

§1. A Convenient Method of Calibrating Relative Sensitivity of Multi-Channel Thomson Scattering Diagnostic System

Narihara, K., Yamada, I., Hayashi, H.

The Large Helical Device (LHD) is equipped with a 200-channel Thomson scattering diagnostic (TS) [1], which can yield space-resolved electron temperature (Te) and density (ne) profiles along the major radius passing the magnetic axis at a horizontally elongated poloidal section. Through repeated spectrum calibrations of the polychromators, the data quality of the electron temperature profile has reached a satisfactory level, though not yet perfect. On the contrary, the data quality of ne is far from satisfactory due to incomplete absolute sensitivity calibration of each polychromator. Initially we planned to do absolute-calibration using hydrogen-Raman scattering, but abandoned this for the safety reason. Instead, we tried several times nitrogen-Raman scattering calibration, but, to date, the results are not reproducible and far from satisfactory. The deduced ne profile with the calibration has much larger channel-to-channel variations than the un-calibrated ne profile. The reason for this was speculated that the nitrogen-Raman spectra lie at the very steep wing of the first filter in the polychromator, which makes the measurement to be very sensitive to change of the filter-characteristics caused, for example, by changes in room temperature or in the light-collection-geometry. We must repeat many trials further. In order to pursue this tedious calibration work efficiently, we developed a convenient method to measure relative sensitivities among the polychromators as described below.

To simulate light coming from the scattering volumes in a plasma and passing the view window, we used light diffusively reflected from a BaSO4-coated plate (33 cm x 60 cm) set on the surface of the viewing window in the airside. The thickly coated BaSO4 was checked to reflect with little spectrum distortion. The BaSO4-plate was illuminated by 10 ns pulse light guided by an optical fiber from an optical parametric oscillator (OPO). A light-expander with a rectangular aperture similar to the window shape was attached at the exit of the optical fiber. The wavelength of the OPO was swept between 1020-1060 nm to measure the sensitivity of the first filter-detector combination. Trial and errors and careful checks were necessary to eliminate stray optical paths linking the OPO to the input of the polychromators. The OPO output, which fluctuates appreciably, was monitored by an ultra-fast thermopile detector to normalize the spectrum-responsivity. With this experimental setup, we measured the sensitivities of the first spectral-channel of the polychromators. The wavelength-responsivity relations (filter functions) of the color channel proximate to the laser wavelength (1064.3 nm) are over-plotted for 114 polychromators in Fig.1. We can see that the height and width of the filter-function varies appreciably polychromator-to-polychromator. The repeated measurements over weeks showed a good

reproducibility. Combining the calculated data on the scattering length and the solid angle for each spatial-channel with the filter-function thus measured, we can obtain the coefficients necessary for deducing ne profile. The ne profile thus obtained (OPO channel#4 data) are shown in Fig.2 together with the uncalibrated profile (DC all channel data). There still remains large channel-to-channel variations, though much larger one are removed. In addition to these channel-to-channel variations, the right-left asymmetry in the profile is a problem yet to be solved. We must make continued great efforts.

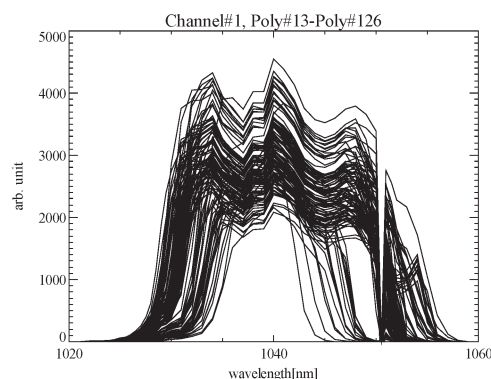


Fig. 1. Wavelength-dependent-responsivities of the color channel proximate to the laser wavelength.

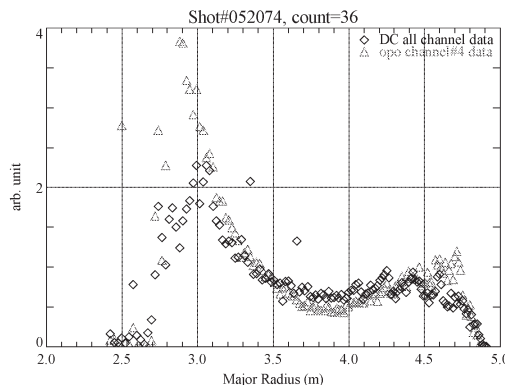


Fig. 2. ne profiles with (triangle-mark) and without (diamond-mark) the calibration.

[1] Narihara, K., Yamada, I., Hayashi, H., Yamauchi, K. Rev. Sci. Instrum. 72, (2001), 1122.