Improvement of signal-to-noise ratio in Thomson scattering diagnostics by an accumulation of 100 laser pulses within 5 milliseconds

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The signal-to-noise ratio (SNR) of the Thomson scattering diagnostics usually becomes small in high electron temperature, T_e, plasmas because of the low electron density, n_e. In order to derive precise T_e, averaging of signals in time or spatial positions are made [1]. Recently, operation with an Nd:YAG laser with high repetition rate up to 20 kHz started in the Thomson scattering system on the Large Helical Device (LHD) in order for the high temporal resolution [2]. In the 20 kHz operation, 100 laser pulses, each of which has almost 1 J of the pulse energy, are irradiated in 5 ms with the interval of 50 µs. Therefore, assuming that T_e does not change in 5 ms, it is possible to add up all signals by the 100 laser pulses.

Figure 1 shows signals which were detected by a polychromator (Poly#57) in the Thomson scattering system on LHD. The closest channel to the laser wavelength is Ch. 1. Raw data by one laser pulse are shown in Fig. 1 (a). The SNR may be small because of the small signal intensity, except Ch. 5. The observed position by Poly#57 is near the plasma center. High T_e is expected since this plasma was heated by the electron cyclotron heating (ECH) with the injection power of 3.2 MW and n_e was almost 2×10^{18} m^{-3}. Figure 1 (b) and (c) show averaged signals of 10 signals in almost 0.5 ms and 100 signals in 5 ms, respectively. The signal components become clear in Fig. (b) and (c). The blue horizontal dashed line shows the background level which determined by averaging the data in the first 50 ns. This background level is important for the integration of the signals in time. It is still affected by noise in Fig. 1 (b), while the effect of noise seems to disappear in Fig. 1 (c). The value of T_e and the error of T_e will be evaluated for each case.
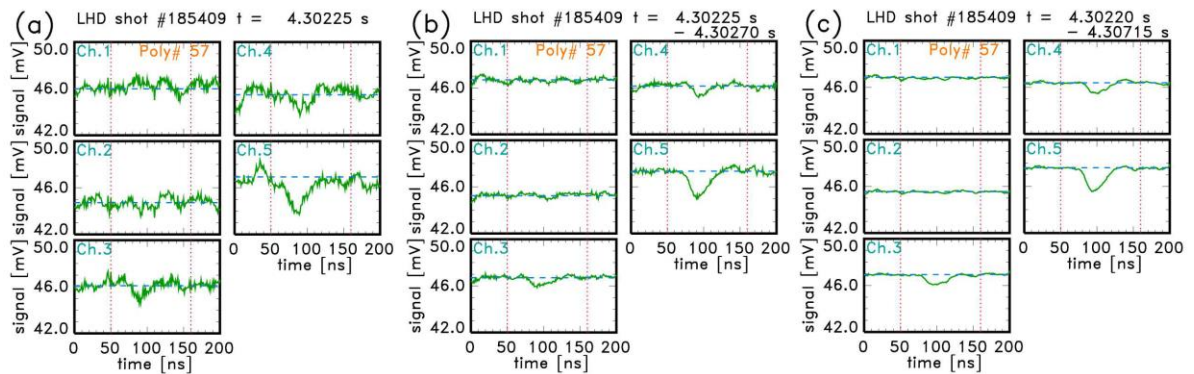

Figure 1. Thomson scattering signals in a polychromator on LHD. (a) Raw signals by one laser pulse. (b) 10 signals in almost 0.5 ms are averaged. (c) 100 signals in 5 ms are averaged.

[1] I. Yamada, *et al.*, JINST, **7** (2012) C05007.
[2] H. Funaba, *et al.,* Sci. Rep. **12** (2022) 15112.

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