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Implementation of large imaging calorimeters

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The next generation of collider detectors will make full use of Particle Flow algorithms, requiring full imaging calorimeters. The latter have been developed during the past 15 years by the CALICE collaboration and are now reaching maturity. The state-of-the-art and the remaining challenges will be presented for all investigated readout types. We will describe the commissioning, including beam test results, of large scale technological prototypes and the raw performances such as energy resolution, linearity and studies exploiting the distinct features of granular calorimeters regarding pattern recognition. At the time of conference new results obtained in recent (2021/22) beam tests with a technological prototype of a highly granular silicon tungsten electromagnetic calorimeter standalone and combined with the CALICE analogue hadron calorimeter (SiPM on Tile) will be available. Further, the design of experiments addressing the requirements and potential of imaging calorimetry will be discussed. Promising techniques for dedicated devices inverse APD or segmented crystal calorimeters will also be highlighted. Recently, also first results with high resolution timing devices have been obtained. The integration of these devices in the CALICE prototypes is one of the major goals in the coming years.

Prototypes of electromagnetic and hadronic imaging calorimeters developed by the CALICE collaboration provide an unprecedented wealth of highly granular data of hadronic showers for a variety of active sensor elements and different absorber materials. We discuss detailed measurements of the spatial and the time structure of hadronic showers to characterise the different stages of hadronic cascades in the calorimeters, in comparison with GEANT4-based simulations using different hadronic physics models. These studies also extend to the two different absorber materials, steel and tungsten, used in the prototypes. The high granularity of the detectors is exploited in the reconstruction of hadronic energy, both in individual detectors and combined electromagnetic and hadronic systems, making use of software compensation and semi-digital energy reconstruction. The results include new simulation studies that predict the reliable operation of granular calorimeters. Further we show how granularity and the application of multivariate analysis algorithms enable the separation of close-by particles. Granular calorimeters are also an ideal testing ground for the application of machine learning techniques. We will outline how these techniques are applied to CALICE data and in the CALICE simulation framework.

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