# §52. Construction of a Thomson Scattering System for the QUEST Spherical Tokamak Device

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A Thomson scattering is a standard technique for electron temperature and density measurements. Since the scattering cross-section is very small, an efficient system is necessary to measure low density plasmas. Non-inductive start-up spherical tokamak (ST) plasma generated in the QUEST device is one such case, where the plasma is generated by RF waves, and the densities are less than $10^{18}$ [$m^{-3}$] in recent experiments.

In the fiscal year 2010, a YAG laser system, a stage for laser injection and light collection optics, laser injection and exit ports and a light collecting window were installed on the QEUST device (Fig. 1). On the MH14 port, both a laser injection port and a light collection window are attached. The scattering angle for the center of the plasma ($R$=0.68 m) is about 166°. The injection and the exit windows are made of fused quartz and placed at the Brewster's angle.

Figure 2 shows the vacuum side photograph of the port. A large quartz window (with an effective diameter of 318 mm and a thickness of 30 mm) and a paired folding panel shutter, a movable target can be seen. The solid angle of the window is about 0.067 str. for the scattering volume located at the center of the plasma. We are preparing for a spherical mirror (with a diameter of 500 mm and a focal length of 500 mm) and a fiber optics (with a diameter of 2 mm and an N.A. of 0.37). With a numerical ray trace calculation, we confirmed that the present light collection optics has the effective $L\Omega$ as large as 1 mm-str. Here, $L$ is the scattering length and $\Omega$ is the solid angle of observation. A movable target composed of a magneto-coupling transfer rod (with a stroke of 1.4 m) and a stainless steel plate was installed above the laser injection port. This target is used for the optics alignment for the entire measurement region (0.34 m < R < 1.08 m). A paired folding panel shutter made of stainless steel was installed, which can be opened or closed by rotating each piece. The shape and position of the shutter were optimized numerically so that it is compact enough to fit in the port; does not touch the plasma; and does not partially block off the viewing scope.

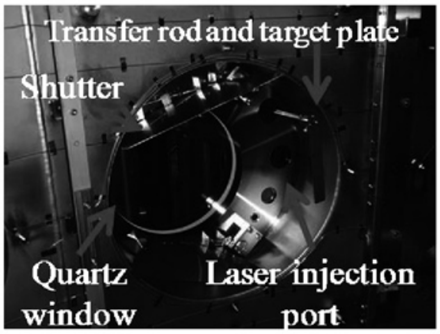


Fig. 2 Vacuum side photograph of the laser injection and correcting window port (MH14).

The large scattering angle (e.g. 166°) gives larger scattering length and hence the larger signal, which is favorable for measuring low density plasma. In addition, we are preparing for a multiple-pass Thomson scattering configuration to increase the SN ratio for the low density plasmas. As a test of the configuration, we have modified the Thomson scattering system in the TST-2 spherical tokamak device, and made a double-pass Thomson scattering configuration. Figure 3 shows a typical scattered light waveform in the double-pass system, where the first peak, the back-scattering signal, and the second, the forward-scattering signal, are well separated.

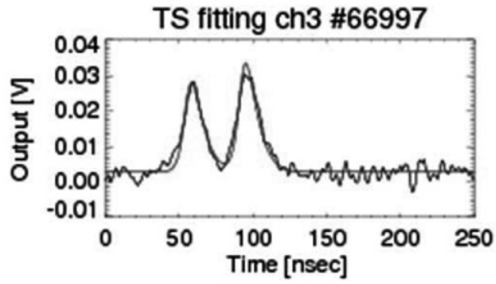


Fig.3 Waveform of a Thomson scattering signal (black) measured by the polychromator developed in the fiscal year 2009 and fitting to the template double pulse shape (red).

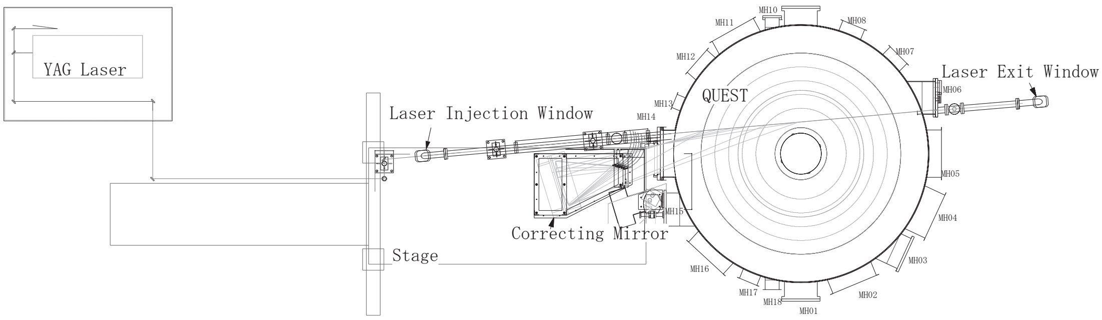


Fig.1. Plane view of the Thomson scattering system on the QUEST device.