BACKGROUND INFORMATION

▪ CHERENKOV DETECTOR ASSEMBLY

Dr. Huber's group at the UofR Physics Department is constructing a Cherenkov particle detector, which will be used at the Thomas Jefferson National Accelerator Facility (JLab), a U.S. federal research facility in Newport News, Virginia. The detector will be sensitive to various types of particle radiation used in physics experiments.

The vessel would be filled with high pressure C4F8 gas (a form of freon), to 1.7 atmospheres (absolute pressure). As high energy charged particles traverse the high pressure gas in the vessel, they will create Cherenkov light, which will be focused via 30 spherical mirrors onto photo-multiplier tubes (PMTs) viewing through ports around the edge of the vessel. As the C4F8 gas is quite expensive (US$50 k/fill), leakage of the gas from the vessel must be kept to a very low level. Furthermore, infiltration of atmospheric oxygen gas into the vessel (even when filled to high pressure, due to the negative partial pressure) must be minimized. In 2021, we completed a prototype of 1.3 sections of this detector, to verify that the detector design meets all requirements. We are now moving to the second stage, which is a request for funding from the Canada Foundation for Innovation (CFI) for the full-scale detector, consisting of 10 sections as described in Figure 1. For this, we are seeking a budgetary quote for the proposal to CFI.

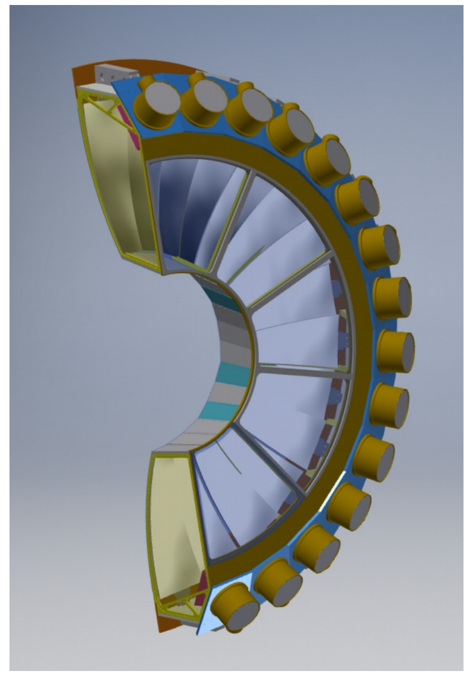

Figure 1: The right side of the Cherenkov detector, consisting of 5 sections. It is mirrored by an additional 5 sections at left (not shown). The two sections mate securely together to form a complete ring of 10 modules of detectors, with 3 mirrors in each

The request consists of two main tasks:

1. **Fabrication of the large machined parts.** Due to the size and quantity of parts required, they cannot be machined by the University of Regina Science Machine Shop. Therefore, we are seeking the parts to be made at a professional facility.

   The construction drawings have been prepared for us by our collaborators at Duke University, Durham, North Carolina. Note that all dimensions are in INCHES. A parts list, a bolt sheet, and drawings of all required items is attached. Sides with bolt holes have to fit snugly (with epoxy and/or RTV sealant) to hold the high pressure gas. The indicated pockets on several pieces are to allow internal part clearance and can be machined roughly with water-jet or other technique.

   Since the detector will ultimately be delivered to JLab, U.S. federal research facility, we are required to follow certain regulations to ensure they are legally able to take delivery of our item. Our construction drawings have undergone a thorough review by JLab engineers to ensure our design meets their pressure vessel requirements. All base material supplied, as well as all supplied bolts and nuts, must have Material Test Reports or a Certificate of Conformance to the ASTM specifications.

Note regarding parts list item SP-10-02-00 “Front window”: The 10 thin front windows (and 4 spares) will be fabricated from 0.040” thick aerospace-grade 2024-T4 alloy sheet. If it is difficult for the vendor to procure this material, one option is for UofR to order it from an aerospace supplier (e.g. ASM Aerospace Materials, Pompano Beach, Florida) and have it drop shipped to the vendor to be cut to the required front window size.

Also note that 1/8” O-rings are required for sealing the front window against the vessel.

Note regarding item SP-10-01-16 “Back window”: This is made of 0.25” aluminum sheet which is rolled to an 86.055” inside bend radius. Due to the rolling, special care is needed to make sure the back window holes mate with the corresponding holes on the ribs (SP-10-01-07). For the prototype, this was accomplished with some difficulty, by drilling the holes in the back window after it was rolled. Much time can be saved by drilling the holes prior to rolling the back window sheet, but in this case one needs to take the final rolled shape into account when drilling the holes on the flat plate. Please see the additional information in file 20210219_Proto_window_Fab_notes.pdf

Full setup step and 3D PDF (viewable in Acrobat Reader) are in files
HG_Cherenkov_Layout_202201_v3.0_flatreadout.stp
HG_Cherenkov_Layout_202201_v3.0_flatreadout.pdf

2. **Assembly and pressure testing.** During operation, the vessel will be filled to high pressure for data-taking periods extending up to 6 months long, then depressurized (with the C4F8 gas captured in a tank), before being filled again for the next data taking period. During each 6 month period, the vessel is expected to lose no more than 2.5% of its initial (absolute) pressure without top-up.

To ensure that the vessel is capable of safely holding the high pressure gas without leakage for an extended period, we will require that a pressure test be performed at the vendor facility prior to delivery.

We are open to alternate sealing suggestions from the vendor that will achieve a similar or better leak rate, but based on our experience with the 1.3 sector prototype completed in 2021, we have developed the following plan:

- After the parts are machined, the two halves of the vessel are separately assembled (5 sections each).
- Epoxy is generously applied to mating surfaces prior to them being bolted together. After bolting together, the epoxy is allowed to fully cure.
- Residual leaks are identified by methodically spraying the vessel joints with a soapy water mixture, and sealed from the inside with a low-outgas RTV sealant (e.g. DOWSIL

RTV 832). This step is iterated as required until all leaks have been identified and sealed.

- The performance is verified by successfully passing a two week holding test with <0.1 PSI pressure drop. With vendor approval, we might send a representative to witness the final pressure test prior to delivery.

Using a similar method (using only RTV but no epoxy), when filling the prototype vessel with dry air to an absolute pressure of 26.5 PSI (relative pressure 11.8 PSI), it lost only 1.5% of the initial (absolute) pressure over a 100 day period. We expect the use of the epoxy will result in significant time savings in the sealing process, and further improvements to the leak rate.

The cost estimate for both tasks 1,2 should be listed separately. There is no reason why the machining and assembly/testing tasks have to be done by the same vendor, but in this case it would be preferable if the two vendors are in close proximity to each other, in case corrections to the machining need to be made to ensure a good fitment.

The full application to CFI is due no later than June 1. We prefer to have the budgetary estimates no later than May 1, if possible. The actual construction is expected to occur in 2024-25, and we will include a budget contingency in the proposal for projected price increases between now and then.