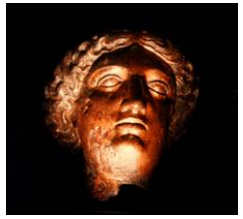
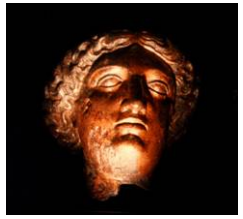


The MINER*v*A Experiment

NuINT 07
Fermilab
May 31st, 2007

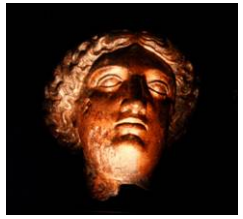
Jeff Nelson
William & Mary
(for the Collaboration)

Overview

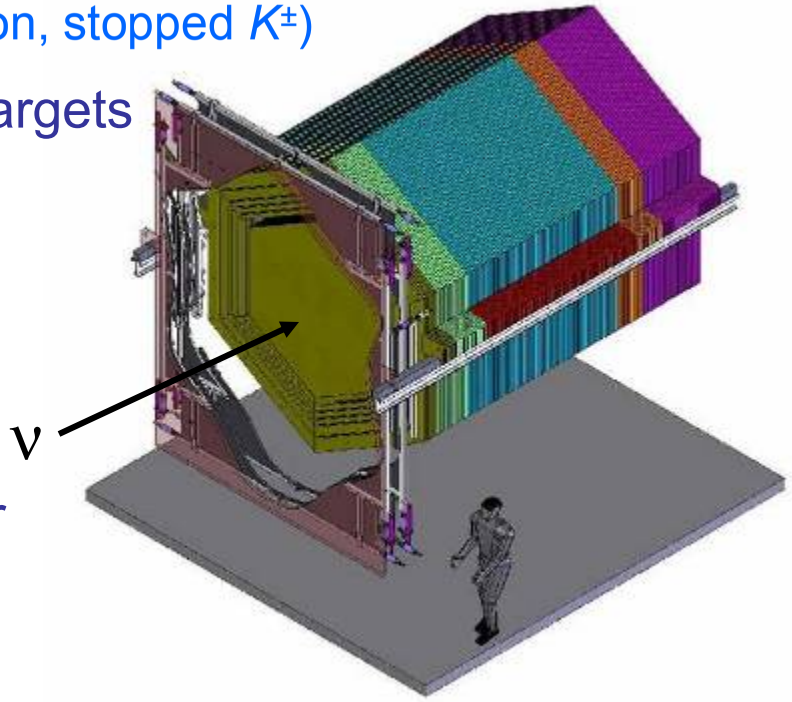


- MINER*v*A goals
- Detector overview
- Detector capabilities
- Status and achievements
- MINER*v*A schedule

The MINER*v*A Detector

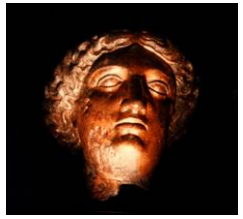


- MINER*v*A is an active core of segmented solid scintillator
- Objectives
  - Precision tracking (including low momentum recoil protons)
  - Particle identification
  - 3 ns (RMS) per hit timing (track direction, stopped $K^{\pm}$)
- Upstream region has LHe, C, Fe, Pb targets
- Core surrounded by electromagnetic and hadronic calorimeters
  - Photon, neutral pions, and hadronic energy measurement
- MINOS near detector as muon catcher



MINERvA
Jeff Nelson
NuINT07

The MINERvA Experiment



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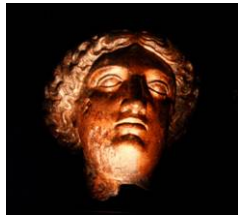
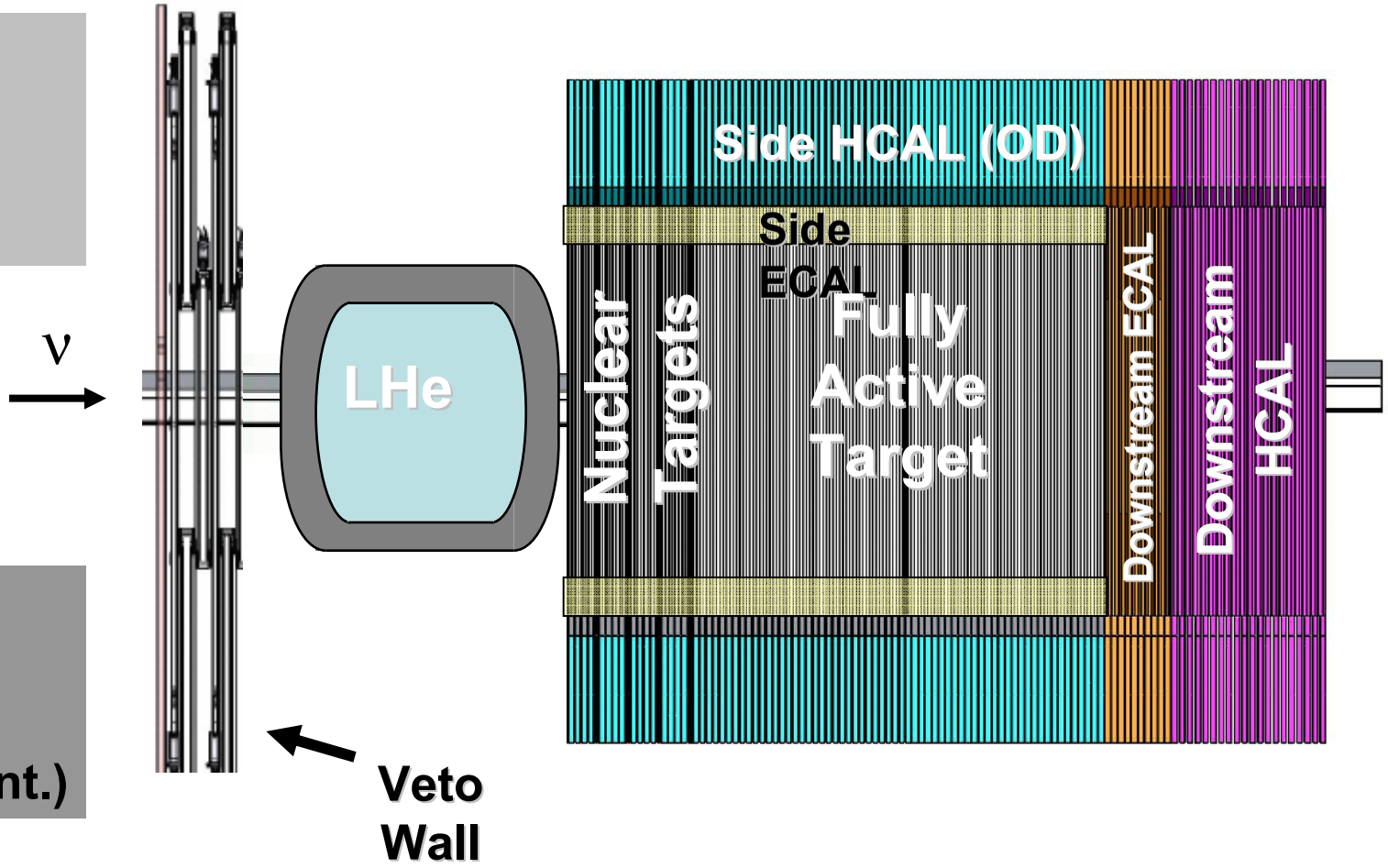
MINERvA Structure

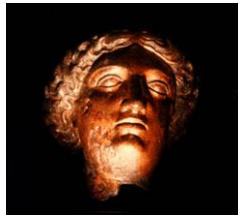


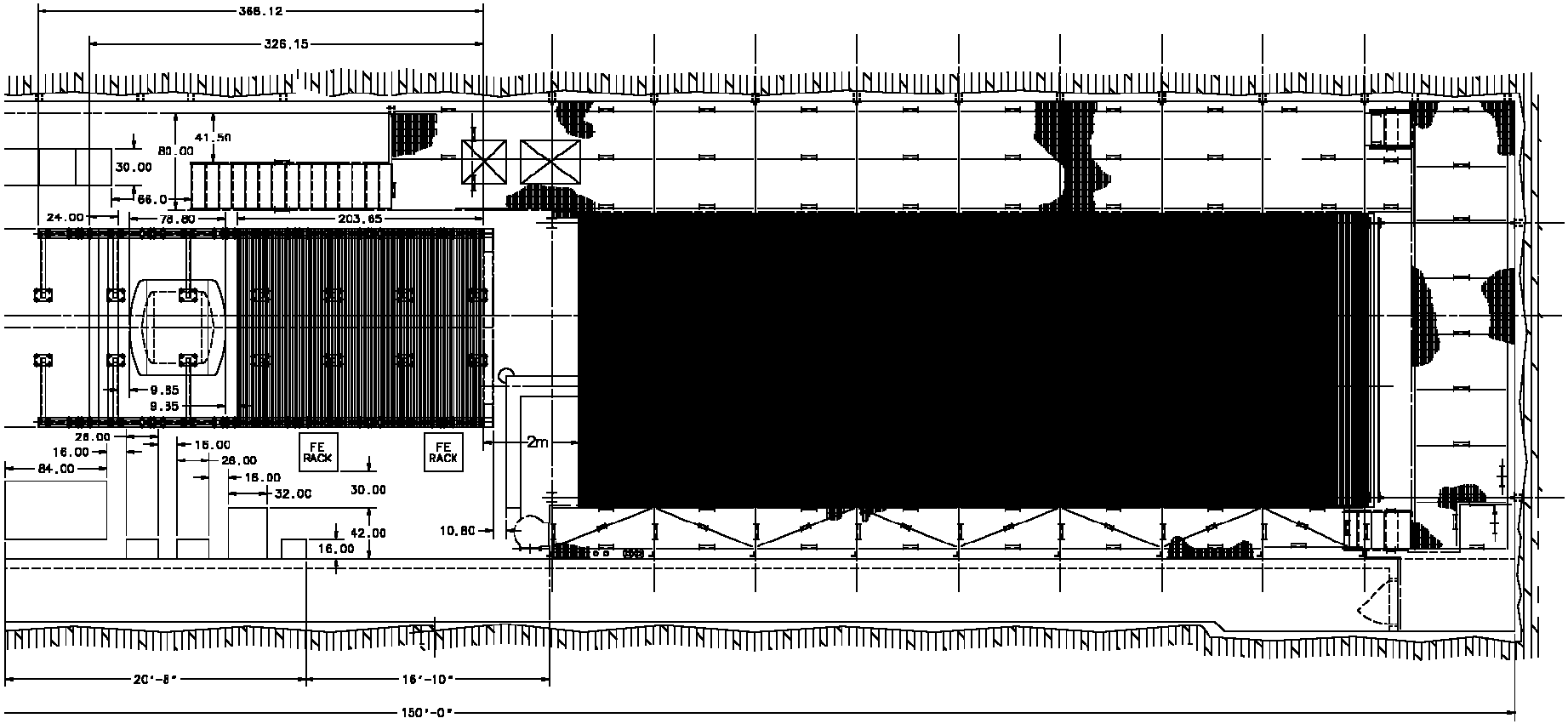
Fully Active Target: 8.3 tons

Nuclear Targets: 6.2 tons (40% scint.)

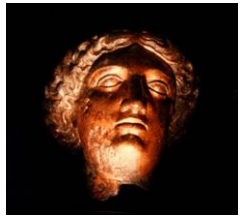


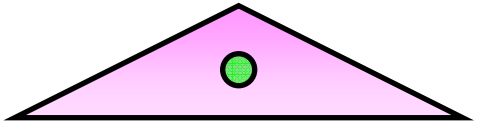
MINERvA & MINOS





MINERvA Optics



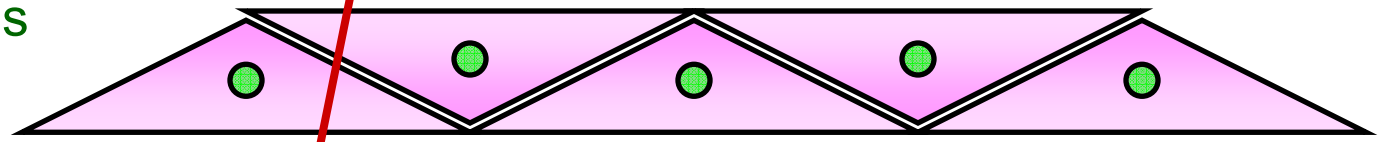


1.7 × 3.3 cm^2 strips

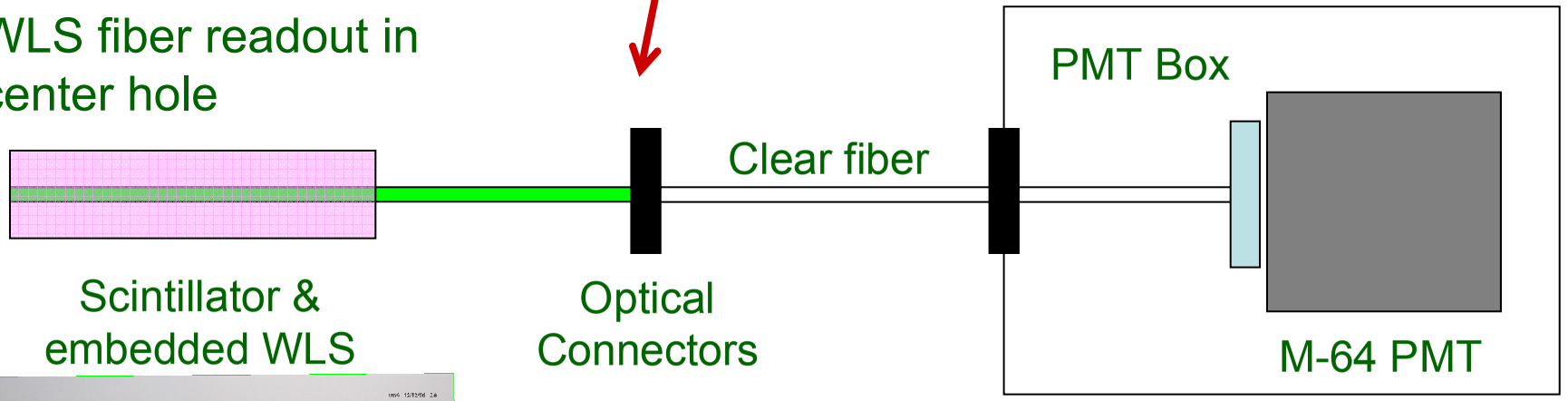
Particle

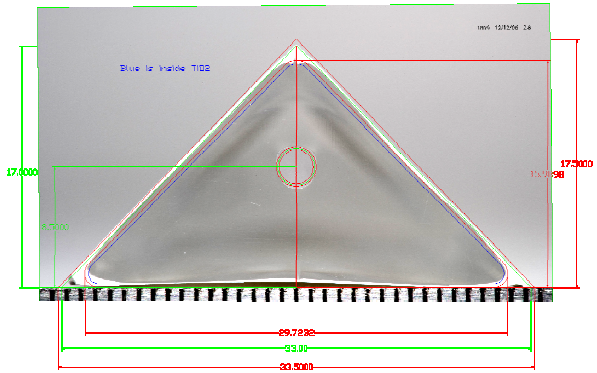
Assembled into 127 strip planes

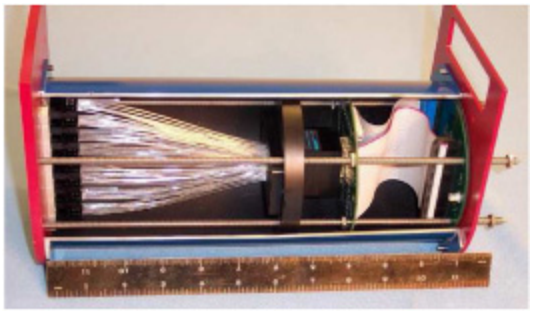
Position by charge sharing



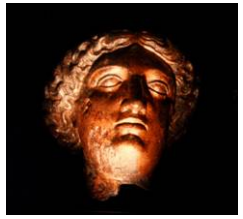
WLS fiber readout in center hole

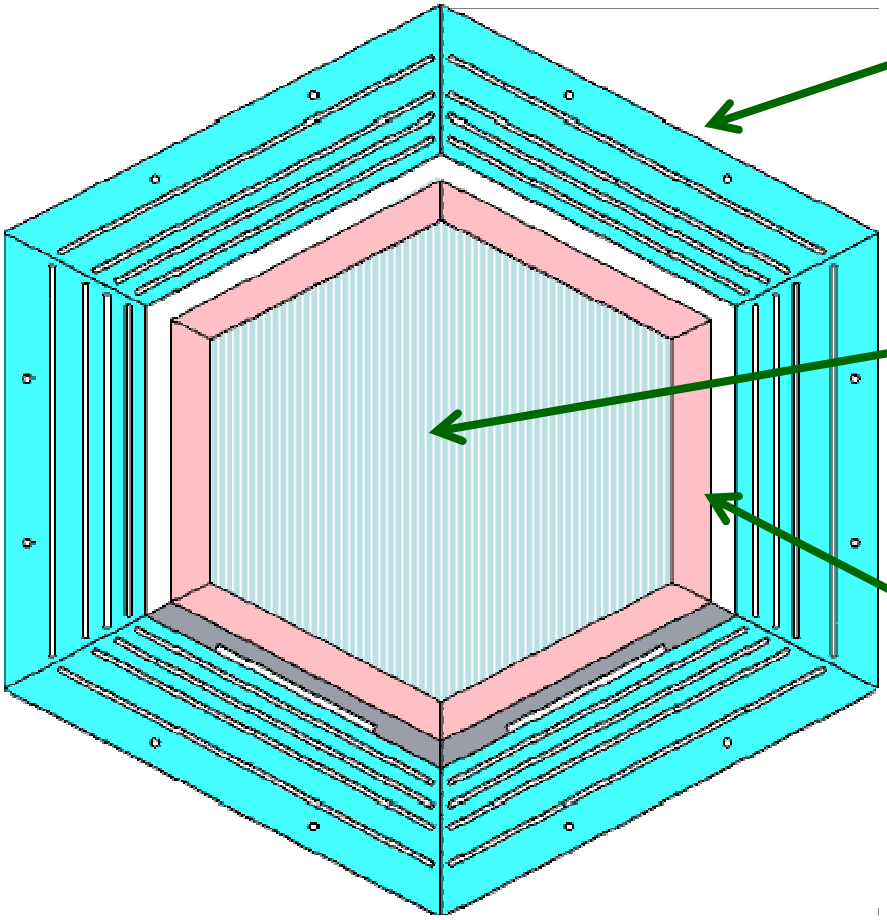






MINERvA Detector Module





Outer Detector (OD)
"Towers" of iron & scintillator for hadron calorimetry

Inner Detector (ID)
Hexagonal X, U, V planes for 3D tracking

Lead for EM calorimetry

MINERνA
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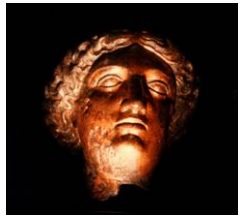
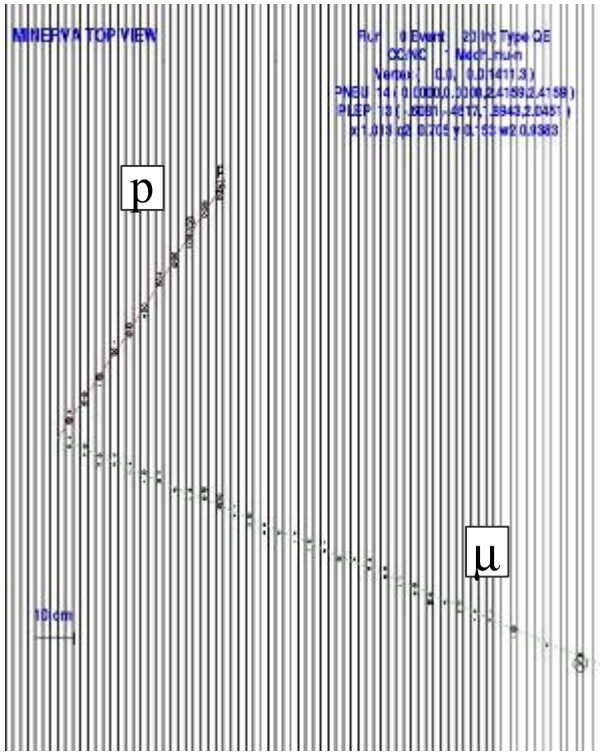
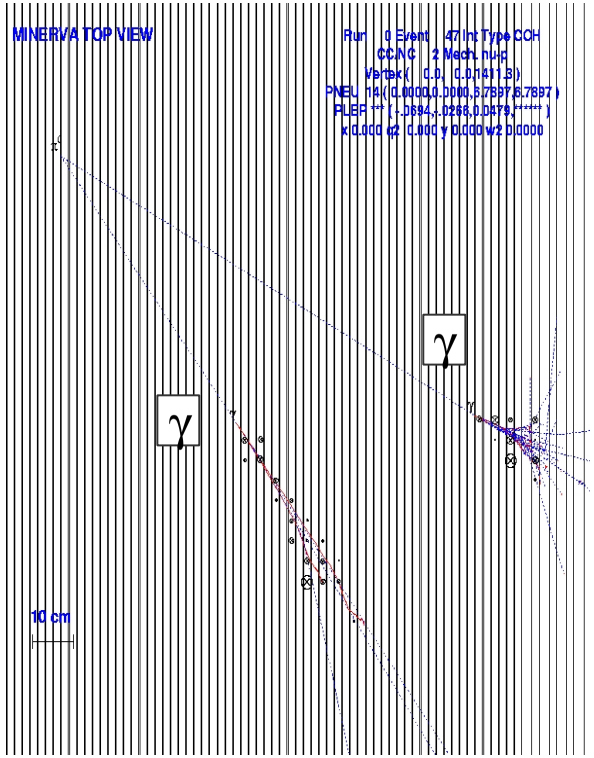
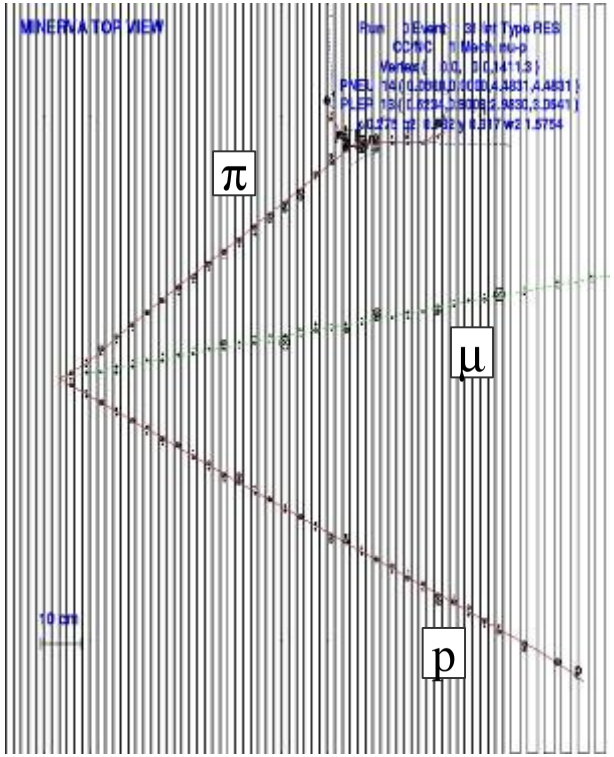
NuINT07

Some MINERνA Events









Quasielastic event

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

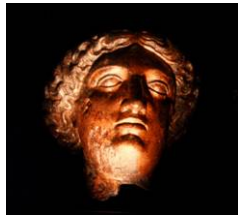
Neutral Current π^0

$\nu_\mu\, A \rightarrow \nu_\mu A\, \pi^0$

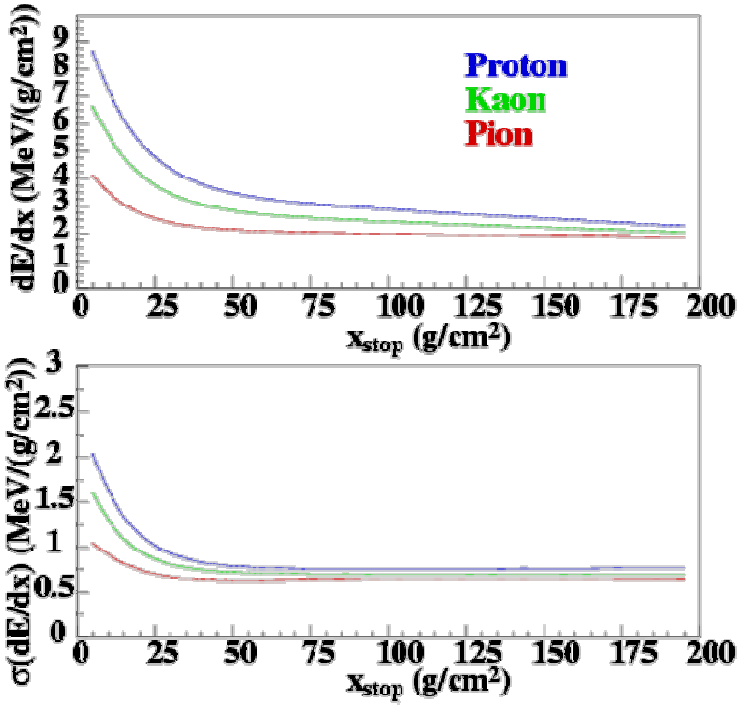
Resonance production

$\nu_\mu\, p \rightarrow \mu^-\, \Delta^{++} \rightarrow \mu^-\, p\, \pi^+$

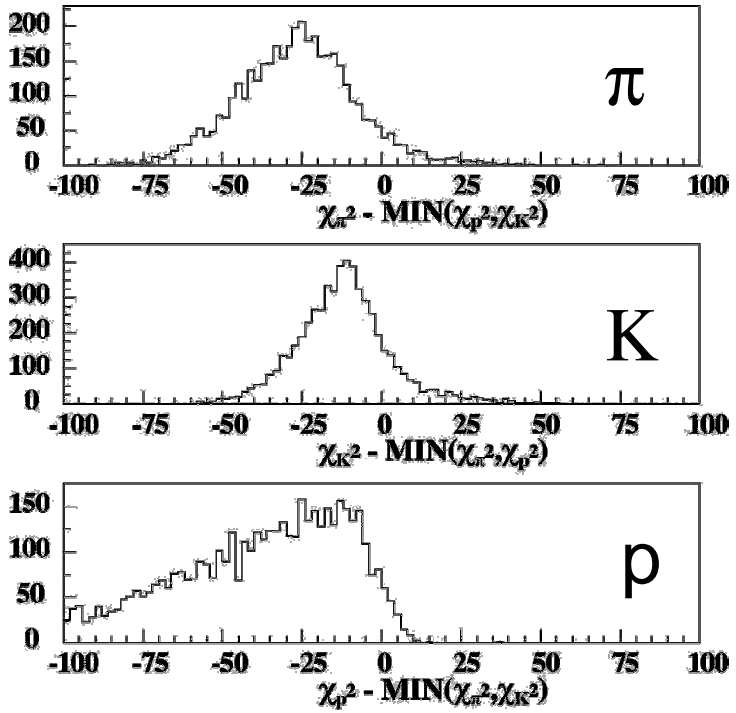
Particle Identification



- Particle ID by dE/dx in strips and endpoint activity

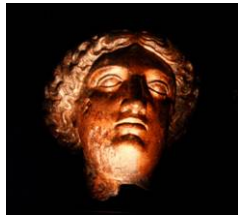


X^2 differences between right and best wrong hypothesis

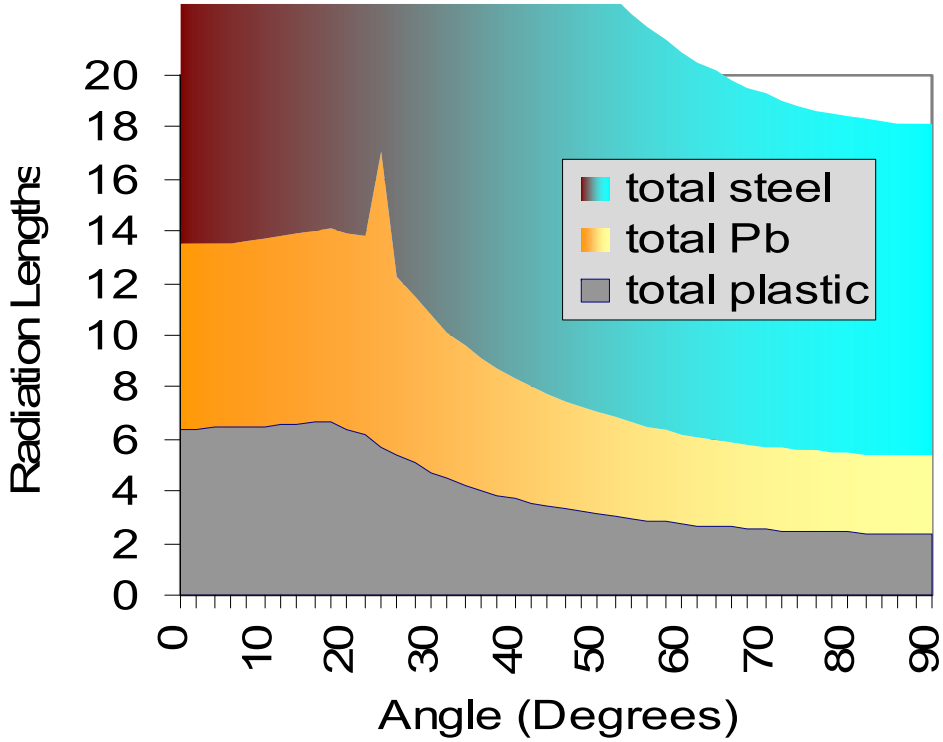


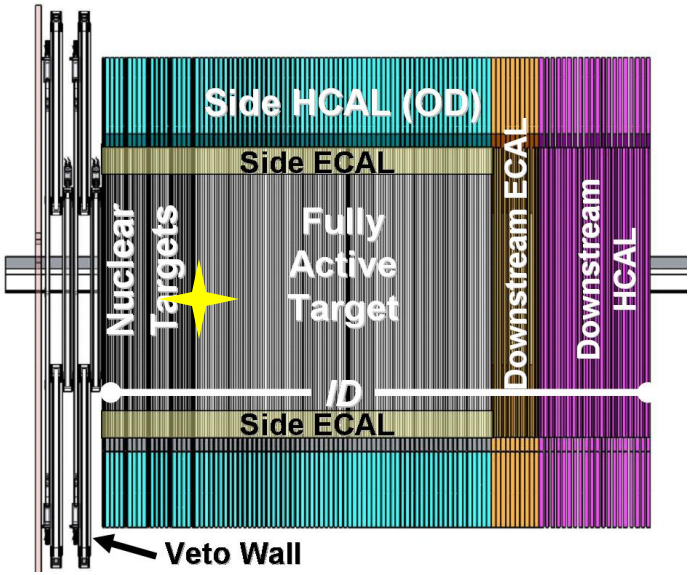
- Many dE/dx samples for good discrimination
  - Sensitive to light yield

MINERvA as Calorimeter

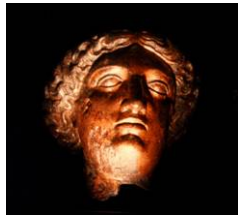


- Material thickness in radiation lengths
  - Side & downstream ECALs have 2mm Pb plates

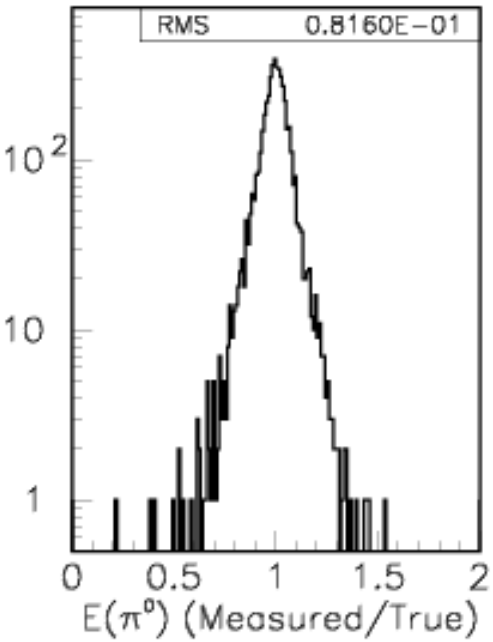


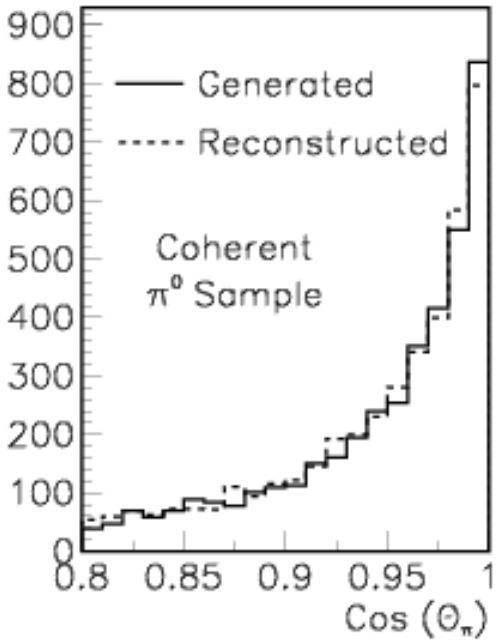


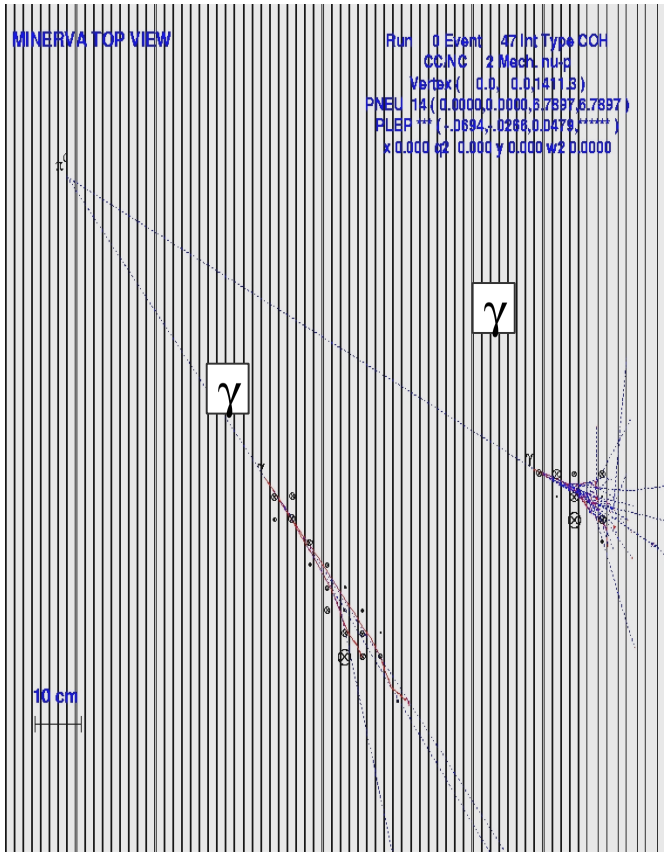
Neutral Pions



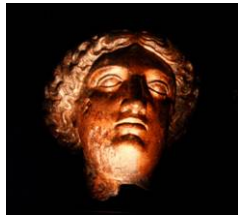
- Photons cleanly identified and tracked
  - π^0 energy res.: 6%/√E (GeV)
- For coherent pion production, angular resolution < physics width
  - See Hugh Gallagher's Talk



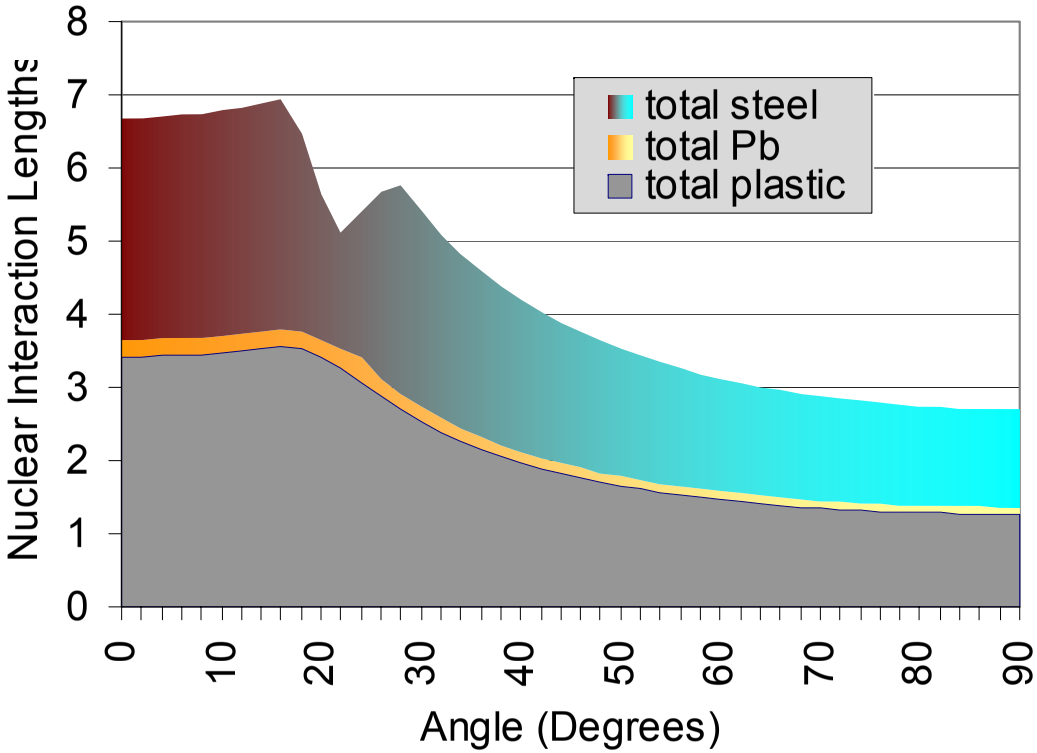


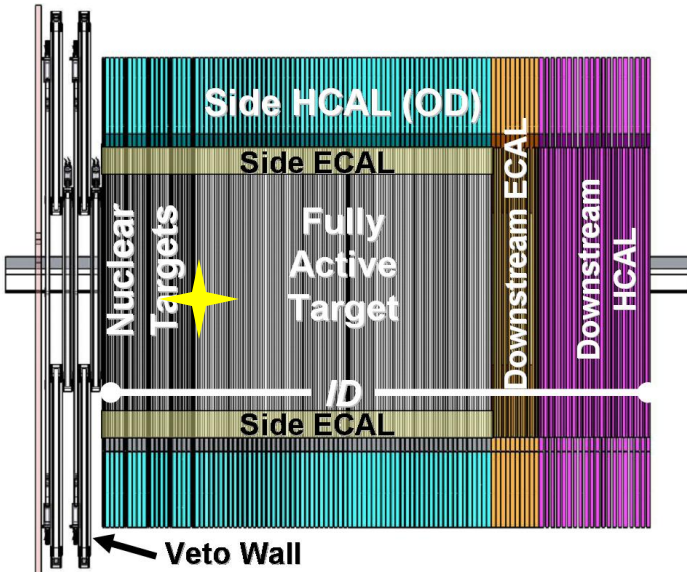


MINERvA as Calorimeter

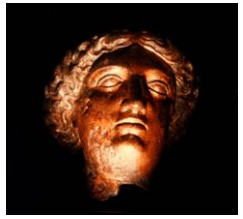


- Material thickness in nuclear interaction lengths

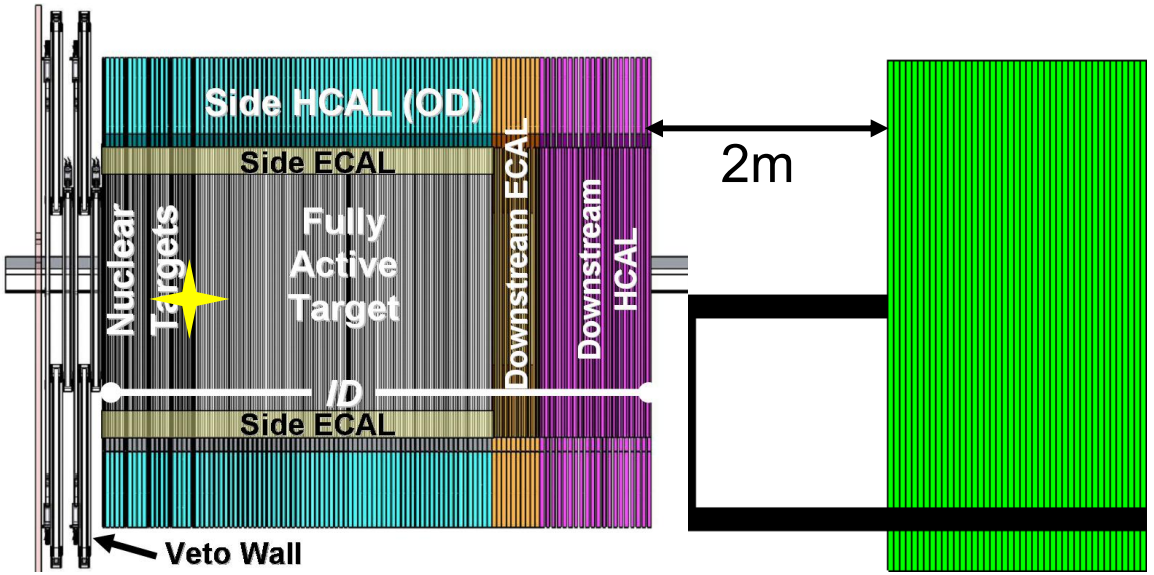


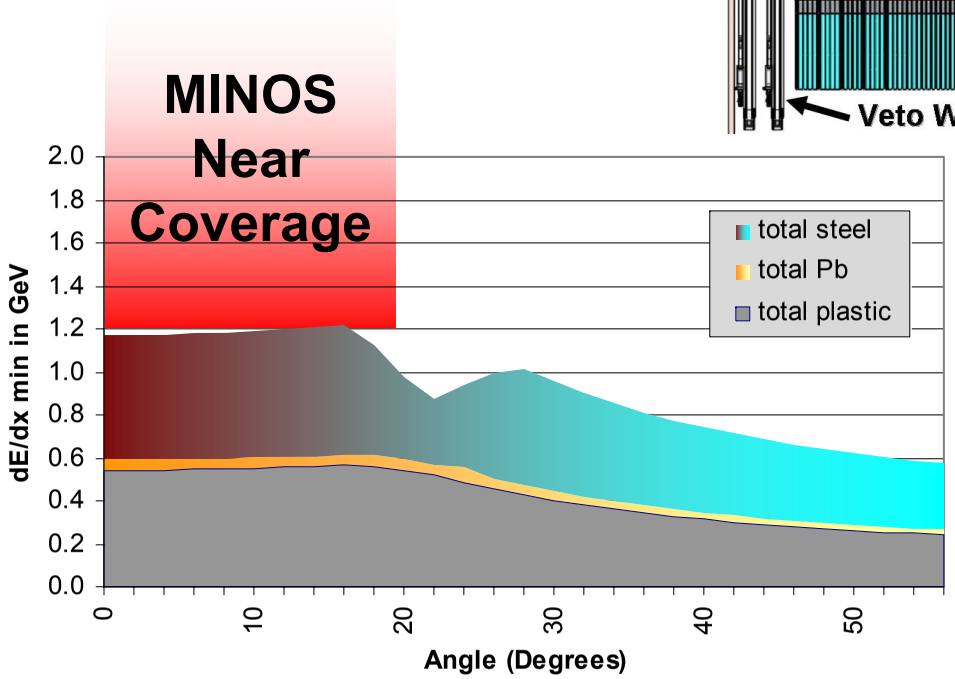


MINERvA as range tracker



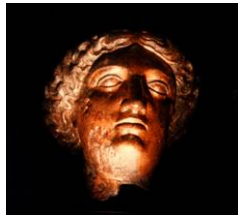
- Material thickness in $(dE/dx)_{min}$



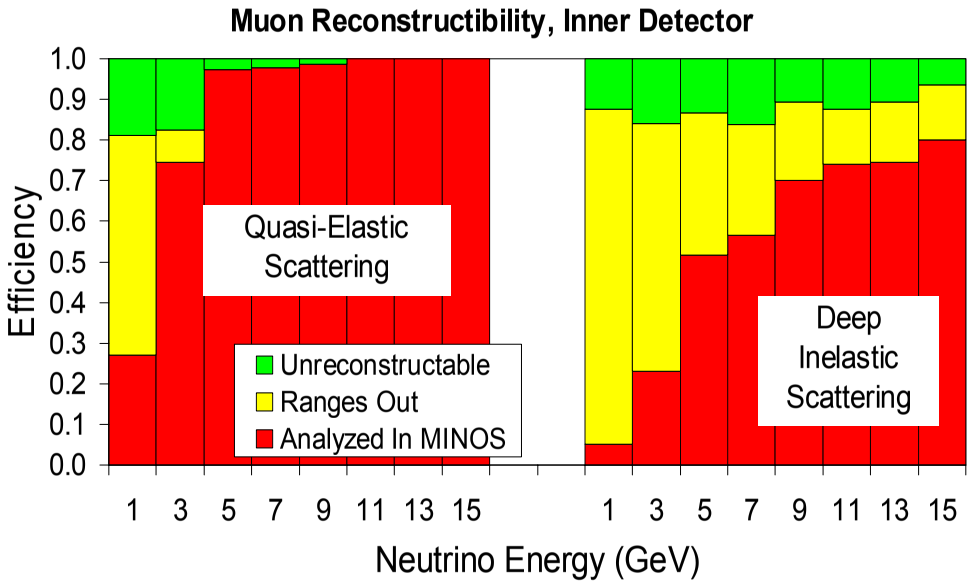


- Largely rely on MINOS near detector
  - For high momentum
  - Analyze by
    - Range for lower energy muons
    - Curvature in the magnetics field for higher energy muons (δp/p~12%)

Muon Acceptance

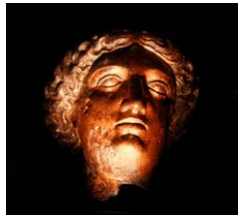


- Look at acceptance for muons
  - High x DIS (x > 0.7)
    - Analyzed in MINOS: >90% active TGT, >80% nucl target
  - High Q^2 Quasi-Elastic
    - Analyzed in MINOS: >99% active TGT, >86% nucl. target

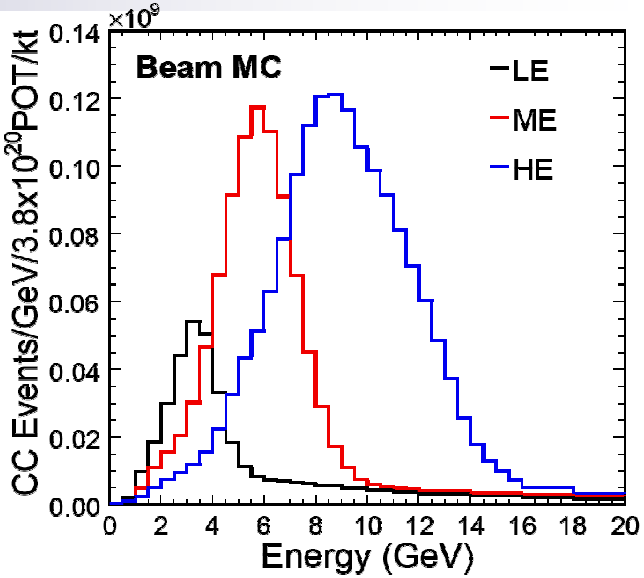


Event Sample

Assume: 4.0 x 10^{20} POT LE and 12.0 x 10^{20} POT ME beam



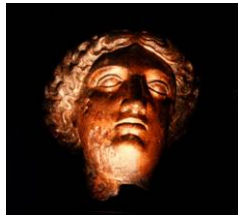
Target	Fiducial Vol. (tons)	Expected CC Yields (10^6)
CH (scintillator)	3	9.0
He	0.2	0.6
C	0.15	0.4
Fe	0.7	2.0
Pb	0.85	2.5



Main CC Physics Topics (Statistics in active target only - CH)

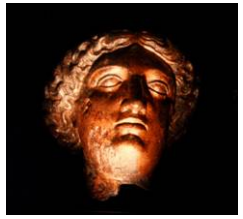
- Quasi-elastic — 0.8 M events
- Resonance Production — 1.7 M total
- Transition: Resonance to DIS — 2.1 M events
- DIS, Structure Funcs. and high-x PDFs — 4.3 M DIS events
- Coherent Pion Production — 89 K CC / 44 K NC
- Strange and Charm Particle Production — > 240 K fully reconstructed events
- Generalized Parton Distributions — ~ 10 K events

Physics Goals

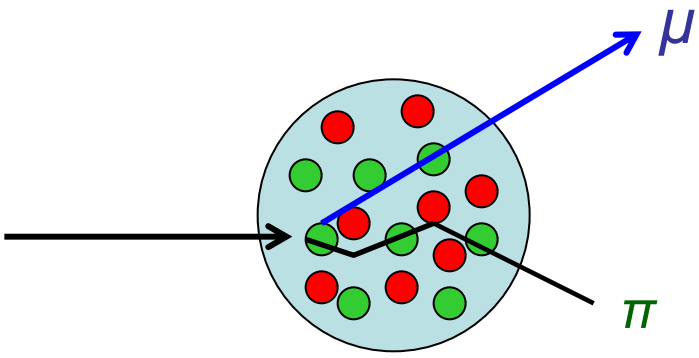


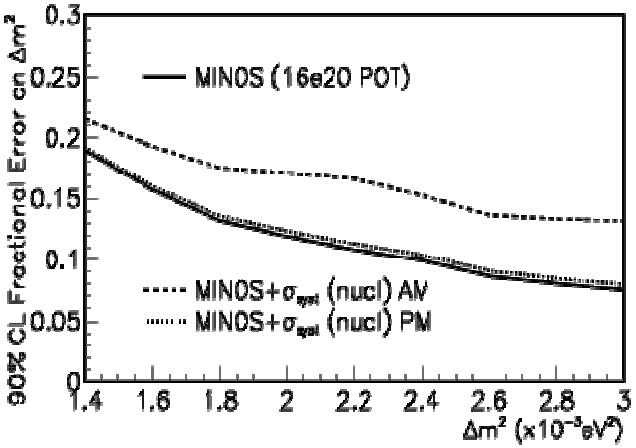
- Axial form factor of the nucleon (See Rich Gran's Talk)
  - Accurately measured over a wide Q^2 range.
- Resonance production in both NC & CC neutrino interactions
  - Statistically significant measurements with 1-5 GeV neutrinos
  - Study of "duality" with neutrinos
- Coherent pion production (See Hugh Gallagher's Talk)
  - Statistically significant measurements of A-dependence
- Strange particle production
  - Important backgrounds for proton decay
- Parton distribution functions
  - Measurement of high-x behavior of quarks
- Generalized parton distributions
- Nuclear effects
  - Expect some significant differences for ν-A vs e/μ-A nuclear effects

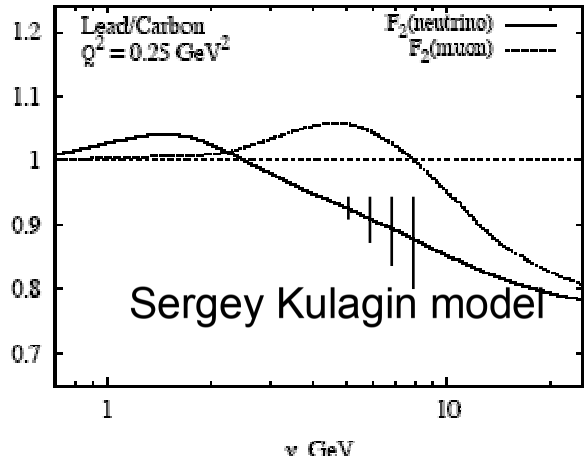
Impact on Δm^2 Measurement



- MINOS statistical errors & systematic errors due to nuclear correction
  - Shown
    - Pre-MINERvA (AM)
    - Post-MINERvA (PM)
  - Pion / nucleon absorption
  - Intra-nuclear scattering effects
  - Shadowing with neutrinos
- Extrapolation of nuclear effects from Low *A* to high *A* (e.g. He → Fe)

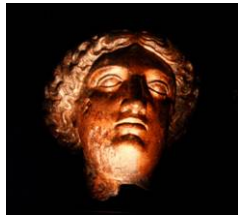




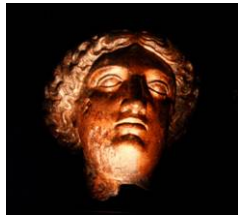


F_2, Pb/C (MINERvA stat. errors)

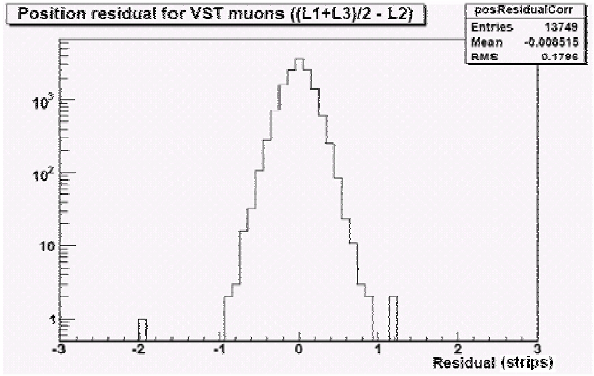
Recent advances & plans

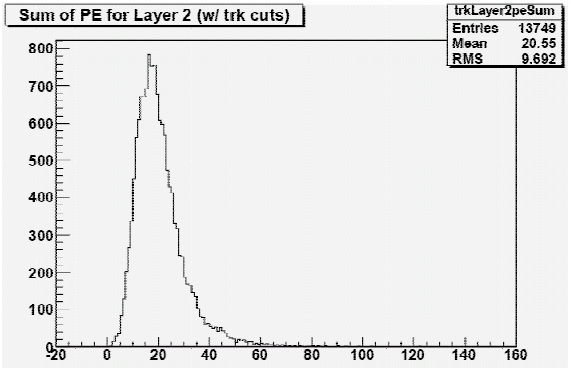


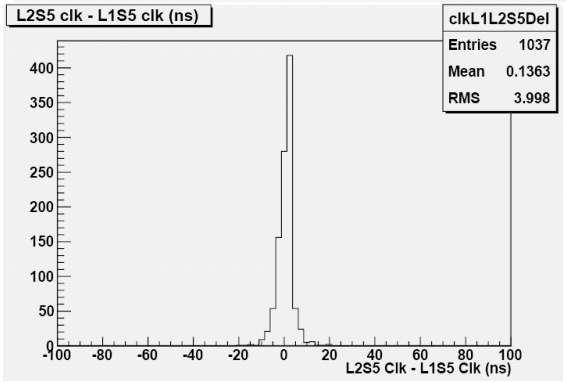
Vertical Slice Test



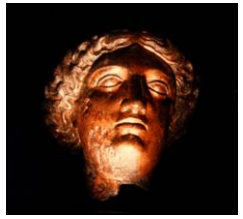
- Small test detector tested using cosmic muons
- Light Yield: 6.5 pe/MeV
  - Specification is > 4 pe/MeV
- Position Resolution: 2.5 mm
  - Spec is 3.0 mm
- Timing Resolution: 2.8 ns
- Overall: Everything works as required !



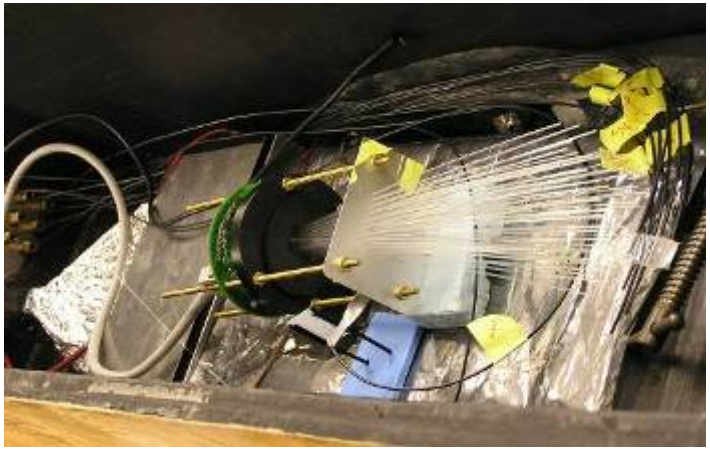




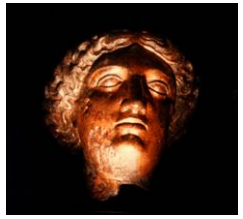
MINERvA readout



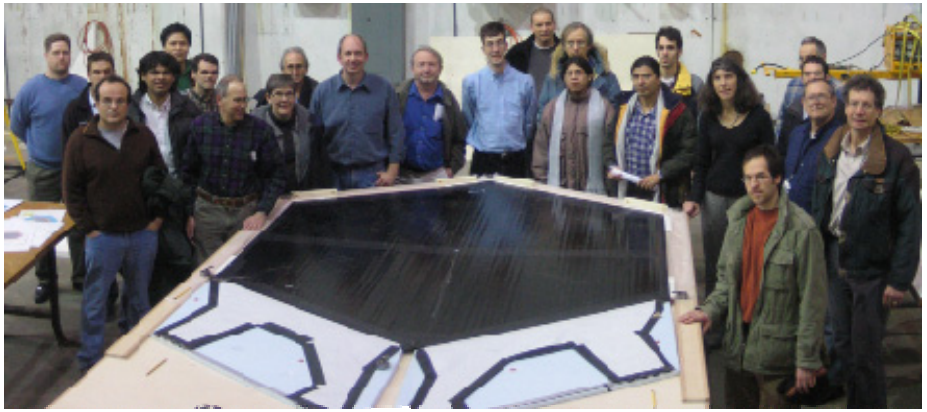
- Completed a long series of R&D test over the last two years
- Full tests with readout chain
- Light injection calibrations system tested
- PMT housing production well underway
- 40 PMTs delivered for testing

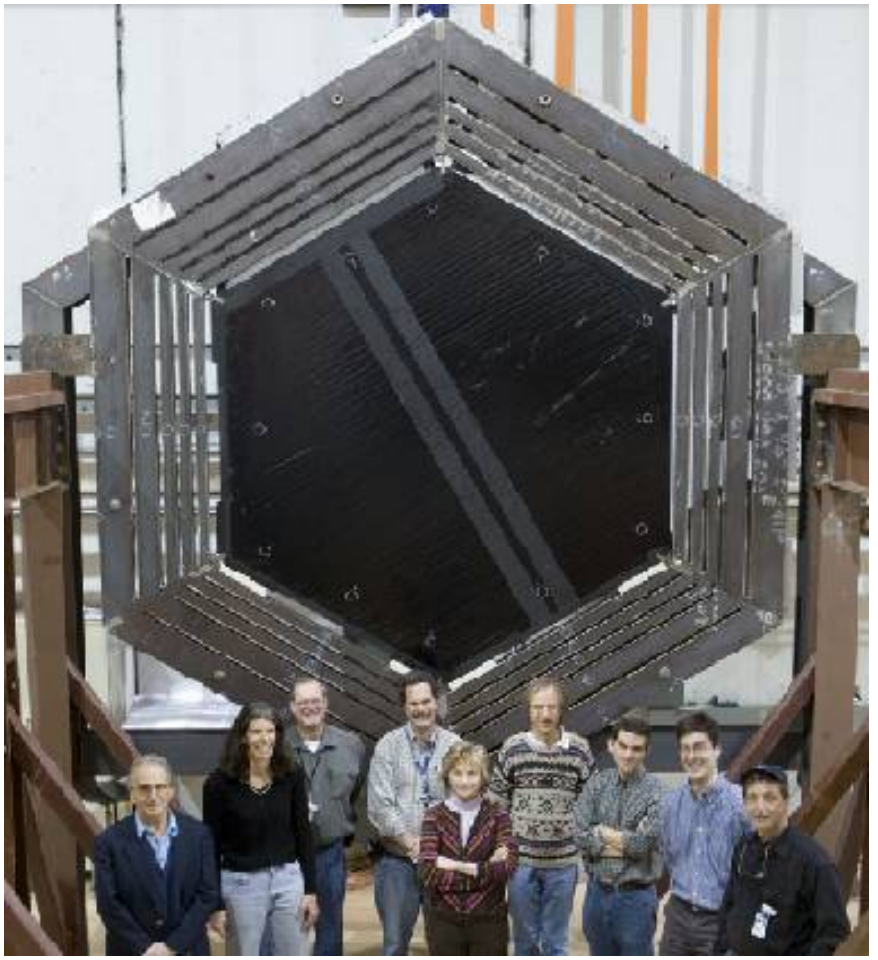


Full Module Prototype

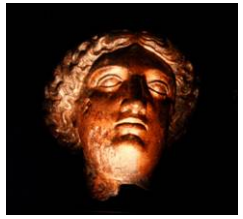


- 1st full assembly of a MINERvA module
  - Test mechanical structure
    - Integrated of inner and outer detectors
  - Two planes of scintillator
    - Two stereo views
  - Planes tested with source for uniformity
  - Completed this Spring

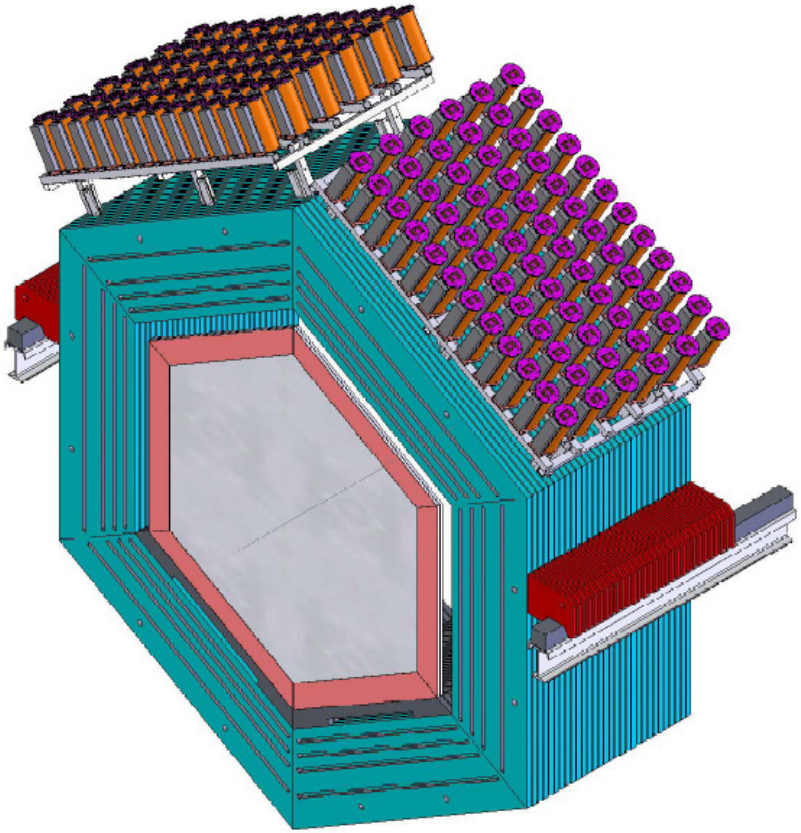




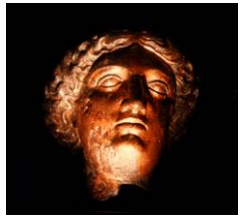
Looking forward



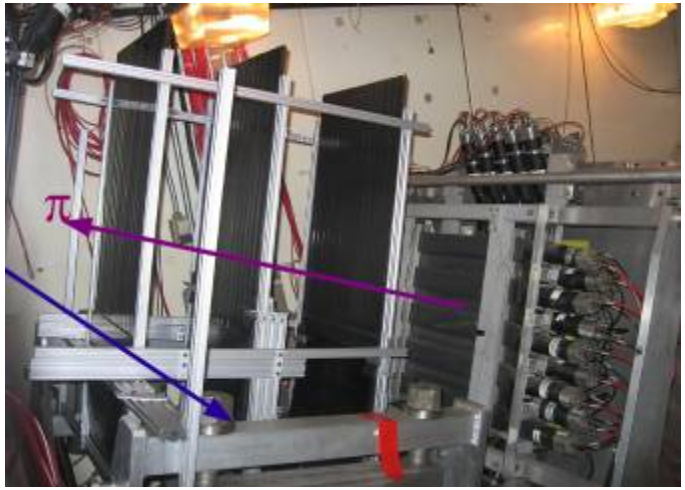
- Tracking prototype
  - Large scale systems integration
    - 10 target modules
    - 10 ECAL module
  - Currently under construction
    - To be completed in early 2008
  - Initially deployed on surface for cosmic tests
    - Plan to install in NuMI for a beam test
- Fully integrated test of all detector systems
  - Measure uniformity across many planes
  - Full installation tests and post-installation testing and calibration
  - Test tracking capability

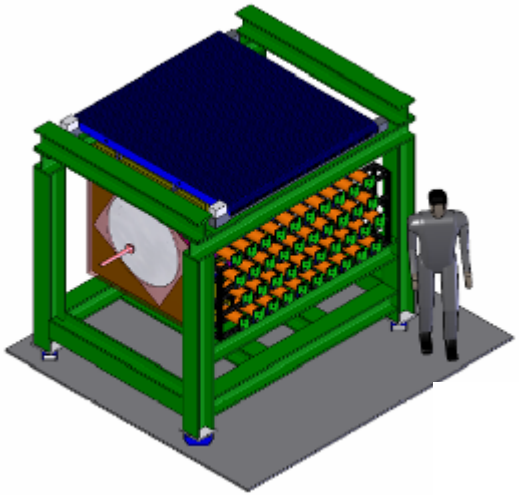


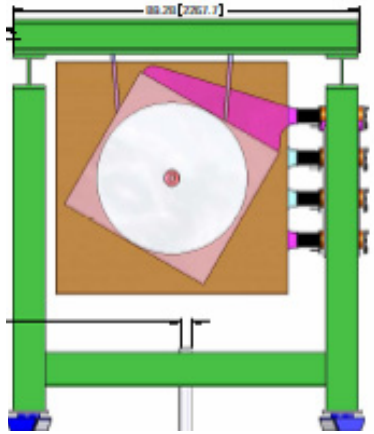
Test beam program



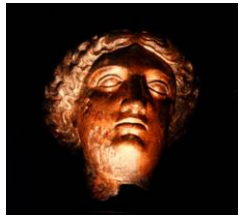
- 2 phases
- Small array in the SOS spectrometer at JLab
  - 150 to 450 MeV pions
  - Spectrometer tracking
  - 3 planes with a steel plate
- Larger detector in the MTEST at Fermilab
  - 40 planes of target
    - 1 m^2 active area
    - Full XUXV tracking structure
  - Removable Pd and Fe plates
  - Planning a new tertiary beam for sub GeV particles
  - Run plan in 2008





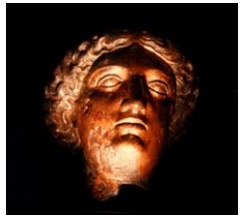


MINERvA schedule



- MINERvA received DOE critical decision (CD) 3a approval this Spring
  - Authorization for advanced purchases
  - Bulk purchases being executed for WLS fiber, Clear fiber, optical connectors
- Review for full construction authorization (CD 3b) this Summer
  - Included in FY08 Presidential Budget for Department of Energy
- Construction to start this Fall
- Detector installation and commissioning in 2009

Summary



- MINERvA is unique in worldwide program
  - The NuMI intensity and flexibility provides
    - Opportunity for precision neutrino interaction measurements over a wide range of neutrino energies
  - Detector with various nuclear targets allows detailed study of neutrino nuclear effects
  - Crucial input to future oscillation measurements
- MINERvA is on track
  - Detector technology has been demonstrated
    - First detector module assembled and tested
    - Building a large integration prototype
    - Test beam program underway
  - Received DOE CD 3a approval this Spring
  - Detector construction starts this Fall
  - Commissioning to start in 2009