March 1 , 2013

Final Report
Fermilab Experiment Operational Readiness Review

1. Introduction

The Head of the Fermilab Program Planning, Steve Geer, charged a committee to review the operational readiness of the MINOS+, MINERvA, SeaQuest, and NOvA experiments for beam start-up and data taking in the spring of 2013. The charge is provided in Appendix A and the committee membership is provided in Appendix B. The review took place on February 8, 2013 and the relevant materials are available from this URL, https://indico.fnal.gov/conferenceDisplay.py?confId=6314. Following the last talk, the committee met to discuss first impressions, to formulate additional questions, and to make writing assignments. In the week following the review some additional material was provided in response to requests and questions from the committee.

In developing their commissioning and data-taking plans, the experiments were told to assume that:

- the shutdown will end May 31, 2013;
- the NuMI target will operate in the medium energy (ME) configuration;
- first useable beam to the NuMI target should occur in week 2;
- first useable beam to the SeaQuest target should occur in week 5;
- the beam commissioning will take about 3 months total at which point the NuMI target should be receiving about 5E19 POT/month and the SeaQuest target should be receiving a few E12 POT/spill;
- it will take several months to fully commission the new systems required to reach 700 kW on the NuMI target.

More details are provided in the first presentation from the review website.

This report describes the findings 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 in the days following the review, 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 experiments in order to provide them with an opportunity to correct factual errors. The findings and recommendations enumerated represent the consensus opinion of the committee as a whole.

2. MINOS+

2.1 Findings

The MINOS+ experiment is on track for being ready for commissioning and data taking by the end of May 2013.

The MINOS+ collaboration has well-developed commissioning, data-taking, and data-processing plans based on their previous seven years of experience.

The MINOS+ collaboration appears to have sufficient computing resources for 2013.

The technical crew at the far detector (FD) site is currently short-handed, which requires a reduction in the number of hours for which the mine is staffed. The opening has been advertised and a new hire is expected to occur well before the end of May.

Operating in the ME configuration will increase the occupancy in the near detector (ND), which slows the reconstruction algorithms by a factor of about two. A program to improve the performance of the reconstruction code has been implemented. In addition, there is the possibility of assigning additional cpu resources for data reconstruction while minimally impacting the ability of the collaboration to perform data analysis. Monte Carlo studies indicate that the reconstruction at the higher occupancies is robust.

MINERvA relies on MINOS+ to provide reconstructed MINOS+ data for MINERvA triggered events.

Special runs with the NuMI horn will be required to calibrate and understand the ME production spectrum. A good modeling of this spectrum is needed in order for MINOS+ to achieve their target physics sensitivities.

MINOS+ relies on PREP to provide maintenance and repair support for some of its experimental equipment.

There have been changes in the database and software tools for monitoring the status of the beam. Some work remains to integrate these tools into the MINOS+ online and offline software environments.

The commissioning and data-taking plans require about a dozen FTE spanning 32 service positions (including what's required to reconstruct the data and monitor the reconstructed-data quality). The collaboration provides about 35 FTE of effort and has so far committed to filling 30 of the service positions.

The analysis plan assumes 4E20 POT in advance of the Neutrino 2014 conference scheduled for June 2014. This is consistent with the accelerator division's (AD) goal of providing 5E19 POT/month starting in September, although with little schedule contingency.

The MINOS+ collaboration is about a factor of two smaller than the MINOS collaboration.

During LE running, MINERvA helped provide 24/7 maintenance of the MINOS ND. For the ME running, MINERvA is unlikely able to provide the same level of support.

All the NuMI experiments need the NuMI monitoring system (ie. the muon alcoves) to be instrumented and commissioned prior to the start of data-taking.

2.2 Recommendations

The laboratory should work with MINOS+ and the rest of the NuMI program to develop a plan that gives MINOS+ and MINERvA the special horn runs they need in order to understand the ME production spectrum, and gives MINERvA the information they need to make a target decision.

The spokespersons should work with SCD/PREP to develop an agreement that ensures continued support of PREP equipment.

The spokespersons should work with the collaboration to fill the last remaining service positions.

The spokespersons should work with the collaboration to ensure adequate resources will be available for taking the data, reconstructing the data, and performing analysis over the lifetime of the experiment.

The laboratory should work with the NuMI experiments to develop a plan that ensures the muon alcoves are instrumented and commissioned for the start of data taking, and to ensure they are maintained for the duration of the run.

The spokespersons should monitor the status of the additional hire to the FD technical crew. If a full crew cannot be in place when commissioning and data-taking begin, understand the implications for detector operations and take appropriate steps to mitigate any associated risks to personnel, to the detector, or to the commissioning goals.

The spokespersons should monitor the cpu performance improvements to the reconstruction algorithms and ensure they do not come at the cost of significantly degrading the experimental sensitivity. Understand whether or not there are any implications for MINERvA and, if so, work with them to mitigate risks to their physics program.

The spokespersons of MINOS+ and MINERvA should clearly communicate with each other their needs concerning the maintenance of the MINOS+ ND and work with the laboratory to develop a plan to meet those needs.

The spokespersons should work with the laboratory to ensure the beam monitoring capabilities are ready for the start of data taking.

The spokespersons should consider whether or not an agreement with MINERvA, concerning their reconstruction needs, is warranted. If so, develop one with them.

3. Sea Quest

3.1 Findings

Based on their experience from the 2012 run, the SeaQuest experiment embarked on a significant upgrade of the experiment's capabilities including: the addition of a beam intensity monitor, new PMT bases in station 1 (ST1), replacing the ST1 tracking chamber, replacing a tracking chamber on the lower portion of station 3 (ST3-), repairing the upstream tracking chamber at station 3 (ST3+), upgrading the TDC microcode, upgrading portions of the DAQ, and miscellaneous improvements to the shielding and infrastructure in the experimental hall.

The SeaQuest experiment has a well-developed plan and has the necessary resources, largely from the collaboration, for implementing the full suite of upgrades discussed in the previous paragraph.

The SeaQuest experiment has a well-developed commissioning plan based on their 2012 running.

The software necessary to reconstruct and analyze the SeaQuest data has been demonstrated using the 2012 commissioning run. Tests are being performed to understand how increased occupancy affects the software performance.

The computing resources available to SeaQuest should be sufficient for the 2013 running.

The current upgrade activities and preparations for beam consume most of the collaboration's personnel resources, leaving little effort available to prepare for physics analysis beyond ensuring the reconstruction software is ready.

The schematic design for the readout module of the beam intensity monitor has only just begun.

The new ST1 tracking chamber doubles the acceptance of events in the most interesting *x*-bins of the SeaQuest analysis compared to the old ST1 tracking chamber.

The new ST1 tracking chamber is being built by the Univ. of Colorado and is currently scheduled to arrive ready for installation in July or August 2013, after data-taking has begun. The old ST1 tracking chamber is being refurbished as a fall-back.

Prior to 2013 commissioning, SeaQuest will need to survey and align their detector elements. Their current plan implements this campaign in two phases through March and April.

SeaQuest relies on SCD/PREP to provide maintenance and repair support for some of its experimental equipment.

SeaQuest needs a few days of effort from John Vorin's group for several separate jobs, including: stacking additional neutron shielding that affects the ST1 tracking chamber; installing the new ST1 tracking chamber once it's ready; and installing some additional support rails to allow easy maintenance of the hodoscope stations.

The large variations in beam intensity observed in the 2012 running caused significant problems for SeaQuest and compromise the physics sensitivity of the experiment. The AD has identified a number of possible causes for the spikes in intensity and believes that the spill quality will be greatly improved in the upcoming run.

SeaQuest needs approximately 0.5E18 POT on any one target to achieve a sensitivity that warrants a first publication.

SeaQuest needs a total of 5.2E18 POT on each target to reach their final sensitivity.

SeaQuest has a required duty factor of >50% with a goal of 80%, where the duty factor is defined as <I>^2 / <I^2> averaged over all RF buckets in a spill.

3.2 Recommendations

The spokespersons should explore with AD the possibility of their demonstrating, as early as possible, that the intensity variation problems that plagued the 2012 running have been addressed.

The schedules for most of the upgrade projects appear to have little schedule contingency. The experiment should remain vigilant across the full breadth of projects to ensure none of them gets significantly delayed. The readout boards for the beam intensity monitor and the new ST1 tracking chamber appear to carry the most schedule risk.

The experiment should try to accelerate the schedule for the ST1 tracking chamber while continuing to develop fall-back plans in the event it won't be ready for the start of data taking in late June.

The experiment should try to accelerate the schedule for the readout module of the beam intensity monitor.

The experiment should work with the Survey and Alignment Group to develop a plan that meets the experiment's needs on the necessary timescale.

The experiment should work with the PPD Experiment Installation Group to ensure the necessary effort for the various tasks is obtained on timescales that minimally affect SeaQuest's data-taking plans.

The spokespersons should work with SCD/PREP to develop an agreement that ensures continued support of PREP equipment.

The spokespersons should develop plans to ensure the reconstruction software is ready for the new tracking chambers and for the higher multiplicities that will result from higher intensity operation (i.e. ~1E13 protons/spill).

4. NOνA

4.1 Findings

At the time of the review, 7 blocks had been installed and 1 block had been filled (out of 28 total blocks) at the FD.

All aspects of the FD assembly appear to be proceeding more-or-less as scheduled, with the exception of the installation of APDs, which is not scheduled to begin until mid-March.

By the time data-taking begins in June there ought to be 4 ktons of detector mass in place, 3 ktons of which ought to be fully instrumented and ready for data-taking.

The NOvA collaboration has well-developed commissioning, data-taking, and data-processing plans based on their experience with NDOS operations.

The NOvA collaboration has sufficient personnel resources to finish the detector construction and to implement the commissioning, data-taking, and data-processing plans.

The computing resources are sufficient for the NOvA goals in 2013.

The NOvA collaboration will begin detector shifts March 11, 2013 to aid in commissioning the FD and to prepare for data-taking with beam.

The performance of the reconstruction software and other necessary software tools has been demonstrated using NDOS data and a mock data challenge simulating the FD data.

The capability of NOvA to report physics results at the Neutrino-2014 conference in June 2014 depends on whether or not the ND construction and commissioning schedule are completed in a timely fashion.

One of the NOvA project's key performance parameters (KPP) requires that a neutrino event be recorded in each FD super-block. Early beam performance is crucial to satisfying this KPP in a timely fashion (e.g. 1 month at 300 kW has a 93% probability of producing a neutrino event in the first super-block).

When taking data, NOvA relies on a direct video link between the Fermilab NOvA control room and the FD site.

Because it operates off axis, NOvA does not anticipate needing many special runs with different horn configurations in order to understand and adequately model the ME production spectrum.

The NOvA run plan affects the MINERvA target strategy. Presently, NOvA estimates it will need at least 1 year of data taking in neutrino mode (depending on the accelerator performance) prior to switching to anti-neutrino mode.

4.2 Recommendations

The accelerator performance has important consequences for both the NOvA project KPPs and the NOvA collaboration's near term analysis plans. The AD should provide a realistic estimate of the number of POT at NuMI, as a function of time, for the coming year. The project should use this projection to refine estimates of KPP schedules. The collaboration should use this projection to refine estimates of physics sensitivity for the Neutrino-2014 conference.

The laboratory should work with NOvA and the rest of the NuMI program to develop a plan that gives MINOS+ and MINERvA the special horn runs they need in order to understand the ME production spectrum, and gives MINERvA the information they need to make a target decision.

The project, together with the collaboration, should remain vigilant in maintaining the FD schedule.

The project, together with the collaboration, should explore ways to accelerate the ND schedule.

The spokespersons should ensure that any change in run plans is communicated to the rest of the NuMI program.

The spokespersons should explore with the laboratory cost effective ways to establish the direct video link required for detector operations.

5. MINERνA

5.1 Findings

The MINERvA experiment has a clear idea of the upgrades and additional work needed to be ready for commissioning and data taking by June 2013.

The MINERvA collaboration has commissioning and data-taking plans based on their previous running experience.

MINERvA's reconstruction software has been demonstrated in previous running. They rely on MINOS+ to provide information for through-going muons.

The CROC-E upgrade is required to accommodate the increased spill rate of the ME running. The current schedule has 6 weeks of contingency.

The water target needs to be refilled and potentially needs some repair. The materials necessary for the repair are in hand.

The helium target system requires maintenance work on the cryo-cooler. The resources necessary for the maintenance are in hand. It takes about two months to fill the helium target and prepare it for data taking. Filling the helium target would require an additional $20k in M&S funding.

MINERvA's target strategy is affected by NOvA's run plan.

Dan Ruggiero provides important technical support to MINERvA and carries with him historical expertise obtained during detector design and construction.

Some PPD personnel are being trained to replace the PMT boxes.

For data processing and analysis, the MINERvA experiment needs to migrate to using more cache. The utilities and hardware for doing so exist.

To accomplish its physics goals for ME running, MINERvA requires a test beam run to establish its hadronic calorimeter energy scale. This run will require resources from the collaboration and from the laboratory. This run could occur in FY14.

The MINERvA experiment needs about 16 physicist FTE for detector operations, data reconstruction, and Monte Carlo. The collaboration can provide 30 physicist FTE. The ratio of FTE-available-from-the-collaboration to FTE-needed is worse than the MINOS+ ratio.

During LE running, MINERvA helped provide 24/7 maintenance of the MINOS ND. For the ME running, MINERvA is unlikely able to provide the same level of support.

MINERvA has not yet published any cross section results using the full statistics from the LE run.

The MINERvA collaboration listed about 20 FTE are needed in 2013-2015 to analyze and publish the LE and ME data.

The MINERvA collaboration had 10 post-docs and 14 graduate students for the LE run. They currently have 6 post-docs and 12 graduates students involved in the ME preparations and running.

5.2 Recommendations

The spokespersons should continue engaging the funding agencies, the laboratory, and the collaborating institutions in a discussion of how to strengthen the collaboration in order to ensure adequate resources will be available for taking the data, reconstructing the data, and performing analysis over the lifetime of the experiment.

The spokespersons should work with the collaboration to identify and train the people necessary to fulfill the vacant detector-operations and data-reconstruction roles. They should identify expertise that will move-on in the coming year and develop succession plans.

Where short-falls in detector operations are identified, the spokespersons should engage PPD in a discussion of how the division can help provide additional personnel resources.

The spokespersons should make a decision regarding the helium target and work with the laboratory to develop a realistic schedule for preparing the target for data taking. Integrate that schedule with the experiment's run plan.

The spokespersons should make a decision regarding the water target and work with the laboratory to develop a realistic schedule for accomplishing that plan. Integrate that schedule with the experiment's run plan.

The spokespersons should produce a prioritized list of analyses. They should develop a plan to ensure the highest priority analyses have the necessary personnel resources assigned and are published in a timely fashion.

The collaboration should work with SCD to develop and implement a realistic data-handling plan that makes better use of the existing cache capabilities.

The spokespersons should remain vigilant to ensure the CROC-E upgrade is commissioned and ready for data taking when beam returns in June 2013.

The spokespersons of MINERvA and MINOS+ should clearly communicate with each other their needs concerning the maintenance of the MINOS+ ND and work with the laboratory to develop a plan to meet those needs.

The laboratory should work with MINERvA and the rest of the NuMI program to develop a plan that gives MINOS+ and MINERvA the special horn runs they need in order to understand the ME production spectrum, and gives MINERvA the information they need to make a target decision.

The spokespersons should consider whether or not an agreement with MINOS+, concerning the MINERvA reconstruction needs, is warranted. If so, develop one with them.

The spokespersons should work with the laboratory to develop a plan to determine the hadronic calorimeter energy scale for the ME running. The plan should include a realistic estimate of the personnel resources needed from the collaboration and from the laboratory. The spokespersons should ensure that the collaboration's analysis/publication plan and the collaboration's resource plan are both consistent with the plan for obtaining the calorimeter energy scale.

6. Summary

The MINOS+, MINERvA, SeaQuest, and NOvA experiments were reviewed for their operational readiness. For the purposes of the review, we assumed that beam commissioning begins June 1, 2013, with first beam to the NuMI target arriving about a week later, and first beam to the SeaQuest target arriving about 4 weeks later.

In general, the detector hardware and the online and offline software of all four experiments are on track to be ready for commissioning and data taking once the beam returns in June. Most items have 4-6 weeks of schedule contingency. There are a few items with little to no schedule contingency: the new ST1 tracking chamber for SeaQuest and (potentially) the helium target refurbishment and filling

for MINERvA. All the collaborations need to remain vigilant in order to maintain their current schedules.

In general, all four experiments have well defined physics and commissioning goals. For MINOS+, SeaQuest, and MINERvA those are largely based on previous running experience. For NOvA those are based partly on the NDOS running experience and partly on a mock data challenge that mimicked FD data and analysis. The neutrino experiments are focused on having new results ready for the Neutrino-2014 conference in June 2014. The sensitivity they'll be able to achieve critically depends upon the beam line performance and the total POT delivered to NuMI. The success of SeaQuest critically depends on whether or not the beam intensity variations that plagued the 2012 running have been addressed.

The NOvA experiment appears to have adequate resources for meeting their commissioning, data-taking, and analysis goals. Similarly, the MINOS+ and SeaQuest experiments appear to have adequate resources, but the with a smaller margin. The MINERvA experiment has no margin, needing about the same number of FTE for commissioning, data-taking, and analysis as available in the collaboration. This is not a robust situation and requires careful planning, analysis prioritization, and the development of a plan, in conjunction with all the stake holders, for how the collaboration might be strengthened.

There are risks to each of the experiment's physics capabilities. MINOS+ requires a set of special runs with the horn in order to understand the ME production spectrum. SeaQuest requires a duty factor >50% with limited intensity variations across the spill and from spill-to-spill. MINERvA will eventually require a test beam run to determine the energy scale of its hadronic calorimeter. NOvA needs about a month of good data with the full ND in place. All of these require lab resources to succeed.

There are both common and competing interests among the experiments, particularly within the NuMI program. In addition, the resources available from the collaborations and from the laboratory are limited and stretched. Given these facts, the laboratory will need to continue working with all the stake holders to further develop a careful and coordinated plan that optimizes the experiments' collective chances for success.

Appendix A – Charge

January 14 , 2013

Experiment Readiness Review
February 8th, 2013

The Fermilab 2012-13 accelerator shutdown is currently scheduled to end in May. Once accelerator operations are re-established, four experiments should be ready to begin utilizing the beams: MINOS+, MINERvA, NOvA (with a partially completed detector), and SeaQuest. We would like the committee to review, for each experiment, the preparations for taking data, including the current status of the detector, the status of the online and offline software, the plans for completing the preparations, and the run plans. In particular, for each experiment:

1. What are the critical path activities and associated milestones for getting the detector hardware and analysis software ready for first beam? Is there a realistic plan, based on well identified resources from the laboratory and from the collaboration, for meeting these milestones and maintaining the critical path?

2. Have well defined physics/commissioning goals been specified for the coming 12 months? Is there a well understood run plan, based on realistic expectations for accelerator performance, that meets these goals? Have adequate resources, from the laboratory and the collaboration, been identified for the maintenance and operation of the experiment in meeting these goals?

3. Are there technical/schedule/resource risks that might affect the start of data taking? Are there technical/schedule/resource risks that might affect the physics/commissioning goals identified above? Are there actions that could be taken to mitigate these risks?

We would like a brief written report addressing these questions by February 15th, 2013.

Appendix B – Committee Membership

Kevin Burkett (Fermilab)
Doug Glenzinski (Fermilab – Chair)
Jaco Konigsberg (U. Florida)
Bill Louis (LANL)
Bob Tschirhart (Fermilab)
Julie Whitmore (Fermilab)