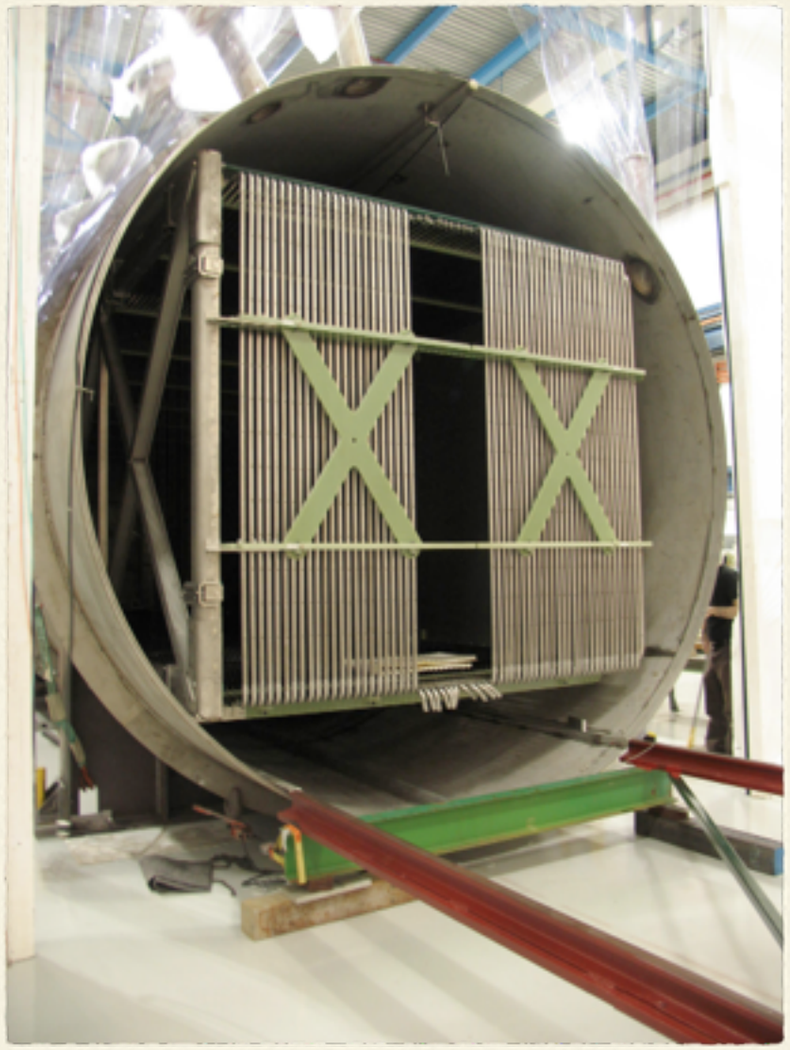


The current status of the MicroBooNE experiment

Tingjun Yang
FNAL

June 12, 2014

MicroBooNE Collaboration + Project Team

Brookhaven: M. Bishai, H. Chen, K. Chen, S. Duffin, J. Farrell, F. Lanni, Y. Li, D. Lissauer, G. Mahler, D. Makowiecki, J. Mead, X. Qian, V. Radeka, S. Rescia, A. Ruga, J. Sondericker, C. Thorn, B. Yu, C. Zhang

University of Cambridge: A. Blake, J. Marshall, M. Thomson

University of Chicago: W. Foreman, J. Ho, D. Schmitz, J. Zennamo

University of Cincinnati: R. Grosso, J. St. John, R. Johnson, B. Littlejohn

Columbia University: N. Bishop, L. Camilleri, D. Caratelli, C. Chi, V. Genty, G. Karagiorgi, D. Kaleko, B. Seligman, M. Shaevitz, B. Sippach, K. Terao, B. Willis

Fermilab: R. Acciarri, L. Bagby, B. Baller, D. Bogert, B. Carls, H. Greenlee, C. James, E. James, H. Jostlein, M. Kirby, S. Lockwitz, B. Lundberg, A. Marchionni, S. Pordes, J. Raaf, G. Rameika+, B. Rebel, A. Schukraft, S. Wolbers, T. Yang, G.P. Zeller*

Kansas State University: T. Bolton, S. Farooq, S. Gollapinni, G. Horton-Smith

Los Alamos: G. Garvey, J. Gonzales, W. Ketchum, B. Louis, G. Mills, Z. Pavlovic, R. Van de Water, K. Yarritu

MIT: W. Barletta, L. Bugel, G. Collin, J. Conrad, C. Ignarra, B. Jones, J. Moon, M. Moulai, J. Spitz, M. Toups, T. Wongjirad

Michigan State University: C. Bromberg, D. Edmunds

New Mexico State University: T. Miceli, V. Papavassiliou, S. Pate, K. Woodruff

Otterbein University: N. Tagg

University of Oxford: G. Barr, M. Bass, R. Guenette

University of Pittsburgh: S. Dytman, D. Naples, V. Paolone

Princeton University: K. McDonald, B. Sands

Saint Mary's University of Minnesota: P. Nienaber

SLAC: M. Convery, B. Eberly, M. Graham, D. Muller, Y-T. Tsai

Syracuse University: J. Asaadi, J. Esquivel, M. Soderberg

University of Texas at Austin: S. Cao, J. Huang, K. Lang, R. Mehdiyev

University of Bern, Switzerland: A. Ereditato, D. Goeldi, I. Kreslo, M. Luethi, C. Rudolf von Rohr, T. Strauss, M. Weber

INFN, Italy: F. Cavanna, O. Palamara *(currently at Yale)*

Virginia Tech: M. Jen, L. Kalousis, C. Mariani

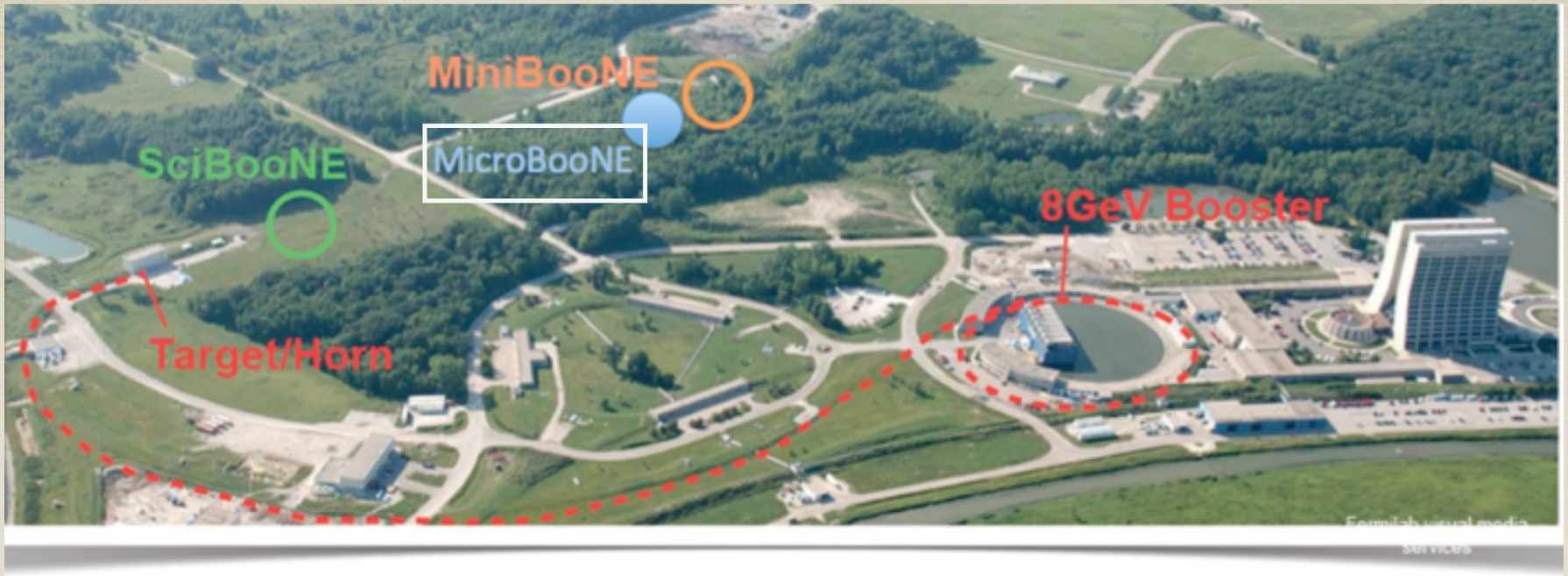
Yale University: C. Adams, E. Church, B. Fleming*, E. Gramellini, A. Hackenburg, B. Russell, A. Szelc

total team (collaboration + project):
3 countries
23 institutions
134 collaborators (includes project team)

* spokespeople,
\+ project manager

Many contributions from all groups in design, construction, and pre-commissioning!

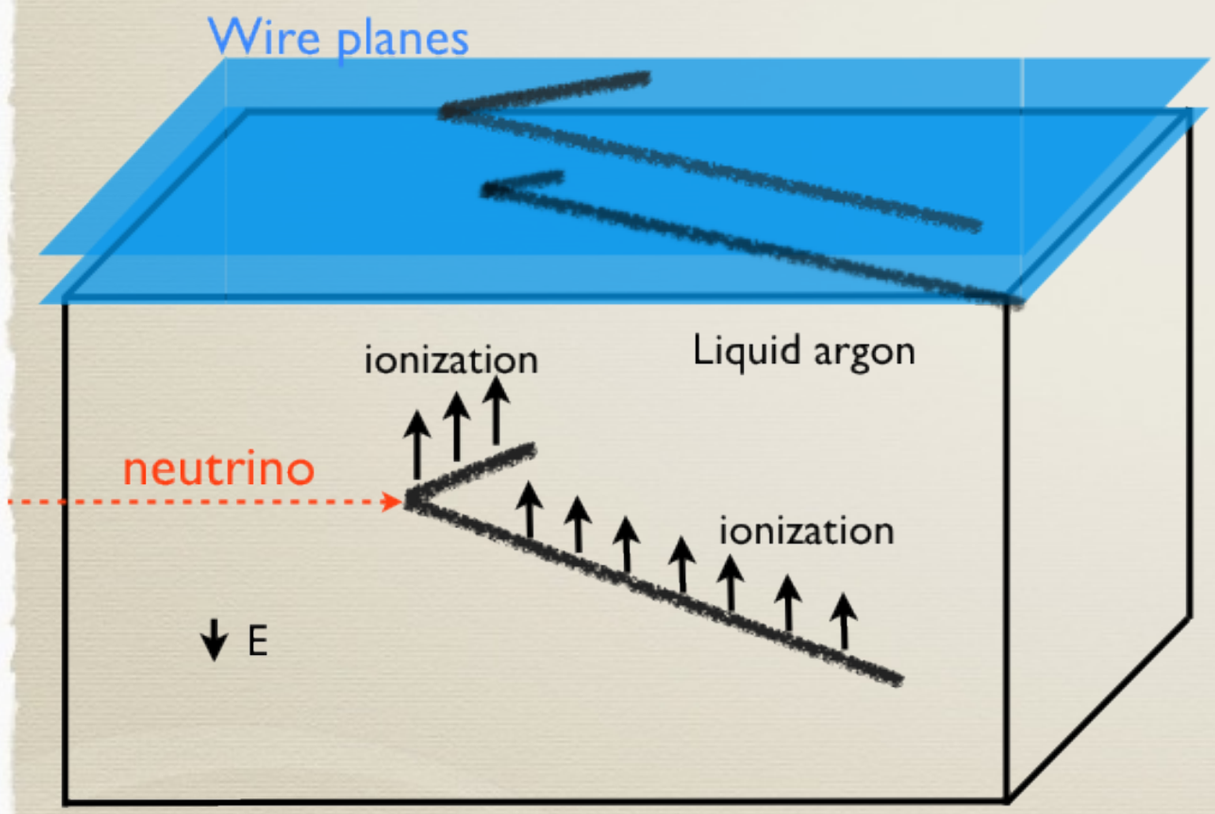
Introduction



* 170-ton liquid argon time projection chamber (LArTPC).
* 470 m downstream of Booster neutrino beam target.
* Broad-band neutrino beam peaked at 800 MeV.
* Goals
  - Study the low-energy electron-like excess observed by the MiniBooNE experiment.
  - Make high-precision low energy (~1 GeV) neutrino cross section measurements in argon.
  - R&D for future multi-kt LArTPCs.
* Construction was funded by DOE and NSF.

Liquid Argon Time Projection Chamber

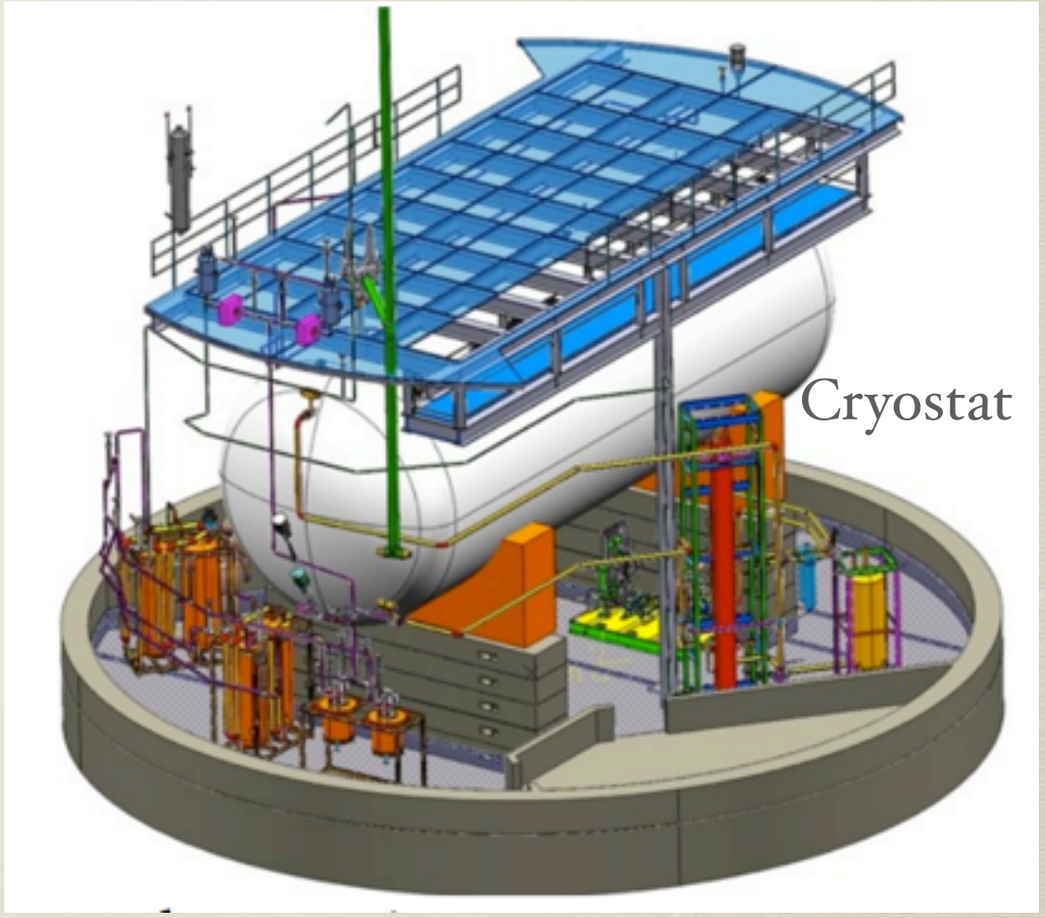
Photo Multiplier Tubes



* Ionization electrons drifted by electric field and read out by wire planes - 1.6 ms maximum drift time.
* High voltage provides electric field.
* Scintillation light recorded by PMT provides trigger information - a few ns scintillation time.
* Requires high-purity liquid argon.

MicroBooNE

* 170 ton cryostat, purify liquid argon without initial evacuation.
* TPC dimensions: 2.5×2.4×10.4 m^3.
* Long drift: 2.5 m
* E = 500 V/cm → HV = 128 kV
* 3 wire planes to read out ionization electrons. Wire spacing is 3 mm.
* Cold electronics: Immersed in liquid argon to reduce noise levels.
* 32 PMTs to record scintillation light.


Cryostat

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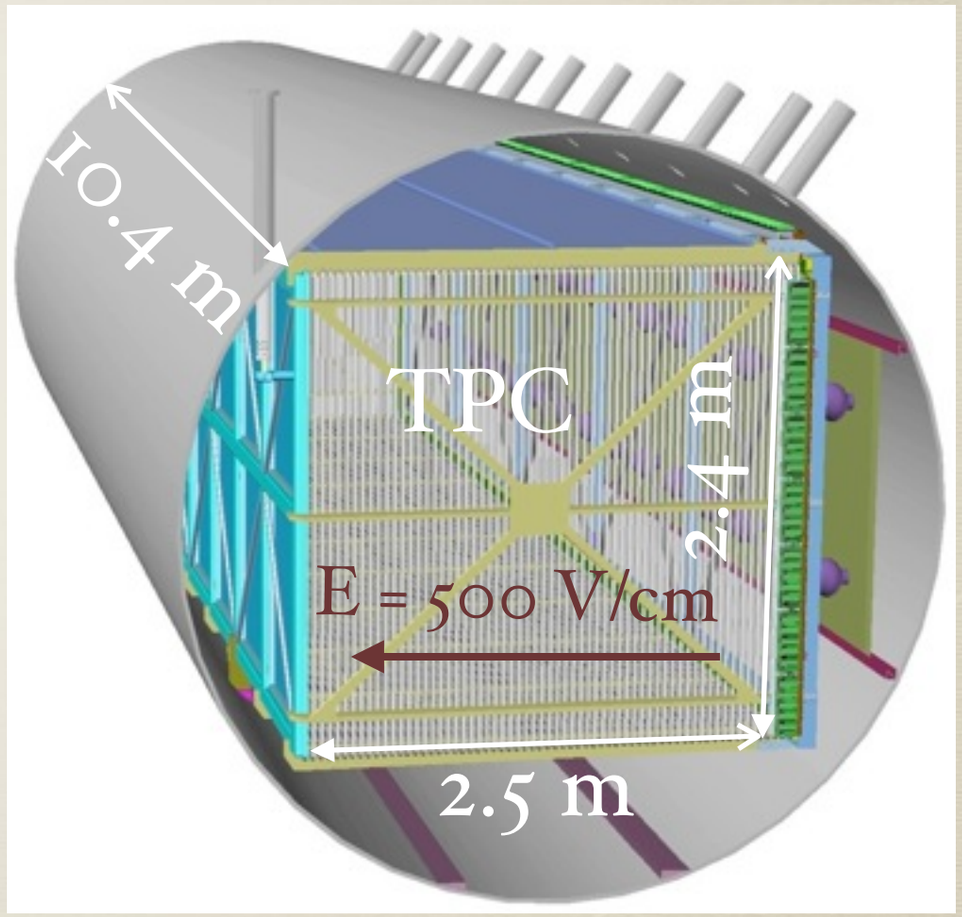

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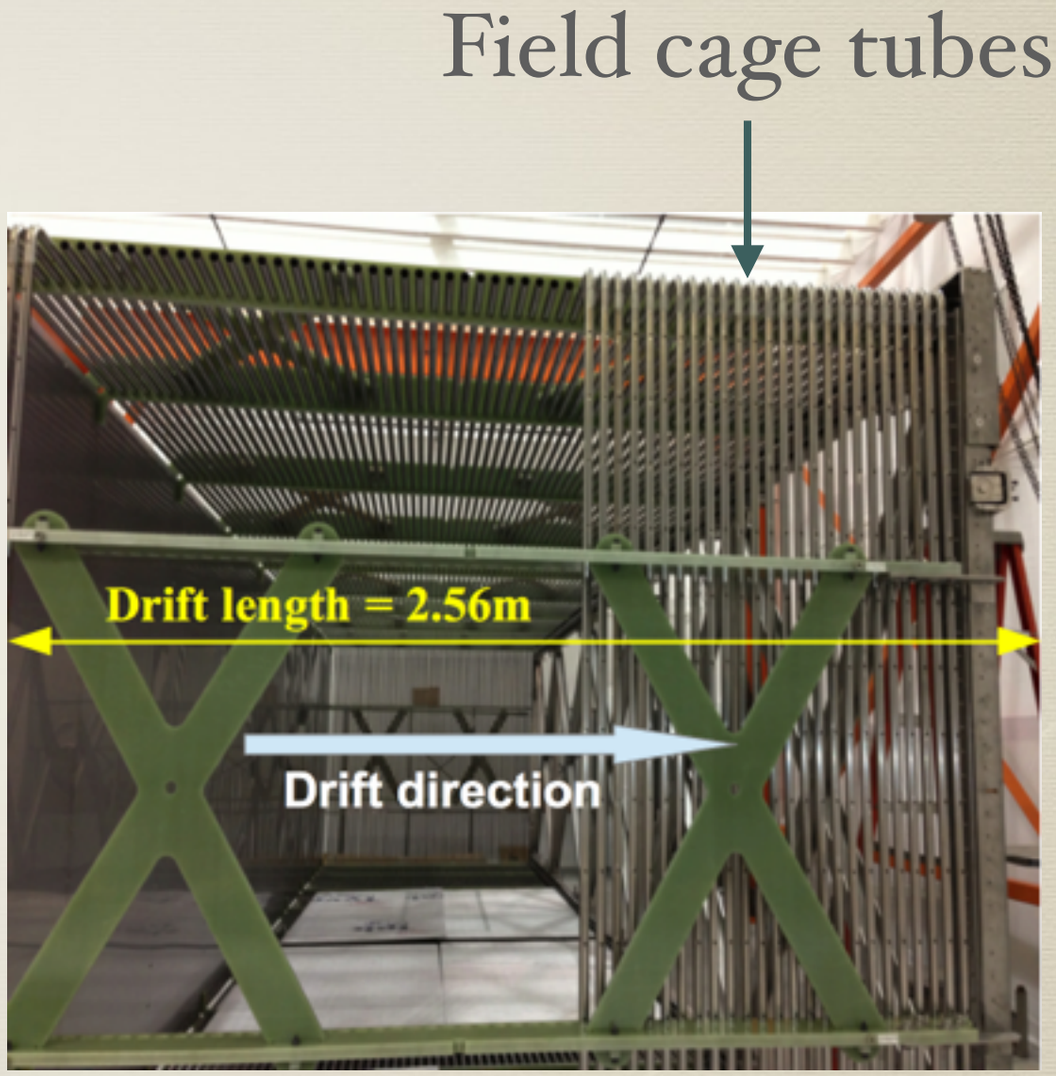

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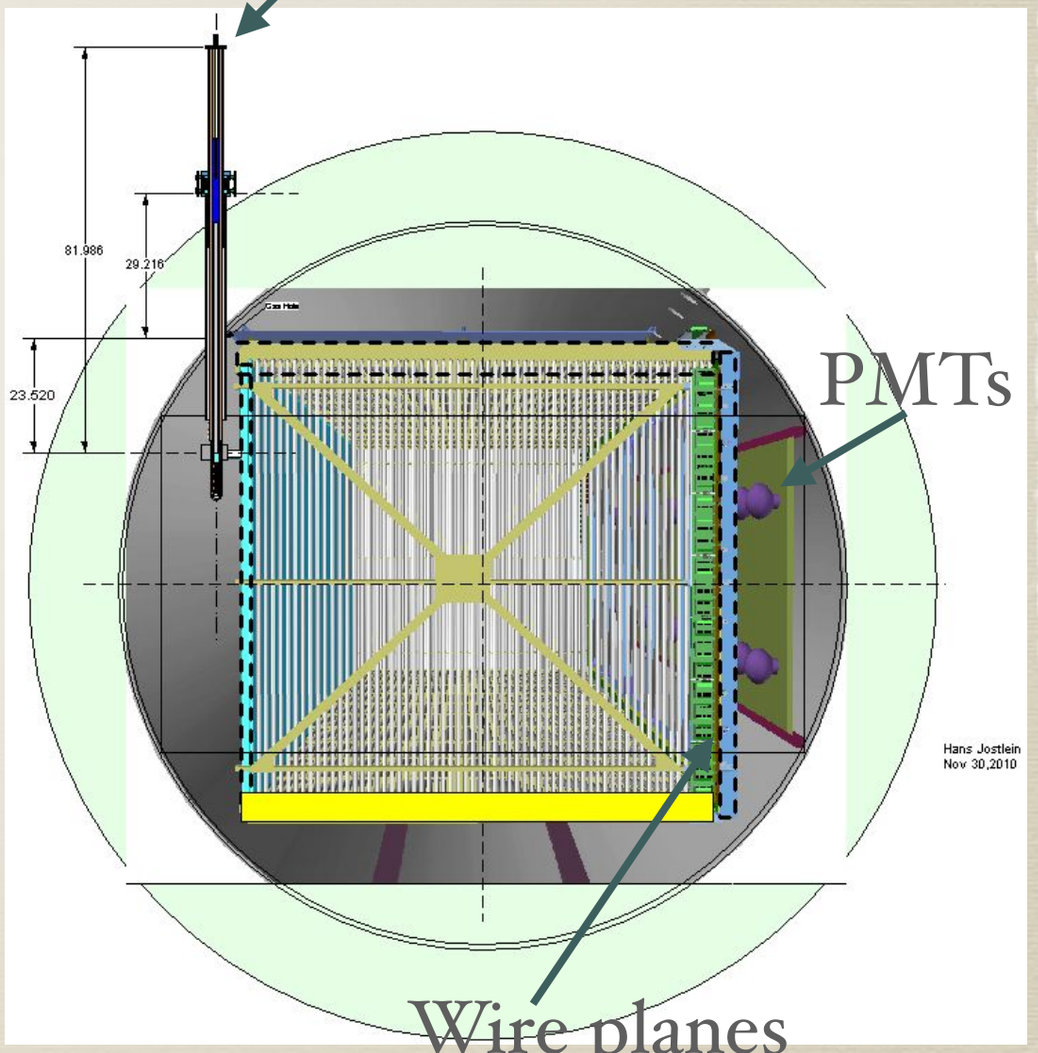

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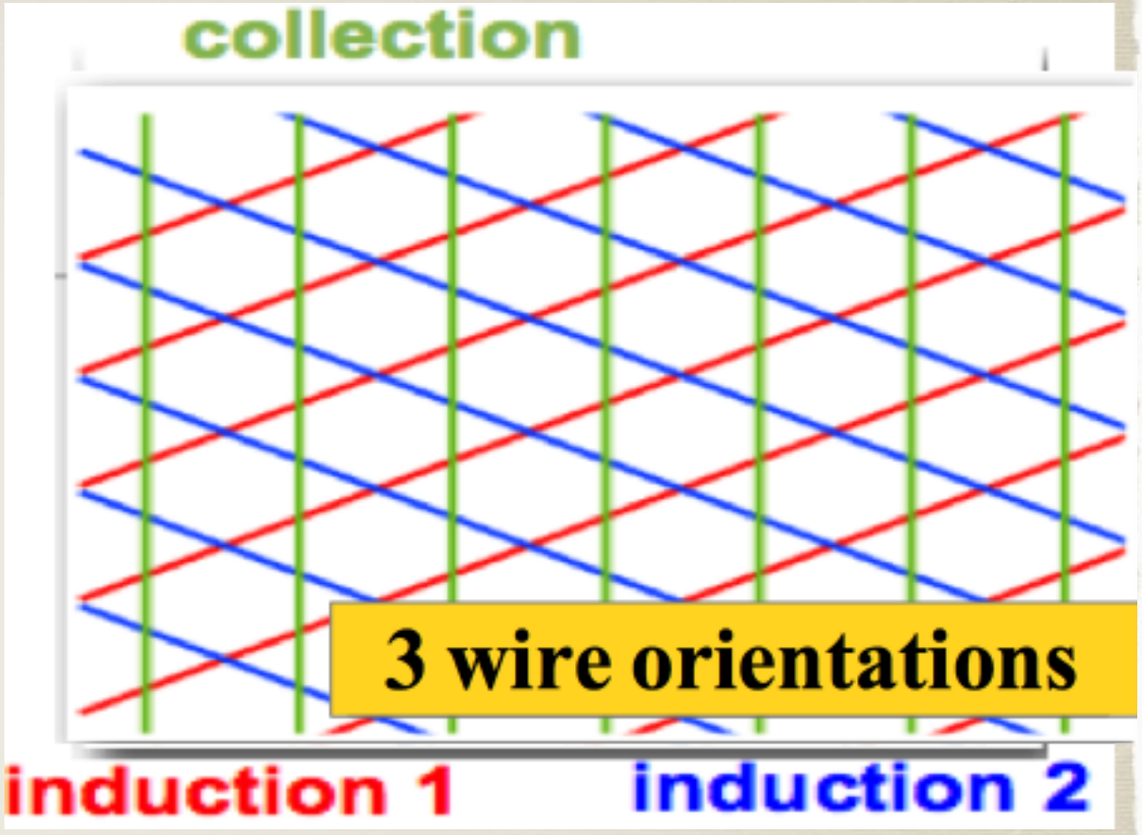

Total wire count: 8256
Different wire orientations enable 3D tracking

MicroBooNE

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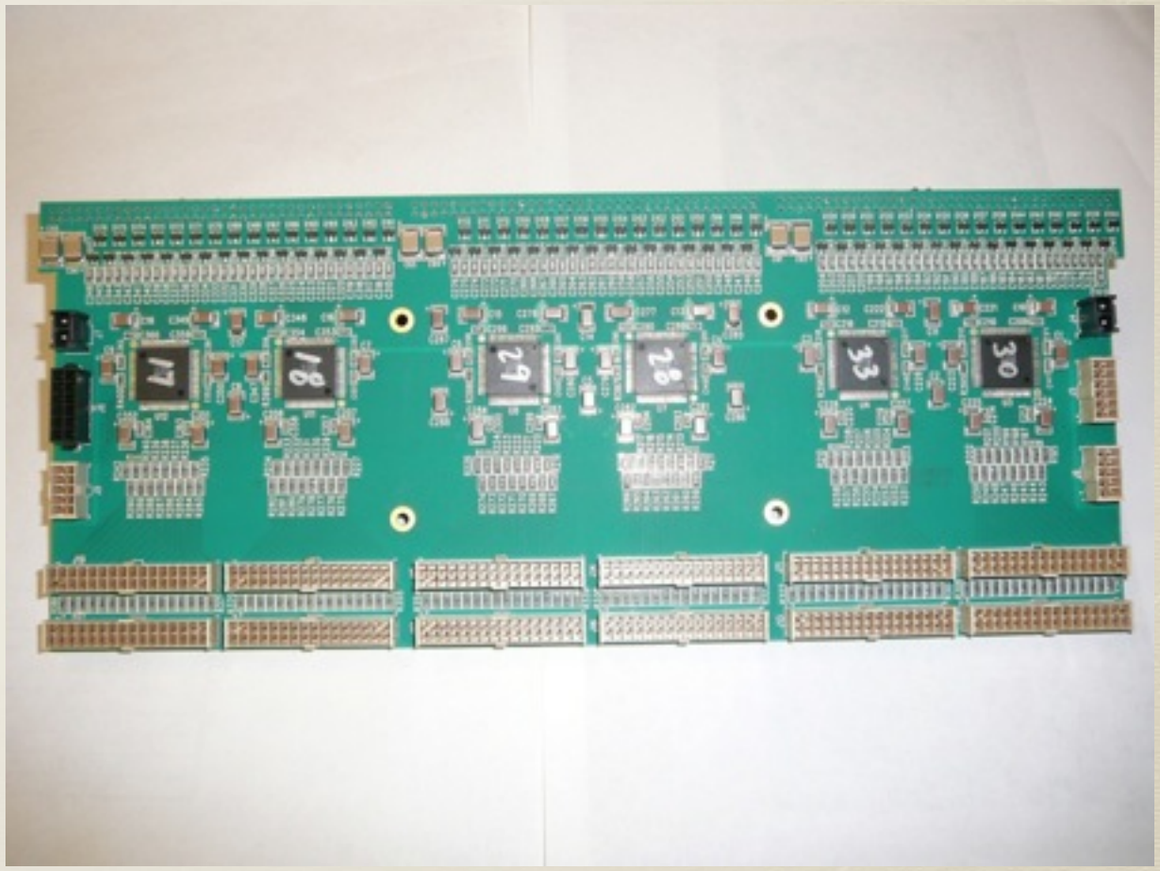

Cold motherboard with 12 ASIC chips

MicroBooNE

* 170 ton cryostat, purify liquid argon without initial evacuation.
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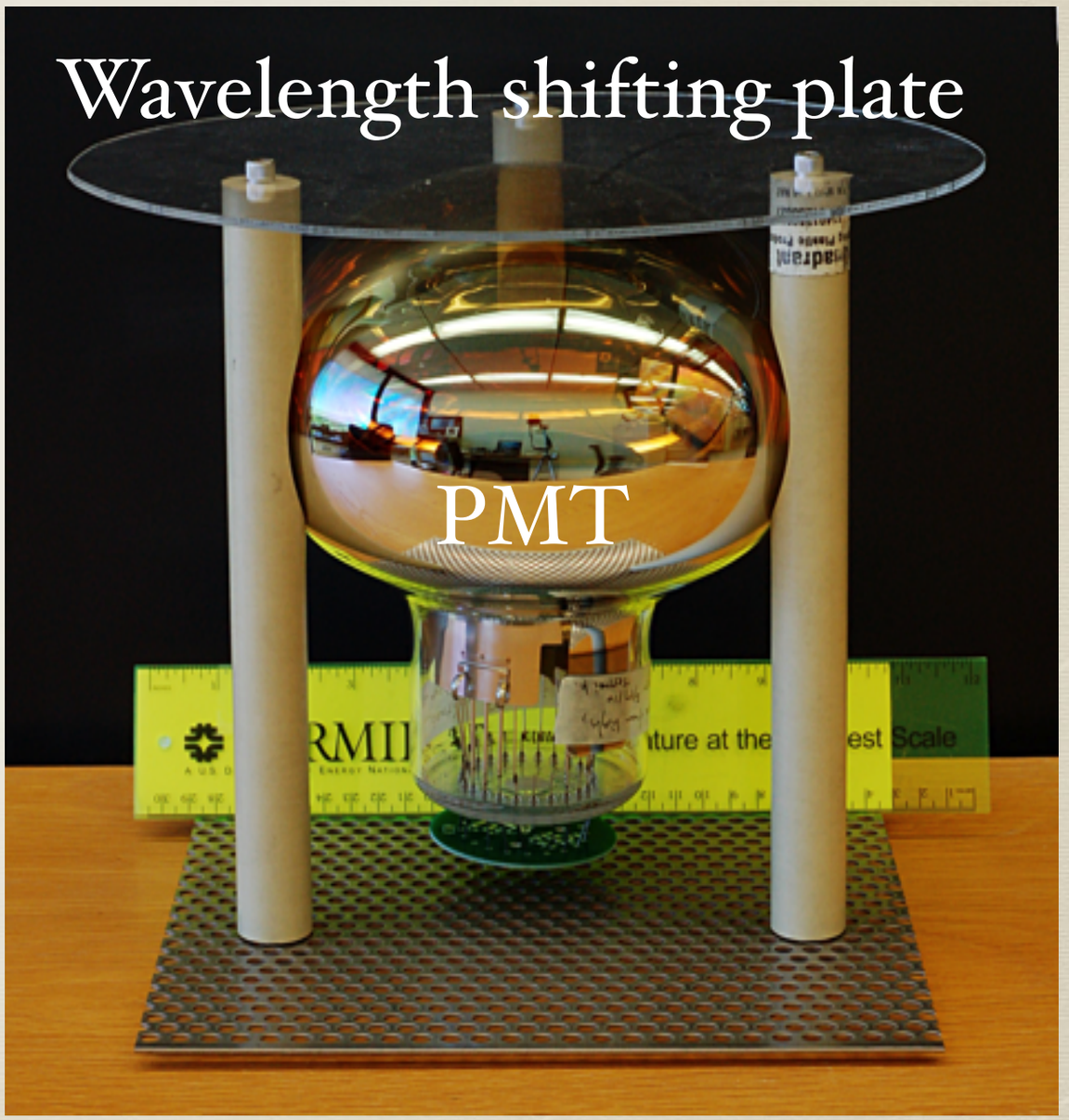
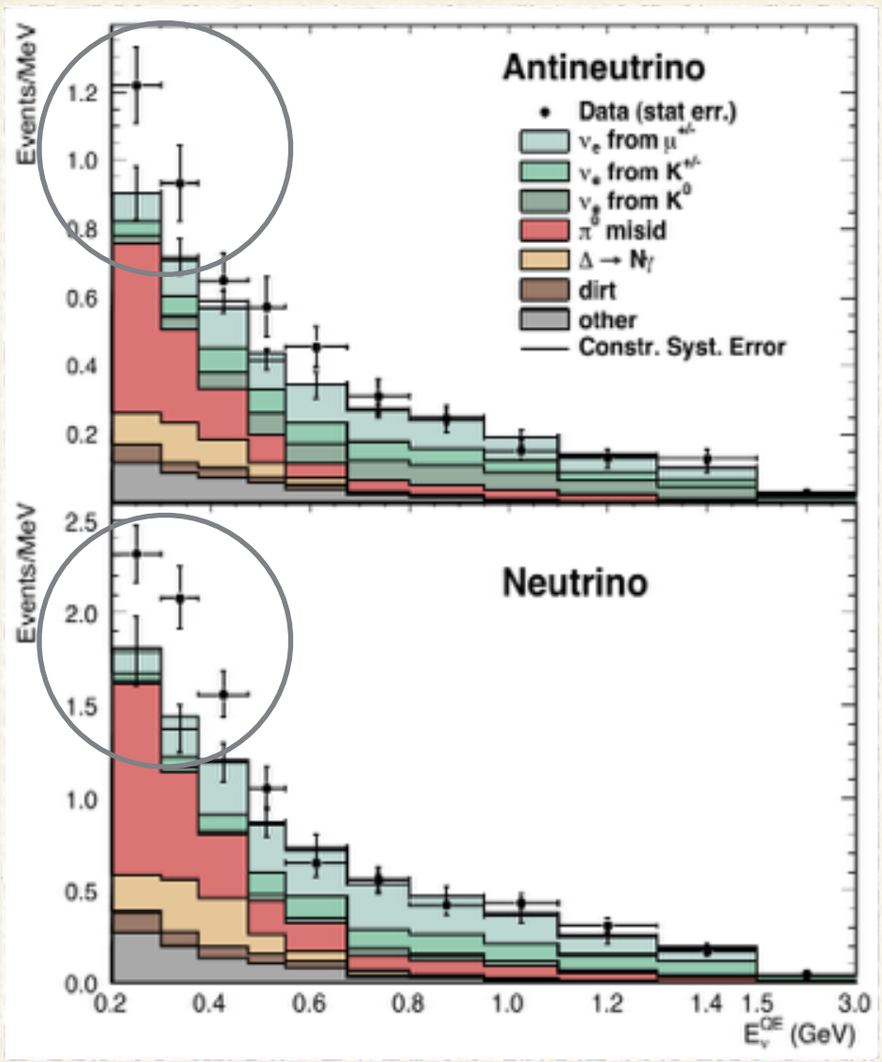


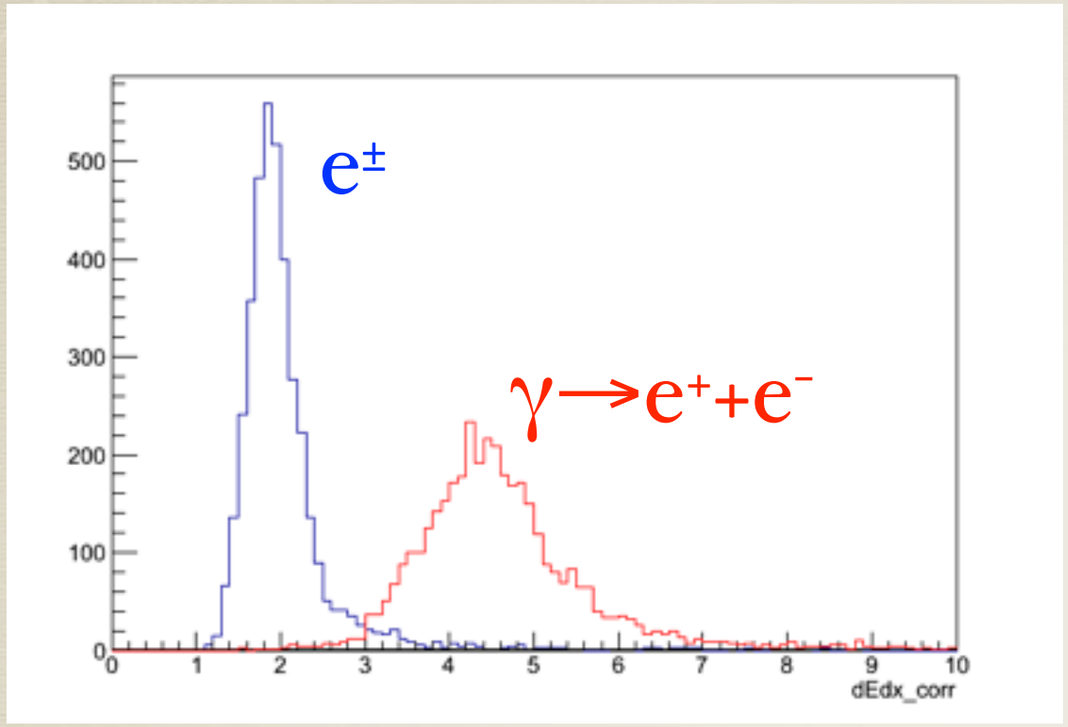
Explore MiniBooNE low-E excess

MiniBooNE



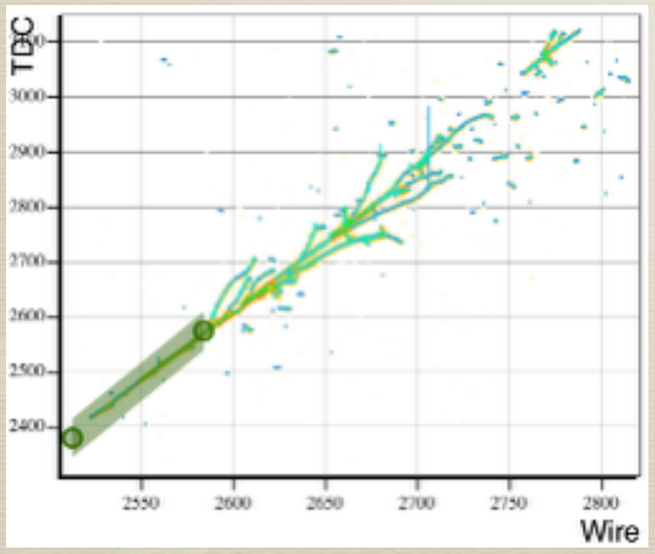
- MiniBooNE observed excess of electron-like data at low-E in both neutrino and antineutrino samples.
- If the excess are electrons, they can be candidate for sterile neutrinos.
- The excess can also be photon background.

e/γ separation in LArTPC

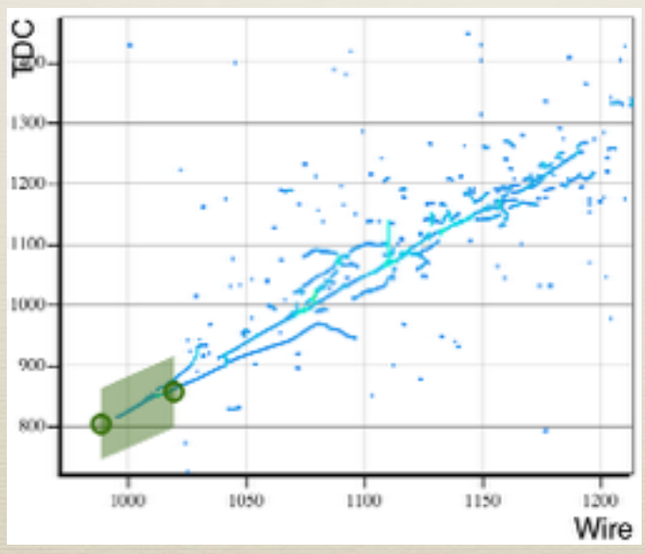


dE/dx at shower vertex distinguishes **e** (1 MIP) from **e^+e^-** (2 MIPs)

e

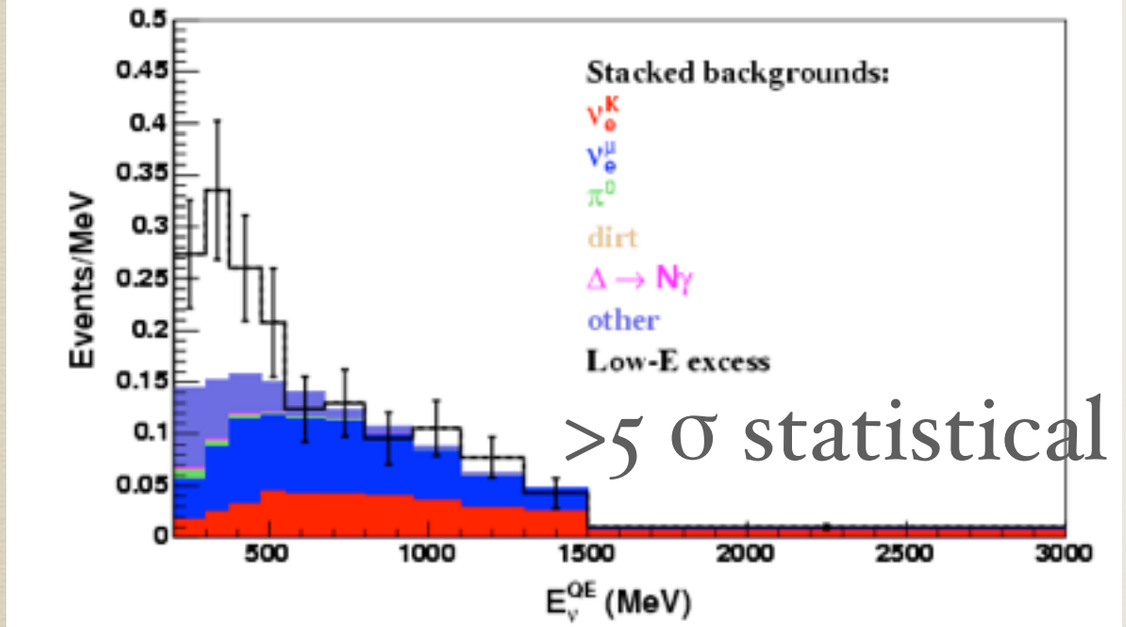


γ

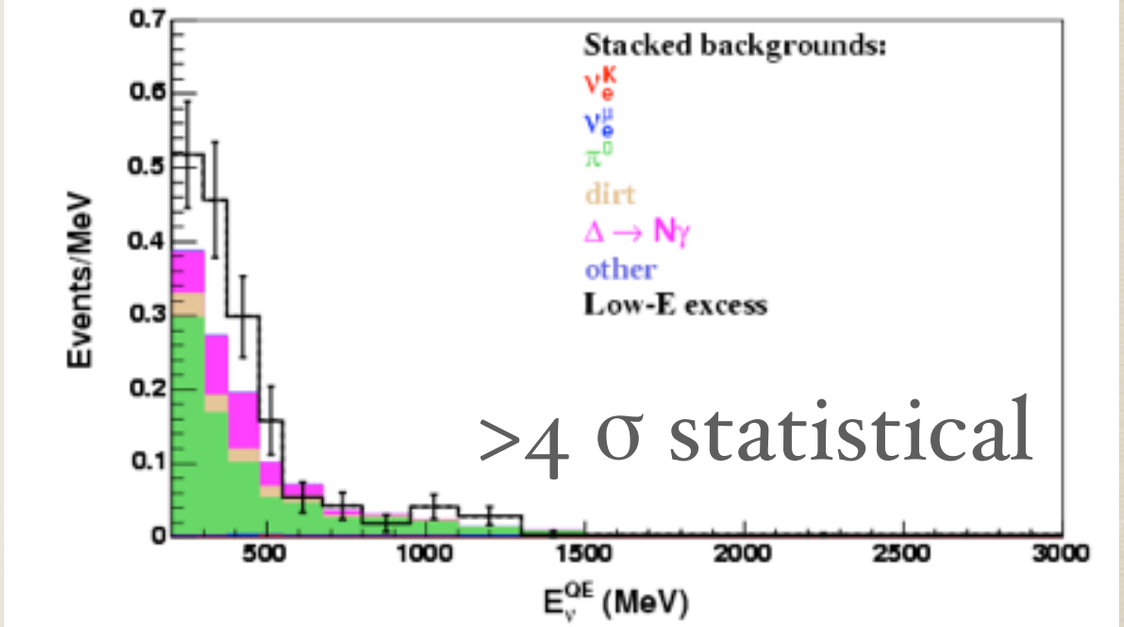


Resolving MiniBooNE low-E excess

MicroBooNE



>5 σ statistical



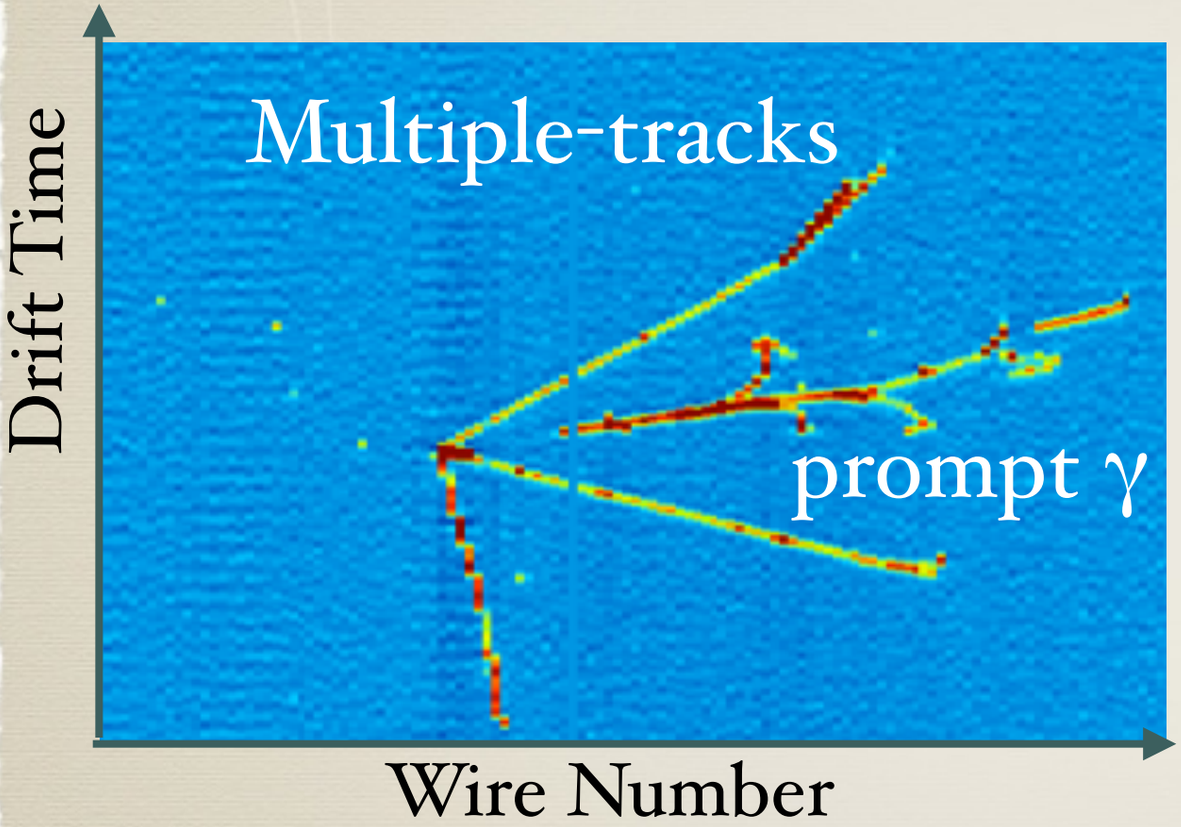
>4 σ statistical

If excess are electrons, with electron selection

If excess are photons, with photon selection

Low-E neutrino cross section measurements

ArgoNeuT data



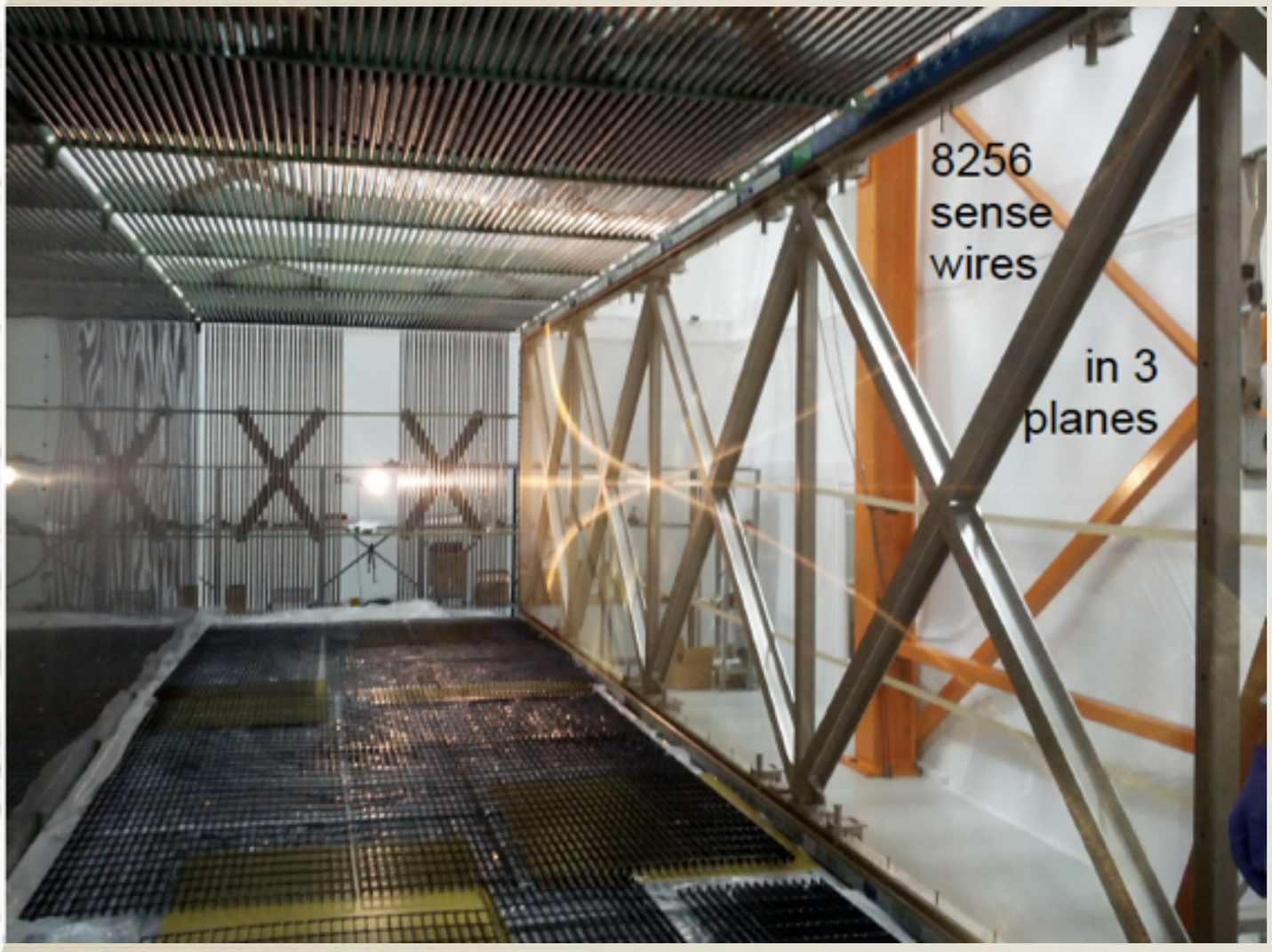
Event Rates for MicroBooNE (90-ton fiducial mass)

	BNB	NuMI
Total Events	145k	60k
ν_μ CCQE	68k	25k
NC π^0	8k	3k
ν_e CCQE	0.4k	1.2k
POT	6×10^{20}	8×10^{20}

Projected Event Rates for MicroBooNE in 2-3 years.

- High-resolution LArTPC provides detailed information on neutrino-Ar interactions.
  - Ideal for study of neutrino cross sections and nuclear effects.

TPC and Anode Wires



TPC assembled and wire stringing complete in May 2013.

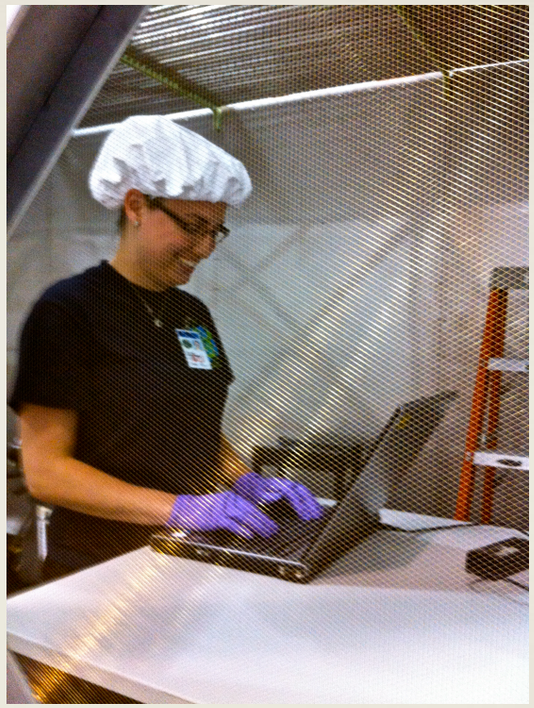
A lot of progress since then.

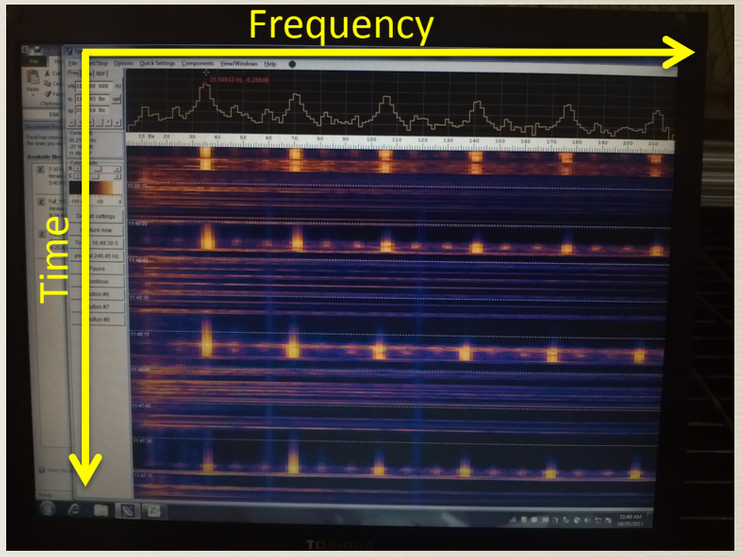
Task List (Red=Done)

* Tasks at DAB (Do Assembly Building)
  * Install cable tray and cold cables
  * Wire tension measurements (all wires)
  * Cold electronics installation and testing
  * Final survey of TPC
  * Install final field cage tubes
  * Install RTDs on TPC
  * Install PMT array
  * Insert TPC in cryostat
  * Connect cold cables
  * Final checks
  * Weld endcap
* Tasks at LArTF (Liquid Argon Test Facility)
  * Complete Phase I cryo piping
  * Install vessel
  * Insulate vessel
  * Install platform & racks
  * Cabling and test readout
  * Install Phase-2 cryo (compressor & cool-down)

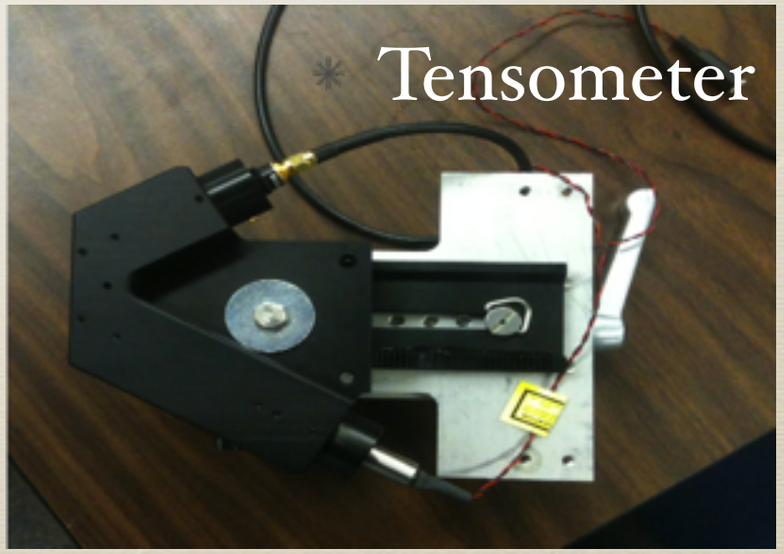
Wire Tension Measurements

* Laser Tensometer – Wire tension device from UW, Madison
* MicroBooNE students/ postdocs and teacher interns (FNAL TRAC program) helped immensely with these measurements and with analyzing the data.
* Completed measurement of all wires (within tolerance) November 2013.





Spectrum analyzer.



TPC Final Assembly

* TPC modifications to increase safety factor in case of HV breakdown

Softer bend radius on corner field cage tubes

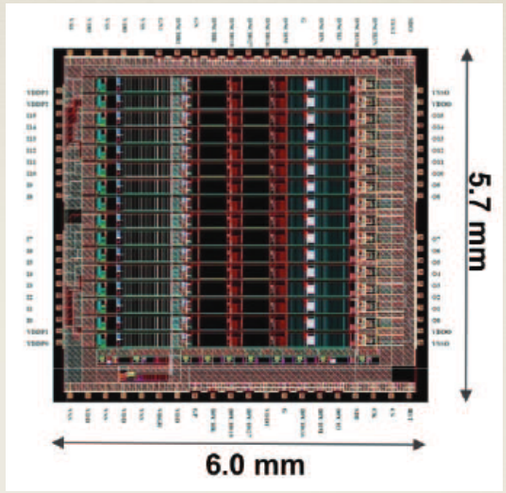
Slim Mox

Metallux HVR 969.23

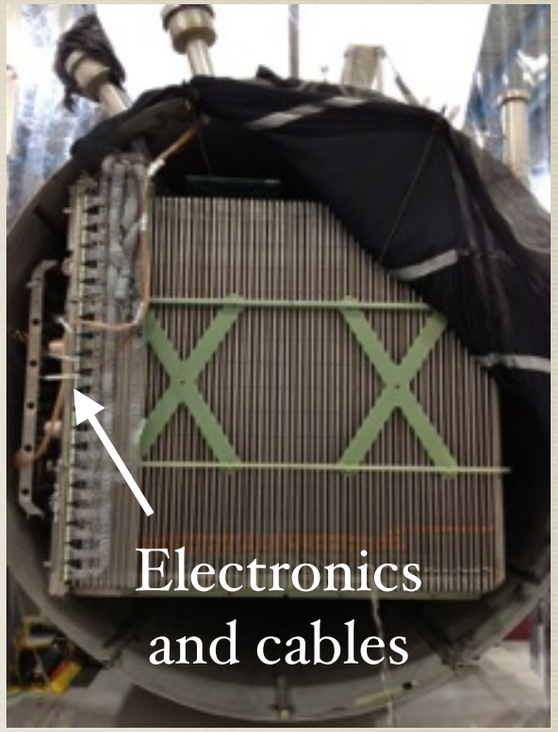
Replace some resistors with more robust ones and add surge protection devices.

Cold Electronics

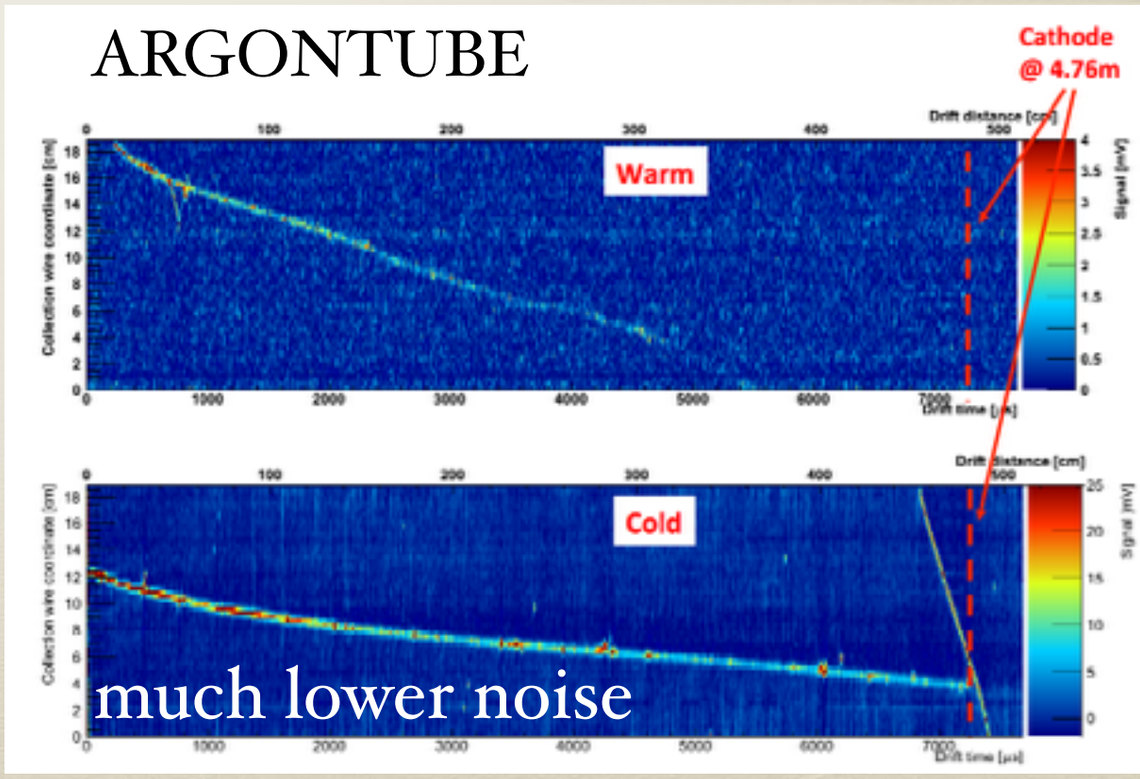
* Traditional preamplifier is located outside cryostat – warm electronics.
* MicroBooNE has developed a 180 nm CMOS ASIC (Application-Specific Integrated Circuit) to be operated in LAr in close proximity to the wire end: reduce cable length and noise
* All cold motherboards installed and tested last summer.



ASIC



ARGONTUBE

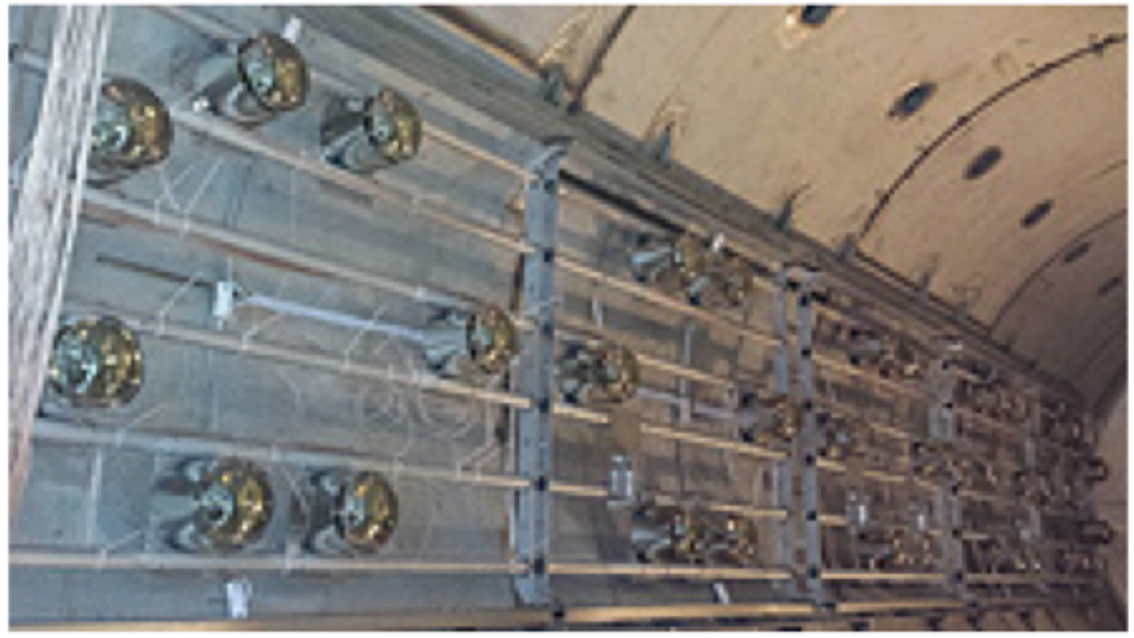


Optical System

* Scintillation light from particle interactions provides trigger information and t0.
* MicroBooNE uses 32 PMTs to capture and measure scintillation light.
* Developed a LED flasher system for calibration of gain and t0.
* Important R&D on LAr optical properties.
* Final assembly of PMT array and installation in the detector September 2013.

Construction Update Fermilab Today

Optical system installed in MicroBooNE detector

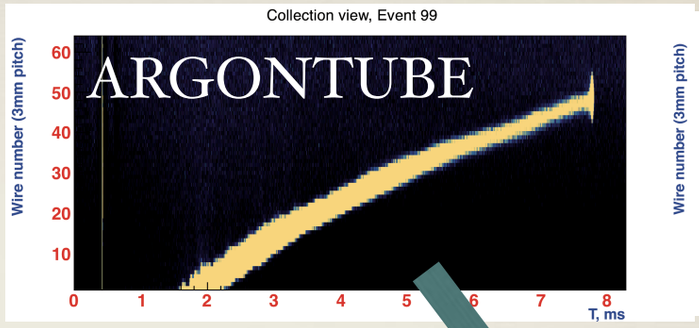


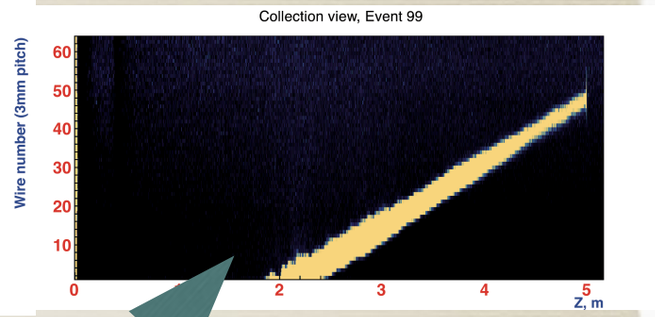
MicroBooNE's optical system, which captures and measures light resulting from particle interactions, was recently installed in the experiment's detector. *Photo: Matt Toups, MIT*

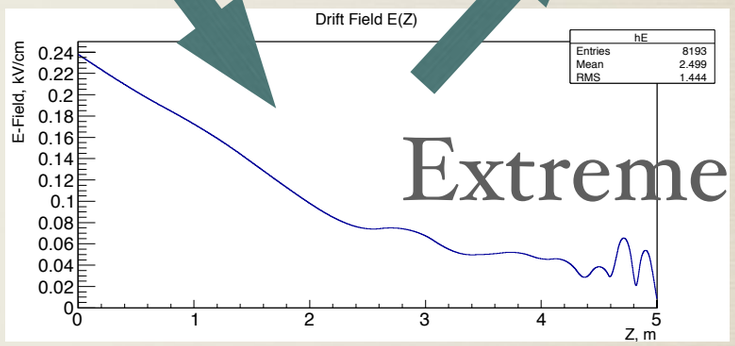
UV-Laser Calibration System

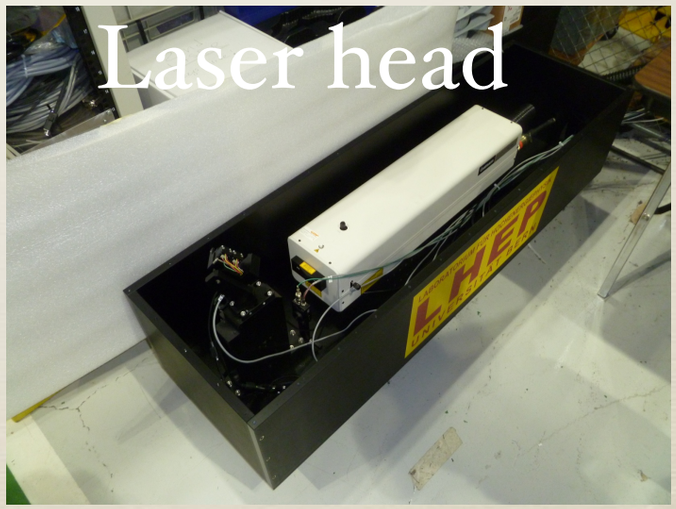
University of Bern arXiv:1304.6961

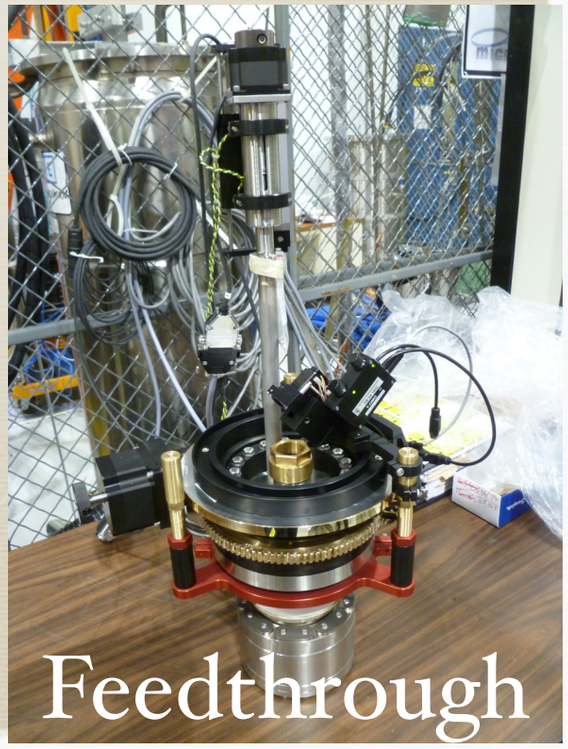
* UV-laser calibration system to measure E-field map and correct track distortion.
* It also measures the electron lifetime in liquid argon.
* All components of the UV-Laser system are operational at DAB.











Installation in the Cryostat

December 20, 2013

HV Feedthrough Test Fit

Endcap Welded

May 20, 2014

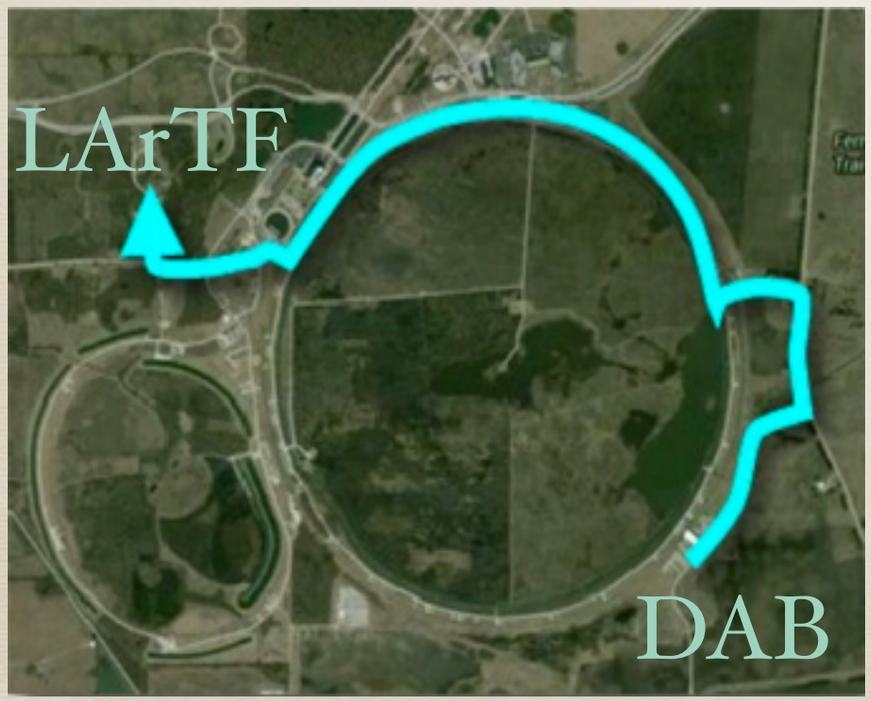
Construction Update Fermilab Today

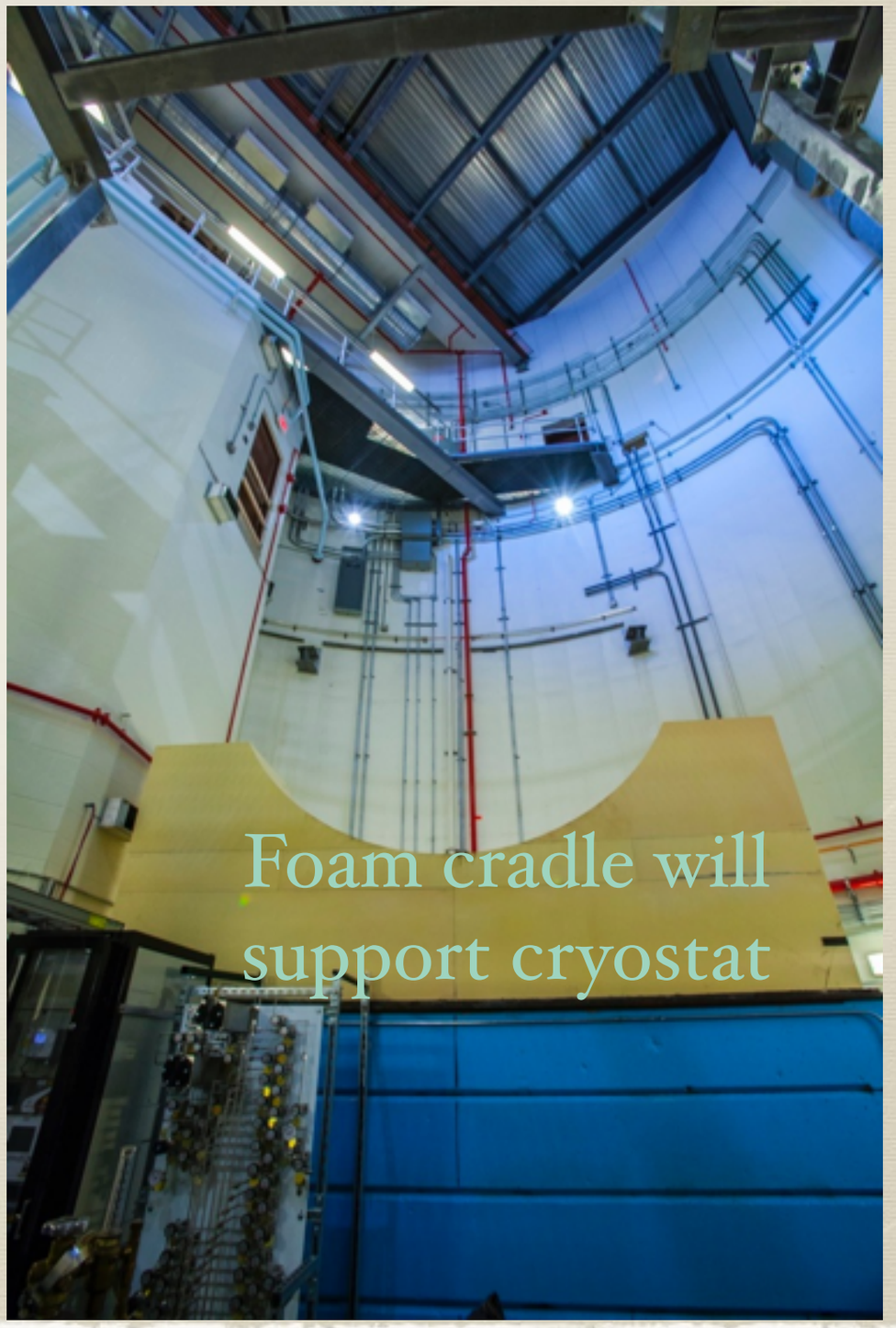
MicroBooNE time projection chamber sealed

Now that the MicroBooNE time projection chamber is sealed up, it's ready to be moved to its permanent home. *Photo: Reidar Hahn*

Move vessel to LArTF – June 23

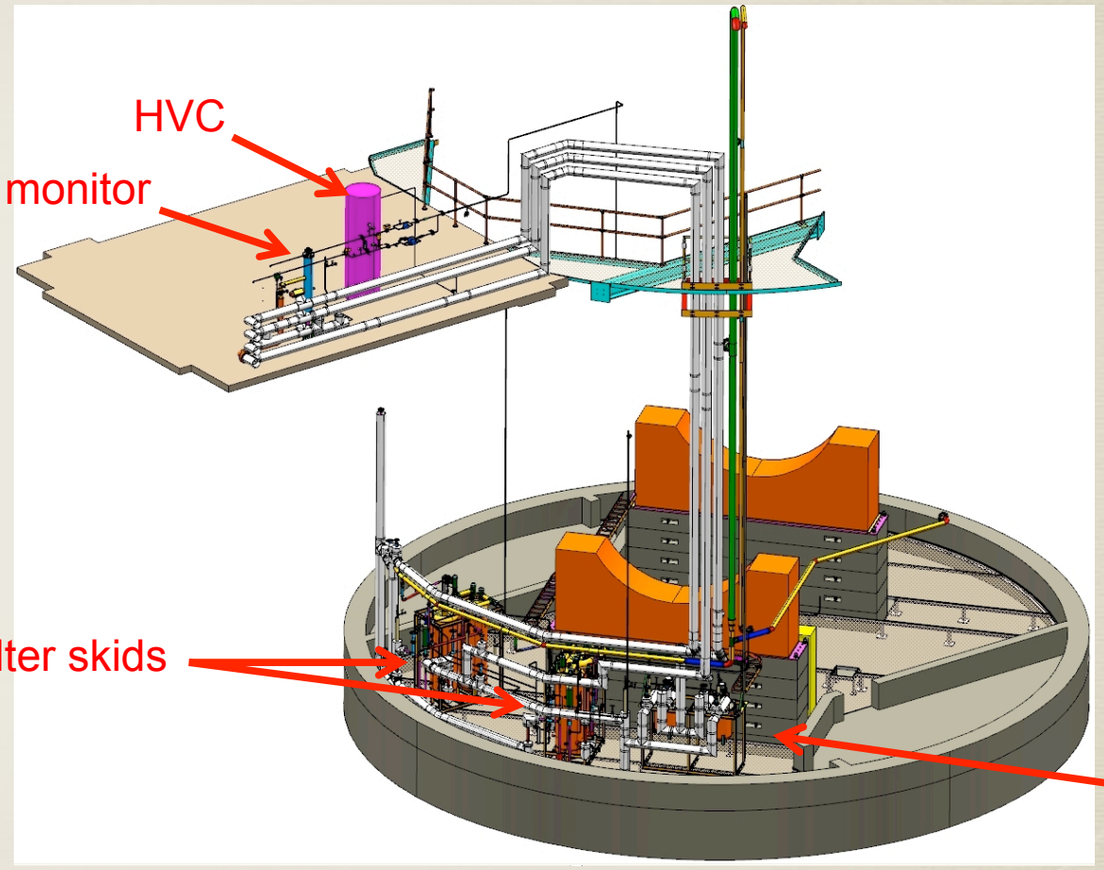
LArTF: Liquid Argon Test Facility





Cryogenics at LArTF

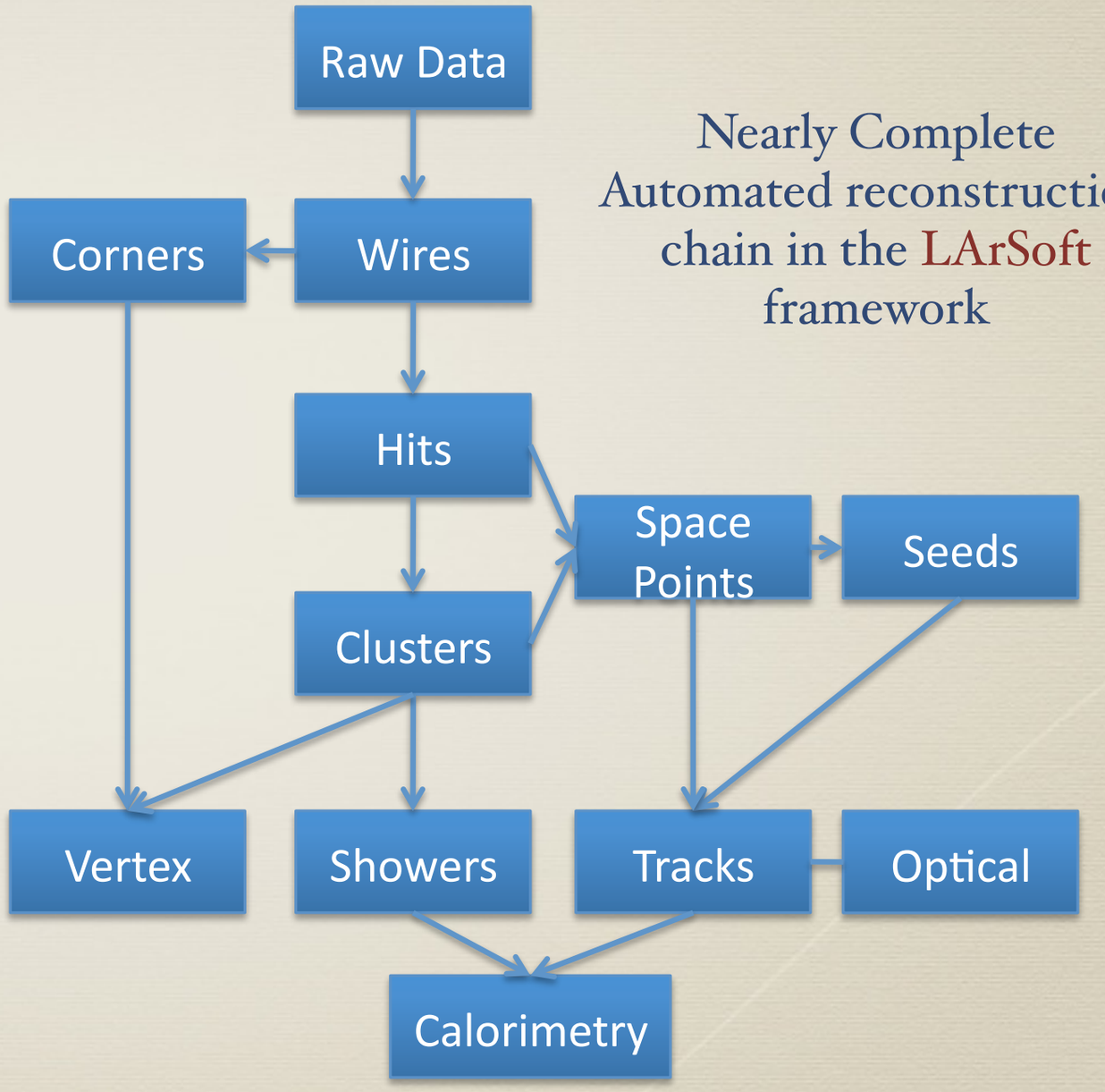
* Phase I without cryostat completed successfully.
* HV Cryostat (HVC) is producing valuable results to understand HV breakdowns in LAr.
* A lifetime of 3.5 ms is measured (<100 ppt equivalent O_2 concentration).
* Phase II will start after cryostat is installed and insulated.



Results from HVC and purity monitor will be shown at the LArTPC workshop.

Analysis Tools

* Analysis Tools sub-groups in place and developing tools since May, 2013
* Regular MC challenges.
* Progress on Reconstruction/ simulation/software tools.
* Reconstruction workshop at Yale in March, 2014.
* >90% efficiency to reconstruct cosmic muons.



Nearly Complete Automated reconstruction chain in the LArSoft framework

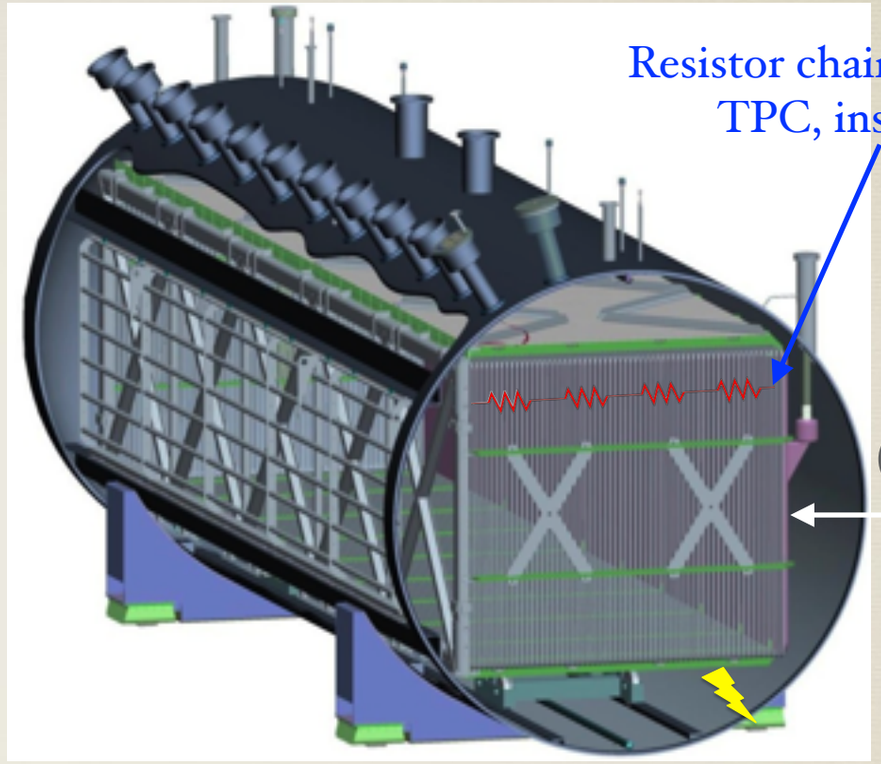
Summary

- Detector to move to LArTF in late June.
- Transition to Operations underway.
  - Commissioning Team planning commissioning phase
  - Nearly complete reconstruction chain
- We are very thankful to all of the collaborators and Fermilab staff that have helped us get this far!

Thank you for your attention!

Resistor Chain

* A chain of resistors between field cage tubes keep electric field uniform.
* 4x1GΩ Slim Mox (Ohmite) resistors were installed between adjacent tubes.
* Prior to welding of endcap, we discovered a potential problem if HV breaks down.
* A discharge between a tube and ground could pose very high voltage (up to ~90 kV) to some resistors and destroy all of them through cascade.



Upgraded Resistor Chain

* After a lot of discussions and extensive tests, we decided to replace some resistors and add surge protection devices.

* 2x500MΩ "Zebra" resistors for the first 16 tubes (near cathode) - rated for 100 kV.

* 4x1GΩ Slim Mox resistors for the rest 48 tubes - rated for 10 kV.

* Surge protection devices (varistor) for the first 32 tubes.

"Zebra"