LAPPD^{TM} / MCP-PMT

Goal:

- Adapt LAPPD^{TM} to EIC requirements (magnetic fields, pixelated readout)

FY 18 Report:

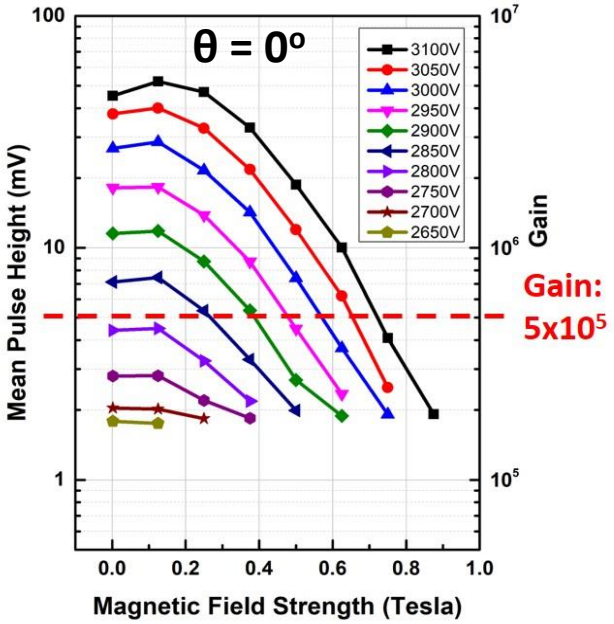
- 6 cm MCP-PMT characterized in details in magnetic fields
- 20 cm LAPPD characterized in magnetic fields
- Pixelated readout baseline tested in beamline

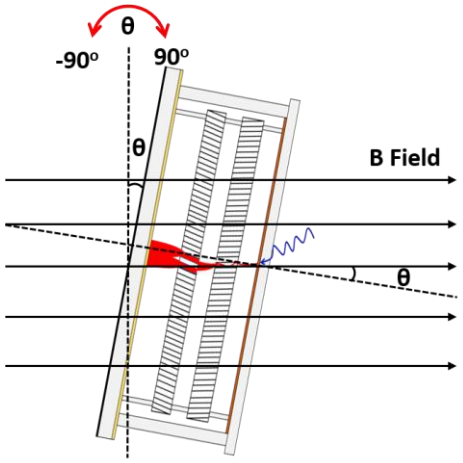
FY 19 Proposed tasks:

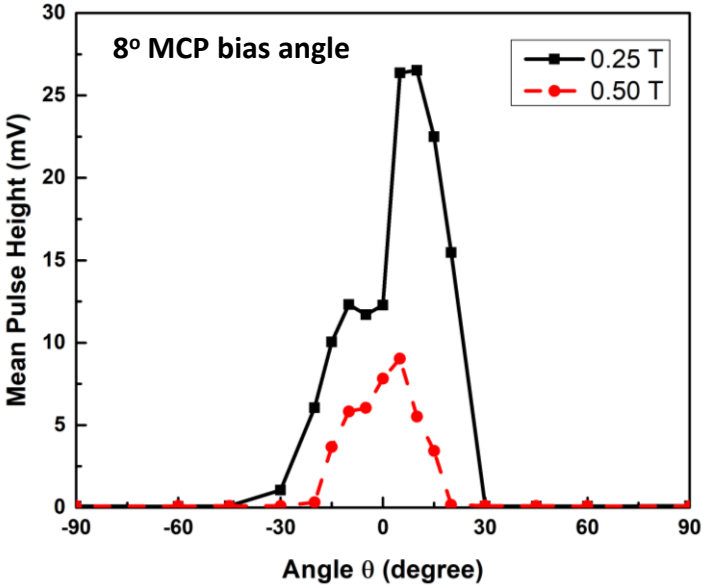
- MCP-PMT after pulse study to better understand the ion feedback for LAPPD
- Improvement of RMS timing by modifying the bias voltages
- Produce a detector with 5μm pore size MCP and minimum spacing to further improve magnetic-field performance and fast timing (possibly <10 ps)
- Test of MCP-PMT/LAPPD with different configurations (smaller pore size and reduced spacing) in lab and in a magnetic fields
- Demonstration of capacitive-coupling pixelated readout through ALD coated glass

LAPPDs – Characteristics (6 cm ones) in magnetic fields

Independently biased design

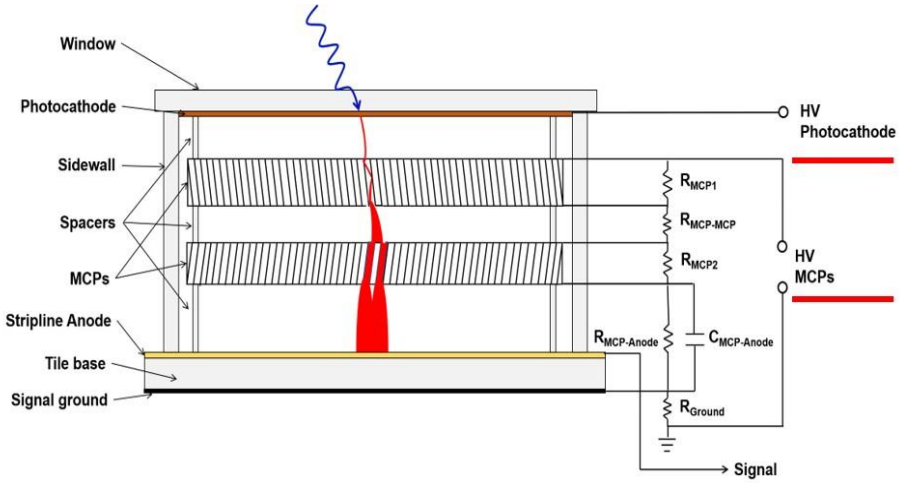


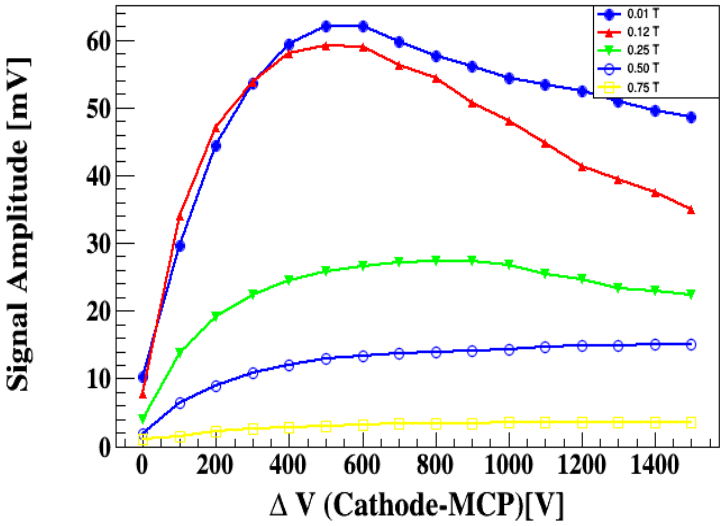




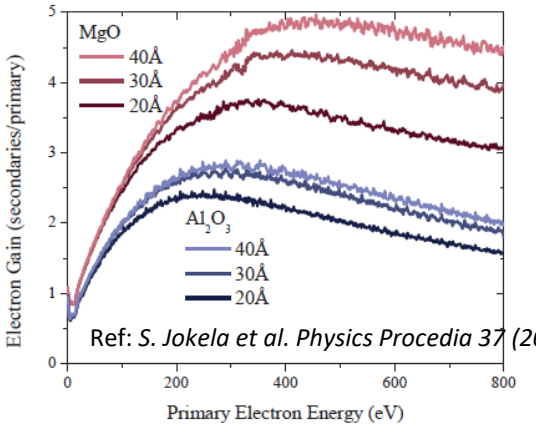
- MCP-PMT characteristics in dependence of: Magnetic field strength, HV, tilt angle, and gap voltages were all tested in magnetic fields
- Baseline tests show for a device with Gain > $5x10^5$, Magnetic Field tolerance is 0.7 T
- The MCP-PMT performance in magnetic field is clearly angle related, due to the 8^o MCP bias angle, the highest gain is obtained around 8^o.
- Notice the two peaks around $\pm 8^o$, indicating the effect from upper and lower MCP bias angles are different. Simulation is undergoing with collaborators to explain the different effect.

LAPPDs – Characteristics (6 cm ones) in magnetic fields





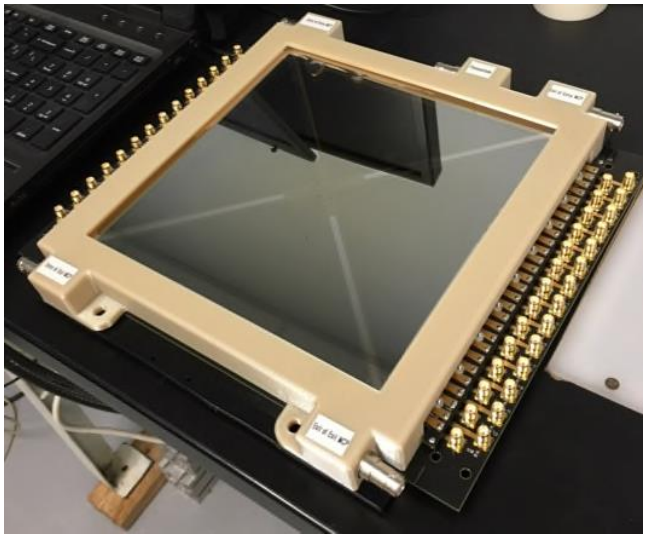
- HV(MCPs) was fixed, varies the HV of first gap ΔHV(photocathode–top MCP) by adjusting HV (Cathode).
- Gain increases as ΔHV increases to a maximum then decreases, this can be explained by the MCP gain dependence of primary electron energy.



MCP-PMTs design/operation in magnetic fields resulted in a **SBIR phase 1 award** (Incomand ANL, $150k for 9 months) to develop magnetic field tolerant LAPPD^{TM} (> 1.5 Tesla)

LAPPDs – Characteristics (20 cm) in magnetic fields

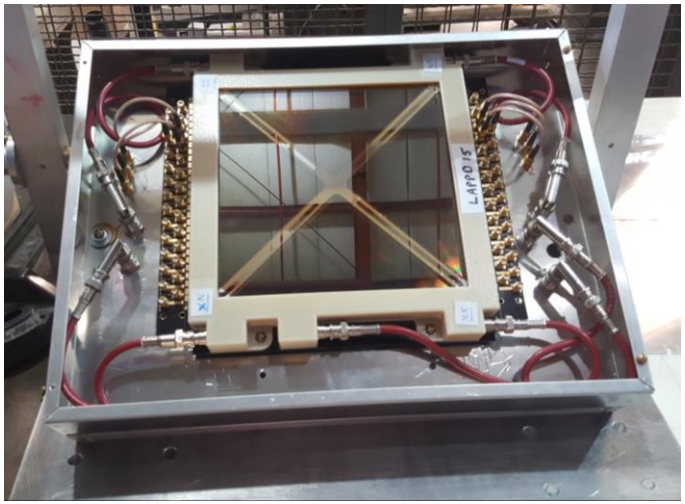
Commercial LAPPD™ delivered and installed at ANL B field facility



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

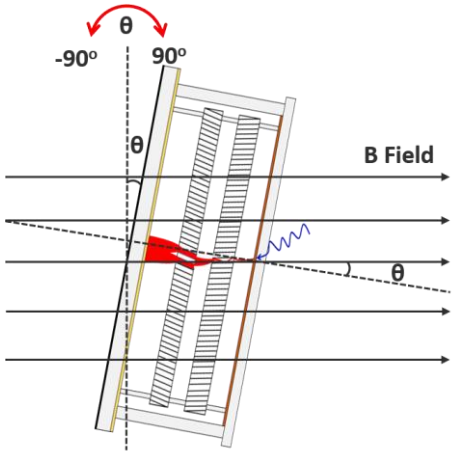
Pore size: 20 µm

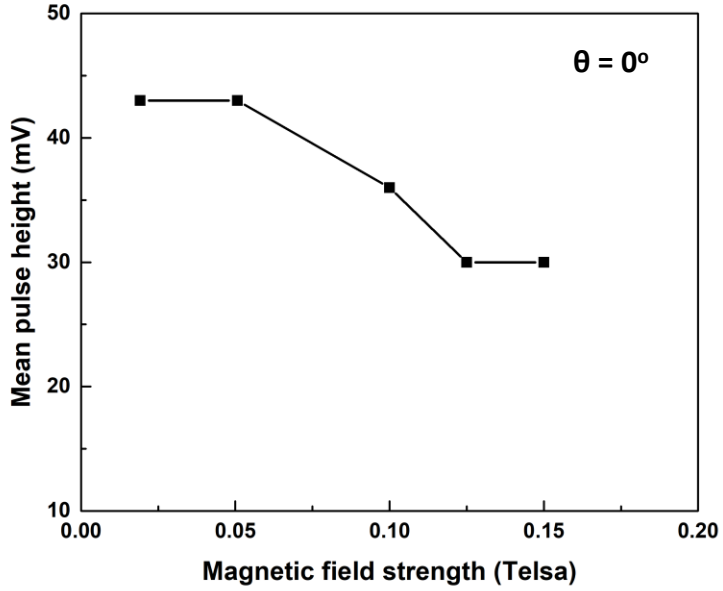
Activation area: 195 mm x 195 mm

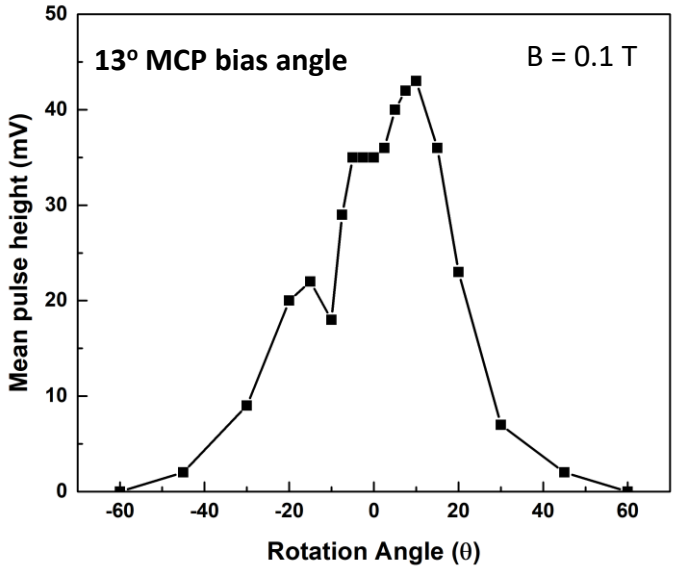


LAPPDs – Characteristics (20 cm) in magnetic fields

Due to the magnetic sensitive components (Kovar is used as shims in the current LAPPD^{TM}), we can not go to high magnet field test, a new LAPPD^{TM} with non-magnet components is scheduled to be fabricated and tested in Sep. 2018. The results here demonstrate the capability of the facility for 20 cm LAPPD^{TM}.



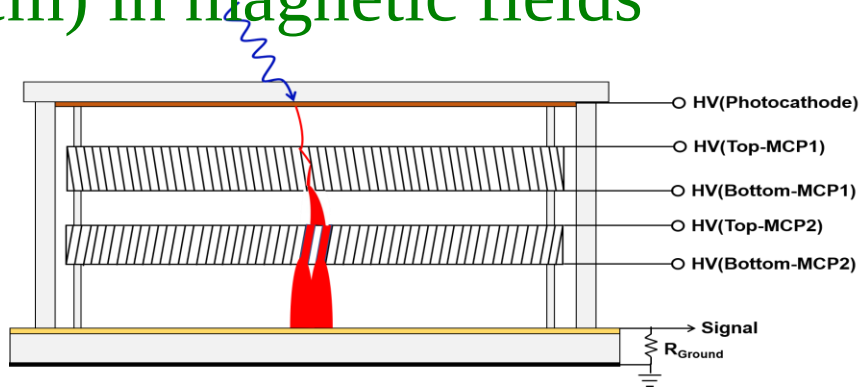


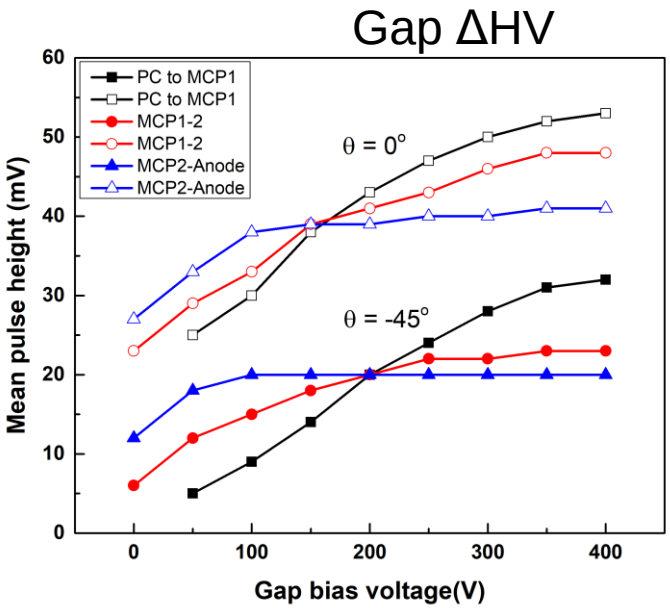


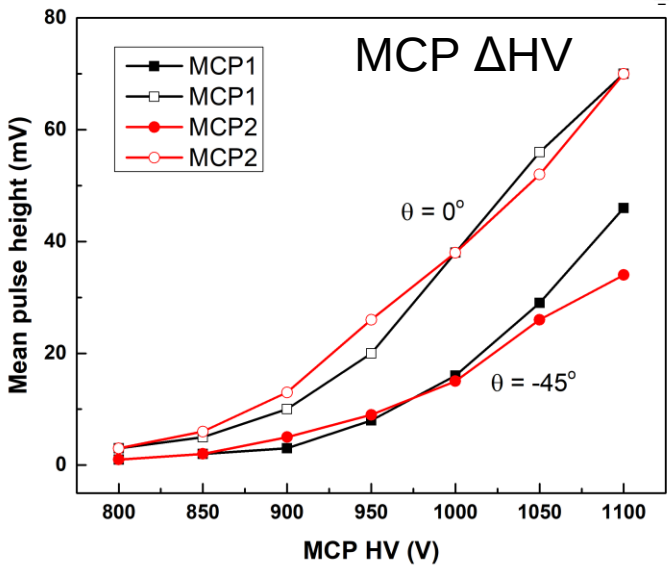
- Similar behavior as 6 cm MCP-PMT: gain decrease as the magnetic field increases
- Two local gain maximum corresponding to the 13° bias angle of MCPs used in LAPPD^{TM}

LAPPDs – Characteristics (20 cm) in magnetic fields

Gap and MCP ΔHV dependence



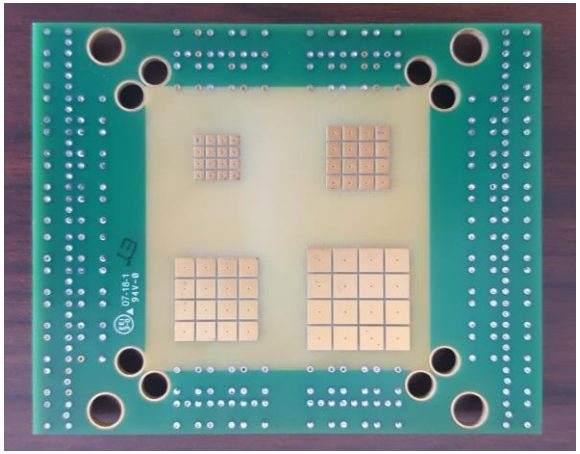




- HV applied to all three gaps affects the gain of the LAPPD
- HV between the photocathode and MCP1 gap has the greatest slope, indicating the strongest effect
- LAPPD gain becomes a constant with the MCP2-Anode bias HV above a threshold
- HV applied to MCPs seems to have NO preference, equally affects the LAPPD gain

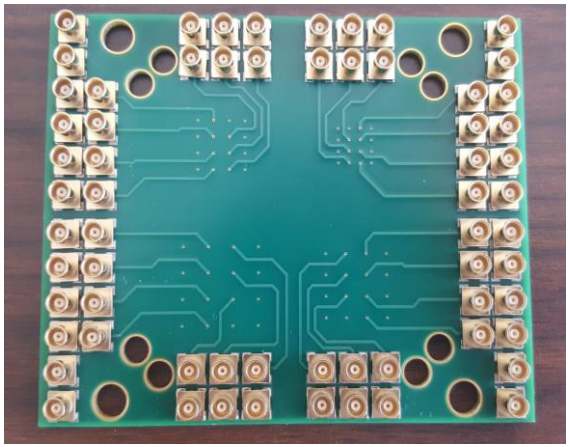
LAPPDs – Pixelated readout

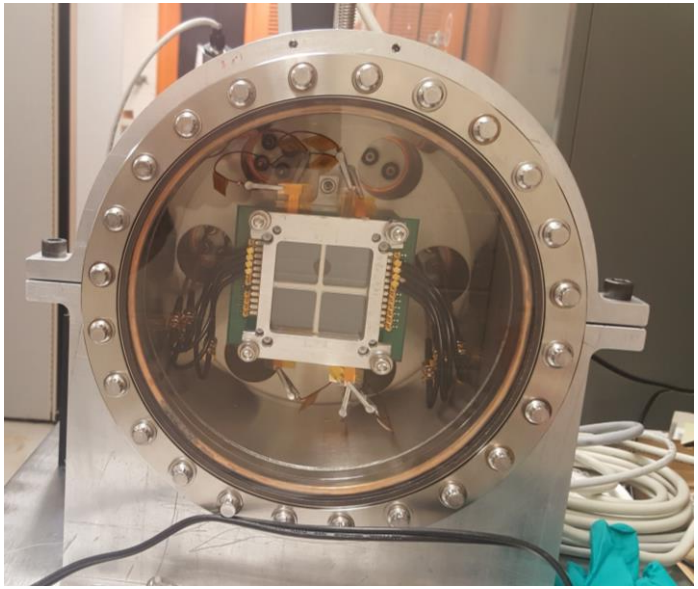
Demountable chamber installed on the stage of Fermilab Test Beam Facility MT6.2C

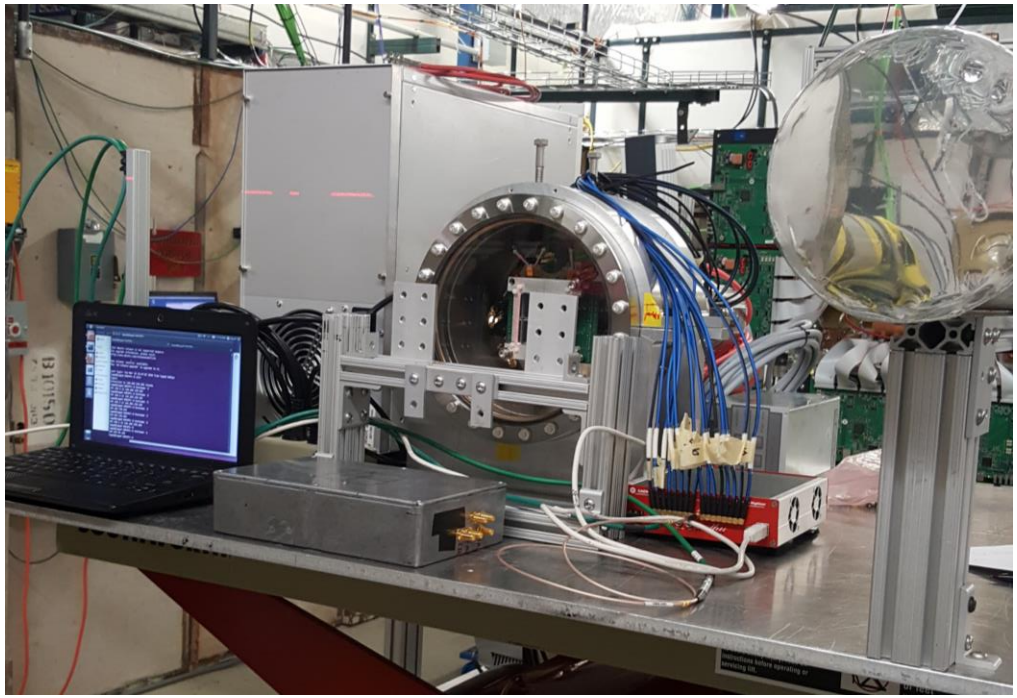


Pad sizes:
2mm x 2mm
3mm x 3mm
4mm x 4mm
5mm x 5mm

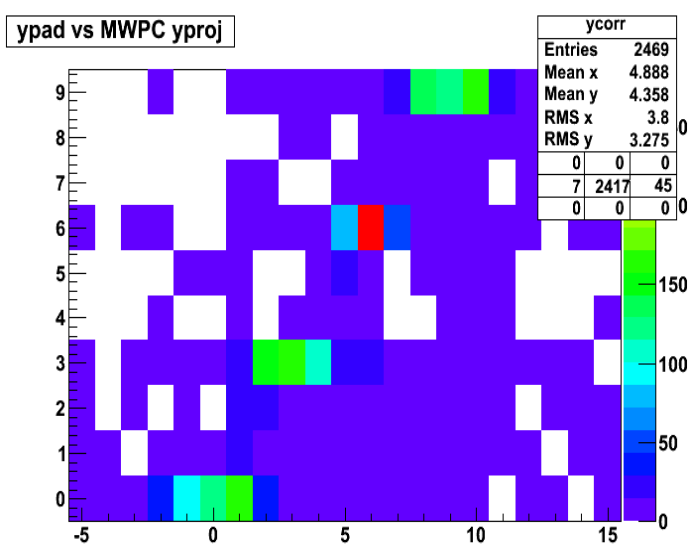
Spacing between pads:
0.5 mm

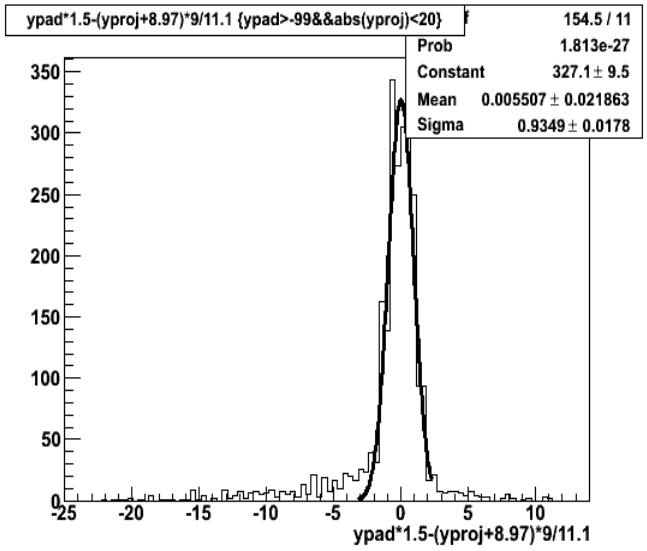






LAPPDs – Pixelated readout





Example correlation between the y-axis of a 3 mm x 3 mm pad and the MWPC projection

Pixel size	2 mm x 2 mm	3 mm x 3 mm	4 mm x 4 mm
σ (x)	-	1.01 mm	1.11 mm
σ (y)	0.73 mm	0.93 mm	1.43 mm
σ (expected)	0.6 mm	0.9 mm	1.2 mm

- Expected position resolution σ (expected) = pixel size/√12
- Beamline experiment preliminary results show that experimental position resolutions are close to the expected position resolutions

LAPPDs – Conclusion

- LAPPD/MCP-PMTs were characterized in details in magnetic fields
- Further development of magnetic field tolerant LAPPD progresses well
- Pixelated readout development for LAPPD was started, will be the next focus
- LAPPD R&D, DIRC R&D, electronics R&D are well aligned with each other for demonstration of DIRC prototype with LAPPD^{TM} sensors