Modern e−e− colliders will reach an exceedingly high level of luminosity, like SuperKEKB, Super Charm-Tau Factory (SCTF) proposed by Russia, and Super Tau-Charm Facility (STCF) proposed by China. Under such a high event rate and additional beam background, the electromagnetic calorimeter should be capable of maintaining good energy and position resolution while dealing with pile-up pulses and fake signals. A calorimeter system based on fast pure CsI crystal, read out by avalanche photodiodes, highlighting good time resolution and high granularity is designed for STCF. This poster will expand from three aspects: Tests of the scintillator counter; Geometry optimization and simulated performance of calorimeter system; Severe performance deterioration caused by beam background with possible solutions.

Abstract

Modern e−e− colliders will reach an exceedingly high level of luminosity, like SuperKEKB, Super Charm-Tau Factory (SCTF) proposed by Russia, and Super Tau-Charm Facility (STCF) proposed by China. Under such a high event rate and additional beam background, the electromagnetic calorimeter should be capable of maintaining good energy and position resolution while dealing with pile-up pulses and fake signals. A calorimeter system based on fast pure CsI crystal, read out by avalanche photodiodes, highlighting good time resolution and high granularity is designed for STCF. This poster will expand from three aspects: Tests of the scintillator counter; Geometry optimization and simulated performance of calorimeter system; Severe performance deterioration caused by beam background with possible solutions.

Introduction

The proposed Super Tau Charm Facility in China is a symmetric double ring electron-positron collider. It is designed to have a center-of-mass energy ranging from 2 GeV to 7 GeV, and peaking luminosity beyond $0.5 \times 10^{32} \text{cm}^{-2}\text{s}^{-1}$ at $\sqrt{s} = 4\text{GeV}$. It also maintains the potential for luminosity upgrade and beam polarization in the future.

Tests of the scintillation counter

STCF EMC is a homogeneous calorimeter consisting of more than $8000$ scintillation counters. The main components of one counter are listed below:

- Pure CsI crystal: $5 \times 5 \times 28\text{cm}^3$, $\tau \approx 10\text{ns}$, can tolerate more than $1 \times 10^9$ rad TID.
- Avalanche photodiode: $4 \times 10 \times 10\text{mm}^2$, $\text{QE} = 70\%$ ($\geq 420\text{nm}$), Gain = 50.
- Tetroxet 3 $\times 75\text{ mm}$ thickness, reflectance $> 0.95$ $\%$ at $300\text{nm}$.
- CSA based electronics: By using 3 JFET in parallel, the total electronic noise is $1025\text{e}$ under room temperature [1].

Geometry design and simulated performance of ECAL system

To mitigate the effect of energy leakage in gap between crystals, a defocusing ECAL geometry is proposed. In both x-y plane and x-y plane, the direction of gaps are tuned away from interaction point.

Based on GEANT4, simulation result shows that the front end size of crystal should be smaller than $3 \times 3\text{cm}^2$ to achieve a position resolution better than 4 mm. Meanwhile, no apparent deterioration of energy resolution is observed for smaller crystal.

Effect of pile-up and possible solution

On STCF, the event rate of secondary photons induced by beam background exceeds $1 \times 10^8\text{Hz}[2]$. This will result in large fake photon rate and severe pile-up effect. According to GEANT4 simulation, energy resolution gets 4 times worse under 50 MeV.

Conclusion

- A light yield of $155\text{pe}/\text{MeV}$ is achieved based on a pure CsI scintillation counter.
- The overall geometry design and performance simulation are finished, indicating the crystal with a size of $3 \times 3 \times 26\text{cm}^3$ satisfies position resolution requirement.
- finish based multi-pulse fit shows decent performance to deal with pile-up effect under small electronic noise.
- Further work on improving counter SNR, counter timing performance and mitigating pile-up effect are undergoing.

References
