§70. High Resolution Spectrum for Ion Velocity Distribution Function by Collective Thomson Scattering in the Large Helical Device

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Fast ion physics are major concern in fusion plasmas. One of possible methods to diagnose confined fast ions is to use a collective Thomson scattering (CTS) technique with a millimeter wave and mega-watt power. In the LHD campaign of 2011, we have made progress on the CTS diagnostic in the Large Helical Device (LHD). Three major points are improved in the hardware and the data analysis. We have installed a fast digitizer for high frequency resolution CTS spectra. Another is the fast scanning antenna system with the synchronization to a common trigger signal. The last one is the code preparation for the comparison between measured and simulated CTS spectra. The progress in the fast digitizer for high frequency resolution CTS spectra is reported here.

One of capabilities for the collective Thomson scattering (CTS) diagnostics is to measure the ratio of ion species in confined plasmas. Since the CTS diagnostics is sensitive to the ion Bernstein waves (IBWs) and the ion cyclotron motions, the feature is appeared in the CTS spectrum as a fine structure. One can detect the fine structure in the CTS spectrum under a specific condition that the fluctuation wave vector k^{δ} is perpendicular to the magnetic field. The fine structure has the multiple peaks related to the harmonics of the ion cyclotron frequency $n\omega_{ci}$. Therefore the frequency resolution of the CTS receiver system is required to be less than $\omega_{ci}/2\pi$. In 14th campaign of LHD experiment, we used a fast sampling and wide bandwidth oscilloscope and demonstrated it for CTS diagnostics in LHD plasma discharges. The schematic diagram of the CTS receiver system is shown in Fig. 1. The 15th campaign of LHD experiment, we have installed the new fast digitizer (NI PXIe-5186) with 1 GB memory, instead of the previous fast oscilloscope with 256 MB. Therefore the data acquisition time is increased.

Fig. 2 shows the measured CTS spectrum at the location, $\rho = 0.61$, where the probing beam from 2O port and the receiving beam from 1.5L port are set to $(3.9, 0.6, 0)_{2O}$ and $(3.6, -0.28)_{1.5L}$, respectively. The probing beam is modulated at 50 Hz for subtracting the electron cyclotron emission from the measured scattered radiation. After the background ECE subtraction, the CTS spectra are obtained by both the 32 channel receiver and the fast digitizer simultaneously, as shown in Fig. 3. The spectrum must be the same shape for both methods, but they are slightly disagreement at the lower frequency side around -1 GHz. We would find out the cause of the disagreement.

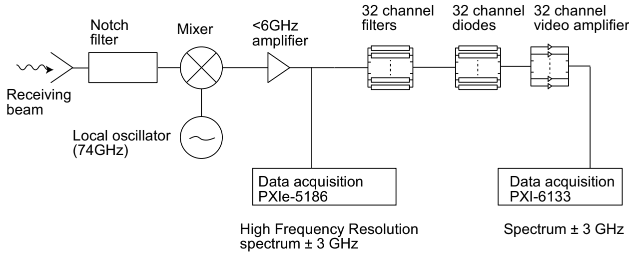

Fig. 1. Schematic diagram of the CTS receiver system with the 32 channel broad band receiver and the fast sampling digitizer for CTS diagnostics.

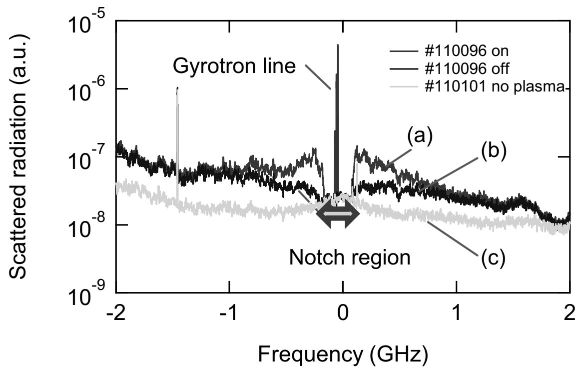

Fig. 2. Measured spectra for (a) probing beam on, (b) probing beam off, (c) system noise.

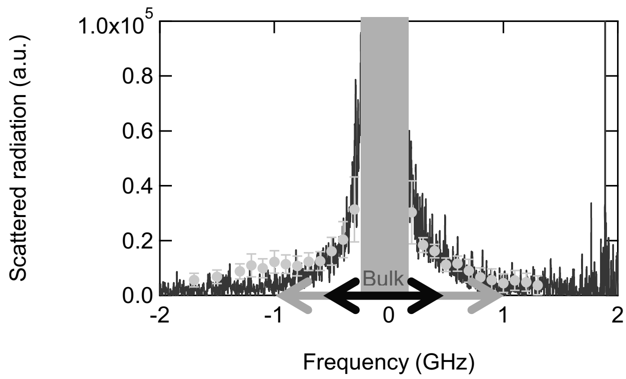

Fig. 3. Comparison between the CTS spectrum measured by 32 channel receiver (closed circles) and the fast digitizer (solid line) for LHD shot#110096. The hatched region is a poor sensitivity due to inside the notch filer.