Technical, Cost, and Schedule Review of the CLAS12 RICH

On October 13, 2015 a technical, cost, and schedule midterm review was held of the CLAS12 RICH detector project. The review panel, convened by Rolf Ent, included Thomas K. Hemmick (chair), Clara Matteuzzi, David Abbott, Curtis A. Meyer, Javier Gomez, Bob Miller, and Allison Lung. Formal presentations were given by P. Rossi (Overview, Management Plan), A. Kim (PMT), M. Contalbrigo (Aerogel), M. Turisini (Electronics), D. Orecchini (Mechanics), M. Mirazita (Mirrors), S. Tomassini (Installation & Integration), and S. Pisano (Software). E. Bartosz sat in as DOE observer.

All presentations were of excellent quality and reflected an impressive body of work and significant progress toward bringing the project to a successful completion. It is clear that the collaboration is talented, enthusiastic, and hard working. We also recognize substantial and critical support of multiple institutions, particularly the leading effort from INFN that have been necessary to bring the project to its current advanced state and will lead in the future to a second RICH detector sector.

CHARGE-1: The technical status of the project, including completeness of scope and fabrication progress;

Findings – Technical Status

1. The MA-PMT procurement and testing are well ahead of schedule.
2. The initial contract for the MA-PMT has been shifted from the H8500 to the H12700 model, and most of the contract will be for H12700 tubes. The team members expect to deploy the tubes in a geometry to minimize any impacts from the differences in the tubes.
3. The critical path item, as presented to the committee, is the Aerogel procurement.
4. Using the existing quality assurance criteria, only 17% of delivered tiles pass, lower than the 25% estimate used in project planning.
5. The detailed model of the MA-PMT performance will be an excellent reference document.
6. The FEE schedule has experienced slip due to MAROC production that does not affect the project completion date since it is not on the critical path.
7. The FEE have been tested for radiation upsets and show no change in the non-volatile memory, but a non-zero rate of volatile memory bit flips.
8. Engineers at Argonne are providing some design effort on WBS 7.5: Mechanics. An Italian company, TECNAVAN, has been identified which can perform mechanical assembly in situ and ship the three pieces directly to Jefferson Lab.
9. The RICH group has opted to change the design of the curved mirrors from a radius of 4.0 meters to 2.7 meters as a means of improving the delivery schedule by reusing an existing master.
10. Calibration software used to analyze test beam data is currently being upgraded for use with first beam data to allow for rapid demonstration that the RICH device meets the project KPP.

11. The FEE (MAROC ASIC and FPGA boards) for readout of the MAPMTs is a fruitful result of collaboration with the JLab fast electronics group. This FEE system is already being considered for several other experiments/detectors at the Lab.

Comments – Technical Status

1. The change in planned radius of the spherical mirrors will shrink the radius of the Cherenkov rings. The team should be ready to show that the new radius is still large enough so as not to impact performance. A measurement of the d_0 of the mirror after coating would be useful to confirm that the quality of the mirror is preserved. Also tests of the radiation resistance of the coating can be useful.
2. To the extent that reconstruction and calibration is added to the project, the deliverables should have minimal dependence on other CLAS-12 software.
3. Moving to a common data geometry description for both simulation and reconstruction should happen sooner rather than later.
4. It would be good to revisit all the Aerogel specifications specifically asking how they impact ultimate performance.
5. Analysis of the current data on radiation exposure of the FEE has just begun. The current rate of bit flips would have no significant affect if these applied only to the data itself, since accidental hits would be far below any realistic dark current expectations and missing hits would be far below intrinsic statistical fluctuations. The danger is therefore confined to volatile information used by the FPGA code (*e.g.* state machine variables or runtime parameters). These vulnerable values will likely occupy a tiny fraction of the programmed chip and could be alleviated to a large extent by programmed redundancy. Nonetheless, the collaboration should complete its calculation of the upset rate to quantitatively confirm the current indication that this is a manageable concern. In addition any further data on radiation tolerance for these electronics can be very helpful to other experiments using them at JLab.
6. Characterization of the MAPMTs after delivery is of the highest quality and demonstrates a thorough understanding of these devices. This is particularly important for new devices like the H12700.
7. Based on the current readout/DAQ design, there looks to be a minimum of 3-4 bytes of data per hit from the binary output of the MAROC chip. At the worst case occupancy defined in the TDR (20%), this corresponds to a 15KB event size from the RICH detector (391 MAROC Chips X 64 chan/chip X 3 Bytes/chan X 20%). At 20KHz the resulting data rate is around 300MB/s. This far exceeds the current practical limit for VME readout of 5 SSP modules in a single crate. Some form of sparsification or compression at the SSP will need to be considered.

Recommendations – Technical Design

1. The committee was convinced that the relaxation of the flatness constraint to 2.5 mm will not adversely affect the physics performance of the RICH. We therefore recommend that the collaboration pursue the aerogel remediation plan as outlined in their presentations.

Charge-2: The feasibility and completeness of the budget and schedule, including workforce availability.

Findings - Budget & Schedule

1. The RICH Program started on September 30, 2013 following a technical, cost, and schedule review at Jefferson Lab. A set of ~35 Level 1 and Level 2 milestones are being used to track schedule progress for nine WBS elements.
2. The total project cost for Jefferson Lab scope is $1,670K. Funds spent as of September 30, 2015 are $42K on WBS 7.1 (Project Management), and $1,061K on WBS 7.2 (MA-PMTs).
3. An updated schedule was presented showing ~6 month delay in aerogel procurement, ~7 month delay in production of FE and DAQ FPGA boards, and ~11 month delay in completion of mirror production.
4. Schedule goal is to complete the RICH assembly in time for a summer 2017 installation, with the aerogel procurement as the critical path item.

Comments – Budget and Schedule

1. Cost contingency should be held at the Project level rather than the WBS level. For example, the final contract cost for the MAPMTs was significantly below initial estimates which resulted in cost contingency that can and should be used to support other areas of the Project, as needed.
2. Prompt completion of the aerogel order will assist both in completion of production and in the project's ability to capture the benefits of a currently favorable exchange rate.
3. The cost of Argonne engineers working on WBS 7.5 (Mechanics) needs to be included in the project total since they are supported by DOE funds.
4. The costs associated with management of the Project through the extended FY18 completion date should be added to the plan.
5. The scope, deliverables, and cost of the proposed new Calibration effort should be further developed with detailed labor estimates, and included in the Program Management Plan.
6. The Project cost tables in the Program Management Plan and future presentations should be updated to reflect the standard DOE project management application of fringe benefits, overhead, and escalation to the base costs. A separate table should be used to show how contingency is estimated at the WBS level, and summarized at the Project level.
7. The cost contingency was estimated by the committee to be ~17% to ~21% depending on assumptions regarding overhead application and contingency for each WBS level. This is considered too low for this stage of the project given that there is significant material delivery pending for the aerogel, mirror, and FEE contracts.
8. The term "float" should be used in a manner that is consistent with accepted DOE project management tools. The use of a resource loaded planning tool with the inclusion of appropriate linkages will both generate and track consistent schedule float values. JLab has extensive in-house experience with such tools and the collaboration should fully exploit this expertise.
9. Together with the 12 GeV Upgrade project and the Physics Division, a detailed schedule for work on-site at JLab including contingencies should be developed to guarantee space is available when the RICH project needs it.

Recommendations – Budget and Schedule

1. The RICH project should work with JLab management to understand the estimate to complete (ETC), including project management through completion, Argonne engineers, and any new scope.
2. The project should add the appropriate calibration resources necessary to demonstrate satisfaction of the KPP.
3. The committee recommends 40% contingency on the ETC as warranted by the technical and schedule risks associated with aerogel and other remaining procurements.
4. The Program Management Plan should be updated by the end of calendar year 2015 to reflect the recommendations included in this report.

Charge-3: The installation plan and the integration of the RICH detector in CLAS12.

Findings – Installation and Integration

1. The RICH team has produced a new plan for RICH assembly that opts for use of the EEL building clean room (currently housing the CLAS12 drift chambers) rather than assembly on the Hall B floor.
2. This plan includes a dark room for mirror characterization and space for an assembly frame used for RICH construction.
3. The fully completed and sealed RICH is planned to be delivered as a single unit using a custom cart rolled down the Hall B ramp.

Comments – Installation and Integration

1. A more complete search of air-based cooling solutions should be conducted with consultation of the Hall B engineering staff.
2. Use of the clean room for mirror testing and RICH assembly should be compared to the existing schedule for clean room use. Contingency plans in case of slippage of this schedule should be formulated.
3. The collaboration should consider whether time/effort can be saved by adapting the LTCC lift fixture to the RICH needs rather than building a new one.
4. The Hall B ramp will certainly jostle the detector significantly. A complete estimate of the risks during ramp use should be made and include both loss of mirror alignment and possible damage to the aerogel (e.g. scraping of tiles upon their neighbors or their supporting wires) resulting is aerogel dust within the RICH volume.

Recommendations – Installation and Integration

1. The RICH project should provide all engineering calculations necessary to demonstrate code compliance for all appropriate equipment and operating conditions thereof.