Development of A SPIROC2E-Based Scintillator Test Platform for CEPC AHCAL Prototype

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Introduction

The Circular Electron Positron Collider (CEPC) is one of next generation colliders aiming at a huge amount of the Higgs, W and Z bosons generating and its 70 cm × 70 cm × 40 -layer AHCAL (Analog Hadron Calorimeter) prototype is under construction. The prototype AHCAL is a sampling calorimeter with steel as the absorber and scintillator tiles and SiPM (Silicon Photomultiplier) as sensitive medium. And It contains about 12,000 40 mm × 40 mm scintillators.

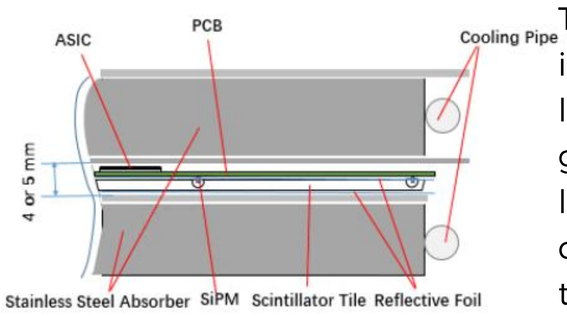

Fig.1 Cross-sectional view of a single layer of AHCAL prototype

The single layer structure is shown in Fig.1. The uniformity of scintillator light yield is a vital factor which greatly influences the energy linearity and resolution of the calorimeter. This paper describes a test platform which can measure the light yield of every scintillator used in the AHCAL prototype.

SPIROC2E Features

The whole test platform is designed based on 4 SPIROC2E chips, each of which owns 36 SiPM readout channels. Fig.2 shows the picture of a single SPIROC2E chip, and the global view is shown in Fig.3. It has the following advantages:

- Low noise
- High precision
- Large dynamic range
- Low power consumption
- Large number of readout channels

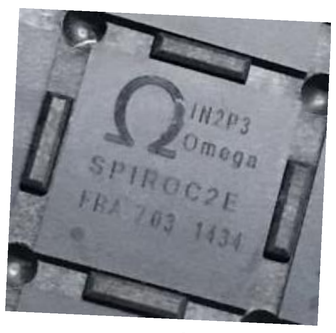

Fig.2 Top view of SPIROC2E

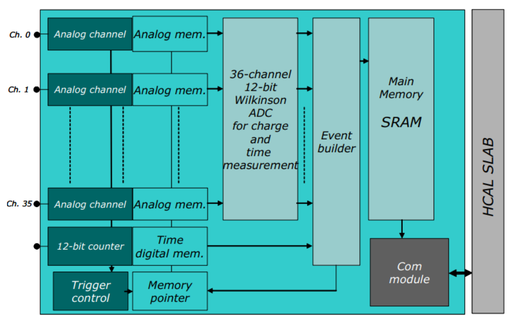

Fig.3 Global view of SPIROC2E

Moreover, there is an internal DAC for SiPM gain adjustment of each channel.

Light Yield of Scintillators

Light yield is one of the most important characteristics of scintillators, which can be various due to producing and wrapping damage. The uniformity of the light yield is hard to be corrected in the calorimeter, and will eventually contributes to the linearity and resolution of the energy reconstruction. The greater the non-uniformity between different channels, the worse the energy resolution of the reconstructed particles. A piece of scintillator tile is shown in Fig.4. In order to measure the uniformity of the light yield of the scintillators, a SPIROC2E-based platform is established in this paper.

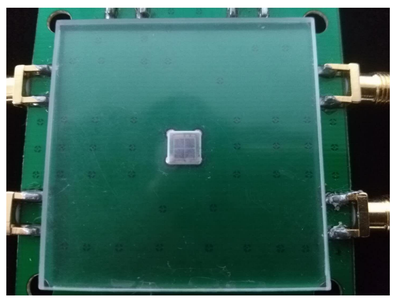

Fig.4 Top view of a piece of scintillator tile

Test Platform

The test platform which runs in a dark box to shield environmental light consists of a PC, a readout electronic system, and a ^{90}Sr radioactive source on a stepping motor. Fig.5 shows the basic structure of the platform.

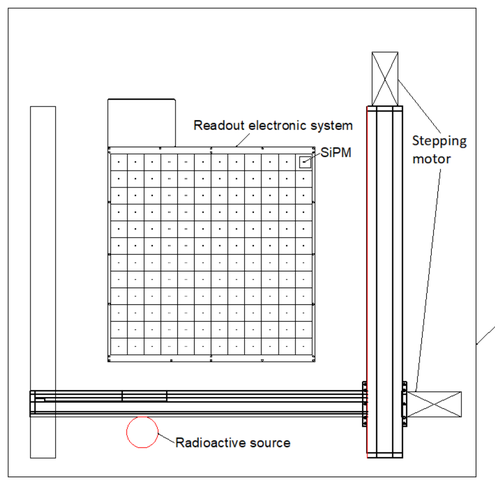

Fig.5 Overview of the test platform

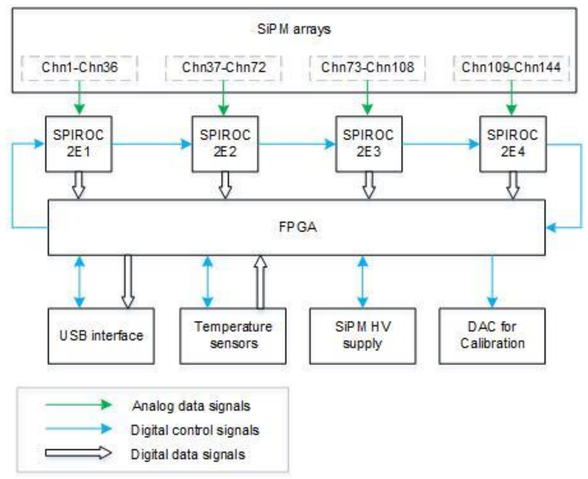

Fig.6 Overview of the readout electronic system

There're 144 scintillator positions on the test platform, each of which contains a SiPM and an electronic readout channel. The stepping motor is programmed to move above the scintillators by a self-written software. As shown in Fig.6, When a test is started, each channel is ready to collect, sample, digitize the incident signal and then sends the charge and timing information to PC, while the ^{90}Sr radioactive source is controlled to stay on the top of the first tested scintillator. After a fixed interval, 10 minutes for example, charge information is enough to extrapolate the light yield of the current scintillator and the source is moved to the next scintillator for another test unless all scintillators tested. Since the valid digital data from SPIROC2E chips is characterized with a "hit" signal, offline analysis is easy to be carried out and the light yield of every scintillator is obtained. In that way the whole test process for all scintillators will work out automatically without redundant intervention.

Temperature Compensation

SiPM gain difference, which could result from production and using damage, should be controlled strictly in order to test the light yield of scintillators. Even the same type SiPMs have distinctive gains, and are strongly dependent on temperature. So temperature monitoring system is established based on temperature sensors located evenly in all SiPM cells. Thanks to the internal DAC of SPIROC2E chip, the bias voltage for each SiPM can be tuned to minimize the gain difference according to the feedback from the temperature monitors.

Conclusion

A SPIROC2E-based scintillator test platform for the AHCAL prototype has been developed, including the dark box, the stepping motor, the radioactive source, the readout electronic system and temperature monitors. It makes it practical to measure and eliminate the light yield difference which is significant for the energy linearity and resolution of the calorimeter.

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