



Status of the NuMI Project

DOE Annual Program Review

Greg Bock

NuMI Project Manager

March 18, 2003

Outline

- Project overview
- Progress during the past year
- Schedule & Funding
- Plans for the coming year
- Summary and Outlook

NuMI (**N**eutrinos at the **M**ain **I**njector)

MINOS (**M**ain **I**njector **N**eutrino **O**scillation **S**earch)



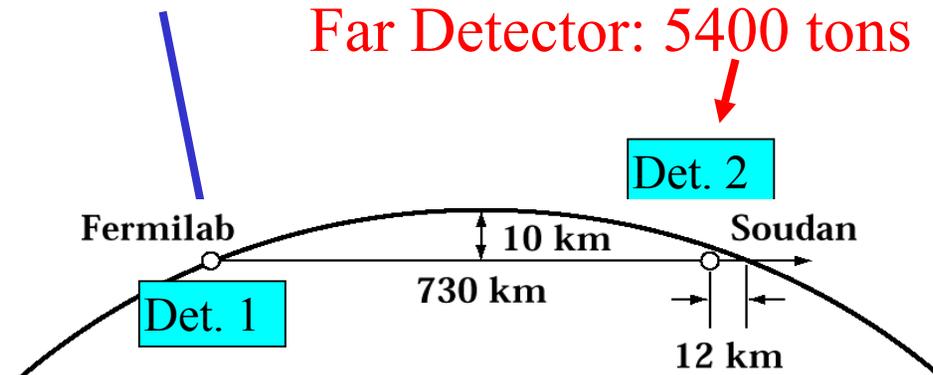
NuMI Project

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



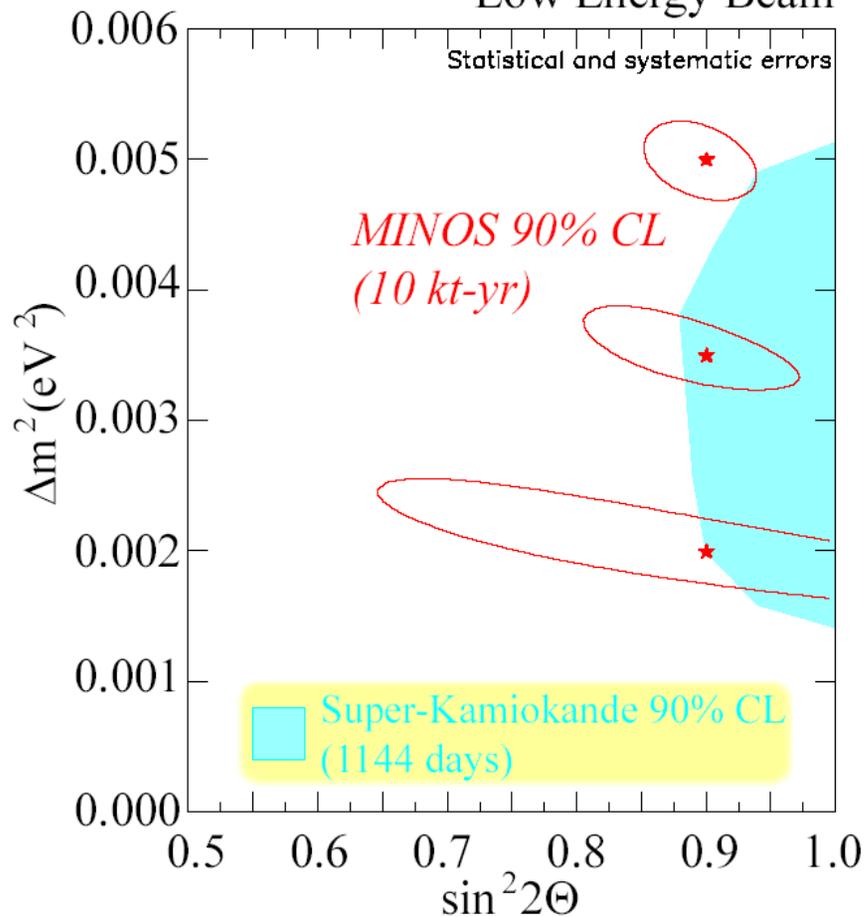


MINOS Sensitivity (8E20 Protons)

- From ν_μ disappearance signal

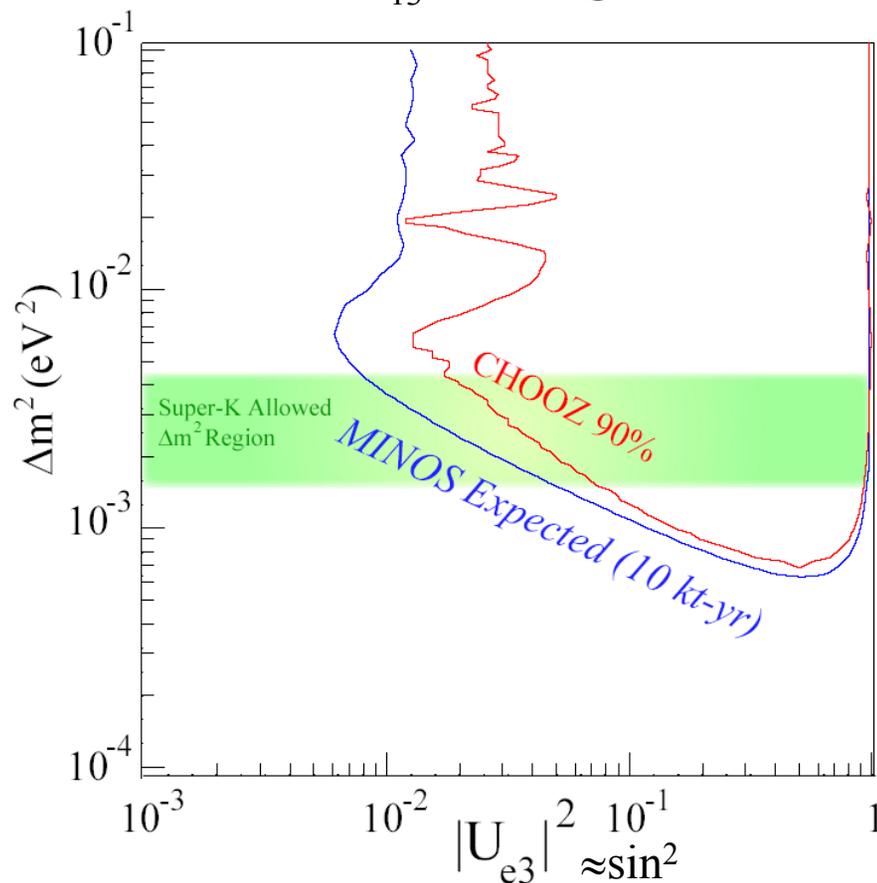
« Measure Δm_{23}^2 to $\sim 10\%$

Low Energy Beam



- Probe for $\nu_\mu \rightarrow \nu_e$ appearance

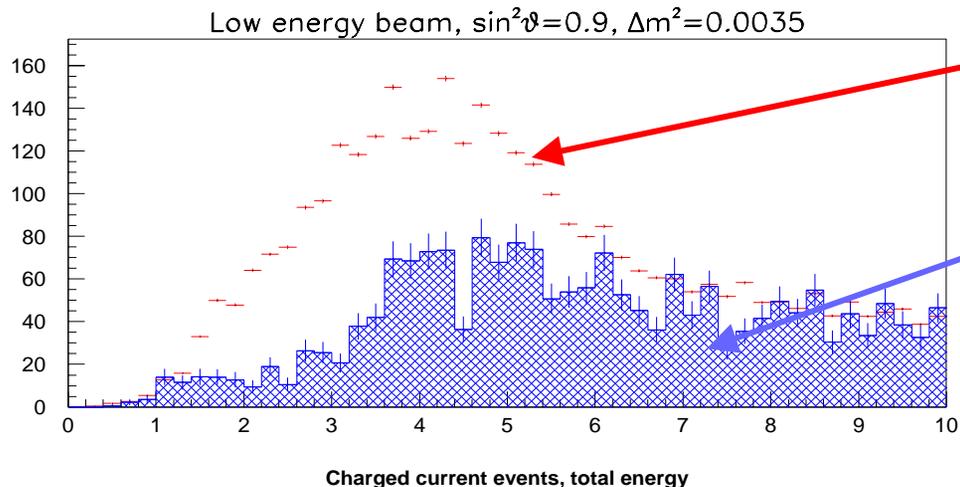
« Sensitivity at the level of
 $\sin^2 2\theta_{13} > 0.06$ @ 90%CL





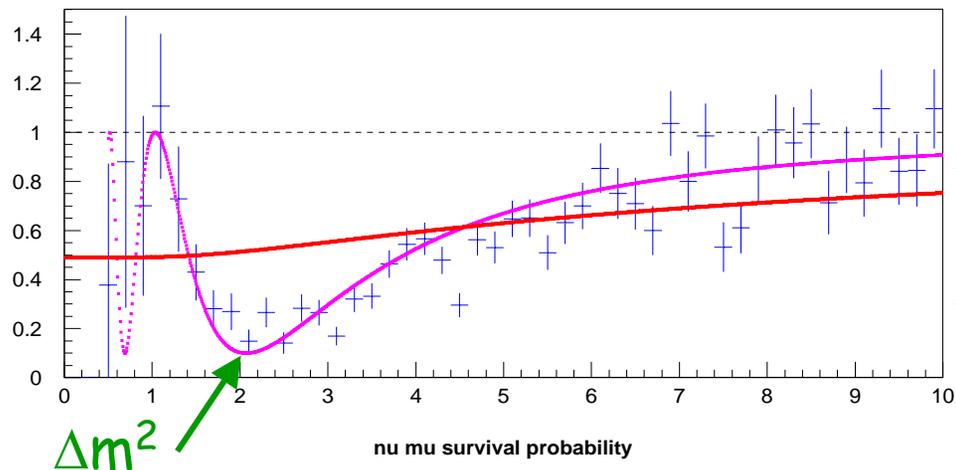
MINOS

Possible result in 2005



Expected event spectrum

Observed event spectrum



Ratio: survival probability

Mixing angle



Project Scope

- **TEC** = WBS 1.0 NuMI Facility (\$109M)
 - « Construction of beam line facility at Fermilab
 - « project scope includes
 - * underground excavation and outfitting of tunnels and halls
 - * construction of two surface buildings
 - * 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



Progress Since Last March

- Conventional Construction
 - « Excavation completed !
 - « Service Buildings and Outfitting under contract and well underway
- Technical Components
 - « Primary beam re-designed. Fabrication underway. Installation in progress. Starting to plan for commissioning and operations
- MINOS Detectors
 - « First of 2 Far Detector SuperModules complete and recording atmospheric neutrino data. The second will be finished later this summer. Good progress on Near Detector. Calibration data taken.
- During the past year over \$30M of progress. As of January 31, \$34M to go.
- We remain on the plan--scope, cost, and schedule.



Management Meetings, Reports, Reviews

- Semi-annual DOE Review of the NuMI Project held in May and December
 - « No action items, except to hold the next review. Some concerns about final engineering on Technical Component systems. We have addressed those.
 - « Added more Level 3 milestones.
 - « Typically 2 or 3 dozen recommendations
- Director's 2nd Installation Review (followup from December)
 - « Focus on summer shutdowns with overview of whole project.
- Numerous internal engineering and safety reviews of technical components being convened by management.



Management Meetings, Reports, Reviews

- Comprehensive financial, schedule, and narrative monthly report to DOE Project Manager. Weekly meeting with DoE Project Manager. Monthly video meetings with Headquarters. Supplemental Monthly Reporting against DOE Milestones in the PARS system continues . Detailed weekly reports to DOE continuing.
- Semi-annual UK MINOS Management meetings
- PMG Meetings (progress reporting and change control board) chaired by Deputy Director held roughly monthly.
- Collaboration Meetings in Minneapolis and Sussex, UK, Fermilab, and South Carolina—emphasizing physics at far detector, calibration studies at CERN, and beam issues
- DOE visitors included: Robert Card, (DOE Undersecretary), David Stadler, (Deputy Assistant Secretary) DOE Inspector General Audit , Phil Debenham, Peter Rosen

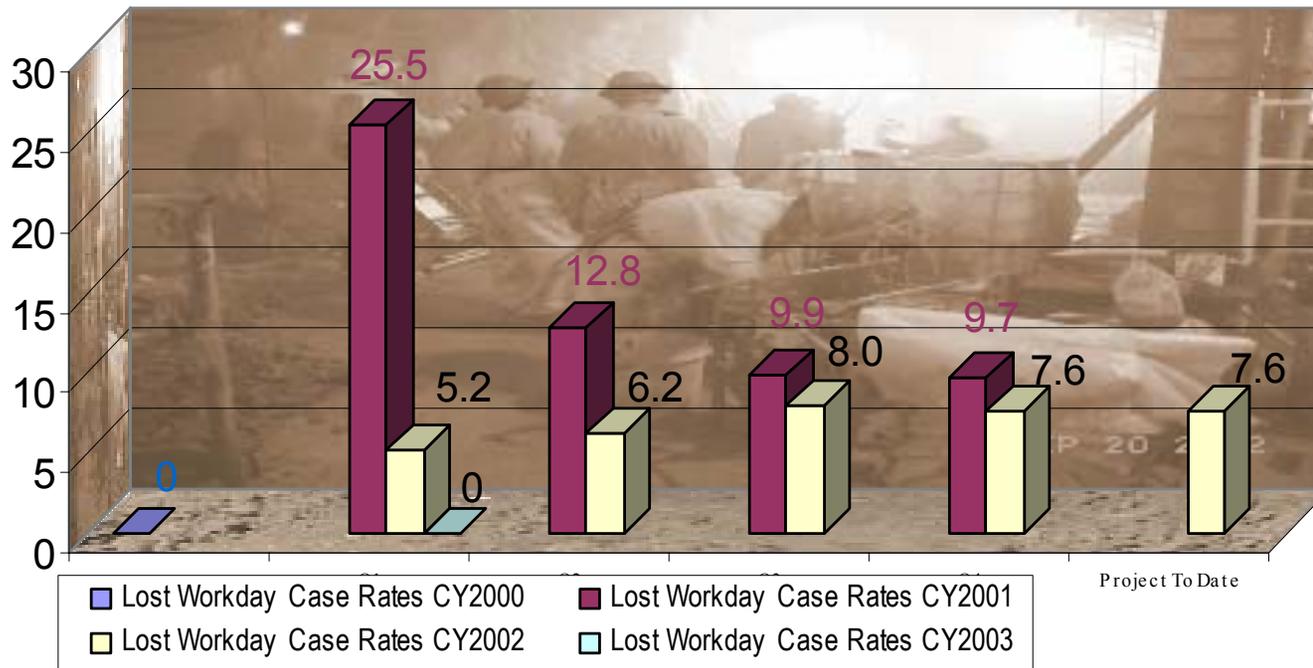


Environment, Safety and Health

- Safety across the project remains uppermost on all our minds.
- Re-emphasizing throughout the project taking time to plan ahead, identify hazards, put controls in place, monitor, assess.
- Added ES&H staff to cover increase in activities for FY03
- Increased consideration to ES&H in SB&O package as well as incorporating our experiences of the past years.
- Take action when violations occur. Four workers removed from SBO job for violations of safety procedures. Investigate incidents and implement appropriate corrective actions.
- To date, no injuries on the SBO job.
- Beamline component ES&H reviews continue. Walkthroughs of Fermilab sites instituted.
- Continuing to monitor Environmental compliance of our contractors. New water treatment plan in place.

Construction Safety

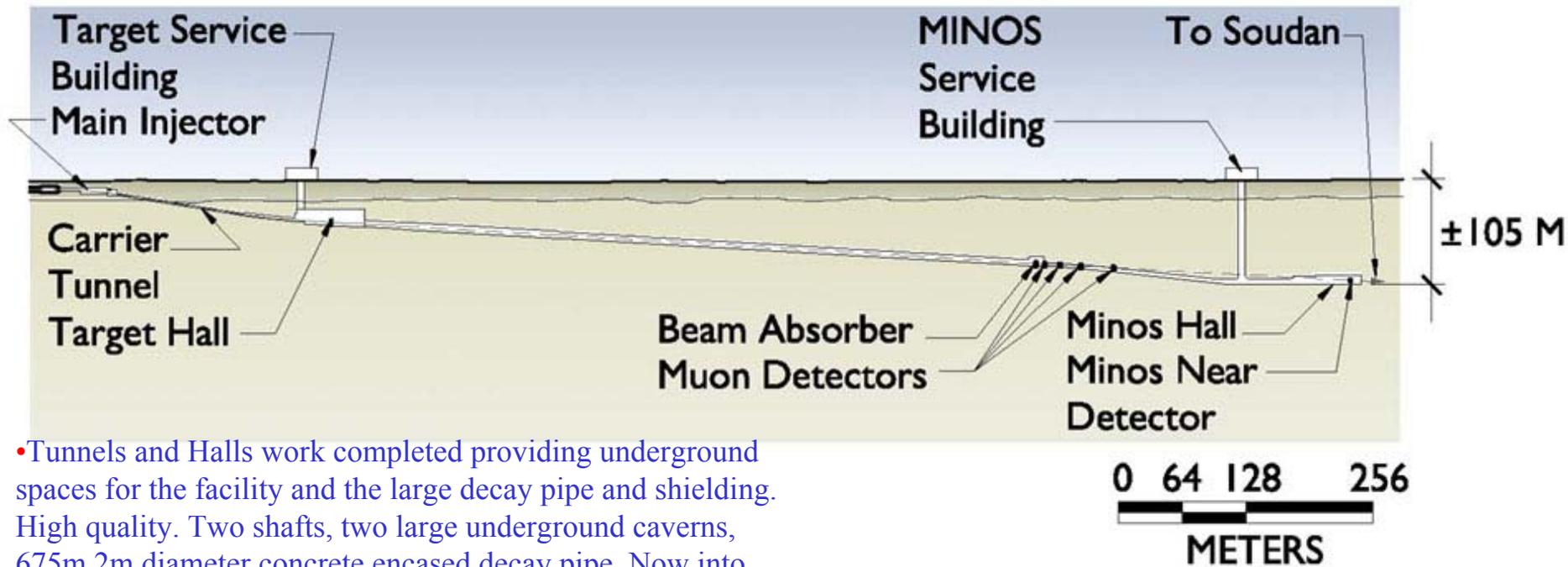
NuMI Tunnel & Halls Lost Workday Case Rates





MINOS

NuMI Conventional Facilities



•Tunnels and Halls work completed providing underground spaces for the facility and the large decay pipe and shielding. High quality. Two shafts, two large underground caverns, 675m 2m diameter concrete encased decay pipe. Now into contract closeout phase.

•Service Buildings and Outfitting contract (SBO) Two surface buildings and underground outfitting of the tunnels. Incorporated much of what we learned over the last couple years managing the tunneling contract Office staffing contract language, ES&H expectations, and scheduling requirements. Full NTP issued on November 22.



NuMI Tunnels and Halls

- Product is complete and of high quality. It was a tough job with a good finish.
- Contract Closeout team established by the project replacing the Tunnels and Halls Construction Management Office. Charged with closing out the the Healy contract equitably, so that only costs that are due and allowed are incurred. Team lead by Procurement Manager and Underground Construction Manager includes a negotiator, claims strategy advisors, geotechnical experts, cost estimators, auditors, and potentially litigators
- Significant costs accompanying both the schedule delays and the preparation for defense of claims
 - « Our Geo-technical Baseline characterization was sound
 - « Some potential claims already settled
 - « Disputes Resolution Board Process underway
 - « Our increased management costs were large—field and office and consultants. We intend to seek damages as a result
 - « We have enough to pay what we will owe, but not what the contractor will seek. Lab provides claims/litigation support.



Service Buildings and Outfitting

- Last large contract on project—4 bids, all came in higher than expected. Led to a project-wide effort over the summer. Implemented a risk mitigation exercise we conducted last spring in preparation for such an event, and implemented \$1M savings in Technical Components Reviewed Technical Components and MINOS contingency and risk analyses. Determined we could afford it. Concurrence from Laboratory and DOE management in a series of reviews. Contract awarded to Ragnar Benson, Inc of Park Ridge, IL for \$17.9M
- Off to a good start. Approximately 30% complete. However, we are noticing some schedule issues (~3 weeks); contractor agrees: has promised a “workaround schedule” which could make use of more hours/day, days/week or more staff. We have had to work hard **with** RBI to instill our safety culture. Watching very carefully.



OCT 17 200



Underground Enclosures in January





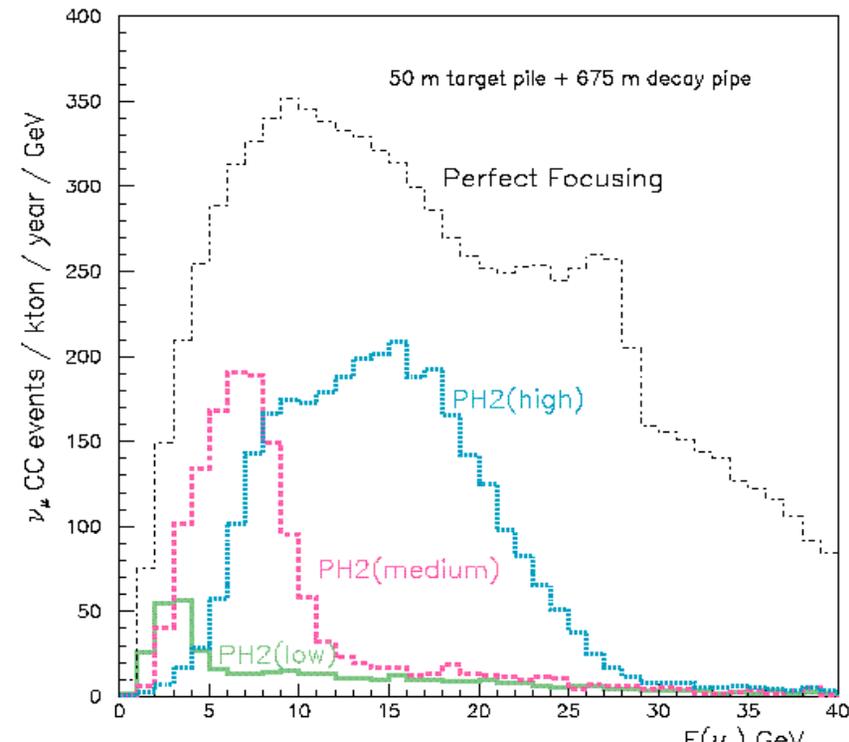
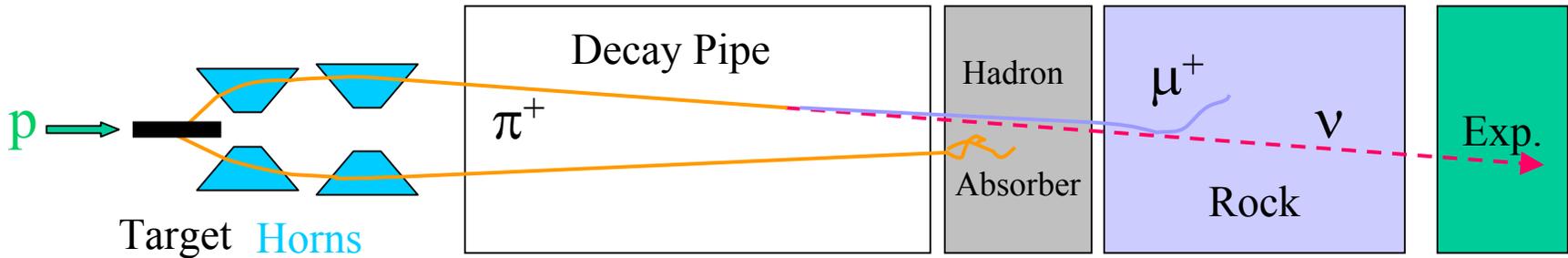
Underground Enclosures in January



Pre



NuMI: Flexible Neutrino Beam



Expected CC Events Rates in MINOS Far detector

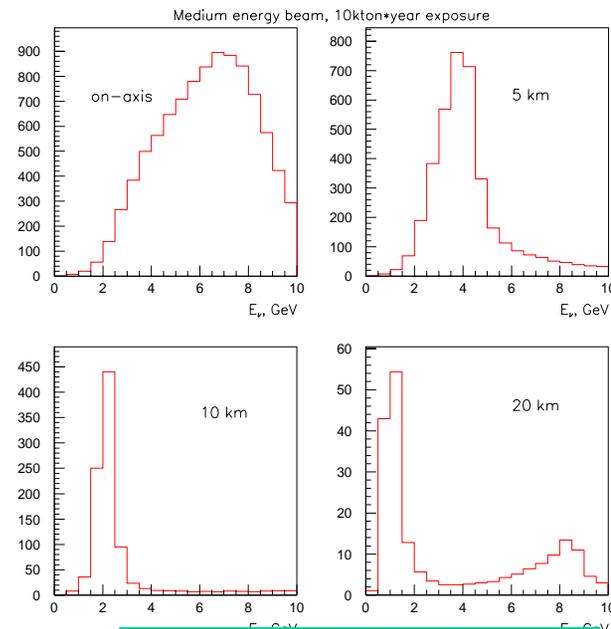
- «High 8,000 ev/2E20 p
- «Medium 3,600 ev/2E20 p
- «Low 1,400 ev/2E20 p



MINOS

Off-axis NuMI Beams come for Free

- Beam energy defined by the detector position
- Narrow energy range (minimize NC-induced background)
- Simultaneous operation (with MINOS and/or other detectors)
- ~ 2 GeV energy :
 - Below tau threshold
 - Relatively high rates per proton, especially for **antineutrinos**
- Matter effects to amplify to differentiate mass hierarchies
- Baselines 700 – 1000 km



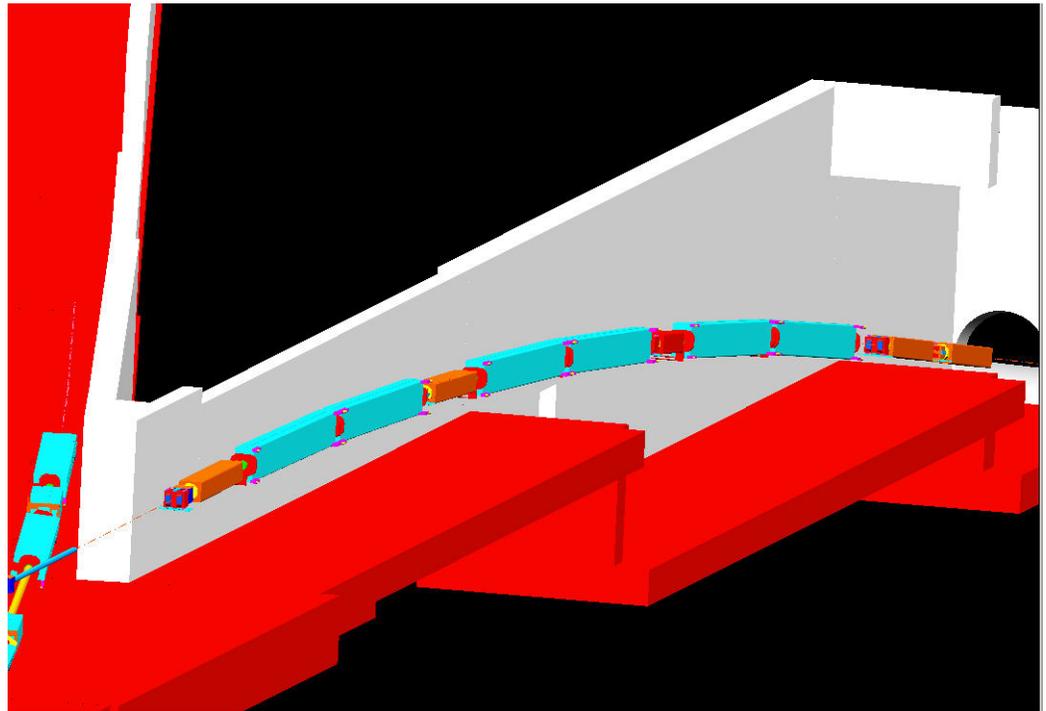


Technical Components

- Significant technical progress being made in all areas and on goals. Engineering levels OK. Major designs complete. Costs holding constant since 2001.
- Primary Beam Design (Beamsheet) accepted by Main Injector.
- Technical Components Handbook V2.0 released.
- Much progress on installation activity and planning.
- Internal assessment reviews continue.
- Fabrication of Neutrino Beam components on schedule with float and reasonable staffing. No changes being discussed.



Installation Challenge: NuMI in the Main Injector Tunnel

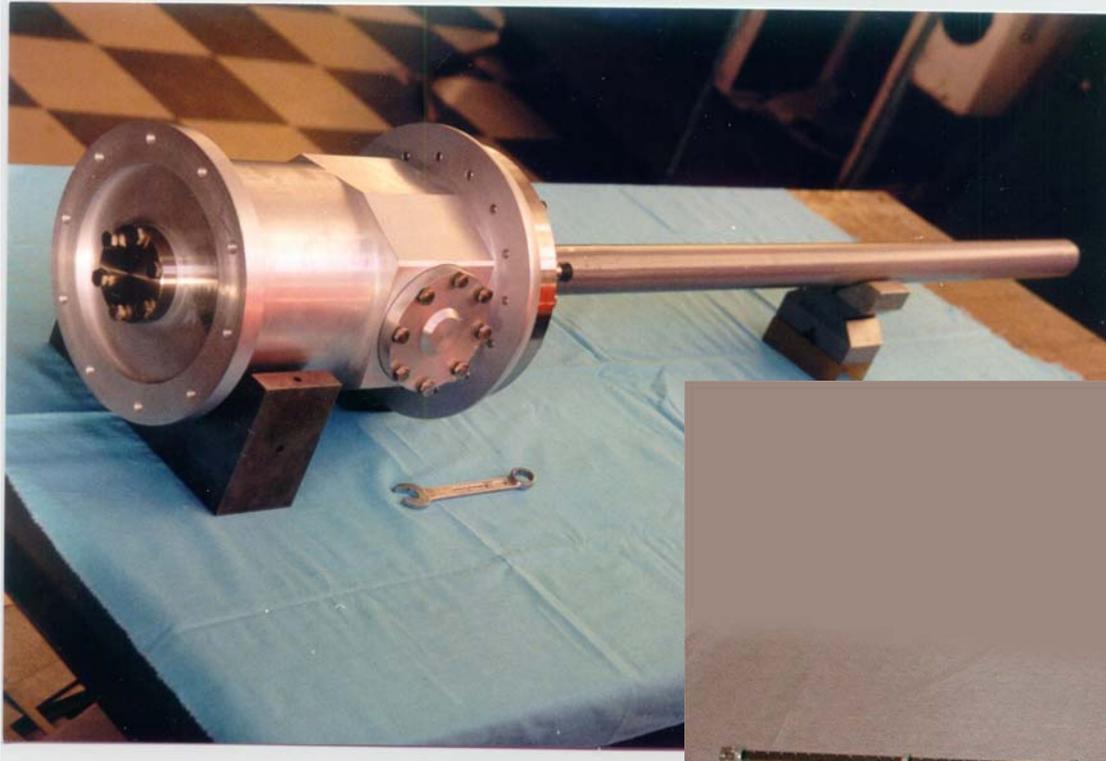


MI ring on bottom,
Recycler on top, NuMI
in the middle
(fit between two accelerators)

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

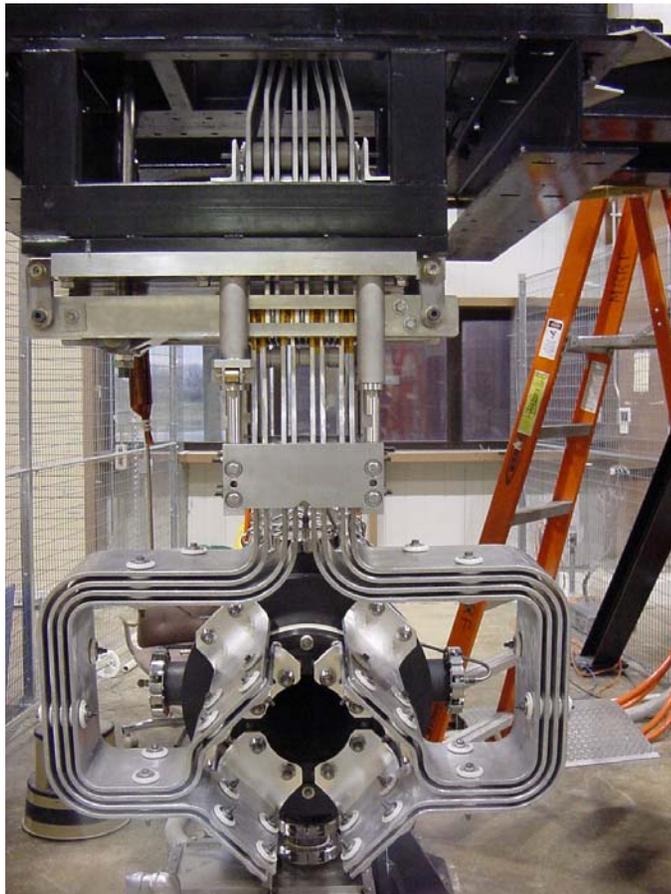


NuMI Target arrived from IHEP





NuMI Focussing System



(Spare) Horn 1 current
distribution system



Assembly of inner and outer
conductors of (production)
Horn 2. (DOE L-1-6)



Installation, Commissioning and Transition to Operations

- Installation underway and continuing over next 20 months
 - « January Shutdown: LCW piping , cable tray, cables
 - « Summer Shutdowns: Lambertsons, Kickers, Instrumentation, magnets, cranes, etc
 - « NuMI enclosures in Fall: Pre-target, Target Hall, Absorber hall, Muon monitoring alcoves, MINOS detector hall, and buildings
 - « Director's Reviews periodically
- Commissioning Plan developed
 - « Technical Components L3 Managers led by Bruce Baller
 - « Concentration on CD4 goals
- Evolution to initial operational intensity
 - « $2.5E13$ protons , 5/6 batches, $5E12$ in Booster , 1.9s cycle
 - « Integration into BD/HQ planning underway: tasks, people, studies
 - « Multi-batch studies, dampers, beam loading compensation, booster shielding, booster notch and timing, possible RF upgrades



MINOS Far Detector

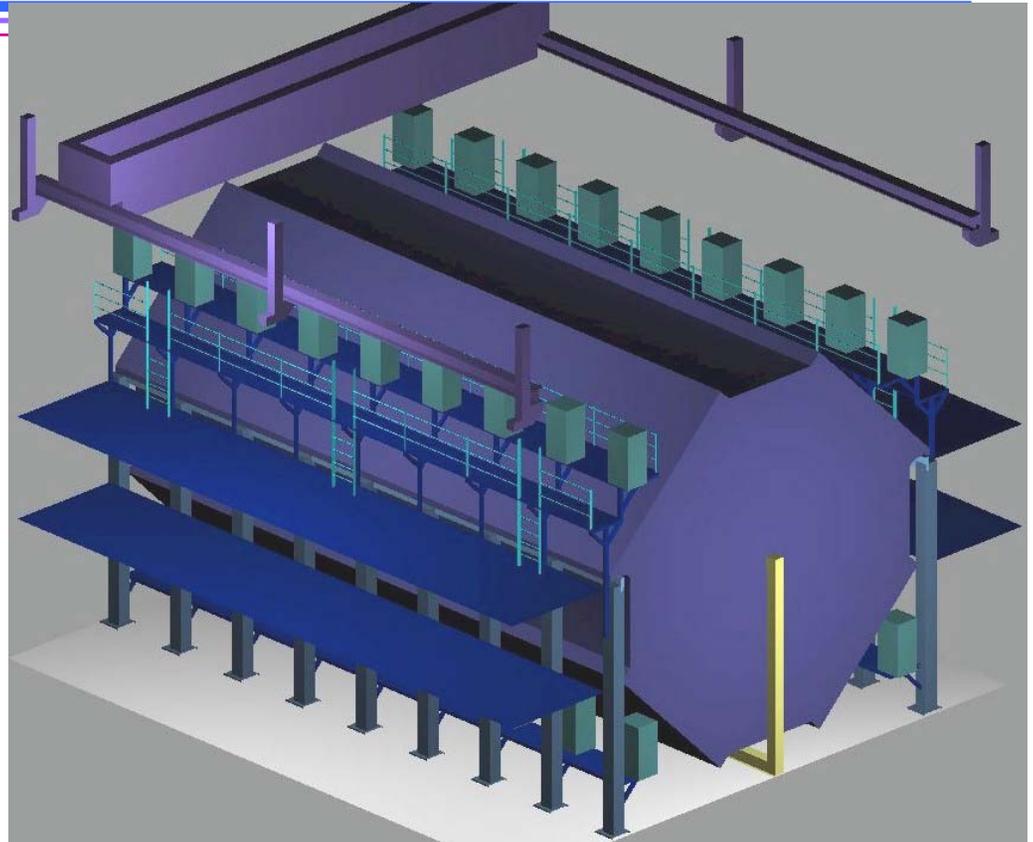
- 8m octagonal steel & scintillator tracking calorimeter

- Sampling every 2.54 cm
- 4cm wide strips of scintillator
- 2 sections, 15m each
- 5.4 kton total mass
- $55\%/\sqrt{E}$ for hadrons
- $23\%/\sqrt{E}$ for electrons

- Magnetized Iron ($B \sim 1.5T$)

- 484 planes of scintillator

- 26,000 m²



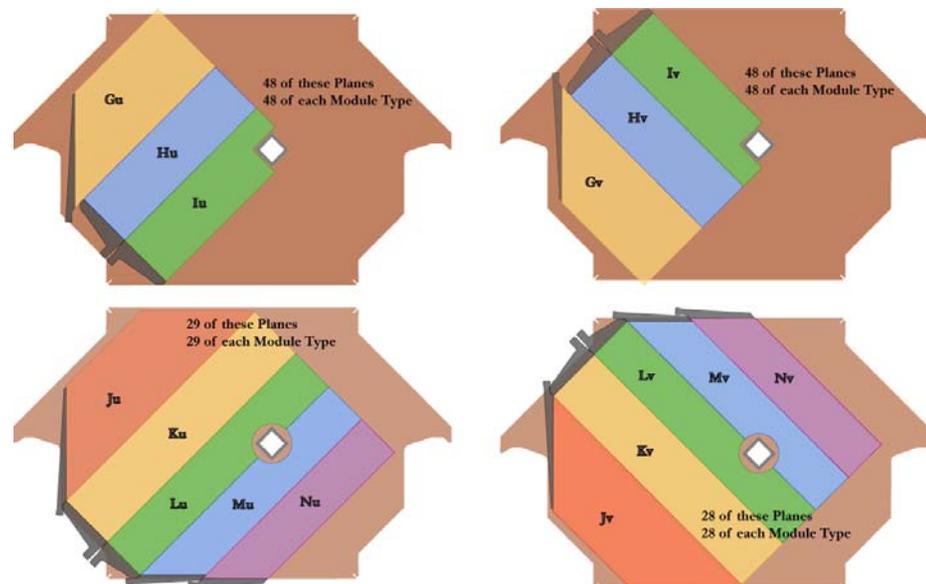
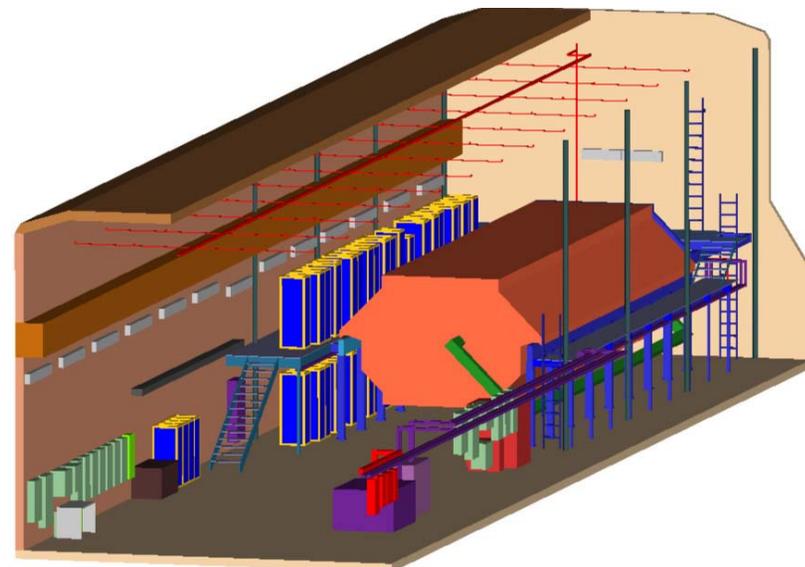
One Supermodule of the Far Detector...



MINOS

Near Detector

- **3.8 x 4.8m** “octagonal” steel & scintillator tracking calorimeter
- Same basic construction, sampling and response as the far detector.
- No multiplexing in the main part of the detector due to small size and high rates.
 - « Hamamatsu M64 PMT
 - « Faster Electronics (QIE)
- **282 planes of steel**
- **153 planes of scintillator**



Detector Status



- Installed plane 426 (of 484).
- Installation end game being implemented. Factories shutting down.
 - The B field has been turned on for the 1st Super Module and data are being recorded The current analysis is focusing on upward going μ 's and ν interactions
 - CALDET tests at CERN in 2002 (150 channels) and 2003 (1500 channels) testing ND/FD electronics



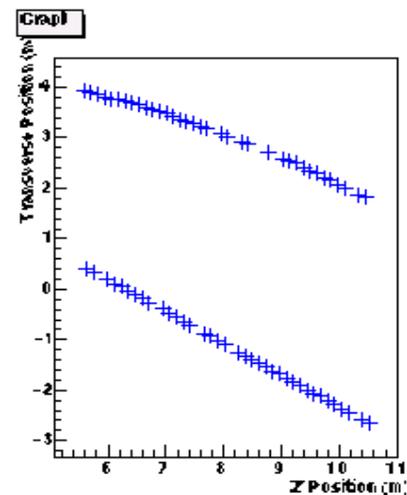
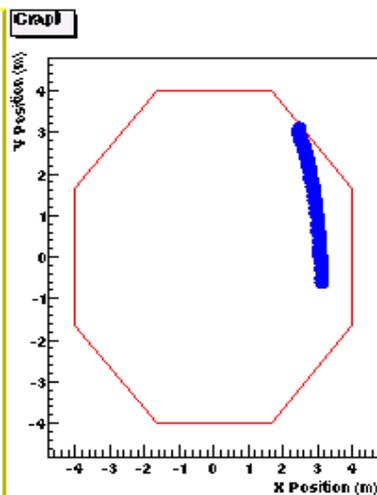
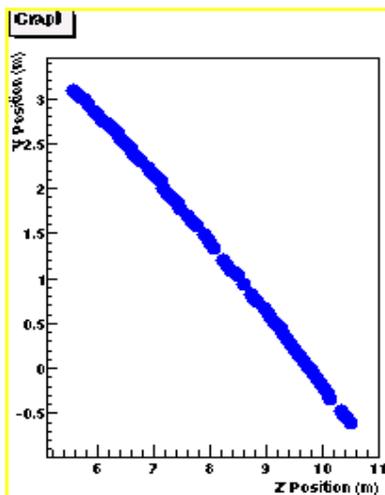
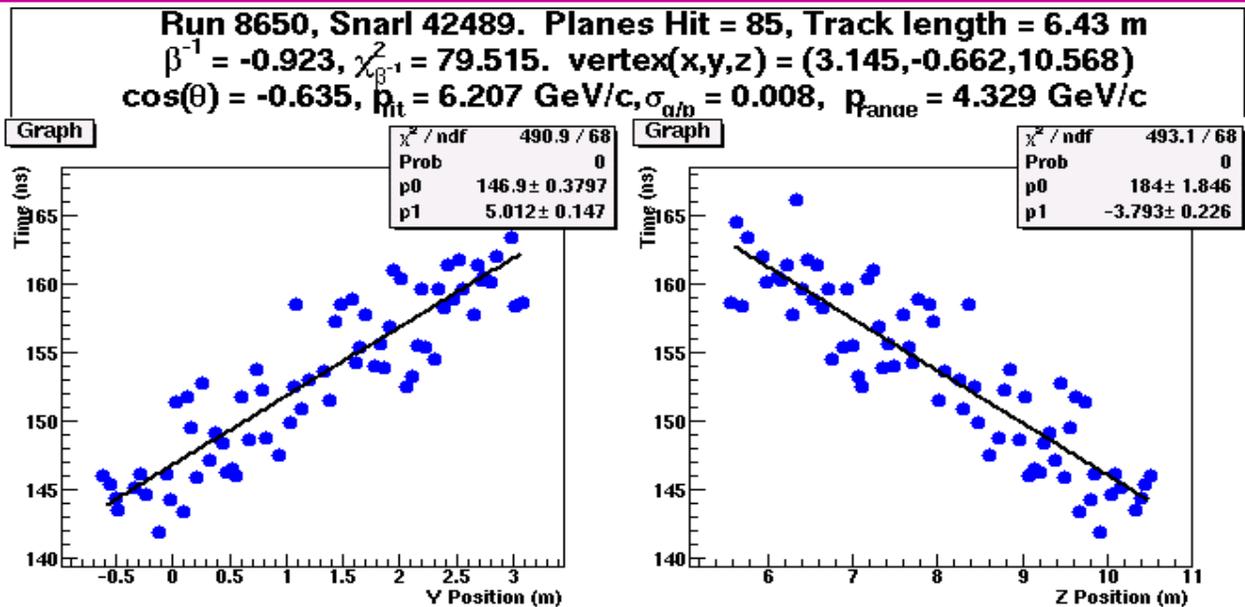
Atmospheric Neutrino Physics

- MINOS is the first large underground detector which has a magnetic field.
 - «Measure charge/momentum of muons from $\sim 0.5-70$ GeV/c momentum.
 - «Events with the neutrino interaction in the detector but where the muon exits still have complete E_ν measurement: L/E measurements.
- Event direction reconstructed using timing and topology.
- Able to identify CC ν_μ and $\bar{\nu}_\mu$ events from NC and CC ν_e events over a very broad energy range as long as $p_\mu > \sim 1$ GeV/c.
- We can directly compare whether atmospheric ν_μ and $\bar{\nu}_\mu$ oscillate in the same way.

Events in 24 kT years	Neutrino	Antineutrino
Contained vertex with muon	620	400
Upgoing muon	280	120



Atmospheric Neutrino Interaction

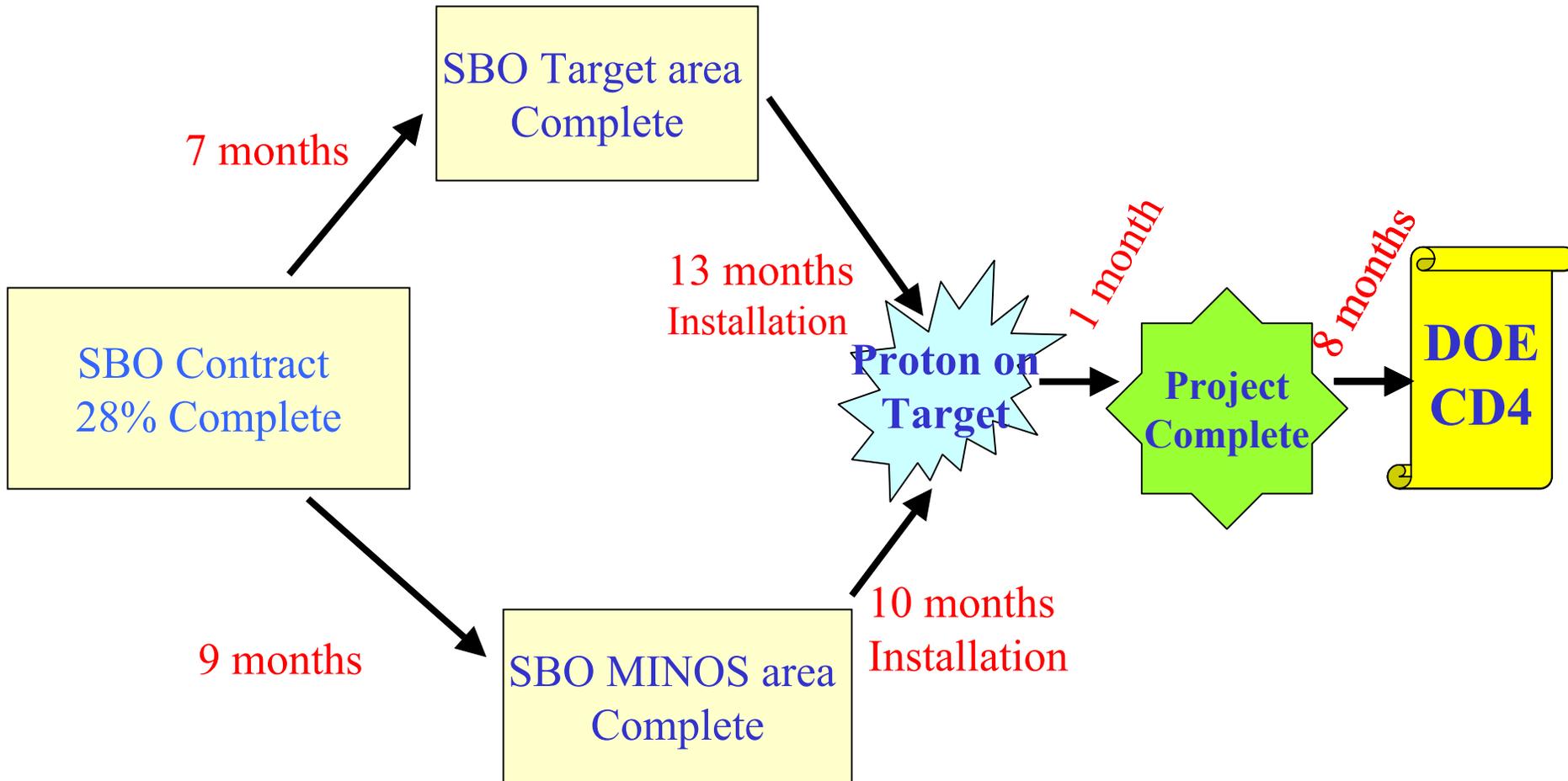




NuMI Schedule

- The critical path remains the completion of the civil construction at Fermilab and the subsequent installation of the NuMI technical components.
- The schedule contains float. The schedule is integrated and resource loaded. Re-estimates of critical activities are underway with the goal of accelerating the project.
- We have been on schedule or slightly ahead for the past 21 months.

Project Schedule to Completion





Doe Milestones FY2002-2005

(Shaded milestones completed since March 2002)

Milestone Description	PEP Milestone #	DOE Milestones (As of 12/2001)	Current Month's Forecast Milestone	DOE Milestone Variance (Cal Days)	Notes
Cosmic Rays Observed in Far Detector	L-2-10	3/22/2002	8/31/2001	203	Complete
Technology Choice Made for Muon Monitors	L-2-16	5/30/2002	12/10/2001	171	Complete
Service Building & Outfitting Bid Package Out	L-1-10	7/30/2002	2/25/2002	155	Complete
75% Scintillator Produced	L-2-19	8/30/2002	5/24/2002	98	Complete
Near Detector Hall Excavation Complete	L-2-7	12/30/2002	8/30/2002	122	Complete
Target Hall Excavation Complete	L-1-5	12/30/2002	10/4/2002	87	Complete
Lambertson & C-Magnets Assembled & Tested	L-2-12	2/1/2003	10/31/2002	93	Complete
First Far Detector Super Mod Complete & Tested	L-1-7	3/15/2003	7/24/2002	234	Complete
Inner & Outer Conductors for First Production Horn Assembled	L-1-6	4/14/2003	2/5/2003	68	Complete
Target Service Building Shell Complete	L-2-18	9/30/2003	7/7/2003	85	
Near Plane Pre-assembly Complete	L-2-20	10/10/2003	12/17/2002	297	Complete
Far Detector Complete & Tested	L-1-8	4/25/2004	9/10/2003	228	
Beneficial Occupancy of Service Buildings at Fermilab	L-2-11	5/31/2004	12/12/2003	171	
Start Commissioning with Both Near and Far DAQ	L-2-21	8/30/2004	4/1/2004	151	
Complete Installation of Horn Power Supply	L-2-17	9/1/2004	9/18/2003	349	
MI Stub Installation Complete	L-2-15	3/11/2005	10/1/2004	161	
Near Detector Complete & Tested	L-2-14	3/31/2005	9/24/2004	188	
First Horn Installed	L-2-13	4/7/2005	5/25/2004	317	
Start Commissioning	L-1-9	9/1/2005	12/8/2004	267	
CD-4 Start Operations	L-0-3	9/30/2005	1/19/2005	254	End of Commissioning

Beam in 21 months



MINOS

Financial Summary as of January 31, 2003

WBS	Amount	Estimated	ETC	%	Obligated		Contingency	
	Authorized	Cost	(BAC - BCWP)	Complete	\$	%	\$	%
As of January 31, 2003								
TEC	109,242	97,608	27,473	72%	84,092	86%	11,634	42%
1.1		26,311	12,372	53%	15,662	60%		
1.2		66,867	13,689	80%	66,103	99%		
1.3		4,430	1,411	68%	2,327	53%		
OPC	62,200	58,773	6,493	89%	54,053	92%	3,427	53%
2.0		42,554	6,477	85%	38,272	90%		
3.0		16,218	16	100%	15,781	97%		
TPC	171,442	156,381	33,966	78%	138,145	88%	15,061	44%

Report Date	% Complete
March 2002	62% with \$64M to go
September 2002	73% with \$45M to go
March 2003 (PROJECTION)	81% with \$30M to go

*Work proceeding at
\$2.5-3M/month*

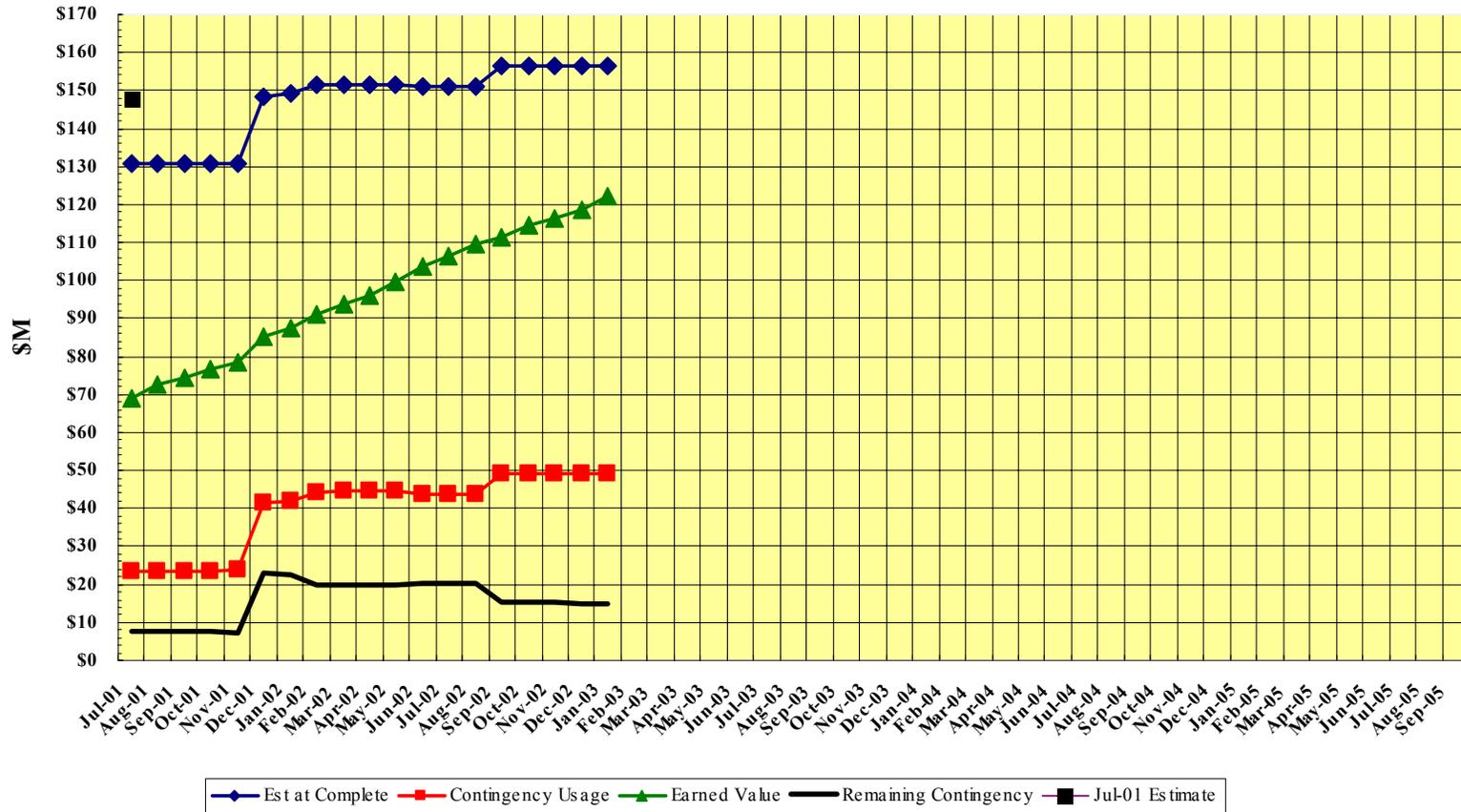
*\$30M progress in the last 10
mos*

Remaining contingency OK



NuMI Project Status

NuMI Total Project Cost





Progress in “2002” (since last March)

- Underground excavation completed successfully and contract closeout underway.
- Outfitting underway and largely on schedule
- Installation schedule fully developed and more equipment installed in Main Injector enclosures
- Primary Beam re-design completed; under construction
- First of the two Far Detector Super-Modules completed and taking physics data; the second on schedule for Summer 2003
- Full scale production of technical components underway. System designs complete.
- Near Detector Plane Pre-assembly complete. ND Electronics production underway.
- Successful beam tests of electronics: CALDET.



Expected Progress in 2003

- Far Detector: complete and taking physics quality atmospheric neutrino data
- Summer Installation in Main Injector enclosure—magnets, crane, instrumentation, and more
- Technical Component fabrication peak year
- Finish Service Buildings and Outfitting; progress on closeout of Tunnels and Halls
- Fall Installations begin at Target and MINOS sites
- ES&H Performance continuing to improve
- Planning for “readiness reviews” including SAD
- Beam studies in FMI and Booster underway



Conclusion

-
-
- We remain on the schedule and budget established in June 2001
 - Service Buildings & Outfitting contract well underway. Needs constant attention by the construction office staff; staff is up to the job. Complete in the Fall 2003.
 - Technical components team is meeting its 2003 plan.
 - Far Detector doing physics, finishing far construction, near electronics project underway on schedule.
 - Successful installation during Jan. shutdown. Focusing on summer shutdowns (2003 and 2004).
 - Last year was a good year, not easy, but good. We are looking forward to the next stages of the NuMI Project.