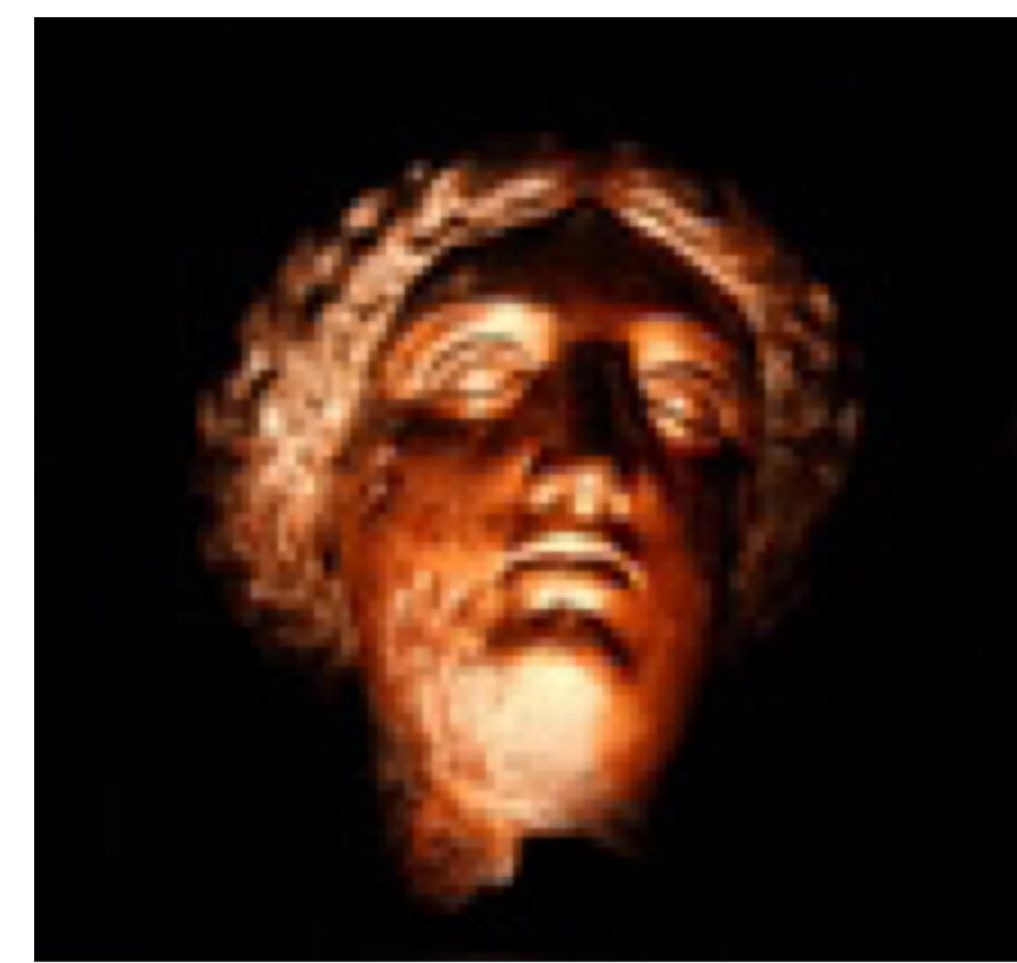
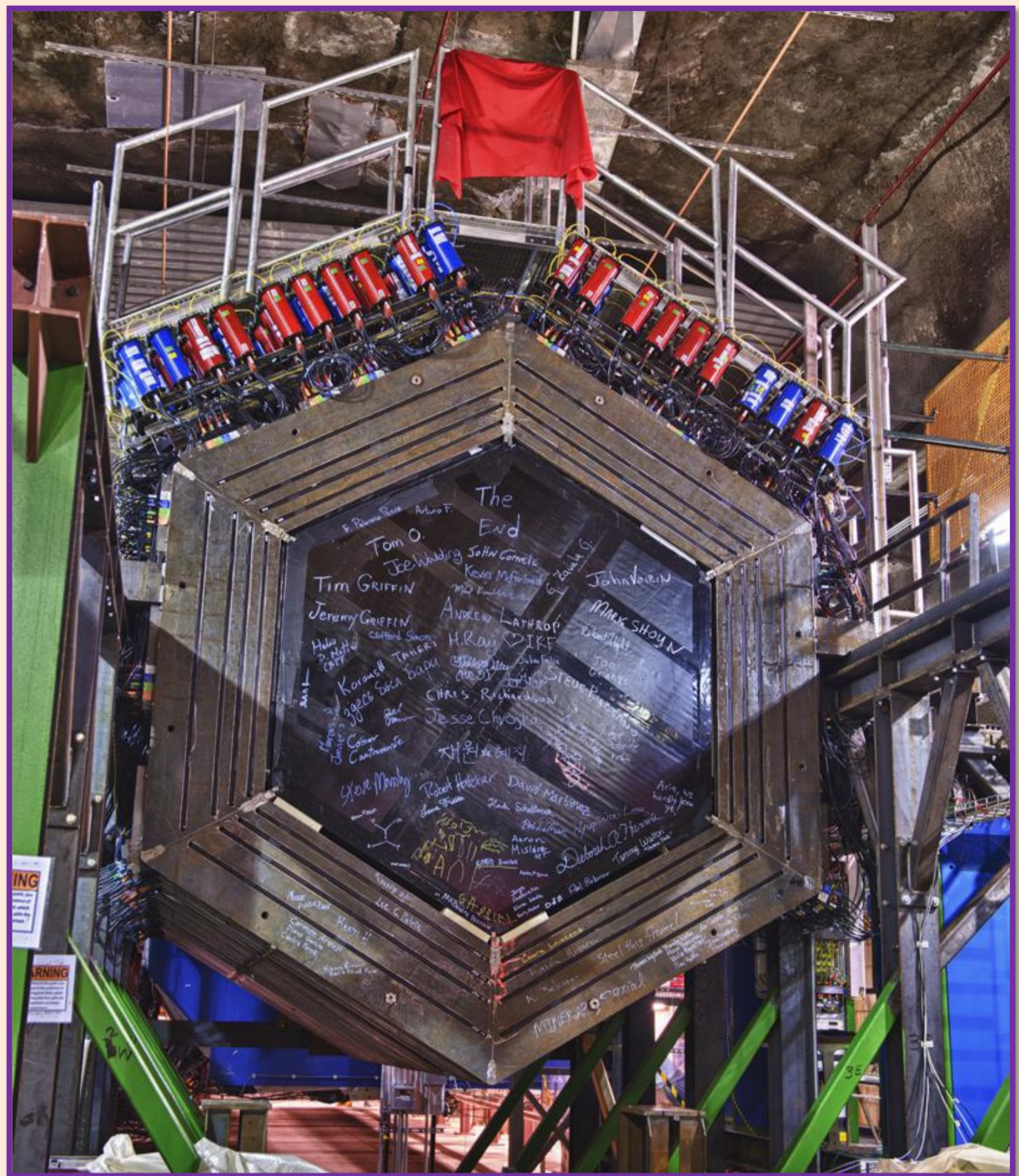


# Calibrating MINERvA: $\nu$ beam and $e, p, \pi^\pm$ test beam

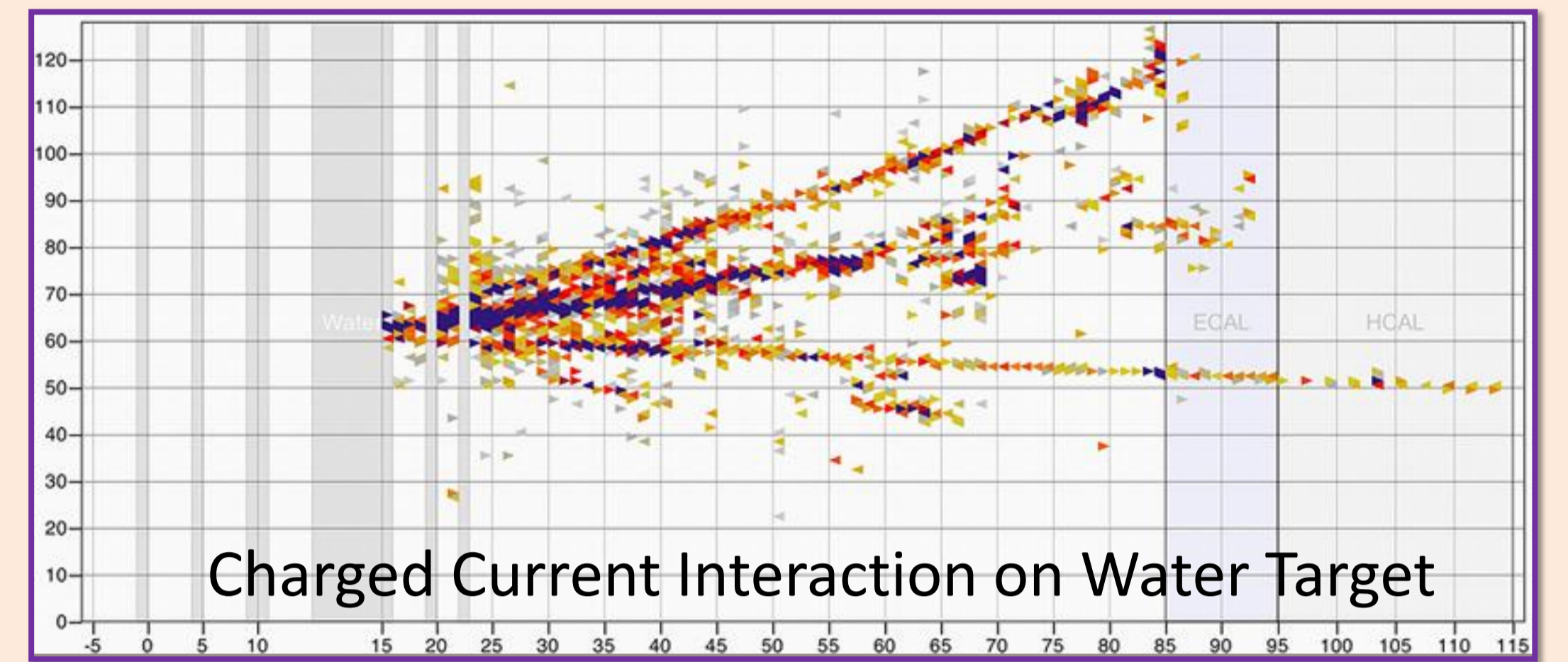
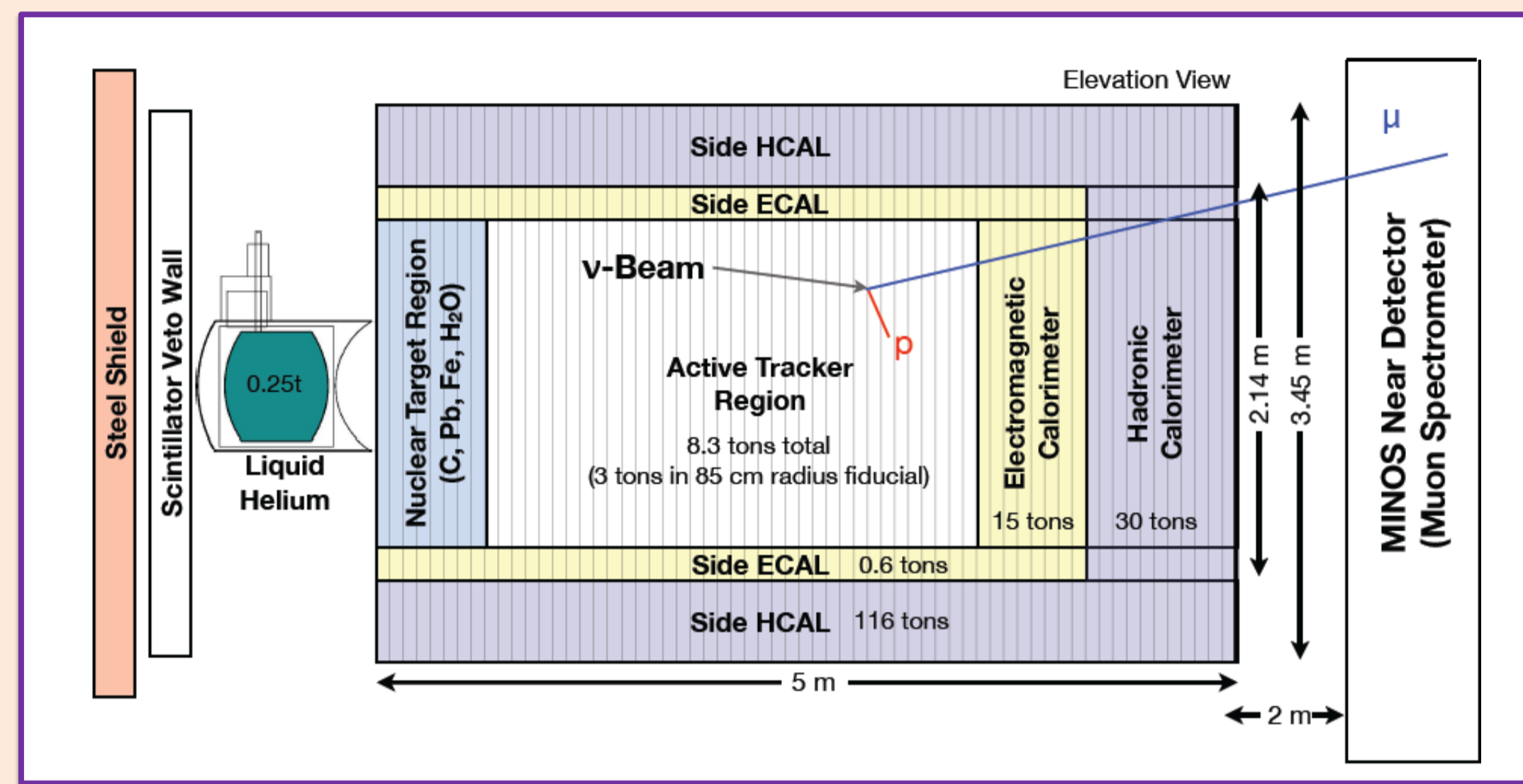
Deborah Harris, Fermilab • Chris Marshall, University of Rochester  
on behalf of MINERvA



## MINERvA is a dedicated neutrino-nucleus cross-section experiment



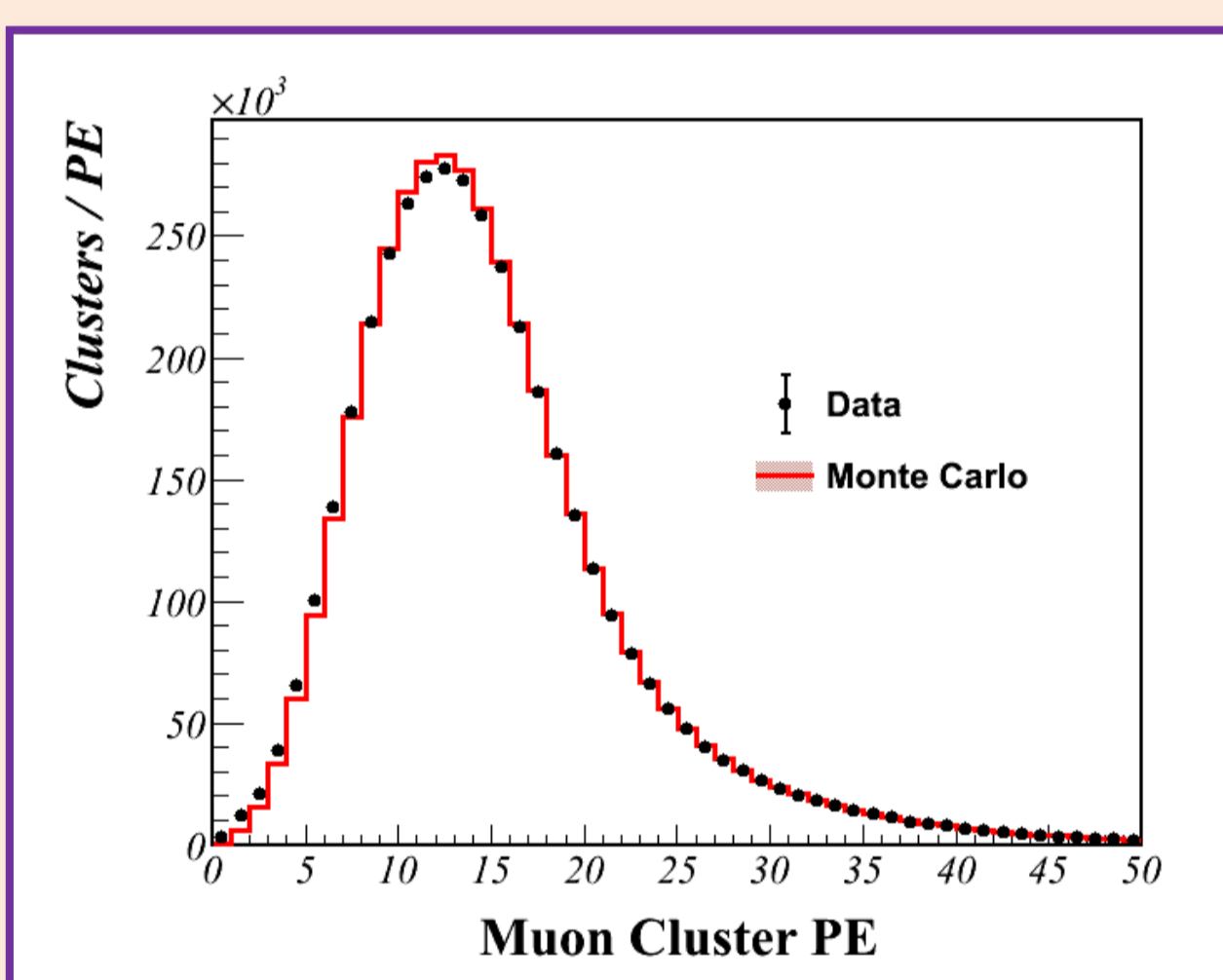
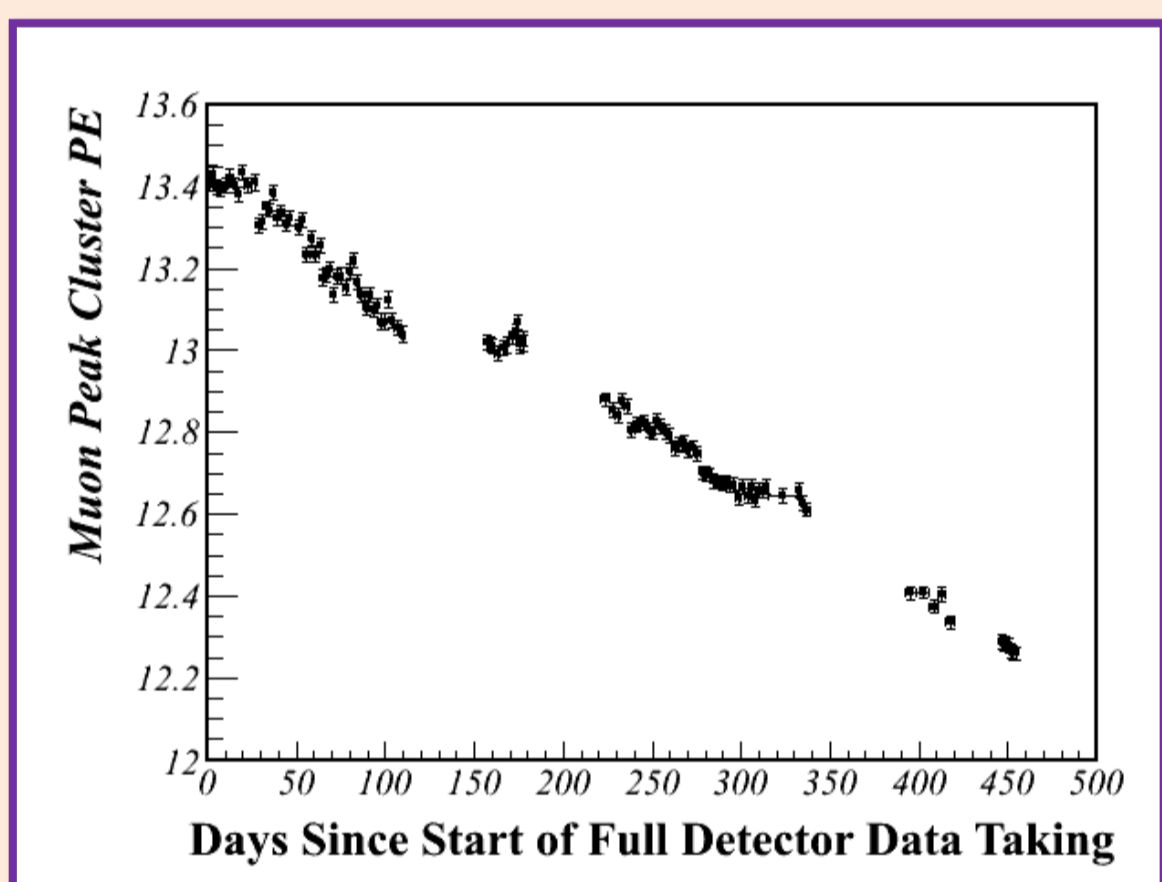
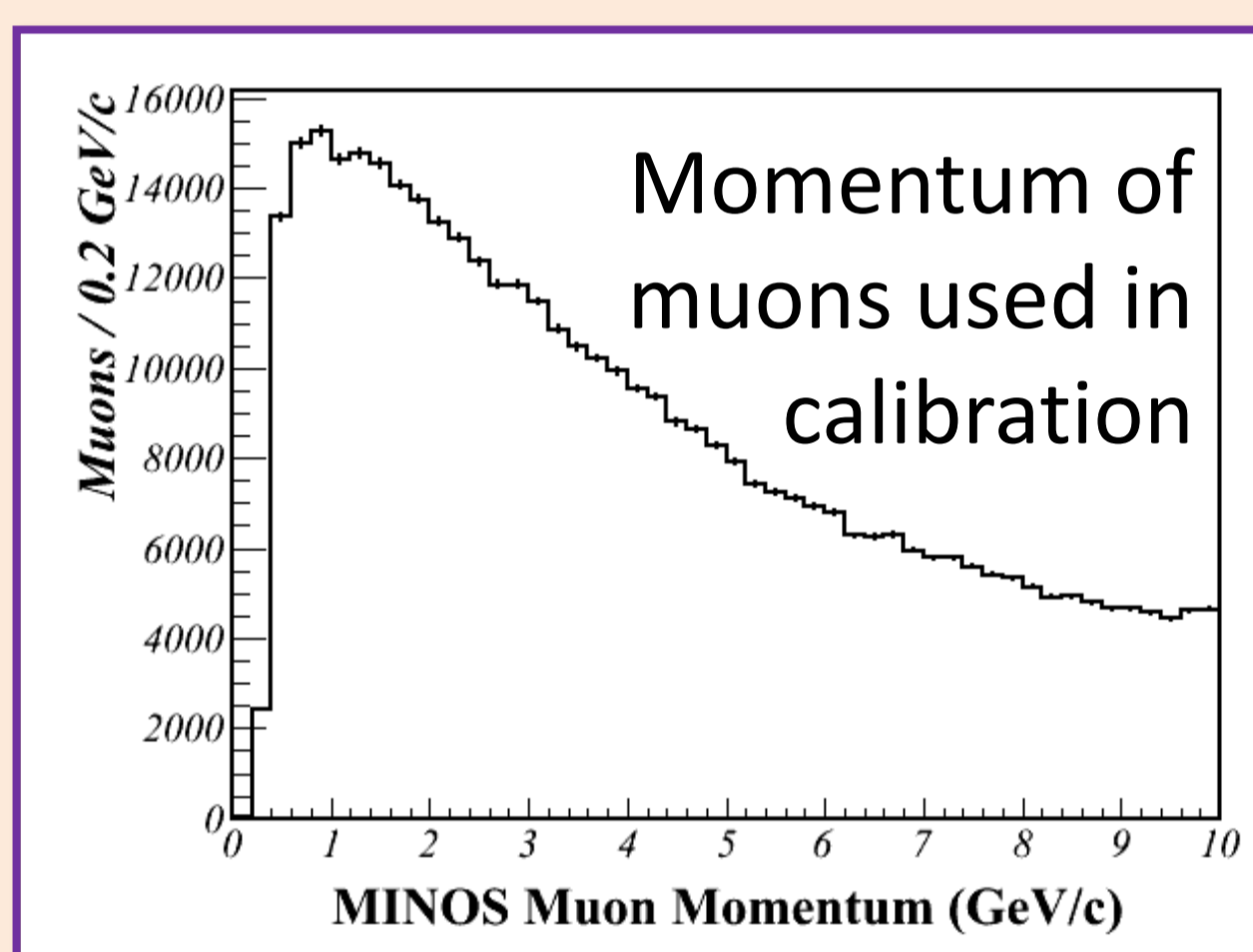
- Will provide important input to future neutrino oscillation experiments
- Single detector with multiple nuclear targets allows study of nuclear effects in  $\nu$  interactions
- Makes use of the NuMI neutrino beam and the MINOS Near Detector at Fermilab
- Active detector: triangular scintillator bars form 1.7cm thick planes, WLS and clear fiber cables to PMT's
- Downstream Calorimetry: 20 planes interleaved with 2mm Pb (ECAL) then 20 with 2.54cm steel (HCAL)



## In Situ ( $\nu$ beam) Calibration

### Muons

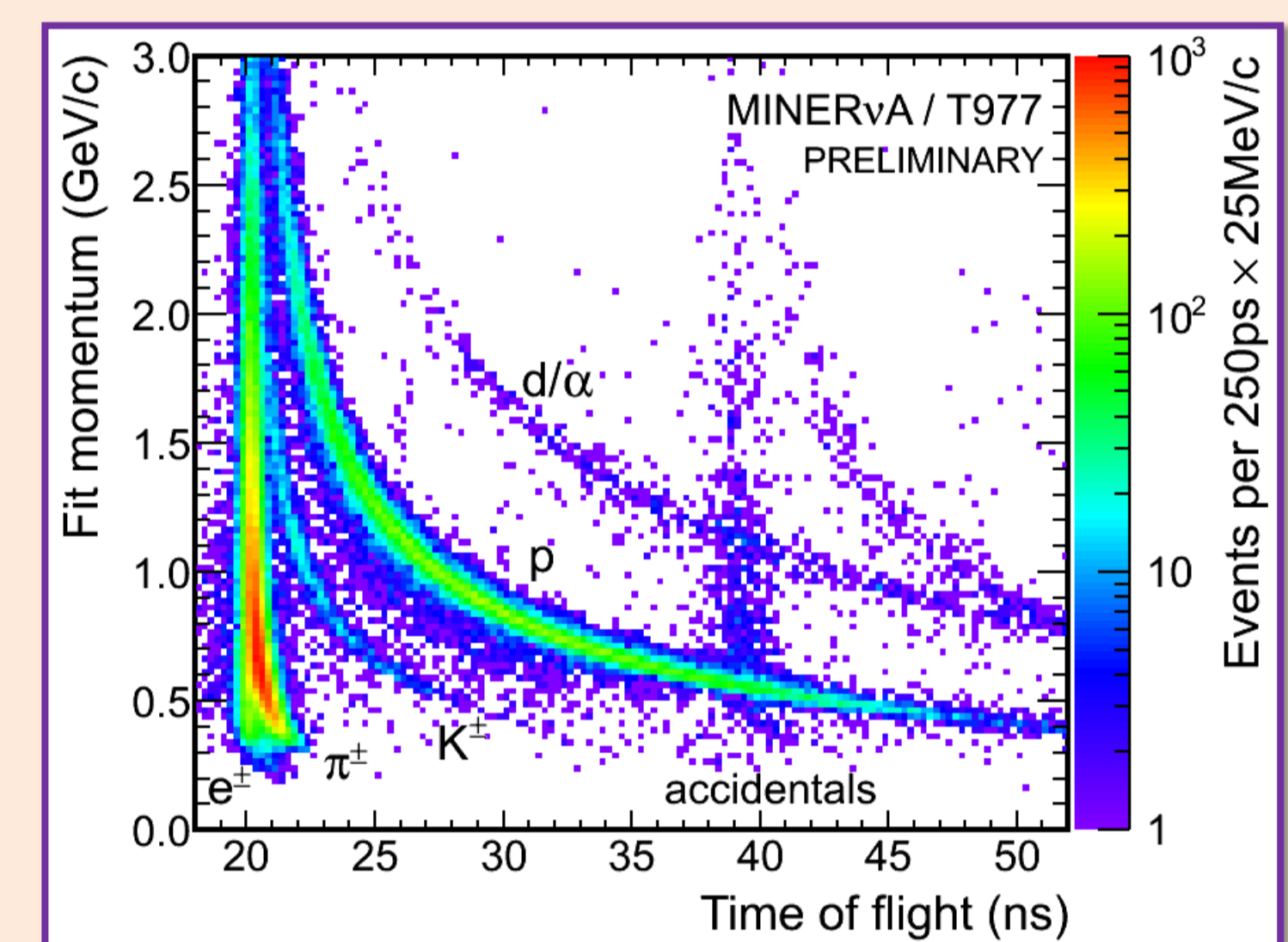
$\nu_\mu$  interactions in the rock upstream of the detector provide a continuous calibration source of known energy deposition. Observe light yield loss of (7-10%/year) over time from scintillator aging at 80°F.



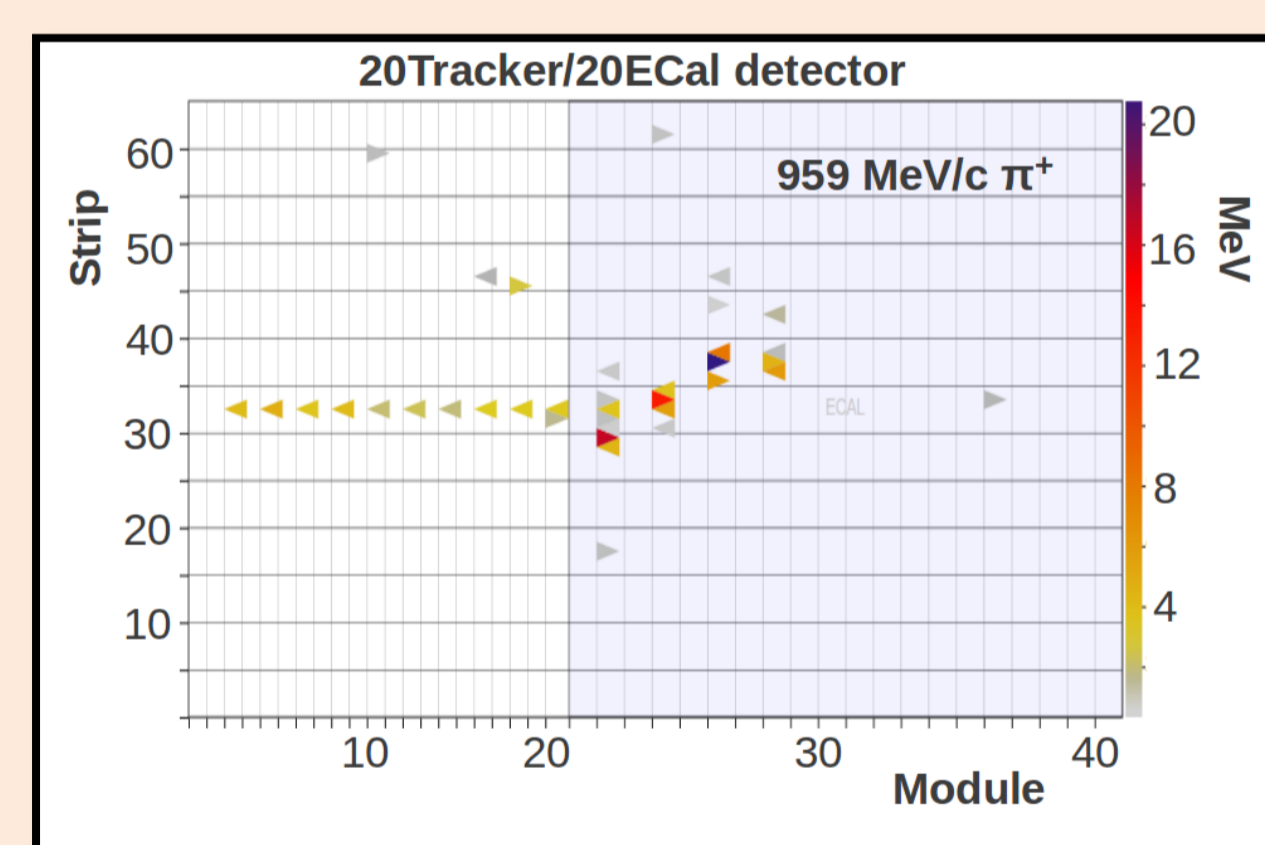
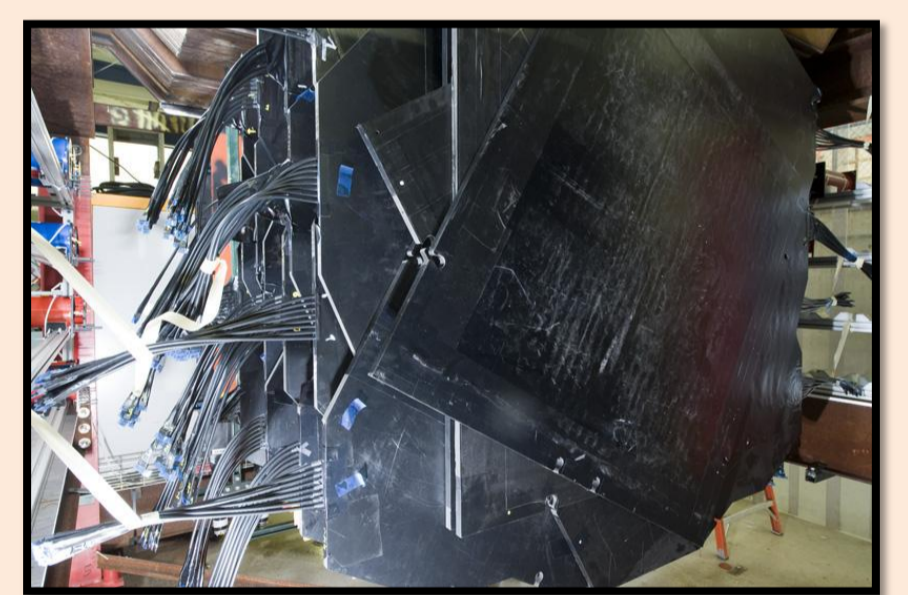
## Test Beam Calibration



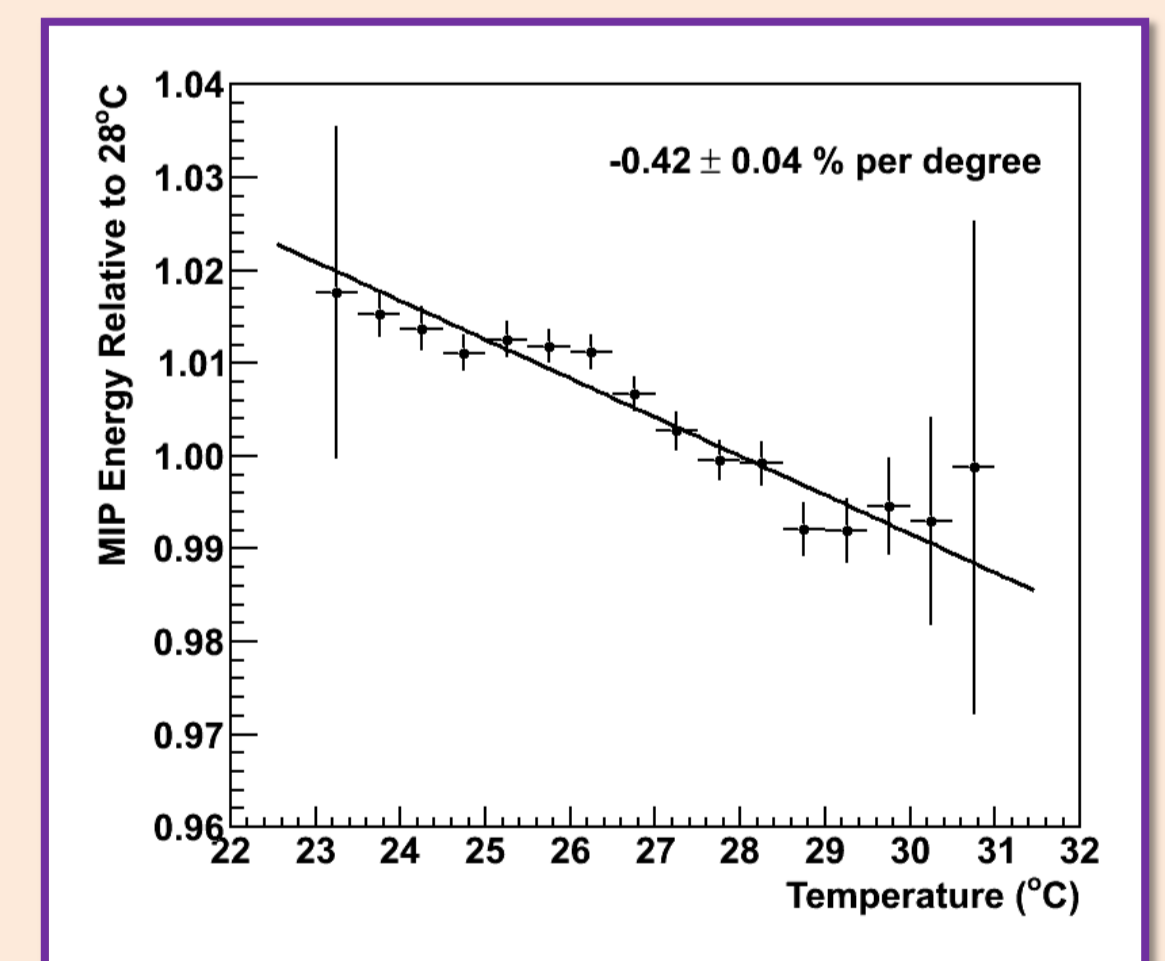
At the Fermilab Test Beam Facility: 16 GeV incident  $\pi$  beam on Cu followed by collimator, spectrometer, and time of flight system



Test Beam Detector: 40 (1.1m)<sup>2</sup> planes with reconfigurable absorbers (steel, lead), to test different parts of full detector

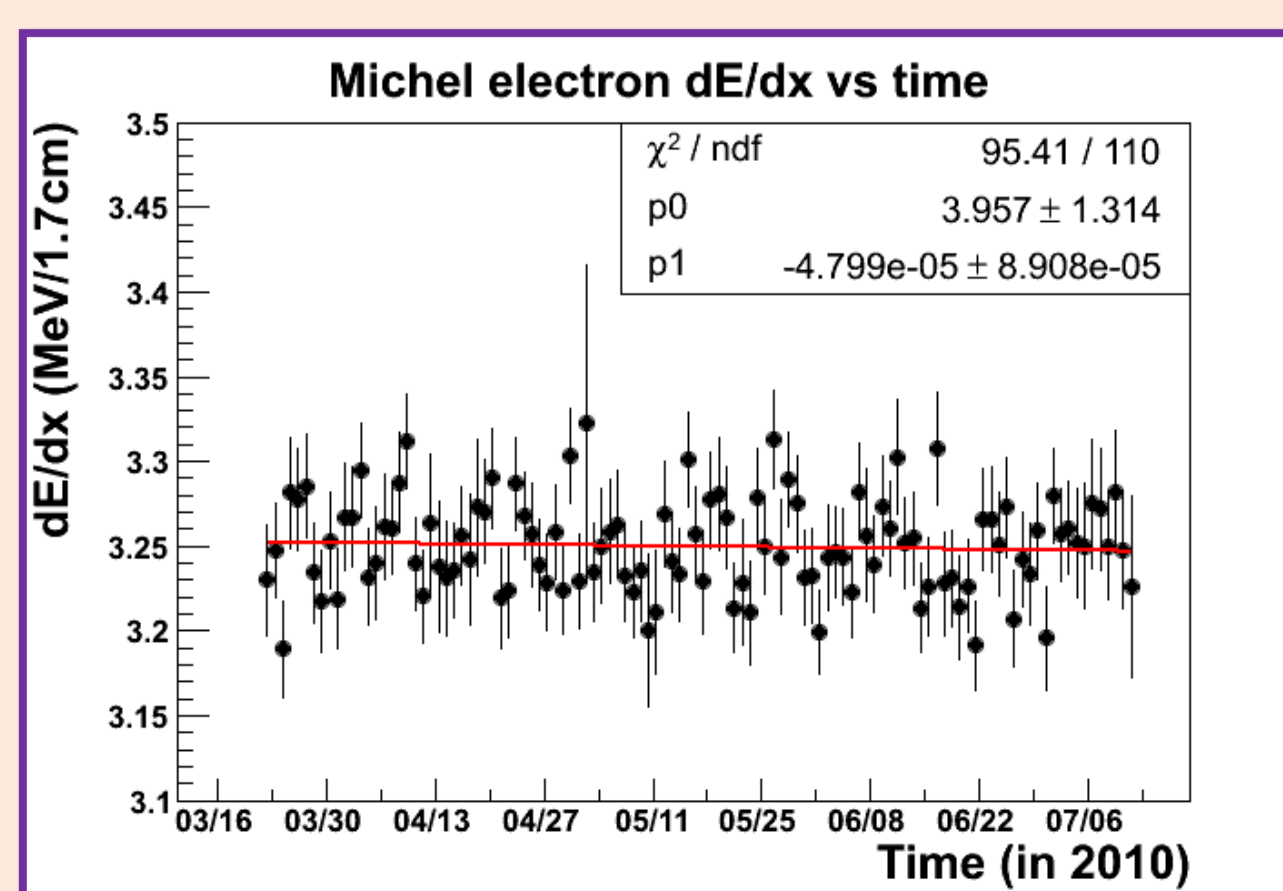
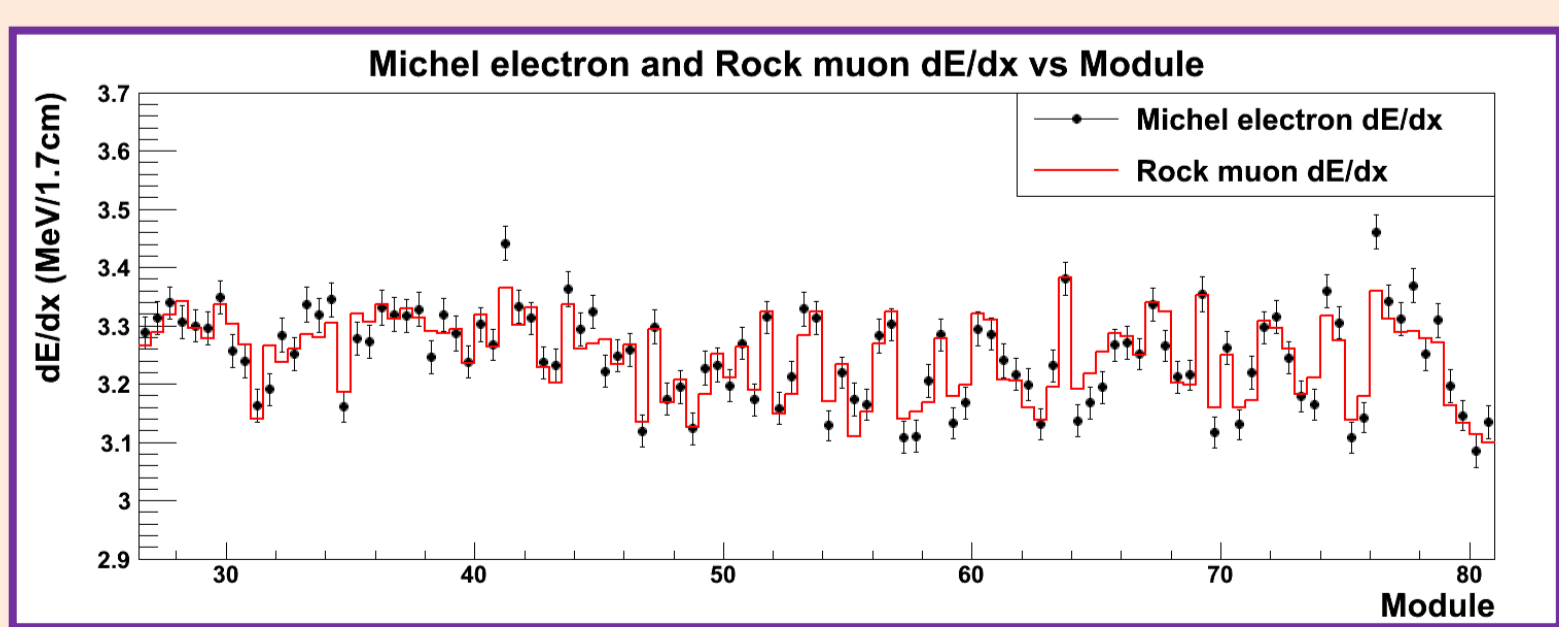
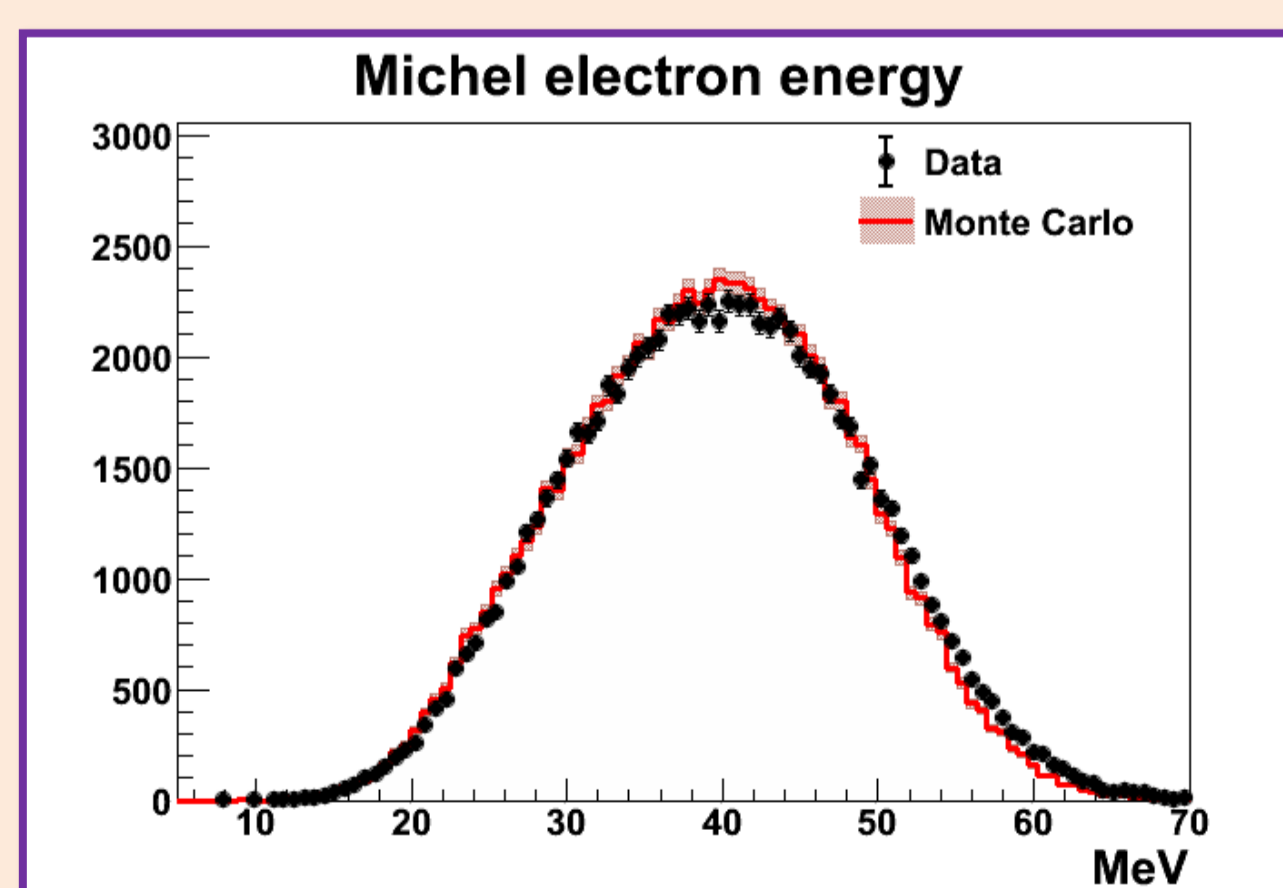
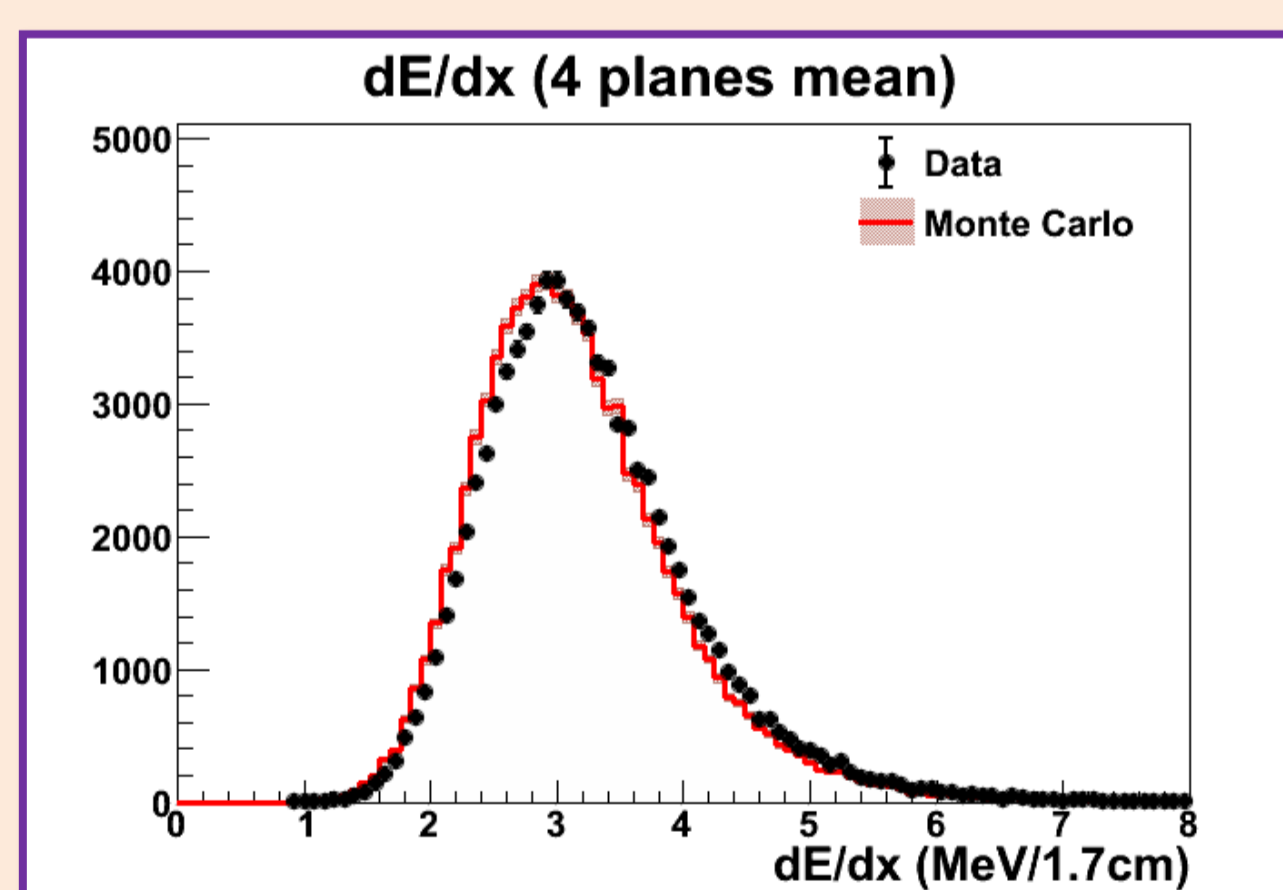


Use cosmic ray muon data taken every night during the run to measure the temperature dependence and strip to strip variations. Apply corrections to *in situ* test beam muons to set overall energy scale, apply all corrections to the hadron beam data.

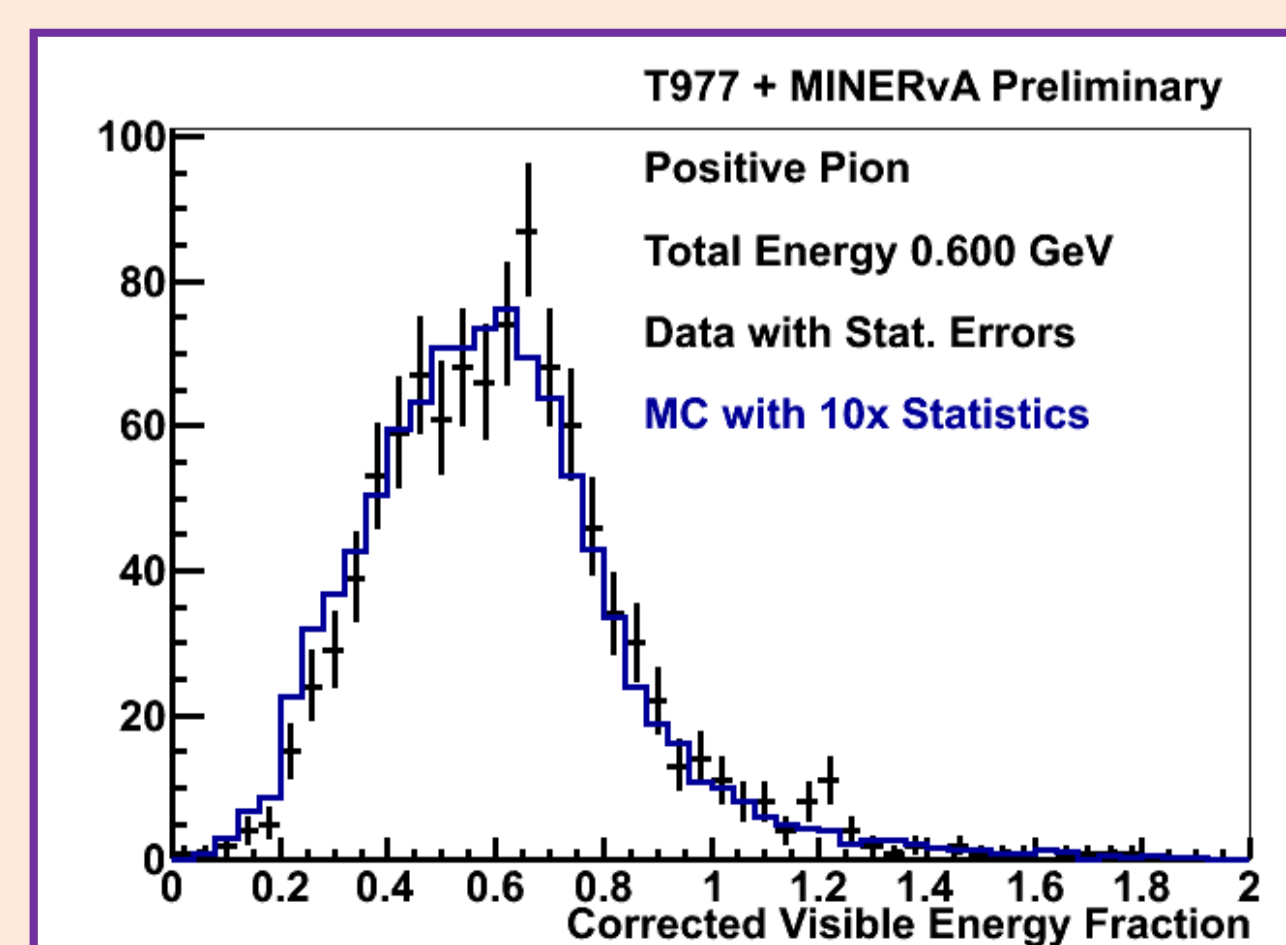


### Michel Electrons

Muons that stop and decay in the inner detector provide an independent sample that test the energy scale calibration as determined by the muon sample described above.



Time and module dependence of Michel Electron Sample, as compared to muon sample (muon energy dependence vs time is flat by definition).



$\pi^\pm$  response at 600 +/- 50 MeV  $\pi^\pm$  energy (above) and response vs. energy (at right). Absolute 3.9% systematic on the response energy scale common to data and MC not shown, data/mc relative uncertainty shown as blue band.

