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Development and Progress of the Readout Electronics for STCF ECAL

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Super Tau-Charm Facility (STCF) is one of important options for accelerator-based particle physics after Beijing Electron-Positron Collider (BEPC-II) in China, which aims at ultra-precise measurement and new physics search in tau-charm energy region with about 100 times higher luminosity. The electromagnetic calorimeter (ECAL), as an important part of the spectrometer, needs to meet the demand of high-efficiency and high-resolution gamma detection, electron and hadron discrimination, etc. STCF ECAL is designed as a fully absorbing detector, and its absorber is selected as Pure CsI (pCsI) owing to the fast response (30 ns decay time), high mass density and good radiation hardness. Due to the relatively low light yield of pCsI and the strong magnetic environment in the experiment, avalanche photodiode (APD) is adopted to convert the scintillation light into current signal with a gain of about 50. Based on the detection unit composed of pCsI and APD, the readout electronics needs to meet the following requirements according to simulation:

- 6732 crystals in barrel, 1938 crystals in endcap
- Single channel hit rate about 400 kHz in barrel and 3 MHz in endcap
- High background about 1 MHz in barrel and 10 MHz in endcap
- Dynamic range from 2 fC to 2000 fC with input equivalent noise charge less than 0.4 fC
- Time resolution better than 150 ps (1GeV) for γ/ n separation

Charge sensitive amplifier (CSA) is selected to measure the scintillation current from APD. By optimization of amplification stage and shaping time, the readout electronics realizes a noise performance of about 0.16 fC with one S8664-0505 APD. In time measurement, a time resolution better than 150 ps is achieved with leading-edge timing and Time-to-Digital Converter (TDC) integrated in Field-Programmable Gate Array (FPGA). Due to the high luminosity of STCF, the time information of piled up signals would be lost in leading-edge timing. Time measurement based on waveform fitting is also studied and a similar performance is also realized, which satisfies the requirements.

Summary

STCF will provide a unique platform for Tau-Charm physics and hadron physics research in China. ECAL as an important part of the spectrometer, its performance will directly affect the experiment results. In this report, a readout electronics for STCF ECAL based on CSA is studied. A noise level of 0.16 fC is realized with one S8664-0505 APD connected. In terms of time measurement, a timing accuracy of 150 ps is achieved for the electronics with leading-edge timing. To avoid loss of time information caused by pile up in leading-edge timing, the method of waveform fitting is also studied and a similar performance is achieved, which meets the demand of requirements.

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