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Hadronic energy resolution of a highly granular scintillator-steel hadron calorimeter using software compensation techniques

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ABSTRACT: The energy resolution of a highly granular $1\,\mathrm{m}^3$ analogue scintillator-steel hadronic calorimeter is studied using charged pions with energies from 10 GeV to 80 GeV at the CERN SPS. The energy resolution for single hadrons is determined to be approximately $58\%/\sqrt{E/\mathrm{GeV}}$. This resolution is improved to approximately $45\%/\sqrt{E/\mathrm{GeV}}$ with software compensation techniques. These techniques take advantage of the event-by-event information about the substructure of hadronic showers which is provided by the imaging capabilities of the calorimeter. The energy reconstruction is improved either with corrections based on the local energy density or by applying a single correction factor to the event energy sum derived from a global measure of the shower energy density. The application of the compensation algorithms to GEANT4 simulations yield resolution improvements comparable to those observed for real data.

KEYWORDS: hadronic calorimetry; imaging calorimetry; software compensation.

Contents

1. Introduction

The physics goals of future high-energy lepton colliders such as the ILC [1] or CLIC [2] put stringent requirements on the detector systems. For example, the efficient event-by-event separation of heavy bosons in hadronic final states requires a jet energy resolution of better than 4% [1]. This is achievable with Particle Flow Algorithms (PFA) combined with highly granular calorimeters [3, 4, 5]. The CALICE collaboration has constructed and extensively studied highly granular electromagnetic and hadronic calorimeter prototypes to evaluate detector technologies for future linear collider experiments. These calorimeters have been successfully operated in various test beam experiments in different configurations at DESY, CERN and Fermilab from 2006 until 2012. The unprecedented granularity of the CALICE calorimeter prototypes allows the structure of hadronic showers to be studied with high spatial resolution, in order to validate different simulation

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