Inclusive Charged Current Ratio Measurements in MINERνA

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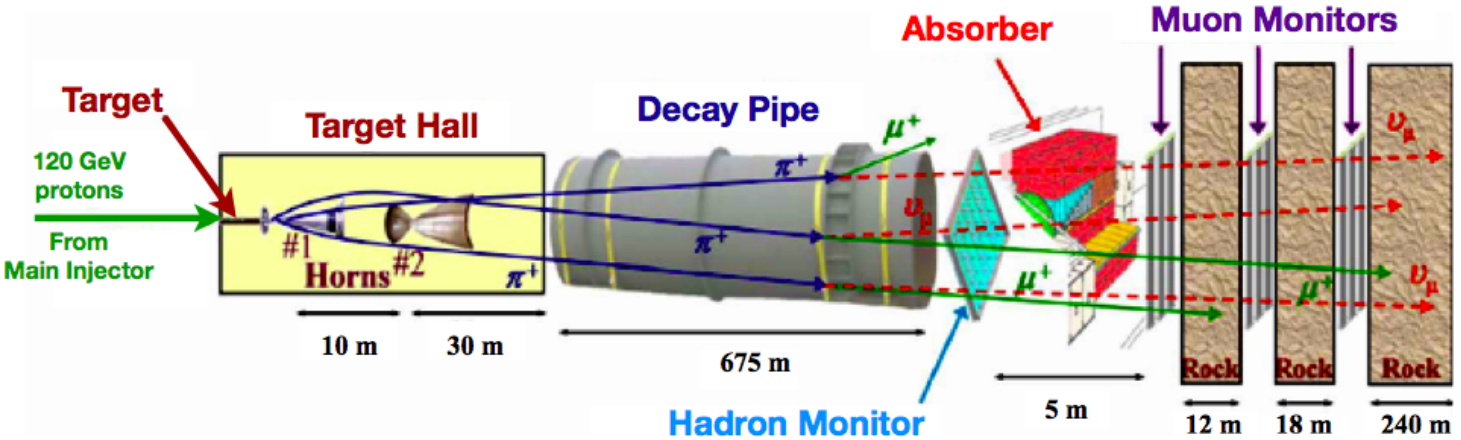
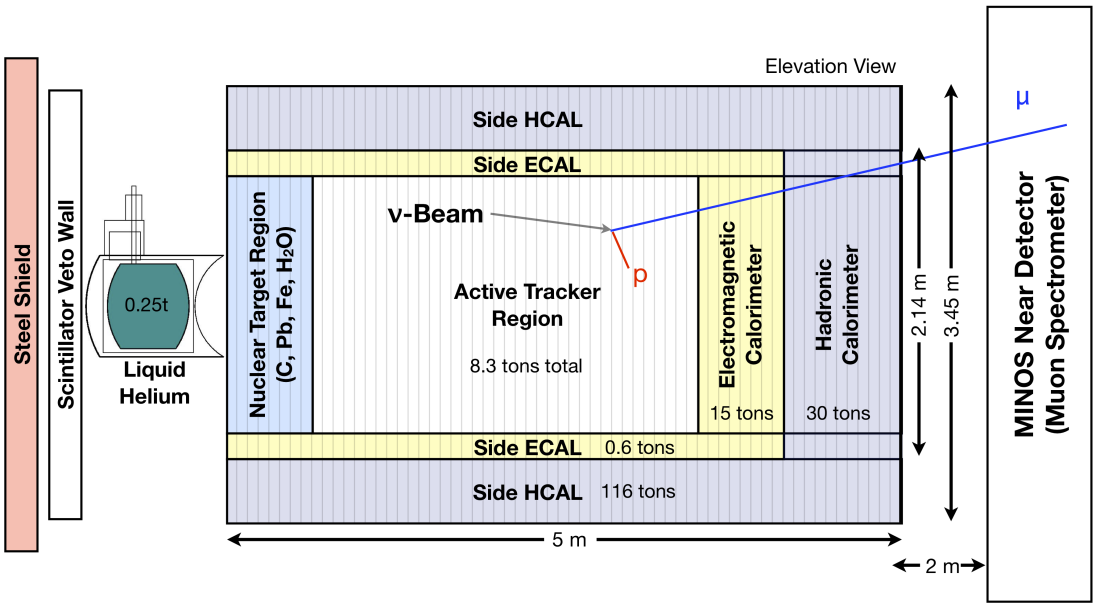
The MINERνA Experiment - Neutrino Beam

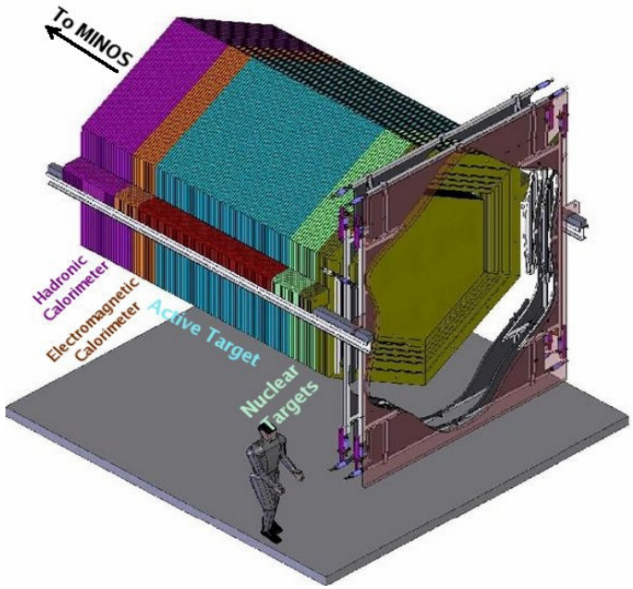


The NuMI beamine, image courtesy of R. Zwaska

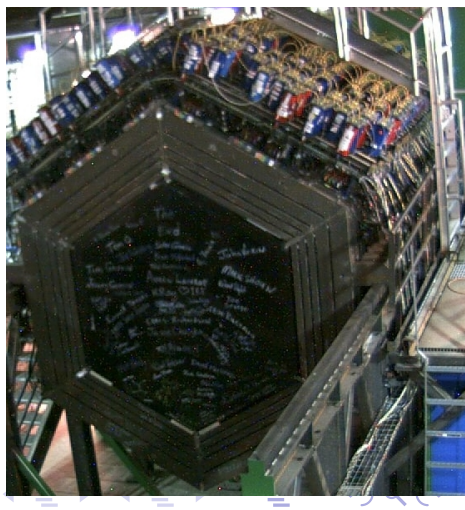
- The NuMI beam is located at Fermilab.
- MINERνA recieves muon neutrinos from the NuMI neutrino beam. It is located with its long axis on the NuMI beam.
- Typical neutrino energies are 1-6 GeV
- J. Walding will discuss this in more detail.

The MINERνA Detector

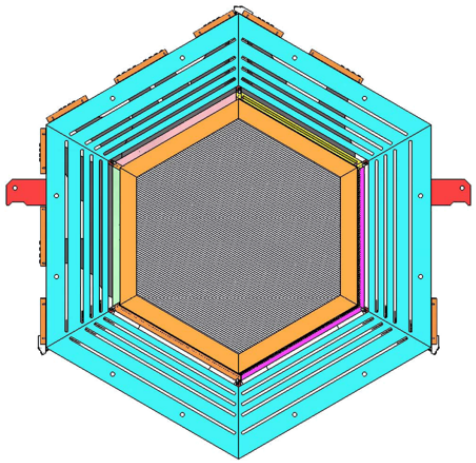




- MINERνA has multiple upstream target materials. (C, CH,Fe,Pb,Water,and liquid He)
- High resolution "Tracker" region (mostly scintillator)
- The "ECAL" calorimetry region is shown in light yellow.
- The "HCAL" calorimetry region is shown in light blue.
- "Outer" detector steel and scintillator region is shown in light blue (Side HCAL).
- MINOS detector (not pictured) acts as muon spectrometer.
- MINOS has a focusing magnetic field.
- note:right hand plots do not show Helium target

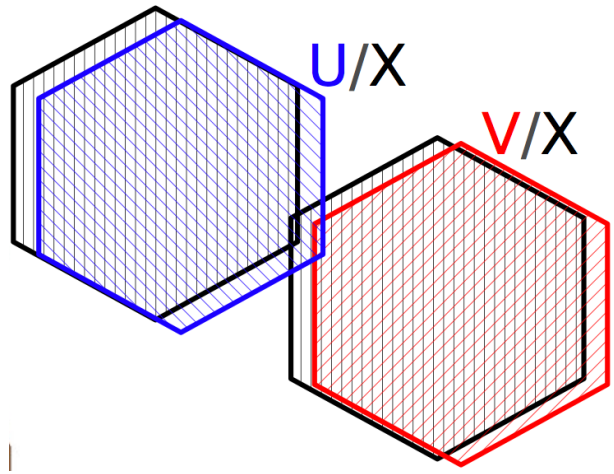


The MINERνA Experiment - Detector Modules



Module Schematic

Nuclear Target Module

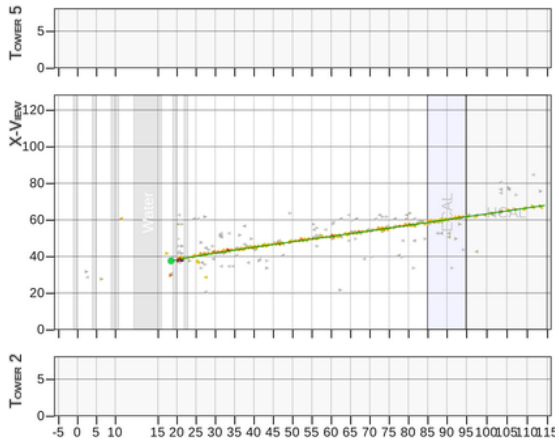


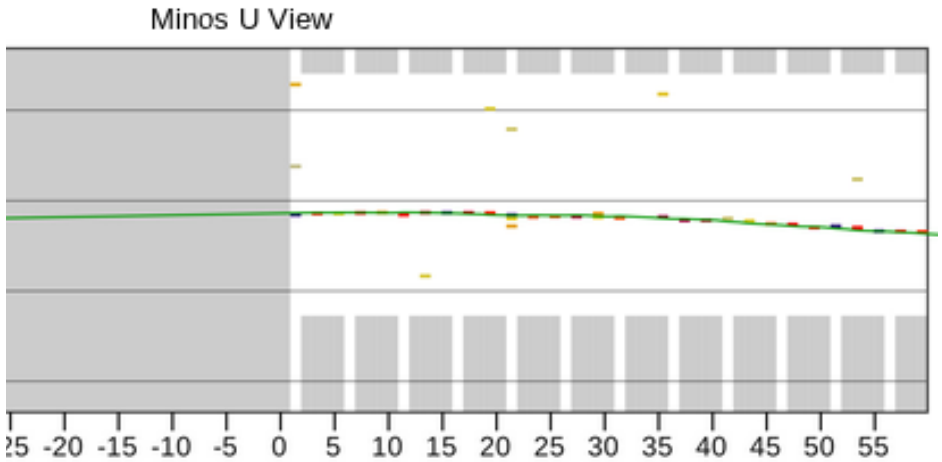
X U and V views

- Each module is a hexagon of active scintillator or target material surrounded by an iron and scintillator "outer detector".
- The outer detector scintillator bars are perpendicular to the radial direction.
- Nuclear target modules contain one or more inactive target materials.
- Scintillator modules contain scintillator strips in one of 3 set directions (X, U, and V).

Reconstruction in MINERνA - Monte Carlo Events

μ enters MINOS

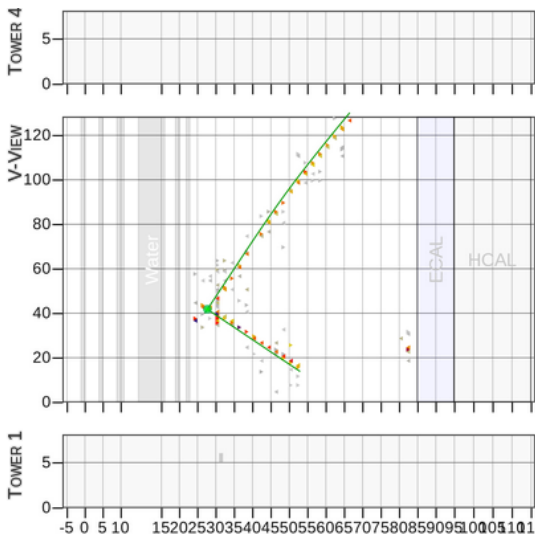




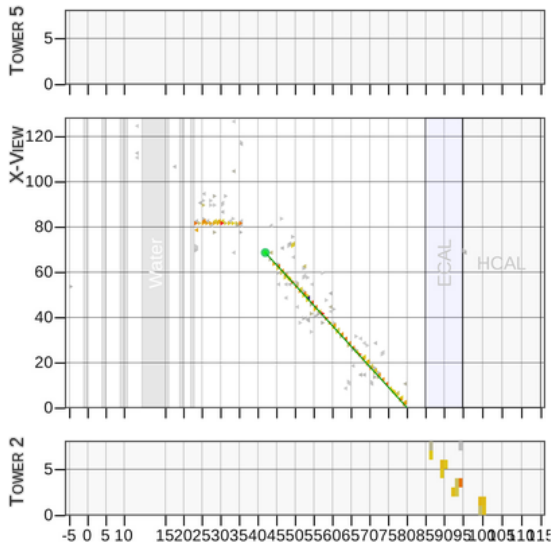
Strip (X) direction $\rightarrow$

Module Number (beam direction) $\rightarrow$

μ leaves Inner Detector?

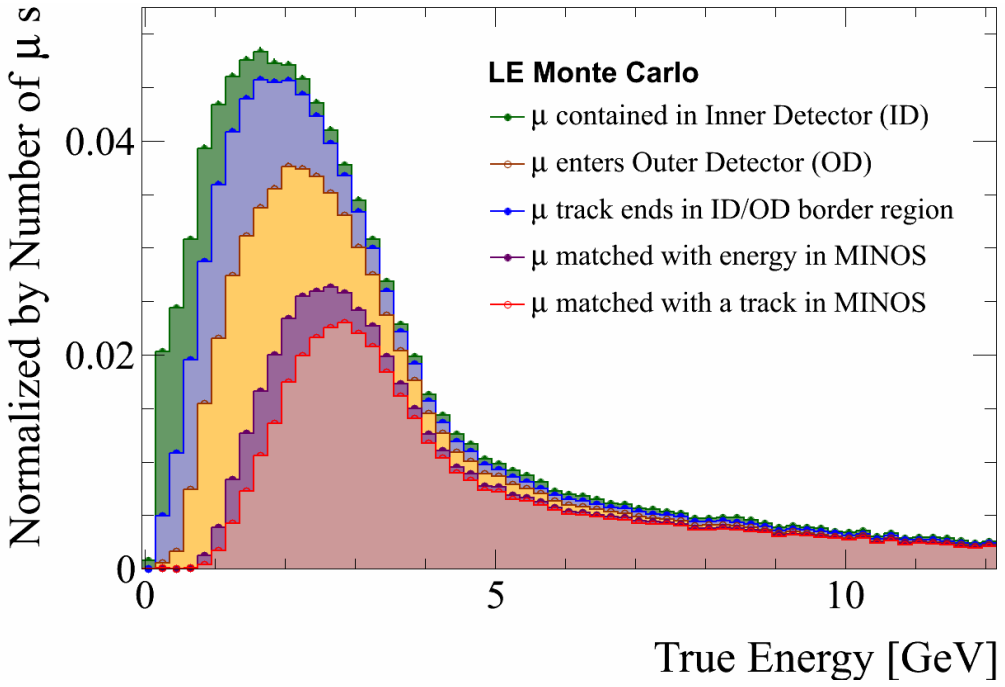


μ leaves Outer Detector?



Muon Selection in MINERνA

Muon identification is important to charged current analyses
($\nu_\mu + N \rightarrow \mu^- + X^+$)



- Muons that enter MINOS can reconstruct charge sign and energy.
- Muons that escape out the sides have lower energy.
- Energy estimate for muons that do not enter MINOS comes from a dE/dx profile.

Future work will incorporate improved energy muons not well contained in the MINERνA or MINOS detectors.

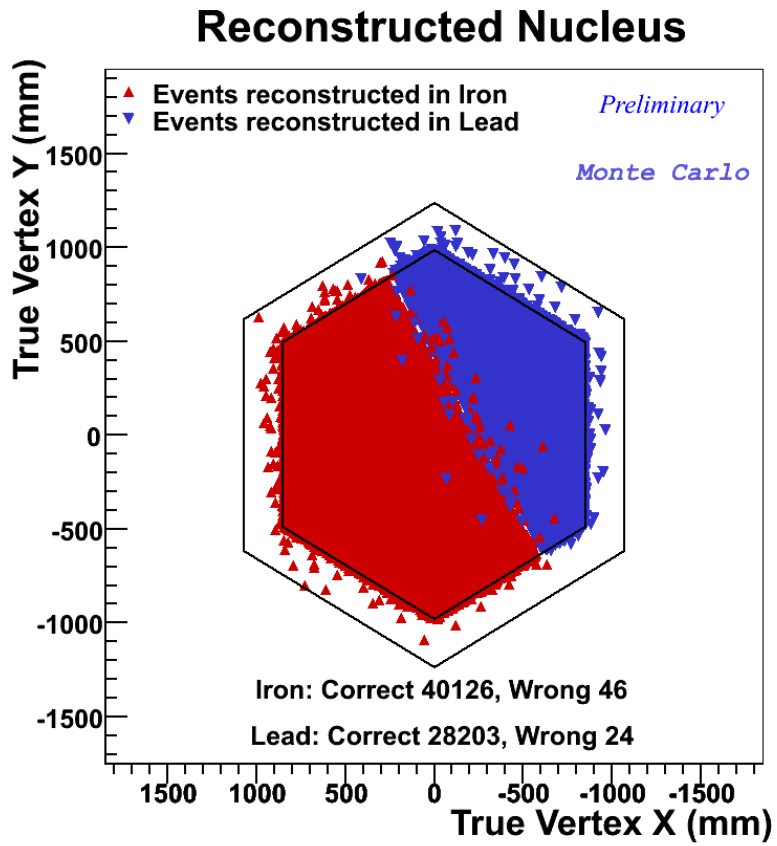
Charged Current Inclusive Ratios

- **Measure the number of charged current events from different targets and take the ratio**
- Neutrino cross sections versus A will provide more detail for neutrino oscillation experiments.
- Ratios probe nuclear effects.
- Inclusive charged current event ***ratios*** are not affected by flux uncertanties.
- Bridge the gap between cross section measurements on different materials with different neutrino beams (different fluxes).

Charged Current Inclusive Ratios in MINERνA Finding the Nuclear Target

By using a ratio of iron to lead, we minimize the cross section uncertainty. This will measure potential nuclear effects dependent on the nuclear size. Selection is events with a minos-matched muon.

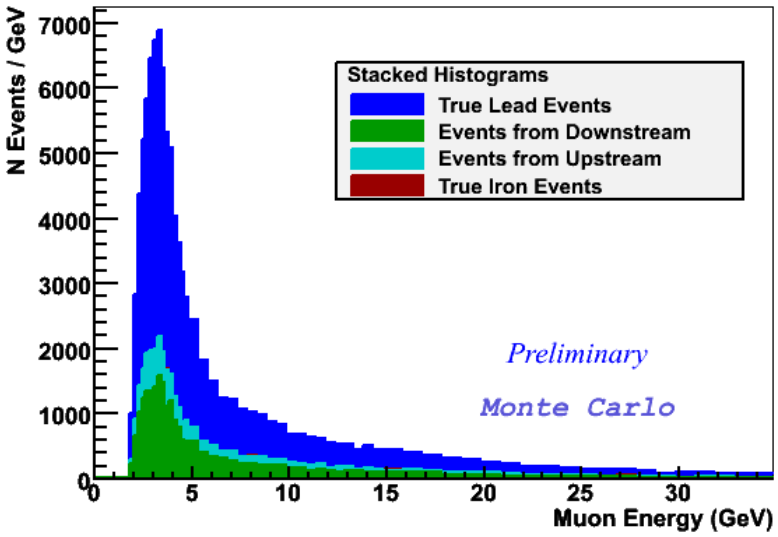
Nuclear Target Module

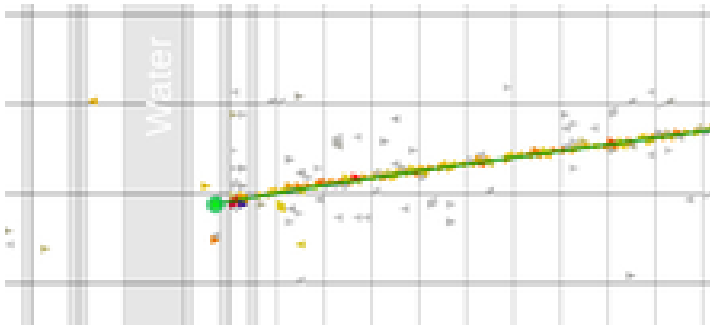


Vertex reconstruction in MINERνA has a low transverse misidentification rate.

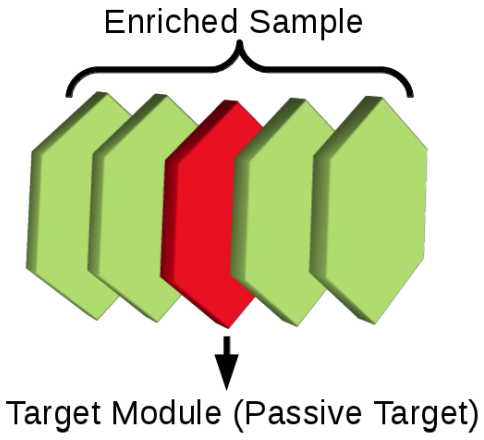
Charged Current Inclusive Ratios in MINERνA Irreducible Backgrounds

Contamination from nearby scintillator planes is inevitable because of passive target material. Use "Enriched" samples that include nearby planes.





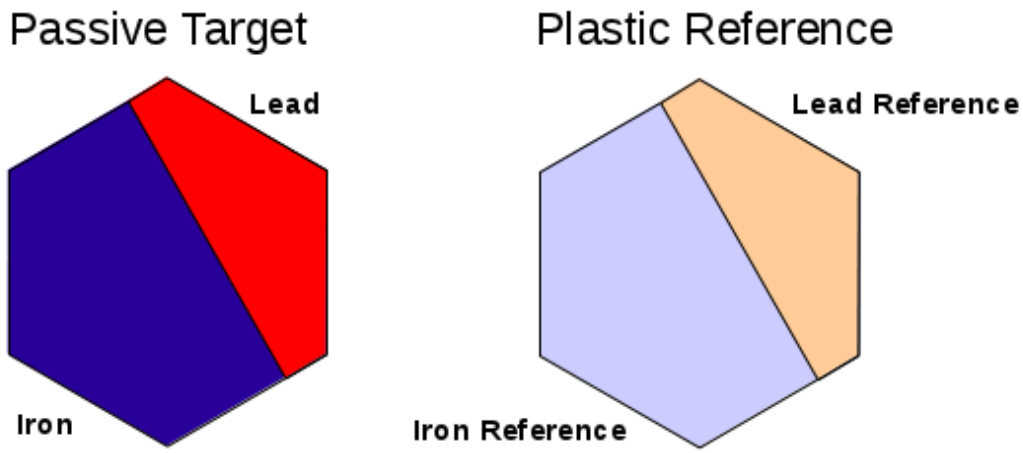
Does this event end in the passive (grey) target or actve (white) plastic?

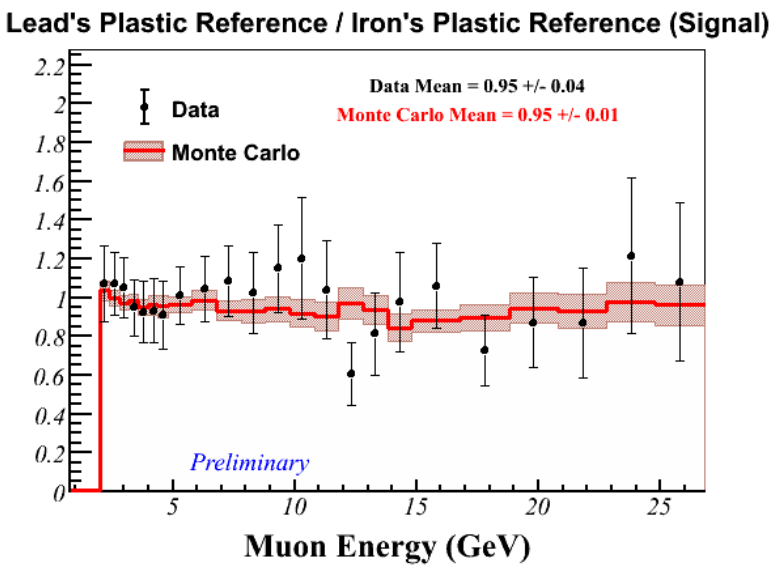


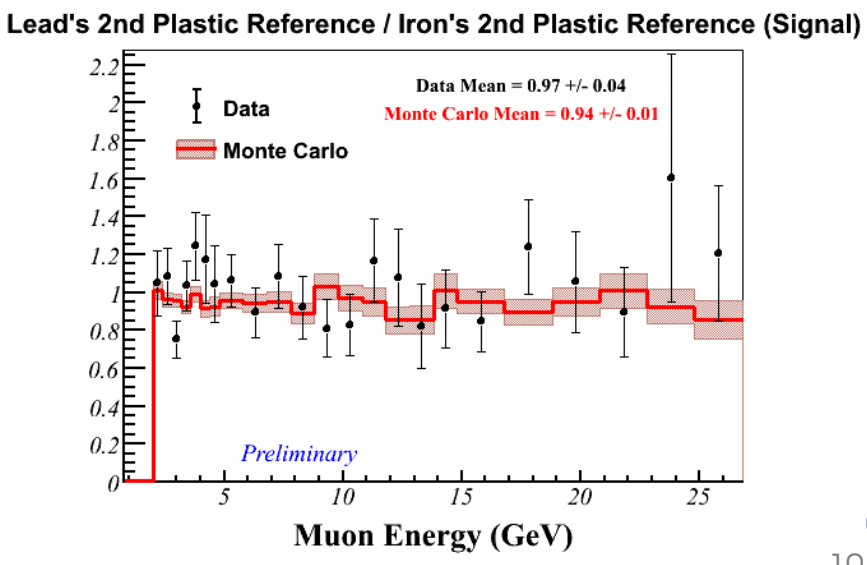
Extrapolate from nearby scintillator planes to estimate the plastic component to each signal.

Charged Current Inclusive Ratios in MINERνA Estimate Geometric Acceptance Effects

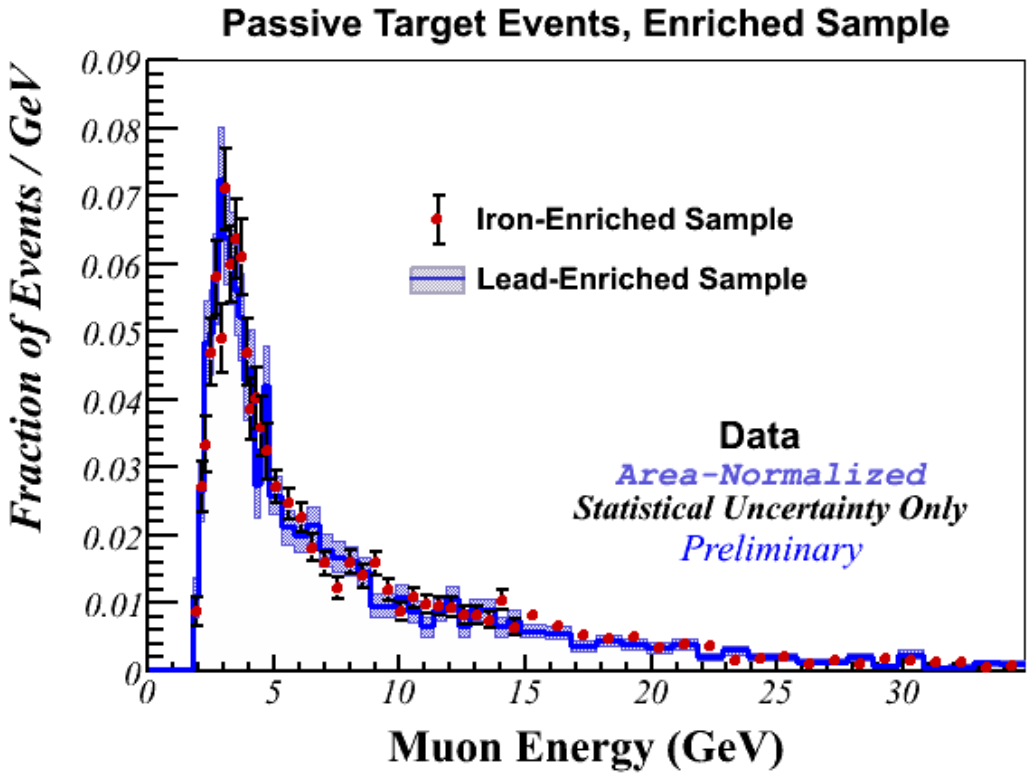
A plastic (CH) reference with the same geometry as the target to reduce differences due to geometric effects







Charged Current Inclusive Ratios in MINERνA Final Thoughts



- Only muons that pass through minos are used in this sample.
- 910^{19} POT - 20% of the expected data.

Summary

- MINERνA is a unique detector that is making strides in precision measurements of neutrino cross sections at low energy.
- A variety nuclear targets allow for detailed measurements of cross sections versus A.
- Inclusive cross section ratio measurements are a priority measurement for MINERνA with results expected soon.
- Currently working on improvements to tracking, vertexing, increasing the low-energy muon sample.
- Thank you for your attention!

The Minerva Experiment

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Centro Brasileiro de Pesquisas Fisicas, Rio de Janeiro, Brazil
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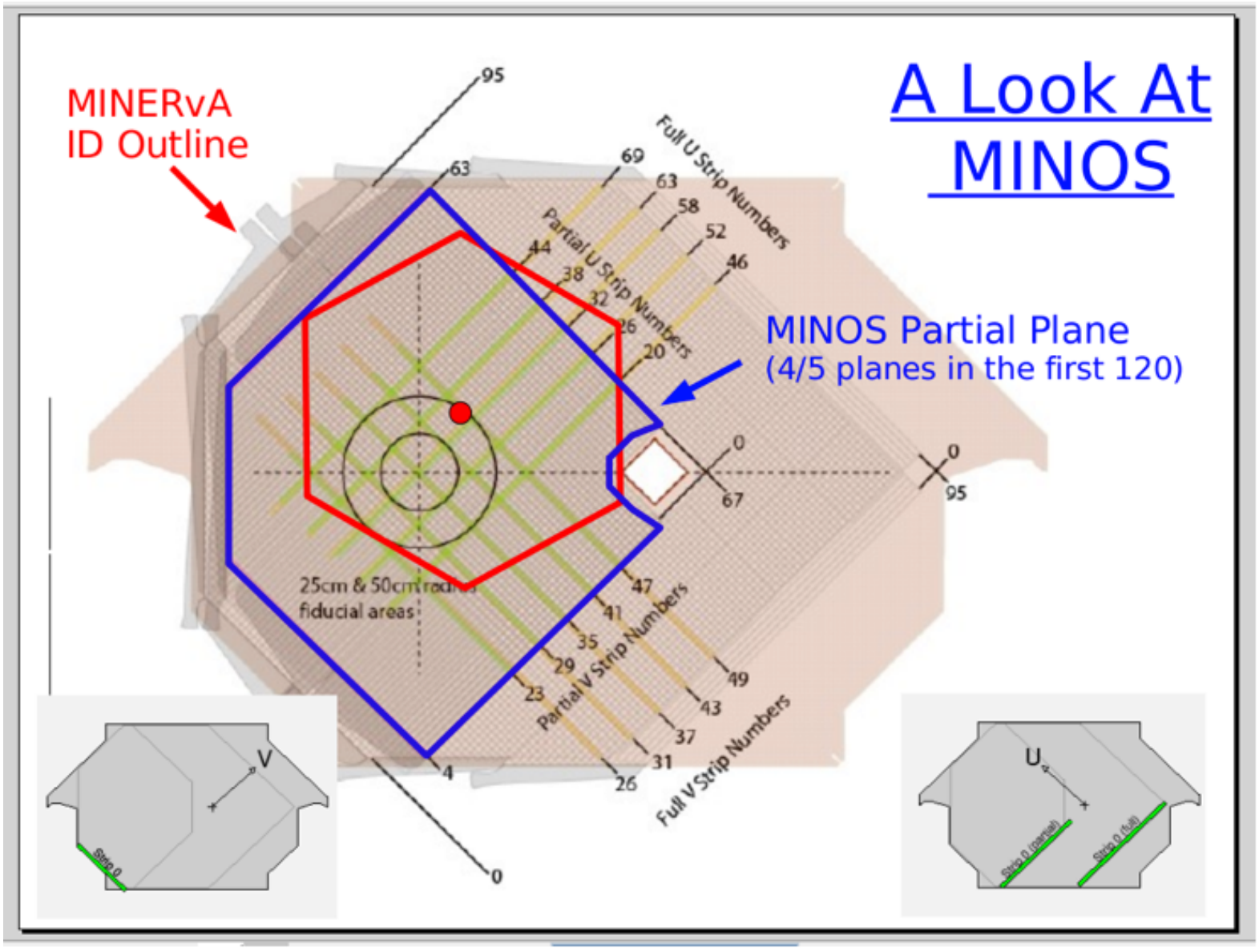
Fermi National Accelerator Lab, Batavia, IL
University of Florida, Gainsville, FL
Universidad de Guanajuato, Guanajuato, Mexico
Hampton University, Hampton, VA
Institute for Nuclear Research, Moscow, Russia
James Madison University, Harrisonburg, VA
Mass. Coll. of Liberal Arts, North Adams, MA
University of Minnesota-Duluth, Duluth, MN
Northwestern University, Evanston, IL
Otterbein College, Westerville, OH
University of Pittsburgh, Pittsburgh, PA
Pontificia Universidad Catolica del Peru, Lima, Peru
University of Rochester, Rochester, NY
Rutgers University, Piscataway, NJ
Universidad Tecnica Federico Santa Maria, Valparaiso, Chile
University of Texas, Austin, TX
Tufts University, Medford, MA
Universidad Nacional de Ingenieria, Lima, Peru
College of William & Mary, Williamsburg, VA

Backup Slides

Minos /Minerva Transverse view



Extrapolation of CH