Variable Aperture White-Beam Photon Mask (Slits) for Canted Undulator Beamlines

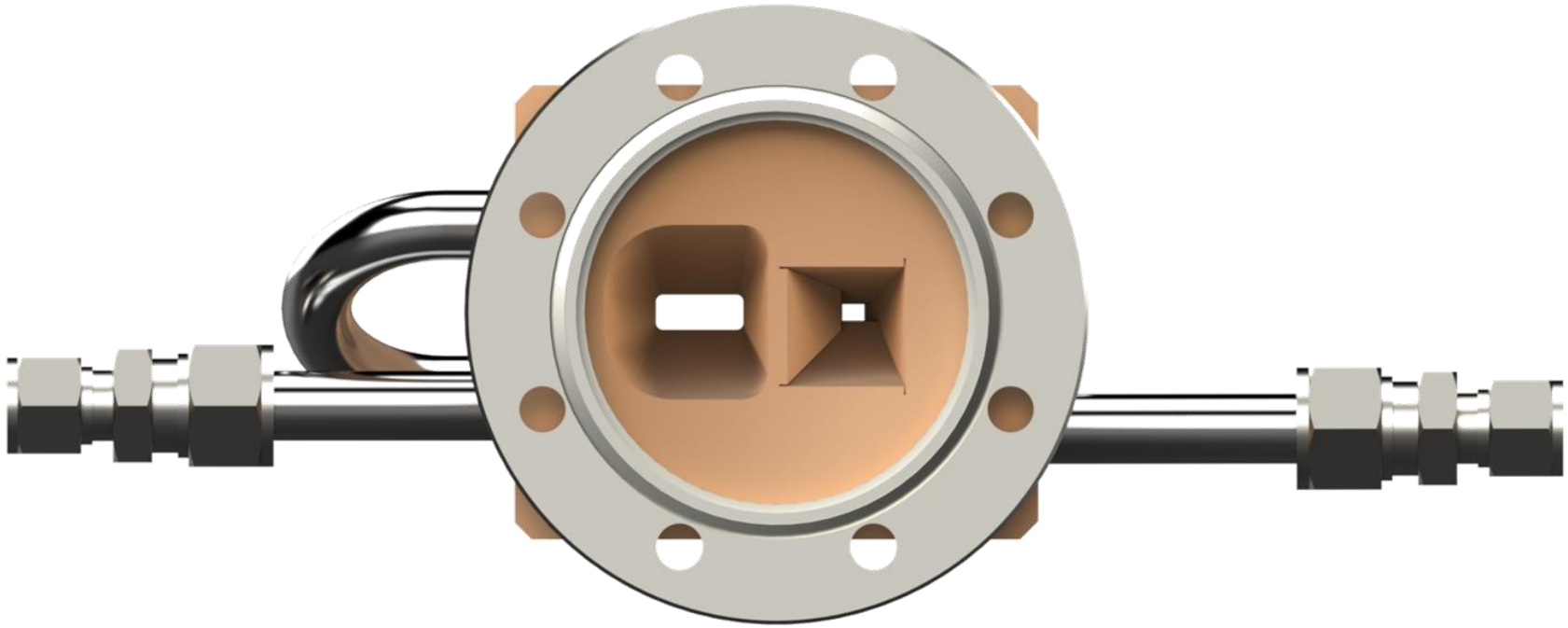
Oliver Schmidt, Mohan Ramanathan, Dana Capatina, Bill Toter

Advanced Photon Source

Argonne National Laboratory

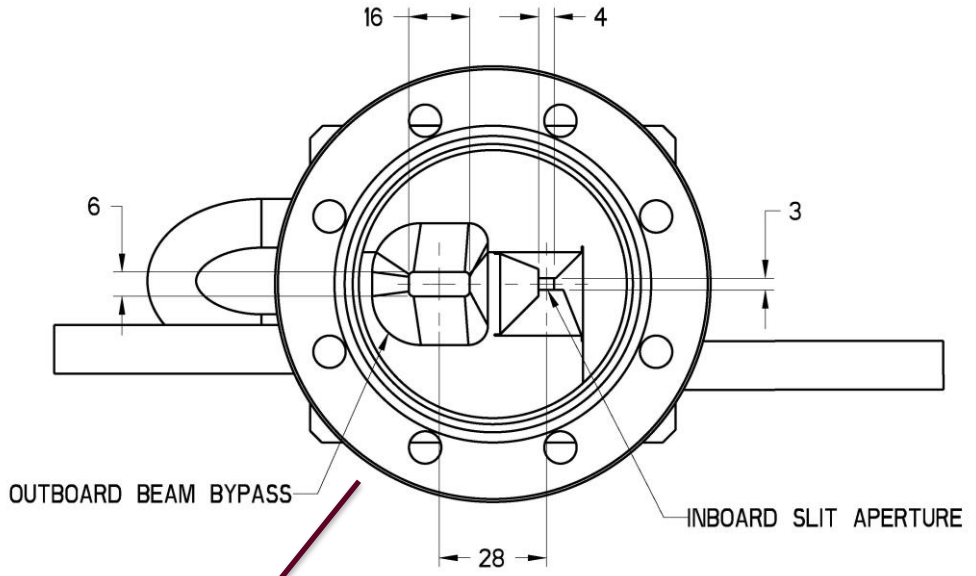
Features

- Geometry specific to a standard APS 1mrad canted undulator ID beamlines , however same principles could be applied for other applications
- Slits work by symmetrically pivoting on an axis between internal opposing edges
- Single assembly defines all four edges of x-ray beam
- Second aperture allows other beam to pass through unaffected
- No internal moving parts

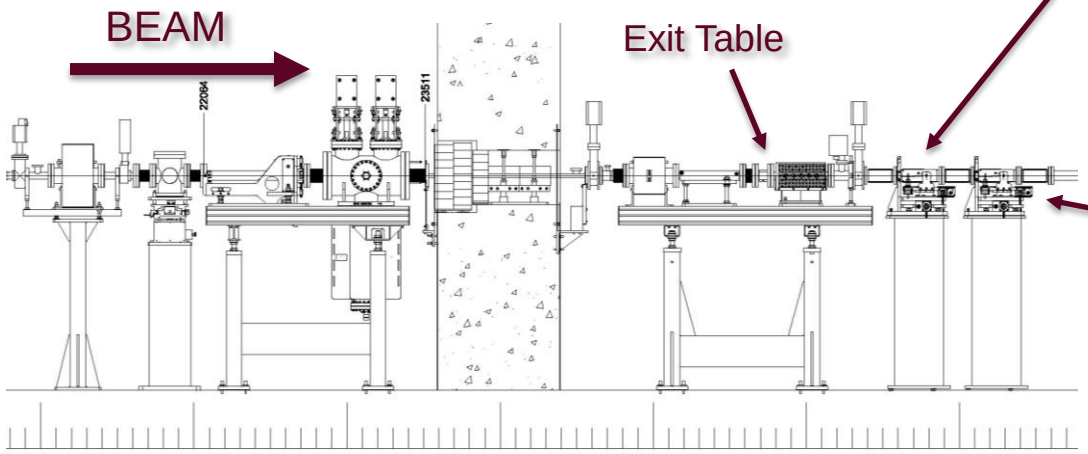


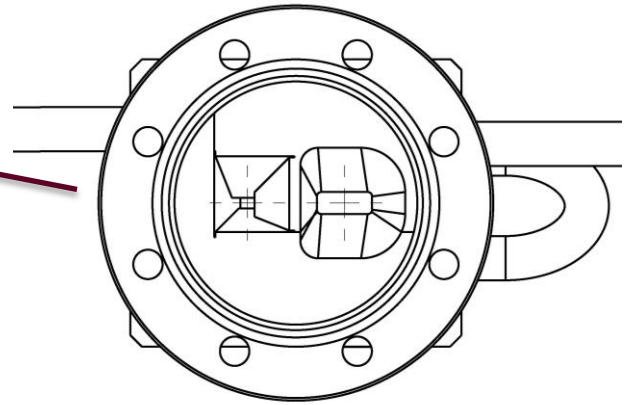
Operating Envelope

- Located directly downstream of exit table at around 27 meters from source
- Installed with variable aperture centered on beam
- Bypass aperture allows second beam to pass through when installed between 26 and 30 meters
- Outboard slits identical but inverted
- Saves valuable space along beamline



Inboard Slits

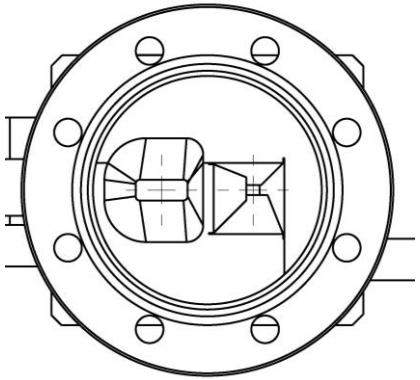


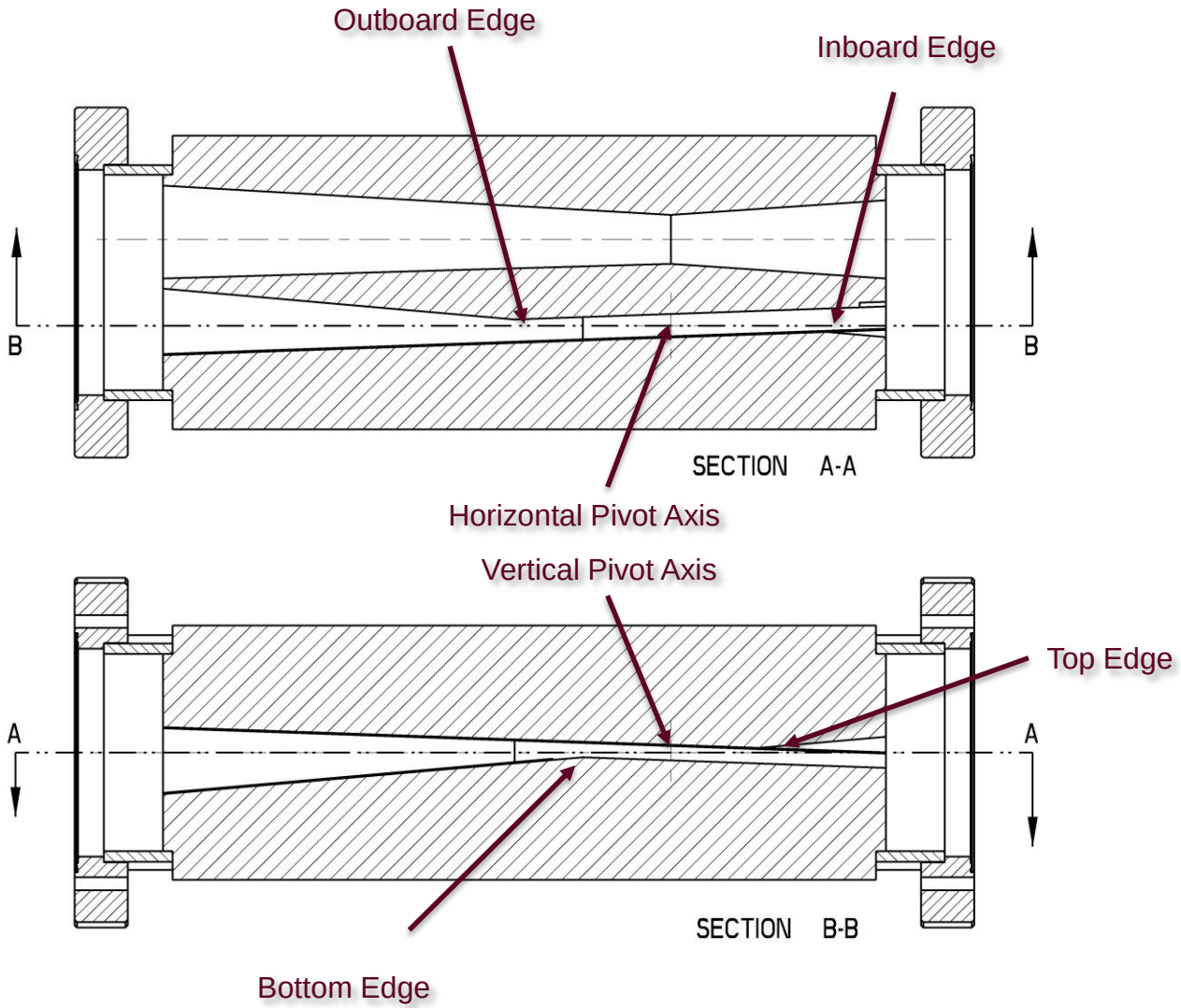


Outboard Slits

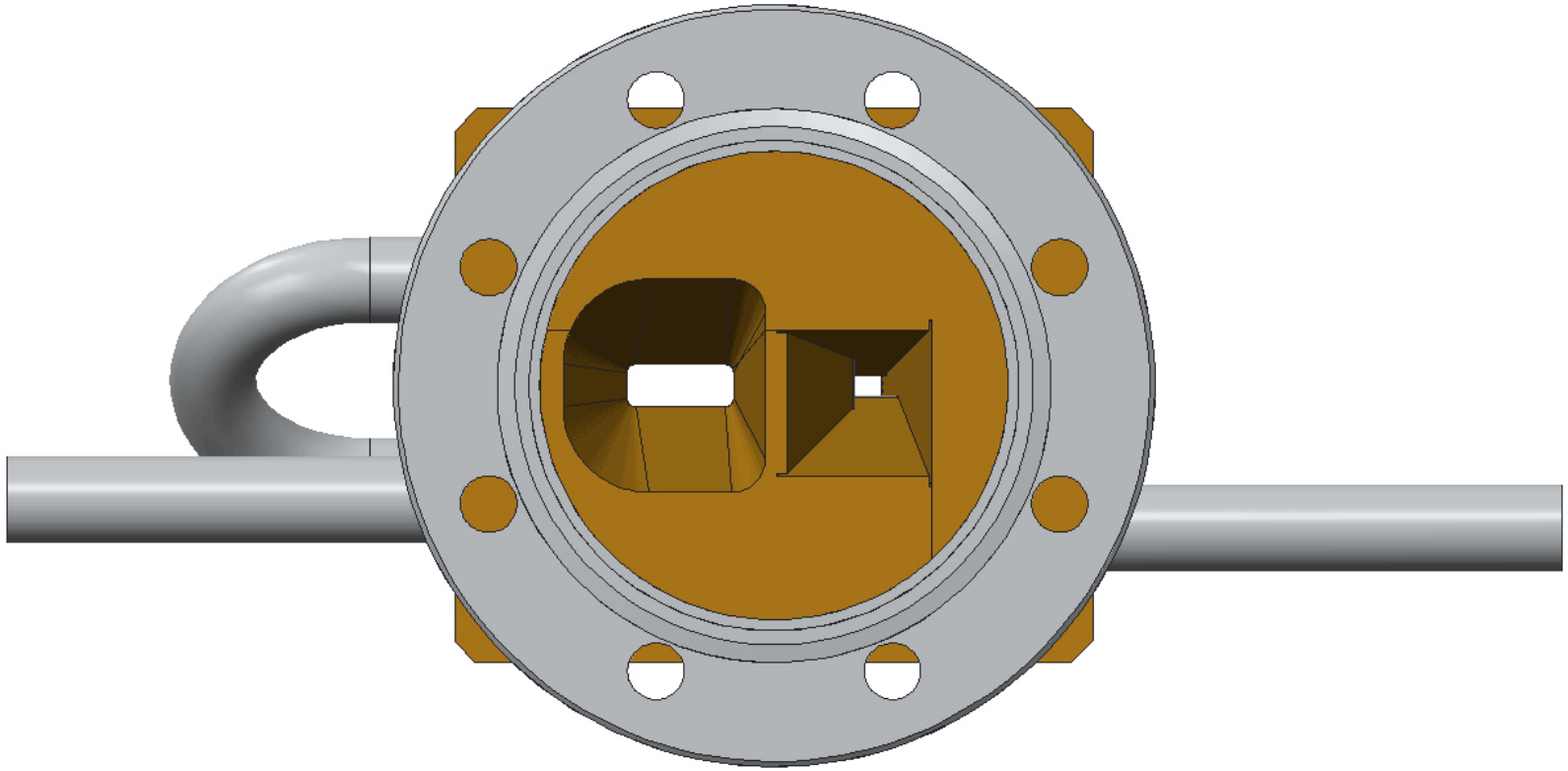
Cutaway View

- Mask body pivots around single point
- Defines beam both horizontally and vertically
- Horizontal and vertical axes intersect at single pivot point

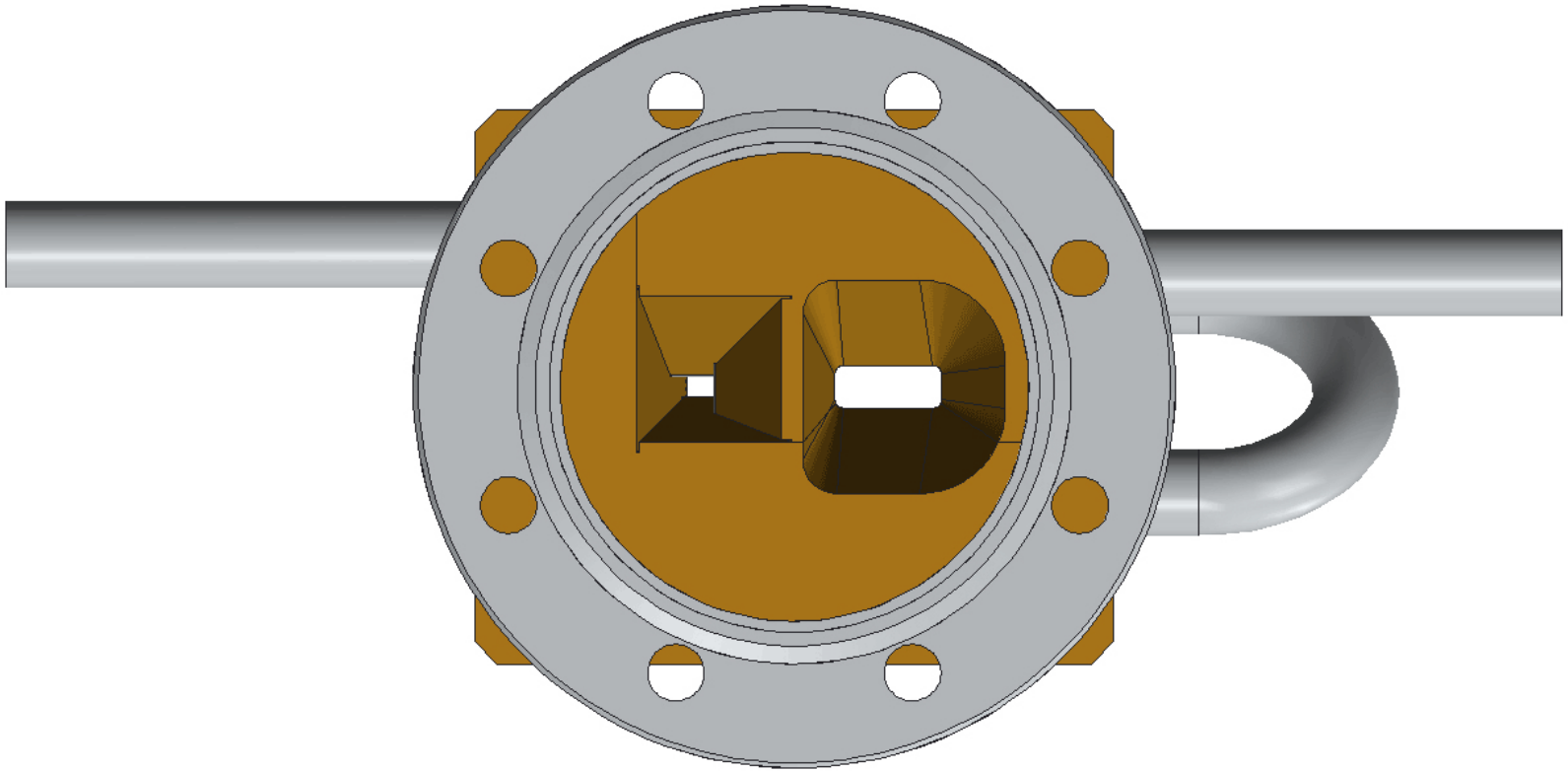




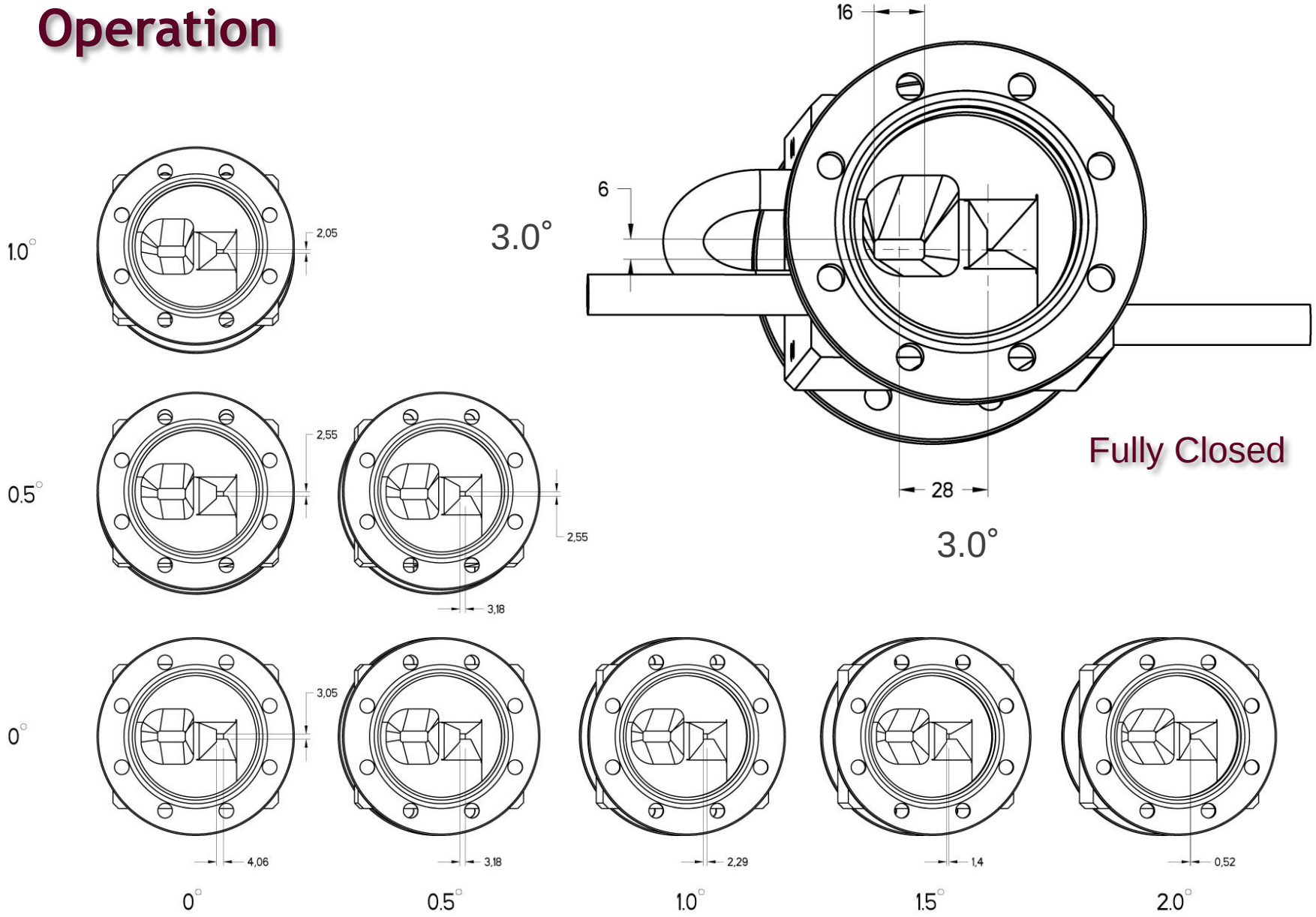
Inboard Slits



Outboard Slits

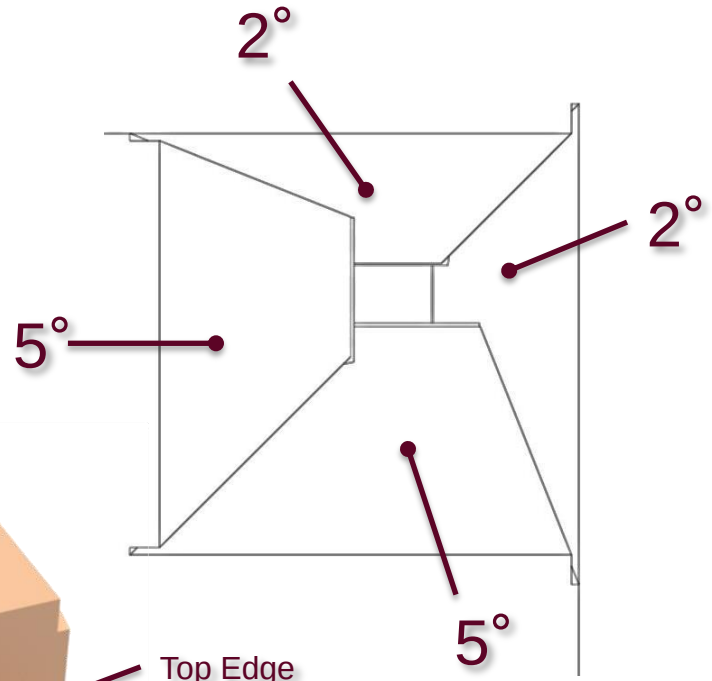


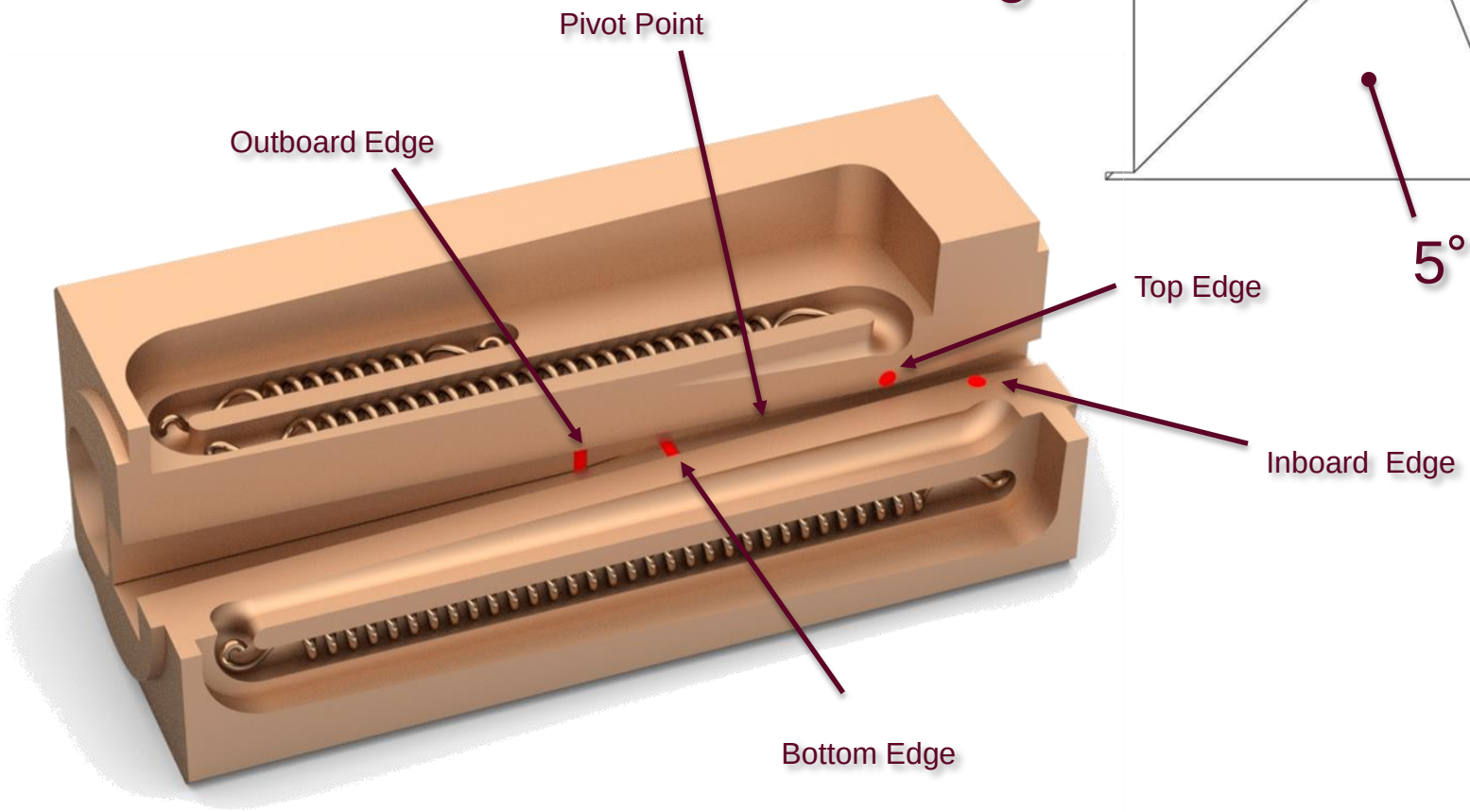
Operation


16
6
28
3.0°
Fully Closed
3.0°
1.0°
2,05
0.5°
2,55
2,55
3,18
0°
3,05
4,06
3,18
2,29
1,4
0,52
0°
0.5°
1.0°
1.5°
2.0°

Internal Geometry

- Beam absorbing surface angles change from 5 ° to 2 °
- Stress reliefs cut into corners to eliminate stress
- Edges staggered to cover relief which creates sharp corners

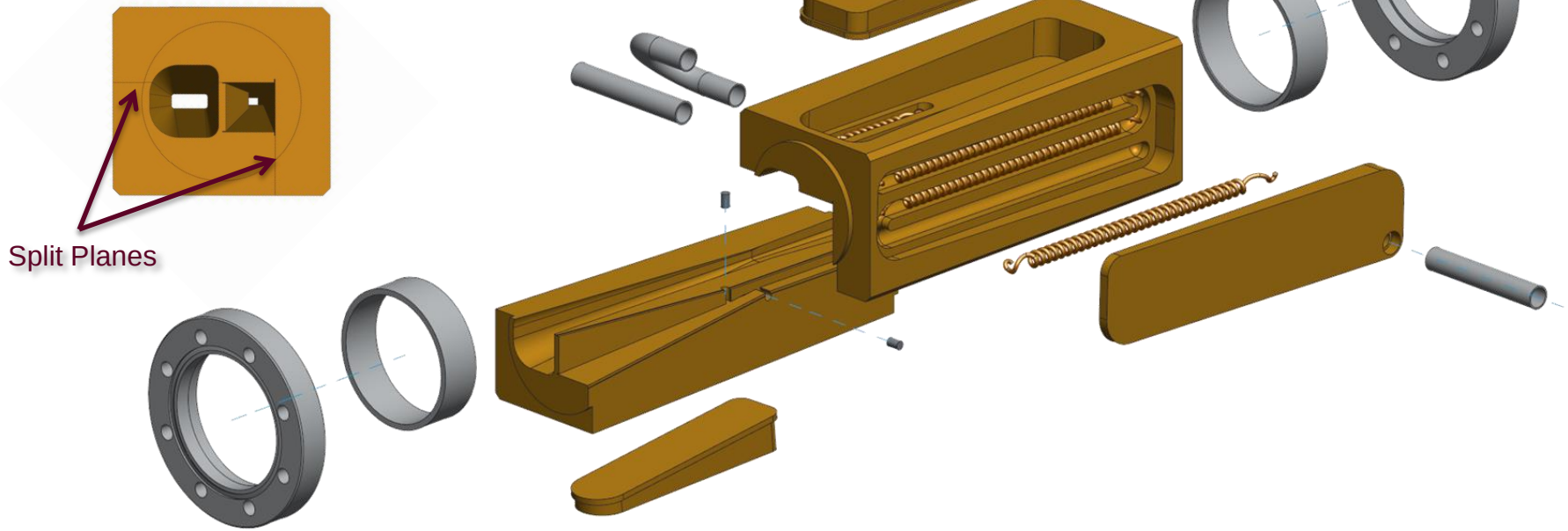




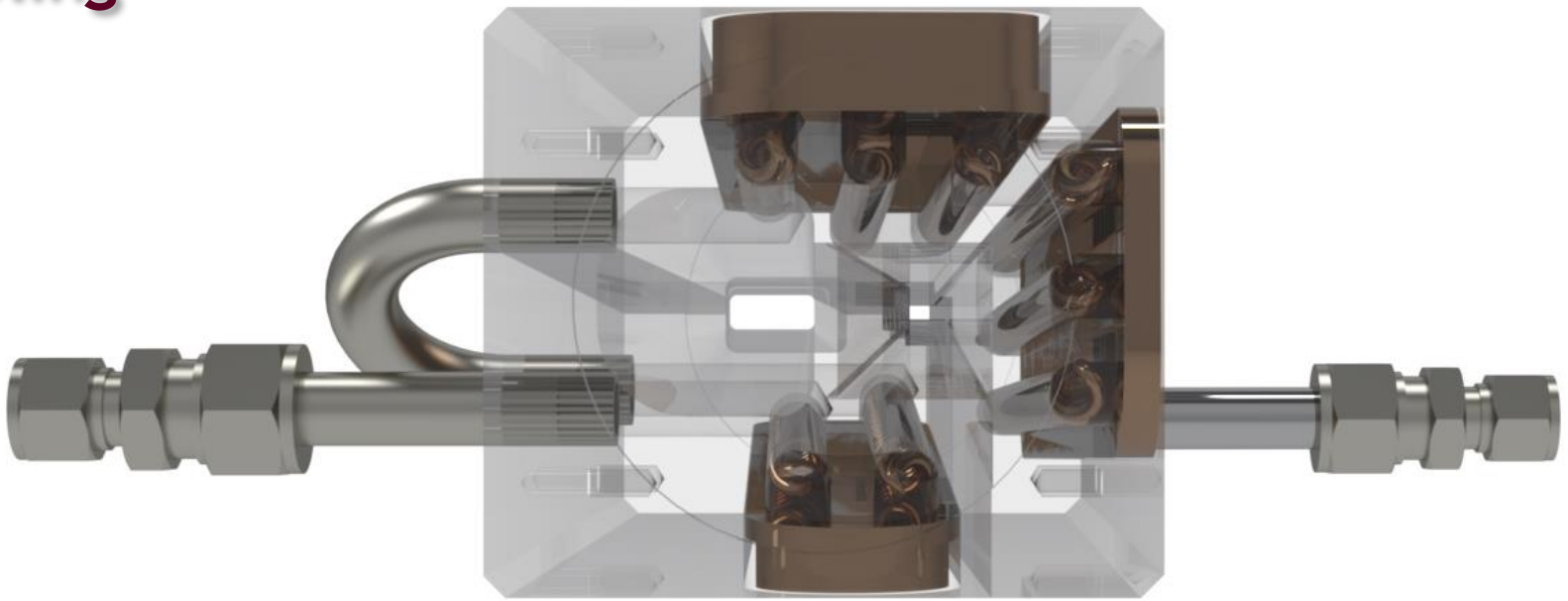
Fabrication Process

Direct wire EDM of internal geometry impossible due to overlapping conditions required for operation

- Glidcop blank first separated along two adjacent beam absorbing surfaces using wire EDM
- Internal geometry conventionally machined along with water channels and
- Two halves brazed back together along with water channel covers and vacuum/pressure tested
- Ends cleaned and locating boss machined for flange adapter sleeves
- Flange adapter sleeves brazed to ends
- Conflat flanges tig welded to adapter sleeves



Water Cooling



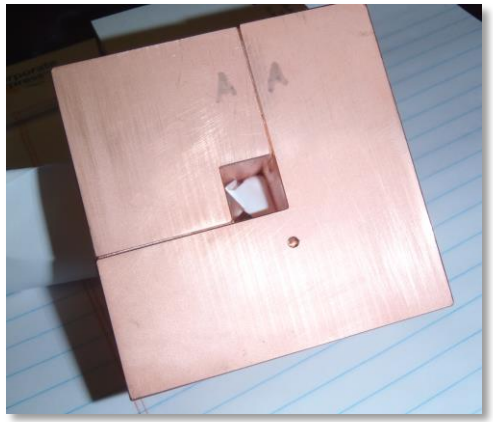
- Water passages machined in series to guarantee consistent flow throughout device
- Wire-coil inserts employed for enhanced heat transfer [1, 2]
- Internally linked water passages across two sides with jumper across brazed surface to avoid water to vacuum joint

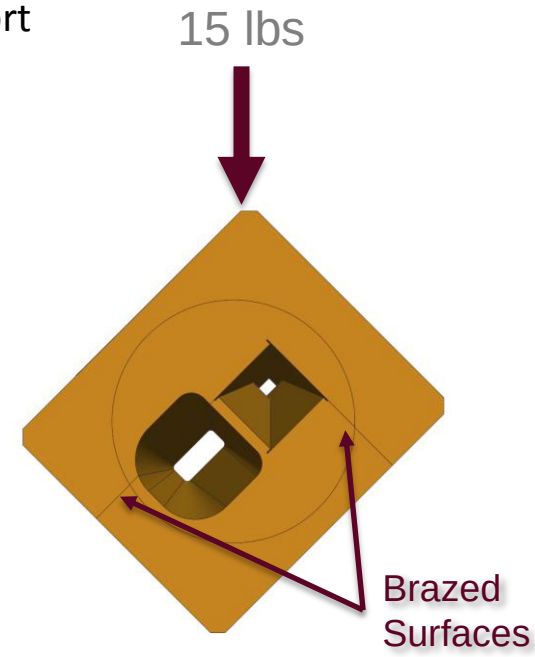
[1]J.T. Collins, and W.R. O'Brien, "Heat transfer optimization for APS high-heat-load/flux components", APS Science 2007, p. 169.

[2]J.T. Collins, C.M. Conley, J.N. Attig, and M.M. Baehl, "Enhanced heat transfer using wire-coil inserts for high-heat-load applications", MEDSI02.

Brazing

- Test brazes with 50/50 Au/Cu foil were conducted and the best results were achieved with a machined surface finish of 32 RMS and a 0.004 thick continuous foil applied to the joint.
- Sample brazes were sectioned and polished and revealed good fusion to the parent metal. There appeared to be some non-continuous centerline porosity; however the fusion was excellent, with small amounts of gold diffusing into the GlidCop.
- Final brazing was conducted in a positive pressure dry hydrogen retort
- Body oriented at 45 degrees in furnace to avoid excess braze material running onto beam absorbing surfaces
- A second cycle was repeated to braze the stainless steel flange adapters, oxygen free copper cooling covers and stainless steel cooling tubes to the previously brazed GlidCop body.





Brazing Orientation

* W. Toter and S Sharma," Analysis of Gold-Copper Braze Joints in GlidCop® for UHV Components at the Advanced Photon Source" Argonne National Laboratory. (2004)

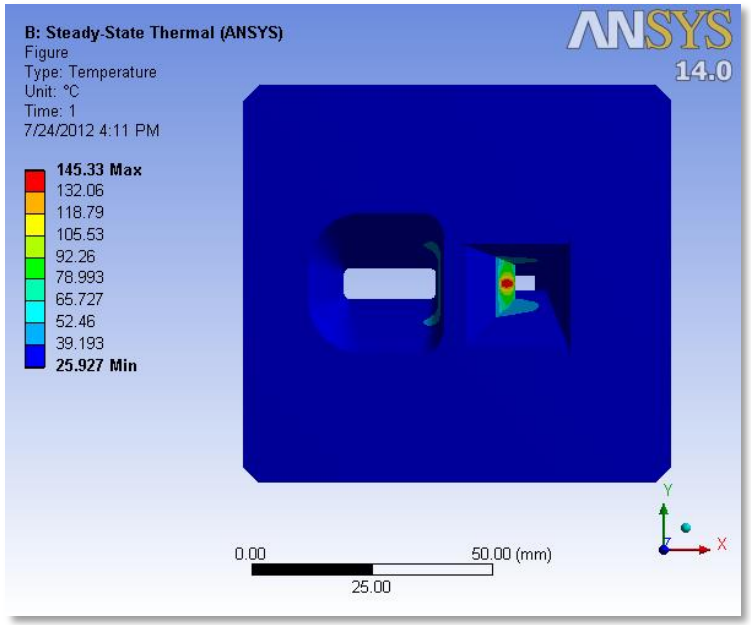
Thermal Analysis

Worst-case condition evaluated

- Full x-ray beam concentrated on single inside surface
- Fully open condition with surface at maximum incident angle of 5 degrees
- Highest possible beam flux considered with shortened 3.3 cm period undulator ‘A’
- In normal operation, beam will be evenly distributed across 4 surfaces

Conditions

- 100 mA
- k_{peak} = 2.845 for 10.5 mm undulator gap
- h = 0.010 W/mm^2/ °C @ 25.6 °C
  (0.5gpm, .38” channel, coils)
- Distance from source 26.8 m
- Beam size at component 3.16 mm x 2.10 mm
- Total Power at slits 1149 W
- Peak power density (normal incidence) 205.6 W/mm^2



Results

Inside Wall

- T_{max} = 145.3 °C
- T_{wall} = 43 °C
- $\sigma_{VM\ max}$ = 207.5MPa

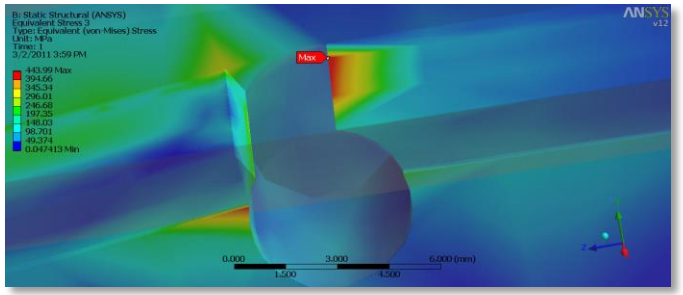
Side Wall

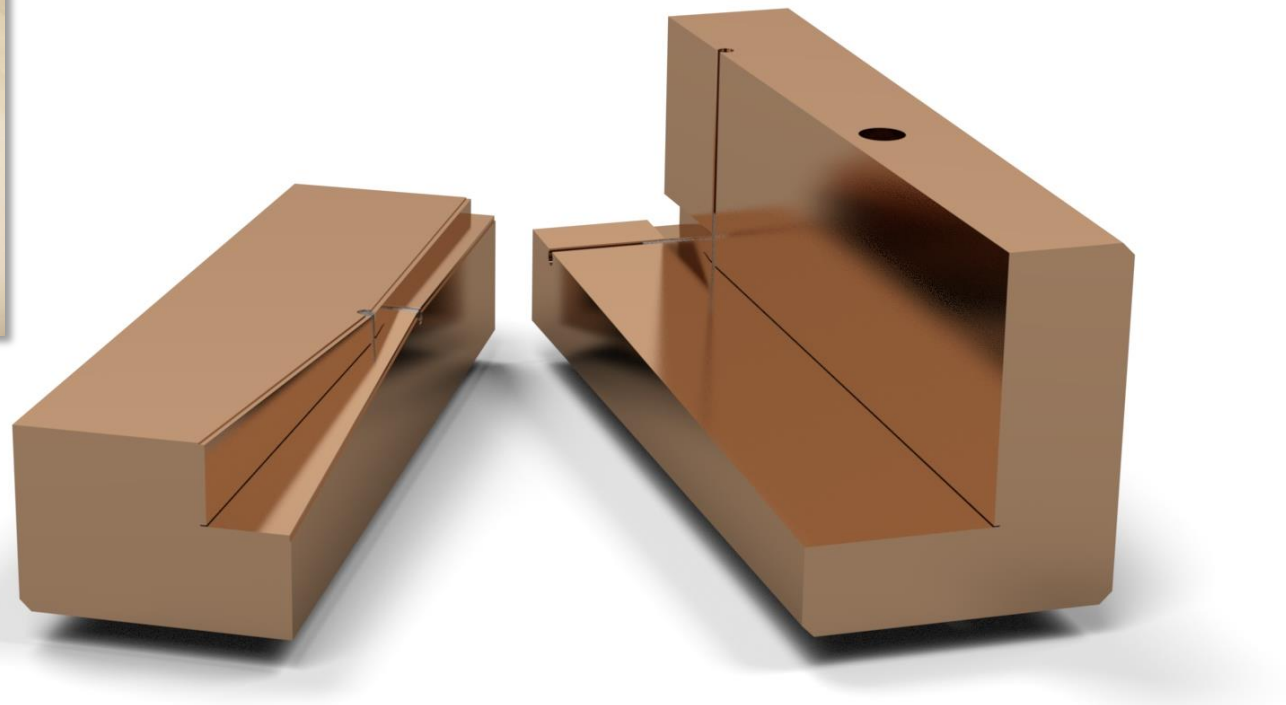
- T_{max} = 136.1 °C
- T_{wall} = 54 °C
- $\sigma_{VM\ max}$ = 194.3MPa

Max current 192.8mA (based on current APS criteria)

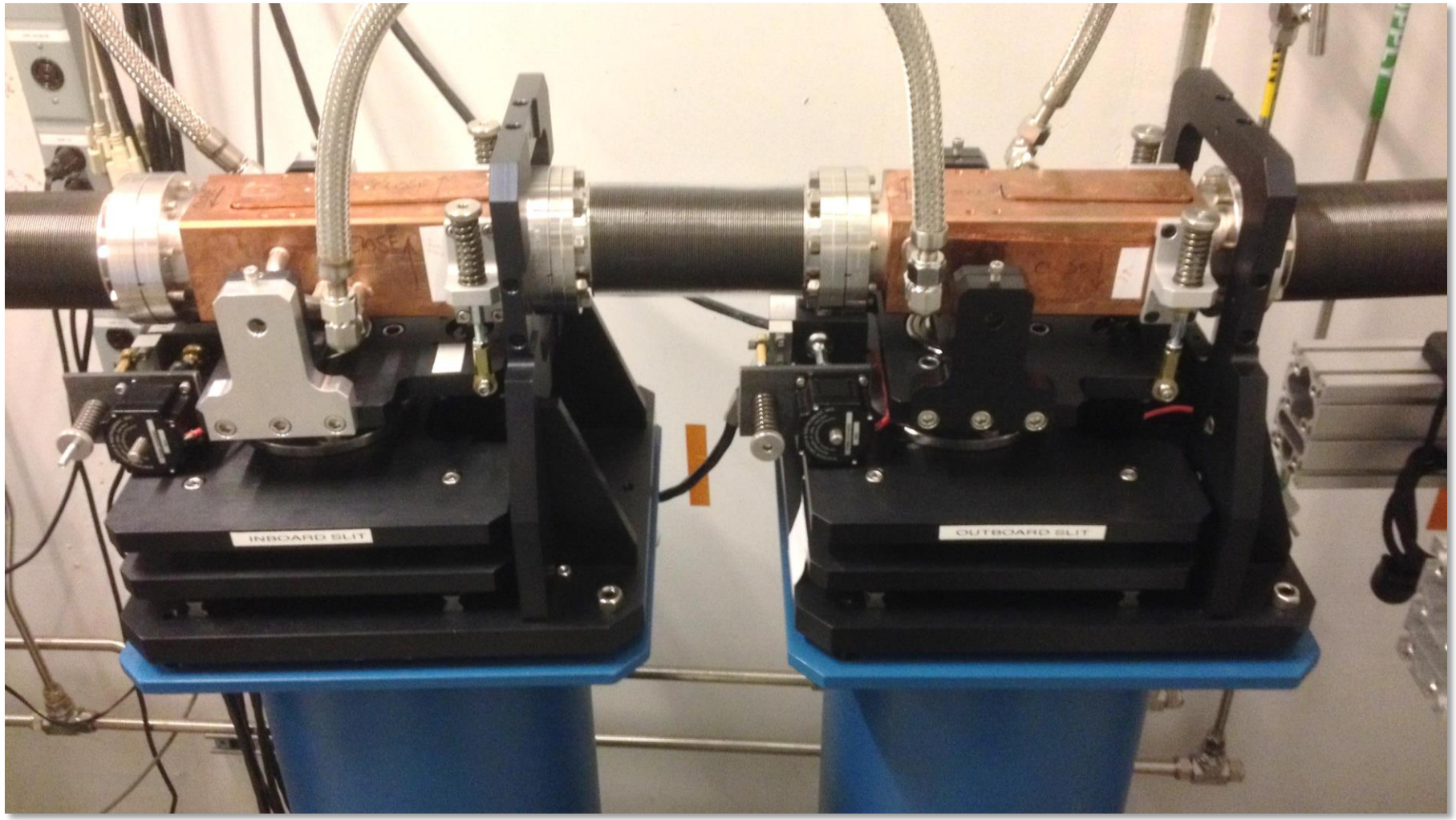
Tungsten Edge Option

- Crisp beam edge
- 3/16 hole drilled slightly above tangent to beam strike surface
- 3/16 diameter tungsten rod inserted and brazed with Au/Cu paste

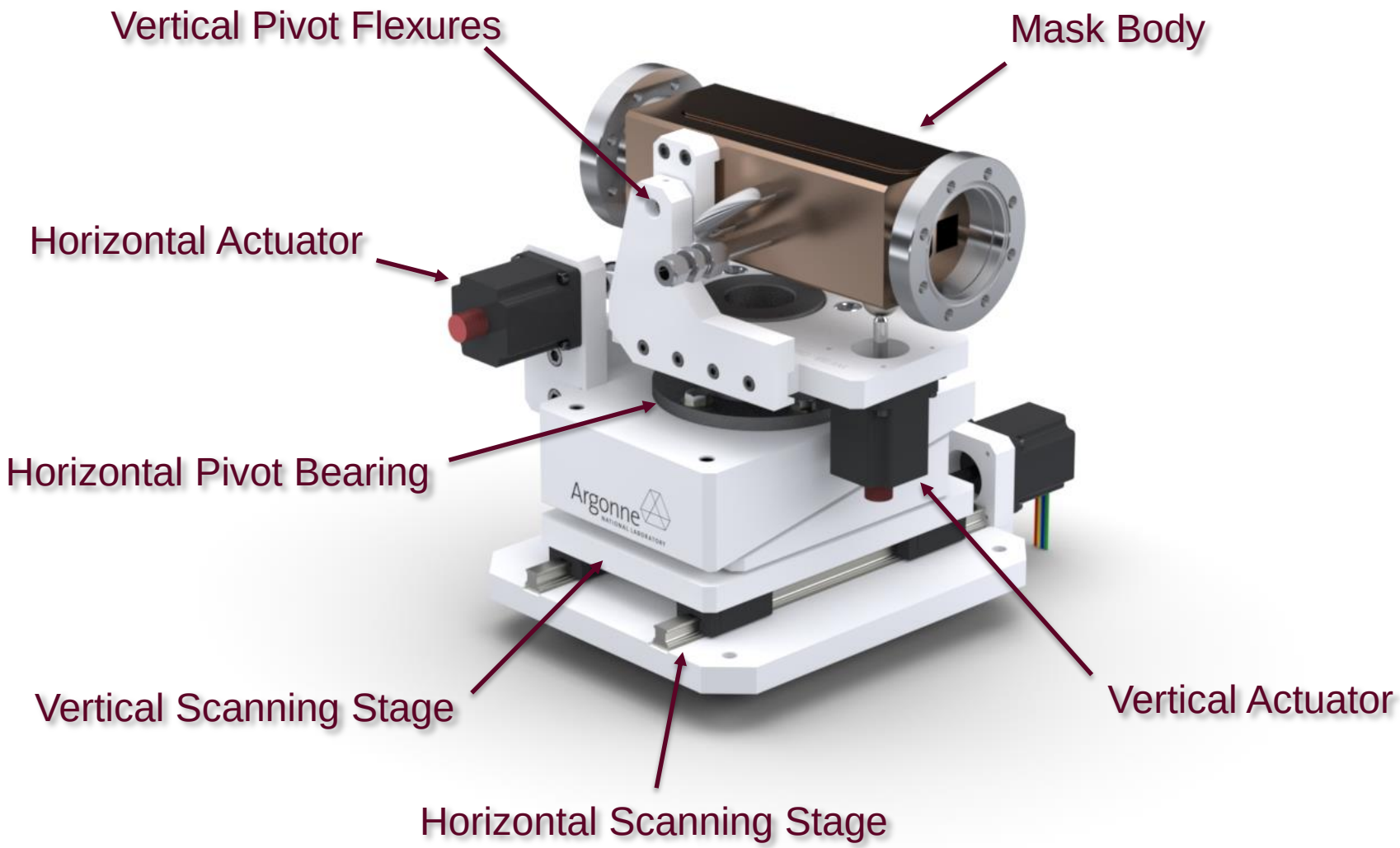




Sector34-ID Installation



Next Generation Actuator Assembly



Don’t Reinvent the Wheel Bearing

- Standard OEM automotive hub bearing (Timken 513020)
- Engineered to be extremely robust
- Twin tapered roller bearing
- Short profile – 1.8 inches flange to flange
- Factory pre-loaded
- Compact design
- Symmetric hole pattern and parallel mounting surfaces easily integrated into actuator assembly
- Less than $100USD!
- Additional built in anti-lock brake sensor completely useless for our application (so far)