

Design of Temperature Compensation System for SiPM based on SPIROC2E



A. Zhou^{1,2}, Z. Shen^{*,1,2}, S. Zhao^{1,2}, C. Feng^{1,2}, S. Liu^{1,2}

¹ State Key Laboratory of Particle Detection and Electronics, University of Science and Technology of China, Hefei 230026, China

² Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China

*Corresponding author



Introduction

Higgs boson is of great significance to the development of high energy physics.

CEPC(Circular Electron-Positron Collider) is the first phase of CEPC-SPPC. CEPC could generate positive and negative electron pairs with a centroid energy of up to 240 GeV, which collide in the ring at a time interval of about 3.5 us, with a brightness of $2 * 10^{34} cm^{-2} s^{-1}$, and generate a large number of Higgs particles and Z particles.

ECAL (Electromagnetic Calorimeter) is an important part of CEPC concept detector. The electromagnetic energy meter mainly measures 30% of photons in jet. To achieve this goal, the pre research technical scheme adopts the way of scintillator array + SiPM stack, and forms a sampling type energy meter with tungsten plate absorber.

SiPMs is sensitive to temperature, and it's widely used in ECAL. When ECAL is working, the temperature in ECAL varies greatly based on different locations from time to time. So we build a temperature compensation system to keep the SiPMs gain basically the same disregard of their locations

Aim

To build a automatically temperature compensation system and this system shall have the following functions:

- The frequency of temperature compensation adapts to the speed of temperature change
- The differences among SiPMs' gains less than 10% after temperature compensation

Materials

Our system mainly consists of 3 parts. Front end signal acquisition system includes 2 PCBs. ECAL base unit board(EBU board) and data interface board (DIF). EBU board is under the control of the DIF board directly. The detection results are transmitted to server through the DIF board(Fig 1). Other 2 parts is GBT(Giga Byte Transmission) and the server.

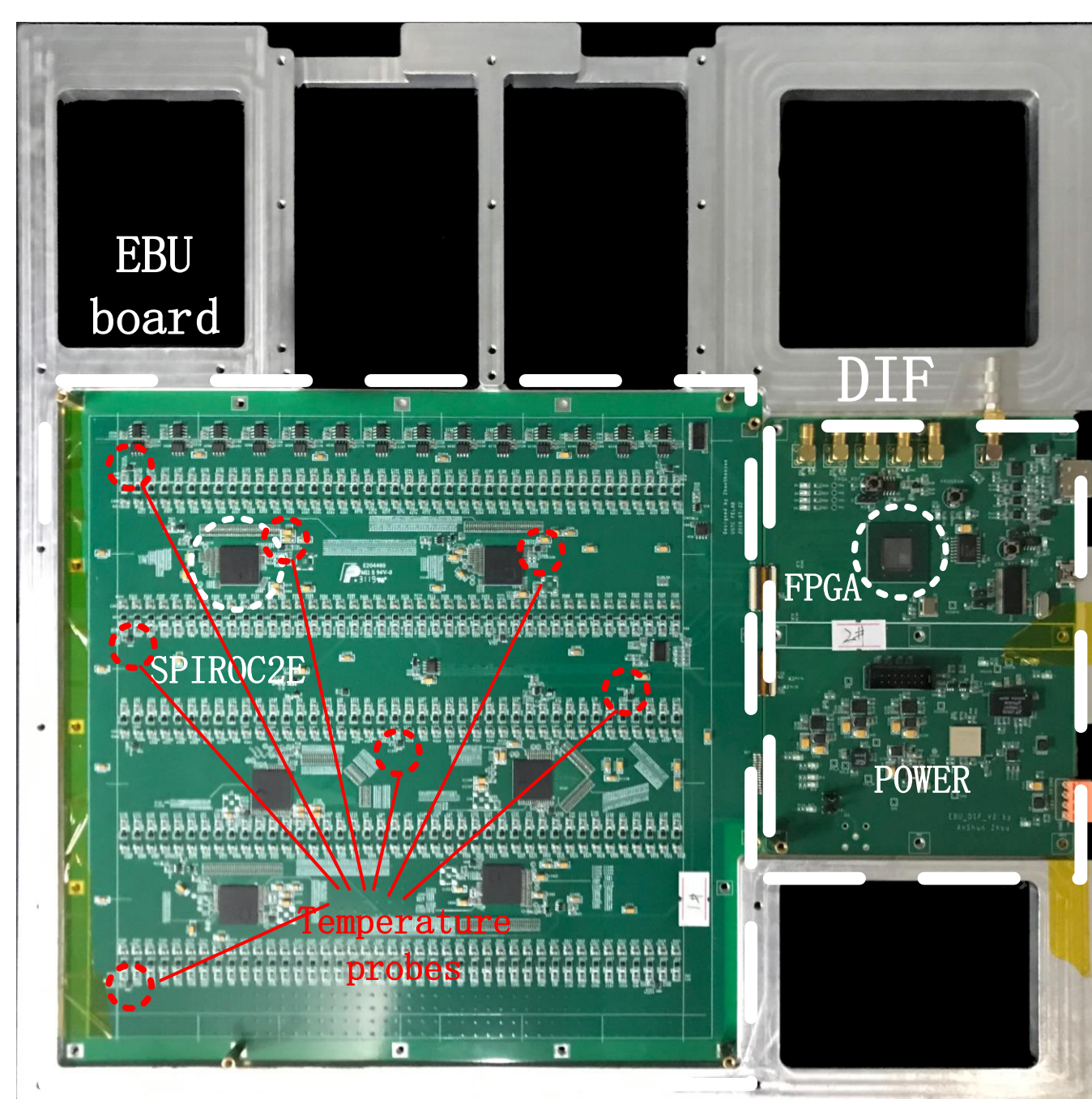


Fig 1 EBU & DIF

EBU board is on the left lower in Fig 1.

DIF board is on the right in Fig 1.

There are 6 spiroc2E ASICs on EBU board(white circle marking). SiPMs are on the back of PCB. Each EBU board is installed with 210 SiPMs.

16 temperature probes are distributed on different location of EBU board(red circle marking)

Every EBU board is installed with 210 SiPMs. There're 30 EBU boards in the ECAL system. We choose SPIROC2E as the front-end ASIC to acquire the signal from SiPMs. 16 temperature probes are evenly distributed on EBU board.

Method

- Reconstruction of temperature field

16 temperature probes were set on the EBU board according to the simulation result (Fig 1). Some of the temperature probes are located near the SPIROC2E while the others are located around the SiPMs.

We use the inverse distance weight interpolation method to rebuild the temperature field with the temperature data from 16 probes. This part is completed by FPGA on the DIF board.

Inverse distance weight interpolation method is based on 2 settings:1) The temperature of all points in the plane is determined by known discrete temperature points;2) Discrete temperature point will influence the points close to it much greater.

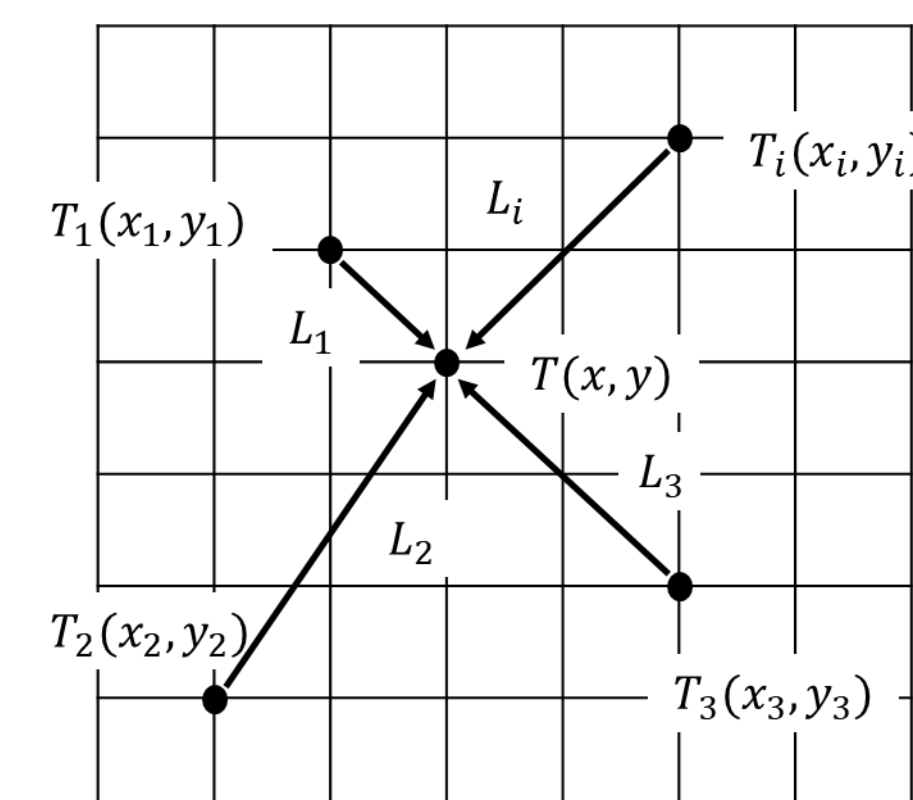


Fig. 2 Temperature field

$T(x, y)$ is the temperature of any unknown point.

$T_i(x_i, y_i)$ is the temperature data of 16 known probes.

L_i is the distance from point i to point unknown.

We can calculate the temperature of the unknown point by the following formula:

$$T(x, y) = \sum_{i=1}^n Q_i T_i$$

$$Q_i = \frac{\frac{1}{L_i}}{\sum \frac{1}{L_i}}$$

- Adjustment of SiPMs operation voltage

The gain of SiPM changes with operation voltage and environment temperature. The higher the temperature or the operation voltage is the higher the gain is. We could reduce the operation when the environment temperature goes higher.

Each one of the SPIROC2E's 36 channels is embedded with an 8-bit output DAC which could provide maximum 5V output. FPGA on the DIF board will configure the DAC according to the result of the reconstruction of temperature field.

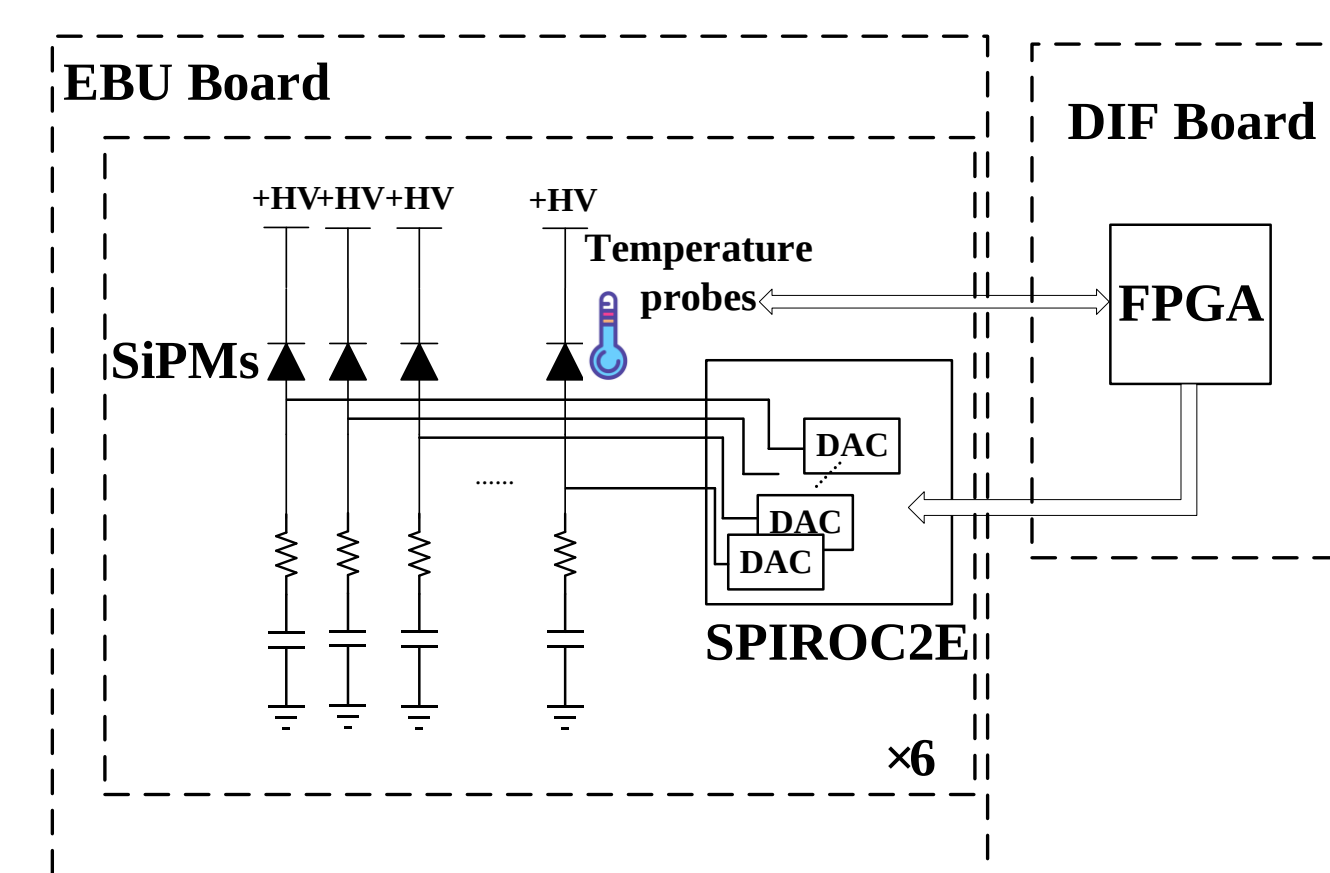


Fig. 3 SPIROC2E & SiPMs

Every input pin of SPIROC2E is connected to the anode of SiPM.

The higher the voltage of the DAC is the lower the operation voltage of the SiPM is.

- Control of temperature compensation system

When the ECAL system is running situation goes much more complicated. In order to coordinate other functions of ECAL with temperature compensation, temperature compensation is under the server's control.

In order to reduce the dead time caused by temperature compensation, it's necessary to low down the frequency of compensation when the temperature is stable. The server can adjust the period of compensation according to ECAL's working condition.

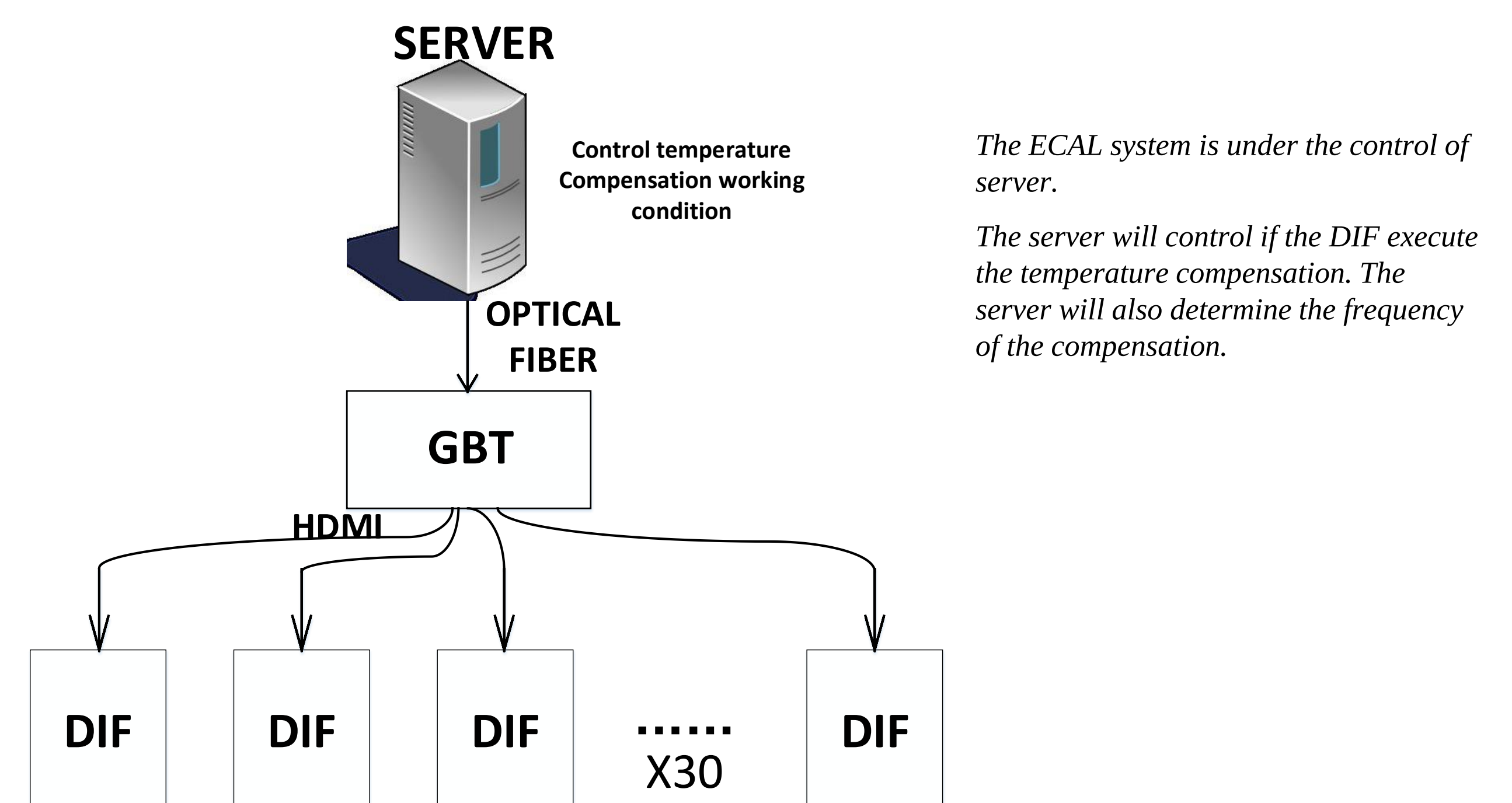


Fig. 4 Server,GBT & DIF

The ECAL system is under the control of server.

The server will control if the DIF execute the temperature compensation. The server will also determine the frequency of the compensation.

Contact

EMAIL: henzt@ustc.edu.cn

Address: Department of modern physics, China University of science and technology, Hefei, Anhui, China

Acknowledgement

Study was supported by the National Natural Science Foundation of China (11635007) and the National Key Program for S&T Research and Development (Grant No.:2016YFA0400400).