Monitoring of the calibration constants of the DVCS calorimeter

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Abstract

Radiation exposure of the DVCS calorimeter during data taking has degraded the optical properties of the cristals in a time dependent way. This note presents a method which allows to determine the effective gain of each single block all along data taking, relying on the two absolute elastic calibrations performed at the beginning and at the end of the experiment. Consideration of time dependent gain is shown to improve the missing mass resolution, allowing for a better identification of DVCS events.

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1 Introduction

Two absolute elastic calibrations of the electromagnetic calorimeter have been performed during the experiment: the first one on 10/07/2004 (runs 3234-3236) and the second on 11/30/2004 (runs 4994-4997). Between them, data have been collected at kinematics 1, 2, 3, and the neutron setting (kinematic 4 hereafter). Fig. 1 shows the variation of the calibration constants (or effective gains) between the two elastic calibrations for the 132 calorimeter blocks. It can be seen that most of the blocks drifted between these two measurements, resulting from cristal aging under radiation exposure. It is therefore mandatory to monitor this drift all along the experiment in order to achieve a good determination of the missing mass.

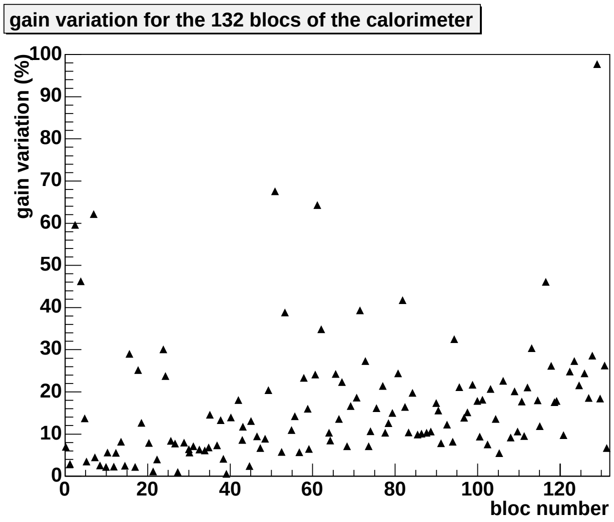

Figure 1. Gain variation in percentage for all calorimeter blocks.

2 Monitoring method

The degradation of the optical properties of the crystals is believed to originate from the overall radiation dose received by each single cristal. A measurement of this optical degradation can be accessed through the charge received by each block.

The Energy of the incident particle (E) is connected to the number of detected photons $N^i(t)$ of the block i at time t via the realtionship:

$$E = G^i(t)\,A^i(t) = c^i\,G^i(t)\,N^i(t) \tag{1}$$

where $G^i(t)$ is the effective gain of the block i at time t, $A^i(t)$ is the signal charge and c^i is a constant depending only of the considered block. Since the energy of the incident particle does not change, the effective gain is then inversely proportional to the detected number of photons (and therefore to the number of absorbed photons). Assuming that aging, which affects the number of absorbed photons, is proportional to the charge received by each block, we can write:

$$\frac{1}{G^i(t)} = \frac{1}{G^i(t_1)} - \left[\frac{1}{G^i(t_1)} - \frac{1}{G^i(t_2)}\right] \frac{C^i(t)}{C^i(t_2)} \tag{2}$$

where t_1 and t_2 are the reference time of the calibration data taking, and where $C^i(t)$ is the charge at time t received by the block i since the first calibration. This charge can be written as the integral of the beam current multiplied by a factor depending of each block

$$C^i(t) = \int_{t_1}^{t} I(x)\,\alpha^i(x)\,dx \quad . \tag{3}$$

where the instantaneous beam current is known every second from accelerator information. The α^i coefficient aims at taking into account the relative position of a block: indeed, aging of a block depends of its position with respect to the beam as well as the target material. For a fixed configuration (same DVCS angle, same target...) α^i is time independent and can be deduced from the dynode current (DC) of the PMTs. In fact, the DC values are directly connected to the relative charge received by each block

$$\alpha^i \equiv DC^i \tag{4}$$

and then for kinematic 1, $C^i(t)$ writes:

$$C^i(t) = \int_{t_1}^{t} I(x)\,\alpha^i(x)\,dx = DC^i(t_1)\,Q_1(t) \quad . \tag{5}$$

Eq. 5 can be normalized with respect to a given block by dividing by $DC^0(t_1)$. Fig. 2 shows normalized DC values of each block. The relative difference between each block indicates the different radiation exposure and shows that, as expected, the blocks closer to the beam are more exposed than the others.

For kinematic 2, additional factors have to be introduced to consider the gain variation, and consequently the DC reading variation during the first kinematic. For the block i this factor is $DC^i(kin1_{end})/DC^i(kin1_{start})$ which leads

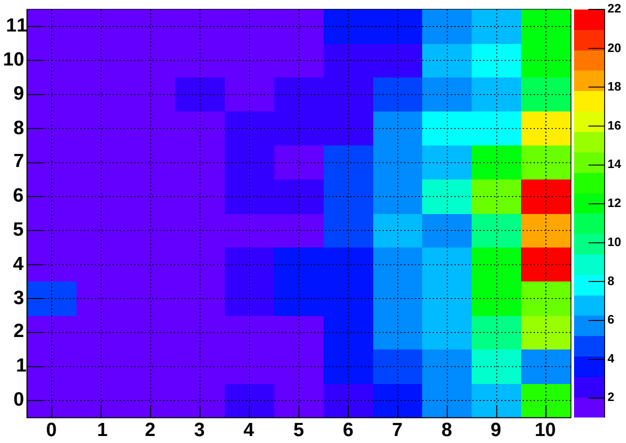

Figure 2. $DC^i(t_1)/DC^0(t_1)$ for the calorimeter blocks.

to the expression

$$C^i(t) = C^i(kin1_{end}) + \frac{DC^i(kin1_{end})}{DC^i(kin1_{start})}\,\frac{DC^i(kin2_{start})}{DC^0(t_1)}\;Q_2(t) \qquad (6)$$

with

$$Q_2(t) = \int_{kin2_{start}}^{t} I(x)\,dx \quad . \qquad (7)$$

The same method can be applied to determine the charge for kinematic 3 and 4, where another factor related to target changes is introduced. Fig. 3 shows the gain variation for 3 blocks of the calorimeter using the monitoring method.

The monitoring method is further applied for the determination of the missing mass for runs taken between the two elastic calibrations. Using time dependent calibration constants, fig. 4 shows the effects on the missing mass for the 50 first runs of the neutron kinematic; a cut on the expected block location in the proton array has been applied and accidentals have been subtracted. It is clearly seen on the right panel of fig. 4 that the reduction of the width of the missing mass spectra allows for a better identification of DVCS events.

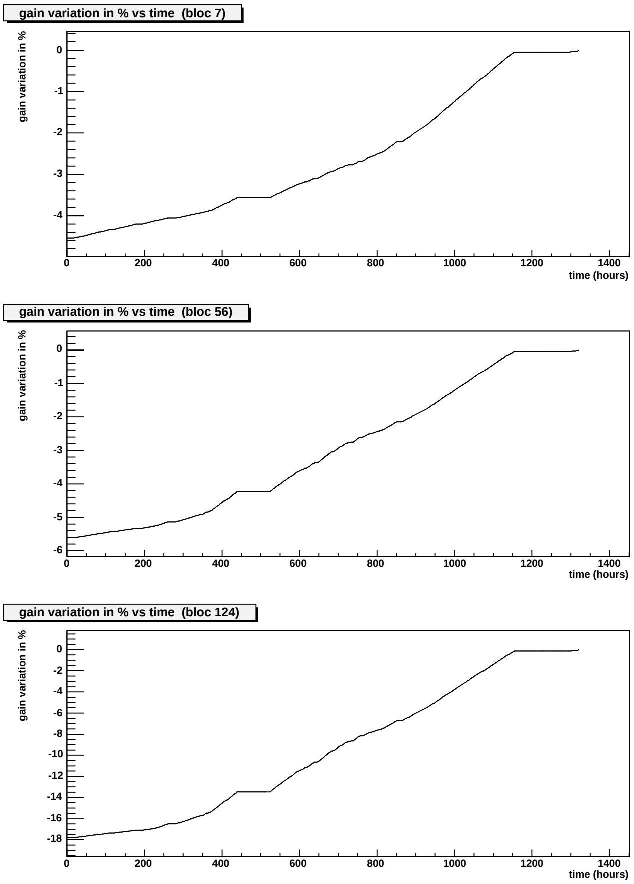

Figure 3. Gain variation in percentage for 3 calorimeter blocks.

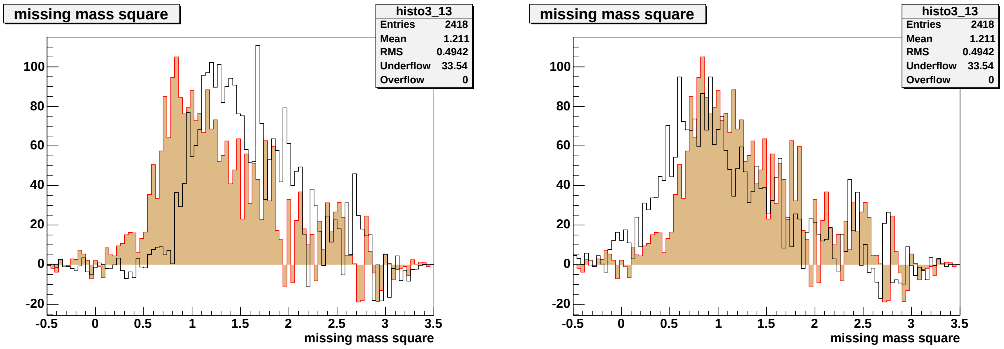

Figure 4. Missing mass spectra using different sets of calibration constants: red histograms correspond to coefficients calculated by the monitoring method; black histograms correspond to the first (left) or the second (right) calibration constants.

3 Comparison with LED results

A LED system has been designed with the aim of monitoring the calorimeter gain during the experiment [1–4]. The several measurements performed during data taking indicate that the aging process affects essentially the entrance of the blocks [5]. Therefore, the photons issued from the LED (outside the block) are more absorbed than those issued from a real particule (Čerenkov effect). Indeed, in the latter case, photons are created inside the block all along the trajectory of the particle, while in the former case, photons are created at the block entrance surface only. This leads to different sensitivities to photon absorbtion. Consequently, no quantitative comparaison can be obtained between the LED measurements and the monitoring method. This also implies that the calibration of the calorimeter using the LED system cannot be done without thorough investigations of aging effects on the optical properties of the blocks.

4 Conclusions

A monitoring scheme based on the relative charge exposure of each single block has been developed which allows to correct for the variations of the optical properties of the crystals through radiation damages. Consideration of time dependent effective gain within this method improves the missing mass determination and resolution. Due to an aging sensitivity different from physics events, the LED system cannot be used at the present stage. The proposed monitoring method is therefore is the only effective possibility to control gain variations during data taking.

References

[1] F.J. Barbosa and P.Y. Bertin, *DVCS Technical Note*, February 2003; http://hallaweb.jlab.org/experiment/DVCS/notes.htm.

[2] C. Ferdi, *DVCS Technical Note*, November 2003; http://www.jlab./~ferdi.

[3] A. Chantelauze, Master Thesis, Université Blaise Pascal, Clermont-Ferrand (France), 2004 http://www.jlab./~ferdi.

[4] C. Ferdi, *DVCS Technical Note*, August 2004; http://www.jlab./~ferdi.

[5] C. Ferdi, *Hall A Electronic Logbook*, September-December 2004.