





ICHEP 2010 Poster Awards



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The **second prize** winners will win **one book** of their choice.



ICHEP 2010 Poster Awards



1st
ex-aequo

Measurements of Atmospheric Neutrinos Using the MINOS Detector

L. A. Corwin (Indiana University) for the MINOS Collaboration

Atmospheric Neutrinos

- Cosmic rays impinging on the atmosphere produce cascades of particles, including neutrinos
- Oscillation of ν_μ to other flavors appears as a ν_μ deficit for certain values of path length (L) and ν energy (E).
- L varies from ~10 to ~13000 km
- MINOS measures L/E across 4 orders of magnitude
- Oscillations in ν_μ and $\bar{\nu}_\mu$ are detected

MINOS Far Detector

The detector is composed of 2.54 cm steel plates (total of 5.4 kton) interleaved with plastic scintillator. Its depth (700 m) provides shielding from cosmic rays. A 1.3 T magnetic field produced by a coil along the long axis allows separation of μ^+ from μ^- and thus ν_μ from $\bar{\nu}_\mu$, which is unique among underground ν detectors.

Data Pre-Selection

Between 1 Aug. 2003 and 1 Aug. 2008, 1657 live days (24.6 kton-Yrs) of data were collected. We select events that have clean showers (ν_e and neutral current interactions) and tracks (ν_μ charged current interactions). Our primary background source is cosmic ray events. The signatures for atmospheric ν are fully contained (FC), partially contained (PC), or upward-going events.

Event Selection

Two Event Categories

- Upward-going tracks from interactions in the detector or rock are identified using timing data.
- FC and PC events within the detector fiducial volume are identified using containment and topology cuts applied to the top of the event and a scintillator shield to veto cosmic ray events.

Events Selected for Analysis

We divide data events into 3 samples:

- FC or PC μ events: 572 events
- Contained Vertex Showers: 292 events
- Induced Rock μ : 264 events

Reconstructed vertex positions are shown above.

Oscillation Results

We divide the data into bins of bins of L/E resolution with 5 bins for FCPC events, 2 bins for rock μ events, and one bin for contained vertex showers. In the limit of two flavor oscillations ($\nu_\mu \leftrightarrow \nu_\tau$), we perform a maximum likelihood fit to the reconstructed L/E distributions to obtain oscillation parameters. For our ν sample, we fix the $\bar{\nu}$ parameters to the the MINOS ν best fit oscillation parameters from 2008. Then, we perform the opposite analysis for our $\bar{\nu}$ sample. Systematic uncertainties are fitted as nuisance parameters. The results of the fit are shown in the contours and values below. Limits and uncertainties are at the 90% confidence level.

$7 \times 10^{-3} < \frac{|\Delta m_{32}^2|}{\text{eV}^2} < 17 \times 10^{-3}$

$|\Delta m_{32}^2| = 2.6_{-1.3}^{+4.4} \times 10^{-3} \text{ eV}^2$ $|\Delta m_{32}^2| = 1.8_{-0.6}^{+1.5} \times 10^{-3} \text{ eV}^2$

$\sin^2(2\theta_{23}) > 0.58$ $\sin^2(2\theta_{23}) > 0.60$

Charge Ratio Results

We use a high resolution subset of data with clean tracks and well-measured charge to calculate ratio of ν_μ to $\bar{\nu}_\mu$ events. We compare this ratio for data and MC (using the 2008 MINOS oscillation parameters) to check the consistency of ν_μ to $\bar{\nu}_\mu$ oscillations. The resulting double ratio is consistent with unity and thus with equal oscillations for ν_μ and $\bar{\nu}_\mu$.

$\frac{R_{\text{Data}}}{R_{\text{MC}}} = 1.04_{-0.10}^{+0.11} \pm 0.10$

Future: Mass Hierarchy

The ability of MINOS to distinguish between ν and $\bar{\nu}$ allows us to search for the mass hierarchy. The number of μ^+ and μ^- , for certain values of energy and angle, depends on the mass hierarchy. The plots at left show the the events rates for μ^+ calculated from simulations for MINOS for the normal (top) and inverted (middle) hierarchies. Plotted at bottom is the difference between the two rates, divided by their uncertainty.

We are currently determining how to use statistical tests (such as χ^2 or Kolmogorov - Smirnov) to compare the atmospheric data with simulations for the two hierarchies and calculate which hierarchy is more consistent with our data.

We plan to include the additional data taken since 1 Aug. 2008 in this search.

$|\Delta m_{32}^2| - |\Delta m_{32}^2| = 0.4_{-1.2}^{+2.5} \times 10^{-3} \text{ eV}^2$
(for $\sin^2(2\theta_{23}) = \sin^2(2\theta_{23}) = 1.0$)

Luke Corwin

‘Measurements of Atmospheric Neutrinos using the MINOS Detector’

THE NEW $(g-2)_\mu$ EXPERIMENT AT FERMILAB

A PROPOSAL TO MEASURE THE MUON ANOMALOUS MAGNETIC MOMENT TO 0.14 PPM PRECISION

ANOMALOUS MAGNETIC MOMENT

$$\vec{\mu} = g \left(\frac{Qe\hbar}{2m} \right) \vec{s} \quad a_\mu = \frac{(g-2)_\mu}{2}$$

$\Delta a_\mu(\text{meas} - \text{predicted}) = (255 \pm 80) \times 10^{-11}$

NEW PHYSICS AND $(g-2)_\mu$

Three general classes:

- I: Order 100 GeV with weak couplings
⇒ within current sensitivity (W, Z, G_F ...)
- II: Several hundred GeV with enhanced couplings
⇒ within current sensitivity (SUSY + $\tan\beta$)
- III: Several hundred GeV with weak couplings
⇒ within sensitivity of new $(g-2)_\mu$ exp at FNAL
⇒ Large overlap with Tevatron/LHC program

Precise determination of fundamental parameters

Expands planned lepton flavor violation program

$(g-2)_\mu$ AND THE GLOBAL PROGRAM

Complements ongoing flavor program

THE EXPERIMENT

Use existing E821 storage ring from Brookhaven

Count positrons with new, segmented calorimeters

Shim magnet to $\langle \partial B \rangle_{\text{ring}} < 1 \text{ ppm}$

Polarized μ at ρ_{magic}

\vec{s} leads \vec{p} due to precession

#positrons versus time maps spin precession

$a_\mu = \left(\frac{m}{e} \right) \frac{\omega_a}{B}$

WHY FERMILAB

Can use existing \bar{p} production facility

10x longer π decay channel

5-10x higher μ/p

5x higher fill rate so same instantaneous rate

21x E821 stats in < 2 years

STATUS

Strongly endorsed by Fermilab Physics Advisory Committee and supported by Fermilab Management

Being reviewed this summer by DOE Office of Science

International collaboration of >70 scientists in 22 institutions ready and able to conduct experiment. Can take data as early as 2014.

FUTURE

Next few years: World class μ program at Fermilab with new $(g-2)_\mu$ and Mu2e

Next generation: Continue and expand program using available intensity from Project X

BRENDAN CASEY

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Brendan Casey

‘The new $(g-2)_\mu$ Experiment at Fermilab’



ICHEP 2010 Poster Awards



2nd
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Measurement of the charge ratio of atmospheric muons with the CMS detector

Lars Sonnenschein
on behalf of the CMS collaboration

A measurement is presented of the flux ratio of positive and negative muons from cosmic ray interactions in the atmosphere, using data collected by the CMS detector at ground level and in the underground experimental cavern. The excellent performance of the CMS detector allowed detection of muons in the momentum range from 5 GeV/c to 1 TeV/c. For muon momenta below 100 GeV/c the flux ratio is measured to be a constant $1.2766 \pm 0.0032(\text{stat.}) \pm 0.0032(\text{syst.})$, the most precise measurement to date. At higher momenta an increase in the charge ratio is observed, in agreement with models of muon production in cosmic ray showers and compatible with previous measurements by deep underground experiments.

Muon production in atmospheric showers

The CMS detector

CMS and surroundings

Cosmic-ray muons crossing the CMS detector

Muon system and symmetric fiducial volume

Charge ratio as a function of muon (vertical) momentum

Bottom sector: left-right symmetry and CMS at surface (2006) hit distribution

Three CMS cosmic-ray muon analyses combined

- CMS at surface (2006): $3.3 \cdot 10^5$ standalone-muon track events selected
- CMS underground (2008): $2.45 \cdot 10^5$ global muon track events selected
- $1.6 \cdot 10^6$ standalone-muon track events selected

Results:

$$R(\mu^+/\mu^-) = 1.2766 \pm 0.0032(\text{stat.}) \pm 0.0032(\text{syst.})$$

$$R(\mu^+/\mu^-) = 1.2728 \pm 0.0032(\text{stat.}) \pm 0.0032(\text{syst.})$$

Lars Sonnenschein

‘Measurement of the charge ratio of Atmospheric Muons with the CMS Detector’

New Experiments with Antiprotons

Daniel M. Kaplan
for the Fermilab pbar Collaboration

Abstract
Fermilab operates the world's most intense source of antiprotons. Experiments have been proposed that can use those antiprotons either parasitically during Tevatron Collider running or after the Tevatron Collider finishes in about 2011. We summarize the physics goals and potential of the proposed experiments.

Proposed Exp'tal Approaches

- FNAL Antiproton Source is world's most intense – even after FAIR@Darmstadt turns on (~2018)
- Opportunity for small, simple experiments soon after Tevatron finishes
- Medium-Energy experiment: “upgraded E835” with magnetic spectrometry:
 - use existing E760 calorimeter, BESS solenoid, & DØ VLPC photodetectors & DAQ boards
- $\mathcal{L} \sim 10^{32}$ feasible $\Rightarrow \sim 10^8 \bar{p}p \rightarrow \Omega^- \bar{\Omega}^+$ events/year
- Slow- \bar{H} expts: decelerate in MI & degrade into trap
- Possible future upgrade: add small decelerator ring

Hyperon CPV & Rare Decays

Example Feynman diagrams (Standard Model):

tree:

penguin:

New physics can contribute too!

Asymm.	Mode	SM	NP
A_Λ	$\Lambda \rightarrow p\pi$	$\leq 10^{-5}$	$\leq 6 \times 10^{-4}$
$A_{\Xi\Lambda}$	$\Xi \rightarrow \Lambda\pi, \Lambda \rightarrow p\pi$	$\leq 0.5 \times 10^{-4}$	$\leq 1.9 \times 10^{-3}$
$A_{\Omega\Lambda}$	$\Omega \rightarrow \Lambda K, \Lambda \rightarrow p\pi$	$\leq 4 \times 10^{-5}$	$\leq 8 \times 10^{-3}$
$\Delta_{\Xi\pi}$	$\Xi \rightarrow \Xi^0\pi$	$\leq 2 \times 10^{-5}$	$\leq 2 \times 10^{-4}$
$\Delta_{\Lambda K}$	$\Omega \rightarrow \Lambda K$	$\leq 1 \times 10^{-5}$	$\leq 1 \times 10^{-3}$

Rare decays:

- HyperCP observed $3 \Sigma^+ \rightarrow p\mu^+\mu^-$ events
- Consistent with new low-mass $X^0 \rightarrow \mu^+\mu^-$

Aim to start with $\bar{p}p \rightarrow \Omega^- \bar{\Omega}^+$

Sensitive to $B \sim 10^{-6}$, CP asymm $\sim 10^{-4}$

Probe both parity-conserving and violating interactions \Rightarrow complementary to K & B studies

Antihydrogen Measurements

\bar{H} -in-flight CPT test feasible:

Measuring the antihydrogen Lamb shift with a relativistic antihydrogen beam

Interferometric \bar{H} gravity test: \bar{H} direct limit

- simple solution to missing antimatter & dark energy: \rightarrow could matter & antimatter repel gravitationally!
- more generally, quantum gravity can have scalar & vector terms as well as tensor $\Rightarrow \bar{g}/g = 1 \pm \epsilon$
- measurement feasible with proven technology (trapping, atomic interferometer)
- goal: determine ϵ first to 10^{-4} (gratings), then 10^{-9} (lasers)

First test of Equivalence Principle for antimatter

Charmonium & XYZ States

- $\bar{p}p$ can directly form states of all non-exotic J^{PC}
- $\bar{p}p$ capable of precision mass & width meas^{ts}, e.g.:

FNAL E760 $\sigma_m(\text{beam}) = 0.5 \text{ MeV}$

Directly study singlet states: $\eta_c, h_c, \eta_c(2S)$ & other non- 1^- states (e.g., χ_{c1})

Are XYZ states charmonium or hybrids or...?

State	J^{PC}	Mass	Decay Modes
X(3872)	1^{++}	3871.2±0.5	$J/\psi \eta, J/\psi \eta', \psi(2S) \eta, J/\psi \gamma$
X(3872)	2^{++}	3875.5±0.7	$D^0 D^0 \pi^0$
Z(3930)	2^{--}	3929±6	$D^0 D^0, D^+ D^-$
Y(3940)	2^{--}	3943±17	$J/\psi \omega$
X(3940)	2^{--}	3942±9	$D^0 D^0$
Y(4008)	1^-	4008±65	$J/\psi \eta'$
X(4160)	2^{--}	4156±27	$D^0 D^0$
Y(4260)	1^-	4259.4±84.4±247	$J/\psi \eta, J/\psi \eta', \psi(2S) \eta, J/\psi K^+ K^-$
Y(4350)	1^-	4324, 4361	$\psi(2S) \eta'$
Z(4430)	$2^?$	4433±5	$\psi(2S) \eta'$
Y(4620)	1^-	4464±13	$\psi(2S) \eta'$

Charm CPV

- $\sigma(\bar{p}p \rightarrow D^* \bar{D}) \sim 1 \mu\text{b}$
- $\Rightarrow 10^{10}$ events produced
- charm mixing: new physics?
- Potential world's-most-sensitive measurement

Daniel Kaplan

‘New Experiments with Antiprotons’



Future IUPAP CII sponsored conferences

<http://www.iupap.org/>

- 25th International Symposium on Lepton-Photon Interactions
 - **LP 2011** in **Mumbai, India**
 - August 22-27, 2011
- 36th International Conference on High Energy Physics
 - **ICHEP 2012** in **Melbourne, Australia**
 - July 4 -11 2012 - note date change
- Proposals for LP 2013 & ICHEP 2014 were reviewed by CII this week.



IUPAP Commission on Particles and Fields (CII)



<http://www.iupap.org/>

FUTURE IUPAP C I I sponsored conferences

- 26th International Symposium on Lepton-Photon Interactions
 - **LP 2013** will be hosted by SLAC in the **USA**

- 37th International Conference on High Energy Physics
 - **ICHEP 2014** will be in Valencia, **Spain**

IUPAP Commission on Particles and Fields (C I I)



<http://www.iupap.org/>

We look forward to seeing you
at the Lepton Photon
Symposium in Mumbai
August 22-27, 2011



IUPAP Commission on Particles and Fields (C11) - iupapc11.org



<http://www.iupap.org/>

More information:

CII Website: iupapcii.org

CII Document database: <http://docdb.fnal.gov/CII/>

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