§7. Development of ECE Imaging System by the Use of 1-D Horn Antenna Array

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A combined system of microwave imaging reflectometry (MIR) and electron cyclotron emission imaging (ECEI) has been developed for Large Helical Device (LHD)[1]. Microwave imaging diagnostics has a potential to observe fluctuations of electron density and electron temperature in magnetically confined high temperature plasmas. When the plasma density and temperature are sufficiently high, the intensity of electron cyclotron emission (ECE) in magnetically confined plasmas is approximated as black body radiation. The electron temperature profile can be determined by measuring the intensity of each frequency of the ECE, since the ECE frequency corresponds to the radial position of emission. By using a 1-D receiving antenna array, 2-D ECE profiles (radial and vertical directions) can be obtained. The electron temperature is considered to be equal on the same magnetic flux surface so that ECEI can be one of the most powerful diagnostics to investigate MHD instabilities.

Before the 14th LHD experimental campaign, the observation range of ECEI system was in the frequency range of 97 – 104 GHz. In experiments at low fields (B_{ax} < 1.5 T), the frequency range is higher than ECE frequencies. On the other hand in experiments at high fields (B_{ax} > 2.5 T), the ECEI observation range covers only near the plasma edge (ex. $\rho = 0.95 \sim 1.0$). In LHD, experiments with B_{ax} from 1.5 to 2.5 T are extremely rare. Hence, in order to adapt to standard experimental conditions, the shift of the observation frequency into lower or higher ones is needed.

Figure 1 shows elements of an ECEI detector array. This detector consists of 4 parts, horn antenna, waveguide, mixer and IF amplifier. The antenna array was firstly developed for MIR as 2-D detector array[2]. The ECE radiated from the plasma and the local oscillation (LO) wave enter through the horn antenna, and propagate to a mixer passing through the waveguide. The ECE signals are down-converted into IF signals in the frequency range of 2 – 9 GHz are amplified with IF amplifiers, and power spectra are obtained with band-pass filters and detectors. However, two IF signals which cause cross talks are generated from ECE signals in both sides of the LO frequency. Filtering is necessary to restrict ECE signals in either side the LO frequency.

Figure 2 indicates dimensional drawing of a test production element. The element has a long rectangular waveguide section with side-length of 2.28 mm. The waveguide serves as a high-pass filter with a cutoff frequency of 65 GHz. By the use of LO wave at 66 GHz and the 2–9 GHz multi-frequency detector element, the observation range corresponds to the frequency range of 68 – 75 GHz and the elimination range corresponds to the frequency range of 57 – 64 GHz. Figure 3 shows the sensitivity of an element of ECEI detector with 66-GHz LO signal. The abscissa indicates test source frequencies, and the ordinate indicates sensitivities. Although the sensitivity drops with increasing frequency in the observation range, the sensitivity is much lower in the elimination range.

To install this detector for the next experimental campaign, improving method of the sensitivity decline is required.

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1) Kuwahara, D. et al.: Rev. Sci. Inst. **81**, 10D919 (2010).
2) Kuwahara, D. et al.: J. Plasma Fusion Res. SERIES, Vol. 9, pp. 125-130 (2010).

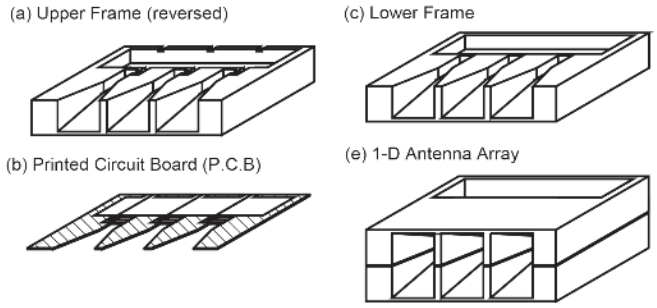

Figure 1 ECEI detector array assembly drawing.

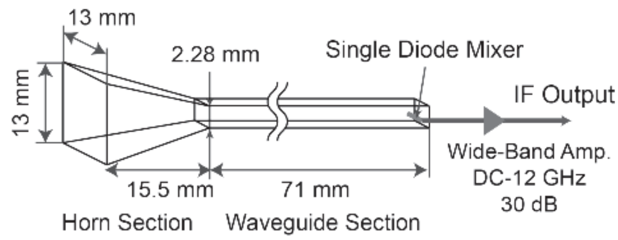

Figure 2 Dimensional drawing of an element.

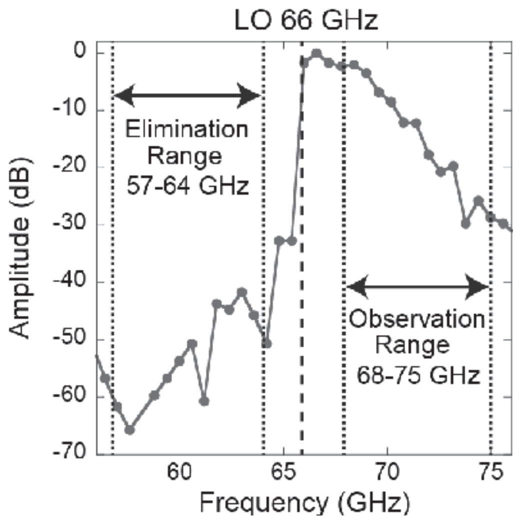

Figure 3 Frequency response of ECEI detector.