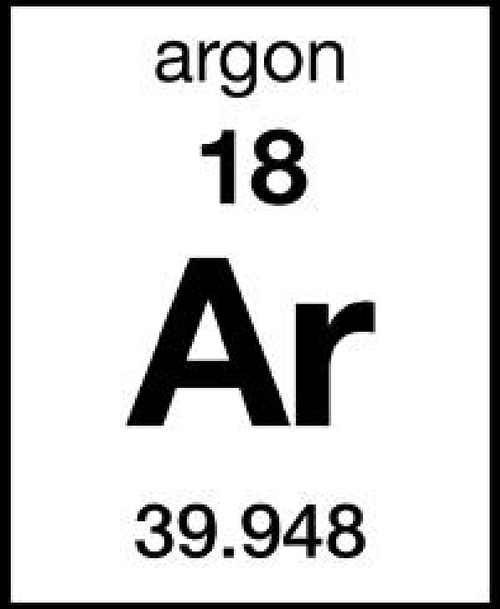
LArIAT



Liquid Argon In A Testbeam

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University of Cincinnati

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Why Put LArTPCs in a Testbeam?

A whole generation of Liquid Argon particle detectors is coming.

We want to know as well as possible their Energy Resolution and Particle ID Capabilities.

What else can be done with them? (Wire plane geometries, LAr doping, field geometries, etc…)

Work already done:

- WARP 50L Teststand
- ICARUS 3ton & T600 with cosmics
- T32 250L in JPARC charged beam

Outline

Science Goals

The Device

The Beam

Present State and Schedule

Science Goals

Phase I: Modified ArgoNeut detector

Single-Track calibrations (recombination/charge-energy calibration)

e/gamma shower discrimination

Particle ID optimization

Charge-sign determination without magnetic field

Phase II: Larger-Volume TPC (TBD)

Collective topology reconstruction (detected/incident energy calibration)

EM & Hadronic shower characterization

LarTPC R&D

Single-Track Calibrations

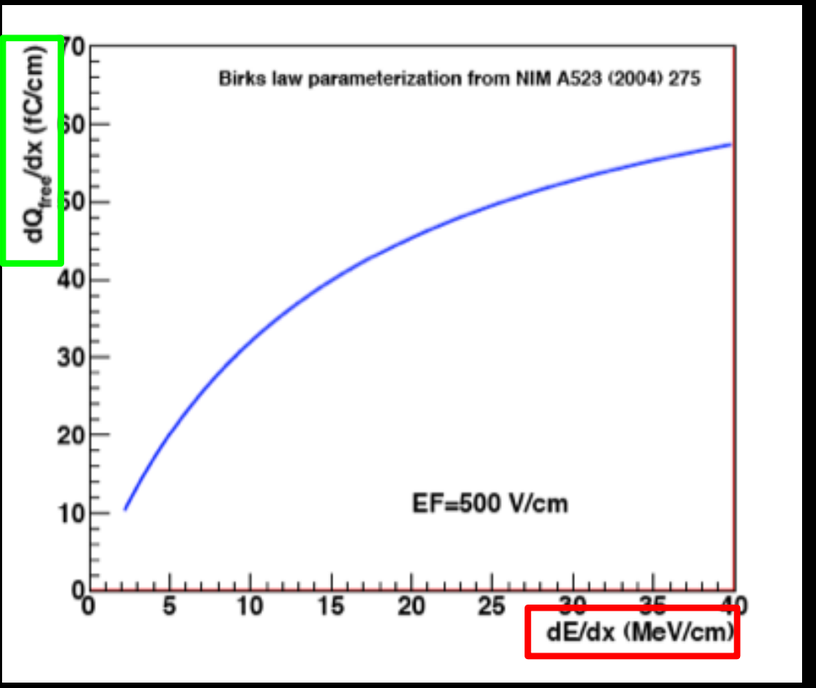
Ionization yield : deposited energy ratio

Birks parameterization well-validated below

15 MeV/cm. ICARUS data above 15-20 MeV/cm cosmic ray data sparse and stat limited.

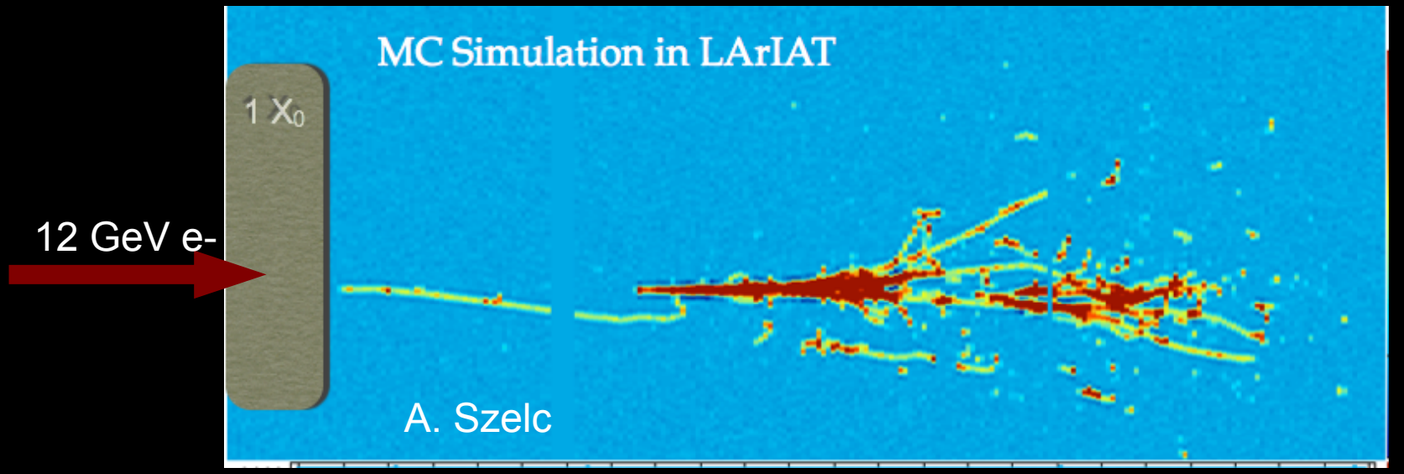
Stopping particles up to ~400 MeV for:

- Extended energy deposition range (dE/dx)
- Different E field values (~0.3 – 1.0 kV/cm)
- Different track-to-field angles

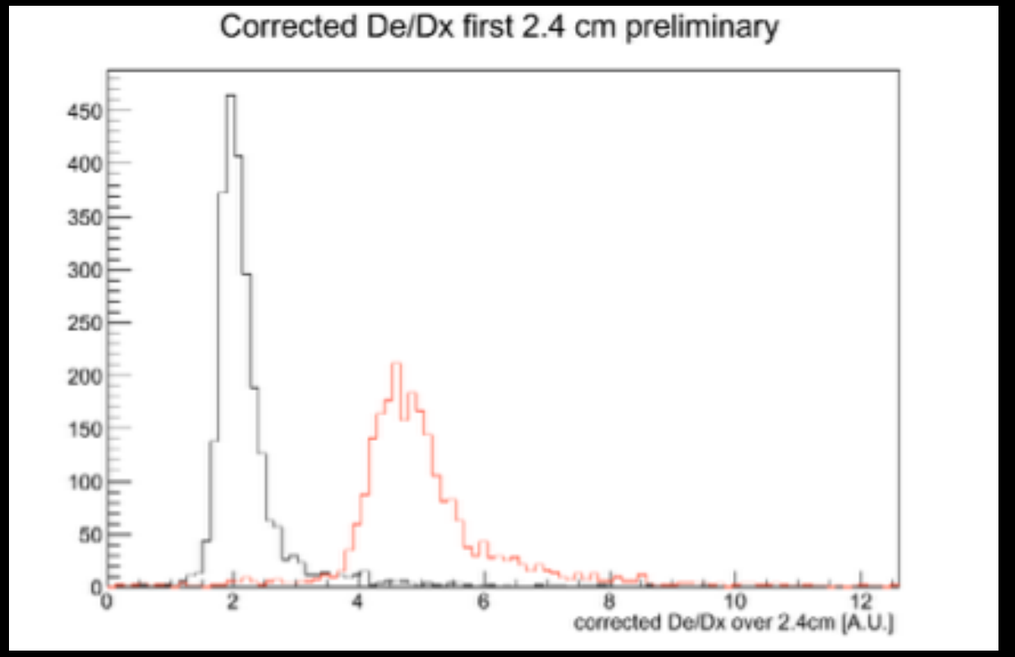


e/gamma Discrimination

Initial track of shower either singly ionizing (e-) or doubly (gamma → e+e-) ionizing.



Separation efficiency & sample purity in LarTPC will be experimentally measured with large statistics.



Optimization of PID Methods

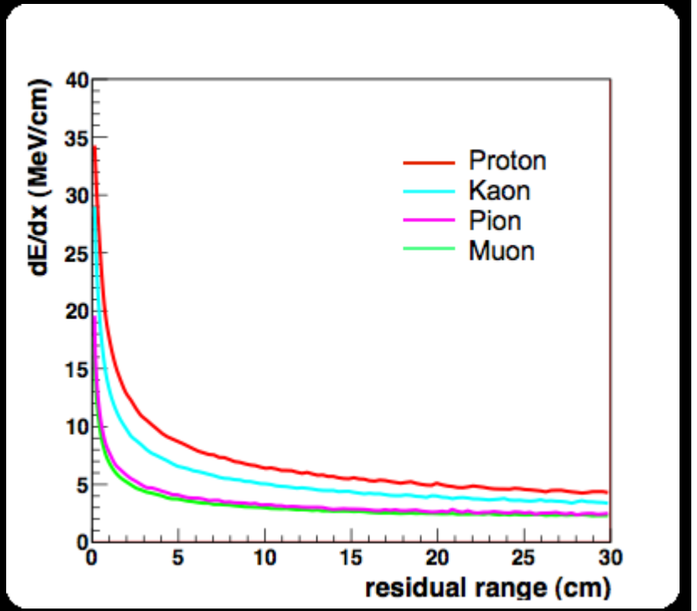
Single-track calibration + 3D imaging

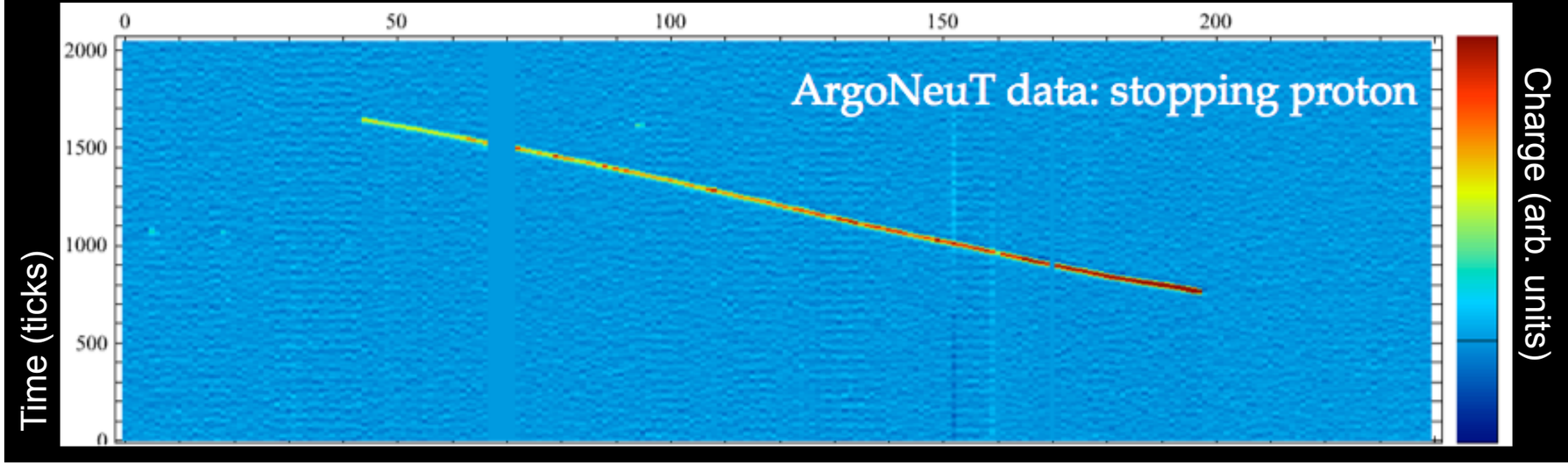
→ dE/dx vs. residual range

High-stats data experimentally determine:

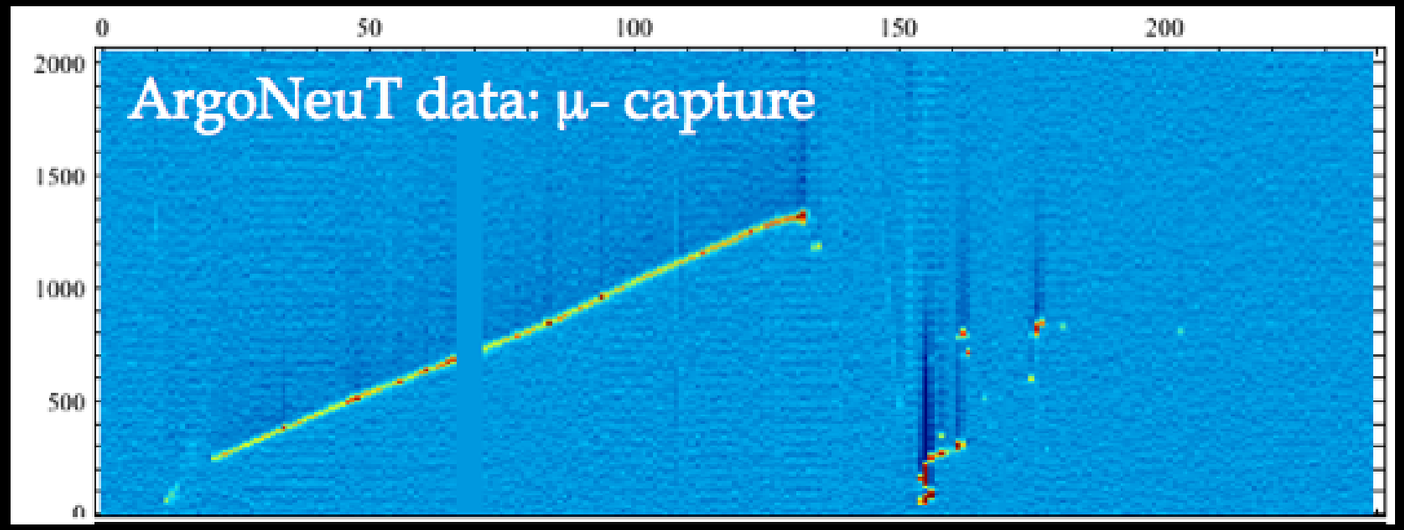
- Proton ID, Kaon ID

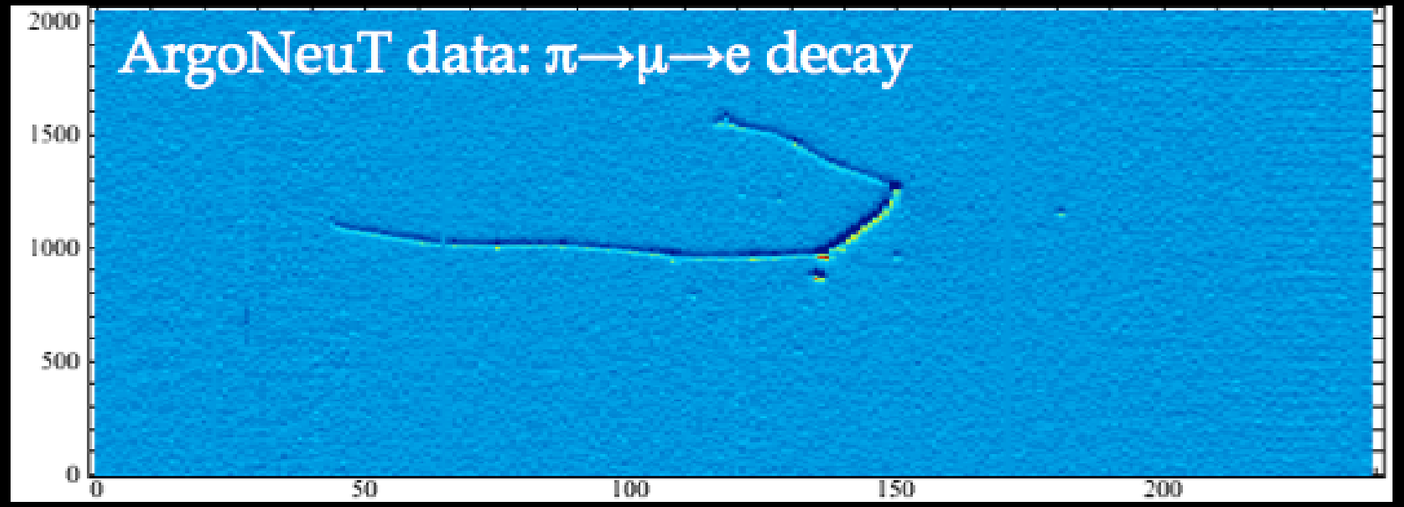
- p/K & π/μ separation efficiency & selection purity





Magnet-Free Charge-Sign Determination





μ+ only decay in matter

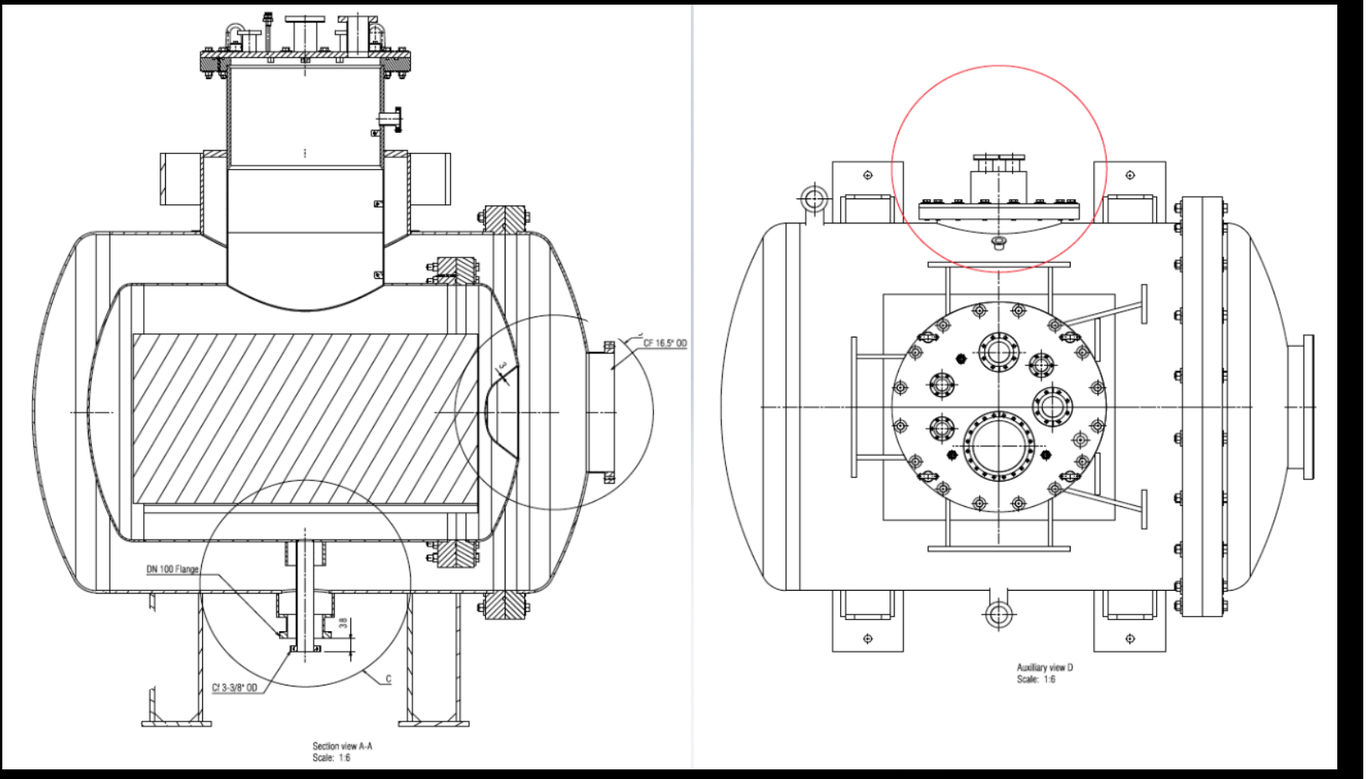
μ- undergo nuclear capture followed by gamma or n emmission (75%) or decay.

Statistical study of capture on pre-determined sign in Ar and sign-selection capabilities have not been explored before.

The Device: Phase I

The ArgoNeut LArTPC with 3 modifications:

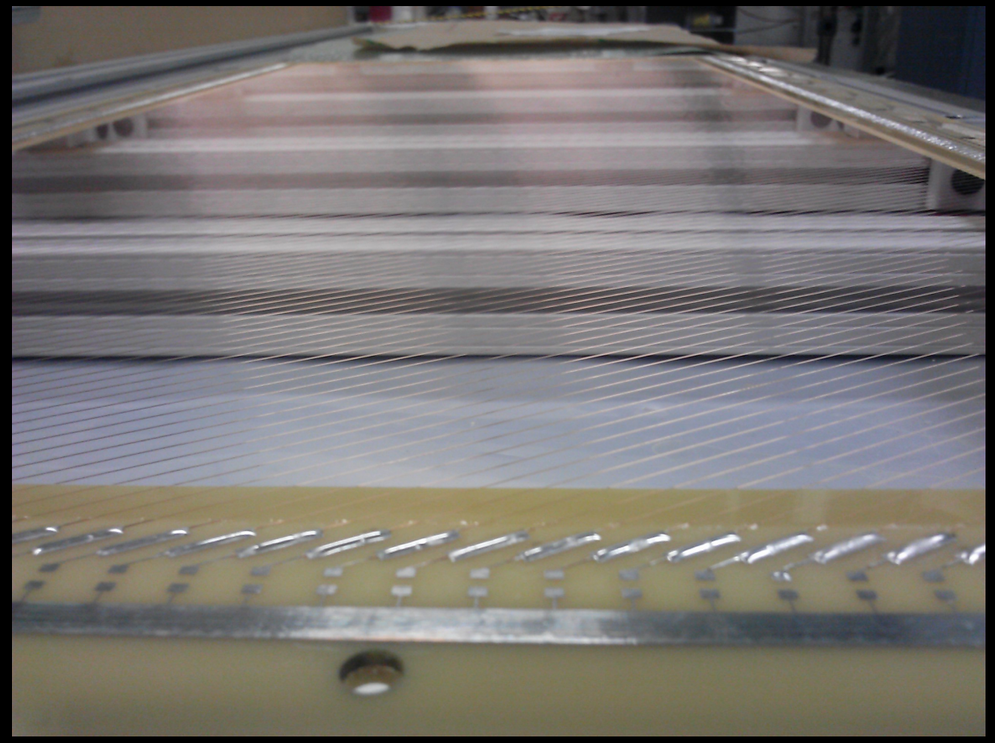
- Bottom port for LAr circulation
- Side ports for light detection
  - 2 PMTs
  - 2 SiPMs
- Ti front window for admitting charged beam*

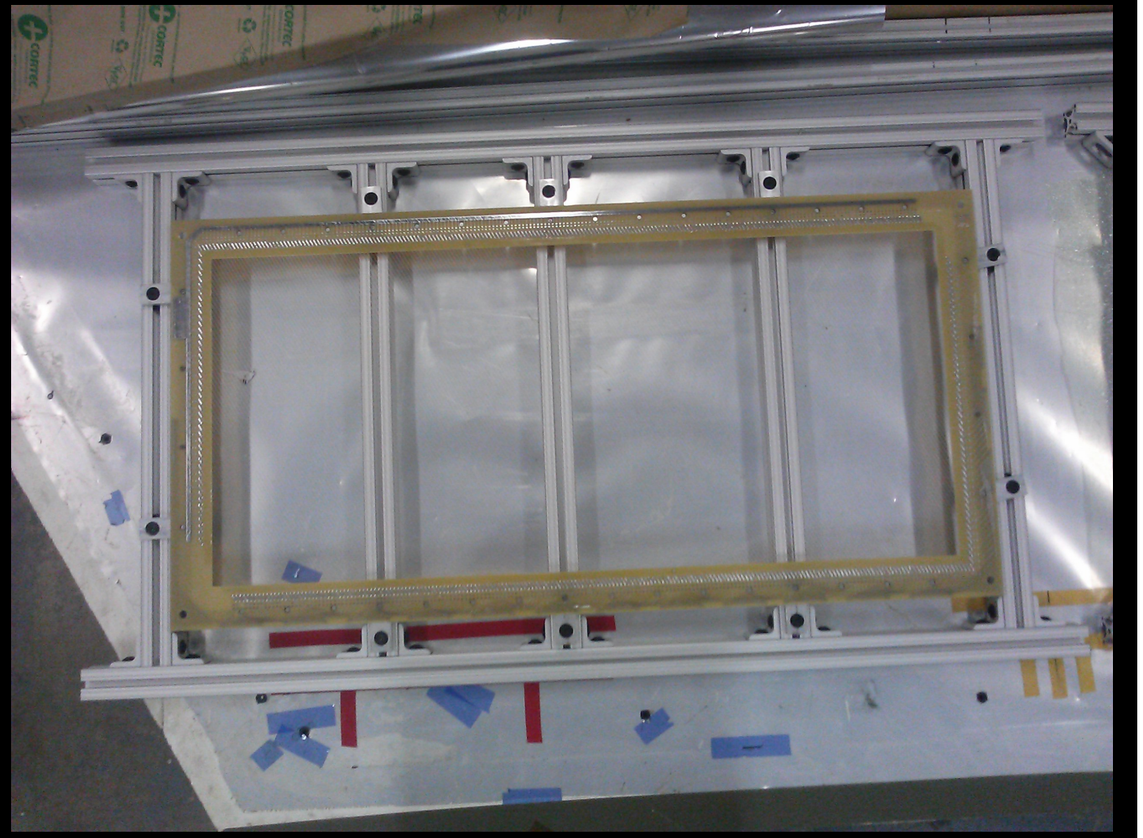


Present State: Preparing Cryostat & TPC

Modified ArgoNeut vacuum-walled cryostat

New wire planes





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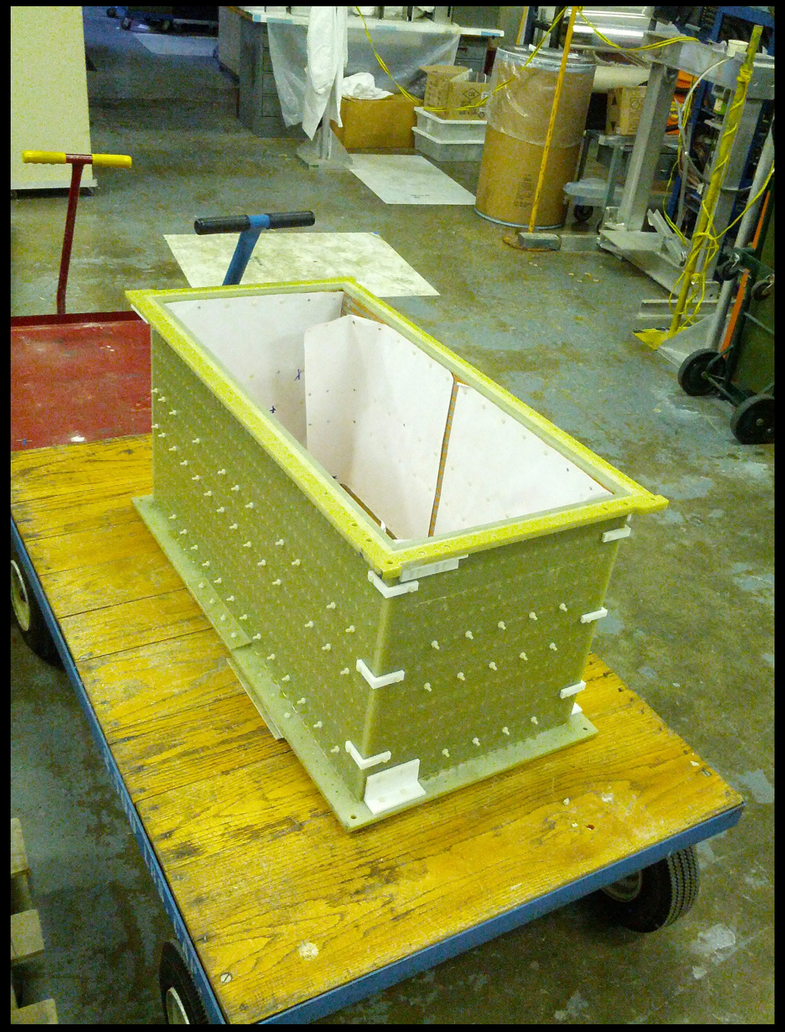
Modified ArgoNeut vacuum-walled cryostat



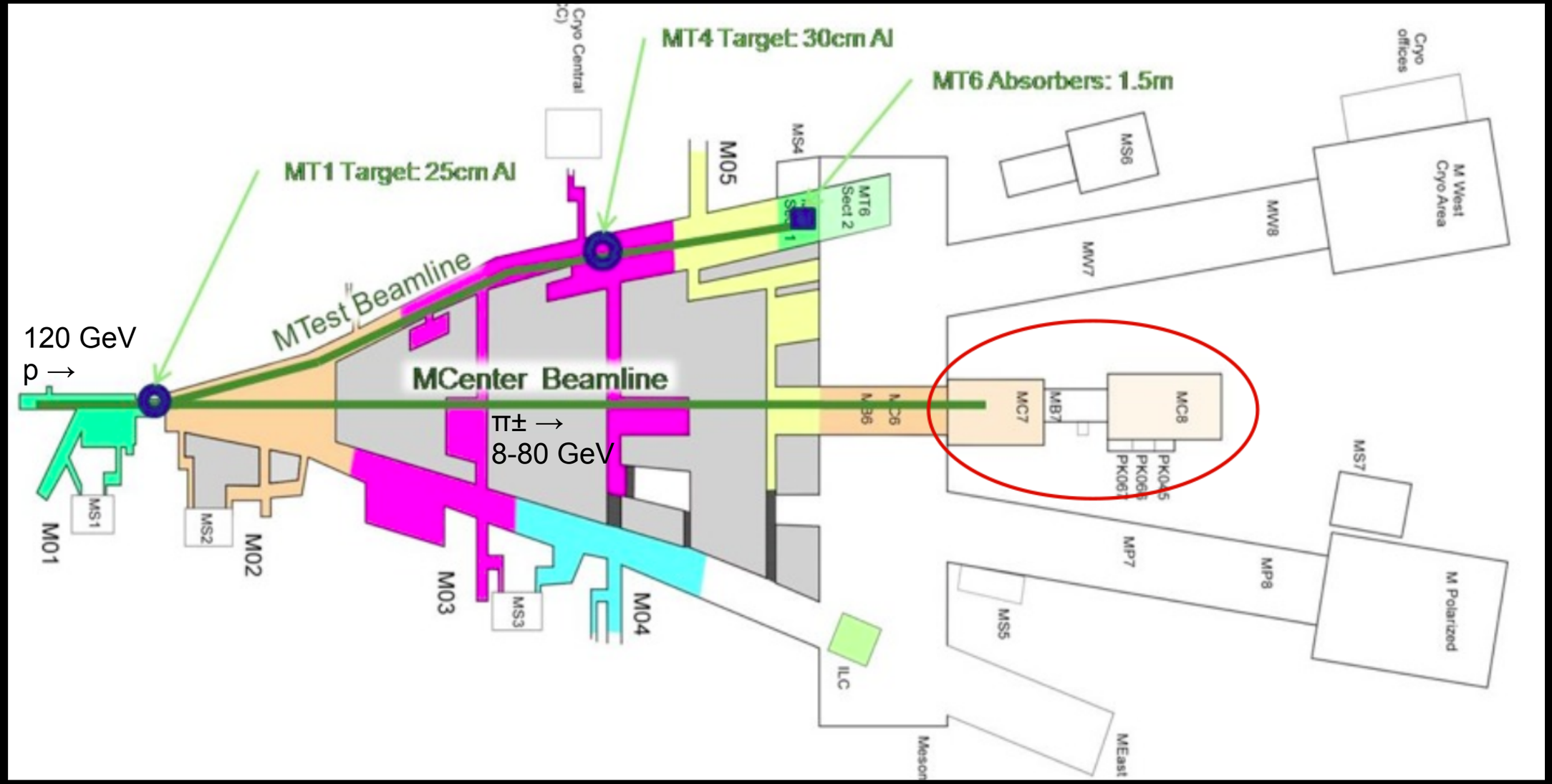
New wire planes

New temp sensors

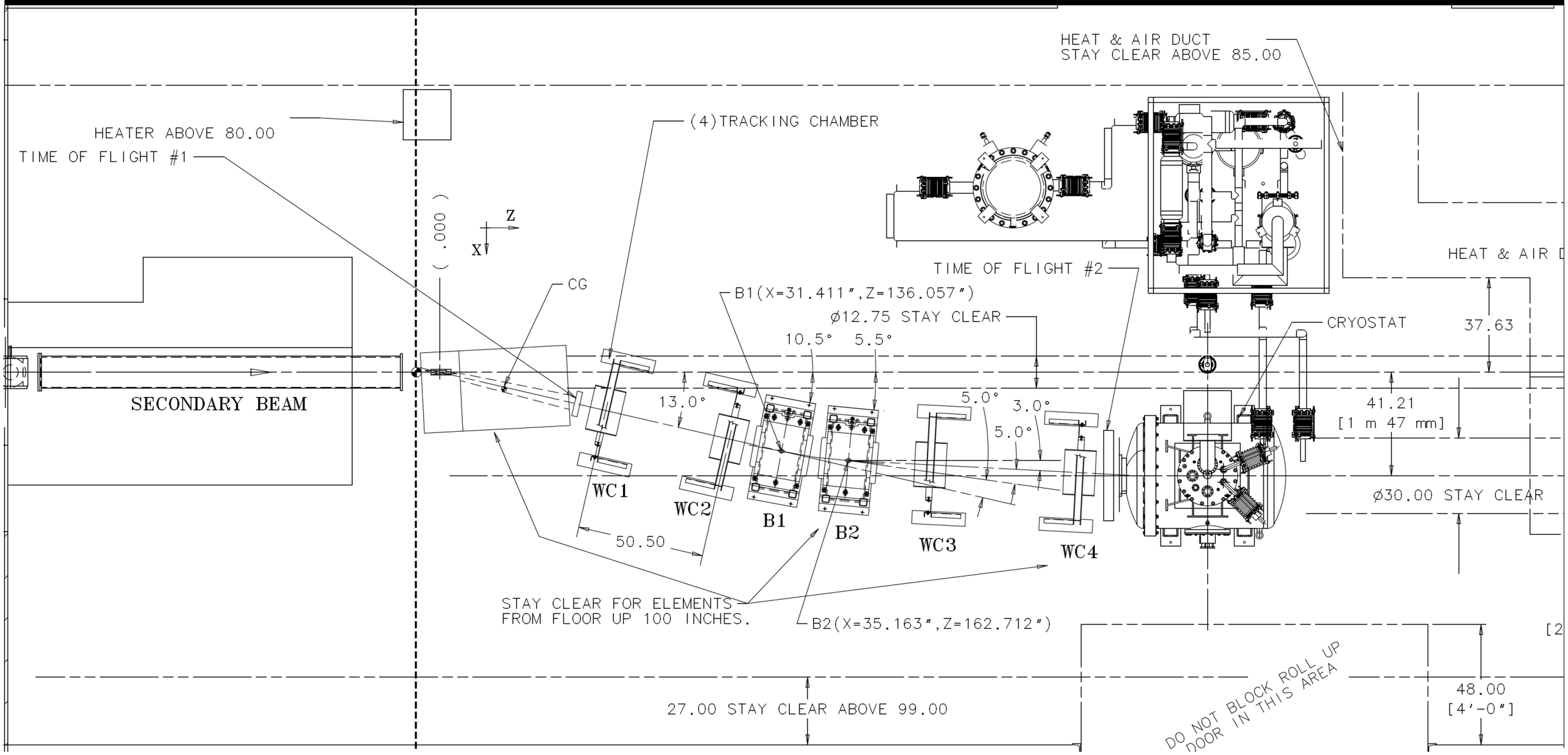
TPB*-coated foils to enhance scintillation detection efficiency

*Ask me!

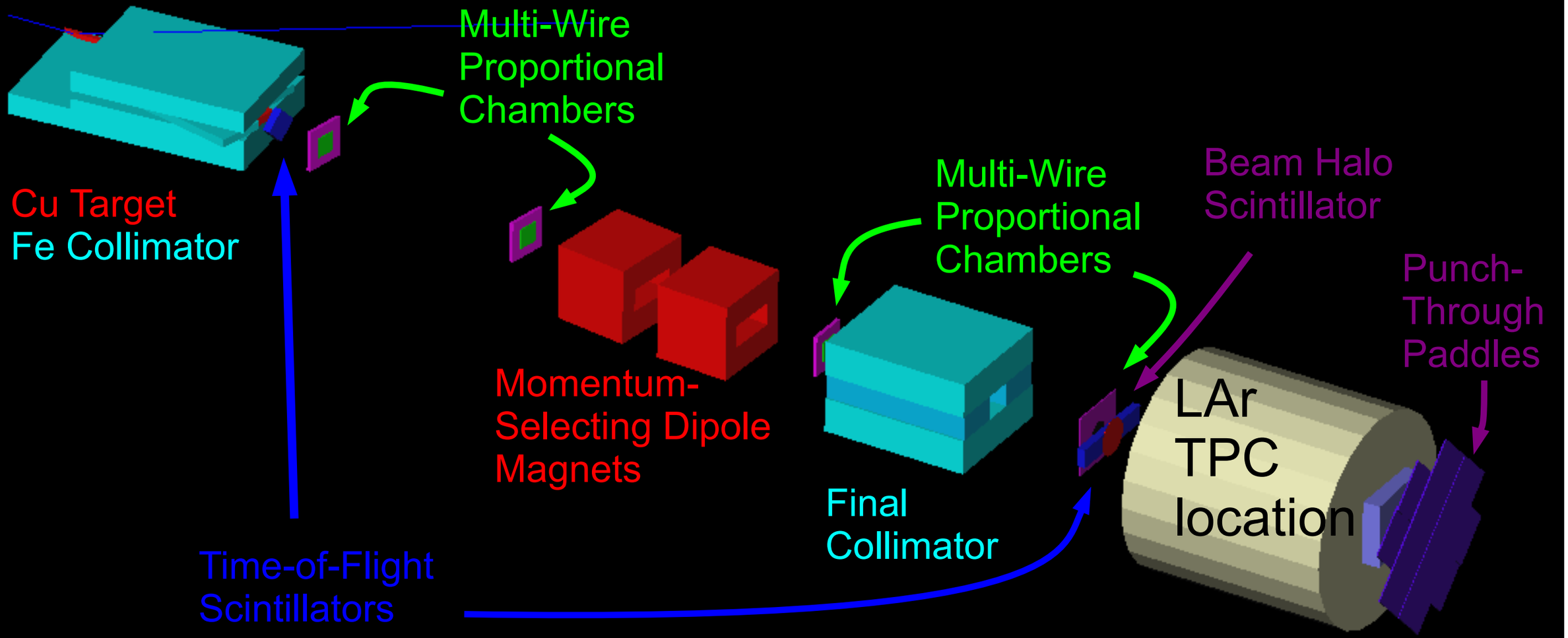
Fermilab Testbeam Facility



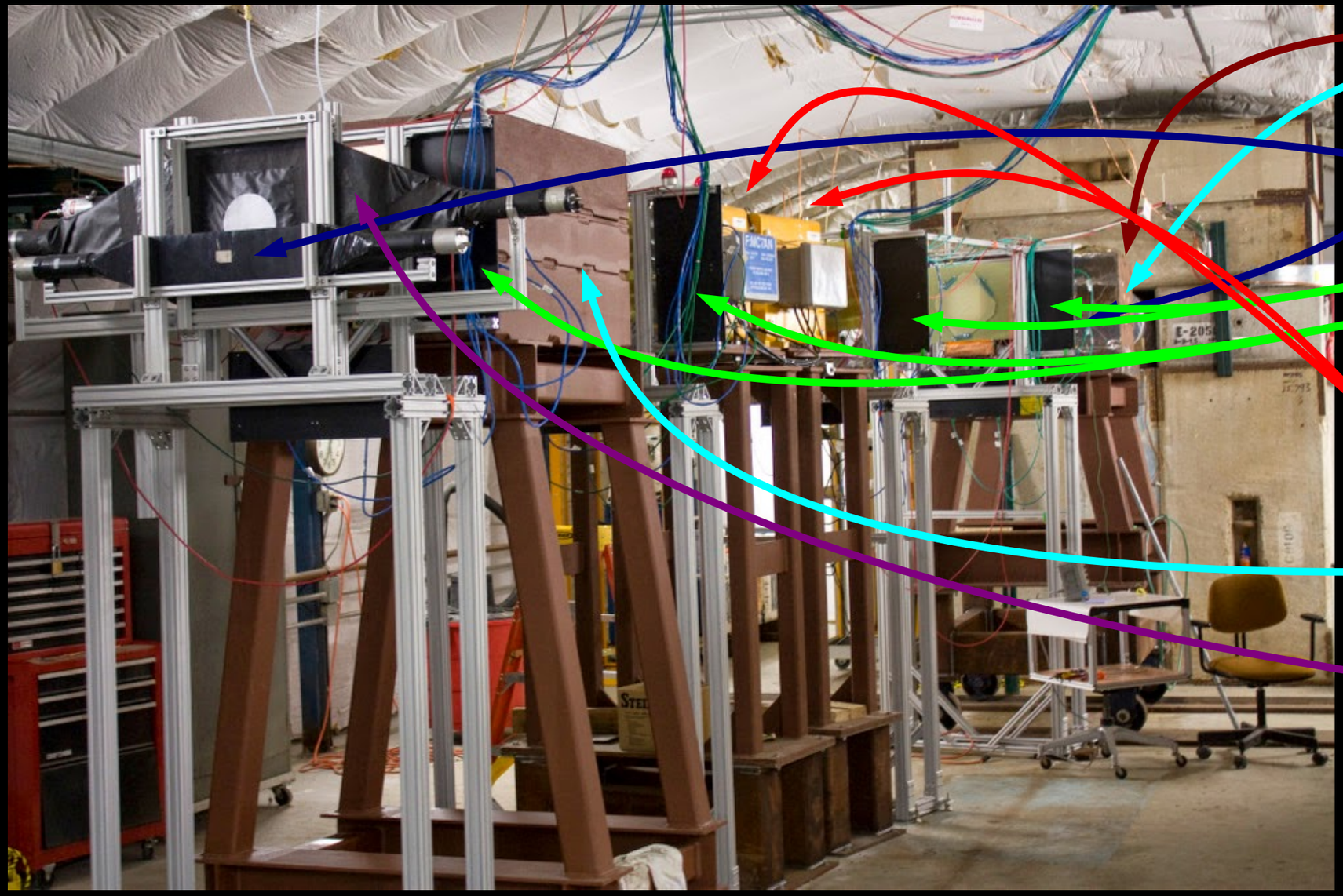
Fermilab Testbeam Facility



Present State: Commissioning Beam



Present State: Commissioning Beam



Cu Target

Fe Collimator

Time-of-Flight Scintillators

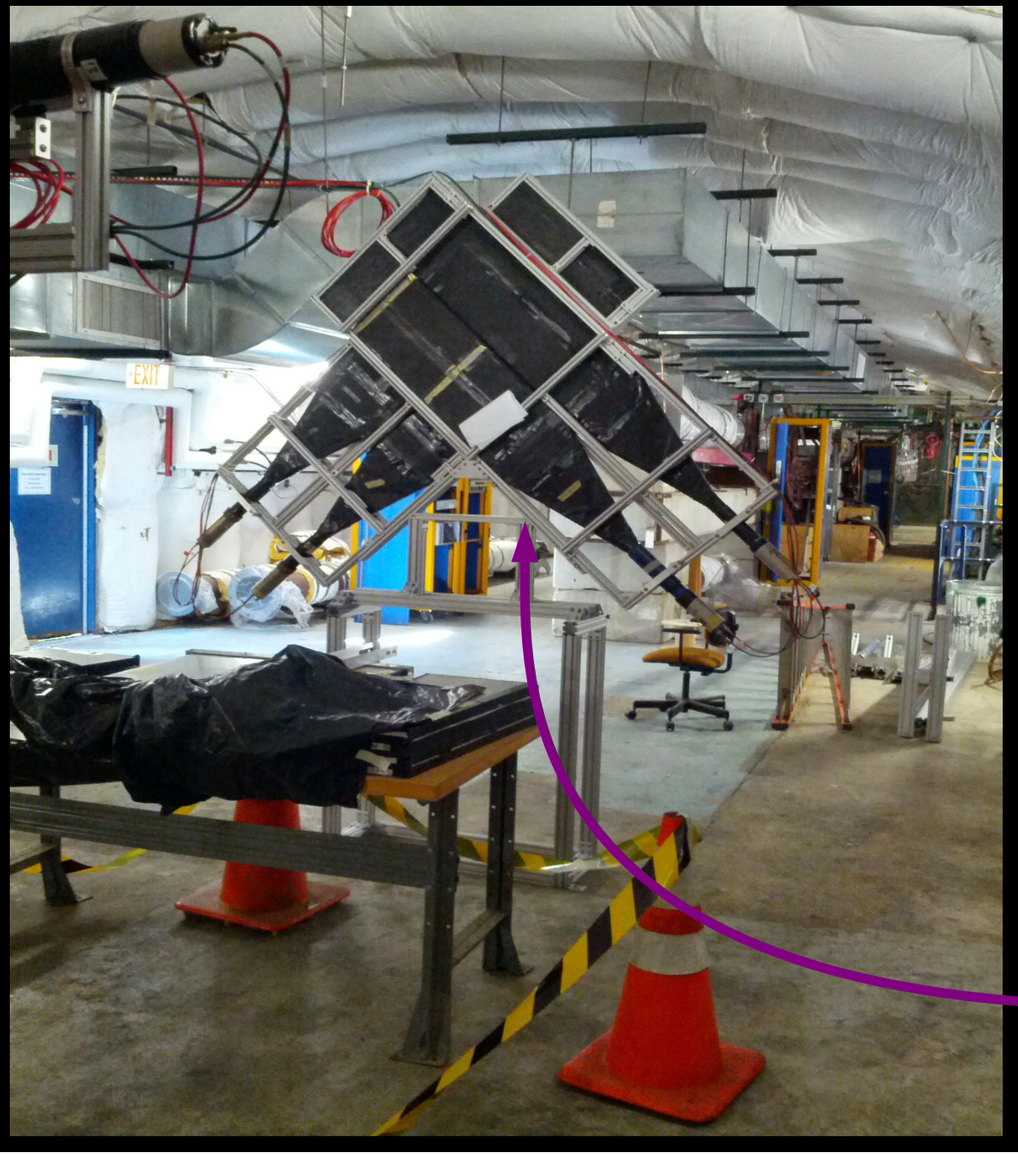
Multi-Wire Proportional Chambers

Momentum-Selecting Dipole Magnets

Final Collimator

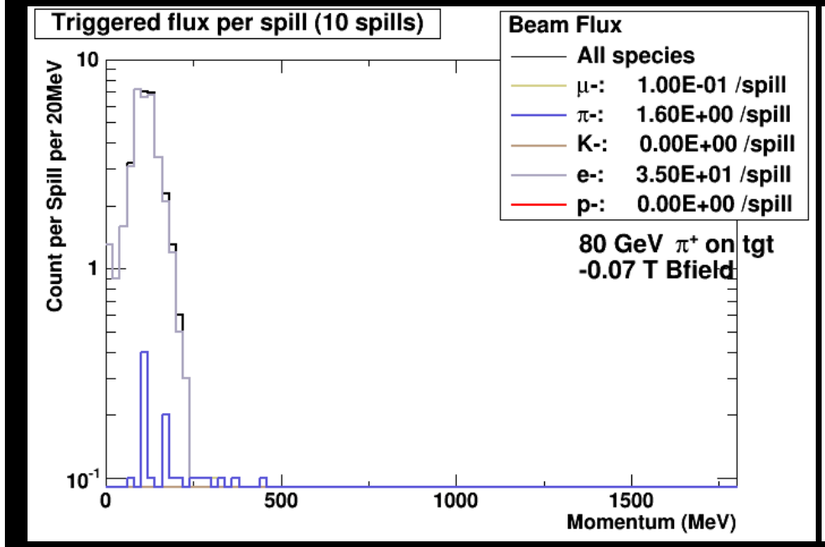
Beam Halo Scintillator

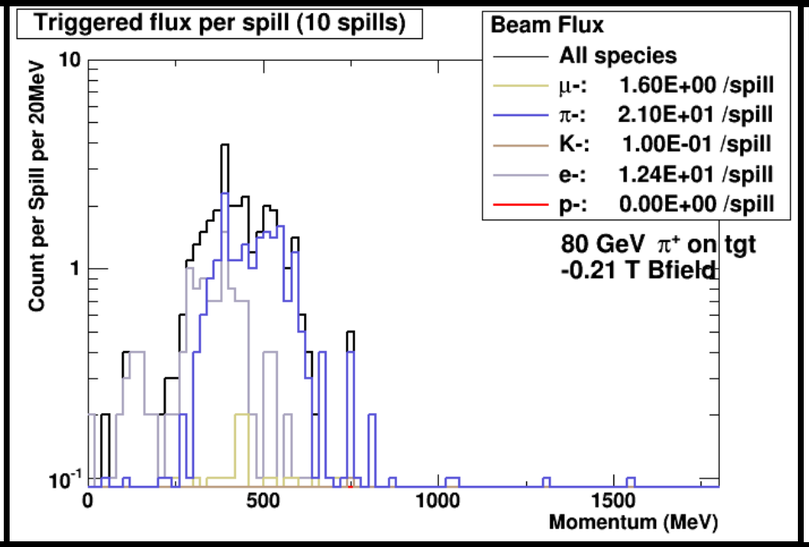
Present State: Commissioning Beam

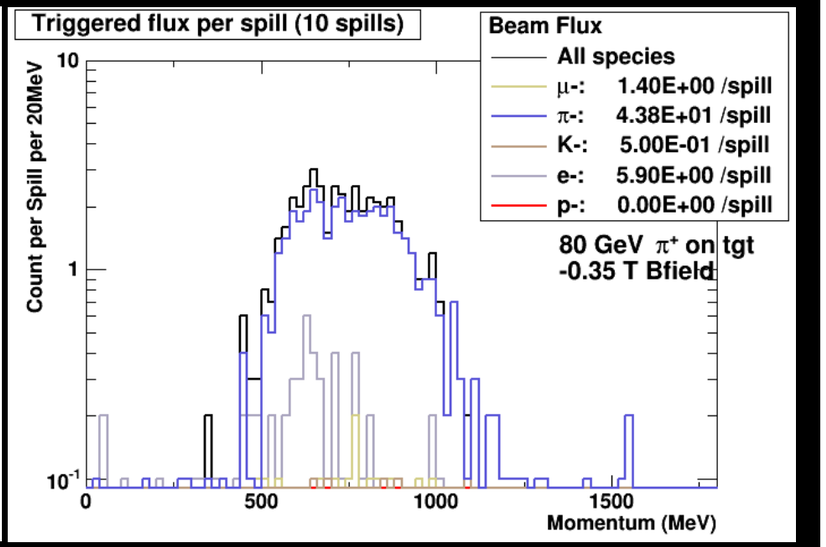


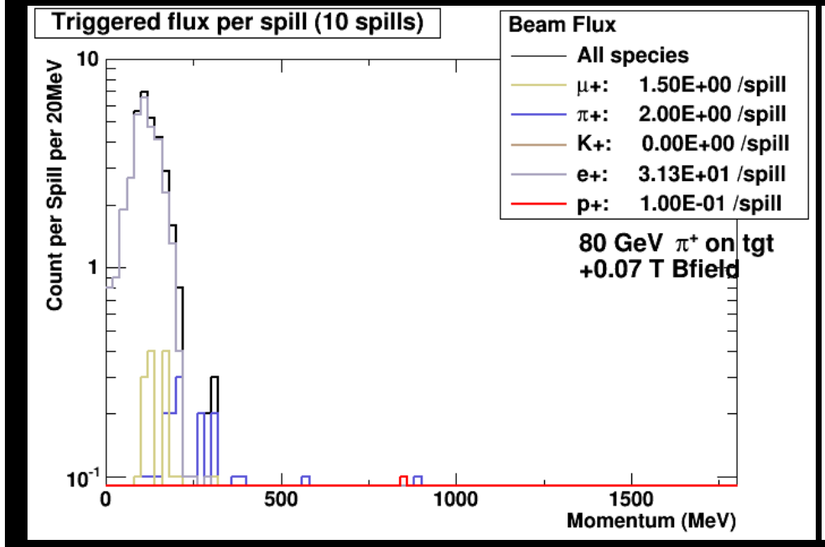
Cu Target
Fe Collimator
Time-of-Flight Scintillators
Multi-Wire Proportional Chambers
Momentum-Selecting Dipole Magnets
Final Collimator
Beam Halo Scintillator
Punch-Through Paddles

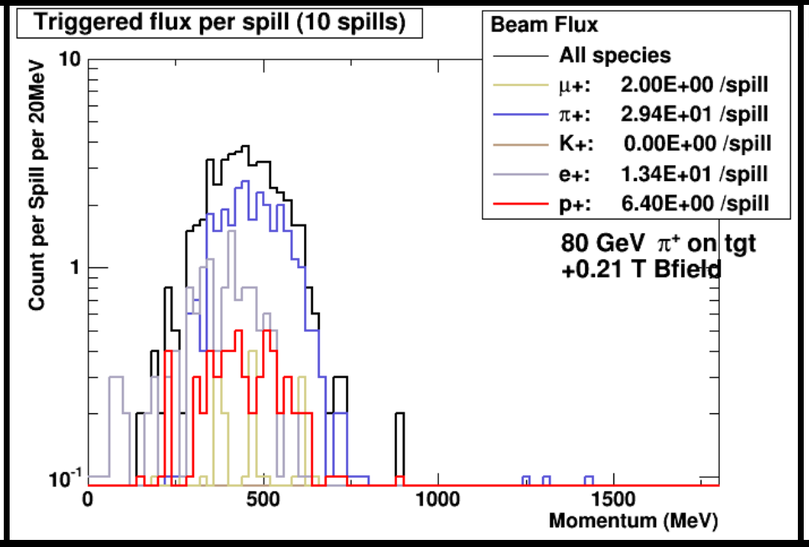
Tertiary Beam Spectrum (Simulation)

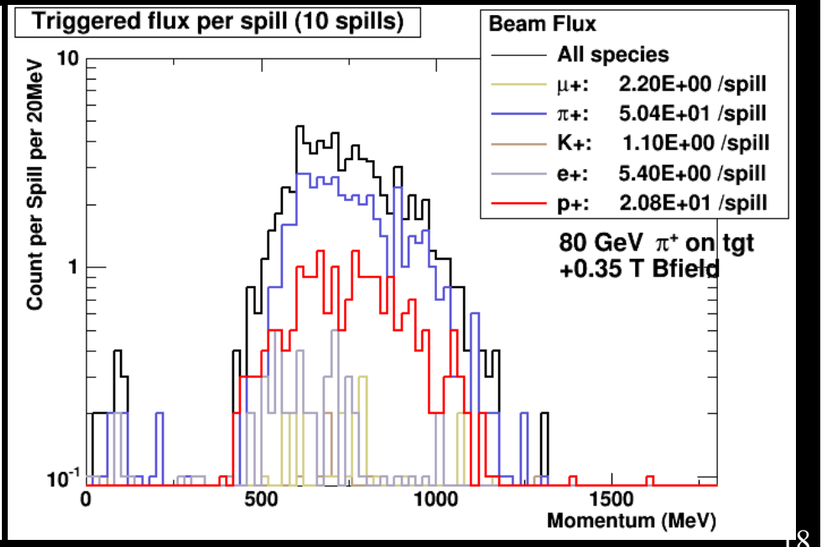




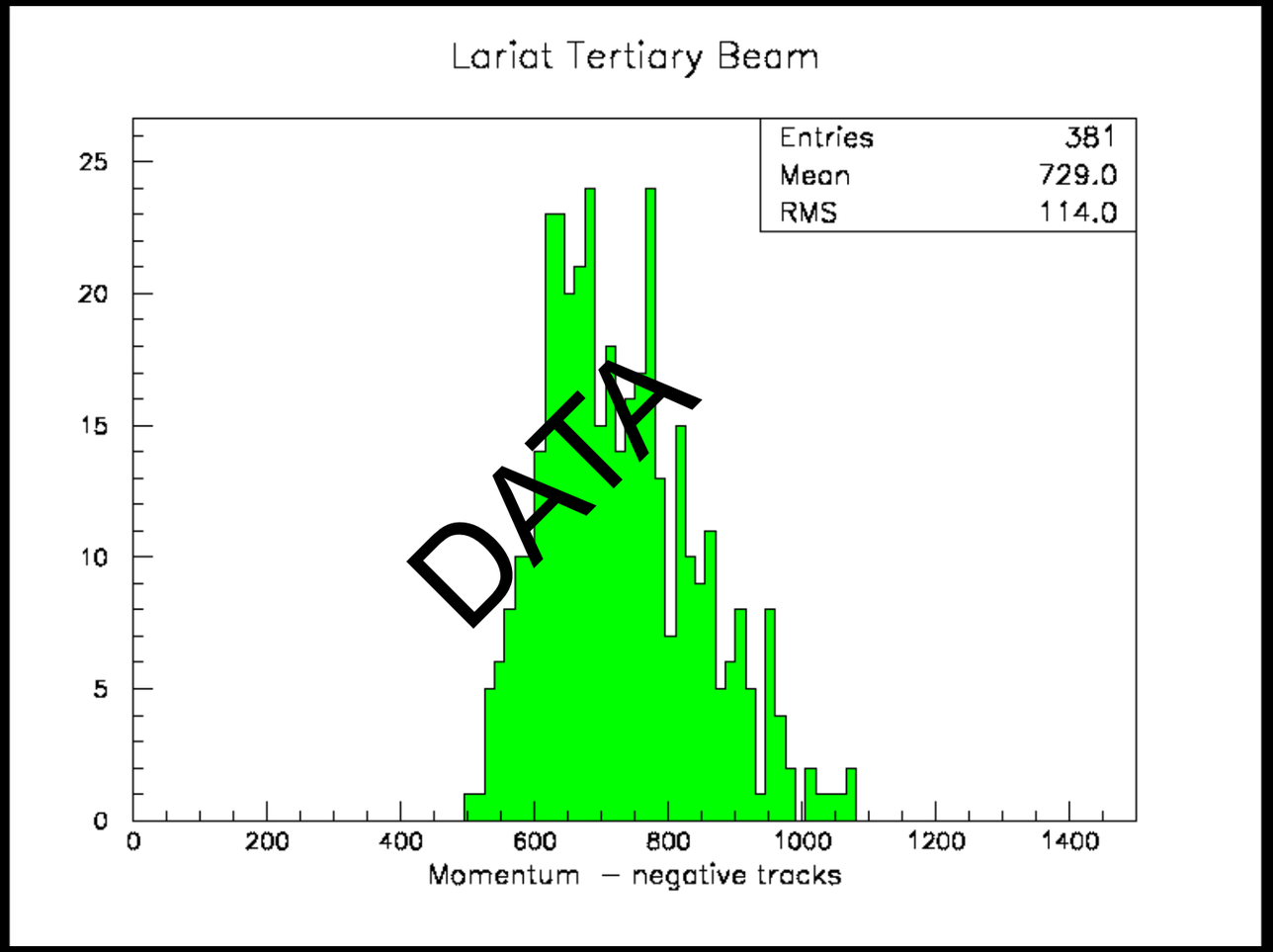


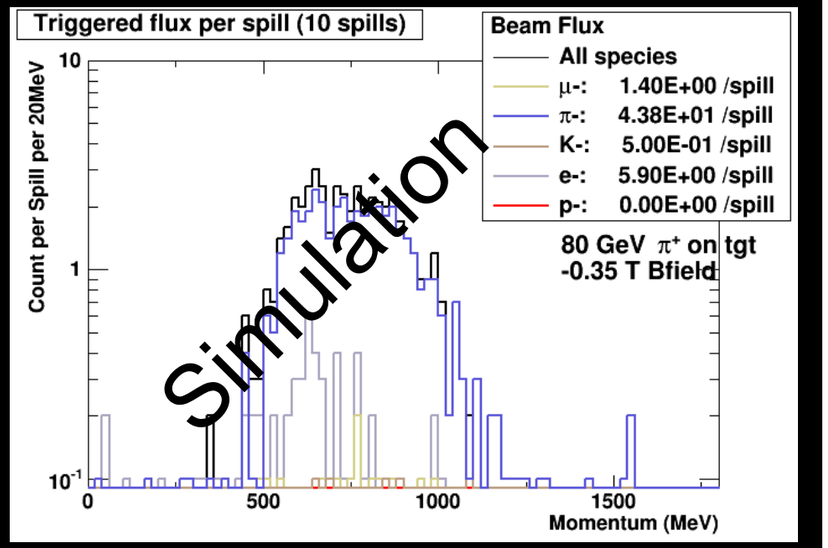






Tertiary Beam Spectrum





32 GeV/c π+ Secondary Beam

Aug. 21 run, 119 actual spills (~ 8 -10 empty),

15,933 triggers

Coming Up

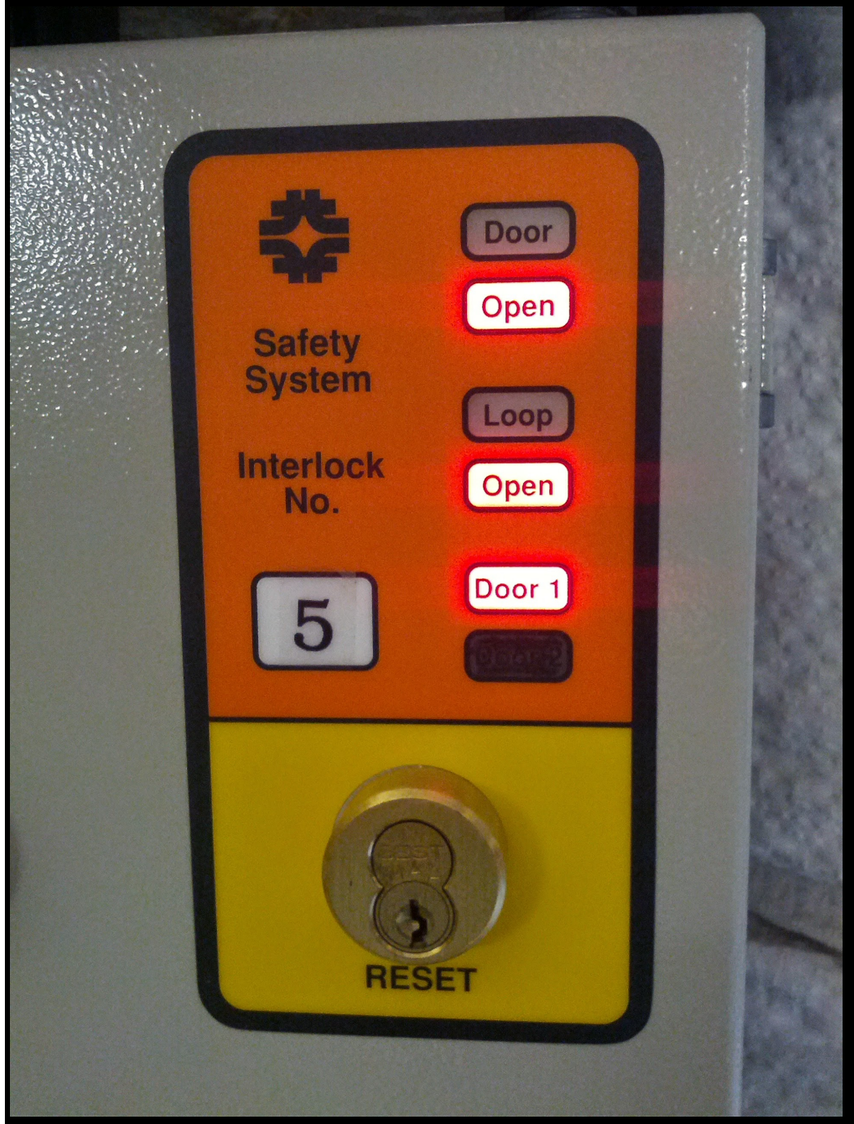
Continue commissioning tertiary beam & beamline detectors

- Exercising full DAQ & trigger, no TPC

Sept. 5 Fermilab accelerator complex shutdown (~6 wks.)

- Complete TPC assembly, insertion into cryostat vessel
- Chill & fill cryostat
- Connect readout and collect cosmics

LarTPC data added to the mix after beam returns

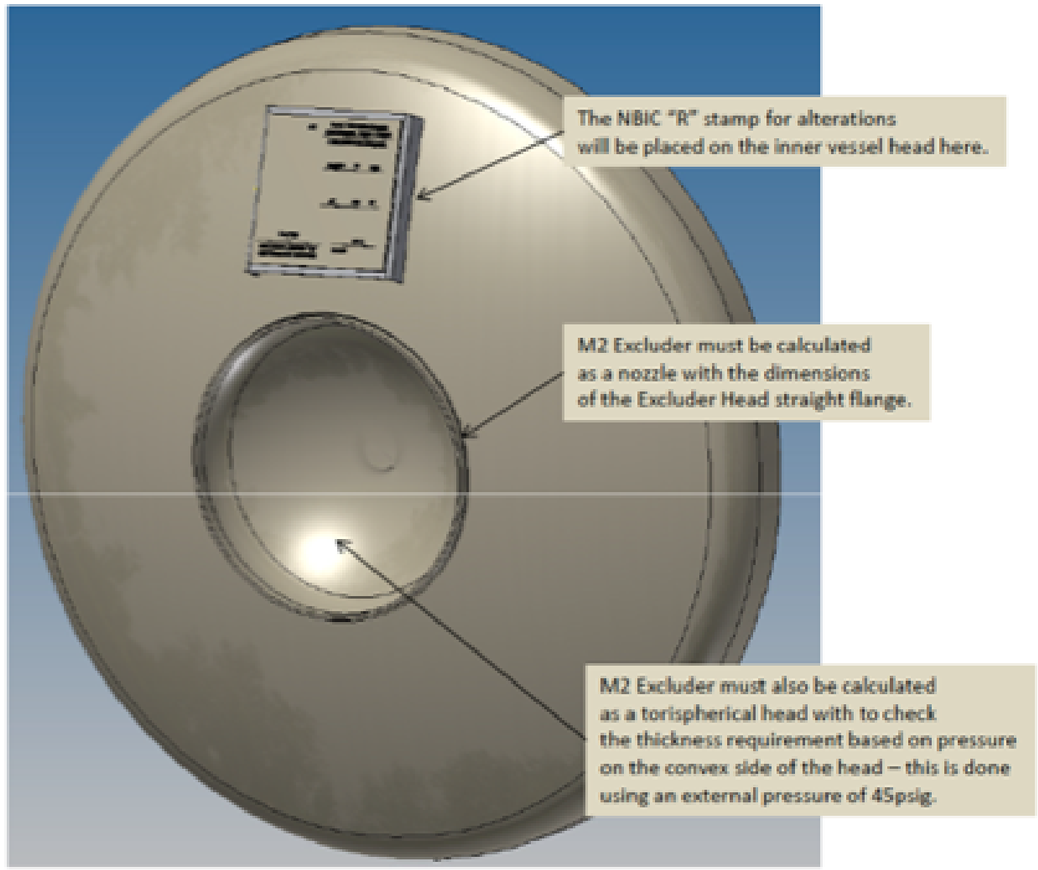

Door
Open
Safety
System
Loop
Interlock
No.
Open
5
Door 1
RESET

Thank You!

The Device: Phase I

Ti front window for admitting charged beam*

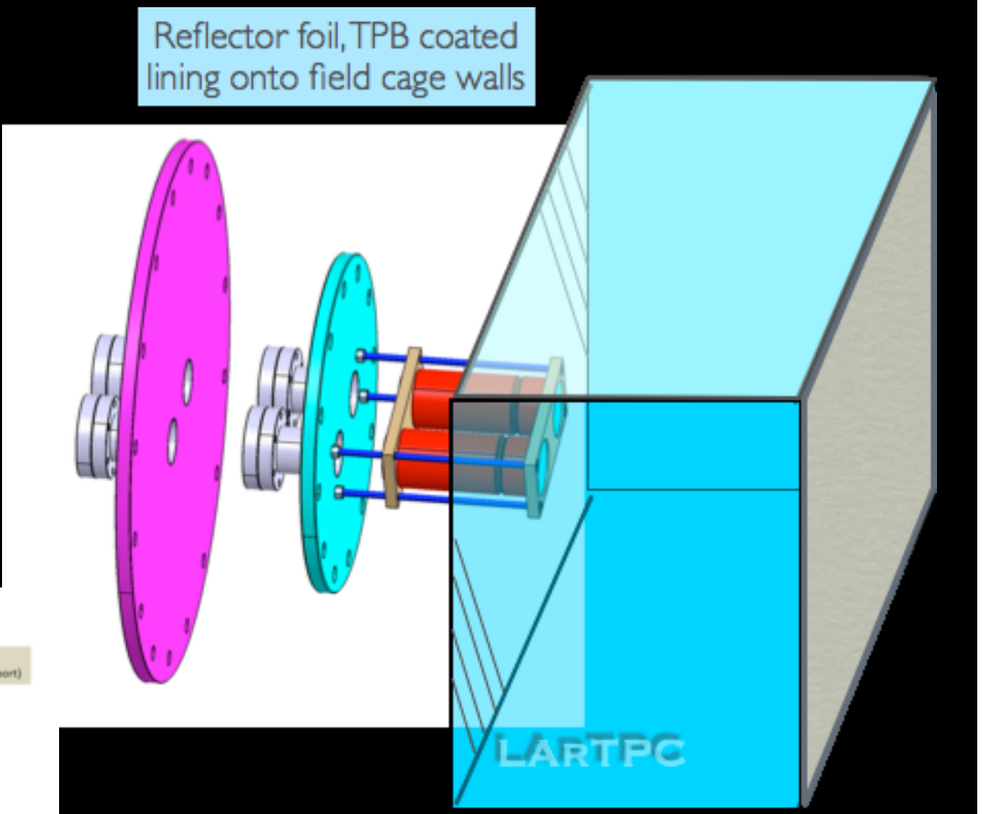
* “LAr excluder” pushes vacuum wall into inner LAr volume, reduces interactions before TPC

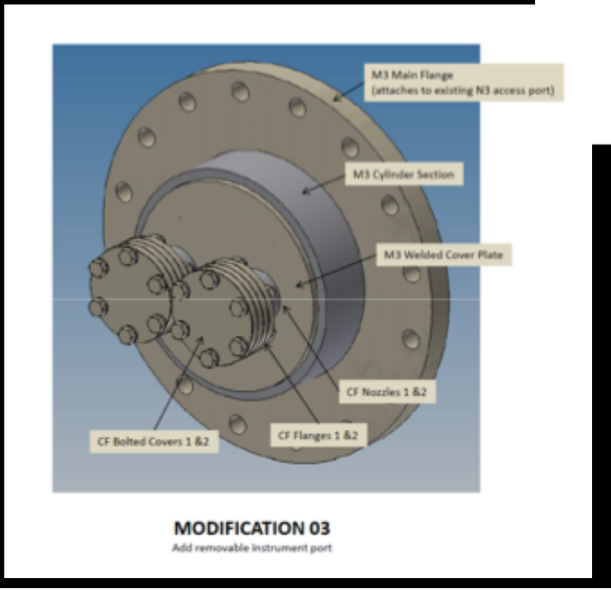


The Device: Phase I

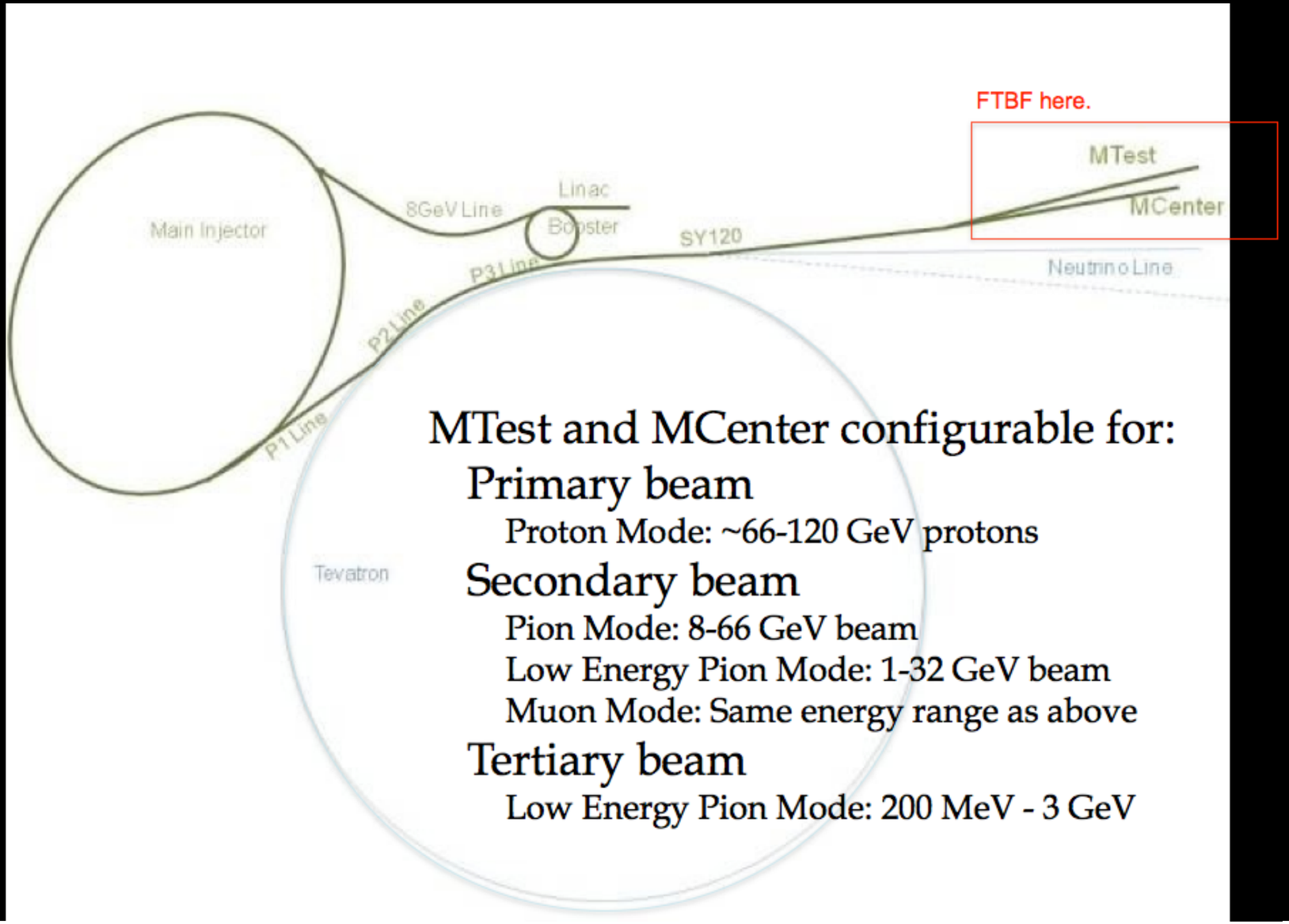
2 PMTs and 2 SiPMs view LAr volume through wire planes.

TPB foils line other surfaces of TPC, converting scintillation VUV to PMT-detectable photon energies.





Fermilab Accelerator Complex



MTest and MCenter configurable for:

Primary beam

Proton Mode: ~66-120 GeV protons

Secondary beam

Pion Mode: 8-66 GeV beam

Low Energy Pion Mode: 1-32 GeV beam

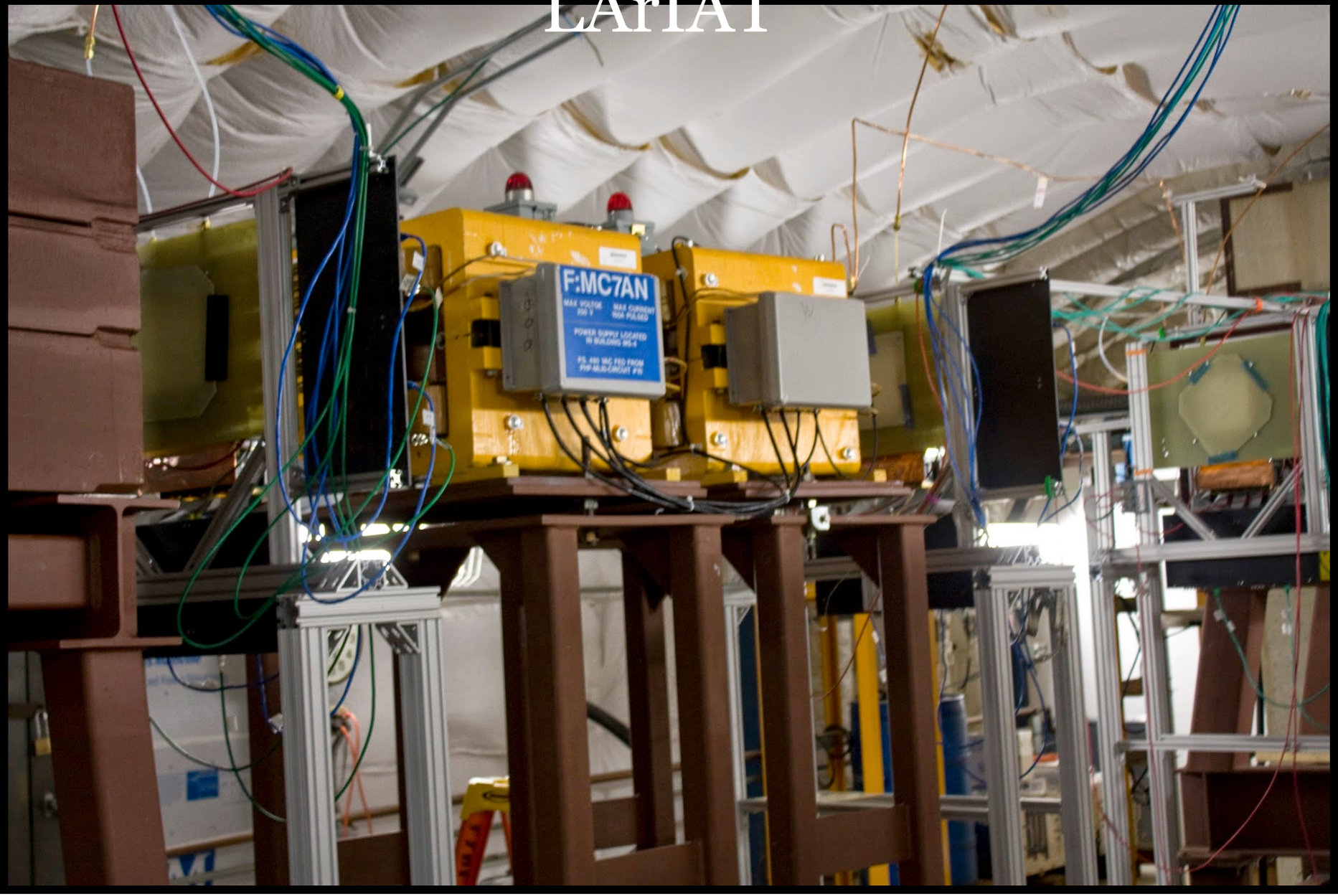
Muon Mode: Same energy range as above

Tertiary beam

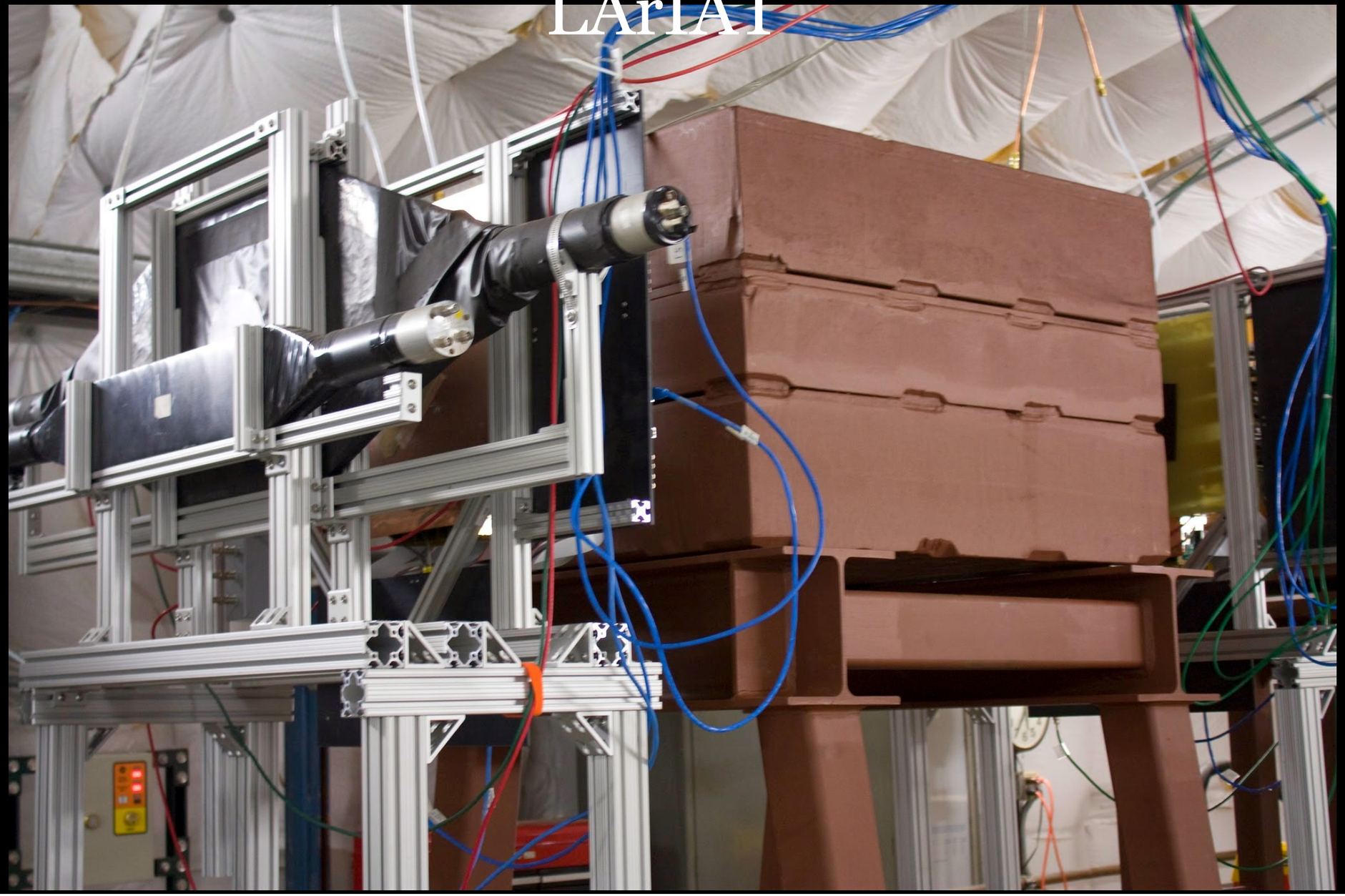
Low Energy Pion Mode: 200 MeV - 3 GeV

LArIAT

LArIAT



LArIAT



LArIAT

LArIAT