LAPPD Large Sealed Tube Facility, Indium Seal and Photocathode Progress

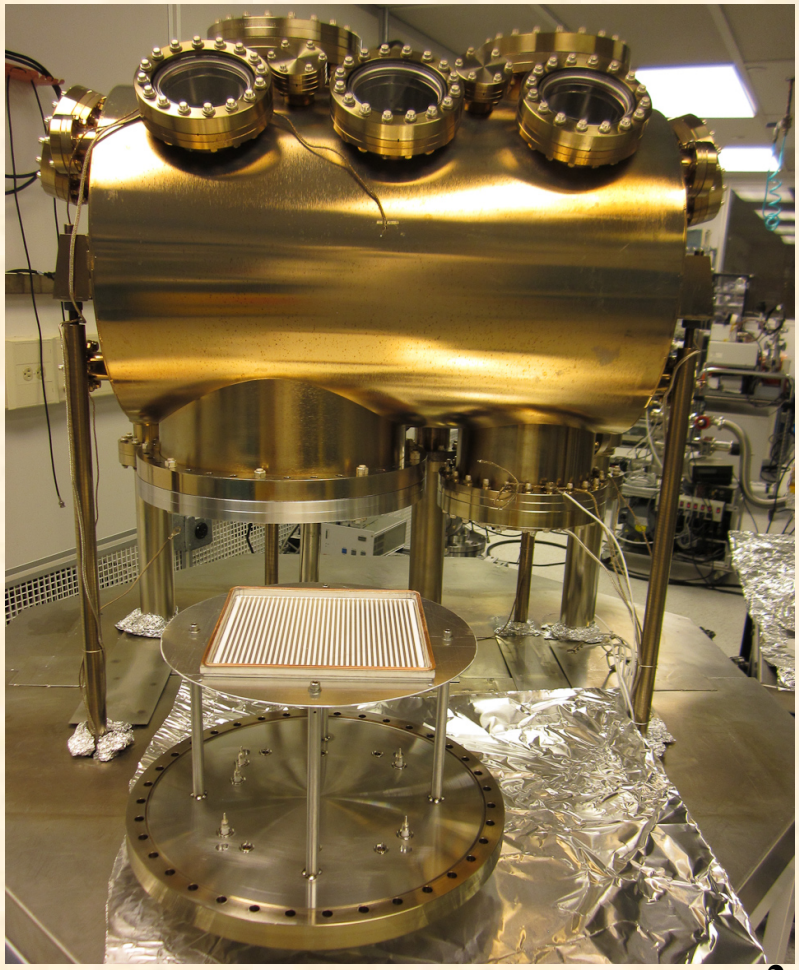
Ossy Siegmund, Sharon Jelinsky, Jason McPhate, Joe Tedesco

Experimental Astrophysics Group,
Space Sciences Laboratory,
U. California at Berkeley

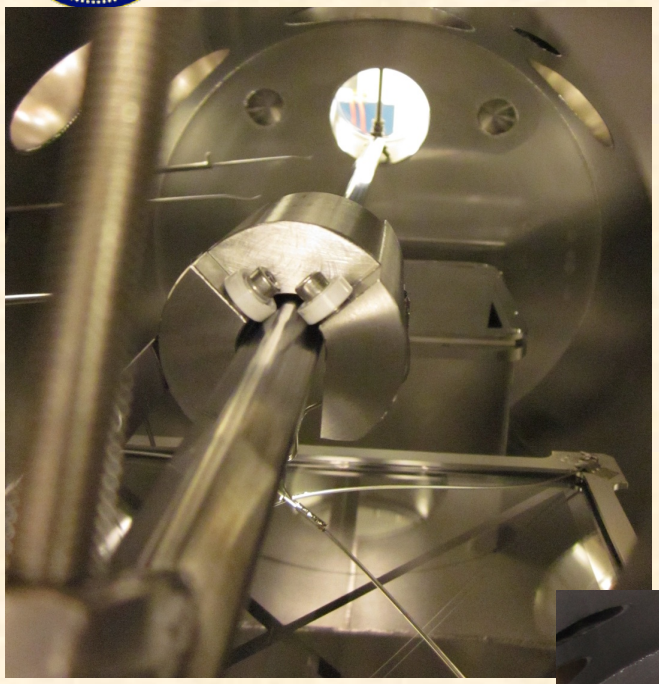
UCB 8” Sealed Tube Device Process Tank

Process tank commissioned & ready for tube process. 8” cathode run completed successfully. Base pressure low 10^{-10} torr.

Process tank for sealed tube processing, photocathode deposition and transfer seal. Detector flange & platform tooling complete

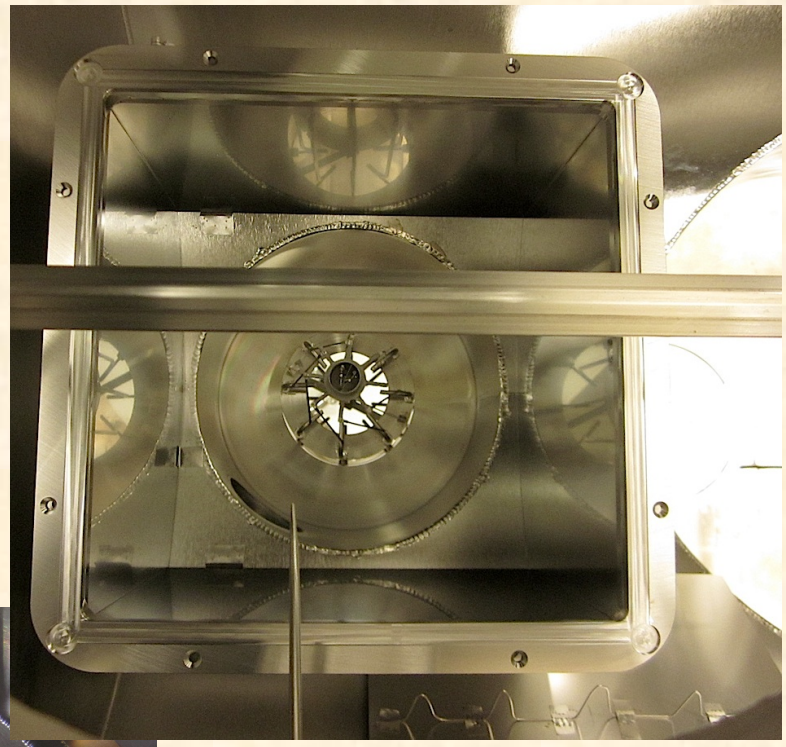


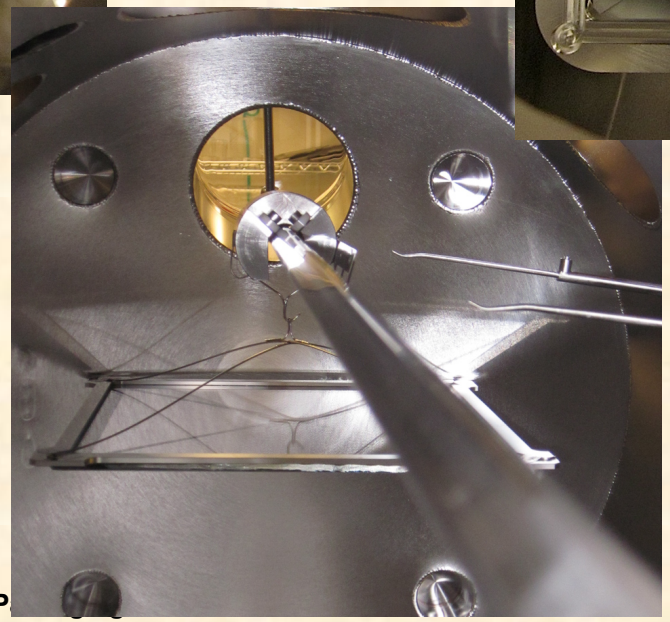
UCB 8” Sealed Tube Device Process Tank



Looking down the window translation mechanism toward the photocathode forming well at the far end.

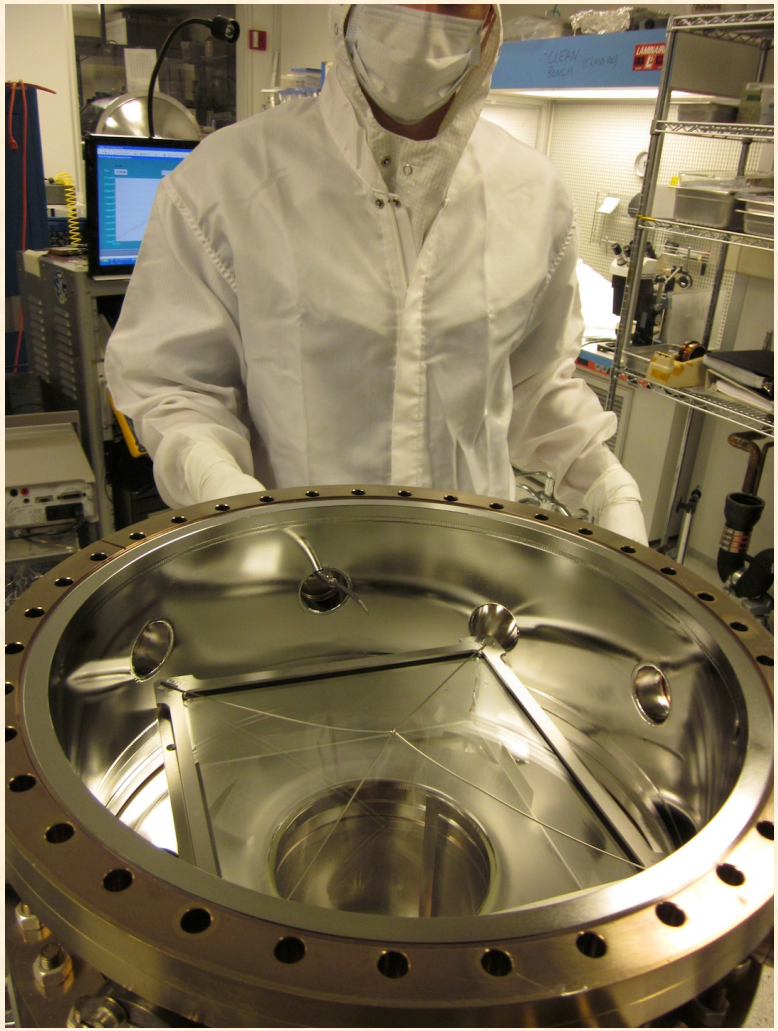
New alkali source setup & 50mg SbPt beads





Window hanging on translation shuttle. Manipulation is performed with the wobble sticks at right.

UCB 8.7” PhotoCathode / Seal Test Chamber

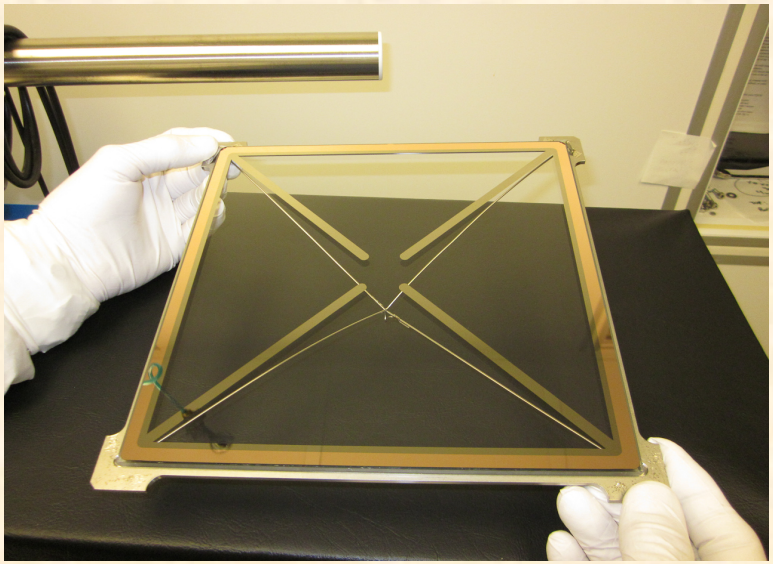


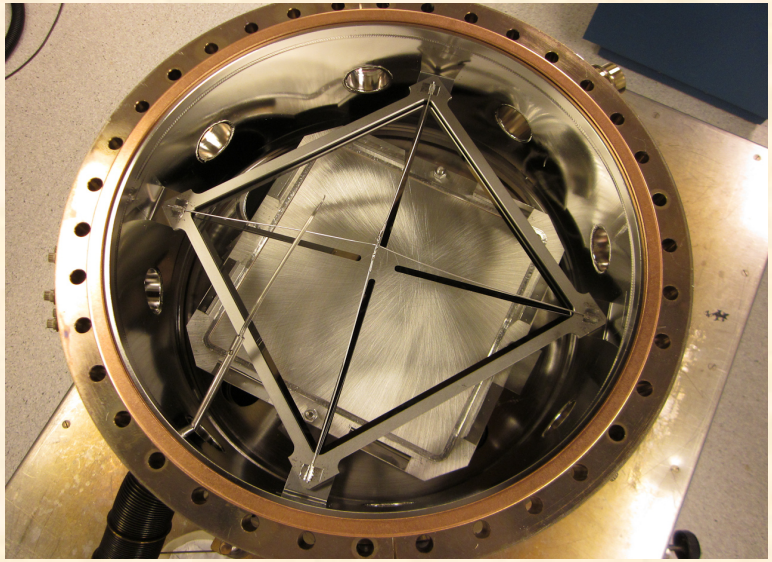
8.7” window loaded

- 8” PC/Seal Test Chamber
  - *<10^{-9} Torr base vacuum,*
  - *RGA operational, fully baked*
- 5mm thick, 8.7” polished B33 windows
  - *NiCr border + copper*
  - *electroded with “X” pattern*
- Oxygen plasma clean,
- Bake at ~365°C for 16 hrs
- Use large 40mm alkali sources.
- Deposited Na_2KSb photocathodes
- RGA records for entire processes
- Cathodes everywhere
  - except extreme corners
- Indium seal tests on copper well, and on glass grooved sidewall

8” Window Hot Seal on Cu Well

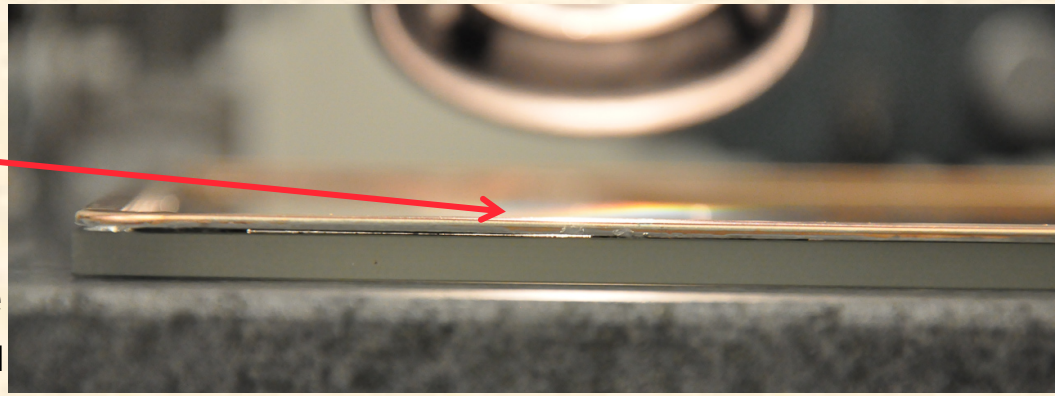
- Indium loaded into free Cu well (not brazed to ceramic wall)
- Skimmed to remove surface oxides
- Vacuum baked to outgas indium and float internally trapped oxides
- 8.66” Borofloat B33 window evaporated with NiCr + Cu
- Installed into 8” cathode/seal test tank
- Heated in vacuum (160°C) and seal attempted
- Post-seal the chamber was cooled and vented
- Same process steps used during tube processing seal
- Obtained good indium wetting to window

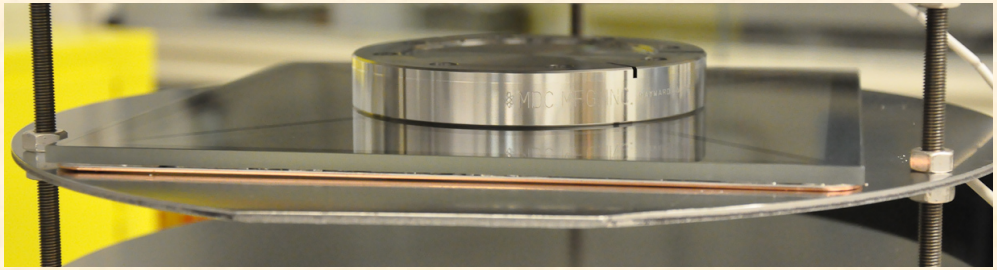


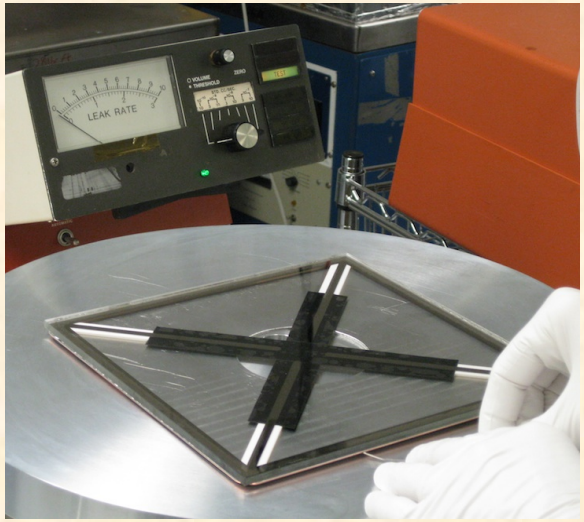


8” Window Hot Seal on Cu Well

- Copper deformed from flat with areas of gapping between window and copper
- Laterally restrained, but vertically free Cu well was not representative of the final assembly (where the Cu is affixed to the flat ceramics)
- Re-heated in vacuum *without* lateral constraint and with weight to re-induce flatness in Cu well.
- Resulting assembly is leak tight to $<10^{-10}$ std.cc/sec of He
- Window supported with X-grid during leak test
  - *No window or X-grid breakage*



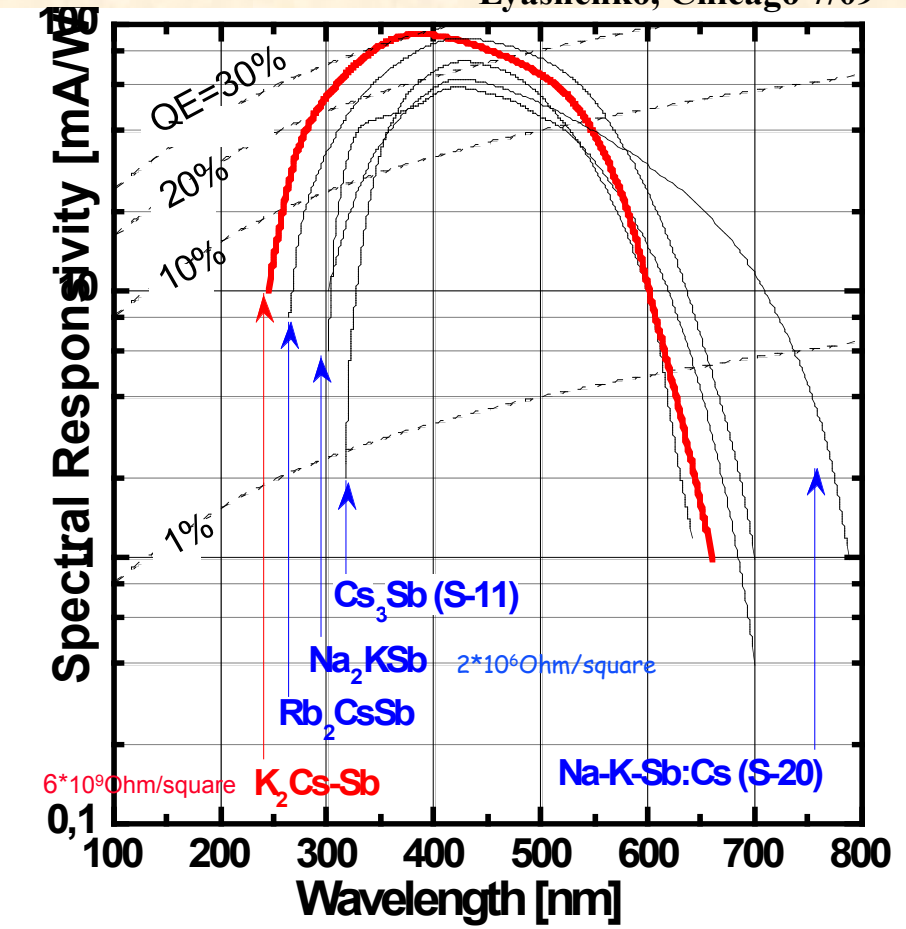




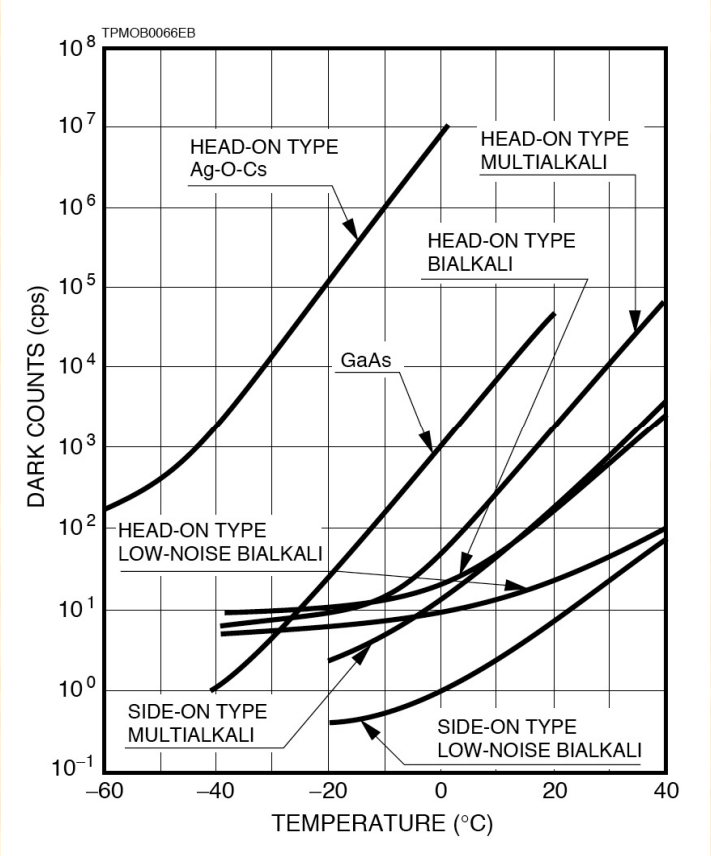
Seal works – but – like the glass sidewall seal, must have enough indium and keep everything flat

Typical Bi-Alkali Cathode Characteristics

Lyashenko, Chicago 7/09



QE and resistivity for various bialkali's
We have used Na_2KSb and K_2CsSb.



Cathode Noise vs Temp.
Expect 10,000 to 40,000 events/ sec for 8" tube bialkali!

8” Photocathode Process Development

UCB window/cathode development:-

- Na_2KSb ~25% QE achieved repeatably on small B33 substrates
- Baseline for 8” tube --Na_2KSb and 5mm B33 window for 8” device and use Inconel border with “X”
  - good QE, high temp stability, uniform, high conductivity, low background

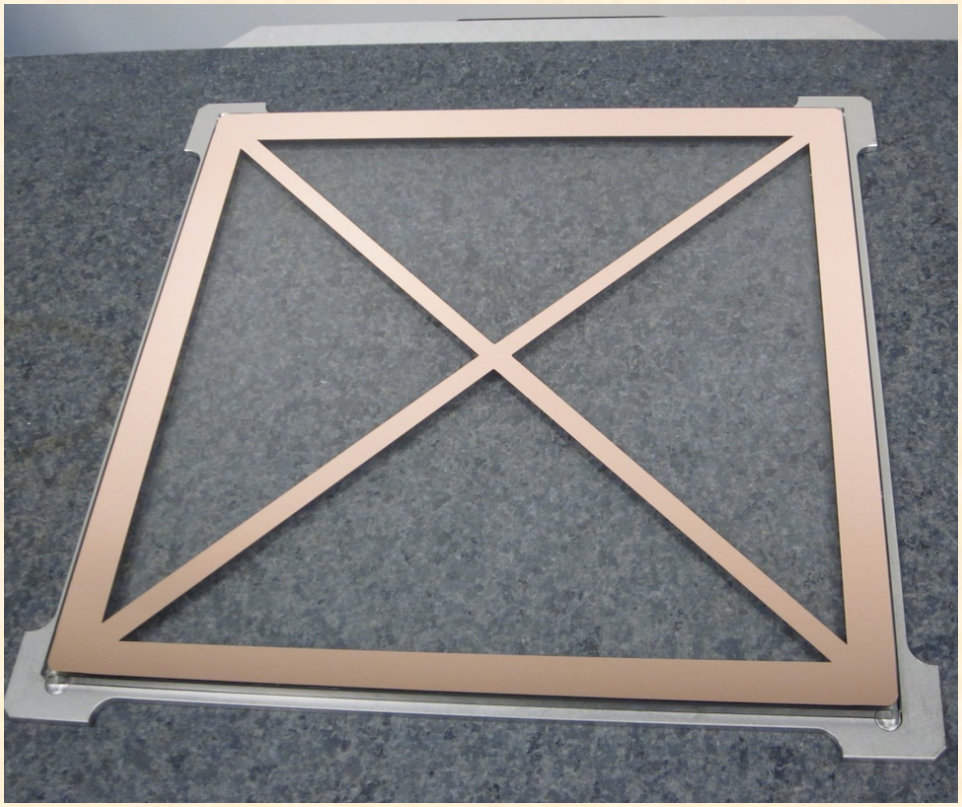
Commissioned 8” cathode & seal process development tank

- Verified deposition method for two good 8” Na_2KSb cathodes
- Optimized alkali sources for large Na_2KSb cathode areas
- Established 8” wet cleaning and plasma cleaning processes
- Established cathode QE levels and stability and uniformity

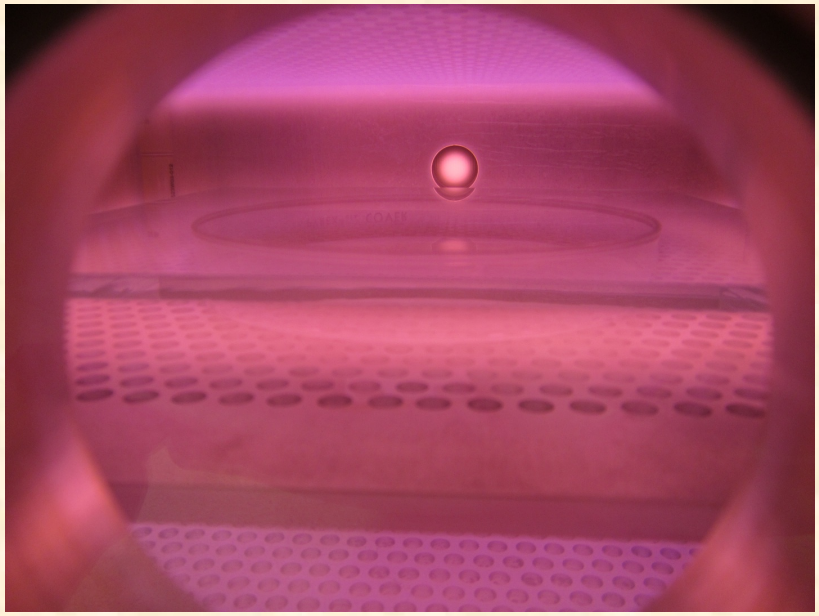
Transferred 8” processes to large sealed tube vacuum tank

- 2 iterations in large process tank – get good, stable QE but uniformity can be improved

Preparation of 8.7” B33 Windows for Cathodes



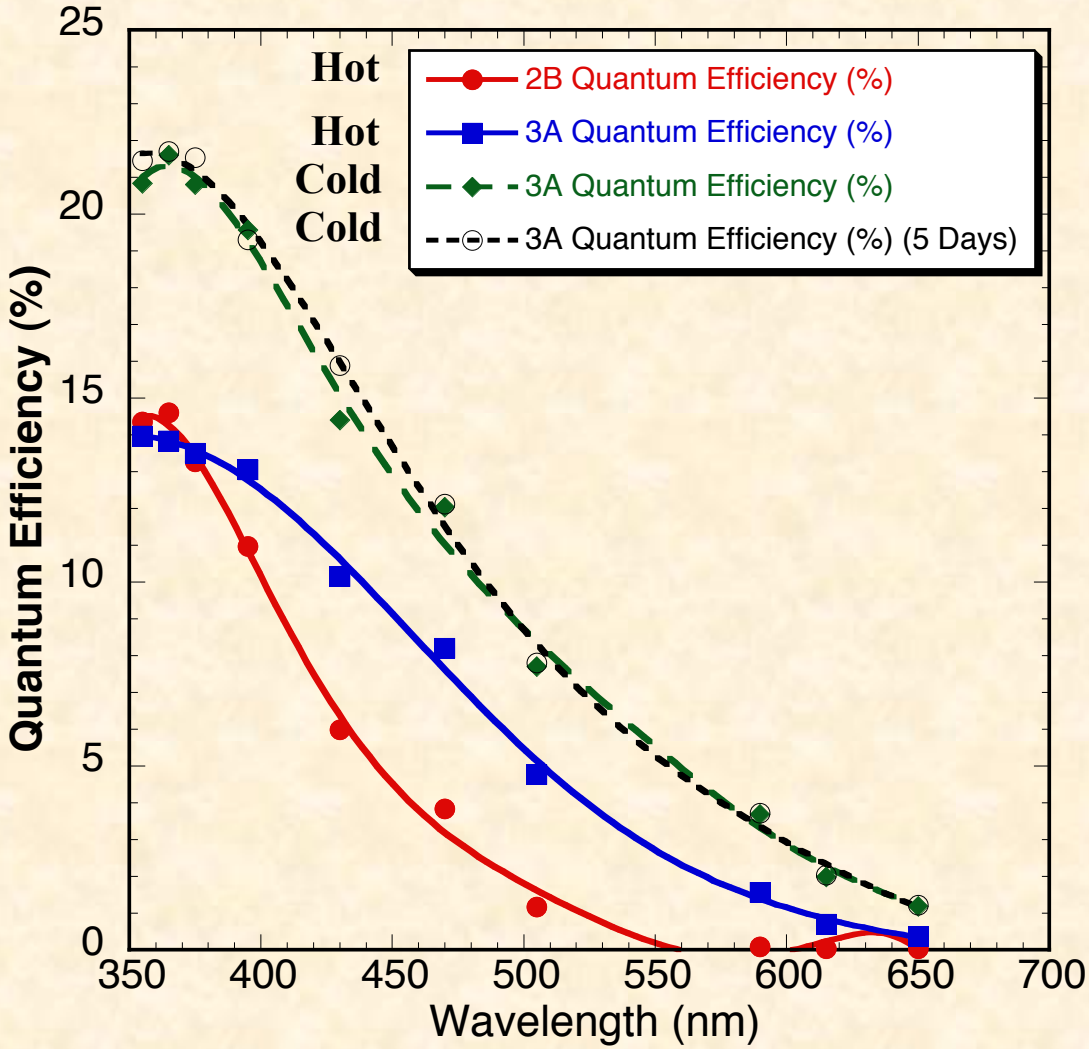
All the tooling is in place. We wet clean, plasma clean, and evaporate NiCr on a window, and load into a holder for photocathode processing.



NiCr electrode border on B33. Corner to corner “X” is also applied to ensure conductivity, copper for window indium seal.

Plasma cleaning

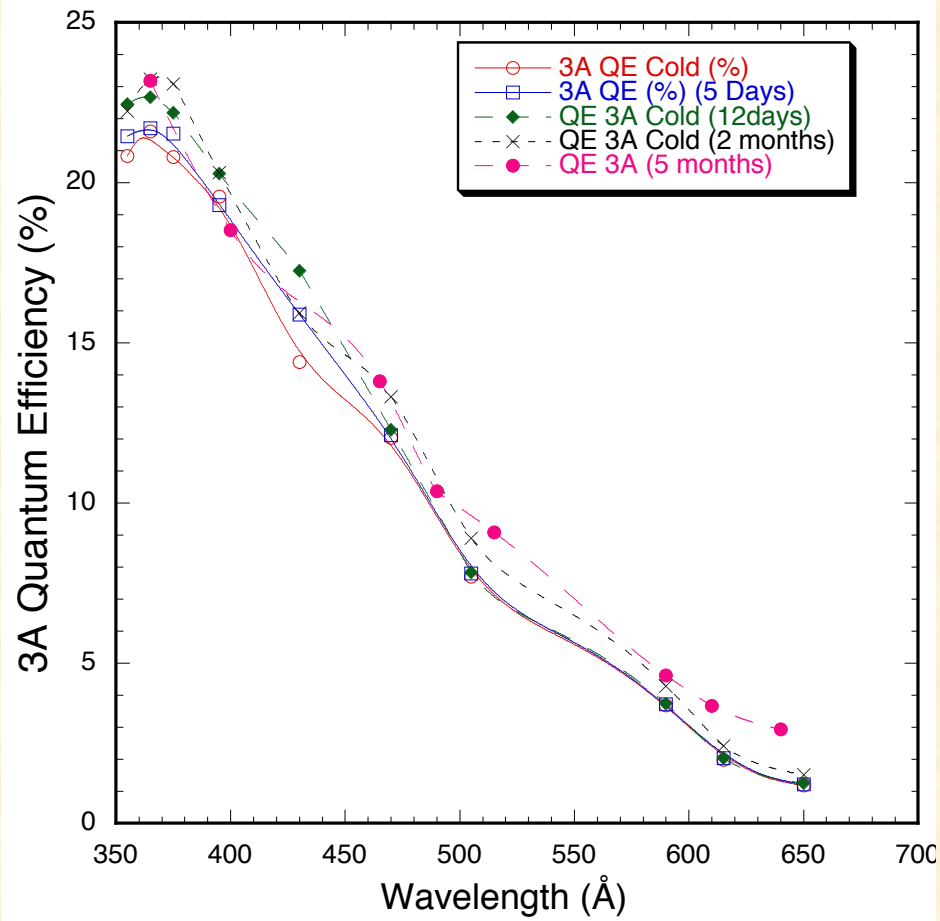
8” Na_2KSb Bialkali Results



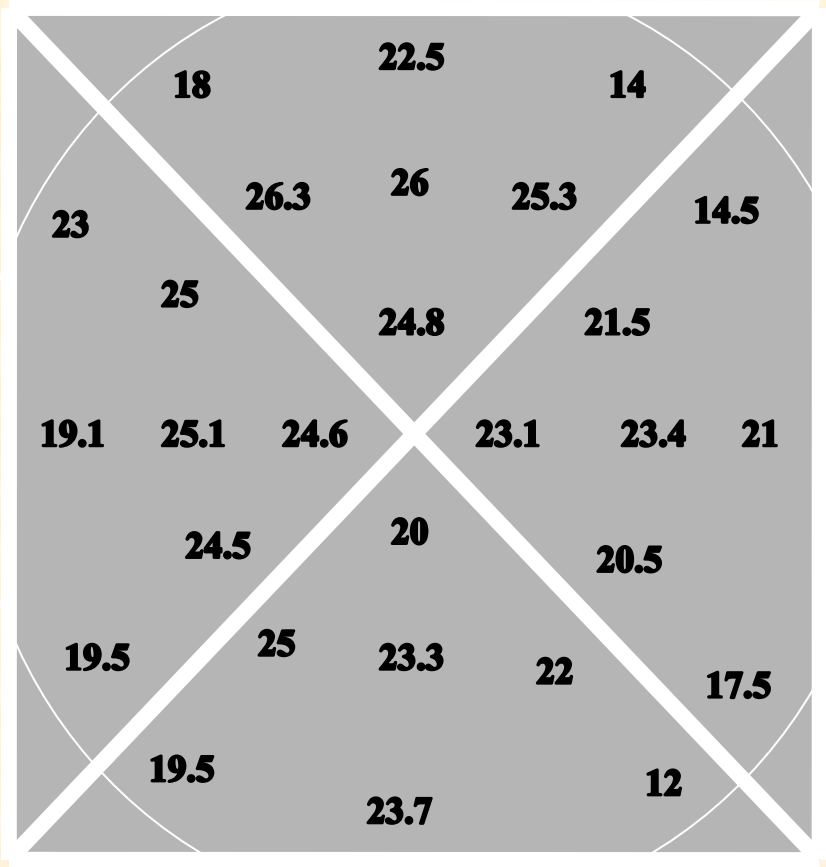
Processed in cathode/seal test chamber.

#3 is a redder cathode than #2. #3 is much thicker, which can be seen in the opacity of the cathode. We get a typical enhancement of the QE after cool-down. The QE remained stable over the 5 days after deposition. This is not corrected for the 5mm thick window transmission which we expect to be about 90%. Average PMT cathodes of this type peak at about 18% so we are above that.

8in #3A Photocathode Uniformity/Stability

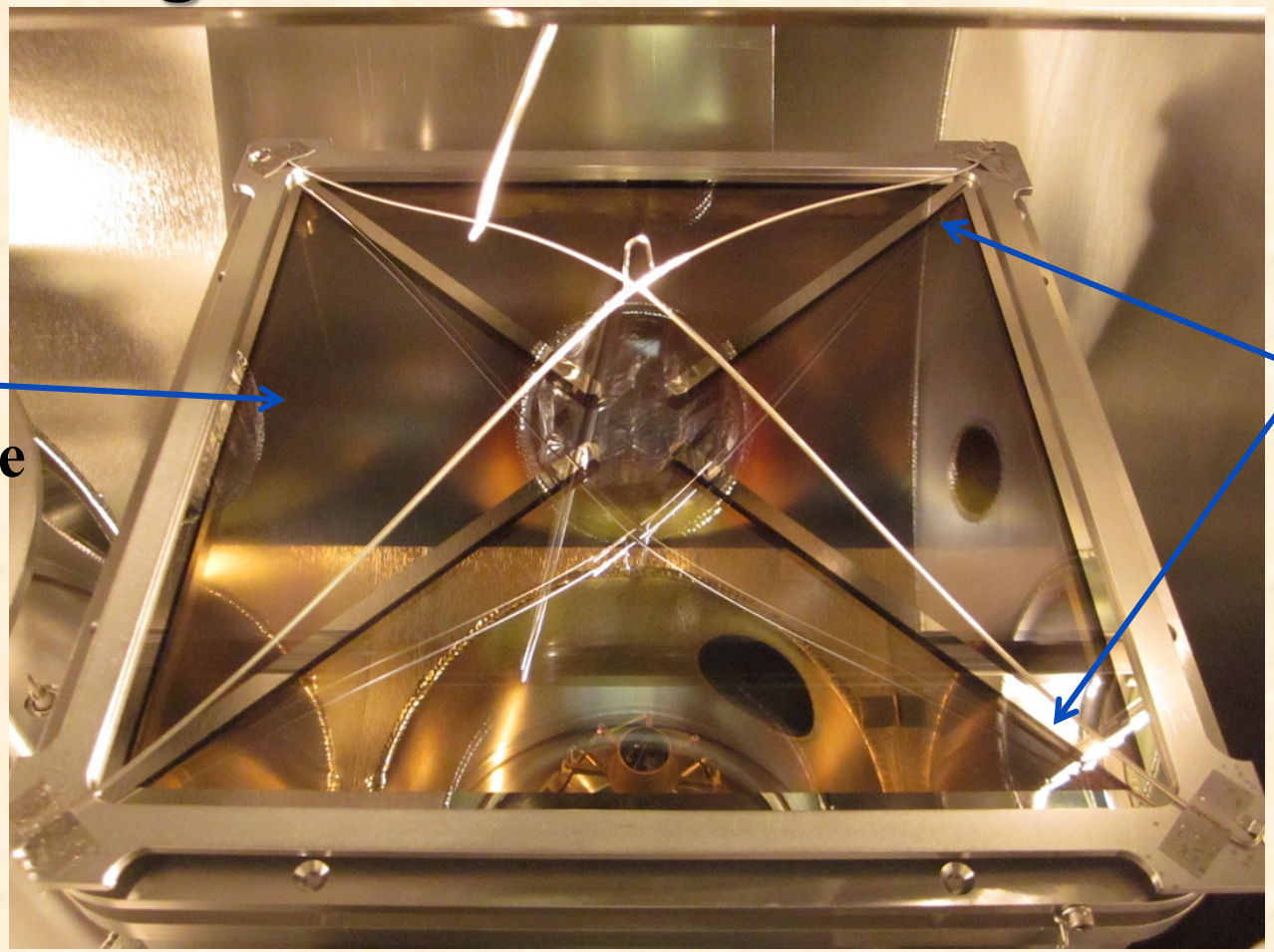


Basic process is a co-evap technique. We get an enhancement of the QE after cool-down. The QE remained stable over the 5 months after deposition.



Cathode Uniformity. Majority of the area is within ±15% of the average QE. There is some obscuration by tooling in some places.

8” B33 Window Na_2KSb Process #5 in Large 8” Sealed Tube Process Tank

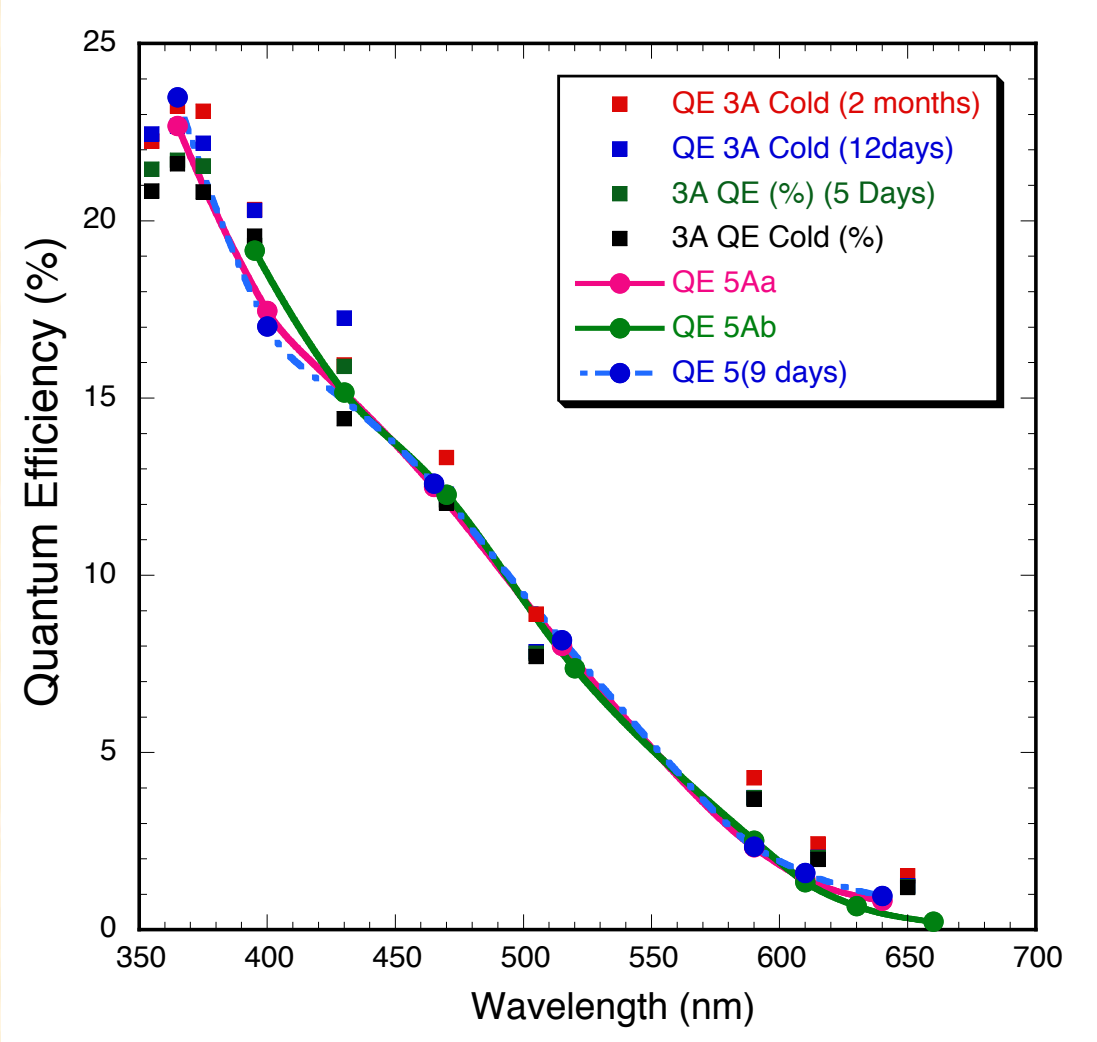


Cathode looks same opacity all over

“X” electrode

Photocathode was measured hot and cold, and was stable a week later

8” - Na_2KSb Bialkali Load #5



Cathode looks quite uniform all over from visual opacity observations.
The cathode shoot process was very “conventional” all reactions went as they should for a good cathode.
QE numbers are almost exactly what we got in the smaller tank on our best 8” cathode – maybe slightly bluer.
Totally stable for 9+ days

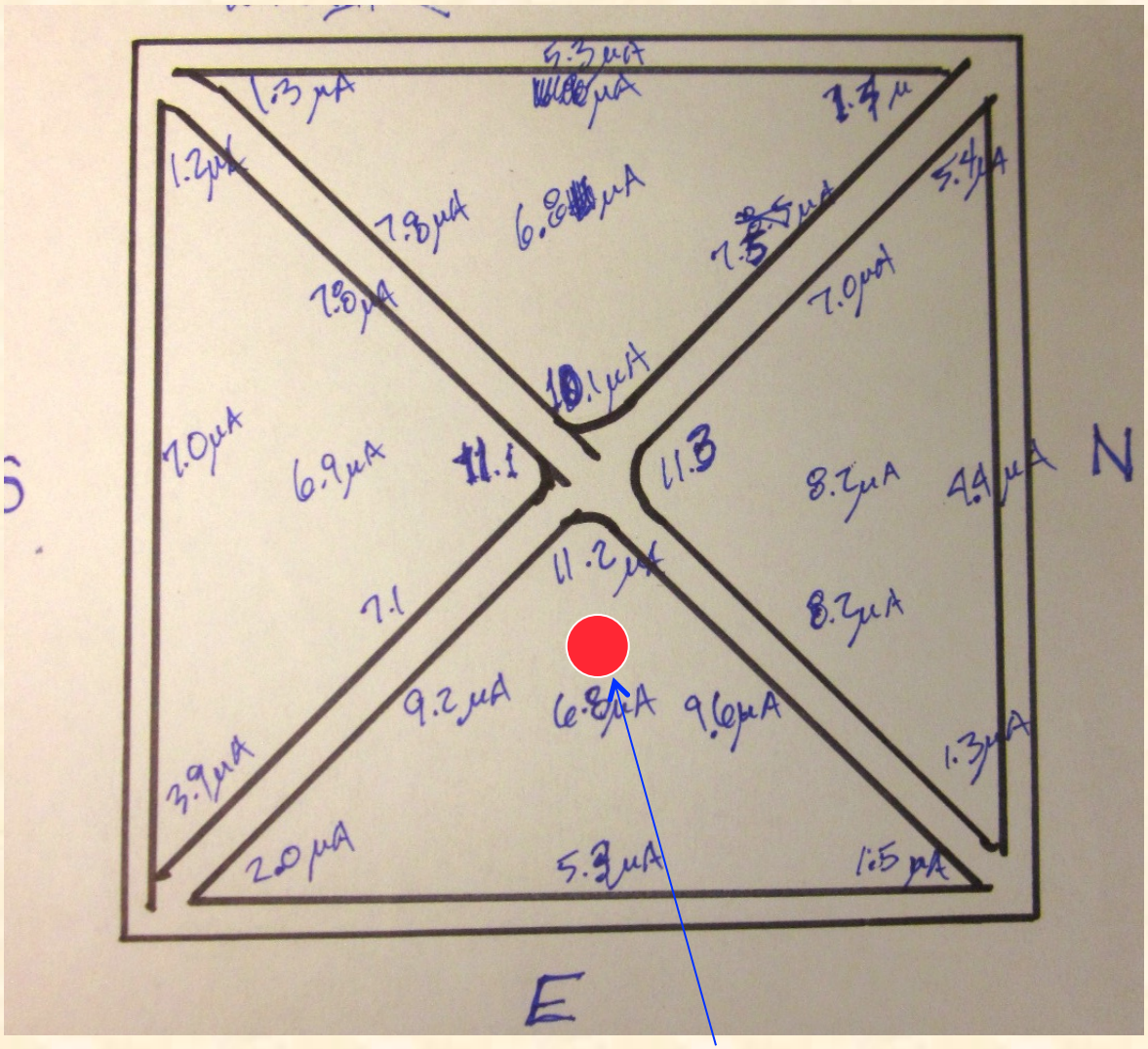
8in Na_2KSb #5 Photocathode Uniformity

There seems to be a center to edge dropoff and the extreme corners are low. Mostly not too bad though. Can tweak process to improve uniformity.

Have to make a more accurate scan, and at more wavelengths.

There is some obscuration by tooling in some places.

Spot illumination with 400nm



QE's measured here

UCB 8” Cathode/Seal Progress Summary

8” PC/Seal Test Chamber

- $<10^{-9}$ Torr base vacuum, RGA operational, fully baked
- 5mm thick, 8.7” polished B33 windows, NiCr border with “X”
- Successfully hot/vacuum sealed window to tube indium well.
- Deposited Na_2KSb photocathodes on 8” windows
  - *~25% QE with good uniformity (±15%) and stability (>5 Mo)*

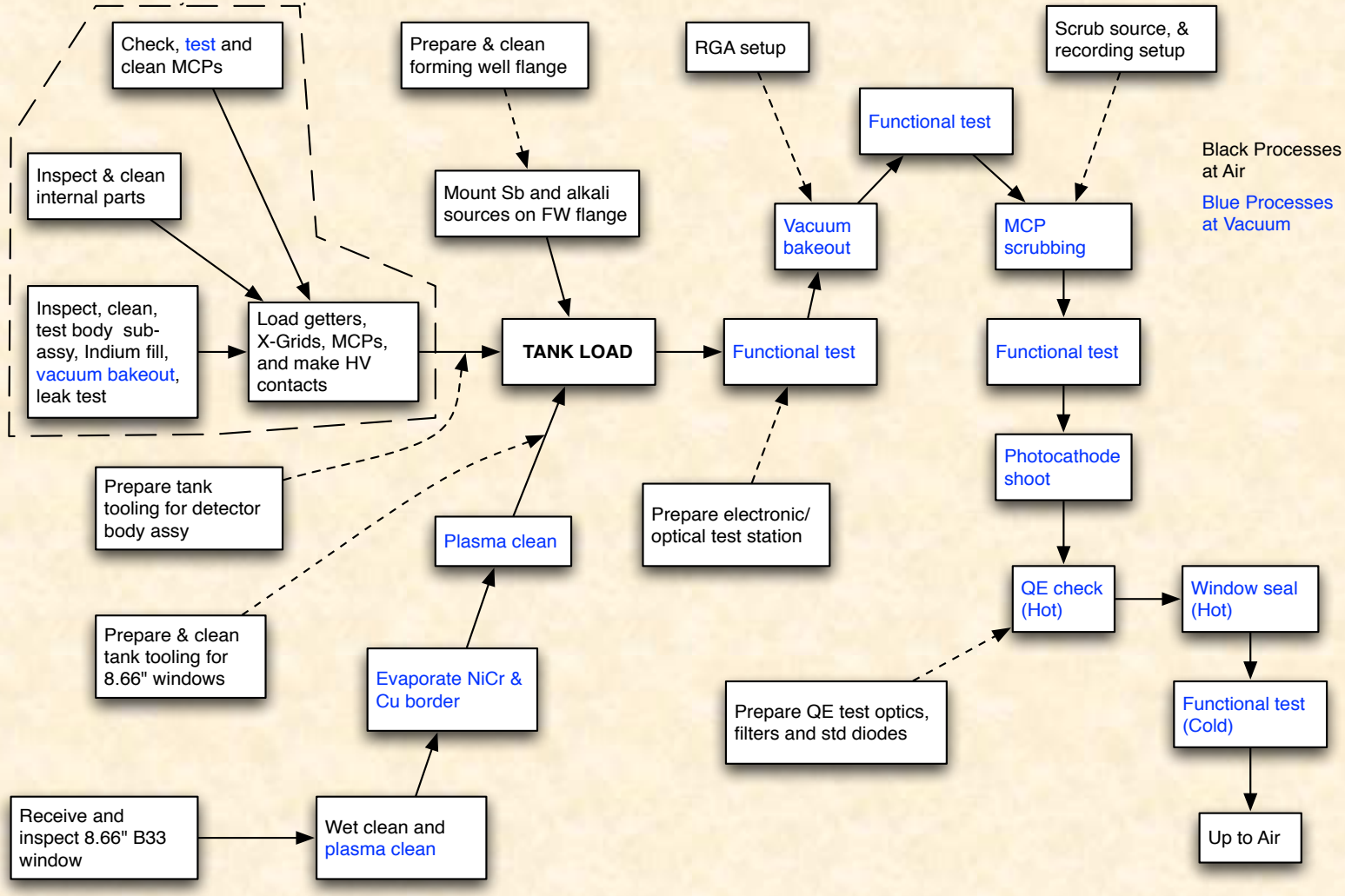
8” Sealed Tube Process Tank

- $<10^{-9}$ Torr base vacuum, RGA operational, fully baked
- Deposited Na_2KSb photocathodes on 8” window
  - *>20% QE with OK uniformity and stability*

Next Steps

- Tweak cathode process for better uniformity
- Prepare and process fully functional LAPPD devices

8” Tube Process Flow



Near-Term Plans

- Practice preparing and assembling a sealed tube detector with "leaky hardware"
  - *Bead blast cleanup*
  - *Indium load and bakeout*
  - *Internal parts loading and fastening*
- Prepare Body #7 (two small leaks) with these processes
  - *Completely assemble tube and install available MCPs*
  - *Load into tank and functional test, if OK follow process chain*
  - *Shoot cathode and seal, check operation before tank unload*
  - *If leaks don't get worse, getters should hold vacuum for hours, allowing us to Vac-Seal joints to make the tube hermetic after tank removal.*
  - *Tube post process functional testing, QE, MCP operation, etc*
- H_2 rebraze body #6 (pins OK, 3 braze joint leaks) as a backup to #7
- Fabricate more brazed bodies from piece parts currently in process (six more assemblies) for future process runs.
- Assemble a brazed body based demountable detector for MCP & electronics testing