§1. Development of the Laser Beam Positioning System for the LHD Thomson Scattering Device

Yamada, I., Narihara, K., Funaba, H., Hayashi, H., Kohmoto, T.,
Takashi, M. (Inst. Adv. Energy, Kyoto Univ.)

The LHD Thomson scattering is one of key diagnostics and routinely measures electron temperature and density profiles of LHD plasmas.[1, 2] Since the laser transport length from the laser system to LHD is 40m, very long, then accurate and stable beam transport is one of the issues to be established for reliable measurements. Especially, misalignment of the laser beam may cause huge errors in measured electron densities.

Laser beam position varies by some reasons, and the fluctuation is roughly divided into two components. One is the beam pointing stability in the laser unit itself. It is relatively fast and pulse-by-pulse fluctuation. The other is relatively slow, and originates mainly from the variation of the optics outside laser unit, such as beam transport mirrors. Previously we developed an active beam control system in order to reduce the fast beam pointing instability about 10 years ago.[3] The pointing stability of the lasers used at that time is quoted to be 0.4 mrad in the catalogue. It was 10 times larger than necessary specification. The beam control system successfully reduced the beam pointing instability by ~1/50. In addition to the pulse-by-pulse fast beam fluctuation, the beam position is moved slowly by the variation of beam transport optics. The long-term instability could not removed successfully by the system for some reasons. Then, we have developed a new beam positioning system for establishing long-term stability. The system is designed to adjust the absolute beam position for a long-term, rather than for reducing the pulse-by-pulse fluctuation.

The newly developed beam positioning system consists of two sets of a reference stabilized HeNe laser, a 2D position sensitive detector (PSD) and two precision mirror control actuators, as shown in Fig.1. By using a couple of beam positioning system, laser beam position inside LHD plasma can be fixed completely. The mirrors M1 and M2 are negative-feedback-controlled by referring the beam position information obtained from PSD1 and PSD2 respectively. Integrated operation is carried out with a LabVIEW system. The operational window is shown in Fig.2. In the previous report,[4] we concluded that the density uncertainties caused from the slow beam variations were ~24 % through the 10th experiment campaign. The error has been decreased to ~10 % or less by the newly developed beam positioning system. The system has worked through the 12th experiment campaign without any serious troubles. It is noted that some algorisms for safe operation have been included in the controller. For example, deep feedback may cause undesirable oscillating phenomena. Then the degree of the negative-feedback has been set somewhat weakly. The system will be further improved in the next experiment campaign. For example, improving the algorism and optimizing some parameters used in the negative-feedback will increase the accuracy.

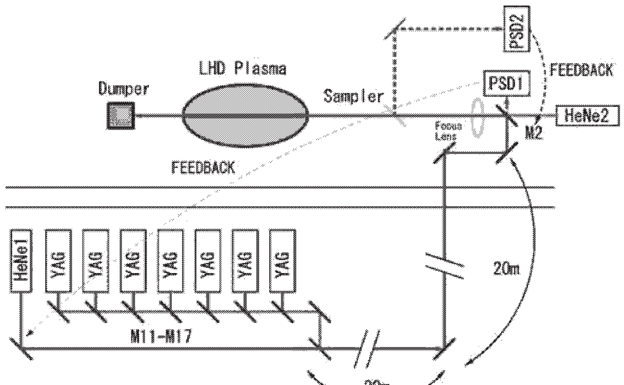

Fig.1. Schematic diagram of the beam positioning system.

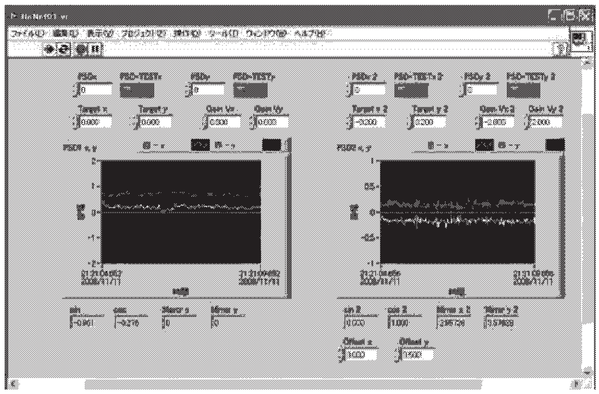

Fig.2 Screen shot of the beam positioning system based on LabVIEW. Right part shows the beam positioning controller #1, and the left one is for #2. The curves in each window indicate beam positions, x-direction and y-direction.

1 Narihara, K., *et al.*, Fusion Eng. Design, Vol.34-35, 67-72 (1997).
2 Narihara, K., *et al.*, Rev. Sci. Instrum., Vol.72, 1122 (2001).
3 I. Yamada *et al.*, Rev. Sci. Instrum., Vol.72, 1126 (2001).
4 I. Yamada *et al.*, NIFS Ann. Rep. 2007-2008, 141 (2008).