170 GHz, 2 MW, CW Coaxial Cavity Gyrotron for ITER
- status and results obtained on a pre-prototype tube -

B. Piosczyk[1a], S. Alberti[2], D. Bariou[7], P. Benin[7], T. Bonicelli[5], G. Dammertz[1a], O. Dumbrajs[6], D. Fasel[2], E. Giguet[7], T. Goodman[2], R. Heidinger[1b], M. Henderson[2], J.P. Hogge[2], S. Illy[1a], J. Jin[1a], W. Leonhardt[1a], C. Lievin[7], G. Michel[4], P.L. Mondino[5], L. Porte[2], T. Rzesnick[1a]i, M. Schmid[1a], M. Thumm[1a,3], M.Q. Tran[2], X. Yang[1a]

[1]Forschungszentrum Karlsruhe (FZK), Association EURATOM-FZK, [a]IHM, [b]IMF I, D-76021 Karlsruhe, Germany; [2]CRPP Lausanne, Association EURATOM-Confédération Suisse; [3]Universität Karlsruhe, IHE, D-76128 Karlsruhe, Germany; [4]IPP Greifswald, Association EURATOM-IPP, D-17491 Greifswald, Germany; [5] EFDA, D-85748 Garching, Germany; [6] HUT Helsinki, Association EURATOM-TEKES, FIN-02150 Espoo, Finland; [7]Thales Electron Devices (TED), F-78141 Vélizy-Villacoublay, France

e-mail : bernhard.piosczyk@ihm.fzk.de; phone : (+49) 7247 –82 3541 ; fax : (+49) 7247-82 4874

In proof of principle experiments carried out at FZK Karlsruhe on a 165 GHz coaxial tube during the last years, the feasibility of manufacturing a 2 MW, CW coaxial cavity gyrotron at 170 GHz has been demonstrated and information necessary for a technical design has been obtained [1,2]. Based on these results and on the experience acquired during the development of the 1MW, CW, 140 GHz gyrotron for W7-X, the technical feasibility has been studied before EFDA placed a contract at TED for procurement of a first industrial prototype of a 2 MW, CW, 170 GHz coaxial cavity gyrotron as could be used for ITER. The development work on the prototype tube is performed in cooperation between European research centers together with TED. Within this cooperation the physical specifications and the design of the components are done by the research institutions and TED is responsible for the technological aspects and manufacturing.

To prove the design of critical components under relevant conditions, experimental studies with a short pulse (≤ 5 ms) experimental 170 GHz coaxial cavity gyrotron ("pre-prototype") have been performed. This pre-prototype utilizes the same $TE_{34,19}$ mode and same cavity with up-taper, launcher and mirrors as designed for the industrial prototype and a very similar electron gun. In summary the following experimental results have been obtained with the pre-prototype gyrotron [3]:

- Parasitic low frequency oscillations at ~259 and ~328 MHz have been successfully suppressed. The LF resonances have been found in numerical simulations using the code "CST microwave studio". Consequences for the industrial prototype tube have been drawn.
- The performance of the electron gun and electron beam has been found to be in agreement with the design objective as far as the properties have been observable during the gyrotron operation. Stable operation up to $I_b \approx 80$ A and $U_c \approx 80$ kV has been obtained without any beam instabilities.
- The nominal co-rotating $TE_{-34,19}$ mode at 170 GHz has been excited stably in single-mode operation over a wide parameter range. However, the experimental results are not fully in agreement with calculations. In particular, the observed mode sequence is more dense than predicted by simulations limiting the excitation range of the nominal mode to lower voltages than expected. At a reduced magnetic field ($B_{cav} = 6.72$ T) and at an accelerating voltage of 73 kV a microwave output power of 1.15 MW was obtained.
- The performance of the q.o. RF output system has been studied both at low power levels ("cold") and at high power ("hot") with the gyrotron. A reasonable agreement has been found between the "cold" and "hot" measurements and the calculations. The Gaussian content of the RF output beam is unfortunately fairly low. An improved RF output system is under design. The amount of stray microwave losses has been measured to be around 8 % of P_{out}. Efficient internal absorbers for the stray radiation have been tested. Based on the results such absorbers will be installed in the prototype tube.

References:

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