An RF Chopped Electron Beam Driver for H-Type Cavities

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During the last three years a high power rf generator design capable of providing several MW rf power at frequencies between 200 and 300 MHz has been investigated. Instead of using conventional techniques for bunch formation in electron beam based generators like grids or longitudinal velocity modulation it is based on an innovative scheme which was first proposed in 1986 [1]. It allows to directly drive the resonant mode of an H-type cavity by the electron beam resulting in a much simplified rf driver system. The basic concept is to use a continuous electron beam produced by a thermionic gun. The time structure of the electron beam is achieved by a rf driven chopping system using the E×B drift which deflects about 80% of the beam to a suppressed collector where the main part of the beam energy is recovered. The remaining bunched electron beam is injected into the IH tank where the beam energy will drive the IH_{110} mode. To increase the efficiency of the beam deflection a second deflector stage working on dc potential may be added [2]. The setup of the total system is shown in Fig. 1. To prove the feasibility of the proposed rf generator the individual components were simulated with the three dimensional particle in cell code TS3 which is part of the simulation package MAFIA. It is capable of solving Maxwell´s equations including the self fields of charged particles in motion. Starting with the high perveance electron gun the simulations resulted in a reasonable geometry which delivers a 100 A, 100 keV beam with a radius of 5 mm which is injected into a confining magnetic field with a flux density of 100 mT.

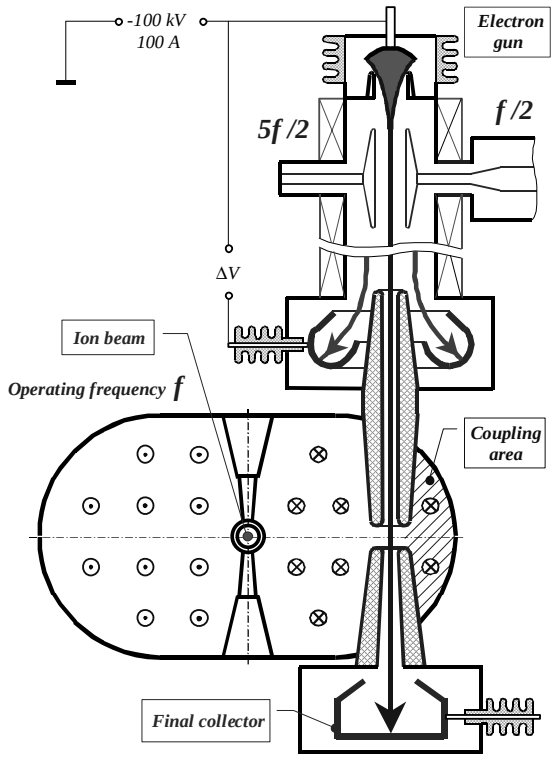

Figure 1: Setup of the total rf system

The chopper stage is directly connected to the gun exit and driven by an rf of about 50 kV while the dc stage needs a potential of about 60 kV. The appropriate rf voltage results from superposing two sinusoidal signals with the frequencies f/2 and 5f/2 at an amplitude ratio of 5:1. Figure 2 shows the resulting electron density distribution right behind the two deflecting stages predicted by the simulations.

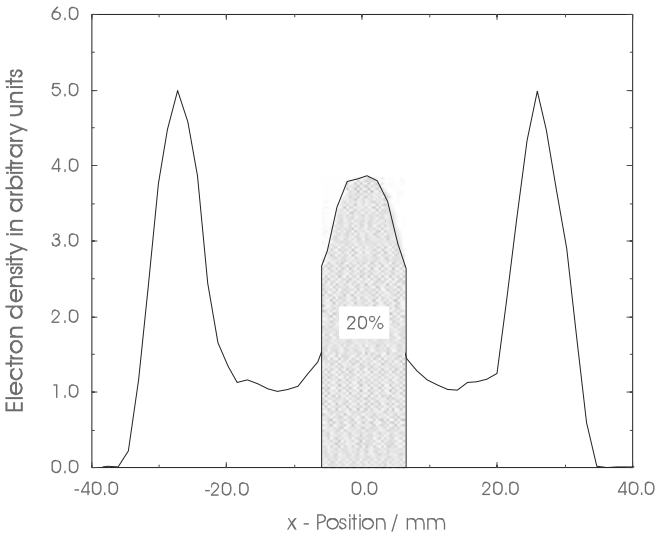

Figure 2: Electron density distribution behind the deflector

The hatched area corresponds to a transverse beam width of ±6.3 mm. Longitudinally the beam has a rectangular profile with a length of about 96 degree in units of the operating frequency of 200 MHz [3].

A 200 MHz prototype of the deflector is under construction at the IAP, University of Frankfurt. Its purpose is to demonstrate the chopper principle and to compare the results with the predictions of the simulations.

References

[1] U. Ratzinger, Doctoral thesis, TU München, 1986, p.53

[2] S. Minaev, U. Ratzinger, GSI Arbeitsnotiz ALG16129HF

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