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Physics Procedia 37 (2012) 198 – 204

Physics Procedia

TIPP 2011 - Technology and Instrumentation for Particle Physics 2011

# Concept and status of the CALICE analog hadron calorimeter engineering prototype

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**Abstract**

A basic prototype for an analog hadron calorimeter for a future linear collider detector is currently being realized by the CALICE collaboration. The aim is to show the feasibility to build a realistic detector with fully integrated readout electronics. An important aspect of the design is the improvement of the jet energy resolution by measuring details of the shower development with a highly granular device and combining them with the information from the tracking detectors. Therefore, the signals are sampled by small scintillating tiles that are read out by silicon photomultipliers. The ASICs are integrated into the calorimeter layers and are developed for minimal power dissipation. An embedded LED system per channel is used for calibration. The prototype has been tested extensively and the concept as well as results from the DESY test setups are reported here.



*Keywords:* ILC, ILD, CALICE, AHCAL, electronics

## 1. Introduction

The CALICE collaboration [1] is currently developing a new engineering prototype [2] of the analog hadron calorimeter (AHCAL) option for a future linear collider (LC) experiment. A major aspect of the design is the improvement of the jet energy resolution by measuring details of the spatial development of all hadronic showers inside a jet. These information are combined with the information obtained from the tracking systems in order to measure only the energies of neutral particles with the calorimeter system. This concept is known as *particle flow* and has been validated [3] with the physics prototype [4] of the CALICE AHCAL. The aim of developing an engineering prototype is to demonstrate that a scalable device can be built that meets the reqirements of a realistic LC detector, such as fully integrated front-end electronics in the active layers of the calorimeter. It is based on scintillating tiles, that are read out by silicon photomultipliers (SiPMs).

First subunits (HCAL base unit, HBU) with 144 detector channels of size $36{\times}36\ \mathrm{cm}^2$ have been produced and extensively tested in the laboratory as well as in the DESY test beam facility [2, 5, 6]. They include the scintillating tiles, four front-end low power dissipation SPIROC2 ASICs [7] and the light calibration and

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doi:10.1016/j.phpro.2012.02.366

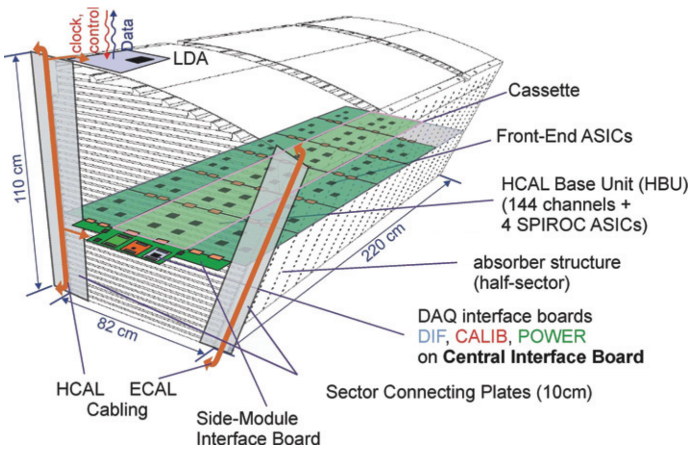


Fig. 1. 1/16 HCAL half-barrel with 48 layers containing three slabs each. The DAQ interface modules are also shown.

gain-monitoring system. The first version of the detector/DAQ interface modules is used for power supply and slow control programming. For studying a realistic LC operation mode the power supply module allows for switching off individual detector components within the LC bunch train structure (*power pulsing*) [8].

Recently all sub-components of the HBU (tiles, ASICs, calibration system) as well as the DAQ modules have been redesigned in order to optimize the performance and the spatial dimensions. First tests have been performed with the next generation SPIROC2b ASIC [9]. In this report the concept and the status of the design as well as results from test measurements are presented.

## 2. Design and status of the engineering prototype

The design of one half-octant of the AHCAL is shown in Fig. 1. It consists of 48 layers, giving a total thickness of 110 cm. The barrel is divided into two sections, which have a length of 220 cm each. One layer consists of the 16 mm thick stainless steel or 10 mm thick tungsten absorber plate and an active layer part. This active part consists of the scintillating tiles with an attached SiPM as photo detector and the embedded front-end electronics with the readout chips and the calibration system. Each layer has about 2500 channels, which adds up to about 4 million channels for the whole barrel calorimeter.

### *2.1. HCAL base units*

A single layer is divided into three parallel slabs, each of which consists of six HBUs that are interconnected by ultra-thin flexleads. The first version of the HBU has been tested extensively at DESY with charge injection and LED light as well as in the DESY electron test beam environment [2]. It features 144 detector channels of $3 \times 3\,\mathrm{cm}^2$ size. The signal for each channel is produced by a scintillating tile with 3 mm thickness, that includes a straight wavelength shifting fiber coupled to a SiPM with a size of $1.27\,\mathrm{mm}^2$ on one side and to a mirror on the other side. The SiPM comprises 796 pixels [10] with a gain of $\sim 5 \cdot 10^6$. The tiles are connected to the PCB by two alignment pins that are plugged into holes in the PCB, while the nominal intertile distance is $100\,\mu$m. A photo of the actual tile assebly is shown in Fig. 2.

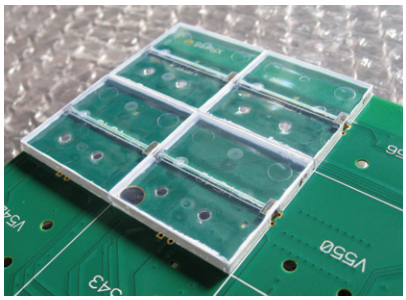

Fig. 2. Scintillating tiles with embedded wavelength shifting fiber, SiPM, mirror and alignment pins as they are assembled below the PCB.