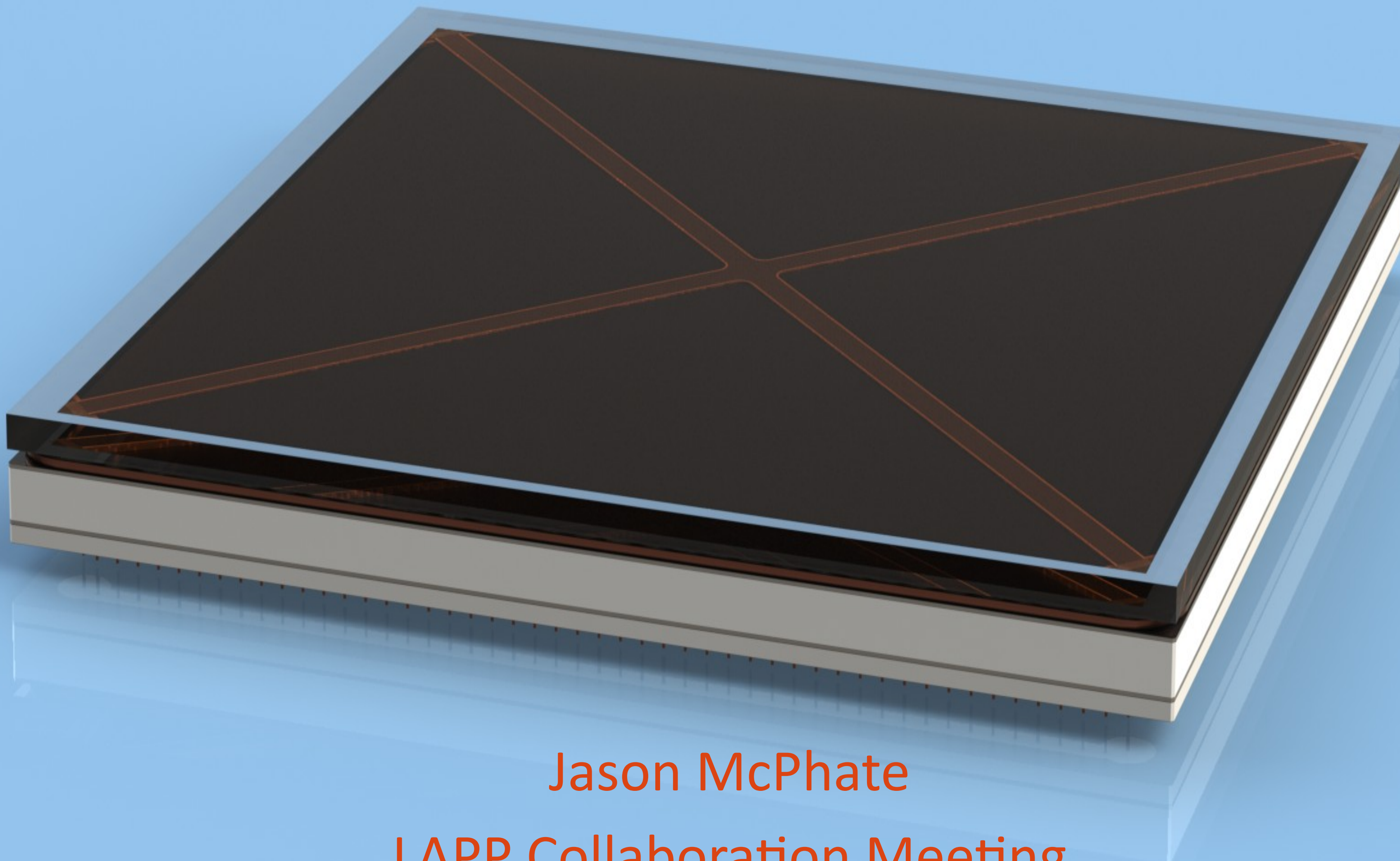
8” Ceramic Package Design & Status



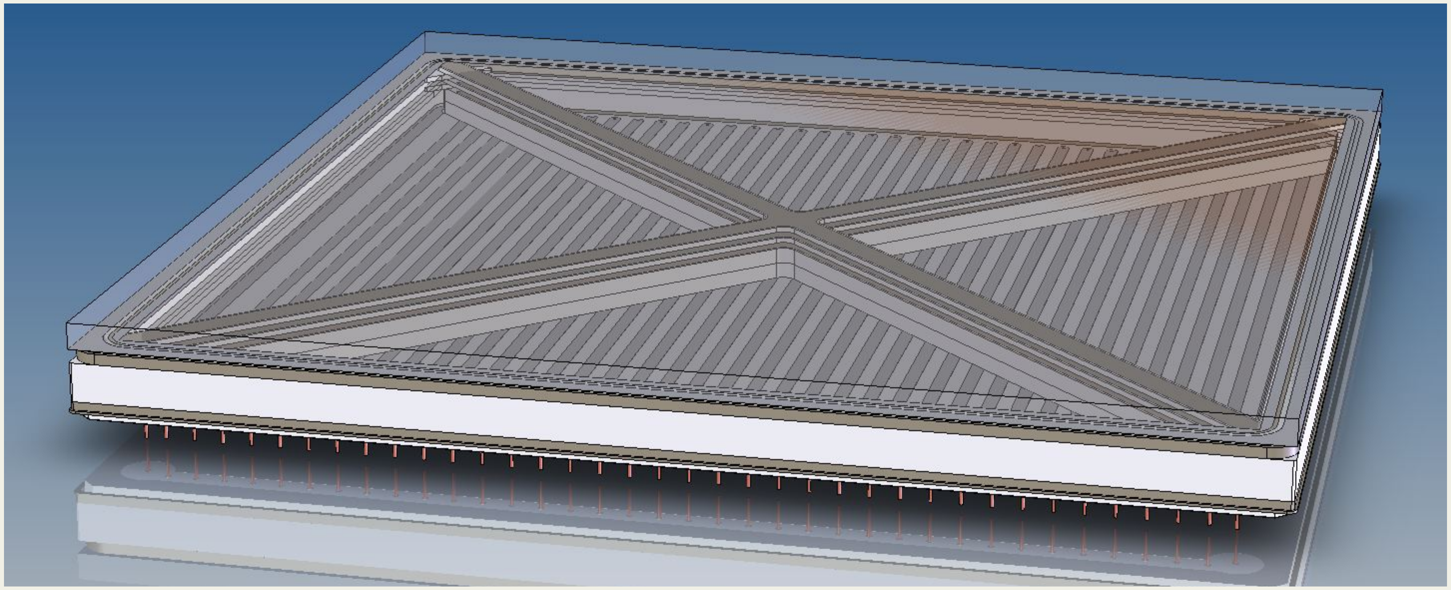
Jason McPhate

LAPP Collaboration Meeting

10 December 2011

X-Tube Design

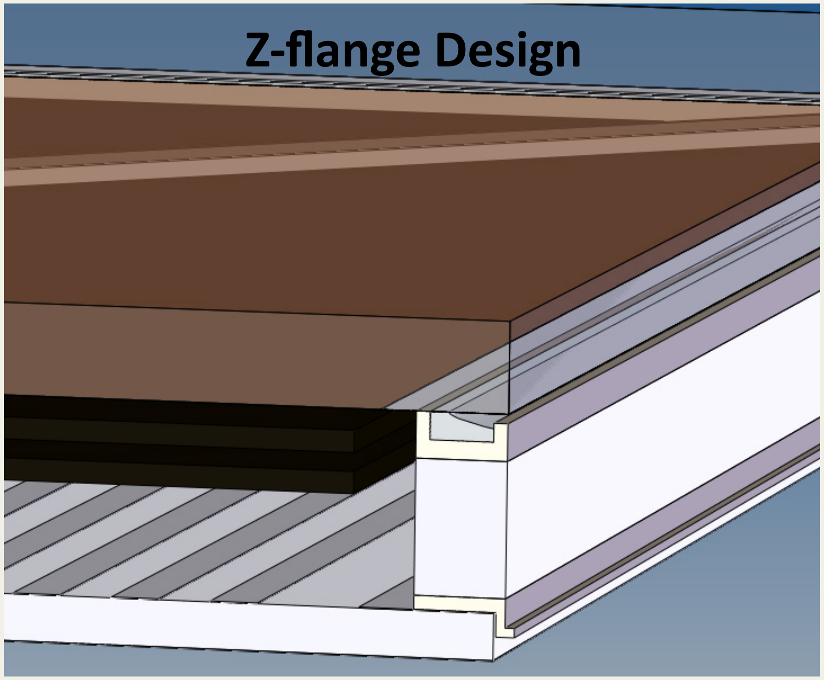
- Ceramic/Kovar brazed body
- Ceramic/Hi-Temp Anode with signal and HV pins
- “X”-Grid support for MCPs and window/anode
- Machined Kovar indium well (hot seal)
- Dual purpose bottom Kovar flange allows change to glass-to-metal seal Kovar backplate

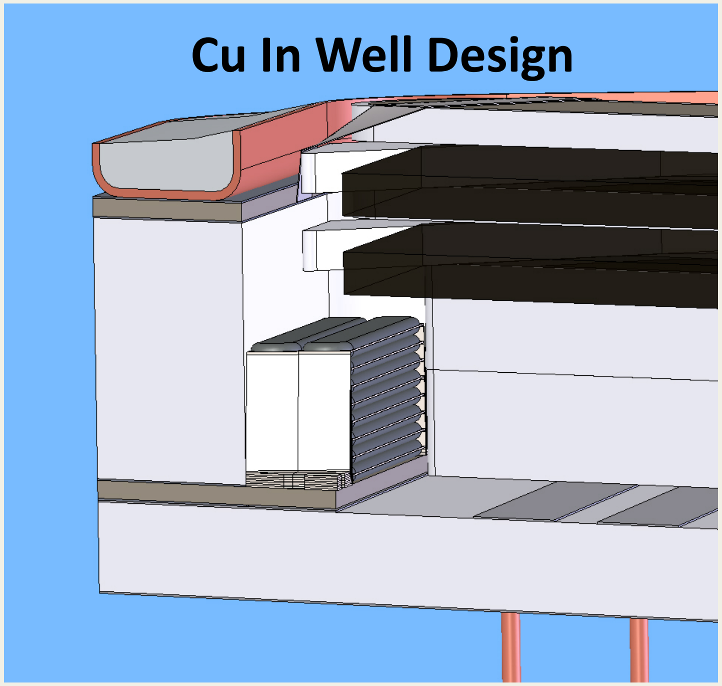


Modifications since Godparents ("Z"-flange)

- Machined Kovar indium well
- "Z" section bottom flange
- Reduced number of anode strips (now 36)

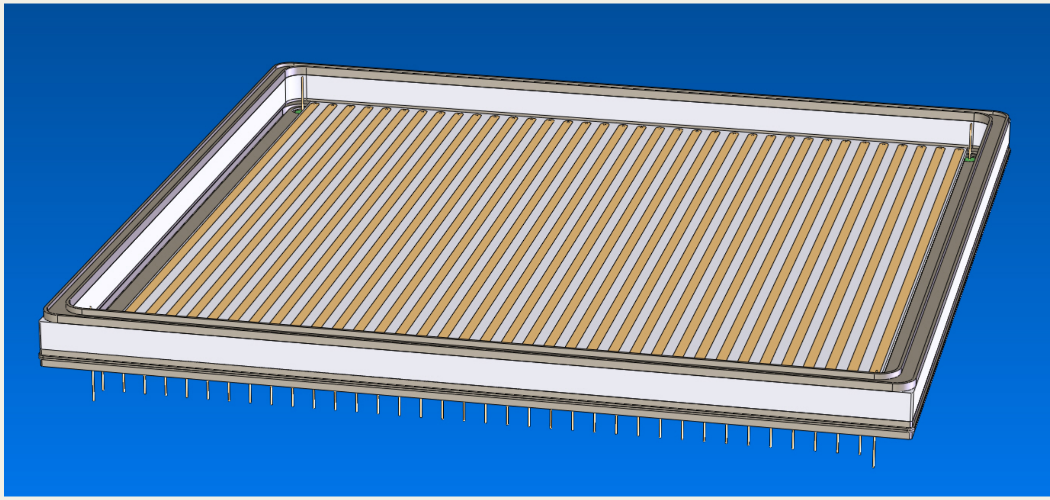
- Stamped copper indium well
- Kovar flange between ceramic and copper
- Flat bottom flange
- Anode with 48 strips

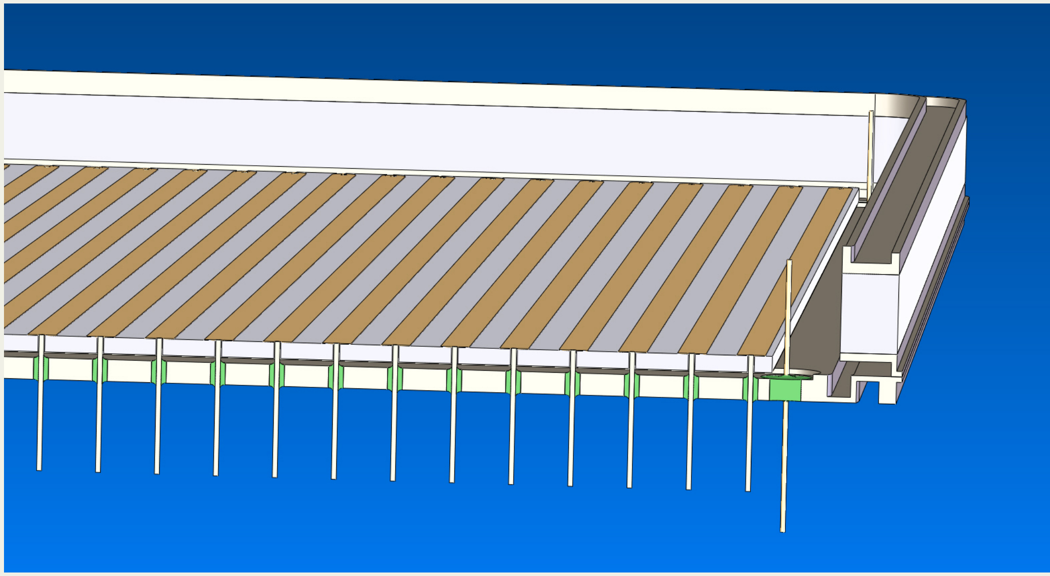




Why the Z-flange?

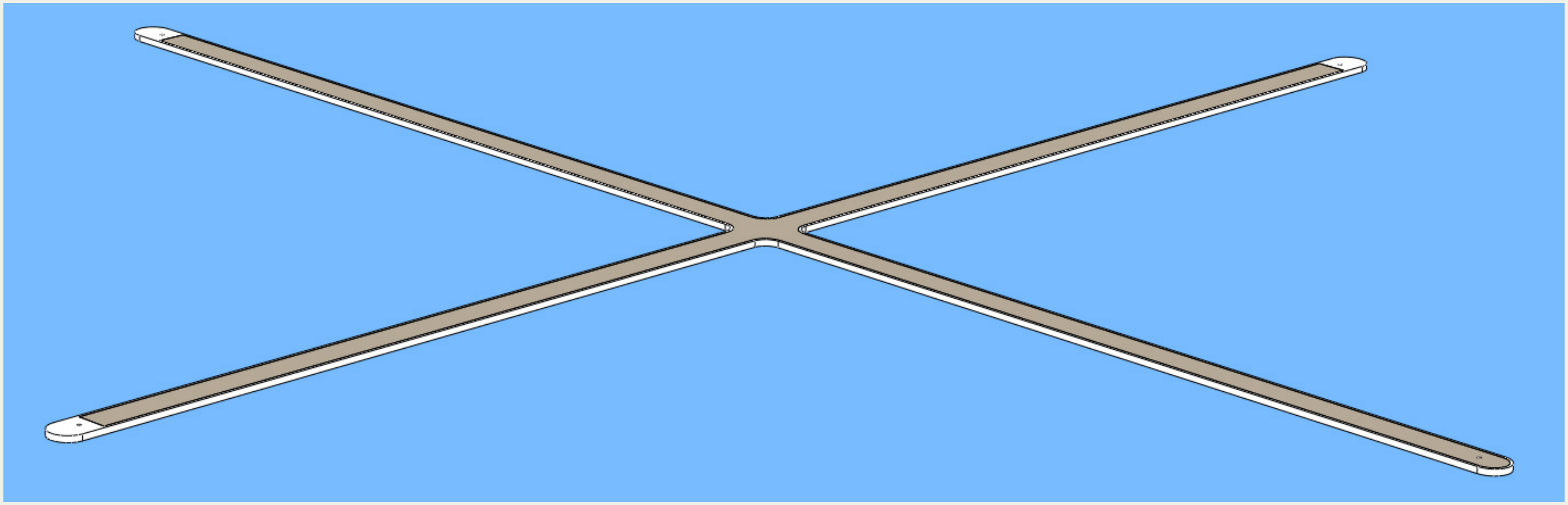
- Allows back-up design for the tube backend
  - Kovar glass-to-metal seal backplate that laser welds to Z-flange
  - Flex built in to flange/backplate
  - Divorces anode from seal, can be thinner (less x-talk)
  - Thick-film anode (better conduction)
- Why not primary?
  - Unknown vendor relations
  - Unfamiliar with capabilities
  - Difficulties with fit of HV
  - Expensive backplate



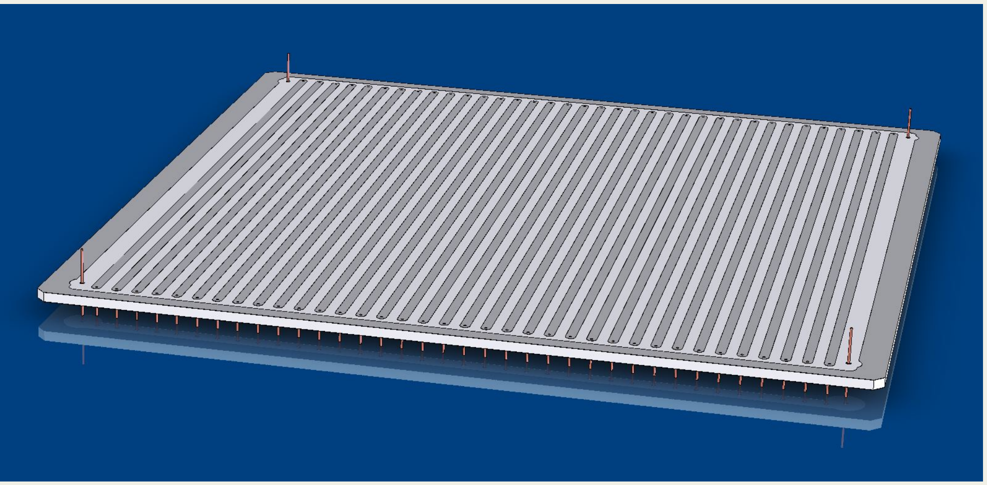


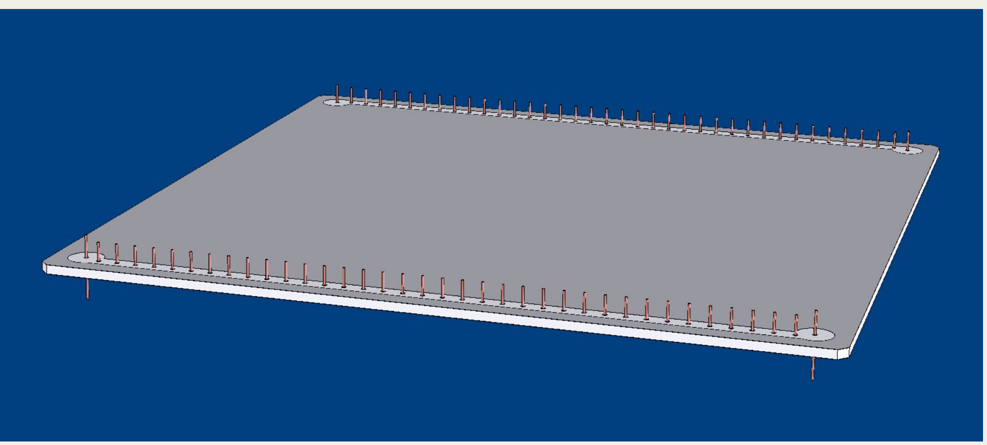
X-Grid Spacer Review

- Material: 96% Alumina
- 0.25” wide -> total area 5.26 in^2 (compare to 7.75 in^2 for square grid)
- 1 mm thick spacers for cathode and inter-MCP gaps
- 2x .120” (6.1 mm) for anode gap
- Open architecture allows good pumping paths to getters
- Support MCP corners to minimize flexure
- Added bonus of being used for HV distribution and MCP hold-down



Anode Design

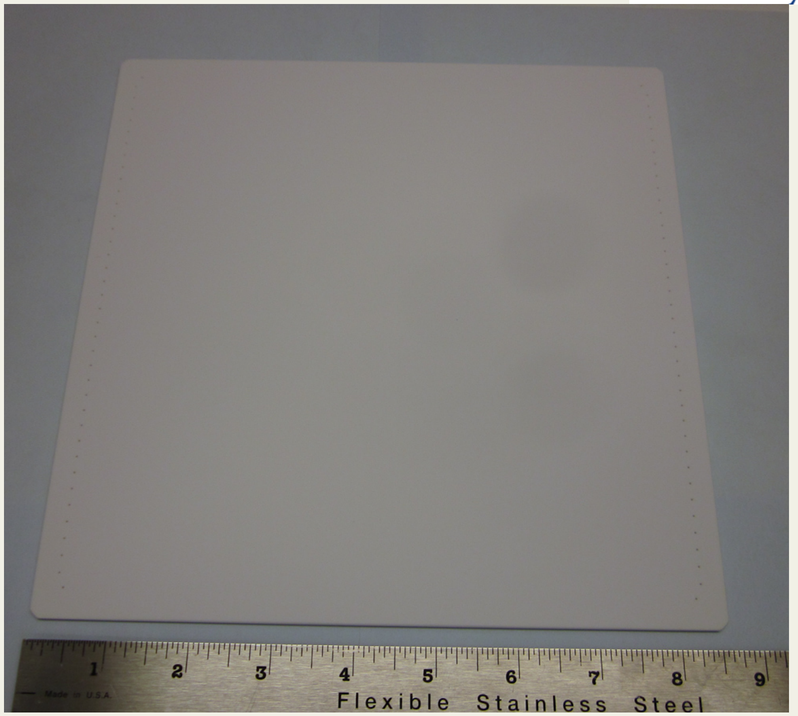


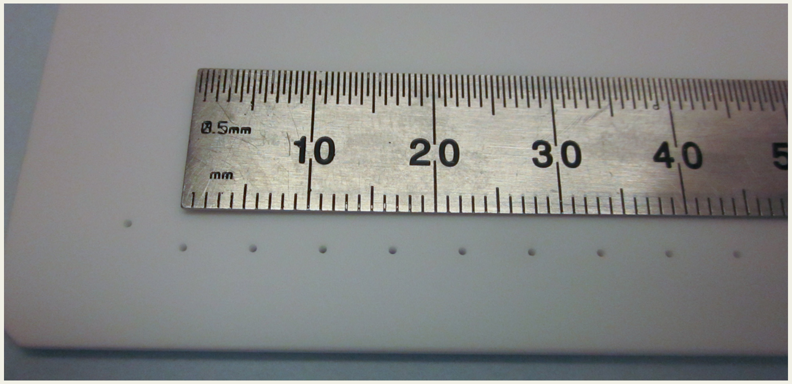


- .100” thick 96% alumina substrate, laser cut edges and pilot holes for signal/HV pins
- Diamond grind edges and ream holes to final size – eliminates stress cracking and cleans up edges
- W, Mo-Mn metallization – HiTemp process (fired at 1450°C)
- Interior
  - 36x .102” wide strips on .214” pitch
  - Solid metallization border for braze
- Exterior
  - Essentially complete ground plane
- All metal surfaces electrolessly plated with Ni
  - Subsequent electroplating with Au or Ag if needed for conduction
- Cu plated Kovar pins brazed into holes with CuSil washers (850°C braze) – 72 signal, 4 HV

Anode Status - Substrates

- Received 10” x 10” x .100” alumina substrates
- Had to send them back for re-flattening (out of spec)
- Rough laser cut and final machining completed
- Sent to Ben (braze/anode vendor) this week

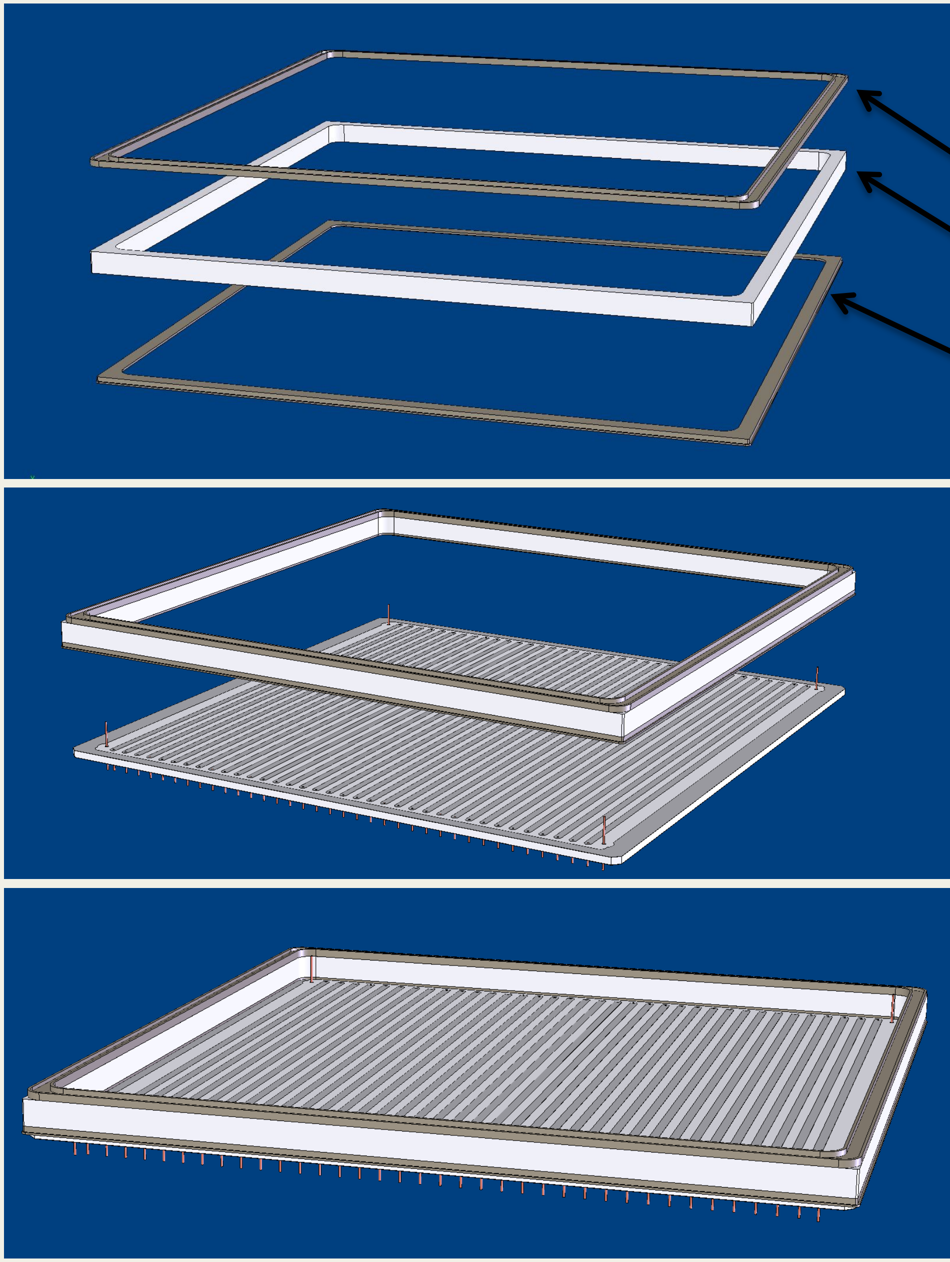




Anode Status - Patterning

- Strip bandwidth/impedance testing on 4.5” alumina blanks by Hervè used to finalize strip design
- Ben cannot screen items this large – Will have Phil Jaynes at Cat-i do the screening
- Ben designs artwork and provides material, Phil screens and dries, Ben hydrogen fires.
- Ben brazes in pins (CuSil braze alloy – 850°C)
- Expect this process to start in January
- Need braze tooling to control pin heights – design and fab

Tube Brazing Scheme

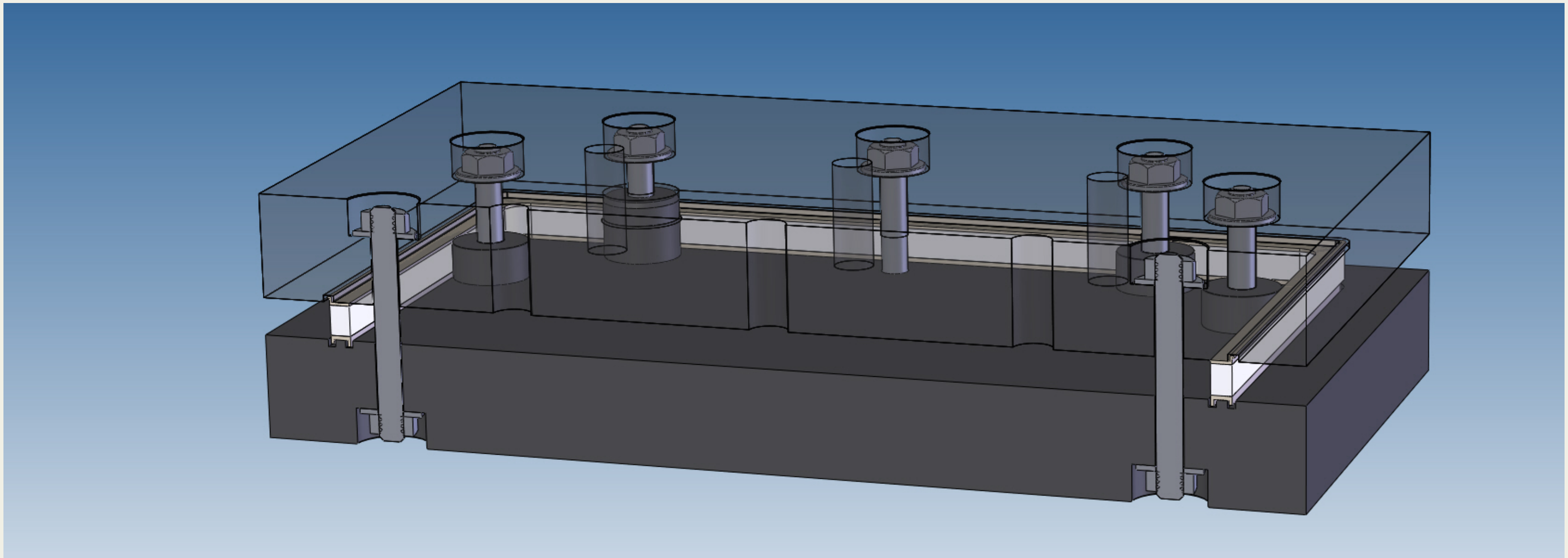


- Brazed Body Assembly (BBA)
  - Machined Kovar In well
  - Alumina wall
  - Kovar Z-flange
  - CuSil braze alloy (850°C braze)
- BBA-Anode Assembly
  - InCuSil braze alloy (750°C braze)
  - Avoids remelt of anode CuSil
- Three braze joints in final assembly

Brazed Body Status

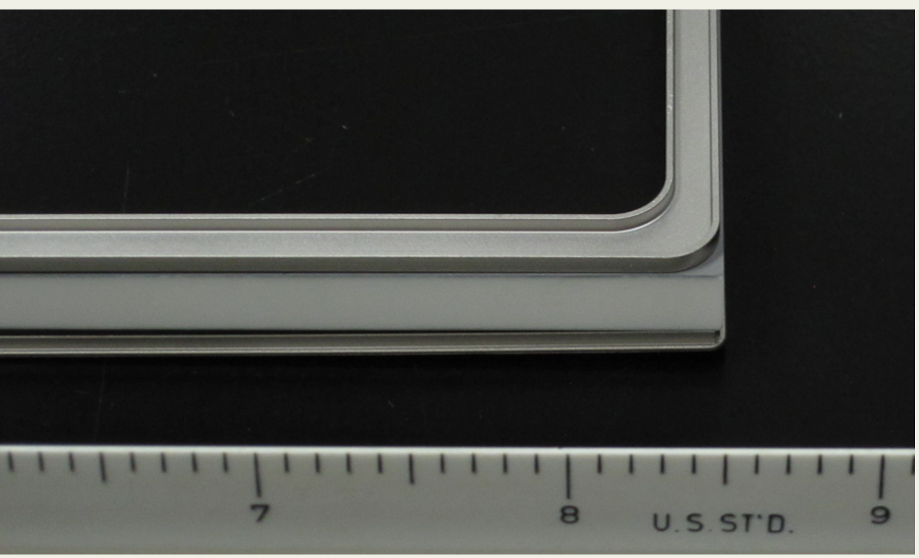
- Designed and manufactured Kovar indium wells (6 pc)
- Designed and manufactured Kovar Z-flanges (6 pc)
- All Kovar parts have been Ni sintered in prep for braze
- Two ceramic walls have been metallized, one has had Ni plate-up for braze (just complete)
- CuSil braze material just received, cut and sent to Ben
- Braze tooling designed, manufactured and with Ben
- Positioned to attempt first braze next week

8” Tube Braze Tooling



- Graphite to reduce sticking of braze run-out
- Molybdenum compression rods and nuts (low expansion)
- Grooves in graphite sized to accommodate the thermal expansion of the Kovar
- Piece part alignment by dowels on the interior to allow expansion
- A similar design was recently used successfully for a 5” diameter braze
- Need two more fixtures
    - Anode pins braze
    - BBA-Anode braze

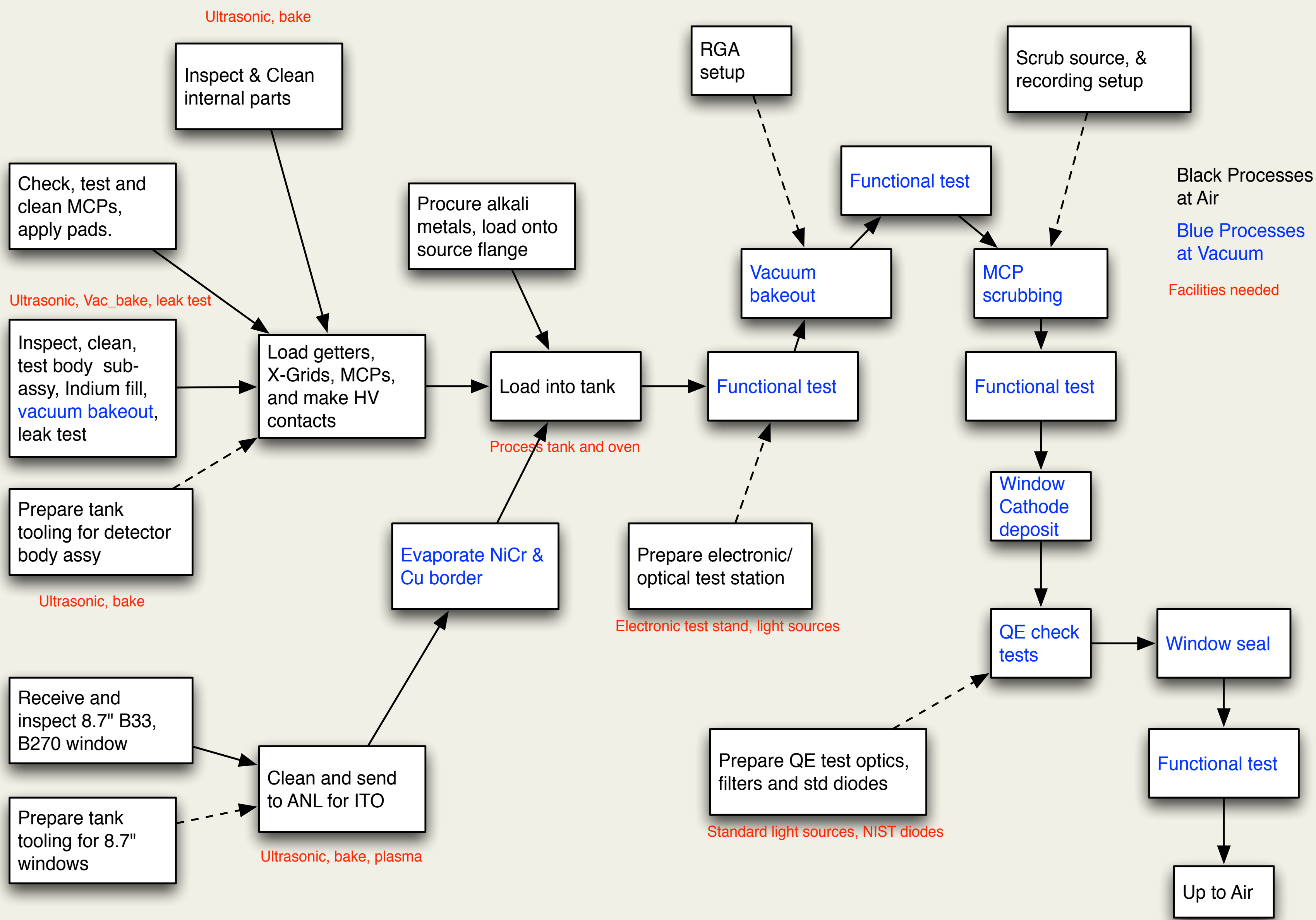
Braze Body Next Steps



- Brazed body parts ready for first braze
- Principal concern is the warpage of the parts (ceramic in particular) – Hermetic?

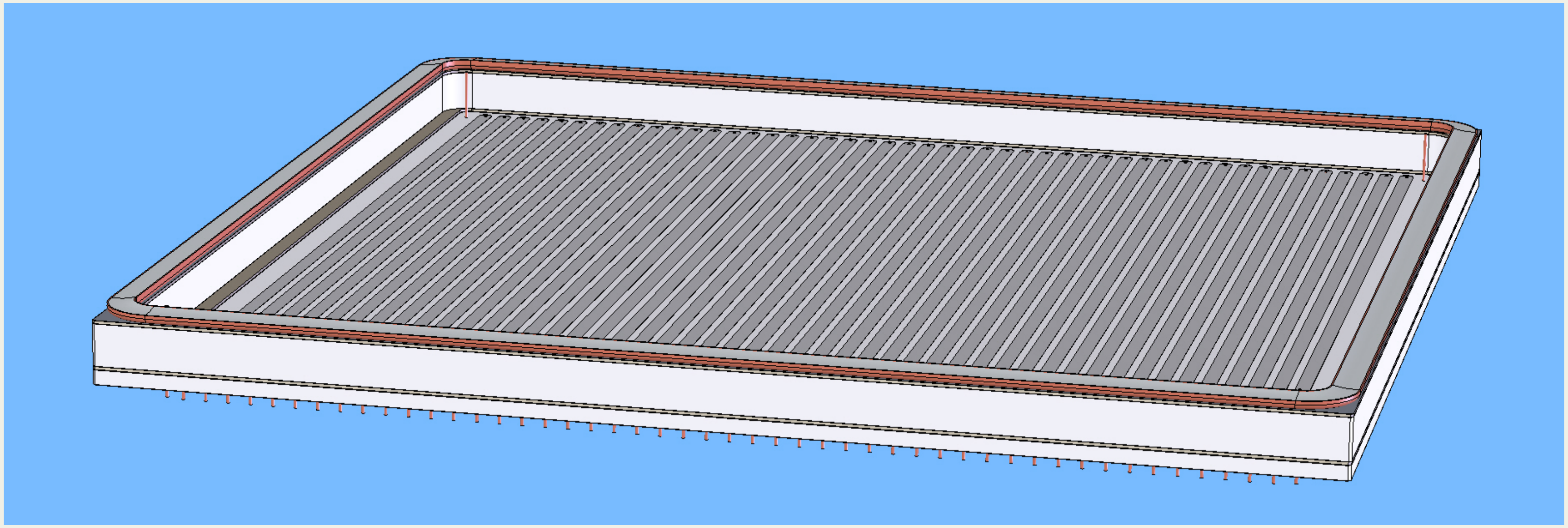
- Post-Braze Testing
  - Leak checking – need fixtures
  - Indium seal testing in 8” photocathode chamber
  - Leak check of In seal – another fixture for window support

8” Tube Process Flow



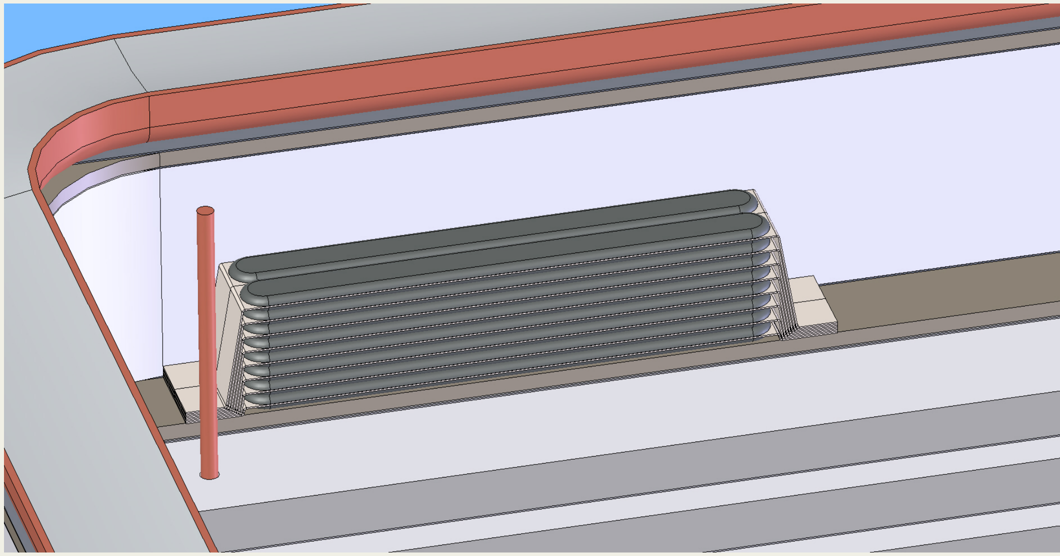
BBA Pre-Process Preparation

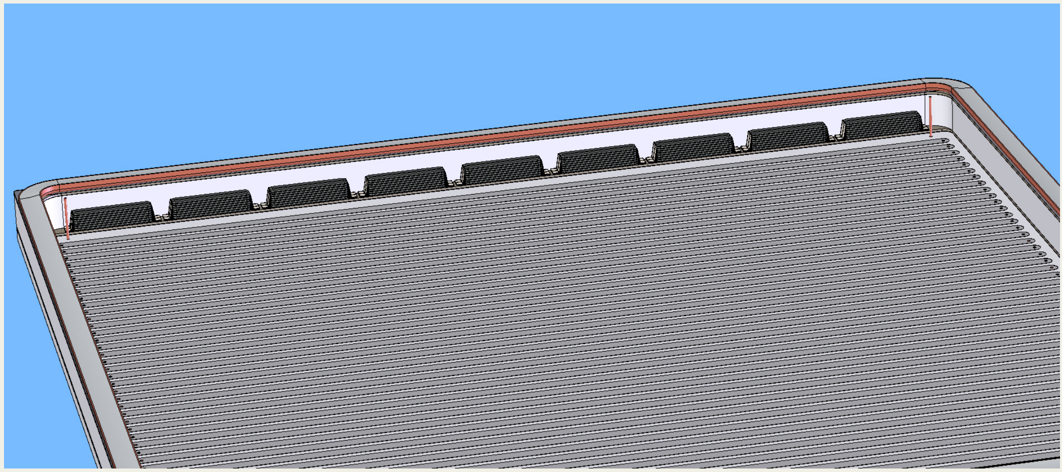
- Leak check (requires support jig)
- Load InBi alloy in cup
- Remove indium oxide
- Vacuum bake to outgas indium (chamber build in progress)
- Leak check (first assembly bake)
- More oxide removal if needed
- Install getters
- Ready for tube build



Getters

- SAES St-122 getter strips
  - Getter material bonded sintered onto .002” Ni shim
  - Passively activated by 350°C tube processing temperature
- Spot weld strips down to bottom Kovar flange
- Total of ~300 getter strips
  - N_2 pumping speed ~30 l/s, (CO & H_2 better)
  - Using Dean’s 8” MCP outgassing rate -> tube pressure ~ 10^{-10} torr
- Robust design, if labor intensive
- Top getters well clear of bottom MCP



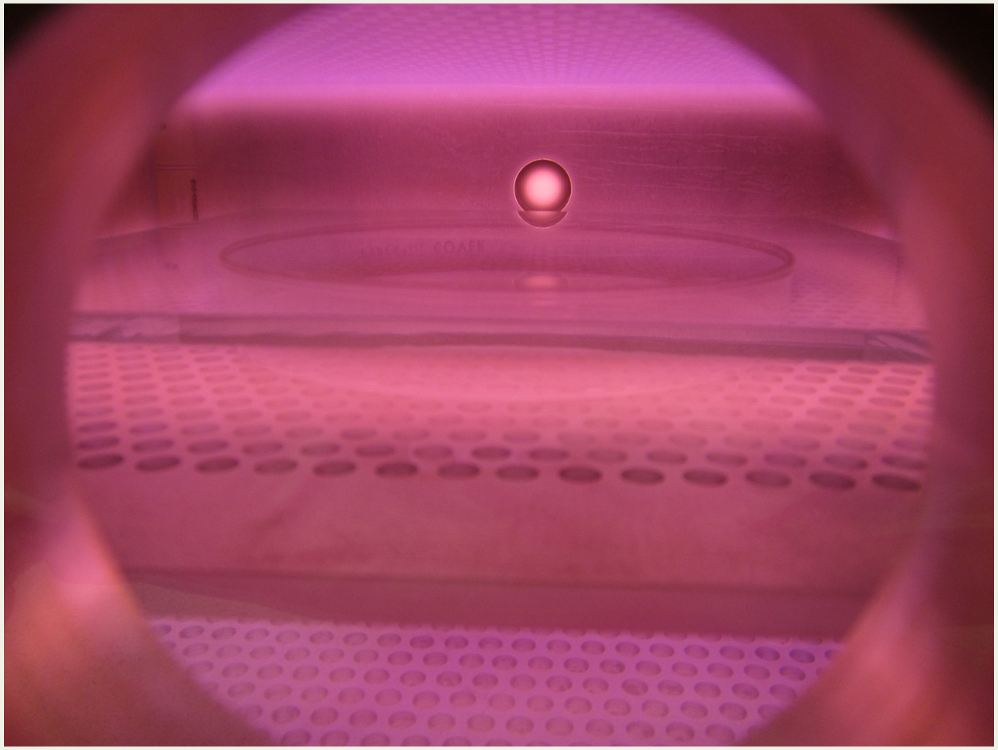


Tube Internal Parts Preparation

- MCPs get standard treatment
  - Ultrasonic clean in 50/50 Iso/Methyl mixture
  - Air bake to dry (~100°C)
- Other bits (X-grids, HV contacts, etc.)
  - Standard wet clean process
    - Ultrasonic in Valtron/DI water mix
    - DI water rinse
    - Ultrasonic in DI water
    - Ultrasonic in isopropanol
    - Air bake to dry (~100°C)
- Alcohols are Nano-Grade to minimize residues and particulates

Window Preparation

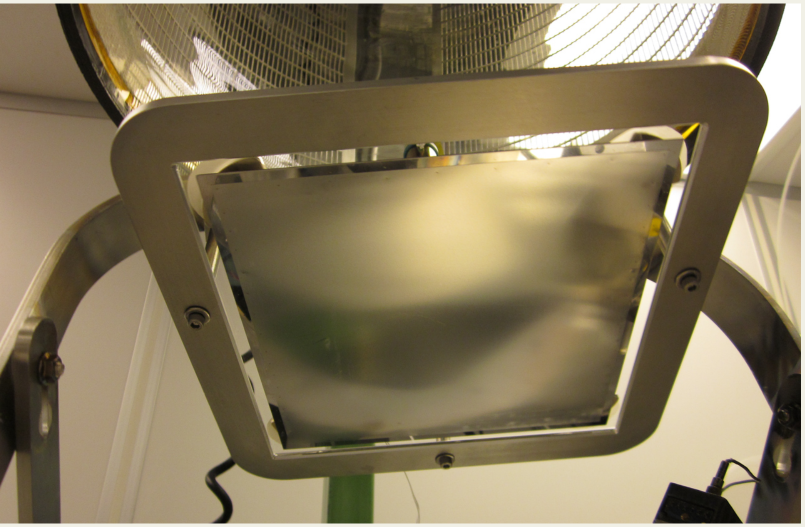
- Standard wet cleaning
  - Add mechanical scrubbing with calcium carbonate slurry to get water break if needed
- Plasma clean

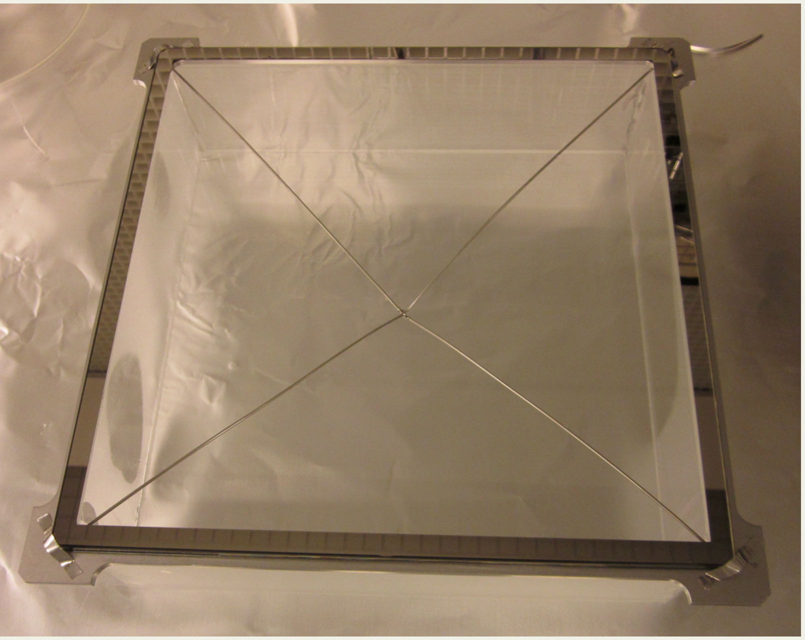


Large plasma asher installed in clean room.

8" window being plasma cleaned

Window Preparation (cont)

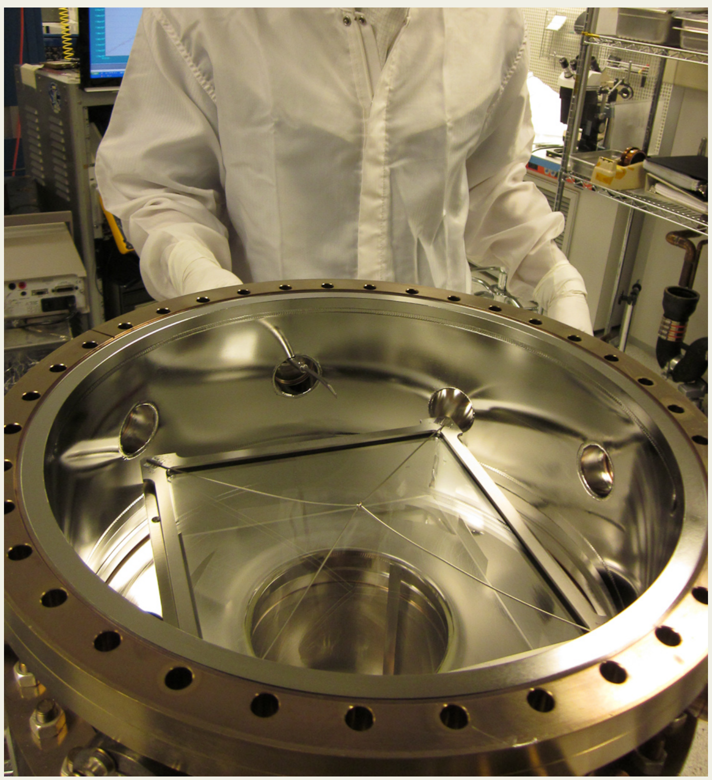




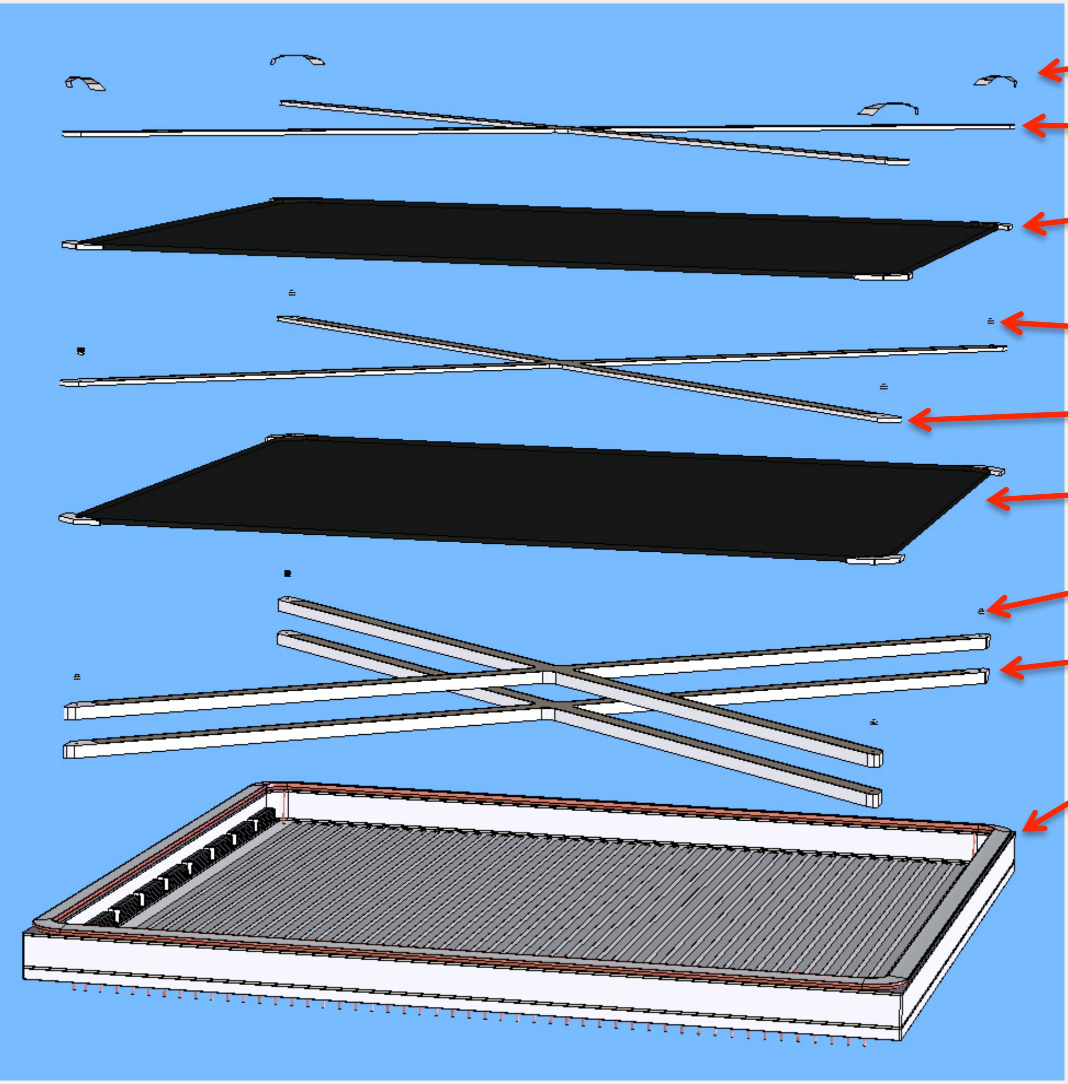
- Apply metallic border with sputtering system
  - NiCr first for adhesion to glass and photocathode contact
  - Possible NiCr grid for cathode conductivity
  - Cu next for indium seal wetting
- Install into transfer fixture
  - For manipulation in the process chamber
- Ready for installation in process chamber
  - Store in vacuum until ready to perform chamber load

8” Window Nest

- Glass forming well and associated window nest have been used in the 8” photocathode chamber
- Same design with slight modifications will be used in the large process chamber



Internal Stack Assembly



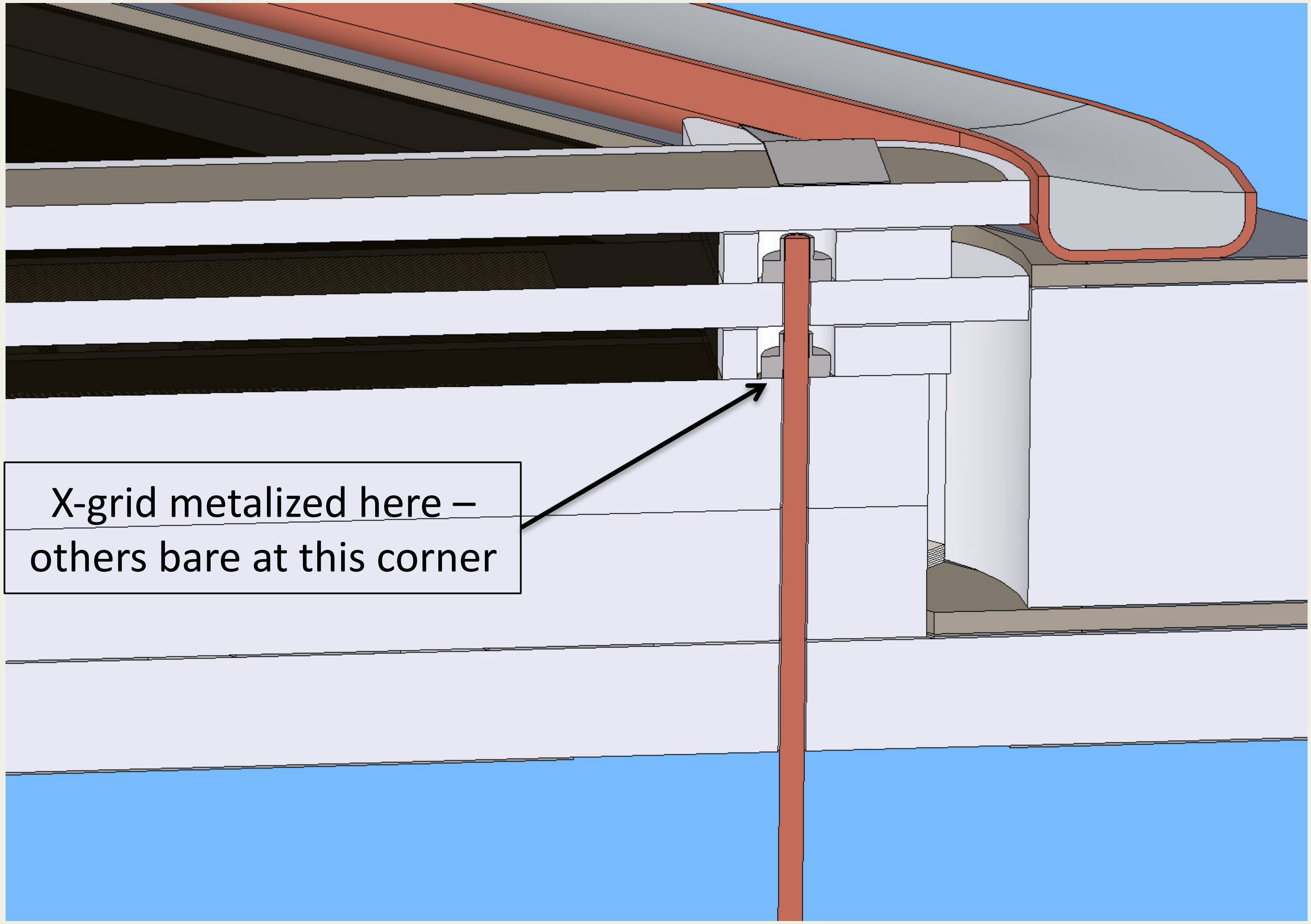
- Stack hold-down straps
- Top X-Grid – 1 mm thick
- Top MCP – with anti-rotation blocks at corners
- HV contacts
- Middle X-Grid – 1 mm thick
- Bottom MCP (w/ A-R blocks)
- HV contacts
- Anode gap X-Grids - .120” ea
- Prepared BBA (indium and getters)

- Internal stack height .003” shorter than walls to ensure seal

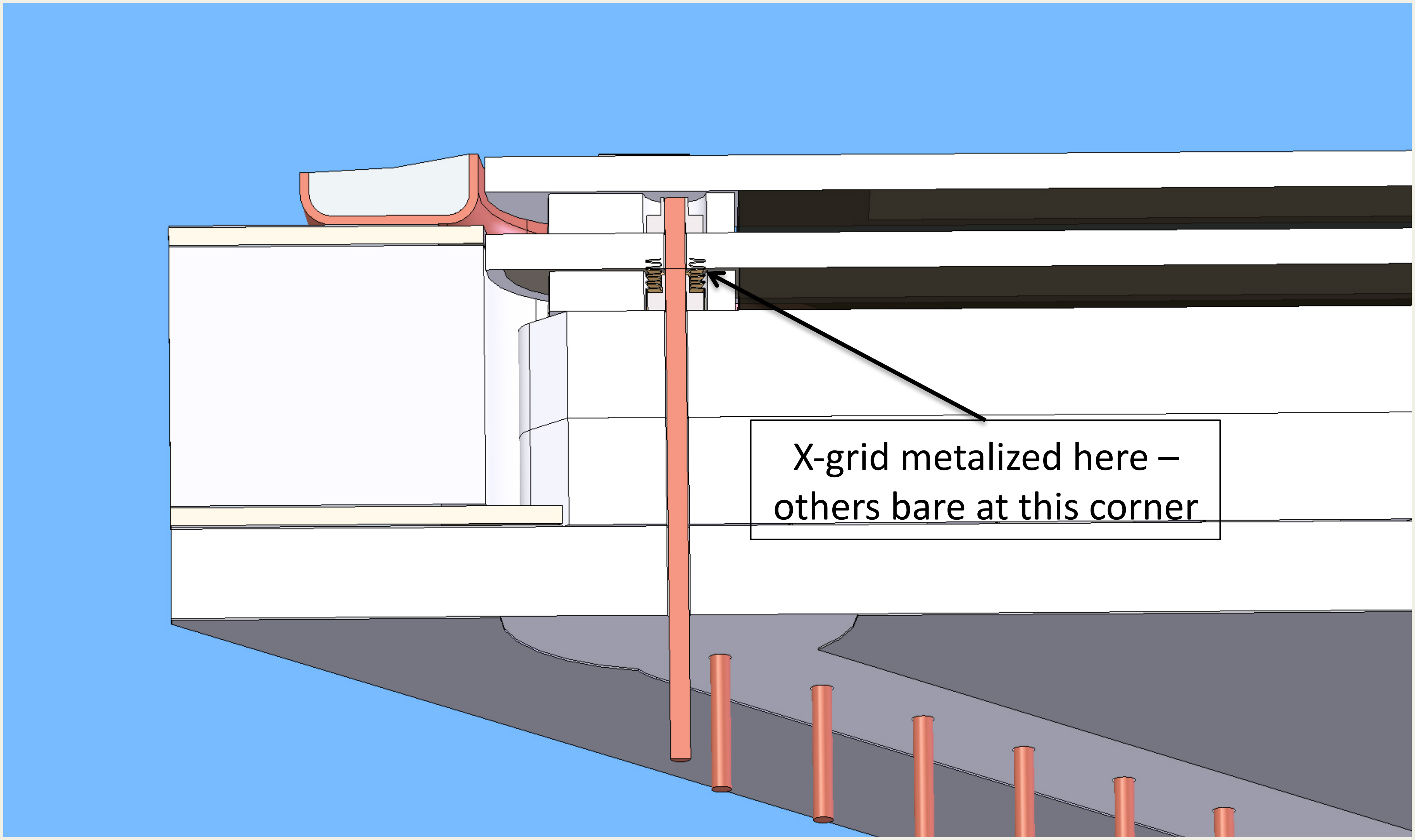
HV Contact Scheme

- Four HV pins through anode (one in each corner) for MCP HV's
- Cathode HV provided externally
- Each of the lower X-grids have locating holes in the ends of the arms
- Top-hat washer spot-welded to all pins at all levels to hold down stack
- Each X-grid is metalized (evaporated NiCr) and oriented to provide unique contact of each MCP surface to only one pin
- Contacts to MCP top surfaces (X-grid bottoms) made by miniature Ni bellow contact
- Top X-grid lacks holes to provide insulation between cathode and HV pins
- Top of stack "strapped down" to the top Kovar flange with two overlapping, spot welded .001" thick stainless shims (at all corners)

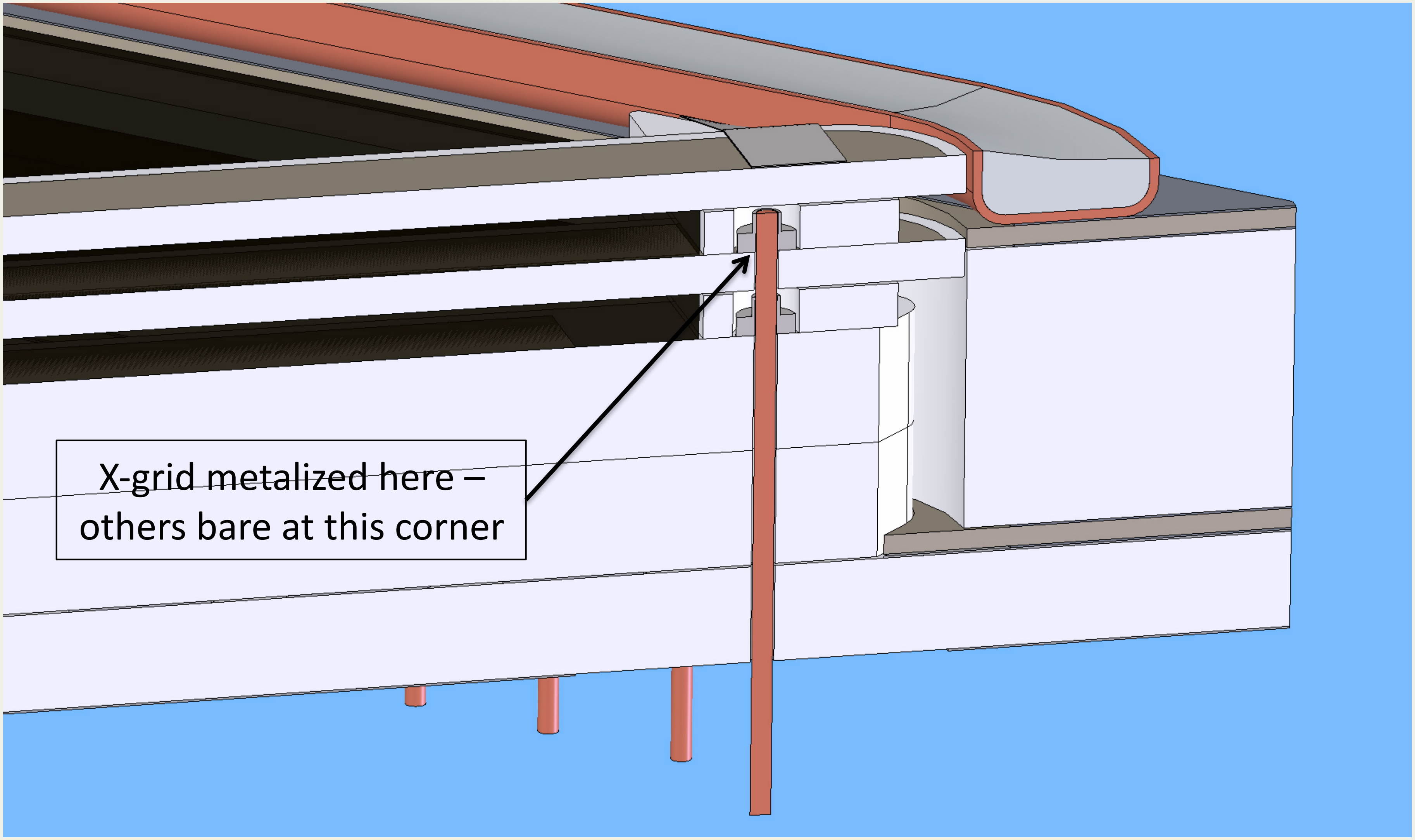
HV1 (Bottom) Contact Detail



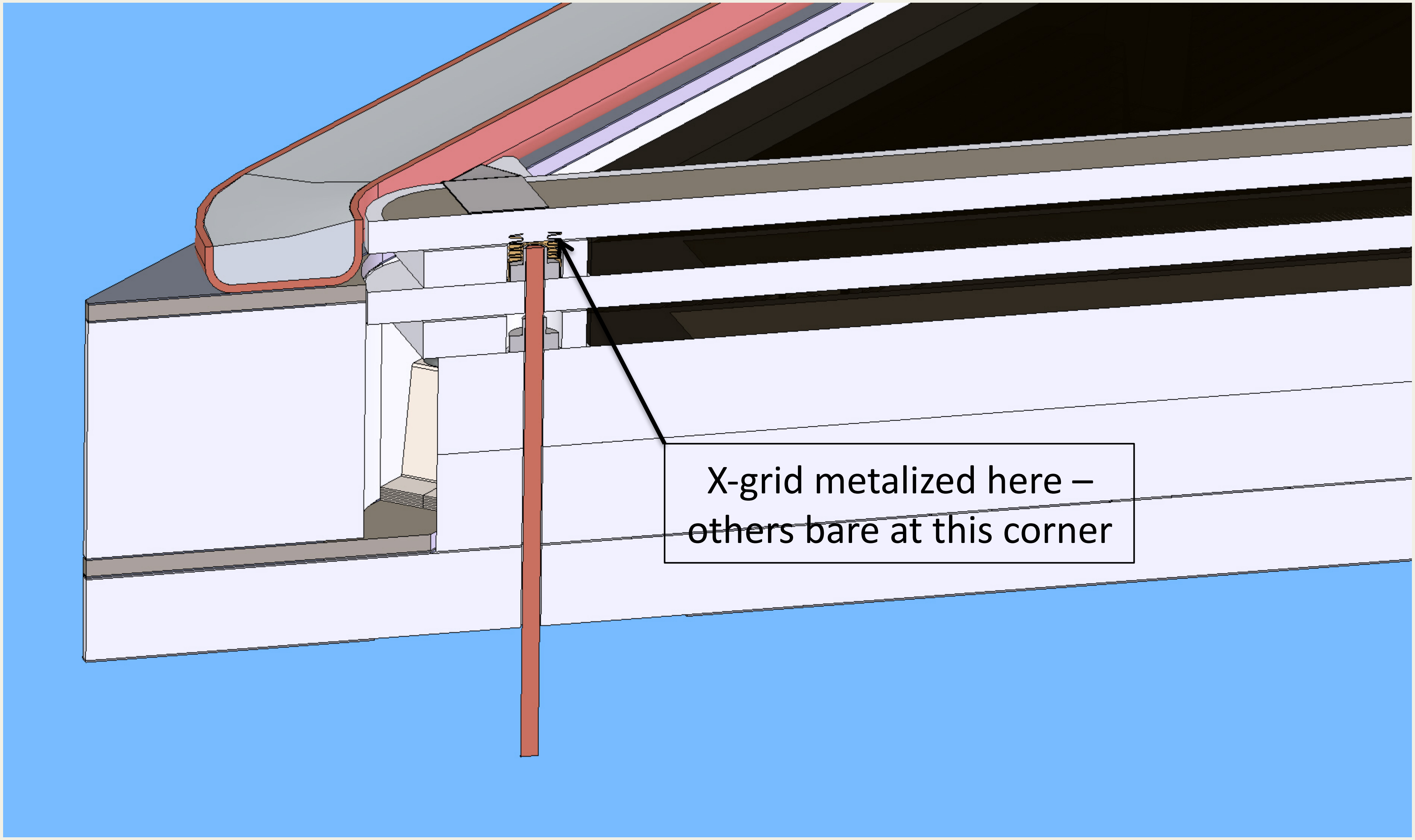
HV2 (Lower-Middle) Contact Detail



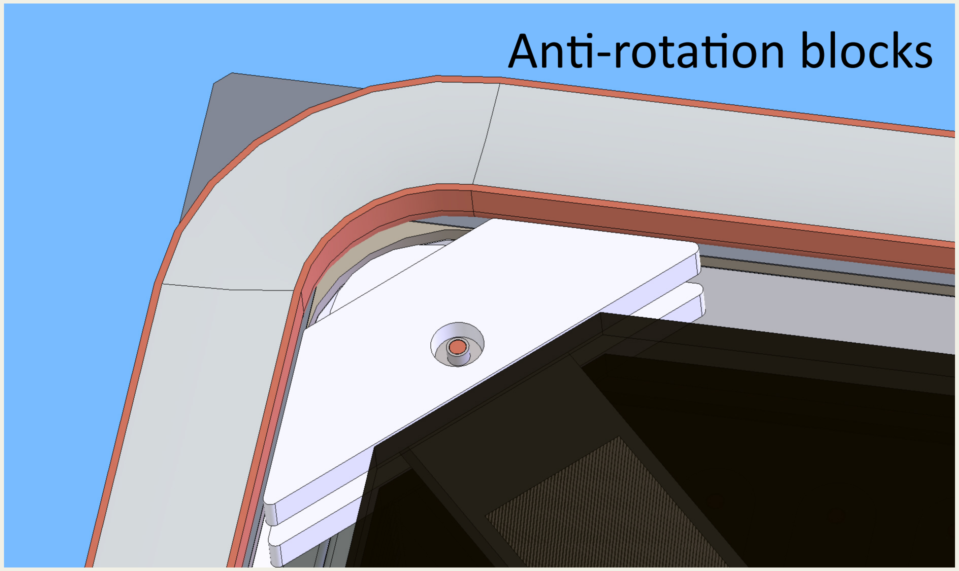
HV3 (Upper-Middle) Contact Detail

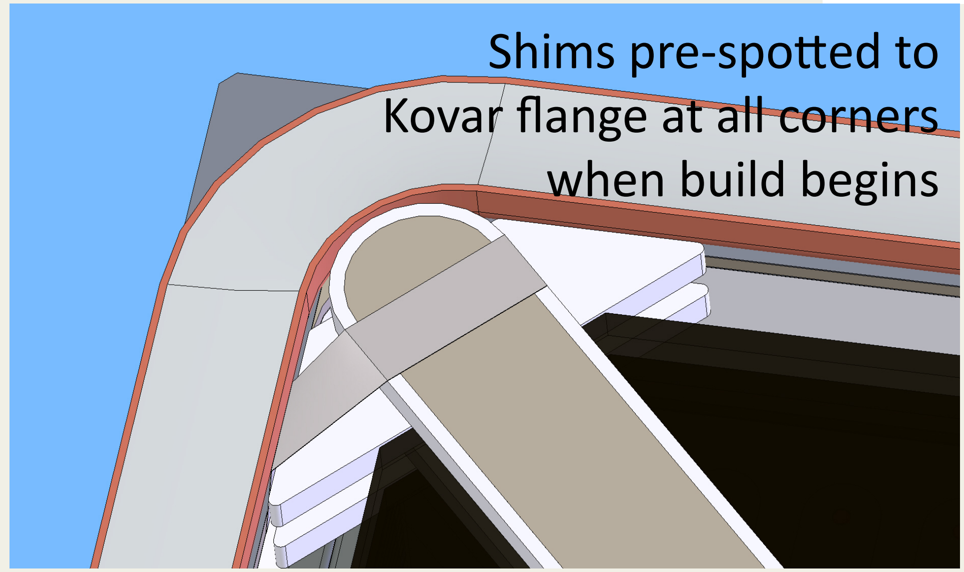


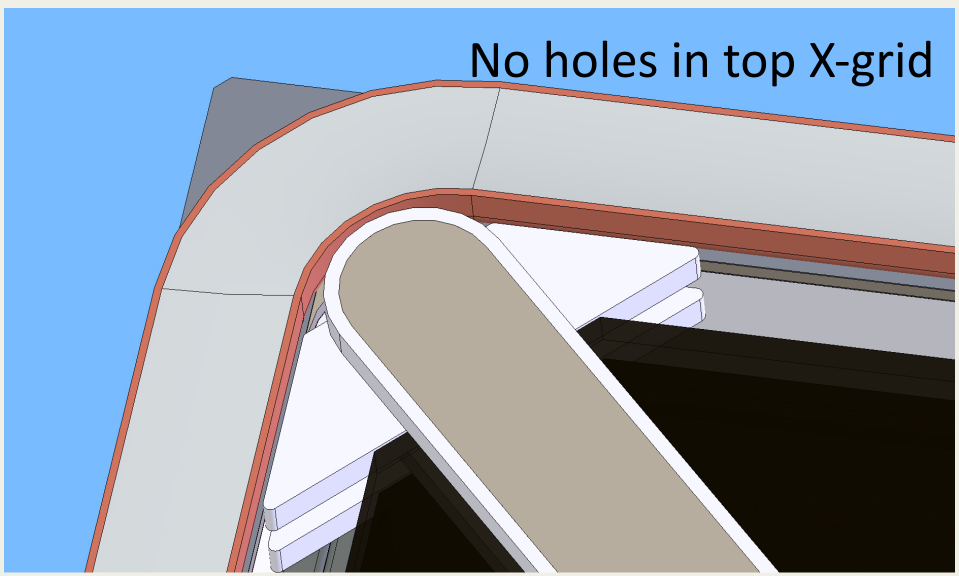
HV4 (Top) Contact Detail

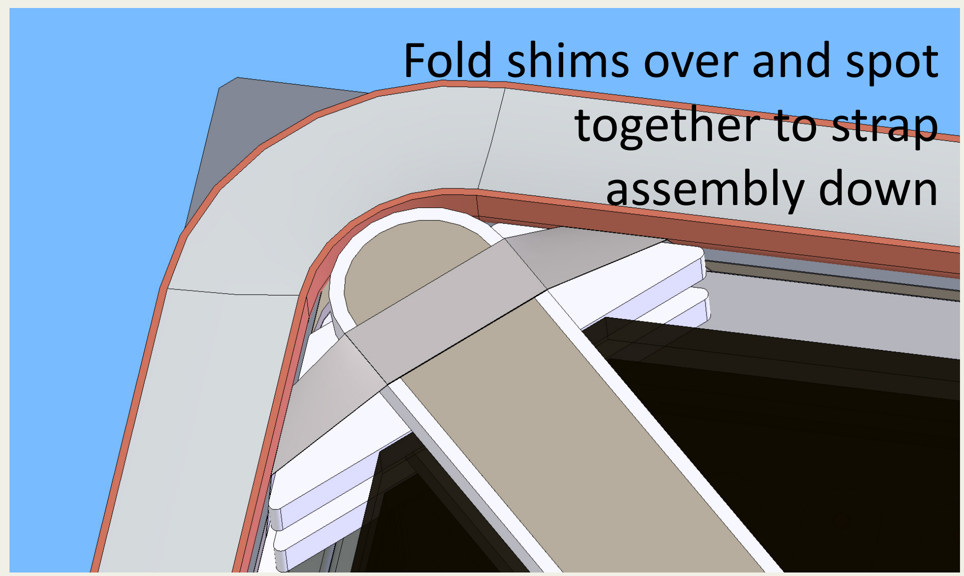


Top Lashing and Anti-Rotation Details





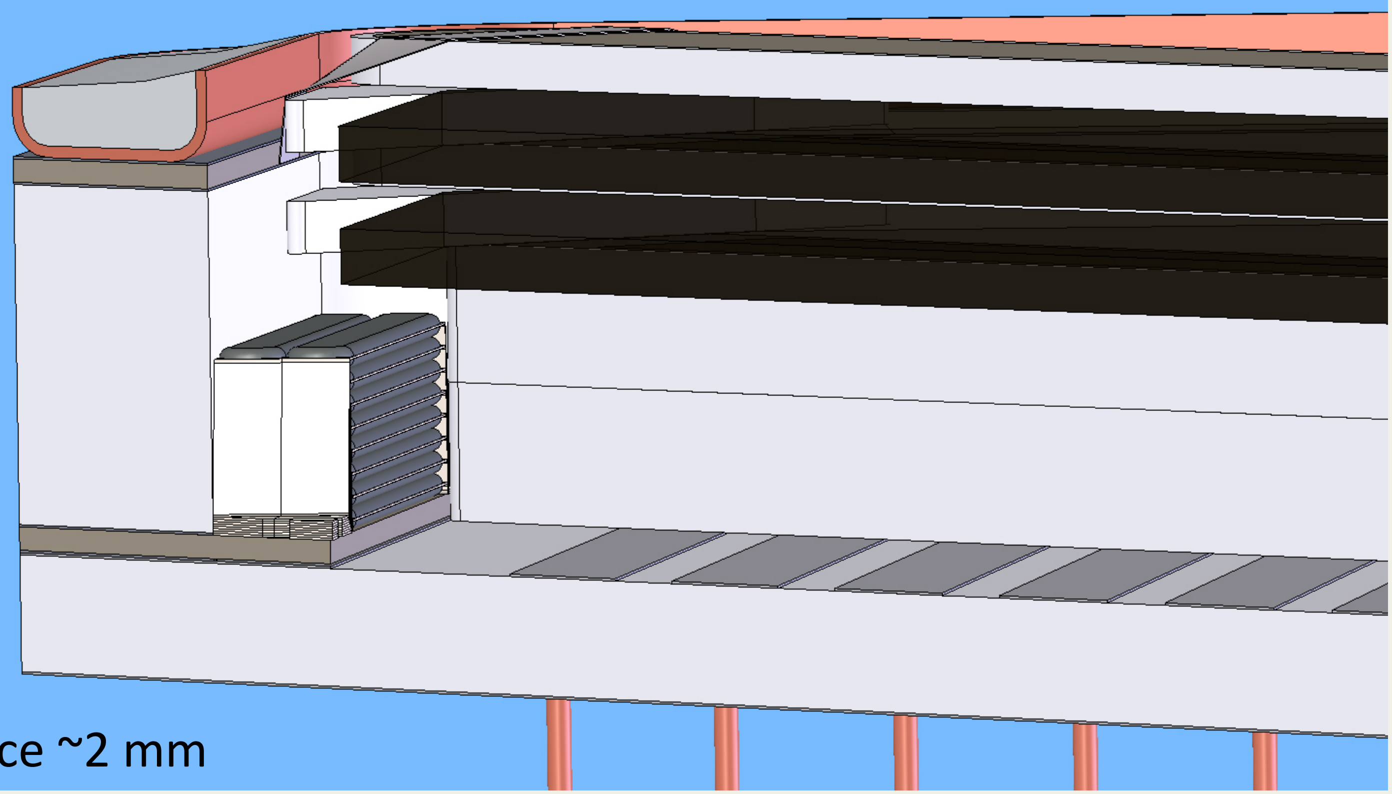




One More Detail

Clear and open pumping from all active areas of the MCPs

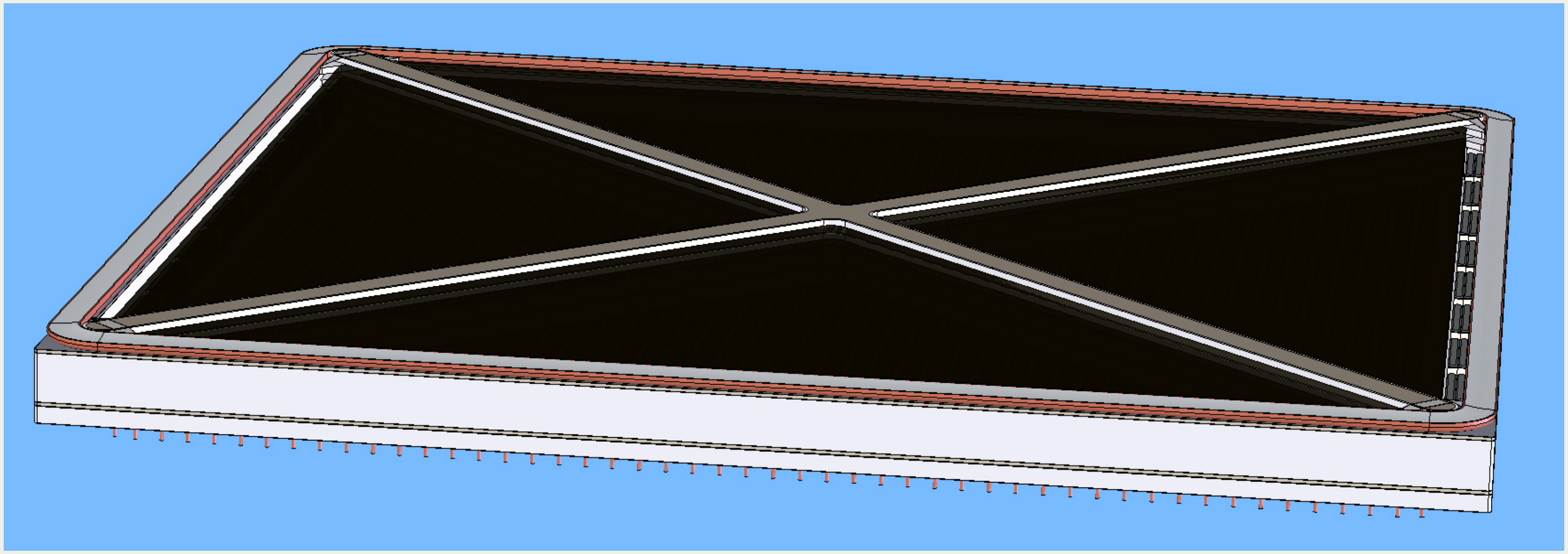
Good pump path around bottom X-grids



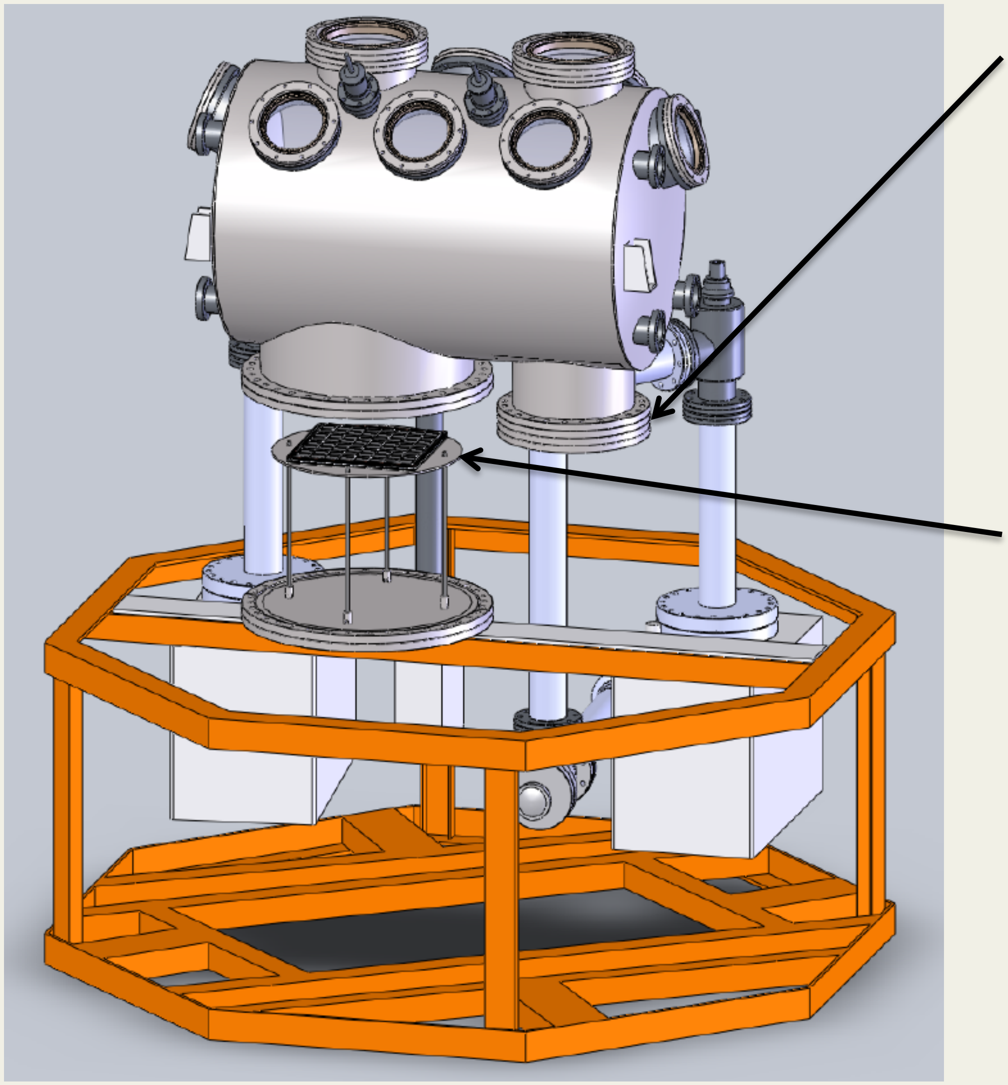
Getter HV clearance ~2 mm

Tube Ready for Processing

- Verify nothing is protruding above the seal seat
- Carefully inspect for any dust on the MCPs
- Verify electrical contact to the MCPs from the exterior pins
- Verify the MCP resistance is as expected
- Check for short circuits
- Anything else that might cause a vacuum break?
- Ready for chamber load

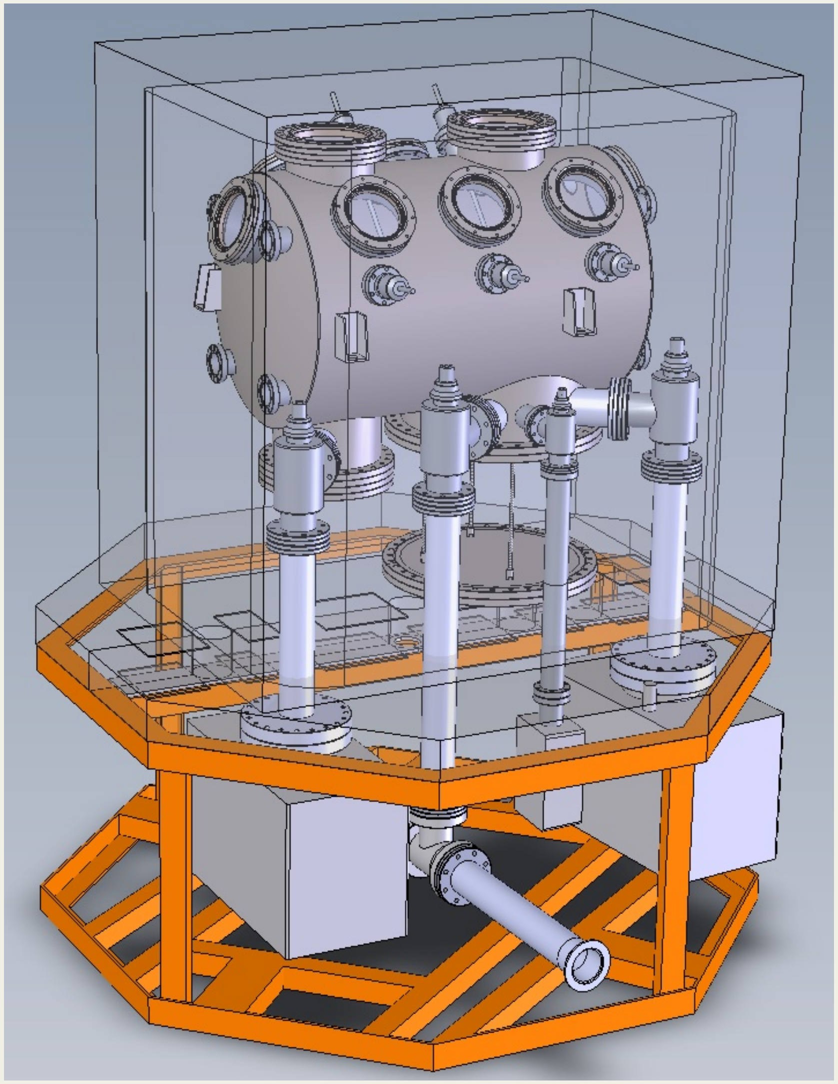


Process Chamber Load



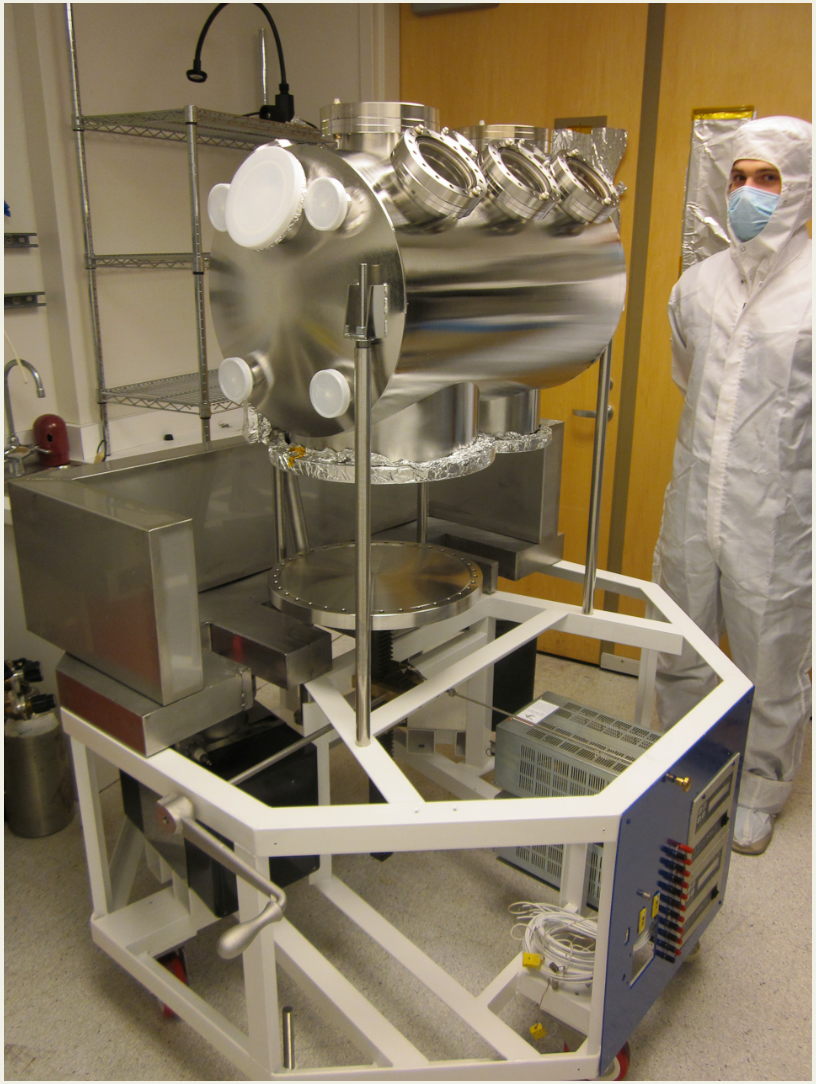
- Cathode materials loaded in the forming well
- Tooling needed during process in the chamber
- Window on handling fixture loaded
- Tube loaded onto support flange
- Test conductivity from the tube to outside the flange
- Seal chamber and evacuate
- Functional test the detector

Tube Processing



- 350°C utility bake (12-24 hours) on turbo
- Functional test detector
- Switch to ion pumps
- Scrub the MCPs (3-4 days?)
- Shoot photocathode at elevated temperature (~190°C)
- Measure QE while hot
- Seal the tube on the cool down
- Once cool measure the QE again
- Last at vacuum functional test (but with window on now)
- Vent chamber
- Monitor tube for signs of leakage

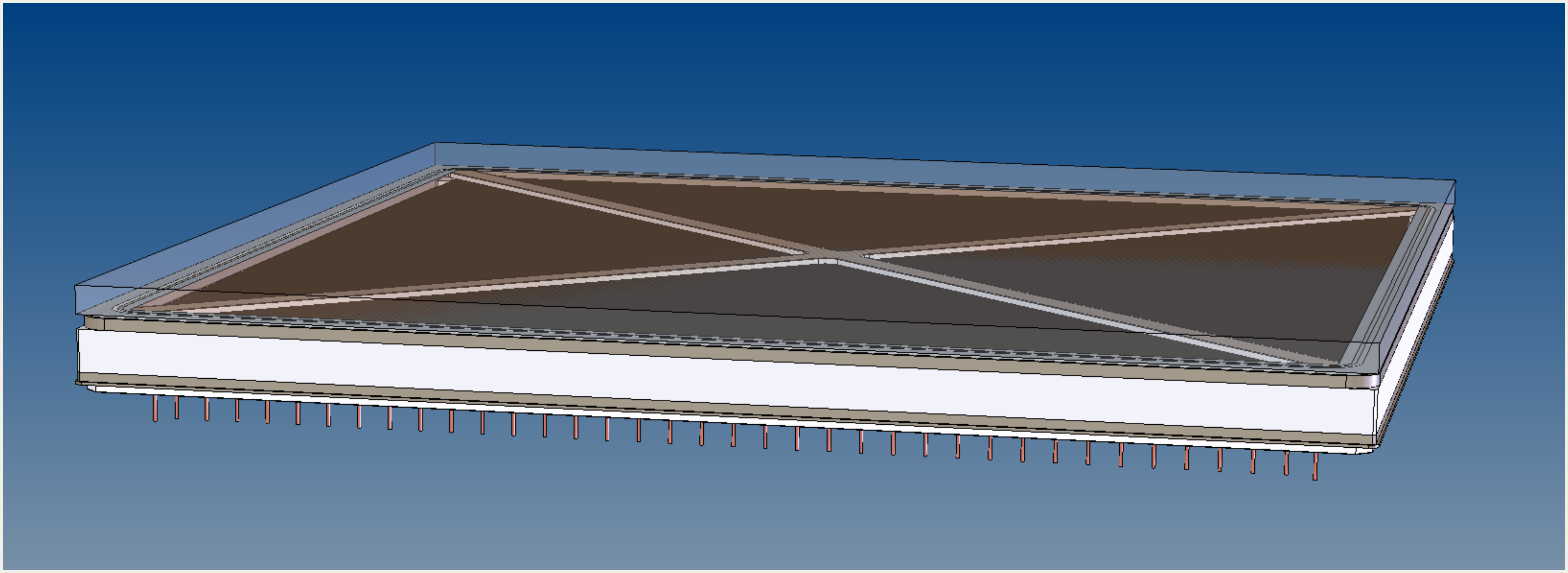
Large Tube Process Chamber



Process chamber for 8” tubes is ready for clean prior to final build-up – then into H_2 bake-out.

Finished Tube

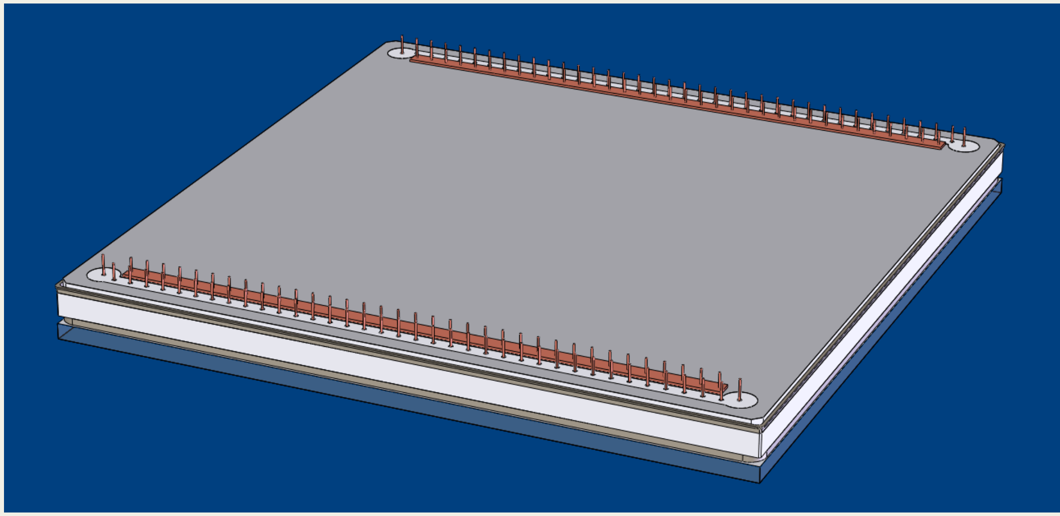
- Remove tube from process chamber
- Integrate with test setup for more detailed functional testing
- Perform "normal" image and gain characterizations
- Ready for integration with LAPP electronics

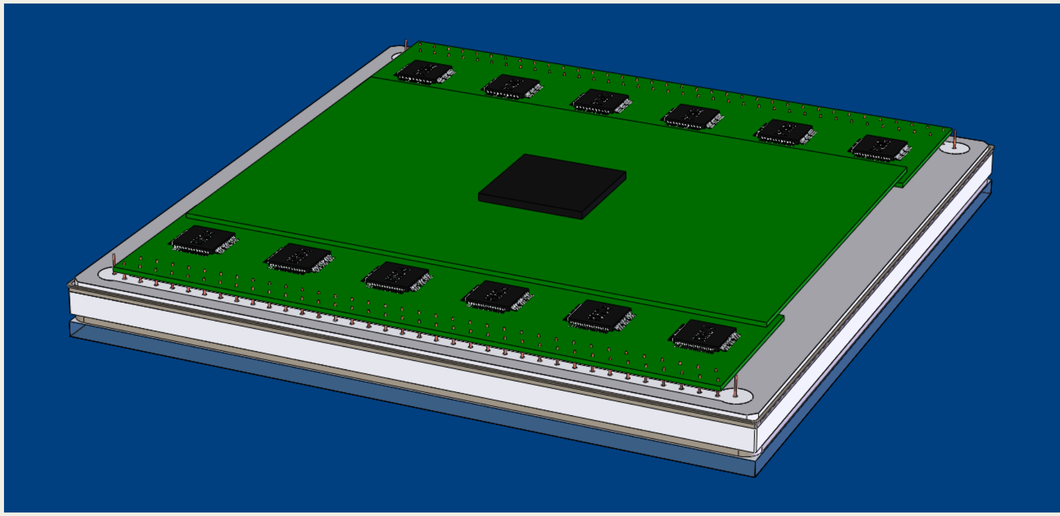


Electronics Packaging Strawman

- Conductive epoxy ground pin arrays to tube back ground plane
- Analog cards, probably 3 per side (not as shown)
- Interconnect to digital board with readout interface

- HV supplied separately for now – resistive bridge and single supply or multiple supplies





Concerns

- Non-flatness of ceramic parts post metallization
  - What will the anode do when metalized?
  - Can flatten with minimal force, but what happens when released?
  - Will the final assembly look like a potato chip?
- Can the MCPs support the pressure from the window and anode?
  - Need to test compressive strength of MCPs
  - Assuming compressive strength equals tensile strength (likely higher), then get FOS ~ 5 for .25" wide X-grid
  - Can widen the X-grids if needed

More Concerns

- Tolerance on getting the internal and external stack heights appropriate
  - Want the inside height ~.003” shorter (±.001” or so)
  - May require post braze machining of seal surface
- Manipulating the window in the process chamber
  - Large, heavy, square window with only a modest number of simple wobble stick manipulators (space limited)
  - Need to design a rail based shuttle system inside the tank

Even More Concerns

- Edges of MCPs may well be “hot” (high background)
  - Block these counts by putting a square frame around one of the X-grids
  - Best choice for this is the top anode gap X-grid
    - Doesn’t close in pumping space
    - Prevents the getters from leaning in toward active area
- Time
  - Pieces are coming together (finally) – we need to keep this momentum
  - Not a lot of latitude for error now.