A Look at MINERvA

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Hampton University Nuclear Physics Group Meeting

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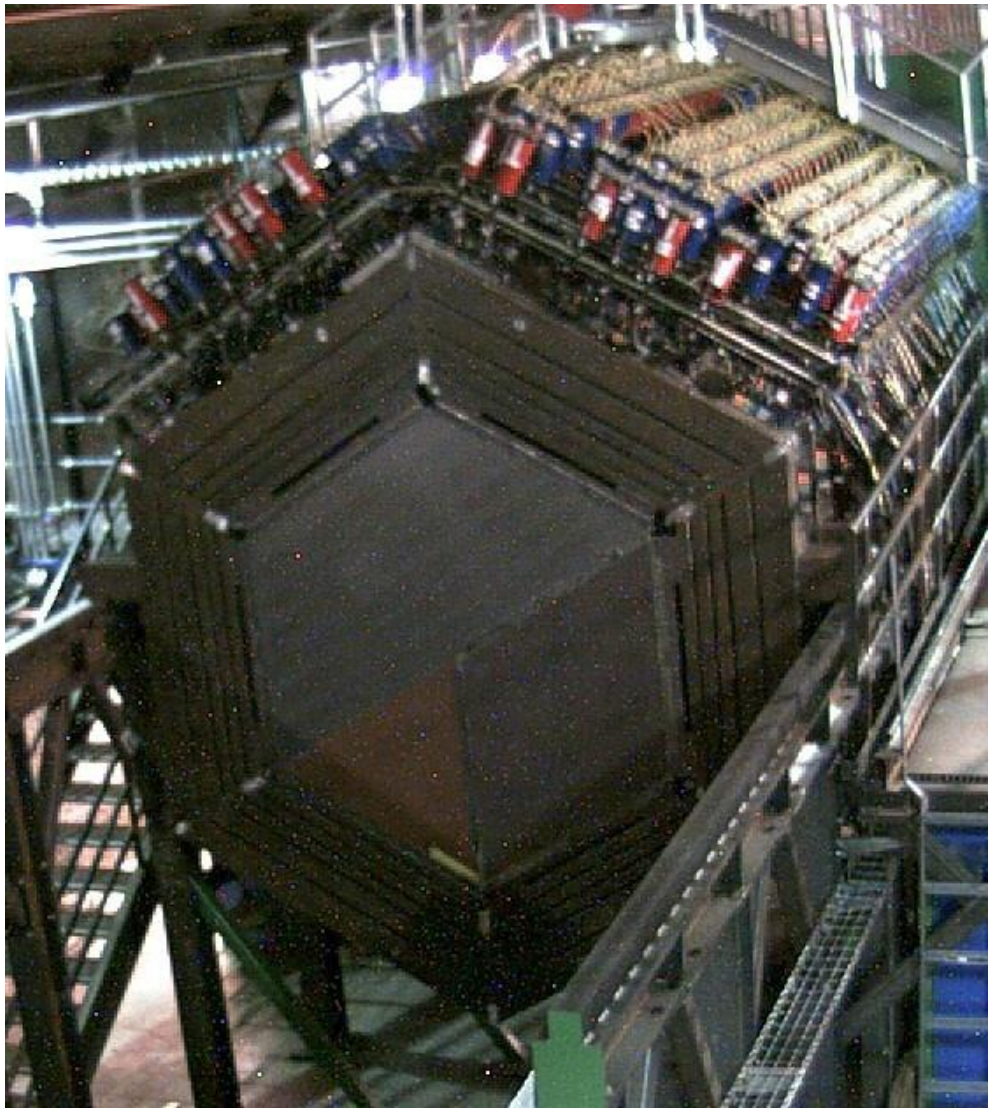
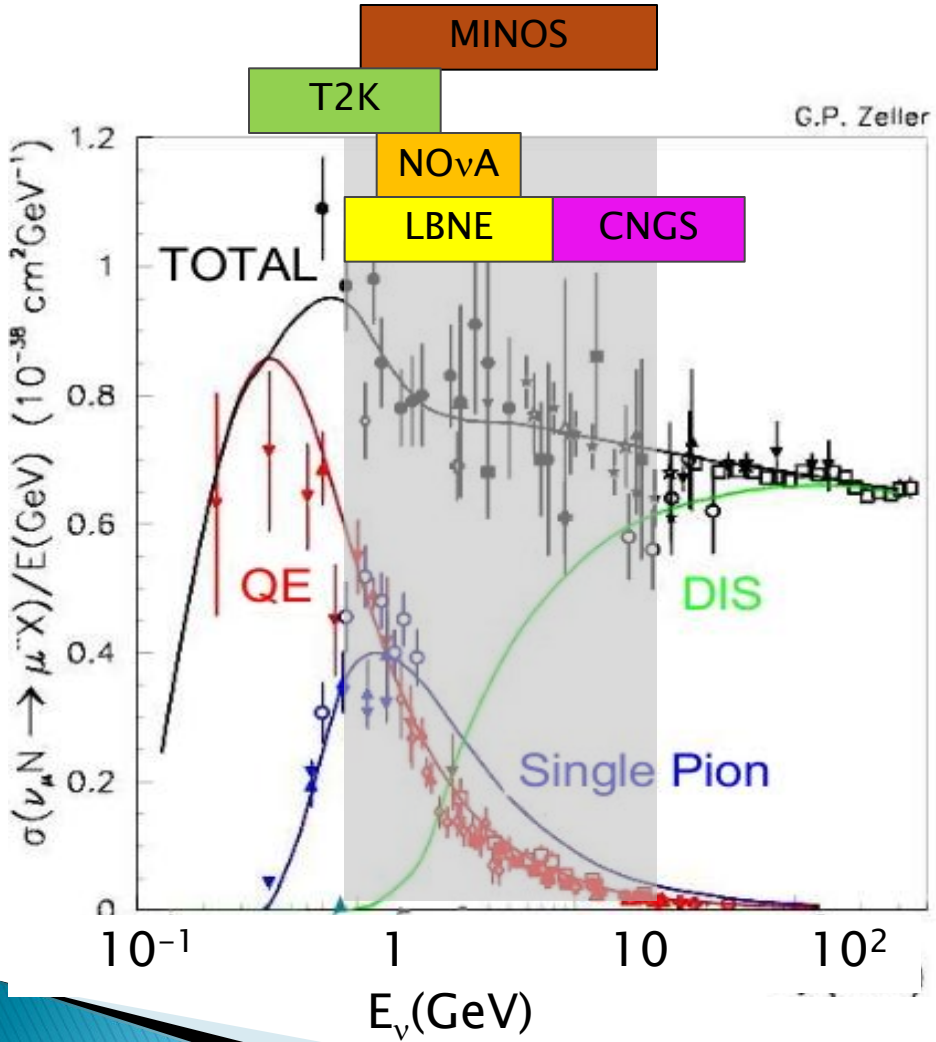
Outline

- Physics Motivation
- Detector Description
- Event Reconstruction
- Analysis



MINERvA Physics Motivation

Main INjection ExpeRiment ν-A

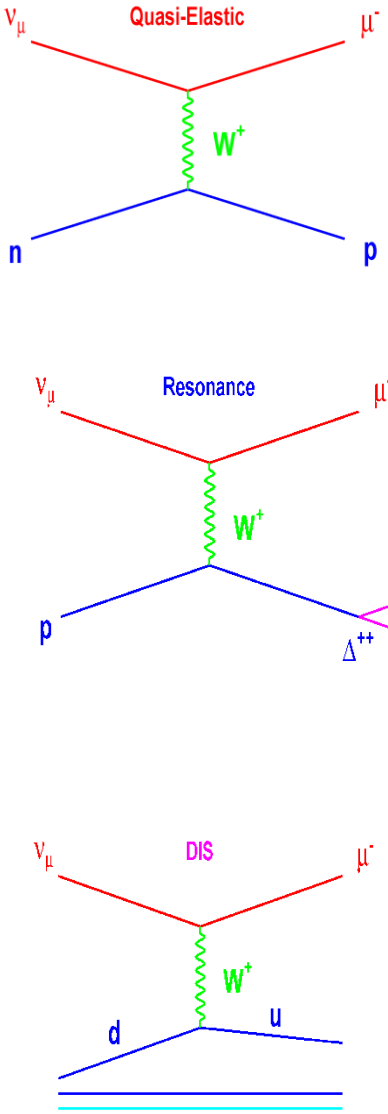


- MINERvA is designed to measure the inclusive and exclusive cross section of anti-neutrino and neutrino nucleus scattering.
- MINERvA will address the 1-20 GeV neutrino energy.
- Due to low-statistics, there is some conflict in the cross-section in the low energy region.

note: plot does not include MiniBooNE or SciBooNE data

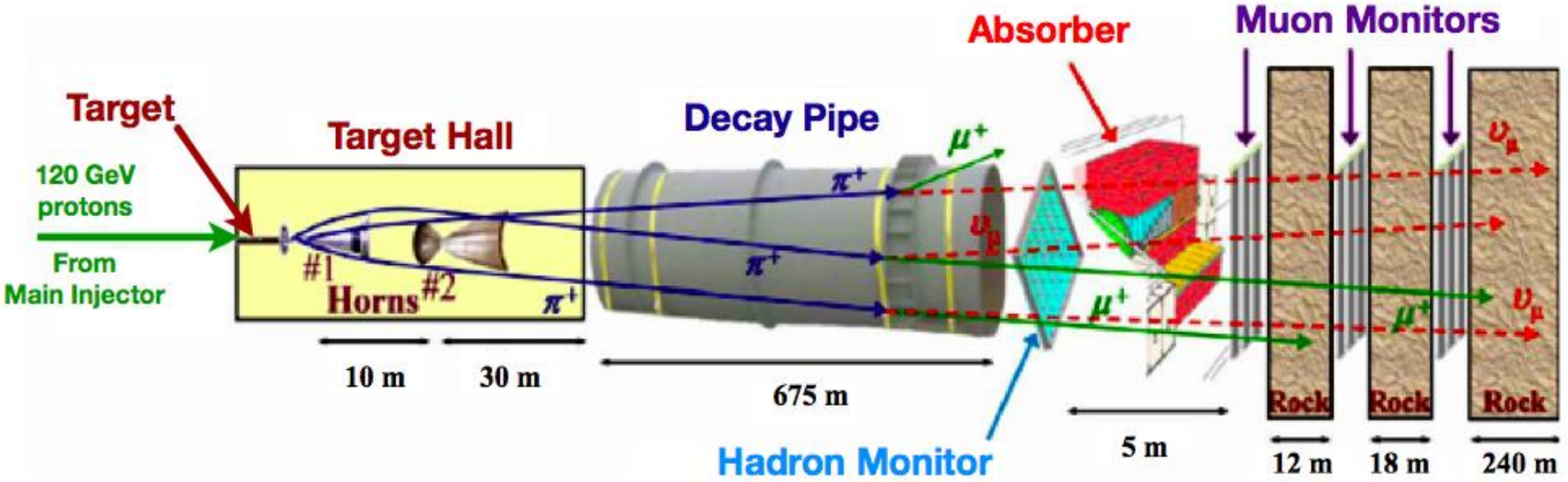
- Good tracking and vertexing resolution, allows MINERvA to identify the struck target materials.

- As a function of A, measured the hadronic energy, the final state multiplicities, studied the A-dependence of inclusive and exclusive processes as function of QSquared and neutrino energy.



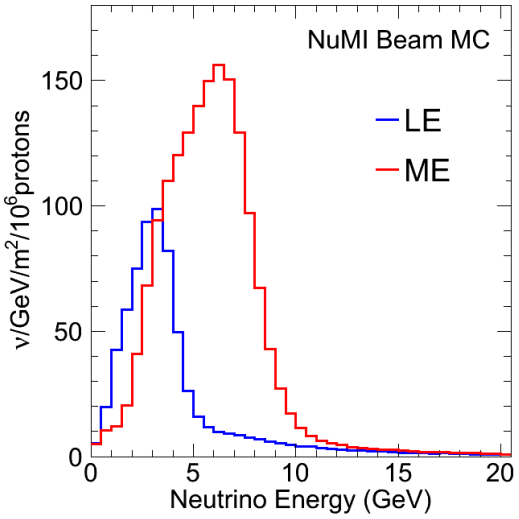
MINERvA Detector Package

The NuMI Beamline



$pC \rightarrow \pi^{+/-} \rightarrow \mu^{+/-}(\nu/\bar{\nu})$

❖pions decay in flight to produce neutrino beam



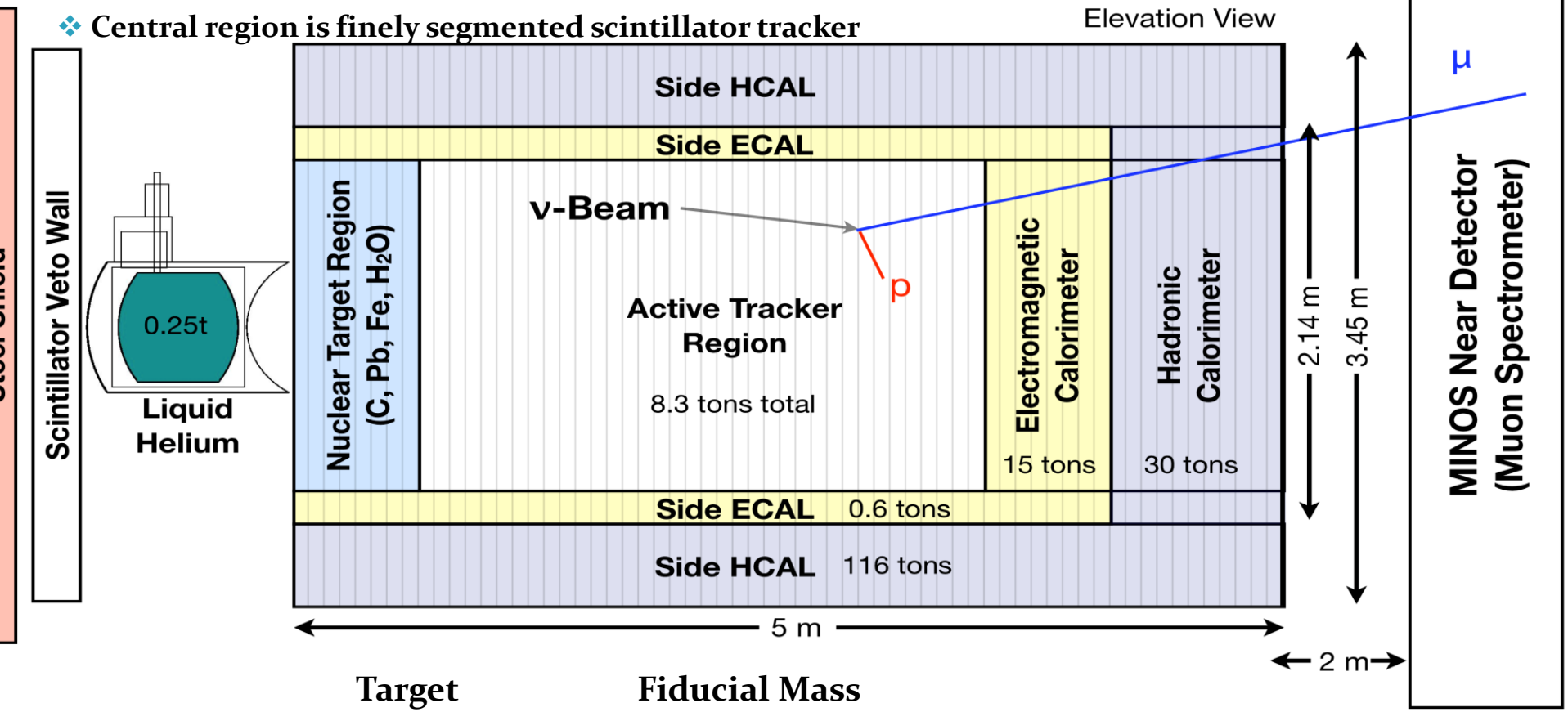
Magnetic focus horns

❖Polarity of the horns produce a neutrino or anti-neutrino beam.

❖Movable target and horns allow for energy tunable beam.

MINERvA Detector

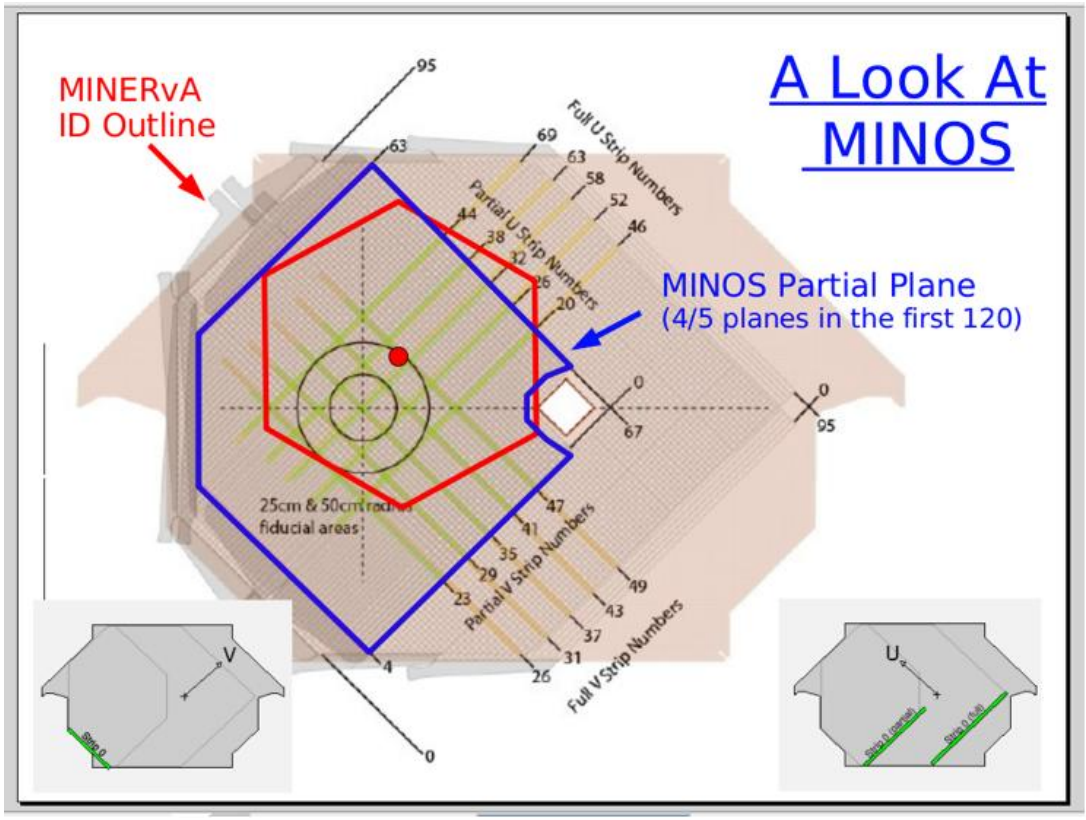
- Detector comprised of 120 "modules" stacked along the beam direction
- Central region is finely segmented scintillator tracker



Target	Fiducial Mass
Liquid He	0.25 tons
C	0.17 tons
Fe	0.97 tons
Pb	0.98 tons
CH (tracker)	6.43 tons (85 cm fiducial radius)

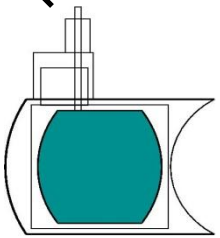
MINOS Detector

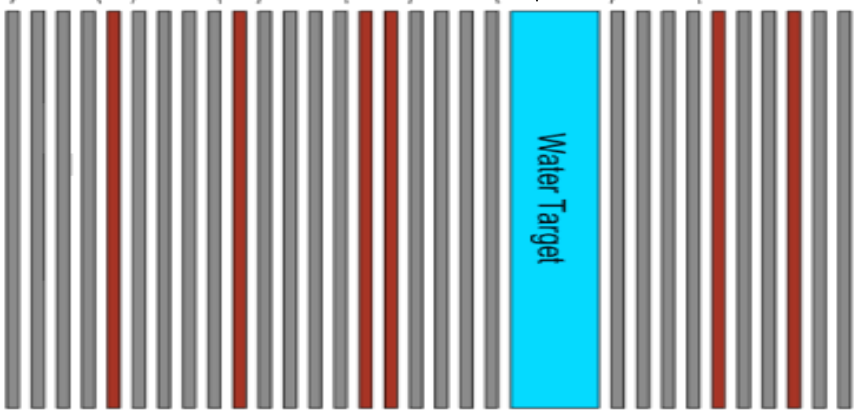
- detects the muon for forward scattering
- muon energy threshold is about 2 GeV
- good angular acceptance of scattering from about10 to 20 degrees
- provides the charge of the muon



MINERvA Detector Passive Targets

Liquid Helium



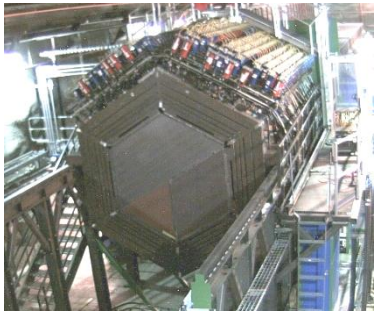


Water

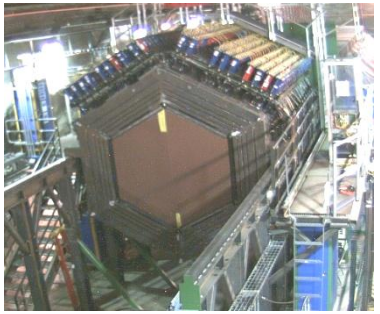
Fe 2.5 cm/Pb 2.5 cm

Fe 2.5 cm/Pb 2.5 cm

C 7.6 cm, Fe 2.5 cm, Pb 2.5cm



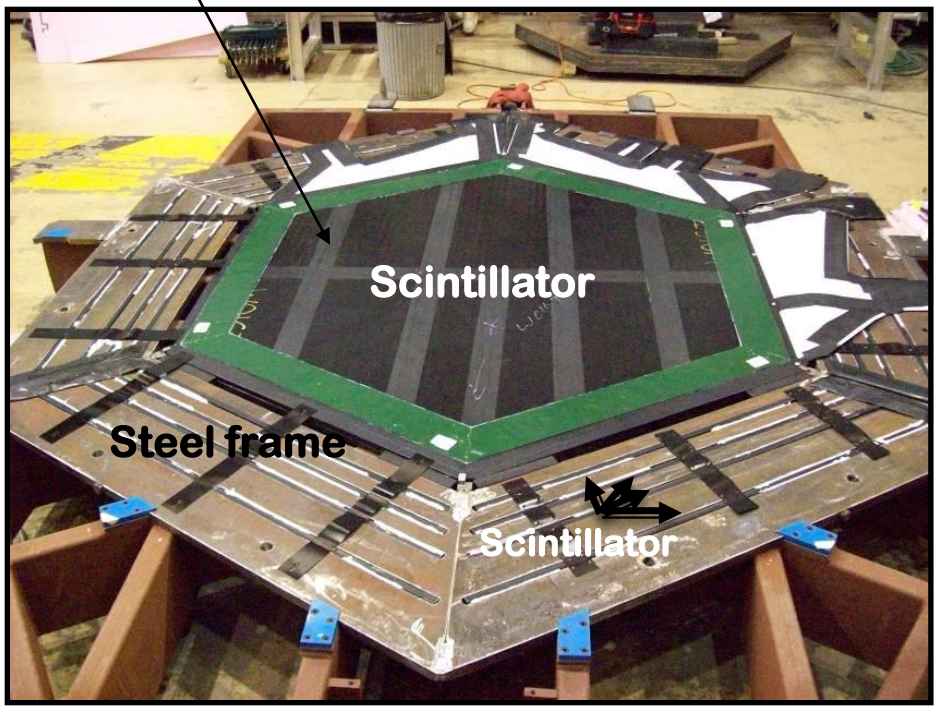
Pb 0.8 cm

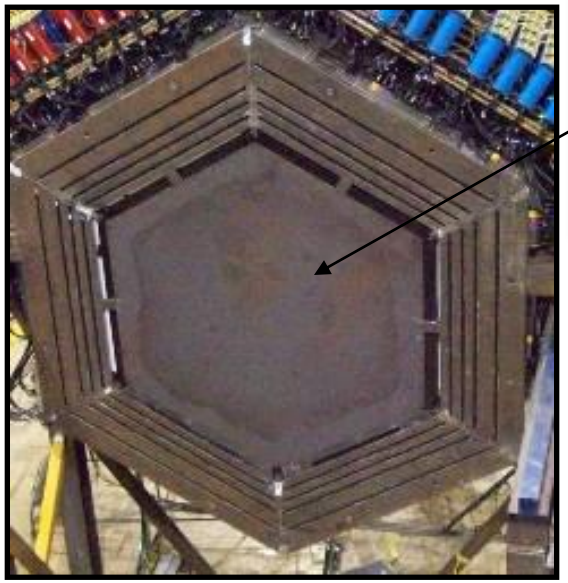


Fe 1.3 cm/Pb 1.3 cm

Tracker and Calorimeter Modules

1) Tracker modules have two planes of segmented scintilator measuring two different views (UX or VX)

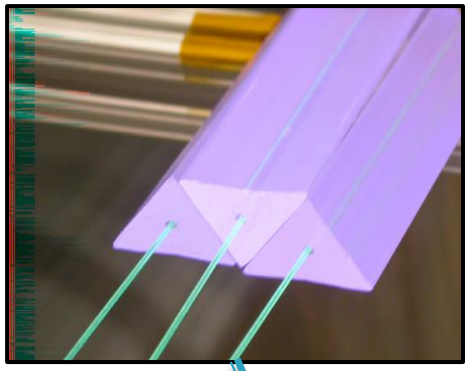




3) Hadronic Calorimeter (HCAL) modules include 1 inch thick steel absorber and one scintillator plane

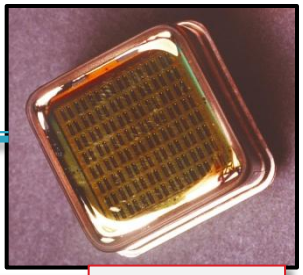
2) Electromagnetic Calorimeter (ECAL) modules incorporate two 2 mm thick lead absorbers with 2 scintillator planes

Scintillator Planes & Readout

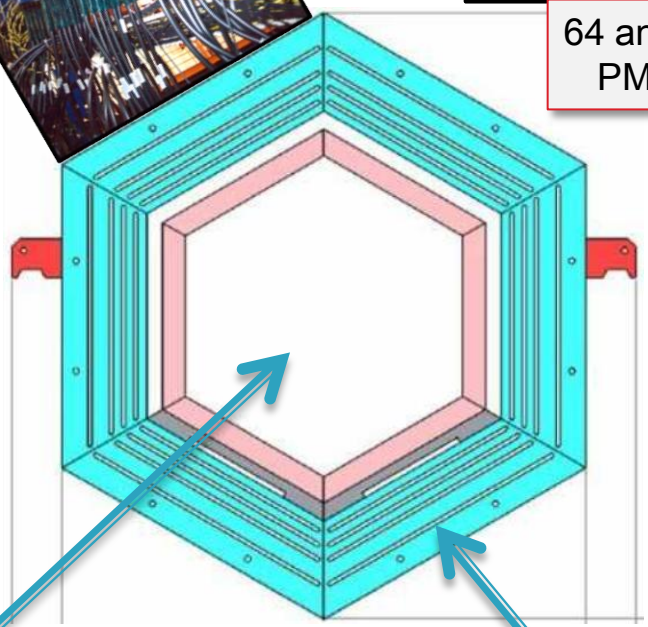


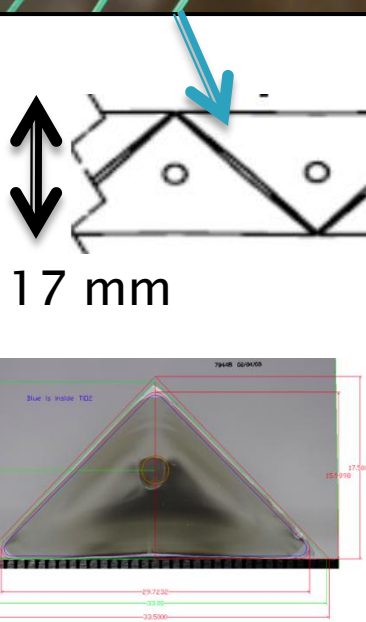
Extruded plastic scintillator & wavelength shifting fibers

Triangular geometry allows charge sharing for improved position resolution



64 anode PMTs

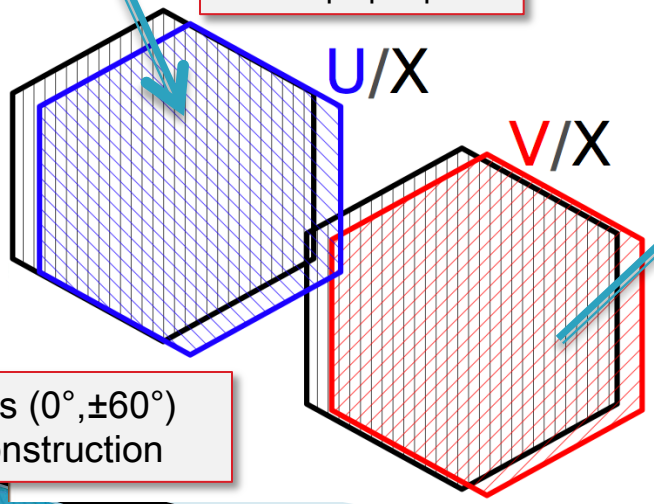




16.7 mm

17 mm

127 strips per plane



Three views (0°,±60°) for 3D reconstruction

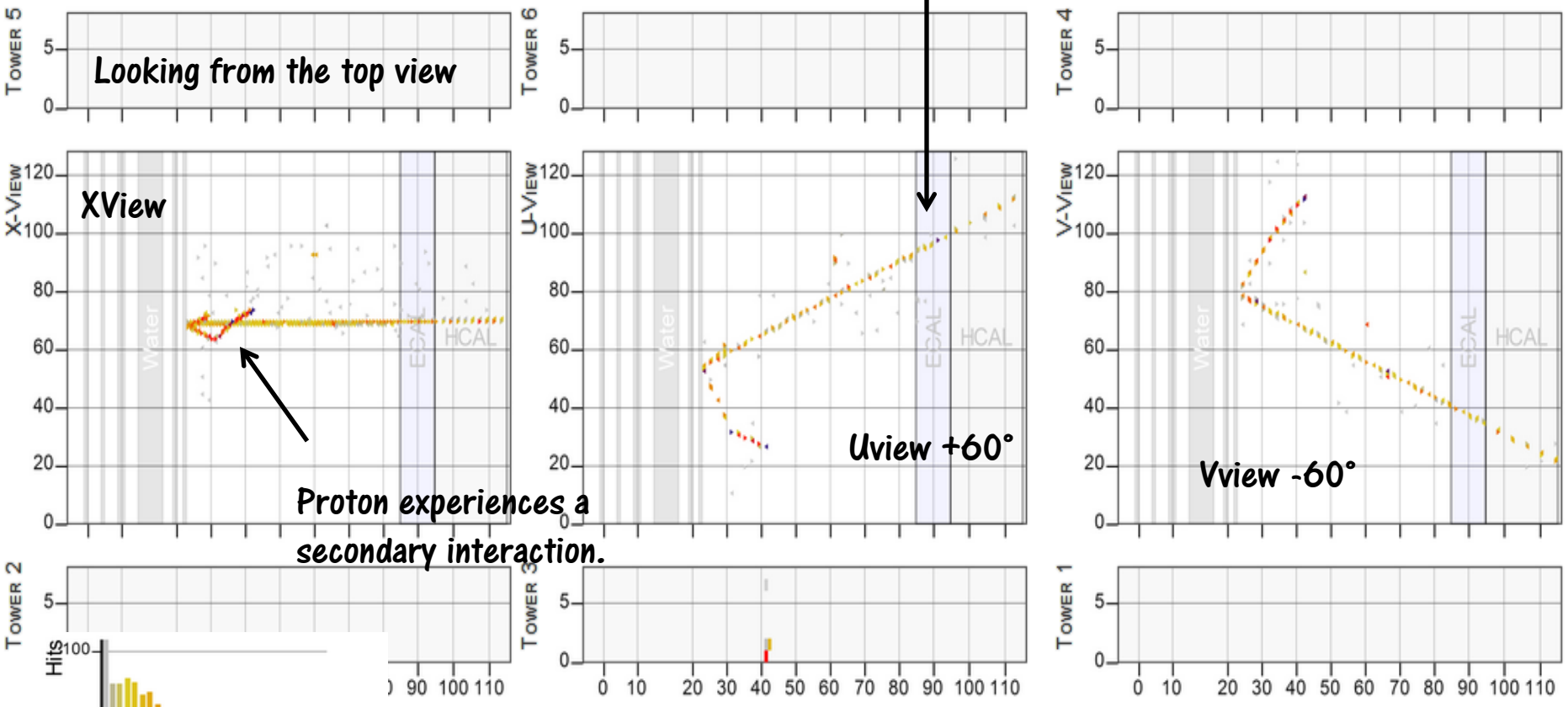
Iron outer detector instrumented for calorimetry

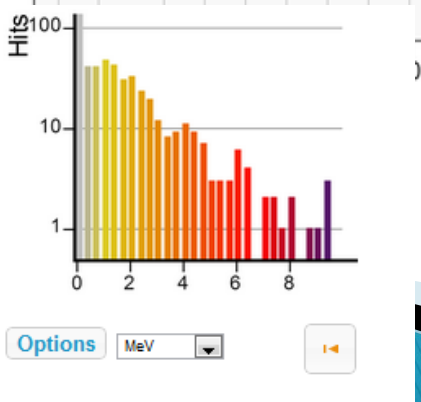
Reconstructing Neutrino Events

MC

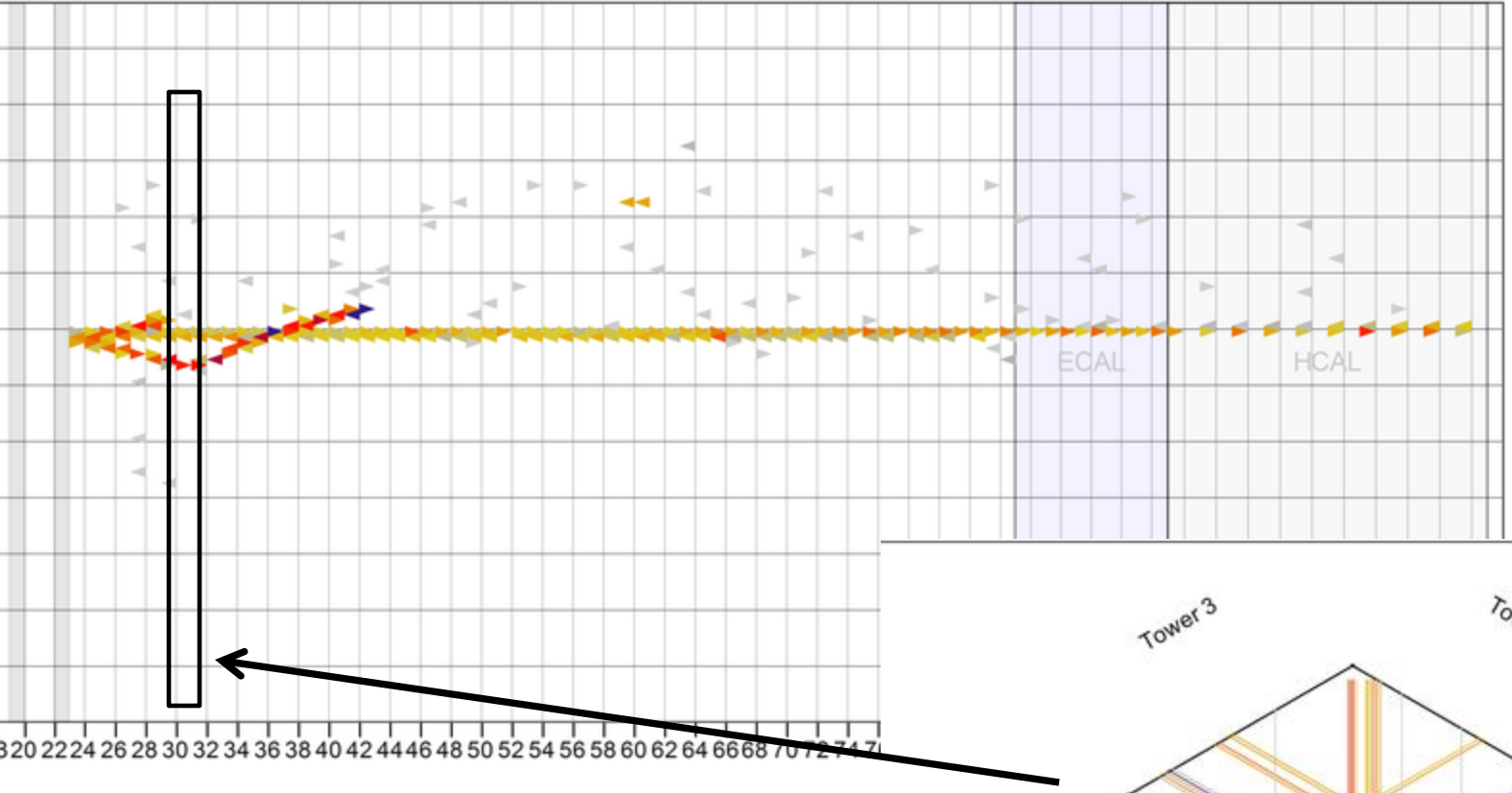
Neutrino beam direction

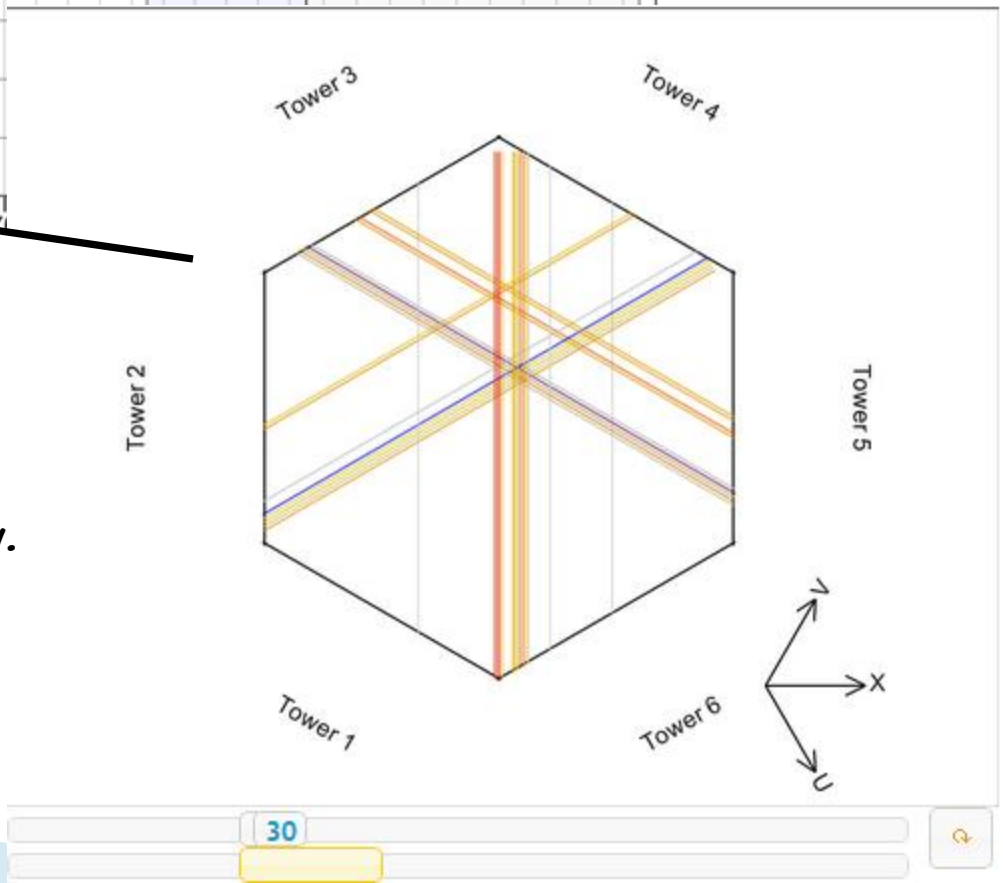
Muon appears to exit detector.





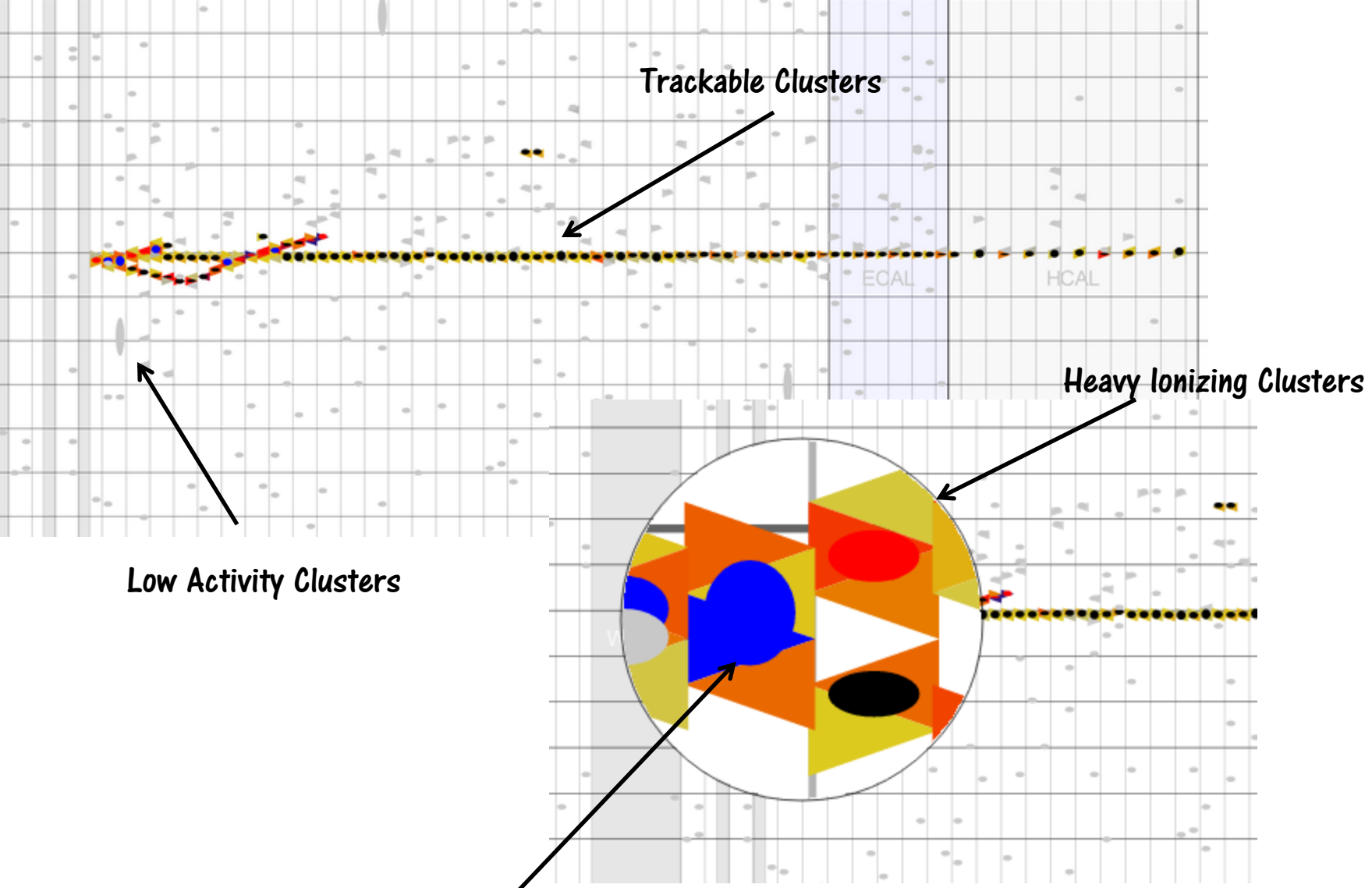
Charged Current Quasi-Elastic neutrino interaction off Iron

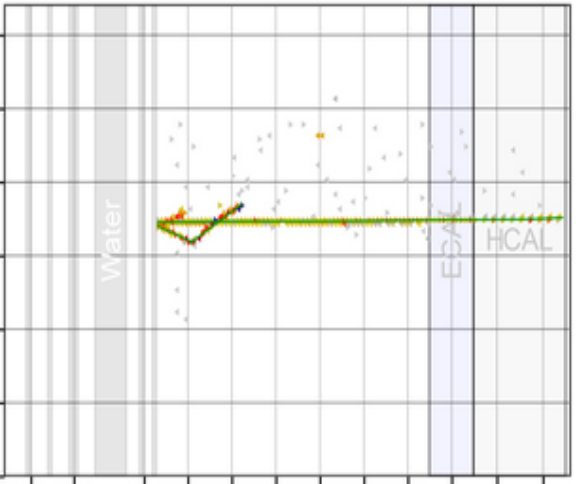


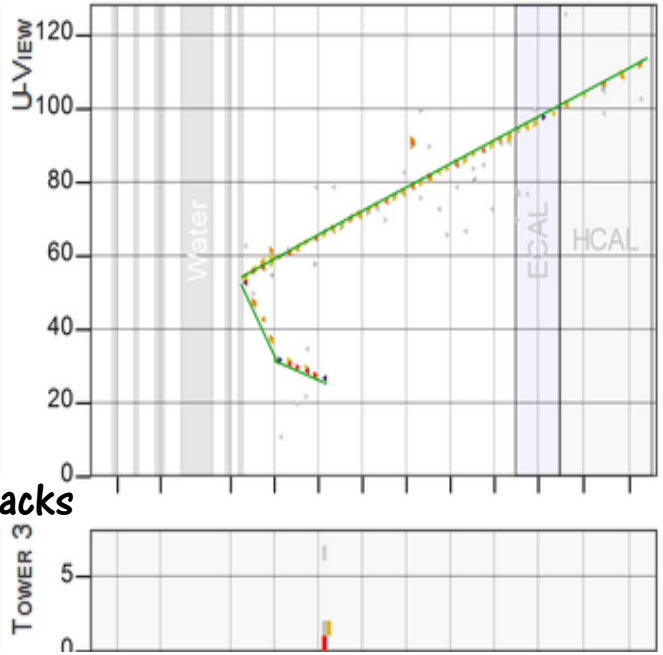


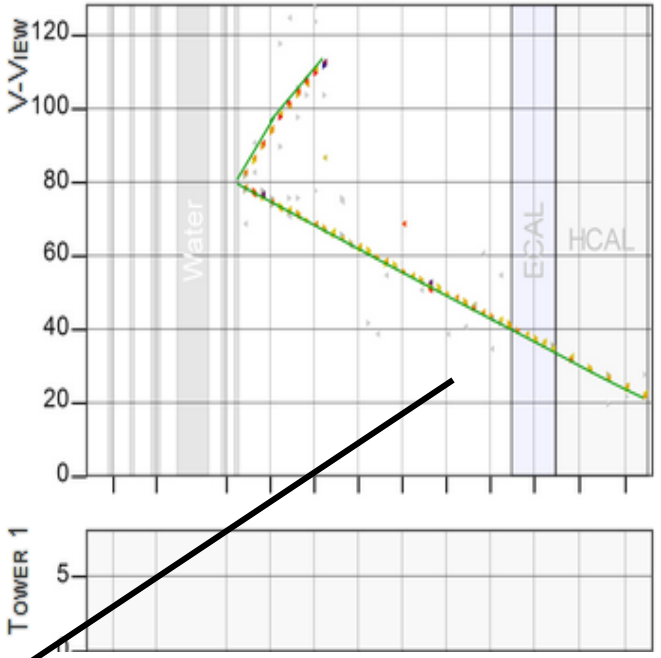
Adjacent hits in a plane grouped together to form clusters.

Clusters are also classified by the width and density.

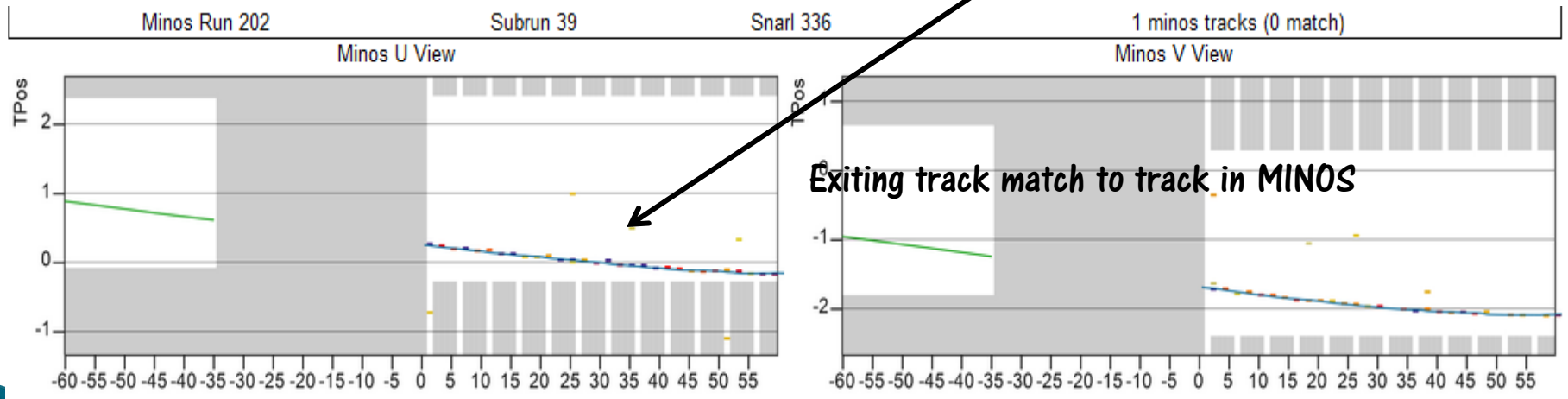

Trackable Clusters
ECAL
HCAL
Heavy Ionizing Clusters
Low Activity Clusters
Super Clusters







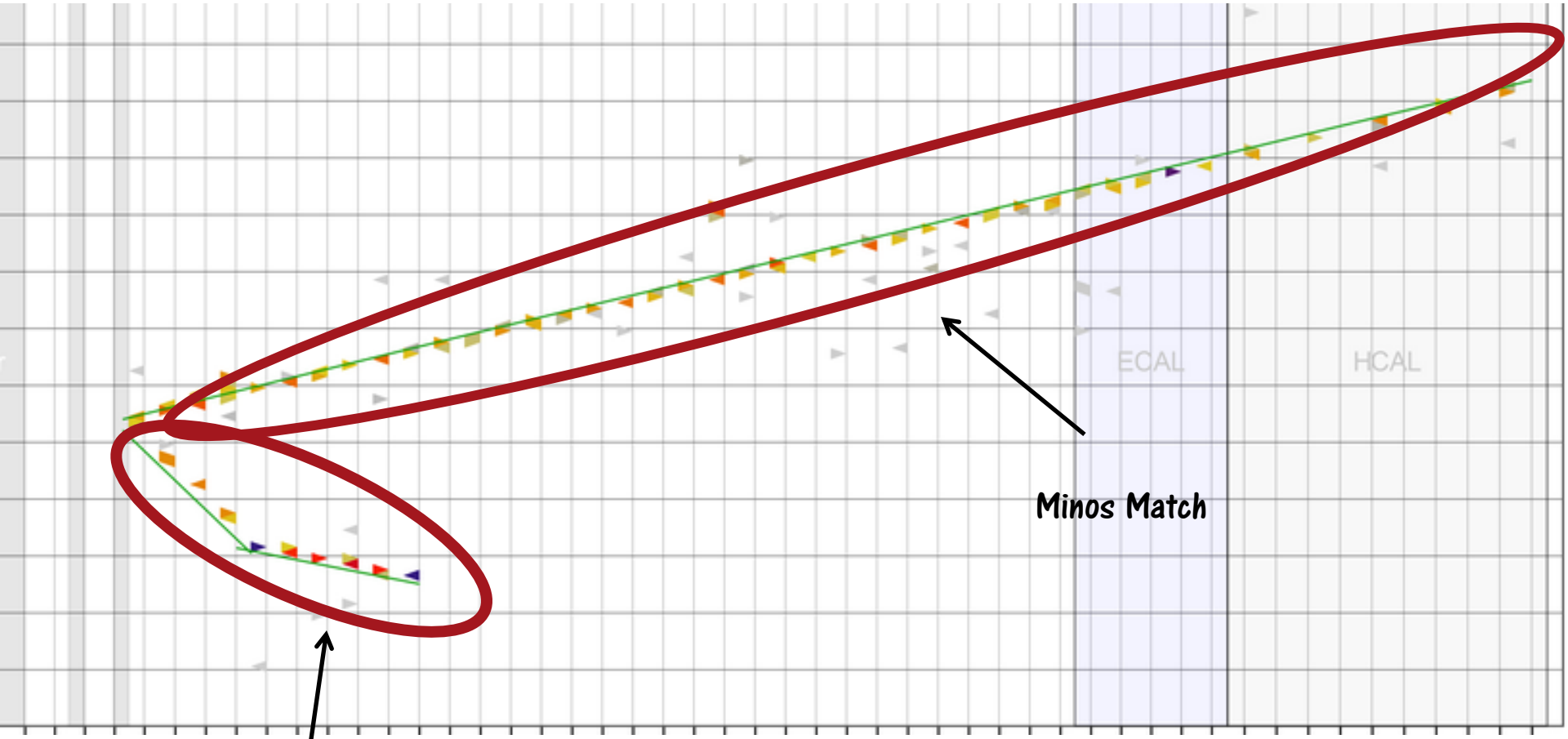
3 reconstructed tracks



Exiting track match to track in MINOS

These files where not may with the reconstruction which includes vertexing! But we do have vertex reconstruction!

Creation of Prongs: Bag of reconstructed objects, not designed to represent a primary particle, however in many cases the prong does.

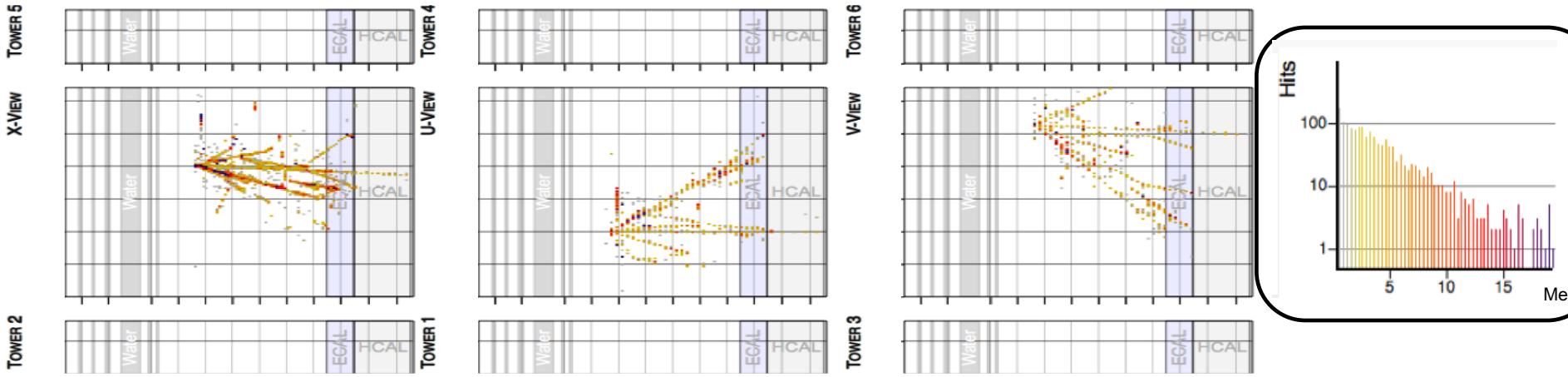


Some of my development work for MINERvA:

- ❖reconstructed the energy for all of the track based prongs
- ❖Create particles for the contained prongs (distinguishing between the protons and pions)

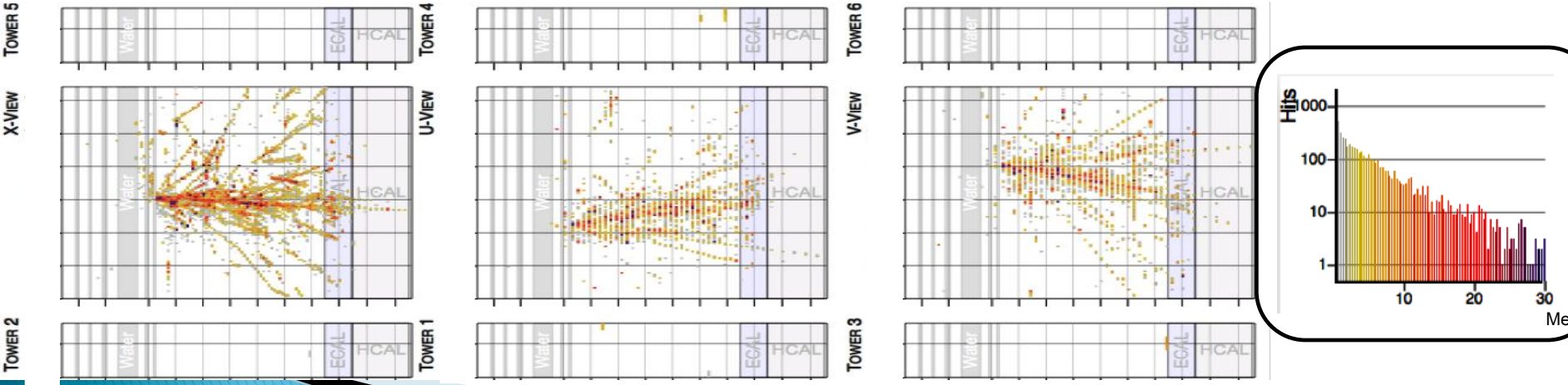
- Most of the MINERvA (anti) neutrino interaction are not nice two-track quasi-elastic.

- Things can get very complicated.



Charged-current DIS candidates

DATA



Analysis Overview

Measurement

- **Analysis Topic:**
  - Measure the ratios of the A–dependent differential cross section as a function of QSquared and Neutrino Energy for the CCQEL Two–Track channel for the Low Energy Neutrino Beam Run (expected to get less than 4e20 POT exposure).
  - Analysis will include events from Target 3 and 5.
    - Water target was not and will not be installed during the remaining period of the Low Energy Beam Run.
  - Signal Topology is defined as two–track like prongs events with some fuzz around the vertex.
  - Either the muon or the proton must be momentum analyzable.
  - Events where both particles are momentum analyzable:
    - Studied hadron propagation in different materials.

Event Rate Studies

- Generated 2.5e19 POT, LE neutrino genie events:
  - After applying a series of cuts on the truth information:
    1. Neutrino vertex (85cm hexagon apothem)
    2. Charged Current and quasi elastic
    3. Hadronic Final State Particles: No pions and trackable proton
    4. Proton's prong destruction vertex (90cm hexagon apothem)

Target/material	Lead	Iron	Carbon	Total
Target 3	75	72	86	233
Target 5	83	108		191
Total	158	180	86	424

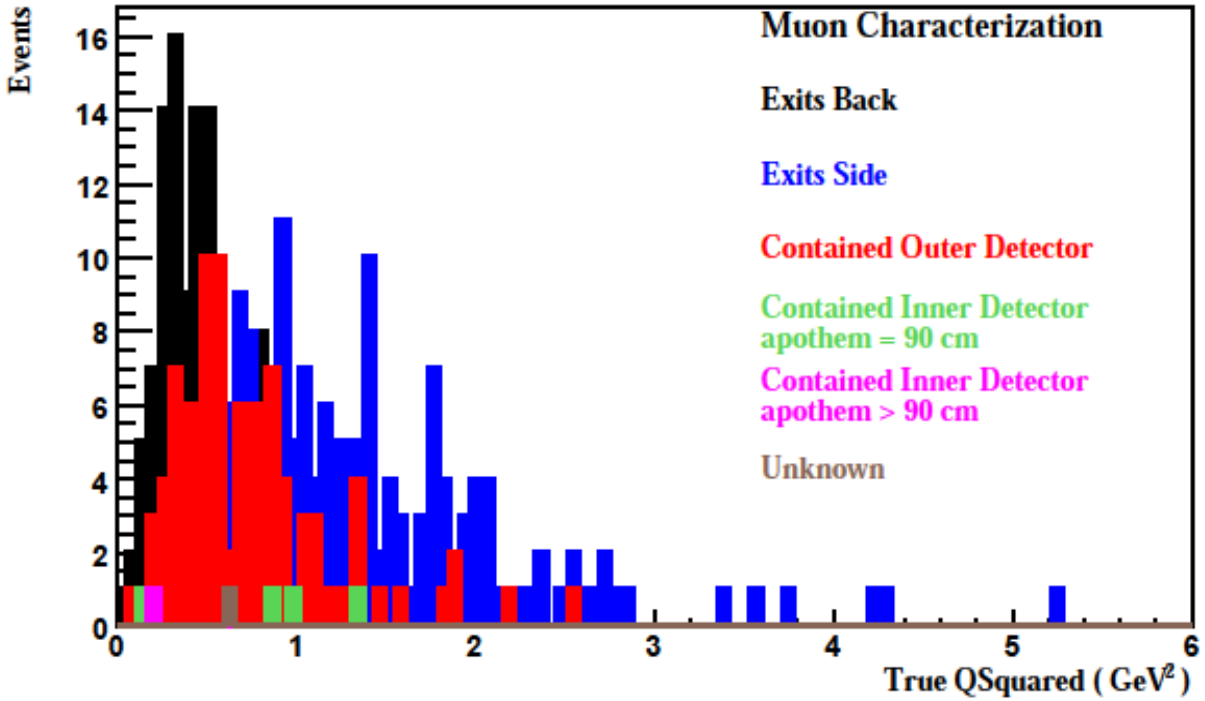
❖In the region of the moderate to high Qsquared, majority of the muons are contained or exits the Outer Detector.

❖Must get a handle on discriminating between contained and exiting OD muons.

- ❖ For now, any OD muons, whose last hit is in the fourth story, are classified as exiting while all others are contained.

❖Understand how well we can reconstructed the neutrino energy and qsquared knowing the proton's direction and energy and only the muon's direction.

❖Understand how well do we need to reconstruct these observables.



BackGround (Resonance Production)

- After applying a series of cuts on the truth information:
  1. Neutrino vertex (85 cm hexagon apothem)
  2. Charged Current and resonance
  3. Hadronic Final State Particles: trackable proton and one of the following:
     - no pions, only untrackable charged pions, only neutral pions, or both untrackable and neutral pions
  4. Proton's prong destruction vertex

Target/material	Lead	Iron	Carbon	Total
Target 3	113	184	171	468
Target 5	160	205		365
Total	273	389	171	833

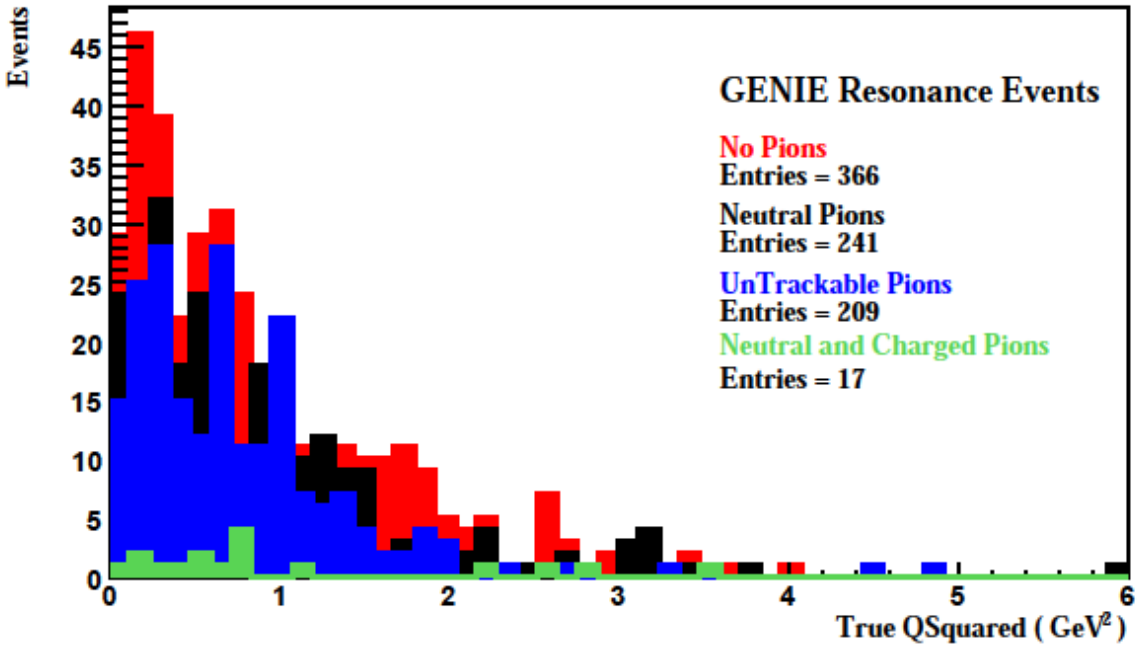
❖For the event rate calculation, failed to cut events with neutrons and photons with large kinetic energy.

❖ Not really concern about neutral pions, we can use a blobbing tool to cut events with electromagnetic showers/blobs (EM group).

❖ Biggest worry is the events without any or only untrackable pions in the final state.
- Topological these are QE–Like.

❖Possible to use a Michel tag to remove untrackable pions resonance events.

❖Currently studying if we can possible used the CC–QEL hypothesis knowing the proton's direction and angle and only the muon's direction to cut resonance events.



Summary

1. There are two fast track analyses (anti neutrino CCQE in the tracker region and inclusive CC in target 5) that I can rely on to help understand backgrounds from physics interactions and impurities from scintillator.

2. Our calibration and reconstruction have improved tremendously in the last year. And the new reconstruction scheme will make it easier to develop and understand tools need for my analysis.


The End
Say Thank You to
MINERvA for providing
many of these slides!
WARNING
1W
GO GATORS!