Study on Inconsistency of Bigpads in the ARGO-YBJ experiment with Iso-gradient Method

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Abstract: The ARGO-YBJ experiment is a full coverage array of Resistive Plate Chambers (RPC) with an active area of 6700 m^2. Study on inconsistency of Bigpads with iso-gradient method is performed. After inconsistency correction, inconsistency of Bigpads decreases down to 1.5%. Moreover, By means of the iso-gradient method, number of particles calibration by the telescope can be propagated to all bigpads, and stability of bigpads is obtained which is -2.15%/year in average.

Keywords: RPC, bigpad, inconsistency correction, iso-gradient method

1 Introduction

The ARGO-YBJ experiment is made by a single layer of Resistive Plate Chambers (RPCs) [1] housed in a large building (100×110 m^2). The detector has a modular structure: the basic module is a cluster (5.7×7.6 m^2), made of 12 RPCs (2.8×1.25 m^2 each). 130 of these clusters are organized in a full coverage carpet of 5600 m^2 with active area ∼93%; this central detector is surrounded by 23 additional clusters with a coverage of ∼40% ("guard ring") to improve the core location reconstruction. The detector installation has been completed in 2007.
Each RPC is read via 80 strips (6.75×61.8 cm^2), logically organized in 10 pads of (55.6×61.8 cm^2) that are individually recorded and that represent the high granularity pixels of the detector. The RPC carpet is connected to two different DAQs, working independently, corresponding to the two operation modes, shower and scaler. In shower mode, for each event the location and timing of every detected particle is recorded, allowing the lateral distribution and arrival direction reconstruction; in scaler mode the total counts are measured every 0.5 s: for each cluster, the signal coming from the 120 pads is added up and put in coincidence in a narrow time window (150 ns), giving the counting rates of ≥1, ≥2, ≥3, ≥4 particles, that are read by four independent scaler channels. The corresponding measured counting rates are ∼ 40 kHz, ∼ 2 kHz, ∼ 300 Hz and ∼ 120 Hz. In addition the signal of each RPC chamber is picked out by two large size pads ($1.4 \times 1.25\ m^2$), called BigPads, in analog read-out mode with a 12 bits ADC. This makes possible to extend the measurement range of particle density up to $10^4\ particles/m^2$ [2, 3] and the primary cosmic ray energy from some tens of TeV up to several PeV.

The ARGO RPC carpet is composed of 3120 bigpads. Inconsistency among so many bigpads exists unavoidably. It is hard to directly measure inconsistency of bigpads one by one, but we may take advantage of high statistics of cosmic ray air showers, which have a certain symmetric structure of number of secondary particles. In this paper, we make efforts to research on inconsistency of bigpads with a new method, iso-gradient method, by means of data sampled by the carpet.

2 iso-gradient method

For each bigpad, electronics calibration is made with an input pulse generated with DAC, and is read out with ADC of the bigpad. Most of bigpads have normal electronics calibration except for 23 bigpads including 12 without electronics calibration and 11 with abnormal electronics calibration. In the following analysis, the 23 bigpads are removed, and the electronics calibration data are used with interpolation method. Therefore ADC counts are transformed into DAC pulse height (PH).

In one shower, which is approximately axial-symmetric, number of particles at the same distance from the core is almost same. In practise, there are some inconsistency in bigpads so that PHs, measurement of number of particles in bigpads, are different at the distance, but the avarage value of PHs, $< PH >$, at the distance is close to real number of particles. Consequently, for one bigpad, relative difference R

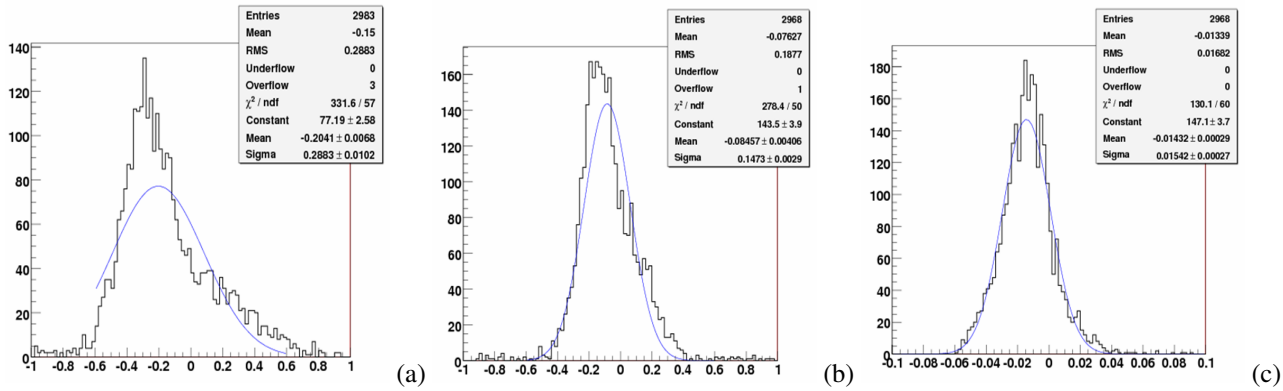

Figure 1: distribution of R_0 of all bigpads from one tape of real data. a: from rawdata, b: After electronics calibration. c: After two iterations of inconsistency correction

$$R = \frac{PH - < PH >}{< PH >} \quad (1)$$

is inconsistency value of the bigpad, of course, with some fluctuation due to not absolute symmetry of the shower and difference between the bigpads. This fluctuation can be reduced by using average value of R, R_0, from a mount of air showers. Moreover, R_0 can be used to correct inconsistency of the bigpad by

$$PH_1 = \frac{PH}{1 + R_0} \quad (2)$$

and it can be proceeded in n iterations

$$PH_n = \frac{PH_{n-1}}{1 + R_{0,n}} = \frac{PH}{\prod_{k=1}^{n}(1 + R_{0,k})} = C0 \times PH \quad (3)$$

where C0 is final inconsistency correction of the bigpad, which can be used simply by multiplying PH directly.

This method, so called the iso-gradient method, is proceeded for real data. Figure 1 is from data of one tape, half a day. It shows that from rawdata (ADC counts),distribution of R_0 has a width 28.8% (Figure 1.a) and is not symmetric. After the electronics calibration, distribution of R_0 changes better to 18.7% but still large(Figure 1.b). After two iterations of inconsistency correction, distribution of R_0 changes to 1.5% close to expectation of Monte Carlo simulation (Figure 1.c). There still is a deviation of -1.4% from 0 because of large deviation in rawdata Figure 1.a), but it is not serious because it is relative and will be corrected during propagation of absolute number of particles calibration (see below).

The iso-gradient method is tested by Monte Carlo simulation by using CORSIKA to generate air showers. Before inputting fluctuation, distribution of R_0 has a width (RMS or sigma of Gaussian fitting) of 1.4% . After inputting fluctuation of 10% randomly sampled in uniform distribution, distribution of R_0 has a width 7.0% . After two iterations of inconsistency correction, distribution of R_0 has a width 1.2% , close to one before inputting fluctuation.

The average value of charge $< Q >$ is taken advantage to study effect of the inconsistency correction of all individuals of bigpads. Data of one tape are used. For rawdata, data after the electronics calibration and data after the inconsistency correction, 'charge' means ADC count, PH and PH' with selection of $ADC > 10$, $PH > 40$ and $PH' > 40$ respectively which are consistent with each other according to the electronics calibration data. Distributions of $< Q >$ in the three cases have fluctuation RMS/mean=20%, 21% and 9.8% respectively and indicate that the inconsistency correction can reduce inconsistency 11% which is consistent with the result of distribution of R_0 (see section 3). Moreover, 2D distributions of $< Q >$ (Figure 2) show that after inconsistency correction $< Q >$ of bigpads are much more uniform than before.

Figure 3 shows effect of the electronics calibration and inconsistency correction on one individual shower. It indicates that inconsistency correction removes the "false cores" due to inconsistency of detection by bigpads, and recovers good structure of one shower.

3 Propagation of number of particles calibration from the telescope to bigpads

By means of the iso-gradient method, number of particles calibration by the telescope [3] can be propagated to all bigpads. Totally 1.6×10^4 matching events between the telescope and the RPC carpet are selected. In order to proceed the iso-gradient method, which requires that showers must be dropped in the carpet uniformly, only the clusters closed to the telescope are used. Charges of bigpads have been dealt with the electronics calibration and the inconsistency correction Distribution of R_0 of the selected bigpads and scintillator No.1 of the telescope is obtained (Figure 4), and R_0 is relative difference of scintillator No.1 of the telescope, and then $C0_{tel} = 1/(1+R_0)$. In consequence, after multiplying PH's by $C0_{tel}$, number of particles calibration by the telescope is propagated to all bigpads, i.e., absolute number of particles detected by bigpads are obtained.

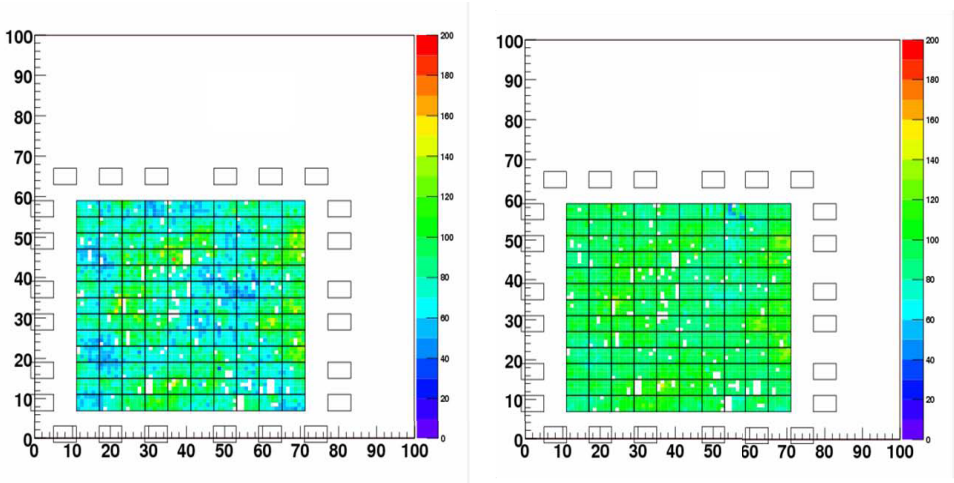

Figure 2: 2D distribution of the average value of charge $< Q >$ of all bigpads from data of one tape. a: from rawdata, b: After the electronics calibration and the inconsistency correction

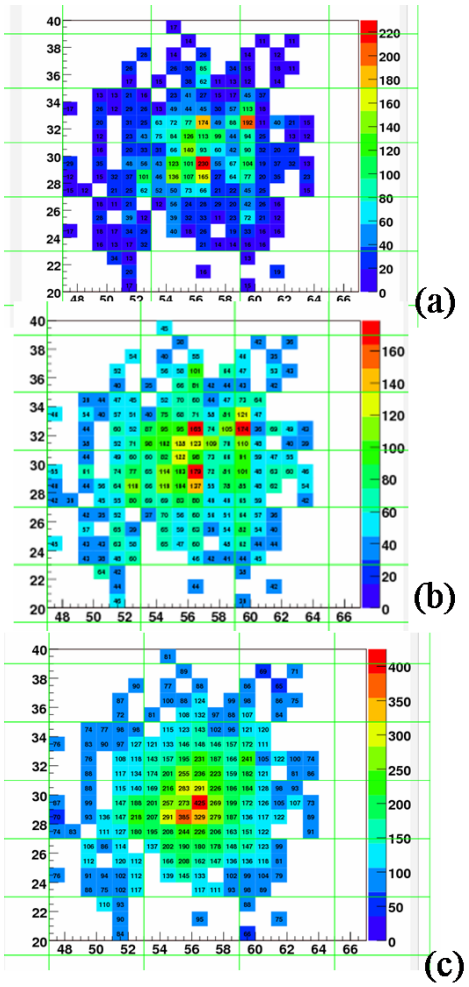

Figure 3: one event. a: from rawdata, b: After the electronics calibration. c: After the inconsistency correction and transformed into density of particles.

4 Stability of all bigpads

At present, full scale of bigpads is set 20V and local trigger 72 which means only high energy showers can trigger

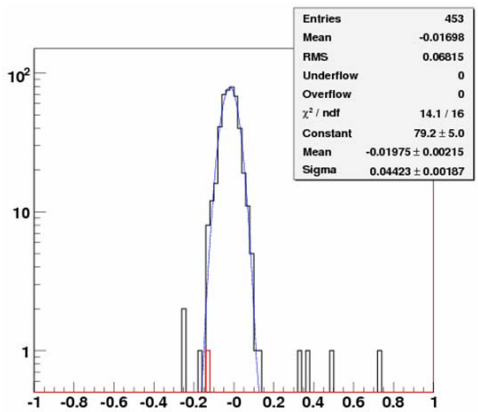

Figure 4: Distribution of R_0 of the selected matching bigpads and scintillator No.1 of the telescope (the red one)

bigpads. Such high energy showers are not influenced significantly by environment such as temperature, pressure, etc. Consequently, the average value of charge $< Q >$ is a suitable parameter for study on stability of bigpads. After the electronics calibration and inconsistency correction, $< Q >$ of each tape of each bigpad is calculated for data from TAPE3070 in October 2010 to February 2011. Duration of data in one tape is half a day and occupancy of each bigpad is 200 in average. Figure 5 is of one bigpad. For each bigpad, linear fitting is performed to get intersection p0 and slope p1, and stability is calculated as r=p1/0.5*365/p0. For the bigpad of Figure 5 r=-0.89%/year. Figure 6 gives distribution of p0, p1 and r of 2974 bigpads (95% of total ones) and average value of stability r is -2.15%/year.

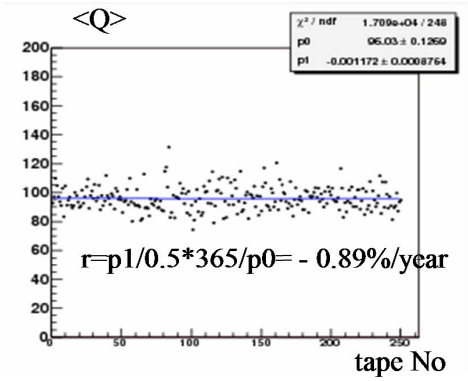

Figure 5: the average value of charge $< Q >$ of one bigpad varies with tapes.

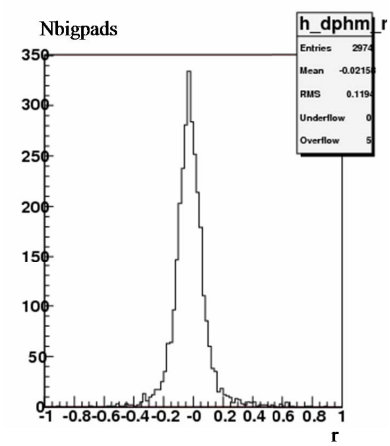

Figure 6: distribution of stability value r of all bigpads.

5 Conclusion

The iso-gradient method is proved to be effective for inconsistency study and inconsistency correction. After inconsistency correction, inconsistency of Bigpads decreases down to 1.5%. By means of the iso-gradient method, number of particles calibration by the telescope is propagated to all bigpads. Up to present, the RPC carpet is indicated to be running stably.

References

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