0° Magnetic Spectrograph for SNAKE

A. Hauptner, G. Datzmann, G. Dollinger, H. J. Körner, P. Reichart, and O. Schmelmer

As a new part of instrumentation for SNAKE (**S**upraleitendes **N**anoskop für **a**ngewandte **k**ernphysikalische **E**xperimente) [1] the 0° spectrograph has been built up and tested. This device enables STIM (**s**canning **t**ransmission **i**on **m**icroscopy) experiments with a submicron ion beam diameter due to the focussing action of a superconducting multipole lens [2]. The 0° spectrograph analyzes the energy of the transmitted ions with a relative energy resolution in the order of about 1×10^{-5}. Thus, it is possible to measure two–dimensional thickness profiles of samples as well as fundamental interactions of high energetic ions with matter.

The main component of the spectrograph is the 90° vertical magnet, the former analyzing magnet behind the tandem, which has been already put at the end of the 0° beamline in 1996. In order to obtain the required ion optical performance, the 0° spectrograph was completed by installing two independent quadrupole singlet magnets. An overview of the whole setup can be seen in fig.1.

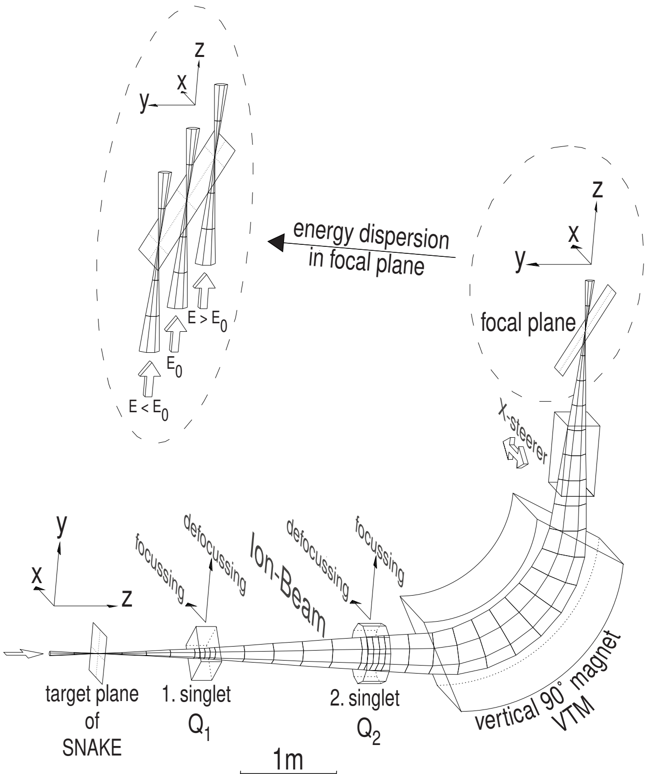

Fig. 1: The 0° spectrograph at a glance. The transversal expansion of the ion beam is scaled by a factor of 50.

Calculations [3] have shown a relative energy dispersion along the focal plane of $2.1 \times 10^{-4}\, mm^{-1}$.

In order to operate the 0° spectrograph with the intended energy resolution of about 1×10^{-5}, a focal plane detector providing a spatial resolution in one dimension of better than $50\,\mu m$ had to be selected. This has been done by testing a CCD (**c**harge **c**oupled **d**evice) Linear Image Sensor with 2048 channels (pixels) for the detection of high energetic ions. Employing this detector, which was originally constructed for optical applications, a spatial resolution of $14\,\mu m$ for both light (e.g. 20 MeV protons) and heavy (e.g. 90 MeV S) ions can be reached. For minimum ionizing particles the CCD sensor additionally offers the possibility to detect many ions within one readout cycle, leading to a high counting rate of more than $100\,kHz$. In that case, a typical output signal of the detector, coming along one serial line, looks like the one shown in fig.2.

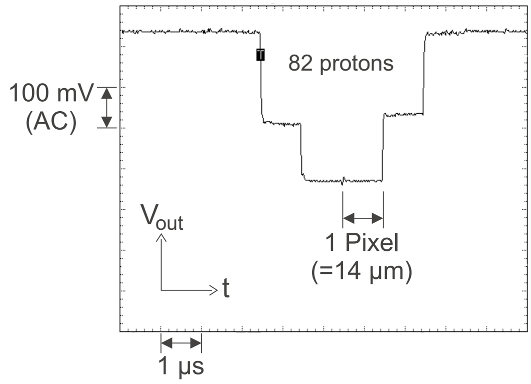

Fig. 2: Response of the CCD sensor using 20 MeV protons. 82 ions hit four detector pixels within one readout cycle of $2\,ms$.

The whole arrangement, ion optical components and focal plane detector, was tested in three beam times in autumn 1999 using 20 MeV protons and 90 MeV sulfur ions. An energy spectrum of 90 MeV $^{32}S^{+8}$ measured with the 0° spectrograph is shown in fig.3.

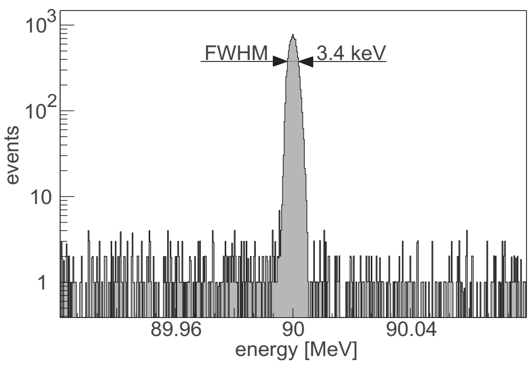

Fig. 3: Energy spectrum of a 90 MeV $^{32}S^{+8}$ beam without target.

The relative energy resolution reached is 3.8×10^{-5} (FWHM). This was possible due to a sharp beam energy achieved by cutting down the beam with the object and image slits in front of and behind the 90° analyzing magnet.

References

[1] G. Dollinger *et al.*, this report, p.89
[2] G. Datzmann *et al.*, this report, p.90
[3] A. Hauptner, diploma thesis, TU München, 1999