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High granularity Semi-Digital Hadronic Calorimeter using GRPCs

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ABSTRACT

A Semi-Digital Hadronic Calorimeter using Glass Resistive Plate Chambers (GRPCs) is one of the calorimeters candidates proposed for particle physics experiments at the future electrons collider. It is a high granular calorimeter which is required for application of the particle flow algorithm in order to improve the jet energy resolution to achieve $30\%/\sqrt{E}$ as one of the goals of these experiments.

1. Introduction

The CALICE collaboration has developed several calorimeter prototypes to evaluate the more appropriate one to be used in the future Linear Collider [1]. One of them is the Semi-Digital Hadronic Calorimeter (SDHCAL) constructed in IPNL with the collaboration of many laboratories. During 2009–2012 several tests beam have been performed at CERN with encouraging results [2]. We present here the preliminary results obtained in the last test beam at CERN such as the efficiency of the detector, the development of the hadron shower showing the shower profile compared to Monte Carlo simulation with Geant4 [3].

2. The Semi-Digital Hadron Calorimeter

The SDHCAL prototype is a sampling calorimeter with a size of $\approx 1\ \mathrm{m}^3$ with 50 alternating layers using 2 cm of absorbing plates and 6 mm of instrumented layers (Fig. 1). For this study steel has been adopted as an absorber material. The sensitive medium of 1.2 mm is the gas gap which is a mixture of TFE (93%), isobutane (5%) and SF_6 (22%).

The high granularity is insured by finely segmented readout planes which are divided into pads of size of $1\ \mathrm{cm}^2$ where the signal created by the passage of the charged particles through the gas gap was collected. However, the increase of the granularity is accompanied by the decrease of the pad size and therefore the increase of the number of readout channels. The SDHCAL counts 460 800 channels.

Fig. 2 shows a readout plane dedicated to a large chamber of $1\ \mathrm{m}^2$. Each plane is formed by six cards consisting of 32×48 pads resulting in 9216 pads per $1\ \mathrm{m}^2$. The cards are connected two by two and count 48 HARDROCs (HAdronic Rpc Detector ReadOut Chip) [4], the important element of the acquisition and derived by a DIF (Detector InterFace).

To reduce heat dissipation and avoid using a cooling system which could degrade the homogeneity and the hermiticity of the calorimeter, and thanks to the structure of the beam at the Linear Collider, the electronic readout developed for the SDHCAL has allowed a decrease of the power dissipated by a factor of 200 [5].

The GRPCs are robust detectors giving good efficiency and multiplicity and can be produced at low cost. We realized many measurements with different technological choices to select the most appropriate of them [2]. Such studies demonstrate the homogenity of our detector (Fig. 3).

Fig. 4 shows the latest version of the prototype recently tested in beam in SPS at CERN. We present thereafter the preliminary results obtained during this test.

3. Test beam preliminary results

The CALICE SDHCAL prototype has been tested at the CERN PS and SPS in April/May 2012 with a mixed beam for an energy range from 1 to 100 GeV. The efficiency measured with 50 chambers is good and exceed 95% (Fig. 5 (Left)). Fig. 5 (Right) shows an event display of a hadronic shower. Fig. 6 shows a comparison between the Longitudinal and Transverse shower

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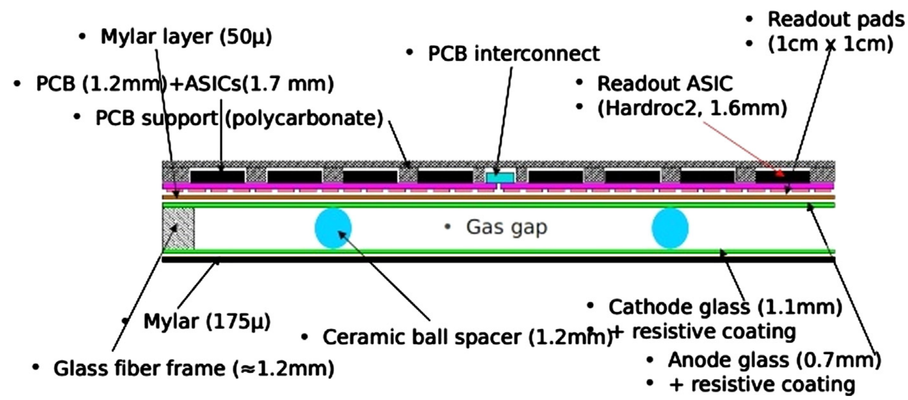

Fig. 1. Schematic view of a Glass Resistive Plate Chamber.

Fig. 2. Development of electronic readout for a large GRPC: size of 1 m^2.

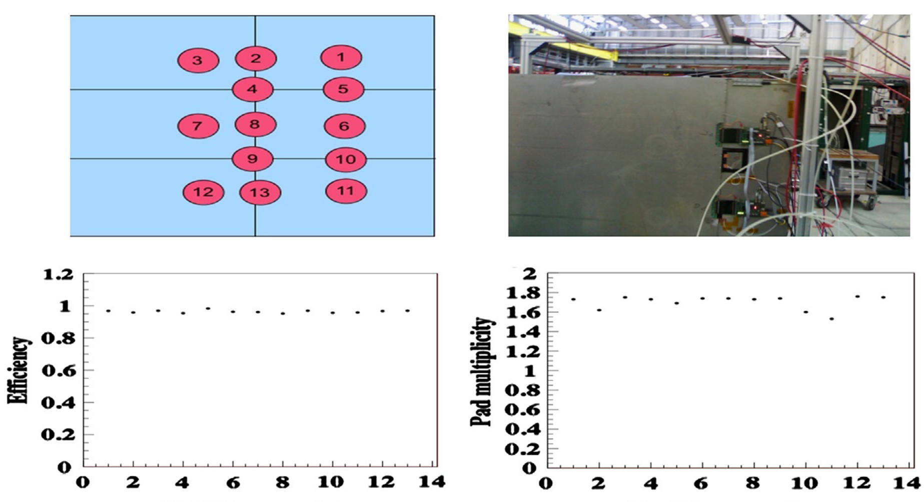

Fig. 3. Efficiency and multiplicity for different zones of the large GRPC.

profile obtained with data for a pion of 50 GeV (Top) and a simulation done in the same conditions with Geant4. The Linearity and the Energy resolution studies using the test beam data are in progress and should be compared to MC Simulation (Fig. 7).

4. Conclusion

A Hadronic calorimeter prototype with 50 GRPCs have been tested in the beam at Cern during April/May 2012 with momentum from 1 to 100 GeV. Good performance and stability were

Fig. 4. Construction of the SDHCAL prototype 460 800 electronics channels and self-supporting mechanical structure 50 working with power-pulsing.

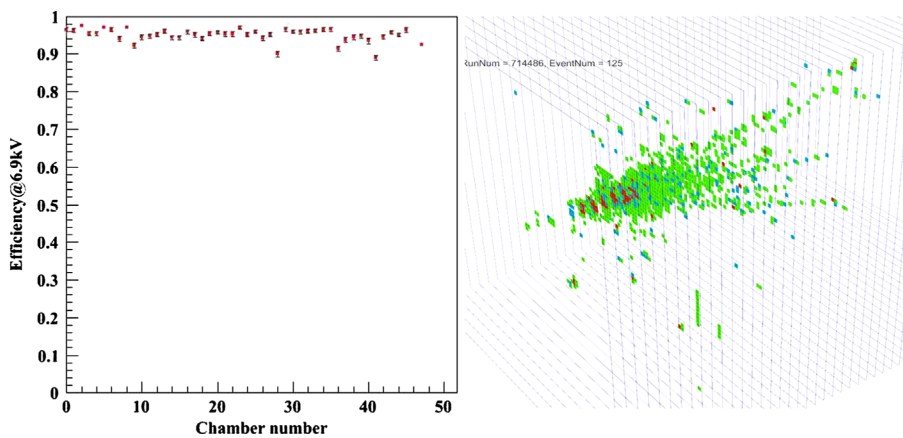

Fig. 5. Efficiency recorded on 50 chambers of the physical prototype on the CERN H2 beam (Left). Hadronic showers registered with the physical prototype at test beam, H2 line at CERN (Right).

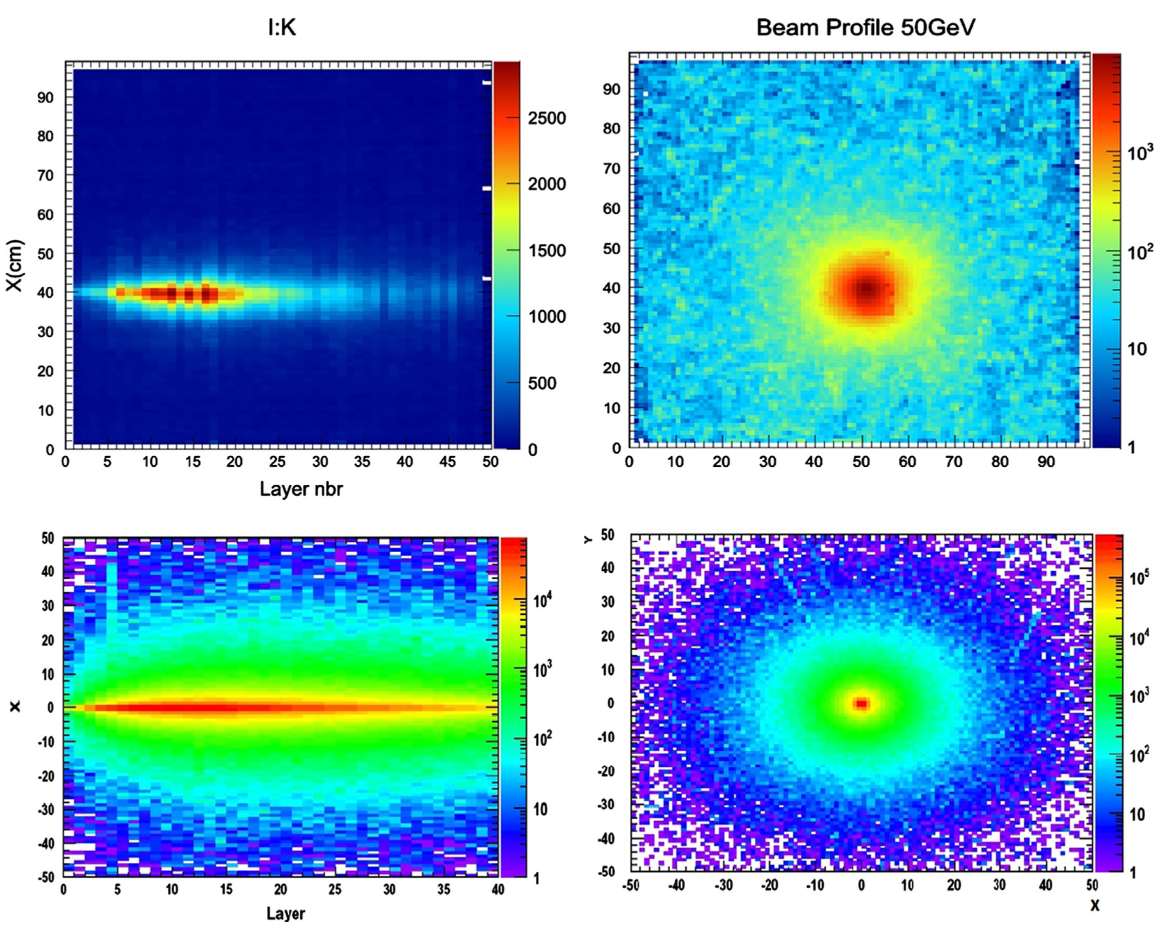

Fig. 6. Longitudinal and transversal shower profile for data (Top) compared with Monte Carlo simulation (Bottom) for 50 GeV Pion.

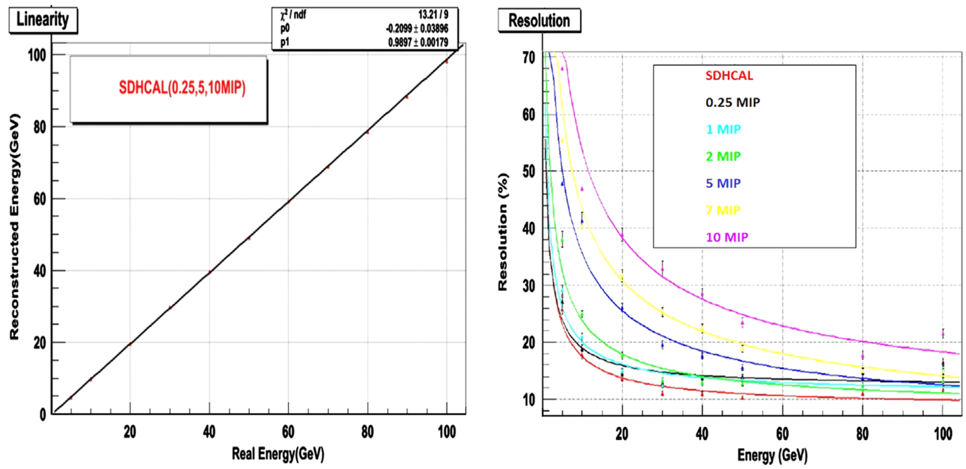

Fig. 7. Linearity and energy resolution obtained with MC simulation.

shown without problems resulting in good efficiency in excess of 95%. The SDHCAL showed also a good development of the hadronic showers.

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