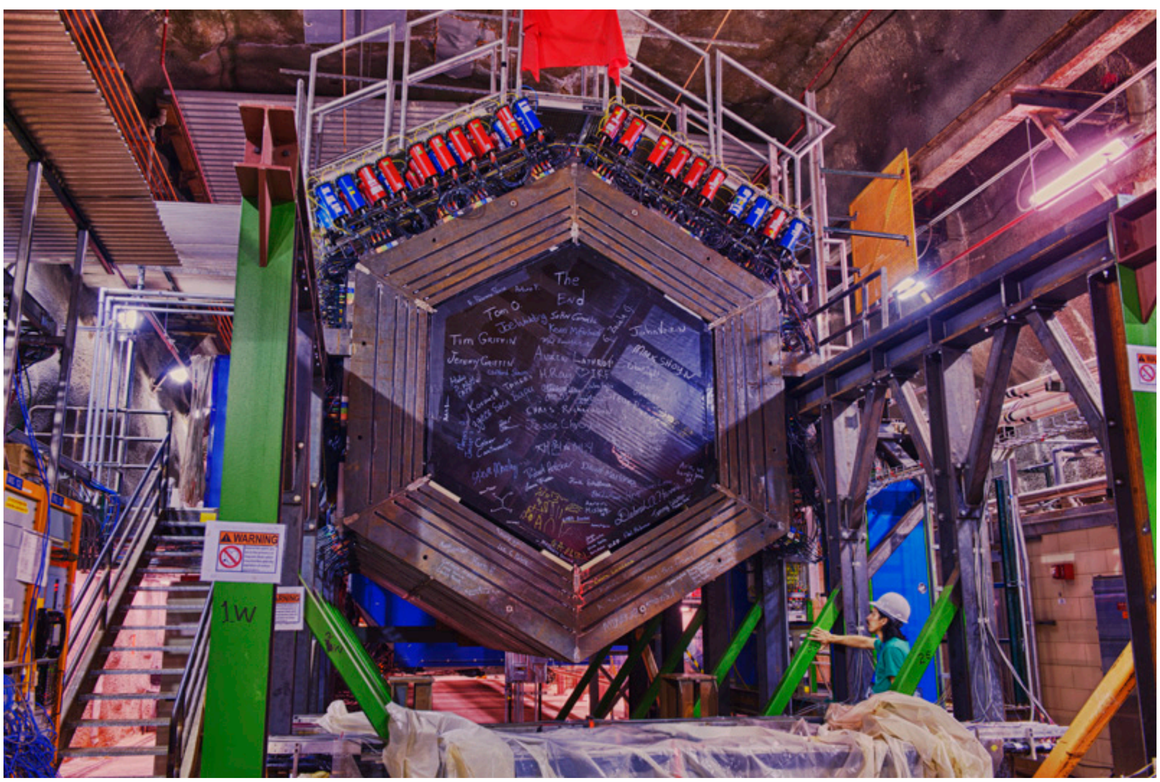
Experimental Operations Plan

MINERvA Experiment (E-938)

Fermi National Accelerator Laboratory

v 4.4: February 24, 2017



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Introduction

Fermilab experiment E938, the Main Injector Neutrino ExpeRiment to study ν-A interactions (MINERνA, but spelled MINERvA) is a dedicated neutrino interaction experiment in the NuMI beam line. The elements that allow it to make precise measurements include

- a high intensity neutrino beam that can run in both neutrino-enhanced and antineutrino-enhanced configurations
- passive targets of helium, carbon, water, iron, and lead
- a fine granularity scintillator tracker that also acts as a CH target, surrounded on the sides and back by electromagnetic and hadronic calorimeters
- the MINOS Near Detector which provides muon charge and momentum measurements, located 2m downstream of the MINERvA detector

1 SCIENCE GOALS

The goal of the MINERvA physics program is to measure the effects of the nucleus on a wide range of neutrino interactions, for a wide range of nuclei. By making measurements on nuclei both lighter and heavier than those used in neutrino oscillation experiments, MINERvA can test the models of nuclear effects that are crucial for precision oscillation measurements. Since nuclear effects may be different between neutrinos and antineutrinos, and because oscillation experiments ultimately will measure both probabilities to study CP violation and neutrino mass hierarchy, MINERvA needs a substantial antineutrino exposure to complete its science mission.

In order to complete its physics program, MINERvA makes use of the MINOS Near Detector which sits 2m downstream of the MINERvA detector. The MINOS detector provides not only a muon momentum measurement for muons that have over 0.5 GeV when they enter the MINOS detector, but also provides charge identification for those muons. This is particularly important when the experiment is running in an antineutrino-enhanced beam, because the neutrino contamination in that beam is substantial. The MINERvA and MINOS detectors operate with separate data acquisition systems, software, and reconstruction, but use the same timing information from the accelerator instrumentation system to match information in the two detectors from the same interaction.

MINERvA's first run was from 2009 through 2012, and MINERvA integrated 3×10^{20} (2×10^{20}) protons on target in neutrino (antineutrino) mode during the Low Energy (average neutrino energy ~3GeV) run, and is currently analyzing those data and publishing results on several different channels that are important to oscillation experiments. As of the writing of this document, MINERvA has published (or will have published) 15 articles in peer-reviewed journals about neutrino interactions in the Low Energy data set. Many of these measurements are the first measurement of its kind, or the most high precision measurement of a process, or the first time a given neutrino process has been measured at all.

Data taking in the Medium Energy (average neutrino energy ~6GeV) mode started in 2013, and as of this writing, the experiment has collected over 10×10^{20} protons on target (POT) in the neutrino configuration (where positive pions are focused). This amount is equal to the neutrino statistics originally requested by the collaboration. In addition to neutrino mode data, however, the MINERvA physics program has also requested 12×10^{20} protons on target in antineutrino configuration. With these data sets in hand MINERvA will be able to search for the nuclear ("EMC") effects at the few per cent precision level in both neutrino and antineutrino interactions. This will also mean a factor of roughly10 (25) increase in event statistics above the Low Energy data set, thereby enabling MINERvA to make measurements of a wide range of channels on a wide range of nuclei, from carbon to lead. This increase in statistics comes not only from the larger number of integrated protons, but also from the increase in flux per proton on target (shown below) and in some cases the increase of the cross section that comes with the increased neutrino energy.

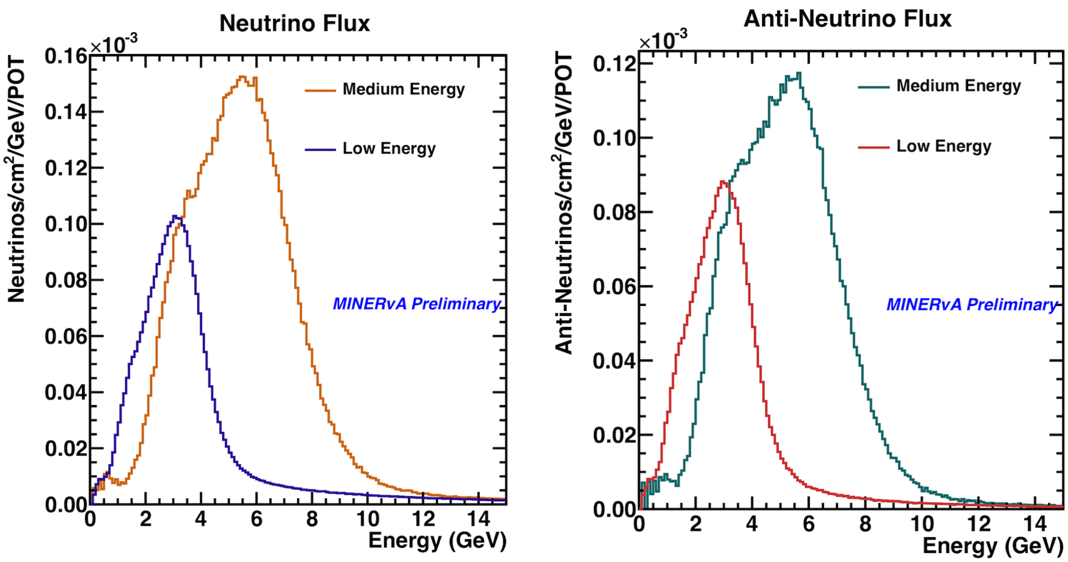


Figure 1 shows the neutrino (left) and antineutrino (right) fluxes at the MINERvA Detector for both the low and medium energy, neutrino- and antineutrino-enhanced NuMI configurations.

This Experimental Operations Plan covers in detail the MINERvA experiment including not only the MINERvA detector but also the MINOS near detector, which as of June 29 2016 has been operated by the MINERvA collaboration, since MINOS+ has ceased operations. In the remainder of this document, the detector will still be referred to as the MINOS Near Detector.

2 EXPERIMENTAL DESIGN

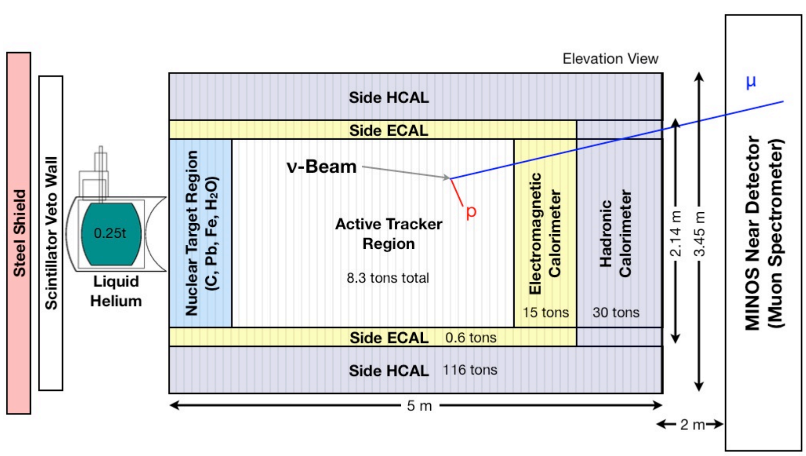
2.1 NuMI Beam

The NuMI beam is produced using protons extracted from the Main Injector and transported down the NuMI beamline. The protons are focused onto a production target. A set of magnetic horns focuses the secondary particles, mainly pions and kaons, into a decay pipe 677 m long. The meson decays in this region produce a neutrino beam comprised of mostly muon-type neutrinos. A hadron absorber and rock barrier upstream of the on axis underground cavern absorb the charged particles, leaving a beam composed only of neutrinos.

2.2 MINERvA Detector

The MINERvA detector consists of a core of scintillator strips surrounded by electromagnetic and hadronic calorimeters on the sides and downstream end of the detector. The strips are perpendicular to the z-axis (which is very nearly the beam axis) and are arranged in planes with a 1.7cm strip-to-strip pitch. Three plane orientations (0^o, +-60^o rotations around the z-axis) enable reconstruction of the neutrino interaction point, the tracks of outgoing charged particles, and calorimetric reconstruction of other particles in the interaction. The 3.0ns timing resolution is adequate for separating multiple interactions within a single beam spill.

The most upstream part of the detector includes five solid targets of different materials, numbered from upstream to downstream, each separated by four active tracking modules. Target 4 is made of lead, while the other targets are composed of two or three materials arranged at differing transverse positions filling the $x - y$ plane. Targets 1, 2, and 5 are constructed of steel and lead plates joined together; Target 3 is composed of graphite, steel, and lead. The total fiducial masses of the C, Fe, and Pb in the nuclear target region are 0.159, 0.628, and 0.711 tons respectively. There is also a water target that holds 0.3 tons of water, and there is currently a cryostat that can hold 0.3 tons of liquid helium. There is a large veto wall that consists of two planes of scintillator paddles interleaved with two large planes of steel to signal when muons from upstream neutrino interactions enter the front of the MINERvA detector.



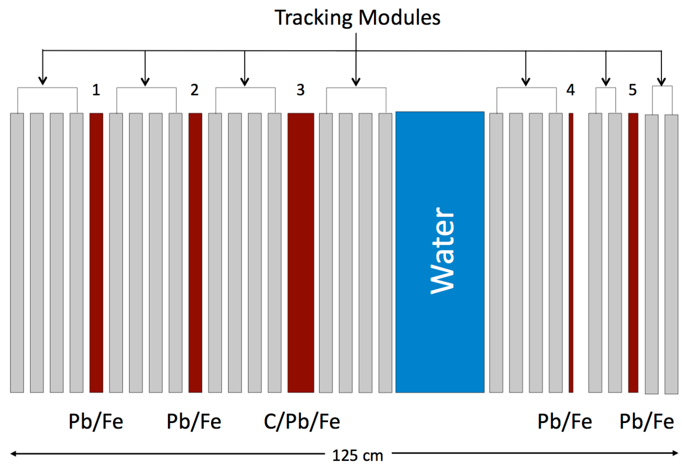


Figure 2 (top) shows a schematic of the MINERvA detector, as viewed from the side. The bottom figure shows the details of the nuclear target region downstream of the helium target and upstream of the active tracker region.

2.3 MINOS Near Detector (MINERvA Spectrometer)

As described in the 2013 MINOS+ Technical Scope of Work, the MINOS Near Detector (ND) is located 2 meters downstream of the MINERvA hadron calorimeter, and weighs a total of 1 kton. The detector is comprised of 1inch thick steel plates and 1cm thick scintillator strip planes read out via wavelength shifting fiber by Hamamatsu M64 multi-anode PMT's. The energy resolution for hadronic showers is 55%/√E, for electrons it is 22%/√E, and for muons the momentum resolution is about 12% from curvature and about 6%* from range.The detector has a magnetic field, with an average value of 1.2 T, which allows the identification of charged current neutrino and anti-neutrino interactions on an event-by-event basis. The MINOS Data Acquisition system is separate from that of the MINERvA detector and is described in the IEEE Trans.Nucl.Sci. 51 (2004) 451-455, and for the Medium Energy configuration the upgrade is described in arXiv:1506.02197.

2.4 MINERvA Data Acquisition

The DAQ, slow controls (SC), and near-online monitoring ("nearline") systems are built around MINERvA-specific readout electronics. Light from the scintillator strips is delivered via wavelength shifting fiber to Hamamatsu R7600 64-channel multi-anode photomultiplier tubes (PMTs). A small number of single-anode PMTs are also mounted for the Veto Wall described above.

Each PMT is read out by a Front End Board (FEB) mounting six Application-Specific Integrated Circuit (ASIC) chips (TRIP-t chips) that digitize and store charge using pipeline ADCs. Input charges from the PMT anodes are divided into high, medium, and low gain channels using a capacitive divider to increase the dynamic range. The high gain is 1.25 fC/ADC, the medium is 4 fC/ADC, and the low is 15.6 fC/ADC. The FEBs generate the high voltage for most of the PMTs using an on-board Cockroft-Walton

(CW) generator. The control circuitry resides on the FEB, while the CW chain itself resides on the base, with appropriate taps for each dynode.

A small number of the PMTs are single-anode and use resistor-base technology for voltage control. These PMTs are used to read out the Veto Wall and employ a separate voltage control system discussed below.

All FEB operations are controlled by a Spartan 3E Field-Programmable Gate Array (FPGA) chip. The FPGAs decode timing signals received over the unshielded twisted pair (UTP) cables, sequence the Trip-t chips and decode and respond appropriately to communication frames received over the data link. The FPGA also controls the CW and other aspects of FEB operation. For data collection, the boards are daisy-chained together (into "chains") using standard UTP ethernet networking cables with a custom protocol and Low Voltage Differential Signaling (LVDS). Of the four pairs in the cable, one is dedicated to timing, including clock and encoded signals, one is dedicated for data, one is used to indicate the sync-lock status of the data Serializer/Deserializer (SERDES) and one for a test pulse.

The readout chain is connected at both ends to a custom VME module called the Chain Readout Controller with Ethernet (CROC-E, see Minerva DocDB 7113, 8172). A CROC-E supports four Front End (FE) channels, each serving one chain of up to twelve FEBs, though no chain is longer than ten FEBs in MINERvA. Each of the four CROC-E channels contains a 128 kB dual-port memory for storing messages (called "frames") from the FEBs. During operation, each FE channel records all the data from every FEB attached to its chain in parallel. The CROC-Es in turn receive timing and trigger commands from another custom VME module, the CROC Interface Module (CRIM, see Minerva DocDB 1238, 4297), each of which distributes timing to up to four CROC-Es. MINERvA uses two VME crates, each containing a CAEN V2718 crate controller, two CRIMs, and roughly a half-dozen CROCs. Note that the Ethernet readout interface for the CROC-E is not currently used. It was developed to further parallelize readout in case we need to increase the repeat-rate for the Main Injector in the future, but for the current (and currently foreseeable) data rates, it is not required.

The CROC-Es and FEBs are both controlled by flexible, programmable firmware. We have responded to changes in the beam (for example, higher intensity) by optimizing firmware to increase the number of available hit buffers in the FEBs and to add extra CRC (data integrity checksum) words to the data stream in the CROC-Es. These various firmware upgrades are highly beneficial to the experiment but require very thorough attention because they may potentially deeply affect the performance of the detector.

3 ORGANIZATION AND GOVERNANCE

The MINERvA collaboration consists (as of April 2016) of 42 Ph.D. physicists and 19 (5) graduate students in PhD (Masters) programs from 19 institutions in 7 countries: Brazil, Peru, Chile, Mexico, Switzerland, the United Kingdom and the United States.

The collaboration members from institutions outside the United States consist of 11 Ph.D. physicists and 9 PhD and Masters students from 5 institutions.

MINERvA has an Institutional Board consisting of one representative from each collaboration institution. The Institutional Board approves and modifies the collaboration bylaws[1], admits new institutions and senior members to the collaboration, and sets shift, authorship, and publication policies.

The scientific leadership of the MINERvA collaboration consists of two co-spokespersons, who are elected for staggered two-year terms by the entire collaboration.

The co-spokespersons are advised by an Executive Committee, which has 6 members elected by the entire collaboration for two-year staggered terms and includes the Institutional Board Chair as an ex-officio member.

To carry out the mission of the experiment, the spokespersons have appointed several working groups charged with detector operations, data processing and physics analysis.

3.1 Working Groups

The working groups responsible for the ingredients of publication quality physics analyses are:

- Detector operations, which is outlined in the subsequent sections in detail.
- Calibration, which is responsible for the time and energy calibration of the MINERvA and MINOS Near Detectors.
- Reconstruction and Algorithms, this group is responsible for overseeing the development of new algorithms or improvements to older ones. This group also determines when it is time to cut a new release or start a new production pass of either data or simulation, or both.
- Computing Infrastructure, which is responsible for maintenance of MINERvA software and execution of data production for calibration and analysis. The leader of the group, along with the Scientific Computing Division Liaison, works with Fermilab Computing and consults with that division to develop annual budget plans to support MINERvA computing. Fermilab support for MINERvA computing is covered in a TSW.[2]
- The Physics and Analysis Coordinator, who is charged with oversight of the physics working groups, to coordinate among the groups and identify areas of common interest. The Physics and Analysis coordinator works with the working group leaders to set and facilitate progress towards analysis milestones.

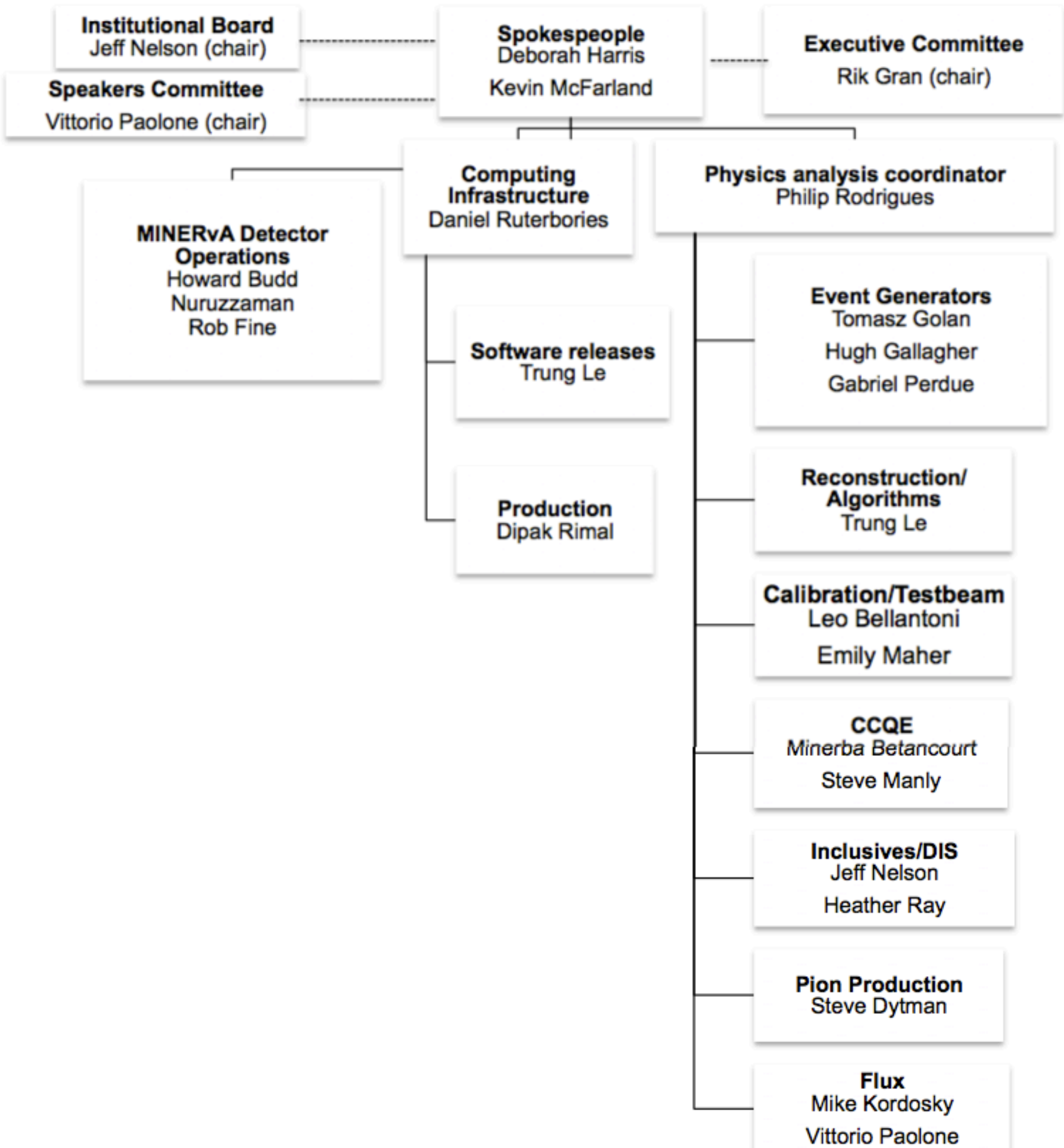


Figure 2: The MINERvA Collaboration Organization Chart

3.2 Operations Group

The MINERvA Operations Group Organization chart is shown in Figure 3. The roles and responsibilities are defined in this section.

The Run Coordinator is charged with optimizing the use of the MINERvA and MINOS Detectors to meet the physics goals of the experiment. In consultation with the spokespersons, the Run Coordinator will direct and decide the priority and scheduling of detector systems development and maintenance. The Run Coordinator has responsibility for scheduling shifts, maintaining shift procedures, and maintaining the systems expert on-call list. The Run Coordinator will be the primary contact between the experiment and the Fermilab Main Control Room and NuMI Underground Areas group and will be responsible for reports to the weekly All Experimenters' Meeting.

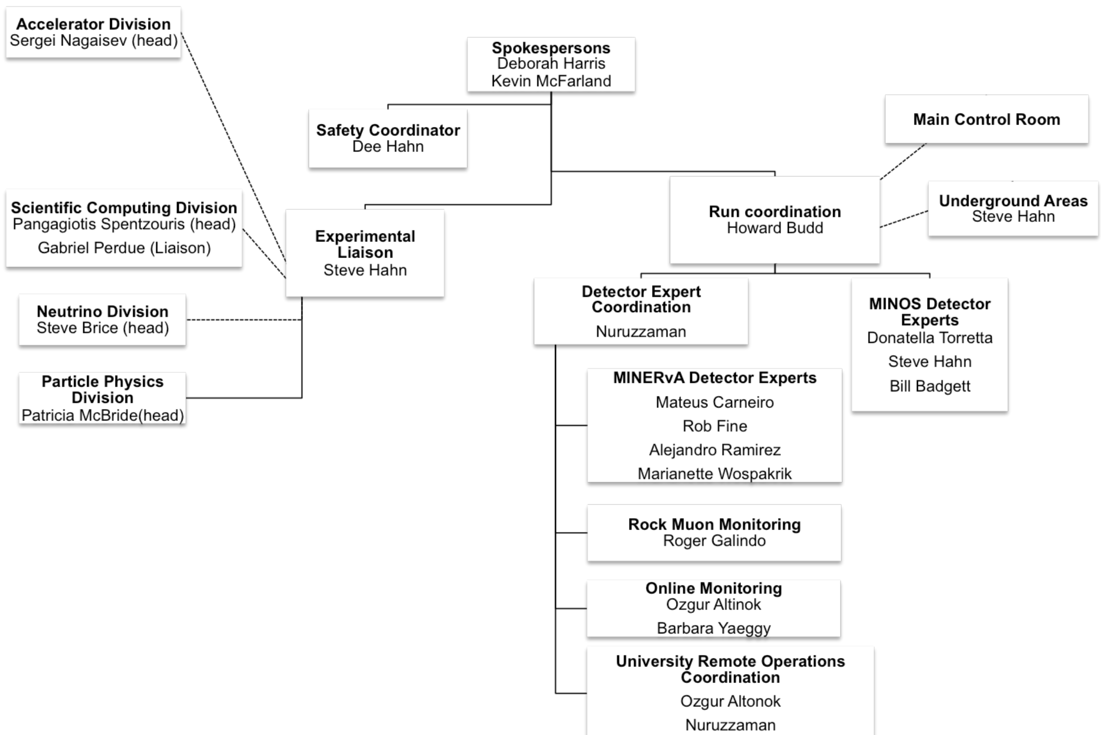


Figure 3: the MINERvA Operations Organization Chart, names are as of October 2016

The <u>Safety Coordinator</u> is charged with making sure that all the MINERvA shifters are adequately trained for the shifts they plan to take, and organizing special training courses as the need arises. She also updates the Individual Training Needs Assessments under the direction of the spokespeople. The Safety Coordinator also assists with shift scheduling in the event of unforeseen shift staffing problems and other shift matters as needed. The Safety Coordinator also serves on the Shift Committee that is occasionally called to advise on shift policy matters (not shown on the organization chart).

The <u>Experimental Liaison</u> serves as a line of communication between the MINERvA Operations group and the Fermilab operations support groups inside the Neutrino Division, and the Accelerator and Particle Physics Divisions. The Experimental Liaison is charged with identifying the resource needs for operation, maintenance, and repair of equipment required for MINERvA operations. The Run Coordinator is charged identifying the resource needs that are based in the University support groups. The Scientific Computing Division liaison also interfaces directly with the MINERvA collaboration as he is a MINERvA collaborator.

The Run Coordinator and Detector Expert Coordinator are appointed by the spokespersons with consultation by the Executive Committee. The exact lengths of these periods will be dictated by circumstances. The Run Coordinator, Detector Expert Coordinator, and Experimental Liaison all help the spokesperson assemble the Operations Budget.

Five working groups or experts report to the Run Coordinator:

- The Detector Expert working group is charged with staffing the detector expert shifts and doing routine fixes to problems that arise such as restarting the DAQ or reloading the hardware configuration files. This group carries a pager and covers shifts 24/7 in case of problems that result in loss of beam or loss of data quality.
- The Rock Monitoring expert is charged with development, maintenance, and online support of tools to monitor data and beam quality as demonstrated by tracking and reconstruction of muons from upstream neutrino interactions ("rock muons").
- The Online Monitoring experts are responsible for executing maintenance and repair work on the online monitoring programs that demonstrate real-time detector performance.
- The University Remote Operations (UROC) Coordination experts are responsible for ensuring that shifters at remote shift locations have functioning infrastructure to allow them to take shifts remotely. This includes with development, maintenance, and online support of tools to monitor data and beam quality remotely.
- The MINOS Detector Expert Group are members of the Neutrino Division's Operations Support Group, and they are available to MINERvA Detector Experts for consultation and problem-solving in order to maintain and operate the MINOS Near Detector. The MINERvA Detector Experts are the first responders to problems with the MINOS Near Detector and will contact the MINOS Detector Expert Group only if additional expertise is needed. The Operations Support Group also holds the information about the MINOS Near Detector Spare Stock, and the expertise about the Near Detector Magnet coil and power supply.

3.3 Shifts

Shifts for running the MINERvA experiment are the shared responsibility of the Ph.D. physicists and graduate students, although undergraduates are also allowed to take shifts provided adequate training. In addition to regular shifters, a "Detector Expert Shift" is also filled, which only a few people can take (the Detector Expert training lasts for a few months) to provide assistance when problems arise that are beyond the expertise of the shifters. The shifters' responsibilities are to follow the run plan set out by the Run Coordinator, to see that the detectors are running properly, and to see that the data is of high quality, as determined from the diagnostic online monitoring [3].

For five months prior to the 2016 summer shutdown there were two 8 hour shifts, and the owl shift was done on a checklist basis, if the beam is on. Each shift is staffed by one person, plus one Detector Expert who is on call 24/7. There is a "watchdog process" that pages the Detector Expert if for any reason the DAQ stops operating while there is beam being sent to the detector. If the beam is off for an extended time there may only be checklist-based day shifts on weekdays. It is anticipated that the shift policy will evolve as the running becomes more (or less) routine. The total additional loss of physics quality data due to this new procedure has been measured over these five months at no more than 3 hours, or about one tenth of one per cent.

4 FERMILAB ROLES AND RESOURCES

Appendix B shows the high level Fermilab organization. The MINERvA experiment gets support mainly from the Accelerator Division (AD), Fermilab Computing (Core Computing and Scientific Computing Divisions), the Neutrino Division (ND), and the Particle Physics Division (PPD).

4.1 Accelerator Division

The Accelerator Division is responsible for commissioning, operation and maintenance of the primary proton beam line, the target station and the hadron absorber. The line of demarcation between Accelerator Division and Neutrino Division responsibilities is, unless otherwise noted, the large "elephant" doors just upstream of the MINOS shaft.

The Accelerator Division will also be responsible for monitoring intensity and beam quality of the primary proton beam. Overall monitoring of the primary proton beam intensity within 3% is required by the experiment.

The MINERvA Experiment depends on support from a number of departments within AD. AD provides a liaison to the MINERvA. The deliverables and services expected from each of these groups are described below.

Resources within the Particle Physics Division which affect MINERvA operations are directly coordinated between the Technical Support Department and Particle Physics Division management. Resources needed from Fermilab Computing are specified in the MINERvA computing TSW. Any resources needed from other divisions are coordinated on a case by case basis by the Technical Support Department.

4.1.1 External Beams Department

The External Beams Department is the proprietor of the NuMI beamline from the Main Injector to the pre-target area. The department provides a Machine Coordinator who is in charge of beamline operations and serves as the point of contact for MINERvA questions involving the beam. The Machine Coordinator's responsibilities concern both operational status and requests from MINERvA for changes in the primary beamline. The department also provides a Beamline Physicist who aids in day-to-day operational issues and assists the Machine Coordinator as required. The External Beams Department contains personnel expert in various elements of the design, operation and troubleshooting of any beamline, and are called upon by the Machine Coordinator as needed.

4.1.2 Target Systems Department

The Target Systems Department coordinates the NuMI Beamline from the pretarget area to the hadron absorber and muon alcoves. The Department's responsibilities concern operation status and request from MINERvA for changes in the target station or hadron absorber. In addition, budgeting and purchasing of spare equipment and changes to equipment in the NuMI target hall is coordinated by this department.

Storage and disposal of radioactive components is provided by the Target Systems Department. Components which will fit in the Target Service include the NuMI targets. Failed horns are currently stored at the C0 Remote Handling Facility. This facility also allows hot cell operations for repair and study of components. There is a plan underway to increase storage at C0 for longer term component sequestration, which should be complete in 2018. In addition, the laboratory has a phased disposal model which will allow a limited number of components per year to be sent to the Nevada National Security Site. The first shipment (PH2-01) is scheduled for September 2016, with the second following several months later.

4.1.3 Controls Department

The Controls Department is responsible for the front-end computers, links, crates and control cards for the operation of all equipment from the Main Injector to the hadron absorber. These responsibilities include the hardware and software of the Beam Permit System. The Department maintains several pieces of application software for controlling beamlines, specific instances of which are used by NuMI-based experiments. It is responsible for the maintenance of the accelerator consoles in the MINERvA Control Room (ROC-West) and NuMI service buildings. It installed and maintains several Programmable Logic Controllers dealing with target chase cooling and various water systems including beamline LCW, target hall and absorber RAW and near detector cooling. The computer networking in the NuMI underground and above ground installations is also the responsibility of Controls. The Controls Department is also responsible for the support of the ACNET system, which is used by the MINERvA Detector Controls System.

4.1.4 Electrical Department

The Electrical Department is responsible for all of the power supplies needed to run the magnets of the primary beamline. It is responsible for the NuMI extraction kicker and its power supply, the large pulsed power supply of the NuMI focusing horns and the electronic control of beamline vacuum.

4.1.5 Instrumentation Department

The Instrumentation Department is responsible for the maintenance and calibration of primary beamline monitoring devices – loss monitors, total loss monitors, BPMs and toroids.

4.1.6 Main Injector, Booster, and Mechanical Support Departments

The Main Injector Department is responsible for providing beam with appropriate parameters on NuMI timeline cycles. Such parameters include, but are not limited to, intensity, emittance and orbit stability.

The Booster Department is responsible for supplying proper beam to the Main Injector.

The Mechanical Support Department is responsible for operational support and maintenance, including magnet changes, of all the mechanical equipment in the Accelerator Division controlled areas. This includes vacuum and water systems throughout the beamline as well as the decay pipe region and the hadron absorber. The department has responsibility for technical support of equipment in the target hall and associated areas, including horns, targets, RAW systems, target pile cooling and dehumidification.

4.1.7 Operations Department

The Operations Department is responsible for accelerating and extracting 120 GeV primary protons into the NuMI Primary Proton beamline and for maintaining the beam parameters throughout the line and onto the NuMI target. The primary beamline is controlled from the AD Main Control Room. The Operations Department is responsible for the administration of accesses to MI65 areas, the Muon Alcoves and the Absorber, and for resecuring these areas after a Supervised Access. AD provides first response to alarms in these areas.

4.2 Computing Divisions

Fermilab Computing supports the needs of the MINERvA experiment computing through provision, maintenance and support of common, and in some cases experiment specific, core and scientific services and software.

Table 1 shows the Core Computing Services that the MINERvA experiment uses.

Core Services:	
Authentication and Directory Services	Standard KCA and DNS services provided.
Central Web Hosting	Support for the MINERvA central web server and MINERvA DocDB.
Database Hosting	Database hosting and database infrastructure used by MINERvA.
Desktop Services	Windows and Mac desktop support for the computers covered by the Managed Services contract.
Fermilab (Data Center) Facilities	Laboratory space for DAQ test stands and buffer test facility remaining at Fermilab.

Network Services	Standard support for detector facilities. Essential MINERvA related network devices are supported for 24x7 service.
Networked Storage Hosting	Support for home areas and data disks; Part of the data processing, simulation and analysis scientific computing system support
Service Desk	Issue and notification reporting, handling and tracking.

Fermilab Computing provides a Liaison to the MINERvA experiment, whose responsibilities include maintaining excellent communications between the experiment and Computing as well as giving attention to ensuring the computing needs, agreements, issues and any other relevant items between the experiment and Fermilab Computing are addressed in a timely and mutually agreed upon manner.

Fermilab Computing provides DAQ support to MINERvA by software support and also by system administrative support of underground and control room computers.

The services Fermilab Computing provides to MINERvA are detailed in the MINERvA computing TSW.[2]
The tables below give the list of services supported for MINERvA computing operations.

Table 2 shows the various scientific services that MINERvA currently uses.

Scientific Services	
Grid and Cloud Computing	Batch processing on Grid accessible systems at Fermilab as well as offsite through the Open Science Grid. Jobsub, GlideinWMS and other software for processing and analysis.
Scientific Collaboration Tools	MINERvA code repositories hosted through cdcvs.fnal.gov, redmine, and the electronic log-book application.
Scientific Computing Systems	Control Room computing system and workstation administrative support. Support for interactive, batch processing, simulation and analysis computing systems at Fermilab. Hosting of some scientific databases.
Scientific Data Management	SAM, IFDH, FTS and other data handling software and systems.
Scientific Data Storage and Access	Enstore based tape storage services. Tape handling and curation. dCache based data disk services and systems.
Scientific Databases	Applications and database infrastructure for identified MINERvA online and offline databases
Scientific Software	ROOT, and other software tools.
Simulation Software	Support for Geant4 and GENIE.

Table 3 shows FY17 Estimates for Scientific Computing resource needs

Scientific Data Storage and Access	
Shared RW	500 TB
Shared Scratch	150 TB
Dedicated Write	60 TB
Dedicated Persistent	188TB
BlueArc	260TB in FY17, will decrease in future years
New/additional capacity	1000 TB
Server and Storage Support	
Static Interactive Service	5 static services
Other Static Services	2 static services
Dynamic Services, average	1 dynamic service
Dynamic Services, peak	1 dynamic service
cvmfs Service	yes
Build & Release Service	no
Database Service	mysql 1
Batch Worker Nodes	
OSG opportunistic yearly integral	3,051k CPU-hours
FermiGrid Yearly Integral	15,300k CPU-hours

4.3 Environment, Safety, Health & Quality Section

The Environment, Safety, Health & Quality Section (ESH&Q) is responsible for providing guidance in all ESH matters, and has assigned Neutrino Division a Neutrino Division Safety Officer as the point-of-contact for ESH concerns. All Fermilab Environment Safety and Health Manuals (FESHM) apply to Neutrino Division.

ESH&Q Section coordinates underground safety training for the NuMI and MINOS areas. The emergency procedures associated with working underground are described in the underground training course.

The ESH&Q Section's Interlock Group oversees access control to the pre-target beamline enclosure, target hall, decay pipe region, absorber hall and muon alcoves. Oversight is also provided for radiation and electrical safety in the region of the primary proton beam through various access control keys, enclosure interlocks, electrical permits to power supplies, interlocked radiation detectors, and beam inhibit critical devices.

4.4 Neutrino Division

The Neutrino Division is responsible for the operation of the MINERvA experiment and experiment-related activities at Fermilab. Figure 7 shows the Neutrino Department organization chart.

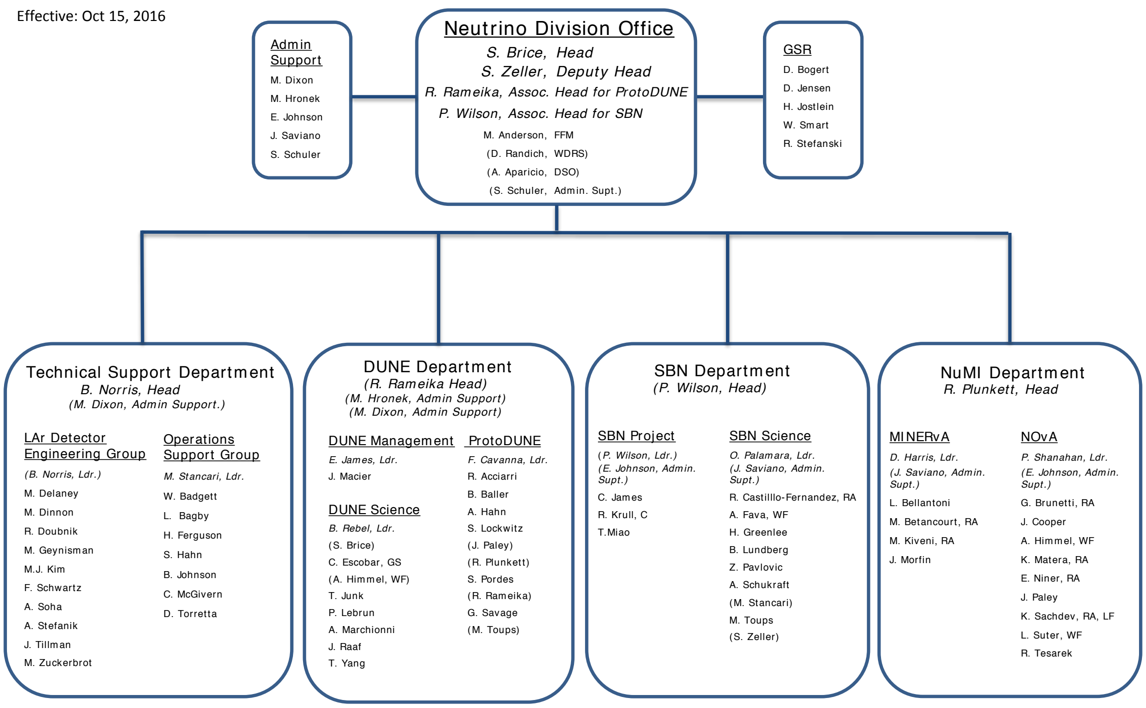


Figure 7: Neutrino Division Organization Chart

The Neutrino Division provides an administrative organization for the Fermilab staff working on MINERvA, as well as a center for experimental operations, data analysis and future planning. It also provides the funds for the operation and maintenance needs of the MINERvA Detector and those parts of the NuMI/MINERvA facility for which it is the landlord.

The Neutrino Division provides office space for both resident and visiting MINERvA collaborators. Office space provided is commensurate with the amount of time spent at Fermilab.

The Neutrino division Technical Support Department provides an Experimental Operations Liaison who, under the guidance of the MINERvA Run Coordinator, coordinates spare equipment for the MINERvA and MINOS detectors either directly or through SOW's with collaborating institutions. For the case of the MINOS Near Detector, there is an annual SOW with Argonne for repairs of Near Detector Electronics boards.

4.4.1 Operations Support Group

The ND/TS Operations Support Group (OSG) is responsible, either directly or by coordination, for the maintenance and repair of the coil for the MINOS Near Detector, the water-cooling for the electronics and dry air systems in the Near Detector Hall at Fermilab, including interlocks that talk to the MINERvA and MINOS controls systems. The OGS provides support to MINERvA for the MINOS Near Detector electronics. The OSG provides, either directly or by coordination, maintenance and support for the

MINOS (on axis) underground cavern. The MINERvA experiment may request additional services from personnel in the Particle Physics Division, that are described in that section of this document. These requests are coordinated through the Experiment Liaison Officer (ELO) and the Underground Area Coordinator (UAC), who are both in the OSG. In previous years this group has worked a combined 30 FTE-weeks per year on these activities. That level of support is predicted to be required going forward, but since the routine repairs will be done by MINERvA collaborators it is estimated that the number of FTE-weeks provided by the OSG will be significantly reduced. This level of support required assumes the MINOS Near Detector does not suffer more frequent failures due to aging components.

Technicians coordinated by OSG are also responsible for repair services for mechanical systems in the ND-controlled areas of the NuMI facility. The systems include the MINOS electronics water cooling system, and the MINOS Near Detector Coil Power supply and LCW cooling system.

This group also supports MINERvA collaborators in debugging the unpacking for the MINERvA Data Acquisition system. As changes with the firmware are made, corresponding changes to the unpacking must also occur. The 2016 firmware upgrade ("v97") has just been completed, and required several FTE-weeks of this group's time, working with MINERvA collaborators and personnel from the PPD, as described below. If any future problems are uncovered with this firmware there may be a few extra FTE-days of support needed. This group also has the expertise to improve the diagnostics in the MINERvA Data Acquisition system, which would again result in lower downtimes. The estimate is that the diagnostic improvements would take roughly 2-4 FTE weeks for personnel in this group.

This group also supports MINERvA collaborators in their work with members of the Scientific Computing Division to maintain the underground computers. This includes replacing them after they are no longer covered by warrantee, upgrading them from one version of Scientific Linux to another, making sure the computers are compliant with whatever Computer Security regulations that are imposed by the Laboratory. This effort requires several FTE-days per year, on average. This group also coordinates, with the Run Coordinator's input, the installation and repair of the Uninterrupted Power Supplies used for the MINERvA Detector (including the Veto Wall). This work is estimated to take only a few FTE-days per year.

The MINERvA experiment shares ND underground space with various tests and other experiments. Access to the underground areas is controlled via training, access keys, limited occupancy and badging in and out when entering or exiting the areas, respectively. Specification of rules and procedures for access to the underground areas and coordination of permits for work to be performed in the ND underground areas are the responsibility of the Underground Area Coordinator.

4.5 Particle Physics Division

The Particle Physics Division (PPD) provides several services to enable the MINERvA experiment to take physics quality data. These services are coordinated by the Experimental Liaison, or the Run Coordinator, if the Experimental Liaison designates this.

4.5.1 Detector Development and Operations Department

Mechanical Technicians in PPD's Detector Development and Operations Department are occasionally requested to remove of the roof above the MINERvA detector, replace of phototubes or Front End Boards that are not near the access walkways near the MINERvA detector, inspect and clean of the drip pans on the ceiling above the MINERvA detector, and rig items down the MINOS shaft or in the MINOS underground cavern. The roof removal takes 2-3 technicians about 3 hours, and another 3 hours to replace the roof. The roof removal happens about 6 times a year, which adds to 1 FTE-week. The drip pans are inspected once a month, and that takes 2 technicians 3 hours, which adds to 2 FTE-weeks a year. PMT Boxes tend to be replaced about 6 times a year, and this activity takes 2 technicians about one day, so that adds up to 2.5 FTE-weeks per year.

Expertise at the lab to repair MINERvA's PMT boxes currently resides in the Detector Development and Operations Department, and we estimate that 1 FTE-week per year is needed for this activity.

This group also provides personnel to fill and empty the water target, with the guidance of the MINERvA run coordinator, and to measure the thickness of the water target when it is full to prevent the water target expansion from compromising the scintillator planes in the nuclear target region of the detector. The water target fill takes 3-4 technicians one day to fill, and then inspection and measurement occurs once a week and takes a few hours including getting to the underground enclosure.

These actions are scheduled in advance, and as much as possible, scheduled to take place during the mechanical technician workdays, since MINERvA component replacement is relatively rare and the detector can still take physics quality data even if certain channels on a given phototube or front end board have compromised performance and need replacement.

The Detector Development and Operations Department also provides building management services for the MINOS facility.

4.5.2 Mechanical Engineering Department

Expertise for MINERvA's helium cryostat resides in Particle Physics Division's Mechanical Engineering Department, and that department has the personnel who empty or fill the helium cryogenic target, and personnel in that group provide regular oversight of the cryogenic controls system while the target is full. This group also determines if the cryocooler needs to be refurbished (which occurs once every year or two of operations), and if the Oxygen Deficiency Hazard monitors need replacing. The helium target takes 3 people 2 weeks to fill it: one cryo engineer and two technicians (usually from the DDO group). In normal steady state running someone from this group checks the web page daily for a few minutes, and then once a week someone from this group does a checklist underground that takes about 2 hours including overhead. The total effort from this group is 6 FTE-weeks to fill, and then 5 FTE-weeks of inspection per year.

4.5.3 Electrical Engineering Department

The table below lists the current responsibilities for maintenance of MINERvA electronics components. The electronics for MINERvA were designed and tested by the Electronics Engineering Department of the Particle Physics Division and the expertise for this system resides there (at the time the system was developed, the Neutrino Department was under the Particle Physics Division).

In order for the MINERvA Front End Electronics to perform at high efficiency during the 700kW era there are small changes that are needed in the Front End Board firmware. These changes have been designed and the firmware has been written, mostly in FY15, and will be installed during the FY16 shutdown. Although MINERvA collaborators, together with EOD group members, will update the firmware underground in the FY16 shutdown, it is anticipated that some guidance from PPD EED will be needed to complete the firmware upgrade and commission it underground (and would take from 3-4 FTE-weeks of time from this group). Tests of the firmware are also underway on a test stand above ground, and the PPD EED will provide assistance to collaborators who are doing those tests.

There is currently a timing problem in the MINERvA DAQ, and is linked to the long recovery time that we experience every time there is an unscheduled power outage. The fix to this problem has been designed, but to implement this fix there is an estimated need of 4-5 FTE-weeks of this group's time. It is estimated that this problem would get worse when the accelerator goes to higher proton power so fixing this before the end of the FY16 shutdown is of high priority.

The EED group is also extremely familiar with the slow controls for the MINERvA detector. These controls are what maintain the phototubes on high voltage. Members of this group can provide guidance to students who are creating documentation for the slow controls system, and the estimate is that this could take up to a half an FTE-week of time integrated over a month.

The EED group also provides expertise on repairing components. Repairs of the Front End Boards usually involve diagnosing a board and determining which Trip-t chip needs replacing, and then replacing the chip. The estimate is that for the 110 spare Front End Boards, we would need about 1.5FTE-weeks total of this group's time to assist in a production mode repair effort. The Light Injection System, if it were to fail, could also be repaired by this group, although it would take an estimated FTE-month of time from this group.

Table 4 shows the various MINERvA Electronics components and the responsible party for each component.

System	Responsibilities
Low Voltage Supplies	Repair or replacement by Fermilab
Front End Boards	Testing by collaboration, repair by PPD and calibration by Pittsburgh
PMT Boxes	Repair by Fermilab (Janina Gielata in DDO)
Chain Read Out Controller with Ethernet	Maintenance by Fermilab
Power Distribution System (FESB's)	Repair and maintenance by Fermilab
Chain Readout Interface Module	Testing by collaboration, repair by PPD
Minerva Timing Module (MTM)	Testing by collaboration repair by PPD
All MINOS Electronics	Maintenance by Fermilab, some repair by Argonne

5 PERSONNEL RESOURCE SUMMARIES

The collaboration spends approximately 20% of its personnel resources on operations, including Operations and Processing of the MINOS Near Detector. That effort is summarized in the following table:

Table 5 shows the collaboration resources in units of FTE that are devoted to Detector and Computing Operations.

Detector Operations Total	4.6
Run Coordination	0.8
Detector Expert Coordination	0.8
Detector Experts (6 x 0.2FTE plus two training)	1.6
Shift Work (8 hours a day, 7 days a week)	1.4
Computing Total	2.9
Computing Infrastructure	1.0
Production	0.7
Keepup Processing	0.45
MINOS Data Quality and validation	0.2
Software Releases	0.5

The Particle Physics and Neutrino Division personnel resources required for support of the MINERvA Operations at the level of about 1.6FTE, not including administrative support which is provided by the Neutrino Division. The following table lists the individual Fermilab Particle Physics and Neutrino Division resource needs based on the tasks defined above, as of the end of the 2016 Accelerator shutdown:

Table 6 shows the estimated personnel resource usage by MINERvA from the Particle Physics and Neutrino Divisions, not including MINERvA collaborator scientific efforts.

Division	Particle Physics	Neutrino

Department	Mechanical Engineering	Detector Development and Operations	Electronics Engineering	Operations Group
Task				
Liquid Targets	6	9		
Cavern Operations (roof, drip pans, PMT box swaps)		3	2.5	
PMT/FEB testing and repair	1		1.5	
FEB Firmware Upgrade consulting			0.5	5
Solving current DAQ problems			5	4
Slow Control and DAQ diagnostics			2.5	
Light Injection support			0-4	
Underground computing and UPS needs	1			11
MINOS Near Detector and Coil Operations	0.5			10
Experiment Liaison				6
Shifter training and support		9		
Administrative support				
Total (FTE-weeks)	8.5	21	12-16	36
Total (FTE)	0.2	0.4	0.26	0.72

6 SPARES

The following table lists current spares for the MINERvA Detector. This list does not include spare components for the NuMI Beamline.

Table 7 shows the spares currently available for use in the MINERvA Detector.

Item	# used in MINERvA	Spares
Front End Board (FEB)	511	110
Photo Multiplier Tube (PMT)	511	72
Chain Read Out Controller with Ethernet (CROCE)	15	20
Front End Support Board (FESB)	15	5
Chain Readout Interface Module (CRIM)	4	2
Minerva Timing Module (MTM)	1	1
Data Acquisition (DAQ) Computer	1	1

The following table lists the current spares for the major MINOS Near Detector electronics components. A more complete list can be found in Minerva-docdb 12107.

Table 8 shows the components used and the current spare stock for the MINOS Near detector.

Item	Designed or initially supplied by	# used in MINOS ND	Spares
Light Injection Pulser Box	Sussex		
64 Multi-Anode (M64) Photomultiplier Tubes	Hamamatsu	190	7
M64 Bases	Oxford	190	7
PMT Alner Boxes	RAL	190	7
VME Master Crates	Wiener	8	1
Front End Crates	Wiener	8	1
Clock Boards	FNAL/IIT	3	0
Keeper Boards	ANL	45	5
Minder Readout Cards	ANL	587	14
MENU Frontend Cards	FNAL/ANL	16x776=12416	700
Rack Protection Boxes	BIRA/Duluth	8	1
GPS Receiver	Commercial/Oxford	1	2
MVME5500	Commercial	8	Over 20
DAQ PC	Commercial	1	3
DAQ Power Distribution Unit (PDU)	Commercial	1	0

7 BUDGET

7.1 MINERvA and MINOS Detector Operations Budget

The FY17-20 annual operations budget M&S estimate is given in the following table. This budget does not include the costs for any MINERvA spare component replacement other than DAQ computers and some of the power supplies, and repair for some of the MINOS DAQ modules from Argonne. This budget also does not include the cost of the gas for the NuMI muon monitoring system, which historically was included in the MINOS Near Detector budget.

Table 9 shows the MINERvA and MINOS yearly Operations Budget Estimate and justification for each item.

Item	cost (k$)	Comment
Liquid Helium and Nitrogen for MINERvA	25	Based on current costs
ODH Heads	4	replace each year
Crycooler refurbishment	12	assume we refurbish one per year
DAQ computers for MINERvA	5	assume we have to replace 1 per year
Argonne subcontract	40	MINOS electronics repairs (32k in FY16)
UROC Hardware	9	assume 3 new UROC's per year

CAEN Controller	8	only need if one breaks
CAEN PCI Card	8	only need if one breaks
Nearline Monitoring PC's	8	one need if one breaks
Consumables for PMT box repair work	10	MINERvA
Test Stand PC replacement	5	only need if one breaks
Spare Minder Cards	4	want 8 more minders
Spare Fan Packs (Rack mounted)	4	rack mounted
Materials and Shop MINOS test stand (cables)	3	
PMT and DAQ Test stands (consumables)	3	MINERvA PMT and DAQ
PC's for MINOS DAQ	10	replace old CDF ones, 4x2.5k each
DCS Computer for MINOS	3	
VxWorks License	25	Needed for MINOS, was 21 in fy15
Wiener Power Supply (5k each)	5	
Air filters for electronics racks	2	MINOS
Total	193	

7.2 MINERvA Computing Budget

The MINERvA computing budget described here includes the budget that is required to process and analyze both the MINERvA and the MINOS Near Detector data. The computing division is a matrixed organization and so the numbers shown here represent an approximate measure of the portion of scientific computing division's resources that end up being used for MINERvA tasks. In particular, the labor costs labeled "MINERvA total" should NOT be considered as part of the incremental cost of running MINERvA. The incremental labor costs are also given below, and are typically a factor of 5 lower. The costs for the 14-month period are defined in the following table: these are an estimate based on current projections of usage for the out years.

Table 10 shows the per unit costs for various resources (M&S and labor) for scientific computing division that are used in later tables in this document.

Resouce	**Details**	**Cost**
enstore tape	using T10K 8.5 TB tapes - cost per tape	$215.00
dCache disk	persistent plus "differential" for scratch and R/W - cost per TB	$120.00
CPU	cost per hour	$0.01
SCD Support	cost per FTE years	$135,000.00

Table 11 shows the 14-month computing costs for the MINERvA and MINOS detector data, including processing needed from first calibration to final publication analysis.

Media Type - Tape	**TB written in the past year**	**Adjusted TB**	**Cost**
tape raw binary	16	18.67	$560
tape supp / cal digits	15.5	18.08	$543
tape reco	23.2	27.07	$812
tape simulation	418.3	488.02	$14,641
Media Type - Disk	**Total TB allocated (private) / in-use (public)**		
persistent dCache	193		$5,629.17
raw data write dCache	132		$3,850.00
read/write pools dCache	470		$13,708.33
public scratch dCache	76		$2,216.67
Total media cost			**$41,959.17**

Marginal cost of computing	**1 year CPU hours (millions)**	**CPU Hours**	**Cost**
data processing	3.9	4.55	$45,500
simulation processing	11.7	13.65	$136,500

Computing Labor	**Neutrino Experiments (total FTE)**	**MINERvA (total FTE)**	**Neutrino Experiments (Incremental)**	**MINERvA (Incremental)**
Software Development and Support	17.92	0.93	6.72	0.64
Operations	16.73	2.5	4	0.55
Facilities	22.4	2.45	4.5	0.53
Total	57.05	5.88	15.22	1.72

Total computing and media cost		$223,959
SCD Support Services (5.88 FTE-year, 14 month period)		$1,715,000
Incremental Support Services (1.72 FTE-year, 14 month period		$501,667

Grand total (incremental)	**$725,625**

7.3 The FY17-20 annual operations Common Fund

MINERvA will follow the Fermilab policy on common funds.

8 RUN PLAN

The first phase of MINERvA is defined 10×10^{20} protons on target (POT) in neutrino mode (which has already been accumulated as of this writing), and 12×10^{20} POT in antineutrino mode. This would be a 4-year run at the nominal rate of 6×10^{20} POT/yr, if the run plan were to accommodate this request in such a way to optimize the MINERvA run plan. The decision to switch from neutrino to antineutrino running configuration is owned by the directorate (influenced by the NOvA run plan and results), and depending on the chosen run plan it may take longer to accumulate the full exposure.

The first analysis results from the Medium Energy Beam are expected in early FY17. Because the physics program of the Medium Energy Beam is primarily in the nuclear target measurements where statistics are at a premium, the publication of those results may depend somewhat on the planned switch(es) from neutrino to antineutrino running.

APPENDIX A: LIST OF MINERVA PUBLICATIONS

Physics Publications:

"First evidence of coherent K+ meson production in neutrino-nucleus scattering" Phys. Rev. Lett. 117, 061802 (2016)

"Measurement of K+ production in charged-current νμ interactions" Phys. Rev. D 94, 012002 (2016)

"Cross sections for neutrino and antineutrino induced pion production on hydrocarbon in the few-GeV region using MINERvA" Phys. Rev. D 94, 052005 (2016).

"Evidence for neutral-current diffractive neutral pion production from hydrogen in neutrino interactions on hydrocarbon" Phys. Rev. Lett. 117, 111801 (2016)

"Measurement of Neutrino Flux using Neutrino-Electron Elastic Scattering", Phys. Rev. D 93, 112007 (2016).

"Measurement of Partonic Nuclear Effects in Deep-Inelastic Neutrino Scattering using MINERvA", Phys. Rev. D 93, 071101 (2016).

"Identification of nuclear effects in neutrino-carbon interactions at low three-momentum transfer", Phys. Rev. Lett. 116, 071802 (2016).

"Measurement of electron neutrino quasielastic and quasielastic-like scattering on hydrocarbon at average Eν of 3.6 GeV", Phys. Rev. Lett 116, 081802 (2016).

"Single neutral pion production by charged-current anti-νμ interactions on hydrocarbon at average Eν of 3.6 GeV", Phys.Lett. B749 130-136 (2015).

"Measurement of muon plus proton final states in νμ Interactions on Hydrocarbon at average Eν of 4.2 GeV" Phys. Rev. D91, 071301 (2015).

"Measurement of Coherent Production of π± in Neutrino and Anti-Neutrino Beams on Carbon from Eν of 1.5 to 20 GeV", Phys. Rev.Lett. 113, 261802 (2014).

"Charged Pion Production in νμ Interactions on Hydrocarbon at average Eν of 4.0 GeV" , Phys.Rev. D92, 092008 (2015).

"Measurement of ratios of ν_{μ} charged-current cross sections on C, Fe, and Pb to CH at neutrino energies 2–20 GeV", Phys. Rev. Lett. 112, 231801 (2014).

"Measurement of Muon Neutrino Quasi-Elastic Scattering on a Hydrocarbon Target at Eν~3.5 GeV", Phys. Rev. Lett. 111, 022502 (2013).

"Measurement of Muon Antineutrino Quasi-Elastic Scattering on a Hydrocarbon Target at Eν~3.5 GeV", Phys. Rev. Lett. 111, 022501 (2013).

Technical Publications:

"MINERvA neutrino detector response measured with test beam data", Nucl. Inst. Meth. A789, pp 28-42 (2015).

"Design, Calibration and Performance of the MINERvA Detector", Nucl. Inst. and Meth. A743, 130, (2014).

"Demonstration of Communications using Neutrinos", Mod.Phys.Lett. A27, 1250077 (2012)

"The MINERvA data acquisition system and infrastructure", Nucl.Instrum.Meth. A694, 179-192 (2012).

"Arachne – A web-based event viewer for MINERvA", Nucl.Inst.Meth. 676, 44-49 (2012).

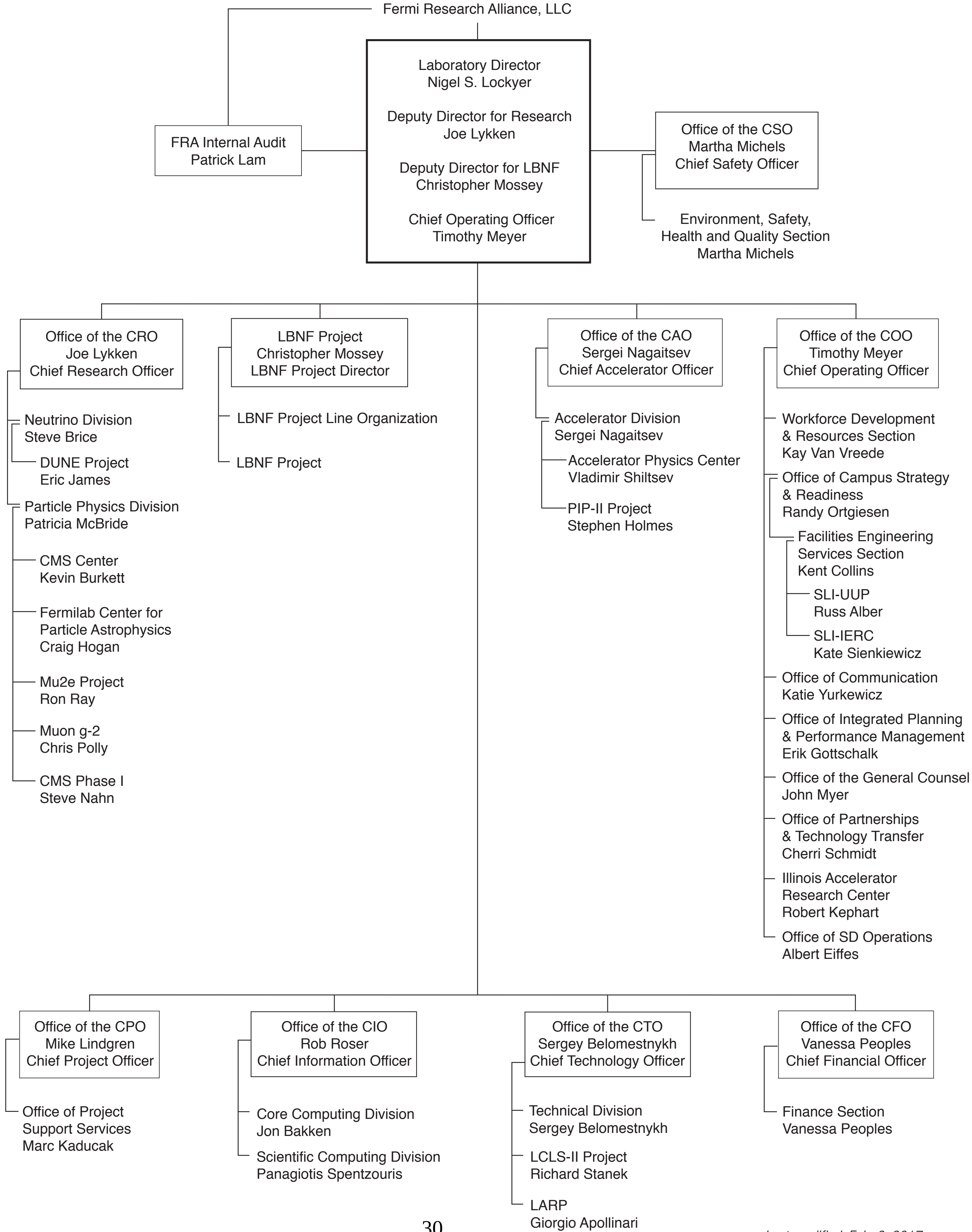
APPENDIX B: LIST OF ACRONYMS

ACNET	Accelerator Control Network
AD	Accelerator Division
ADC	Analog to Digital Converter
APD	Avalanche Photodiode
ASIC	Application-Specific Integrated Circuit
BlueArc	Name of a computer network storage device manufacturer
CC	Charge Current
CCD	Core Computing Division
CIO	Chief Information Officer
CRO	Chief Research Officer
CY	Calendar Year
DAQ	Data Acquisition System
dCache	A disk-based front-end data buffering for the Enstore mass storage system
DCM	Data Concentrator Module
DCS	Detector Controls System
DNS	Domain Name System
DocDB	Document Database
EC	Executive Committee
Enstore	A tape storage access and management system
EPICS	Experimental Physics and Industrial Control System
ES&H	Environment. Safety, and Health
FD	Far Detector
FEB	Front-End Board
FPGA	Field-Programmable Gate Array
FTS	File Transfer System
FY	Fiscal Year
GPS	Global Positioning System
HV	High Voltage
IB	Institutional Board
IFDH	Intensity Frontier Data Handling
IFIX	Proprietary name of supervisory monitoring and control program
KCA	Keon Certificate Authority
LCW	Low-Conductivity Water
LV	Low Voltage
M&S	Materials and Supplies
MINOS	**M**ain **I**njector **N**eutrino **O**scillation **S**earch
MOU	Memorandum of Understanding
NC	Neutral Current
ND	Neutrino Division or Near Detector
ND/TS	Neutrino Division Technical Support Department
NOνA	**N**uMI **O**ff-axis ν_e **A**ppearance Experiment
NuMI	**N**eutrinos from the **M**ain **I**njector
OSG	Operation Support Group
PDB	Power Distribution Boards

PMNS	Pontecorvo–Maki–Nakagawa–Sakata
POT	Protons on Target
PS	Power Supply
PVC	Polyvinyl Chloride
RAW	Radioactive Water
ROC	Remote Operations Center
SAM	Sequential Access with Metadata
SCD	Scientific Computing Division
T2K	Tokai to Kamioka Experiment
TDU	Time Distribution Unit
TEC	Thermoelectric Cooler
TECC	Thermoelectric Cooler Controller
TSW	Technical Statement of Work (formerly MOU)
UAC	Underground Area Coordinator

Fermilab Organization

APPENDIX C: Fermilab Organizational Chart



Last modified: Feb. 6, 2017

APPENDIX D: COLLABORATION INSTITUTIONAL RESPONSIBILITIES

The following list represents a snap shot of the responsibilities of MINERvA institutions (as of March 2016). In each case a total FTE collaborator count follows the institution name. When the responsibilities of the institution matches specifically to an item present in the MINERvA organizational charts those are tallied in lists that follow. Participation in the experiment which applies generally (for example, supervision of students) is not broken out in these smaller totals. Also, these FTE levels do not include undergraduate effort, but do include Masters Students, PhD Students, postdocs, professors, and physicists.

CBPF / 3.7 FTE
1.0 FTE Detector Expert

University of Florida / 3.15 FTE
0.7 FTE Production Processing / 0.5 FTE Inclusives Analysis Group Convernorship

Fermilab / 6.35 FTE
0.5 FTE CCQE Analysis subgroup leadership / 0.3 FTE Latin American Student and Postdoc Coordination / 0.25 Test Beam Analysis subgroup Leadership / 0.75FTE Spokesperson

University of Geneva / 0.33 FTE

University of Guanajuato / 5.8 FTE
0.5 FTE Detector Operations / 0.3 FTE Online Monitoring

Massachussetts College of Liberal Arts / 1.0 FTE
1.0 FTE Calibration Group Leadership

Northwestern University / 0.5 FTE
0.25 FTE Keepup Processing

Oregon State University / 0.5 FTE
0.25 FTE Keepup Processing

Otterbein/ 0.33 FTE
0.15 FTE Collaboration Management Tools (shift scheduler, publications, collaboration membership) / 0.10 FTE MINOS Calibrations

Oxford University / 2.2 FTE

University of Pittsburgh / 1.15 FTE
0.5 FTE Pion Analysis Subgroup Coordination / 0.15 FTE Speakers Committee Coordination / 0.5 FTE Calibrations /0.15 FTE Flux Group Deputy Convenorship

PUCP / 3.4 FTE
0.2 FTE Calibration / 0.2 FTE Detector simulation / 0.9 FTE Beam data and simulation / 1.3 FTE nue and NC analysis

University of Rochester / 13.73 FTE
2.0 FTE Operations / 1.0 FTE Computing Infrastructure / 0.5 FTE CCQE Analysis subgroup leadership / 0.5 FTE Analysis Coordinator / 0.75 FTE Spokesperson / 0.5 FTE Calibrations / 0.25 FTE Event Generator Coordinator

Rutgers University / 0.8 FTE
0.4 FTE Detector Operations / 0.2 Detector monitoring and controls

Tufts University / 1.75 FTE
0.5 FTE Event Generator / 0.5 FTE UROC Maintenance and Online Monitoring / 0.5 FTE Computing and Infrastructure Coordination

University of Minnesota-Duluth / 0.5 FTE

UNI / 3.0 FTE

USM / 2.7 FTE
0.5 FTE Rock Muon Monitoring Infrastructure support / 1.25 FTE Machine Learning Subroup

College of William and Mary / 3.5 FTE
0.5 FTE Inclusives Analysis Subgroup convenorship / 0.5 FTE Flux Group Convenorship

REFERENCES

1. MINERvA Collaboration Bylaws, http://minerva-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=2664
2. MINERvA Computing TSW, http://cd-docdb.fnal.gov/cgi-bin/ShowDocument?docid=5616
3. MINERvA Shift Wiki, https://cdcvs.fnal.gov/redmine/projects/minerva-ops/wiki/Minerva_Shift

The EOP submitted for the MINERvA Collaboration by:

Kevin McFarland University of Rochester MINERvA Co-spokesperson	Deborah Harris Fermilab MINERvA Co-spokesperson

The EOP reviewed and resource requests acknowledged by:

03/09/2017

Steve Brice, Head - Neutrino Division, Fermilab — Date

04/04/2017

Patricia McBride, Head – Particle Physics Division, Fermilab — Date

04/12/2017

Sergei Nagaitsev, Head-Accelerator Division & CAO, Fermilab — Date

06/27/2017

Robert Roser, Chief Information Officer, Fermilab — Date

06/30/2017

Joseph Lykken, Fermilab Deputy Director, Chief Research Officer — Date