Multianode Photomultiplier Tube Studies for Imaging Applications

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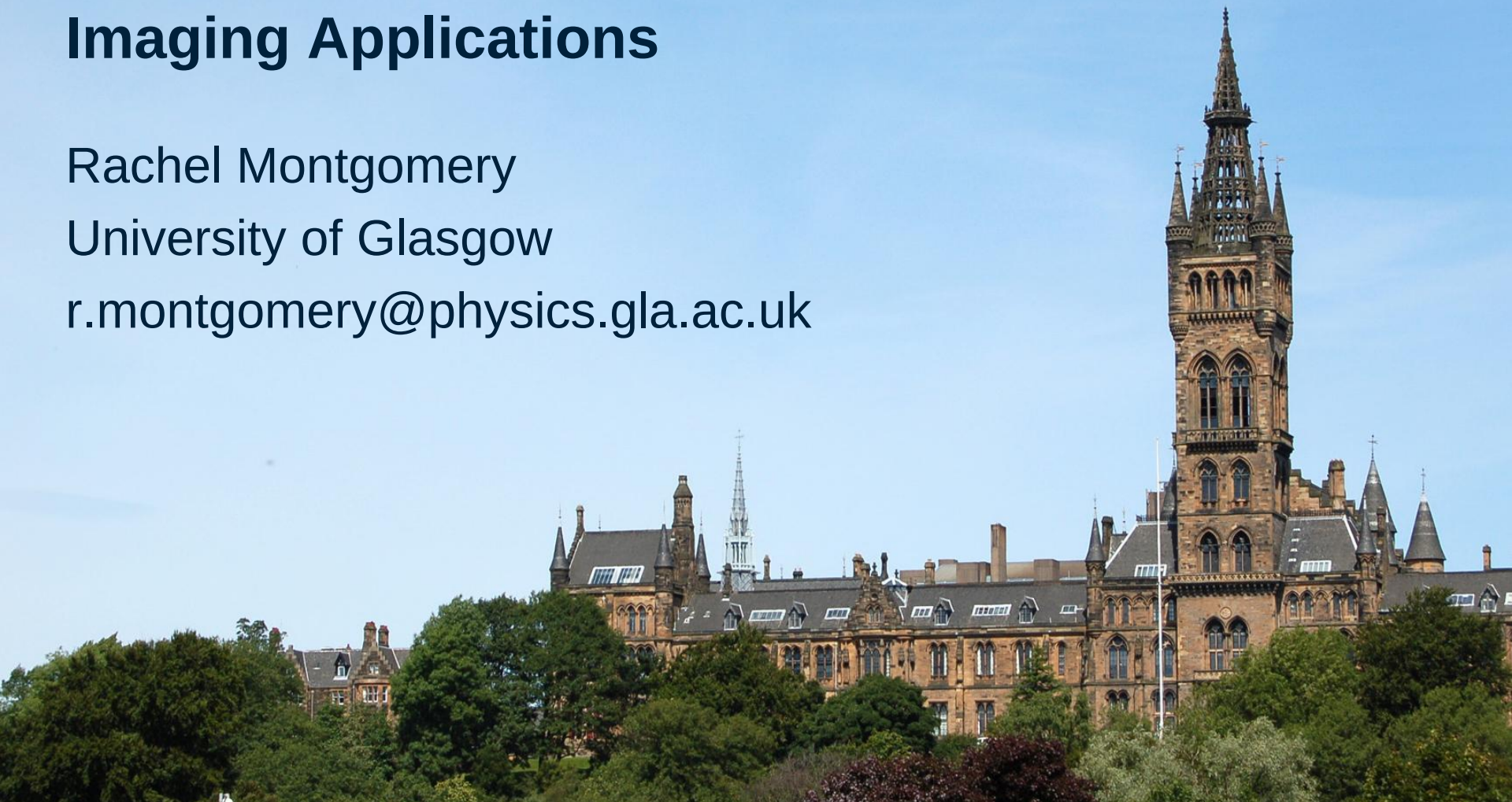

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Outline

Multianode Photomultiplier Tubes (MAPMTs):

- Design, crosstalk, applications
- Hamamatsu H8500 and H9500 MAPMTs

Experimental Setup:

- Laser scan method

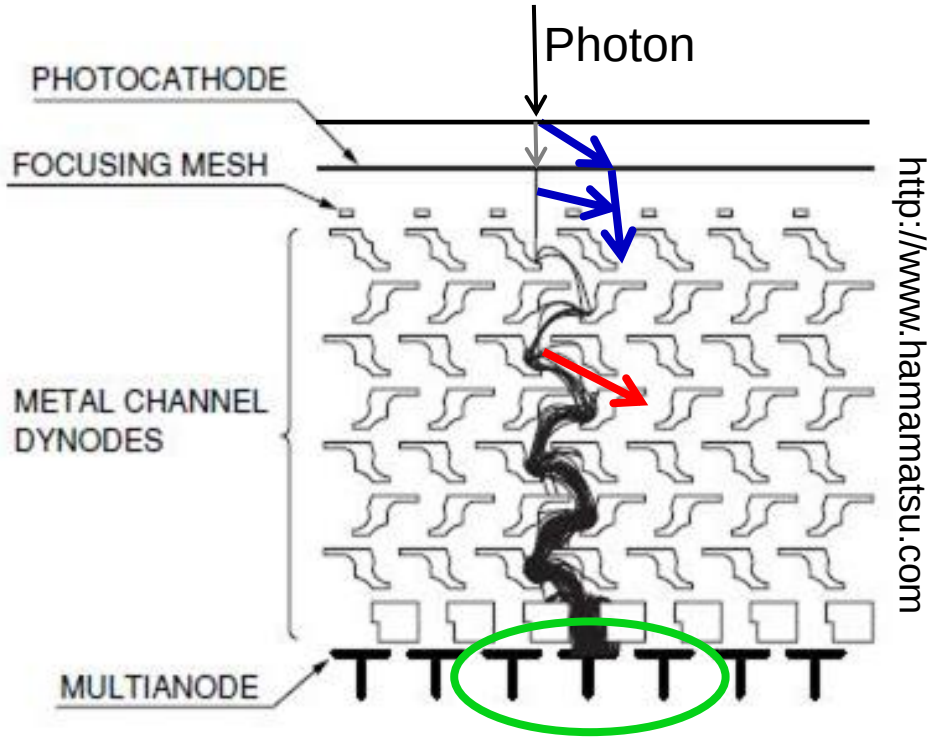
Scan Results:

- H8500 single photon scans
- H8500 and H9500 multiphoton scans

Summary:

- Overview of findings

Multianode Photomultiplier Tubes (MAPMTs)



Crosstalk mechanisms:

- Optical
- Charge spill over
- Electro - magnetic

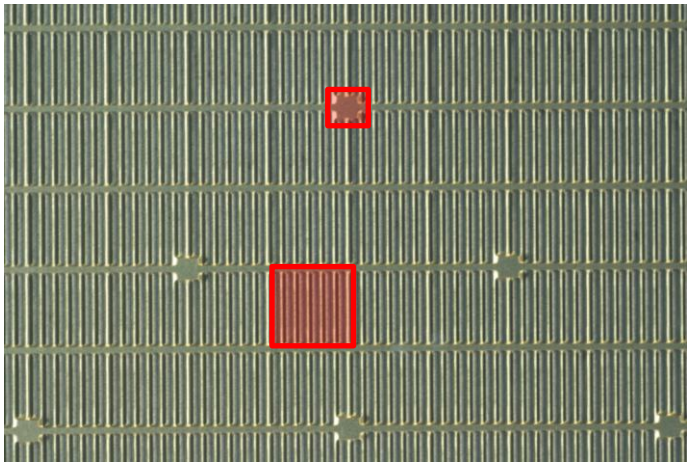
Applications

- Particle identification detectors, e.g. RICH counters
- Medical imaging devices, e.g. SPECT, PET

Hamamatsu H8500 and H9500 MAPMTs

MAPMT	Active Area (mm)	Number Of Pixels	Pixel Size (mm)	Packing Fraction (%)
H8500	49 x 49	64 (8 x 8 matrix)	5.8 x 5.8	89
H9500	49 x 49	256 (16 x 16 matrix)	2.8 x 2.8	89

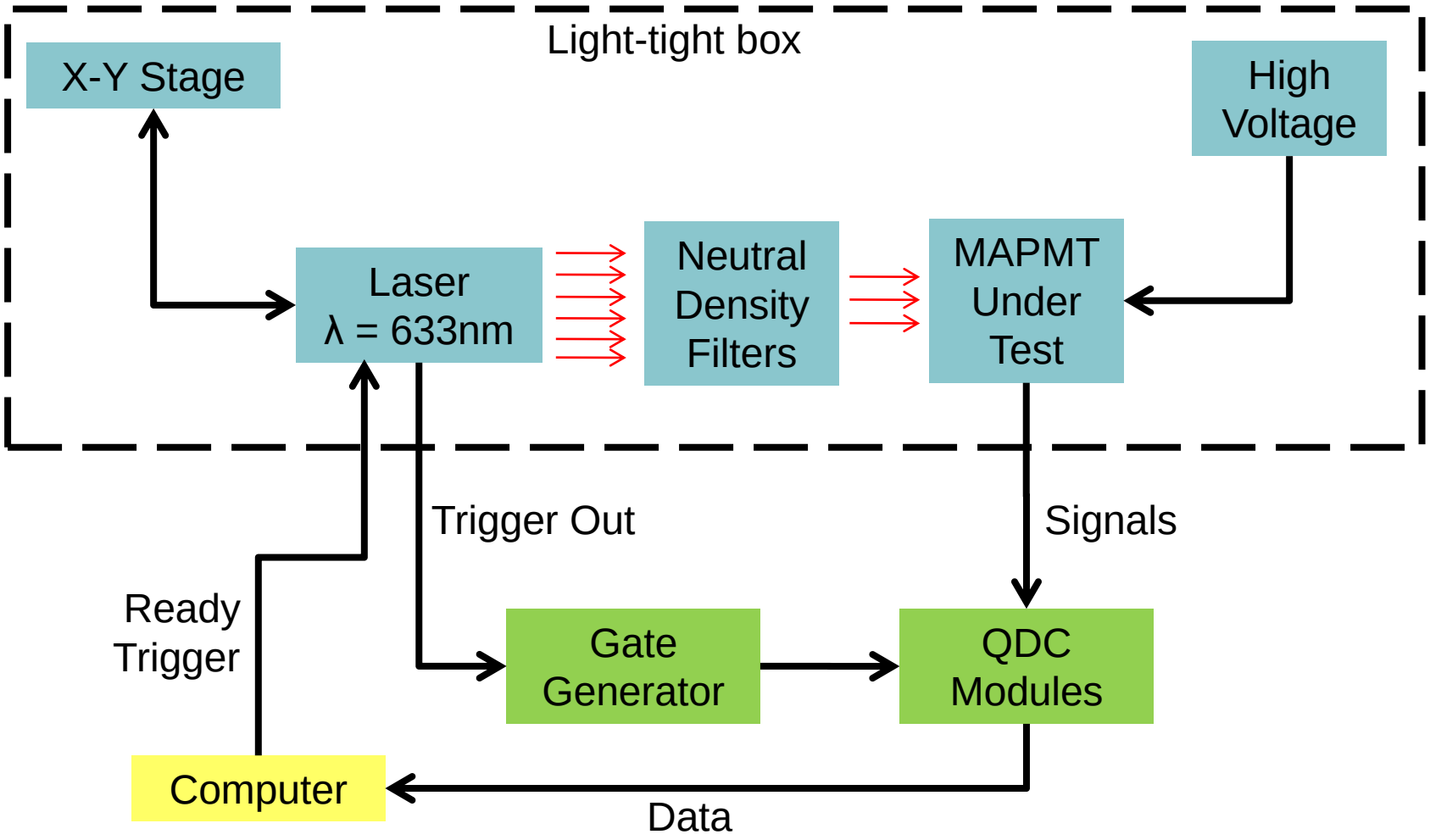
H8500



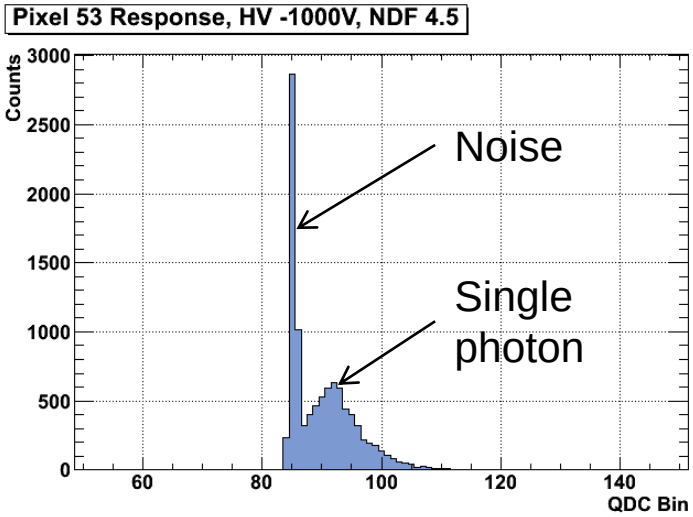
Metal channel dynodes

H9500

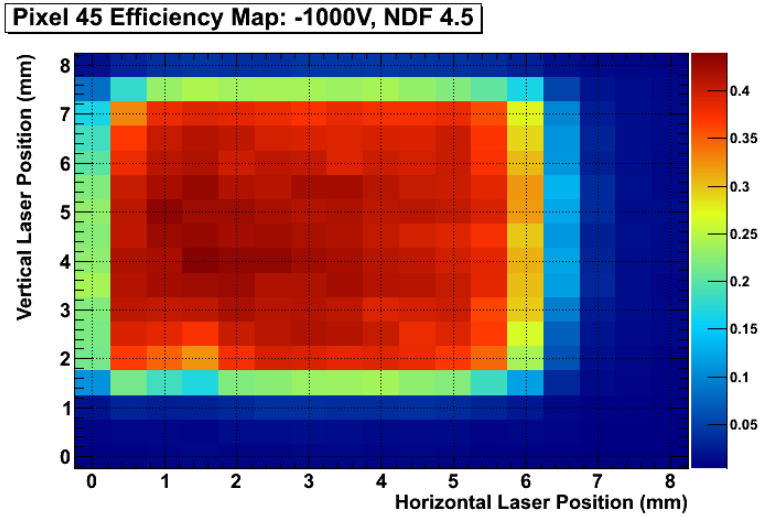
Experimental Setup and Method

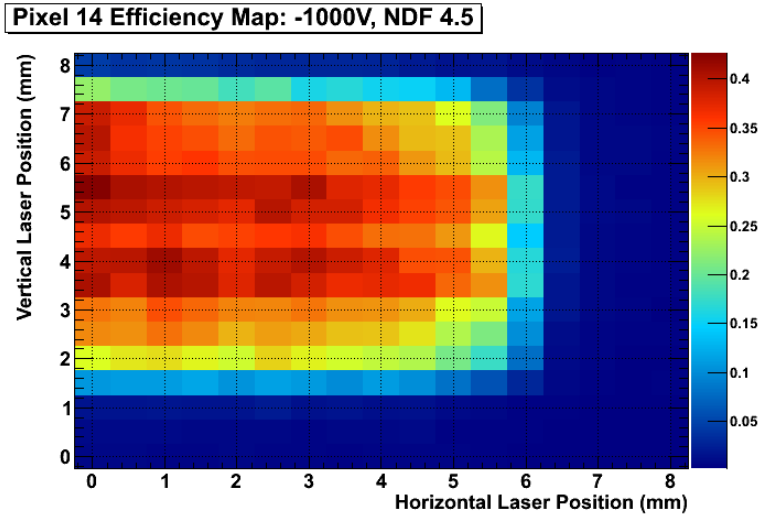


H8500 Single Photon Scans, 1mm laser beam diameter

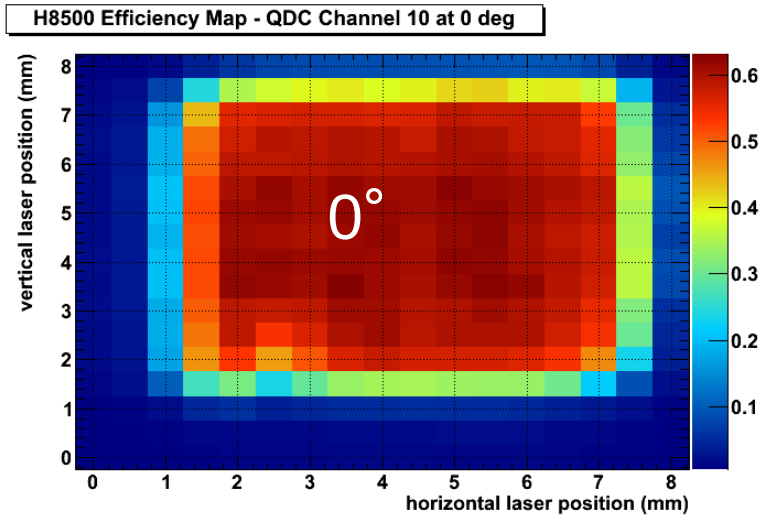


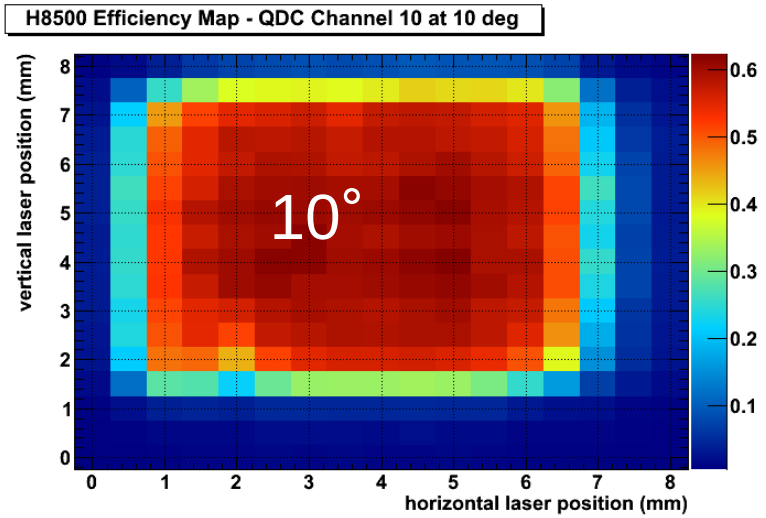
- Detection efficiencies for CLAS12 RICH prototype
- Pixel pitch scans showed homogenous efficiency across detector

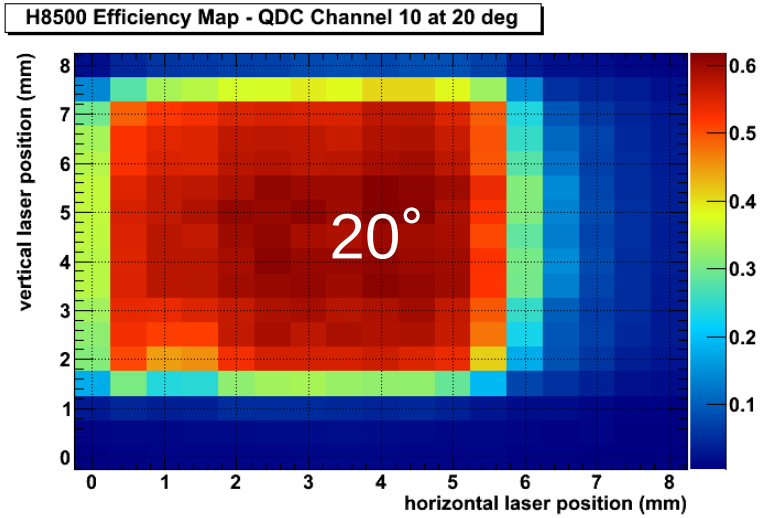


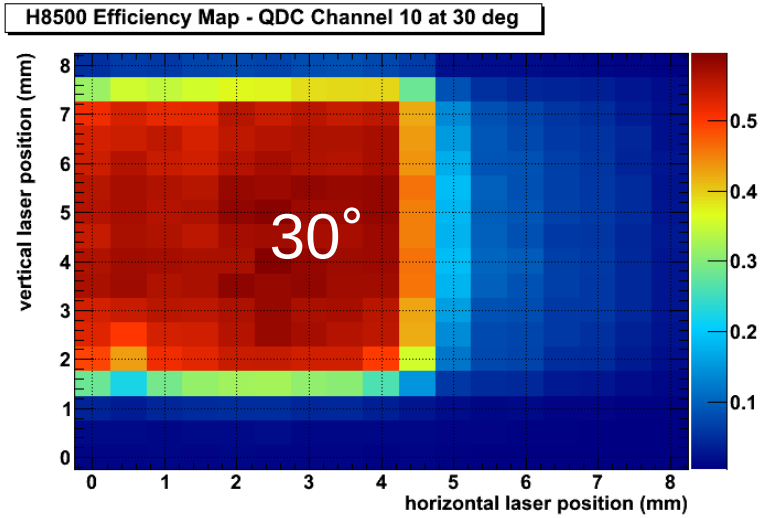


H8500 Single Photon Scans, 1mm laser beam diameter



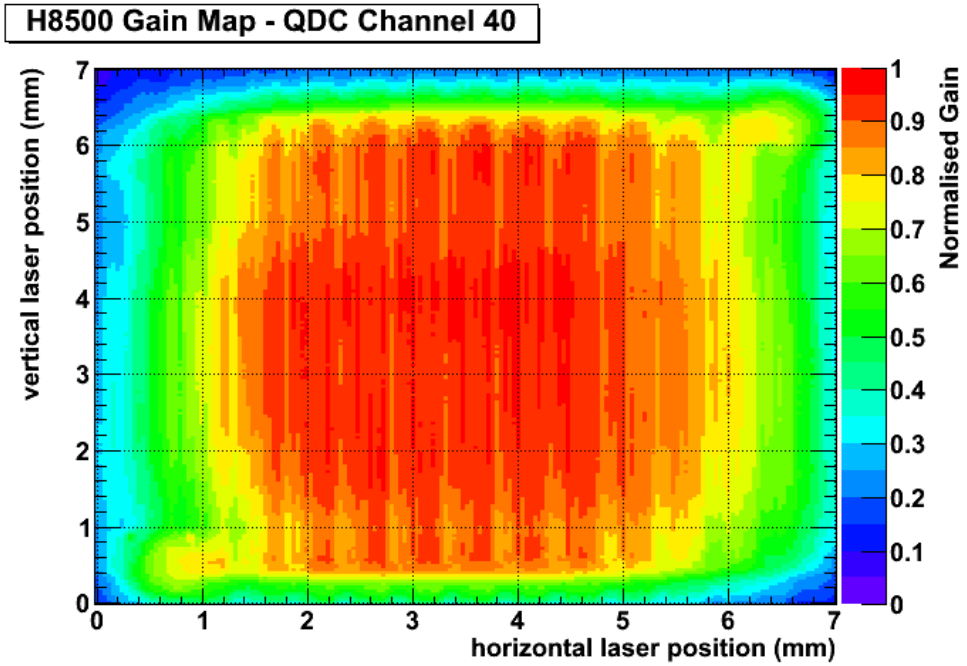




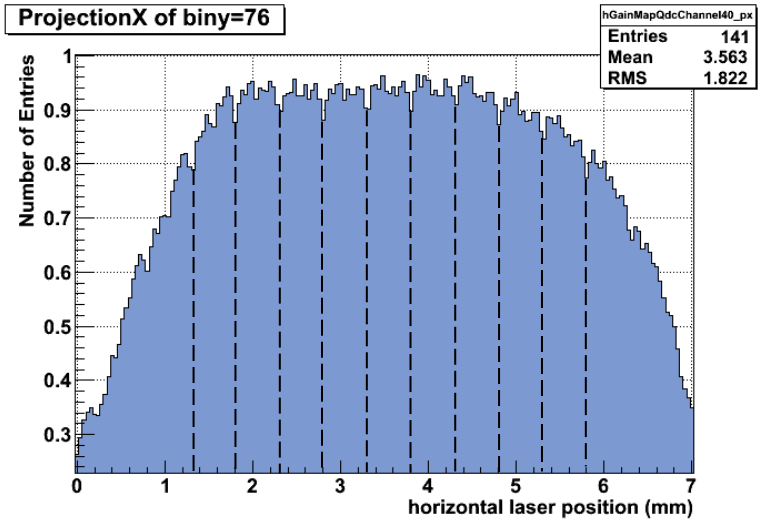


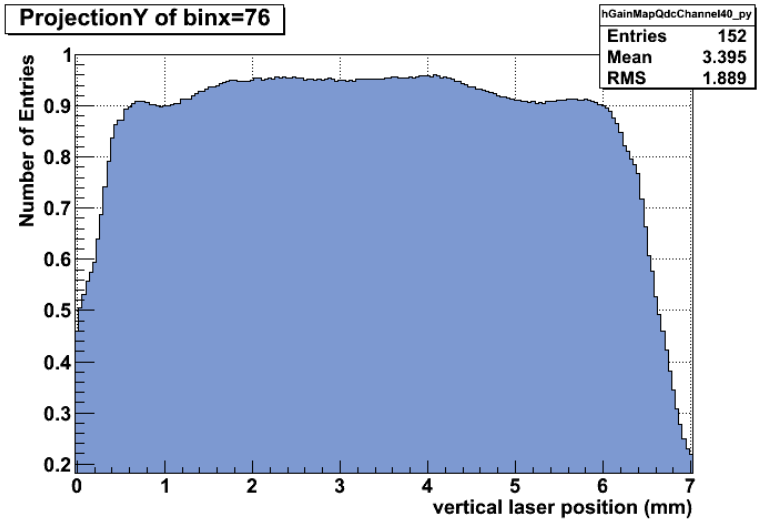
H8500 Multiphoton Scans – Pixel Response

- 0.1mm beam, ~ 260 photoelectrons
- 0.04mm step scan of 1 pixel



- Horizontal segmentation of dynode chains corresponding to expected number

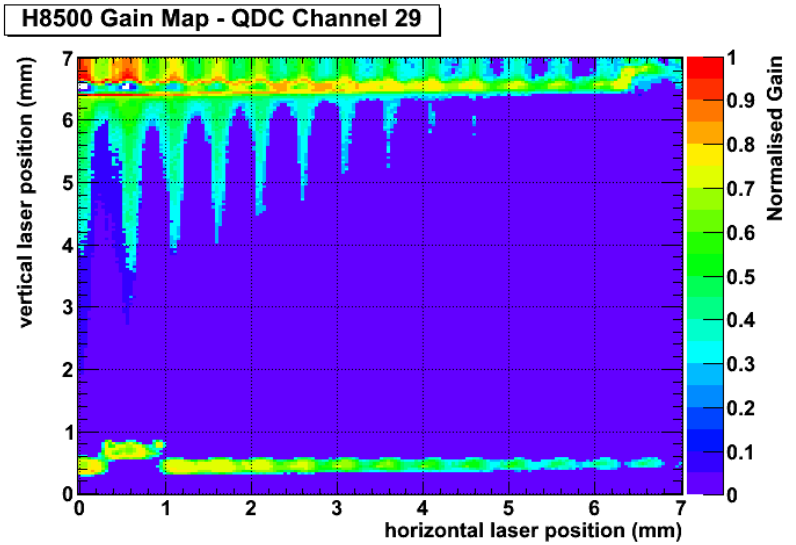


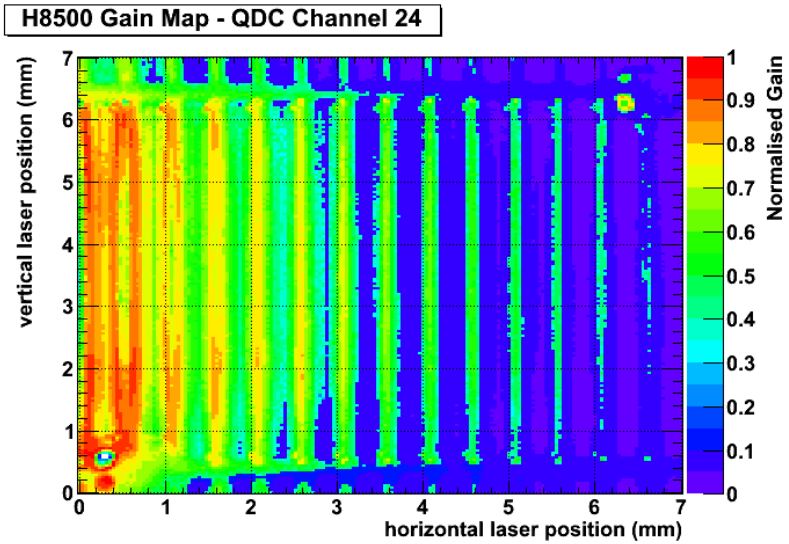


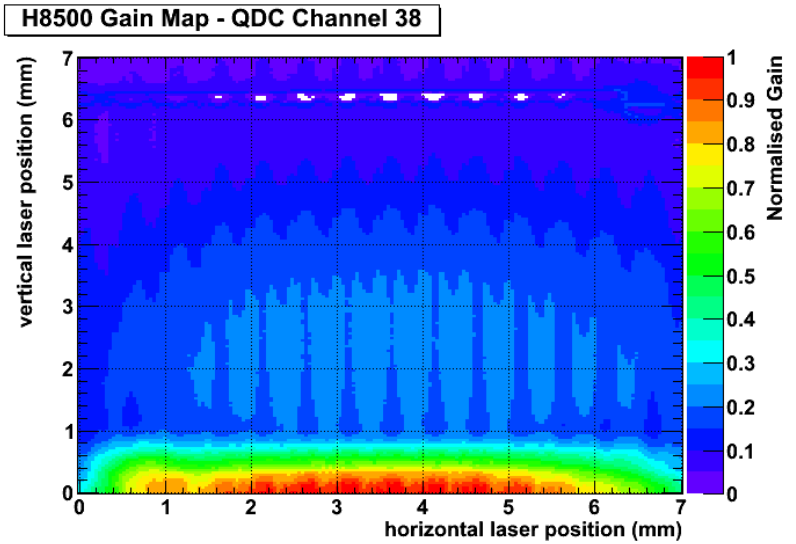
H8500 Multiphoton Scans – Crosstalk

Relative pixel positions and QDC channel mapping

28	**29**	44
26	27	42
24	25	**40**
22	23	**38**
20	21	36

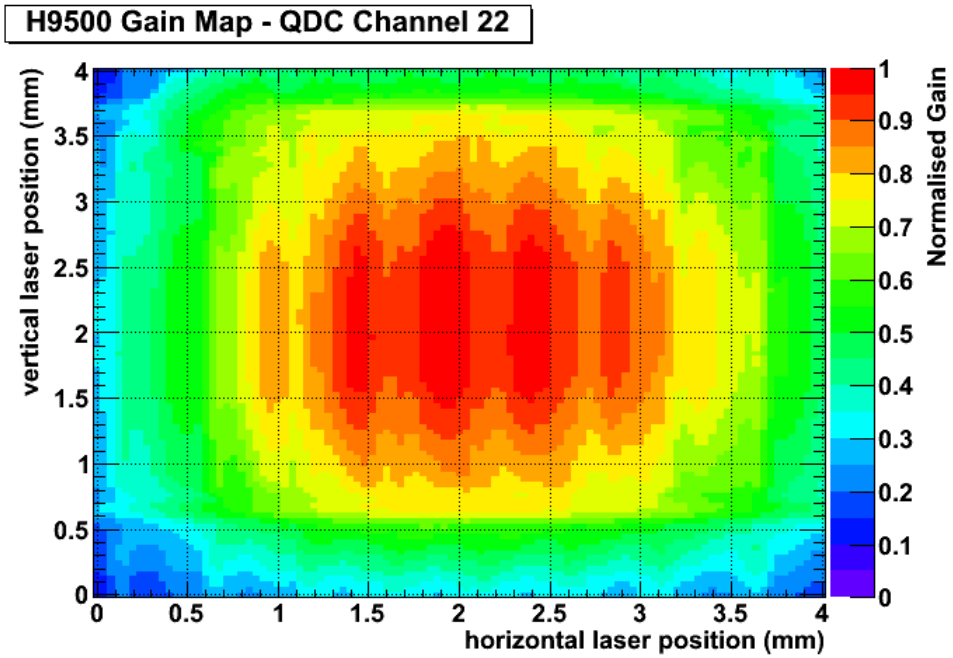




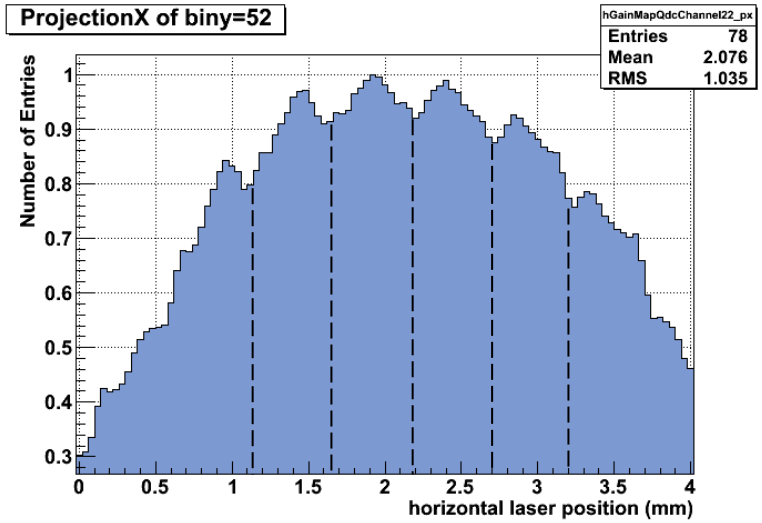


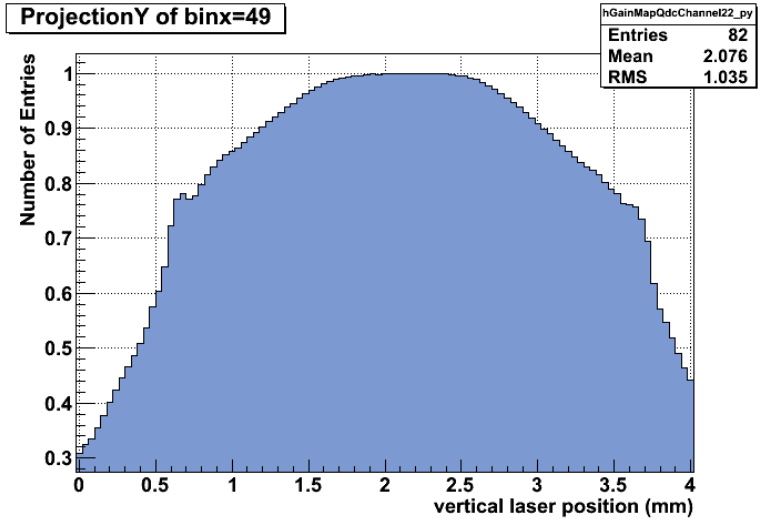
H9500 Multiphoton Scans - Pixel Response

- 0.1mm beam, ~ 530 photons
- 0.04mm step scan of 1 pixel



- Horizontal segmentation of dynode chains corresponding to expected number, less than for H8500





H9500 Multiphoton Scans - Pixel Response

- 0.1mm beam, ~ 530 photons
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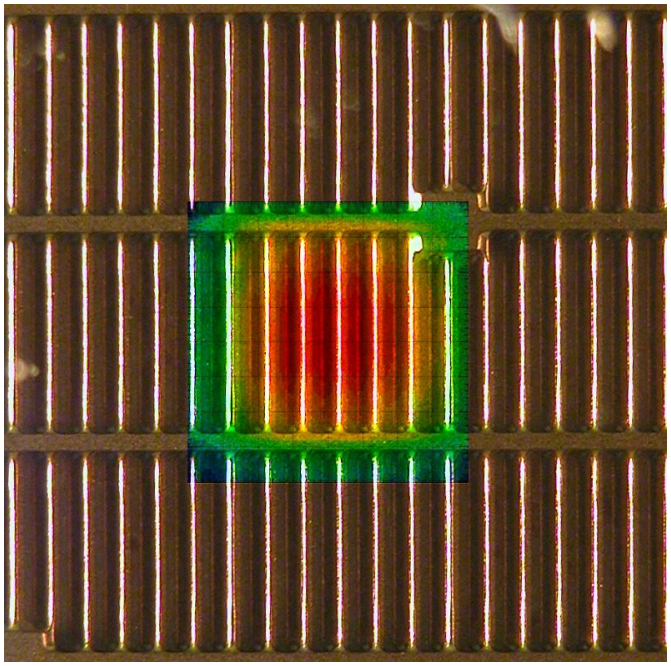

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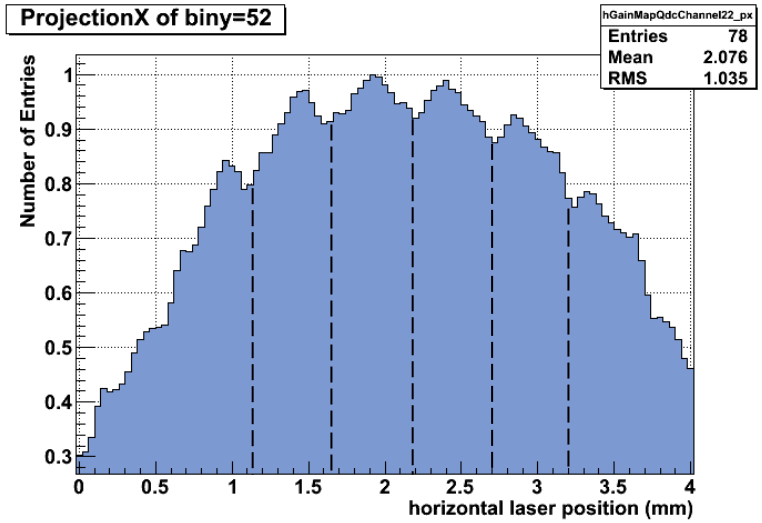
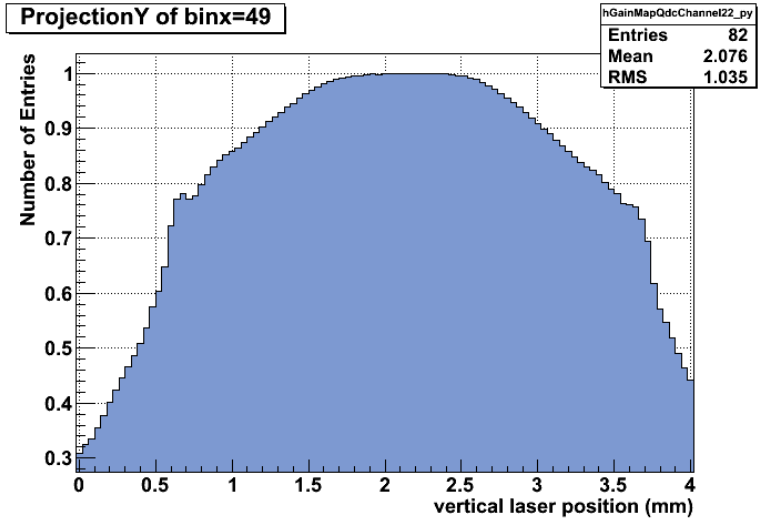
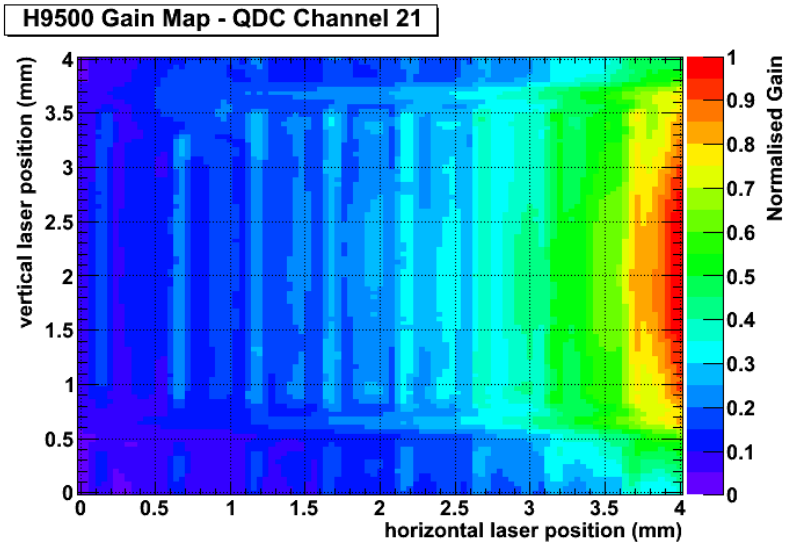


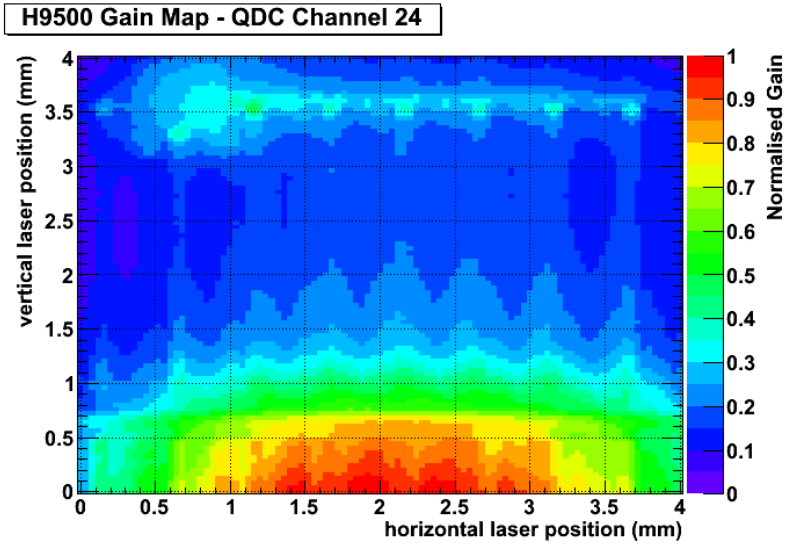


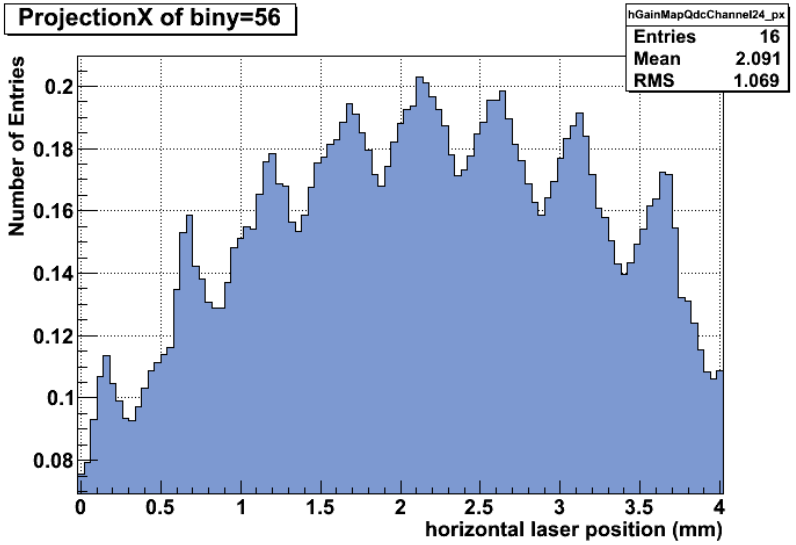
H9500 Multiphoton Scans – Crosstalk

Relative pixel positions and QDC channel mapping

18	17	15	
20	19	13	14
22	**21**	11	12
24	23	9	10
26	25	7	8



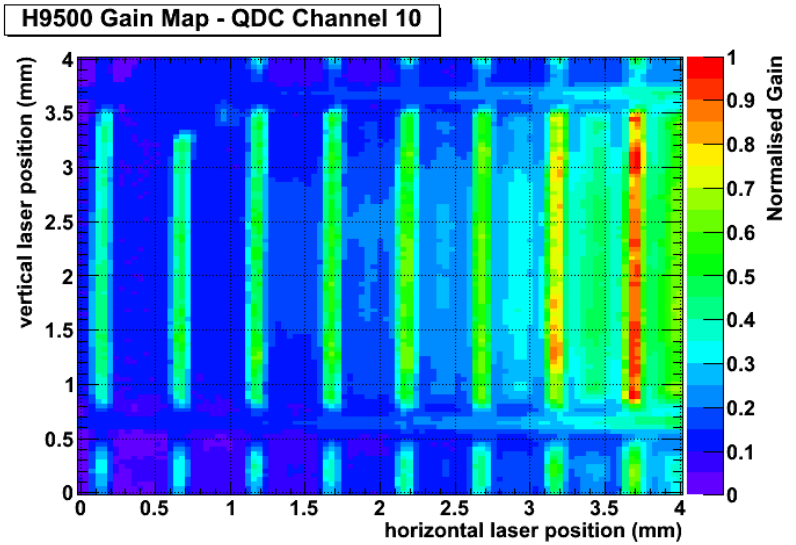


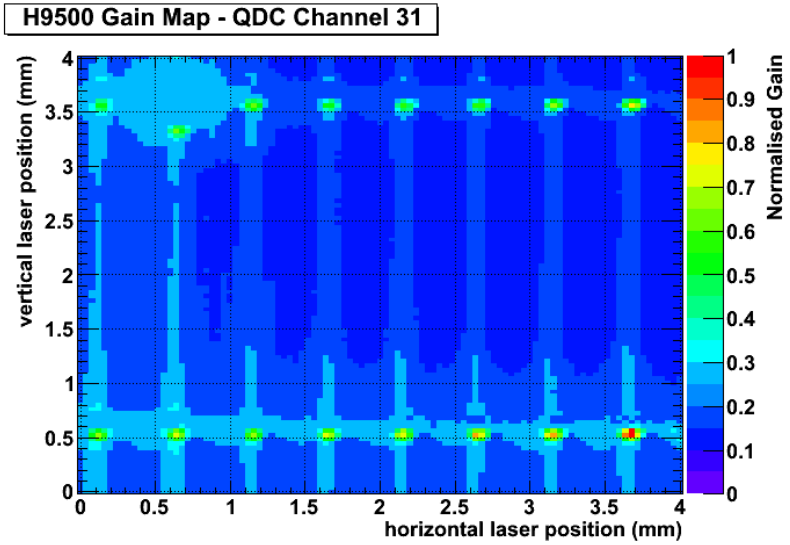


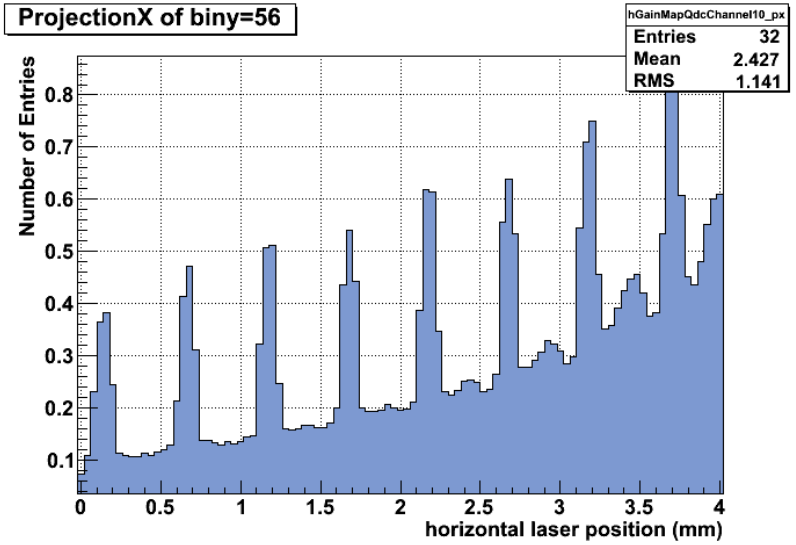
H9500 Multiphoton Scans – Crosstalk

Relative pixel positions and QDC channel mapping

22	21	11	12
24	23	9	**10**
26	25	7	8
28	27	5	6
30	29	3	4
	31	1	2







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Summary

Position sensitive MAPMTs:

- Enhancing performance of imaging detectors

Single photon scans of H8500 MAPMT:

- Homogenous detection efficiencies across MAPMT
- Independent of photon angles

Multiphoton scans of H8500 and H9500 MAPMTs:

- Response and crosstalk pattern dependence upon dynode arrangement and metal mesh construction

Further studies:

- H7546 MAPMT (different dynode arrangement)

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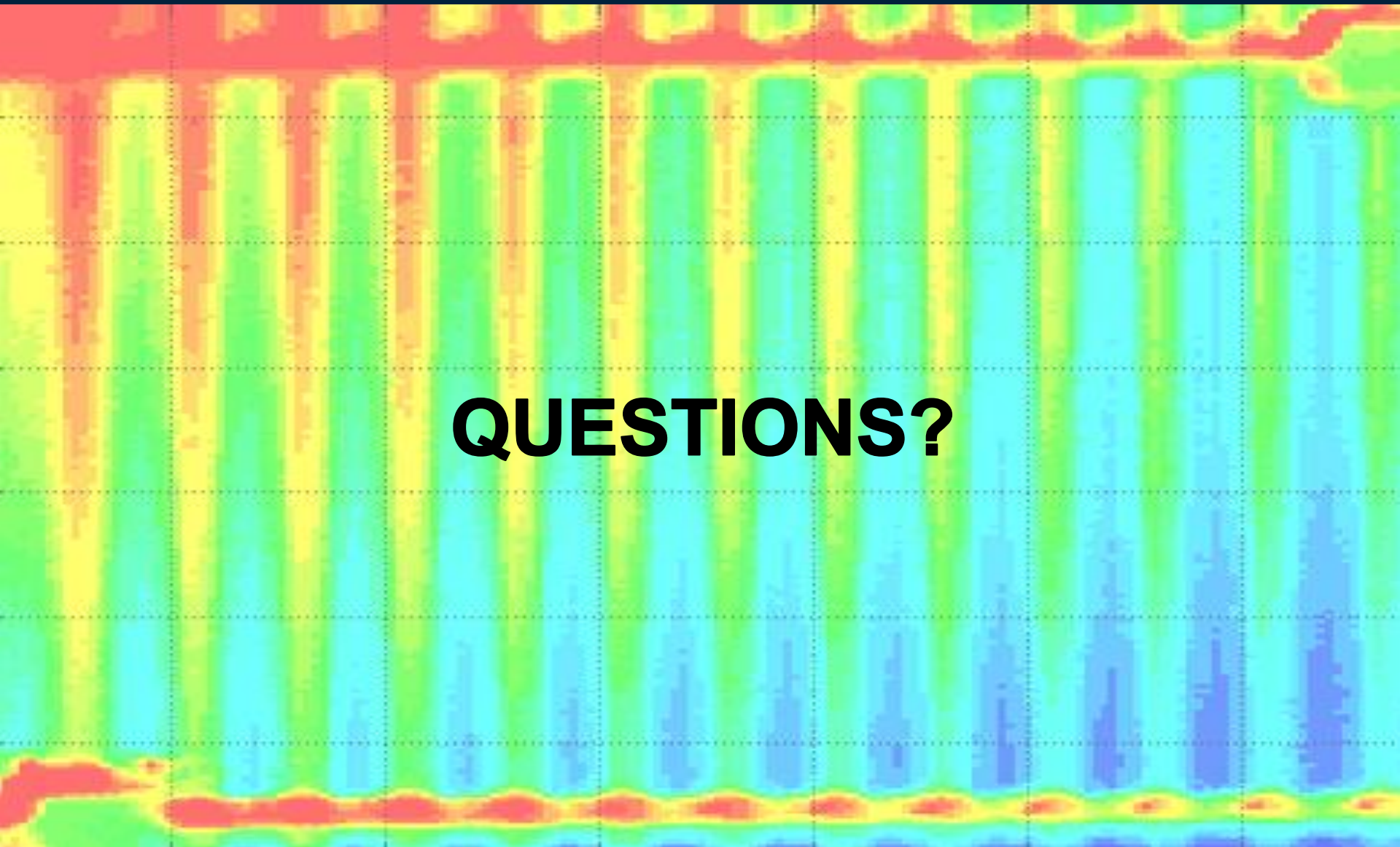
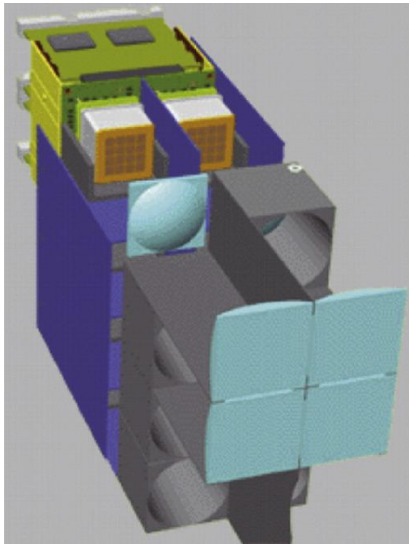


MAPMT Applications

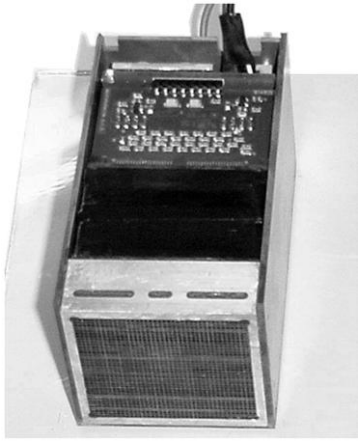
- Particle identification detectors e.g. Cherenkov counters:
  - HERA-B Hamamatsu R5900-00-M16
  - COMPASS Hamamatsu R7600-03-M16



HERA-B RICH:

http://dx.doi.org/10.1016/j.nima.2010.11.127

- Medical imaging e.g. PET, SPECT, small animal gamma cameras

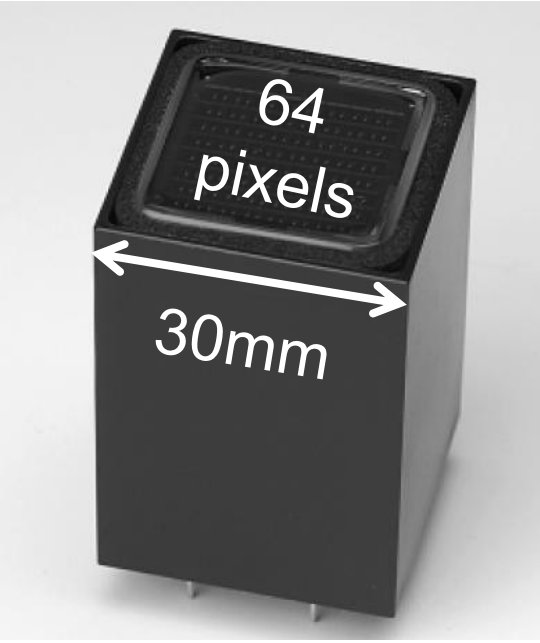


H9500 with CsI(Tl) array:

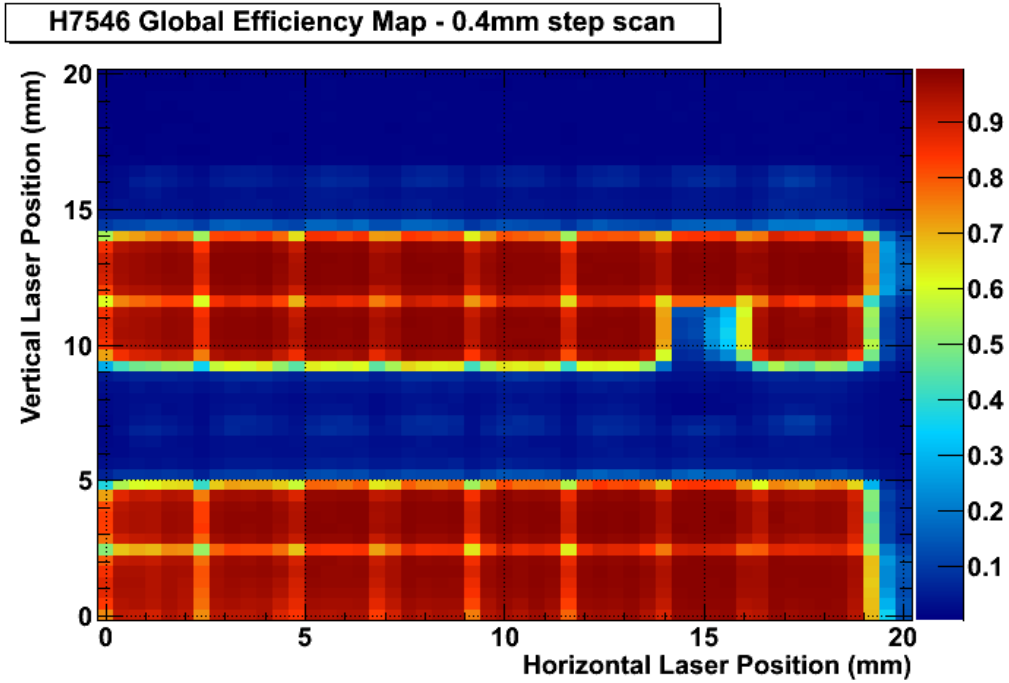
http://dx.doi.org/10.1016/j.nima.2008.05.052

Hamamatsu H7546 MAPMT

- Enhanced photocathode – superior single photon detection efficiency

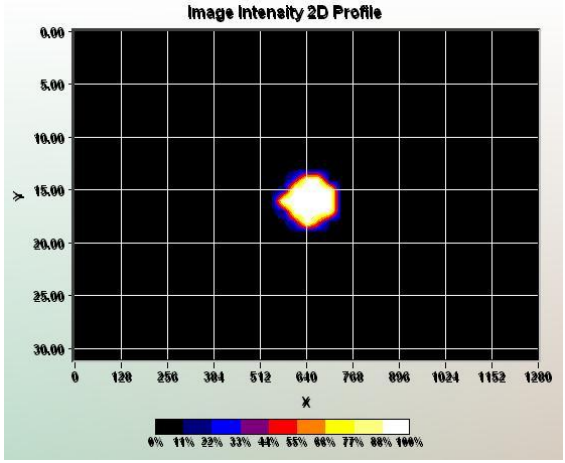


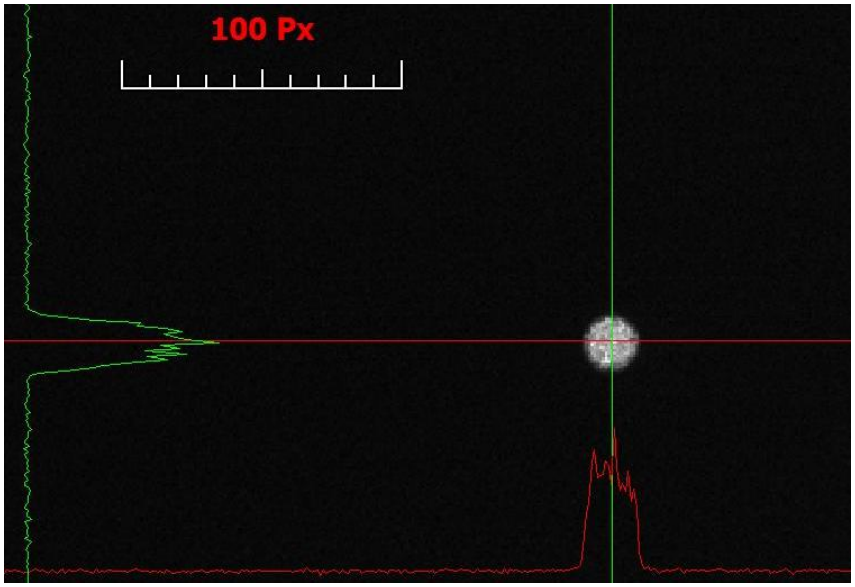
H7546 data sheet,
http://www.hamamatsu.com

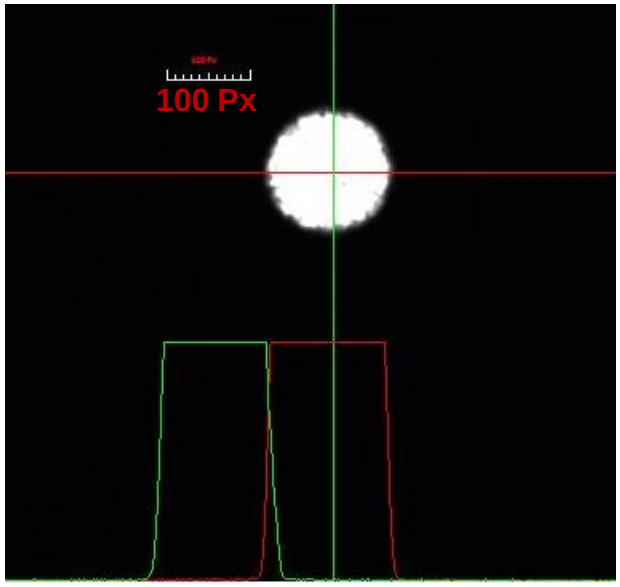


Measuring Laser Beam Diameters with a CCD

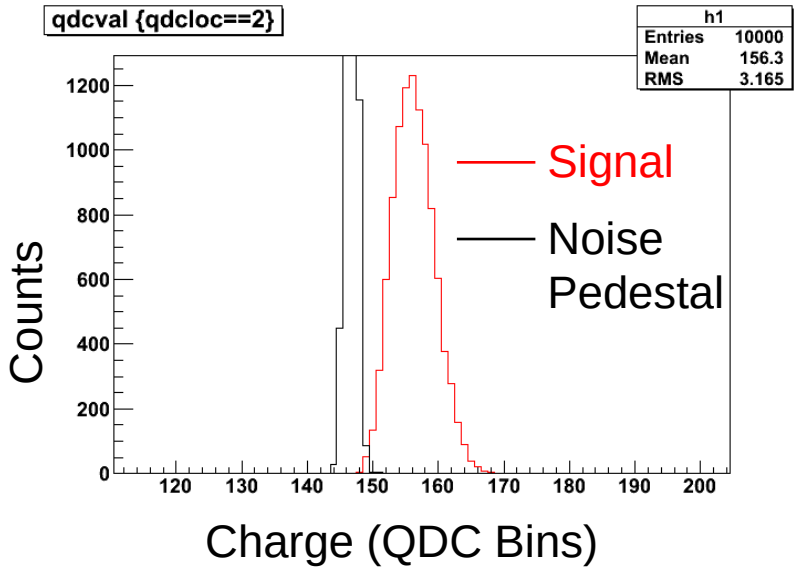
- CCD beam image just before saturation
- FWHM of intensity profile [CCD pixels]
- 1 CCD pixel diameter = 6.45μm
- Obtain laser diameter [m]

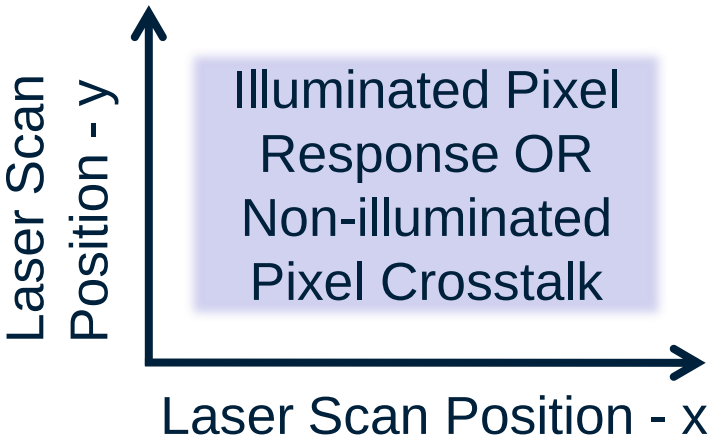






General Analysis Method





- **Detection efficiency**
  - Signal fraction above noise threshold cut
- **Gain**
  - Peak to pedestal separation

- **For every laser position:**
  - extract, analyse signals for **all** channels readout
  - calculate detection efficiency, gain
  - plot results against laser position during scan

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H8500 MAPMT Homogeneity