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MCP as secondary emission (SE) active layer for fast and high radiation resistant Shower Maximum (SM) detector or calorimeter

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MCP Based Detectors,

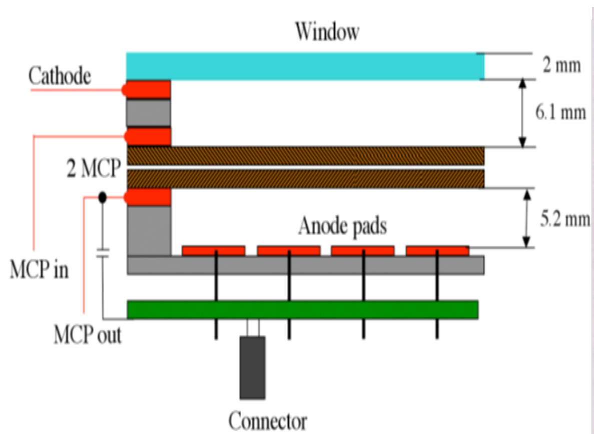
December 3, 2014, ANL

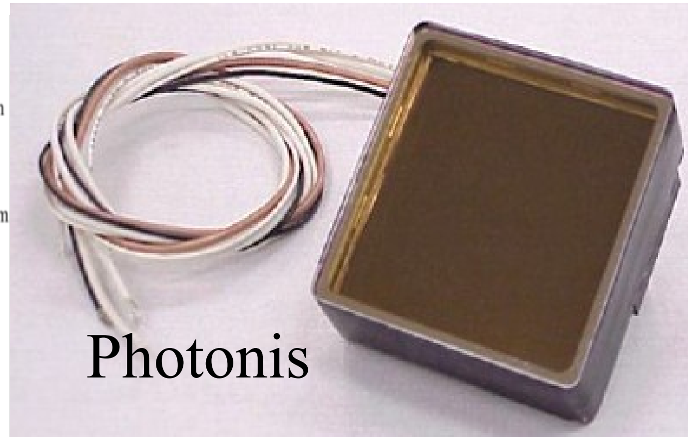
We proposed to use an electron multipliers, e.g. MCPs, venetian blind or meshes dynode as the active elements for new type of calorimeters (rad resistant and fast) in 1990 [1].

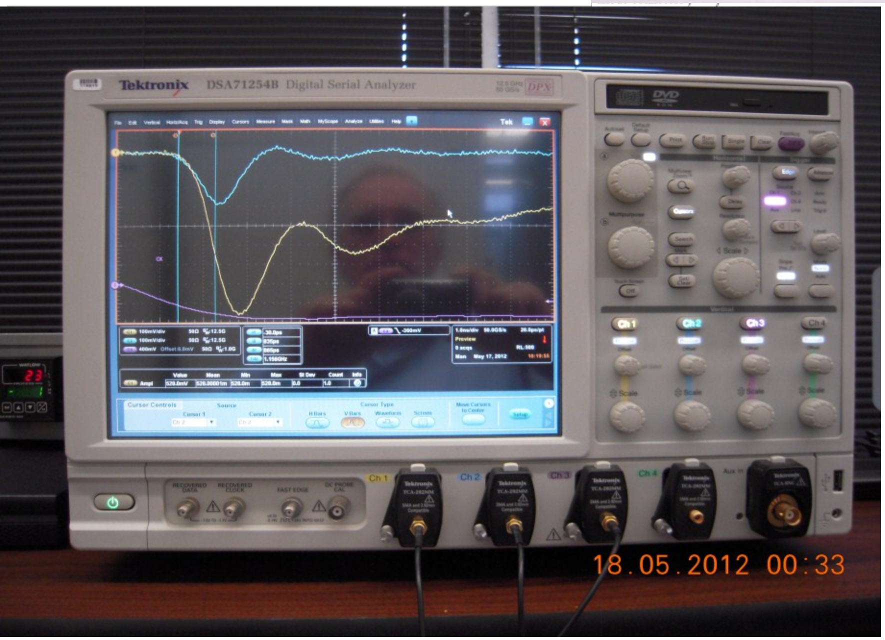
- Proposed approach allows to make a fast and radiation resistant calorimeter or shower maximum (SM) detector. The longitudinal shower profile was measured at 5 GeV and 26 GeV electron beams. The obtained signal was very short (~1 ns) with big pulse amplitude (up to 100 mV/100 Ohm). This was clear approval of efficient direct detection of secondary particles of electromagnetic (EM) shower. We had not reliable MC for EM shower secodaries below 10 keV, that's why we did the measurements.
- The cost of MCP was the main limit to make such detectors. That's why we stopped the R&D about 25 years ago. But the cost could be reduced significantly (due to LAPPD), that's why we started the R&D again. We should emphasize that we do not need LAPPD photocathode (PC) for the application. This also could be additional saving in development of such detectors.
- Up to now we have measured: timing of SM with MCP at FTBF and got ~37 ps of time resolution. We have approved T1058 experiment at FNAL. The goal is to make and test secondary emitter calorimeter (SEC). LAPPD MCPs without photocathode (PC) could be one of the option of active layers in such calorimeter. Another attractive properties of such SM or calorimeter could be 2-dimentional map of energy and timing information at each sampling depth, and possible separation of electromagnetic and hadron's energy based on difference in timing and size.

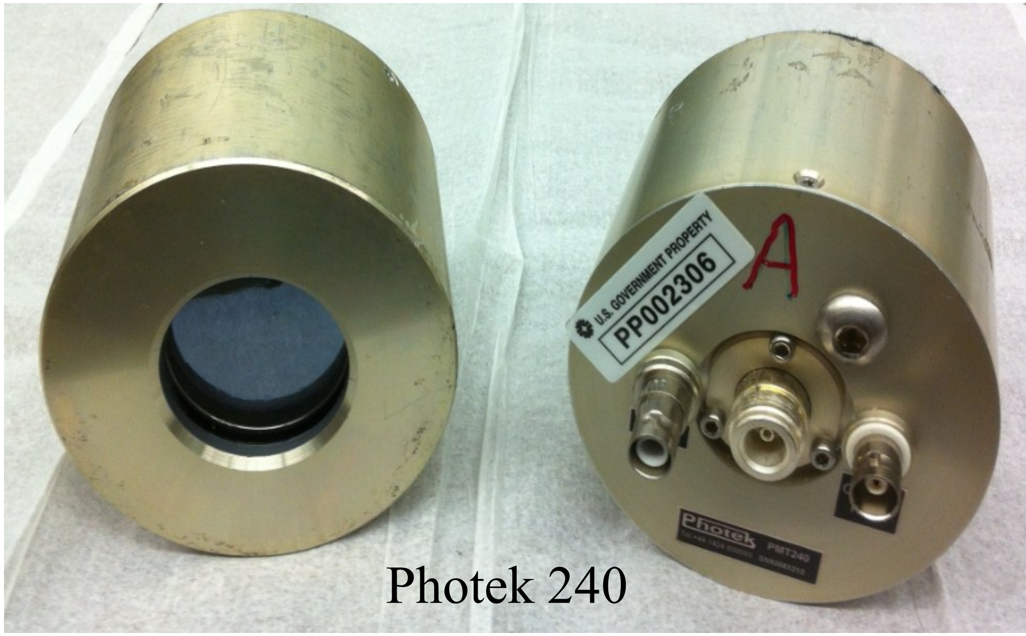
[1] On possibility to make a new type of calorimeter: radiation resistant and fast. Derevschikov A. at al., Preprint IHEP 90-99, Protvino, 1990.

Best MCP-PMT for timing. Photek 240, Photonis XP85012. MCP w/o PC are also good









DSA7125B digital serial analyzer, 20 ps sampling, borrowed from AD, we made database for Spicing

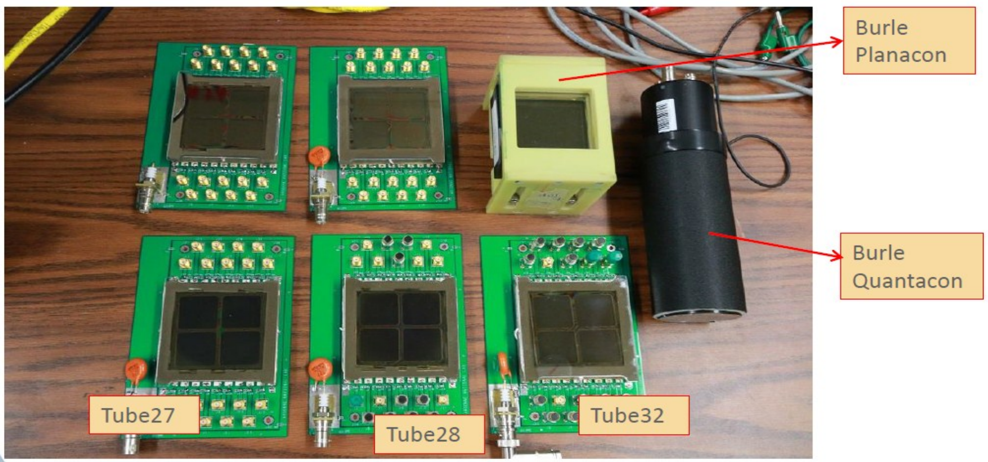
Timing nonuniformity of the Photek 240 across 41 mm diameter <1.7 ps. SPTR ~35 ps.

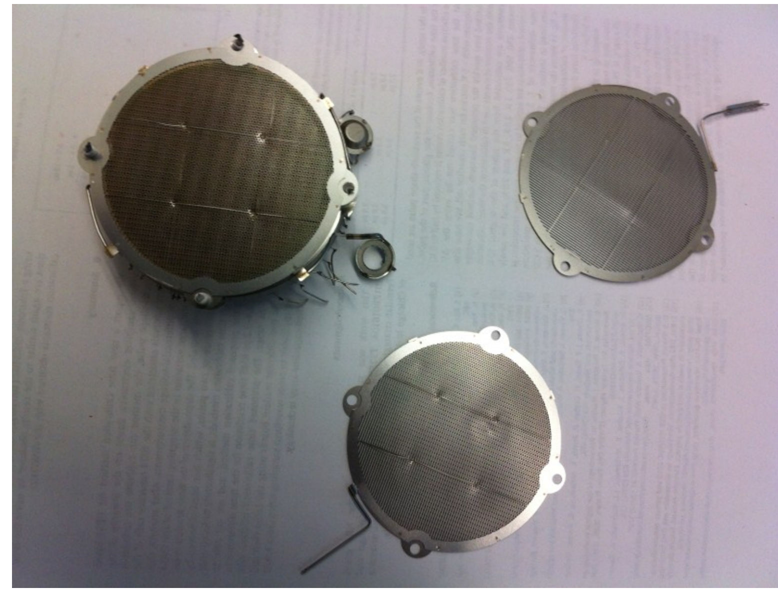
"Development of a 10 ps level time of flight systems in the Fermilab Test Beam Facility". A. Ronzhin, M. Albrow, M. Demarteau, S. Los, S. Malik, A. Pronko, E. Ramberg, A. Zatserklianiy. NIM, A 623 (2010) 931-941.

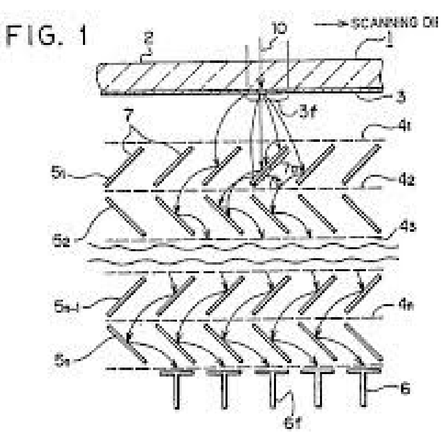
During LAPPD review at ANL on October 21, 2014, we agreed to test the 6 cm x 6 cm MCP, produced at Argonne as an active layer of the SM detector at Fermilab TB.

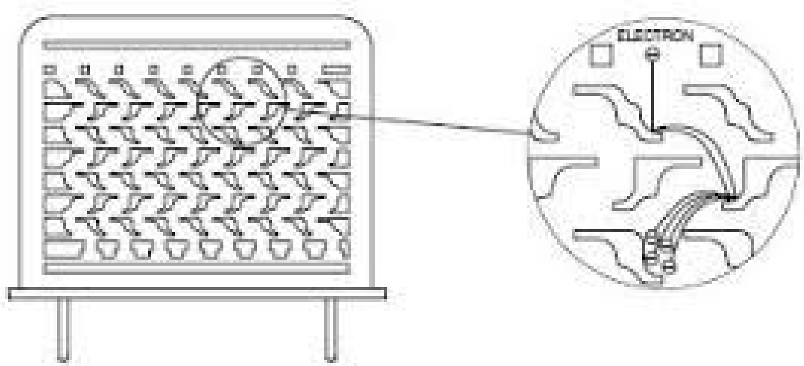
Another possible SE options to test for SM could be meshes, venetian blinds, etc.

- Burle Quantacon and Planacon MCP-PMT as reference detectors
- Tube27, Tube28 and Tube32 tested with a blue laser @ANL-HEP



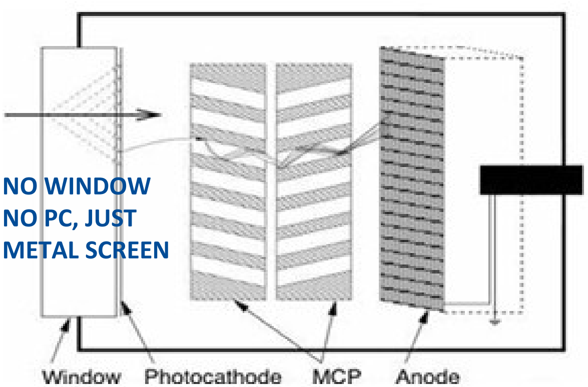


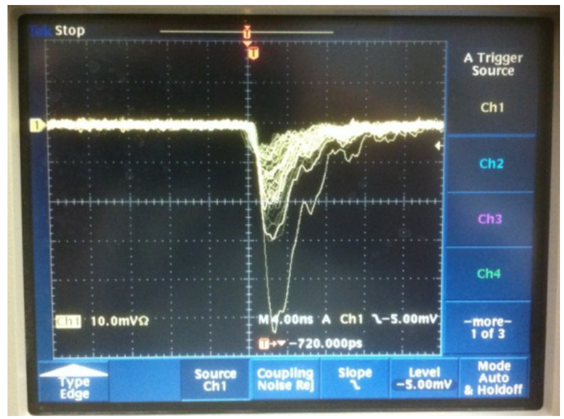


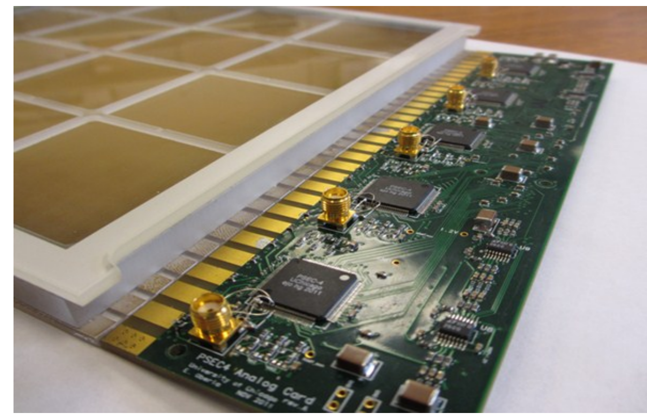


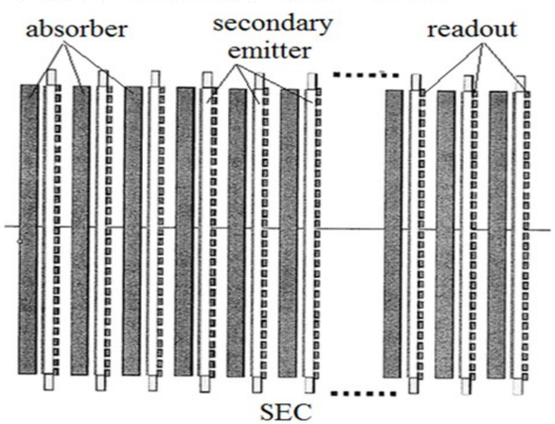
FNAL, Caltech, UC. Test of Shower Maximum (SM) Detector at FTBF. Possibly to insert the SM into CMS HGCAL, needs in ~15 mm of slot size. Status T1058, SEC.

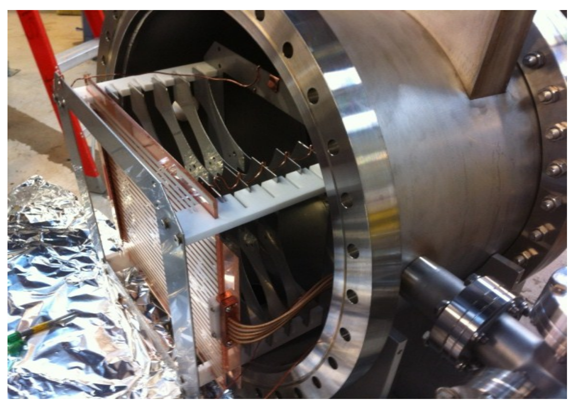
MCP is an electron multiplier that detects and multiplies electrons in two dimensions. MCP is sensitive to ions, vacuum UV rays, X-rays, etc., and so can be used as devices to detect their position and energy. So far radioactive sources to check MCP functionality used. But we still need more precise tool to monitor and control stability of MCP gain, noise, etc. It is no PC.

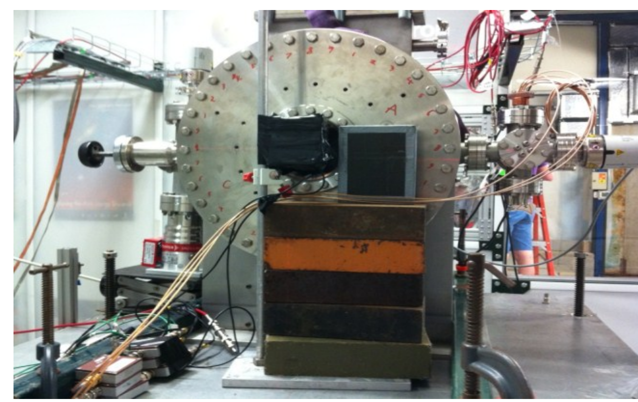












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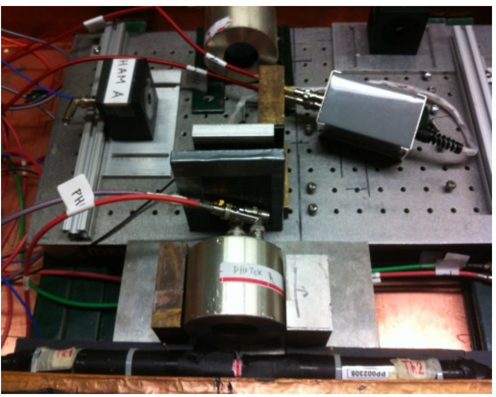
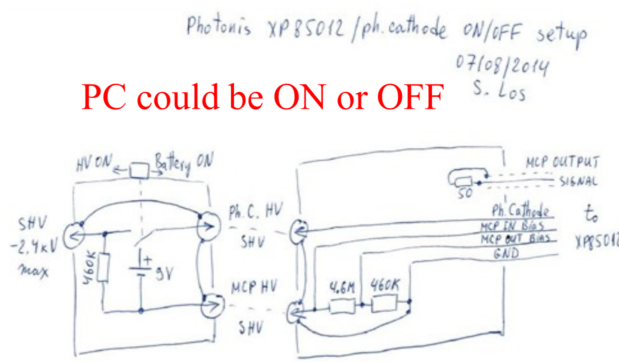
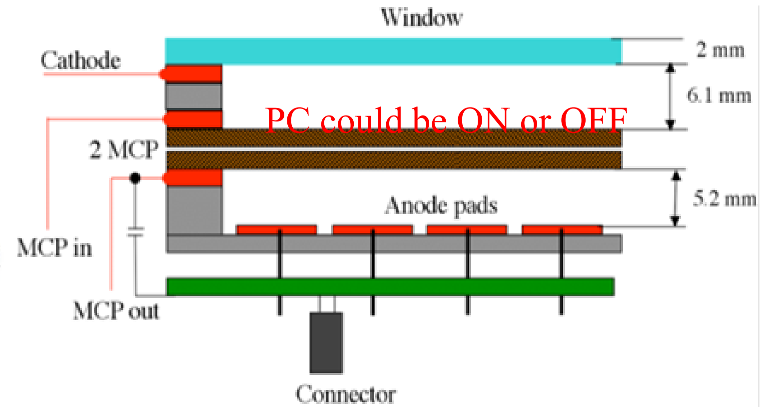
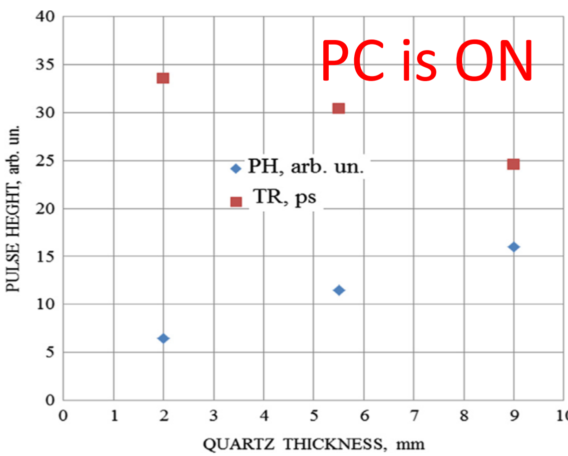
FNAL, Caltech, UC. Development of a New Fast Shower Maximum Detector based on Micro Channel Plate as an active element.

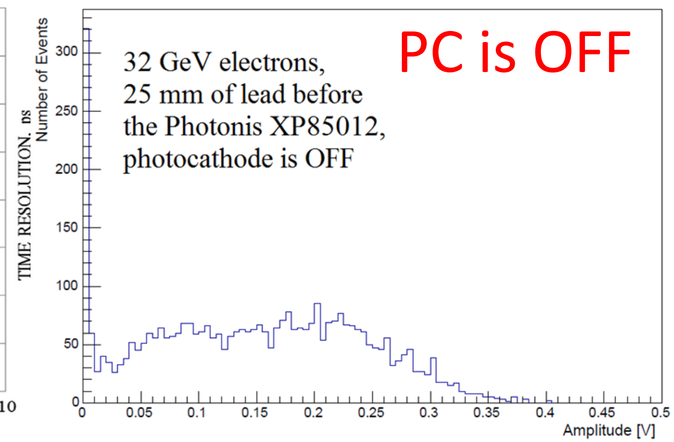
MCP- PMT and direct measurements with Micro Channel Plate (MCP) as shower maximum detector performed at the Fermilab Test Beam Facility with 120 GeV primary proton beam and 8 GeV, 16 GeV and 32 GeV secondary beams. We obtained time resolution for the SM detector based on the MCP at the level of ~37 ps and ~100% registration efficiency. This demonstrate that SM secondary particles detect well by the MCP.

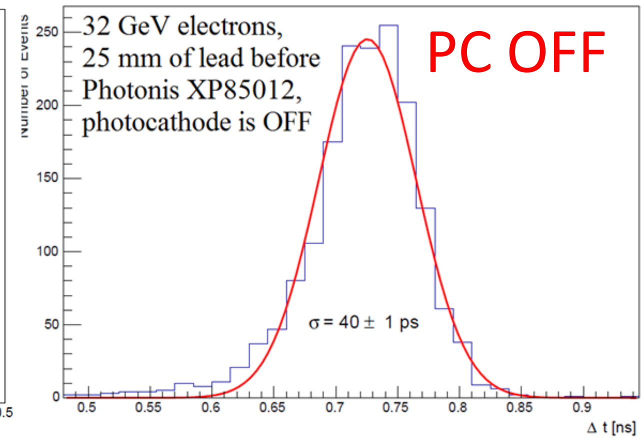












"Development of a new fast shower maximum detector based on micro channel plates photomultipliers (MCP-PMT) as an active element".
A. Ronzhin, S. Los, E. Ramberg, M. Spiropulu, A. Apresyan, S. Xie, H. Kim, A. Zatserklyaniy. NIM, A759 (2014) pp. 65–73.

Summary and Future Plans

- Next test beam. Chevron program. Continue study of SMs with secondary emitters (SE) as an active layer. Check MCPs of different size. Test different absorber materials. Currently we study SM with XP85012 (PC OFF, 4x4) as the SM active layer. ANL, 6cmx6cm MCP PMT is another option. We also can study different type of SE (meshes, venetian blinds, etc.) for the SM depending on results of MCP irradiation (e.g. in Warrenville proton cancer center).
- We already obtained ~ 37 ps time resolution (TR) of the SM with MCP at FTBF. TR for PC ON a bit better due to Cherenkov light deposit. The TR is slowly dependent on electron beam energy in the range 8 GeV - 32 GeV. Continue timing improvement with new readout (Photonis XP850112, 8x8 matrix) based on fast wave forms digitizers (e.g. DRS4, PSEC). New digitizer test goal is to obtain more readout channels at low cost and check reliability. Test different type of readout with anodes as strip line (SL), pixels, and matrix. Goal is measurements of timing and spacing.
- We plan to make Monte Carlo for the SEC (Nikolai Mokhov, FNAL, CERN)
- Test beam. Continue test of SEC in frame of T1058. Check MCP efficiency and timing for MIPs, measure charge per tile and pulse shape examples with protons. Equalize the gains, inter calibrate different MCPs. Calibrate the strips within the MCP, scan perpendicular to strip lines, measure response uniformity, space and time resolution. Repeat some of measurements with muons for final calibration. Possible two shower separation, each anode pixel is readout separately.
- Measurements on electron beam. Measure longitudinal and transverse profiles. Time resolution between individual tiles. Time resolution with respect to the reference. Resolution on the start of the shower position, transverse and longitudinal, energy resolution.
- Perform energy scan going up in electron energies to 8, 12, 16, 20 GeV.
- Perform MCPs radiation study.