

# The TORCH PMT, a close packing, long life MCP-PMT for Cherenkov applications with a novel high granularity multi-anode

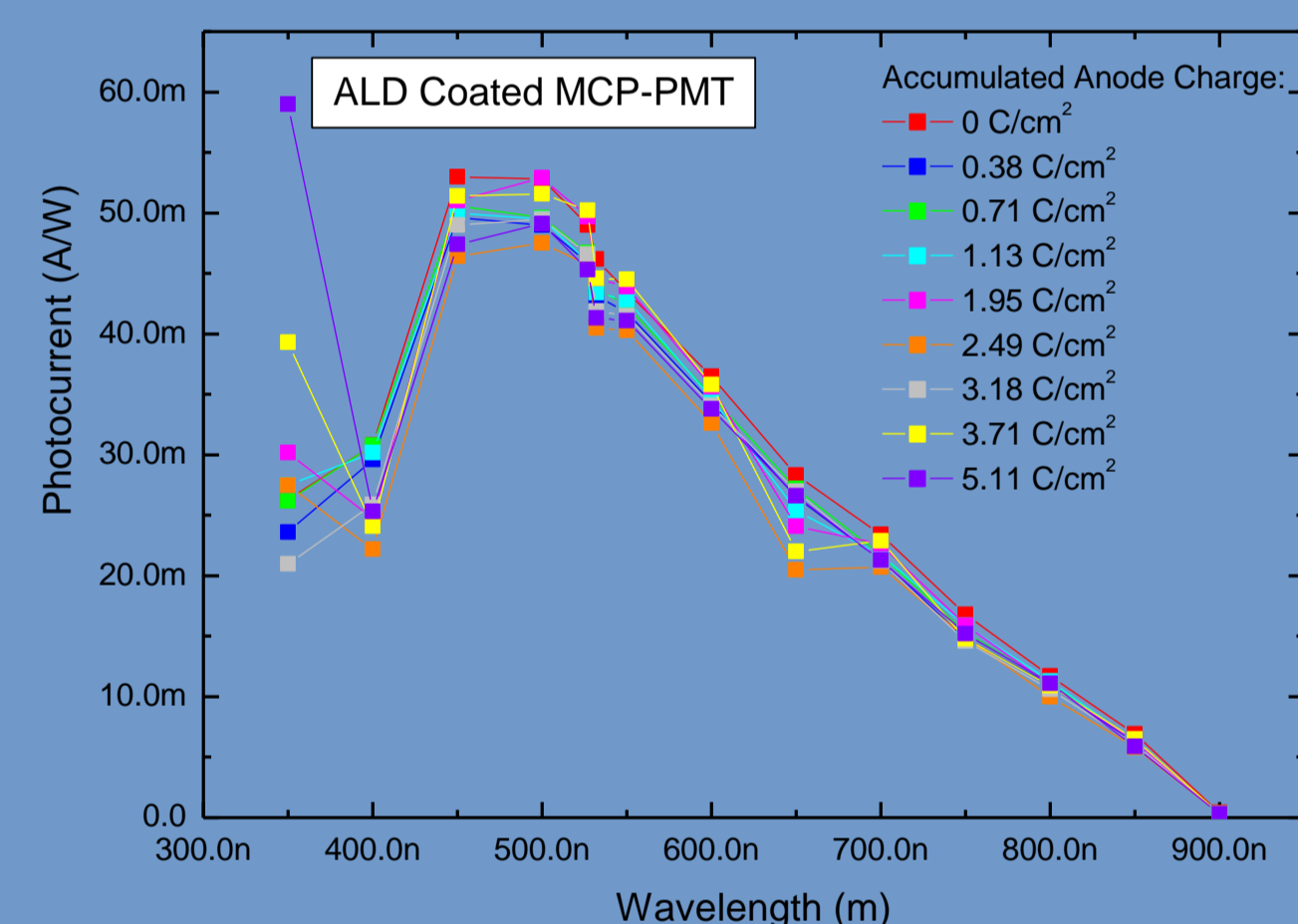
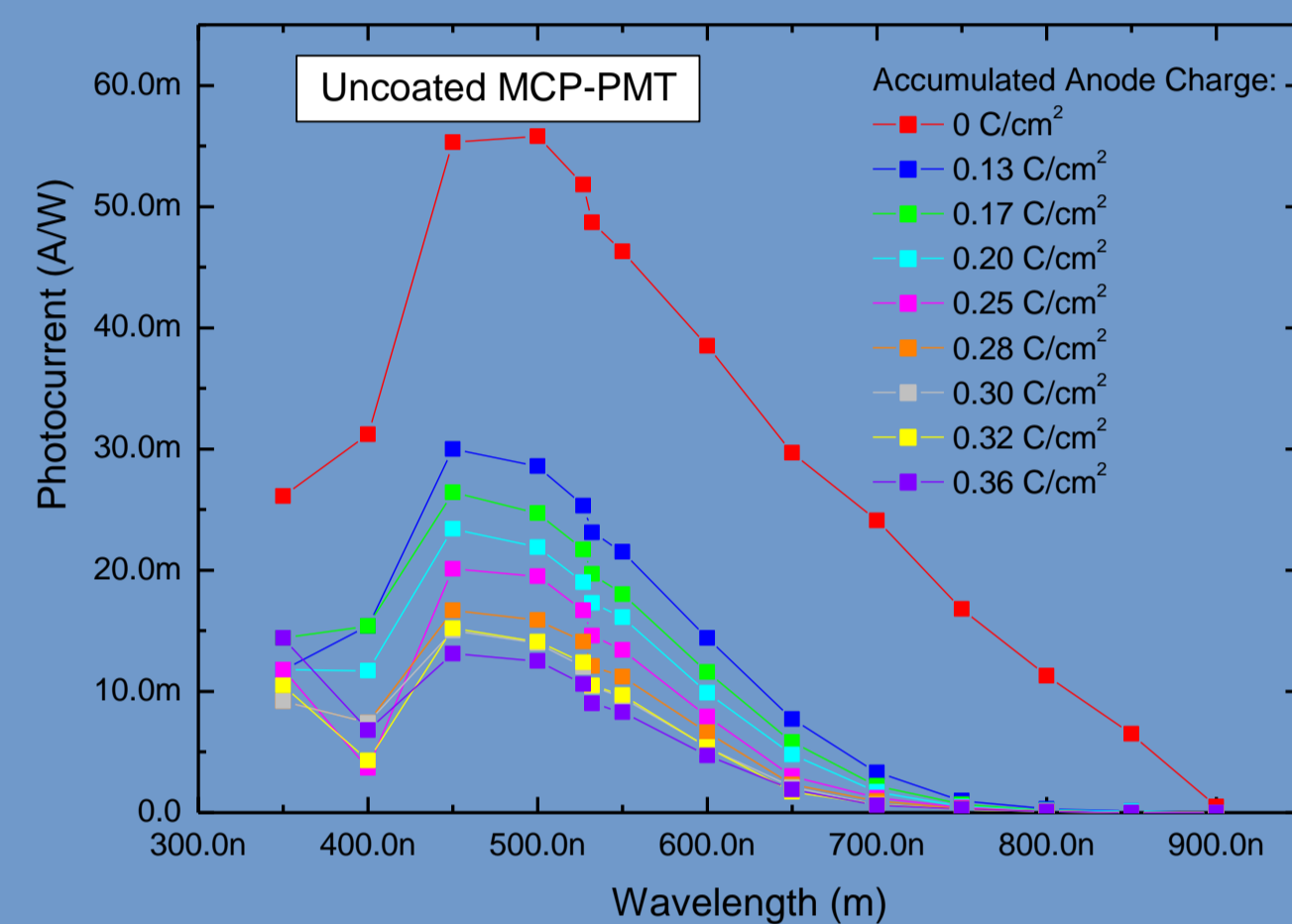
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TORCH was an ERC funded R&D project proposed to upgrade LHCb Particle ID capabilities in the 2-10 GeV/c region, a collaboration between CERN, Photek and the Universities of Oxford and Bristol. Photek's role was to develop a novel square MCP detector with < 100 ps photon timing accuracy and the following technical aims:

- A lifetime of 5 C/cm<sup>2</sup> of accumulated anode charge or better
- A multi-anode readout equivalent to 8x128 pixels, fine pitch resolution target  $\sigma = 0.12$  mm
- Close packing on two opposing sides with a fill factor of 88% or better (53 mm width within a 60 mm envelope)

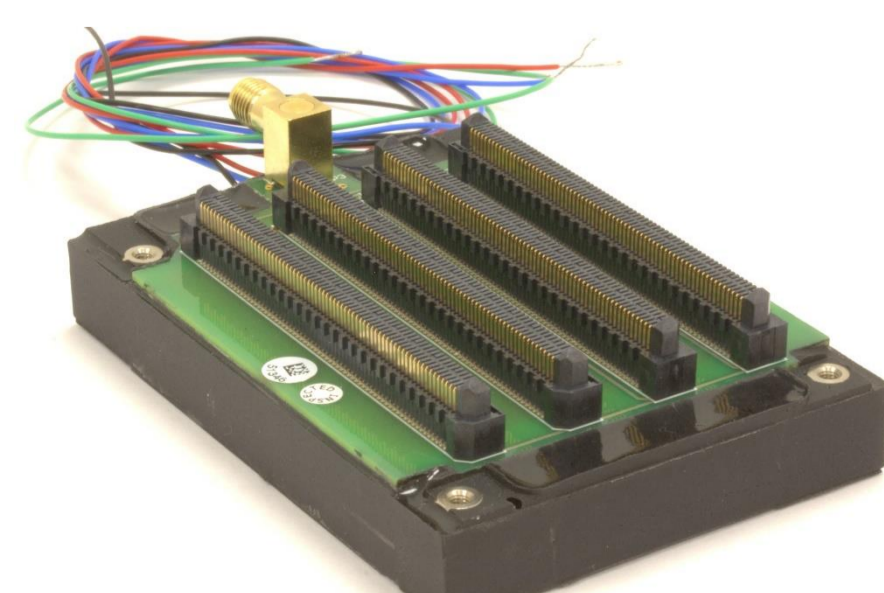
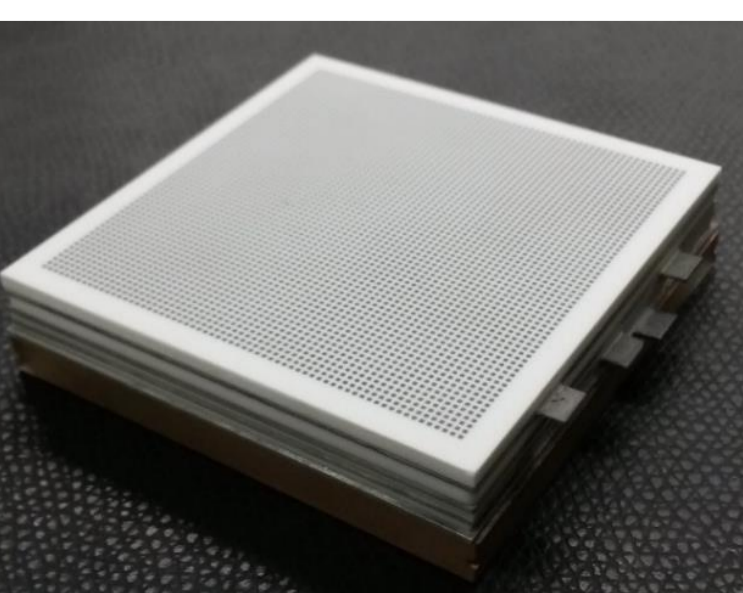
## Lifetime

- Using established conformal coating of MCPs by Atomic Layer Deposition (ALD) to prevent ion feedback
- Accelerated test:  $\sim 800$  nA / cm<sup>2</sup> for  $\sim 14$  weeks over small area



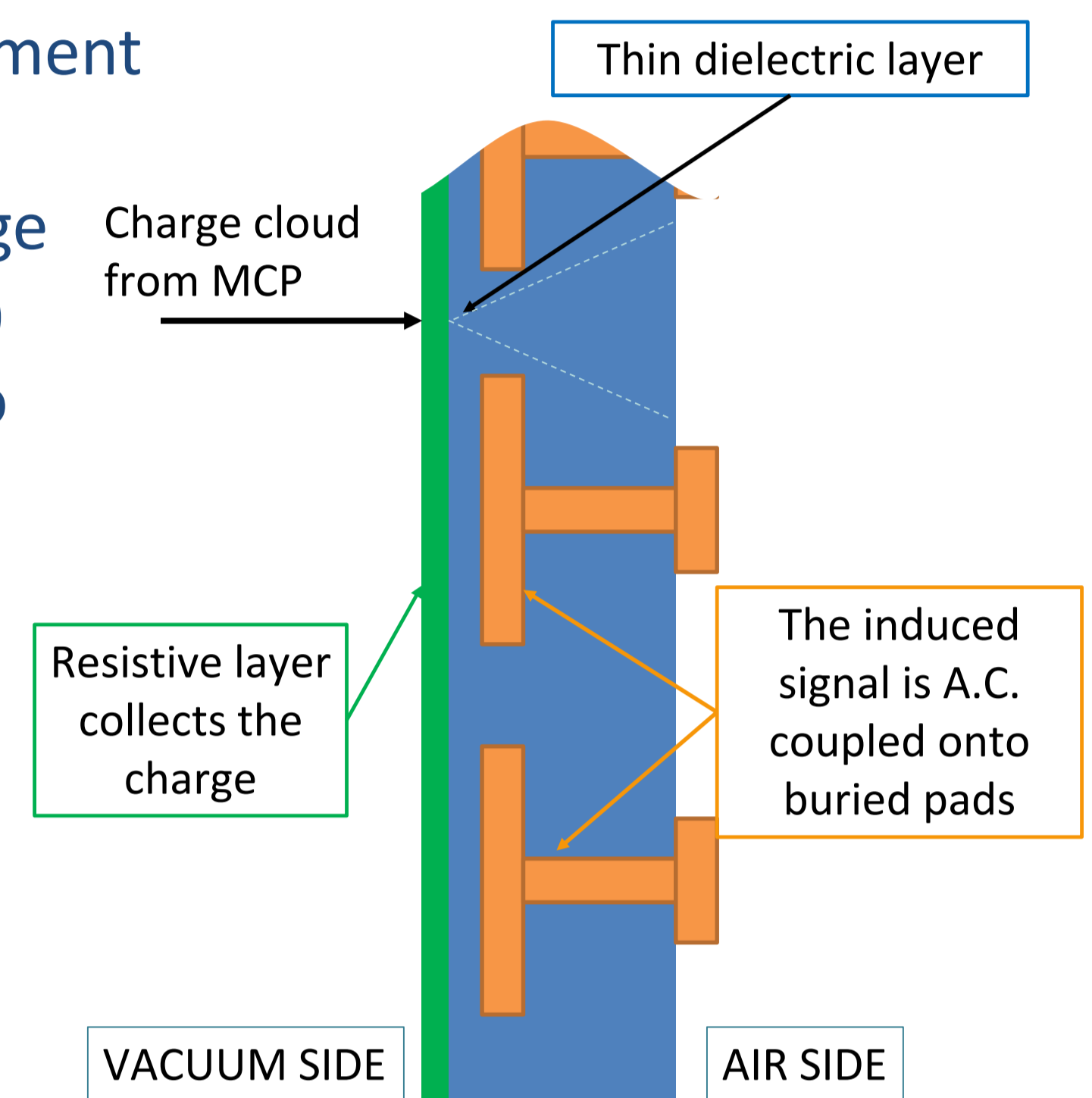
## Square Tube Development

- All tube manufacturing had to be reconfigured to fit the square format:
  - Brazing
  - MCP fixing
  - Input window sealing
- Anisotropic Conductive Film (ACF) bonding developed for 64 x 8 anode connections to external PCB
- 10 devices delivered to CERN in 2017
- DC anode version spun out into AuraTek™ brand
- Separate project incorporating Photek multi-anode PMTs and TOFPET readout (See poster by J. Lapington)



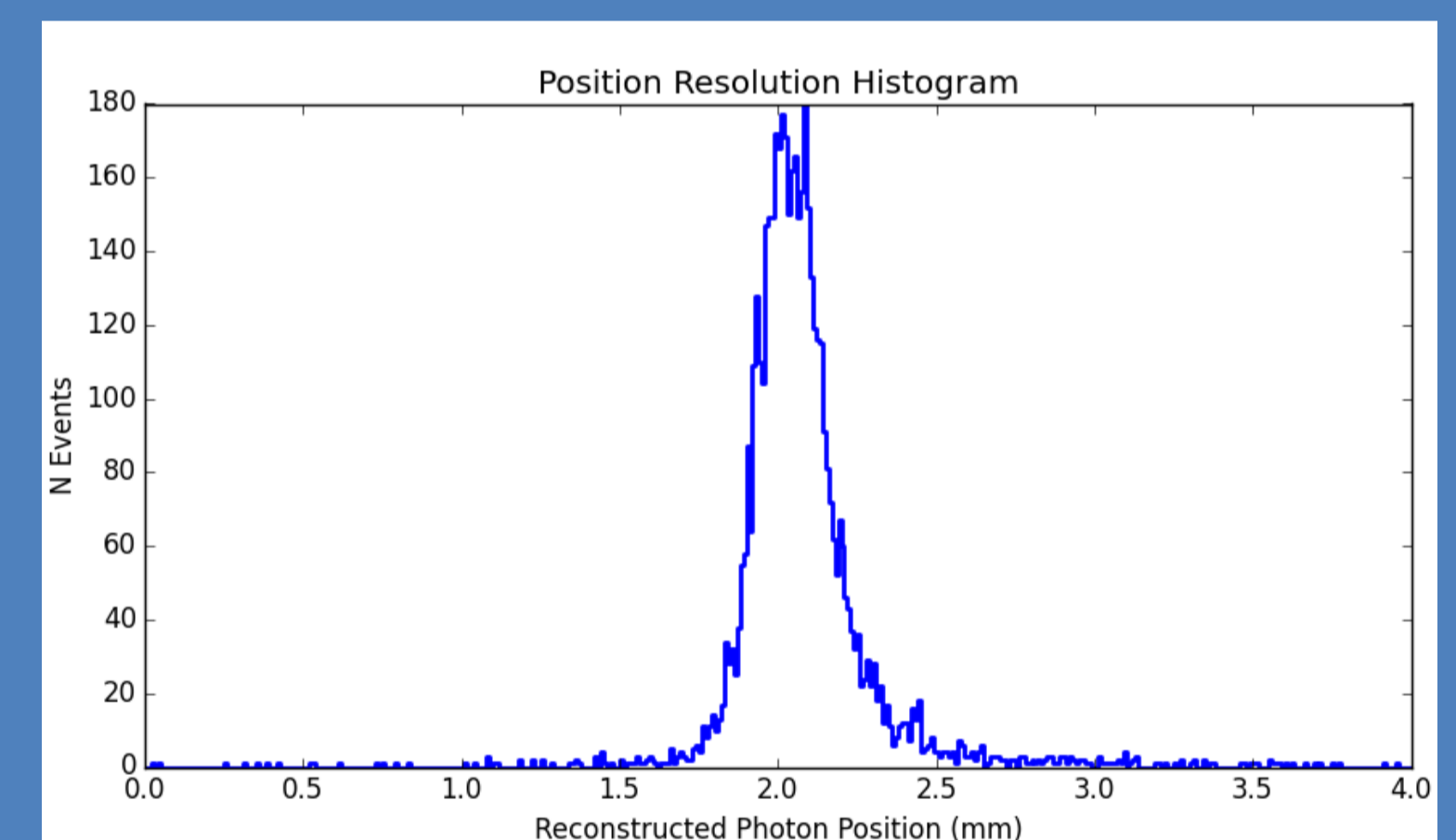
## Novel Development: The TORCH Anode

- Unable to achieve fine pitch requirement through direct-coupled anodes
- Introduce a dielectric between charge collection and readout (AC coupling)
- Spreads the MCP charge footprint to share between pads
- Upper limit on charge sharing set by TORCH occupancy restriction
- Solved by using buried pads
- Use charge sharing algorithm to reconstruct photon position
- AC coupled anode allows the photocathode to be operated at 0 V



## Position Resolution – Result 1

- Charge measured on 4-channel oscilloscope
- TORCH target  $\sigma = 0.12$  mm
- $\sigma = 0.096$  mm (0.225 mm FWHM) derived from pads on a 0.83 mm pitch

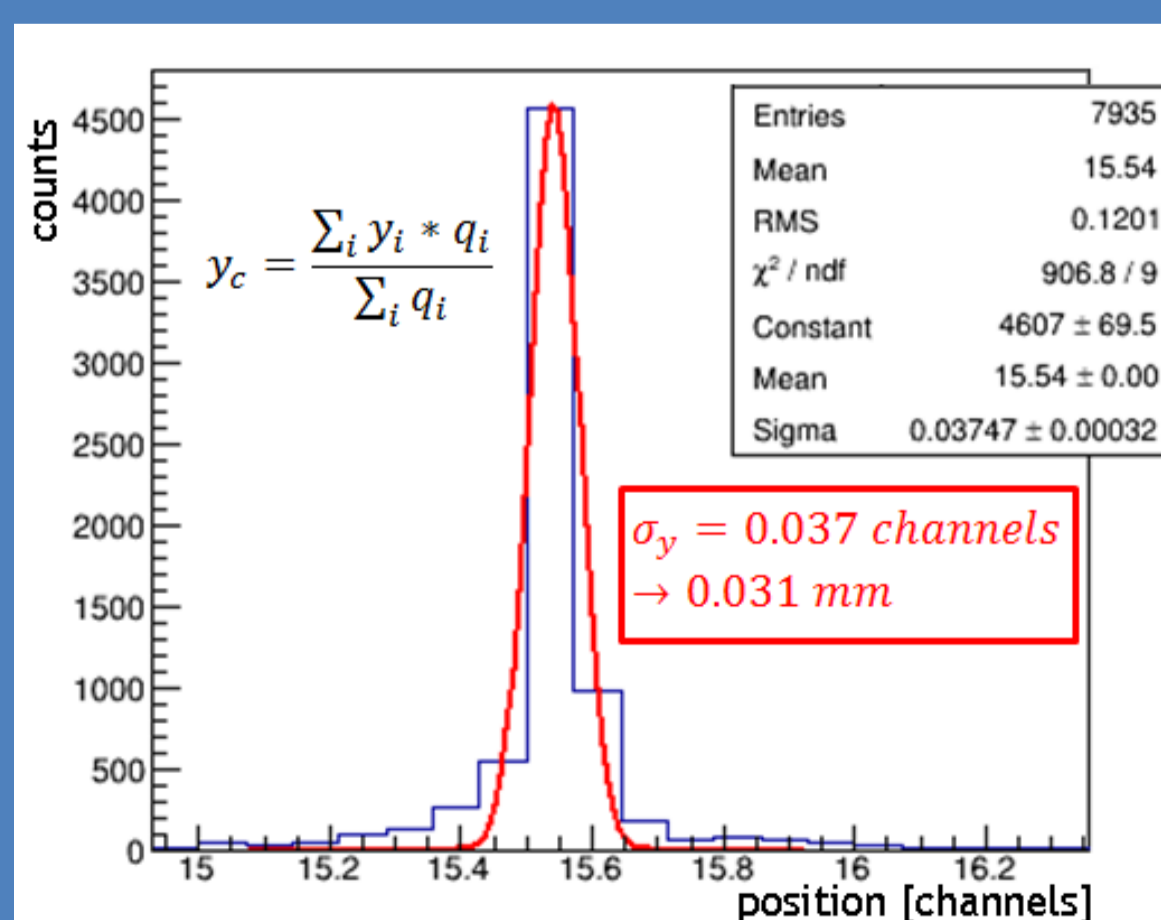


$$x = \frac{\sum_{i=0}^3 x_i q_i}{Q}$$

$x_i$  is co-ordinate of pad,  $q_i$  is charge collected by pad  $i$ ,  $Q$  is the sum of all charge collected

## Result 2

- Obtained by L. Castillo García et al JINST 11 C05022 (2016)



- Using combination of NINO and HPTDC ASICs intended for TORCH prototype for timing and charge measurement
- Single position of focussed laser spot on detector
- $\sigma = 0.031$  mm

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