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Development of Thomson scattering diagnostics in the QUEST spherical tokamak device

QUEST球状トカマクにおけるトムソン散乱計測の開発

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The goal of QUEST spherical tokmak research is steady state operation by RF current drive and controlled PWI. Thomson scattering diagnostics is important to analysis the RF current driven plasma. We used a Nd:YAG laser with an energy of 1.65 J , a repetition rate of 10 Hz, a spherical mirror for collection of the scattering light, and polychromators for spectroscope. Since the Thomson scattering signal is weak at low density, many pulse signals from steady state plasmas are accumulated. We obtained preliminary result and the electron temperature is about 90 eV for the plasma with a plasma current of 10 kA.

1. Introduction

A steady state operation by RF current drive and controlled PWI is goal in QUEST spherical tokmak (ST) research. The QUEST is an ST with a major radius R = 0.68 m and a minor radius a = 0.4 m [1]. RF system with a frequency of 8.2GHz is used for the current drive, and excitation of electron Berstein wave is expected. The typical electron density is 2×10^{17} m^{-3} by interferometer.

Thomson scattering (TS) measurement is a highly reliable measurement of electron temperature, and many devices are equipped with a TS system. The temperature and density is useful for equilibrium analysis and also useful for understanding the RF current driven plasmas.

The scattering signal is weak and diagnostic is expected to be difficult for the low density current driven plasma. However, the period of steady state is over a second and laser of repetition rate is 10Hz. Therefore, accumulation of many pulse signals is possible.

2. Diagnostic system

The TS system is similar to TST-2 [2] using the same power of Q-switch Nd:YAG laser, the same polychromator and the same optical fiber. The system consists of the incident optics, light collection optics, and spectroscopic system. The Nd:YAG laser have a wavelength of 1064 nm, a pulse width of about 7 ns, a repetition rate of 10 Hz, and an output beam diameter of less than 9 mm.

For collection of scattering light, we use a spherical mirror. The spherical mirror has a radius of 0.5 m, a curvature radius of 1 m and a coating of gold. The measurement is backward scattering of 165 - 171 degree. A diagram of laser injection, light scattering and light focusing is shown in Fig.1. There are six measurement points in the system. Table I shows the scattering angle, the scattering length and the solid angle at each measurement point. We used a large-N.A. (= 0.37) optical fiber [2] to collect the reflected light from the spherical mirror.

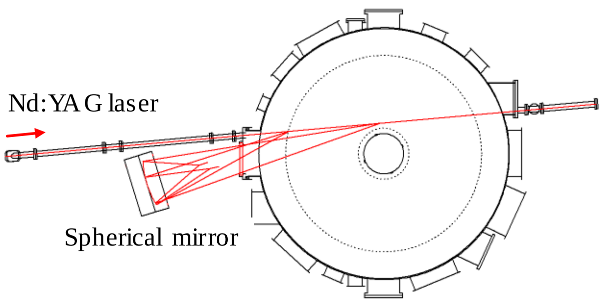

Fig.1. A diagram of QUEST device and collection optics.

A fast response polychromator unit was developed for QUEST and TST-2 [4]. We are planning to install a multiple path configuration, which is very attractive because of the simultaneous measurement of the forward and the backward scattering. The polychromator has avalanche photodiodes and interference filters.

Table I. scattering angle, length and solid angle at each measurement points

Radius [mm]	Scattering angle [degree]	Scattering length [mm]	Solid angle [sr]
340	171	52.9	0.0282
488	169	39.2	0.0365
636	168	32.4	0.0430
784	167	26.7	0.0506
932	166	21.9	0.0597
1080	165	17.7	0.0711

3. Measuring result

We measured the plasmas with gas puff during discharge. The plasma current is 10 kA and duration time is 2s (Fig.2.). We measured at point of major radius = 784.

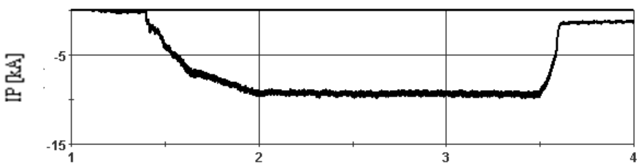

Fig.2. The plasma current evolution of Shot No.15069.

The signal to noise (S/N) ratio of one pulse signal is low. We integrate a pulse signal and plot in Fig.3. The recording system is not synchronized to the QUEST operation at present. 21-40th pulses seems to be the scattering signals from and the plasma, because the period of large (integrated) signal is similar to the plasma current duration. These signals were accumulated and shown in Fig.4, and subtitle shows central wavelength and FWHM of each filter in the polychromator. We integrate accumulated signals and fit to a Maxwell distribution (Fig.5). The calculated electron temperature is 93±9 eV.

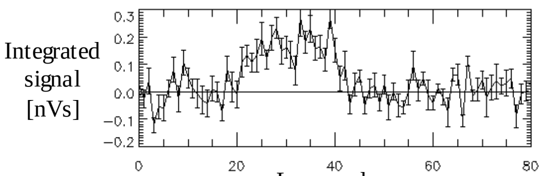

Fig.3. A Integrated signal of a detected signal.

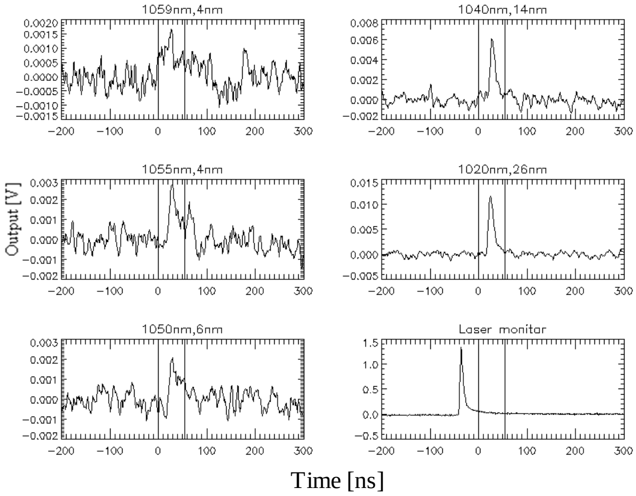

Fig.4. Accumulated signals from 21-40th laser injections.

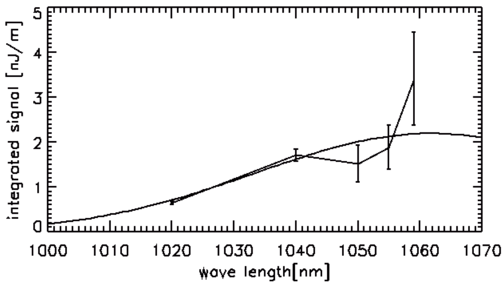

Fig.5. Fitting to a Maxwell distribution.

4. Summery and future works

We built a Thomson scattering system for QUEST, and then Thomson scattering signals were obtained for the first time. The preliminary electron temperature was about 90 eV for a QUEST steady state plasma with a plasma current of 10 kA. We are planning the following works. A trigger system synchronized to the QUEST device operation is needed. For absolute calibration of the density, Ramman scattering calibration is in progress. Recording system for simultaneous multi-channnel measuring is also needed.

Acknowledgments

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