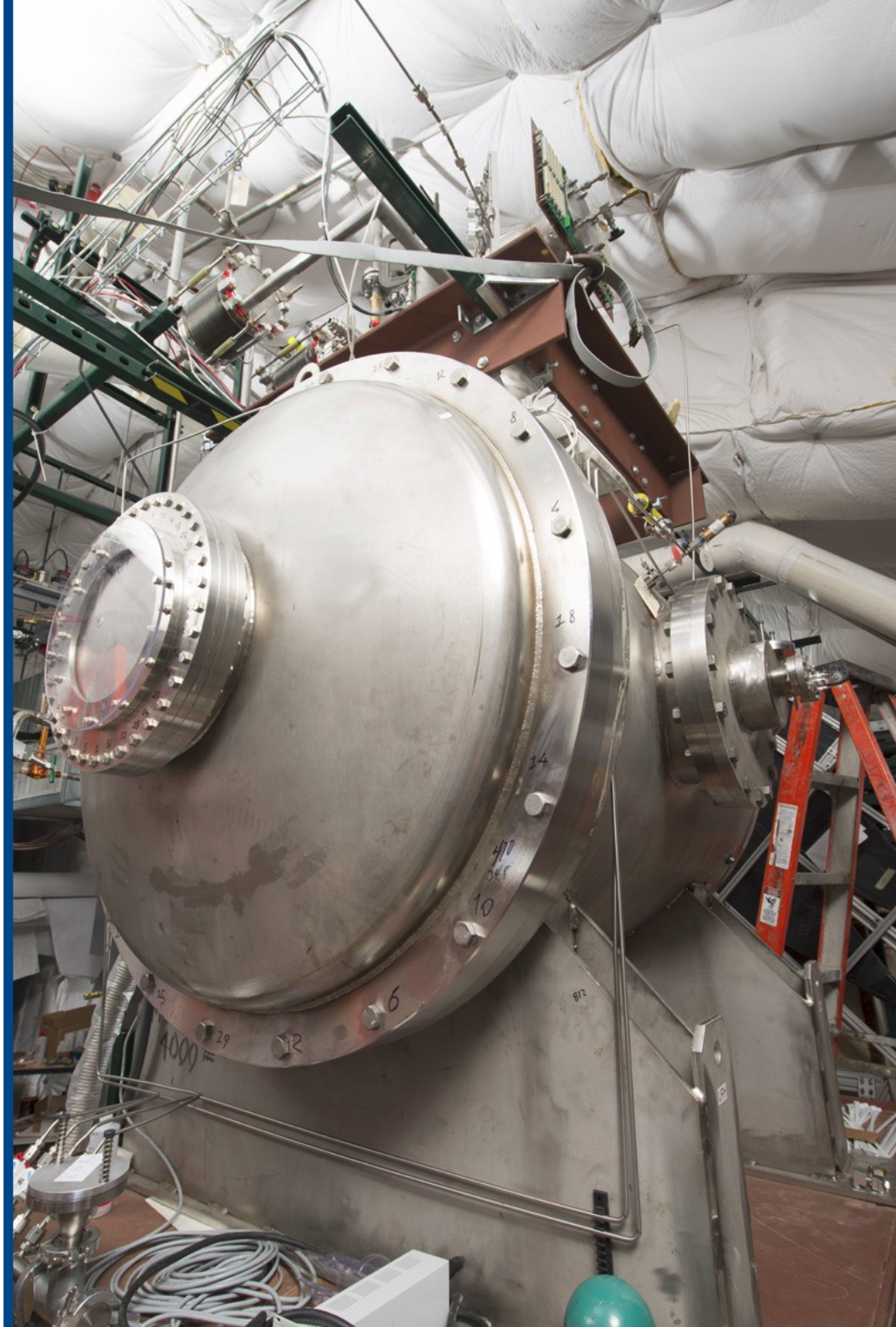
FERMILAB-SLIDES-18-073-PPD

# LArIAT In 10 Minutes

## New Perspectives 2018

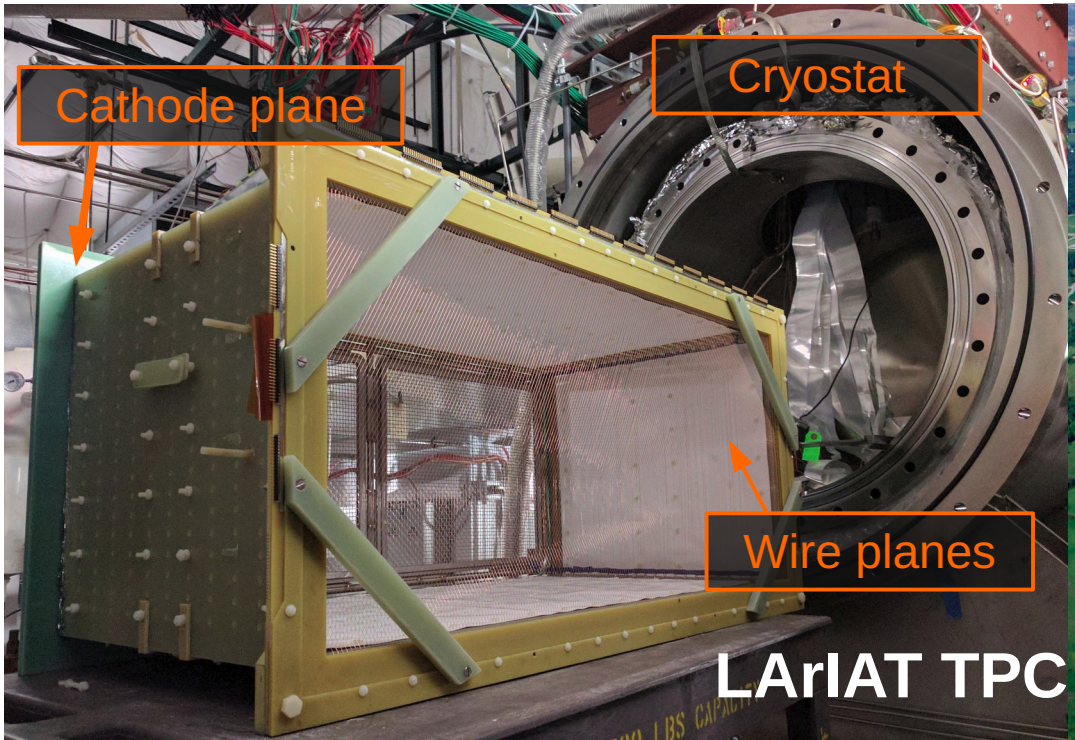
Hunter Sullivan
University of Texas at Arlington
On behalf of the LArIAT Collaboration at Fermilab

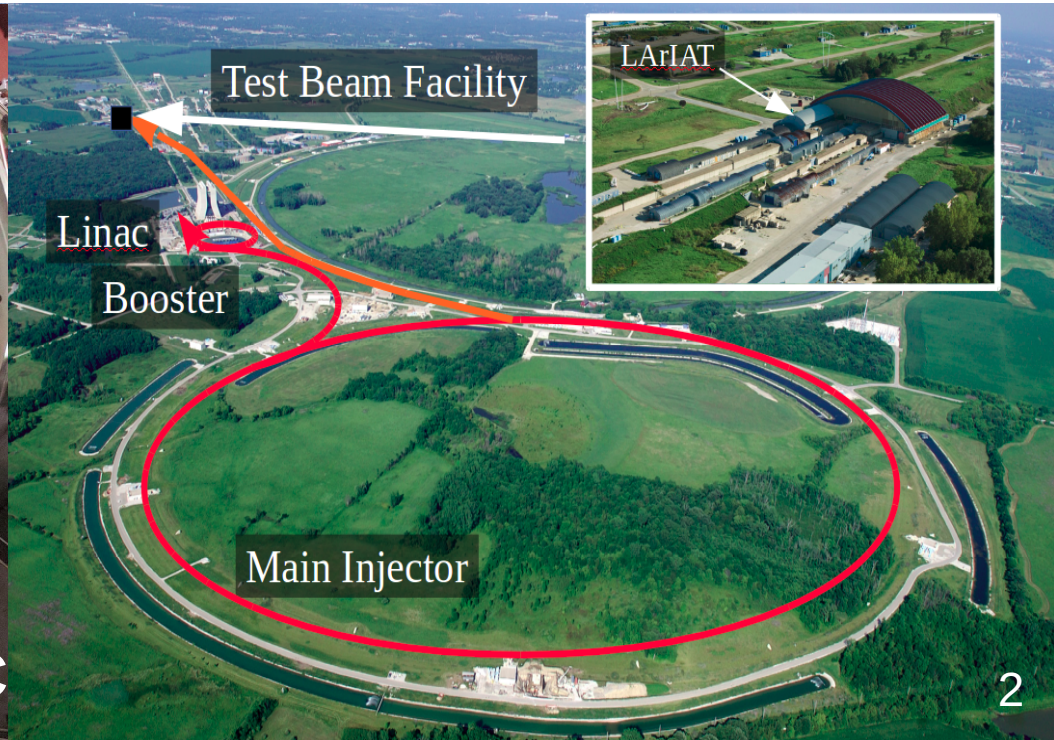


This document was prepared by [LArIAT Collaboration] using the resources of the Fermi National Accelerator Laboratory (Fermilab), a U.S. Department of Energy, Office of Science, HEP User Facility. Fermilab is managed by Fermi Research Alliance, LLC (FRA), acting under Contract No. DE-AC02-07CH11359.

# What is LArIAT?

- **LArIAT (Liquid Argon In A Test beam) is a 170-liter-active-volume TPC exposed to a charged particle beam**
  - Auxiliary detectors to tag particle species and incident momenta
- **The LArIAT program aims to characterize LArTPC response for particles and energy ranges relevant for DUNE**
  - Pions, Kaons, Muons, Electrons, Protons

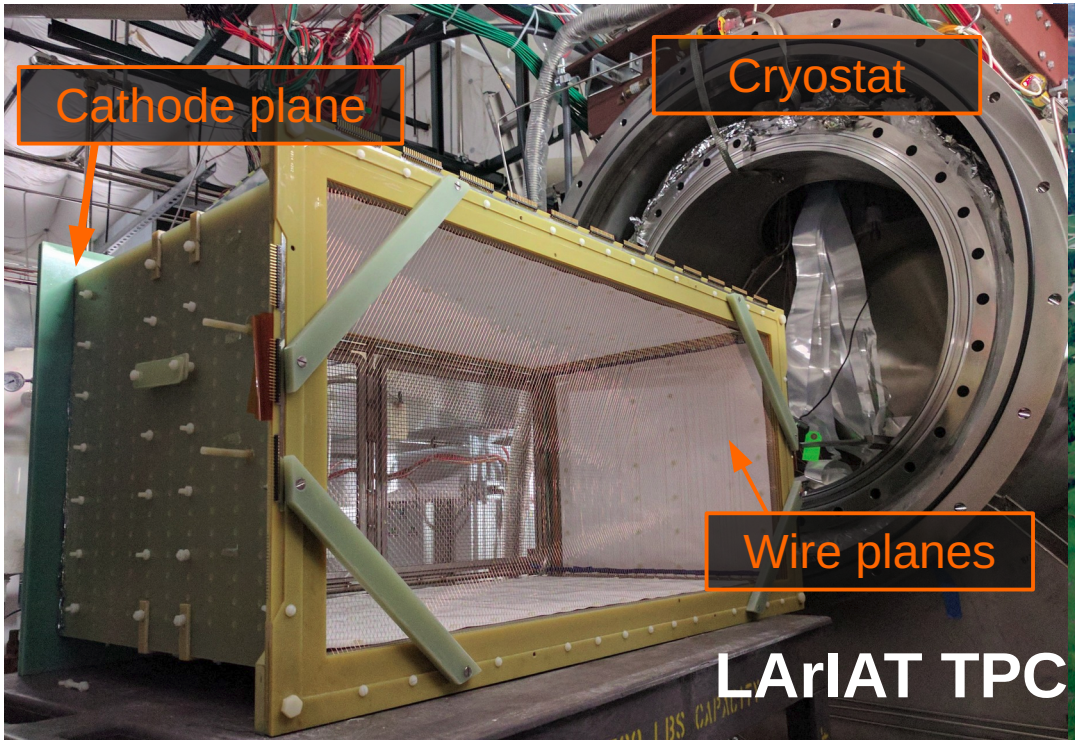


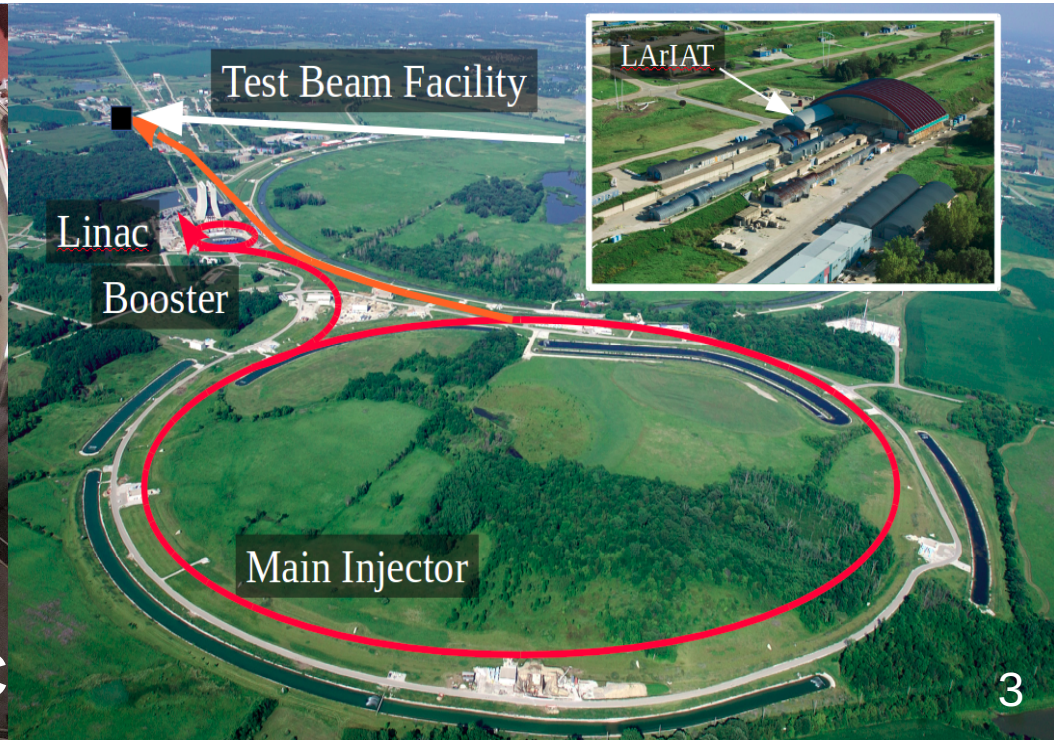



# What is LArIAT?

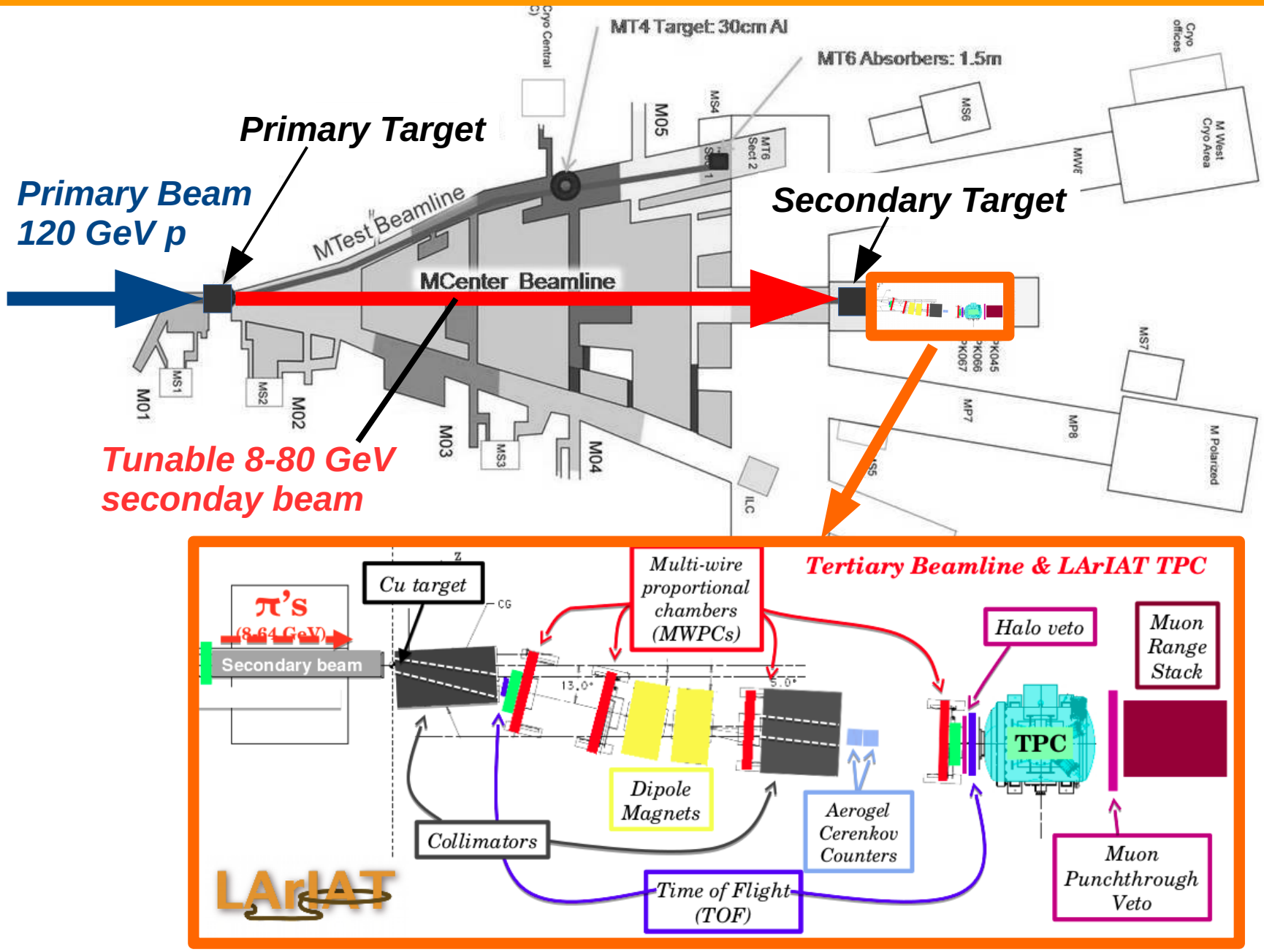
- **LArIAT (Liquid Argon In A Test beam) is a 170-liter-active-volume TPC exposed to a charged particle beam**
  - Auxiliary detectors to tag particle species and incident momenta
- **The LArIAT program aims to characterize LArTPC response for particles and energy ranges relevant for DUNE**
  - Pions, Kaons, Muons, Electrons, Protons

Ideal environment for validating reconstruction and PID alogithms, and testing new detector technologies!

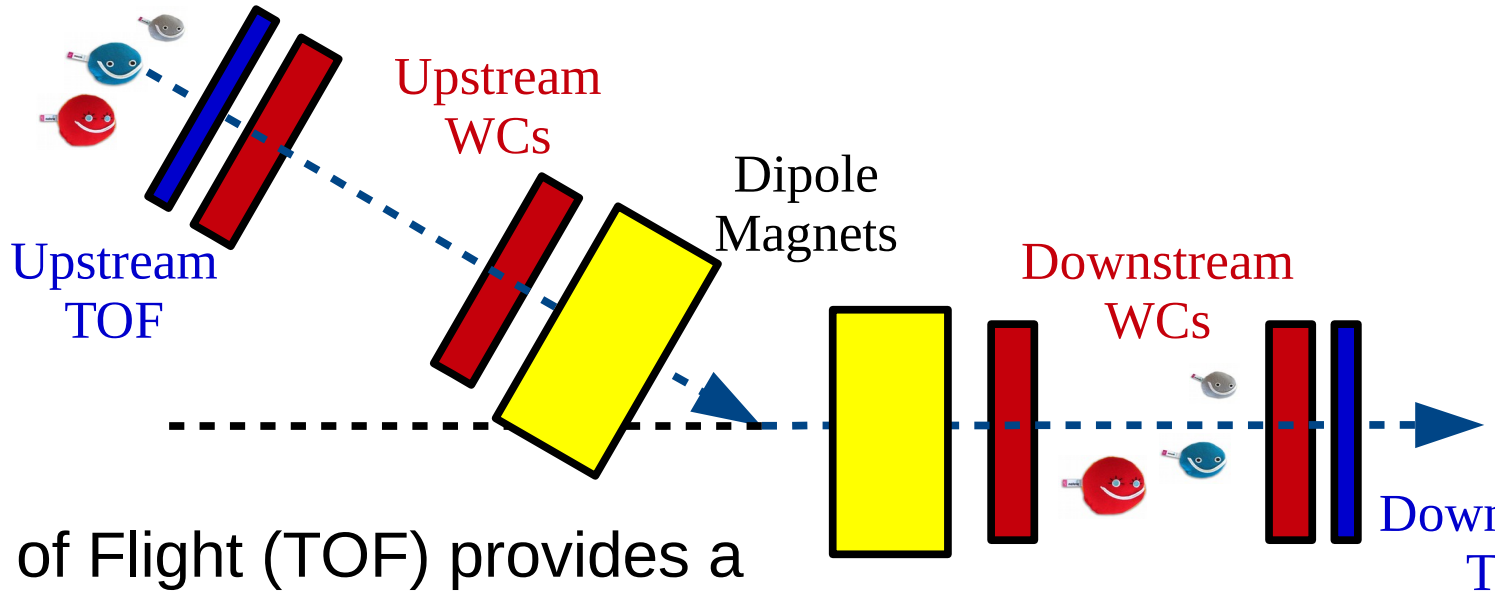


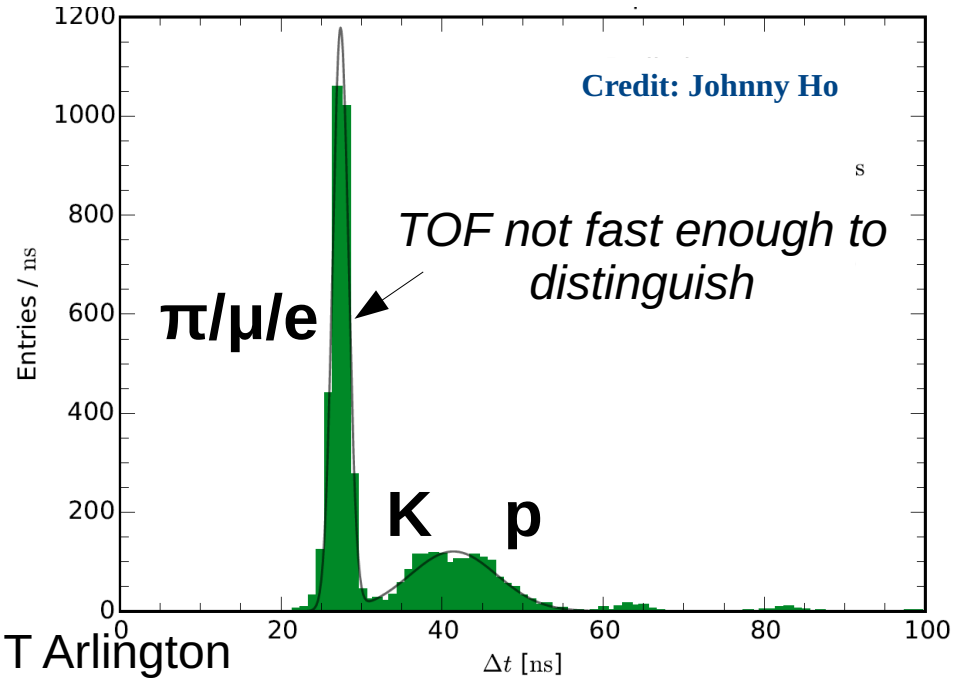
# Beamline at FTBF



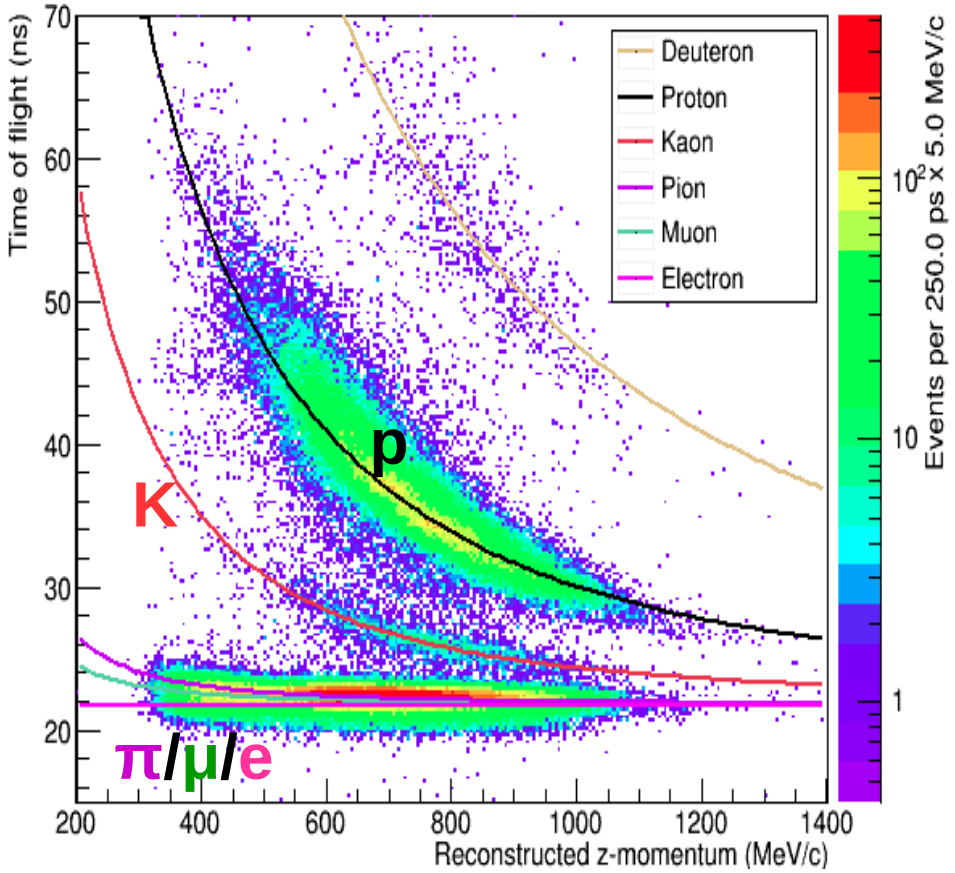
# PID: Wire Chambers and TOF

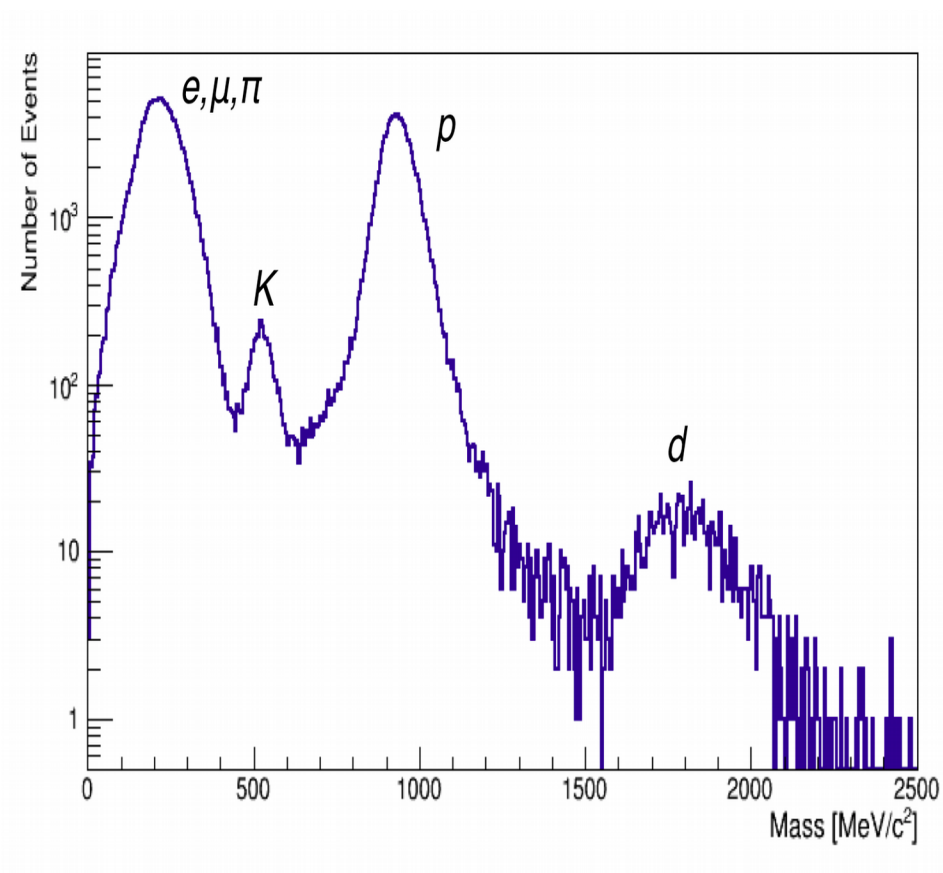



- Time of Flight (TOF) provides a clock
- Signals from pair of wire chambers define particle trajectory before and after magnets
- Momentum is calculated using trajectories and magnetic field



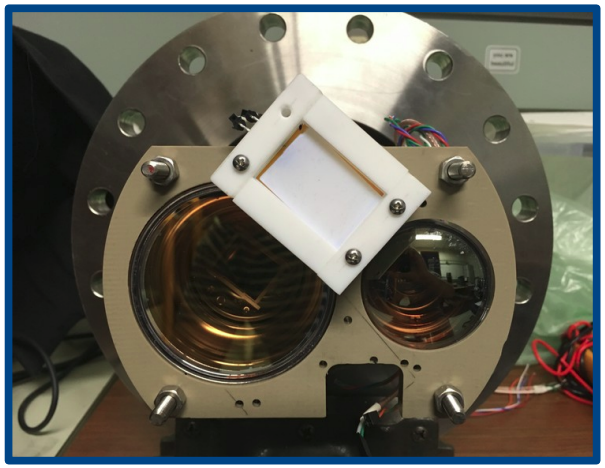
# PID: Wire Chambers and TOF

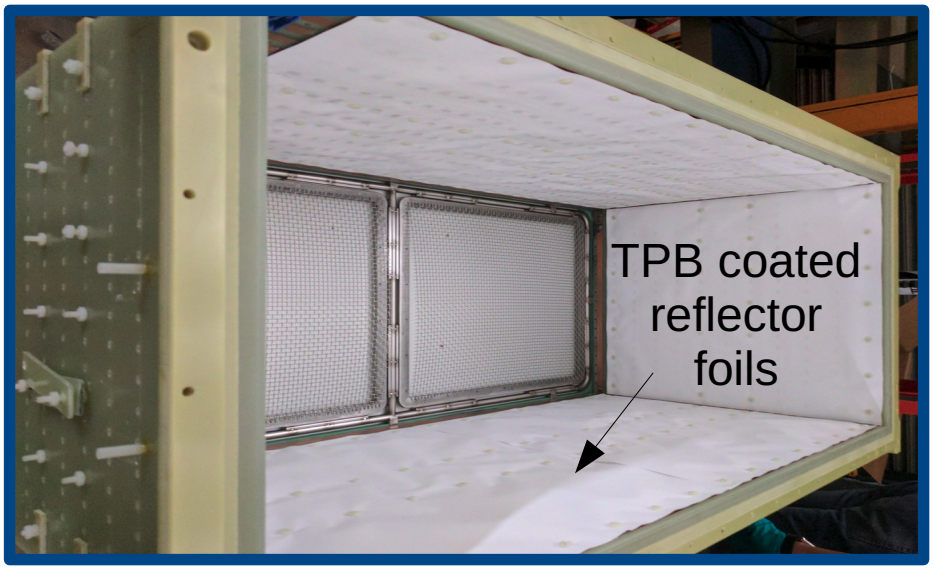


# Inside the Cryostat

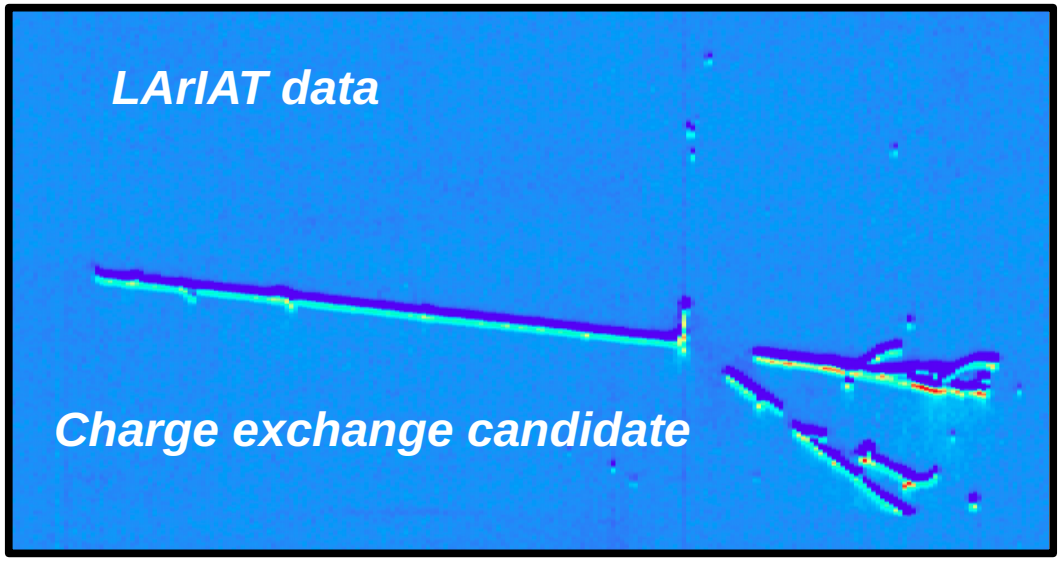
- **Pulse shaping and amplifying cold ASICs**
  - Run 2: ~70:1 S/N
- **Scintillation light readout**
  - PMTs/SiPMs
  - ARAPUCA light trap
- **Wavelength shifting reflector foils shifts scintillation light to visible**
  - Improved light yield and uniformity

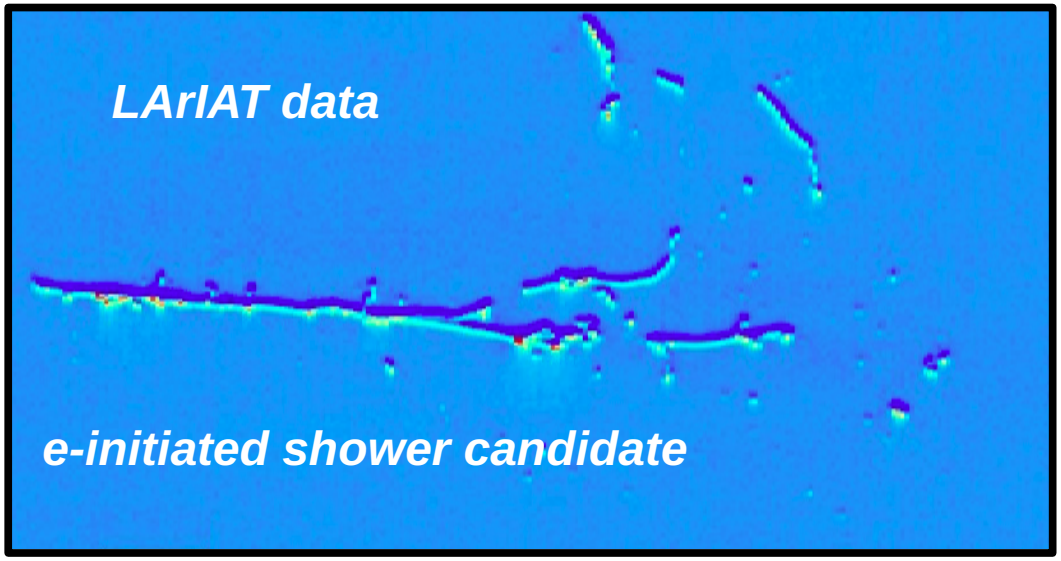




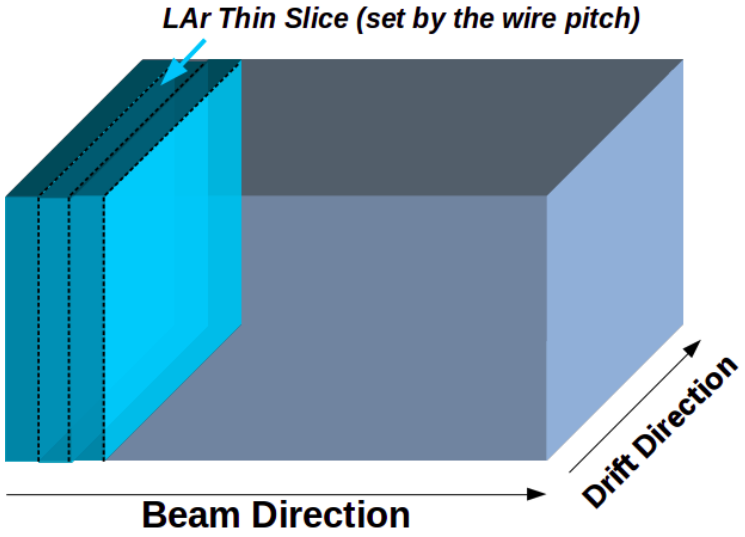
# LArIAT Physics Goals and R&D

- **Inclusive and exclusive hadron-argon cross sections**
  - Pion-Ar
  - Kaon-Ar
  - Proton-Ar
- **e/$\gamma$ shower identification**
- **Particle ID and reconstruction**
- **Ionization and scintillation light yield studies**



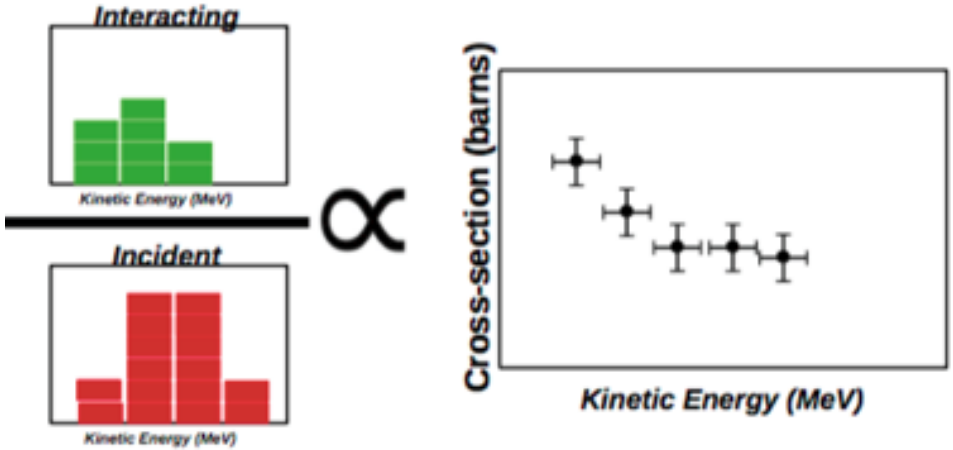



# Measuring the Cross-Section: Thin-Slab Method




$$P_{Survival} = e^{-\sigma_{TOT} n \delta X}$$

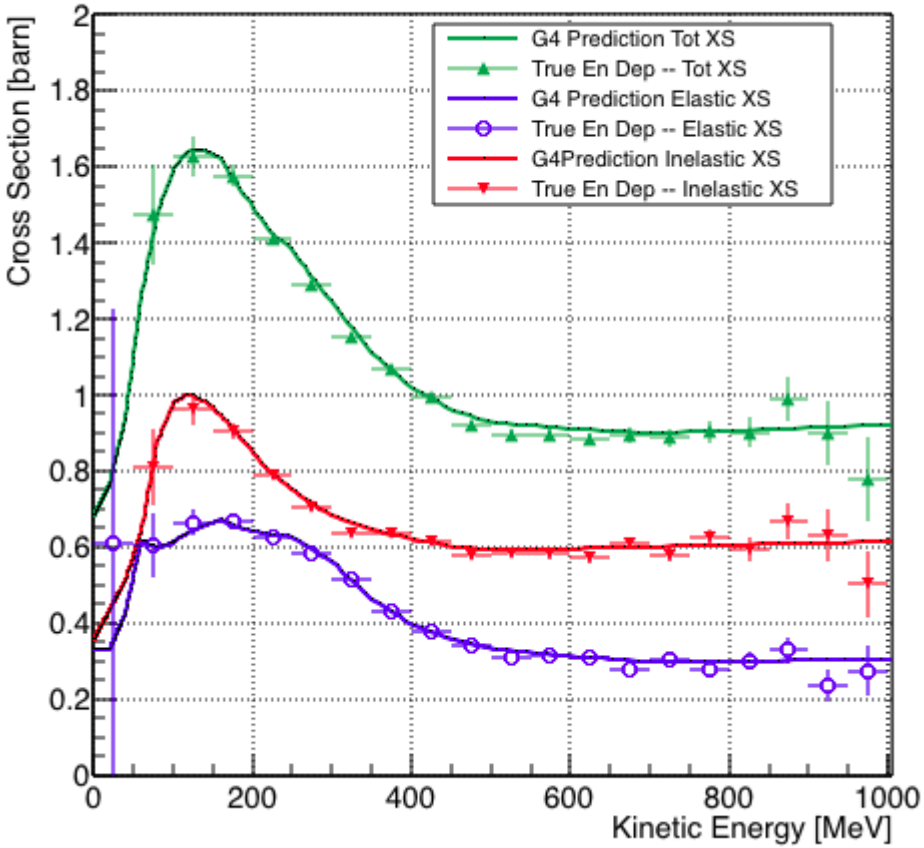
$$P_{Interacting} = \frac{N_{Interacting}}{N_{Incident}}$$



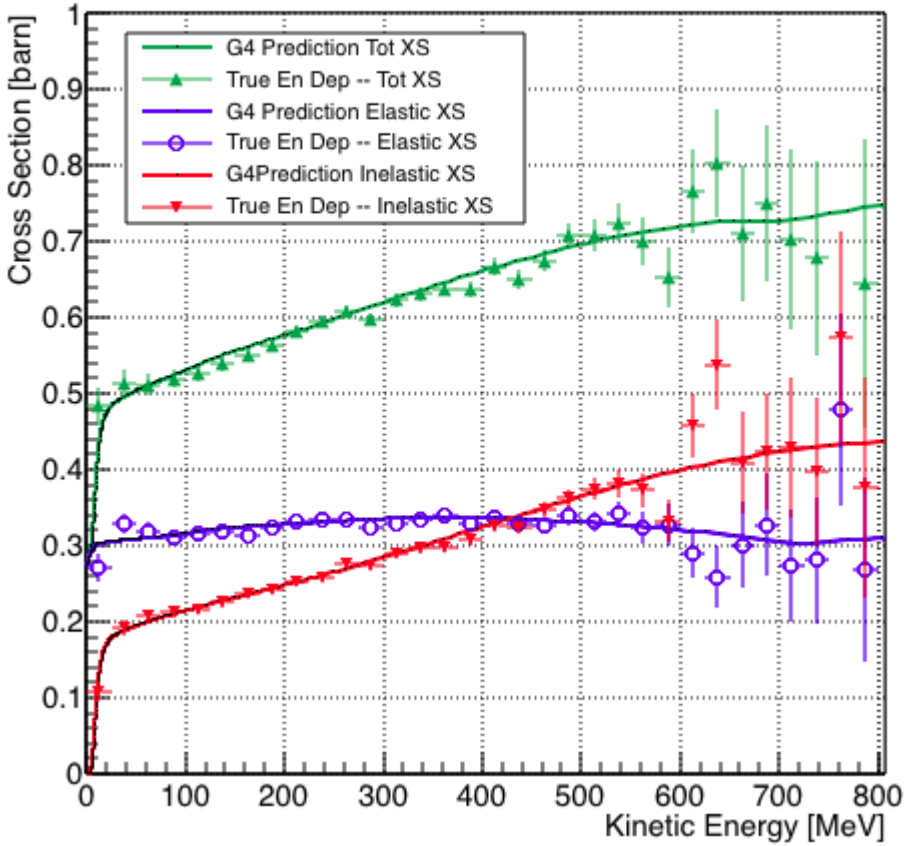

$$\sigma_{TOT} \approx \frac{1}{n\delta X} \frac{N_{interacting}(E_i)}{N_{incident}(E_i)}$$

# $\pi^-$—Ar and $K^+$—Ar Total Hadronic Cross Section

## $\pi^-$Ar Cross Section



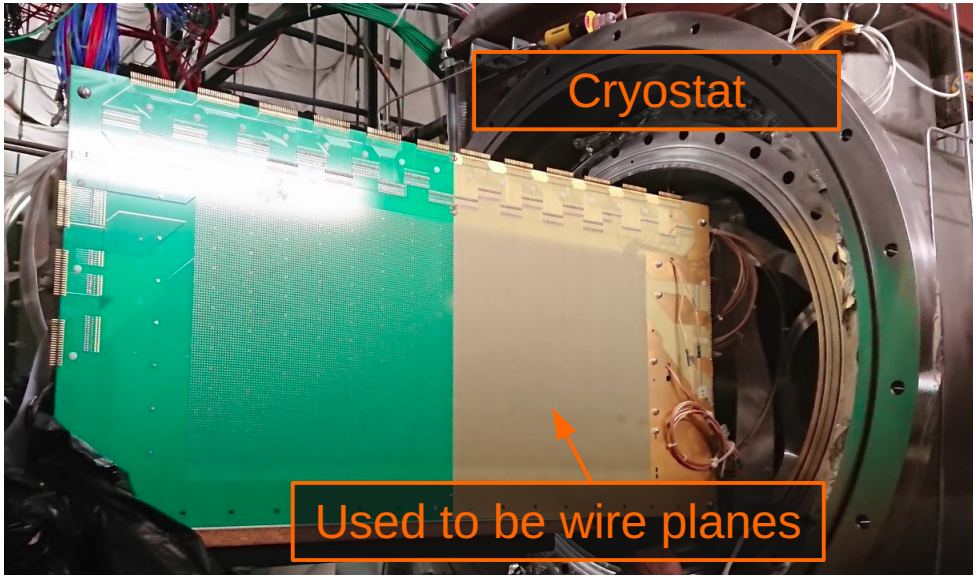

## $K^+$Ar Cross Section

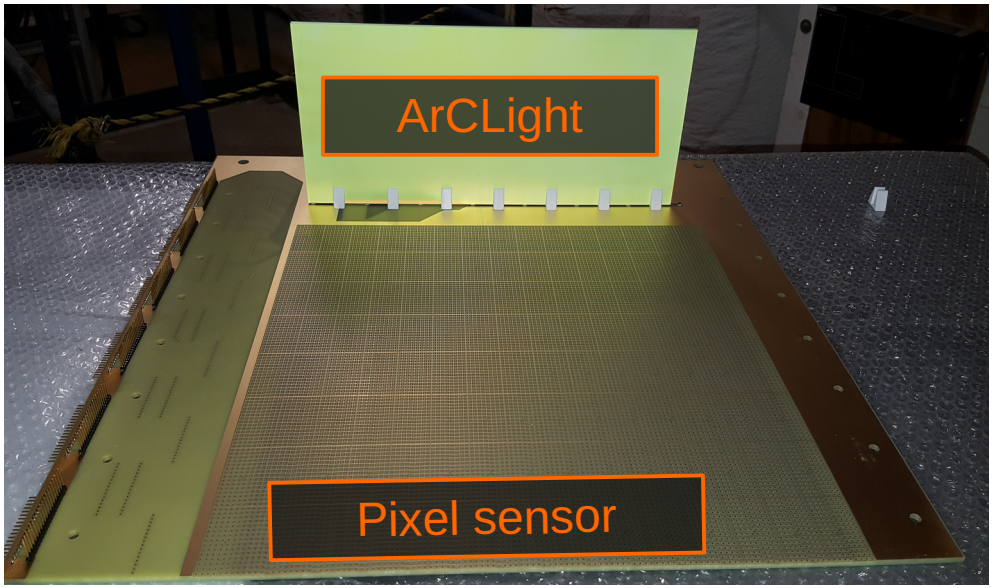



**Credit: Elena Gramellini**

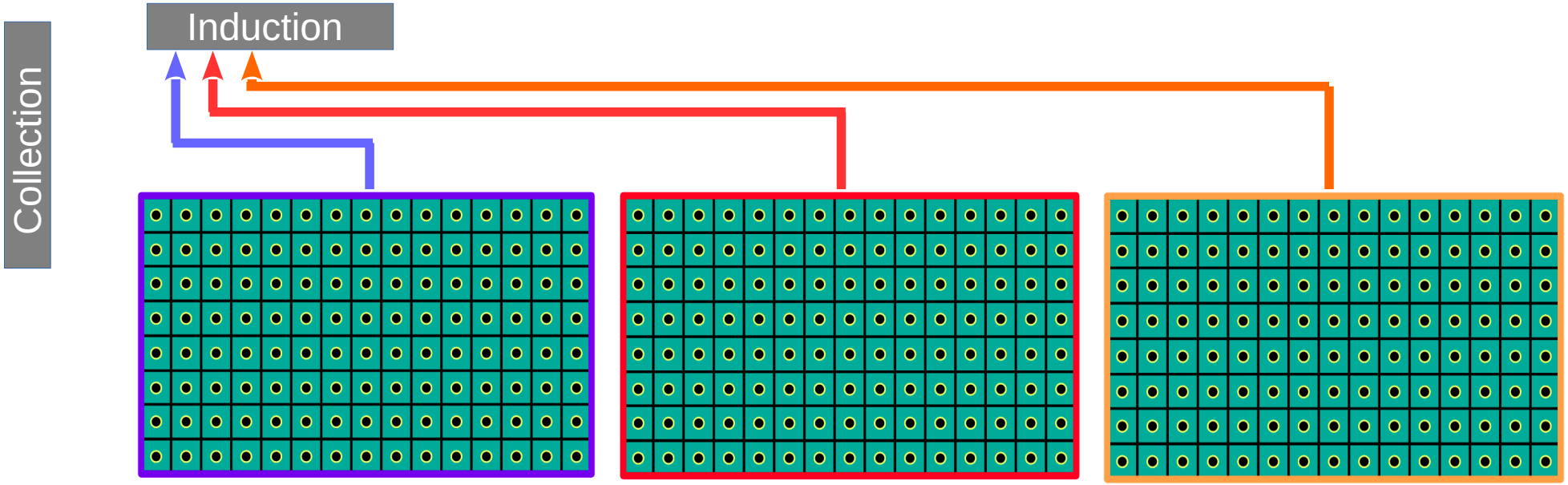
# PixLAr: Pixelated Liquid Argon

- **Replaced wire planes with pixel PCB**
  - Based on the option being considered for DUNE ND
  - 72 $cm^2$ active pixel area
  - Total number of pixels: 28,800
- **Had to make use of analog multiplexing scheme to accommodate existing cold electronics (480 channels)**
  - Dedicated cold electronics currently in development
- **ArCLight Detector (Developed by Bern)**
  - Similar to ARAPUCA light trap, but uses WLS plastic
- **Main goals of PixLAr**
  - Feasibility of pixelated LArTPC
  - Use test beam to develop tools and perform physics measurements

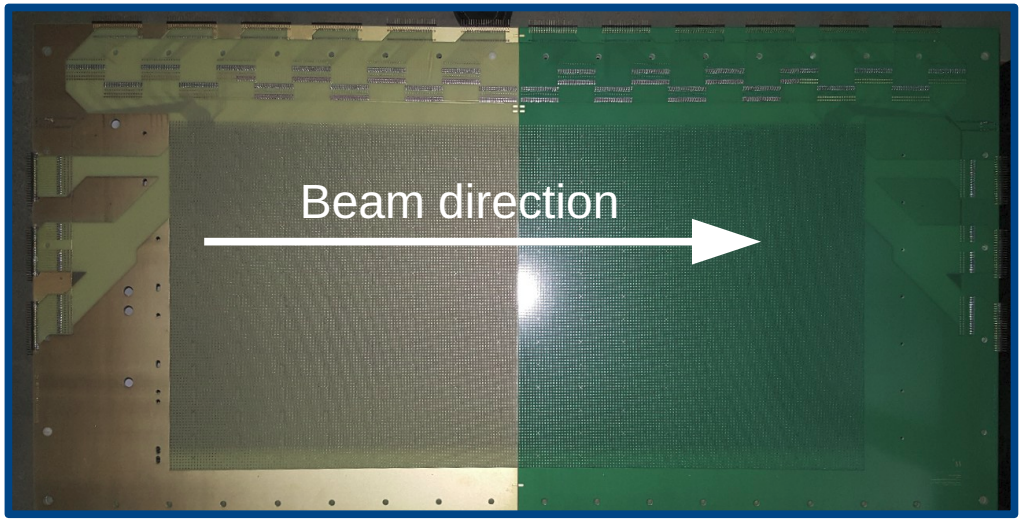


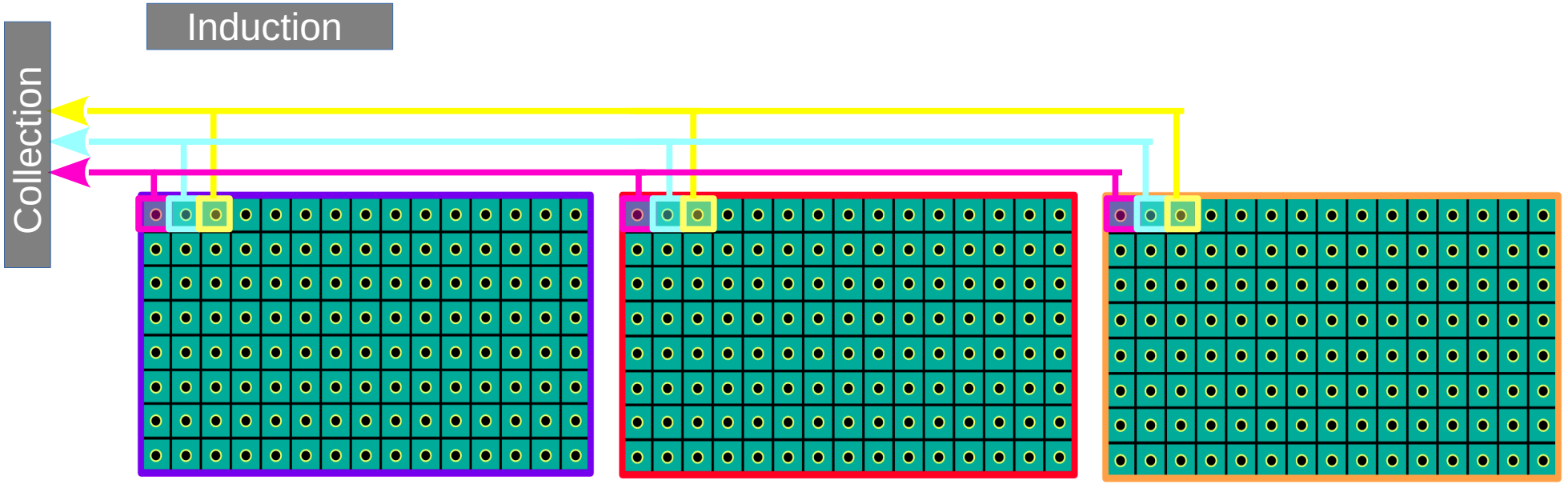
# PixLAr: The Pixel Plane




- **Broken into two halves**
- **Pixels are grouped into 8x15 arrays called Regions Of Interest (ROI) outlined by conductive traces**
  - Each ROI is mapped to an individual readout channel
- **Each PCB contains 120 ROI**



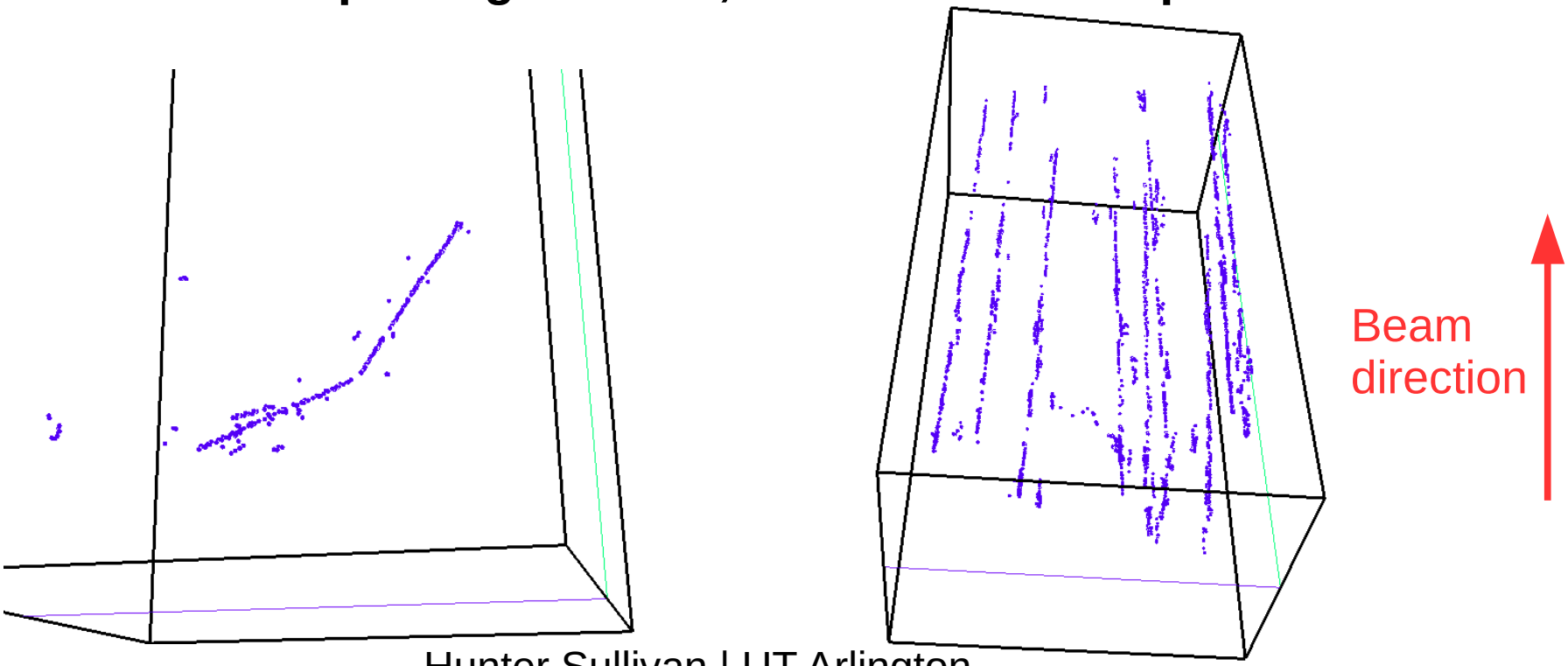
# PixLAr: The Pixel Plane




- **Each pixel from each ROI is mapped to the same readout channel**
- **Each ROI contains 120 pixels**
  - 120 ROI * 2 PCBs * 120 pixels/ROI/PCB = 28,800 pixels

# PixLAr: Reconstruction

- **A match is made when a pixel pulse and ROI pulse overlap in time which gives direct access to 3D space points**
  - Track fitting and calorimetry are in development
- **Ambiguities still arise but are much easier to handle**
- **Even with multiplexing scheme, can resolve multiple tracks**



# Conclusion

- **LArIAT is devoted to the precise characterization and calibration of LArTPCs**
  - Optimizing charged particle reconstruction and ID
  - Testing new technologies
- **Valuable input for short and long baseline experiments**
  - Inclusive hadron-argon cross-section measurements
- **Coming soon**
  - Exclusive channels
  - Light collection/shower separation studies

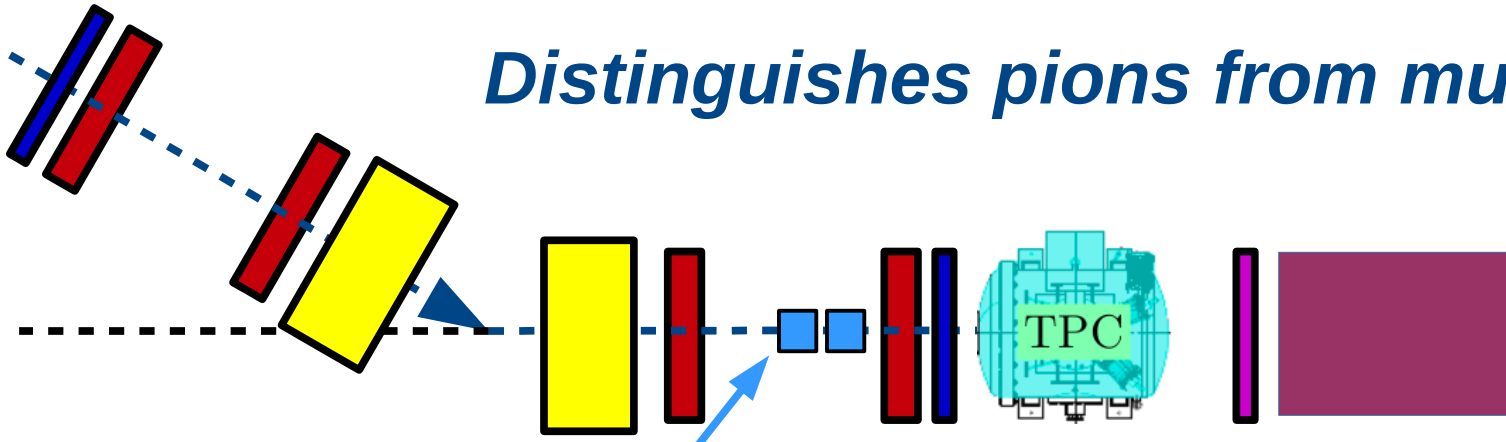
Stay tuned!

# Thank you!

# Backup slides

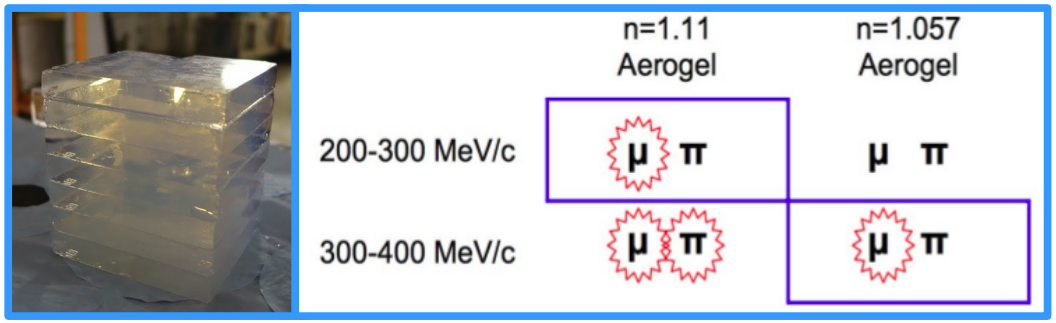
# PID: Aerogel Cherenkov Counters and MURS

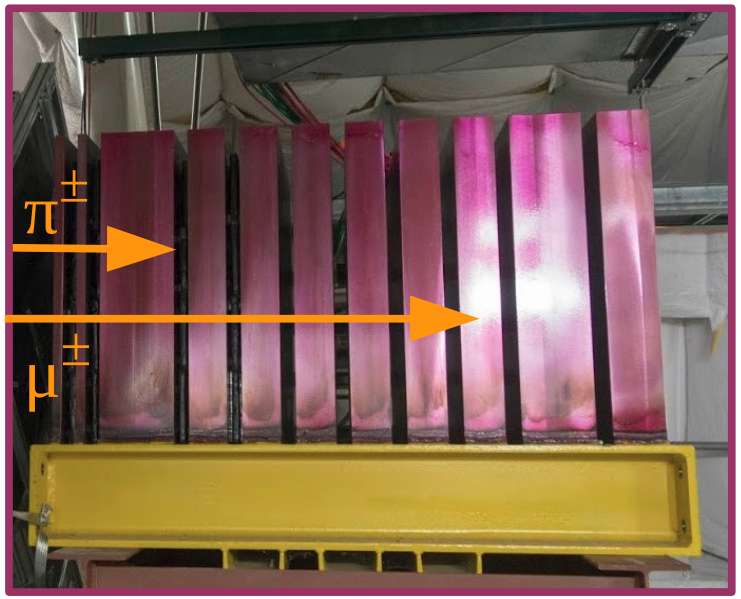
***Distinguishes pions from muons***




Aerogel Cherenkov Counters

Muon Range Stack (MURS)




- **Pions and muons produce Cherenkov light differently for certain momenta ranges**
- **Muons will penetrate further into the range stack**

# ArCLight

- Inspired by ARAPUCA
- Inner cavity filled with polymer sheet doped with WLS dye (long attenuation length)
- Low volume, several square meter coverage