Energy calibration of the COSY-11 neutron detector

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During the year 2002 each out of the 12 detection segments of the COSY-11 neutron detector [1] has been improved by mounting additional light guides and photomultipiers, and at present the light signals produced in the scintillation layers are read out at two sides of the segment. This improves the time resolution of the detector significantly [2], which is a crucial factor, for example for the identification of the short living Σ^+ hyperon produced via the $pp \to nK^+\Sigma^+$ reaction. Additionally 12 new detection modules have been built and presently the neutron detector consists of 24 modules such as the one shown in figure 1.

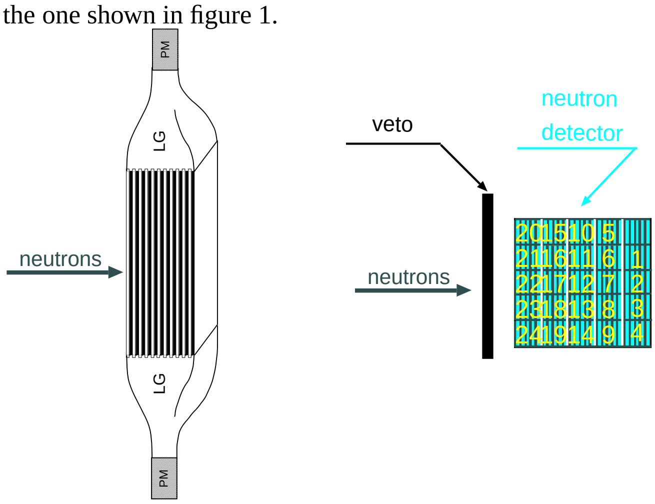

Fig. 1: **(left)** Scheme of a neutron detector module. Eleven plastic scintillator plates (white layers) with dimensions of $270 \times 90 \times 5$ mm^3 are interlayed by the same amount of lead sheets (dark layers). LG and PM denote light guides and photomultipliers, respectively. **(right)** Configuration of segments as used in the experiment.

The sum of the energy signals as well as the sum of the time signals from both edges of a segment are in a good approximation independed of the position at which the light was produced inside a module. Therefore the distributions over all detection segments of these sums may serve for the determination of position and time at which a primary neutron hits a detector.

The energy calibration for each of the 24 modules has been performed using the experimental setup presented in figure 2.

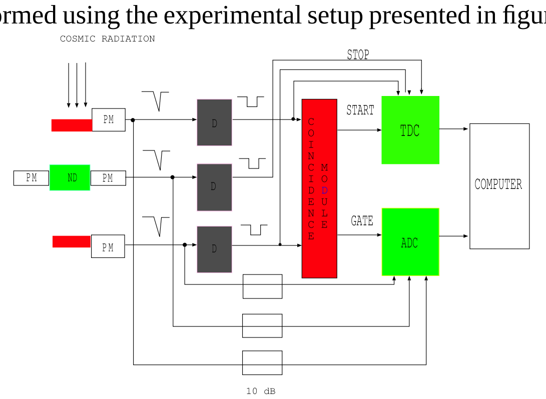

Fig. 2: Experimental setup for the energy calibration of the neutron detector. *TDC* and *ADC* denote the time to digital and charge to digital converters, and *D* stands for the discriminator.

Cosmic rays, covering the solid angle defined by two scintillator planes, induce reactions in the neutron detector module. Light originated from these reactions is collected through the specially shaped light guides [1] onto the photomultipliers. The electronic signals are then processed as indicated in figure 2.

Figure 3 shows an example of the energy spectrum obtained during these tests.

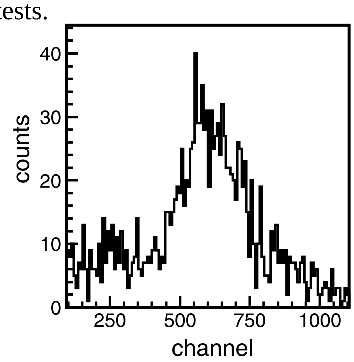

Fig. 3: An example of an ADC spectrum obtained during the test measurement with cosmic rays.

The main goal of the calibration was to set up the gains for every single module, in order to simplify the online monitoring of the detector functioning and the interpretation of the data. For example, having equal gains for all segments we could, in the first approximation, estimate a total energy deposited in the detector as a sum of amplitudes from all individual signals and we could use the same discrimination level for all detection modules. The appropriate voltages for each of the 48 photomultipliers have been extracted and applied during the June ’02 measurements. Figure 4 compares the number of hits per module between the experiment and Monte-Carlo calculations.

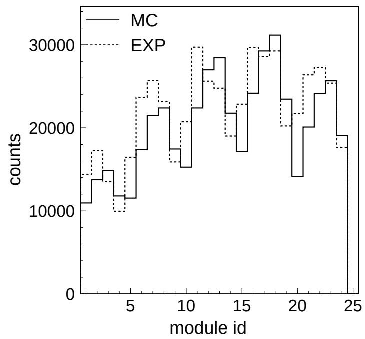

Fig. 4: Number of hits per individual module from both Monte-Carlo (solid line) and experiment (dashed line). Module id’s are defined in the right panel of figure 1.

There are slight differences in the relative counting rate between various modules yet the general trend of the observed structure coincides well with the result of the simulations based on the GEANT code. Figure 4 indicates that the energy calibrations were performed correctly with an accuracy of a few percent.

References:

[1] P. Moskal et al., Ann. Rep. 1996, IKP FZ-Jülich, **Jül-3365**, 35.

[2] T. Rożek and P. Moskal, contribution in this report.

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