

# The MicroBooNE Experiment

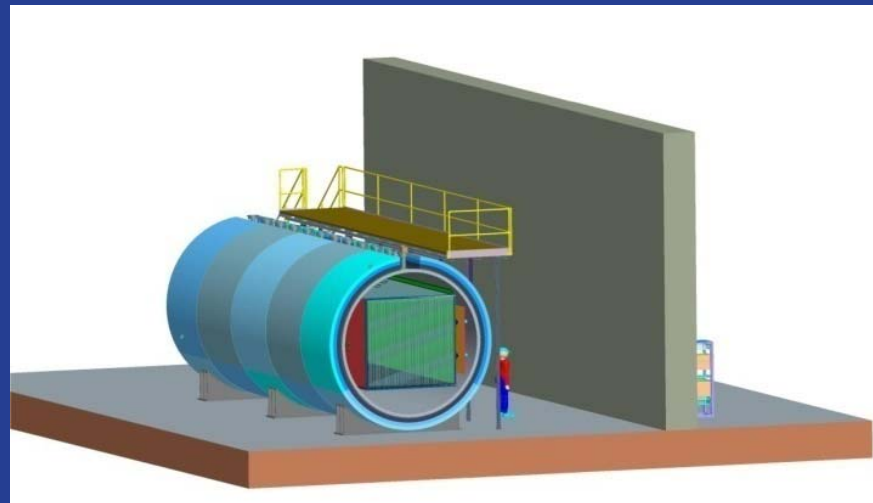
Liquid Argon Detector  
Future Neutrino Experiment Project



# Introduction

MicroBooNE is –

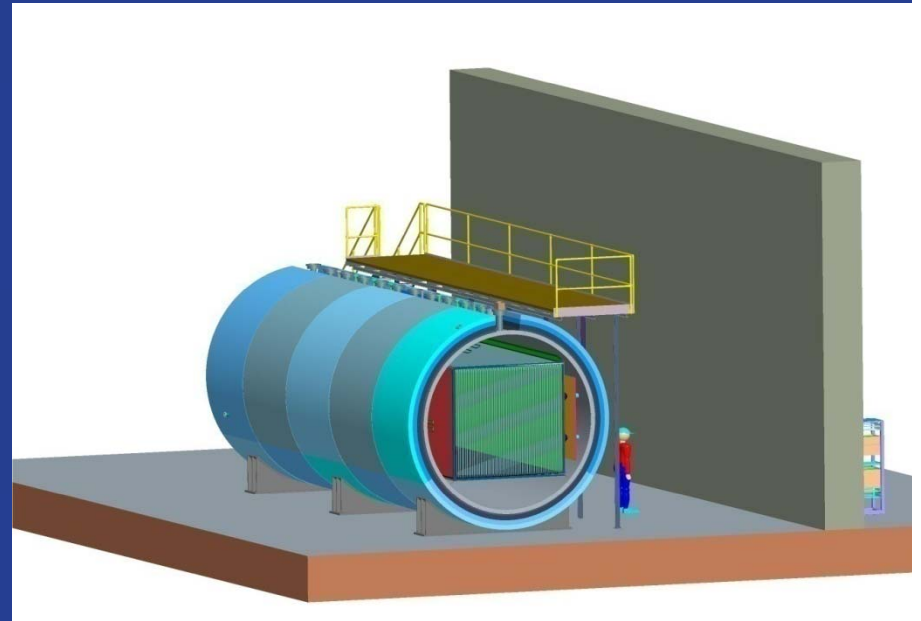
- A liquid argon Time Projection Chamber (LAr-TPC), placed next to the Mini-BooNE detector enclosure
- Combines physics and hardware R&D goals, using both to assess the technology for massive neutrino detectors



# Introduction

## ■ Detector Overview

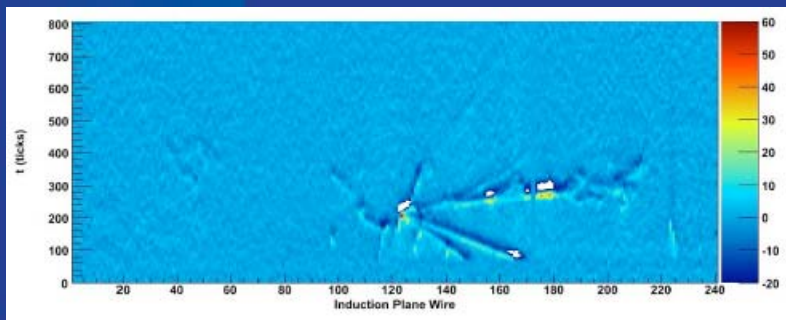
- Single-walled insulated cylindrical vessel ~12m long, ~3.5m diameter
- Holds ~170 tons of liquid argon
- ~70 ton fiducial volume, inside the TPC
- 2.6m drift (500 V/cm E-field gives a 1.6 ms drift time)
- 3 readout planes (+30-degrees, vertical)
- ~10,000 channels
- pre-amplifiers, sitting in cold argon gas, above TPC; digitizing electronics located outside the vessel
- ~40 PMTs for trigger
- Cryogenic system for purification and recirculation



# Why LAr-TPC

- An attractive detector technology for neutrino physics
  - Fine-grained spatial resolution, energy deposition information

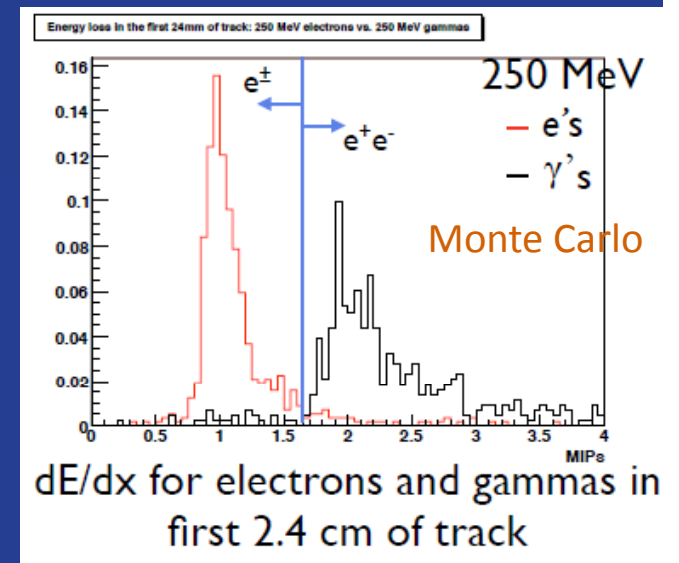
LAr-TPC detectors produce amazing bubble-chamber like visualization of events



ArgoNeuT neutrino event, June 2009

One can have particle ID capability, from  $dE/dx$  along a track

In particular,  $e$ - $\gamma$  separation



- Detectors for neutrino appearance experiments need good  $e$ - $\gamma$  separation, to identify CC  $\nu_e$  signal events from NC background events

# LAr-TPC Development Program

- In principle, these detectors are scalable to large sizes
  - Future neutrino experiments will require massive detectors
- US efforts with the technology have been expanding in recent years
  - At FNAL – Cryogenic Test Stands at PAB, ArgoNeuT

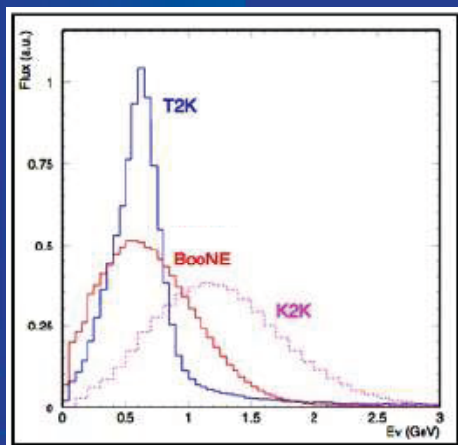


The MicroBooNE experiment offers a step along the LAr-TPC development path, with the opportunity to perform physics measurements in a neutrino beam  
(see P. Shanahan's plenary talk)

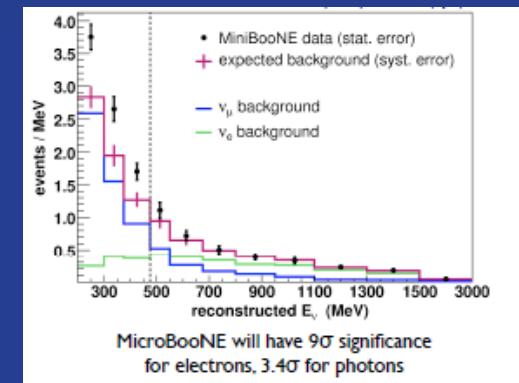


# Physics Goals

- Physics results will be primarily in neutrino interaction cross-sections
  - The BNB neutrino spectrum is exactly the neutrino energy in the 2<sup>nd</sup> oscillation maximum expected in the proposed LBNE beamline
  - It is also the spectrum observed in the T2K beam – why SciBooNE was here
  - Cross section results will inform NOvA, T2K, and LBNE



- In measuring cross sections, we will record and identify the events which fall into the MiniBooNE low energy excess

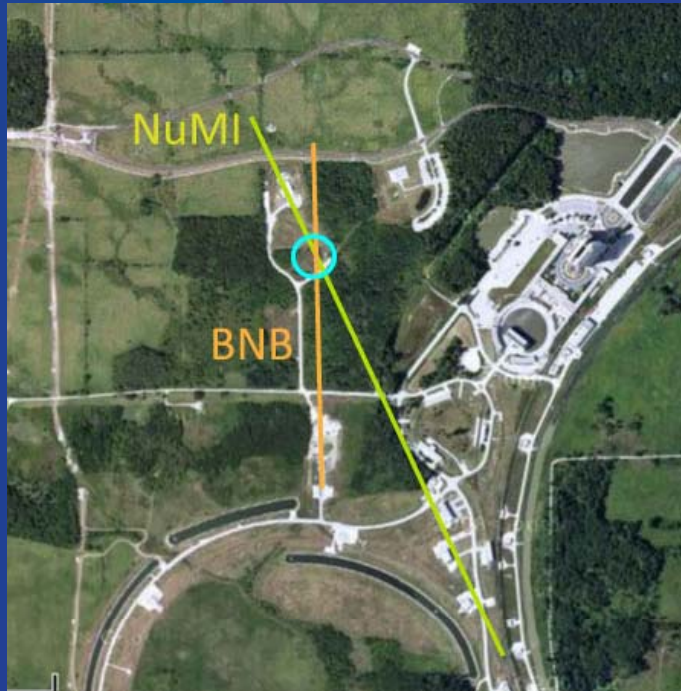


- Software development, in simulation and reconstruction, is a focus of the collaboration. No LAr-TPC has yet had a fully automated event reconstruction
- Operating with physics goals in a neutrino beam provides an excellent assessment of the detector technology strengths and weaknesses

# R&D Goals

- MicroBooNE can make contributions to the technical planning for LAr-TPC detectors proposed for future long-baseline neutrino experiments
  - Attain sufficient argon purity without prior evacuation to pull out impurities, via cold gas purge before filling
  - Attain low-noise electronics operation
  - Long drift length, which tests purity and reconstruction schemes
  - PMT operation in cryogenics, for neutrino event triggering ability
  - Data handling – what does it take to be “always on” and sensitive to super-nova and proton decay?
  - Construction methods – assembly in a can
  - Software development is being done with future detectors in mind

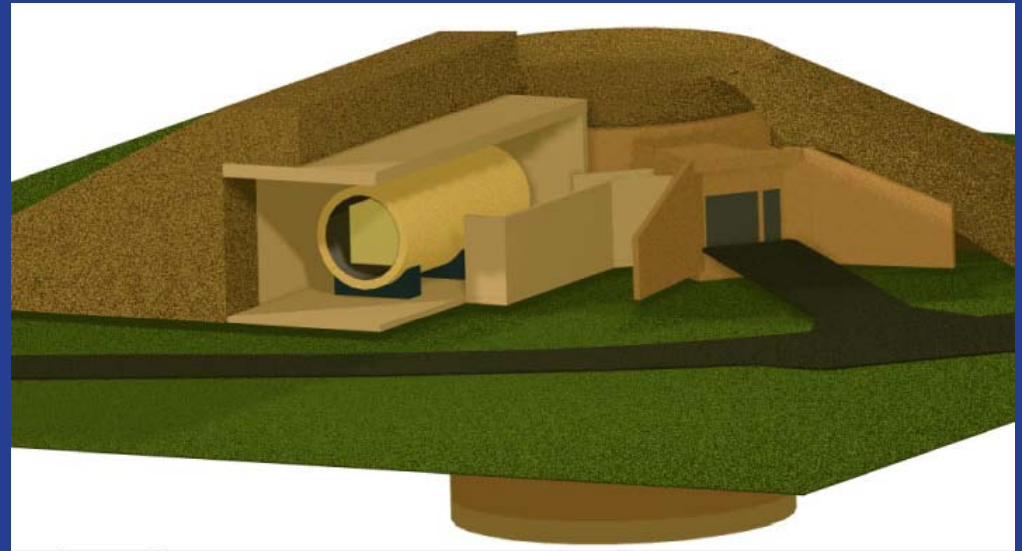
# Detector Location



	BNB	NuMI
Total Events	100k	60k
$\nu_\mu$ CCQE	39k	21k
NC $\pi^0$	8k	7k
$\nu_e$ CCQE	250	1.7k
POT/year	$2-3 \times 10^{20}$	$4 \times 10^{20}$

- ~2 years running

Neutrino beams are not laser-pointer-focused  
 The detector will see off-axis NuMI neutrinos



On the surface, next to MiniBooNE enclosure

- An addition to that enclosure – connected by a hallway
- On the Booster Neutrino Beam axis (plan view, not elevation)
  - No changes to the BNB



# Status

- Approved by the Lab in July 2008
- Collaboration growth, approximately doubled, to present ~60 scientists & postdocs from 11 Institutions
- Design, construction, installation managed as a Lab/DOE Project
  - Project Manager appointed by FNAL Oct 2008
  - WBS, Level 2 sub-systems laid out
    - Cryostat & Cryogenics – FNAL, BNL
    - Active Detectors – TPC & Phototubes – Yale, MIT, BNL
    - On-Detector Electronics – BNL, FNAL
    - Digitizing Electronics – Columbia, BNL, FNAL
    - DAQ & Monitoring – Princeton
    - Building – FNAL
    - Installation – FNAL, BNL

# Status

- **DOE Project Timeline**

- Mission Need – CD-0 – document currently circulating within DOE
  - Project provided information and materials winter/spring 2009
- Starting the Project Review Process
  - Document preparation – Conceptual Design Report, other project docs
  - Design Reviews – by sub-system, invite experts from outside the collaboration to review and comment

- Hope to schedule a Director's CD-1 Readiness Review, and a following DOE CD-1 Review, by the end of calendar 2009

- CD-4 in 2013

- **Work hard to keep the total Project cost under \$20M**

- Cost estimate process in progress, based on conceptual design
- Expect about \$1.5M in NSF contributions
- Have funding guidance from the Lab, no firm funding profile
- DOE can provide MIE funds starting FY-11

# Current Work

- R&D in FY09 and FY10, toward final designs
  - MOU/SOW with collaborating institutions in progress now
- Cryostat/Cryogenics development (FNAL, BNL)
  - Investigating vessel support options (saddles, slings) and their impact on the Building
  - Investigating insulation materials and methods
- TPC development (Yale, BNL)
  - Risk analysis of wire breakage, using data from test stands, both existing and to-be-developed
  - Develop a prototype semi-automated wire-winding machine
  - Investigate methods to measure wire tension during installation
  - Study the mechanical reliability of pressed-in field cage resistors

# Current Work, continued

- R&D in FY09 and FY10, toward final designs
  - Photodetector development (MIT, FNAL)
    - Prototype a base for the phototubes
    - Set up phototube preparation and testing assembly line at PAB
    - Prototype support frame, used to store tubes after testing
  - Electronics development (BNL, Columbia, FNAL, MSU)
    - Produce a small quantity of the boards described in the CDR
    - Develop test stations for the readout chain (vertical slice)
    - Develop FPGA code
    - Investigate data compression algorithms (ArgoNeuT data)
    - Investigate options to the CDR design
  - Installation planning
    - Continuing discussions on how the detector is installed, and how the installation procedure affects the design

# Summary

MicroBooNE combines detector R&D with physics

- Pursues R&D questions relevant to massive LArTPC detectors
- In progress
  - Becoming organized as a Project
  - Entering the R&D preliminary design phase
  - Getting ready for Project reviews