

MicroBooNE status and a 2 LAr-detector experiment at FNAL

Roxanne Guenette
Yale University

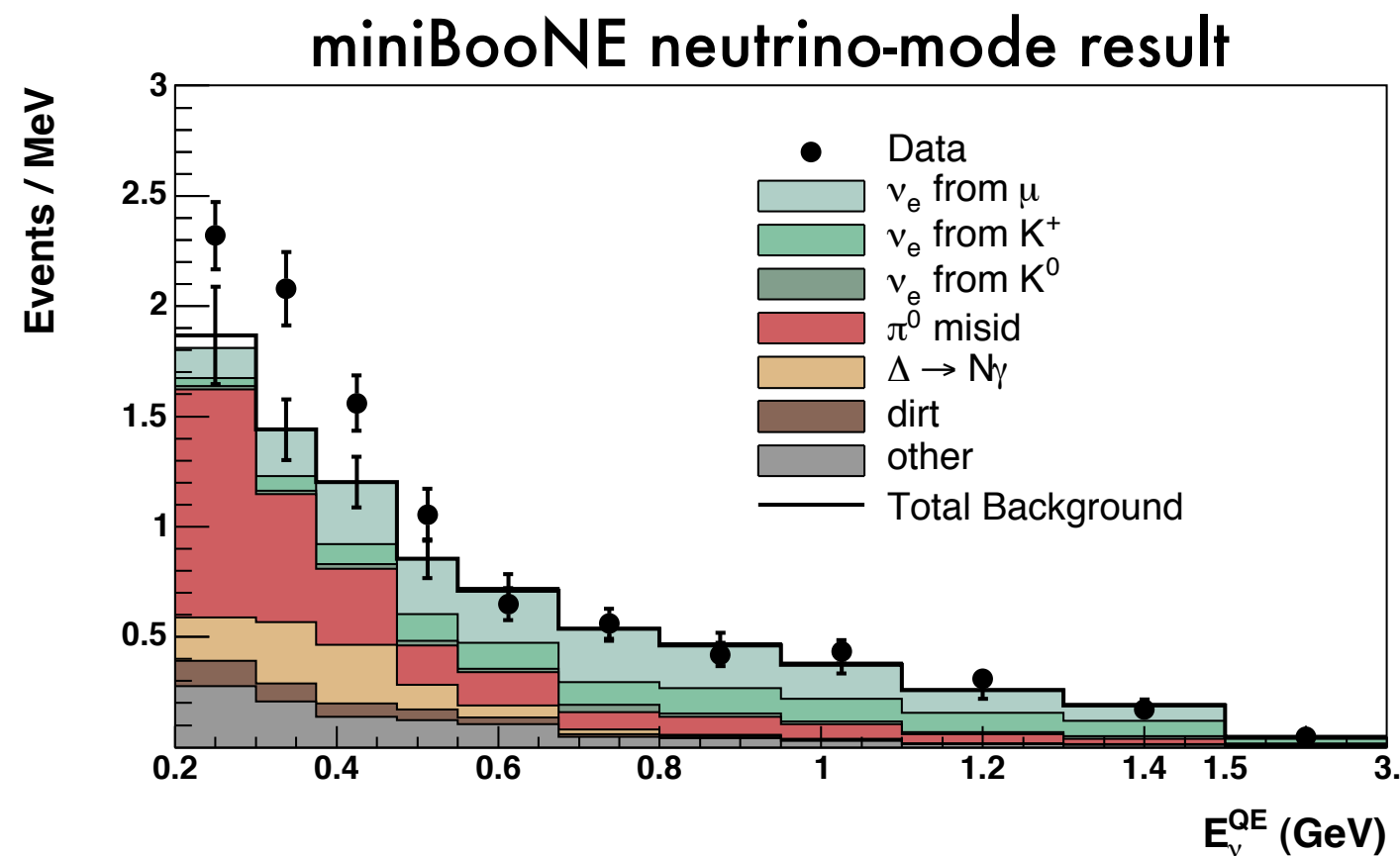
GLA11
06-8-2011

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








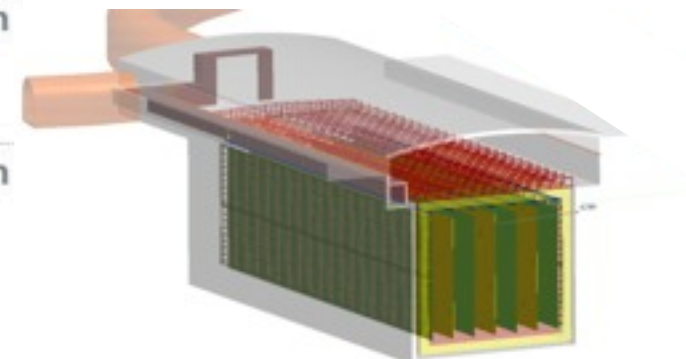
Phys.Rev.Lett.102, 2009

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

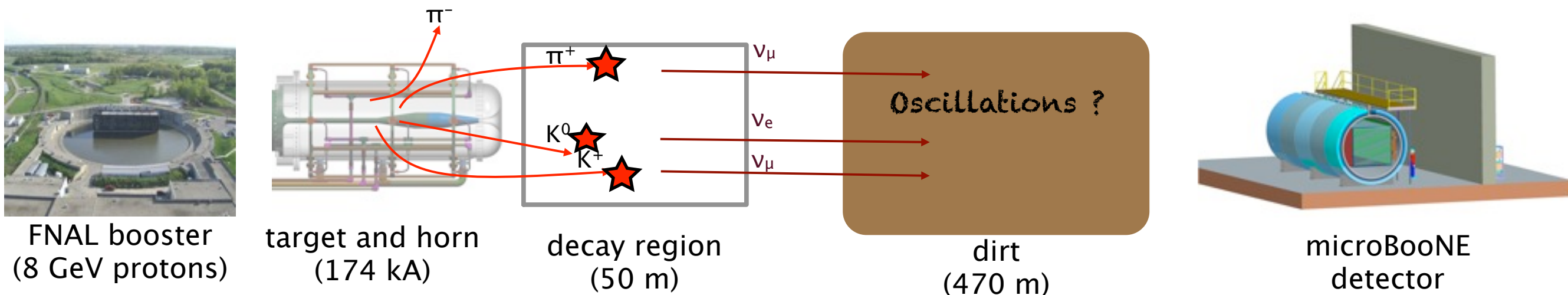
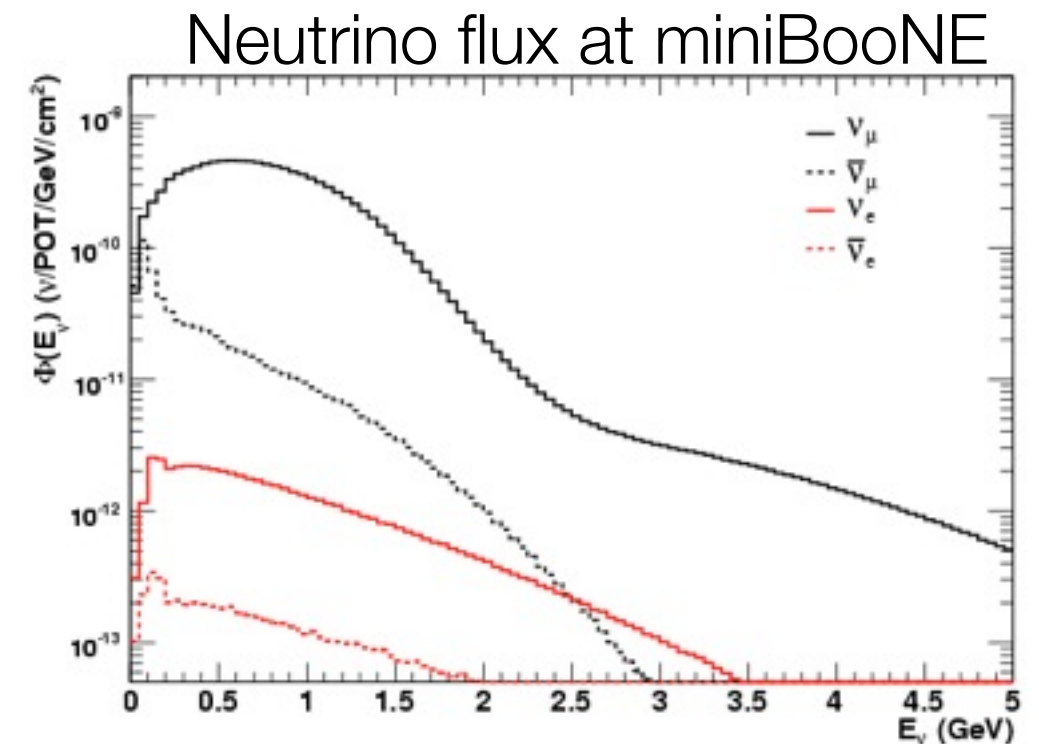
Liquid-Argon Time Projection Chambers Outlook of R&D Program in the US

		Active Volume
Yale TPC & Bo Yale TPC: Dismantled Bo: Operational		0.00002 kton
		15x ↓
ArgoNeuT Operational Physics: Measure neutrino-argon cross sections		0.0003 kton
		330x ↓
MicroBooNE Construction begins 2010 Physics: Investigate low-energy neutrino interactions		0.1 kton
		4 x 50x ↓
LAr TPC for LBNE R&D in progress Physics: Measure neutrino oscillations at 1,000+ km		20 kton
Final goal Replicate proven technology Physics: Search for CP violation in neutrino sector		N x 20 kton



The microBooNE experiment

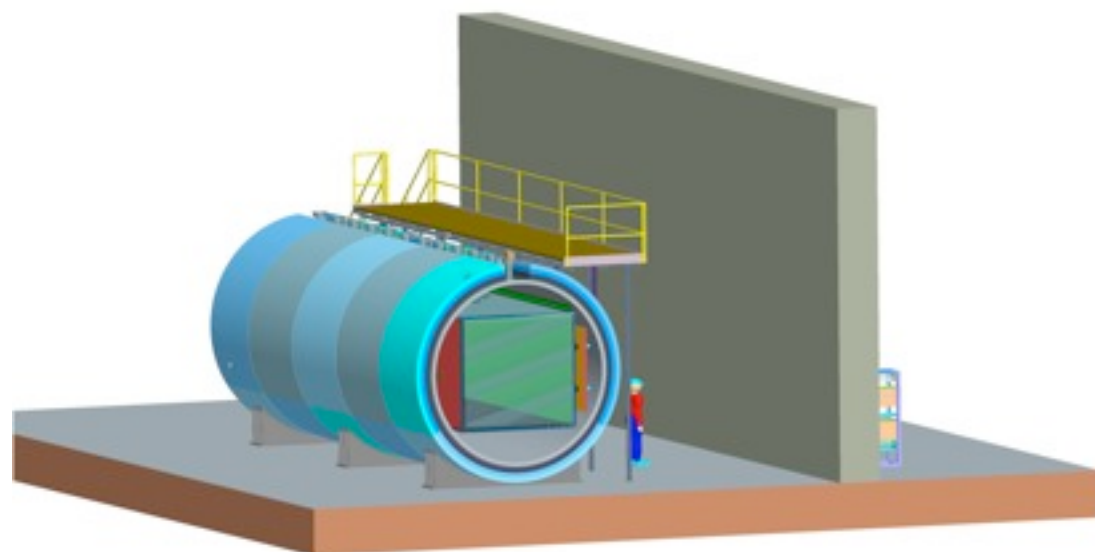
- Detector technology: LAr TPC
- Detector location: 470m (<100m away from miniBooNE) in order to get the ~same flux



MicroBooNE goals

PHYSICS GOALS

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

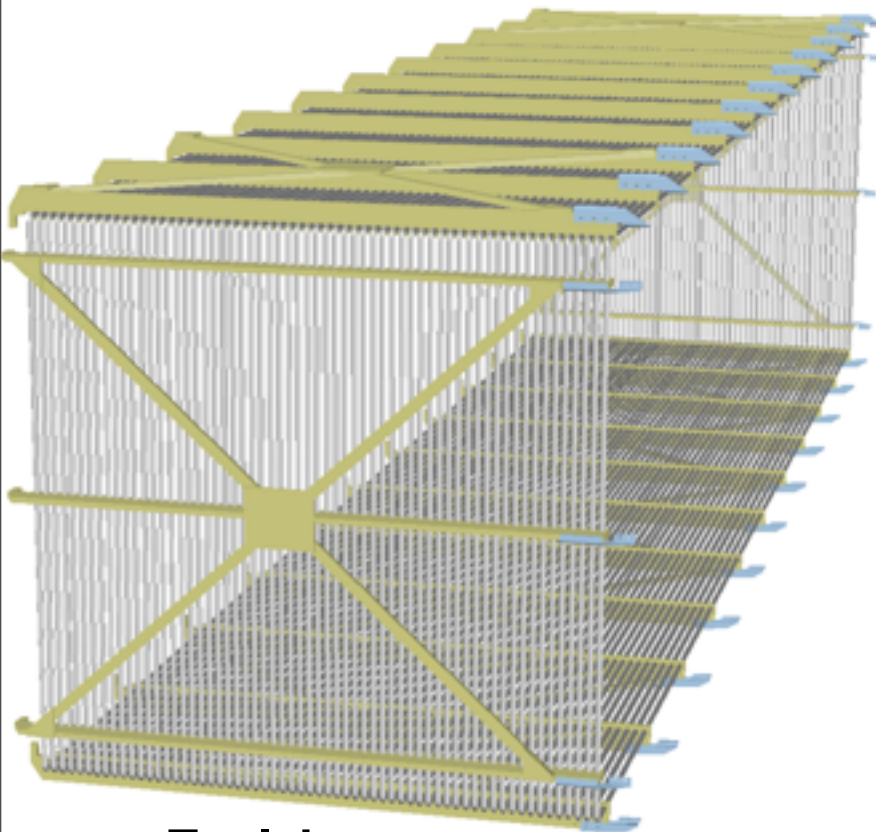
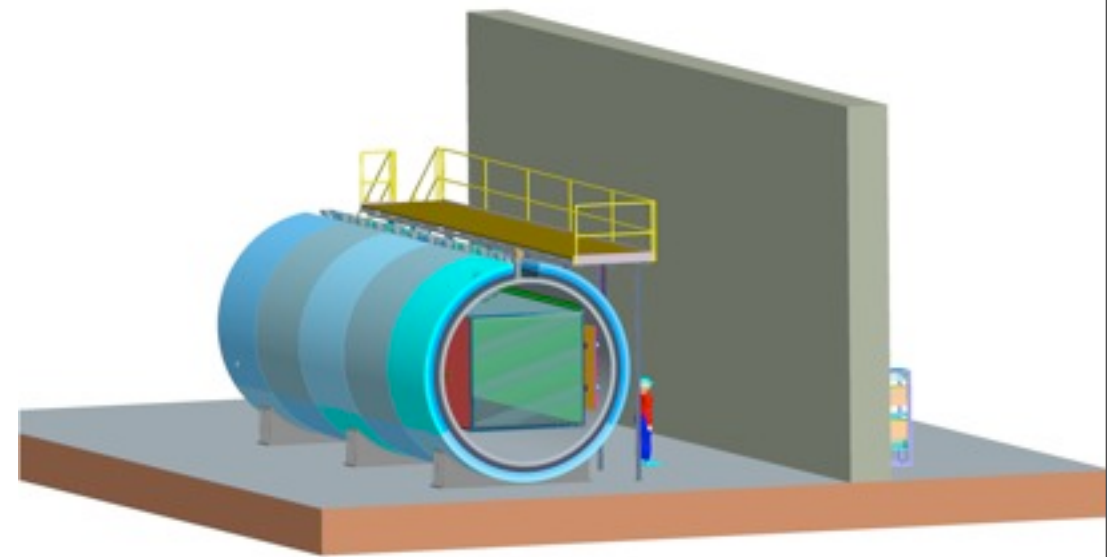


LAr TPC DEVELOPMENT GOALS

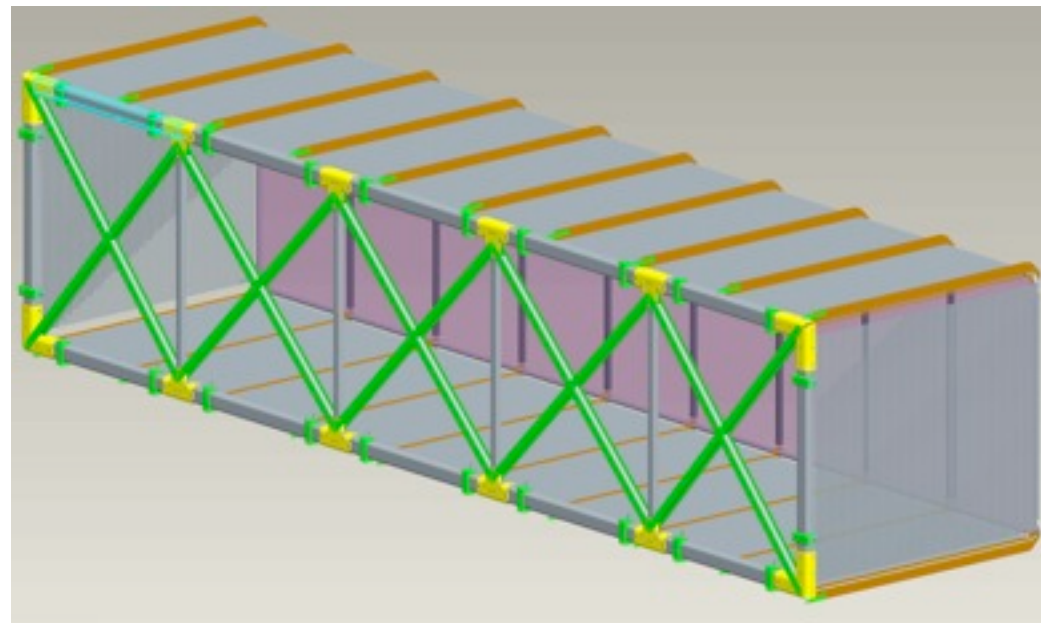
- Demonstrate the electron/photon separation
- Develop cold electronics
- Test purity in large detector
- Test ability to run on/near the surface for proton decay studies in LAr TPC
- Develop analysis tools
- Develop cost scaling model for larger detector

The microBooNE detector

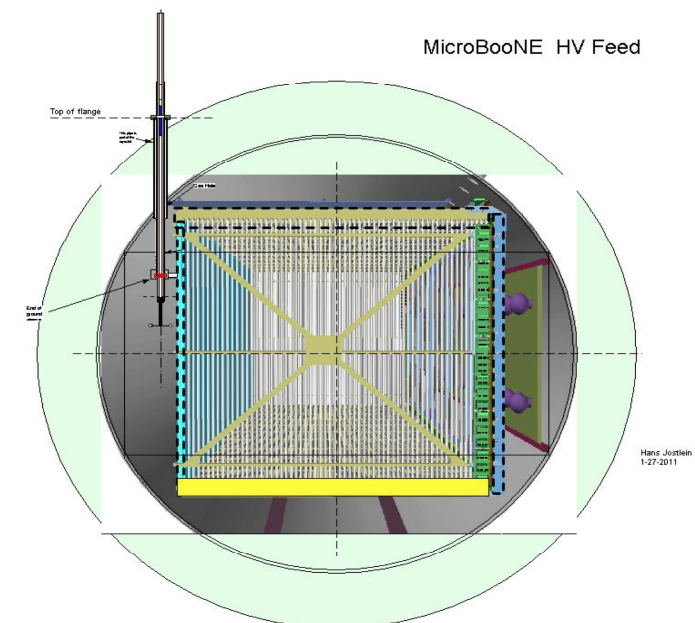
- 170 tons total liquid argon
- 86 tons active volume (60t fiducial)
- TPC dimensions: 2.5m x 2.3m x 10.4m
- 30 PMTs



Field cage



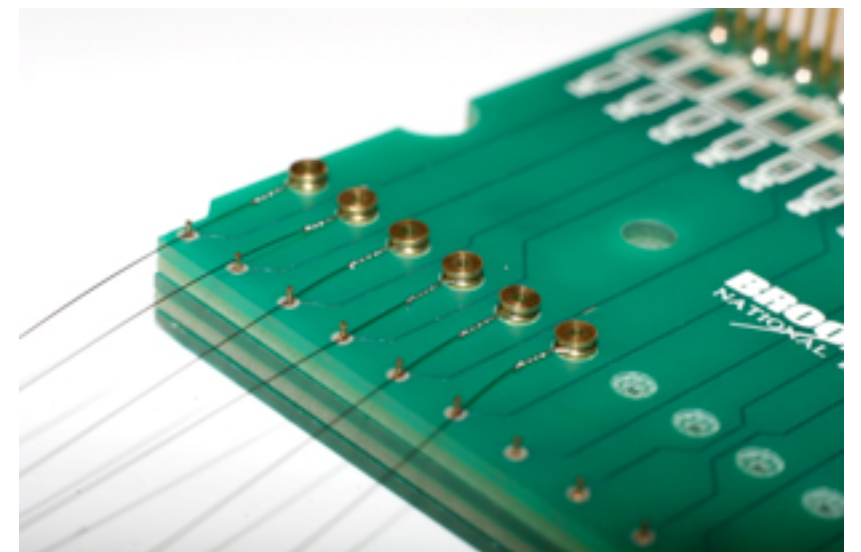
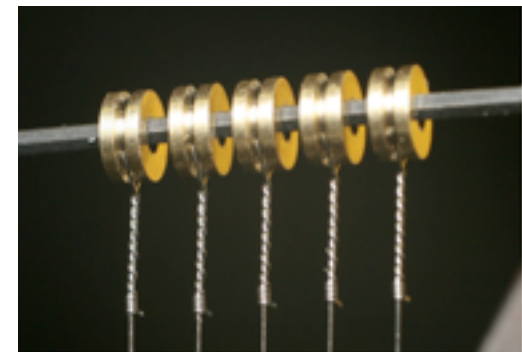
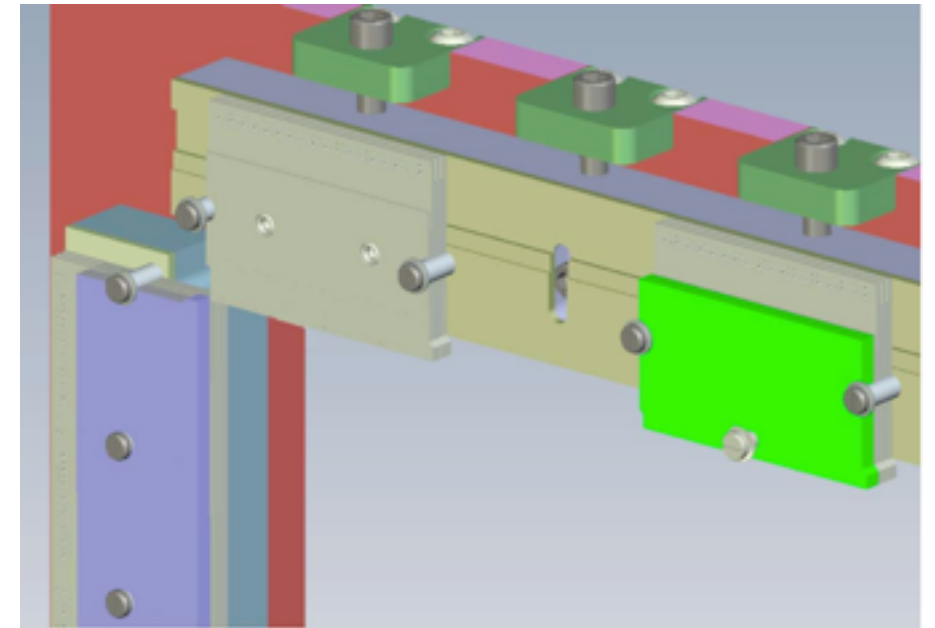
Field cage, anode and cathode planes



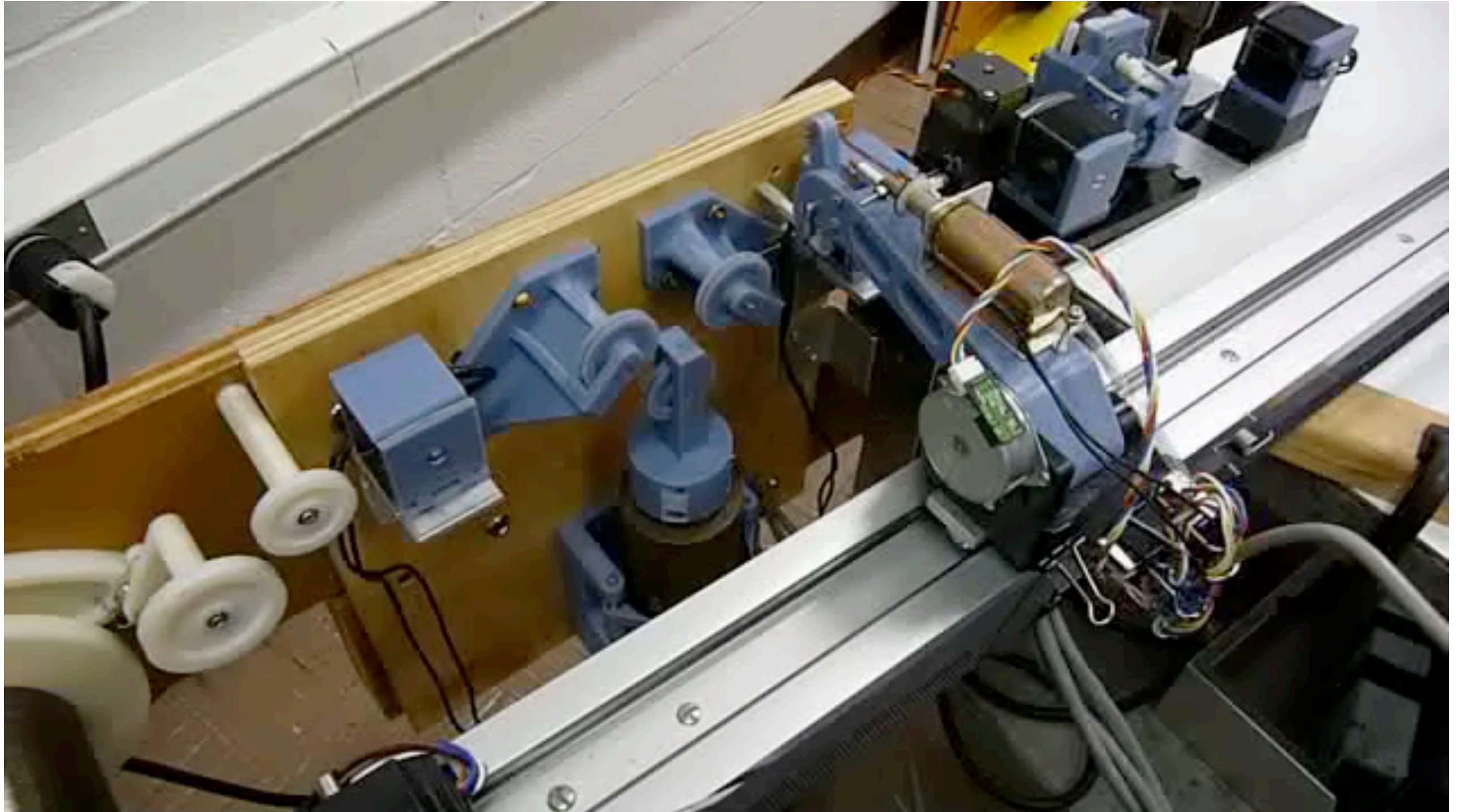
Cross section of TPC inside cryostat⁷

The microBooNE detector

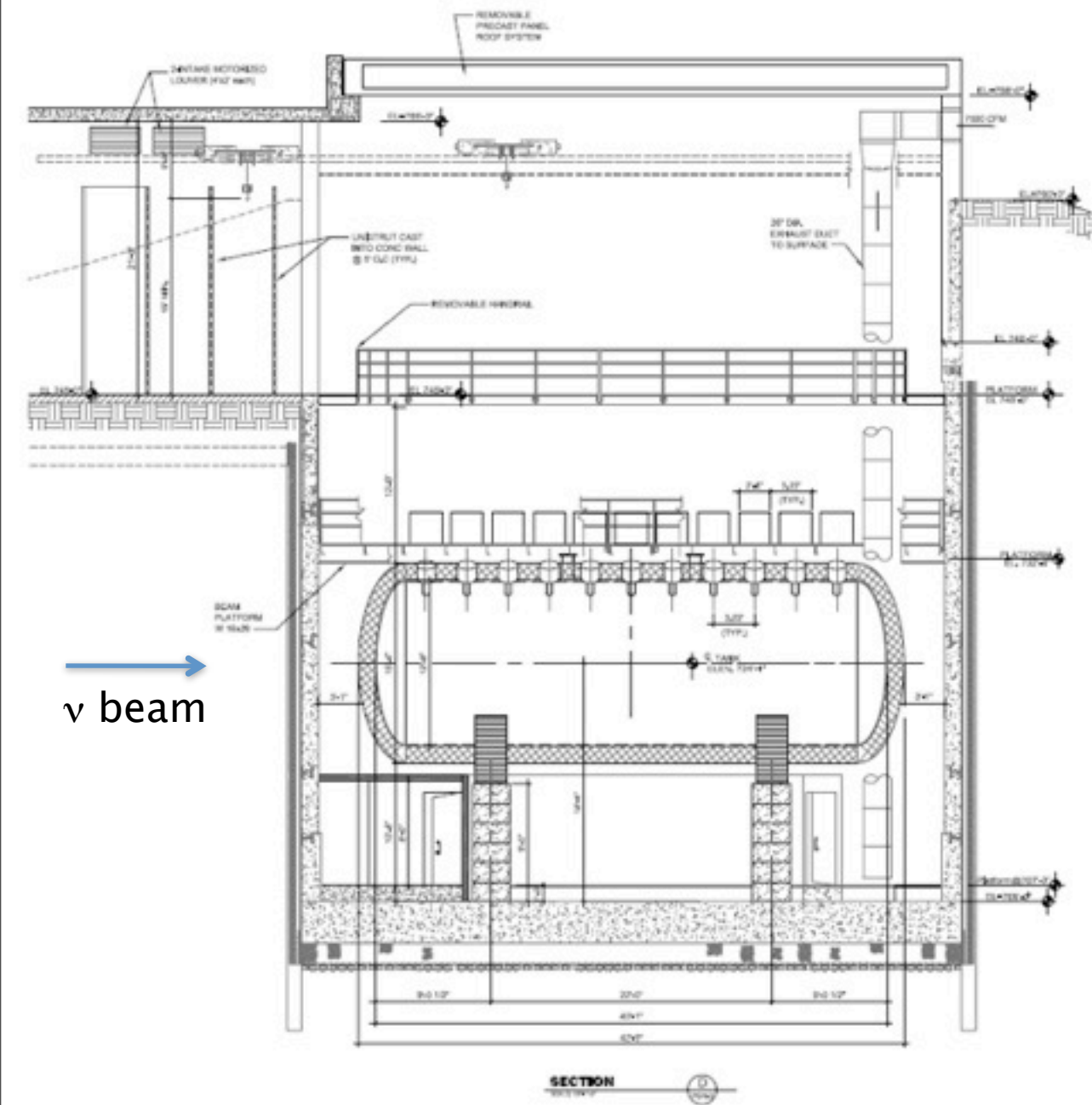
- 3 wire planes (U,V,Y)
 - Y (3456 wires): vertical
 - U (2400 wires): $+60^\circ$
 - V (2400 wires): -60°
- 3mm wire pitch
- Wires are in stainless steel coated with copper and gold flash: high breakload and low resistance
- Wire attachment via ferrule fixed on wire carrier boards
- Fully automated wire winding machine



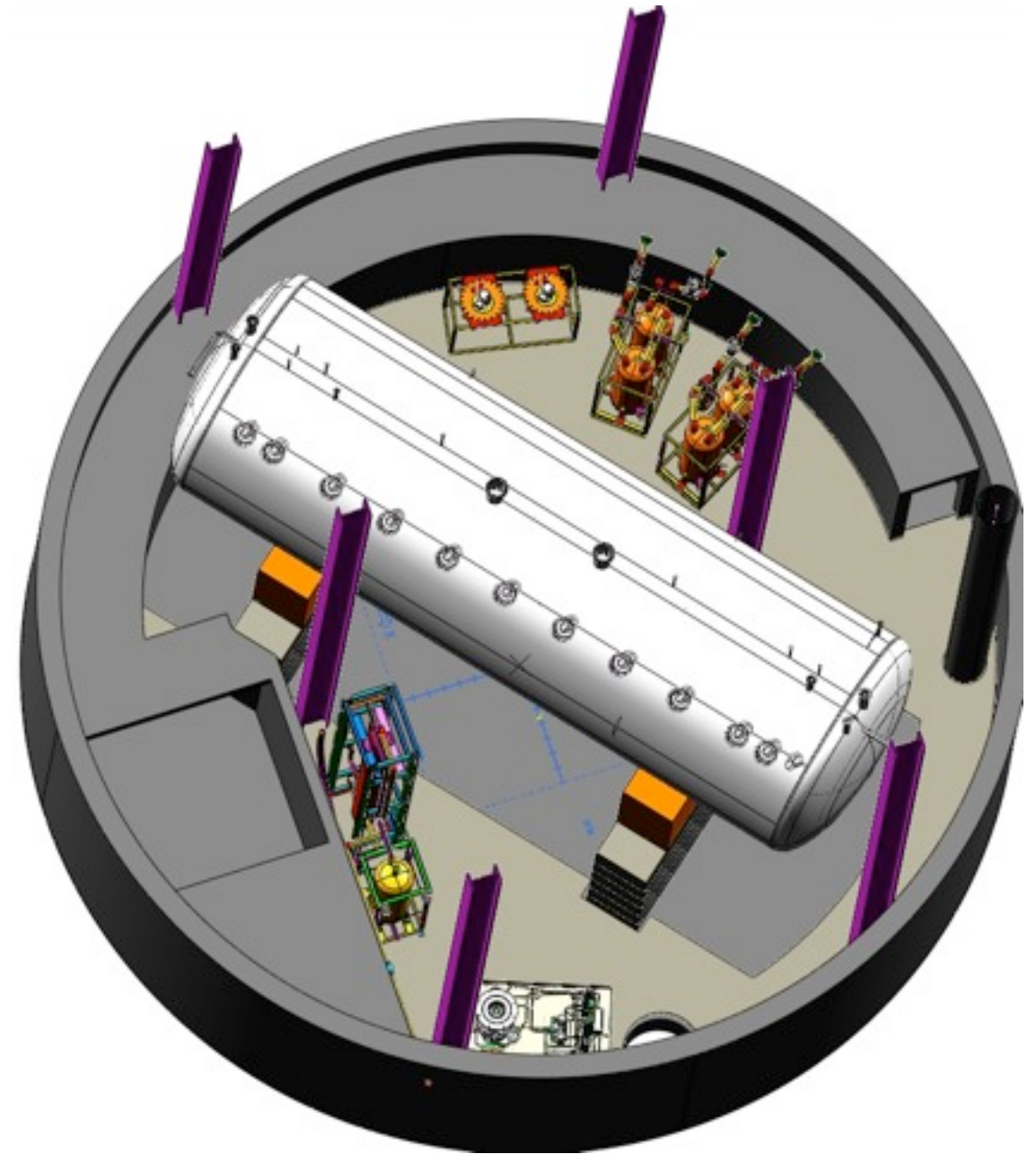
Wire winding machine



The microBooNE detector in-situ



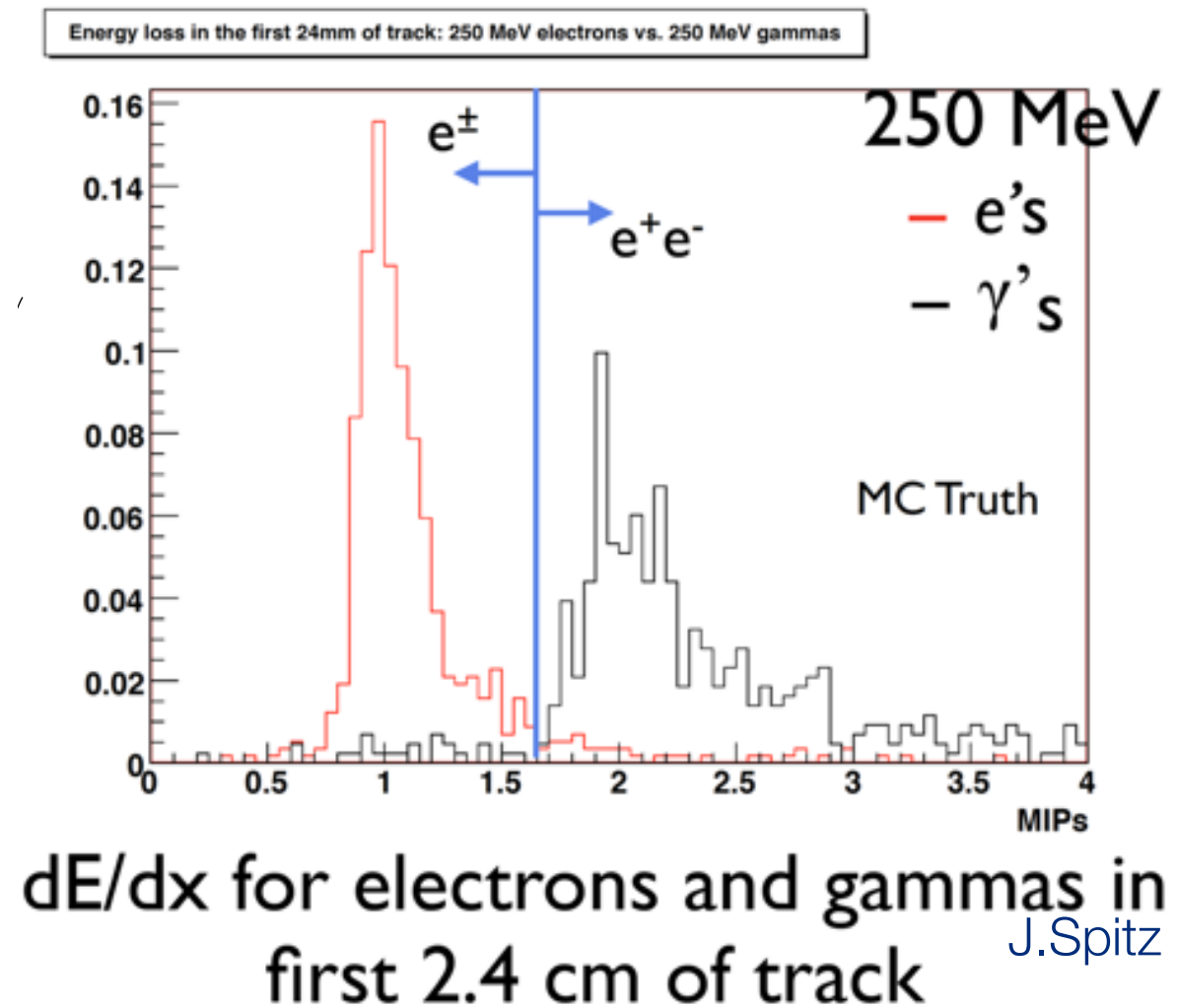
Detector in hall on beam axis, below grade



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 $\sim 2\times$ better than miniBooNE
- MicroBooNE sensitivity at low energies efficiency down to tens of MeV (compared to ~ 200 MeV for miniBooNE)

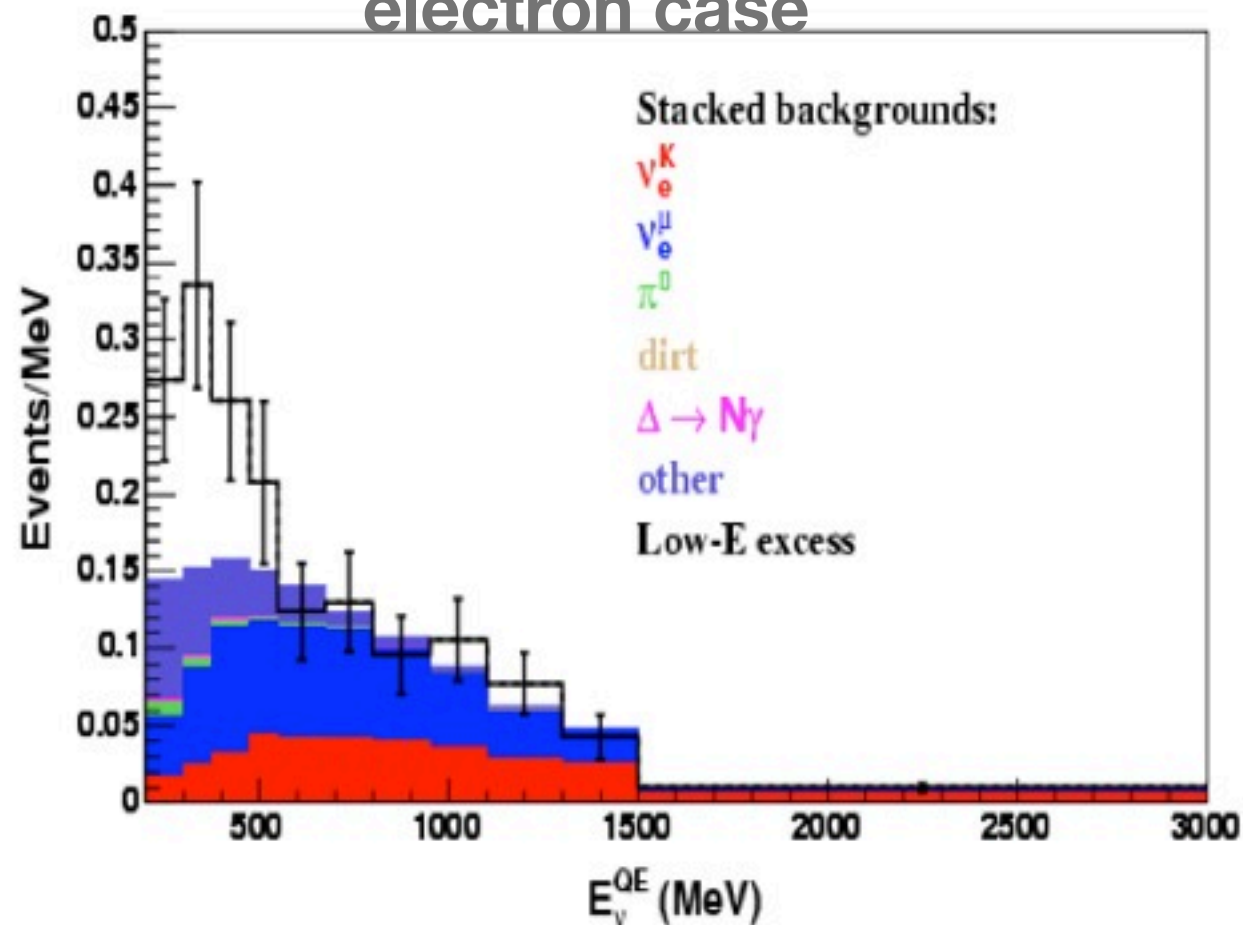


MicroBooNE addressing the miniBooNE excess

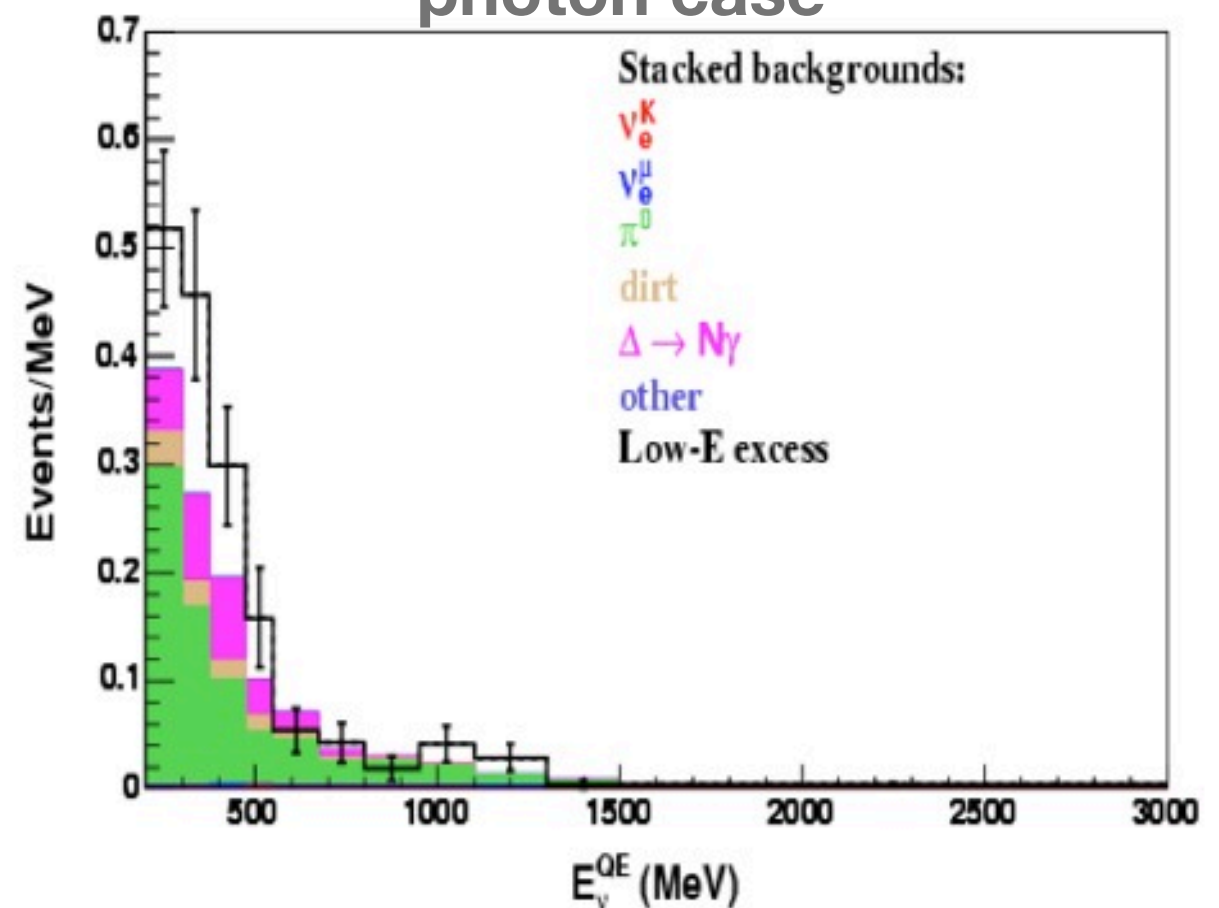
(6.6×10^{20} POT neutrino mode)

For microBooNE, as a counting experiment: 5σ sensitivity if excess is ν_e s,
 4σ sensitivity if excess is γ s

electron case



photon case



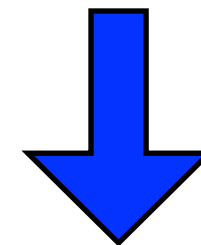
MicroBooNE: measuring cross sections

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

production mode	# events
CC QE ($\nu_\mu n \rightarrow \mu^- p$)	60,161
NC elastic ($\nu_\mu N \rightarrow \nu_\mu N$)	19,409
CC resonant π^+ ($\nu_\mu N \rightarrow \mu^- N \pi^+$)	25,149
CC resonant π^0 ($\nu_\mu n \rightarrow \mu^- p \pi^0$)	6,994
NC resonant π^0 ($\nu_\mu N \rightarrow \nu_\mu N \pi^0$)	7,388
NC resonant π^\pm ($\nu_\mu N \rightarrow \nu_\mu N' \pi^\pm$)	4,796
CC DIS ($\nu_\mu N \rightarrow \mu^- X, W > 2 \text{ GeV}$)	1,229
NC DIS ($\nu_\mu N \rightarrow \nu_\mu X, W > 2 \text{ GeV}$)	456
NC coherent π^0 ($\nu_\mu A \rightarrow \nu_\mu A \pi^0$)	1,694
CC coherent π^+ ($\nu_\mu A \rightarrow \mu^- A \pi^+$)	2,626
NC kaon ($\nu_\mu N \rightarrow \nu_\mu K X$)	39
CC kaon ($\nu_\mu N \rightarrow \mu^- K X$)	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

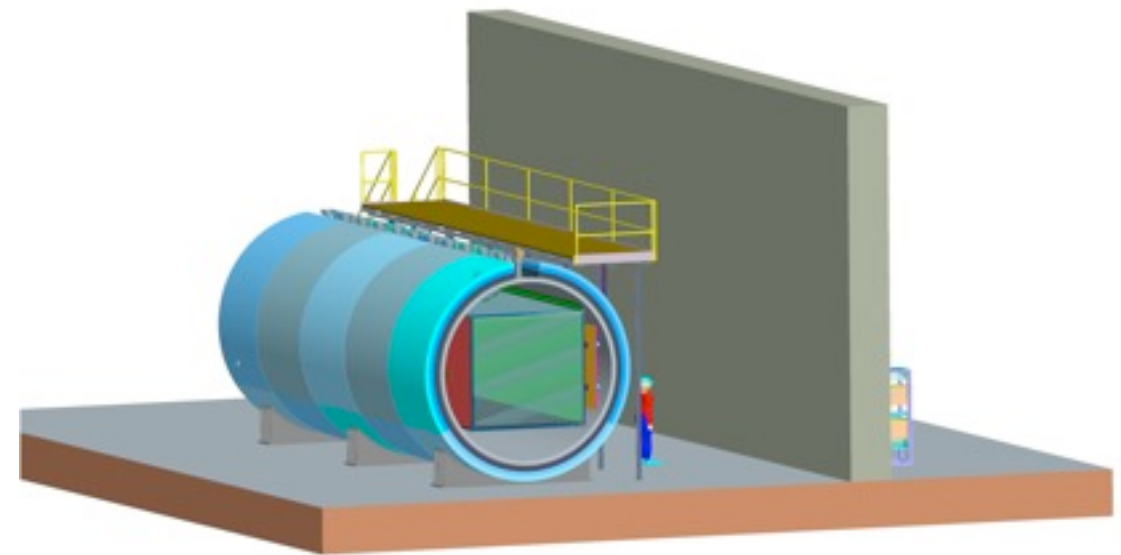
- Coherent vs resonant pion production
- K production: cross section and proton decay studies
- ν_e cross sections



- ◆ Good statistics for rare channels
- ◆ Low energy threshold
- ◆ Resolution of activity at the vertex to observe nuclear effects

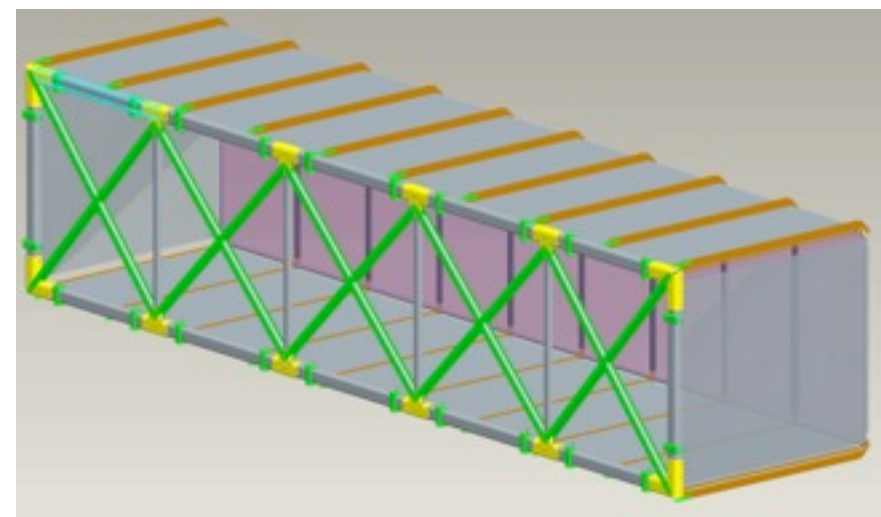
MicroBooNE current status

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



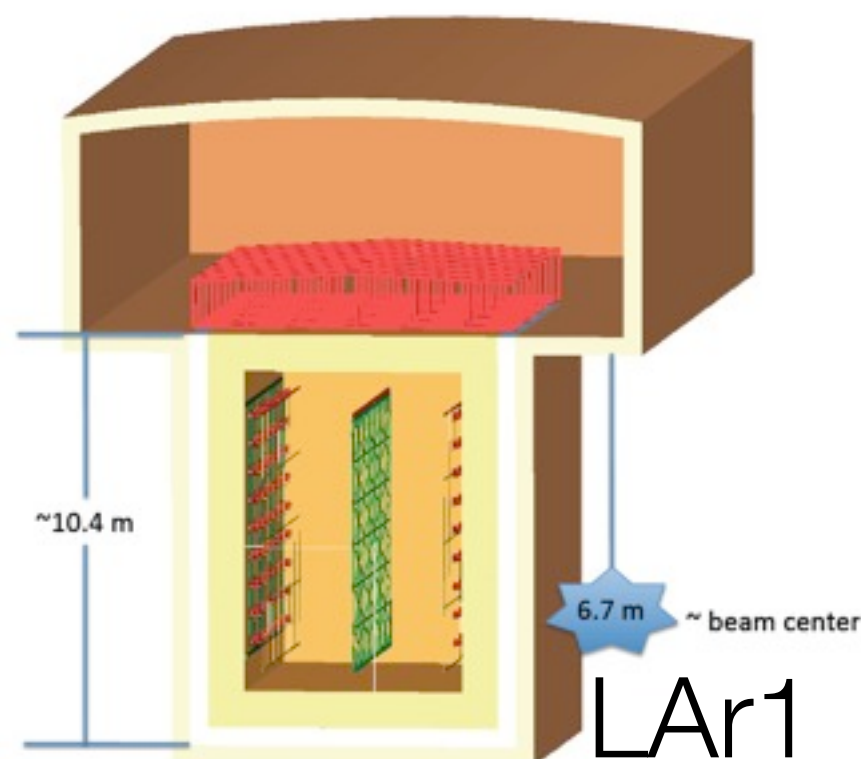
★ • CD-2/3a will take place this Summer 2011 → Begin construction
You are here

- Data taking starting 2013



Beyond microBooNE: Addressing LSND/miniBooNE excesses

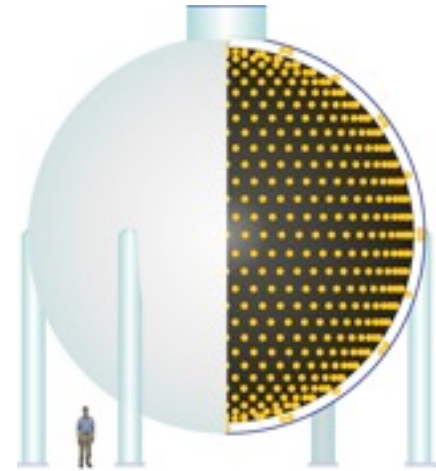
- From 2013, microBooNE will take data to fulfill its physics goals
- But in parallel and in future, microBooNE could be used to search for miniBooNE/LSND event excesses
- MicroBooNE II could be combined to a large LAr (larLAr) TPC to have a near/far configuration (different locations possible)



Beyond microBooNE: Addressing miniBooNE/LSND excesses

Example path:

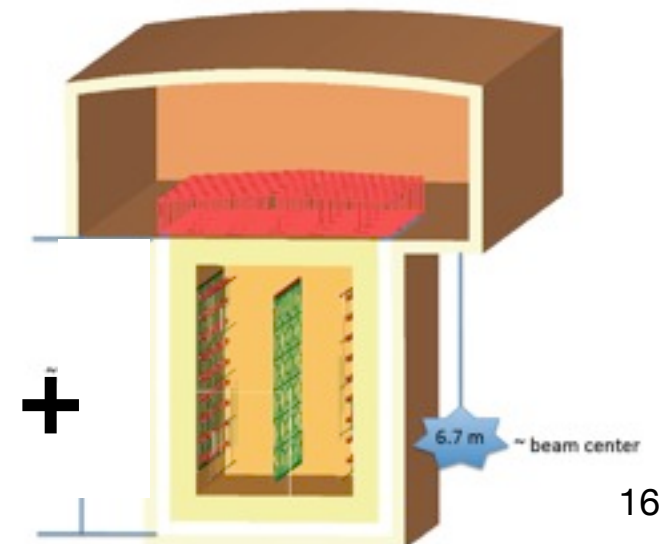
PHASE 0: Ongoing miniBooNE data taking in anti-neutrino mode
(currently)



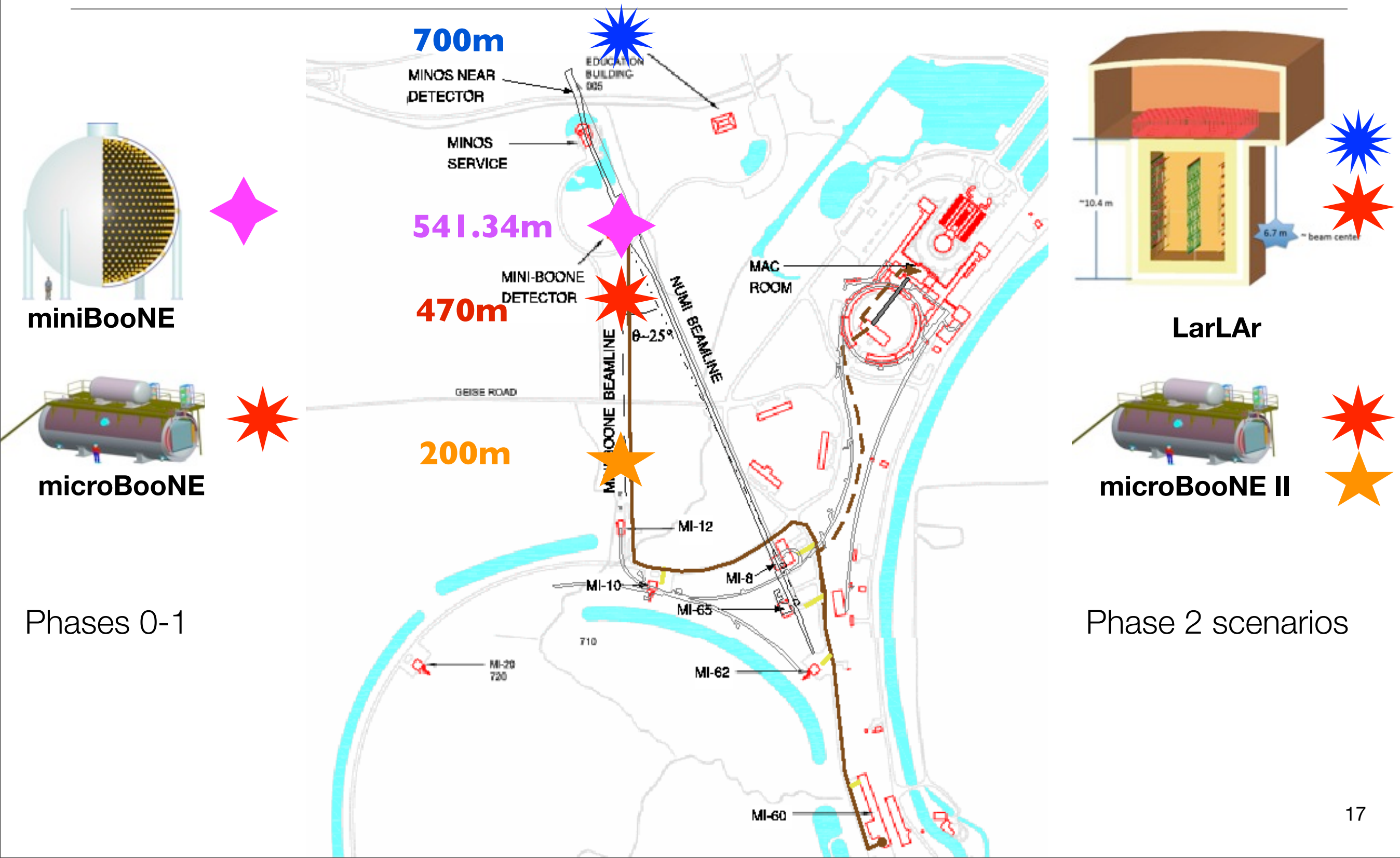
PHASE 1: MicroBooNE turns on and acquire data in neutrino mode to address miniBooNE excess (2013-...)



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



The neutrino beamline at FNAL



Phases 0-1

Phase 2 scenarios

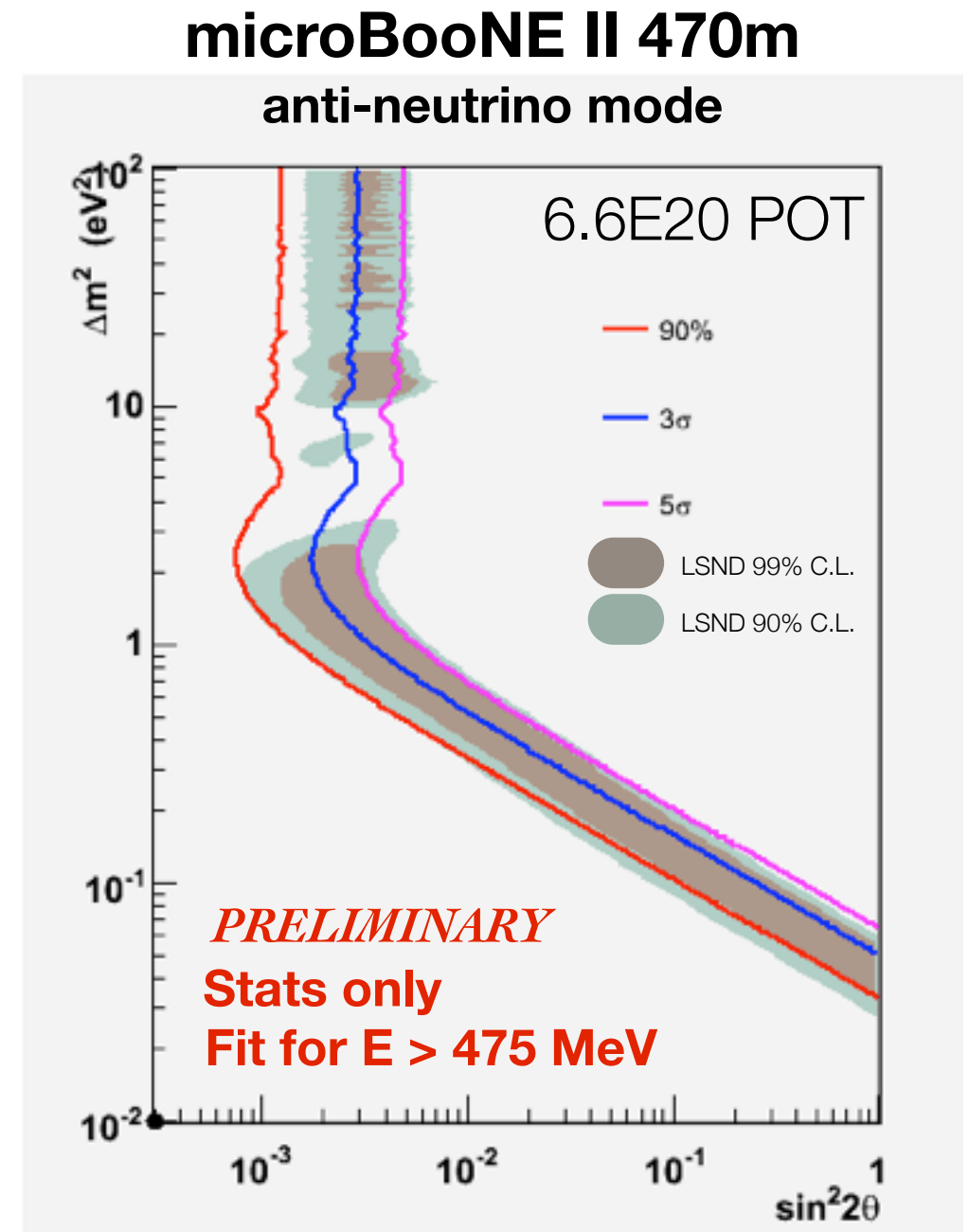
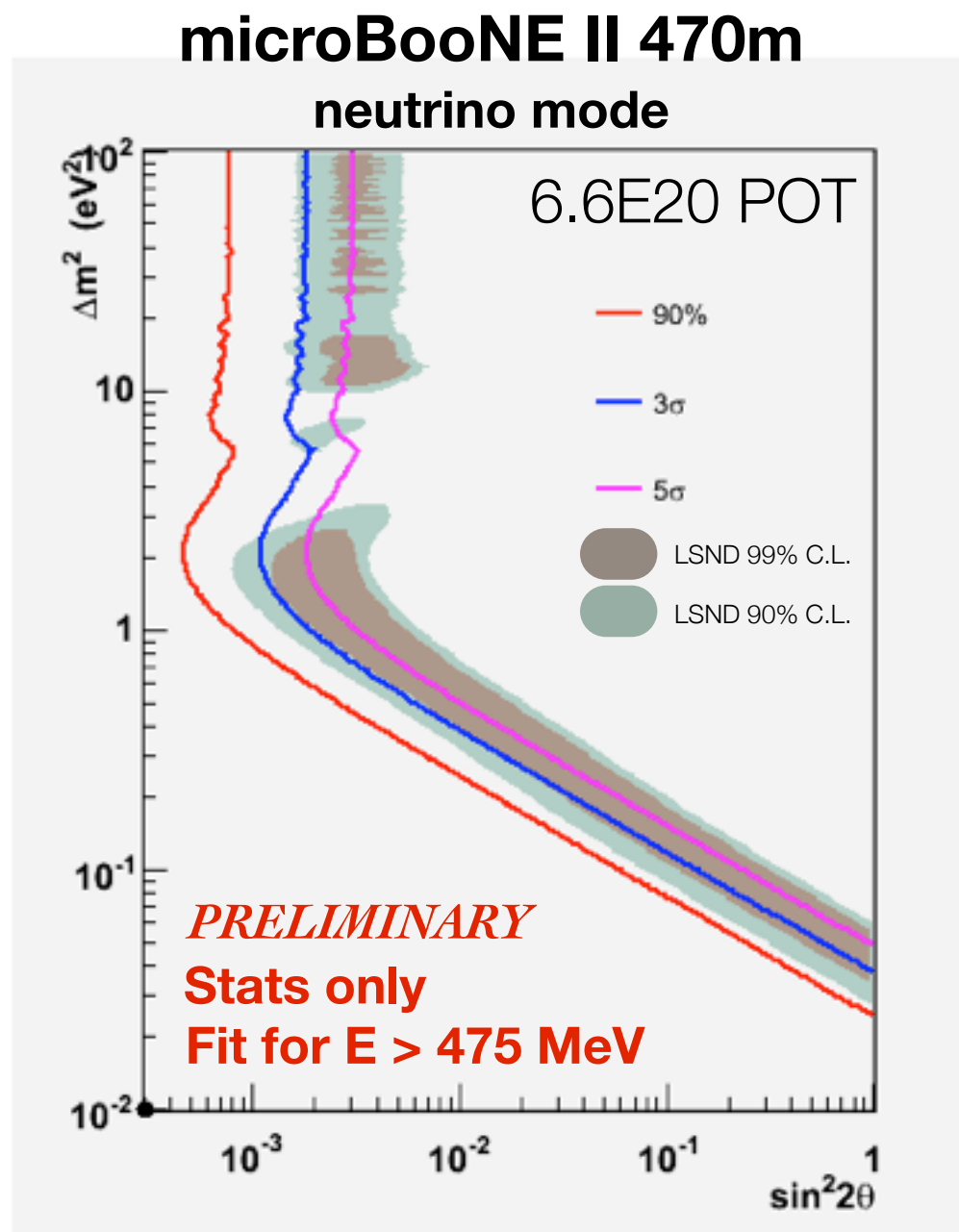
Sensitivity studies for microBooNE II and LarLAr to a simple 2-neutrino model

- 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 microBooNE II and 347.5t for LarLAr
- Assume a flat 80% efficiency for ν reconstruction

Simulations all done using LArSoft

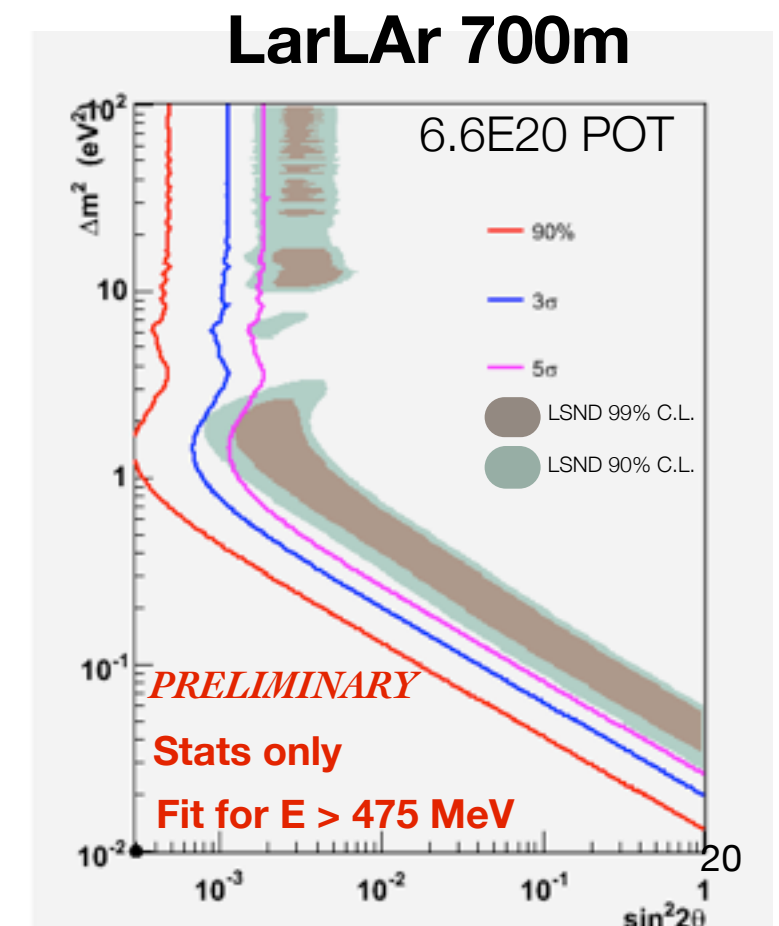
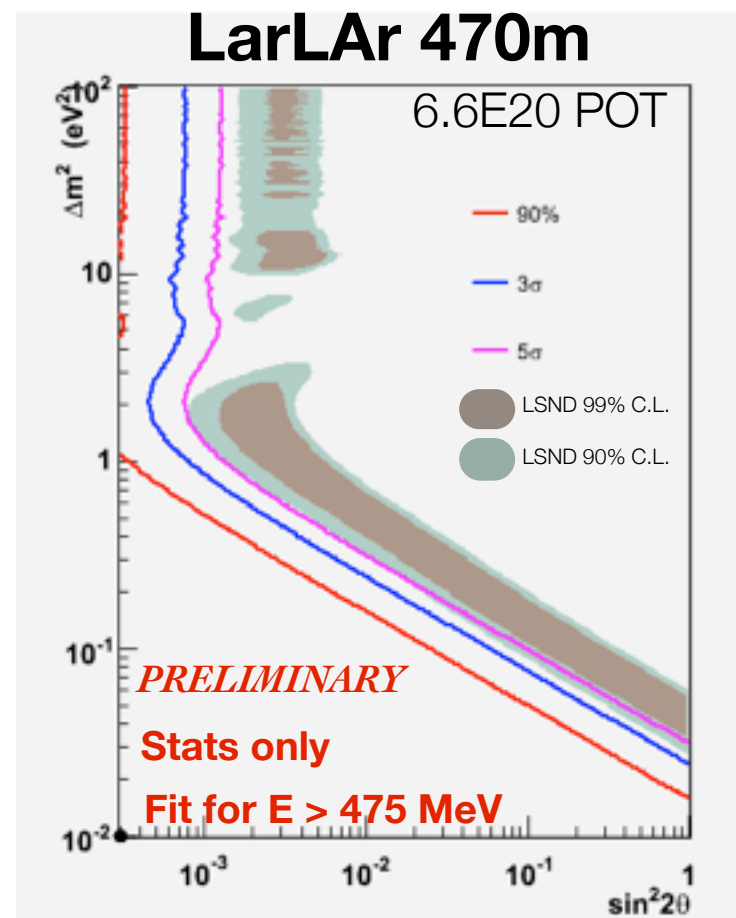
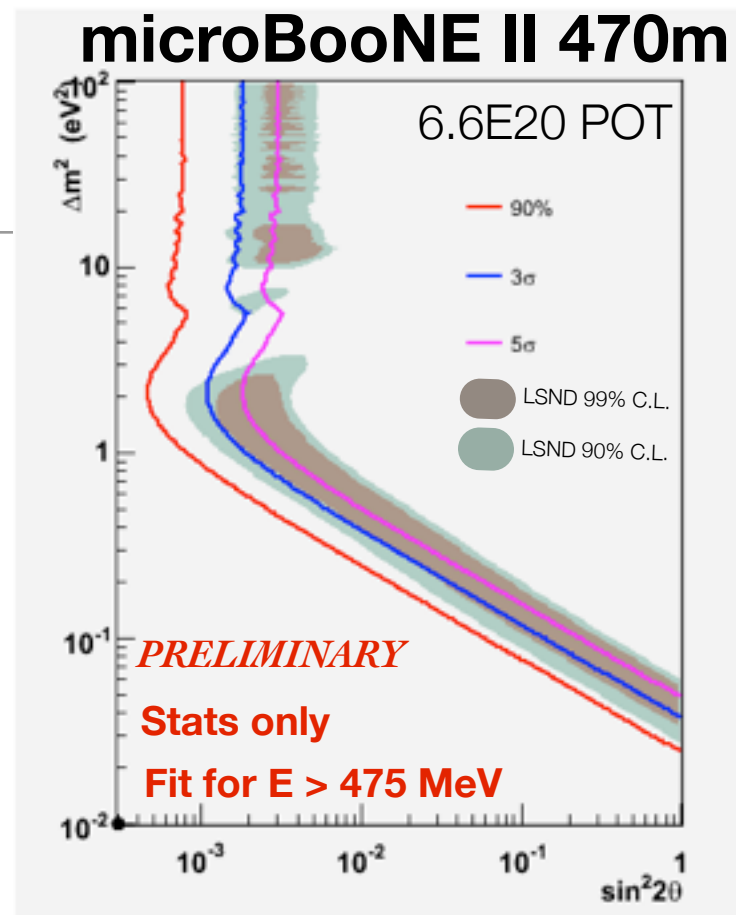
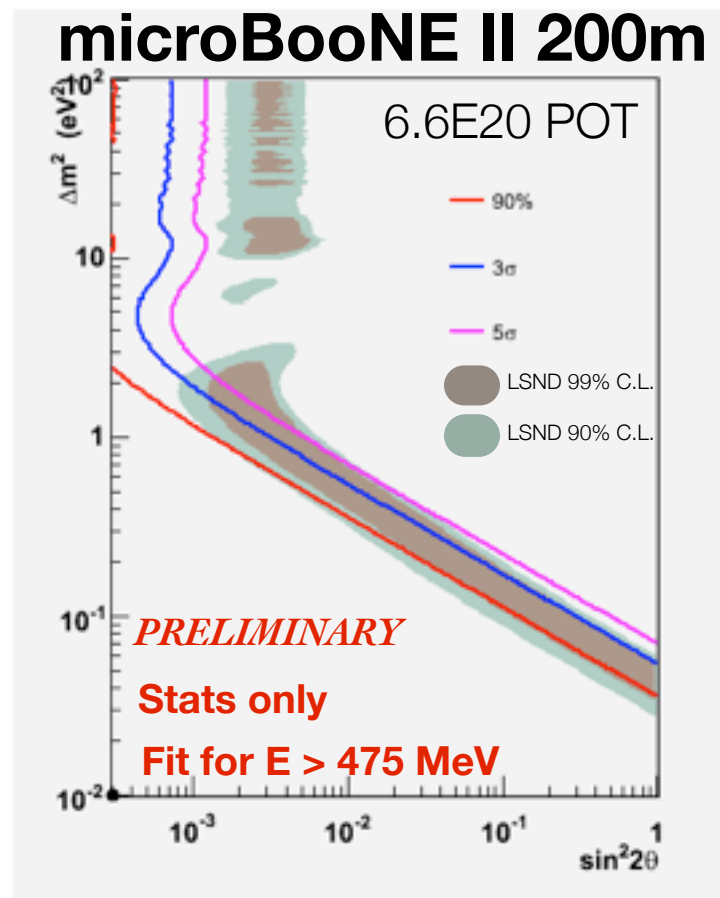
See E.Church talk

MicroBooNE II sensitivity to LSND excess*



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

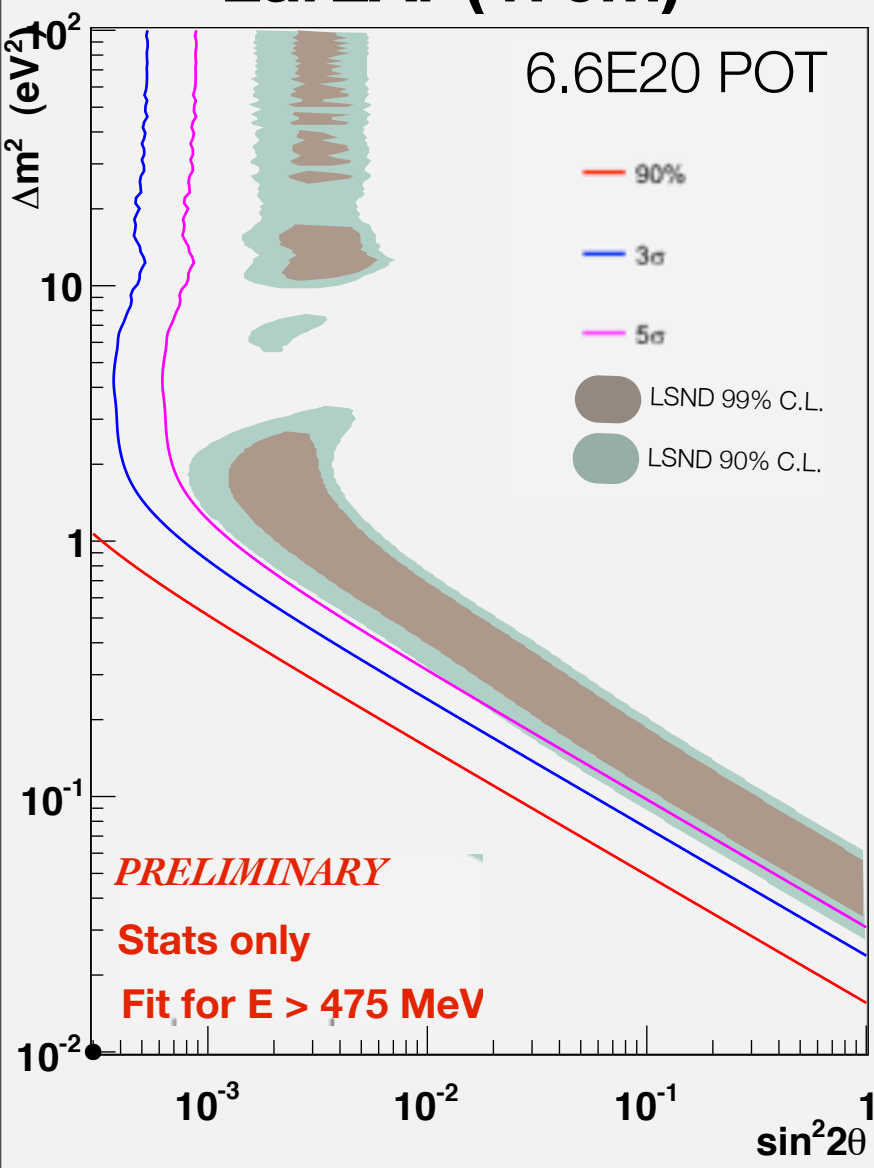
Sensitivities* in **neutrino** mode for microBooNE II and LarLAr



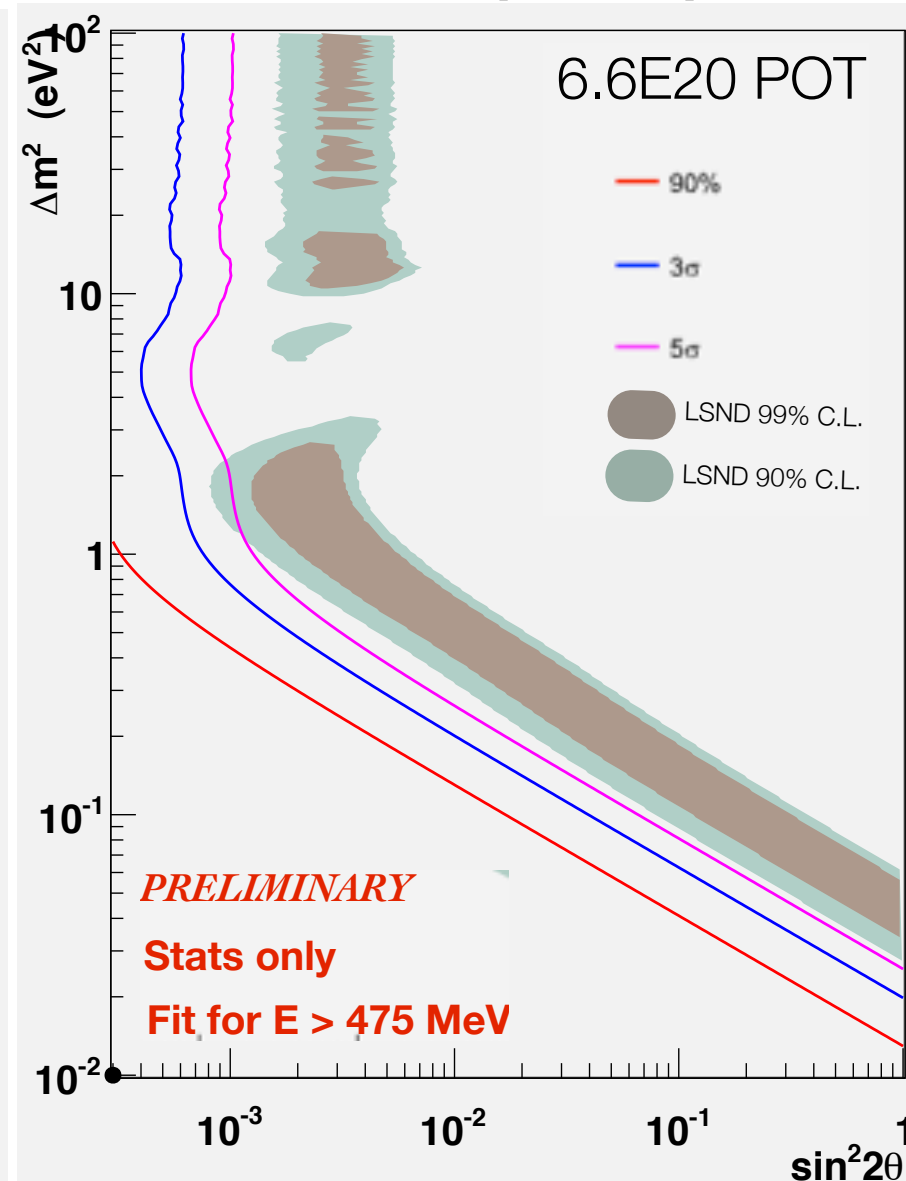
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Sensitivities* in **neutrino** mode for microBooNE II and LarLAr

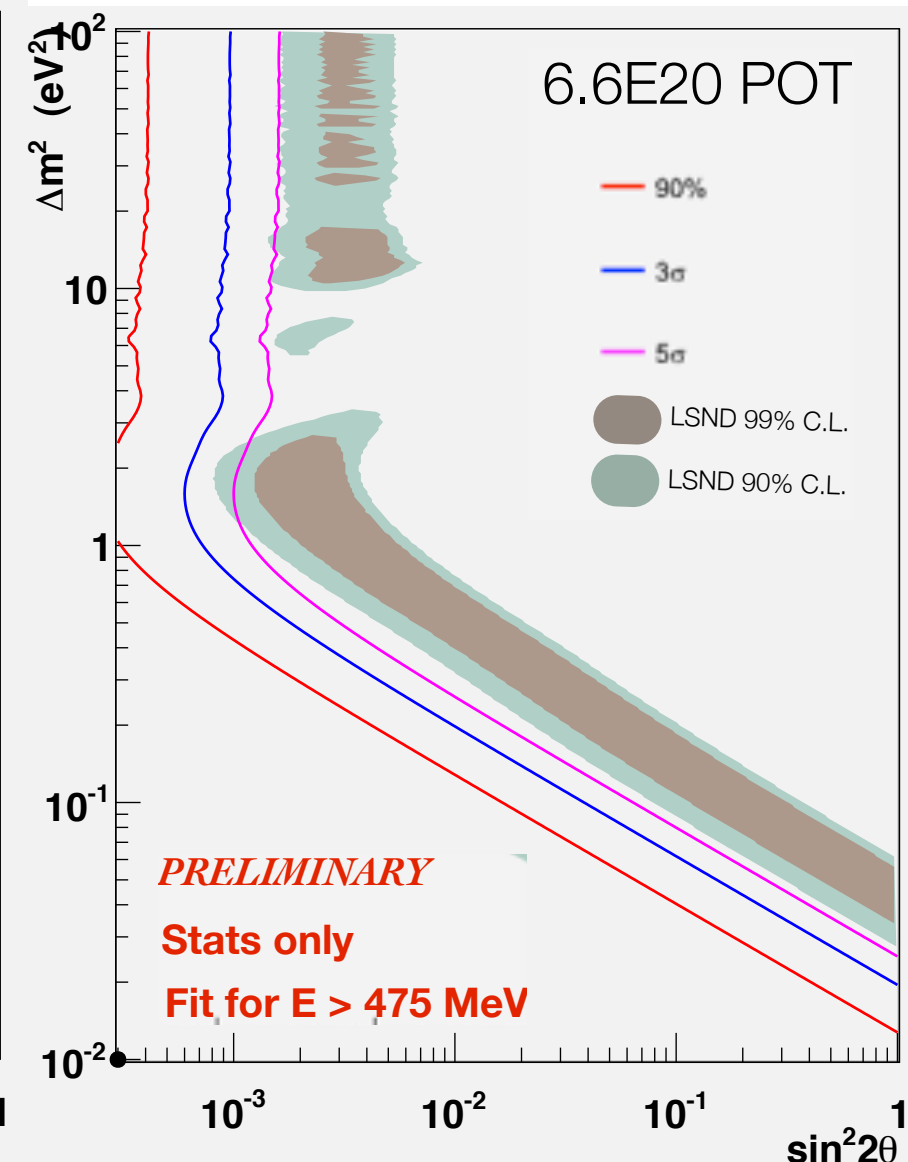
MicroBooNE II (200m)
LarLAr⁺ (470m)



MicroBooNE II (200m)
LarLAr⁺ (700m)

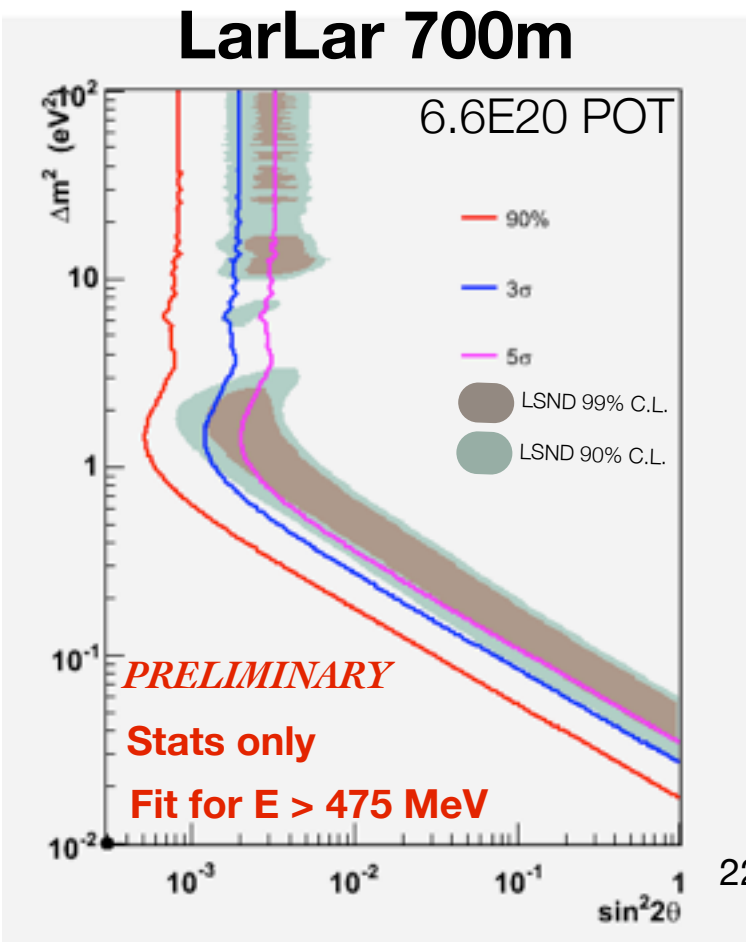
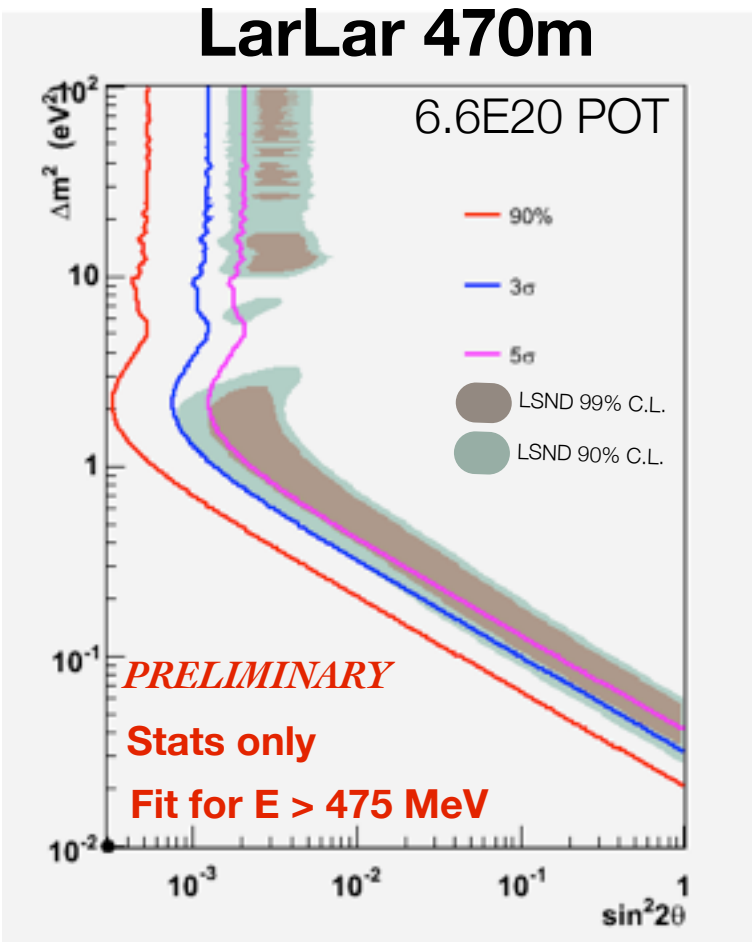
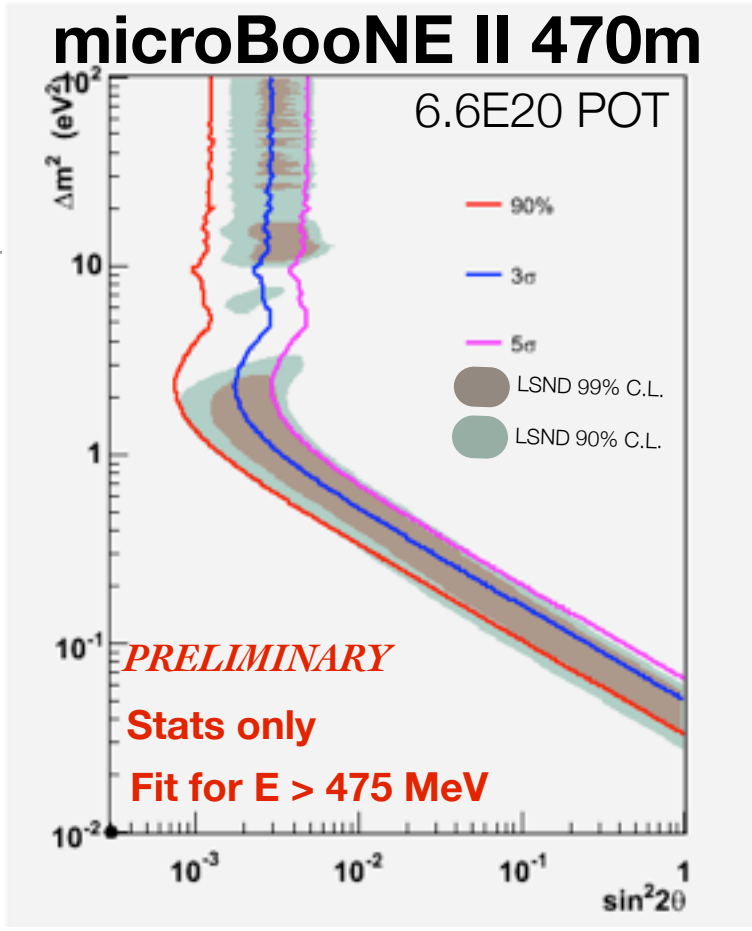
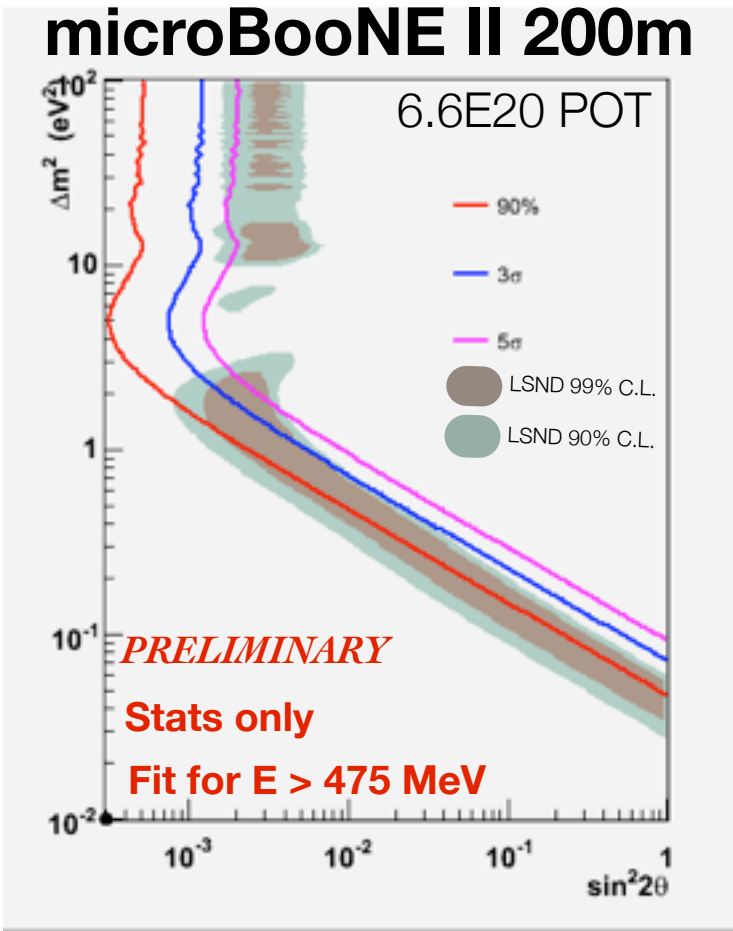


MicroBooNE II (470m)
LarLAr⁺ (700m)



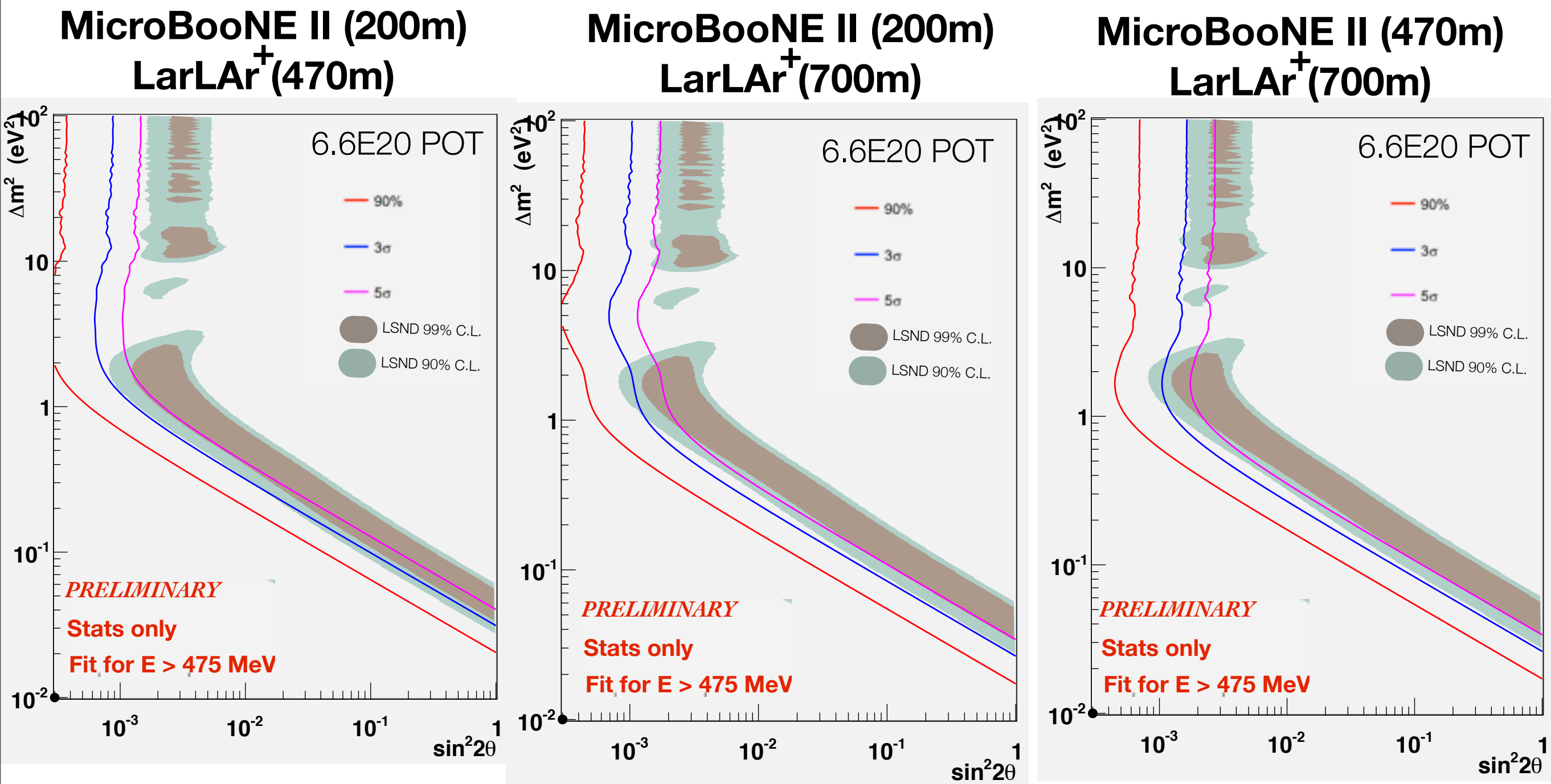
* The studies here only consider a simple 2-neutrino model

Sensitivities* in **anti-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



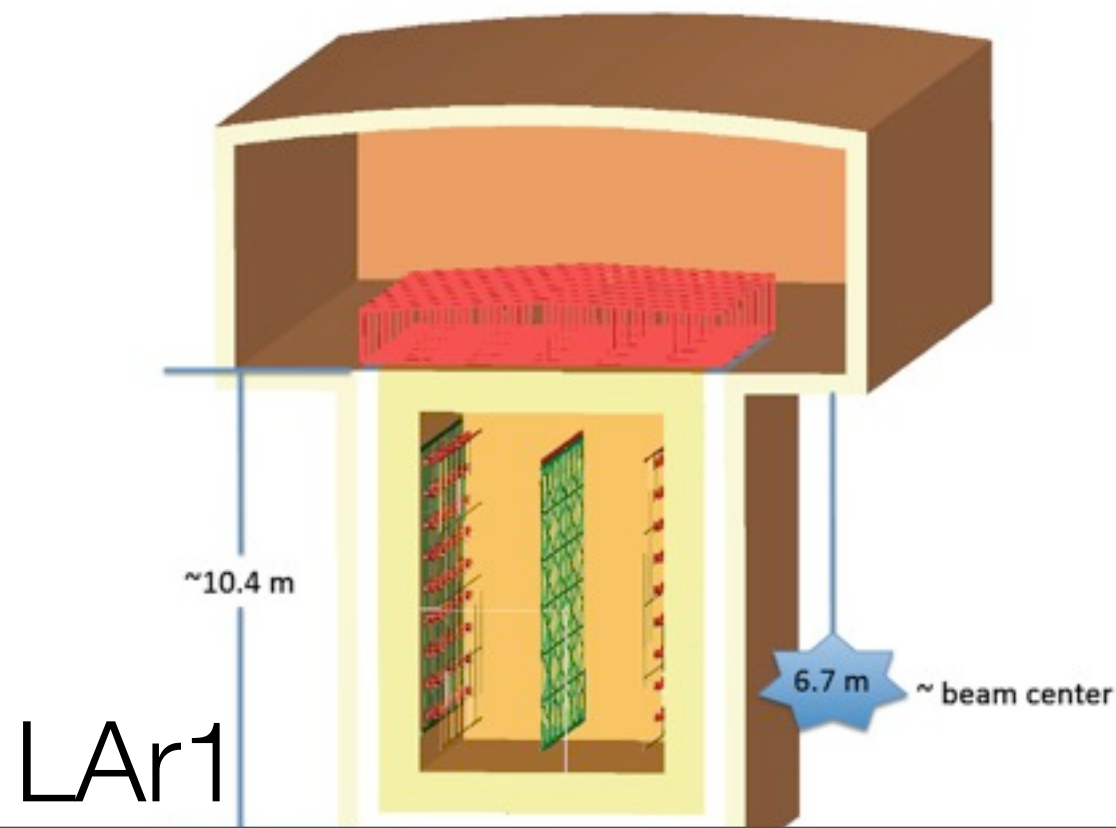
* The studies here only consider a simple 2-neutrino model

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 ($\sim 1\text{kt}$) 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...)

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 **See B.Baller's talk**
- 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 and backgrounds

Word on studies to perform: the optimal baseline

