§20. High Resolution Spectrum 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 this fiscal year, we have made major progresses on the data acquisition and the analysis of the CTS diagnostic[1)] in the Large Helical Device (LHD). Here we report the data acquisition developed.

The CTS spectrum was measured at the maximum overlap position to obtain the features of the ions and the plasma parameters. The fine frequency resolved CTS spectra have been measured by the fast digitizer and the filter bank receiver simultaneously. The intermediate frequency (IF) signals were stored in the LHD database for the fast digitizer with a sampling rate of 12.5 GS/s of a bandwidth of 6 GHz, in addition, for the filter bank receiver with a sampling rate of 100 KS/s. The time-domain data for the fast digitizer were converted to frequency-domain data by fast Fourier transform (FFT). The fine CTS spectrum in Fig. 1 was taken from the CTS spectrogram averaged over the time at t = 4.05–4.052 s; the scattered radiation was calculated by subtracting the ECE background spectrum at t = 4.060 s from the measured signal. The observed CTS spectrum of the bulk-ion region has the sufficient intensity on the positive frequency side; conversely, the CTS spectrum has too low intensity on the negative frequency side that is not sufficient enough to be fitted by the theoretical model, because of the attenuation of the signal by the notch filter for the probe beam. Therefore, it is necessary to adjust the bandwidth of the notch filter on the negative frequency side. From Gaussian fitting, the center of the bulk CTS spectrum is found at 77.019 GHz, from which we can, in principle, estimate the bulk-ion rotation-velocity. However, the present data are not accurate because of the lack of data on the negative frequency side. The monitored gyrotron frequency is 76.985 GHz. The two edges of the notch filter are 76.85 GHz for the low-frequency side and 77.085 GHz for the high-frequency side. Ideally, the lower-frequency edge should be shifted by a few megahertz toward higher frequencies. Other strong peaks are also detected in the spectrum at less than 75 GHz and more than 79 GHz. These spurious radiations in the probe beam are originated from the gyrotron. The spurious radiation in the frequency and time of the transient phase of the anode voltage, which is expected from the mode competition calculation in frequency and time, can be suppressed by optimizing the gyrotron operation mode[2)]. From the CTS spectrogram, the probe beam frequency chirps down by approximately a few tens of megahertz during the ON timing. Stray radiations from other gyrotrons are also observed inside the bandwidth of the notch filter with the attenuation greater than 120 dB. This is caused by the multiple reflections of the injected gyrotron beams from ports with different toroidal angles.

The CTS spectrum measured by the filter bank receiver is averaged over 4 milliseconds at t = 4.056 sec. The intensity is scaled to fit that of the fine CTS spectrum, as is shown in Fig. 1. Both spectra agree with each other except spurious radiations from the gyrotron.

From the result, the fine CTS spectrum gives us the solution to obtain the ion temperature from the fitting of theoretical curve.

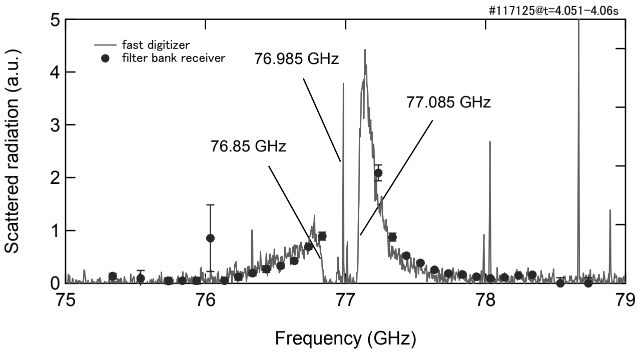

Fig. 1. Fine CTS spectrum measured by the CTS receiver with the fast digitizer for LHD#117125. The CTS spectrum measured by the filter bank receiver is plotted for the comparison. The magnetic configuration of LHD is B_t = 2.75 T and R_{ax} = 3.6 m.

1) Nishiura, M., Kubo, S., Tanaka, K. *et al.* : Nucl. Fusion **54**(2014) 023006.

2) Ogasawara, S., Kubo, S., Nishiura, M. *et al.* : Rev. Sci. Instrum. **83**(2012) 10D731.