The New Microbeam Facility

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A new target station with a microbeam facility is under developement. It shall be able to produce beamspots with a diameter in the sub-μm range for light and heavy ions with energies up to 200 MeV$\cdot Q^2/A$. Since there are a lot of "low" energy ion micro beams installed all over the world with energies < 5 MeV$\cdot Q^2/A$, the planned facility will offer new capabilities in materials analyses and in ion beam modifications of materials. Especially high proton energies (10 - 30 MeV) will allow hydrogen analyses of up to 100 μm thick samples with sub-μm resolution. In addition, increased sensitivity is obtained for PIXE of high Z material. Using heavy ions and an accurate energy determination the measurement of ions transmitted through thin samples (STIM) will result in a microscopic thickness scan with high depth resolution. The energy measurement will be performed with the old 90^0 analysing magnet which will be replaced by a new one in 1996. The microbeam spot will be produced in two steps along the zero degree beam line in the experimental hall I. Starting at the image waist behind the analysing magnet a combination of two magnetic quadrupole doublet lenses leads to an overall demagnification of 200 horizontally and vertically, with a total system length of 30 m. The main contribution to the demagnification is due to the second lens, which is designed as a superconducting doublet lens (microlens). It will be fabricated essentially in house. A cross section of the lens is shown in Fig. 1. Some lens data are given in Table 1. The microlens will be placed into a He-bath cryostat. In the experimental chamber adjacent to the cryostat the free working space between the chamber wall and the micro-spot is about 100 mm. When focusing a beam to a spot size below μm the mechanical and the magnetical tolerances of the last lens are very tight. A main part of the microlens is the central ceramic core, which defines the exact position of the poles. The outer surface of this tube will be grinded with a tolerance of a few μm according to the pole contour. The poles are pressed against the core by springs between the poles and the yoke. To obtain a pure quadrupole field, the pole contour has to be hyperbolic and should extend generally to radii much larger than the pole-tip radius r_0. This however produces large fields between adjacent poles in the region not used for the beam, limiting the maximum pole-tip field. In our microlens the hyperbolic pole contour ends at 1.5 r_0. As a result the maximum field in the poles is only two times the pole-tip field. In order to force the magnetic field to the ideal one, superconducting NbTi foils are positioned along field lines of the desired field. The foils are fixed to the ceramic surface which is grinded to this ideal contour between the poles. In the foils superconducting currents are induced preventing field components normal to the foil. These currents generate a magnetic field which cancels the field errors within the volume defined by the contours of the poles and the foils. A possible unbalance in the magnetic flux through the poles (different gaps at the springs) is prevented by two sets of extra windings on the poles. Outside the yoke these windings are connected forming superconducting current loops. One loop serves for zero total flux in the x-z plane, the other in the y-z plane. This leads to a cancellation of all 2n-pole fields with odd n.

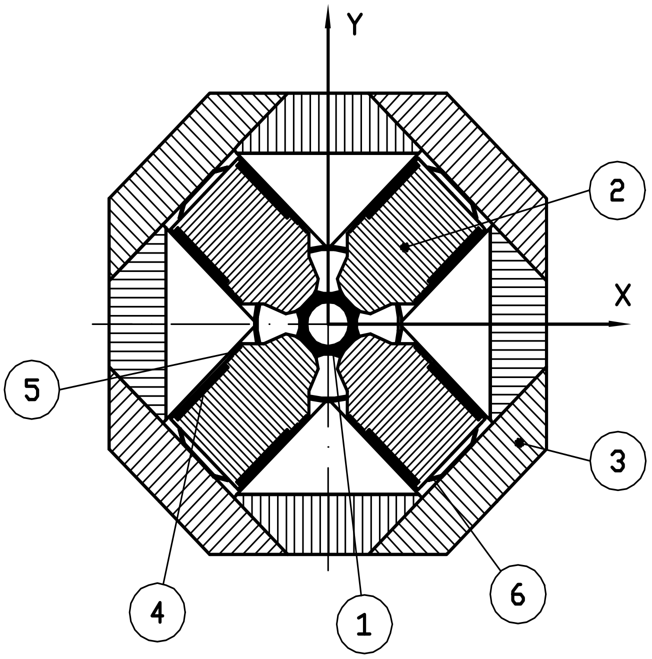

Fig. 1: Cross section of the microlens: 1: ceramic core, 2: pole, 3: yoke, 4: supercond. coil, 5: extra windings, 6: springs

total length	380 mm
max. pole-tip field	1.2 T
max. field in poles	2.4 T
max. field in yoke	1.8 T
pole-tip radius r_0	10 mm
pole material	FeCo
yoke material	Fe
central tube material	Al_2O_3
beam aperture radius	7.5 mm
coil wire	ϕ 0.3 mm NbTi filament
max. current density	170 A/mm^2
field correcting foils	multilayer NbTi

Table 1: Some data of the microlens

A ray tracing program has been written especially for the correction of lens aberations. The program applies a specific treatment of the fringe fields including the influence of the superconducting foils. As a result of extensive calculations, the maximum value for the octupole component needed to correct geometrical aberations is 3 % of the quadrupole component. These 8-pole and higher order corrections will be superposed to the quadrupole field by a corresponding modification of the pole- and the foil contours. To get more parameters for these corrections the second quadrupole in the doublet lens is subdivided, leading to in total three magnetic sections in the lens. A small dynamical correction can be achieved generating electrical octupole components using high voltage applied to the foils.