Run Group L

ALERT Update

Whitney Armstrong

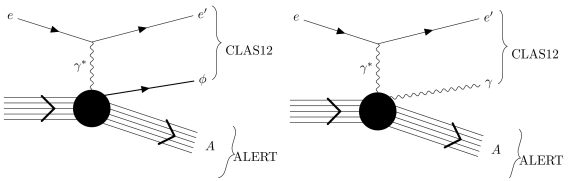
July 12, 2023

ALERT Run Group

Scheduled for July 2024

A comprehensive program to study QCD in Nuclei with CLAS12

Nuclear GPDS

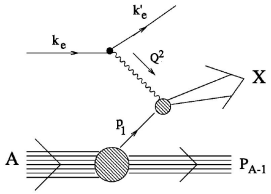


$^4\mathrm{He}(e, e'\ ^4\mathrm{He}\ \gamma)$

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

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

Tagged EMC Effect



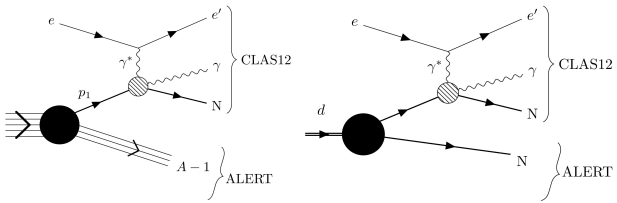
$^4\mathrm{He}(e, e' + {}^3\mathrm{H})\,\mathrm{X}$

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

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

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

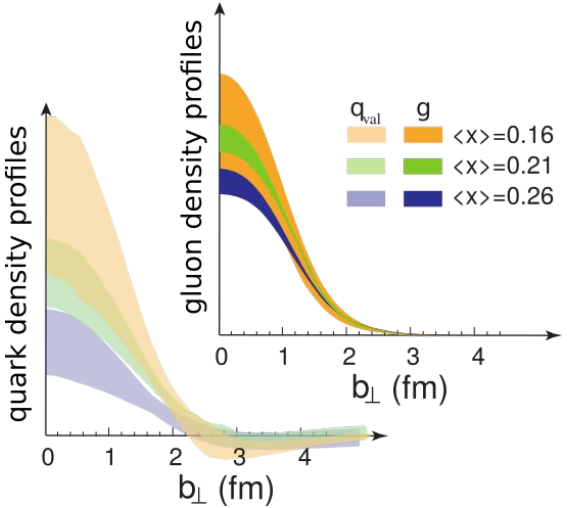
ALERT will also investigate other processes: tagged SIDIS, 3BBU, tagged QE scattering, exclusive meson production, and more

ALERT Run Group

Scheduled for July 2024

A comprehensive program to study QCD in Nuclei with CLAS12

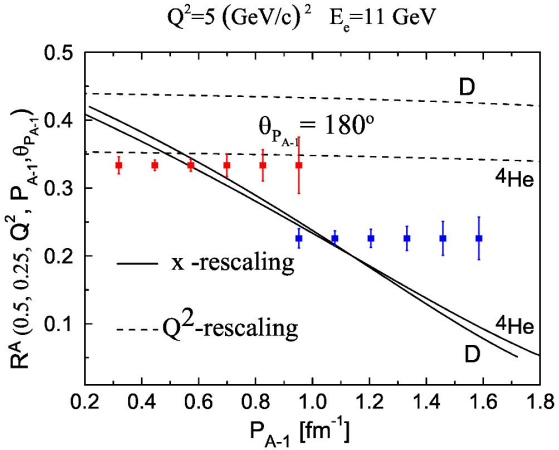
Nuclear GPDS



Explore the quark and gluon structure of ^{4}He

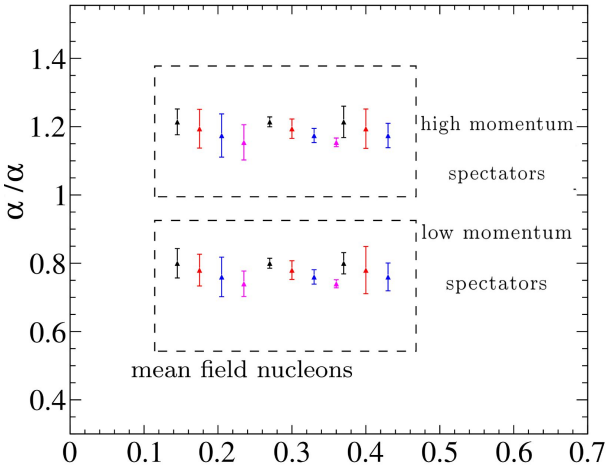
Compare quark and gluon radii

Tagged EMC Effect



Address key questions about the EMC Effect with spectator tagging

Tagged DVCS

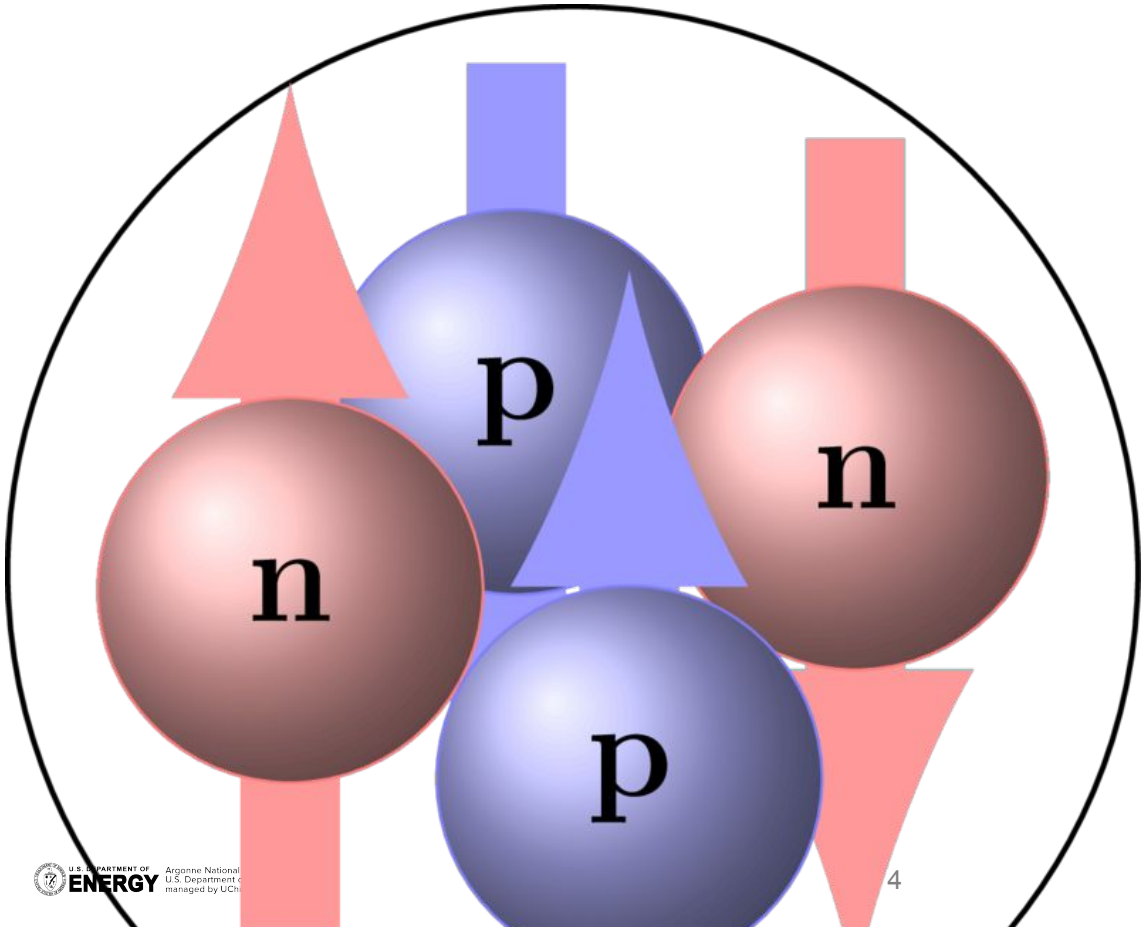


Unravel EMC Effect^x in He

Connect partonic and nucleonic modification

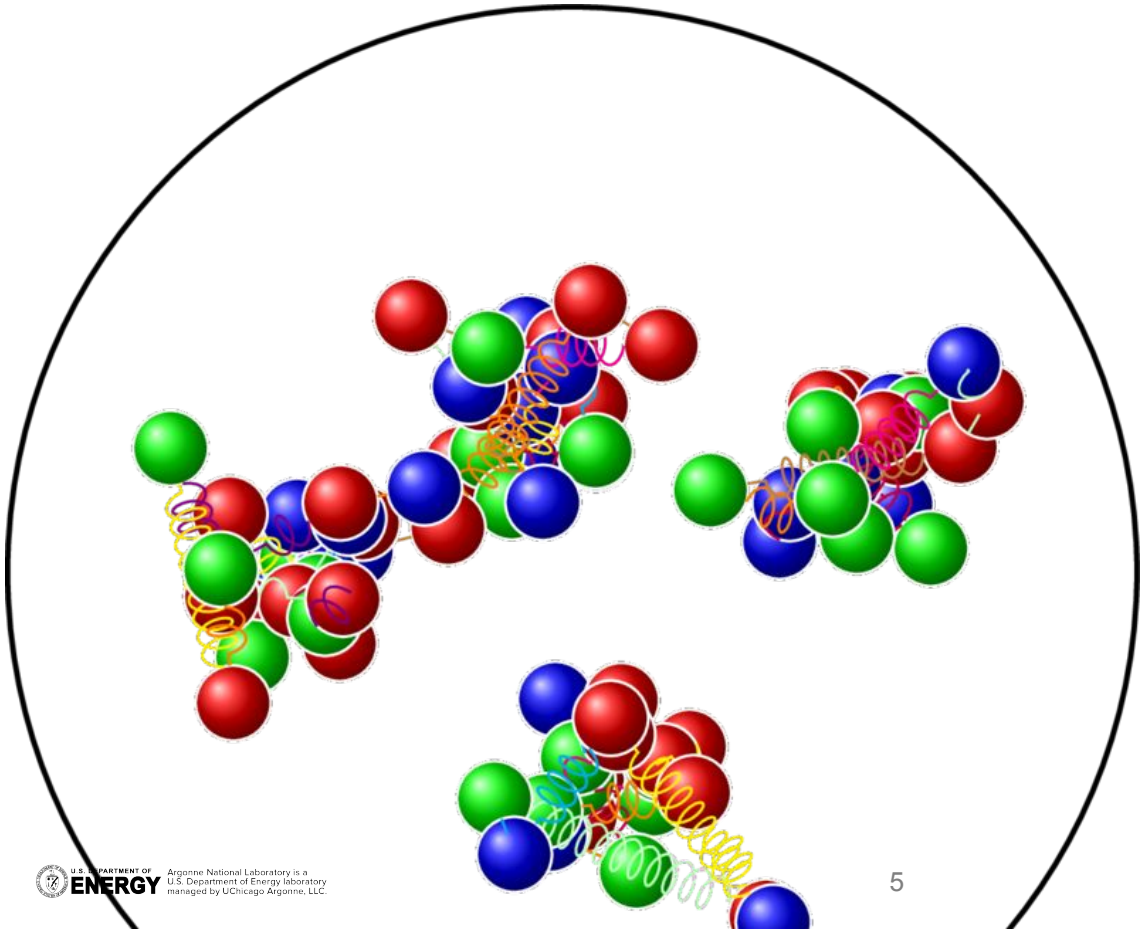
ALERT is a natural bridge from JLab 12 GeV to the EIC

The Partonic Structure of the α Particle



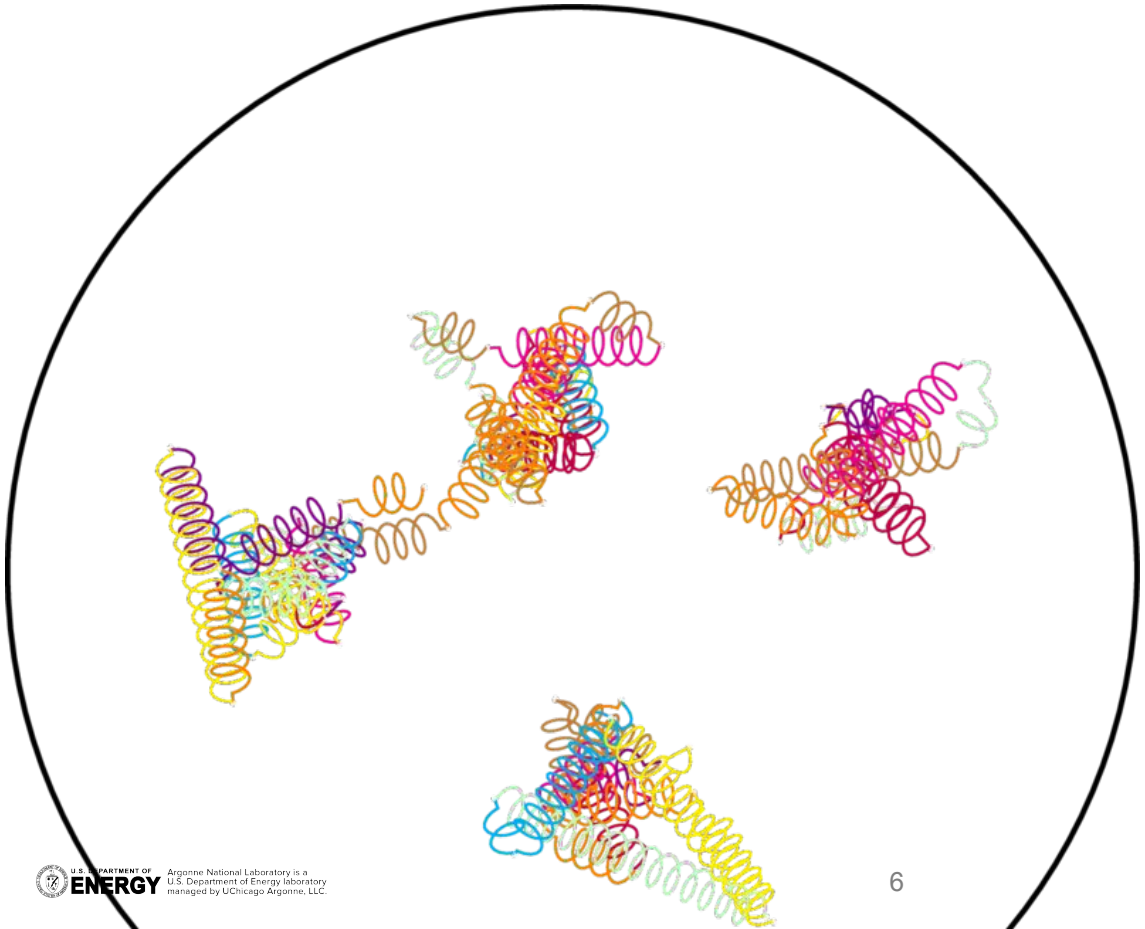
- Two goggles to view the nucleus

The Partonic Structure of the α Particle



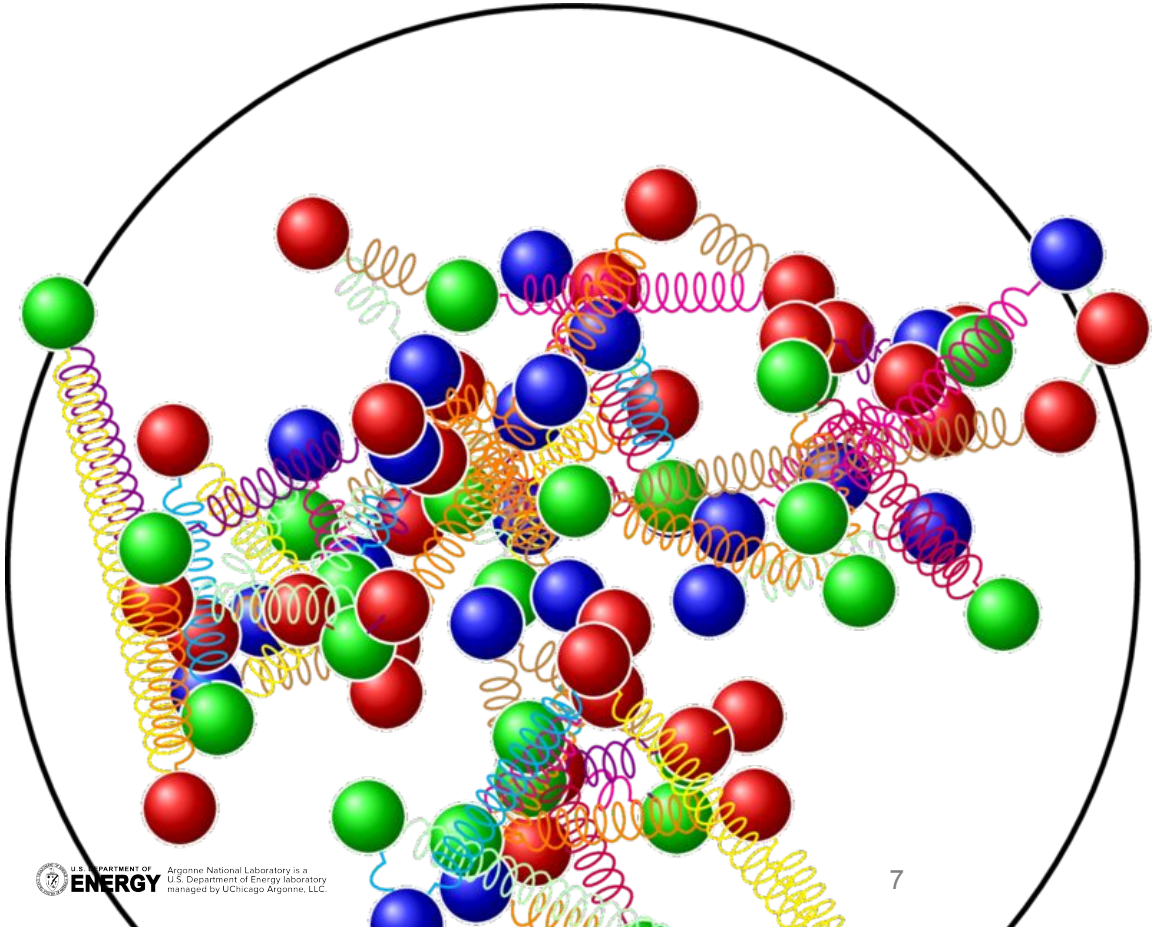
- Two goggles to view the nucleus
- Coherent DVCS to probe the charge profile

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

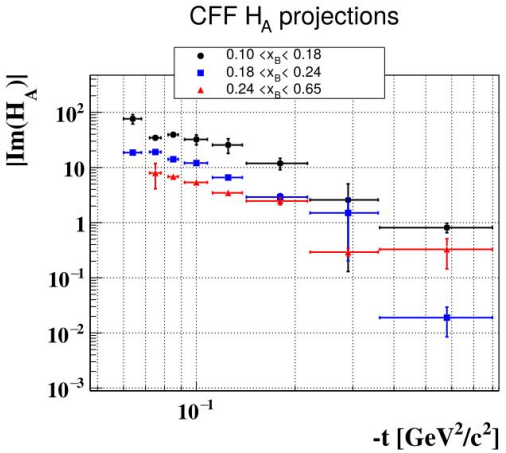


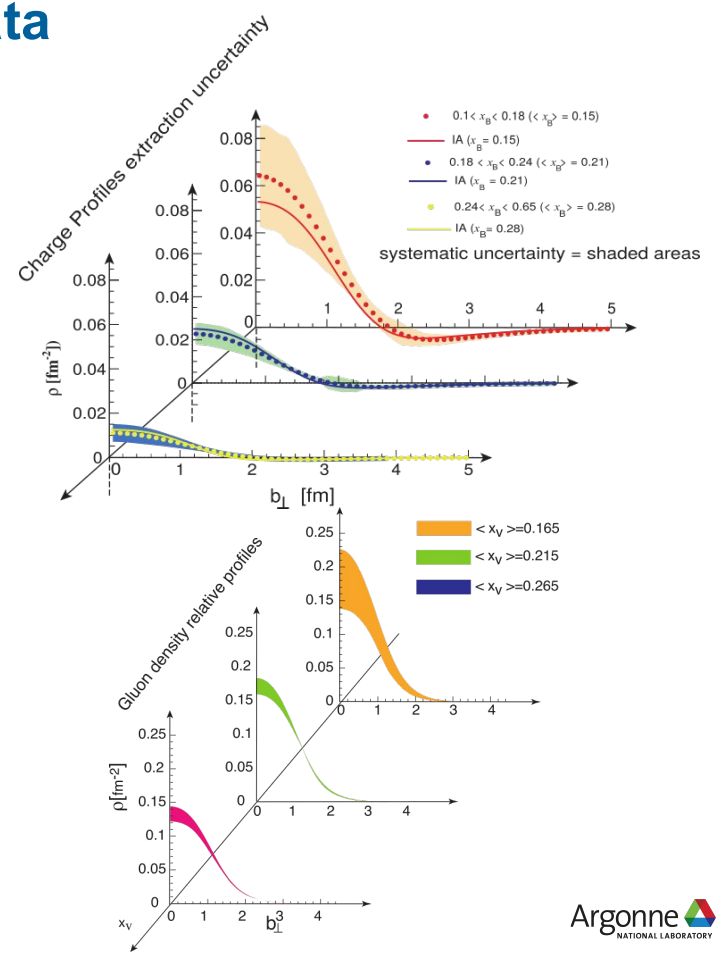
- Two goggles to view the nucleus
- Coherent DVCS to probe the charge profile
- Coherent φ production to probe the gluon profile
- How does the **gluonic form factor** compare to the **charge form factor?**

^{4}He Transverse Quark and Gluon Densities

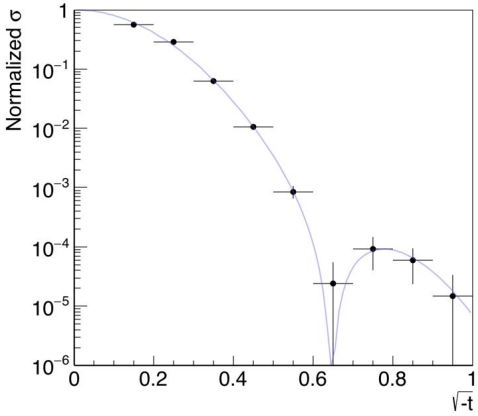
A self contained analysis with ALERT data

Coherent
DVCS
Charge Profile





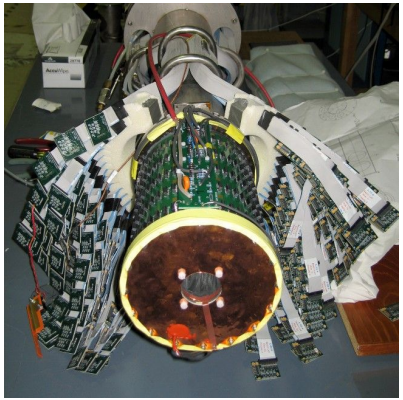
Exclusive
φ Production
Gluon profile

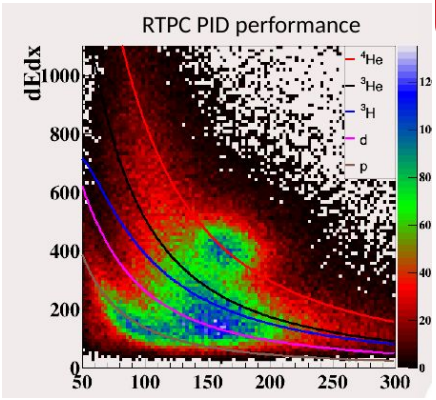


ALERT - A Low Energy Recoil Tracker

Past experiences

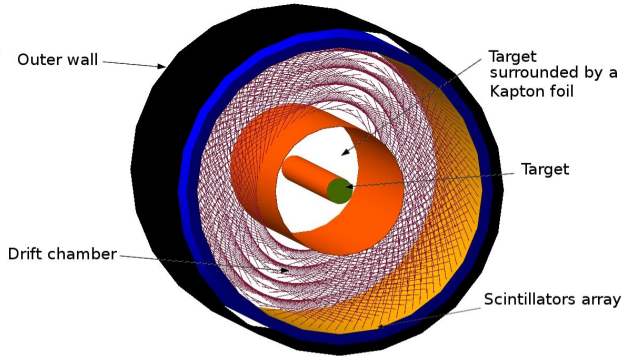
- Previous (eg6) and current (BONUS) RTPC detectors do not meet experimental needs
- eg6 RTPC had long drift time and lacked full PID capabilities
- BONUS12 RTPC will be similar in scope and detect recoil protons only





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}

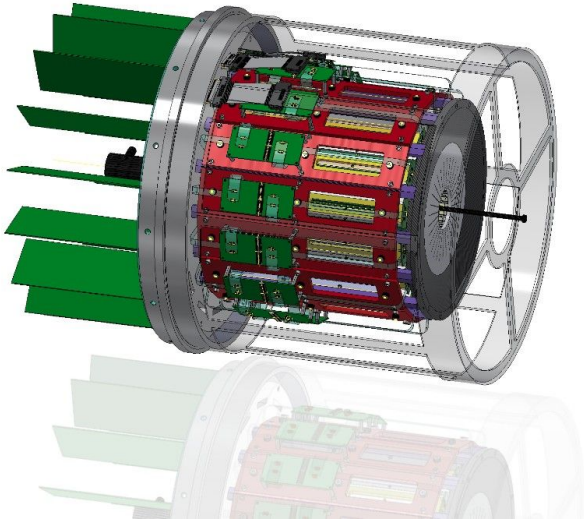


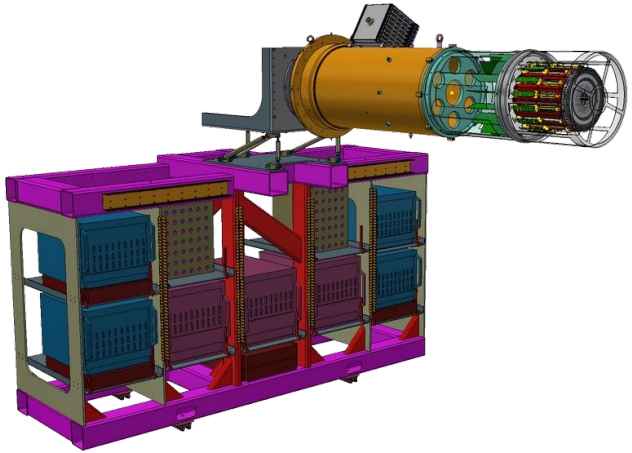
ALERT Detector

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





ALERT ToF

- Time-of-Flight PID
- Small barrel of segmented scintillators
- Under construction at Argonne
- PETIROC-based SiPM readout led by JLab (Ben Raydo)

→Currently scheduled to start on September 19th 2024

Gas Target

- Gas Target and gas system very similar to BONUS target
- Managed by JLab's Hall-B technical team
- High pressure straw target gases: H_2, D_2, and ^4He

Hyperbolic Drift Chamber Performance

Prototype Tests

Successful prototype test at the **ALTO facility** with proton/^{4}He at energies matching ALERT detector (T ~ 6-18 MeV)

- Track resolution: 120 μm
- High detection efficiency

→95% for protons

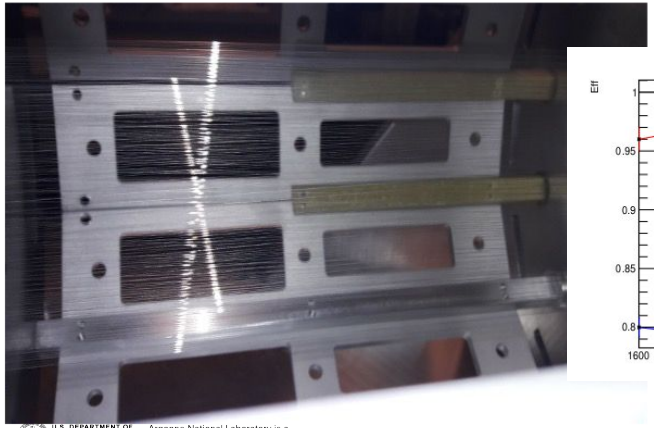
→99% for alphas

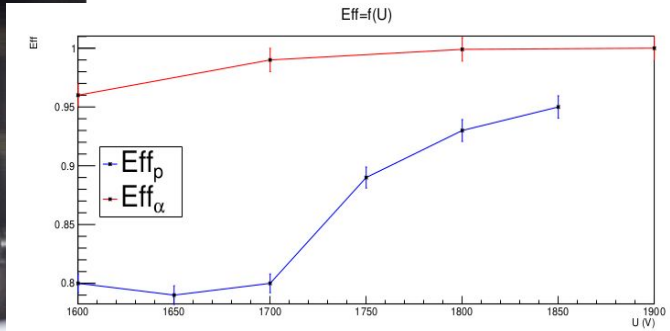
AHDC design is fully validated

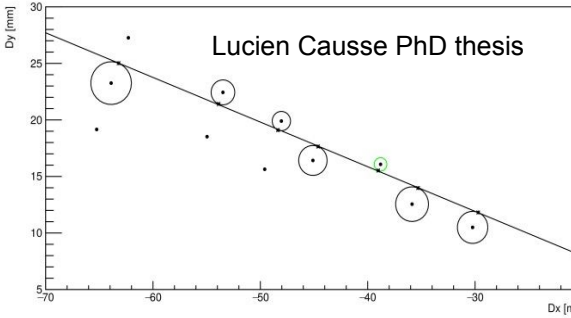
High magnetic field test at **Argonne**

- AHDC transportation demonstration
- Detector operates normally in 3T field.
- No issues identified during transportation of prototype

AHDC parts and full chamber arrive at JLab this week!



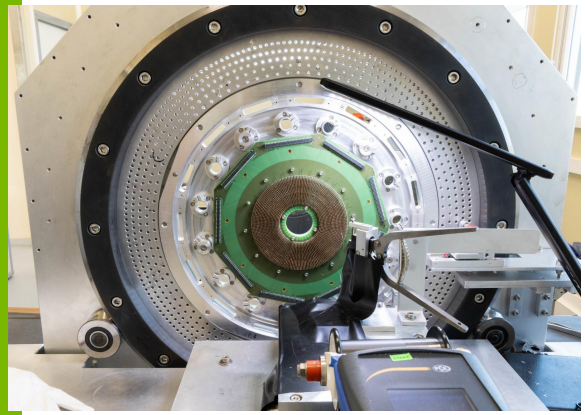


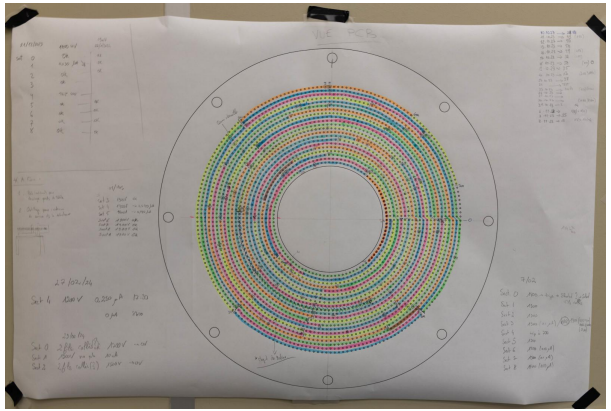


Stringing of ALERT drift chamber

Stringing of the ALERT Hyperbolic Drift Chamber (AHDC)

- Started on October 10, 2024 in IJCLab (Orsay, France)
- Time intensive job, necessitates two trained technicians
- See previous updates for the detailed procedure





Slides Courtesy of R.Dupre and G.Charles

AHDC Stringing is done

AHDC completed on the 1st of March

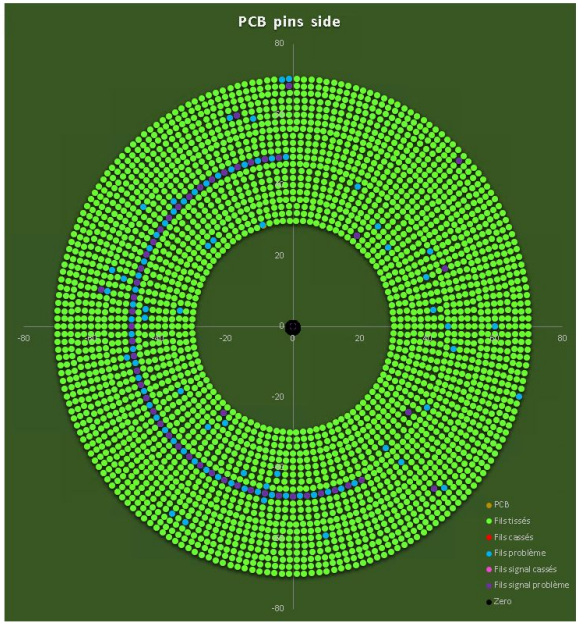
All wires are in and working

- We had issues, but they are all repaired
- We have documented all of them

ALERT AHDC | Logbook_v4.1 |

Fils tissés	**2895**	*95,67%*	Date de démarrage	10/10/2023	
Fils cassés	**0**	*0,00%*	Cadence	50 fils/jour	
Fils tissés problème	**131**	*4,33%*	Date de fin estimée	10/02/2024	
Fils signal cassés	0				
Fils signal problème	50				

NB FILS A TISSER	3026
FIL TISSES	3026
RESTE A TISSER	0



Slides Courtesy of R.Dupre and G.Charles

ALERT AHDC delivery to JLab

We sent some of the tools

- Assembly table and tools

The detector will fly with the Orsay team on the 17th of March

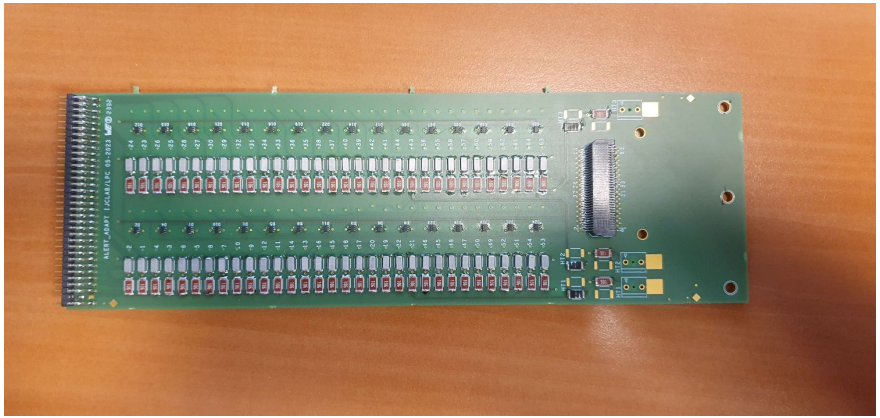
- We booked its seat
- The team will reassemble the setup
  - **Including a temporary gas enclosure**
- Make repairs if needed

Slides Courtesy of R.Dupre and G.Charles

AHDC test and boards

Boards assuring coupling with the electronics

- HV transfer to the pins and protection of the electronics
  - They are cabled and tested up to 2000V



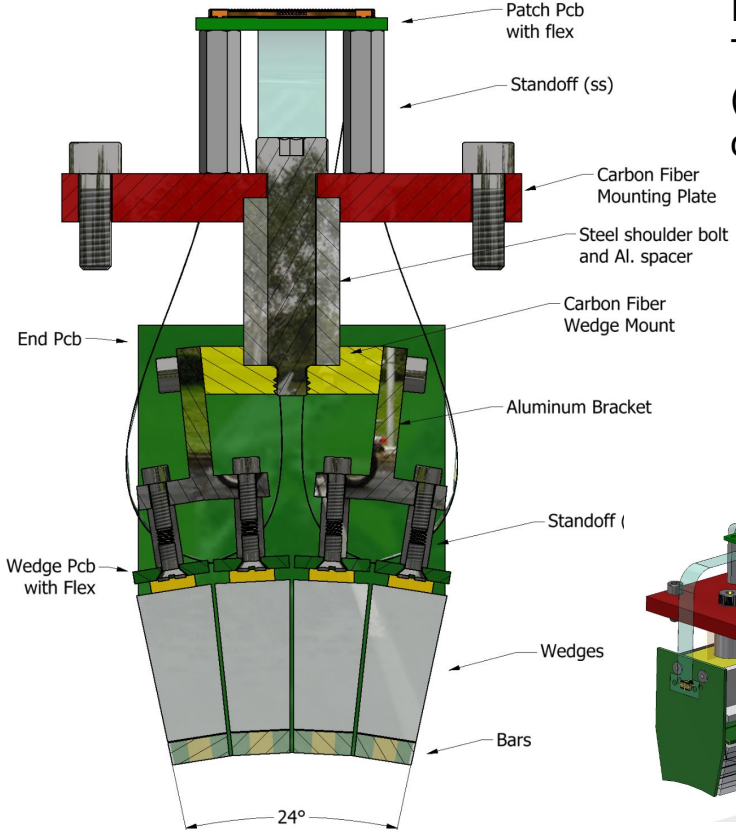
The detector was tested with a radioactive source

- Alpha source placed at the center of the detector
- The test was performed at 1700V in air
- Dark counting rate was about 100 Hz and raised to 200 Hz with the source.

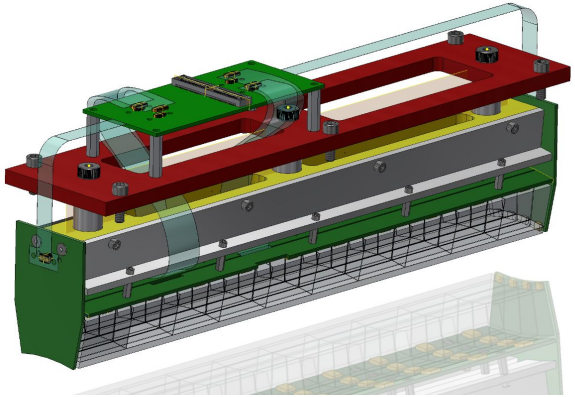
More advanced tests will be done in April at JLab

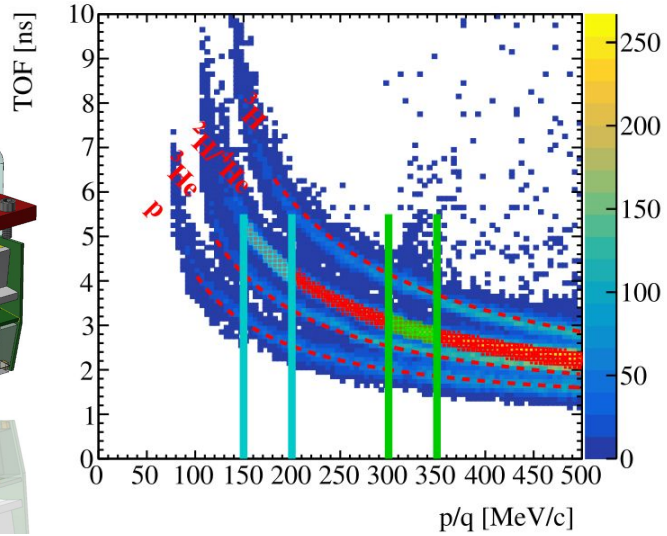
Slides Courtesy of R.Dupre and G.Charles

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**

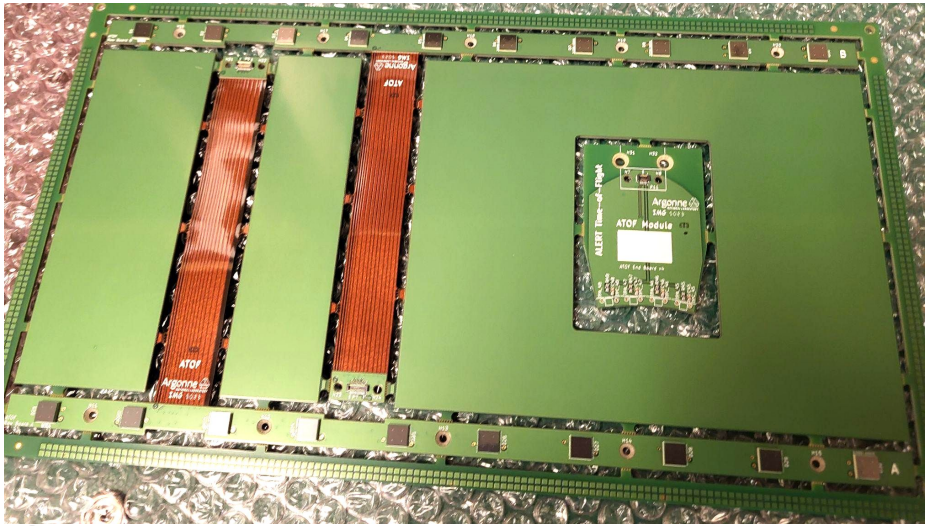


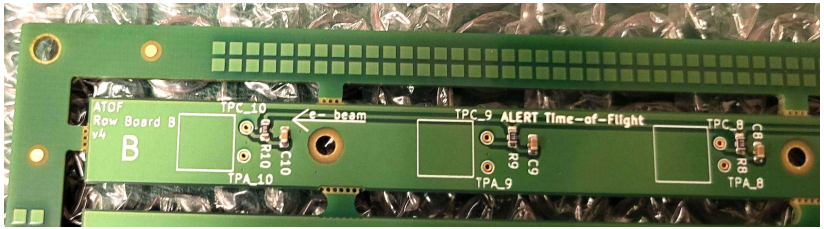


ATOF Detector Boards

SiPM board panels

- New design includes biasing RC located near SiPMs (decoupling and current limiting)
- Additional temperature monitoring diodes on all boards.

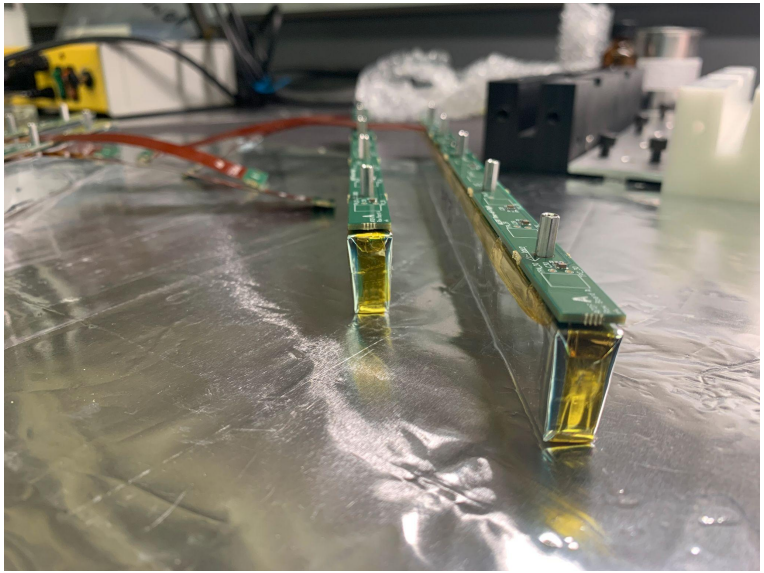




Gluing Scintillator Wedges to Row boards.

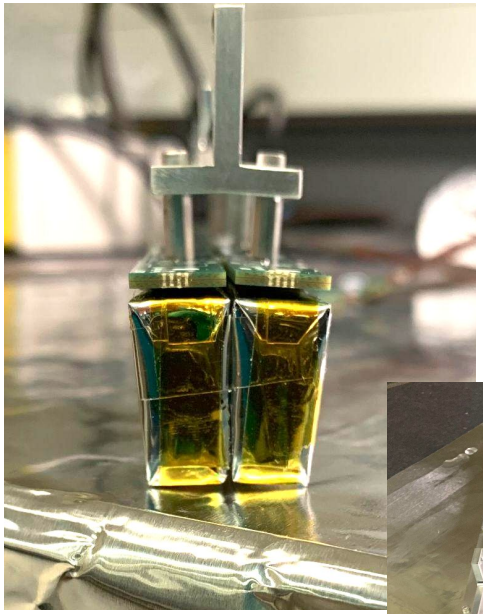
Standoffs added to each Row board before gluing

Row gluing jig used for precisely locating row boards and scintillator after applying optical epoxy to each SiPM



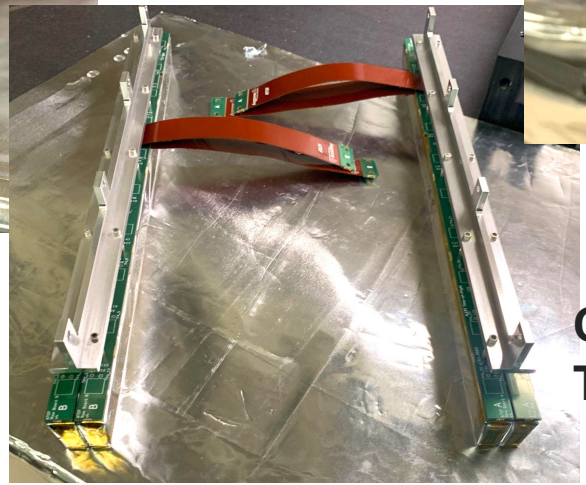
Courtesy of Tom O'Connor

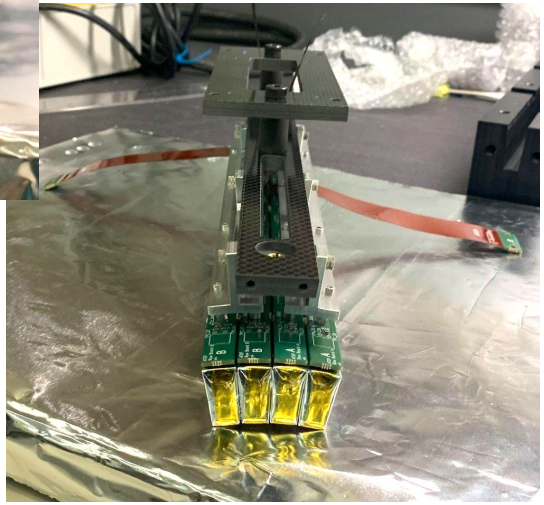
Scintillator Row Assembly



Row Brackets connected to carbon fiber plate on 12 deg. side.

Carbon fiber top plate connected with shoulder bolts to accommodate any position variations during assembly



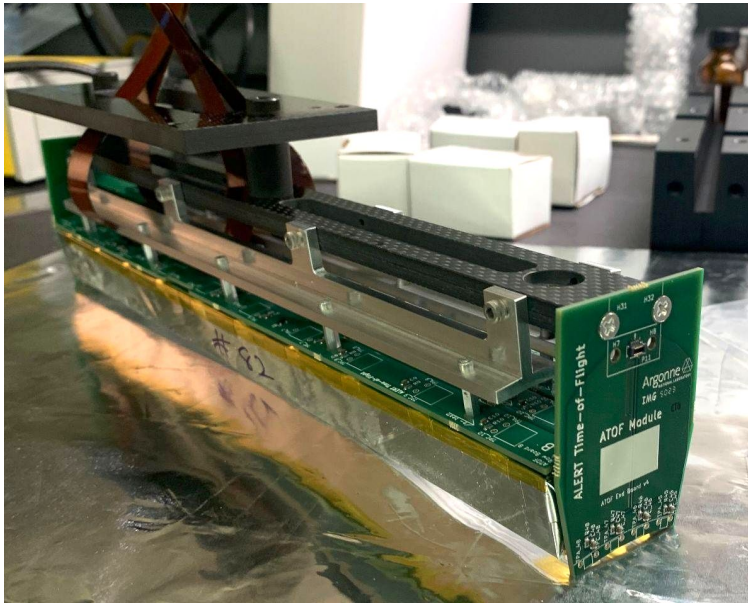


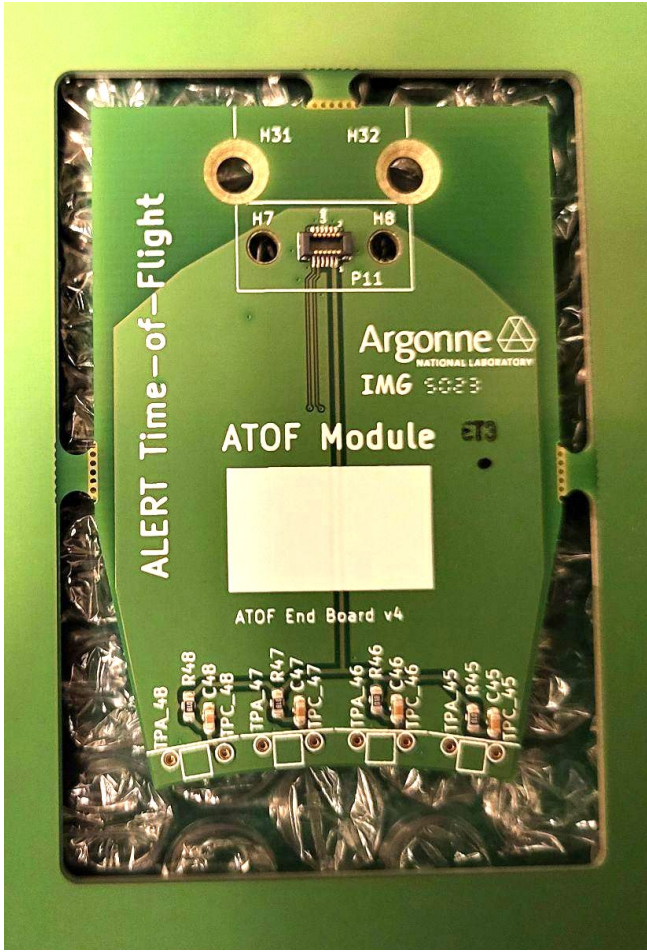
2 rows connected to (6 deg) angled bracket

Courtesy of Tom O'Connor

Endboard and Scintillator Bar

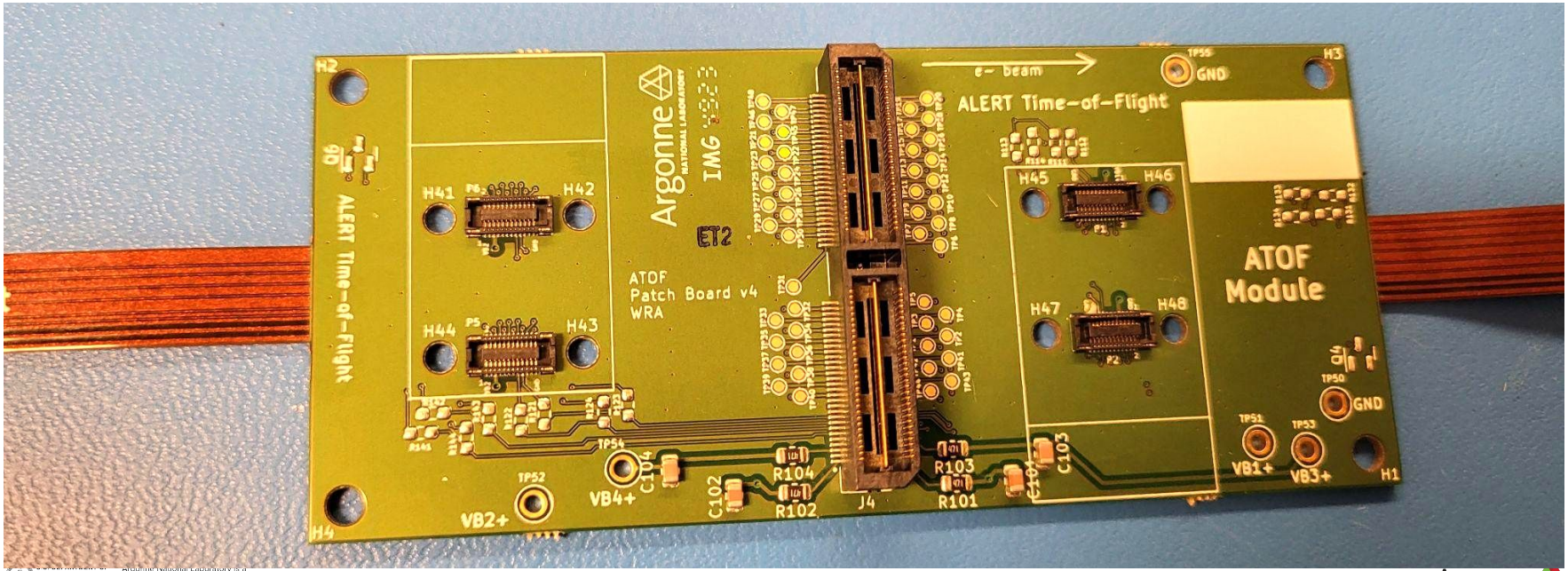
- End boards added to assembly
- Bare scintillator bars (4 per module) glued at each end to a 2x2 mm^2 SiPM
- Flex lead connect to top mounted “Patch Board”





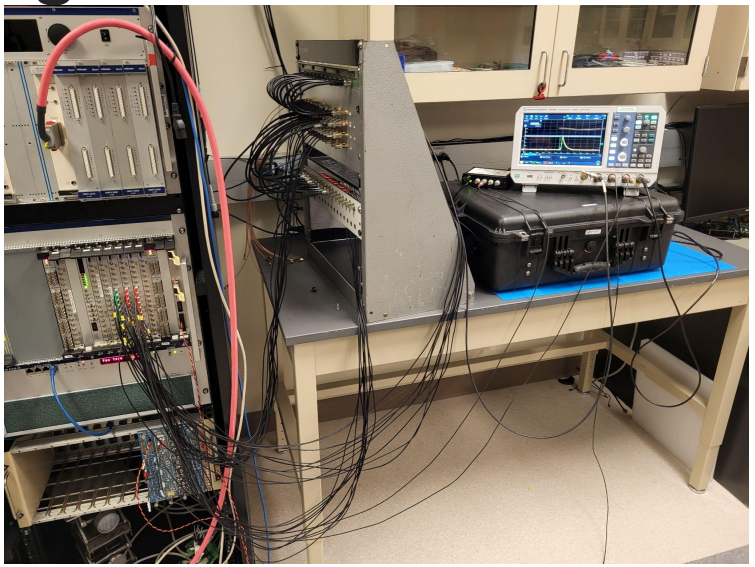
ATOF Patch Board

- New design includes a number of test points for SiPMs and power.
- Flex leads connect to front and back “End boards”.
- Row board’s flex leads connect to patch panel (4 connections total).
- 0-ohm resistors select up to 4 temperature diode locations per module.



ATOF Board and Redout Testing

- ATOF board assemblies have been checked
- Breakout board with 48 coax connectors and biasing supply connectors enables looking at individual signals on scope.
- Darkbox setup to characterize SiPMs with led pulser (and later module using sealed sources)
- Connecting all 48 signals to FADCs for SiPM characterization
- **Primary Petiroc2A readout electronics fabricated and tested** at JLab (Ben Raydo)
- Waveform digitizing readout modules fabricated and undergoing tests at NALU (Ryan Pang)



ALERT Detector Cart and Support Tube

- Eddy current analysis and FEA of for different support tube materials
  - SS and Al had their tradeoffs
  - G10 selected for support tube to reduce weight and eliminate eddy currents

Eric Sun

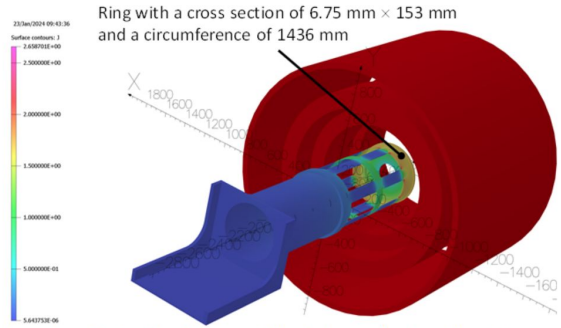
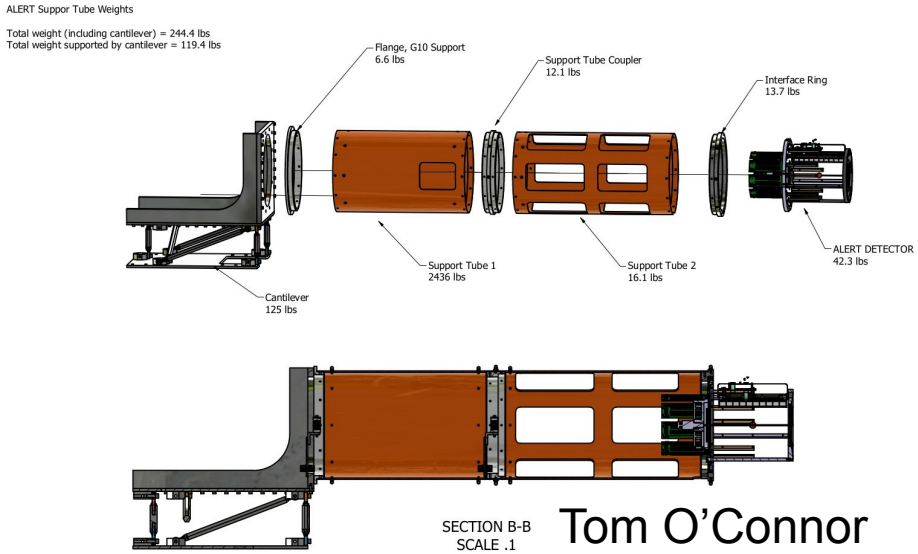
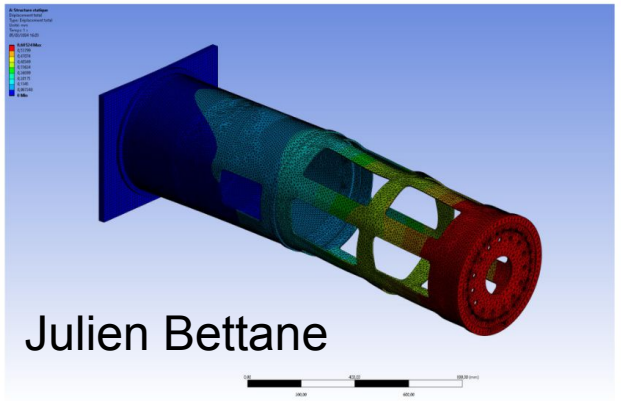


Fig. 6 Current density of the eddy current with the aluminum cantilever beam (the unit is A/mm²)



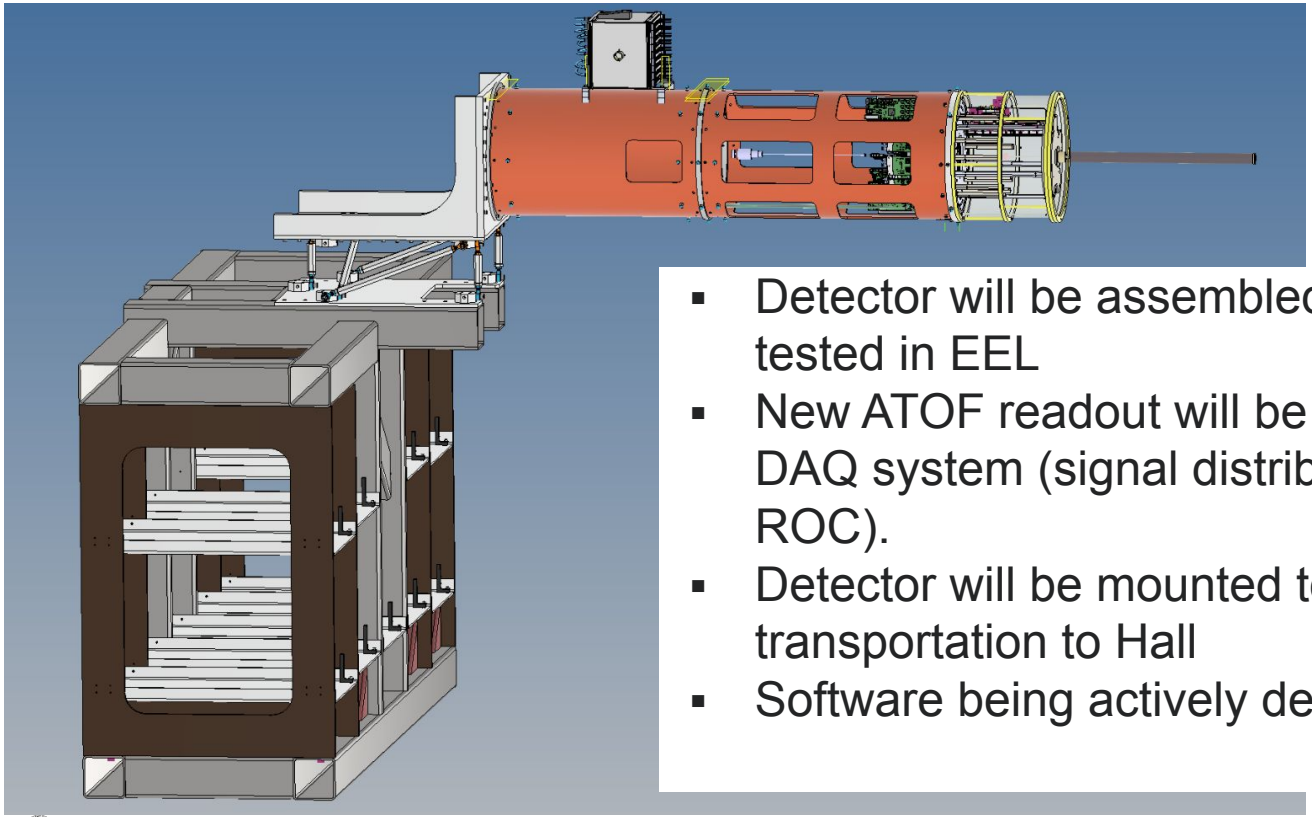
Tom O'Connor



Julien Bettane

Run Group L Preparation

Exciting and busy time for ALERT project



- Detector will be assembled in clean room and tested in EEL
- New ATOF readout will be integrated into full DAQ system (signal distribution with TI-PCIe ROC).
- Detector will be mounted to support tube for transportation to Hall
- Software being actively developed

Summary

ALERT construction is nearly complete

- ALERT Experiments (RG-L) form a comprehensive program studying nuclear effects in light nuclei
- Significant progress on all detector subsystems
- Getting ready to install in the Hall **August 2024** and start running mid **September 2024**

ALERT Collaboration Meeting on March 18th and 19th (next week)

Also weekly ALERT software meetings every Friday afternoon.

Thank You!

HDC Transportation and Magnetic Field Test

Shipped from Orsay to Argonne High Field Test Facility

HDC Transportation and Magnetic Field Test

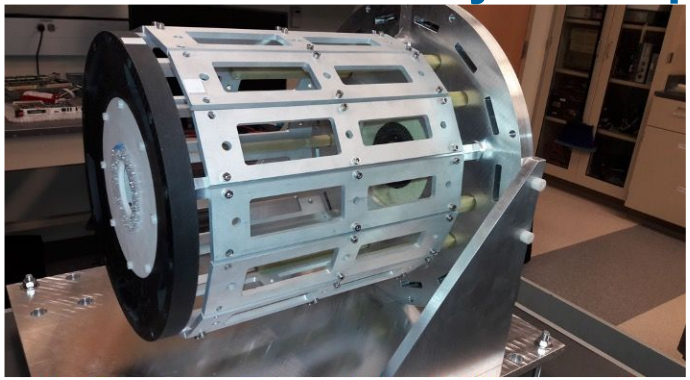
Shipped from Orsay to Argonne High Field Test Facility

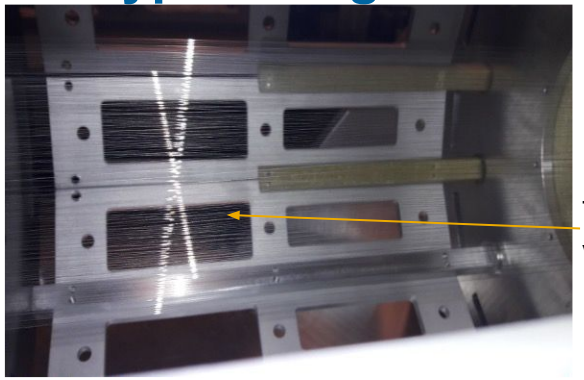
No transportation-related problems with full scale drift chamber prototype

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

Hyperbolic Drift Chamber Construction

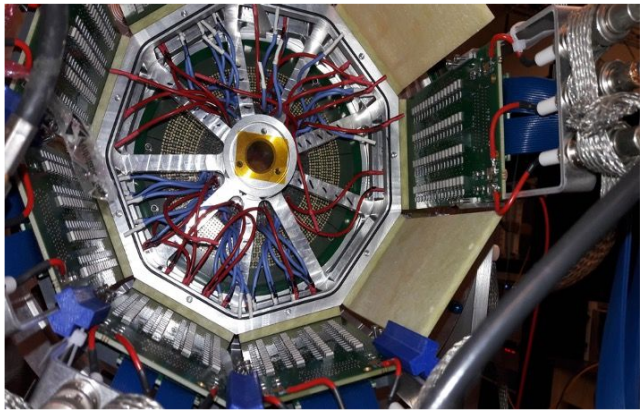
Full Scale – Partially wired prototype at Argonne

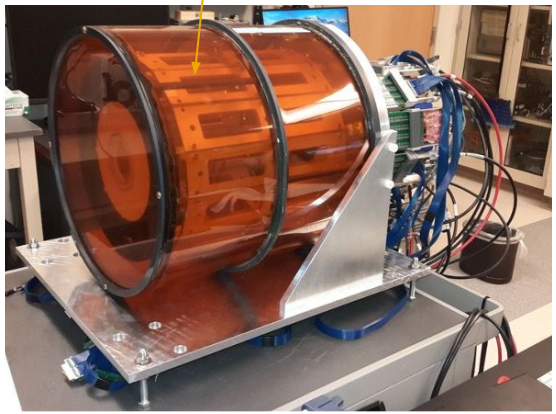




Two stereo angles of wires visible with flash

Prototype mounting plate and drift gas containment





Simulation and Reconstruction Software Status

Simulation in GEMC

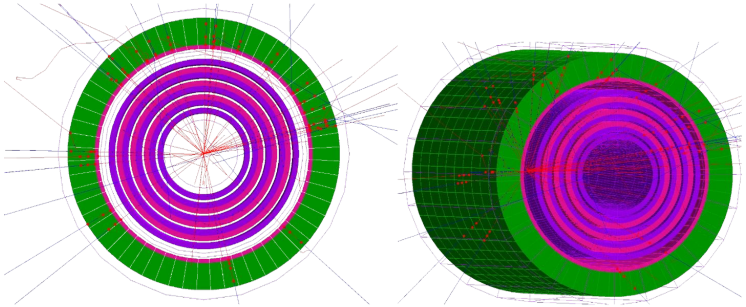
- Fully in place, with a basic digitization
- Todo: improve ATOF digitization to match readout capabilities (Petiroc or NALU)

Calibration

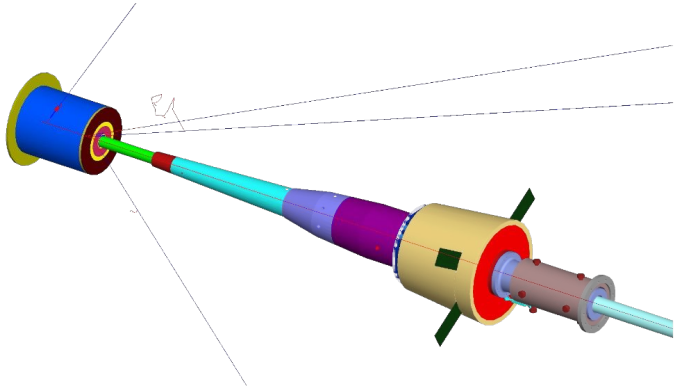
- Systems are in place for ATOF
- Still working on drift chamber calibration code

Reconstruction

- Basic helix fit and Kalman filters exist
- The Kalman filter needs to be refined and pushed upstream
- Exploring AI Techniques for ALERT Tracking
- Adapting CLAS12 AI tools for ALERT tracking and PID
- Todo: Develop combined AHDC track and ATOF data for best PID reconstruction

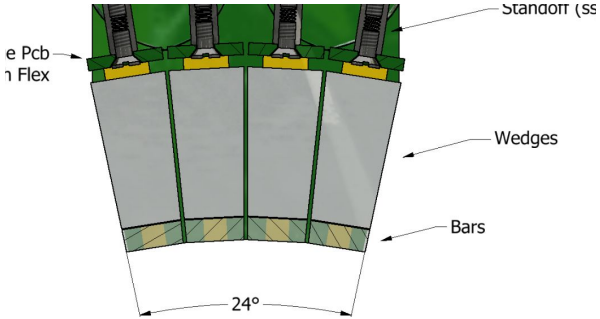


ATOF in green & magenta; AHDC in purple & red. *GEMC* geometry.



New Mexico State U., Mississippi State U., Temple & Jefferson Lab

ATOF PID

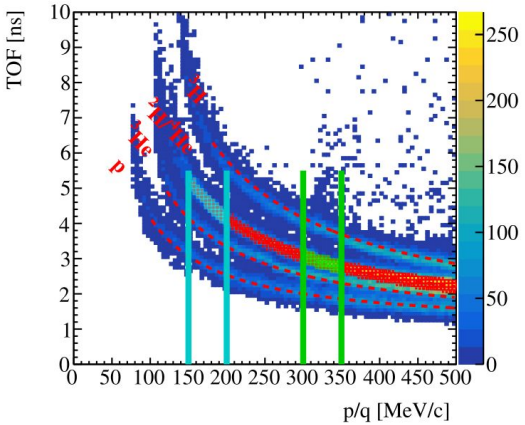


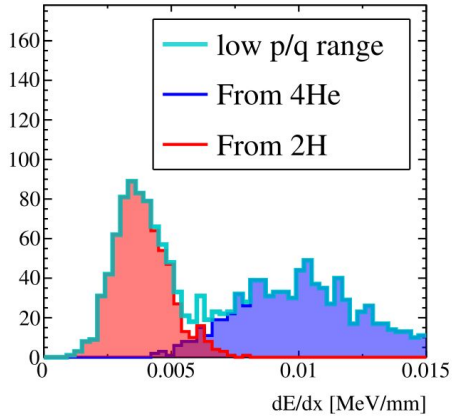
Need < 150 ps time resolution

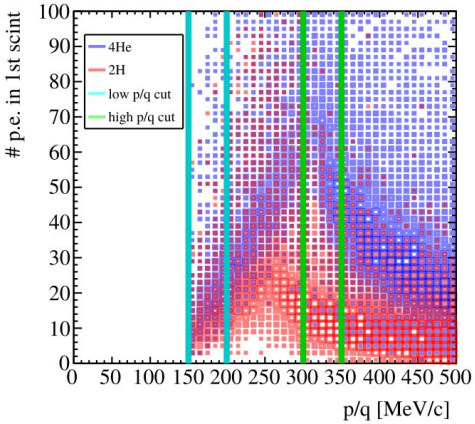
Inner bar thickness : 3 mm.
Outer wedge thickness : 2 cm.

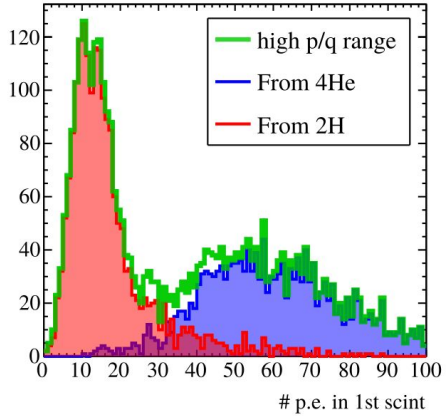
TOF separates light ions, except **^{4}He/^{2}H** which have same m/q ratio

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



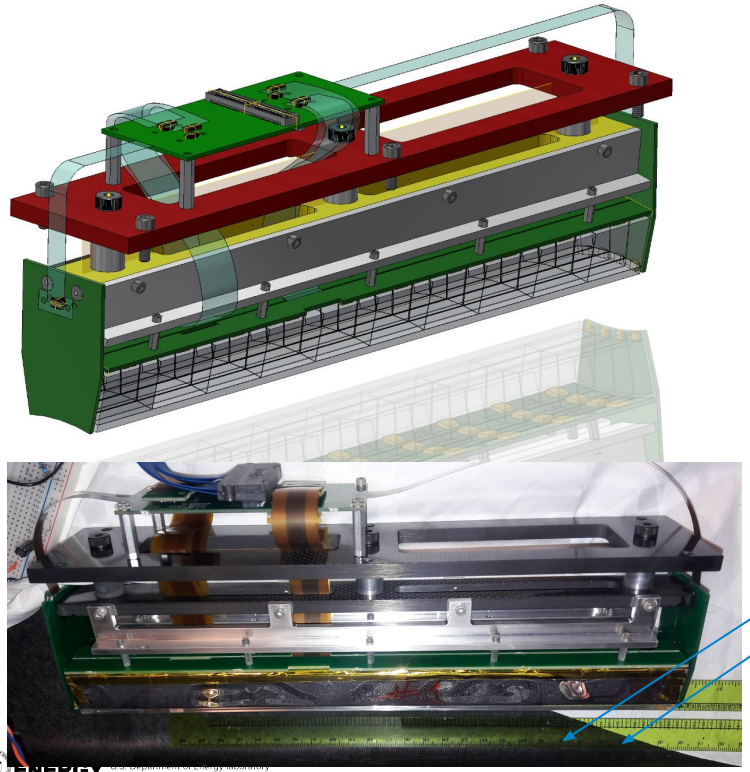




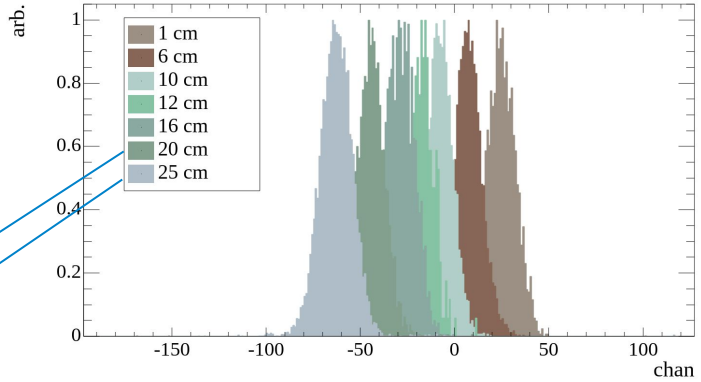


ATOF Prototype Module

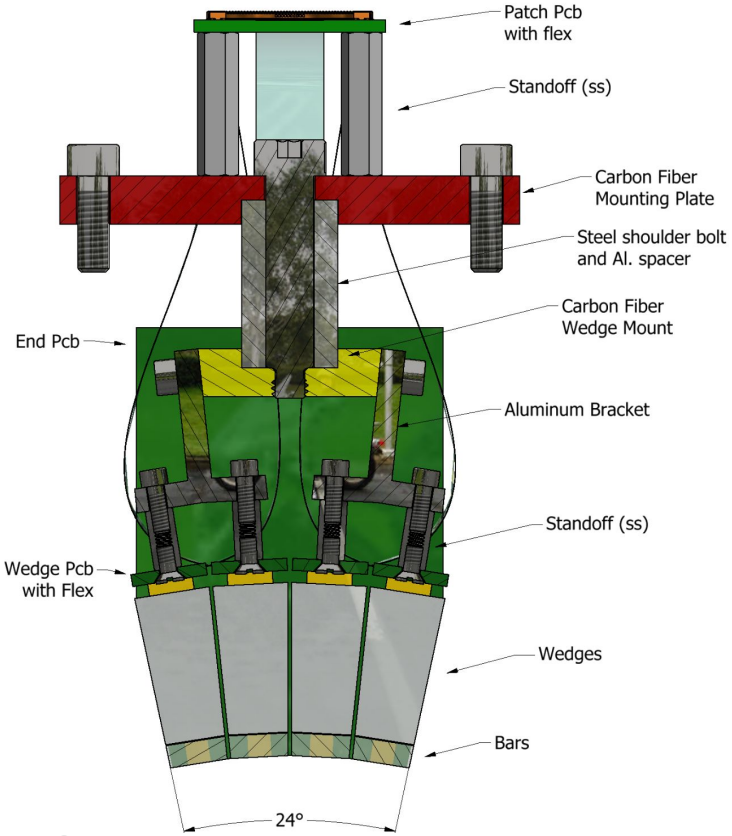
Americium-241 source placed against the module's inner bar scintillator at various locations



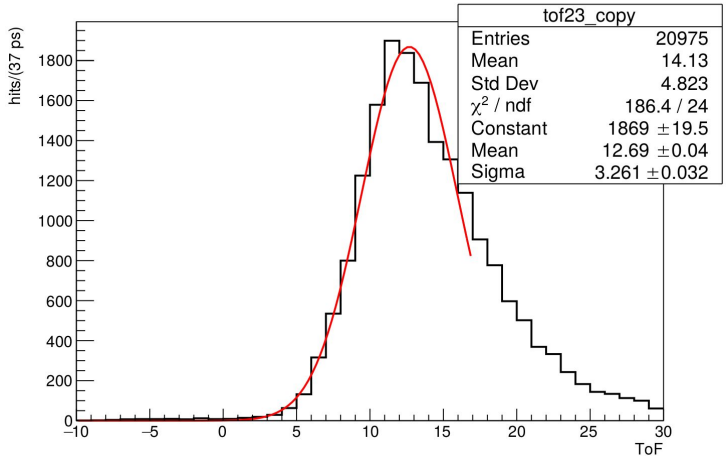
TDC difference for the module's bar sipms for different locations of the 241 Am source.



ATOF Module Construction and Performance



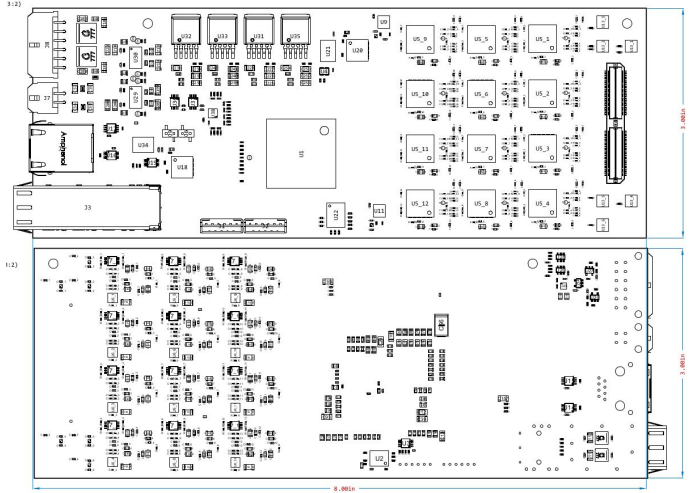
- Tested wedge time resolution with ^{241}Am source
- σ = 85 − 125 ps
- Observed tails in timing peak due to large source area → future improvement.
- No data corrections or fine tuning of ASIC config → Easily meeting 150 ps timing requirement of experiment!



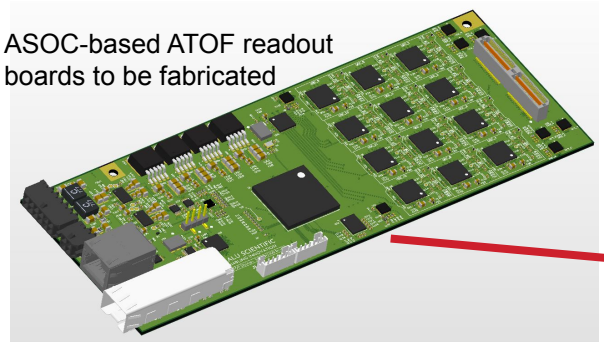
ATOF Readout Electronics

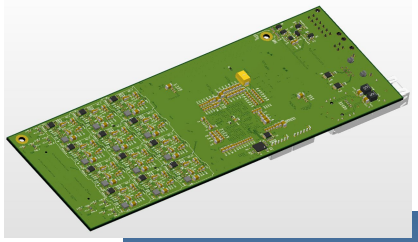
Petiroc2A and NALU ASOC Readout

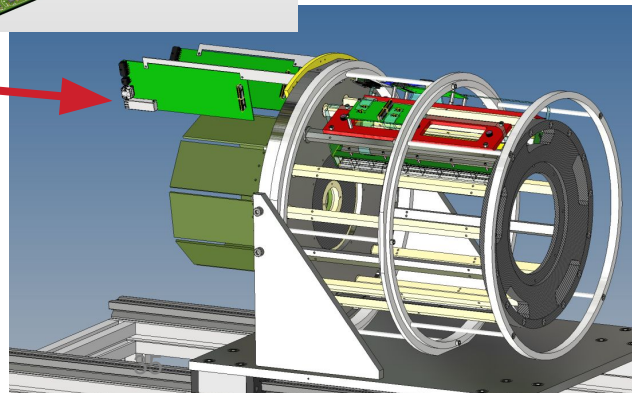
- NALU readout board tested and FW being developed
- Petiroc readout first article tested and final assembly is in progress
- Boards use the same FPGA, power, signal distribution, SFP transceiver connections, signal connector and overall board dimensions
- Nalu team has expertise on FW/SW and will work with JLab FE group on FW and DAQ integration

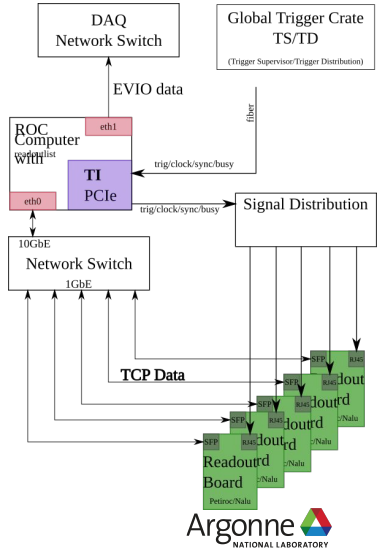


ASOC-based ATOF readout boards to be fabricated





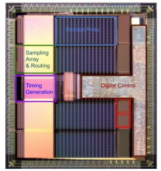




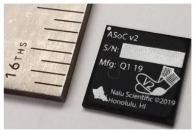
NALU ASOC-Based ATOF Readout

ASoC: Analog to digital converter System on a Chip

Leverages previously funded
DOE NP SBIR I/II DE-SC0015231



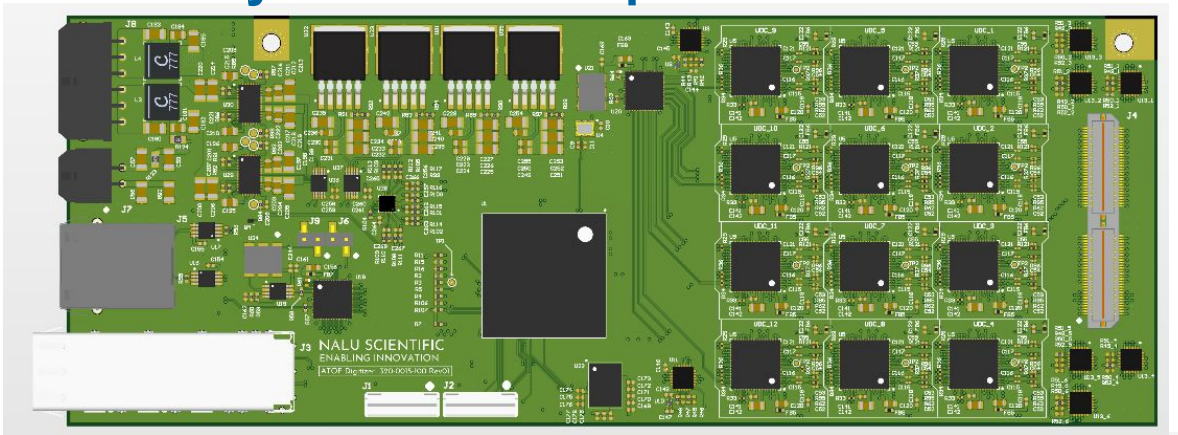
Fabricated

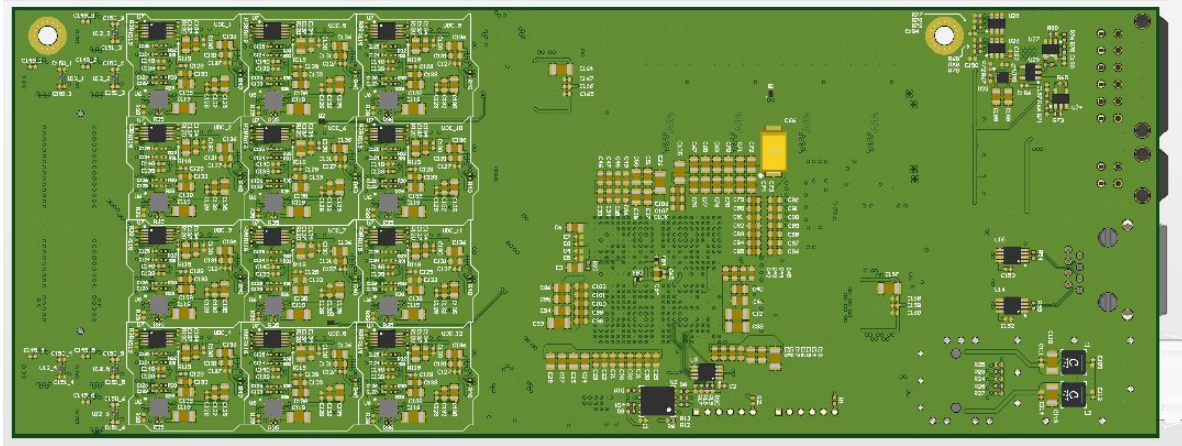


Parameter	Spec (measured)
Sample rate	2.4-3.2GSa/s
Number of Channels	4
Sampling Depth	16kSa/channel
Signal Range	0-2.5V
Resolution	12 bits*
Supply Voltage	2.5V
RMS noise	~1 mV
Digital Clock frequency	25MHz
Timing resolution	<25ps**
Power	140mW/channel
Analog Bandwidth	950MHz

Key Contribution:

- High performance digitizer: 3+ Gsa/s
- Highly integrated
- Commercially available
- 5mm x 5mm die size





- Aim to fabricate 2 (of 15) high performance readout modules
- ASOC provides enhanced readout capabilities (WF digitizing, time resolution, feature extraction)
- Goal is to provide systematic check of Petiroc boards
  → Important for high rate run configuration