Department of Energy
Washington, DC 20585

JAN 10 2014

Dr. John Jaros
SLAC National Accelerator Laboratory
2575 Sand Hill Road, MS 43
Menlo Park, CA 94025

Dear Dr. Jaros:

I have enclosed the report of the Department of Energy (DOE), Office of High Energy Physics (HEP) review of the Heavy Photon Search (HPS) experiment held on July 11, 2013, at the Gaithersburg Hilton in Gaithersburg, MD. The goal of the review was an assessment of the plans for HPS to design, install, and commission its apparatus in time for data taking at Thomas Jefferson National Accelerator Facility in FY 2015.

I would like to thank you and your staffs for the clarity of the presentations and the general quality of the review. The review proceeded smoothly and the presentations by the HPS team were technically sound, well organized, and informative.

The review committee was favorably impressed by the review and its associated materials. They did, however, make several comments and recommendations which the HPS team should consider. Please address the review committee's suggestions and recommendations in a response to this office within the calendar year.

I hope that the review report is helpful to you in planning for HPS data taking in FY 2015. We look forward to the regular updates on HPS progress that you should provide to DOE HEP Intensity Frontier Program Manager Dr. Alan Stone.

Sincerely,

Glen Crawford
Director, Research and Technology Division
for High Energy Physics

Enclosure

cc: J. Gillo, DOE NP
S. Zimmerman, DOE NP
D. MacFarlane, SLAC
R. McKeown, TJNAF
H. Montgomery, TJNAF
S. Stepanyan, TJNAF
M. Holtrip, U. of New Hampshire

Division of Research and Technology
Office of High Energy Physics
U.S. Department of Energy
Washington, DC

U.S. DEPARTMENT OF
ENERGY

Report from the Review of the SLAC Heavy Photon Search Experiment

July 11, 2013
Gaithersburg, Maryland

Contents

1 Introduction

The Office of High Energy Physics (HEP) mission is to support a program focused on three frontiers of scientific discovery. At the Energy Frontier, powerful accelerators investigate the constituents and architecture of the universe. At the Intensity Frontier, very intense beams and highly sensitive detectors offer a second, unique pathway to investigate rare events in nature. At the Cosmic Frontier, natural sources of particles from space reveal the nature of the universe. Together these three interrelated discovery frontiers create a complete picture, advancing the Department of Energy missions through the development of key cutting-edge technologies and the training of future generations of scientists.

Experimental searches for heavy photons and other signatures of dark forces attract increasing interest for their potential in gaining insights into dark matter. As such, these experiments address important problems in both the intensity and cosmic frontiers of HEP research. One such experiment, the Heavy Photon Search (HPS) at the Thomas Jefferson National Accelerator Facility (TJNAF) has demonstrated the potential to significantly improve constraints on the mass and couplings of a heavy photon. HPS searches for heavy photons through two signatures: a narrow peak in the electron positron mass distribution in the reaction e-A→e-e+e-A' or an observation of detached e+e- vertices from the same reaction that have a spatial distribution consistent with that of decay of a finite lifetime neutral particle. The HPS experiment is co-led by John Jaros of SLAC, and HEP provides the support for the experiment through the SLAC group. To date, this support, provided on the basis of a positive outcome from an external merit review conducted by HEP in 2011, allowed HPS to install detector components at TJNAF for a test run utilizing a low-rate photon beam in 2012.

This document addresses the review of a new proposal from SLAC to install, commission, and take data with the full HPS experimental apparatus in FY-2015. The full apparatus would be installed in a downstream alcove on Hall B at TJNAF. Its components include a silicon vertex tracker (SVT), a data acquisition system for the SVT (SVT DAQ), an electromagnetic calorimeter (ECAL), a muon detector, a trigger system, beam line elements, beam monitoring, an overall data acquisition system (DAQ), and online and offline software. SLAC has primary responsibility for the SVT, SVT DAQ, and project management. French and Italian groups provide funding and support for the ECAL. TJNAF has responsibility for most of the remaining elements. Equipment, beam time, and physicist time from TJNAF are provided at no cost to HEP, but HEP must compensate TJNAF for some technician and engineering time. The muon detector is not part of the initial configuration of HPS; it would be an upgrade. The main technical challenges with HPS are operating the SVT very close to the high intensity Continuous Electron Beam Accelerator Facility (CEBAF) electron beam and handling the high DAQ rates.

Logistical and scheduling issues for HPS are complicated by the ongoing 12 GeV upgrade of CEBAF at TJNAF. The DOE Office of Nuclear Physics (NP) has imposed strict requirements that

HPS cannot impede progress on the CEBAF 12 GeV upgrade or the related CEBAF Large Acceptance Spectrometer (CLAS)-12 detector upgrade in Hall B.

2 Review Procedure

HEP prepared a review charge letter, presented in full in Section 5.1. The charge was sent to the SLAC HPS group on April 23, 2013. Its essential element consists of a request by experts in the field to evaluate the HPS proposal according to five standard HEP merit review points:

1. The quality and impact of the research by the HPS collaboration in the recent past;
2. The scientific significance, merit, and feasibility of the proposed research;
3. The competence and future promise of the HPS collaboration for carrying out the proposed research;
4. The adequacy of resources for carrying out the proposed research, and cost-effectiveness of the research investment; and
5. The quality of the support and infrastructure provided by the participating laboratories;

Five points more specific to the proposal were added:

6. Did the HPS collaboration successfully demonstrate the technical feasibility of its detector design in its 2012 test run at the TJNAF?
7. Has the HPS collaboration developed technical designs and construction and commissioning plans for its components (SVT, SVT DAQ, ECAL, muon detector, trigger, beam line, beam monitoring, DAQ, online and offline software) that are consistent with readiness to begin taking data in FY15 in the low energy beam (2.2 GeV, 1.1 GeV and if available 6.6 GeV) in Hall B at TJNAF?
8. Has the HPS collaboration identified and costed for the appropriate manpower and other resources consistent with readiness to take data in FY15?
9. Has the HPS collaboration presented estimates of cost and schedule that are consistent with readiness to take data in FY15?
10. Has the HPS collaboration developed a credible staging plan for installation of detector components that will allow for data taking in FY15?

The SLAC HPS group prepared a proposal (FWP 100176 dated May 13, 2013) that was sent out for review by six experts in the field, five of whom are high energy physicists and one of whom is a national laboratory project management specialist. These reviewers were also asked to be on a panel that would hear presentations from the HPS collaboration and have a chance to pose further questions about the HPS program. The experts delivered their reviews to HEP by July 5, 2013. The panel convened on July 11, 2013 at the Gaithersburg Hilton in Gaithersburg, MD, meeting for the full day. Representatives from NP attended all sessions of the panel meeting. Sections 5.2 and 5.3 contain the list of review participants and the review agenda, respectively.

The panelists produced a second set of reviews in a "findings, comments and recommendations" format that was presented to the HPS collaborators at the end of the day in the form of a PowerPoint presentation. The closeout report is reproduced in Section 5.4.

3 Summary of Merit Reviews

3.1 Standard HEP Merit Criteria (Charge Points 1-5)

Reviewers felt that the HPS collaboration consisted of many strong physicists; however some noted that few results have been produced by the collaboration itself yet.

Reviewer 4 summarized a common view: *"Let me say at the outset that the HPS collaboration is a strong group with many talented members who have a history of accomplishment in electron accelerator-based HEP. However, as a rather recent collaboration they have not been in a position to have completed any physics research yet."*

The merit of the work was deemed high by all reviewers; however, the technical challenges were recognized.

Reviewer 1: *"The heavy photon search experiment at TJNAF is an important component of the current experimental effort to understand the origin of dark matter. Until now, experiments have assumed that the lightest supersymmetric neutral particle is the most likely candidate for Dark Matter. The heavy photon experiment searches for alternative possible origin of dark matter. It is a worthwhile search given the large investment in experiments aimed at the direct detection of dark matter."*

Reviewer 2: *"The proposed research is very challenging given the enormous background rates and the high rate environment but the collaboration has laid out analysis strategies and a detector configuration that appear to be adequate for discovering these new particles if they exist. This has been backed up with test run data."*

Nobody had any issues with the competence and future promise of the research team.

Reviewer 5: *"The HPS collaboration is strong. Particularly, four highly reputable US and French national laboratories are involved, and the PIs are leaders in the field. There is no question about the competence, and the future promise is implicitly high."*

Panelists had generally favorable comments on the adequacy of research and the cost-effectiveness of the investments. Concerns were raised about the lack of a muon detector in the baseline design.

Reviewer 5: *"It is imperative to support experiment such as HPS with a high physics value per dollar. It seems the resources are adequate, and the cost effectiveness is great. It is tantalizing to think of the possibility of a heavy photon lurking around the corner and HPS will find it."*

Reviewer 4: *"The resources provided are adequate to meet the physics goals of the experiment. However, important components such as a muon system have been relegated to an upgrade or require external funding. It is important to note that since this is an exploratory search in a coupling region that hasn't been covered in the past, the more multi-purpose the apparatus can be, the better. "*

Laboratory support from SLAC and TJNAF was deemed excellent, although a reviewer noted that schedule complications would be much reduced if resources could be found to install HPS in Hall A at TJNAF.

Reviewer 3: *"Support from SLAC and TJNAF also seems good and bodes well. However, it seems to me that there would be much more flexibility in this whole project if the HPS experiment could be installed in Hall A, since it would be basically decoupled from CLAS-12."*

The head of the PPA division of SLAC and the Deputy Director for Science and Technology at TJNAF both attended the review and expressed their support for the experiment.

3.2 Successful 2012 test beam (Charge Point 6)

Reviewers felt that while the test beam run was largely successful, some open questions remain concerning the viability of the apparatus.

Reviewer 2: *"To a large extent, yes. The silicon alignment procedure was demonstrated to work and the detector occupancies were as expected once hot channels were removed. That probably retires the largest technical risk associated with the experiment. The calorimeter calibration was thorough and well documented. There are aspects of the silicon readout that will eventually need to operate in the vacuum but were not tested in this run. My guess is that the performance of those components in vacuum, near the beam, in the magnet, is probably now one of the larger technical risks."*

Reviewer 3: *"One particular item in these test run results sticks out to me though. The SVT was surveyed, but not aligned with tracks. The explanations that go along with Figure 50 in the proposal state that extrapolated track position resolutions at the HPS target at 10 cm upstream need to be about 100 microns. If I understand Figure 50 and the intrinsic resolutions correctly, it looks to me that this resolution will be about 300 microns, not 100 microns."*

Reviewer 4: *"I had to do a calculation from some of the tabulated numbers to make an estimate which led me to the conclusion, admittedly possibly wrong, that the rate of*

electromagnetic particle (photons instead of the originally proposed electrons) interaction in the targets was 10^4 times less than originally proposed for the test run. If this is true, clearly, in some respects the detectors have not been fully proven."

Reviewer 5: *"The simulated tracker and ECAL occupancies are particularly interesting. For the ECAL, the stated maximum rate is 500 kHz for hit over 100 MeV while some dead time is incurred when the FADC was read with hit above threshold of 75 MeV. Why is there any readout dead time assuming trigger rate is under control? Shouldn't the pre-amp be direct coupled and why not? "*

3.3 Readiness of Detector Design for FY 2105 Running (Charge Point 7)

Reviewers felt that for the most part the collaboration had a viable plan for running in 2015, although several emphasized that the schedule was quite tight.

Reviewer 2: *"Yes. Several components such as the magnets and beam instrumentation are already in place. There seems to be no major design iteration on the test run apparatus that was already demonstrated to work. The designs are advanced, in place, and well documented in the FWP. The schedule and spending profile are fleshed out to a high level of detail. Many of the required technical human resources are identified by name. The division of labor also seems to be well documented and well understood. The collaboration plans to perform engineering reviews as well."*

Reviewer 3: *"The good results of the test run are crucial here. If they had not done this, then I would say that they would not be prepared for such a tight schedule. But since they did have a successful test run, I would say that now they have a good chance of succeeding, but it will be tight if work in Hall B proceeds as planned for CLAS12."*

Reviewer 4: *"The collaboration has developed technical designs and construction and commissioning plans for its components, but I'm not sure if they are consistent with running in 2015. In fact I'm not sure how important it is that they adhere to this very demanding schedule which requires running interleaved with TJNAF 12 GeV upgrade construction. The proposal lacks a description of the experimental landscape including HPS's competitors that would give a context for their schedule. The schedule is quite detailed but difficult for me to evaluate. I note a lot of tasks are in parallel, especially in the electronics and DAQ sections which makes me nervous, given the size of the collaboration and the other activities of many of the members."*

Reviewer 5: *"The FY12 test beam provided invaluable knowledge and experience on rates and equipment technicalities. For designs and construction, it seems it is in very reasonable shape...However the commissioning of the full detector could be a very different story,*

particularly on the trigger and DAQ systems. It will be good to know more details in terms of implementation including manpower and timeline."

3.4 Adequate Costing of Manpower and Resources (Charge Point 8)

Reviewers believed that adequate resources had in the main been identified, but hey made a few suggestions:

Reviewer 3: *"I would add a technical coordinator to the labor costs, and perhaps a deputy."*

Reviewer 4: *"The manpower seems adequate, given the possibility of some relaxation of the schedule. Of course this would tend to raise the cost. There's no discussion of the cost contingency which makes it difficult to judge whether they have the margin."*

Reviewer 5: *"The collaboration has identified and costed for hardware. I assume there is enough manpower connected to each sub-detector or sub-project. However, it will be nice to see a breakdown on the anticipated number of engineers, postdocs, graduate students, and staff, and how much time they will commit on each of the major subsystem. The trigger FPGA software of various modules seems non-trivial. A detail discussion is needed."*

3.5 Costs and Schedule Consistent with FY 2015 Running (Charge Point 9)

Reviewers recognized that the experiment had a path towards running, but that it would be challenging to traverse this path.

Reviewer 2: *"The schedule contains several milestones and reviews that should enable the collaboration to adequately track progress and react to any delays. It would be helpful if the critical path was highlighted in some way...The requested funding profile matches the spending profile so as long as that funding profile can be maintained the experiment should be ready for 2015 running."*

Reviewer 3: *"I think there needs to be further discussion on mitigating risks in their preferred plan of installing downstream in Hall B and commissioning on nights and weekends while simultaneous activity occurs in this area during normal business hours."*

Reviewer 5: *"With the 'Hall B Downstream' plan and the proposed cost and schedule, it is possible that the collaboration is ready to take data in FY15. On the way to get high quality data, it will take time to commission, to fine tune subsystem, and to integrate the detector elements. I like very much the proposed ways to work around the Torus assembly once the accelerator is in operation in Q2-Q3."*

3.6 Credible staging plan for FY2015 Running (Charge Point 10)

Reviewers felt that the staging plan had a good chance to be successful, although one noted again the impact of not having the muon system in place in the first phase of running.

Reviewer 2: *"The collaboration has adapted their design so that they can be ready for taking data in FY2015. The changes still allow the core physics goals to be reached but I'm sure the collaboration agrees with me that the removal of the muon system represents a significant loss in physics potential. It would be nice to see what level of muon identification is achievable with E/p between the tracker and the calorimeter."*

Reviewer 4: *"The staging plan for running in FY15 is not completely worked out and is admittedly provisional. However I believe that as long as they have the good will of the TJNAF management, they have a reasonable chance to run before the completion of the 12 GeV upgrade."*

Reviewer 5: *"The more sophisticated the detector (and therefore the size of collaboration), the more detail of a staging plan is needed. HPS is not huge, but not small either. For example, because of the large number of tracker readouts, it is good to know about the cabling (signals and power) plan."*

3.7 Closeout Report Recommendations

The full closeout report is summarized in Section 5.4. Panelists, with major input from a national laboratory project specialist, made three recommendations, which are reproduced here:

1. Create (or maintain) a resource loaded schedule which includes the non-costed scientific time.
2. Add "off-project" interface milestones related to TJNAF's 12 GeV schedule to the HPS schedule.
3. Additional integration planning with TJNAF 12 GeV personnel relating to Hall B progress (regardless of the upstream/downstream decision) is crucial to HPS success. The HPS project team should clearly identify a technical coordinator to address these issues.

4 Program Manager Recommendation

A panel of independent experts strongly endorsed the physics program of the HPS experiment and issued qualified endorsements of the technical designs, construction and commissioning plans, and cost and schedule estimates. HPS can run in Hall B of TJNAF in FY2015 if it is provided with sufficient resources and can keep on schedule. However, construction activities associated with the CEBAF 12 GeV upgrade and associated CLAS-12 upgrade in Hall B present serious schedule risks.

The level of funding for each fiscal year will be set by the HEP program manager according to the needs of HPS, programmatic priorities within HEP and budget constraints. The funding

structure could be significantly altered at the discretion of HEP if conditions at TJNAF imply significant delays to the HPS schedule.

HEP funding for the HPS is therefore recommended on a contingent basis. The three recommendations from this review panel must be implemented. In addition, progress in the experiments and relevant developments at TJNAF must be reported to HEP and NP in regular monthly meetings and a written report submitted every quarter. A draft of the experimental operations plan (EOP) for HPS should be submitted to HEP by the end of the 2013. Finally, a progress review of HPS should be conducted within a year.

5 Appendixes

5.1 Charge Letter

Department of Energy
Washington, DC 20585

APR 2 3 2013

MEMORANDUM FOR ALAN STONE

FROM: GLEN CRAWFORD, DIRECTOR EC
RESEARCH AND TECHNOLOGY DIVISION
OFFICE OF HIGH ENERGY PHYSICS

SUBJECT: Review of the HPS Experiment

Experimental searches for heavy photons and other signatures of dark forces attract increasing interest for their potential in gaining insights into dark matter. As such, these experiments address important problems in both the intensity and cosmic frontiers of high energy physics research. One such experiment, the Heavy Photon Search (HPS) at the Thomas Jefferson National Accelerator Facility (TJNAF) has demonstrated the potential to significantly improve constraints on the mass and couplings of a heavy photon.

This letter is to request that you conduct a review of the HPS experiment on July 11, 2013 in the Washington, DC area. The purpose of this review is to assess the scientific goals of the HPS experiment, the technical plan for achieving these scientific goals, and the feasibility of the technical plan. A team of independent experts should be assembled who can provide you with cogent and considered input on these issues.

Specifically, we request an evaluation of:

1. The quality and impact of the research by the HPS collaboration in the recent past;
2. The scientific significance, merit, and feasibility of the proposed research;
3. The competence and future promise of the HPS collaboration for carrying out the proposed research;
4. The adequacy of resources for carrying out the proposed research, and cost-effectiveness of the research investment;
5. The quality of the support and infrastructure provided by the participating laboratories.

In addition, we would like answers to the following more specific questions:

1. Did the HPS collaboration successfully demonstrate the technical feasibility of its detector design in its 2012 test run at the TJNAF?
2. Has the HPS collaboration developed technical designs and construction and commissioning plans for its components (SVT, SVT DAQ, ECAL, muon detector, trigger, beam line, beam monitoring, DAQ, online and offline software) that are consistent with readiness to begin taking data in FY15 in the low energy beam (2.2 GeV, 1.1 GeV and if available 6.6 GeV) in Hall B at TJNAF?

3. Has the HPS collaboration identified and costed for the appropriate manpower and other resources consistent with readiness to take data in FY15?
4. Has the HPS collaboration presented estimates of cost and schedule that are consistent with readiness to take data in FY15?
5. Has the HPS collaboration developed a credible staging plan for installation of detector components that will allow for data taking in FY15?

I encourage you to interact with the proponents at the review and provide them with whatever immediate feedback you find appropriate. Upon the completion of the review, each peer reviewer should send a letter summarizing their individual findings and evaluations. These letters will be confidential within OHEP.

Based in part on the evaluations provided by the peer reviewers, you should compile a written report of your overall assessment of the HPS experiment by September 1, 2013. This report should include a recommendation on whether to fund the design, construction, commissioning, and operation of the first phase of the experiment for the period of FY14-FY16.

cc: J. Siegrist, DOE
M. Procario, DOE
J. Gillo, DOE
S. Zimmerman, DOE
J. Jaros, SLAC
S. Stepanyan, TJNAF
M. Holtrip, U. of New Hampshire
D. MacFarlane, SLAC
R. McKeown, TJNAF
H. Montgomery, TJNAF
S. Gonzalez, NSF
R. Ruchti, NSF

5.2 Review Participants

HPS R&D proposal review				
July 11, 2013	08:30-18:30	Hilton Gaithersburg	620 Perry Parkway, Gaithersburg, MD, 20877	
Estimated attendance	33			
	Last Name	**First**	**Institution**	
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	Bolton	Tim		
	Siegrist	Jim		
	Crawford	Glen		
	Procario	Mike		
	Marsiske	Helmut		
	Kogut	John		
DOE NP	Zimmermann	Sergio		
	Gillo	Jehanne		
	Barnes	Ted		

5.3 Review Agenda

7/11/2013

Time	#mi	Topic	Speaker	Comments	Session
7:30	60	Breakfast			Open
8:30	10	Welcome & HPS Charge	Alan/Tim		Closed
8:40	35	Executive Session with Panel		Discuss & Clarify Charge; Review questions on submitted materials from labs	Closed
9:15	15	Break		Setup for morning session	Open
		HPS Morning Sessions		Time allotted includes Q&A	Open
9:30	30	HPS Overview	John Jaros		Open
10:00	25	Beamline	Stepan Stepanyan		Open
10:25	35	Silicon Vertex Tracker	Tim Nelson		Open
11:00	25	SVT DAQ	Ryan Herbst		Open
11:25	35	Ecal and Trigger Performance	Raphael Dupre		Open
12:00	60	Lunch		Option for executive discussion	Open
		HPS Afternoon Sessions		Time allotted includes Q&A	Open
13:00	25	Trigger/DAQ	Sergey Boyarinov		Open
13:25	25	Software, Monitoring, Data Management	Maurik Holtrop		Open
13:50	25	Readiness for Electron Running	Takashi Maruyama		Open
14:15	25	Physics Reach/ Run Plan	Matt Graham		Open
14:40	35	Budget, Schedule, Management	Marco Oriunno		Open
15:15	15	Break			Open
15:30	120	Executive Session with Panel		Discussions, prepare and review for closeout.	Closed
17:30	15	Break			Open
17:45	30	Closeout Report and Discussion	Alan/Tim		Open
18:15		Adjourn			

5.4 Closeout Report

5.4.1 General Findings and Comments

- *Findings:*

1. Management from both SLAC and TJNAF were present at the review. TJNAF management is actively involved in coordinating HPS and the 12 GeV upgrade.

- Comments:

1. A Technical Coordinator may be needed during the installation and operation phase of the HPS experiment.
2. HPS could potentially produce the first physics publication from the upgraded Hall B at TJNAF.

5.4.2 Successful 2012 test beam (Charge Point 6)

- *Findings:*

1. HPS clearly had a successful test run in many ways. Without such a Test Run, it would have been hard to consider the tight HPS schedule credible.

- Comments:

1. HPS needs to fully analyze the test data and publish in peer-reviewed journals. This will help uncover possible problems. This is particularly true for the SVT alignment.
2. If you have 30k photoelectrons/GeV in the ECAL, is an APD upgrade going to help overall resolution?
3. The DAQ was only tested at 10% of final expected rate. HPS should consider high-rate tests of the full system before the full run.

- *Recommendations:*

1. None

5.4.3 Readiness of Detector Design for FY 2105 Running (Charge Point 7)

- *Findings:*

1. The design for the full experiment is based on the existing successful design from the Test Run.
2. Upgrades and modifications are evolutionary and modest, and several members of the collaboration are involved with software.
3. Given the experience at TJNAF, the beamline monitoring and operation are clearly in good shape.

- Comments:

1. Commissioning plans are not detailed enough, especially given the apparent short timeline for installation, commissioning and running. Doing this all on nights and weekends will require a very tight run plan with close cooperation and communication with TJNAF and Hall B managers (daily contact).
2. Online software development should continue so that they are able to quickly monitor and analyze data online during data taking. They could add a monitoring stream to the DAQ, for example.
3. A mock data challenge before running would be useful.
4. A high rate full system test as soon as possible is crucial since the Test Run was performed at only 10% of the expected rate
5. Consider techniques, like using extra targets and off-axis beam, to assist with aligning the SVT which will be crucial for needed vertex resolution
6. Offline software for the muon system was discussed, but muon ID using the ECAL might be a higher priority.
7. The collaboration should consider adding additional design reviews for the ECAL, DAQ, etc.

- *Recommendations:*

1. None.

5.4.4 Adequate Costing of Manpower and Resources (Charge Point 8)

- Comments:

1. A schedule which showed both hours and durations by task would have been most helpful in assessing the appropriateness of resources.
2. Essentially the same team that executed the successful 2012 HPS experiment will be responsible for the proposed experiment, which lends a level of confidence to the cost and schedule estimated.

- *Recommendations:*

1. Create (or maintain) a resource loaded schedule which includes the non-costed scientific time.
2. Add "off-project" interface milestones related to TJNAF's 12 GeV schedule to the HPS schedule.

5.4.5 Costs and Schedule Consistent with FY 2015 Running (Charge Point 9)

- *Findings:*

1. Estimated costs and schedule by task were presented.

- Comments:

1. Schedule slack is not specifically identified within task lines, which makes it difficult to assess overall schedule contingency.
2. It may be informative to make a copy of the schedule and perform a "what if" analysis, removing float from tasks and determining the earliest possible finish date.
3. A critical path analysis was not presented. It would be very helpful for reviewing and managing the project.

- *Recommendations:*

1. None.

5.4.6 Credible staging plan for FY2015 Running (Charge Point 10)

- *Findings:*

1. It has recently been proposed that the location for the HPS experiment be changed from an upstream position to a downstream position in TJNAF's Hall B.

- Comments:

1. A detailed staging schedule was not shown for either upstream or downstream option.
2. No ES&H milestones or reviews were mentioned.

- *Recommendations:*

1. Additional integration planning with TJNAF 12 GeV personnel relating to Hall B progress (regardless of the upstream/downstream decision) is crucial to HPS success. The HPS project team should clearly identify a technical coordinator to address these issues.