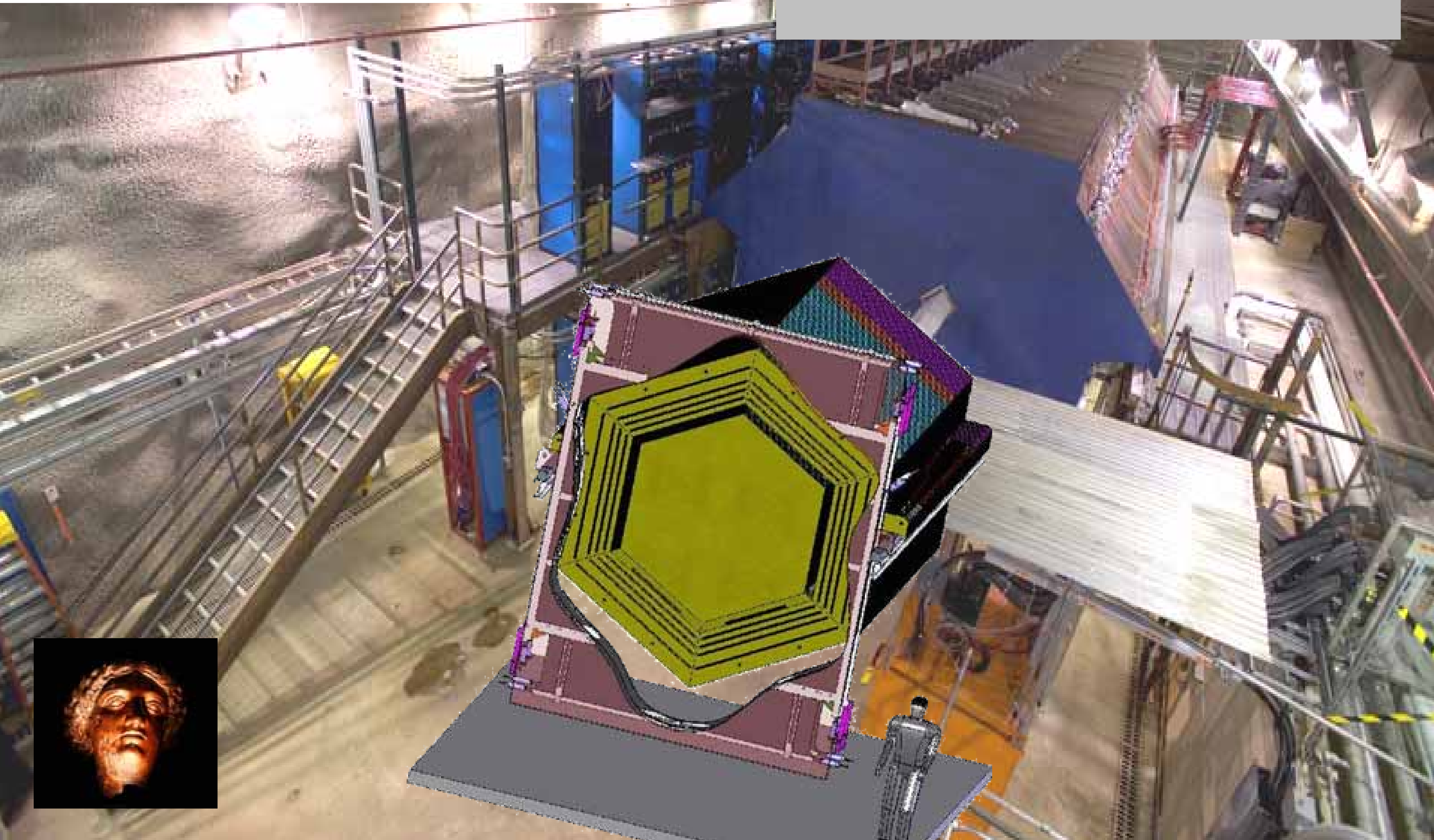
MINERνA

Main INjector ExpeRiment for ν-A

Active segmented scintillator detector: 5.87 tons

Nuclear targets of C, Fe and Pb

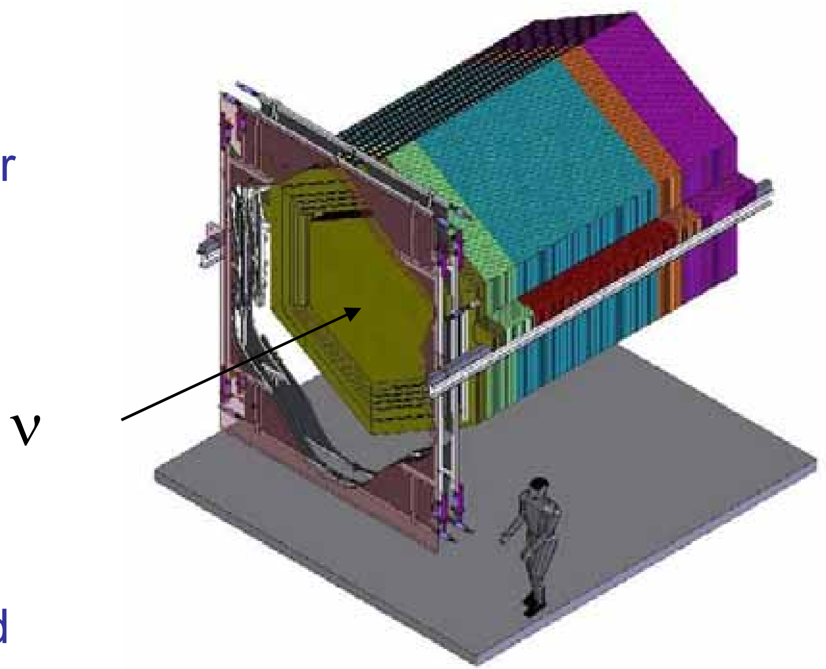


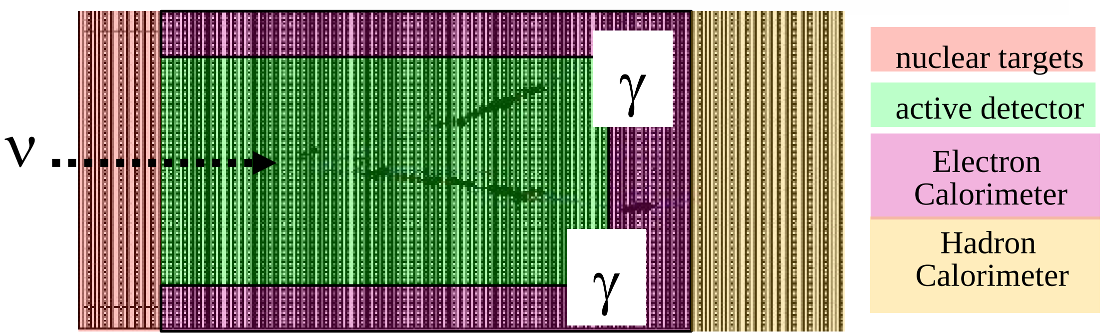
MINERvA in Brief

- MINER*v*A is a compact, fully active neutrino detector designed to study neutrino-nucleus interactions with unprecedented detail
- The detector will be placed in the NuMI beam line directly upstream of the MINOS Near Detector
- MINERvA is unique in the worldwide program
  - The NuMI beam intensity provides
    - An opportunity for precision neutrino interaction measurements
    - A wide range of neutrino energies
  - The detector, with several nuclear targets, allows a first study of nuclear effects in neutrino interactions
  - MINERvA provides crucial input to current and future oscillation measurements
- The MINERvA Review Timeline
  - FNAL PAC Stage 1 Approval April 2004
  - Initial Project FNAL Review, January 2005
  - CD-0 granted June 2006
  - FNAL CD-2/3a Readiness Review August 2006
  - DOE Combined CD-1/2/3a Review December 5, 2006

MINERvA's Detector

- MINER*v*A proposes to build a low-risk detector with simple, well-understood technology
- Active core is segmented solid scintillator
  - Tracking (including low momentum recoil protons)
  - Particle identification
  - 3 ns (RMS) per hit timing (track direction, identify stopped *K*±)
  - Passive nuclear targets interspersed
- Core surrounded by electromagnetic and hadronic calorimeters
  - Photon (π^0) & hadron energy measurement
- MINOS Near Detector as muon catcher





MINERvA and Oscillations

The 2004 ***APS Multidivisional Neutrino Study Report*** which set a roadmap for neutrino physics predicated its recommendations on a set of assumptions about current and future programs including:

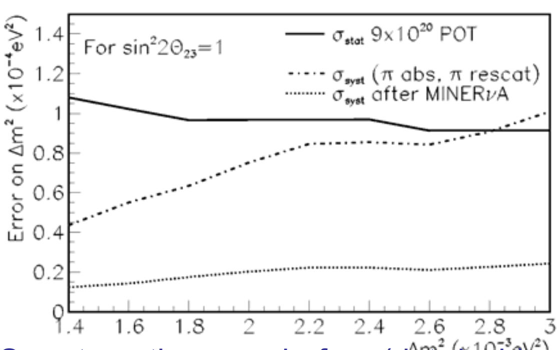
support for current experiments, international cooperation, underground facilities, R&D on detectors and accelerators, and

"determination of the neutrino reaction and production cross sections required for a precise understanding of neutrino-oscillation physics and the neutrino astronomy of astrophysical and cosmological sources. Our broad and exacting program of neutrino physics is built upon precise knowledge of how neutrinos interact with matter."

MINERvA and Oscillations

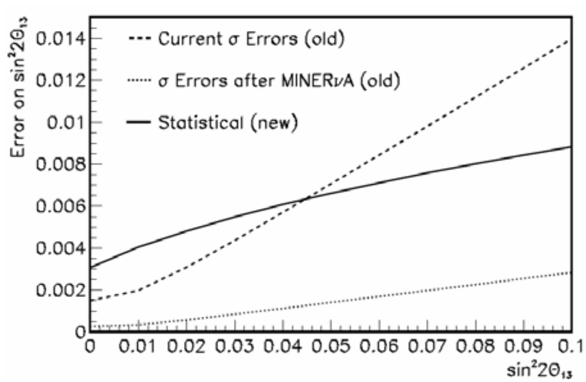
- MINERvA helps oscillation physics
  - by studying effect of nuclear medium on signal and background processes
  - by studying backgrounds over a wide neutrino energy range
- NuMI beam and nuclear targets are unique, enabling technologies

- MINOS: MINERvA can help with better Intranuclear Rescattering Measurements

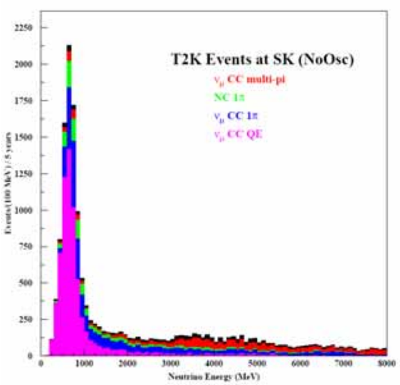


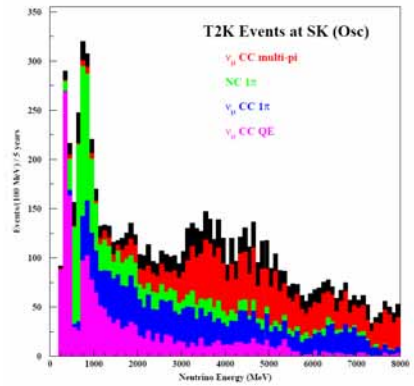
MINOS systematic errors before (dot-dash) and after (dot-dot) input from MINERvA

- NOvA: MINERvA distinguishes both background and SIGNAL cross sections in way that NOvA near detector cannot



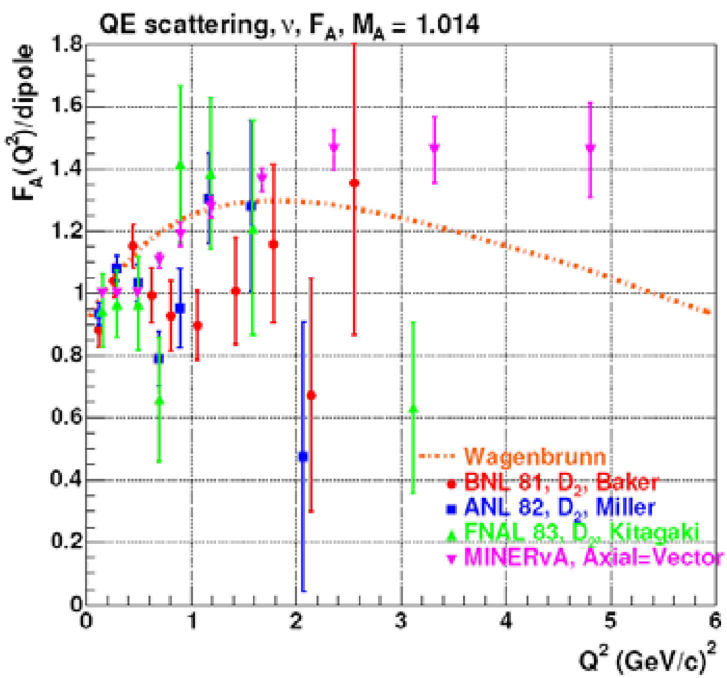
- T2K: MINERvA helps by measuring backgrounds from high energy neutrinos that the T2K near detectors cannot access



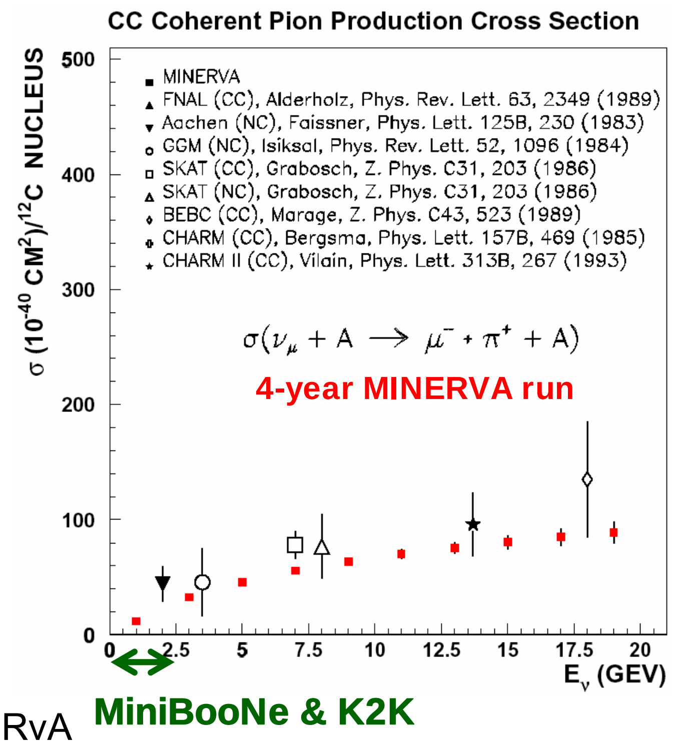


MINERvA and Cross Section Measurements (examples)

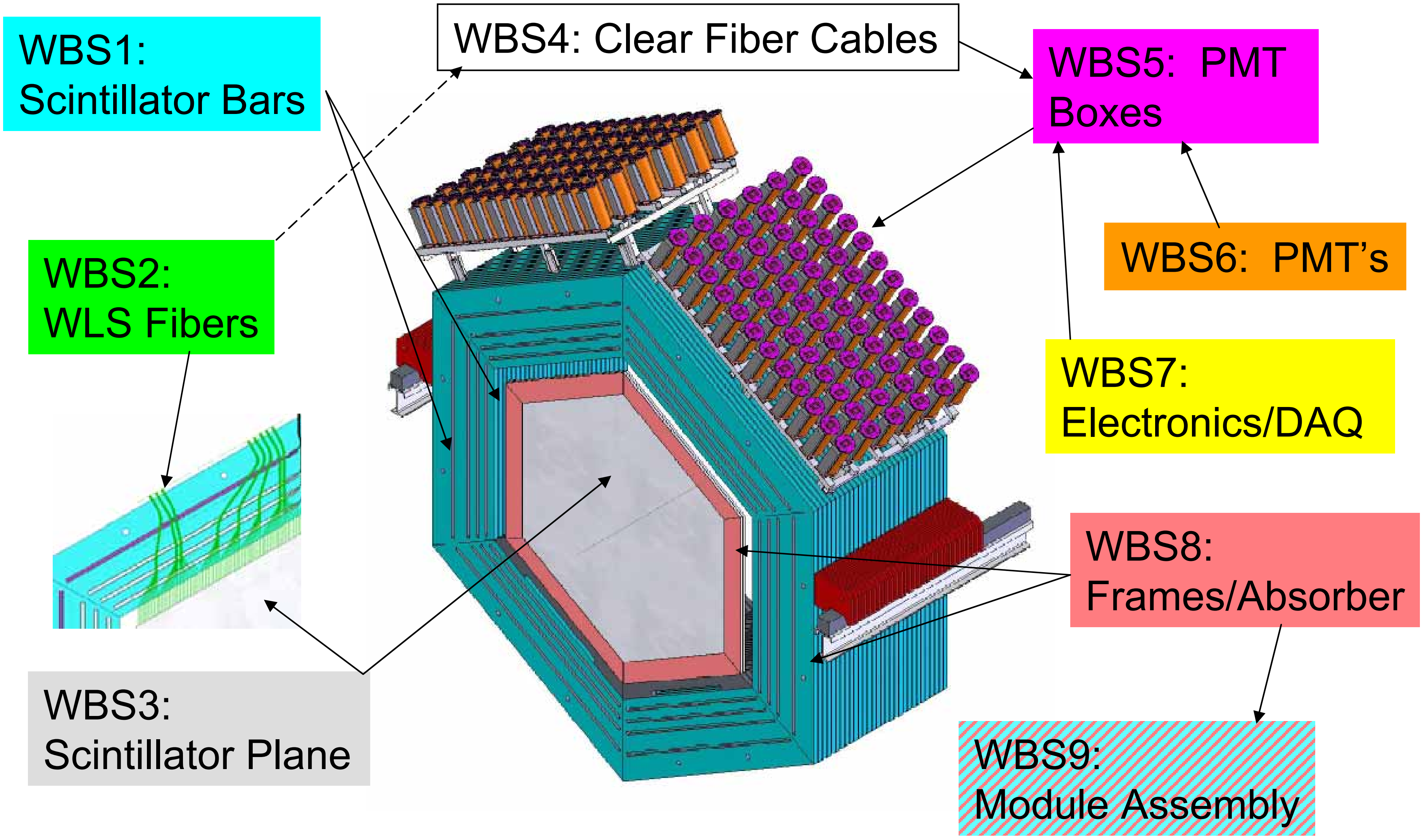
- Quasi-elastic Cross Section
  - First precise measurements at high Q^2 of proton axial form factor
  - First study in nuclear modification of form factors conjectured at low Q^2



- Coherent π production Cross Section
  - Overwhelming statistics (> 100 increase)
  - Wide energy range
  - Range of nuclear targets (C, Fe, Pb)
  - MINERvA is in a position to measure this important background for ν_e appearance and to check recent surprising K2K null result



Overview of MINERvA Detector



WBS & Universities

1 Scintillator Extrusion - Anna Pla-Dalmau (FNAL, NIU, PI Victor Rykalin)

2 WLS Fibers – Howard Budd (Rochester, PI Kevin McFarland)

3 Scintillator Plane Assembly – Jeff Nelson (William& Mary, also Hampton University PI Cynthia Keppel)

4. Clear Fiber Cables – Howard Budd (Rochester, PI Kevin McFarland)

5 PMT Boxes – Tony Mann (Tufts, also Rutgers PI Ron Ransome) and Steve Dytman (University of Pittsburgh)

6 PMT Procurement & Testing – Ioana Niculescu (James Madison University) and George Tzanakos (University of Athens, Greece)

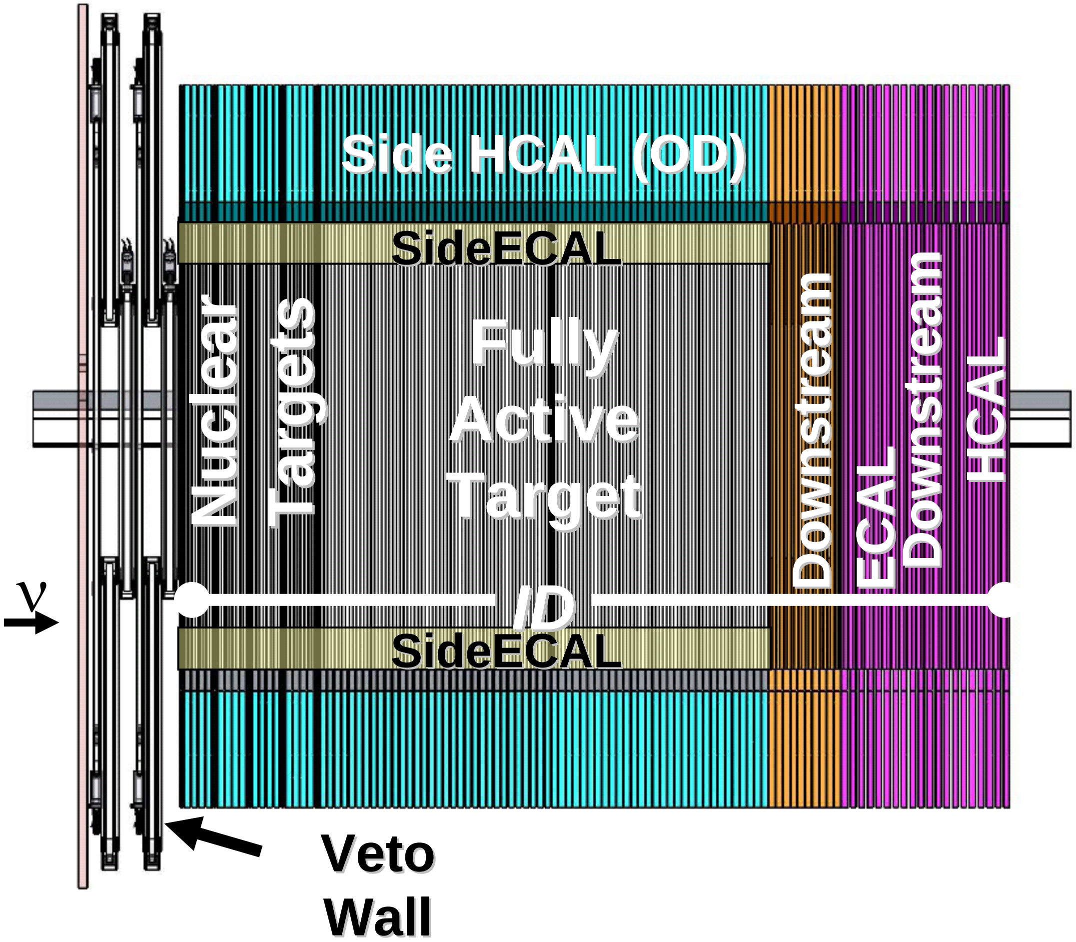
7 Electronics & DAQ – Vittorio Paolone (University of Pittsburgh)

8 Frame, Absorbers & Stand – Jim Kilmer (FNAL)

9 Module Assembly & Installation –Bob Bradford (Rochester, PI Kevin McFarland)

10 Project Management – Deborah Harris (FNAL)

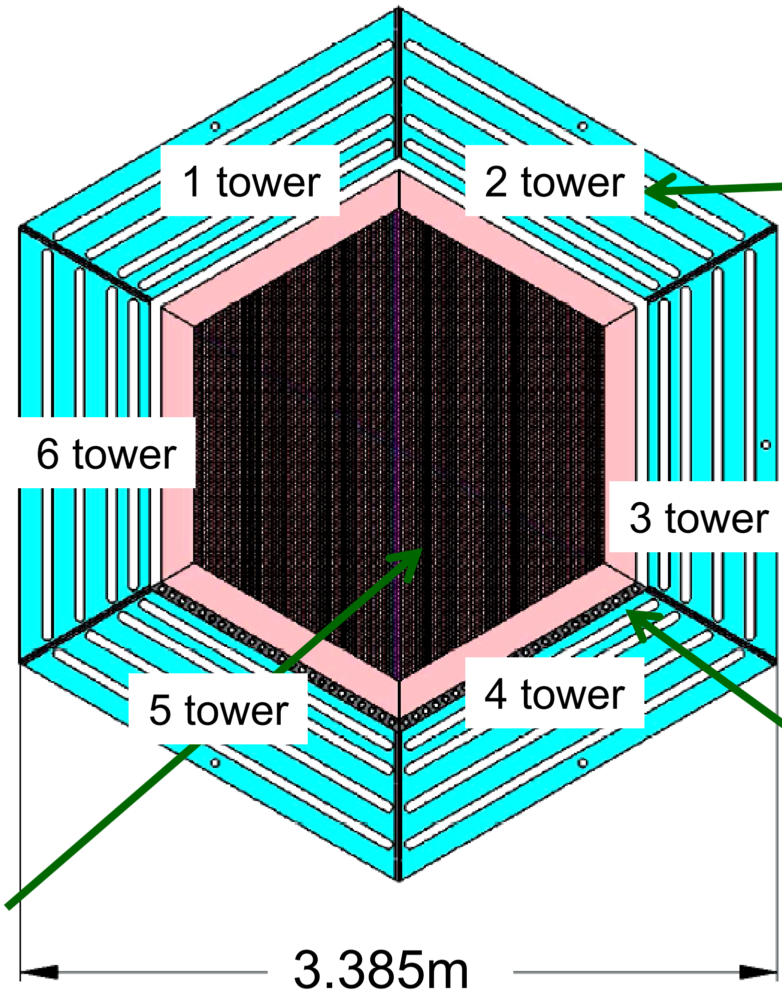
Basic Detector Geometry



- Downstream Calorimeters: 20 modules, 2% active, sheets of lead (Electromagnetic Calorimetry) or steel (Hadronic calorimetry) between scintillator planes
- 2 thin lead "rings" for side Electromagnetic Calorimetry

	Module/Frame	Scintillator Planes
Nuclear Targets	18	36
Active Target	60	120
DS ECAL	10	20
DS HCAL	20	20
Totals	108	196

MINERvA Detector Plane



<u>Outer Detector</u> (OD) Layers of iron/scintillator for hadron calorimetry: 6 Towers

- **30,272 channels**
  - 80% in inner hexagon
  - 20% in Outer detector
- **473 M-64 PMTs** (64 channels)

Lead Sheets for EM calorimetry

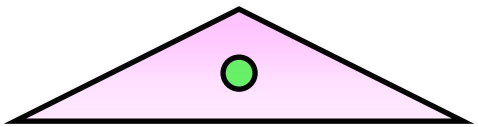
- **1 wave length shifting fiber per scintillator**, which transitions to a clear fiber and then to the PMT
- **128 pieces of scintillator per Inner Detector plane**
- **8 pieces of scintillator per Outer Detector tower, 6 OD detector towers per plane**

<u>Inner Detector</u> Hexagon – X, U, V planes for stereo view

MINERvA Optics

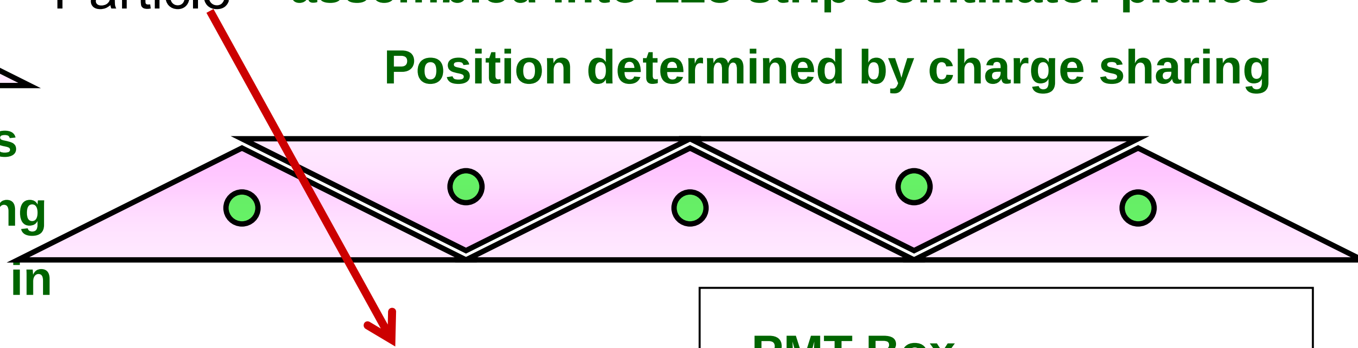
(Inner detector scintillator and optics shown, Outer Detector has similar optics but rectangular scintillator)

Scintillator



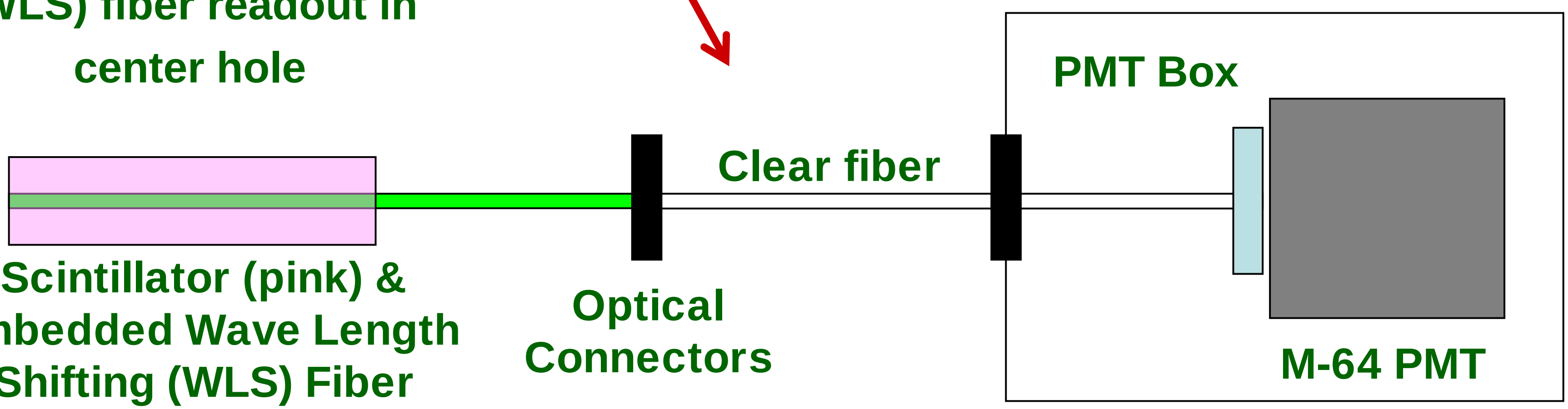
For the Inner Detector, scintillator is assembled into 128 strip scintillator planes

Position determined by charge sharing



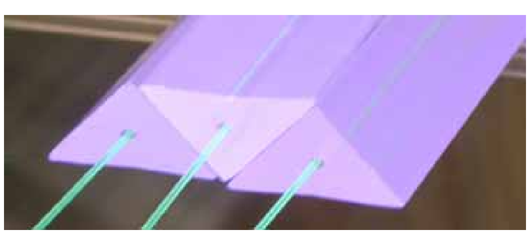
1.7 × 3.3 cm^2 strips

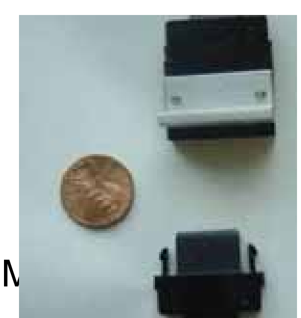
Wave Length Shifting (WLS) fiber readout in center hole

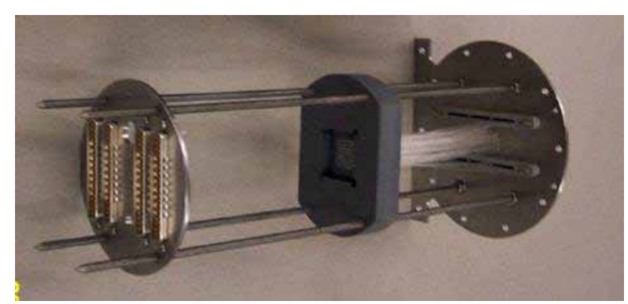


Scintillator (pink) & embedded Wave Length Shifting (WLS) Fiber

Optical Connectors

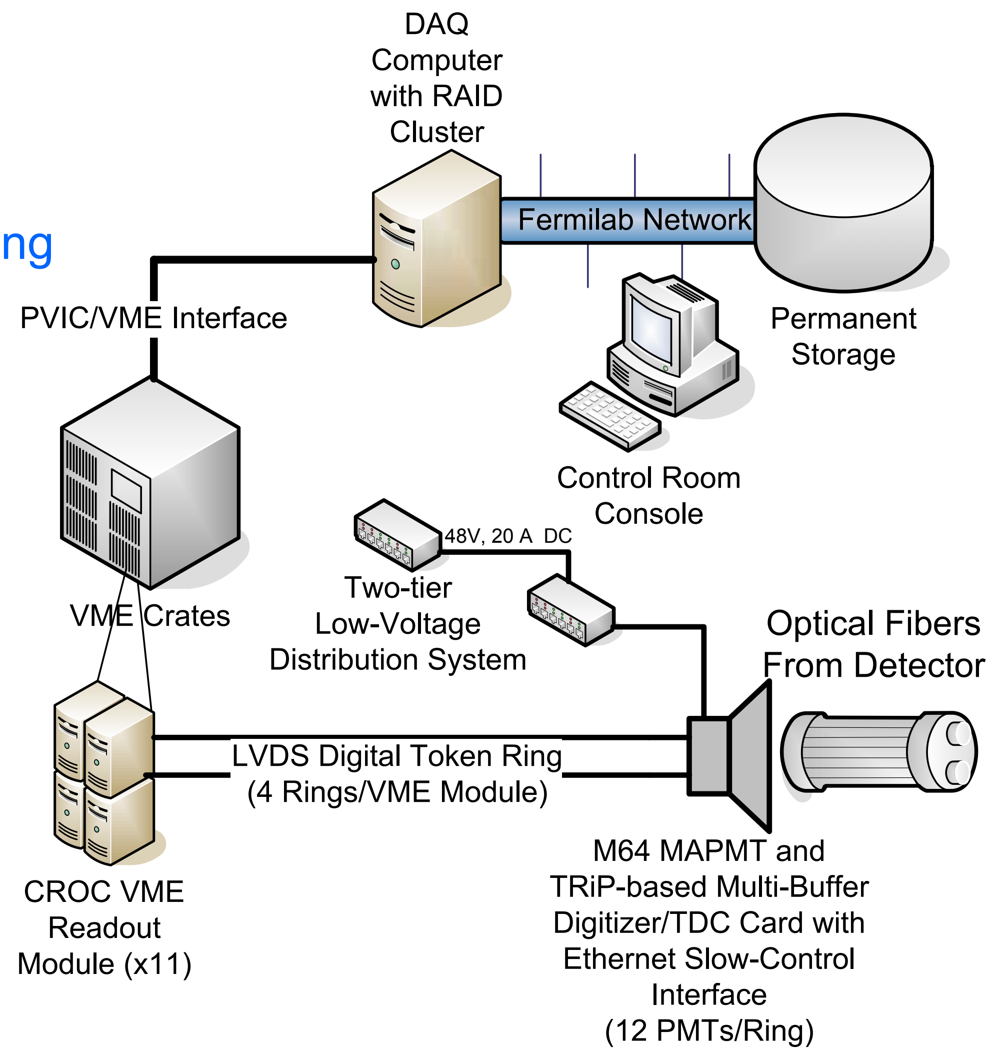






MINERvA Electronics

- **Front End Boards**
  - One board per PMT
  - High Voltage (700-800V)
  - Digitization via Trip Chips, taking advantage of D0 design work
  - Timing
- **CROC Boards and DAQ**
  - One board per 48 PMT's
  - Front-end/computer interface
  - Distribute trigger and synchronization
  - 3 VME crates & one DAQ computer
- **Power and rack protection**
  - Uses 48V power
  - 7kW needed



Highlights of each Year

- **FY06-FY07: R&D and Assembly and Testing Process Prototyping**
  - Make co-extruded scintillator and test
  - R&D on making bulk clear fiber cables
  - WLS fiber qualification and prototypes
  - Scintillator Plane assembly R&D, prototype plane and module assembly
  - PMT box assembly R&D and prototypes
  - Electronics R&D continues: Front-End board, CROC module
  - PMT testing and alignment procedures defined and tested
  - Outer Detector frame prototypes and Module assembly R&D
  - *20 Module Prototype constructed in FY07*
- **FY08: construction begins**
  - Remaining R&D: mostly electronics design
  - Bulk purchases: PMT's, WLS fiber, Clear fiber, PMT box components, steel and lead purchases
- **FY09: complete construction**
  - Buy LV system, remaining PMT's, Front End electronics, assemble second half of PMT boxes and scintillator planes

Overview of Work by Fund Types

- R&D Includes all design work, prototyping, and testing apparatus :
  - Scintillator and fiber prototyping and testing
  - Preliminary purchase of 10 PMTs
  - Electronics & DAQ systems for prototyping and testing PMTs, testing PMT boxes
  - One full module prototype (from scintillator through DAQ and module mapper)
  - 20-Module Tracking Prototype
  - Prototype Detector Stand

- MIE Includes:
  - Construction of Detector and some spares

Organization Chart