NC π^0 Production in the MiniBooNE Antineutrino Data

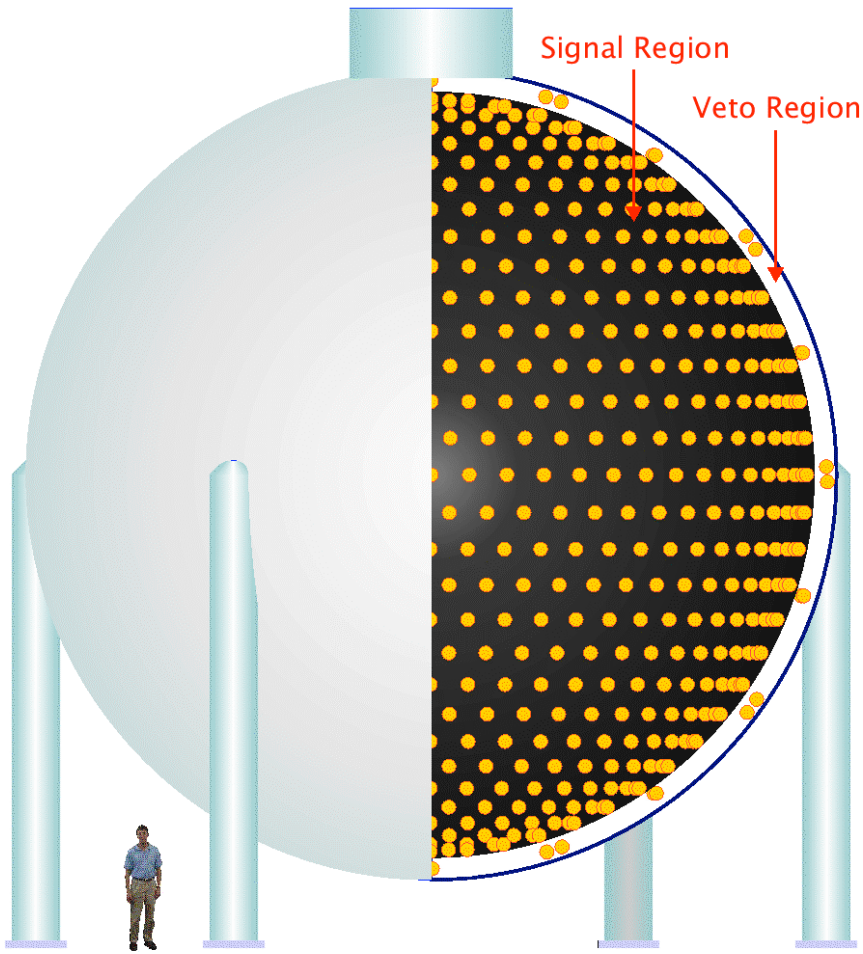
Van Nguyen
Columbia University
for the MiniBooNE collaboration

NuFact07
August 8th, 2007

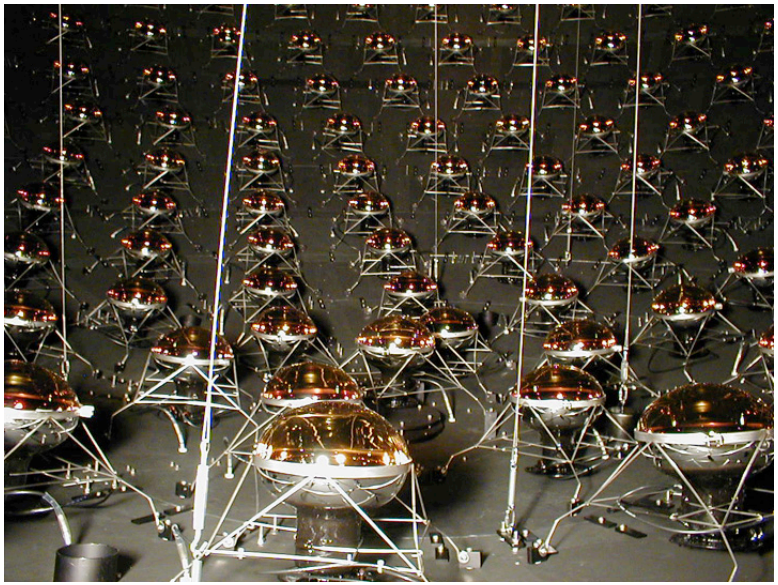
Outline

- MiniBooNE detector
- NC π^0 production
- Objective and method of current analysis
- MC/Data comparisons
- Summary

The MiniBooNE Detector

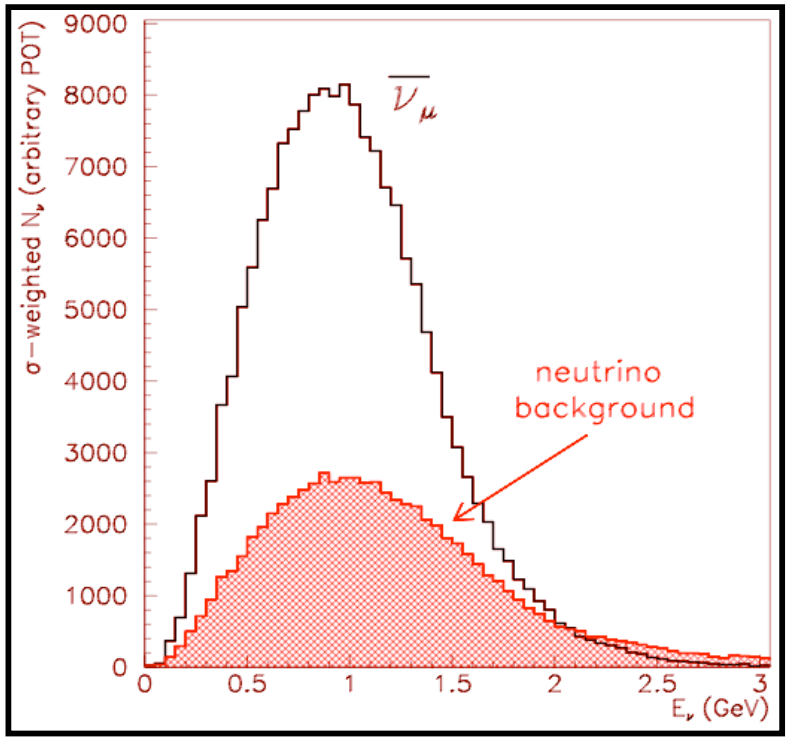


- 12-meter diameter spherical ta
- 1280 PMT in inner region
- 240 PMT in outer veto region
- 800 tons pure mineral oil



MiniBooNE Antineutrino Running

- Started antineutrino running in January 2006
- Has the world's largest sample of reconstructed π^0's produced by antineutrinos (over 1500 events)!
- Need to contend with neutrino aka "wrong-sign" (WS) background

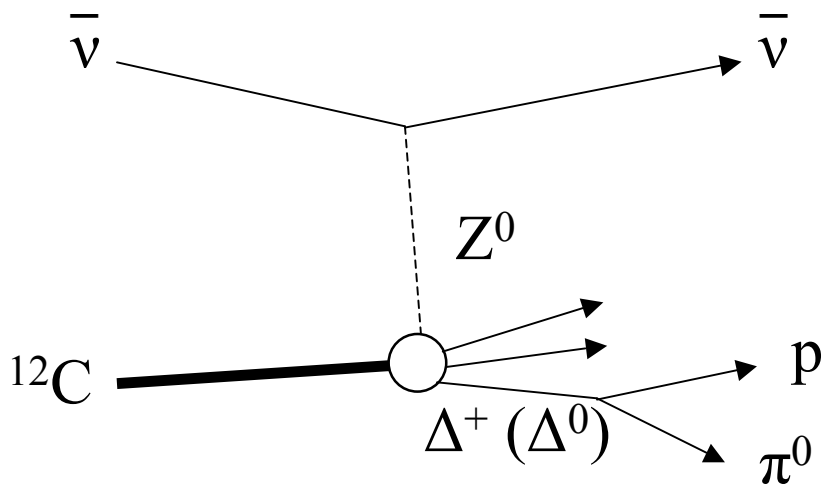


- In **antineutrino mode**, neutrinos are ~30% of the total events (as opposed to neutrino mode where antineutrinos are ~2% of the total events)

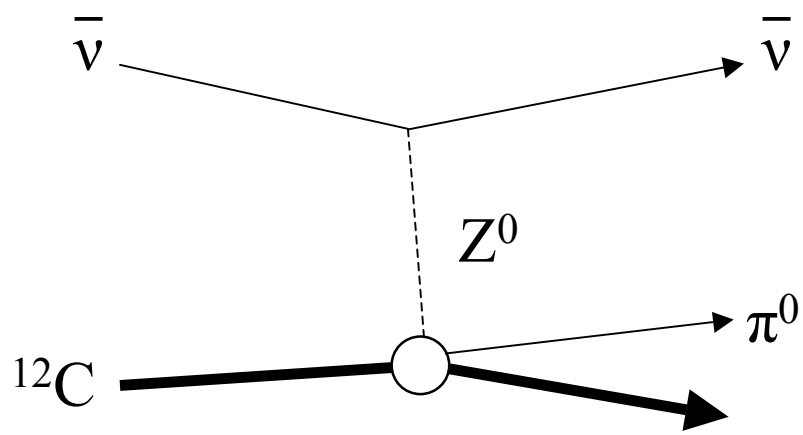
NC π^0 Production

NC π^0's can be created through resonant and coherent production:

- Resonant NC π^0 production:

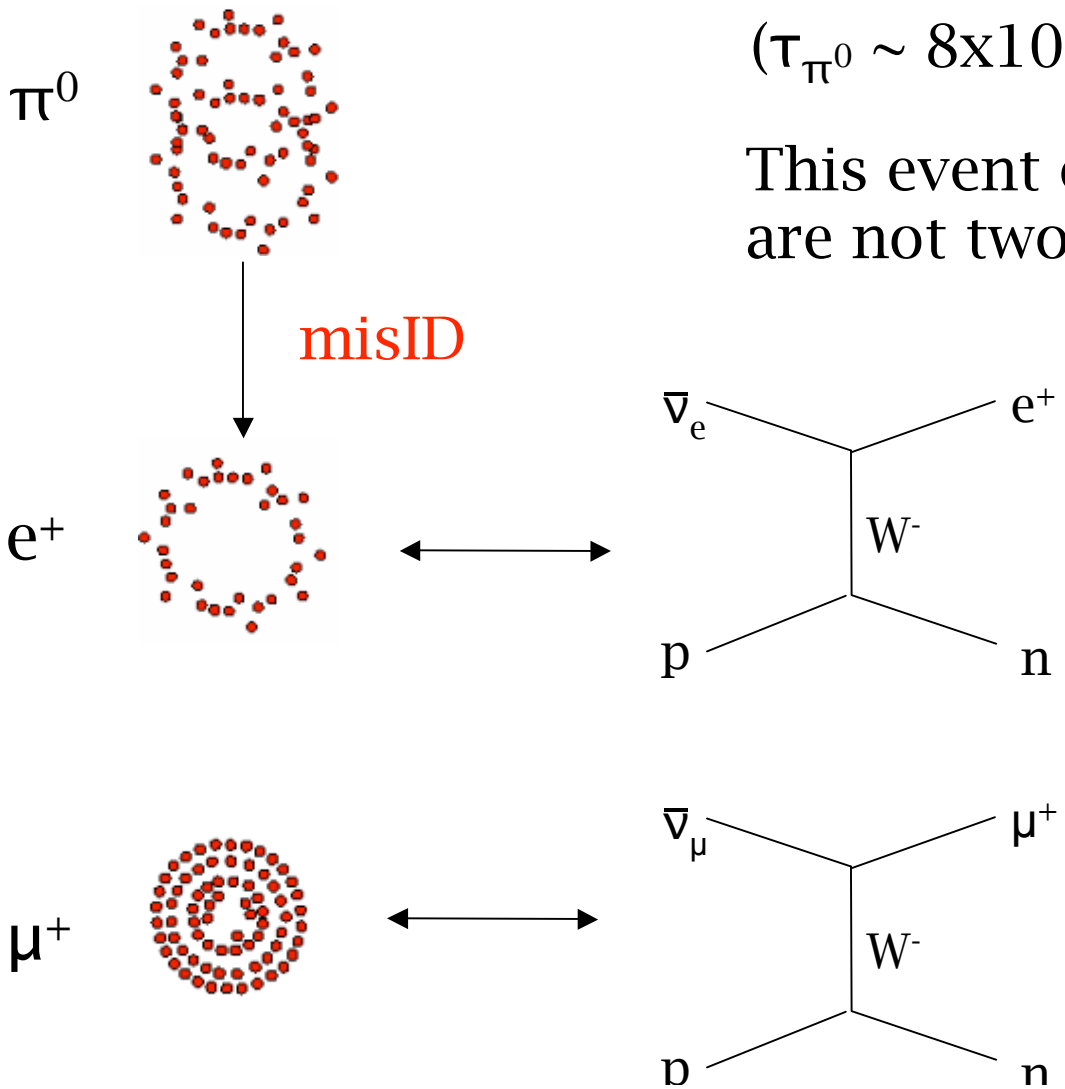


- **Coherent NC π^0** production: (Signature: π^0 which is highly forward-going)



NC π^0 Production cont'd

MiniBooNE event signatures



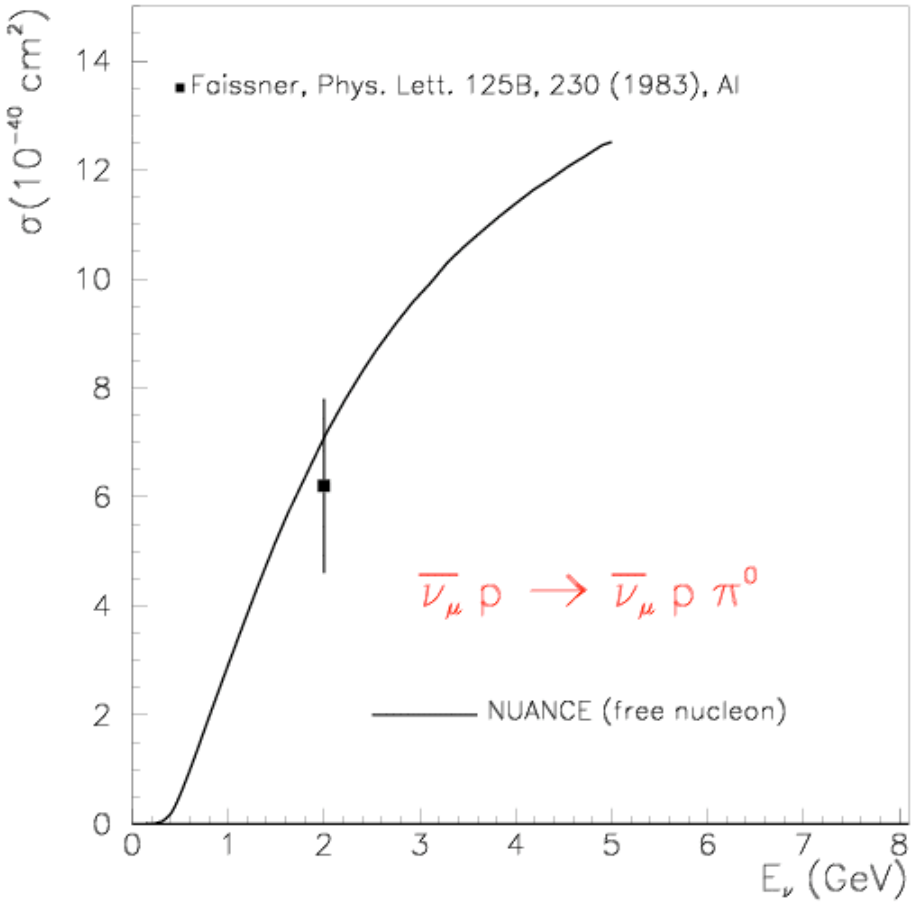
A π^0 decays promptly into two photo

($\tau_{\pi^0} \sim 8\text{x}10^{-17}$ s).

This event can be misidentified if the are not two resolvable tracks.

Understanding of thes events is crucial!

Present Antineutrino NC π^0 Data



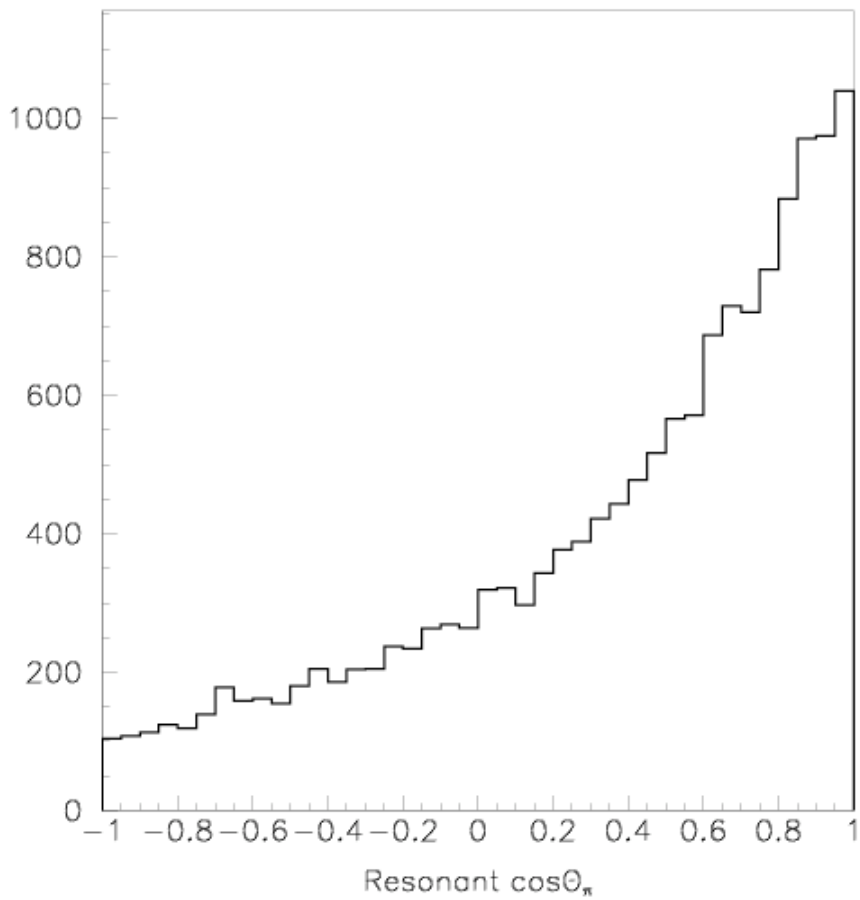
- Only one published measurem of the absolute rate of antineutrino NC π^0 productio this measurement was reporte with 25% uncertainty at 2 GeV
- Current theoretical models on coherent π^0 cross sections ca vary by up to an order of magnitude in their predictions low energy, the region most relevant for $\overset{(-)}{\nu}$ oscillation experiments.

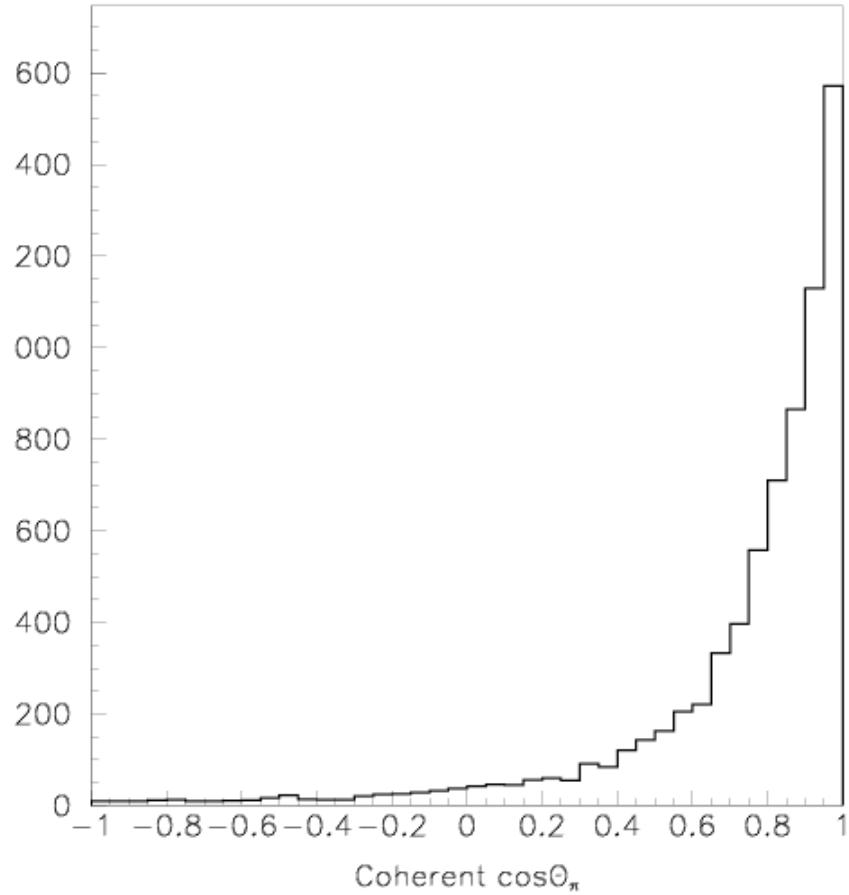
Objective

- To measure the rate of π^0 production and use it to constrain this background in an oscillation search.
  - Specifically, we aim for a measurement of the total π^0 production in bins of true π^0 momentum.

Cosθ and Coherent π^0 Production

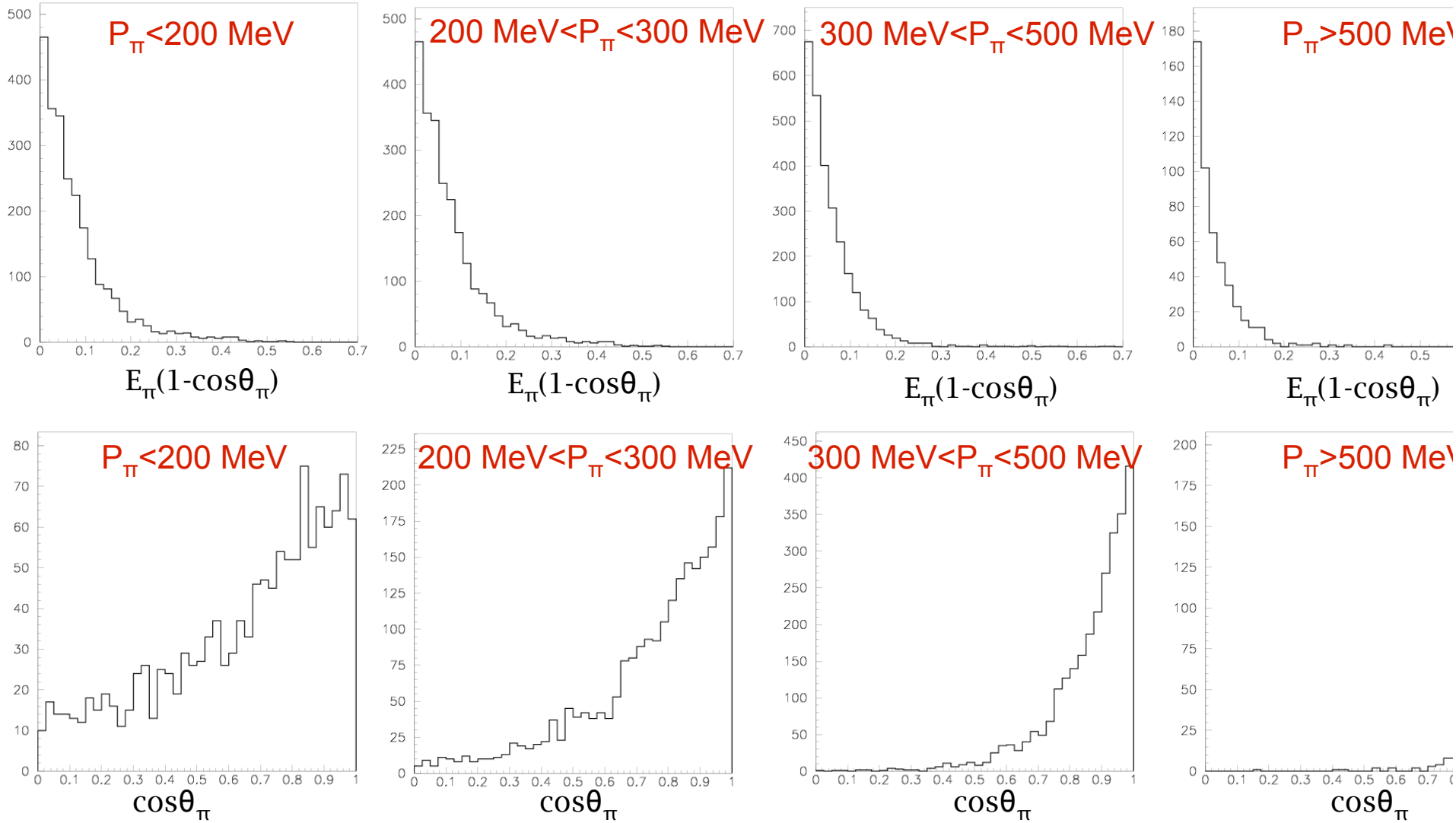
Coherent and resonant production are distinguishable by $\cos\theta_\pi$, which is the cosine of the lab angle of the outgoing π wrt to the beam direction.





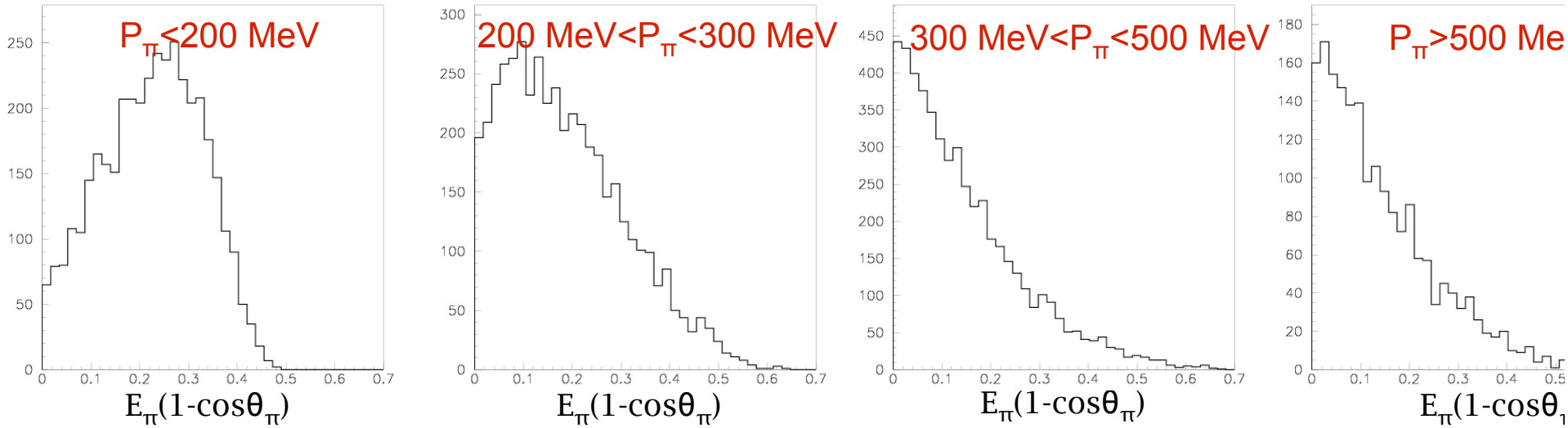
We can use this fact to extract a measure of the coherent fraction.

Study Coherent π^0's in Terms of $E_\pi(1-\cos$



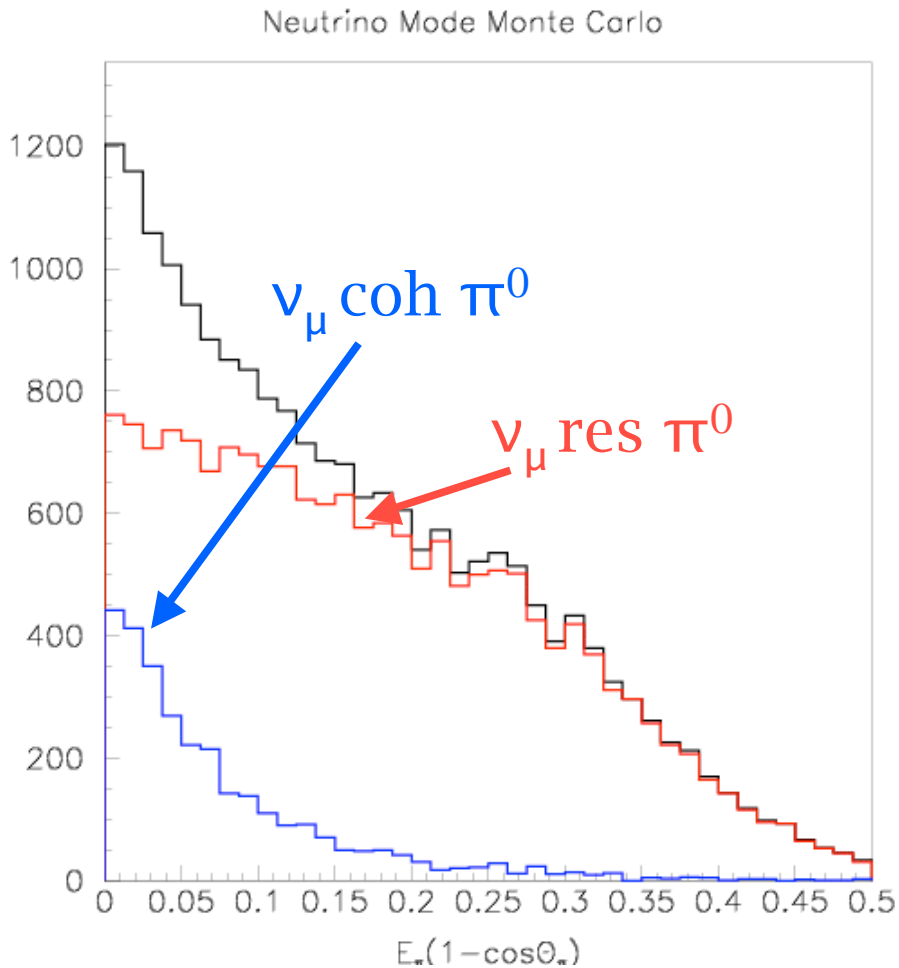
In coherent events, $E_\pi(1-\cos\theta_\pi)$ has a more regular shape, as a function of momentum, than $\cos\theta_\pi$ alone, so we'll fit for the coherent content as a function of this energy weighted angular

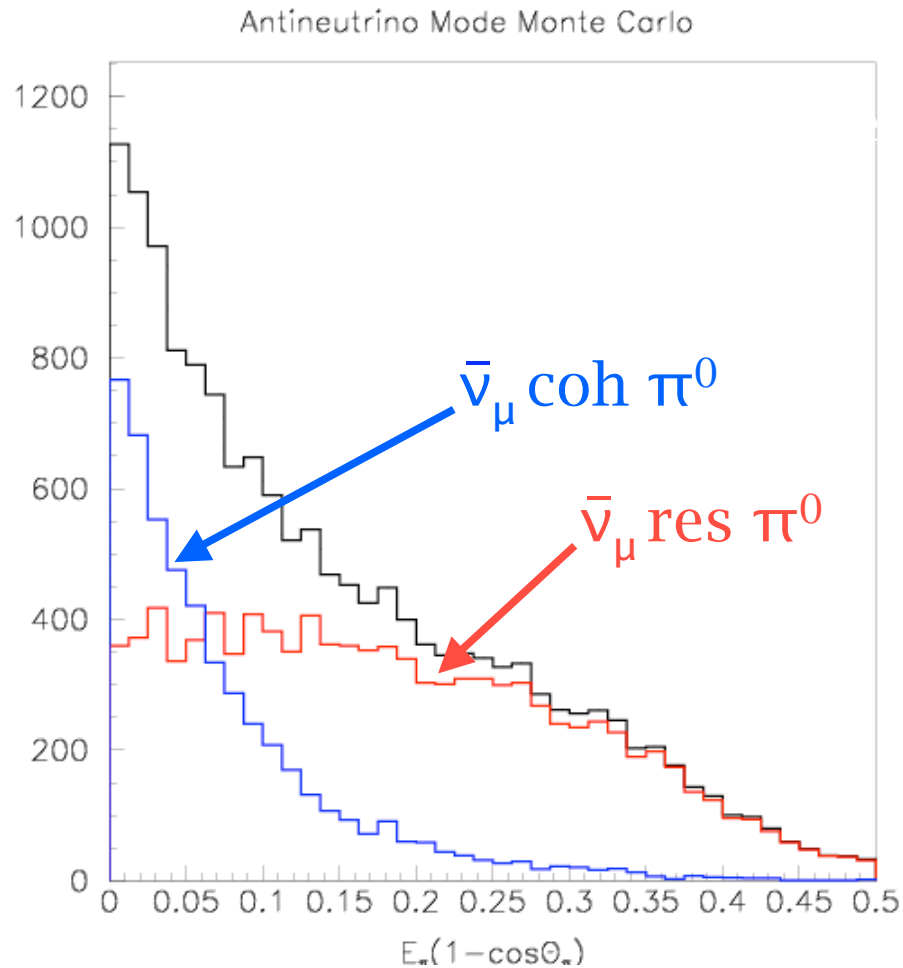
Study Coherent π^0's in terms of $E_\pi(1-\cos$



Meanwhile $E_\pi(1-\cos\theta_\pi)$ can have a large variation in the resonant process in this energy range.

Coherent NC π^0's in ν vs. $\bar{\nu}$ Running





- 20% is coherent production

- 40% is coherent production
- "enhanced" coherent sample

Generated π^0 angular distribution for NC ν (left) and $\bar{\nu}$ (right) scattering.

Event Selection

Pre-cuts:

Only one sub-event (no decaying μ, NC)

Veto hits < 6 (eliminates cosmic rays)

Tank hits > 200 (above Michel endpoint)

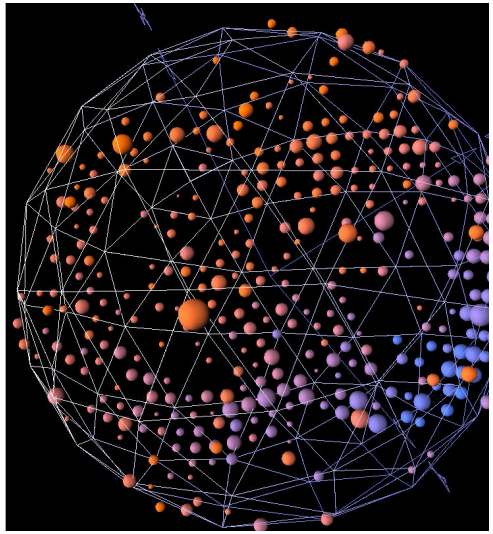
Event radius < 500 cm (fiducial cut)

NC π^0 analysis cuts:

eμ likelihood prefers e hypothesis (EM-like)

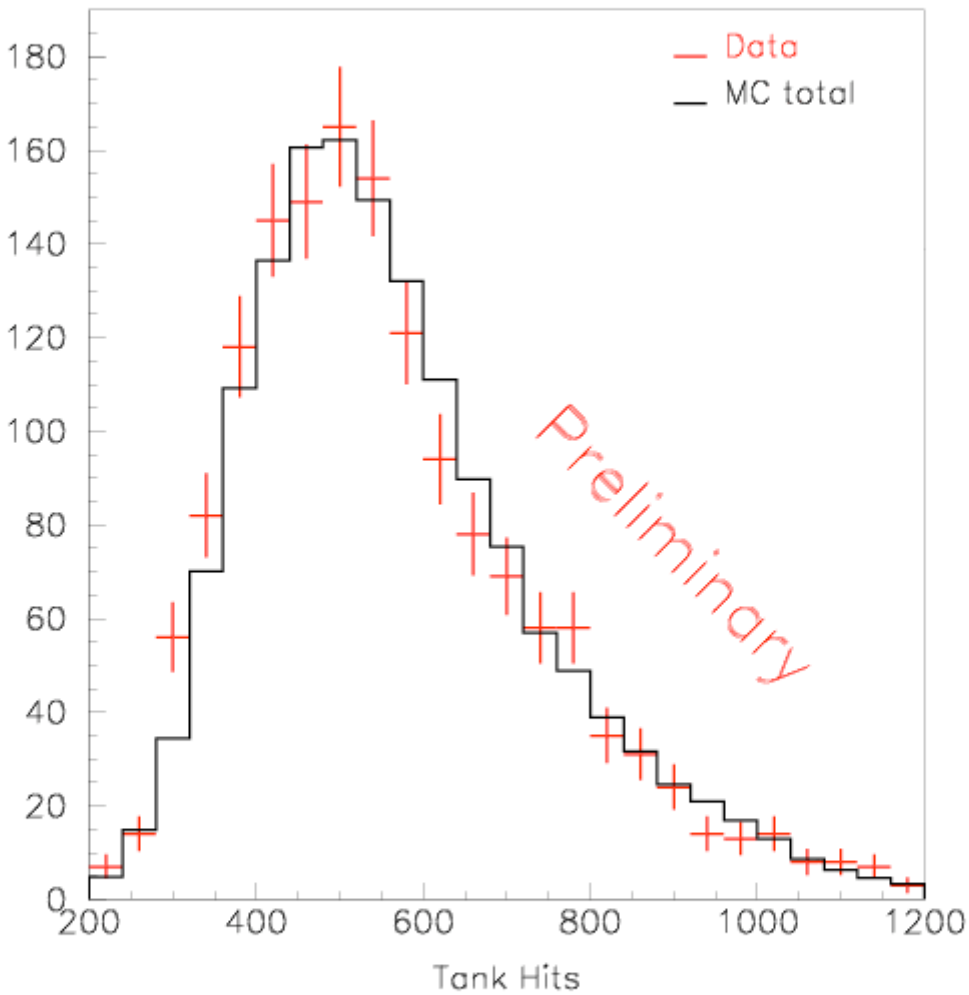
eπ likelihood prefers π^0 hypothesis (2ring)

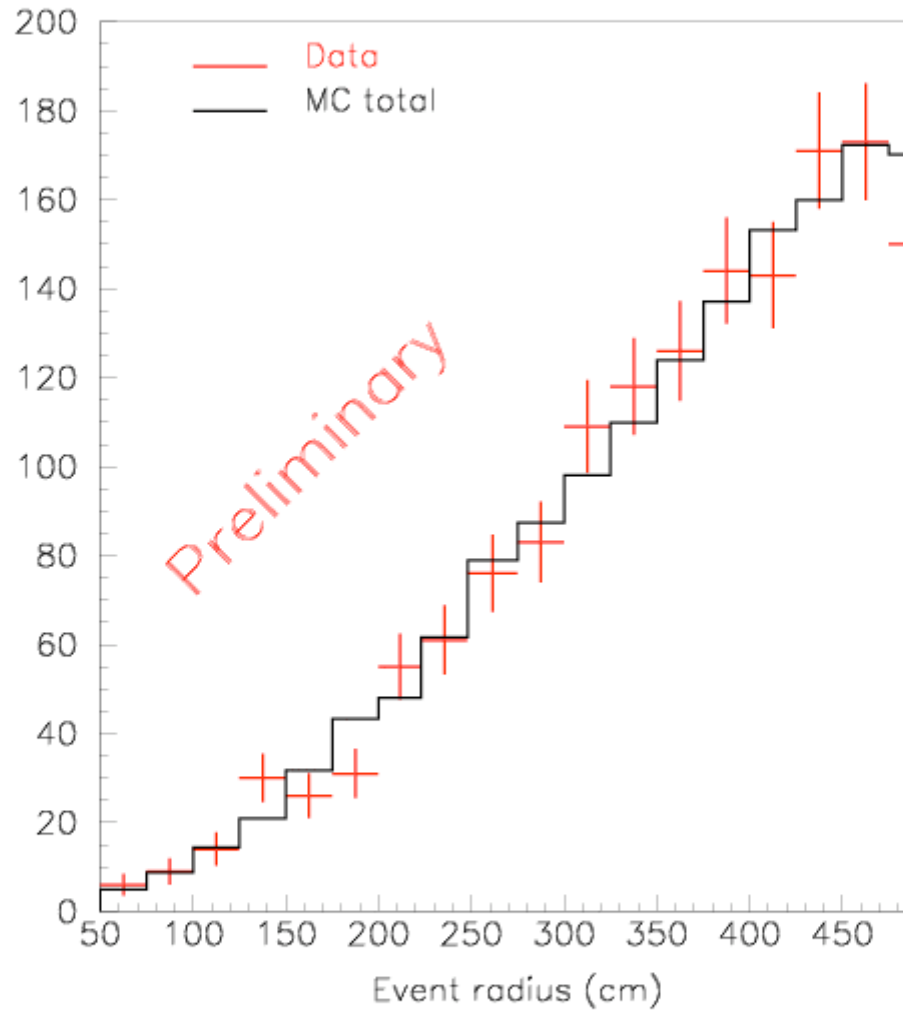
80 MeV/c^2<$m_{\gamma\gamma}$<200 MeV/c^2 (mass window)



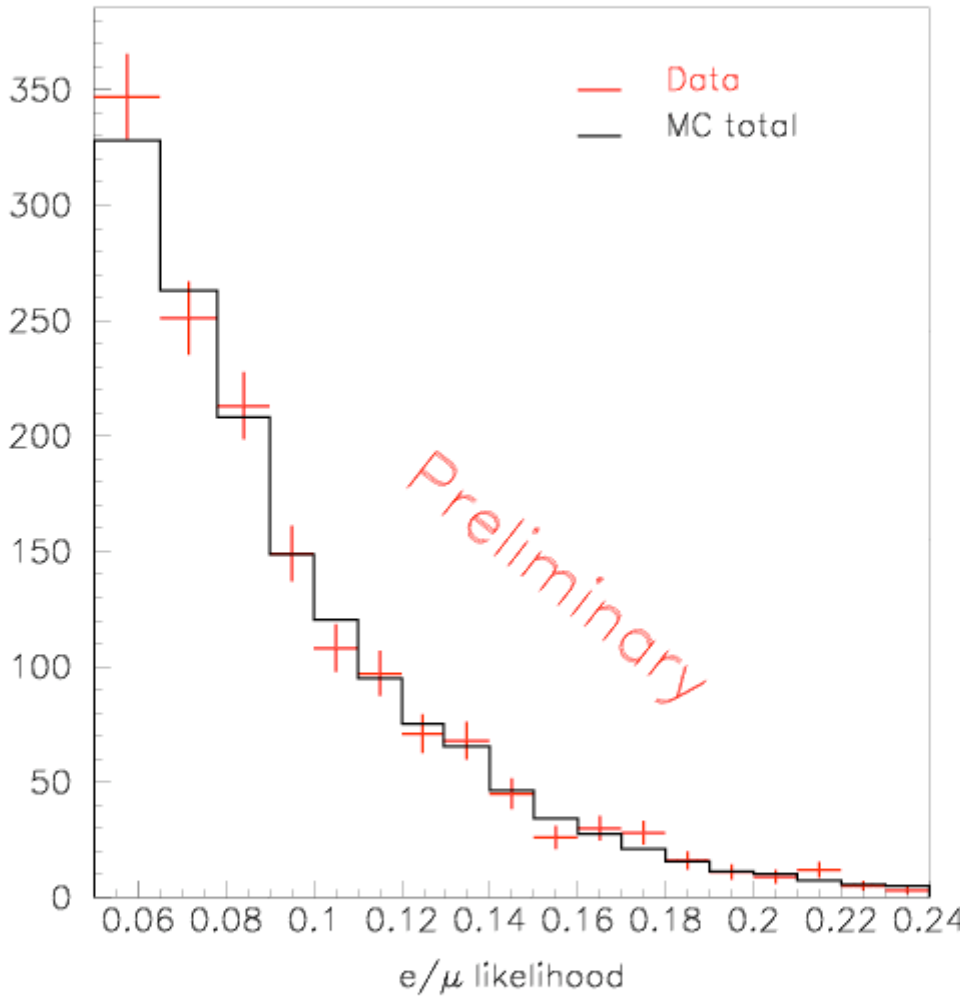
MiniBooNE π^0 candid

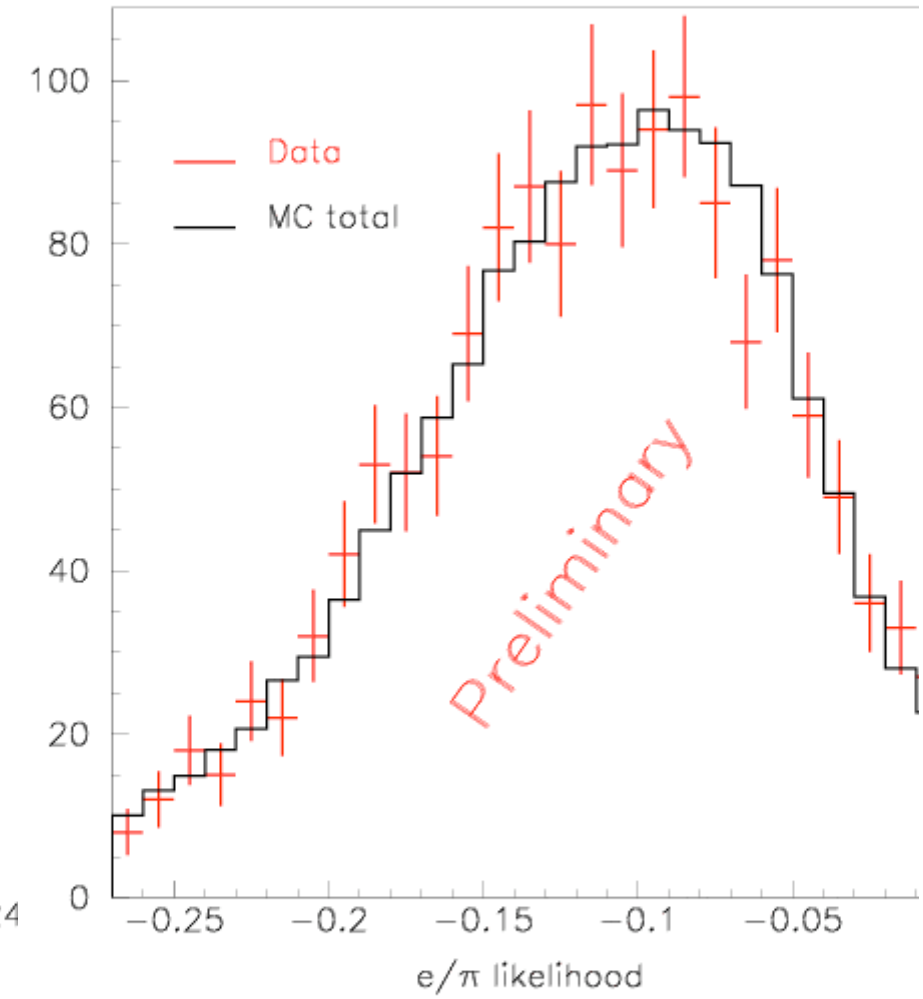
Data/MC Comparison for Variables We Cut On





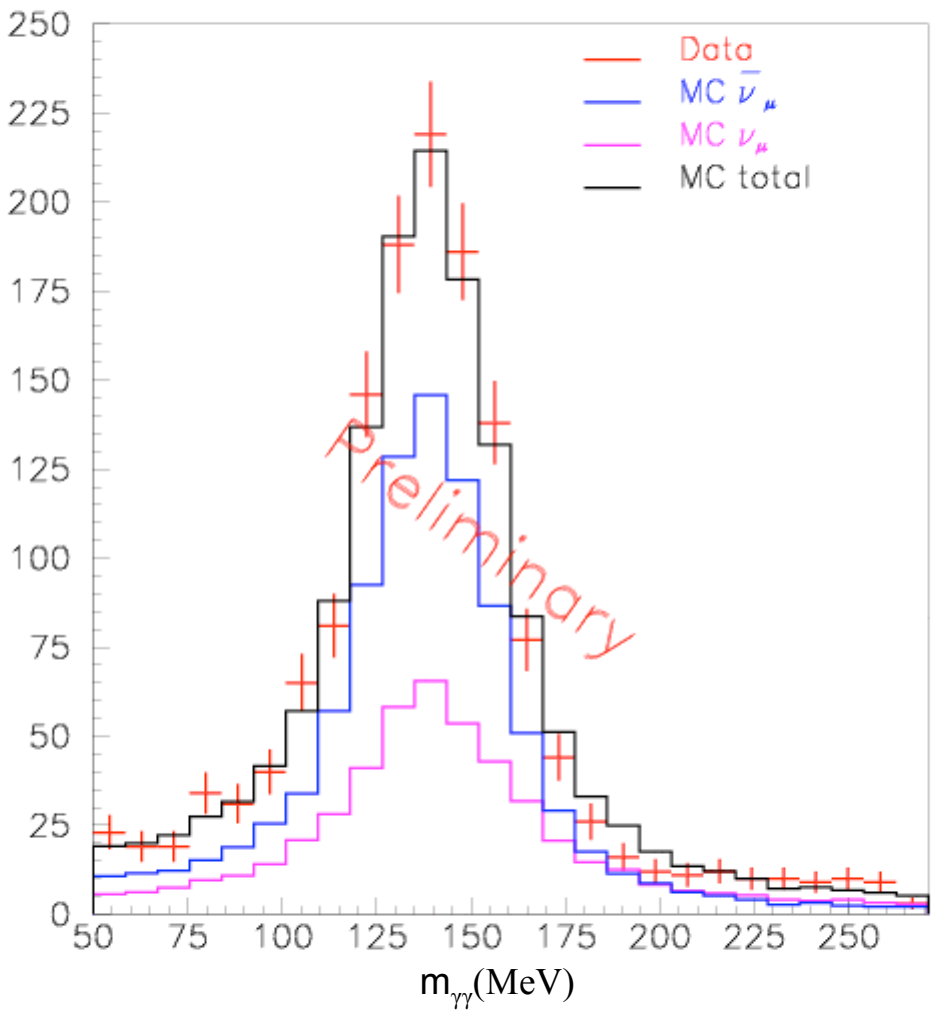
Note: Plots are relatively normalized with statistical errors



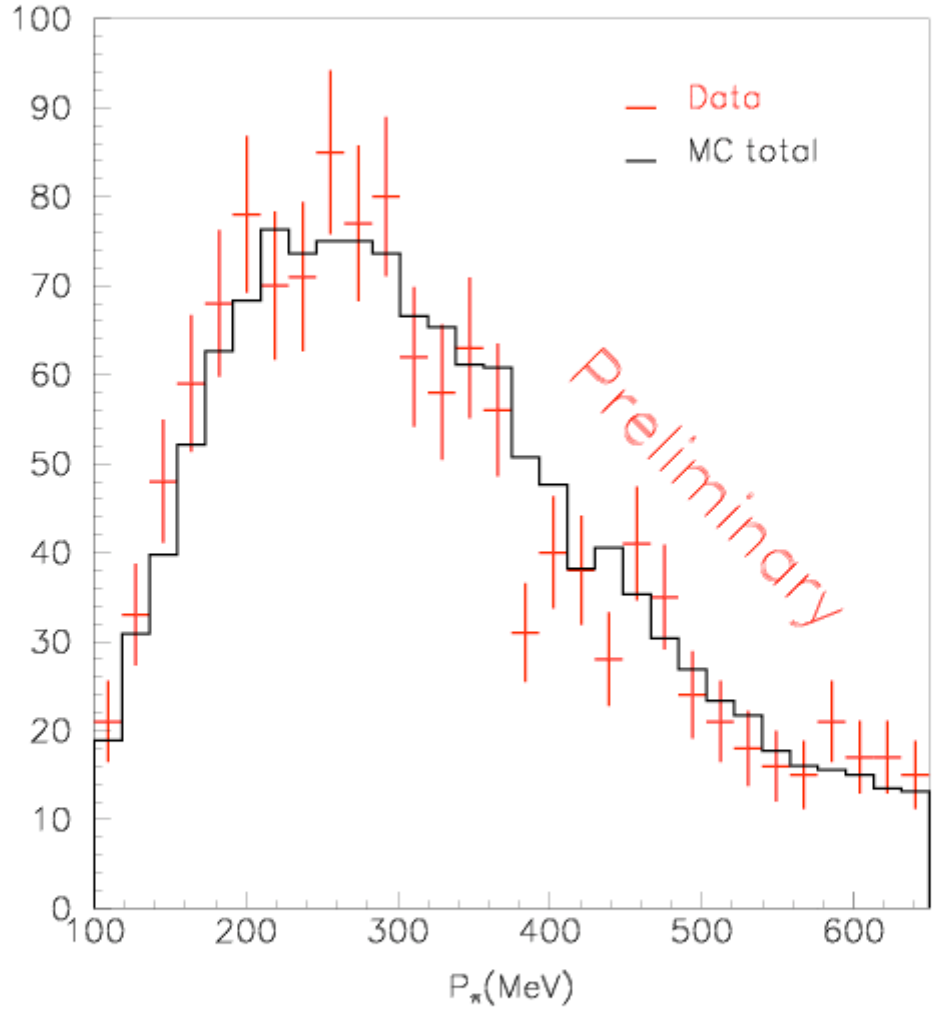


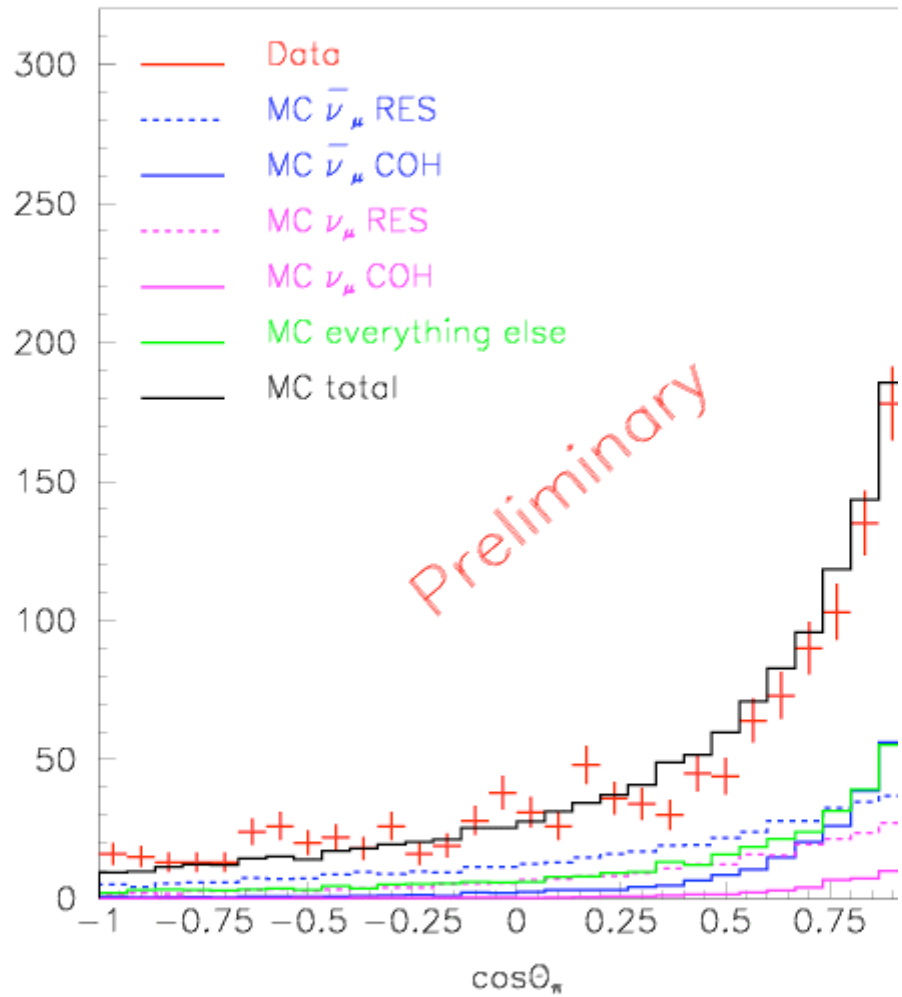
Note: Plots are relatively normalized with statistical errors

π^0 Kinematics



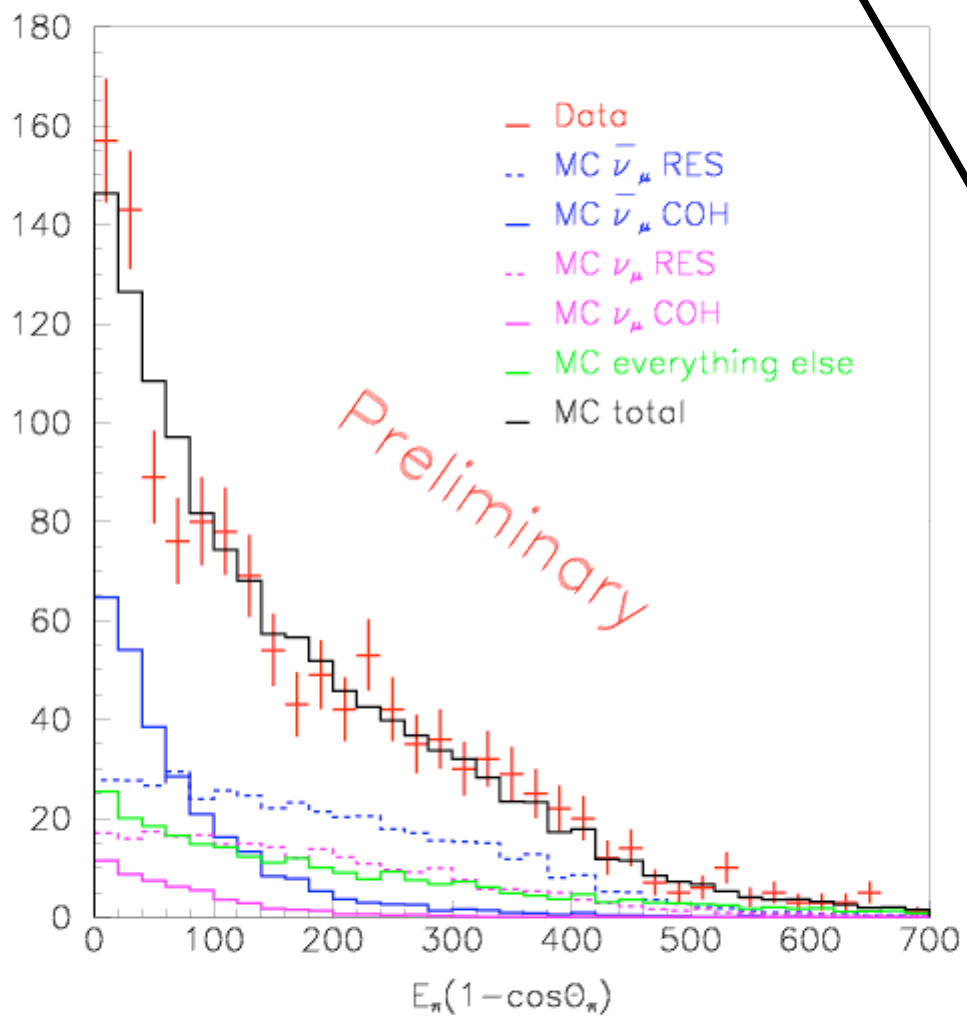
Note: Plots is relatively normalized with statistical errors o

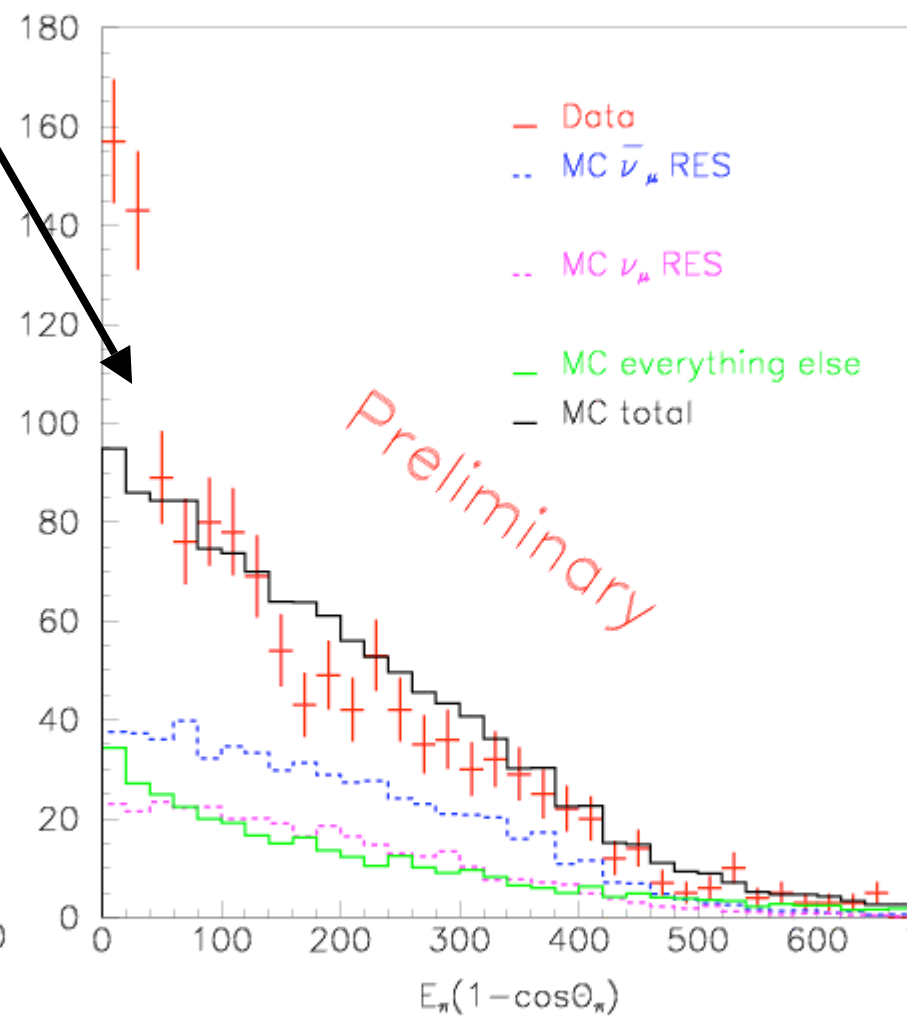




Note: Plots are relatively normalized with statistical errors

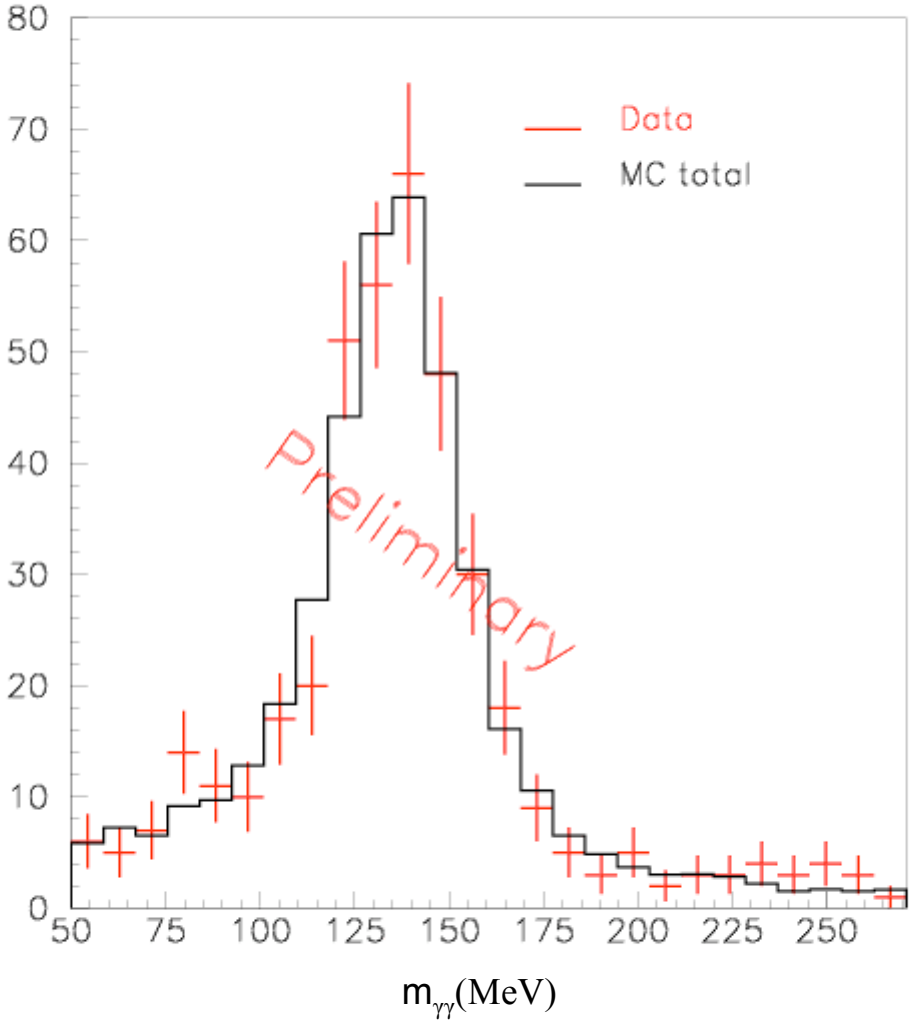
Suggestive of antineutrino
NC coherent π^0 production

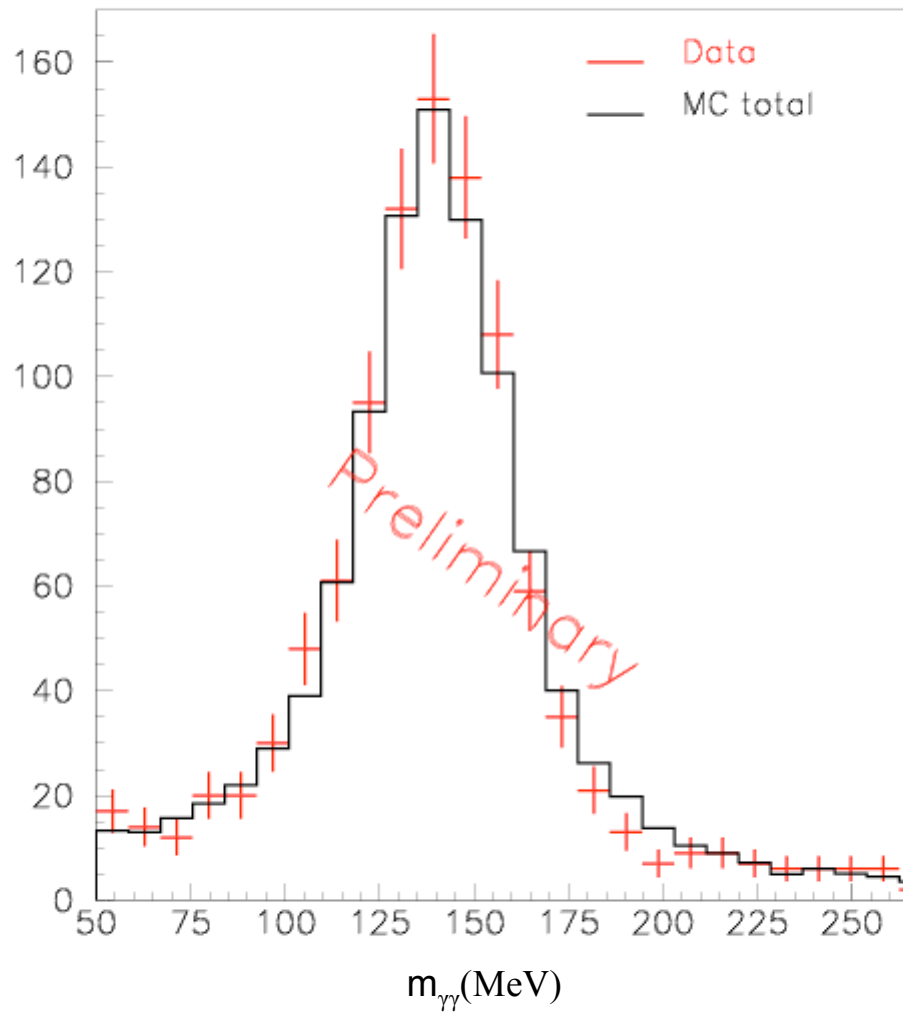




No COH contribution

Note: Plots are relatively normalized with statistical errors

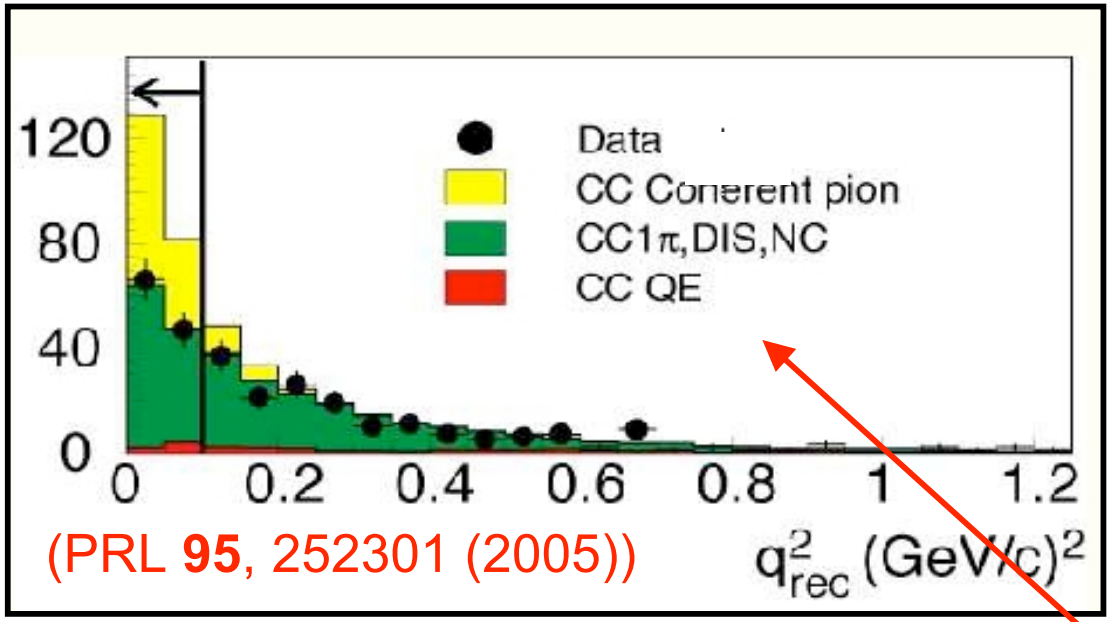


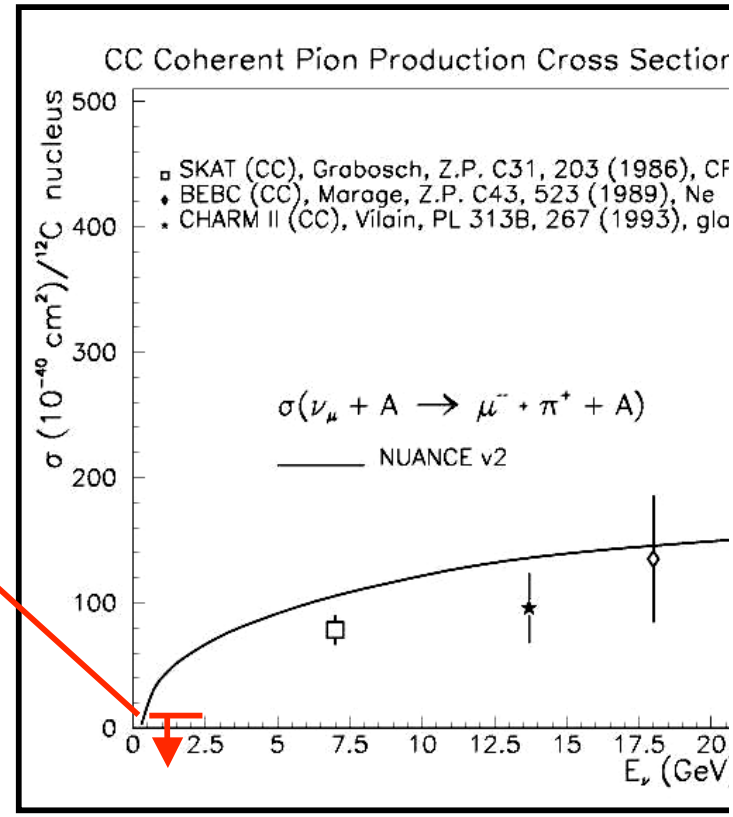


Left: $m_{\gamma\gamma}$ with $0<E_{\pi}(1-\cos\theta_{\pi})<50$ MeV
Right: $m_{\gamma\gamma}$ with $50<E_{\pi}(1-\cos\theta_{\pi})<700$ MeV

Note: Plots are relatively normalized with statistical errors

K2K CC Coherent π^+ Results





- Saw no evidence for coherent CC π^+ production
- Models need to explain both MiniBooNE and K2K coherer NC π^0 results along with K2K CC π^+ results

Summary

- There is good agreement between data and MC for π^0's i the MiniBooNE antineutrino data
- The data suggests antineutrino NC coherent π^0 production
- Next step: fit for an exact coherent fraction in the nubar data (been done for the neutrino sample) with systematic errors

Acknowledgments

I would like to give many thanks to:

Janet Conrad

Sam Zeller

Richard Van de Water

Hirohisa Tanaka

Kendall Mahn

Alexis Aguilar

Jon Link

Heather Ray

and the NSF