NuMI

MINOS

NuMI Project CD4 Commissioning

Critical Decision 4 (CD4)

Commissioning

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Fermilab

- NuMI Commissioning
- CD4 Commissioning
- Brief comments on "other" commissioning
- Concluding Remarks

Commissioning Types

- Pre-commissioning and checkouts
  - NuMI Technical Components Commissioning Plan , March 24, 2003
  - MINOS Detector commissioning during installation
- CD4 commissioning (this talk)
- Main Injector commissioning for operation
- NuMI beam commissioning for physics
- MINOS detector commissioning for physics

What is CD4 Commissioning?

- DOE construction projects pass through several official phases marked by "Critical Decision" points (CD) during their lives.
- There are four of these Critical Decision points in the life the NuMI:
  - CD1: Approve Mission Need (1997)
  - CD2: Approve Baseline (1999)
  - CD3: Start Construction (1999)
  - CD4: Start Operations
- Critical Decision 4 (CD4) will be issued after specific technical goals defined in the DOE's NuMI Project Execution Plan (PEP) are achieved.

NuMI CD4 Goals

- CD4 goals were established in 1999 and modified to account for the low energy beam in 2001 during the re-baseline of the project.
- When DOE is satisfied that the CD4 goals are attained (more on this later), it declares the project "commissioned" and gives permission to "start operations".
- What most of us think of as "commissioning" ***begins***, not ends, at that point.

NuMI CD4 Goals

- In the earliest stages of a project it is easier to make poor choices for CD4 goals than it is to make good choices.
- During the re-baseline process, we were mindful of examples of goals from other DOE projects that turned out to be too ambitious or too trivial.
- Commissioning requirements for NuMI were developed to:
  - Demonstrate a functioning Far Detector (atmospheric neutrinos and muons)
  - Demonstrate a functioning Beamline and Near Detector (with beam neutrinos)

DOE Project Execution Plan excerpt:

The critical technical goals of the NuMI project are listed in Table --a and --b. The commissioning goals are the parameter values that must be achieved for approval to start operations (Critical Decision 4) and are given in Table --a. The operational goals, which are needed for the project to accomplish its scientific objectives, are expected to be reached after several years of operation. Operational goals are given in Table --b. The NuMI project will have sensitivity to a wide range of parameter space to search for neutrino oscillations. Recent scientific results from Japan strongly indicate the most promising area to search within this parameter space. The project will begin in its "Low Energy" beam configuration. The commissioning goals will use cosmic rays and atmospheric neutrinos to demonstrate the effectiveness of the far neutrino detector. Measurements made with the beamline monitoring instrumentation will assure that the neutrino beam is aimed correctly at the far detector. While it is a goal to observe NuMI beam neutrinos in the far detector at the earliest stages of operation, it is recognized that Nature's value for neutrino oscillation parameters may preclude detection of neutrinos until substantial (operational-level) proton intensities have been delivered. These commissioning goals shall not require undue radioactivation of the target station components.

PEP Commissioning Goals

Parameter	Measurement	Commissioning Goal
Proton intensity in target hall	Toroid (or equivalent) beam intensity monitor at entrance to the Target Hall	Greater than $1x10^{12}$ 120 GeV protons/spill
Beam alignment	Transverse distributions of the proton beam and secondary beams.	Proton direction established to within 1 mr of the known direction to the Far Detector in the Soudan mine.
Neutrino beam energy	Near detector event energy	Low energy, 2-4 GeV
Cosmic ray muons detected in the MINOS Near Detector	Near Detector data read out through DAQ system	Majority of the 153 Near Detector planes sensitive to muons
Near detector neutrino flux	Charged current event rate in 1.5 ton fiducial region	Observe neutrinos in the Near Detector produced by the NuMI beam
Cosmic ray muons and atmospheric neutrinos detected in each of the two MINOS Far Detector Super Modules	Far Detector data read out through DAQ system	Majority of the 484 planes of the Far Detector sensitive to muons and atmospheric neutrinos.

Table 1(a) Technical Commissioning Goals

PEP Commissioning Goals

Parameter	Measurement	Commissioning Goal
Proton intensity in target hall	Toroid (or equivalent) beam intensity monitor at entrance to the Target Hall	Greater than $1x10^{12}$ 120 GeV protons/spill

One or more spills of at least 1E12 120 GeV protons will be extracted from the Main injector and register on the on the toroid located in the NuMI pre-target area. Documentation of achievement will be a copy of an AD control system page showing magnet currents and the toroid readout.

PEP Commissioning Goals

Parameter	Measurement	Commissioning Goal
Beam alignment	Transverse distributions of the proton beam and secondary beams.	Proton direction established to within 1 mr of the known direction to the Far Detector in the Soudan mine.

The neutrino beam is approximately 1km wide 735km away at Soudan and its direction is established by the proton beam at Fermilab . This goal will be met by measurments in beamline instrumentation in the proton transport system combined with instrumentation at the end of the 675 meter decay pipe.

PEP Commissioning Goals

Parameter	Measurement	Commissioning Goal
Neutrino beam energy	Near detector event energy	Low energy, 2-4 GeV
Near detector neutrino flux	Charged current event rate in 1.5 ton fiducial region	Observe neutrinos in the Near Detector produced by the NuMI beam

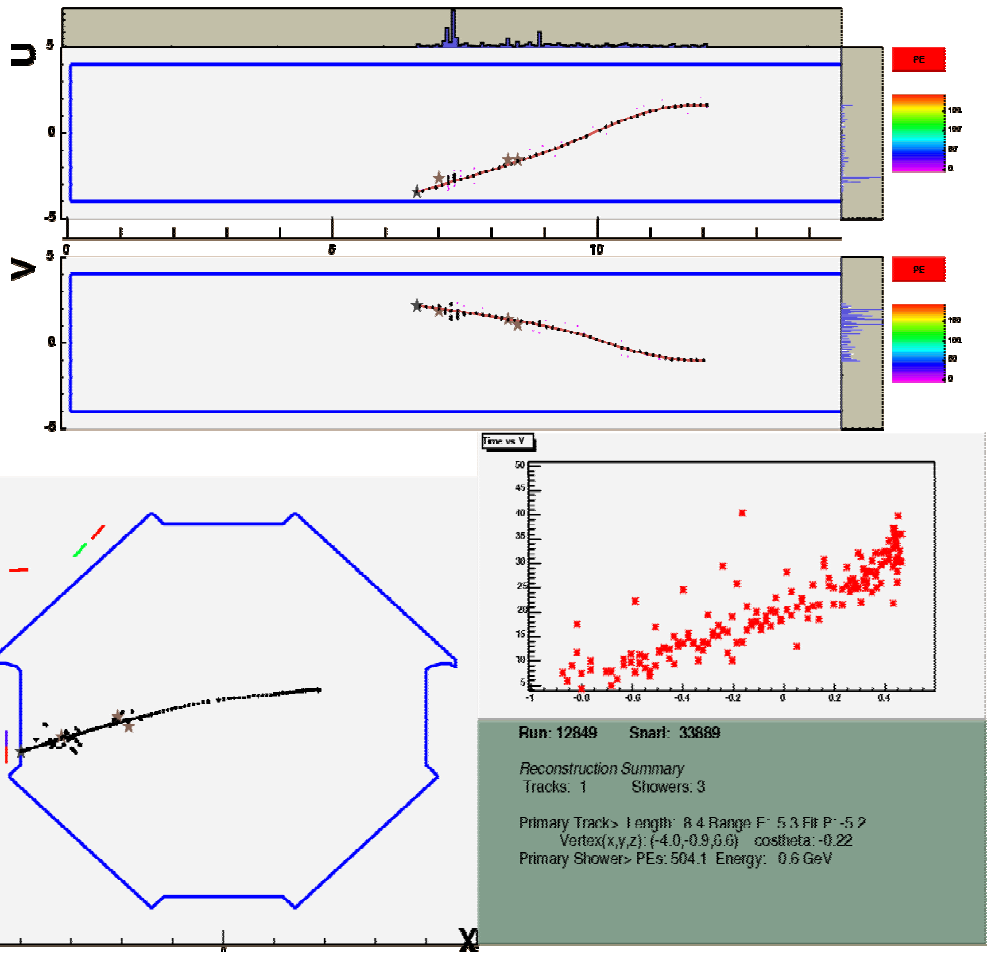
A few charged current muon interactions observed in the near detector and read out throught the DAQ system will be observed in coincidence with the short 10 microsecond proton beam spill. The general direction of the muon tracks will further indicate that the proton beam was the source of the muons. The approximate energy of the muons will be determined by the tracks' range in the near detector.

PEP Commissioning Goals

Parameter	Measurement	Commissioning Goal
Cosmic ray muons detected in the MINOS Near Detector	Near Detector data read out through DAQ system	Majority of the 153 Near Detector planes sensitive to muons
Cosmic ray muons and atmospheric neutrinos detected in each of the two MINOS Far Detector Super Modules	Far Detector data read out through DAQ system	Majority of the 484 planes of the Far Detector sensitive to muons and atmospheric neutrinos.

Muons from cosmic rays will be observed in both the Near and Far MINOS detectors. Additionally atmospheric neutrino interactions will be observed in the Far detector. A plot such as the one on the next slide from the Far Detector DAQ will verify that the majority of the planes are efficient. (The plane efficiency is certainly in the upper 90% range.)

Atmospheric Neutrinos in Far Detector



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

Analogous plots for Near Detector events will be produced

PEP Operational Goals (after years of operation)

Parameter	Measurement	Operational Goal
Proton intensity in target hall	Toroid (or equivalent) beam intensity monitor at entrance to the Target Hall	$4x10^{13}$/spill $3.6x10^{20}$/year
Beam alignment	Transverse distributions of the proton beam and secondary beams.	Neutrino Beam centered on Far Detector to +/-0.2mr
Neutrino beam energy	Near detector event energy	Low energy, 2-4 GeV Medium energy, 4-8 GeV High energy, 8-16 GeV
Near detector neutrino flux	Charged current event rate in 1.5 ton fiducial region	$1.5x10^{-15}$ events/proton
Far detector neutrino flux*	Charged current event rate	$4x10^{-18}$ events/proton
Muon momentum resolution +	Curvature vs. range in magnetic overlap region	14%
Hadron energy resolution +	Test beam	$\Delta E/E = 70\%/E^{1/2} + 8\%$
Detection efficiency for charged current events +	Event length distribution	90% with <4% neutral current contamination

*Assuming 50% reduction from neutrino oscillations
+Applies to both near and far detectors

Table 1(b) Technical Operational Goals

Comments on other commissioning

- We have commissioning plan for technical components (plan link is on http://www-numi.fnal.gov/projectdocs.html)
- Fermilab Main Injector has plans for evolution to initial operational intensity capability by late 2004:
  - 2.5E13 protons , 5/6 batches, 5E12 in Booster , 1.9s cycle
- Joint NuMI/FMI commissioning workshop in the Spring
- Detector commissioning includes above ground pre-commissioning as well as plane by plane during installation

Concluding Remarks

- Soon we will document these CD4 criteria in a brief memo to the DOE NuMI Project Director (a'la FMI).
- Plan to present our achievement of the Far Detector CD4 goal before the May DOE review of the project.
- Achieve CD4 ASAP after the 2004 shutdown.
- Move to operational and physics commissioning
- Spring 2004 Commissioning Workshop between NuMI and FMI
- Link to Technical Components and Main Injector commissioning plans:
  - http://www-numi.fnal.gov/internal/local_access/doe_nov_03_review/Commissioning.html