LAPPD MCP-PMT Recent Progress and Future Development Plans

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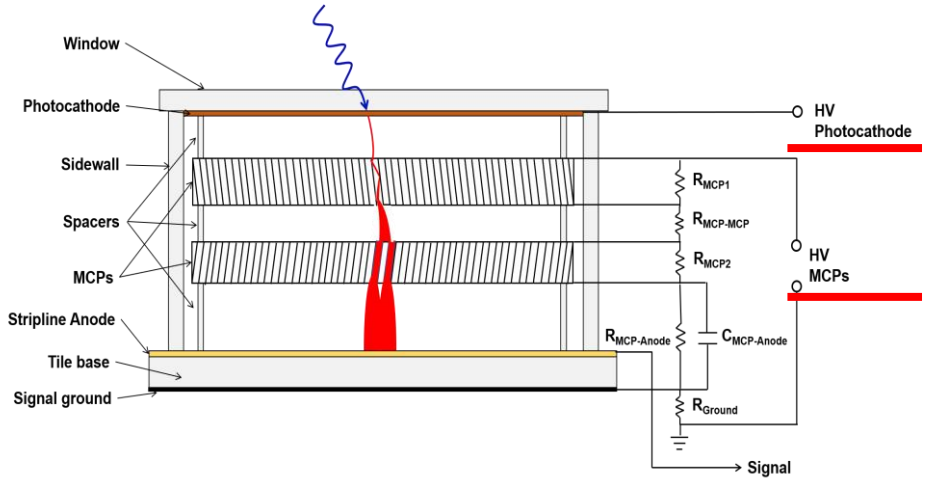
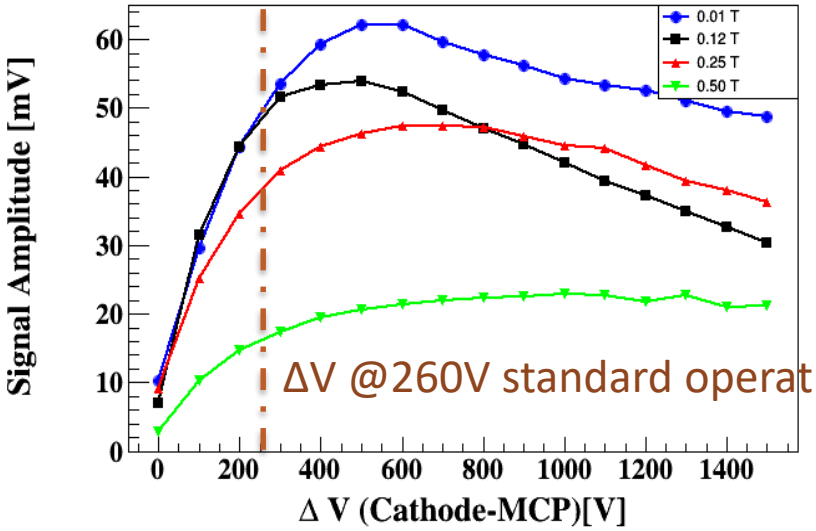
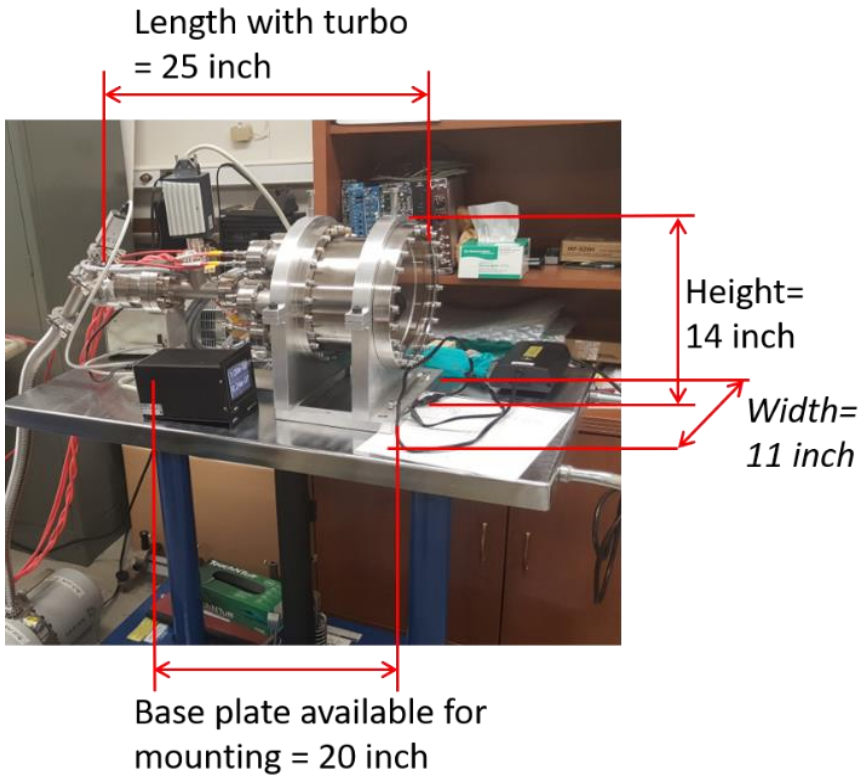
Photocathode HV dependence measurement

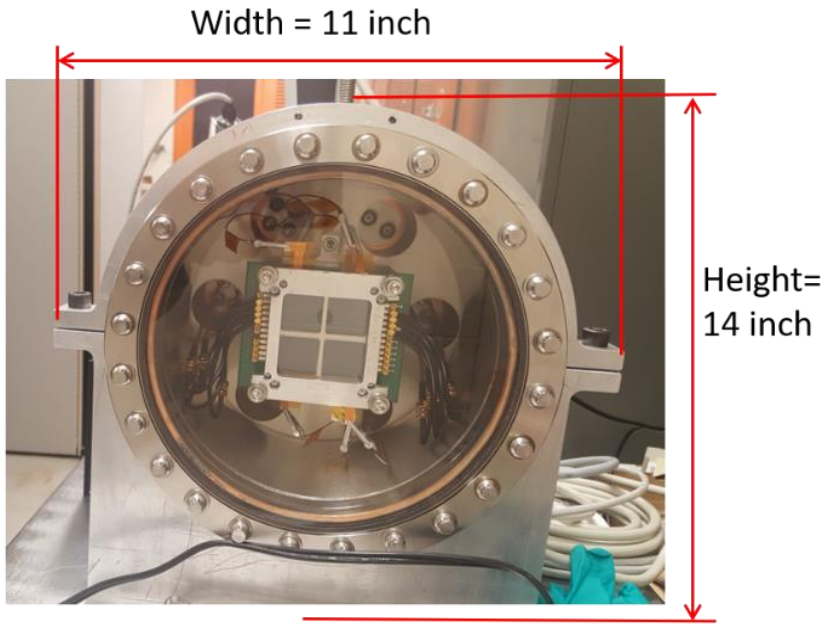




- The B filed test for this run is to study the affects of bias voltage (ΔV) between photocathode and MCP1
- Same setup as last year's run, the bias voltage connection of Photocathode is isolated from the rest of the stack, so that ΔV can be adjusted independently.
- Maximum gain was obtained at ΔV ~ 500V, operation ΔV needs to increase comparing to previous standard operation.
- Results show different affects after the gain reaches the maximum in low/high magnetic field strengths. The gain starts decrease after the maximum value for PMT in low magnetic field, while the gain keeps a plateau after the maximum value for PMT in high magnetic field.

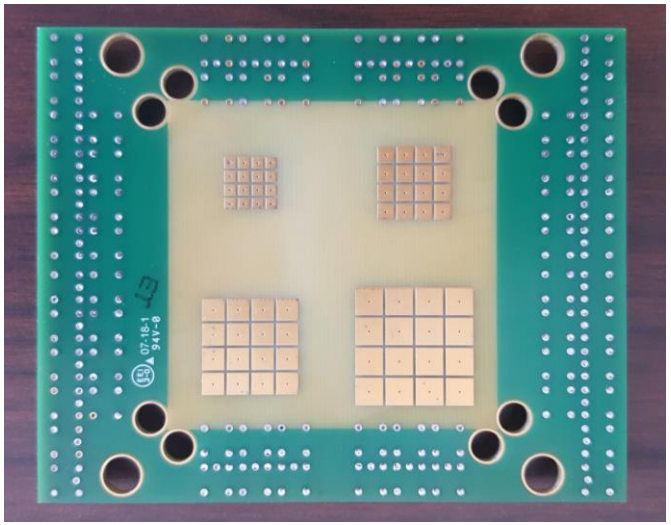
Fermi Beamline Experiment (Mar. 13 - 27)



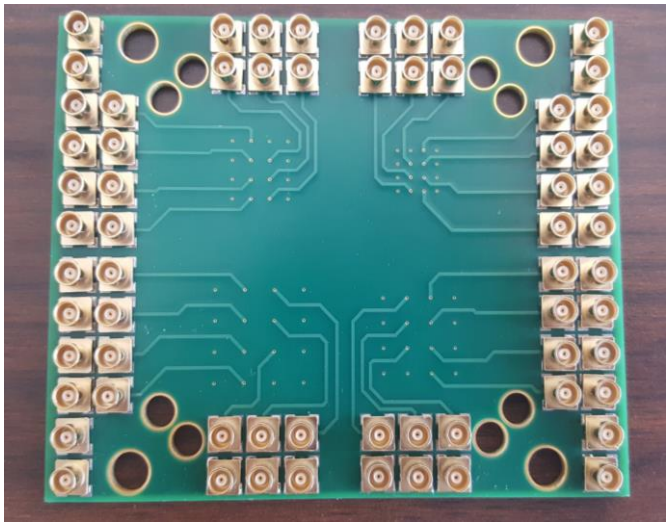


- The production facility was busy July 2017 – Jan 2018 on producing MCP-PMTs for 4x standard MCP-PMTs for proto-DUNE, 1x for UTA lifetime test. Now on photocathode study, will open for EIC MCP-PMT (small pore, reduced spacing) in May 2018.
- A demountable vacuum chamber was designed and built for MCP-PMT study
- Aluminum photocathode, MCP stacks and readout board are all replaceable, various configurations can be studied in the chamber without building a device

Fermi Beamline Experiment (Mar. 13 - 27)



Front to tile base



Back to electronics

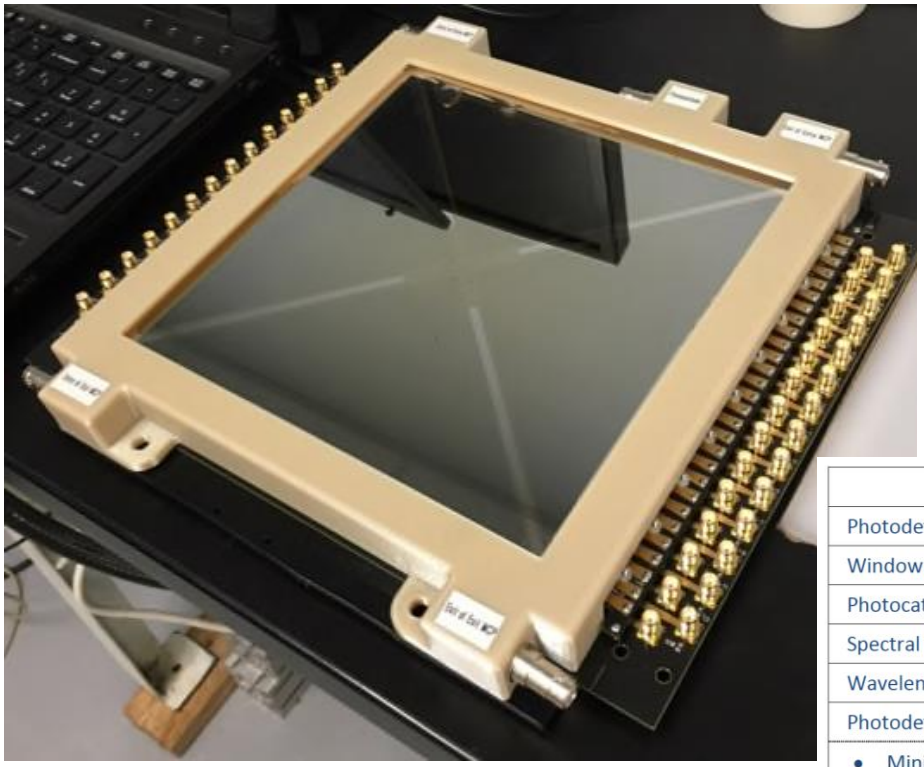
Pad sizes:
2mm x 2mm
3mm x 3mm
4mm x 4mm
5mm x 5mm

Spacing between pads:
0.5 mm

- **Capacitive pads readout was designed, glass coated with 5 nm Cr (sheet resistance 150 Ω/□)**
- **Under installation in the chamber at ANL now**
- **For this beam test, mainly rate capability (R&D committee requested), also interested in timing, position resolution, cross talk etc.**

Incom Inc. progress

Incom Inc. recently sold and shipped two LAPPDs to early adopters for their evaluation and use. The first went to Matt Wetstein at Iowa State University for the ANNIE Program, and the second went to Erik Brubaker at Sandia National Laboratory.



- **Michael Minot (director of LAPPD) is visiting ANL on Mar. 15, will bring us a low performance LAPPD with packages for ANL LAPPD B field test fixture design.**

Feature	Parameter
Photodetector Material	Borosilicate Glass
Window Material	Fused Silica Glass
Photocathode Material	Multi-Alkali (K_2NaSb)
Spectral Response (nm)	160-850
Wavelength – Maximum Sensitivity (nm)	≤ 365 nm
Photodetector Active Area Dimensions	195mm X 195mm
• Minimum Effective Area	34,989 mm^2
• Active fraction with Edge Frame X-Spacers	92%
Anode Data Strip Configuration	28 silver strips, Width = 5.2 mm, gap 1.7 mm, nominal 50 Ω Impedance
Voltage Distribution	5 taps for independent control of voltage to the photocathode and entry and exit of MCP

Incom magnetic field SBIR Phase I schedule (FY18)

Phase I objective:

ANL:

1. **Testing of 20 cm LAPPD in B field**
2. **Demonstrate improvement of 6 cm MCP-PMT in B field with 10µm and 5 µm pore size MCPs and reduced spacing**

Incom Inc.:

Manufacture 10 µm and 5 µm MCPs with large area (20 cm 10 µm, 6 cm 5 µm)

	Month								
	1	2	3	4	5	6	7	8	9
Task 1: Magnetic Response Characterize a 20 x 20 cm LAPPD at the ANL Magnet Test Facility									
Produce an LAPPD Device without magnetic materials at Incom	■								
Magnetic Field Characterize a non-magnetic LAPPD at ANL		■	■						
Task 2. Manufacture MCPs with 10µ Pore Size and a 6 x 6 cm Device Form Factor at Incom									
MegaDraw a Glass Capillary Array block with 10µ pores at Incom	■	■							
Manufacture and test MCPs with 10µ pore Size and 6 x 6cm area at Incom			■	■	■	■			
Task 3. Produce 6 x 6 cm MCP-PMT Devices with 10µ Pore Size and Magnet Test at ANL									
Produce 6 x 6 cm MCP-PMT Devices with 10µ pores at ANL		■	■	■	■	■			
Magnetic Field Characterize MCP-PMTs with 10m pores at ANL				■	■	■	■	■	■
Task 4. Manufacture GCAs and MCPs with 5µ Pore Size and 6cm x 6cm Area at Incom									
MegaDraw a Glass Capillary Array block with 5µ pores at Incom					■	■			
Manufacture and test MCPs with 5µ pore Size and 6 x 6cm area at Incom							■	■	■
Task 5: Begin Modifying LAPPD to Eliminate Magnetic Materials and to Optimize Gaps									
Design a modified non-magnetic Gen II LAPPD with pixellated readout at Incom								■	■

Milestones to secure Phase II grant

Proposal for Phase II will be focused on the development of 20 cm LAPPD with magnetic field tolerance and integration of pixelated readout to optimize LAPPD for EIC-PID construction.

Milestones for phase I SBIR (ANL work):

- 20 cm LAPPD B field test (first 3 month, by June 30th)
- Production and B field test of 6 cm MCP-PMT with 10 µm MCPs and reduced spacing (by Sep 30th)
- Production and B field test of 6 cm MCP-PMT with 5 µm MCPs and reduced spacing (by Dec 30th)

Besides the above milestones, ANL works on pixelated readout to further enhance Phase II grant aiming for LAPPD optimization for EIC PID application

Current LAPPD pixelated readout development by Incom and UChicago using ceramic base for capacitive coupling, Incom standard LAPPD is all glass packaging, much cheaper and established sealing process by Incom. ANL works on demonstration of pixelated readout using glass base to replace the ceramic one.

Pixelated readout milestone

- Pixelated readout Fermi beam test, examine the rate capability (Mar. 2018)
- Pixelated readout test at ANL lab using glass with different resistance coating (Sep. 2018)
- Production of **4X 6cm MCP-PMT** with 10 µm MCPs and pad readout. (FY2019)
- Receive **1X 20cm LAPPD** with 20 µm MCPs and ceramic pad readout (FY2019)

When Incom SBIR Phase II grant gets approved, eRD 14 will start to receive 20 cm LAPPD with B field as well as pad readout for various PID detectors testing for EIC.

eRD14 Long Term Development Plan - Sensor point of view

Goal: Demonstrate EIC PID detector: DIRC and mRICH (dRICH?)