Use of Flat Panel Microchannel Plates in Sampling Calorimeters with Timing

Anatoly Ronzhin (Fermilab) and Henry Frisch (EFI, Univ. of Chicago)

White Paper submitted to Snowmass 2013

April 9, 2013

Electron multipliers were first proposed as the active elements in calorimeters in 1990 [1]. The attractive properties of such calorimeters are: 1) a 2-dimensional map of energy at each sampling depth; 2) timing information at each depth; and 3) possible separation of electromagnetic and hadronic energy based on the differences in timing and spectrum of Cherenkov and scintillation light [2,3].

An electron-multiplier-based sampling calorimeter requires thin planar detectors at an affordable cost. Large-area photodetectors based on ALD-functionalized 20-cm-square borosilicate glass capillary micro-channel plates (MCPs), currently being developed by the LAPPD Collaboration [4], are candidates for the active elements.

Here we propose using large-area MCPs assembled without the usual bialkali photocathodes as the active element in sampling calorimeters, as described in Ref. [1]. LAPPD modules without photocathodes can be economically assembled in a glove box and then pumped and sealed using the process to construct photomultipliers, bypassing the slow and expensive vacuum-transfer process required by bialkali photocathodes[5].

The first use of electron multipliers, in this case MCPs, as an active element in multi-layer sampling calorimeters is described in Ref. [1]. A chevron of two MCPs in vacuum (left-hand panel of Fig. 1) was located behind a tungsten plate on which 5 GeV and 26 GeV electrons were incident as shown in the middle panel of Fig. 1. The amplitude of the MCP signal (right-hand panel) as a function of the tungsten thickness was measured. The primary electrons produce a shower of secondary particles, including positron-electron pairs and gammas; the response of the MCPs is proportional to the number of particles in the shower, which is dependent on the initial particle energy.

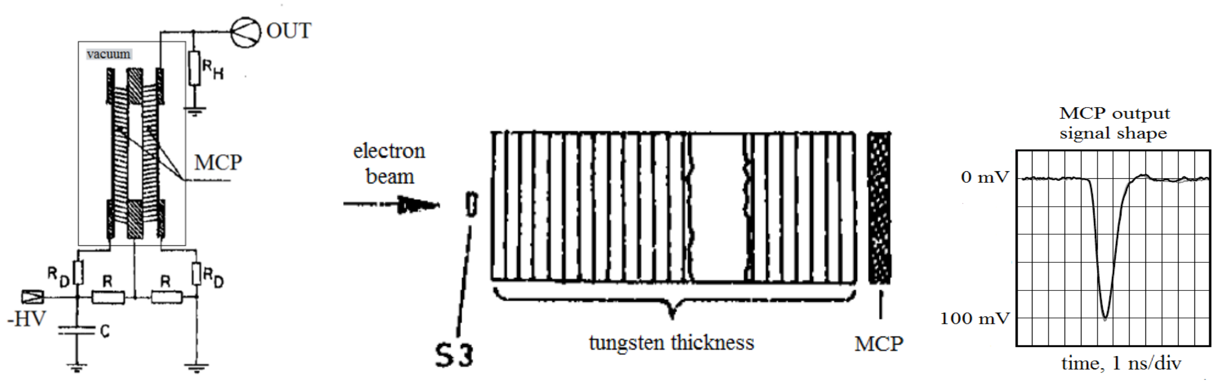

Fig 1. The electrical schematic of the tested device based on 2 MCPs (Left), the beam setup (Middle) and a typical signal trace (Right) . The output signal is very short (~2.5 ns). The signal amplitude depends on the thickness of the tungsten absorber.

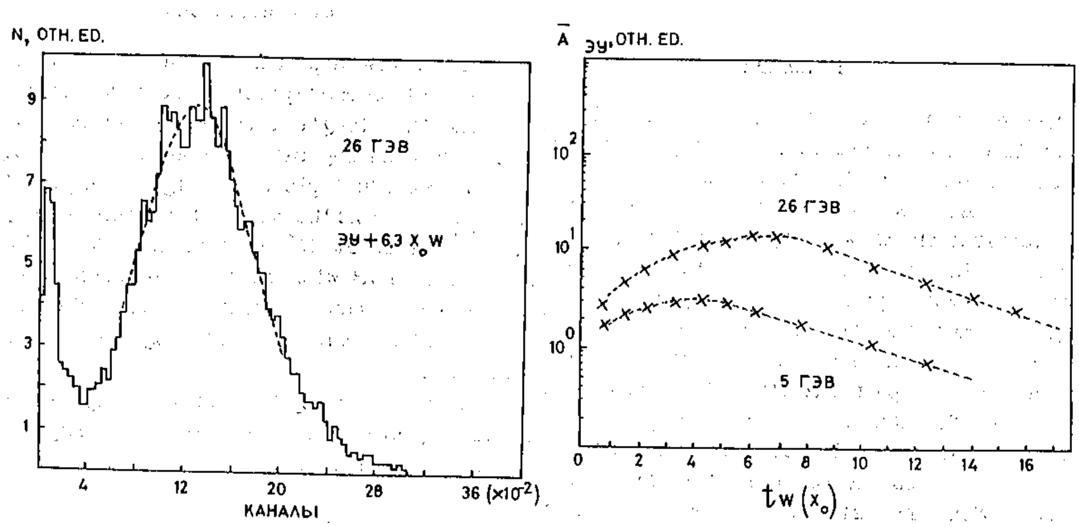

Fig 2. Left: the measured pulse height spectrum from the MCP chevron pair for 26 GeV electrons after 6.3 radiation lengths of tungsten absorber. Right: the measured shower profile for 26 (top) and 5 GeV (bottom) electrons versus depth in radiation length (from Ref. 1).

We propose to investigate the possibility of producing an electromagnetic calorimeter based on W and Pb absorber plates sandwiched with LAPPD detectors. Measurements can be made with bare plates, Cherenkov radiators, and/or scintillator. The LAPPD Collaboration has developed a thin, flat, system package that provides both 2D energy maps and correlated timing, including a vertical slice of a complete DAQ system [6]. Tests will be made with a fast laser, radioactive sources, and test beams at Fermilab and/or SLAC. If the results are promising we would like to construct and test a full-size electromagnetic calorimeter module large enough to contain high-energy showers, although this will require investment in additional chips, boards, and person-power.

We thank our all our colleagues in LAPPD, with special thanks to Joe Gregar of the ANL glass shop for his superlative glass work, on which this development depends.

Bibliography:

1. A. A. Derevshchikov, V. Yu. Khodyrev, V.I. Kryshkin, V.E. Rakhmatov, A. I. Ronzhin, "On possibility to make a new type of calorimeter: radiation resistant and fast". Preprint IFVE 90-99, Protvino, Russia, 1990.

2. H. J. Frisch, "The Development of Large-Area Thin Planar Psec Photodetectors", IEEE Nuclear Science Symposium and Medical Imaging Conference, Knoxville Ky, Oct. 2010

3. Frisch H. J.; Genat, J-F; Grabas,H; Kao, C-M; Chen, C-T; Kim, H. ; Tang, F; Pending US Patent Application 13/044,442 USE OF FLAT PANEL MICROCHANNEL PHOTOMULTIPLIERS IN SAMPLING CALORIMETERS WITH TIMING

4. The LAPPD Collaboration: see http://psec.uchicago.edu. The link to the Library leads to links to the Document, Figure, and Image Libraries, as well as Workshops on Fast Timing, Photocathodes, and applications.

5. The highly-reactive nature of bialkali photocathodes precludes exposure to air.

6. E. Oberla, "A Fast Waveform Digitization ASIC-based DAQ for a Position- and Time-Sensing Large Area Photodetector System, PHOTDET2012, LAL Orsay, June 2012.