Abstract

i-MCP is an R&D project aimed at the exploitation of secondary emission of electrons from the surface of micro-channel plates (MCP) for fast timing of charged particles and showers in high rate environments. The usage of MCPs in “ionisation” mode has long been proposed and is used extensively in ion time-of-flight mass spectrometers. What has not been investigated in depth is their use to detect the ionizing component of showers. The fast time resolution of MCPs exceeds anything that has been previously used in calorimeters, and, if exploited effectively, could aid in the event reconstruction at high luminosities. Results from tests with electrons with energies up to 150 GeV of MCP devices with different characteristics will be presented, in particular detection efficiency and time resolution.

Pile-up @ future hadron colliders

Pile-up at hadron colliders: several interactions per bunch-crossing. LHC Run1 = 25 PU
HL-LHC (2024): 140 PU. Time spread ~200ps
Significant deterioration of forward calorimeter performance is expected in very dense environment

Ideas: use time-of-flight information in calorimeters to aid the full event reconstruction [1]
- pile-up mitigation: remove energy deposits in calorimeters not associated to the hard interaction (e.g. pile-up jets identification, improve MET resolution...)
- triangulate high energy photons from Higgs decay

Test beam results of MCP in “ionisation mode” for detection of single charged particles and EM showers

MCP as MIP/EM shower TOF detector

PMT-MCP mode
- High efficiency & excellent time resolution (~20ps)
- Issues: lifetime + radiation hardness of photocathode

i-MCP mode
- Secondary emission in the MCP, no photocathode
- Potentially more radiation hard, robust/easier assembly

Test performed @ BINP
Superconducting coil: 0-4.5T
Picoscend laser on PMT-MCP (8μm)
λ=823nm
pulse width 30ps (FWHM)
10-30 photoelectrons per pulse
Moderate loss up to 3T, bigger losses beyond that: loss ~ factor 15 for axial field @ 4T
Expected to scale with pore size: to be checked with 4 μm pores

Conclusions & next steps

i-MCP detector offers an excellent candidate for a fast, efficient and radiation hard detector to be used in future hadron colliders
- single charged particle: reached ~70% efficiency with 30ps time resolution
- EM showers: 100% after 2 Xe, 25ps time resolution

i-MCP can be integrated in a pre-shower device independent of the EM calorimeter technology used
- EM energy resolution contribution to be fully verified

R&D is progressing further. MCP configurations under test
- higher aspect ratio MCP (1:90)

References


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