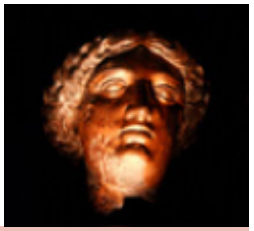

Impact for Cross Section Experiments, MINERνA

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Exciting Times

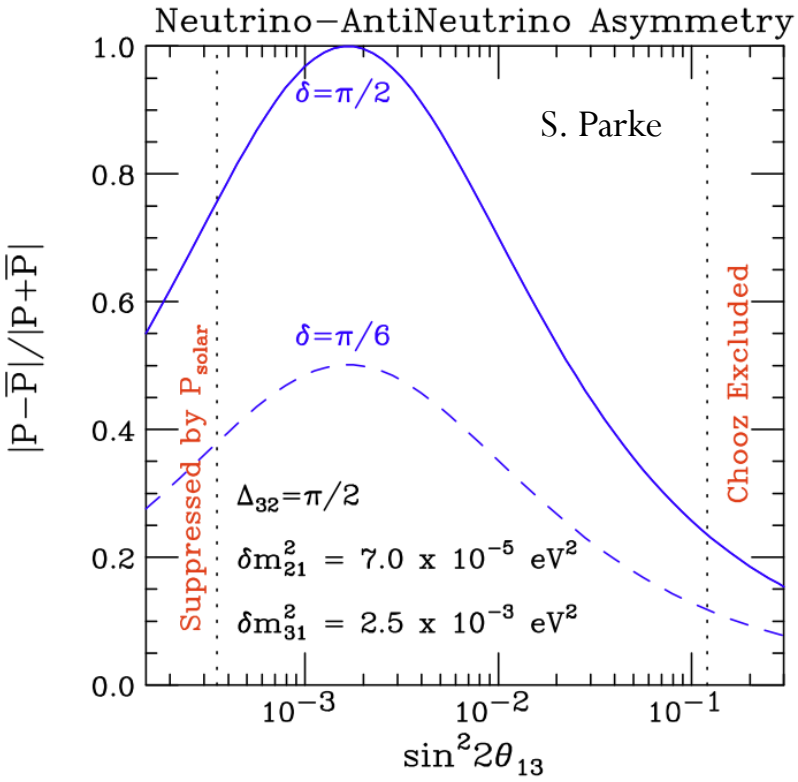
- It's thrilling how six events can shift one's focus and create much excitement!
- Obviously, a long way still to go with measuring θ_{13}, but the hint that it is large brings daydreams of measuring CP violation through oscillations
- What effect might this have on MINERνA's focus as we work to collect and analyze our data?

Appearance Systematics

- **Hint of a larger θ_{13} is GREAT news!**
  - Statistics are so important in the long-baseline neutrino game
- **But clearly, in the most basic sense, ↓ statistical errors means ↑ emphasis on systematics**
  - Understanding backgrounds has always been a high priority
    - In particular, neutral-current reactions that feed down from higher energies
    - Far detector flux very different from near detector due to acceptance/oscillations
  - With larger signal, signal reactions become important too
    - Energy reconstruction in CC events
    - Oscillations are all about measuring energy dependence, need to understand precisely relationship between visible energy in detectors and incoming neutrino energy
    - Neutrino experiments use heavier nuclei in detectors (C,O,Ar,Fe) to increase event rates, but nuclear effects in neutrino interactions are significant and not well known. Affects backgrounds and, again, $E_\nu(E_{vis})$

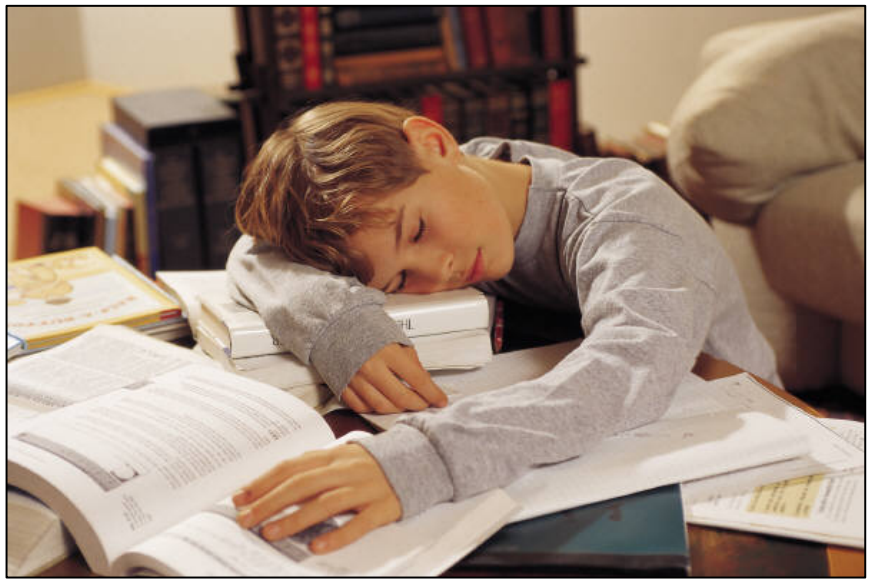
CP Systematics

- **In a more detailed sense, larger θ_{13} means smaller ν / anti-ν asymmetries for the same value of δ_{CP}**
  - Challenging to measure CP violation, measure order 1% differences in oscillation probabilities
  - Need a detailed understanding of ν / anti-ν differences
    - event rates
      - different fluxes
      - different cross sections
      - different background levels
    - energy reconstruction
      - different nuclear effects
      - $E_\nu \rightarrow E_{vis} \neq E_{\bar{\nu}} \rightarrow E_{vis}$



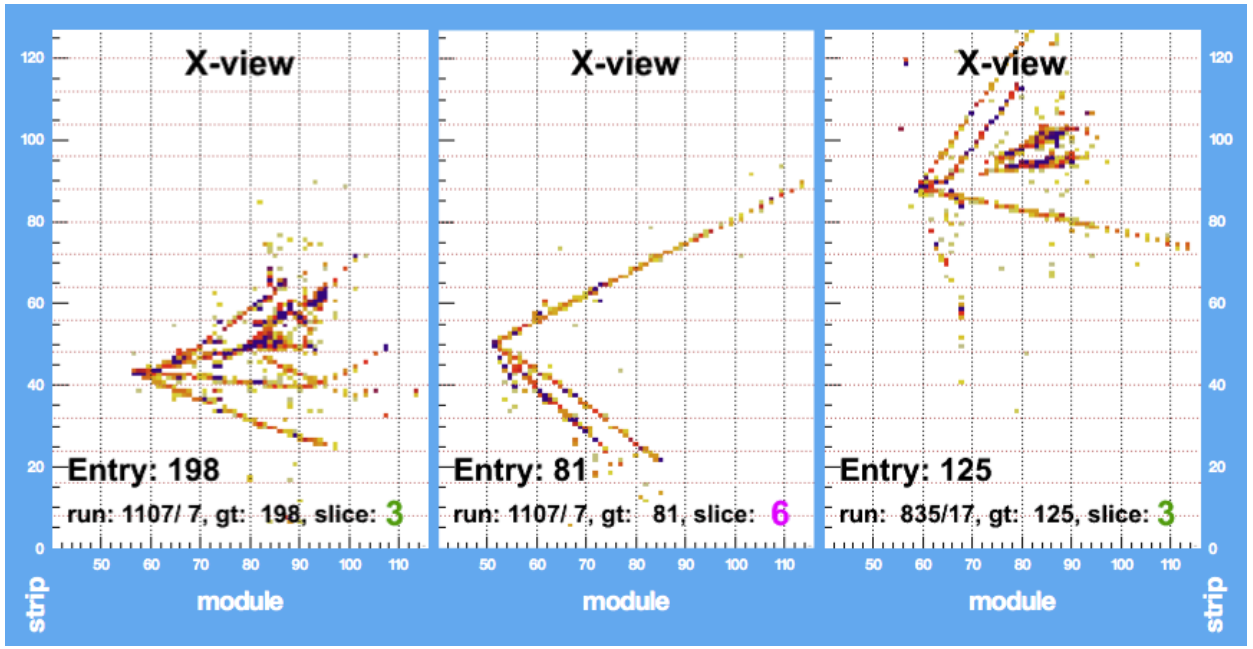
Gotta Do Your Homework

- **Larger θ_{13} is great for discovery and precision measurement reach of current and next generation long-baseline experiments**
  - We'll need to do everything we can to constrain systematics
- **A nice problem to have, but we have homework to do**



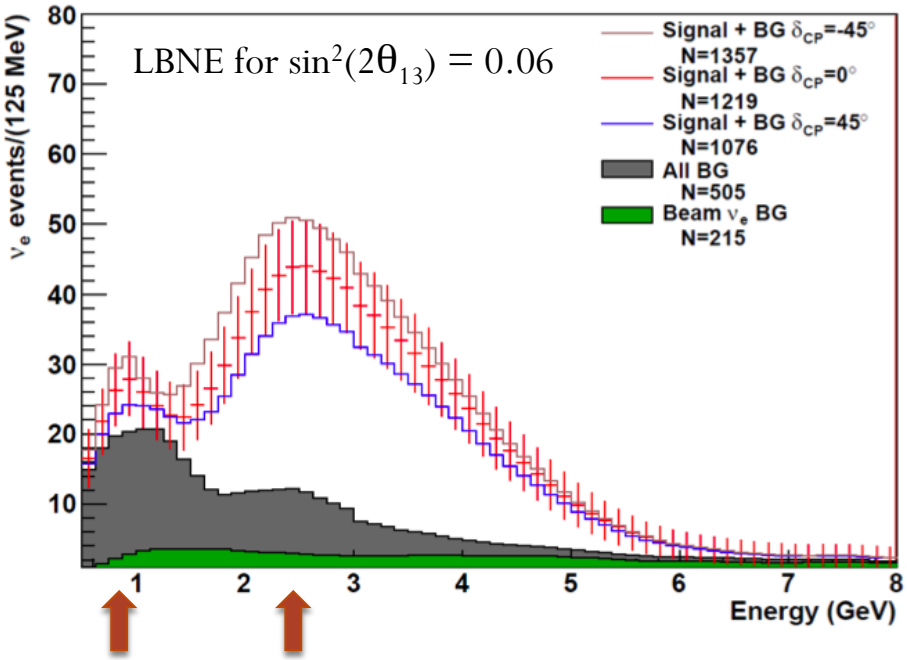
MINERvA Basics

- Finely-segmented, fully-active scintillator detector core surrounded by electromagnetic and hadronic calorimetry
  - Ability to fully reconstruct *exclusive final states*
  - Also do the physics of high-energy, high-multiplicity *inclusive event samples*
- Range of nuclear targets (He,C,H_2O,Fe,Pb) in single detector (and flux) for measuring A dependence, untangling nuclear effects in neutrino interactions



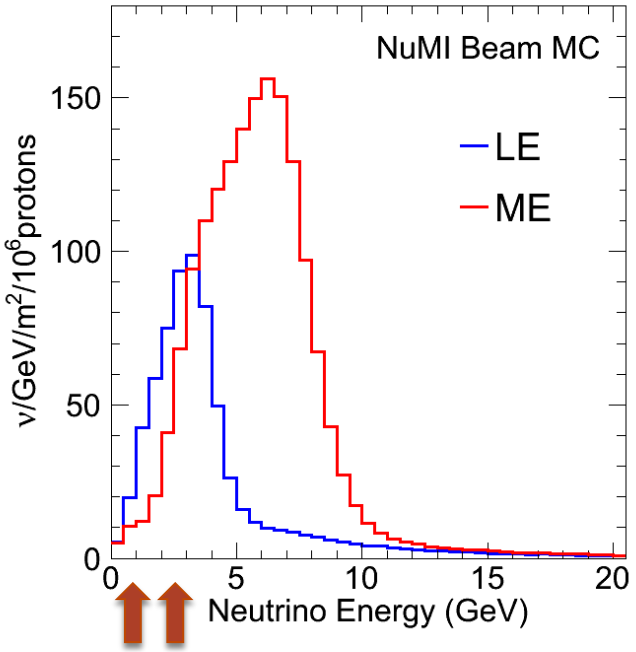
Energy Range

- **MINERνA will collect data in two different fluxes**
  - Rich nuclear physics program using the medium energy (ME) flux
  - But the key to making contributions to LB oscillation experiments is the low energy (LE) data, where we are pushing hard now to collect the needed statistics



2nd osc max

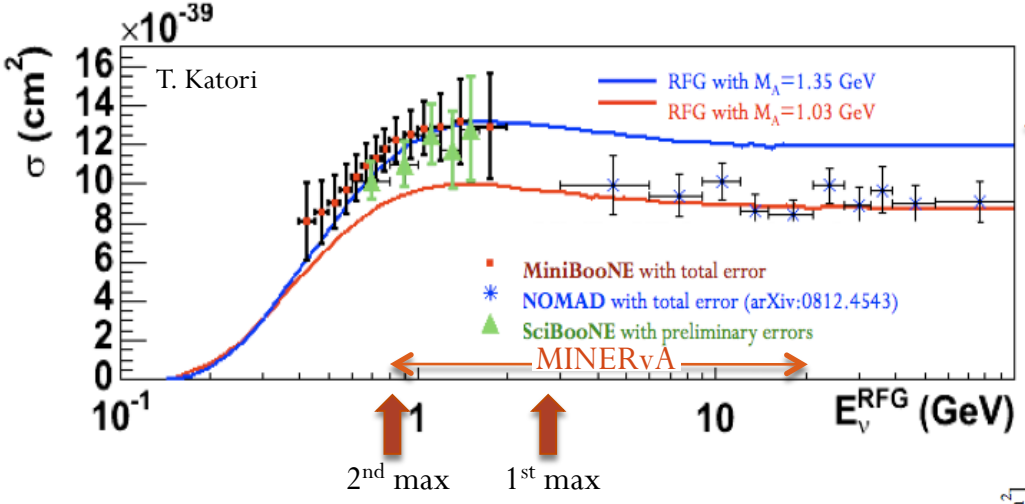
1st osc max



In ME, low energy flux is reduced and high energy flux creates increased backgrounds

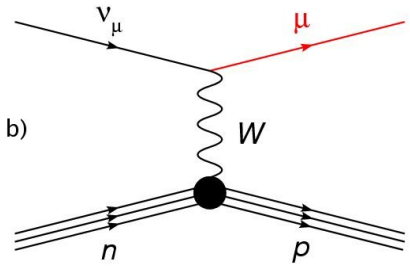
Example: QE Scattering

- **How much of CC cross section is quasi-elastic like?**

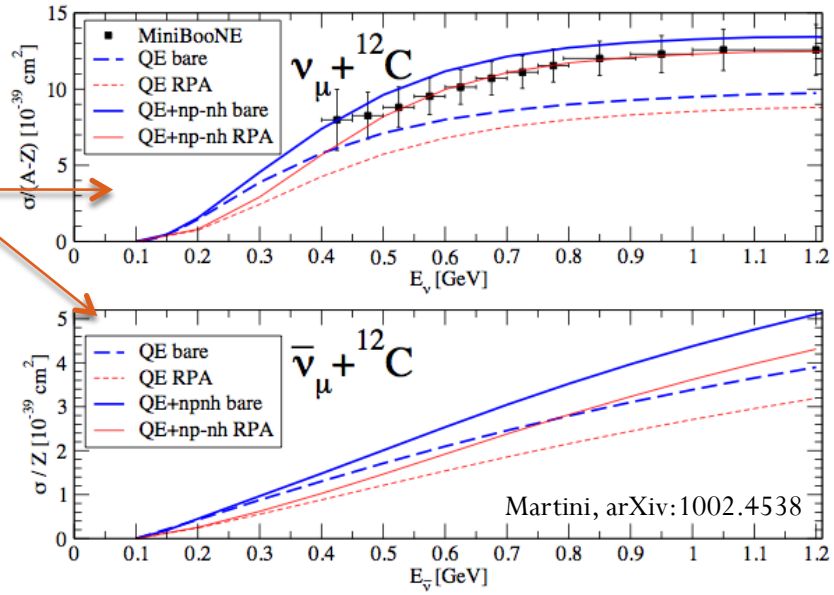


Tension in different data sets not understood (~30% difference)

Much recent theoretical effort to explain Mini/SciBooNE data



Often explanations have different effects on neutrino/antineutrino cross sections



This is the exclusive channel for which we have the most data and understand the best

Summary

- **MINERνA (with many collaborators involved in present/future oscillation experiments):**
  - Shares the excitement for this first hint of θ_{13}
  - Also recognizes that in many ways larger θ_{13} increases the need for precise measurements of cross sections and improved models of nuclear effects in neutrino scattering to help maximize the reach of experiments like NOνA and LBNE
- **Reinforces the motivation for precise measurements of low-energy, exclusive neutrino interactions on multiple nuclear targets**