Coherent NC π^0 Production in the MiniBooNE Antineutrino Data

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PHENO 2008

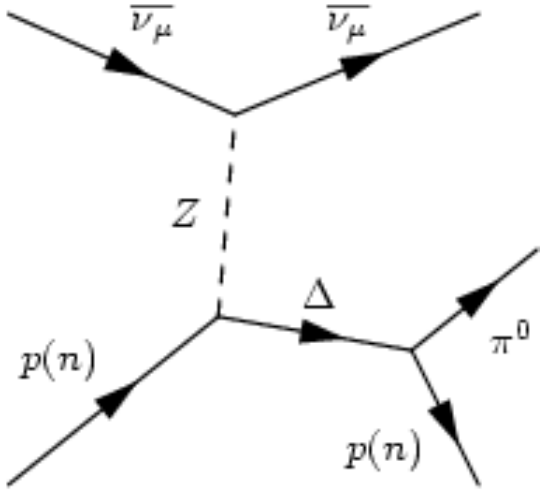
Outline

- NC π^0 production
- Motivation
- Analysis
- Preliminary results
- Summary

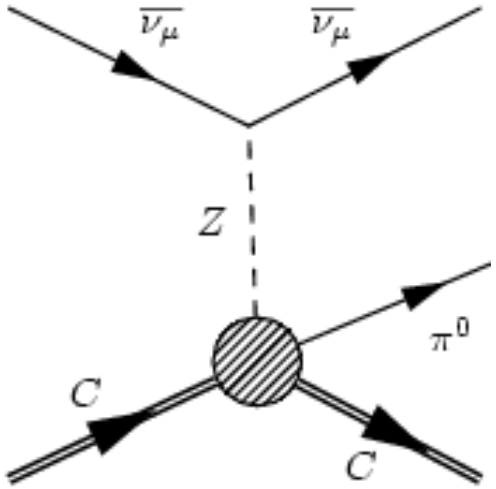
NC π^0 Production

At low energy, NC π^0's can be created through resonant and coherent production:

- Resonant NC π^0 production:

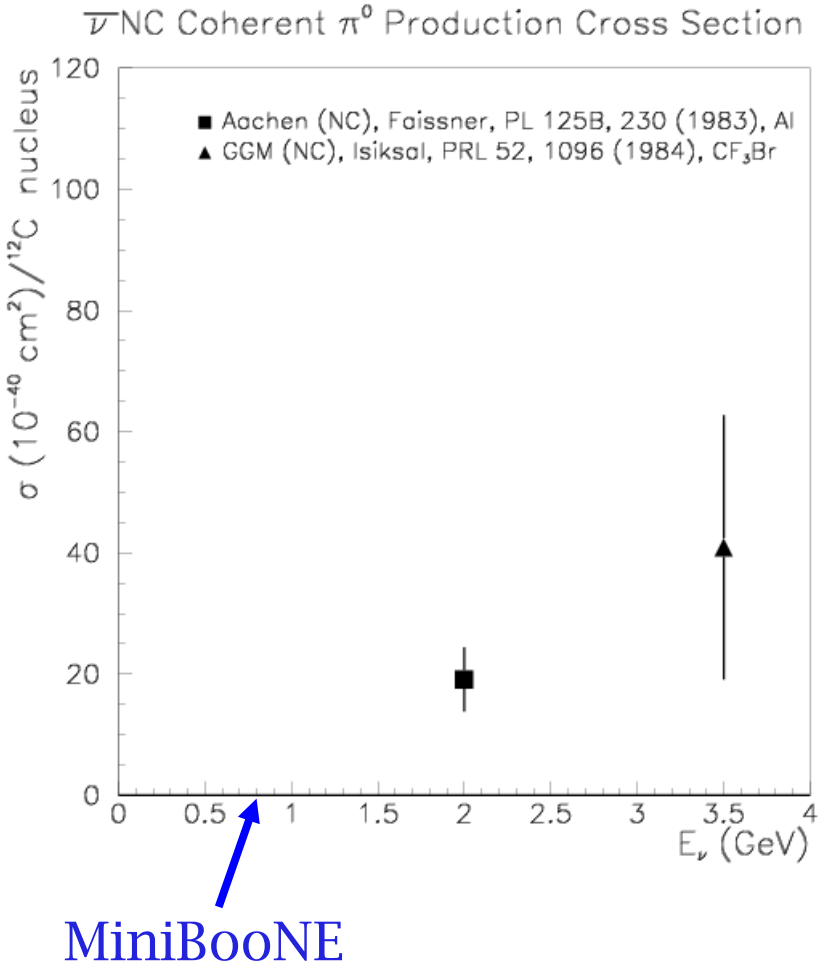


- **Coherent NC π^0** production:
  (Signature: π^0 which is highly forward–going)



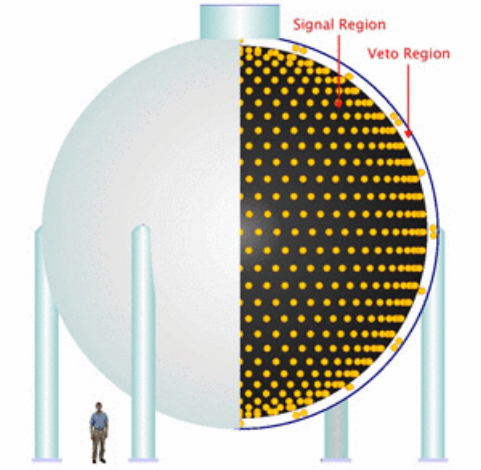
Why study coherent NC π^0 production?

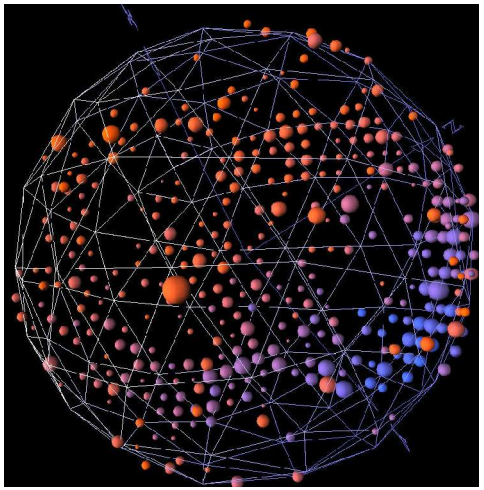
- NC π^0 events are the dominant background to $\overline{\nu_\mu} \rightarrow \overline{\nu_e}$ $(\nu_\mu \rightarrow \nu_e)$ oscillation searches
- In particular, coherent production is much more challenging to predict theoretically than resonant processes at these energies (<2 GeV)
- Furthermore, there are few experimental measurements, with none at very low energy
- The analysis in this talk represents the first time we are probing this region experimentally



NC π^0's in MiniBooNE

- MiniBooNE, an expt at Fermilab designed to measure ν oscillations, turns out to be very well-suited for π^0 physics
- Large, open-volume Čerenkov detector with full angular coverage is really good at π^0 ID and containment
- MiniBooNE has the world's largest samples of NC π^0 events in interactions with ~1 GeV neutrinos (over 28k)* and with ~1 GeV antineutrinos (over 1.7k)*

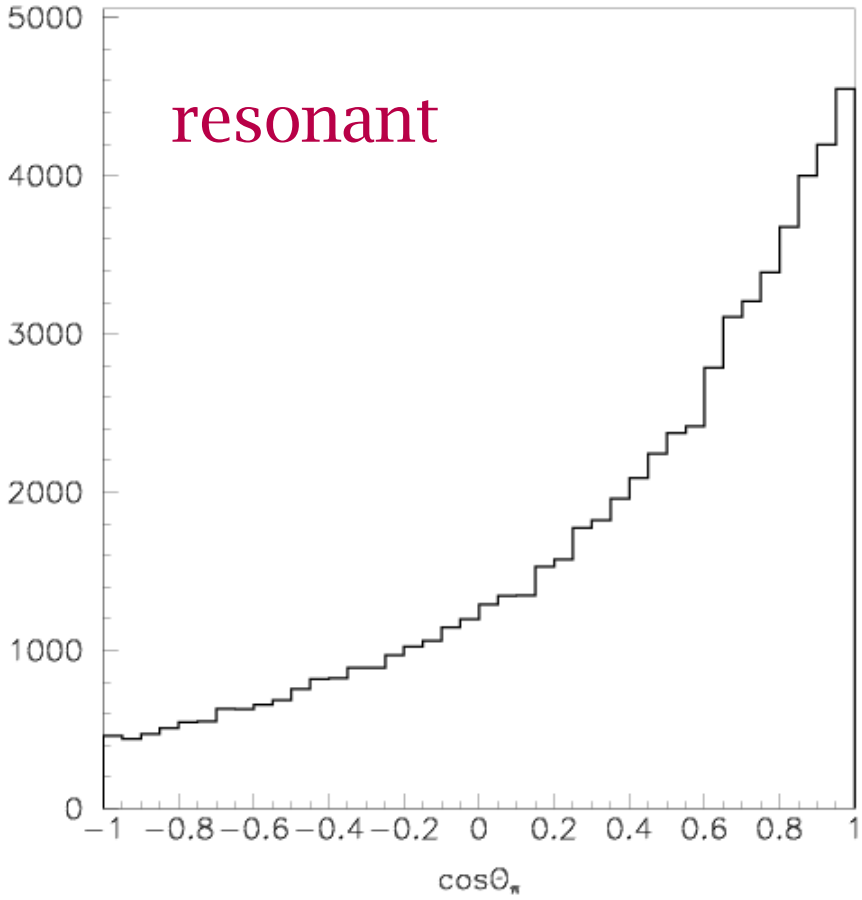


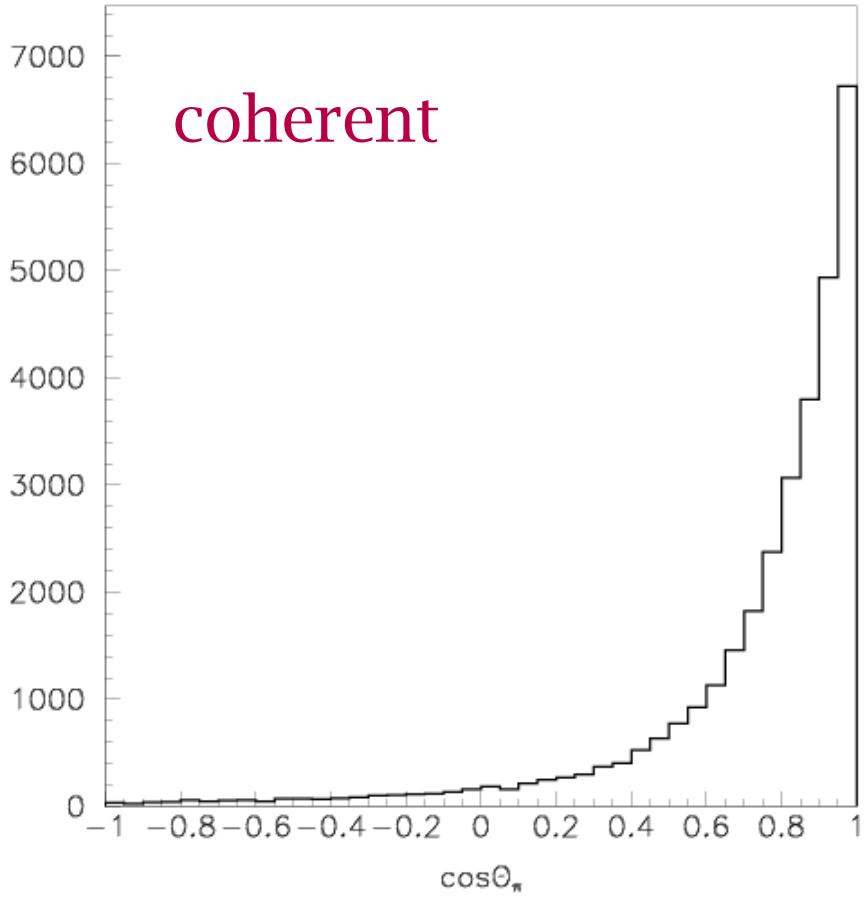


*additional antineutrino data being collected

Cosθ and Coherent π^0 Production

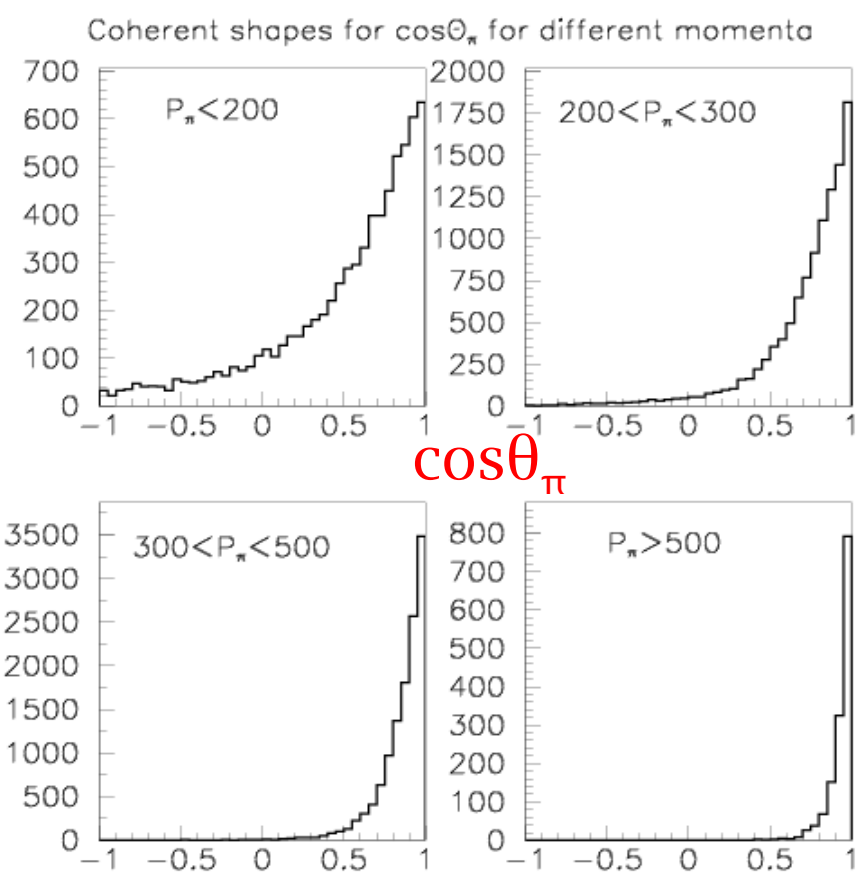
Coherent and resonant production are distinguishable by $\cos\theta_\pi$, which is the cosine of the lab angle of the outgoing π^0 wrt to the beam direction.

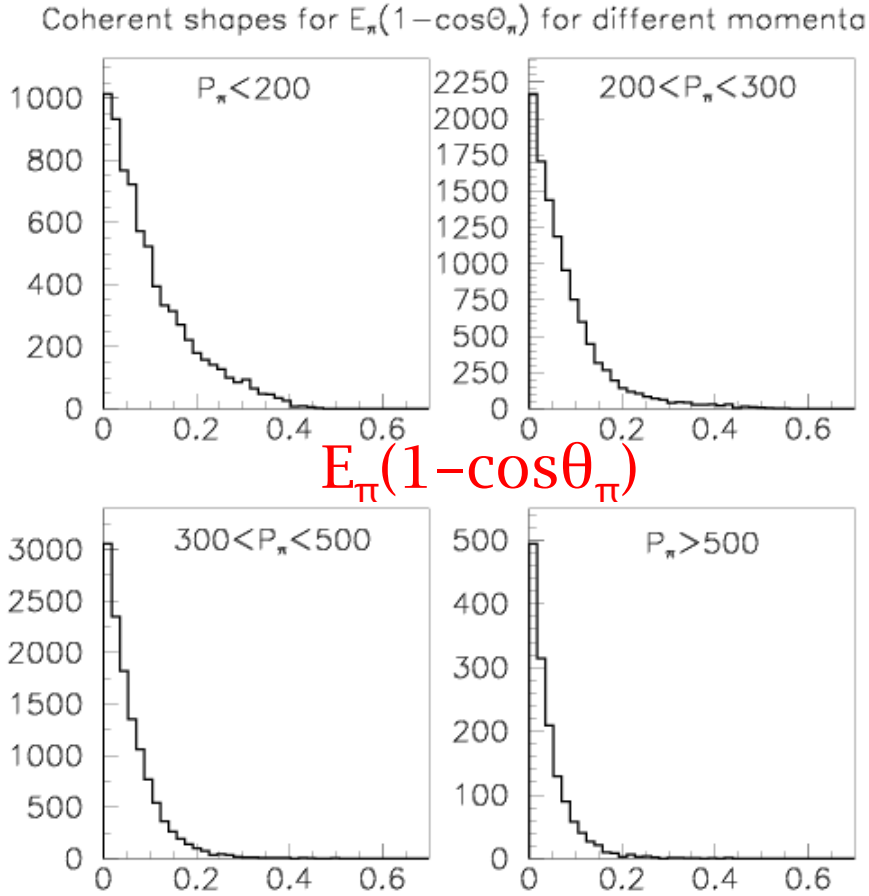




We can use this fact to extract a measure of the coherent fraction.

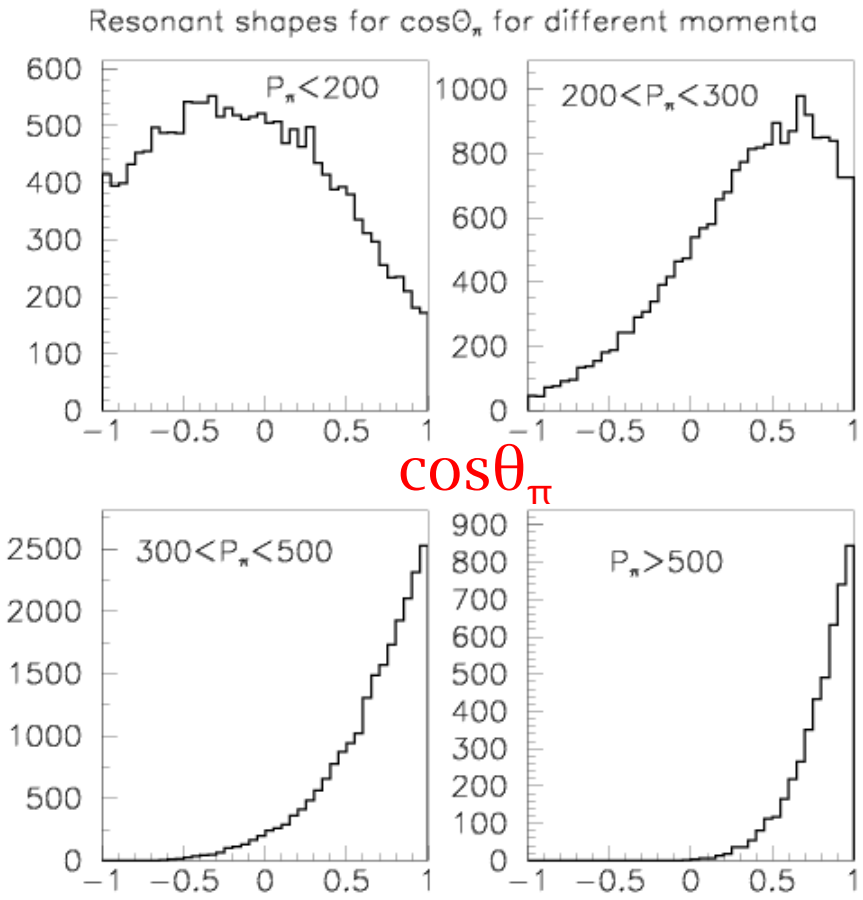
Study Coherent π^0's in Terms of $E_\pi(1-\cos\theta_\pi)$

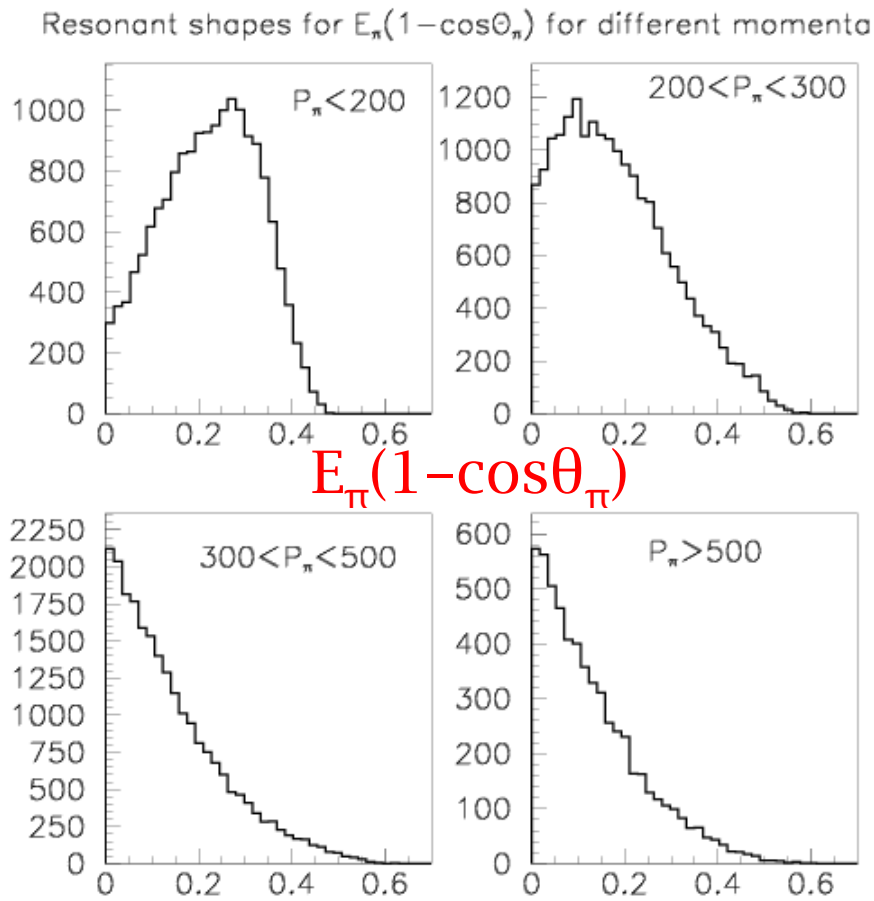




In coherent events, $E_\pi(1-\cos\theta_\pi)$ has a more regular shape, as a function of momentum, than $\cos\theta_\pi$ alone, so we'll fit for the coherent content as a function of this energy weighted angular distribution.

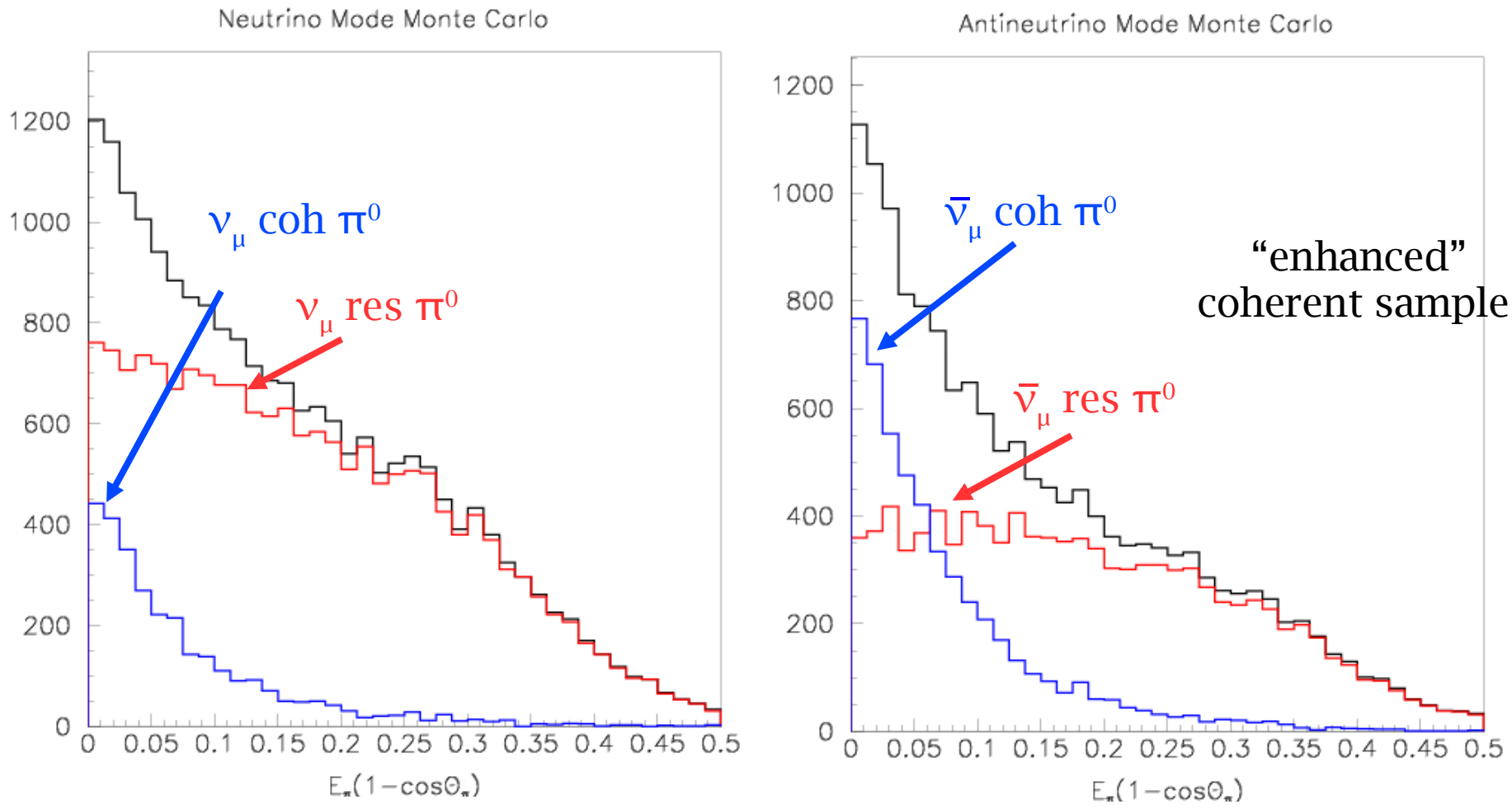
Study Coherent π^0's in terms of $E_\pi(1-\cos\theta_\pi)$





Meanwhile the resonant distributions can have a large variation in this energy range.

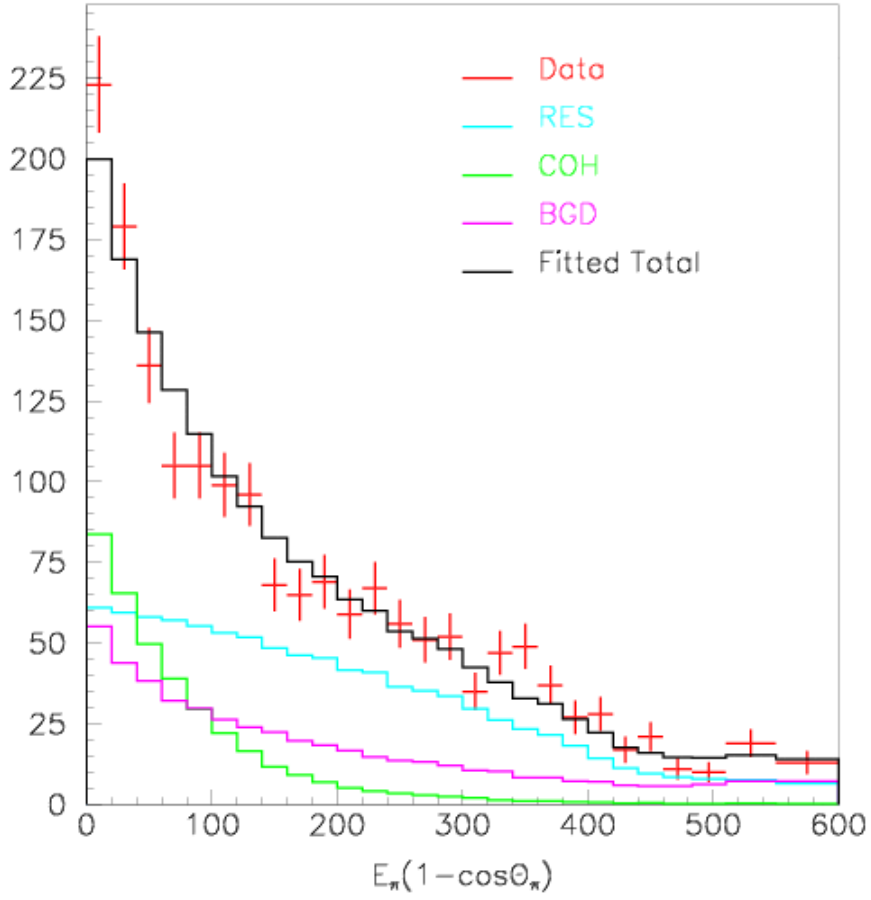
Coherent NC π^0's in ν vs. $\bar{\nu}$ Running

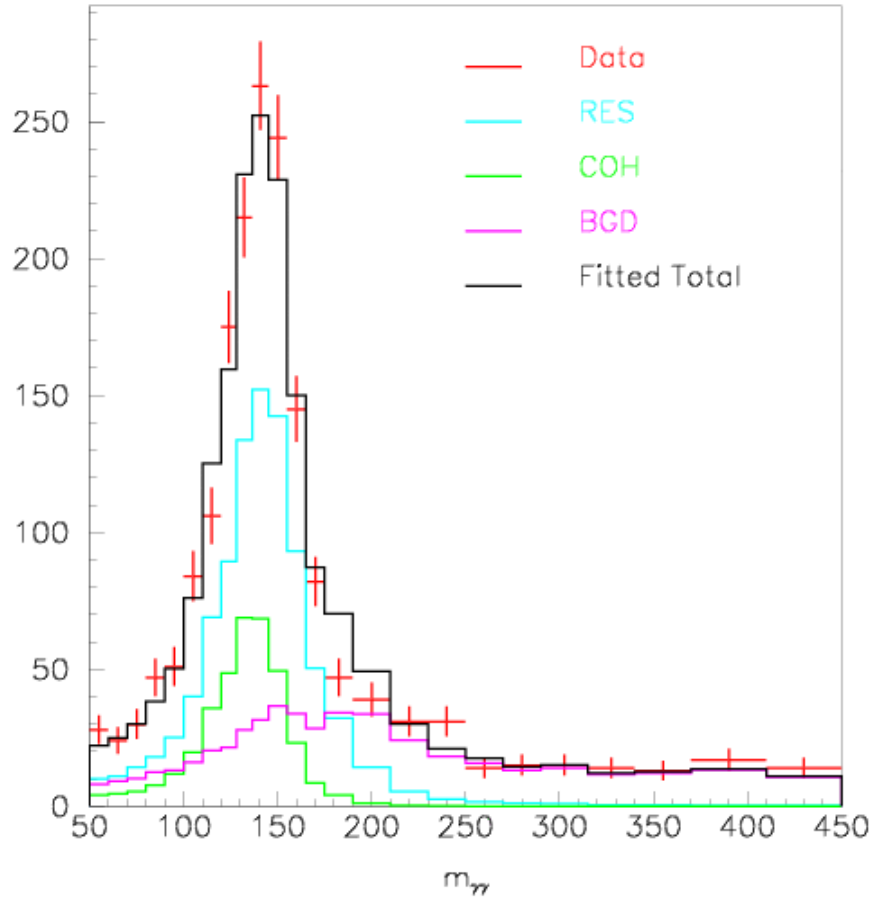


Generated π^0 angular distribution for NC ν (left) and $\bar{\nu}$(right) scattering.

Preliminary Nubar Coherent Fit Results

- MiniBooNE clearly sees evidence for coherent NC π^0 production in both neutrino and antineutrino modes at a rate that is ~1.5x lower than the R–S model prediction, which is the most widely used model in ν expts
- Antineutrino mode fit results are shown below





Conclusions

- MiniBooNE has amassed the world's largest samples of NC π^0 events in interactions with ~1 GeV (anti)neutrinos and sees strong evidence for coherent production in both modes, where the search in antineutrino mode is the first of its kind at low energy (< 2 GeV)