Plasma Diagnostics on a Confined Nonneutral Plasma Column

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Gabor lenses have been built and successfully been used for the focussing of particle beams [1]. In the case of a positive ion beam the space charge of the confined electron cloud may cause an over compensation of the ion beam space charge force and consequently focus the beam. The nonneutral plasma (NNP) column is influenced by the external fields and its action on the beam can be expressed by the emittance growth. Experiments using a high field Gabor lens have shown a correlation between the thermalization of the enclosed electron cloud and the focussing quality [2].

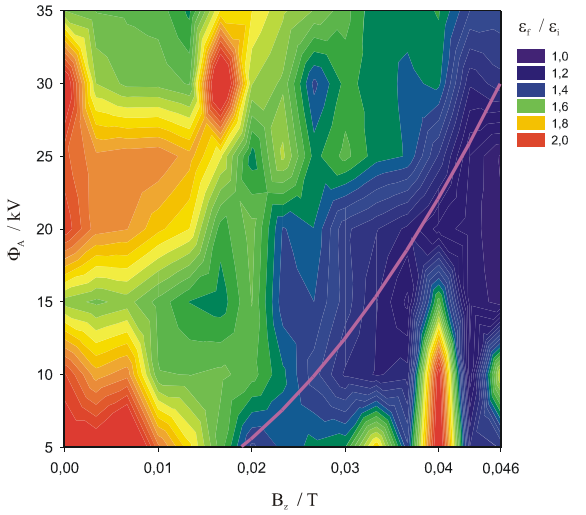

Fig. 1: Measured emittance growth as a function of the external fields using a high field Gabor lens and a 440 keV He^+ beam.

The nonneutral plasma was assumed to be thermalized with-similar strengths in longitudinal and radial confinement (purple line). Far from these parameter setup a variety of plasma instabilities leads into a degradation of the focussing capabilities of this lens type [3]. A three segmented Gabor lens was constructed recently for a more detailed investigation of the plasma parameters as a function of the external fields.

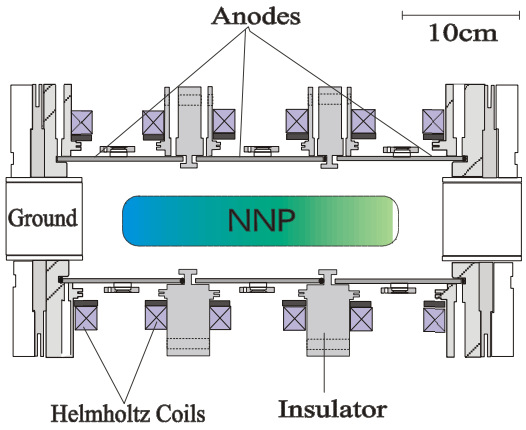

Fig. 2: Schematic drawing of the three segmented Gabor lens.

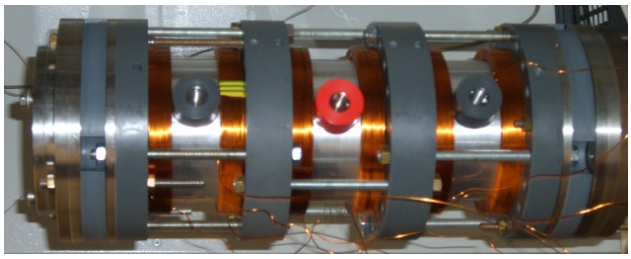

Fig. 3: Photograph of the three segmented Gabor lens.

The total length of this device is about 0.4 m and gives the possibility to confine a plasma column with a length of at most 0.36m. The longitudinal confinement is provided by an segmented anode with radius r_A = 0.032m and $\Phi_{A,max}$ = 6kV To allow transverse observation of the electron column the magnetic field of Helmholtz coils (up to 15mT on axis) is used for the radial confinement. Fig. 4 shows the magnetic field on the lens axis calculated by a Biot-Savart solver in comparison with field measurements.

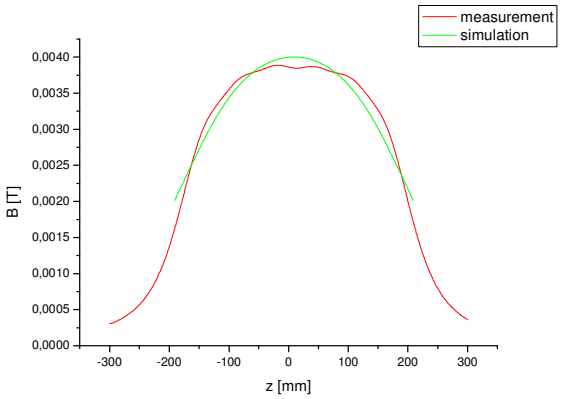

Fig. 4: Calculated and measured magnetic field distribution provided be the Helmholz coils for I = 1A.

The commissioning of the lens has already started and the light emitted by the interaction between the electron cloud and the residual gas has been observed. The experiments under preparation will concentrate on the spectral analyses of the emitted light to evaluate the temperature and density of the confined NNP.

References

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[2] O. Meusel, Focussing and Transport of Ion Beams using Space charge Lenses, Dissertation, IAP, 2006, http://publikationen.ub.uni-frankfurt.de/volltexte/2006/2828/

[3] R.C. Davidson, Physics of Nonneutral Plasmas, Imperial College Press, London, 2001