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A novel high-granularity crystal calorimeter

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Future electron-positron colliders, or Higgs factories, impose stringent requirements on the energy resolutions of hadron and jets for the precision physic programs of the Higgs, Z, W bosons and the top quark. Based on the particle-flow paradigm, a novel highly granular crystal electromagnetic calorimeter (ECAL) has been proposed to address major challenges from the jet reconstruction and to achieve the optimal electromagnetic energy resolution of around $2-3\ \%/\sqrt{E(GeV)}$ with the homogenous structure.

R&D efforts are ongoing to evaluate the requirements on the sensitive detector units and and physics potentials of the crystal calorimeter concept within a full detector system. The requirements on crystal options, photon sensors as well as readout electronics are parameterised and quantified in a full simulation model based on Geant4. Experiments including characterisations of crystals and silicon photomultipliers (SiPMs) have been followed to validate simulation results and optimise simulation parameters. A small-scale ECAL module with a crystal matrix and SiPM arrays is under development for future beam tests to study the performance of EM showers.

Physics performance of the crystal ECAL has been studied with some Higgs physics benchmarks using the particle-flow algorithm "ArborPFA". Compared with the sampling structure of the existing high granularity calorimeters, the crystal ECAL option poses extra difficulties for the cluster pattern recognition and thus demands further PFA optimisations. Progress has been made on optimising the ArborPFA algorithm and parameters therein, leading to a significant improvement of the separation efficiency for close-by showers.

For the highly granular crystal ECAL, a new detector layout has been proposed with long crystal bars arranged to be orthogonal to each other in two neighbouring layers, and targets for a maximum longitudinal segmentation, minimum inactive materials in between and a significant reduction of readout channels (with 2-channel readout at both ends of each long crystal bar), but it also poses challenges of the pattern recognition and separation of close-by showers. Therefore, a dedicated reconstruction software is also being developed to address these challenges.

This contribution will present the latest results on the novel crystal ECAL, including simulation and reconstruction studies, hardware developments and physics potentials.

In-person participation

No

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