§10. Development of Electron Cyclotron Emission Imaging System on LHD

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A combined system of Microwave Imaging Reflectometry (MIR) and the Electron Cyclotron Emission Imaging (ECEI) has been developed for Large Helical Device (LHD)[1]. Microwave imaging diagnostics has potential to observe the fluctuations of electron density and electron temperature profiles in magnetically confined high temperature plasmas. When the plasma density and temperature are sufficiently high, the intensity of Electron Cyclotron Emission (ECE) equals to black body radiation in magnetically confined plasmas. 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 poloidal 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.

Figure 1 shows a block diagram of the ECEI detection system. The ECE signals from plasma are focused on a Horn-antenna Mixer Array (HMA) with focusing optics. In HMA, each antenna element receives both ECE signals and Local Oscillation (LO) signal, and mixer unit generates IF signals. The frequency spectrum of IF signal is detected with a multi-frequency detector. The central frequencies are set from 2 GHz to 9 GHz with 1-GHz steps. The designed bandwidth of each channel is 500 MHz. Figure 2 shows the observation area of this system in the case of B_{ax} = 2.1 T, R_{ax} = 3.6 m magnetic configuration. Sight lines are determined by the optic system while the radial channels are determined by the ECE frequency corresponding to the magnetic field strength.

An example of ECEI signals is shown in Fig. 3. Fig. 3(a) indicates two ECE signals observed by different antenna channels at the same frequency. Fig. 3(b) shows ECE spectrum of the "pol_2ch, 104 GHz" signal. During 7.2 s to 7.7 s, fluctuations around 2 kHz were observed.

For the next experimental campaign, we plan to change the observation frequency range. Currently, it is between 97 GHz to 104 GHz. However, this frequency range does not match with normal LHD experimental conditions. The observation range of a new system will be set at frequencies of 68 – 75 GHz. This range overlaps conventional ECE diagnostics installed on LHD.

1) Kuwahara, D. et al.: Rev. Sci. Inst. **81**, 10D919 (2010)

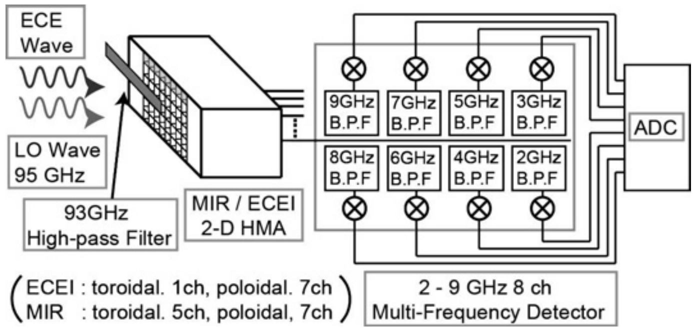

Fig. 1 ECEI detection system. ECE signals are down-converted into 2 - 9 GHz IF signals by LO wave and each HMA element. Multi-frequency detector measures spectrum of IF signals.

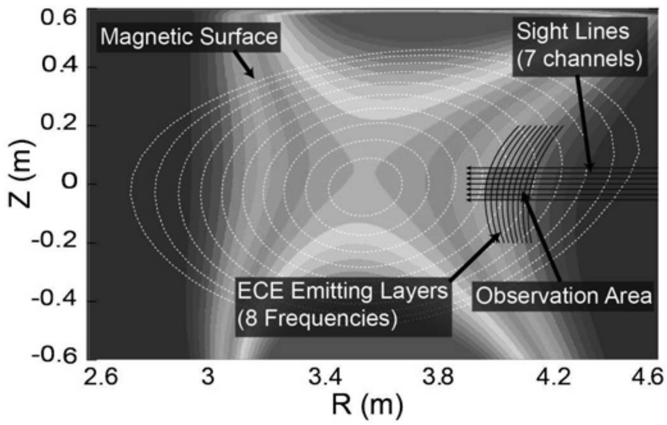

Fig. 2 Observation area of ECE imaging. Color indicates the magnetic field strength of B_{ax} = 2.1 T, R_{ax} = 3.6 m experiment. Observation area is determined by sight lines of antenna elements and magnetic field.

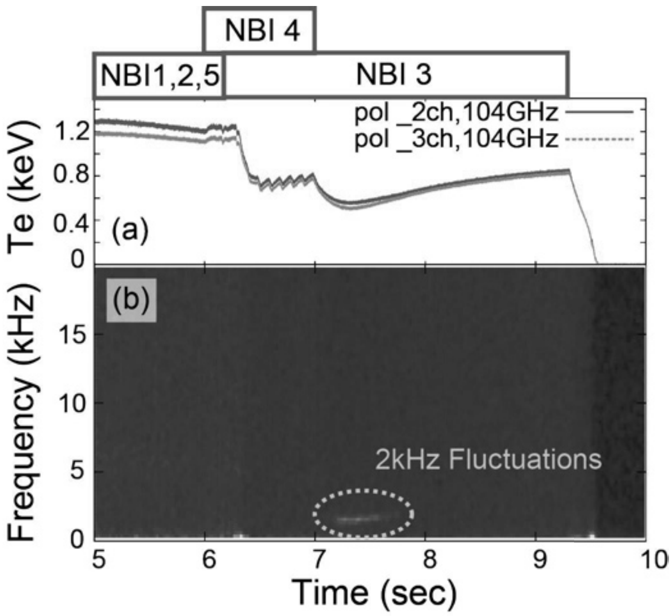

Fig. 3 An example of ECE waveforms and FFT analysis. (a) Waveforms at the same frequency and from different antenna channels (poloidal direction). (b) Spectrum time evolution of pol_2ch at 104GHz.