Journal of Physics: Conference Series **160** (2009) 012009 doi:10.1088/1742-6596/160/1/012009

Status of Electro-Magnetic Calorimeter in BESIII

Li ZHOU Junguang-LU Tao-HU Xiao-CAI Mingyi-DONG

Jian-FANG Boxiang-YU Zhigang-WANG Zhenghua-AN

Institute of High Energy Physics, Chinese Academy of Sciences

19 Yuquanlu Road，Shijingshang District Beijing 100049，CHINA

zhoul@mail.ihep.ac.cn

1. Introduction

The Electro-Magnetic Calorimeter (EMC) plays an important role in the BESIII detector, whose primary function is to measure precisely energies and positions of electrons and photons. High detection efficiency and good resolutions for lower energy photons are very important for the electromagnetic calorimeter of BES III.

The general physics requirements of the BESIII detector leading to the design of the EMC based on CsI(Tl) crystals, with the following expected performance:

- The measurable energy range of electron or photon is from 20 MeV to 2 GeV. The energy resolution is about $2.5\%/\sqrt{E(GeV)}$, good energy resolution is important especially in the energy region below 500 MeV.
- The position resolution for EM shower is $\sigma_{x,y} \le 6mm/\sqrt{E(GeV)}$.
- A neutral(γ) energy trigger is provided.
- A good e/π separation in the energy region above 200 MeV is expected.
- Crystals have a fine granularity and signal readout so that overlapping showers can be reconstructed, especially for high energy π^0's. The electronics noise for each crystal should be less than 220 KeV.

2. Construction of the EM Calorimeter

The CsI(Tl) calorimeter are composed of one barrel and two endcap sections . The barrel has an inner radius of 94 cm and a length of 275cm, covering the polar angle of 146.5° - 33.5°(cosθ ～0.83). The endcaps with inner radius of 50cm are placed at $z = \pm 138$ cm from the collision point, covering the polar angle of 32.5° - 21.3°. The total acceptance is 93 % of 4π . A small gap of about 5cm between endcaps and the barrel is reserved for mechanical supporting structure, cables and cooling pipes. in the barrel ,There are 44 rings of crystals along the z direction., 120 crystals in Φ.All crystals with a small tilt angle of 1.5° in the Φ direction and 1°～3° in the θ direction. Each endcap consists of 6 rings and split into two half circles. The entire calorimeter have 6240 CsI(Tl) crystals with a total weight of about 24 tons.

The shape and dimension of barrel crystals are illustrated in Fig.2-1. the section of crystal. Crystals typically have a front face of about 5cm × 5cm and a rear face of about 6.5cm × 6.5cm. The length of all crystals is 28 cm(15X_0). For easy manufacture, two out of four side faces of crystals are perpendicular to the front and the rear faces. The shape of endcap crystals is more complicated due to varying radius of the rings, and the dimension of the crystal close to the boundary of half circle may be different from the inner ones. There are 31 types of crystals and a total of 960 crystals for the endcap.

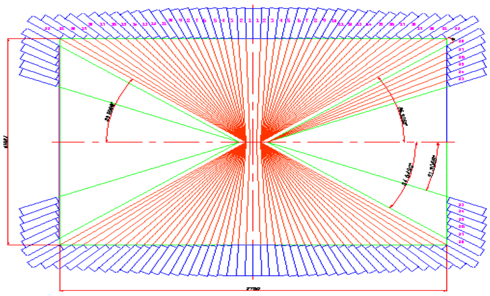
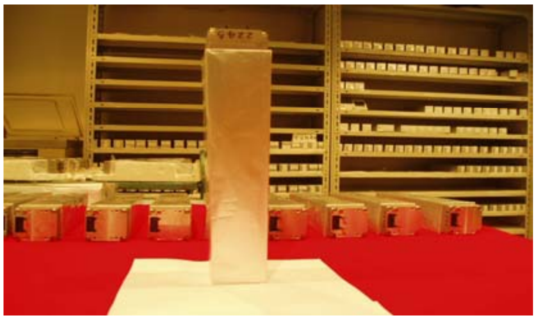



Fig.2.1Configuration of the electromagnetic calorimeter (left) One of Cs(Tl) crystal detector(right)

3. Quality Control

All crystal was manufactured by France Sanit –Gobain, Shanghai Institute of Ceramics, Beijing Hamamatsu and 3000, 1920, 1320 piece respective. CsI(Tl) crystals from mass production should satisfy a number of requirements: relatively light output>42%, light uniformity<7%, The tolerance of the crystal dimension is defined as +0, -200 μm for all transverse dimensions, ± 1mm for length. and radiation hardness <20% decrease of light output after 1000rads (Small sample) or < 9% decrease of light output after 100rads(real size) .

3.1 light output and Uniformity

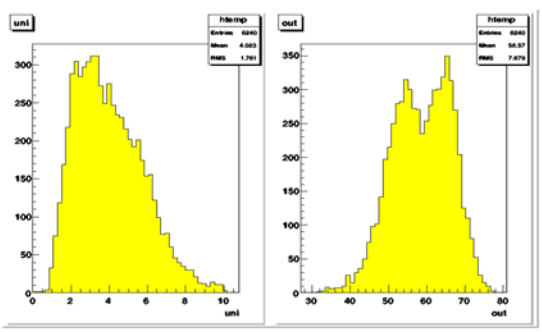


Fig.3.1 Relations the light output and the uniformity

The light output of a crystal is defined as the number of photoelectrons per MeV. When a crystal is wrapped by 2 layers of 130 μm thick Tyvek, coupled to two photodiodes (S2744-08), readout by an amplifier with 1 μs shaping time, the light output should be more than 5000 photoelectrons per MeV. A 2-inch Bialkali photomultiplier, PMT is used for testing of crystals. Each crystal is tested by measuring the position of 662 KeV γ ray photoelectric peak using a ^{137}Cs source, at 9 points along the long direction of crystal. There is a 0.3mm air gap between the crystal and the PMT. The light output of a crystal is defined as the average of the 9 measurements and will be normalized to the light output of a small reference CsI(Tl) crystal with 1 inch in diameter and 1 inch in length. Result is shown in Fig.3.1, it include barrel and endcape crystal total are 6280 piece.

3.2 Radiation Hardness

With the expected dose of the BESIII calorimeter of about 300 rad/year, the decrease of the light output of CsI(Tl) is required to be less than 10%/Krad in normal operation, and less than 20%/Krad after CsI(Tl) crystals are irradiated for short time by the ^{60}Co γ source with a high radiation dose. Total 482 crystal are rejected hereinto 4 is dimension problem.

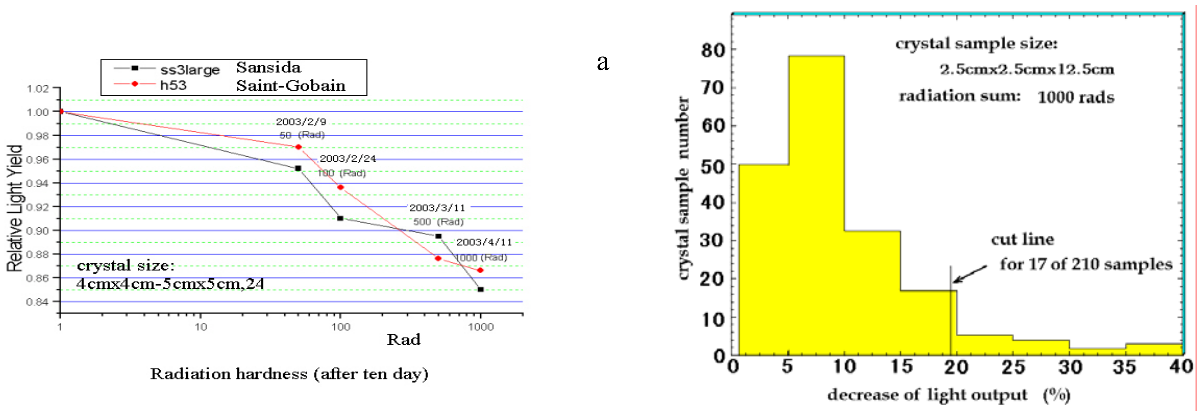


Fig.3.1Radiation hardness of the large CsI(Tl) crystals from different manufacturers(left) . 17 pieces of 210 samples have not passed (right)

3.3 Photodiodes and Charge Sensitive Preamplifiers

Hamamatsu S2744-08 is selected as the photodiode to be used. Its exterior dimension is 14.2mm× 27mm. The photosensitive area is 10cm x 20cm and the thickness is 300μm. 13088 pieces of photodiodes were burned in 65 degree for 150 hours at a reverse voltage of 70V in IHEP Beijing.

Photodiodes, crystals and preamplifiers are selected and grouped together, so as to make the gains of all calorimeter modules similar. Measured the noise of each photodiode and the 60 KeV X-ray peak position of the 241Am X-ray source, the noise level of the photodiode and the relative gain of each electronic channel can be calibrated.

4. The Construction of CsI(Tl) Modules

A CsI(Tl) crystal module consists of one CsI(Tl) crystal and two photodiodes. The crystal (except the rear surface) are firstly wrapped in a 260μ thick Tyvek sheet, and then wrapped in a 50μ laminated sheet with 25μ aluminum and 25 μ Mylar. The aluminum layer works for shielding against the electronic noise, and the Mylar is used to isolate each crystal electrically from others and also isolate the detector from the support structure. The rear end of the crystal is the window for collecting scintillation light. Two pieces of type S2744-08 photodiodes are glued at the central part of the crystal rear surface via a 3mm thick Lucite with a size of $2.1cm \times 2.5cm$. Epoxy glue is used both for CsI-lucite and Lucite-photodiode joints. Before gluing, except the area for Lucite-photodiode, the rest part of the rear surface is covered by a 500μ thick Tyvek reflection sheet. Four taped holes are drilled on the centerlines of four sides of the rear face by a special technique. An 8 mm thick aluminum base plate with a cut area for photodiodes is fixed to the crystal rear end by four self-tapping screws. An aluminum shield box covering two preamplifiers is fixed to the aluminum base plate with other four screws. The electrical ground of the preamplifier is connected to the shield box and the aluminum shield layer to avoid external noise interference. There is a rectangle hole on the shield box for settling the monitoring light fiber. Through this hole and the prefabricated holes of aluminum base plate and the Tyvek reflection sheet, one end of the fiber with metal sheath contacts the rear surface of the crystal to inject monitoring light. All processes of the assembly are kept in a dry room with humidity less then 10% and at a constant temperature

.

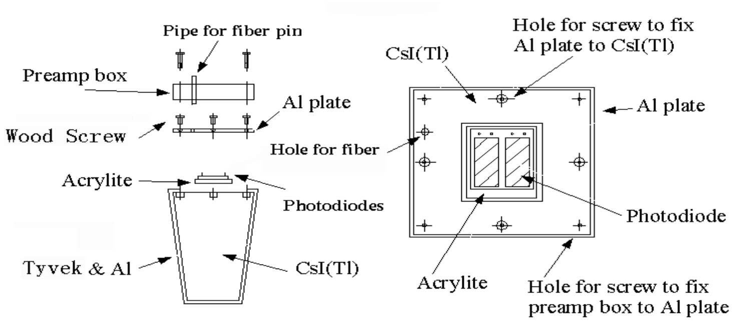
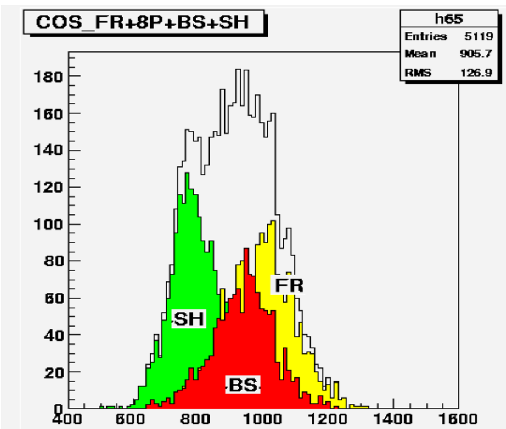


Fig.4.1Assembly of a CsI (Tl) crystal module

5. Cosmic-ray test

After the detector modules are assembled, the differences in their gain should be evaluated by using cosmic-ray, before installing the crystals into the calorimeter structure. When a cosmic-ray muon passes through the crystal being laid horizontally, about 25 MeV is deposited. If the accuracy of the track length of the incident particle in the crystal reaches about ±3mm and a crystal are measured at 9 points longitudinally, with a total of about 4000 events, nine distributions of pulse heights per cm path can be obtained, with an energy resolution of about 10% and the accuracy of the pulse height peak of about 2%. Fig.5.1 are Relative light out test result, all crystal are content to the request.



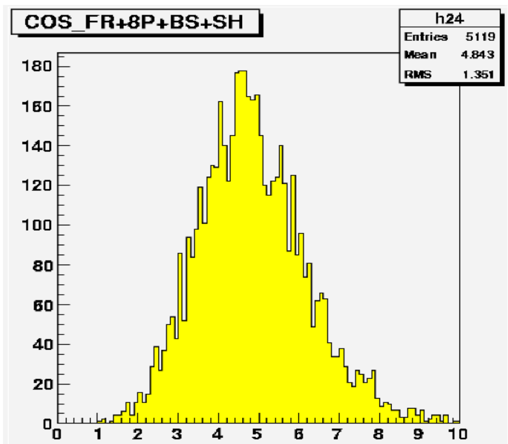


Fig.5.1 The light output and the uniformity, FR is France Sanit –Gobain,

SH is Shanghai Institute of Ceramics, BS is Beijing Hamamatsu

The cosmic-ray test setup could load 60 crystal modules simultaneously for test, and each test takes 72 hours. In addition, this setup also includes random calibration pulse and LED fiber monitoring system. The former is used to calibrate the electronic noise and pedestal and the latter is used to calibrate the relationship between the light intensities and the energies of cosmic ray muon. The data of the cosmic-ray tests are as the basic data of each crystal module.

6. Support Structure of Crystal

The mechanical structure of the calorimeter consists of a barrel and two endcaps. They should support all the inner detectors such as TOF and drift chambers, and attached to the main structure (iron yoke) of the detector. Each endcap consists of two half rings, which has to be movable so that inner detector can be accessed. The container of the barrel calorimeter is a slat structure and is divided into 60 (in Φ direction) compartments, each contain two rows of crystals (88 crystals). The 60 stainless steel bars are connected to the two stainless steel end-rings with screws. The inner edge of the stainless steel bars are connected to the stainless steel opening-cut girder and its two sides through two stainless steel reinforce bars are joined with the two adjacent stainless steel bars. Thus the whole support frame is joined together. In order to be disassembled easily for fixing inner detectors, each endcap consists of two half rings. When BES III inner detectors need to be repaired, the iron yoke of endcap can be moved away about 1430mm along the beam direction (east-west direction) and the two half rings are moved separately in the south-north direction. The available space is enough to examine and repair the main drift chamber (MDC).

7. Conclusion

BESIII Barrel Electro-Magnetic Calorimeter has been sitting in super conduct loop in this autumn, all detector module passed test by cosmic ray and LED fiber system check, we can expect that we will enjoy more physics in future.

Fig.7.1 installation EMC, left is barrel right is endcap

References

[1] BESIII design report 2003
[2] Bell collaboration, Nucl. Instrum. Meth. A479, 117-232 (2002).
[3] KEK Progress Report 1995 April-1996 Mach
[4] BABAR collaboration, Nucl. Instrum. Meth. A479, 1 (2002).
[5] BarBar Collaboration, A systematic Study of Radiation Damage to Large Crystals of CsI(Tl) in the BarBar Detector, Calor2002 report