Multianode Photomultiplier Tube Studies for Imaging Applications

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Multianode Photomultiplier Tubes (MAPMTs):
- Design, crosstalk
- Hamamatsu H8500, H9500 and H7546 MAPMTs
- Applications

CLAS12 RICH Tests:
- Setup, method, Observations

Sub-millimetre Precision Studies:
- Homogeneity of MAPMT responses and crosstalk patterns
- H8500 MAPMT dynode 12 studies

Summary:
- Overview of findings
Multianode Photomultiplier Tubes (MAPMTs)

Position Sensitive Readout

**Crosstalk mechanisms** (which may compromise position sensitivity):

- Optical
- Charge spill over
- Electro-magnetic

Modified from: http://www.hamamatsu.com
<table>
<thead>
<tr>
<th>MAPMT</th>
<th>Active Area (mm)</th>
<th>Number Of Pixels</th>
<th>Pixel Size (mm)</th>
<th>Packing Fraction (%)</th>
<th>Photocathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>H8500</td>
<td>49 x 49</td>
<td>64 (8 x 8)</td>
<td>5.8 x 5.8</td>
<td>89</td>
<td>Bialkali</td>
</tr>
<tr>
<td>H9500</td>
<td>49 x 49</td>
<td>256 (16 x 16)</td>
<td>2.8 x 2.8</td>
<td>89</td>
<td>Bialkali</td>
</tr>
<tr>
<td>H7546</td>
<td>18.1 x 18.1</td>
<td>64 (8 x 8)</td>
<td>2.0 x 2.0</td>
<td>78</td>
<td>Super Bialkali</td>
</tr>
</tbody>
</table>

[Hamamatsu H8500, H9500 and H7546 MAPMTs](http://www.hamamatsu.com)
Applications

- Particle identification detectors, e.g. RICH counters (CLAS12 Proximity RICH)

- Medical imaging devices, e.g. SPECT, PET, radionuclide imaging

Applications – CLAS12 RICH

Requirements:

• Efficient single photon detection capabilities
• Pixel size < 1cm x 1cm
• High packing fraction and minimal deadspace

Tested MAPMTs at Glasgow:

• H8500
• H7546 plus light catcher
CLAS12 Tests - Experimental Setup

X-Y Stage

Laser $\lambda = 633\text{nm}$

Neutral Density Filters

MAPMT Under Test

Light-tight box

High Voltage

Ready Trigger

Trigger Out

Gate Generator

QDC Modules

Computer

Data

Signals
H8500 Single Photoelectron Scans, 1mm Beam Diameter

- **Pixel 53 Response, HV -1000V, NDF 4.5**
  - Noise
  - Single photoelectron

- **H8500 Global Efficiency Map: -1000V, NDF 4.5**

- **Pixel 45 Efficiency Map: -1000V, NDF 4.5**

- **Pixel 14 Efficiency Map: -1000V, NDF 4.5**

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H8500 Single Photoelectron Scans, 1mm Beam Diameter, 0.5mm Steps
Studying the fine structures of the MAPMTs...
Sub-millimetre Precision Laser Scans

- **H8500** – 11 dynode chains/pixel
- **H9500** – 6 dynode chains/pixel
- **H7546** – 2 dynode chains/pixel

- **0.1mm** laser beam diameter used to scan such sub-structures at a sub-millimetre precision
H9500 Pixel Responses

- 0.04mm step scans of single pixel
- Several light levels
- Segmentation of dynode chains
- Effects begin to wash out, but still present, with increasing light level

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H9500 Pixel Responses

- 0.04mm step scans of single pixel
- Several light levels
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H9500 Pixel Responses

- 0.04mm step scans of single pixel
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- Segmentation of dynode chains
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H9500 Crosstalk

- Crosstalk patterns show dependencies upon dynode mesh arrangement.
- Constructional features are further revealed with increasing photon levels.

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H8500 Pixel Responses

- 0.04mm step scans of single pixel
- Several light levels
- Segmentation of dynode chains
- Effects begin to wash out, but still present, with increasing light level

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H8500 Pixel Responses

- 0.04mm step scans of single pixel
- Several light levels
- Segmentation of dynode chains
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• 0.04mm step scans of single pixel
• Several light levels
• Segmentation of dynode chains
• Effects begin to wash out, but still present, with increasing light level
H8500 Crosstalk

Single Photoelectron

20 Photoelectrons

260 Photoelectrons

X-slice

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H8500 Crosstalk

Crosstalk from constructional support structures

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• Charge and timing of dynode 12 (common last dynode) signals included into setup
• Useful for self-triggering
Timing and charge spectra of H8500 common last dynode signals:

Centre pitch scans show efficiencies, gains and timing mimic relative differences between pixels.

Average $\sigma_1$ time resolutions for:
- 20 photoelectrons = 67.5ps
- Single photoelectron = 154.4ps
H8500 Common Last Dynode (D12) Studies

Single Photoelectron, Efficiency, Single Pixel
0.06mm Steps

20 Photoelectrons, Efficiency, Single Pixel
0.05mm Steps

Single Photoelectron, Timing
0.06mm Steps

20 Photoelectrons, Timing
0.05mm Steps
H7546 Pixel Responses

- 0.04mm step scans
- Several light levels
- Different dynode arrangement from H8500 and H9500 visible
- At high light levels, central focussing electrode becomes highest gain region

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H7546 Pixel Responses

Single Photoelectron

20 Photoelectrons

300 Photoelectrons

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H7546 Crosstalk

Single Photoelectron

20 Photoelectrons

300 Photoelectrons

300 Photoelectrons
Position sensitive MAPMTs:
- Enhancing performance of imaging detectors
- Detection/surface homogeneity and crosstalk studies vital

Sub-millimetre precision laser scans of H8500, H9500 and H7546:
- Reveal response and crosstalk pattern dependencies upon dynode arrangements and mesh construction
- Observed at several light intensities
- Crosstalk patterns become stronger at larger light intensities (as expected)

H8500 dynode 12 studies:
- Common last dynode signals are also affected by MAPMT construction

Future tests:
- Dynode 12 studies for the H9500 and H7546
- Sub-millimetre scans for MCPPMTs and SiPMs
QUESTIONS?