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Fast reciprocating Langmuir probe assembly for the initial spatial profile measurement of edge plasma parameters in the KSTAR machine

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A fast reciprocating Langmuir probe assembly (FRLPA) [1-3] is prepared to obtain the radial profiles of plasma parameters and the fluctuation of each parameter in the scrap off layer (SOL) region during a plasma discharge in the Korea Superconducting Tokamak Advanced Research (KSTAR) machine. The FRLPA consists of the probe drive system, probe head and probe circuit. A linear actuator by using an electric servomotor and a pneumatic cylinder, as the probe drive system for the FRLPA, are used for slow and fast movements, respectively (see Fig.1). Thus, the FRLPA can do a fast reciprocating motion during a plasma shot or a step motion on a shot by shot basis. Details on the drive system were described in the previous works [1-3]. The drive system can be remotely controlled by a personal computer (PC). The elapsed distance of the probe head in the FRLPA was measured by a position transducer (PT) and a linear scale (LS). The LS can be used to monitor the distance for the control of the FRLPA movement.

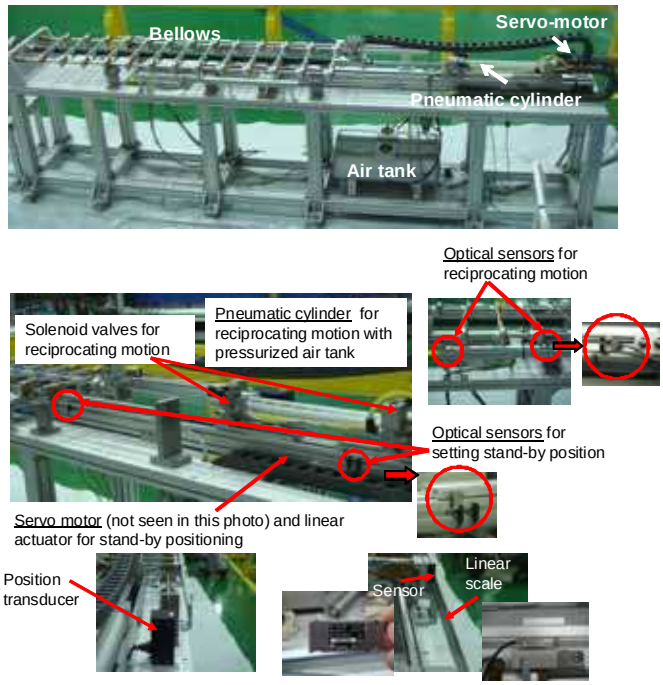

Figure 1. Assembled FRLPA before the installation, its drive components and position monitor systems in the FRLPA.

Figure 2 shows the experimental set-up for performance test of the drive system in the FRLPA. In the experiment, a PC remotely actuated the controller for the drive system by using an external pulse (5V, 5μs). Data of the elapsed distances measured by the PT and the LC during the FRLPA movement were transferred to the digitizer and the PC, respectively. Thus, data from the LC can be used to monitor the elapsed distance in the experiment. The number of the fast reciprocating motion during a given time interval can be easily varied by changing a set value of the cycle count in the monitor for distance and speed as shown in Fig. 2 before the FRLPA movement.

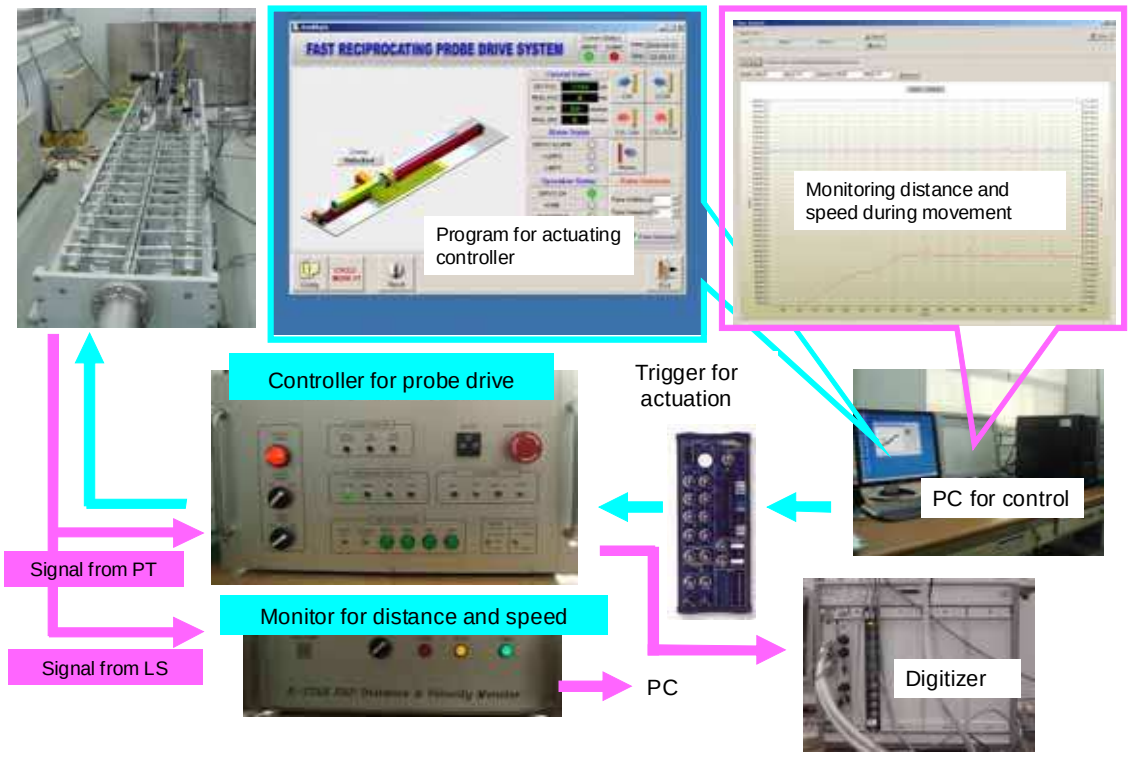

Figure 2. Experimental set-up for the performance test of the FRLPA movement.

From the experimental results of the performance test as shown in Fig. 3, it is found that the maximum speed in the fast reciprocating motion can be achieved up to 1.8 m/s during the elapsed distance of about 40 cm. The typical times passed during a forward and a backward movement in a reciprocating motion are about 300 and 410 ms, respectively. For the reciprocating motion of more than 2 times during a given time, the time interval between two reciprocating motions is about 2.7 s. The number of the reciprocating motion during a setting time can be increased up to 12 times. The measured distance from the LS agrees with the measured value from TS within a discrepancy of 1.5 %.

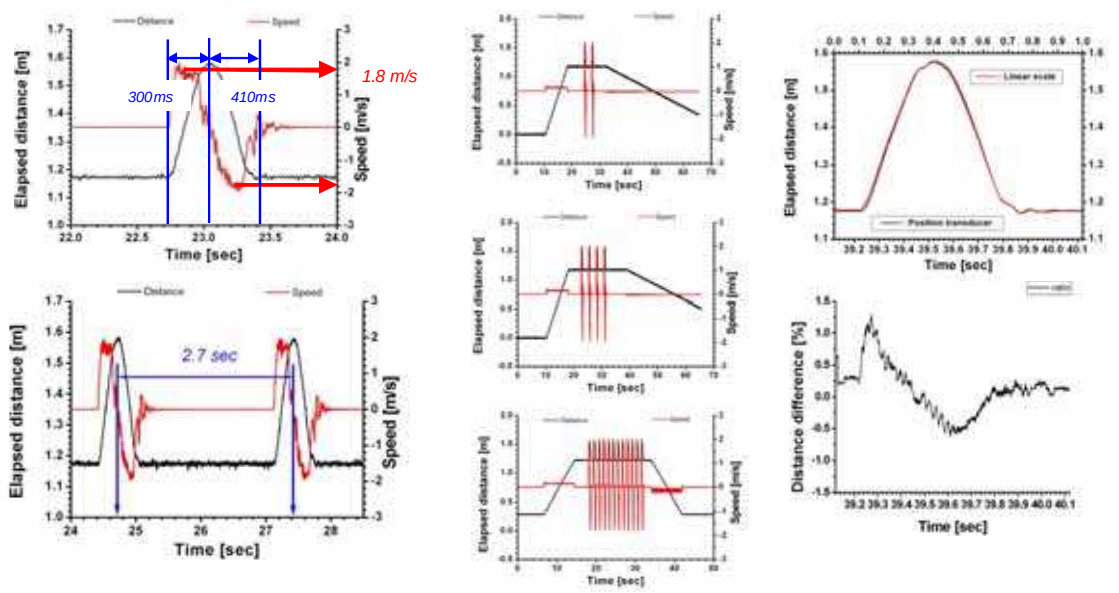

Figure 3. Typical measured elapsed distance and speed during the performance test of drive system in the FRLPA (left side) and comparison between two elapsed distances from PT and LS (right side).

The probe head is a modular type for easy replacement, and five probe tips in the head are used for the triple and Mach probe measurements as shown in Fig. 4. The tips in the probe head are fabricated with the carbon fiber composite (CX-31) and the electrical insulating components are fabricated with the boron nitride (Grade XP, 94 % purity). The tips are configured so that the magnetic field line is perpendicular to the tip's surface at the edge; the orientation-angle the probe tips is set as 11.8 degree by considering the pitch angle of the magnetic field line for the ultimate values of operational parameters in the KSTAR machine such as the toroidal field of 3 T and the total current of 2 MA.

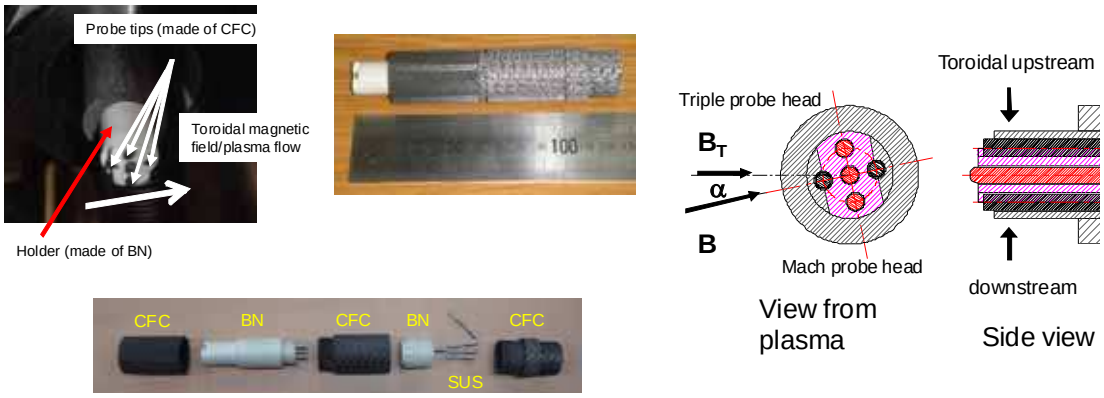

Figure 4. Probe head in the FRLPA (left side) and the orientation of the probe tips by considering the pitch angle of magnetic field line (right side). Here B_T and B are the toroidal and total magnetic fields, respectively, and α is the pitch angle of the magnetic field line.

The FRLPA with the total length of about 5.2 m is installed at a horizontal port of the KSTAR machine as shown in Fig.5. The FRLPA will be used for the initial spatial profile measurement of plasma parameters in the SOL region for circular-ohmic plasma during the next experimental campaign in the KSTAR machine where the first plasma operation was successfully achieved. The measured parameters are electron temperature, plasma density, ion saturation current, floating potential and plasma flow velocity.

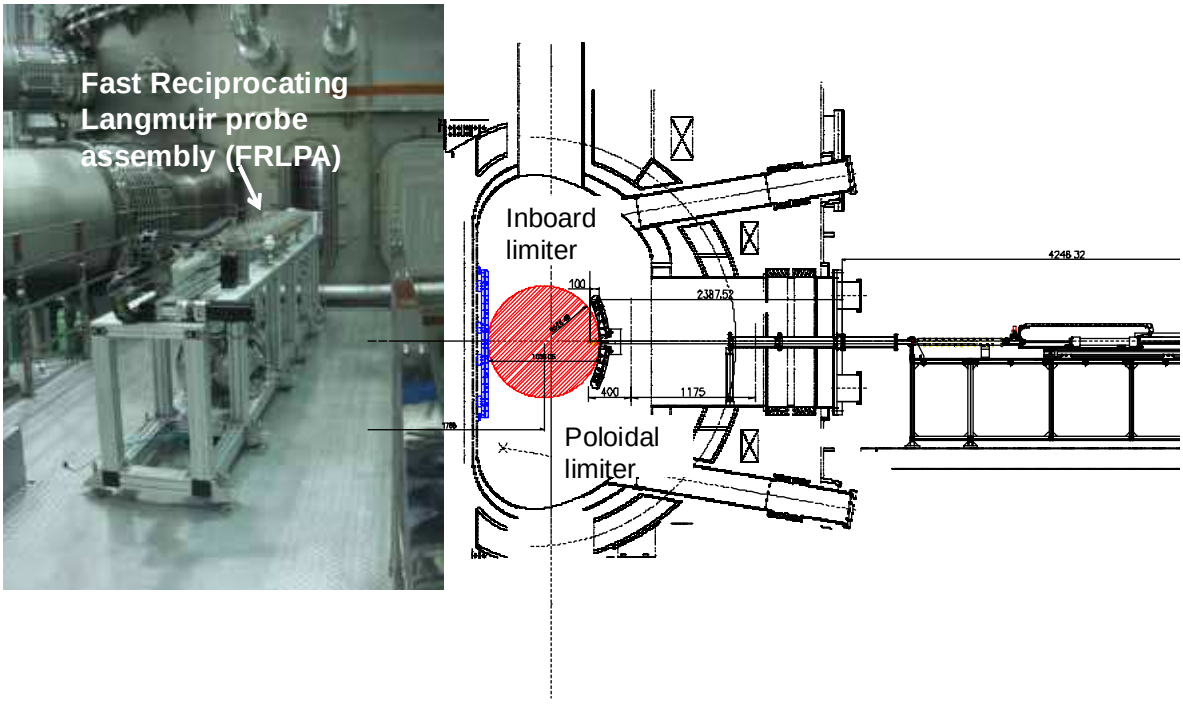

Figure 5. FRLPA for the spatial profile measurement of edge plasma parameters in the KSTAR machine.

Acknowledgement

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References

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