§18. Development of Collective Thomson Scattering Diagnostic in the Large Helical Device

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Fast ion physics are major concern in fusion plasmas as well as bulk ion one. One of possible methods for diagnosing confined bulk and fast ions is to use a collective Thomson scattering (CTS) technique with a millimeter wave and mega-watt power. As other options, the fuel ratio of D/H, the ion temperature, and the flow velocity have also reported in TEXTOR and ASDEX-Upgrade using this method. In the LHD campaign of 2012, we have made major three progresses on the CTS diagnostic in the Large Helical Device (LHD).

The precise overlap between probing and receiving beams is essential to distinct a local scattered radiation, in order to discriminate the signal of the scattered radiation from that of the background electron cyclotron emission. Therefore an antenna was aligned using a laser and a low power millimeter wave in LHD vacuum vessel before the LHD vacuum evacuation, because of the secular change due to the mechanical drive. The target is located in a vacuum vessel, and the sources of laser and millimeter wave were attached and each of them was emitted from the end of wave guide of the outside of the LHD vessel. We aligned the 1.5L receiver antenna last year. The 2-O probing beam antenna, which is commonly used for electron cyclotron heating, was checked first time. The error of toroidal direction of about 10 cm at R = 4.0 m was corrected.

After the adjustment of 2-O antenna, we have carried out the beam overlap scan during plasma discharges. To obtain the scattered radiation, we subtract the electron cyclotron emission from the received signal by modulating the probing beam. Fig. 1 shows the variation of scattered radiation, when the receiving beam direction was scanned to across the probing beam. At t = 4.1 s the receiving beam scan was started, and it once remained at t = 4.62 s. At t = 4.82 s, it was returned to the initial position. The signals of ch5 and ch27 for fast ions, and ch17 for bulk ions were selected. From Fig. 1, when the the distance was zero at 4.3 and 5.2 s, the signal of each channel became maximum. This means the beam overlap becomes maximum, as we expected. At t < 4.2 s, and > 5.4 s and t = 4.62-4.82 s, the beam overlap would be zero. But the signal of scattered radiation only for ch17 changed

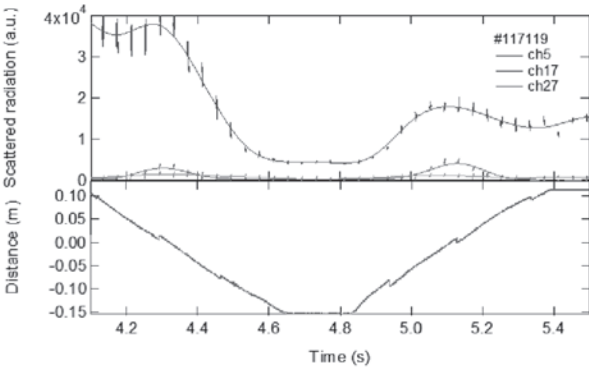

Fig. 1 The signal of scattered radiation was measured, when the beam overlap was scanned. Lower plot shows the distance between the probing and the receiving beams.

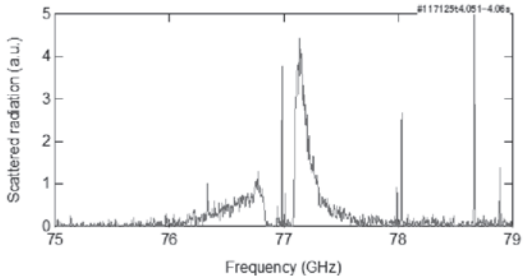

Fig. 2 Fine CTS spectrum measured by fast digitizer. Ion temperature and flow velocity could be estimated from the spectrum expansion and the frequency shift, respectively.

at the high signal level. In some cases, we found that the scattered signal exists at the off-overlapped position as the background signal. The reason should be understood clearly to estimate the ion velocity distribution. We also observed the beam distortion, which depends on density and temperature. This would be confirmed by using the ray tracing code.

The fine CTS spectrum could be obtained routinely shot by shot as shown in Fig. 2. These signals would be analyzed to obtain the ion temperature and flow velocity.

A notch filter for the rejection of stray light from gigahertz range heating sources was developed to protect a vulnerable microwave plasma diagnostic system. As one of the applications, we consider the installation of the notch filter into the receiver of a collective Thomson scattering diagnostic in the LHD. Experimental observations indicate that two types of notch filters are required for main and spurious mode rejection; they have very narrow, steep shapes to avoid disturbing the diagnostic signal. On the basis of numerically simulated results, notch filters were fabricated, and their performance was evaluated. An attenuation level of 35 dB at 74.746 GHz with a 3 dB bandwidth of 0.49 GHz is achieved by two pairs of resonator cavities. This attenuation is acceptable in our study. To achieve this characteristic, we have carried out many trial fabrications and the cavity adjustment.