Charged Current Quasi-elastic Neutrino Analysis at MINERνA

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Introduction

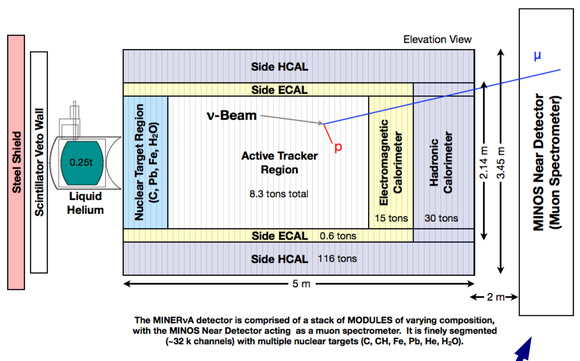
MINERνA (Main Injector Experiment ν-A)

Dedicated neutrino-nucleus scattering experiment in the 1-10 GeV energy range.
Uses the high intensity NuMI neutrino beamline at Fermilab.
Designed to study nuclear effects in neutrino interactions using a variety of nuclei (C, Fe, Pb, plastic, He and H_2O).
It will, among other things, measure the cross section of the ν_μ and anti-ν_μ Charged Current Quasi-Elastic interactions.

Experimental Setup

MINERνA Detector

Fully-active finely-grained scintillator surrounded by electromagnetic and hadronic calorimeters.

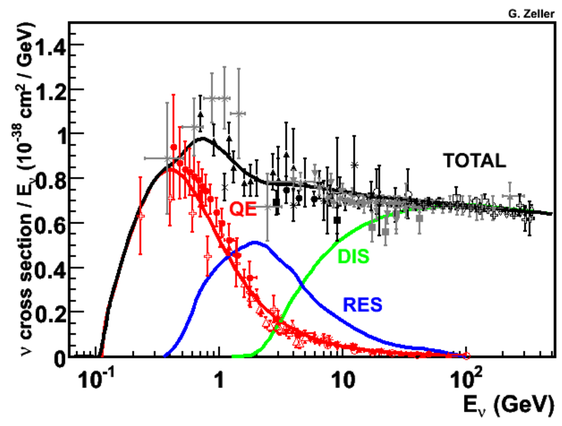


MINERνA uses MINOS near detector as muon spectrometer.
Muons leaving the back of MINERνA can be analysed by MINOS.
Magnetic field in MINOS allows μ momentum and sign reconstruction.

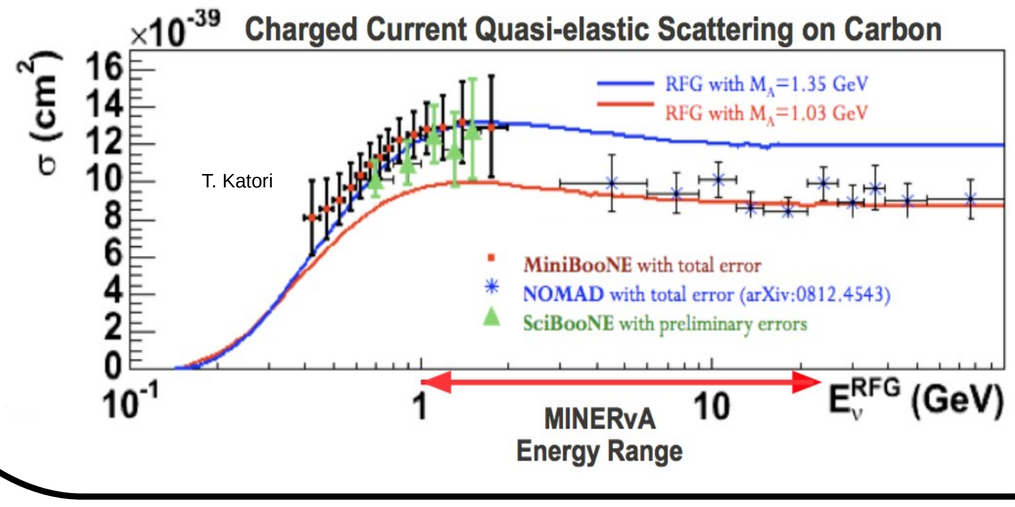
Motivation

CCQE ν Measurements

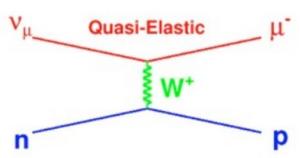
Very important channel for neutrino oscillation experiments.
Extraction of nucleon Axial-Vector Form Factor - the axial vector mass M_A in the dipole approximation.



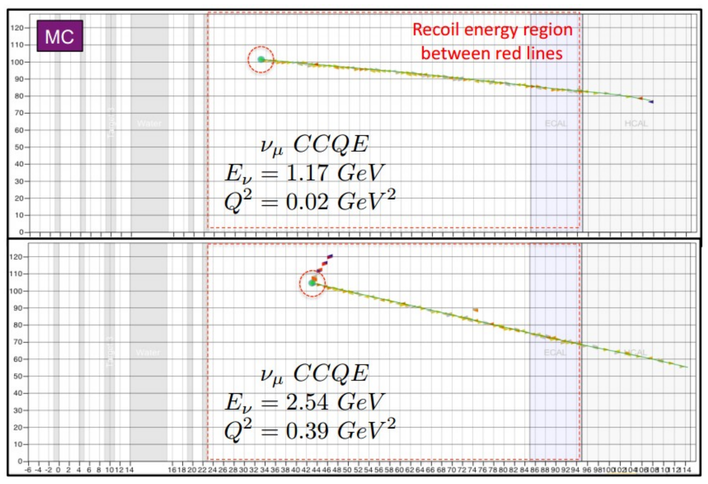
Cross section is only known with large uncertainties and there is inconsistency between experiments.



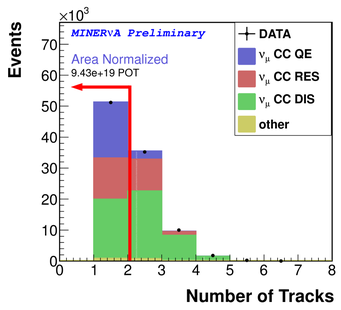
Event Selection



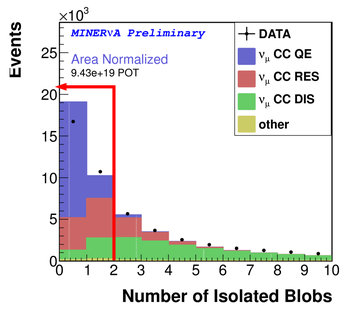
Requires one negative μ reconstructed in the MINOS near detector and with its origin inside MINERνA's fiducial volume.



Only one track (μ track)



Less than 2 isolated energy depositions (blobs)



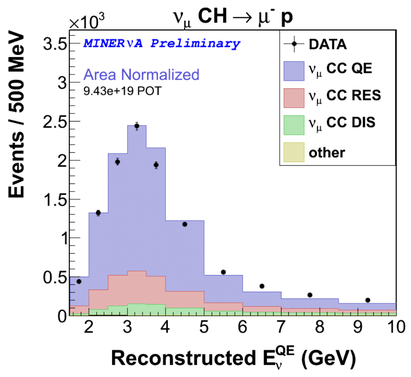
E_ν and Q^2 reconstruction assuming QE kinematics

$$E_{\nu_\mu}^{QE} = \frac{2(m_n-\varepsilon_B)E_\mu - [(m_n-\varepsilon_B)^2 + m_\mu^2 - m_p^2]}{2[(m_n-\varepsilon_B) - E_\mu + p_\mu \cos\theta_\mu]}$$

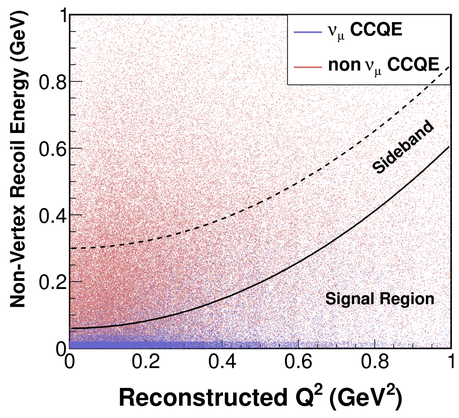
$$Q^2 = 2E_{\nu_\mu}^{QE}(E_\mu - p_\mu\cos\theta_\mu) - m_\mu^2$$

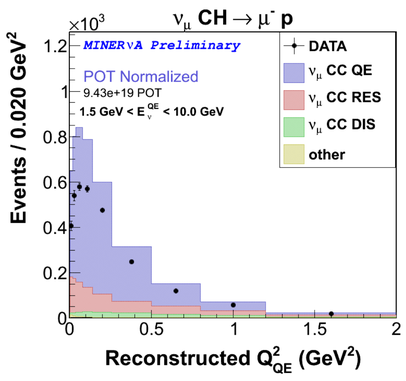
$$\varepsilon_B = 30\ MeV$$

Signal distributions



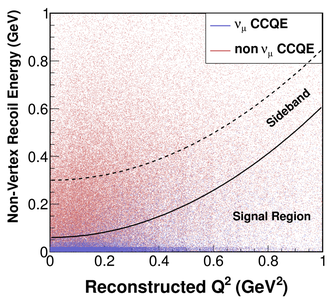
Q^2 dependent recoil energy to reject non-QE events.
To avoid biasing the analysis by relying in the Monte Carlo simulation of vertex energy that is not complete, we select QE events by looking at non-vertex energy. In the future, vertex energy will be studied very carefully.



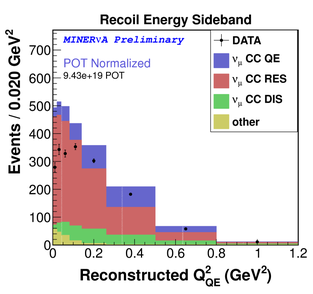


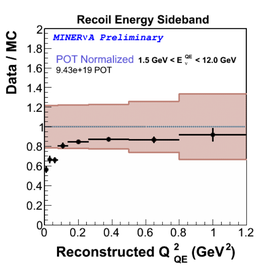
Background Scale

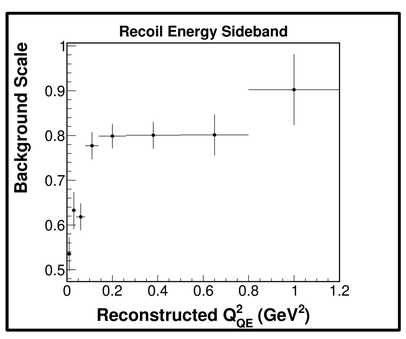
Use Sideband sample, that is dominated by background (non-QE) events, to constraint background.

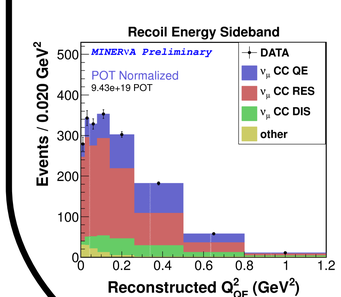


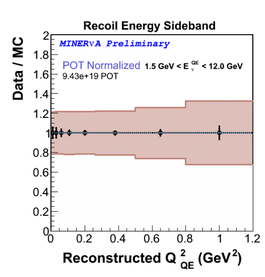
Compute a "Background Scale" as a function of reconstructed Q^2 by comparing Data and MC in Sideband reconstructed Q^2 distribution.





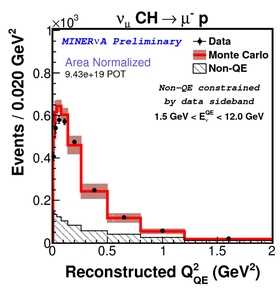


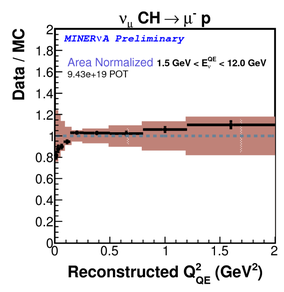




Data and MC agree perfectly after scaling MC background (non-QE) events in Sideband Q^2 distribution.

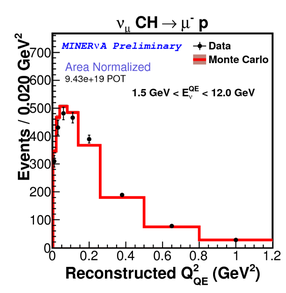
Towards a Cross Section Measurement

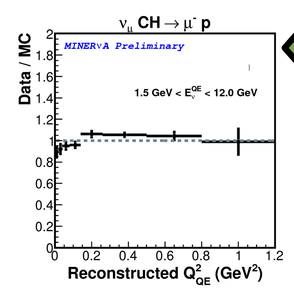




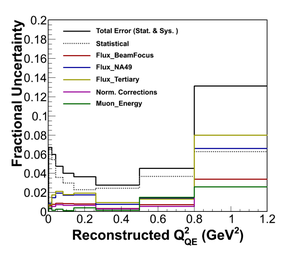
Data shows statistical uncertainty only.
MC shows statistical and systematic uncertainties.

Background Subtraction

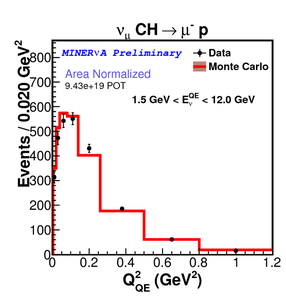


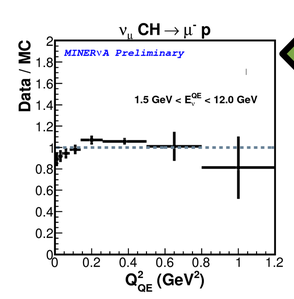


Data shows statistical and background subtraction uncertainties.
MC shows statistical uncertainty only.

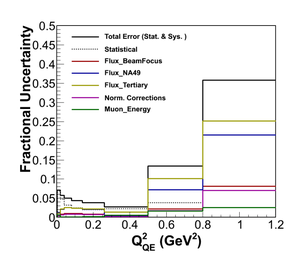


Iterative Bayesian Unfolding





Data shows statistical, background subtraction and unfolding uncertainties.
MC shows statistical uncertainty only.



Efficiency corrected distribution and cross section will coming soon!