SIDDHARTA Technical Note IR - 7

Rate dependence of the SDD response (signal position and resolution) during the trigger tests on a 30 mm^2 chip performed at the Beam Test Facility (BTF) of LNF in the period 13 – 28 July 2004

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1. Introduction

After an accurate testing of an array of 7 Silicon Drift Detectors (SDD), 5 mm^2 each [1], in laboratory and on the BTF facility [2] in 2003 and beginning of 2004, in March 2004 a new SDD prototype was delivered for testing by MPE and PNSensor. The new prototype has a surface of 30 mm^2 – so only a factor about 3 smaller than the final device (1 cm^2). The new device, which is in many aspects different with respect to the previous one, being closer in design to the final one, was equipped with a prototype electronics. A series of measurements then started. The first measurements, performed in the laboratory, showed that the SDD chip worked properly.

Consequently, a test on the trigger of this new device equipped with the prototype electronics, was performed at the BTF facility in the period 13-28 July 2004. The results of the tests performed on the trigger were very successful [3].

In the present Note the results of a study of the dependence of peak positions and resolution on the incident rate are reported. As it will be shown, the results do depend rather drastically on the incident rate (m.i.p.s. particles). This dependence was qualified under BTF conditions. The obtained results do reproduce what was previously obtained in laboratory, by using a Sr source.

An eventual dependence of the peak-position on the incident rate on SDD detectors, would eventually imply a systematic error on the SIDDHARTA results. Taking into account the aim of SIDDHARTA – an eV measurement of kaonic hydrogen and the first measurement of kaonic deuterium – such a systematic error cannot be beyond some eV.

The present achievements, together with the results in laboratory, proved to be very important in designing a new electronics, which corrects the rate dependence within acceptale level.

In Section 2 the experimental results are presented, while in Section 3 they are discussed and the future plans briefly presented.

2. Experimental results

The 30 mm^2 SDD chip setup with which the measurements at the BTF were performed was described in detail in [3] – so we shall not present it here again. While in [3] the experimental results for what concerns the trigger capacity were discussed in detail, in the present work we shall concentrate on the aspect of the dependence of peak position and resolution on the incident rate.

We have performed various trigger tests, under different incident rates. The rates were chosen such as to be comparable with those measured by DEAR on DAΦNE. Actually a safety factor of more than 10/channel was taken into account.

While, extrapolating from the measured background rate in DEAR, the mean value of the incident rate on the SIDDHARTA 1 cm^2 chip channel is expected to be about 4-5 Hz per channel, with a variation of the rate during DAQ of a factor about 5 between the maximal and minimal values, at BTF rates varying from 10 to 200 and 520 per channel Hz were tested. This gives us a larger range for testing the dependence of the measured results on the incident rate.

We consider as reference for the data analysis the parameters of the Copper K_α – peak (position and resolution) – since this is the only signal seen in all spectra (being it generated by the BTF beam – so present independently on the trigger condition).

In Figure 1 we give an example of a measured spectrum, corresponding in this case to the measurement performed for an incident rate of about 10 Hz, generated by the presence of the BTF beam alone, with the trigger on (for comments on trigger see [3]).

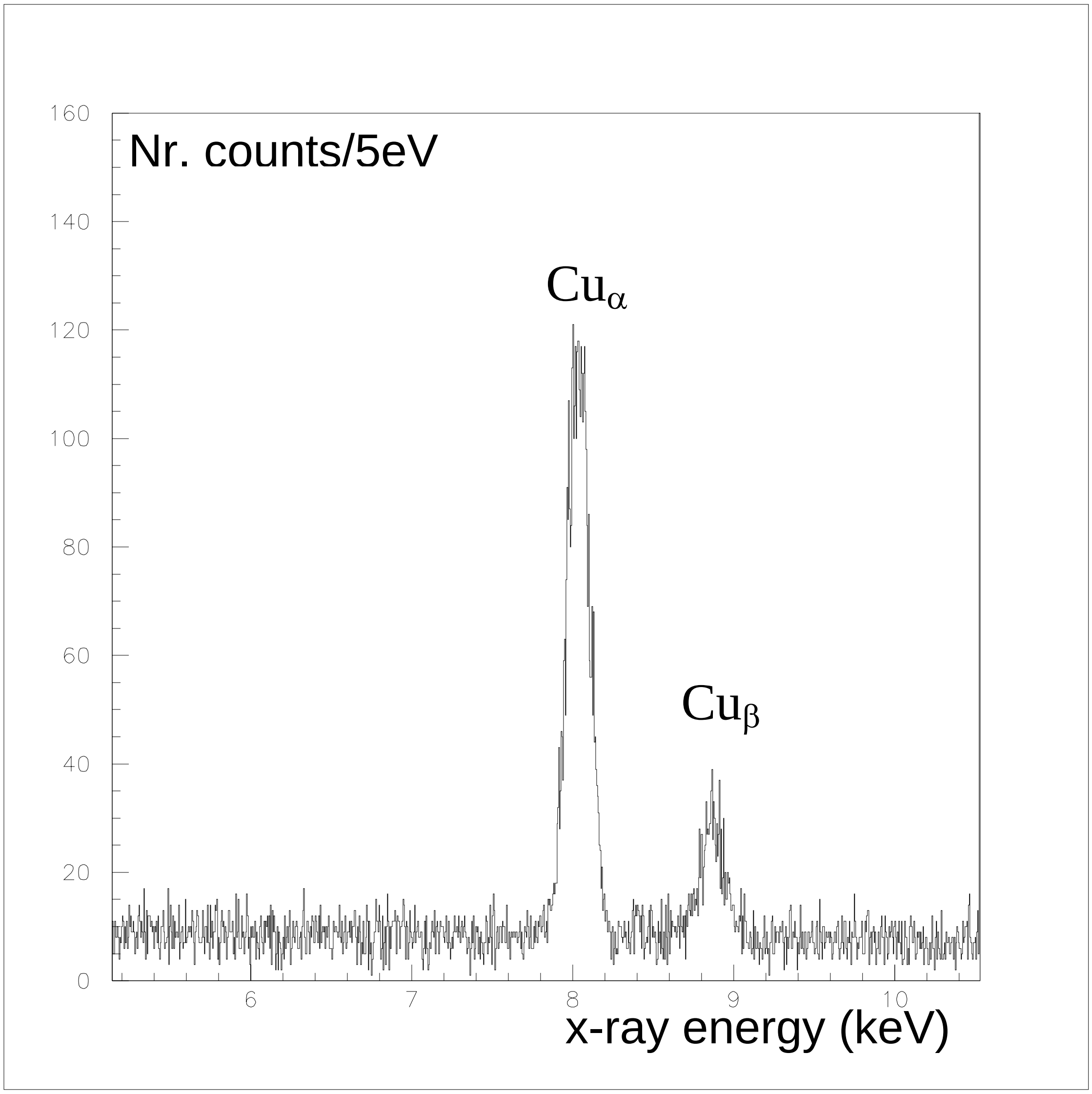

Fig. 1: Energy spectrum obtained with trigger (3μs), with BTF on (572 min), with an incident rate of 10 Hz.

In Fig. 1 the spectrum was already correctly calibrated in energy.

As for a comparison of different results, the parameters of the copper K_α peak (position and resolution) were considered.

In Table 1 the results obtained in various measurements are reported.

Table 1: Experimental results on the Cu K_α parameters

Measurement type	Incident rate (Hz)	Energy difference w.r.t. first measurement (taken as calibration)	Exp. resolution Γ (eV)
Only BTF beam	**10**	**-**	**161 +/- 2**
BTF + Sr + Fe (trigger ON)	**160 (Sr)+ 20 (Fe)+ 10 (BTF)**	**29.3 +/- 2.1**	**183 +/- 3**
BTF + Sr + Fe (trigger ON)	**490 (Sr)+ 20 (Fe)+ 10 (BTF)**	**74.5 +/- 4.1**	**224 +/- 4**

3. Discussion of the experimental results and future plans

In the previous Section, the results of the measurements performed during a test of the trigger for a 30 mm^2 SDD chip, performed at the BTF facility at Frascati National Laboratory, were briefly presented. In particular, the dependence of the results, seen as Copper K_α peak position and resolution, on the incident rate on the SDD surface, were analyzed. Three individual measurements were performed, with rates going from 10, to 200 and 520 Hz. The main part of this rate is constituted of charged (m.i.p.) particles, releasing about 160 keV each in the SDD.

The electronics with which the SDD chip was equipped is a preliminary electronics, not specially designed for the experiment. The goal of this study was to characterize the parameter variations as function of the rate and, based on the conclusions, to design a new electronics.

By the analysis of the results presented in Table 1, one deduce that a variation of about 75 eV (increase of about 1%) equivalent peak position at about 8 keV (Copper position) for an increase of incident rate from 10 to 520 Hz is obtained. This increase is accompanied by decrease in the experimental resolution from 161 to 224 eV (increase of about 40%).

Since the goal of the SIDDHARTA experiment is to perform a measurement at eV level precision, the systematics should be kept under control at eV as well. This goal can be achieved in two main ways:

- by calibrating the apparatus (i.e. SDD detectors) at DAFNE, such as to know the variations as function of the rate delivered by DAFNE and to correct for it offline;
- by building a readout electronics which varies with the incident rate at <0.1%, i.e. at eV level

In this stage of the experiment, when electronics is still under design and is still to be built, the second solution is our goal. In order to reach this goal, a solution was identified in using a Charge Preamplifier. This solution will be matter of another Technical Report.

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A first production run for this type of electronics, specially designed for SIDDHARTA, is undergoing and tests will start soon.

Acknowledgements

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Bibliography

[2] SIDDHARTA Collaboration: SIDDHARTA Technical Note IR-1 "Tests of prototype Silicon Drift Detectors to be used in **SIDDHARTA (S**ilicon **D**rift **D**etector for **H**adronic **A**tom **R**esearch by **T**iming **A**pplication) performed at the Beam Test Facility (BTF) of LNF in the period 21 – 31 July 2003, ***25 August 2003***

[1] DAFNE Technical Note: LC-2: DAFNE-Linac Test Beam and
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[1] M. Bragadireanu *et. al.*, SIDDHARTA Technical Note IR-5 "Tests of trigger on 30 mm^2 Silicon Drift Detector prototype performed at the Beam Test Facility (BTF) of LNF in the period 13 – 28 July 2004", *2 November 2004.*