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December 12, 2016

Dr. Cherry Murray
Director, Office of Science
U.S. Department of Energy

Dear Dr. Murray:

The Report of the Committee of Visitors to the High Energy Physics Advisory Panel was presented at HEPAP's meeting on December 1st and 2nd, 2016. This Committee of Visitors reviewed the fiscal years 2013, 2014, and 2015. HEPAP discussed the Report extensively following its presentation, made some changes in wording or details of the recommendations, and approved the Report.

The CoV found that the award process followed by the Office of High Energy Physics (HEP) and the leadership of HEP management have resulted in a broad, strong particle physics portfolio. HEP has managed to balance the many aspects of the program within challenging budget constraints. The project portfolio is of appropriate depth and uniqueness, and the program as a whole has many world-leading capabilities in experimental and theoretical research. HEP has moved the U.S. particle physics program toward the goals set out in HEPAP's 2014 P5 Report. A number of important new projects have been launched during this period, and HEP is forging strong international partnerships on the large projects. The COV commended HEP for the quick, successful formation of the international DUNE/LBNF collaboration and the rapid progress on the international neutrino program hosted at Fermilab. It commended HEP as well for the organized progress on the LHC detector upgrades.

Nonetheless, a recurrent theme in the HEPAP discussion was the health of the Research Program, which has experienced programmatic reductions in funding in order to increase the fraction of the HEP budget invested in projects. This shift in funding was recommended by the 2014 P5 subpanel, as well as the 2013 COV, as particle physics builds for the future. The project fraction has by FY16 climbed to 24%, near the upper end of P5's target range of 20-25% as noted by the COV, and at the same time the research fraction has fallen to 41%, barely above the P5 guideline of $> 40\%$. The cumulative reductions to the budget of the Research Program (not including Early Career Awards) are large, 21% over the last five years (2011-2016). Theory research, Energy Frontier research, and Advanced Technology R&D experienced cuts of 24%, 32%, and 36%, respectively.

HEPAP is extremely concerned regarding the health and vitality of the Research Program at this time. It is concerned that current funding levels are inadequate for each of the subprograms of the Research Program to realize the full scientific potential of the field's facilities, experiments, and scientists. It is concerned about the capability of the research communities in the experimental frontiers to operate and fully harvest the physics potential of new projects. It is concerned about the capability of the theory community to identify new directions for the field and to support the experimental program. It is concerned about the capability of the advanced technology R&D community, particularly in accelerator R&D, to discover and develop the advances that will enable the field's next-generation accelerators and experiments. HEPAP is concerned that further reduction in funding will do lasting damage to the field, particularly in the field's ability to train young scientists for careers in particle physics or elsewhere in science and technology.

HEPAP recognizes the very constrained funding environment of HEP; nevertheless, it advises that further reductions in funding for the Research Program be a last resort as the field's projects are constructed. HEPAP emphasizes the strong scientific potential of the P5 report and urges that funding be found to support its full strategic vision, keeping construction of HEP's projects on track, efficiently operating existing and new facilities, and sustaining the vitality of the research community in order that it is capable of fully realizing the scientific potential of the HEP program.

HEPAP submits to you the Report of the Committee of Visitors.

Respectfully yours, on behalf of HEPAP,

Andrew J. Lankford
Chair, High Energy Physics Advisory Panel

Cc: Steven Binkley, Deputy Director for Science Programs, Office of Science
James Siegrist, Associate Director for Science of High Energy Physics
Glen Crawford, Director, Research & Technology Division, Office of High Energy Physics
Michael Procario, Director, Facilities Division, Office of High Energy Physics

Report of the Committee of Visitors

Office of High Energy Physics

to the
High Energy Physics Advisory Panel

Review of Fiscal Years 2013, 2014, 2015

Germantown, Maryland
September 26-29, 2016

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Executive Summary

A review of the DOE Office of High Energy Physics (HEP) for the fiscal years 2013-2015 was conducted on September 27-29, 2016 by a Committee of Visitors (CoV) convened by the High Energy Physics Advisory Panel (HEPAP). Overall, the CoV finds that HEP follows effective processes regarding proposal actions and monitoring. The award process and the leadership of HEP management have resulted in a broad particle physics portfolio which is of appropriate depth and uniqueness and which has many world-leading capabilities in experimental and theoretical research.

During the three-year period covered by this CoV review, the comparative review process of the HEP Research Program has successfully completed a full cycle. The review process supports an outstanding set of physics research programs in theory, along with the energy, cosmic, and intensity frontiers and an accelerator R&D program that is world-leading in several aspects. The review process, with its comparative nature, is an effective tool towards achieving optimal research programs within tightly constrained budgets.

Recommendation 1: Continue the comparative reviews of university and laboratory research proposals and activities.

HEP has done a very good job moving the U.S. particle physics program toward the goals set out in HEPAP's 2014 P5 Report, which was released in the middle of the review period. A number of important new projects have been launched during this period, and funding for project construction has recently reached the upper end of the P5 target of 20-25% of overall HEP funding. Funding for the Research Program has been kept above the recommended 40% threshold, but only barely. HEP strategic planning within realistic budget guidance will require careful consideration in order to establish and maintain the optimal balance among the three main lines of HEP funding: Project construction, Research Program including R&D, and Operations.

Although the P5 report established very useful overall guidance of the program and HEP has managed the program well within that framework, changing conditions will mean that, as time goes on, some corrections will become necessary. It will be constructive for HEP to seek advice from HEPAP while defining these tactical corrections.

Recommendation 2: Adopt, in consultation with HEPAP, an annual mechanism to determine the best plan of action to implement the P5 vision. In such cases where HEP deviates from the strategic advice, the case should be clearly explained to the community through discussion with HEPAP.

Operations funding has also been squeezed by increases in funding for new projects. The CoV anticipates that stresses on the operations budget will build as existing projects are completed

and go into operation. Not only will new projects add to operations funding needs, additional longer term needs will arise from the HL-LHC and LBNF/DUNE programs. Reaping the maximum scientific payoffs from these newly launched projects will also require maintaining healthy research program funding across all HEP frontiers. Increased emphasis will need to be placed on timely planning for the transition from projects and upgrades to operations.

Recommendation 3: Work closely with the Laboratories and with Project Management and Program Management teams to develop a comprehensive strategic plan, consistent with P5 guidance, that anticipates the needs for future operating funds that will arise from improvement, upgrade and MIE projects. The plan should account for the funding needs not only of accelerator and experimental operations, but also of software, computing, and technical support for the new experimental programs. Develop a similar comprehensive plan for future research program needs, once again taking into account the need for research efforts to maximize the scientific return on improved, upgraded, and new facilities and experiments.

Table of Contents

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1. Introduction

This report documents the findings from a Committee of Visitors (CoV) that was charged by the High Energy Physics Advisory Panel (HEPAP) to evaluate the processes and programs in the Office of High Energy Physics (HEP). The CoV met at the Department of Energy facilities in Germantown, Maryland, for three days on September 27-29, 2016. This was the fifth in the series of Office of High Energy Physics CoV triennial reviews; the first held in April 2004, with subsequent reviews in 2007, 2010, and 2013.

2. The Charge to the Committee of Visitors

The charge to the CoV was established in a letter from Andrew Lankford, HEPAP chair, to Sally Dawson, CoV chair. The letter is attached as Appendix I. The CoV was charged to address the operations of HEP during the fiscal years 2013, 2014, 2015. Specific areas to be considered by separate subpanels were:

1. Energy Frontier Experiment
2. Intensity Frontier Experiment
3. Cosmic Frontier Experiment
4. Theory
5. Accelerator R&D
6. Facility Operations
7. Projects

HEP management of computing and detector R&D was reviewed through cross-cutting groups described below.

The CoV was asked to focus on the following major elements: (i) For both the DOE laboratory projects (Field Work Proposals, FWPs) and grants program, assess the efficacy and quality of the process used to solicit, review, recommend, and document proposal actions and to monitor active projects and programs. (ii) Within the boundaries defined by the DOE missions and available funding, comment on how the award process has affected the breadth and depth of portfolio elements, and the national and international standing of the portfolio elements.

3. The Committee Membership

The CoV membership was selected by the CoV chair, Dr. Sally Dawson, in consultation with the chair of HEPAP and the upper levels of HEP management. The members were chosen to represent a cross-section of experts in scientific fields relevant to the activities supported by the Office of

High Energy Physics. A balance was achieved between researchers who currently receive funding from HEP and those that do not, among academic and national laboratory researchers, and between those that have previously served on a CoV and those that have not.

Given the size of the office and the breadth of programmatic areas, a sizable committee was assembled. The CoV consisted of a total of 34 members, plus the chair and was divided among seven subpanels for the reading of the grant and FWP folders.

The following CoV members served as the leaders for the subpanels: Drew Baden (Energy Frontier), Jack Ritchie (Intensity Frontier), Rachel Bean (Cosmic Frontier), Lance Dixon (Theory), Stuart Henderson (Accelerator R&D), Edward O'Brien (Facilities Operations), and Gary Sanders (Projects).

In addition, four cross groups were formed to look at issues common to multiple subpanels: P5 alignment (chaired by Rick van Kooten), the comparative review process (Paul Grannis), detector R&D (William Trischuk) and computing (Lothar Bauerdick). All other CoV members had a secondary assignment to a cross group.

A full listing of the CoV members, their subpanel assignments, and their cross group assignments are given in Appendix II and Appendix III, respectively.

4. The Review Process

The CoV assembled in Germantown at 8:30 AM on Tuesday, September 27, and adjourned at 3:30 PM on Thursday, September 29. The agenda for the review is attached as Appendix IV.

Prior to convening in Germantown, each CoV member was supplied with the link to the HEP CoV website that included a comprehensive set of information pertaining to: the CoV process, the core research activities, the procedures used by HEP in reviewing both university and national laboratory applications, a copy of the 2013 HEP CoV report together with the response from HEP, and the report template. This comprehensive documentation was found to be useful in setting the stage for the actual review and enabled the panel members to be prepared for the review. Additional information was also supplied to each member during the meeting of the CoV review. The CoV website also included copies of the plenary presentations, a more detailed overview of each of the HEP programs, and a summary of the EPSCoR program.

The CoV review began with a reiteration of the charge from the CoV Chair Dr. Sally Dawson. This was followed by an overview of the Research and Technology Division by Dr. Glen Crawford, and an overview of Operations and Projects by Dr. Michael Procario. The program managers also gave talks on the status of their program areas and specific issues. The CoV members were then presented with details of the overall review process by the CoV Chair, Dr. Sally Dawson, before adjourning to their subpanel break-out rooms.

Five subpanels were supplied with hard copy sets of proposal folders to evaluate the Research and Technology Division award/decline/monitor process. For grants, these proposals were distributed among four types of programmatic decisions: easy awards, easy declines, difficult awards, and difficult declines, with a total of more than 10 proposals per panel. In general, the number of proposals reviewed reflected the budget and numbers of applications for the subprograms. The subpanels were free to request any additional materials (including folders for other proposals) and information that they felt would help them in their evaluation process.

The first reading of folders occupied the remainder of the first day with the subpanels preparing preliminary conclusions that were discussed with the CoV Chair, and shared with the HEP management. Informal discussion and documentation continued well into the evening.

During the morning of the second day, the subpanels met again to discuss findings. At mid-day, the cross groups met to discuss general issues that were common to the subpanels. During the afternoon of the second day, the members of each subpanel reconvened with the subpanel leads to merge and finalize the findings and to prepare materials for the final report. The entire CoV then met in executive session to discuss and reach consensus on the major findings and recommendations. This discussion continued during the morning of the third day.

On the afternoon of the third day the CoV Chair and CoV panel met and presented the major findings and recommendations to HEP management, and then to all HEP staff.

The written reports from the panels (Appendices V - XI) and the conclusions and recommendations drawn from the executive sessions provided the basis for this report.

5. General Findings of the CoV

The findings and recommendations of the subpanels are contained in a series of Appendices. This section contains findings that are relevant across subpanel boundaries. Many of the findings of the subpanels are contained in Section 5, as they were more generally relevant than just the individual subpanels.

5.1 P5 Alignment

Findings: In general, HEP has made a concerted effort to follow the project-specific, program-wide, and research-enabling recommendations from P5. The points of departure from the P5 recommendations have been in the areas of accelerator R&D and in not allowing for the adequate support of small projects.

P5 recommendation #4 states, “Maintain a program of projects of all scales, from the largest international projects to mid- and small-scale projects.” When funding is tight, small-scale pro-

jects tend to be squeezed out. Although the Intensity Frontier did have a call for funding for small to mid-sized short baseline neutrino projects, there were still difficulties in funding appropriate small projects over the CoV period.

Shortly after the P5 report was released, there were significant reductions in the accelerator R&D funding through the GARD (General Accelerator R&D) program, including cuts to superconducting RF R&D. There was a net funding reduction of accelerator R&D of approximately 10% overall over the CoV period, including a reduction in university-based accelerator R&D of about 25%. The latter does not align well with P5 recommendation #23: "Support the discipline of accelerator science through advanced accelerator facilities and through funding for university programs."

After the P5 report was released a HEPAP subpanel provided detailed guidance on the implementation of accelerator R&D to provide alignment with P5 priorities and to assess and identify the most promising research areas for the GARD program. HEP is working towards following the recommendations of the accelerator R&D report, although deferring action on some of the recommendations, pending formation of road maps and availability of funding.

FACET-II was approved, although the April 2015 report of the HEPAP subcommittee on Accelerator R&D recommended that it be approved only in the scenario of dedicated opportunity-inspired funding ("Scenario C"). Approval was made in response to enthusiasm of the Office of Science and at the highest levels of DOE and because the only window of opportunity for installation of FACET-II is during LCLS-II construction.

Comments: The decision to construct FACET-II was not in agreement with the recommendations of the P5 subpanel. In such cases where HEP deviates from the strategic advice, the case should be clearly explained to the community through discussion with HEPAP.

HEP is commended for aligning the particle physics program with the recommendations of the P5 report and reasonably maintaining the priorities of the report. We are particularly pleased that the formation of the international DUNE/LBNF collaboration has been successful so quickly, achieving a major goal in the steps towards the Fermilab beam-based long baseline neutrino program, as well as the organized progress on the LHC detector upgrades as being the top-priority large project in the near term. However, funding for the Energy Frontier research program has consistently decreased at a slow rate while research program funding for the Intensity and Cosmic frontiers has remained flat or increased only slightly. There is also concern about obtaining a level of adequate funding for accelerator R&D in the future and further concern that adequate funds for the support of well-justified small projects are not being allocated.

The P5 report states, "A thriving theory program is essential for both identifying new directions for the field and supporting the current experimental program." As detailed in the Theory panel's report, the continued reduction in funding for the theory program and the large loss of

funded PI's results in a program that is difficult to characterize as "thriving", which will very likely have a negative impact on the P5 program.

Findings: There are three P5 program-wide recommendations related to the fraction of budget allocated to research programs:

> P5 Recommendation #5**:** Increase the budget fraction invested in construction of projects to the 20%–25% range. To limit reductions in research program funding, P5 adopted a guideline that its budget fraction should be >40% in the budget planning exercises. The three main budget categories are project construction, the research program, and operations.
>
> P5 Recommendation #7: Any further reduction in the level of effort for research should be planned with care, including assessment of potential damage in addition to alignment with the P5 vision.
>
> P5 Recommendation #8: As with the research program and construction projects, facility and laboratory operations budgets should be evaluated to ensure alignment with the P5 vision.

During the CoV period, the fraction of the budget allocated to the research program has fallen steadily and that allocated to project construction increased steadily, and these trends have continued to the current time such that the FY17 President's budget has research programs at 40% and project construction at 25% of the total budget. These are within the P5 target range, but are now at the maximum of the project fraction range and at the minimum of the research fraction range.

Comments: There are concerns that this will likely continue in the future, with the fraction for the research program area falling below 40%. These trends will be exacerbated by a sizeable component of the DUNE/LBNF project (underground excavation) being moved up in time by approximately two years and the approval of FACET-II.

The implementation of the strategic plan of recommendation 3 requires close attention to the P5 plan.

Finding: P5 considered three funding scenarios:

- Scenario A: Flat for three years from the 2013 budget and then 2% increase per year.
- Scenario B: Flat for three years from the 2014 budget request and then 3% increase per year.
- Scenario C: unconstrained.

HEP is currently at a level of funding just above the flat level of Scenario B.

Comments: Although the level of funding to execute the P5 program is currently reasonable, it relies on consistent budget increases in following years. If funding does not increase at least with inflation over many years, or other such scenarios falling below Scenario A in later years, there are questions as to how the P5 program can be effectively implemented. This leads to recommendation 2 in the Executive Summary.

Finding: The document provided to the COV indicating researchers who transitioned or straddled frontiers provides useful information.

Comments: Critical input for strategic planning for implementation of P5 projects includes estimates and profiles of FTE involvement in each project and frontier.

Improved tracking and projection of FTEs among projects and frontiers to include estimates of future movements and numbers will be important to profile effort and ensure adequate FTEs for implementing P5 projects.

Comment: Transparency is very important, especially in eras where budgets are stressed. It is important that funding be consistent with P5 priorities. It is understood that there are many factors that contribute to the final yearly expenditures for the different frontier research budgets. We could not, however, understand the rationale for the distribution of the reserves among the frontiers.

Recommendation 4: Augment discussion with HEPAP of budgets by annually presenting the disposition of reserves and explaining how the final HEP allocations to the research programs of the frontiers are consistent with P5 recommendations.

5.2 Comparative Review Process

Finding: The comparative reviews of university grant proposals and laboratory research efforts were instituted in 2012 and 2013 respectively, supplementing the more traditional mail-in reviews. By the end of the current CoV review period, such reviews have been held for the Energy, Intensity and Cosmic Frontiers, Theory, and Accelerator R&D. This full cycle of reviews offers a good opportunity to assess the utility of the comparative review process.

Comment: The comparative review process is an improvement over previous mail-in only reviews. It has matured and is operating well. The process provides reliable guidance to program managers. Solicitations (FOAs) are clearly written, and HEP has made efforts (e.g. PI meetings) to educate PIs about the comparative review process. The reviews serve to identify the best science for meeting HEP program goals. Mail-in reviews remain essential inputs to the comparative review process. This leads to recommendation 1 in the Executive Summary.

Finding: During the CoV review period, 50 proposals requested funding for work in frontiers not previously part of a group's activity.

Comment: Given the nature of the comparative reviews focused on a single frontier, judgments of the quality of work done by proponents in a different frontier may be difficult to make. Panels reviewing proposals that seek funding in a new frontier would benefit from information about previous accomplishments of the proponents.

Comment: Although the CoV discussed the possibility of a new layer of cross-frontier comparative reviews (as is done for Early Career awards), the needs of the different frontiers are quite different and this extra layer would be difficult to manage, so we do not advocate this addition.

Recommendation 5: HEP should work to reduce barriers to migration of researchers from one frontier to another.

Finding: Some laboratory comparative review reports took more than a year after the review to be released.

Comment: These reports are directed to lab management. In order to be useful they should be completed in a more timely manner.

Recommendation 6: Deliver laboratory comparative review reports no later than six months after the review is held.

Finding: The comparative reviews of university proposals and laboratory research activity differ considerably. In the case of the university proposals, comparisons are made among all proposals in a frontier for the given year. For the laboratory reviews, evaluations are made of individual researchers but comparisons across laboratories and with universities are not generally made. Such variations in reviewing stem in large part from the differences in the impact of negative reviews and in the roles and responsibilities in the HEP program between laboratories and universities.

Comment: Although the CoV does not recommend direct comparative review of university and laboratory research personnel, it does feel that some comparison and cross calibration would be useful.

Recommendation 7: Appoint members of recent university panels to the laboratory comparative review panels in each program area in order to help gauge the uniformity of quality between laboratory and university research.

Finding: The comparative reviews of experimentalists at the labs are not at the same level of detail as theorists at the labs and experimentalists at universities.

Comment: This is a complex and difficult issue, and the metrics for evaluating lab scientists must be developed in a way that recognizes their operational and service responsibilities, in addition to their research.

Recommendation 8: Encourage HEPAP to form a study group to consider whether the agencies should convene a subpanel to evaluate different roles and responsibilities in university and laboratory research, and the ways in which this research is evaluated.

Comment: To give a balanced view of each proposal, we feel that at least three, preferably four, reviews should be obtained for each PI (e.g., two mail-in and at least two panel reviews). The community should be urged to take such review functions seriously. The recently established sessions with PIs may be a useful place to communicate this.

Recommendation 9: Ensure an adequate number (at least 3) of reviewers for each PI.

Comment: DOE program managers often consult with project leaders, experiment spokespersons and other managers of programs in the field.

Recommendation 10: Inform review panels about relevant information obtained by DOE program managers concerning project operational or infrastructure responsibilities and experiment leadership roles.

Comment: Good documentation of all elements leading to a program manager's decision is essential, both for CoV review and when changes are made in HEP program managers.

Recommendation 11: Include more information about why proposals were declined in both the declination letters and the folders.

Finding: Some declined proposals are resubmitted several times with minimal change in proposed activities.

Comment: Acting upon resubmitted weak proposals can require considerable attention from program managers and from peer reviewers.

Comment: A one-page description of how the resubmitted proposal differs from the original could facilitate this process.

Recommendation 12: Seek ways to mitigate the load arising from repeated submissions of rejected proposals.

Comment: Early Career Awards are a very important part of the HEP program, funding the top young PIs. It is important to ensure that they are properly and carefully reviewed, which can be challenging since the Early Career Awards include all research areas. It is often difficult to form a single "super-panel" with all the necessary expertise.

Recommendation 13: Form mini-panels to review Early Career proposals in related fields. At least one member from each mini-panel should be a member of the larger super-panel deciding Early Career Awards

Finding: Undergraduate institutions with small research portfolios have a difficult time getting good reviews and funding.

Comment: Proposals submitted by undergraduate research institutions are at a disadvantage when directly competing with proposals submitted by research-intensive institutions. There is a case for support of such proposals, which would also benefit diversity and outreach.

Recommendation 14: Ensure that the review process recognizes the potential contributions to the DOE mission from qualified applicants at a wide range of institutions, including non-Ph.D. granting colleges.

Finding: The CoV experimental frontier subpanels separately discussed many of the same issues. The comparative review process was very similar across the three frontiers. Several of the requests for information to the HEP staff were similar.

Comment: A common CoV discussion of many issues related to the experimental frontiers is desirable. The present CoV subpanels are stove-piped into separate frontiers, thus necessitating the cross groups, often conducting parallel discussions of common issues.

Viewing proposals by the CoV across frontiers will help to gauge the uniformity in the quality of different sectors of the program.

Recommendation 15: Change the organization of future CoVs to amalgamate the review of the three experimental frontiers into one subpanel that is smaller than the sum of the three current subpanels.

Comment: Some time will need to be devoted to specific topics pertinent to each specific frontier in an amalgamated CoV review of the experimental frontiers.

5.3 General Detector R&D

The unique detector R&D and test beam facilities supported by HEP (KA25) at the national labs are crucial to the HEP program and its future.

Findings: Funding to support the R&D facilities at the labs represents a relatively high funding floor. Given the budget pressures in HEP, the detector R&D (KA25) budget has shrunk by 25%, significantly more than the overall HEP budget. Thus, the 25% reduction in funding in this area, over the last two years, represents an almost 1/3 reduction in ongoing generic detector R&D.

Detector R&D funding, during the period of interest to this CoV, has been focused on high priority P5 projects as suggested in P5 recommendation #27. In FY2014 $3M of KA25 funds were shifted to FNAL short baseline neutrino operations: a natural outcome of the liquid argon neutrino detector R&D that preceded it. Further, the LHC detector upgrades and dark matter detector R&D have been advanced, through KA25 funding, to the point where projects are now being launched to build final detectors for their respective experiments. HEP is considering how to foster collaboration between labs and universities to optimize detector R&D across the program as mandated by P5 recommendation #28.

Comments: Generic detector R&D underpins all future HEP experiments. P5 recommendation #27 also called for a return to a more balanced mix of long-term detector R&D and short-term R&D when the technical challenges of current high-priority projects are met. This return has not yet begun. Examples of longer term R&D that will enable future experiments include reducing the material and power needs for silicon trackers for future energy frontier experiments and larger collection area silicon photomultipliers for dark matter experiments.

Recommendation 16: Restore a balanced generic detector R&D program as soon as possible after the technical challenges of current high-priority P5 projects are met.

Findings: HEP hired a new R&D program manager late in the period of interest to the CoV. Detector R&D efforts at labs, supported by the KA25 budget, were the subject of a dedicated comparative review in early 2016, but the result of that review is beyond the scope of the current CoV. The KA25 budget also supports university-based detector R&D through FOAs that are typically oversubscribed by a factor of three.

Comments: We note that projects often support (and fund) final detector R&D phases before construction. For example, the Mu2e project conducted $8.2M of detector R&D in areas such as tracking, calorimetry, cosmic ray veto, and trigger/DAQ. Other examples include CDMS with ~$3M of Other Project Cost investments. Collecting this information systematically would provide a more complete picture of the detector R&D that is supported by the HEP program.

Recommendation 17: Work with the high energy physics community to generate a roadmap for investments in detector R&D based on future research needs of the field.

5.4 Computing

Findings: Computing and software are a large cost factor, approaching 50% of operations cost in some experimental areas. This cost is born largely by efforts funded through operations and research. Most if not all new projects and upgrades come with significant computing needs. Also, changes in computing technologies require software modernization and further development of the workforce expertise in the field.

There has been an initiative to encourage broader use of DOE High Performance Computing (HPC) resources. For example, at NERSC in 2015, HEP received allocations of in total 340 million CPU hours in 2015, a magnitude that is at the scale of LHC computing. Additionally, hundreds of millions of CPU hours were made available to HEP science through ALCC and INCITE.

Comments: Demands for a healthy software and computing program are increasing. The program needs scientists to be engaged in R&D and to develop and maintain a computing infrastructure that is useful and adapted to the scientific data workflow needs of experiments. This requires labs and universities to strengthen partnerships on software engineering and support. We note the example of DES, where interagency agreements have left critical computing support to other agencies, causing risks. When DOE recognized the need for additional help on DES computing, it made a significant impact accelerating the pace of science output.

Computing and software development needs are typically not part of the planning of projects, although they cause very significant cost to operations and research. For example, LBNE started a commendable effort in 2014 for outlining a computing model and computing cost estimates, but there is no indication of follow-up with DUNE.

HL-LHC upgrades will cause a significant demand for increased computing capabilities when moving into operations and, while the detector upgrade projects move forward, strategic planning to address operations and computing cost does not yet exist. Such planning needs to be done early in the process of defining projects. There could be significant cost savings by optimizing detector design in areas where computing dominates the operations cost, as is true for the LHC detectors.

The $8.5M/year “Computational HEP” budget could be key to enabling transformational change, injecting additional effort and expertise addressing key issues of strategic importance, by adding to, focusing and enabling existing on-going computing efforts in experiments and at the labs. These additional efforts could nurture focused strategic initiatives to control future computing costs by improvements in computing models, software modernization and training. This approach is in line with P5 recommendation #29 on computing, and it needs to acquire a laser-sharp focus on the most pressing upcoming challenges in HEP software and computing.

HEP needs to continue to encourage the particle physics community to develop a clear technical vision of how to address technology issues, such as how to make effective use of new hardware, scale the data management capabilities, etc. It should also encourage the community to engage more and across frontiers in taking the next steps towards realization of such a vision. For this purpose, the HEP-CCE (Center of Computational Excellence) should bring the relevant parties together in more areas, work with complementary community efforts like HSF, and enable coordination and strong collaboration internationally and across agencies.

Strategic planning for computing and software development could include a HEPAP subpanel, a workshop sponsored by HEP, or input from the DPF.

Recommendation 18: Include planning for computing and software development into the planning for new initiatives.

5.5 Diversity Issues

Finding: HEP has worked hard to improve the balance on its review panels.

Comments: Inadequate demographic information is available to assess the success rate of different populations that apply for funding by HEP. Implicit bias in reviews is a concern, but conclusions cannot be drawn without data. Improved demographic information would facilitate tracking of progress in achieving diversity in particle physics. Under-representation of women and minorities in physics as a whole continues to be a challenge. Greater attention should be paid to promoting an inclusive environment in order to provide encouragement to research groups to improve the diversity of the HEP workforce. HEP review processes for university groups and laboratories should consider activities that promote diversity and inclusion in the workforce and in the workplace.

Recommendation 19: Develop a plan for increasing diversity in the programs HEP supports. HEP should work with the office of science to obtain demographic information, including information at the proposal stage.

5.6 Communication

Finding: HEP recognizes that communication with active researchers is essential for the success of the program and has worked hard to communicate with the community about program priorities as outlined by P5, as well as the requirements of proposal submissions.

Recommendation 20: Continue and enlarge the effort by HEP staff to make presentations about program priorities and to have PI meetings at major conferences.

Comment: This may require an increase in travel funding.

5.7 Research Scientists

Finding: The requirement of an appendix in proposals describing the work of each university research scientist has resulted in more information being available to the mail-in reviewers and to the review panels than previously.

Comment: This new HEP policy has been constructive and beneficial to the research program. Research scientists making critical contributions either to research or to operation of experiments have been carefully evaluated and support has continued for those with unique skills.

Recommendation 21: Continue to encourage appendices describing the work of each university research scientists in proposals.

Recommendation 22: Consider for support, through research and operations funding, research scientists making clear and critical contributions to experiments and construction projects.

Appendix I: Charge from the HEPAP Chair, Prof. Andrew Lankford, to the Chair of the CoV, Dr. Sally Dawson.

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DEPARTMENT OF PHYSICS AND ASTRONOMY

IRVINE, CALIFORNIA 92697-4575
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July 20, 2016

Dr. Sally Dawson
Physics Department, Mail Stop 510A
Brookhaven National Laboratory
P.O. Box 5000
Upton, NY 11973-5000

Dear Sally,

Thank you for agreeing to chair the 2016 Committee of Visitors (COV) review of the Department of Energy (DOE) Office of High Energy Physics (HEP). The review should be conducted in accordance with the Guidance for DOE Office of Science Committee of Visitors Reviews, issued by the Deputy Director for Science Programs on May 1, 2009 found at the following url:

http://science.energy.gov/~/media/sc-2/pdf/presentations/guidance_for_doe_sc_cov_reviews_v1.pdf

The COV subpanel is asked to assess the operations of HEP during the fiscal years 2013, 2014, and 2015. In particular, as indicated in the Guidance for COV Reviews, the subpanel should assess: (1) the efficacy and quality of the processes used to solicit, review, recommend, monitor, and document application and proposal actions; and (2) the quality of the resulting portfolio, including its breadth and depth of portfolio elements, its national and international standing, and the progress HEP has made toward its long-term program goals since the last review of these milestones by HEPAP. The COV should comment on the effectiveness of DOE implementation of the long-term goals and priorities recommended in the 2014 report of the Particle Physics Project Prioritization Panel (P5). Are the recommendations of P5 and of other recent HEPAP subpanels being reasonably followed? Are the actions of HEP maintaining the capabilities needed for healthy laboratory and university programs? Comments and suggestions for improving HEP processes and their implementation and on the observed strengths or weaknesses in any component or sub-component of the HEP portfolio would be appreciated. The COV should assess progress in addressing the recommendations of the previous (2013) COV. It should also identify any significant issues that the COV is not able to appropriately consider within the limited timespan of this review but which deserve subsequent consideration.

The results of this review should be documented in a report with findings, comments, and recommendations clearly articulated. The report should be completed for consideration by HEPAP at its December 1-2, 2016 meeting and submitted to the agency shortly thereafter. I appreciate the COV's willingness to take on this important activity and look forward to its final report.

Sincerely yours,

Andrew J. Lankford

Andrew J. Lankford
Professor of Physics, University of California, Irvine
Chair, High Energy Physics Advisory Panel

Appendix II: CoV Members and Contact Information

First Name	Last Name	Affiliation	Email Address
Hiroaki	Aihara	Tokyo	aihara@phys.s.u-tokyo.ac.jp
Drew	Baden	Maryland	drew@umd.edu
Lothar	Bauerdick	Fermilab	bauerdick@fnal.gov
Rachel	Bean	Cornell	rbean@astro.cornell.edu
Frank	Calaprice	Princeton	frankc@princeton.edu
Sally	Dawson	BNL	sallydawsonbnl@gmail.com
Lance	Dixon	SLAC	lance@slac.stanford.edu
Roger	Erickson	SLAC	roger@slac.stanford.edu
Brenna	Flaugher	Fermilab	brenna@fnal.gov
Andre de	Gouvea	Northwestern	degouvea@northwestern.edu
Paul	Grannis	Stony Brook	pgrannis@sunysb.edu
Tao	Han	Pittsburgh	than@pitt.edu
Deborah	Harris	Fermilab	dharris@fnal.gov
Stuart	Henderson	ANL	hendersons@aps.anl.gov
Ian	Hinchliffe	LBNL	i_hinchliffe@lbl.gov
Tom	Katsouleas	Virginia	tck6r@virginia.edu
James	Kerby	ANL	jkerby@aps.anl.gov
Rick Van	Kooten	Indiana	rvankoot@indiana.edu
Andreas	Kronfeld	Fermilab	ask@fnal.gov
Albion	Lawrence	Brandeis	albion@brandeis.edu
Allison	Lung	JLab	lung@jlab.org
Patricia	McBride	Fermilab	mcbride@fnal.gov
Daniel	McKinsey	Berkeley	daniel.mckinsey@berkeley.edu
Edward	O'Brien	BNL	eobrien@bnl.gov
Katsunobu	Oide	KEK	Katsunobu.Oide@kek.jp; oide1@icloud.com
John	Parsons	Columbia	parsons@nevis.columbia.edu
Fulvia	Pilat	JLab	Fulvia.Pilat@jlab.org
Laura	Reina	FSU	reina@hep.fsu.edu
Jack	Ritchie	Texas	ritchie@physics.utexas.edu
James	Rosenzweig	UCLA	rosenzweig@physics.ucla.edu
Gary	Sanders	Caltech	sanders@caltech.edu
Stefan	Soldner-Rembold	Manchester	stefan.soldner-rembold@manchester.ac.uk
Michael	Syphers	Fermilab	syphers@fnal.gov
Tim	Tait	UC Irvine	ttait@uci.edu
William	Trischuk	Toronto	william@physics.utoronto.ca
Mark	Trodden	Pennsylvania	trodden@physics.upenn.edu
Phillip Michael	Tuts	Columbia	tuts@nevis.columbia.edu
Steven	Vigdor	Indiana	vigdor@indiana.edu

Appendix III: CoV Subpanel Assignments

First Name	Last Name	Affiliation	Chair/Subpanel Chair/Panelist
Sally	Dawson	BNL	CoV Chair
Lothar	Bauerdick	Fermilab	Subpanel Chair - Cross Group Computing
Paul	Grannis	Stony Brook	Subpanel Chair - Cross Group Comparative Review
Rick Van	Kooten	Indiana	Subpanel Chair - Cross Group P5
William	Trischuk	Toronto	Subpanel Chair - Cross Group Detectors
Drew	Baden	Maryland	Subpanel Chair - Energy Frontier
Tao	Han	Pittsburgh	Panelist - Energy Frontier
Ian	Hinchliffe	LBNL	Panelist - Energy Frontier
Patricia	McBride	Fermilab	Panelist - Energy Frontier
John	Parsons	Columbia	Panelist - Energy Frontier
Jack	Ritchie	Texas	Subpanel Chair - Intensity Frontier
Hiroaki	Aihara	Tokyo	Panelist - Intensity Frontier
Andre de	Gouvea	Northwestern	Panelist - Intensity Frontier
Deborah	Harris	Fermilab	Panelist - Intensity Frontier
Stefan	Soldner-Rembold	Manchester	Panelist - Intensity Frontier
Rachel	Bean	Cornell	Subpanel Chair - Cosmic Frontier
Frank	Calaprice	Princeton	Panelist - Cosmic Frontier
Brenna	Flaugher	Fermilab	Panelist - Cosmic Frontier
Daniel	McKinsey	Berkeley	Panelist - Cosmic Frontier
Mark	Trodden	Pennsylvania	Panelist - Cosmic Frontier
Lance	Dixon	SLAC	Subpanel Chair - Theory
Andreas	Kronfeld	Fermilab	Panelist - Theory
Albion	Lawrence	Brandeis	Panelist - Theory
Laura	Reina	FSU	Panelist - Theory
Tim	Tait	UC Irvine	Panelist - Theory
Stuart	Henderson	ANL	Subpanel Chair - Accelerator
Tom	Katsouleas	Virginia	Panelist - Accelerator
Fulvia	Pilat	JLab	Panelist - Accelerator
James	Rosenzweig	UCLA	Panelist - Accelerator
Michael	Syphers	Fermilab	Panelist - Accelerator
Edward	O'Brien	BNL	Subpanel Chair - Operations
Roger	Erickson	SLAC	Panelist - Operations
Katsunobu	Oide	KEK	Panelist - Operations
Steven	Vigdor	Indiana	Panelist - Operations
Gary	Sanders	Caltech	Subpanel Chair - Projects
James	Kerby	ANL	Panelist - Projects
Allison	Lung	JLab	Panelist - Projects
Phillip Michael	Tuts	Columbia	Panelist - Projects

COV - Cross-Cutting Panel Assignments				
Wednesday September 28th from 12:30-1:30pm				
First Name	Last Name	Affiliation	Cross-Cutting Assignment	Conference Room
William	Trischuk	Toronto	Subpanel Chair - Cross Group Detectors	A-410
Frank	Calaprice	Princeton	Panelist - Cross Group Detectors	A-410
Deborah	Harris	Fermilab	Panelist - Cross Group Detectors	A-410
Stuart	Henderson	ANL	Panelist - Cross Group Detectors	A-410
Allison	Lung	Jlab	Panelist - Cross Group Detectors	A-410
Patricia	McBride	Fermilab	Panelist - Cross Group Detectors	A-410
Edward	O'Brien	BNL	Panelist - Cross Group Detectors	A-410
Fulvia	Pilat	Jlab	Panelist - Cross Group Detectors	A-410
Paul	Grannis	SUNY	Subpanel Chair - Cross Group Comparative Review	E-301
Drew	Baden	Maryland	Panelist - Cross Group Comparative Review	E-301
Lance	Dixon	SLAC	Panelist - Cross Group Comparative Review	E-301
Roger	Erickson	SLAC	Panelist - Cross Group Comparative Review	E-301
Ian	Hinchliffe	LBNL	Panelist - Cross Group Comparative Review	E-301
Tom	Katsouleas	Virginia	Panelist - Cross Group Comparative Review	E-301
Laura	Reina	FSU	Panelist - Cross Group Comparative Review	E-301
Jack	Ritchie	Texas	Panelist - Cross Group Comparative Review	E-301
Mark	Trodden	Pennsylvania	Panelist - Cross Group Comparative Review	E-301
Phillip Michael	Tuts	Columbia	Panelist - Cross Group Comparative Review	E-301
Rick Van	Kooten	Indiana	Subpanel Chair - Cross Group P5	E-401
Hiroaki	Aihara	Tokyo	Panelist - Cross Group P5	E-401
Rachel	Bean	Cornell	Panelist - Cross Group P5	E-401
Andre de	Gouvea	Northwestern	Panelist - Cross Group P5	E-401
Tao	Han	Pittsburgh	Panelist - Cross Group P5	E-401
Albion	Lawrence	Brandeis	Panelist - Cross Group P5	E-401
Daniel	McKinsey	Berkeley	Panelist - Cross Group P5	E-401
Katsunobu	Oide	KEK	Panelist - Cross Group P5	E-401
James	Rosenzweig	UCLA	Panelist - Cross Group P5	E-401
Tim	Tait	California, Irvine	Panelist - Cross Group P5	E-401
James	Kerby	ANL	Panelist - Cross Group P5	E-401
Lothar	Bauerdick	Fermilab	Subpanel Chair - Cross Group Computing	G-207
Brenna	Flaugher	Fermilab	Panelist - Cross Group Computing	G-207
Andreas	Kronfeld	Fermilab	Panelist - Cross Group Computing	G-207
John	Parsons	Columbia	Panelist - Cross Group Computing	G-207
Gary	Sanders	CalTech	Panelist - Cross Group Computing	G-207
Stefan	Soldner-Rembold	Manchester	Panelist - Cross Group Computing	G-207
Michael	Syphers	Fermilab	Panelist - Cross Group Computing	G-207
Steven	Vigdor	Indiana	Panelist - Cross Group Computing	G-207

Appendix IV: CoV Agenda

Tuesday, September 27, 2016			
Time	**Activity**	**Participants/Lead**	**Location**
7:30 am	Shuttle Pickup	Members/Christie Ashton	In Front of Hotel
7:30 am - 8:30 am	Check-in Germantown Facility	HEP Staff/Christie Ashton	North Lobby
8:30 am - 8:45 am	Welcome	Jim Siegrist, HEP Director	A-410
8:45 am - 9:15 am	COV Executive Session	Sally Dawson, COV Chair	A-410
9:15 am - 9:45 am	Research and Technology Overview and 2013 Action Items	Glen Crawford, Division Director	A-410
9:45 am – 10:15 am	Operations and Projects	Mike Procario, Division Director	A-410
10:15 am - 10:30 am	Refreshment Break (coffee/snacks/drinks)		A-410
10:30 am – 10:45 am	Energy Frontier Research	Abid Patwa	A-410
10:45 am – 11:00 am	Intensity Frontier Research	Alan Stone	A-410
11:00 am – 11:15 am	Cosmic Frontier Research	Kathy Turner	A-410
11:15 am – 11:30 am	Theory	Simona Rolli	A-410
11:30 am – 11:45 am	Accelerator R&D	L.K. Len	A-410
11:45 am – 12:00 noon	Accelerator Stewardship and other Technologies	Eric Colby	A-410
12:00 noon – 12:15 pm	Budget Process	Alan Stone	A-410
12:15 pm - 1:15 pm	Working Lunch	COV Members only	A-410
1:15 pm- 3:00 pm Panel Breakout #1 And Cross Group Leader Assignments during breakouts	Panel 1 – Energy Frontier Experiment Panel 2 – Intensity Frontier Experiment Panel 3 – Cosmic Frontier Experiment Panel 4 – Theory Panel 5 – Accelerator R&D Panel 6 – Facility Operations Panel 7 - Projects • Preliminary Review of Folders Grannis: Panel 1 (1:30-2:15); Panel 2 (2:15-3:00) Van Kooten: Panel 3 (1:30-2:15); Panel 1 (2:15-3:00) Trischuk: Panel 7 (1:30-2:15); Panel 2 (2:15-3:00) Bauerdick: Panel 2 (1:30-2:15); Panel 3 (2:15-3:00)	Panel 1 – subpanel chair, Lead Drew Baden HEP Rep: Abid Patwa	E-164
		Panel 2 – subpanel chair, Jack Ritchie HEP Rep: Alan Stone	G-207
		Panel 3 – subpanel chair, Rachel Bean HEP Rep: Kathy Turner	G-426
		Panel 4 – subpanel chair, Lance Dixon HEP Rep: Simona Rolli	F-441
		Panel 5 – subpanel chair, Stuart Henderson HEP Reps: L.K. Len and Eric Colby	E-114
		Panel 6 – subpanel chair, Ed O'Brien HEP Rep: John Kogut	E-401
		Panel 7 – subpanel chair, Gary Sanders HEP Rep: Ted Lavine	E-301
3:00 pm - 3:30 pm	Refreshment Break (coffee/snacks/drinks)		H-401
3:30 pm - 5:30 pm Panel Breakout #2 And Cross Group Leader Assignments during breakouts	Same Breakout Panels and Meeting Locations as Listed in Panel Breakout #1 • Review Folders • Formulate Panel Questions/unforeseen Issues to discuss with HEP Grannis: Panel 3 (3:30-4:30); Panel 5 (4:30-5:30) Van Kooten: Panel 2 (3:30-4:30); Panel 6 (4:30-5:30) Trischuk: Panel 1 (3:30-4:30); Panel 3 (4:30-5:30) Bauerdick: Panel 5 (3:30-4:30); Panel 1 (4:30-5:30)		
5:30 pm – 6:00 pm	Panel Questions/unforeseen Issues to discuss with HEP	All Panels and HEP staff	A-410
6:00 pm	Check-out Germantown Facility	COV Members/Christie Ashton	North Lobby
6:30 pm	Shuttle Pickup	COV Members	In Front of Hotel
6:30 pm – 8:30 pm	HEP-hosted working dinner	HEP/COV Members	That's Amore
8:30 pm	Shuttle Pickup	COV Members	That's Amore
9:00 pm	Shuttle Drop Off	COV Members	In Front of Hotel

Wednesday, September 28, 2016			
7:30 am	Shuttle Pick-up	COV Members/Christie Ashton	In Front of Hotel
8:00 am - 8:30 am	Check-in Germantown Facility	COV Members/Christie Ashton/HEP Staff	North Lobby
8:30 am – 9:00 am	COV Chair and Panel Chairs	Sally Dawson, all Subpanel Chairs	A-410
8:30 am - 10:00 am Panel Breakout # 3 And Cross Group Leader Assignments during breakouts	Panel 1 – Energy Frontier Experiment Panel 2 – Intensity Frontier Experiment Panel 3 – Cosmic Frontier Experiment Panel 4 – Theory Panel 5 – Accelerator R&D Panel 6 – Facility Operations Panel 7 - Projects • Review of Folders • Formulate Panel Comments Refreshments (continental break-fast/coffee/drinks) will be in H-401 Grannis: Panel 4 (8:30-9:30) Van Kooten: Panel 7 (8:30-9:30) Trischuk: Panel 5 (8:30-9:30) Bauerdick: Panel 6 (8:30-9:30)	Panel 1 – subpanel chair, Drew Baden HEP Rep: Abid Patwa	E-164
		Panel 2 – subpanel chair, Jack Ritchie HEP Rep: Alan Stone	G-207
		Panel 3 – subpanel chair, Rachel Bean HEP Rep: Kathy Turner	G-426
		Panel 4 – subpanel chair, Lance Dixon HEP Rep: Simona Rolli	F-441
		Panel 5 – subpanel chair, Stuart Henderson HEP Reps: L.K. Len and Eric Colby	E-114
		Panel 6 – subpanel chair, Edward O'Brien HEP Rep: John Kogut	E-401
		Panel 7 – subpanel chair, Gary Sanders HEP Rep: Ted Lavine	E-301
10:00 am - 10:30 am	Refreshment Break (coffee/snacks/drinks)		H-401
10:30 am – 11:30 am	Meet with HEP management	COV Chair, Jim Siegrist, Glen Crawford, Mike Procario	A-410
11:30 am – 12:30 pm	Working Lunch	COV Members only	A-410
12:30 pm - 1:30 pm Panel Breakout #4	Cross-Cutting Discussion Panel 1 – Detector Panel 2 – Comparative Review Panel 3 – P5 Panel 4 – Computing	Panel 1 – subpanel chair, William Trischuk	A-410
		Panel 2 – subpanel chair, Paul Grannis	E-301
		Panel 3 – subpanel chair, Rick Van Kooten	E-401
		Panel 4 – subpanel chair, Lothar Bauerdick	G-207
1:30 pm - 3:00 pm Second Reading of Select-ed Folders	All Panels meet as Listed in Panel Breakout #3 to do second reading of selected materials • Review Folders • Formulate Panel Questions		
3:00 pm – 3:15 pm	Refreshment Break (coffee/snacks/drinks)		H-401
3:15 pm – 4:30 pm Panel Breakout # 5	Same Breakout Panels and Meeting Locations as Listed in Panel Breakout #3 • Draft of Panel Findings, Recommendations		
4:30 pm – 5:30pm	Discussion of Findings, Recommendations	COV Members	A-410
5:30 pm – 6:00 pm	Check-out Germantown Facility	COV members/Christie Ashton	North Lobby
6:00 pm	Shuttle Return to Hotel	COV Members/Christie Ashton	North Entrance
	Dinner	COV Members	On their own

Thursday, September 29, 2016			
7:30 am	Shuttle Pick-up	COV members/Christie Ashton	In Front of Hotel
8:00 am - 8:30 am	Check-in Germantown Facility	COV members/Christie Ashton/HEP Staff	North Lobby
8:30 am - 10:00 am Panel Breakout # 6	Panel 1 – Energy Frontier Experiment Panel 2 – Intensity Frontier Experiment Panel 3 – Cosmic Frontier Experiment Panel 4 – Theory Panel 5 – Accelerator R&D Panel 6 – Facility Operations Panel 7 - Projects • Finalize Panel Recommendations • Report Writing Refreshments (continental breakfast/coffee/drinks) will be in H-401 from 8:00am-10:00am	Panel 1 – subpanel chair, Drew Baden HEP Rep: Abid Patwa	E-164
		Panel 2 – subpanel chair, Jack Ritchie HEP Rep: Alan Stone	G-207
		Panel 3 – subpanel chair, Rachel Bean HEP Rep: Kathy Turner	G-426
		Panel 4 – subpanel chair, Lance Dixon HEP Rep: Simona Rolli	F-441
		Panel 5 – subpanel chair, Stuart Henderson HEP Reps: L.K. Len and Eric Colby	E-114
		Panel 6 – subpanel chair, Edward O'Brien HEP Rep: John Kogut	E-401
		Panel 7 – subpanel chair, Gary Sanders HEP Rep: Ted Lavine	E-301
10:00 am -10:30 am	Refreshment Break (coffee/snacks/drinks)		A-410
10:30 am – 11:30 am	COV Closed Session	COV Members	A-410
11:30 am - 12:30 pm	Working Lunch	COV Members	A-410
12:30 pm – 1:30 pm	COV Closed Session	COV Members and HEP Management	A-410
1:30 pm – 3:30 pm	COV Closed Session	COV Members and all HEP Staff	A-410
3:30 pm	Adjourn – Thank You		

Appendix V: Summary Report from Energy Frontier Subpanel

Comment: The review process for the Energy Frontier (EF) is carried out optimally with respect to minimizing the result of budget reductions in this important frontier. The program manager has very good relationships with people in the field. We believe that there is overall trust among the PIs that the project manager is doing the best possible job, that he is transparent, and that he is as helpful as he can possibly be. His performance is reflected in the fact that the PIs on LHC experiments are very productive and have played major roles in post-Higgs discovery analyses and BSM searches. The U.S. community is having an impact in the ATLAS and CMS HL-HLC upgrades, and will continue to play important roles there. The impact of the U.S. community in CMS is reflected by the recent election as Spokesperson of Joel Butler, a well-respected member of the U.S. particle physics community.

Finding*:* Funding to the Energy Frontier research program has declined from $86.2M to $77.3M over the period of this review, the biggest absolute drop among HEP programs.

Comment*:* There is a serious concern that if the trend for significant reductions in EF funding continues, the HEP program will become misaligned with the P5 recommendations, making progress in this high priority program a challenge. The result would be a future risk that the maximal science for the investment would not be obtained.

Finding*:* The HEP EF Project Manager discusses the M&O and upgrade tasks of individual PIs with the panels.

Comments*:* Proposals often do not adequately communicate the M&O tasks performed by the group under review, or the importance of those tasks, as evaluated by the project managers in the experiments. These tasks can be critical to the success of a particular subsystem on the experiment, and to the experiment itself. Failure to take into account important contributions to M&O tasks does not accomplish what the comparative reviews are after, namely ascertaining the impact and excellence of the group and PI being reviewed. The HEP EF Project Manager should continue to consult with the project management of the experiments to understand which M&O and upgrade tasks and which proposals are critical for the success of the CMS and ATLAS experiments. The relevant information should be communicated to the panels in such a way that the panel members can use this as part of their evaluation.

Finding: There are two university-based groups receiving support from the energy frontier research program that are working on detector development for a possible future electron-positron collider. This work, as it is detector-specific, cannot be supported from the generic detector R&D program. The total funds from the energy frontier program are small.

Comments: Positive international developments, such as Japanese approval of the ILC, could cause an increase in the number of proposals for work on detectors for lepton colliders. In the current challenging budget environment, funding such proposals from within the energy frontier

could only come at the cost of reduced support for groups working on LHC experiments.

Recommendation #2 recommends consultation with HEPAP regularly in the implementation of the P5 plan. This includes any significant redirection of resources within the frontiers to activities not included in the P5 plan.

Appendix VI: Summary Reports from Cosmic Frontier Subpanel

Findings: The Cosmic Frontier program is responsible for enabling experimental physics utilizing naturally created sources: astrophysical photons across the electromagnetic spectrum, from microwave to gamma ray energies, atmospheric and astrophysical neutrinos, and dark matter particles. These are detected with ground-based telescopes and arrays, space missions and underground detectors. Principal science drivers include the nature of dark energy, dark matter and gravity on cosmic scales, the composition and acceleration mechanisms of cosmic rays and the properties of primordial inflation.¶

Five different budget areas are supported under the program, including university research, research at DOE Labs, and support for R&D, small project fabrication and experimental operations.

The program is balancing research operations for a suite of internationally recognized current experiments (Dark Energy ``Stage III": BOSS, DES, eBOSS; Dark Matter ``G1": ADMX-2a, SuperCDMS-Soudan, LUX, DAMIC, DarkSide-50, COUPP/PICO-60; CMB: SPT-Pol; Cosmic/Gamma Ray - Auger, VERITAS, HAWC, Fermi/LAT, AMS-02) with construction and pre-commissioning activities for an impressive selection of next-generation experiments (Dark Energy ``Stage IV": LSST, DESI; Dark Matter ``G2": ADMX-G2, LZ, SuperCDMS-SNOLAB; CMB: SPT-3G, CMB-S4).

Comments: The projects well-utilize expertise from many DOE Labs and university groups and frequently involve engagement with other agencies, principally NSF and NASA. Scientists both from other Frontiers and who have not previously worked on DOE experiments entered the Cosmic Frontier program during the period of the CoV review, to work on these experiments. This led to increasing proposal pressure and highlighted the need to facilitate efficient transitions across Frontiers as recommended in Recommendation 5.

The next generation Dark Energy projects, LSST and DESI, are international endeavors in which DOE is a principal lead. Managing the portfolio presents a challenge, in supporting both the research and operations activities to ensure DOE maintains science leadership; LSST and DESI will start to take data while the current experiments are still underway. In addition, to the challenge to support eventual operations, there is a current shortage of funds to support the construction of the G2 dark matter experiments on a timely basis. This is an immediate problem that may damage their competitive edge. This leads to Recommendation 3.

While support for the approved projects is critical to the overall success of the program, pressure on the total budget has severely limited funding for R&D. The new types of detectors required to take the next steps in measuring and understanding the cosmos will take many years to develop.

The proposal review process is working well and is well managed by the program manager.

The Program Manager is doing an excellent job in balancing and managing investment and support for the different sub-areas within the frontier.

Dark energy and dark matter detection are rapidly evolving areas with significant international competition, with a number of experiments coming online in the next 5 years. DOE has devoted substantial cosmic frontier MIE project funds to the construction of major international dark energy and direct detection dark matter experiments. Operations and research funding for the four dark sector experiments nearing completion will be necessary to secure DOE's scientific leadership and return on investment.

Research scientists working in the cosmic frontier often have difficulty obtaining funding.

As the current suite of new Cosmic Frontier projects begins construction, there will soon be a need to plan new projects, such as the P5-recommended Generation 3 dark matter direct detection experiments, S4 cosmic microwave background projects, the next generation of photometric and spectroscopic large scale structure surveys.

Appendix VII: Summary Report from the Intensity Frontier Subpanel

Findings: The Intensity Frontier program uses intense beams and ultra-sensitive detectors to search for new physics. At present it focuses on neutrino experiments that seek to elucidate the nature of neutrinos, measure CP violation in neutrino oscillations, or to find possible sterile neutrinos. The Intensity Frontier program also includes dark matter searches, muon decay experiments, and quark-flavor experiments.

One goal of this program is to establish Fermilab as the leading international center for neutrino studies. Reaching this goal hinges ultimately on the successful execution of the DUNE experiment, which is in an R&D phase. Fermilab's near- and intermediate-term programs include the running NOvA experiment and a series of muon (g-2 and Mu2e) and short-baseline neutrino experiments (MicroBooNE, Minerva, ICARUS, and SBND). However, the Intensity Frontier program is not limited to Fermilab. It also includes experiments addressing a variety of topics in other labs and around the world. For instance, U.S. participation in Belle II is an important component of this program.

In all, the HEP Intensity Frontier research program is a diverse one that provides an important complement to the Energy and Cosmic Frontier programs. We judge it to be focused on appropriate topics, well-diversified, and well-managed.

There has not been a full-time Program Manager at HEP for the Intensity Frontier for approximately two years. The duties have been covered by a combination of people who have other important responsibilities.

Comment: As a result of the extra duties associated with multiple responsibilities, the level of oversight in the Intensity Frontier has been less than in previous years.

Recommendation 23: Fill the Program Manager position for the Intensity Frontier as soon as possible.

Findings*:* The Intensity Frontier program and the associated research community have adopted the P5 recommendations and are implementing them purposefully.

The comparative reviews of universities introduced in 2012 have matured into a process that provides reliable guidance to program managers. Solicitations (FOAs) are clearly written, and HEP has made efforts (e.g., PI meetings) to educate PIs about the application process. The use of panels works well.

The landscape of liquid-argon neutrino experiments has been rapidly changing over the review period. There are now several current and future liquid argon experiments and projects within the DOE portfolio on different time scales, but with significant overlap in terms of techniques and challenges.

Comment: The activity on the several current and future liquid argon experiments and projects will require careful management of the program and coordination of grant applications across these different experiments to avoid duplication of efforts and efficient use of resources.

Finding: The Intensity Frontier Fellowship Program at Fermilab was successfully implemented during the time period being evaluated.

Comment: The Intensity Frontier Fellowship Program has had a very positive impact across all aspects of Intensity Frontier research. It should be continued at the current level of support if at all possible.

Appendix VIII: Summary Report from Theory Subpanel

Comments: In many areas of theoretical research, including beyond-the-standard model physics and string/formal theory, the research supported by the DOE remains world leading. This is true despite the fact that around 20% fewer theory PIs are funded than five years ago, and even the funded university PIs have fewer resources with which to conduct research (students and post-docs) than before. In some areas, such as precision theory for colliders, Europe currently is significantly ahead of the U.S., although that situation strongly reflects university hiring preferences. Although many DOE-supported PIs currently continue to conduct world-class research with fewer resources, the reduction in the number of PhD students, and especially postdocs, seriously impairs the future health of US particle theory.

The grant proposal progress reports provide adequate monitoring of the theoretical research funded at universities, although the principal peer review is provided by the comparative review process at the time of the next funding opportunity. The laboratory institutional reviews provide mid-term monitoring of the laboratory theoretical research efforts, as well as their synergies with experimental research at the labs. Again the three-year (now going to four-year) laboratory theory comparative review provides the main critical assessment.

Finding: The university theory comparative reviews involve grouping proposals into five quintiles, or tiers. Between 2013 and 2014 the format of the review summary provided to the CoV changed, from a ranking of institutions to a ranking of individual PIs.

Comment: This change improved transparency, was very beneficial toward assessing the review process, and is to be commended.

Finding*:* The budget for theoretical physics decreased by nearly $2,000,000 from FY2013 to FY2015, from a starting point that already could not support PIs ranked in the fourth tier out of five. This reduction took place in proportion to the shift of funds from research to projects. Consequently, the number of funded PIs was reduced by 25, which is a bit more than 10%. Many researchers ranked in the third tier are on the brink of losing funding. The top funded PIs who are ranked in tier 1 can support at most one postdoc and one (halftime) graduate student

Comment*:* In the university theory program, the awards were capped at a maximum of $150,000/year for the PIs ranked in tier 1, in order not to have to defund even more PIs in a declining budget. The committee concurred with this difficult decision. It also concluded that further defunding of PIs ranked in tier 3 would irreversibly harm the breadth and depth of U.S. particle theory research. (Researchers with tiers 4 and 5 rankings are already completely defunded.)

Comment: The P5 report notes that “A thriving theory program is essential for both identifying new directions for the field and supporting the current experimental program,” echoing similar language from the 2013 CoV. The theory program in its current state cannot be described as

thriving. Further cuts will stop research by PIs with tier 3 ranking, many of whom provide unique and significant contributions to the overall HEP program. The shift from research to projects seems to have proceeded without attending adequately to the adverse consequences on theory research. The lattice QCD infrastructure project also experienced a budget reduction during the period under review. In summary, the breadth and depth of the theory program, including its ability to deliver results crucial to the experimental program, are at risk.

Recommendation 24: Work to restore a thriving and intellectually diverse theory program as mentioned as essential in the P5 report. Support for theory as a fraction of the research budget should not fall below the current level, in order that the scientists ranked in tiers 1, 2, and 3 remain adequately supported.

Findings: The structural features of PAMS make the review process difficult for HEP staff and for reviewers.

Given the overall envelope of funding, the comparative review process works well toward maximizing the theoretical physics output funded by HEP. In particular, the tier rankings and declination choices within each year seem largely appropriate to the Committee.

Except in 2013, formal theorists were under-represented on the theory comparative review panel, relative to the interests of the theorists being reviewed.

Recommendation 25*:* The proportion of panelists should better reflect the balance of thrusts among the PIs being reviewed in order to provide more informed discussion and rankings.

Finding: The very strong (in numbers and quality) 2014/2017/… cohort led to many PIs in this year to be ranked lower than if they had been in another year. The option of two- or four-year funding has been used to "load balance" by moving theorists in this cohort to other cohorts, but it has not fully evened the load.

Comment: The practice of "load balancing" described above should be continued as necessary.

Finding: The previous CoV recommended hiring an IPA for theory from a university.

Recommendation 26: We reiterate this recommendation. Such a hire will assist with the heavy peak workload and should help provide a balanced perspective to program

Finding: The theory program manager at HEP has raised the question of eliminating summer salary for PIs in the presentation to the CoV.

Comment: Summer salary recognizes the PIs own research efforts throughout the academic year as well as during the summer. Its elimination would devalue particle physics at universities. We recommend against its elimination.

Appendix IX: Summary Report from Accelerator R&D Subpanel

Finding: The comparative review process led to only 50-60% of renewal proposals being funded in a given year, which is significantly lower than before.

Comments: The subcommittee found the processes for grant proposal evaluation to be professionally managed and well-documented. We found that well-regarded and knowledgeable reviewers were engaged; appropriate panels were assembled, of adequate size and breadth; and decisions were carried out in a timely manner. The continued breadth and balance of the panels are essential to enable balancing of the portfolio.

The comparative review process works very well and has created a mechanism for prioritizing the best science and for providing a path for terminating less productive though positively reviewed programs. This process is essential for achieving balance in the portfolio.

HEP adapted the proposal cycle schedule well to accommodate the uncertainties of the federal budgeting process.

It will be helpful in the future to provide the CoV access to PAMS, if it can be done in a way that preserves the anonymity of the review process.

Finding: The main mechanisms for regular monitoring of the general Accelerator R&D program are periodic program reviews, institutional science and technology reviews, written progress reports, and site visits. The GARD program portfolio is assessed at annual university comparative reviews, ad-hoc GARD reviews of laboratories and projects, as well as a GARD Program Review that included visits to all GARD-funded laboratories during this review period. The directed R&D programs LARP and MAP programs also had dedicated ad-hoc reviews during this CoV period.

Comments: The overall level and quality of GARD monitoring is good, and the CoV encourages similar mechanisms be put in place for the Accelerator Stewardship program as it matures, in order that the two programs can be optimally coordinated and synergies explored.

We are concerned that continuing limitations on travel of federal employees may adversely impact the quality of overall program monitoring. While formal reviews are essential, more informal site visits and interactions at workshops and conferences with the investigators are an important component of program monitoring. We were told of situations of federal employees monitoring programs who have not been able to visit the institutions carrying out the work.

A recommendation of the 2013 CoV to increase monitoring of the LARP program outcome and to carefully plan the transition from R&D program to construction project was followed and resulted in a comprehensive review of the LARP program during this CoV period. The review provided appropriate feedback on LARP progress and on next steps for transitioning LARP to the Hi-Lumi project.

HEP makes an ongoing significant investment in the areas of superconducting radio frequency (SRF) for particle acceleration and of superconducting (SC) magnets. The COV thinks that an overall monitoring and coordination of these areas at a national level can be beneficial, in order to better coordinate and leverage R&D supported by other offices in DOE/SC and outside DOE. The "roadmap" activities in these areas being guided by the program management are highly encouraged.

The program should be monitored to ensure appropriate balance between identified research thrusts. For example, the committee notes that the source/targetry thrust needs further development.

It would be useful to establish research-thrust-appropriate metrics to monitor the quality and impact of the GARD program, and use them to track progress as the program evolves.

Recommendation 27: Develop the tools and capability within the reporting process to gather and collate field-appropriate metrics (e.g. publications, citations, patents, successful prototypes, etc.) that would be useful to evaluate the productivity and impact of the GARD research programs.

Findings: The main programs in the HEP accelerator R&D portfolio in 2013-15 were General Accelerator R&D (GARD), Accelerator Stewardship, and the directed R&D programs LARP and MAP.

The development of superconducting RF cavities, of cavity surface polishing and processing techniques, and of breakdown/multipactoring theoretical understanding have been led by efforts funded by GARD.

During FY13-15, GARD funded research in superconductor and superconducting cable development for high-field magnets for use in accelerators and other applications. Supported activities included fundamental high-temperature superconductor research, joining of superconducting cables in magnet applications, studies of limitations of superconducting materials, and development of superconducting cyclotron designs for medical applications.

Comments*:* The level of information exchange and coordination with other DOE/SC accelerator R&D programs (e.g. BES, NP) and outside-DOE (e.g. NSF) is good, and it is being widened by the Accelerator Stewardship program, which by its very nature is geared towards non-HEP stakeholders.

The CoV finds that the program managers of GARD and Accelerator Stewardship are doing a good job managing their programs with professionalism and a commitment to program quality and impact.

The quality of GARD-funded science is high. While consistent metrics are lacking, anecdotally this review period appears to be one in which GARD science flourished. A significant number of high-impact publications in *Science* and *Nature* were produced in this period. Breakthroughs in

technology are also noted, including advances in SRF (high Q) and in SC magnets. Likewise, the success of FACET and BELLA, including their results, are notable.

The GARD program supports world-leading research across a range of subjects, from advanced acceleration, to significant breakthroughs in superconducting radiofrequency cavity performance improvements, to superconducting materials and magnet development.

The U.S. is arguably the world leader in high-field SC magnet development as a direct consequence of the magnet program funded through GARD. It has had this role for several decades and it is imperative that the program continues to provide leadership roles in the future development of magnets for accelerator upgrades and future particle accelerators and colliders.

In more recent times, the development of superconducting RF cavity research funded through GARD has also had major impact in the field. Record accelerating gradients for such devices and improvements to the quality factor Q and Q-slope have been achieved through the development of surface cleaning and processing techniques. These advances are impacting the development of upcoming accelerator systems such as the LCLS-II at SLAC and other future high-intensity accelerators throughout the world.

Finding*:* Funding for the GARD program declined by approximately 30% from FY2013 to FY2015. A large portion of this decrease resulted from funding for SRF project-related activities being redirected to the PIP-II project at FNAL. Nonetheless, the residual outcome was a net reduction in GARD-funded accelerator R&D of approximately 10%; including an approximately 25% reduction in university research funding.

Comment: The CoV is deeply concerned by the decline in GARD-funded research, including the erosion of base accelerator R&D funding in order to meet the needs of projects within the highly constrained funding environment. The decline in funding for university PI's is particularly concerning. At universities, the ability does not exist to re-appropriate researchers later when they are needed. A large net outflow of previously funded university PIs from the GARD research program has resulted, with a loss of capabilities and expertise from HEP that could become permanent. Decreases in the number of funded PIs has the potential to further limit the supply of new Ph.D.'s

Finding: During this period, the GARD program absorbed approximately $12M in operation costs of R&D facilities (principally SRF and SC magnet test stands and associated cryogenic operations) that were previously supported by Accelerator Operations accounts. In addition, project-directed SRF activities in the GARD portfolio were moved to project-funded activities.

Comment*:* Given the significant changes in accounting or accelerator R&D activities that involved large shifts in funding, the evolution of the GARD research portfolio is difficult to follow. Perhaps there is a better way to categorize costs to show (and track) the trend in long-term and medium-term accelerator R&D.

Findings*:* Following the recommendation by the P5 report, the Muon Accelerator Program (MAP) was reformulated to plan the ramp-down and termination of MAP. A review of MAP was conducted in late FY2014 that served as the basis for the ramp-down plan, which has largely been followed since.

A HEPAP Accelerator R&D Subpanel study was commissioned as recommended by the P5 report. The report of this subpanel was completed in the second half of FY2015. Initial budget adjustment to the report is evident in FY2016.

The HEPAP Accelerator R&D Subpanel recommended FACET-II as a Scenario C activity. FACET-II is proceeding with project approval.

Comment: The recommendations of the P5 report are driving the dynamics within the GARD portfolio. In particular, the ramp-down of the MAP program and the reformulation of the SRF activities were initiated during this CoV review period. The directions outlined in the report of the HEPAP subpanel are being implemented now, beyond the timescale of this CoV review.

The HEPAP Accelerator R&D Subpanel suggested that some residual fundamental accelerator R&D activities included in the MAP program might transition to the GARD program. A deliberate plan to transition various residual activities is not defined; rather it is expected that individual PIs may apply for GARD funds if they wish to propose continuing muon-related fundamental research.

Following the publication of the HEPAP Accelerator R&D report, the GARD program manager initiated two "road-mapping" activities. The first was organized to encourage the formulation of a community-based R&D roadmap for advanced accelerator (wakefield) concepts. A second was initiated to focus on integrated superconducting magnet R&D priorities. The CoV commends these activities. They have the benefit of serving to integrate laboratory and university activities toward common goals, as well as of strengthening the connection between the community and the program. The SC magnet roadmap report needs to be finalized. The CoV encourages creation and implementation of roadmaps for the other GARD thrusts. For example, roadmaps for the SRF and targetry programs need to be developed.

Recommendation 28*:* Consider creating and implementing roadmaps to define research priorities for the GARD research thrusts not yet mapped.

Recommendation 29: Work to address the accelerator R&D subpanel recommendations to ensure a healthy and vigorous basic accelerator R&D portfolio.

Findings: The Accelerator Stewardship program has begun in response to the Congressional mandate, funding six proposals at $7.9M over this period. Those programs have already produced six patents and significant cost sharing with private industry (exceeding $2.5M).

The use of the Accelerator Test Facility (ATF) at BNL by private industry is significant, highlighting

the ATF's role in the Stewardship program.

The success rate of proposals for the Accelerator Stewardship program is only 6%, significantly lower than typical for HEP and other federal programs.

Comments: The low success rate for proposals to the Accelerator Stewardship program reflects both the high demand and restrictive nature of the program's mandate (i.e., proposals must have support expressed by a customer other than HEP).

The CoV finds that the program manager of the Accelerator Stewardship is doing a good job managing the program with professionalism and a commitment to program quality and impact.

The CoV encourages similar monitoring mechanisms be put in place for the Accelerator Stewardship program, as it matures, as now exist for the GARD program. Similar mechanisms will facilitate the optimal coordination and exploration of synergies of the two programs.

The CoV finds great potential value in the Accelerator Stewardship program. It offers the possibility of transformative advances for societal needs. For instance, compact gantries for light ion therapy are a possible outcome of the funded program. The gap between invention and commercialization is long and needs continued support.

In the absence of separate Congressional line item funding, the Accelerator Stewardship program funding is in tension with research program funding.

Findings: The U.S. Particle Accelerator School (USPAS) is supported by the GARD program. A review of USPAS was held by a HEPAP subcommittee in May 2015. The subcommittee found that the USPAS program "effectively and efficiently serves the critical needs for accelerator workforce development and training in the U.S." USPAS holds sessions twice per year, with typically 150 trainees per session. Trainees earn graduate credit from the sponsoring university, which rotates among many U.S. institutions, often co-located with a DOE national laboratory. Roughly 20% of the attendees for these schools are from outside the United States. Approximately 10% of the instructors at the USPAS sessions also are from outside the U.S.

The USPAS and the CERN Accelerator School (CAS) organize occasional joint sessions, the Joint International Accelerator Schools. One such event was held in 2014 in Newport Beach, CA. Instructors and trainees were drawn roughly equally from the two regions.

Comment: The U.S. Particle Accelerator School has had a long and successful history, and the present three-year review period is no exception. The impact on the world accelerator community is clearly apparent and is vital for the development and training of the national laboratory workforce. It will be important for the next CoV to assess the efficacy of the new governance structure for USPAS that is being initiated now.

Appendix X: Summary Report from Facility Operations Subpanel

The operation of the HEP facilities Fermilab, FACET, and ATF, as well as experimental support for US-ATLAS, US-CMS and SURF, has gone very well despite continuous budget and resource pressure. The success of the facility operations is due in good part to close communication and coordination between HEP, the laboratories and the experiments, or facility users. Facility operations will remain successful as long as communication and coordination continue to be effective, priorities are agreed to and properly implemented, and the frequency and depth of reviews are appropriately optimized. Excellence in facility operations is an important ingredient to a world-class program.

Finding:

The Facility Operations and Projects Division funds operations of three national user facilities at Fermilab, FACET and ATF, plus experiment support operations for US-CMS, US-ATLAS, and SURF.

Comments:

HEP has initiated discussions about how to optimize operations and research across their complex of five national laboratories with major HEP funding, in an effort to determine how best to support as much of the P5 plan as possible if future DOE-HEP budgets are less than optimal. The organization of these efforts is under negotiation with the laboratories. The CoV considers this initiative to be important, but very challenging.

A series of ambitious large-scale projects have been launched or are planned within the DOE-HEP complex with schedules extending more than a decade into the future. These projects have compelling scientific justification consistent with the guidance of the P5 report. However, in an era of flat budgets, these projects would necessarily draw on resources that would otherwise support the accelerator operations programs. The new projects, together with a strong commitment to devote at least 40% of the HEP budget to the HEP research programs, have put pressure on the facilities operations budgets and staffing levels that are being felt now and threaten to become more severe in the years ahead. In the absence of funding increases, the CoV sees significant challenges ahead to ensure a healthy operations program while still allowing the major new initiatives to proceed on the anticipated schedules. The CoV was assured that a strategic plan for balancing resources and priorities among projects, research, and facilities operations is under development for a period extending five years forward. The need for this plan is implicit in Recommendation 3 in the Executive Summary of this report.

US-LHC

Findings:

U.S. LHC Detector Operations is supported by a combination of DOE and NSF funds. The responsibilities of the U.S. LHC Operations program include:

- The operations and maintenance of U.S.-built detector components for the ATLAS and CMS experiments.
- Support of U.S. Tier-1 (DOE), Tier-2 (NSF) computing centers, and the U.S.-CERN LHC Trans-Atlantic Network (DOE).
- Software and computing support of analysis
- Pre-project R&D for LHC detector upgrades in collaboration with international partners.
- Payment of U.S. share of ATLAS and CMS Maintenance & Operations common fund costs

The U.S.-LHC Operations budget was $56.9M FY2013, $54.1M FY2014, and $51.5M FY2015. The budget reduction between FY2014 and FY2015 is not expected to be a long-term trend but an attempt to deal with a large carryover from FY2014 operating funds.

The U.S. LHC experiments are currently performing Energy Frontier research, carrying out the U.S. LHC Operations program, and working on US-ATLAS and US-CMS upgrade projects for both the phase-1 and phase-2 upgrades.

The U.S.-LHC Operations is managed by the Energy Frontier program manager who is matrixed to the Facilities Operations to cover this responsibility with the assistance from other members of the Facilities Division.

Operation metrics have been defined to track performance for major operations tasks.

U.S.-LHC Operations is reviewed annually together with NSF. There is a semi-annual meeting of the Joint Oversight Group (JOG) to track Operations progress and discuss outstanding issues, and bi-weekly phone calls between DOE, NSF, and US-ATLAS and US-CMS.

Comments:

The current set of regularly scheduled reviews and meetings allow the DOE managers to effectively track U.S. LHC Operations performance. No additional reviews are required.

Operation metrics are well defined and effective in tracking operations performance.

U.S.-LHC Operation activities are well managed; however, the large collection of parallel activities in Operations, Research and, Upgrades is a challenge to carry out without schedule or re-

source conflicts. The management organization is good and the assignment of the Energy Frontier Program Manager to oversee the U.S.-LHC Operations is working very well. It is vital to the success of the U.S.-LHC program that operation, research, and upgrades continue to work together in an efficient and well-coordinated way.

The unexpectedly rapid increase in luminosity at LHC is generating demands to increase data storage and processing capabilities at the Tier-1 centers in the short term, stressing already tight operations budgets for the U.S.-LHC programs.

FNAL

Findings:

Fermilab is the premier accelerator facility for high energy physics in the United States. Since the end of the Tevatron run in 2011, Fermilab's programs have been directed primarily to providing and continuing to develop the world's most intense source of high energy neutrino beams and to developing a muon campus with the capability of delivering intense muon beams to the Muon g-2 and Mu2e experiments.

DOE oversight of the Fermilab accelerator developments has been managed through an ongoing series of reviews, including a comprehensive science and technology (S&T) review in 2013, an institutional review in 2015, and a detailed facilities operations review in 2016, as well as more narrowly focused reviews on ongoing projects. In addition, monthly reports provide detailed information on technical progress and achievement of performance metrics. Weekly telephone discussions between Fermilab and DOE headquarters personnel ensure prompt communication of new or unexpected developments.

HEP is looking into transitioning from a 12-18 month S&T review schedule to 18-24 month cycle.

Fermilab S&T and institutional reviews during FY2013-2015 have highlighted stresses on the Computing Division in meeting new demands for software and computing support for the short- and long-baseline neutrino programs, in addition to their other support roles. These demands seem especially significant for the new ProtoDUNE project. The laboratory was requested to develop a 3-5 year strategic plan for meeting anticipated computing needs, including hardware replacements as well as staffing issues.

The Proton Improvement Project ("PIP"), which consisted of a set of AIP and GPP projects to refurbish and upgrade several critical subsystems of the injector, booster, and recycler rings, has resulted in a proton beam power on target approaching 700 kW and is on the path to a PIP-II goal of 1.2 MW on target by the time it is needed for the LBNF program.

Ongoing improvements to proton beam power and to the Muon Campus at Fermilab have been managed via a succession of Accelerator Improvement and General Plant Projects, rather than as MIEs. The future PIP-II upgrade will be handled as an MIE project.

Partly in response to the external review findings, increased attention has been focused on the need for further maintenance and refurbishment of older accelerator systems and associated power supplies and related equipment. These findings have led to a "PIP Plus" program to address these concerns incrementally as opportunities and resources allow. "PIP plus" is anticipated to increase the proton beam power to 800 kW.

Comments:

Given the pressure on operations budgets during an era of substantially increased project funding and the criticality of Fermilab operations to most aspects of the P5 plan, a detailed review of Fermilab operations costs and risks has been essential. The COV is pleased to hear that such a thorough review was held in FY16. HEP is awaiting the laboratory's response to recommendations made by that review.

HEP monitoring and reviewing of the PIP and Muon Campus upgrades at Fermilab are being carried-out at essentially the same level as that required for MIE projects, even though these upgrades have not been funded as MIE projects. The upgrades appear to be proceeding well.

The success of the PIP accelerator upgrade projects and the continuing delivery of neutrino beams to experiments attest to the effectiveness of the management and oversight programs. The committee questions whether the frequency of external reviews and the overlap of charges to the review committees may exceed an optimum level. The burden on the labs and DOE may be exceeding the value of the reviews. HEP staff should be commended for considering the reduction in frequency of reviews where appropriate.

In response to the FY2015 Fermilab Institutional Review, the laboratory management has been requested to provide a more coherent and compelling plan for the Short-Baseline Neutrino program. This plan has been presented to HEP.

The computing needs of new projects are seldom covered adequately in project budgets, but rather place additional demands on operations funding that are often clarified late in the planning process. This tendency is likely to be a major concern in the future for both LBNF/DUNE and the HL-LHC era.

After the anticipated completion of the Muon Campus upgrades in FY2017, there are likely to be appreciably increased operations costs for the Fermilab accelerator complex. It is not clear that the laboratory has carefully evaluated these operations cost increases.

HEP is well aware of the budget pressures that will be introduced by transitioning from ongoing projects to operations at a time when LBNF/DUNE project funding will be ramping up and re-

search funding will continue to hover very near the desirable 40% budgetary threshold. Planning for these transitions will require more detailed and timely operations assessments from the projects and laboratories involved.

FACET and SURF

Findings:

FACET has successfully operated during 2013 through 2015 for unique pioneering experiments on an ultra-high gradient accelerator (2013), high-efficiency, two-bunch acceleration (2013), multi-GeV positron acceleration (2014), ionization injection and 100+ GHz metallic structures (2015), etc. These experiments were carried out by a wide variety of international participants from undergraduates to faculty members of both universities and laboratories. Machine availability reached 87%. It shut down in April 2016 for the installation of LCLS-II.

FACET is incompatible with LCLS-II. FACET-II will be a successor to FACET. It is being built during the LCLS-II construction to provide better performances with a new layout.

SURF is a special project based on the strong contribution by the South Dakota Science and Technology Authority (SDSTA). HEP is spending about $15M/year mainly for pumping water from the underground at the site and for lift maintenance and repairs.

A review of the SURF project is being planned.

Comments:

FACET operated at a very high availability level for a frontier facility. User access to FACET worked well considering that it was located inside an operating LINAC tunnel.

SURF is being run very well without any serious issues or safety concerns.

Appendix XI: Summary Report from Projects Subpanel

Findings: The DOE processes used to manage projects are well established and are effectively used by HEP. Except for comments below related to steps taken in the very earliest project development stages, we find that HEP is managing to a very high standard.

The portfolio is of very high quality and is developing rapidly into the recommended P5 portfolio.

The steps taken by HEP since the release of the P5 report are essentially consistent with the P5 recommendations.

The HEP Facility Operations & Projects Division managed around twelve projects with total project cost (TPC) greater than $5M in each year of this CoV period, (FY2013-2015). The CoV was shown fifteen projects managed by the Facilities Division. Of those fifteen projects, during the FY2013-2015 period: four completed CD-4 (APUL, BELLA, MicroBooNE, NOvA); seven completed CD-3/3A/3B (LSST, Mu2e, Muon g-2, LHC ATLAS Phase I upgrade, LHC CMS Phase I upgrade, LZ, Belle II); one completed CD-2 (DESI); and three completed CD-1 (FACET-II, SuperCDMS, LBNF/DUNE).

The range of projects includes small, mid-size, and large with TPC values between $13M and $1.8B.

Projects with costs below $5M are managed through the HEP Research Division.

Discussion acknowledged that there is a healthy pipeline of future projects headed towards CD-1 summing to ~1B or more (PIP-II, LHC Accelerator, CMS, ATLAS, CMB-S4) each of which is probably more than $100M.

The oversight process includes reviews, monthly reports, and oversight by the HEP Program Managers, Integrated Project Team, and the Federal Project Directors. The DOE Critical Decision process is followed with selective tailoring for small projects or unique situations.

In the performance tracking process, projects were mostly “green” and occasionally “yellow” but never “red” during the review period. This performance justifies the Division’s continuing flexibility to tailor the CD process to optimize project performance.

Matrixed staffing from the Research Division and the Associate Director’s Office augment the Facility Operations & Projects Division staff to help manage specific projects matched to staff member’s expertise. IPAs and consultants are also used when advantageous. It was reported that this approach provided adequate staffing and promoted coordination with other divisions.

HEP has responded to the P5 guidance and redirected the program in accordance with the P5 report. For example:

- Priority is being given to the LHC upgrades in the immediate future
- Priority is being given to the LBNF/DUNE and PIP-II program for the longer horizon
- Projects have grown to around 25% of the total budget, though, with LBNF/DUNE, PIP-II and the expected LHC upgrades, this fraction may grow to a higher level.

HEP tailors the level of management oversight for the size of the project, project readiness, and available funding, within the 413.3b guidance.

Application of the CD and reporting process in the early development stages (CD-0, CD-1) demonstrated that some projects were not sufficiently transparent and that their lack of readiness was not apparent in the reporting. It was reported to the CoV that in a few instances intervention by HEP through the cognizant Laboratory was not effective until a Laboratory Director's Review or Office of Project Assessment (OPA) review displayed the project's shortcomings.

The dark matter efforts LZ and SuperCDMS are each proceeding under strengthened laboratory management. In the case of LZ, strengthening has led to the project now being baselined and progressing through fabrication; in the case of SuperCDMS, strengthening is leading towards a CD-2 review in the coming year (July 2017).

Following recommendations of the P5 report, the LBNF/DUNE Project was formulated during this CoV period. The Project achieved CD-0, CD-1, and CD-3A Approval.

In the LBNF/DUNE project, an approximately $300M civil and caverning subproject was advanced by approximately three years by use of a CD-3A process conducted before the overall CD-2 review. This review was held in order to advance the execution of the high risk and long lead time excavation and caverning, to prepare the utility spaces for cryogenic systems required before the main technical installations in the project, and to demonstrate to international partners the U.S. DOE commitment to the project.

Comments: Tailoring of Critical Decisions has been used appropriately to match project scale, to address long lead procurement needs, and to mitigate early technical risk in projects. Splitting of construction related critical decision approvals into too many steps, suggested by project leaders in one case, could indicate a lack of understanding of project scope and related risks, and should be avoided.

For small to mid-size projects, additional HEP guidance and oversight during the pre-baseline stages may mitigate the risk of later cost growth. HEP should work to ensure that the expectations for that reporting are understood and adhered to by the projects.

HEP expressed surprise at the cost growth seen in some projects between CD-0 and CD-2. There are many factors that can lead to growth, including communication (see previous comment) and inexperienced project teams. However, cost growth can be normal as a project moves from a CD-1 cost range to a CD-2 cost baseline, as both the technical design and the

funding profile mature. While validating and ensuring the quality of a CD-1 cost range is important, it remains a cost range, and HEP should continue to work closely with the project teams through this phase. Again, transmitting expectations for each CD step is critical.

The development of the project portfolio has essentially followed the P5 plan. However, funding needs for the project portfolio will require new funds and/or funds beyond the nominal ~25% of the current HEP annual budget. This may impact other areas of the program such as facilities operations and/or forcing the research percentage below 40%. However, the addition of new funding into the budget may still allow the research budget to grow in dollar terms. HEP should remain vigilant to ensure an optimal balanced portfolio.

The LBNF/DUNE Project plan has captured all DOE contributions within an international context with crisply defined roles and responsibilities, with Fermilab serving as the host lab.

The LBNF/DUNE schedule has been advanced in part by requesting additional funding allowing for an earlier than anticipated CD-3A start on civil construction and allowing the project to buy down risk. However, if the full requested additional funding is not secured, HEP should assess the impact on the remainder of the portfolio.

Due to the initiation of the several P5-endorsed large-scale projects near the end of this COV period, it is a concern that few new small to mid-size projects will be possible for a number of years.

Recommendation 30: Re-evaluate the staffing needed to successfully support the multiple larger projects on the horizon.

Comment: The matrixing of personnel as project managers has worked well to date. However, with multiple larger projects on the immediate horizon, the role of the federal managers for each of these may be increased.