LANL EDM COST & SCHEDULE REVIEW

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Committee Members

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I. Introduction

The proposal, "A New Search for the Neutron Electric Dipole Moment", describes a new technique for measuring the neutron electric dipole moment (EDM) to a level of 1E-28 e.cm, which is more than two orders of magnitude better than the current best measurement. It has long been recognized that a measurement of the neutron EDM is a probe of fundamental symmetries in physics. It was first pointed out by Purcell and Ramsey in 1950 that such a measurement would be a test of parity, which was then considered inviolable. The first measurement by Smith, Purcell and Ramsey produced an upper limit of 5E-20 e.cm. For some years after that, there was little activity until CP violation was discovered and was linked directly with T violation via the CPT theorem. A measurement of a non-zero value for the neutron EDM is a direct indication of T violation that in turn implies CP violation. Thus a measurement of the neutron EDM is one of the ways in which the physics underlying CP violation can be probed directly.

The Standard Model (SM) prediction of the neutron EDM is at the 1E-31 e.cm level, far below the reach of even this proposed experiment. However there are many models that have been proposed, which are extensions beyond the SM and which raise up the predicted value of the neutron EDM by seven orders of magnitude from the SM limit. Most of these models will be severely constrained or even eliminated at the measurement level expected from this experiment. Moreover, New Physics, beyond the SM, could be exposed by this measurement.

In the 40+ years since the first measurement, increasingly sophisticated and sensitive experiments have reduced the upper limit on the value of the neutron EDM by about six orders of magnitude. Several techniques have been used during this time, but the more recent and sensitive experiments have all used Ultra-Cold Neutrons (UCN). This experiment was designed to take advantage of the new sources of UCN: LANSCE at LANL and SNS being constructed at ORNL. However, because of the time scales involved for getting the experiment set up and running, it has been decided to make the measurement only at SNS.

The measurement technique employed with UCN is to trap the neutrons and study their precession frequency when their spins are aligned in the plane perpendicular to a static magnetic field. Application of a static electric field parallel (anti-parallel) to the magnetic field will change the Larmor precession frequency of the neutron in proportion to the EDM. This proposal adopts the strategy of placing the neutron trap in superfluid He4, maintained at a temperature of 300 mK. In the trap, along with the neutrons, are atoms of He3 that are made to precess in the same plane as the neutrons. The measurement of the neutron EDM comes from a precise measurement of the difference in the precession frequencies of the neutrons and He3 atoms when a strong electric Field, parallel or anti-parallel to the magnetic field, is turned on.

The cryogenic operation necessary to maintain the neutron trap is essentially a scaling up of more modest operations and is, overall, under control. There are many difficult technical issues associated with producing and maintaining the neutrons and He3 atoms at the required levels in the superfluid and with the manipulations and measurements necessary under cryogenic conditions. A substantial number have already been addressed, though many remain.

The technical challenge of this project is being met through the extensive R&D program that the EDM Collaboration is carrying out in order to establish an optimal design for the experiment. This review was called to establish that the collaboration has, after a period of R&D, a better understanding of the cost and schedule, and the related project controls, than was possible at the time of the proposal submission.

II. Cost

The committee was asked to judge the cost of the experiment in FY05 dollars, and the adequacy of the contingency at this stage of development of the project. The estimate in the cost and schedule report provided to the committee in advance of the review (dated February 4, 2005) was $15.1M which broadly covers the PED, Construction, and Pre-Ops phases of the project. We note that it is critical for funding to become available to complete the R&D phase of this project as outlined in the 2005 R&D proposal in order to proceed to the PED phase with a solid foundation for the technical design decisions.

During the review presentations we learned that a typo had just been discovered in a cost spread sheet resulting in a correction of $300k in the project cost. The committee felt that the overall project estimate was reasonable, although several areas have the potential for modest changes, plus and minus. For example, the estimate for Project Management included just a part-time effort. We believe that in order to meet the project needs, one FTE of effort will be required. Depending on the final project management organization, this may be split between a Project Manager and the financial/schedule tracking support provided by a project office. The committee noted that in the current organizational structure, the experiment spokesperson and the project manager are the same person. In our opinion, this dual responsibility is not consistent with current DOE project management expectations, and may not provide the most effective control of cost, schedule, and performance. Correcting for the typo and the additional project management effort, the estimate is increased to approximately $16M.

Other areas which may lead to small increased costs are subsystem interface issues, spare parts, shipping costs, and the support equipment and tooling assumed to be available at the SNS EDM building. Examination of other areas may lead to reductions in the project cost, such as sharing technical decisions with the SNS FNPB project on the final beamline design. Also, the labor versus procurement split presented to the committee is certainly adequate for this stage of development. Closer examination may show that there is some double counting with a “contributed” university labor being inadvertently included in the project costs. Generally, we find the estimates for contingency are adequate for this stage of the project. We are comfortable confirming a cost for the PED/Construction/Pre-Ops estimate at $16M +/- $2M, with an upper bound of $20M if further checks are all additive.

III. Schedule

The neutron EDM collaboration presented a well-thought-out schedule which included detailed time estimates for both the design and construction phase of the experiment. Overall the committee was impressed with what seems to be a very realistic scenario for moving from the R&D phase to the construction phase of the experiment. But where appropriate, it would be useful to show more of the R&D work on the WBS. Some detailed comments concerning the WBS are included below.

The committee was pleased to see that the proposed schedule included reasonable float for major construction items. Without carrying out a detailed analysis, the committee felt that the schedule, including the float, was realistic. Several problems were noted with the WBS. The WBS dictionary elements include links to other items such as cost sheets, time estimates, and bases for estimates. While convenient for developing the worksheets, this is not the standard WBS dictionary format which DOE expects to see. Also a better breakdown of costs is needed in the WBS sheets. It is important to specify labor and parts separately under the general 'procurement' category. Items that are being purchased as a package from a vendor need to be clearly identified so that there is no ambiguity that those items do not require a further cost breakdown. An overall breakdown of labor versus parts is needed for the project in order to verify that labor costs are reasonable. The possibility of double counting labor costs should be carefully checked and eliminated if indeed it has occurred.

Defining the critical path items for the project is important. Developing a summary time-line of these items is useful to determine if the analysis looks correct. Avoid labeling WBS elements as critical path items just because they have a long duration. Milestones are needed throughout the project to provide convenient reporting points. Avoid bunching milestones into a small window of time. The use of 'install' in the present WBS is not commensurate with the meaning of this word at DOE and should be changed. Finally, WBS element 15 should be removed. Escalation should be incorporated into the overall budgets and not be listed as an item to be tracked.

IV. Profile

The committee felt that the funding profile proposed by the collaboration was overall quite reasonable; it appeared consistent with the needs of the experiment, while appropriately deferring costs whenever possible. The primary recommendation of the committee in this area was to separately identify the proposed contributions from DOE and NSF in the profile. Such a breakdown may mitigate what at first glance appears to be a potential problem: namely, the moderate spike in the requested funding in the first two years of the proposal, which is largely due to initial equipment needs. The committee felt that NSF is likely to be receptive to committing a large fraction of its contribution to equipment purchases at the beginning of the project, while DOE would likely prefer a flatter profile for its contributions over the time of the project. In this way, the combination of the two agencies' contributions could fit well with the total profile proposed by the collaboration.

In keeping with its charge, the committee discussed the possibility of a phased approach to funding for the neutron EDM project. The committee saw little benefit in such a phased approach, and instead strongly recommends that the start date and duration not be pushed far beyond the collaboration's proposed timeline.

This conclusion arose from several related points. First, it was noted that the neutron EDM collaboration has been engaged in an unusually long, intense, and successful preconceptual design program. This work has built a very substantial momentum for the project, even before submission of the proposal. The committee felt there was a danger of losing this momentum, should the start of funding be too long delayed. While a few scientific issues remain to be addressed by the collaboration, the strong track record of recent progress makes it appear very likely that these difficulties will be solved naturally during the design and construction phases as outlined in the collaboration's proposed timeline. In addition, it was agreed that the collaboration is unusually strong, with many distinguished members both from national laboratories and from top-ranked universities. Such active scientific leaders are likely to be drawn away to other projects if funding for the neutron EDM is not adequate to make timely progress. Finally, the committee noted the dangerous increases in total cost that can result from extending the duration of such a project beyond its natural timescale. These increases - due, for example, to increased escalation, and to the need to retain technicians on payroll over longer periods - can be substantial, and should be avoided if at all possible.

V. Conclusion

The review committee finds that the EDM collaboration has done a good job of studying costs in a short time and an outstanding job of R&D. The contingency (~35%) is adequate, and based on a full level of necessary R&D funding, the estimated cost for the PED/Construction/Pre-ops phases of the EDM project is $16M+-$2M (less than $20M).

The proposed schedule (FY07 start and taking data in FY11) looks reasonable with the proposed funding profile. Also, the contingency looks reasonable.

The committee is concerned that a funding delay will negatively affect the momentum of this important experiment and the coherence of this strong collaboration. We find that a phased approach to construction is not sensible. We hope that joint DOE/NSF funding can match the proposed funding profile.