Plan for 8-Inch Photocathode for the Single-Tile Factory

Zikri Yusof (ANL)

Klaus Attenkover (ANL), Marcel Demarteau (ANL), Henry Frisch (ANL/UofC), Joe Gregar (ANL), Seon Woo Lee (ANL), Richard Northrop (UofC), Sasha Paramonov (ANL), Anatoly Ronzhin (FNAL), Greg Salberg (FNAL), Bob Wagner (ANL), Deal Walters (ANL), Junqi Xie (ANL)

Punchline

Adapt the Burle/Photonis USA recipe for photocathode fabrication in PMTs as much as we can to grow the 8-inch photocathode.

WHY?

- Cleaning and handling of glass substrate is “less fussy”. The *in situ* O_2 plasma dosing serves a dual purpose, including the final cleaning the glass surface.
- Alkali metals deposition inside a glass enclosure via the use of its vapor pressure enables no line-of-sight growth and is more uniform.

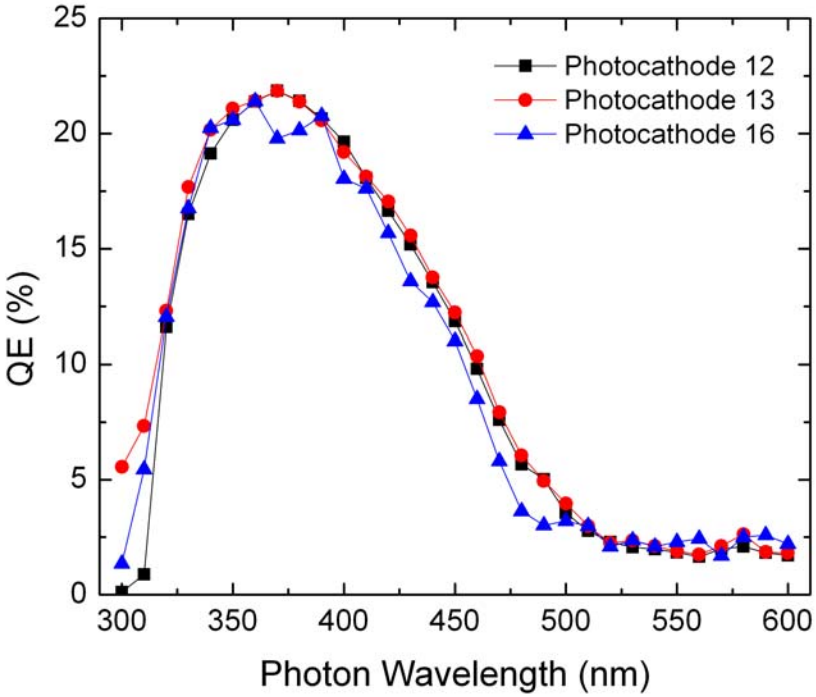
Lessons Learned From PMT Photocathode Fabrication

- Substrate cleaning procedure. Rudimentary cleaning for normal UHV components (Liqui-nox/citronox, alcohol, etc.). Bakeout duration and temperature;
- Oxygen discharge cleaning before Sb deposition;
- Oxygen discharge oxidation of first Sb layer to enhance long-wavelength absorption;
- Optical reflectivity monitoring of Sb layer to determine thickness – when to stop.
- Alkali metals deposition in glass vessel – using vapor pressure to flood the chamber alkali metal vapor – no line-of-sight issues;
- Monitoring of photocurrent during alkali metals deposition – when to stop.

But can these lessons be transposed to a larger, transfer photocathode?

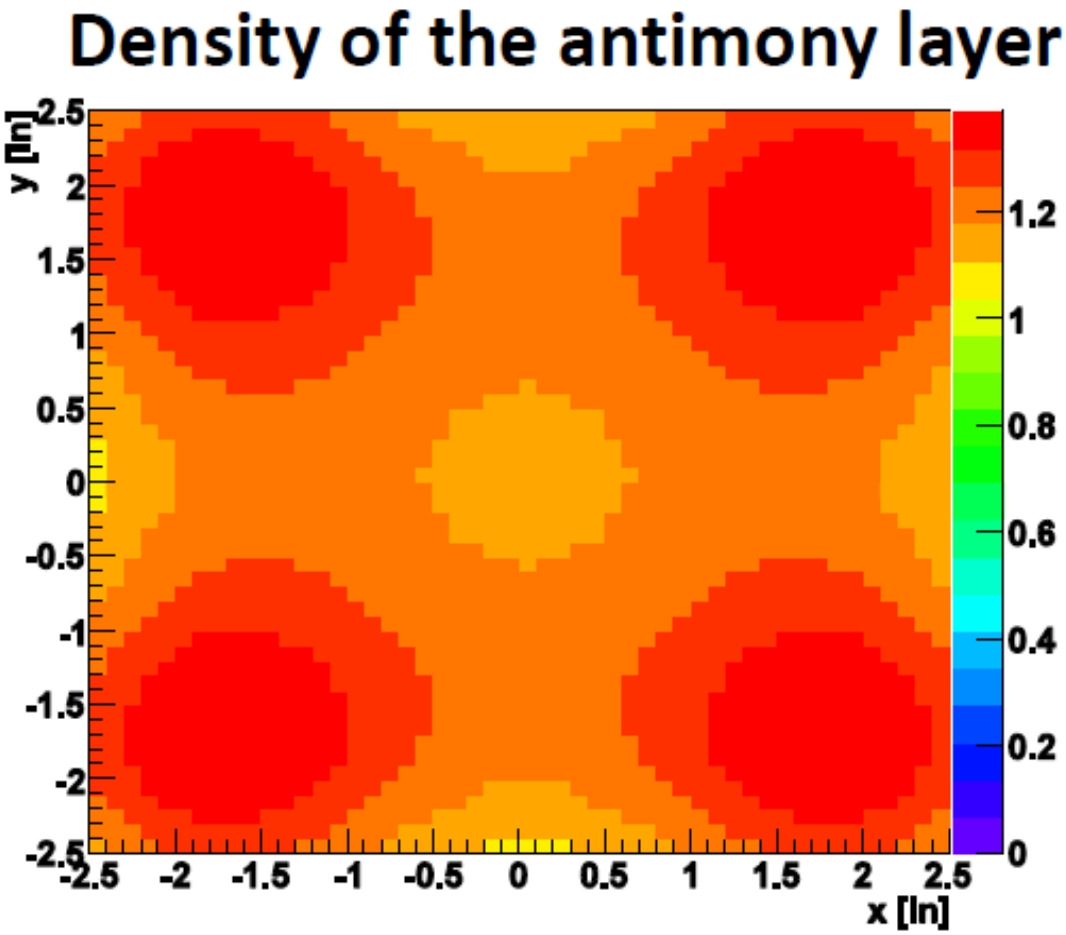
Current Progress – Bialkali Photocathode Growth in PMTs

- The PMT photocathode growth system purchased from Photonis USA has been commissioned in the new Photocathode laboratory;
- KCsSb photocathodes have been grown inside PMTs.



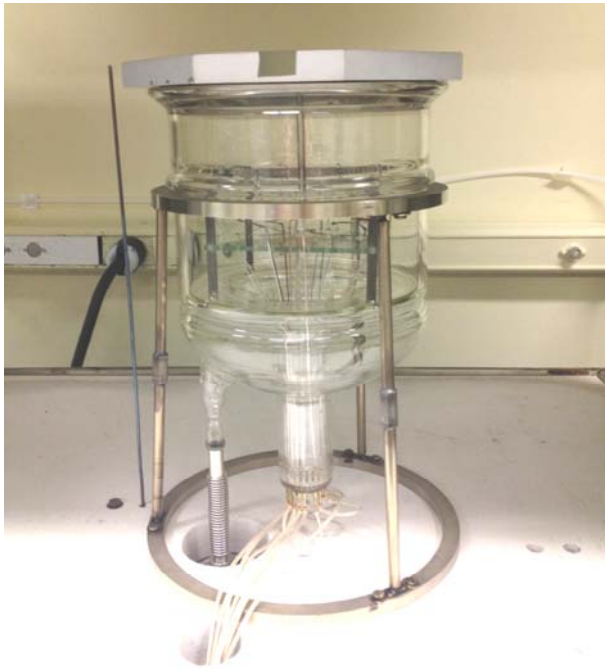
Current Progress – 4”x4” Bialkali Photocathode Growth in Glass Chalice – Simulation of Sb Evaporation

- Numerical simulation of Sb thickness as a function of Sb beads arrangements and distance from window;
- 4 Sb beads arrangement
- 2.5” distance from the window;
- This arrangement produces sufficient uniformity on a 4”x4” window as our starting point;
- This assumes all the beads perform identically.

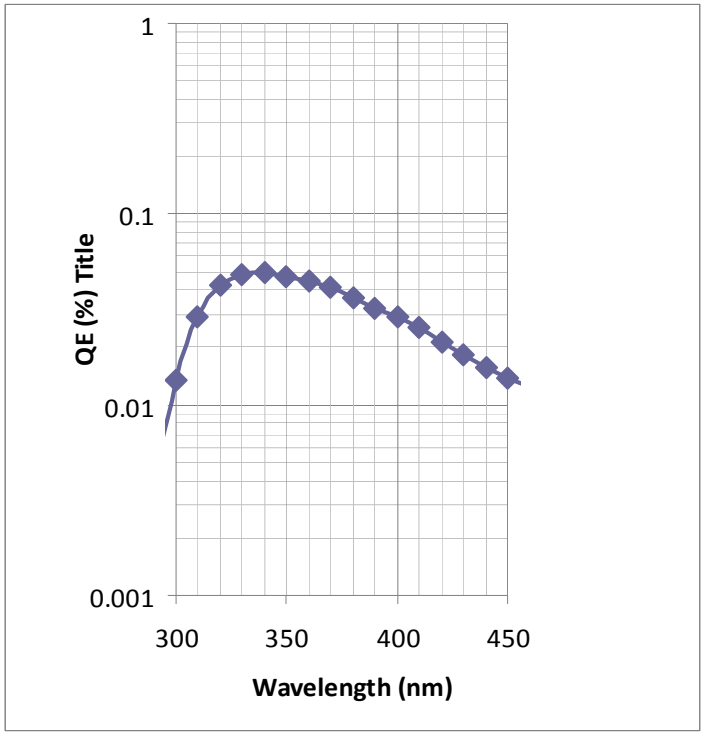


Current Progress – 4”x4” Bialkali Photocathode Growth in Glass Chalice

- The glass chalice is a test-bed for scaling up the size the photocathode;
- Potential issues such as Sb beads arrangements, O_2 plasma dosing, large-volume glass enclosure, etc. are being studied and tackled. This gives us a good idea on issues we might face for the 8” photocathodes;

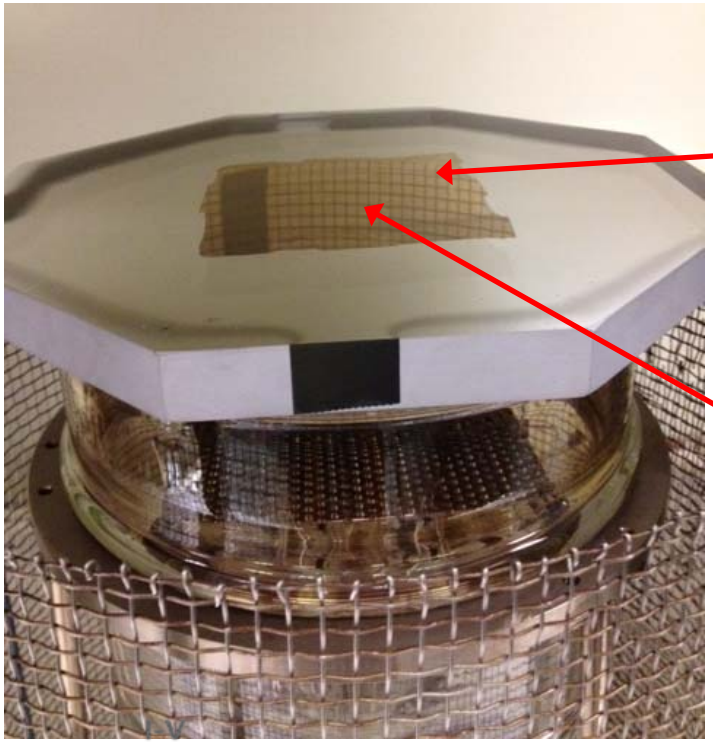


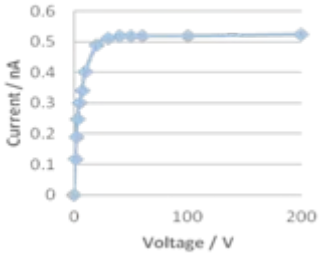
Glass chalice currently mounted in the Burle equipment

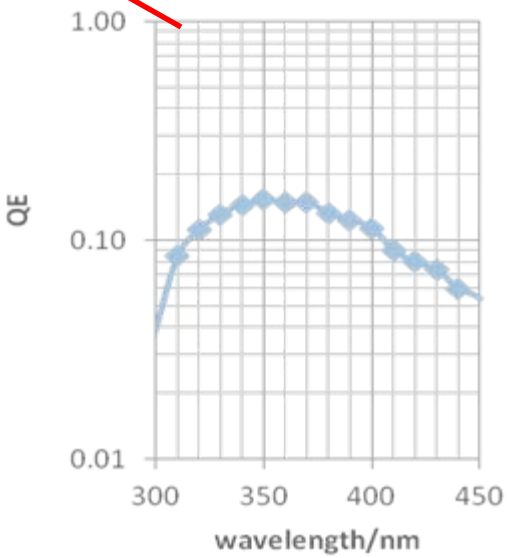


Initial attempt at KCsSb deposition on top plate; ~5% at 330 nm; no proper O_2 dosing; ran out of Cs.

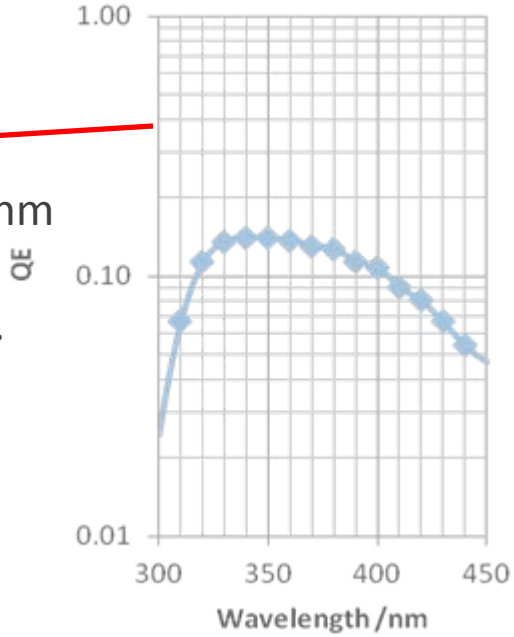
Current Progress – 4”x4” Bialkali Photocathode Growth in Glass Chalice – Photocathode Grown Yesterday





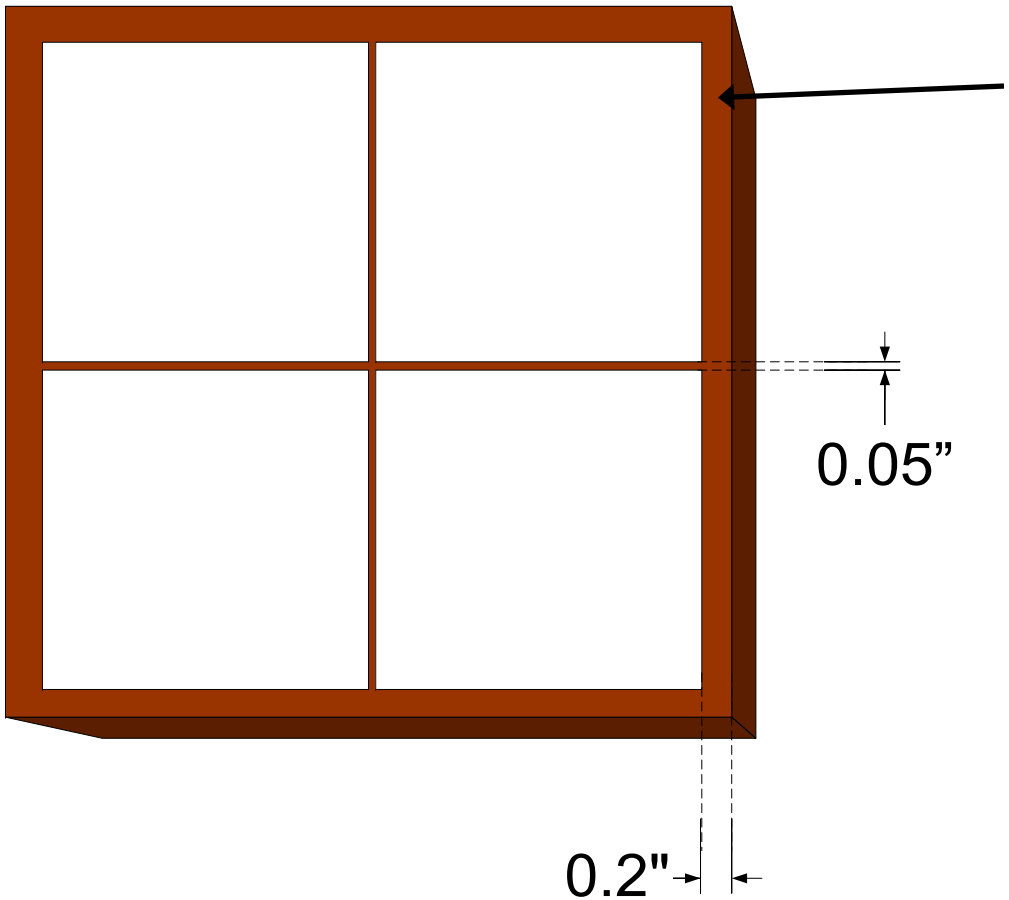


~15% QE at 350 nm at the center area.



~14% QE at 340 nm at the upper-right area.

Plan for 8” Tile For the Single-Tile Factory -1 Metallic Contacts on Glass Top Plate

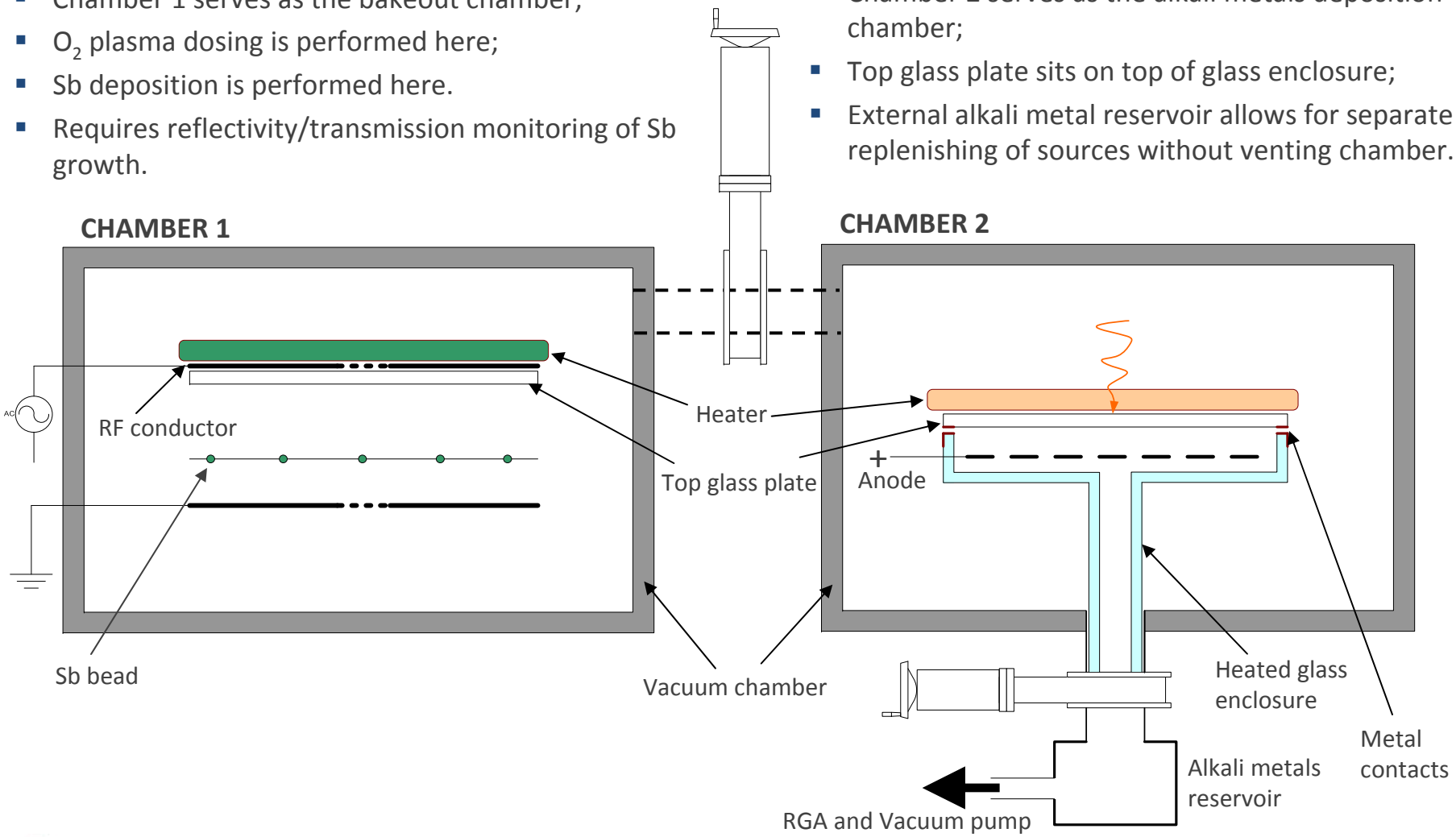


- Aluminum or nichrome metal contacts on glass plate;
- Enables electrical contact with the photocathode;
- Grid pattern to minimize charging effects.

Plan for 8” Tile For the Single-Tile Factory -2 Deposition Chambers

- Chamber 1 serves as the bakeout chamber;
- O_2 plasma dosing is performed here;
- Sb deposition is performed here.
- Requires reflectivity/transmission monitoring of Sb growth.

- Chamber 2 serves as the alkali metals deposition chamber;
- Top glass plate sits on top of glass enclosure;
- External alkali metal reservoir allows for separate replenishing of sources without venting chamber.



Potential Issues

- Uniformity of Sb deposition. Sb thickness will be simulated, similar to the one performed for the 4”x4” photocathode, to find the optimum arrangement for the Sb beads. However, there is still the potential issue that the beads do not all evaporate at the same rate each time.
- Charging effects on the photocathode – increase grid density?
- Cooling rate of photocathode plate at the end.
- How long of a wait before it is sealed?
- A whole zoo of engineering challenges.

We have a UHV chamber that will be used to test various parameters, such as the thickness of Sb that corresponds to a particular transmission/reflectance.

Summary

- We have made significant progress in gaining the skills to grow photocathodes, starting with PMTs, and migrating to a larger scale 4”x4” photocathodes in the glass chalice.
- Adapting the “philosophy” from PMT photocathode growth, we will fabricate 8” bialkali photocathode onto the glass plate.
- Bakeout and O2 plasma dosing will provide the last in situ cleaning of the plate.
- It may be simpler logistically for the process to be performed in two separate UHV chambers.
- The alkali metals will be deposited onto the glass plate within a glass enclosure. The enclosure will be entirely inside a UHV chamber.

Please visit the Detector Photocathode Laboratory on the 2nd floor in Bldg. 360, Rm. C244