Development of the DAQ system of Chinese high energy cosmic ray detector in space

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Abstract: The main purpose of the Chinese high energy cosmic ray detector in space is to measure the energy spectrum of high energy electron and gamma ray. The energy range of the detector is about 50GeV-10TeV. The detector consists of BGO calorimeter and scintillation hodoscope. This paper will introduce the data acquisition system (DAQ) of the whole detector, which packages the data from the calorimeter and hodoscope and sends it to the mass memory in the satellite.

Keywords: High energy cosmic ray detector, DAQ, BGO Calorimeter, Scintillation hodoscope

1 Introduction

In recent years, several experiments such as ATIC [1], Pamela [2] have reported some abnormity in high energy electron spectrum. All the results may indicate there are nearby sources of electron and positron. To understand the characteristic of the spectrum bump, the Chinese high energy cosmic ray detector in space is proposed by Purple Mountain Observatory. The goal of the detector is to measure the energy spectrum of high energy electron and gammy ray with high resolution and high background rejection.

2 1Architecture of instrument

The Chinese high energy cosmic ray detector consists of plastic scintillation hodoscope and BGO calorimeter. The detail of detector is described in Ref. [3]. The hodoscope comprise 3 layers of plastic scintillation detector, and each detector element is 1 cm$\times$1cm size. Each layer of scintillation detector is composed of X,Y direction belts. The BGO calorimeter is made of 12 layer of BGO crystal. Each BGO detector element is 2.5cm$\times$2.5cm size. The plastic scintillation detector and BGO are both read out by PMT (photomultiplier tube). Because of the large dynamic range of BGO detector which is about 10^5, the BGO detector use three different dynodes signal of PMT to measure the light from BGO.

The electronic of detector includes FEE (front-end electronic) and DAQ (data acquisition system). The main task of DAQ system is to decode the command from satellite and collect data of FEE to mass memory. Figure 1 is the layout of the electronics module and detectors.

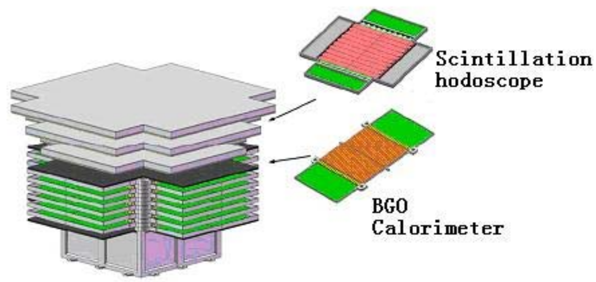

Figure 1: Structure of high energy cosmic detector.

3 Front-end electronics

We have developed the FEE (front-end electronic) for the detector, which is using the Viking chip (VA32HDR14.2) from IDEAS company. The dynamic range of VA32HDR14.2 chip is $0 - +13$pC. Each FEE has 16bit ADC and use FPGA to control the other chip. The ADC data of FEE will send to sub_DAQ board through LVDS signal. Each sub_DAQ board is responsible for 6 FEE's data.

4 Data acquisition system

When a high energy particle hits the detector, the comparator of FEE generates hit signal to trigger system. If it is a good event, trigger system will send a trigger signal to FEE and DAQ system. At the same time, the FEE and DAQ enable the busy signal which disables the new trigger, and FEE begins to digitalize the signal from the detector. When

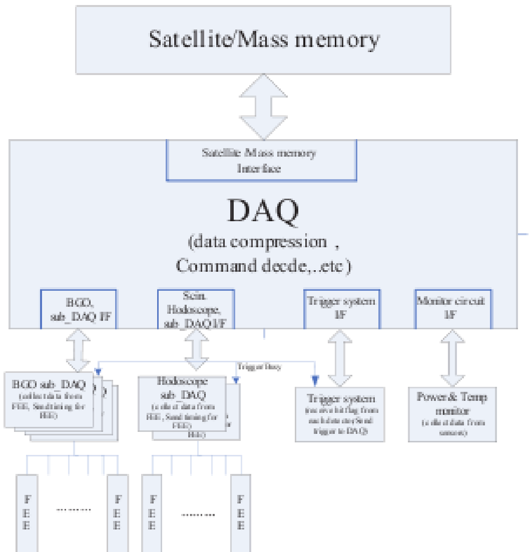

Figure 2: Schematic of electronics.

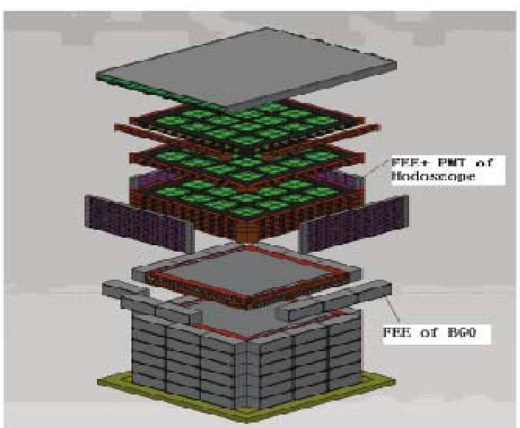

Figure 3: Structure of detector and FEE.

all the detector data are sent to the DAQ, the busy flag will be disable and trigger system begin to wait the next trigger.

Figure 4: Timing of DAQ system.

The DAQ board consists of a high performance LEON3 CPU, interface chips (space wire, other control/status signal), small size DPRAM and a FPGA for control.

The data links between DAQ and sub_DAQ of each detector use spacewire bus. Spacewire is a high speed serial

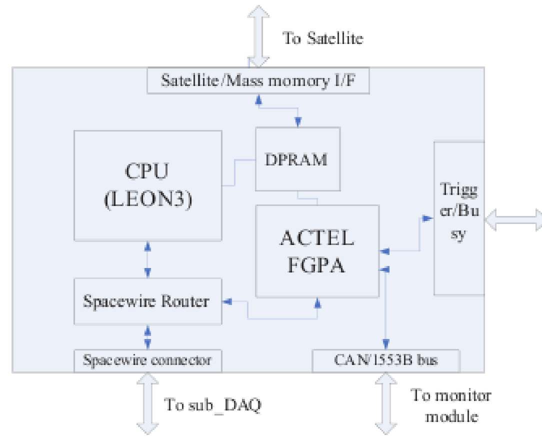

Figure 5: Scheme of DAQ system.

point-point data link, which can send data reliably at high speed (between 2Mbps to 200Mbps) from one unit to another. It can collect FEE's data in real time and make deadtime as short as possible. When the data of each event are transformed, the DAQ will store the data in the DPRAM on board. Then the FPGA will send an interrupt signal to CPU, and CPU will start to process the data with compression algorithm. The compressed data will be sent to mass memory finally.

The other main task of DAQ system is to decode the command from the satellite, and send corresponding command to FEE and trigger system. The commands are including trigger mode setting, energy threshold level, calibration mode setting, etc. The DAQ system is the scheduling center of all the electronics.

5 Summary

We have designed the electronics system as described above. Since May 2011, the prototype of the detector system has been finished and under test. The electronics system of the detector work well and steadily. We will verify the system's performance by high energy particle beam.

References

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[2] O. Adriani, et al., 2009, Nature, 458, 607
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