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

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Photek are in a development program with CERN and the Universities of Oxford and Bristol to produce a novel square PMT for the proposed TORCH detector which is being developed within an ERC project, with potential application in a future upgrade of the LHCb experiment around 2023. The PMT development takes the known performance of Photek microchannel plate (MCP) based detectors of a potential spatial resolution of < 0.1 mm and potential time resolution of < 40 ps rms and aims for a balance of these performance objectives (that often work in opposition) to meet the technical PMT requirements of the proposed TORCH upgrade at LHCb. To achieve high resolution in both time and position and maintain a good level of parallelism in photon detection, a multi-anode approach has to be used.

From a detector manufacturing perspective there are three main challenges in this PMT development: long lifetime, multi-anode output and close packing (requiring a square tube envelope).

1. Long Lifetime

Previous work published by Photek and several other parties have now established the method of atomic layer deposition (ALD) coating of the MCP as being the most effective method of demonstrated a significant lifetime improvement in an MCP-PMT. We will present further evidence of a PMT capable of producing over 5 C / cm2 of anode charge without any detectable reduction in photocathode sensitivity.

1. Multi-Anode Output

The technical requirements of the TORCH PMT include an effective spatial resolution of 128 × 8 pixels within a 53 mm x 53 mm working area. Such high granularity in one direction presents a difficult challenge in terms of manufacturing the segmented anode and also in keeping inter-anode cross talk to a minimum. We will present a novel anode design that combines the image charge technique with a patterned anode, and uses a charge sharing algorithm that produces an inter-pad position resolution beyond the granularity of the pads themselves, 0.225 mm FWHM (sigma ˜ 0.1 mm) derived from pads on a 0.83 mm pitch:

The anode signal is A.C. coupled and the structure is high voltage tolerant, so the input window can be fixed at ground potential which removes any issues with charging effects.

We will describe the methods of coupling the detector to multiple NINO chips, a 32-channel time-over-threshold ASIC using ACF (anisotropic conductive film) that minimises any parasitic input capacitance by allowing very close proximity between the NINO and the detector. We will build on previous results of software simulations that combine the pulse height variation from the detector and NINO threshold levels to predict a position resolution to show initial results using the NINO ASIC and the first multi-anode tube prototypes.

1. Close Packing (requiring a square tube envelope)

The technical challenge for Photek is to produce a square tube envelope that has a fill factor of > 88 % working width over the total detector size (including housing) in one direction. We will present results from the first square PMT prototypes demonstrating the fill factor ratio.

We will present results from the first square PMT prototypes demonstrating the required fill factor ratio.

Summary

Photek are currently in a three year development program to produce a novel square PMT for the proposed TORCH detector which is being developed within an ERC project, with potential application in a future upgrade of the LHCb experiment around 2023. The PMT will be MCP based for the inherent timing accuracy that this brings, and has three main novel features that need to be developed:

1. Long lifetime, it should be able to produce 5 C / cm2 of accumulated anode charge without noticeable degradation in sensitivity.
2. Multi-anode output with an effective spatial resolution of 128 × 8 pixels within a 53 mm x 53 mm working area.
3. Close packing on 2 opposing sides with an active width fill factor target of 88% in one direction.

We will present further evidence of the significant beneficial effect that an ALD (Atomic Layer Deposition) coating on the MCPs has on the life time of an MCP-PMT.

We have developed a novel anode design that combines the image charge technique with a patterned anode, and uses a charge sharing algorithm that produces an inter-pad position resolution beyond the granularity of the pads themselves: 0.225 mm FWHM (sigma ˜ 0.1 mm) derived from pads on a 0.83 mm pitch. We will also show initial results using the multi-channel NINO ASIC and the first multi-anode tube prototypes.

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