

# Pion Production

S.Dytman for S. Singh & M.Sorel

Charged and neutral pions  
Coherent and 'regular' pion production

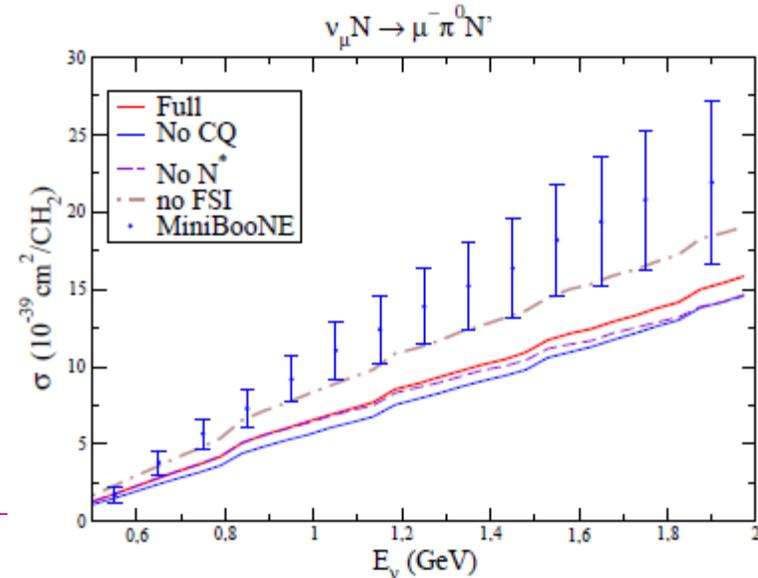
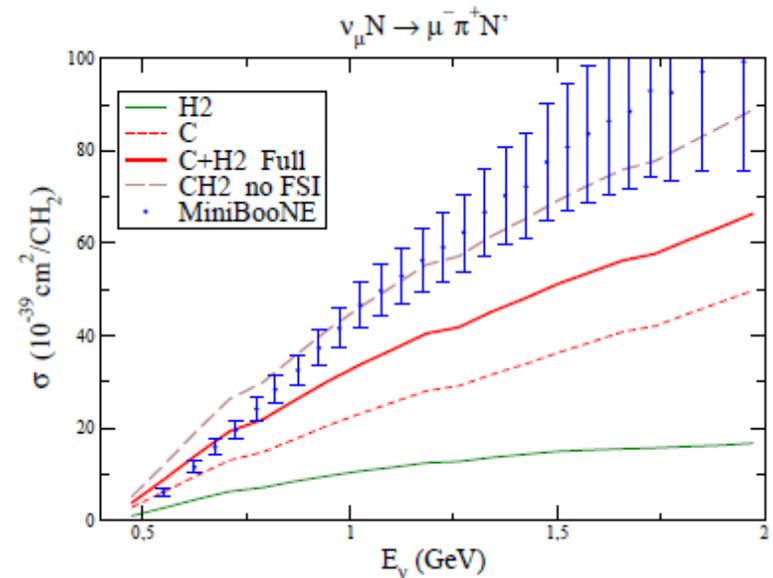
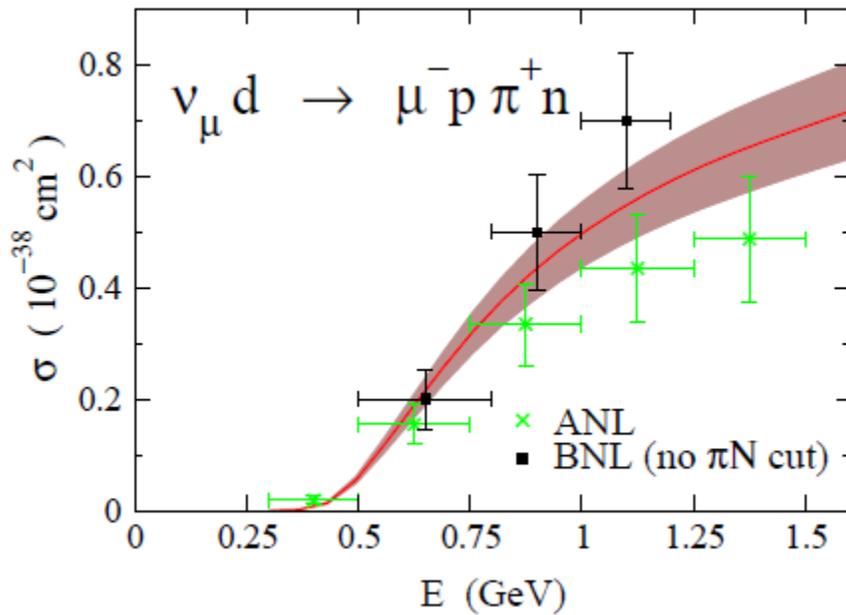
# I. 'tension' between nucleon and nucleus data for pion production

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- ▶ For nucleon, only data is old bubble chamber (BNL, ANL)
  - ▶ Low statistics
  - ▶ Uncertain flux determination
- ▶ For nucleus, recent MiniBooNE data (Wilking, Nelson)
  - ▶ High statistics
  - ▶ Careful flux determination
- ▶ For someone with long history in hadron and electron scattering, this seems backward. Normally, quality nucleon data is core of all calculations.

# Hernandez, Nieves, Vicente-Vacas

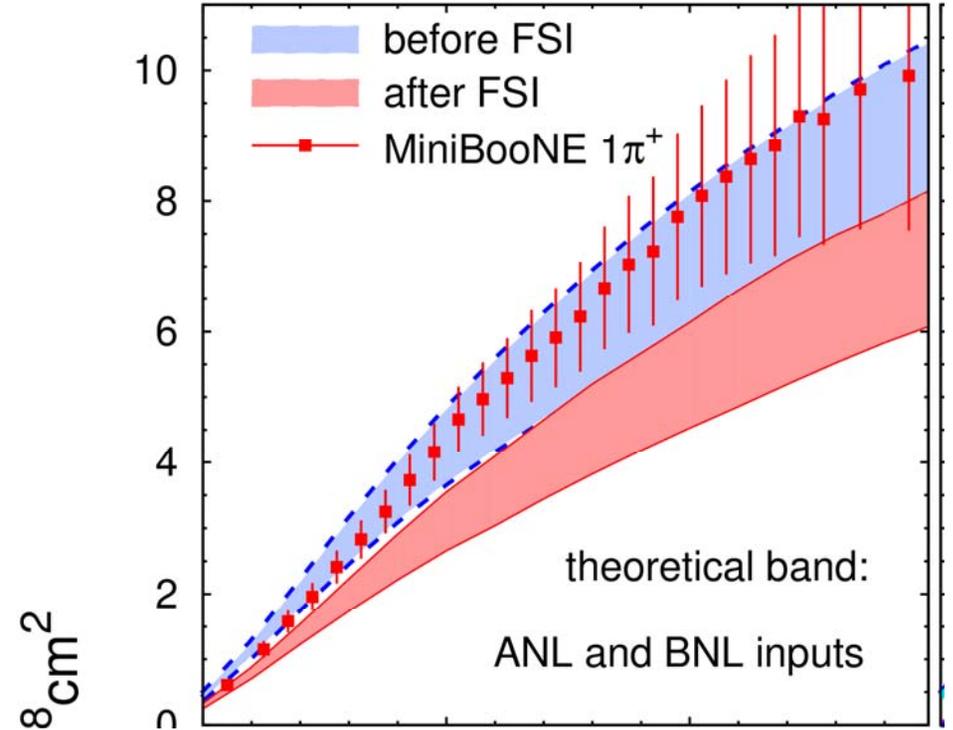
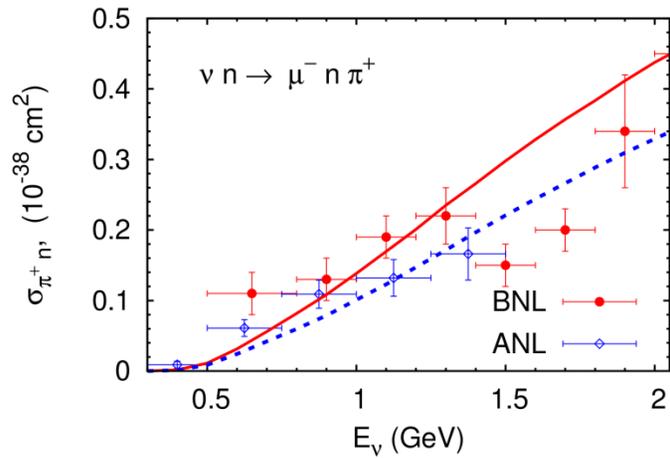
## Account for flux, syst errors



# Lalakulich, Mosel

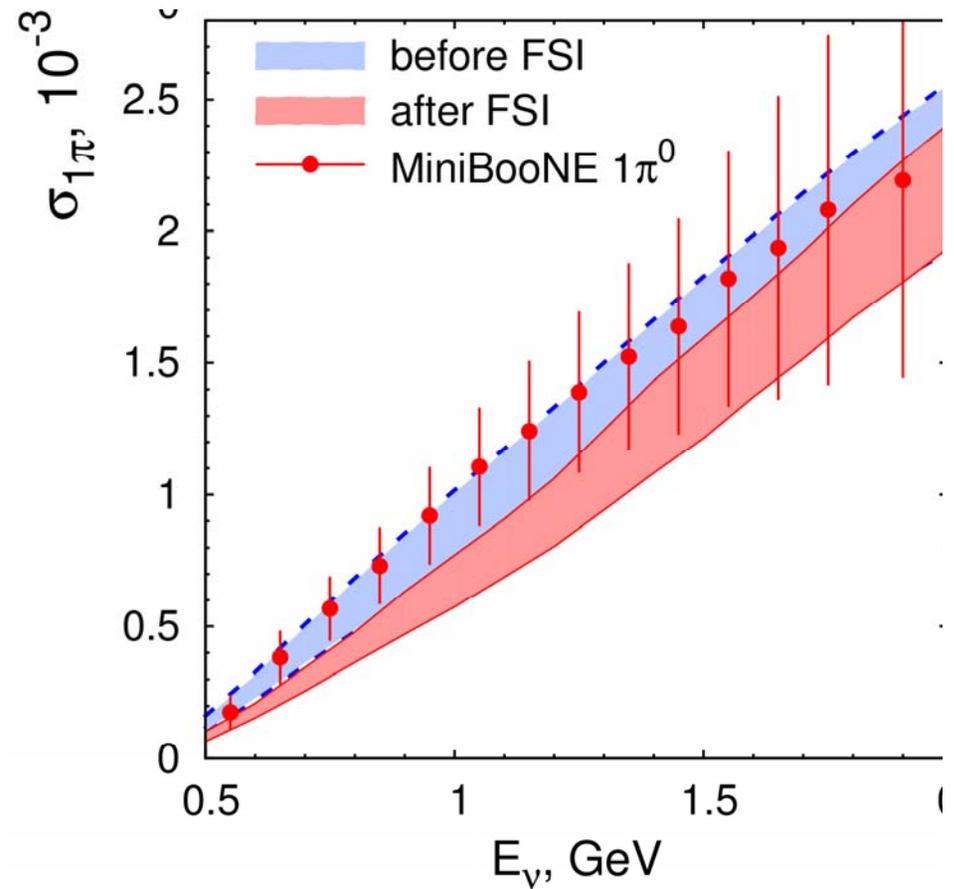
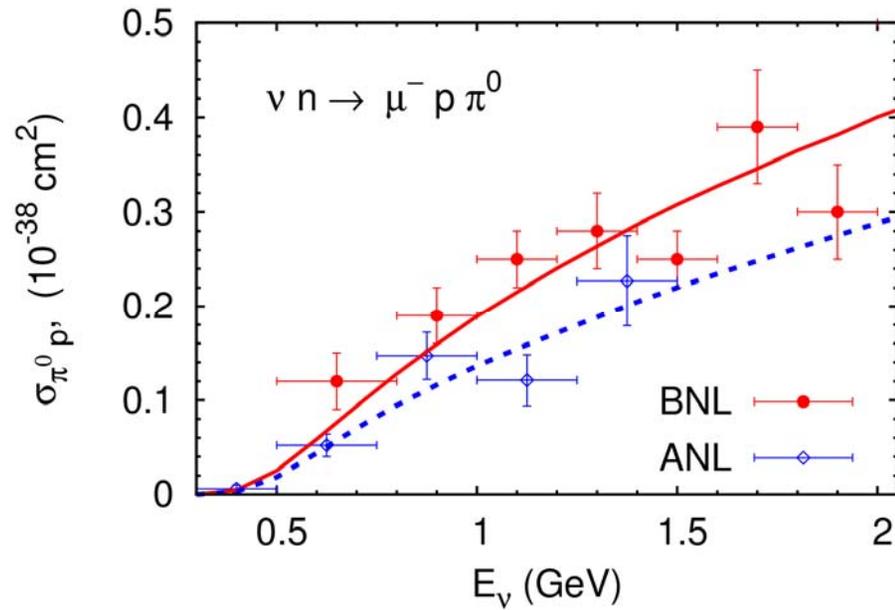
## Span N data

$\pi^+$



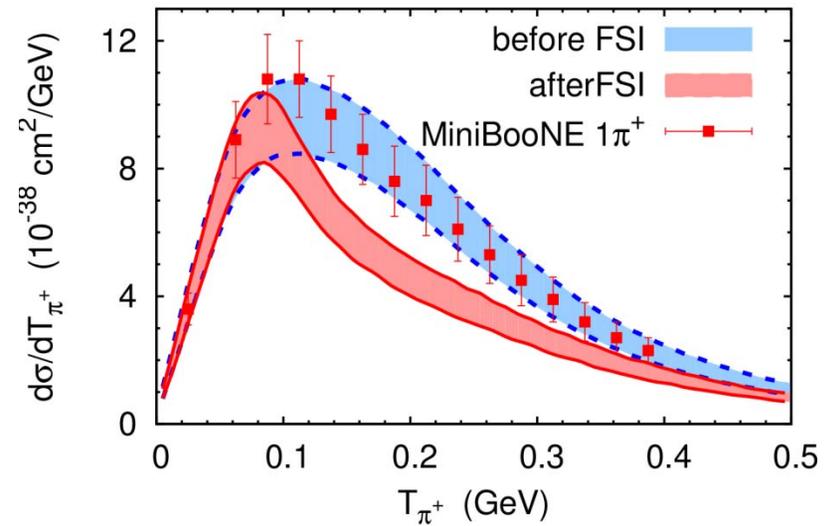
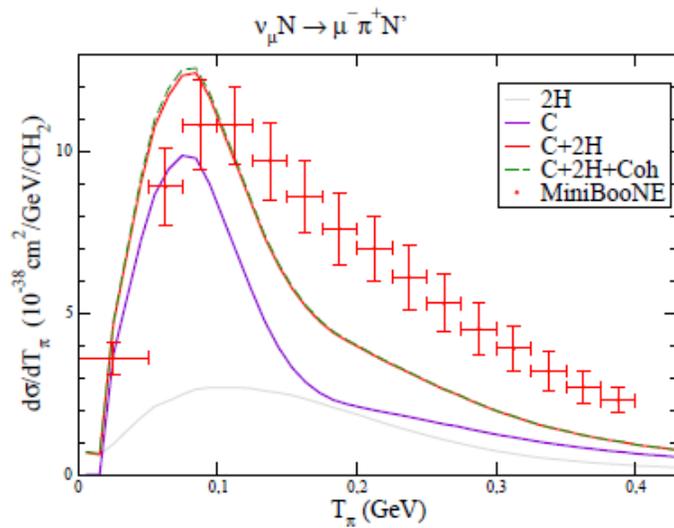
# Lalakulich, Mosel

$\pi^0$



# $\pi^+$ momentum distributions

## FSI gives wrong shape

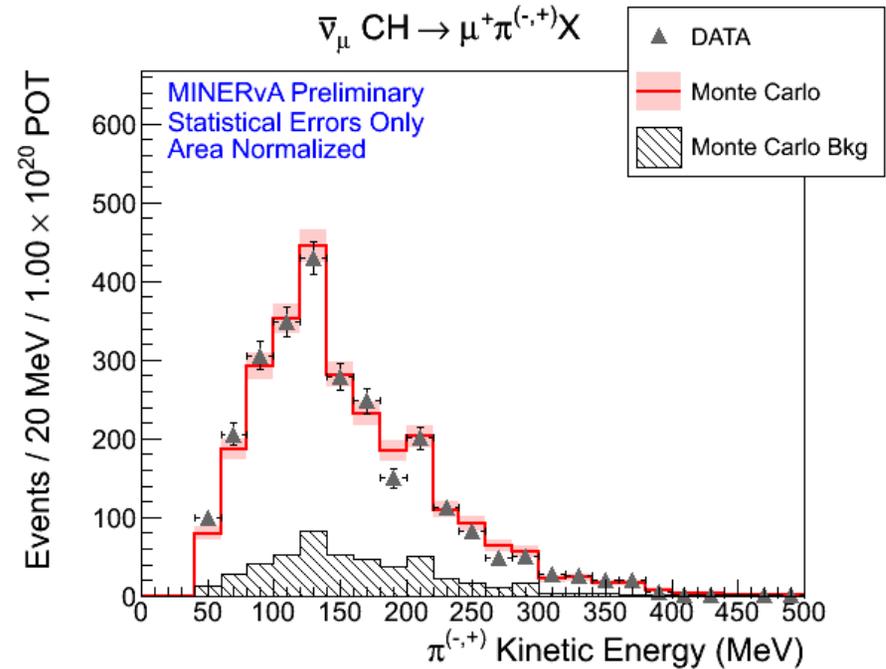
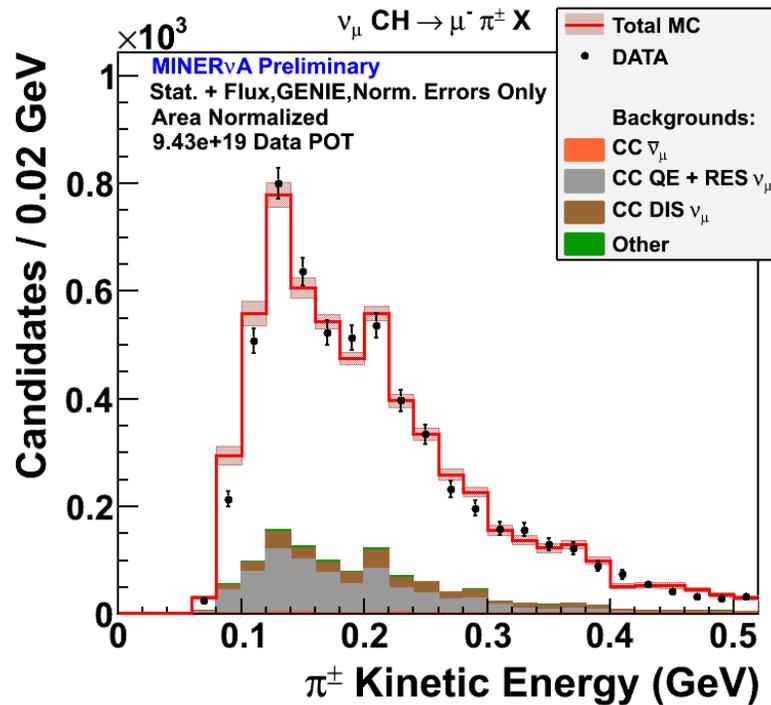


# Solution?

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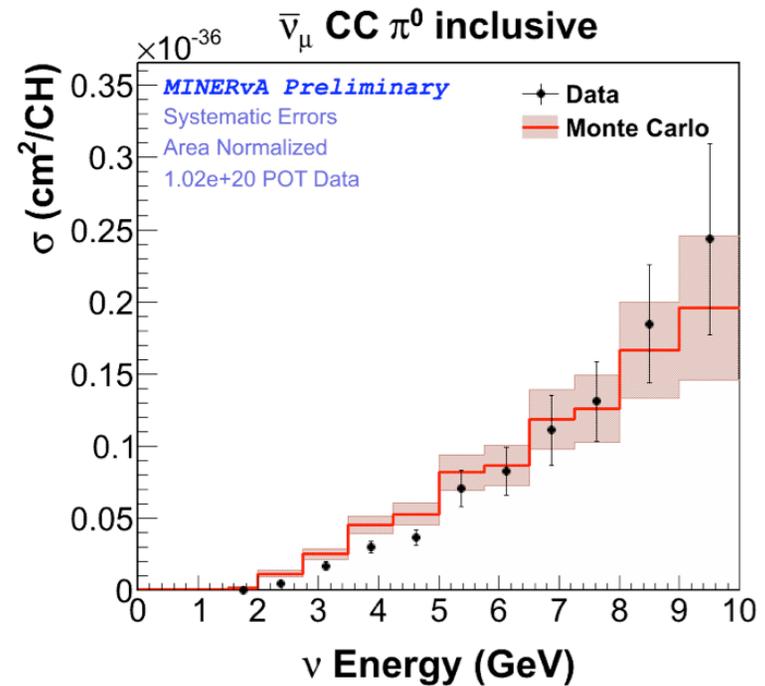
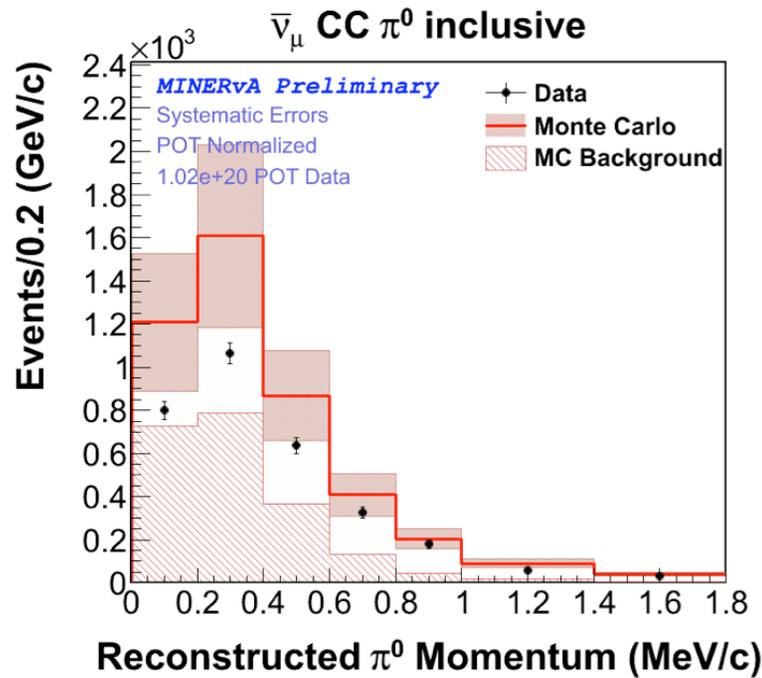
- ▶ Is ANL or BNL better? (apparently not)
- ▶ Can they be reconciled? (Sobczyk vs. others)
- ▶ Can theory tell us what N data should be? (too many uncertainties)
- ▶ Can more data be taken?
  - ▶ Minerva might have D tgt in future (5 GeV beam)
  - ▶ Minerva might be able to pull H data out of CH data.

## II. Lots of new data coming - Minerva $\pi^\pm$



Both  $\nu$  and  $\bar{\nu}$  (25, 80% of statistics)  
 very high purity, not efficiency corrected  
 ISSUE: Avg  $E_\nu \sim 3$  GeV ( $\sim$ half  $W < 1.7$  GeV, rest DIS)  
 can they (do they need to) isolate resonant region?

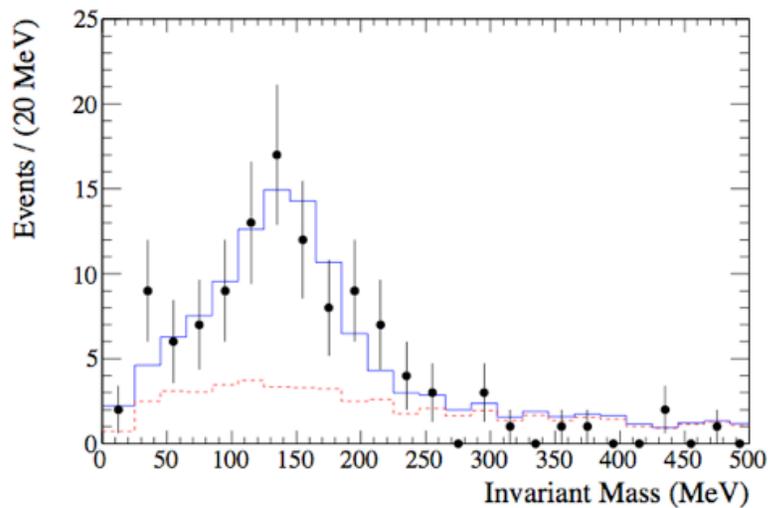
# Minerva $\pi^0$ and CC coherent



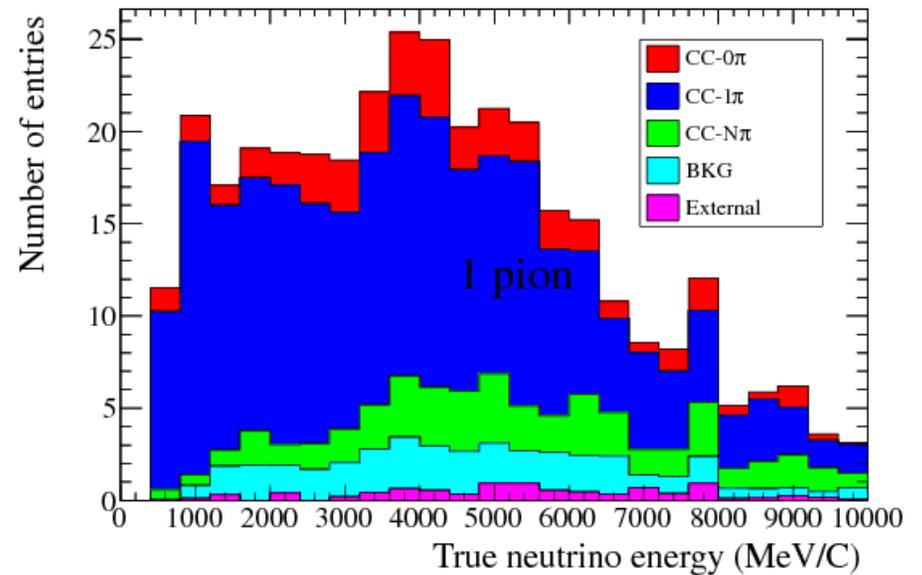
$\nu$  bar plastic (also  $\nu$  &  $\nu$  bar plastic coherent)  
 ISSUE: Avg  $E_\nu \sim 5$  GeV to get good eff, purity  
 both inclusive and 'exclusive'

# T2K (ND280)

## $\pi^0$ result (P0D)



## $\pi^+$ anticipated result (TPC)



$$R = \frac{N_{\pi^0}^{Data}}{N_{\pi^0}^{MC}} \bigg/ \frac{N_{CC}^{Data}}{N_{CC}^{MC}} = 0.81 \pm 0.15(stat) \pm 0.14(sys)$$

peak energy  $\sim 600$  MeV  
 easier for theorists  
 also lower energy  $\pi^+$ , CC  $\pi^0$ ,  
 'coherent' future

# Summary

- ▶ New calculation for  $K, \eta$  production (Athar + collabs)
  - ▶ small, but measurable in Minerva
- ▶ New calculation for  $\gamma$  emission (Alvarez-Ruso + collabs).
  - ▶ goal is to understand MiniBooNE deficit at low  $E_\nu$ .
  - ▶ redo calculation of Hill with nuclear effects

