Beam Energy Studies at the Minerva Test Beam Detector

Aaron Bercellie

2015 New Perspectives
On Behalf of the Minerνa Test Beam II Group

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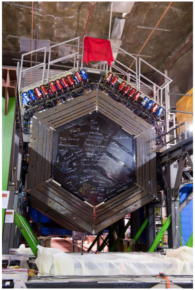
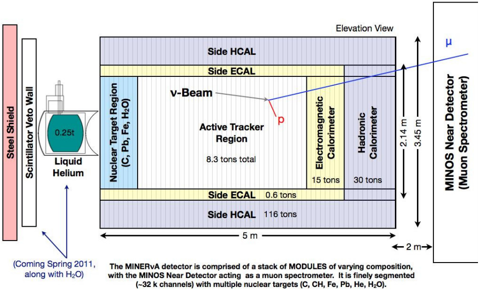
UNIVERSITY of ROCHESTER

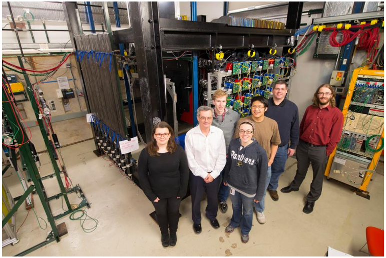
The MINERνA Experiment





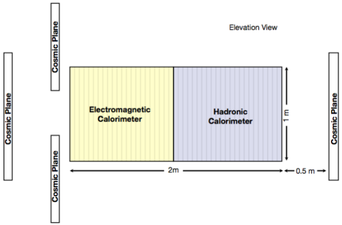
- The largest systematic concern of current generation neutrino oscillation experiments (T2K, NOνA) is the prediction of background events
  - The uncertainties in nucleon and nuclear models make predicting these events difficult
- Since 2010, MINERνA has collected data on neutrino cross sections using the NuMI beamline at Fermilab
  - Charged particles are tracked by strips of scintillator arranged in planes
  - Has multiple heavy nuclei targets upstream of this tracking region
  - Uses the downstream MINOS near detector as a muon catcher

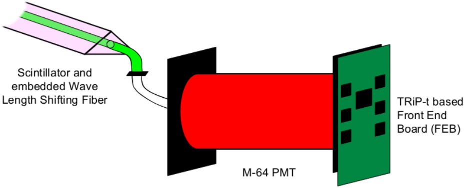
MINERνA Test Beam

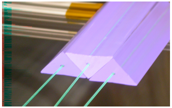


- In order to measure the correct cross section, we must measure the kinematics the particles produced by the neutrino interaction
- Therefore, we must understand the response of charged particles within our detector over a wide range of energies
- Using the same type of detector technology used in the MINERνA main detector, we have built a smaller detector at the Fermilab Test Beam Facility (FTBF)
  - MINERνA Test Beam uses the MTEST beamline, which delivers a secondary beam of specified momentum and polarity to our test beam detector
- Primary objectives focus on analyzing the energy response of the detector as well as the properties of hadronic and electron showers
  - Understanding how electrons shower within the MINERνA detector lowers the systematic uncertainties in measurements of ν_e CCQE and ν_e elastic scattering (see talk by E. Valencia)

MINERνA Test Beam Detector and Technology

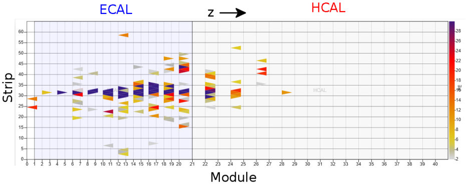




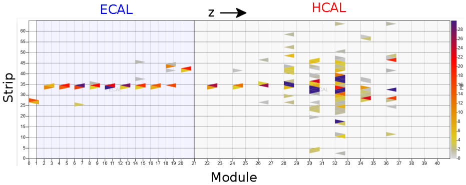


- The MINERνA Test Beam detector has active tracking planes stacked with passive material
- Easily reconfigurable to study different particle responses
- Various subdetectors allow for particle identification and quality control
  - Have the ability to trigger or veto electron events
- Active tracker is made of scinitillator strips which produce light which is collected by wave length shifting fiber
  - Downstream moving particles must go through at least 2 strips due to the triangular design
- A 64 channel photomultiplier tube amplifies the scintillated light into charge, which is then digitized and stored on a front end board

First Results

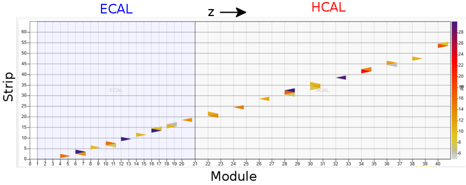


8 GeV e^+ Shower



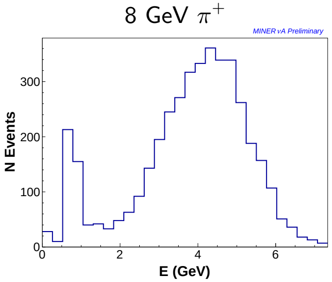
8 GeV π^+ Shower

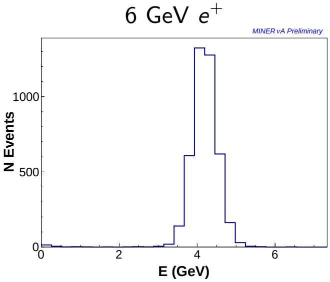
- First data run was taken during April and May of this year
- There are two separate data sets: one where electrons are selected from the beam, and one where the electrons are vetoed so we can study muons and pions
  - These Arachne event displays show the behavior of the particle species in our detector
- One of the first tests of our data looks at the distribution of total energy deposited in our detector

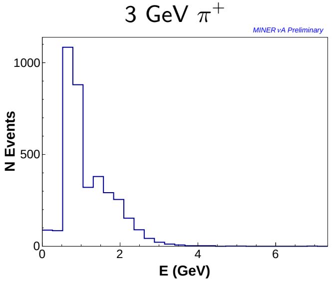


Cosmic Muon

Energy Distributions

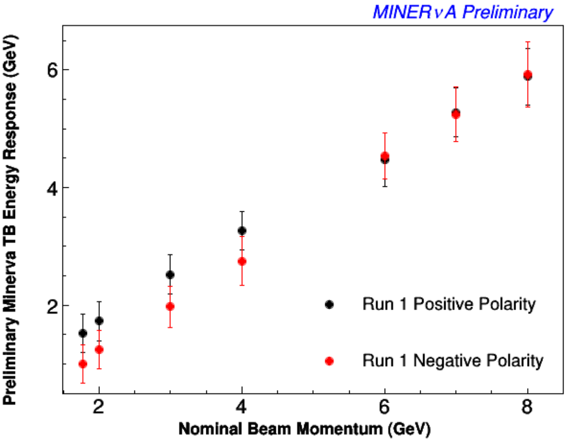






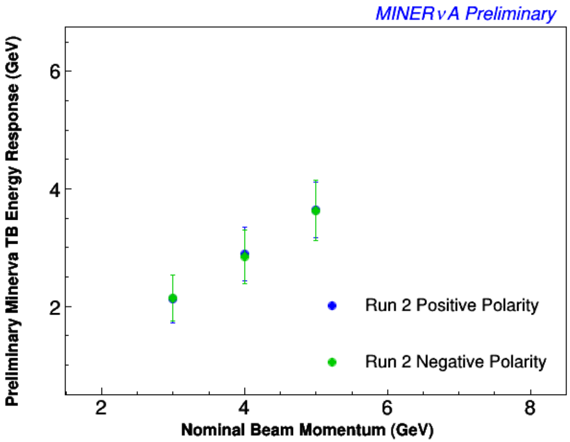
- For our pion runs, we can clearly see two distinct peaks
  - The peak on the left is the energy distribution of muons
  - The peak on the right is the energy distribution of pions
  - At lower energies, these two peaks overlap, making particle identification difficult
- For the electron runs, there is one clearly defined peak
  - Allows for a comparson of detector response over all energies

Discrepancy in the Electron Data



- Looking at our entire electron data set, we noticed that there was a discrepancy between the energy deposited for positive and negative polarity
  - No physics justification for the discrepancy from the detector technology

An Early Success



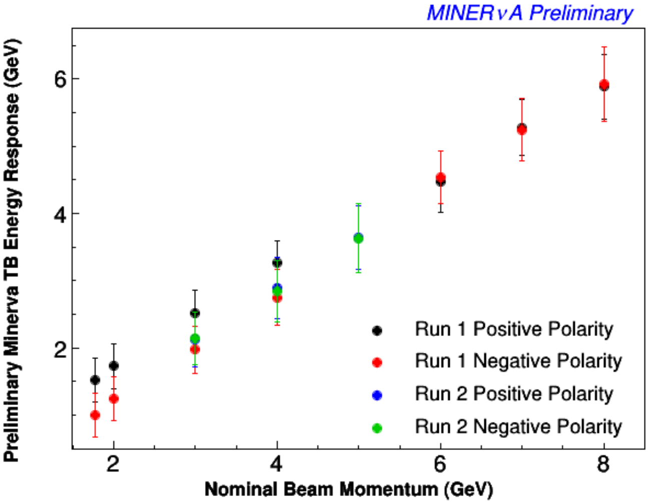
- The MINERνA Test Beam group has worked closely with the Accelerator Division in order to improve the tuning of the beam
  - There was a miscalibration in the probes which measured the magnetic field strength, leading to an incorrectly reported momentum
- New data taken after recalibrations show improvement in consistency between polarities

Conclusions

- Our early data analysis has shown the capabilities of the MINERνA test beam detector
- MINERνA Test Beam will continue to collect and analyze data on detector response to improve the systematic uncertainties of the MINERνA experiment
- Plan to see more results from our medium energy runs the main detector

Backup slides

Electron Response with Run 1 and 2 Data



Absolute Energy Calibration Using of Out of Spill Muons

- Used three cuts to isolate out of spill particles that go through most of the detector
    1. Looked at hits with PE$\geq$ 5 (cut out noise)
    2. Removed contributions from the first two and the last two planes (greater cosmic variation)
    3. Must got through 32 of the remaining 37 planes
- To get the conversion factor, compare the peak of the unweighted PE per plane with the peak of the Landau distribution
- For all run configurations, the peak of the unweighted PE per plane is on average at 22.67 PE
    - For TBI, the peak was found at 21.9 PE
- Testbeam I MC showed the peak of the Landau distribution at 2.97 MeV for ECAL/HCAL
- Therefore, one can estimate a rough conversion of 7.6 PE/MeV