Commissioning the MINOS detectors

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What is MINOS?
Construction schedule
Atmospheric neutrinos
Calibration Detector results
Future

What is MINOS?

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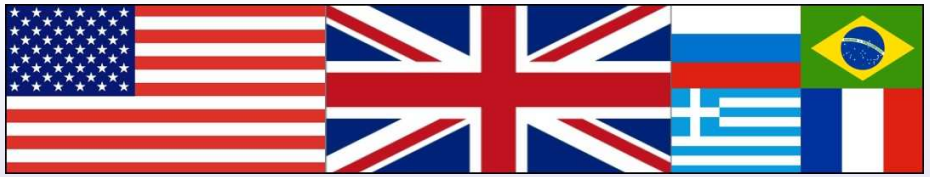
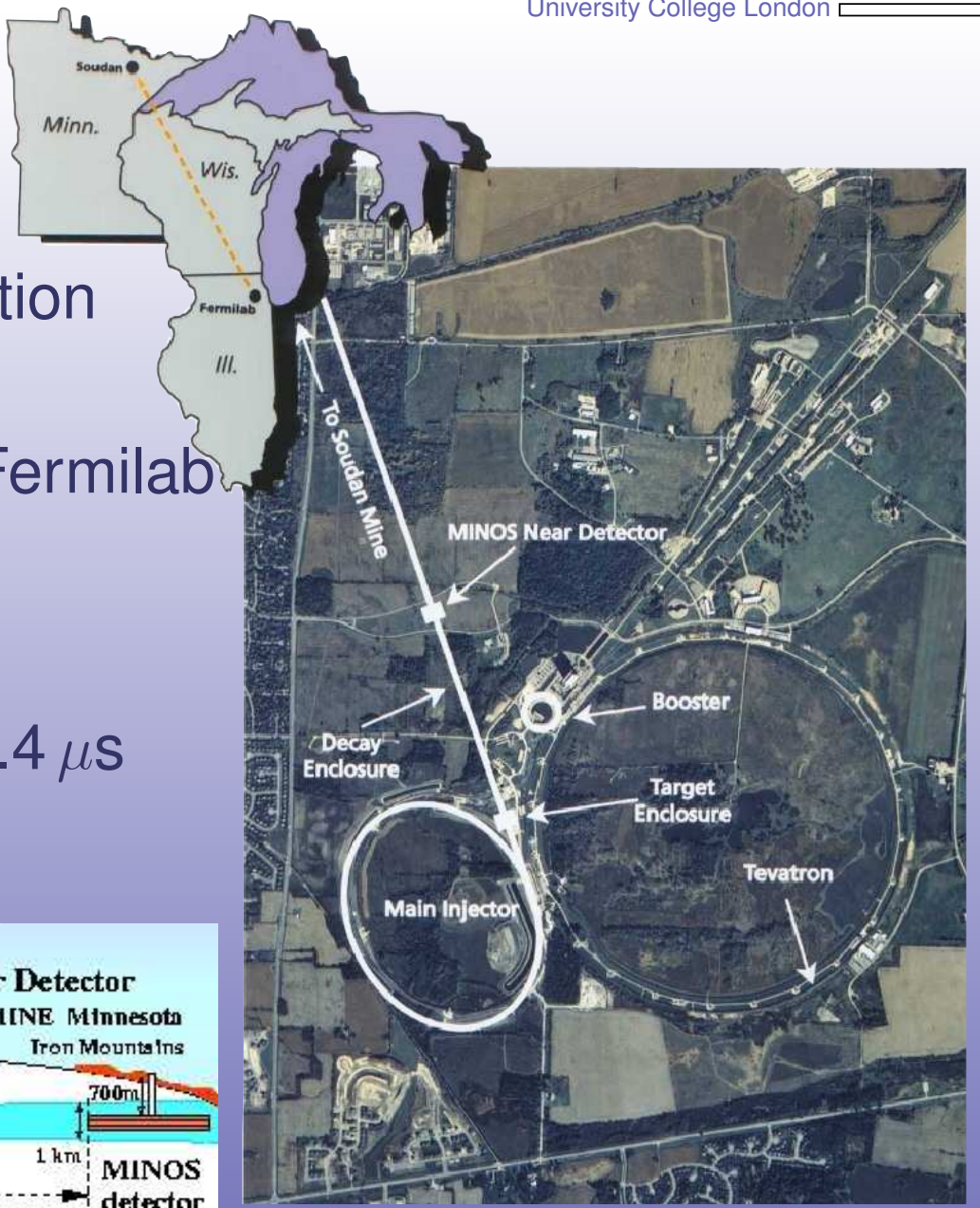
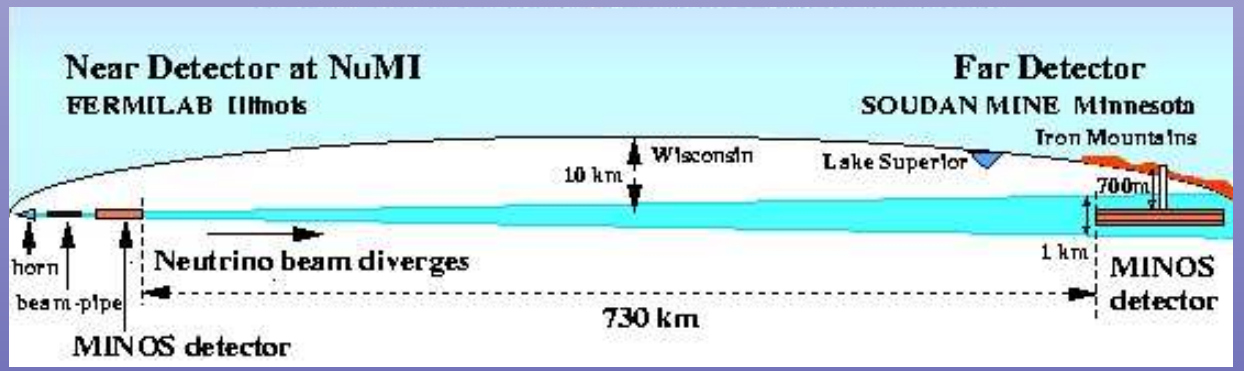




- Long baseline neutrino oscillation experiment
- Steel/scintillator detectors at Fermilab and Soudan
- $p \rightarrow \pi \rightarrow \nu$ in Main Injector
- High Intensity—4×10^{13} p in 8.4 μs
- 4×10^{20} protons per year



Detector Technology

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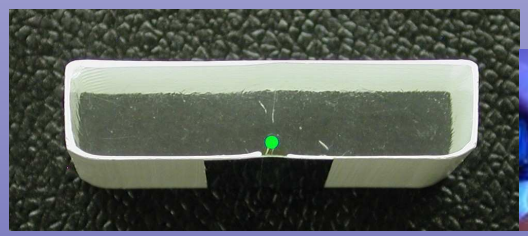
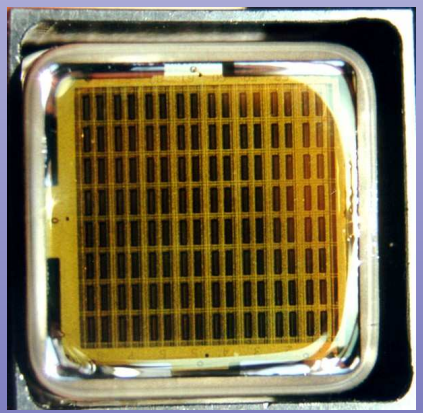


- Planes of 1” thick steel
- Plastic scintillator strips
  - ⇒ Read out by wavelength-shifting fibres and Hamamatsu Multianode PMTS (M16 and M64)
- 8× multiplexing in far detector



Construction Progress

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- Far detector at Soudan, MN
- As of mid-Feb, 410 planes installed (total $\sim$ 483)
- All read out
- Current installation rate $\sim$ 5 planes/week

- First Supermodule magnetized last summer
- Detector complete this summer
- On time and within budget

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Construction at Fermilab

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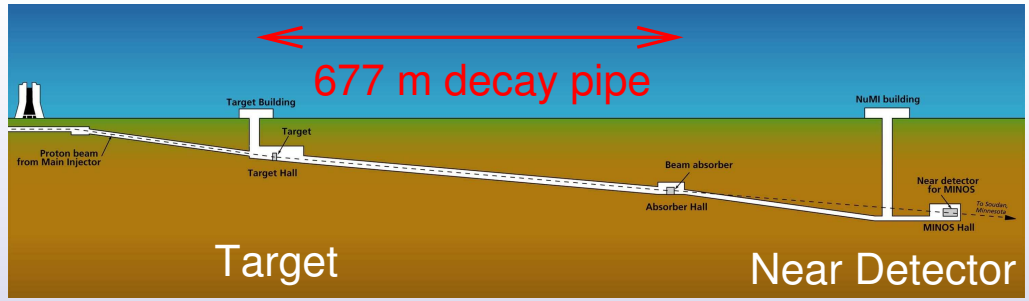
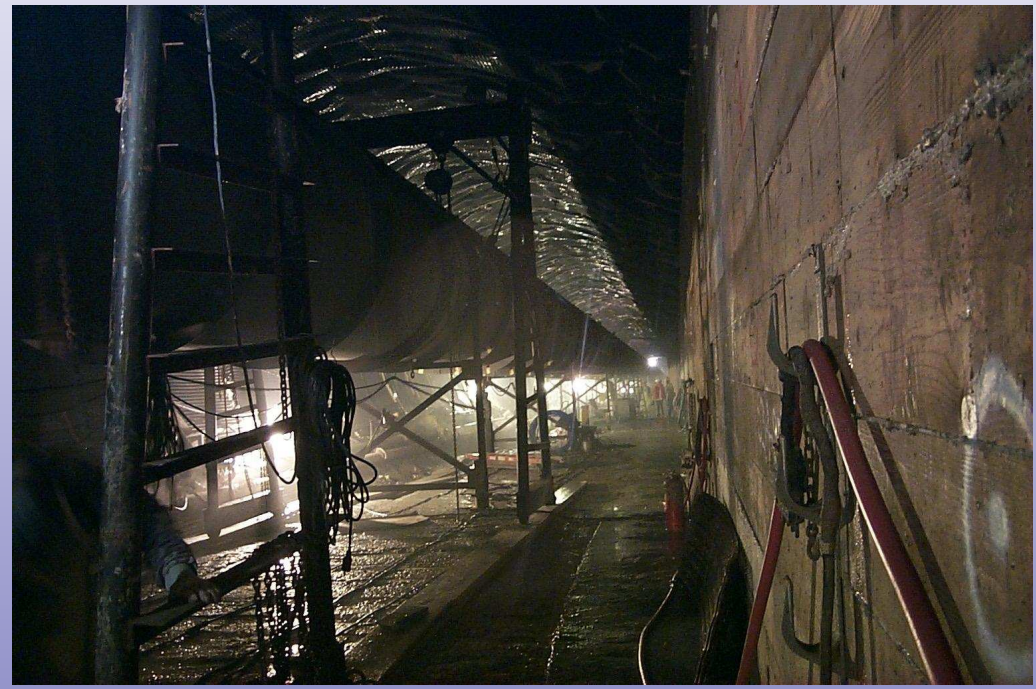
- Tunnelling complete
- Detector Hall and Target Hall outfitting underway





Construction at Fermilab

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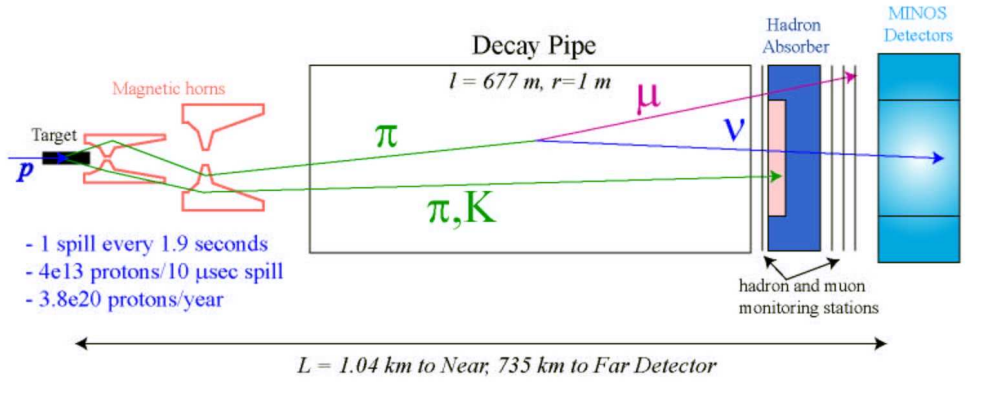
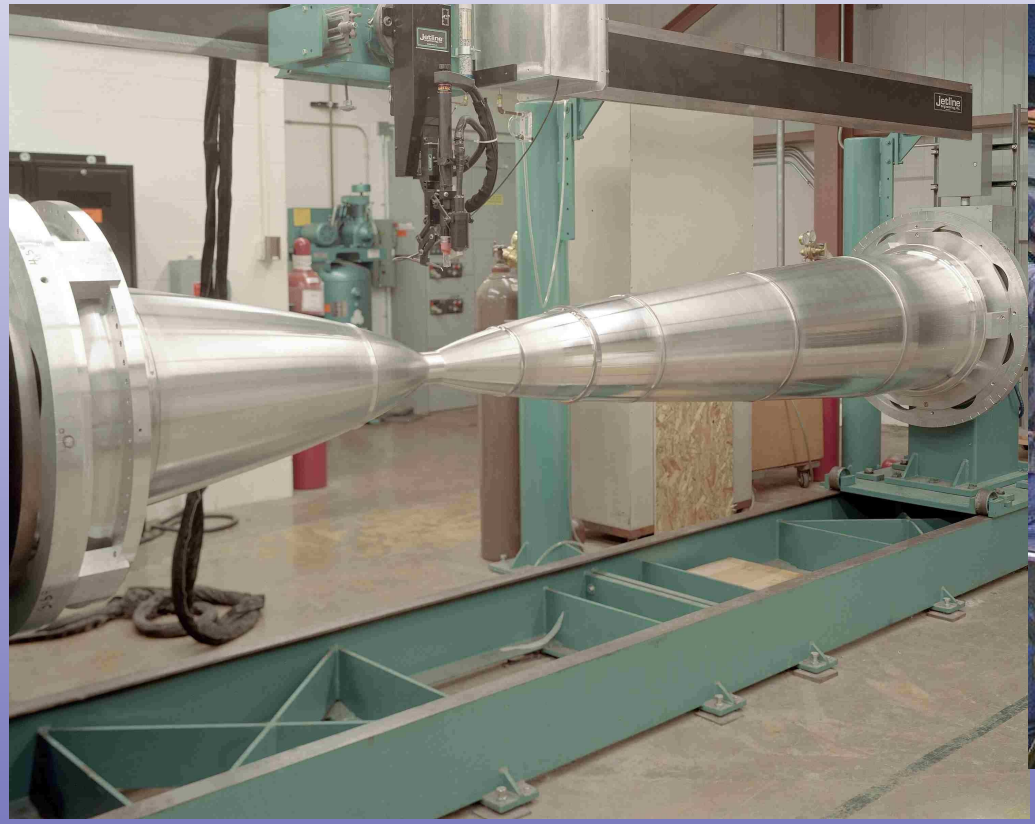
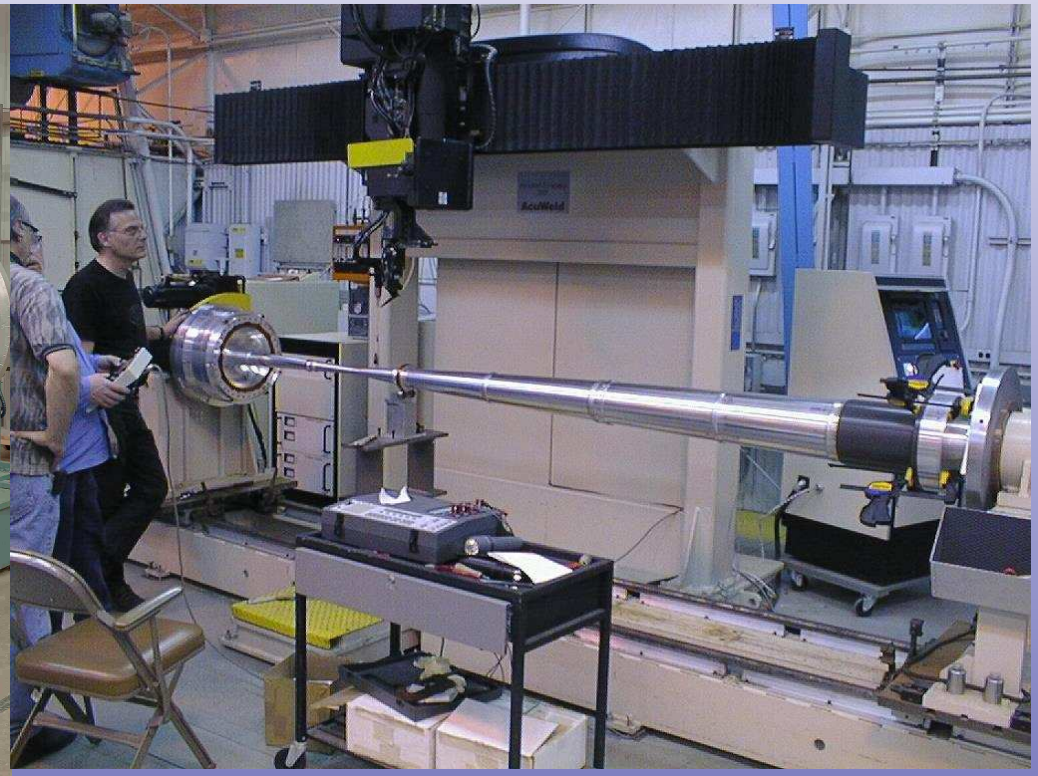
- Tunnelling complete
- Detector Hall and Target Hall outfitting underway
- Horns in fabrication







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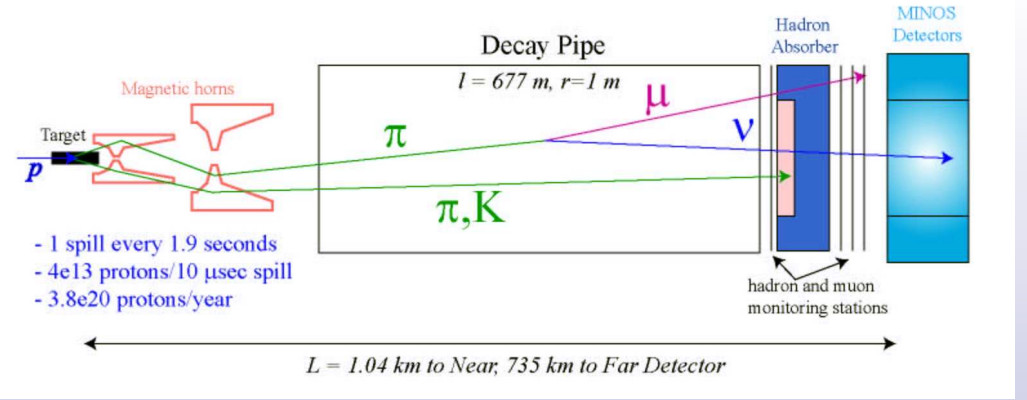

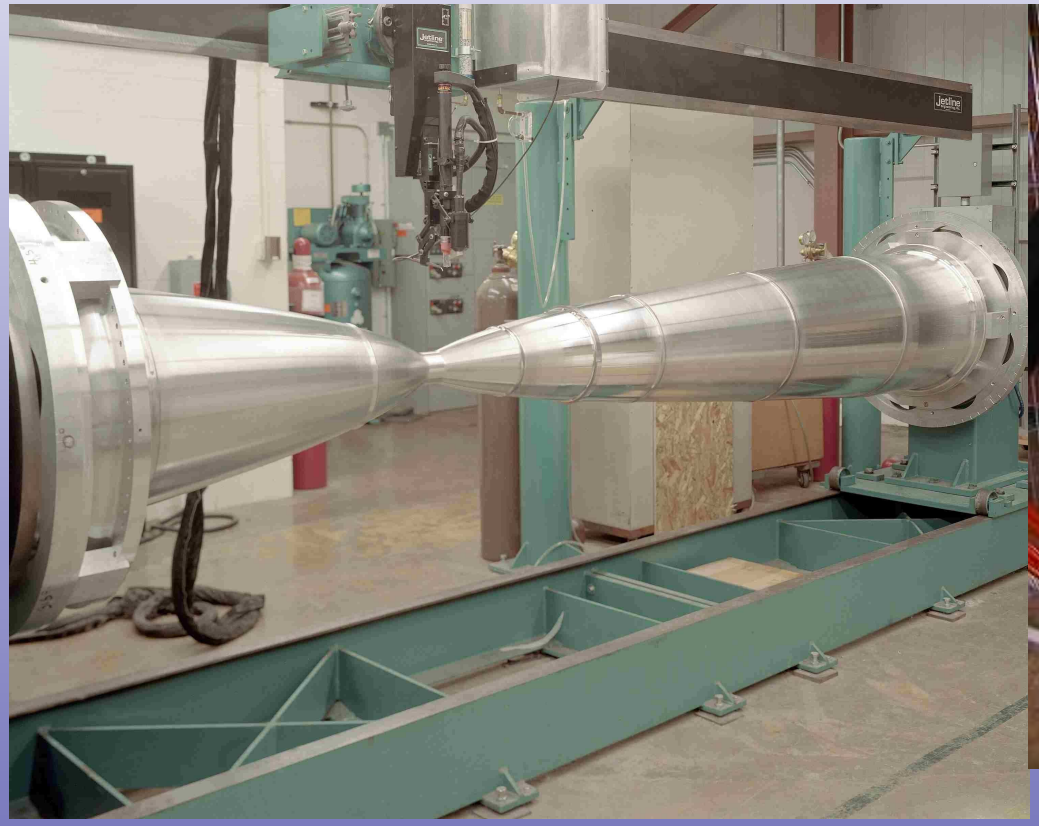

Construction at Fermilab

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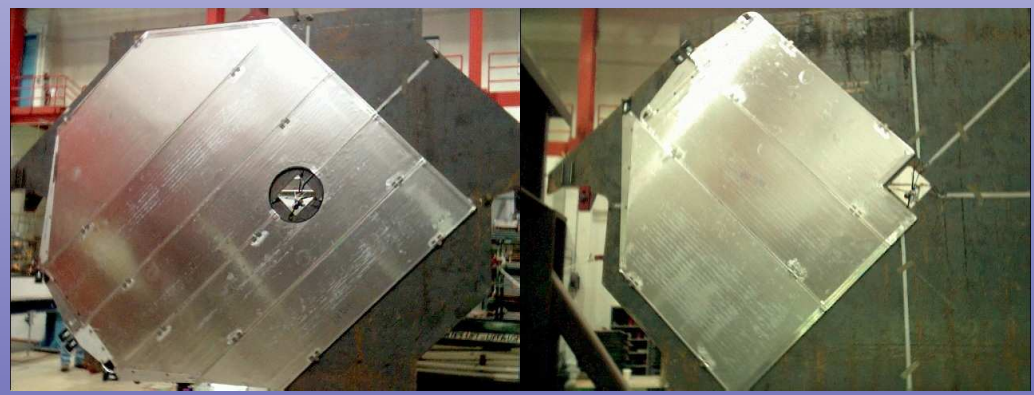
- Tunnelling complete
- Detector Hall and Target Hall outfitting underway
- Horns in fabrication
- All Near detector planes assembled, ready to install
- Beneficial occupancy of ND Hall December ’03
- ND installation complete October ’04
- Beam on end ’04



Atmospherics at the Far Detector

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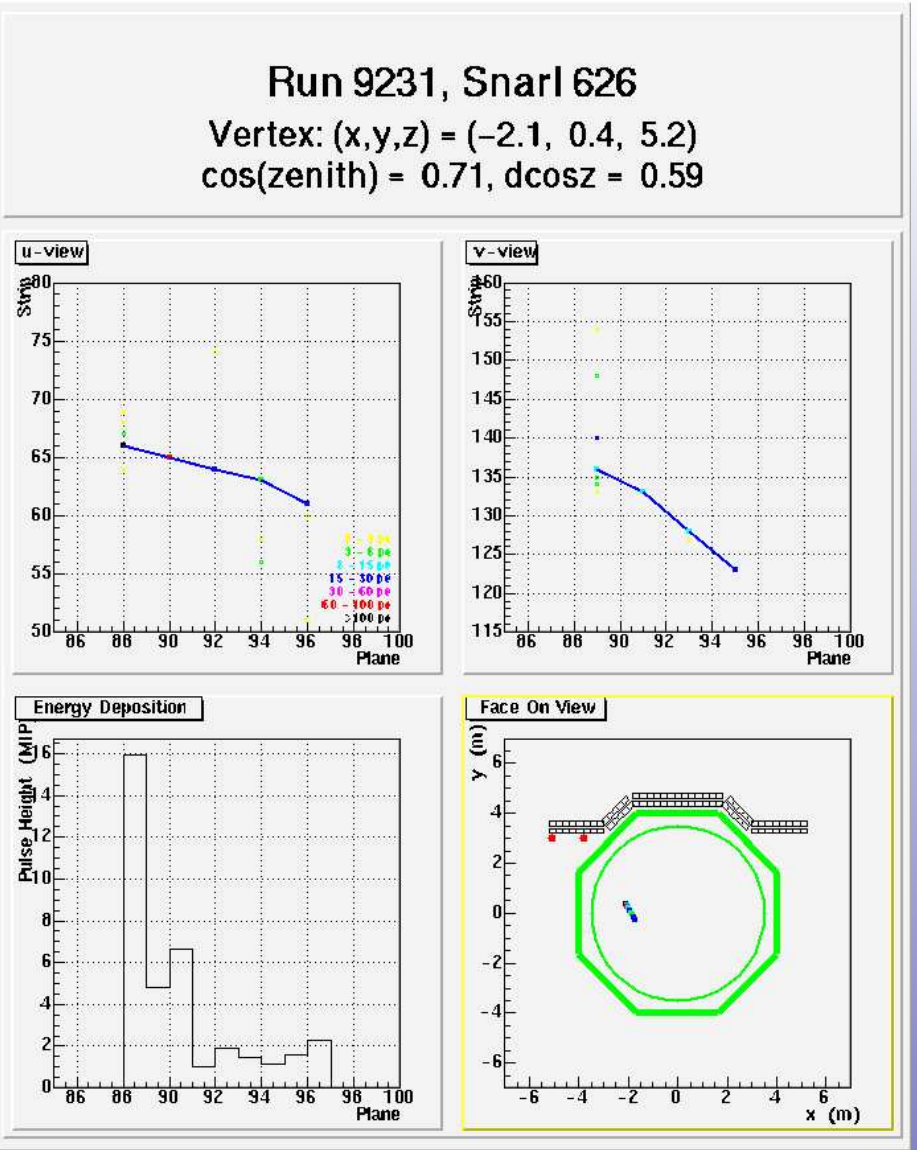
- Veto shield to veto vertical muons



Atmospherics at the Far Detector

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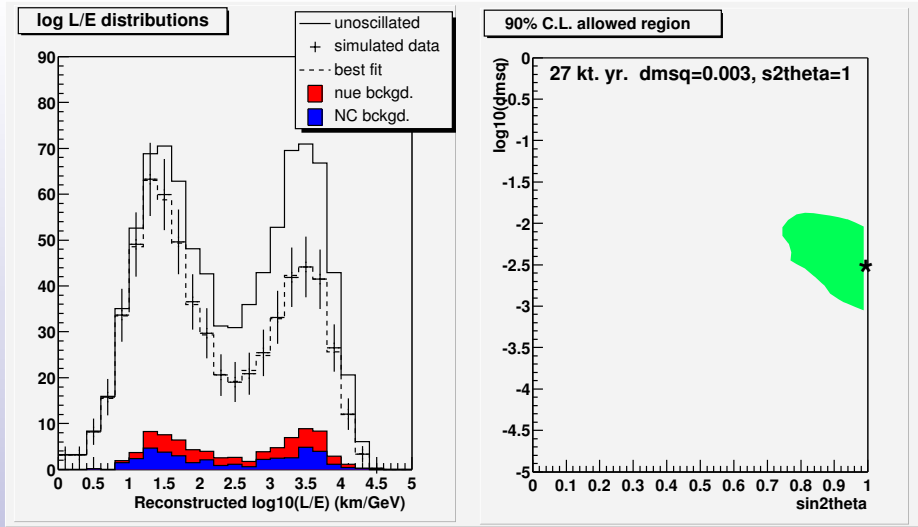
- Veto shield to veto vertical muons
- Why bother looking at atmospherics?



- 5 years of running
- Not as good as SuperK!!

Atmospherics at the Far Detector

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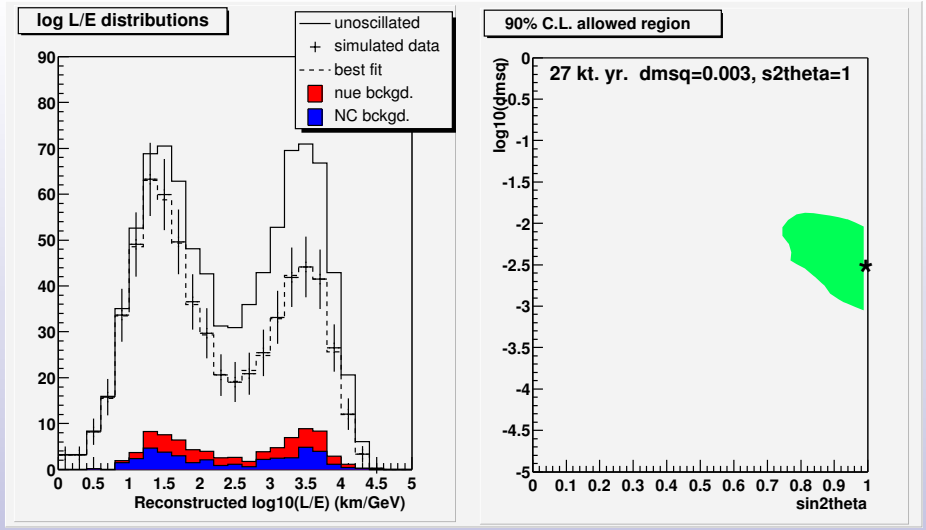
- Veto shield to veto vertical muons
- Why bother looking at atmospherics?
- Good way to debug and understand detector & software before beam
- MINOS is magnetized
  - ⇒ Can distinguish μ^+ and μ^- >1 GeV



- 5 years of running
- Not as good as SuperK!!

# events in 5 years	ν	$\overline{\nu}$
Contained vertex & μ	620	400
Upgoing μ	280	120

Atmospherics at the Far Detector

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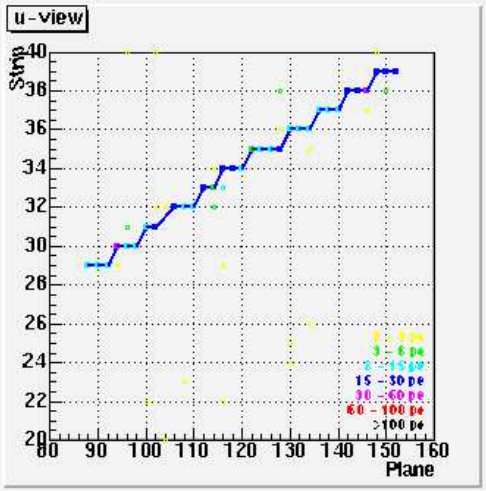
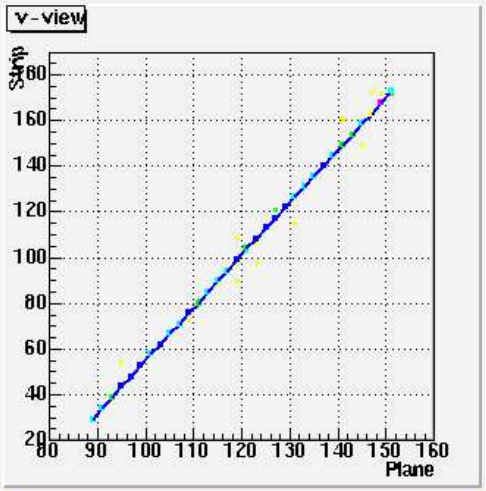
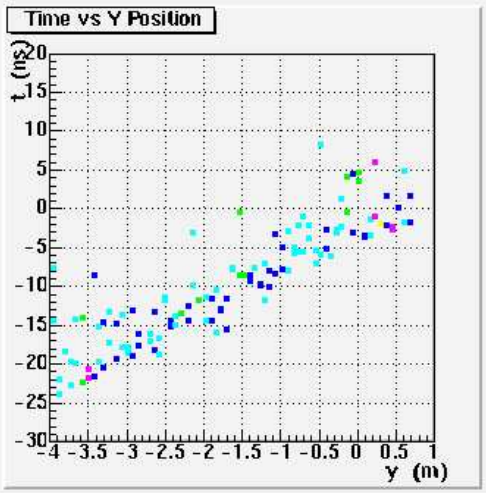
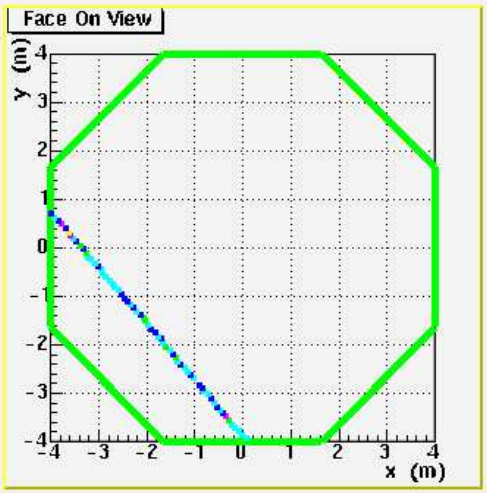
Run 9104, Snarl 43169

Vertex: (x,y,z) = (0.0, −3.9, 5.2)
cos(zenith) = −0.65, 1/beta = −0.98, pfit = −41.53 GeV/c



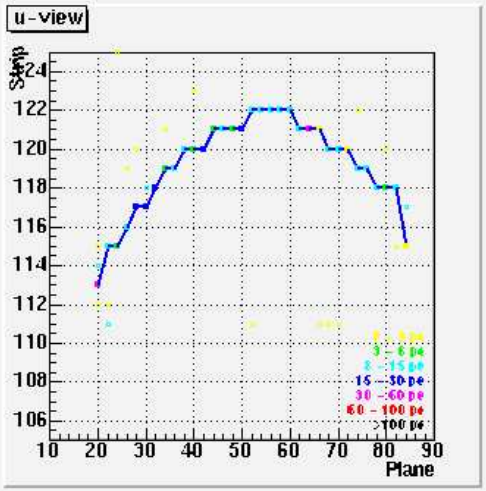


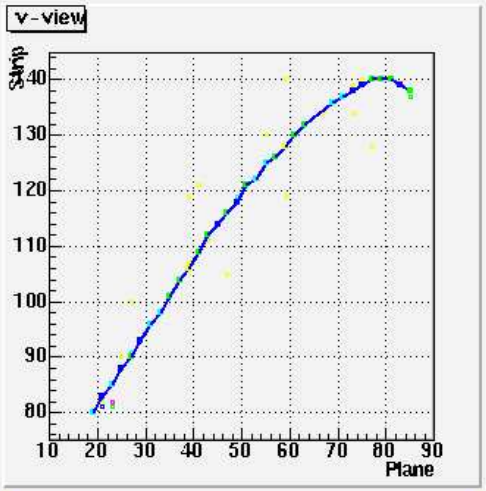


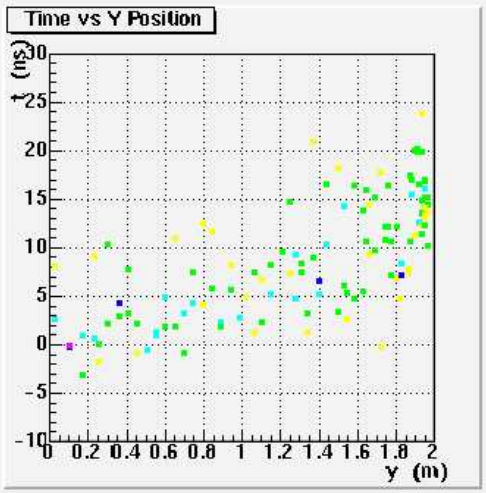


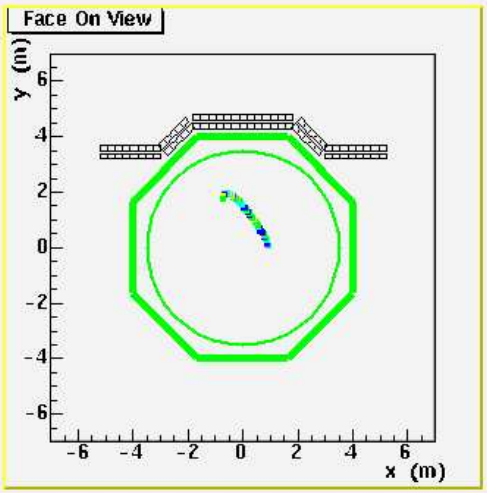
Run 10405, Snarl 503

Vertex: (x,y,z) = (1.0, 0.1, 1.1)
cos(zenith) = −0.41, 1/beta = −1.02, pfit = 3.48 GeV/c









Atmospherics at the Far Detector

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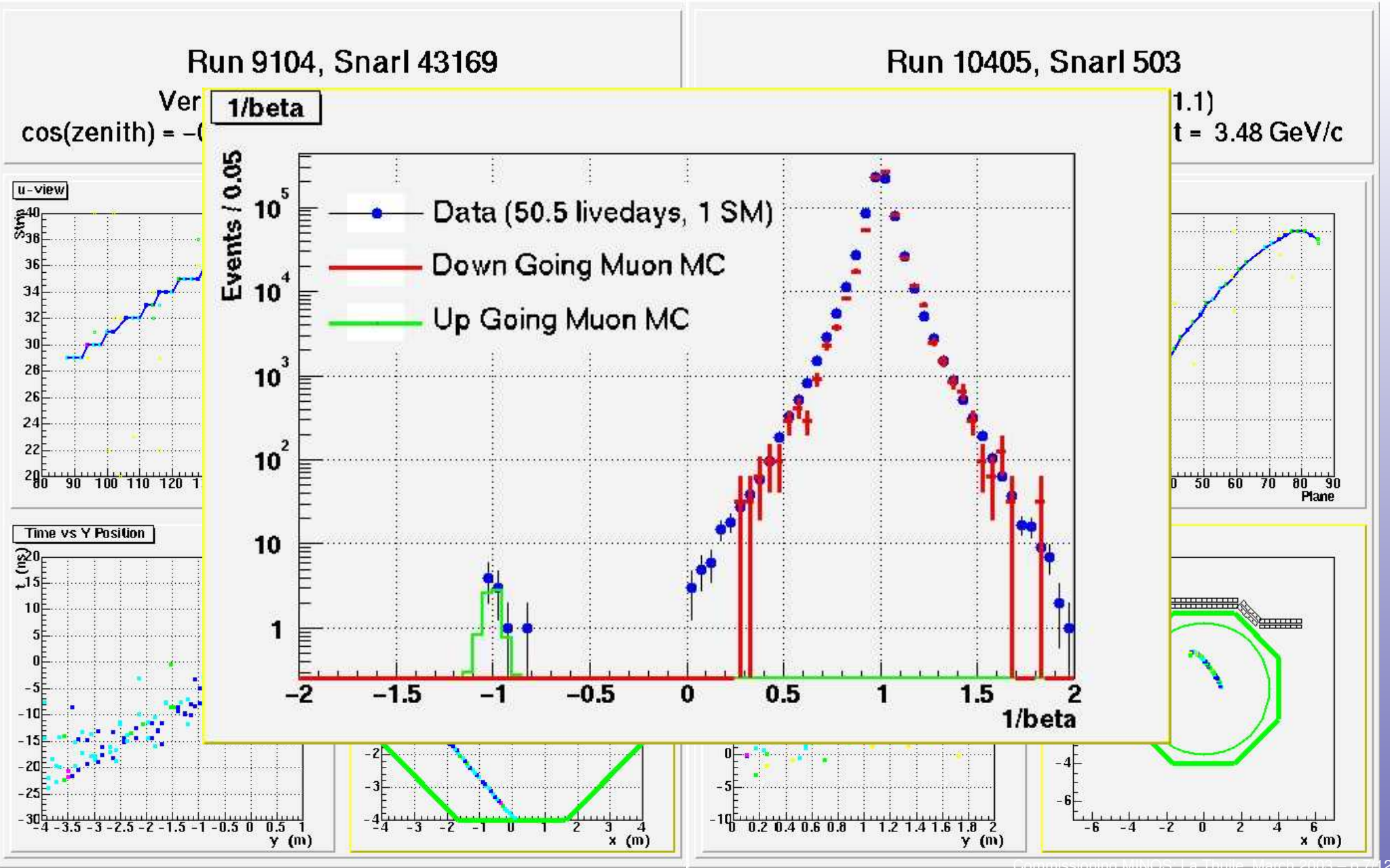

The Calibration Detector

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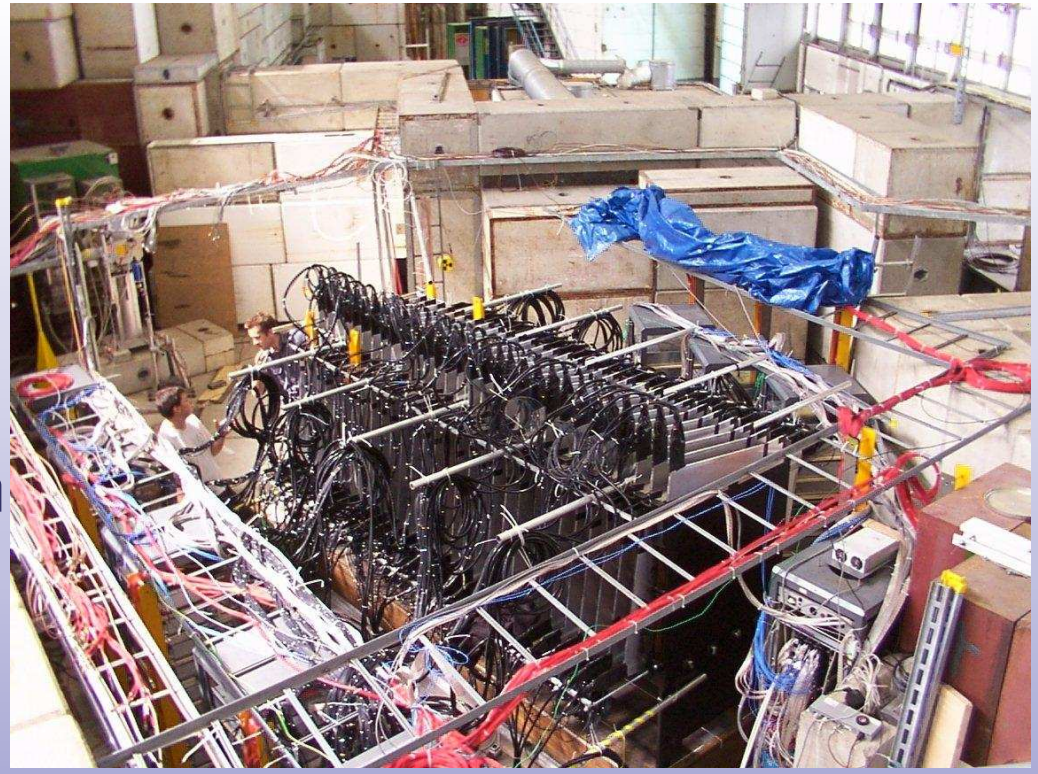
- Main detectors are too big to put in a testbeam, so we built a small one
- Same geometry as MINOS, but smaller
- T11, T7 beamlines at CERN in 2001, 2002, 2003
  - ⇒ Understand response to p, π, e, μ of different energies
  - ⇒ Compare near and far detector electronics
  - ⇒ Debug & test detector subsystems
  - ⇒ Study reconstruction software



- CalDet in T11 at CERN
- Just like MINOS, but no magnetic field
- WLS fibres to read out on one side—model a larger detector

Testing the calibration

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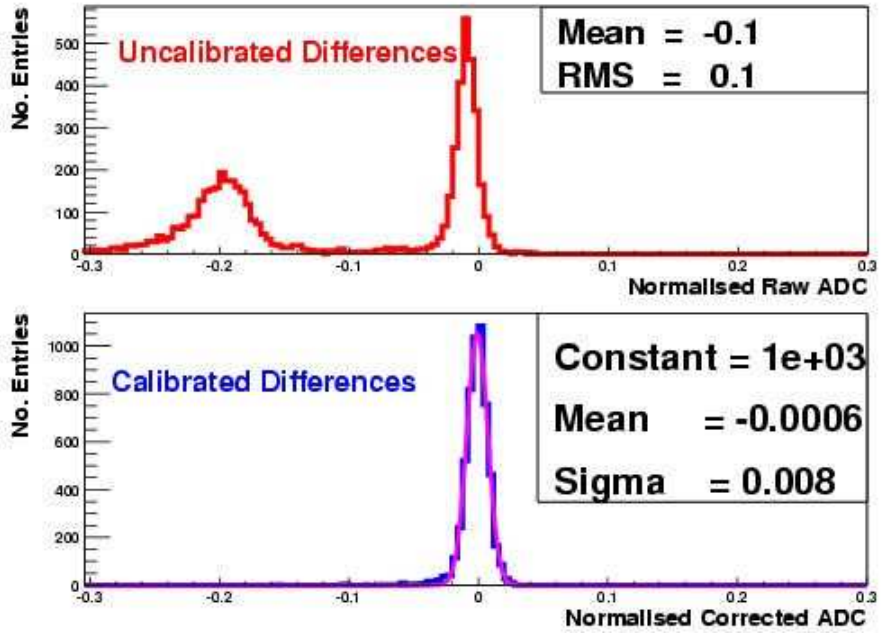
- LED pulser system to monitor gain changes and linearity
- Check it works...
  - ⇒ Turn the HV down 50V
  - ⇒ LED calibration removes the gain change to better than 1%



CalDet—Particle ID

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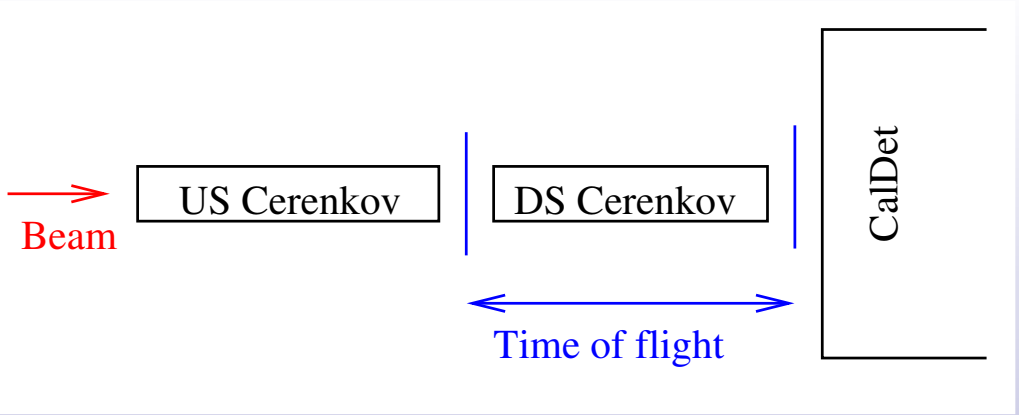

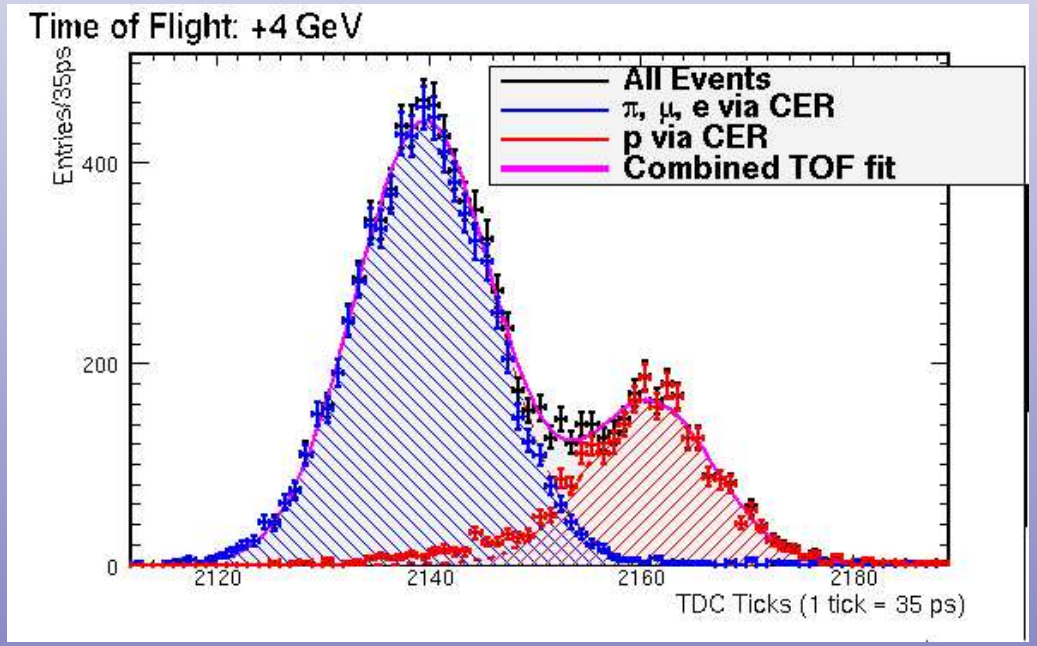

- Beam energies from 0.2 to 10 GeV
- Beam contains e, π, p, μ in somewhat unknown quantities
- Separate e, $(\pi + \mu)$, p with Čerenkov and ToF
- ToF good up to about 4 GeV, then use Čerenkovs at different pressures

CalDet—results

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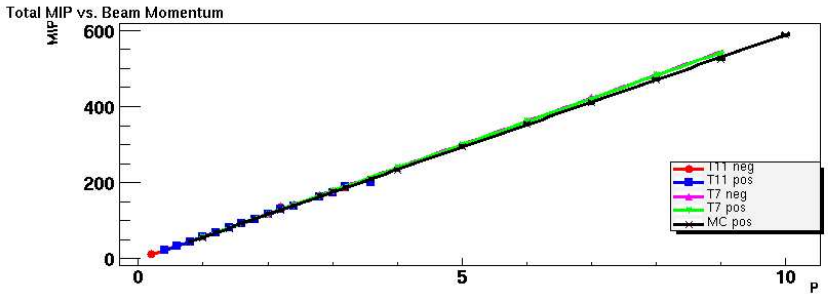
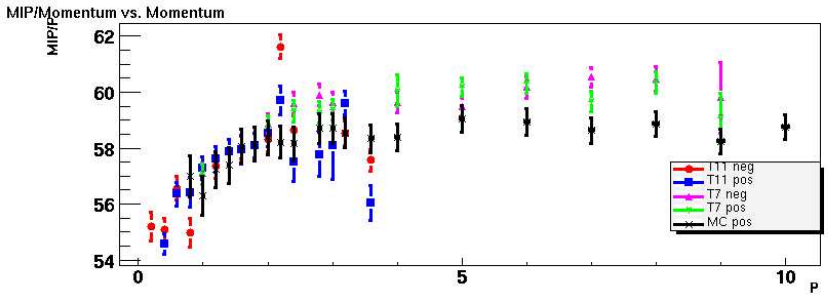
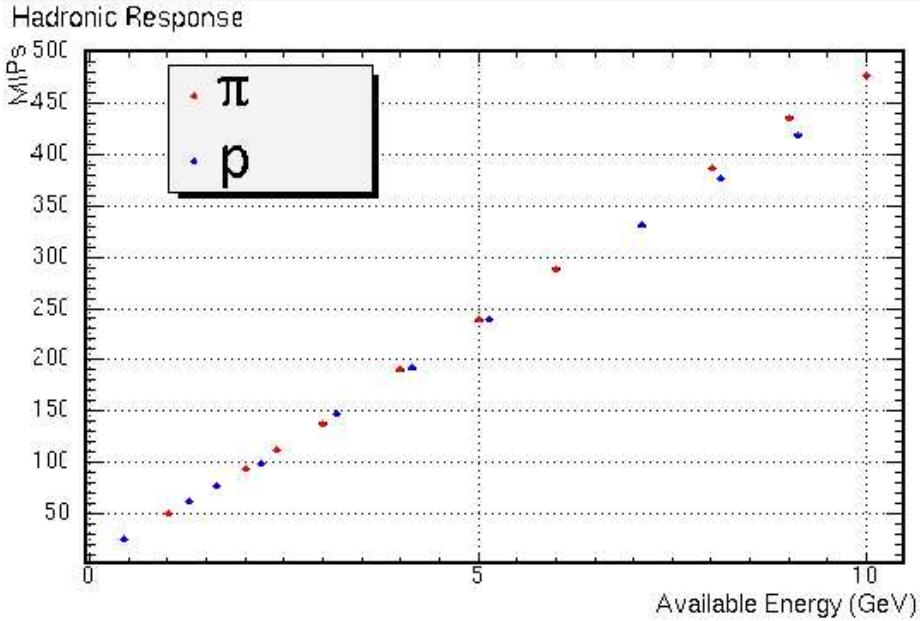
Electrons





- Good agreement with Monte Carlo
- Good agreement between T11 and T7 beamlines

Hadrons



- Less well understood in MC
- Compare G3+GHEISHA, G3+FLUKA, G4
- Data seem to favour Geant 4
- Work ongoing...

Summary

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- All construction under way and on target
- Beam comes on end 2004
- Detectors will be ready
- Far detector has started to take atmospheric data with a magnetic field
- Will measure Δm^2 and $\sin^2 2\theta$ to better than 10%
- Also have some capability to look for subdominant $\nu_\mu \rightarrow \nu_e$ and measure U_{e3}