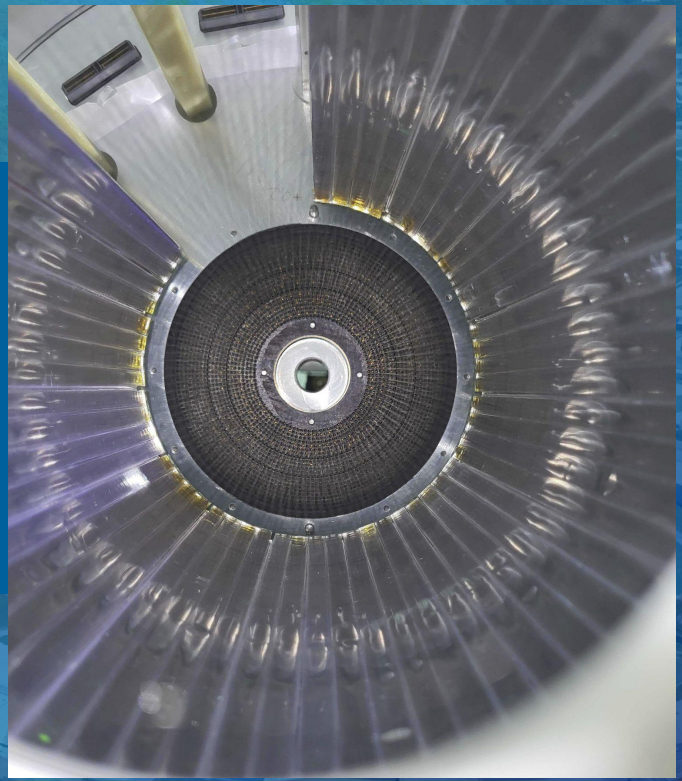
# ALERT Update



Run Group L

Whitney Armstrong

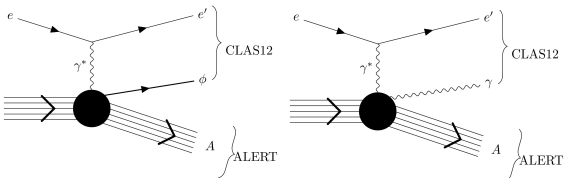
November 13, 2024

# ALERT Run Group

Scheduled for July 2024

## A comprehensive program to study QCD in Nuclei with CLAS12

### Nuclear GPDS

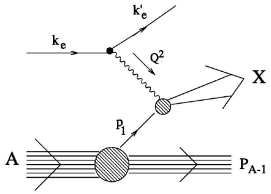



$^4\mathrm{He}(e, e'\ ^4\mathrm{He}\ \gamma)$

$^4\mathrm{He}(e, e'\ ^4\mathrm{He}\ \phi)$

Explore the **transverse charge and gluon** structure of $^4$He

### Tagged EMC Effect



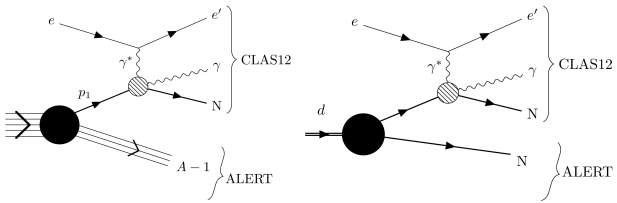

$^4\mathrm{He}(e, e' + {}^3\mathrm{H})\,\mathrm{X}$

$^4\mathrm{He}(e, e' + {}^3\mathrm{He})\,\mathrm{X}$

$^2\mathrm{H}(e, e' + p)\,\mathrm{X}$

Test FSI and rescaling models

### Tagged DVCS




$^4\mathrm{He}(e, e'\gamma\, p + {}^3\mathrm{H})$

$^4\mathrm{He}(e, e'\gamma + {}^3\mathrm{He})n$

$^2\mathrm{H}(e, e'\gamma + p)n$

Systematic control of FSI effects

**Partonic and nucleonic interpretation**

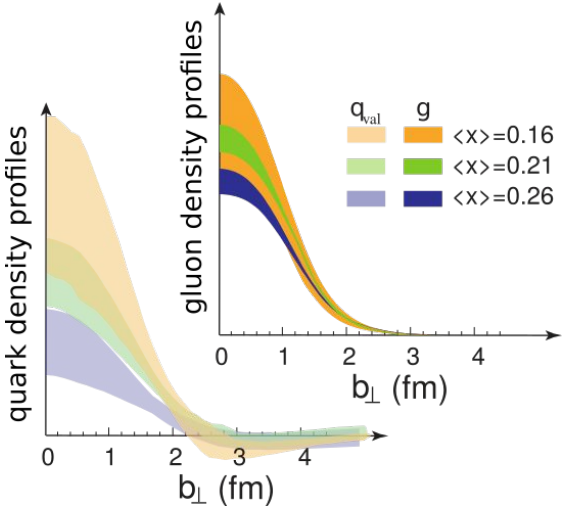
**ALERT will also investigate other processes: tagged SIDIS, 3BBU, tagged QE scattering, exclusive meson production, and more**

# ALERT Run Group

Scheduled for July 2024

## A comprehensive program to study QCD in Nuclei with CLAS12

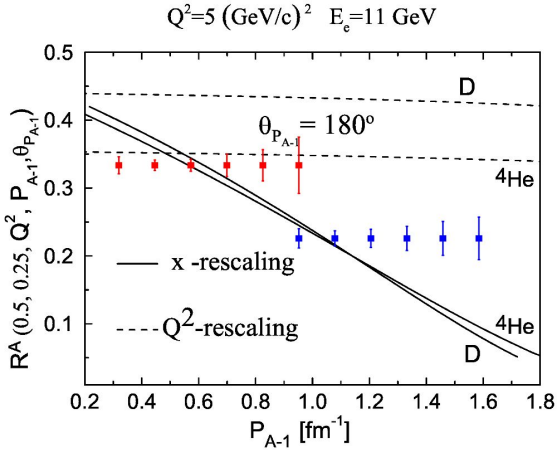
### Nuclear GPDS




Explore the quark and gluon structure of $^4$He

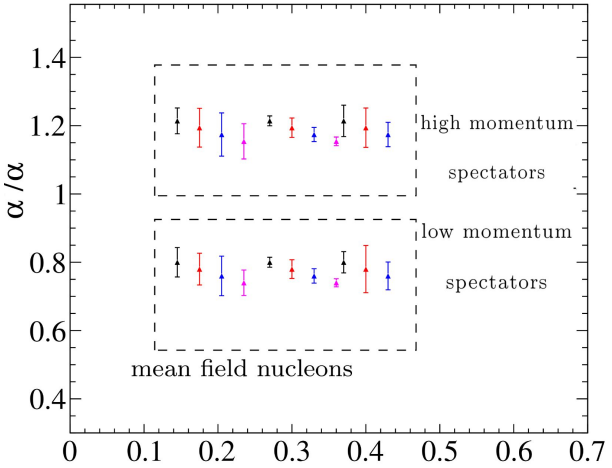
**Compare quark and gluon radii**

### Tagged EMC Effect




Address key questions about the EMC Effect with spectator tagging

### Tagged DVCS

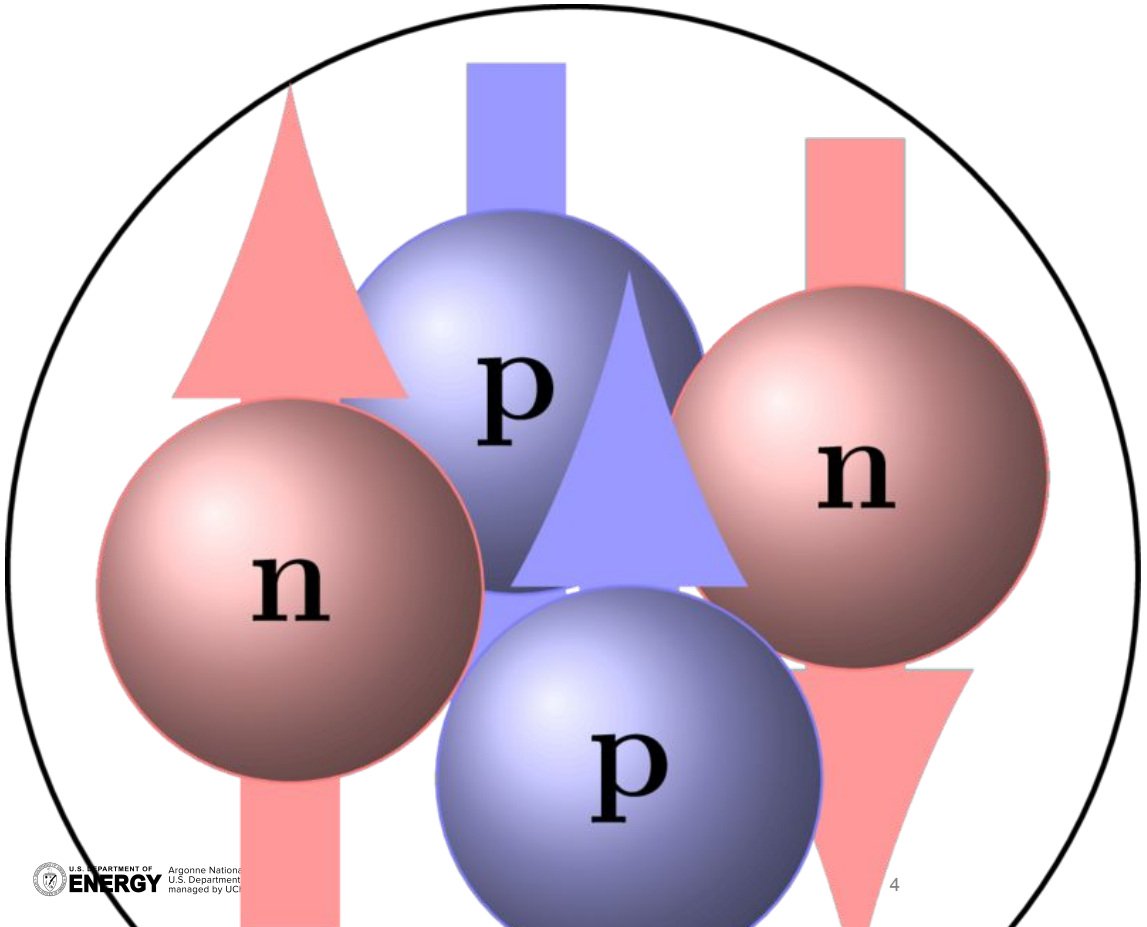



Unravel EMC Effect[x]

Connect partonic and nucleonic modification

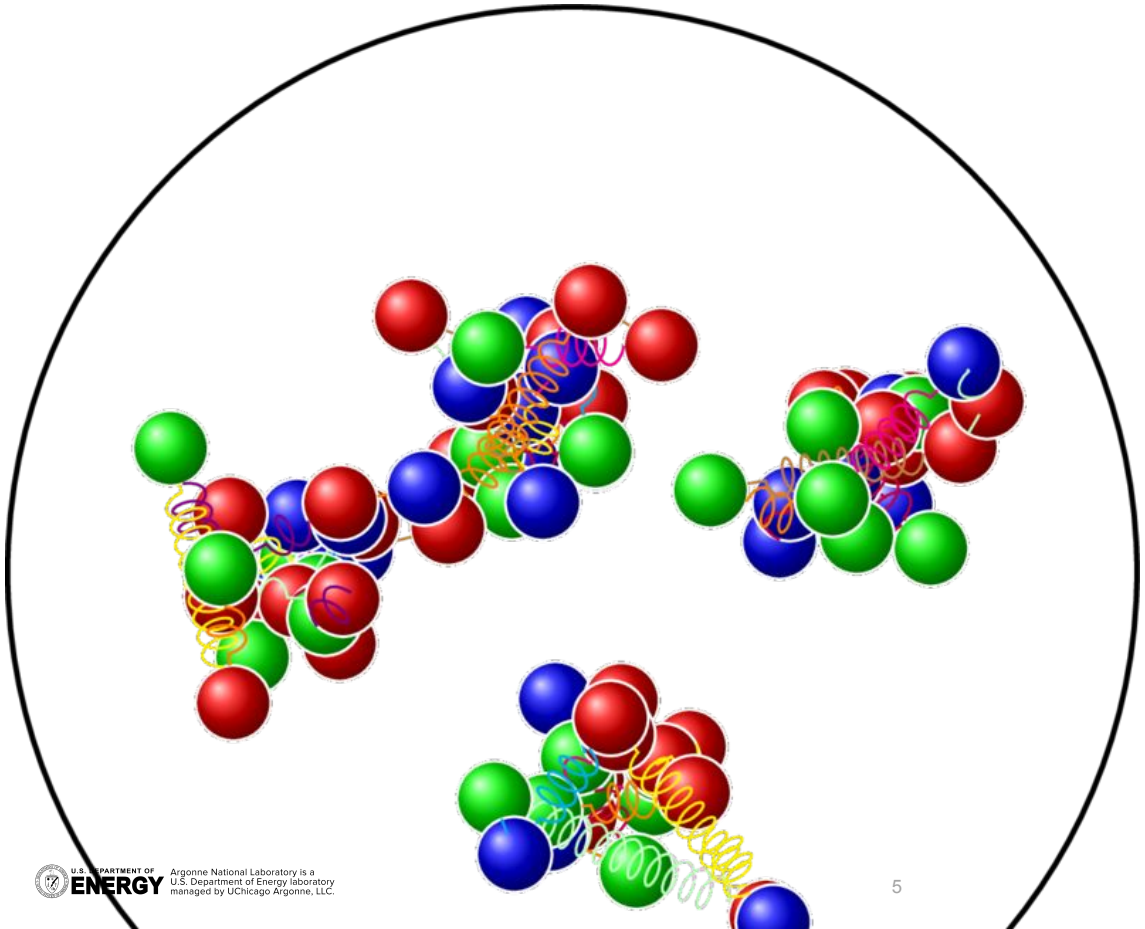
**ALERT is a natural bridge from JLab 12 GeV to the EIC**

# The Partonic Structure of the α Particle




- Two goggles to view the nucleus

# The Partonic Structure of the α Particle

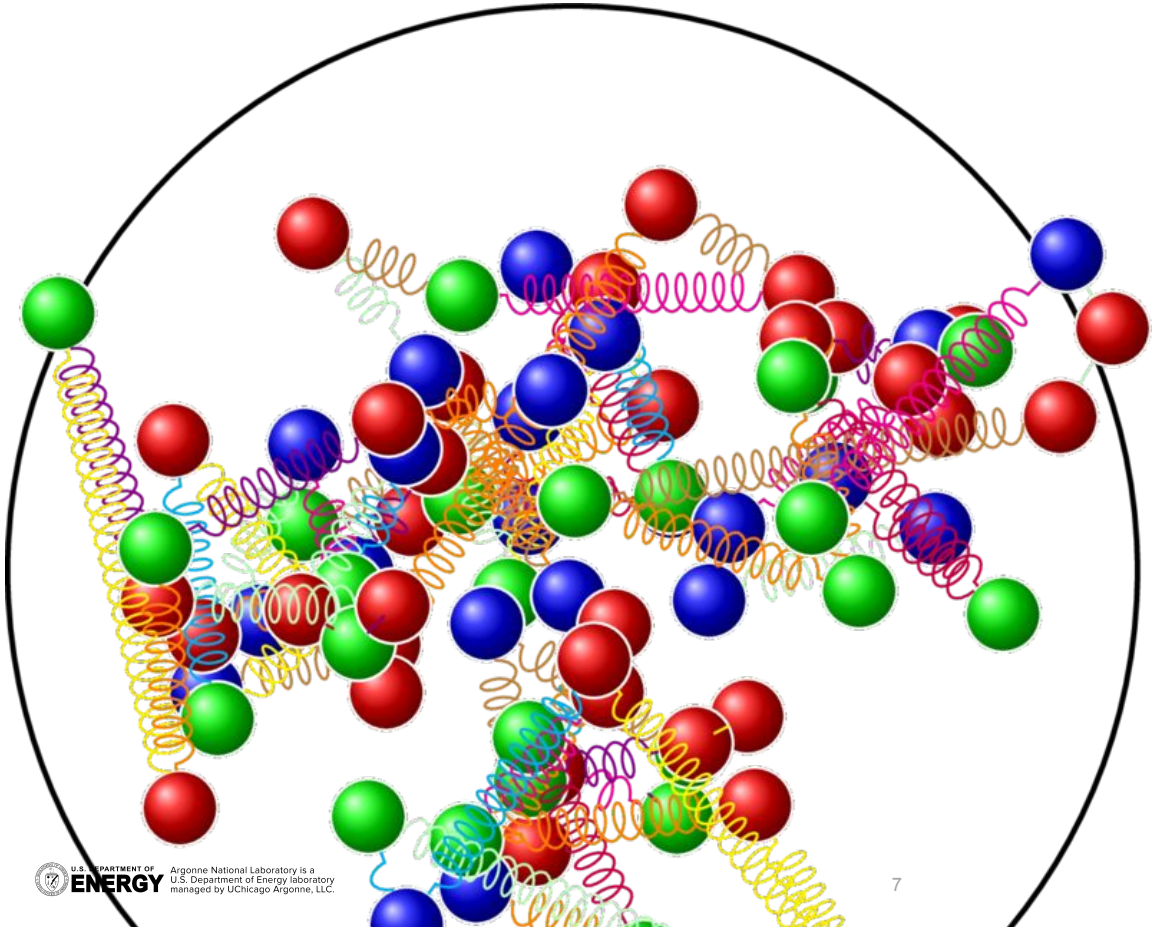


- Two goggles to view the nucleus
- Coherent DVCS to probe the charge profile

# The Partonic Structure of the α Particle

- Two goggles to view the nucleus
- Coherent DVCS to probe the charge profile
- Coherent φ production to probe the gluon profile

# The Partonic Structure of the α Particle

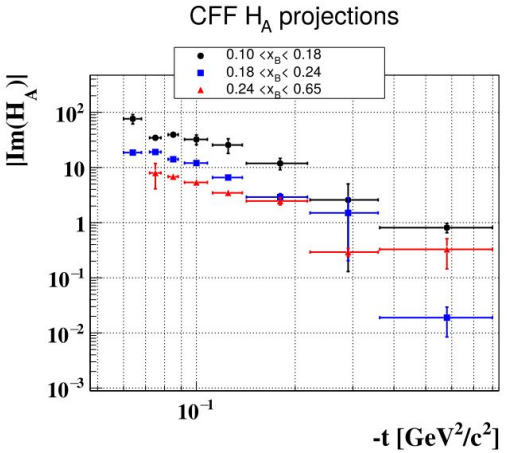


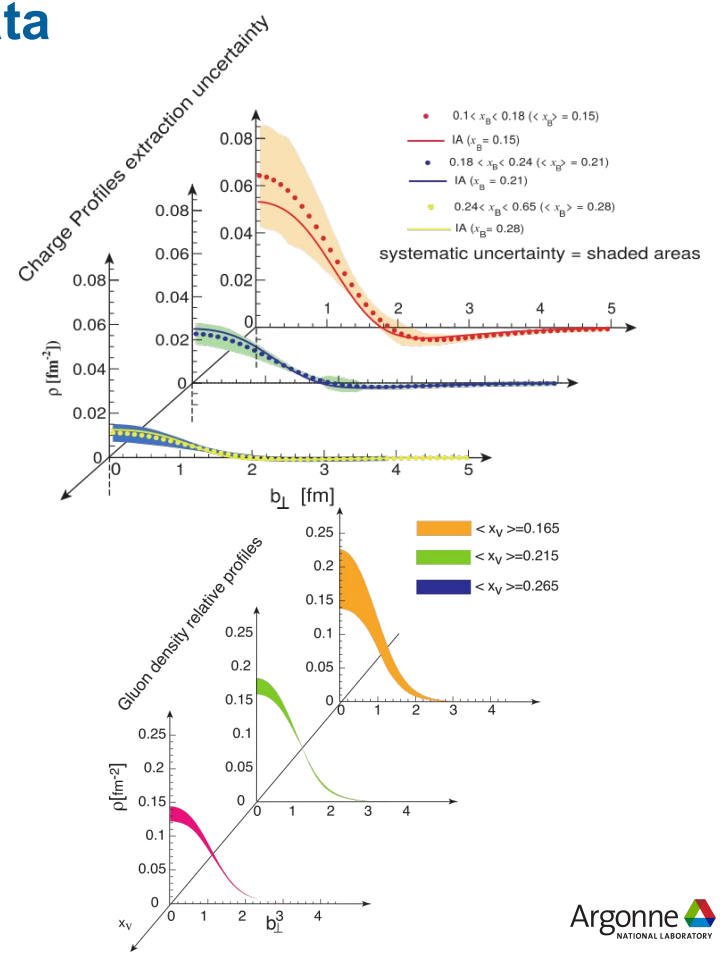
- Two goggles to view the nucleus
- Coherent DVCS to probe the charge profile
- Coherent φ production to probe the gluon profile
- How does the **gluonic form factor** compare to the **charge form factor?**

# $^4$He Transverse Quark and Gluon Densities

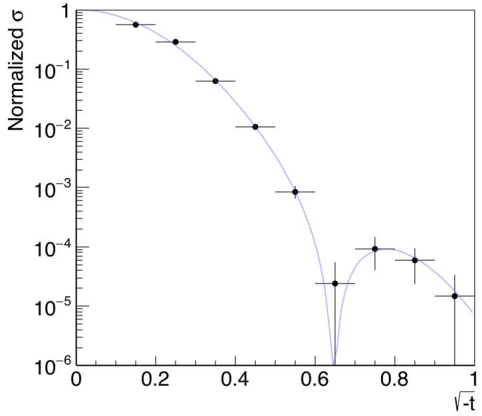
## A self contained analysis with ALERT data

Coherent
DVCS
**Charge Profile**



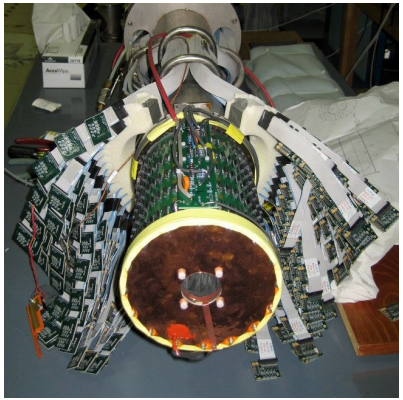

Exclusive
φ Production
**Gluon profile**

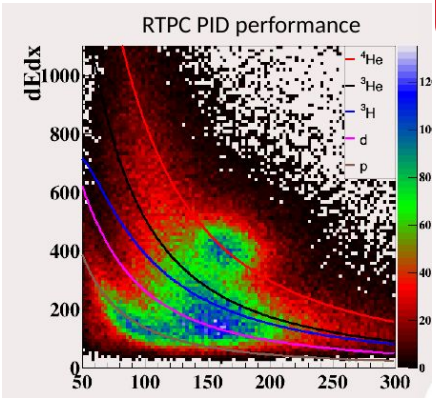


# ALERT - A Low Energy Recoil Tracker

## Past experiences

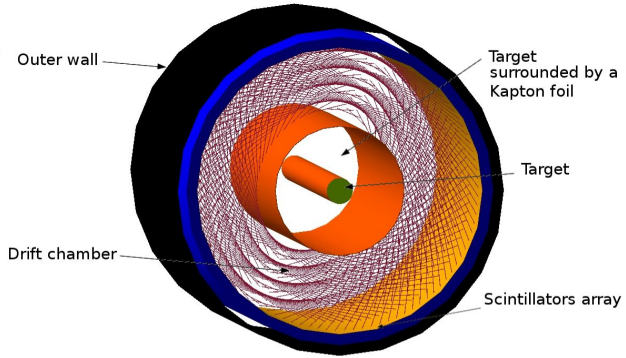
- Previous (eg6) and current (BONUS) RTPC detectors do not meet experimental needs
- eg6 RTPC had long drift time and lacked full PID capabilities
- BONUS12 RTPC will be similar in scope and detect recoil protons






## ALERT Requirements

- Identify light ions: H, $^{2}$H, $^{3}$H, $^{3}$He, and $^{4}$He
- Detect the lowest momentum possible (close to beamline)
- Handle **high rates** with low occupancy
- Survive high radiation environment
  → high luminosity: L ~ few $10^{35}$

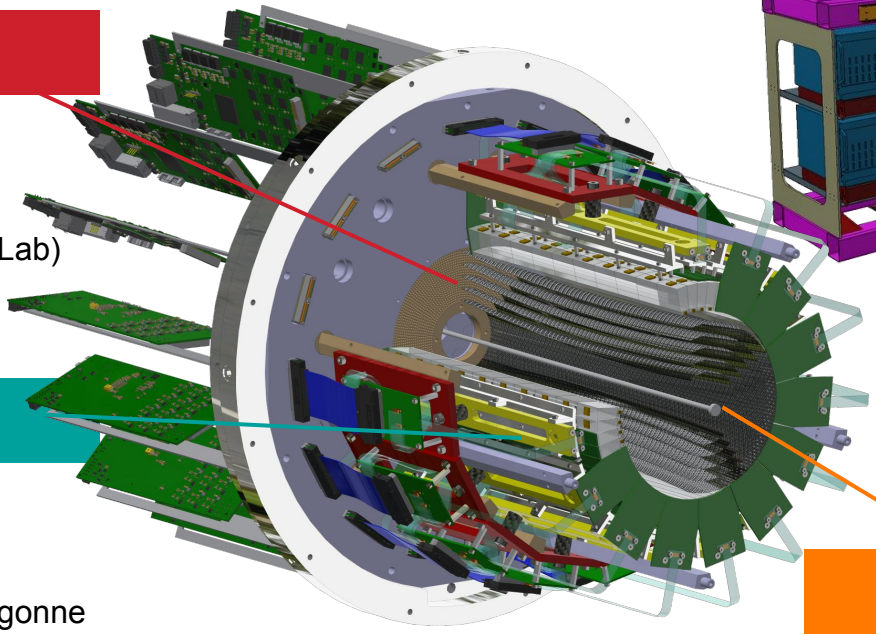


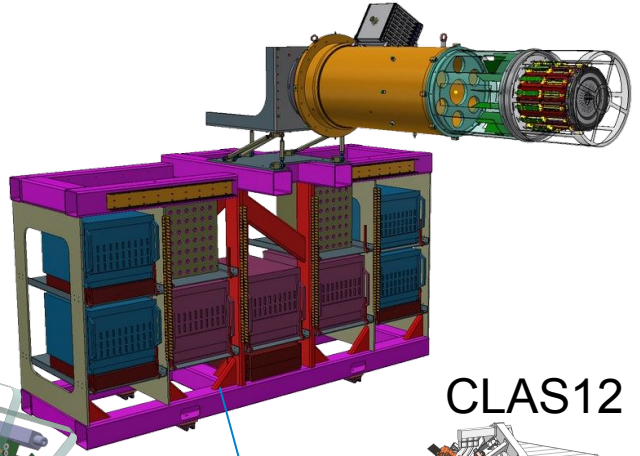
# ALERT Detector

## Hyperbolic Drift Chamber and ToF Hodoscope

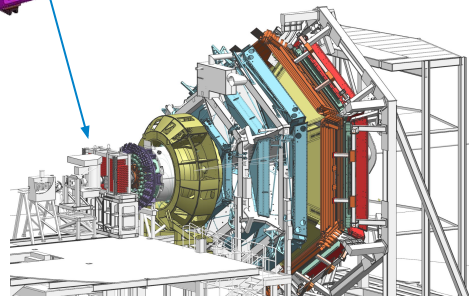
### ALERT HDC

- 2 mm Al wire spacing
- 10 degree stereo angle (hyperbolic shape)
- Constructed at Orsay (IJCLab)
- DREAM FE readout board





CLAS12



### ALERT ToF

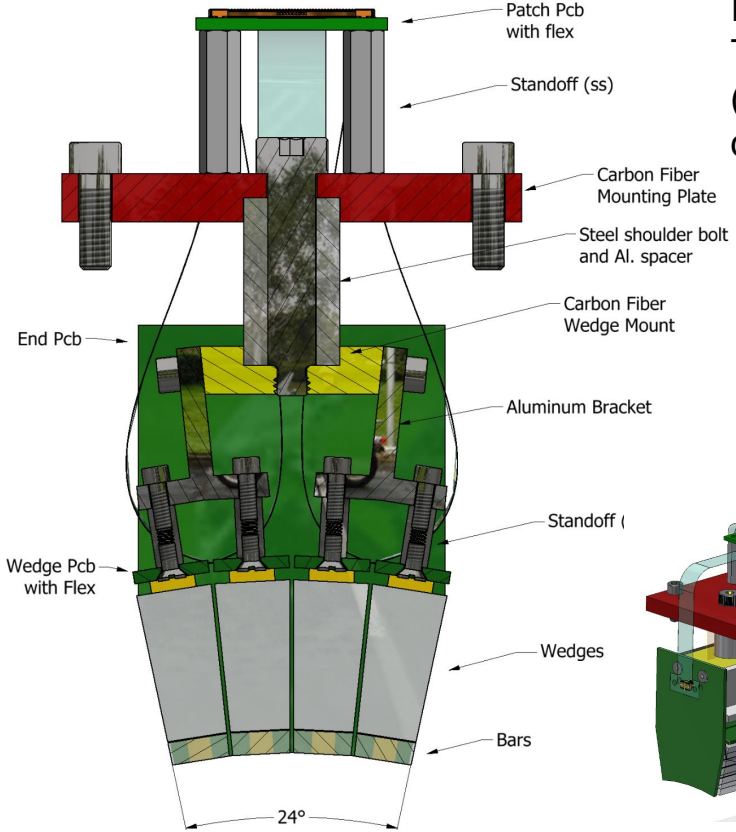
- Time-of-Flight PID
- Small barrel of segmented scintillators
- Modules constructed at Argonne
- PETIROC-based SiPM readout led by JLab FE group
- Additional NALU WF digitizing readout

→Currently scheduled to start Feb. 2025

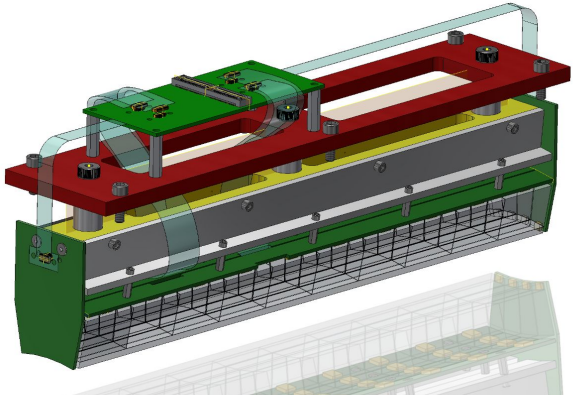
### Gas Target

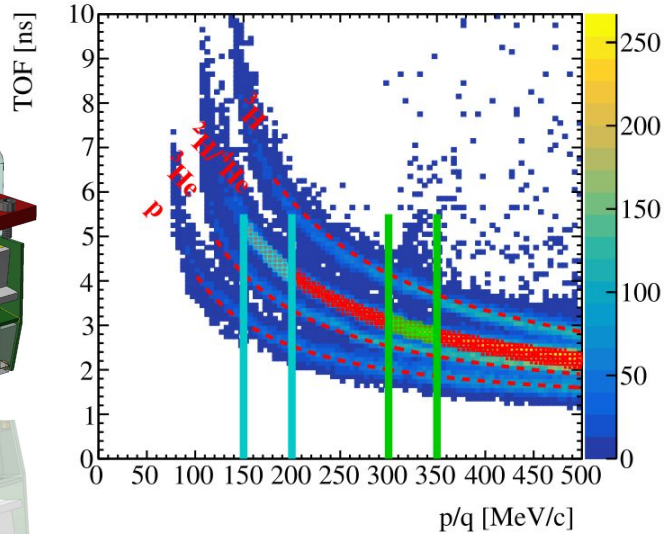
- Managed by JLab's Hall-B technical team
- High pressure straw target gases: $H_2$, $D_2$, and $^4He$

# ATOF Module Construction and Performance



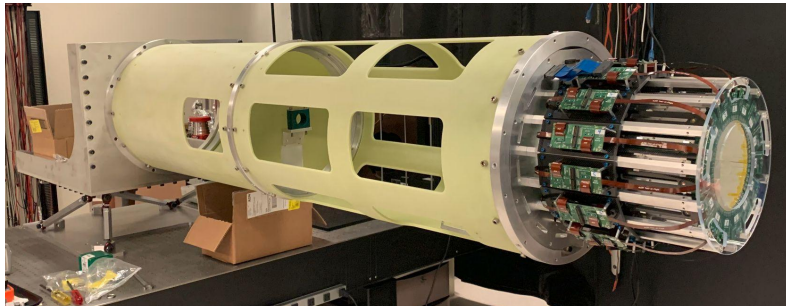

Inner bar thickness : 3 mm. Outer wedge thickness : 2 cm.
TOF separation of ions, **$^{4}$He/$^{2}$H** have same TOF distribution (due to m/q ratio)
dE/dx and inner scintillator bar separate **$^{4}$He and $^{2}$H**

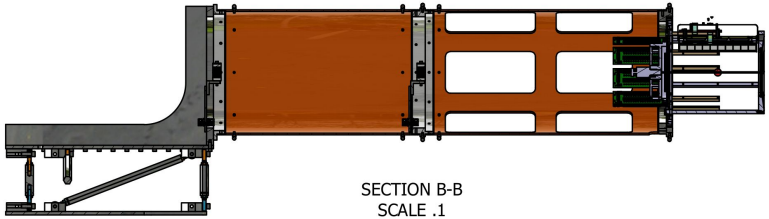


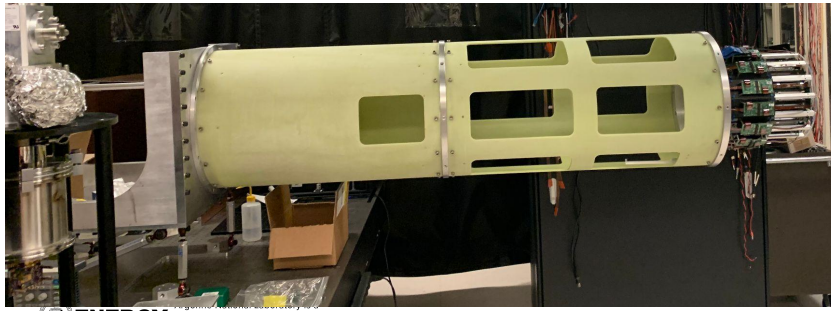


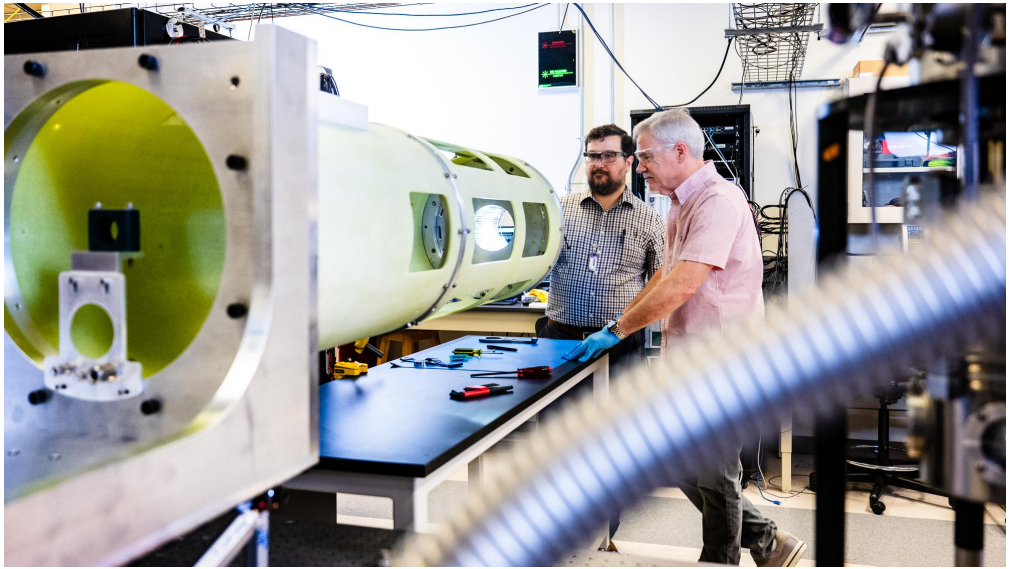
# Detector Support Assembly

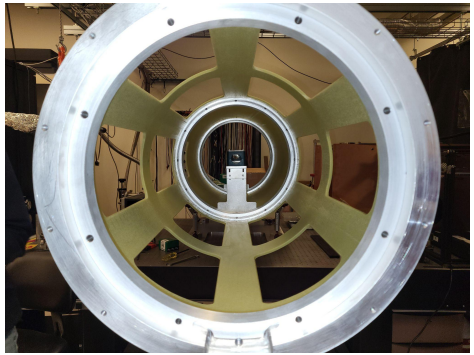
## Support Tube and ATOF





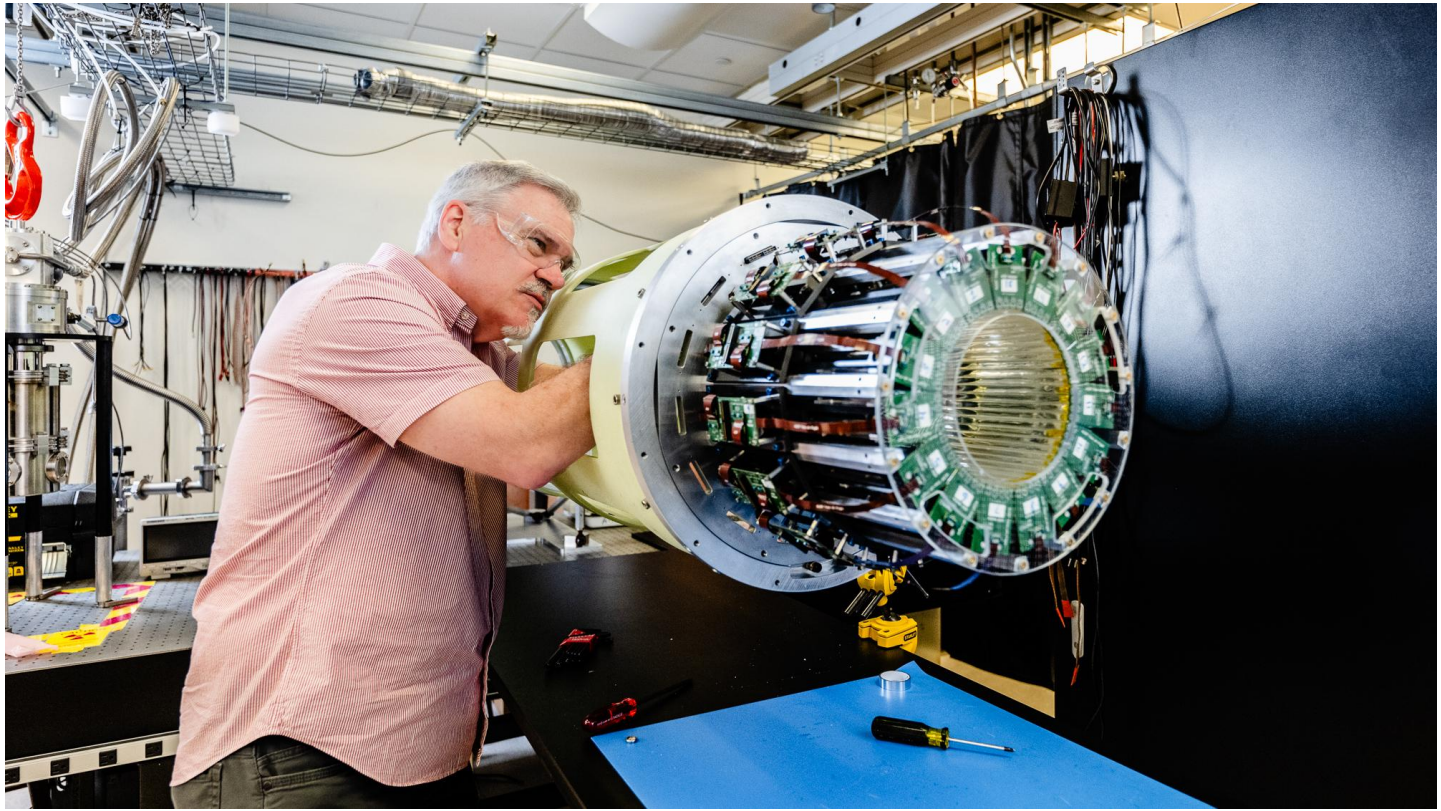







# Detector Assembly Progress

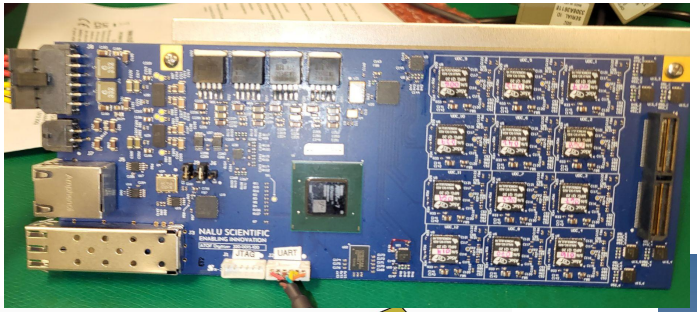
## Design and Mechanical Construction by Tom O’Connor

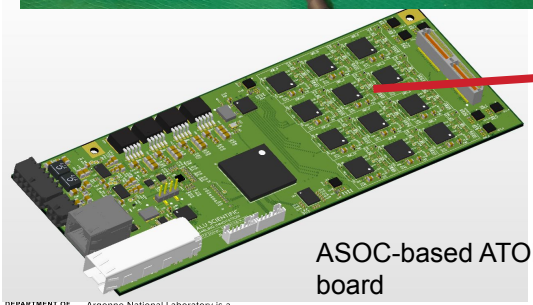


# ATOF Readout Electronics

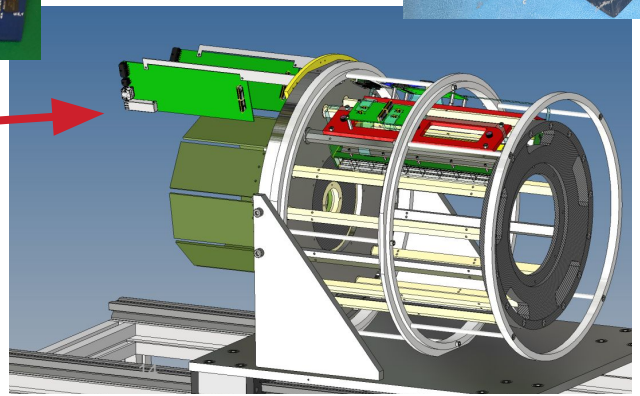
## Petiroc2A and NALU ASOC Readout

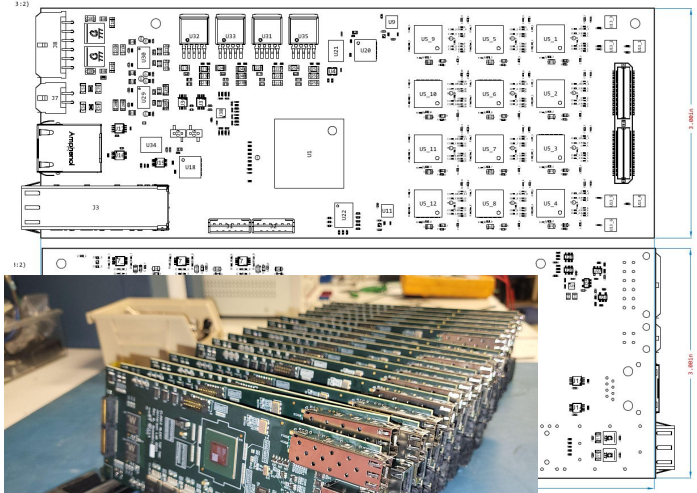
- NALU readout board undergoing tests and firmware development
- Petiroc-based readout boards fabricated and tested.
- Boards use the same FPGA, power, signal distribution, SFP transceiver connections, signal connector and overall board dimensions
- Will use one NALU WF digitizing mode for systematic checks during high luminosity configuration.



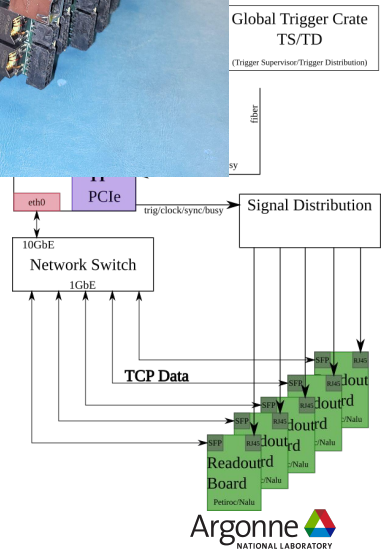


ASOC-based ATOF readout board







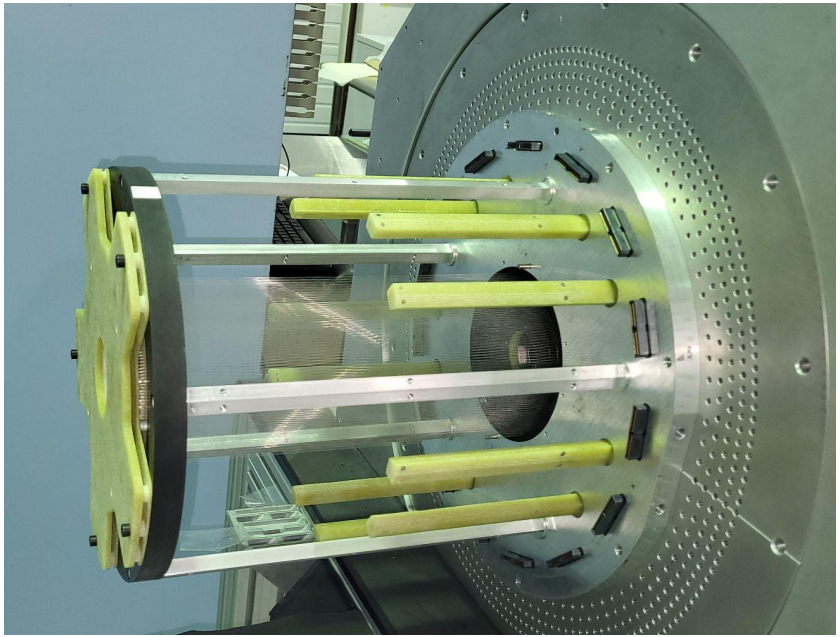


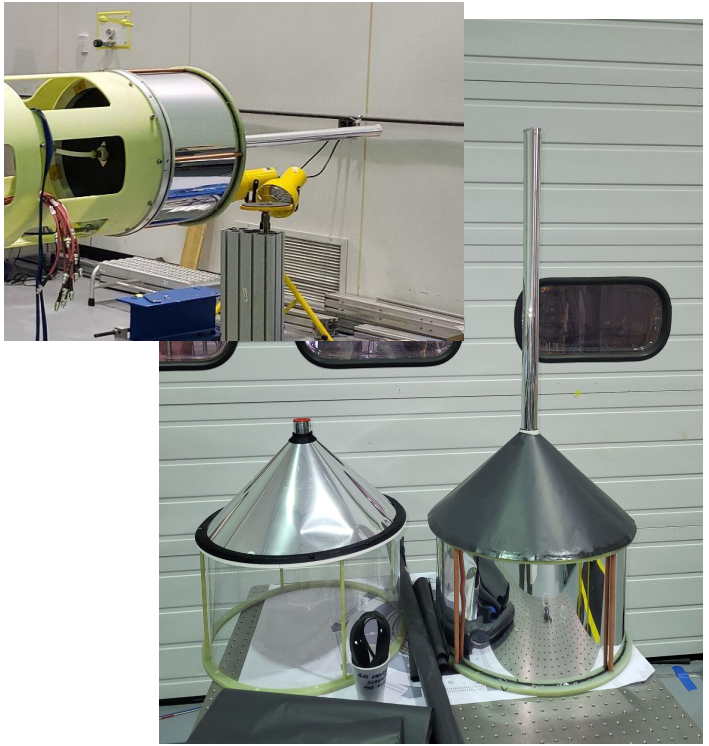
# ALERT at JLab


ALERT support tube in the high-bay clean room in EEL building at JLab

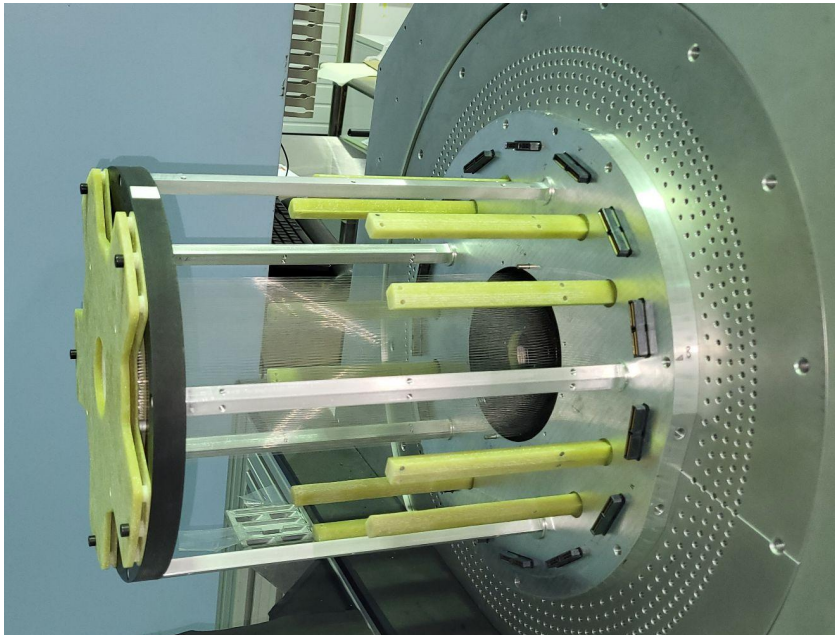
# ALERT Detector

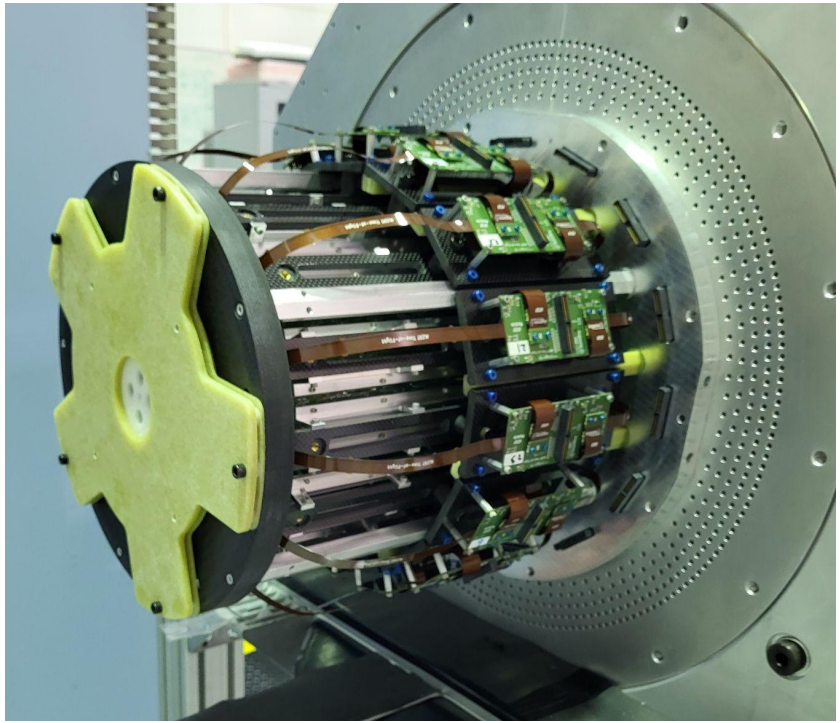
## Alert Hyperbolic Drift Chamber



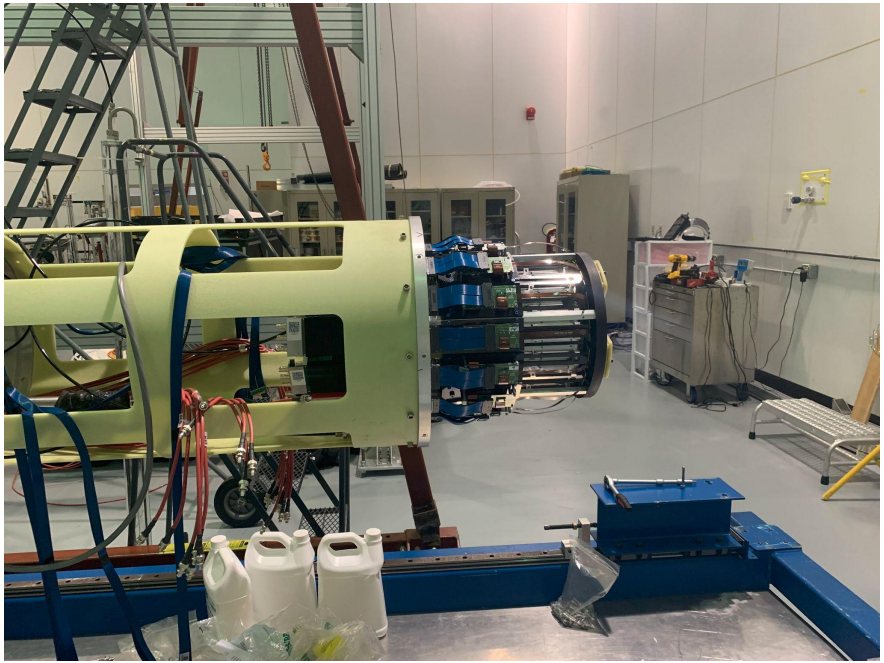


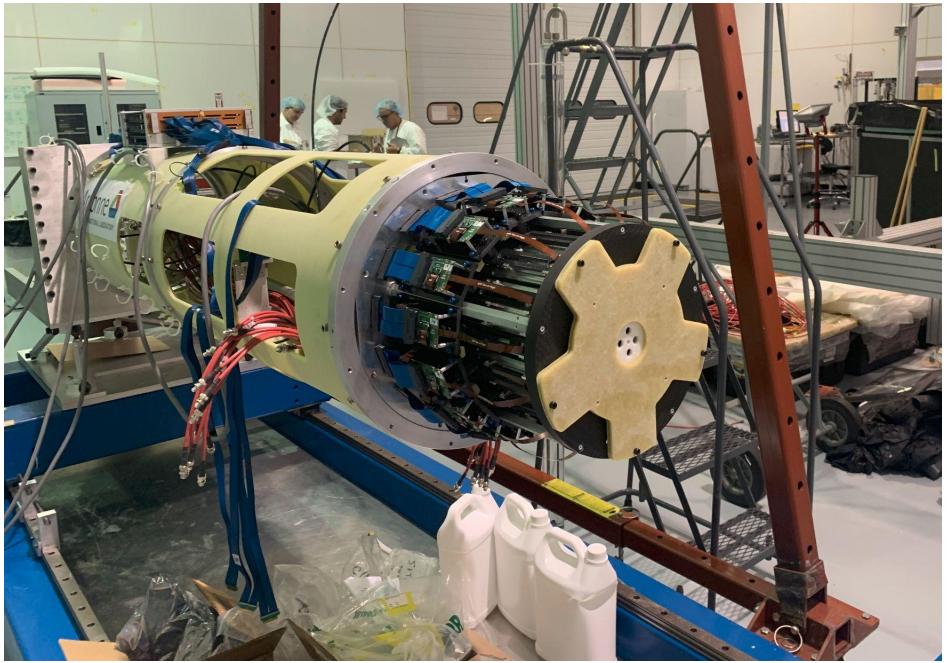
# ATOF Module Installation





# Detector Moved to Support Tube

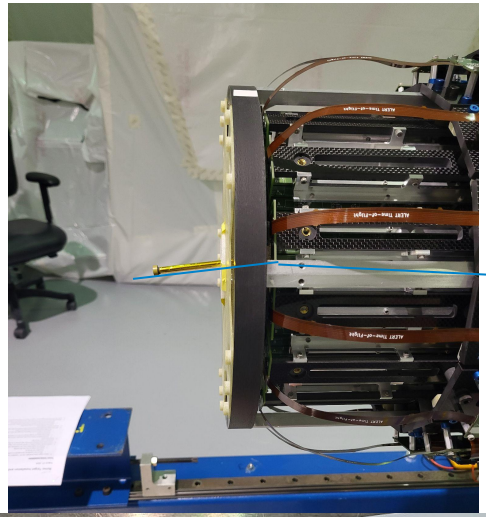


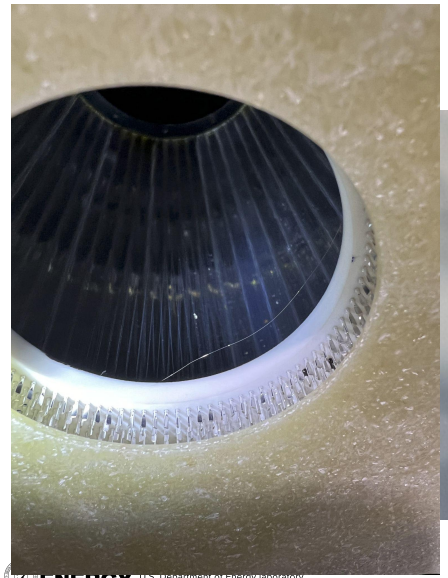


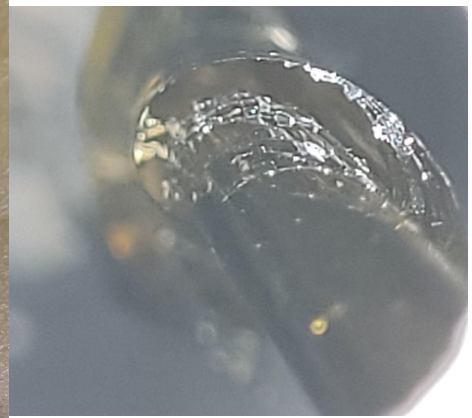
# Target Straw Failure and AHDC Wire Damaged

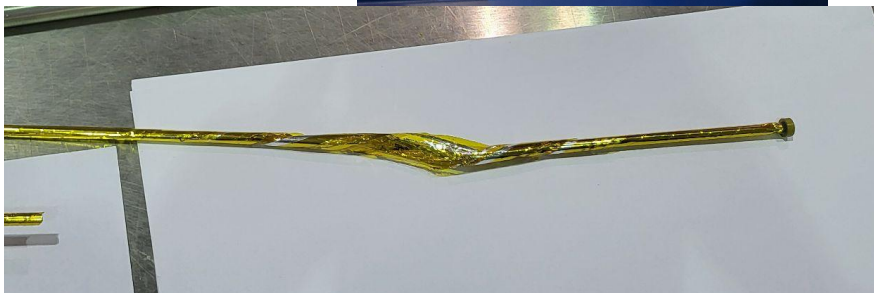
## First week of October

- During BOM installation the target straw failed and damaged AHDC wire
- Orsay group flew in and quickly repaired the wire
- New target procedures developed

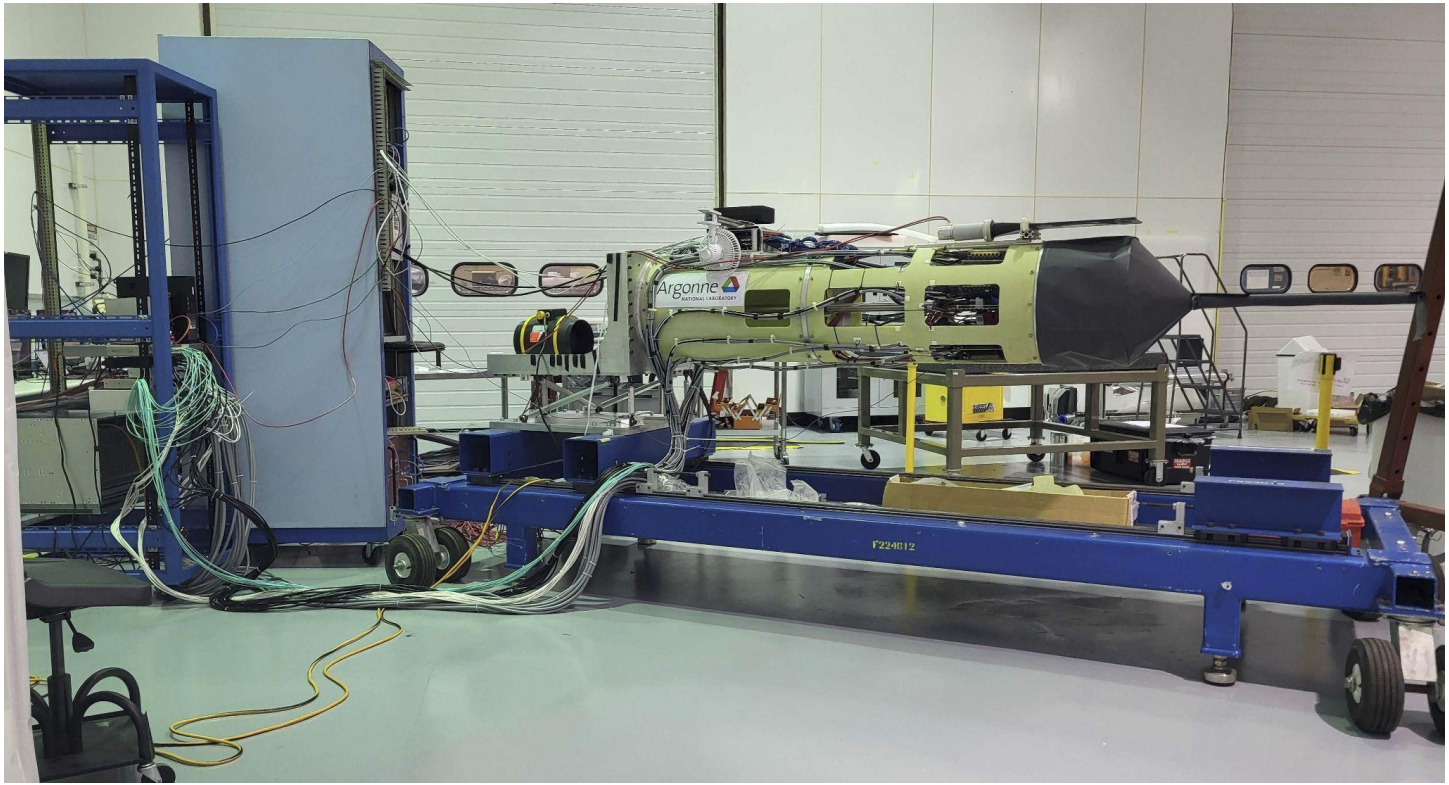








# ALERT Detector In EEL

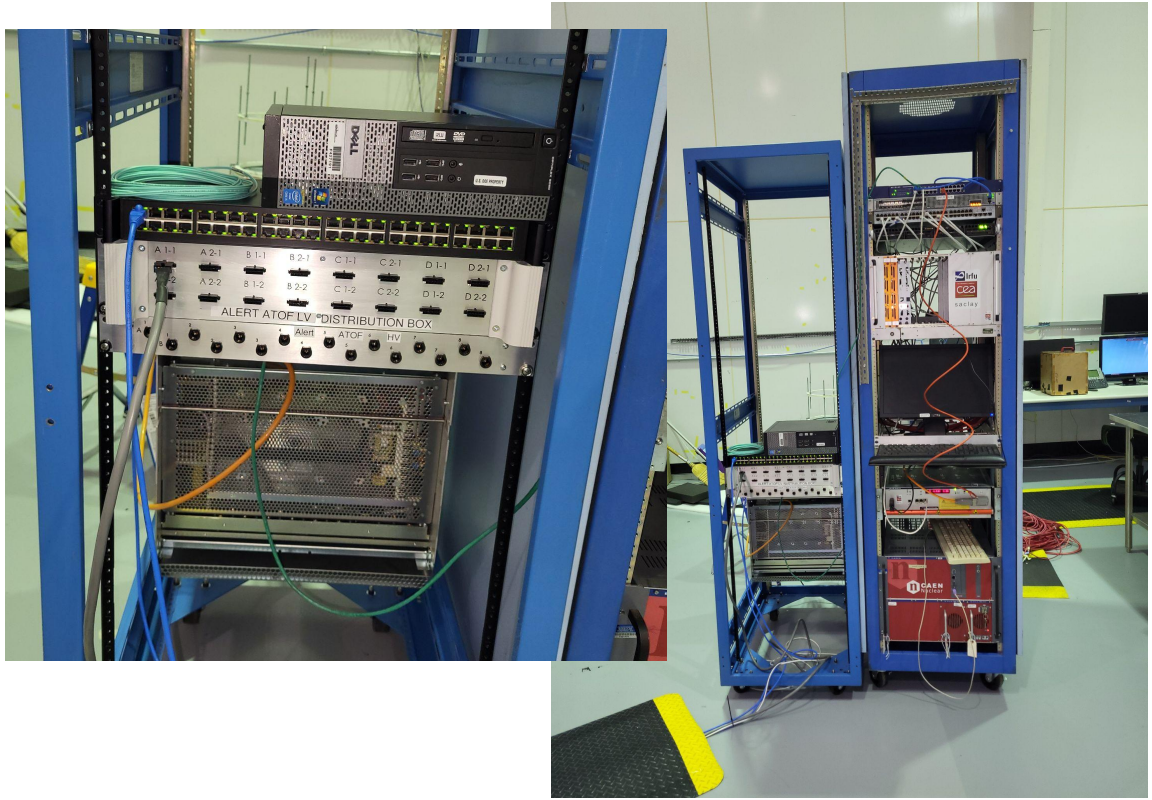


# DAQ Setup in EEL

## ATOF setup

Power supplies (LV and SiPM Bias) and their distribution boxes

Signal distribution box and ROC computer with PCIe TI



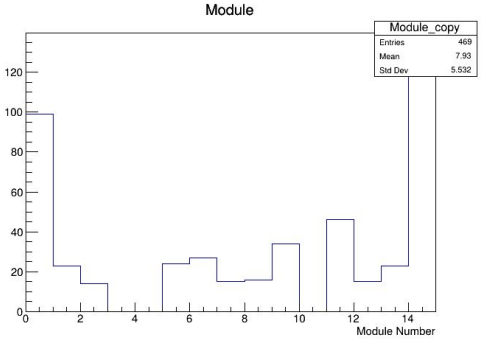
# ALERT DAQ Testing

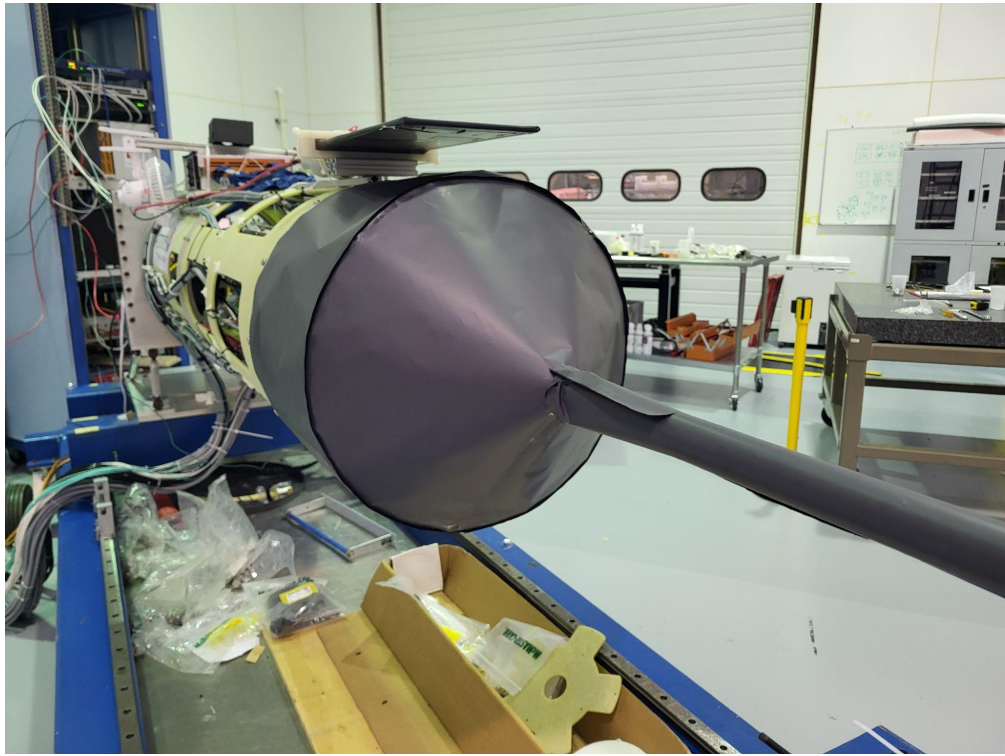
We were able to test the ATOF and AHDC DAQ in the EEL

Cosmic data was taken with ATOF

Implemented decoders for ATOF and AHDC

Currently working on online monitoring tools

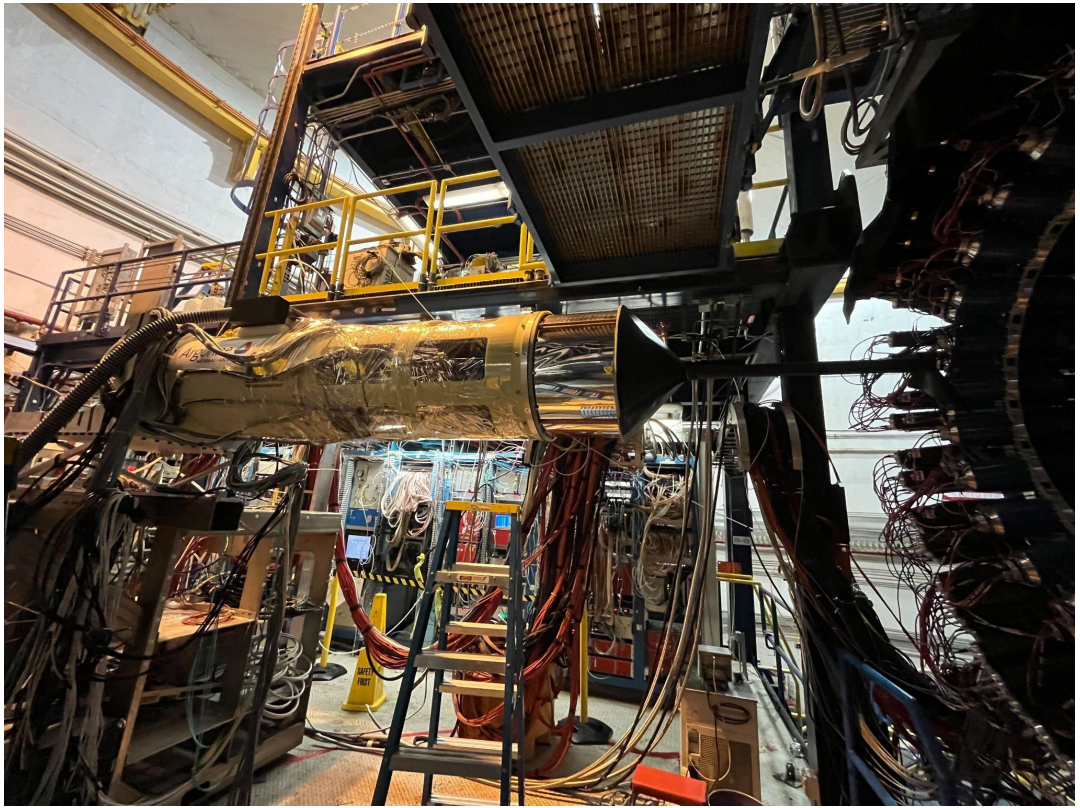


# ALERT In Hall B

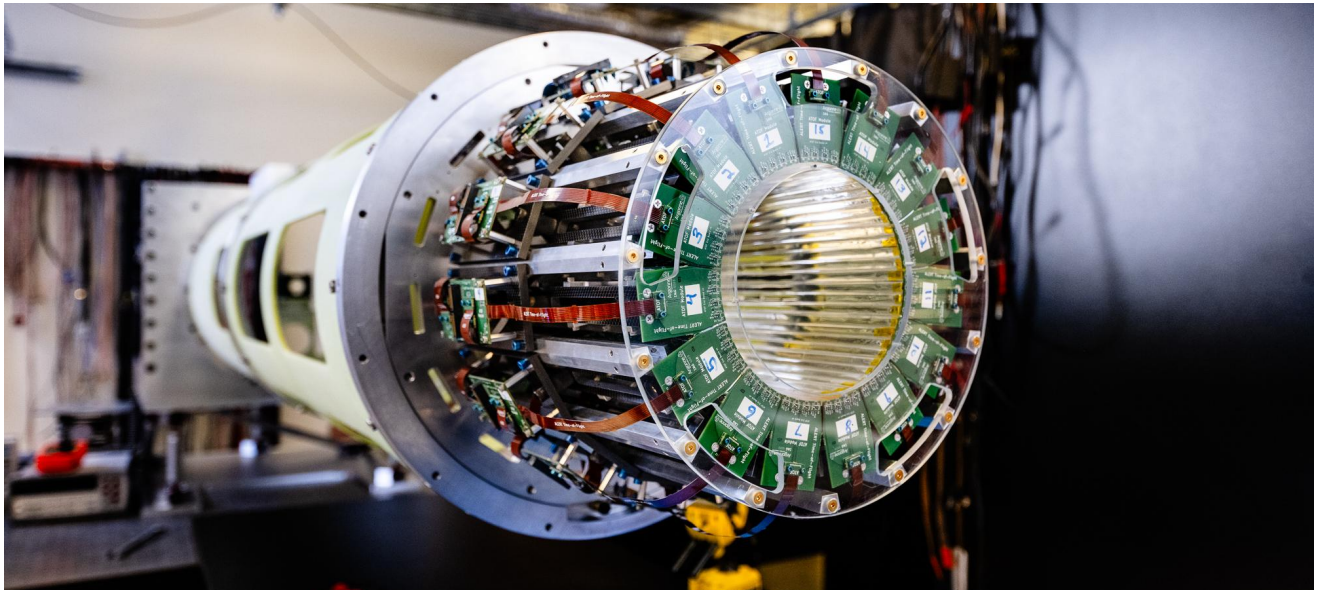
Detector moved to hall last week
Currently working on bringing all subsystems online.

Will begin taking cosmic data as soon as DAQ is ready.



# Summary

- ALERT experiments are a comprehensive program to study QCD in nuclei
- We hope to grow physics impact with new ALERT proposals
- ALERT is scheduled to take first beam ~Feb. 2025
- Detector recently moved to hall and making good progress.

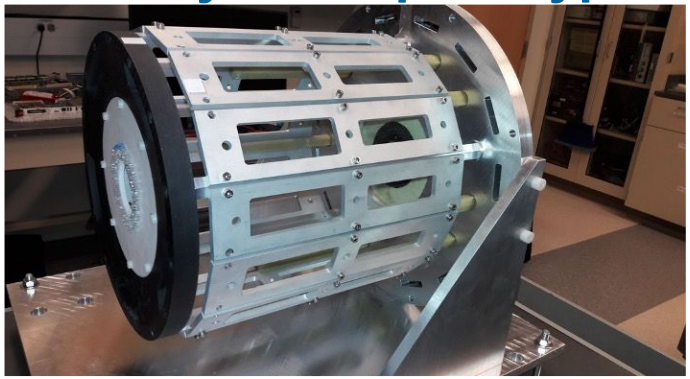


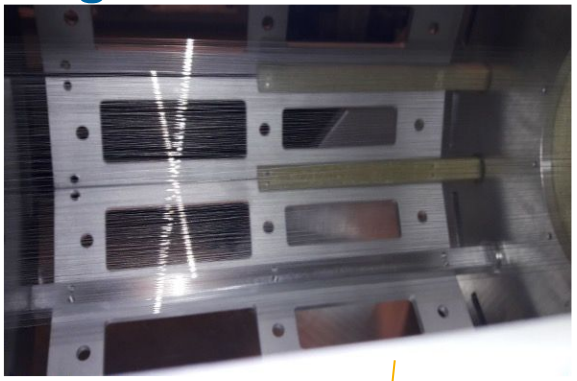
# Thank You!

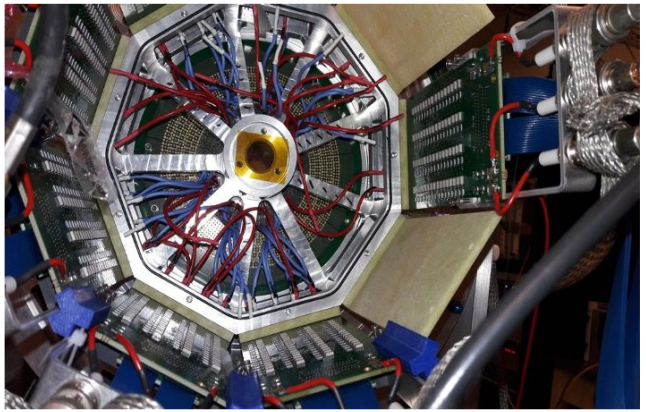
# Backup

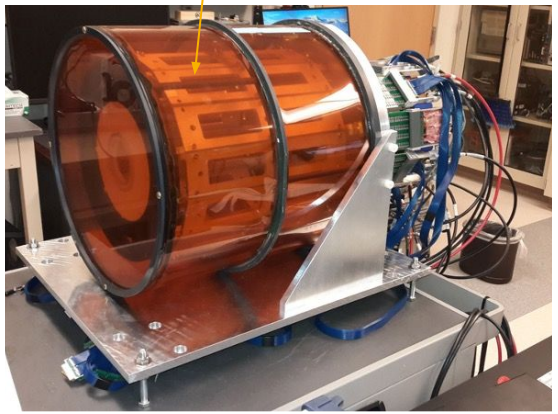
# Hyperbolic Drift Chamber Construction

## Full Scale – Partially wired prototype at Argonne









# HDC Transportation and Magnetic Field Test

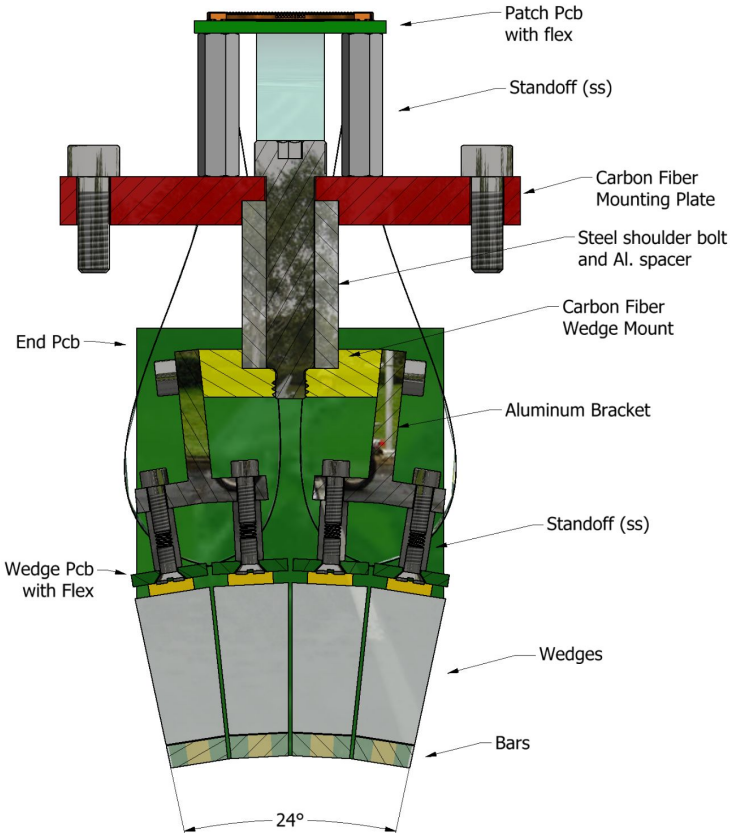
## Shipped from Orsay to Argonne High Field Test Facility

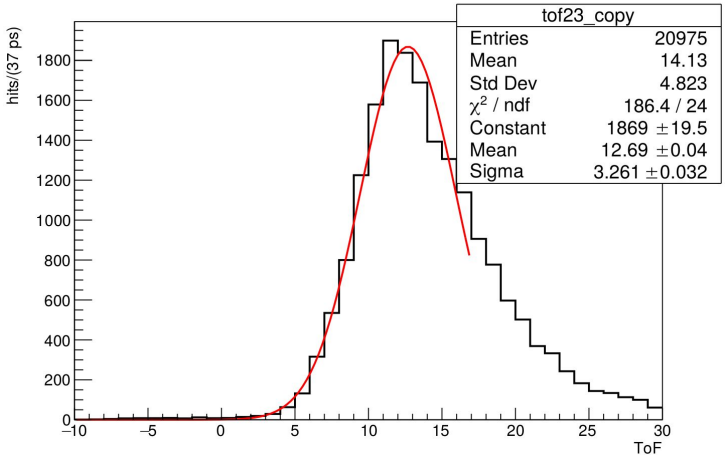
**No transportation-related problems** with full scale drift chamber prototype

High Field Test data taking went rather smoothly after setting up HV and readout
→ Took HV scan runs with detector in/out of the 3T magnetic field
→ Also took HV scans using ~5.5 MeV alphas from $^{241}$Am source.
→ Rates shifted in field to adjacent wires as expected

Gabriel Charles is leading the test data analysis. Results should be ready for the task force meeting at the end of the month.

# ATOF Module Construction and Performance

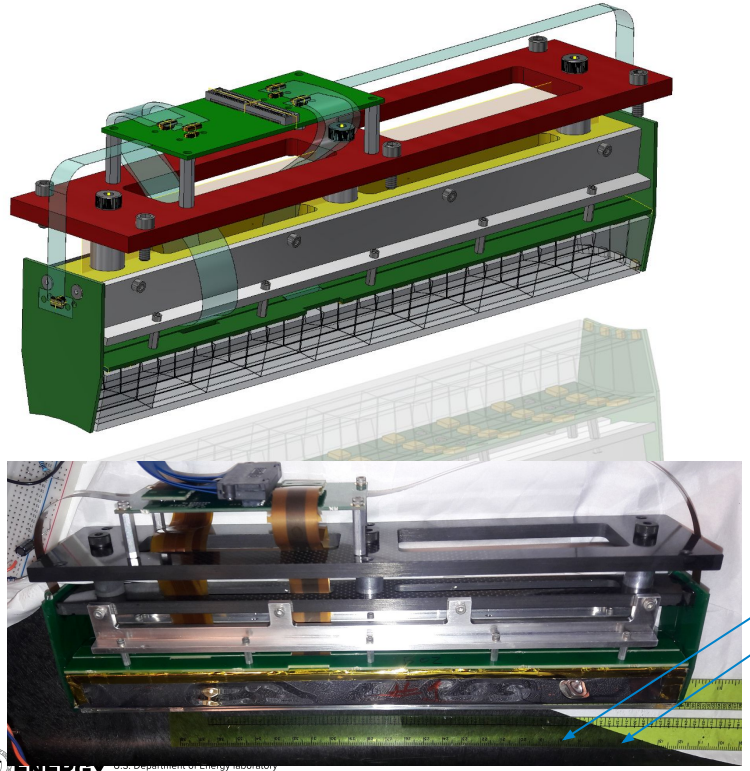


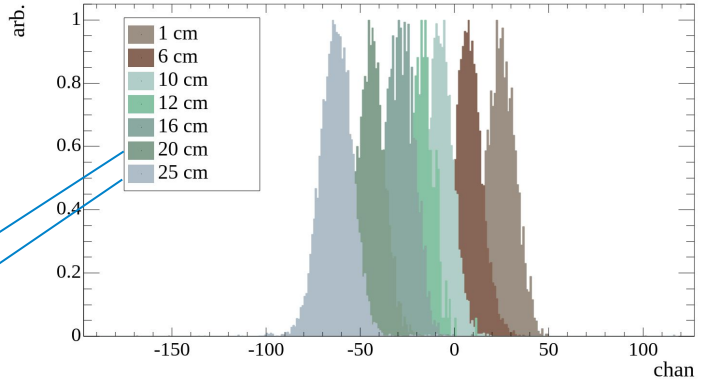

- Tested wedge time resolution with $^{241}$Am source
- σ = 85 − 125 ps
- Observed tails in timing peak due to large source area → future improvement.
- No data corrections or fine tuning of ASIC config → Easily meeting 150 ps timing requirement of experiment!

# ATOF Prototype Module

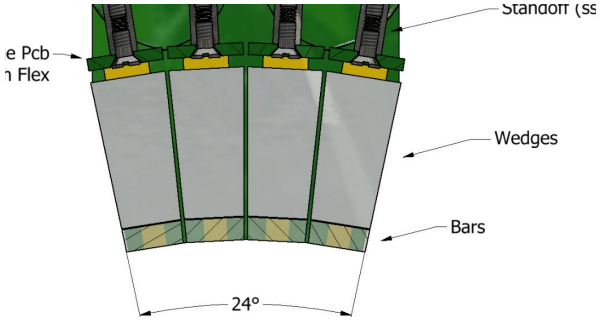
## Americium-241 source placed against the module's inner bar scintillator at various locations



TDC difference for the module's bar sipms for different locations of the 241 Am source.



# ATOF PID

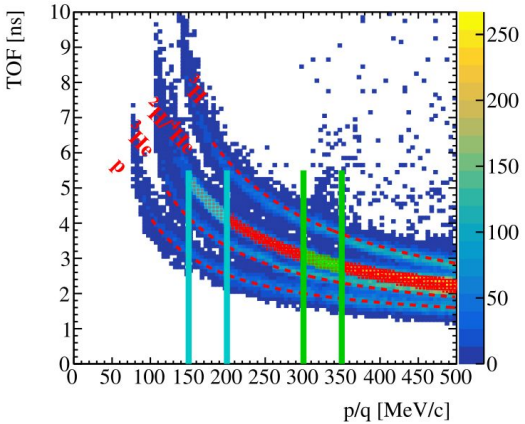


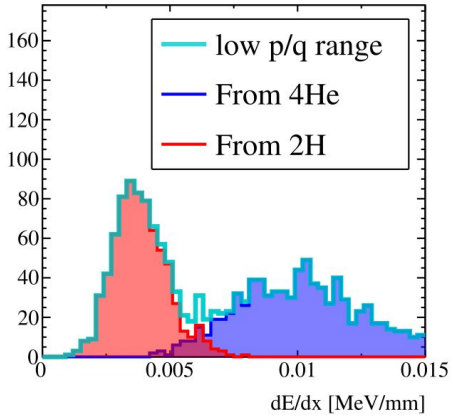

Need < 150 ps time resolution

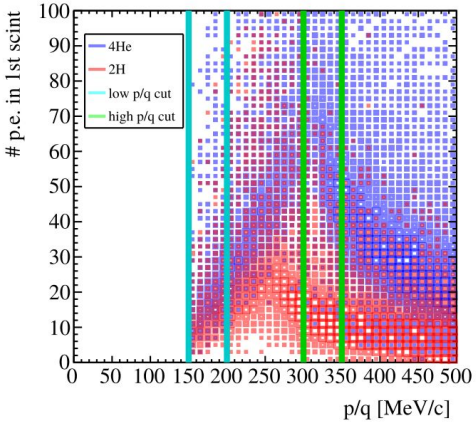
Inner bar thickness : 3 mm.
Outer wedge thickness : 2 cm.

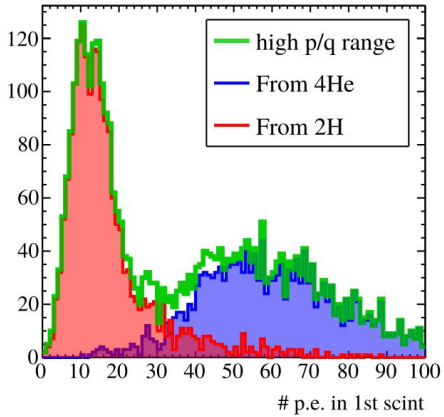
TOF separates light ions, except **$^4$He/$^2$H** which have same m/q ratio

dE/dx and signal from inner scintillator bar separates **$^4$He and $^2$H**



# Hyperbolic Drift Chamber Performance

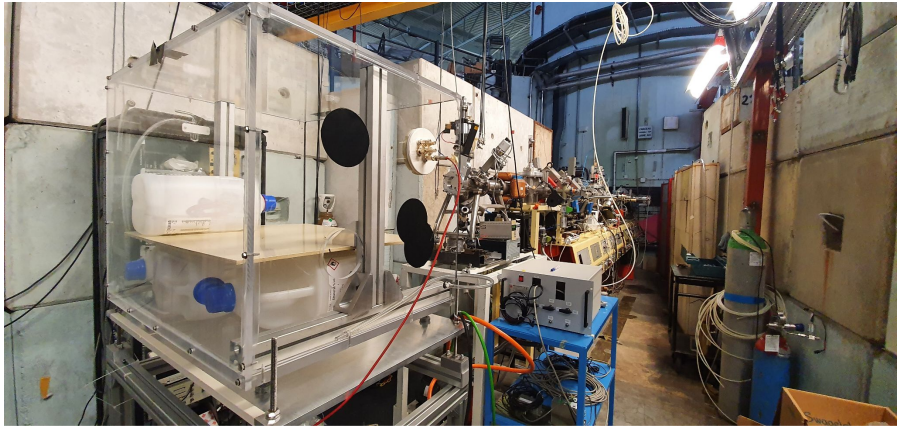
## Prototype Tests

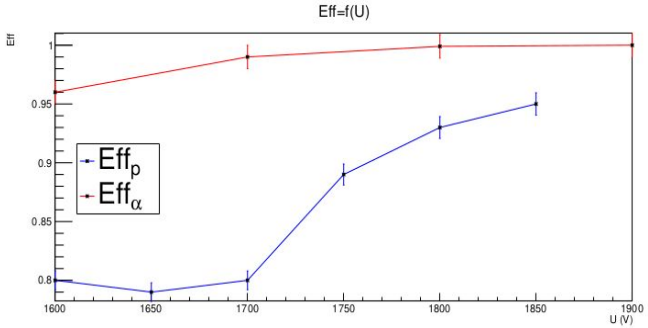
Successful first prototype test at the **ALTO facility** with protons and $^4$He at energies comparable to those detected by ALERT (T ~ 6-18 MeV)

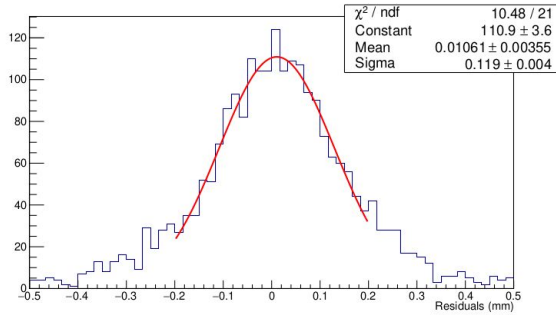
- Results finalized (Lucien Causse PhD thesis)
- Track resolution: 120 μm
- High detection efficiency

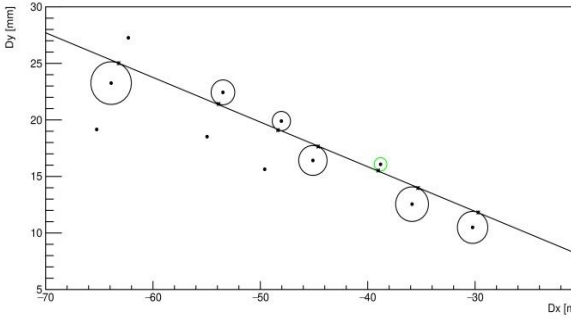
→95% for protons
→99% for alphas

**AHDC design is fully validated**





# Gluon Form Factor

$$|\langle H_g \rangle|(t) \propto \sqrt{\frac{d\sigma_L}{dt}(t - t_{min}) \Big/ \frac{d\sigma_L}{dt}(0)}$$

$$\frac{d\sigma_L}{dt}(^4\mathrm{He}) \propto |\langle H_g \rangle|^2$$

$$\frac{d\sigma_L}{dt} = \frac{1}{(\epsilon + 1/R)\Gamma(Q^2, x_B, E)} \frac{d^3\sigma}{dQ^2 dx_B dt}$$

$$W(\cos\theta_H) = \frac{3}{4}\left[(1 - r_{00}^{04}) + (3r_{00}^{04} - 1)\cos^2\theta_H\right]$$

$$r_{00}^{04} = \frac{\epsilon R}{1 + \epsilon R}$$