Impact of MINERνA Design, Assembly, and Installation on Fermilab

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Abstract

This document describes the impact that the design, assembly, and installation of the MINERνA experiment will have on Fermilab. This document will not cover the impact that the experiment will have during operations, nor does it address the broad physics impact the experiment itself will have on the field of particle physics. It should be emphasized that the current MINERνA proposal is for an on-beam-axis experiment running parasitically to MINOS. There is no off-axis running, and no special beam requests.

1 The MINERνA Experiment

The NuMI neutrino facility, designed for the MINOS neutrino oscillation experiment, will yield several orders of magnitude more events per kg of detector per year of exposure than the higher-energy Tevatron neutrino beam. This dramatic increase in intensity will allow us to initiate a vigorous research program with a much lighter and more fine-grained detector, and with smaller targets than the massive iron, marble and other high-A detector materials used in the past.

That these facilities are designed to study neutrino oscillations points out the second advantage of these neutrino experiments: An excellent knowledge of the neutrino beam itself will be required to reduce the beam-associated systematic uncertainties of the oscillation result. This knowledge of the neutrino spectrum will also reduce the beam systematics in the measurement of neutrino-scattering phenomena. In addition, because neutrino oscillation experiments need to use low-energy neutrinos and massive nuclear targets, there is a clear need to better understand low-energy neutrino-Nucleus interactions.

To take advantage of these major improvements in experimental neutrino physics possible with the NuMI beam and facility, a collaboration of elementary particle and nuclear physics groups and institutions named "MINERνA" (Main INjector ExpeRiment ν–A) has been formed. The goal of the MINERνA experiment is to perform a high-statistics neutrino-nucleus scattering experiment using a fine-grained detector located on-axis, upstream of the MINOS near detector. The proposal for this experiment (P-938) was submitted to the Fermilab PAC at their December 2003 meeting and was given encouragement at that meeting.

2 The MINERνA Detector

The physics goals outlined in the proposal can be met by a relatively compact and active target/detector consisting of a central section of essentially solid scintillator bars. This central detector is surrounded on all sides by an electromagnetic calorimeter, a hadronic calorimeter and a magnetized muon-identifier and spectrometer. The detector has the approximate overall shape of a hexagon (to permit three stereo views) with a cross-section of 3.55 m minor and 4.10 m major axis. The length is up to 5.7 m, depending on how close the detector can be placed to the MINOS near detector as in Fig. 1. The active plastic scintillator volume is 6.1 tons allowing variable sized fiducial volumes depending on the physics channel being studied. At the upstream end of the detector are nuclear targets consisting of C, Fe and Pb. Significant granularity and vertex-reconstruction accuracy can be achieved by the use of triangular-shaped extruded plastic scintillator (CH) bars with an optical fiber placed in a groove at the base of the bar for readout. Recent work at the Fermilab Scintillator R&D Facility has shown that using light division across triangularly shaped scintillator strips of this size can yield coordinate resolutions of a few millimeters. The orientations of the scintillator strips are alternated so that efficient pattern recognition and tracking can be performed. Following the downstream end of the central detector are electromagnetic and hadronic calorimeters. The MINERνA detector should be placed on the beam axis and as close as possible to the upstream face of the MINOS near detector in order to use that detector's magnetic field, steel, and instrumented planes as an external muon-identifier and spectrometer for the forward-going muons, and as a calorimeter for any hadronic energy exiting the central detector. Moving the detector further upstream from the MINOS detector will decrease the acceptance for muons in the MINOS detector. If necessary a 90-ton "muon ranger", consisting of 1.2 m of segmented and magnetized iron with scintillator planes, will be added to help identify and measure the momentum of low-energy muons. For high-energy muons, the MINOS near detector will provide much better momentum resolution than the muon ranger. The size of the various components of the detector is shown in Table 1.

With a comparatively simple and straightforward active detector technology, the most complicated parts of MINERνA are the photosensors and their associated readout electronics. The photosensor and electronics choices for the experiment were therefore dictated by a combination of cost, required R&D, risk and availability of on-site expertise. Ultimately, we chose to pursue a solution based on multi-anode photomultiplier tubes (MAPMTs). The tube chosen is an incremental design improvement from the one used in the MINOS near detector, and we expect much of the experience gained by the MINOS collaboration with these detectors to be applicable. For the front-end digitization and timing, the best performing system with the least required R&D is a scheme based on D0 TriP ASIC. The TriP chip is a redesign of the readout ASIC for the D0 fiber tracker and preshower originally motivated by the need

Sub-Detector	Mass (metric tons)
Active Target	6.1
Side ECAL	8.5
US ECAL (Pb Target)	3.5
US HCAL (Fe Target)	7.0
OD Framing the Target Regions	126.5
DS ECAL	19.8
DS HCAL	26.4
Veto	15.1
MR/Toroid (if required)	90.8
Total	302.1

Table 1: Mass by sub-detector

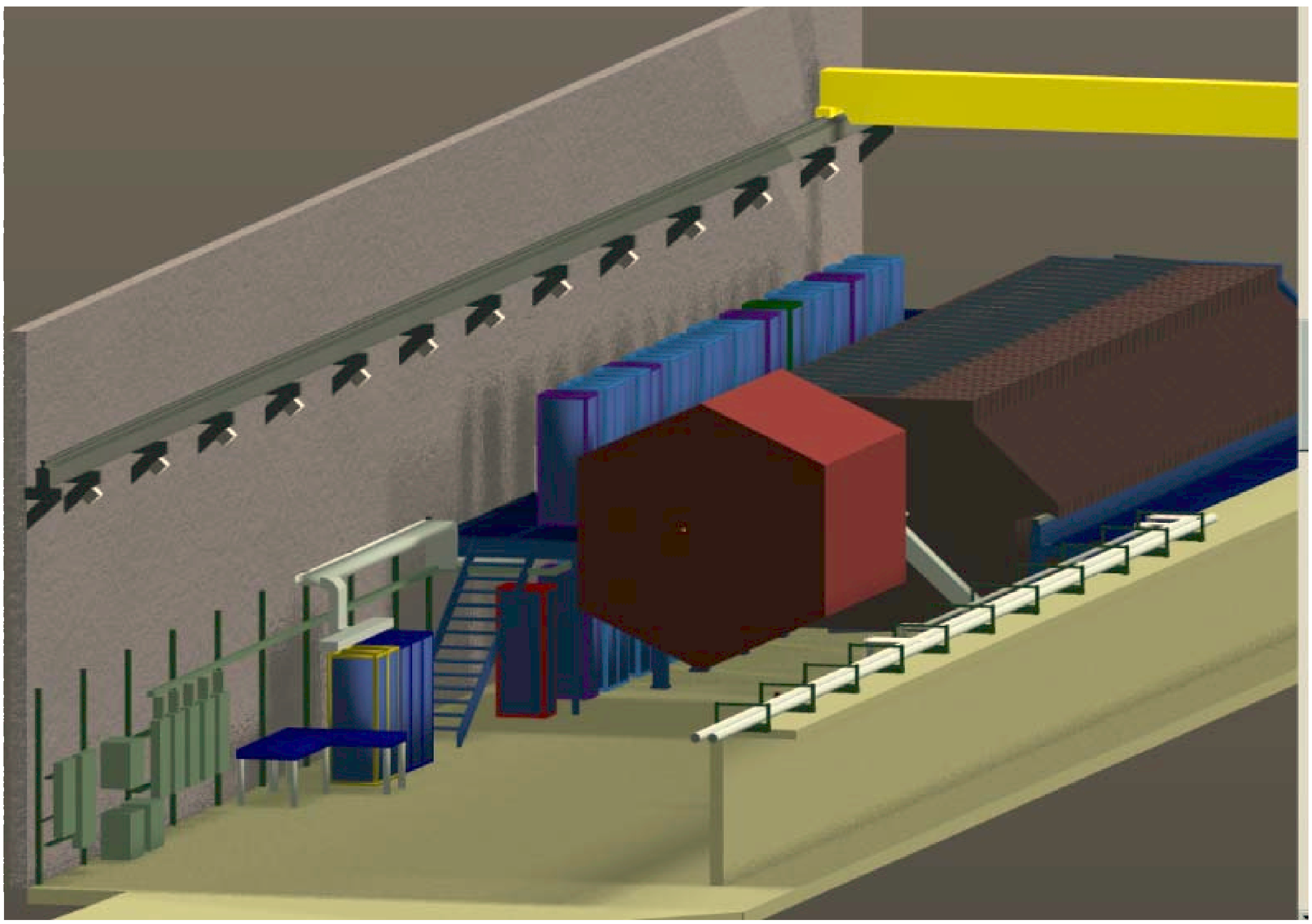

Figure 1: View of the proposed MINERνA detector (without a support stand), and the MINOS detector, looking downstream.

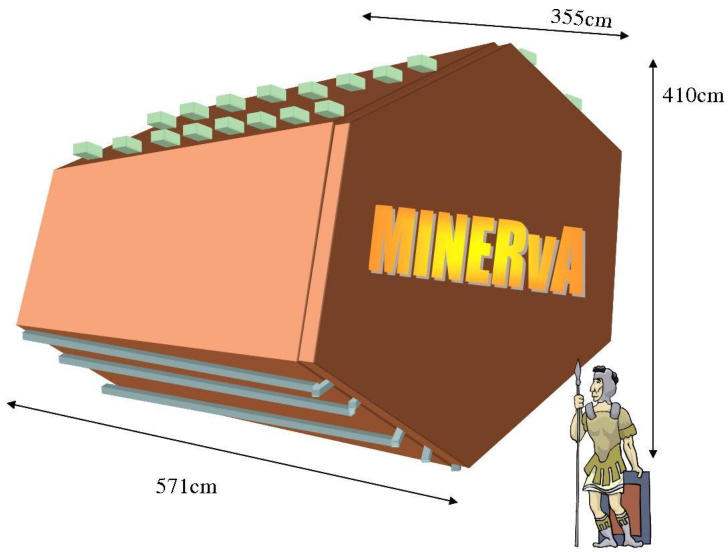

Figure 2: Outline of MINERνA detector, with the optional muon ranger, to illustrate shape and scale. Note the locations of the PMT readout boxes on top of the detector, coils on the bottom.

to run at 132 ns bunch crossings in the TeVatron. A production run of one version of TriP has been completed; however, since the TeVatron run plans do not now call for 132 ns operation, these chips will not see their original use. These existing chips, however, could be recycled into use in MINERνA. The MAPMTs will be mounted directly on the front-end boards to reduce input capacitance. Therefore, the front-end board and PMT need to reside in a single light-tight box with optical cables from the detector as input. In our preliminary design, each PMT box will have a single PMT and front-end electronics for its 64 channels, along with a Cockcroft-Walton HV generator. To minimize the length of the clear fiber cables, we plan to mount the PMT boxes directly on the upper parts of the MINERνA detector, on the two highest sides of the hexagon to avoid conflict with the coils or side clearance of the detector as shown in Fig. 2. This will require magnetic shielding of the MAPMTs.

3 The MINERνA R&D Program

The R&D project for MINERνA attempts to use as much expertise and completed R&D effort from Fermilab experiments or generic efforts as possible. For this reason we have chosen scintillator bars and their cross-sectional shape to take advantage of the Fermilab Scintillator R&D facility experience, and we have adapted MAPMT to capitalize on the MINOS expertise. We have also adopted the TriP chip to take advantage of the significant D0 R&D effort on this front-end chip. Since the MINERνA collaboration wants to construct the detector, install it and begin taking data on a short timescale, we will continue to take advantage of existing expertise wherever possible. We have requested a space of $10m \times 8m$ in the New Muon Lab to conduct our R& D program. By using the New Muon Lab we can take advantage of needed test equipment, used by MINOS, already located there.

3.1 Expected R& D Efforts in FY2004

The R&D effort for the current year will be directed toward a full scale ”Vertical Slice Test” of the detector. A board will be developed to test the TriP chip. It will be connected to MINOS hardware to use a 64-channel scintillator array to test tracking, electronics, light yield and noise via cosmic ray triggers. This will require close collaboration with the ASIC project to construct the board. The details on optical connectors and cables will be developed as part of the Slice Test.

For the vertical slice DAQ board, PPD is supplying the electrical engineering to design the board. MINERνA collaborators will build the detector and fund the materials. Minor requests from FNAL-PPD are possible, such as polishing and mirroring of about 80 WLS fibers, or some cutting of scintillator stock for the detector, but we are still discussing the details. We expect to ask Fermilab personnel for consulting help, but no more: as an example, we will continue to consult with Fermilab engineers on our progress.

3.2 Expected Accomplishments in FY2005 and beyond

Our goal is to be in production within FY05. In early FY05 (maybe late FY04) we will want to test some dies (developed by NIU with non-Fermilab funding) in the Lab 5 extrusion facility. There may be other small tasks best done by Fermilab engineers (e.g., first FEA of the frame), but those so far are at the level of ”spare time” tasks.

We would then like to pursue a test-beam run with a full-scale cross-section of the MINERνA Detector. Further R&D leading up to this test and as a consequence of the result of this test can well be imagined.

4 MINERνA Design Tasks for Fermilab

The detector, electronics, and readout are being designed by physicists and engineers from universities, and fabricated primarily by university technicians. However, it is forseen that Fermilab will take over the responsibility for designing those items which are of a safety concern. This includes the stand that holds the detector in the MINOS near detector hall, as well as a shorter version that will be used during assembly in a space provided by Fermilab–we have requested the New Muon Lab. The installation procedure and associated lifting fixtures, the low voltage distribution system and anything associated with power supplies will also be designed by Fermilab engineers.

Many of the design tasks are similar to MINOS and as much as possible we have tried to base these estimates on MINOS costs. The next three sections give details on some of the design tasks which are then summarized, along with less involved design tasks, in Table 3.

4.1 Detector Stand Design

We assume a stand for the detector comprising two rails approximately 20 feet in length. Each rail is supported by four vertical posts of structural steel, with a structural steel bookend at the downstream end. The ”keys,” which lock the 4-plane module assemblies into the structure, are made of stainless steel to prevent the supports from becoming magnetized. A combination of stainless and brass is also a possibility. There will be 100 of these (2 each for 50 modules) and their manufacture will constitute most of the machinist’s time for this item. The sum weight of all of the modules is estimated to be 211 tons

Personnel	Time Needed	Cost (k$)
1 Engineer	2 months	22
3 Technicians	2 weeks	10
1 Safety Officer	2 days	1
		Total: 33

Table 2: List of personnel needed to design, construct and test the MINERνA strongback.

plus a possible 91 tons for the muon ranger, exclusive of cabling, electronics and other accoutrements. The preliminary design calls for the stand to support 400 tons.

4.2 Detector Strongback Design

This task is assumed to be straightforward, based on experience with the MINOS strongbacks. It is possible that some materials left over from MINOS could be used in the fabrication of the strongback. One attractive possibility is to assemble the modules on the strong back, and the individual pieces would therefore be lifted with slings and placed on the strongback. In this way an additional custom-built lifting fixture other than the strongback itself will not be necessary. Time and personnel estimates are given in Table 2.

4.3 Front-end Electronics

The front-end electronics decision was based on research already performed in collaboration with the ASIC project group within Fermilab's Electrical Engineering Department. We considered the Viking chip used by the MINOS far detector, the QIE chip used by the MINOS near detector and the TriP chip used by D0. The ASIC project was of immense help in determining that the TriP chip could be used by MINERνA and the TriP chip was ultimately chosen. We will need continued design help from the ASIC Project to develop the front-end board, using the TriP chip, to be used in this year's R&D effort and, eventually, in the experiment.

4.4 Design Summary

A list of design tasks and the length of time each would require is given in Table 3.

5 Fabrication

The detector, because of its size, should be assembled on site. A space to establish a fabrication facility for the detector modules is requested in the New Muon Lab. It is assumed that Fermilab would be responsible only for safety oversight and welding, rigging, or crane usage. The bulk of the assembly will be done by university technicians. In contrast, Fermilab will take full responsibility for the installation of the detector.

Because of the safety concerns it is assumed that Fermilab will be responsible for fabrication of the detector stand and strongback, as well as the cart which will transport the detector modules from the bottom of the MINOS shaft to the stand. We assume the fabrication cost of the strongback would

Task	Division	Personnel	Time	Cost (K$)
Installation Procedure	PPD	Mech. Eng.	4 months	45
	PPD	Drafting	2 months	14
Detector Stand for Near Hall (including bookend and drip protection)	PPD	Mech Eng. and draftsperson	5 weeks	14
Strongback for Module Transport	PPD	Mech. Eng.	2 months	22
Review of Module Assembly Procedure	PPD	Mech. Eng.	1 months	11
Low Voltage System (5kW)	PPD	Elec. Eng.	3 months	33
TriP-chip front-end Board	PPD	Elec. Eng.	12 months	130
				Total: 268

Table 3: List of design tasks undertaken by Fermilab Engineers and draftspeople, and an estimate for the time required for each task. Costs are calculated assuming $130k/year total cost per engineer and $80k/year total cost per draftsperson.

Personnel	Time Needed	Cost (k$)
1 Engineer	5 weeks	13
1 Draftsman	5 weeks	8
3 Technicians	14 weeks	67
1 Machinist	9 weeks	20
1 Welder	3 weeks	9
1 Safety Officer	3 weeks	7
3 Riggers (2+super)	3 weeks	31
		Total: 155

Table 4: List of personnel and time required for the design, assembly, and installation of the detector suport structure. Broken into phases, design is $21k, assembly and installation are each estimated at half of the remainder, or $52k.

be that of a MINOS near detector strongback, approximately $12k. If the existing MINOS cart can be modified for MINERνA use then that would be done.

5.1 Detector Support Structure Fabrication

We intend to build two support structures, one shorter structure for module assembly and one for support in the MINOS near hall. The module assembly and the assembly stand itself would be at New Muon Lab. The underground support structure should also be assembled first on the surface, at the New Muon Lab. The purpose of the above-ground assembly is to test the structure itself and de-bug assembly procedures. It will be modified as necessary, then disassembled and moved underground to the MINOS hall. All critical welds will be made on the surface. Underground assembly will consist of rigging and bolting.

No detailed cost estimates for time and materials are available as of this writing. Estimates, given in Table 4 for personnel and time are integrated over the entire fabrication and installation period, which is assumed to take nine weeks from the start of fabrication to completion of the installation underground.

Task	Division	Personnel	Time	Cost (k$)
Detector Stand for Near Hall (including bookend and drip protection)	PPD	Technician	6 weeks	66
Installation Strongback	PPD	Tech	2 weeks	11
Strongback Safety Oversight	ES& H	Engineer	2 days	1
Module Assembly Prototyping	PPD	Safety Oversight Welder Crane Operator	.1FTE $\times$6months .2FTE$\times$6mos .2FTE$\times$6 months	13 15 8
Module Assembly	PPD	same as prototype	12 months	72
Internal Alignment	PPD	Survey crew	1 week	3.5
				Total: 190

Table 5: List of fabrication tasks undertaken or aided by Fermilab technicians or surveyors, and an estimate for the time required for each task.

5.2 Fabrication Impact Summary

First of all, the space for fabrication of the modules at New Muon Lab is requested. The remainder of the impact on Fermilab during the fabrication phase is summarized in Table 5.

6 Installation

6.1 Quiet Power Requirements and Installation

The current design of the detector calls for a complement of electronics and DAQ components that will not quite fill one electronics rack:

- A total of 10 VME readout modules, filling half of one VME crate
- One or two PVIC/VME interface modules (one per crate)
- A to be specified number of additional modules for timestamp and trigger logic. Approximately one crate worth.
- A slow-control system that is Ethernet-based with 600 Ethernet channels involving a two-tiered LAN.
- A DAQ computer

The sum power draw of these items is estimated to be 3kW

Also in the rack is the low-voltage power supply to the 595 front-end boards mounted in the individual PMT boxes that include a Cockcroft-Walton for the PMT. The power required per PMT box will be order 7 watts requiring a power supply with a total output of 5 kW. Total Quiet power required for read-out electronics, DAQ computer, front-end electronics and the PMTs is 8kW.

To accomodate this, and any other currently unforeseen quiet power needs, MINERνA proposes to add a 75kVA transformer to the MINOS hall, in addition to the two 75kVA and one 45kVA transformers already serving MINOS. Like the three existing transformers, the MINERνA one would be fed from the main 750kVA quiet power transformer, at 480V. Unused taps with sufficient current capacity exist on this line. The estimated cost for the 75kVA transformer and its panel boards is approximately $8k. An additional $24k would be required in electrician labor to install the transformer, conduits, and panel boards, but this amount could be substantially less depending on the precise location of the components within the MINOS hall.

6.2 Magnet Power Supply

MINERνA will use 48 turns at 500 amps (24 kA-turns) to power the magnetic component of the detector. A 240 kW PEI power supply will likely be used for the MINERνA magnet, and would need to supply 500A at an estimated 60V. Unused PEI 240 supplies exist at Fermilab, but may need refurbishing of controls and transformer at a cost of up to $22k. We are aware that the MINOS coil eventually required that the original design for 48 coils be modified by combing a set of six coils into a bar and powering the magnet as an 8-turn coil at 5000 amps. Were we to adopt this procedure we would need to run an 8-coil geometry at 3000 amps.

The MINOS magnet will draw an estimated 80kW on a power supply fed by a 400A/480V transformer. Accounting for efficiencies of the supplies, the MINOS and MINERνA magnet power supplies combined are expected to draw less than 200 kVA (236A) from the 400A/480V transformer. In this case, MINERνA will only need to add a seperate disconnect for the new power supply. The expected cost is approximately $5k of electrician labor and $0.5k for the disconnect.

6.3 Module Installation Schedule

The time needed to install the detector modules was based on the MINOS intallation plan. For the part of the MINOS detector that has scintillator planes between every plane of steel, one crew of 4 technicians (plus a task manager) will make two trips per day from New Muon Laboratory to the MINOS near hall. Between delivery of each steel-scintillator unit, MINOS physicists will commission each plane and check for light leaks or any possible damage to the unit. For the "spectrometer" part of the MINOS detector, namely one plane of steel instrumented with scintillator followed by 4 planes of "blank" steel, the crew will make one trip a day, where they expect to transport, lower down the shaft, and install all 5 planes in one day, ending on an instumented plane which then gets commissioned by physicists.

MINERνA also has two kinds of detector regions: for the muon ranger, should it be required, the segmentation is similar, where there will be 3 planes of scintillator, with two steel sections made up of nine 2"-thick planes sandwiched between the scintillator. Similarly the hadron calorimeter region will have instrumented planes separated again by 2" steel plates. These regions will be installed with 1 instrumented plane trip plus blank steel per day, while the other regions will be installed with two trips per day. Table 6 gives a list of the number of modules, their weights, and how many days it is expected to install them using this schedule.

6.4 Computing Support

This is difficult to quantify without a more exact knowledge of MINERνAś computing and electronics needs. We do know that the total acquired data size is only 10^6 bits per spill, so even with 10^7 spills per year, this is $< 1TB$/year We can also make some qualitative estimates of required support from the Computing Division, as shown in Table 7.

Detector Region	Number (modules)	Mass/Module (tons)	Time to Install (days)
Inner Detector	30	3.6	15
Upstream ECAL	6	3.8	3
Nuclear Targets	4	3.9	2
Downstream ECAL	5	4	3
Downstream HCAL	5	5.3	5
Muon Ranger	3 +18 planes	3.6	3
			Total: 33

Table 6: Table of detector modules, their weights, and the estimated times to install them, assuming a schedule similar to the MINOS installation schedule.

Personnel	Time required	Task
Liaison	1 week	Prepare MOU
System Manager	1 week	Manage offline computing resources
Programmer	3 weeks	Support for CRL (if adopted)
2 Technicians	2 weeks	Install additional ethernet lines in Lab E and MINOS hall
PREP Staff		MINERνAś PREP needs are not yet fully understood But one rack will be needed

Table 7: Personnel, time required, and tasks that the MINERνA experiment will likely need from the computing division. The MINERνA collaboration has not yet made a decision on whether to use a Control Room Logbook (CRL), but the provision for it is made here.

6.5 ES&H Oversight of Radioactive Sources

The MINERνA collaboration has not yet made a decision on whether to use radioactive sources, but the provision for them is made in this impact statement. Two uses of radioactive sources may be foreseen for the MINERνA experiment. The first is pre-installation calibration and mapping of the scintillator strips, using a mapper setup similar to that used for MINOS. The second is *in situ* calibration of the strips with sources mounted in the detector. Both applications would require support from the ES&H Section's Radiation Physics Group. The sources would have to be brought into the Fermilab inventory and transported by a source technician. Installation of sources in a mapper or detector would also need source tech oversight. Some members of the collaboration may also require Rad Worker and Radioactive Source training. In total, we estimate these issues will require the efforts of an engineering physicist for 1 week, 1 technician for 3 weeks, and one trainer for 1 week.

6.6 ES&H Training for Underground Access

Any collaborators who work on or access the detector in the near detector hall will have to have underground safety training. Some may already have had such training for work on NuMI/MINOS, but we assume that most will not. This is expected to take the time of 1 Trainer one full time week equivalent.

6.7 Possible Modification to MINOS Rack Platform

The proposed location of the MINERνA detector and stand would impinge on a "keep-clear" egress space on the west side of the hall. The location of the egress space is currently determined by the stairs to the MINOS rack platform. It is possible that this space competition can be resolved by displacing the detector slightly to the east, with negligble impact on the low energy beam configuration. However, it may be preferable to extend the MINOS readout rack platform, and move the stairs to a location upstream of the MINERνA detector. An estimate for the purchase and installation of the new platform section, and the displacement of the stairs, is \$10k: \$1.2k for 3 person days of work, and \$9k for the frame and the grating.

6.8 MINERνA Cooling Requirements

The heat generated by the MINERνA experiment into the MINOS hall has to be removed. This has been seen at the MINOS far detector at Soudan. At Soudan, all the heat went into the air and into the cavern rock initially. However, once the rock warmed up, the rate of heat going into the rock decreased and they have found it necessary to increase the air flow thru the cavern to keep the temperature from rising above 70 F.

The same effect is expected to occur at MINOS Near Detector hall. Initially heat will be added to the rock intentionally to raise the cavern temperature in an attempt to lower the relative humidity. For MINOS Near, the cooling system has been designed to put all of the anticipated heat from the experiment into the sump pump water which is being pumped to the surface. This should result in a sump discharge water temperature of something in excess of 70 F, an increase of some 17 F over the initial temperature of the cooling water.

The heat generated by MINERνA experiment will come from several sources.

- The magnet coil heat loss is directly calculated to be order 30 kW. This may vary depending on the B-H characteristics of the steel eventually used for the MINERνA magnet. The MINOS

Heat Source	Heat Load
magnet coil	30 kW
magnet power supply	10 kW
electronics rack	2 kW
600 PMT boxes	4 kW
TOTAL	46 kW

Table 8: MINERνA heat sources and the heat load expected from each source

near-detector coil running at 40 kA-turns, with coils over twice as long as the MINERνA coils, is expected to generate 48 kW of heat.

- The magnet power supply - a PEI 240 - has a maximum heat loss to water of 10 kW.
- The 8 kW draw of the electronics rack running at 80% efficiency yields a heat loss of 1.6 kW. This 2 kW of heat can either be carried away via water-cooling, as in MINOS, or can be vented into the air and carried away by the coils. It is a small perturbation to either load.
- Each of the approximately 600 PMT boxes mounted on the detector will contain the front-end TriP chip electronics and a Cockcroft-Walton to power the PMT. The sum wattage to power each PMT box is then approximately 7 W. For the heating estimate we assume that the entire 7 W is released as heat suggesting that 4 kW of heat is released into the air from this source.

Table 8 summarizes the expected heat load from the MINERνA installation.

The MINOS heat load is estimated to be 120 kW. There are taps for additional HVAC units sized to remove an additional 36 kW from the air in near detector hall. However, the current system (without using these additional taps) hasn't yet been shown to be sufficient with MINOS loads. The additional heat to the water cooling system from MINERνA is an order 40% added load, the major part being the MINERνA magnet. Since magnets are regularly cooled with 95 F water, the increase in water temperature should be manageable without the need for additional chillers.

6.9 Installation Summary

Table 9 gives a summary of all the installation tasks that will be the responsibility of Fermilab.

7 Summary

The MINERνA experiment is in the very fortunate position of being able to pursue an excellent physics program, of significant importance to the long-range neutrino physics objectives of Fermilab and the international neutrino physics community, without excessive impact on Fermilab. The total cost of the impact is estimated here to be $832k.

MINERνA does not need any civil-construction, MINERνA does not need a new beam, MINERνA does not even need special run-conditions for the beam it will be using since it will run parasitically with the MINOS experiment. The MINERνA experiment is designed to be installed in a small part of the large empty space upstream of the MINOS near-detector within the fully outfitted, for MINOS,

Task	Division	Personnel	Time	Cost (K$)
Bookend	PPD	2+1 Riggers	2 days	4
Transport Cart	PPD	2+1 Riggers	1 day	2
Detector Stand	PPD	2+1 Riggers	3 weeks	69
Module Installation	PPD	4-technician crew and Task Manager	7 weeks	85
Electronics Rack	PPD	1 rigger	0.5 day	0.7
PMT boxes in the shaft	PPD	1 rigger	0.5 day	0.7
PMT boxes on detector	experimenters			-
Magnet Coil and Cooling	PPD	4 tech crew	6 weeks	70
Refurbish Magnet Power Supply	PPD	techs, riggers	1 week	22
Install Magnet Power Supply	PPD	2 tech crew, riggers	1 week	12
Quiet Power Panel Boards	PPD	techs and		
Install		electricians		24
Provide		M& S		8
Accelerator Gate Logic and GPS Synch	AD			-
Possible MINOS readout platform mod.	PPD	4 Techs	3 days	1.2
Frame and Grating for platform mod.	PPD			8.7
Alignment	PPD	Survey Crew (3)	2 weeks	7
General Safety review and Inspection	PPD	6 Safety Officers (Engineers)	1 week	60
				Total: 374.3

Table 9: List of installation tasks undertaken or aided by Fermilab technicians or surveyors, and an estimate for the time required for each task.

near detector hall. Every attempt is being made by the MINERνA experiment to capitalize on the experience gained in designing, fabricating and installing the MINOS near detector to minimize the impact on the Lab and permit rapid mounting of the experiment. This is also to the benefit of the MINERνA experiment since our goal is to start taking data in FY2006, allowing us to obtain physics results in time to be of use also to the MINOS data analysis.