Multi-Anode Square Microchannel Plate Photomultiplier Tube

AuraTek™ MAPMT253

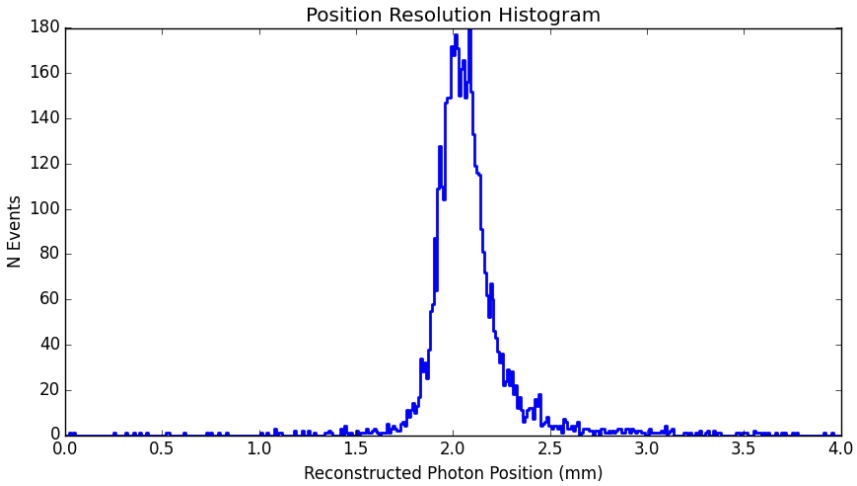
Dr James Milnes

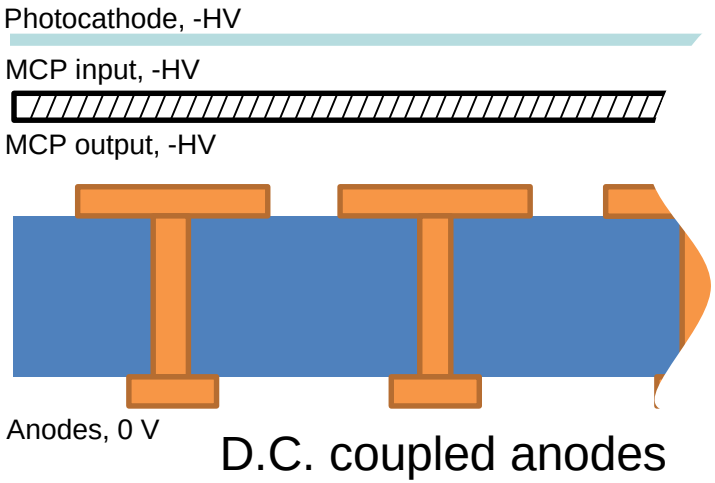
AuraTek™ MAPMT253

- A 64×64 anode square MCP-PMT
- Derived from novel PMT development with the TORCH group
- Unique build provides short front (1.5 – 2 mm) and rear (3 mm) gaps
- Anode pattern can be reconfigured using Anisotropic Conductive Film (ACF) to simplify layout, e.g. 8×8 (PANDA), 64×8 (TORCH)
- Sample devices provided to Erlangen, Argonne, CERN (AFP) & JLAB (EIC)

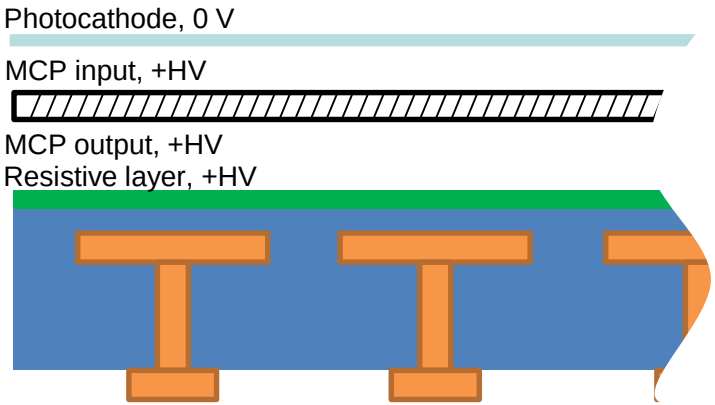
TORCH Design

- The TORCH project developed a novel anode that deliberately spread the charge across 2 - 3 pads
- Position reconstructed by the relative charge measured on each channel
- TORCH target σ = 0.12 mm
- σ = 0.096 mm (0.225 mm FWHM) derived from pads on a 0.828 mm pitch
- The MAPMT253 uses the traditional D.C. coupled anode





D.C. coupled anodes

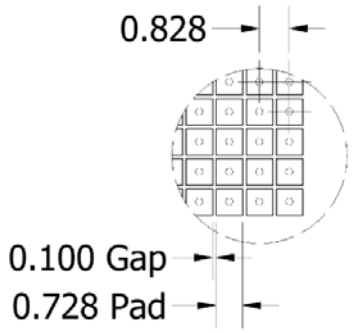


A.C. coupled anodes

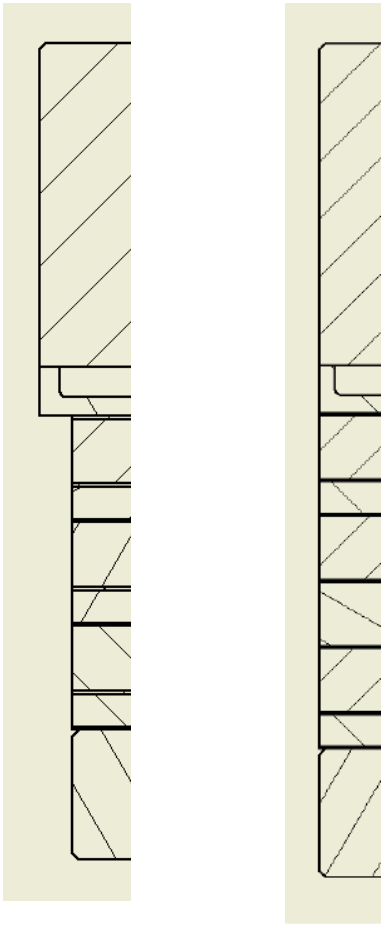
AuraTek™ MAPMT253
Geometrical / Mechanical

Mechanical Properties	MAPMT253
Input Window Material	Fused Silica or Sapphire
Input Window Thickness (mm)	5.0
Photocathode area (mm)	53×53
Photocathode – MCP Gap (mm)	1.6
MCP – Anode Gap (mm)	3.0
MCP Pore Diameter* (μm)	15
Bare Tube Dimensions (mm)	59×59×13
Housed Tube Dimensions (mm)	60×61×13
Native Anode Pattern	64×64
Native Anode Pitch (mm)	0.828

**Currently assessing 6 μm pore MCPs*



TORCH MAPMT253

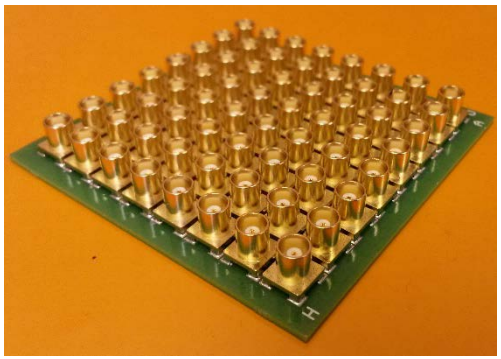


AuraTek™ MAPMT253
Anode Format Options

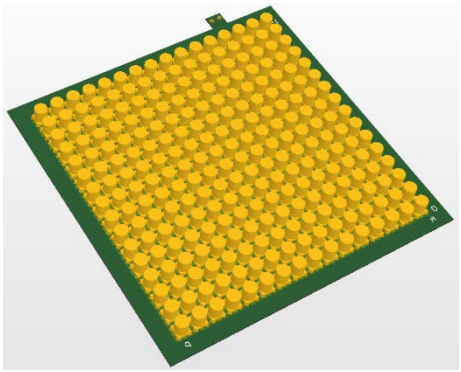
PHOTEK
ENVISAGE THE FUTURE

- Unrealistic to individually connect all 4096 connections in 64×64 array to front-end electronics
- However, this format gives flexibility to gang pads together
- We have an ACF (anisotropic conductive film) kit to bond various PCB designs to the output pads of the PMT

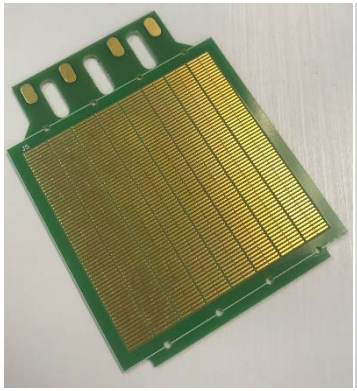
- Gang 8×8 pads together
- 8×8 array
- e.g. MCX co-ax

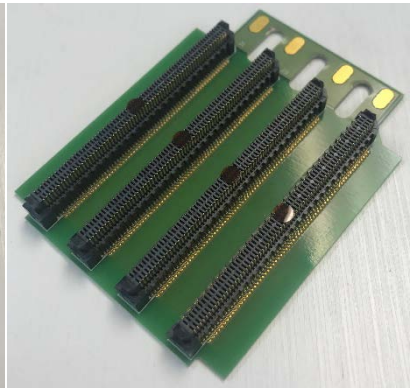


- Gang 4×4 pads together
- 16×16 array
- e.g. SSMCX co-ax



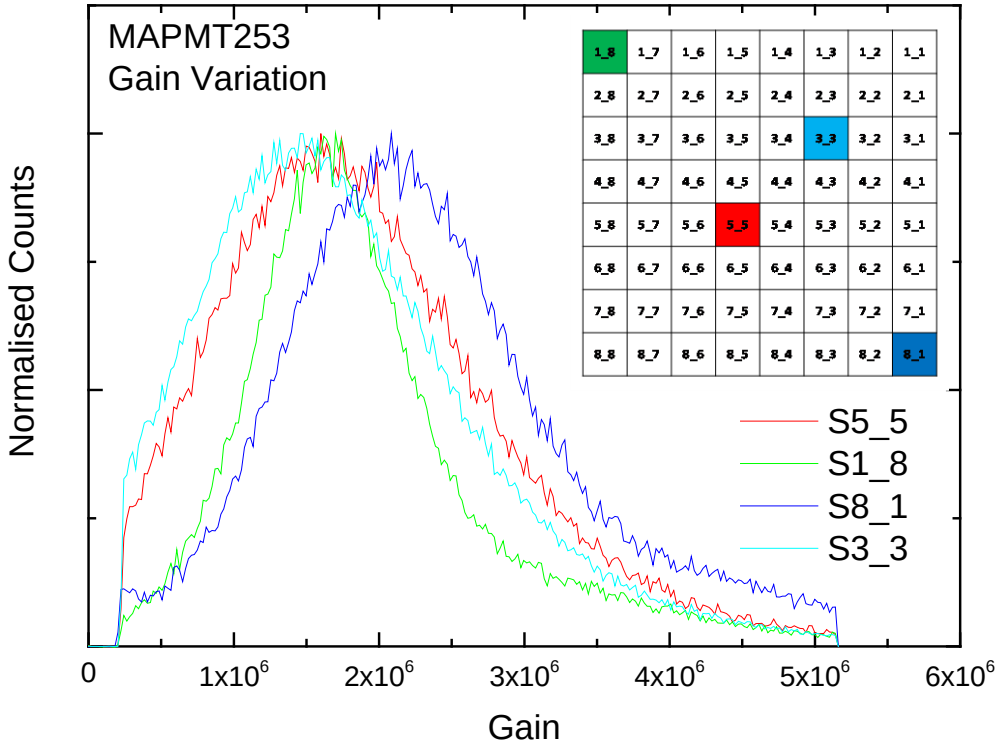
- Gang 8×1 pads together
- 8×64 array
- e.g. Samtec 140-pin multi-way





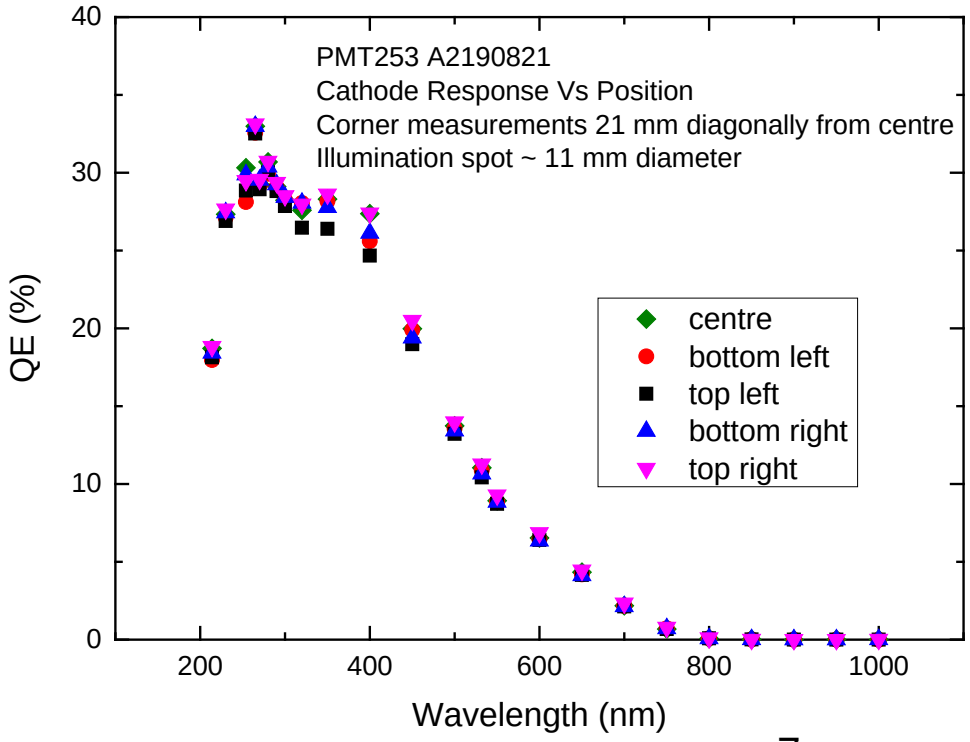
AuraTek™ MAPMT253
Gain & Uniformity

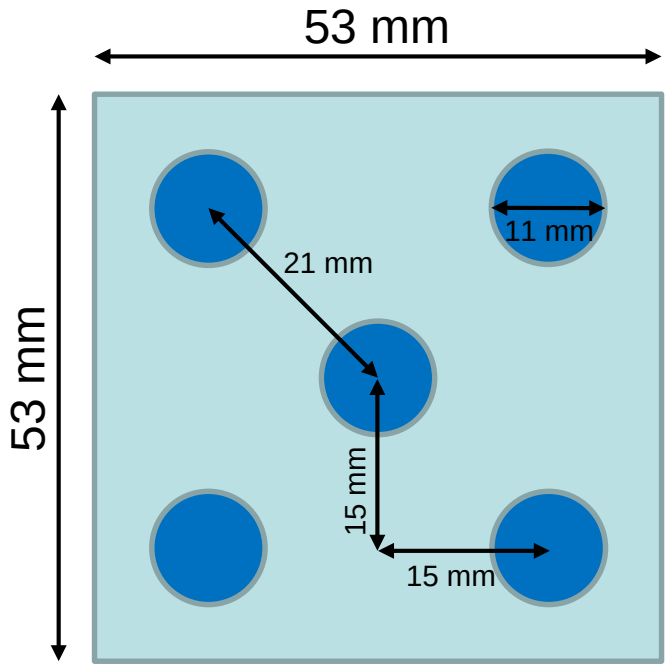
- Test device configured with 8×8 readout pattern
- Nominal gain 10^6
- These results show Peak / Valley > 8 and max/min ratio of 1.5



AuraTek™ MAPMT253
Photocathode Uniformity

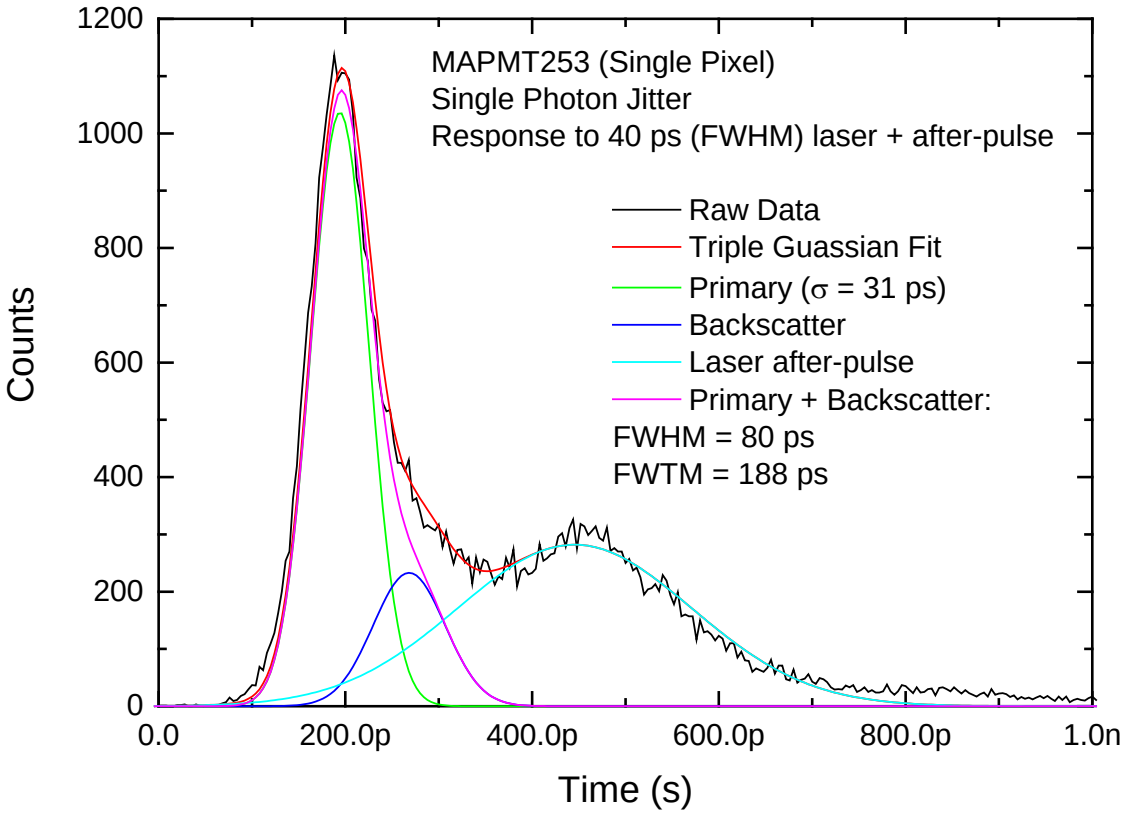
- The cathode uniformity was analysed by spot measurements using the Photek photometer
- Photometer spot size ø ~ 11 mm
- Full cathode scanner should be operational soon





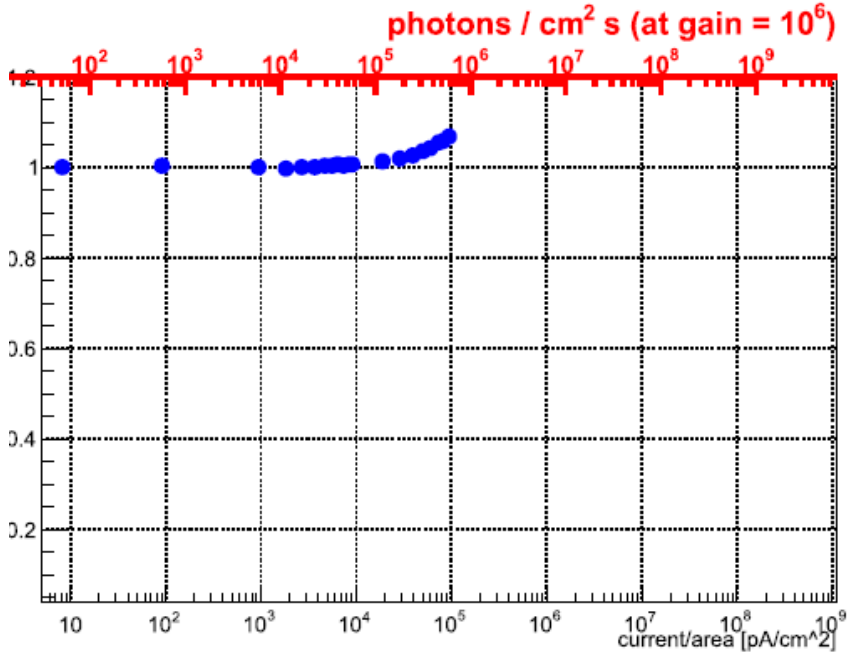
AuraTek™ MAPMT253
Single Photon Timing Accuracy

- Gain ~ 10^6
- Photek LPG-650 laser source ~ 40 ps FWHM
- Signals measured on LeCroy Wavemaster 808Zi-A (8 GHz, 40 GS/s), measuring each pulse's timestamp at 50% of peak amplitude on the leading edge to correct for amplitude walk
- Referenced against Photek PD010 photodiode reference
- Test device configured with 8×8 readout pattern, single channel analysed

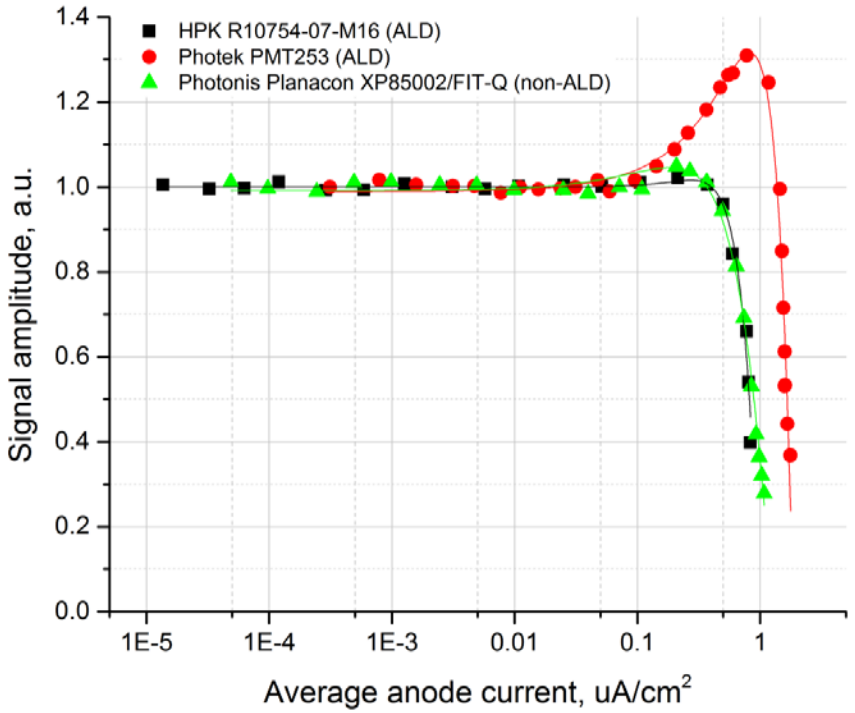


AuraTek™ MAPMT253
Rate Capability

- Tested OK up to 0.6 MHz/cm^2 at Erlangen
- Independently verified by AFP group on the same device
- Strip current could be ~ 50% higher

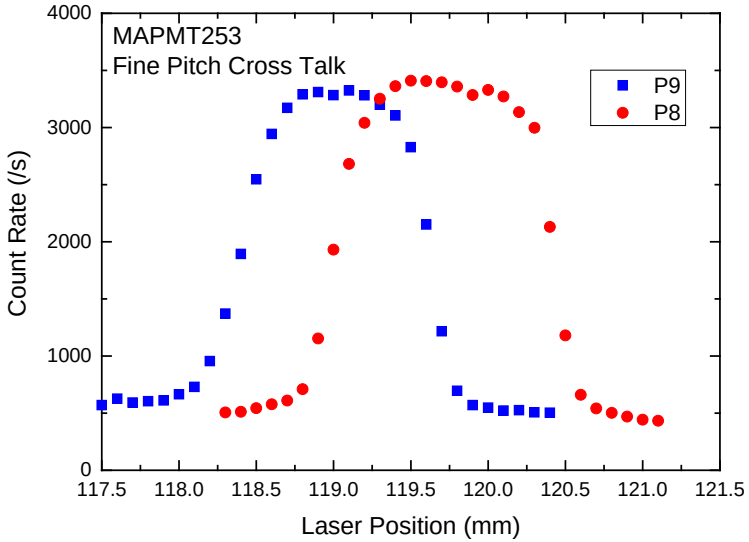


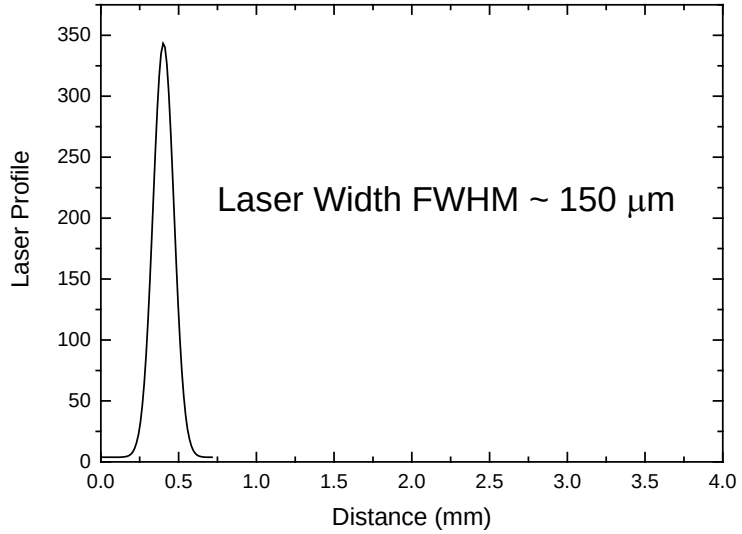
Thanks to Albert Lehmann



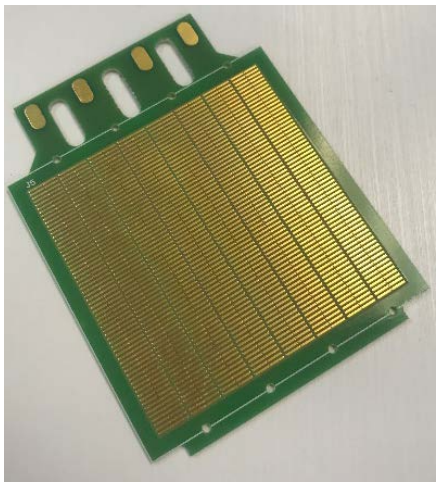
Thanks to Yury Melikyan & Tom Sykora

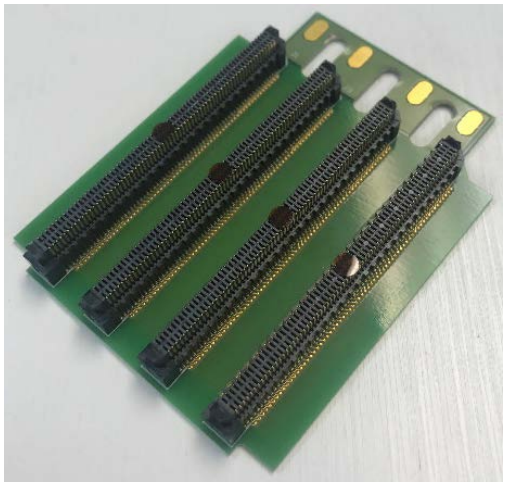
AuraTek™ MAPMT253
Fine Pitch Cross Talk





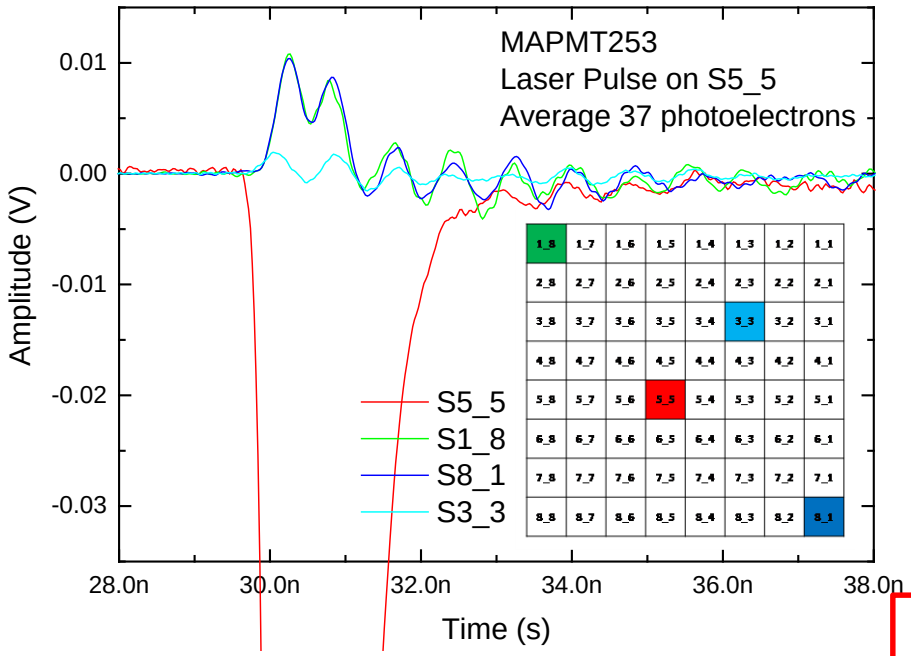
- Test device configured with 8×64 readout pattern (TORCH design)
- 0.828 mm pitch between channels
- Single photon gain peak ~ 1.2×10^6
- Threshold 50% of gain peak
- Photek LPG-650 focussed to ~ 150 μm spot

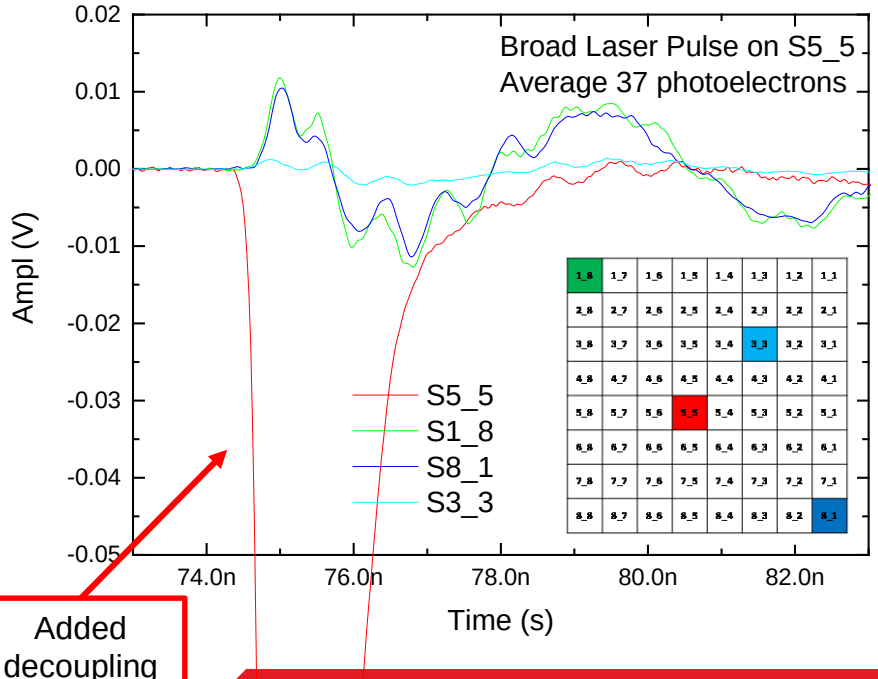




AuraTek™ MAPMT253
Edge Effects (multi-photon)

- Perimeter anodes exhibit an inverted signal at a level of 2.5 – 3.0% of the peak pulse amplitude
- The amplitude of this edge effect remains 2.5 – 3.0% of the peak signal independent of pulse amplitude
- Since the amplitude of the edge effect is inverted it should not create false triggers
- For reference, the average signal for a single photon in these measurements had amplitude of 12 mV
- Adding a decoupling capacitor to the MCP Output electrode actually made the effect worse!

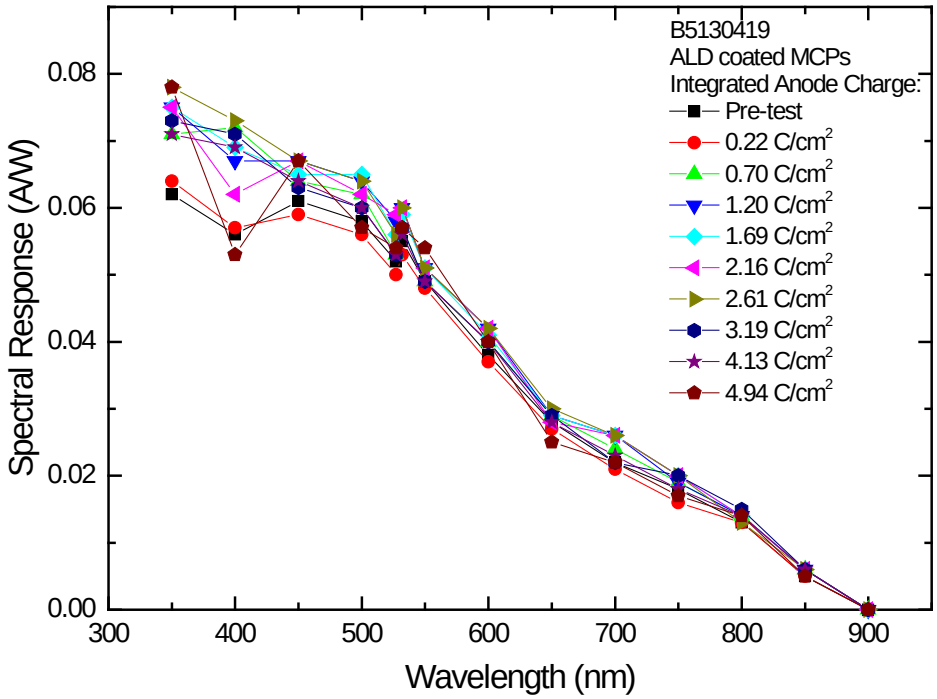




Added decoupling capacitor

AuraTek™ MAPMT253 Lifetime

- We have achieved an accumulated anode charge of > 5 C/cm^2 on several test devices and are working towards further improvements
- We performed an audit on square PMT manufacture, looking at:
  - Materials & preparation
  - ALD coating & baking
  - MCP scrubbing
- Currently making more devices for life tests

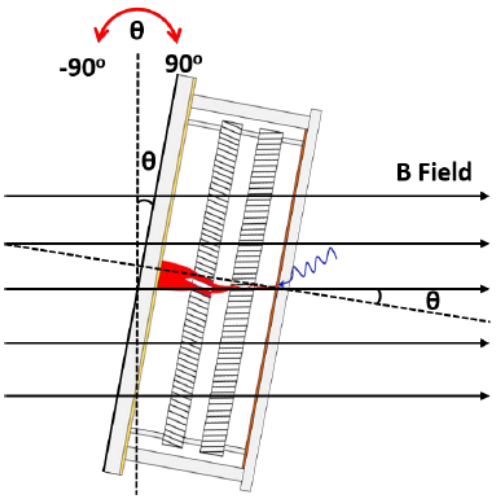


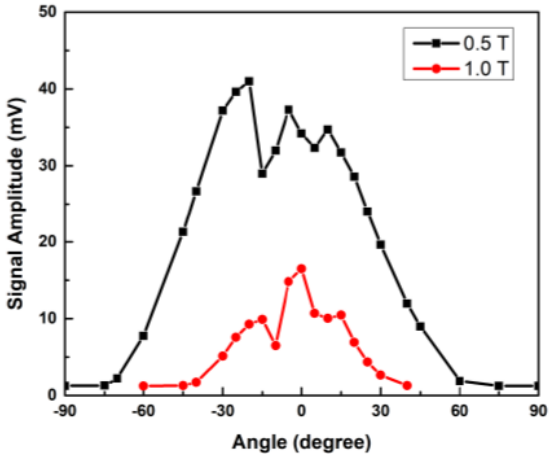
AuraTek™ MAPMT253
Detective Quantum Efficiency

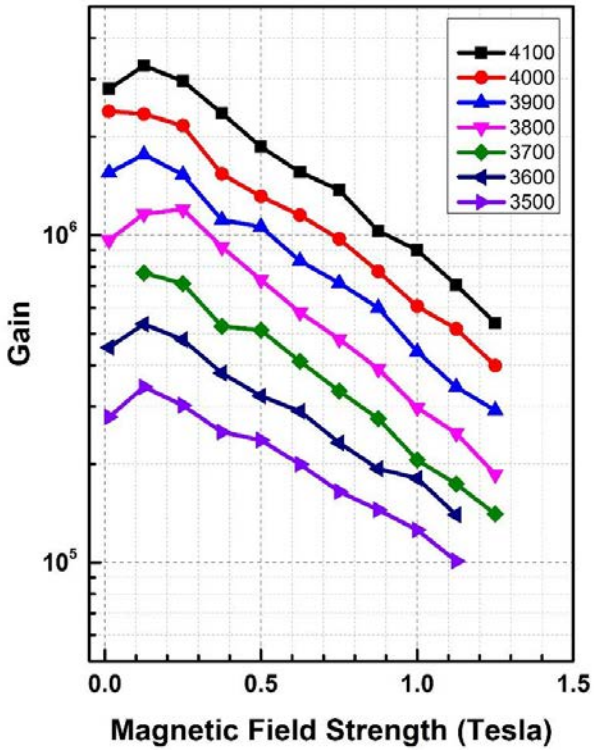
- Detective Quantum Efficiency: DQE = Photocathode QE × MCP Collection Efficiency (CE)
- Traditional MCPs have ~ 60% CE
- We have a method that:
  - Directly measures the photocathode current
  - Scales the input light to photon counting level
  - Measures photon detection rate
- Using the same MCP glass and ALD coating as the MAPMT253, we have measured CE of ~ 90%
- CE measured at Erlangen ~ 83% (±10%) *Thanks to Albert Lehmann*

AuraTek™ MAPMT253
Magnetic Field Effects

- Magnetic field experiments by Junqi Xie of Argonne National Labs
- We expect this to improve considerably with the switch to 6 μm pore MCPs
- Junqi has also shown that a magnetic field does not affect the position of the electron shower







With thanks to…

The members of the TORCH collaboration at the University of Bristol, CERN and the University of Oxford

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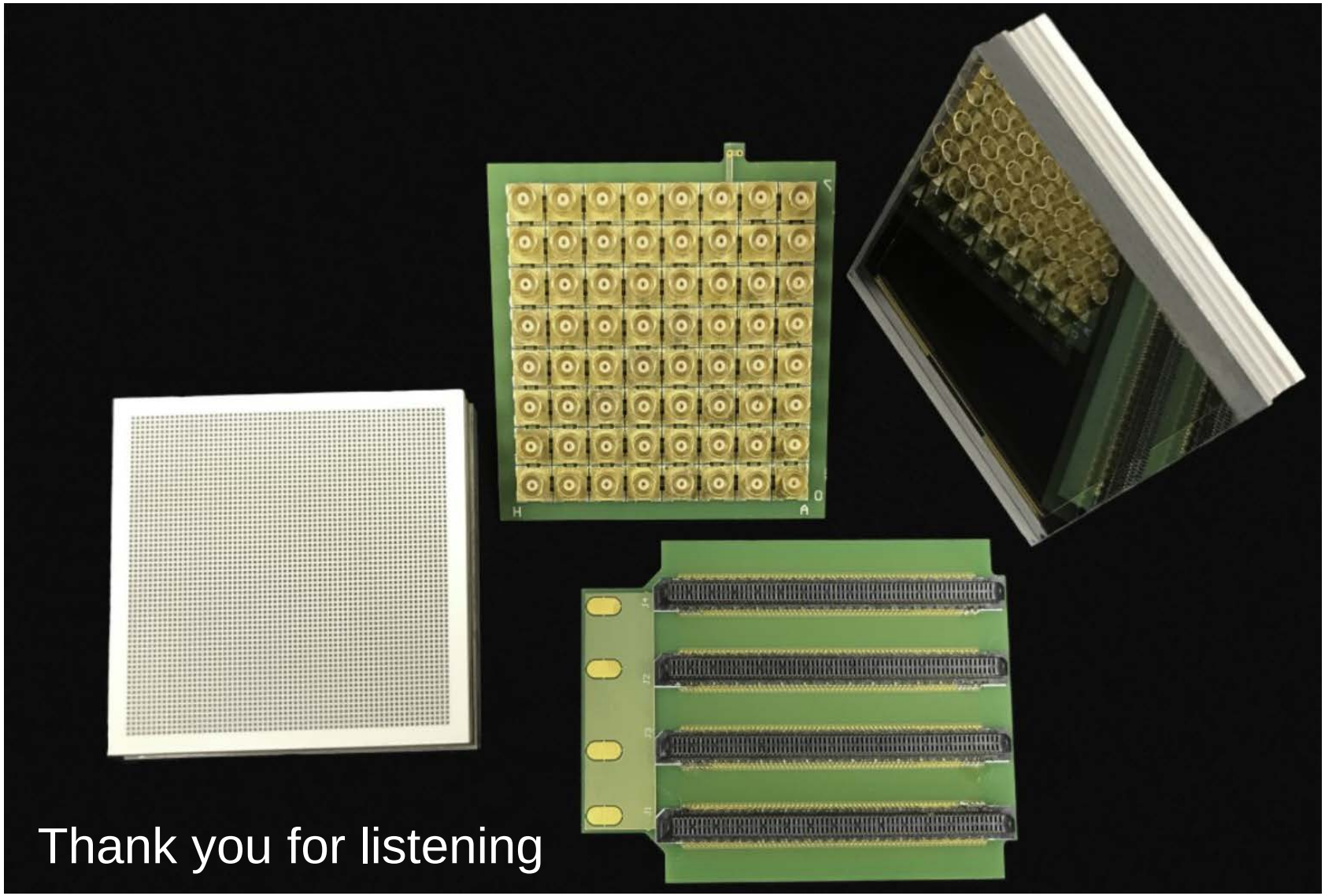
Thank you for listening