Progress on the development of a low-cost fast-timing microchannel plate photodetector

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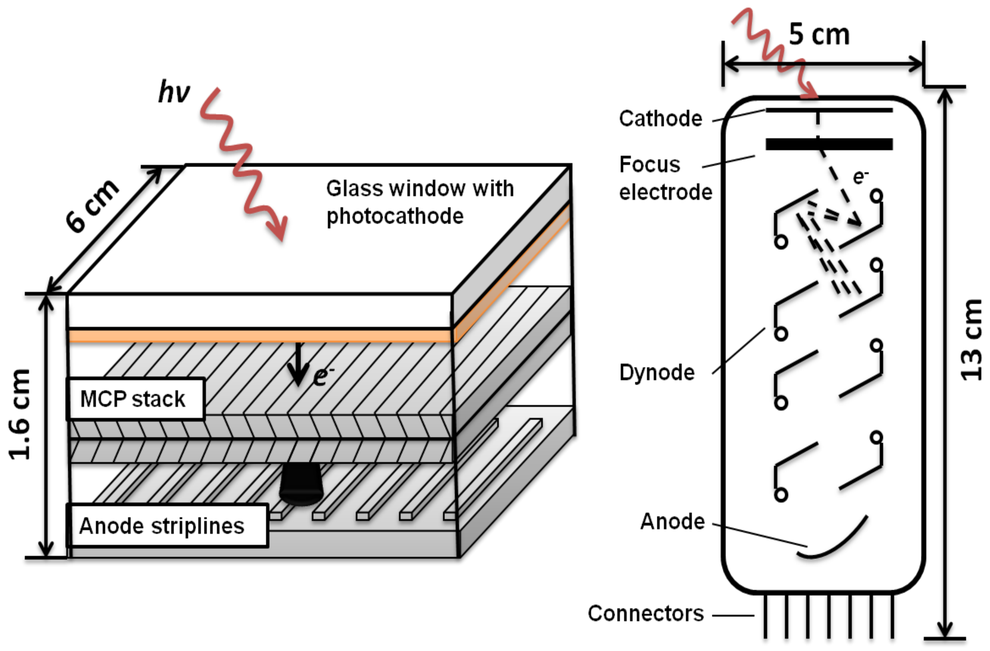
Introduction

Photomultiplier tubes (PMTs) have been widely used in high energy physics particle detection methods, such as time of flight (TOF) measurements, calorimetry and Cherenkov light detection. New or upgraded detectors in particle and nuclear physics call for next generation photo detectors with high time and position resolutions as well as low cost, large area, high quantum efficiency (QE), high gain, low dark current and time of flight response.

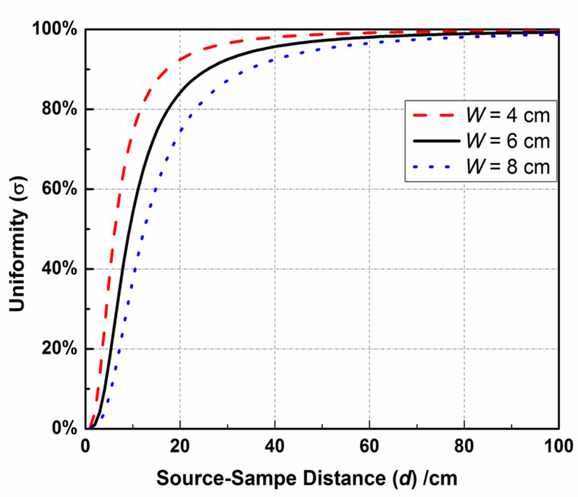
The large-area picoseconds photodetector (LAPPD) collaboration, a joint effort of Argonne National Laboratory, the University of Chicago, the University of California-Berkeley, the University of Hawaii, and industry partner Incom, Inc., is currently developing large-area, modular photo-detector systems composed of thin, planar, glass-body modules based on newly developed MCP technology. The overall goal of this research project is to develop 20 cm x 20 cm large-area photodetectors capable of mm-scale spatial resolution and pico-second time resolution. A new photodetector production facility capable of producing 6 cm x 6 cm photodetector was designed and constructed at Argonne National Laboratory as a low cost, lower risk path towards commercialization of large area picosecond photodetectors. The new facility consists of load lock, MCP scrubing chamber, photocathode growth chamber and sealing chamber. Knudsen effusion cells, widely used in molecular beam epitaxy technique, are incorporated into the photocathode growth chamber to achieve molecular beam sources for uniform stoichiometric bialkali K_2CsSb photocathode growth. This poster presents the structure of 6 cm x 6 cm MCP photodetector, the design concept and commissioning of photocathode growth chamber and the fabrication and initial test results of prototype MCP photodetector with bialkali photocathode.

6 cm x 6 cm MCP photodetector assembly



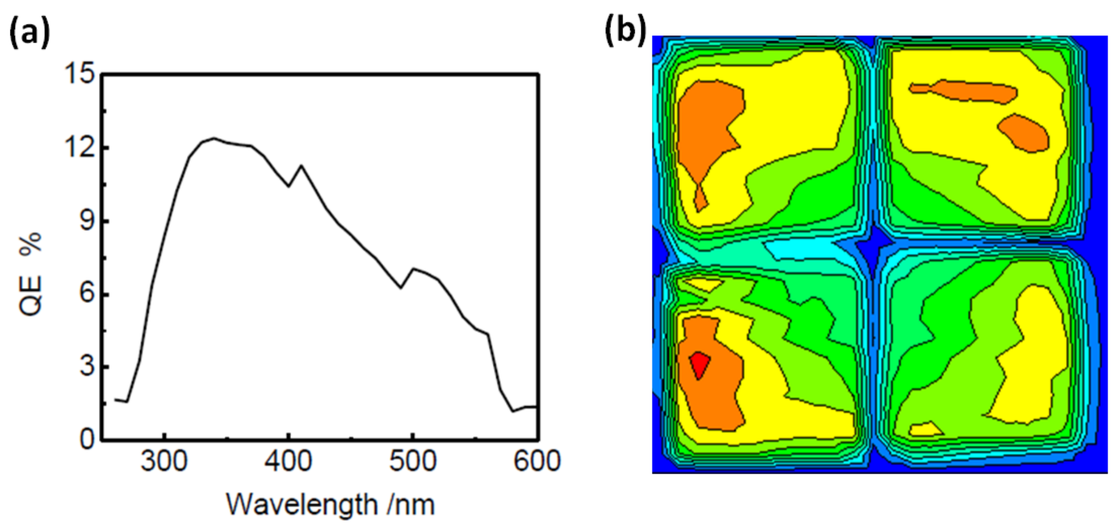
Schematics of MCP-based photodetector (left) and conventional photomultiplier (right). note the dimensions are not drawn in scale. The dynode series in conventional PMT are replaced by thin MCP stacks and so the volume of the MCP-based photodetector is significantly reduced. The planar design also provides high position resolution.

Simulation of uniform film deposition



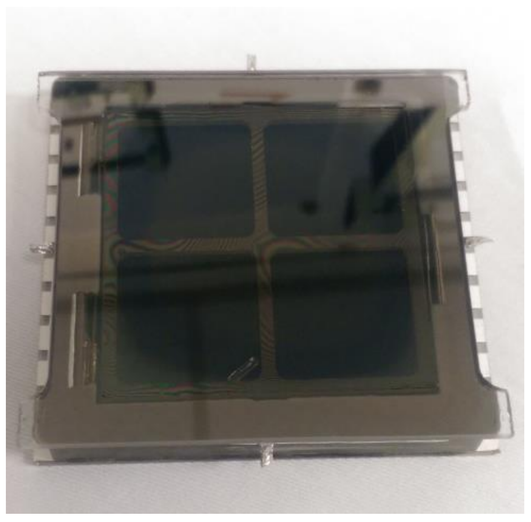
Uniformity dependence on source-sample distance and sample size. For our system, the photocathode substrate size is 6cm x 6cm, thus the minimum source-sample distance is ~ 40 cm to achieve non-uniformity better than 5%.

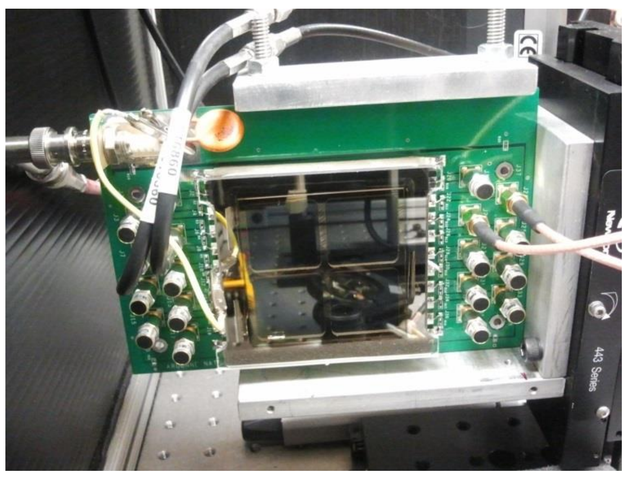
Growth and characterization of bialkali photocathode



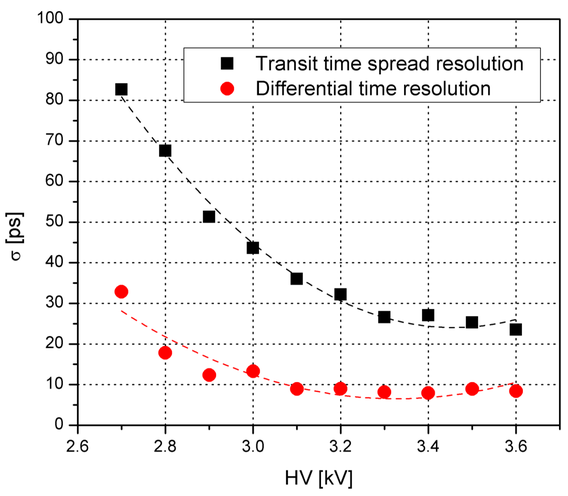
(a) The dependence of the photocathode QE on the wavelength ranging 250 nm – 600 nm. The photocathode exhibits peak QE ~13% at 350 nm. (b) QE uniformity of the photocathode on 6cm X 6cm glass substrate, the blue cross and edge areas are due to the spacer in contact with the photocathode.

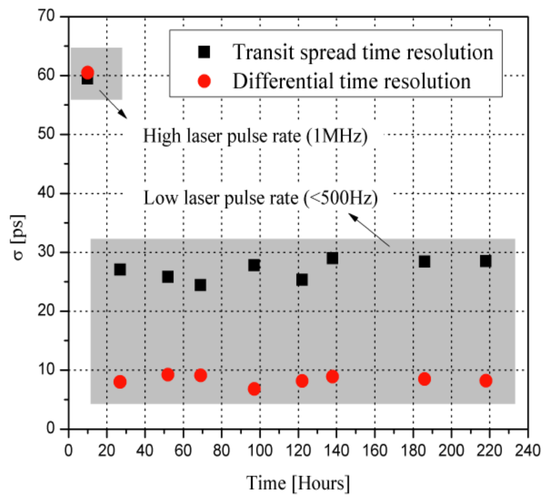
Prototype of 6 cm x 6 cm photodetector





(Left) Image of 6 cm x 6 cm photodetector prototype, spacers and MCPs are visible through the light brown color photocathode. (Right) 6 cm x 6 cm photodetector prototype under testing. The device is connected to electronic readout board through the silver strip lines.





(Left) Time resolution of the prototype photodetector can reach as low as 25 ps, position resolution can reach as low as 8 ps, corresponding to 1.2 mm. (Right) The life time test of 6 cm x 6 cm photodetector prototype, no decay was observed after 10 days of fabrication.

Acknowledgements

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