The MINOS experiment

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- concept
- physics reach
- detector
- beamline
- BNL contrib.
- current status
- conclusions

















Main Injector Neutrino Oscillation Search

collaboration of 175 physicists 32 institutes 6 countries

BNL group:
M. Diwan
B. Viren
M. Bishai
D. Jaffe
M. Dierckxsens



Argonne – Athens – Benedictine - Brookhaven – Caltech – Cambridge – Campinas – Fermilab – College de France – Harvard – IIT – Indiana – ITEP Moscow – Lebedev – Livermore – Minnesota, Twin Cities – Minnesota, Duluth – Oxford – Pittsburgh – Protvino – Rutherford Appleton – Sao Paulo – South Carolina – Stanford – Sussex – Texas A&M – Texas-Austin – Tufts – UCL – Western Washington – William & Mary – Wisconsin





Magnetized iron scintillator sampling calorimeter:
1 inch steel for showering
4.1x1cm² scintillator strips
1.2mm wavelength shifting fiber
Hamamatsu multi-channel PMTs
consecutive planes have orthogonal strips











Near Detector (ND)

0.98kt, 100m underground
partially instrumented
high-rate electronics
single ended strip readout





Far Detector (FD)

- 5.4kt, 700m underground
 fully instrumented
 both strip ends read out,
 - 8-fold multiplexed
- veto shield for cosmics











First observed contained event with interaction vertex inside fiducial volume

neutral current candidate







 $\log_{10}[L(km)/E(GeV)]$

 FD taken cosmic data since July 2003
 Fully and partially contained neutrino interactions
 oscillation analysis
 ∨ ⇔ anti-v separation
 hep-ex/0512036 accepted Phys. Rev. D







assume equal oscillations for v, \overline{v}





Fermilab Main Injector

120 GeV protons
2.5 10¹³ protons on target (PoT) per spill
1.9s rep. rate
~10 μs spill

⇒ beam power: 250 kW



SFERMILAB #98-765D











1E20)

Protons

First neutrino interaction in ND: Jan. 21, 2005

Physics run: March 05 – Feb. 06: 1.4x10²⁰ PoT Most at Low Energy Delivered Protons-on-Target (PoT) configuration for 40 E12) Calibrated PoT: ²rotons per Spill (11 35 maximum sensitivity pHE (1.599E+18 PoT) pME (1.177E+18 PoT) 30 to atmospheric LE (1.355E+20 PoT) All (1.389E+20 PoT) 25 oscillations result

Achieved:

- 3x10²⁰ PoT/spill
- 270 kW (~30 min)



W Beam Configurations









- Raw beam monitoring data stream (B. Viren)
- Online beam monitoring (M. Bishai, B. Viren)
- Processing beam data (B. Viren, M. Bishai, M. Dierckxsens)
- Beam stability studies (M. Bishai, M. Dierckxsens)







Beam Monitoring Database Framework (B. Viren, M. Bishai, M. Dierckxsens)

- database on spill-by-spill basis
- provides easy, robust, reliable interface to match detector data with beam monitoring data

Incorporation of beam mon. info, such as PoT per spill, into standard analysis (M. Dierckxsens)

- Interface for applying beam quality cuts (M. Dierckxsens, Minos-doc-1486)
- Systematics of counting protons on target (M. Bishai, Minos-doc-1491)





Correlating beam monitoring with ND data (M. Dierckxsens)

Reconstructed Interactions versus Protons on Target per Spill







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Pre-selection cuts:

- beam & det. quality cuts
 events with tracks
 topological cuts to remove cosmics:
 - fiducial cuts (r & z)
 - track-beam angle

CC/NC separation:

- Likelihood-based "PID" using PDFs of:
 - event length
 - r track p.h. per plane
 - r track p.h. fraction

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PDF PID parameter distribution for true CC and NC events







MINOS has adopted a blind analysis approach:

- far data: unknown fraction is hidden, unknown function of event length & pulse height
- r near data: completely open
- open box after studies show satisfying results (which will be very soon...)
- Preliminary results of first "10²⁰" PoT (actual 0.93x10²⁰)
- Publication with full dataset of first year (~1.3x10²⁰ PoT)













BNL has strong interest in v appearance

- First sensitivity study (M. Diwan, B. Viren, Numi-714)
- **M**. Diwan is co-convener of v_a analysis group
- Recently developed analysis strategy: Try to estimate all backgrounds from data.
- Expected events for 1.4x10²⁰ PoT:

NC	2.80	(66%)	$sin^2 2\theta_{23} = 1.0$
CC	0.62	(15%)	$\Delta m_{32}^2 = 0.0025 \text{ eV}^2$
Beam $v_{_{\rm e}}$	0.58	(14%)	$\sin^2 2\theta_{13} = 0.12$
\mathcal{V}_{τ} ($ riangle m^2$ =2.5x10 ⁻³ eV ²)	0.23	(5%)	
total background	4.23		2.8 signal events
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V Electron Appearance





W Electron Appearance



- Muon removal from reconstructed CC v_{μ} interactions: \cdot estimate the NC contamination
- Estimate v_{ρ} FD flux from \overline{v}_{μ} in ND (D. Jaffe)
 - ✓ FD v_{e} flux dominated by $\mu^{+} \rightarrow e^{+}v_{e}\overline{v}_{\mu}$
 - \checkmark Measure μ^+ decay component in ND $\overline{\nu}_{_{\rm II}}$ event rate







- MINOS finished first year of data taking collecting in total 1.4x10²⁰ protons on target
- BNL has contributed substantially to the commissioning, in particular to beam monitoring readout and data analysis
- Preliminary v_{μ} disappearance result will follow soon using 0.93x10²⁰ PoT
- Solid v_{a} appearance analysis in development