§47. Electron Temperature Measurement on the QUEST Spherical Tokamak Device

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An efficient and compact Thomson scattering system has been developed for the QUEST device. In the fiscal year 2011, the construction of the system was completed, and we have started temperature measurements.

The system consists of a laser, a spherical mirror, and a polychromator. The laser has a wavelength of 1064 nm, an energy of 1.65 J, a repetition rate of 10 Hz. The output beam is focused near the center of the plasma by a lens which has a focal length of 4 m. For collection of the scattering light, we use a spherical mirror, which has a radius of 0.5 m, a curvature radius of 1 m. The system was designed to measure six spatial points in the plasma (major radius: 340 - 1080 mm). The scattering angle is 162 - 171 degrees. The scattering length is 17 - 51 mm, and the solid angle is 0.03 - 0.05 sr. We used a large N.A. (= 0.37) optical fiber (ϕ:2 mm) to collect the reflected light from the spherical mirror. A fast response polychromator unit, which has six avalanche photodiodes (APDs) and interference filters, was developed.

We measured the plasma of the mixture of hydrogen and helium. The plasma current was 15 kA, which was sustained by an RF (8.2 GHz) power of 110 kW, and the discharge duration is about 4 s. The plasma had inboard null configuration. Since the signal to noise (S/N) ratio of one pulse signal is low, the scattering signals were accumulated. Figure 1 shows the averaged signals for each wavelength channel and the signal of a laser monitor PIN diode. In this case, the scattering point was located at the major radius of 784 mm and signals from 81 laser injections were accumulated. The averaged signals were integrated from 0 ns to 80 ns to extract the scattering component. The noise was estimated from the scatter of time integrated signals at the periods before and after the scattering light.

A Maxwell distribution function, which has two free parameters: temperature and intensity, was integrated with the wavelength sensitivity for each channel and compared with the corresponding wavelength channel signal. These integrated values are compared in Fig. 2. Note that vertical values are divided by the wavelength width for each interference filter to show the shape of spectrum. Parameters to yield the best fit were searched. The electron temperature was 41 ± 5 eV for this case.

By moving the fiber position, we obtained the electron temperature profile (Fig. 3). At each spatial point, scattering signals were accumulated for 3 - 6 discharges. The closed flux region was R = 480 - 980 mm, which is calculated by RTfit.

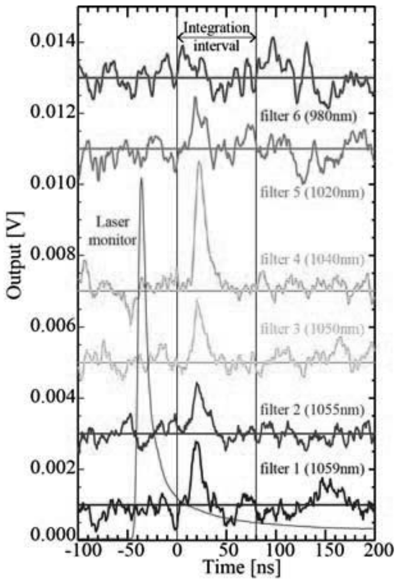

Fig.1 Averaged scattering signals from 81 laser injections. Three similar discharges were used.

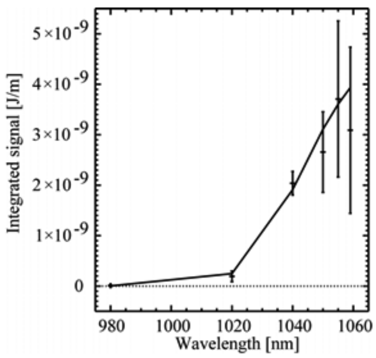

Fig. 2 Fitting to a Maxwell distribution. The cross points with error bar show the integrated scattering signal. The polygonal curve shows fitted values.

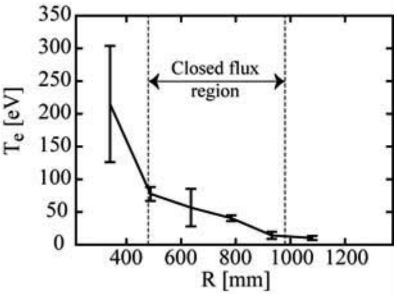

Fig. 3 The electron temperature profile of the inboard null configuration plasma. The dashed lines show the last closed flux surface calculated by RTfit.

In summary, we built a Thomson scattering system for QUEST, and Thomson scattering signals with the maximum S/N ratio of about 10 were obtained. The electron temperature was about 10 - 80 eV for the core plasma in a QUEST steady state operation with the inboard null configuration.