APS UPGRADE INSERTION DEVICE VACUUM CHAMBER DESIGN

Solutions to Long, Thin Wall Aluminum Vacuum Chamber Design Challenges

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NORTH AMERICAN PARTICLE ACCELERATOR CONFERENCE

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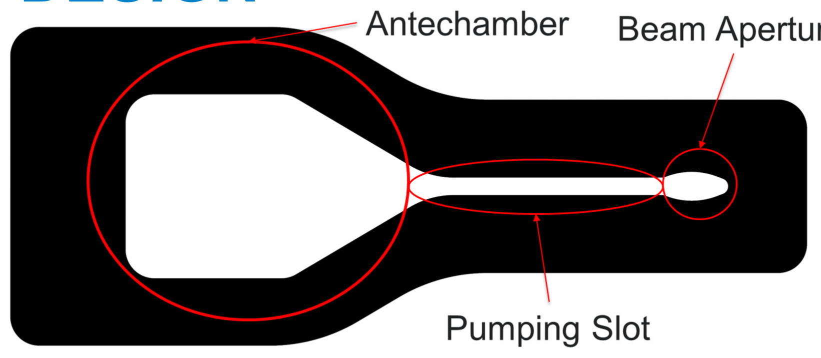
INTRODUCTION

The APS-Upgrade (APSU) project plan calls for the current APS 40-sector storage ring (SR) to be retrofitted with a new 6 GeV, 200 mA storage ring optimized for brightness above 4 keV. Thirty-one of the forty sector straight sections will be dedicated to Hybrid Permanent Magnet Undulators (HPMU) which will produce photons at various energies to ID beamline users based on their needs. Each HPMU straight section requires a vacuum system to ensure UHV continuity between the upstream and downstream sector arc vacuum systems. The following is an overview of the IDVC design process with an emphasis on the design challenges encountered.

IDVC EXTRUSION DESIGN

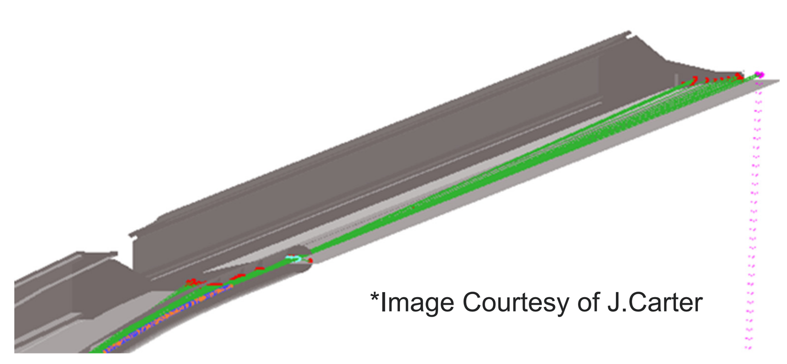
- Manufacturer provided guidance on acceptable tolerance bands for each critical feature
- Used tolerance band guidance to perform FEA parametric studies to determine minimum wall thicknesses around critical features
- Used raytracing analysis to verify that no synchrotron scraping occurs at tolerance limits



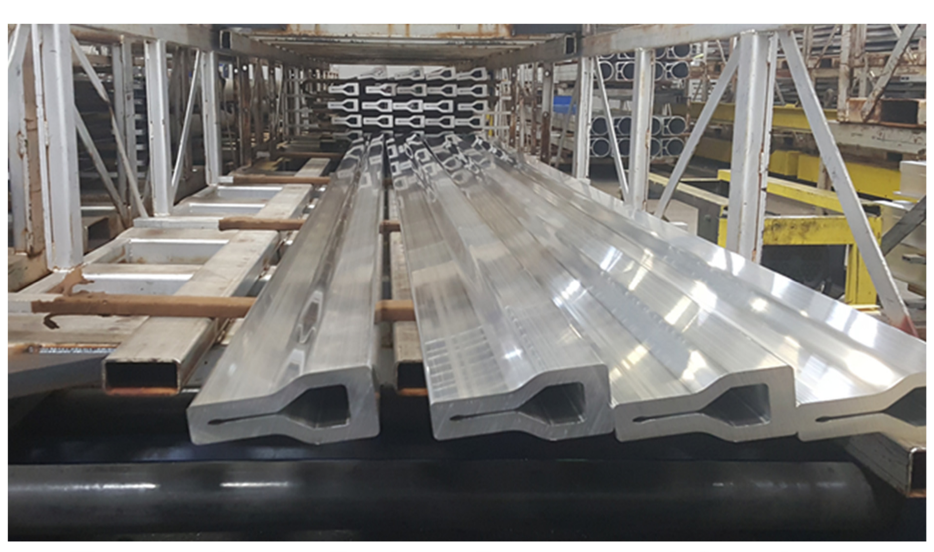
Extrusion Critical Features

Pumping Slot Half-Height (mm)	Maximum σ (MPa)	Maximum Deflection (mm)	Factor of Safety (σ_y/σ_{max})
1.75	58.7	0.20	2.11
2.25	74.5	0.30	1.66
2.30	77.3	0.31	1.60
2.35	80.4	0.33	1.54
2.40	83.9	0.35	1.48
2.45	88.3	0.38	1.40
2.50	92.9	0.41	1.33
2.55	98.3	0.44	1.26
2.60	104.7	0.47	1.18
2.65	112.0	0.51	1.11
3.00	197.5	1.07	0.63

Data Obtained from Parametric Pumping Slot Analysis



SynRad Ray Trace Model

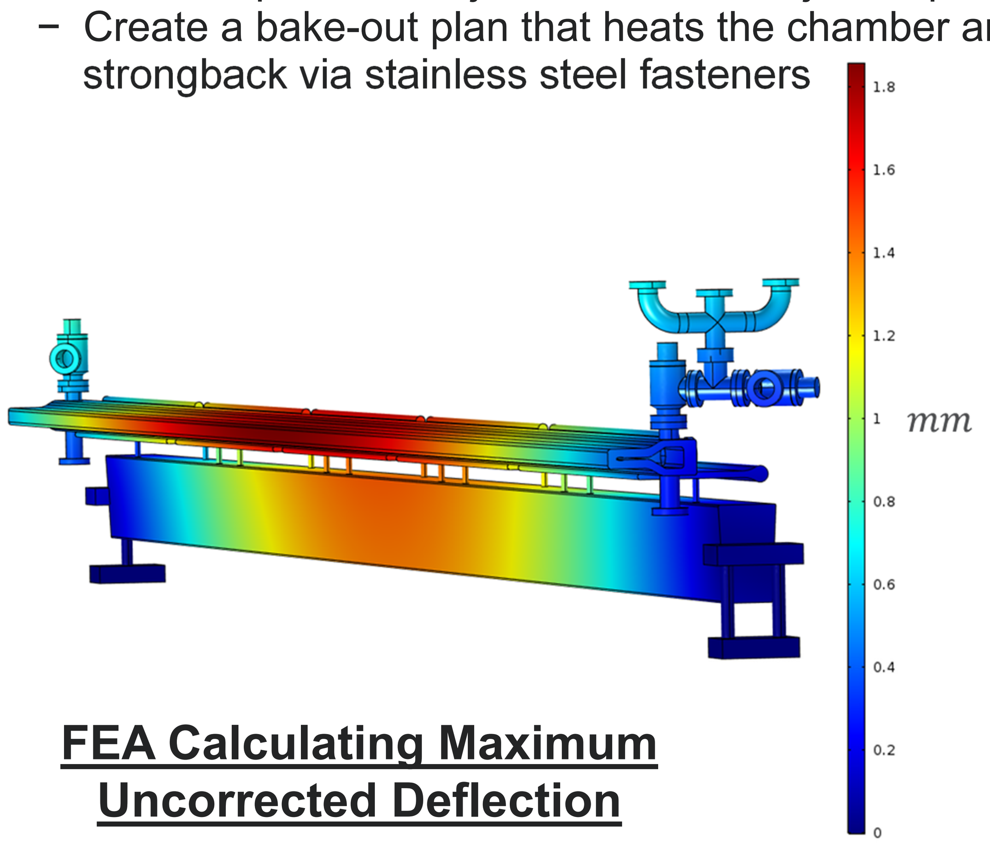


Extrusions Being Prepared for Aging

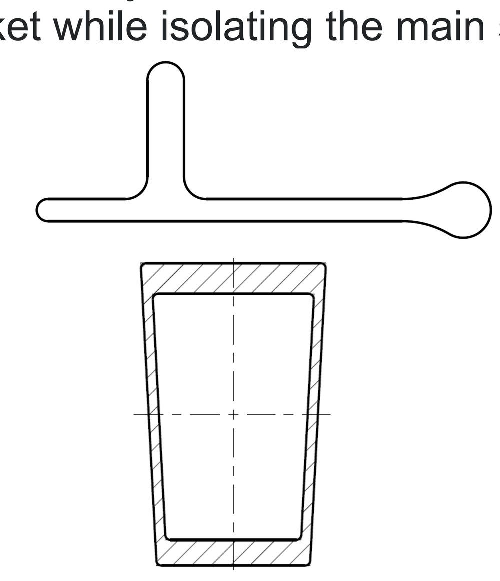
Die Being Prepared for Press

IDVC SUPPORT AND ALIGNMENT SYSTEM

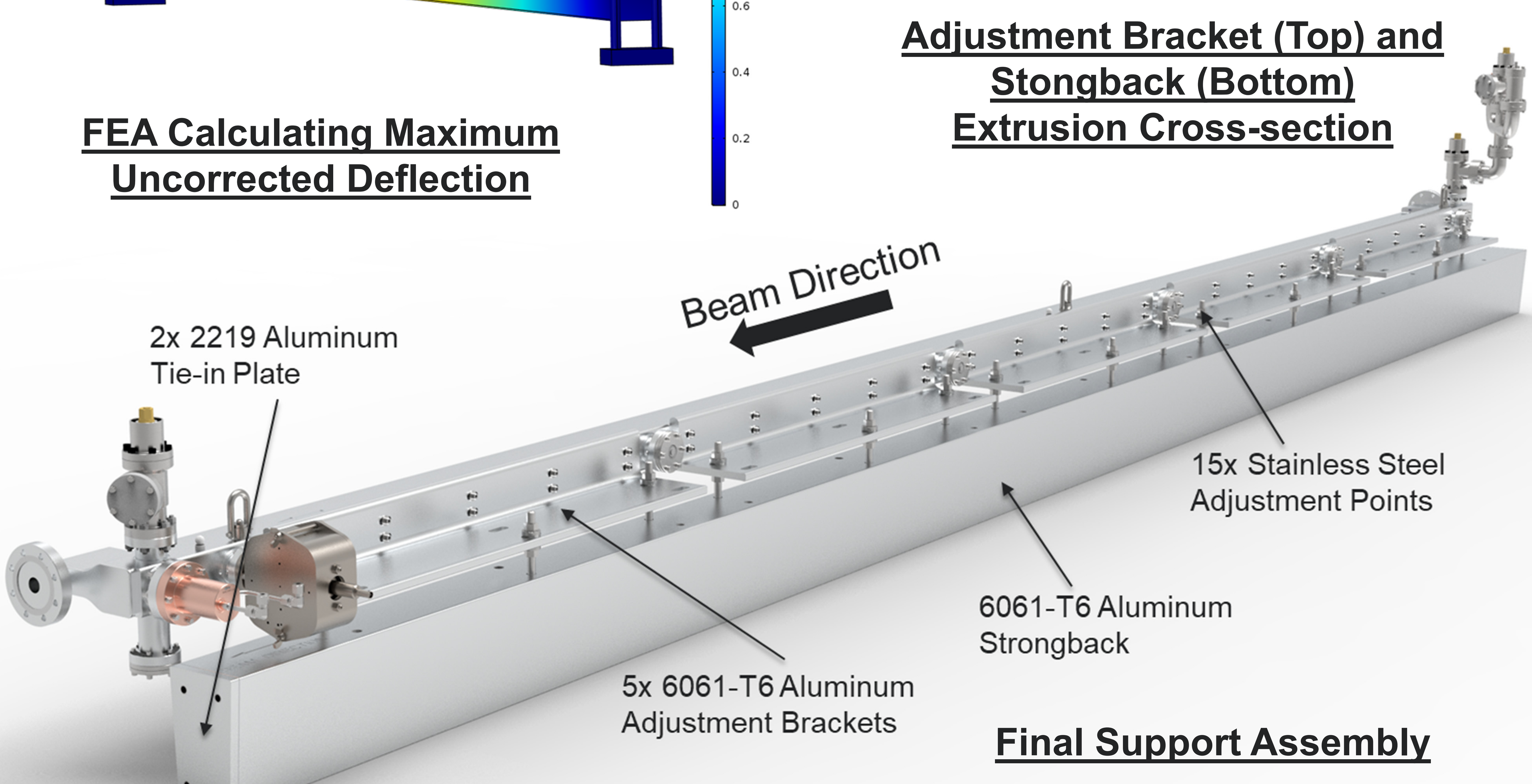
- Support the chamber across the entire length of the straight section
- Utilize multiple points of adjustment across the back of the chamber to make fine positon correction
- Allow for points of adjustment at the adjacent plinths for coarse adjustment
- Create a bake-out plan that heats the chamber and L-bracket while isolating the main support strongback via stainless steel fasteners



FEA Calculating Maximum Uncorrected Deflection



Adjustment Bracket (Top) and Stongback (Bottom) Extrusion Cross-section

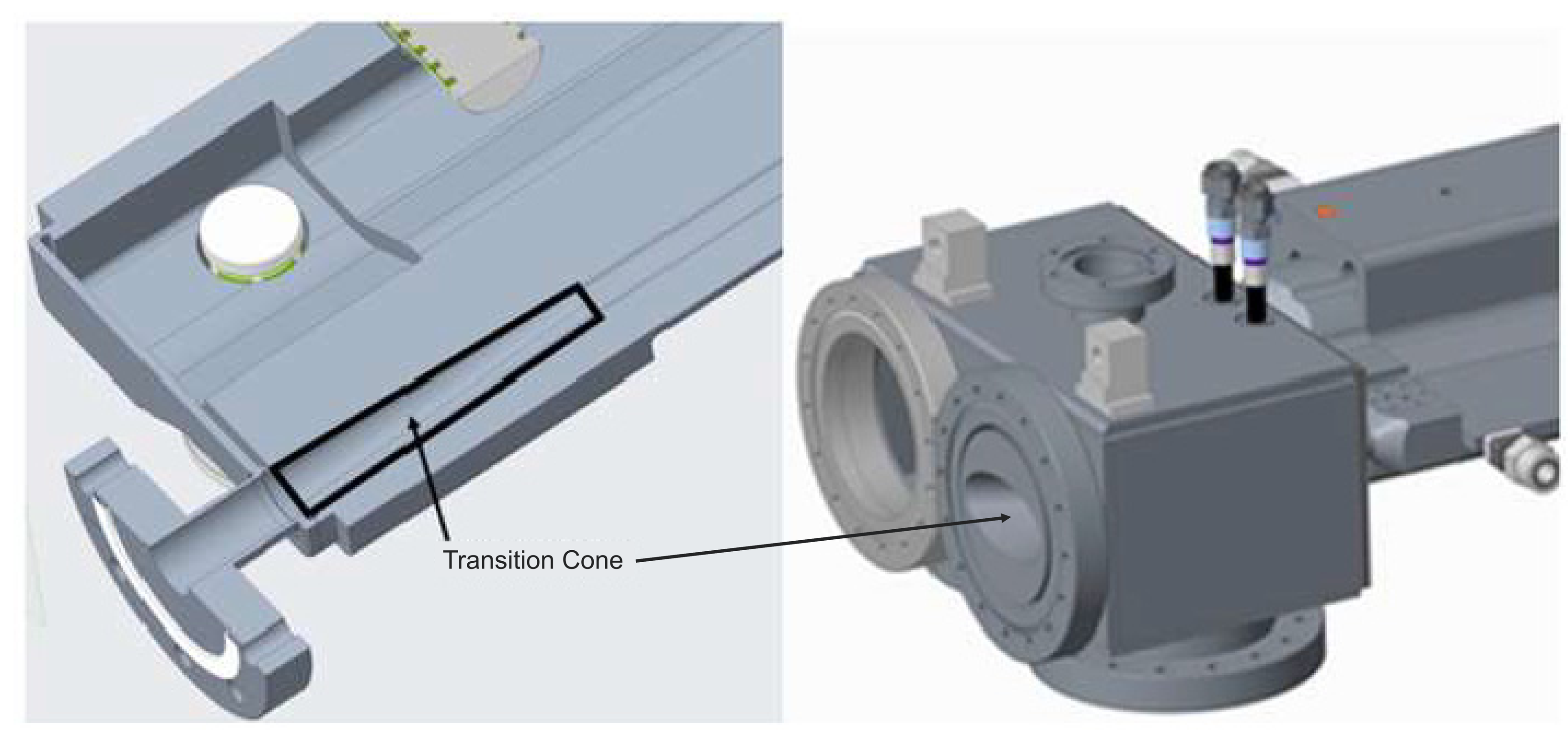


Final Support Assembly

Sector Layout with ID Straight Section Shown in Red

IDVC POST EXTRUSION FABRICATION

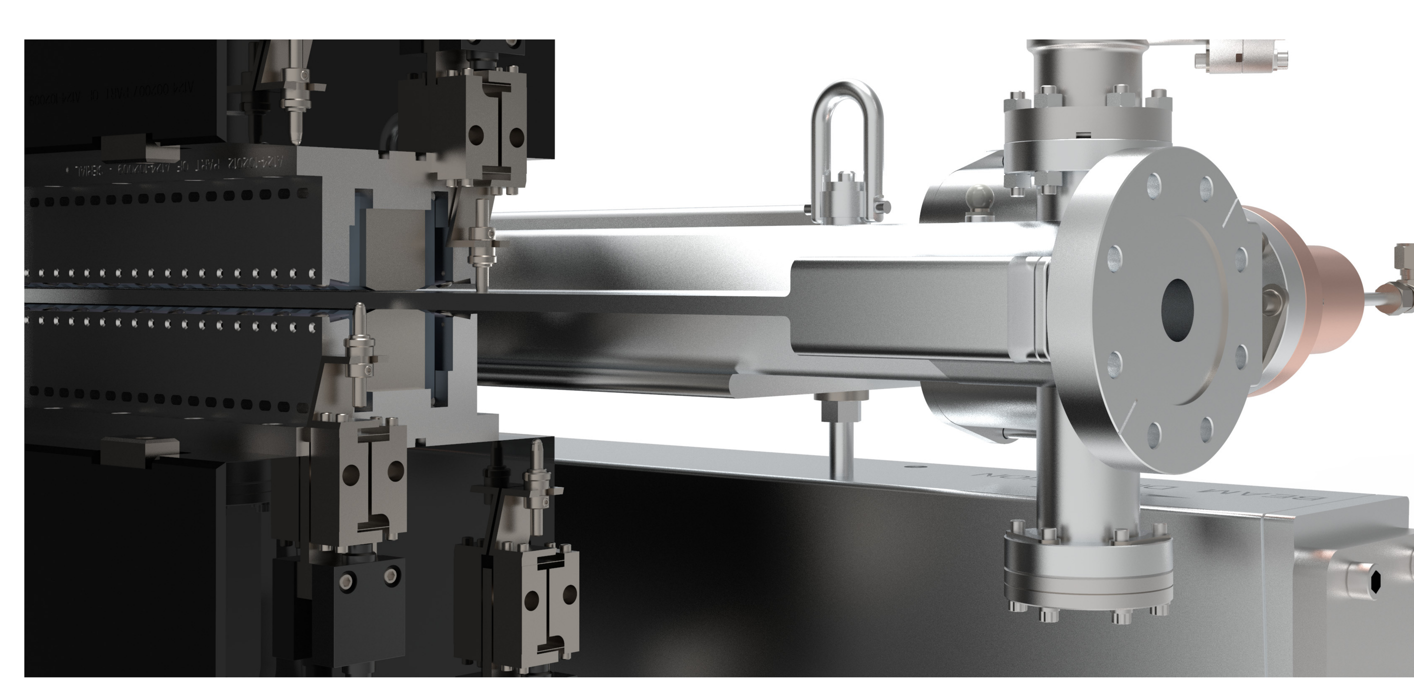
- Perform R&D to determine manufacturing process for incorporating the beam aperture transition cone into the ends of the aluminum extrusion
- Minimize weld bead and discontinuities within the beam aperture:
  - Place welds at the largest aperture and remove excessive weld under-bead
  - Minimize weld joints needed to seal the vacuum chamber
- Perform FEA to determine minimum wall thickness required to avoid yielding the material in the wall plus a factor of safety



Integrated Transition Cone Design (Left) vs Original APS IDVC Transition Design (Right)

Plunge EDM Transition Test Piece

Conventionally Machined Transition Test Piece



Thin Nose Region with Insertion Device

CONCLUSIONS

A straight section vacuum system has been designed for the APS upgrade project. The vacuum system allows for seamless beam transit across the entire ~5.36-meter length of the IDVC within straight sections equipped with HPMU's. Additionally, the design incorporates many new proven design ideas such as incorporating long transitions into the ends of the IDVC. These new features, along with a distributed support and alignment system, allow the design to meet the numerous challenging functional requirements constraining the IDVC design.

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