Fermilab

Closeout Presentations

from

Director's Preliminary Review

of

NOνA

July 18-20, 2005

07.19.2005

Preliminary Director's Review of NOvA Project

2.0 Detector

Giorgio Apollinari, Rich Stanek, Linda Stutte

FINDINGS

- NOvA is a totally active detector with the ability to identify ~2 GeV electrons & discriminate them from comparable energy π^0's and muons.
- The basic detecting element is a 4cm x 6cm x 15m cell filled with liquid scintillator read out by a doubled WLS fiber connected to an APD. The overall final detector transverse size was determined by practical considerations such as the maximum truck size available.
- The achieved detector parameters are:
  - S/N = 10/1 for MIPs.
  - A measured 12.5 p.e. /MIP (2.2cm x 4.2cm cell) and an expected light yield of 25 p.e. /MIP (3.9cm x 6cm cell) at the far end of a 16.7m long cell.
  - Simulated $\sigma_E/_E$ ~10%/sqrt (E) for electrons.
- Production of modules (a module contains 32 cells, for a total of ~24k modules) is planned in 3 separate factories, with the "raw materials" (PVC extrusions, WLS fibers, optical connectors, etc) delivered from various production sites. The location of APDs and FEE installation on the modules was unclear. The modules (with or w/o FEE) are then shipped to the Far site, glued in supermodules 8 layers deep and installed (installation covered in Section 5.0).
- The planned production rate for each factory is 10 modules/one shift/day using a 4-person crew.
- QA/QC is planned at the supplier (PVC) and factory sites:
  - PVC – mechanical dimensions, reflectivity
  - Fibers – sampling measurements for attenuation length and response
  - Factories – module pressure test, fiber continuity (redone at far site along with additional tests for APDs and muon response checks after liquid scintillator filling).

  Technical specs for QA/QC are not yet specified.

COMMENTS

- The detector is expected to run for 10-20 years. Past neutrino detectors with liquid scintillator have needed to stir the liquid on the time scale of ~ 5 years in order to maintain the response. NOvA is using fully oxygenated scintillator (see page 36 in proposal) so have already accounted for this pulse height reduction.
- Environmental controls shouldn't be overlooked. The liquid scintillator would be irreparably damaged if the temperature drops below –25F. Fortunately the 3m overburden and sheer thermal mass of the detector should prevent this. The APDs need to run at –15 ^{0}C and thus must be located in dry atmosphere boxes with perhaps a N_2 purge to avoid condensation of ice crystals on the fibers.
- Pattern recognition of and/or discrimination between electrons and π^0's were not presented in the review, although a lot of work was reported in executive session. A presentation on how the detector will be used would have been helpful to the reviewers.
- We saw considerable discussion about design alternatives that have been rejected but little about optimization that had been performed on the chosen geometry/detector element (for example cell size). We understand several optimization steps have been performed. Documentation will be helpful to future reviewers.
- The proposed length of time needed for module assembly (2 FTE-hours/module) was considered optimistic and needs to be checked in a factory environment.
- Many choices still need to be taken. A large number of them will be decided in the R&D program needed for a prototype near detector in the coming year(s). This is a critical step for the experiment and more detailed planning is needed here. This includes:
    - Adhesive investigation
    - Buckling/creeps studies
    - Tooling and fixtures
    - Full-scale extrusions to learn/develop assembly steps and procedures.

RECOMMENDATIONS

- Define the way you will use the detector to discriminate electrons and various backgrounds. Use this method to show the optimization steps used to define the basic detector parameters (cells size, light yield/MIP, uniformity of response, energy resolution, calibration requirements, …). Management should adopt the basic technical parameters.
- The Project engineer should insure himself that all the R&D results are engineered to his satisfaction. Appropriate engineering calculations and notes should record any test on small-scale models and show the expected behavior of large-scale elements.
- The Management and the Project Engineer must adopt a Document/Process Control system to insure Configuration control and uniformity of assembly among the project factories.
- Mixing of the liquid scintillator appears to increase the risk of the project. Management should consider adopting bulk purchase of the scintillator as a baseline at this point.

- Upon determination of the minimum specification on light yield, continue, if necessary, light yield R&D exploring fibers with higher WLS concentration or PVC with more TiO_2.
- Continue to refine and develop the QA specs and assembly procedures for the factories.
- Start investigating the possible module factory sites for availability of space and facilities to insure a proper production flow.
- Explore multiple vendors and quotes for “high value” or “highly repetitive tasks”: PVC, mineral oil, optical connectors, PC boards, shipments, etc.
- Converge as quickly as reasonably possible on the assembly of a full 8 plane, 15m x 15m super-module to explore the feasibility of the assembly and lifting conceptual ideas.
- Coordinate the logistics of the detector assembly and shipment (both at the factories and at the Far Site) through the appointment of a Logistics Engineer.
- (To the Lab) Adequate funding at the level of 1M$ /year for detector development should be in place to insure the success of the R&D Program.

CHARGE QUESTIONS

8.1 Are the physics requirement stated ?

Partially yes.

- *Stated*: general goals: measure ~2 GeV electrons, reject μ and π^0 backgrounds, SN neutrinos.
- *Not stated or clearly presented*: clear definition of appearance of bkg. in detectors (beyond the "fuzzy" vs. "clean" vs. "blob" definitions, especially for events containing π^0's), handles to reject bkg., required noise level to operate as an Neutrino Oscillation or a SN detector .

8.2 Have the physics requirements been translated into technical performance requirements / specifications ?

No. Technical performance information is "sprinkled" around in the NOvA proposal, but is not summarized in a table as "NOvA specifications" or officially adopted and defended by the NOvA management.

Examples:

- *High Detector Level:* missing spec. on the required energy resolution, response stability with time/temperature/…
- *Low Detector Level:* Cell shape (only 1 table, showing that increasing the cell depth (longitudinal) increases the FoM – page 78 of NOvA proposal), light yield, cell calibration/equalization, mechanical "banana" effects on extrusions, centering of fibers on APD pixels, etc.
- *Assembly Level:* Leak rate specs with pneumatic testing, "absolute measurement" of reflectivity of PVC, fiber attn. length.

8.3 Is it a reasonable design ? Can the design be built ? Does the design meet the technical specifications ?

Is it a reasonable design ?

The module design is reasonable. The design provides ~20-25 pe/MIPs @ far end. APDs provide a 10/1 S/N. "Aging" over a period of ~5-10 years appears under control. The supermodule design requires additional engineering work.

Can the design be built ?

Probably yes. No major problem foreseen in the module (36 cells) assembly. The bottleneck will be the assembly procedures and/or tooling in the Far Site assembly area.. Serious engineering work at the level of 4-5 FTEs for ~1-1.5 years needs to start immediately on the final assembly and tooling.

Does the design meet the technical specifications ?

Technical specs need to be stated explicitly.

Director's Preliminary Review of NOvA
July 18 – 20, 2005
3.0 Building and Outfitting

Karen Hellman, ANL
Randy Ortgiesen, FNAL

- **Findings:**

  - The cost estimate (including identified contingency) appears reasonable to accomplish the building and outfitting scope of work as described. FESS has completed a detailed preliminary cost estimate on this scope of work and is actively managing the areas that can impact the cost such as the conditions of excavation.

  - Life Safety and Code analysis, Construction cost estimating has been performed by FESS staff. Construction cost estimates have been appropriately based on Means data for construction in Minn.

  - Building and outfitting design will be performed by FESS staff. Construction documents will be developed with consultant support led by FESS. FESS staff has experience in the design and construction of similar facilities.

  - Site selection has been narrowed down to two potential locations. Both sites appear to be functionally acceptable. Cost for site access upgrades is included in the site costs. The sitework schedule of 8 months includes 4 months of winter construction. Since initial work is excavation that can occur during the winter months, the schedule should not be impacted by weather delays.

  - Right-of-Way agreements will be needed from two landowners in order to access the Ash River site and any cost required from this is not part of the project cost and may get picked up by U of Minn.

  - Building construction contracts will be procured and managed by U of Minn. Staff. U of Minn will functionally report to the project office to maintain consistent project status reporting to DOE. This arrangement will be specified in a Memorandum of Understanding.

  - Design for outfitting is less developed than the building at this time. There is potential for the tanker building to be eliminated or downsized once shipping strategy for scintillator supply is determined.

- Backup generator for electric service has been incorporated to accommodate the likely possibility of outages on the sites only radial electric feed.

- Sustainability and Leadership in Environmental and Energy Design (LEED) is intended to be part of the design considerations.

3.0 Building and Outfitting

- **Comments**

  - Consideration should be given to the cost of providing water and sanitary service to the candidate sites.

  - Consider engaging consultants to provide an additional cost estimate for construction. Utilize consultant for cost reconciliation purposes.

  - Performing a constructability review would be advantageous considering the remote location of the site and the multiple engineering interfaces.

  - Engage code officials from U of Minn as early as possible in the Comment and Compliance review.

  - Review, design and document solutions for prevention of accidental release of scintillator outside the containment area. Building enclosure must consider issues such as settling and cracking.

  - Project should recognize the financial impact of delays in CD-1. Currently, the Lab is providing funding for conceptual design by FESS and environmental work by consultants. Conceptual design work should continue seamlessly if delays are encountered.

  - Site Maintenance and Security & Safeguards cost estimates to support construction are included but should be better assessed to determine the adequacy of the cost estimates.

  - An assumption that sufficient electric capacity exists at the site boundary was made. This should be verified since this has the potential to impact cost.

3.0 Building and Outfitting

- **Recommendations**

  - It is critical to the project for a determination to be delivered on the "construction" within a grant issue. This has the potential of causing delays if not resolved early in the design phase. (to be addressed as a Management comment)

  - Investigation into the applicability of Space Offset policy for new construction needs to be completed. This could potentially impact cost if demolition becomes necessary to offset the new construction square footage.

NOνA
Preliminary Director's Review
July 18-20, 2005

Electronics, Trigger, and DAQ
Closeout Report

Reviewers: P. Wilson, S. Fuess

Outline

- Front end electronics
  - Findings / Comments / Recommendations
- Trigger and DAQ
  - Findings / Comments / Recommendations

Findings will be skipped in this presentation

Front end electronics

- Findings:
  - The physics requirements were not directly translated into the technical requirements. We learned that the design goals are:
    - Signal:Noise = 10:1 for MIP signal
    - Dynamic range = 10 bits
    - Cross talk ~ 2%
    - Linearity is not an explicit strong requirement
  - The Supernova search adds additional requirements
    - ~ 20 second buffering
    - Free-running trigger

Front end electronics (cont'd)

- Findings (Photodetector):
  - Avalanche Photodiode (APD) is technology of choice
    - Good Quantum Efficiency at relevant wavelengths
    - Pixel size can match fiber bundles for 32-cell module
    - Stable, uniform
    - Requires –15° C operation
    - Alternatives considered (phototubes, SiPM APDs, VLPCs, HPDs) as too expensive, low QE, or insufficiently mature

Front end electronics (cont'd)

- Findings (Front end board):
  - APD read out with ASIC and ADC, with 2 options
    - SCA based on existing MASDA design
      - Lower noise
    - Analog MUX feeding into ADC
      - More appropriate for Supernova trigger
  - On board FPGA used for data sparsification, buffering, interface to DAQ and slow controls
  - Scheme exists for mechanical configuration of board including fiber mounting and alignment

Front end electronics (cont'd)

- Findings (APD details):
  - Required APD development:
    - New array structure, with pixels sized and oriented for 32 fiber pairs
  - Operating environment requires Thermo-electric (TEL) coolers
  - Proof of principle test completed
    - Using off-the-shelf amplifier (MASDA)
    - Not optimized: 70pf MASDA input, but 10pf for APD
    - ~ 6:1 Signal:Noise obtained, consistent with calculations

Front end electronics (cont'd)

- Findings (Plans):
  - Steps in place for prototyping APD and readout
    - Quote from Hammamatsu
    - Schedule for ASIC development, circuit board development, one design revision cycle
  - Prototype FE boards will support both SCA and multiplexor methods
  - QA/QC issues have been considered, with plans for testing at multiple stages and locations in production chain

Front end electronics (cont'd)

- Findings (Management):
  - WBS exists to Level 6, but not resource loaded
    - WBS structure splits R&D / near / far efforts, though technical management similar
  - The schedule is in it's infancy, only minimally developed
    - Shown for FE board prototype development
  - The costs were only roughly shown ($7.2M + 55% contingency)
    - Prototype electronics costs given
    - Remaining per-unit costs estimated

Front end electronics (cont'd)

- Comments:
  - A conceptual technical solution was presented which has a reasonable probability of meeting the technical requirements of the experiment.
  - The path between desired physics sensitivities and technical performance requirements should be presented in the future
  - Detailed WBS, resource loaded schedule is not yet in place

Front end electronics (cont'd)

- Comments:
  - There are a number of Technical challenges, some will require difficult decisions:
    - Noise performance of ASIC and choice of ASICs between SCA or multiplexor options
    - APD cooling requires TEC, ~ 2 watts/board
      - Could be significantly more than 2 watts
      - Air or water cooled?
    - Tight mechanical specifications for PCB manufacturing to get correct fiber / APD alignment
    - Humidity control (10 years!) in fiber-APD gap

Front end electronics (cont'd)

- Comments:
  - More Technical challenges, some will require difficult decisions:
    - 400 V bias supply with on-board Cockroft-Walton circuit
    - Extensive low voltage network
    - Failure rate of components should be known or estimated at a level appropriate for ~30,000 items
      - e.g. APD, Cockroft-Walton chip, TE cooler

Front end electronics (cont'd)

- Comments:
  - Some production costs appear low. Total Cost estimate is $10/channel with 55% contingency. For example:
    - LV supplies are $6/FE board.
    - Assuming 10W per board and CDF experience would expect $20-50/board for LV power with the high end for very low noise front-end.
  - Additional people are needed now for testing of electronics systems
  - Need to work on systems engineering:
    - Cooling, power, slow control

Front end electronics (cont'd)

- Recommendations:
  - Current APD, ASIC, and board development plans should be fully supported to demonstrate performance ASAP
  - Review would benefit from (at least) a few examples showing the change in physics sensitivity as a function of the technical requirements. For example:
    - Cell size
    - Electronics signal:noise

Front end electronics (cont'd)

- Recommendations:
  - Resource loaded schedule should be developed
  - Schedule should include milestones for significant technical decision points, and include tasks and effort leading up to these decisions
    - Methodology for reaching decision should be clear
  - Costs should be updated to reflect correct number of modules / boards

Trigger & DAQ

- Findings:
  - Early stage of conceptual design
  - WBS exists to Level 6, but mainly as conceptual placeholders
    - WBS structure splits R&D/near/far efforts, though technical management similar
  - No schedule exists
    - Representative of early stage of design

Trigger & DAQ

- Findings:
  - Costs were shown for current conceptual design
    - Per component basis, major components only
    - No Trigger/DAQ costs presented for near detector or R&D ($0 in spreadsheets)
    - Trigger/DAQ will not be a major cost driver for the detector (currently $1.3M + 55% contingency)

Trigger & DAQ (cont'd)

- Findings (Requirements):
  - Technical requirements driven by beam structure and Supernova signature
    - Beam data: store 30 μsec (±15 around spill)
    - Background: 100x beam data of random 30 μsec windows
    - Supernova: store up to 20 sec based on trigger
  - Data rate driven by cosmic rate (with assumption of overburden), with small addition from signal(s)
    - ~ 120 kBytes/sec per module
    - Occupancy of ~ 10^{-4} in 20 MHz clock period

Trigger & DAQ

- Comments:
  - Very early stage of conceptual design
    - But what was presented seems to be a workable solution
    - Evident that collaboration is collecting experts sufficient to fully develop design

Trigger & DAQ (cont'd)

- Comments:
  - Need better presentation of Trigger & DAQ requirements:
    - Occupancy/rate for cosmics
    - Occupancy/rate for beam spill and random background
    - Simple tabular presentation of average and peak rates, buffering required to carry peak rate at each stage.
  - There should be a technical requirements document for the Trigger & DAQ

Trigger & DAQ (cont'd)

- Comments:
  - Need some money for R&D and near detector. Should be small in both cases. Currently zero in cost estimate.
  - Plan is still quite new. No show stoppers. Cost not evaluated, but should not be significant.

Trigger & DAQ (cont'd)

- Recommendations:
  - Electronics, Trigger, and DAQ requirements should be established (and presented)
    - buffering on FE boards
    - sparsification of data
    - time-stamping of "events"
  - Requirements should be considered for the integrated path
    - For example, buffering at each element from electronics to data logging

Trigger & DAQ (cont'd)

- Recommendations:
  - Should plan on using prototype detector as vertical slice test of FE electronics and DAQ/Trigger. This should include as much of the infrastructure as possible (eg TE cooling). Could also start software development (monitoring, event displays)
  - Thinking about integration of slow controls and monitoring should begin immediately

07.20.2005

Preliminary Director's Review of NOvA Project

5.0 Assembly and Installation

D. Denisov, P. Lukens

Findings:

1. This part of the review covers assembly and installation of NOvA detectors after pre-assembled modules are delivered from production sites to detectors sites.
2. NOvA Collaboration presented conceptual plan of assembly and installation of far and near detectors made of PVC modules filled, after installation, with liquid scintillator.
3. The far detector will consist of 24 thousand 32 cells extrusions with $3.9x6.0cm^2$ cross section. Total weight of the far detector is 30 ktons with sizes of $15.7x15.7x132m^3$. Near detector has similar design with smaller sizes and total weight of 262 tons.
4. Assembled and tested at "assembly factories" modules will be delivered to detector site, "glued" together into sub-units, installed in the detector, filled with liquid scintillator and then commissioned with front-end and readout electronics.
5. Many important assembly and installation issues, like deformation of PVC under pressure or minimal temperature scintillator should be stored at have been presented.
6. Preliminary versions of cost estimate and schedule as well as WBS structure for assembly and installation are developed.

Comments:

1. Overall plan for assembly and installation of the NOvA detector is reasonable and has no obvious "show stoppers".
2. Assembly of the NOvA detector requires coordination of multiple vendors, including three modules production sites, to deliver timely. This process has to be well organized with clear responsibilities and contingency plans. Option to have considerable storage space(s) has to be evaluated.
3. Building size has to provide safe and convenient detector assembly, commissioning and many years of operation. Access to detectors/electronics has to be well understood and, if necessary, accommodated by building design changes.
4. For the current level of project development ("within factor of 2") schedule for assembly of the detector as well as costs associated with installation process are reasonable.

5. As most of the modules are not expected to be tested with ionizing radiation before they are installed in the detector, quality control on each production and assembly step is critical. Tests of some fraction of the modules before installation in the detector with scintillator as well as timely test of all modules after filling with scintillator after installation in the detector are advisable.
6. Few elements of the detectors/electronics have been fully tested/prototyped. It is critical to finish R&D part of the project soon, otherwise schedule and cost estimate of the full project are hard to develop/defend.
7. Managers for assembly and installation have to be identified. They have to start active participation in the project planning on the earliest stages.
8. Specifications for detector assembly parameters and modules/sub-units testing have to be developed, documented and made available to all involved project participants. These specifications have to include required hermeticity of the modules, fibers optical properties, sizes of the assembled modules/sub-units, "banana shape" specifications, etc.
9. Handling (raising) of the detector sub-units with weight of ~30 tons with thin PVC walls is a challenging procedure. The whole detector assembly procedure heavily relies on it. It is critical to develop this procedure and tooling to perform this operation safely.
10. Crane capacity is close to the sub-unit weight. For option of handling sub-units with crane to be available optimization between crane capacity and module weight is advisable.

Recommendations:

1. Concentrate on converging on design of the detector/electronics and assembly tooling/procedures.
2. Develop prioritized list of R&D tasks. Funds needed to perform critical R&D to finalize detector design have to be provided to the Collaboration by Fermilab and Collaboration groups.
3. Converge on selection of "adhesive" to hold parts of modules and detector planes together and start long term tests of the selected choice(s).
4. Identify Collaboration groups/members to be involved in the detector installation, assembly and commissioning.
5. Construct ~full size ~8 planes sub-unit to develop/verify assembly and testing procedures and finite element analysis calculations.

6.0 Project Management

Reviewers: M. Lindgren, P. Lukens,

Findings

The project presented a high level physics requirements talk, and a talk that covered the scope of the project, method of work, detector description, an overview of the OBS and WBS, and some thoughts on decommissioning and next steps. The WBS presented has 6 level 2 subprojects, including one for Project Management. There are currently 4 Level 2 manager positions not filled for the remaining 5 level 2 subprojects. The WBS structure shown was not designed to follow the Organizational Breakdown Structure at Level 2 and below.

To summarize:

- The project has a WBS.
- A schedule was shown in the form of desirable milestones
- The project does not have a resource loaded schedule
- A management team is not yet in place.
- No requirements documents were shown.
- The project has not yet begun drafting the AEP, PEP, PMP, or TDR
- Management expects to spend $3M in R&D (M&S only) in FY05-07.
- Overall cost was projected to be $188M for TEC, which includes 40% contingency, and $9M in R&D, all in ’05 dollars.
- Total cost for project management was given as $3.537M, plus 25% contingency.

Comments

The project is to be commended for their rapid response to changing circumstances. The addition of a Project Engineer, Scheduler, and Budget Officer will greatly strengthen the Project office. The reviewers feel that getting these key people in place early is very good.

We feel that the project office should be further strengthened by the addition of a Safety officer, QA specialist, and Procurement expediter. Organization of a joint DOE/PPD/UM safety committee should be started soon. A QA specialist in the Project office would provide valuable assistance in coordinating uniform and high standards of work in the distributed factories.

The estimate of TEC and R&D is showing substantial improvement, and the project team is clearly making progress on finding errors and fixing them. The project team is clearly very committed to moving from working from spreadsheets to an RLS, and this is very good. The spreadsheet showing the cost was done at a high level, and had forced the contingency to be 40% by adding unassigned funds to the total. We do not have enough of a feel for the accuracy of the lower level cost estimates to offer advice on specific contingencies or the overall TEC presented, but feel that the overall level of contingency is too low for a project at this stage. The general feeling was that 50% contingency would be an appropriate minimum.

The project is committed to competitive bidding for procurements, and has a good plan for utilizing multiple vendors to minimize costs. The challenge will be to seek out these vendors. They need to continue to work hard to get additional quotes on many of the smaller procurements.

The collaboration needs to continue to work hard on generating requirements documents for the project. This will assist everyone in defining the technical solutions which will in turn put the costs on a much firmer basis.

The cost estimate for Project Management seemed low for a project of this size, which will be executed largely away from the Fermilab site. We would encourage the travel and software costs be revisited with that in mind.

The available R&D funds are not large, while the need for R&D is large, so direction of that R&D should be well understood and controlled by project management.

Project management showed a strong commitment to working with the DOE and the University of Minnesota to make sure there are no problems in the far site selection, development, and operation.

Project management spoke to a schedule which was tied to a CD-3 date of Oct. 2006. This is not achievable in our judgment, given the current state of preparation, and a realistic assessment of the likely schedule for reviews and document preparation. A reasonable expectation for this date is 18 months after the placement of level 2 managers into all the needed positions.

Recommendations

- We recommend a modification to the WBS that makes the far detector structure (WBS 1.5) more similar to the procurement items.
- We recommend that effort begin immediately to draft the AEP, PEP, and PMP.
- Requirements documents should be generated wherever they are not currently complete.
- We recommend that the level 2 management positions be filled as soon as possible, so that resource loaded schedules can be developed.
- Given the likely limited R&D funds available, the R&D program must be strongly focused and prioritized. The project should clearly understand which tasks must be funded by R&D, and what could be funded after CD-1 by PED funds.
- Project management costs should be reviewed and compared to similar projects.
- Fermilab procurement personnel should be brought on board and fully integrated into the planning for executing the three large procurements in time to be ready to participate in a CD-1 review.
- Development of the PMG membership list should continue, and should consider adding a University of Minnesota representative.
- A schedule for the steps leading to CD-3 approval has been developed by the Fermilab Office of Project Management Oversight. This schedule is a useful tool, and illustrates the critical path for completion of the project. We recommend that the preparation for the Critical Decision 1 (CD-1) review be given the highest priority at this time. This preparation will require dedicated level 2 managers, and probably a single contact person for the coordination of the AS/PEP/PMP documentation. This preparatory work is largely within the control of the physicists in the collaboration.

- We encourage the collaboration to prepare for a CD-1 with an incomplete/imperfect plan for the procurement of scintillator, manufacture of extrusions, and assembly of modules, if a redirection of effort can expedite the first steps in the DOE approval process. These are details of the design that can probably be completed after CD-1 approval. This approval may also free up funds for the design work and first run of parts for the full detector. Preparation for a CD-1 review can proceed independently of the availability of R&D funds from the laboratory or other external issues.

Charge Questions

8.9 Is there an appropriate management organizational structure in place or proposed to accomplish the design and construction?

Yes, we believe an appropriate structure has been proposed, but has yet to be fully staffed. The committee has recommended that WBS 1.5 be deleted and replaced with the 4 level 4 WBS elements currently contained within it. That should work well.

8.10 Have responsibilities been assigned or have they been proposed?

Yes, in certain areas. The project office responsibilities are well understood, but the required university commitments for the factories, etc. are not in place. The University of Minnesota seems to be involved at the appropriate level, the project and lab should continue to work with them.

8.11 Are there adequate staffing resources available or planned for this effort?

Not able to determine this. The project does not have an RLS yet, so could not show labor resources required. This is an area the project should work hard on over the next several months.

8.12 Is there a funding plan available or proposed to meet the resource requirements to realize the detector?

No. No funding profile was presented by the project, which is to be expected, as they do not yet have a resource loaded schedule.

7.0 Cost and Schedule

Rich Stanek

Ed Temple

Dean Hoffer

Findings

- NOvA has identified 15 key milestones that estimates a project completion in July 2011 based on a construction start in FY07 and without schedule contingency.
- A WBS has been developed down to level 6 in some branches. A resource loaded schedule has not been started.
- NOvA estimated that it will take 4 to 6 months to develop a resource loaded schedule to the level required for a CD-1 review.
- NOvA presented TEC for construction at $187,744K and $9,079K for R&D.

Findings (cont.)

- Most cost estimates were based on FY05 dollars.
- A Basis of Estimate Cost Book has been started which is indexed to link the estimates to the WBS structure.
- The cost estimates exist in the form of Excel spreadsheets.

Comments

- NOvA is to be congratulated on adding the Scheduler and Budget Officers early in the process, which will help in developing the resource loaded schedule and cost estimate.
- NOvA should identify what FY they are going to use as their base year for cost estimates and convert their cost estimates to that year.

Recommendations

- Continue to develop and refine the WBS to the lowest level deliverables and then start to develop the resource loaded schedule.
- Identify the Level 2 and 3 Managers quickly in order to support the development of the detailed resource loaded schedule.

Recommendations (cont.)

- The Review Committee believes that both the TEC and R&D estimated costs appear to be low. It is felt that both Base and Contingency estimates need to be increased, but an actual dollar amount could not be recommended. Further scrubbing of the cost estimate will be accomplished by R&D leading to better definition of tasks and the development of a resource loaded schedule. The following are some examples where cost increases are recommended:

Recommendations (cont.)

- The base estimate for Liquid Scintillator (WBS 1.2) should be increased for purchasing premixed scintillator in order to transfer the risk associated with NOvA mixing the scintillator. Additionally increase the contingency estimate to cover risk of the impact of increasing oil prices.
- Estimated square footage for painting the building interior wall for secondary containment was low by a factor of 2. Increase of $90K.
- Project Management WBS 1.6 and 2.6 to be increased for additional Level 2 managers, additional project office staff, increase Supplies & Software (currently $5K per year) and increase travel (currently $4K per year per L1/L2)

Questions

8.4 Has a Work Breakdown Structure (WBS) been developed or other listing of cost elements been prepared?

A detailed Work Breakdown Structure is in the process of being developed. It exists to Level 4 and is expanded in some sections to Level 5 or 6. The cost estimate is currently contained in the high level elements of this WBS. The original cost estimate numbers are still kept in the cost option comparison Excel spreadsheet.

8.5 Do the cost estimates for each WBS (or cost) element have a sound basis and are they reasonable?

The present estimate is a mixture of detailed costs (backed up by vendor information/quotes, engineering calculations and other written documents), high level estimates, and placeholders. Some of the estimates draw on the recent MINOS experience and just need to be escalated to the base year. The cost estimate should be reviewed for consistency with the present technical design and examined to improve its accuracy.

8.6 Is there a schedule for the project?

A project schedule does not yet exist but is currently being developed. There is a very rough timeline, developed by the project manager that increments with durations from time t = 0. However, this does not include detailed tasks, interdependencies or contingencies.

8.7 If so, are the activity durations reasonable for the assumed resources?

Detailed durations exist for a few critical tasks, such as factory assembly of modules. These durations are backed up by some Time in Motion studies and estimates based on MINOS experience. The assembly sequences have an assumed ramp up and down included in the duration. Both the duration and the resources for module assembly appeared to the Committee to be optimistic estimates given the extraordinary size of the modules (handling issues) and the possible need for additional non-touch labor.

Civil construction duration estimates appear reasonable assuming the bulk of the Title II design is completed prior to time t = 0.

8.8 Has the schedule been "resource loaded"?

No, the schedule is still being developed and has not been resource loaded. Given the recent experience of the project management team with other schedules and cost estimates, there is little doubt that given enough time, a good system will be established.

NOvA Preliminary Director's Review
Executive Summary

TECHNICAL

The NOvA Collaboration has proposed an off-axis electron neutrino appearance experiment using the NuMI beam. They envision a 30,000 ton totally active detector based on liquid scintillator located near the surface in northern Minnesota.

The physics requirements and a detector concept were presented. NOvA will measure or determine limits on Theta13 and contribute to resolution of the mass ordering. Alternate designs for several of the technical subsystems that had been considered were mentioned. Optimizations of the selected design were listed and areas where further work is needed and / or intended were mentioned or discussed in the breakout sessions. Considerations of these and other alternates and optimizations will be described along with simulation studies in a Conceptual Design Report.

Currently design features are being incorporated to record and identify supernovae events should one occur during the active life of NOvA in addition to the NuMI beamline aspect of the experiment.

The committee strongly supports the development of a prototype near detector to test early on many aspects of NOvA. Furthermore, we suggest a full-scale 8-plane sub-block and demonstration of the lifting / erection fixture.

COST

A preliminary cost estimates of $188M (in FY05$) for the MIE and $9.1 for R&D were given. This includes an overall contingency of 40% on the MIE. This preliminary estimate is considered by the committee to be optimistic for both the base estimate and contingency.

SCHEDULE

A list of high level milestones were presented in a NOvA timeline. These included a 4½ year construction period starting in October 2006. This assumed completing an advanced conceptual design report for the Conventional Facilities during the R&D phase to allow site work to start immediately upon receipt of construction funds early in FY07. A more detailed schedule that is resource loaded is not yet available. Such a schedule is required for CD-1.

FUNDING

No funding profile was given. However, it was noted that the $188M TEC over 5 years implies more than $35M per year for flat funding and that amount would be needed the first year to get the building, which is on the critical path, underway quickly.

The committee believes that fully funding R&D in 06 and 07 is extremely important.

MANAGEMENT

The NOvA proposal was developed by the Collaboration. An interim Project Office has been assigned key staff including a Project Director, Deputy Project Director, Project Engineer, Scheduler, Budget Officer and persons to help develop project documentation. Some key project risks were identified.

The committee feels it is extremely important to assign Level 2 and 3 Managers as soon as possible and get them heavily involved in fleshing out the WBS and developing the schedule and resource loading it. The Conceptual Design Report and DOE required documentation to support CD-1 are also next stage critical tasks.