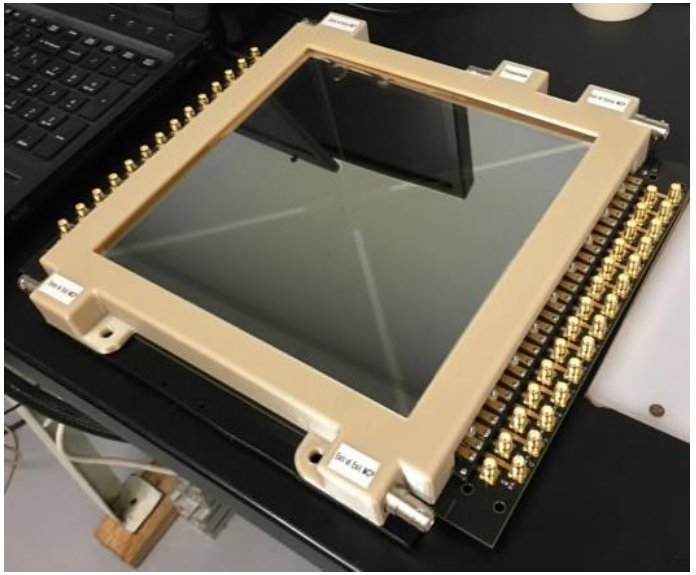
EIC-PID MEETING

# UPDATE ON LAPPD:

# EVALUATION OF LAPPDS FOR NUCLEAR PHYSICS PROGRAMS



**JUNQI XIE**

Medium Energy Physics
Argonne National Laboratory
9700 S Cass Ave., Lemont, IL 60439
jxie@anl.gov

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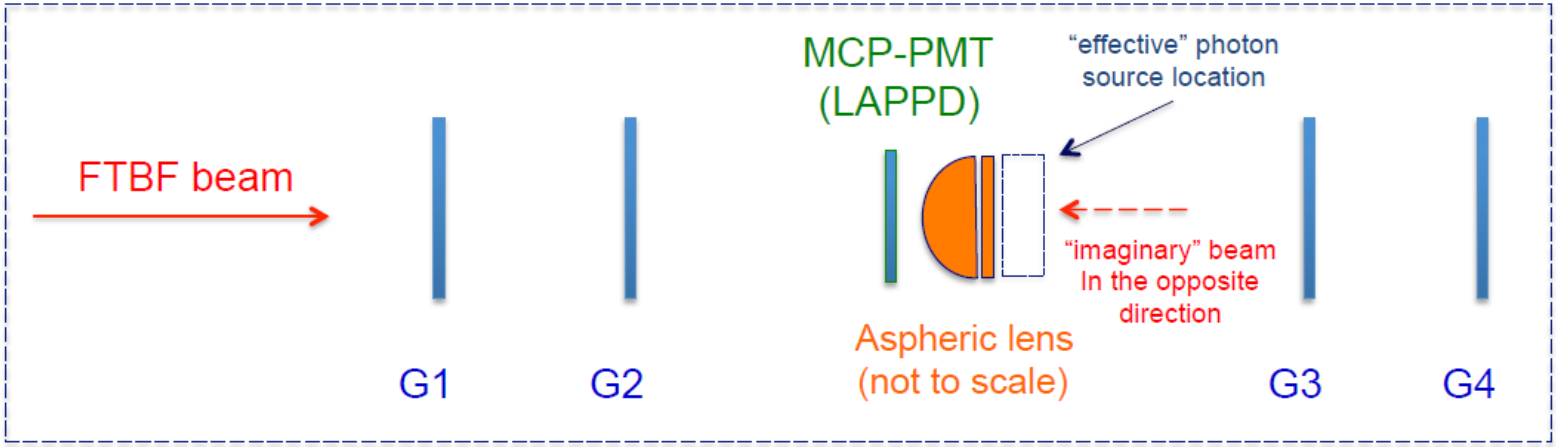
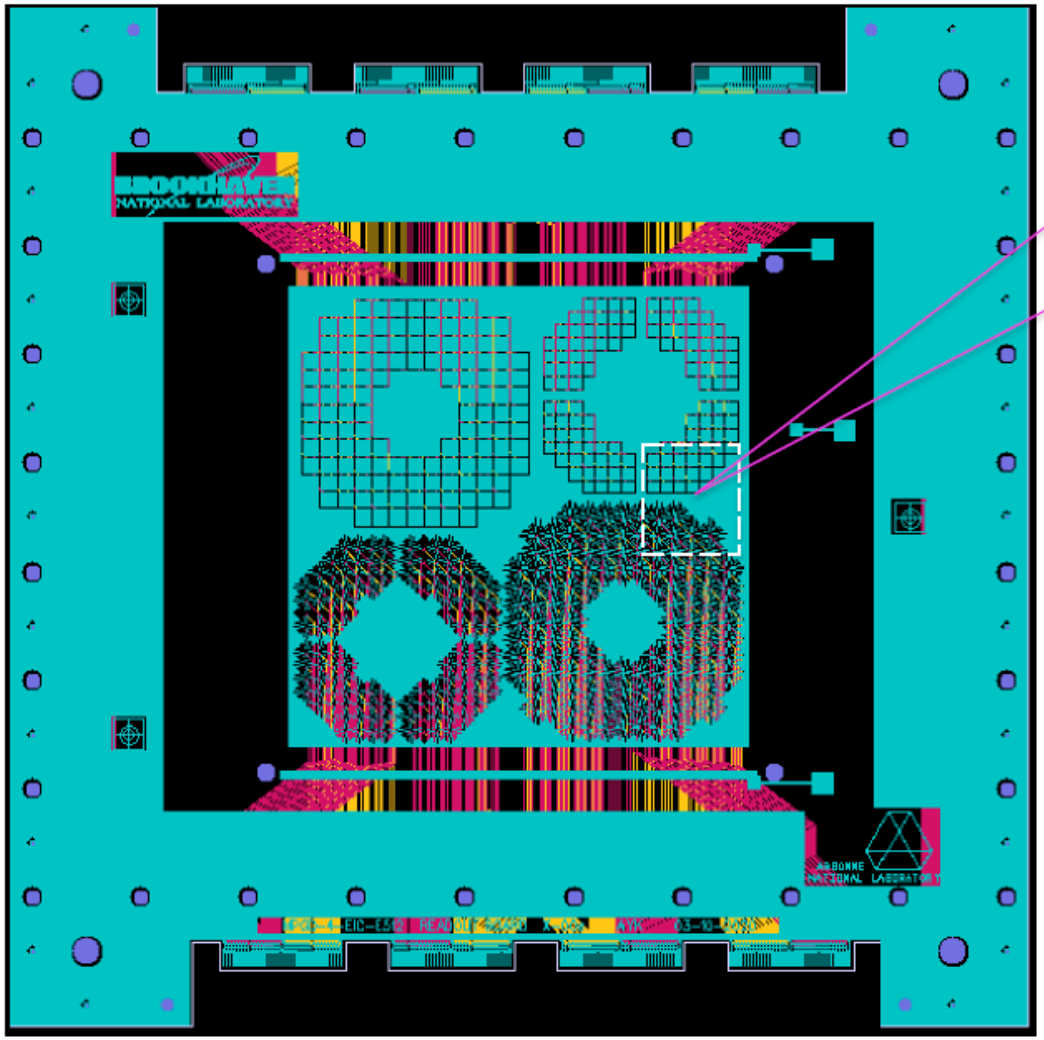
# GEN II LAPPD FERMILAB EVALUATION

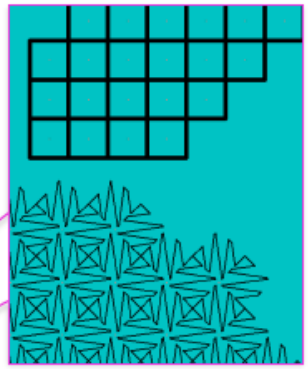
Experiment was prepared, but delayed due to COVID-19.
Refer to A. Kiselve talk to EIC-PID for details: https://indico.bnl.gov/event/8101/

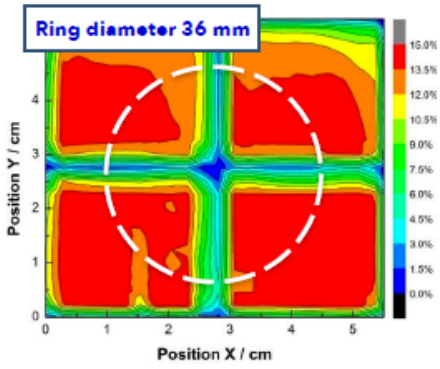



- GEM tracker (2x2 100x100 mm$^2$ COMPASS 2D chambers)
- *Either* Argonne MCP-PMT *or* Incom LAPPD (only 128 DRS4 channels)
- Small thick fused silica aspheric lens from Edmund Optics:
  - MCP-MPT: #87-975, 12.5 mm diameter, 10.0 mm effective focal length, 8.0 mm central thickness
  - LAPPD : #67-265, 25.0 mm diameter, 20.0 mm effective focal length, 14.0 mm central thickness
- *Backward reflection of Cherenkov light* on the rear flat lens surface
  - A single ~$400 off the shelf optical component ...
  - ... with minimum of required modifications (the ground side needs to be black painted though)
  - "Perfect" optics for all photons, which do not hit the side surface (those will be absorbed): a single refraction of a mirror-imaged Cherenkov light cone + refraction on the MCP-PMT window; no spherical aberrations and no parasitic reflections inside the lens

# Readout PCB for Argonne MCP-PMTs



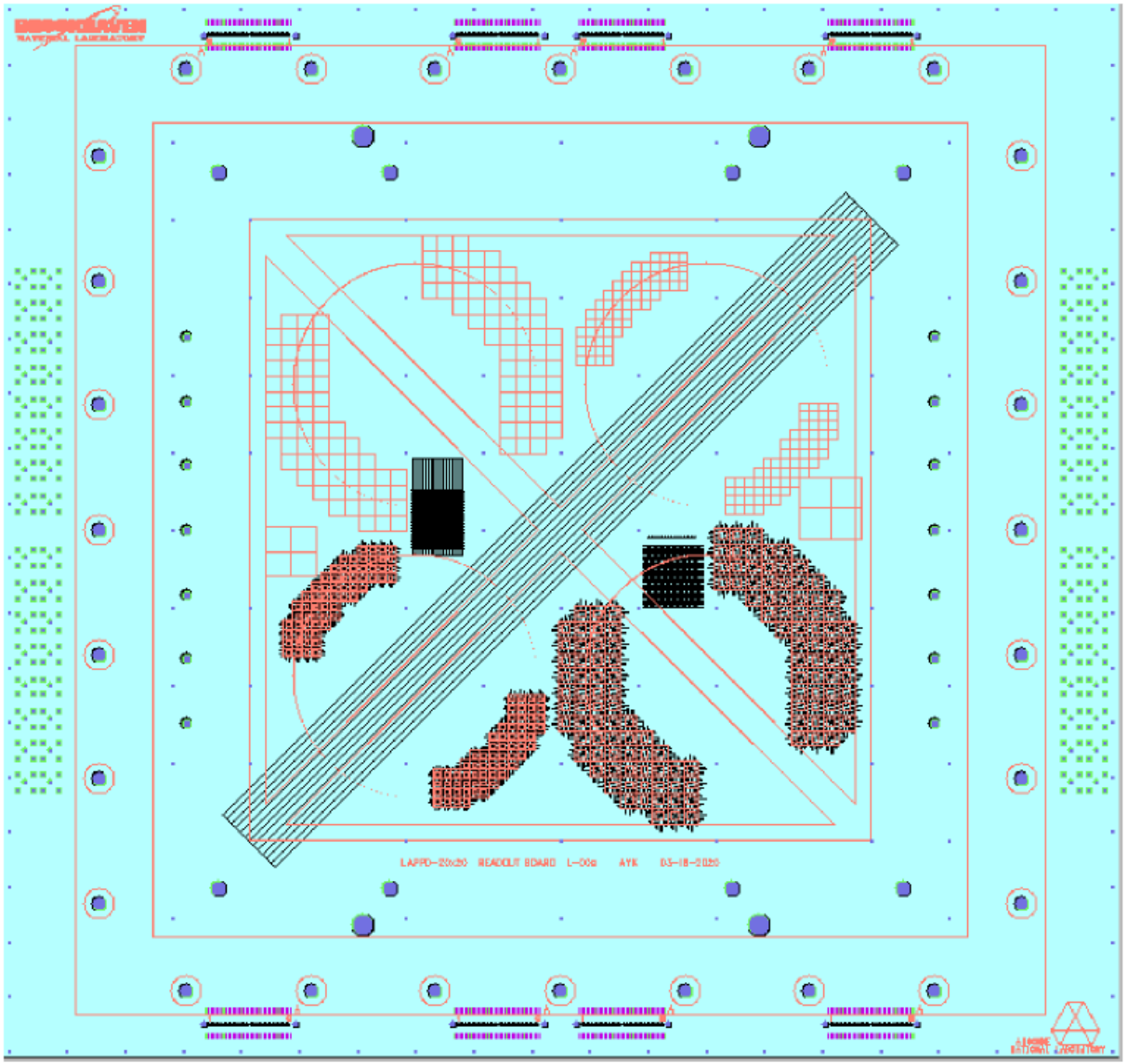





- 3mm and 4mm pad quadrants, with and without charge sharing
- 128 pads per quadrant
- Each of the quadrants is tuned to detect ~36 mm diameter rings
- 6 layers, with traces routed away in a simple 50 Ohm micro-strip configuration (two signal layers in a chess-board-like fashion)
- A pair of adapter cards (edge-to-edge and edge-to-MCX) will be used
- BNL MPGD prototype form-factor

**-> shipped to BNL already (but we have not seen it yet)**

# Readout board for Incom LAPPDs



- 3mm and 5mm pad quadrants, with and without charge sharing
- 128 pads per quadrant
- Each of the quadrants is tuned to detect ~76 mm diameter rings
- 8 layers, with traces routed away in a shielded 50 Ohm coplanar waveguide configuration
- Soldered high density connectors and edge-to-MCX adapter cards will be used
- Several other pad spots through the onboard MCX connectors
- Form-factor and mounting scheme match the “new” LAPPD enclosure

This board is now produced as well. Ready to ship to us.

# GEN II LAPPD FERMILAB EVALUATION

**In brief:**
**Experiment was prepared, but delayed due to COVID-19**

Fermilab beamline was canceled for 2020.

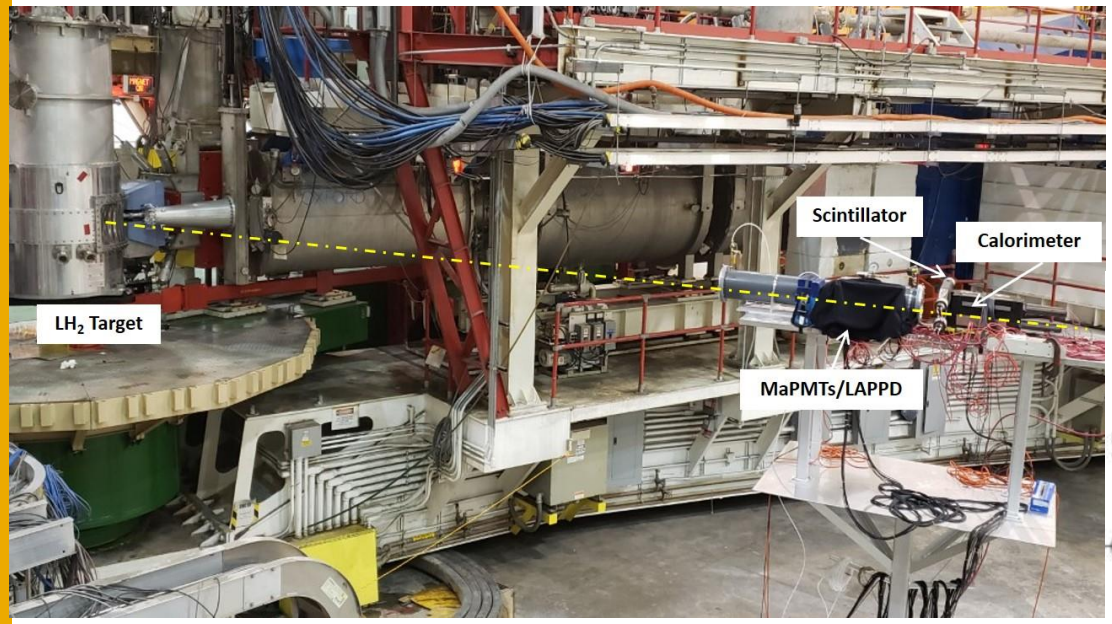
**Incom is still open, Gen III HRPPD SBIR was awarded, development on going.**

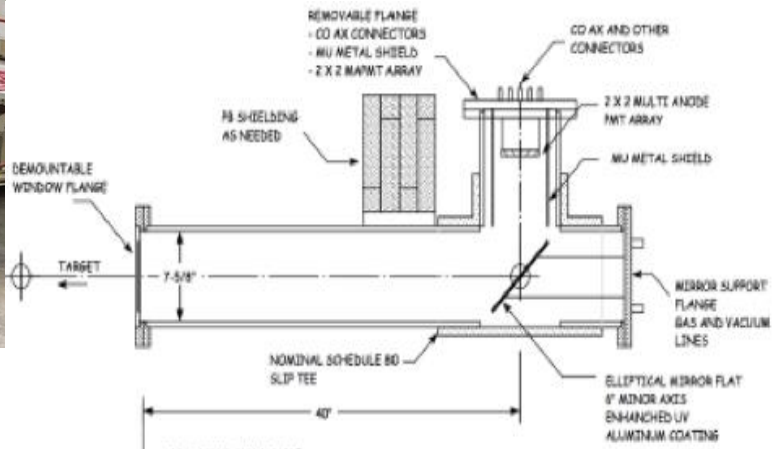
**Looking forward:**

- **Bench test of Gen II LAPPD before next beamline test**
- **Spring 2021 will be the earliest time for us to back for beamline test, experiment to be combined:**

1. **Argonne MCP-PMT test**
2. **Gen II LAPPD test**
3. **mRICH module with Gen II LAPPD as photosensor test**

# HIGH RATE EVALUATION OF LAPPD FOR SOLID



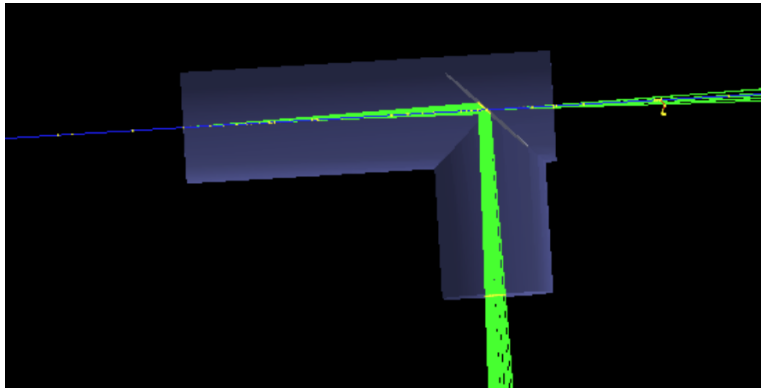




Small Cherenkov telescope installed in Hall C at JLab

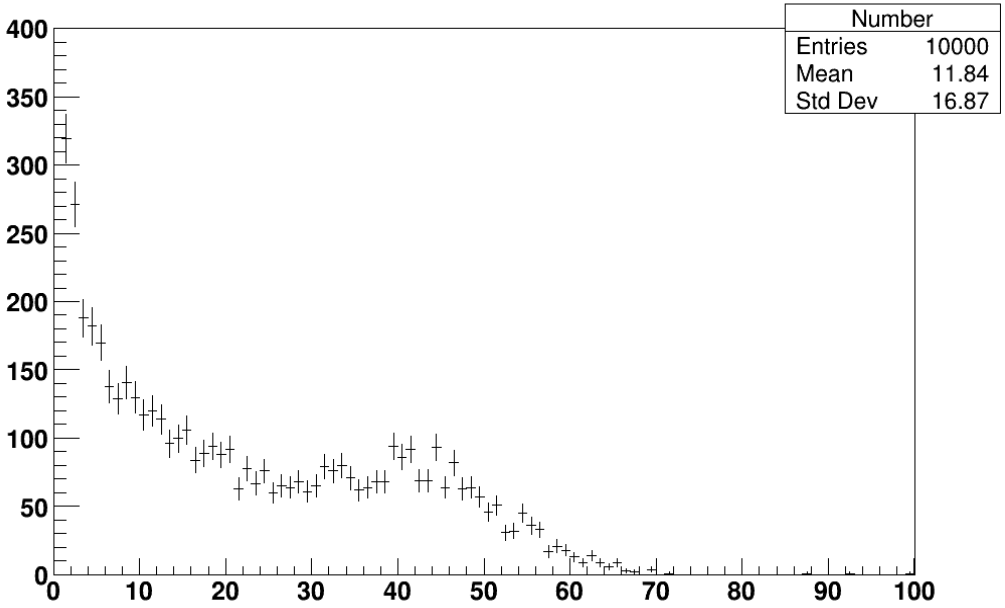
- 8.1 GeV electron beam on $LH_2$ target
- Setup is 4.8 meters away facing target
- Scintillators and calorimeters as trigger, $CO_2$ as gaseous radiator
- Accommodate 2x2 MaPMT array and LAPPD
- High rate background open environment

# COMPUTER SIMULATION

## Simple Cherenkov simulation using GEANT4 (35% QE used).



Number of Cherenkov photoelectrons




## Mathematical calculation

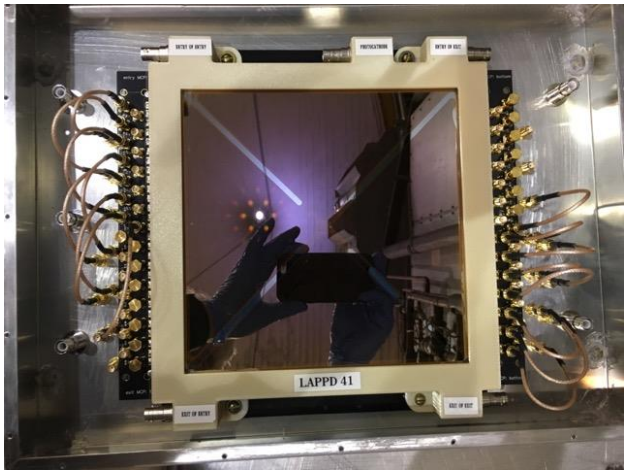
| Gas | $\theta_c^{max}$ ($\beta$~1) | Outer Diameter | Inner Diameter | Nphoton (200-500 nm) | Nphoton (300-500 nm) | H8500 | | H12700 | | Gen-I LAPPD | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | QE (400 nm) | Npe | QE (400 nm) | Npe | QE (400 nm) | Npe |
| $CO_2$ | 1.7° | 7.72 cm | 1.18 cm | 135 | 60 | 28% | 30.2* | 35% | 37.8* | 7.3% | 10.8* |

*Considering QE distribution (200-500 nm), Npe = Nphoton × MaxQE × 80%

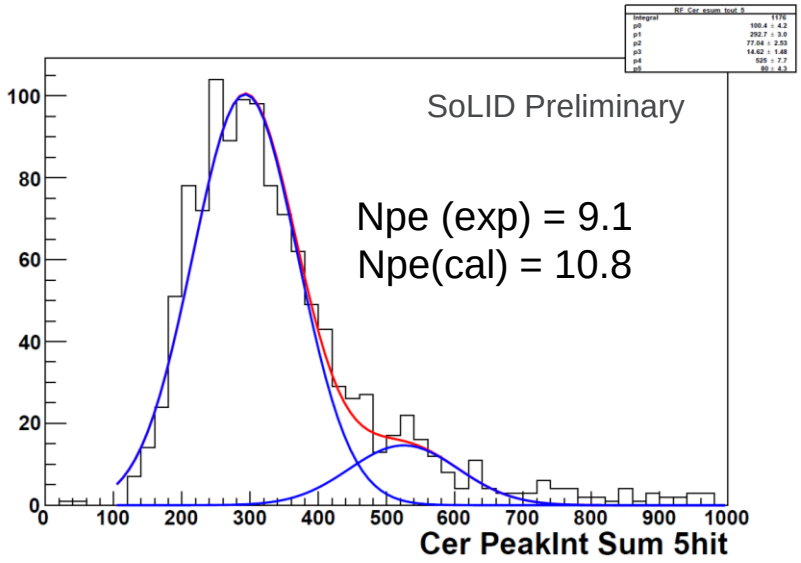
# Cherenkov Test of LAPPD at JLab Hall C

## Received LAPPD#41: Gen I

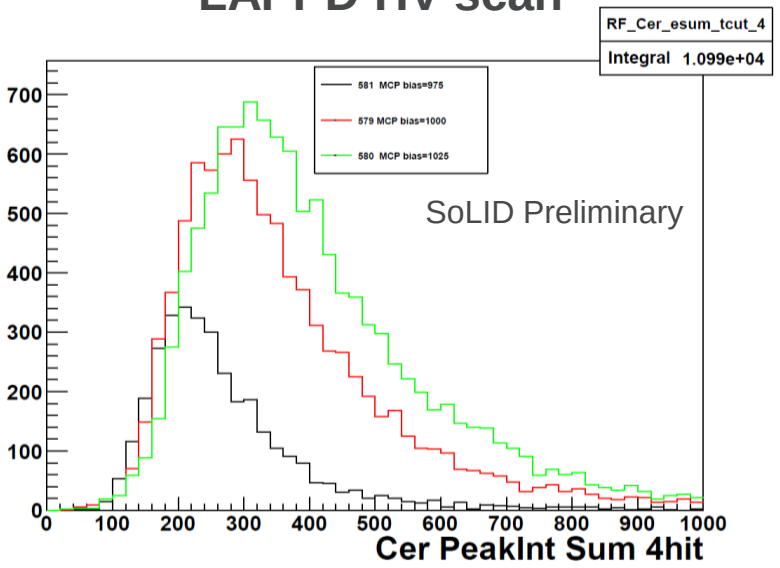
| | |
|---|---|
| Window material | Fused silica |
| Readout anode | Inside stripline |
| Quantum Efficiency | Mean: 7.3%, Maximum: 11% |
| Gain | $5.4\times10^6$ with MCPs @ 975V |
| Time resolution | 56 ps |




## Results



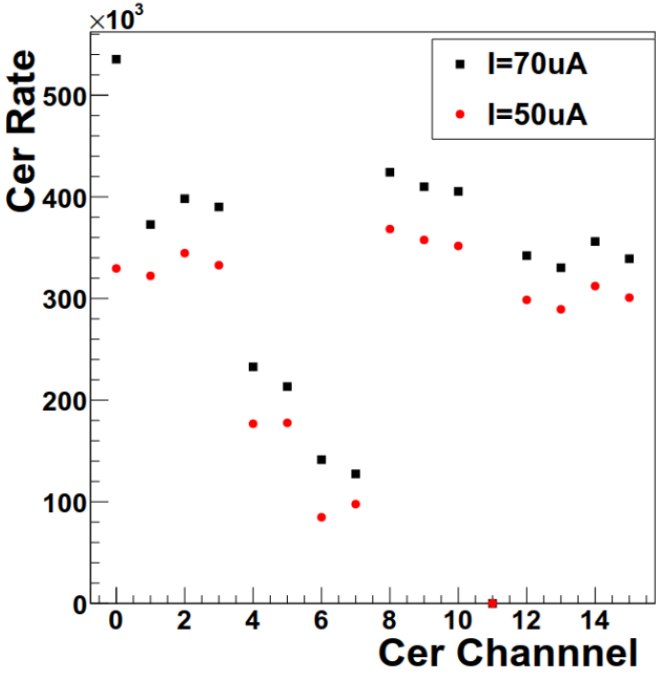

LAPPD HV scan




JLab Hall C test shows that the LAPPD might work in the Hall C environment to separate Cherenkov events (needs further results check with experts), but it is clear that **the stripline readout, low QE made our results inconclusive.**

# EXPERIMENT ELECTRONICS RATE ESTIMATION

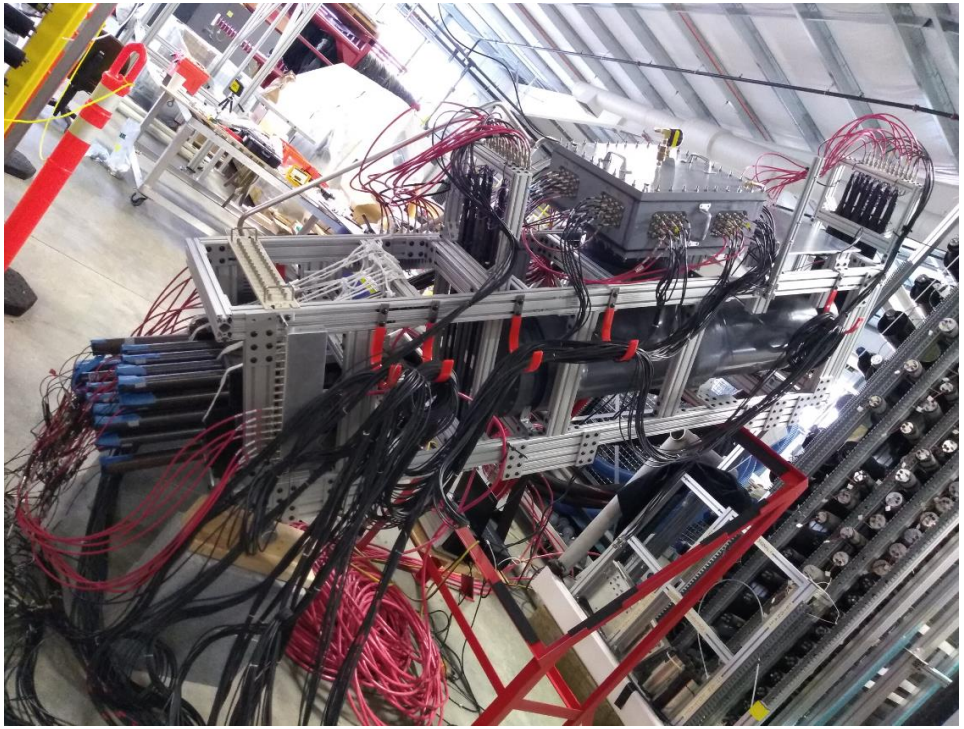
Rate estimation for each channel




The event rate for each quadrant is ~400 kHz, that is ~ 1.5 MHz rate per MaPMT, or 60 kHz/cm$^2$.

Rate for each channel was estimated by counting the number of event with firing channel number > 0 .
FADC electronics handles this rate good. LAPPD works in the current rate environment.

# SOLID PRE R&D CHERENKOV PROTOTYPE



Gen II LAPPD with 25x25 mm pixel pads for Cherenkov counter

LAPPD was delivered at JLab before the COVID-19 pandemic.