MicroBooNE status and a 2 LAr-detector experiment at FNAL

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Outline

- Overview of the microBooNE experiment
    - Description of the detector
    - Scientific goals
    - Current status
- 2 detector experiment: microBooNE II + Large LAr in the BNB
- Studies for 2 LAr detectors sensitivity to LSND/miniBooNE excesses
- Conclusions

MicroBooNE context: The MiniBooNE low-energy excess

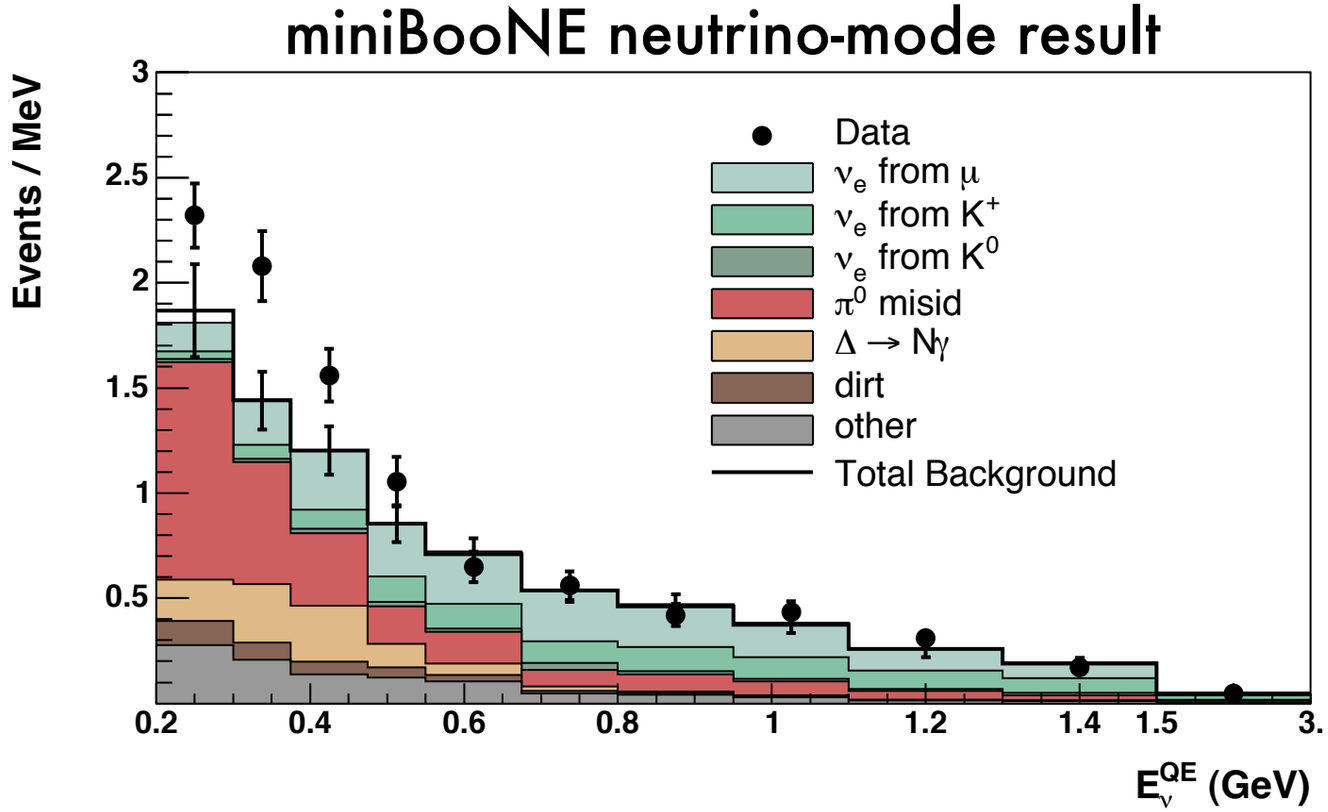
- MiniBooNE experiment observed an excess (3σ) of low-energy (200 MeV - 475 MeV) events in neutrino mode

- The excess events are electron-like: e^-/γ

- Efforts to understand the excess

- MiniBooNE cannot distinguish between electrons and photons

- Need of a new detector (new technology) to address the miniBooNE low-energy excess

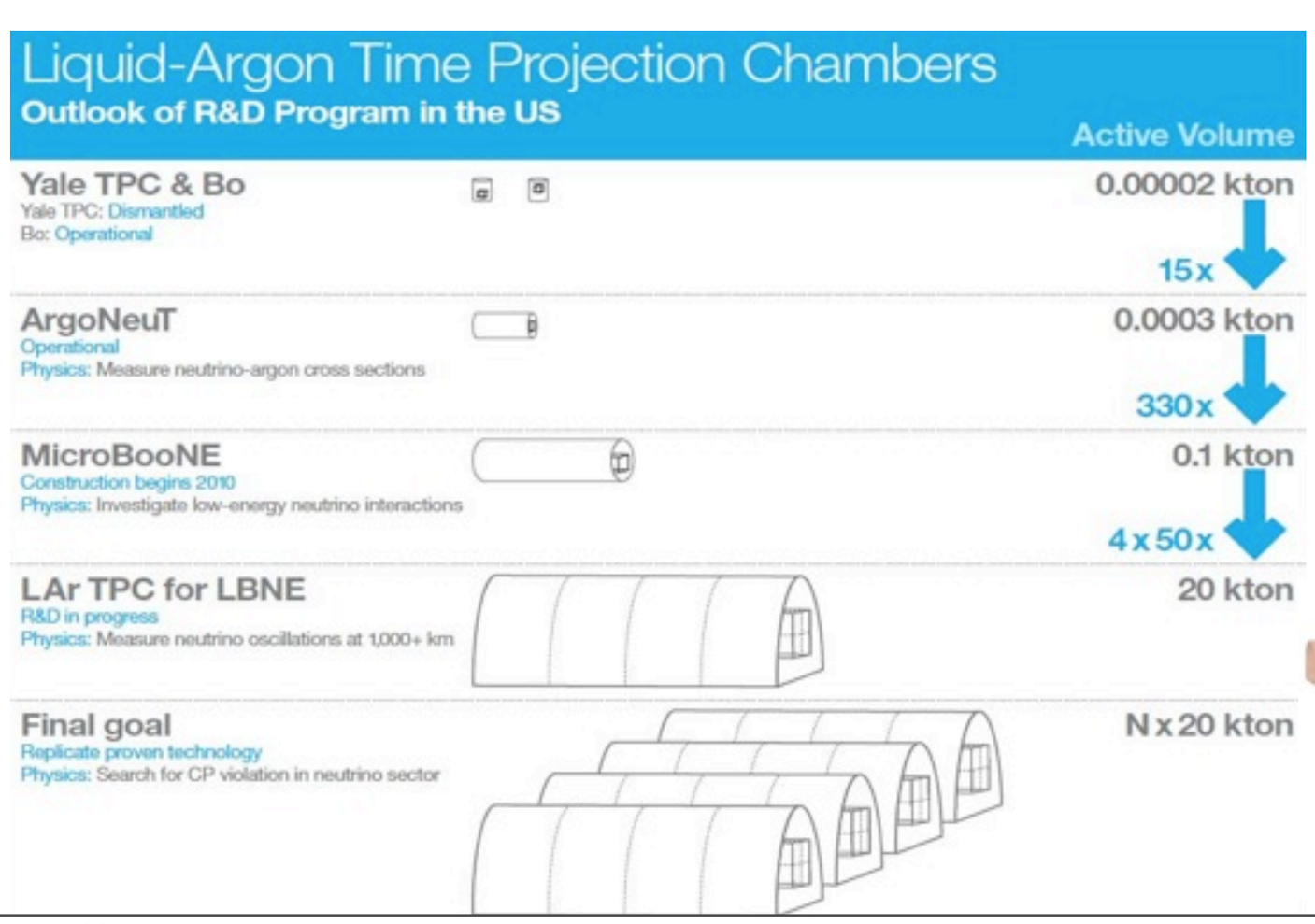


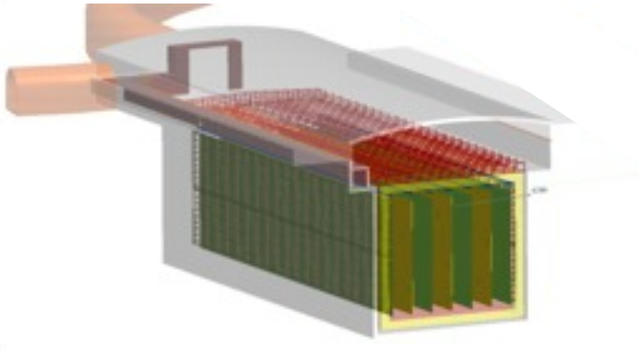
Phys.Rev.Lett.102, 2009

MicroBooNE context: Technology development

- LAr technologies have been considered for very large scale neutrino detectors (scalability, precision and calorimetry)

- But the scalability has not been demonstrated yet

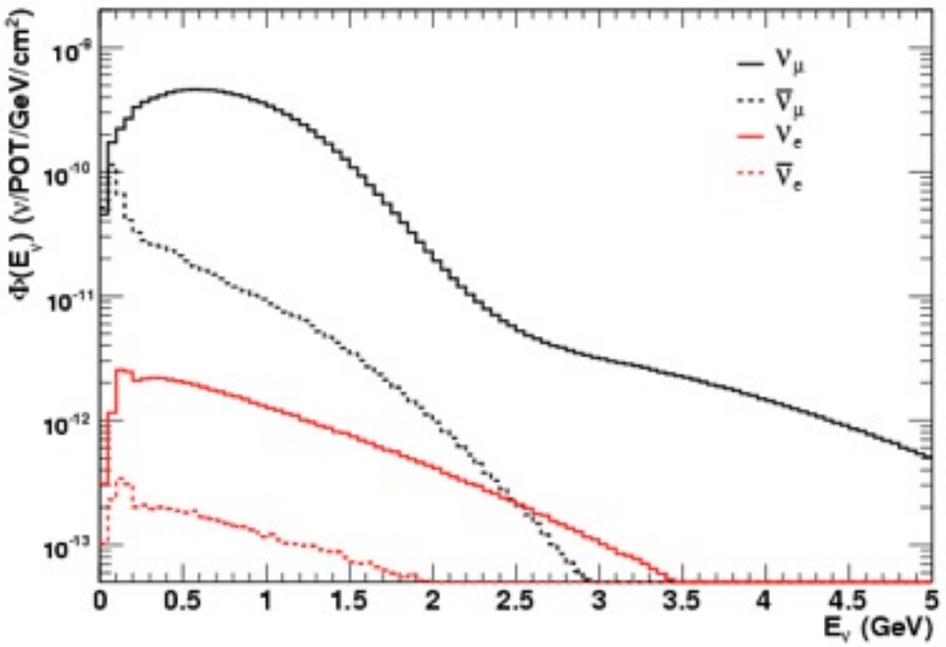




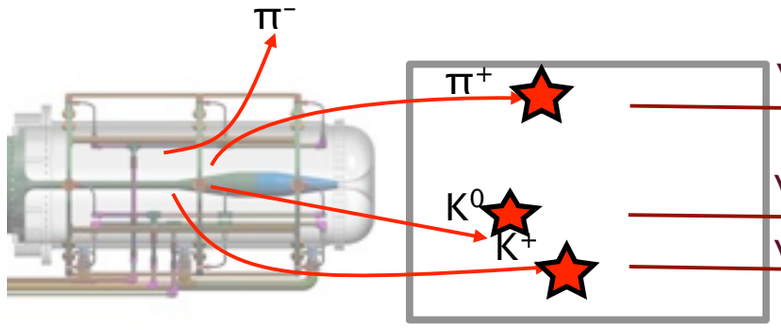
The microBooNE experiment

- Detector technology: LAr TPC
- Detector location: 470m (<100m away from miniBooNE) in order to get the ~same flux

Neutrino flux at miniBooNE



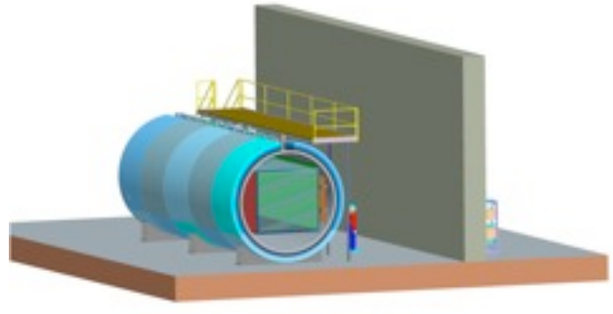
FNAL booster
(8 GeV protons)



target and horn
(174 kA)

decay region
(50 m)

dirt
(470 m)

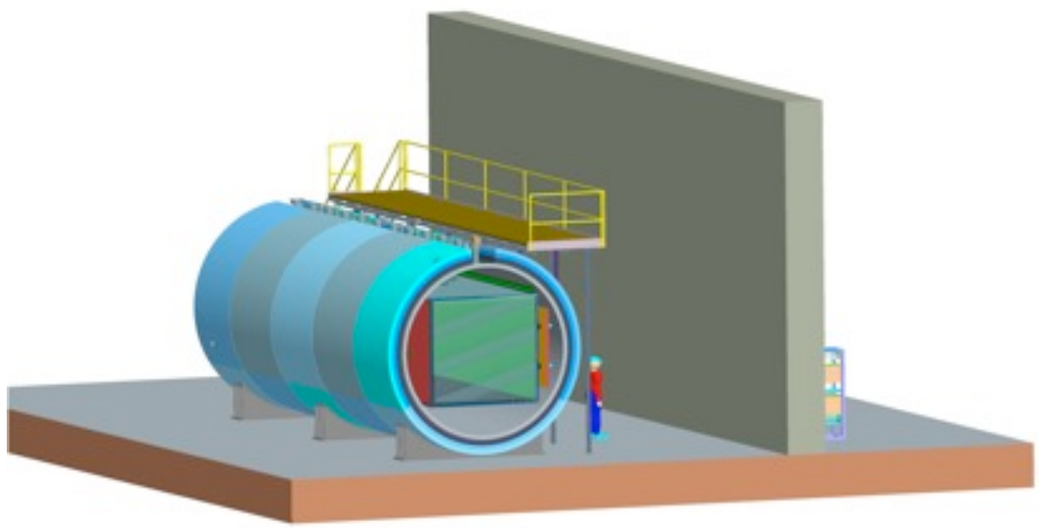


microBooNE
detector

MicroBooNE goals

PHYSICS GOALS

- Address the miniBooNE low energy excess
- Measure low energy cross sections

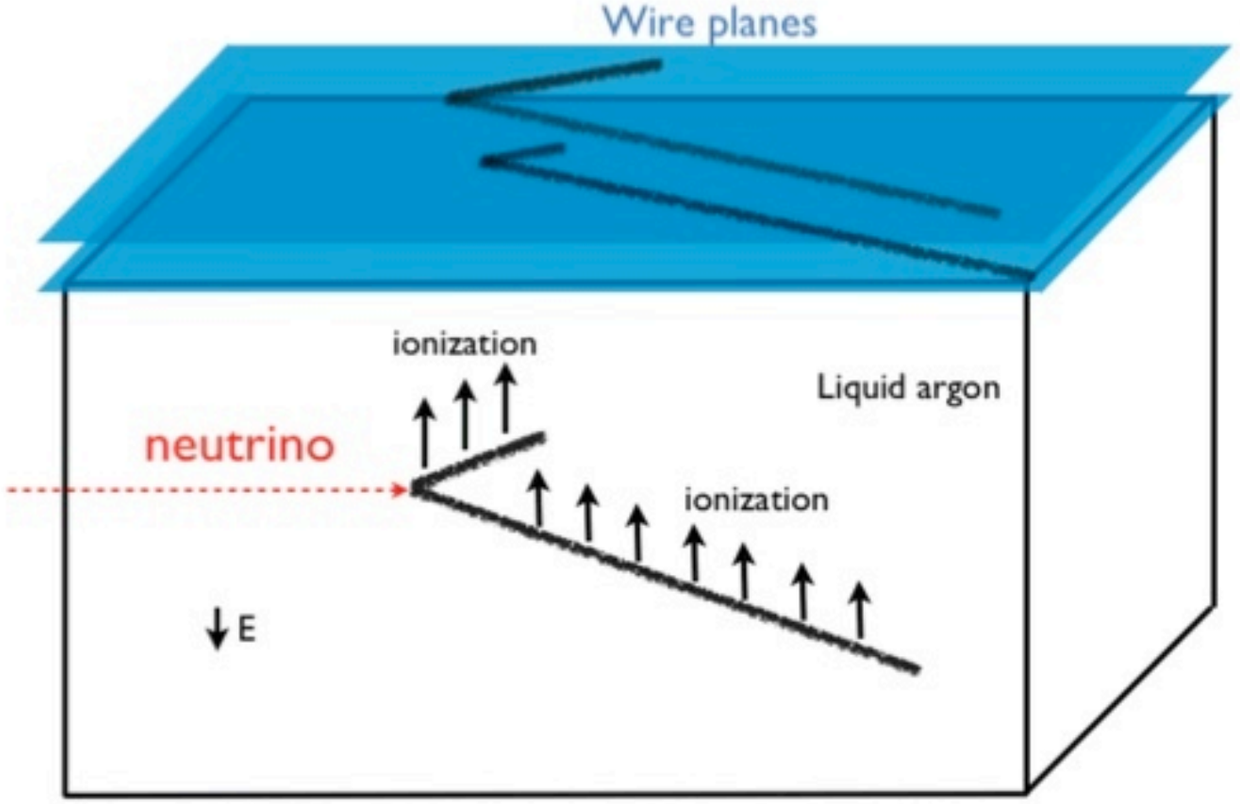


LAr TPC DEVELOPMENT GOALS

- Demonstrate the electron/photon separation
- Develop cold electronics
- Test purity in large detector
- Test ability to run on/near the surface for proton decay studies in LAr TPC
- Develop analysis tools
- Develop cost scaling model for larger detector

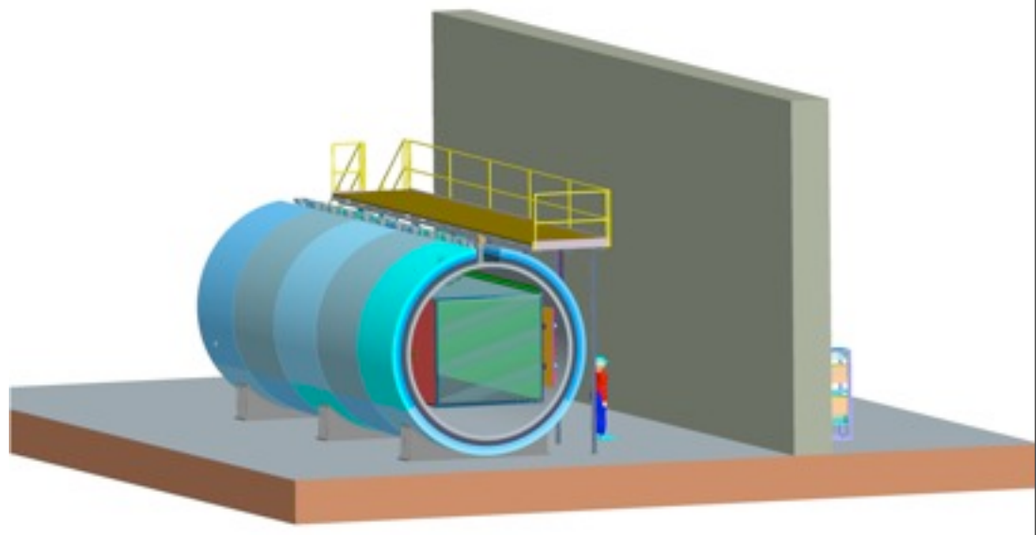
LAr TPC concept

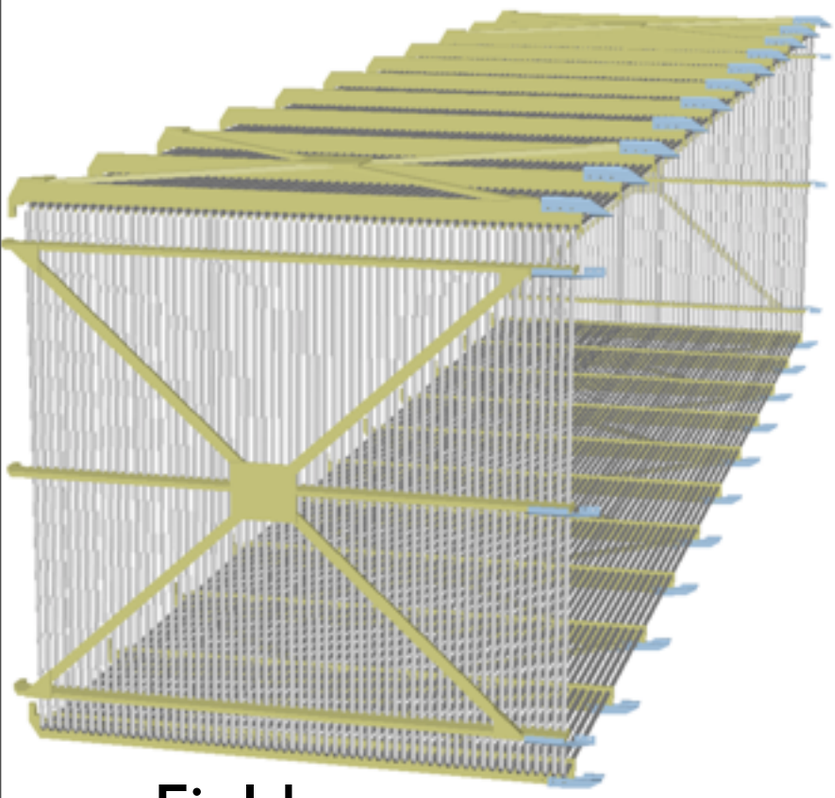
- See M. Soderberg on ArgoNeuT



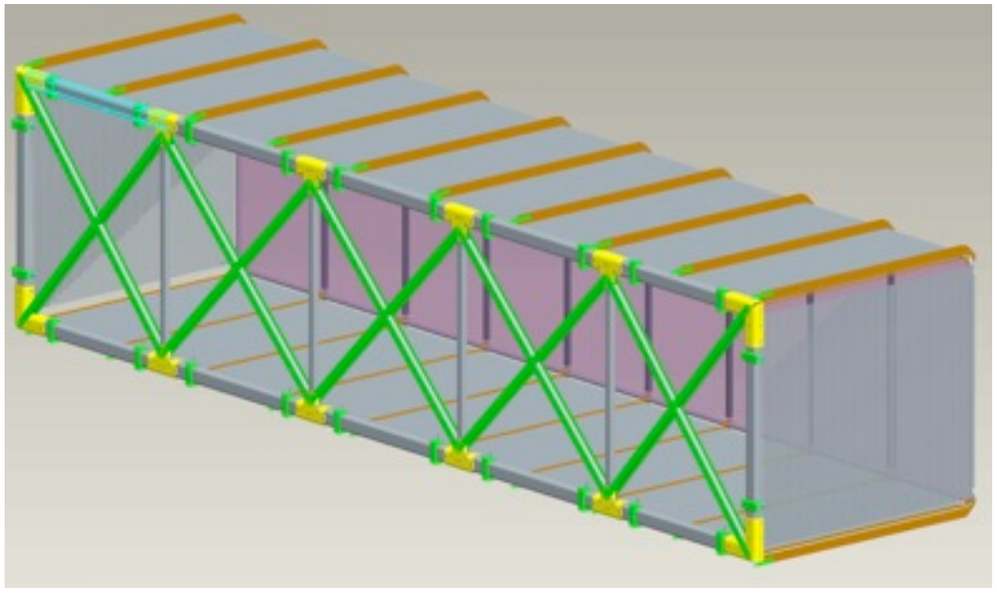
The microBooNE detector

- 170 tons total liquid argon
- 86 tons active volume (60t fiducial)
- TPC dimensions: 2.5m x 2.3m x 10.4m
- 30 PMTs

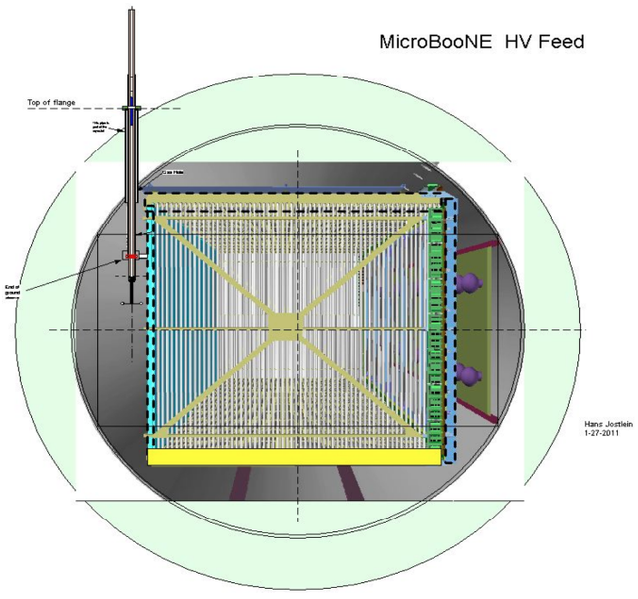




Field cage



Field cage, anode and cathode planes



Cross section of TPC inside cryostat

The microBooNE detector

- 3 wire planes (U,V,Y)

  Y (3456 wires): vertical

  U (2400 wires): +60°

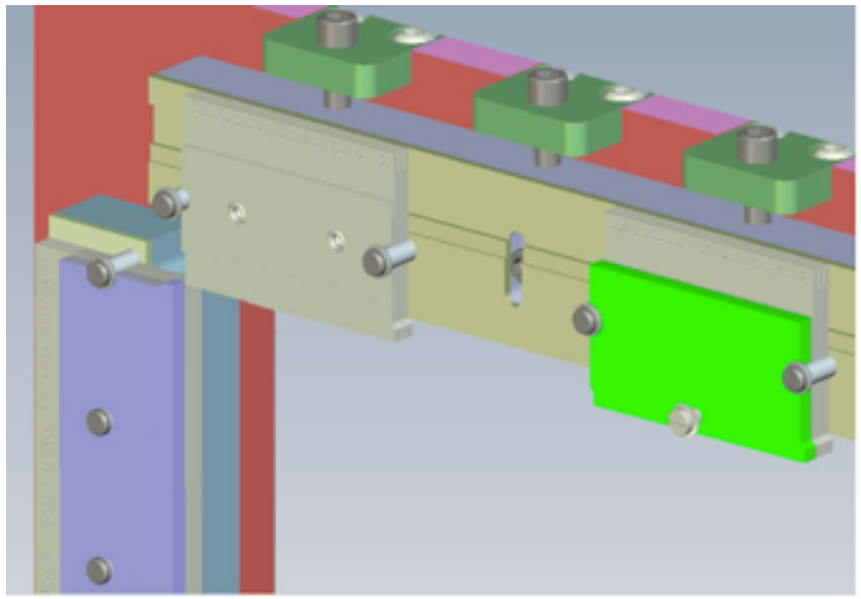
  V (2400 wires): -60°

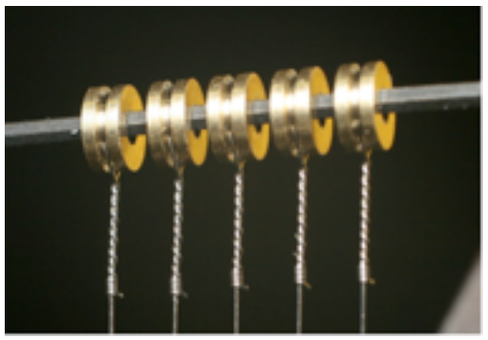
- 3mm wire pitch

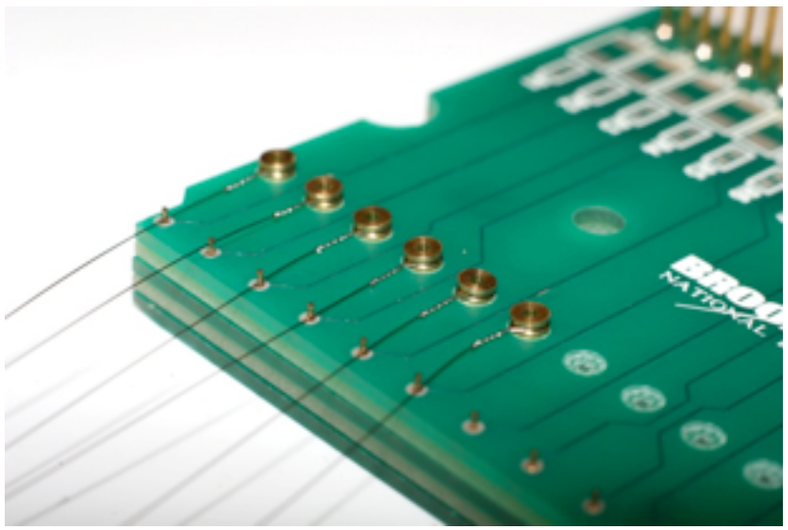
- Wires are in stainless steel coated with copper and gold flash: high breakload and low resistance

- Wire attachment via ferrule fixed on wire carrier boards

- Fully automated wire winding machine

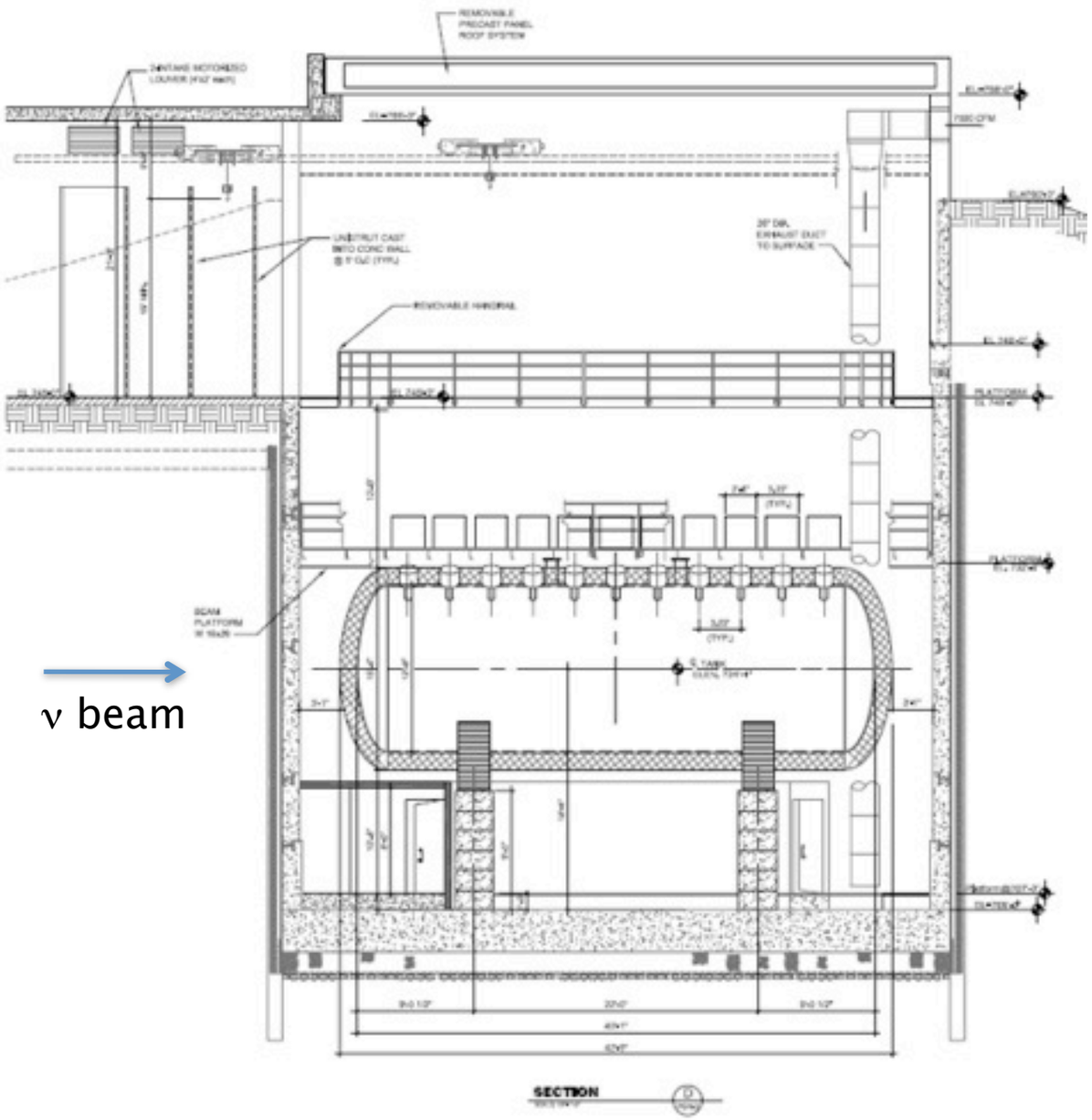






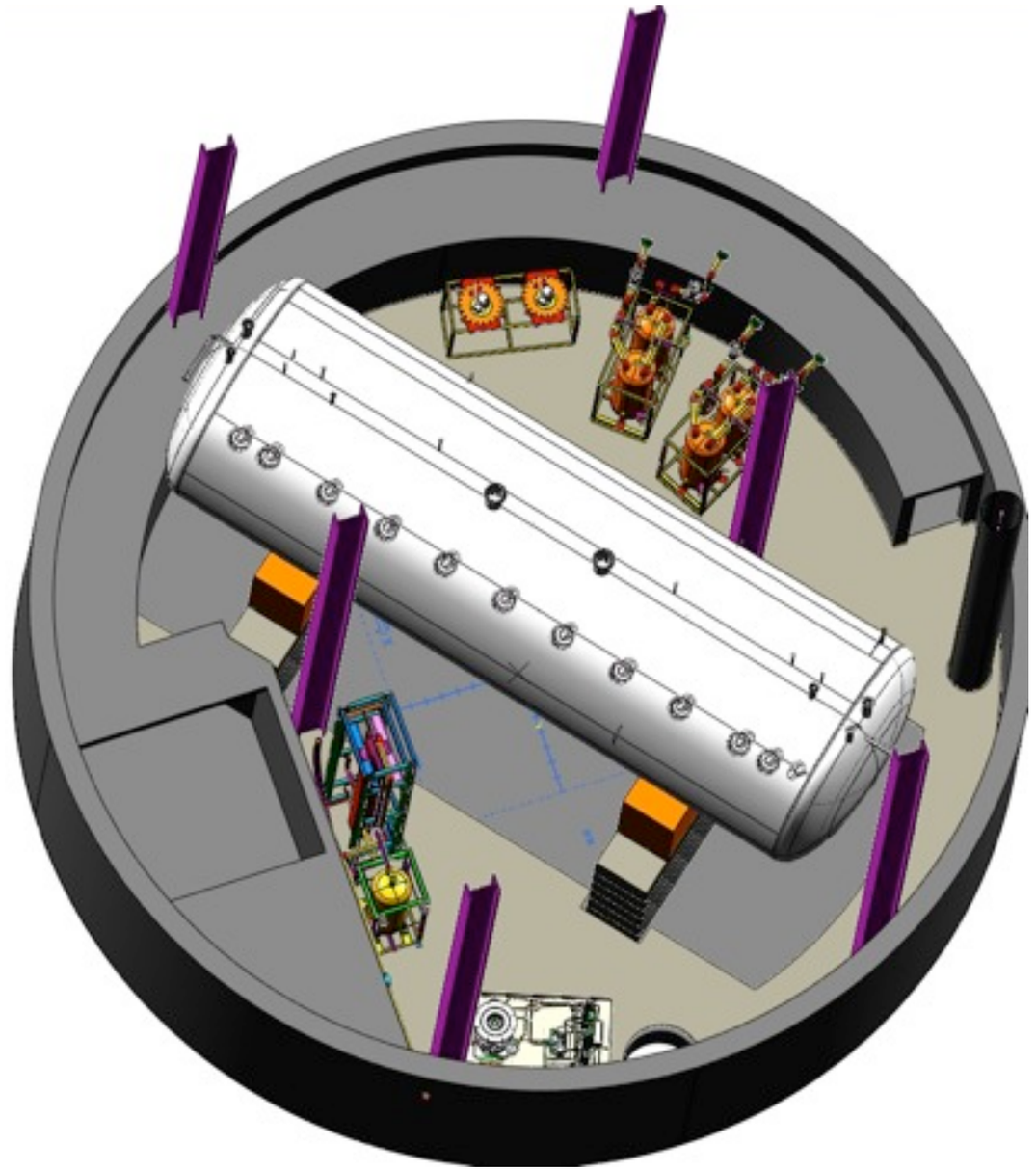
Wire winding machine

The microBooNE detector in-situu



ν beam

Detector in hall on beam axis, below grade



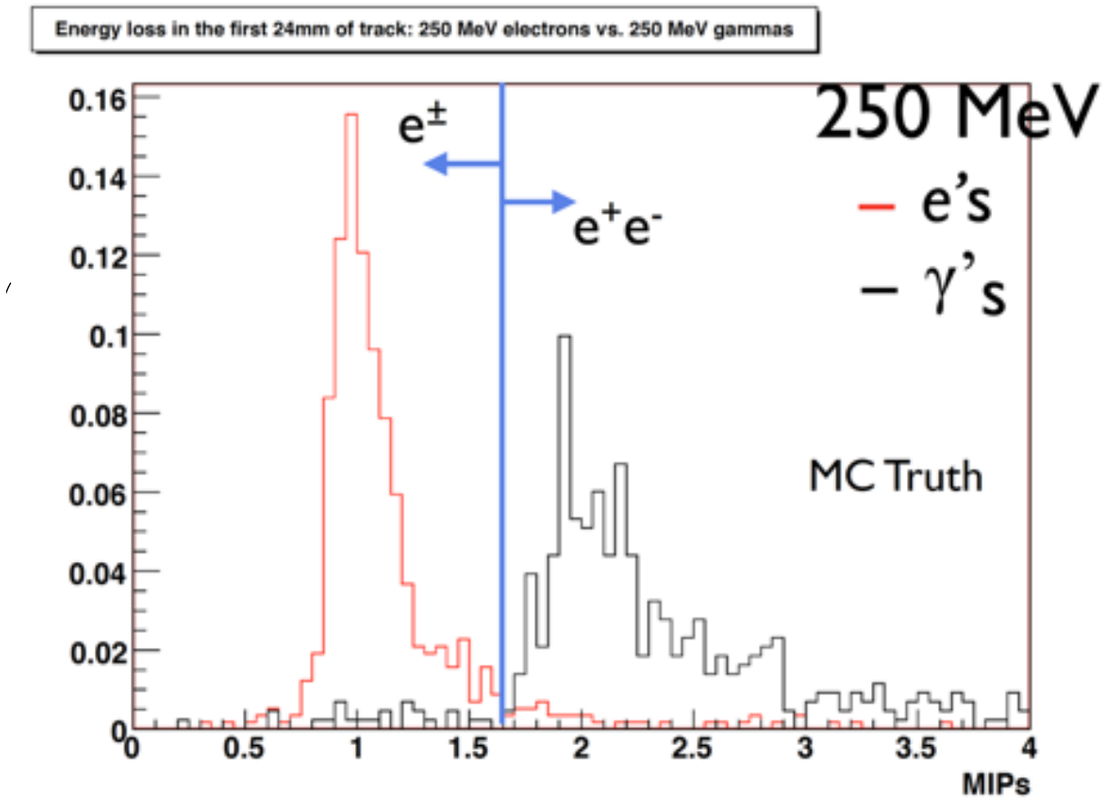
Top View of detector and components

MicroBooNE addressing the miniBooNE excess (neutrino mode)

- MicroBooNE ability to distinguish between electrons and photons will remove ν_μ induced single photon backgrounds

- MicroBooNE ν_e efficiency ~2x better than miniBooNE

- MicroBooNE sensitivity at low energies efficiency down to tens of MeV (compared to ~200 MeV for miniBooNE)



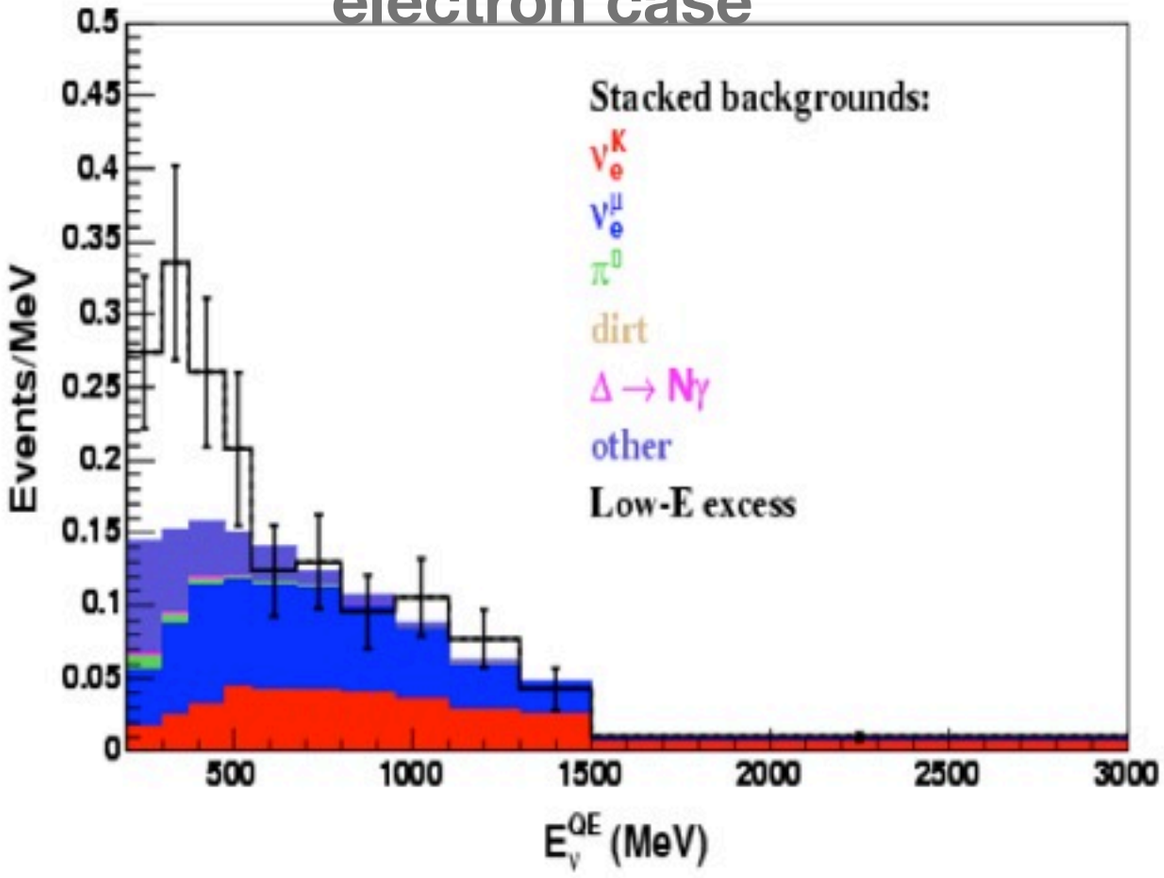
dE/dx for electrons and gammas in first 2.4 cm of track

J.Spitz

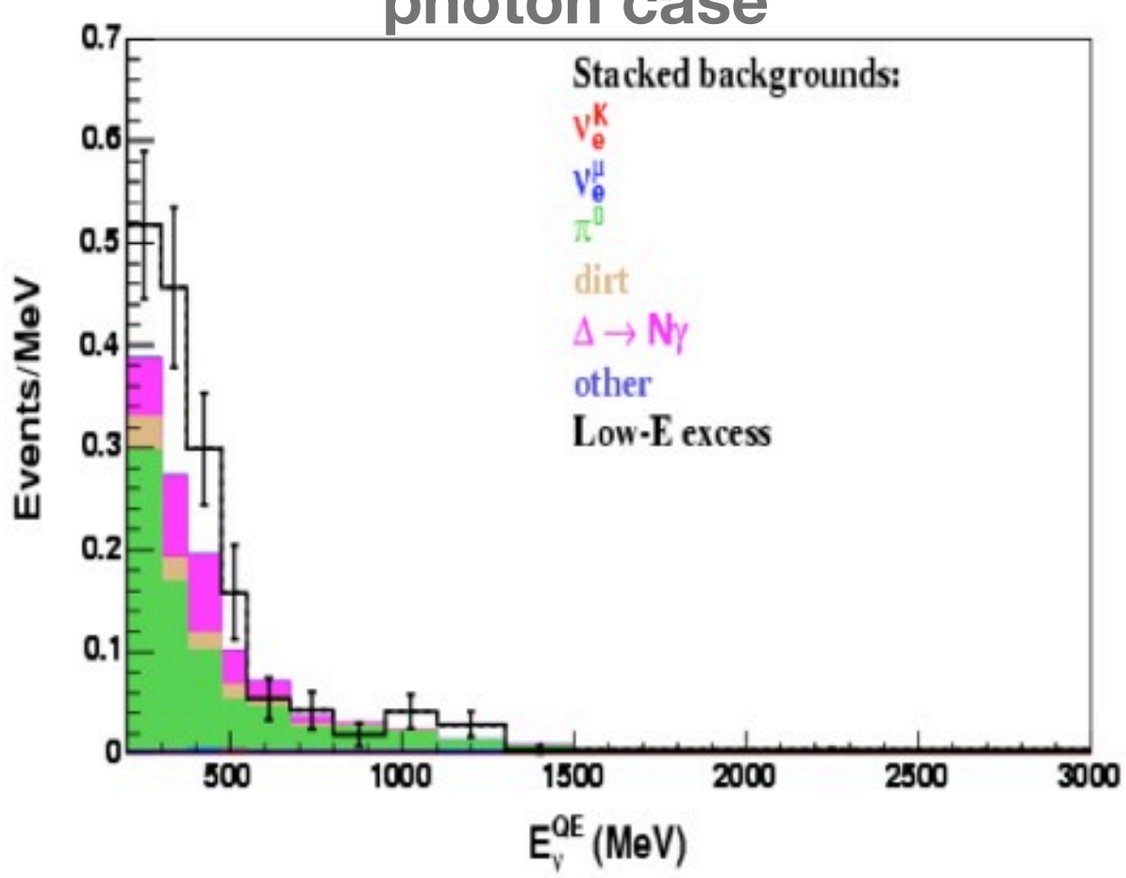
MicroBooNE addressing the miniBooNE excess
(6.6x10^{20} POT neutrino mode)

For microBooNE, as a counting experiment: 5σ sensitivity if excess is ν_es,
4σ sensitivity if excess is γs

electron case



photon case



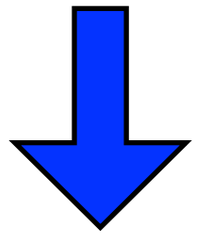
MicroBooNE: measuring cross sections

Expected event rates for 6.6 x 10^{20} POT on the BNB neutrino target

production mode	# events
CC QE ($\nu_\mu n \to \mu^- p$)	60,161
NC elastic ($\nu_\mu N \to \nu_\mu N$)	19,409
CC resonant π^+ ($\nu_\mu N \to \mu^- N \pi^+$)	25,149
CC resonant π^0 ($\nu_\mu n \to \mu^- p \pi^0$)	6,994
NC resonant π^0 ($\nu_\mu N \to \nu_\mu N \pi^0$)	7,388
NC resonant $\pi^\pm$ ($\nu_\mu N \to \nu_\mu N' \pi^\pm$)	4,796
CC DIS ($\nu_\mu N \to \mu^- X$, $W > 2$ GeV)	1,229
NC DIS ($\nu_\mu N \to \nu_\mu X$, $W > 2$ GeV)	456
NC coherent π^0 ($\nu_\mu A \to \nu_\mu A \pi^0$)	1,694
CC coherent π^+ ($\nu_\mu A \to \mu^- A \pi^+$)	2,626
NC kaon ($\nu_\mu N \to \nu_\mu K X$)	39
CC kaon ($\nu_\mu N \to \mu^- K X$)	117
other ν_μ	3,678
total ν_μ CC	98,849
total ν_μ NC+CC	133,580
ν_e QE	326
ν_e CC	657

Low energy cross-section measurements

- Coherent vs resonant pion production
- K production: cross section and proton decay studies
- ν_e cross sections



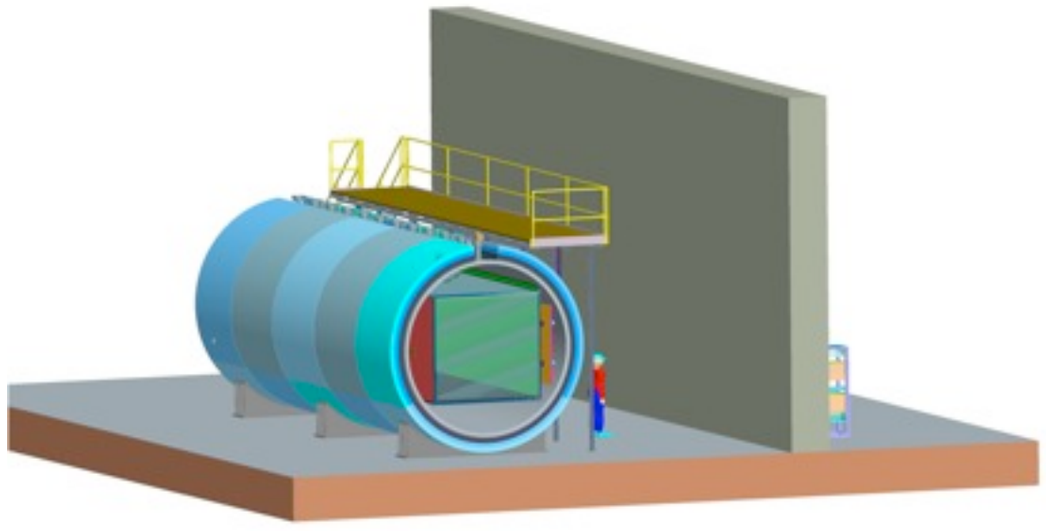
✦Good statistics for rare channels

✦Low energy threshold

✦Resolution of activity at the vertex to observe nuclear effects

MicroBooNE current status

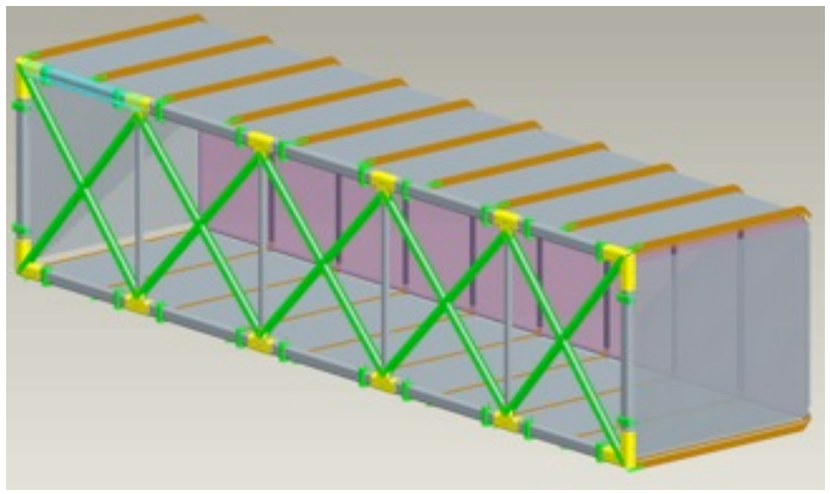
- Stage 1 approval in 2008
- CD-0 in 2009
- CD-1 in 2010



- CD-2/3a will take place this Summer 2011 → Begin construction

You are here

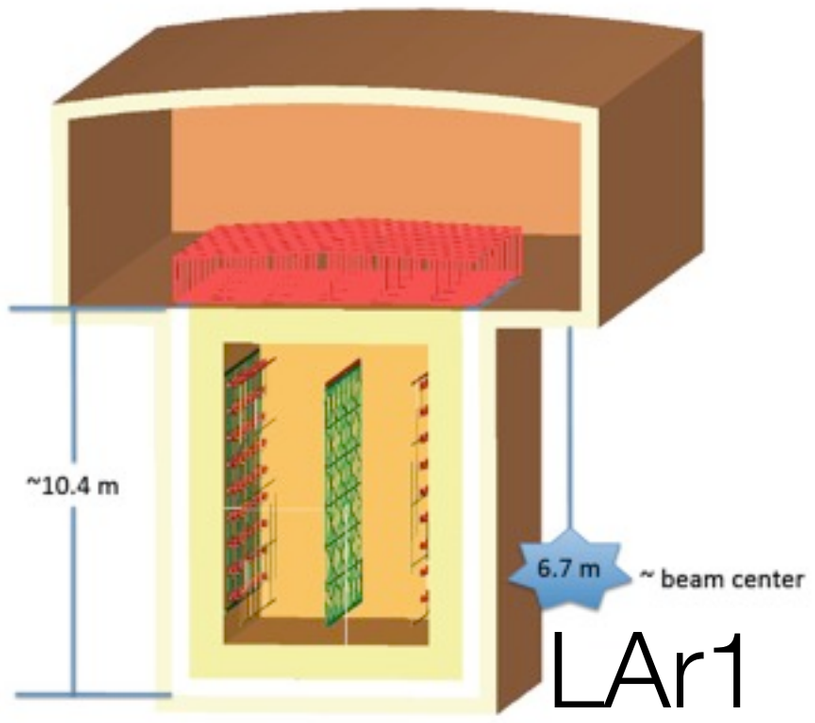
- Data taking starting 2013



Joint DOE/NSF project

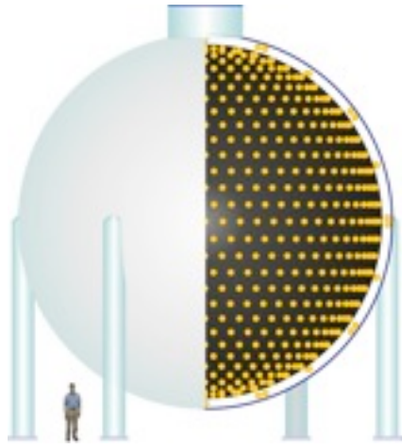
Beyond microBooNE: Addressing LSND/miniBooNE excesses

- From 2013, microBooNE will take data to fulfill its physics goals
- But in parallel and in future, microBooNE could be used to search for miniBooNE/LSND event excesses
- MicroBooNE II could be combined to a large LAr (larLAr) TPC to have a near/far configuration (different locations possible)



Beyond microBooNE: Addressing miniBooNE/LSND excesses

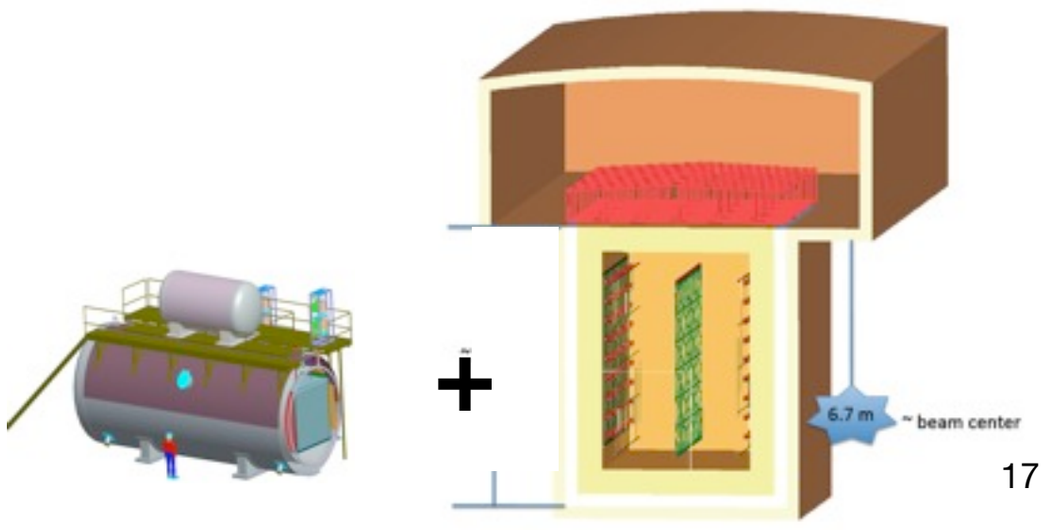
Example path:



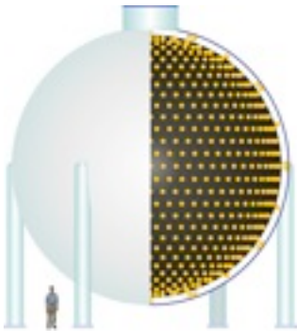
PHASE 0: Ongoing miniBooNE data taking in anti-neutrino mode (currently)

PHASE 1: MicroBooNE turns on and acquire data in neutrino mode to address miniBooNE excess (2013-...)

PHASE 2: Set up an near/far configuration experiment with microBooNE II a large (~1 kt) LAr detector

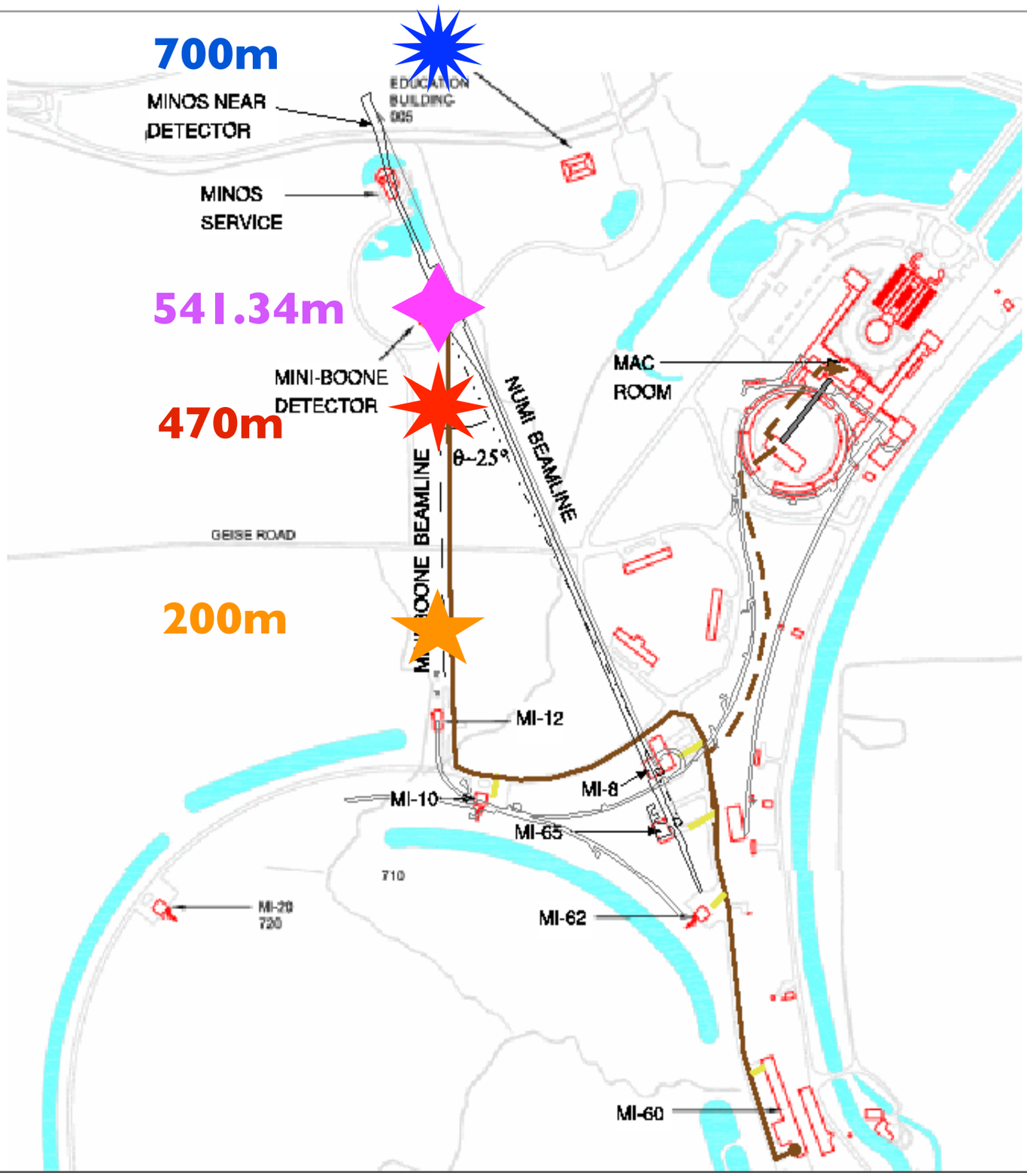


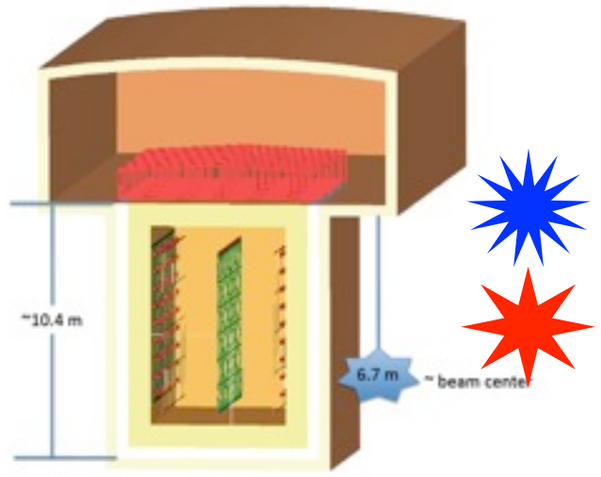
The neutrino beamline at FNAL



miniBooNE

microBooNE





LarLAr

microBooNE II

Phases 0-1

Phase 2 scenarios

Sensitivity studies for microBooNE II and LarLAr to a simple 2-neutrino model

- Neutrino events where generated with GENIE from BNB fluxes for different baselines

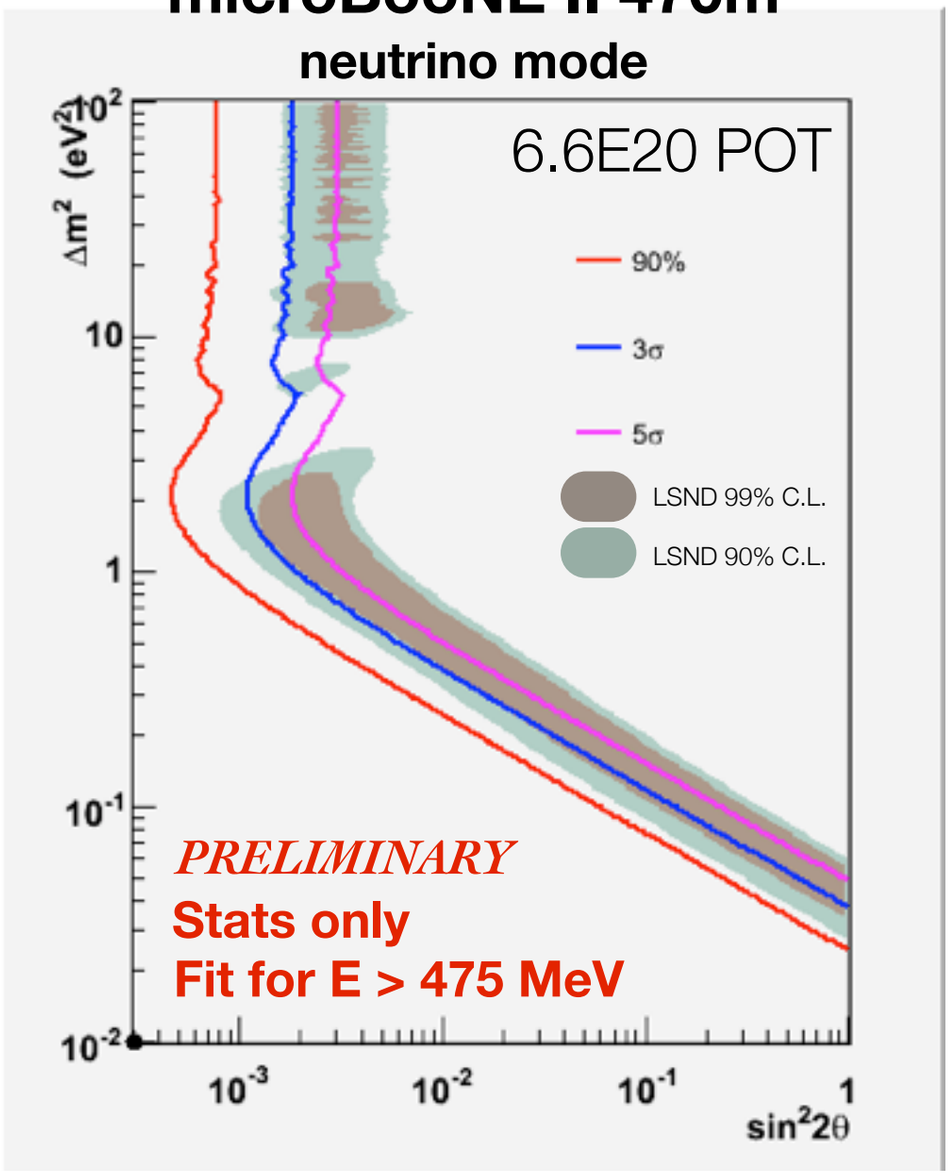
- For now, no systematic errors have been taken into account and no background is included (work in progress) → Statistical errors ONLY

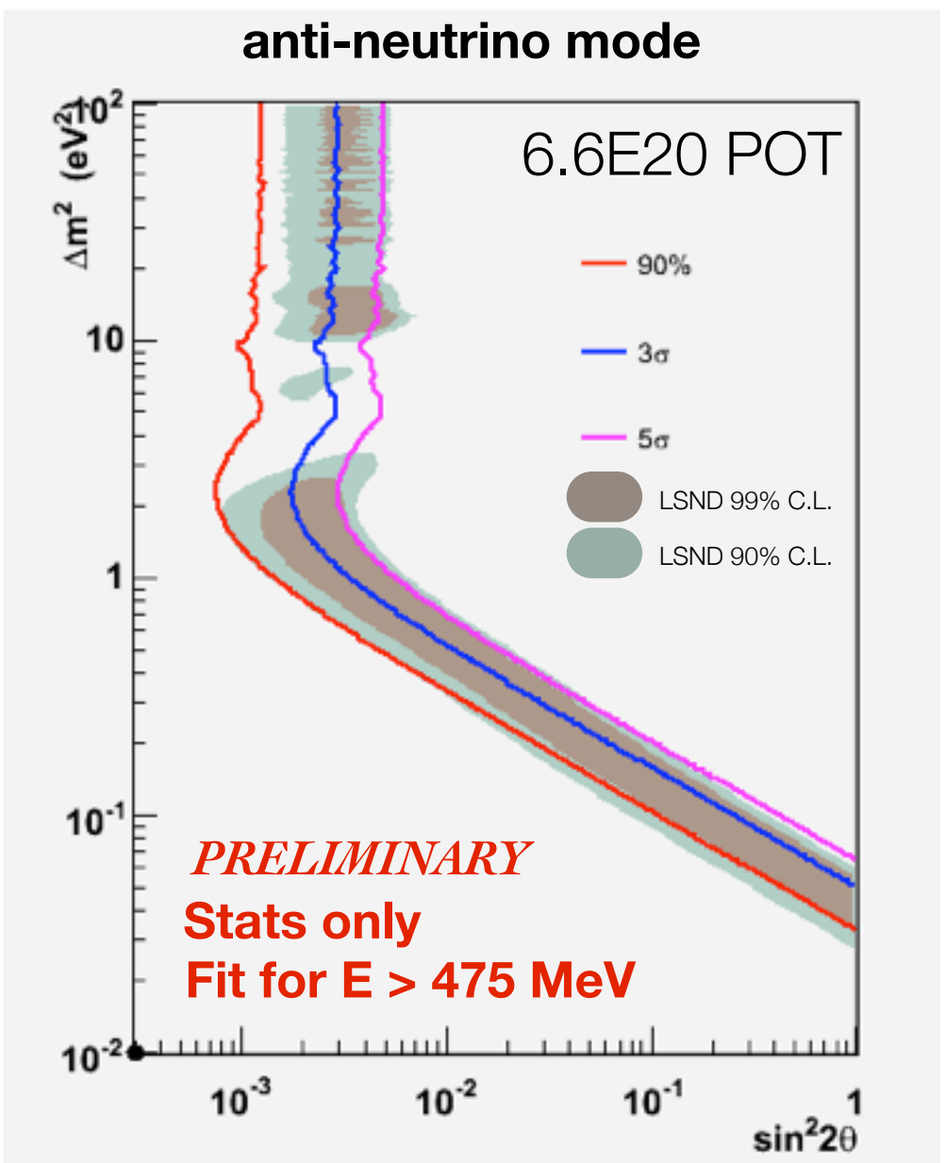
- Assume fiducial volume of 61.4t for micrBooNE II and 347.5t for LarLAr

- Assume a flat 80% efficiency for ν reconstruction

Simulations all done using LArSoft

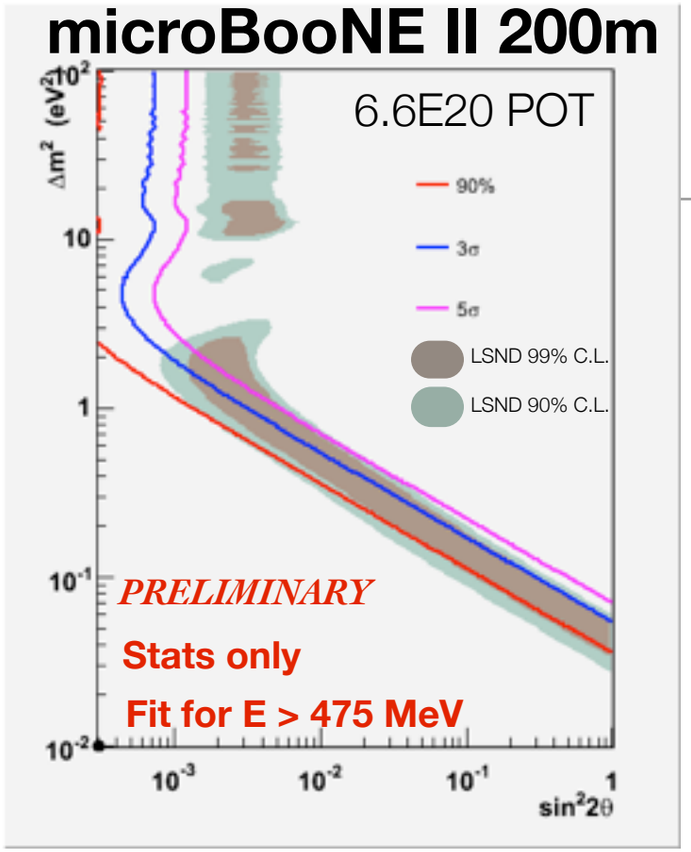
MicroBooNE II sensitivity to LSND excess*

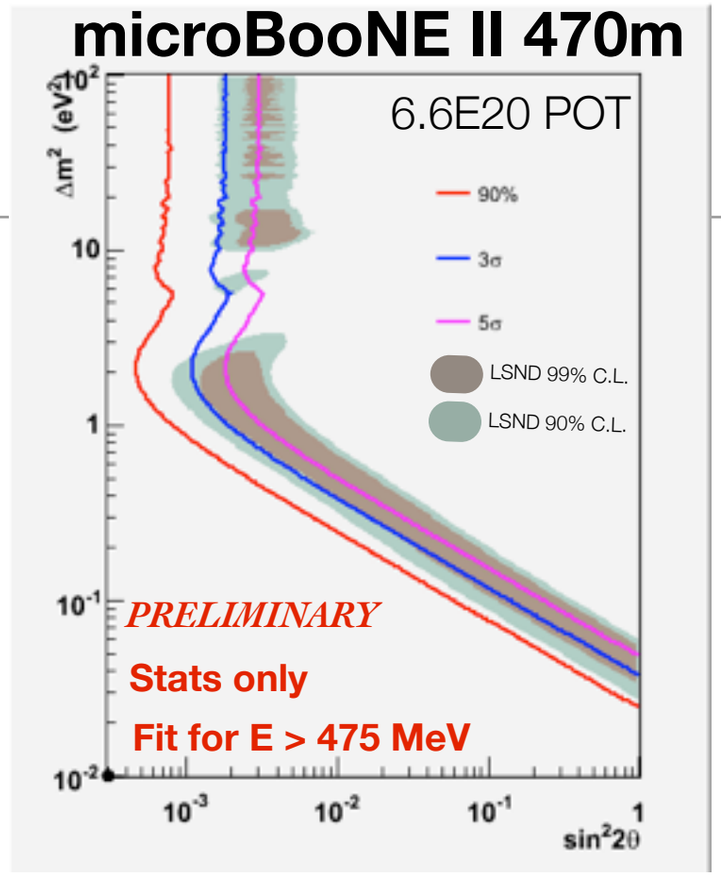


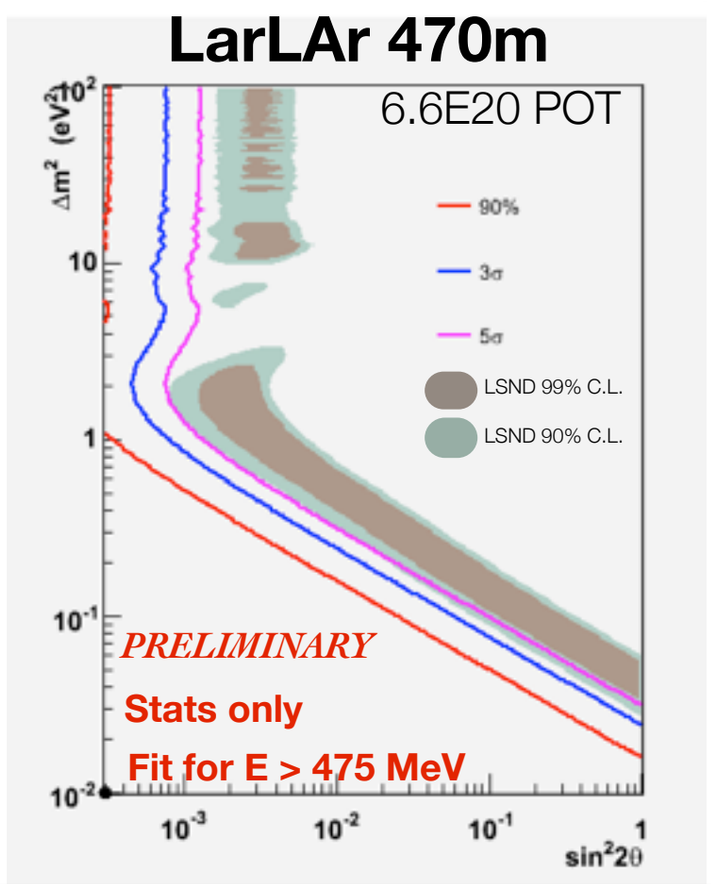


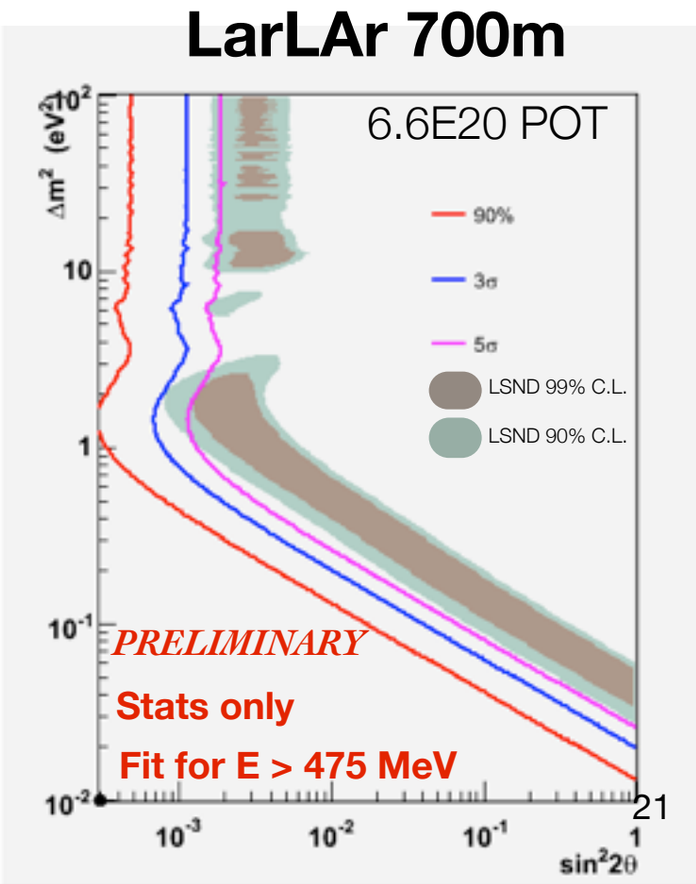
* The studies here only consider a simple 2-neutrino model

Sensitivities* in **neutrino** mode for microBooNE II and LarLAr





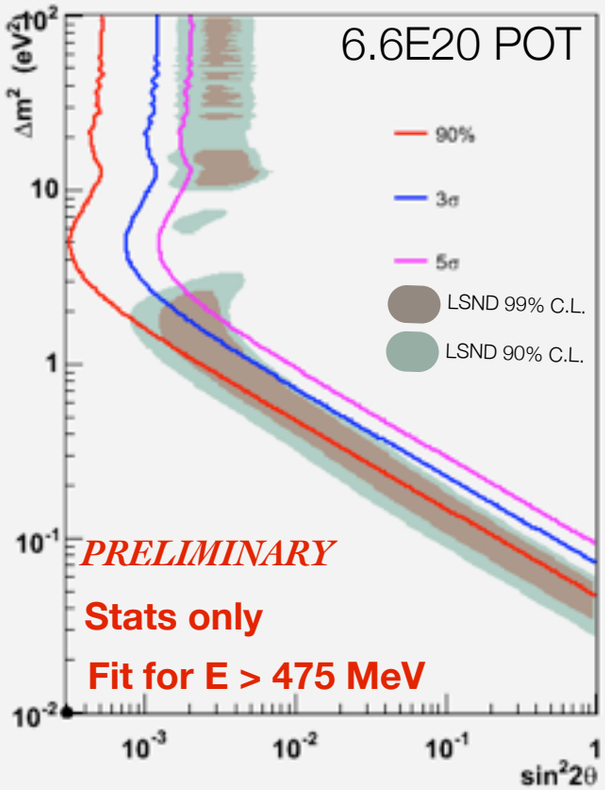




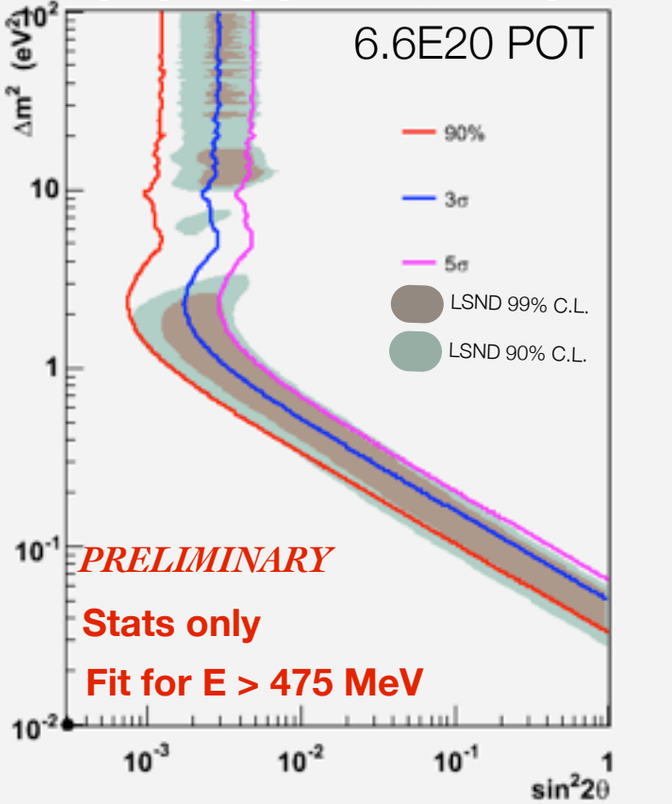
* The studies here only consider a simple 2-neutrino model

Sensitivities* in **anti-neutrino** mode for microBooNE II and LarLAr

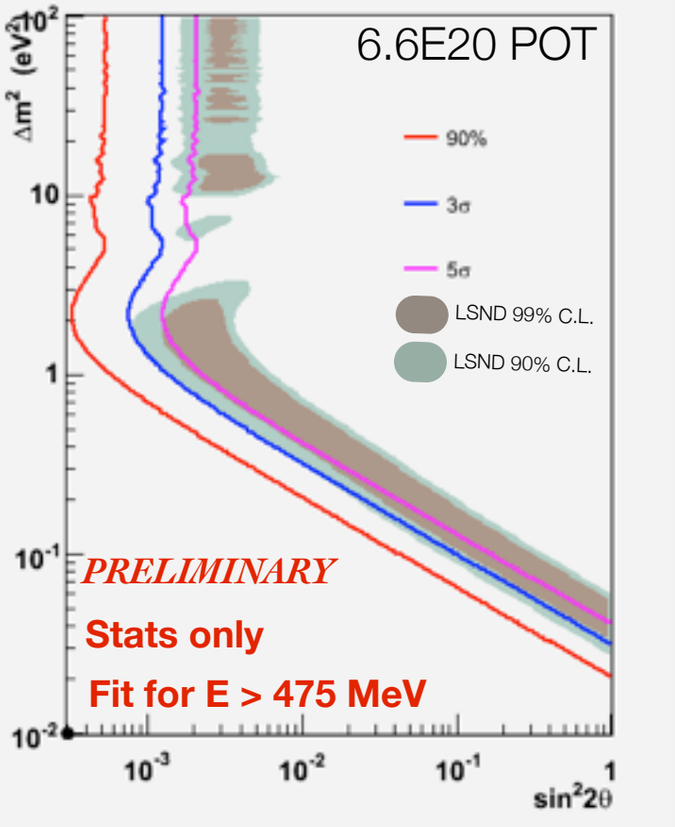
microBooNE II 200m



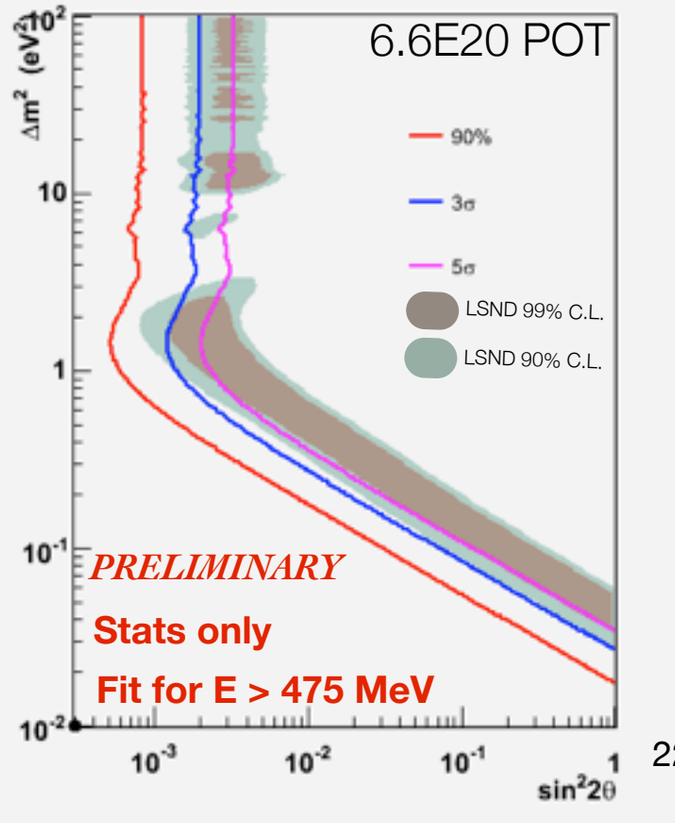
microBooNE II 470m



LarLar 470m



LarLar 700m



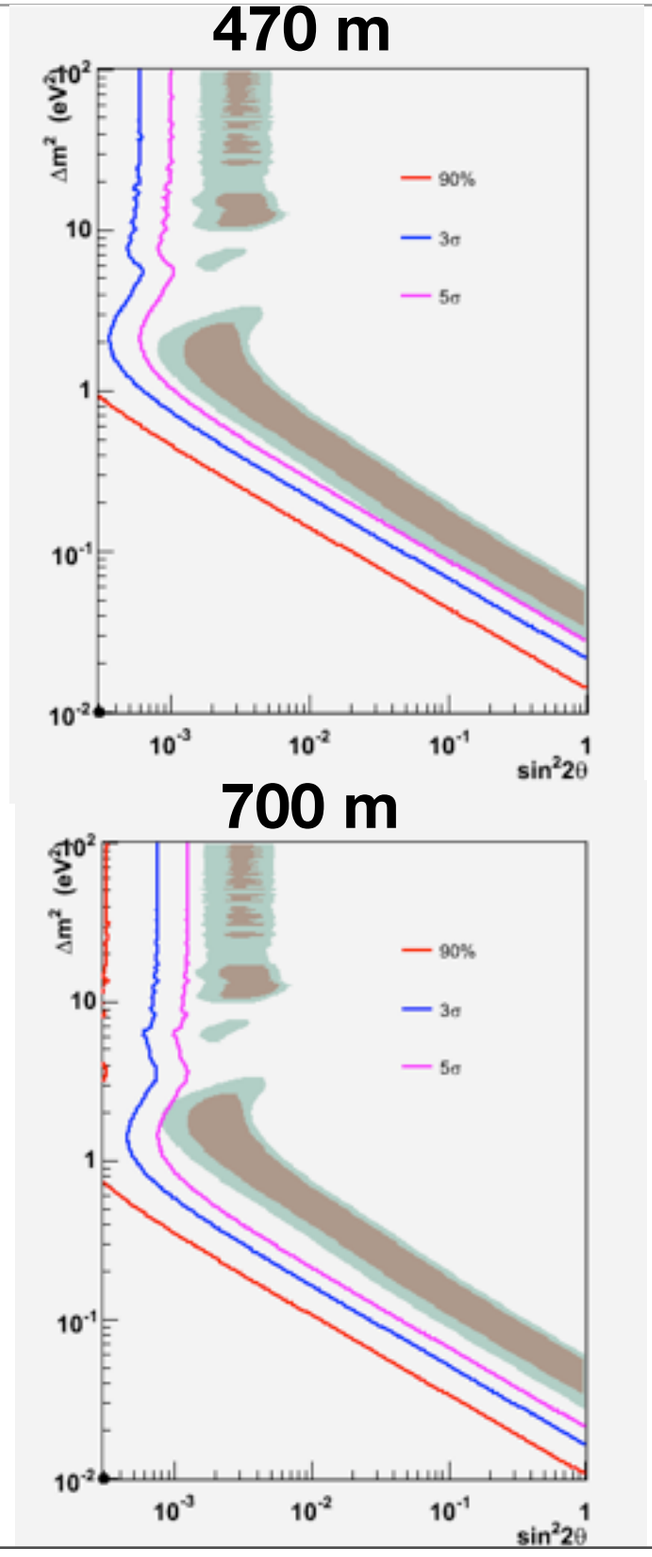
* The studies here only consider a simple 2-neutrino model

What would it take to exclude LSND at 5sigma?*

Detector + baseline	POT required in nu mode*	POT required in nubar mode*
microBooNE II 470m	~ 60E20 (20-30 y)	~ 160E20 (50-80 y)
LarLAr 470m	~ 10E20 (3-5 y)	~ 30E20 (10-15 y)
LarLAr 700m	~ 15E20 (5-7 y)	~ 50E20 (15-25 y)

* 1 detector only (no combined analysis)

* Considering a simple 2-neutrino model



Take away

- Configuration makes this a direct test of the excess seen, independent of the interpretation of the signal

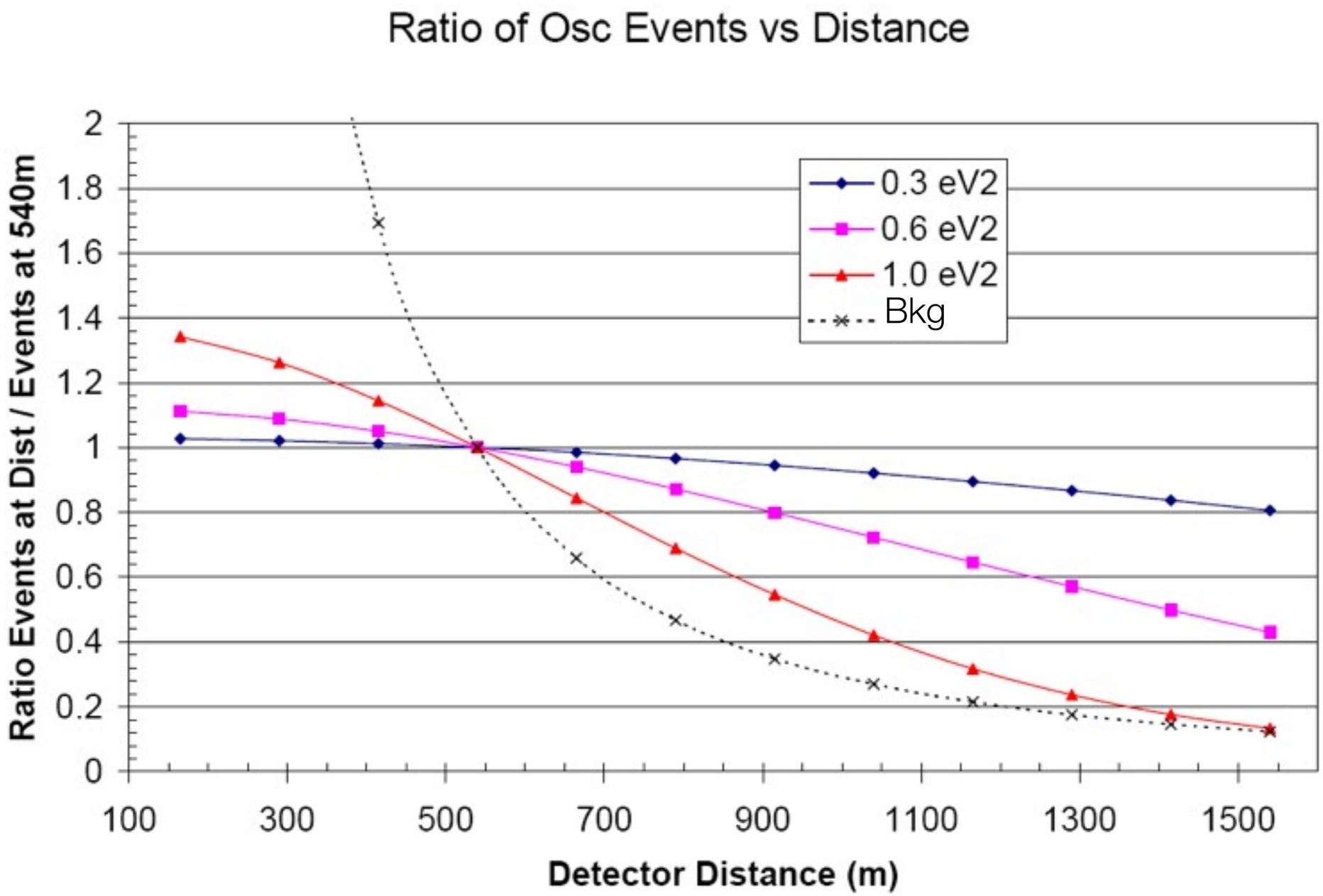
- It is clear that having a large LAr detector (~ 1kt) is a huge advantage in addressing miniBooNE/LSND anomalies

- Using a near/far configuration with microBooNE II is also very appealing, reducing the systematic errors

- Studies need to be refined to show how the systematics will affect the sensitivities

- More neutrino models have to be investigated in order to see how a near/far detector configuration could constrain them (ν_μ disappearance, CP violation...)

Word on studies to perform: the optimal baseline



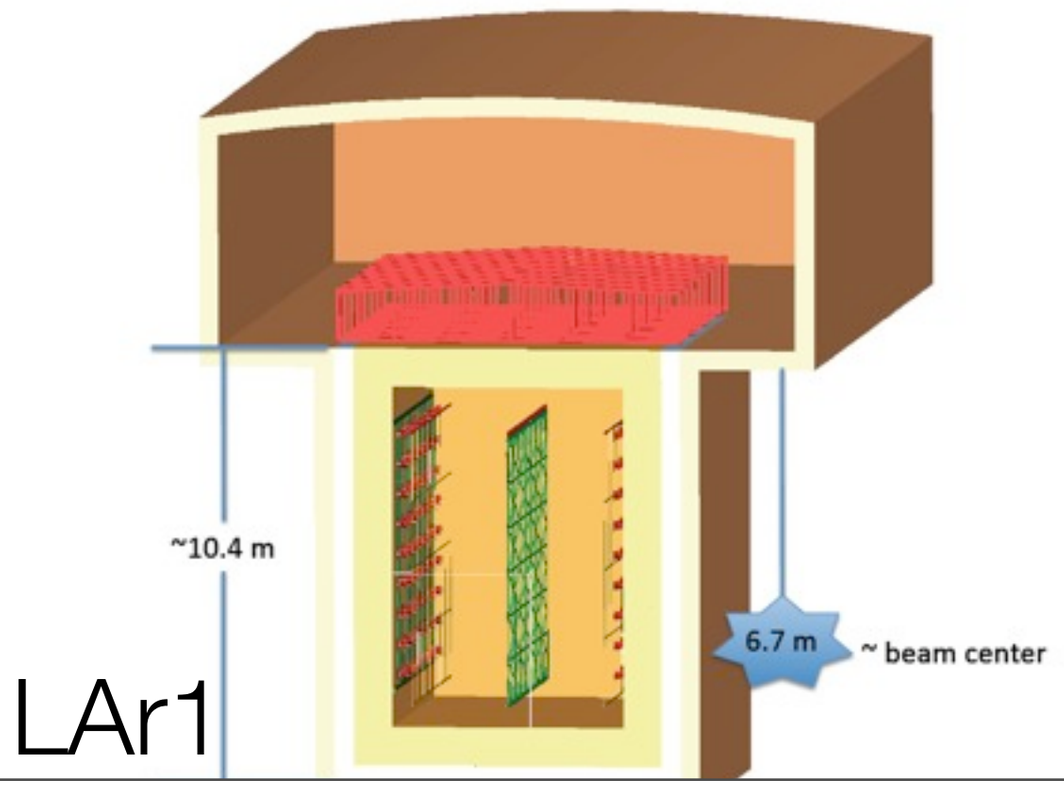
provided by M. Shaevitz

Where can you find a 1 kt LAr detector?

- LBNE is developing an engineering prototype ~1kt-scale LAr TPC (LAr1) to test CPAs/APAs, cold electronics, membrane cryostat and purity/filtration systems

- That detector (or a copy of it) could be fully instrumented and used for neutrino detection

- Placing such a detector in a neutrino beam would do great physics



Conclusions

- MicroBooNE is coming along. Construction will start after the CD-2/3a review this summer.

- Combining microBooNE II with a large LAr detector would be a powerful configuration which could decisively address miniBooNE/LSND excesses.

- A lot of work is being done to show how well a near/far detector configuration would do to constrain different neutrino models

- Stay tuned for sensitivity results including systematics, combined detector fit...