Fermilab
Physics Advisory Committee Report
Sanford Laboratory, July 5-9, 2017

Executive Summary

The Physics Advisory Committee (PAC) met at the Sanford Laboratory to consider the Fermilab program in the context of the Particle Physics Project Prioritization Panel (P5) report: "Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global Context." In this meeting the PAC was asked to focus on the status of running and planned experiments in the neutrino program, any pressing matters, and their impact on the success of the full program. The PAC was also asked to review the status of the accelerator and beam allocation and scheduling, and the impact to the current and upcoming experiments under flat budget and reduced budget scenarios. The exercise of the impact of reduced budget scenarios that could curtail the physics program is useful as a readiness and prioritization test, something that the HEP field had to already practice in order to arrive to the P5 plan which is now successfully implemented. The PAC held a very useful half-day meeting at Fermilab on June 29 with the participation of the Laboratory Management to prepare the July 5-9 meeting at Sanford.

The PAC commends the Laboratory on their meeting all their milestones and fulfilling all the requests for beam to the entire program on budget and faster than required. For example, the BNB has performed sufficiently well to enable the initial MicroBooNE beam request to be completed one year ahead of schedule. The PAC was pleased to hear of the success of the first ANNIE run and of the production of precision timing technology by industry, the R&D of which was funded by the DOE through SBIR and Detector R&D programs in the past decade. The PAC learned about the status and planning of SeaQuest beyond the currently completed E906 program towards E1039 (Drell-Yan with polarized target) and a proposed extension to perform dark photon searches (P1067). The PAC is looking forward to the SeaQuest collaboration converging on a funding model from DOE NP. The PAC requested an overview of theoretical neutrino physics and relevant synergies between NP and HEP to be discussed in the Fall PAC meeting at Fermilab.

The PAC learned about the Laboratory's important mission-related axes on i) Accelerator Science and ii) Big Data & Computation R&D. The mission of the Fermilab Accelerator Science and Technology (FAST) Facility is to develop a fully-equipped test facility to support research and development of accelerator technology for the next generation of particle accelerators in all science domains. The facility will also serve as a training ground for the next generation of accelerator scientists. The focus of this effort is the unique Integrable Optics Test Accelerator (IOTA) ring which will accept injection with either 150 MeV electrons from a photoinjector-based superconducting RF linear accelerator or 2.5 MeV protons (H^+) from the duo-plasmatron IOTA Proton Injector. Besides R&D work on optical stochastic cooling and beam dynamics towards improved emittance, FAST could serve as a prime facility for calibration of dark matter sensors using monochromatic low energy neutrons. The PAC endorses the support and dedicated funding of innovative developments in the Accelerator Science area and looks forward to hear more on the Laboratory's Computation thrust at the Fall PAC meeting at at Fermilab in November 2017. The PAC discussed with the Laboratory the formation of a Data Scrutiny Group that will scrutinize the requirements and scientific justification of the experiments' computing resources request to the Laboratory. This effort will be prepared and launched at the Fall 2017 PAC meeting at FNAL.

The PAC heard about the progress of MicroBooNE, the first operating experiment of the SBN program. Much progress has been achieved and early results have been published in terms of understanding the detector performance and the reconstruction framework since the last PAC meeting. The committee and the entire LArTPC community are anticipating with excitement precision physics results from MicroBooNE by the end of 2017 (cross section results) targeting low energy excess analysis for Neutrino18 and beyond. This will also provide important validation of the expected LArTPC performance. The Committee recognizes the hard work of the collaboration and their responsibility as the first large scale LArTPC experiment at Fermilab.

The PAC was especially impressed with the communications and exchanges between MicroBooNE, LArIAT and DUNE, towards valuable *"lessons learned"* that can inform design decisions and accelerate the success of the success of the SBN, ProtoDUNE and DUNE programs. Similarly, the PAC was very pleased by the efforts among the SBN experiments towards a synergistic, coherent and unified physics program starting from the analysis tools used. We are looking forward to hearing from SBN leaders at the next PAC meeting on their progress towards a unified organization for the operations-era to make the best use of the beam and to fully exploit the data from the SBN detectors.

The PAC heard a very informative presentation from LBNC and their review of the Fermilab-based neutrino program with the objective to ensure the success of DUNE and mitigate any risks, be they technology, design, resource, or schedule related. The long discussion of the PAC with the DUNE leadership on the SBN *"lessons learned"* from the DUNE point of view was very useful and prompted the PAC to request an update on technology design decisions, the calibration program and the organizational framework of DUNE after the next LBNC (October 2017) during the next PAC meeting. The PAC notes that the SBN and DUNE leadership are fully cognizant of the success the laboratory and the entire HEP field is expecting of their program.

The next U.S. particle physics community planning process is expected to begin two or three years from now. The global HEP community has started their planning process. Japan is expected to announce their decisions on large scale HEP projects including ILC and HyperK within the next 24 months and the update process of the European Strategy for Particle Physics will be launched in September 2017 and expects to make their plan public in 2020. The PAC discussed the steps the Laboratory and its scientific staff are taking to ensure adequate preparation for this process in the US, especially including and engaging the greater US and International HEP communities, and designing the process and preparation of the physics program planning exercise.

Given the Office of Science Quantum Information Science (QIS) national priority and the HEP/DOE near term and longer term emphasis on new computational and foundational techniques via QIS and the vision of the P5 science drivers exploiting entanglement and QIS technology, the Laboratory presented a survey of areas where they can contribute to the R&D in the QIS program. The Laboratory presented a set of opportunities, most notably in the areas of quantum sensors with applications on searches for new physics in the dark sector and quantum machine learning with applications on optimization problems. Beyond that the Laboratory is exploring foundational QIS areas and highly leveraged small scale quantum computing and networking engineering areas. The PAC took note of the justification of such a program and expressed caution on taking up engineering inspired problems in the QIS areas. The PAC is enthusiastic about the QIS areas strongly coupled to the HEP science drivers and mission. An excellent overview talk on searches for low mass dark matter and hidden sectors using instrumentation based on quantum phases of matter was presented by Kathryn Zurek. The multiple experimental opportunities and synergy with condensed matter physics & material science in building new experiments were underlined in this presentation.

The PAC will review and comment on the very robust and successful ongoing NOvA, LHC/CMS as well as the muon physics program during the Fall 2017 PAC meeting.

The Committee thanks all the presenters for their excellent reports and interesting discussions. We also thank Steve Geer and Hema Ramamoorthi for their flawless support of the PAC meeting. We are grateful to the Sanford Lab and its staff for their hospitality and support of this meeting.

1. Accelerator Prospects for FY18

We ask the committee to review the accelerator run plans and proton allocations for FY18 and comment on the impact on the scientific opportunities if it becomes necessary to significantly reduce the amount of running.

The accelerator division has successfully met FY17 performance goals. They made improvements to the Booster shielding and have been running regularly at and above the NuMI goal of 700 kW. The Accelerator Division is to be commended for this achievement. The Proton Improvement Plan (PIP) is almost complete, incorporating a number of Linac and Booster improvements, with a goal of final completion in FY18.

Beam commissioning to g-2 is underway; currently the Delivery Ring is being bypassed. Some limitations leading to decreased performance will be addressed during the summer 2017 shutdown.

When the g-2 beam line installation and the current set of improvements are complete, the Accelerator Division expects to be in a steady-state mode, capable of operating for more than 10 months/year.

The operations priorities for FY18-24 are to:

- Continue to deliver beam to NOvA at 700+ kW, achieve performance metrics and support the full experimental program
- Operate beam to the g-2 experiment and in FY20 commission the beam for Mu2e.
- Complete the PIP, which will ensure useful operating life of the Linac through 2025 and of the Booster through 2030.
- Develop and execute a further PIP-1+ to increase power to NOvA to ~900 kW prior to PIP-II. This last improvement significantly enhances the competitiveness of NOvA for mass ordering and CP sensitivity in a worldwide context.

The Accelerator Division is not pursuing the new horn system for the BNB.

The PAC endorses these Laboratory priorities. It is the sense of the PAC that beam needs for NOvA are the highest of these priorities. The PAC would like to request an update on the planning and scheduling for PIP-I+ and beyond, as well as the impact on the optimization of the NOvA program in the next PAC meeting.

Impacts of reduced running

Reduction of accelerator running to only three months in FY18 would lead to a highly curtailed program with many problems related to retaining the workforce. The principal users of the beams—notably NOvA, g-2, and the Fermilab Test Beam Facility (FTBF)-- have studied the impact of reduced running. The impact on NOvA would be about 37% less antineutrino running in FY18. This would have serious impacts on the competitiveness of NOvA for their target physics results: it would virtually eliminate the possibility of a 2 sigma mass ordering determination by Neutrino 2018, risk the race for 3 sigma mass ordering with JUNO, and cede the race for 2 sigma and 3 sigma CP-violation results to T2K. The impact on g-2 would be severe, resulting in a full year delay in physics results and possibly cascading impacts to Mu2e and LBNF. The successful FTBF program currently accommodates nearly all requests from a diverse community of users (including non-HEP). Reduced running time would require a down-select of test beam users.

2. SeaQuest

Approved SeaQuest running has now been completed. The achievable beam quality for the experiment has enabled the experiment to exploit about one-third of the delivered beam, and hence record about one-third of the originally anticipated data sample. The SeaQuest / E-1039 (DY with polarized target) are considering requesting future running. We ask the PAC to comment on the SeaQuest/E-1039 status and plans, and on any explicit requests they may have for FY18.

The Fermilab E-906/SeaQuest experiment is part of a series of fixed target Drell-Yan experiments at Fermilab designed to measure the quark and antiquark structure of the nucleon. The approved running has been completed with FY17 using about one third of the delivered protons.

Two SeaQuest extensions, E1039 and P1067, have been proposed. E1039 uses a polarized target in E906 to probe a possible Sivers asymmetry by measuring whether the Drell-Yan yield depends on the target polarization. The proposal has received strong support by a DOE Office of Nuclear Physics (NP) review in Spring 2017. P1067 is a beam dump experiment with the goal to search for dark photons with a sensitivity prospect beyond current bounds. It uses two large scintillator plates around the KTeV magnet which serve as displaced dimuon trigger. P1067 would run parasitically with E1039.

The E906 collaboration expressed the desire for an additional year of data taking. However, E906 recognizes the importance of E1039 and would step aside should E1039 receive the required funding for installation and operation in beam. At this time neither SeaQuest experiment is making a specific request, pending a funding request to DOE NP.

A recommendation by the PAC for SeaQuest and its extensions will be considered at the appropriate time when the SeaQuest collaboration receives funds from DOE NP to support installation and operation.

3. ANNIE

We ask the committee to comment on the proposed ANNIE activities in FY18 and beyond.

The ANNIE experiment has as its goal the characterization of final state neutrons originating from neutrino interactions through their capture in Gd, and measurement of the emitted gamma rays with photosensors. Phase-1 of the experiment that comprised building the majority of the apparatus and using PMTs as photosensors had the goal to demonstrate the capability of vetoing the dominant neutron background. The collaboration concluded that these backgrounds can be reduced to a tolerable level. Phase-2 of the experiment provides the addition of novel Large Area Picosecond Photodetectors (LAPPD) with ~50 ps single photoelectron time resolution and the completion of other parts of the detector. First industrial LAPPD prototypes were delivered and are being tested by the collaboration. Simulation studies suggest the superiority of the LAPPD-based vertex resolution over that using PMTs.

The PAC was impressed with the progress achieved by the collaboration and considers both the physics goals and the technological R&D of high interest. The attractiveness of the experiment is underlined by several new international institutions (including Edinburgh and five German institutions) having joined or seeking to contribute to the experiment.

The resource request to Fermilab for Phase-2 of engineering and operational support being relatively modest, the PAC recommends to support ANNIE beginning in FY18 with Phase-2 physics data-taking expected to start in Fall 2018 contingent to DOE funding.

4. MicroBooNE: Lessons learned & FY18 Running

The initial MicroBooNE request was for 6.6E20 POT. The experiment is also approved for an additional 6.6E20 POT in the "SBN era." It was initially thought that this additional running would be coincident with the other SBN-experiment running. However, the BNB has performed sufficiently well to enable the initial request to be completed ahead of schedule. MicroBooNE is requesting continued running beyond the initial 6.6E20 POT in FY18. We ask the committee to comment on the MicroBooNE plan for FY18 and beyond keeping in mind the goals of the experiment.

The PAC congratulates MicroBooNE on its continued progress as the vanguard of the LArTPC effort. We were pleased to see the release of detailed public technical notes describing operational experience, calibration methods, and analysis methods.

At the start of FY18, the collaboration has accumulated 6.1E20 POT (6.8E20 were delivered) and is expected to accrue a total of approximately 9E20 POT by the end of FY18. The collaboration is expected to profit significantly from data beyond the original allotment. As the experiment matured, the quality of the data improved. The cosmic ray tagger system (a notable international contribution by Bern) was also only recently installed; accruing a larger data set that can profit from it is also valuable. For these reasons, the PAC recommends continued running in FY18 beyond the initial 6.6E20.

The PAC notes that when the second 6.6E20 was approved it was assumed that the data would be taken concurrently with ICARUS running and that there would be sufficient resources to execute the SBN program. However, MicroBooNE is requesting the *"6.6E20 SBN era"* to start early and the Laboratory is reassessing the resources needed for the SBN program. At this point, there is not enough information available to decide on running MicroBooNE in FY19 before the start of the SBN program, which is expected early in CY19 when ICARUS begins taking data. Such a decision will depend on understanding the impact of more data on the MicroBooNE physics goals. The PAC needs to be convinced about the ultimate performance of MicroBooNE. In particular, the committee would like to understand in more detail the staging of the physics results, calibration results, and the impact of the detector performance on MicroBooNE's ability to definitively address the low-energy excess measured by MiniBooNE, as reported by the MicroBooNE collaboration at this meeting.

We ask the committee to comment on the lessons learned from MicroBooNE to date and the plans to ensure effective utilization of the experience gained, keeping in mind that one of the motivations for the MicroBooNE experiment is to provide experience and information that will help prepare for the LBNF/DUNE era.

As mentioned above, we would like to commend the MicroBooNE collaboration for producing detailed public technical notes to document their experience. In addition, MicroBooNE has provided invaluable information about the challenges and successes of making measurements with an LArTPC. The recent "Joint DUNE/SBN Lessons Learned'' workshop was very successful, providing a forum for discussing the problems experienced and the solutions found by the currently operating FNAL LArTPC detectors. Among the critical areas identified were problems with electronics noise and performance, and the important role played by in situ calibrations.

MicroBooNE's electronics noise issues fell into three categories: 10 kHz noise from voltage regulators, 36 kHz high voltage ripple noise, and a "burst'' noise source whose origin has not yet been identified. The first two noise sources were initially mitigated with software solutions, and were ultimately fixed with small hardware upgrades that were in place in 2016. The third noise source does not appear to affect their physics program given that it is above the bandwidth of their nominal 2 microsecond shaping time. Excluding these sources of pickup noise, however, the noise levels in the cold for MicroBooNE are excellent. The electronics noise issues at the 35 T prototype were more severe and did compromise its measurement program, although clever software mitigation strategies were developed that allowed some analyses - timing offsets, external counter positions, electron lifetime - to be performed, albeit at low precision. Not all sources of noise in the 35T have been identified and understood.

The in situ calibration analyses in MicroBooNE have made very good progress in measuring electron lifetime and dealing with the difficult problem of space charge. The covariance of these two issues proved to be a particularly difficult problem that has now been understood, although differences between the measurement of space charge spatial distortions and predictions of these effects based on calculations still need to be tracked down. The PAC looks forward to seeing very soon the results of the laser calibration system and whether measurements done with it will provide better agreement with the calculations. Measurements of recombination are in progress, and it will be interesting to see if MicroBooNE's measurement of recombination parameters will be in agreement with earlier measurements by ICARUS. If these parameters are universal, then it will greatly simplify the calibration program for the DUNE far detector. Measurements of diffusion are also ongoing but very challenging, as they depend on many other things, including the electronics front-end response. The importance of both external counters and the laser system for understanding and testing the detector response were highlighted in the workshop.

It is the sense of the PAC that workshops open to all scientists operating LArTPCs should continue on a regular basis. The next such workshop should include the presentation of precision cross section measurements currently being pursued by the MicroBooNE Collaboration. These will, for example, inform the analysis and calibration needs of DUNE.

5. SBN Update

We ask the PAC to comment on the status of preparations for the SBN program.

The committee would like to thank the SBN coordinator for the detailed update on the SBN program. We congratulate the Laboratory on the rapid progress on preparing the conventional facilities, including the completion of the SBND and ICARUS buildings. We also eagerly anticipate the upcoming arrival of the ICARUS detector on the Fermilab site.

The committee also heard about cost issues that may result in delays relative to the technically driven schedule, leading to an approximately one-year delay in the start of SBND (FY21). The committee is concerned about this delay since it increases the overlap of the SBN program and DUNE construction, exacerbating the potential conflict for resources at a critical time for DUNE. At the same time, the SBND schedule continues to appear aggressive. We encourage the laboratory to explore options, including redirecting or finding additional resources, to maintain the technically driven schedule.

As the operational phase for the SBN near- and far-detectors draws closer it is important that the three SBN Collaborations develop the tools and operations era organization to make the best use of the beam and to fully exploit the data from the three detectors including a unified oscillation analysis. We ask the committee to comment on the plans to accomplish this, the synergies among the experiments and the progress to date.

The PAC was very pleased to hear the substantial progress in coordinating the operations and analyses efforts across the SBN Collaborations. In addition to workshops, regular meetings are now being held involving all three collaborations, with software tools and analysis strategies being incorporated into a single framework. The PAC views these developments as essential to the timely production of robust results from the SBN program. We encourage the SBN Collaborations to continue this process in consultation with the LBNC, identifying milestones and benchmarks, and defining the analysis organization in advance of the start of operations. We also encourage the SBN Collaborations to carefully consider protocols for releasing and publishing oscillation results and other analyses that would involve a joint effort across the SBN program, and to formalize those protocols in a Memorandum of Understanding co-signed by the SBN Collaborations.

6. LBNC/DUNE

The LBNC reviews progress and gives advice on LBNF and DUNE. We ask the PAC to comment on recent progress. The near-term Fermilab neutrino program in general, and the SBN experiments in particular, are expected to help inform decisions that affect the preparations for the DUNE era. We ask the committee to comment on the process of identifying the important lessons from the SBN experiments and using these lessons to benefit the future program.

The PAC heard a report from the LBNC on both the status of LBNF and DUNE, and its comments and recommendations from two recent reviews (March and June 2017). LBNF is well positioned to start underground construction within the approved CD-3A scope, once FY17 authorized funding is made available at Fermilab. The ProtoDUNE effort is advancing well, with significant progress at CERN on construction of the two cryostats. The PAC agrees with the LBNC recommendations, including the need to formulate a comprehensive test plan and reserve sufficient schedule time for cryogenic operations of the ProtoDUNE cryostats as large-scale engineering prototypes for the full DUNE far detector cryostats.

DUNE stated that ProtoDUNE-SP will not likely serve as an engineering demonstration, at least initially, for the single phase electronic readout system. This is unfortunate since such a test is clearly essential to demonstrate the performance and reliability of the engineering solution. The PAC fully supports the request by the LBNC for a comprehensive strategy, which makes provision for an extensive test program, by October 2017. The PAC views the state of the single phase electronics to be a critical risk for the future of the far detector, which will require the collaboration to identify strong leadership to resolve. The new electronics consortium management should be empowered to make decisions as required for rapid turnaround of this system. The PAC expects that, at the time of the TDR review, the LBNC will closely scrutinize the leadership of the detector consortia, the depth and experience of the institutional partners, and their ability to deal with identified project risks. DUNE will want to ensure that consortia will meet this high standard to avoid late surprises.

The PAC requests that the LBNC continue to monitor closely the development of an overall strategy for the readout electronics, including any cold elements, for the single phase far detector TPC, as well as plans for a large-scale validation test if this should prove not possible, at least initially, in ProtoDUNE-SP. The LBNC should report back at the next PAC meeting on the proposed strategy adopted by DUNE and its analysis of the planned solution(s). There may be an opportunity to demonstrate the viability of at least one of the alternative electronics strategies, e.g. use of a commercial ADC in the cold, in conjunction with the pending SBND decision on electronics implementation, so the LBNC and Fermilab management should monitor the SBND electronics task force and its recommendations with this possible synergy in mind.

The PAC heard reports from a recent joint lessons learned workshop between DUNE and MicroBooNE. This is a very welcome development, which provided significant operational experience from MicroBooNE, including calibration systems, and should be incorporated in DUNE planning for the far detector design and, to the extent possible, the ProtoDUNE-SP design and the program goals.

The PAC further requests that the LBNC monitor closely the development of an overall strategy for: i) calibration of the DUNE far detector TPCs ii) incorporating lessons learned from MicroBooNE and other currently operating relevant LAr TPCs. The PAC requests that the LBNC reviews the stated goals for the ProtoDUNE program, with an eye to the flow down from physics to technical requirements (specific liquid argon purity level; HV operating level and stability; tolerance on wire tension and breakage rate; allowed fraction of dead channels and failure rate; noise level for electronic channels; calibration) to ensure a reliable, stable and attainable (based on previous LAr TPCs) operational parameter space for physics production. In particular, the PAC notes that the quantitative requirements defining the milestones for the ProtoDUNE-SP program as defined in DUNE-DOC-1675 be made tighter, as specific as possible, and conforming to attainable standards.

Recently, the 1x1x3 dual phase prototype (WA105) began operations and has recorded first cosmic ray tracks, in an important first demonstration of this technology. Based on further experience with this prototype, a similar set of specific goals and parameters should be developed for ProtoDUNE-DP.

7. Snowmass/P5 planning exercise preparation

The next U.S. particle physics community planning process is expected to begin two or three years from now. The committee is asked to review the steps the Laboratory is taking and on steps the Laboratory should take to ensure adequate preparation for this process, including engaging the Fermilab *community and the greater HEP community, and establishing and communicating what has to happen and when.*

The Laboratory described an internal process for engaging the Fermilab science community in long-range planning. Given the upcoming plans for a new Snowmass study followed by a P5 panel report, Fermilab is considering the relationship between the larger HEP community planning process and these internal discussions. It may well be that the effectiveness of the Snowmass process would be enhanced by some targeted study by segments of the HEP community, particularly for new ideas. The PAC suggests that Fermilab, in consultation with the DPF leadership and potentially the other HEP laboratories, help formulate a strategy to identify suitable preparatory workshops and new topics that might benefit from such preparatory study in advance of Snowmass itself. An analysis of the last Snowmass process in consultation with the leaders of that effort should be undertaken to identify ways in which improvements can be made to best prepare this time around. In particular, the role of preparatory studies and white papers should be identified.

8. Quantum Information Science

There are Fermilab scientist efforts on developing / exploiting quantum systems for future particle physics and particle-astrophysics experiments. We ask the committee to review these efforts to date and comment on the appropriateness and strategy for engaging in this new area.

The PAC was informed about the ongoing and proposed Fermilab plan in the general area of quantum information science, which focuses broadly on quantum sensors and quantum computing and communication. More specifically, the proposed activity is in the areas of: i) Quantum sensors ii) Superconducting technology iii) HEP applications for near-term quantum computing and iv) Quantum networks. The Lab recognizes that while it has not had traditionally leadership role in the past, it has the potential to work toward maximizing the impact on HEP science in the near and longer term. The Fermilab planning and implementation effort is valuable in that it will provide useful information to the wider HEP community and use and develop new collaborations with academia, government Labs, and industry. Development of this technology in the service of the primary Fermilab HEP mission makes sense.

It is the sense of the PAC that the effort in quantum sensors -- with associated work in superconducting technology -- is extremely well-motivated and with high-impact science possibilities on a relatively short timescale and without high cost margins. Focus areas include direct (low-mass) dark matter experiments, including axion searches. In particular, this was seen as an attractive area for innovative scientists to make their mark, and therefore particularly attractive for the younger HEP generation. The PAC noted, however, that this program needs to be managed such that it does not become too diffuse (in a way that may not be consistent with a national laboratory effort).

It is hard to predict at what point quantum computing applications will be able to broadly impact HEP science. It is likely, but not certain, that quantum simulation applications in, e.g., quantum chemistry, will reach maturity at an earlier stage, perhaps within the next decade. Nevertheless, it is the sense of the PAC that work on possible HEP-relevant applications in quantum algorithms (including machine learning and optimization) should be encouraged.

Quantum networks fall at a somewhat later stage of the quantum technology development roadmap as relevant to HEP science. The PAC recommended caution in pursuing this direction beyond an engagement that uses only a minimal level of laboratory resources.

Overall, the PAC was enthusiastic about the quantum sensor initiative and the use of LDRD and private funding in promoting this effort. This area is of central importance to HEP and is a natural first target for the broader QIS initiative at Fermilab. The other areas were not considered mature enough at this stage for the PAC to provide more specific feedback other than what has been mentioned above.