APS UPGRADE SUPERCONDUCTING UNDULATOR VACUUM CHAMBER DESIGN

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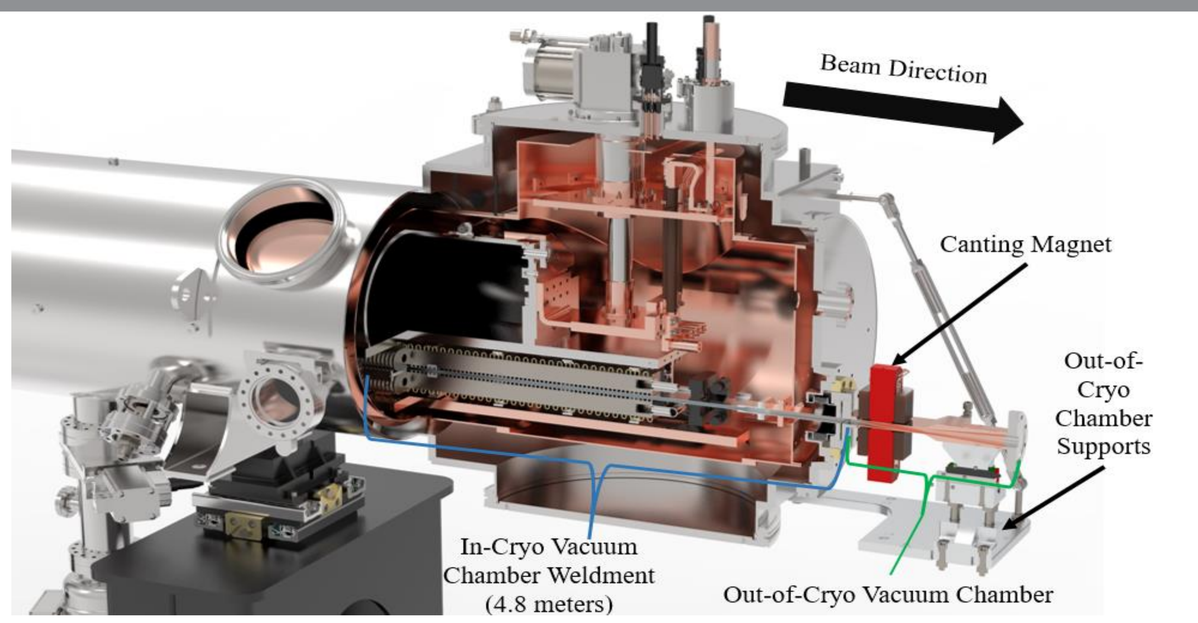
INTRODUCTION

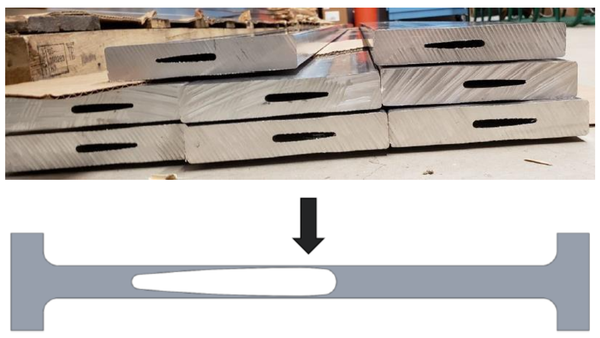
The Advance Photon Source Upgrade (APSU) project plans to retrofit the current APS Storage Ring (SR) with a 6 GeV, 200 mA SR optimized for brightness above 4 keV. Four (4) of the forty (40) Straight Sections (SS) will be equipped with Super Conducting Undulators (SCUs) which will produce photons at various energies to ID beamline users based on their needs. Two (2) sectors will be canted and two (2) will be inline configurations.

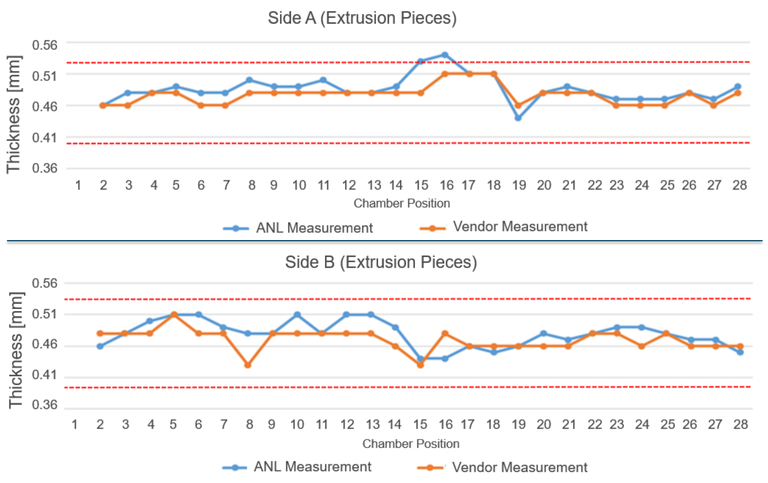


IN-CRYO VACUUM SYSTEM

EXTRUSION

- Al 6063-T5 prime material
- Oversized outer geometry with tighter tolerances on aperture
- Aperture geometry allows radiation fan to pass through system without depositing the heat load on the chamber wall
- Inner surface has mirror finish (polished die)



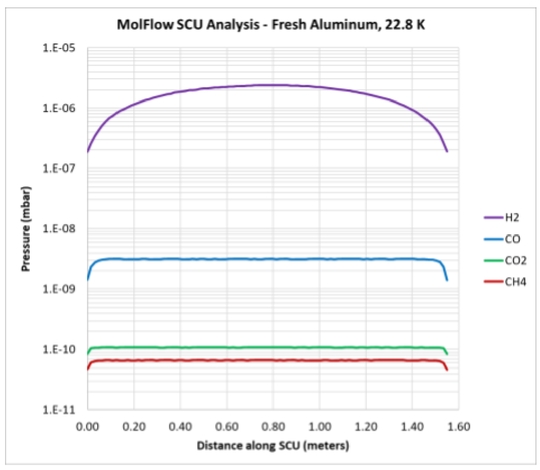


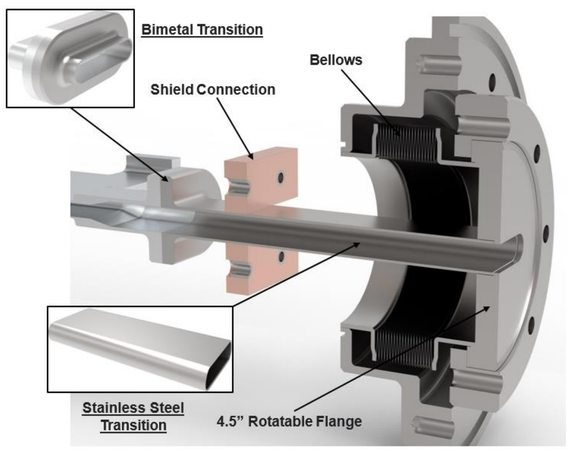
FABRICATION FEASIBILITY

- Machined to a $400\mu m$ thick wall on top and bottom
- Test machining completed on a similar geometry
- ANL verified measurement

VACUUM PRESSURE

- Vacuum Pressure Requirement: $< 2.0\ x\ 10^{-10} Torr$
- Conductance limited resulting in cryo-pumping requirement
- Sticking probabilities and outgassing rates empirically determined at CERN as a function of temp.
- Operating temperature $< 20K$ to achieve optimal pressure profile through the chamber

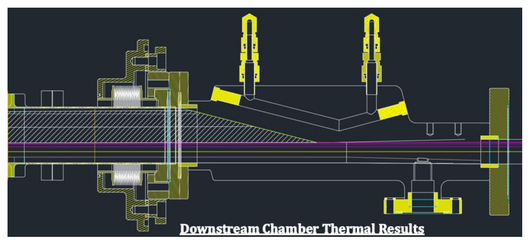




THERMAL CONSTRAINTS

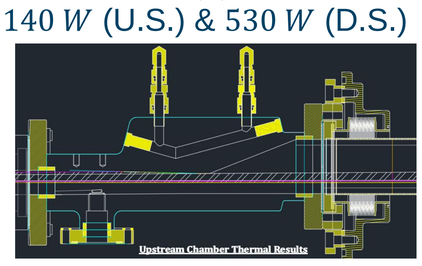
- Chamber Operating Temperature: 20 K
- Magnet Operating Temperature: 4K
- Copper Shield Intercepts: 35K
- External Temperature: 25.6°C
- 14mm max. contraction at both sides
- Bellows accommodates with $FOS > 3$

OUT-OF-CRYO VACUUM SYSTEMS



RAYTRACE

- Ideal and Off-orbit cases considered
- Peak Power Density: $13\ ^{W}/_{mm^2}$ (U.S.) & $6\ ^{W}/_{mm^2}$ (D.S.)
- Total Power: $140\ W$ (U.S.) & $530\ W$ (D.S.)

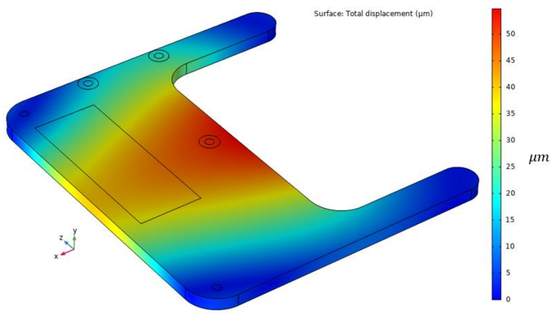


FABRICATION PROCESS

- Uniform System for Canted & Inline Configurations
- Magnetic Gap: 13.5 mm with clearance Gap (top & bottom): 0.5 mm
- Aperture Height: 10.3 mm with 1.0 mm wall thickness
- Braze before final machining and welding to avoid deformation in internal area

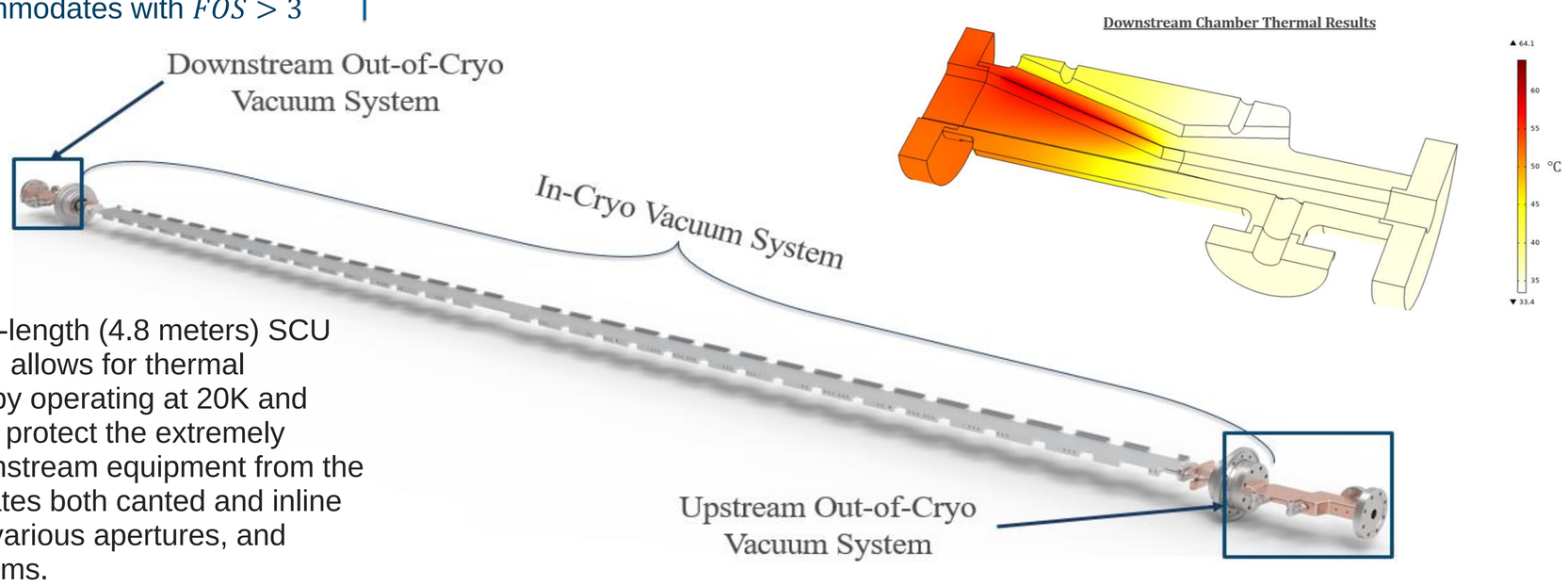
STRUCTURAL ANALYSIS

- Many opportunities for course and fine adjustment
- Semi-Uniform System for U.S. & D.S. Chambers and Inline & Canted Configurations
- Suspended from Cryostat Housing with available correction for resulting deflection
- Resulting Stress is $\ll$ Yield



THERMAL ANALYSIS

- Material fatigue is not a concern for $T < 200℃$
- Heat Transfer to In-Cryo system is minimized



CONCLUSIONS

A 5.383 meter long vacuum system was developed for the full-length (4.8 meters) SCU for APS-U. The In-Cryo Vacuum Weldment is 4.8 meters long, allows for thermal contraction, and complies with the required sector pressures by operating at 20K and relying on cryo-pumping. The Out-of-Cryo Vacuum Chambers protect the extremely temperature-sensitive In-Cryo System and 1.2 meters of downstream equipment from the upstream bending magnets. The vacuum system accommodates both canted and inline configurations, incorporates seamless transitions among the various apertures, and provides UHV continuity between the other SR Vacuum Systems.

U.S. DEPARTMENT OF ENERGY
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