October 31, 2016

Final Report
MINERvA Operational Readiness Review

1. Introduction

The Fermilab Program Planning Office (Steve Geer, Pushpa Bhat) charged a committee to review the operational readiness of the MINERvA experiment in the fall of 2016. The charge is provided in Appendix A and the committee membership is provided in Appendix B. The review took place on 17-18 October, 2016 and the agenda and the relevant materials are available from this URL, https://indico.fnal.gov/conferenceDisplay.py?confId=13047. Following the last talk, the committee met to discuss first impressions, to formulate additional questions, and to make writing assignments. In the days following the review some additional material was provided in response to requests and questions from the committee.

This report describes the findings, comments, and recommendations of the committee based on the talks presented at the review, on the answers to the questions asked during the review, on the additional material provided, and on discussions among the committee members. Prior to the issuance of this Final Report, a draft version was shared with the spokespersons of the experiment in order to provide them with an opportunity to correct any factual errors. The report summary and the recommendations enumerated represent the consensus opinion of the committee as a whole.

Each section below addresses one of the principal charge questions. The names of the committee members whose primary responsibility it was to address this particular charge question are included in parentheses at the beginning of each section. The lead writer has her/his name starred (*). Each section includes "Findings", "Comments", and "Recommendations".

2. Charge question #1

(A. Aparicio, M. Convery*, R. Tesarek)

Is there a completed Experiment Operations Plan (EOP) document that has been updated to include the additional scope from the MINOS ND? The document should include: (a) A description of operations tasks and how they will be covered, (b) ES&H activities and how they will be managed, (c) Organization charts showing the management structure for the experiment and how it interfaces with the laboratory, (d) The model for data processing and analysis including the budget and effort

required, (e) A list of the identified resources available, and (f) A description of the roles and responsibilities of each institution.

Yes, a completed EOP exists. It still needs to obtain signoffs.

2.1 Findings

- An Experimental Operations Plan for the MINERvA Experiment has been written (dated October 14, 2016) and describes the main operational tasks of the experiment.

- The EOP also describes the roles of Fermilab divisions and sections, including ESH&Q.

- The 14-month computing cost for data processing and analysis is $726k.

- In addition to the "snapshot" list of institutional roles in the EOP, the MINERvA conducts an annual "Who Does What" survey.

- Footnotes corresponding to asterisks are missing in the EOP.

2.2 Comments

-The EOP contains references to work being done in the FY16 shutdown that should be updated.

- Consider including the table of FTE for operations from the laboratory and the collaboration in the EOP.

2.3 Recommendations

1. Finalize the EOP and obtain the required sign-offs.

3. Charge question # 2

(B. Louis, R. Plunkett*)

Are the MINOS ND performance and calibration requirements well established for the needs of the MINERvA physics program, and is there a clear plan for achieving these requirements? Have the necessary resources been identified? Given the availability of resources, are the expectations for the detector performance and data taking efficiencies realistic? Is there a clear plan for monitoring the MINOS ND data

quality and has the team available for this task in the coming year tested the associated infrastructure?

Yes, MINERvA has understood the need for a smooth transition to operation of the MINOS ND. Many items required for this transition have been identified. Cross-training for hardware maintenance has begun

3.1 Findings

-MINERvA has begun the process of carrying out routine hardware maintenance, with Fermilab staff used as advisers.

- Most components have adequate spares, with inventory to be completed after recovery of some items from Soudan.

- The MINERvA collaboration contains an expert on the custom light injection system.

- Tests of calibration and monitoring results obtained by MINERvA and compared directly with the equivalent results from MINOS were not presented.

- MINERvA has made a detailed analysis of alternatives to full calibration of the MINOS ND, in case simplification is required.

- Estimates for laboratory resources were presented with uncertainties at the fraction of FTE levels.

- The expertise for operating the MINOS ND comes primarily from Neutrino and Particle Physics Divisions and carries over to MINERvA. The estimate for all ND operations is approximately 1.0 - 1.5 FTE, assuming no major crises.

- The MINERvA operations organization chart lists the MINOS Detector Experts to be Steve Hahn, Donatella Torretta, and Bill Badgett. Their involvement has been at the 0.5 FTE level over the past few years, but the expectation is that this will reduce to the 0.25 FTE level. Collaboration students and postdocs are being trained to take over their responsibilities.

- The ND magnet gets an annual checkup, the LeCroy HV1440 units get cleaned out annually, and there is an electronics repair contract with Gary Drake of ANL. In addition, there are additional parts coming to Fermilab from the MINOS FD.

- Automated processes are in place for data validation, bad channel finding, and data quality monitoring.

- Most MINOS calibrations change very slowly, corresponding to <1% variation yearly. The collaboration has determined that the MINOS ND PE calibration, which has been increasing at ~2%/year, is absolutely needed, while the Drift and Linearity calibrations would be nice to have.

- MINERvA acknowledges that expertise has been lost and that the biggest concerns are the light detection hardware and the online software.

3.2 Comments

- Encourage continued increased involvement of the collaboration to achieve 0.1 FTE level of Neutrino Division effort on DAQ.

- Effort to train an additional expert in the light injection system would help reduce the risk of a problem with this system.

- Greatly simplified calibration will still allow the physics program to proceed.

- The ability to service underground computing needs to be maintained.

3.3 Recommendations

2. Demonstrate and document operations of the full MINOS ND processing chain.

3. Decide in a timely way exactly which MINOS calibrations the experiment will perform. Develop a plan and identify the resources required to perform these calibrations.

4. Charge question #3

(M. Dolinski, J. Whitmore*)

Is there a well-understood run plan for FY17, consistent with accelerator schedule and performance? Have adequate resources from the laboratory and the collaboration been identified for an efficient and safe running of the experiment and for maintenance of the detector, and is it clear who is responsible for what?

Yes, the run plan for FY17 is well understood and consistent with the accelerator performance and schedule. Yes, the collaboration has written an EOP that details the FTE needs from the laboratory and the collaboration for efficient and safe maintenance & operation of the experiment.

4.1 Findings

- The PAC recommended MINERvA be delivered a minimum of 6E20 POT in anti-neutrino mode. The total request from MINERvA was 12E20 POT in anti-neutrino mode. Reaching this total is subject to the anti-neutrino-mode run plan for FY18-FY19, which has not yet been determined.

- The accelerator can deliver 700kW of beam for FY17-FY18, with 630 kW allocated for neutrino operation. This corresponds to 3-5E20 POT/yr.

- Program Planning determines the split of neutrino v. anti-neutrino v. special runs, with significant consideration given to the discovery potential of NOvA, which is the primary user of the beam.

- The run plan for FY17 is well defined. MINERvA expects to collect 2E20 Protons-On-Target (POT) for Medium Energy (ME) neutrino running and 3-4E20 POT for anti-neutrino running in FY17.

- MINERvA has 62 collaborators from 20 institutions, corresponding to a total of 42 FTE. The FTE commitment combines the effort for both operations and analyses.

- The MINERvA FY17 M&O resource needs were presented. From the collaboration, 8.5 FTE are needed for Operations with another 15.3 FTE needed for Calibration/Simulations/Tools. This represents ~50% of the total available FTE for the collaboration. The requested M&S budget is between $90k-150k/year.

- Collaboration resource needs have been documented in the EOP. Experts and lab resources have been identified by name where possible. Detector experts are students who train the next generation of experts. A succession plan for experts who are phasing out, either through retirement or from moving onto other experiments, was not presented. In particular, there is no succession plan for the Run Coordinator.

- Hardware spares are in hand for the experiment (enough for 8 years of running) and electronics test stands.

- FEB replacement is migrating to detector experts (collaboration resource).

- A swap of a MINERvA PMT requires two people. Currently, only two PPD technicians are trained to perform this work.

- The collaboration is reducing the reliance on ND MINOS detector experts by training the MINERvA detector experts (graduate students). A total of 1.6 FTE from ND and PPD is requested going forward.

- MINERvA presented a plan to reduce the FTE needs for shift monitoring of the MINERvA experiment by a factor of 3.

- ESH&Q safety concerns and mitigation plans are in place, with oversight from qualified FNAL ESH&Q personnel. MINERvA experimental hazards are not new (cryogenics/ ODH, electronics, underground).

- MINERvA started to monitor the MINOS ND during MINERvA data taking in the fall of 2011.

- A low energy (LE) neutrino dataset was collected in 2009-2012. The collaboration is using the effort for this dataset to estimate the effort and resource needs for the upcoming ME dataset.

4.2 Comments

- The laboratory is committed to delivering the PAC recommended 6E12 POT in anti-neutrino mode. The run plan for FY 2017 is well understood, with an agreement with NOvA of 3-4E20 POT of anti-neutrino running in FY17. The anti-neutrino-mode running in FY18 and beyond will depend on NOvA needs. The MINERvA collaboration should have a prioritized analysis plan based on a total delivered POT of 6E12 for anti-neutrino running.

- As presented, the available FY17 resources from the collaboration and the laboratory are sufficient to meet the experiment's M&O needs.

- The MINERvA collaboration has been monitoring the MINOS detector during shifts for 5 years. This has given them the necessary experience to take on the additional responsibility of MINOS M&O.

- Responsibility for MINOS detector maintenance is migrating from ND to the collaboration. In many cases, training and succession plans are well thought out. In some cases (Run Coordinator), succession plan needs to be defined.

- The collaboration should be commended for making an operations plan to reduce the effort required for MINERvA. Care should be taken to ensure that data quality does not suffer with this reduced oversight.

- MINERvA should include a resource need profile for the experiment for FY17-FY20 in the EOP. The experiment should identify personnel that will likely have to be replaced over the FY17-20 timescale and should consider developing a succession plan for inclusion in the EOP.

4.3 Recommendations

4. Work closely with the Fermilab Program Planning Office to coordinate MINERvA anti-neutrino run plans with the NOvA experiment's plans for FY17 and beyond.

5. Work with the laboratory to identify and train additional personnel to swap MINERvA PMTs.

5. Charge question #4

(A. Norman*)

Are there robust plans for data processing and data analysis? Have adequate resources from the [laboratory and] collaboration been identified for data analysis to meet the set goals?

Yes. The MINERvA experiment has demonstrated the ability to plan for and execute the data processing and data analysis necessary for producing physics results. They have demonstrated that they can accurately assess the computing resources they require and have presented reasonable projections of the resources they will need to process and analyze the medium energy data sets.

5.1 Findings

-The MINERvA collaboration has completed multiple full production passes over their current LE and ME neutrino-mode data sets.

- The most recent full MINERvA production campaign took approximately one year from its start to full completion. It involved the integration of multiple changes to the simulation and analysis stack and required validation.

- The MINERvA collaboration estimates that the computing resources needed for a full analysis of their existing medium energy data are approximately 16M CPU hours and about 500 TB of tape storage in FY17. These resource projections were presented to the Scientific Computing Division and are consistent with what the division can provide to the experiment.

- The MINERvA collaboration is in the midst of migrating their software/computing infrastructure so that it is compatible with the Open Science Grid.

- The MINERvA collaboration has taken over responsibility for the MINOS ND data processing.

- The MINERvA collaboration enumerated the currently active analyses using the ME datasets.

- The MINERvA collaboration does not have a formal planning process for determining when a full data processing/re-processing is triggered or scheduled.

5.2 Comments

- The production campaigns for the LE and ME neutrino datasets are similar in scope as to what will be required for the anti-neutrino data set.

- The MINERvA collaboration's last full production campaign is a reasonable model for understanding the scope of work that will be required for ME anti-neutrino data analysis.

- The computing resources and support that have been requested by the MINERvA experiment are reasonable, but in the current constrained budgetary climate, there may be a need to adjust resource allocations based on the impact of the work being performed. The MINERvA experiment should be prepared to consider how they would change the scope or timeline for their anti-neutrino analysis if they were unable to obtain all the computing resources they have requested. The MINERvA experiment is also encouraged to understand and present their current/future analysis efforts in a manner that makes clear the impact the results may have on the neutrino community as a whole.

- The MINERvA collaboration's effort to modernize their software/computing infrastructure will allow the experiment to leverage more resources for their core production activities and will allow the experiment to absorb more readily any unanticipated computing needs (specifically increase simulation needs). This may be particularly important in a constrained budgetary environment where not all the requested resources are available from Fermilab. MINERvA is encouraged to continue this modernization and to look for other ways to expand their available resource pool (i.e. find ways to improve on the current 80% job efficiency or other small optimizations that can help reduce waste and reclaim resources).

- The MINERvA collaboration may find it advantageous to formalize their process for determining the "triggers" and timelines that are required for initiating their large scale and common production processing. Moreover, they may want to develop analysis strategies that target specific physics results for public consumption on deadlines (meaning at major conferences) that are concurrent with

the needs of the larger community. Doing so will allow the experiment to "work backwards" from the conference dates to determine when processing efforts should start and how they can be balanced. This will be a boon to both the experiment and the community.

- The MINERvA collaboration should be applauded for their efforts to assume the MINOS production infrastructure and data processing. The presented integration between MINERvA and MINOS computing appears to be well motivated and sustainable given the available effort.

5.3 Recommendations

6. Use a prioritized ME publication plan to develop a schedule for simulation and data processing.

6. Charge question #5

(D. Denisov*, J. Konigsberg)

Are there clear goals set for reporting and publishing the results from the experiment in a timely fashion?

Yes, there is a well-defined set of low energy and medium energy results that the MINERvA collaboration is working to publish.

6.1 Findings

- The MINERvA collaboration published 16 papers based on the low energy data set collected in 2009-2012: 8 PRLs, 7 PRDs and 1 PLB.

- The collaboration has presented 15 W&C talks.

- There are 8 additional analyses of low energy data in various stages of readiness for publication .

- There are 11 medium energy analyses in progress.

- The leadership of the MINERvA collaboration expressed a preference for releasing results only on the "full" datasets, which, for the anti-neutrino running, is projected to be 6E20 POT (12E20 POT requested).

- The determination of the (anti-)neutrino fluxes is required for most of the (anti-) neutrino analysis efforts. This is not yet available for any of the ME data sets.

6.2 Comments

- The collaboration has a well-established process and methodology to review analyses that has resulted in successful journal publications.

- While the rate of publications is reasonable, the current plan envisions publications approximately a year after all data is on hand. Comments were made as to the possibility of publishing some results earlier with a sub-set of the data. This might line up better with the timelines for students and postdocs and possibly help optimize the impact on the neutrino community at large.

- While the collaboration has not identified "flagship" analyses, the prioritization of analysis topics could help focus the collaboration efforts on areas most relevant for the neutrino community.

- The presentations did not make it clear how the results from the MINERvA experiment might *quantitatively* affect the reach of the neutrino oscillation experiments or the studies of the EMC effect. It is advisable to pursue this clarification with studies for the most important analyses, including taking into account statistical and systematic uncertainties and expected POT numbers.

- While performing an analysis only on full (complete) datasets may reduce the overall analysis load, having intermediate analysis results either in stages or at definite break points in the experiment's life cycle, may prove to be more impactful to the physics community.

- Knowledge of the fluxes and uncertainties associated with anti-neutrino running is a major undertaking and is most likely on the critical path for most of the ME analyses including the anti-neutrino results. The chance that this portion of the analysis is delayed or stalls due to lack of scientific personpower is a very real risk to the success of the experiment. This issue has ramifications beyond MINERvA.

- The MINERvA collaboration presented the current organization for the active ME analysis work. This should be expanded to map out all of the analysis work that the collaboration wants to accomplish over the next 2-3 years. In particular the relative impact of the different analyses should be considered. This will allow for both prioritization and long term planning for the resources, effort and timelines that will be needed to meet targeted publication and presentation milestones.

6.3 Recommendations

7. Develop a plan to submit for publication all remaining low energy results within 8-12 months.

8. Together with the Accelerator Division and other relevant experts, work expeditiously on understanding the neutrino flux in the medium energy data.

9. Develop a prioritized list of medium energy publications for both neutrino and anti-neutrino datasets.

10. Analyze the pros and cons of publishing some medium energy results based on a partial dataset. Consider the possibility of having a more timely impact on the broader community when making this decision.

7. Charge question #6

(D. Glenzinski*, all)

Does the committee recommend further actions to ensure full exploitation of the MINERvA program?

Yes. Ensure adequate resources are devoted to bringing the ME analyses to publication in a timely manner.

7.1 Findings

- A significant effort is still engaged in analyzing the low energy data set.

- The flux is not yet fully understood for the medium energy neutrino data set.

7.2 Comments

- If the low energy analyses linger too long or the flux issue is not resolved in a timely manner, there is a non-negligible risk that the medium energy results may be significantly delayed, particularly those associated with anti-neutrino running.

7.3 Recommendations

None.

8. Summary

The MINERvA experiment was reviewed for its data-taking and analysis operations readiness. The review committee was provided with a set of MINERvA documents relevant to addressing the charge questions. The MINERvA collaboration also made a full day's worth of presentations to the review committee. The committee was grateful for all the collaboration's effort to provide detailed input.

The MINERvA collaboration is to be congratulated for its success to date. It has collected significant data sets in neutrino mode in both the low energy and medium energy NuMI configurations. The detector operations are performed safely and data is collected with high efficiency. The collaboration has established a strong record of publication. There are several analyses using the low energy data set that will soon be published. The collaboration is preparing in earnest for producing results using the medium energy data set. The MINERvA collaboration leadership has worked with the laboratory and the collaboration to identify the resources required to safely and efficiently collect, analyze, and publish the data over the next 2-3 years. Overall the committee was impressed with MINERvA, and they are in a strong position to continue their success.

The committee identified one main risk facing MINERvA. Namely, the collaboration needs to ensure that sufficient resources are directed towards the characterization and analysis of the medium energy data sets. It is important that those analyses converge in a timely manner, particularly for the medium energy anti-neutrino mode data sets, which will be collected last and will thus mark the end of MINERvA running.

Appendix A – Charge

MINERvA Experiment Operations Review
October 17-18, 2016

The MINERvA Experiment had a successful operations readiness review (ORR) in Feb. 2013, has run well thus far and collected neutrino interactions data with an integrated ~11E20 protons on target (POT). The experiment is approved to continue to run in order to accumulate a minimum of 6E20 POT in the antineutrino mode (MINERvA"s request is for 12E20), as a secondary user in the NUMI beam. Fermilab's run plan is to deliver another 2E20 POT in the neutrino mode (as per NOvA's request) before switching to antineutrino mode. MINERvA is also taking over the responsibility of operating the MINOS+ near detector (ND), as MINOS+ has completed its data-taking but the ND is used by MINERvA for muon identification. Because of these reasons, this interim experiment operations review is being held. The focus of this review will be the degree to which the collaboration is ready to assume the M&O responsibility for the MINOS ND and the associated data monitoring, as well as overall data processing and analysis.

We would like the committee to review the preparations for future MINERvA running, plans for maintenance & operations of the detectors, data taking and analysis, and the run plan.

In particular:

1. Is there a completed Experiment Operations Plan (EOP) document that has been updated to include the additional scope from the MINOS ND? The document should include: (a) A description of operations tasks and how they will be covered, (b) ES&H activities and how they will be managed, (c) Organization charts showing the management structure for the experiment and how it interfaces with the laboratory, (d) The model for data processing and analysis including the budget and effort required, (e) A list of the identified resources available, and (f) A description of the roles and responsibilities of each institution.

2. Are the MINOS ND performance and calibration requirements well established for the needs of the MINERvA physics program, and is there a clear plan for achieving these requirements? Have the necessary resources been identified? Given the availability of resources, are the expectations for the detector performance and data taking efficiencies realistic? Is there a clear plan for monitoring the MINOS ND data quality and has the team available for this task in the coming year tested the associated infrastructure?

3. Is there a well-understood run plan for FY17, consistent with accelerator schedule and performance? Have adequate resources from the laboratory and the collaboration been identified for an efficient and safe running of the experiment and for maintenance of the detector, and is it clear who is responsible for what?

4. Are there robust plans for data processing and data analysis? Have adequate resources from the collaboration been identified for data analysis to meet the set goals?

5. Are there clear goals set for reporting and publishing the results from the experiment in a timely fashion?

6. Does the committee recommend further actions to ensure full exploitation of the MINERvA program?

We request a brief written closeout report from the committee addressing these questions by October 28, 2016.

Appendix B – Committee Membership

Angela Aparicio (Fermilab)
Mary Convery (Fermilab)
Dmitri Denisov (Fermilab)
Michelle Dolinski (Drexel U.)
Doug Glenzinski (Fermilab – Chair)
Jaco Konigsberg (U. Florida)
Bill Louis (LANL)
Andrew Norman (Fermilab)
Rob Plunkett (Fermilab)
Rick Tesarek (Fermilab)
Julie Whitmore (Fermilab)