A Novel High Precision Slit System

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A new high precision slit system has been developed and tested for the ion microscope **SNAKE** (**S**upraleitendes **N**anoskop fuer **A**ngewandte **K**ernphysikalische **E**xperimente) [1]. Various technical efforts were made to meet the requirements of this facility which will be operated with protons with energies up to $30 MeV$ having a range of several mm in matter. Therefore the requirements for the slits defining the object are not trivial.

The actual slits are made by nearly atomically flat germanium and have a cylindrical shape with a radius of $50mm$ which limits transmission through slit edges. Both halfs of the slit are tangentially shifted ($30mm$). Therefore the slits can be overlapped and the beam can be faded out without destroying the surface of the slit wafer. As there will be an image size of $100nm$ and a total demagnification factor of 200 in both transversal directions object slits must be opened only $20\mu m$. Each slit edge can be driven separately in one micrometer steps by a linear transporter. Linear expansion due to heating up the slits by beam current (e.g. $\Delta l = 5\mu m$ at $\Delta T = 10K$) is compensated by a special heating control. Its aim is to keep the temperature of the slits high and constant even under beam current fluctuations. So a variation of expansion is eliminated. To reduce vibrations originating from the beam tube (up to $60\mu m$) the slits are connected to the tube by flexible couplings. A technical drawing of one half of a slit is shown in fig. 1.

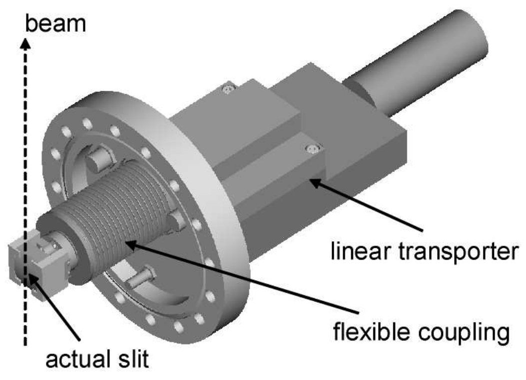

Fig. 1: Technical drawing of one part of a slit.

A pair of slits was tested using $20MeV$ protons. High resolution energy distributions of transmitted particles were measured by means of a Q3D magnetic spectrograph. Simultaneously angle distributions were measured. fig. 2 (top) shows the energy distribution of the proton beam without the new slit (dotted line) and the distribution with the new slit with an aperture of $12\mu m$ (solid line). The accepted vertical angle of these measurements is $\pm 2.5mrad$. Both distributions show a peak at $20MeV$ which corresponds to the actual beam energy and a low energy tail below $19.98MeV$. The energy distribution without the new slits shows a low energy tail with a tail/peak ratio of 1.37% which is due to the beam preparation (conventional analysing slits, beam reduction, etc.). Considering the measurement with the new slit opened only $12\mu m$ the ratio is the same within the errors. Since there is no increase of the ratio there is no significant reduction of the quality of the beam for distances of the slit edges down to $12\mu m$.

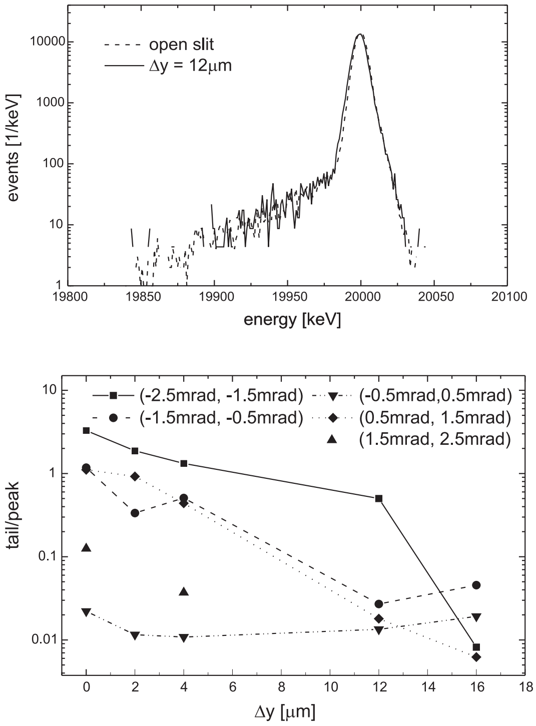

Fig. 2: Top: Energy distribution of the $20MeV$ proton beam without the new slit (dotted line) and the distribution using the new slit being $12\mu m$ open (solid line). Bottom: Ratio tail/peak versus distance of slit edges for different angle intervals.

In fig. 2 (bottom) the ratio tail/peak in dependence of the distance of the slit edges is shown for five angle intervals measured (angle perpendicular to the slit edge). For almost all measured angles the low energy tail increases when the opening decreases. The ratio tail/peak is even greater than one for angles between -2.5 and $-1.5mrad$. Only for particles detected within $\pm 0.5mrad$ the ratio is almost constant. The additional number of particles suffered from energy loss at the new slits larger than $20keV$ and without scattering to angles larger than $0.5mrad$ is less than 0.6% compared to the open slits. The behaviour of the ratio shows the strong correlation of small angle scattering and energy loss: Ions suffered from energy loss are mainly scattered off the beam axis. In general, these projectiles reduce the beam quality seriously. However, since the maximal accepted angle of SNAKE defined by divergence slits is smaller than $0.1mrad$ in both transversal directions particles suffered energy loss and small angle scattering are faded out by a large extent and do not influence beam quality. Therfore the new slits are perfectly suited for the ion microscope SNAKE.

References

[1] G. Datzmann *et al.*, Jahresbericht 1997, p. 106