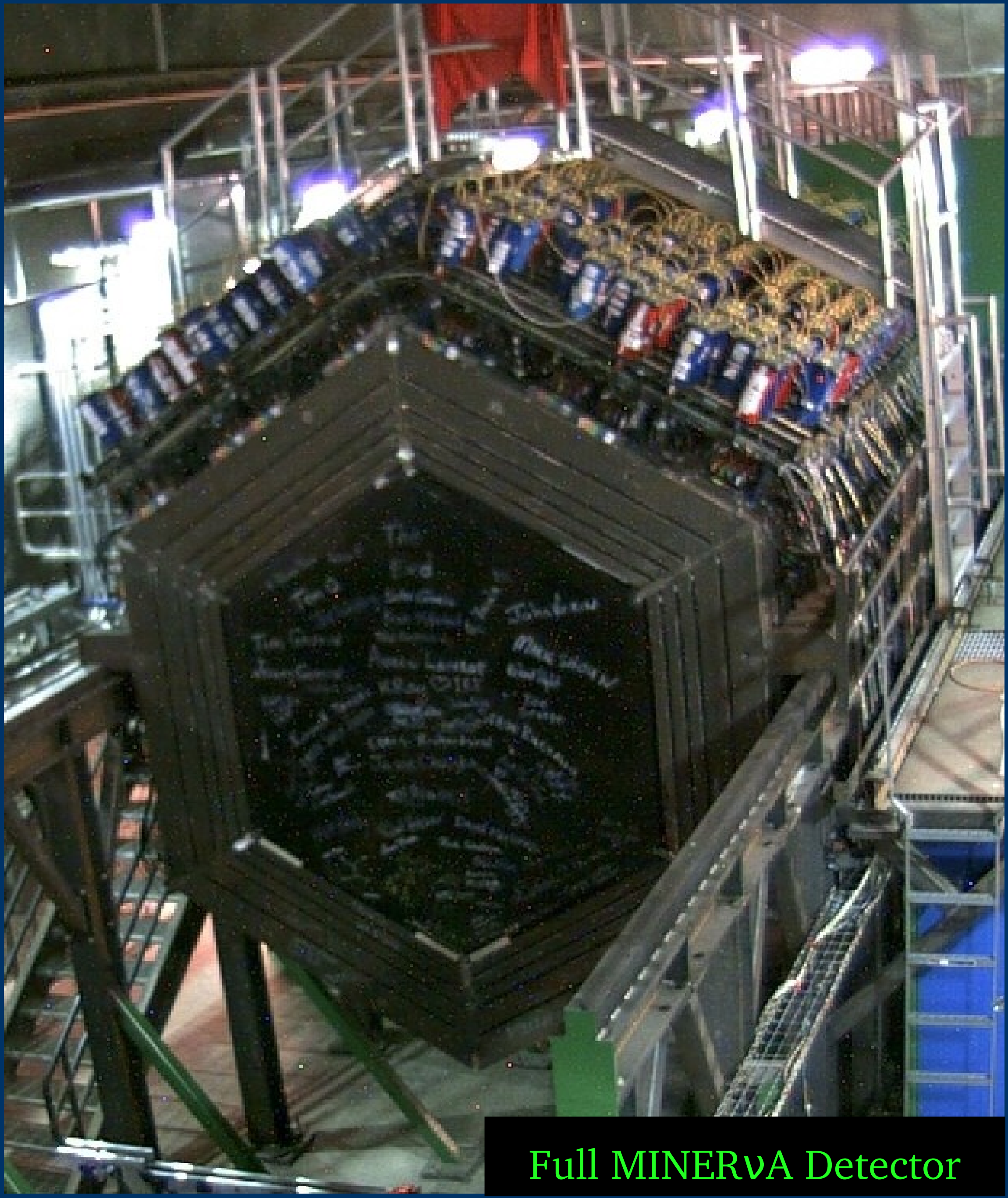

Full MINERνA Detector

# The MINERνA Experiment


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CBPF – Brazil


On behalf of MINERνA Collaboration

User's Meeting, June 2-3, 2010

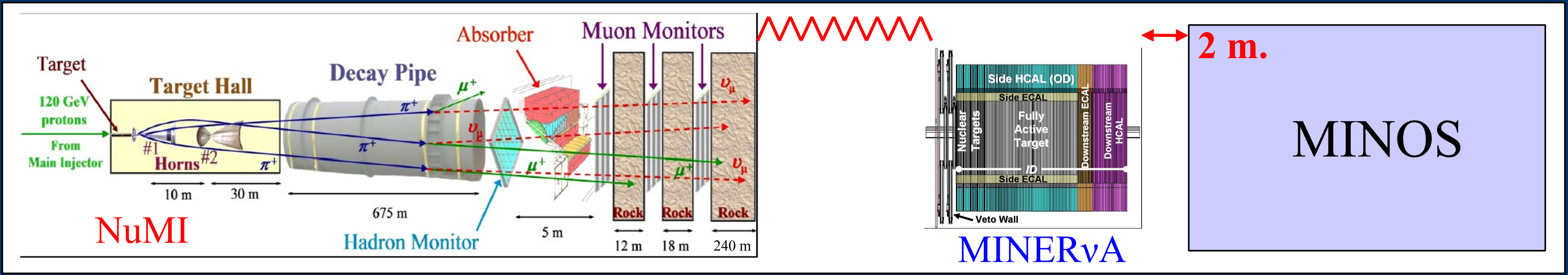
# Outline

- MINERνA Overview
- Phases of MINERνA
- How do we get Physics from the MINERνA Detector?

# MINER$\nu$A Overview

# The MINERνA Experiment

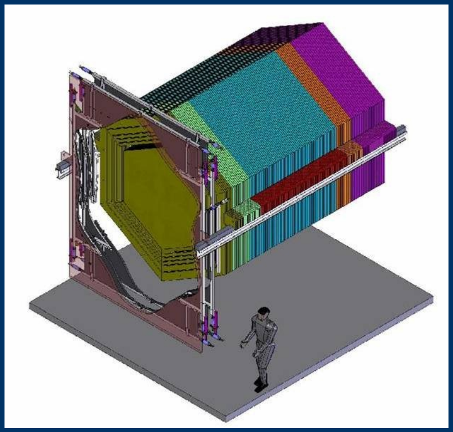
- MINERνA: A high precision scattering experiment designed to:
  - study neutrino-nucleus interactions in unprecedented detail.
  - make measurements needed for current and future oscillation exper.
  - study weak interactions with neutrinos-nuclei.
- The MINERνA detector operates in the NuMI beamline at Fermilab upstream of the MINOS near detector.



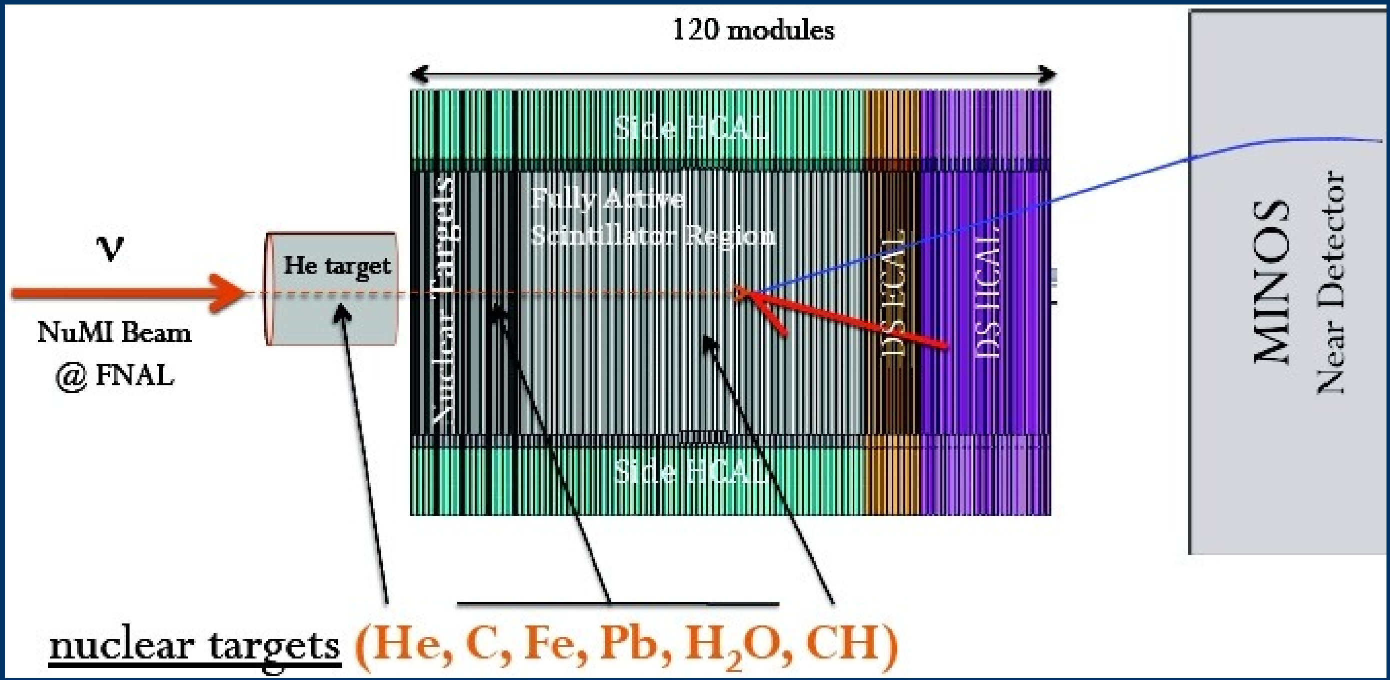

- Goals: Minerva is unique in the worldwide program:
  - NuMI intensity provides an opportunity for precise neutrino interaction measurements with a wide range of energies (1-20 GeV).
  - Several different targets allow the first study of nuclear effects in neutrino scattering.

# The MINERνA Detector

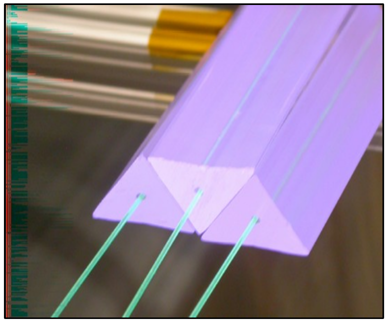
- MINERνA has an active core of segmented solid scintillator.



- Fine segmentation of scintillator allows:
  - Tracking (including low momentum recoil protons).
  - Particle identification.
  - Good timing resolution to see K decays.
- Core surrounded by electromagnetic and hadronic calorimeters.
  - Photon ($\pi^0$) and hadron energy measurement.
- Upstream region has C, Fe, Pb, $H_2O$ (this month) and LHe (this fall) targets.
- MINOS near detector acts as a muon catcher.

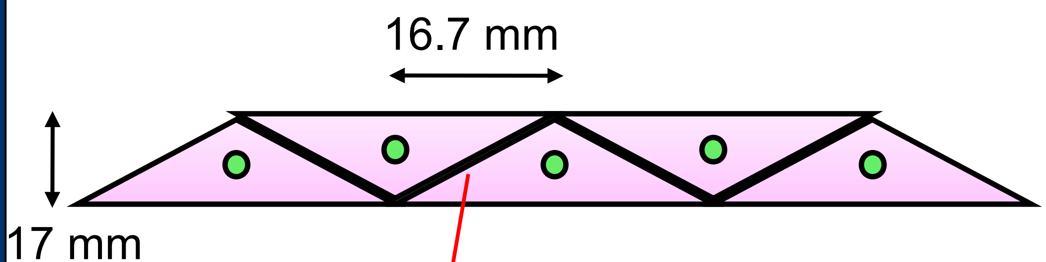


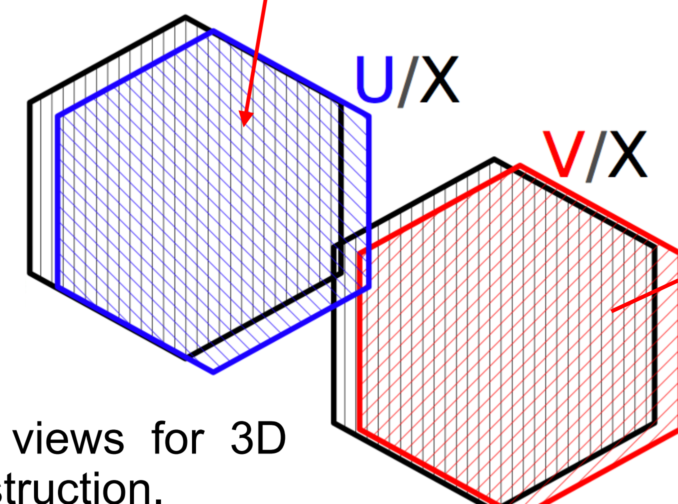
# The MINERνA Detector



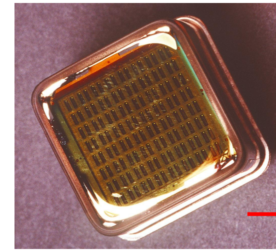
Extruded plastic scintillator + wavelength shifters.

Triangular geometry allows charge sharing for better position resolution.

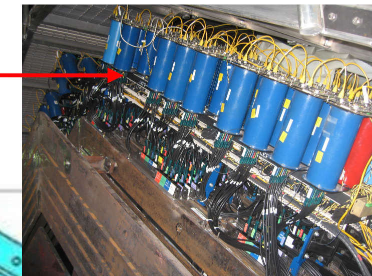


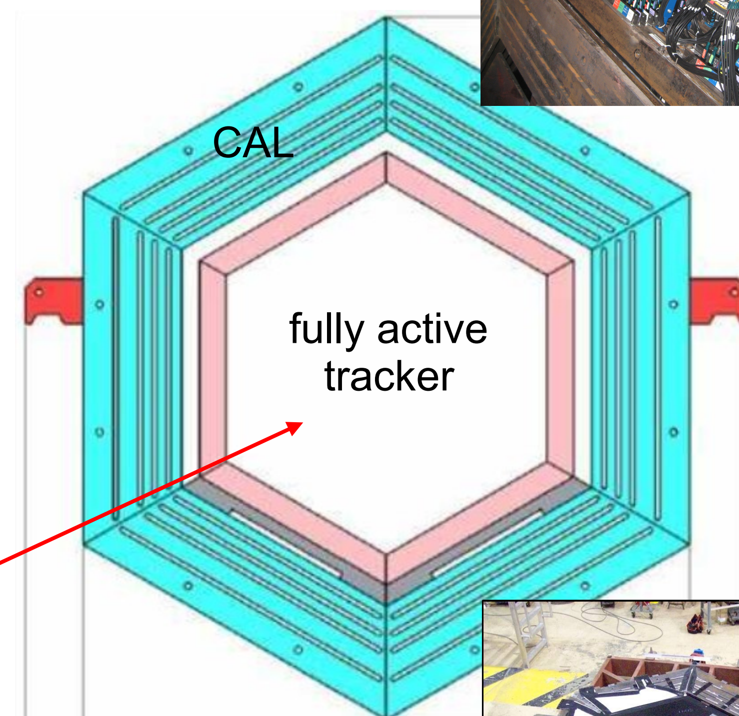




Three views for 3D reconstruction.

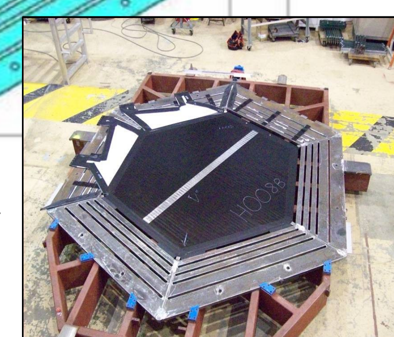


64 anode PMT's





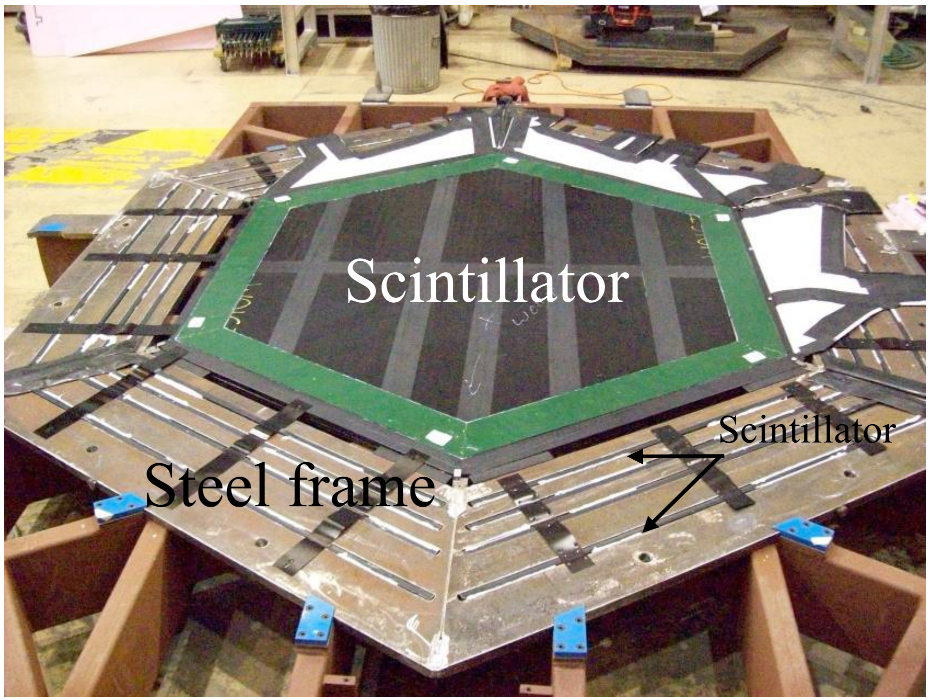

Iron outer detector instrumented for EM calorimetry.

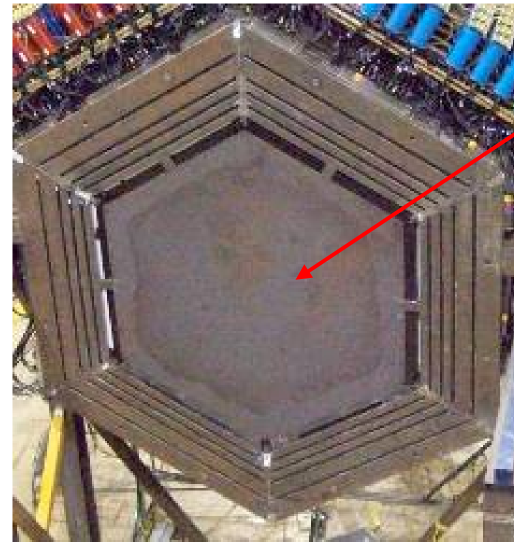


# The MINERνA Detector

## 4 basic module types

**Tracker** modules have two planes of scintillator.



**HCAL** modules include 1" steel absorber and only one scintillator plane.

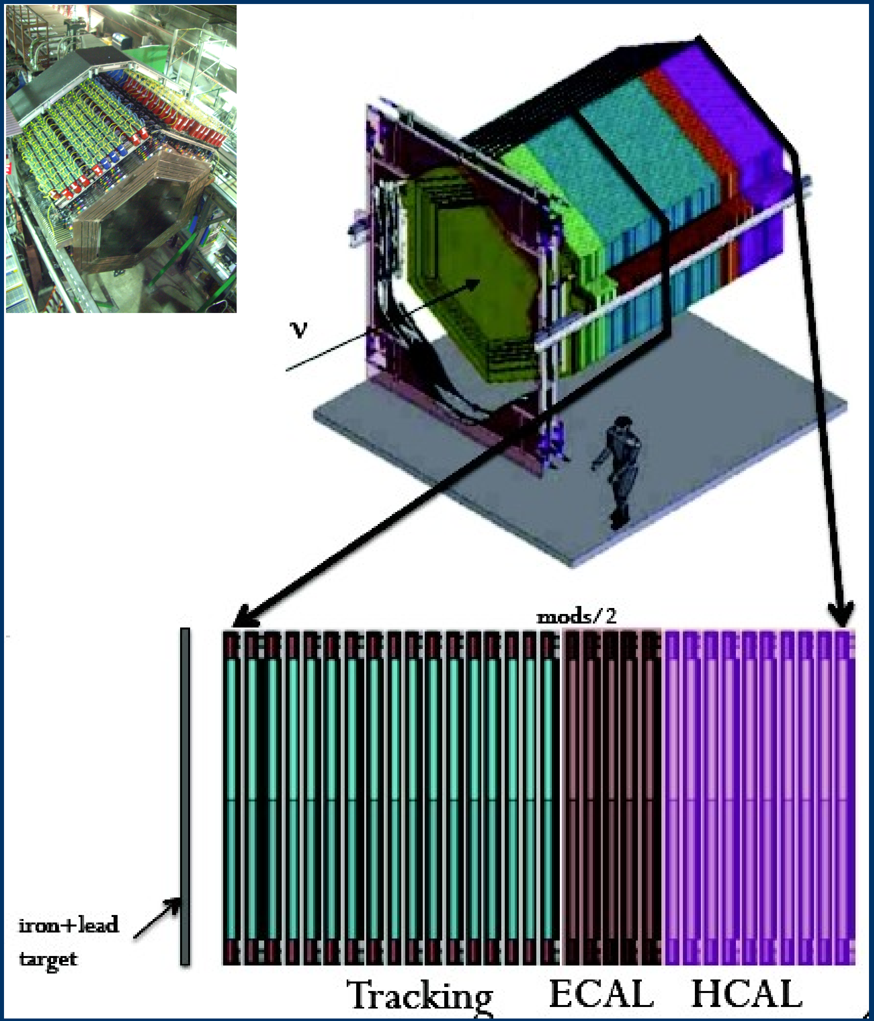
**Nuclear target** modules have no central scintillator. The target material is welded inside outer steel frame.

**ECAL** modules incorporate 2 mm Pb absorbers with 2 scint. planes.

# Phases of MINERνA

# Frozen Detector (FD)

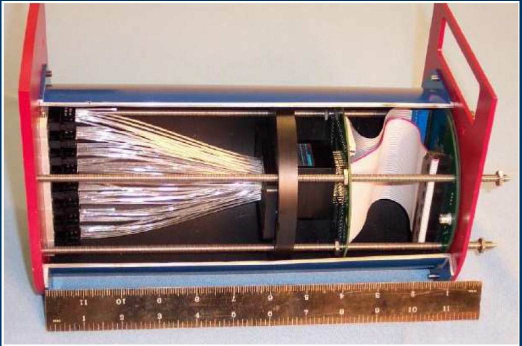
- FD: 64 full-sized MINERνA modules installed (~55% of full detector).
  - 34 tracking modules.
  - 10 ECAL modules.
  - 20 HCAL modules.

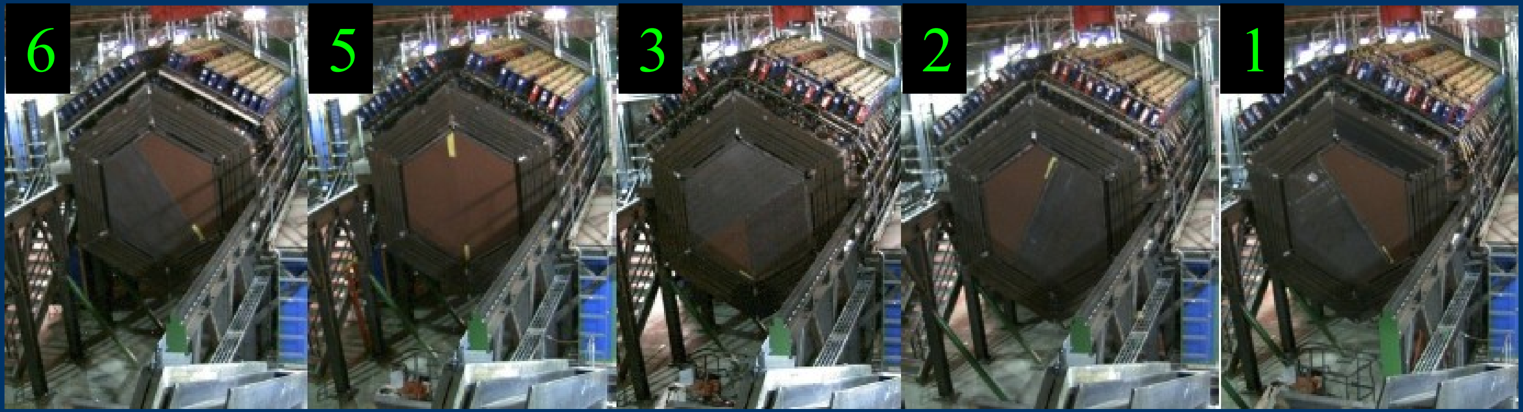



- 1 nuclear target module was included in the installation. (¼ ton Fe and ¼ ton Pb for 50% of the run).
- 272 PMT's installed (~ 17k channels).
- Took 8.4e19 protons on target in NuMI antineutrino mode from Nov 11, 2009 – March 22, 2010.
- Installation of upstream portion of the MINERνA detector began on Jan 5, 2010 (kept taking antineutrino data during installation period).

# Current MINERvA Detector

- Started taking NuMI neutrino data on March 22, 2010.
  - 84 tracking modules (24 in nuclear region + 60 in active region).
  - 10 ECAL modules.
  - 20 HCAL modules.
  - 6 nuclear targets:
    - Target 1: 50% Fe, 50% Pb
    - Target 2: 50% Fe, 50% Pb (reversed order)
    - Target 3: C, Fe, Pb
    - Target 4: Water
    - Target 5: Thin Pb
    - Target 6: 50% Fe, 50% Pb (thiner than Mod. 1, 2)
  - 491 M-64 PMT's installed (31,424 channels)



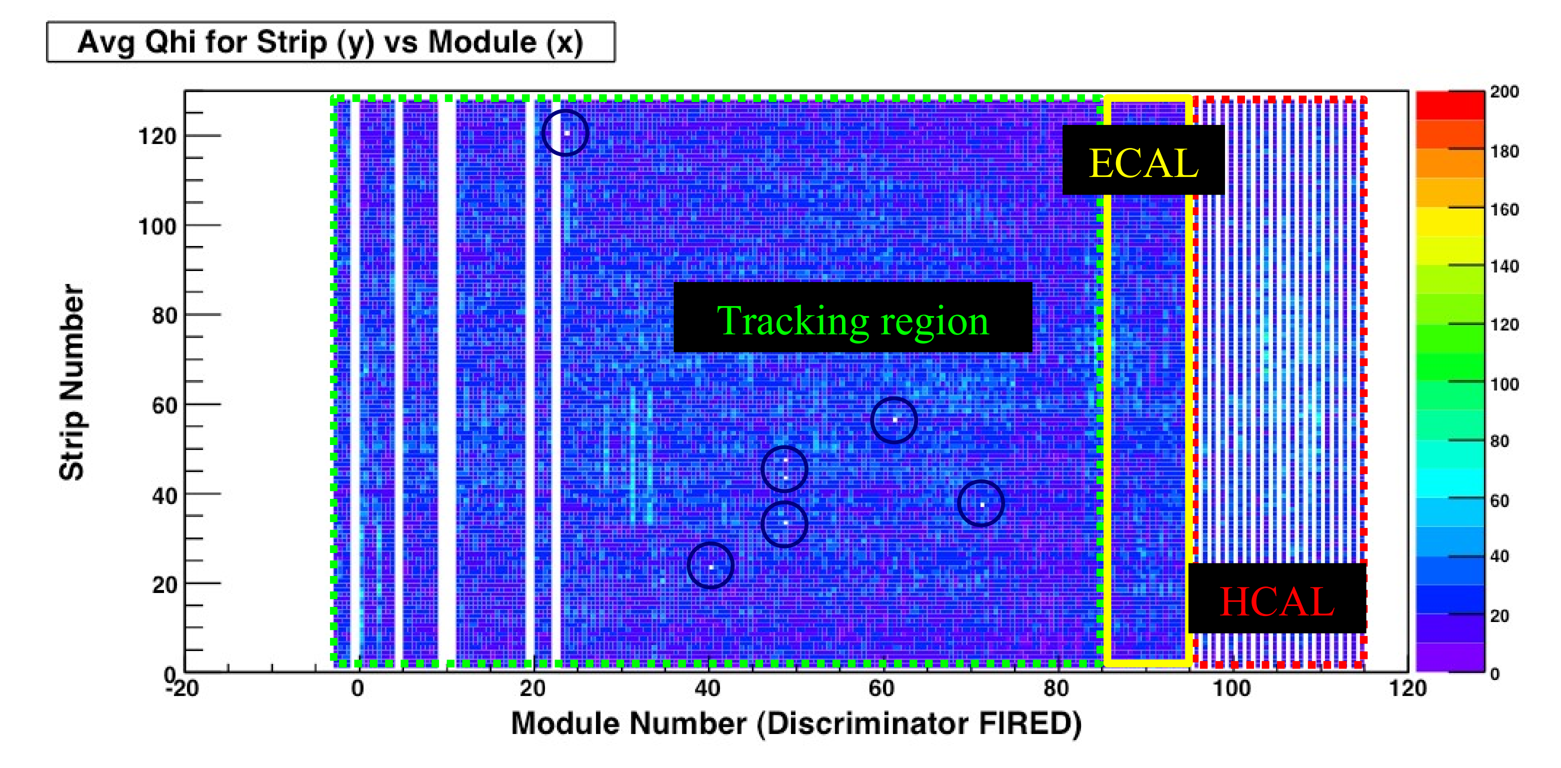



# How do we get Physics from the MINERνA Detector?

# Physics Analysis

- Data Taking Check tools

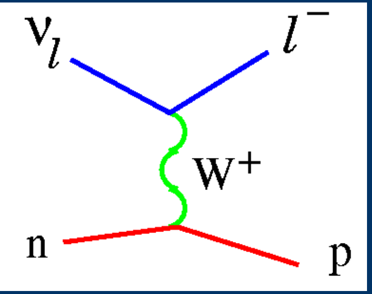
Occupancy plot of the MINERνA detector in the NuMI beam. Colors correspond to pulse height in ADC counts.

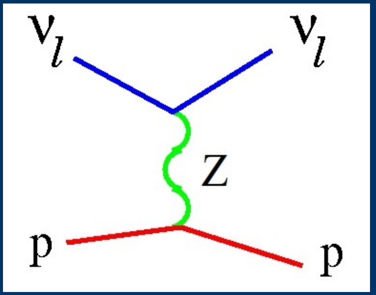



Less than 20 dead channels in the full detector out of more than 31k channels.

# Physics Analysis

- Initial Physics Channel Goals
  - Quasi-elastic
    - Comparable simple topology (one or two prong) for $\nu$.
      - » $\mu$ identification and momentum from MINOS, no second track for low $Q^2$.
      - » if there is a second track most often can be identified as a proton.
    - Only one track for $\bar{\nu}$.
  - NC elastic
    - A single proton track as a final state.
  - CC events ratios for different current targets as a function of $\mu$ kinematics.

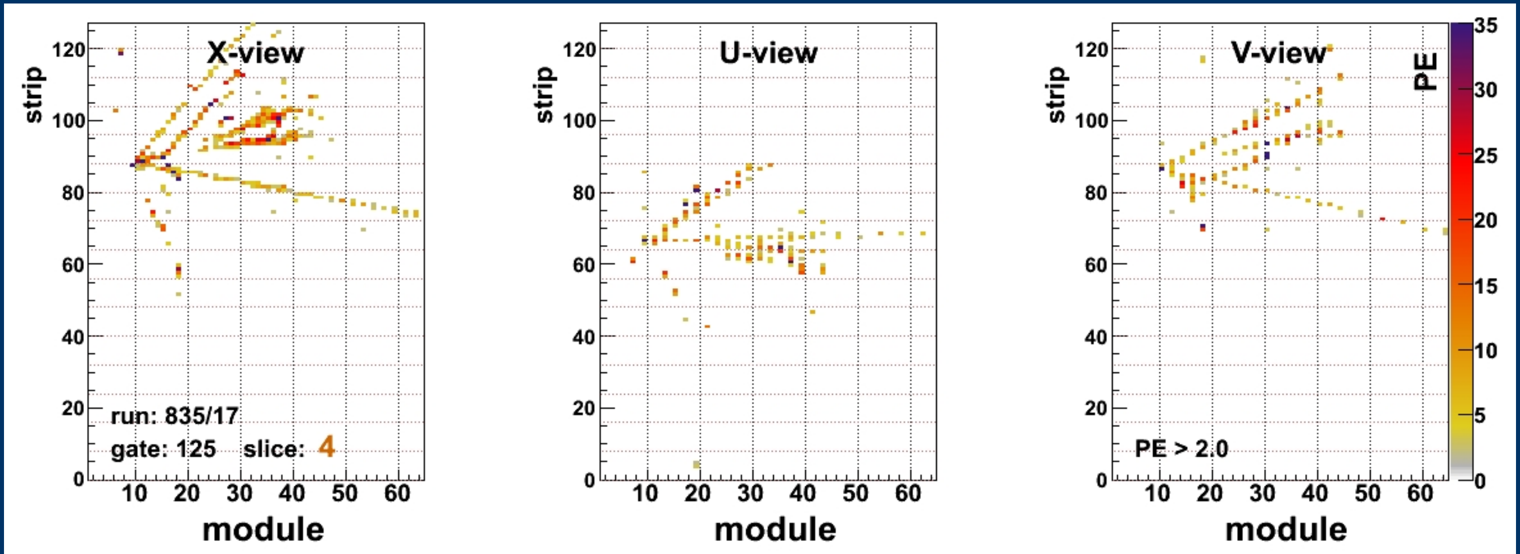


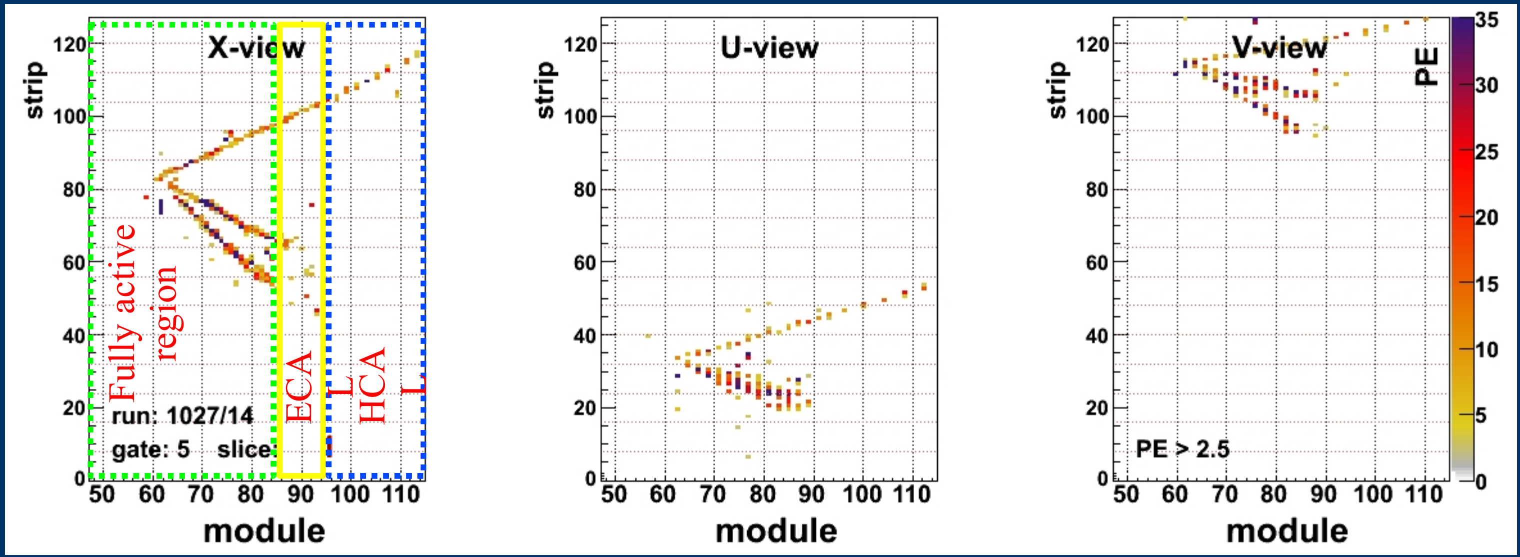



# Physics Analysis

- Event Display: Good visibility of tracks in multiple particle final states and secondary interactions

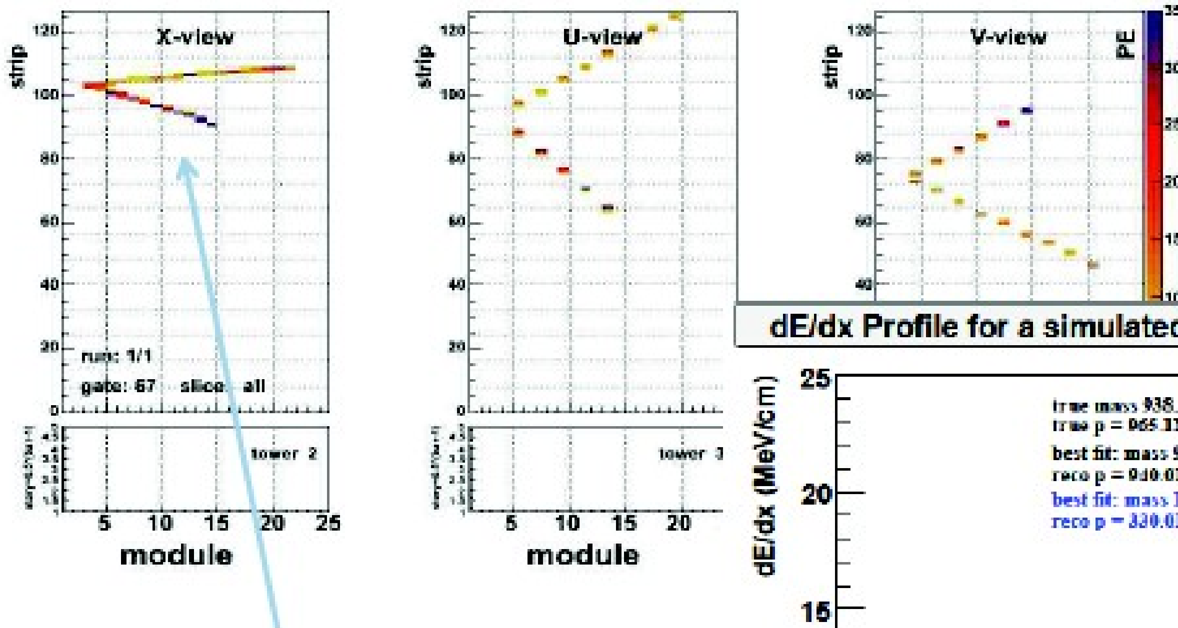
Events from anti-neutrino running period.



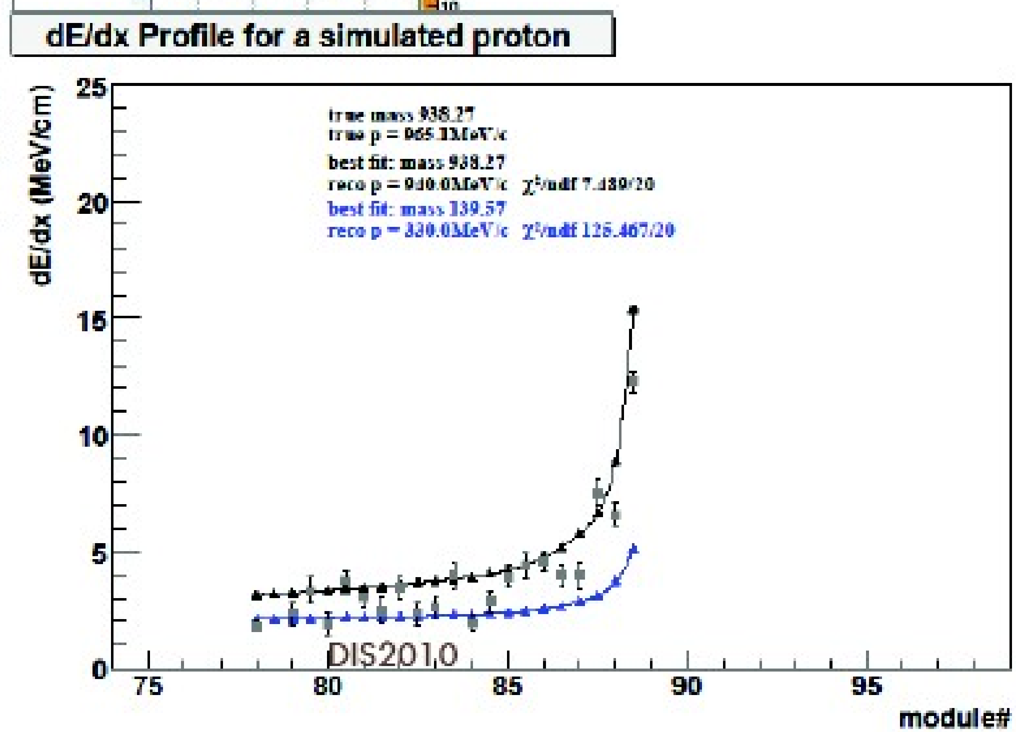
# Physics Analysis

- Particle Identification by dE/dx: GENIE Simulation



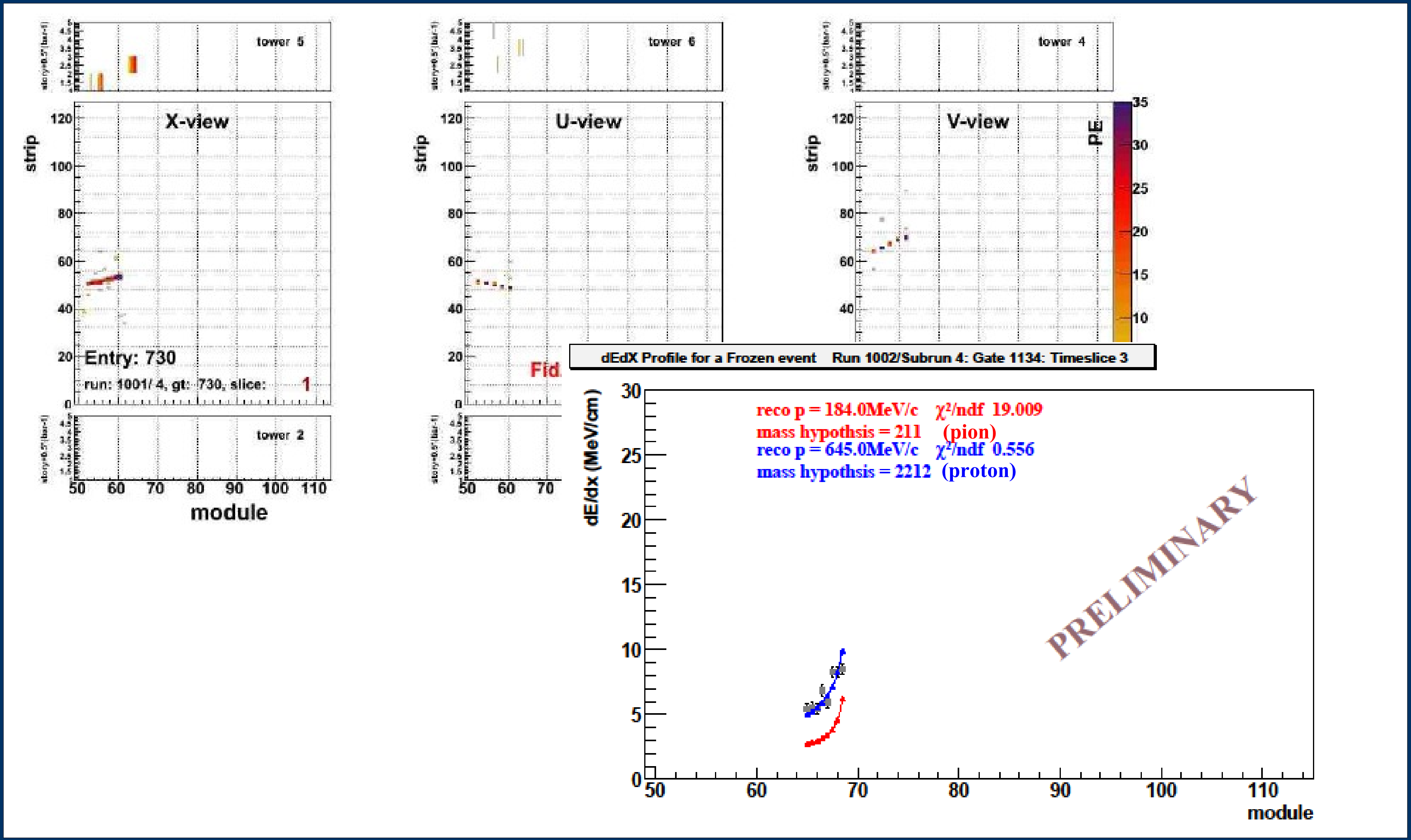

Contained proton prong

$$\nu_\mu + n \rightarrow \mu^- + p$$



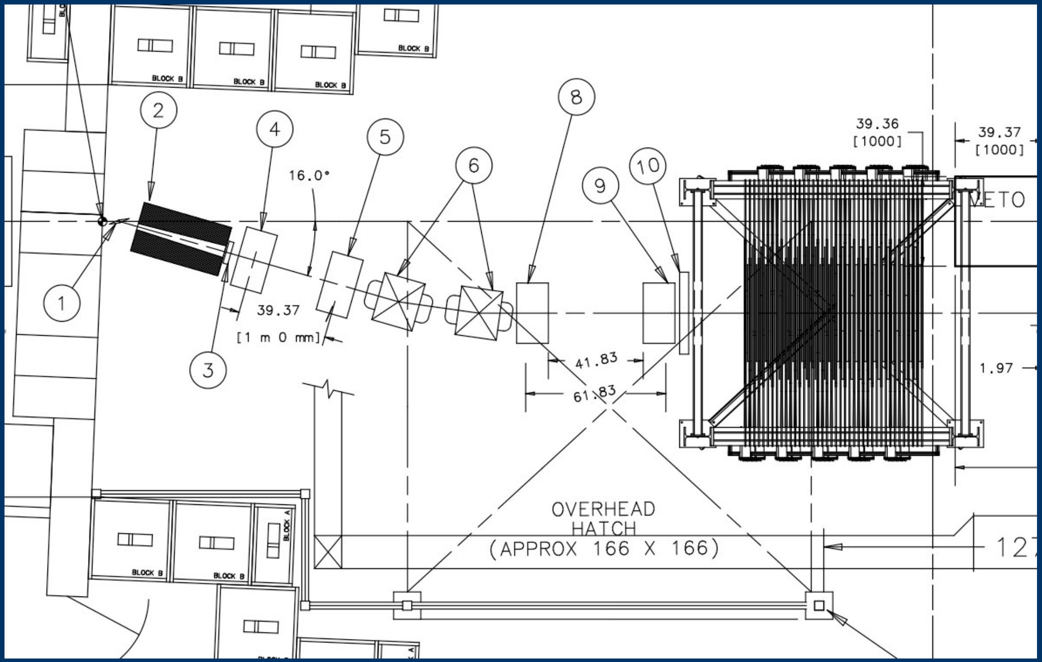
# Physics Analysis

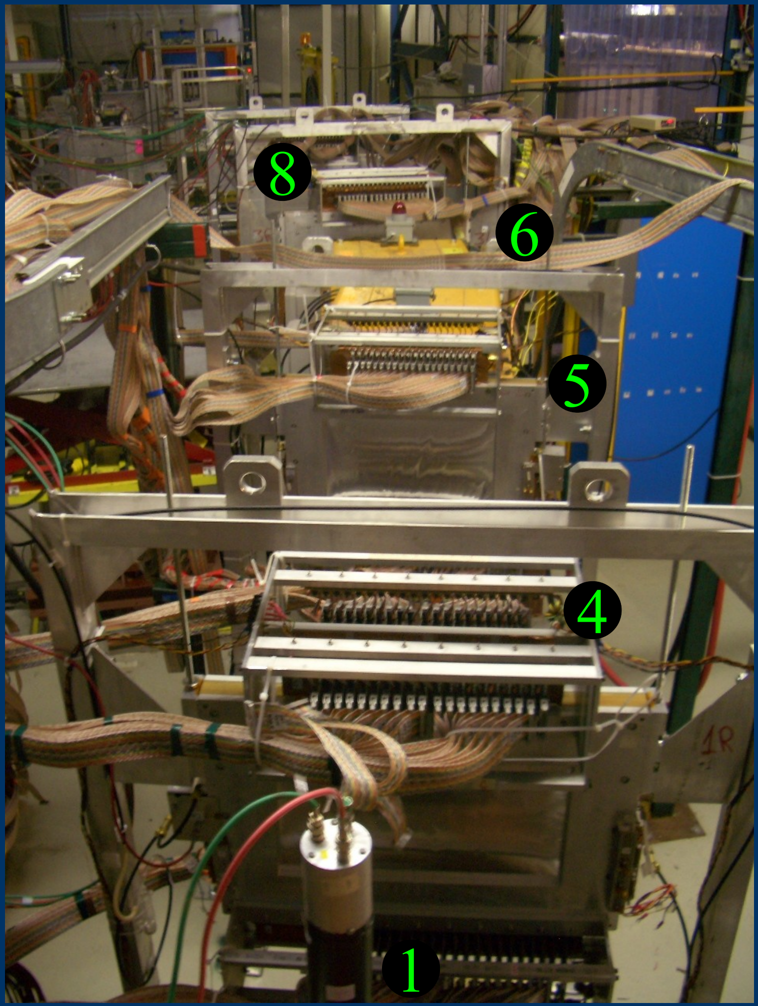
- Particle Identification by dE/dx: Frozen Detector data



# MTest Tertiary Test Beam

- Will provide the hadronic response calibration.
- 16 GeV pion beam creates tertiary beam of 300 MeV – 1.2 GeV.
- 40 planes, XUXV orientation as in full MINERvA.
- Reconfigurable Pb, Fe and scintillator modules to emulate different detector regions.
- Smaller than full detector: ~1.1 x 1.1 $m^2$.



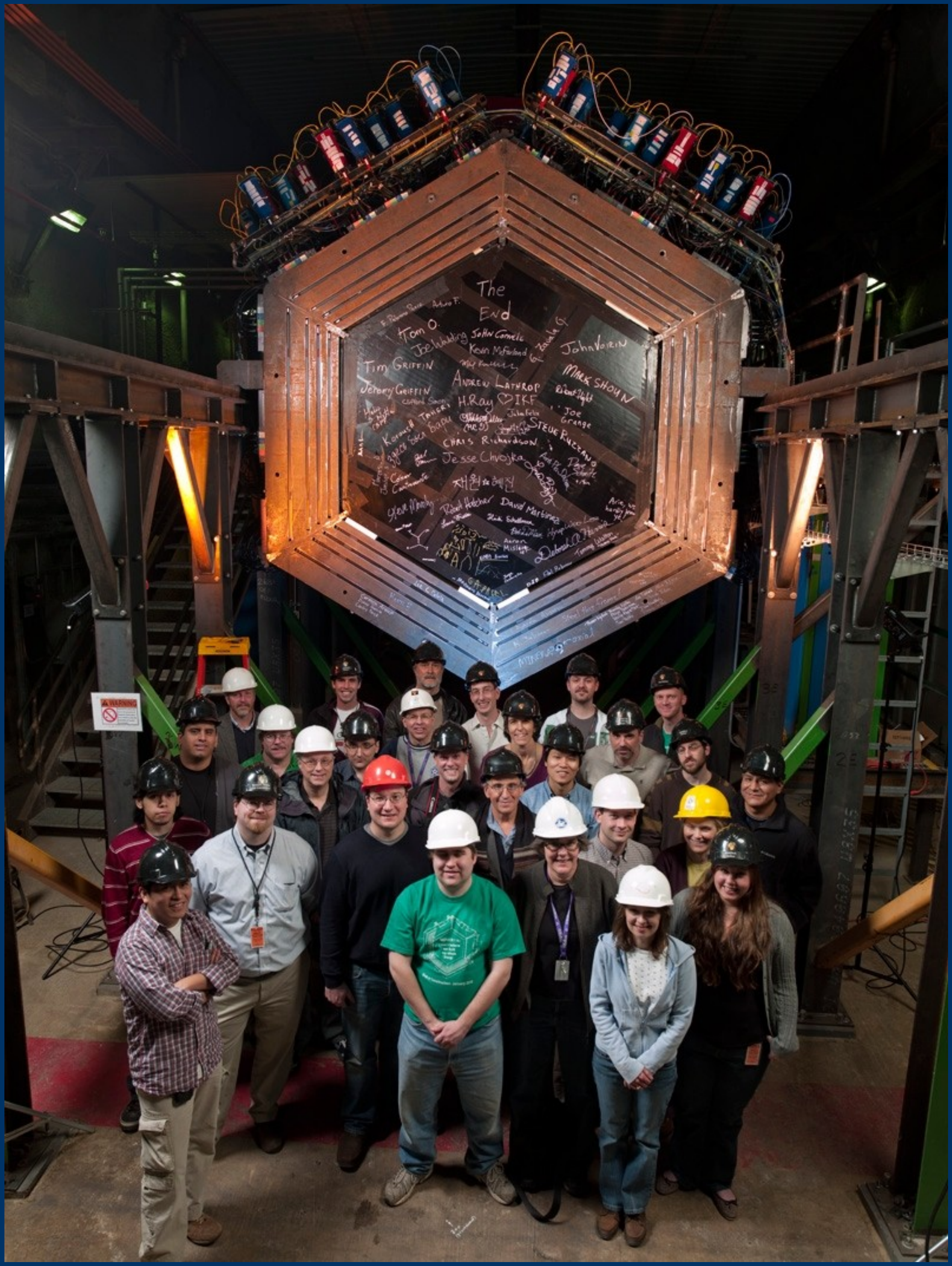




1: Pion Beam
3,10: Time of Flight Triggers
4,5,8,9: Wire Chambers
6: Magnets

# Summary

- MINERνA is an experiment designed to study neutrino-nucleus interaction in great detail and to support present and future oscillation experiments.
- We took 4 months of anti-neutrino data with 55% of the detector. Reconstruction of these data has already started.
- Installation of current MINERνA detector was completed in March 2010, and currently taking data with NuMI low energy neutrino beam.
- NuMI medium energy neutrino beam with NOνA after 2012 shutdown.
- Stay tuned for cross section and nuclear effect measurements.

# Thank you



Special thanks to:

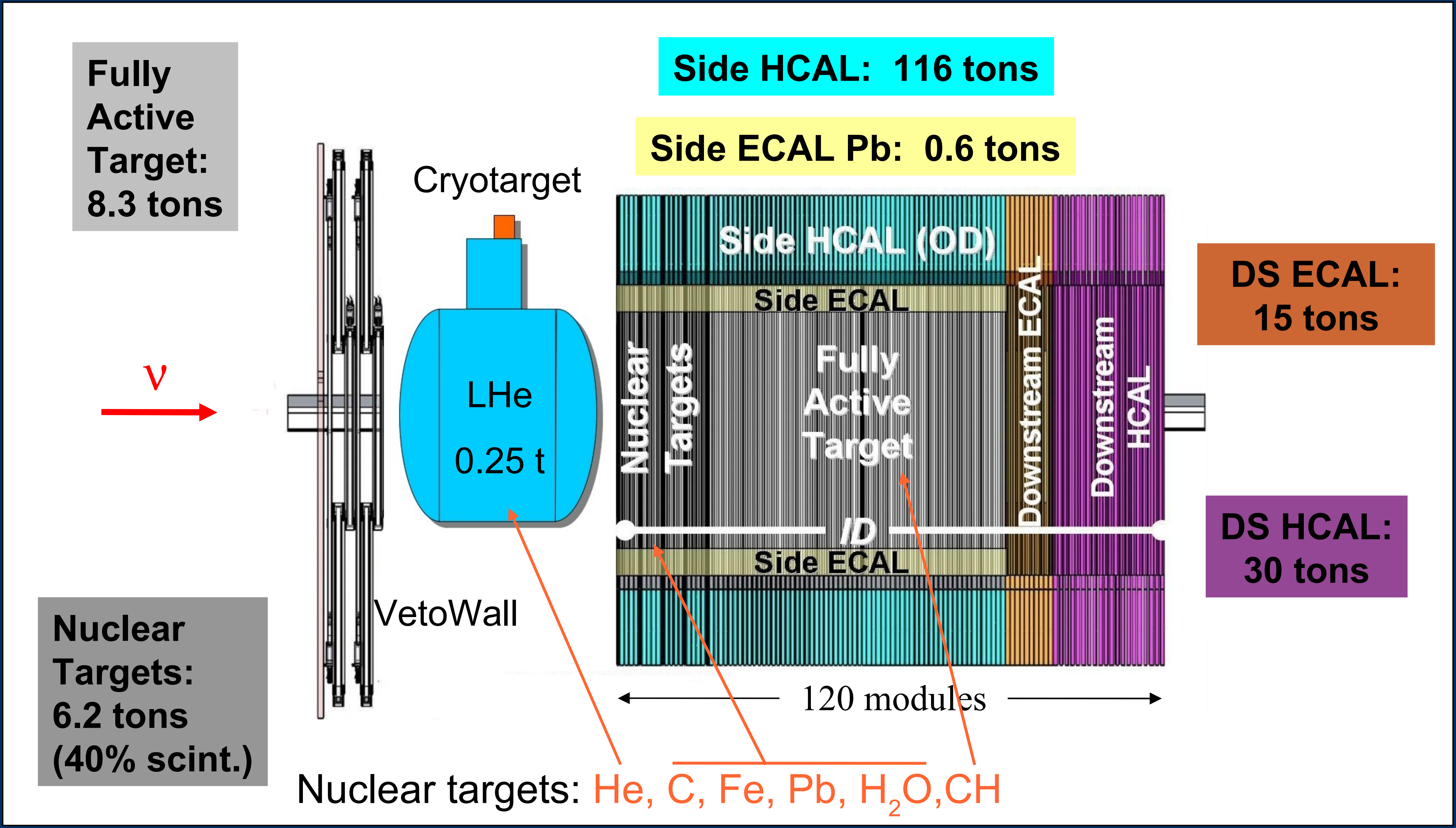
Accelerator Division
and
Particle Physics Division

# The MINERνA Collaboration

- University of Athens, Athens, Greece
- Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil
- University of California, Irvine, California
- Fermi National Accelerator Laboratory, Batavia, Illinois
- University of Florida, Gainesville, Florida
- Universidad de Guanajuato, Guanajuato, México
- Hampton University, Hampton, Virginia
- Institute for Nuclear Research, Moscow, Russia
- James Madison University, Harrisonburg, Virginia
- University of Minnesota-Duluth, Duluth, Minessota
- Northwestern University, Evanston, Illinois
- Otterbein College, Westerville, Ohio
- University of Pittsburgh, Pittsburgh, Pennsylvania
- Pontificia Universidad Católica del Perú, Lima, Perú
- University of Rochester, Rochester, New York
- Rutgers University, New Brunswick, New Jesrsey
- Universidad Técnica Federico Santa Maria, Valparaíso, Chile
- University of Texas, Austin, Texas
- Tufts University, Medford, Massachusetts
- Universidad Nacional de Ingeniería, Lima, Perú
- The College of William and Mary, Williamsburg, Virginia

# Backup

# Final MINERνA Detector Set-up



# MINERvA Energy Range