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HRPPD final PED

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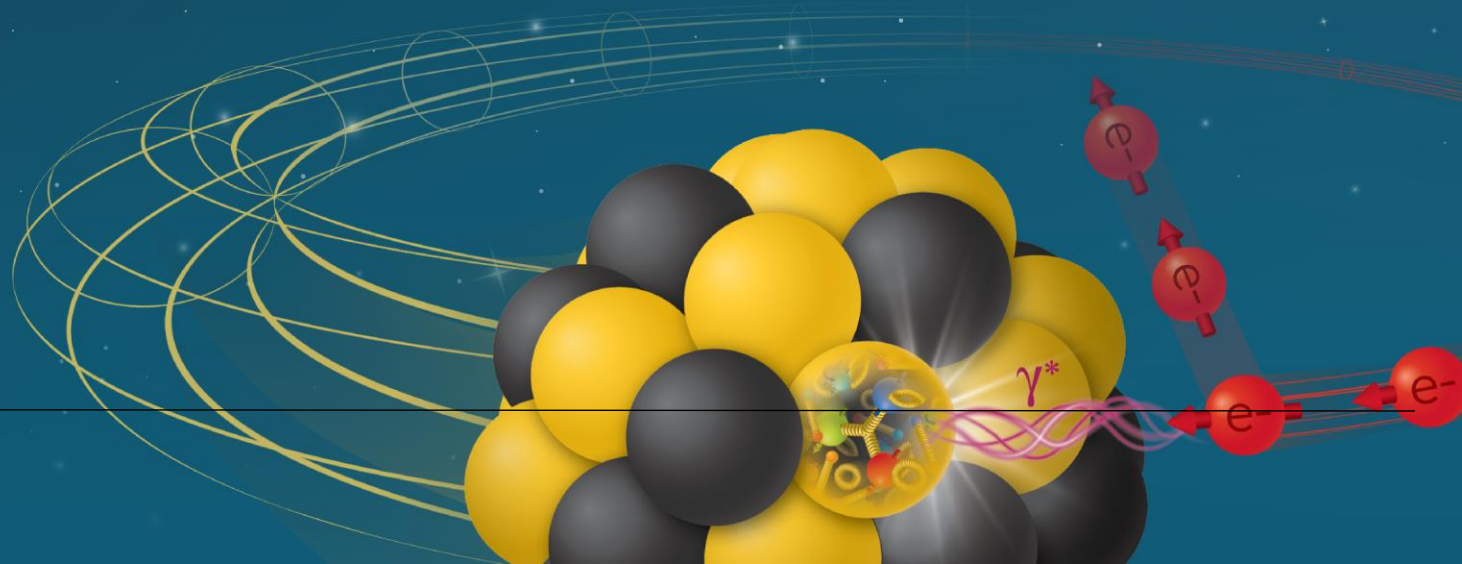
10/20/2025 ePIC TIC



Goals of final PED

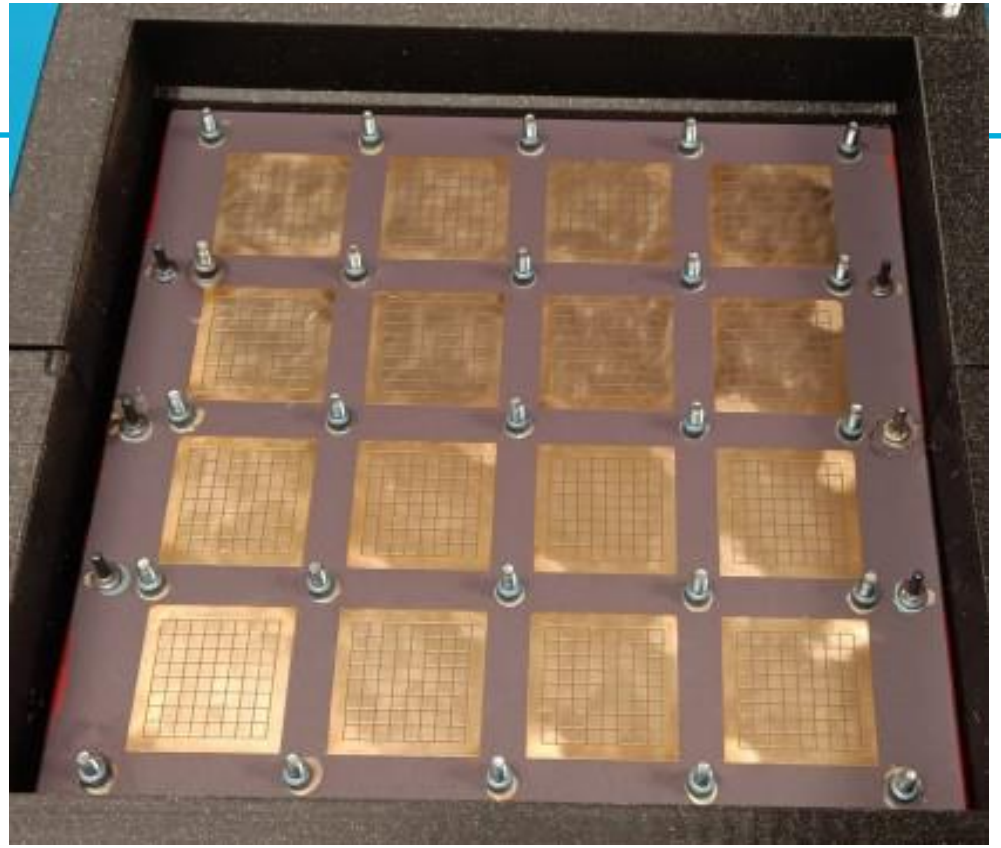
Two main goals:

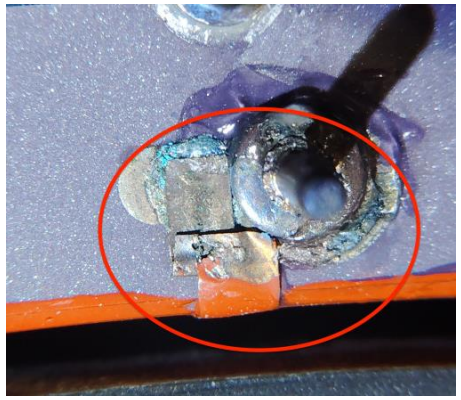
A) Fix and optimize all short comings of the first HRPPD evaluation

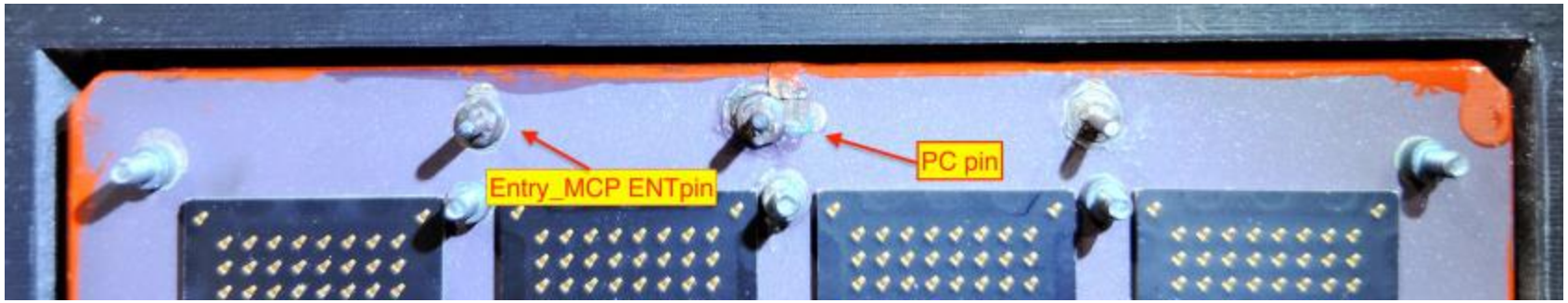
B) Explore modifications to enhance PDE to match hpDIRC requirements.

Fix and Optimize

- Back Plane mounting points for readout PCB.
- HV connection tabs.
- HV connection to MCPs and Cathode.
- Gold Plated anode connection pad protection.
- Ceramic back plane with improved trace routing and isolation (JLAB design effort).
- Entrance Window material (sapphire)







Enhance PDE (photon detection efficiency)

Why:

- In recent years most companies producing standard MCP-PMTs stopped production
- Only one vendor left, Photek: took 21 month to produce one with suboptimal quality (small vacuum leak)
- Current baseline choice of such sensors for hpDIRC very likely unattainable. NEED BACKUP SOLUTION

How:

- HRPPD most obvious candidate with improved PDE
- Investigate **A**tomic **L**ayer **D**eposition (ALD) coating with MgO of first MCP (HRPPD has 2)
- Create two AC-coupled HRPPD with such coatings for evaluation
- Apply optimized coating (based on evaluation results) on DC-coupled HRPPDs

Worst case scenario:
ALD coating not successful, chose HRPPD anyway for hpDIRC and reach 2.7σ π/K separation instead of 3σ at 6GeV/c

SOW objectives (current Draft)

EIC-Incom 2025/2026 SOW contract Objectives

The main objectives of this SOW are design modifications aimed at increasing photosensor operational robustness and life expectancy under real experimental conditions, a number of mechanical design optimizations, as well as incremental performance improvements based on suggestions and lessons learned from the ongoing evaluation studies. A short summary of the most substantial modifications are listed below, with more details found in the section Statement of Work:

- Window material sapphire.
- Modified High voltage connection scheme inside of the vacuum volume
- Improved signal trace isolation in the ceramic stack-up
- Re-design of the high voltage connection scheme on the outside of the anode plate
- Robust mechanical screw attachment on the rear side of the anode plate
- Protection of gold-plated anode pads during production.
- Improved Ion getter configuration, and quantification of expected performance increase

In addition to the items listed above, Incom will work on a best effort basis to improve the Photon Detection Efficiency of the HRPPD performance. This would make the detector meet the requirements for the high-performance DIRC readout application. This has become more critical as alternative photo sensor candidates to the current baseline (of the hpDIRC detector) which may not be a viable solution given the current market situation.

SOW scope (current Draft)

2025/2026 SOW Scope and Deliverables

The full scope of this PED effort is divided into two major parts.
In the first part Incom is to perform sensor design modifications towards the final EIC Design HRPPD requirements and mass production readiness.
This is followed by a second part of subsequent manufacturing of six sensors based on the successful design modifications to allow a sensor QA evaluation process including beam tests. This quantity will allow a sensor QA evaluation process to give credibility that the anticipated final EIC HRPPD sensor design and production is feasible on a scale required by EIC, as well as to conduct a variety of pfRICH and hpDIRC related studies in addition to the generic performance evaluation.

It is expected that a pair of *capacitively coupled HRPPDs* will be produced with one with of the two HRPPDs having the MCP#1 Ni/Cr electrode layer be covered with a MgO emissive ALD coating, during the initial first phase of of this PED (design work phase) and shipped to BNL on a rental basis for evaluation prior to the start of the second part of this PED, the production of the six DC-coupled HRPPDs. This scheme will allow to establish the parameters of treatment of the MCP layers for the production of the six HRPPD test articles in the second part of the PED.

The produced six tiles will have either a similar or a different configuration of the MCP#1 electrode coating and MCP#1,2 resistivity, based on the outcome of the design phase. However, all the tiles are expected to be produced in a single batch, at a rate of one per month or faster, on a schedule which fits best Incom's internal production planning and allows to perform a thorough in-house evaluation. It is expected that the provided standard test reports will be appended by a PDE and a timing distribution RMS measurement.