The MicroBooNE Experiment

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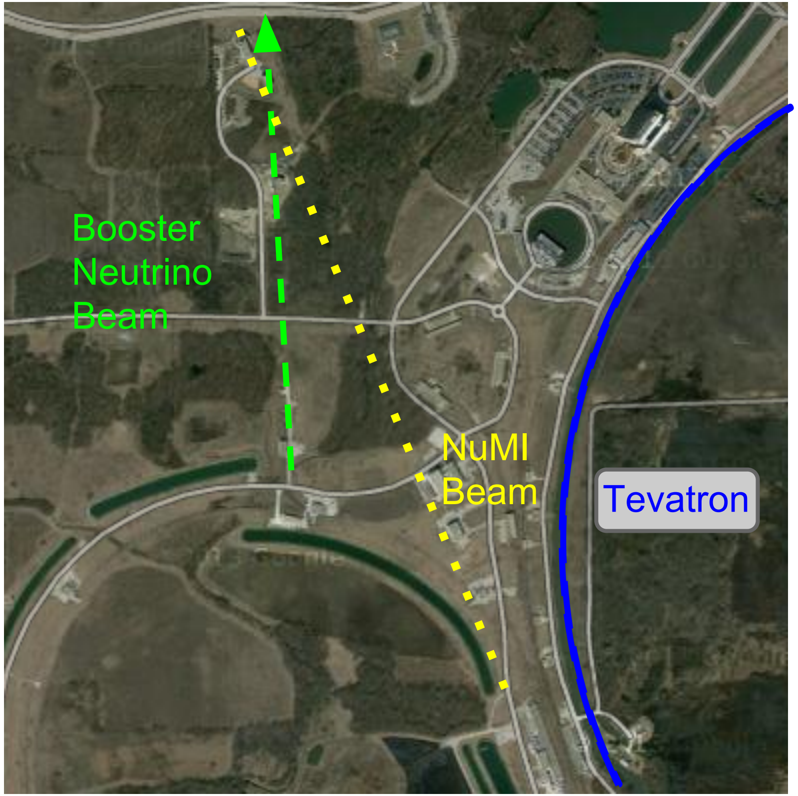
On Behalf of The MicroBooNE Collaboration

MicroBooNE

- Liquid Argon (LAr) Time-Projection Chamber (TPC) with 87 ton active volume.
- Stationed at Fermilab in the Booster Neutrino beam
- Major goals of MicroBooNE:
  - Investigate MiniBooNE's low energy excess
  - Wide range of cross section measurements of neutrinos on Ar
  - R&D for future large LAr detectors



MiniBooNE Low Energy Excess

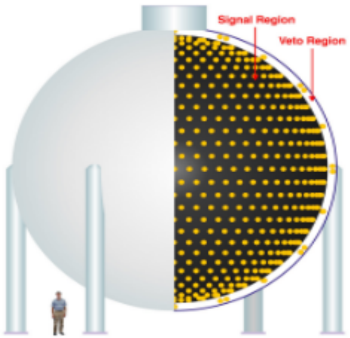
The MiniBooNE Detector

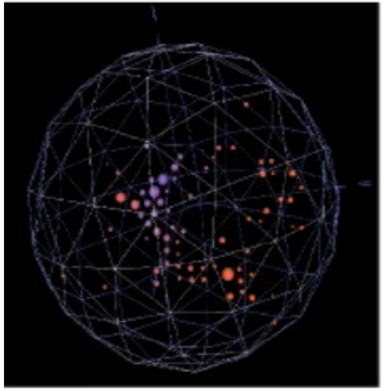
- Short baseline neutrino oscillation physics
- Mineral oil Cherenkov detector
- Collected data in the Booster Beamline at Fermilab (2001-2012)

The MiniBooNE Results:

- Unexpected >3σ (statistical & systematic, combined) excess
- Excess is at lower energies(< 0.6 GeV)
- Events were electron/photon like
- Excess in neutrino and anti-neutrino interactions

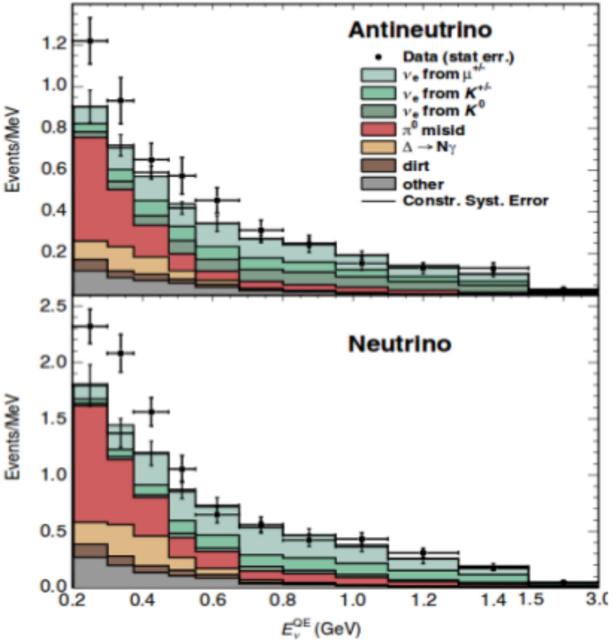
MiniBooNE Detector





$\nu_e n \rightarrow e^- p$

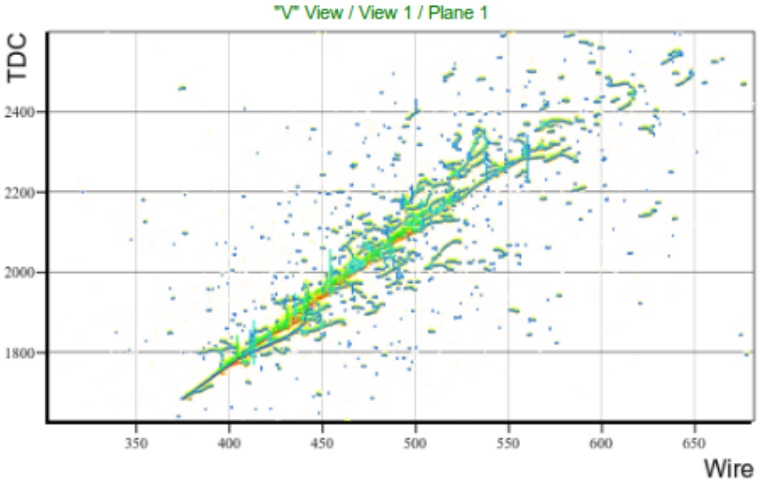
Phys. Rev. Lett. 110, 161801 (2013)

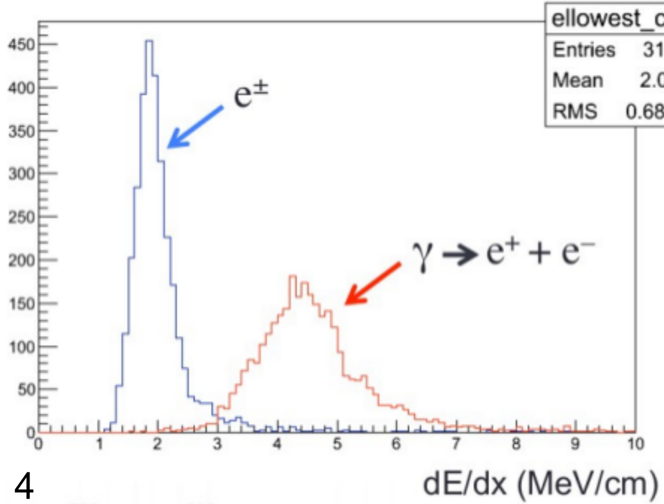


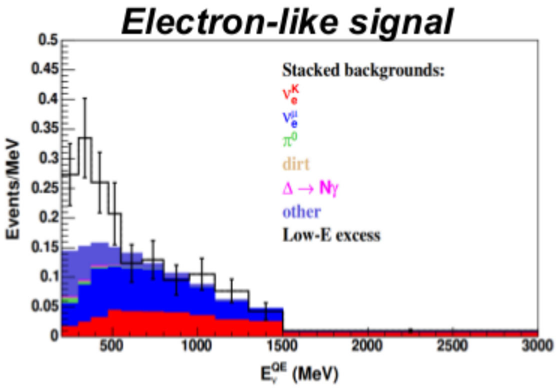
Motivation for LAr Detector

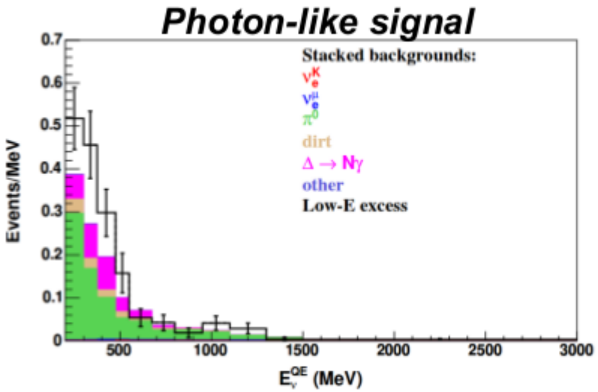
Imaging Capabilities:

- LArTPC's can easily differentiate between an electron or photon induced electromagnetic shower based on ionization of the first few cm of the EM-shower









Cross Sections and R&D

Cross Section:

- First high statistics measurement of neutrinos on LAr
- High resolution events allow for great signal to background separation

R&D:

- Argon purity in a unevacuated detector
- Large scale cryogenic low-noise electronics
- Understanding construction costs of large detectors

Process		**No. Events**
	ν_μ *Events (By Final State Topology)*	
CC Inclusive		88,098
CC 0 π	$\nu_\mu N \to \mu + Np$	56,580
	$\cdot\ \nu_\mu N \to \mu + 0\text{p}$	12,680
	$\cdot\ \nu_\mu N \to \mu + 1\text{p}$	31,670
	$\cdot\ \nu_\mu N \to \mu + 2\text{p}$	5,803
	$\cdot\ \nu_\mu N \to \mu + \geq 3\text{p}$	6,427
CC 1 $\pi^\pm$	$\nu_\mu N \to \mu + \text{nucleons} + 1\pi^\pm$	21,887
CC $\geq 2\pi^\pm$	$\nu_\mu N \to \mu + \text{nucleons} + \geq 2\pi^\pm$	1,953
CC $\geq 1\pi^0$	$\nu_\mu N \to \text{nucleons} + \geq 1\pi^0$	9,678
NC Inclusive		33,000
NC 0 π	$\nu_\mu N \to \text{nucleons}$	21,509
NC 1 $\pi^\pm$	$\nu_\mu N \to \text{nucleons} + 1\pi^\pm$	4,886
NC $\geq 2\pi^\pm$	$\nu_\mu N \to \text{nucleons} + \geq 2\pi^\pm$	635
NC $\geq 1\pi^0$	$\nu_\mu N \to \text{nucleons} + \geq 1\pi^0$	6,657
	ν_e *Events*	
CC Inclusive		567
NC Inclusive		207
Total ν_μ and ν_e Events		121,099

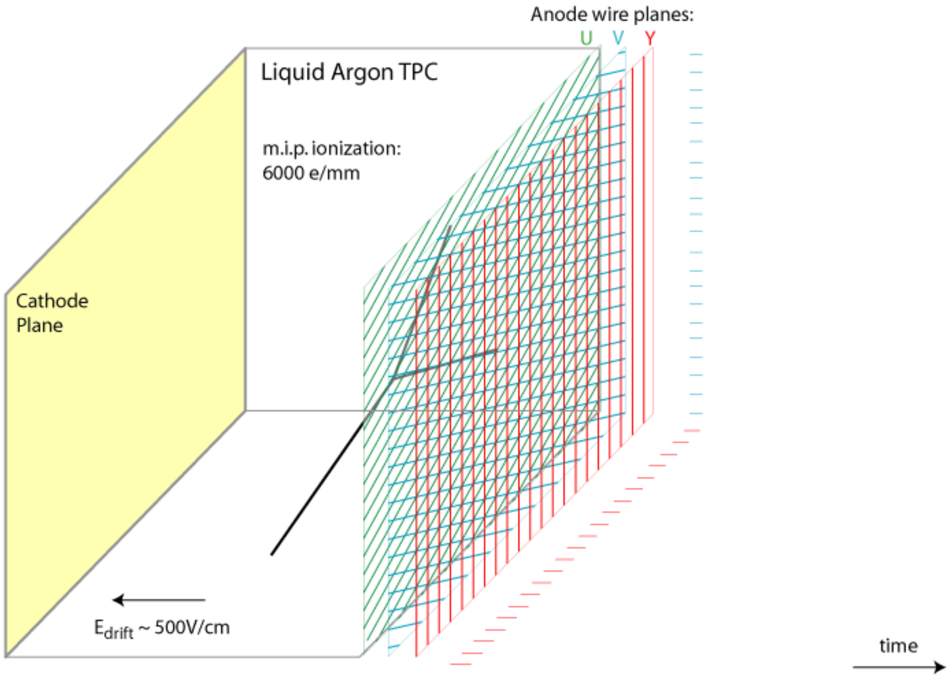
Why Argon?

	He	Ne	Ar	Kr	Xe	Water
Boiling Point [K] @ 1atm	4.2	27.1	87.3	120.0	165.0	373
Density [g/cm^3]	0.125	1.2	1.4	2.4	3.0	1
Radiation Length [cm]	755.2	24.0	14.0	4.9	2.8	36.1
Scintillation [γ /MeV]	19,000	30,000	40,000	25,000	42,000	
dE/dx [MeV/cm]	0.24	1.4	2.1	3.0	3.8	1.9
Scintillation λ [nm]	80	78	128	150	175	

- High density (good target)
- Small radiation length (~14cm)
- Good dielectric properties
- Track ionizations can drift over long distance if kept pure
- Argon is relatively inexpensive

How a TPC Works

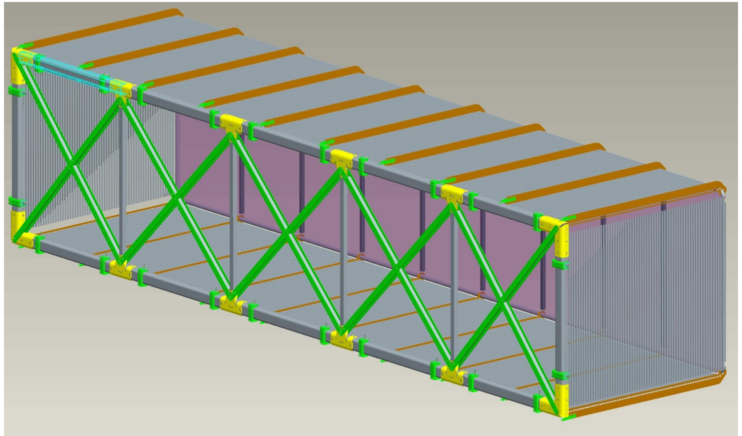
- Neutrino interactions in LAr produce ionization tracks and scintillation light
- Photomultiplier tubes instantly see scintillation light and start recording data
- A uniform electric field drifts the ionization electrons to wire planes
- Data is read out from sense wires and reconstructed using wire and time information

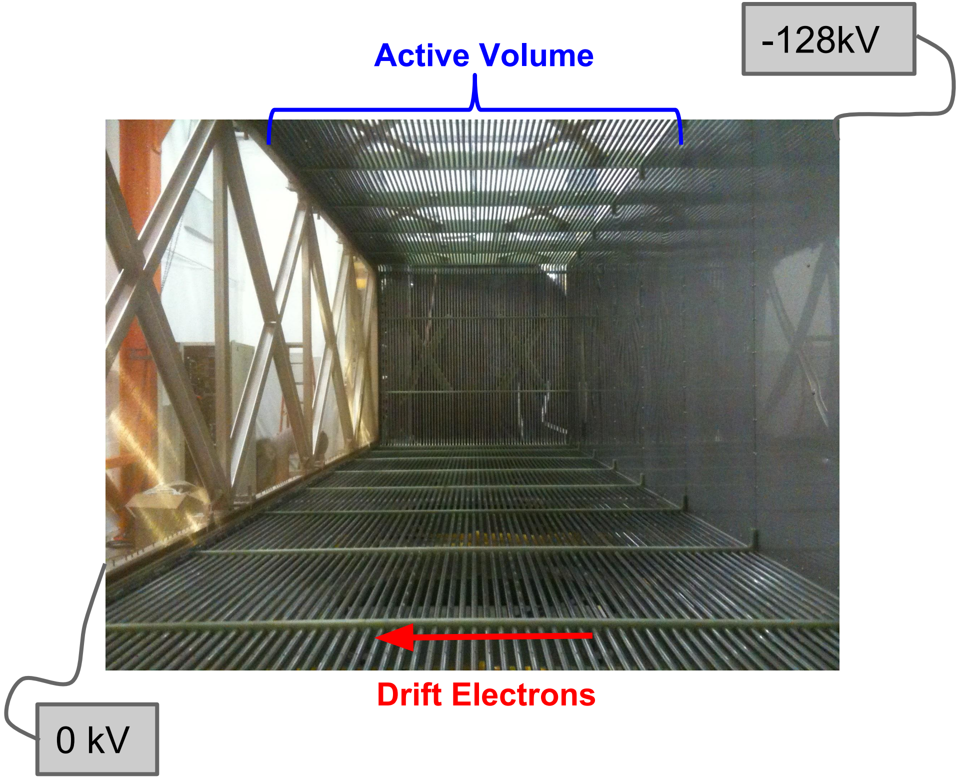


MicroBooNE TPC

TPC Dimensions:

- 10.3 m long x 2.3 m tall x 2.5 m wide (drift distance)
- 87 tons active mass
- 3 wire planes u,v,y (u,v ± 60°)





Wire Installation

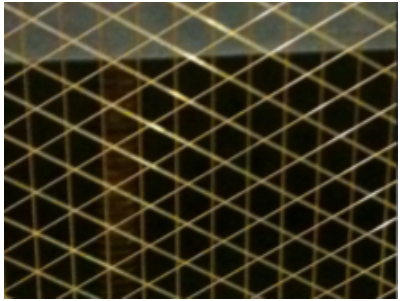
8256 Sense Wires:

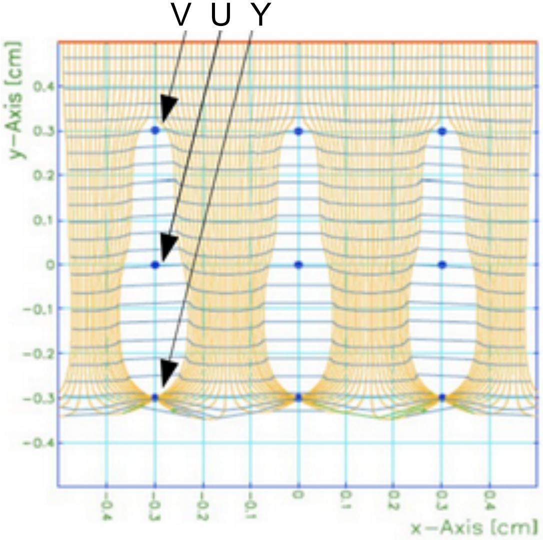
- 3456 collection wires (vertical)
- 4800 induction wires (+/- 60°)

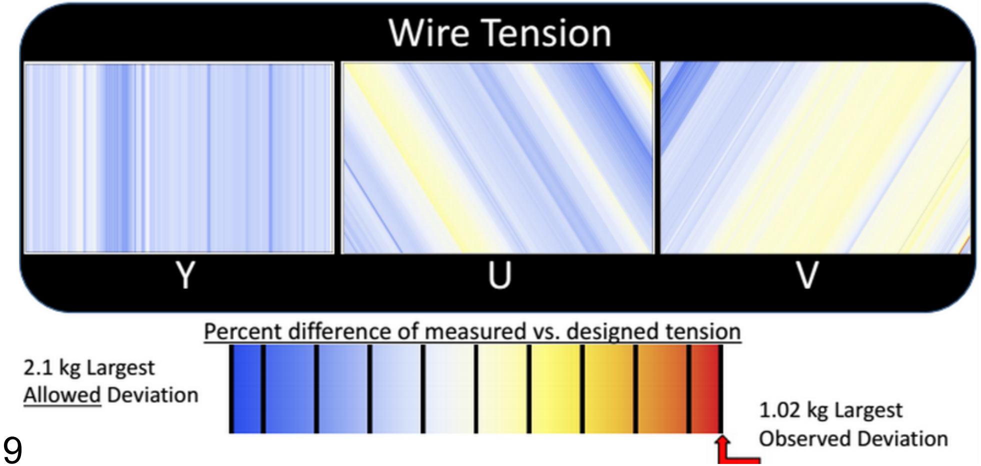
Wires are 150μm diameter

- SS Cu/Au plated

All Wires Tensioned to 0.7kg







Transparency Condition

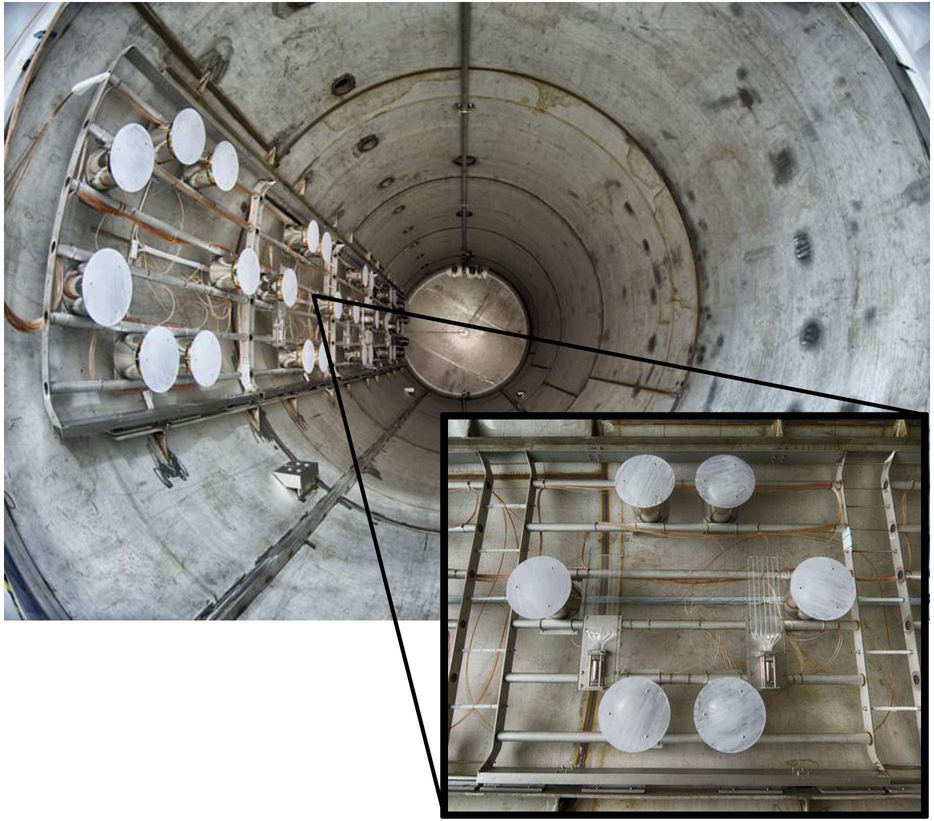
$$\frac{E_2}{E_1} > \frac{1+\rho}{1-\rho}$$

$$\rho = 2\pi r/p$$

r = radius
p = pitch

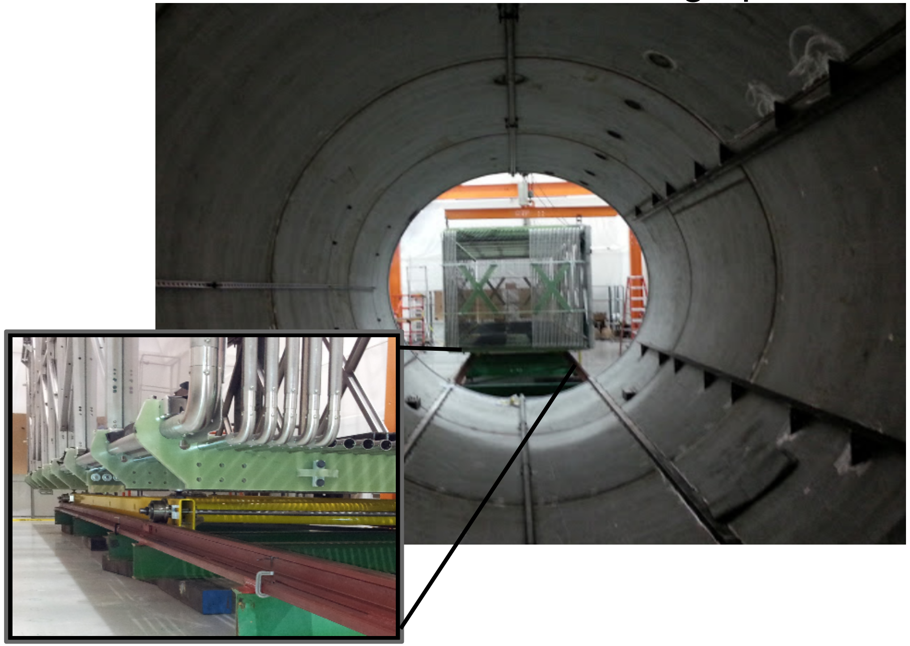
PMT's

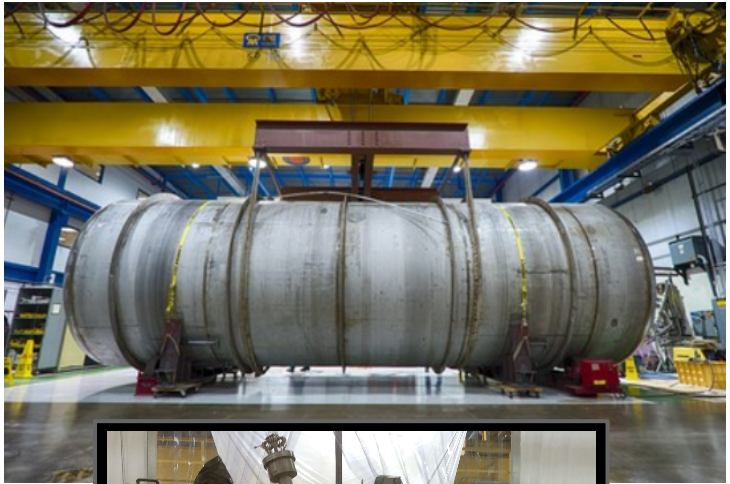
- Liquid argon produces scintillation light at 128nm (VUV)
- Acrylic plates coated with Tetraphenyl Butadiene(TPB) shift the light's wavelength from 128 → 425 nm
- Two components of scintillation light
  - Fast: 6ns after interaction(25%)
  - Slow: 1.6μs after interaction(75%)
- PMT's are used as a trigger and cosmic ray rejection
- MicroBooNE implements an array of 32 PMT's

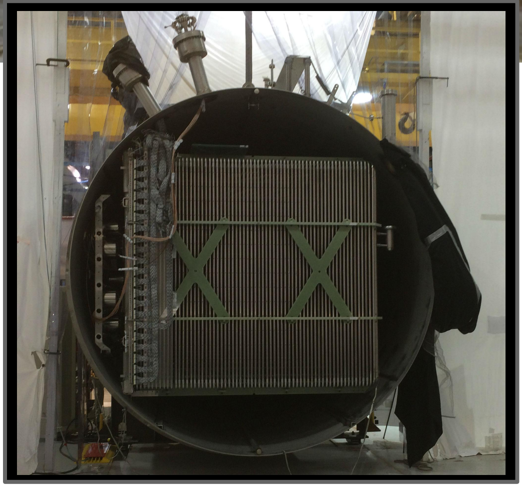


Cryostat/Installation

- The MicroBooNE Cryostat is designed to hold 170 tons of LAr
- Single walled vessel that will be insulated with foam during operation

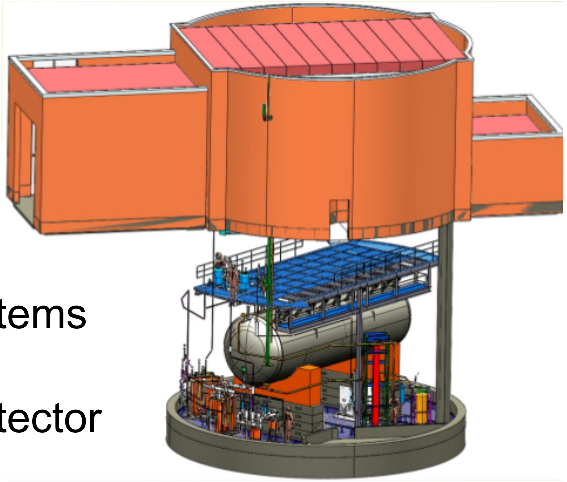






Current Status Future Plans for MicroBooNE

- TPC is currently in the cryostat
- Final adjustments underway in preparation to permanently welding the vessel closed
- Transport TPC+cryo to Liquid Argon Test Facility(LArTF)



- Connect cryogenic systems
- Foam insulate detector
- Begin cooling down detector
- Take data!

Thanks for listening
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Look forward to an exciting year for MicroBooNE!