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The CALICE hadron calorimeters - beam test results and new developments.

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A prototype of a highly granular CALICE scintillator-steel hadron calorimeter using SiPMs as photodetectors has been tested in electron and hadron beams at CERN and Fermilab in the energy range 1-80 GeV. More than 7600 SiPMs - the highest number ever used - performed well over a period longer than 2 years and did not show an increase of noise. The electron data were used to validate the detector understanding and its calibration. The analysis of the first part of data from hadron beams leads to the energy resolution of 61%/√E which can be further improved to 49%/√E applying energy dependent weights. The data on the longitudinal and transverse shower shapes allow discrimination among hadronization models of GEANT4. Specifically QGSP_BERT and LHEP predictions were compared to the data. The beam test data allow in situ calibration possibilities to be evaluated.

The next step in the calorimeter development for the ILD detector of the ILC, is the construction of a technical prototype - a calorimeter wedge segment of dimensions 80 x 110 x 230 cm3 with most of the front-end and calibration electronics included in the detector volume. The electronics aims at several new goals - power pulsing, auto-triggering, analogue pipelining and ADC and TDC integration.

We also present the alternative concept of a Digital Hadron Calorimeter (DHCAL) for use in a detector optimized for the application of Particle Flow Algorithms to the measurement of jet energies. We report on two lines of R&D being pursued by the CALICE Collaboration following different read-out and integration concepts.
Both are based on glass resistive pad chambers with 1 cm2 pad read-out, alternative amplification techniques like GEMs or Micromegas are also being considered.

One series of studies applies a single threshold (1-bit) to the signal charges, providing digital readout with the front end part integrated on the pad board. We report on detailed measurements with a small scale prototype in the Fermilab test beam using muons, positrons, pions, and protons and in the laboratory using cosmic rays. The results validate the concept and have served as the basis for the design to fully instrument the 1m3 CALICE test beam absorber structure. An update on the ongoing construction of the active modules will be given.

An alternative approach is to use semi-digital readout electronics following a design close to the one to be used in the future linear collider experiments. One feature of this electronics integration concept is that it would not require active cooling but rely on power-pulsed electronics. Based on this concept, a small prototype was built and tested with success at the CERN PS test beam in 2008. To validate completely this new concept a scalable prototype structure of 1mˆ3 volume is being planned. A few GRPCs as large as 1 mˆ2 were built with a new design with emphasis on minimized dead zones and optimized gas flow. The GRPCs were tested with an electronics board of the same size, containing 144 64-channel ASICs, representing the largest ever built with the
embedded electronics scheme.

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