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A multifrequency step-tunable gyrotron at FZK

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Frequency tunable gyrotrons are of interest for controlling instabilities in magnetically confined fusion plasmas [1]. For devices such as ASDEX-Upgrade, there is interest in a step-tunable gyrotron operating at frequencies between about 105 GHz and 140 GHz.

For this purpose, and as an extension of previous experiments [2], and in a cooperative parallel development with the Institute of Applied Physics in Nizhny Novgorod [3], we plan to perform experiments on a multifrequency gyrotron, which is designed to operate in the $TE_{22,8}$ mode at 140 GHz and the $TE_{19,6}$ mode at 111 GHz or the $TE_{17,6}$ mode at 105 GHz, as well as some other intermediate modes. The tube will be equipped with an advanced quasi-optical launcher, three special beam forming mirrors, and a CVD-diamond Brewster window.

The beam radius for a gyrotron operating in the $TE_{22,n}$ mode at 140 GHz is 7.95-8.00 mm. The cavity radius for the $TE_{22,8}$ mode is 17.96 mm. The optimum beam radius for the other candidate modes is slightly larger than 8 mm and can be adjusted by appropriate setting of the coil currents in the magnet system. It is planned to use the same gun and magnet system as in previous experiments that have been performed on a tube designed to operate at 140 GHz in the $TE_{22,6}$ mode [2, 4]. The magnet system and gun [5] used for this tube provide the possibility to vary the magnetic compression and velocity ratio independent of one another, which seems to be advantageous for varying the frequency over such a wide range. The beam properties were calculated for various accelerating voltages and magnetic field profiles using the program ESRAY [6], which uses boundary fitted coordinates and optimized numerical algorithms.

The resonator design calculations compute beam properties for a given set of coil currents, accelerating voltage and current, and then use these beam properties to compute the output power and efficiency. This is done separately for each mode.

In long pulse or CW operation, the beam space charge will, after a few tens of milliseconds, become neutralized, resulting in a change of beam energy [7]. Since the perpendicular momentum is unaffected by voltage depression, the velocity ratio $\alpha = \beta_\perp/\beta_z$ will also be changed. The values of beam energy and velocity ratio used for startup calculations and for beam optics calculations must include the effects of voltage depression. For desired values of beam energy and velocity ratio in CW operation, it is necessary to determine the effective beam energy and velocity ratio including voltage depression that correspond to these values. Results of simulations for both cases will be presented.

References

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