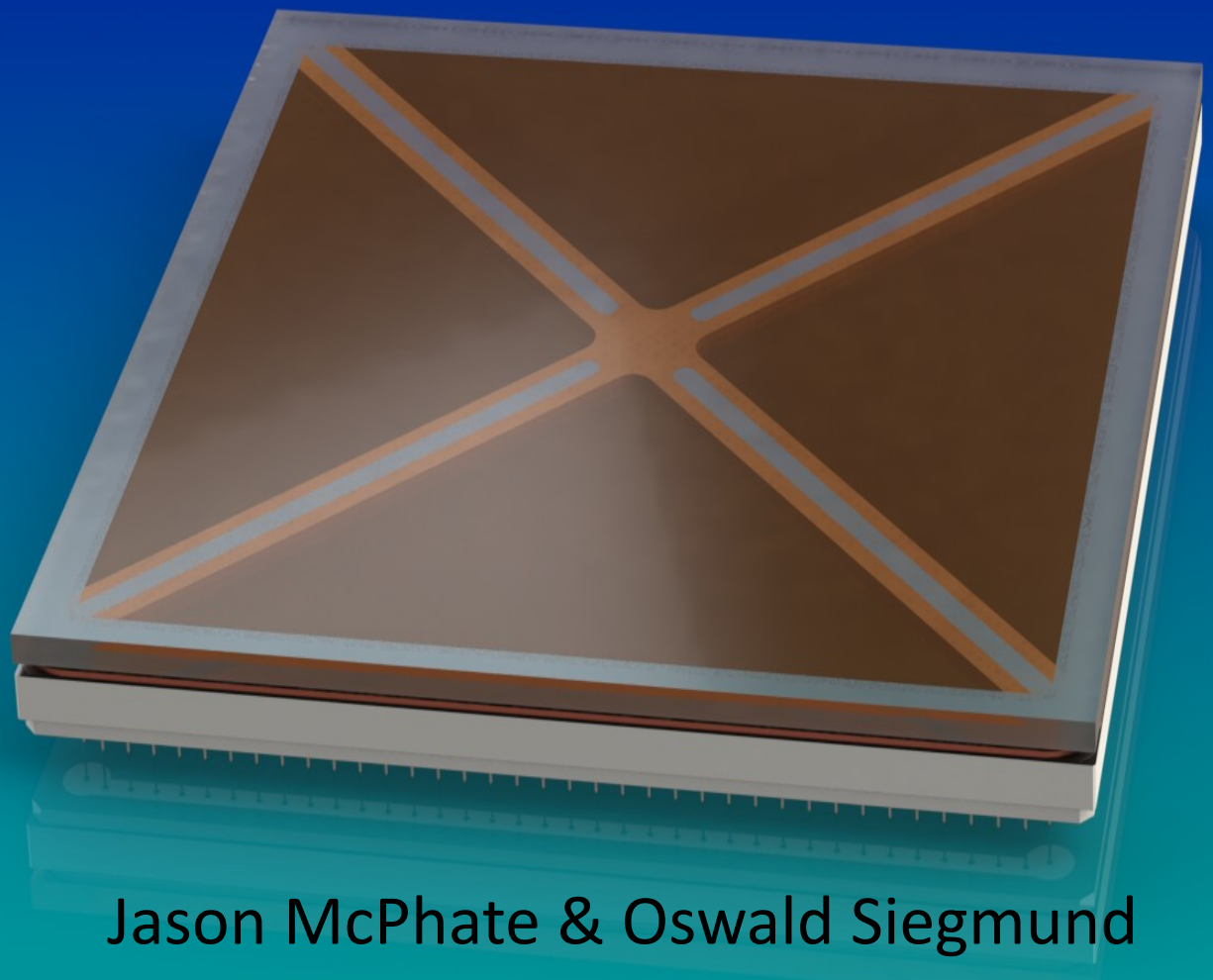
LAPPD Ceramic Package Design, Flow, & Status



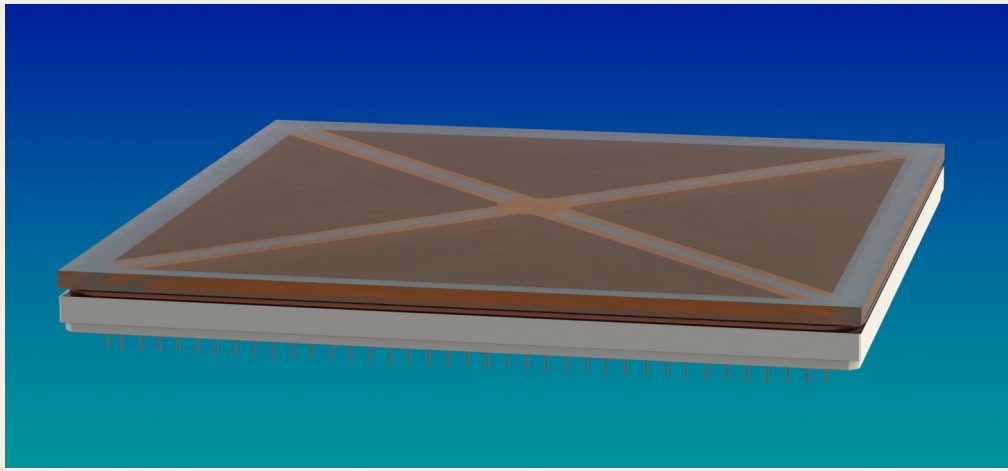
Jason McPhate & Oswald Siegmund

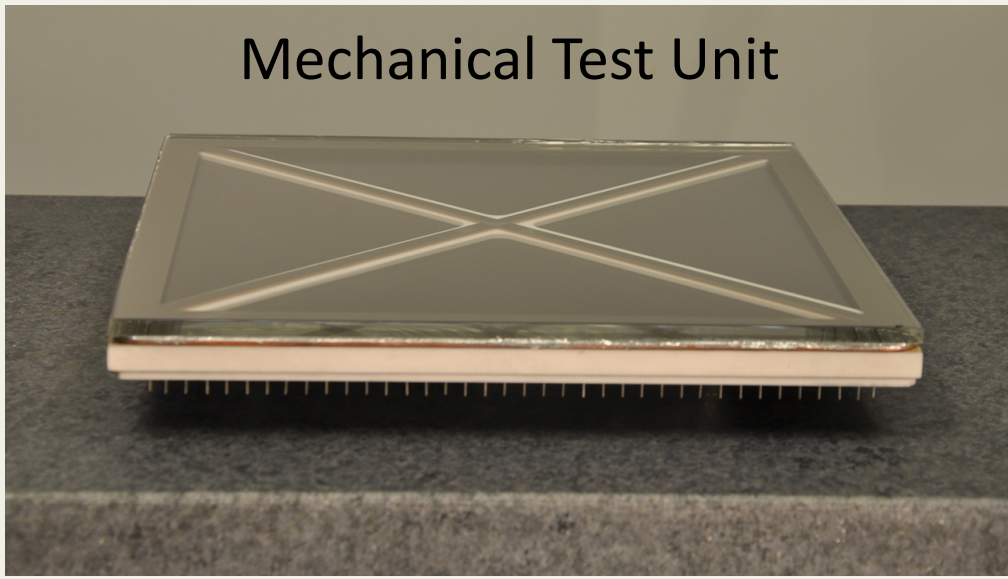
LAPPD Hermetic Package Godparent Review

3 April 2013

Ceramic Package Design Overview

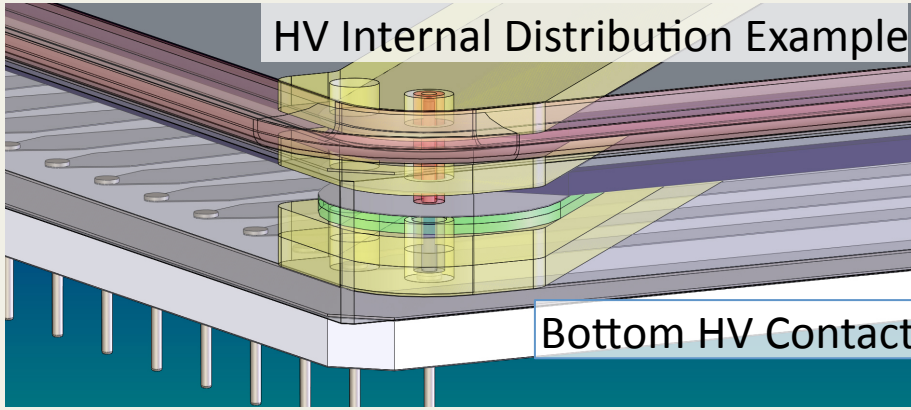
- Use “standard” sealed tube materials and processing
- Ceramic brazed body with Cu indium well
  - Signals and HV passed through the anode on Kovar pins
- 5mm thick borosilicate (Schott B33) window
- Na_2KSb bialkali photocathode
- Hot seal (InBi alloy)
- “X” shaped internal support structure
- 8.66” square, ~0.68” thick (including window)



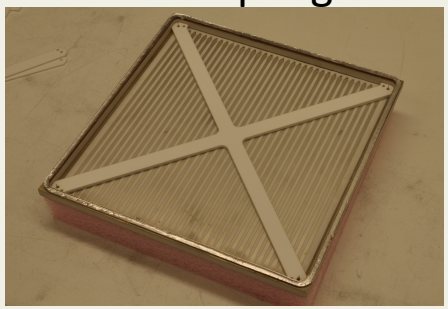


Internal Stack-Up

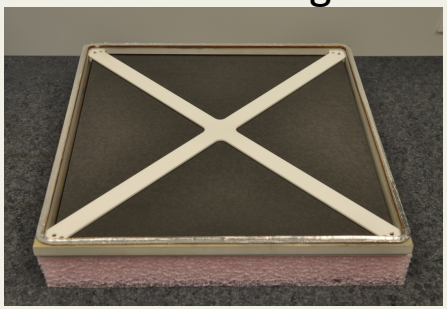
- Large area requires internal support structure to prevent window/anode cracking under atmospheric pressure load
- Desire to support without creating trapped spaces lead to “X” shaped support structures
- Combination of insulating ceramic X-grids and stainless X-shims
- X-grids isolate HV potentials while X-shims facilitate HV distribution (and stack height adjustment)
- Top X-grid serves to retain entire stack during processing
- Total internal stack height is .003” to .006” *below* the top of the Cu well – to ensure window seal

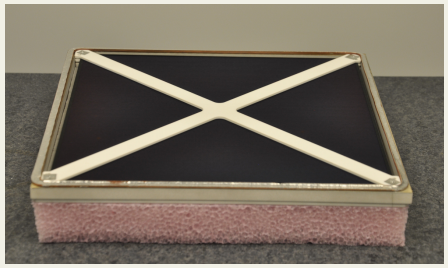


Anode Gap X-grids

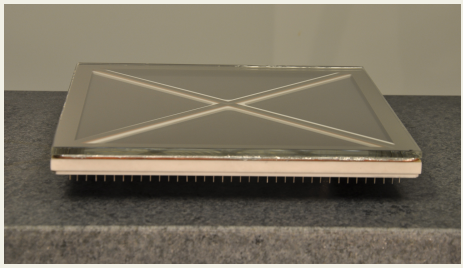


Inter-MCP X-grid





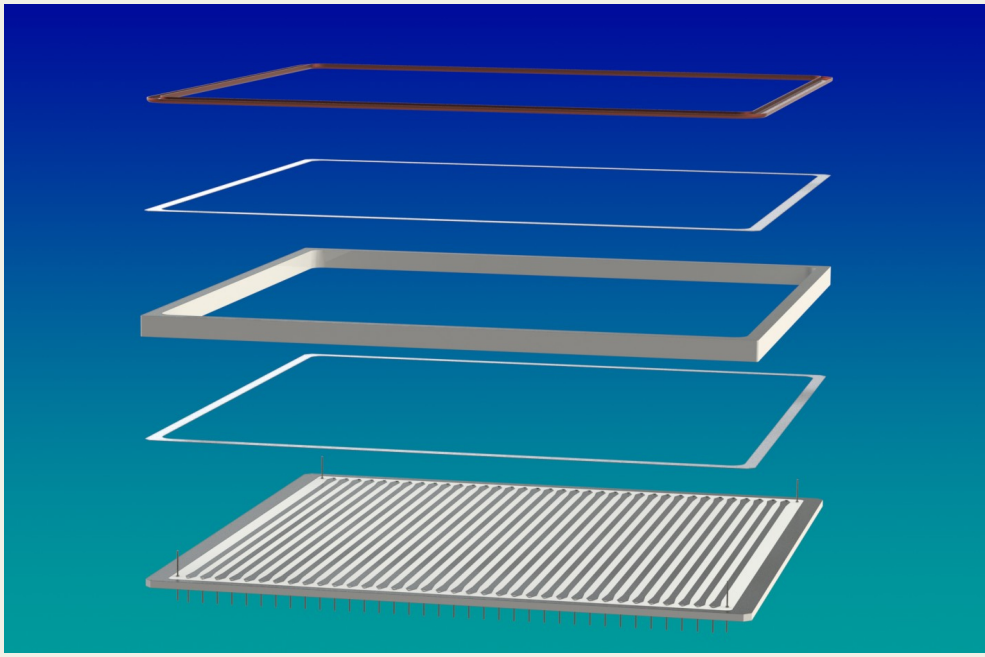
Cathode Gap X-grid

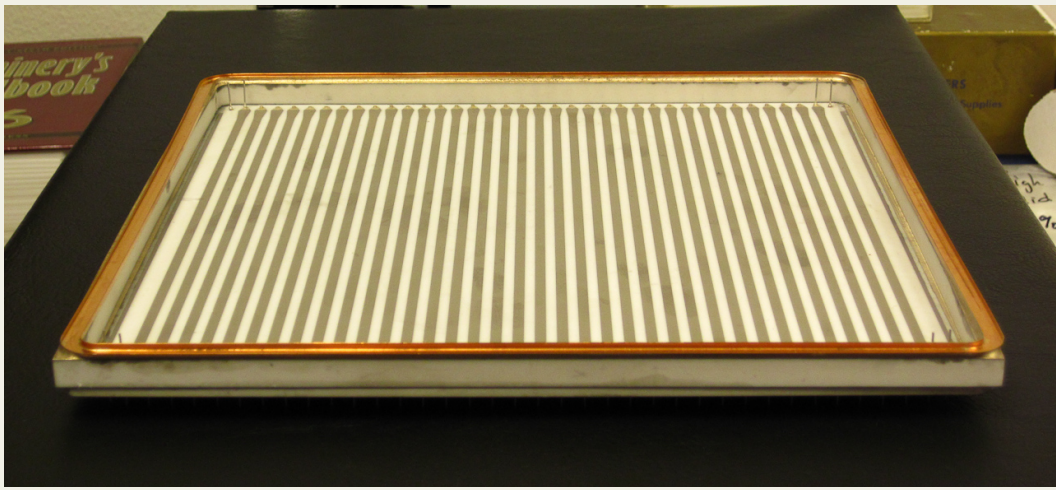


Mech. Test Unit

Ceramic Brazed Body Assembly

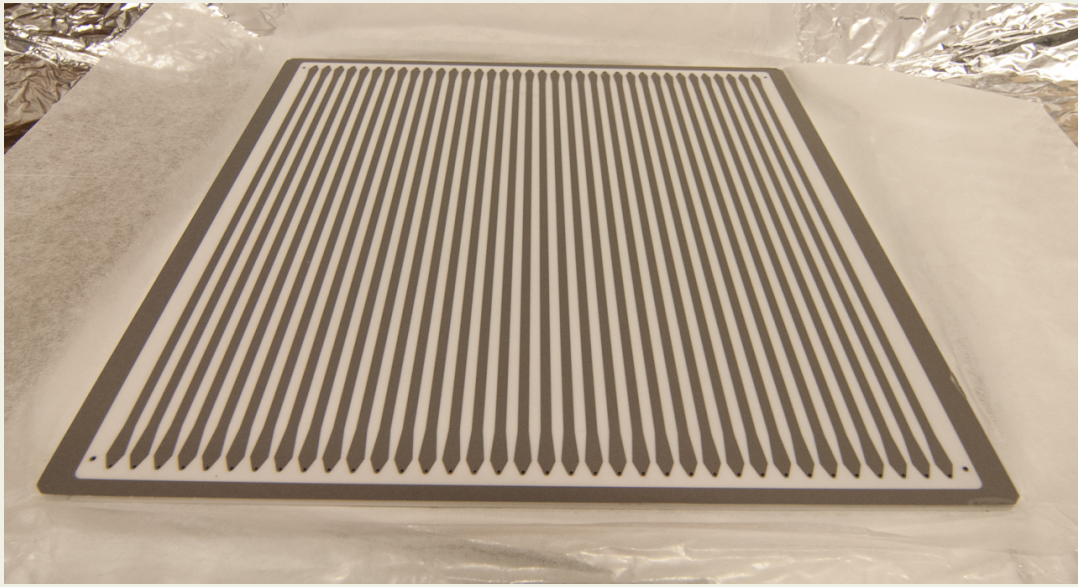
- All materials refractory or metal and proven for vacuum tube manufacturing
- High-temp metallized ceramic anode with Kovar feedthrough pins
- Ceramic sidewall frame
- Indium seal well is stamped from OFE copper (used for optimal indium wetting and ductility)
- Only two braze joints (save for the pins), using InCuSil braze alloy
- Large CTE mismatch between Cu and ceramic, but the Cu is very ductile and does not over-stress the ceramic

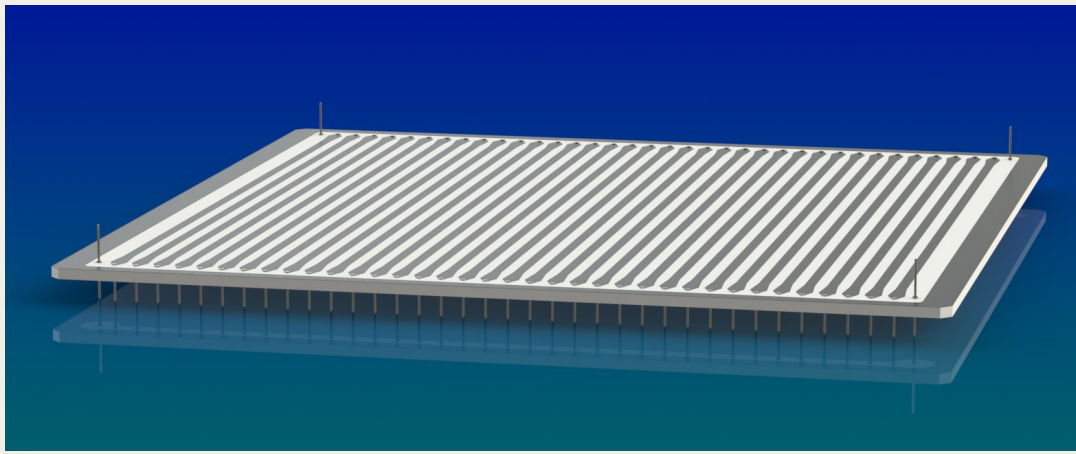




Ceramic Anode

- Substrate is .100” thick 96% alumina
- High-temp metallization
- 36 signal strips inside
- Solid ground plane outside
- Headed Kovar pins for signal and HV feedthrough
- HV pins are double-ended to distribute HV vertically within the tube – one in each corner
- Pins (76 in total) brazed into anode one of two ways
  - CuSil braze prior to body braze (current preferred method)
  - InCuSil braze simultaneously with body braze





History of the Ceramic Package Brazing

- Started with H_2 brazing at United Supertek (USI)
  - Initially CuSil alloy Kovar to alumina brazes, but close but not perfect CTE match coupled with Kovar strength resulted in cracked ceramics – 2 attempts
  - Then InCuSil alloy brazes with Cu indium well (current design) – 1 attempt
  - Not getting constructive process feedback from USI
- Switched to vacuum brazing at Omley Industries
  - Initially did InCuSil alloy brazes with all in one go (anode pins, and body joints) – 4 attempts (all leaky at pins)
  - Switched to two step process. CuSil anode pin braze, then InCuSil body braze – 3 attempts (with improving results)

Two-Step Brazing Process

- Pins brazed into anode first
  - CuSil braze alloy – ~850°C process temperature
  - Stresses are minimal (pins are small) – Multiple re-braze runs possible
  - Mitigates risk at the incursion of increased expense
  - Three consecutive leak-tight anode-pin assemblies since switching to this method
- Body brazed using pre-pinned anode assembly
  - InCuSil braze alloy – ~750°C process temp, so no re-melt of pin braze CuSil alloy
- Improved final assemblies
  - Prior to using the two-step process, assemblies had gross leaks – particularly at the pins
  - The two stage process immediately resulted in assemblies that were much closer to leak tight and incremental progress has been made since

General Braze Comments

- Neither braze vendor was pleased with the metallization on the anodes
  - Screening performed by Cat-i Glass
  - Inconsistent thickness (some quite thin areas) and poor registration
- Neither vendor particularly likes InCuSil – poor wetting characteristics compared to CuSil (for example)
  - Omley has opted to switch anode pin braze to PalCuSil
  - USI has opted to switch anode pin braze to Cu/Au (braze washers on order, should arrive soon)

Recent Braze Activity

- Omley attempted PalCuSil braze on last remaining anode from first batch
  - Unsuccessful after 4 braze runs
  - Know metallization issues with this anode, and leaks seem to be where metallization was scavenged by alloy
- Final 7 sidewalls have been metallized at USI and are ready for braze use. These were done with thicker metallization than the first batch.
- Last 6 anode substrates are in process
  - Laser machining and final machining complete
  - Metallization in progress at USI. Screening being done at USI, and using thicker metallization on these too.
  - Expected delivery 4-5 weeks

Re-Braze of Brazed Body SN07

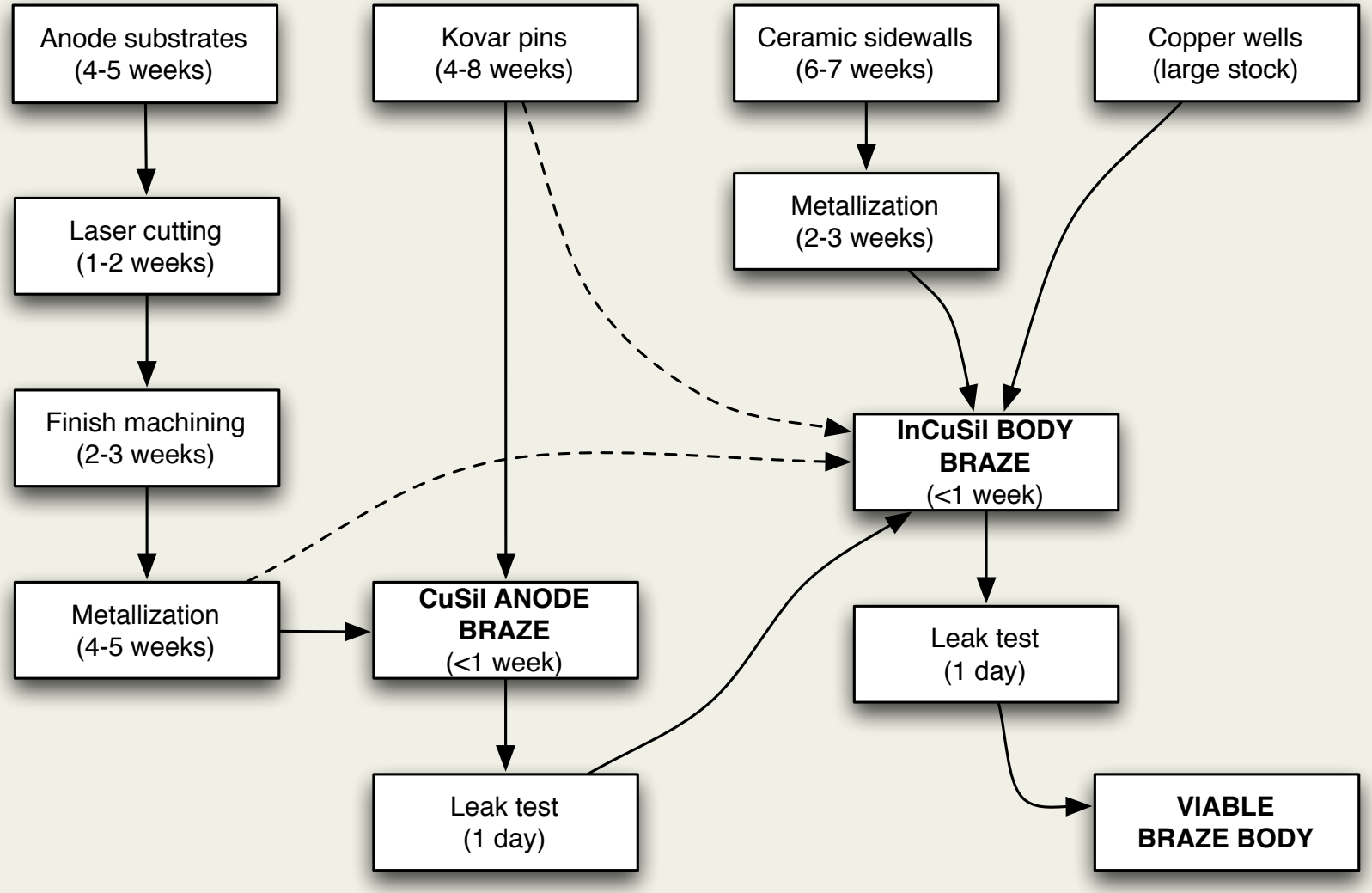
- Performed 2x H_2 re-brazes at USI of Omley BBA SN07
  - Used a slow thermal profile to minimize stresses in the body during reheat
  - First re-braze was a simple reheat with clamping pressure
  - Second re-braze added InCuSil paste at leak sights
  - Can perform multiple processes without destroying bodies
- Greatly improved the leak rate
  - Initial leak rate was 10^{-1} torr-l/s (distributed over several inches)
  - Post first re-braze now $2 \cdot 10^{-6}$ and $4 \cdot 10^{-8}$ leaks. Second re-braze didn't change anything
  - Now our first potential body for a seal tube
- Reinvigorates the H_2 brazing program (with caveat)
  - Requires direct personal involvement at the vendor (to ensure appropriate attention to detail)

Brazing Future Plans

- H_2 braze one anode with Cu/Au alloy at USI
- If it's leak tight, then use it in a CuSil body braze
- If not successful, consider returning to Omley
- We plan to be conservative with our last 6 bites at this apple
- Should get more piece parts in the pipeline once the funding situation has settled out?

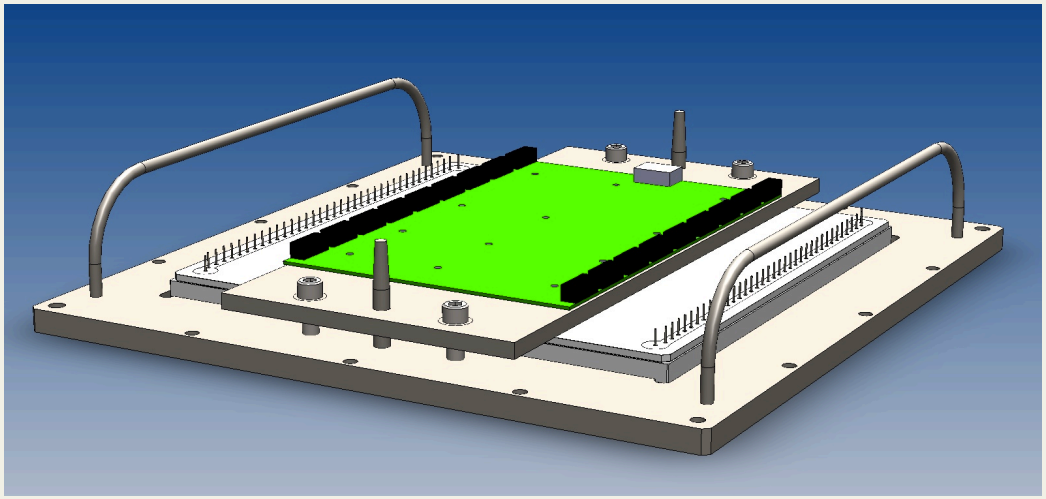
- NB: H_2 brazing at USI is about 40% the cost of vacuum brazing at Omley

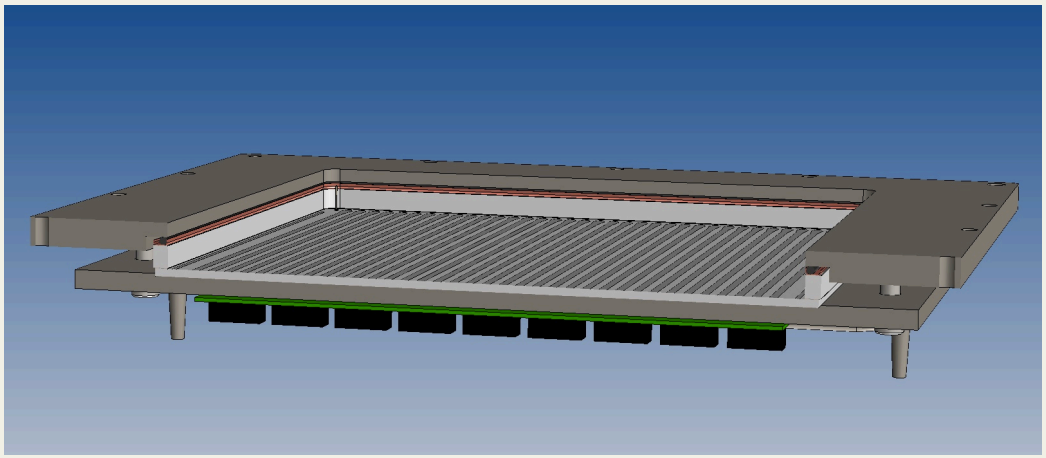
Brazed Body Fabrication Flow



BBA Based Demountable

- Allows tube-like testing of MCP and other internal components in brazed body with UH readout electronics prior to tube fabrication
- A good use for one of the leaky all-InCuSil brazed bodies – Celvaseal the leaks
- Cu indium well o-ring seals to mounting backplate
- Backplate mounts to existing 8” XDL demountable detector tank
- Plate epoxied to anode to minimize vacuum bowing and provide a mounting location for electronics
- Design near completion, going to fabrication soon



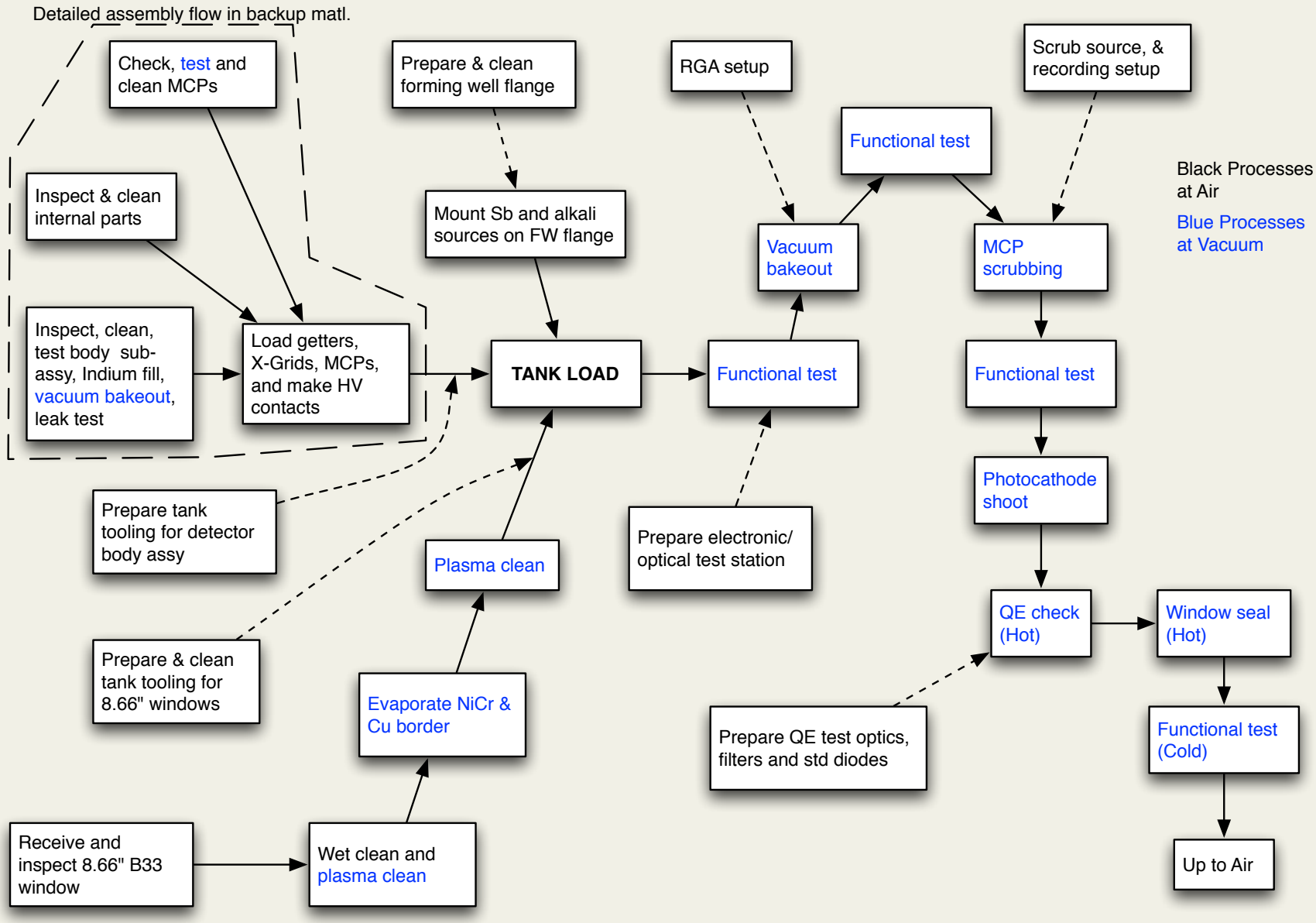


Near-Term Plans

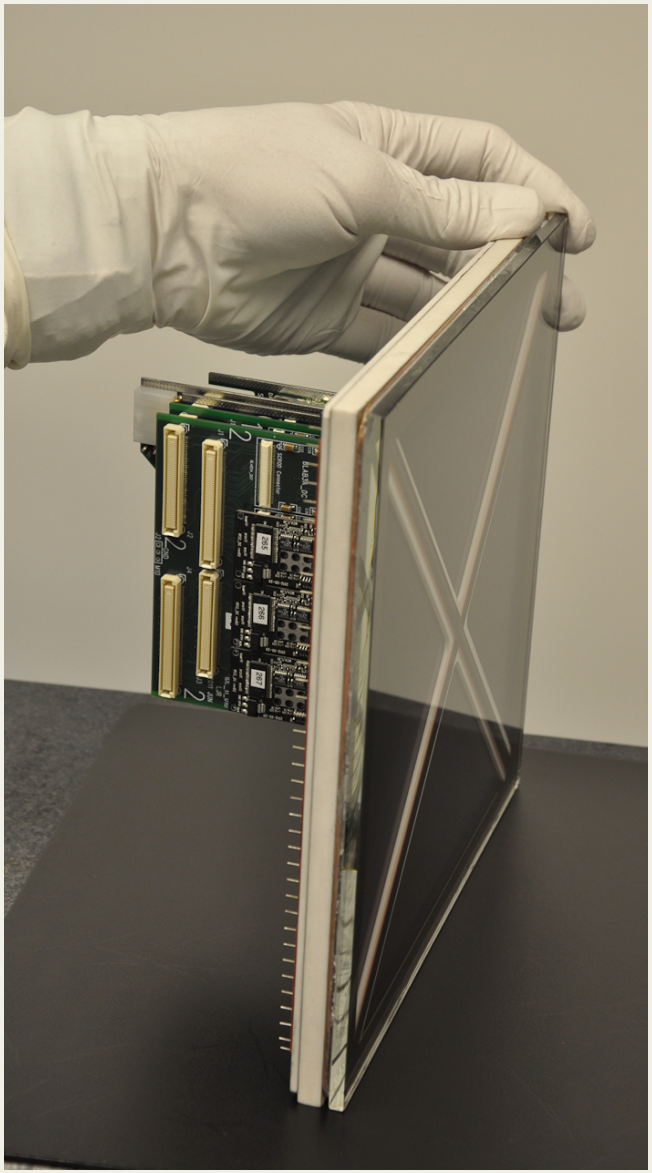
- Fabricate brazed bodies from piece parts currently in process (six assemblies maximum)
- Finalize design & fabricate the BBA demountable
- Push BBA SN07 through tube processing
- Re-braze BBA SN06 as backup to SN07

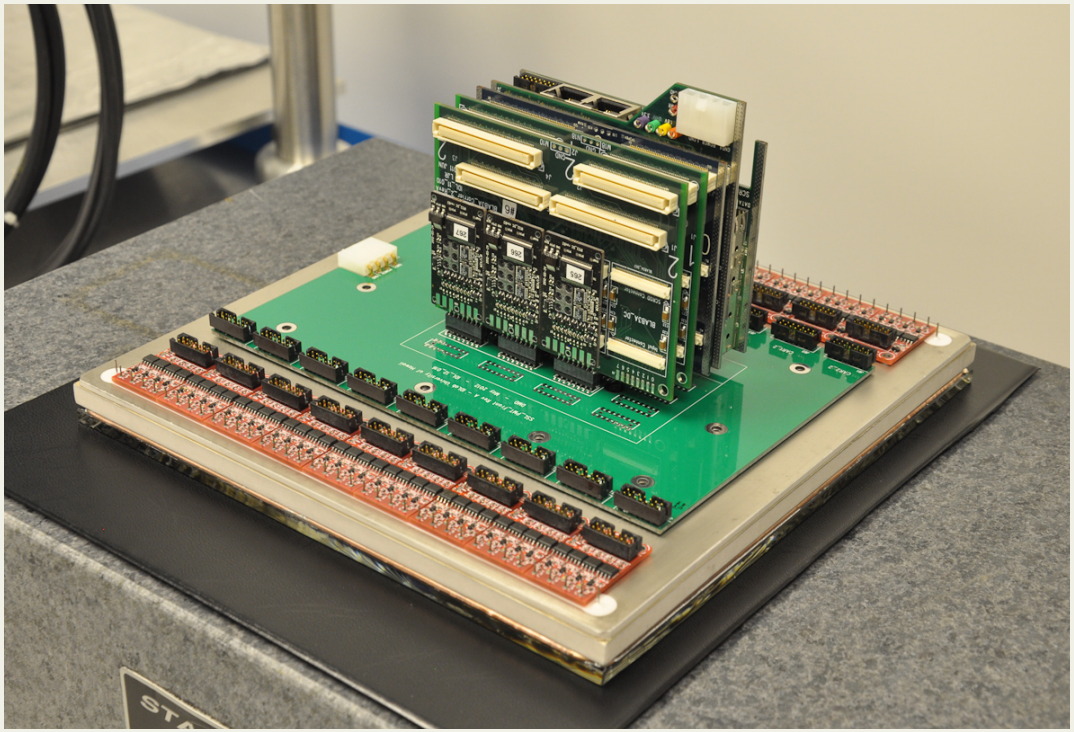
BACKUP SLIDES

8” Tube Process Flow



Ceramic Package Electronics





- Readout electronics for the ceramic package provided by U of Hawaii (Varner talk on Electronics)
- Based on Belle-II iTOP readout electronics
- 18x 4-channel pre-amplifier boards
- 9x 8-channel analog to digital daughter cards
- 1x interface board and 1x power board
- Ready for testing
- Need ceramic package based demountable detector or tube to test