§84. Two-dimensional Edge Plasma Measurements in QUEST

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The main objective of the QUEST project is the establishment of the steady-state operation for the high performance tokamak plasma. In the long pulse discharge, one of the main issues to be solved is the matter of plasma-wall interactions (PWIs). The PWIs are so affected by the edge plasma behavior that it is quite important to establish the diagnostic method.

In this study, the helium beam probe (HeBP) has been developed based on the collaboration program with LHD. The HeBP can measure two-dimensional edge electron temperature and density profiles at the same time using three He I line spectra with the collisional-radiative (CR) model. The HeBP consists of beam source and optical detector. Up to now, the system for QUEST has almost been completed and is ready for the experiment. Figure 1 shows the experimental setup for HeBP in QUEST. The beam is injected from the low filed side of the torus radially. Emissions from the plasma can be detected almost perpendicular to the beam.

For the beam source, a supersonic molecular beam injector with the Laval nozzle is utilized, as shown in Fig. 2, which has been developed in LHD. With this injector, the collimated helium beam can be injected to enhance the spatial resolution of the diagnostics. Signals from the plasma are captured with a high-speed camera with the spectroscopic technique, as shown in Fig. 3. From the objective lens to the detector, signals are transmitted as a two-dimensional image with an image-guide fiber bundle. The image is first split in three images with two half-mirror for three He I lines, then each image goes through each interference filter. Before being captured with a high-speed camera with an image intensifier, those images are aligned on the same frame. The spatial resolution of this diagnostics strongly depends on the beam width, however it can be improved by assuming the toroidal symmetry. Concerning the time resolution, it is affected by the signal to noise ratio, although the frame rate of the high-speed camera itself is up to 100 kHz. Continuous (time evolving) measurement is essentially available, if plasma density does not increase so much during the observation. However continuous gas feed can actually increase the density of the QUEST plasma with small volume. Practically, repetitive short pulse injection of the beam is a solution for this problem.

From two-dimensional information of emission intensities for three He I line spectra, two-dimensional electron temperature and density profiles can be obtained by comparing line intensity ratios between two for each pixel with the CR model.

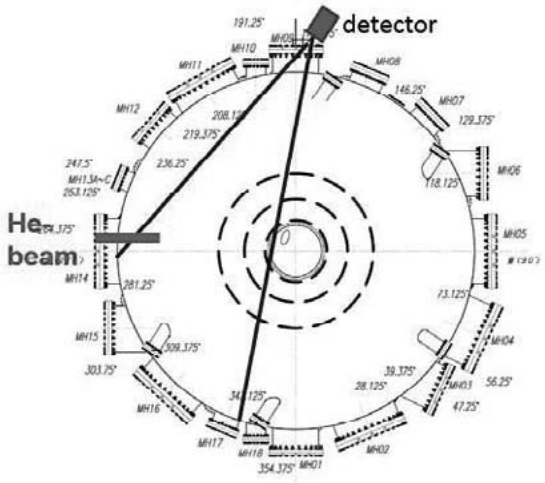

Fig. 1. Experimental setup for HeBP in QUEST.

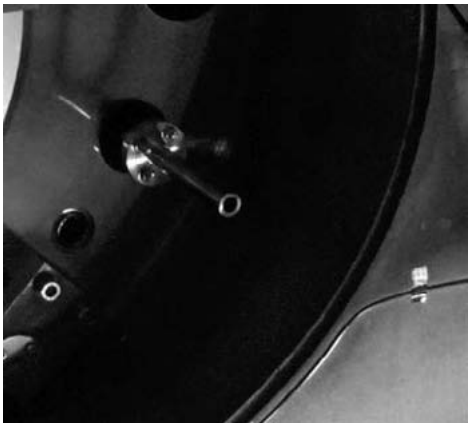

Fig. 2. Laval nozzle installed in QUEST vacuum vessel.

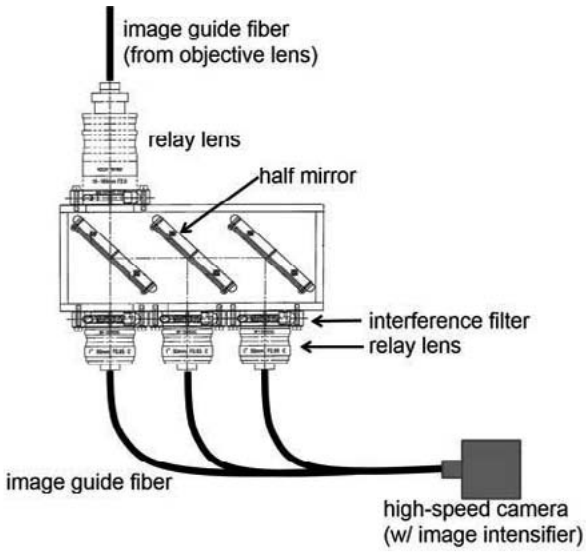

Fig. 3. Optical detection system.