The ANKE Silicon Spectator Tracker ASiST

S. Barsov[1], G. Fiori, T. Krings, I. Lehmann, S. Merzliakov[2], H. Metz, A. Mussgiller, D. Protic, R. Schleichert

The identification and tracking of low energy protons allows to use deuterium as an effective neutron target. Once the polarized **A**tomic **B**eam **S**ource ABS [1] will be installed at the ANKE spectrometer, also polarized proton-proton and proton-deuteron collisions can be studied. Especially the polarized deuteron gas of the ABS allows to study reactions of the type $\vec{p}\vec{n} \rightarrow pnX$ or $\vec{p}\vec{n} \rightarrow dX$.

For this purpose a vertex detector based on double-sided silicon strip detectors inside the vacuum of the COSY ring is under development [2]. Its barrel region will be based on modular silicon tracking telescopes that provide

- ΔE/E proton identification from 2.5 up to 40MeV. The telescope structure of 65/300/300/5500µm thick double-sided Si-strip detectors, read out by high dynamic range electronics [3], allows ΔE/E particle identification over a wide dynamic range.
- self-triggering capabilities. The telescopes identify a particle passage within ≤100ns and provide in combination with the self-triggering chips a fast hit pattern recognition [3].
- particle tracking over a wide range of energies, either 2.5MeV spectator protons or minimum ionizing particles.
- high rate capability with a read-out pitch of ~200µm.

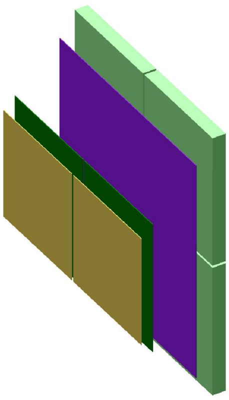

Fig. 1: The ASiST telescope arrangement of the double-sided silicon-strip detectors: Two 65µm thick detectors as inner layer, two and four 300µm thick detectors as middle layers[1] and four 5500µm thick Si(Li) detectors as outer layer. Protons will be tracked and identified from 2.5MeV up to 40MeV.

The basic detection concept of a telescope is to combine proton identification and particle tracking over a wide energy range. The tracking of particles is accomplished by the use of double-sided silicon strip detectors. Measuring the energy loss in the individual layers of the telescope allows to identify stopped particles by the ΔE/E method. The minimum energy of a proton to be tracked is given by the thickness of the most inner layer. It will be detected as soon as it punches through the inner layer with a minimum energy loss in the second layer. The maximum energy of protons to be identified is given by the range within the telescope and therefore by the total thickness of all detection layers. Especially the recent development of very thick (≥5mm) double-sided micro structured Si(Li) [4] and very thin (≤65µm) double-sided Si-detectors provides the use of the telescopes over a wide range of particle energies. The self-triggering capability of all detectors introduces the options to start a read-out on a particle passage and to set fast timing coincidences with other detector components of the ANKE spectrometer. Figure 1 shows the principle arrangement of the detectors within a single telescope.

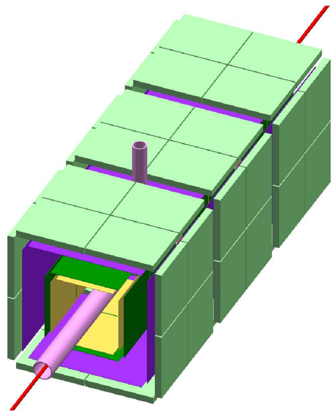

Fig. 2: 12 telescopes are arranged around the 40cm long storage cell of the polarized atomic beam source.

12 of these telescopes are foreseen to cover the barrel region of the ANKE vertex detector. Figure 2 shows a possible arrangement of these telescopes around a 40cm long ABS storage cell.

The assembly of the UHV compatible read-out boards for the ASiST telescopes is described in [5], first measurements are reported in [6]

References:

[1] M. Mikirtytchiants et al., *Beam Properties of the ANKE Atomic Beam Source*, contribution to this report.
[2] R. Schleichert et al., *Combined Spectator and Vertex Detection at ANKE*, Annual Report 2000 of the IKP, FZ-Juelich (2000), p.26.
[3] A. Mussgiller et al., *Evaluation of front-end Chips for Silicon Strip Detectors*, Annual Report 1999 of the IKP, FZ-Juelich (1999), p.31.
[4] D. Protic et al., *Development of Double-sided Microstructured Si(Li)-Detectors*, contribution to this report.
[5] L. Conin et al., *A Flexible Printed Board for the ASiST Chip Readout*, contribution to this report.
[6] A. Mussgiller et al., *Experimental Results from an ASiST Prototype*, contribution to this report.

[1] PNPI Gatchina, Russia
[2] JINR Dubna. Russia

[1] The 3rd layer is optional to guaranty redundancy in the case of multiple track events.

A Flexible Printed Board for the ASiST Chip Readout

L. Conin, N. Dolfus, G. Fiori, H. Hadamek, T. Krings, S. Merzliakov[1], A. Mussgiller, D. Protic, R. Schleichert

The readout electronics of the ANKE Silicon Tracking Telescope ASiST [1] is based on the chip combination VA32HDR_2 and TA32CG of the Norwegian company *ideas* [2]. The VA32HDR_2 houses 32 preamplifiers and 32 slow shaper amplifiers (2µs) whereas the TA32CG provides 32 corresponding fast shaper amplifiers (100ns) and discriminators to get timing and trigger signals.

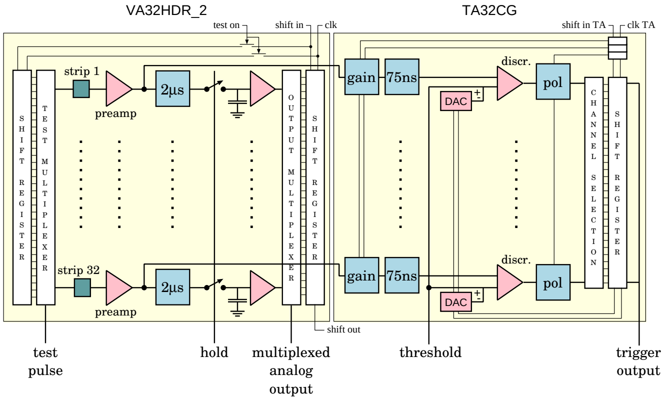

Fig. 1. The block diagram of the VA32HDR_2 and the TA32CG chips. The individual preamplifier outputs of the VA32HDR_2 are directly bonded to the inputs of the TA32CG. In the simplest trigger configuration the trigger output of the TA32CG directly serves to generate a hold signal for the VA32HDR_2.

In the in-vacuum prototype assembly of the ASiST, 7 chip-pairs (7*32=224 readout channels) are glued and some SMD components are soldered on a flexible printed board, the so-called Y-Flex [3]. Figure 2 shows a photo of a single foil. Each double-sided detector will be equipped with 2 of these foils. The material (**L**iquid **C**rystal **P**olymer, LCP) has been chosen for two reasons: First it is not magnetic or electrically conductive, which is important in the 1.6T environment of the ANKE spectrometer magnet. Second it is designed to incorporate a minimum amount of water. This feature is extremely attractive to minimize the pumping time to reach ultra high vacuum conditions.

Before bonding the chips, the foil is glued on a simple 0.635mm Al_2O_3 ceramic plate to have a rigid support in the region of the chips.

The total assembly of a single flexible printed board has been checked for its ultra-high vacuum compatibility. Figure 3 shows the rest-gas spectrum. The remaining gas components are no severe problem the COSY vacuum and can easily be pumped.

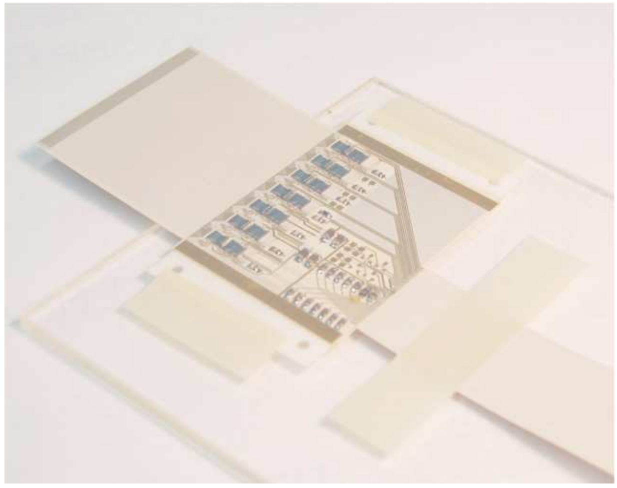

Fig. 2. The Y-Flex flexible printed board with 7 chip-pairs glued on it. To the left side the foil is directly glued to the detector. The right side interfaces to the vacuum feed-through.

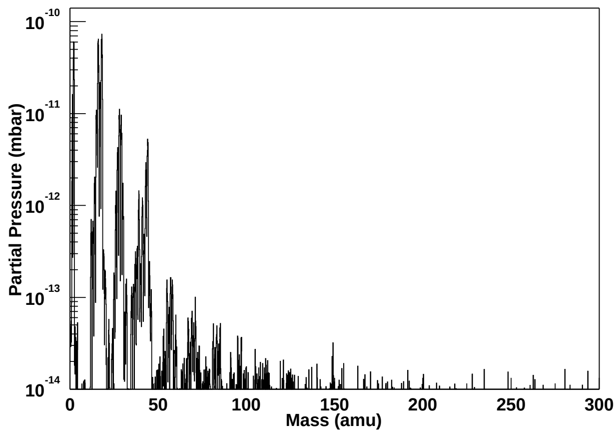

Fig. 3. The rest-gas spectrum of the Y-Flex flexible printed board. The total pressure at which the spectrum has been taken is $1.6*10^{-9}$mbar. The total assembly is fully UHV compatible.

References:

[1] S. Barsov et al., *The ANKE Silicon Spectator Tracker ASiST*, contribution to this report.

[2] A. Mussgiller et al., *Evaluation of front-end Chips for Silicon Strip Detectors*, Annual Report 1999 of the IKP, FZ-Juelich (1999), p.31.

[3] Yamaichi, Flexible Printed Circuit, http://www.yamaichi.de.

[1] JINR Dubna, Russia

Experimental Results from an ASiST Prototype

A. Mussgiller, S. Merzliakov[1], T. Krings, D. Protic, R. Schleichert

A prototype of the ANKE Silicon Spectator Tracker ASiST [1] has been assembled. The setup consists of 3 silicon-strip detectors. The first detector is 65µm thick, with an active area of 40*40mm^2, 40 strips on each side (Micron Semiconductors BB1 design). The second detector is 300µm thick, with an active area of 66.18*51.13mm^2 and 631+1023 strips (Micron Semiconductors Babar IV design). On the *n-side* there are 631 strips: 316 strips and 315 reciprocal strips. Strip plus reciprocal strip have a pitch of 105µm. Already on the detector they are bonded to 315 groups of 4 strips and a single group of 3 strips. Therefore 316 groups of strips (pitch 210µm) are bonded to a Kapton pitch-adapter that furthermore joins the groups to 40 channels: 38 channels in the center, each joining 8 groups, 2 channels at the border, each joining 6 groups. These 40 channels have been equipped with dedicated fast preamplifiers for timing measurements, which are not described here. On the *p-side* there are 1023 strips (512 strips, 511 reciprocal strips) with a pitch of 50µm. On the detector they are bonded together to 256 groups (pitch 200µm): 255 groups of 4 strips, 1 group with 3 strips. These 256 groups are bonded to a pitch-adapter foil. It joins the groups to the 7*32=224 readout-channels of the flexible printed circuit described below: 192 single-group channels in the center, 2*16 channels at the borders, each joining 2 groups.

The last layer is a 5500µm thick single-sided Si(Li) detector with 200 strips and an active area of 47*23mm^2.

The setup has been installed and included into the common ANKE read-out system during a beam-time in September 2001. At a COSY energy of T_p=500MeV data has been taken for the reaction $\vec{p}d \to pX$. Figure 1 shows a typical pedestal distribution in the experimental environment. Without any correction the width (FWHM) is about 53keV. Applying an offline common-mode correction the width of the pedestal distribution can be reduced to about 33keV.

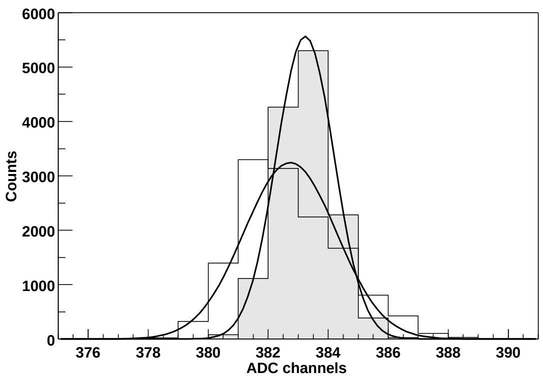

Fig. 1: The typical pedestal distributions measured in ADC channels (15keV/channel): σ=1.54 ADC-channels without common correction, σ=0.96 ADC-channels with an off-line common correction.

Figure 2 shows the energy loss in the first 65µm thin layer versus the energy loss in the second 300µm thick layer. All channels have been energy calibrated by a simple linear approximation taking the pedestal value as zero energy loss and the punch-through points (2.2MeV in 65µm and 6.3MeV in 300µm silicon). The 40 channels of the 65µm (p-side) and the 224 channels of the 300µm (p-side) are summed in the spectrum.

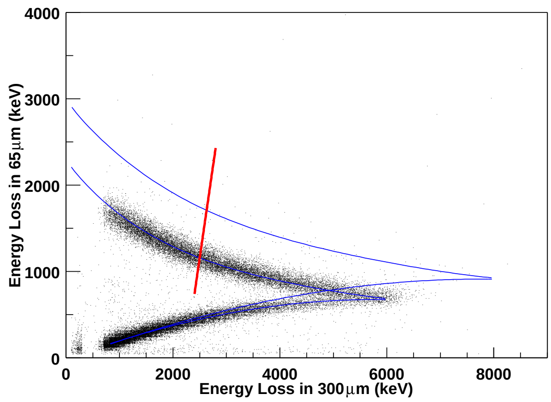

Fig. 2: Energy loss in the 65µm versus the energy loss in the 300µm thick detector. In addition are drawn the SRIM calculations for the energy losses of protons and deuterons.

Even with this simple calibration, not taking into account the non-linearity of the electronic chips, a single narrow proton band appears. The minimum detected proton energy can be extracted to be about 2.5MeV. No deuterons are seen because the telescope is installed in the backward hemisphere of the target where scattered deterons are absent. Nevertheless, the proton-deuteron separation by their energy losses in the first two layers under forward angles of the telescope can be expected to be pretty good as deduced from Figure 3. The energy resolution along the line in Figure 2 is shown to be ~160keV FWHM, which proofs the good performance of the 65µm thick detector.

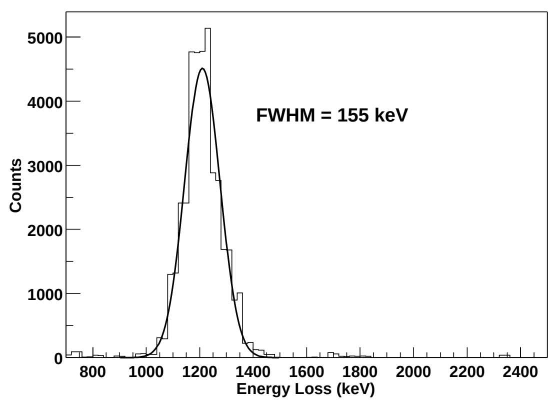

Fig. 3: Projection along the line in Figure 2 results in an energy resolution of about 160keV FWHM

References:

[1] S. Barsov et al., *The ANKE Silicon Spectator Tracker ASiST*, contribution to this report.

[1] JINR Dubna, Russia