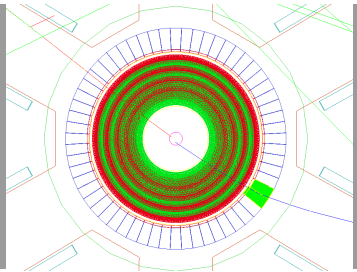
CLAS12 ALERT Project Status

A Low Energy Recoil Tracker



Whitney Armstrong
Argonne National Laboratory

ALERT Collaboration

November 12, 2020

Argonne NATIONAL LABORATORY

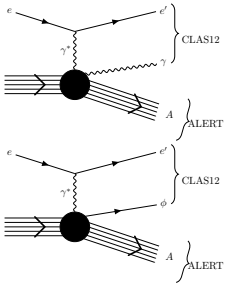
The ALERT Experiments

A comprehensive program to study nuclear effects

Coherent Processes on ^{4}He

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

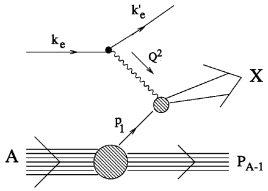
Explores the partonic structure of ^{4}He



DIS on ^{4}He and ^{2}H : Tagged EMC Effect

- $^4\mathrm{He}(e, e' + ^3\mathrm{H})\mathrm{X}$ (proton DIS)
- $^4\mathrm{He}(e, e' + ^3\mathrm{He})\mathrm{X}$ (neutron DIS)
- $^2\mathrm{H}(e, e' + p)\mathrm{X}$ (neutron DIS)

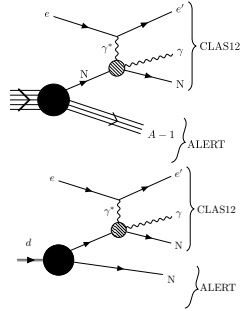
Test FSI and rescaling models



Incoherent processes on ^{4}He and ^{2}H

- $^4\mathrm{He}(e, e'\gamma\, p + ^3\mathrm{H})$
- $^4\mathrm{He}(e, e'\gamma + ^3\mathrm{He})n$
- $^2\mathrm{H}(e, e'\gamma + p)n$

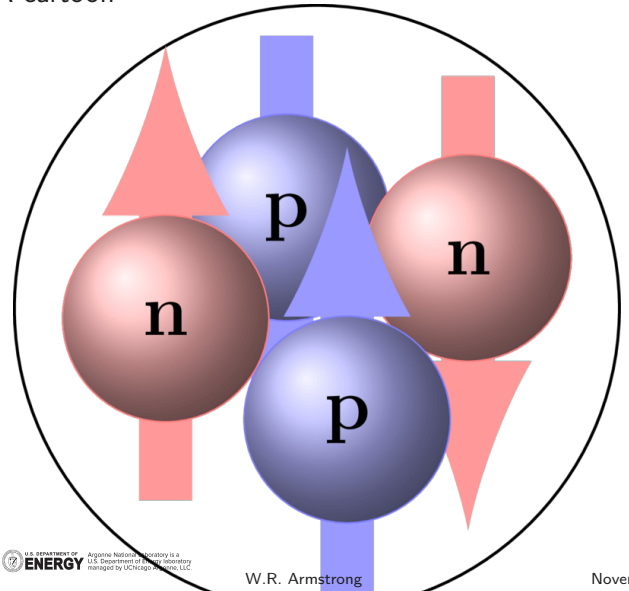
Identify medium modified nucleons



And many more channels for free

The Partonic Structure of the alpha particle

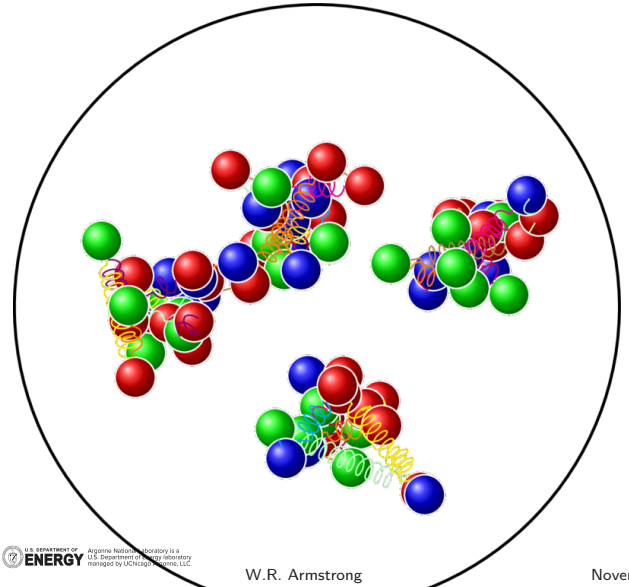
A cartoon



- Two goggles to view the nucleus

The Partonic Structure of the alpha particle

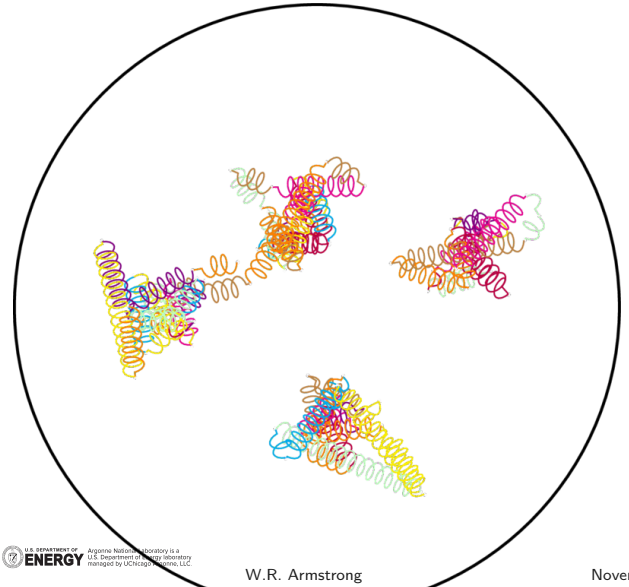
A cartoon



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

The Partonic Structure of the alpha particle

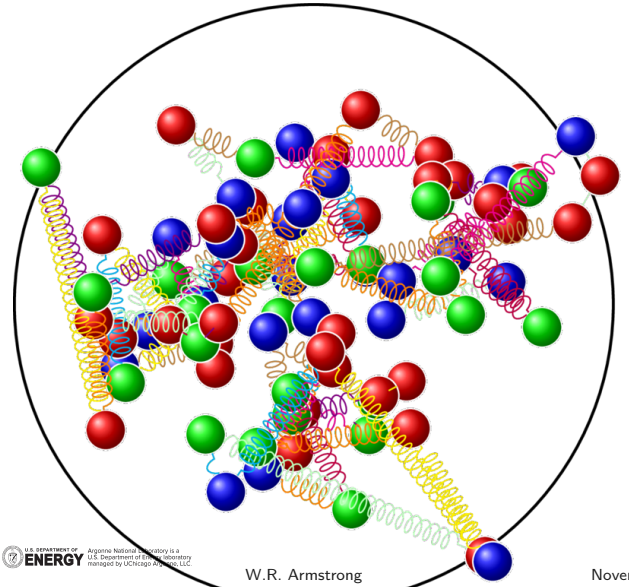
A cartoon



- 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 alpha particle

A cartoon



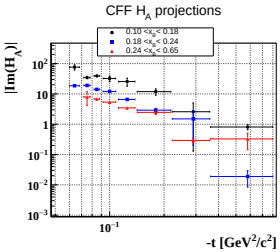
- Two goggles to view the nucleus
- Coherent DVCS to probe the charge profile
- Coherent ϕ production to probe the gluon profile
- How does the gluonic form factor compare to the charge?

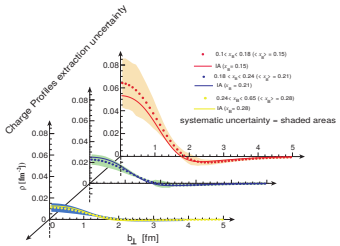
4He Transverse Quark and Gluon Densities

Coherent scattering on ^{4}He

DVCS

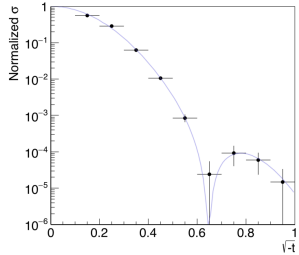
Charge profile

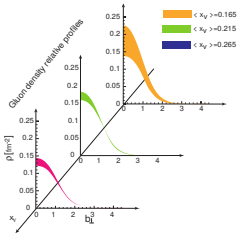




ϕ Production

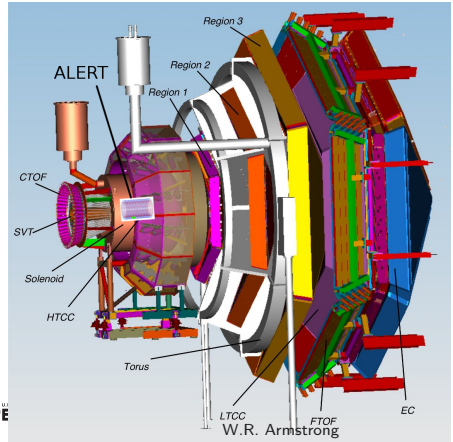
Gluon profile





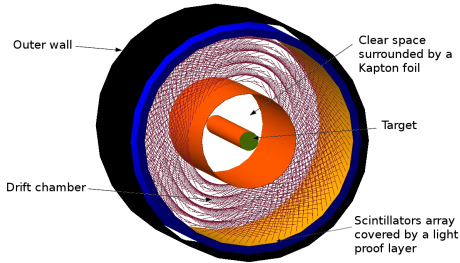
Experimental Setup: CLAS12 + ALERT

- Use CLAS12 to detect scattered electron, e', and forward scattered hadrons.
- A low energy recoil tracker (ALERT) will detect the spectator recoil or coherently scattered nucleus



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**
- Survive high radiation environment $\rightarrow$ **high luminosity**

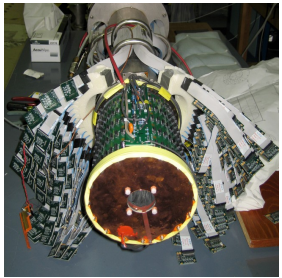


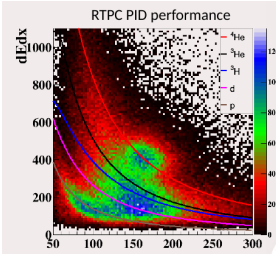
Why ALERT?

A reminder

A new detector is needed

- Existing and proposed detectors (RTPCs) do not meet experimental needs



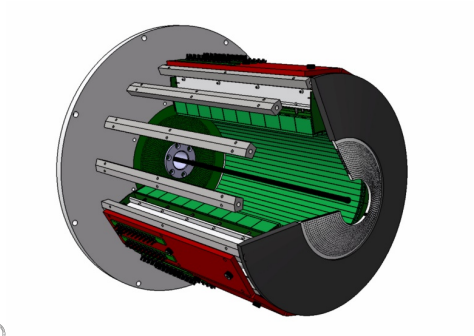


- ALERT is designed to operate in CLAS12's 5 T field
- Run group will operate at **CLAS12 luminosity limit** and **Hall-B beam current limit**
- ALERT will **provide full PID** of light ions, protons to ^{4}He

ALERT Design

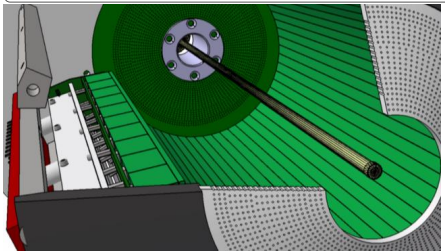
Basic Design

- Detector will surround a $\sim$3 atm gas target cell which is 6 mm in radius and constructed with 25 μm kapton walls
- Hyperbolic drift chamber with 10° stereo angle.
- Outer scintillator hodoscope for PID

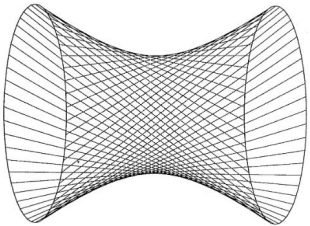


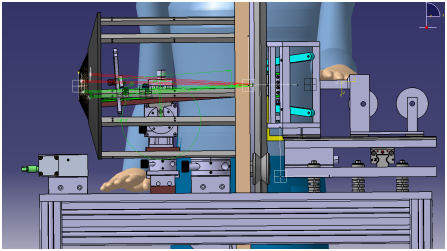
Hyperbolic Drift Chamber (HDC) Design

- 2 mm wire separation
- 10° stereo angle
- Minimize material (windows/walls)
- Detects $\theta \sim 30^\circ$ to 170°
- Acceptance minimum momenta:
  protons $\rightarrow$ 70 MeV/c
  ^{4}He $\rightarrow$ 240 MeV/c



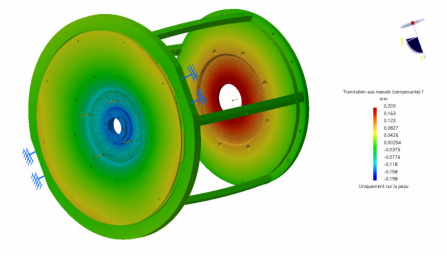
ALERT Hyperbolic Drift Chamber (HDC)





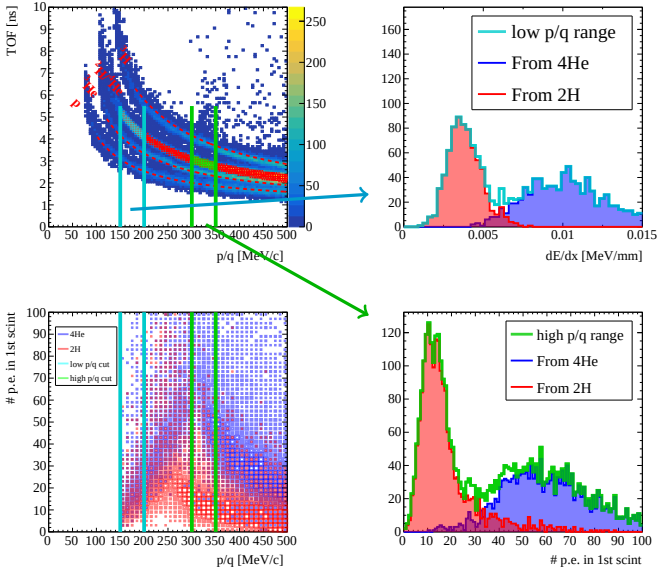
HDC Status

- Simulations of stresses on endplates complete
- MACOR forward endplate fabricated
- Wire assembly tools and jig for full detector



Courtesy of Julien Bettane

ALERT Time-of-flight (ATOF)



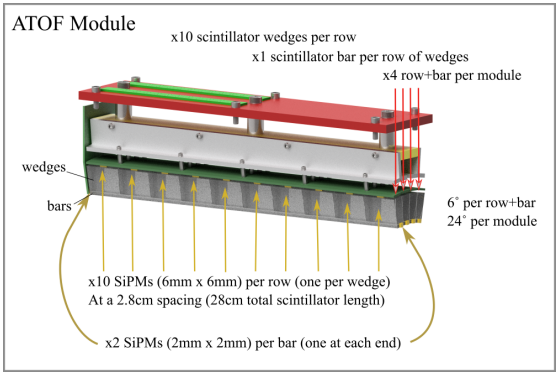
Design

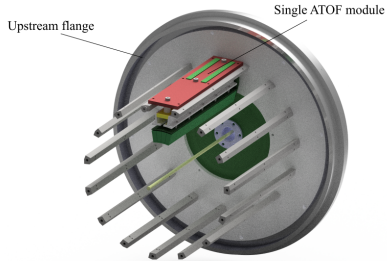
Goal of 150 ps time resolution

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

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

ATOF Module





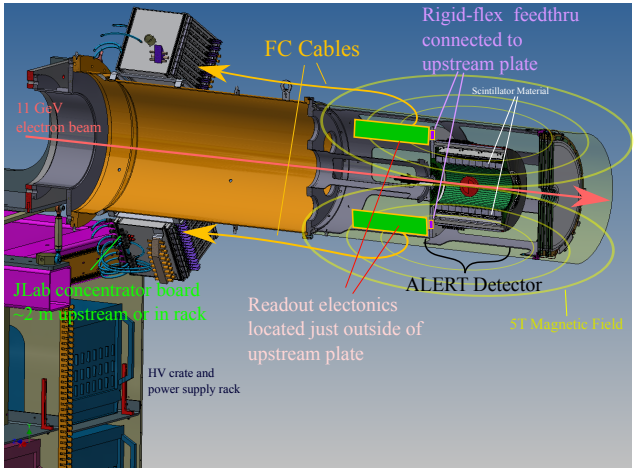
Note this is a older module design.

Module design status

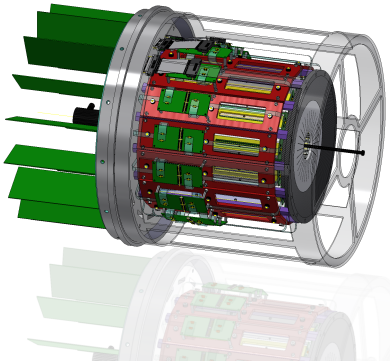
- Conceptual design of rigid-flex PCBs and assembly complete.
- Design freeze of HDC's PCB radius needed to finalize ATOF module design .

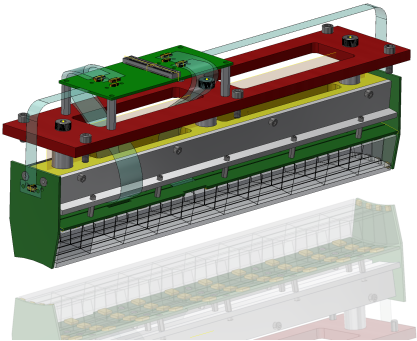
ATOF System Layout

- Readout electronics will mount on the upstream plate of ALERT
- All active components will be outside of the drift gas volume
- Developing modular readout electronics with engineering support from Nalu Scientific and JLab Fast electronics group
  → JLab – Petiroc2A readout board (standard)
  → Nalu – ASOC readout board (waveform digitizing)

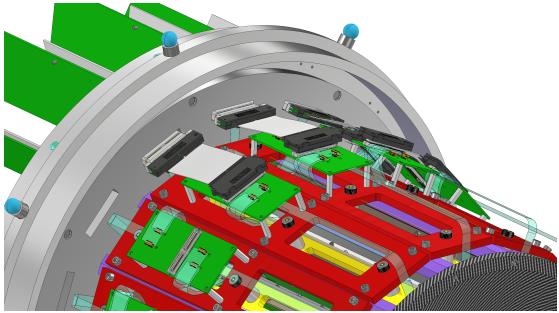


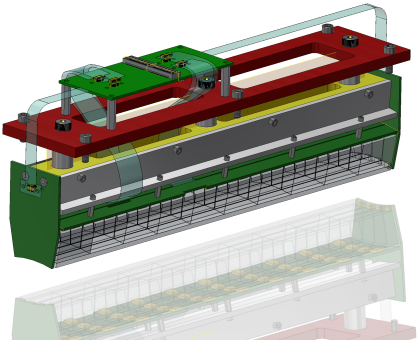
Latest Mechanical Design



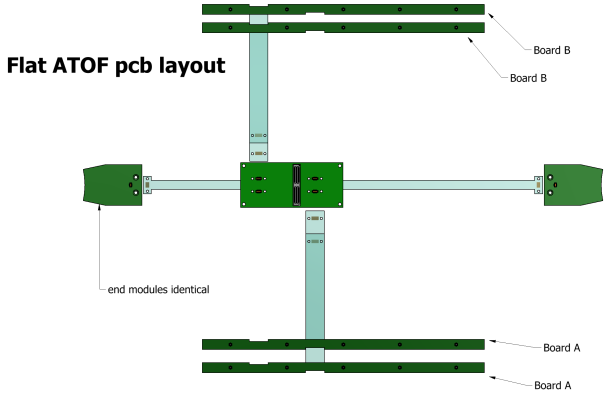


Latest Mechanical Design

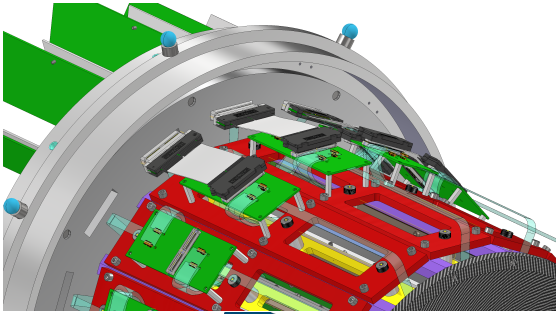


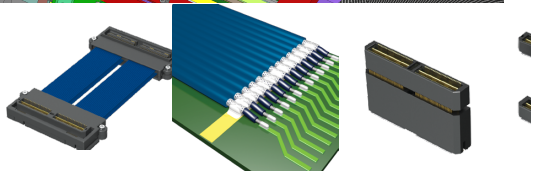


ATOF Rigid-Flex PCB



Cable and Connectors





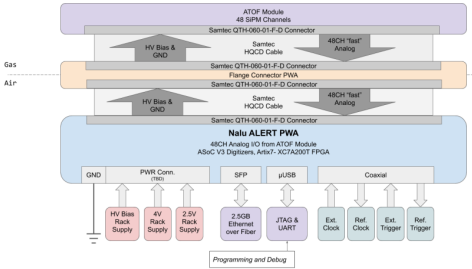


Figure 2: High level block diagram defining the Nalu digitizer interfaces to the rest of the ATOF system

Readout Board Design

Nalu Readout Board block diagrams

- Trade study complete.
- Phase II development underway.

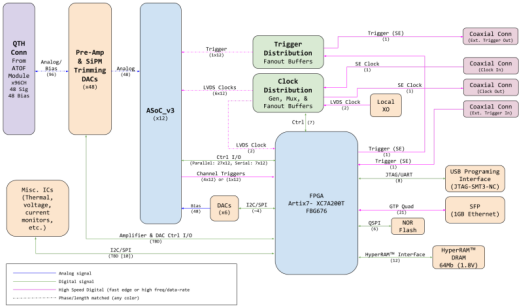


Figure 3. Digitizer board level block diagram

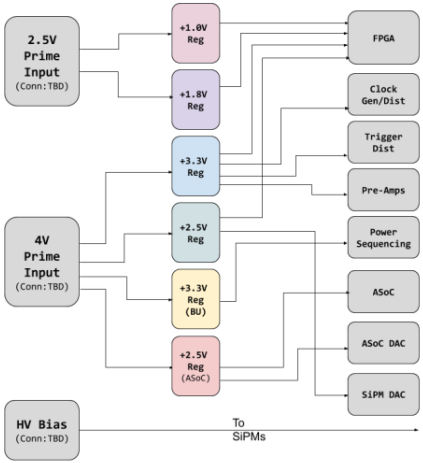
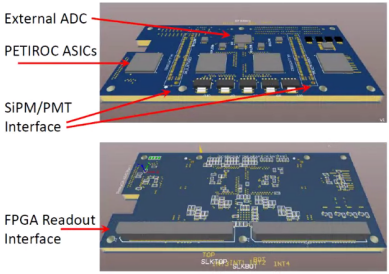


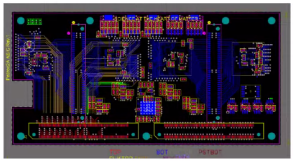
Figure 5: Power Tree

Prototype Petiroc2A Readout Board

PETIROC ASIC PCB Status



- Placement was redone to optimize SiPM -> ASIC traces
- Routing in progress - probably another week or two before ready for assembly



Features:

- 128 channels (PMT or SiPM inputs)
- Few to few thousand photoelectron charge measurement sensitivity
- <50ps hit timing resolution
- Expected >50kHz trigger rate capable
- Optical readout with Jlab FPGA readout board. Jlab CODA integration with SSP backend optical concentrator.

Courtesy Ben Raydo

The ATOF Readout Module Team

Argonne

Tom O'Connor	MEP
Todd Hayden	HEP Electronics group
Tim Cundiff	HEP Electronics group
W.A.	MEP

Tom is ALERT design and integration lead.
HEP fast electronics group is design the rigid-flex PCBs.

JLab

Ben Raydo	Fast Electronics group
Chris Cuevas	Fast Electronics group
and others	

JLab is developing the primary Petiroc2A readout board.
Ben is local JLab electronics expert.

Nalu Scientific

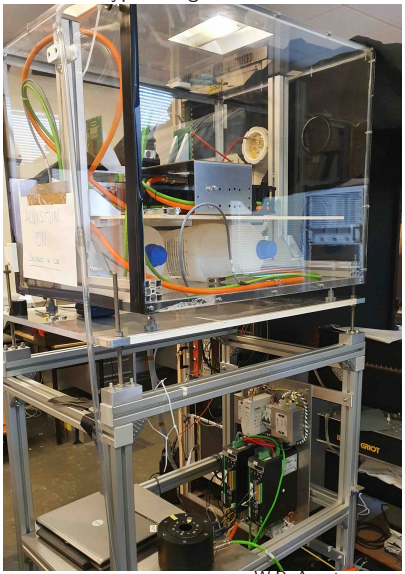
Isar Mostafanezhad	Lead
Ryan Pang	Board design
Luca Macchiarulo	Firmware
and others.	

Nalu is developing ASOC (waveform digitizer) based readout board.
Trade study report expected late July.

ATOF Readout Electronics meeting every 2 weeks on Friday.

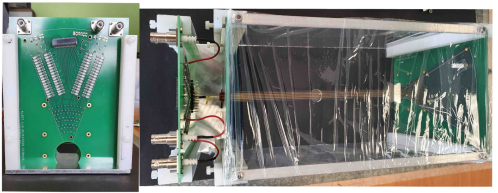
ALERT at ALTO Beam Test

HDC Prototype and gas box:

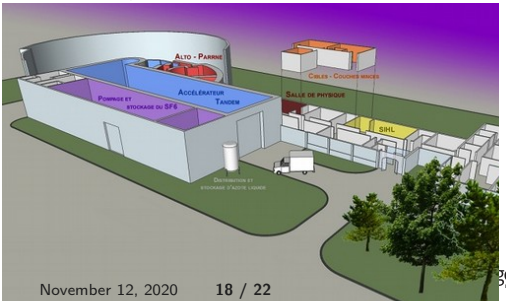


W.R. Armstrong

Prototype 3

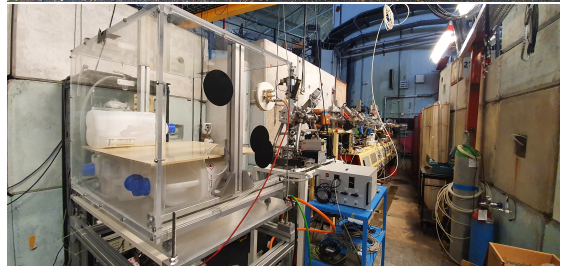


ALTO at Orsay:



AHDC at ALTO Beam Test

- Will run with alpha, proton and deuteron (time permitting).
- Energies will be the same as those targeted for experiment.
- Trigger will be external silicon detector or the accelerator RF signal.
- Will study the efficiency, position/time resolutions, and energy loss.
- Beam test starts next week – scheduled for two weeks running 18 hour days.



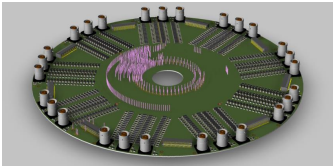
ALERT Status and Plans

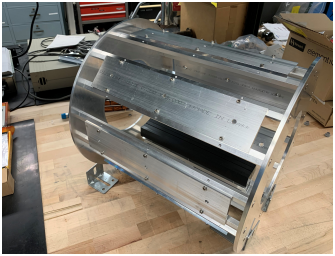
- Prototype tests underway.
- Future tests include:
  → High field facility tests
  → In-beam prototype tests at ALTO
- Working closely with **Hall B Task Force** to prepare for experiment
- Followup to Nov. 2019 ERR expected early spring 2021
- Some delays due to COVID19
- Detailed project schedule and plans. (not yet considered for beam time scheduling)

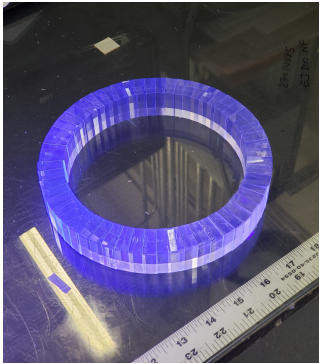
- Significant progress on hardware and software fronts

Summary

- Physics of ALERT is a comprehensive program to study nuclear effects
- ALERT design and construction is steadily progressing.





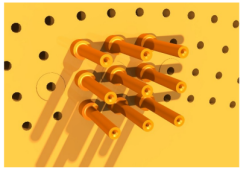


Thank you!

backup

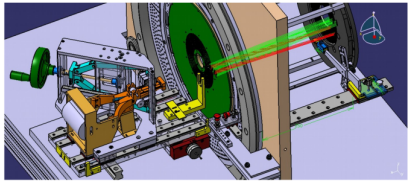
HDC Wire Tooling

Attaching the wires

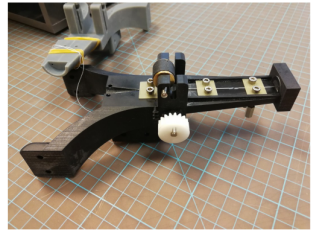


Wires are crimped to the PCB via feedthroughs

Crimping thanks to specific tooling



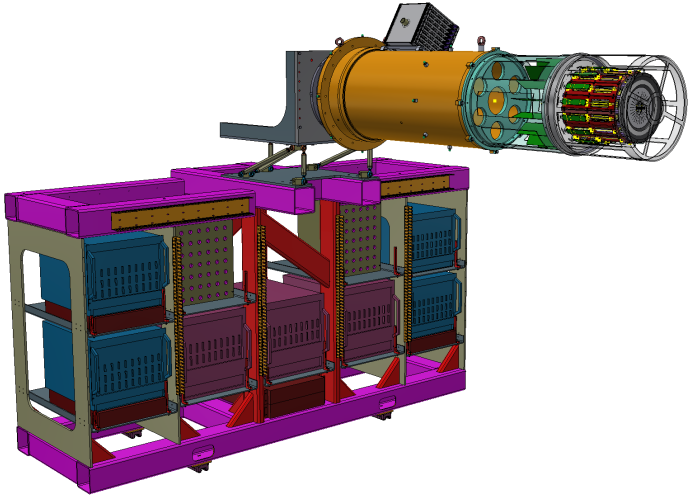
General view of wire insertion and crimping tooling



Some of the elements have already been successfully tested

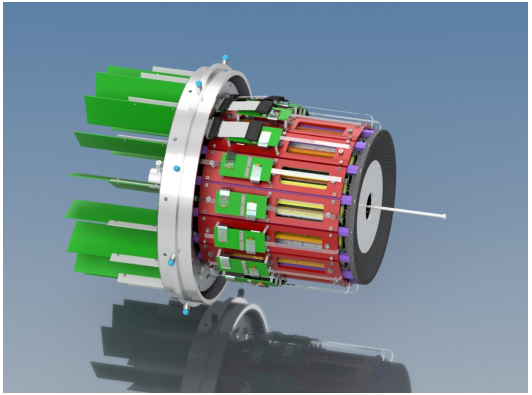
Courtesy Gabriel Charles

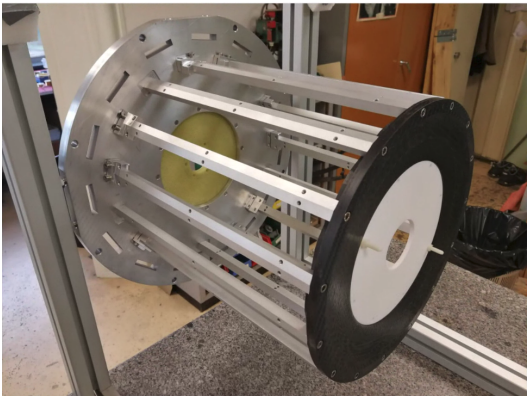
ALERT Cart



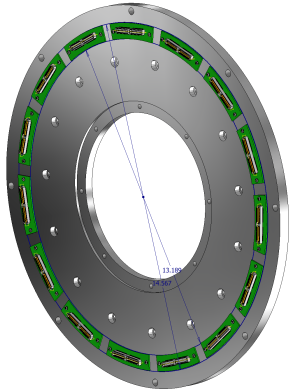
Courtesy Tom O'Connor

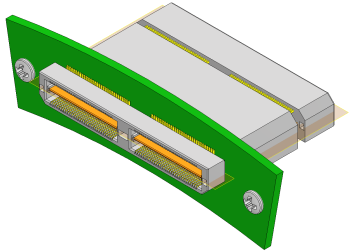
ALERT Support Structure



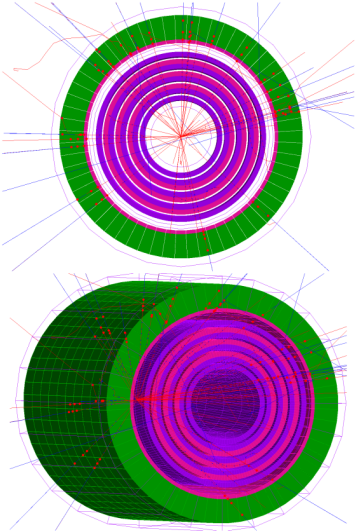


Upstream Plate





ALERT Simulation



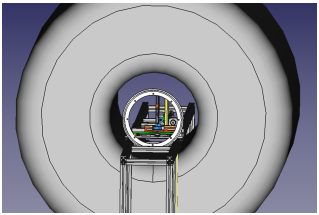
ATOF in green & magenta; AHDC in purple & red. *GEMC* geometry.

Argonne High Field Test Facility

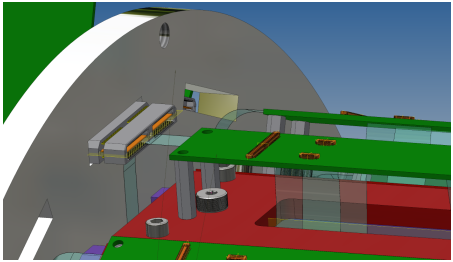
Maximum Field	4 T
Bore diameter	
with gradient coils	68 cm
w/o gradient coils	90 cm
Homogeneity	10^{-5}
Removable rails	

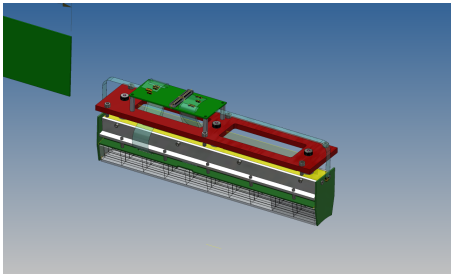
In field tests:

1. ATOF readout electronics – test component magnetics.
2. HDC prototype – wire forces
3. Full ALERT detector



ATOF Readout Module Boards





- Upstream plate feed-through connector design
- Rigid-flex PCB will connect SiPMs to upstream readout electronics
- Interchangeable readout modules (Petiroc2A and Nalu's ASOC) connect to JLab's SSP concentrator.