SoLID Heavy Gas Cherenkov Update

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(on behalf of the HGC group)

Duke University

University of Regina

Stony Brook University

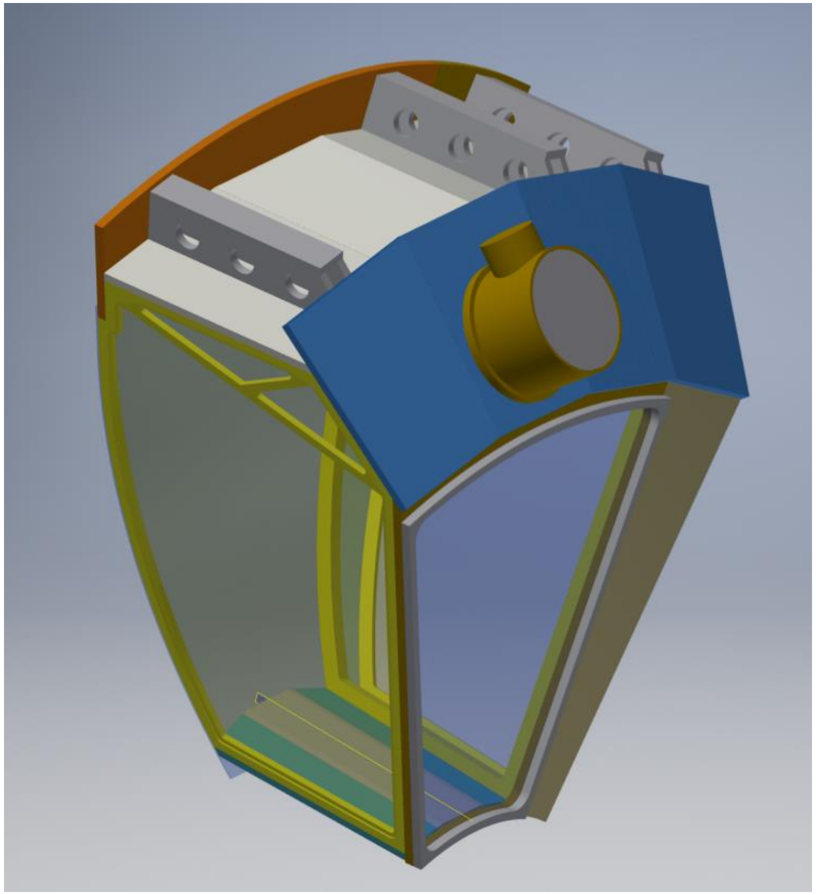
SoLID Collaboration Meeting. June 10, 2021

HGC Prototyping Update

C$125k grants allow the U.Regina group to construct 1⅓ SoLID HGC modules for testing

Questions to be addressed:

- Vessel leakage at 1.7 atm operating pressure (investigate design options)
- Vessel deformation at pressure
- Performance of thin entrance window (test several options)



Conceptual design by Gary Swift, Duke U.

University of Regina

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NSERC CRSNG

FRN: SAPIN-2021-00026

Vessel arrival from vendor March 30, 2020

Vendor:

IMM INDUSTRIAL MACHINE & MFG INC

Vessel arrived assembled, after vendor did dry fit to assure machining tolerances were achieved

Vessel weight: 700kg

Due to covid-19 shutdown, and some machine shop personnel issues, minimal work proceeded in the remainder of 2020. Work resumed in earnest in January 2021.

Item 1: Front Window Testing

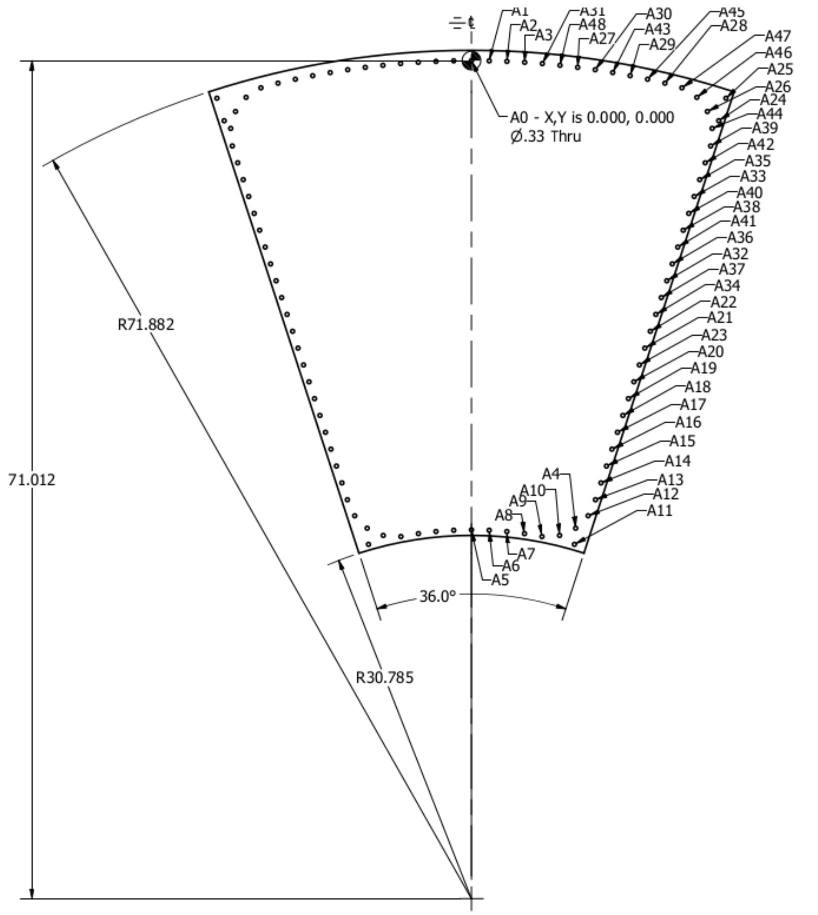
Sept 2019 SoLID Director’s Review:

“The main concerns about the Heavy Gas Cerenkov were focused on the large gas windows. It is clear that more testing/studies are needed...”

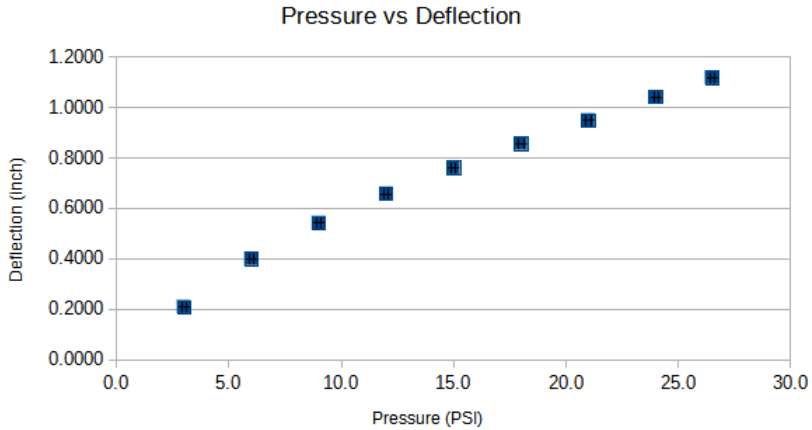
Verbally, it was suggested that we investigate a thin aluminum window, in addition to the carbon fiber entrance window already tested.

Material: 0.040” 2024-T4 Aluminum alloy sheet left over from the SHMS Heavy Gas Cherenkov. Two windows were made for testing. The PRAD entrance window also used the Hall C design.

Since the HGC vessel geometry had been adjusted since our original tests, a new window testing jig had to be procured



AL Entrance Window Test Results



Test Protocol (Whit Seay):

- C_4F_8 pressure is 1.7 atm absolute, 0.7 atm differential (10.3 psi)
- Need to test window to 2x differential pressure (20.6 psi, 1065 Torr)

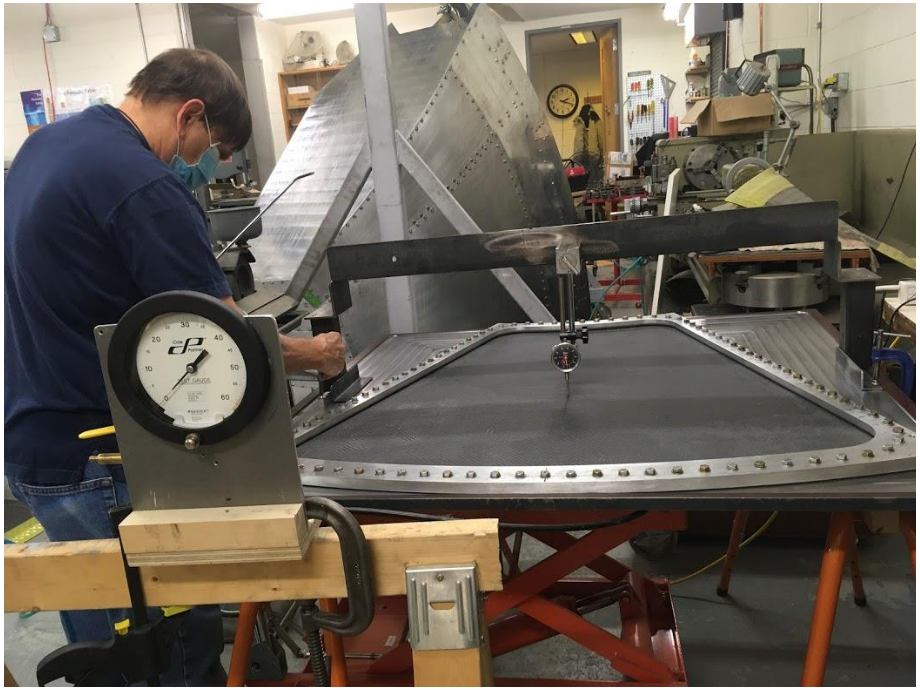
AL window performed well, holding the pressure for long periods of time with minimal leakage at 26 psi

- $Leak_{min}$=5x10^{-5} Torr-L/sec at test pressure (2.5 mg/day C_4F_8)
- Cannot discount some leakage was from test setup

Maximum deflection of the window was 4.5 cm at test pressure

- Window bulge flattens with time after pressure was removed (3.5 to 1.3 cm in a few days)
- Subsequent inflations had 1cm larger bulge than initial inflation

CFb Entrance Window Results



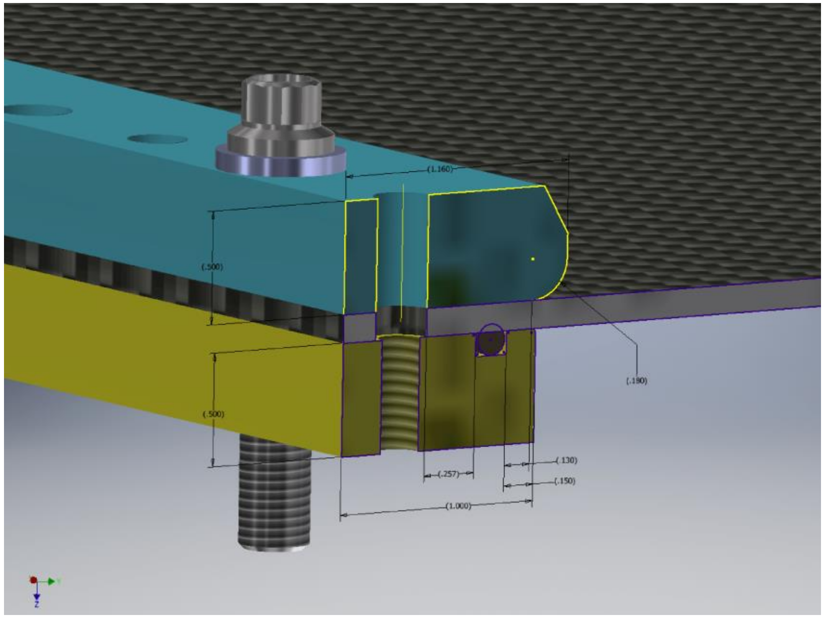
CFb window was made by a different instrument maker than earlier versions, with better 12k 2x2 twill weave vs old 3k 2x2

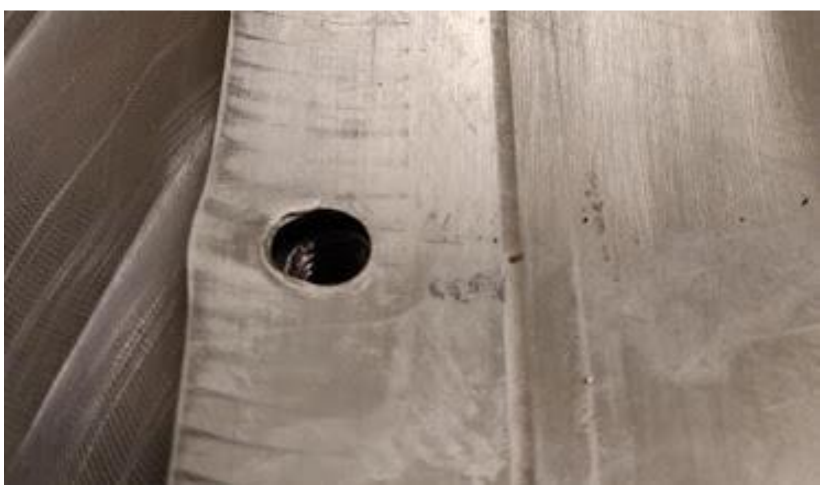
- First test was with Tedlar lining from CLAS-12 LTCC
- *Leak*$_{min}$=6.2x10^{-3} Torr-L/sec at test pressure (0.3 g/day C_4F_8)
- Second test was same Kevlar reinforced Mylar used in earlier tests
- The CFb bolt holes ripped during second test, causing pressure failure

Maximum deflection of the window was 4.5 cm at test pressure

- Similar bulge overall to AL, except that there was less relaxation after pressure release, and less change from initial inflation

Entrance Window Clamping





Gary Swift (Duke) significantly improved the window clamp design in 2019, following our earlier experience and input from Whit Seay

- Thicker window clamp
- More space between O-ring groove and window entrance

In addition to the CFb window slippage on previous slide, the AL window also experienced some slippage when the bolts were not torqued to a sufficient level of uniformity

This indicates the window clamp design is not yet sufficient

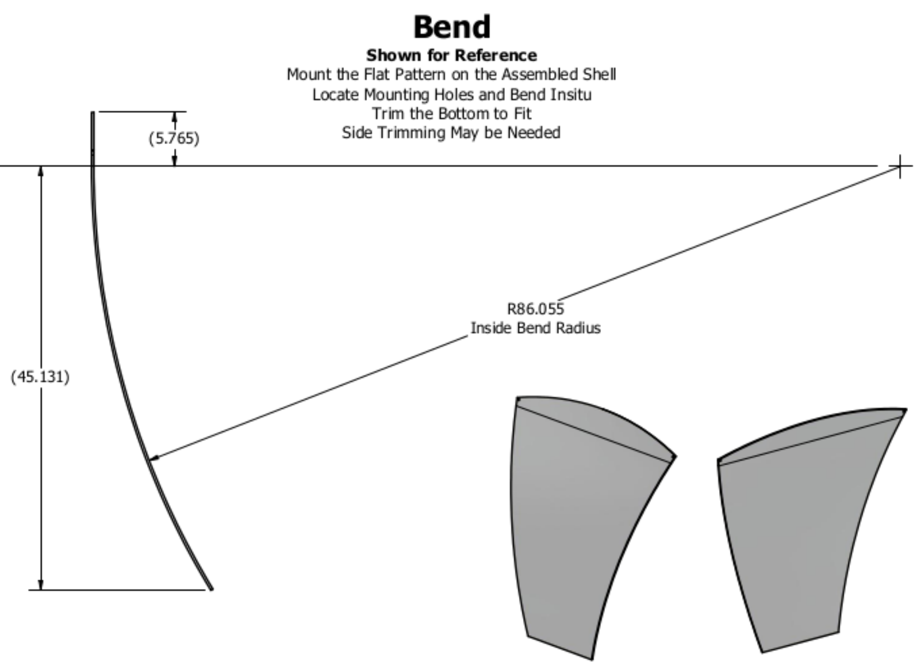
- Most likely, decreased bolt spacing is needed (Whit Seay), as increased bolt diameter requires a wider frame
- This will need to be tested again with project funds

Entrance Window Test Conclusions

- **The 0.04" 2024-T4 Aluminum Window met all performance specifications, tested at a higher pressure than specified by Whit Seay (2.5x operating)**
- Despite the good performance of our earlier Carbon Fiber Epoxy window (SoLID DocDB: 212), the non-repeatability of the procedure with different personnel and the failure of the new window indicates this is not a good design choice
- **Aluminum front window will be used for the HGC**

- The pressure differential range is similar (smaller) than for the SHMS HGC (where same window material is used), so further window testing should not be needed
- The new window clamp design is a significant improvement, but further refinement of design and testing will be needed with SoLID project funds

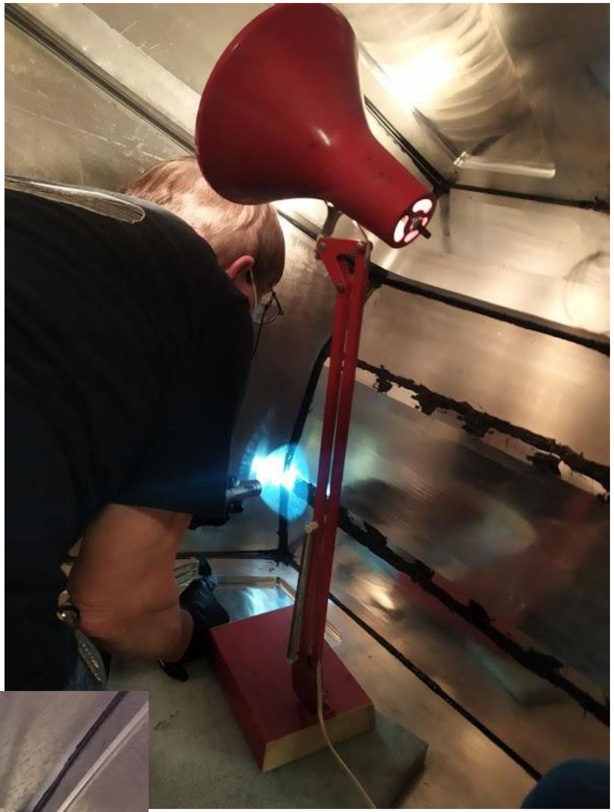
Item 2: Attach Back Window to Vessel

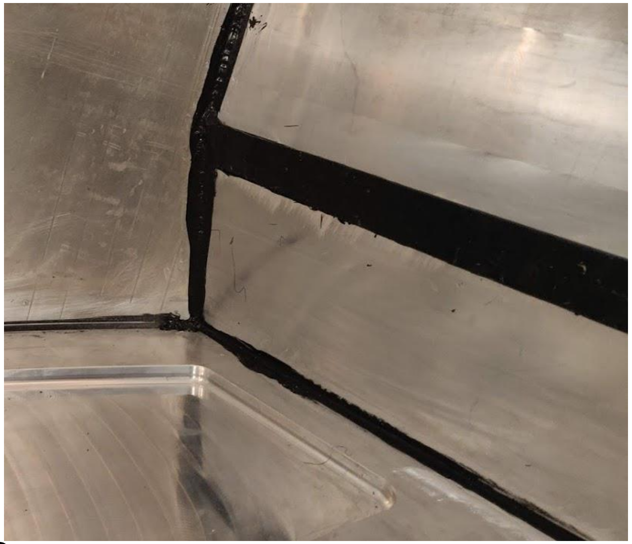


- Back window thickness (1/4” AL) and shape was optimized by extensive CAD modeling (Gary Swift)
- To ensure a good fitment (needed for pressure seal), the bolt holes were pre-drilled in the window only, and were transferred by hand to the vessel, which was then drilled to match
- This was a laborious process only for the prototype. The actual detector will need a much faster method.

Item 3: Vessel Leak Sealing

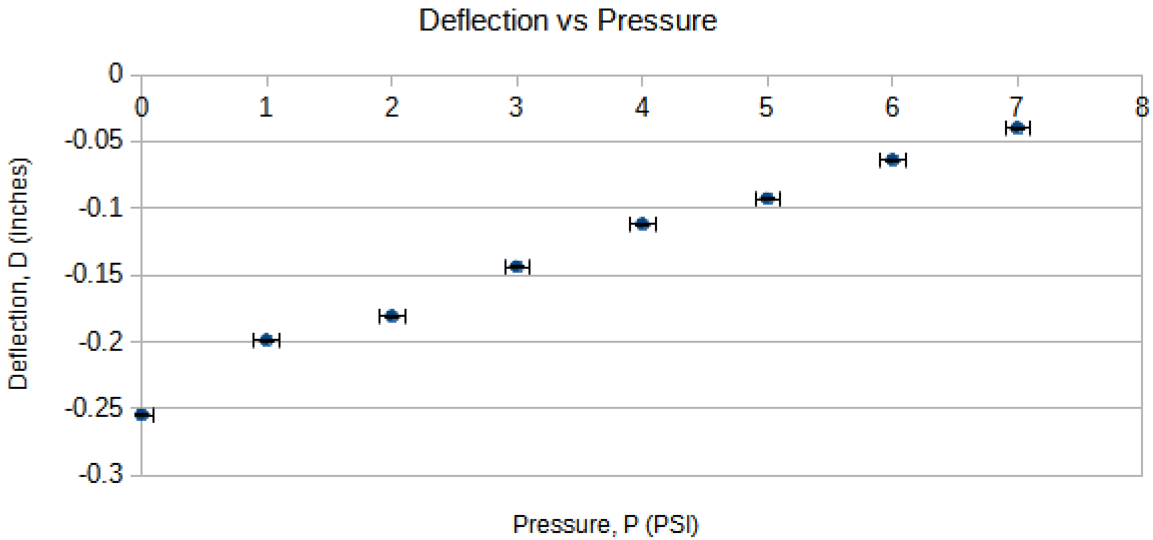
- Vessel was cleaned with ethanol, acetone
- Vessel joints then sealed using **DOWSIL RTV 832** sealant used also on the GRINCH Cherenkov. Minimal outgassing when cured
- Vessel pressurized with air compressor and large leaks identified using soapy water
- Scratches to the walls to improve adhesion and a large RTV bead got all of the joints properly sealed
- A few design mistakes were identified as leakage through bolt holes drilled too deep (almost through)





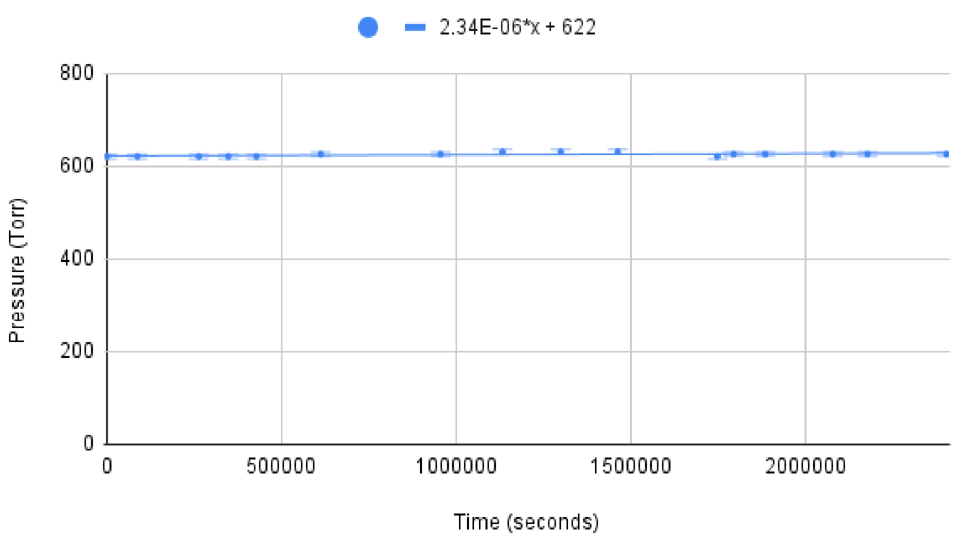
Vessel Side Panel Deflection Measurement

- Measurement of the deflection of the vessel side panel was made as it was deflated from 8 to 0 psi
- Window deflection of ~6 mm (0.25”) observed
- A second test at 12 psi is planned
- **Vessel is designed for 3x safety factor, but some clearance in SoLID will be needed to accommodate HGC “swelling”**



Vessel Long-Term Leak Test

- The most sensitive check for leaks was done following the procedure used on the GRINCH Cherenkov
  - The vessel was pressurized to 12 psi with a mix of 1% hydrogen/99% dry air
  - Leaks were identified with EzFlex Combustible Gas Detector (natural gas sniffer)
- **One month pressure test at 12 psi indicated negligible leakage**
- **Two month test with dry air in progress**



Test Protocol (Whit Seay):

- C_4F_8 pressure is 1.7 atm absolute, 0.7atm differential (10.3 psi)
- Need to test vessel to 1.15x differential pressure (11.8 psi)

Vessel Test Conclusions

- **Vessel design performed very well, and was able to easily accommodate the 1.15x pressure test (12 psi) for an extended period with no safety issues**
  - Our feedback on the design has been given to Gary Swift, and we expect these small improvements to be implemented in the final detector
- After some iterations, the **DOWSIL RTV 832 sealant performed beyond our expectations**, with negligible vessel leakage indicated after 1 month
- RTV performance depends on how well the sealant is applied. For the final detector, we propose for the vendor to apply epoxy between the vessel joints as it is assembled, and RTV used to do a final seal after individual sections are delivered to JLab for HGC assembly and testing

Acknowledgements

- Canadian HGC prototyping funds are exhausted, and final project closure reports are being prepared for the funding agencies (CFI and Fedoruk Centre)
- Two test result reports will be posted soon on SoLID DocDB
- **Huge thanks go to Dan Kolybaba, who was able to help us out between January and April!**

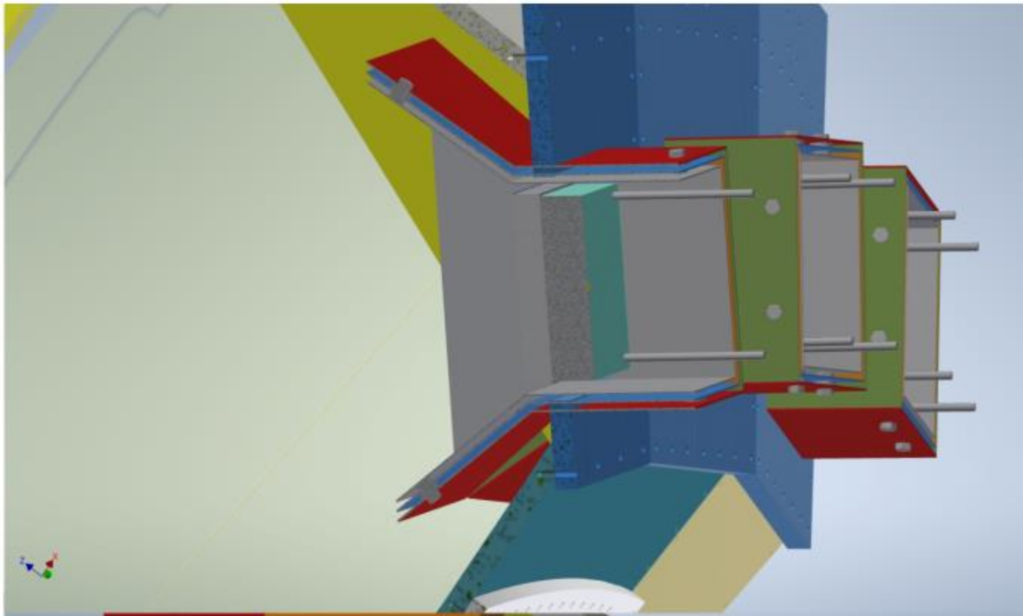
Thanks also to:

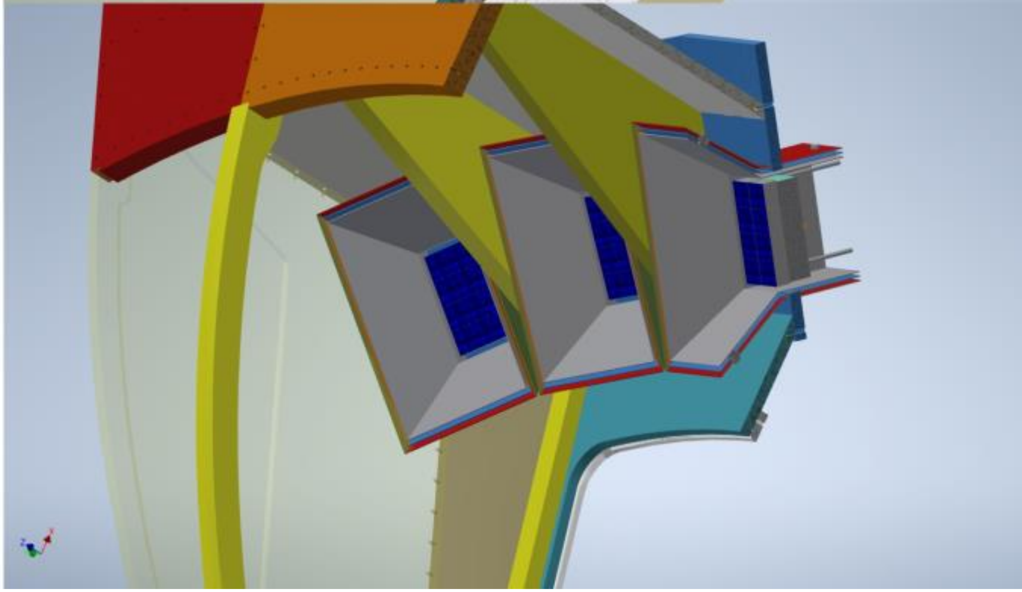
Emma Kirby, Co-Op student
Stephen Kay, PDF
Grad Students:

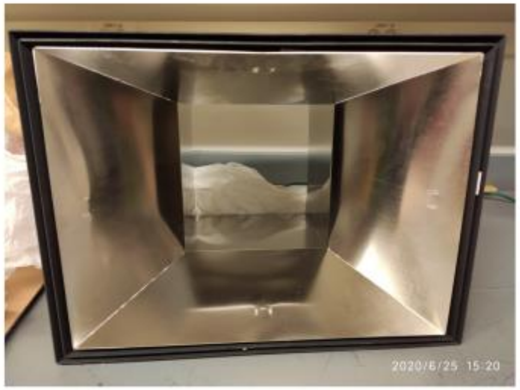
- Ali Usman
- Vijay Kumar
- Muhammad Junaid
- Nathan Heinrich

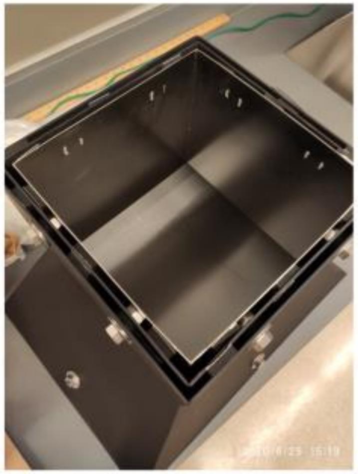
Once the Prototype is at Duke

- Make mockup shielding and readout assembly and test its mounting in the prototype
- Need to finish shielding test at JLab first



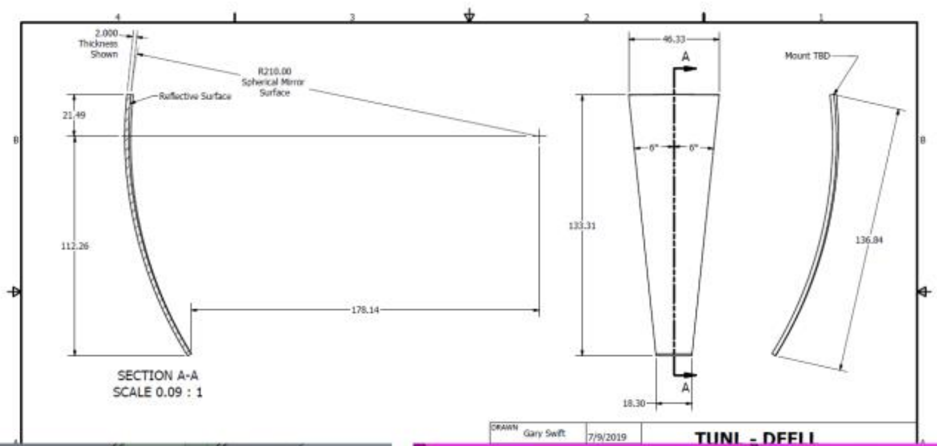


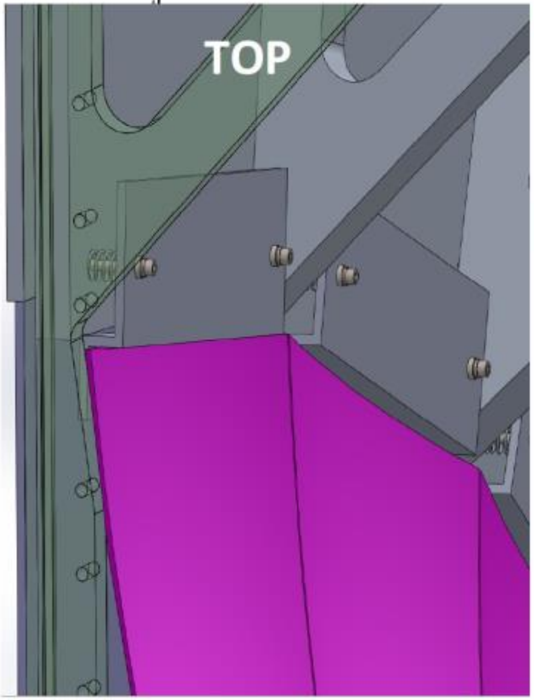


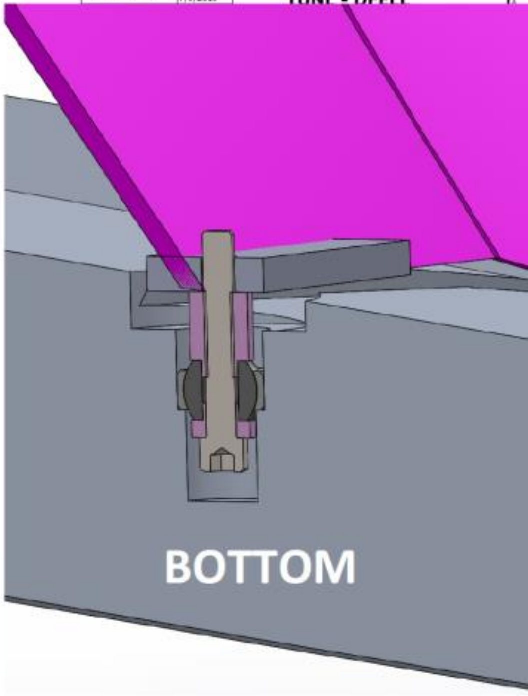


Once the Prototype is at Duke

- Make mockup mirrors and test its mounting in the prototype
- Need to work with LGC to identify proper mirror base







Mirror Coating Facility at SBU

Stony Brook University

- Evaporator installation complete
  - Commissioning completed
  - First evaporation performed




Mirror Coating Facility at SBU

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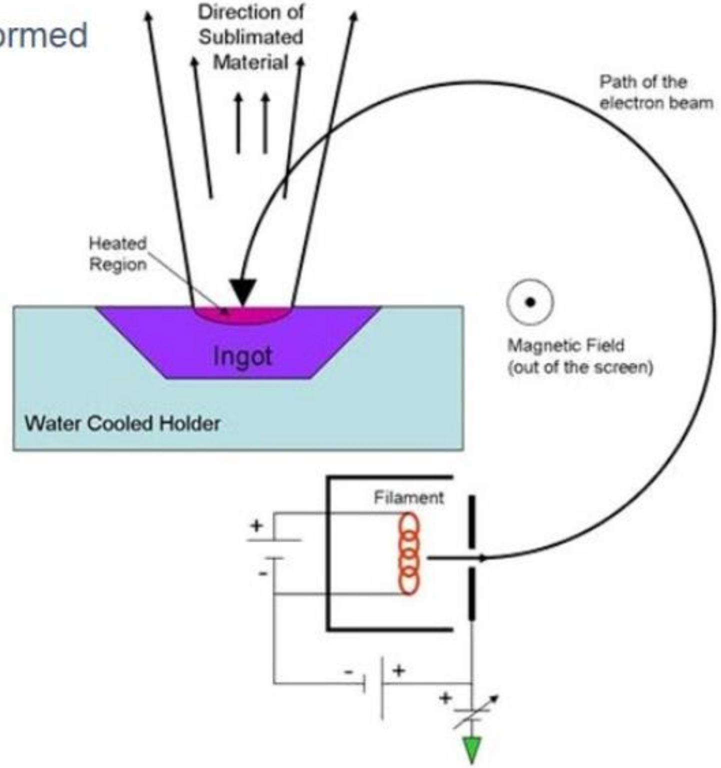
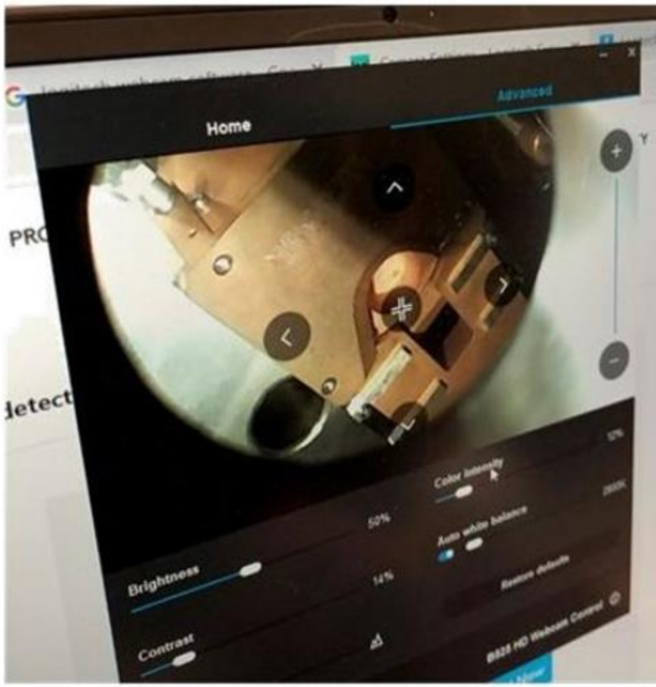
  - First evaporation performed



Live camera picture of e-beam



Mirror Coating Facility at SBU

Stony Brook University

- First real application in progress
  - TPC central membrane evaporation → IBF calibration pattern