Fermilab

PPD Project Review of the COUPP 60 kg Detector

May 28, 2009

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1. Committee Charge

The committee is charged with reviewing the COUPP 60 kg experiment, including the status of the current phase in the NUMI tunnel and the proposed deployment in a deep underground site. The intent is to help prepare the collaboration for a CD-1 style DOE review (appropriately scaled to the size of the project) that will be scheduled for the fall. Specifically, we would like the committee to evaluate:

- Brief overview of the science goals for COUPP 60 kg and a comparison with other direct detection experiments
- Technical requirements and current status of the 60 kg apparatus
- Organization of the collaboration, particularly the management structure
- Status and plans for WBS, budget and schedule
- Deployment, commissioning and operations schedule for the NUMI tunnel
- Milestones to be achieved at NUMI before moving to deep underground site
- Evaluation of underground sites for deployment of the 60 kg apparatus after the NUMI run
- Deployment, commissioning and operations schedule and budget for a deep underground site
- Documentation and ES&H status
- Proposed funding plan

The committee should be familiar with the previous review:

http://www-ppd.fnal.gov/DivOffice/internal_rd/Reviews.htm

and the collaboration should be expected to address recommendations of the previous review committee in their presentations. We ask that the committee provide a written report jointly to PPD, FCPA and the COUPP collaboration within two weeks after the May 11 review.

2. The Committee

Fritz DeJongh
Debbie Harris
Kurt Krempetz
Ron Ray – Chair

3. Agenda

May 11, 2009
Location: Hornet's Nest (WH8X)

12:00 Executive session
12:30 Introductory remarks (Ray, Baller)
12:35 Overview of technique, collaboration activities and physics goals (Collar)
1:05 Project organization, schedule and budget (Sonnenschein)
1:35 Bubble chamber design and construction (Rucinski)
2:05 Data acquisition (Cooper)
2:25 Video and illumination (Hu)
2:40 Underground infrastructure, water tank and siting issues (Ramberg)
3:00 Summary (Sonnenschein)
3:15 Executive session
4:00 Closeout

4. General Comments

Technical competence is this group's strong suit and it came through loud and clear throughout the review. However, DOE Reviews are technical, cost, schedule and management reviews. In particular, the Project must convince the DOE that it can accomplish it's technical goals while living within a cost and schedule profile and that it has a team in place that can manage this process and react appropriately when things don't go according to plan. Developing and demonstrating this level of competence for the 60 kg system will be an asset as this group takes bigger steps in the future.

The history and status of COUPP can be confusing to reviewers who are not familiar with the program. The Committee strongly recommends that the Project focus as much as possible on the 60 kg device and clearly state what work has been completed and what work remains. For the scheduled Director's Review, the Project should focus on installation and operation of the 60 kg device in the NuMI tunnel. A separate request, and presumably a separate review, will be required for operation at a deep underground site. For future reviews, less technical detail would be appropriate.

In the sections that follow, we discuss each of the items in the charge.

5. Science Goals

Findings

The COUPP bubble chamber approach to the hunt for Dark Matter is very promising. Results published from the COUPP-2 run already provide the world's most stringent limits on low-mass WIMP-proton interactions. The plan for the COUPP-60 apparatus is to start with an engineering run at D0 with a natural-quartz vessel. A COUPP-60 run in the NUMI tunnel with a synthetic-quartz vessel would then significantly extend the science results and be a major step forward in the COUPP program. This step should achieve:

1) High live-time operation of the 60 Kg system in an underground site with a muon veto.
2) Demonstration of a reduced wall-rate with the synthetic quartz vessel.
3) Demonstration of improved fluid handling and CF3I purity to reduce alpha decays in the bulk.
4) Further characterization of acoustic signal differences between nuclear recoils and alpha decays.

The science-performance goal for the NUMI run is to achieve a background level of less than one untagged event per kg-day, compared to ~70 for the published COUPP-2 results. When this is achieved, along with reliable operation, efficient triggering, and high live-time, the collaboration would propose to move the COUPP-60 apparatus to a deep underground site, which would allow further efforts in background reduction with much reduced complications from cosmic-rays.

Comments

The committee finds the science goals to be compelling, and the criteria for moving to a deep site to be reasonable.

Recommendations

The committee has the following recommendations for improvements to the introductory talk for the Director's Review:

1) The science goals for the 60 kg NUMI run should be more prominently laid-out, and should include sensitivity curves assuming the background goal of the experiment.
2) The COUPP-60 experiment in the NUMI tunnel should be more clearly described as a step in the context of the overall COUPP program.
3) The acoustic signal R&D should be described more as an integral part of the COUPP program, rather than a parasitic appendage.

6. Technical Requirements and Status of the 60 kg Device.

Findings

The background goal for the 60 kg run on the Fermilab site is < 1 event per kg per day.

The muon veto requirements vary depending on the location of the 60 kg device. In the MINOS cavern the rate of cosmic rays results in about 100,000 background neutrons in a 200-day run. No realistic veto will work under these circumstances. At Soudan the rate is down by a factor of 1000 and most veto technologies will work. At Snowlab, the cosmic ray rate is sufficiently low that no veto is required.

The design torque for the quartz to metal seal is 40 ft-lbs resulting in a gold seal leak rate of 10^{-6} mbar –l/s.

The trigger and DAQ are required to photograph a well-illuminated, sensitive, bubble chamber at ~100Hz with VGA resolution (480X640) Black and white cameras and to signal a trigger when an image changes. It must operate reliably at a remote location. The lumens per pixel required from the backlighting system have been determined experimentally and has a safety factor of 2 built in.

There are three significant installation steps for the 60 kg detector: cleaning of inner vessel, assembly of the clear vessel with the flange and bellows and insertion of the vessel assembly. A class 100 or better clean room is required for assembly of the vessel with the bellows. The insertion stage for the MINOS location will be above ground, but for a deep site, it will be at the final detector location. This requires a minimum 17-foot hook height, with a gantry or monorail crane.

The infrastructure requirements for a deep underground site were presented. They include specifications for assembly space, power requirements, compressed air, networking and off-hours access.

The controls and hydraulics systems were commissioned last year.

Operating point and fatigue analyses of the expansion chamber have been performed.

The high purity final bubble chamber exists as an unassembled expansion assembly and synthetically fused silica jar. It needs to be cleaned and assembled.

The design for a high purity fluid handling system is completed. It remains to be commissioned and validated.

Comments

The technical requirements could have been presented more clearly and concisely. The technical requirements that were described were scattered throughout many presentations, making it hard to get a clear handle on what the technical requirements were. Many of the technical requirements seem to be defined as "do the best you can".

There is, no doubt, a long list of technical requirements for the bubble chamber but they were not described.

In Ramberg's talk the neutron background rates from cosmic rays were well described for the various locations where the 60 kg device might operate but the actual requirement for background rate was only presented in Collar's talk.

The assembly requirements were reasonably well documented but the requirements for cleaning the inner vessel were not given.

The infrastructure requirements for the experiment site were well documented.

The high purity fluid handling system was described but no purity requirements were given.

The current status of the 60 kg apparatus was mostly in the talk about Bubble chamber design and construction. The talk covered this subject matter well.

The status of the trigger, DAQ and lighting systems were well described.

Recommendations

1. For the Director's Review, the Technical requirements should be presented in a more organized and structured way. For every L2 system there should be a dedicated slide titled "Technical Requirements."

2. The minimum technical requirements required for a successful experiment should be described. Accompanying the description can be supporting statements describing how these requirements can be met or exceeded and what the benefit of exceeding the requirements might be.

3. In describing the status of the apparatus the Project should clearly delineate the tasks that have been completed, the tasks that are underway and the tasks yet to begin.

7. Organization of the Collaboration

Findings

The COUPP collaboration consists of 8 Fermilab physicists, 2 University faculty, 1 post-docs, 2 graduate students, and a few undergraduate students. There is also a large number of Fermilab technical staff that has worked at various levels of effort on the experiment. Because the collaboration is small, the management structure includes most members of the collaboration, and in fact in the organization chart presented includes several names listed in more than one place.

Comments

The organization chart that was shown did not include any ES&H specialist, nor did it include a project scheduler or budget officer. The talks later described interactions with ES&H and with Ken Domann to develop a schedule. The organization chart did not show any links with PPD, although clearly the experiment receives technical support and budget through PPD.

Reviewers may conclude that the project is spread too thin when they see people's names appearing in multiple organizational boxes. One way to address this would be to give, for each L2 activity, a concise description of the activity, the budget for that activity and the amount of work remaining.

For future reviews, a clearer discussion of interfaces between the various WBS elements would be helpful. For such a small experiment an "integration coordinator" need not be identified, but it would still be helpful to show that integration of the separate components has been considered.

Recommendations

1. Identify a single point of contact for ES&H and add that name to the Organization chart.
2. The budget and schedule officers who are already involved should be noted on the organization chart.
3. Acknowledging the advisory (and funding) role of PPD would help DOE better understand COUPP in the context of the laboratory.
4. For future reviews there should be a discussion of interfaces between the various WBS elements.

8. Status and Plans for WBS, Budget and Schedule

Findings

Sonnenschein presented a one-page summary of the schedule that includes 225 WBS items (including milestones), and described the schedule as having more detail for items that are on the critical path, and also as having less detail (but still some) for activities that have taken place in the past (since the schedule was only developed in the past month in preparation for the upcoming DOE review). The COUPP experiment has been operating for several years (since receiving stage I approval in September 2006).

Sonnenschein also presented the Fermilab SWF and M&S budget for FY09, broken down by both professional category (scientist, technician, engineer) and also by division (PPD, Computing, Accelerator). The SWF budget was based on a constant level of effort over the full year, given how much effort was reported through March 2009.

Comments

Because there is only a "high level of detail" in the tasks that are deemed to be on the critical path, it is hard to understand how far other tasks are from the critical path. Also, because only one summary of the schedule was shown, it was hard to evaluate much about the schedule itself.

The labor needs for COUPP were given in terms of Fermilab-based labor. It would be helpful to understand what level of effort is required from the University-based labor. Similarly, it was not clear if the M&S shown by Sonnenschein was the M&S needs from Fermilab for the remaining work to completion, or if these were the M&S needs for the entire fiscal year. It would also be helpful to see what the M&S budget authority is for COUPP this fiscal year, and whether or not there were university in kind (or NSF) contributions to this effort as well. Again because there was not much detail given in the

M&S budget request it's not clear if this budget is adequate to achieve the goals set forth by the experiment.

It would be helpful for management to create a schedule of "what is left to do" for WBS 1.x alone at similar enough levels of detail so that it is clear at least roughly how far each of the various activities are from being critical path, and to look at what the risks are for those activities to become the critical path.

Similarly, it would helpful for the management to describe what the M&S needs are for the remainder of the experiment, what the cost drivers are, and how uncertain those needs are. If the costs overrun that prediction, are there decreases in scope (or schedule delays) that could be made to still provide a maximum of sensitivity to dark matter.

There was some feeling on the committee that the schedule presented was aggressive.

Recommendations

1. The Project should work with PPD to open additional budget codes so that R&D costs can be separated from construction costs in the future.

2. The Project should resource-load their schedule and use this as the basis for labor costs. The schedule should also include any resource limitations that will result from the summer shutdown.

3. The Project should clearly identify the cost to completion as well as the costs that have already been incurred and a total project cost.

9. Deployment, Commissioning and Operations Schedule for the NuMI Tunnel

Findings

A schedule was shown that required 1 week for moving the 60 kg apparatus from DAB to the NUMI tunnel.

A duration of 1 month was scheduled to install the detector, fill it, review it and obtain the required approvals.

The schedule contains a 2-week commissioning period.

The experiment plans to finish testing of the device in PAB and begins underground installation at NuMI in early August.

Comments

It is not clear what level of effort is needed for underground installation.

The schedule for moving the apparatus seems reasonable. The schedule for installation and commissioning appears to be optimistic. The overall schedule did not appear to contain any contingency.

One of the primary objectives of the scheduled Director's Review will be the installation and operation of the 60 kg device in the NuMI tunnel. A separate request, and presumably a separate review, will be required for operation at a deep underground site. Working out the details for the NuMI site should be a priority.

Recommendations

1. The project should consider its resource needs in the context of the overall laboratory schedule. For example, is there work that will be delayed due to technician availability during the accelerator shutdown?

2. The Project should review the schedule for installation and commissioning and add appropriate contingency.

10. Milestones to be Achieved at NuMI Before Moving to a Deep Underground Site

Findings

The list of technical and scientific milestones that must be achieved at NuMI before moving to a deep underground site were described. In particular, a live-time fraction of > 50% must be achieved, an efficient trigger must be established, reliable operation must be demonstrated while the device is unattended, there must be less than 1 untagged background event/kg/day, the alpha rates must be lower that the background rate and the efficiency for tagging cosmic ray events must be > 90%.

Comments

The technical milestones that must be achieved before moving underground were clearly described by Sonnenschein. These criteria appear reasonable, specific and well though out.

Recommendations

None.

11. Deployment, Commissioning and Operations Schedule and Budget for a Deep Underground Site

Findings

The list of technical and scientific milestones that must be achieved at NuMI before moving to a deep underground site were described.

A deep underground site report is should be completed by mid-July that will describe the site options and estimate the cost for installation and operation.

Comments

A reasonable set of high-level tasks was presented for identifying and moving to a deep site. However, no cost or schedule was shown for deployment, commissioning or operation at a deep underground site.

Ramberg provided a good basis for comparison of various deep underground sites.

Recommendations

The deep underground site report under preparation should include a WBS, cost and schedule.

12. Documentation and ES&H Status

Findings

Sonnenschein showed a list of documents that had been written and a list of additional documents that they thought might be needed. The later category included a resource-loaded schedule, basis of estimate document and a document for deep site activities that includes a WBS, cost and schedule.

Comments

The list that was shown was relatively comprehensive. The committee did not look at any of the documents, so we cannot judge whether the existing documentation is adequate.

The one obvious omission from the list was a Project Management Plan (PMP). Because of the size of the effort a PMP need not be lengthy. Appropriately modifying the CDMS PMP would likely be sufficient.

It would be helpful for the collaboration to provide a more concise one-page summary of the schedule going forward, a WBS dictionary for the remaining tasks to be completed, and a more cohesive schedule for the steps between operations at NuMI and operations at a deeper underground site.

Recommendations

1. Produce a simple Project Management Plan, possibly starting from the CDMS PMP.

2. Update the WBS dictionary to clearly identify scope and deliverables.

3. Produce a simple basis of estimate document for the work remaining.

13. Proposed Funding Plan

Findings

No funding plan was presented at the review.

Comments

It is presumed that the collaboration will understand what the background levels are for the 60 kg device at NuMI within FY09, therefore no funding request for FY10 was presented. It would be useful for the collaboration to consider the possibility of delays in the summer that might lead to a need for funding for WBS 1 in FY10. Furthermore, the level of funding in FY10 to get to the later stages of this work should be presented to increase the possibility of those funds being provided.

Recommendations

1. Develop a funding plan that includes all of the activities that remain to be completed.

2. Develop a funding plan for completing activities in the NuMI tunnel. This plan should include M&S, engineering and technician effort as well as the effort required to develop a WBS, cost and schedule.

3. Develop a funding plan for evaluating deep underground sites. This plan should include M&S, engineering and technician effort as well as the effort required to develop a WBS, cost and schedule.