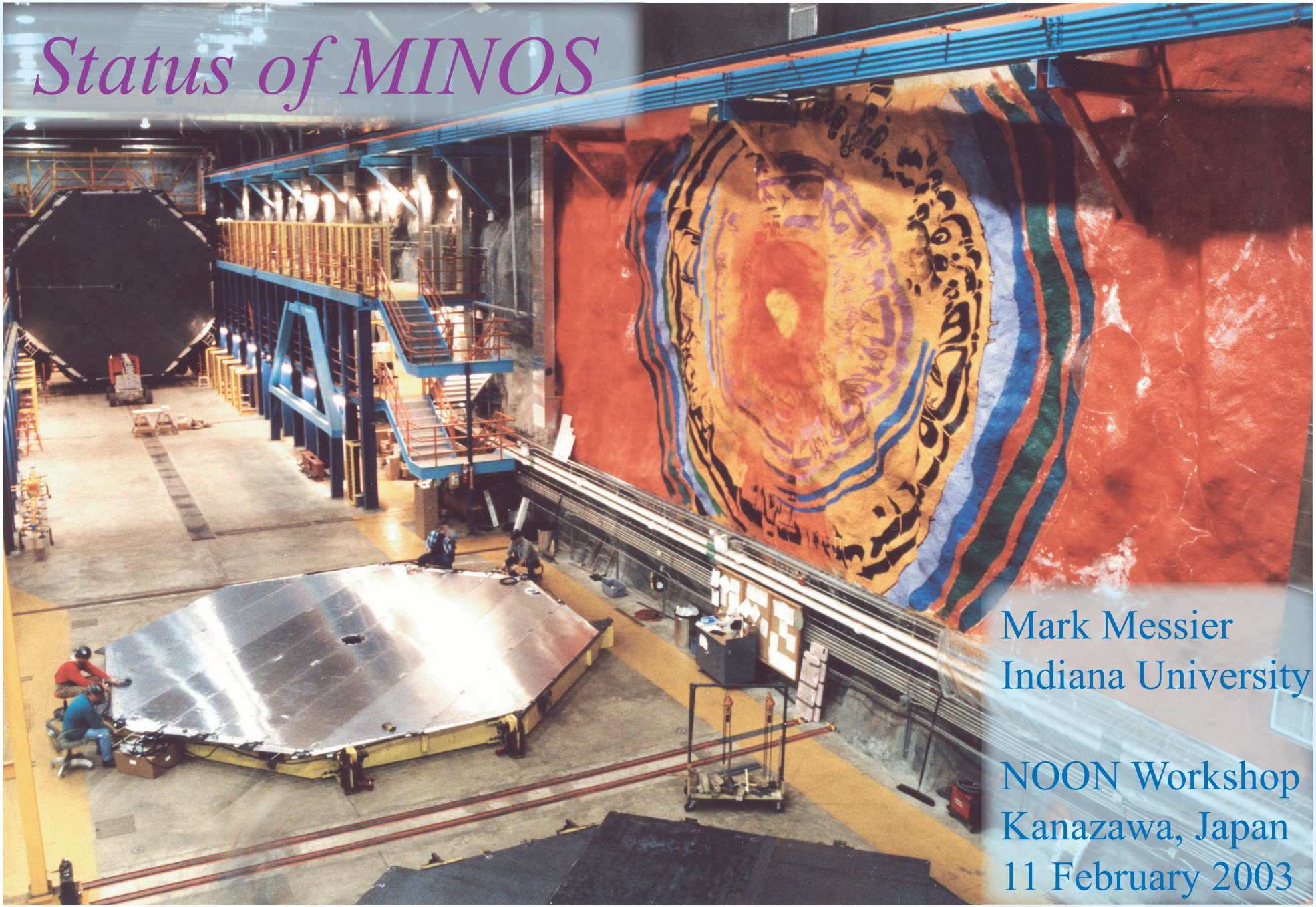
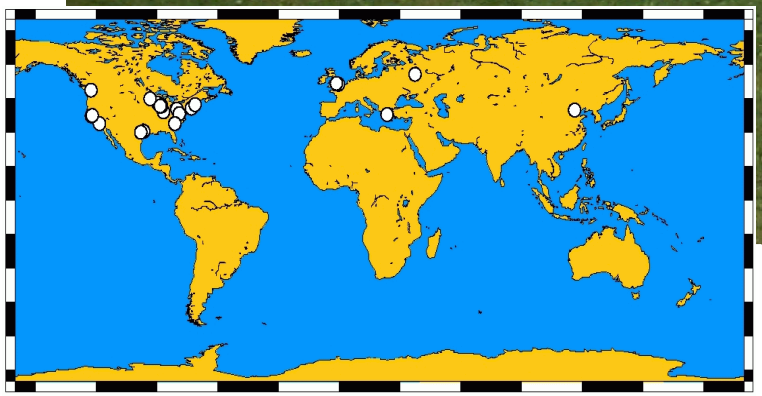
Status of MINOS



Mark Messier
Indiana University

NOON Workshop
Kanazawa, Japan
11 February 2003

The MINOS Collaboration



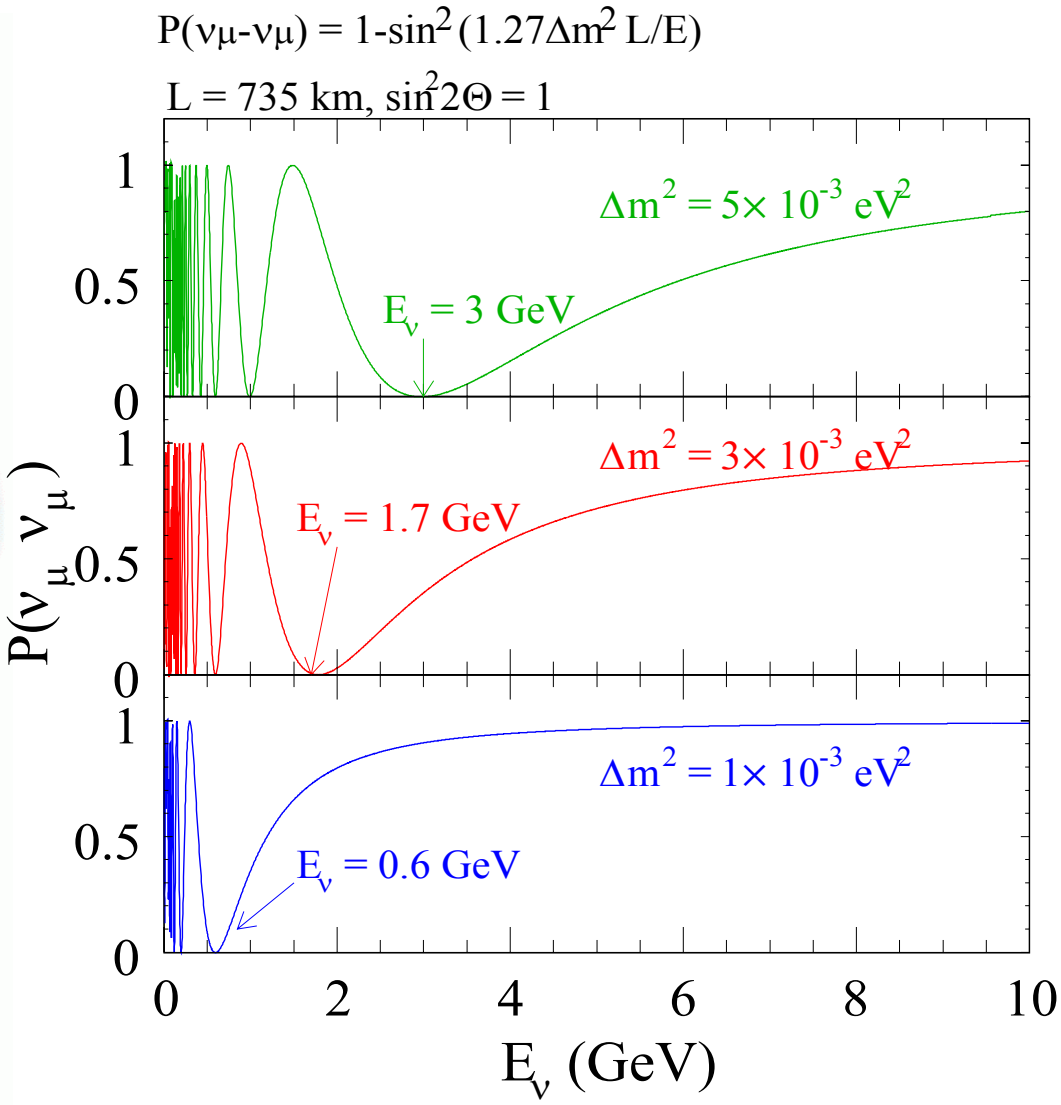
Argonne Athens Brookhaven Caltech Cambridge Chicago
Elmhurst Fermilab Harvard IHEPBeijing Indiana ITEPMoscow
James Madison Lebedev Livermore UCLLondon Macalester
Protvino Rutherford South Carolina Stanford Sussex
Texas A&M TexasAustin Tufts Western Washington Wisconsin

MINOS Experiment

Neutrino beam from Fermilab Main Injector (up to 25 GeV)

Two detectors, one at Fermilab, one in Soudan, Minnesota

Compare neutrino energy spectra at both sites to measure oscillation probability

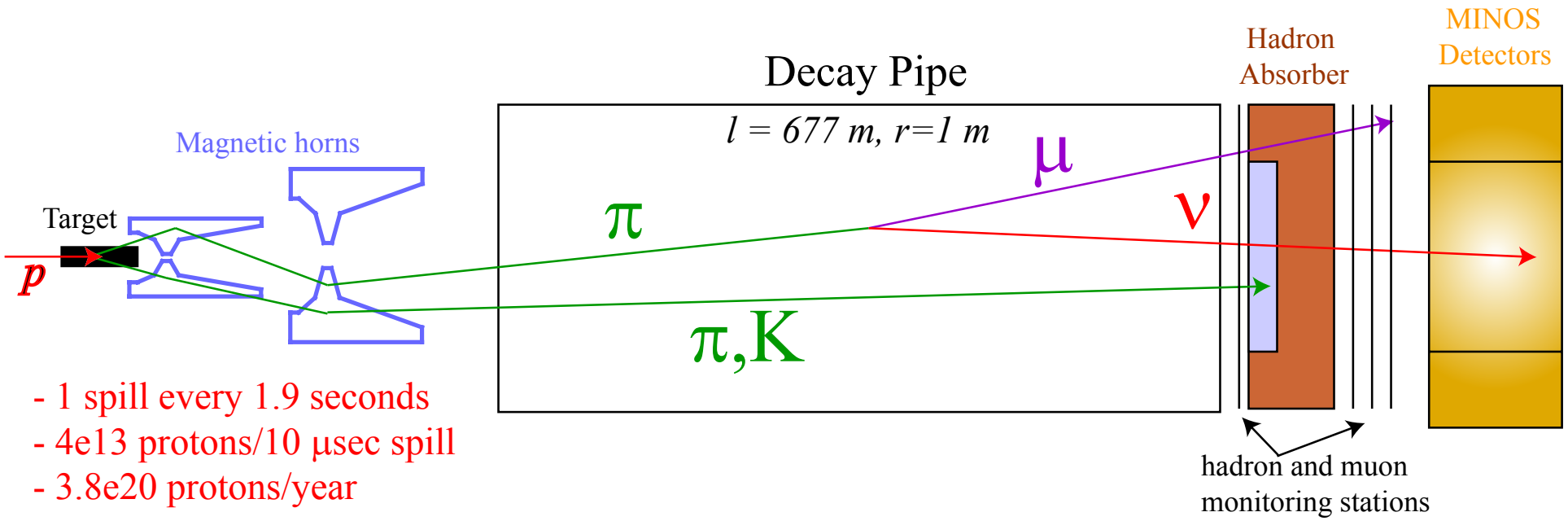


Neutrinos at the Main Injector (NuMI)

120 GeV/c protons strike graphite target

Magnetic horns focus charged mesons (pions and kaons)

Pions and kaons decay giving neutrinos



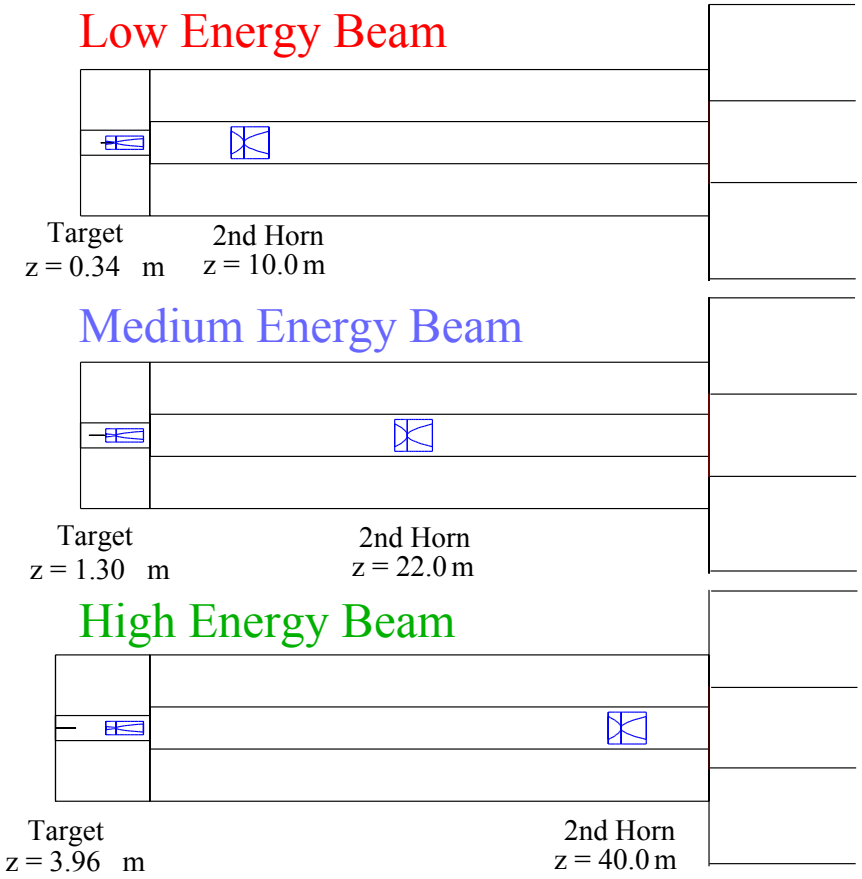
- 1 spill every 1.9 seconds
- 4e13 protons/10 μsec spill
- 3.8e20 protons/year

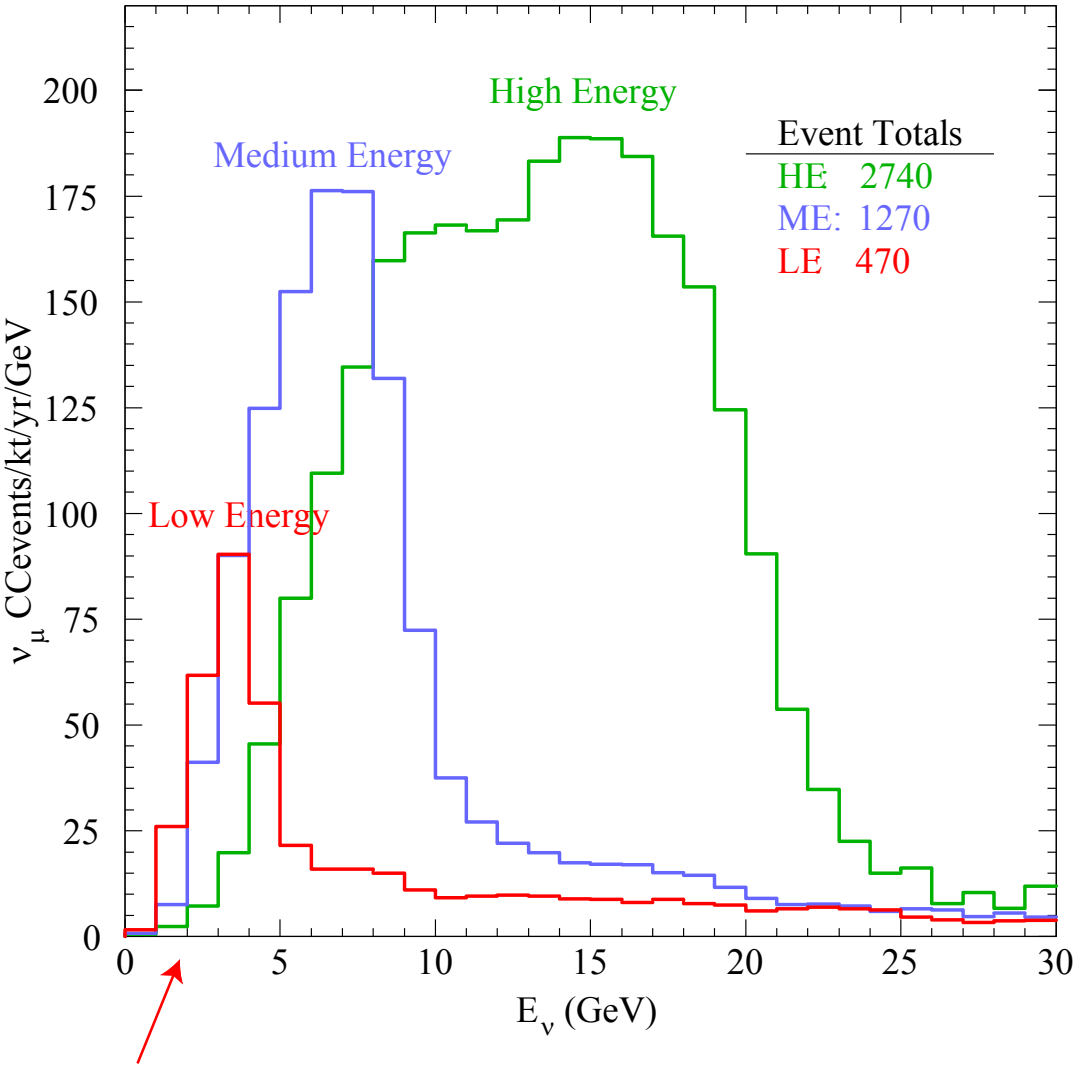
Vary target and horn positions to select
low, medium, and high energy neutrino beams

Fermilab Site

NuMI Beam Spectra

Vary target and horn 2 position for different beam tunes





Low energy beam selected to start

The MINOS Far Detector

Steel / Scintillator

2.5 cm thick steel plates

4 cm x 1 cm polystyrene
- encased in Al cover

15,000 Amp-turn coil

486 layers 5.4 kTon

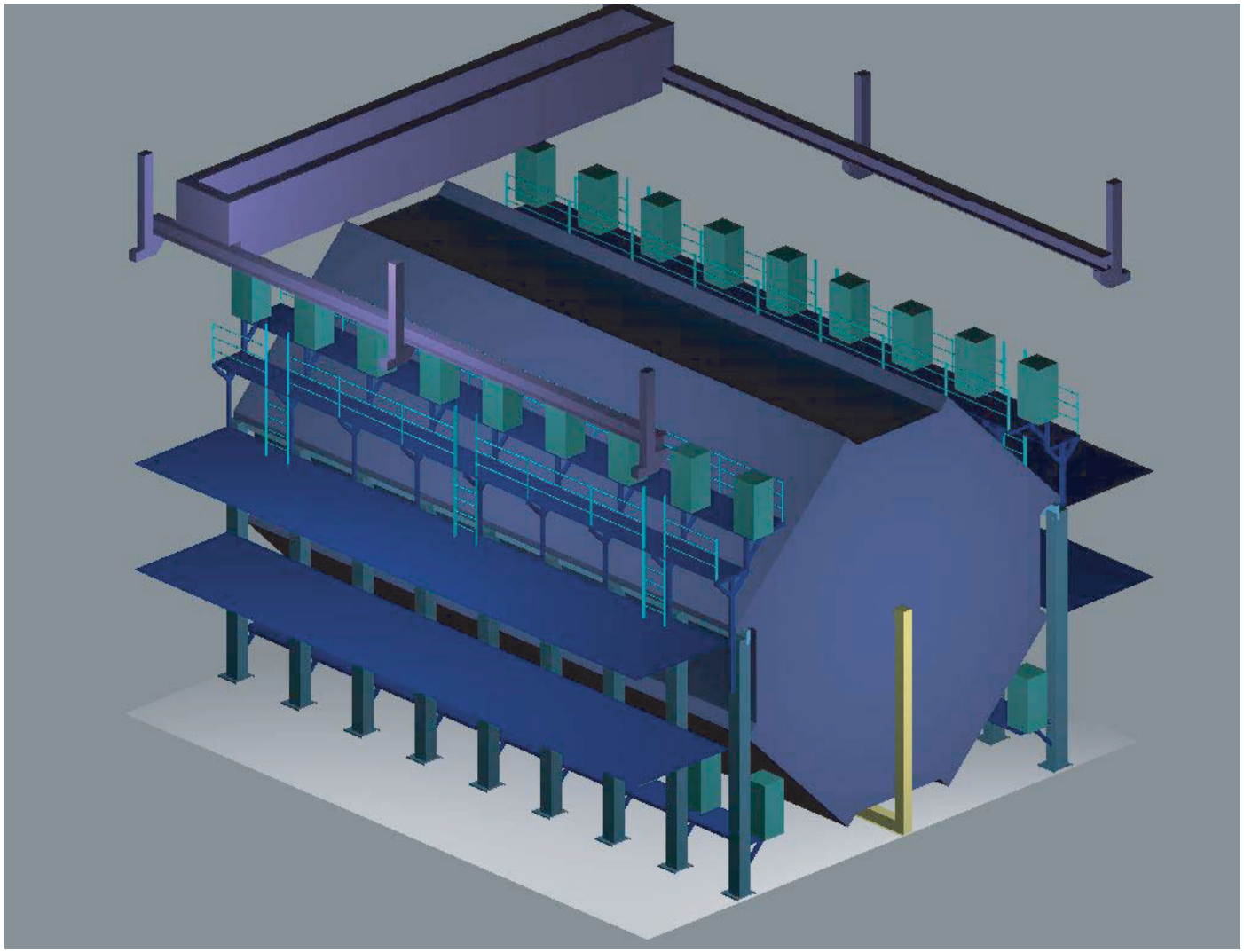
Readout:

WLS fibers gludes into grove in scintillator double sided readout

Hamamatsu M16 PMT's
8 fibers/pixel

IDE VA front end chips
pulseheight and time

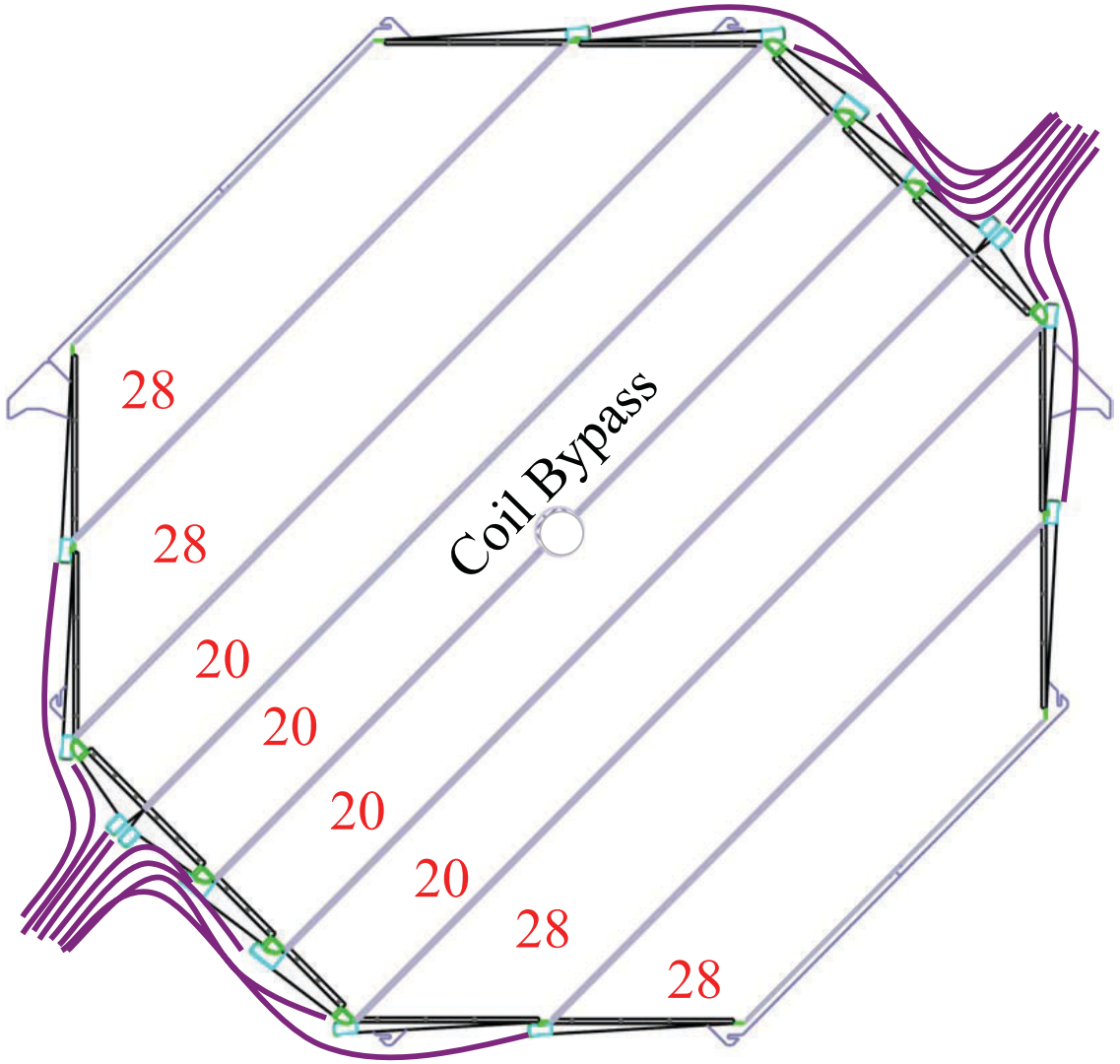
GPS to sync. to MI spill



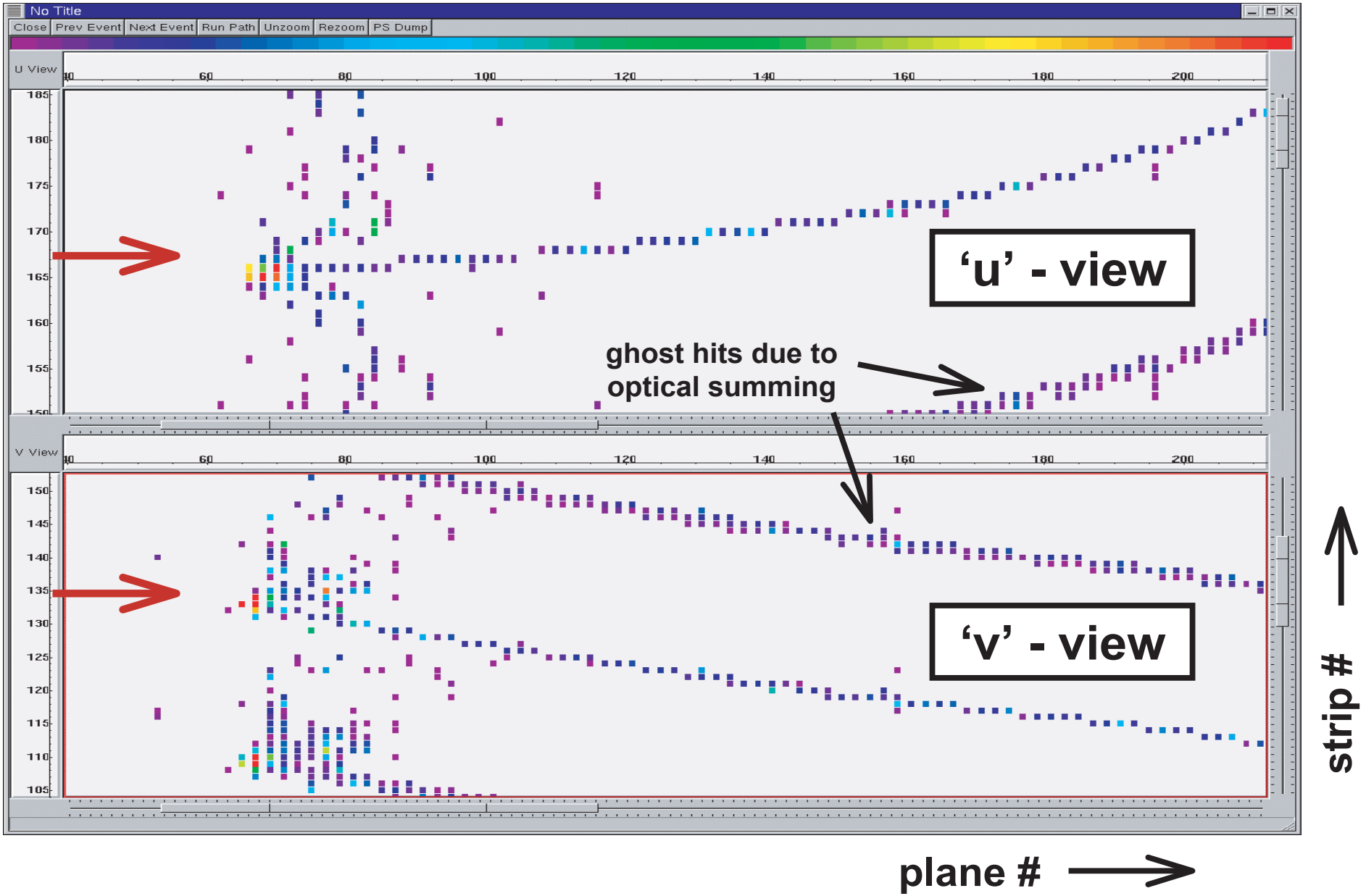
1 of 2 super-modules
248 planes: 8m x 8m x 15m

Far Detector Module Layout

- 8 modules cover one far detector steel plane
- Four 20-wide modules in middle (perp. ends)
- Four 28-wide modules on edges (45 deg ends)
- Two center modules have coil-hole cutout



Simulated Muon Neutrino Interaction



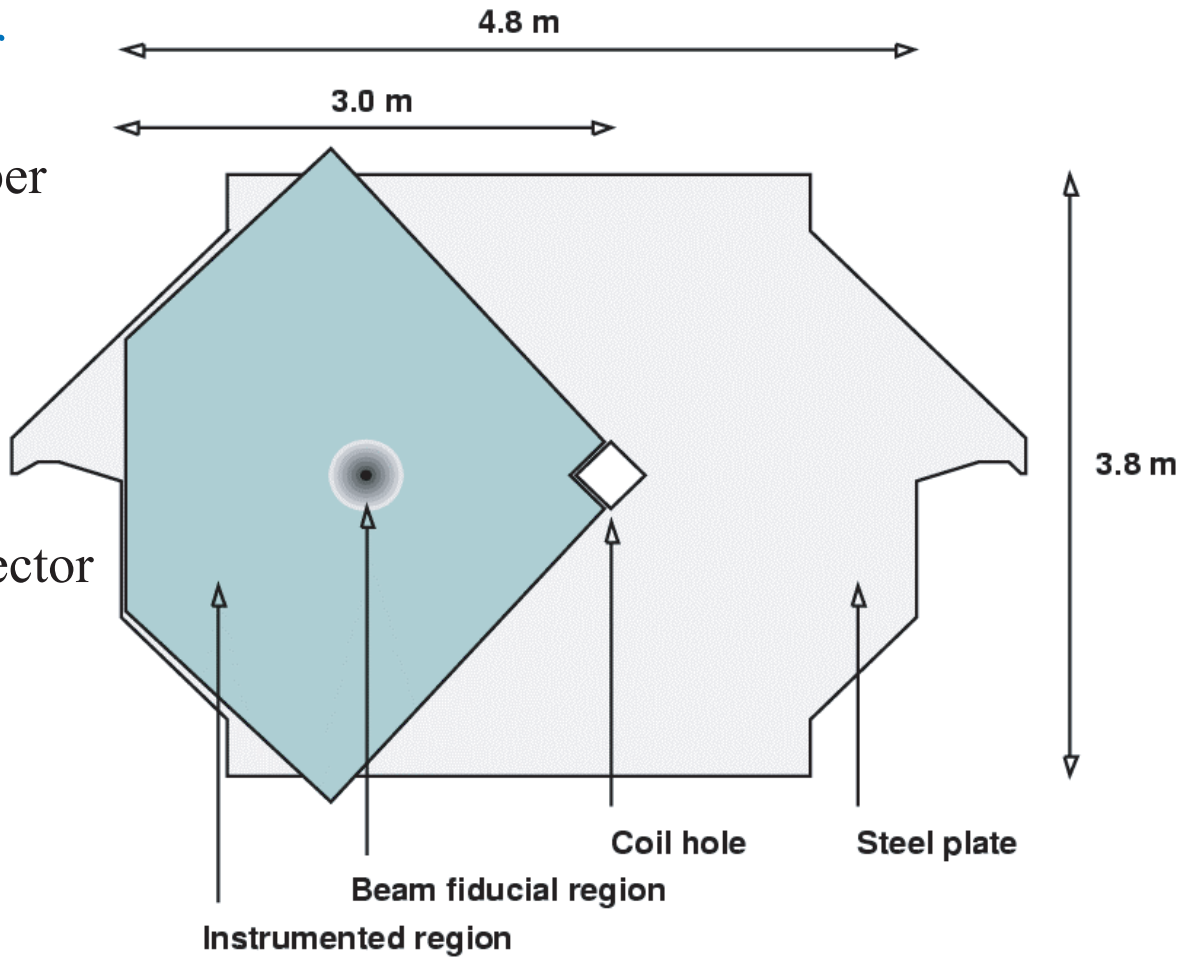
MINOS Near Detector

1 Ton version of the far detector

290 m downstream of hadron absorber
beam size is small

4 regions:
veto, target, shower, spectrometer

Construction is as similiar to far detector as possible



Readout:

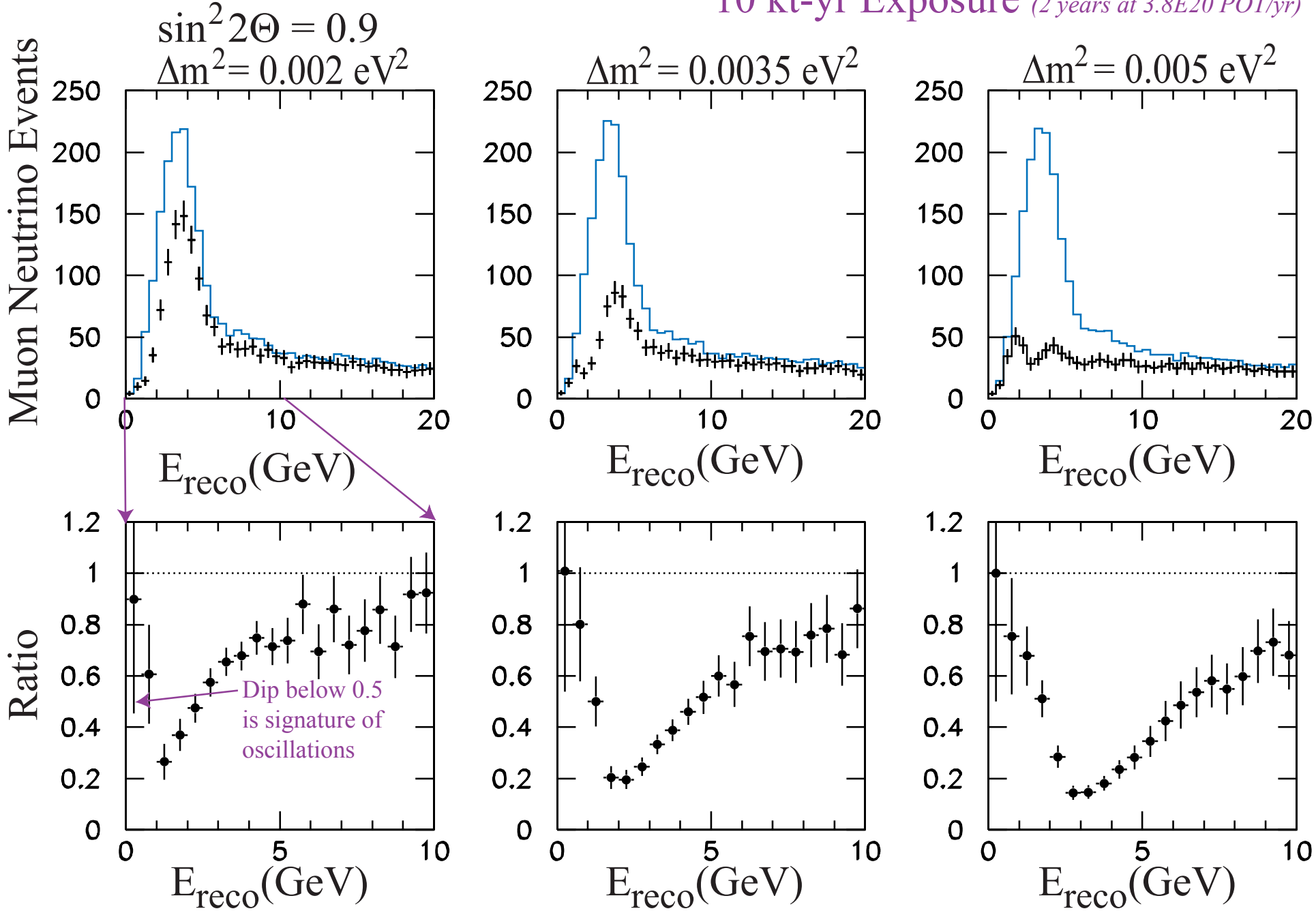
Hamamatsu M64 PMT's

High instantaneous rates
(~50 events/8 usec spill)

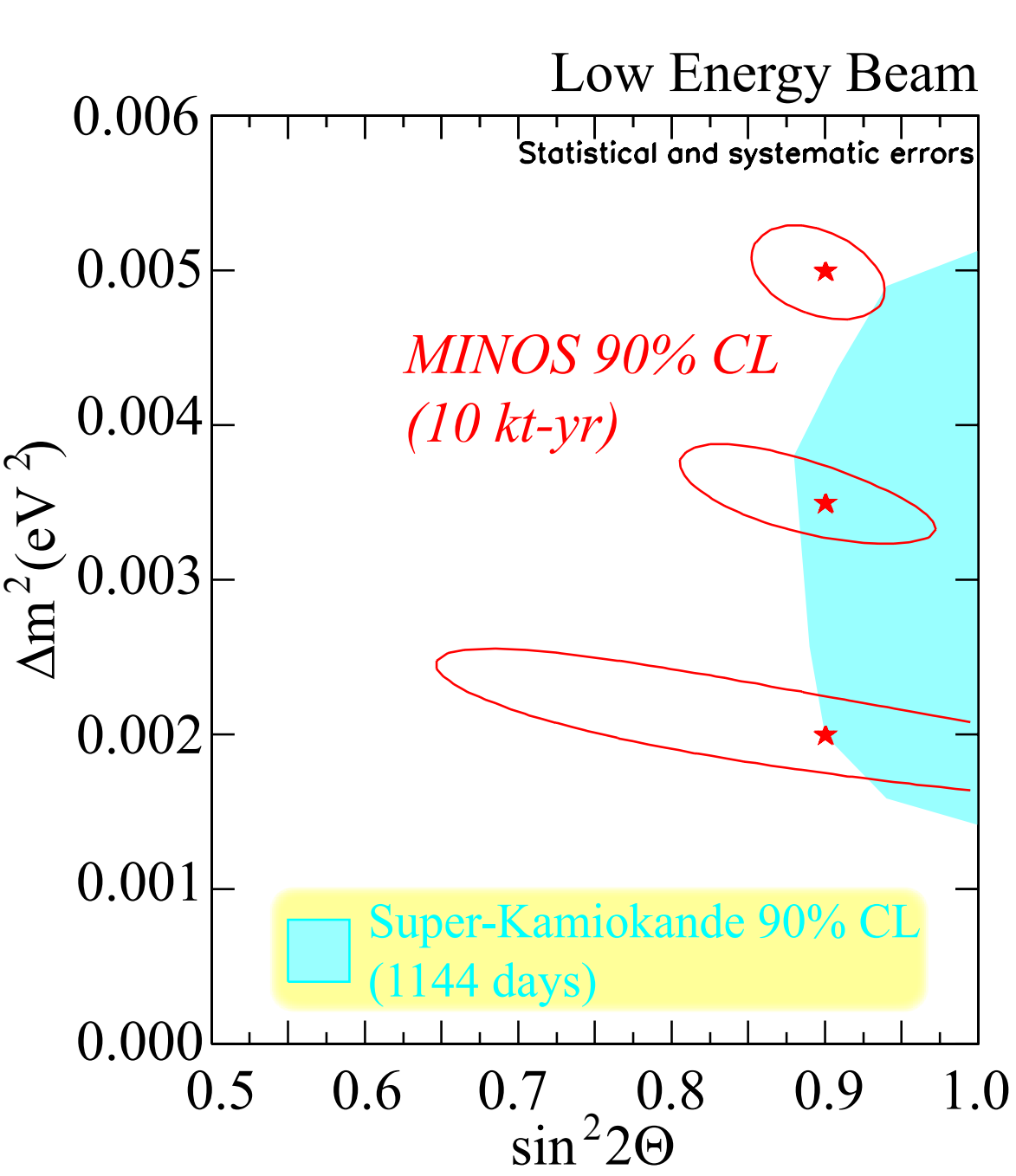
Fast front end electronics needed: FNAL QIE ships (based on KTeV version)

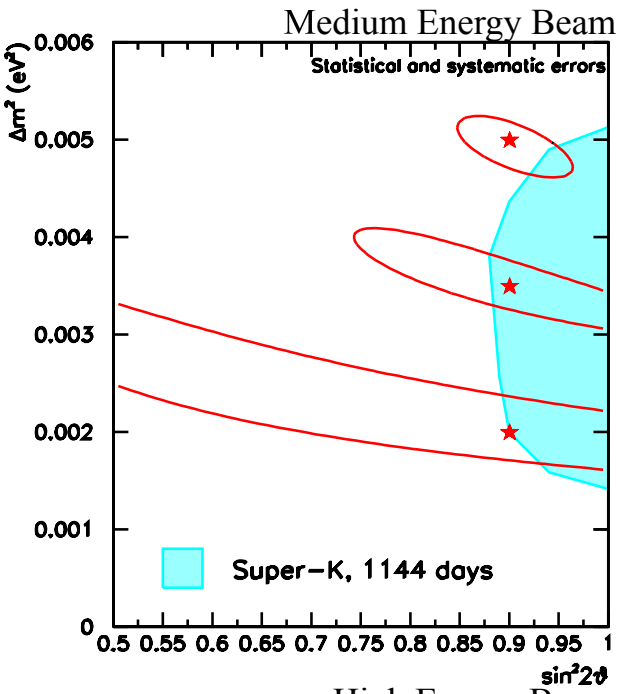
MINOS Energy Spectra

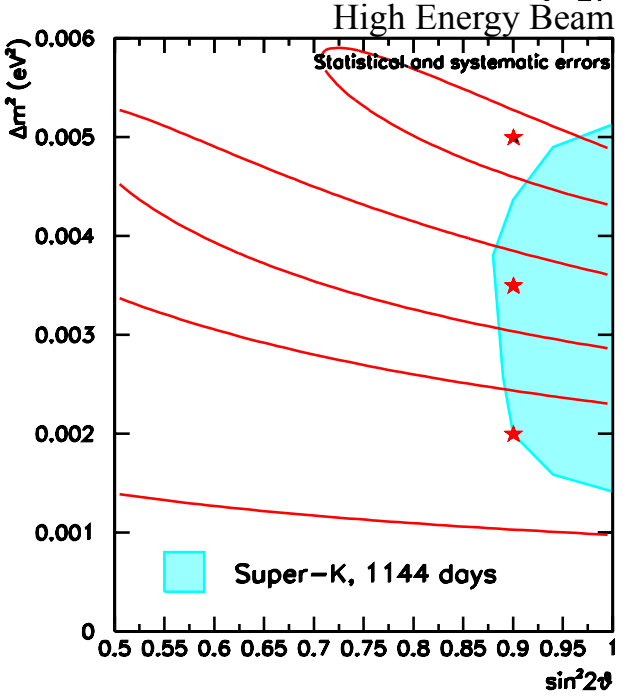
Low Energy Beam
10 kt-yr Exposure *(2 years at 3.8E20 POT/yr)*



MINOS Parameter Measurements

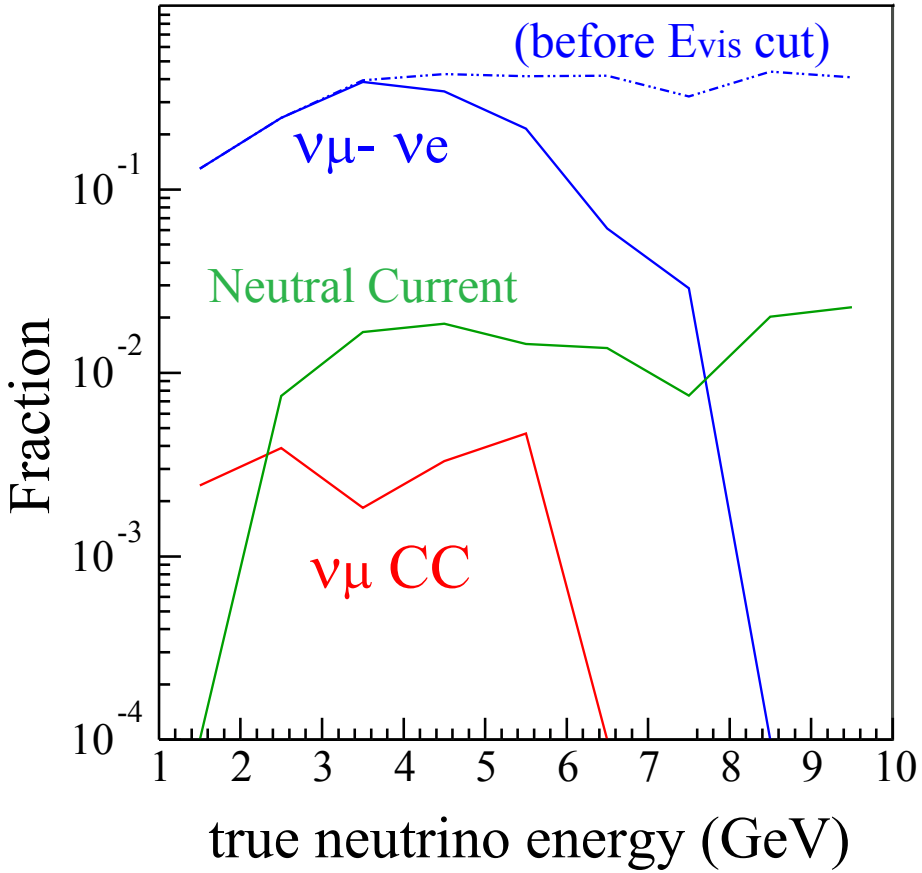




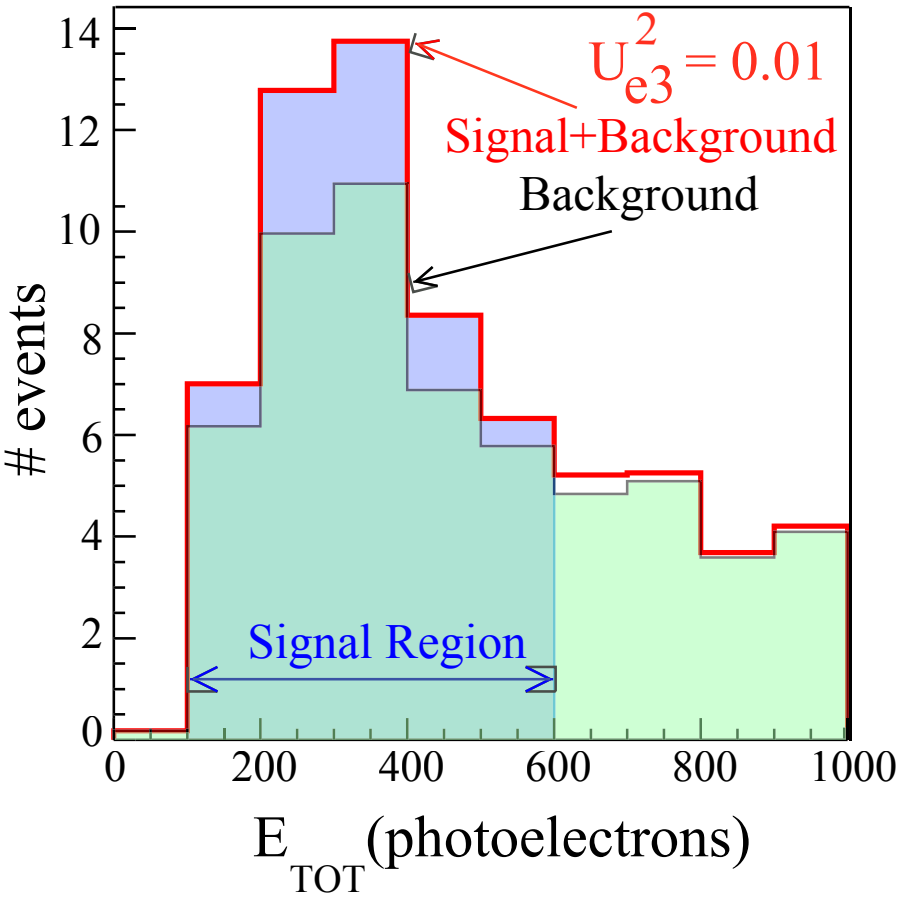


Electron Neutrino Appearance

Select electron showers based on neural net analysis of shower shapes



MINOS Low Energy Beam

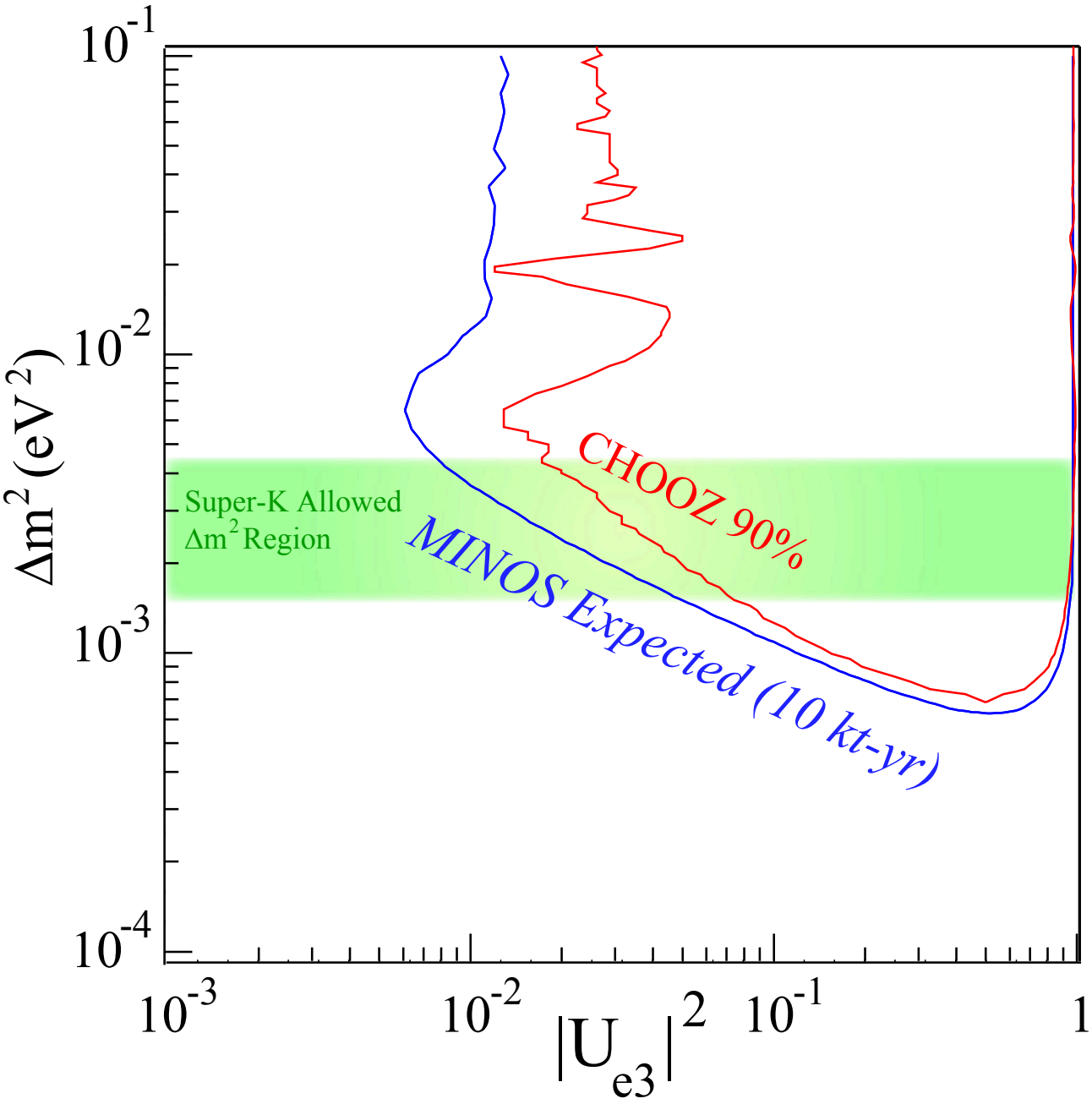


$\nu_\mu \rightarrow \nu_e$

8 νμ - νe

26 Neutral Current
5 Beam νe
4 νμ CC
3 νμ-ντ

MINOS Electron Neutrino Appearance



Event Rates

$U_{e3}^2 = 0.01$

$\Delta m^2 = 0.003\ eV^2$

8 ν_μ - ν_e

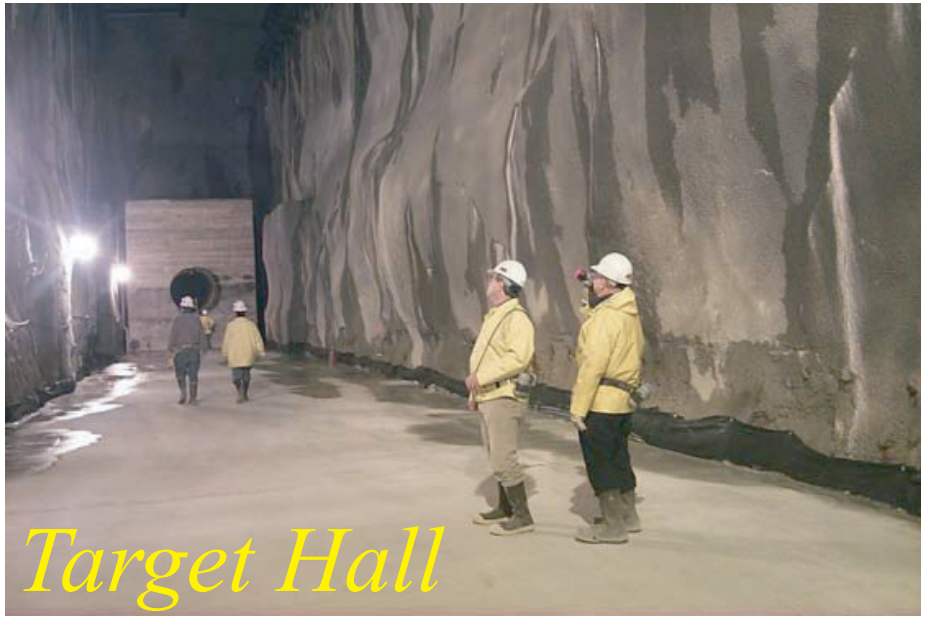
26 Neutral Current

5 Beam ν_e

4 ν_μ

3 ν_μ–ν_τ

NuMI Construction



NuMI Excavation complete

Outfitting underway. Occupancy November '03

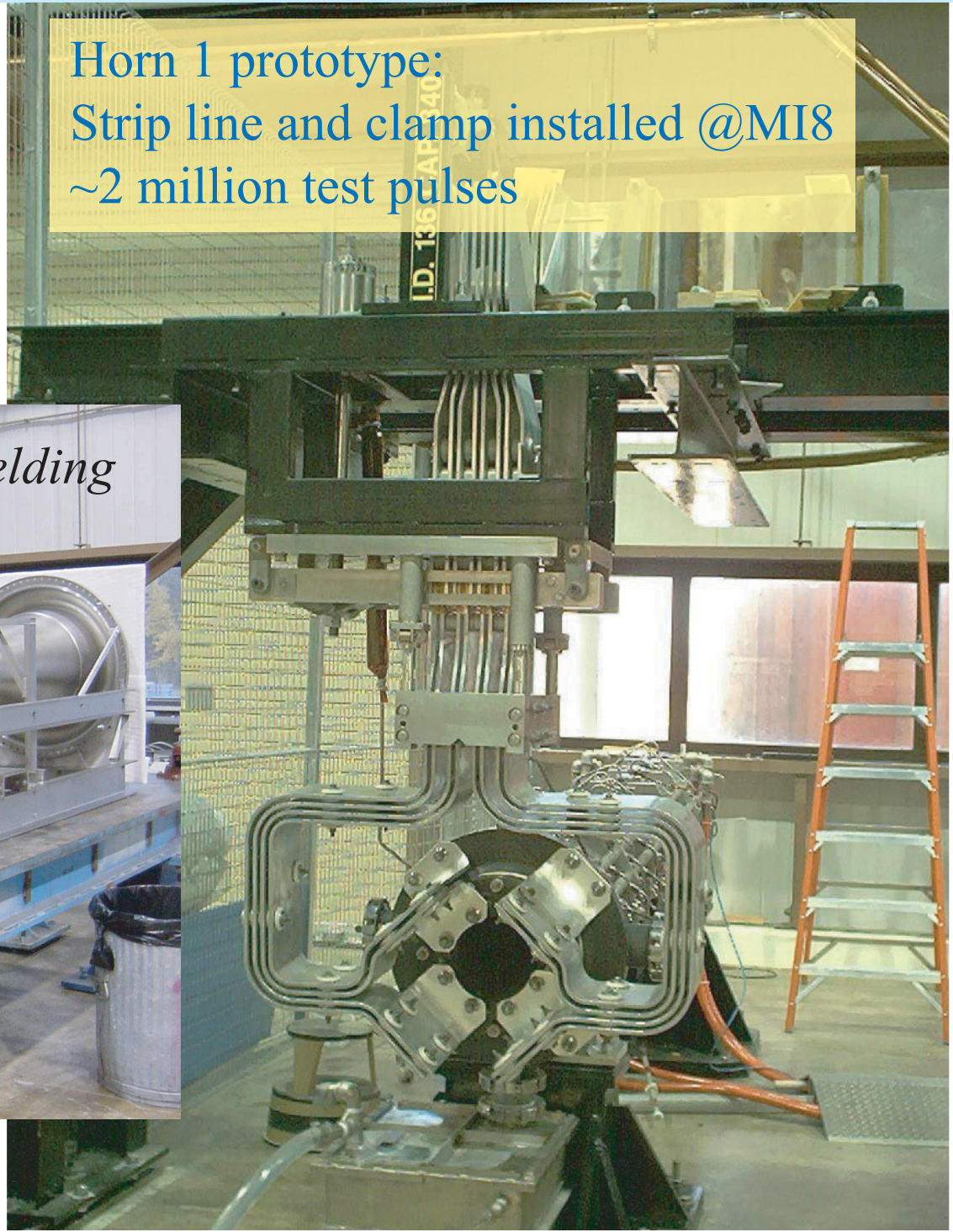
NuMI Horn Components

Horn 2:

Welding and nickel coating complete
Construction well within specs.
Assembly will start soon

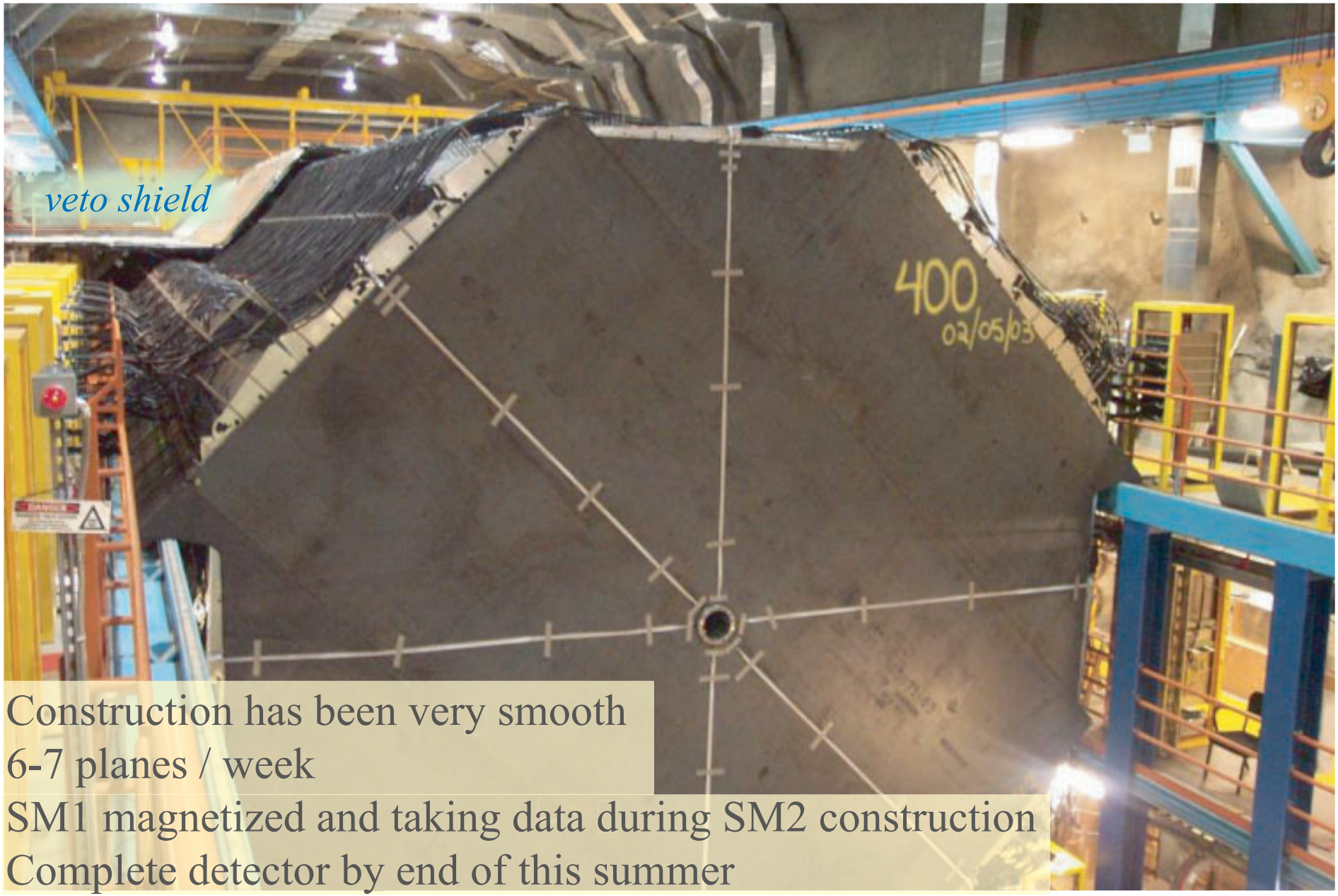
Horn 1: Welding in progress

Horn 2 inner conductor during welding



Horn 1 prototype:
Strip line and clamp installed @MI8
~2 million test pulses

MINOS Far Detector



Construction has been very smooth

6-7 planes / week

SM1 magnetized and taking data during SM2 construction

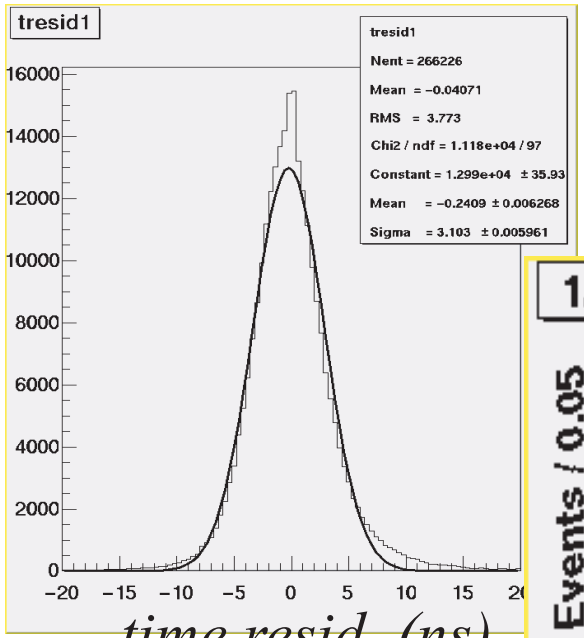
Complete detector by end of this summer

Near Detector Assembly at New Muon Lab

Near detector modules are assembled on surface

Practicing underground installation

Upward-Going Muons

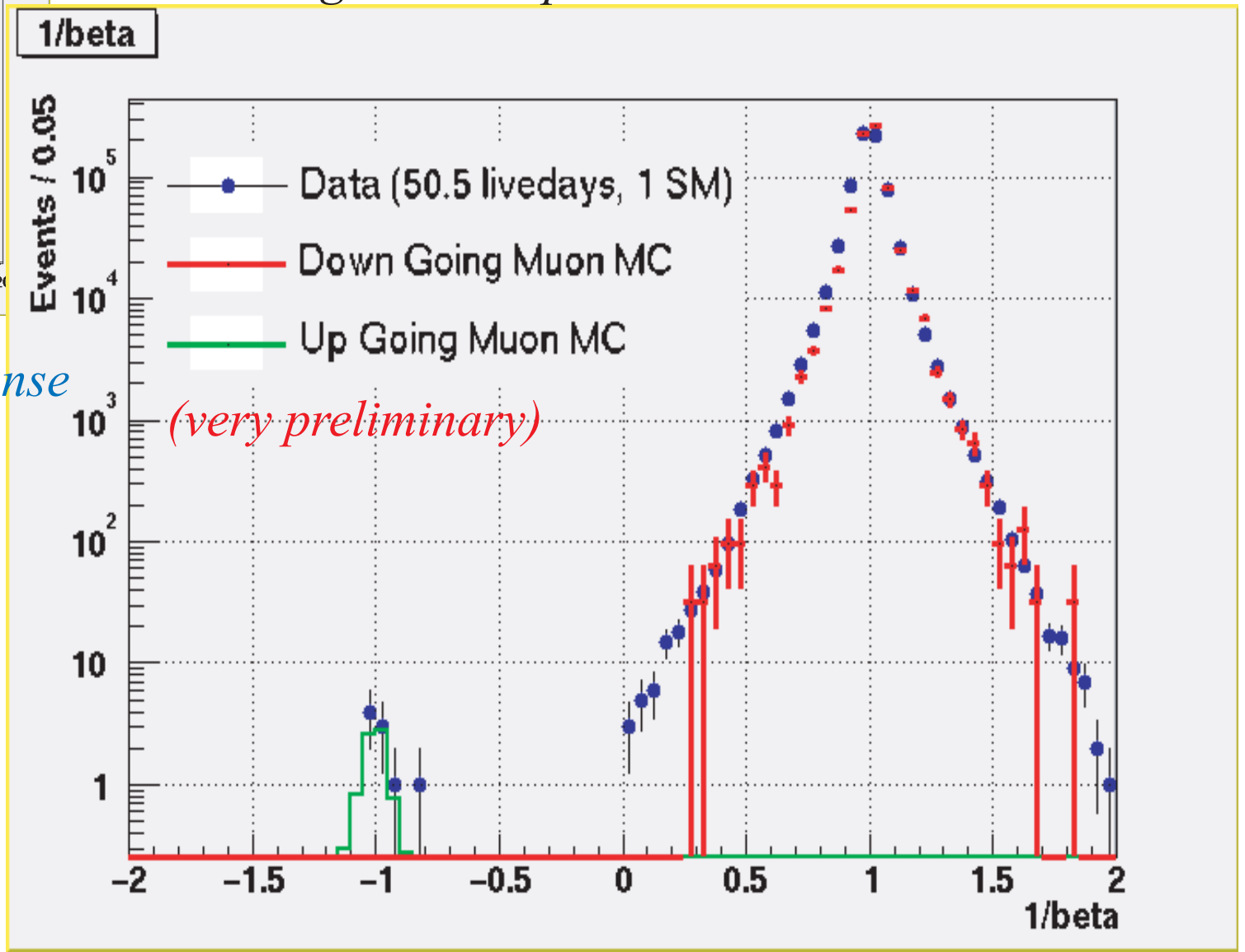


time resid. (ns)

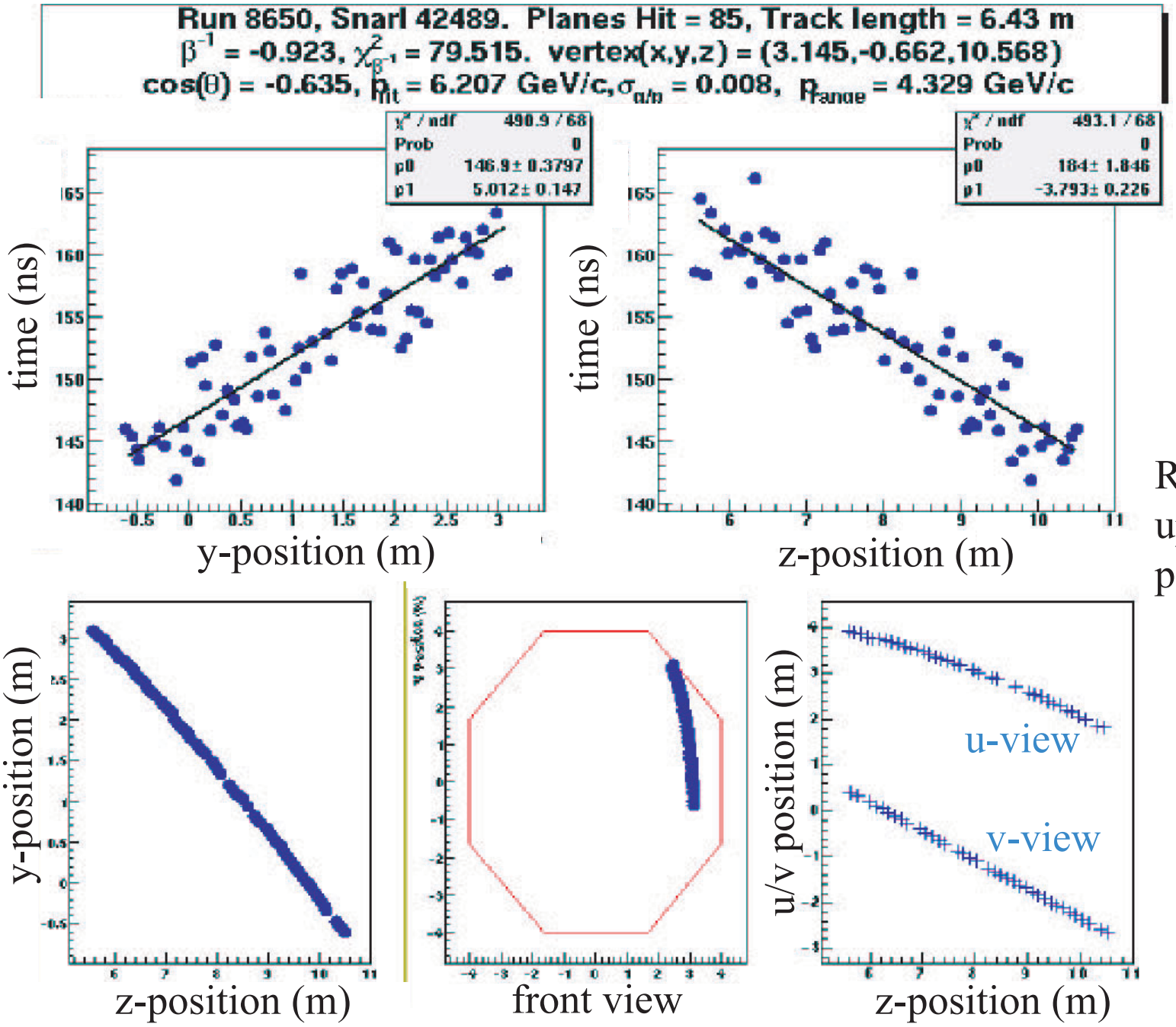
Calibrate time response with cosmic muons.
σ ~ 2.6 ns

Allows for upward/ downward-going descrimination

SM1 Running w/ field since July 2002
Expect ~100 upmu's /year/2 super-modules
Can sign-select up to ~40 GeV

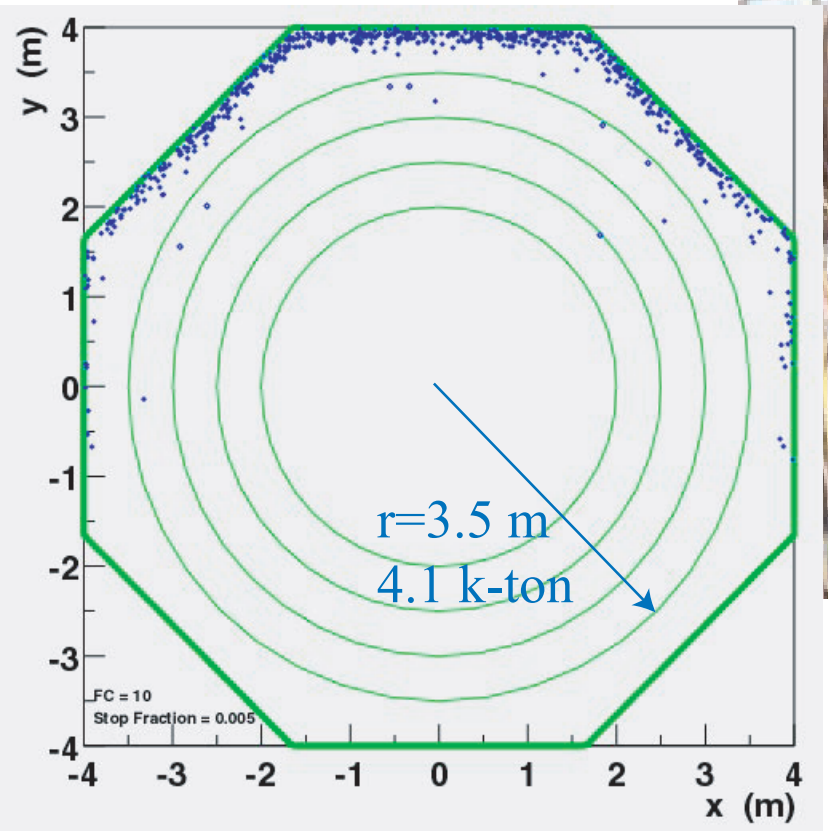


Atmospheric Neutrino $\bar{\nu}\mu$ Event



Real data!
upward going
partially-contained

Veto Shield



Reconstructed verticies of cosmic-ray muon events

MINOS is not hermetic. Cosmic-rays can fake contained events

Install prototype shield to veto comic rays from fully- and partially-contained samples

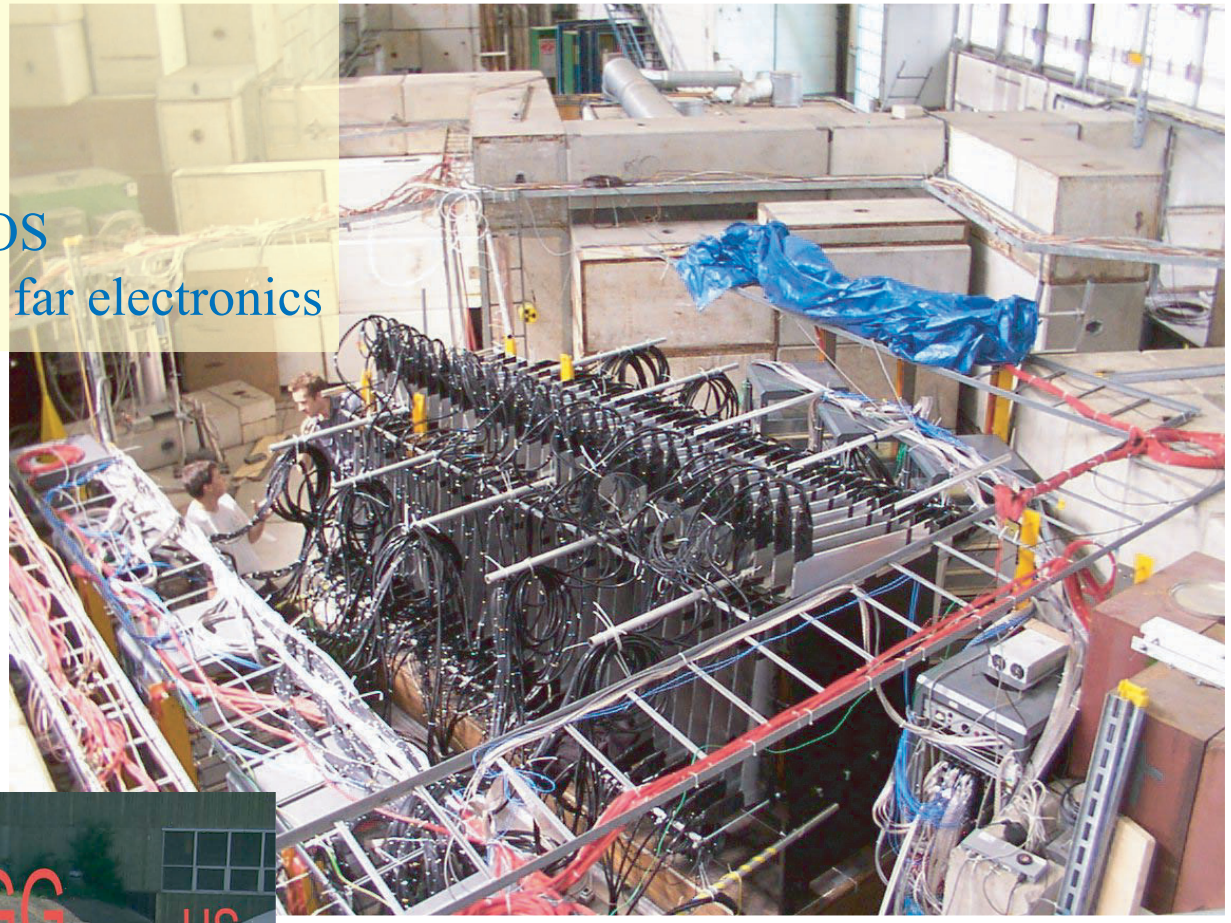
Understanding MINOS

Calibration detector at CERN

e/μ/π/p test beams

Sets absolute energy scale for MINOS

cross--check differences in near and far electronics



Understanding NuMI

MIPP hadron production experiment

Will make measurements of hadron production using NuMI target in addition to surveys of thin targets in range from 15-120 GeV

First data expected this summer

Summary

NuMI

NuMI Tunnel Excavation complete
Occupancy of target hall in November 2003
Smooth progress on technical components
Commission beam in December 2004
First NuMI run January 2005

MINOS

Far detector complete. Magnetized since July 2002
First atmospheric neutrino data with B-field!
  upward-going muons
  fully-contained and partially contained muons
Complete far detector by end of summer 2003