MicroBooNE Status and Recent Results

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Rencontres de Moriond EW 2016

MicroBooNE: Some Motivation

- MicroBooNE is at the intersection of
  - Investigating open short baseline neutrino questions
  - Developing the technical knowledge to design, build, and operate a large ν detector for the future

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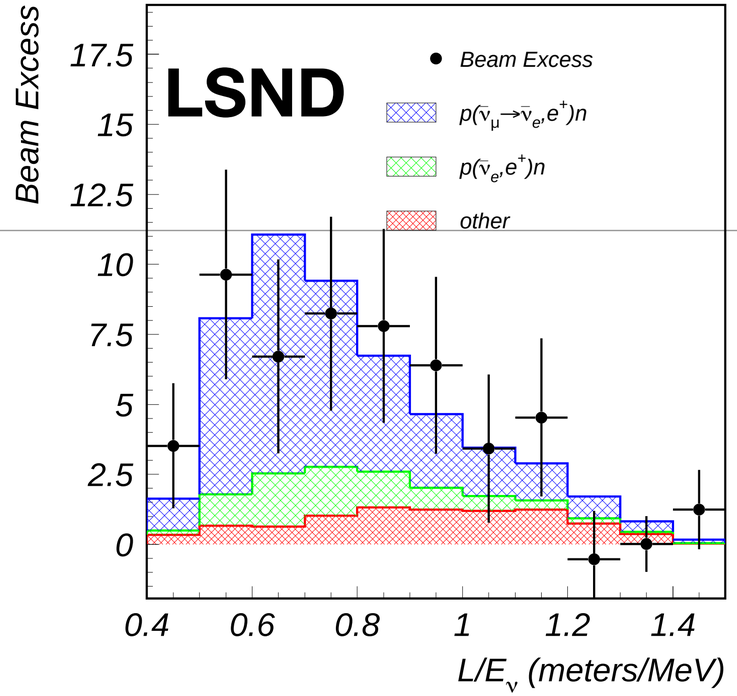

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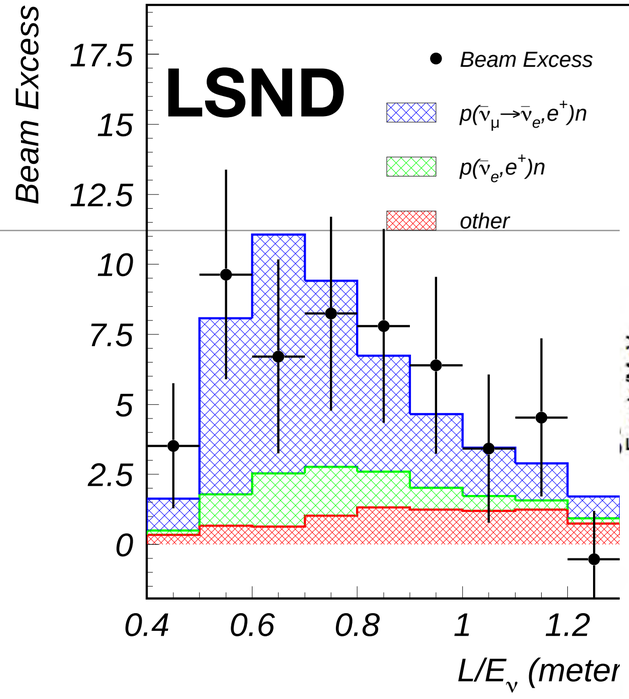

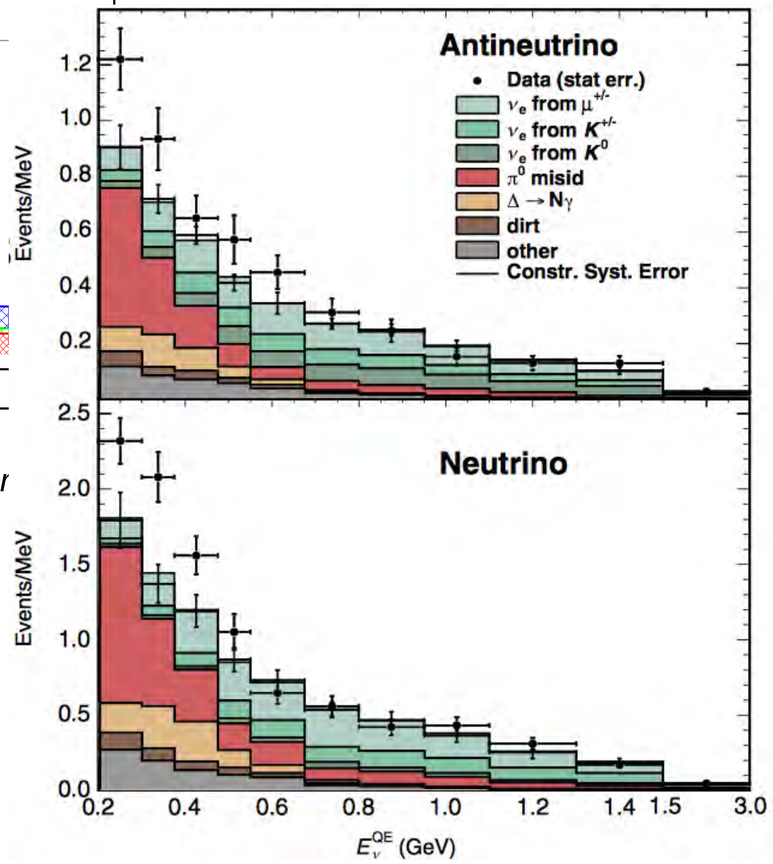

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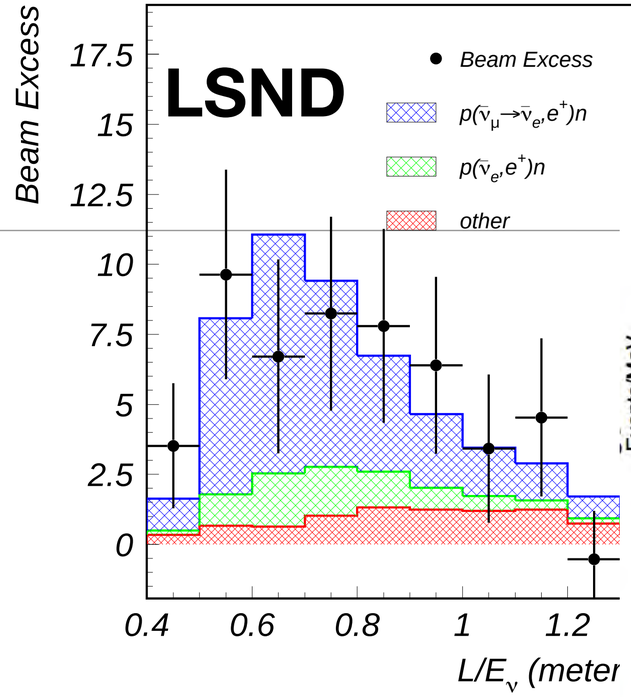

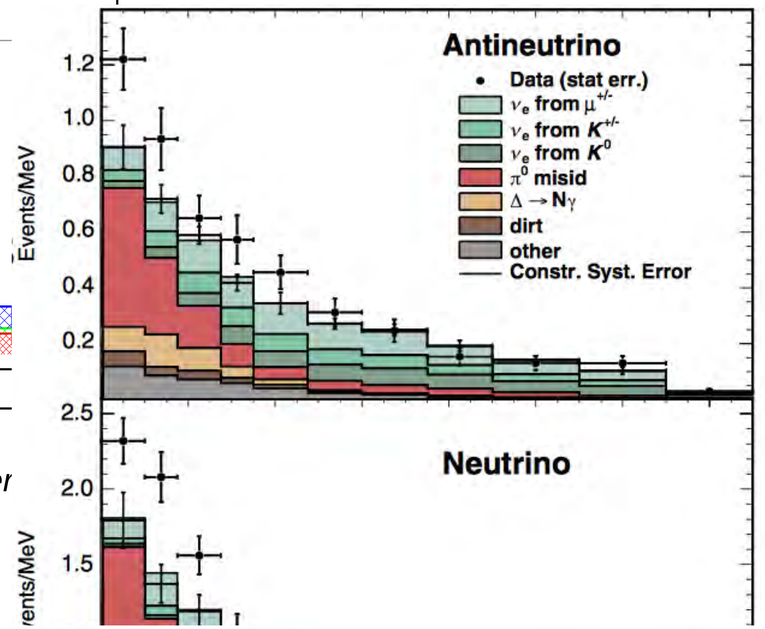

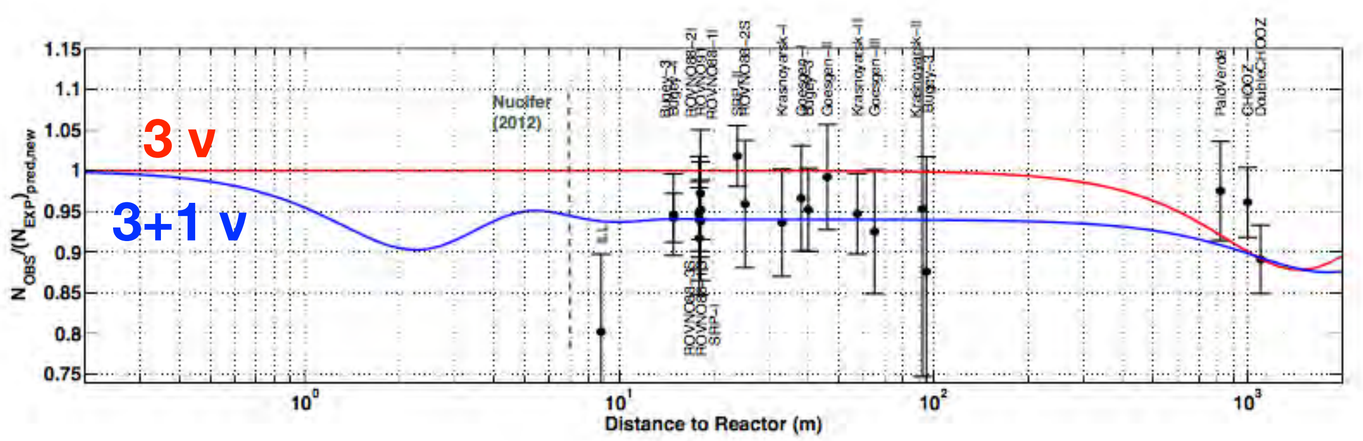

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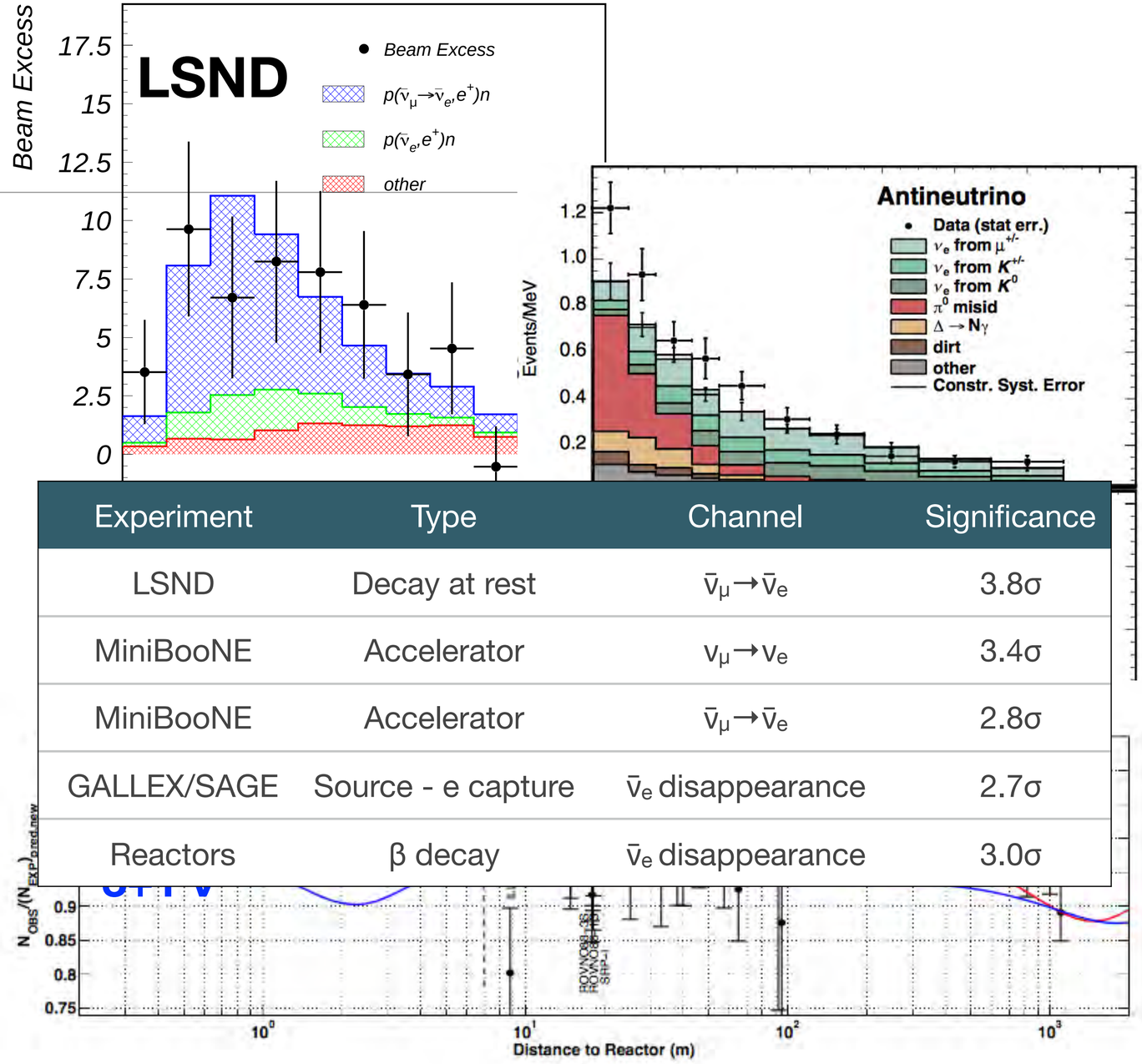
  - Taken together, these results could all be explained by a sterile ν state (see B. Kayser's talk)



Experiment	Type	Channel	Significance
LSND	Decay at rest	$\bar{\nu}_\mu \to \bar{\nu}_e$	3.8σ
MiniBooNE	Accelerator	$\nu_\mu \to \nu_e$	3.4σ
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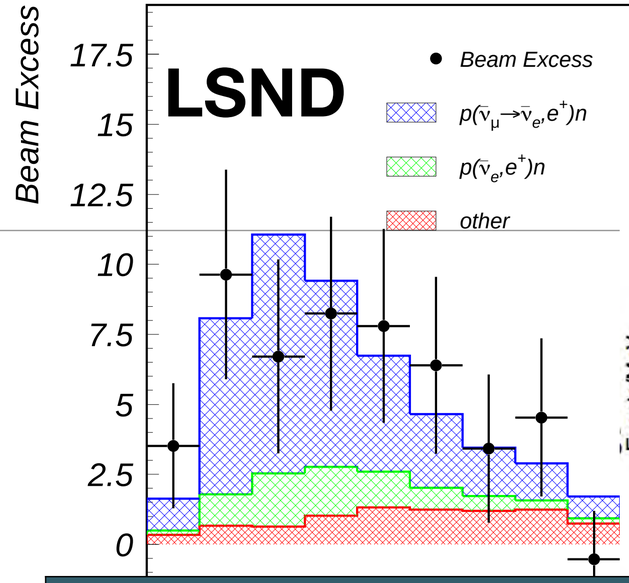
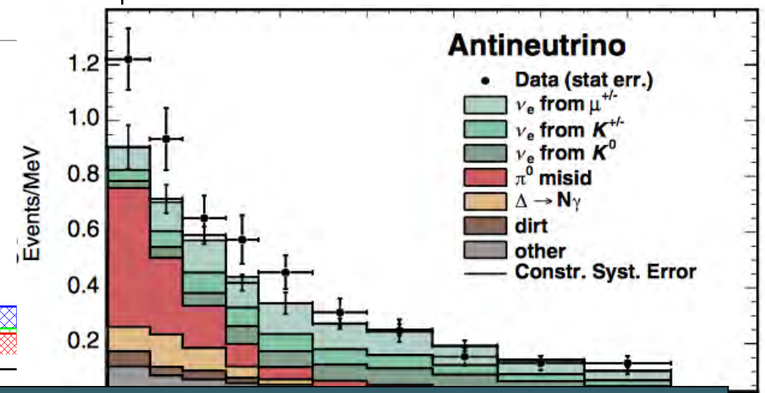
  - Please see: http://arxiv.org/pdf/1204.5379v1.pdf





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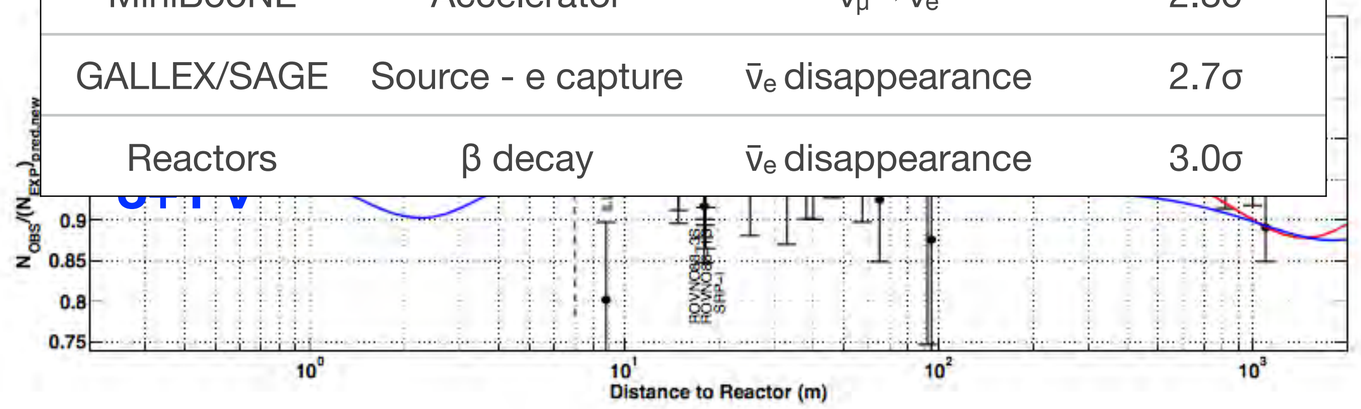
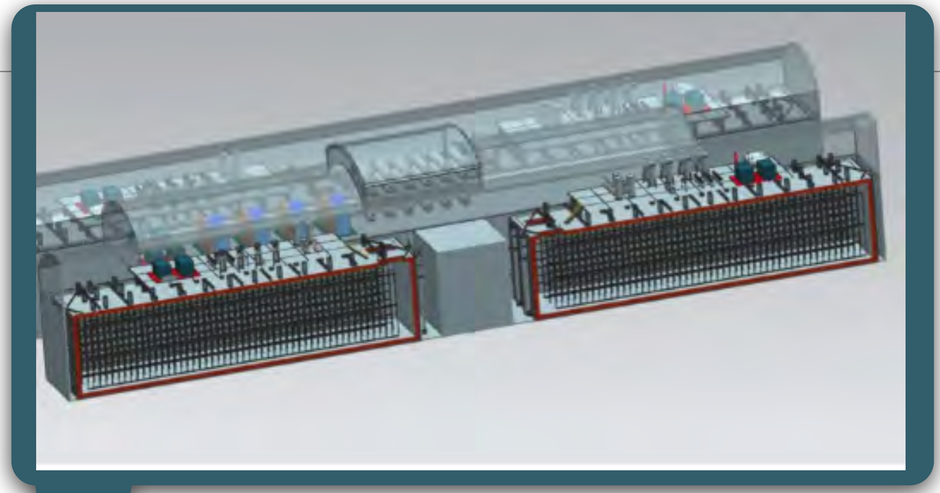
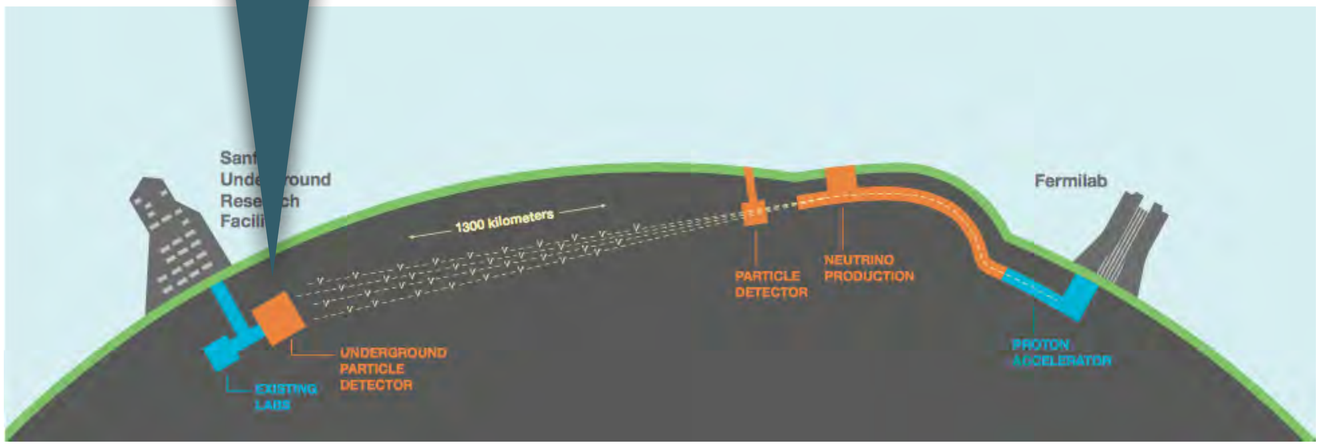


MicroBooNE: Motivation

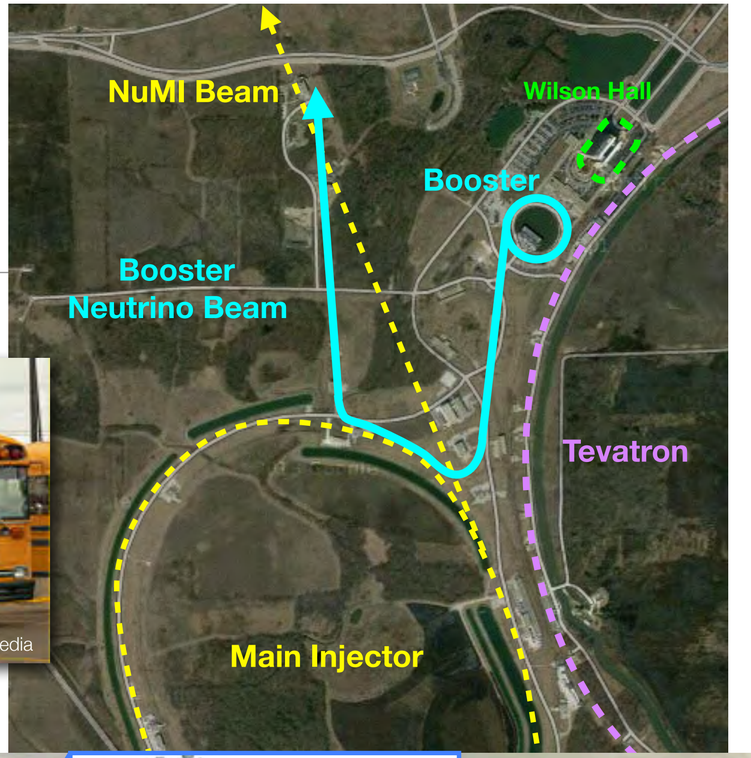
- Developing the technical knowledge to design, build, and operate a large ν detector for the future
  - DUNE: 40 kT detector (240x larger!)
  - To be built in South Dakota, USA
  - Primary goal is to study CP violation





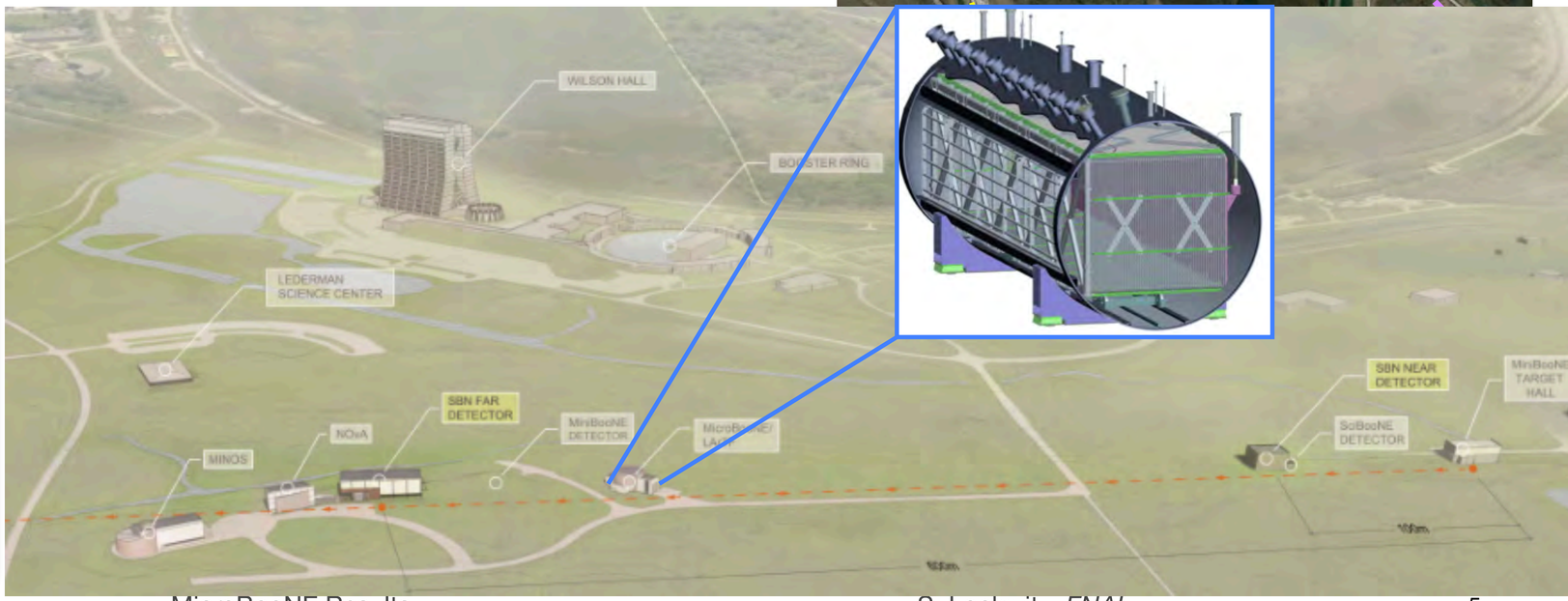
On to MicroBooNE

- MicroBooNE is a new experiment in the Booster beam line at Fermilab
- Located here, similar L/E to MiniBooNE
  - It will investigate the short baseline anomalies…
- And it is a LArTPC!
  - ICARUS demonstrated the capability of LArTPCs
  - With MicroBooNE, we'll gain experience needed for a number of future planned LArTPCs (DUNE, SBND, protoDune)
  - ν cross sections
  - R&D for LArTPCs



By the numbers:

- **2.56 x 2.33 x 10.36 m active volume**
- **170 T (86 T active)**
- **8256 wires, 3 planes, 3 mm pitch**
- **32 8" PMTs**



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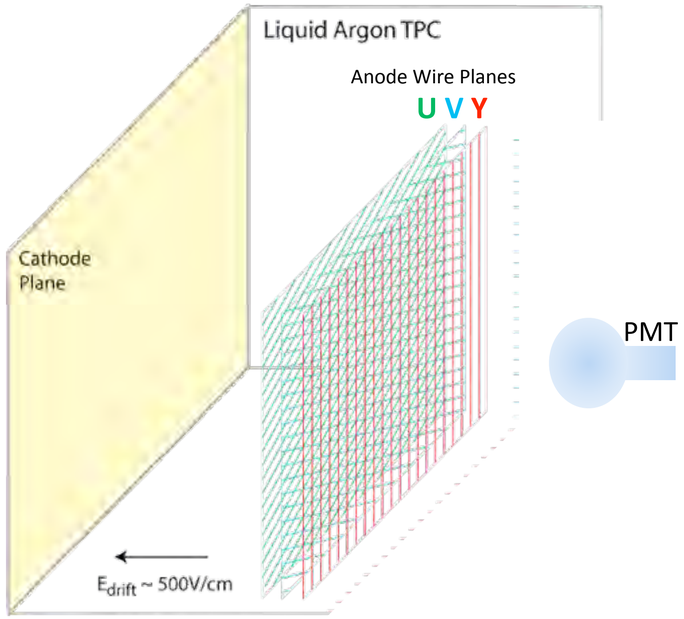

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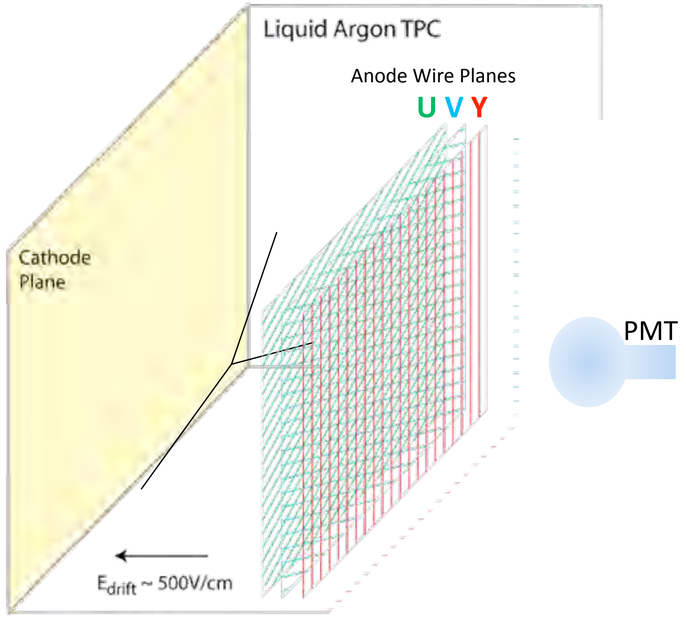

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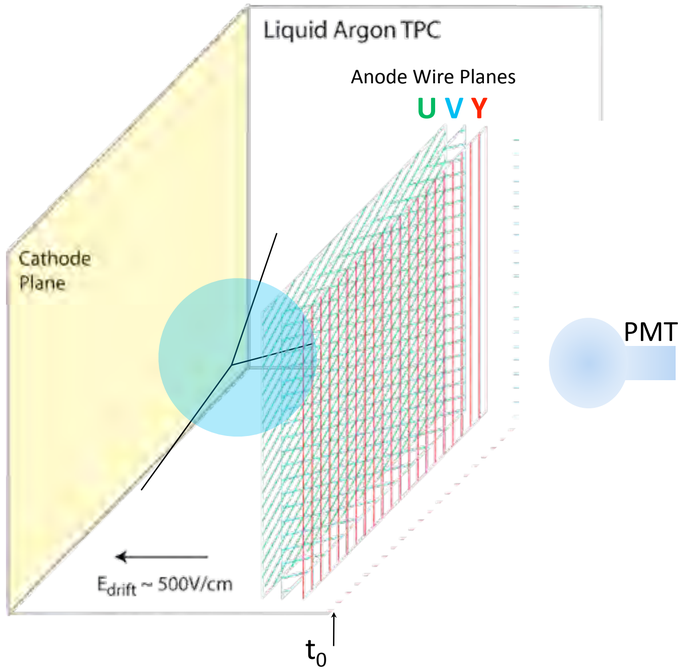

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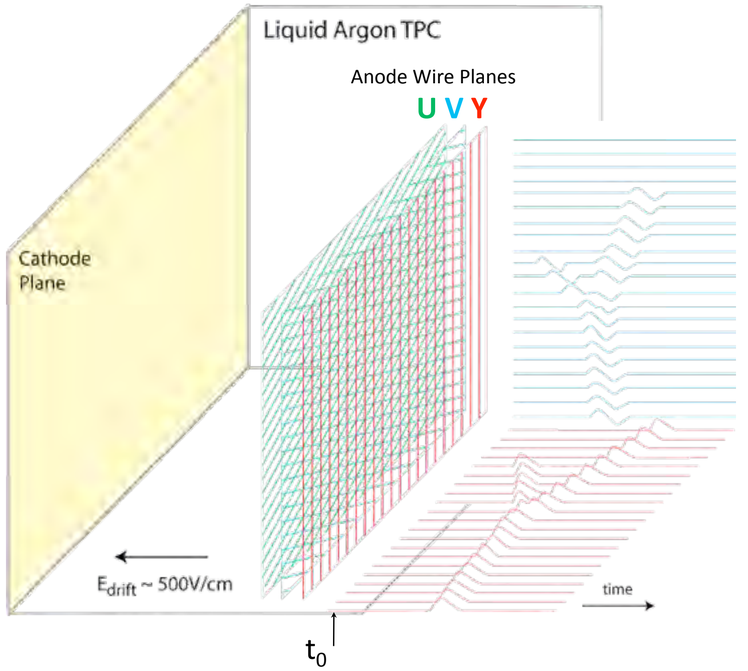

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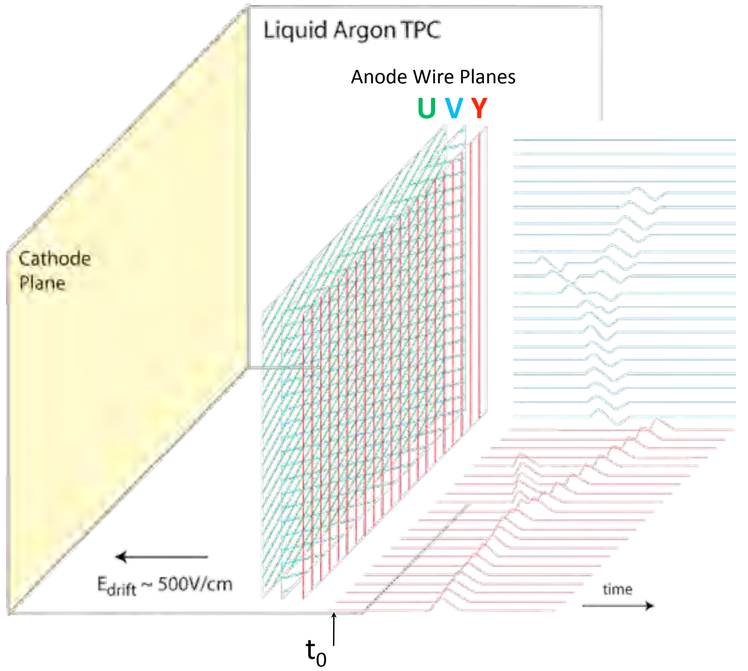

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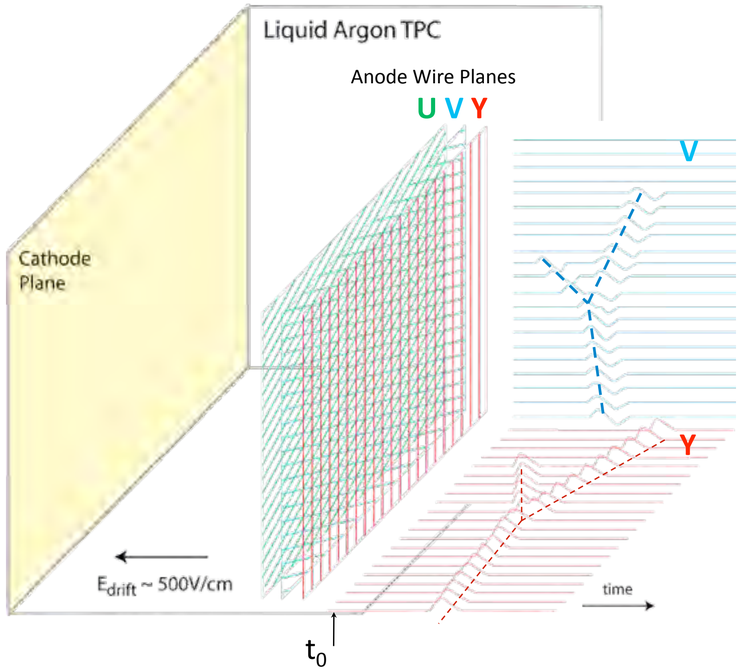

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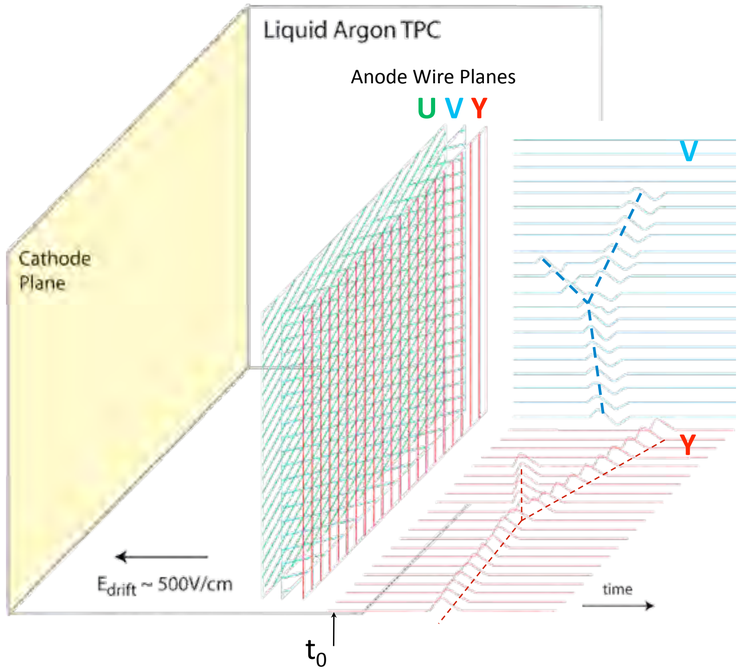

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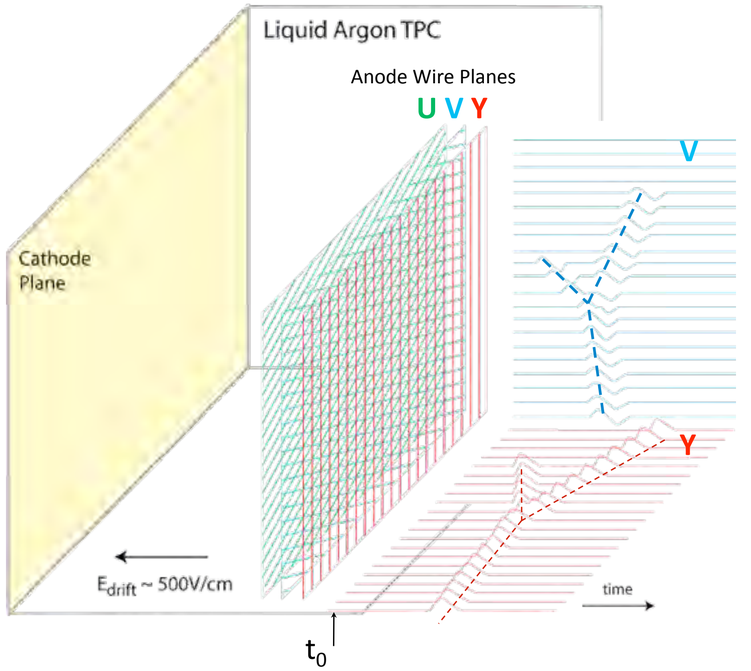
  - Drift distance is found from knowing t_0 & v_d → Time projection!



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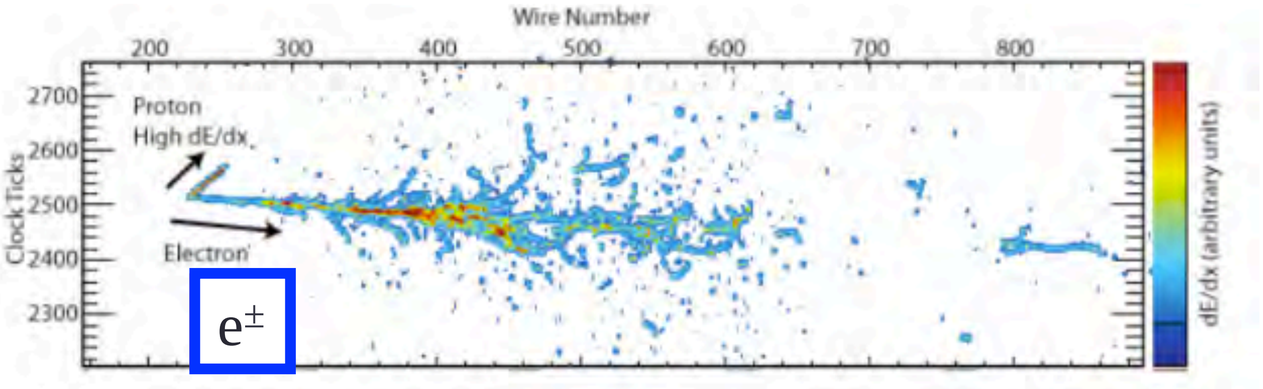
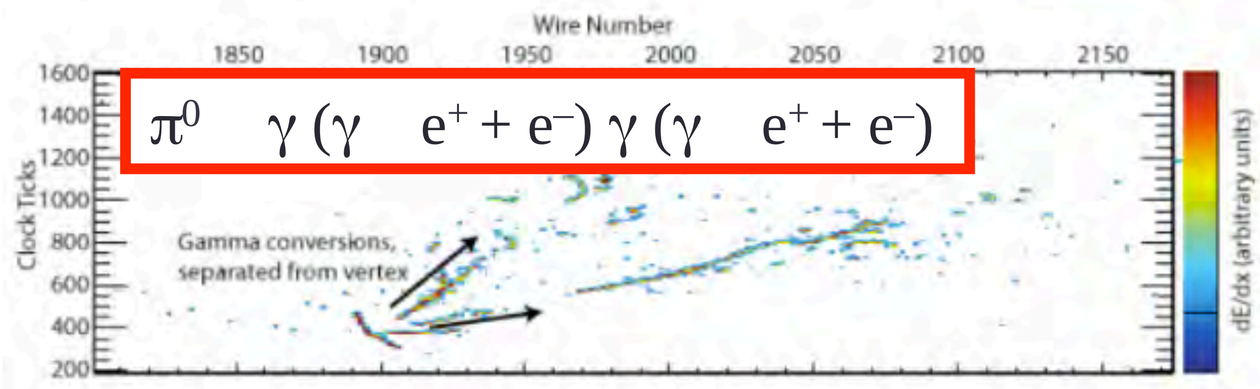
What is a LArTPC?

- And it produces events like this:
- And allows us to differentiate e's and γ's
  - Using event topologies and dE/dx





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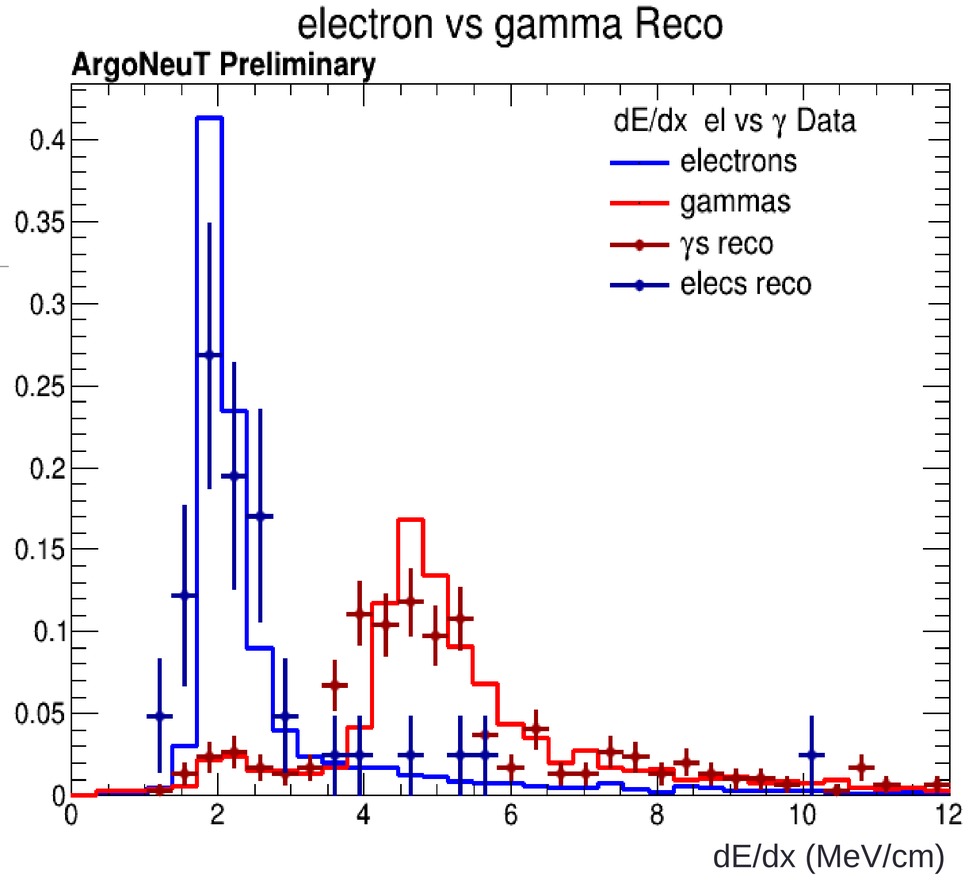
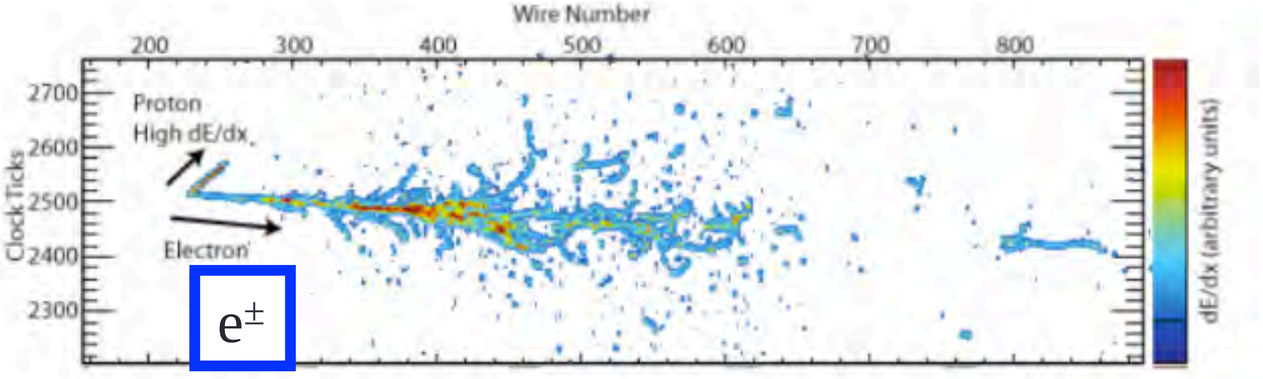
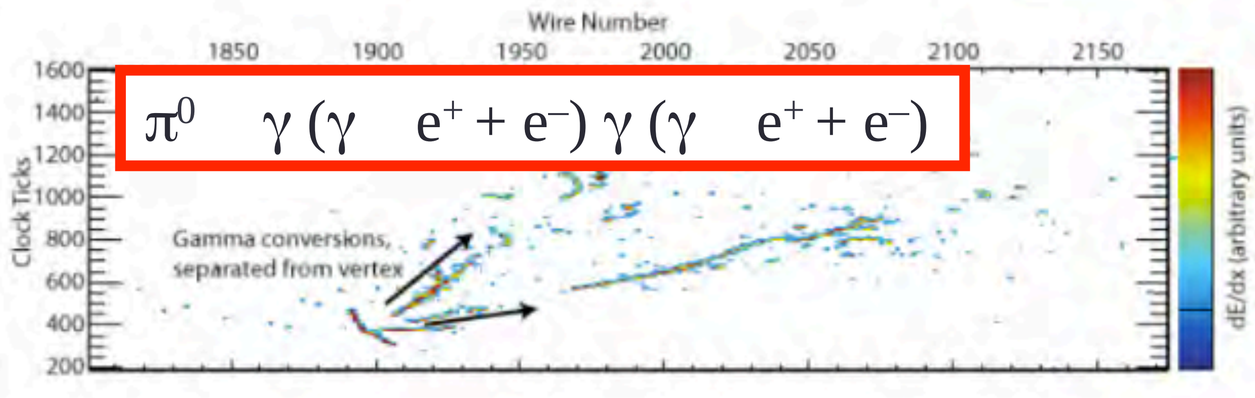


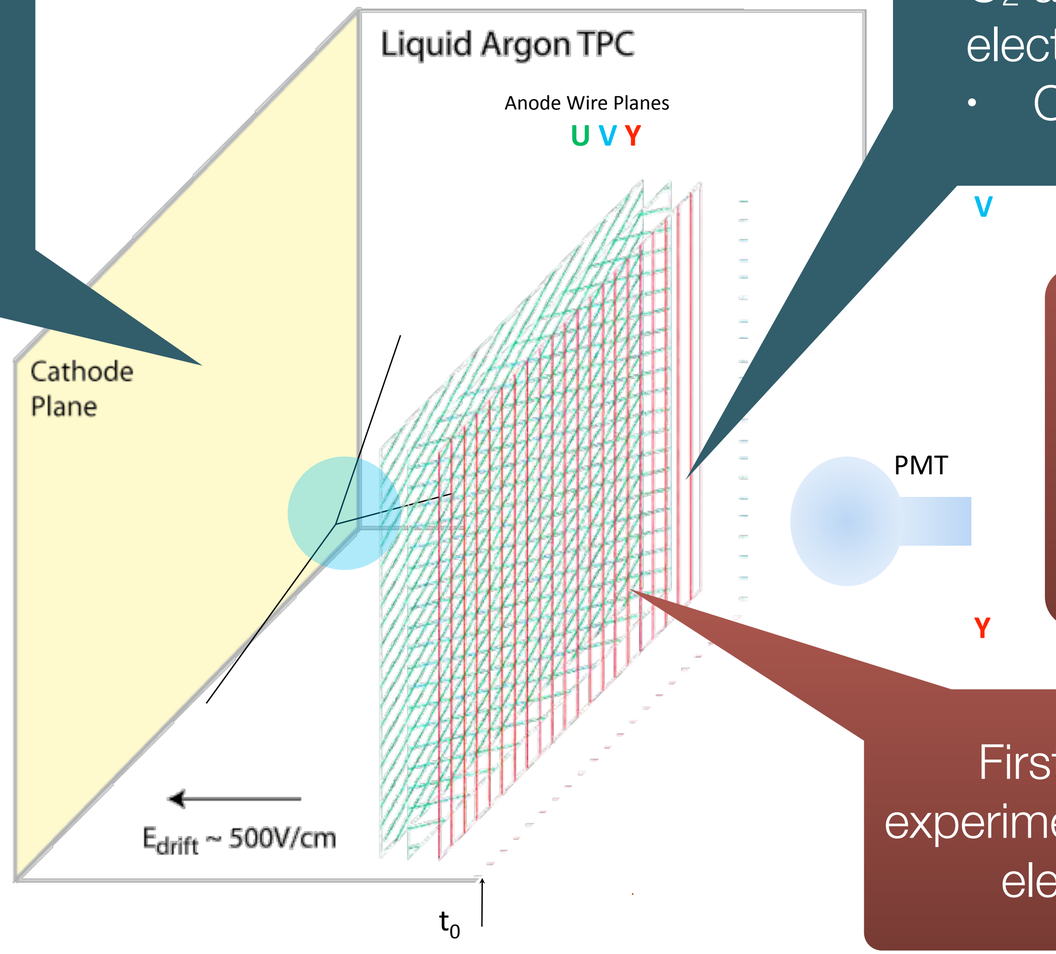




Key Considerations in LArTPCs

Cathode Voltage:
Needs to produce a field ~10s kV/m to drift signal electrons

First LArTPC in a neutrino beam with a 2.56 m drift



LAr Purity:

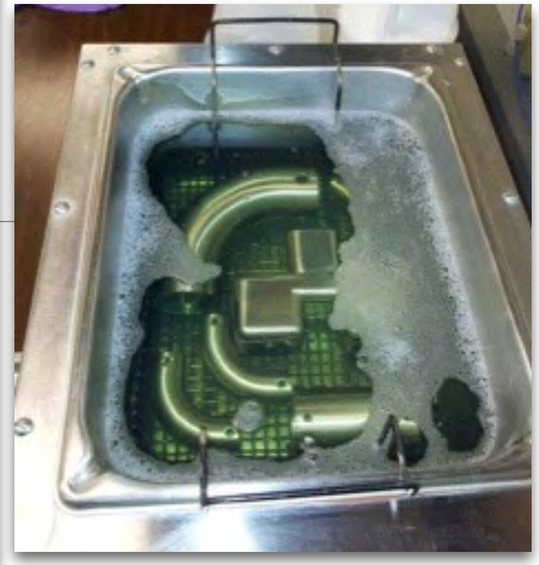
- Nitrogen quenches scintillation light
  - N_2 < 1 ppm
- O_2 and H_2O reduce the signal electrons from ionization
  - O_2 < 100 ppt O_2 equivalent

First neutrino experiment to attain purity without pulling a vacuum. Important for future experiments.

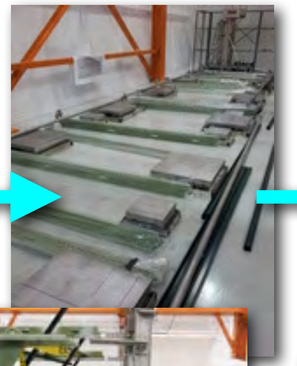
First neutrino experiment using cold electronics

MicroBooNE Construction & Installation

- Parts clean in 2012
- Constructed in 2012-2013
- Wire installation spring 2013







MicroBooNE Construction & Installation

- Inserted into the cryostat Dec. 2013.
  - Cold electronics installed, extensive testing, end cap welded on
- Transferred to LArTF (June 2014)
- Insulated with foam (not vacuum jacketed)
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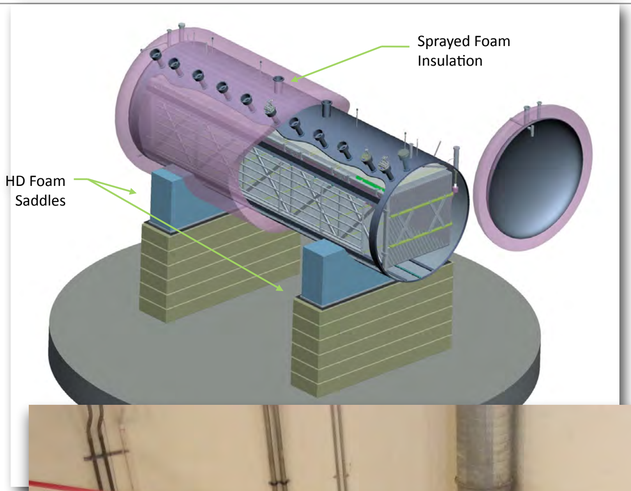
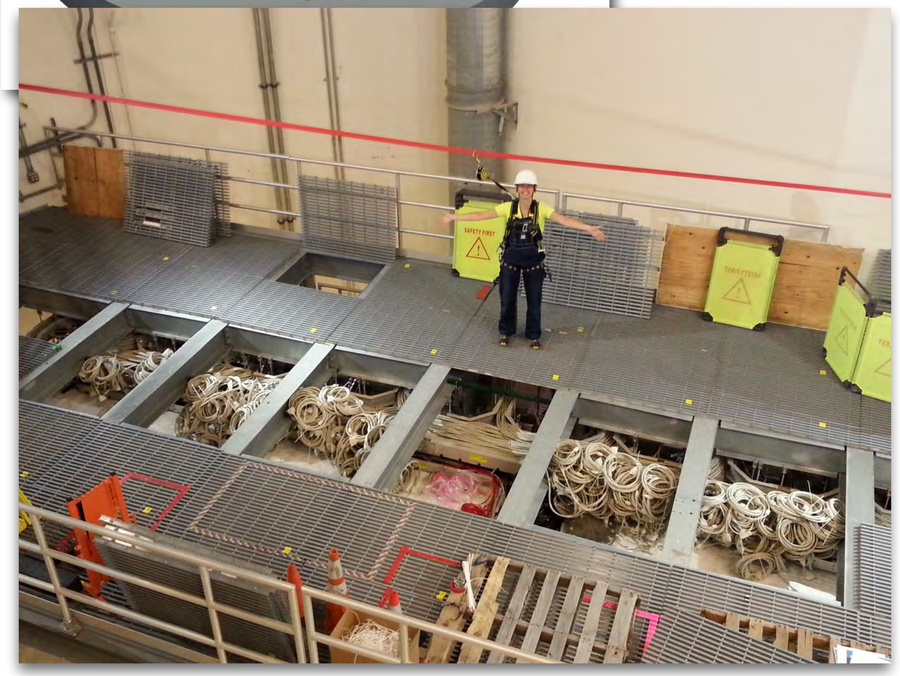
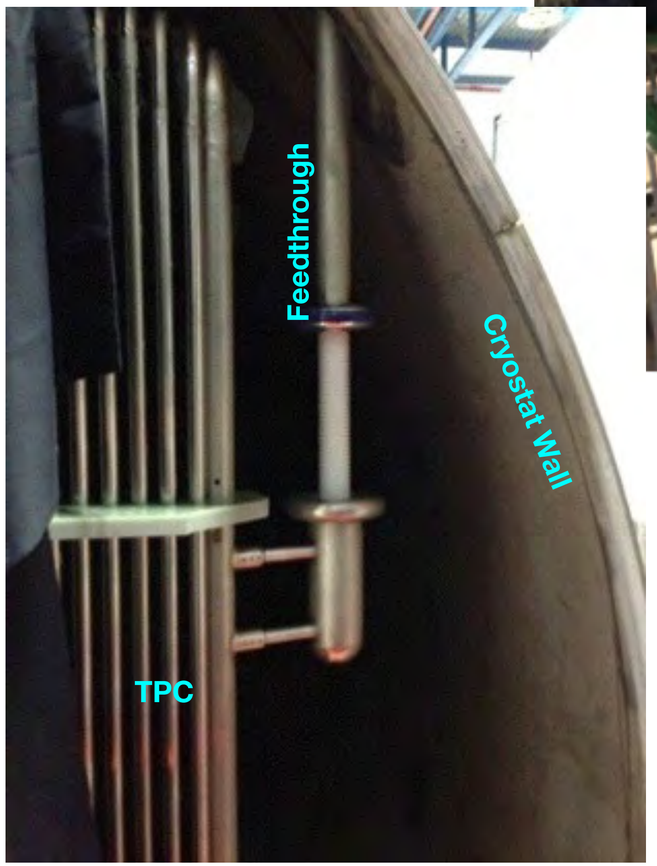




MicroBooNE Installation: HV Feedthrough

- The HV feedthrough was installed on 11/18/2014
- Prior to insertion, it was tested in an different cryostat for 4 days at -128 kV in ultra-pure liquid argon
- While developing and testing the feedthrough, I found that the dielectric strength of LAr not as expected….
  - Feel free to talk about this further with me.



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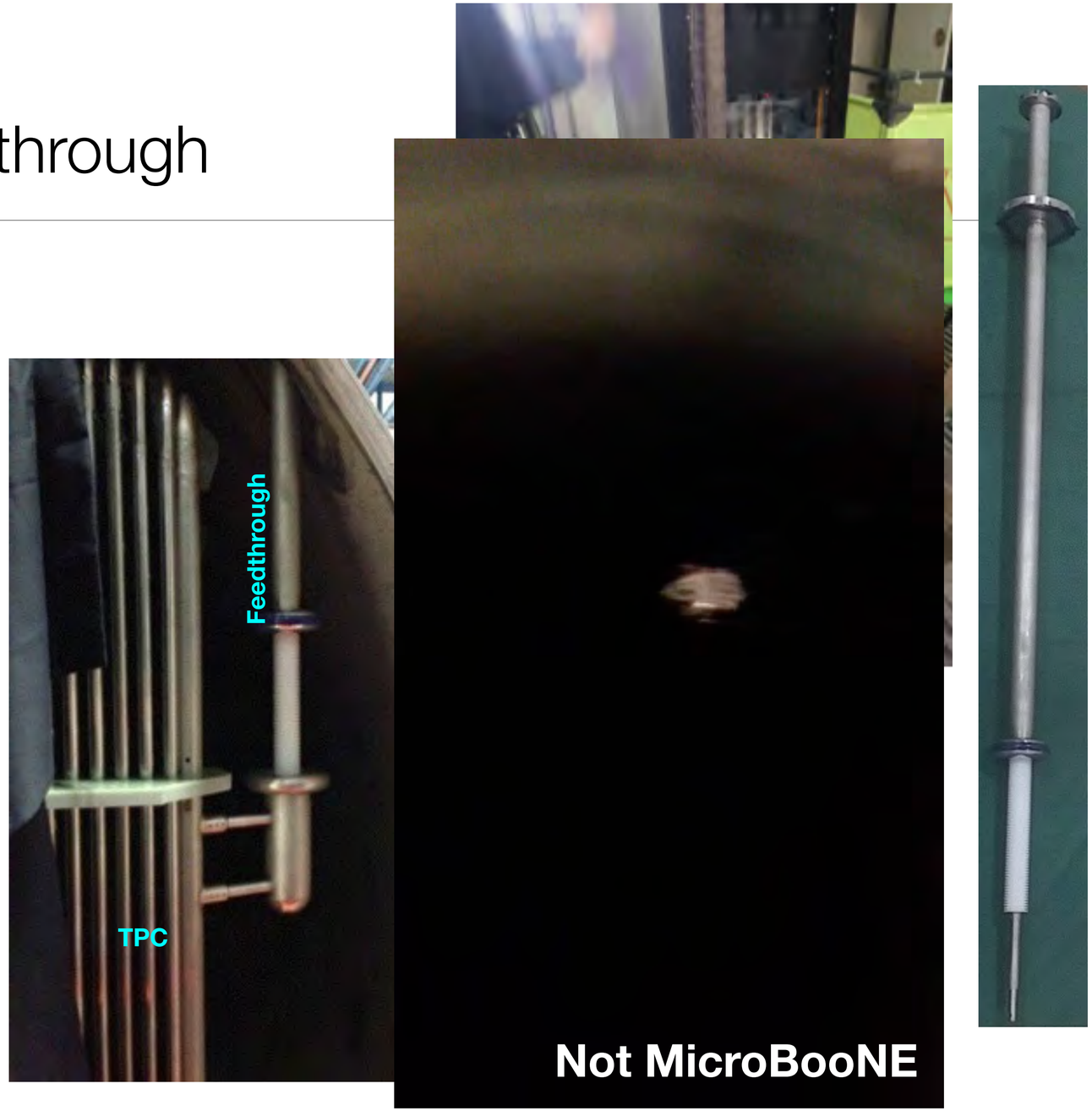
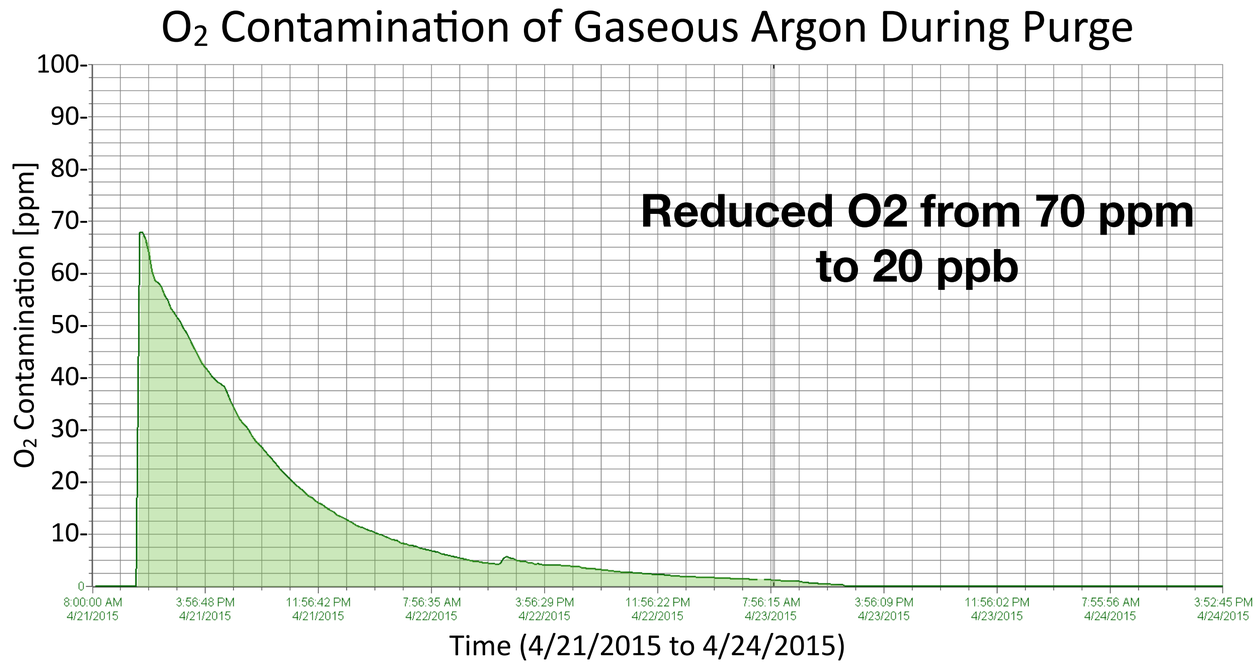
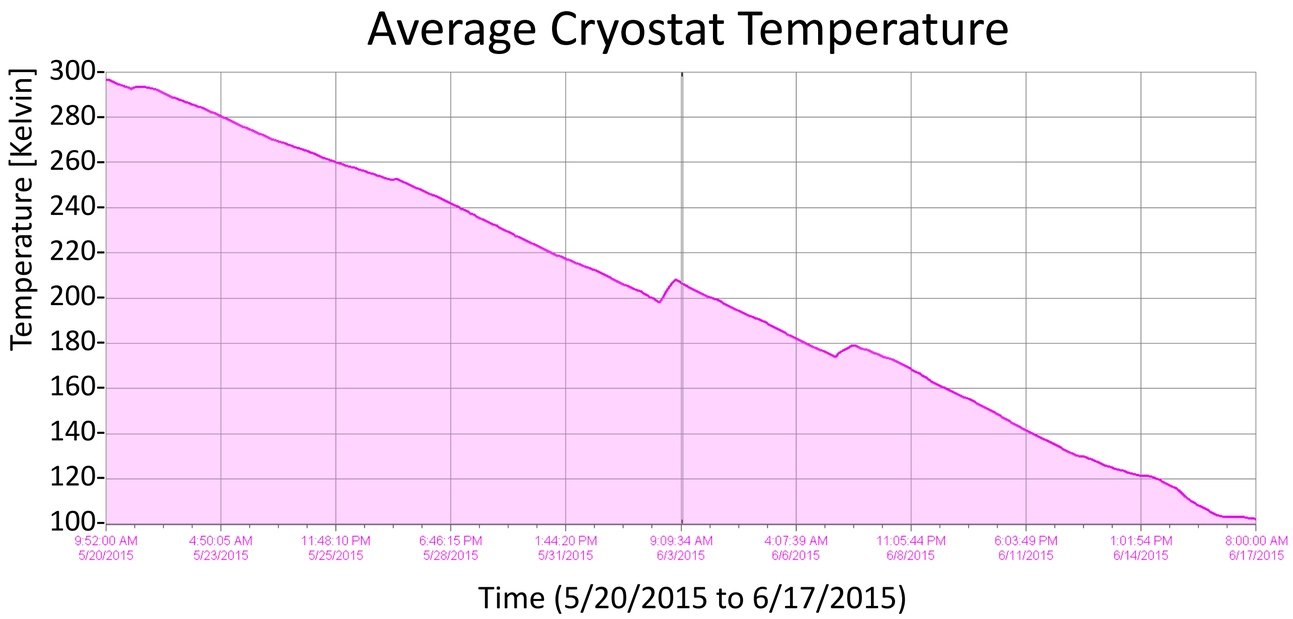


MicroBooNE Commissioning

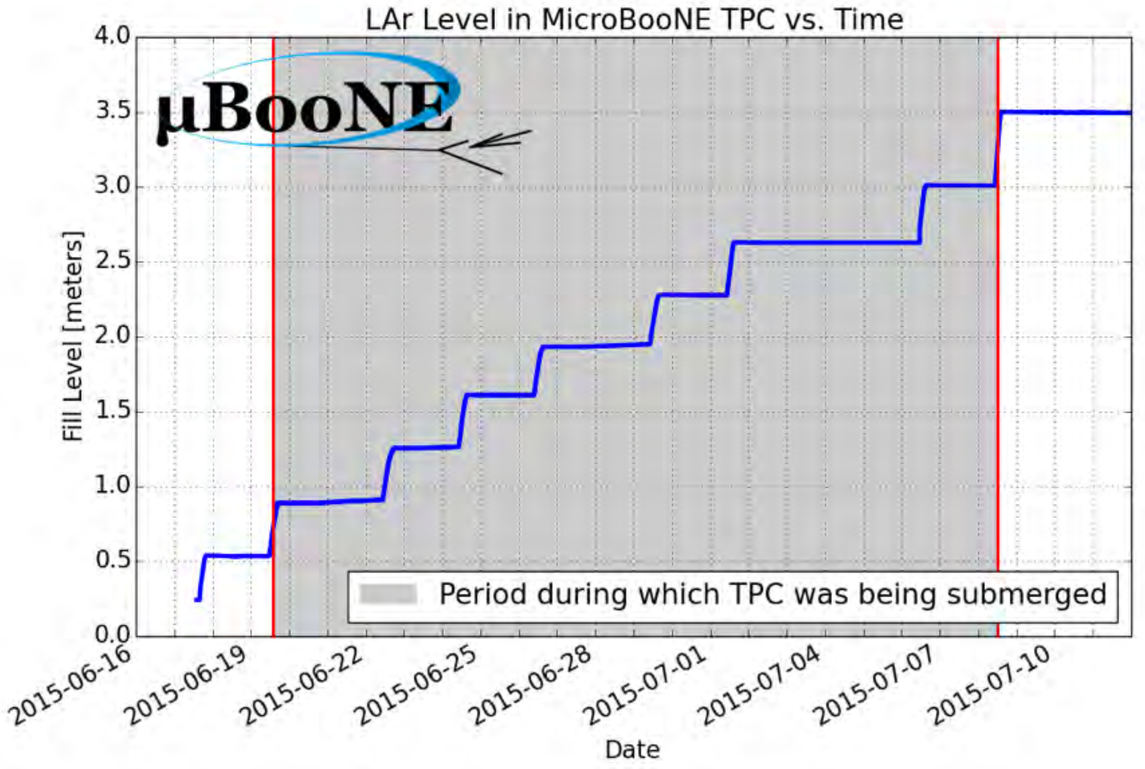
- Purged with argon gas
  - Flush impurities (no vacuum pulled)
- Cooled down the argon gas before filling
  - Reduces outgassing —> better quality liquid after after filling





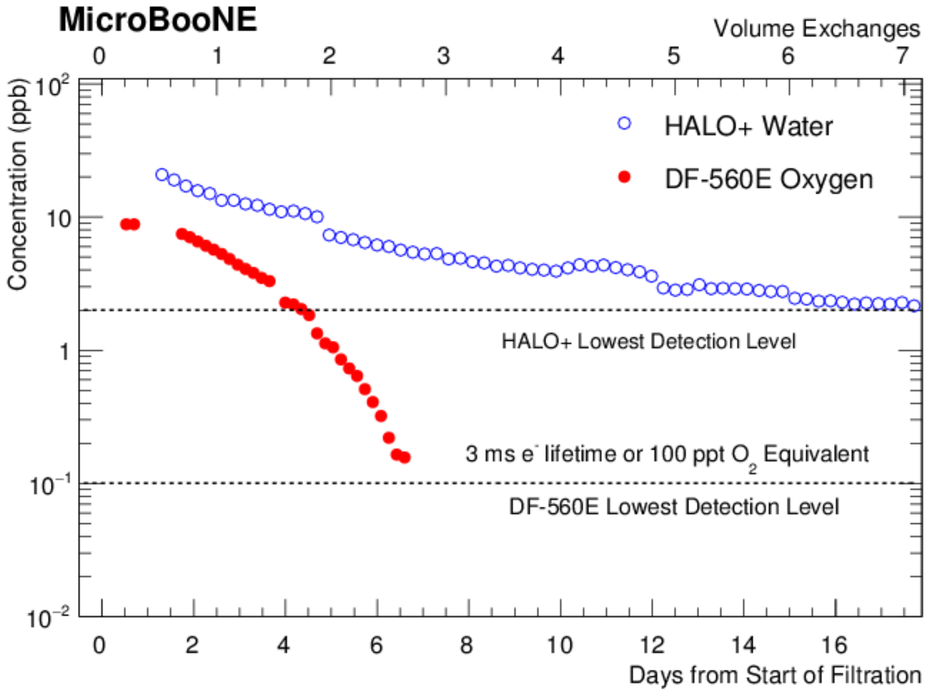
MicroBooNE Commissioning

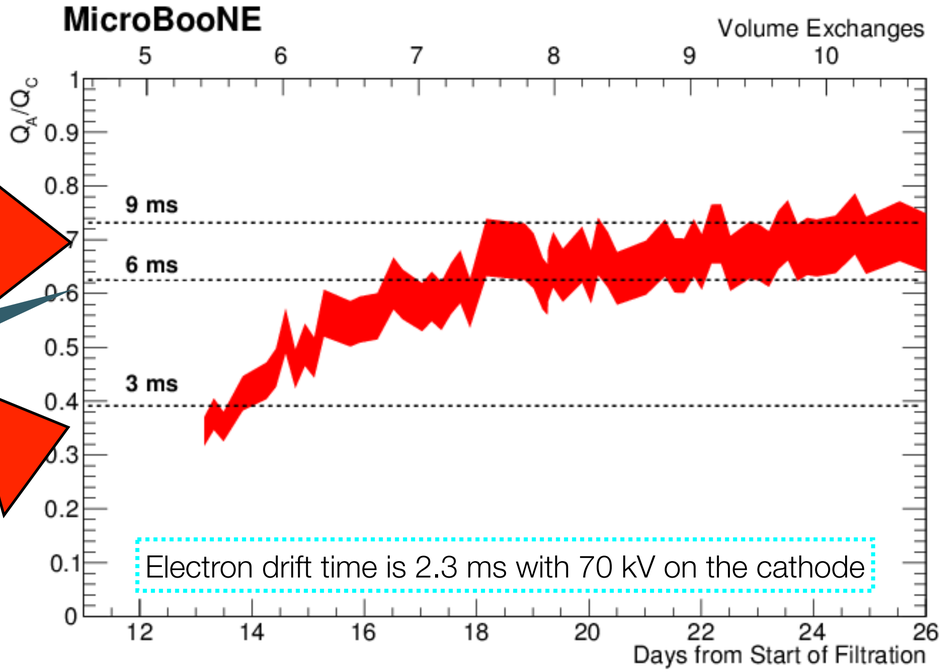
- Filled with clean liquid argon
  - 170 T, 86 T active
  - Specified at $N_2 < 2$ ppm, $O_2 < 1$ ppm
    - All truckloads were better than this
  - Took 9 truckloads and 28 days



MicroBooNE Commissioning

- Started filtering the liquid to purify further on July 24, 2015
- Gas analyzers monitoring
  - Sensitive down to 2 ppb water, 100 ppt O_2
- Purity monitors for 10-100 ppt O_2 equivalent contamination
- Beat the design goal 3 ms!
- Consistently run at 9 ms!



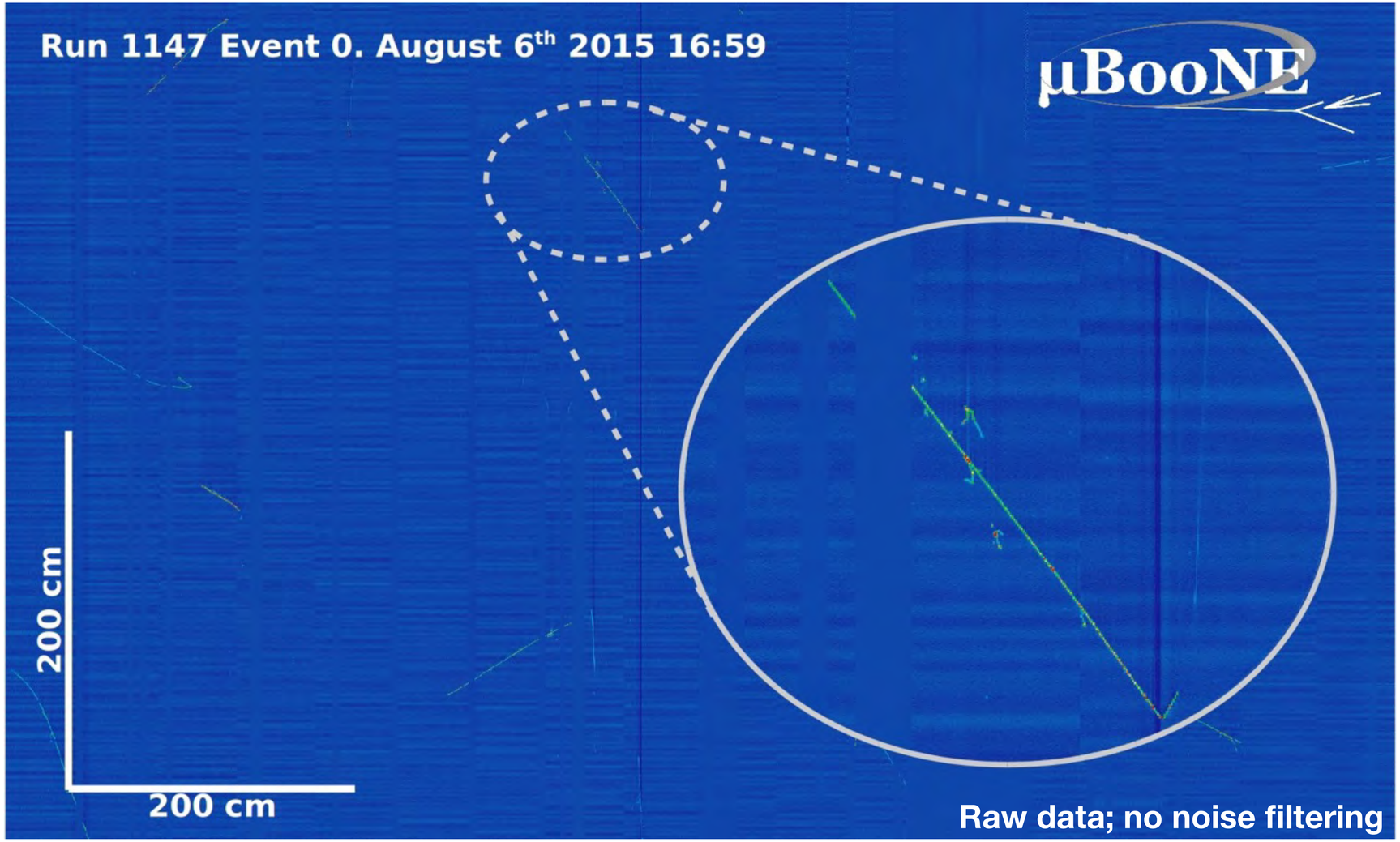


Where we run!

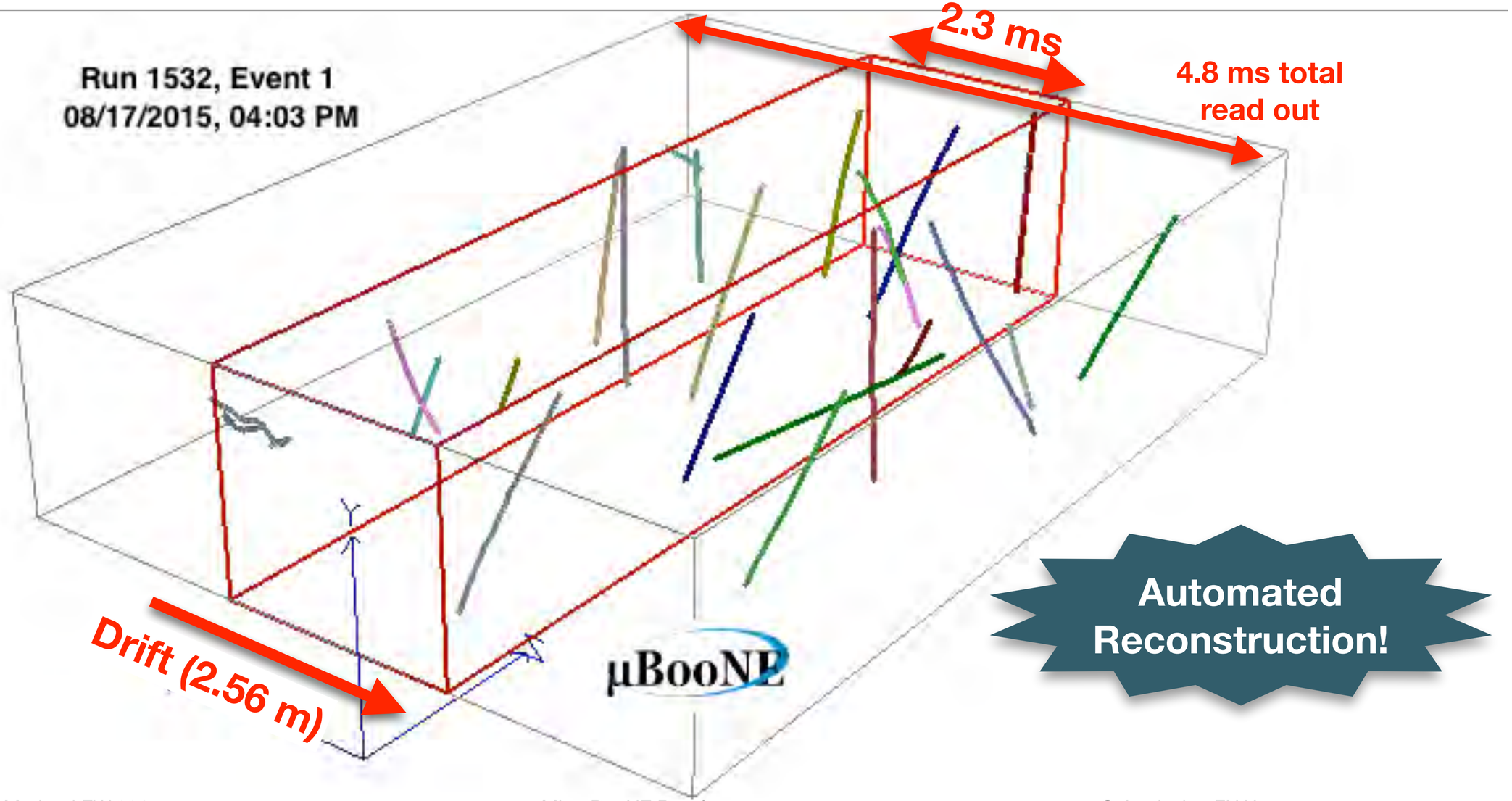
< 50 ppt O2

MicroBooNE Commissioning: High Voltage Turn On!

- We turned the HV on the cathode and saw cosmic events immediately!

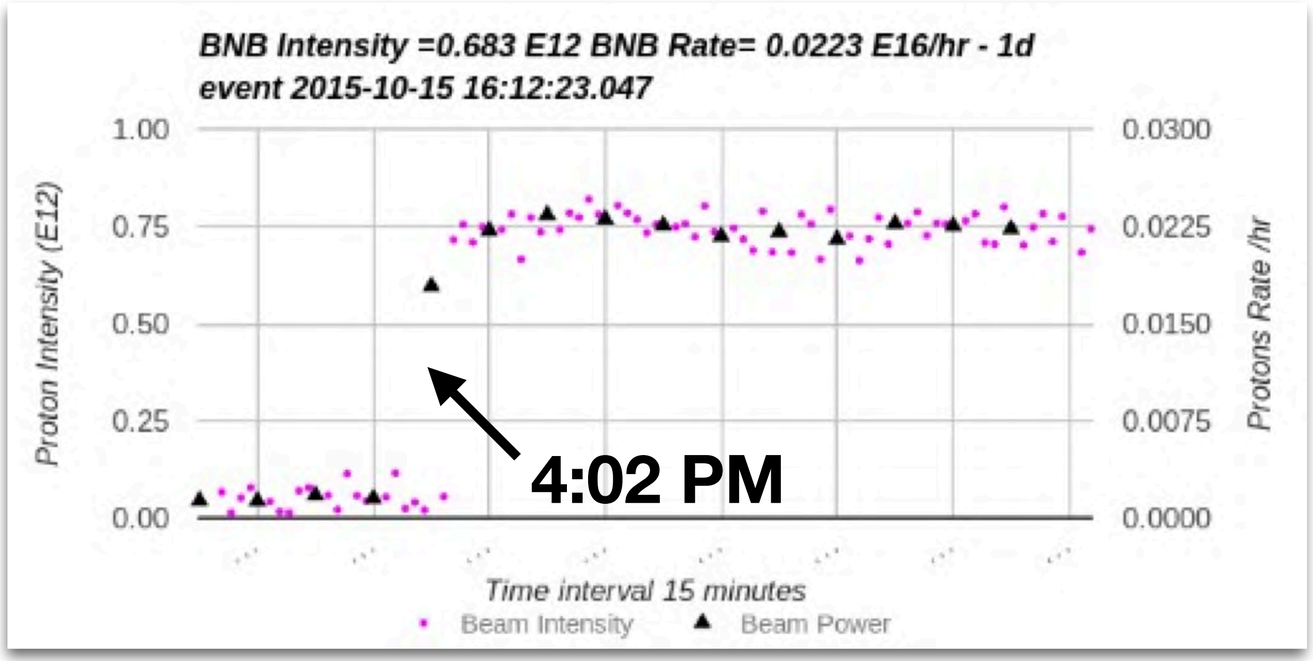


Continued Commissioning with Cosmics



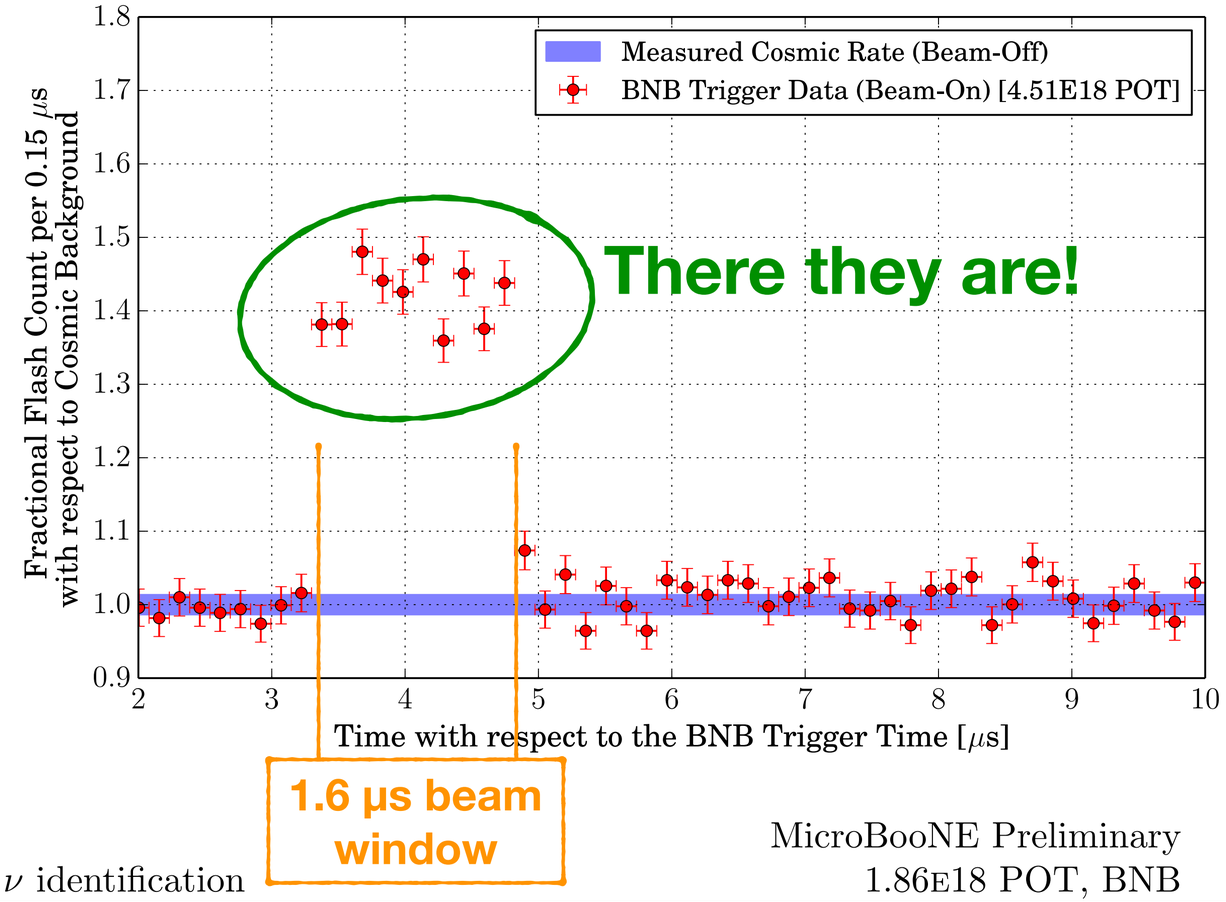
Neutrino Beam

- On October 15, 2015, we received our first neutrino beam!



Neutrino Hunt!

- Being near the surface, the activity in the cryostat dominantly comes from cosmics
- Using the PMTs, we looked for light related to the Booster timing signals:
- In an effort to see first neutrinos, we cut hard on the automated reconstruction
  - Cut on detector boundaries and light information
  - Excess over background is there! Low efficiency, but high purity:

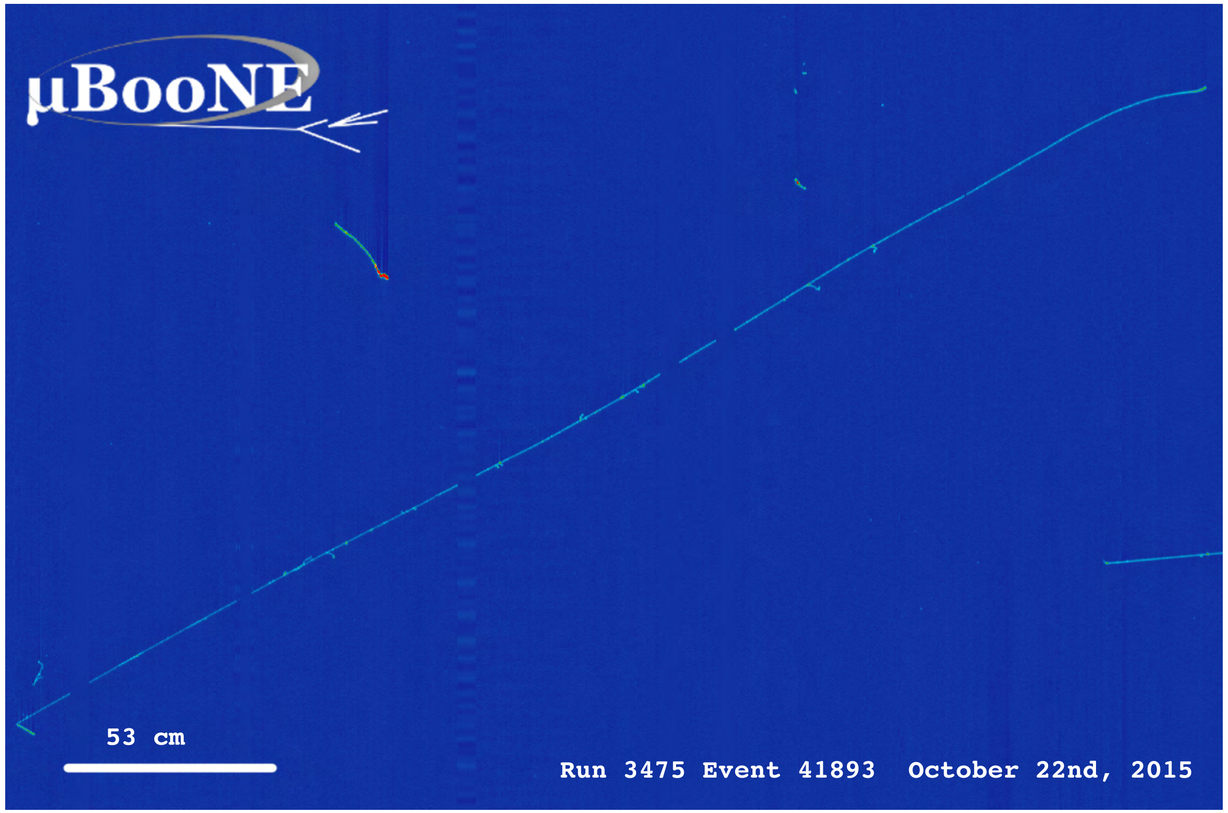


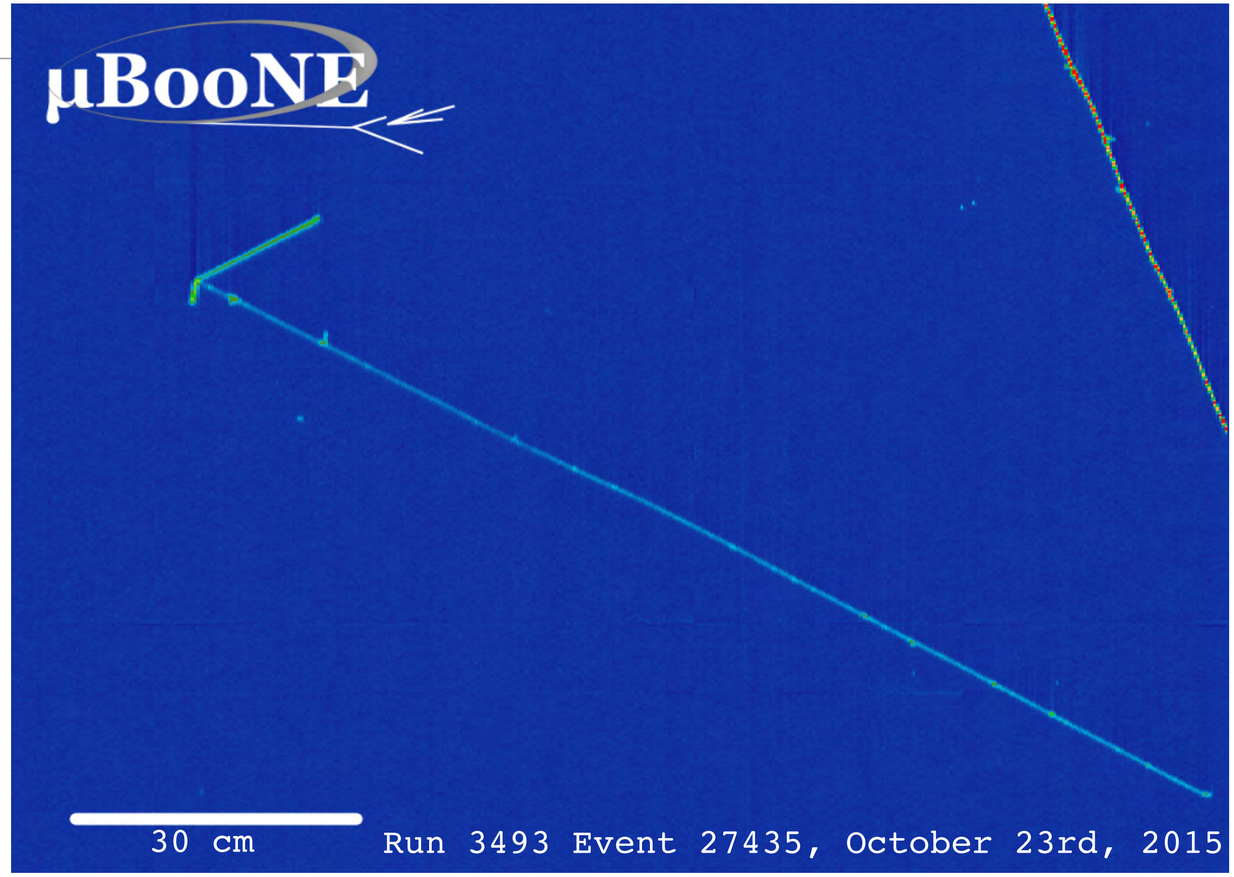
First ν identification

MicroBooNE Preliminary
1.86E18 POT, BNB

Number of events	Automated event selection Optical + 3D-based	Automated event selection Optical + 2D-based
Non-beam background (expected)	4.6 ± 2.6	385 ± 24
Total observed	18	463

First Neutrino Candidates!

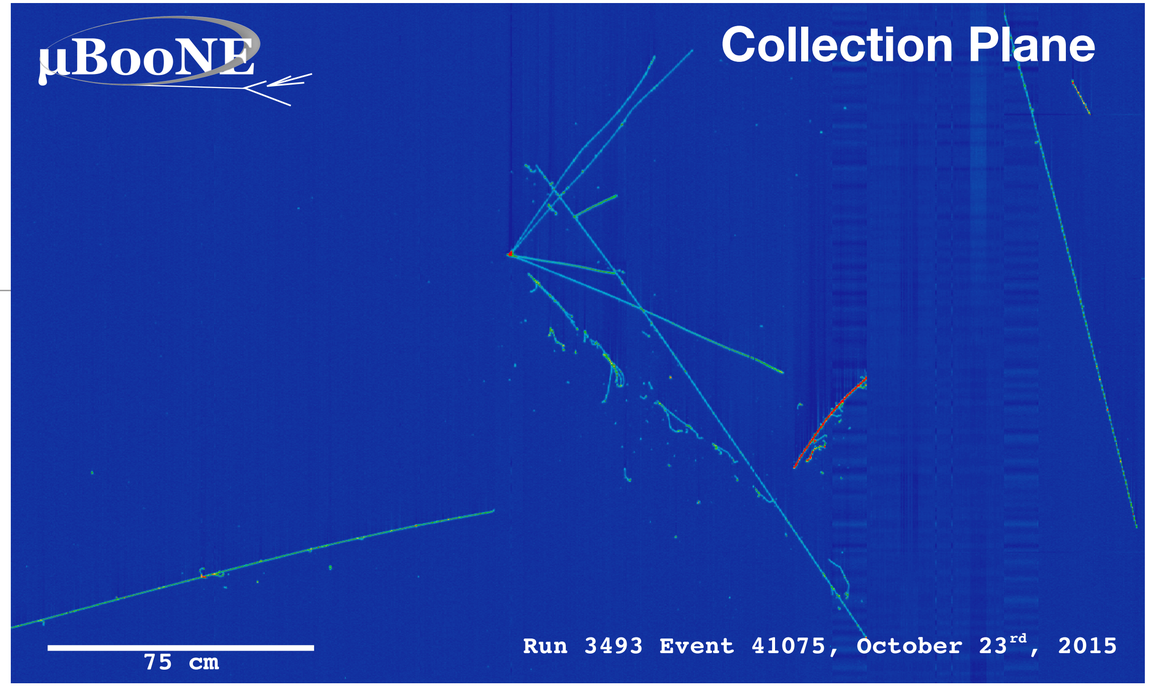


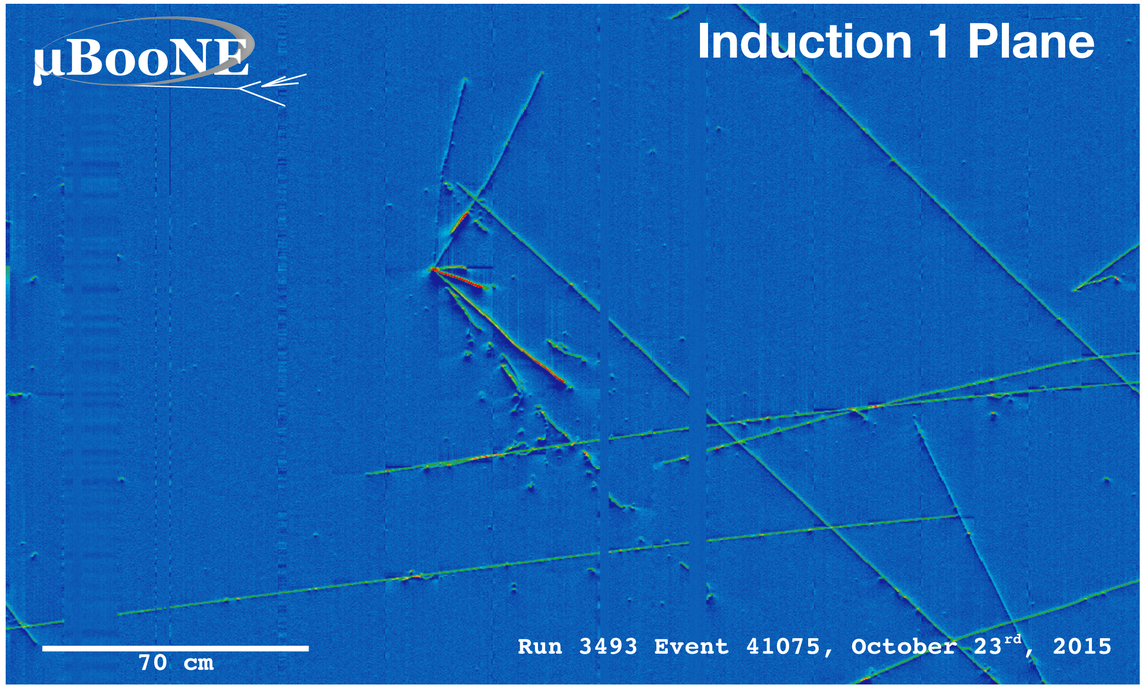


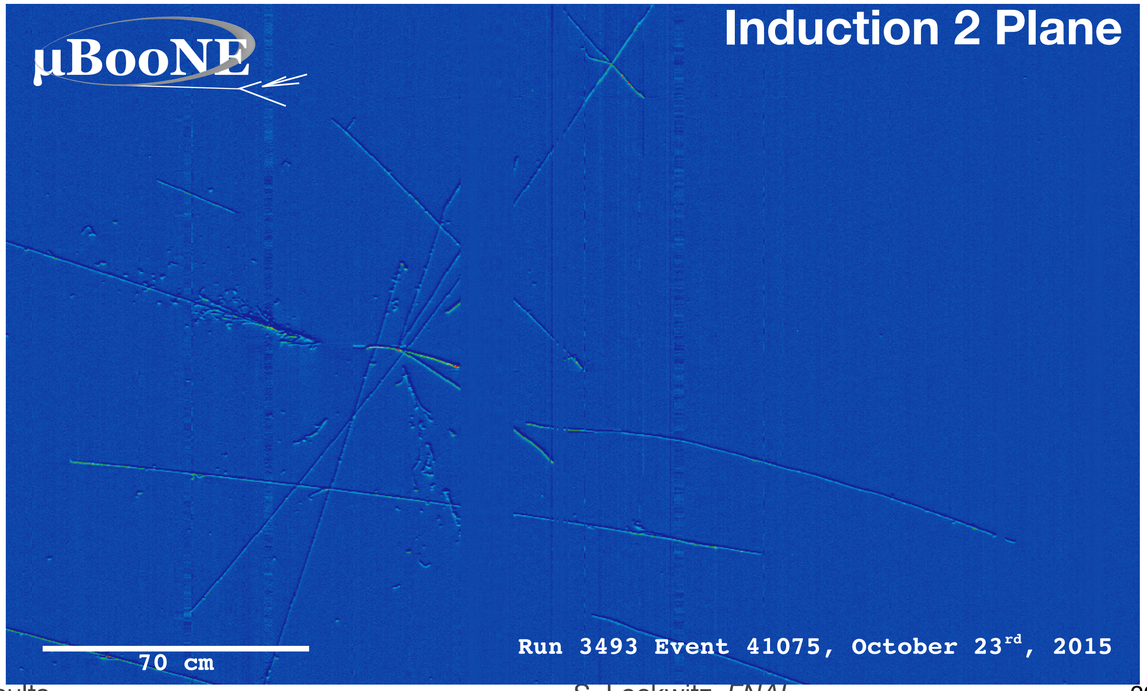
- More than just pretty event displays — events were identified using reconstruction from both the wire readout and the light collection system!

First Neutrino Candidates!

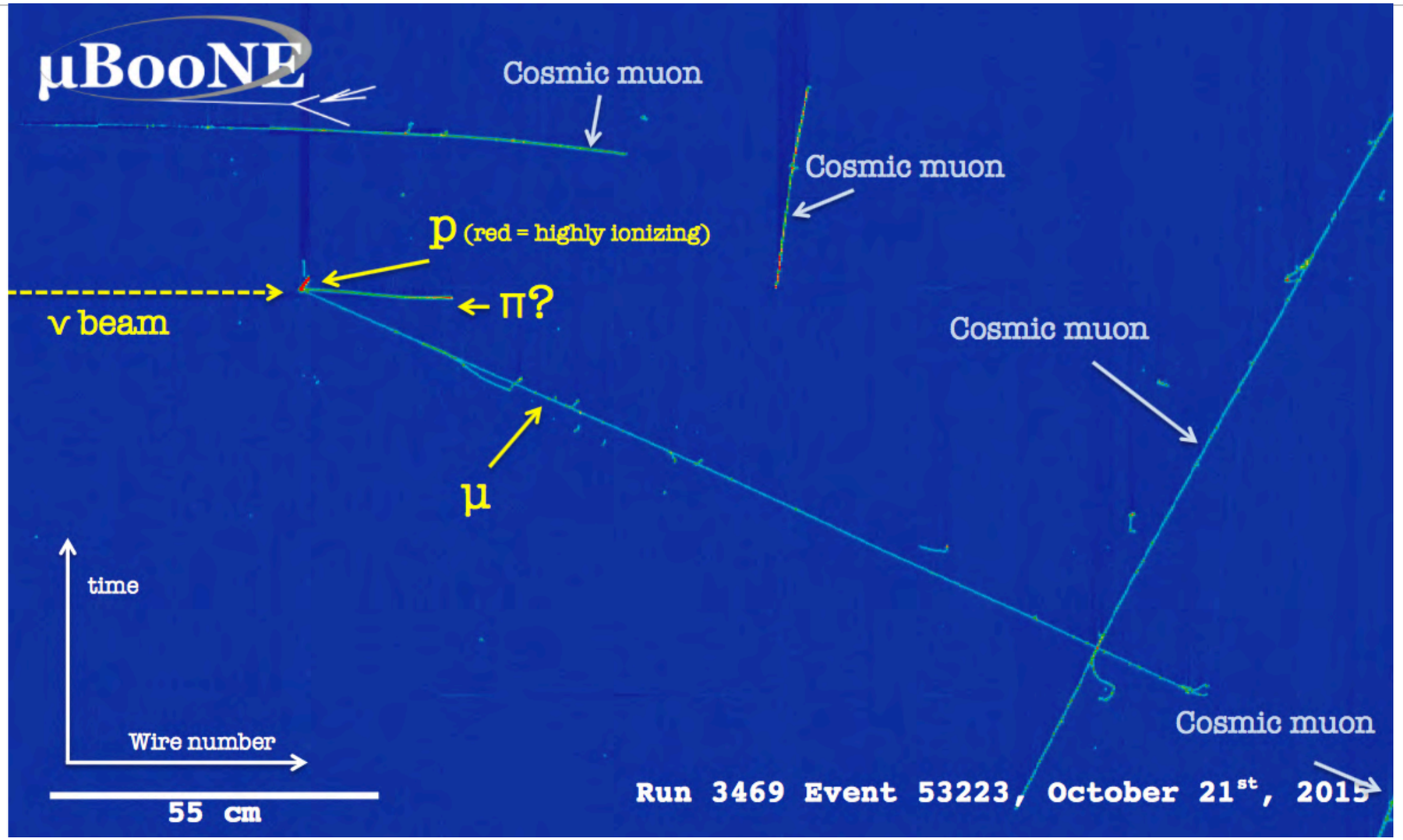
- 3 plane view of the same event:







First Neutrino Events

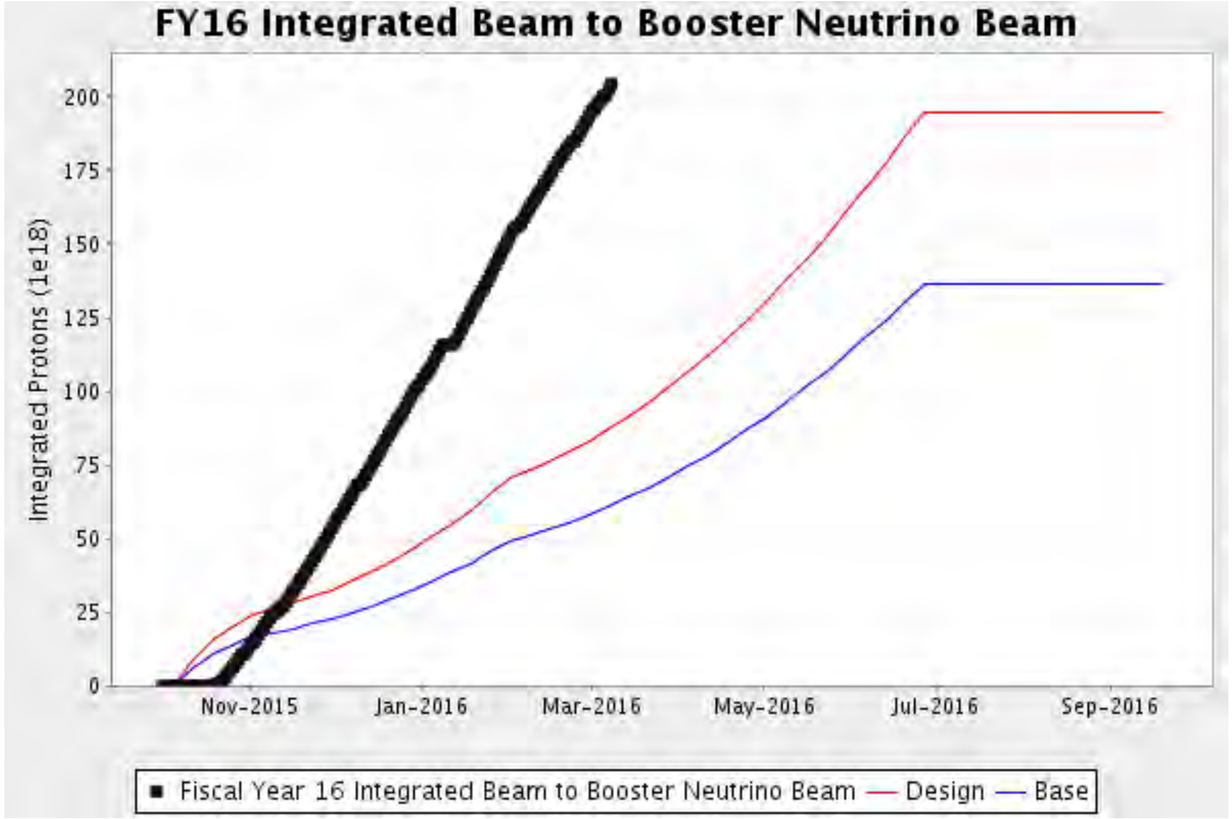



μBooNE


μBooNE

Outlook

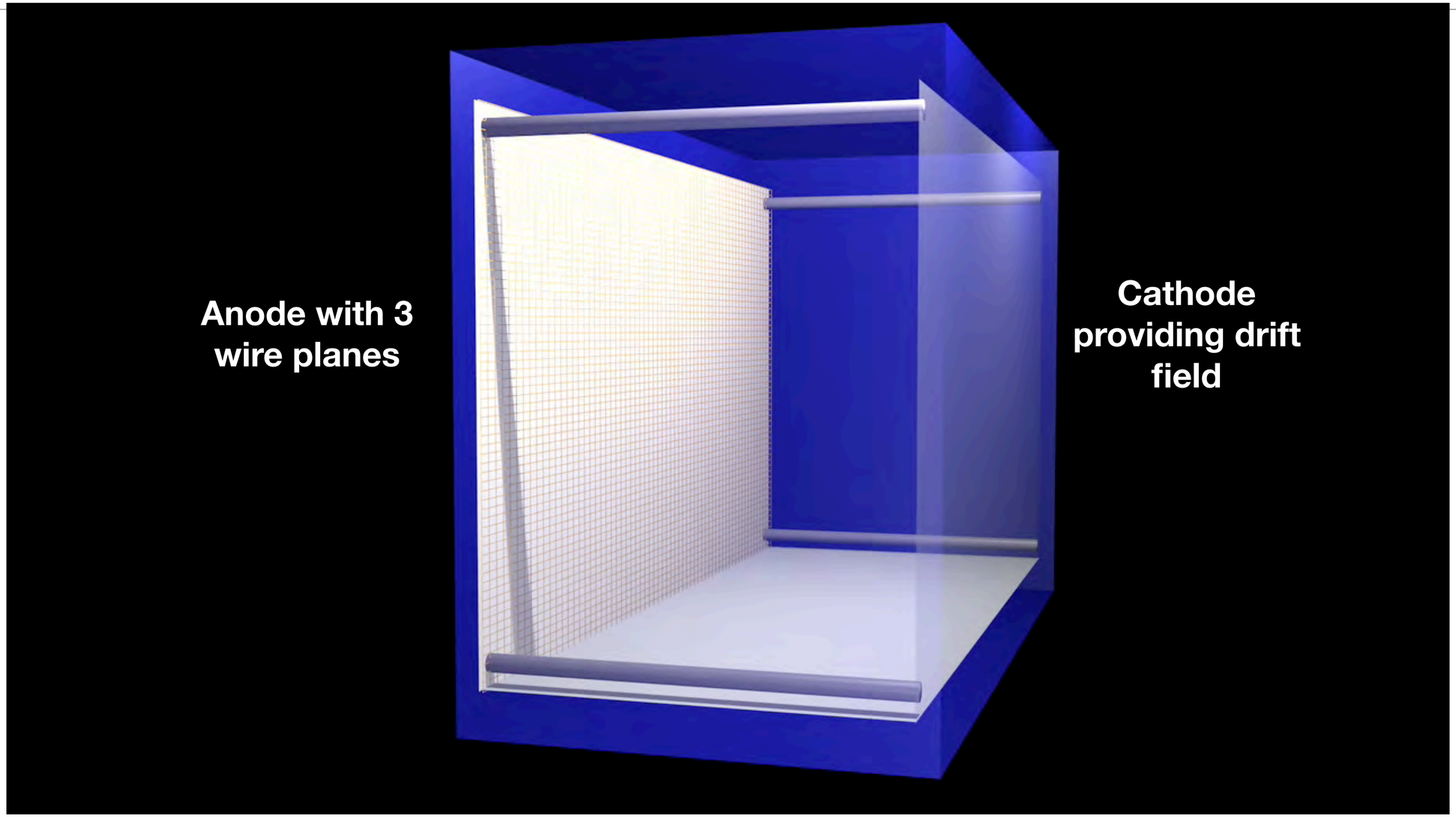
- We are collecting data — a lot of data (1/4 of our planned data):
- With our improved trigger knowledge, we are reprocessing data for our first neutrino analyses
- We expect our first neutrino results within the year
- Thank you!



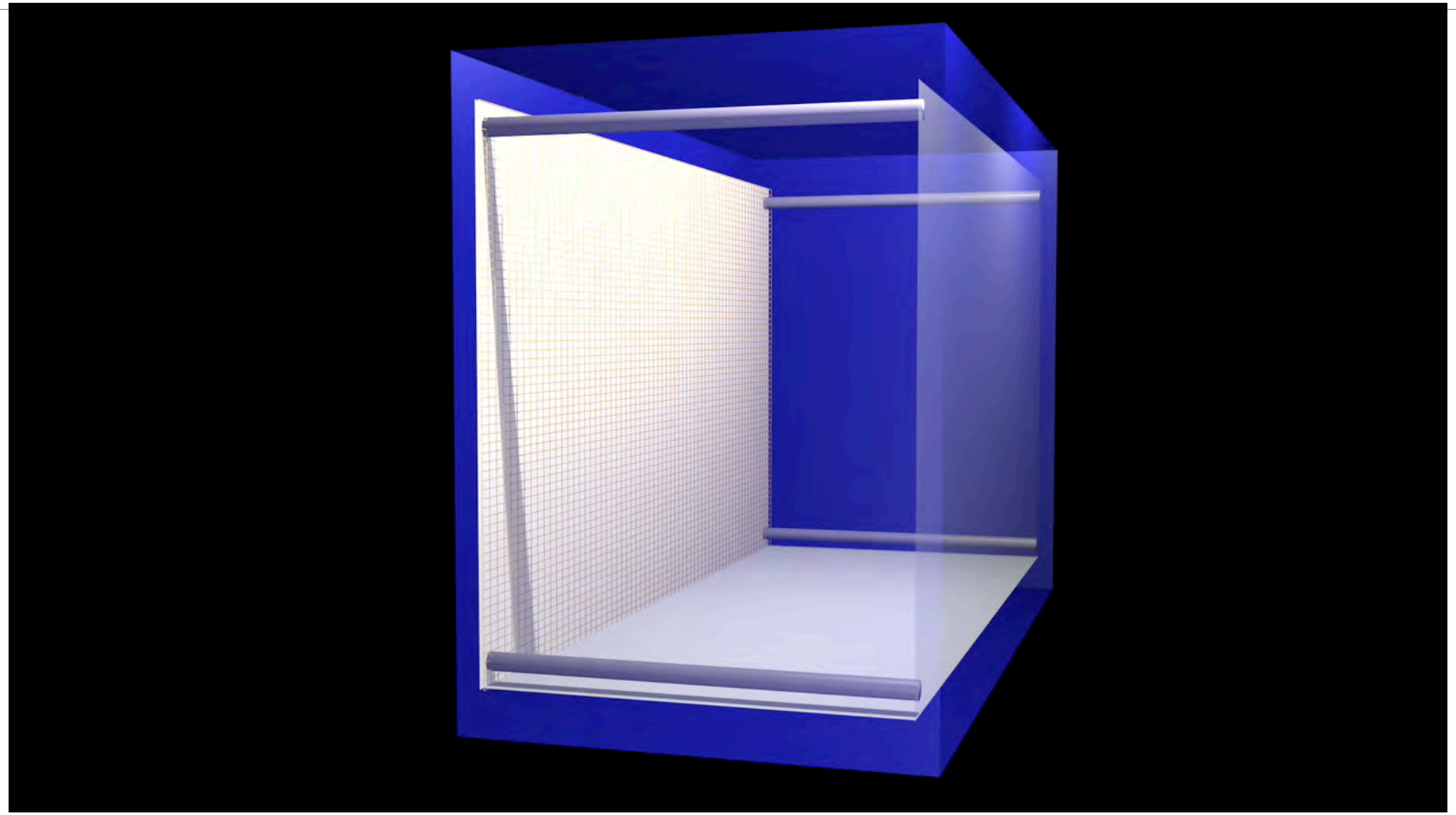
http://www-bd.fnal.gov/FixedTargetPlots/yesterday/ProtonPlots.html

Back Up Slides

TPC Animation

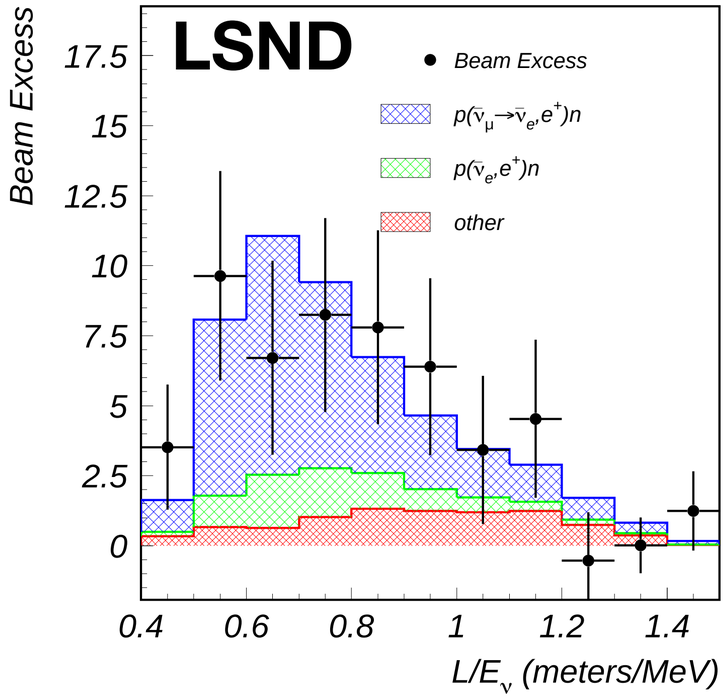


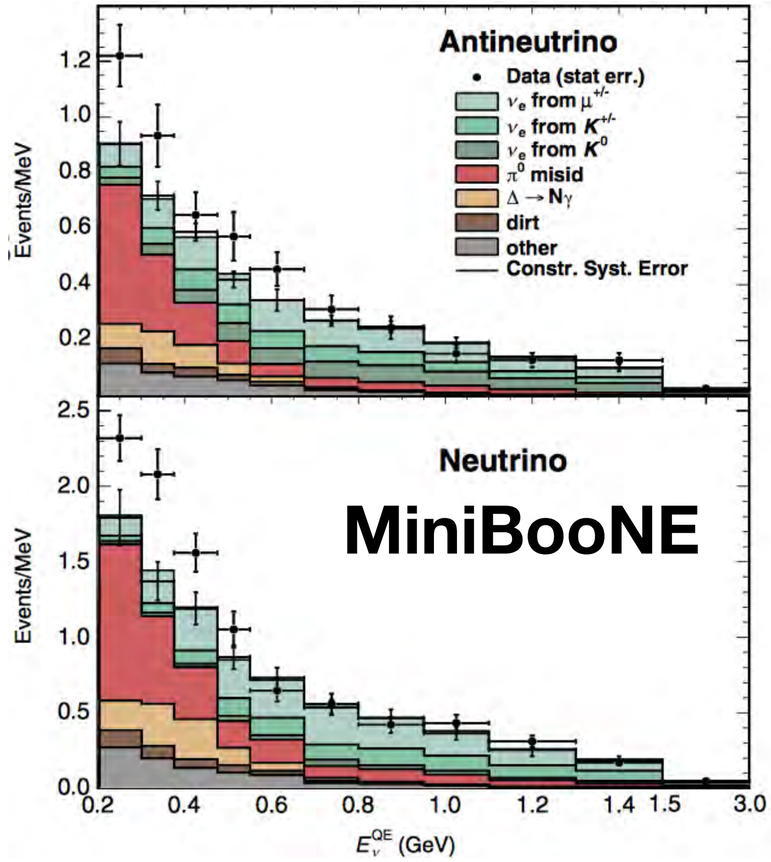
TPC Animation



What is MicroBooNE? Some Background Information

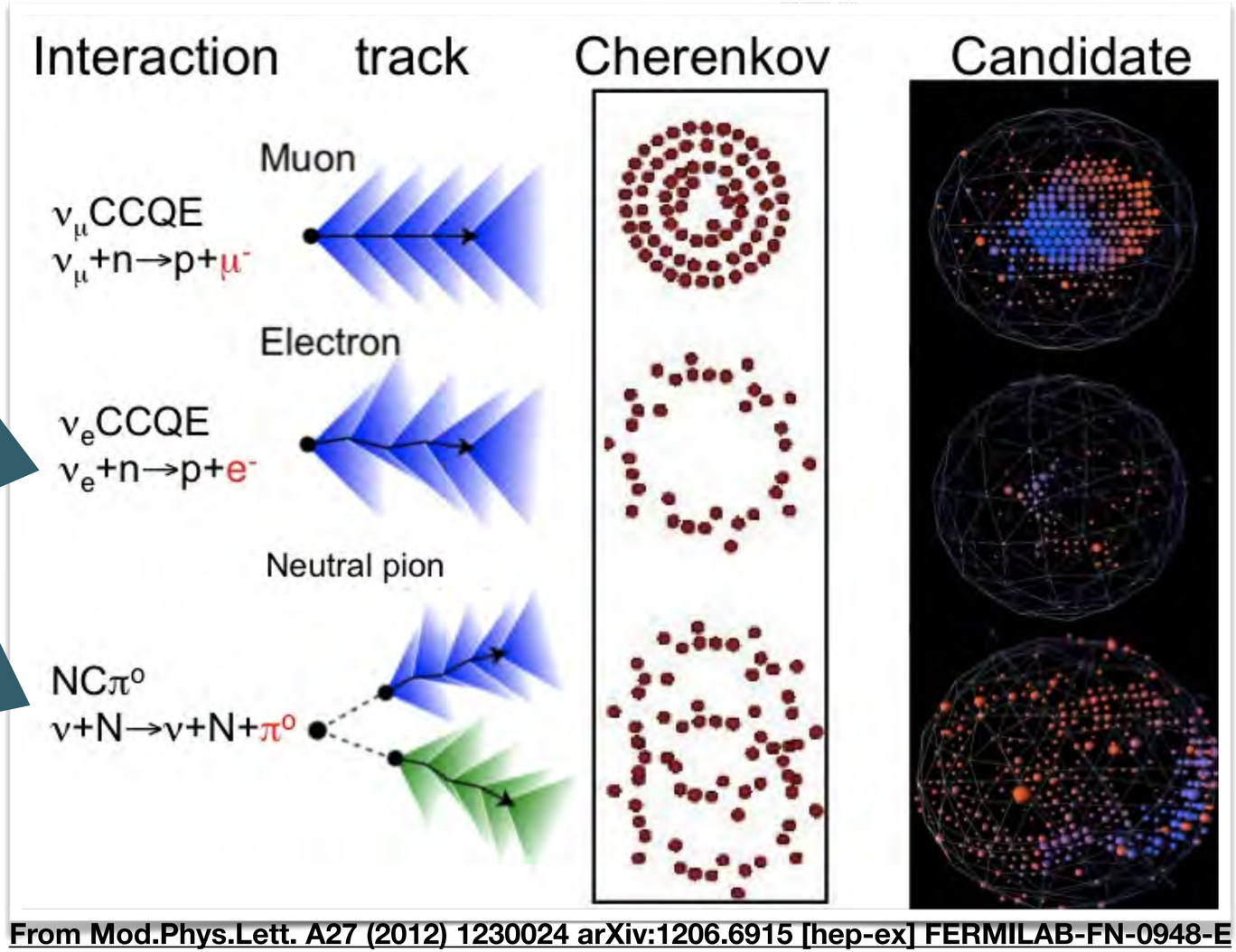
- The LSND anomaly:
  - LSND was a doped mineral oil scintillator detector, set at an L/E ~ 1 m/MeV (L ~30 m)
  - They saw and excess of anti-ν_e events from anti-ν_μ
- MiniBooNE was a mineral oil based Cherenkov detector in the Booster neutrino beam line at Fermilab
  - L/E ~ 1 m/MeV (L ~541):
- MiniBooNE saw an unexpected low-energy excess:





What is MicroBooNE? A Background

- Sterile ν's? Upward fluctuation in π^o's?
- There could be difficulty in separating γ's from e's:



From Mod.Phys.Lett. A27 (2012) 1230024 arXiv:1206.6915 [hep-ex] FERMILAB-FN-0948-E

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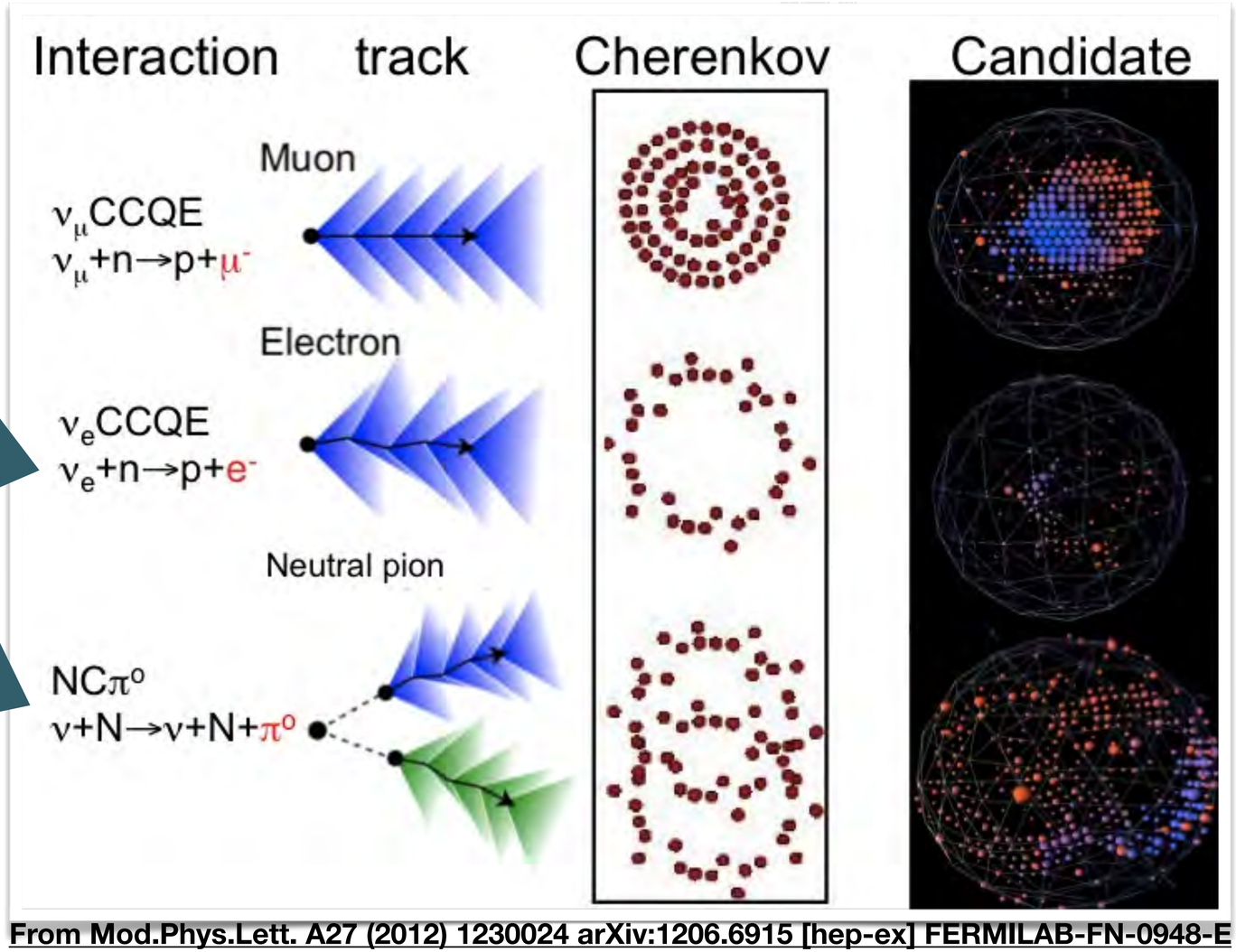

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Data and Beam

Physics Requirements	
Measurement	Requirements
MiniBooNE low energy excess established as electrons to >5σ	6.6×10^{20} POT , 70 t active volume.
MiniBooNE low energy excess established as photons to >4σ	6.6×10^{20} POT , 70 t active volume.
Electron/photon discrimination by track dE/dx near vertex.	3 mm pitch, 3 mm plane separation, and 80% efficiency for e/γ separation algorithm.
$\nu_\mu \rightarrow \nu_e$ search above 475 MeV to overlap LSND $\sin^2(2\theta)$ at high Δm^2 90% CL allowed region to 3σ.	6.6×10^{20} POT, 70 t active volume, and MiniBooNE baseline.
Cross section measurements in Table 2.1 with $\sigma_{STAT} \sim \sigma_{SYST}$.	6.6×10^{20} POT, 70 t active volume.
σ_θ sufficient for coherent pion production identification.	3 mm pitch, 3 mm plane separation.
Elastic proton scattering via recoil proton detection.	40 MeV equivalent summed PMT trigger threshold.
γ/e/π/K/p separation over full BNB energy range and detection of nucleons from Ar breakup.	3 mm pitch, 3 mm plane separation, and >50 MIP single TPC channel dynamic range.
Supernova detection via SNEWS trigger.	1 hour data buffering.