MicroBooNE

Motivation
Concept
Construction

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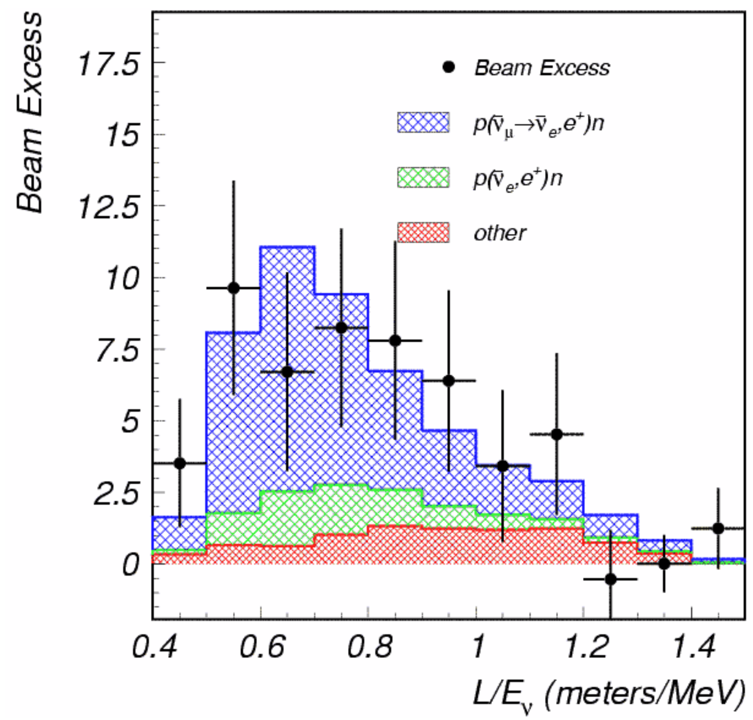
DNP 2014

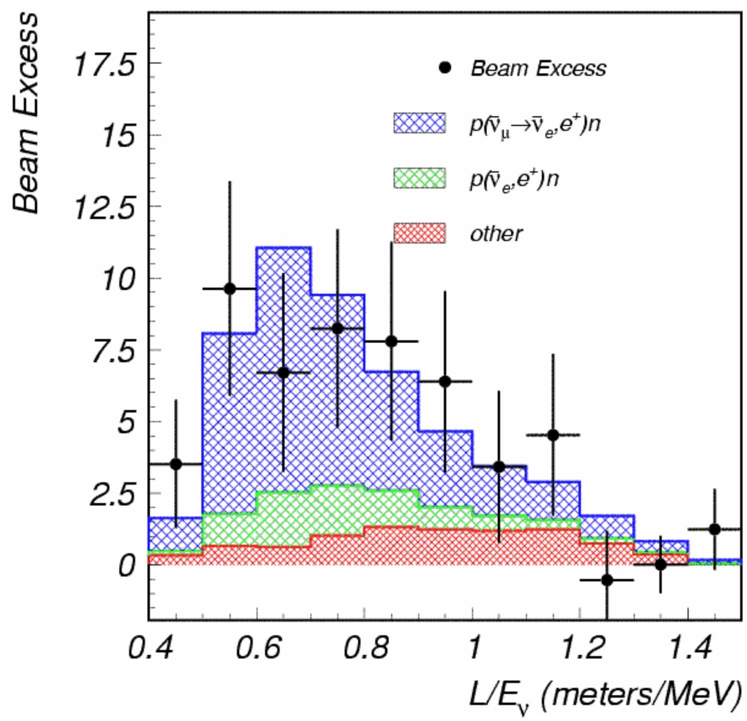
Neutrino Oscillation

$$P(\nu_\mu \to \nu_e) = \sin^2 2\theta \sin^2(1.27\Delta m^2 \frac{L}{E})$$



- Δm^2 gives the oscillation frequency.
- L is the flight length of the neutrino
- E is the energy of the neutrino
- Different experiments probe different regions of L/E phase space

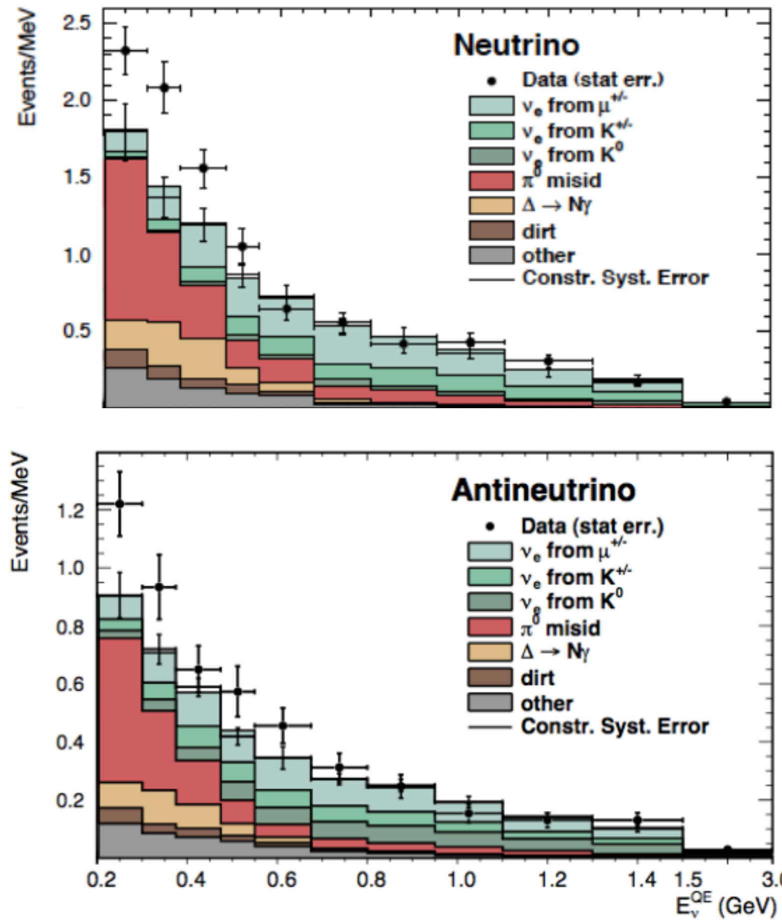
Motivation: Resolving Short Baseline Oscillation $\nu_\mu \rightarrow \nu_e$ Anomalies



Unexpected excess in LSND,

$\bar{\nu}_\mu \rightarrow \bar{\nu}_e$

Δm^2 ~ 1 eV^2 signal shown in blue



Excesses also seen by MiniBooNE

$\nu_\mu \rightarrow \nu_e$ and $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$

[hep-ex/0104049]

[PRL 110, 161801 (2013)]

Is it oscillations?

3+1 gives a poor fit to existing data (ν *vs.* $\bar{\nu}$ disagreement)

Fits want at least 3+2

[arXiv:1303.3011]
[arxiv: 1207.4765]

What's the cause of the MiniBooNE excess?

Is it…

electron-like → oscillations

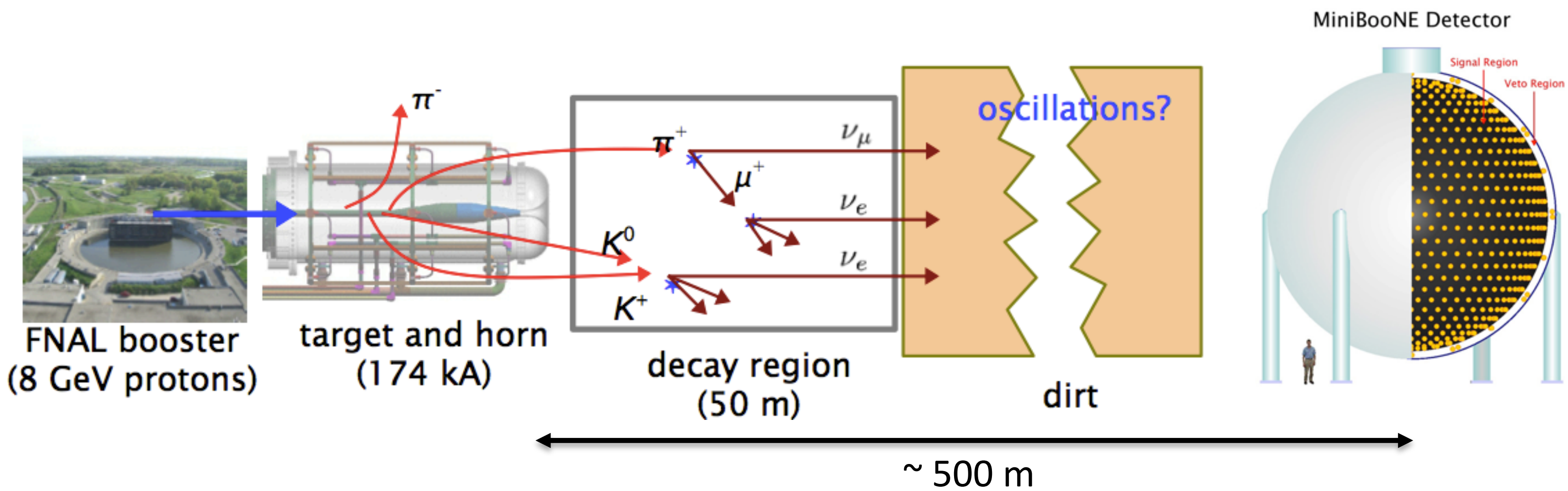
photon-like → an unknown background

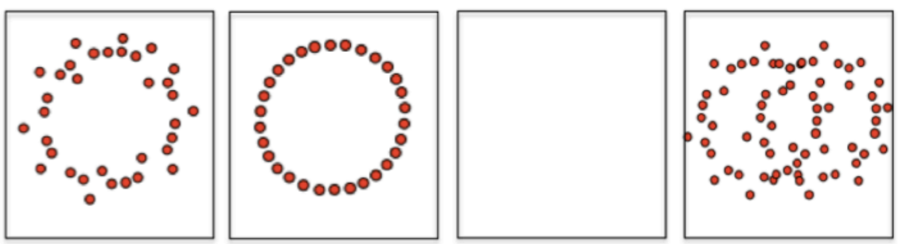
a combination of electron and photon signal

…?

The MiniBooNE Cherenkov detector cannot distinguish *e* from γ

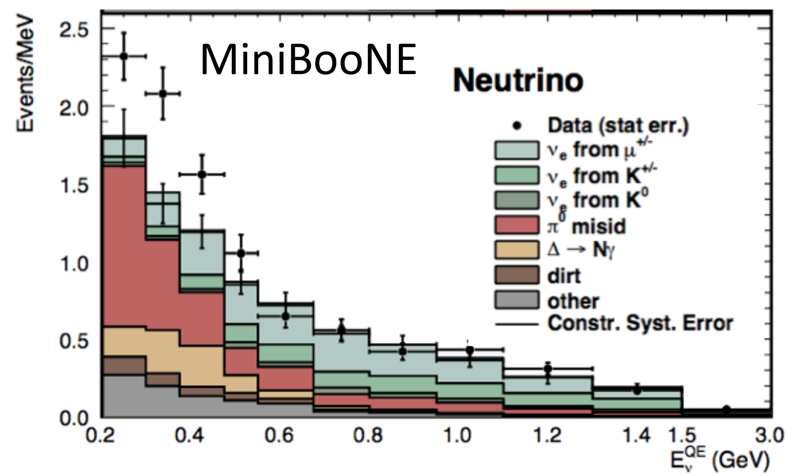
The MiniBooNE Design



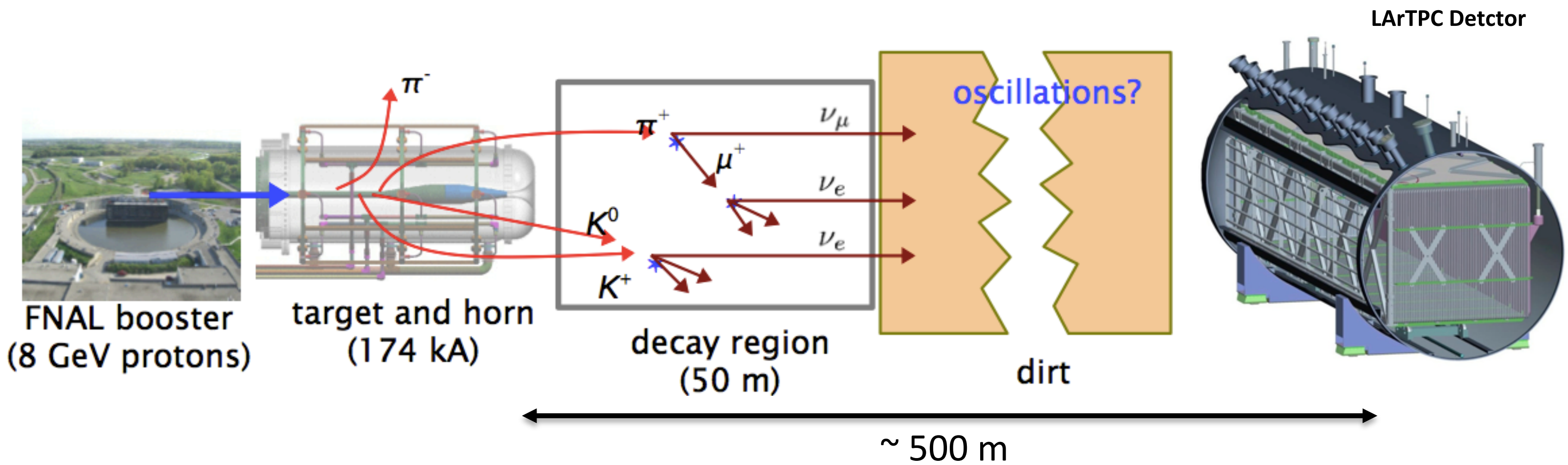


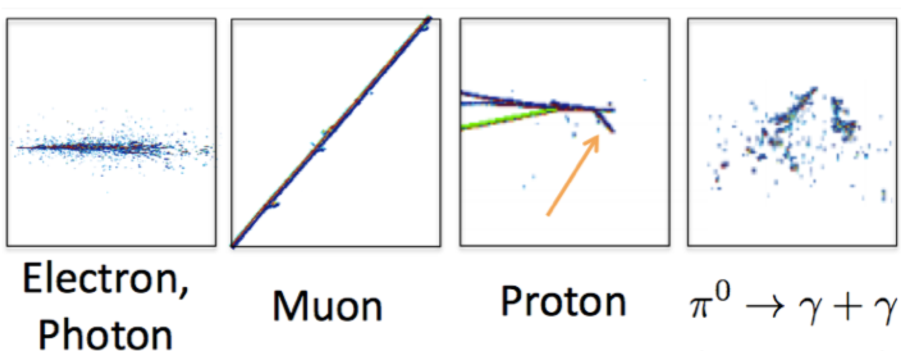
Electron, Photon | Muon | Proton | $\pi^0 \to \gamma + \gamma$

(Cherenkov Detector)

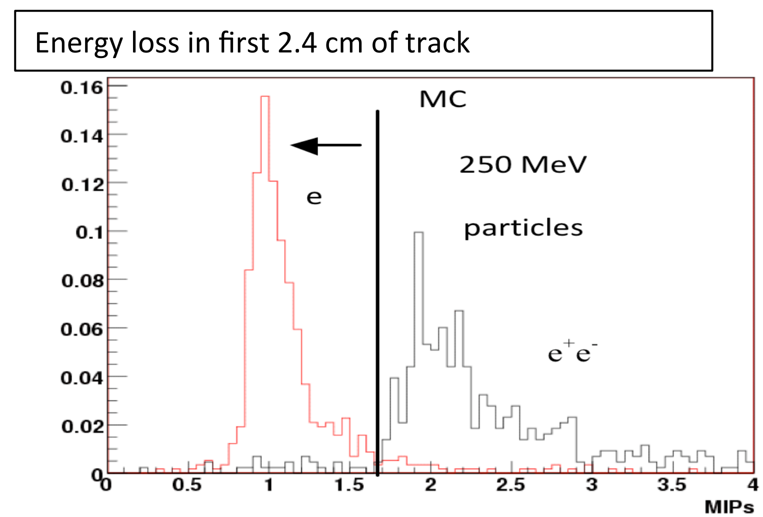


An alternative: the LArTPC detector



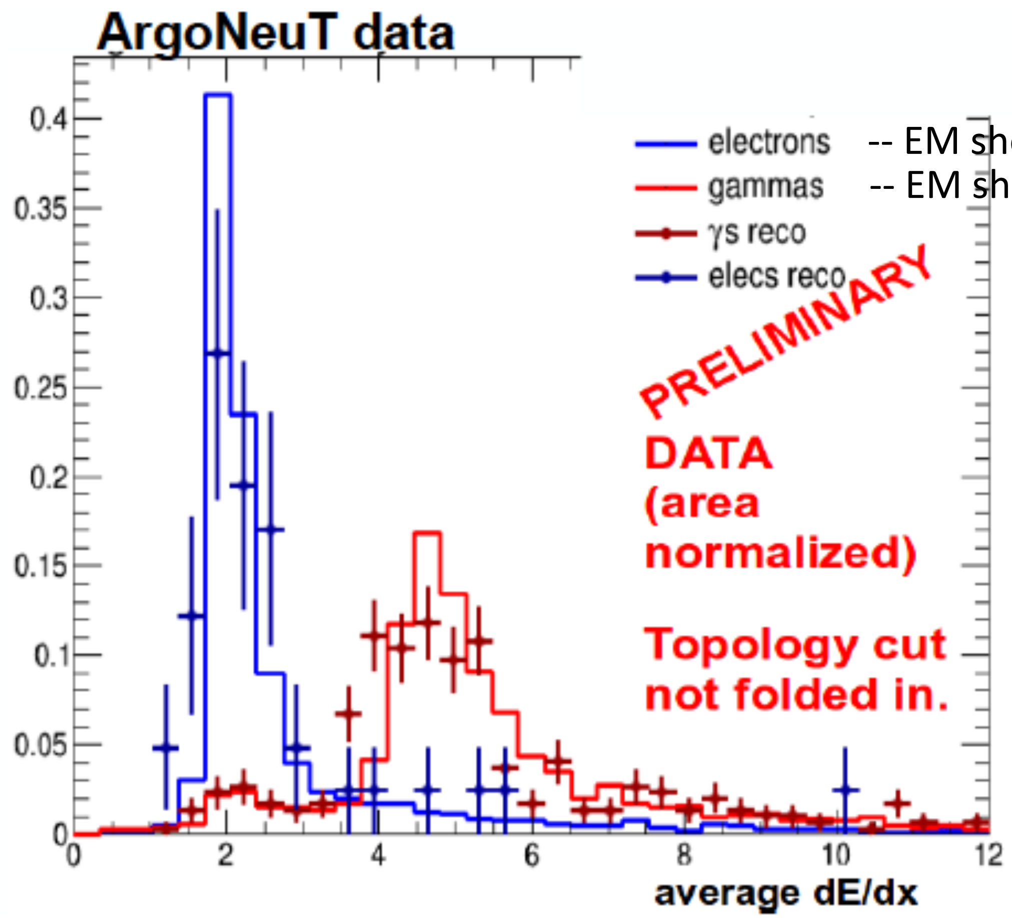


Liquid Argon Time Projection Chamber (LArTPC)



LArTPC = "Modern Bubble Chamber" with 3D track reconstruction

The key is the e/γ separation using early-track dE/dx!
Demonstration this idea works from the ArgoNeuT LArTPC <u>data</u>:

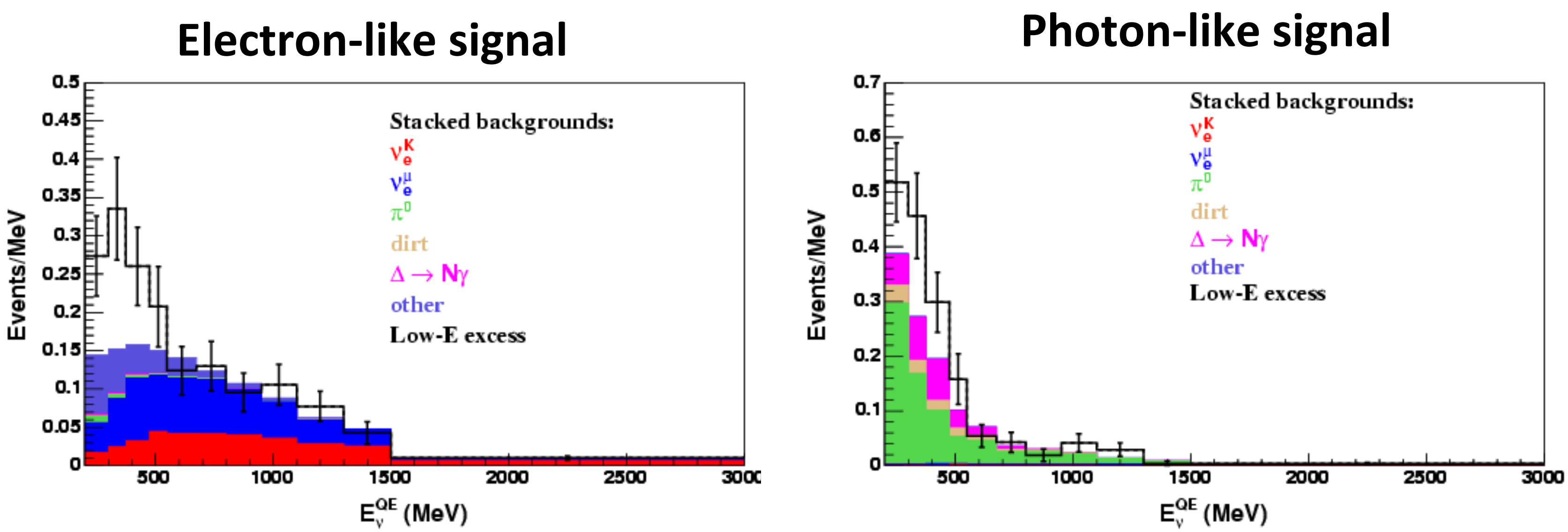


-- EM showers attached to vertex
-- EM showers separated from vertex

ArgoNeuT is a very small LArTPC that ran in the NuMI beamline at FNAL

How the MicroBooNE LArTPC addresses the anomalies:

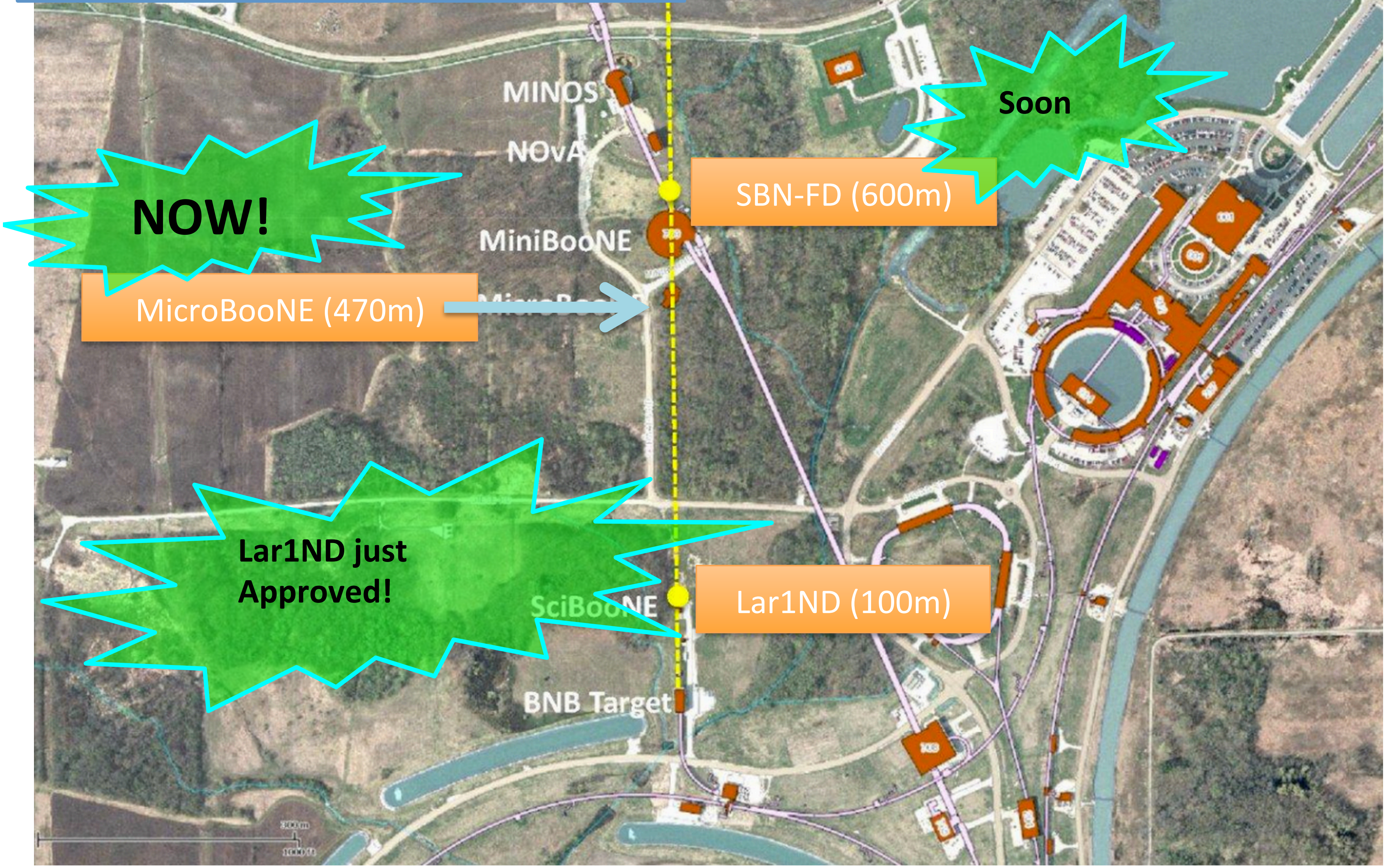
Same beamline, but 100 m upstream of MiniBooNE
Very different detector – LArTPC trades statistics for systematics
Initially address whether the MiniBooNE excess was *e* or γ:



In the next phase become a part of an LArTPC based SBL program…

Fermilab LAr SBN Program

[Fermilab-Proposal-1053]



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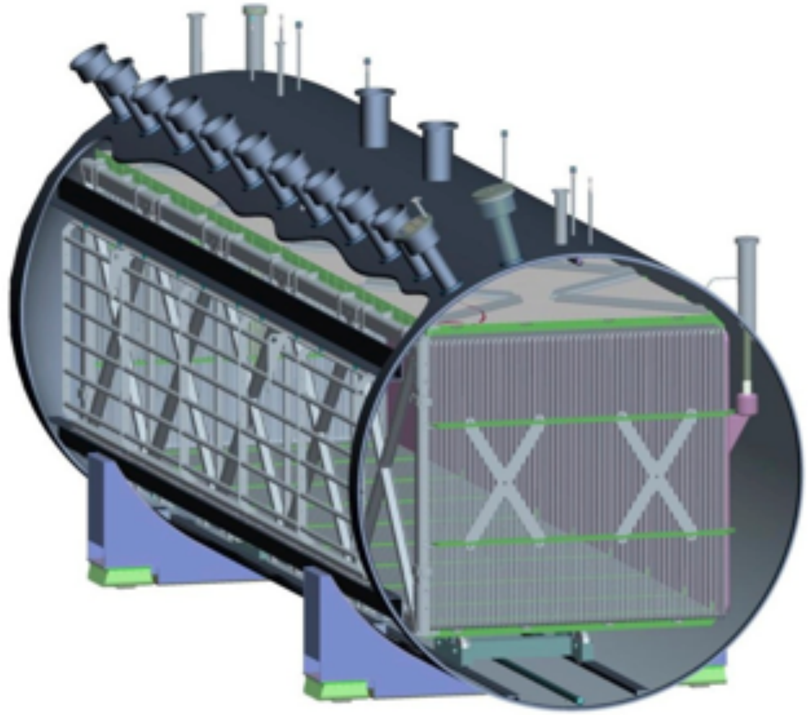
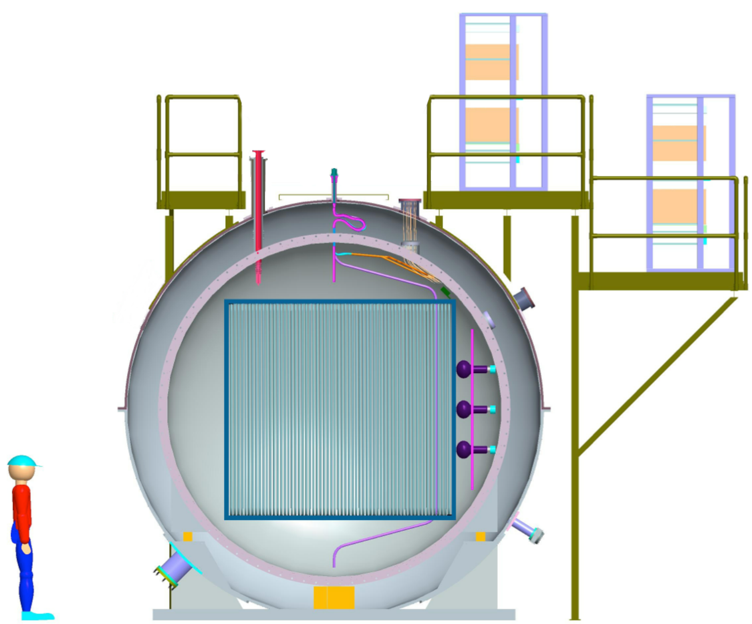
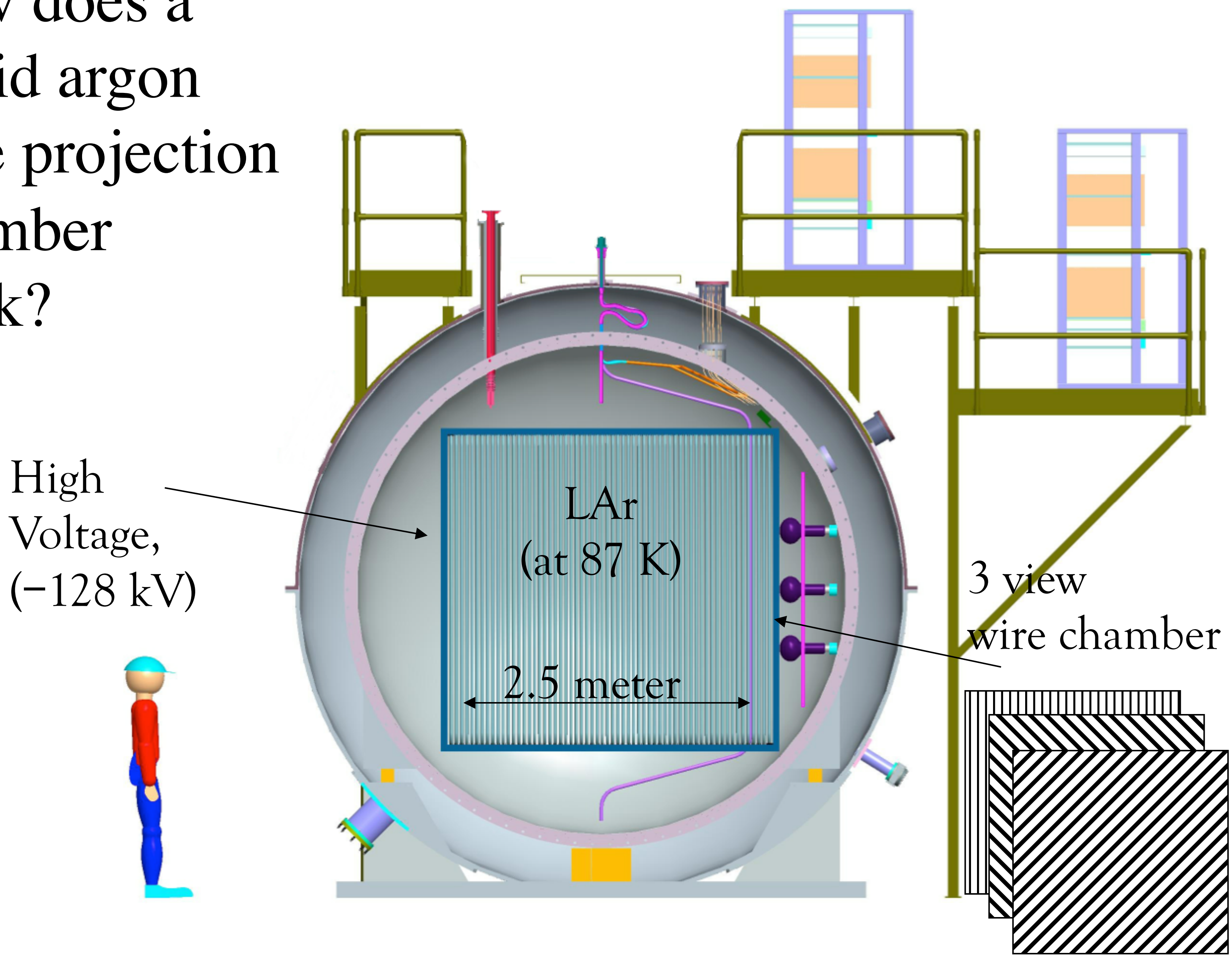


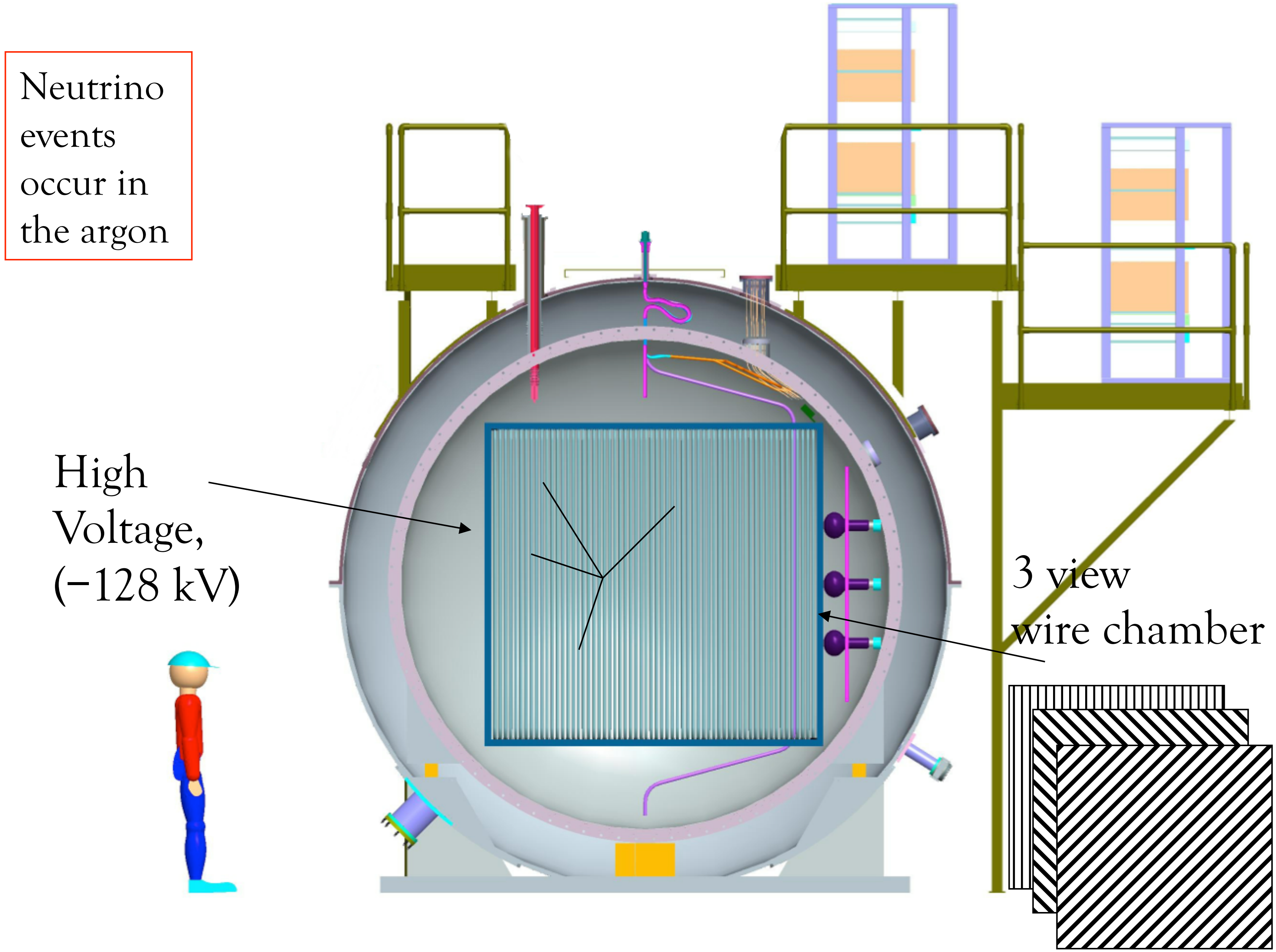


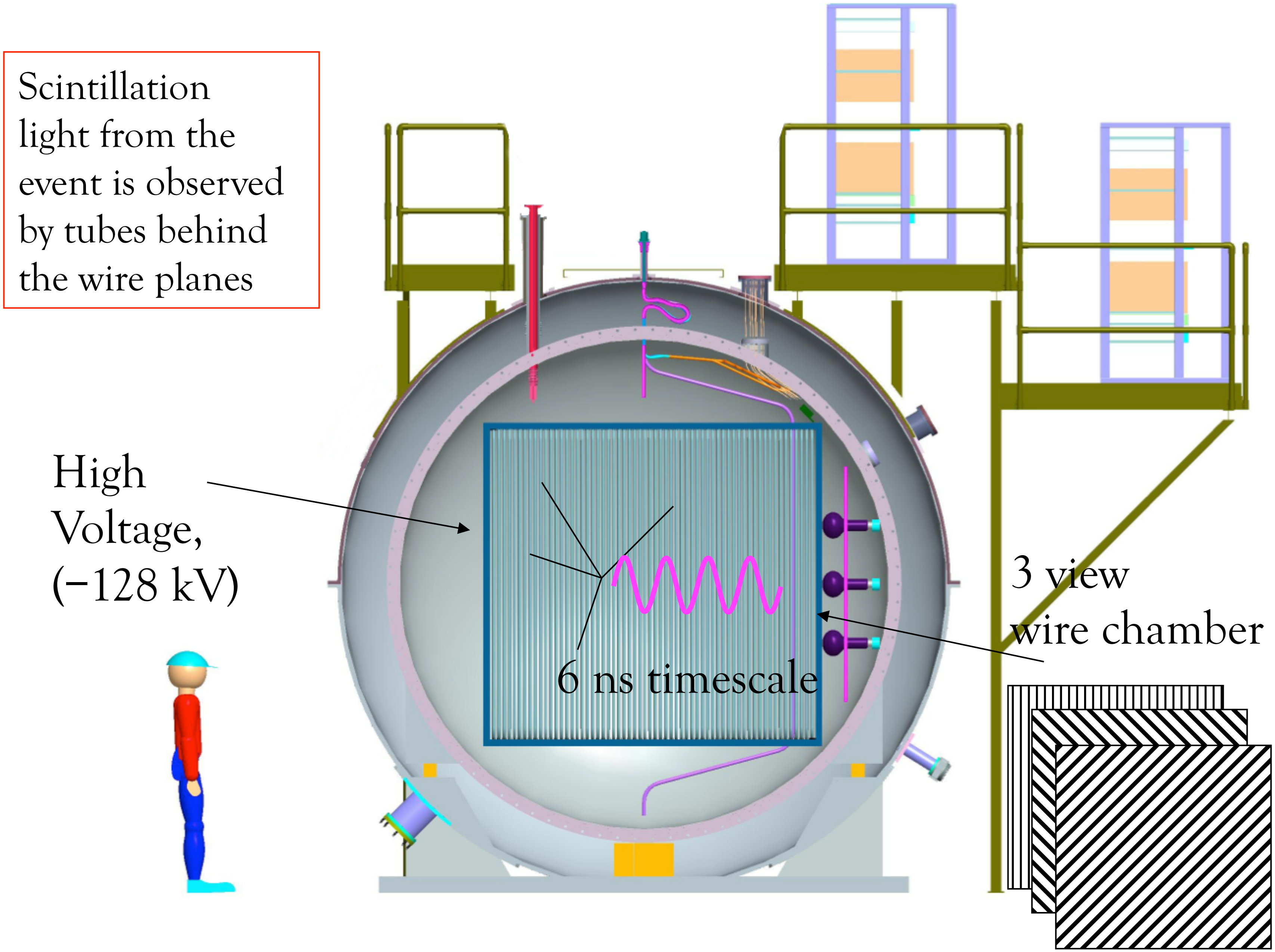
MicroBooNE…

A 170 ton state-of-the-art liquid argon
time projection chamber,
to run at Fermilab in 2015

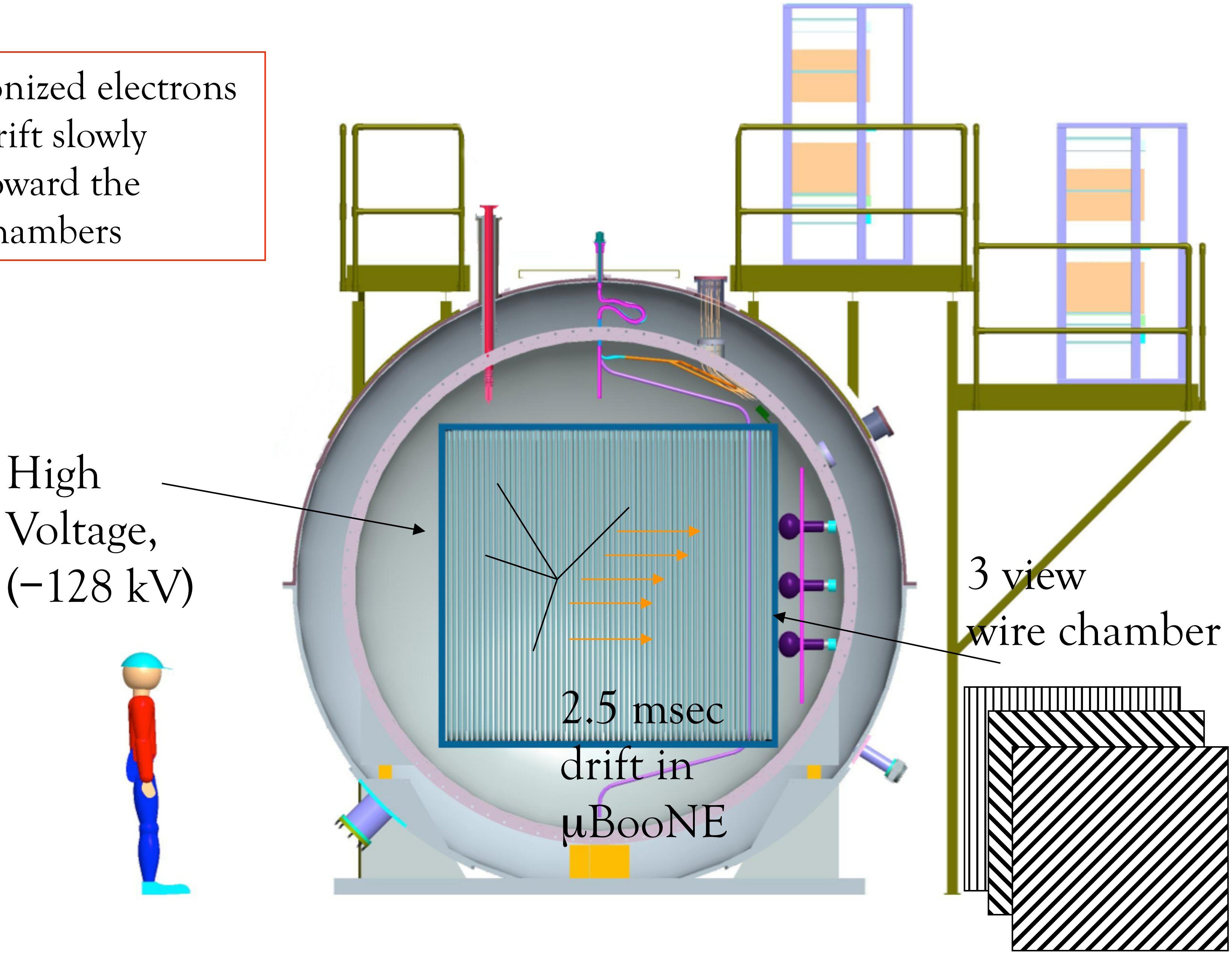
How does a liquid argon time projection chamber work?



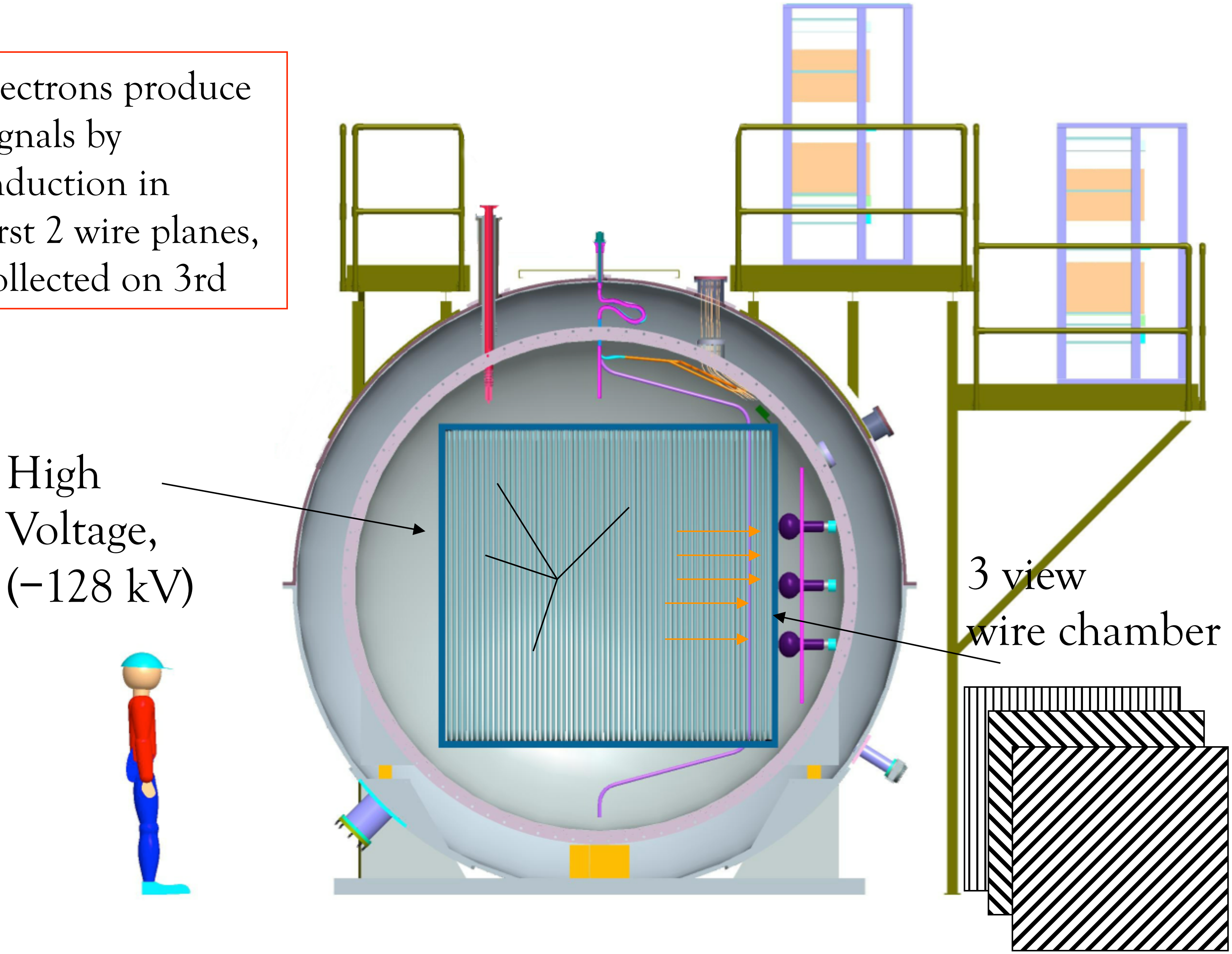

Neutrino events occur in the argon
High Voltage, (−128 kV)
3 view wire chamber


Scintillation light from the event is observed by tubes behind the wire planes
High Voltage, (−128 kV)
6 ns timescale
3 view wire chamber

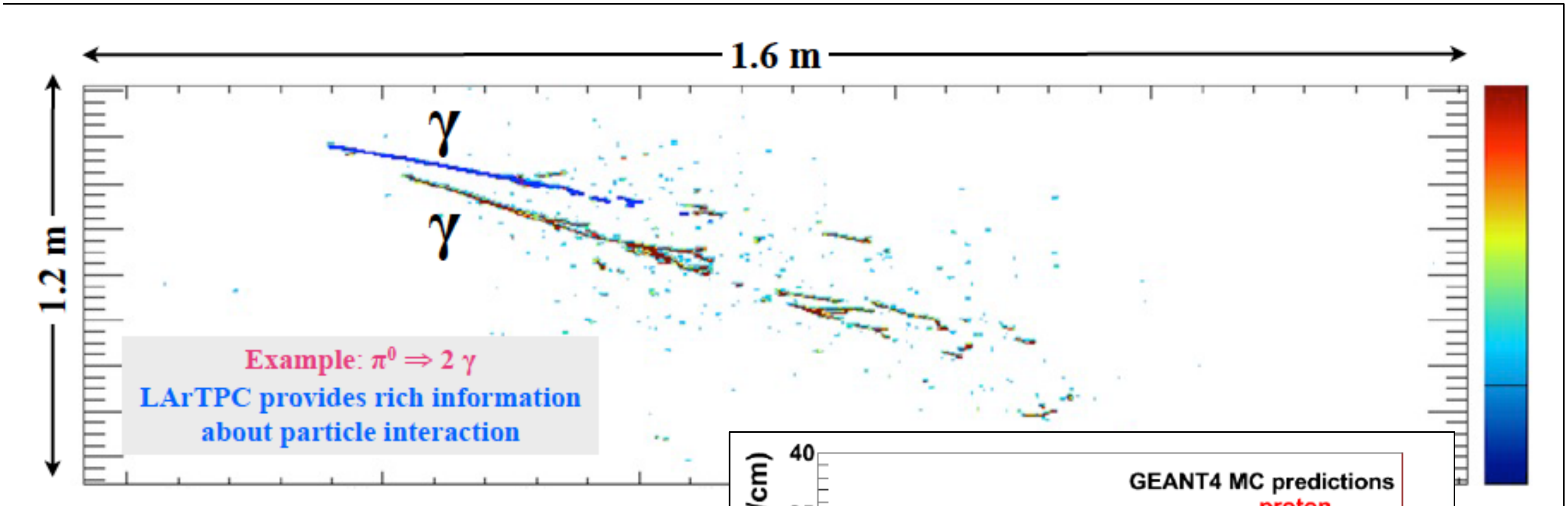
ionized electrons drift slowly toward the chambers

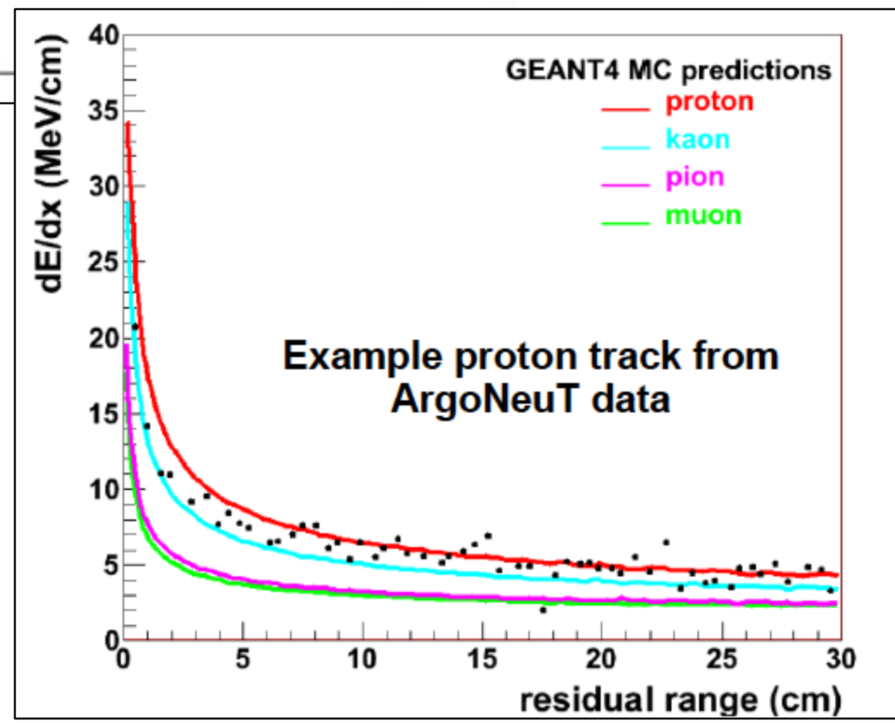


electrons produce signals by induction in first 2 wire planes, collected on 3rd

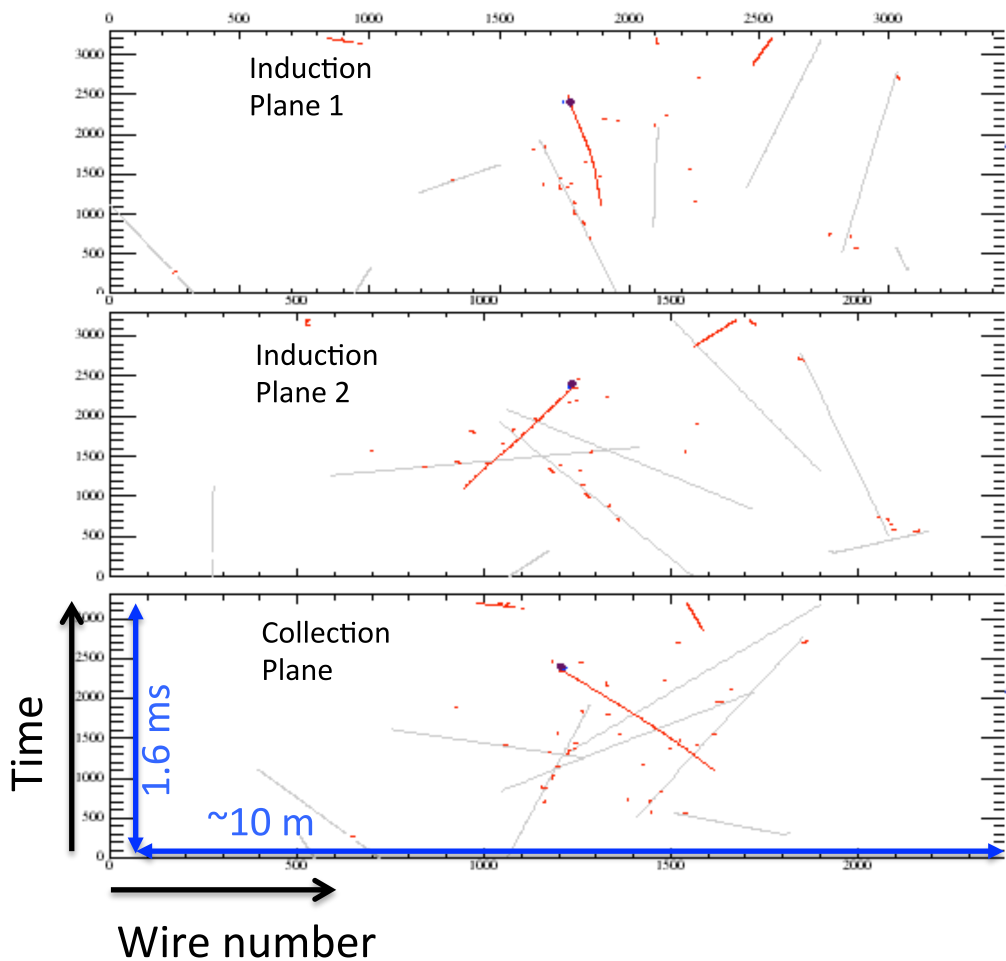


Uses of the TPC: Track reconstruction, Calorimetry, PID

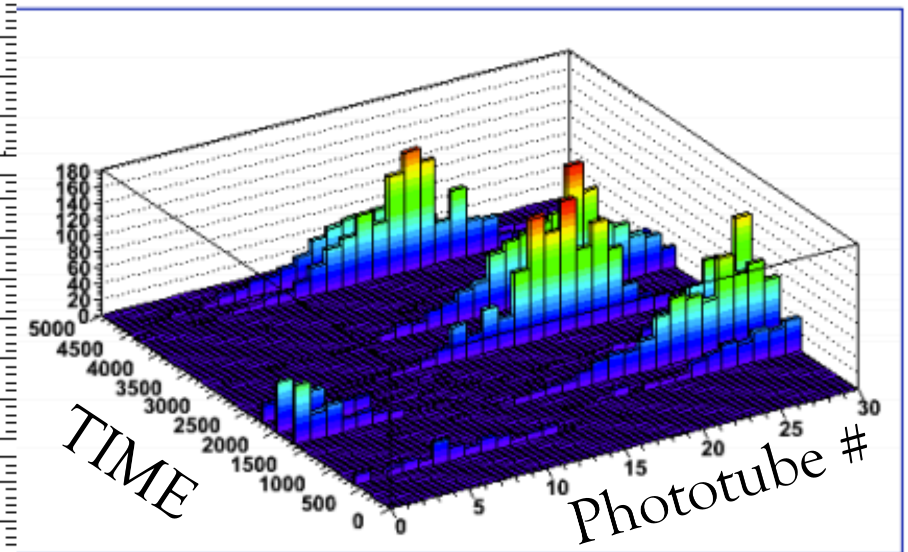




Use of light collection: Cosmic Ray Rejection



Connect light flash to track,
Was it in-time?



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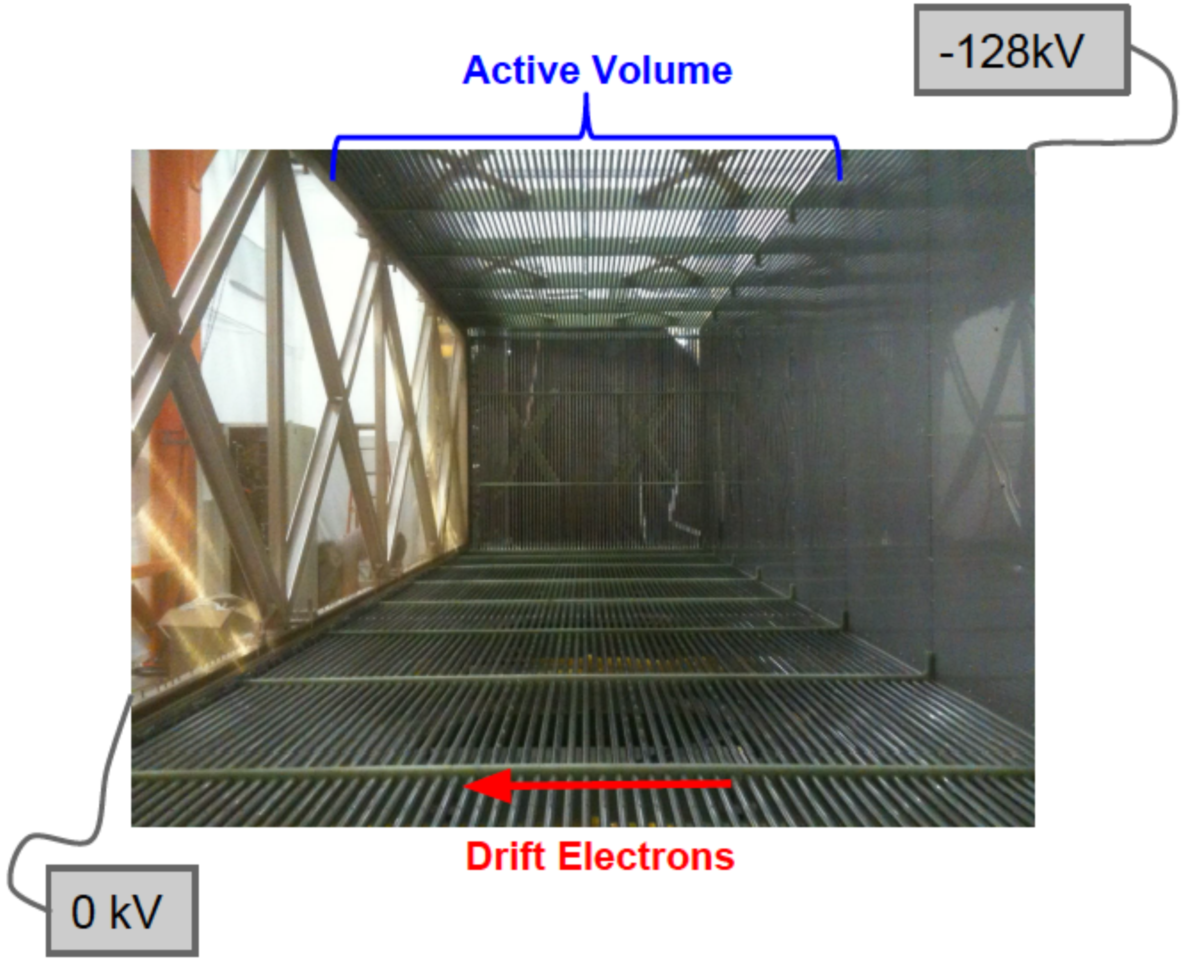
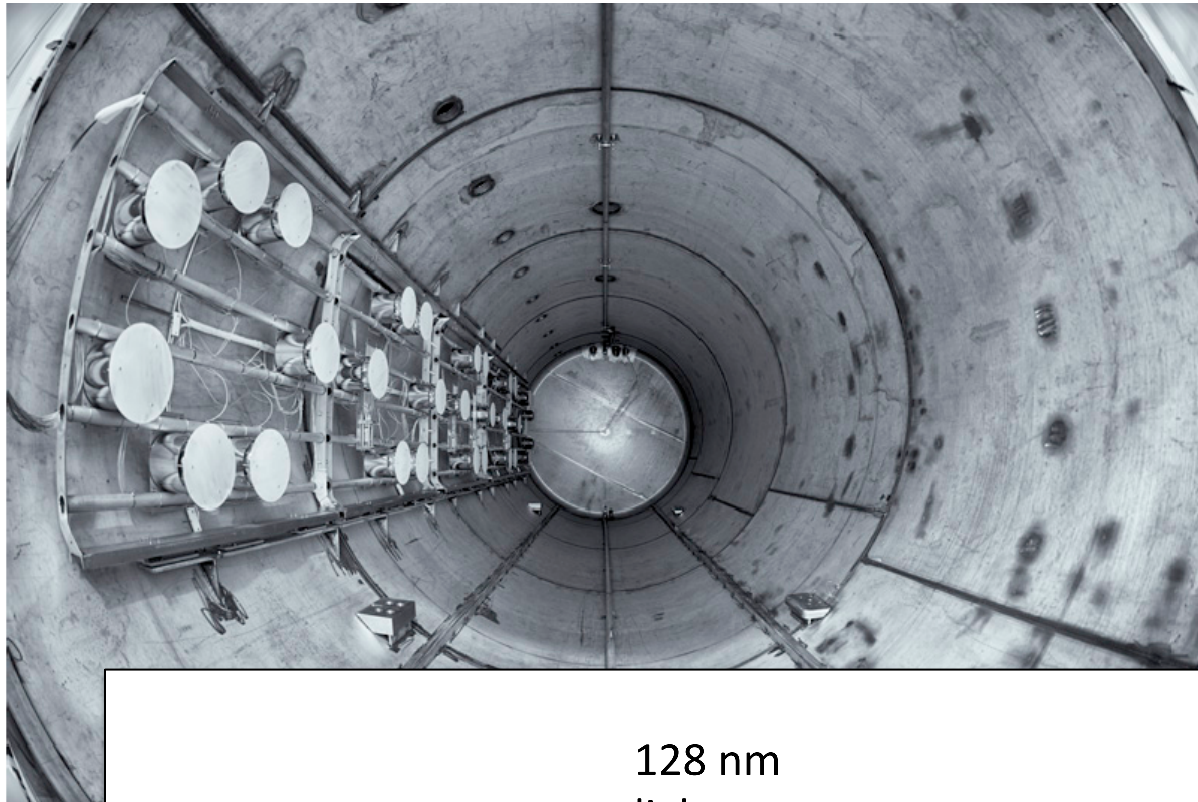
The TPC

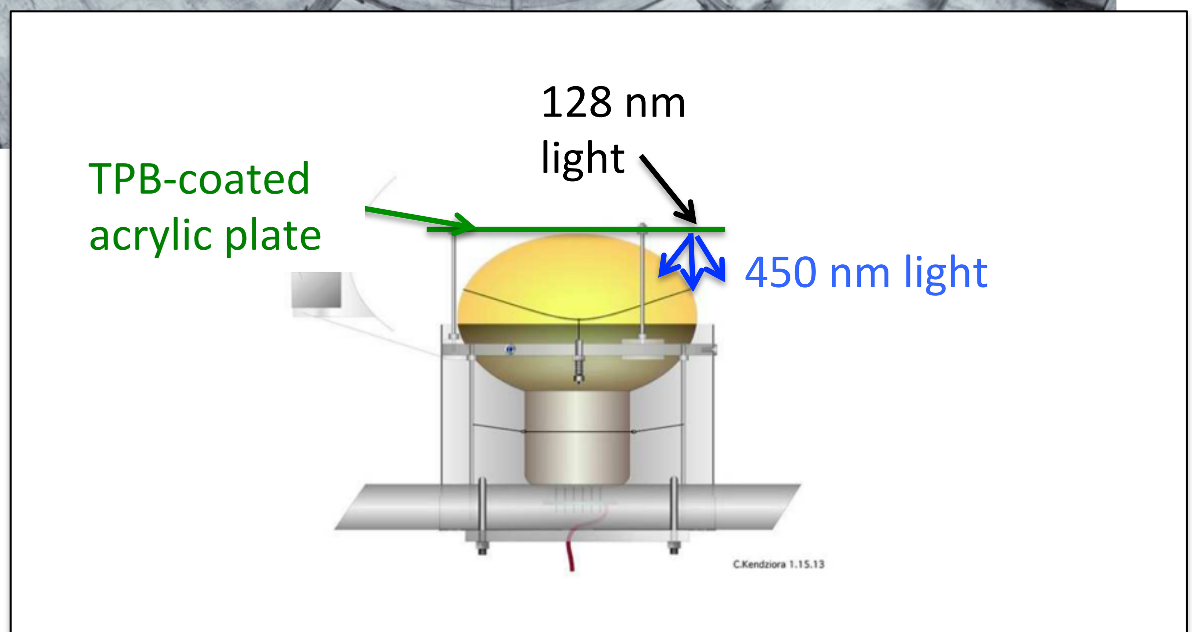
- Dimensions:
  - 10.3 m long x
    2.3 m tall x
    2.5 m wide
  - 80 t fiducial volume,
    170 t total
- 8256 wire channels
  - 3456 Collection channels
- Wires oriented w.r.t. the vertical
  - 4800 Induction channels
- Wires oriented +/- 60°



The Light Collection

- 32 cryo PMTs
- Each with wave length shifting plates in front





Inserting TPC

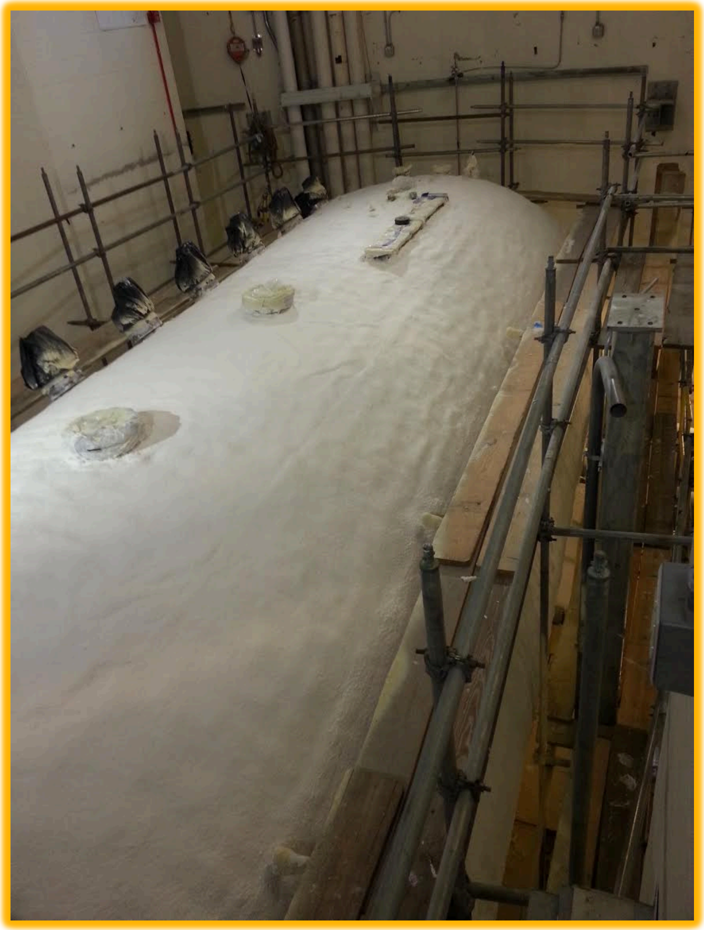
December 2013

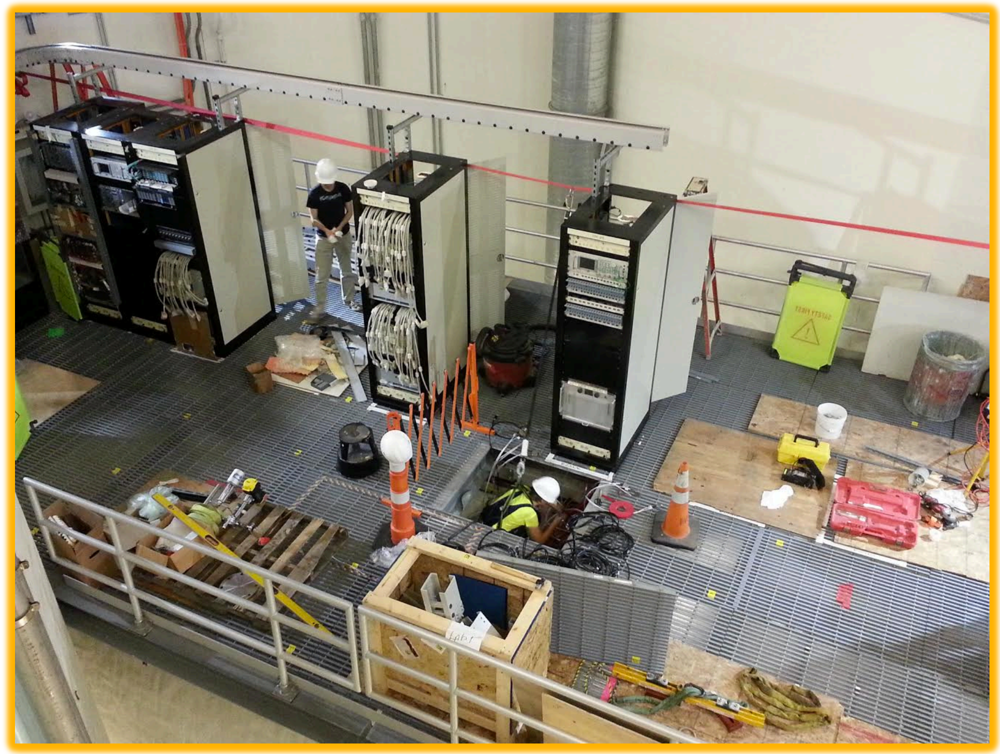
Putting end cap on...

Summer 2014

Load the detector on a truck,
Drive it around the Tevatron Ring…

… lower it into the building…





… coat it with insulation…

… and install electronics.

- Finish the LAr piping
- Cool and fill with LAr

Thank you.