# MCP-PMT Innovations at Incom

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## Abstract:

Innovations to reduce afterpulsing, develop MCP-PMTs with 6 um microchannel plates for improved time resolution and rate capacity and a compact position sensitive MCP-PMT are in progress at Incom.

A hydrophobic ALD film has been developed for use on top of an MgO secondary electron emission film. It is intended to reject water layers from air exposure, thereby reducing the load of adsorbed water load in the microchannels that leads to afterpulsing and photocathode degradation.

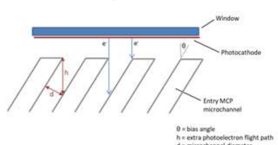
Using a technique that combines aluminosilicate glass microchannel substrates with ALD films for resistance and secondary electron emission, Incom is reducing the diameter of the microchannels to 6 um. A 33 mm diameter size is in development, to be followed by scaleup to a 10 cm square size.

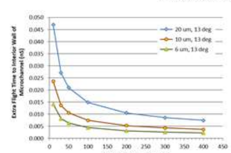
A compact, 43 mm diameter MCP-PMT with a position sensitive, capacitively-coupled anode has been constructed to serve as both a test device for 6 um microchannel plates and as a routinely manufactured product.

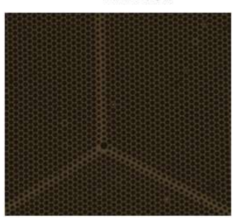
Finally, a square format 56 mm MCP-PMT is in development to have a scintillator with as a window. It is intended for use with PET medical imaging, where timing and position sensitivity may be degraded by a thick window. A barrier is required between the photocathode and scintillator to prevent unwanted diffusion and compositional changes. A thin fused silica window may also be used on this device.

## Six Micron MCPs

- MCPs with 6 micron channels are in development at Incom through a US Department of Energy SBIR program.
- A preliminary MCP size of 33 mm is in fabrication.
- The next step is a scaleup to 10 cm square MCPs.
- The microchannel diameter affects the time resolution because of the various depths in the channel at which the first photoelectron strikes.
- A smaller diameter channel reduces the variation in depth of the first strike, and improves time resolution.
- A 6 um 60:1 MCP has a thickness of 0.360 mm, and is a challenge to grind, polish and clean with reasonable yields.



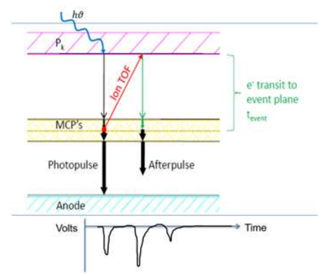
Inspection photo of 6 um glass substrate
Aug 8, 2025

## Summary:

- Recent innovations in MCP-PMT design at Incom include evaluation of a hydrophobic layer on top of the MgO electron emission film in the MCPs. Initial measurements produced a gain of 8.3E6 at 1200 volts/MCP. Gain showed improvement with scrubbing.
- MCPs in the glass substrate/ALD format but with 6 um channels are in prototype fabrication. The first samples are 33 mm in diameter. Some minor block fusing issues appeared in the first channel assembly, to be addressed in the next iteration. These will provide the good gain and lifetime of presently available 20 and 10 um MCPs, but will improve timing and high rate tolerance.
- A 56 mm square MCP-PMT is in development for use in PET medical imaging, using a scintillator as a window. It will improve timing and position resolution for PET measurements, but may also be used for direct photon detection.

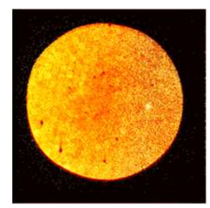
## Hydrophobic ALD coating on SEE Layer

- Afterpulses in MCP-PMTs are created by the MCP electron cascade.
- As the electrons fall through the MCP potential they may strike an atom or molecule attached to the microchannel wall.
- With sufficient electron impact energy, the atom may be removed from the wall and ionized.
- Driven by the MCP voltage, the ion will proceed back up the microchannel toward the photocathode.
- If it escapes the microchannel, it will implant in the photocathode, changing the composition of the photocathode. This typically results in a lower quantum efficiency and photoelectron production.
- Adsorbed material may be removed from the microchannel walls by baking and scrubbing the MCPs before sealing the device. It is a slow process.
- Using the technique of ALD films for resistive and emissive layers on microchannel surfaces, Argonne National Lab is developing a **hydrophobic ALD film** to reject water films from air exposure. This may reduce the water burden on the baking and scrubbing process, and therefore reduce afterpulsing in the MCP-PMT.
- A top ALD layer of a hydrophobic film on top of MgO will alter the secondary electron emission. The two layers create a compound emission material, and secondary electrons will be derived from both, depending on their emissive properties.
- Initial test of the hydrophobic coating on an MgO ALD MCP demonstrated a gain of 8E6 and good spatial uniformity. The gain is somewhat lower than what is expected from an MgO MCP, but has increased with brief scrubbing.
- A test of afterpulsing is planned, using a witness MCP pair where a photocathode would be in an MCP-PMT. The afterpulse rate will be measured in coincidence with MCP pulses, and compared to the afterpulse rate in routinely made MgO ALD MCPs.




**Ix. Tzoka**, V. A. Chirayath, L. Moore, J. Asaadi, A. Brandt, University of Texas/Arlington, **CPAD2023**

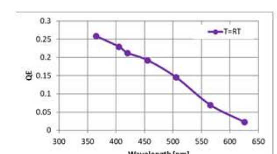
- Gain map for 33 mm sample MCPs with hydrophobic coating
- Mean Gain: 8.32E6 at 1200 V/MCP
- MCPs: EX-084/
- CJ49763-001

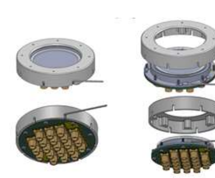


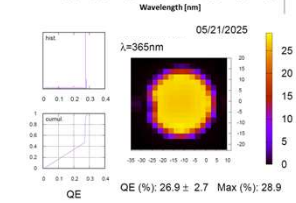
## Compact Circular MCP-PMT

- MCPs with 6 micron channels are in development at Incom through a US Department of Energy SBIR program.
- A preliminary MCP size of 33 mm is in fabrication. This compact MCP-PMT will demonstrate the performance of these MCPs.
- Device features:
  - 43 mm outer diameter
  - 1.0 or 1.5 mm thick window
  - 1 mm thick ceramic anode
  - 33 mm MCPs
  - Capacitively-coupled
  - Position sensitive
  - Pixelated signal board
  - 10 um or 6 um MCPs

43 mm device with no MCPs – test of sealing and quantum efficiency






## Compact Square 56 mm MCP-PMT

- A square 56 mm MCP-PMT is in development for use with a scintillator as the window.
- A fused silica window is an alternative for photon detection.
- A technique to apply a photocathode to the scintillator is also in development. A barrier layer between the scintillator and the photocathode inhibits chemical reactions or elemental diffusion between the two.
- Fused silica window thickness: 2.0 mm
- Anode thickness: 1.0 to 1.5 mm
- A signal board is provided underneath, A user-developed board may be easily installed instead.