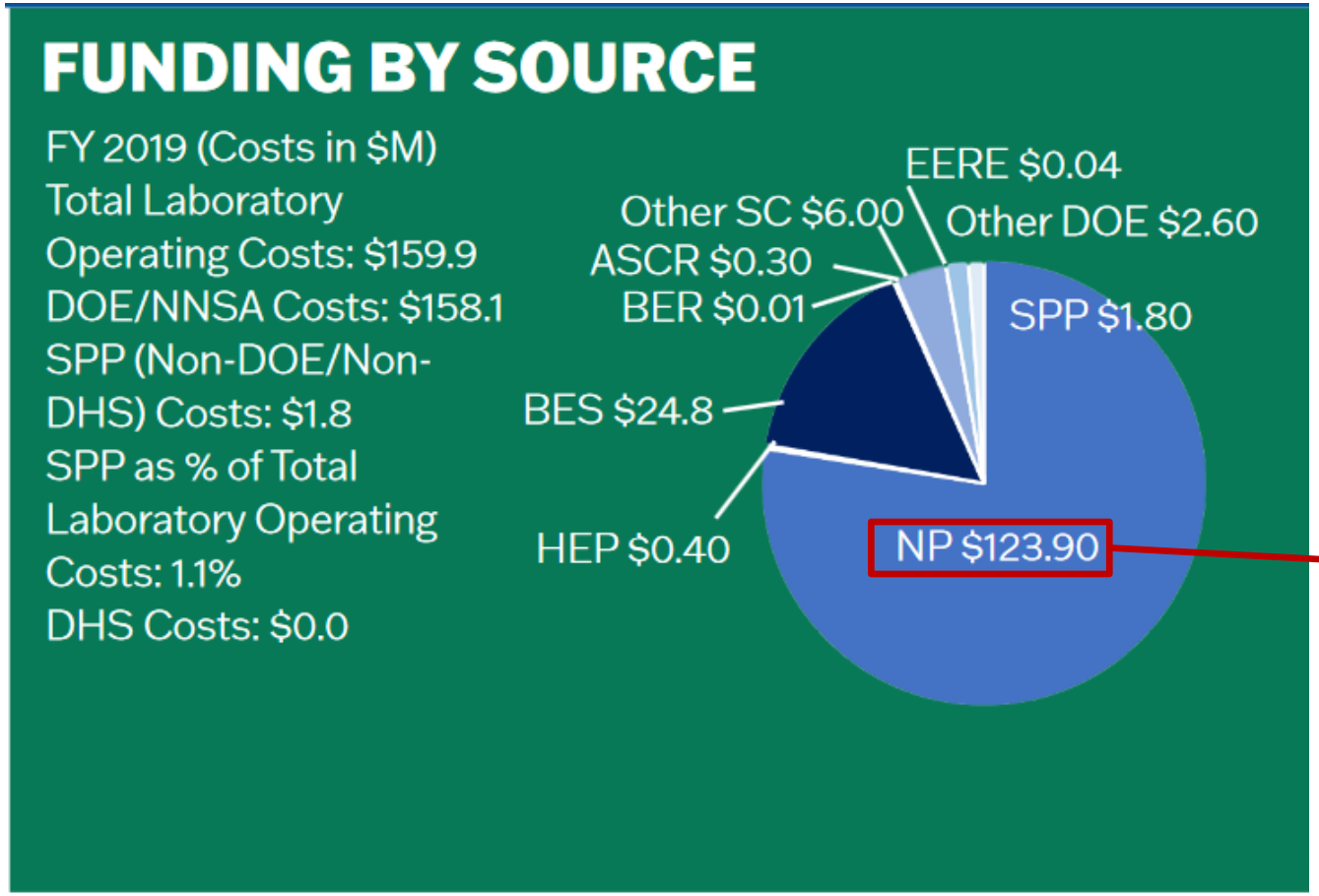
# Jefferson Lab as a DOE National Laboratory

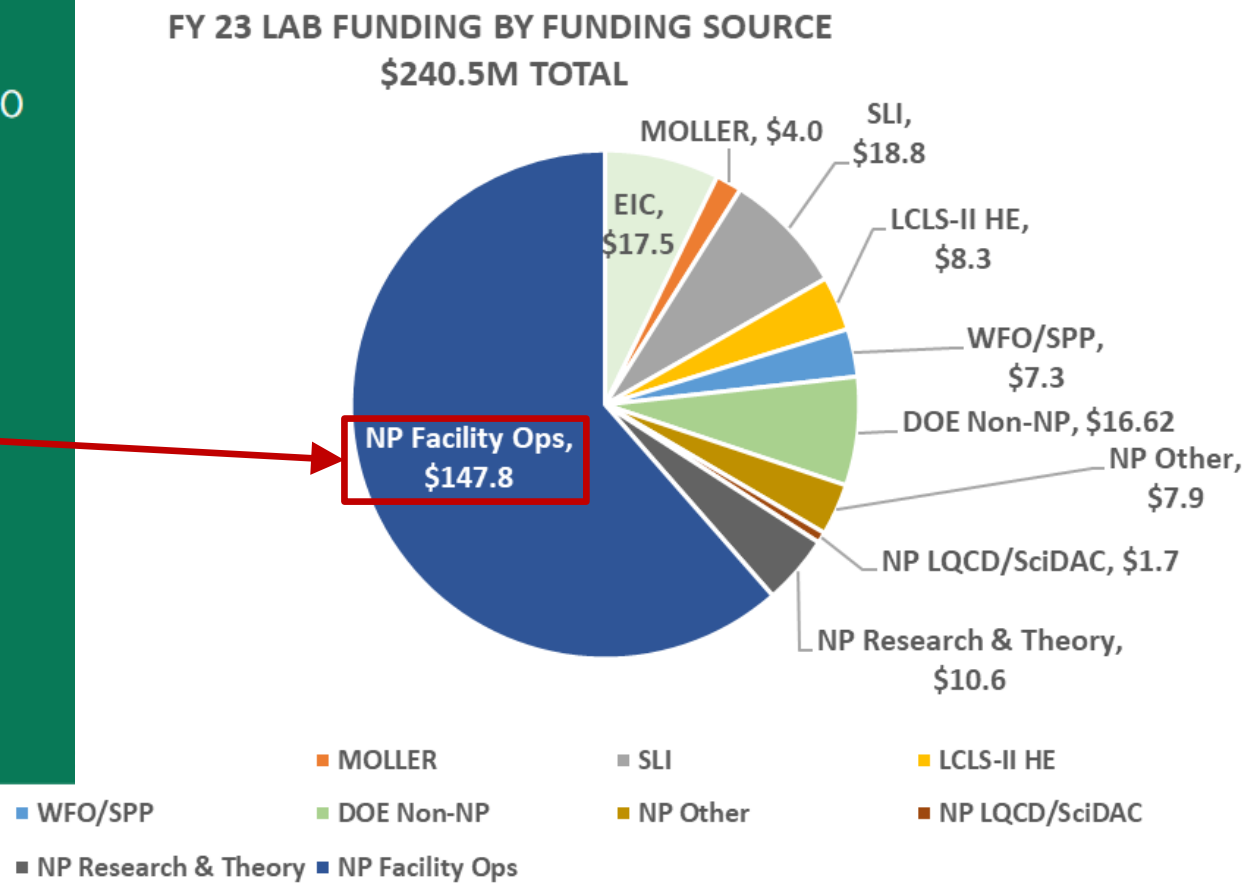



Jefferson Lab is a **program-dedicated, single-purpose laboratory**

[DOE: The State of the DOE National Laboratories: 2020 Edition]

# Jefferson Lab Funding Sources

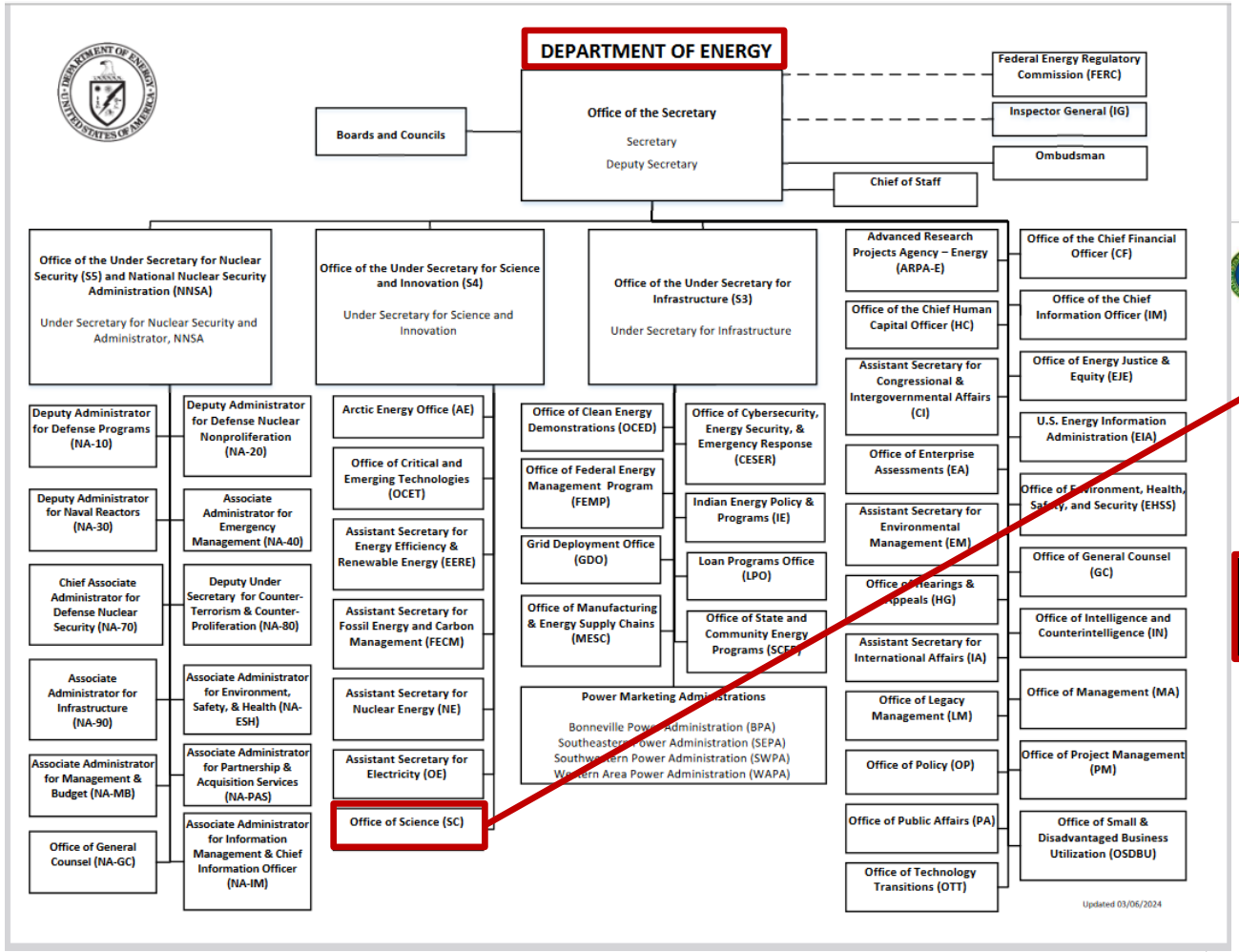



Jefferson Lab Funding (in 2019): DOE 99% of which Nuclear Physics (NP) is 78%

[DOE: The State of the DOE National Laboratories: 2020 Edition]

# DOE & Office of Science Organizational Charts




# DOE Budget in Brief

SCIENCE

($K)

| | FY 2023 Enacted | FY 2024 Annualized CR | FY 2025 Request | FY 2025 Request vs FY 2023 Enacted $ | FY 2025 Request vs FY 2023 Enacted % |
|---|---|---|---|---|---|
| **Office of Science** | | | | | |
| Advanced Scientific Computing Research | 1,068,000 | 1,033,108 | 1,152,682 | +84,682 | +7.93% |
| Basic Energy Sciences | 2,534,000 | 2,503,632 | 2,582,285 | +48,285 | +1.91% |
| Biological and Environmental Research | 908,685 | 835,644 | 945,225 | +36,540 | +4.02% |
| Fusion Energy Sciences | 763,222 | 804,668 | 844,496 | +81,274 | +10.65% |
| High Energy Physics | 1,166,000 | 1,196,301 | 1,230,768 | +64,768 | +5.55% |
| Nuclear Physics | 805,196 | 771,203 | 833,091 | +27,895 | +3.46% |
| Isotope R&D and Production | 109,451 | 153,551 | 183,900 | +74,449 | +68.02% |
| Accelerator R&D and Production | 27,436 | 29,175 | 31,273 | +3,837 | +13.99% |
| Workforce Development for Teachers and Scientists | 42,000 | 42,100 | 43,100 | +1,100 | +2.62% |
| Science Laboratories Infrastructure | 280,700 | 293,918 | 295,180 | +14,480 | +5.16% |
| Safeguards and Security | 184,099 | 200,000 | 195,000 | +10,901 | +5.92% |
| Program Direction | 211,211 | 236,700 | 246,000 | +34,789 | +16.47% |
| **Total, Office of Science** | **8,100,000** | **8,100,000** | **8,583,000** | **+483,000** | **+5.96%** |

While inflation was ~ 4%, **Nuclear Physics** budget **went down** from 2023 to 24 **by 4%**

[DOE FY 2025 Budget Justification, https://www.energy.gov/cfo/articles/fy-2025-budget-justification, 11 March 2024]

# Nuclear Physics Budget in Brief

(dollars in thousands)

| | FY 2023 Enacted | FY 2024 Annualized CR | FY 2025 Request | FY 2025 Request vs FY 2023 Enacted |
|---|---|---|---|---|
| **Nuclear Physics** | | | | |
| Medium Energy, Research | 59,083 | 50,055 | 50,592 | -8,491 |
| Medium Energy, Operations | 149,834 | 138,620 | 147,244 | -2,590 |
| **Total, Medium Energy Physics** | **208,917** | **188,675** | **197,836** | **-11,081** |
| Heavy Ion, Research | 46,149 | 45,474 | 43,349 | -2,800 |
| Heavy Ion, Operations | 182,087 | 166,993 | 181,126 | -961 |
| Heavy Ion, Projects | 20,000 | 2,850 | 2,850 | -17,150 |
| **Total, Heavy Ion Physics** | **248,236** | **215,317** | **227,325** | **-20,911** |
| Low Energy, Research | 77,651 | 75,159 | 72,334 | -5,317 |
| Low Energy, Operations | 128,579 | 120,401 | 135,646 | +7,067 |
| Low Energy, Projects | 23,940 | 9,259 | 5,259 | -18,681 |
| **Total, Low Energy Physics** | **230,170** | **204,819** | **213,239** | **-16,931** |
| Theory, Research | 67,873 | 67,392 | 84,691 | +16,818 |
| **Total, Nuclear Theory** | **67,873** | **67,392** | **84,691** | **+16,818** |
| **Subtotal, Nuclear Physics** | **755,196** | **676,203** | **723,091** | **-32,105** |
| **Construction** | | | | |
| 20-SC-52 Electron Ion Collider (EIC), BNL | 50,000 | 95,000 | 110,000 | +60,000 |
| **Subtotal, Construction** | **50,000** | **95,000** | **110,000** | **+60,000** |
| **Total, Nuclear Physics** | **805,196** | **771,203** | **833,091** | **+27,895** |

JLab: Medium Energy

Jefferson Lab's Research and Operations **from FY23 to 24: −10%**

# Effect on CEBAF Operating Hours

(dollars in thousands)

| | FY 2023 Enacted | FY 2023 Current | FY 2024 Annualized CR | FY 2025 Request | FY 2025 Request vs FY 2023 Enacted |
|---|---|---|---|---|---|
| **Scientific User Facilities - Type A** | | | | | |
| **Relativistic Heavy Ion Collider** | **182,087** | **182,045** | **166,993** | **181,126** | **-961** |
| Number of Users | 1,010 | 1,053 | 1,010 | 1,010 | – |
| Achieved Operating Hours | – | 1,641 | – | – | – |
| Planned Operating Hours | 2,400 | 2,400 | – | 3,100 | +700 |
| **Continuous Electron Beam Accelerator Facility** | **149,834** | **147,942** | **138,620** | **147,244** | **-2,590** |
| Number of Users | 1,730 | 1,904 | 1,730 | 1,800 | +70 |
| Achieved Operating Hours | – | 3,306 | – | – | – |
| Planned Operating Hours | 4,100 | 4,100 | 2,240 | 3,170 | -930 |

CEBAF Operations Hours:

**From FY23 to 24: −1860 hrs. = −78 days**

**From FY23 to 25: −930 hrs. = −39 days**

# Safety Issues

# Lock-out Tag-out Safety Pause

LOTO Pause and Restart Process

Updated Guidance for All-LOTO Pause & Restart

Hazardous Energy Control Lock-out Tag-out Update and Meeting

Jefferson Lal
Thomas Jefferson National A

## MESSAGE FROM THE CHIE

**May 22, 2024**
**SUBJECT: LOTO Pause and Restart**
**CONTACT: Johnathon Huff, jhuff@jl**

Dear JLab Team,

As a result of LOTO (lock-out tag-out) work. During today's SAD (scheduled meeting is mandatory for anyone perfo

While observing SAD LOTO activities,

- Missing PPE (personal protectiv
- PPE that is damaged or not app
- No pre-job briefing in some insta

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Thomas Jefferson National Accelerator Fac

## MESSAGE FROM THE CHIEF OPERATIN

**May 24, 2024**
**SUBJECT: Updated Guidance for All-LOTO Pause &**
**CONTACT: Johnathon Huff, jhuff@jlab.org; John Rie**

Dear JLab Team,

After we received more information from the investigati pause include all hazardous energy control LOTO work **implementing a lockout/tagout (LOTO) pause on all control. This includes all sources of hazardous ene**

Further, there shall be no work performed on any syste the SAD until we complete a verification of each syster in the field. This full assessment and verification of the the start of the scheduled accelerator down period that underway.

Jefferson Lab
Thomas Jefferson National Accelerator Facility

## MESSAGE FROM THE CHIEF OPERATING OFFICER

**May 29, 2024**
**SUBJECT: Hazardous Energy Control Lock-out Tag-out Update and Meeting**
**CONTACT: John Riesbeck, riesbeck@jlab.org**

Dear JLab Team,

On Thursday, May 30, at 9:30 a.m., there will be a mandatory all-hands meeting led by Lab Director Stuart Henderson in the CEBAF Center auditorium and via Zoom to address issues identified with hazardous energy control (HEC) lock-out tag-out (LOTO) work.

Over the weekend, a cross-organizational team developed the Hazardous Energy Control Lock-Out Tag-Out Pause and Restart Plan in order to establish our path forward. In the interim, no one may perform any HEC LOTO work until they have successfully completed the competency evaluation process led by John Riesbeck, the electrical safety program lead and myself. The evaluations will be performed on a schedule based on priority established by the SAD Oversight Committee and approved by lab leadership. The committee will add additional team members to include all work, not just work related to the SAD.

Jefferson Lab is (again) in a Safety Pause

# Status of Hall-B Operations

# Timeline Since SAD 2023

| SAD or scheduled Run Group | Setup / Status | Target | Beam Energy | Start Date | End Date | Scheduled Calendar Days | Remaining PAC Days Before Run | Scheduled PAC Days | Actual PAC Days from ABUs | Remaining PAC Days After Run |
|---|---|---|---|---|---|---|---|---|---|---|
| **RG-D** | | liq. D2 & nuclear | 11 | 2023-10-01 | 2023-12-15 | 75 | 30 | 38 | 40 | 0 |
| **RG-K** | | liq. H2 | 6,4 | 2023-12-15 | 2023-12-18 | 3 | 88 | 2 | 2 | 86 |
| | winter break | change | | 2023-12-18 | 2024-01-10 | 23 | | | | |
| **RG-K** | | liq. H2 | 6,4 | 2024-01-11 | 2024-02-12 | 32 | 86 | 16 | 19 | 67 |
| **RG-K** | | liq. H2 | 8,4 | 2024-02-12 | 2024-03-11 | 28 | 67 | 14 | 16 | 51 |
| | | change | | 2024-03-11 | 2024-03-15 | 4 | | 2 | | |
| **RG-E** | | liq. D2 & nuclear | 11 | 2024-03-15 | 2024-05-20 | 66 | 60 | 33 | 27 | 33 |
| **SAD 2024** | | | | 2024-05-20 | | | **sum:** | **104** | **104** | |

- **March 11**, RG-K finished data-taking after two months with $\ell H_2$ at lower-pass beam energies and reached highest momentum resolutions in CLAS12 for baryon spectroscopy (new DC settings)
- **May 19**, RG-E ended data-taking for what amounted to 27 of 33 PAC days that were scheduled
- 4.5 Weeks FY22 and 30 Weeks FY23: **50% efficiency** for PAC days wrt. calendar days (+/- 20%)

# Hadrons and Cold Nuclear Matter

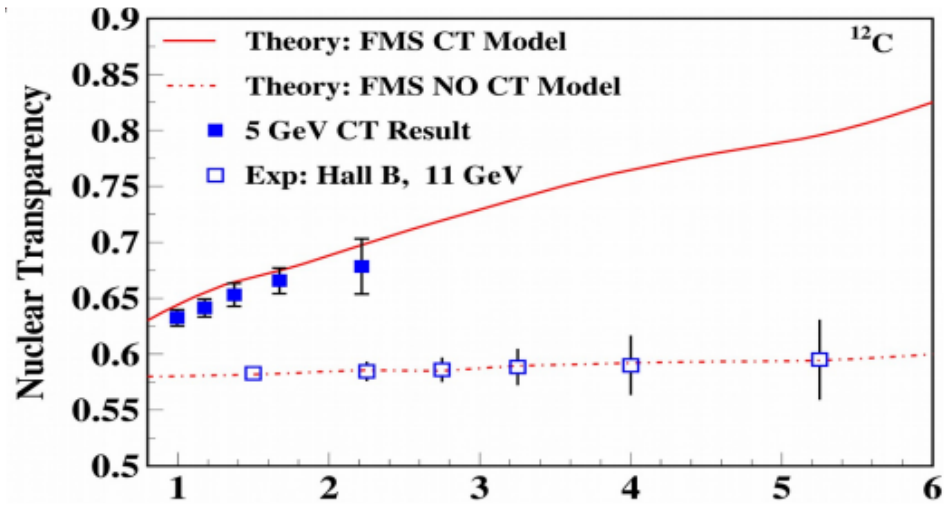
| Proposal | Physics | Exp. Contact | Rating | PAC | Jeop. | Group Days | Equipment | Energy | Group Contact | Target | Complete |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **E12-06-106** | Color transparency in exclusive vector meson production | L. El Fassi | B+ | 30 | 48 | **30** | CLAS12 | 11 | **RG-D** L. El Fassi | Nuclear & liquid $D_2$ | **40 d 100%** |
| E12-06-106A | Nuclear TMDs | R. Dupre | | 48 | | | | | | | |
| **E12-06-117** | Quark propagation and hadron formation | W. Brooks | A- | 30 | 48 | **60** | CLAS12 | 11 | **RG-E** H. Hakobyan | Nuclear & liquid $D_2$ | **27 d 45%** |
| E12-06-117A | Dihadron measurements in electron-nucleus scattering | M. Arratia | | 48 | | | | | | | |

- **RG-D** used out-bending torus polarity and 3 different solid target materials separated from $\ell D_2$
- **RG-E** used in-bending torus polarity and 5 different solid target materials simultaneously with $\ell D_2$
- **RG-E** needs factor 2 more statistics to access hadrons that are produced with smaller cross-section

Together, a large fraction of data-taking for **Hadrons and Cold Nuclear Matter** program completed

# Run Group D Preliminary Results

Color Transparency $T_A$ data, theory, projections:




The CT signature is the increase of the medium "nuclear" transparency, $T_A$, as a function of the four-momentum transfer squared, $Q^2$.

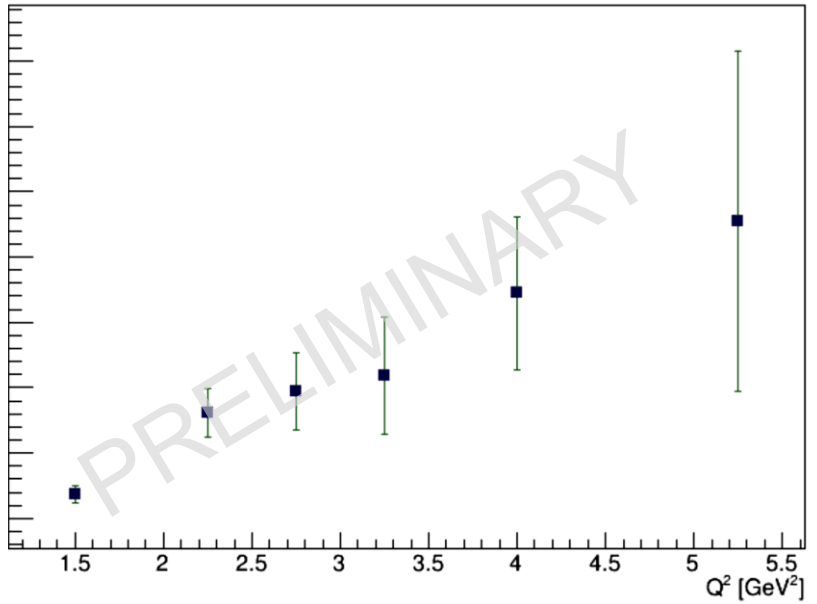
$$T_A = \frac{\sigma_A}{A\,\sigma_N}$$

$\sigma_A$ is the nuclear cross section

$\sigma_N$ is the free (nucleon) cross section

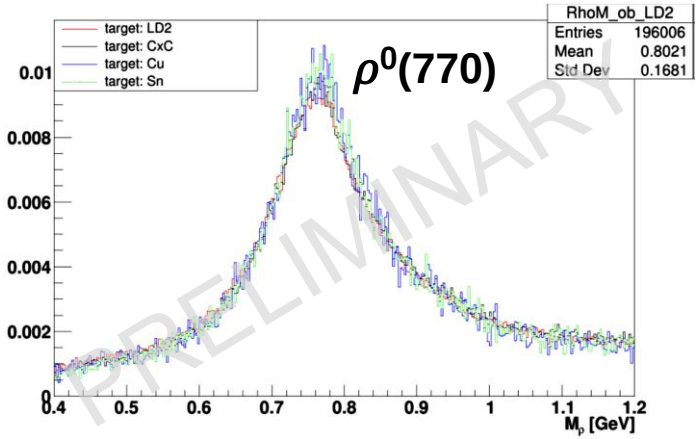
**Four solid RG-D targets:**
- Cu x Sn : 182 mC
- C x C : 30 mC
- ℓD2 cryo-target: 32 mC

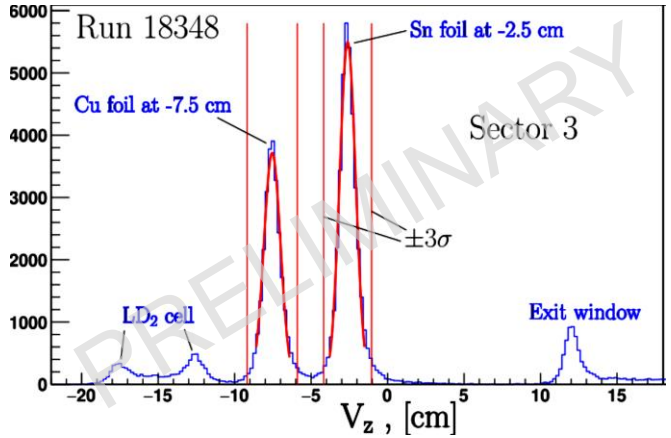
Nuclear Transparency




[Matthew Maynes, APS April Meeting 2024]

$\pi^+ \pi^-$ invariant mass for solid targets + $\ell D_2$:

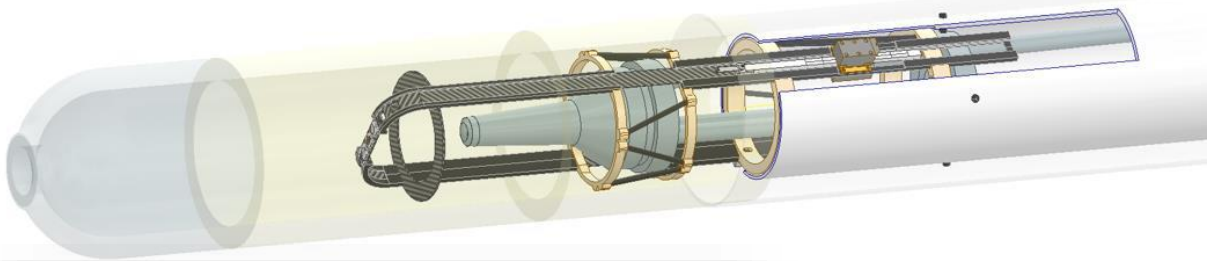


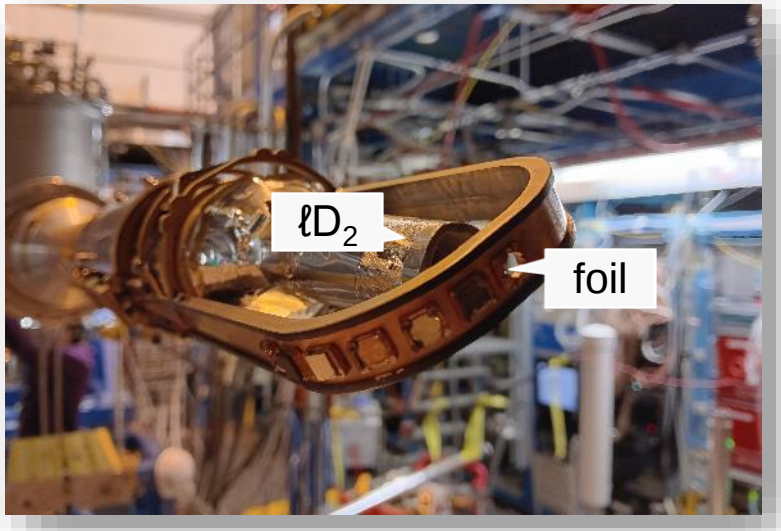




- **~15%** of the data set for carbon target analyzed
- Cuts on kinematics for exclusive diffractive and **incoherent $\rho^0$ electroproduction off nuclei**
- After initial alignment and online calibration, **offline calibration** to start in the next few weeks

RG-D analysis is well on track despite waiting for new alignment procedures

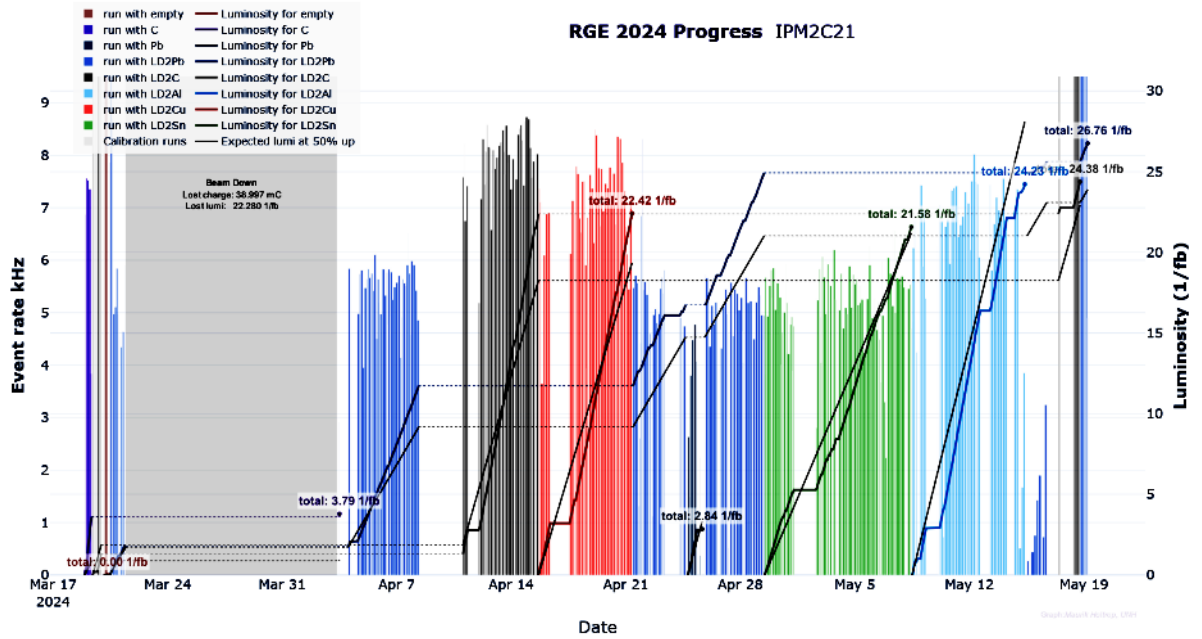
# Run Group E Data-Taking Summary

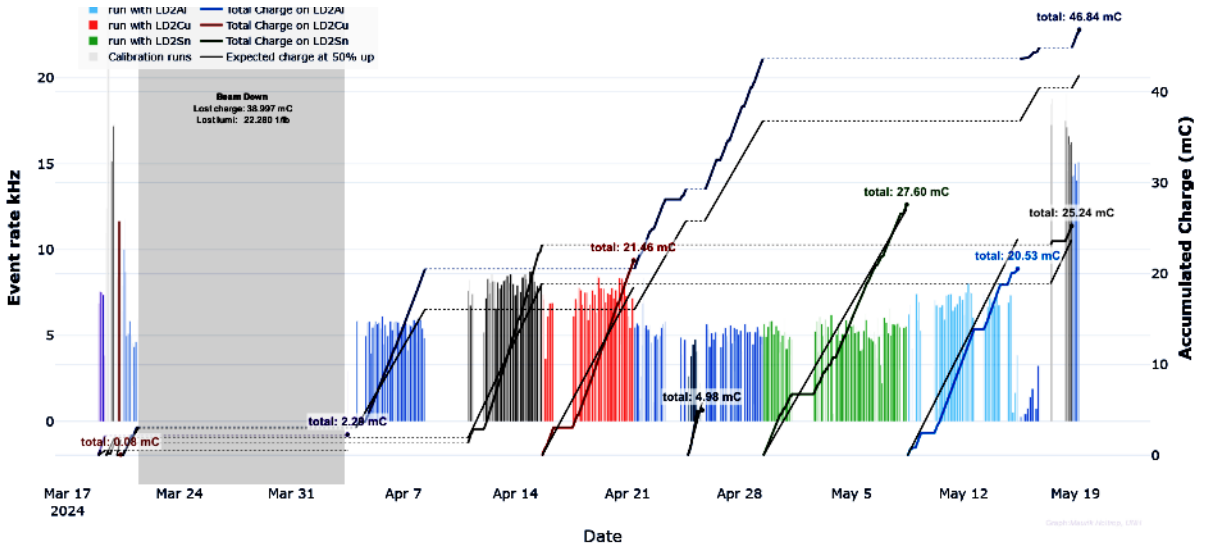





Data-taking on **five solid RG-E targets** with comparable luminosity:

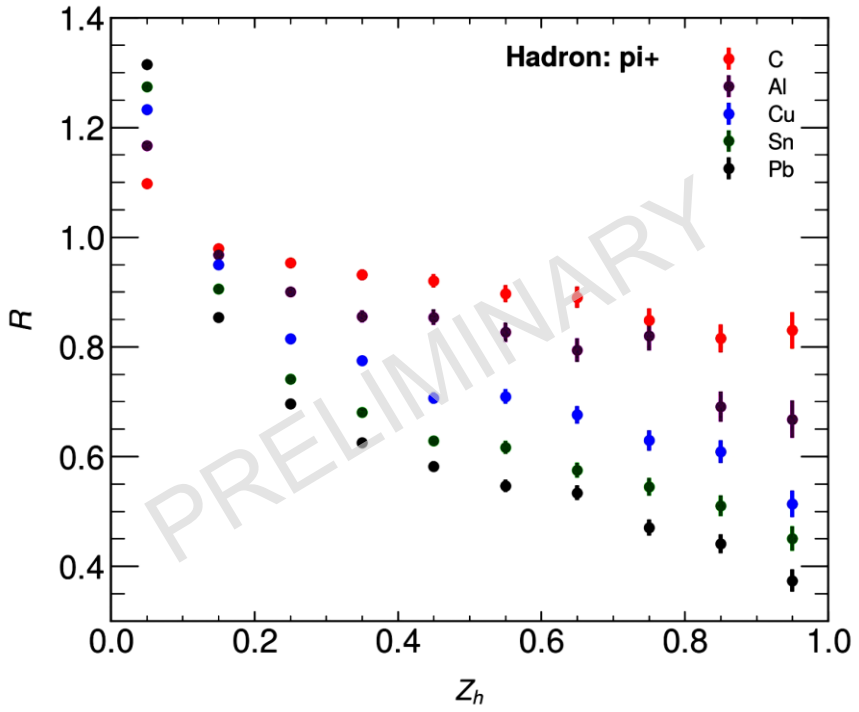
- C x $\ell D_2$ : 23 1/fb
- Al x $\ell D_2$ : 24 1/fb
- Cu x $\ell D_2$ : 22 1/fb
- Sn x $\ell D_2$ : 22 1/fb
- Pb x $\ell D_2$ : 26 1/fb

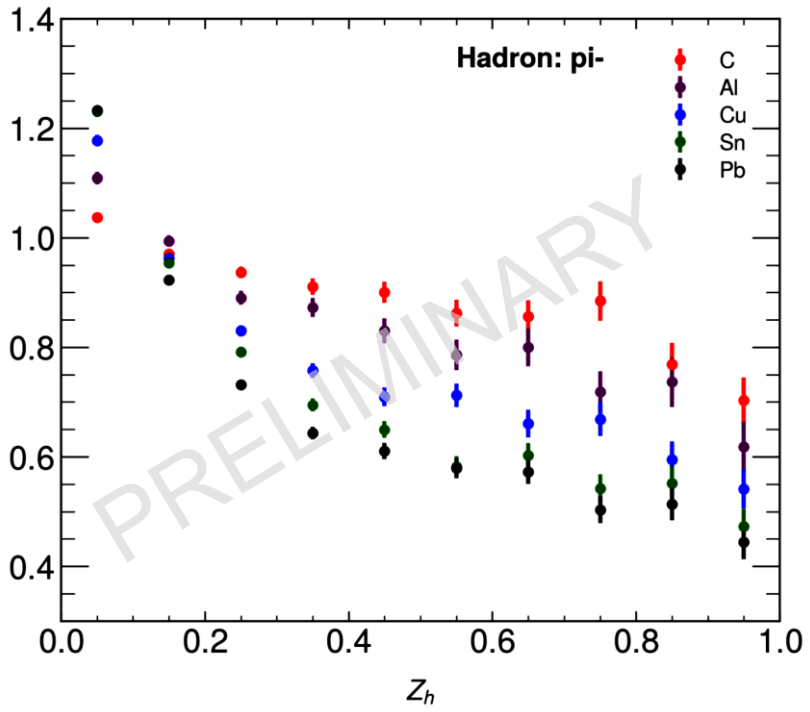


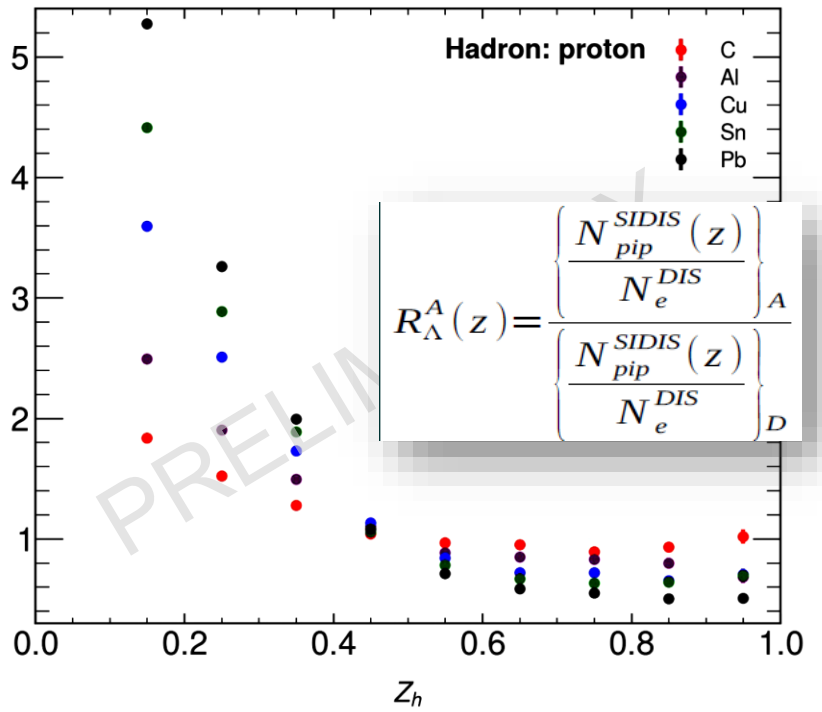




- **Double-target system performed excellent** with fast solid-target changes along with stable & robust operation
- **Major downtimes** of 50 + 270 hours **due to** two vacuum events / beam strikes in the **accelerator**
- Completed necessary calibration and extra runs (e.g., empty, luminosity scans, in- vs. out-bending polarity)

# Run Group E Online Analysis




$$R_A^A(z) = \frac{\left\{\frac{N_{pip}^{SIDIS}(z)}{N_e^{DIS}}\right\}_A}{\left\{\frac{N_{pip}^{SIDIS}(z)}{N_e^{DIS}}\right\}_D}$$

Data quality and statistics seem good enough for high-level physics output

- Comprehensive study of impact of the **nuclear medium** on **quark hadronization**
- A **multidimensional kinematical analysis** of hadrons in DIS

- Simultaneous data from $\ell D_2$ and nuclear targets to allow **cancellation of systematic uncertainties**

- Extends CLAS6 EG2 with …
  - Higher luminosity
  - Different nuclei
  - Higher beam energy
  - Polarized beam

[Matias Lopez, Milan Ungerer Muñoz, and Antonio Radic, independently by Uditha Weerasinghe, May 2024]

# Near-Term Schedule 2024-25

| SAD or scheduled Run Group | Setup / Status | Target | Beam Energy | Start Date | End Date | Scheduled Calendar Days | Remaining PAC Days Before Run | Scheduled PAC Days | Actual PAC Days from ABUs | Remaining PAC Days After Run |
|---|---|---|---|---|---|---|---|---|---|---|
| **RG-L** | ALERT | high pressure gas | 11 | 2024-11-01 | 2024-12-18 | 47 | 55 | 23 | | 31 |
| | winter break | | | 2024-12-16 | 2025-01-12 | 27 | | | | |
| **RG-L** | ALERT | high pressure gas | 11 | 2024-01-12 | 2024-03-15 | 63 | 31 | 31 | | 0 |
| **RG-T** | ALERT | high pressure gas | 6,6 | 2024-03-15 | 2024-04-18 | 34 | 17 | 17 | | 0 |
| **SAD 2025** | | | | | | | **sum:** | **72** | | |

- **Low-pass run with ALERT** was awarded 17 PAC days by last year's PAC51
- With **only 24 weeks of physics operation**, planned **RG-E and RG-K** runs are **cancelled**

By next SAD, ALERT will be finished even if there are some unscheduled downtimes

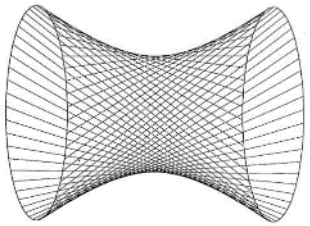
# ALERT Run Groups

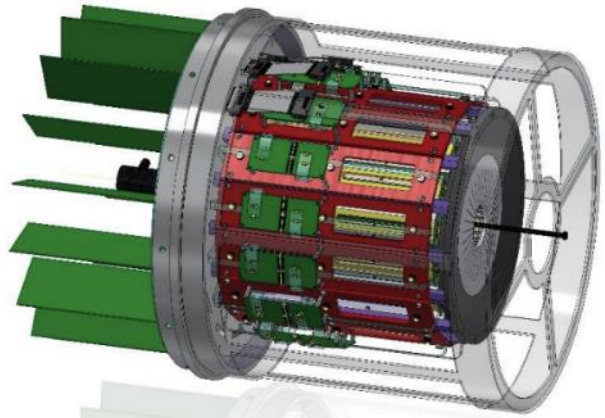
| Proposal | Physics | Exp. Contact | Rating | PAC | Group Days | Equipment | Energy | Group Contact | Target |
|---|---|---|---|---|---|---|---|---|---|
| **E12-17-012** | Partonic structure of light nuclei | Z. Meziani | A- | 45 | **55** | CLAS12; ALERT | 11 | **L** R. Dupre | High pressure gaseous H, D, $^4$He |
| E12-17-012A | Tagged EMC measurements on light nuclei | R. Dupre | | 45 | | | | | |
| E12-17-012B | Spectator-tagged DVCS on light nuclei | W. Armstrong | | 45 | | | | | |
| E12-17-012C | Other physics opportunities with ALERT | M. Defurne | | 45 | | | | | |
| **E12-23-013** | Measuring short-range correlations with ALERT | F. Hauenstein | A | 51 | **17** | | 6.6 | **T** | |

## A Low Energy Recoil Tracker (ALERT)

– Hyperbolic drift chamber
– Time-of-Flight array
– Target straw for $H_2$, $D_2$, and $^4$He
  30 cm active length, 6 mm Ø

| Measurement | Particles detected | $p$ range | $\theta$ range |
|---|---|---|---|
| Nuclear GPDs | $^4$He | $230 < p < 400 MeV/c$ | $\pi/4 < \theta < \pi/2$ rad |
| Tagged EMC | p, $^3$H, $^3$He | $70 < p < 250\,MeV/c$ | As close to $\pi$ as possible |
| Tagged DVCS | p, $^3$H, $^3$He | $70 < p < 250 MeV/c$ | As close to $\pi$ as possible |





## Collaborative effort within CLAS12

– ANL, IJCLab, JLab, New Mexico SU, MSU, ODU and Temple

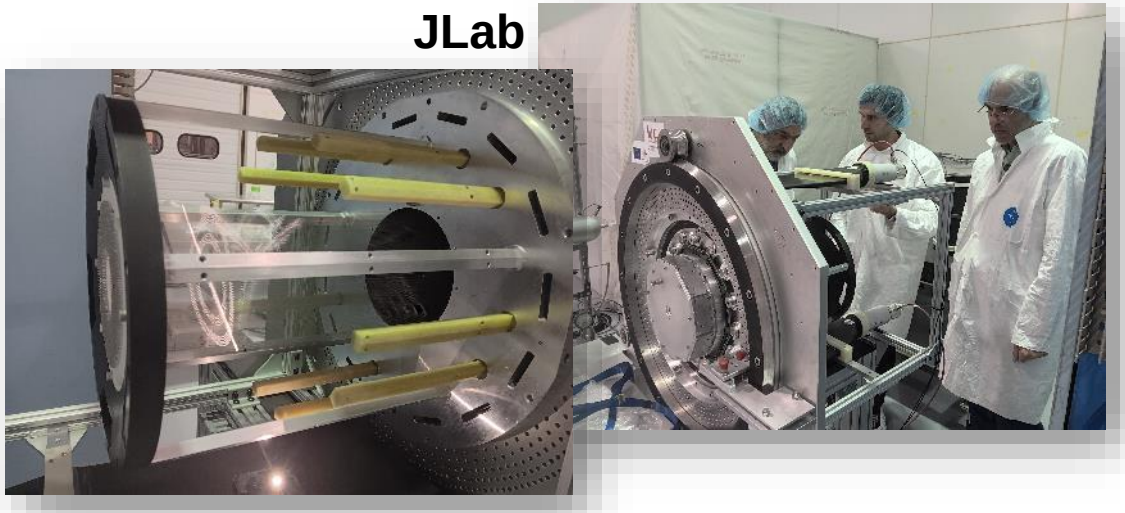
## ALERT Collaboration Meeting at JLab March 18-19, 2024

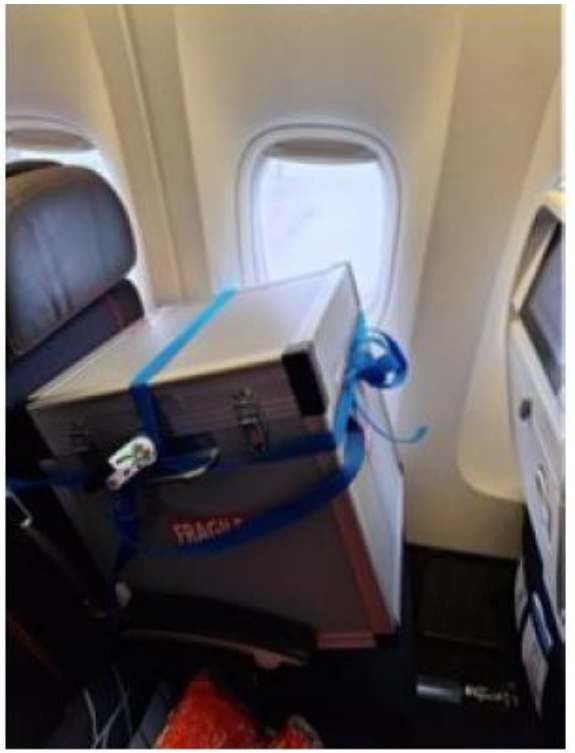
ALERT is effectively replacing the CVT detector similarly to the BONuS12 experiment

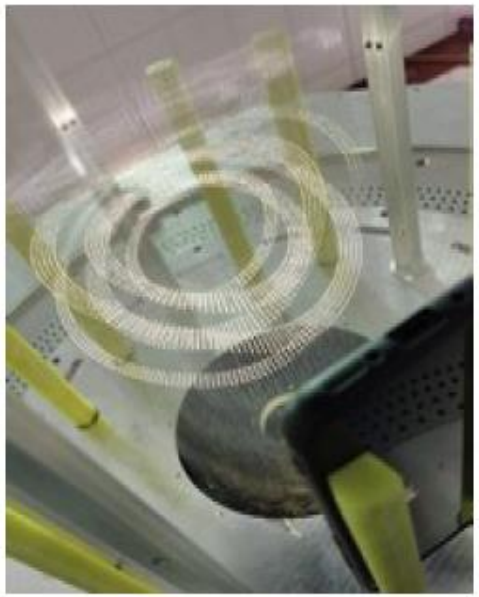
# ALERT Drift Chamber (AHDC)

- **DC**: 30 cm active length, 576 signal + 2450 guard wires = 3026 wires, Al 30 µm diameter, 20° stereo angle, operating gas $He_4$ - $CO_2$

**JLab**







**IJCLab, France**

**Stringing of ALERT wire chamber**

– Sept. 2023 to early March 2024

**Delivered to JLab in April 2024**

– No problems detected after transportation

– All wires except one produce correct signals

– Gas systems are operating

– Data-taking with cosmic rays in EEL building

[Raphaël Dupré, May 2024]

# ALERT Time-Of-Flight (ATOF)

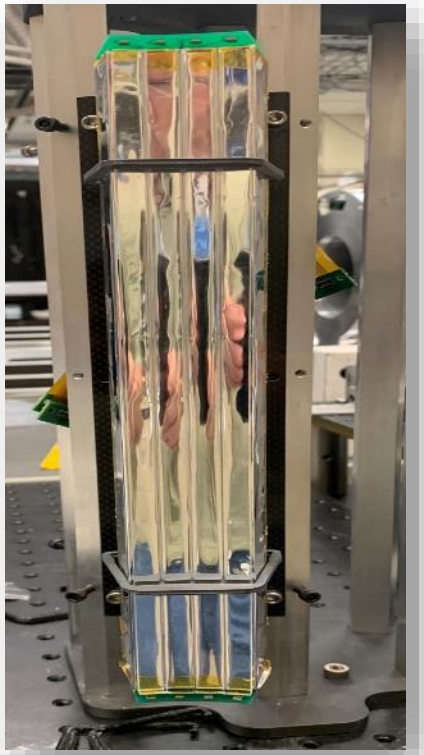
- **TOF**: Two layers of scintillators with SiPM readout, 28 cm length, 15 sub-assemblies: 600 wedges, 60 bars

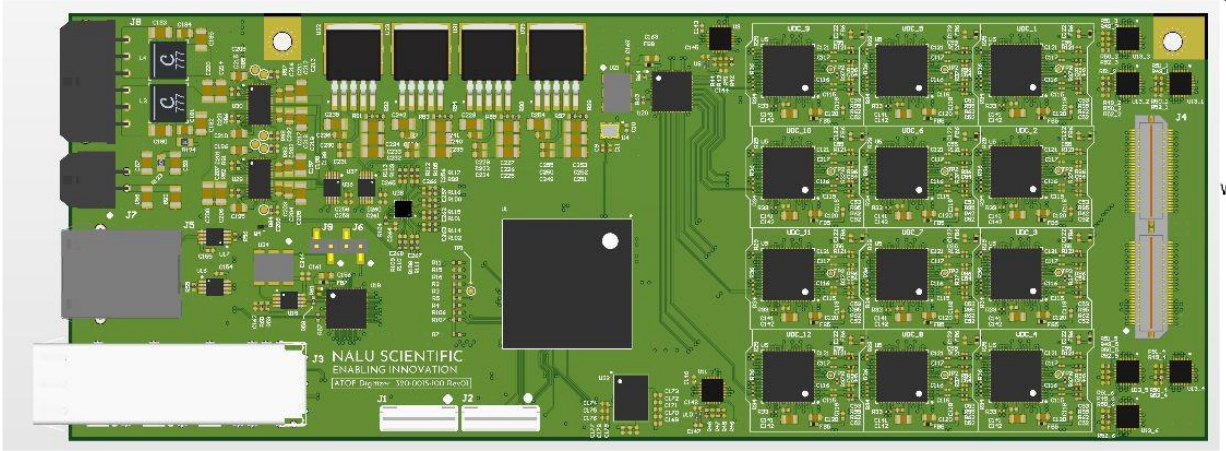
– **Provides PID** for light ions through TOF and topology (inner bar vs. outer wedges)

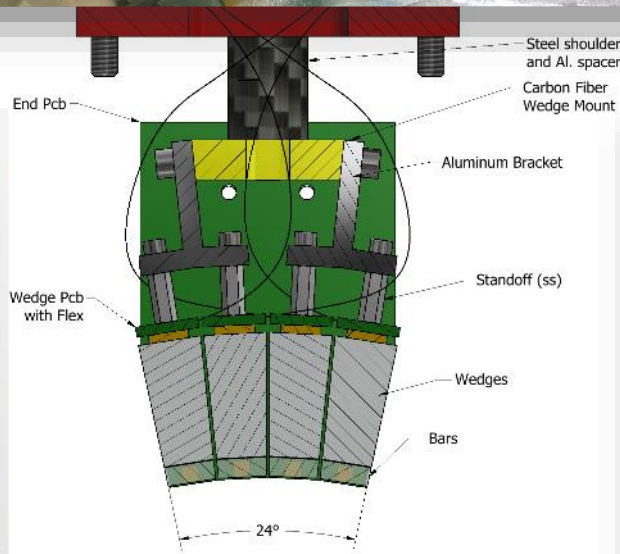
– **All 15** modules assembled

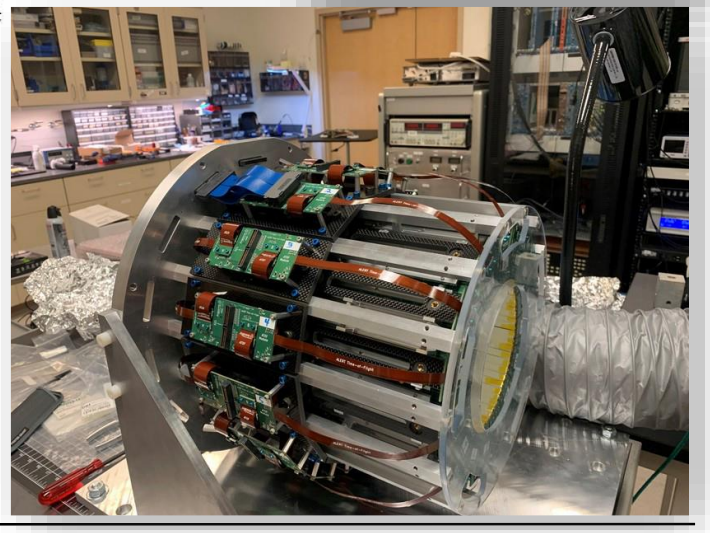
**Electronics**

– 19 PETIROC boards from JLab
– One NALU board from ANL for checks
– Power supplies and cabling in progress



[Raphaël Dupré, May 2024]

# Conditional Schedule 2025-26

| SAD or scheduled Run Group | Setup / Status | Target | Beam Energy | Start Date | End Date | Scheduled Calendar Days | Remaining PAC Days Before Run | Scheduled PAC Days | Actual PAC Days from ABUs | Remaining PAC Days After Run |
|---|---|---|---|---|---|---|---|---|---|---|
| **Assuming ~ 100 PAC days in this period and successful Experiment Readiness Review in 2024** | | | | | | | | | | |
| **RG-O** | PRad-II | gas jet | 0,7; 2,1; 3.5 | 2025-26 | | 80 | 40 | 40 | | 0 |
| | reconfigure | change | | | | 7 | | 4 | | |
| **RG-Q** | X17 search | Ta foil | 2,2; 3,3 | 2025-26 | | 120 | 60 | 60 | | 0 |
| **SAD 2026** | | | | | | | **sum:** | **104** | | |

- The **$\pi^0$TFF** experiment requires additional 67 PAC days and full HyCal readout: cannot run with the other experiments, can possibly be combined with future DRad
- **PRad-II and X17** can **run without outer HyCAL**; PRad-II will cover the proposed $Q^2$-range with a higher beam energy in the awarded number of PAC days
- Youri Sharabian and Phillip Dobrenz are providing additional support
- Experiments need to pass **ERR this year**

# Conditional Schedule 2026-27

| SAD or scheduled Run Group | Setup / Status | Target | Beam Energy | Start Date | End Date | Scheduled Calendar Days | Remaining PAC Days Before Run | Scheduled PAC Days | Actual PAC Days from ABUs | Remaining PAC Days After Run |
|---|---|---|---|---|---|---|---|---|---|---|
| **Assuming ~ 100 PAC days in this period and successful Experiment Readiness Review in 2025** | | | | | | | | | | |
| **RG-C** | | long. pol. NH3/ND3 | 11 | | 2026-27 | 80 | 40 | 40 | | 0 |
| **RG-G** | | long. pol. 7LiD | 11 | | 2026-27 | 110 | 55 | 55 | | 0 |
| **SAD 2027** | reconfigure | change | | | | | **sum:** | **95** | | |

- The centerpiece, the **longitudinal polarized target**, has been constructed and used
- **RG-C** will have **to return** for 40 days to complete its approved 120 PAC day program
- Consecutive execution of RG-C and RG-G would minimize substantial overhead
- RG-G no longer requests a double target but will alternate between $NH_3$ and $^7LiD$, so **no modifications to the polarized target will be necessary**
- For producing paramagnetic radicals needed for DNP, **irradiation** using 8 MeV beam from injector and a variable temperature **cryostat**, commissioning expected 2024-25
- **Well aligned** with the **Spin-Polarized Fusion Project** (new engineer, technician, …)

# Conditional Schedule 2027-28

| SAD or scheduled Run Group | Setup / Status | Target | Beam Energy | Start Date | End Date | Scheduled Calendar Days | Remaining PAC Days Before Run | Scheduled PAC Days | Actual PAC Days from ABUs | Remaining PAC Days After Run |
|---|---|---|---|---|---|---|---|---|---|---|
| **Assuming ~ 100 PAC days in this period and new SVTs for HPS being ready** | | | | | | | | | | |
| **RG-E** | | liq. D2 & nuclear | 11 | | 2027-28 | 66 | 33 | 33 | | 0 |
| | reconfigure | change | | | | 7 | | 4 | | |
| **RG-I** | HPS | nuclear | 4,4 | | 2027-28 | 120 | 105 | 60 | | 45 |
| **SAD 2028** | | | | | | | **sum:** | **97** | | |

- **Completion of RG-E** with CLAS12
- Setup change between CLAS12 and HPS should be quick (possibly in winter break)
- The remaining 105 PAC days of **HPS** are split into two-pass and one-pass runs with **60 PAC days** to run 2027-28 with ≃ 4 GeV and the rest with ≃ 2 GeV in the future
- Worldwide competition from experiments currently taking data or coming online and the full data set is needed for reaching the proposed exclusion limits

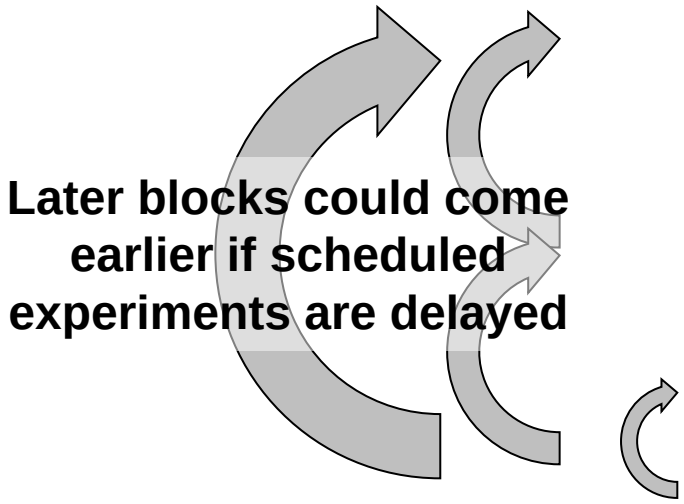
# Scheduling Aspects

**PRad-II**: HyCAL installation and operation, hydrogen gas jet target installation and operation, use of tagger & HyCAL transporter, layout and construction of new beamline elements, design and construction of new veto counter

**RG-G**: availability, irradiation, polarization, and relaxation of $^{7}$LiD target material

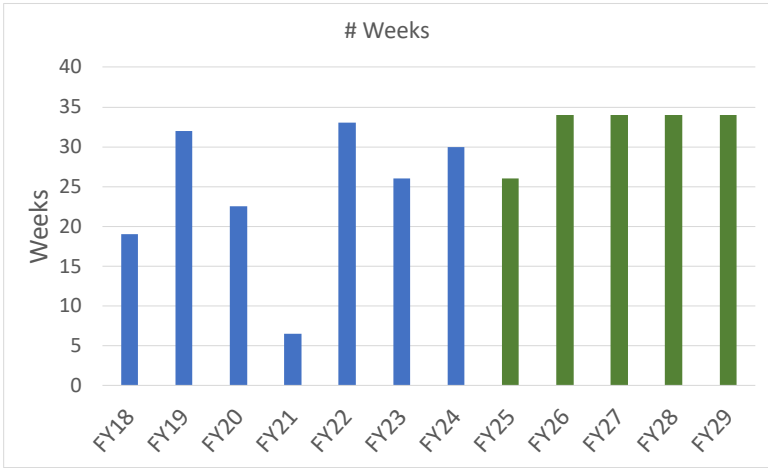
**HPS**: New silicon microstrip vertex trackers (SVT)

Experiment readiness




| | | |
|---|---|---|
| **RG-L** | ALERT | 2024-25 |
| **RG-O** | PRad-II | 2025-26 |
| **RG-Q** | X17 search | 2025-26 |
| **RG-C** | pol. NH3/ND3 | 2026-27 |
| **RG-G** | pol. 7LiD | 2026-27 |
| **RG-E** | LD2 & nuclear | 2027-28 |
| **RG-I** | HPS | 2027-28 |

Beam availability




Except for RG-E, none of the experiments is ready-to-go

*Thank you for your attention!*

- Budget Issues
- Safety Issues
- Hall-B:
  - Status of Experiments
  - Schedule of Experiments