Status of Multi-alkali Photo-cathode Production and Characterization at ANL

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Outline

- "Internal Goals" of Photocathode Group
- Resources: Infrastructure
- Review of the progress steps
- Progress in ANL
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  - Cathodes grown using Burle equipment
  - The chalice design
  - Sb beads arrangements for the chalice
- Summary

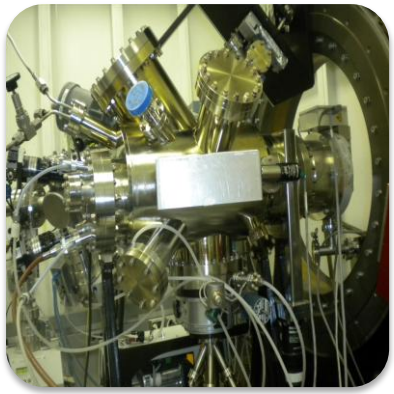
“Internal Goals” of Photocathode Group

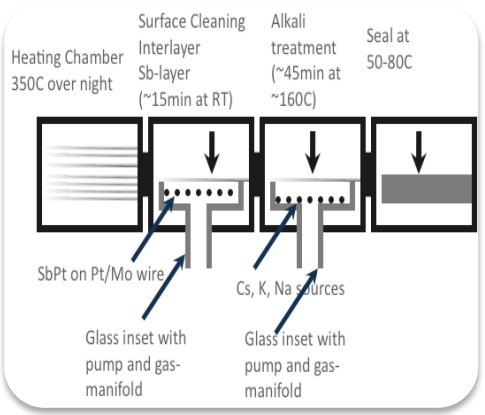
- Short term goals: end of second year (FY2011)
  - Installing all necessary infrastructure (besides production line at ANL)
  - Defining a clear scientific program to achieve high QE-PC’s

- Medium term goals: end of this program (end of FY2012)
  - Demonstrating a clear pathway for knowledge transfer of basic sciences program to production program
  - Developing at least one recipe with high QE (>25%) which can be produced in an industrial way

- Long term goals:
  - Photocathode with 50% QE and wavelength tuning
  - Establishing a photocathode center (collaboration with other labs) which enables
    - Access for general users
    - Cross-correlates most of the main “players”
    - Provides access to state-of-the-art basic sciences tools, fosters collaborations inside the community, and bridges the gap between basic sciences and industry

Resources: Infrastructure





Basic Sciences Program

- Growth and Characterization Facility
- General Lab-Infrastructure
- User facility use
  - APS
  - NSLS
  - Nano center BNL/ANL

Large Area Development

- Burle Equipment
- Source Development Infrastructure

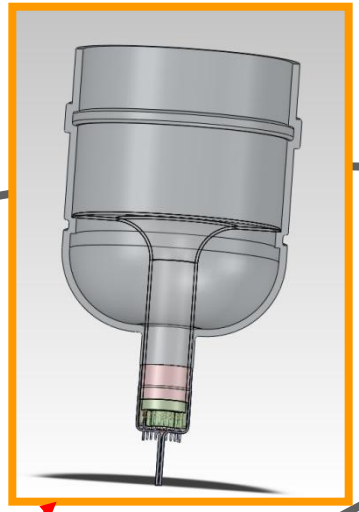
Production Unit (8”x8”) (not yet existing)

- Test Facility for Recipe optimization (Industrial standard)
- Detector Integration Facility

Review On Why We Are Using The Burle Equipment

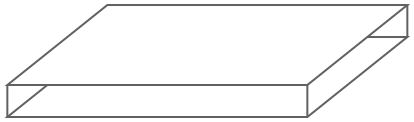
The path towards the 8”x8” photocathode is not a straight line and passes through very “interesting” neighborhoods.

PMT



4”x4”
(Chalice)

Both PMT and Chalice make use of the Burle equipment



8”x8” photocathode

Review On Why We Are Using The Burle Equipment - Lessons From PMT and Chalice

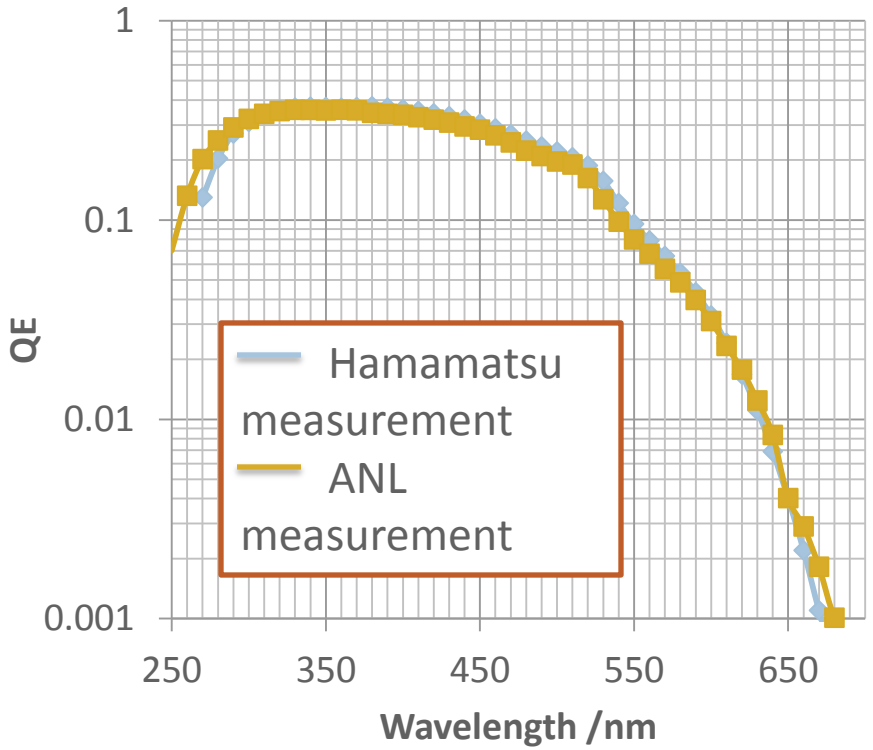
- Oxygen discharge cleaning;
- Deposition in glass structure/enclosure;
- Sb deposition monitoring via reflectivity measurement;
- Bakeout temperature, deposition temperature;
- Alkali metals deposition – when to stop.

Apply these to the fabrication of 8”x8” photocathode.

Progress in ANL

- Home built optical station was commissioned and used for both in situ and ex situ electrical/optical measurement.
- Burle equipment was delivered and commissioned.
- Bialkali photocathodes (KCsSb) with QE as high as 24% have been fabricated using the Burle equipment and PMT tubes.
- Glass chalice for fabrication of 4”x4” photocathode was made and installed.
- Film deposition uniformity was calculated.

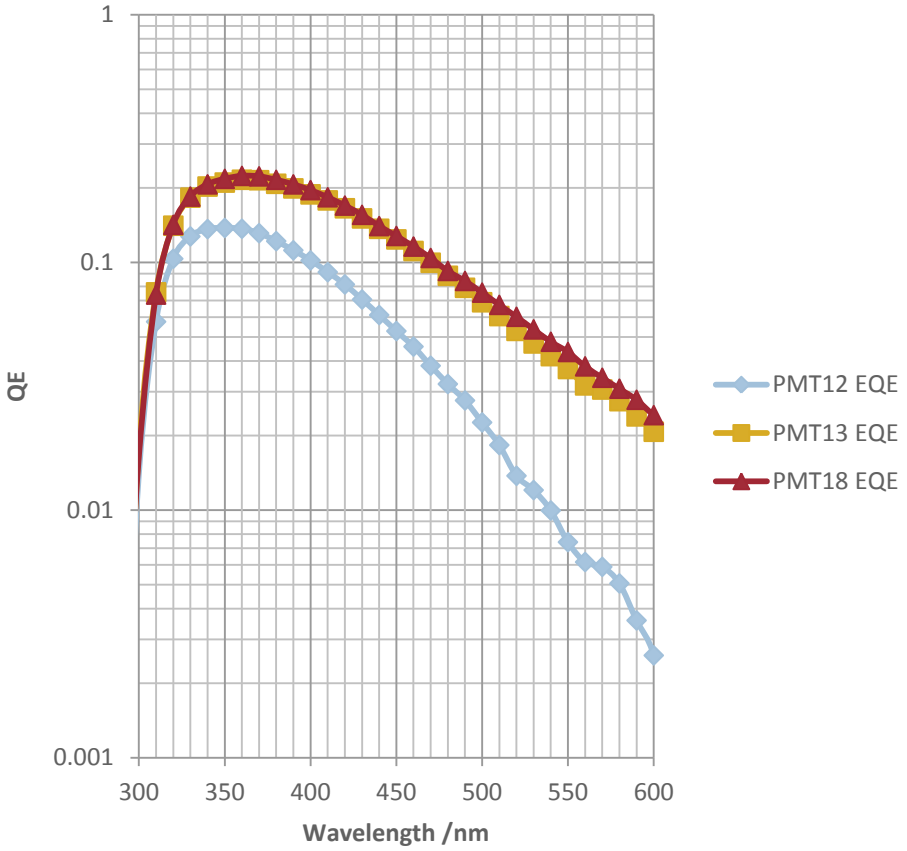
Commissioning of Optical Station



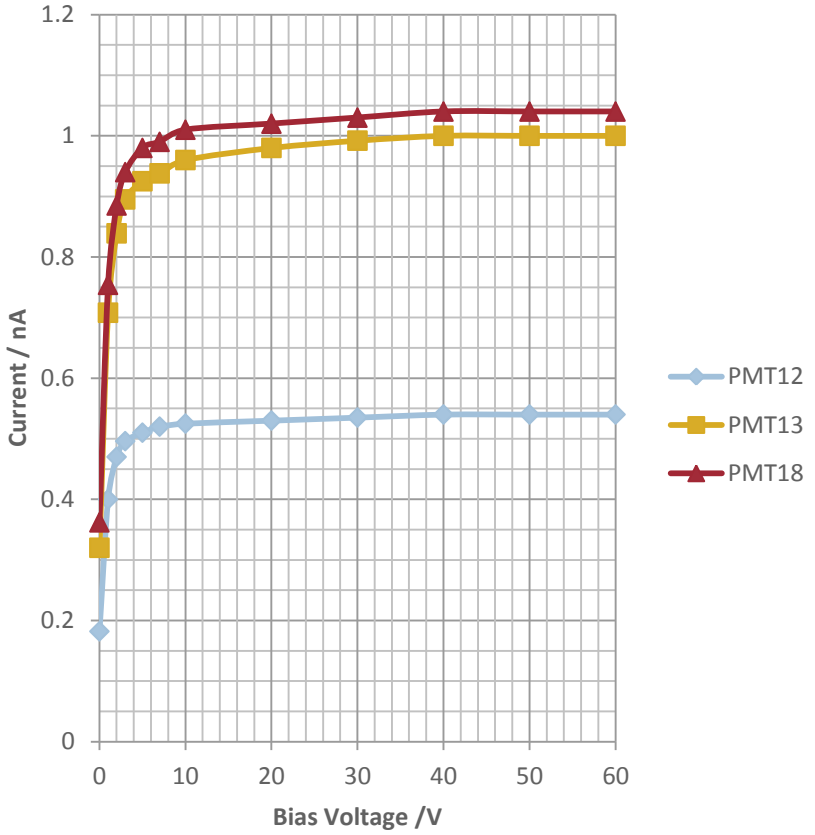
Movable optical station can be used for both in situ and ex situ QE measurements. QE measurement by Hamamatsu and ANL optical station agree well with each other indicating the home-built optical station is reliable.

Cathodes grown using Burle Equipment

QE Measurement

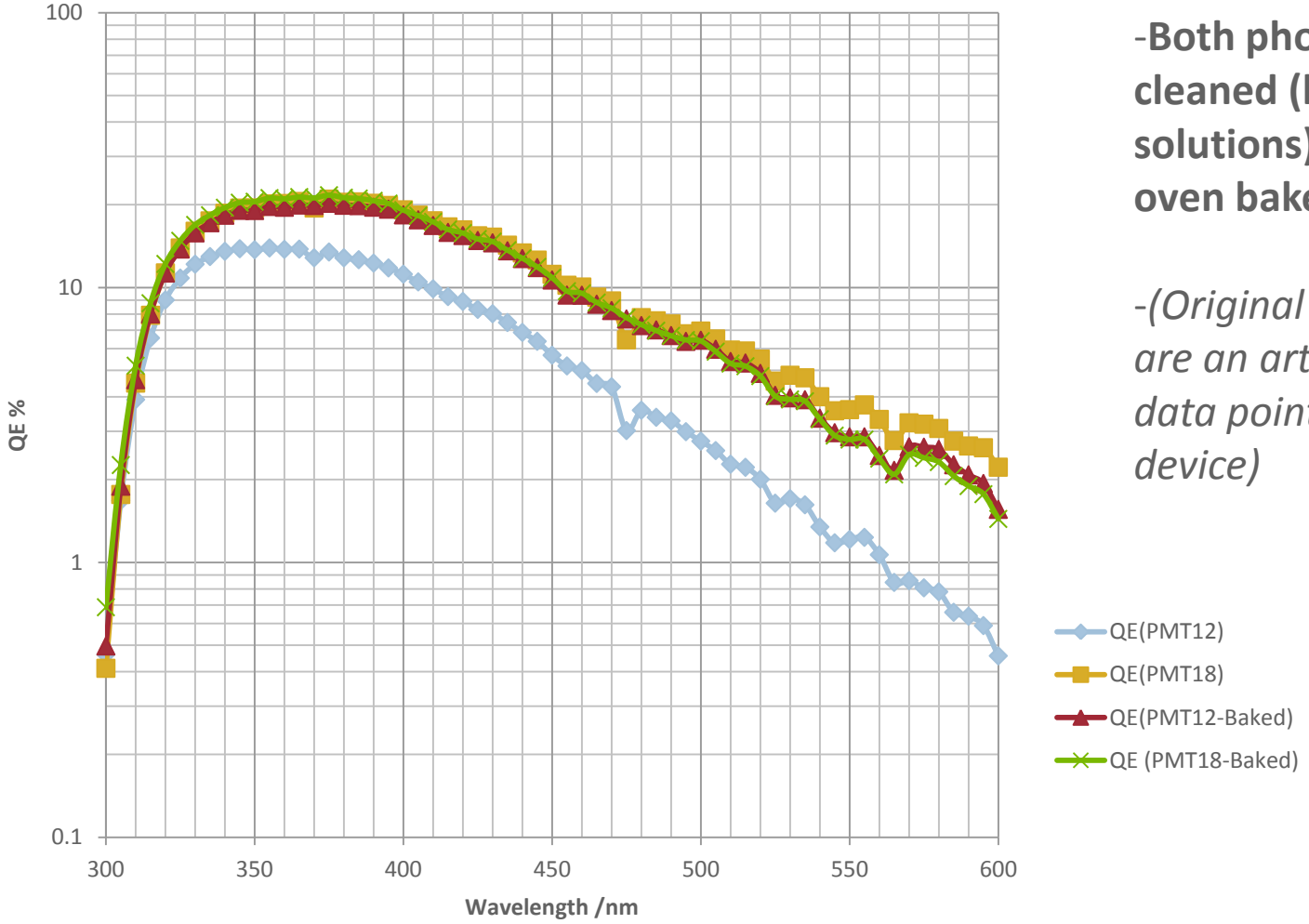


I-V Characteristic



Cathodes exhibit characteristic I-V behavior, with QE as high as 24% at 370 nm.

QE Improvement after Baking Treatment



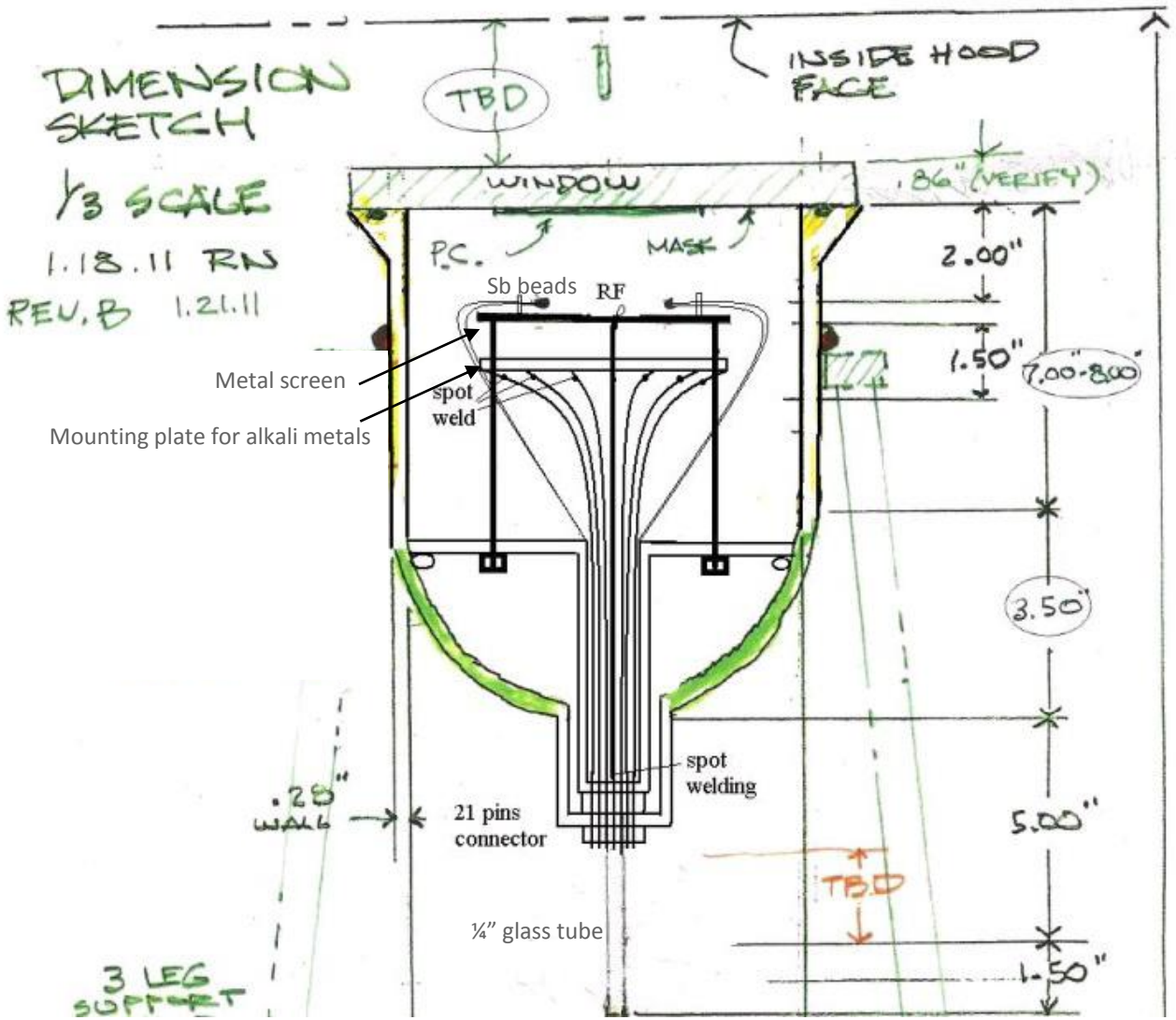
-Both phototubes were cleaned (hot acid solutions), followed by oven bake 140°C for 2 hrs

-(Original 475 nm features are an artifact from bad data point in the reference device)

QE of low QE sample is improved after baking treatment, further study is required to understand the process.

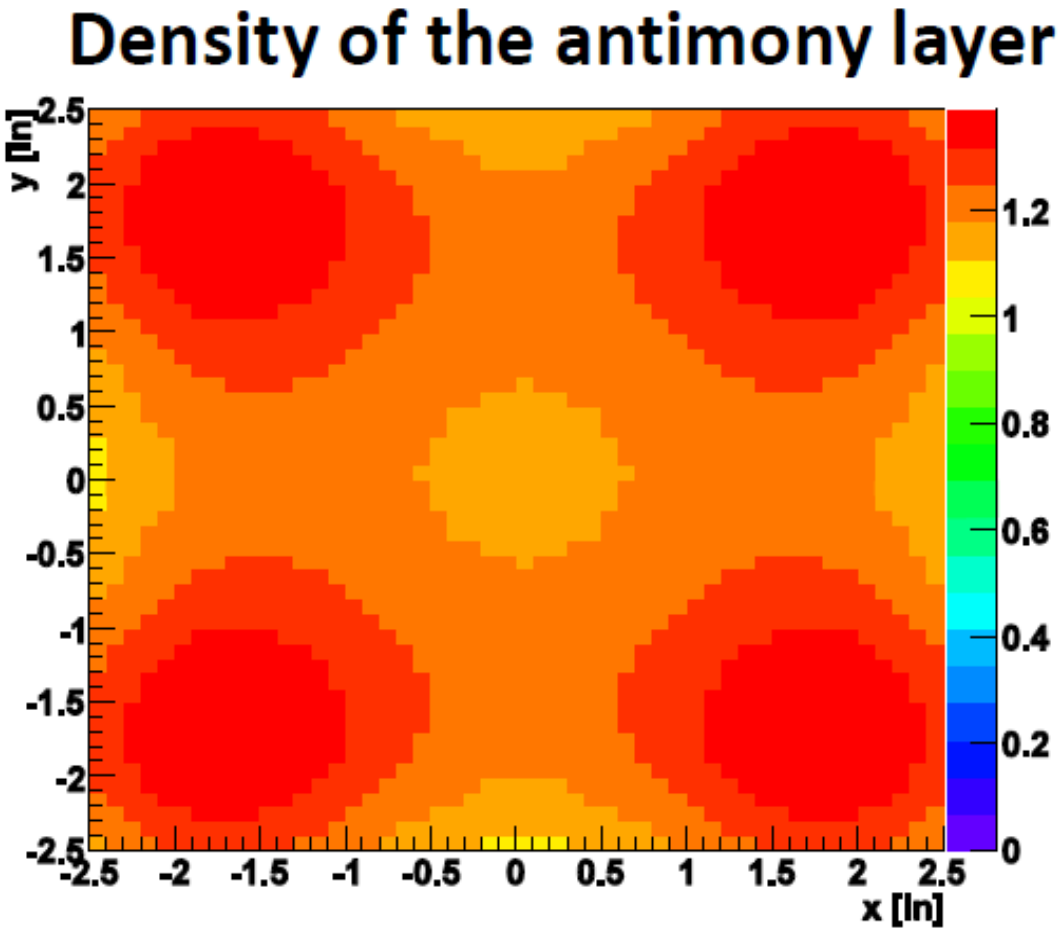
The Chalice Design

- Inside top window will be the photocathode substrate. Window is sealed with o-rings to chalice's body under vacuum;
- Sb beads mounted on top of metal screen;
- Metal screen acts as RF return during oxygen discharge and as anode during alkali metals deposition;
- Alkali metals mounted on non-conducting plate;
- 21 wires to pin connector allows for insert to be pulled out;
- Vacuum pump-out through ¼" glass tube;
- Chalice structure is supported by external legs.



Sb Beads Arrangements For The Chalice

- 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.



Summary

- Progress has been made;
- PMT photocathodes with QE as high as 24% have been produced on site;
- Scaling of PMT photocathode to 4”x4” is progressing via chalice;
- Lessons learned from PMT and chalice will be transposed to 8”x8” photocathode.

To Do List

- Make 4”x4” photocathode – refine and optimize recipe;
- Transpose knowledge to 8”x8” photocathode fabrication.

Scientific Opportunity

If knowledge from 4”x4” photocathode processing can be transposed to 8”x8” photocathode, then the chalice can be used as a “test bed” for research in photocathodes for photodetectors.