

*Department of Energy
Review Committee Report*

on the

Technical, Cost, Schedule, and
Management Review

of the

**NuMI OFF-AXIS
NEUTRINO APPEARANCE
(NO ν A) EXPERIMENT**

July 2009

EXECUTIVE SUMMARY

During the period of July 21-23, 2009, a Department of Energy (DOE) Review Committee conducted a review at Fermi National Accelerator Laboratory (Fermilab) of the NuMI Off-Axis ν_e Appearance Experiment (NOvA) Project. The review was undertaken at the request of Dennis Kovar, Associate Director for the Office of High Energy Physics (OHEP). The Review Committee was chaired by Daniel Lehman, Director of the Office of Project Assessment. The purpose of the review was to assess the progress made since the previous DOE review that was conducted in April 2008. Also, the purpose of this review was to evaluate the project's readiness to proceed to Critical Decision (CD) 3b, which will authorize the remaining 150 million dollars of work. In October 2008, the project requested and was granted approval for CD-3a, which included: construction activities at the Ash River site, Fermilab Accelerator/NuMI upgrades, and some long lead procurements. CD-3b is currently scheduled for October 2009.

The Committee was asked to evaluate whether the remainder of the final design is mature/complete and whether the project is prepared to enter the construction phase beyond the CD-3a and American Recovery and Reinvestment Act (ARRA) approved activities. The Committee was comprised of 20 technical and management experts from DOE national laboratories, DOE headquarters, and U.S. universities.

The NOvA project proposes to upgrade the Fermilab Proton Source and the existing NuMI beam line and construct two new detectors optimized to detect electron neutrino interactions in order to observe the oscillation of muon neutrinos into the electron neutrinos and measure the parameters of that oscillation. One detector (222 tons) would be located on the Fermilab site and one (14,000 tons) would be approximately 800 kilometers away at a northern Minnesota site.

Considering the NOvA project's funding profile in the last two years, significant progress has been made since the CD-2 review. In general, the Committee felt that there were no significant technical risks that would jeopardize the project. However, the Committee has expressed serious concern with the lack of dedicated resources to support the project as this has already resulted in project delays, especially in the areas of Fermilab Accelerator/NuMI upgrades and could also impact the Near/Far Detector Assembly. This situation is further compounded with the opportunity to advance the schedule to take advantage of the 55 million dollars provided by the ARRA in FY 2009.

Overall, the Committee recommended approval of CD-3b as soon as the project schedule is updated, reviewed, and evaluated (by Fermilab) to take into account the revisions that have occurred in funding profile, and the currently anticipated changes in resource allocation and work planning.

The Committee noted the following in the respective technical areas:

- In the area of Accelerator/NuMI Upgrades the Committee judged that the project and the Laboratory have made efficient use of off-project programs that are necessary for NOvA completion, examples are the modification of the 700kW NuMI horns and the production of the gap clearing kicker for the main injector.
- Regarding commodities which include the PVC extrusions, fiber, and scintillator, the ‘just-in-time’ purchase of oil, pseudocumene, and PVC resin and additives carries cost and availability risk. A re-investigation of early procurement and storage (in whole or in part) to reduce these risks is strongly encouraged.
- Progress has made on the Near/Far Detector Assemblies as the module lifter and gluing machine have been prototyped at full scale. Time and motion estimates for Far Detector block assembly have been validated, with minor adjustments, via experience gained in the construction of the Full Size Assembly Prototype.

It was noted that construction of the Ash River Site is underway (approved as part of CD-3a with no technical issues identified. Six bids were received and the successful bid was below the CD-3a estimate. The general contractor preliminary construction schedule has the project being completed three months earlier than the baseline schedule. Construction of the access road is under way and the first round of rock removal took place on July 20, 2009. Final Design of the Near Detector Cavern has not started, no technical issues have been identified, and the preliminary cost estimate appears reasonable.

Within the areas of cost, schedule, and funding it was determined that the schedule is assumed to be constrained by labor resources; this hinders the opportunity to take advantage of schedule advancement opportunities. The project’s ‘to-go’ contingency of 46 percent is healthy.

The Committee judged that the tools are in place and operating to successfully manage the project, but management should make more use of project management tools for what-if scenario analyses. Delineation of ‘unassigned contingency’ is unclear, especially with respect to planning for future contingency use when risk is retired. For the contingency, the project should distinguish between those funds that are estimated to mitigate specific risks, and those that are unencumbered and could be used for enhancements or acceleration of the project.

CONTENTS

Executive Summary	i
1. Introduction.....	1
2. Technical.....	3
2.1 Accelerator and Beam Lines (WBS 1/2.0)	3
2.2 Sites and Building (WBS 1/2.1)	6
2.3 Commodities: PVC Extrusions, Fiber, Scintillator..... (WBS 1/2.2, 1/2.3, 1/2.4)	9
2.4 PVC Module Production (WBS 1/2.5)	10
2.5 Electronics and Data Acquisition (WBS 1/2.6, 1/2.7).....	13
2.6 Near/Far Detector Assembly (WBS 1/2.8, 1/2.9).....	15
3. Environment, Safety and Health.....	21
4. Cost, Schedule and Funding	23
5. Management.....	25

Appendices

- A. Charge Memorandum
- B. Review Participants
- C. Review Agenda
- D. Schedule Table
- E. Funding Chart
- F. Management Chart

1. INTRODUCTION

The NOvA experiment will utilize the NuMI beam source (Neutrinos at the Main Injector or NuMI) at the Fermi National Accelerator Laboratory (Fermilab) to search for Off-axis electron neutrino (ν_e) Appearance. The experiment will study the as-yet unobserved transformation of muon neutrinos into electron neutrinos, with the goal of understanding the mass hierarchy of the different types of neutrinos and the likelihood that CP violation occurs in the neutrino sector. Fermilab's NuMI source produces the world's most intense neutrino beam, the NuMI neutrino beam.

The DOE Office of High Energy Physics (OHEP) requested this Independent Project Review of the NOvA project, for the purpose of evaluating the project's readiness for approval of full construction, CD-3b. The review was chaired by Mr. Daniel Lehman on July 21-23, 2009 at Fermilab.

The NOvA project scope consists of modifications to the existing Fermilab proton accelerators to increase the beam power to 700 kW, improvements in the NuMI beam line to handle the increased power, and the construction of two neutrino detectors: a Near Detector located 1 km from the NuMI target, in a cavern to be excavated on the Fermilab site; and a Far Detector optimized for detection of electron neutrinos, to be constructed in a dedicated housing 810 km away in Northern Minnesota. The Far Detector housing will be partially below grade and will include adequate space and infrastructure to facilitate construction and operation of the Far Detector. It will be shielded from above for cosmic rays by a layer of concrete and barite aggregate. Both detectors will be tracking calorimeters, constructed from PVC extrusions containing liquid scintillator and wavelength-shifting fiber, read-out with avalanche photodiodes. The Near Detector, with a mass of 222 tons, will measure the flux of muon neutrinos produced. The Far Detector, with a mass of 14,000 tons, will be optimized for detecting 2-GeV electron showers while rejecting background events. The Far Detector will measure 16-meters wide, by 16-meters tall, by up to 80-meters long.

The Department of Energy (DOE) Office of Science (SC) approved the sequence of Critical Decisions (CD) for the Electron Neutrino Appearance experiment, so far as follows: the Mission Need (CD-0) was approved in November 2005; the Alternative Selection and Cost Range (CD-1) was approved in May 2007; the Performance Baseline (CD-2) was approved in September 2008; and the Start of Limited Construction (CD-3a) was approved in October 2008.

The project's progress slowed in December 2007 when the FY 2008 Omnibus Spending Bill zeroed-out the project's funding. However, the management team was able to replan and continue work at a low level, and some project funding was restored with the FY 2008 supplemental appropriation.

The project was revived in the FY 2009 appropriation. The 2009 American Recovery and Reinvestment Act (ARRA) accelerated the obligation profile significantly compared to the baseline, permitting some long-lead procurements of civil construction and ready-to-go or sole-source materials to accelerate, thereby reducing risk and locking-in favorable prices due to prevailing economic conditions. At the same time, however, slow remobilization of some of the project's critical labor resources following the interruption of funding caused staffing to lag behind the resource-loaded baseline schedule in some areas. Concern over this discrepancy between the baseline schedule and the working schedule is the subject of several of the findings, comments, and recommendations of this report.

Nevertheless, the project's working schedule and revised Estimate To Complete take advantage of the opportunity to advance completion of the Far Detector by several months relative to the baseline, as a result of the accelerated funding by the ARRA (provided that the risks remaining in the project are adequately managed). The estimated cost at completion remains within the approved Total Project Cost of \$278 million with adequate contingency. The CD-4 milestone is November 2014, with ten months of schedule contingency in the baseline schedule.

2. TECHNICAL

2.1 Accelerator and Beam lines (WBS 1/2.0)

2.1.1 Findings

The scope in the Accelerator and Beam Lines (WBS 2.0) includes upgrades to the accelerator and NuMI target and is known as “Accelerator and NuMI Upgrades” (ANU) within the project. The scope of the accelerator portion of the project is to provide the capability of increasing the beam power of the 120 GeV beam from the Main Injector (MI) from 400kW presently on NuMI to 700kW on NOvA. For NOvA, the MI has to accelerate $4.8E13$ protons to 120 GeV every 1.33 sec. This involves changes to the Recycler Ring (RR) and MI. The RR changes include:

- A new injection line into the RR.
- A new extraction line from the RR.
- A new 53 MHz radio frequency (RF) system.
- Upgrade of the beam instrumentation.
- A new RR low-level RF (LLRF) system.

The MI changes include:

- Two 53 MHz cavities.
- A quadrupole power supply upgrade for faster cycling.

Work has continued off-project on the gap-clearing kicker (GCK), which addresses an important ALARA (as low as reasonably achievable) issue for the RR injection line installation; it should mitigate the significant activation of the injection dipole. This was considered to be one of the more technically challenging designs. It will first be installed and commissioned in the MI, and later replicated in the RR.

The status of the RR work was presented. Injection line optics is complete with future design work including modifications to existing magnets and one new magnet design. Extraction line optics is complete and again modifications are required to existing magnets. The RF system requires a new cavity design but this is similar to existing cavities and not considered a design challenge; the copper is on order this was included in the CD-3a list. The GCK discussed above is complete and ready for installation in the summer shutdown.

The status of the MI was presented. Both RF cavities that were built from existing spares have been conditioned and tested and work has started on the two bias supplies. The cavities will be installed at locations where penetrations in the tunnel already exist. Bus bars for the cavity tuners were moved off-project and the work is now complete.

All the kicker systems need leak-tight ceramic beam tubes and the project has been working with five different vendors to establish a sound procedure for brazing the kovar flanges onto the alumina beam tubes. The vendors have had varying success but the project now has eight leak-tight tubes on site and seven of these will be installed with kickers during the shutdown.

The scope of the NuMI portion of the project includes:

- Design of a new medium energy target (700 kW) and associated equipment.
- Reconfiguration of the shielding and relocation of Horn 2.
- Upgrade cooling and power supplies.

The target is being designed by the Institute of High Energy Physics (IHEP) in Russia, the institute that designed the existing low energy target. The design is at advanced stage and checks of the finite element analysis are being completed by project personnel. All technical difficulties seem to have been overcome. The NuMI primary proton beam is at the 90 percent design stage. Design analysis work on the modification to Horn 1 is also advanced thermal analysis models presented confirmed a sound engineering design. Target hall infrastructure, which includes the Horn 2 relocation shielding re-configuration, etc., is at the 80 percent design stage, this work has been well planned and the removal/installation design presented was sound. Cooling and utilities are at the 60 percent design stage and is on-going.

2.1.2 Comments

The Committee commended the team for the significant progress made since the CD-2 review—this is even more impressive considering the budget problems in the last two years and the effect that this could have had on moral and team building. This is an experienced, motivated, and very competent team.

The project and the Laboratory made efficient use of off-project programs that are necessary for NOvA completion, examples are the modification of the 700 kW NuMI horns, the production of the GCK for the MI and the bus bars for the RF cavity tuners.

The Committee considers the major impediment towards advancement of remaining design work on accelerator and beam lines will be manpower availability. NOvA competes with Operations (Tevatron, NuMI) and with other efforts in the Accelerator Division (Project-X, R&D).

The areas of design that are not yet completed do not seem to present significant technical risks and the Committee was confident that the very competent NOvA team has the necessary technical expertise well in hand. The main risk is associated with potential insufficient resources and schedule delays.

The operational experience with the low energy target and NuMI operations is important to plan operations and improve reliability of the NOvA beam line.

The Tevatron will potentially end operations at the end of FY 2011. At present RR installation and beam line installation start well into 2012. This presents the project with an opportunity to advance the schedule.

The project team should identify what resources are necessary to advance the schedule for accelerator and beam lines to the end of FY 2011 and merge the RR and NuMI shutdowns.

The scope of removal/installation work is wide enough that plans for shutdown coordination should be put in place as soon as possible.

During discussions with staff regarding installation activities in areas of the accelerator that will be activated and the work required in the target hall it is obvious that ALARA principles are being addressed during the design process. This is commendable and undoubtedly based on past experience of the team members.

During the CD-2 review WBS 2.0 was reviewed extensively with regard to the credibility of cost and schedule estimates. Discussions with project staff revealed that their basis of estimates had not changed to any extent therefore no review was carried out.

2.1.3 Recommendations

1. Determine the resources required to complete the work and obtain a commitment from the laboratory management to supply the necessary resources. Update the resource loaded schedule to reflect the updated planned commitment.
2. Identify a shutdown coordinator to work on detailed organization of the complex

shutdown activities.

2.2 Sites and Building (WBS 1/2.1)

2.2.1 Findings

The final design of Near Detector Surface Enclosure has not been completed. Alternative construction materials have been evaluated and precast concrete has been identified as the preferred material.

No technical issues were identified. The facility will house the Near Detector until the underground cavern is ready to have the detector installed. The estimated cost of construction appears to be adequate and maybe a little high for the structure.

The project team should proceed to complete final design and then construct the enclosure prior to the arrival of the detector. The design is a relatively small expense and the project would be well-positioned to receive the detector and take advantage of the construction market and any schedule recovery from the fabrication and installation of the near detector.

The final design of the Near Detector Cavern has not started. No significant technical issues have been identified. The preliminary cost estimate and contingency appear reasonable.

The selection of the Architect/Engineer (A/E) for the final design has been selected and a proposal is under negotiation. The award of the contract to the A/E has a good possibility of being expedited since Fermilab has an on-call contract for design services. The final design of the Near Detector Cavern could take up to 12 months to complete.

The project plans to issue the resulting bid documents early enough to award a construction contract six months ahead of the planned year-long shutdown.

Construction of the Far Detector Building at the Ash River Site is underway (approved as part of CD-3a). There are no technical issues that have been identified. The construction contract bid was under the estimate and the schedule for completion is shorter than the Request for Proposal. The access road and building contracts were combined into a single construction contract primarily due to the additional funding received by the project.

The contractor successfully completed the first round of excavation on Monday, July 20, 2009. Congratulations.

The project is appropriately staffed for the design and construction of the project facilities. The technical issues that remain are routine and pose no specific problems. Costs are tracking well, especially with the award of the construction contract. Management is committed to providing the funding necessary for the remaining design effort to begin very soon.

2.2.2 Comments

The design and construction of the cavern pose no technical issues. The size, shape, and location of the cavern are based on preliminary, two-dimensional geotechnical analyses in shale.

The ground is well characterized. The new underground construction represents approximately ten percent of the previous excavated volume for the MINOS cavern and due to its proximity, the ground around the Near Detector Cavern is well known and understood.

The most significant aspect of the design for the new cavern is the size of the rock pillar that will remain between the new and existing tunnel/cavern. The size of this pillar will be evaluated during the final design.

A second access will be provided between the two caverns for emergency exit reasons. The second access will also provide an alternative path for utilities and may simplify the ventilation of the completed cavern.

The preliminary cost estimate is reasonable and complete. Two separate cost models have been provided by separate consultants. The cost models were reconciled and the construction method was selected. This will assist with the preparation of the final design and future construction cost estimates.

The design phase should be completed as soon as possible. Complete the design in time to award a construction contract well in advance of the planned beam shutdown. Assuming some conservative durations for the design and construction periods, the final design should start within the next few months. This will provide the best opportunity for the project to meet schedule for installation of the six-block detector test assembly in the Near Detector Cavern.

Negotiations for the final design are underway with a selected A/E firm with experience at Fermilab so the project is well positioned to take advantage provided the funding is released soon. The design cost estimate needs some review to align with the current construction plan.

Fermilab has on-call contracts with several A/E firms so awarding this design should not be a prolonged process. The duration is estimated to be 12 months and this should allow the advertising for construction to proceed in time for contract award well in advance of the planned year-long shutdown.

Fermilab has assigned the key staff to undertake this task. The task is appropriately staffed to undertake the final design of the Near Detector Cavern.

Construction of the Far Detector Building at the Ash River Site is underway. No significant technical issues have been identified. Six bids received and they were within 1.3 percent of each other. To mitigate risk on the site an Unforeseen Condition clause was added to the bid package and the successful general contractor accepted this clause. The successful bid was \$15 million below the CD-3a estimate. The general contractor preliminary construction schedule has the project being completed three months earlier than the baseline schedule. Construction of access road is under way and the first round of rock removal took place on Monday. A key staff member is assigned to manage this project for Fermilab in conjunction with University of Minnesota (UM), which will oversee the construction.

2.2.3 Recommendations

1. Award the final design contract for the Near Detector Cavern and the Near Detector Surface Enclosure by October 1, 2009.
2. Re-evaluate contingency for the various projects. Suggest 15 percent contingency estimate be added to the construction (Ash River Project) for owner-directed and contractor changes. Suggest 30 percent contingency estimate for work to go on the Near Detector Facilities. Complete by October 1, 2009.
3. Prepare a list of tasks that can be advanced to the benefit of the project. This list should include purchase of equipment and materials that can be purchased now and effectively obligate the current funding. Complete by September 1, 2009.

2.3 Commodities: PVC Extrusions, Fiber, Scintillator (WBS 1/2.2, 1/2.3, 1/2.4)

2.3.1 Findings

Commodities include the PVC Extrusions, Fiber, and Scintillator. The design is at the approximately 95 percent level (varying from approximately 80 to 100 percent). The Commodities are fully specified and vendors have been identified. Quality control/quality assurance (QC/QA) procedures and the shipping and transportation plans are well defined and there was substantial progress in the manufacture of fixtures and measuring devices during the R&D phase.

The cost and schedule contingency appear adequate with a few concerns as discussed in the comments below. The mineral oil costs assume a crude oil price of \$75/barrel with increased contingency that would cover a price up to \$128/barrel. There is only one vendor (Kuraray) for the fiber; however, there is a reliable quote for a fixed fiber price (Japanese Yen). The schedules for PVC Extrusions, Fiber, and Scintillator have been advanced recently by five to ten months. CD-3a has allowed for the purchase of waveshifters (purchase order issued), PVC extrusion tooling, and the purchase of 1000 km of fiber.

Overall, there are clear lines of responsibility in the groups responsible for purchase and qualification of the commodities, and the personnel involved are experts in their field and well aware of the various problems that may arise.

2.3.2 Comments

Just-in-time purchase of oil, pseudocumene, PVC resin, and additives carries cost and availability risk. The Committee encouraged a re-investigation of early procurement and storage, in whole or in part, to reduce these risks. The Committee also encouraged consideration of increasing the baseline amount of fluor by 20 percent. This would increase light output by ten percent and would reduce the number of modules that do not meet the goal of 28 photoelectrons. In addition, the assigned waste fractions in the base purchase of some commodities (0 percent on scintillator elements and three percent on fiber) are very small. A more pessimistic waste assumption might be more appropriately included in the base cost and not as part of cost contingency.

Extrusion costs (greater than \$10 million) are based on a quote from a single vendor dated May 2007. The risks of reliance on a single vendor may mean that contingency of 25 percent is too small.

Documentation of wavelength shifting fiber QA/QC is required for CD-3b. The procedures are well developed, and a document incorporating results from R&D spools is in preparation.

2.3.3 Recommendation

1. Procure the PVC Resin, Extrusions, Fiber, and Scintillator as soon as needed.

2.4 PVC Module Production (WBS 1/2.5)

2.4.1 Findings

The PVC module factory in Minneapolis will produce 11,000 modules in two years at the rate of 30 modules per day. This production includes installation of wavelength shifting optical fibers in each cell to readout the scintillator. The ends of the PVC extrusions are closed with a set of molded seals to prevent leaks. At one end of the PVC extrusions is a manifold that provides the ability to fill the extrusions with liquid scintillator, as well as guiding the optical fibers into each cell. The factory will occupy at 60,000 square feet space with an additional 65,000 square feet space for storage of both extrusions and finished modules. This represents a change in plans from the original just-in-time production to a plan that provides storage space to buffer the extrusion production, as well as storage space for the finished modules since the Ash River site will have very little storage space.

The production steps have been carefully studied and each separate operation has been timed to show the production of 30 modules per day with a crew of roughly 35-40 people is possible. The factory is expected to operate roughly ten hours per day. They plan to use mostly student labor for this production. Safety oversight is provided by the UM according to Fermilab and Occupational Health and Safety Administration (OHSA) rules as detailed in a Memorandum of Understanding (MOU).

2.4.2 Comments

The Committee commended the UM team for the good work accomplished since the October 2007 DOE/SC review. In particular, the two-glue solution provides a strong structural seal of the PVC extrusions. Many of the molded pieces have been prototyped.

However, as a result of the lack of funding during FY 2008, the design and prototyping of the module production was severely impacted. The major result of this interruption was the

delay in the final design and production of molded parts for the manifold. This delay has impacted not only the finalization of the module design, but has also delayed any prototype production of full-size modules. Hence they have not been able to finalize the transportation plans for the final modules to Ash River, and the prototyping of the final assembly process with the manifolds has been delayed.

Many details remain to be addressed or validated, but in most cases these details are known and it is UM's intent to address them. The design for the individual components is very well known and the project team demonstrated its intimate knowledge. The details that need to evolve mostly relate to the assembly of the modules and the interface between the components. Some gluing joints are 'blind', in that the glue is injected into a completely enclosed cavity and the only evidence of fill is glue exiting the port on the opposite side of the injection port. Since there are two paths in the manifold injections, it is possible that one path is not adequately filled and this should be investigated when parts are available. The production components that retain or route the fibers have been available for only a short time and it is possible that some locating glue will be used. There has been no evaluation of the flow paths or rates for the scintillator filling operation, and some operational experience is needed before finalizing the designs.

The factory requires a number of ancillary mechanical aids, such as lifting fixtures, tilting tables, transportation aids, etc. In general, these are of fairly simple design but will impact the safe operation of the factory. The vacuum lifter has not been analyzed for stress and is not designed to any standard. The design of this lifting device should conform to ASME BTH-1 and ASME B30.20 that establish the accepted safe practice for design and operation of below-the-hook lifting devices. Similarly, the operation of the lifter depends heavily upon the integrity of the vacuum cups, but the inspection, maintenance, and replacement schedule has not been specified. An adequate inspection, maintenance, and replacement schedule is necessary for safe conduct of lifting operations. The manufacturing operations will rely significantly on 150 tilting tables, which is a sound idea, but these devices have not been engineered nor manufactured to an inspection program to assure adequate life for the intended operations. These devices will be used by students to support and handle objects approaching 1,000 pounds, and safe operation requires adequate safety factors and inspection. Other handling devices, if any, require similar evaluation.

Installation and integration requirements can have a significant impact on the detector engineering and design. Close coordination between the detector design and engineering effort and the project integration/installation group is very important to develop a final design that incorporates the overall needs and requirements of the experiment. For example:

- The final design of the vertical module base requires an understanding of the actual method used to support the detectors. The final design should complement the support conditions used to calculate the chamber design stresses.
- Final assembly tolerances and requirements needed for installation in the experiment.
- The scintillator oil filling system design and filling procedures can influence the chamber design:
 - Parts' design and the test pressures used during chamber assembly should be based on the maximum possible oil head pressure that the chambers could be exposed to during filling, operations, and draining/oil removal.
 - Is an over-pressure device required, e.g., a pressure relief valve?
 - Should a visual oil-level indication or another method of oil-level indication be incorporated into the design.
- The present manifold design contains a provision for the removal of oil from a horizontal chamber, however there is no provision for removal of oil from a vertical chamber.

The UM team has made significant progress in developing some training and assembly procedures, and in the development of a database for recording component and module parameters, but all the documents have not been completed. The UM quality assurance plan and its implementation for the Far Detector module production should be reviewed for completeness and conformance with the NOvA QA Plan. The rest of the documentation of assembly, test, and training procedures needs to be completed before module production can proceed.

Potential issues have not been completely evaluated or the evaluations have not been documented. The UM team did not believe PVC dust from cutting operations would be an issue for detector performance, but the discussion indicated that the possibility would be remote given the cleaning or assembly operations specified. The possibility of O-ring contamination of the scintillator should be investigated. The potential for fiber fatigue during shipment has not been completely evaluated, but some testing has been conducted and not documented. The complete range of potential contaminants to the scintillator should be evaluated and documented. Fiber fatigue, and other potential impacts to the modules due to shipping need to be evaluated and documented.

Externally, vertical, and horizontal modules will look the same, but the potential to inadvertently interchange modules in the block buildup is significant. Theoretically, module identification should prevent this, but a more obvious identifier, like a color code, will make the proper identification readily apparent to all workers and not just those that can read the bar code.

An evaluation of all aspects of module assembly needs to be completed and documented. The original design considered a 32-cell extrusion, but the final design uses two 16-cell extrusions glued together. The extrusions are banana shaped, the quantity of glue along the gluing length is not controlled, and only the clamping pressure along one edge is controlled. This can permit significant variation in the alignment and shape of the two extrusions. On a module level this may be small but may become significant when the modules are stacked. The requirements for misalignment and nonuniformity have been specified, but they should be evaluated in a full-size prototype assembly. Other gluing surfaces may have a similar impact, so all gluing surfaces should be evaluated for the potential impact that glue quantity nonuniformity could have on module dimensions. Some glue is applied with robots and the uniformity should be documented. Significant effort has gone into the QA of glue mixing and ratios, which is to be applauded, but quantity is just as significant to proper manufacture and should be verified.

2.4.3 Recommendations

1. Improve integration coordination to devise effective scintillator loading/drainage procedures.
2. Provide additional engineering to finish factory tooling items and certify compliance with safety codes.
3. Complete documentation of assembly, test, QA, and training procedures and have them reviewed by NOvA management.

2.5 Electronics and Data Acquisition (WBS 1/2.6, 1/2.7)

2.5.1 Findings

The Electronics system consists of approximately 12,000 detector-mounted avalanche photodiodes modules (APD), front-end boards (FEB) and associated power and cooling. The Data Acquisition (DAQ) system consists of data concentrator boards and timing distribution boards. In addition there is DAQ software and DCS hardware and software for slow controls.

About 50 percent of the total cost is in the APD assemblies, purchased components, whose cost will be determined after the vendor's prototype run in late 2009.

The FEB is in near final state of prototyping and incorporates a NOvA custom ASIC

(application-specific integrated circuit).

A new cooling concept has been proposed that would greatly simplify the system integration by eliminating cooling H₂O.

A vertical slice test has been performed that couples a single prototype APD and FEB to a small but representative detector element and the performance was found to be adequate.

An integration test of FEB to DCM is underway. High- and low-voltage power supplies from two possible vendors are under evaluation. Test stands and test procedures are being developed for the APD and FEB. Detailed designs and mockups have been made for detector services routing. There are advanced designs for the DAQ custom hardware.

Resources to re-staff the DAQ effort after the effects of the budget crisis have been identified and requirements documents are in place.

2.5.2 Comments

The Near Detector surface test is a one-fiftieth scale test of the Far Detector and provides a critical opportunity to identify possible performance issues not uncovered in the vertical slice test. It may also be useful in demonstrating the completeness of the integration plan and verifying the new cooling concept. This test, conducted aggressively, should serve to qualify all the final hardware designs.

The design of the system services and DAQ and DCS components is complete and opportunities to bring forward some procurements should be identified.

Packaging and testing of the analog-to-digital converter (ADC) from CERN was approved at CD-3a but there has been little progress. Delays related to export control issues have been cited but follow-up is needed.

The ease of access, the programmability of many hardware parameters and in-situ firmware updating of the system provide great flexibility to deal with unanticipated experimental conditions.

There is an ambitious plan for signal processing firmware in the FEB. A detailed requirements document should be put in place and the adequacy of the available resources should be evaluated. Including another collaboration member in this activity could mitigate some risk.

Despite repeated recommendations to hold technical reviews, none appear to have been held. The present review was too brief to serve as a detailed technical review taking advantage of available external expertise.

The newly assembled DAQ software team appears to be off to a good start. However, the team is spread over several institutions and many individuals. The effectiveness of this team in completing their tasks should be carefully monitored.

The electronics cost, at roughly \$50/channel, is in line with other similar systems, but the basis of estimate has not been revised since the previous Lehman review and should be revisited/updated.

The formal schedule shows roughly a year of schedule contingency. Management should carefully monitor and plan for possible delays in critical components (APD, ASIC, ADC). In addition, early physics opportunities may be missed unless some fraction of the electronics system is available prior to the schedule driven dates.

2.5.3 Recommendation

1. Conduct technical design review(s), including outside experts, prior to procuring critical components.

2.6 Near/Far Detector Assembly (WBS 1/2.8, 1/2.9)

2.6.1 Findings

The scope of work includes design of detector structures and definition of assembly procedures including validation of the structural stability of the Far Detector over an expected 20-year lifetime and construction of the Full Size Assembly Prototype (FSAP) and the Full Height Engineering Prototype (FHEP). The scope also includes: preparation of the Near Detector site and its infrastructure; design and fabrication assembly fixtures; integrate the components from other Level 2 tasks; assemble scintillator modules into 31 plane blocks and install them; fill the modules with scintillator; outfit the blocks with readout devices and their services; and

coordinate QA and checkout with the other Level 2 tasks. The Far Detector is composed of 31 blocks, assembled five blocks at a time into superblocks, constituting the 14kt detector. The Near Detector is composed of six smaller blocks amounting to approximately 0.2kt.

Further progress has been made on the issue of structural stability. Test of PVC creep are consistent with expectations. An evaluation by an independent expert confirms the NOvA design. A long-term (at least two years) hydrostatic test, under the full 50-foot head, has been begun on the PVC extrusion end seal glue joint.

The Integration Prototype Near Detector, which was planned to consist of four blocks of the Near Detector and to be located in the MINOS service building, has been re-scoped to include construction of the full six-block (each of 31 layers) Near Detector as well as the muon catcher, in a new temporary surface structure, the Near Detector Surface Enclosure. The blocks will be assembled at Argonne National Laboratory (ANL) and shipped to Fermilab, where they will be filled and fitted-out in the surface building. As this surface building is located off-axis to the NuMI beam line, it will be possible to gain data taking experience before the underground cavern is ready.

The Near Detector will be located in a new cavern adjacent to the MINOS Near Detector Hall. Two experienced companies reviewed the requirements and recommended road-header excavation of this cavern. When the cavern is complete, the Near Detector modules will be drained, transported to the cavern, and filled and fit-out.

The schedule for Near Detector assembly has been advanced two years from the baseline. Construction will be complete in July 2010. The Estimate-At-Completion was adjusted downward by \$166K as a consequence of early completion of the Near Detector.

The design of the Near Detector is about 50 percent complete.

Assembly of the Far Detector provides many challenges. Full length (approximately 50 feet) modules must be moved, adhesive applied, and then assembled into the 31 layer approximately 50-ft by 50-ft blocks. Construction of the FSAP gives early experience with these issues. A vacuum lifting fixture has been developed at ANL, constructed, and used to move hundreds of module extrusions. An adhesive dispenser has been constructed and tested. A second pump with four feeds will be added before Far Detector block production. Five of the six layers of the FSAP had been assembled before this review; by the third layer, assembly time had been reduced to four hours, confirming Technical Design Review estimates: adhesive exposed time is satisfactory.

A laser system is being investigated for use in determining layer flatness as the blocks are assembled.

The Full Height Engineering Prototype will actually be 11/12 height, to conform to the dimensions of the test hall. It will be one-sixth of the full width, and will be composed of the full 31 layers. It will be filled with water to test distortions compared to the finite element analysis.

Critical to the assembly of the Far Detector is the Block Pivoter. It provides an elevated horizontal surface for assembly of the block. After assembly, the pivoter is used to rotate the block vertical, and move it into position as part of the NOvA detector. An engineering review of the conceptual design was held in April 2008; comments from the review were fed back into the design. Progress on the design has continued during 2009.

Conceptual design and parts modeling are done. Engineering calculations have been begun and are, for the most part, completed. Many of the fabrication drawings have been started, with many of these completed. Only the FHEP bookend has been fully fabricated. Without special care in fabrication, this weld-up structure that is about a sixth of the size of the production block pivoter and is produced via the same technique, satisfies the flatness specification over most of its surface. A block pivoter, full depth section with pivoting mechanisms, will be built to use with construction and righting of the FHEP. The block pivoter construction and testing has been moved forward, relative to the baseline schedule, by about six months.

The design of the Far Detector is about 70 percent complete.

2.6.2 Comments

There has been substantial progress in moving the Near/Far Assembly tasks forward since the October 2007 DOE/SC review. Most of this progress has occurred in the last six months, as much of the engineering team has become re-engaged in the experiment.

Design of the Near Detector Technical Systems is about 75 percent complete. For the active detector and south bookend, the design is approximately 95 percent complete. Other items, such as the muon catcher, are less mature, but there is a clear path forward. Tooling needed for construction of the blocks is in hand. Documentation exists in the NOvA repository, and drawings are complete. The Near Detector assembly was added to the CD-3a scope recently. Construction of the Near Detector blocks is ready to proceed.

The construction of the full Near Detector, for installation in a surface building, has been significantly advanced. Design of the muon catcher should be pursued aggressively to get the

maximum benefit from this schedule advance. The completed mechanical detector provides a critical test bed for the readout system and for the fit-out with instrumentation and services of the detector, as well as an excellent opportunity to gain experience with the performance of detector before it is lowered into the cavern. The Committee judged that early full instrumentation of this detector should be given high priority. The Near Detector Surface Enclosure construction must be pursued in a timely manner to provide maximum benefit from the Near Detector tests.

Design of the Far Detector is estimated to be about 70 percent complete. Some of the critical tooling has been prototyped, with lessons learned fed back into completing final design. There is a clear path forward on design. Many drawings are already completed, approved, and placed in the drawing repository. However, matrixing of engineering effort at Fermilab presents a serious challenge to completing the design. If adequate engineering resources are available, design should be finished in less than a year.

The validity of the finite element analysis of Far Detector block stability was confirmed by expert review and, more importantly, by the measured performance of prototypes.

The module lifter and gluing machine have been prototyped at full scale. The process took three months longer than expected, but the resulting devices have performed very well: the optimization has been worth it.

Time and motion estimates for Far Detector block assembly have been validated, with minor adjustments, via experience gained in the construction of the Full Size Assembly Prototype. This has been a very valuable exercise.

The Near Detector blocks will be drained before being moved from the surface building to the cavern. This drain feature could be studied to see if it can be applied to the Far Detector for the eventual decontamination and decommissioning (D&D) of the detector after a long service life.

The grouting of the Far Detector vertical modules to the pallet has had a minor change in concept. This could be tested in the fabrication of the Near Detector blocks. In the Far Detector, it may be helpful to grout the pallet to the floor.

Weld-up of the FHEP bookend gives some confidence that the welding scheme that will be used to assemble the Block Pivoter will produce a surface that meets flatness requirements for block assembly.

The Block Pivoter rotates the block into a vertical position and sets the pallet on the floor. There is a temporary shear stress on the block after it is rotated and before it is set on the floor that may need investigation.

An attractive solution for the worker platforms that surround three sides of the assembly table atop the Block Pivoter, and which must provide a safe elevated work platform, has been identified. The cost of this commercial procurement is reasonable.

Work on electronics associated infrastructure has moved forward with the addition of university personnel to the effort. Concern remains for the effectiveness of the overall integration effort, though it has improved since the October 2007 DOE/SC review.

Scintillator filling system design has progressed adequately.

2.6.3 Recommendations

1. Conduct a final design review of the Block Pivoter incorporating the experience gained from the FHEP block pivot prototype before the Block Pivoter's release to fabrication. Include a thorough look at worker safety—fall protection issues need very careful consideration.
2. Near Detector Assembly is ready for CD-3b approval.

Intentionally Blank

3. ENVIRONMENTAL, SAFETY and HEALTH

3.1 Findings

The Environment, Safety, and Health (ES&H) programs are effective and properly staffed. The staff is highly experienced and provides appropriate support to the project.

The ES&H aspects of the project are being properly addressed. The appropriate Hazard Analyses have been completed, and scope, schedule, and costs necessary for safety have been incorporated into the respective baseline. The National Environmental Policy Act (NEPA) documentation was approved on June 11, 2008. Furthermore, all required permits to support ongoing construction at the Ash River site are in place.

Integrated Safety Management (ISM) principles are effectively incorporated into the project and the project has responded satisfactorily to recommendations from prior independent project reviews.

3.2 Comments

Staffing levels and areas of expertise are appropriate for this stage of the project; the ES&H program will provide appropriate and timely support.

ES&H personnel have been properly involved in all phases of work planning, and have excellent knowledge of the plans. Of note, the appropriate hazard analyses have been completed, and the respective safety documentation is sufficient for this stage of the project.

The project spans two national laboratories, numerous educational institutions, and two States. The Project Execution Plan and the respective MOUs clearly delineate roles and responsibilities with respect to ES&H.

Project support documents are extensive and well-written, and efforts to update and maintain the documents are planned.

3.3 Recommendation

1. ES&H interfaces between all parties have been formalized; ES&H staff should ensure communications are maintained throughout the life of the project. Of specific note, the ANL Industrial Hygiene Group has been intimately involved with the project since August 2006, and results of their efforts to monitor worker safety and health associated with pilot production of PVC modules should serve as a foundation for the University of Minnesota's (UM) ES&H recommendations for full-scale production of PVC modules. Furthermore, UM may access the expertise of subject matter experts for addressing ES&H concerns with hoisting and rigging operations, as well as elevated work, at the Ash River site.

4. COST, SCHEDULE and FUNDING

4.1 Findings and Comments

The current NOvA project schedule completion (CD-4) is November 2014. A critical path schedule for the NOvA project has been developed and is being utilized. This schedule has 3,688 activities and 463 milestones.

The NOvA project baseline schedule has 200 days of schedule contingency to CD-4. The NOvA project utilizes a working (or forecast) schedule. The working schedule is updated regularly. The current NOvA project working schedule has 275 days of scheduled contingency to CD-4. This potential schedule advancement is substantially due to the ARRA funds.

The regular updates to the project schedule are one part of the Project Controls/Earned Value Management System (EVMS), which is established and is being implemented on the NOvA project.

ARRA funds totaling \$55 million were received on May 15, 2009. Some advantage of the ARRA funds was taken to advance portions of the schedule. The post-ARRA NOvA project funding profile exceeds the cumulative costs and obligations for the baseline NOvA project. The headroom between the funding profile and the cumulative costs and obligations provides opportunities to be more aggressive with advancing the schedule. Figure 5-1 shows the current yearly funding profile versus the CD-2 baseline profile.

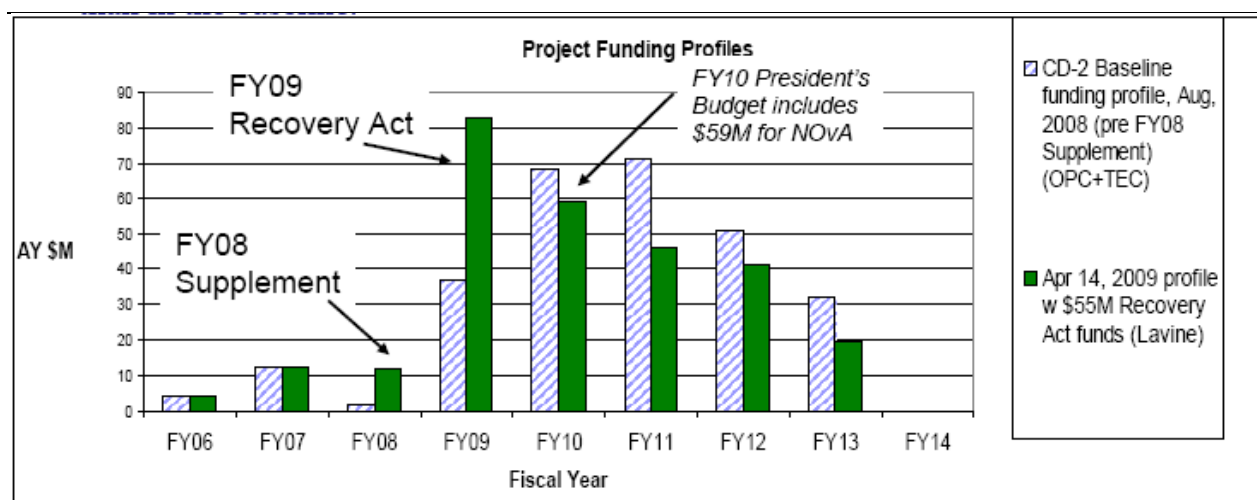


Figure 5-1. NOvA Current Yearly Funding Profile

4.2 Recommendation

1. Evaluate additional opportunities to further advance schedule with available contingency prior to CD-3b.

5. MANAGEMENT

5.1 Findings

The Project Execution Plan (PEP) for the NOvA project has recently been updated, but it has not been finalized and further adjustments are underway. MOUs and contracts are in place for all institutions. A checklist was provided by the NOvA project team indicating the CD-3 documentation required, what documents satisfied these requirements, and where the documents could be found on the review website. A single page master schedule with critical path was shown. Overall schedule contingency is at ten months in the baseline and 13 months in the working schedule. All project management systems are in use by the NOvA project team, including configuration control, project document control, engineering document control, and change control (the EVMS and costing system (incorporating Open Plan™ and Cobra™ software), the NOvA DocDB, the Change Control Database (in Microsoft Access™), and existing Fermilab engineering document management systems). The methods of configuration control are aligned with the PEP. Formal change control is in place, and is a robust system that has been regularly exercised by the NOvA project team with 80 changes to-date. The EVMS has recently been reviewed for DOE certification.

5.2 Comments

The NOvA project team should be commended for their efforts to respond to continuing changes in the funding profile since baselining the NOvA project. The NOvA project team is a good one, with the Work Breakdown Structure (WBS) managers fully engaged in executing their Level 2 elements of the project. The MOUs and contracts that are now in place for all institutional partners appear to be working well. The required documentation is in place for final CD-3. Staffing has remained an issue as both the resource requirements of the NOvA project and the availability of resources change.

The risk registry is detailed, but it is unclear whether it is being fully utilized and updated on a regular basis. In some cases, contingency estimates may not reflect all risk, although there is more than adequate total contingency in cost and schedule available at this stage of the project. Delineation of ‘unassigned contingency’ is unclear, especially with respect to planning for future contingency use when risk is retired. For the unassigned contingency, the project should distinguish between those funds that are in fact held to mitigate risks, and those that are unencumbered and could be used for enhancements or acceleration of the project. All the tools

are in place and operating to successfully manage the project, but management could make more use of project management tools for ‘what-if’ scenario analyses.

5.3 Recommendations

1. Update and finalize the PEP.
2. Update the schedule to take into account the changes that have occurred in funding profile, and currently anticipated changes in resource allocation, availability, and work planning.
3. Update the contingency estimates to include all risks.
4. Utilize available contingency funds to mitigate risks and advance the schedule.
5. Approve CD-3b for the NOVA project after addressing these recommendations.

APPENDIX A

CHARGE MEMORANDUM

United States Government

Department of Energy

memorandum

DATE: **MAY 08 2009**
REPLY TO:
ATTN OF: Office of Science

SUBJECT: Project Review of the NOvA Project CD-3B

TO: Daniel Lehman, Director,
Office of Project Assessment, SC-28

The Department of Energy (DOE) Office of High Energy Physics (OHEP) requests that a CD-3B Independent Project Review for the NUMI Off-Axis Neutrino Appearance (NOvA) Project be conducted on July 21-23, 2009, at Fermi National Accelerator Laboratory (Fermilab). The purpose of this review is to evaluate the project's readiness for approval of Critical Decision 3B (Approve Construction).

On September 25, 2008, DOE approved CD-3A (Approve Limited Construction). With CD-3A, DOE approved long lead procurements and a limited set of other construction activities. A limited number of items beyond the CD-3A list have been approved by DOE for procurement in support of the 2009 Recovery Act (RA). CD-3B will be an approval of the remaining items of construction necessary prior to CD-4.

The NOvA project will fabricate and install upgrades to the Fermilab proton source and NuMI facility to enhance the neutrino beam intensity, and will build two neutrino detectors to use this beam (a smaller "near detector" on the Fermilab site and a larger "far detector" 810 kilometers away in Northern Minnesota).

The NOvA Project Acquisition Strategy calls for Northern Minnesota site preparation work, access road upgrade and far detector enclosure construction to be completed by the University of Minnesota under a financial assistance agreement. These construction costs are captured as part of the Other Project Costs and therefore part of the Total Project Costs. The project management team and the university work together to ensure proper integration of the university's efforts into the overall project. CD-3A approval covered site preparation and access road construction, and a subsequent DOE approval was provided to start construction of the far detector enclosure building in support of the Recovery Act.

In your review, please evaluate whether the remainder of final design for NOvA project is complete and whether the project is prepared to enter the construction phase beyond the CD-3A and Recovery Act approved activities. In performance of a general assessment of progress, current status, and the identification of potential issues, the committee should address the following specific items:

1. Final Design: Is the design sufficiently mature so that the project can initiate procurement and construction? For those elements of the design that are still not finalized, has the project convincingly shown that there are no major issues that need

to be addressed and that they are on a clear path to a final design?

2. **Baseline Cost and Schedule:** Are the current project cost and schedule projections consistent with the approved baseline cost and schedule? Is the contingency remaining adequate for the risks?
3. **Management:** Evaluate the management structure as to its adequacy to deliver the proposed final design within specifications, budget, and schedule. Has the project responded satisfactorily to the recommendations from the previous independent project review?
4. **Construction:** Has there been adequate progress on the construction activities approved under CD-3A? Have Fermilab and the project done the necessary preparations to execute the remaining construction activities?
5. **Documentation:** Is the documentation required by DOE Order 413.3A for CD-3B complete? Has the CD-2 documentation been updated to reflect any changes resulting from the final design?

Ted Lavine is the program manager for the NOvA Project in this office and will serve as the OHEP contact person for the review.

We appreciate your assistance in this matter. As you know, these reviews play an important role in our program. I look forward to receiving your Committee's report.



Dennis Kovar
Associate Director
Office of High Energy Physics

cc:
MProcaro SC-25
T Lavine SC-25
Dkovar SC-25

APPENDIX B

REVIEW PARTICIPANTS

REVIEW COMMITTEE PARTICIPANTS
Department of Energy Review of the
NuMI Off-Axis Neutrino Appearance (NOvA) Experiment
July 21-23, 2009

Daniel R. Lehman, DOE, Chairperson

SC1

Accelerator and Beamlines
(WBS 1/2.0)

* Graeme Murdoch, ORNL
 Fulvia Pilat, BNL

SC2

Sites and Buildings
(WBS 1/2.1)

* Jess Albino, SLAC
 Ove Dyling, BNL

SC3

**Commodities: PVC Extrusions/
 Fiber/Scintillator**
(WBS 1/2.2, 1/2.3, 1/2.4)

* Bill Louis, LANL
 Kevin McFarland, U. of Rochester

SC4

PVC Module and Production
(WBS 1/2.5)

* Dick Loveless, U. of Wisconsin
 Steve Kane, BNL
 Charlie Pearson, BNL

SC5

Electronics and Data Acquisition
(WBS 1/2.6, 1/2.7)

* Rick Van Berg, Penn
 Paul O'Connor, BNL

SC6

Near/Far Detector Assembly
(WBS 1/2.8, 1/2.9)

* Bill Wisniewski, SLAC
 Richard Boyce, SLAC

SC7

**Environment, Safety
 and Health**

* Steve Trotter, ORNL

SC8

**Cost, Schedule
 and Funding**

* Tom Fornek, SLAC
 Kurt Fisher, DOE/SC

SC9

Management
(WBS 2.10)

* Derrick Mancini, ANL
 Howard Gordon, BNL
 Kathy Johnescu, DOE/BSO

Observers

Dennis Kovar, DOE/SC
 Ted Lavine, DOE/SC
 Mike Procario, DOE/SC
 Eli Rosenberg, DOE/SC
 Pepin Carolan, DOE/FSO
 Steve Webster, DOE/FSO
 Gary Brown, DOE/SC

LEGEND

SC Subcommittee

* Chairperson

Count: 19 (excluding observers)

APPENDIX C

REVIEW AGENDA

**Department of Energy Review of the
NuMI Off-Axis Neutrino Appearance (NOvA) Experiment
July 21-23, 2009**

AGENDA

Tuesday, July 21, 2009—Comitium, Wilson Hall

8:00 am	DOE Executive Session— Comitium, Wilson Hall	D. Lehman
9:00 am	Plenary Session	Directorate, TBD
9:00 am	Welcome— 1 West	Directorate TBD
9:05 am	NOvA Science Update	NOvA Spokesperson TBD
9:20 am	Project Overview	J. Cooper
10:30 am	Break—outside 1 West	
11:00 am	Accelerator and NuMI Upgrades	P. Derwent
11:30 am	Site and Building.....	S. Dixon
11:45 am	Scintillator.....	S. Mufson
12:00 pm	Lunch—outside Comitium	
1:00 pm	Fiber	C. Bromberg
1:15 pm	PVC Extrusions.....	R. Talaga
1:30 pm	Extrusion Modules	K. Heller
2:10 pm	Electronics and DAQ	L. Mualem
2:30 pm	Near/Far Detector Assembly.....	P. Lukens
3:00 pm	Break—outside 1 West	
3:30 pm	<u>Subcommittee Breakout Sessions</u>	
	• SC1 Accelerator and Beamline— room TBD	
	• SC2 Site and Building & Near Detector Cavern— TBD	
	• SC3 Commodities: Scintillator, Fiber, and PVC— TBD	
	• SC4 Extrusion Module Production — TBD	
	• SC5 Electronics and DAQ—TBD	
	• SC6 Near and Far Detector Assembly— TBD	
	• SC7 ES&H— TBD	
	• SC8 Cost, Schedule and Funding— TBD	
	• SC9 Project Management— Comitium	
5:00 pm	DOE Executive Session— Comitium	D. Lehman
6:30 pm	Adjourn	

Wednesday, July 22, 2009

- 8:00 am **Subcommittee Breakout Sessions**
- SC1 Accelerator and Beam line— room TBD
 - SC2 Site and Building & Near Detector Cavern— TBD
 - SC3 Commodities: Scintillator, Fiber, and PVC— TBD
 - SC4 Extrusion Module Production — TBD
 - SC5 Electronics and DAQ—TBD
 - SC6 Near and Far Detector Assembly— TBD
 - SC7 ES&H— TBD
 - SC8 Cost, Schedule and Funding— TBD
 - SC9 Project Management— Comitium
- 10:00 am **Break—outside Comitium**
- 10:15 am **Subcommittee Breakout Sessions**
- Continued in same rooms as 8:00 am Sessions
- 12:30 pm **Lunch—outside Comitium**
- 1:30 pm Two Options – D. Lehman to choose Wednesday morning:
Option one: Full Committee Session with NOvA Management **in Comitium**
Option two: Continued Breakout Sessions continued in same rooms as 8:00 am
- 2:30 pm Subcommittee Working Session—**Comitium**
- 3:00 pm DOE Full Committee Executive Session—**Comitium**D. Lehman
- 6:00 pm Adjourn

Thursday, July 23, 2009

- 8:00 am Subcommittee Working Session—**Comitium**
- 10:00 am DOE Full Committee Executive Session Dry Run—**Comitium**.....D. Lehman
- 12:00 pm Working Lunch
- 2:00 pm DOE Summary and Closeout—**1 West**D. Lehman
- 3:00 pm Adjourn

APPENDIX D

SCHEDULE TABLE

APPENDIX E

FUNDING CHART

Funding Profile

	Prior Years	FY 2008	FY 2009	ARRA	FY 2010	FY 2011	FY 2012	FY 2013	Total
TEC	1,000	-	12,670	14,936	59,000	46,220	41,240	19,880	194,926
OPC	15,870	12,034	15,096	40,064	-	-	-	-	83,074
TPC	16,870	12,034	27,766	55,000	59,000	46,220	41,240	19,880	278,000

APPENDIX F

MANAGEMENT
CHART

NOvA Project Organization

