New Microbeam Slit System for High Beam Currents

T. Vallentin*, M. Moser*, W. Carli†, T. Haase*, P. Hartung†, P. Reichart*, G. Dollinger*

At the microprobe SNAKE it is possible to quantify three-dimensional hydrogen distributions in materials via proton-proton scattering. With the newly installed high brightness Multicusp source, larger proton current up to 10 μA [1] has to be transported from the high energy side of the tandem accelerator to SNAKE. Hence smaller divergency is possible, resulting in beam resolution improvement below 1 μm beam spot [1] at sufficient current. The high current requires new slits with better heat dissipation. Additionally the new slits will offer to be used as high precision measuring slits for tandem accelerator stabilisation system.

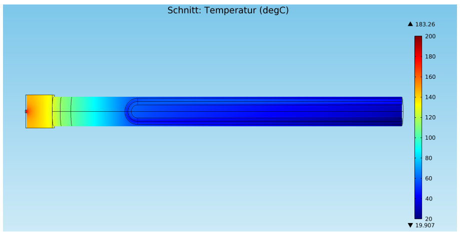

Figure 1: Temperature profile of the coupled heat/flow-simulation in stationary case. The border conditions are an inlet water temperature of 20 °C and thermal radiation in the vacuum and a thermal power input of $\dot{\mathrm{Q}} = 150\,\mathrm{W}$ [2].

Using finite element simulations the requirements for a new microslit system were investigated under maximum power input. The system has to endure $10\,\mu\mathrm{A}$ beam current of protons up to energies of $25\,\mathrm{MeV}$ [1]. For this, we use optimum heat conducting material as aluminium nitride as isolator, copper as carrier material and tungsten as slit bracket material with high melting point, but low radioactive activation. To compensate temporal variable beam load jitter the system is heated by potential-free heating cables to constant temperature and the supplied heat is dissipated by a water cooling. The geometry of the water cooling is configured to circumvent turbulence-induced pressure fluctuation and therefore parasitical vibrations, which would deteriorate the achievable resolution. The simulated attainable temperature profile of the new design is represented in Fig. 1. A very low blur of the object size of $<1.7\,\mu\mathrm{m}$ and a position accurateness of $<0.3\,\mu\mathrm{m}$ is achievable, c.f. [2]. Hence a resolution increase into the sub-μm-range is estimated.

* Institut für Angewandte Physik und Messtechnik LRT2, Fakultät für Luft- und Raumfahrttechnik, Universität der Bundeswehr München, 85577 Neubiberg, Germany

† Maier-Leibniz-Laboraturium der LMU und TU München, 85478 Garching, Germany

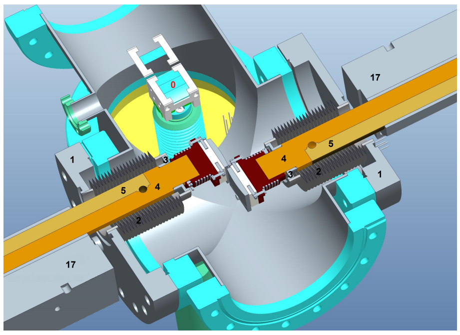

Figure 2: Illustration of the design of the new microslit system, which is integrated in x-direction, in y-direction yet resides the old system (0). The new system is mounted to the beam tube (light blue) by a standard flange DIN100CF (1). The shaft bellows (2) maintain the vacuum in the inside against the outer atmosphere and are hard-soldered to a spacer ring (3) and this to the copper bar (4). The actual water cooling consists of two half shafts (4) and (5). These are mounted via a connection plate (12) to the linear table (17), which is moved by a step motor [3].

The construction of the new microslits is illustrated in Fig. 2. During the further development the water circulation is build up and a heat exchanger with a thermal rating of overall $\dot{\mathrm{Q}} = 600\,\mathrm{W}$ [3] is to be integrated. With a suitable temperature control the cooling water feed temperature has to be maintained to a constant level with accuracy better than $\Delta\mathrm{T}_{\mathrm{kw}} = 2\,\mathrm{K}$ [3]. Otherwise the slit position deviated excessively and uncompensatedly due to the thermal expansion. In addition the surface condition of the tungsten plate is of great significance for the beam transportation. Two present surface qualities have to be compared in upcoming experiments, one with a mechanically lapped surface quality of $\mathrm{Ra} = 0.012\,\mu\mathrm{m}$, one with a plasma arc polished surface up to $\mathrm{Ra} \approx 0.03\,\mu\mathrm{m}$.

REFERENCES

[1] M. Moser, P. Reichart, W. Carli, C. Greubel, K. Peeper, P. Hartung, G. Dollinger. High brilliance multicusp ion source for hydrogen microscopy at SNAKE. Nuclear Instruments and Methods in Physics Research B, 273:226 230, 2012.

[2] T. Vallentin, Design und Simulation eines temperaturstabilisierten Schlitzsystems für den Transport eines hochbrillanten Protonen-Mikrostrahls, bachelor thesis, Universität der Bundeswehr München, Neubiberg, Germany, 2012.

[3] T. Vallentin, Planung des Aufbaus eines temperaturstabilisierten Schlitzsystems für den Transport eines hochbrillanten Protonen-Mikrostrahls, project thesis, Universität der Bundeswehr München, Neubiberg, Germany, 2013.