HIGH POWER CW GYROTRON DEVELOPMENT AT KIT: CURRENT STATUS AND FUTURE PROSPECTS

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ABSTRACT

During the last decades, electron cyclotron resonance heating and current drive (ECRH&CD) has been established as important method to support the operation of the major plasma fusion experiments, like the stellarator Wendelstein 7-X (W7-X) in Greifswald, Germany (which successfully started operation in 2016), or the International Thermonuclear Experimental Reactor ITER, currently under construction at Cadarache, France. High frequency (100 GHz – 200 GHz), high power (~ 1 – 2 MW) gyrotrons are the unique RF sources which meet the extraordinary requirements of those applications. Optimum current drive efficiencies for the prospected Demonstration Power Plant DEMO may require even higher frequencies (> 200 GHz), multi-MW levels of output power together with enhanced efficiency, while frequency-tunability of the RF sources would be favourable for plasma stabilization.
KIT, together with its EU partners, is currently working on several projects related to the design, optimization, construction and testing of gyrotrons for nuclear fusion applications. This includes an upgrade of the 140 GHz gyrotron for W7-X to achieve a continuous wave (CW) output power of 1.5 MW (instead of 1 MW) and investigations to operate the original W7-X gyrotron at higher frequency (175 GHz) and reduced output power (~ 500 kW) to use it as an RF source for collective Thomson scattering (CTS) plasma diagnostics. It also contains further optimization and experimental testing of the EU 1 MW, 170 GHz gyrotron for ITER and theoretical and experimental investigations on 2 MW-class coaxial cavity gyrotrons, where KIT already achieved a record output power value of 2.3 MW at 170 GHz for millisecond pulses. In addition, intensive design and construction work is performed on multi-frequency gyrotrons relevant for DEMO, at the moment targeted for a maximum frequency of 204 GHz. In the context of efficiency enhancements for future power plants, investigations on multi-stage depressed collectors are ongoing, with the goal to set up a first short pulse experiment to verify the expected capabilities of this new type of gyrotron collector.
Within the research and development activities described above, KIT is investing in the development of advanced design tools and components research; to maintain a proper test environment for future gyrotrons the Fusion Long Pulse Gyrotron Laboratory (FULGOR) has been set up at KIT and is now close to final completion. Among other relevant components, it will comprise a 10 MW (90 kV, 120 A) continuous-wave power supply capable to operate with multi-stage depressed collectors and a 10.5 T cryogen free superconducting magnet.

Acknowledgements
This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission. Part of the simulations was performed on the EUROfusion High Performance Computer (Marconi-Fusion).