# The ‘Gen-II’ LAPPD™: Large-Area Ceramic-Body Planar MCP-based Photo-Detectors

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## Abstract

The Gen-II LAPPD™ is a 20×20 cm$^2$ MCP-based photo-detector that has a monolithic ceramic detector base with an anode capacitively-coupled through a thin metal film to an application-specific readout pattern outside of the vacuum package. We discuss the development, including recent progress in producing a photo-cathode on the detector window using the *air-transfer* process. In this process a hermetic seal between the top window with pre-deposited antimony layer and the detector base is done during the detector bake-out. Photo-cathode synthesis is done by introducing alkali vapor into the sealed detector package through a small sealable vacuum port. We have demonstrated the feasibility of several critical process steps including demonstration of cesium transport from a source outside of the detector package to the entire surface of the detector window in the presence of two full-size 20×20 cm$^2$ MCPs inside the detector.

## Gen-II LAPPD™

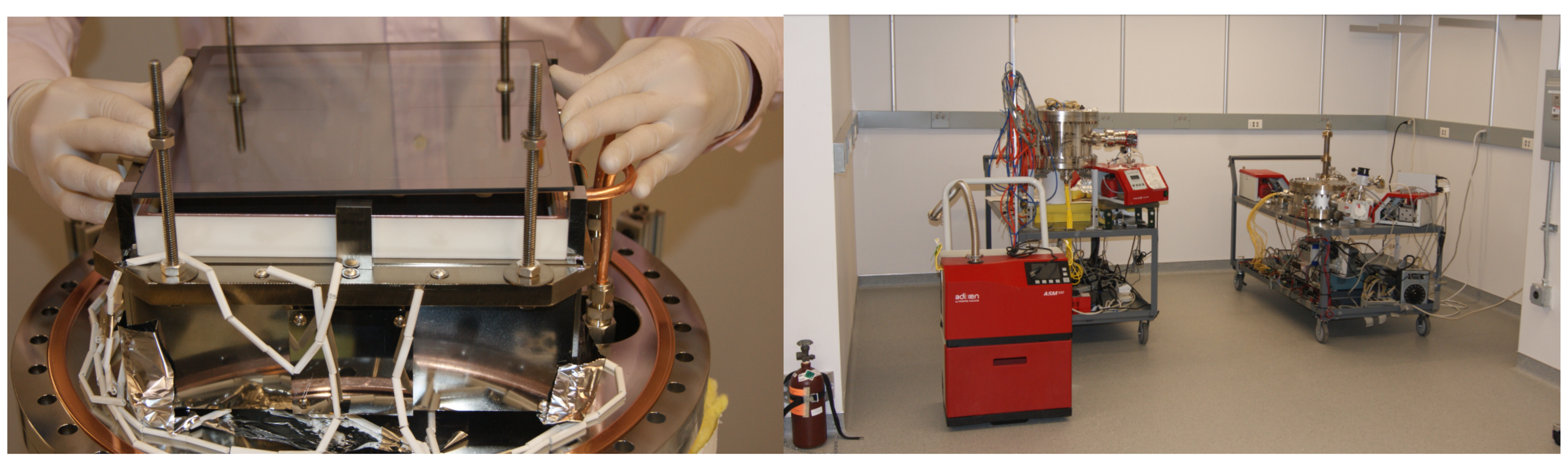
Gen-II LAPPD development is a joint program between the University of Chicago and Incom Inc.

| | Gen-I | Gen-II |
|---|---|---|
| Detector base | Glass | Ceramic |
| Anode | Delay line | Capacitively-coupled |
| Assembly process | Vacuum transfer | Air-transfer (Chicago effort) |

- Gen-I LAPPDs are now commercially available through Incom Inc.
- Ceramic packaging and capacitively-coupled anode are already being implemented at Incom.
- Air-transfer assembly process is under development at the University of Chicago.

In parallel we are developing multi-channel elecrtonics systems (PSEC4) to deploy these detectors in physics experiments, including ANNIE experiment and Fermilab Test-Beam.

## Air-Transfer Process

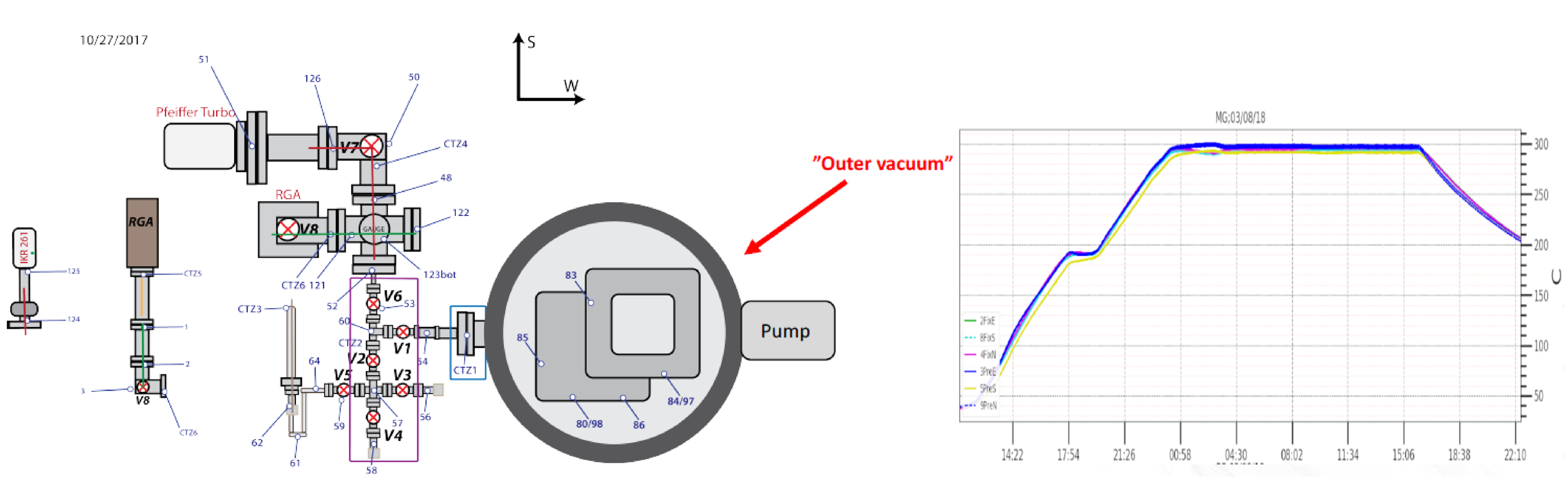


(*Left:*) Air-transfer of the window with pre-deposited layer of Sb. (*Right:*) University of Chicago PSEC Lab with two vacuum processing chambers. Due to their compact size, potentially many chambers could be operated at the same time at a future LAPPD production facility, using a shared vacuum distribution system. Each vacuum processing chamber could accomodate several LAPPDs. This batch production strategy would be similar to PMT batch production.

The goal is to develop an inexpensive process scalable to a production rate of $>$ 50 LAPPDs/week.

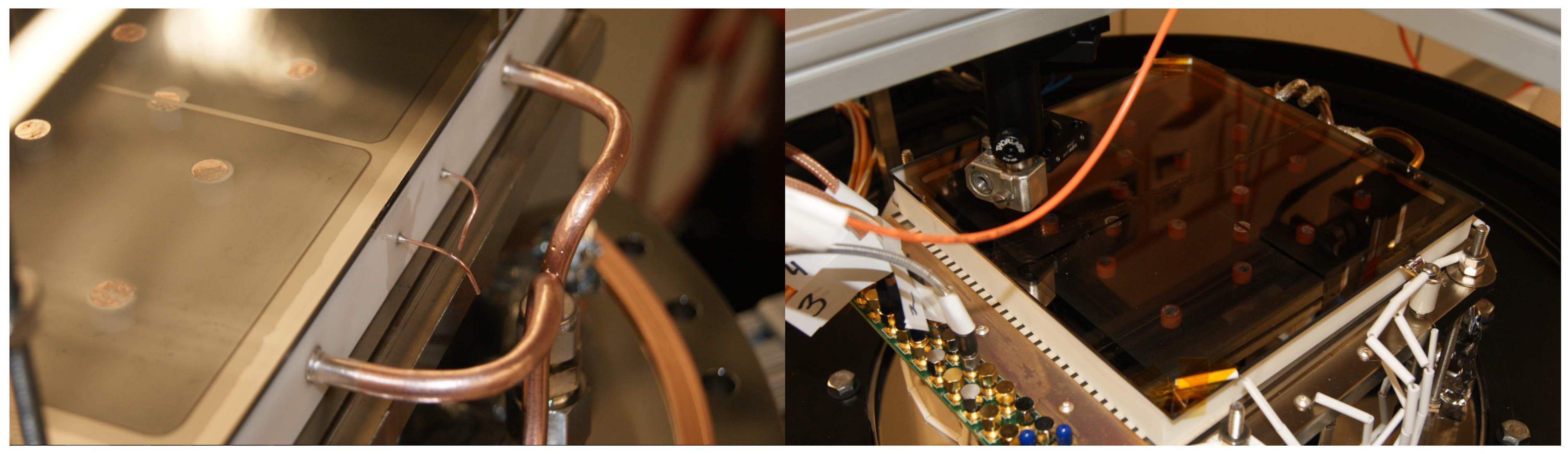
## Bake-Out in Dual Vacuum

Bake-out of the detector vacum envelope and indium seal between the window and the detector body are done in the same heat cycle. The bake-out temperature of $\sim$300 C exceeds indium melting temperature of $\sim$157 C. A dual vacuum system is required to ensure mechanical and vacuum stability.

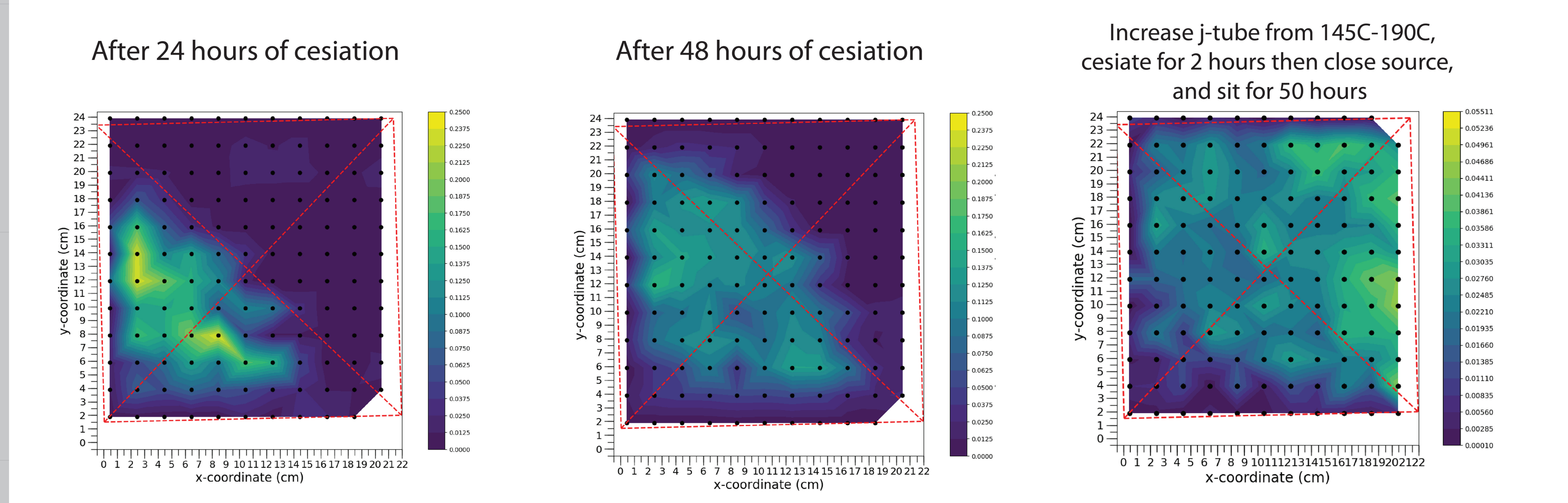



(*Left:*) Schematic view of the processing system that includes the dual-vacuum system and alkali transport system. (*Left:*) Typical bake-out and indium seal heat cycle.

## In-Situ Photo-Cathode Synthesis

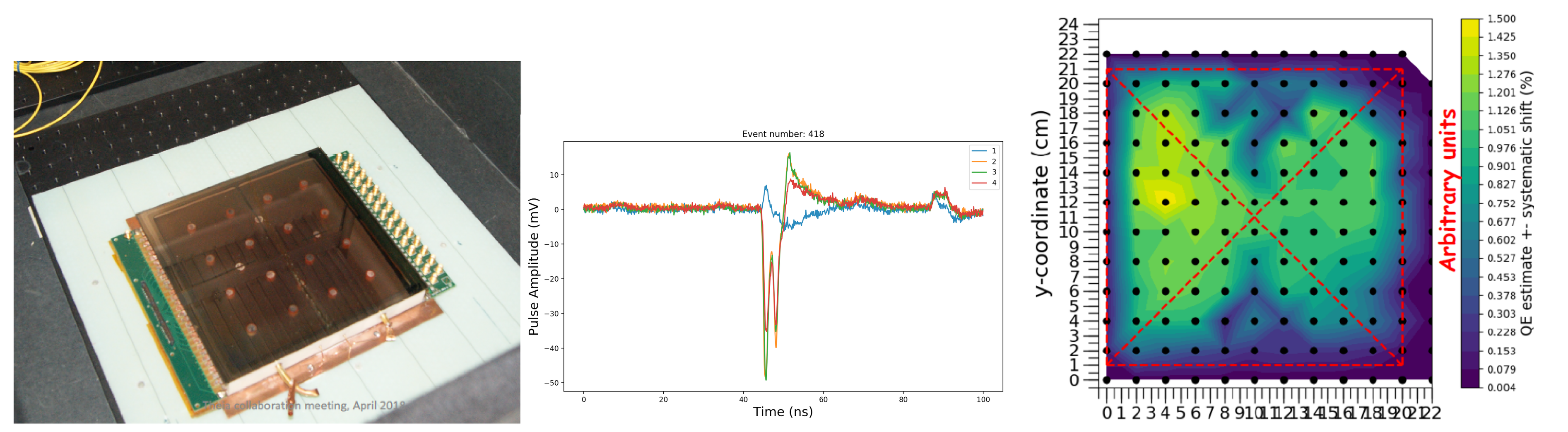


(*Left:*) Top window view after bake-out prior to cesation. (*Right:*) Top window view after cesiation.




In-situ photo-cathode synthesis showing photo-sensitivity expressed in arbitrary units. Direct measurement of photo-current and absolute QE were precluded since the photo-cathode, MCPs, and the anode were interconnected with an internal high-voltage divider as part of a simplified strategy to power the tile (see Refs. 2-3). Future devices will allow direct measurement of photo-current and calibrated QE.

## Results and Conclusions




(*Left:*) Complete Gen-II LAPPD tile-21. (*Middle:*) Pulses from tile-21. (*Right:*) Final photo-sensitivity map of the tile-21 in arbitrary inits. Tile-21 was an early test of cesium transport. Improved photo-cathode uniformity is expected in future devices.

- Demonstrated cesium transport from an external source to the entire surface of the detector window in the presence of two full-size 20×20 cm$^2$ MCPs inside the detector
- MCPs are functional after exposure to cesium during the photo-cathode synthesis

## References and Acknowledgments

*References:*

*1) H. Frisch, M. Wetstein, A. Elagin, ‘Batch Production of Microchannel Plate Photo-Multipliers’, US Patent US9911584B2*
*2) E. Angelico et al., ‘Capacitively Coupled Pickup in MCP-based Photodetectors Using a Conductive Metallic Anode’, Nucl., Instr. Meth. Phys. Res. A846 (2017) 75.*
*3) E. Spieglan, ‘Photocurrent Measurement for a PMT With Resistive HV Divider’, LAPPD Document Library #310.*

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