§16. Developments of Advanced Microwave Diagnostics for Future Fusion Plasma Reactor and Time-Domain Spectroscopy Application to High-Temperature Plasma Measurements

Tokuzawa, T., Nagayama, Y.,
Yoshikawa, M., Kohagura, J., Shima, Y. (Univ. Tsukuba),
Mase, A. (Kyushu Univ.)

In the future fusion plasma reactor, the electron density is an important parameter for plasma control. Especially, a Heliotron-type DEMO reactor (FFHR-d1)[1] will operate on quite high density on the order of $10^{21\text{-}22}$ m^{-3}. In such high-density steady-state fusion plasma and under strong radioactive condition, robust diagnostic techniques will be expected to measure the electron density profile and its fluctuation. One of the possible diagnostics is used by the electromagnetic waves, such as radar. It needs a small access for the measurements. Since the accessibility is one of the challenging issues, it is a big advantage. Figure 1 shows the schematic drawing how microwave diagnostic accesses the plasma. It requires only small port and the waveguide transmission is available.

For measurement of high-dense plasma by a radar technique, the desired frequencies reach the terahertz regime (0.1–10 THz). There is no example to apply the high temperature plasma in the world. It is completely new challenge. Therefore, we need to develop from microwave to THz wave diagnostics for fusion plasma experiments. A time-domain spectroscopy has several attractive features[2]. When a pulsed microwave - THz wave is used for burning plasma, we can obtain several plasma parameters such as electron density profile, line-integrated density, etc.[3]

For the demonstration of this idea in high temperature plasmas, we apply the microwave time-domain spectroscopy in GAMMA-10 central cell. Microwave pulse with a 23 ps of pulse width is amplified and launched from the rectangular horn antenna. The reflected wave from the plasma and also the opposite mirror is obtained in Fig. 2. Here, the oscilloscope is used as a data acquisition. Because of the limitation of its memory size, the data is gathered shot-by-shot. For connecting the data chain, temporal overlapping is applied. Delay time calculated by time-domain analysis is shown in Fig. 3. The dotted line is estimated value with the assumption of the parabolic profile. Over 14 GHz, which frequency is higher than the maximum plasma frequency in this discharge, the observed data is almost similar with the estimated one. However, in the lower frequency range, the discrepancy is large. It might be caused by the reproducibility and/or the profile effect. Therefore, modified system is needed and will apply near future for developing the fusion plasma experiment.

1) A. Sagara et al., Rev. Fusion Eng. Des. **87**, 594 (2012).
2) M. Hangyo, et al., PFR, **2**, S1020 (2007).
3) T. Tokuzawa et al., PFR, **8**, 2402063 (2013).

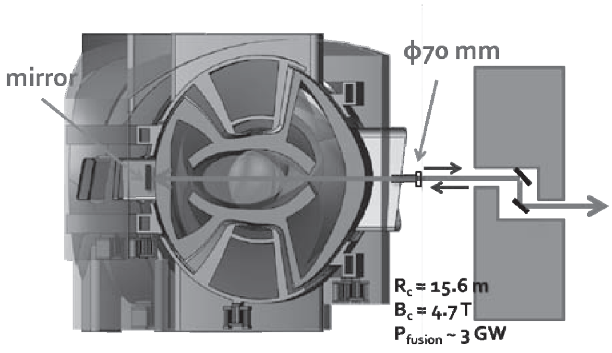

Fig. 1. Example of accessibility for microwave diagnostics in future fusion reactor (FFHR-d1).

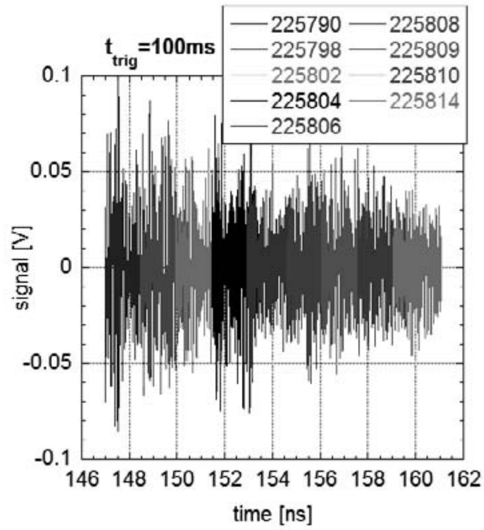

Fig. 2. Temporal waveform of chirping pulsed microwave. Data chain is obtained by some discharges.

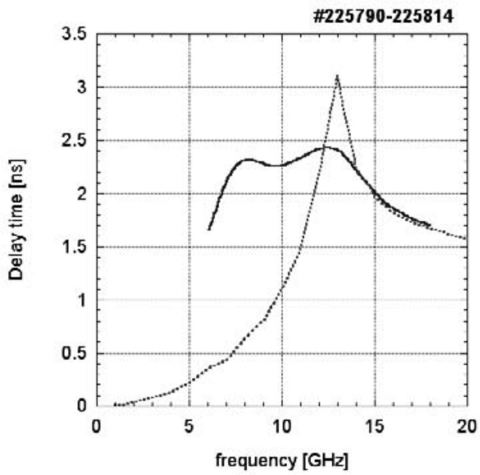

Fig. 3. Observed delay time as a function of launching frequency (solid line) and estimated one (dotted line).