Low energy beam transport using Gabor lenses

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Gabor lenses provide strong cylinder symmetric focusing for low energetic ion beams using a stable space charge cloud [1]. They need drastically reduced magnetic and electrostatic field strength compared with conventional systems. The density distribution of the enclosed space charge is nearly homogeneous and is given by the enclosure conditions in transverse and longitudinal direction [2]. Furthermore, the resulting electrostatic field and therefrom the focusing forces inside the space charge cloud are linear (see fig1.). In case of a positive ion beam the space charge of the confined electrons causes compensation of the ion beam space charge forces. Linear matching of the beam into the acceptance of an RFQ (for $r_{Beam} < r_{Cloud}$) can be provided, for example.

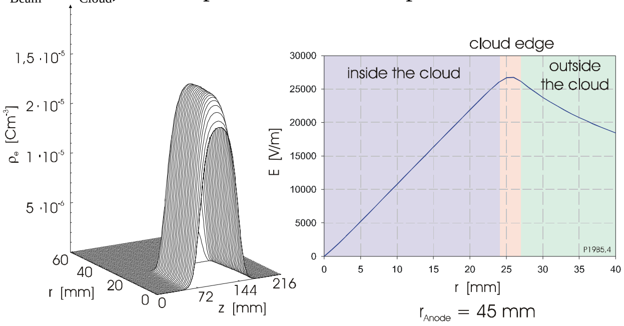

Figure 1: Numerical simulation of the density distribution (left) for the following lens parameters: U_{Anode}=1,9kV and $B_{z,max}$=5,4·10^{-3}T and resulting electrostatic field as a function of lens radius at z=108 mm (right)

To study the capabilities of a Gabor LEBT – system consisting of two lenses to match an ion beam into an RFQ, a testinjector is under construction. Furthermore, to verify the beam focusing of bunched beams using this lens type at beam energies up to 500 keV a new very powerful GL will be installed behind the RFQ. In a first phase the front end of the injector has been constructed. It consists of a volume type ion source, the GL - LEBT - system and several beam diagnostic devices (see fig.2). The ion source delivers a maximum current of 10mA He^+ at 14keV. The LEBT – system consists of a first diagnostic chamber with a differential pumping system and of two Gabor lenses followed by a second diagnostic section. In a first step the emittance of the beam at the entrance of the first lens was measured (see fig. 3 left, He^+, 14keV, 4.5mA, K=3.53·10^{-3}, $\varepsilon_{n,rms,100\%}$ = 0.0225πmmmrad). After integration of the two Gabor lenses the emittance near the RFQ injection point was measured with improved source parameters (see fig. 3 right, He^+, 14keV, 8.4mA, K=6.58·10^{-3}, $\varepsilon_{n,rms,100\%}$ = 0.0598πmmmrad). It shows a phase space distribution just behind the focus for the following lens parameters: first lens U_{Anode}=1,8kV and $B_{z,max}$=5,76·10^{-3}T, second lens U_{Anode}=2,1kV and $B_{z,max}$=6,24·10^{-3}T. Our hitherto experience shows a good reproducibility of the gained results.

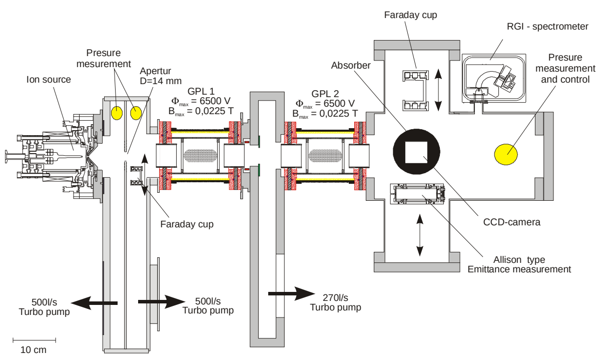

Figure 2: Schematic drawing of the LEBT – system

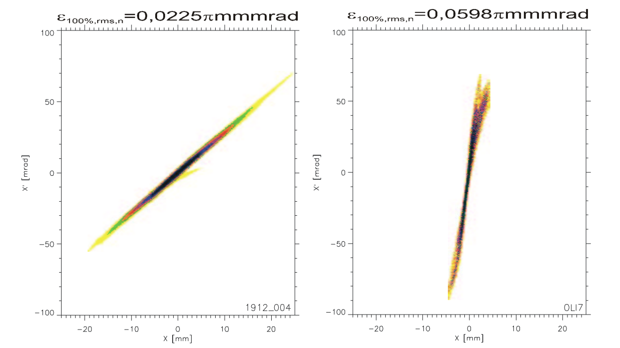

Figure 3: Measured beam phase space distribution at the first lens centre (left) and behind of the Gabor lens system (right).

In a next step the RFQ [3] will be installed behind of the second lens. The beam energy at the RFQ entrance has to be 3,5A·keV with a space charge limiting maximum current of 2,5mA/amu. The RFQ delivers a bunched beam of 110A·keV. A large Gabor lens ($U_{Anode,max}$=65kV $B_{z,max}$=0,2T) already under construction will be installed after the RFQ as well as a target chamber. The injector will give the opportunity to investigate the transport of pulsed He - beams at medium energy (up to 440keV) using Gabor lenses. Additionally the effects of beam wall interaction inside accelerators (wall losses) can be studied in the target chamber. The estimated power density at the focal spot will be nearly P=10^9 W/cm^3 and allows the study of beam – wall interaction which is a very important topic with respect to the dynamic vacuum, current limit of targets, chamber wall destruction etc. at large scale in beam and plasma confinement facilities.

References

[1] J.A.Palkovic Measurement on a Gabor lens for neutralising and focusing a 30keV Proton beam., University of Wisconsin, Madison, 1982

[2] J. Pozimski et al., A Double Gabor Plasma Lens System for HIDIF, GSI-98-09,(1998)

[3] A.Bechtold Construction of an heavy ion RFQ accelerator with high duty cycle. Diploma thesis 1997