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New Developments in Calorimetric Particle Detection

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Abstract

In nuclear, particle and astroparticle physics experiments, calorimeters are used to measure the properties of particles with kinetic energies that range from a fraction of 1 eV to 10^{20} eV or more. These properties are not necessarily limited to the energy carried by these particles, but may concern the entire four-vector, including the particle mass and type. In many modern experiments, large calorimeter systems play a central role, and this is expected to be no different for experiments that are currently being planned/designed for future accelerators.

In this paper, the state of the art as well as new developments in calorimetry are reviewed. The latter are of course inspired by the perceived demands of future experiments, and/or the increasing demands of the current generation of experiments, as these are confronted with, for example, increased luminosity. These demands depend on the particles to be detected by the calorimeter. In electromagnetic calorimeters, radiation hardness of the detector components is a major concern. The generally poor performance of the current generation of hadron calorimeters is considered inadequate for future experiments, and a lot of the R&D in the past decade has focused on improving this performance. The root causes of the problems are investigated and different methods that have been exploited to remedy this situation are evaluated.

In the past two decades, experiments in astroparticle physics have started to make major contributions to our fundamental understanding of physics and of a variety of processes that are inaccessible in laboratory experiments here on Earth. These experiments typically make use of calorimetric particle detection. At the extreme low end of the energy spectrum, ingenious instruments are used to study phenomena involving energy transfers of the order of 1 eV using calorimetric methods. In separate sections, some salient aspects of this work are reviewed.

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1 Introduction

In the past half-century, calorimeters have become very important components of the detector system at almost every experiment in high-energy physics. This is especially true for 4π experiments at high-energy particle colliders, such as the S$\bar{p}p$S, LEP and the LHC at CERN, the Tevatron at Fermilab and RHIC at Brookhaven. Experiments at proposed future colliders such as the FCC (CERN), CEPC (China) and ILC (Japan) would be designed around a powerful central calorimeter system, should these proposed projects be realized. Calorimetric particle detection also plays a crucial role in many astroparticle physics experiments.

A calorimeter is a detector in which the particles to be detected are completely absorbed. The detector provides a signal that is a measure for the energy deposited in the absorption process. In *homogeneous*