Introduction to MINERvA

Quarknet Teachers' Workshop

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SLAC
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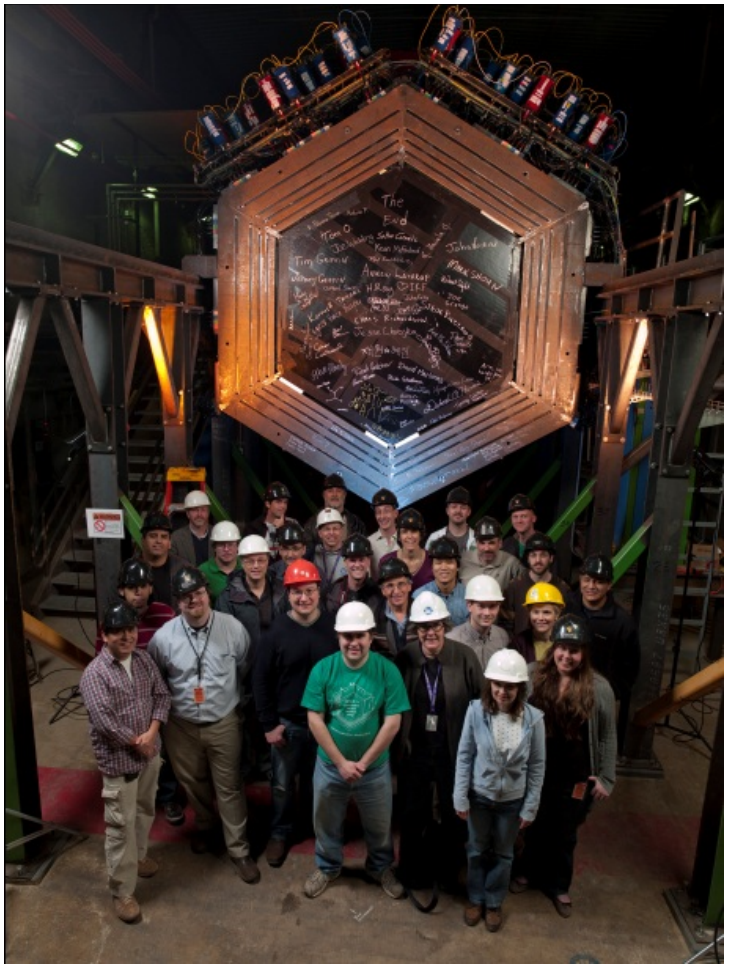
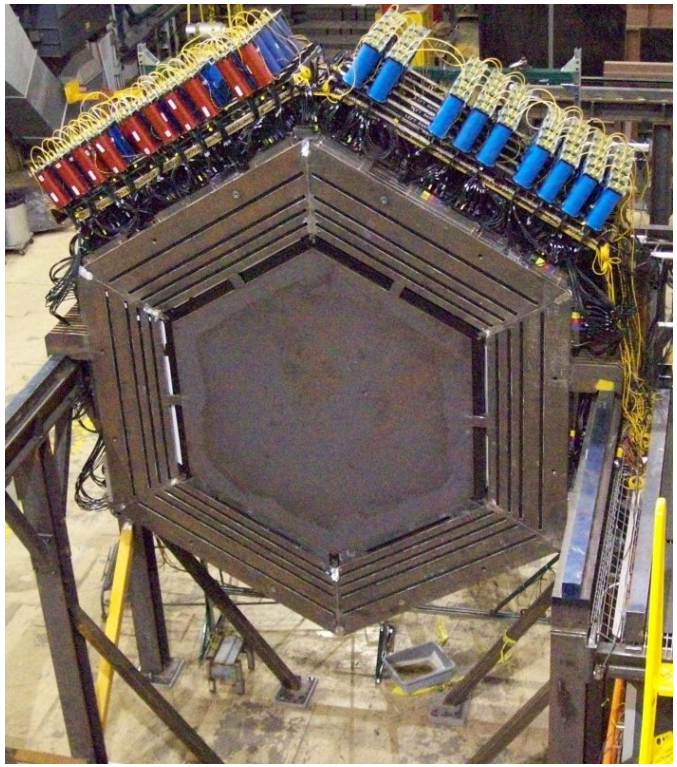
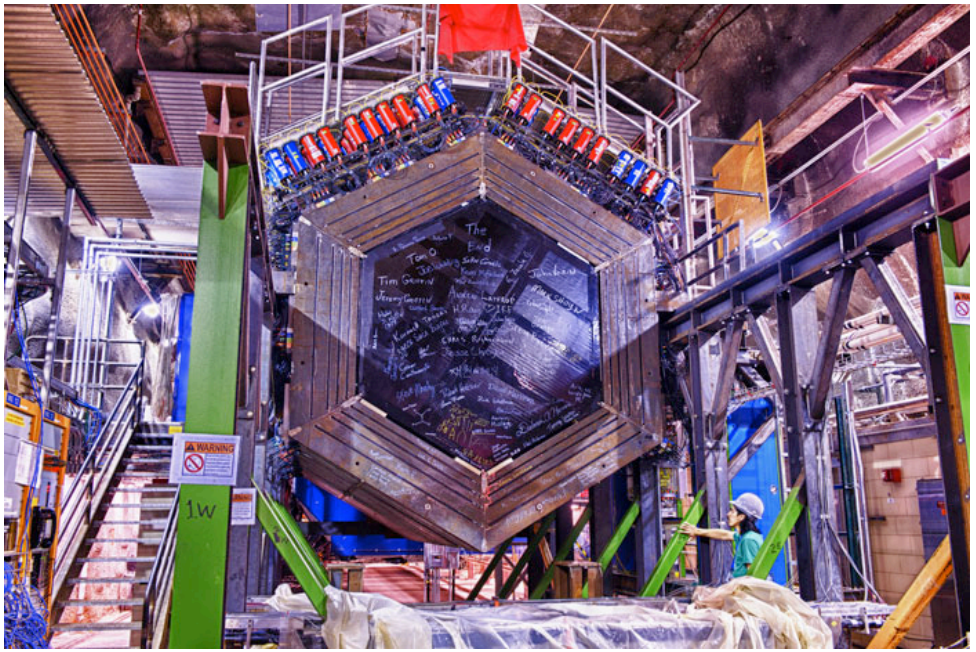


Overview

•MINERvA is designed to study neutrino interactions with matter, supporting the physics goals of short and long baseline neutrino oscillation experiments





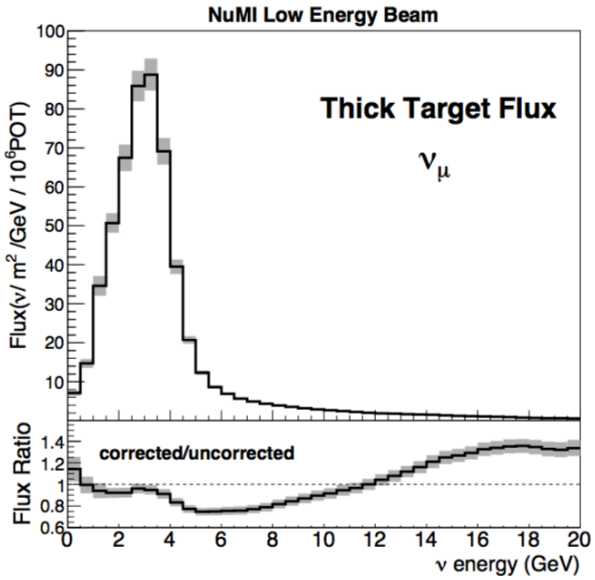
Why Neutrino-Matter Interactions?

•Consider the two-flavor neutrino oscillation oscillation formula:

$$P(\nu_\mu \rightarrow \nu_\mu) \approx 1 - \sin^2 2\theta \sin^2\left(1.27\Delta m^2 \frac{L}{E}\right)$$

•Oscillations depend on L/E, so we need to know the neutrino energy to study oscillation physics

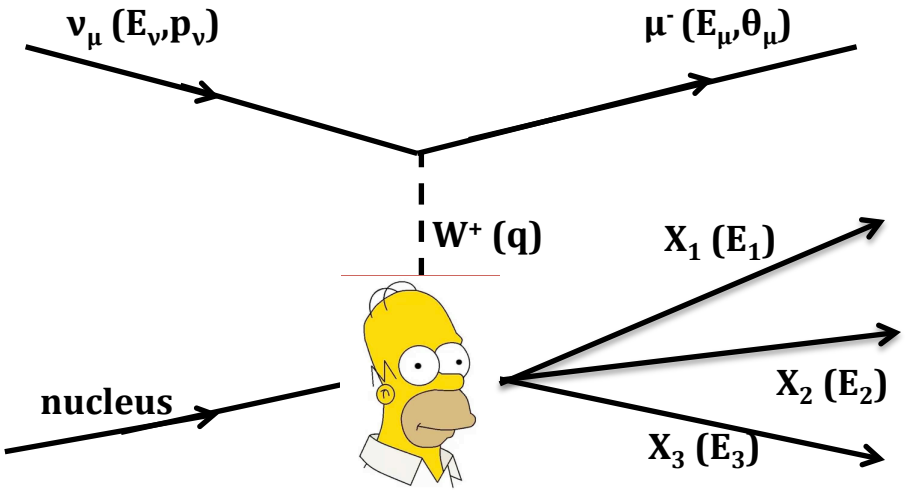
•Unfortunately, mono-energetic neutrino beams currently do not exist!



Neutrino energy spectrum in MINERvA (GeV)

Neutrino Energy Measurement

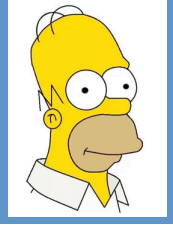
•Select charged current interactions



•Measure the outgoing lepton energy then do one of two things:

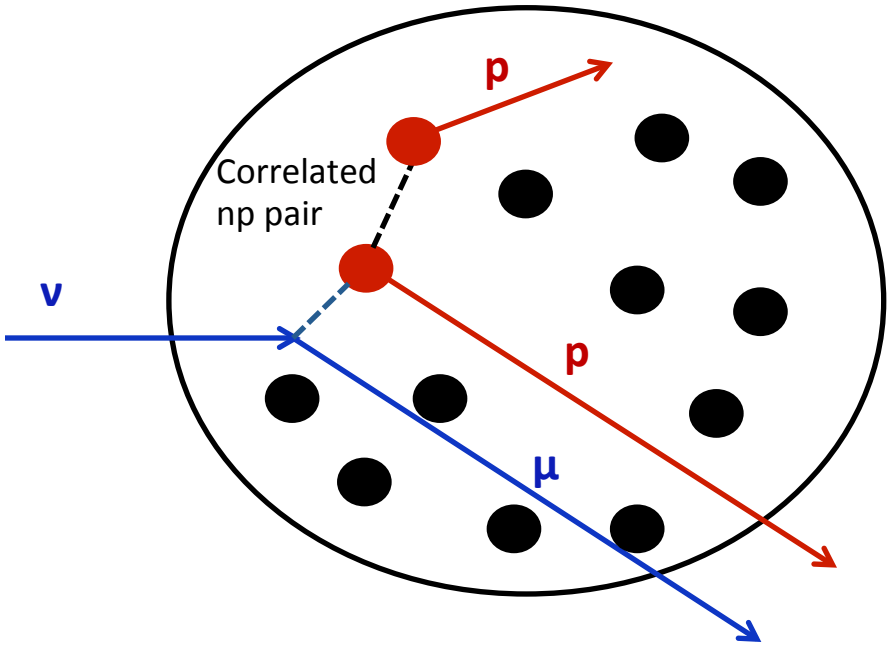
- •Detect all other outgoing particles in the event and measure their energies
- •Or, restrict to a two body final state (Quasi-Elastic) and use 2-body scattering equations (conservation of E and p)

•Wow, two independent methods! What can go wrong?

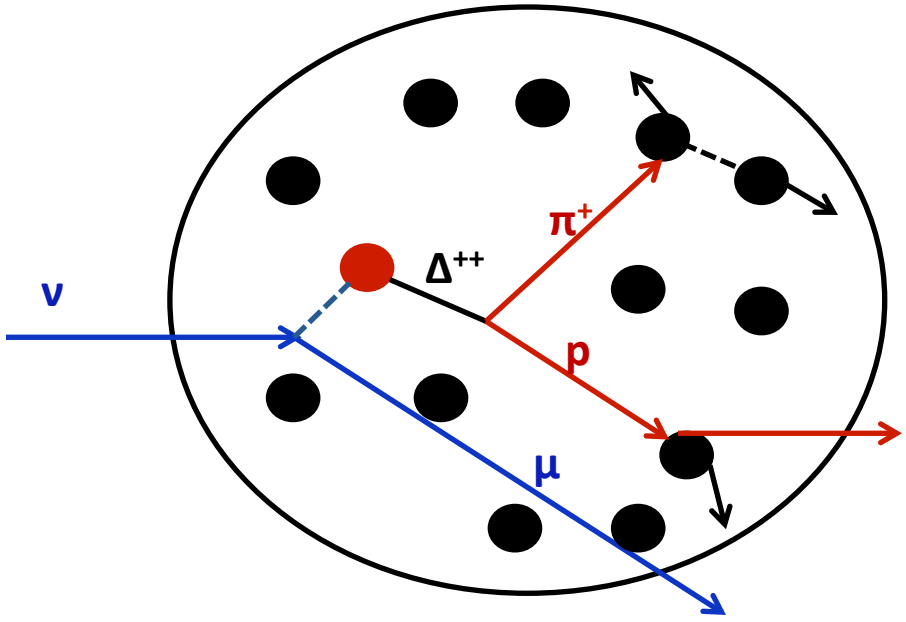


Nuclear Effects

Interaction with correlated nucleons



Final State Interactions

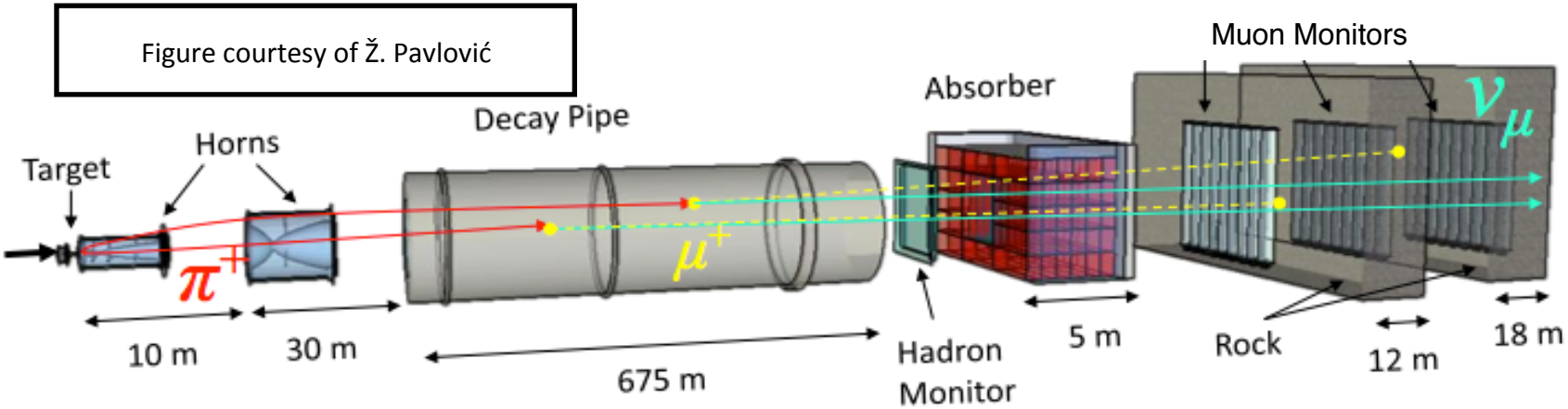


- Just because the final state looks quasi-elastic (two body), doesn't mean that it is!
- No neutrino detector is 100% efficient at detecting all final state particles

Need a complete understanding of neutrino-nucleus interactions to correct for these effects and measure the neutrino energy!

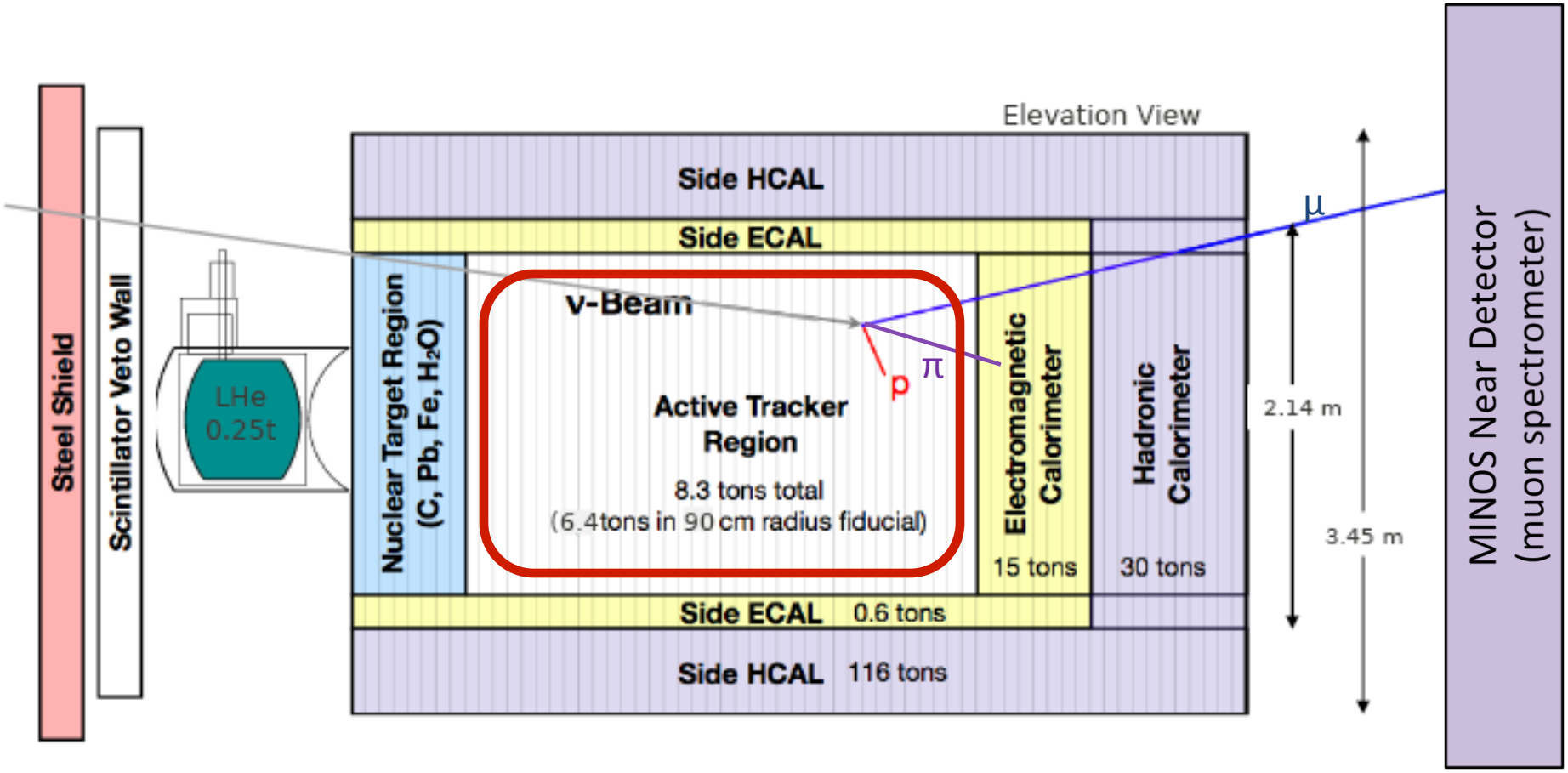
NuMI Beamline

- MINERvA is in the NuMI Beamline
- 120 GeV/c protons on C target
- Magnetic horns can focus + or – particles -> neutrino or antineutrino beam
- Target can be moved relative to the horn to tune beam energy



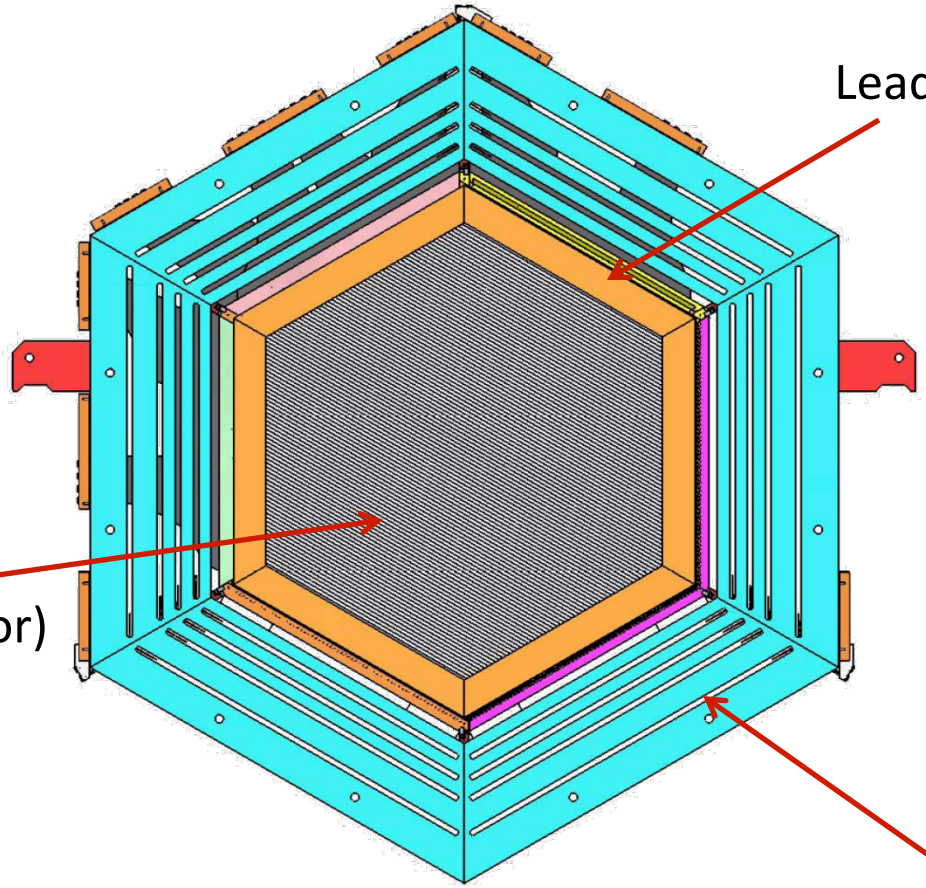
MINERvA Detector

- Fine-grained scintillator tracker (CH) surrounded by calorimeters
- MINOS near detector detects muons that exit MINERvA

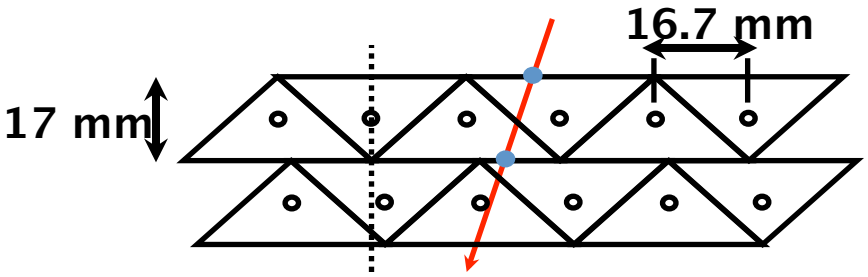


MINERvA Detector

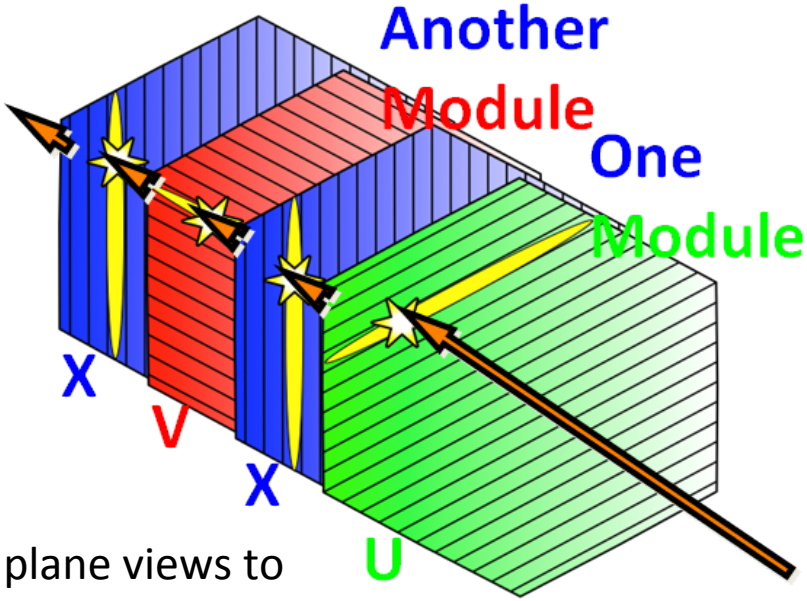
Front view of a tracker module



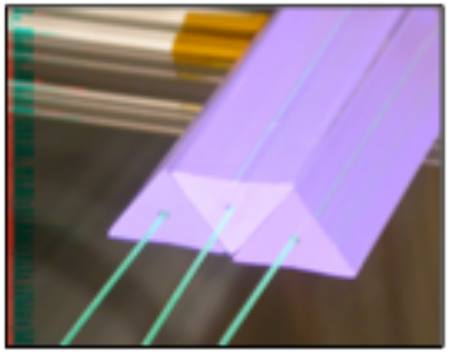
MINERvA Detector

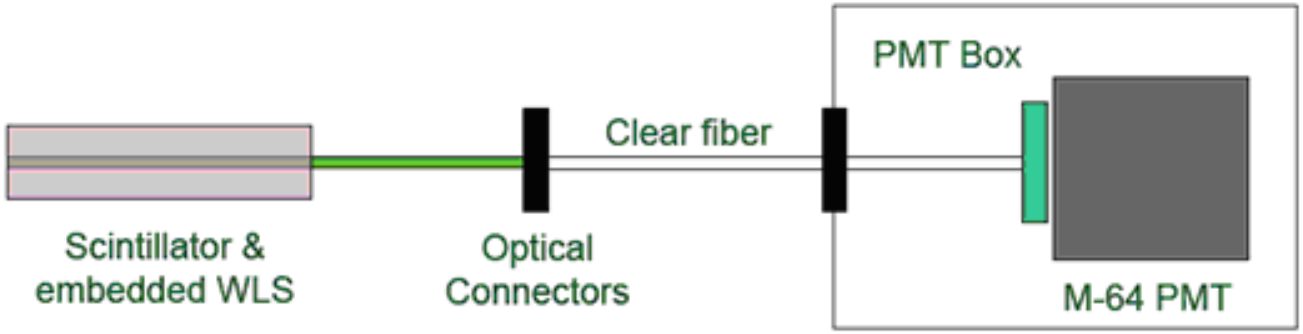


Triangular scintillator strips allows charge-sharing for good position resolution (3 mm)

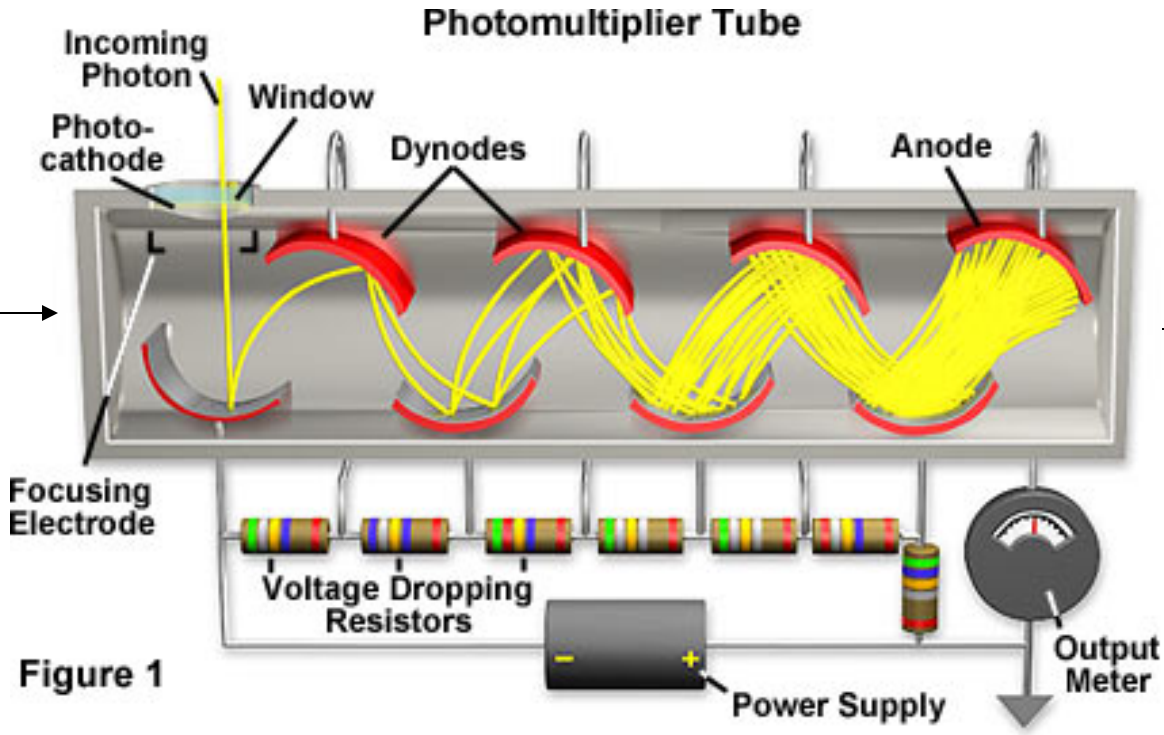


3 different rotated plane views to resolve high-multiplicity events





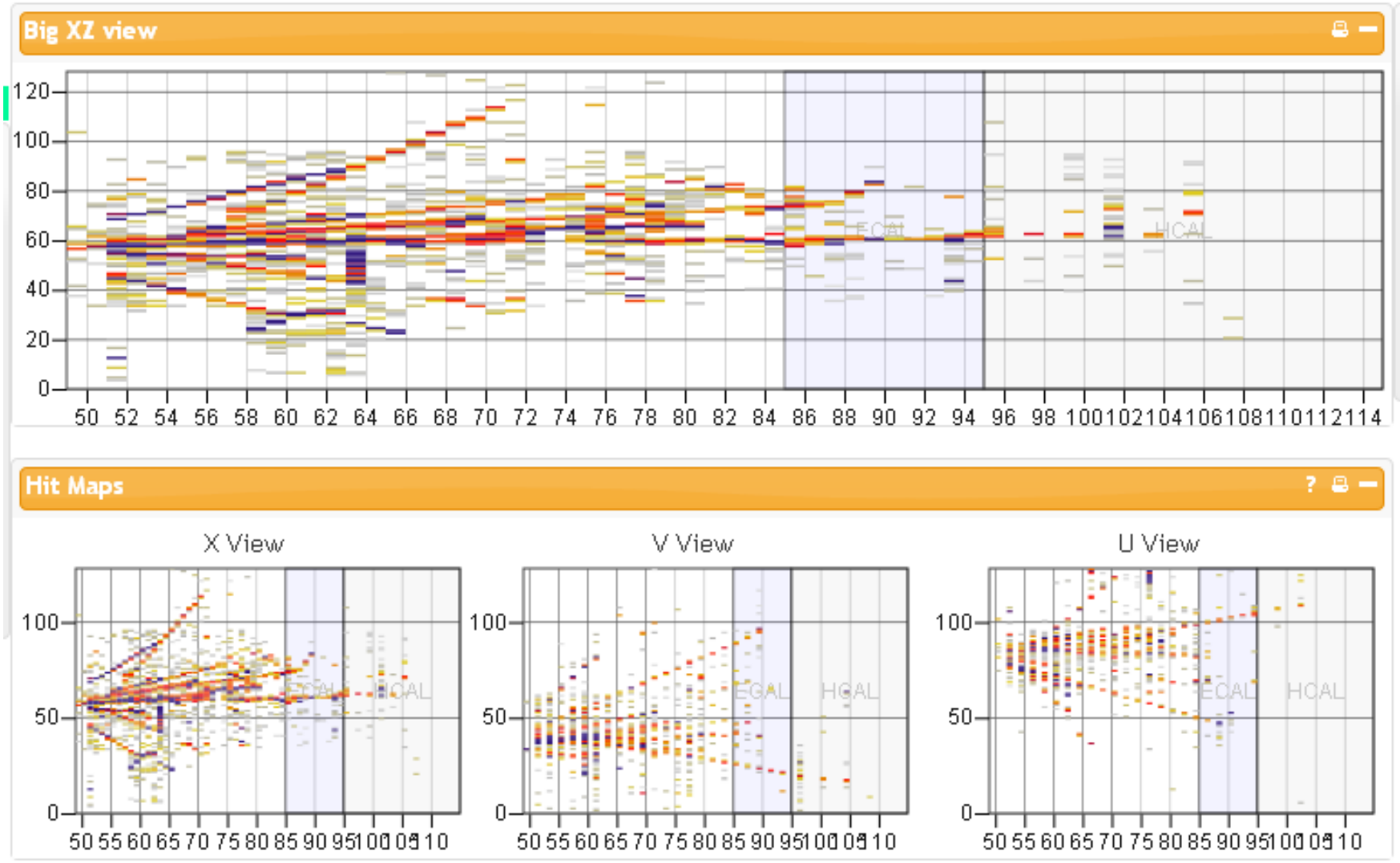
MINERvA PMTs



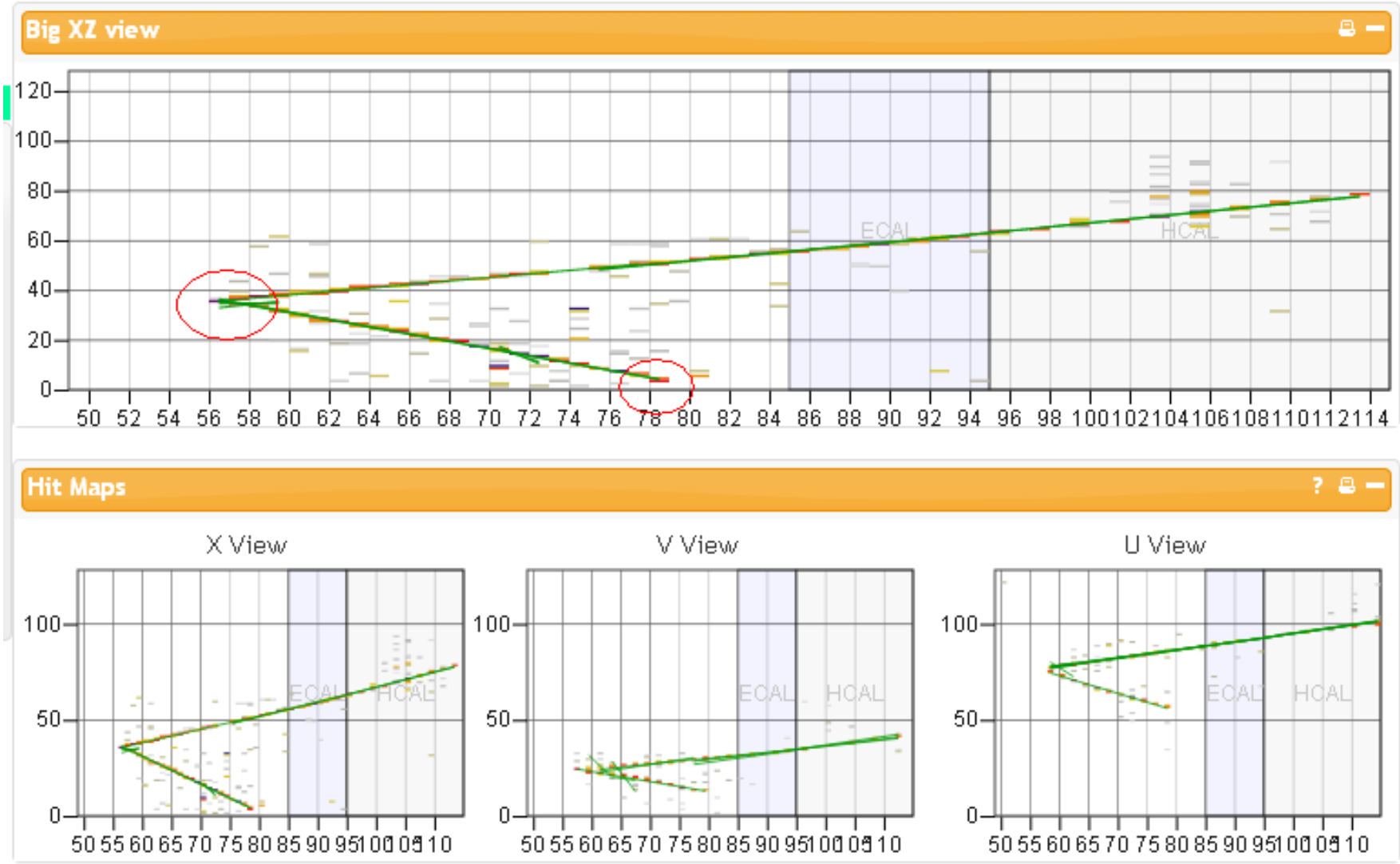
•ns timing resolution: can separate multiple events from the same beam spill, and resolve muon decays

•Outgoing signal integrated and digitized by front-end electronics, then sent to computers for storage and analysis

MINERvA Event Displays



MINERvA Event Displays



Conclusions

- Knowledge of neutrino-nucleus interactions is crucial for studying neutrino oscillations

- MINERvA is a dedicated neutrino-nucleus interaction detector capable of resolving complicated neutrino interactions