SOLID COLLABORATION MEETING



RECENT PROGRESS ON MCP-PMT/LAPPDTM





Large Area Picosecond PhotoDetector (LAPPDTM)

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FOLLOW-UP FROM MY LAST TALK IN 2016 05 AT SOLID COLLABORATION MEETING

My first talk on application of LAPPDTM was given on May, 7, 2016

05/7 (Saturday), Room L102-104

Morning

9:00	GEM-China PDF 🗅	Jianbei Liu
9:15	Discussion	
9:20	GEM-USA PPTX 🗗 PDF 🗅	Kondo Gnanvo
9:35	Discussion	
9:40	MRPC	Yi Wang
9:55	Discussion	
10:00	Fast TOF PPTX	Junqi Xie
10:15	Discussion Last laik IOCUS. IOF	
10:20	Break	
10:40	EM calorimeter PDF 🗅	Xiaochao Zheng
11:10	Discussion	
11:20	Light Gas Cherenkov PDF 🗅	Sylvester Jooster
11:35	Discussions This talk focus: Cherenkov	
11:40	Heavy Gas Cherenkov pptx 🖓 pdf 🗅	Zhiwen Zhao
11:55	Discussions	
12:00	General Discussions	

https://hallaweb.jlab.org/wiki/index.php/Meeting_solid_coll_2016_05



BACKGROUND: LARGE AREA PICOSECOND PHOTODETECTOR (LAPPD)

- LAPPD is a photomultiplier based on new generation microchannel plate, reinvents photodetector using transformational technologies.
- Goals: low-cost, large-area (20 cm x 20 cm), picosecond-timing, mm-position
- Applications: picosecond timing, mm-spatial on large-area
 - ✓ Particle physics: optical TPC, TOF, RICH
 - ✓ Medical imaging: PET scanner, X-ray imaging devices
 - ✓ National security: Detection of neutron and radioactive materials
- Status: Incom, Inc. is routinely producing standard LAPPD on a pilot production basis for test and evaluation by "Early Adopters".







ARGONNE 6 CM MCP-PMT & LAPPDTM

Small form factor LAPPD (6 cm MCP-PMT) was produced at Argonne for R&D. Knowledges, Design and Experiences were transferred to Incom to support commercialization of 20 cm LAPPDTM Commercialization: 20x20 cm²

R&D test bed: 6x6 cm²





- ➤ The Argonne 6 cm MCP-PMT and Incom 20 cm LAPPDTM share the same MCPs and similar internal configuration and signal readout.
- ➤ The Argonne 6 cm MCP-PMT serves as R&D test bed for performance characterization and design optimization; Incom 20 cm LAPPDTM is the final commercialized product.
- Close collaboration and communication (bi-weekly meeting, joint SBIR program), optimized configurations are directly transferred to Incom production line for mass production.

ARGONNE 6 CM MCP-PMT FLEXIBLE DESIGN FROM INITIAL LAPPD

- A glass bottom plate with stripline anode readout
- A glass side wall that is glass-frit bonded to the bottom plate
- A pair of MCPs (20µm pore) separated by a grid spacer.
- Three glass grid spacers.
- A glass top window with a bialkali (K, Cs) photocathode.
- An indium seal between the top window and the sidewall.



A very flexible platform for R&D efforts!

PHOTODETECTOR FABRICATION LAB



The only place in US academia that functional MCP-PMTs with world largest, low-cost Incom MCPs were fabricated.



- Tube processing is very challenging
- Achieved 95% sealing yield



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TEST FACILITIES

Optical Table for photocathode test



ANL g-2 Magnetic Field Test Facility



ps-Laser Facility for timing characterization



JLab/Fermilab Test Beam Facilities





ARGONNE MCP-PMT KEY PERFORMANCE

WITH 20 MICRON MCP PORE SIZE



Signal component



Gain > 10⁷



Timing resolution



Argonne

COMMERCIALIZED GEN-I LAPPDTM KEY PERFORMANCE WITH 20 MICRON MCP PORE SIZE, STRIPLINE READOUT

Credit to: Incom, Inc. LAPPD R&D group





Gain & Timing

Gain vs. MCP voltage LAPPD 25





WITH THE SUCCESS OF GEN-I LAPPDTM COMMERCIALIZATION

NEXT



APPLICATION OF CURRENT LAPPD[™] TO PROJECTS & APPLICATION DRIVEN OPTIMIZATION









Near-term: SoLID

ARGONNE 6 CM MCP-PMT IN MAGNETIC FIELD



Internal resistor chain design Gain drops quickly 0 < B < 0.15 T Individual biased design External HV divider B field tolerance 0 < B < 0.7 T

IBD design with 10 μm MCPs B field tolerance 0 < B < 1.3 T

- Optimization of biased voltages for both MCPs: version 1 -> 2
- Smaller pore size MCPs: version 2 -> 3
 Further improvement: reduced spacing (currently under fabrication) and even smaller pore size (6 µm)

MCP-PMT TIMING RESOLUTION IMPROVEMENT



TransitTime [ps]

Suppressed back scattering signal

TransitTime [ps]

Argonne 🕰



INCOM 20 CM LAPPDTM IN MAGNETIC FIELD

Supported by SBIR Phase I program, Phase II will be submit at end of Jan. 2019.



Magnetic Field Strength (Tesla)

The B field tolerance can also be further enhanced by adjusting the HVs, further study is planned.

PLANNED EXPERIMENT FOR SOLID THIS SPRING

With the fast-timing and magnetic field tolerance, the LAPPDTM may be used for SoLID to replace MAPMTs, significantly suppress the background at high rate environment.

- 1) How is LAPPDTM performance compared to MAPMT?
- 2) What is LAPPD's rate capability? Will it survive at SoLID environment?

Exploring experiments planned during March experiment in Hall C for SoLID:

- 1) 6 cm MCP-PMT (glass window) with wavelength shifter, performance comparison to MAPMT.
- 2) 20 cm LAPPDTM with quartz window performance test at high rate environment.



1) ARGONNE 6 CM MCP-PMT (B33 GLASS WINDOW) COATING WITH P-TERPHENYL WAVELENGTH SHIFTER

MCP-PMT loaded

Credit to: M. Rehfuss, Temple University





Anode J5, J23, J31 were readout (circled in red)

p-Terphenyl border p-Terphenyl spectra



	Rela	^{tive} Gain	•	1000
LED (nm)	J5	J23	J31	800
315	1.11	1.23	1.05	600
285	4.07	3.74	3.61	400
275	13.2	12.0	10.2	200



The relative gain (>10 times at 275 nm) is much larger than what was seen from the UV-glass PMTs (which showed around a ~1.5 gain at 265 nm), due to the strong absorption of B33 glass. N_{PE} $\approx \frac{\mu^2}{\sigma^2}$



1) ARGONNE 6 CM MCP-PMT (B33 GLASS WINDOW) COATED WITH P-TERPHENYL WAVELENGTH SHIFTER



	Before	After
	p-Terphenyl coating	p-Terphenyl coating
QE (300 nm)	5.2 %	7.4 % (1.4 relative gain on QE)
Gain (405 nm, SPE)	1.29×10 ⁷	1.03×10 ⁷
Timing resolution (405 nm, SPE)	55 ps	60 ps

JLAB HALL C HIGH RATE ENVIROMENT EXPT.



- 1) 6 cm MCP-PMT with wavelength shifter coating will be installed and checked in January.
- 2) LAPPDTM with quartz window is under scheduled to be delivered before Mar 8, install Mar 8-11 during beam down time.
- 3) Rate capability experiment on MAPMT, 6 cm MCP-PMT and LAPPDTM will be performed in March accelerator run time.



SUMMARY

- An MCP-PMT fabrication facility was designed and built at Argonne National Laboratory, serving as a very flexible facility for MCP-PMT R&D.
- Knowledge and experience were shared with industry to support commercialization.
- □ LAPPD collaboration successfully commercialized the LAPPDTM.
- R&D on LAPPD towards particle identification application is on going, focusing on design optimization:
 - Magnetic field tolerance
 - Timing resolution
 - Pixel readout
- MCP-PMT with smaller pore size exhibits significantly improved magnetic field tolerance and timing resolution.
- Devices are prepared and beamline experiments are planned targeting SoLID application.



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And many others ...

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Thank you for your attention!

Questions?

