§66. Initial Result of Collective Thomson Scattering System Using 77 GHz Gyrotron for Bulk and Tail Ion Diagnostics in The Large Helical Device

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Confined energetic particle diagnostics is a major concern to thermo nuclear fusion for maintaining and controlling the self burning. One of the strong tools considered is a collective Thomson scattering diagnostic. Recent developments of powerful radiation sources, like mega watt class gyrotrons, made it possible to detect the scattered electromagnetic waves by fluctuations in plasmas. For the bulk and tail ion temperature measurements in the LHD, the collective Thomson scattering (CTS) diagnostic has been proposed using the existing electron cyclotron resonance heating (ECRH) by gyrotron with the frequency of 77 GHz. The CTS is also assessed numerically using the injector and receiver geometry of the LHD with accessible plasma parameters.

The receiver system employed is a high sensitive heterodyne radiometer. It consists of mainly the notch filter, a pin switch, the mixer with local oscillator, filter bank with band pass filters, and crystal detectors. The details are noted in the references [1, 2]. The specification of the notch filter at the centre frequency of 76.95GHz is the attenuation of 120 dB with the bandwidth of 200 MHz, and -3dB with bandwidth of 400 MHz.

The scattered electromagnetic wave propagates through the notch filter, and is converted at the mixer in the range from 300 MHz to 10 GHz. The following filter bank separates the wave into 16 channels, which can detect the scattered radiations with the bandwidth of 100 MHz for bulk component channels and 200 MHz for high energy ones. The local oscillator frequency of 74 GHz was chosen originally, but in the experiment we had to use the alternative oscillator frequency of 77.845 GHz temporally, thus only 8 channels are used.

In LHD discharge #91756, the CTS probing beam is injected at the modulation frequency of 50 Hz to subtract the background ECE radiation from the scattered radiation. The background ECE radiation signal is averaged for a few ms from the trailing edge during the gyrotron off periods. During t = 0.9 ~ 1.8 sec the discharge is sustained by ECRH without energetic neutral beams. The spatial profiles of the electron temperature and density are measured by incoherent Thomson scattering. The reliable parameters become T_e = 0.5 keV and $n_e = 1 \times 10^{19}$ m^{-3} at R = 4.1 m. The measured and expected CTS spectra are plotted for the resolved 8 channels in figure 1 and filter characteristics is shown in figure 2. The calculated CTS spectrum is obtained by assuming that the ion and the electron temperatures are equilibrium condition. It is found that the expected CTS spectrum for the temperatures of 0.5 keV is in better agreement with the measured one, while the discrepancy becomes larger for the temperatures of more than 1.0 keV. However we still need to check the validity of absolute signal levels.

The CTS diagnostics is demonstrated successfully. We expand the number of filter bank channels from 8 to 32 with using the original local frequency of 74 GHz in the forthcoming experimental campaign.

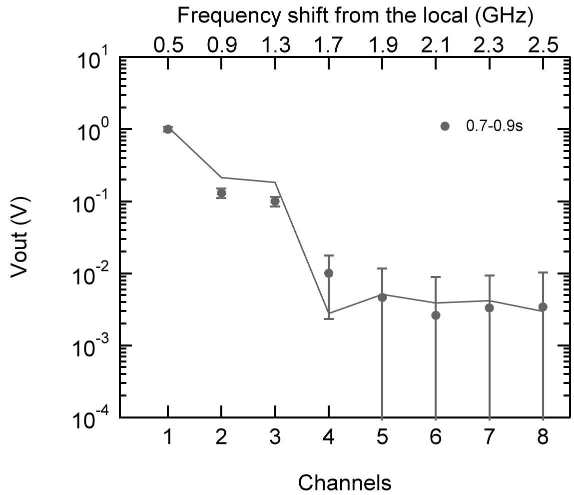

Fig. 1. Measured CTS spectrum (closed circles) is resolved into 8 channels during t = 0.7 ~ 0.9 s

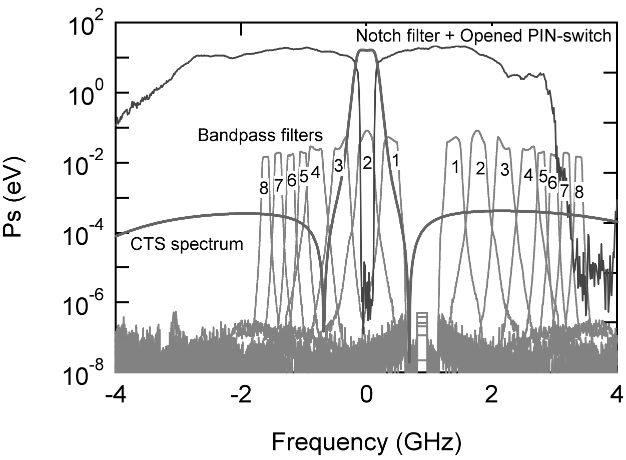

Fig. 2. Each channel is the sum of both side band signals. The calculated CTS spectrum (line) is plotted for $T_e = T_i$ = 0.5 keV. Right figure shows that the characteristics on the notch filter including the PIN-switch and the 8 channel band pass filters are overlaid at the local oscillator frequency of 77.845 GHz, which corresponds to 0.895 GHz on the abscissa.

1) M. Nishiura, *et al.*, Rev. Sci. Instruments 79(2008)10E731.
2) S. Kubo, *et al.*, J. Plasma Fusion Res. 5(2010)S1038.