NuMI

MINOS

NuMI Project

NuMI Project Status

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PAC Meeting
December 12 , 2003
Fermilab

- Introduction and Scope
- Recent Technical Progress
- Status of Cost and Schedule
- Outlook and Summary

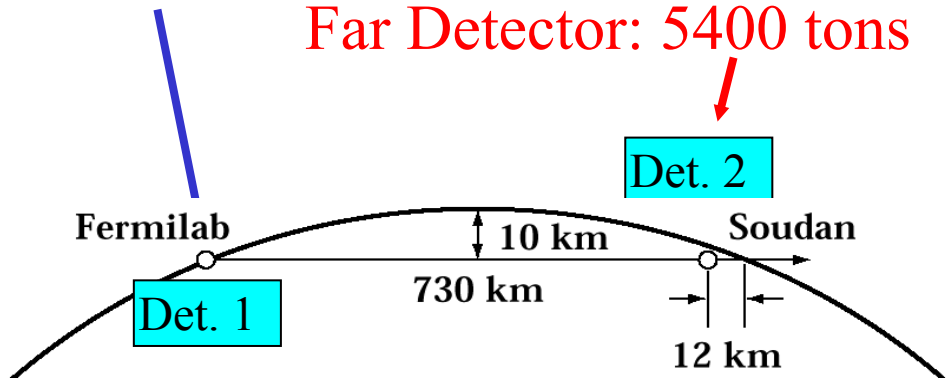
NuMI Project

Construct Facilities and Equipment for a Two Detector Neutrino Oscillation Experiment with Variable Energy Neutrino Beam (Start 2005)

Obtain firm evidence for oscillations and measure oscillation parameters, Δm^2, $\sin^2 2\theta$. Probe for $\nu_\mu \rightarrow \nu_e$ appearance.

Near Detector: 980 tons

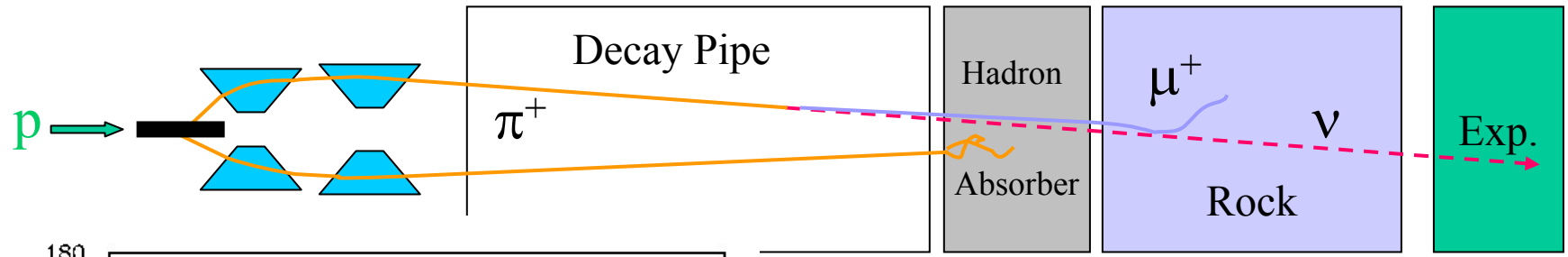
Far Detector: 5400 tons

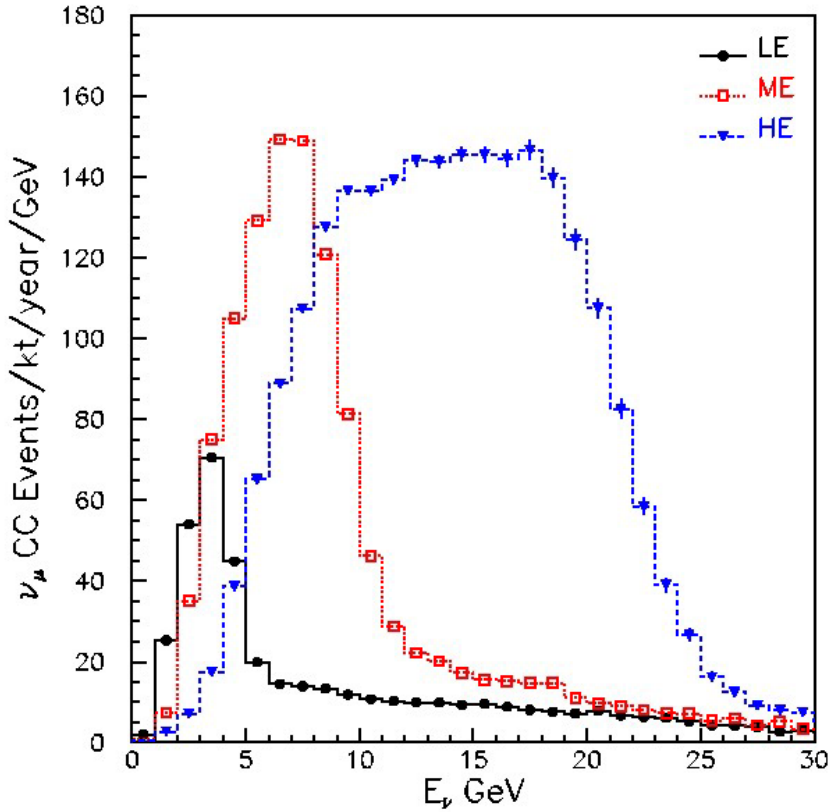


Project Scope

- **TEC** = WBS 1.0 NuMI Facility ($109M)
  - Construction of beam line facility at Fermilab
  - Project scope includes
    - Underground excavation
    - Construction of two surface buildings and outfitting of tunnels and halls
    - Design, construction and installation of technical components in NuMI beamline
- **OPC** = WBS 2.0 MINOS Detector + WBS 3.0 Project Support ($62M)
  - Construction of two detectors and Soudan Far detector cavern
  - Project scope includes
    - WBS 2.0 : design , construction and installation of two detectors
    - WBS 3.0 : early phase of R&D tasks for NuMI and MINOS excavation and outfitting and pre-operating of MINOS Far detector cavern at Soudan Underground Laboratory

NuMI Scientific and Technical Facilities at Fermilab



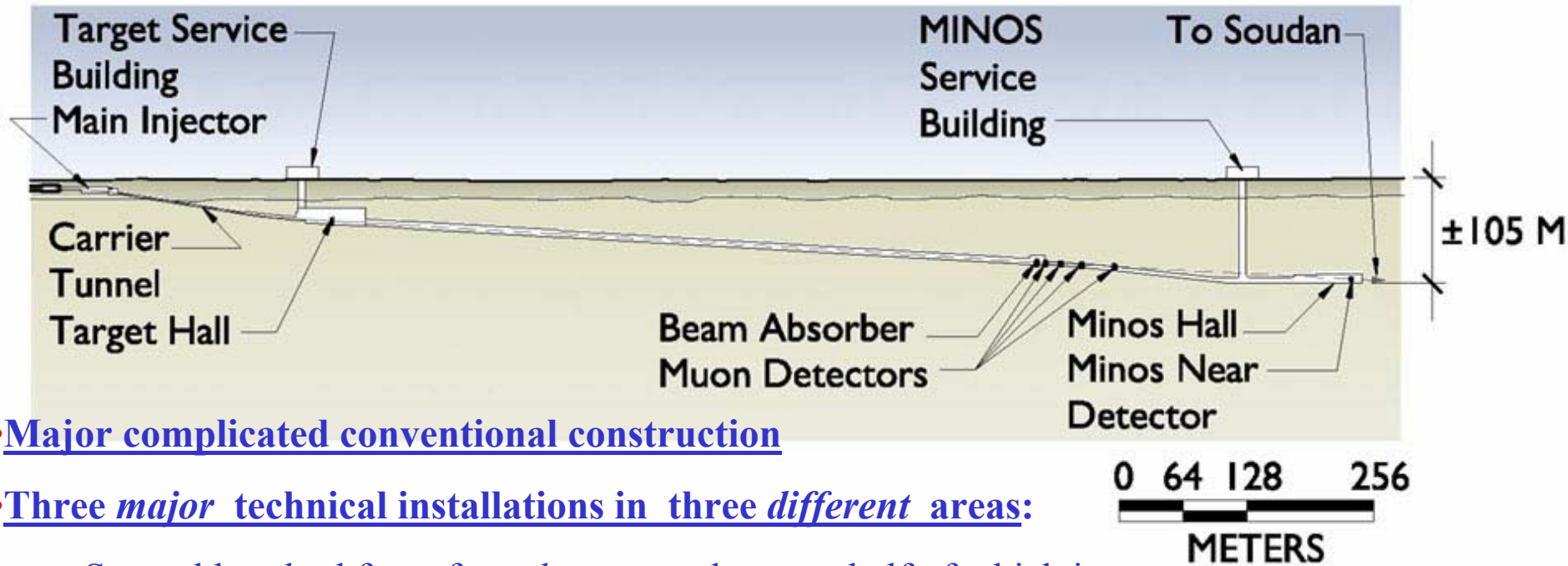


Expected CC Events Rates in MINOS Far detector

- High 8,000 ev/2E20 p
- Medium 3,600 ev/2E20 p
- **Low 1,400 ev/2E20 p**

(OFF-AXIS Beams come for free)

NuMI Conventional Facilities at Fermilab



- **Major complicated conventional construction**
- **Three *major* technical installations in three *different* areas:**
  - Several hundred feet of accelerator enclosure—half of which is between two operating machines
  - Downstream end of carrier tunnel, Pre-Target and Target Areas--primary beam focus, 8KT neutrino beam target station
  - MINOS area—beam monitoring, ~1 KT hadron absorber and ~ 1 KT neutrino detector

Service Buildings and Outfitting

- Beneficial Occupancy of Target area on October 20, 2003. MINOS, estimated for February 2004. Schedule is fine. Construction is now off the critical path (by a little).
- Contingency adequate. Changes under control. Contract will value, roughly $20M. Contract is about 14 months in duration—a major complicated construction project
- ESH performance has been emphasized. A safety incentive award resulted from an injury free work period. There have been 5 injuries in the ~100K hours so far.
- We are still pleased with the performance to date and we are nearing the end.
- Tunnels and Halls Contract Closeout team working on contract closeout with the excavation contractor

NuMI Service Buildings

MI-65

MINOS

NuMI Target Hall

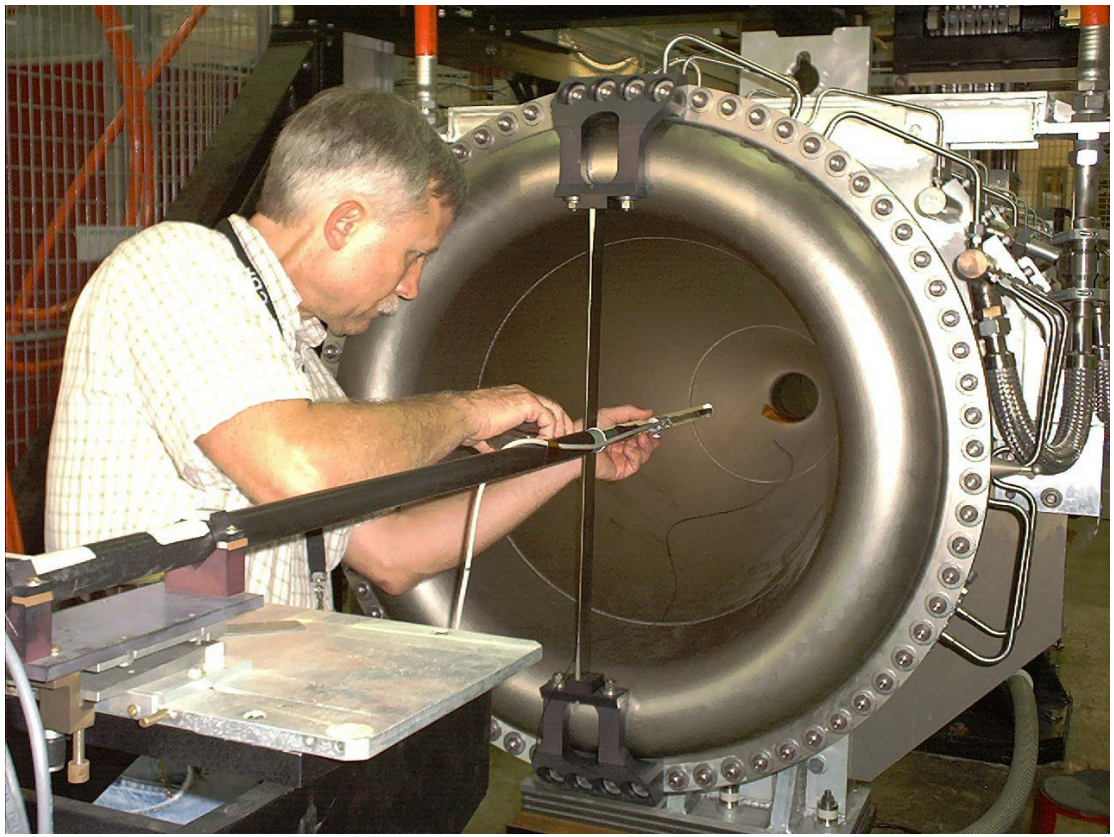
MINOS Near Detector Hall

Technical Components

- **We have made a transition from fabrication to installation.**
- Fabrication of Technical components on schedule with float and reasonable staffing. Costs and schedule essentially holding constant since 2001.
- Technical Components Handbook is being maintained and updated.
- Working well with other accelerator systems department (Main Injector,Recycler, Proton Source) to integrate the NuMI beam into the accelerator complex installation and operation.
- Internal assessment reviews continue. Dozens of internal project milestones are tracked.

Recent Progress

Production Horns

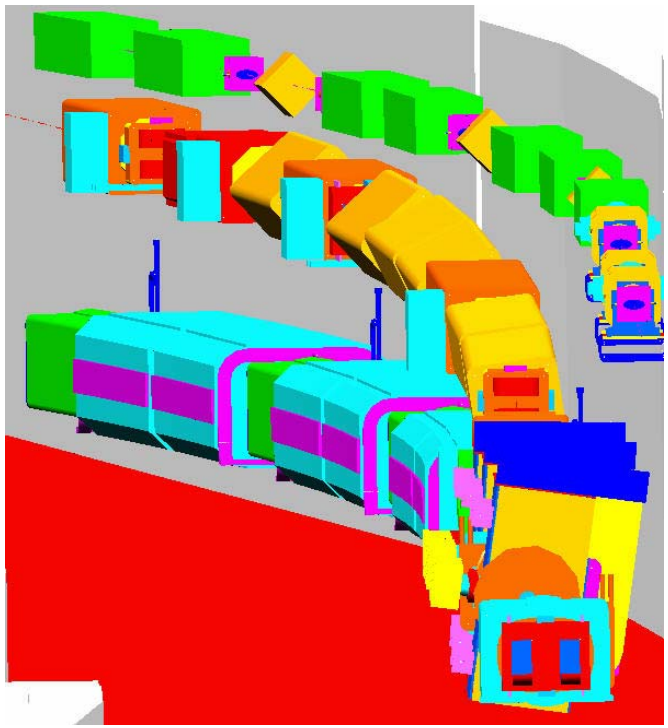


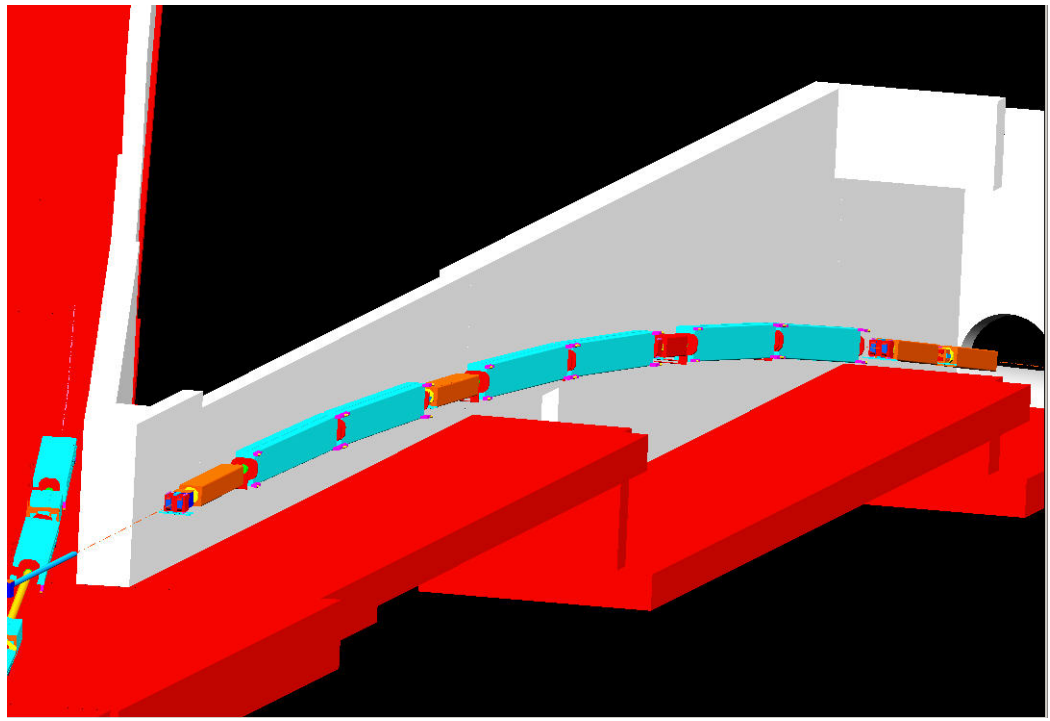
Horn 1 and Horn 2 both assembled, test pulsed, magnetic fields mapped.
Ready for installation.

Target Pile Installation

Downstream end of the Target Pile, looking downhill to Minnesota

Installation Challenge: NuMI in the Main Injector Tunnel

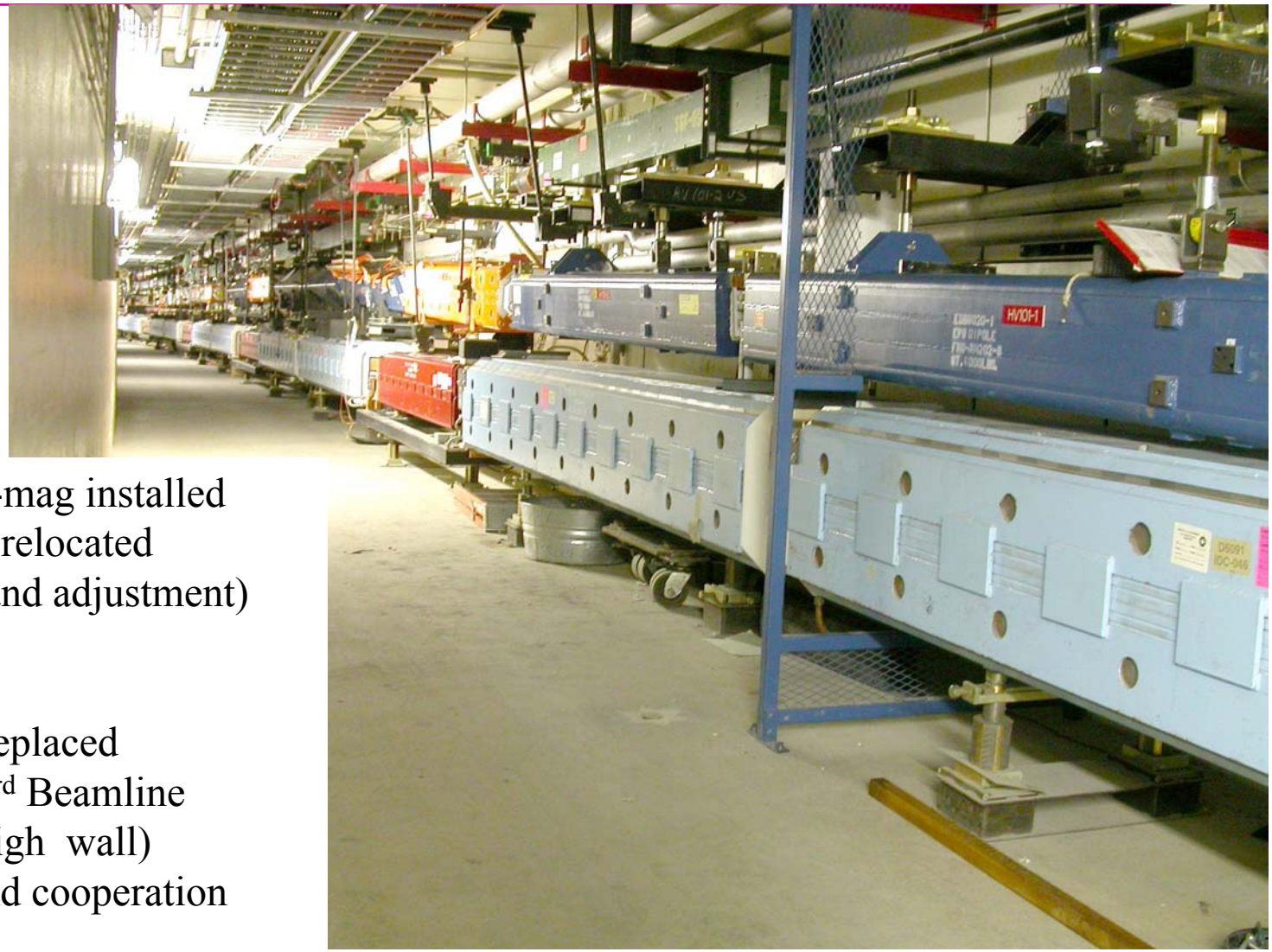




MI ring on bottom, Recycler on top, NuMI in the middle
(fit between two accelerators)

NuMI Stub and Extension
(needs cranes, utilities etc.)

NuMI Extraction Channel
(In the Main Injector)



- Lambertsons and C-mag installed
- MI Instrumentation relocated
- 7 quads (one RR stand adjustment)
- 5 dipoles
- 9/13 rough aligned
- Displaced utilities replaced
- (Not fun to be the 3rd Beamline installed along 10' high wall)

Outstanding work and cooperation with other groups!

NuMI Pre-target

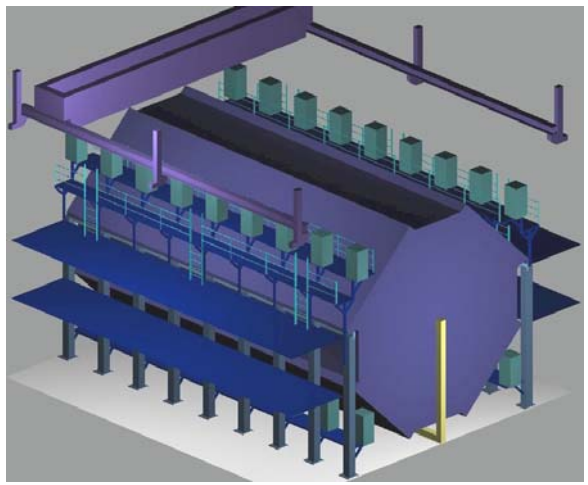
(Upstream end of new NuMI Facility)

Installation Status

- The NuMI part of the FY03 accelerator shutdown was successful; all major tasks were completed on time. All Bends and Quads are in the tunnels. We had many small bumps in the road which were mitigated by an excellent team working in the tunnel. Trims and instrumentation and final hookups are scheduled for 2004 shutdown
- Major intra-laboratory effort BD, PPD, TD especially in recent accelerator enclosure installation. BSS, CD, ES&H, and FESS provide vital support as well
- In MI-65, the installation is underway; we are on schedule after 6 weeks. Manpower freed up from the shutdown in time. Management positions: well-staffed. (1/16 of the target shielding is in place)
- Before we began installation and at daily pre-work meetings the Installation Managers go over the day's work plan and remind the team that safety always has the priority over schedule.
- Costs tracking for installation—over 100 separate tasks being tracked. Initial estimates of complicated MI installation costs seem to fall near our contingency forecast.

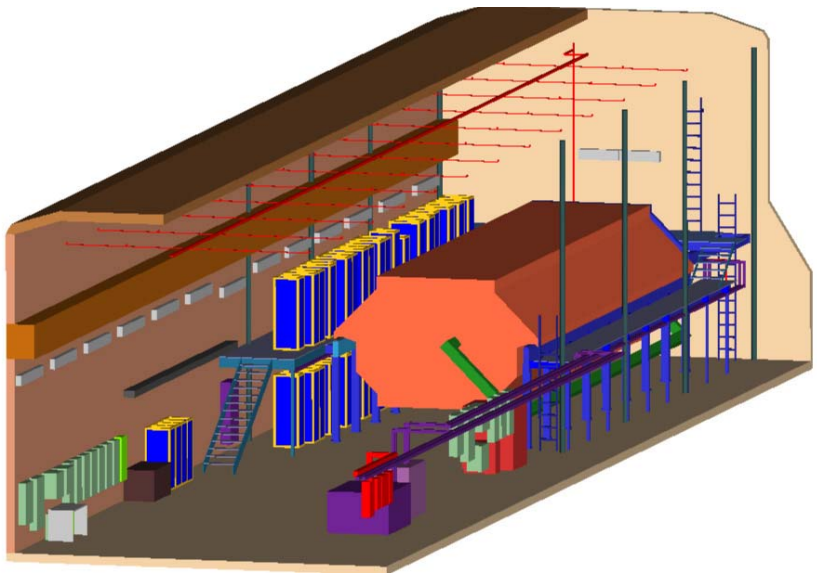
The MINOS Detectors

- Far Detector (Soudan Lab)
  - 8m Octagonal Tracking Calorimeter
  - 2 sections, 15m each
  - 486 planes of steel & scintillator
  - 95,000 scintillator strips
  - **5.4 kT total mass**



One Supermodule of the Far Detctor

- Near Detector (MINOS Hall - FNAL)
  - 3.8 x 4.8m “octagonal” steel & scintillator tracking calorimeter
  - Same basic construction, sampling & response as the far detector
  - 282 planes of steel
  - 153 planes of scintillator



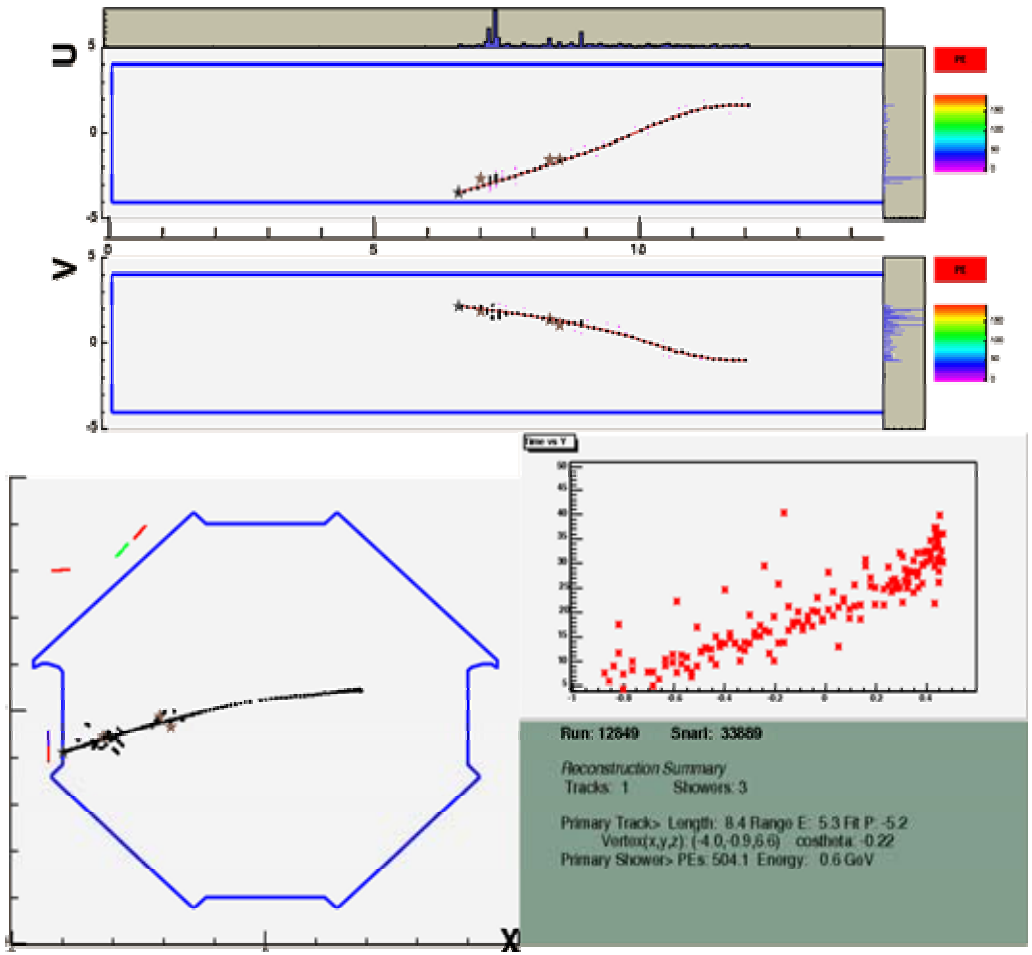
MINOS Far Detector at Soudan Laboratory

Two magnetized Super-modules operate routinely collecting Atmospheric Neutrino Physics Data

Far Detector Installation completed in July 2003

Atmospheric Neutrinos in Far Detector

G. Bock
Physics Advisory Committee
December 12, 2003



MINOS is the first large underground detector which has a magnetic field

We can directly compare whether atmospheric ν_μ and ν_μ oscillate in the same way.

Example Upward Muon
$p_{\mu+} = 5.3$ GeV/c

MINOS Near Detector Status

All Near Detector planes have been pre-assembled; stored at the New Muon Lab awaiting installation in the Near Detector Hall

PMT's and cables delivered; Many components are being installed in the Front-end Electronics racks prior to installation and a major pre-commissioning effort is being mounted.

MINOS Status

- Recent Progress on MINOS detector construction
  - Far Detector Installation is complete (L-1-8)
  - Routine operation of SM1 and SM2 for physics data
  - Far Detector is completely supported by Operations Budget
  - Near Detector Electronics production is nearly complete and extensively tested at Caldet
  - Caldet running complete—Near and Far electronics
  - Near Detector pre-installation tasks continue to make good progress
- As of 9/30/03 Project Baseline is statused 96% complete and 93% of the baseline is costed
  - Have accumulated some real (+) cost variance
  - Current OPC Contingency is $3,414K
- ETC is ~$2,000K (Completion of Near Detector electronics and installation)

CD4 Commissioning and the Transition to Operations

- Commissioning Plan for Project Completion ("CD4")
  - Demonstrate a functioning Far Detector (atmospheric neutrinos and muons)
  - Demonstrate a functioning Beamline and Near Detector (with beam neutrinos)
- Planning for evolution to initial operational intensity has really ramped up
  - 2.5E13 protons , 5/6 batches, 5E12 in Booster , 1.9s cycle
  - Integrated into BD/HQ planning: tasks, people, studies
  - Multi-batch studies, dampers, beam loading compensation, booster shielding, booster notch and timing, possible RF upgrades

Main Injector Commissioning

Multi-batch w/wo transverse dampers

G. Bock
Physics Advisory Committee
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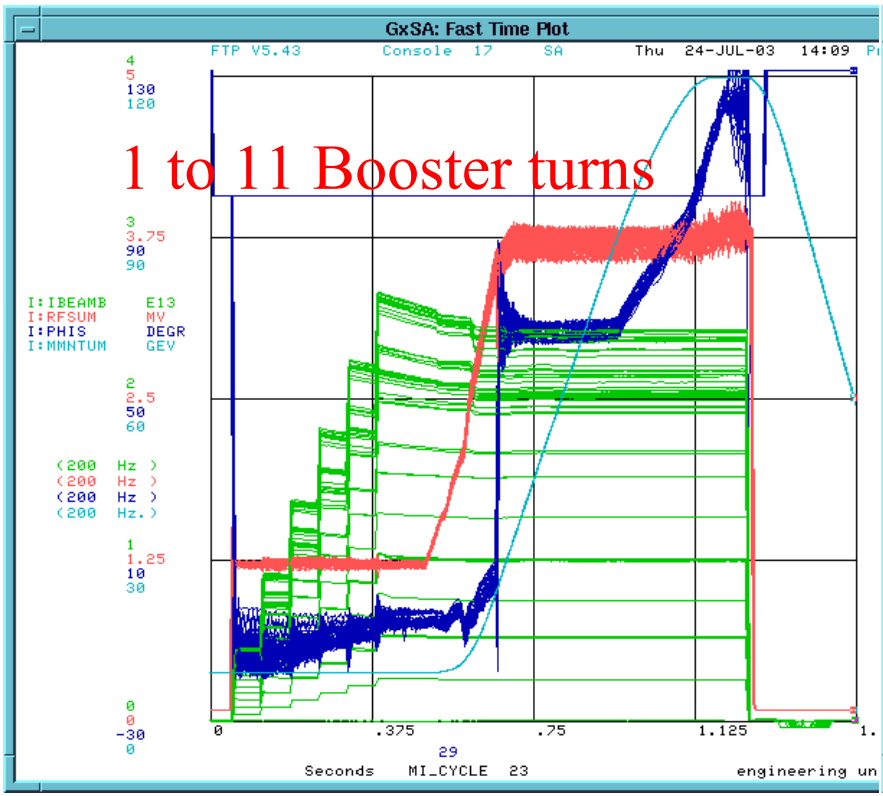
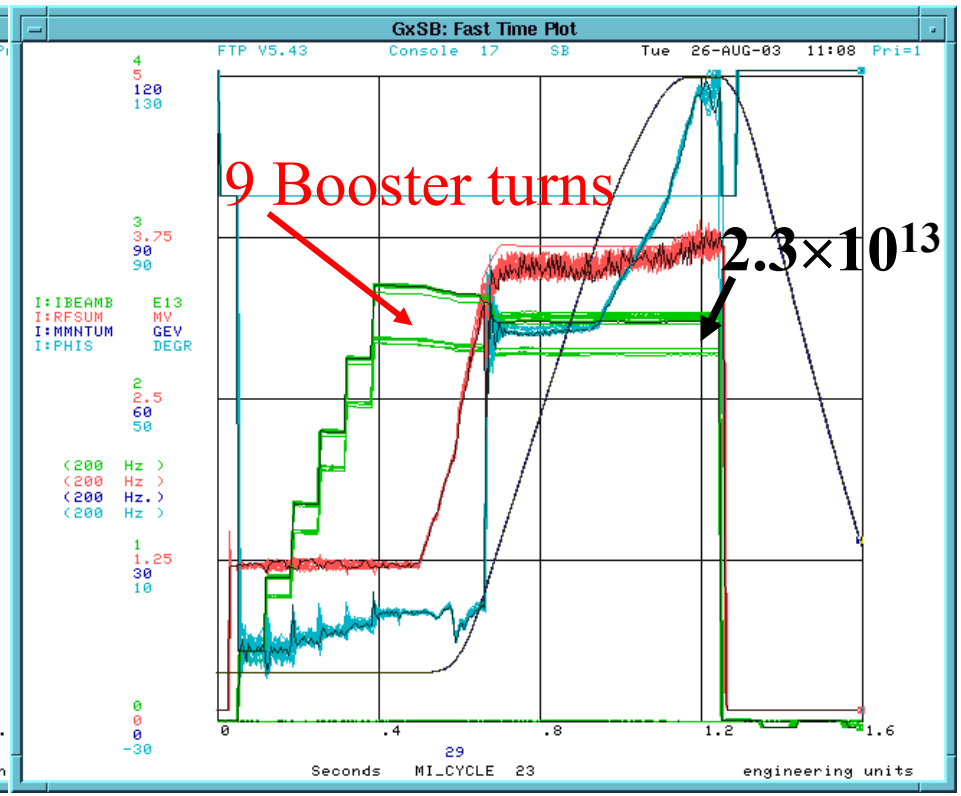
w/o dampers



with dampers



@ 8.9 GeV/c:
ν_X=26.43, ν_Y=25.42, ξ_X=-20, ξ_Y=-16

@ 8.9 GeV/c:
ν_X=26.44, ν_Y=25.47, ξ_X=-5, ξ_Y=-5

MI Commissioning Status

- **Team of Fermilab accelerator physicists and MINOS collaborators in place and planned studies ongoing**
- **A beam intensity of 2.3×10^{13} protons/cycle is now operationally achievable in MI**
- **Good performance of MI transverse dampers**
  - achieved an intensity of 3.3×10^{13} protons in MI at 8 GeV in MI
  - both transverse and longitudinal dampers planned to be fully operational by April 2004
- **Good progress on Booster cogging**
- **Operational and instrumentation issues have been identified**
  - a plan has been developed to address the issues
- **By October 2004 we expect to meet intensity and beam quality goals**

Environment, Safety and Health

- Safety across the project remains uppermost on all our minds. Deep underground facility unique at Fermilab.
- Our safety plan emphasizes Fermilab's safe work policies. Throughout the project we are taking time to plan ahead, identify hazards, put controls in place, monitor, assess, and correct.
- Take action when necessary. Investigate incidents and implement appropriate corrective actions including stand-downs and disciplinary actions.
- Added ES&H staff to cover increase in activities for FY03. We will add more if needed as installation plans develop.
- Documentation team formed: gather and finalize and post documents.
- ES&H reviews continue. Joint BD/PPD Safety Committee provides oversight.
- Continuing to monitor Environmental compliance of our contractors.
- Working on Shielding Assessment and SAD preparation for some time already. Goal is to be ready for approval in April 04.

Management Meetings, Reports, Reviews

- Comprehensive financial, schedule, and narrative monthly report to DoE Project Manager. Supplemental Monthly Reporting against DoE Milestones in the PARS system continues . We have been "in the green" on CPI and SPI since the re-baseline. Supplemental weekly reporting to DOE.
- PMG Meetings chaired by Deputy Director held roughly monthly. Project progress and change control advisory board for the director and an important forum for reporting and discussing Fermilab resources used by NuMI. Weekly meeting with DoE Project Manager. Monthly video meetings with Headquarters.
- Recent collaboration meetings at Fermilab June and September, January meeting in UK. UK MINOS Management meetings bi-annually
- Director's Review of Installation planned after beneficial occupancy of MINOS Hall. Director's Readiness Review for Installation.
- Over a dozen visitors from DOE Headquarters in last year or so.

Continuing Challenges

- We know that keeping project on track is not easy
  - Installation especially in the area inside the Main Injector enclosures. Continue to manage Run II conflicts. This is as hard as we thought, *but we have shown it is not any harder than that*.
  - Installing and commissioning the Near Detector in time for December 2004 is a very large job.
  - Civil construction closeouts are not always easy
  - Follow the proton commissioning plan and achieve initial MINOS operating intensity
  - Continue to aggressively apply the lab's safety program, striving for continuing improvement

Summary

- The NuMI project is being implemented per the Cost, Schedule, and Scope parameters specified in the baseline.
- The whole Lab is helping to achieve a successful completion of the NuMI project.
- Far Detector is now completely installed and taking real data.
- Beamline installation progress, excellent.
- Civil Construction completing.
- Proton commissioning underway.
- Over $15M of earned value in last 6 months ($11M to go). Contingency use minimal in FY03, modest in FY04.
- There is much work ahead, but we are determined to meet the challenges. We are projecting completion in 15 months.