

PESCA Instrument Analog Electronics Accelerator Calibration

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Abstract

The PESCA instrument has been designed and built with the purpose of studying the Solar Energetic Particles and the Anomalous Cosmic Rays from hydrogen to iron in the energy range 1.5-50 MeV/uma. The instrument will be part of the Russian PHOTON satellite payload. The instrument electronic system comprises two blocks: the analog block for the amplification system and the digital block for the data acquisition system. The results of the first analog electronics accelerator calibration is presented. The calibration was performed in GANIL heavy ions accelerator (Caen, France) using fragments produced with Ni ion beam at 52 MeV/uma impinging in the Au and C targets.

1 Introduction:

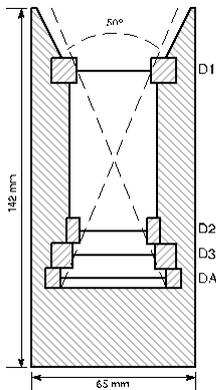


Figure 1: Detector telescope scheme.

The PESCA instrument consists of: one detector telescope (Figure 1) made up of four silicon ion implanted semiconductor detectors placed in an aluminum frame; one analog electronics whose mission is to amplify the four signals generated when one particle passes through the telescope; and one digital electronics, based on MAS281 microprocessor, whose goals are to acquire data from the analog electronics, to temporarily store them in memory and finally, to send them to the on-board satellite computer. A complete analog electronics description can be found in Peral et al. (1995, 1997).

2 Experimental procedure:

In April 1997, an accelerator calibration was performed in the GANIL (Grand Accélérateur National d'Ions Lourds, Caen, France) accelerator. The calibration conditions were: 52 MeV/uma ⁵⁸Ni incident beam; ¹²C (18.5 mg/cm²) and ¹⁹⁷Au (57.9 mg/cm²) targets; the detector telescope was placed at some 45 cm from the target on an arm that can rotate from 2° to 90° respect to the incident beam direction. This work presents one energy calibration method. This method has been developed using one of the data set acquired in GANIL, obtained with ¹⁹⁷Au and with the telescope placed at 7° from the incident beam. The GEANT (Brun et al., 1993) computer code has been used to simulate the experiment done at GANIL.

3 Energy calibration method:

The method consists of comparing the accelerator data to those obtained with the simulation. In order to have energies of reference, we have used the energies of the ΔE -E curves points where the evens that stop in the second detector and those that reach the third detector (arrows in figures 2 a and b) coincide. We have called those points "return points". In order to obtain an accurate determination of those "return points", a contour plot has been made for the region close to those points (figure 3). Figure 3a shows the data matrix and the figures 3 b, c and d show the contour plots for the regions indicated in figure 3a. From the correlation of those points with the simulation ones (figure 2b), it is possible to obtain a preliminary energy calibration $E1=p_1D1+q_1$ and $E2=p_2D2+q_2$ with σ_2 and σ_3 as standard deviations, these values will be used as first data for the final calibration. This final and definitive calibration is obtained minimizing the following χ^2 function:

$$\chi^2 = \frac{\left[\frac{A p_2 - a}{p_1} \right]^2}{\sigma_1^2} + \sum \frac{[p_1 D1 + q_1 - E1]^2}{\sigma_2^2} + \sum \frac{[p_2 D2 + q_2 - E2]^2}{\sigma_3^2}$$

were a and A are the slopes of the straight line shown in the figure 2 a and b respectively, those lines are the result of fitting a straight line to the points done by the ions stopped in D3 and which energies losses in D1 and D2 are proportional to the detector thickness; σ_1 is the worst standard deviation of those two fittings. The first term of the right hand side of that formula takes into account the similarity between the slopes of both straight lines, that fit from accelerator data and that from the simulation points. The other two terms take into account the preliminary calibration described above. Minimizing that function, the p_1 , p_2 , q_1 , q_2 parameters are obtained and therefore the calibration results for D1 and D2 detectors are:

$$E1 = 0.016 D1 - 0.007$$

$$E2 = 0.040 D2 + 0.423$$

To calibrate the third amplification chain, detector D3 chain, the log E2 (once calibrated) is plotted versus D3 for accelerator data (figure 2d), and the log E2 is plotted versus E3 for simulation data (figure 2c). Fitting the straight lines to those data, we obtain the results that are shown in figure 2 c and d and the final calibration:

$$E3 = 0.122 D3 - 0.527$$

Figure 4 shows the calibration results over the simulation data. It can be observed a very good correlation between them, about a relative deviation of 4% in the first and second chains and of 3% in the third chain.

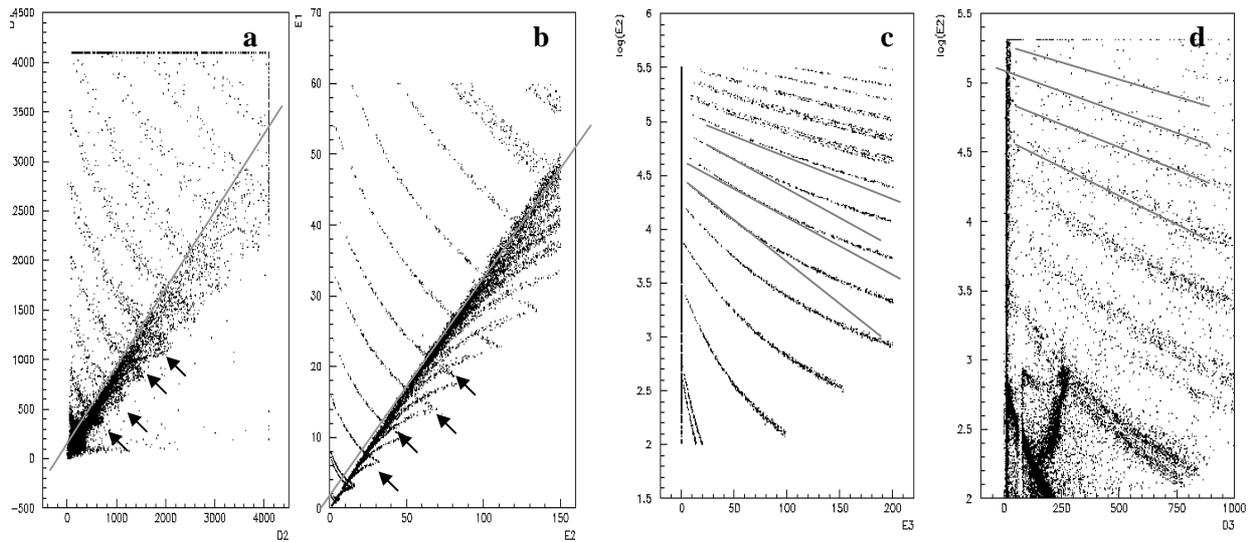


Figure 2: Energy losses matrices: a) D1-D2 (channel number) accelerator data; b) E1-E2 (keV) simulation data, in both figures the arrows indicate the “return points”; c) $\log(E_2)$ -E3 simulation data; d) $\log(E_2)$ -D3 accelerator data.

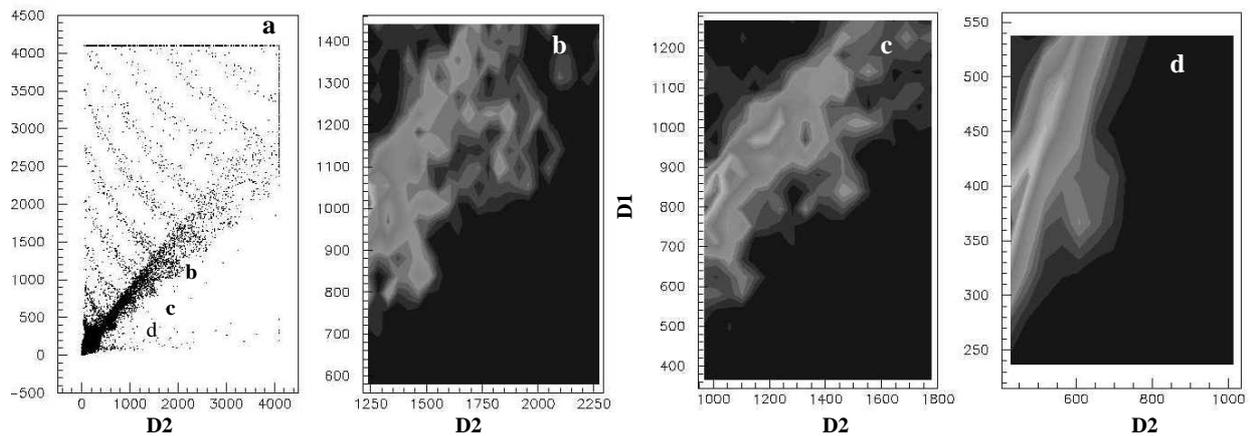


Figure 3: - D1-D2 (channel number) contour plots.

4 Conclusions:

A calibration method has been developed for multi-detectors ΔE -E telescope, this method is based on the plotting aspect of the energy losses matrices. From the figure 4 it is possible to conclude that the method is very accurate.

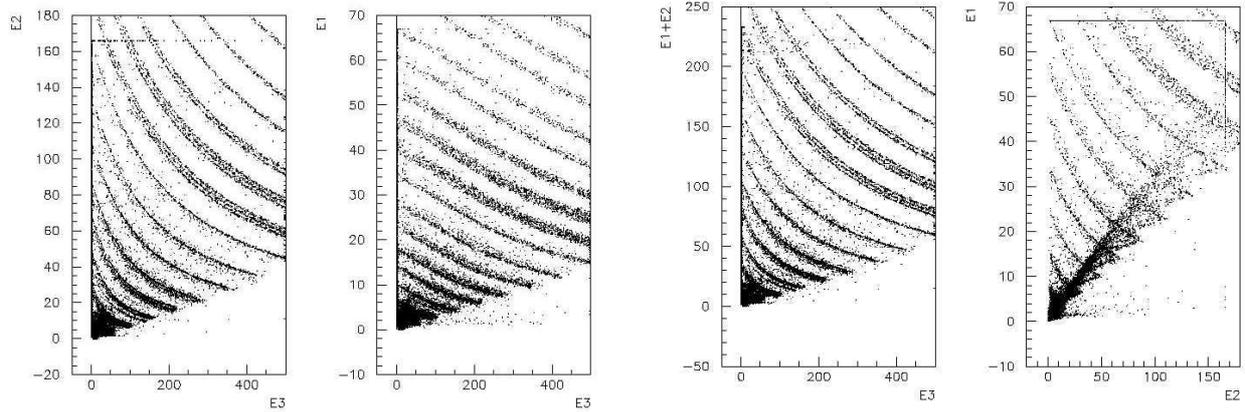


Figure 4: - Energy calibration results over simulation data.

2 Acknowledgment:

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