Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

MAIN INJECTOR EXPERIMENT ν-A (MINERνA)

December 2006

EXECUTIVE SUMMARY

A Department of Energy (DOE) Office of Science review of the Main INjector ExpeRiment ν-A (MINERνA) project, to be located at the Fermi National Accelerator Laboratory, was conducted in Germantown, Maryland on December 5, 2006. The review was conducted at the request of Dr. Robin Staffin, Associate Director for High Energy Physics and chaired by Mr. Stephen Tkaczyk, Office of Project Assessment. The purpose of the review was to verify that the project's technical design adequately addressed the technical requirements, the estimated cost was credible and sufficiently documented, and there was a team capable of managing the fabrication effort. In addition, the review was to verify the adequacy of the final design for a limited number of detector components to be procured.

This review was intended to satisfy the requirements set forth in DOE Order 413.3A for an Independent Project Review (IPR) prior to establishing the technical, cost and schedule baselines at Critical Decision (CD) 2, Approve Performance Baseline; as well as the Execution Readiness IPR for CD-3a, Approve Limited Construction.

The Committee judged that the CD deliverables were sufficiently complete and that the project was ready for CD-1/2/3a approval.

The MINERνA project is the fabrication of a high resolution neutrino detector that will utilize the world's most intense neutrino beam at the Neutrinos at the Main Injector (NuMI) neutrino beam line at Fermilab. The detector will be capable of distinguishing explicit final states from neutrino interactions in the energy range of 1 to 20 GeV and measuring their neutrino cross-sections. The improved understanding of low-energy cross sections gained with MINERνA will provide reduced systematic uncertainties for the ongoing and planned neutrino oscillation experiments.

The MINERνA Total Project Cost is $16.8 million with a Total Estimated Cost or Major Items of Equipment (MIE) of $10.7 million and Other Project Cost of $6.09 million. The total project MIE Base (actual year) is $7.77 million with a total MIE contingency of 38 percent or $2.93 million. The total project R&D Base (actual year) is $4.79 million with a total R&D contingency of 27 percent or $1.3 million.

The overall schedule for MINERνA is approximately 3.75 years, starting with CD-0, Approve Mission Need, approved on June 23, 2006 and CD-4, Approve Start of Operations, scheduled for April 12, 2010. The project critical path includes approximately six months or 13 percent schedule contingency.

The MINERνA project has created an appropriate management structure and has assembled a competent management team.

The ES&H aspects are properly addressed given the project's current stage of development.

The Committee made several recommendations, which are included in this report. There were no specific Action Items resulting from the review.

CONTENTS

Executive Summary i
1. Introduction 1
2. Technical Systems Evaluations 3
   2.1 Scintillator Extrusions (WBS 1.0) 3
   2.2 Wave-Length Shifting Fibers (WBS 2.0) 3
   2.3 Scintillator Detector Assembly (WBS 3.0) 4
   2.4 Clear Fiber Cables and Connectors (WBS 4.0) 5
   2.5 Photomultiplier Tubes Boxes (WBS 5.0) 5
   2.6 Photomultiplier Tubes Procurement and Testing (WBS 6.0) 6
   2.7 Electronics and DAQ (WBS 7.0) 7
   2.8 Frames, Absorbers, and Stands (WBS 8.0) 7
   2.9 Module Assembly and Veto Wall (WBS 9.0) 8
3. Cost, Schedule, Funding, and Long-Lead Procurement 9
4. Project Management (WBS 10.0) and ES&H 13

Appendices
A. Charge Memorandum
B. Review Participants
C. Review Agenda
D. Cost Table
E. Schedule Chart
F. Funding Chart
G. Management Table
H. Justification for the CD-3A

1. INTRODUCTION

The Main INjector ExpeRiment ν-A (MINERνA) project is the fabrication of a high-resolution neutrino detector that will utilize the world's most intense neutrino beam at the Neutrinos at the Main Injector (NuMI) neutrino beam line at Fermi National Accelerator Laboratory (Fermilab). The detector will be capable of distinguishing explicit final states from neutrino interactions in the energy range of 1 GeV to 20 GeV and measuring their neutrino cross-sections. The improved understanding of low-energy cross sections gained with MINERνA will provide reduced systematic uncertainties for the ongoing and planned neutrino oscillation experiments.

MINERνA will be a relatively small detector with an active medium of finely-segmented solid scintillator. The detector design and technology choices, very similar to existing experiments, were made to minimize technical risk. The detector will be sited upstream from the MINOS Near Detector in the NuMI line. The installation and commissioning of the detector are not part of the MINERνA project. While Fermilab has primary management responsibility, the execution of the MINERνA project will be carried out in close collaboration with several universities.

Dr. Raymond Orbach, Director of the Office of Science (SC), approved Critical Decision (CD) 0, Approve Mission Need, for MINERνA on June 23, 2006.

The Office of High Energy Physics (HEP) requested that the Office of Project Assessment conduct a review of the project in preparation for CD-1, Approve Alternative Selection and Cost Range; CD-2, Approve Performance Baseline; and CD-3a, Approve Limited Construction. The review was held on December 5, 2006 and was chaired by Mr. Steve Tkaczyk. The purpose of the review was to verify that the project's technical design adequately addressed the technical requirements, the estimated cost was credible and sufficiently documented, and there was a team capable of managing the fabrication effort. In addition, the review was to verify the adequacy of the final design for a limited number of detector components to be procured.

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2. TECHNICAL SYSTEMS EVALUATIONS

The MINERνA project has presented a feasible plan for the construction of the experiment. There were no technical show-stoppers uncovered that would prevent its successful implementation.

2.1 Scintillator Extrusions (WBS 1.0)

2.1.1 Findings

The MINERνA project chose solid scintillator extrusions as their active detector medium. There are two types of extrusions: those with a triangular cross section for the inner detector and those with a rectangular cross section for the outer detector. Both shapes are coextruded with a jacket of reflecting material and with a central hole for the wavelength shifting fiber. The extrusions are to be fabricated at the Fermilab/NICADD facility.

2.1.2 Comments

There is an experienced and capable team in place for the production scintillator extrusions and the procedures for the production are well-understood. The composition of the plastic scintillator is also understood. Early prototype production runs have successfully extruded the required shapes. This is a proven technology that has been used in the MINOS experiment.

2.1.3 Recommendations

None.

2.2 Wave-Length Shifting Fibers (WBS 2.0)

2.2.1 Findings

The MINERνA project has designed a detector using, wave-length shifting (WLS) fibers embedded in scintillator extrusions. The design of the WLS fiber system uses the flexible version of the fiber from the vendor. In addition, it respects the fiber bend radius for fiber of this diameter. The project plans to test five fibers from each batch for their light output and attenuation length.

2.2.2 Comments

The plan for WLS fiber uses an established vendor with an excellent track record. The processing techniques for fibers have been used extensively. The light output using these fibers has been shown to be sufficient. The requirements for this item are unlikely to change so there is little risk to proceeding with the advance procurement.

2.2.3 Recommendations

None.

2.3 Scintillator Detector Assembly (WBS 3.0)

2.3.1 Findings

The project established the techniques for assembling the scintillator detectors components into the configurations required. They have demonstrated the techniques on half-scale prototypes and used this experience as a basis for their expected production capabilities. Production techniques were validated during the manufacture of components for the vertical slice test. They are planning to produce a substantial tracking prototype assembly prior to final production.

2.3.2 Comments

The design and cost estimates are mature and based on significant experience. The vertical slice test shows that with proper attention sufficient light can be provided. It is important that material usage during assembly be closely monitored, as the cost of these components will mount over time. The tracking prototype will provide useful adjustments to the plans and validate the procedures. A quick, quantitative performance quality assurance test should be considered along with the light leak testing before shipping scintillator assemblies.

2.3.3 Recommendation

1. The project should demonstrate the physics performance impact of any scintillator assembly problems, such as damaged or poorly glued fibers to establish performance criteria. In the absence of a quantitative performance test at the assembly factory, the lag time between shipping from and module mapping activity should be minimized to provide timely feedback to the assembly factory.

2.4 Clear Fiber Cables and Connectors (WBS 4.0)

2.4.1 Findings

Clear fiber cables run from the scintillator strips to the photomultiplier tube boxes. The polyurethane cable boots are molded using a process developed by the MINERνA project. The cables are jacketed and made light tight with commercial tubing. The connectors are modified versions of the ones developed for the CDF Plug Upgrade by the Fujikura Corporation. The ferrules of these connectors are loaded with fiberglass, which dulls diamond cutters, and incurs significant cost in these cutters and in the labor required to change them out frequently during production. The project is investigating a new flycutting technique that would preserve diamond cutters and reduce costs.

2.4.2 Comments

The cable boot molds have been designed and the boot material has been optimized for rapid curing without being so exothermic as to damage fibers. This material choice cuts down on the number of machined molds required. Without optical grease the light transmission is as expected. With optical grease, the transmission (not including fiber attenuation) is well above 90 percent, which is a larger increase than expected. Since the experiment is not light starved, this is not a problem. The new flycutting technique has been shown to work on prototypes.

2.4.3 Recommendation

1. The project should continue to pursue the new flycutting technique, and should verify that it is robust and works well in production before adopting it. Quality control tests for fibre cables need to be more clearly specified.

2.5 Photomultiplier Tubes Boxes (WBS 5.0)

2.5.1 Findings

The photomultiplier tube (PMT) boxes have been designed and prototyped by an experienced team that played a leading role in the MINOS PMT box construction. The design brings eight DDK connectors with eight fibers each into an Optical Decoder Unit on the PMT box and those fibers are routed to a precision cookie that puts a fiber on each of the 64 pixels of the

phototube. A light injection system internal to the PMT boxes was developed that shines LED light through the fibers to monitor PMT gain. The light from the LEDs is monitored for fluctuations by a PIN diode.

2.5.2 Comments

The design for the PMT boxes looks reasonable and prototypes have been constructed. The tolerances on the fiber placement are not restrictive so the lacing should be straightforward. Prototypes of the light injection system have been produced and meet design specifications.

2.5.3 Recommendations

1. The project needs to justify the 27 hot spares and 50 (ten percent?) spares without PMTs in the plan.

2. The design and technical specifications for the light injection system needs to be more clearly described.

2.6 Photomultiplier Tubes Procurement and Testing (WBS 6.0)

2.6.1 Findings

The MINERνA project plans to use the Hamamatsu R7600U-00-M64 64 channel multi-anode photomultiplier tube (MAPMT) for light detection from optical fibers. Roughly 500 of the devices will be required. Some selection of the devices by the Hamamatsu factory is needed to meet the required specifications. It was determined that crosstalk in the PMT could affect the position resolution, a critical component of the measurement. The project has devised a way to minimize the effect and will test all PMTs for the effect. The product of quantum and collection efficiency and gain will be tested to set the operating characteristics of the PMT. The test data can be compared with test data from tubes where the quantum and collection efficiency has been measured by the manufacturer to determine the efficiency of the tube under test.

2.6.2 Comments

The project chose to use a mature product from a well established vendor. The testing plan is reasonable for these devices and will fulfill the requirements and should be capable of detecting a manufacturing problem that would impact the experiment.

2.6.3 Recommendations

None.

2.7 Electronics and DAQ (WBS 7.0)

2.7.1 Findings

The MINERνA project plans to use a front-end readout based on the Trip-t chip designed at Fermilab. Extensive testing of the readout board, chips, and firmware have been performed. The DAQ system uses a custom readout controller in a VME crate interfaced to a main computer via a PVIC/VME link. A vertical slice test was done to demonstrate the proof of principle of the readout design.

2.7.2 Comments

The MINERνA front end readout uses a derivative of a previously used chip with some modifications. The R&D VST has demonstrated proof of principle. DAQ rates are low and the detector and front end electronics should handle expected rates from signals and expected noise sources. The full module test should provide confidence that there are no unexpected noise sources from the detector components. There are plans to readout a single plane of scintillator using the final or near final devices and integrating the on-board CW HV generator. This test will eliminate the potential risk of this device injecting noise into the readout system.

2.7.3 Recommendations

None.

2.8 Frames, Absorbers, and Stands (WBS 8.0)

2.8.1 Findings

The MINERνA project plans to build frames to hold scintillator assemblies. These frames will be loaded with scintillator and mounted on stands during installation. Nuclear target material will be inserted as designed, and absorber materials placed where needed.

2.8.2 Comments

The components of the frames, stands, nuclear targets and absorbers have been designed. The design is based on standards for steel construction and ANSI standards where applicable. The design is similar to that used in the MINOS detectors and uses many of the same personnel. The project is using the available expertise and experience to provide a safe and efficient operation. There do not appear to be any problems here.

2.8.3 Recommendations

None.

2.9 Module Assembly and Veto Wall (WBS 9.0)

2.9.1 Findings

Scintillator plane assembly takes place at William and Mary University and Hampton University, two schools 25 miles apart so that resources can be shared. The steel and absorber material is assembled at Fermilab. The final module assembly and veto wall construction takes place at Fermilab with university labor.

2.9.2 Comments

The assembly plan is well planned. The team is experienced and capable of implementing the plan. One strength of the plan is that well-trained university labor working at Fermilab will be responsible for the final assembly. The final assembly is then immune to Fermilab accelerator shutdowns.

2.9.3 Recommendation

1. The collaboration needs to re-evaluate the CD-4 requirement for module qualification. If only 90 percent of the bars in every scintillator plane were active would the project be “ready to operate” (which in this case means start installation underground)?

3. COST, SCHEDULE, FUNDING, and LONG-LEAD PROCUREMENT

3.1 Findings

The MINERνA Project Total Project Cost (TPC) is $16.8 million with a Total Estimated Cost (TEC) or Major Items of Equipment (MIE) of $10.7 million and Other Project Cost (OPC) of $6.09 million. The total project MIE Base (actual year) is $7.77 million with a total MIE contingency of 38 percent or $2.93 million. The total project R&D Base (actual year) is $4.79 million with a total R&D contingency of 27 percent or $1.3 million.

The total project funding profile/guidance provided by DOE is $10.7 million for MIE and $6.1 million for R&D, respectively. Specifically the funding profile for MIE is $5.4 million in FY 2008; $4.9 million in FY 2009; and $0.4 million in FY 2010. The funding profile for R&D is $0.8 million in FY 2006, $4.9 million in FY 2007 and $0.4 million in FY 2008. Appendix D contains a summary of the project cost estimate and associated funding profile/guidance. The project also developed a detailed cost chart that identifies by Work Breakdown Schedule (WBS) the costs associated with each activity. The detailed cost chart includes: Fund Type (e.g., R&D or MIE); M&S Cost; M&S Contingency Factor; Labor Cost; Labor Contingency; Contingency Total; TPC without Contingency; Burdened, Escalated Base Cost; TPC; and Total Burdened, Escalated Cost. Appendix F contains the detailed Funding Chart.

A WBS and a WBS Dictionary were developed for this project. There are ten Level 2 activities that are then subdivided down in detail, in some instances to Level 5. The ten major WBS activities include: 1.0 Scintillator Extrusion; 2.0 WLS Fibers; 3.0 Scintillator Plane Assembly; 4.0 Clear Fiber Cables; 5.0 Photomultiplier Tube Boxes; 6.0 Photomultiplier Tubes; 7.0 Electronics and DAQ; 8.0 Frames, Absorbers, and Stand; 9.0 Module Assembly and Veto Wall; and 10.0 Project Management. For each WBS subactivity within the WBS Dictionary, details are provided on the specific resources (e.g., M&S, labor) required, activity duration, start/finish dates, and associated costs. Additionally, each sub-activity provides references that support how the Basis of Estimate (BOE) is determined for M&S, Labor and Schedule.

The National Science Foundation, Major Research Instrumentation program is contributing $0.3 million towards project deliverables. The NSF funds provide $0.2 million for R&D associated with calibration of the detector and $0.1 million is applied to the costs for the nuclear targets. These funds are outside the scope of DOE's purview and DOE is not responsible for any off-project costs that may exceed their contingency.

The Project Execution Plan delineates that this project only encompasses the construction and testing of the MINERνA detector. The installation and operation of the detector are excluded from the project to provide the needed flexibility to complete the project to CD-4 independently of scheduling issues associated with NuMI/MINOS and Fermilab Accelerator complex. Since the project does not include installation and final checkout, there is an additional $1.9 million of OPC that is provided in the detailed cost chart that is not considered part of this project.

The overall schedule for this project is approximately 3.75 years, starting with CD-0, Approve Mission Need, approved on June 23, 2006 and CD-4, Approve Start of Operations, scheduled for April 12, 2010. Aside from the work being performed by Fermilab, a significant portion of the work is going to be performed at a number of universities from around the country. The resource-loaded schedule, organized by Level 2 WBS activities, has leads from five different academic institutions managing nine of the ten Level 2 project activities. The project resource-loaded schedule has six Level 1, twenty Level 2, and twenty-seven Level 3 milestones that are distributed throughout the entire life of the project. A confidence level of 85 percent was calculated and applied to all schedule durations on the resource-loaded schedule and project critical path. A 95 percent confidence level was calculated and applied to the dates for the DOE project milestones. Appendix E contains the project's resource-loaded schedule.

A critical path for the project was established, and does not start until August 2, 2007, (Rochester Pre-purchase Funds Released) and runs through April 12, 2010 (CD-4). The critical path focuses primarily on the fabrication, assembly, testing and shipment to Fermilab of the PMT boxes/bases and associated components. The critical path also includes approximately six months or 13 percent schedule contingency. Appendix E contains the critical path portion of the project's schedule.

Because this project is under $20 million, application of an Earned Value Management System (EVMS) is not required and will not be utilized. The project identified over 53 milestones that are populated in the resource-loaded schedule that are to be used as indicators of project progress in lieu of earned value.

The project also presented justification for long-lead procurements of clear fibers, WLS fibers, optical connectors, and the plastic to be used for the PMT alignment holders. The total request amount for the long-lead procurements is $440K, with the bulk of the funds ($231K) for the WLS fibers. Because construction funds for the project will not become available until FY 2008, Fermilab has negotiated with the University of Rochester to purchase these components in FY 2007, predicated on the fact that CD-3a has been approved by DOE for the advance procurement of the

components. Fermilab will then reimburse the University of Rochester in FY 2008, when the long-lead procurement funds are made available by DOE. Appendix H contains the justification for the CD-3a request.

3.2 Comments

The TPC, MIE, and R&D cost estimates are consistent with technical scope and stated performance. Appropriate project contingency has been established and assigned to each individual scheduled activity or task. Based on the risks defined for this project, it was concluded that the overall level of contingency assigned to this project for both MIE and R&D is adequate. The WBS Dictionary adequately breaks down the project into manageable tasks and provides sufficient detail on the BOE for each of the activities or tasks and the costs associated with completing that activity. Additionally, the MINERνA Project Manager and Level 2 Leads were very knowledgeable on the basis and justification for all aspects of the Project costs estimates and associated contingency.

The proposed detailed resource-loaded schedule is reasonable and appropriate based upon the technical tasks required and the proposed funding profile and includes adequate schedule contingency. The critical path was identified, is reasonable, and appropriately includes the six months of schedule contingency. Application of an 85 percent confidence level for the overall schedule and critical path is a sound and defensible approach. Applying a 95 percent confidence level to the DOE project milestones is an excellent approach to ensure milestones are achieved on time. The MINERνA Project Manager and Level 2 Leads demonstrated a sound understanding of both the project resource-loaded schedule and associated critical path.

The project schedule, costs, and contingency appear to be well planned and reasonable. The project TPC, MIE, and R&D cost estimates are consistent and aligned with the project funding profile/guidance provided by the DOE. In regards to cost, schedule, and funding, MINERνA is adequately prepared for CD-1/2 approval.

The project team provided a defensible argument and documentation for the long-lead procurement of clear fibers, WLS fibers, optical connectors, and the plastic to be used for the PMT alignment holders. This justification was supported by relevant, up-to-date BOE that included vendor quotes where applicable. The one misconception was if the long-lead procurements were approved, that the resource-loaded schedule and critical path would eliminate four months of schedule impact, when in-fact both already have the four months removed. In regard to long-lead procurement, MINERνA is adequately prepared for CD-3a.

3.3 Recommendation

1. To minimize project risk and maintain the planned project schedule, the project should move forward with the long-lead procurement of the clear fiber, optical connectors, and the plastic to be used for the PMT alignment holders.

4. MANAGEMENT (WBS 10.0) and ENVIRONMENT, SAFETY and HEALTH

4.1 Findings

The MINERνA project has documented its management structure and has assembled a management team. The project has provided the following documentation for CD-1/2: a signed Acquisition Strategy, Project Execution Plan, Project Management Plan, requirements document, value engineering plan, risk analysis, a signed hazards analysis, design drawings, resource-loaded schedule, detailed WBS dictionary to Level 5, detailed cost book to Level 5, critical path analysis, and funding profile. A Proposal, Technical Proposal, Conceptual Design Report, and Technical Design Report were also provided. In support of CD-3a, the project provided the following documentation: a justification for the CD-3a purchases, bid packages for the four purchases, and a set of drawings and specifications.

The MINERνA project identified ten Level 2 managers, and the integration coordinators were identified and assigned to coordinate the interfaces between WBS 3.0, 8.0 , and 9.0; WBS 5.0 and 7.0; and WBS 1.0, 2.0 , and 4.0.

A Fermilab Director's CD-1 review of the MINERνA project was conducted on December 13-16, 2005 and a Fermilab Director's CD–2/3a review was on August 1-3, 2006. These reviews were thorough, detailed and the project responded to all recommendations. The MINERνA project provided a self-assessment of its preparedness for CD-1/2/3a and currently provides monthly reports to the Federal Project Director. Documentation required by DOE Order 413.3a for CD-1/2/3a is available.

MINERνA project management has requested CD-3a in order to purchase $440K worth of items associated with the PMT box assembly. This task is on the critical path and there is concern that this set of purchases will accelerate the entire project schedule by four months. As part of their bid packages, quotes are provided for purchases of Noryll plastic, optical connectors, WLS fiber, and clear fiber.

4.2 Comments

The MINERνA project created an appropriate management structure and has assembled a competent management team. The management structure and the key personnel are well

documented in the Project Execution Plan, the Project Management Plan, and the MINERνA Management Team Document (version 3 dated October 20, 2006).

The Integration Coordinator roles are detailed in the Project Management Plan, yet they do not show up in the Organization Chart (see Appendix G). Their formal role is in an advisory capacity to the Project Manager.

The Committee concurs with the MINERνA self-assessment that the project has satisfied the criteria for CD-1/2/3a. Regarding the CD-1 criteria:

- The Conceptual Design Report is narrowly tailored to the CD-1 requirements, but is well supported by the Technical Proposal and Technical Design Report.
- The Acquisition Strategy is complete and has been signed (although the Committee recommend a change to the CD-4 milestones).
- The Project Execution Plan is complete, although unsigned (same caveat about CD-4 milestones).
- The Federal Project Director and Integrated Project Team have been appointed.
- The project has passed the Fermilab Director's Design Review.
- A NEPA categorical exclusion was obtained. Hazard Assessment, Safety Assessment, Integrated Safety Management, Risk Management and Quality Assurance Plans were documented.

Regarding the CD-2 criteria:

- The total project scope, cost and schedule were fully detailed, with an appropriate critical path analysis and sufficient milestones.
- The WBS dictionary is sufficiently detailed and complete.
- A Technical Design Report has been completed.
- The project passed the Fermilab Director's Design Review.
- A NEPA categorical exclusion was obtained. Hazard Assessment, Safety Assessment, Integrated Safety Management, Risk Management and Quality Assurance Plans were documented.

The documentation in support of a CD-3a decision appears to be sufficient:

- The bid packages are complete, as are the design specifications for assembling these components into the final PMT boxes. The value/risk management tools were appropriately applied, including this set of purchases.
- The Committee concurred that this set of purchases is likely to lead to a substantial improvement, of approximately four months and that since the purchase price is modest that a positive CD-3a decision would be warranted.

4.3 Recommendations

1. Update the Hazard Assessment Document to include work done at university sites.

2. Update the Memorandum of Understanding with Fermilab regarding the interface with MINOS during Installation and Operations.

3. Provide a less ambiguous MINERνA CD-4 project completion milestone for PMTs and PMT boxes passing tests to a fixed number (such as 425 PMTs and boxes).

4. Obtain the appropriate signatures for the Project Execution Plan, the Project Management Plan, and the Quality Assurance Plan.

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APPENDIX A

CHARGE MEMORANDUM

DOE F 1325.8
(08-93)

United States Government
Department of Energy

memorandum

DATE: November 13, 2006

REPLY TO
ATTN OF: SC-25

SUBJECT: Request to Conduct a CD-1/2/3A Review of the MINERυA Project

TO: Daniel R. Lehman, Director, Office of Project Assessment, SC-1.3

The Main INjector ExpeRiment ν-A (MINERνA) Project will build a detector to study low energy neutrino interactions using the NuMI neutrino beam. I would like to request that you conduct a review of the MINERνA project on December 5, 2006, at DOE Headquarters, Germantown, Maryland. The purpose of this review is to evaluate the project's readiness for approval of Critical Decision 1 (Approve Alterative Selection and Cost Range), 2 (Approve Performance Baseline), and 3A (Approve Limited Construction).

The project has completed both the conceptual design and a technical design and has developed a baseline cost and schedule, so the Office of High Energy Physics is planning to tailor the Critical Decision process and consider both CD-1 and CD-2 together. In order to increase schedule contingency, the project would like to begin the purchase of clear optical fibers, optical connectors, and the plastic used for the phototube alignment holders. CD-3A will be an approval of limited construction to make these purchases and begin fabrication with them. In your review, please evaluate whether these purchases will improve the schedule contingency as described and whether these portions of the design are complete and the project is prepared to make the purchase.

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. Technical Scope: Review the technical scope in order to assure that the proposed design and associated implementation approach satisfies the performance requirements.
2. Cost Estimates: Is the cost estimate consistent with the plan to deliver the technical scope with the stated performance? Is the contingency adequate for the risk?
3. Schedule: Is the proposed schedule reasonable and appropriate in view of the technical tasks and proposed funding profiles? Have the critical paths been identified?

4. Management: Evaluate the management structure as to its adequacy to deliver the proposed technical scope within specifications, budget, and schedule.
5. Limited Construction: Are the requested long-lead procurements and other Construction activities scheduled for FY 2007 necessary to achieve the stated schedule? Have Fermilab and the project done the necessary preparations to execute these activities during FY 2007?
6. Is the document required by DOE Order 413.3A for CD-1, CD-2 and CD-3A complete?

Michael Procario is the program manager for the MINERνA Detector Project in this office and will serve as the Office of High Energy Physics (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. You are asked to submit a formal report to OHEP within 30 days of the review.

/signed/

Robin Staffin
Associate Director
Office of High Energy Physics

cc:
Ray Orbach, SC-1
James Decker, SC-2
Joanna Livengood, SC/FSO
Pier Oddone, FNAL

APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Review of the
Main INjector ExpeRiment ν-A (MINERνA) Project

REVIEW COMMITTEE PARTICIPANTS

Department of Energy

Stephen Tkaczyk, DOE/SC

Review Committee

Steve Kettell, BNL
Joe May, DOE/TJSO
Stuart Mufson, Indiana University
Leon Mualem, University of Minnesota

Observers

Aesook Byon-Wagner, DOE/SC
Mike Procario, DOE/SC
Saul Gonzalez, DOE/SC
Steve Webster, DOE/CH

APPENDIX C

REVIEW AGENDA

Department of Energy Review of the
Main INjector ExpeRiment ν-A (MINERνA) Project

AGENDA

Tuesday, December 5, 2006—U.S DOE Germantown, Conference Room G-426

8:30 am	DOE Executive Session	S. Tkaczyk
9:00 am	Project Overview	D. Harris
9:45 am	Scintillators (WBS 1.0), WLS Fibers (WBS 2.0), and Clear Fiber Cables (WBS 4.0)	K. McFarland
10:15 am	Break	
10:30 am	Phototubes (WBS 6.0), PMT Housing (WBS 5.0), and Electronics and DAQ (WBS 7.0)	R. Ransome
11:00 am	Scintillator Planes (WBS 3.0), Frames (WBS 8.0), and Module Assembly (WBS 9.0)	B. Bradford
11:30 am	Lunch	
12:30 pm	DOE Executive Session	
4:00 pm	Closeout Presentation	
4:30 pm	Adjourn	

APPENDIX D

COST TABLE

MINERνA Detailed Cost Estimate MIE

	WBS		Base w/Indirects (AY M$)			Contingency Estimate			Contingency (AY M$)	Base+ Contingency
			Labor	M&S	Total	Labor	M&S	Total		
M I E	1.0	Scintillator Extrusion	0.27	0.08	0.35	25%	29%	26%	0.09	0.44
	2.0	WLS Fibers	0.33	0.32	0.65	21%	8%	15%	0.10	0.75
	3.0	Scintillator Plane Assembly	0.60	0.21	0.81	30%	48%	34%	0.28	1.09
	4.0	Clear Fiber Cables	0.69	0.35	1.05	37%	13%	29%	0.30	1.35
	5.0	Photomultiplier Tube Boxes	0.40	0.15	0.55	30%	27%	29%	0.16	0.71
	6.0	Photomultiplier Tubes	0.01	1.11	1.12	36%	33%	33%	0.37	1.48
	7.0	Electronics and DAQ	0.10	0.81	0.91	40%	34%	34%	0.31	1.22
	8.0	Frames, Absorbers, and Stand	0.12	0.51	0.63	28%	43%	40%	0.25	0.89
	9.0	Module and Veto Wall Assembly	0.24	0.16	0.40	21%	37%	28%	0.11	0.50
	10.0	Project Management	1.23	0.08	1.31	55%	367%	74%	0.96	2.27
		Total MIE:	**4.00**	**3.77**	**7.77**	**38%**	**38%**	**38%**	**2.93**	**10.70**
OPC		R&D	3.12	1.68	4.79	29%	24%	27%	1.30	6.09
		Total OPC:	**3.12**	**1.68**	**4.79**	**29%**	**24%**	**27%**	**1.30**	**6.09**
		TPC:	**7.12**	**5.45**	**12.57**	**34%**	**34%**	**34%**	**4.23**	**16.80**

MINERνA Detailed Cost Estimate R&D

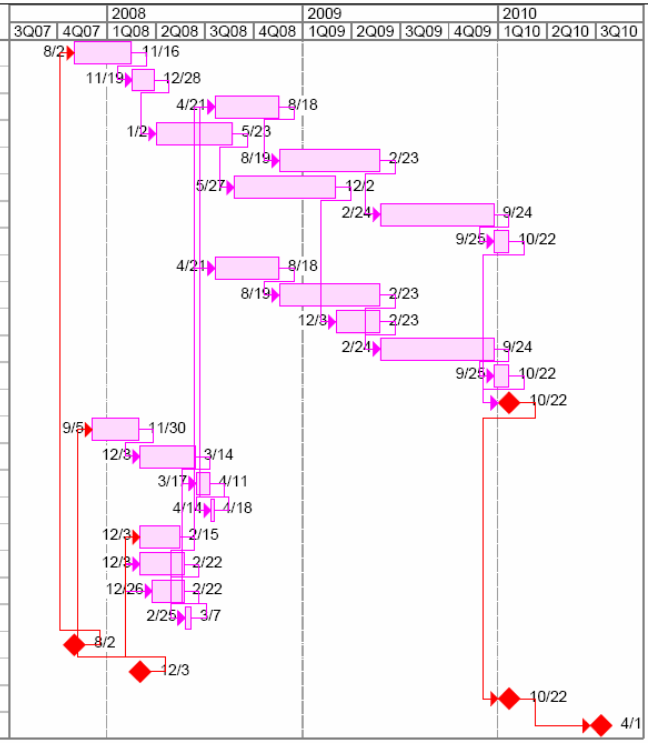
	WBS		Base w/Indirects (AY M$)			Contingency Estimate			Contingency (AY M$)	Base+ Contingency (AY M$)
			Labor	M&S	Total	Labor	M&S	Total		
R & D	1.0	Scintillator Extrusion	0.25	0.04	0.29	15%	27%	17%	0.05	0.34
	2.0	WLS Fibers	0.11	0.08	0.19	24%	16%	21%	0.04	0.23
	3.0	Scintillator Plane Assembly	0.30	0.22	0.52	28%	27%	27%	0.14	0.66
	4.0	Clear Fiber Cables	0.32	0.15	0.47	41%	20%	34%	0.16	0.63
	5.0	Photomultiplier Tube Boxes	0.16	0.11	0.26	22%	13%	18%	0.05	0.31
	6.0	Photomultiplier Tubes	0.09	0.26	0.35	18%	11%	13%	0.05	0.40
	7.0	Electronics and DAQ	0.80	0.40	1.21	34%	14%	27%	0.33	1.53
	8.0	Frames, Absorbers, and Stand	0.25	0.22	0.47	24%	26%	25%	0.12	0.59
	9.0	Module and Veto Wall Assembly	0.33	0.16	0.50	20%	27%	22%	0.11	0.61
	10.0	Project Management	0.50	0.03	0.53	33%	294%	48%	0.26	0.79
		Total R&D:	**3.12**	**1.68**	**4.79**	**29%**	**24%**	**27%**	**1.30**	**6.09**

APPENDIX E

SCHEDULE CHART

MINERνA Critical Path

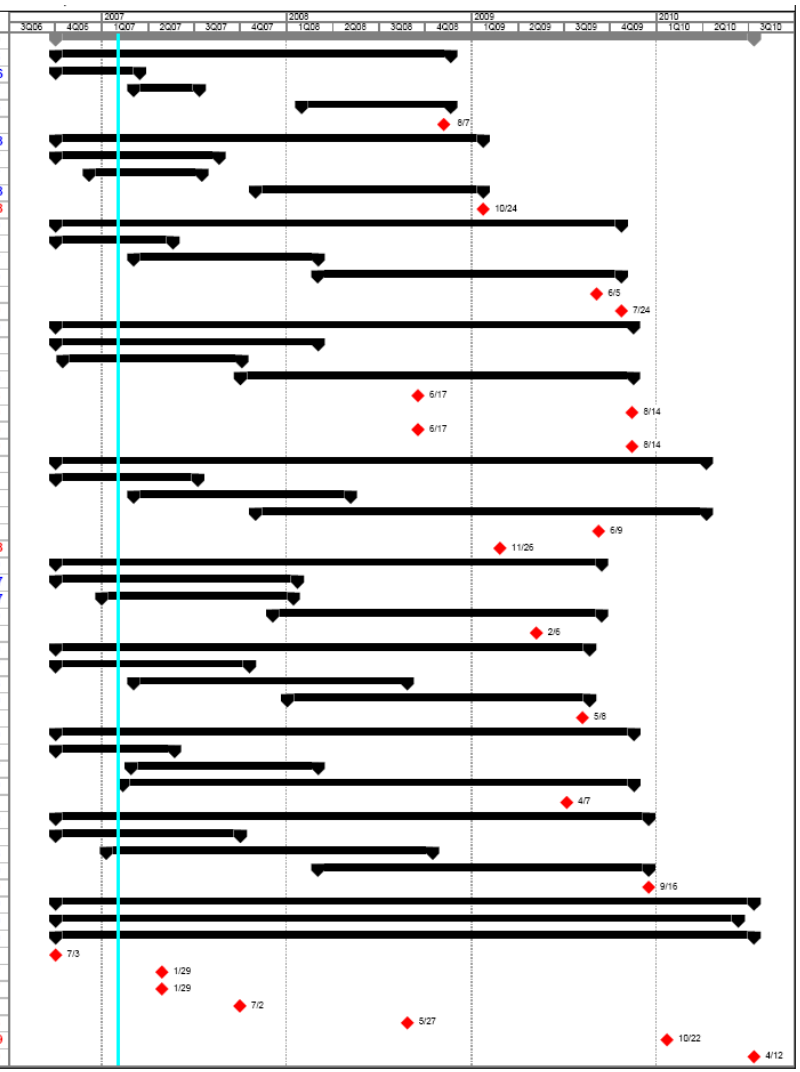
WBS	Task Name	Duration	Start	Finish	Total Slack
5.3.1.1	Produce production alignment holders	15.2 wks	8/2/07	11/16/07	0 wks
5.3.1.3	Produce cookies for 20% of PMT Boxes (110)	5.2 wks	11/19/07	12/28/07	0 wks
5.3.1.7	Assemble and test 1st 20% of PMT boxes at Tufts (55)	16.8 wks	4/21/08	8/18/08	0 wks
5.3.1.9	Produce cookies for 21-50% (166) of PMT Boxes	20.4 wks	1/2/08	5/23/08	0 wks
5.3.1.13	Assemble and test 21% to 50% (83) of PMT boxes at Tufts	25.4 wks	8/19/08	2/23/09	0 wks
5.3.1.15	Produce cookies for 51-100% (274) of PMT Boxes	26.4 wks	5/27/08	12/2/08	0 wks
5.3.1.19	Assemble and test 51% to 86% (98) of PMT boxes at Tufts	30 wks	2/24/09	9/24/09	0 wks
5.3.1.20	Ship 51-86% PMT boxes from Tufts to Fermi (98)	4 wks	9/25/09	10/22/09	0 wks
5.3.2.4	Assemble and test first 20% of PMT boxes at Rutgers (55)	16.8 wks	4/21/08	8/18/08	0 wks
5.3.2.9	Assemble and test 21% to 50% (83) of PMT boxes at Rutgers	25.4 wks	8/19/08	2/23/09	0 wks
5.3.2.13	Weave ODU's into 51-100% (137) of Cookies at Rutgers	10.8 wks	12/3/08	2/23/09	0 wks
5.3.2.14	Assemble and test 51% to 86% (98) of PMT boxes at Rutgers	30 wks	2/24/09	9/24/09	0 wks
5.3.2.15	Ship 51-86% PMT boxes from Rutgers to Fermi (98)	4 wks	9/25/09	10/22/09	0 wks
5.3.4	L3 - All PMT Boxes Shipped to Fermilab	0 wks	10/22/09	10/22/09	0 wks
6.3.1.1	Prepare/submit Procure req for production PMT's	12 wks	9/5/07	11/30/07	0 wks
6.3.1.3	Receive first 40 PMT's at JMU	14 wks	12/3/07	3/14/08	0 wks
6.3.2.1	Attach Holders, Align, and Test first 40 PMT's	4 wks	3/17/08	4/11/08	0 wks
6.3.3.1	Ship first 40 PMT's to box factories	1 wk	4/14/08	4/18/08	0 wks
7.3.2.2.2	Produce/ship jumper cables & Transition boards to Tufts/Rutgers	10 wks	12/3/07	2/15/08	1 wk
7.3.2.4.1	PMT Base production	11 wks	12/3/07	2/22/08	1 wk
7.3.2.4.2	PMT Base checkout and testing	8 wks	12/26/07	2/22/08	1 wk
7.3.2.4.4	Ship PMT Bases to JMU	2 wks	2/25/08	3/7/08	1 wk
10.3.6	L4 - Rochester Pre-purchase Funds Released	0 wks	8/2/07	8/2/07	0 wks
10.3.8	L4 - FY08 Construction Funds Released	0 wks	12/3/07	12/3/07	0 wks
10.3.13	L1 - MINERvA Detector Ready For Installation	0 wks	10/22/09	10/22/09	0 wks
10.3.14	L1 - CD 4	0 wks	4/12/10	4/12/10	0 wks



CP starts in August 2007…limited by FY08 availability of construction funds

MINERνA Resource-Loaded Schedule

WBS	Task Name	Duration	Start	Finish
0	Minerva_Dec06_DOE_Review	189.6 wks	7/3/06	4/12/10
1	Scintillator Extrusion	107.8 wks	7/3/06	8/21/08
1.1	Scintillator Extrusion Prototype Work	23.2 wks	7/3/06	12/15/06
1.2	Tracking Prototype (TP) Scintillator Extrusion	18 wks	12/4/06	4/12/07
1.3	Production Scintillator Extrusion	40.4 wks	11/1/07	8/21/08
1.3.4	L2 - Scintillator Shipping Complete	0 wks	8/7/08	8/7/08
2	WLS Fibers	116.8 wks	7/3/06	10/24/08
2.1	WLS Fiber Prototype Work	44.6 wks	7/3/06	5/21/07
2.2	WLS Fiber Tracking Prototype	30.6 wks	9/7/06	4/17/07
2.3	WLS Fiber Full Production	62.2 wks	8/2/07	10/24/08
2.3.4	L2 - All Detector WLS Fibers Shipped To W&M	0 wks	10/24/08	10/24/08
3	Scintillator Plane Assembly	154 wks	7/3/06	7/24/09
3.1	Plane Prototypes and Outfitting	31.6 wks	7/3/06	2/19/07
3.2	Tracking Detector Scintillator Plane Components	50.4 wks	12/4/06	12/3/07
3.3	Plane Production	82.6 wks	12/3/07	7/24/09
3.3.9	L2 - All Outer Detector Towers Shipped To Fermilab	0 wks	6/5/09	6/5/09
3.3.10	L2 - All Inner Detector Planes Shipped To Fermilab	0 wks	7/24/09	7/24/09
4	Clear Fiber Cables	157.2 wks	7/3/06	8/17/09
4.1	Clear Fiber R&D	71.6 wks	7/3/06	12/3/07
4.2	Clear Fiber For Tracking Prototype	49 wks	7/17/06	7/5/07
4.3	Clear Fiber Production Cables and ODU's	106.8 wks	7/3/07	8/17/09
4.3.5	L3 - Detector ODU Shipments Complete	0 wks	6/17/08	6/17/08
4.3.6	L3 - Detector Clear Fiber Cable Production Complete	0 wks	8/14/09	8/14/09
4.3.7	L2 - Detector ODU Shipments Complete	0 wks	6/17/08	6/17/08
4.3.8	L2 - Detector Clear Fiber Cable Production Complete	0 wks	8/14/09	8/14/09
5	PMT Boxes	176.6 wks	7/3/06	1/8/10
5.1	PMT Box and Light Injector Prototyping & Development	38.6 wks	7/3/06	4/9/07
5.2	Tracking Prototype PMT Box and Light Injection Assembly	58.6 wks	12/4/06	2/5/08
5.3	Production PMT Box and Light Injection Construction	122 wks	8/2/07	1/8/10
5.3.3	L2 - 75% of PMT Boxes Complete	0 wks	6/9/09	6/9/09
5.3.6	L3 - Finish Light Injection System For Full Detector	0 wks	11/26/08	11/26/08
6	PMT Procurement and Testing	148.4 wks	7/3/06	6/15/09
6.1	Photomultiplier Tube R&D	66.2 wks	7/3/06	10/23/07
6.2	Tracking Prototype PMT Procurement and Testing	52.4 wks	10/2/06	10/15/07
6.3	Production PMT Procurement and Testing	89 wks	9/5/07	6/15/09
6.3.4	L2 - 60% of PMT's Shipped To Box Factories	0 wks	2/6/09	2/6/09
7	Electronics and DAQ	145.4 wks	7/3/06	5/22/09
7.1	Electronics and DAQ Prototyping	53 wks	7/3/06	7/20/07
7.2	Tracking Prototype Electronics and DAQ	74.4 wks	12/4/06	5/27/08
7.3	Production Electronics and DAQ	82 wks	10/4/07	5/22/09
7.3.5	L2 - DAQ and Electronics Complete	0 wks	5/8/09	5/8/09
8	Frame, Absorbers and Stand	157.4 wks	7/3/06	8/18/09
8.1	Design and Prototype Procurements	32.2 wks	7/3/06	2/22/07
8.2	Tracking Prototype Materials and Assembly	51 wks	11/29/06	12/3/07
8.3	Production Materials and Assembly	138.8 wks	11/13/06	8/18/09
8.3.1	L2 - Purchase of OD and Nuclear Target Materials Complete	0 wks	4/7/09	4/7/09
9	Module Assembly	161.4 wks	7/3/06	9/16/09
9.1	Assembly R&D	50.4 wks	7/3/06	7/2/07
9.2	Tracking Prototype Module Assembly and Mapping	88.6 wks	10/11/06	7/16/08
9.3	Production Module Assembly and Mapping	90 wks	12/3/07	9/16/09
9.3.6	L2 - All Modules Ready For Installation	0 wks	9/16/09	9/16/09
10	Project Management	189.6 wks	7/3/06	4/12/10
10.1	Fermi Management and Administration	185.4 wks	7/3/06	3/12/10
10.3	Project Milestones	189.6 wks	7/3/06	4/12/10
10.3.1	L1 - CD-0 Granted by DOE	0 wks	7/3/06	7/3/06
10.3.2	L1 - CD-1 Granted by DOE	0 wks	1/29/07	1/29/07
10.3.3	L1 - CD-2 and CD-3A Granted by DOE	0 wks	1/29/07	1/29/07
10.3.4	L1 - CD-3B Granted by DOE	0 wks	7/2/07	7/2/07
10.3.11	L2 - MINERvA Tracking Prototype Detector Ready for Evaluation	0 wks	5/27/08	5/27/08
10.3.13	L1 - MINERvA Detector Ready For Installation	0 wks	10/22/09	10/22/09
10.3.14	L1 - CD 4	0 wks	4/12/10	4/12/10



APPENDIX F

FUNDING CHART

MINERνA MIE Cost Profile

WBS		FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	Total
1.0	Scintillator Extrusion	0.00	0.00	0.35	0.00	0.00	0.35
2.0	WLS Fibers	0.00	0.00	0.64	0.02	0.00	0.65
3.0	Scintillator Plane Assembly	0.00	0.00	0.34	0.47	0.00	0.81
4.0	Clear Fiber Cables	0.00	0.00	0.63	0.42	0.00	1.05
5.0	Photomultiplier Tube Boxes	0.00	0.00	0.28	0.21	0.06	0.55
6.0	Photomultiplier Tubes	0.00	0.00	0.53	0.59	0.00	1.12
7.0	Electronics and DAQ	0.00	0.00	0.49	0.42	0.00	0.91
8.0	Frames, Absorbers, and Stand	0.00	0.00	0.05	0.58	0.00	0.63
9.0	Module Assembly and Veto Wall	0.00	0.00	0.17	0.22	0.00	0.40
10.0	Project Management	0.00	0.00	0.53	0.55	0.22	1.31
	MIE Base (AY M$)	**0.00**	**0.00**	**4.01**	**3.48**	**0.28**	**7.77**
	MIE Contingency Estimate (%)	**0**	**0**	**35%**	**41%**	**41%**	**38%**
	MIE Total Budget Profile (AY M$)	**0.00**	**0.00**	**5.40**	**4.90**	**0.40**	**10.70**
	MIE Funding Guidance (AY M$)	**0.00**	**0.00**	**5.40**	**4.90**	**0.40**	**10.70**

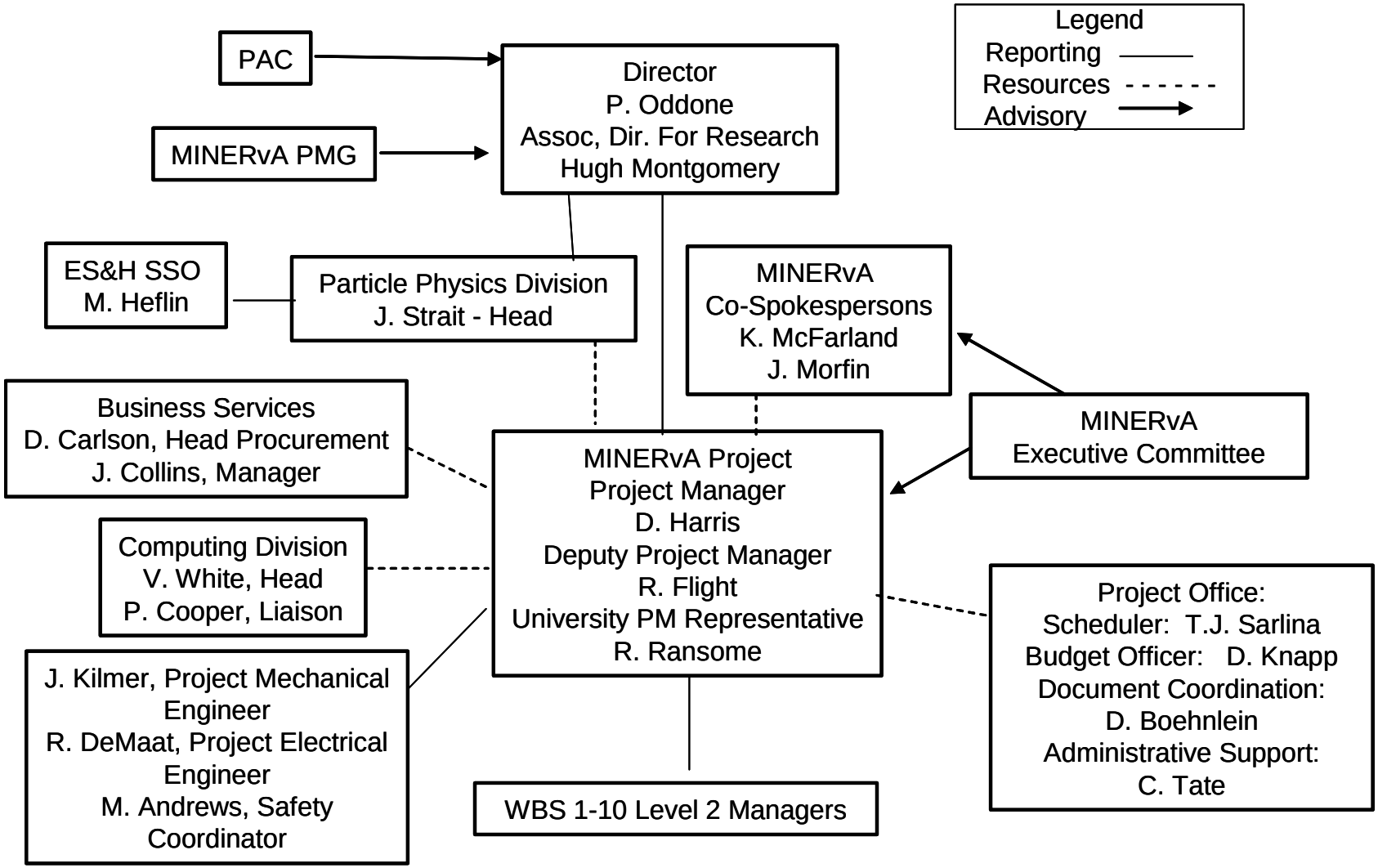
MINERνA R&D Cost Profile

WBS		FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	Total
1.0	Scintillator Extrusion	0.06	0.23	0.00	0	0	0.29
2.0	WLS Fibers	0.01	0.18	0.00	0	0	0.19
3.0	Scintillator Plane Assembly	0.12	0.37	0.03	0	0	0.52
4.0	Clear Fiber Cables	0.09	0.37	0.00	0	0	0.47
5.0	Photomultiplier Tube Boxes	0.04	0.17	0.05	0	0	0.26
6.0	Photomultiplier Tubes	0.06	0.29	0.00	0	0	0.35
7.0	Electronics and DAQ	0.05	0.98	0.17	0	0	1.21
8.0	Frames, Absorbers, and Stand	0.09	0.38	0.00	0	0	0.47
9.0	Module Assembly and Veto Wall	0.09	0.33	0.08	0	0	0.50
10.0	Project Management	0.07	0.47	0.00	0	0	0.53
	R&D Base (AY M$)	**0.68**	**3.77**	**0.34**	**0**	**0**	**4.79**
	R&D Contingency Estimate	**17%**	**29%**	**23%**	**0**	**0**	**27%**
	R&D Total Budget Profile (AY M$)	**0.80**	**4.88**	**0.41**	**0.00**	**0.00**	**6.09**
	R&D Funding Guidance (AY M$)	**0.80**	**4.90**	**0.40**	**0.00**	**0.00**	**6.10**

APPENDIX G

MANAGEMENT TABLE

MINERνA Project Organization



APPENDIX H

JUSTIFICATION FOR CD-3a

Justification for Application for MINERνA CD-3a Approval
Original Note: October 3, 2006
Updated with New Quote Information: November 25, 2006

In order to accelerate the detector construction schedule, the MINERνA project is seeking CD-3a approval concurrent with CD-2 approval.

The MINERνA detector construction takes place along two parallel paths: one path starts with the scintillator bar extrusion, instrumentation, and assembly into planes of scintillator, which are then inserted in lead and instrumented steel frames for calorimetry. The other path is associated with the detector readout: phototubes must be acquired, aligned in precision holders and tested, and then placed in special housings which take the signals from the scintillator through the phototubes and then to the electronics. Clear fiber cables connect the light from the scintillator planes to the phototube housings, and shortened versions of those cables are used internally in the housing. Because of the long-lead time for the delivery of these items, the time required to both make the clear fiber cables that are used internally in the boxes, and the subsequent weaving of the strands of those cables in the boxes, the second path in several months longer than the first path.

By purchasing the clear fiber, the optical connectors, and the plastic to be used for the PMT alignment holders early, the project can reduce the construction period by approximately four months, which is a substantial fraction of the construction time. It is planned to purchase the wavelength shifting fiber early in order to minimize overlap with the NOνA fiber purchase which is anticipated to use the majority of the production resources of the chosen vendor, Kuraray. The fully loaded base costs of these early purchases and their basis of estimate document database numbers are:

Item	Base Cost (FY07 $)	Basis of Estimate Docdb-number
Noryll Plastic	5K	1239
Optical Connectors	53K	926 (UID265)
Wavelength Shifting Fibers (4/5 order)	231K	718
Clear Fiber	151K	926 (UID 263)
Total	440K	

Fermilab and Rochester have negotiated an agreement whereby the University of Rochester agrees to purchase these components in FY 2007. Fermilab will provide a letter to Rochester stating that the funds will be paid to Rochester for purchase of these items when funding for MINERνA is available in FY 2008. Fermilab in turn will only be able to write this letter to Rochester when the project has achieved CD-3a approval for these items.