About MicroBooNE

And Engineering Issues

3/23/2009

MicroBooNE is - -

- A liquid argon Time Projection Chamber detector, located adjacent to the MiniBooNE detector
  - LArTPC
- A detector technology well-suited to neutrino physics
  - Excellent spatial resolution and calorimetry
- In principle scalable to large sizes
  - Future neutrino physics requires massive detectors
- Pioneering work has been the ICARUS collaboration
  - And their work continues
- US efforts with this technology have been expanding in recent years
- MicroBooNE is a step along the development path

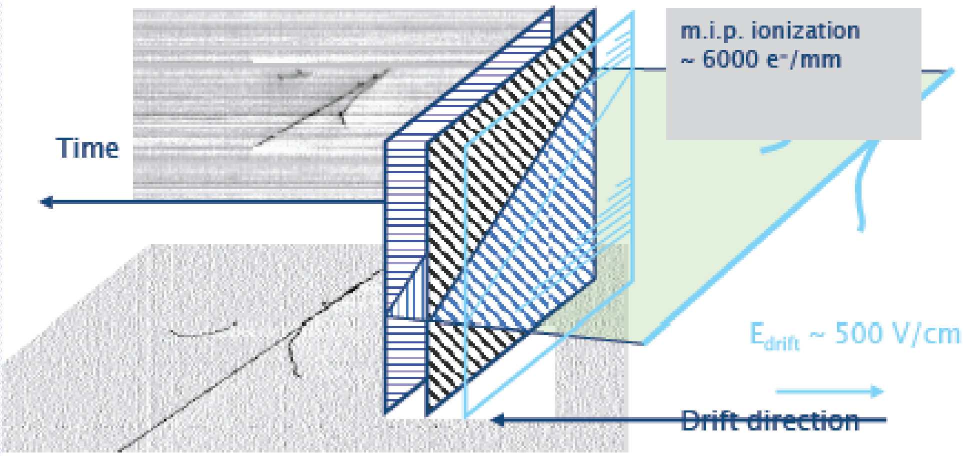
Properties of Noble Liquids

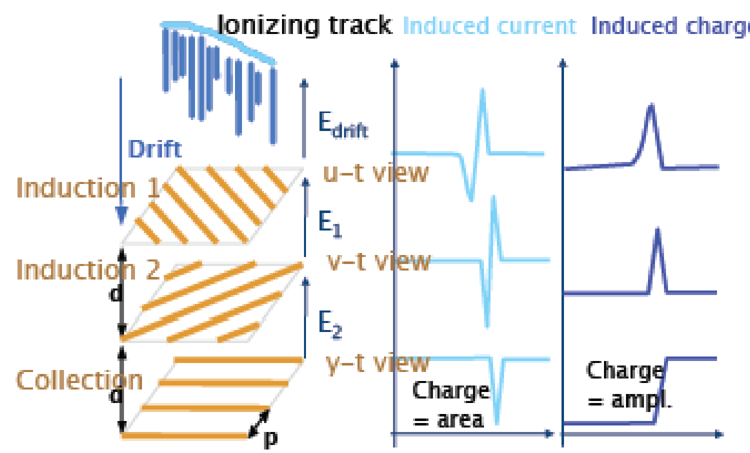
- Both ionization and scintillation light used for detection
- Ionization electrons can be drifted over long distances
- Dielectric properties allow very high voltages to be applied
- Argon is relatively cheap, plentiful

	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	

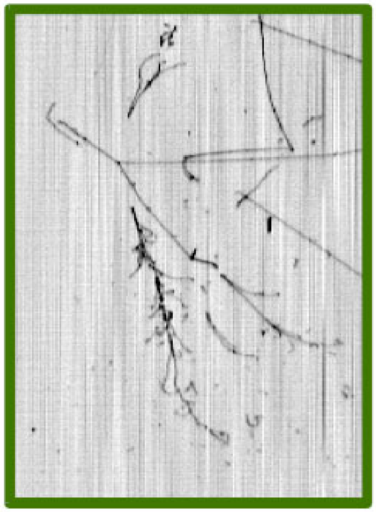
TPC – how it works

- Interactions inside the detector produce ionization particles that drift along electric field lines to readout planes
  - Get a train of pulses, with slight time offsets due to different drift lengths
- Knowledge of the drift velocity, and T0 of events, is used to reconstruct the interaction
- Scintillation light is also present and can be detected by photodetectors





What you get from a LArTPC

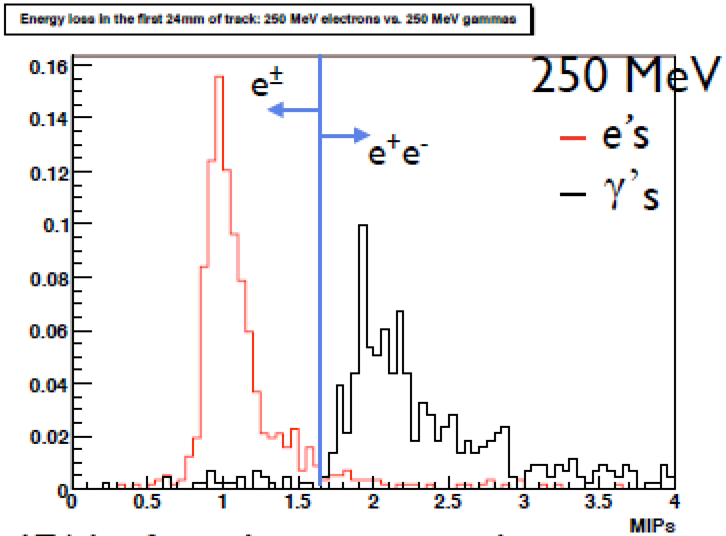


ICARUS Event

Amazing bubble-chamber like events

But also particle ID, from dE/dx along a track

In particular, e-γ separation



dE/dx for electrons and gammas in first 2.4 cm of track

The MiniBooNE low-energy excess events can possibly be better identified by a detector with this ability

Future massive neutrino detectors need good e-g separation, to identify CC ν_e (make an electron) signal events from NC (make γ from π^0) background events

Many challenges to making it work

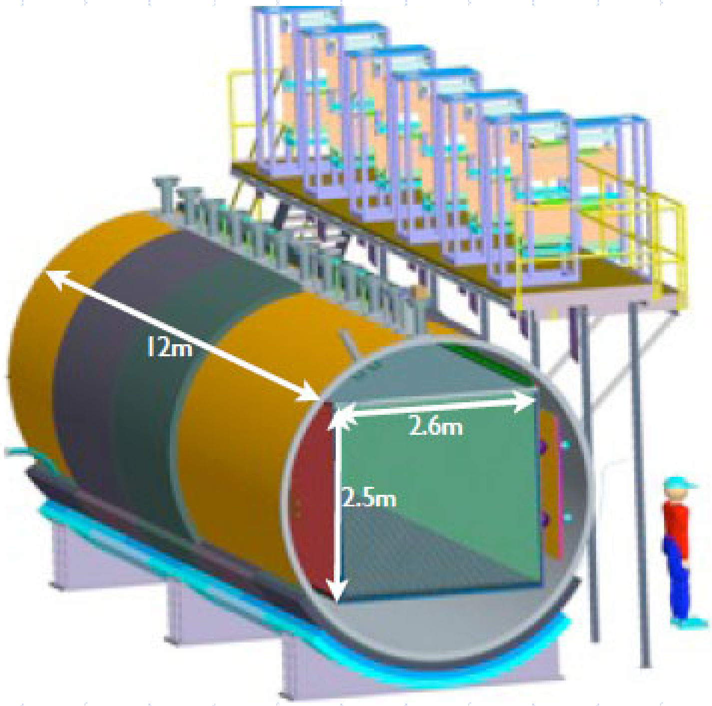
- Argon purity – parts per trillion
  - High purity necessary for long drifts
- Safety issues
  - ODH hazards
  - Pressure vessel – (MicroBooNE is evacuable)
- Vacuum & cryogenics environments take special care
  - Every penetration into the cryostat must be leak-tight
  - Every penetration increases the heat load on the system
- Electronics
  - Signals are small, so sources of electronic noise must be strictly controlle
  - High sampling rate + many wires = lots of raw data

MicroBooNE – conceptual design

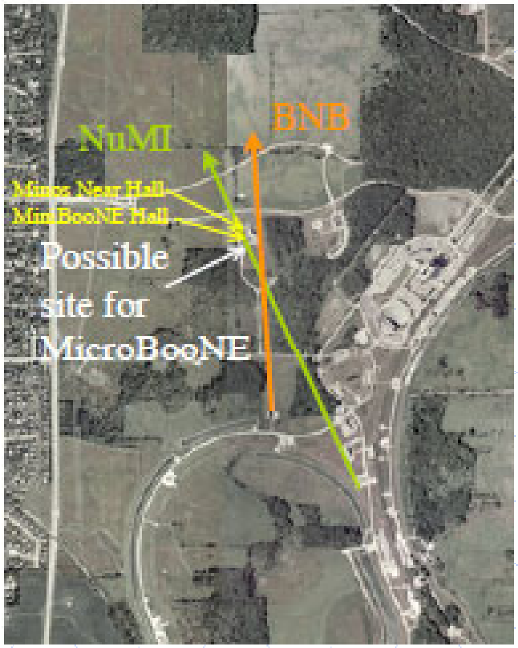
~200 ton cryostat vessel, 12m long, with a ~2.5m square TPC inside

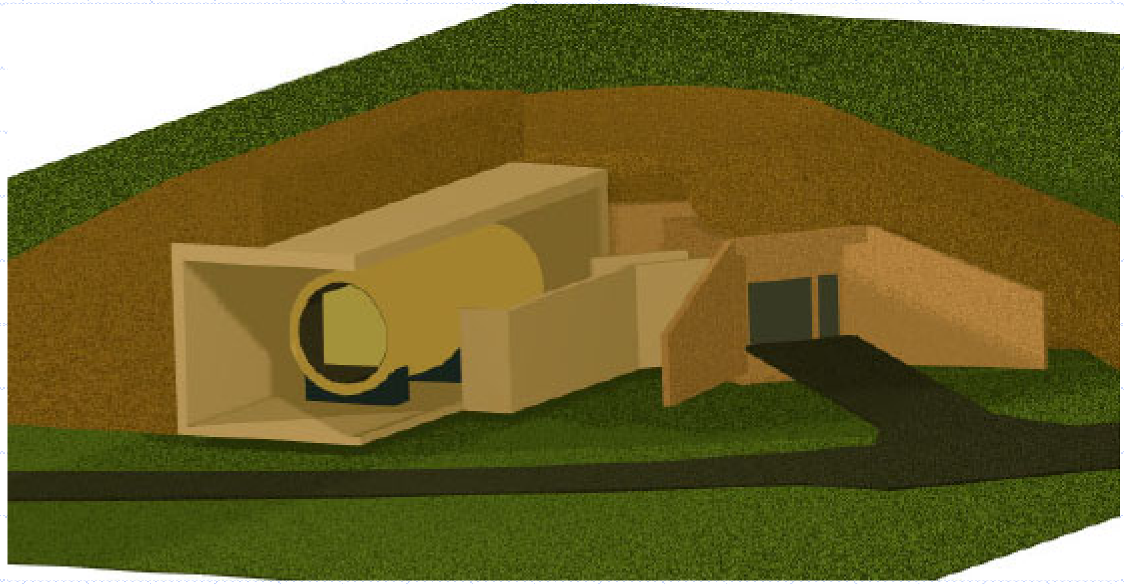
Vessel – as large as can be commercially constructed offsite and delivered by truck

- ~70 ton fiducial volume (inside TPC)
- 2.6m drift (500 V/m) = 1.6ms drift time
- 3 readout planes (+30-degrees induction, vertical collection)
- 10,000 channels
- Cold pre-amplifiers (sit in gas)
- ~30 PMTs for trigger
- Cryogenic system for purification and recirculation



Where

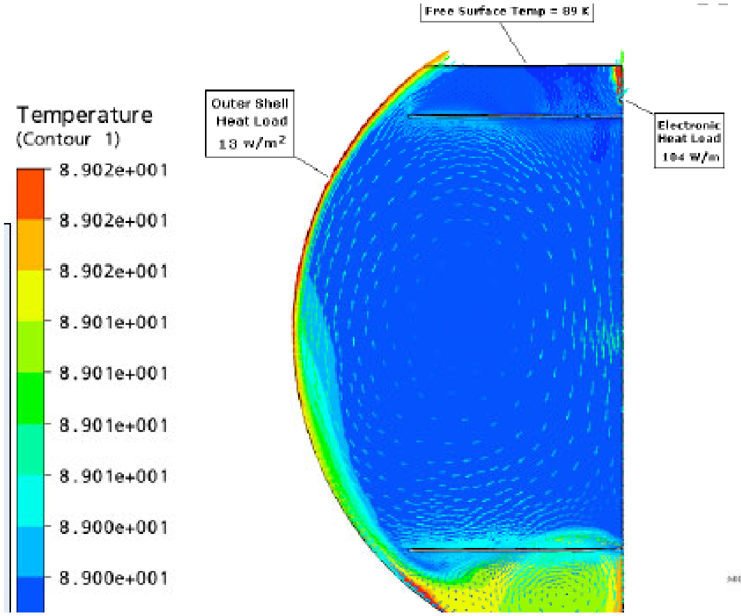




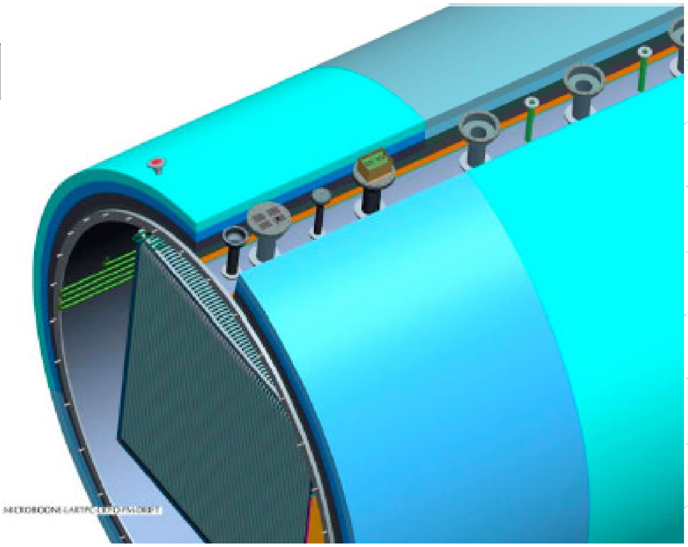
- On surface, next to MiniBooNE enclosure
  - An addition to that enclosure

Cryo systems

- Estimated 13W/m2 heat load (3.4 kW total)
- ~16 inches of spray foam
- Temperature gradient << 0.1K
  - Crucial to reducing track distortions



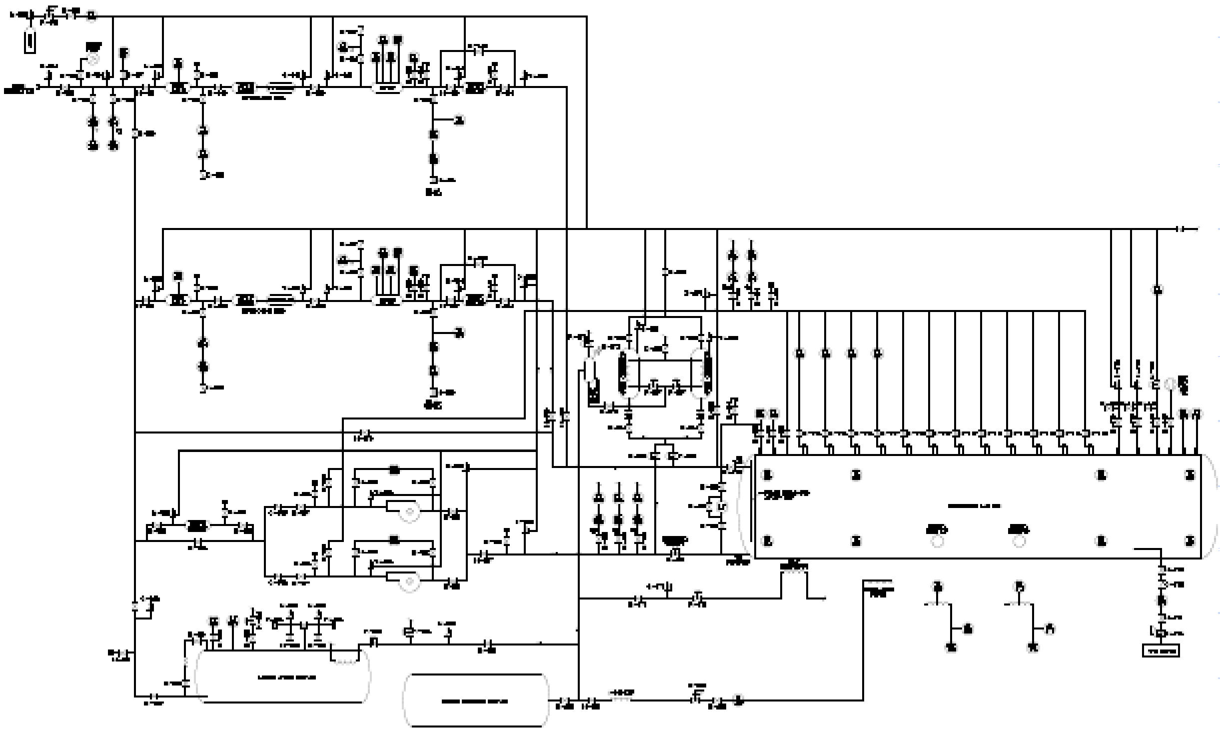
Temperature distribution



Detailed view of insulation/feedthroughs

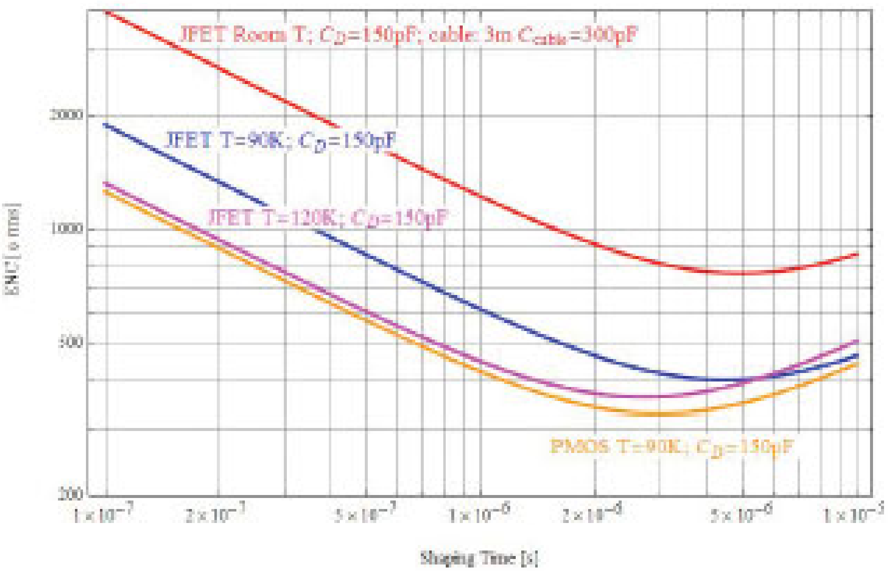
Cryo Systems

- Basic plumbing system



Electronics

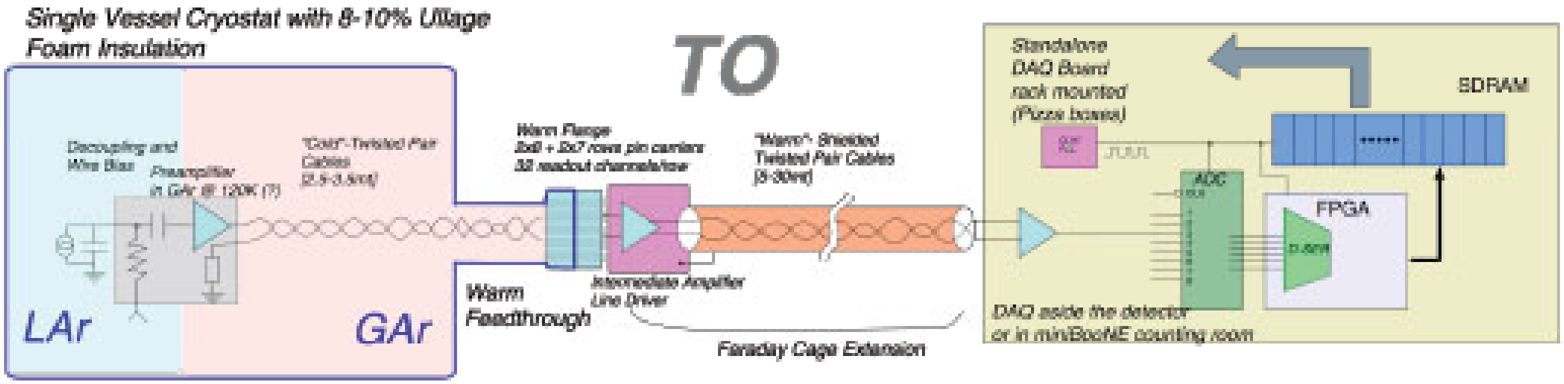
- Pre-amps placed inside vessel, on top of TPC, in cold gas
  - x3 better S/N compared with having them outside vessel
  - Part of R&D to larger detectors, where signals must transit long distances



JFET (T=120 K)/pMOS (T=90K) have similar S/N performace

- JFET – similar S/N performance in cold gas to PMOS in liquid
  - PMOS in liquid is the next R&D step to large detectors

Electronics



Readout Chain

- Pre-amp → feed-through → driver → Digitizer board
  - 2Mhz digitizing rate, 12-bit ADC
  - 10k channels → data compression, lossless
  - 16 Mb per event, hundreds Mb/s recorded

Needs from FNAL

- Cryostat and cryo systems (FNAL + BNL)
- Detector feed-throughs (FNAL, BNL)
- Electronics and Electronics Infrastructure (PPD + collaboration)
- Photodetector - mechanical support and phototube coating
- DAQ (??)
- Building addition (FESS)
- Installation & Integration (FNAL + collaboration)
- Installation activities (technicians)