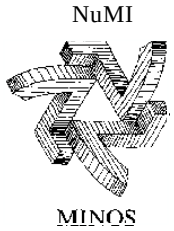


MINOS Update

Robert C. Webb
La Thuile 2002
March 4, 2002

NuMI/MINOS Update

Robert C. Webb

Physics Department
Texas A&M University

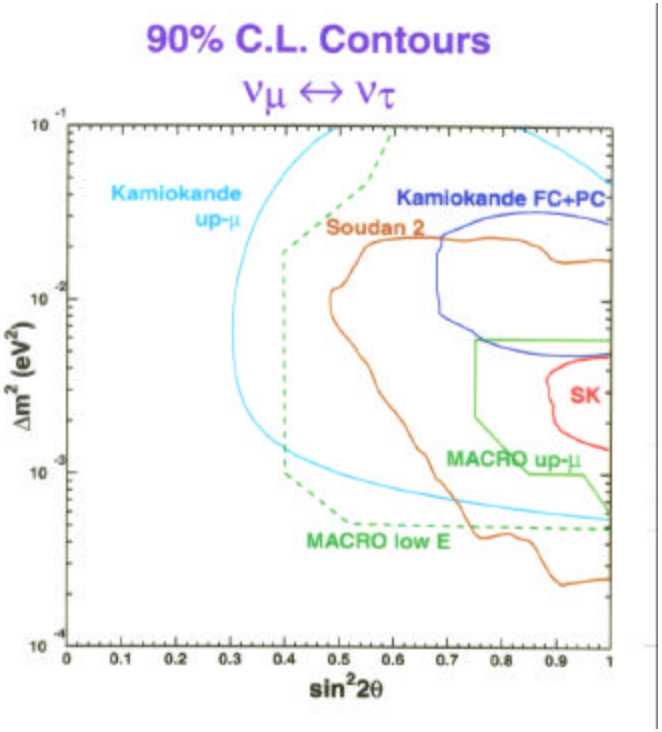
March 4, 2002

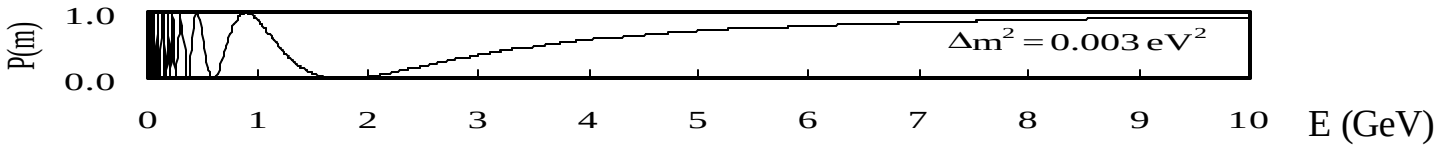
- Introduction
  Neutrino Oscillation Evidence
- Overview of NuMI / MINOS
- Physics Reach of MINOS
- Status of
  - NuMI
  - MINOS
    - Far Detector
    - Cal Det
    - Near Detector
- Summary

MINOS Physics Goals

Robert C. Webb
La Thuile 2002
March 4, 2002
Page 2

- A next generation long baseline neutrino accelerator experiment
  - « Explore the region of oscillation parameter space indicated by the atmospheric neutrino results
- "A hotter beam over a longer baseline"
  - « Match flux and efficiency to the region of the first oscillation maximum
  - « Check the oscillation interpretation through spectral measurements
  - « Obtain improved parameter measurements
  - « Search for sub-dominate modes





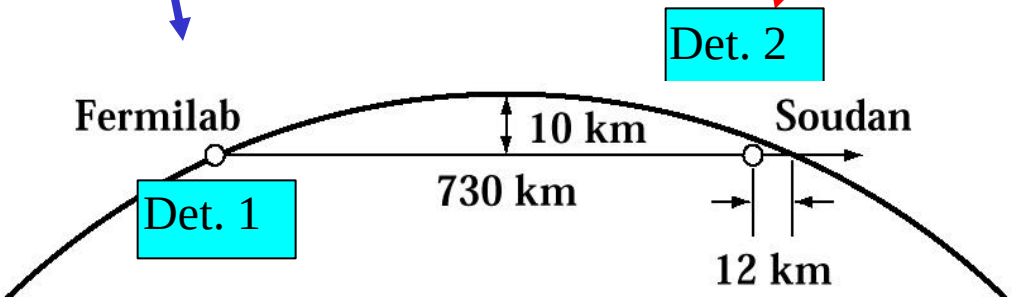
MINOS Experiment

Robert C. Webb

Two Detector Neutrino Oscillation Experiment (Start 2004)

Near Detector: 980 tons

Far Detector: 5400 tons



Producing the NuMI Beam at Fermilab's Main Injector

Robert C. Webb

2.7×10^{20} 120 GeV Protons per year hit the target*

π^+ are produced at wide range of angles

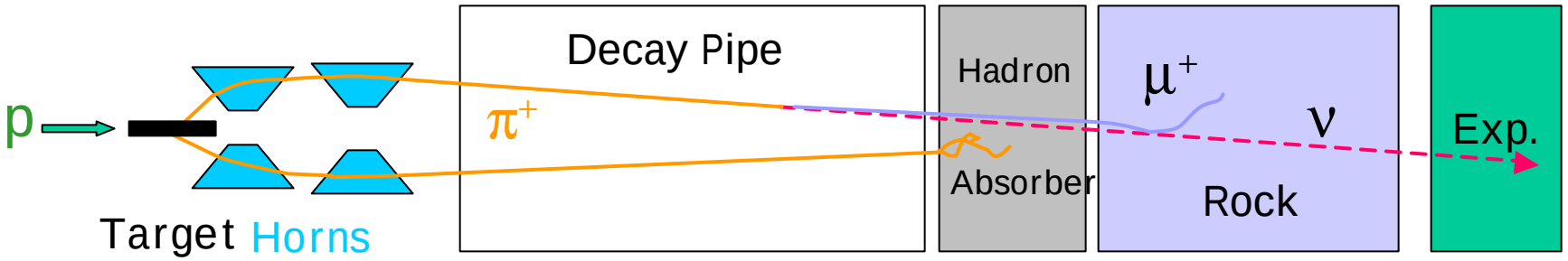
Magnetic horns focus π^+

π^+ decay to $\mu^+\nu_\mu$ in a long evacuated pipe

Left-over π^+ shower in an absorber

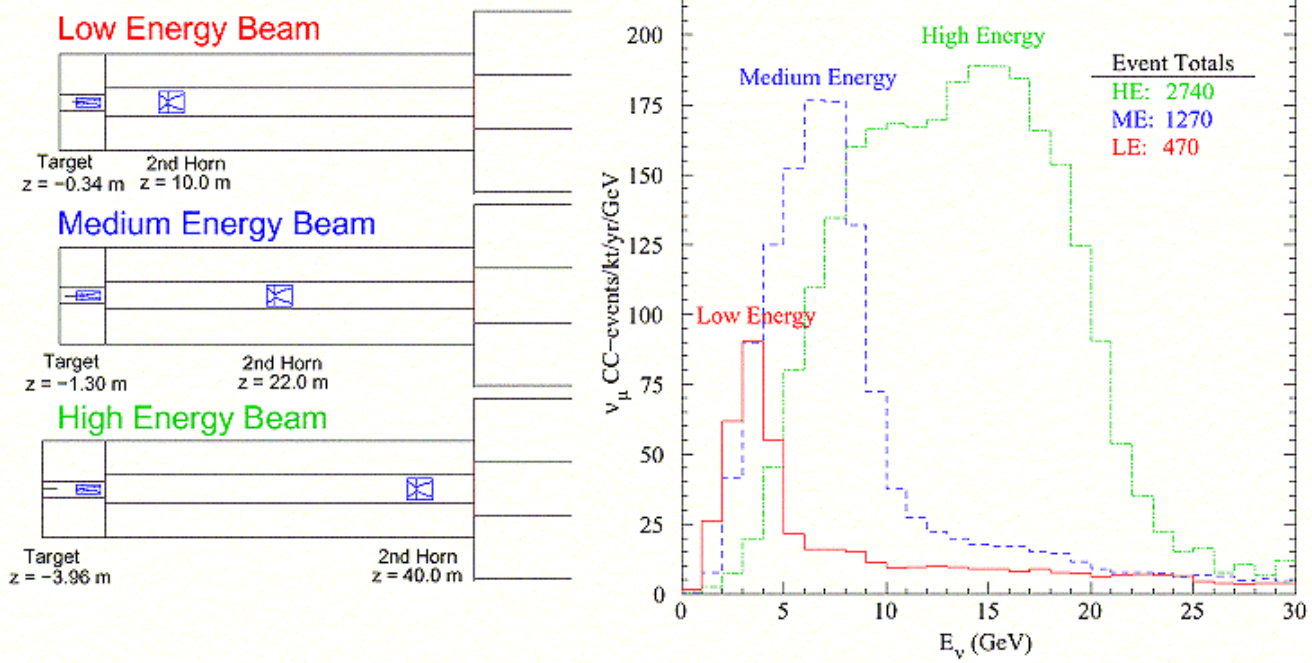
Rock shield ranges out μ^+

ν beam travels through earth to the experiment



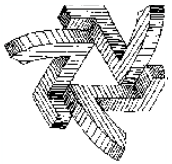
NuMI Horn Configurations and Beam Spectra

Robert C. Webb



Initial running in the “Low Energy” configuration

Expect ~2500 Events per “Canonical” NuMI year



Oscillation effects observable at MINOS

Robert C. Webb

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(ImageMagick)
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other types of printers.

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(ImageMagick)
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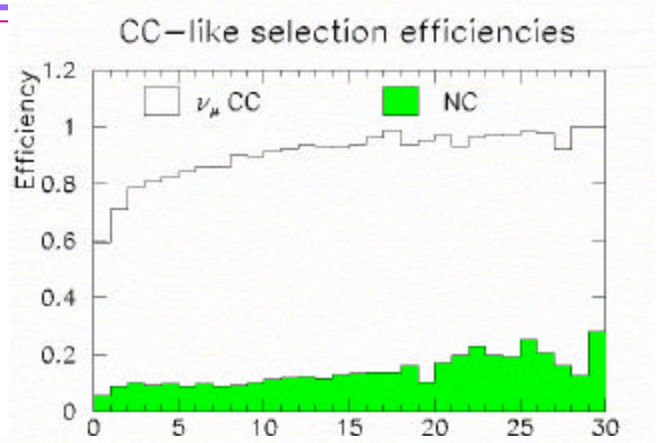
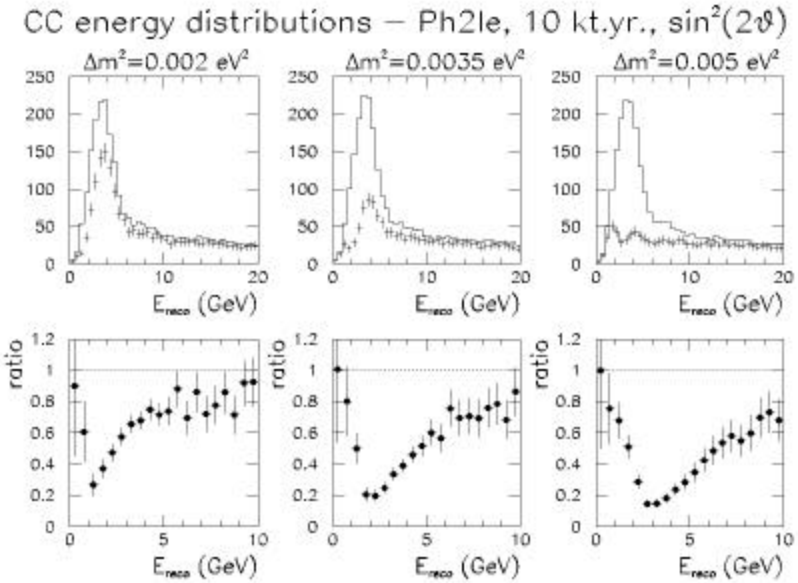
with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

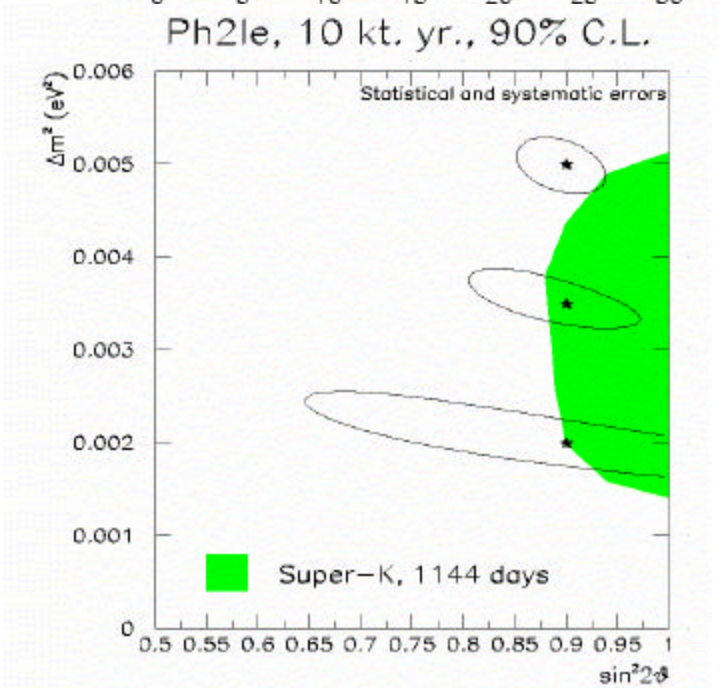
ν_μ CC Event Selection Efficiency and Background Rejection

Robert C. Webb

With high statistics and good event efficiencies in the energy region of interest MINOS will give substantially improved oscillation parameter measurements in a 2-year run







Control of Systematics

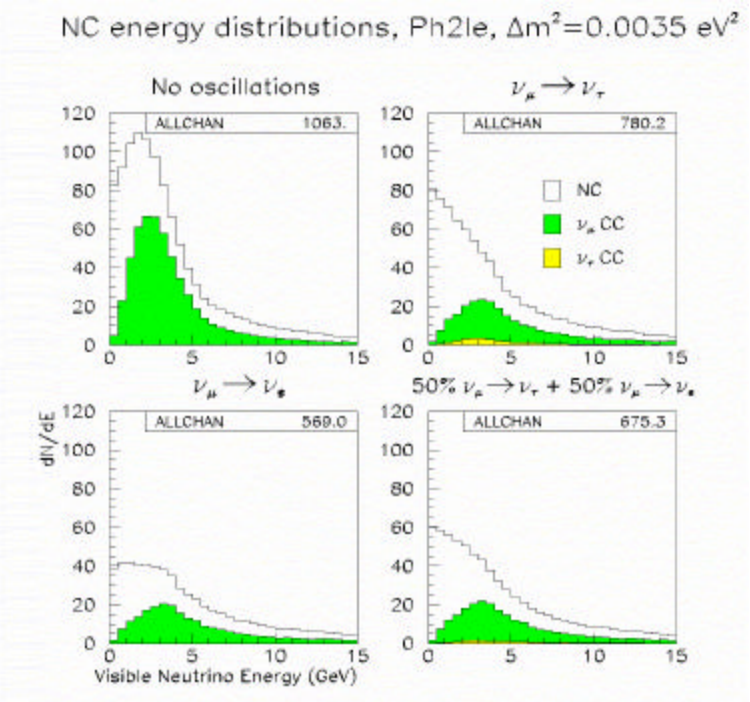
Robert C. Webb

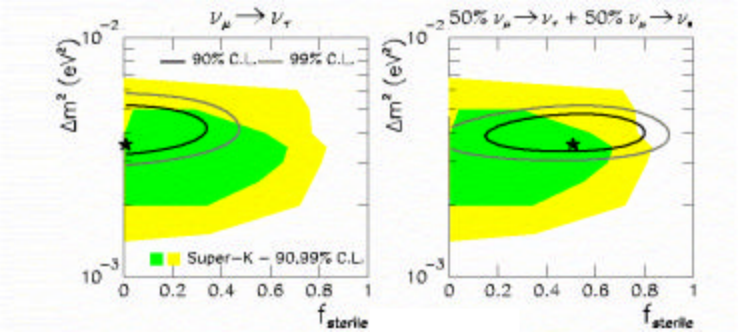
- Near/Far extrapolation
  - « Primary Control comes from extrapolation of data from the near detector
  - « Efforts aiming at production experiments at CERN & FNAL
- Beam pointing checked by
  - « GPS & laser survey with 1km lever arm on the near site and <<1m accuracy at the FD site
  - « Checked with ND beam profile, downstream hadron monitors (spot check), and muon monitors in the absorber pile and rock

Improving Limits on Other Oscillation Modes

Robert C. Webb

- Spectrum of NC-like events in MINOS gives a handle on $\nu_{sterile}$
- An analysis of this data and disappearance data give improved constraints over current limits

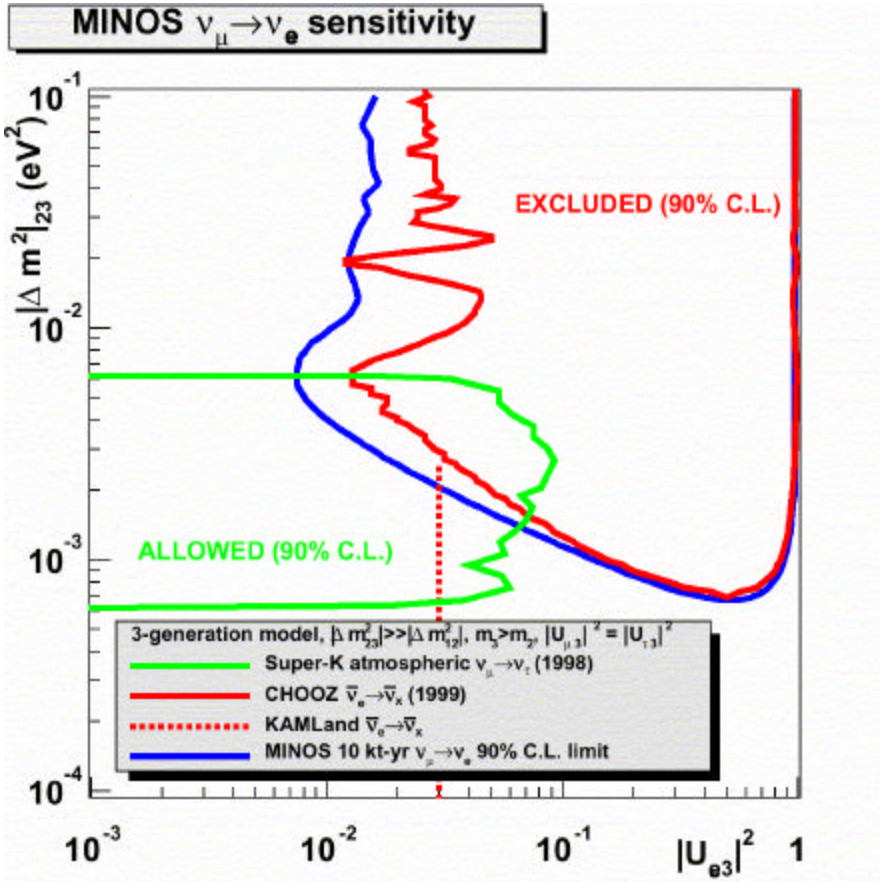




Improved Limits on Sub-dominate Mode

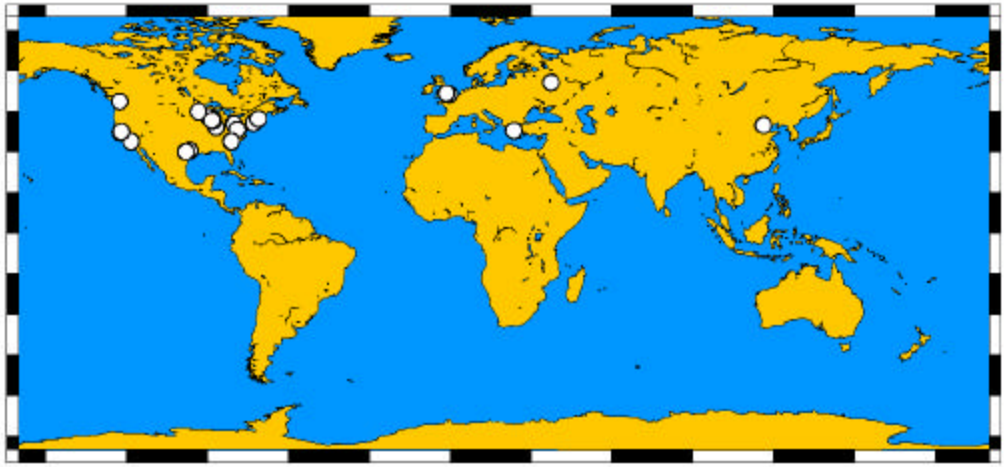
Robert C. Webb

- Analysis uses shower shapes and energies to eliminate backgrounds
- Modest improvement over the current limits
- The limits are shown for a nominal 10kt-year exposure



The MINOS Collaboration

Robert C. Webb



Over 200 Collaborators
from 32 Institutions

Argonne • Athens • Brookhaven • Caltech • Cambridge • Chicago • Dubna • Elmhurst
Fermilab • Harvard • IHEP-Beijing • Illinois Inst. of Technology • Indiana • ITEP-Moscow
Lebedev • Livermore • Macalester • Minnesota • Minnesota-Duluth • Northwestern
Oxford • Pittsburgh • Protvino • Rutherford • South Carolina • Stanford • Sussex • Texas A&M
Texas-Austin • Tufts • University College London • Western Washington • Wisconsin

MINOS Detectors

Robert C. Webb

Basic Ingredients of MINOS detectors

- Fine grained, Iron/scintillator sampling calorimeters
- 2.54cm thick Steel absorbers with toroidal B-field of ~1.3 T
- 1 cm thick, 4 cm wide Scintillator strips
- 1.2 mm diameter wavelength shifter and clear fibers
- Multi-Anode PMT
- Front end Electronics & DAQ

Far Detector at Soudan

- 8m wide octagonal shape
- 486 steel plates
- ~5,400 tons

Near Detector at Fermilab

- 3.8x4.8m squashed octagon
- 282 steel plates
- ~980 tons

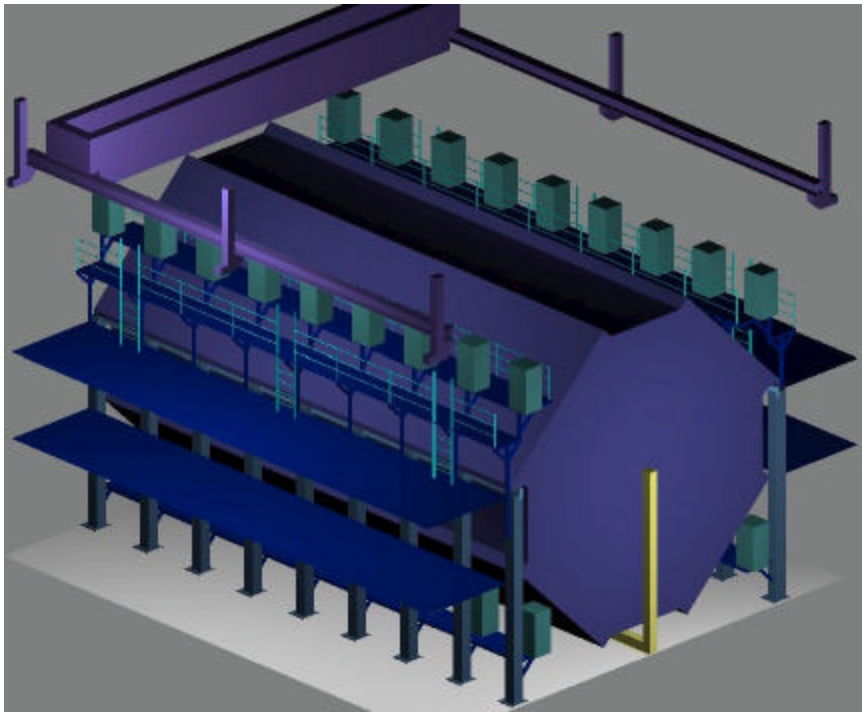
Both Detectors have

- 2-views for tracking

MINOS Far Detector

Robert C. Webb

- 8m Octagonal Tracking Calorimeter
- 486 layers of 2.54cm Fe
- 2 sections, each 15m long
- 4cm wide solid scintillator strips with WLS fiber readout
- 25,800 m^2 active detector planes
- Magnet coil provides $\langle B \rangle \approx 1.3T$
- 5.4kt total mass

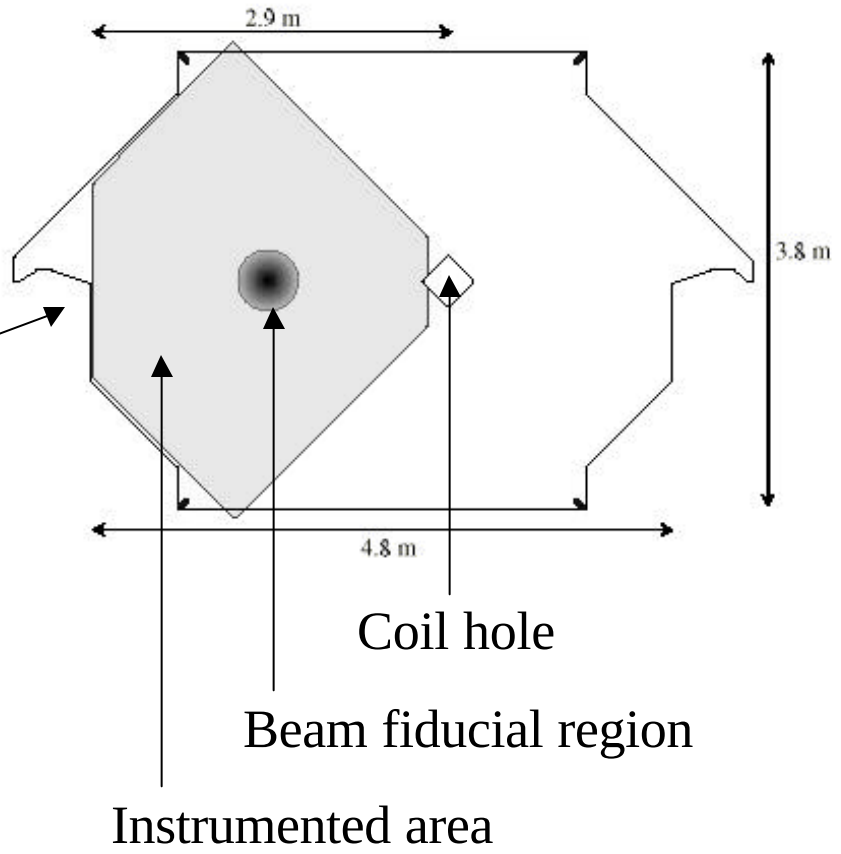


Half of the MINOS Detector

MINOS Near Detector

Robert C. Webb

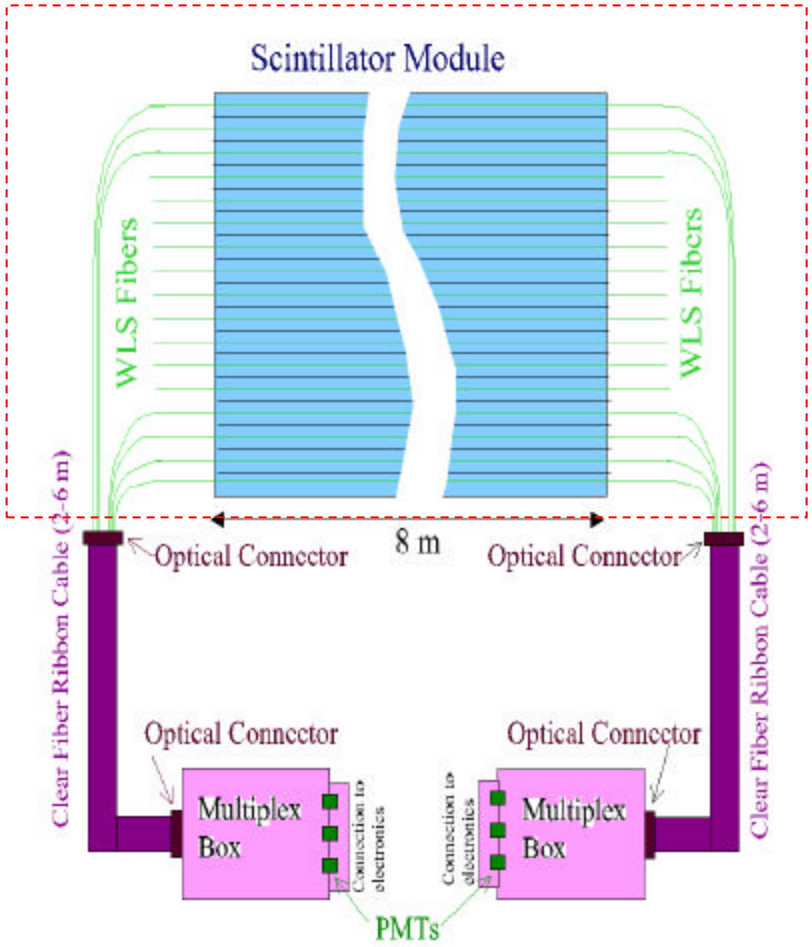
- 16.6 m long, 980 tons
- 282 “squashed octagon” planes
- Forward section: 120 planes
  - 4/5 partially instrumented
  - 1/5 planes: full area coverage
- Spectrometer section:162 planes
  - 4/5 planes not instrumented
  - 1/5 planes: full area coverage



Scintillator Readout Schematic (Far Detector)

Robert C. Webb

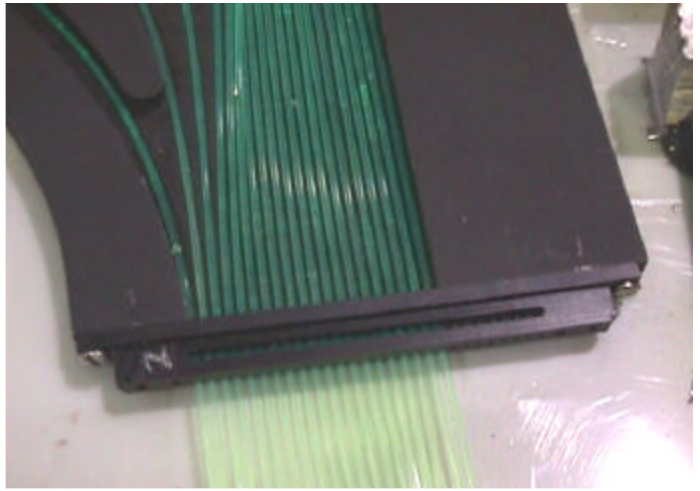
- Strips assembled into 20- or 28-strip “modules”
- Fire resistant aluminum light cases
- 2-ended WLS fiber readout
- WLS to clear fiber cables at module connectors
- MUX boxes route 8 fibers to one PMT pixel

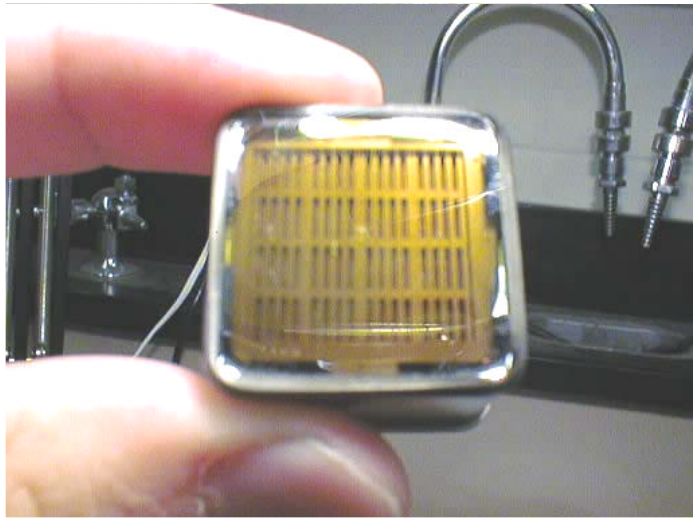


MINOS
Scintillator System

Robert C. Webb

- An 8 m Scintillator Module
- Optical fiber readout
- A 16-channel M16 PMT





NuMI Excavation

Robert C. Webb

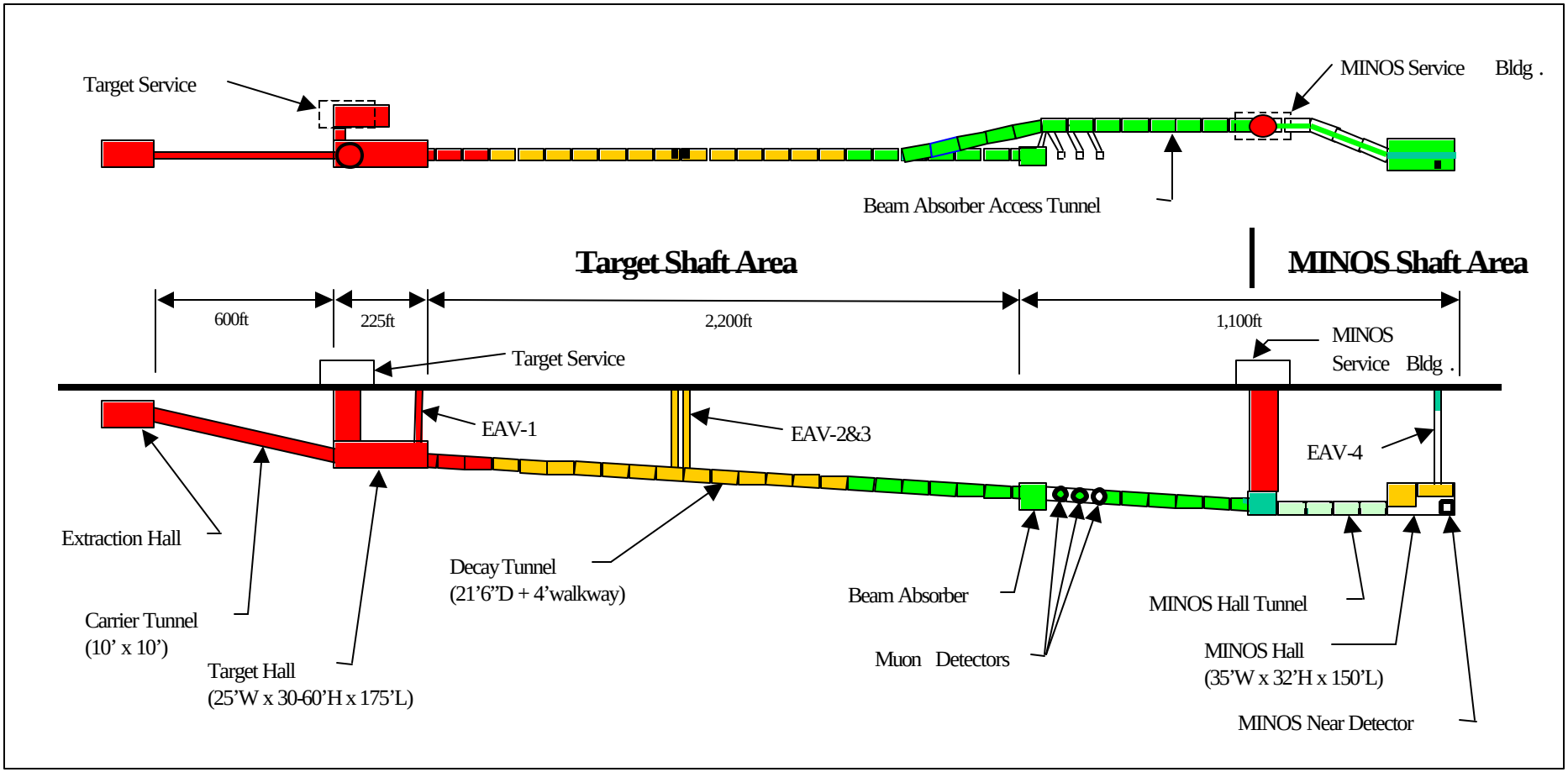
- Drill and blast for the shafts, target hall, support labyrinth, absorber hall, and MINOS near detector hall
- Tunnel boring machine for the decay tunnel and access to the ND hall and beam monitoring areas

NuMI Excavation Summer 2001

Robert C. Webb

NuMI Tunnels and Halls Construction Progress

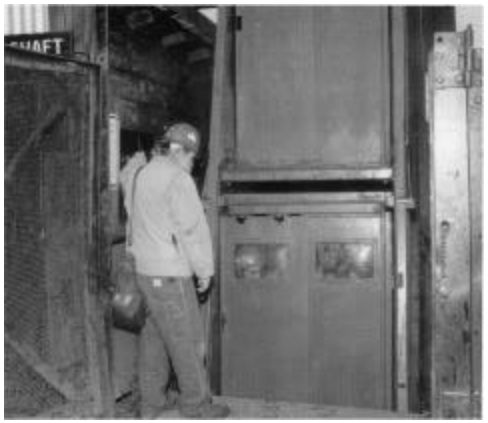
Robert C. Webb
La Thuile 2002
March 4, 2002



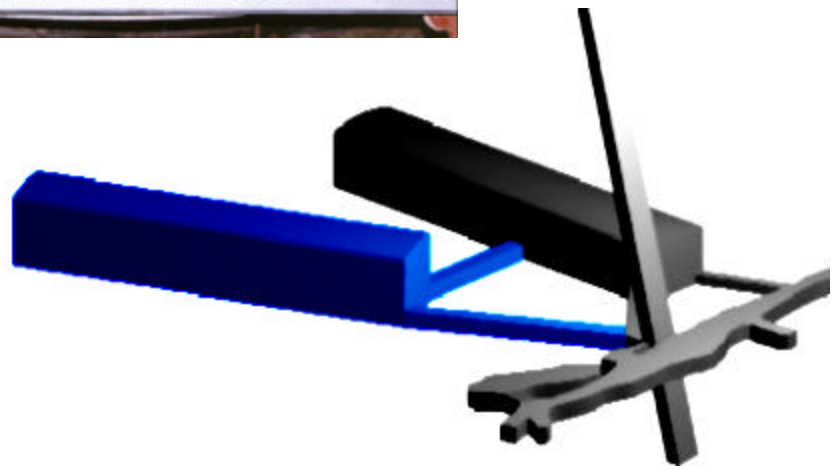
As of June 2001
As of Sep 2001
As of Jan 2002

Soudan Underground Laboratory

Robert C. Webb



The Soudan shaft limits objects to a maximum size of 1m by 2m by 9m



MINOS Progress - Far Detector Hall

Robert C. Webb

MINOS Far Detector Installation - Detector Plane Assembly

Robert C. Webb

Detector plane strongbacks

Scintillator module mounting

Current Status of Far Detector

146 Planes mounted as of 3/1/2002

136 Planes being readout through DAQ

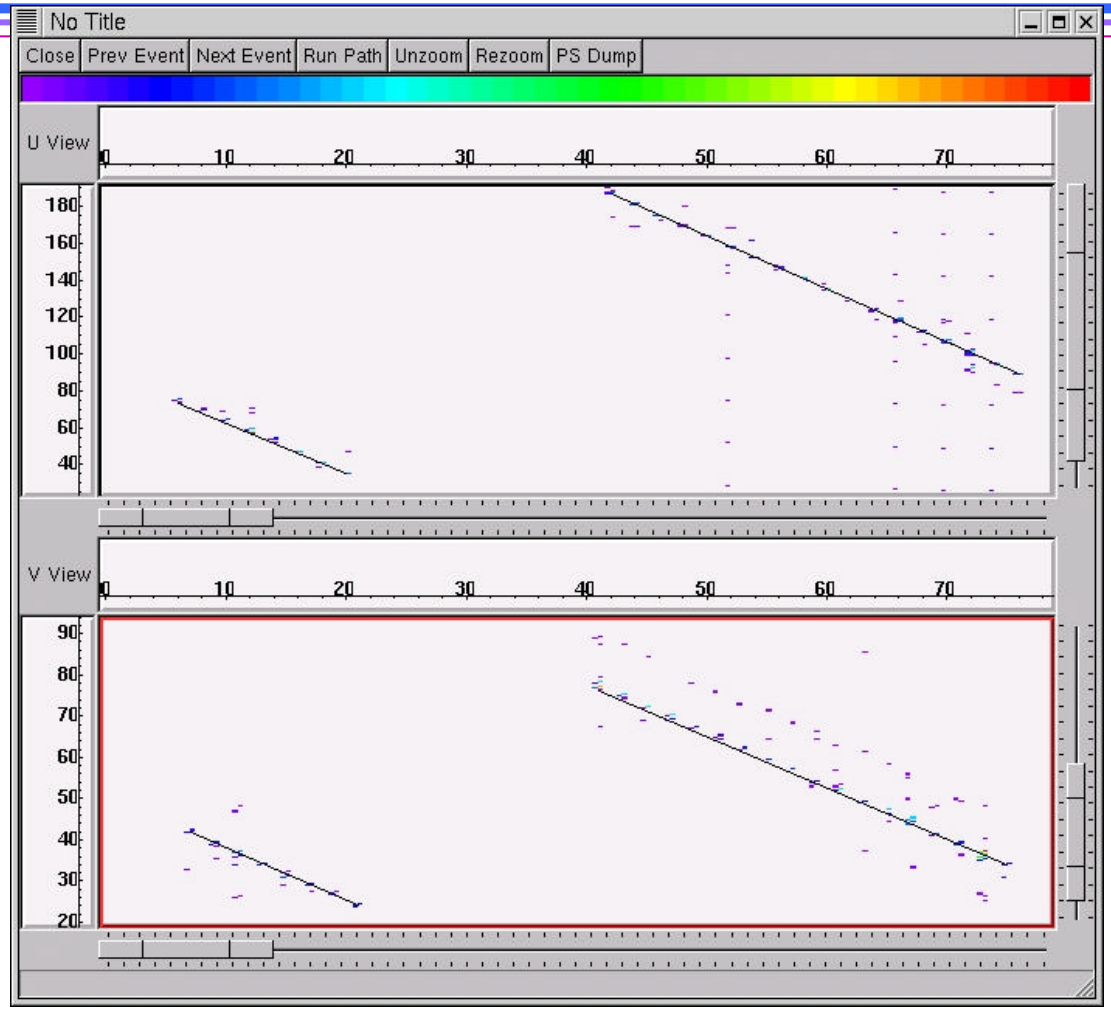
1.6kT of fiducial mass

1/3 pe threshold with 4 out of 5 planes required for trigger

~2% of the detector is being mounted per day at the present rate of assembly

Double Cosmic-Ray Muon in MINOS Far Detector

Robert C. Webb



Scintillator strip number →

'u' view

'v' view

Color indicates pulse size

Extra hits from cross talk and deMUX failures

Lines are from fits by track reconstruction software

Detector plane number (1-76) →

Near Detector Construction

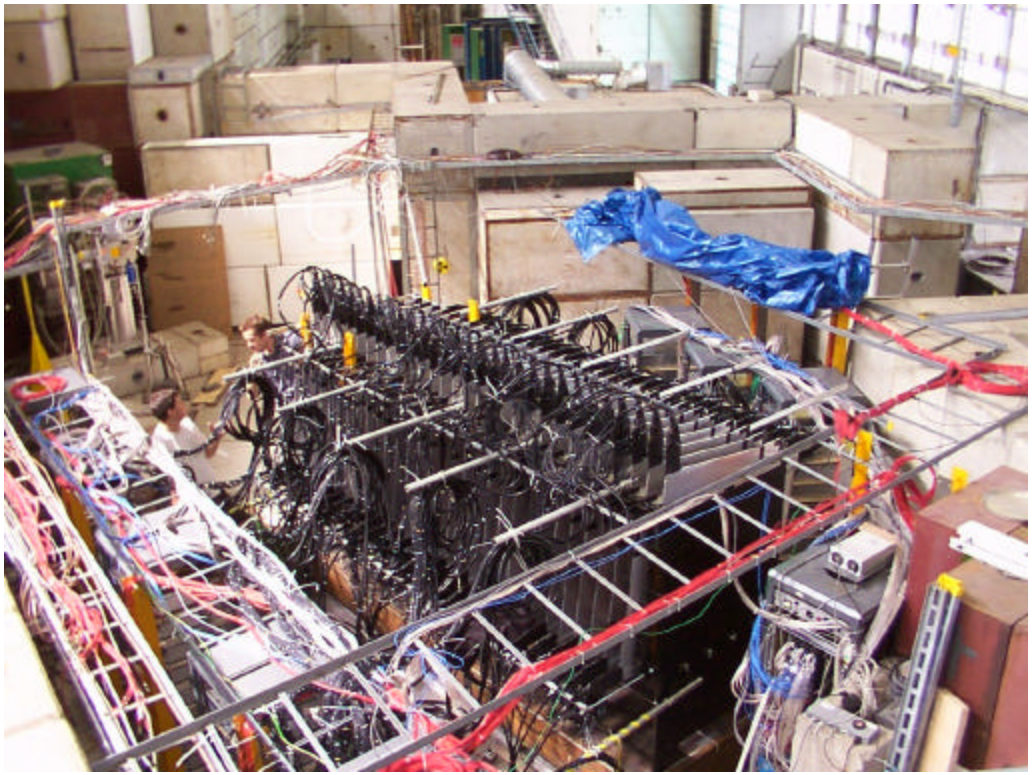
Robert C. Webb

Construction beginning in early 2002(NOW)

The MINOS Calibration Detector

Robert C. Webb

- 60 1m X 1m MINOS modules with Far Detector readout Electronics.
- Assembled in the CERN T11 beam in the Spring of 2001.
- Completed run with energies up to 3 GeV .
- Schedule to run at higher energies in 2002.

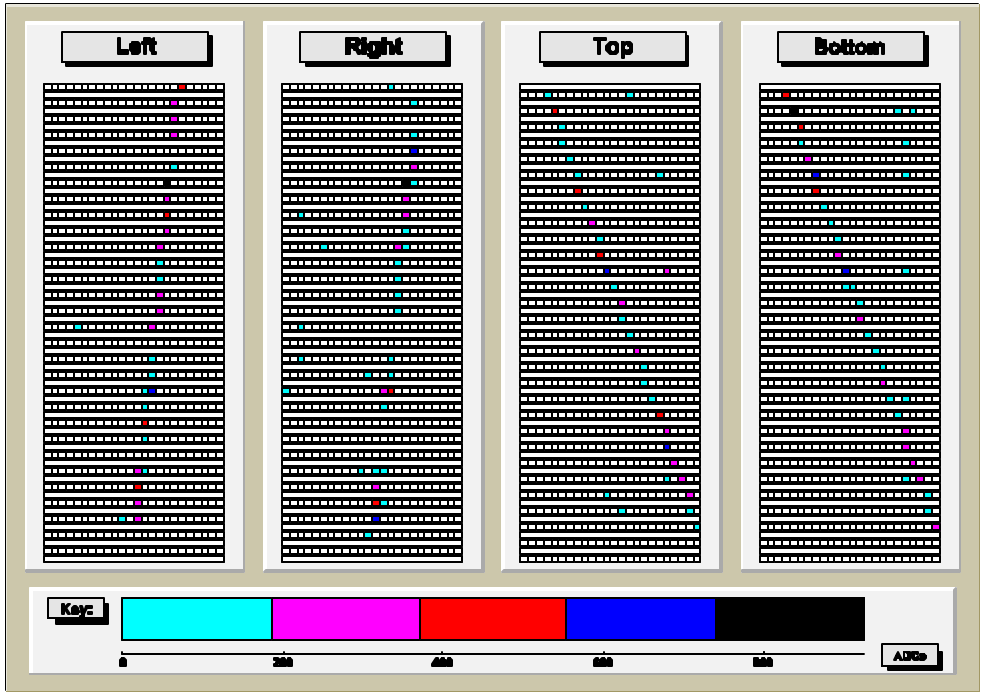


The MINOS Calibration Detector

Robert C. Webb

Data taken with
- Pions
- Electrons
- Protons(using TOF)
- Muons

Sample Muon event displayed to the right



Schedule

Robert C. Webb

- Far Detector installation (’01-’03)
  - « Cosmic rays and atmospheric neutrinos with half the detector (and the magnetic field) in summer 2002
  - « 10kt-years by 2005
  - « CP tests in upward muons and momentum analyzed partially-contained events
- Near Detector assembly and installation (’01-03’)
- Beam line commissioning (’04-’05)

Robert C. Webb

Summary

- MINOS will confront the atmospheric neutrino signal with -
  - High statistics accelerator data
  - Good flavor separation
  - Good control of systematics
- With initial calibration data runs completed at CERN and beginning at Soudan with the *real* detector…
  - We are on the road to exciting neutrino physics in the next few years!