LAPPD Characterization

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Figure 1 – Schematic design of the LAPPD: Left, exploded view: A) Fused silica window with PC on inside surface, B) Chevron pair of ALD-GCA-MCPs, C) three spacers, D) Anode showing 28 strip lines passing under sidewalls. Top right: consolidated view, Bottom right: expanded view of strip line anodes passing under sidewalls.
Incom LAPPD #22
Overview

- Characterized single photon response with fast laser across front face
  - Gain
  - Position resolution
  - Transit time spread
  - Relative detection efficiency
- Explored imaging in multiphoton regime in CHESS
  - Qualitative behavior with variable intensity LED illuminating masks
  - Cherenkov rings from cosmic muons in CHESS
2D Characterization Setup

- Photons from fast fiber coupled laser
- Beam spot generated with aperture
  - Measured spot size 0.6mm
- Aperture and fiber mounted to automated translation stages
- Digitizing results with 8ch oscilloscope
  - Both ends of 4 strips per subscan
- Scanned across front face in 2D
  - Many subscans to cover front face
  - 2mm vertical steps, 7.5mm horizontal steps
- Reporting figures of merit at each point
Detection Efficiency

- Ratio of events with detected hits to all events at each point
  - Maximum normalized to 1
- Significant variation across front face
Transit Time Spread

- Width of average of left and right hit time of nearest strip relative to laser time
- Mode around 70 ps
Horizontal Resolution

- Width of difference of left and right hit time of nearest strip
  - Mode around 30ps
- Must determine signal speed on strip to convert to position...
Horizontal Resolution (signal speed)

- Fitting for propagation speed of each horizontal scan
- Some strip to strip variation
- Mode 11.5 ps/mm → 2.5mm horizontal position resolution
Vertical Resolution

- Charge sharing between strips allows vertical position reconstruction
- Use charge weighted average of strip positions as hit position
- Performs well near strip... few mm resolution
MCP Gain

- Sum charge from all strips, extract mean charge for single photons
- Significant variation across face
- Mode around $5 \times 10^6$
Qualitative Imaging

- Use a pulsed LED to dimly illuminate a mask
- Use hit reconstruction to build a statistical image
  - Time deltas for horizontal position, strip position for vertical
- Explore what intensity causes reconstruction to break down
- First, calibrate relative offsets of strips with a vertical mask...
Vertical mask calibration

- Bad signals (no pulses)
- Spacer blocks hits
Ring mask
LBL Logo mask
Varying photon intensity

Avg 0.26 hits/event
Varying photon intensity

Avg 0.93 hits/event

Histogram showing the distribution of hits per event with a horizontal position range of 0 to 80 mm.
Varying photon intensity

Avg 2.13 hits/event
Multi-PE issues: crosstalk
Ring imaging in CHESS

- CHEreikov and Scintillation Separation
  - Imaging Cherenkov rings from cosmic muons
  - Uses geometry to disentangle timing of both signals
  - Characterizing (water-based) liquid scintillators

- Basic idea: replace PMT array with LAPPD
  - Try to image the Cherenkov rings
CHESS muon event
Reconstructing muon data...

- Reconstructed 20 events with single PE reconstruction algorithm
  - No clear ring visible
  - Many PE around same time fails
- Mostly reconstructing like crosstalk/noise
  - Partially because there is a lot of cross talk
  - Partially because overlapping hits (in time) tend to reconstruct to middle of strip
- Potential application for multi-PE reconstruction algorithms in LAPPDs
  - Discussion with ANNIE ongoing
Conclusions

- Significant variation in behavior across sensitive area
  - Most quantitative results restricted to circular region
- Single Photon Response
  - Transit time spread of ~70 ps
  - Horizontal resolution of ~30 ps
    - Propagation speed of ~11.5 ps/mm → ~2.5 mm
  - Vertical resolution of few mm
  - Nominal gain of $5 \times 10^6$ (highly position dependent)
- Multiphoton behavior is very complicated
  - Easy to identify single/few (2-5) hits
  - Very difficult to disentangle many (10+) hits coincident in time
  - Reconstructing muon Cherenkov rings in CHESS will require some special multi-PE algorithm (if possible)