§13. Development of Two Dimensional Thomson Scattering Measurement System

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The Thomson scattering is the most reliable diagnostic for electron temperature measurement and its extension to two dimensional (2-D) system will contribute significantly to solving electron dynamics in LHD as well as magnetic reconnection in TS-4. We started developing a new cost-effective 2-D Thomson scattering system using multi-reflection of a single laser light and its time-of-flight effect. As shown in Fig. 1, 2-D profiles of electron temperature and density are measured at m x n measurement points covered by the YAG laser reflection on the r-z plane. Novel points for our system is as follows: (1) multiple laser light reflection to cover m x n (2-D) measurement points on r-z plane, (2) usage of time-of–flight to save the number of polychromaters and detectors, and (3) flexible usage of laser path length to control those numbers and delay times of scattering signals. They enable us to develop a low-cost 2-D Thomson scattering system using a single Laser and polychromators equivalent to the 1-D system, because the scattering lights from n measurement points are measured by a single polychromator.

In 2006, we tentatively modified the present single point YAG Thomson scattering system to test the time of flight measurement for two points. Based on those data, we finished designing/ constructing the first 1-D measurement system by Jan.2007. As shown in Fig. 2, its collecting optics and polychromator system are designed for five points (three points for the initial operation). The amount of scattering light was increased by factor 45, due to increase in objective lens diameter from 2.4cm to 8cm and the bundle high NA optical fibers replaced by the single fibers. We measures for the first time, the Raman scattering signals from the three measurement points with the column number m=1 to test the time of flight idea. Figure 3 left shows their signals measured by time evolution of a single APD detectors signal whose central wavelength and band width are 1054nm and 2.5nm and that of the YAG laser signal. It is clearly observed that the three Raman scattering signals were measured with equal time intervals of 50nsec corresponding to laser flight length of 15m. Their cross-talk is negligibly small and the Raman scattering signals increase with the gas pressure in Fig. 3, indicating the validity of this measurement.

In the second year 2007, we are planning to the second 1-D system to demonstrate 3x2 Thomson scattering measurement by adding the APD detectors and polychromators and to decrease the stray light by adding two vacuum vessel extensions with internal mirror arrays.

References

1) T. Sumikawa, Y. Ono et. al , Plasma Fus. Res. 1, p. 014 (2006).
2) K. Yamashita, Y. Ono, K. Narihara et al., 3rd Plasma Conf. IEEJ (Kanazawa, Jan. 07.)

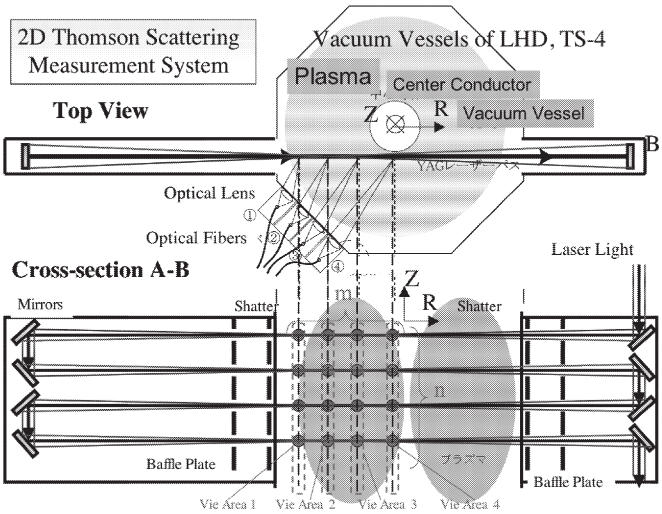

Fig. 1 Schematics of 2-D Thomson Scattering measurement by multiple laser light reflection and its time of flight.

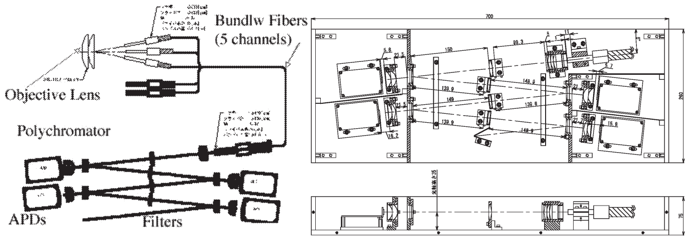

Fig. 2 The completed objective lens system/ polychromator system for three measurement points.

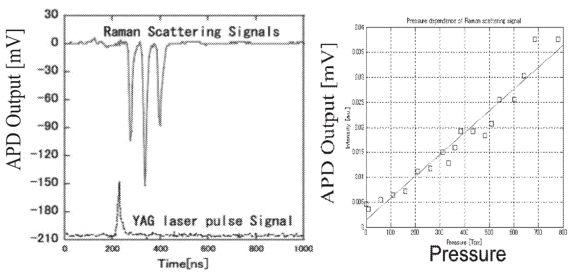

Fig. 3 Time evolutions of YAG laser signal and Raman scattering signals (by APD detectors) from three measurements along the YAG laser path (left) and dependence of Raman scattering signal on gas pressure (right).