MicroBooNE

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for the MicroBooNE Collaboration
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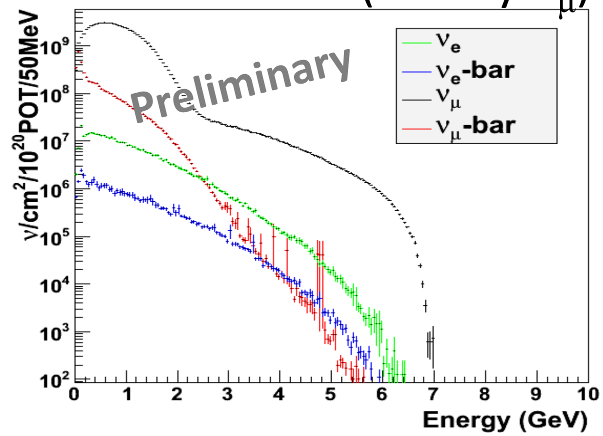
MicroBooNE

- Liquid Argon time projection chamber (LArTPC) with 86 ton active volume
- Will search for ν_e appearance in the Booster Beam, beginning in 2014

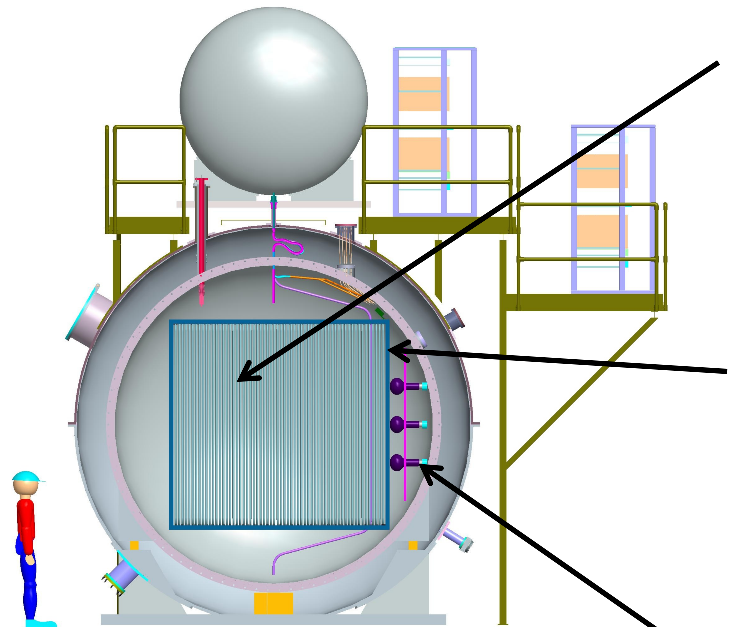
Booster Beam flux at MicroBooNE (mostly ν_μ)

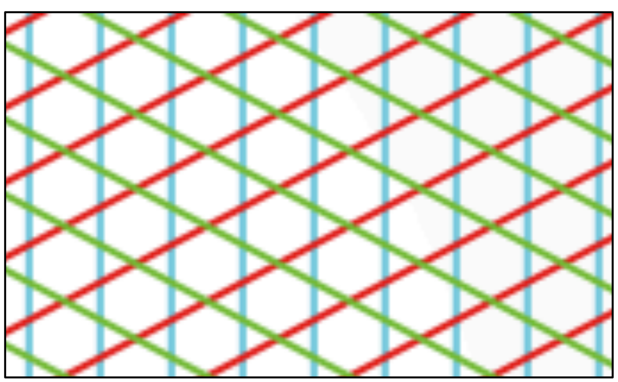


- Major goals of MicroBooNE include
  - R&D test bench for future liquid Argon detectors
  - Refine measurements of neutrino cross sections
  - Investigate the source of the MiniBooNE low energy excess

LArTPC

Liquid Argon Time Projection Chamber



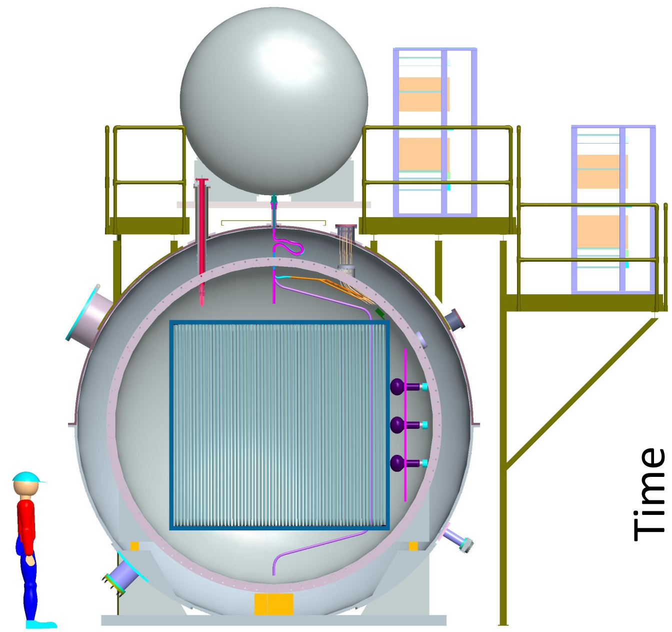


Orientation of wire planes
(wire spacing = 3mm)

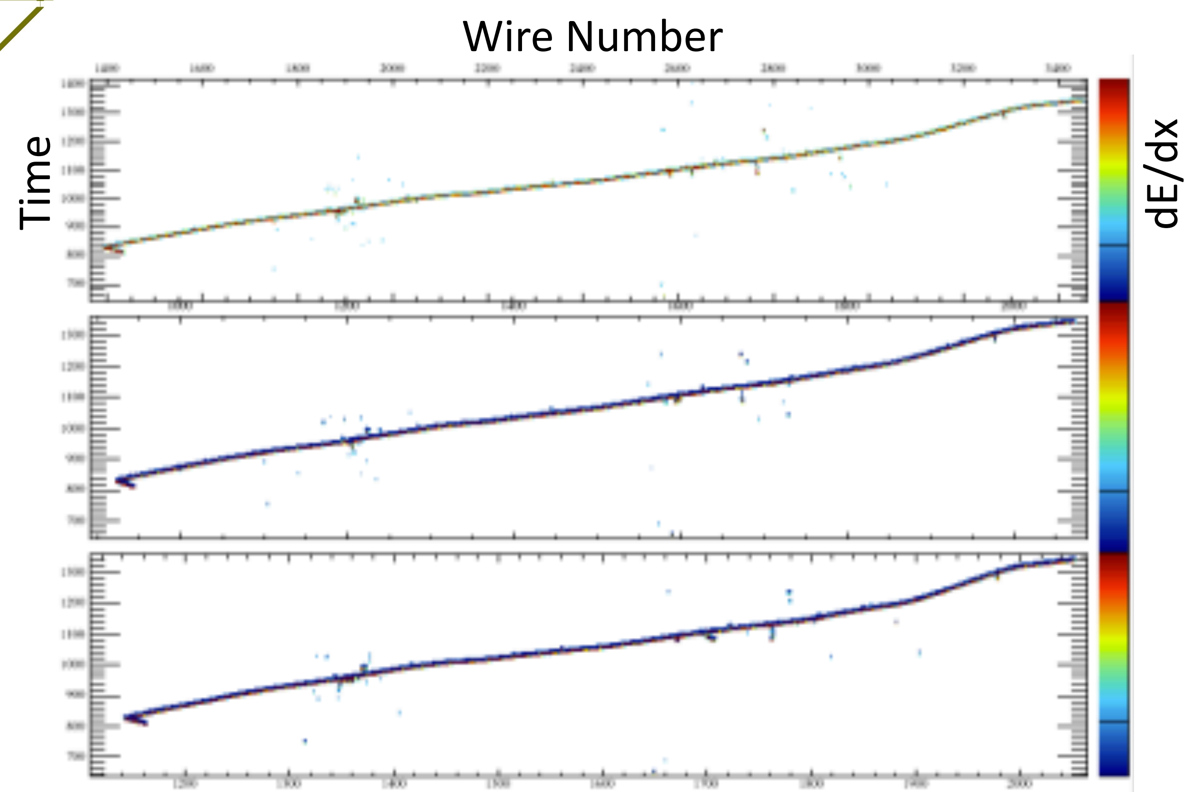
- Detector volume is filled with 170 tons of LAr
- Charged particle tracks ionize Ar atoms in the detector
- Electric field in the detector causes ionization electrons drift towards three wire planes (vertical, +/- 60° from vertical)
- 32 PMTs also detect scintillation light from neutrino and cosmic ray events
- PMTs provide information about the timing of the event

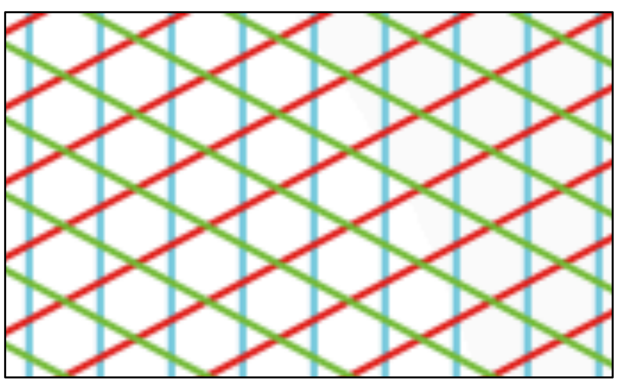
LArTPC

Liquid Argon Time Projection Chamber



- Signals on wire planes + timing information from PMTs are used to reconstruct 3D particle tracks:





Orientation of wire planes
(wire spacing = 3mm)

Looking forward: R&D

LArTPC experiments in the works

Experiment	LAr Volume(s)	Construction begins	Location
ICARUS	600 ton (total)	running	Gran Sasso, Italy
MicroBooNE	170 ton (total)	under construction	FNAL
LAr1 (proposal)	60 ton, 1 kton	projected ~ 2016	FNAL
LBNE	18 ton, 40 kton	projected ~ 2020	FNAL/ Homestake

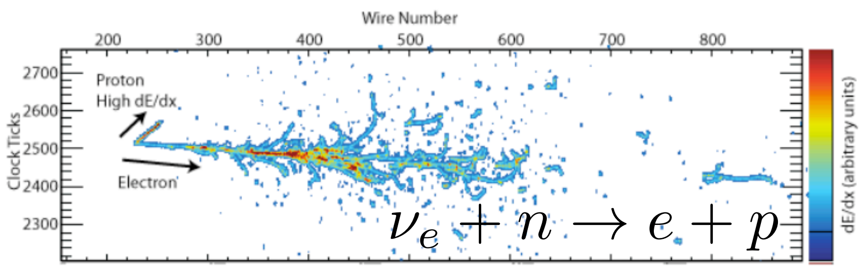
and many more!

- MicroBooNE and other current LAr detectors serve as R&D test benches for future large LArTPCs
- In particular, MicroBooNE will contribute to the development of
  - Cold, readout electronics and Data Acquisition System
  - Event reconstruction software
  - LAr purity without evacuation, etc.

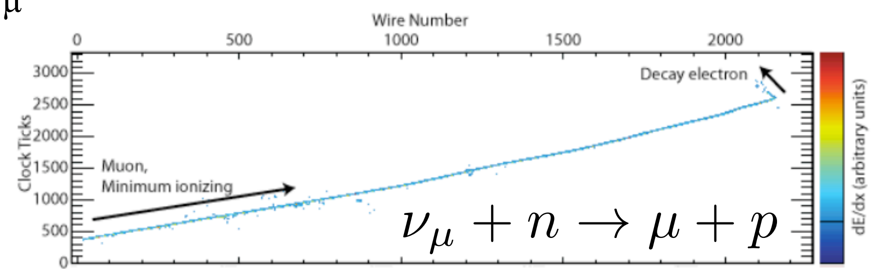
Measuring ν cross sections

- Precise measurements of cross section on Ar are essential for:
  - Testing existing cross section models
  - Developing better neutrino event generators
  - Future LAr experiments
- Can determine interaction channel by looking at final state particles

ν_e CC events have an electron in the final state:



ν_μ CC events have a muon in the final state:



Event rates, generated in Nuance for 6.6 x 10^{20} POT, 60t fid. volume

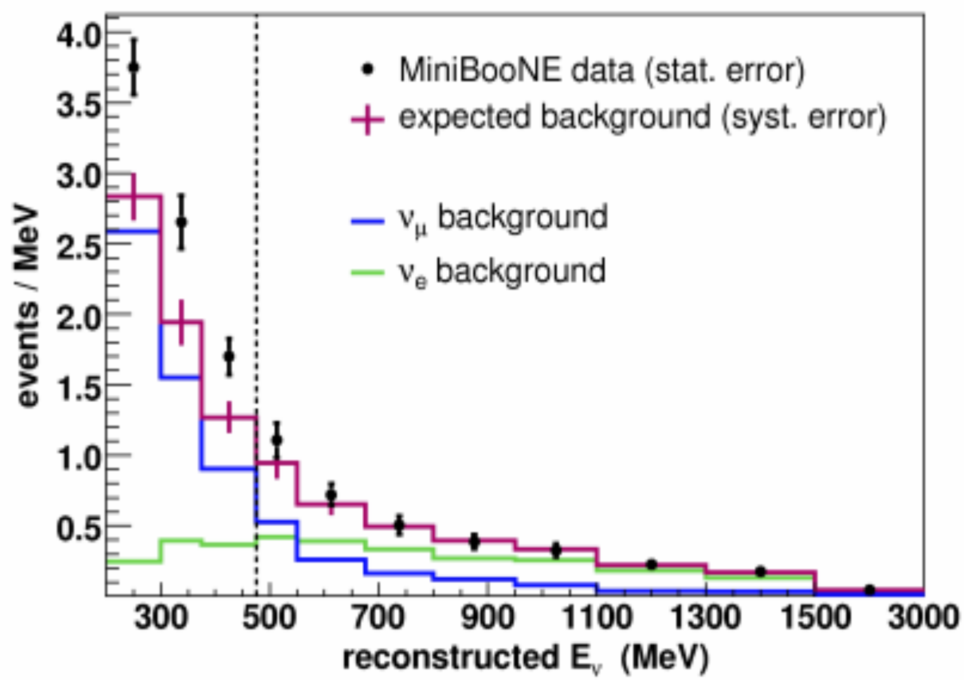
production mode	# events
CC QE ($\nu_\mu n \rightarrow \mu^- p$)	60,161
NC elastic ($\nu_\mu N \rightarrow \nu_\mu N$)	19,409
CC resonant π^+ ($\nu_\mu N \rightarrow \mu^- N \pi^+$)	25,149
CC resonant π^0 ($\nu_\mu n \rightarrow \mu^- p \pi^0$)	6,994
NC resonant π^0 ($\nu_\mu N \rightarrow \nu_\mu N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

Preliminary

MiniBooNE Low Energy Excess

Unexpected results from MicroBooNE's predecessor

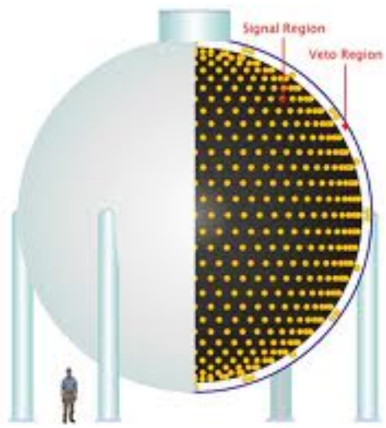
- MiniBooNE searched for ν_e appearance in Booster Beam
- Above 475 MeV: MiniBooNE results agree with background predictions
- **200 – 475 MeV: MiniBooNE measures an unexpected excess of ν_e events**

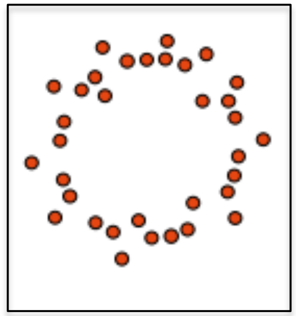


- Is this excess really due to ν_e events? Or is it due to events with a photon in the final state?
- Powerful electron/photon discrimination of LArTPC will allow MicroBooNE to investigate!

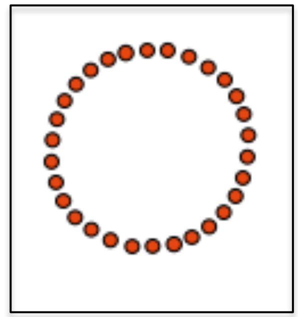
Advantages of the LArTPC for Particle ID

MiniBooNE

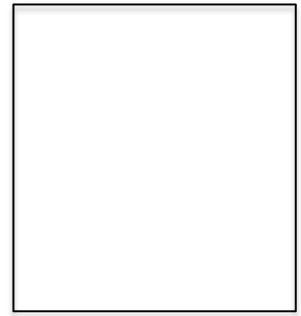




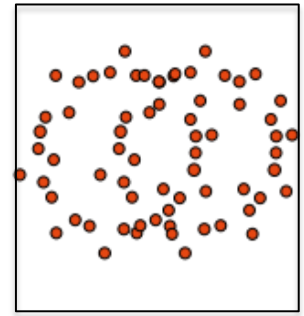
Electron, Photon



Muon



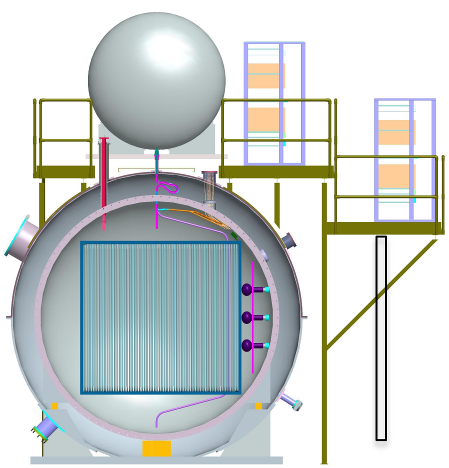
Proton

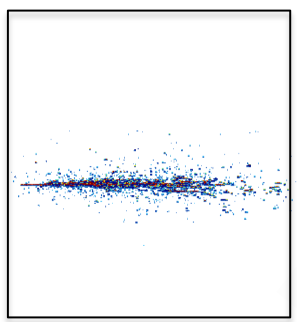


$\pi^0 \rightarrow \gamma + \gamma$

(Cherenkov Detector)

MicroBooNE





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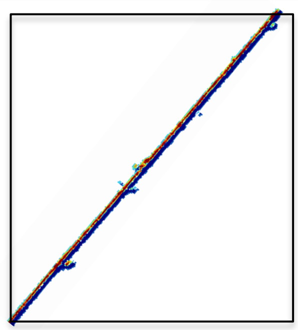

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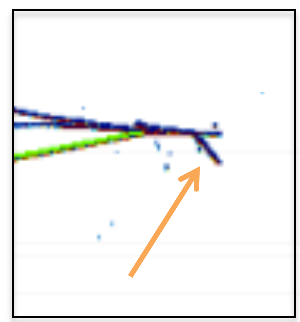

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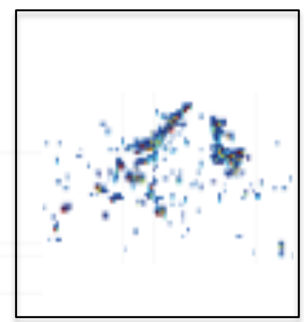
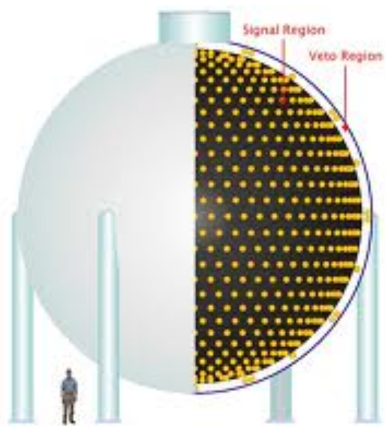


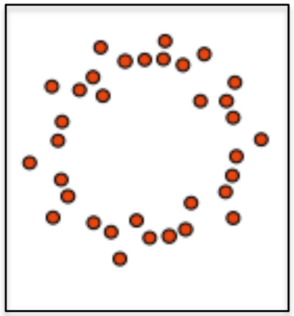
$\pi^0 \rightarrow \gamma + \gamma$

(LArTPC)

Advantages of the LArTPC for Particle ID

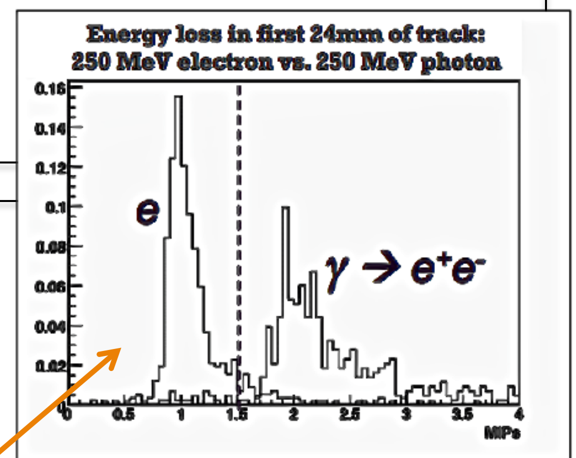
MiniBooNE



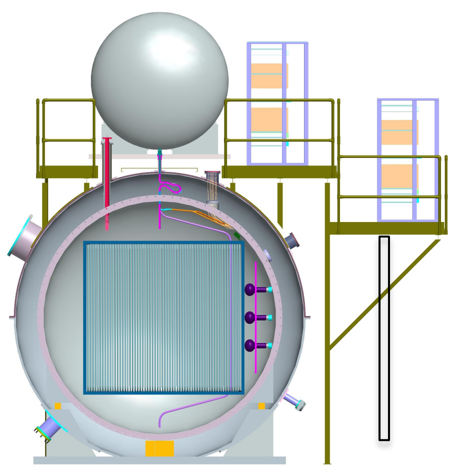


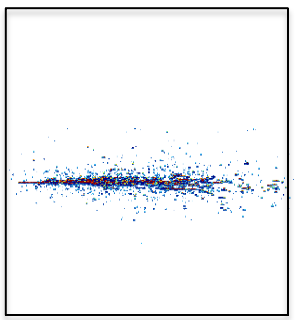
Electron, Photon

- Both electrons and photons appear as fuzzy rings in the MiniBooNE Cherenkov detector
- It is very difficult to distinguish electrons from photons



MicroBooNE



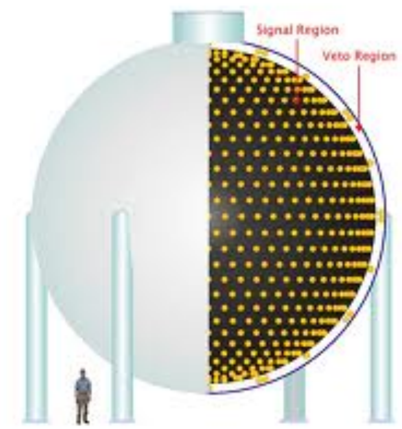


Electron, Photon

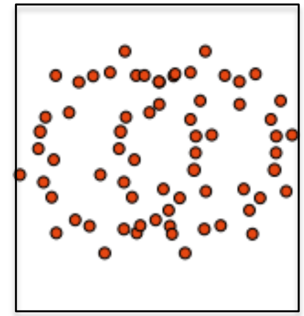
- Can tell electrons and photons apart
- dE/dx in the first few cm of the shower shows 1 MIP for electrons events, 2 MIP for photons

Advantages of the LArTPC for Particle ID

MiniBooNE

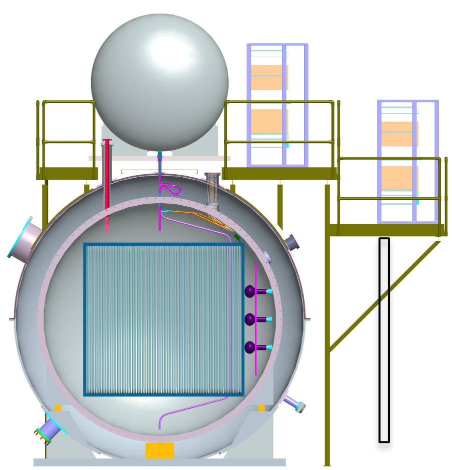


- Events with π^0 in the final state, (e.g. NC π^0 events) appear as two overlapping showers
- If the two rings are not clearly defined and look like a single shower, this can be misidentified as a ν_e event

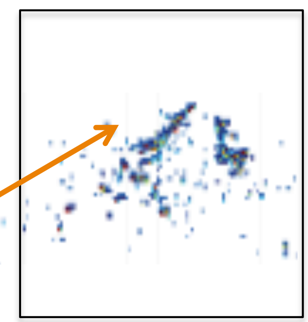


$$\pi^0 \rightarrow \gamma + \gamma$$

MicroBooNE



- Better image of event topology: can see separation between event vertex and start of γ shower(s), separation between 2 γ showers
- This + dE/dx tool allows for better identification of events with π^0 in the final state

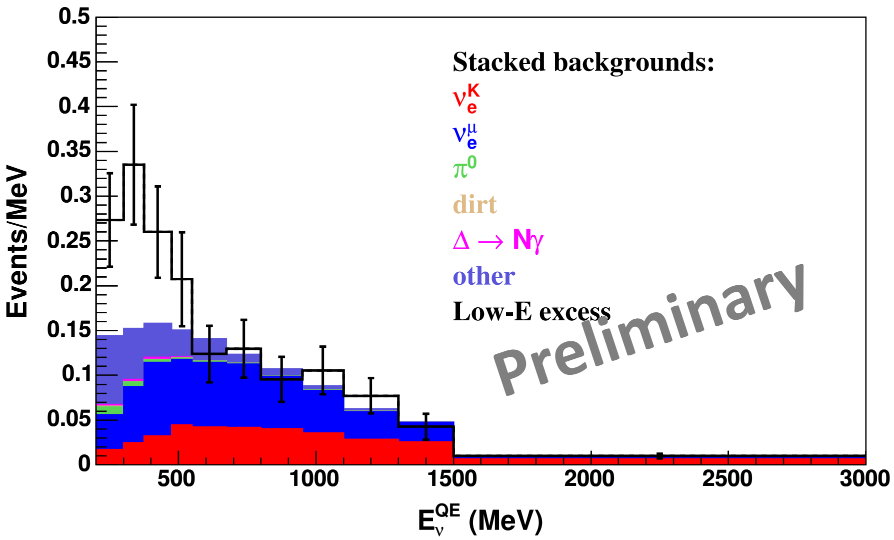


$$\pi^0 \rightarrow \gamma + \gamma$$

MicroBooNE Sensitivities

What MicroBooNE might see…

… if **electron** excess (with e cuts)

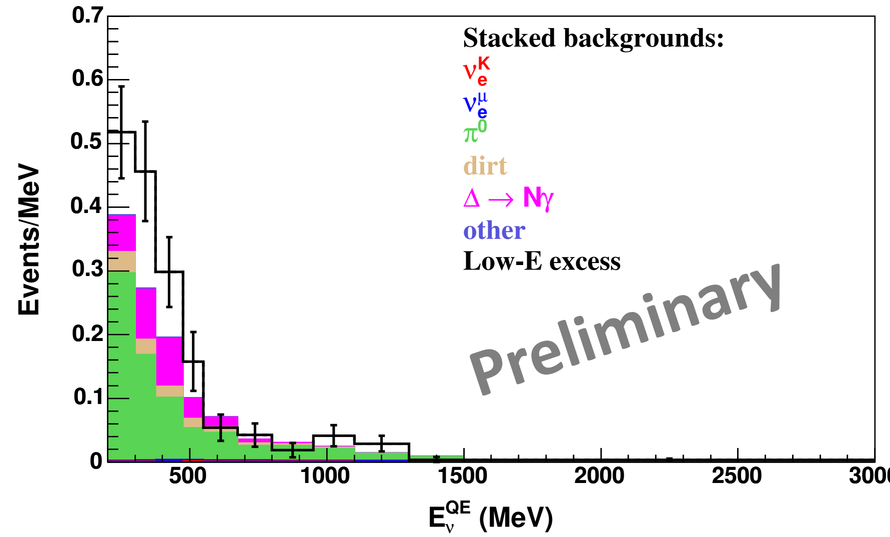


Non-standard neutrino oscillations!

e.g. sterile neutrinos

$$\nu_\mu \rightarrow \nu_s \rightarrow \nu_e$$

… if **photon** excess (with γ cuts)



Misestimated γ and π^0 events?

New type of ν interaction with γ in the final state?

MicroBooNE Sensitivities

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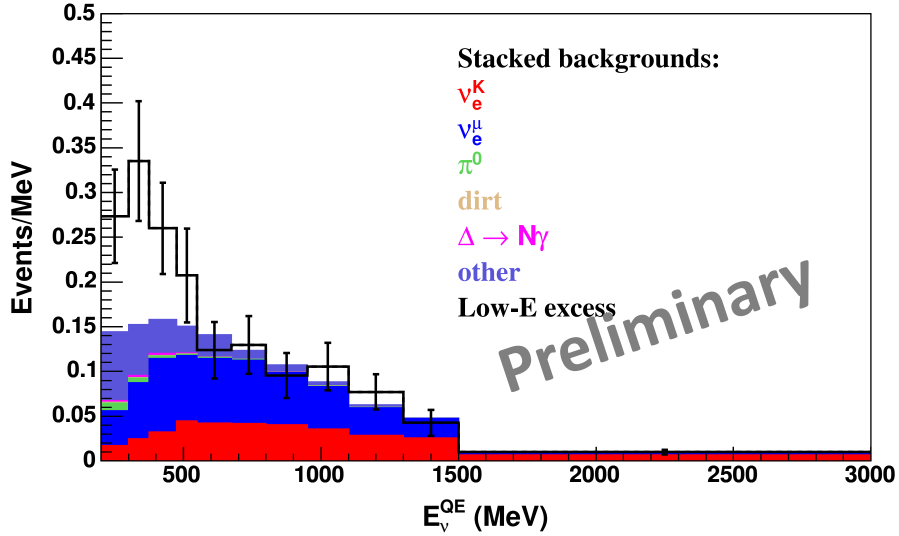

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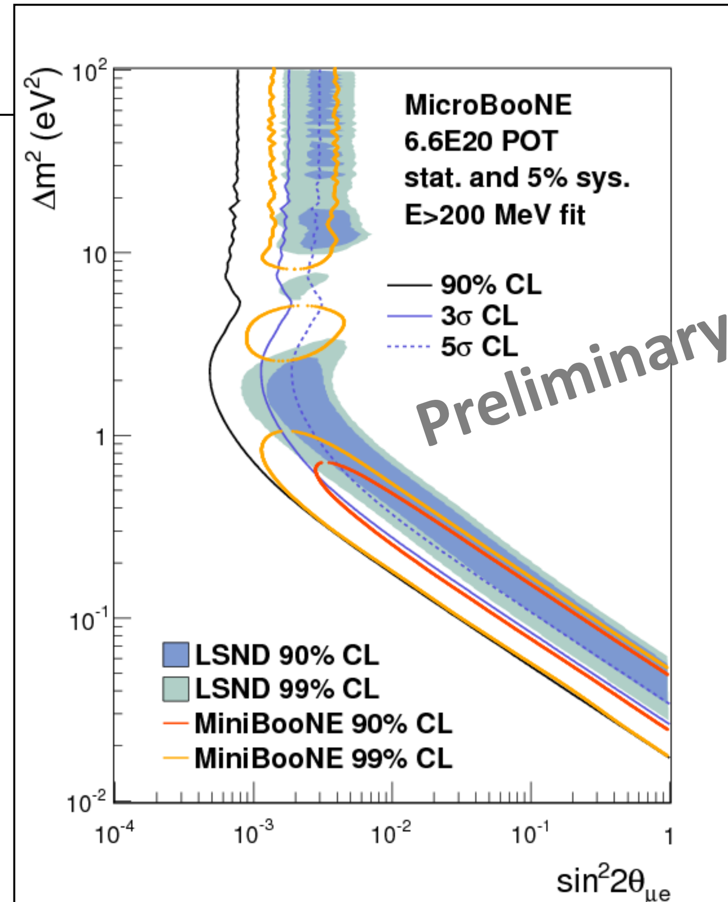
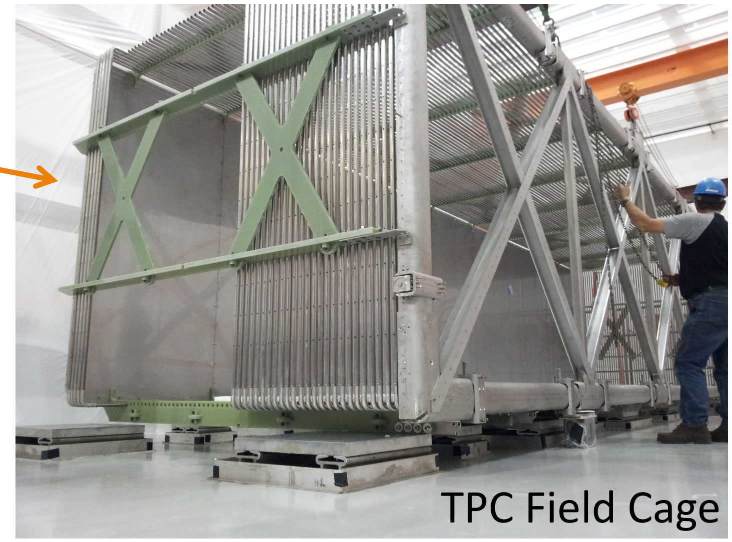


Sensitivity for two neutrino oscillations under the (3+1) sterile neutrino hypothesis

MicroBooNE: Current Status

- TPC field cage & wire planes constructed
- Electronics testing in progress
- Cryostat delivered to Fermilab (March 2013)


TPC Field Cage

- Will take data for 2-3 years (6.6 x 10^{20} POT), beginning in 2014

Thank You!