PREX/CREX Experiment Readiness Review

(PREX/CREX ERR)

Wiki page https://prex.jlab.org/wiki/index.php/PREX-CREX

Review held June 2, 2016

This document dated June 27, 2016

Committee Members:

1. Ed Folts (observer)
2. Arne Freyberger (beam)
3. Javier Gomez (observer)
4. Dave Mack (chair)
5. Chris Keith (target)
6. Todd Kujawa (EHS&Q/electrical)
7. Bert Manzlak (EHS&Q)
8. Jack Segal (power supply)
9. Pavel Degtiarenko (radiation)
10. Mark Wiseman (septum)

1. **What is the operational status of the equipment?**

The major designs are preliminary. The experimenters have conceptual designs for the target system and shielding ready to be developed into a coherent system.

What are the completion/commissioning schedule and tasks?

No completion/commissioning schedule was presented.

Comments:

The target vacuum chamber and motion mechanisms for the target ladders appear to be critical path. With sufficient resources, they can probably progress to more detailed design and engineering phases within the next six months. Nevertheless, the timeline to complete the target by the spring of 2018 would be very tight. Design of support and alignment structure for the target chamber has not yet begun. Allocation of the necessary target group resources would require guidance from the scheduling committee.

Although some iteration will be required, the use of defined "keep outs" would reduce conflicts between parallel design work on the shielding, target, collimation, and optical transport system.

Recommendation:

The next ERR would seem to be the appropriate time for a detailed schedule and final task list. Completion plans and commissioning must be covered at the next review.

2. **Is the ^{48}Ca target geometry optimized for background suppression?**

Yes. (We interpret this to refer to physics measurement backgrounds. The site boundary dose issue is discussed under charge #8.) The existing ^{48}Ca target, tilted 45° from the beam axis, appears to be sufficient for the successful completion of the CREX program. Target impurities have been considered and shown not to be a problem. Studies at the University of Manitoba on the characterization and removal of the oxide layer from the calcium surface should continue and be incorporated into the target's preparation. Further thought must be given as to protecting the target from oxidation during and after the experiment.

Are local shielding and machine protection systems required to minimize detector background in place?

Yes, based on previous experience using a lead target. Detector backgrounds from calcium may be different, however.

Have the proper measures been taken to protect the ^{48}Ca target from oxidation?

Yes. Transfer under oil should prevent oxidation under normal conditions.

Comments:

Machine protection against accidental beam losses and mis-steerings should be considered and planned using the beam loss ionization chambers in the Hall.

Recommendation:

In the event of long term vacuum loss, or if the scattering chamber needs to be brought up to atmospheric pressure, we recommend that the ^{48}Ca target be protected with inert gas. The collaboration also needs to think about how to remove and store the ^{48}Ca target at the end of the experiment.

3. Have the proper measures to protect the ^{208}Pb target from melting been taken?

No. The collaboration anticipates some lead targets may melt even with the thicker 250 μm diamond layers. But based on PREX-I experience, a sufficient number (10) will be installed on the target ladder to ensure the successful completion of PREX-II.

Have measures been taken and defined to prevent and monitor density fluctuations?

Yes. During PREX-I, the experimenters demonstrated that precision synching of the FR to the reversal frequency made the density fluctuations negligible in the helicity correlated asymmetry.

Comments:

The general design of an array of lead targets sandwiched between foils of conducting materials such as diamond-like carbon or graphite appears to be a suitable for the PREX program. There is still time to investigate and test methods to improve the thermal contact between these materials, and/or find better alternatives.

Recommendation:

It is desirable to consider and develop an engineered solution to capture melted lead.

There remains a general lack of understanding of the failure modes of the target. Because the thermal conductivity of diamond is negligible near 4K, a steady-state analysis could conceivably miss the possibility of damage/melting from a too-rapid beam ramp. At the next ERR, the results of a time-dependent analysis from 4K to equilibrium temperature should be presented assuming instant turn-on of the beam.

4. **The septum magnet will be operated at higher current density during CREx. Has the safe and efficient magnet operation at this current density been satisfactorily addressed by the collaboration?**

Not yet. While the gap-shimmed, 3-coil septum appears (optically) to be a viable solution for both PREX and CREX with existing power supplies, additional testing is recommended to check that available pressure drops in Hall A can produce the recommended flow rate. Powered tests may be useful as well.

Is the water-cooling system adequate for the high current?

We were not presented with a convincing estimate. In addition to the two resistive septa and their two power supplies, there are two resistive HRS Q1's and their two power supplies, plus the power supplies for the HRS superconducting magnets: two Q2, two Q3, and two D.

Comments:

The idea was floated that additional shimming of the septum gap would reduce the current required (and hence the cooling water requirements). This has the potential however to reduce the vertical acceptance of the scattered beam envelope.

Recommendation:

A detailed LCW estimate should be presented for the entire experiment.

5. **Does the operation of the septum magnet produce any residual field along the beam line?**

The septum does not produce a significant dipole field, but saturation of the magnetic shield inside the septum yields a residual quadrupole field which magnifies the beam spot on the dump face.

If it does, has its effect on beam transport been evaluated and shielded properly?

See recommendations below.

Recommendations:

The experimenters should

i. Include the effect of the HRS Q1 fringe fields on potential beam deflection, then

ii. Check with Keith Welch that the magnified beam spot is safe for beam dump operation, or develop mitigation procedures.

6. **Have the EHS&Q considerations been properly included in the design of the equipment?**

While the collaboration appears to be on track in this matter, the designs were not at a stage were the details could be evaluated. This should be covered in later design reviews. Some examples of progress included:

i. Features such as the shared target chamber, and the collimator “coffin”, which will reduce radiation exposure to workers.

ii. The collaboration has identified and designated qualified design authorities for some equipment.

iii. The Hall A Lead Engineer demonstrated awareness of the EH&S engineering expectations and requirements.

Comments:

Particularly important areas include: activation of the target system and its impact on personnel during operation, changeover between PREX and CREX, and de-installation of the system.

Recommendation:

The next ERR should give particular attention to whether EHS&Q considerations have been properly included in the near final design of the equipment.

7. **Are the anticipated beam characteristics (parity quality, general stability …) expected to be within the required specification to perform these experiments?**

The beam quality is likely to meet the PREX-II requirements, as these requirements have been previously met in PREX-I. Measurements made during Spring 2016 suggest similar parity quality beam to the 6 GeV era.

Comments:

Parity quality beam for CREX may be more challenging due to the higher gradient and higher RF trip rate (~ 10 trips/hour).

Recommendations:

The Parity Quality Beam team should continue to establish robust parity beam diagnostics in the Hall-A line. Aggressively request the use of beam studies time during beam operations.

Prepare to study parity beam quality with CEBAF at near 2 GeV/pass during Fall 2016 and Spring 2017 beam operations.

8. **Are the radiation levels expected to be generated in the hall acceptable? I.e. has the impact of the radiation generated in the hall equipment and infrastructure been properly calculated and mitigated? This includes:`**
   o The scattering chamber
   o The beam-line downstream of the scattering chamber
   o The instrumentations (electronics, ...)

The Collaboration did a good job in evaluating radiation environment in the PREX-II/CREX experiments and has developed conceptual measures to mitigate the expected high prompt dose rates in the critical areas in the Hall, down to acceptable levels. The calculations are validated/benchmarked against other calculations and against experimental data from previous comparable experiments. The conclusions look quite reliable.

Comments:

It would be good to have a straw-man plan for teardown to reduce worker exposure and so this can be included in the designs of the components.

There were some questions on the element sizes used in the analysis downstream of the collimator, specifically the gate valve. This should be re-examined.

Activation calculations of targets, collimator, interaction region and the beam line should be finalized, to calculate mapping of the possible levels of radiation there, limiting the access to the equipment during the beam interruptions.

Evaluate robustness of the collimator cooling system, considering possible separate cooling water loop; evaluate the need to cool the additional tungsten surrounding the collimator.

De-installation plan should be developed as a part of the engineering design.

Recommendations:

Dose simulations for the HRS power supply platform should be checked against measurements during upcoming Hall A beam operations.

Based on the conceptual shielding design, the site boundary dose is approaching the limit *even assuming no Hall C operation* (primarily due to CREX running). To increase the confidence that the site boundary dose in a given calendar year will not be exceeded, and simplify multi-Hall scheduling, the collaboration should implement their idea of installing additional shielding over the ^{48}Ca target to reduce sky-shine.

Another iteration of the radiation calculations will be needed when the engineering design of the targets and the interaction region is finalized.

9. Are the responsibilities for carrying out each job identified, and are the manpower and other resources necessary to complete them on time in place?

The responsibilities are reasonably identified for this stage of the experiment.

Some amount of design and engineering time is needed in the near term to take the overall experimental set up to a more concrete level so that design concepts can be finalized. These resources are not “in place”.

Recommendations:

The experimenters should work with Hall A management to better quantify their design and engineering needs.

10. Has the equipment ownership, maintenance and control been defined during beam operations?

This was not as well defined as it could be, but there is still time to develop this prior to the experiment.

11. Are the specific documentation and procedures to operate safely and efficiently the equipment, in place and adequate? This includes demonstrated readiness for full rate capability and expedient analysis of the data.

The collaboration is clearly aware of the EHS documentation expectations. However, not all specific documentation and procedures are in place and adequate. Place-holders exist and responsible authors have been assigned which is appropriate for this stage. Time is more than adequate to bring these to completion.