uBooNE Physics Analysis Meeting

-Low Energy Excess-

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Low E excess

We should start thinking about a possible low E analysis structure for MicroBooNE, and start developing necessary tools to get us there.

Today:

Analysis @ MiniBooNE
Thoughts on possible analysis routes @ MicroBooNE

Quantifying MicroBooNE physics potential – short-term

Low E excess

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MB lowE analysis = extension of MB ν_e appearance analysis

it uses ν_e CCQE reconstruction, selection cuts (see next slide), and machinery developed for oscillation search

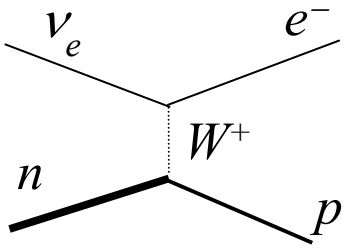
Start with **Flux Prediction x Cross-sections**

→ **Model interactions in detector & apply reconstruction**

→ **Apply PID cuts**

= Event rate prediction: R(E)

$$E = E_\nu^{QE} = \textit{reconstructed neutrino energy} = \frac{2M_n E_l + M_p^2 - M_n^2 - M_l^2}{2(M_n - E_l + \mathbf{p}_l \cdot \mathbf{u}_\nu)}$$



$$\nu_e + n \rightarrow e^- + p$$

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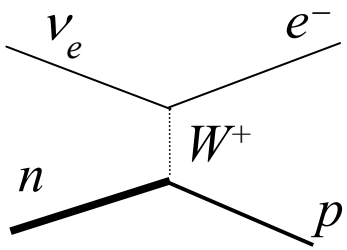

$\nu_e + n \rightarrow e^- + p$

ν_e CCQE selection cuts

Basic cuts:

- ***Exactly 1 subevent*** *(subevent = collection of hits within a ~100ns window)*
- $N_{veto} < 6$ *(removes cosmics)*
- $N_{tank} > 200$ *(tank activity, eliminates e's from muon decays)*
- $R_e < 500$ cm
- (endpoint R_μ) < 488 cm

(ensure entire event is contained sufficiently far from detector wall)

PID cuts:

- $\log(\mathcal{L}_e/\mathcal{L}_\mu) > a_0 + a_1 E_e + a_2 E_e^2$
- $\log(\mathcal{L}_e/\mathcal{L}_{\pi^0}) > b_0 + b_1 E_e + b_2 E_e^2$
- $M_{\gamma\gamma} < c_0 + c_1 E_e + c_2 E_e^2$.

E_e = reconstructed lepton energy under electron hypothesis

a^i, b^i, c^i determined for maximum oscillation sensitivity

How do they translate for MicroBooNE?

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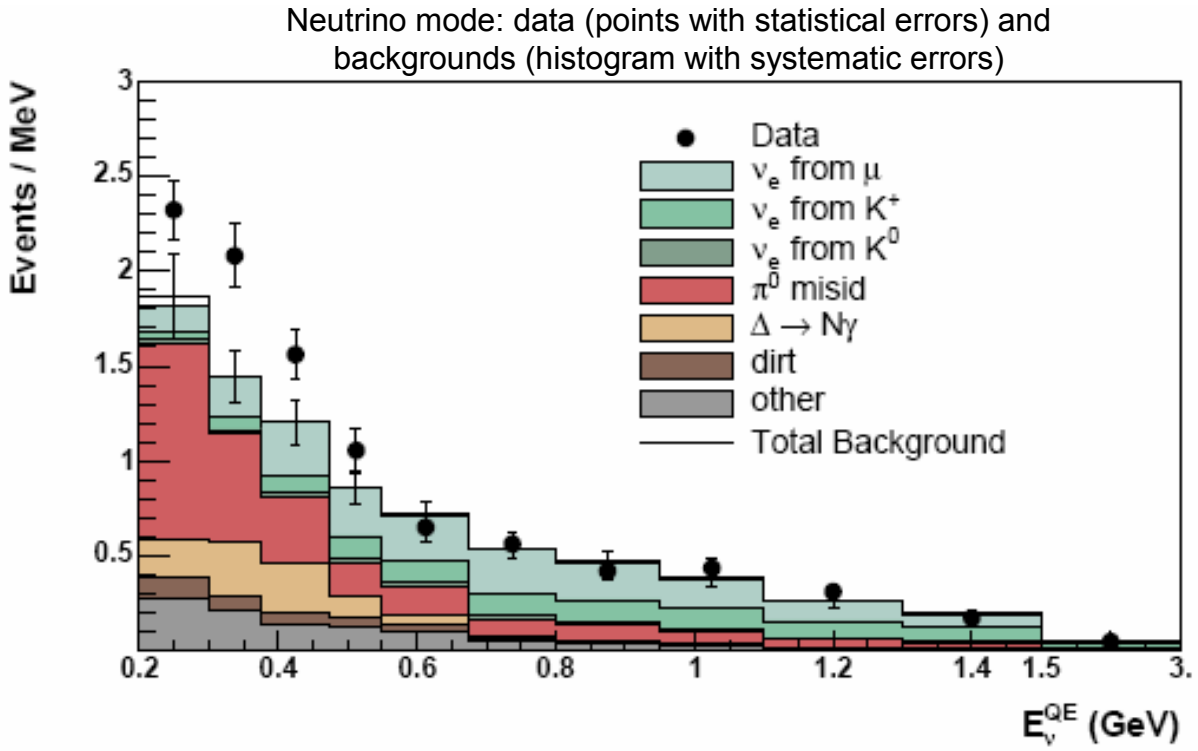
E_ν^{QE} distribution



Note: single-γ events contribute to ν_e CCQE background, especially at low energies

200-475MeV:

MC = 415.2 ± 43.4
Data = 544

Excess = Data – MC = 128.8 ± 43.4
significance = 128.8 / 43.4 = 3.0 σ

Low excess interpretation:
possible with either
$e^{+/-}$ (electron-like) or γ (γ-like)
in the final state

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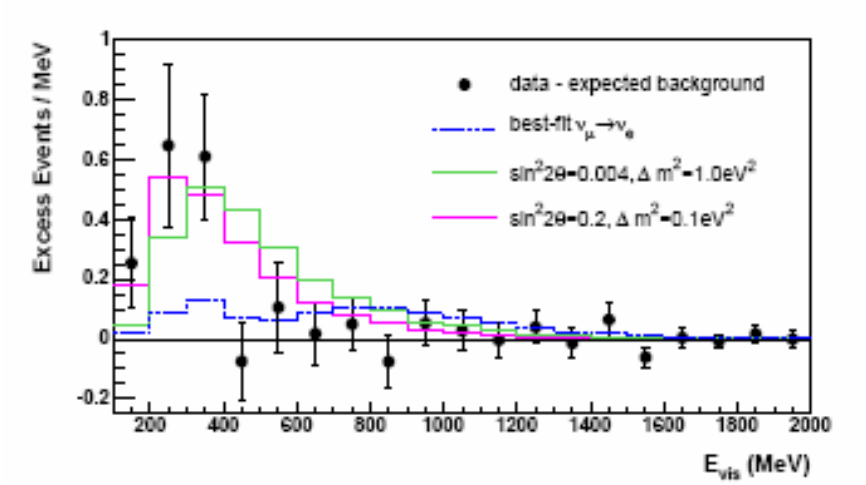
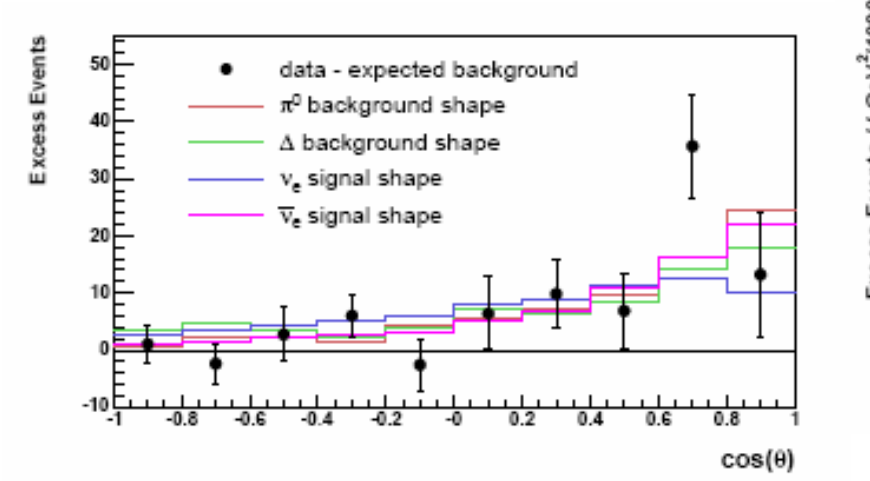
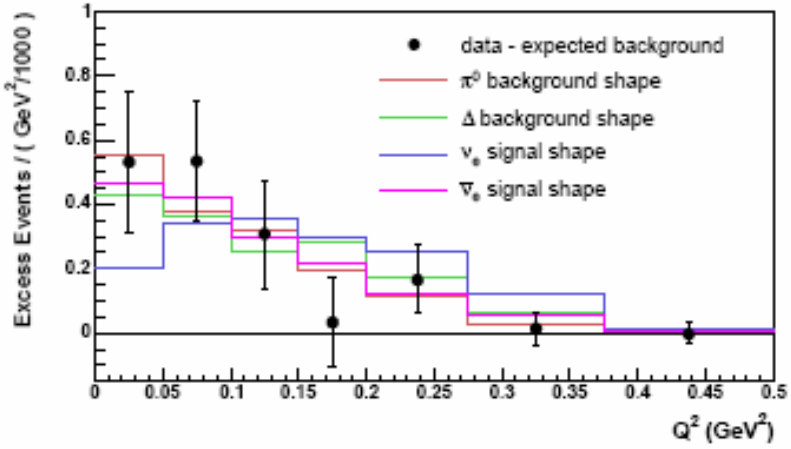
Note: similar information can be extracted as a function of Evis, Uz (=cosθ), etc…





arXiv:0812.2243v2 [hep-ex]



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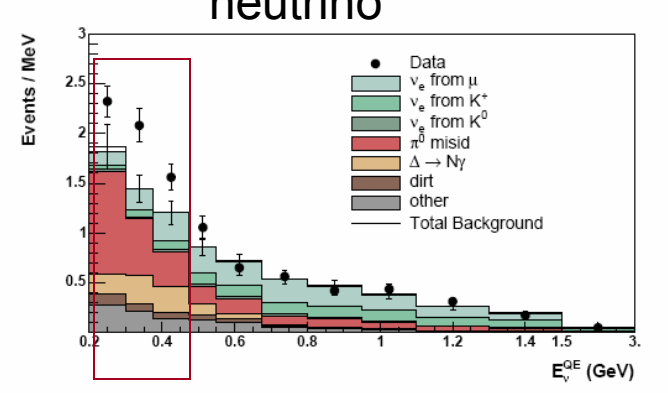
Same analysis for antineutrinos → no excess found

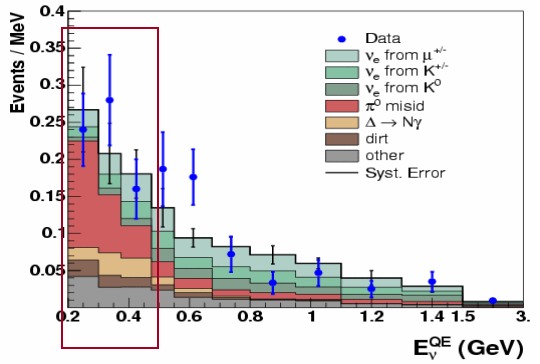
& then **comparison between neutrino and antineutrino results** for quantifying how well **particular physics/background hypothesis** for the low E excess matches the data in both energy distributions (neutrino, and antineutrino)

neutrino



200-475

antineutrino



200-475

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Necessary inputs:

- **Flux, Cross section**
- **Event modeling in detector, reconstruction, and development of selection/PID cuts (eg., e/gamma separation); quantifying detector efficiency**
- **Determination of systematics (see next slide for a list of MB systematics)**

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MB Systematics

Source	ν mode uncer. (%)	
E_ν^{QE} range (MeV)	*200-475*	*475-1100*
Flux from π^+/μ^+ decay	1.8	2.2
Flux from π^-/μ^- decay	0.1	0.2
Flux from K^+ decay	1.4	5.7
Flux from K^- decay	-	-
Flux from K^0 decay	0.5	1.5
Target and beam models	1.3	2.5
ν cross section	5.9	11.9
NC π^0 yield	1.4	1.9
Hadronic interactions	0.8	0.3
External interactions (dirt)	0.8	0.4
Optical model	8.9	2.3
Electronics & DAQ model	5.0	1.7
Total (unconstrained)	*12.3*	*14.2*

Similar

Similar

Very small in uB

?? (need to quantify corresponding uncertainties in uB)

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Necessary inputs:

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Possible uB analysis scheme:

1. Low E hypotheses: all of them either e-like or γ-like

Presumably we will have **two samples to work with: electron-like, and gamma-like**

A uB low energy analysis could make (simultaneous) use of both samples.

→ We need to know how well we can separate γ's(e^+e^-) from e^-'s at energies ~200-475MeV (ArgoNeut will address this)

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Assuming an electron-like sample and a gamma-like uB sample,

we can play a similar game as MB did (comparison of v and $\overline{\nu}$ distributions), comparing how the two samples scale for different low E hypotheses

e.g., start with an underlying scenario as the source of some excess, A and B, in electron-like and gamma-like sample, respectively

[A-B relation determined by the physics in each hypothesis]

Fit Data vs Bkgd+(A or B) for each samples

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Possible uB analysis scheme:

2. A joint analysis can also be done using MB data

E.g., assuming an excess is found by uB, how does it compare to MB excess?

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What can be done quickly (in a month)?

1. Excess expectations @ uB for various low E excess hypotheses

Recall, MB maximum χ^2 probabilities for each hypothesis:

	Stat Only	Correlated Syst	Uncorrelated Syst
Same $\nu,\bar{\nu}$ NC	0.1%	0.1%	6.7%
NC π^0 scaled	3.6%	6.4%	21.5%
POT scaled	0.0%	0.0%	1.8%
Bkgd scaled	2.7%	4.7%	19.2%
CC scaled	2.9%	5.2%	19.9%
Low-E Kaons	0.1%	0.1%	5.9%
ν scaled	38.4%	51.4%	58.0%

Preliminary

Each of these probabilities is associated with an excess prediction for MB neutrino mode → can extrapolate this prediction to a uB prediction and obtain significance

Low E excess

@ MicroBooNE – short term

What can be done quickly (in a month)?

2. A preliminary uB oscillation sensitivity

- Scale event rates from MiniBooNE
- Assume no pi0, delta background
- Assume same flux systematics (no dirt, pi0 systematics)
- Assume no pi0, dirt, hadronic uncertainties