

## Studies on timing performance of BGO crystal scintillator

The future Circular Electron-Positron Collider (CEPC) is envisioned as a large-scale Higgs factory. For the CEPC detector system, a highly granular crystal electromagnetic calorimeter has been proposed to provide 5D information, incorporating x, y, z, E, and t dimensions. This calorimeter features a homogeneous structure with long crystal scintillator bars as the active material, with BGO and SiPM being the preferred components. Time information plays an increasingly critical role in calorimeters. It not only helps to distinguish pile-up effects but also aids in particle identification, shower reconstruction, and enhances the energy resolution of the calorimeter. Consequently, optimizing and understanding the timing performance of this detector design is essential.

The timing resolution of the detector unit, which consists of a BGO crystal and two SiPMs, was optimized using various methods through cosmic ray experiments. The best time resolution at the 1-MIP level for a 40 cm BGO crystal coupled with a specific SiPM is around 1 ns. In beam tests conducted in 2023, the timing resolution of BGO crystal bars under high-energy electron showers was studied, achieving a resolution of 200 ps for signals exceeding 12 MIPs. The study also found that shorter crystals exhibited better time resolution, and the long crystal bars demonstrated good timing resolution uniformity. Additionally, simulations were conducted to investigate the impact of various factors on timing resolution, such as crystal length, decay time, and light yield, as well as the timing characteristics of new materials like BSO.

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