TWEPP 2008

Transmission-Line Readout with Good Time and Space Resolutions for a Planicon MCP-PMT

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Abstract

Time-of-flight techniques with resolution of a one to several picoseconds would allow the measurement of 4-vectors of relativistic particles at high energy colliders, the association of photons with collision vertices, and the construction of spectrometers with which to study muon cooling without magnetic spectrometers.
In order to take advantage of photo-detectors with intrinsic single photo-electron resolutions of tens of picoseconds to build large-area time-of-flight systems, one has to solve the problem of collecting signals over distances large compared to the time resolution while preserving the fast timing properties inherent in the small feature size of the detectors themselves. The solution also has to have a manageable number of electronics channels and low total power. We present here the design of transmission-line readout for a Photonis Planicon micro-channel plate photomultiplier tube (MCP-PMT) that has these characteristics. The MCP-PMT is characterized by single pulse rise times in the order of 200 pSec and transit time spreads (TTS) in the order of 30 pSec, and an anode 32 by 32 array of pads (1024 total). The readout is implemented on a Rogers 4350B printed circuit board with 32 parallel 50-ohm transmission lines on 1.6 mm centers, each traversing one row of pads. The board is soldered to the 32 by 32 array; each transmission line being read out on each end.

We have simulated the electrical properties of the transmission-line readout board with Hyperlynx and Spice simulators. The simulations predict that the readout transmission-lines can achieve a signal bandwidth of 3.5GHz, which should not significantly degrade the time and spatial resolutions intrinsic to the MCP-PMT signals.

The ultimate goal in the front-end electronics is to develop a custom ASIC that incorporates fast sampling of the MCP pulses. This design is in progress. As an intermediate step, we will test the transmission-line architecture using a 40-GS/sec digital oscilloscope as well as Ortec constant-fraction discriminators and time-to-digital converters having approximately 3 pSec resolution. The system will first be tested using the Argonne laser test stand. A first test of the assembled system with relativistic particles is scheduled in the Fermilab Mtest test beam for June 2008. Results from the simulation and tests will be presented.