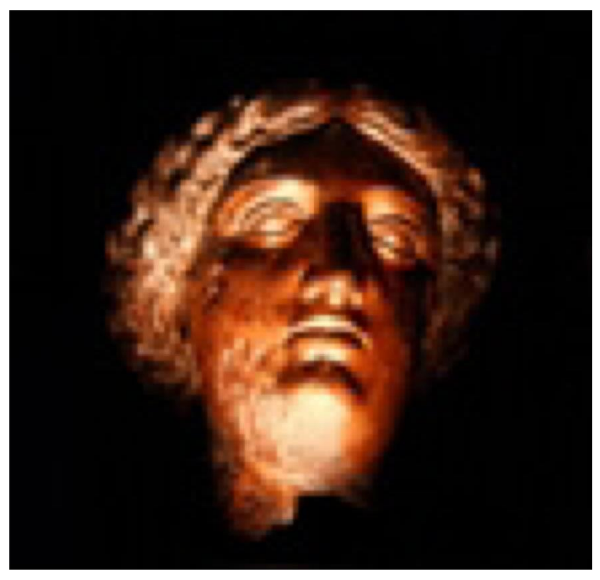
Understanding the NuMI Flux for MINERνA:

Deborah Harris, Fermilab, on behalf of MINERνA

(for more details, see L. Aliaga, NuFact'12)



MINERνA is a dedicated neutrino-nucleus cross-section experiment in the NuMI Beamline

NuMI Beamline Ingredients:

120 GeV Protons, 2 interaction length graphite target, 2 Al Horns, Fe Decay Pipe

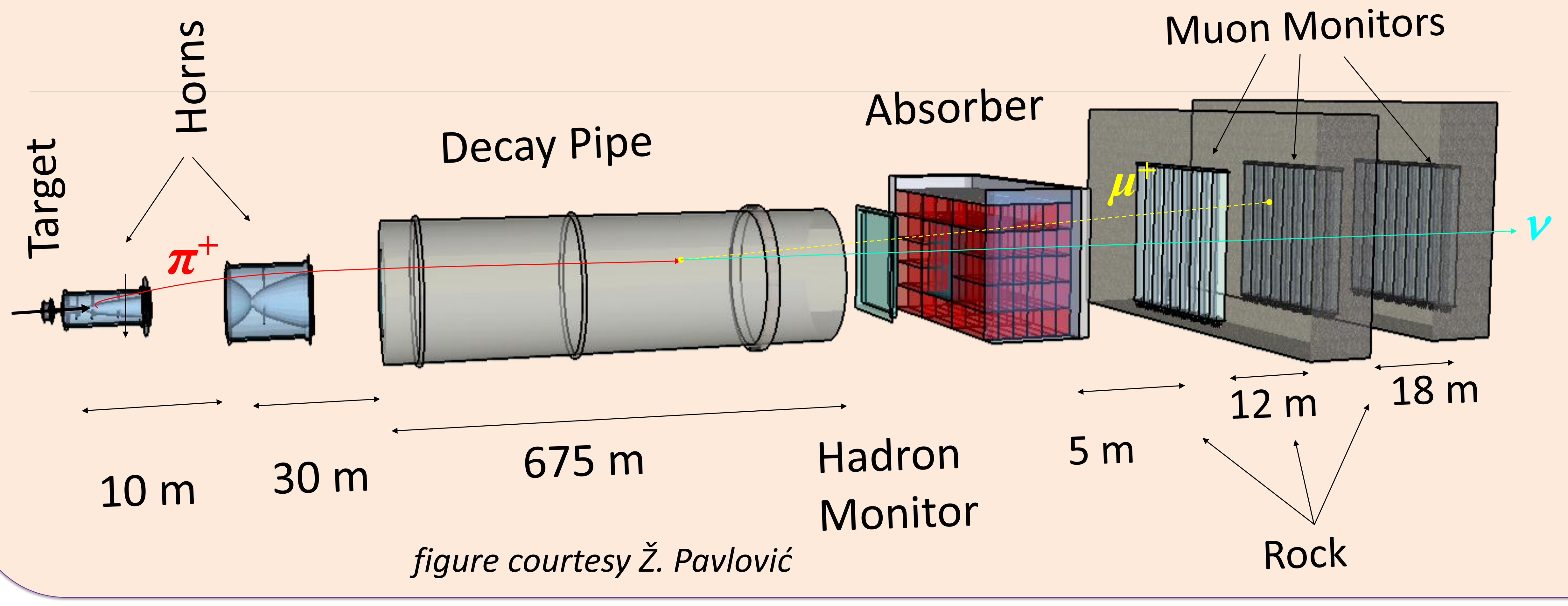
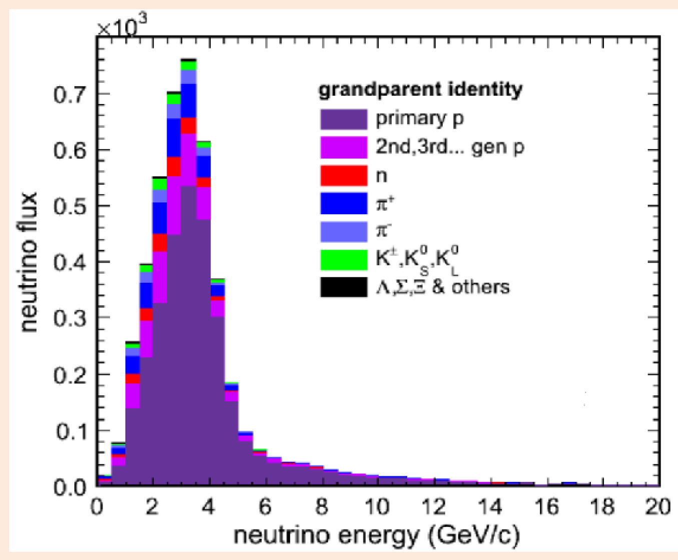


figure courtesy Ž. Pavlović

Different sources of neutrinos have to be constrained by different measurements:
*Primary p→π,K→ν constrained by hadron production data
*Secondary and tertiary π constrained by FTFP model, uncertainty evaluated by comparing different models



Plot shows neutrino flux broken down by production mechanism

Table at right shows sizes of various sources of pions that produce neutrinos, integrated over all energies

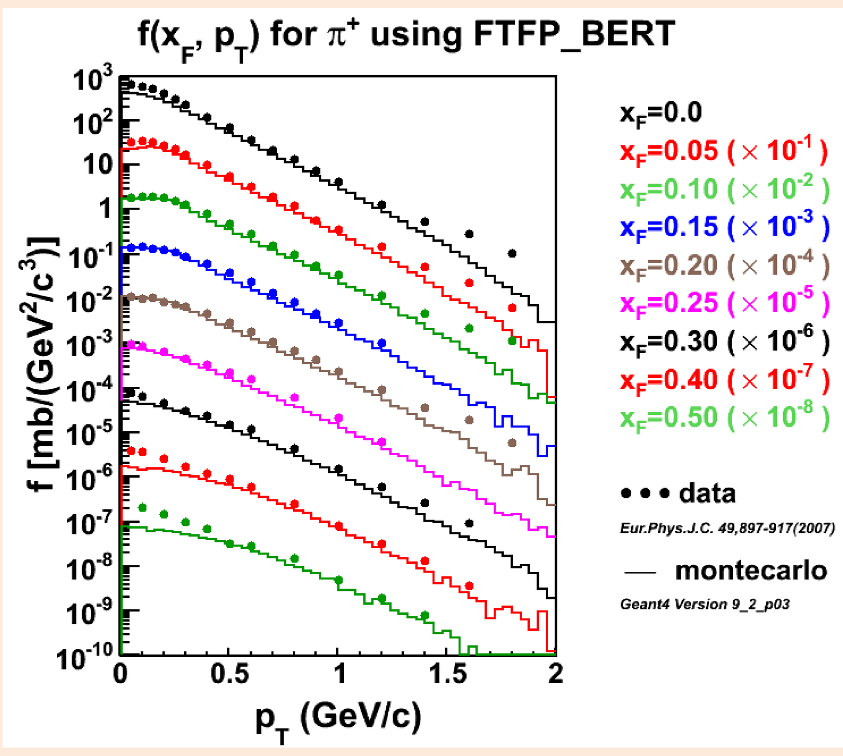
Fraction from target at peak energies is ~70%

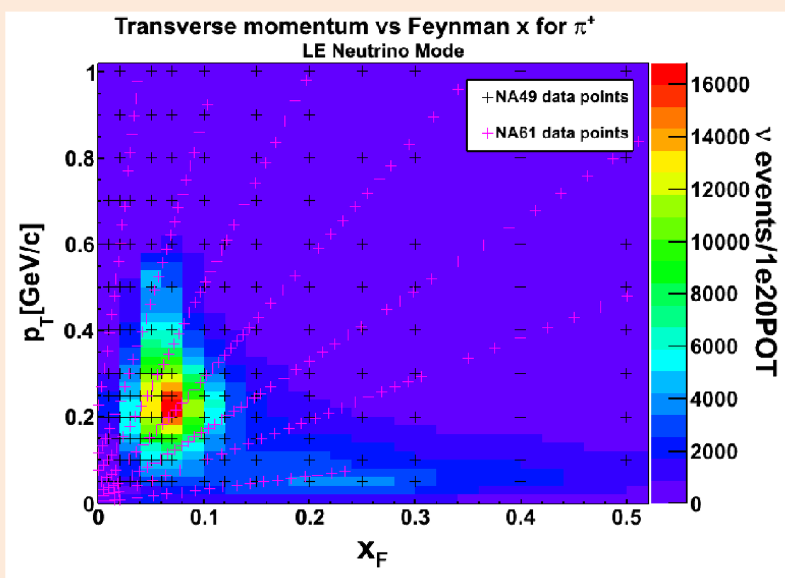
Target Fins (84.4%) & "Budal Monitor (4.6%) [C]"	89.0%
Decay Pipe Walls [Fe]	2.6%
Target Hall Chase [air]	2.2%
Decay Pipe [He]	1.8%
Horn 1 Inner Conductor [Al]	1.5%
All other summed	2.9%

Current Flux Constraints

Hadron Production: NA49

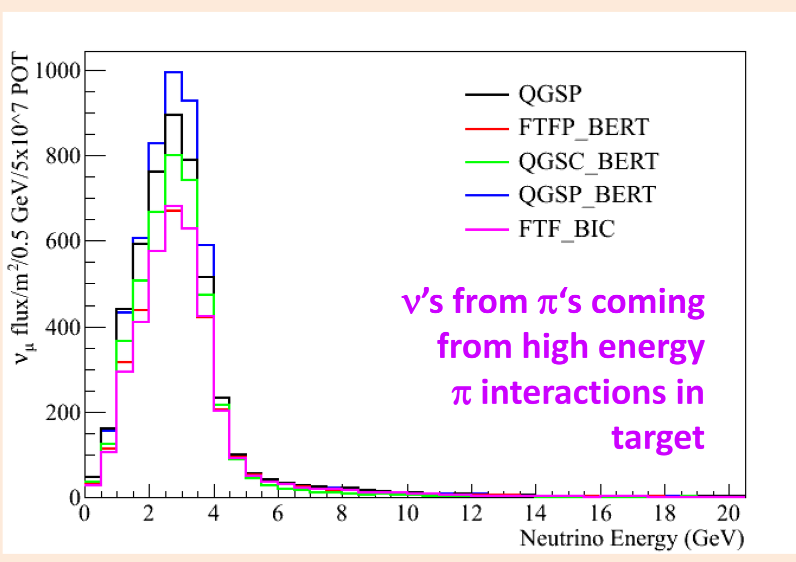
NA49, a hadron production Experiment at CERN, measured pion production with 158GeV protons on a thin graphite target. These data (plot at left) cover the relevant kinematics for the NuMI Beam (plot below)

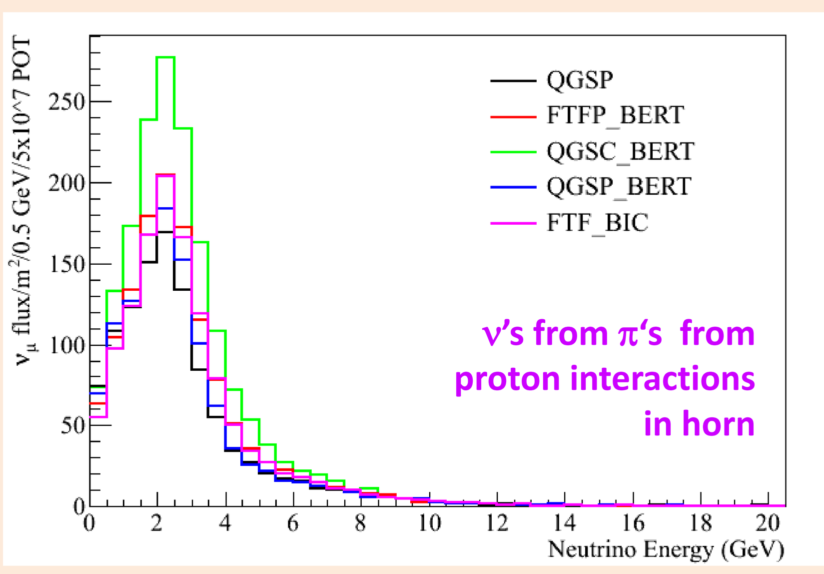




Tertiary Production

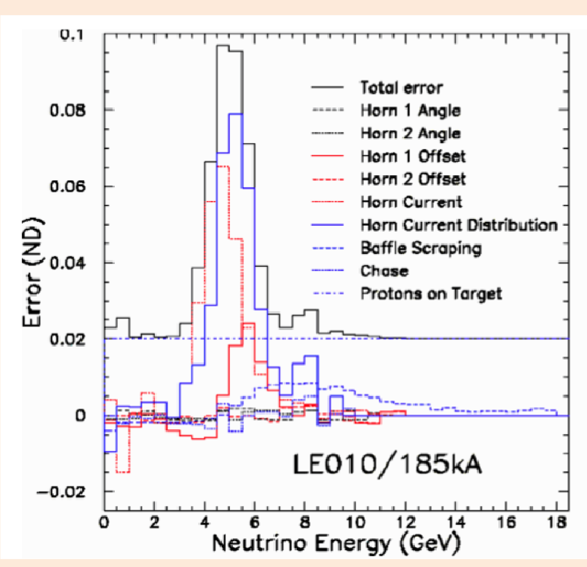
Different hadron cascade models predict different neutrino fluxes from tertiary pion production, as shown in the two plots below: Note the 30% variations at the focusing peak





Beam Focusing

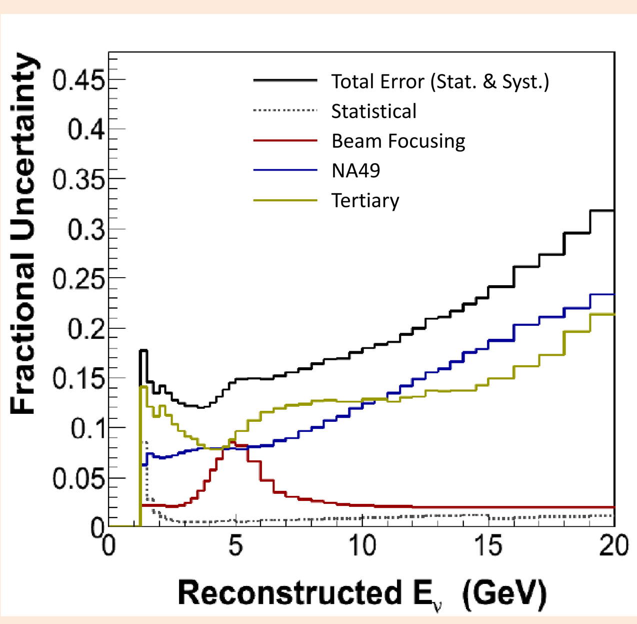
Uncertainties in beamline alignment and horn magnetic field model are estimated to be small at most energies, but are significant (8%) at fall-off of focusing peak (see plot at right)



Z. Pavlovich, "Observation of disappearance of muon neutrinos in the NuMI beam", PhD thesis, UT Austin 2008

Current status of Flux Uncertainties

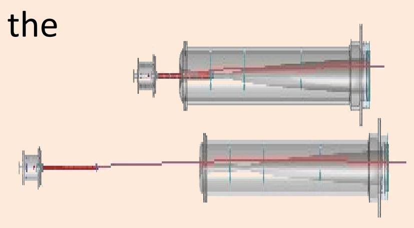
The fractional uncertainties on the ν_μ charged current event rate due to the three sources listed above are given in the plot at the right. Also shown on the plot is the statistical error in the same sample from only a quarter of MINERνA's total Low Energy Neutrino run. The main strategies to reduce these systematic errors are shown on the right panels of this poster.

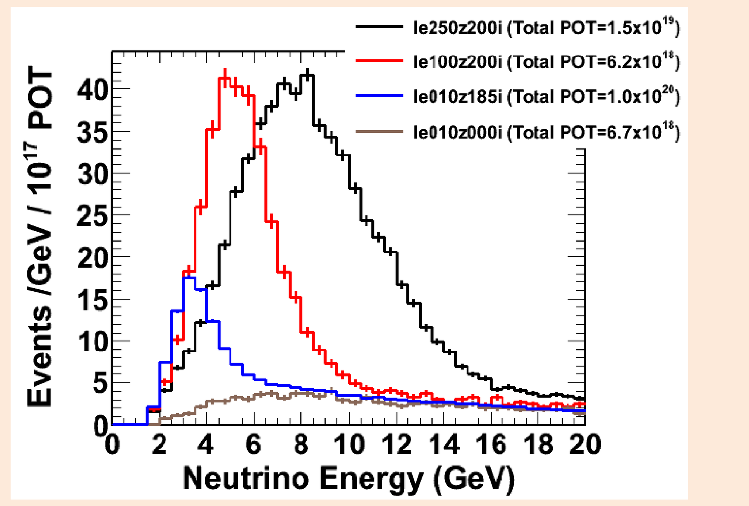


Planned Improvements

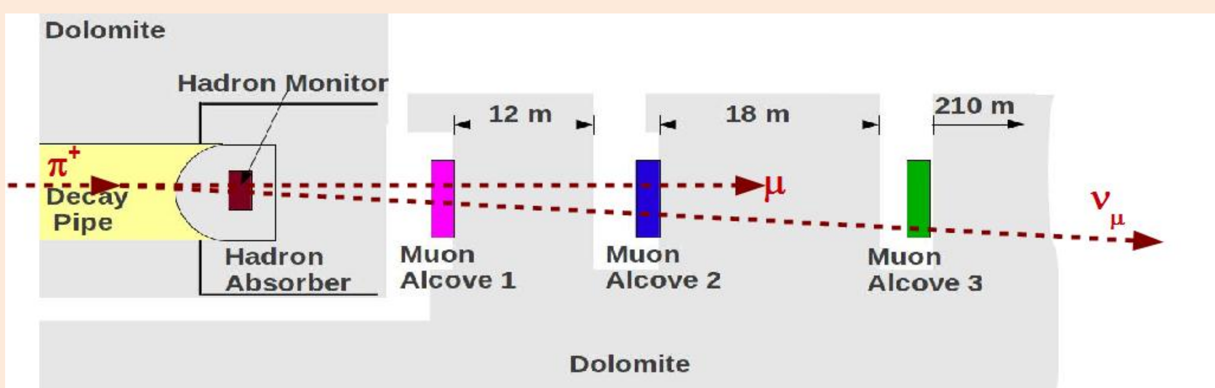
Alternate ν Beam Constraints

The NuMI beamline is unique in that the distance between the target and first focusing horn can be changed with only a few days downtime. By taking both neutrino and muon monitor data at several different target positions MINERvA will place additional constraints on the flux prediction. Figure at right shows spectra for 3 different target positions: nominal, 1m, and 2.5m from nominal, and for the case where the horn current was set to zero.





Constraints from Muon Monitors

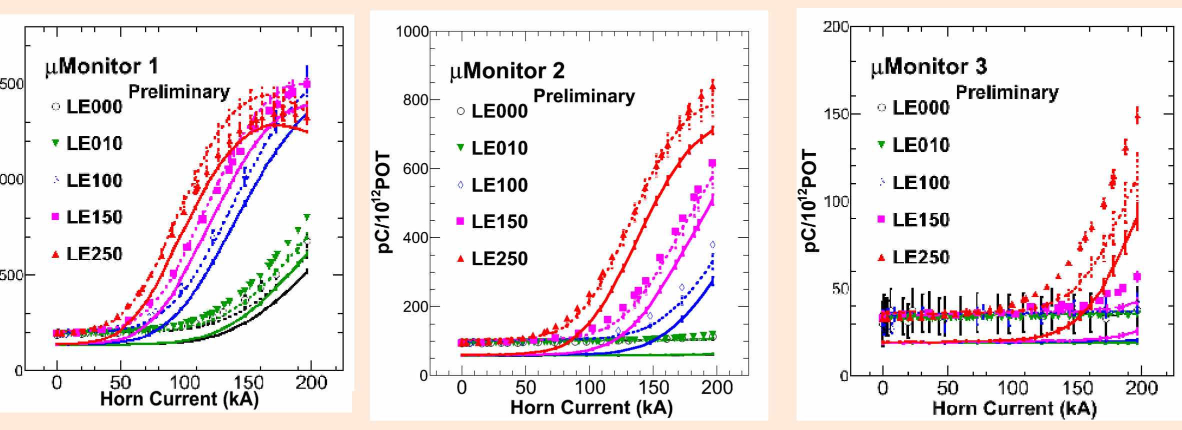


The three different muon monitors each see muons above different thresholds.

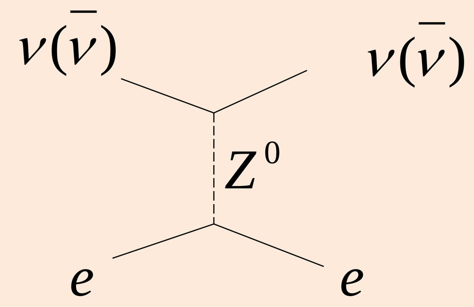
Muon Monitor 1: $E_{\mu,\pi} > 4.2$ GeV & $E_\nu > 1.8$ GeV
Muon Monitor 2: $E_{\mu,\pi} > 11$ GeV & $E_\nu > 4.7$ GeV
Muon Monitor 3: $E_{\mu,\pi} > 21$ GeV & $E_\nu > 9.0$ GeV

For three target positions, MINERνA took several beam pulses at different horn currents, from 0kA to 200kA. The muon rates in each muon monitor for each horn current will provide an additional cross-check of the flux model.

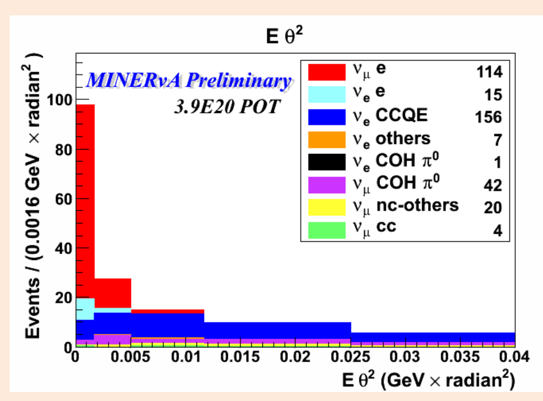
The challenge here is to predict and subtract the delta-ray and neutron backgrounds

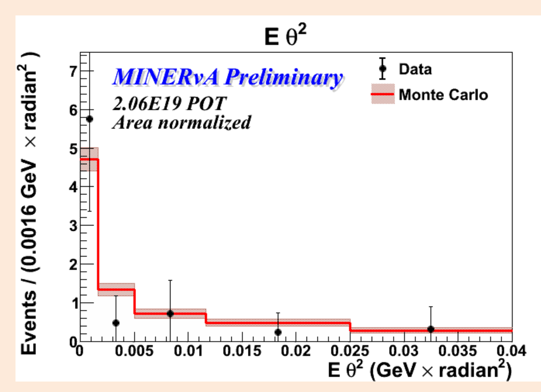


Overall Rate Constraint: Neutrino-Electron Scattering



Simple final state and well understood cross-section provide overall flux constraint. Challenge is to isolate the signal from ne Charged current events: Eθ² provides discrimination, as shown at right. Estimated statistical precision for MINERvA LE Run: 10%
(Ref: J. Park, NuFact'12)





New Hadron Production Measurements: NA61

In order to improve its flux prediction, MINERvA (and other NuMI-based experiments and LBNE) are collaborating with NA61, a new hadron production experiment at CERN. Plans for taking data with 120GeV protons on a thick NuMI target are underway.