Review Committee Report of "A Single Tile Facility"

On the

Design, Cost and Schedule

For the

Large Area Psec Photo-Detector Collaboration

March 2012

EXECUTIVE SUMMARY

A review of the new “Single Tile Facility” being designed at Argonne as part of the Large Area Psec Photodector Collaboration was conducted on March 16,2012 at Argonne National Laboratory (ANL). The purpose of the review was to evaluate the design’s soundness to produce single tiles that meet the specifications, to evaluate the plans for demonstrating the major required techniques for the facility including schedule, budget and resources and to assess the ability of the facility to be adapted to changes in the design should modifications prove necessary.

The review committee concluded there were no showstoppers in the design, but identified possible risks in the design, in the plans and in the ability for the facility to be adapted. These possible risks are outlined in the report along with the committee’s recommended mitigations. In addition, for the success of the design and overall effort the committee felt it was critical to identify someone at Argonne (preferably someone who had experience in making sealed tube devices) that could act as the scientific and management lead of this new single tile facility.

Documentation for this review can be found at the url https://twindico.hep.anl.gov/indico/conferenceDisplay.py?confId=875

Introduction:

The Single Tile Facility is intended to produce glass capillary microchannel plate (MCP) photodetectors in an all-glass package one detector at a time with a baseline of 8” active area. The facility is composed of a single tile system which consists of a four chamber vacuum transfer system, its pumps, manipulators, gauges, and internal subsystems. This system lives within a facility which includes a wet chemistry lab, a photocathode lab and a tile fabrication lab (the latter of which is where the four chamber vacuum transfer system lives). This review was primarily concerned with the design of the single tile system. The identified possible risks and mitigations are broken into 4 areas.

1. Risks and mitigations associated with producing a tube with a good photocathode:

Risk 1: *There is a risk of not being able to maintain ultra-high vacuum given the plan for production of an 8-inch square device each week, and utilizing three points of entry to insert components into the chamber.*

Mitigation 1: Consider using one of the four integrated chambers as a load lock and moving one component at a time into the desired location using the transfer mechanism. This could work if the oxygen plasma/alkali evaporation processes could be consolidated into one chamber.

Risk 2: *The expected base pressure of the system is 10-9 torr, which is one to two orders of magnitude higher than can be achieved with an all metal sealed UHV chamber that is baked at high temperatures (> 300 C). Although the design provides for high temperature baking of tube parts by internal heaters, water will re-adsorb on the parts at a faster rate and the deleterious effects of the additional water vapor at 10-9 torr on photocathode QE and tube life is unknown at this point. The use of an internal heater for uniform heating of the entire glass enclosure in the photocathode chamber may prove difficult and expensive. The use of elastomer gaskets on the gate valves and door seals and the transferred indium seal gasket limits the bake-out temperature and ultimate pressure.*

Mitigation 2: It is recommended to explore the use of metal gaskets for the door seals. After parts are loaded, the tube process schedule should include an external bake out of > 100C for multiple days to decrease the base pressure.

Risk 3: *Materials compatibility*

Mitigation 3: Consider materials compatibility testing by developing a tube with a molten indium seal that could be processed and sealed by Space Sciences. Continue testing and verify elastomers and materials compatibility with photocathodes. Continue R&D and testing to address materials compatibility.

Risk 4: *The ability to measure the photocathode QE in situ was discussed during the review, but no consensus on how this would be implemented was reached.*

Mitigation 4: Recommend to incorporate a QE and uniformity measurement feature for efficient development and optimization of the photocathode process as it would eliminate the need and cost of sealing tubes for *ex situ* measurements. Furthermore, this would make the system more attractive as a user facility as new photocathode materials and processes could be rapidly developed.

Risk 5: The *base pressure may be too high resulting in poor photocathode and lifetime.*

Mitigation 5: The mitigation for this is higher temperature bake out. Alternatively, perhaps adding getter pumping (TSP or NEG) would help.

Risk 6*: Pressure burst from gate value gasket between evaporation of antimony and transfer to next chamber.*

Mitigation 6: A mitigation metal gate value or antimony evaporation in cathode chamber should fix this.

2. Risks and Mitigations associated with producing a good seal:

Risk 1: *There is a risk associated with the Indium seal in how the fixture will be designed and in any outgassing of the indium itself.*

Mitigation 1 This should be investigated sooner rather than later. Find out if there is a significant outgassing on indium in use; also develop a scaled down version of the mechanism that will be used for placing the indium before moving to the full scale version. Define the details of transfer of indium to the tube.

Risk 2*: Engineering challenges and possible process issues related to indium gasket with a thermocompression sealing design.*

Mitigation 2 As opposed to a molten seal, maintaining the ideal cross sectional shape with a solid gasket should improve the seal yield and the use of a cool sealing temperature means that the photocathode will be in a thermodynamically stable state and may improve photocathode quantum efficiency. As pointed out in the review, because indium is a highly malleable and sticky material, the custom manipulator that will hold and precisely place the gasket may require considerable design engineering time and cost that should be allowed for in the budget. Also, the gasket may outgas under compression; verification experiments are recommended and the acquisition of vacuum outgassed material should be considered. In parallel, explore the use of indium or indium alloy melted into a groove with a compression or molten seal process.

3. Risks and Mitigations associated with the Schedule, Budget, and Management:

Risk 1: *Who is the identified leader of the facility?*

Mitigation 1: It is critical to the success of this effort that someone at Argonne is the scientific/management lead of this effort. Dean is doing the engineering work on the vacuum system, but he made it clear that he was building a system that would allow someone else to design the detailed internals for each station. There should be a single person who has ownership of the system scientifically. That person should have experience making sealed tube devices and be responsible for the design of the critical internal parts for each station to make sure the entire system worked together consistently to produce the desired final product. There are a lot of devils in the details and a experienced person dedicated to this system would eliminate a lot of time lost to pitfalls. Without such a person, the task could be done, but the time required to climb the various learning curves and complete the system will be significantly longer than the time line presented at the review.

Risk 2*: Budget and schedule;*

Mitigation 2: Anything that can be done to prove out on a small scale before moving to large scale should be done. In particular, it is recommended that a complete photodetector with all components living together in a system is extremely important. Producing a small scale system and measuring the lifetime of the photodetector sooner rather than later in the program as it is not MCP that limits the lifetime, but the photocathode.

Risk 3*: Budget and schedule – What is the effect on the budget and schedule if the single tile facility design addresses the risks outlined in this report.*

Mitigation 3: Revise budget and schedule of single tile facility design to take into account the risks outlined in this report.

4. Risks and Mitigations associated with Adaptability to changes in the design of the system should modifications prove necessary.

Risk 1: *Translator Reliability*

Mitigation 1: Recommend some sort of capture option for translator; this might make electrical connections easier as well./

Risk 2: *Fractures of tube on vent due to poor bond line thickness indium;*

Mitigation 2: This appears to be a tooling issue. Test to see if you are getting consistent thicknesses with a known gasket

Risk 3: *Reliability of electrical connections*

Mitigation 3: Adding electrical contacts to internals of tube prior to sealing and then disconnect of electrical contacts before moving to next chamber; propose look into this design.

Risk 4: *Final operations:*

Mitigation 4: There are multiple recommendations which have an impact on the final design and operations.

- Review the design of placement and enough viewports and spare ports in general to avoid redesigning which will delay the schedule.
- Make sure support structure assembly and disassembly is sufficiently flexible.
- Include Port aligners on all translators
- QE mapping with a more flexible optical source

Risk 5*:* *Complexity and Modularity of the system*

Mitigation 5: The concept of a modular single tile system has definite advantages. The single tile system has the proper scope to verify process steps prior to moving to a large scale production system. However, the need to transfer the tube body adds engineering complexity. The modularity of the system should reduce risk in terms of rework cost and process development. In the event that a single chamber has to be redesigned, it can be replaced at low cost and work on other process steps can continue. The system appears to have good flexibility for build up to a user facility. Some cathode materials, such as Cs: GaAs, may require a significant rework of the vacuum system, as 0.01 nTorr vacuum may be required. Care should be taken that XHV practices are followed to the extent feasible, to make such a transition more reasonable should it be required.

Conclusion:

The design of a “Single Tile Facility” capable of producing glass capillary microchannel plate (MCP) photodetectors in an all-glass package one detector at a time with a baseline of 8” active area was reviewed. Overall, the design was sound with no showstoppers. However, the committee did find several areas with higher risks for producing a facility on schedule and with the resources presented. These risks and possible mitigations of these risks were presented in this report. The committee recommends the collaboration revise the design and schedule by addressing theses possible risks.

Charge to Committee:

Dr. Karen Byrum
Physicist

High Energy Physics Division
Astrophysics Group Leader
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 360
Argonne, IL 60439-4814

1-630-252-6217 phone
1-630-252-5782 fax
byrum@anl.gov

Dear Reviewer:

A facility to produce all-glass 8” MCP photodetectors will be constructed at Argonne by the Large Area Photodetector collaboration. The initial configuration of the facility will be designed to produce one MCP tile detector at a time. Production of a sealed all-glass tile requires some processes that are either new or have not been scaled to the 8” MCP size to date. These include fabrication of an 8” active area bialkali photocathode on the borosilicate top window which is transferred to the glass tile base containing the internals, and sealing the top window to the sidewall using a pressure indium or indium alloy technique performed at a temperature below 150°C. Provision must be made in the vacuum space of the facility for high temperature bake-out of most components of the tile as well as possible “scrubbing” of the MCPs to remove residual contaminants trapped in the pores and characterization of the photocathode and electrical configuration. Because construction of such a facility is new to the Argonne HEP Division and because the feasibility of some of the techniques is yet to be demonstrated, we would like to conduct a review of the plans for the facility and the techniques it will use.

The charge for the committee is as follows:

Conduct a critical review of the design of a production facility for producing 8” active area sealed glass MCP photodetectors one unit at a time. The review should assess the soundness of the design to produce single tiles that meet the specifications. In particular, we ask the reviewer to evaluate the plans for demonstrating the major required techniques for the facility:

1. Fabrication of a bialkali (K_2CsSb) transfer photocathode scaled to the 8” top window size from the 4” demonstration in the glass vessel used in the Argonne photocathode lab (the “Chalice”).
2. Production of a low temperature seal using indium or indium alloy wire. The review should consider also the surfaces between which the bond is made for suitability.

3. Bake-out at temperatures of 350-400°C for most components of the detector
4. Provision of possible “scrubbing” apparatus for removal of residual contaminants from the MCP pores.

The review should include an assessment of the schedule and budget for the facility as well as the resources needed to construct, commission, and operate the facility. The committee should also assess the ability of the facility to be adapted to changes in the design of the above components should modifications prove necessary. As there has been some concern with the choice of gate valves for isolating sections of the facility chambers, the committee should also consider if the valves and load locks are appropriate for the design. We hope the review can be conducted by mid-March 2012.

For the Large Area Psec Photodetector Collaboration

Karen Byrum

Reviewers:

Paul Hink - Photonis (p.hink@photonisusa.com)
Daniel Leopold – Washington Univ. St Louis (Leopold@wuphys.wustl.edu)
Jason McPhate – SSL Berkeley (mcphate@ssl.berkeley.edu)
John Smedley – BNL (smedley@bnl.gov)
Scott Moulzolf – Univ. of Maine (Scott.moulzolf@maine.edu)

Agenda:

LAPPD Single Tile Factory Review (16 March 2012) - Windows Internet Explorer

LAPPD Single Tile Factory Review

Friday 16 March 2012
from 09:00 to 16:10US/Central
at Argonne National Laboratory (F-240)
chaired by: *Karen Byrum (ANL)*

Description: Review of the design of a production facility for producing 8" active area sealed glass MCP photodetectors one unit at a time.

Material: Slides

Friday 16 March 2012 | top

Friday 16 March 2012

09:00 Coffee & Food

09:30->*09:45* Introduction & Overview (Convener: Karen Byrum (*Argonne*)) slides; slides

09:45->*10:45* Overview of Single Tile Factory Goals & Design Requirements paper

- 09:45 Overview of Goals, Specs, & Timeline (30') (Slides; document; list of actions) — Bob Wagner (*Argonne HEP*)
- 10:15 Overall Single Tile Facility Design Requirements (30') (Slides) — Dean Walters (*Argonne NE*)

10:45->*11:15* Specific Single Tile Factory Components I

- 10:45 Status, Requirements, and Plan for 8" Photocathode (30') (Paper; Slides) — Zikri Yusof (*Argonne HEP*)

11:15 Break

11:30->*12:40* Specific Single Tile Factory Components II

- 11:30 Status, Requirements, and Plan for Thermopressure Top Seal (30') (Slides) — Dean Walters (*Argonne NE*)
- 12:00 Status, Requirements, and Plans for Baking & Scrubbing (20') (Slides) — Bob Wagner (*Argonne HEP*)
- 12:20 Status, Requirements, and Plan for Vacuum Transfer System (20') (Slides) — Dean Walters (*Argonne NE*)

12:40 Working Lunch

13:40->*16:10* Conclusion, Discussion & Questions

- 13:40 Conclusion: Proposed Design & Timeline (45') (Slides) — Dean Walters (*Argonne NE*)
- 14:25 Discussion & Questions (1h45') — Review Committee and Participants