Outline

• Overview of the Experiment
  – Geographical Layout
  – Neutrino Beam
  – MINOS Detectors

• Physics Sensitivity of the Experiment
  – CC Rate and Spectrum Test
  – NC/CC Test

• Recent Progress / Current Activities
  – Conventional Construction
  – Neutrino Beam
  – Detector Developments

• Prognosis for the Future / Schedule

• Conclusions
Status of the MINOS Project

Presentation at the Neutrino2000 Conference
Sudbury, Canada
June 17, 2000

Stanley Wojcicki
Stanford University
Stanford, Ca
The MINOS Collaboration

Over 250 Physicists and Engineers

IHEP-Beijing • Athens • Dubna • ITEP-Moscow • Lebedev • Protvino • Oxford • Rutherford • Sussex • University College London • Argonne • Brookhaven • Caltech • Chicago • Elmhurst • Fermilab • James Madison • Harvard • Indiana • Livermore • Minnesota • Northwestern • Pittsburgh • South Carolina • Stanford • Texas-Austin • Texas A&M • Tufts • Western Washington • Wisconsin
MINOS Experiment

Two Detector Neutrino Oscillation Experiment (Start 2003)

Near Detector: 980 tons
Far Detector: 5400 tons
The Soudan shaft limits objects to a maximum size of 1m by 2m by 9m.
Tuning Neutrino Spectra by Horn/Target Reconfiguration

(a) PH2he High Energy

(b) PH2me Med. Energy

(c) PH2le Low Energy

Target Hall

Decay Pipe

50 m target pile + 675 m decay pipe

$E(\nu_e)$ GeV

$\nu_e$ CC events / kton / year / GeV

Perfect Focusing

PH2(high)

PH2(medium)

PH2(low)
MINOS Far Detector

- 8m Octagonal Tracking Calorimeter
- 486 layers of 2.54cm Fe
- 2 sections, each 15m long
- 4.1cm wide solid scintillator strips with WLS fiber readout
- 25,800 m² active detector planes
- Magnet coil provides $<B> \approx 1.3T$
- 5.4kt total mass
Steel & Scintillator Plane Layout

2-m wide, 0.5-inch thick, steel plates

Scintillator plane
Orientations alternate ±90° in successive planes

Bottom steel plane layer

Top steel plane layer
- 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
Far Detector Cross Section

Rock Bolts

Ventilation

Crane

Electronics

Scintillator Module Manifolds

Support Structure

Magnet Coil
MINOS Near Detector

- 16.6 m long, 980 tons
- 20 "squashed octagon" planes
- **Forward section:** 120 planes
  - 4/5 partially instrumented
  - 1/5 planes: full area coverage
- **Spectrometer section:** 160 planes
  - 3/4 planes not instrumented
  - 1/4 planes: full area coverage
SuperK Overall Best Fit

SK prelim. $\nu_\mu \leftrightarrow \nu_\tau$ osc. Conf. Intervals

☆ Best Fit for all atm-$\nu$
$\sin^2 2\theta = 1$, $\Delta m^2 = 3.2 \times 10^{-3}$ eV$^2$
Uses FC+PC+upthru-$\mu$+upstop-$\mu$
$\alpha = +9\%$, $\eta = -4\%$, FC+PC/upthru=-0.2%
$\chi^2_{\text{min}} = 70.2/82$ dof
No-osc. $\chi^2 = 214.3/84$ dof

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$\Delta m^2$ (eV$^2$)

$\sin^2 2\theta$

68\%CL
90\%CL
99\%CL
MINOS Energy Spectra

10 kt-yr Exposure

Solid lines - energy spectrum without oscillations
Dashed histogram - spectrum in presence of oscillations
Comparison of Different Beams

CC Energy Spectra
68% Contours
10kt-yr exposure
MINOS Oscillation Mode Sensitivity

From T test measurement
(ND-like/CC-like ratio)
10 kt yr exposure

Determination of oscillation mode from the T test becomes more difficult at low $\Delta m^2$
Cavern Excavation

Drill
Blast
Muck
Advantages of Hadronic Hose

- Makes Near spectrum similar to Far
- Reduces Beam Systematics
- Increases Event Rate

Near-Far Comparison: $\nu_\mu$

- PH2ME
- Far Detector
- Near Detector

CC Events/kt-year

$E_\nu$ (GeV)

Relative Neutrino Event Rate

Hose Wire Current

(w/o hose) (design current)
4 Plane Prototype

Built last Summer at Fermilab

Photos by J. Nelson
Cosmic rays in 4PP

**Event display for run 106, event 73**

**Counter-4PP alignment**

Chisq / ndf = 648.8 / 77
Constant = 460.4 ± 5.661
Mean = -0.05713 ± 0.03589
Sigma = 3.441 ± 0.01468

**4PP muon position distribution**

Y(4pp) - Y(counter) (cm)
Machines and Testing

Over 700 miles of scintillator
Over 1500 miles of fiber optics
Over 1250 trips down the shaft

Materials handling tests with 6 tons of steel... make sure it's safe before we try it over a half mile hole!

Fiber gluing machine
Latest Scintillator Results

**Graph 1:**
- **ANL-00-014 type-C module, individual strip response**
- Number of photo electrons
- **Distance along the module in meters**
- Left side readout
- Right side readout

**Graph 2:**
- **ANL-00-014 type-C module, average strip response**
- Number of photo electrons
- **Distance along the module in meters**
- Left side readout
- Right side readout
- Sum up of both ends

**Graph 3:**
- **ANL-00-014 type-C module, Sum of both strip ends**
- **Distance along the module in meters**
- Number of photo electrons

**Graph 4:**
- **ND-4m-VM type-C module, average strip response**
- **Distance along the module in meters**
- Number of photo electrons
- AL/Mylar + ARCON-600 optical glue

*Near Detector Module (long)*
Schedule

- September, 2000 – Soudan Cavern Excavation Complete
- October, 2000 – Start of Scintillator Module Production
- March, 2001 - Start of Far Detector Installation
- September, 2002 – Completion of 1st MINOS SuperModule
- October, 2002 – Start of Installation of Beam Components and Near Detector
- June, 2003 – Start of System Commissioning
- July, 2003 – Completion of Detector Installation
- October, 2003 – Start of Physics Data Taking
Summary

- Physics of $\nu$ Oscillations over a long baseline continues to be a "hot" topic
- MINOS is well positioned to make significant contributions in this area
- Over the last year good progress has been made in all technical areas
- The schedule is tight and the financial situation continues to have uncertainties
- Nevertheless, we are hopeful of achieving our goal of start of data taking in October, 2003
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