

First performance test of multi-frequency gyrotron for ITER and fusion devices

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Introduction: Multi-frequency gyrotron

Multi-frequency gyrotrons can selectively generate a high power millimeter-wave at one of the frequencies. One of the advantages of using the multi-frequency gyrotrons on ITER and fusion devices is that the electron cyclotron heating location in plasma is adjustable by using the multi-frequency injection. It will compensate for an injection angle limitation of the launcher caused by the design limitations in 3-D space and by neutron flux on the components. The gyrotron frequency of ITER and fusion devices are 170 GHz and 200 GHz or higher, respectively. For such purpose, a multi-frequency gyrotron at 170 GHz, 203 GHz, and 236 GHz was developed by modifying the ITER prototype gyrotron.

170/203/236GHz gyrotron and gyrotron test stand

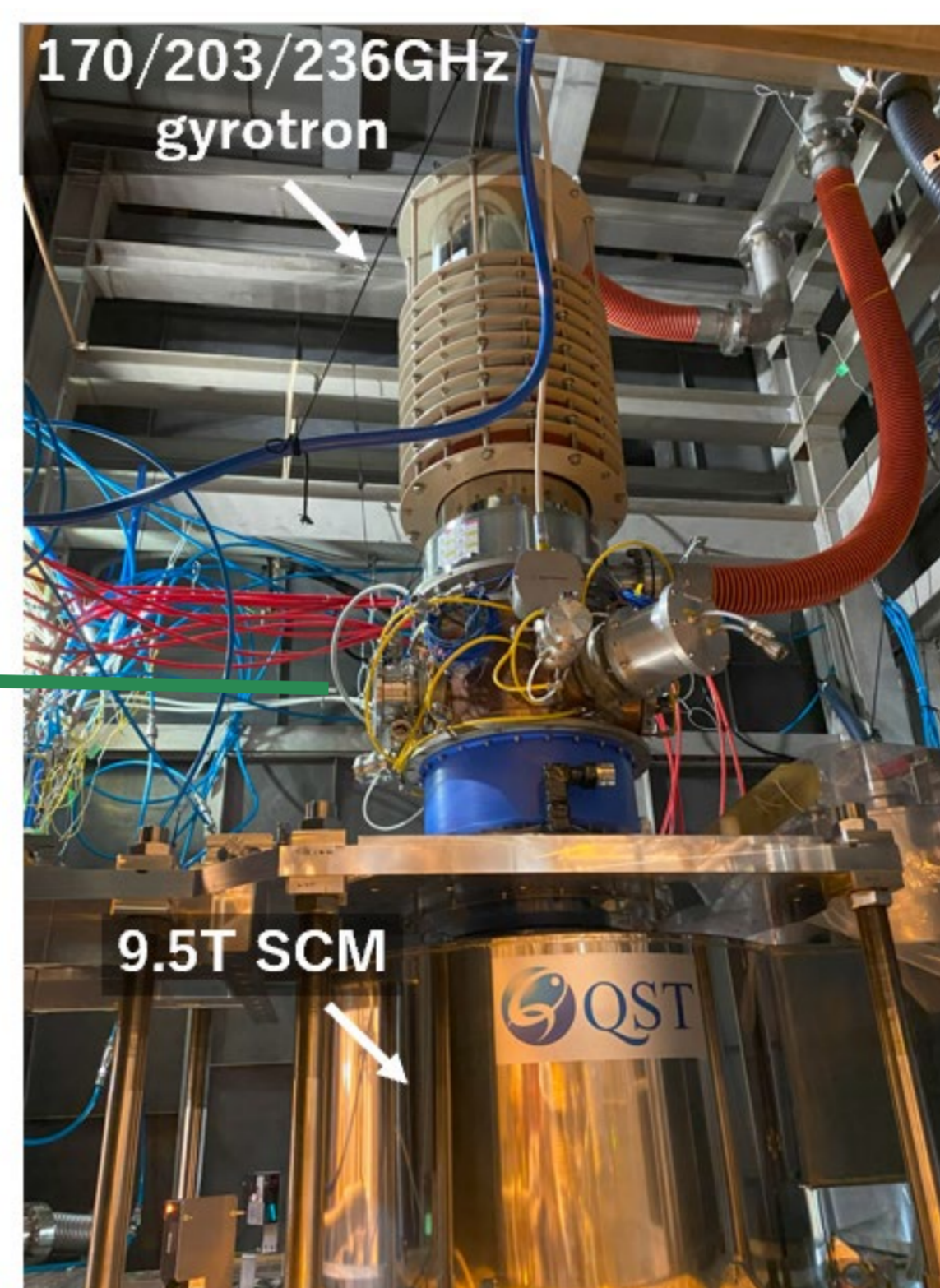
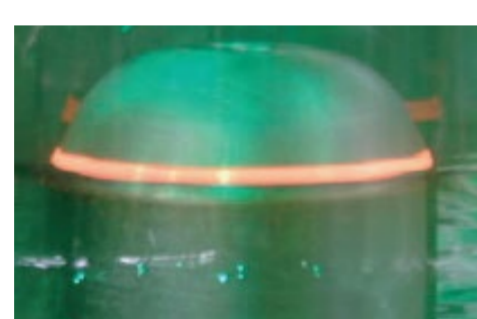
As a first step, the ITER prototype gyrotron was modified to demonstrate the multi-frequency operation at high power. It is known that ITER gyrotron can generate 104 GHz, 137 GHz, 170 GHz and 203 GHz with specific cylindrical modes at the cavity. The magnetron injection gun (MIG) of ITER prototype gyrotron was replaced to new one whose shape was redesigned to produce a high quality electron beam at 170 GHz, 203 GHz, and 236 GHz.



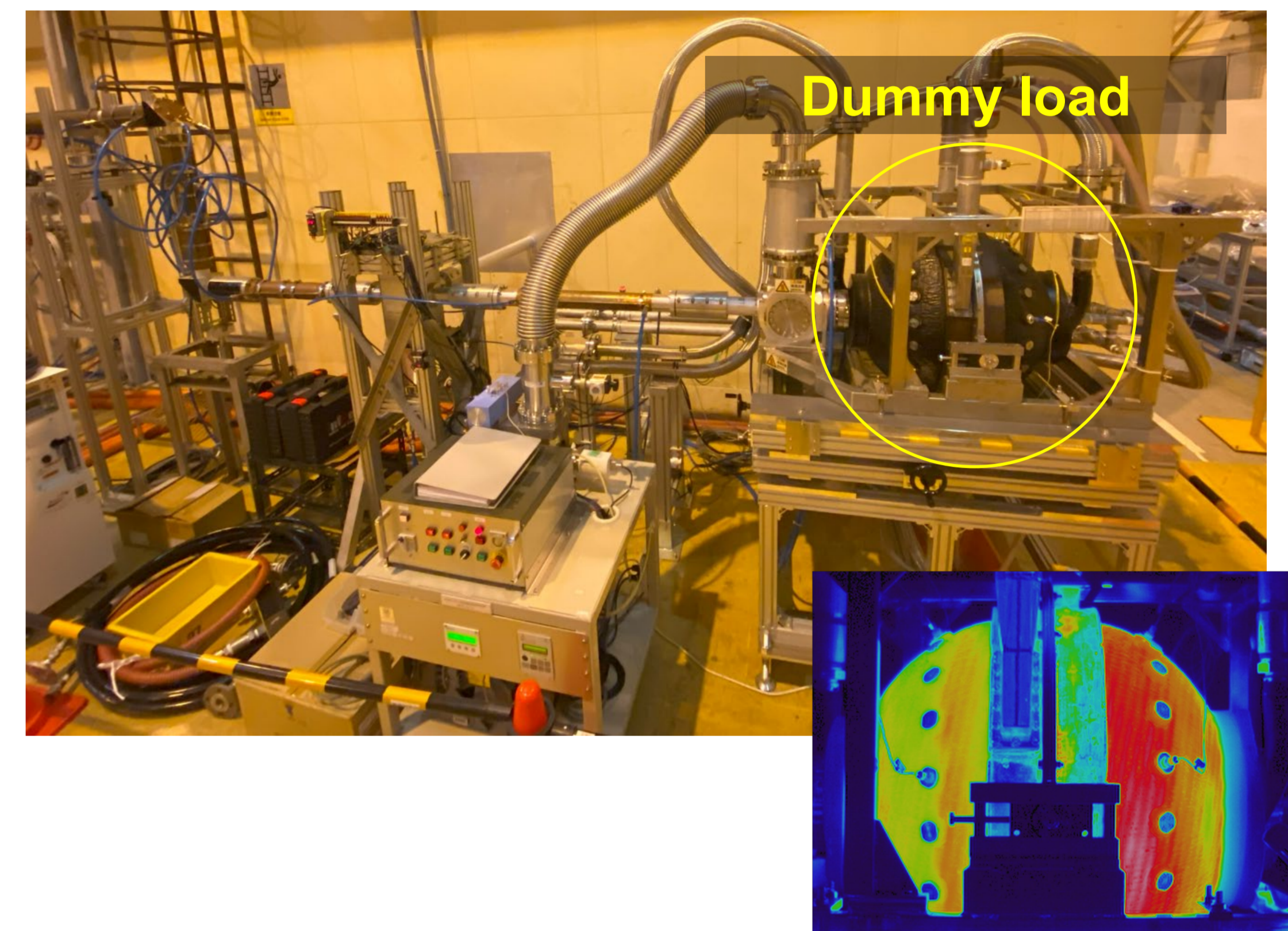
Target values

- Power: ~1 MW
- Osc. eff.: ~25%
- Pulse: ~ 100 s

MIG shape was optimized for 170/203/236 GHz.



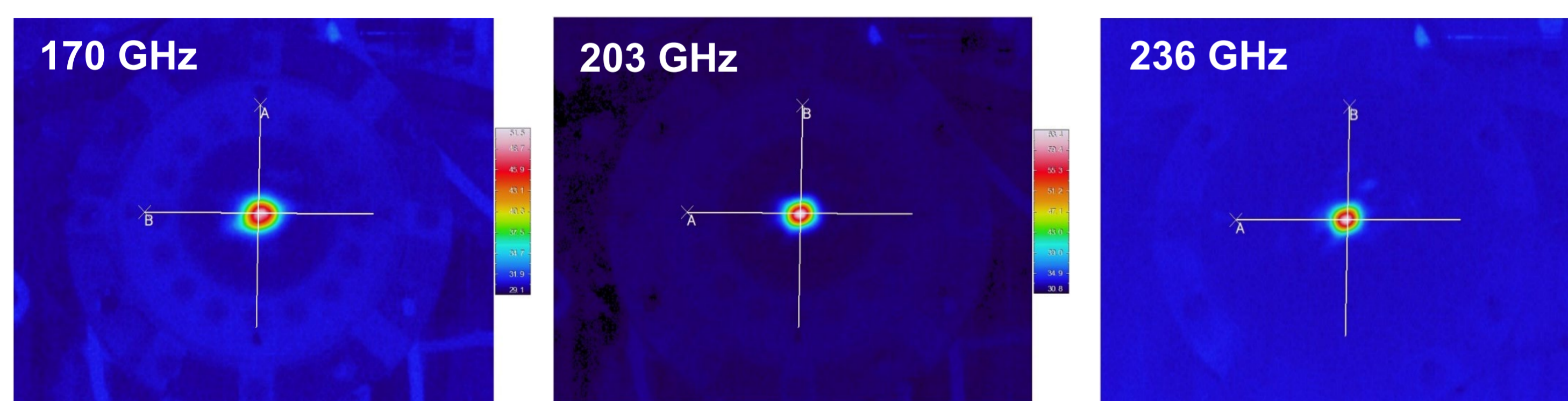
Transmission line



Performance test results of 170/203/236GHz gyrotron

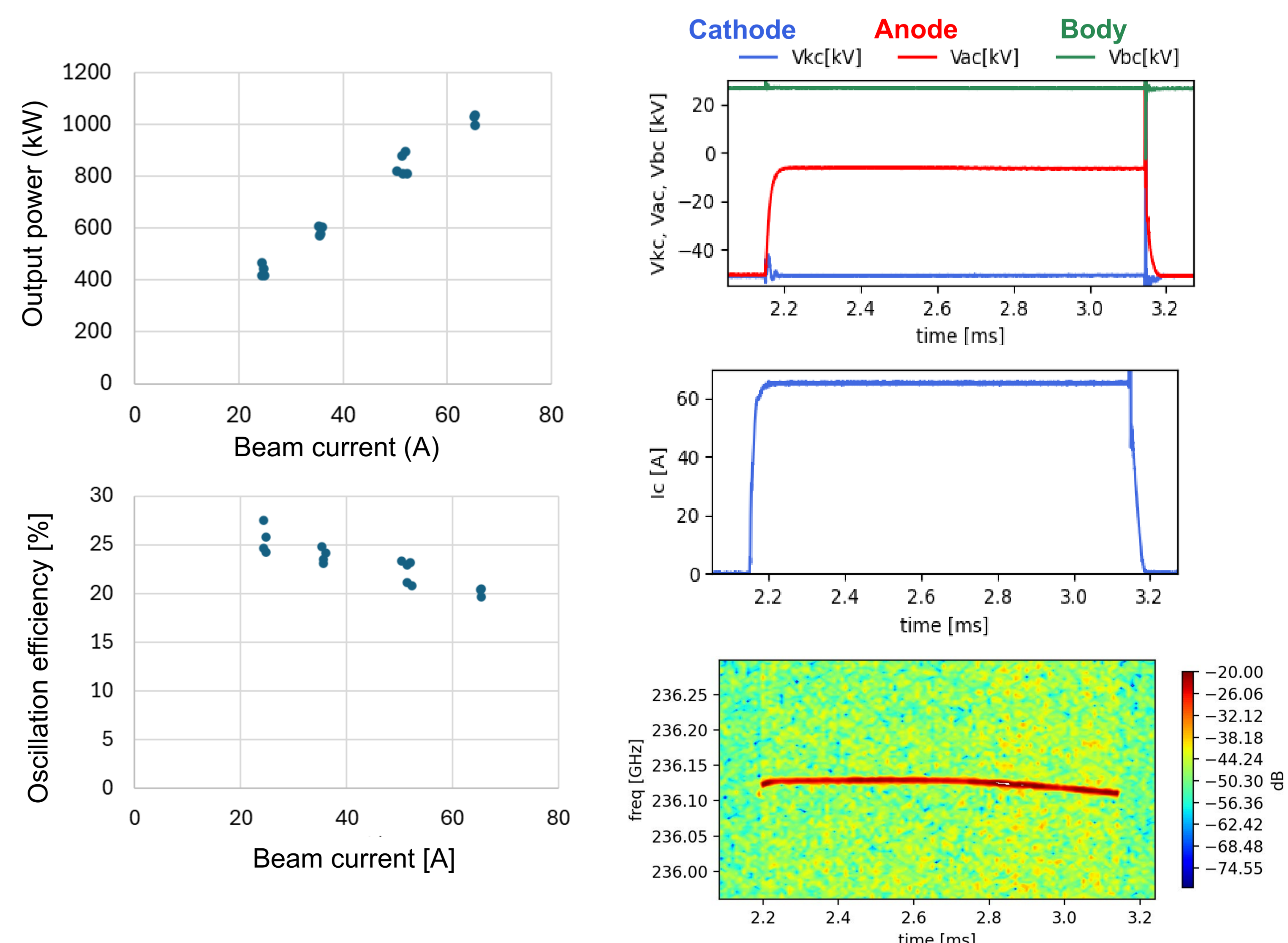
Oscillation test at 170 GHz, 203 GHz, 236 GHz

170/203/236GHz gyrotron successfully oscillated at 170GHz, 203GHz, and 236 GHz as design.



Short pulse test at 236 GHz

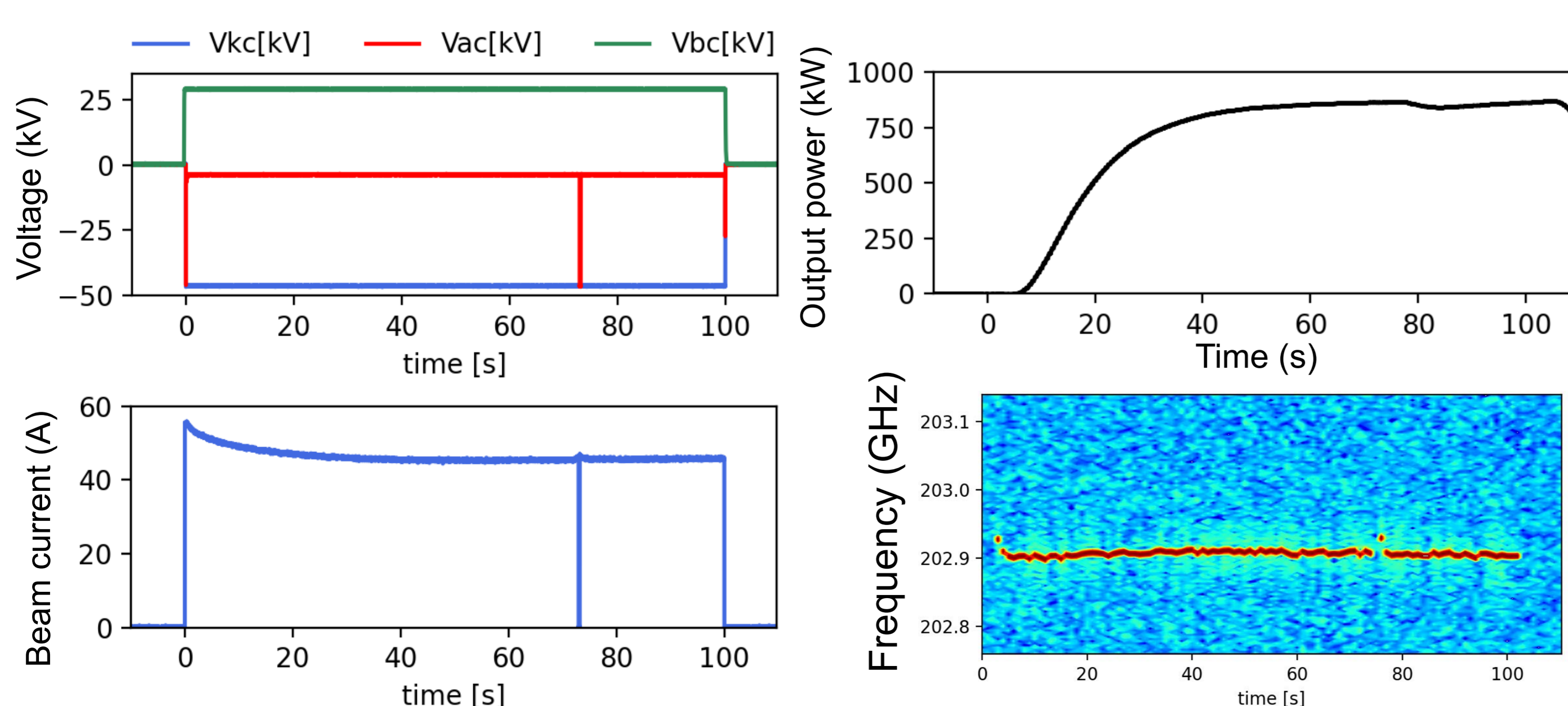
Output power achieved at 1 MW at 236GHz in short pulse operations for 1 ms.



Long pulse test at 203 GHz

- 170/203/236GHz gyrotron achieved 880 kW in a long pulse operation for 100 s.
- With well tuned parameters, the oscillation efficiency achieved 27%.

Gyrotron type	Pulse (s)	Power (kW)	Oscillation efficiency (%)
170/203/236GHz gyrotron	100	750	27
	100	880	25



Summary

The target of multi-frequency operations at 170 GHz, 203 GHz, and 236 GHz with high power were successfully demonstrated by modifying the MIG of ITER prototype gyrotron. The output power achieved 1 MW at 236 GHz in the 1 ms operation. Moreover, the pulse width was successfully extended to 100 s at 203 GHz, and the output power achieved 880 kW. These initial results show a possibility of realizing the multi-frequency high power gyrotron for fusion devices.