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First results from the Lund NMP particle detector system

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ABSTRACT

The design and first results from a Double Sided Silicon Strip Detector (DSSSD) recently installed at the Lund Nuclear Microprobe facility (NMP) are presented. The detector has 64 sector strips and 32 ring strips, which in combination give more than 2000 detector cells, each with characteristics comparable with a standard surface barrier detector (SBD).

The detector has been tested both with radioactive sources and with different ion beams and energies. The most striking features are the high rate virtually pile-up free operation and also the possibility of detailed measurement of angular distributions.

1. Introduction

During the last decades both the nuclear and particle physics experiments have moved towards detector systems with higher and higher granularity. This allows for experiments with higher multiplicities, but also simultaneously providing the experimentalist with more specific angular information about all the emitted particles. Applied nuclear physics normally does not have more than one or two particles out from each event and therefore the fine granularity can be used as a strong pile-up rejection technique. This allows the use of a much larger detector for the same beam intensity and hence shorter time for data acquisition and higher counting statistics. The second advantage of high granularity detectors is the good position resolution, which helps reducing kinematic broadening in particle detection experiments.

In this paper we will present the design and first results from a Double Sided Silicon Strip Detector (DSSSD) recently installed at the Lund NMP. We will present an overview of the experimental set-up, describe the read-out chain and discuss results from the first test runs at the Lund NMP.

2. Experimental set-up

2.1. DSSSD – description

The detector has an outer diameter of 100 mm and an inner hole with 10 mm diameter with the active area of the detector between 14.0 and 85 mm. The active area is divided into 64 radial strips (sectors) on the junction side (P-type) and 32 circular strips (rings) on the ohmic side (N^{++}-side). The inter strip distance is 110 μm on both sides of the detector. The thickness of the detector is 310 μm with a dead layer of 0.55 μm Si-equivalent on the junction side and 2.0 μm on the ohmic side [1]. The detector is mounted and bonded on a printed circuit board together with connectors. In Fig. 1 two photos of the detector are shown, the ring side (a) and the sector side (b). During normal operation the sector side is facing the source of radiation, i.e. the target.

2.2. Front-end electronics (FEE) and DAQ

The analogue signals from DSSSDs are transmitted inside the experimental chamber to the vacuum feed through flange by flat cables. The signals are further processed by front-end electronics manufactured by Mesytec [2] and commercially available on the market. The low noise charge sensitive multichannel MPR-16 preamplifiers [3] are mounted outside the experimental chamber directly on the flange with vacuum feed through. To improve noise immunity and to meet special requirements on energy resolution the signals from the

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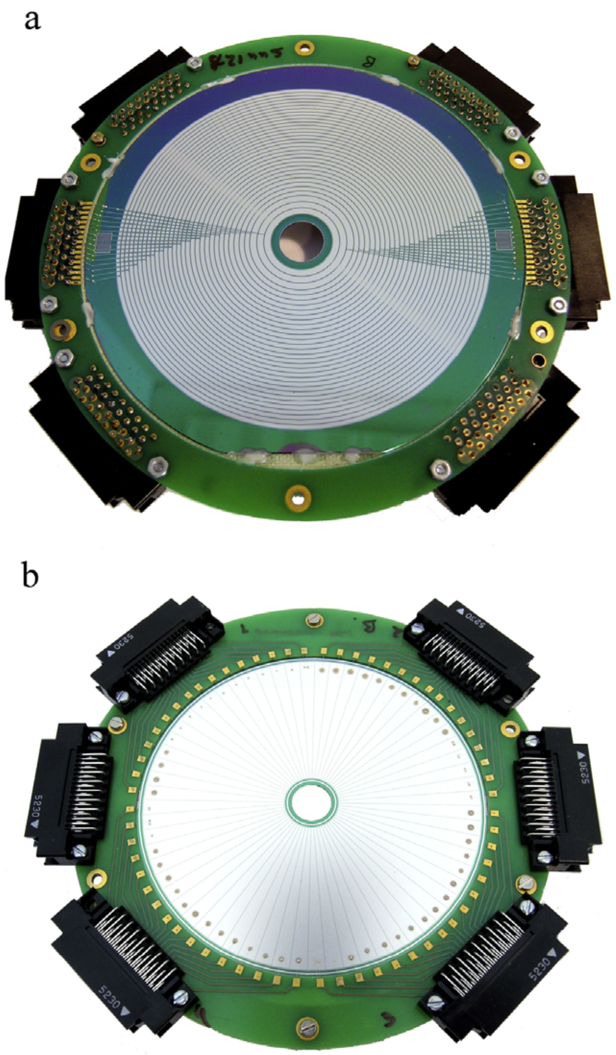

Fig. 1. Photograph of the DSSSD with a 10 mm diameter hole and an outer diameter of 100 mm. In (a) the backside with 32 rings and in (b) the front side with 64 sectors are shown. Requiring signals from both sectors and rings results in more than 2000 channels of detectors.

preamp output are transmitted to STM-16+ [4] shaping/timing filter amplifiers on shielded cables in differential form. The typical energy resolution measured with ^{228}Th alpha source is 0.5% (44 keV FWHM @ 8.780 MeV, C_{det} = 32pF). The STM-16+ leading edge discriminator output, derived from the timing filter amplifier branch, was processed in standard NIM electronics to generate master trigger and the required control signals for Data Acquisition System (DAQ).

The cost effective DAQ system is developed around the SBS 618 VME-PCI interface [5] consisting of one PCI card and one VME main board linked together by an optical cable. Linux has been chosen as the operating system (OS) and SBS-618 driver provided by [6]. The relevant software under this OS has been developed using C/C++ language and ROOT libraries [7]. The front-end digitisers CAEN V785 [8] are housed in a VME crate. Once the digitised signals are ready to be readout, the data are transferred to a PC through the VME-PCI adapter to be saved on storage media and for fast on-line data analysis and visualisation.

3. Experimental results

All tests and experiments discussed below were performed at the new sub-micron beam line at the Lund IBA facility [9,10]. The DSSSD was mounted from the rear plane of the chamber approximately at a position 75 mm from the target. This arrangement made it necessary to dismount the normal eight-element HPGe-detector [11] and its exit flange was used for cable feed through. The DSSSD was optically aligned with the focused beam as a reference point. The IBA-experiments were performed with a proton beam with two different energies, 2.55 and 0.62 MeV, and an alpha beam of 2.75 MeV. The set-up was initiated and calibrated with a ^{228}Th source. For the ion beam experiments typical parameters were currents between 1 and 2 nA and beam spot sizes less than $10 * 10\ \mu m^2$. The beam was normally scanned over a small area ($<200 * 200\ \mu m^2$) and this was controlled by the old CAMAC based DAQ system [12] without recording and transferring information to the DAQ system used.

3.1. Calibration

For non-beam calibration an open ^{228}Th source was placed on the sample ladder in the experimental chamber. Under vacuum a number of discrete alpha peaks in the interval 4–8 MeV can be used for gain adjustment and an initial calibration. To transfer this calibration to proton data, corrections for the dead layer have to be performed.

A second initial test that has to be done is identifying and ordering the individual rings and sectors. To be able to do this the detector was partly shielded by a cable tie and the hit pattern was studied and sector and ring signals were disentangled. In Fig. 2, a typical hit pattern from the ^{228}Th source is shown after all the sectors and rings have been properly assigned.

3.2. Proton scattering

In the first test run an AP1-foil was bombarded with 2.55 MeV protons. The AP1 foil is a thin, 15 $\mu g/cm^2$, plastic foil that mainly consists of carbon, nitrogen, oxygen and hydrogen. From measuring back-scattered particles from C, N and O in the foil three different peaks are expected and were also observed. To evaluate the relative performance of rings and sectors the signal from one of the sectors was correlated with one signal from one of the rings and the result is shown in Fig. 3(a). Three distinct peaks (islands)

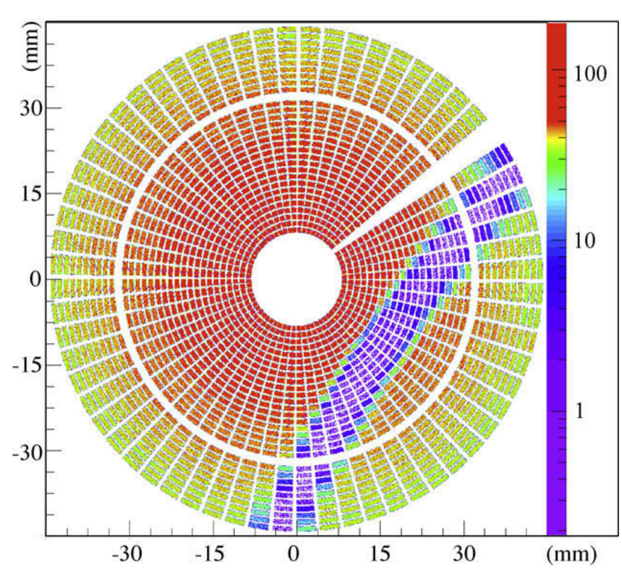

Fig. 2. A hit pattern obtained during the calibration with the ^{228}Th source. The low count area (blue) is due to intentional shading of the detector by a cable tie. The white ring and sector are both due to no signal transfer in the front-end electronics.