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Exploring the structure of hadronic showers and the hadronic energy reconstruction with highly granular calorimeters

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Prototypes of electromagnetic and hadronic imaging calorimeters developed and operated 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. In this presentation, 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, which are then confronted 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. We will report on the performance of these reconstruction techniques for different electromagnetic and hadronic calorimeters, with silicon, scintillator and gaseous active elements. 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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