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SYSTEM PERFORMANCE AND EXPERIMENTS WITH THE 110 GHz MICROWAVE INSTALLATION ON THE DIII–D TOKAMAK

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*Oak Ridge National Laboratory, Oak Ridge, Tennessee.

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ABSTRACT

A powerful microwave system operating at the second harmonic of the electron cyclotron frequency has been commissioned on the DIII–D tokamak. The primary mission of the microwave system is to permit current profile control leading to the improved performance of advanced tokamak operation in quasi-steady state. Initial performance tests and experiments on current drive both near and away from the tokamak axis and on transport have been performed.

1. SYSTEM DESCRIPTION

Two Gycom gyrotrons each of which generates about 750 kW for 1–2 s pulses, and two CPI gyrotrons with diamond windows and rated at 0.9–1.0 MW for 10 s pulses are in service. Two additional CPI 1.0 MW gyrotrons are being installed and a third Gycom gyrotron is available as a spare.

The gyrotron installation features up to 80 m long evacuated transmission lines carrying the $HE_{1,1}$ circular mode without a window at the tokamak. An overview of the system, including the new addition to the DIII–D experimental facility built to house five gyrotrons, is shown schematically in Fig. 1. Each waveguide line contains forward/reflected power monitor miter bends, a pair of grooved polarizing miter mirrors which can be rotated under computer control, a fully integrated vacuum system and a launcher with poloidal scan capability covering the tokamak upper half plane. Two waveguides are equipped with fully articulating launchers which can also be scanned toroidally for co- or counter-current drive, opening up a new class of experiments. The articulating launcher, developed by the Princeton Plasma Physics Laboratory, is shown in Fig. 2.

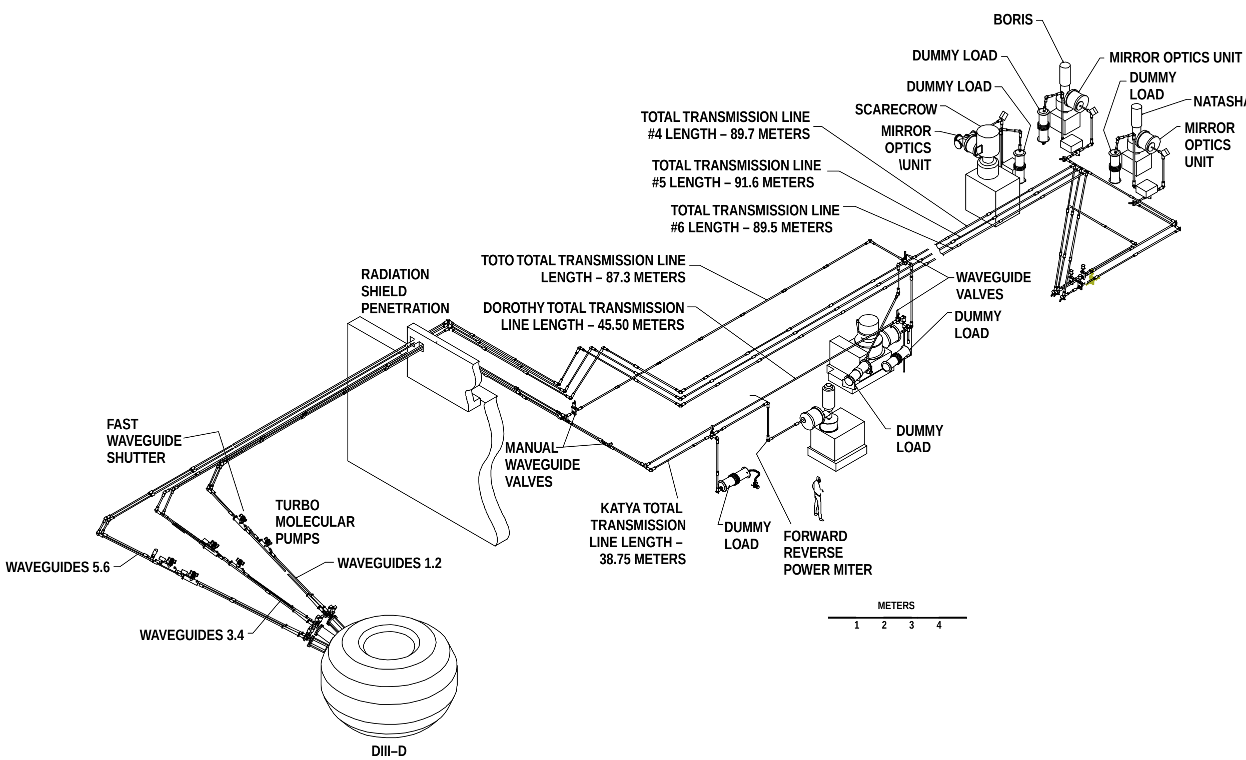

Fig. 1. An overview of the system, including the new addition to the DIII–D experimental facility built to house five gyrotrons.

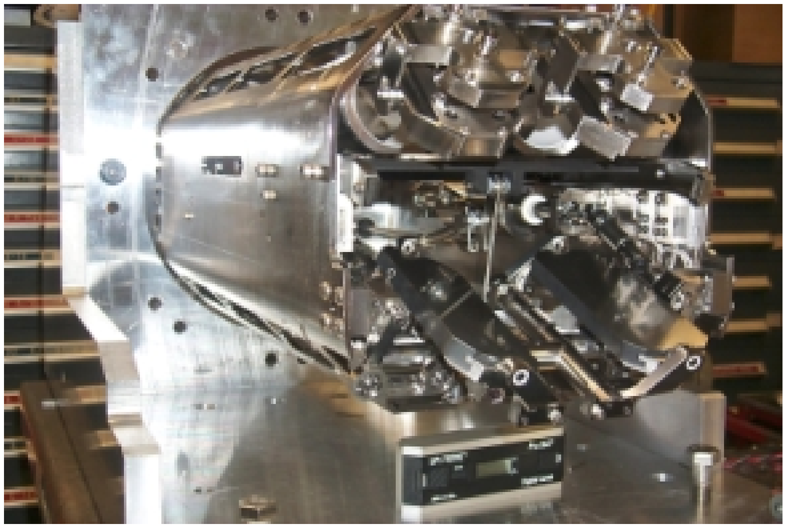

Fig. 2. The articulating launcher, developed by the Princeton Plasma Physics Laboratory.

Phase retrieval and correction using a two mirror relay was employed for the Gycom gyrotrons, which generate flattened rf beam profiles and also for one of the CPI gyrotrons with a Gaussian beam. A single ellipsoidal mirror was used to couple one of the CPI Gaussian beams to the waveguides and the beam quality for this arrangement was excellent. In Fig. 3, the single mirror coupling scheme is presented along with the footprint of the beam on thermally sensitive paper at the waveguide input. The single mirror coupling scheme represents a substantial cost savings, which is possible for the first time with high power gyrotrons generating Gaussian rf beams. Absorbed power in the MOU is less than 10%.

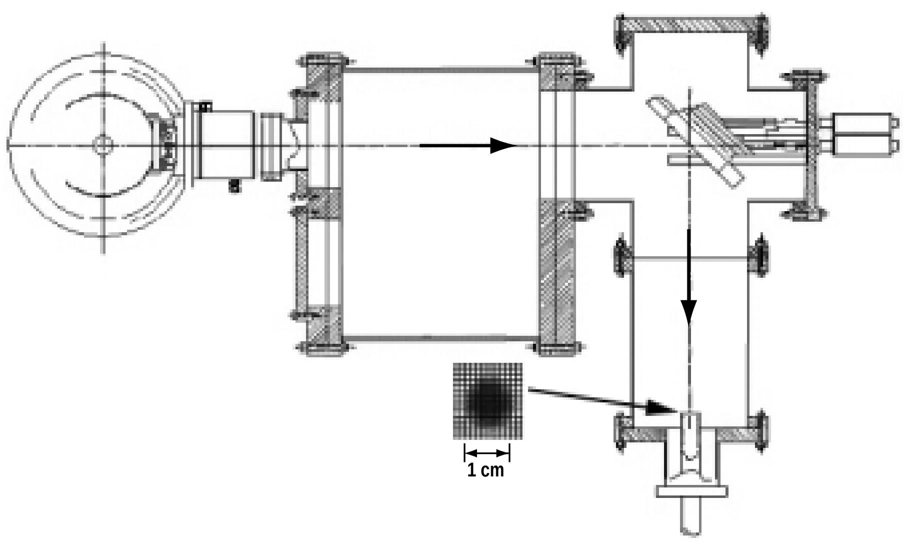

Fig. 3. The single mirror coupling scheme is presented along with the footprint of the beam on thermally sensitive paper at the waveguide input.

2. EXPERIMENTS

The DIII–D gyrotron system has as a primary task the investigation of the physics of tokamak confinement through current profile control and mitigation of MHD instabilities. The system is also used in a support role for plasma preheat and as a heat source for transport studies.

With oblique injection of the rf beam, electron cyclotron waves can drive currents near the cold plasma resonance. The presence of such currents can be diagnosed by the motional Stark effect diagnostic, which measures the direction of the local magnetic field in the tokamak. Although the perturbation in the magnetic field due to rf driven currents is small in the experiments to date, comparison between discharges with and without rf clearly show the presence of these currents through the change in the MSE signals. An example of this is shown in Fig. 4.

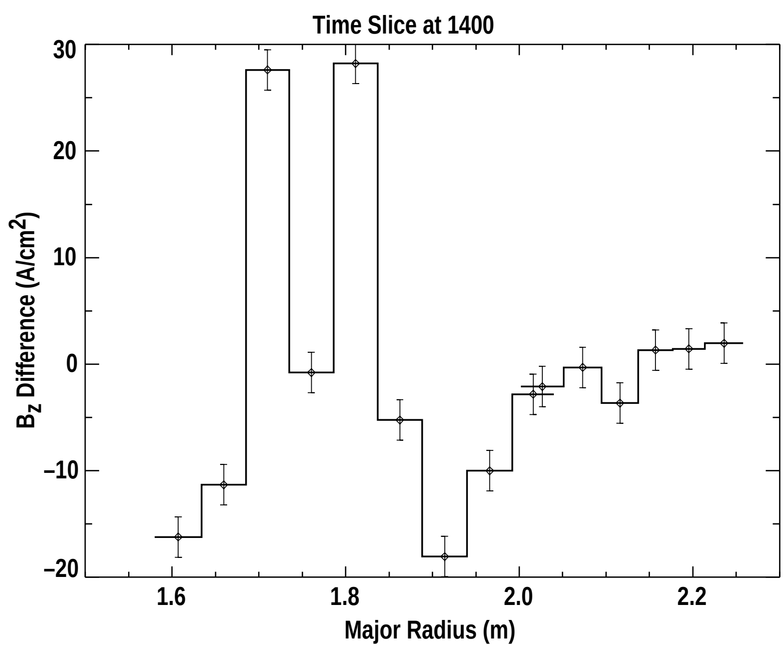

Fig. 4. Although the perturbation in the magnetic field due to rf driven currents is small in the experiments to date, comparison between discharges with and without rf clearly show the presence of these currents through the change in the MSE signals.

Another series of experiments is investigating the formation of transport barriers in the plasma. When a barrier forms, the temperature profile steepens and very large gradients are created. The barriers are associated with very low levels of MHD turbulence and are formed transiently in plasmas with reversed magnetic field shear profiles or by ECCD, which has the potential for steady state barrier maintenance. In Fig. 5, an electron temperature profile is shown in which the transport barrier was formed by application of ECCD early in the development of the discharge.

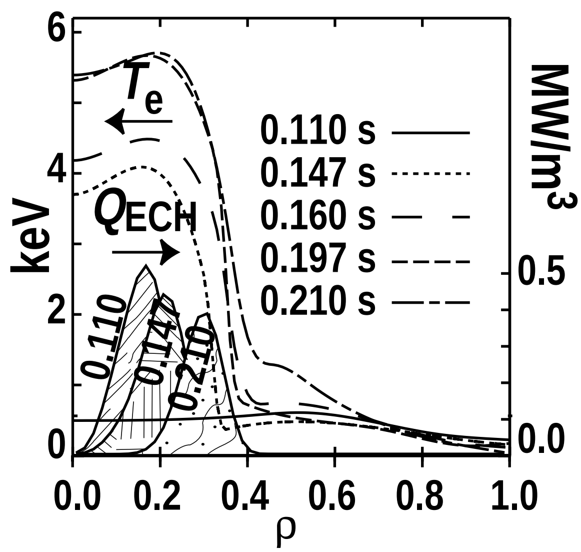

Fig. 5. An electron temperature profile is shown in which the transport barrier was formed by application of ECCD early in the development of the discharge.

3. CONCLUSION

The DIII–D gyrotron system has a mixed complement of high power gyrotrons with versatile capabilities. The present group of four gyrotrons will be expanded to include four more tubes over the next year with a long range plan to phase in still higher power units in the future as they become available.

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