100-HZ THOMSON SCATTERING DIAGNOSTICS ON T-10 TOKAMAK

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At the T-10 tokamak was upgraded Thomson scattering diagnostics that used a Nd:Glass laser and CCD camera as the detector [1]. The main features of the upgraded diagnostics is high-frequency Nd: YAG laser (100 Hz) operating on the second harmonic (532 nm) and a television registration system. New laser can continuously operate for several seconds allowing one to have a temporal picture of the entire plasma discharge, compared to 8 measurements in the previous system configuration.

The laser operates with a pulse energy up to 2,5 J at a duration of 10 ns. Beam diameter is 15 mm. The laser is injected into the tokamak vertically by a multi-pass system with 10 passes of the beam through the plasma volume to increase the total energy. The multi-pass system consists of two spherical mirrors with a double focus in the center of the vacuum chamber. The laser beam enters the chamber through a small hole in the reflecting coating of the lower mirror. After all passes the laser beam escapes the chamber through the inlet. A lens mounted near the entrance of vacuum chamber is used for focusing the input beam in the center of the chamber.

The scattered light from the whole viewing chord of 600 mm length goes through the equatorial window and projected by means of a collection lens onto the fiber optic bundle of 110 mm height. The fiber optic bundle consists of three columns of 250 fibers each. Further the light is transported into the spectrometer by fiber cable of 8 meters long. The spectrometer is similar to RTP Littrow type spectrometer [2] with 100x100 mm grating of 600 lines per mm. At the entrance of spectrometer the fiber bundle transforms by 2 times of a height (decreases), that gives us the corresponding gain in the amount of light, but also a loss in spatial resolution which is ~ 6 mm as a result.

To register collected light the 14 bit CMOS Camera Vision Research Phantom V7.3 with a resolution of 800x600, 22 microns pixel size, and frame rate of more than 6 kHz is used. The camera incorporates an image intensifier with GaAs photocathode and a P43 phosphor, with decay time about 1 millisecond. To avoid loss of light and crosstalk to the next image camera exposure and the minimum interval between the frames were set to 1.5 ms.

Initial spatial calibration and geometric adjustment of acquisition system is performed by injecting a special bar with attached LEDs into the tokamak chamber along a line of laser beam. More precise geometric adjustment transversely to the laser beam is carried out by means of motorized unit, which is connected to the front end of the fiber bundle. The motorized unit allows one to adjust the inclination angle and to carry out the linear movement of the fiber bundle with respect to the collecting lens.

Wavelength calibration was performed according to known line spectrum of the helium lamp and a pronounced known plasma lines (H_α, H_β, Li II, C II, C III). Relative calibration of the system's spectral sensitivity was carried out using a tungsten lamp with a known color temperature. Calibration frames are shown in Figure 1.

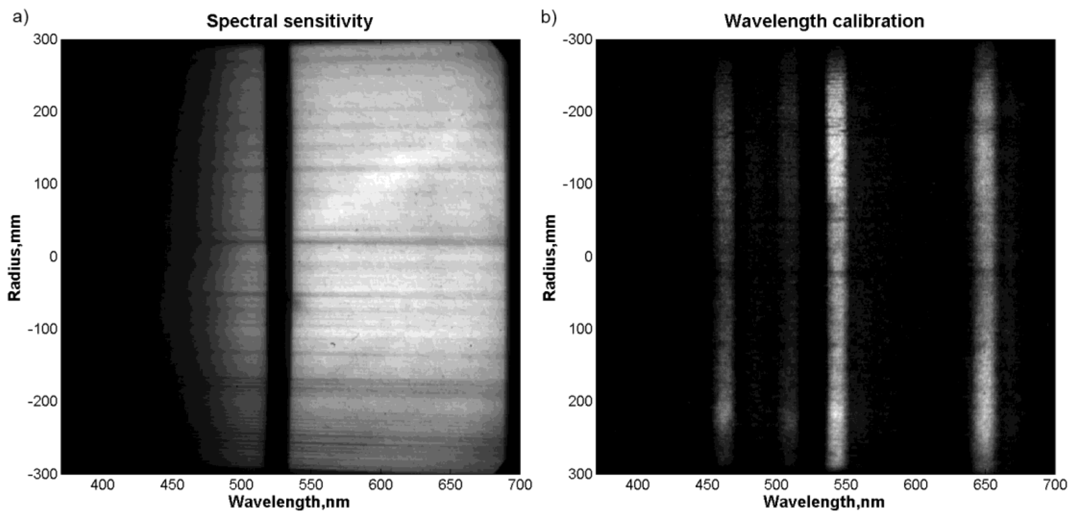

Fig. 1. Calibration frames: a) tungsten lamp for spectral sensitivity, b) plasma background for wavelength calibration.

Figure 2 shows the frames with scattering signal, plasma background and with a result of subtracting one from another. Background subtraction allows us to keep spectral bands of the plasma lines for scattered light measurement.

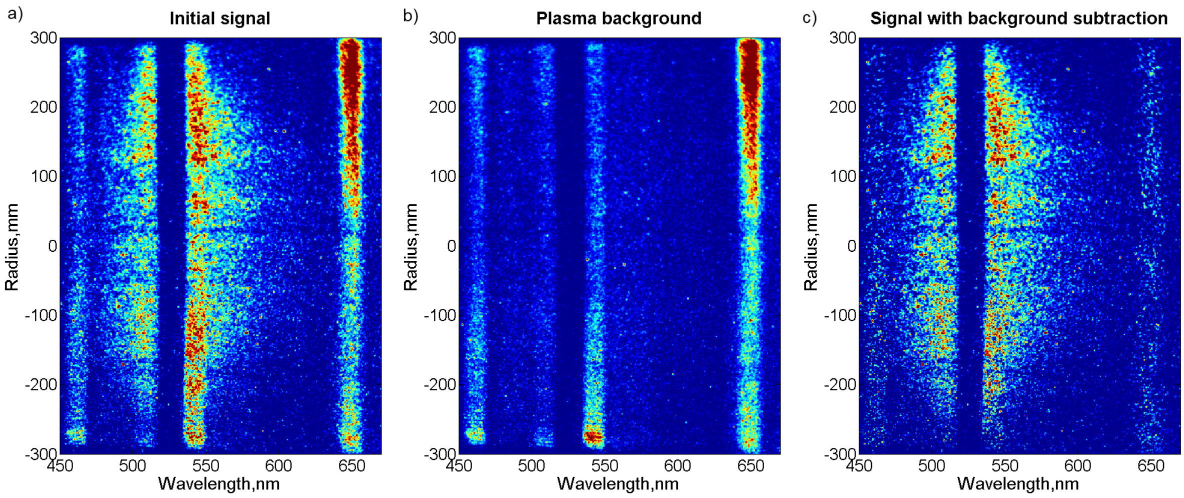

Fig. 2. Background subtraction: a) initial frame b) plasma background c) resulting frame.

Figure 3 shows the first processed results: temporal evolution of the temperature and density profiles in the discharge with an additional ECR heating and electron temperature profile with errors at 520 ms. In this discharge plasma density reaches $n_e = 2{,}0{\cdot}10^{19}m^{-3}$, plasma current I_{pl}= 220 kA, Bφ= 2,42 T, gyrotrons worked from 600 to 790 ms. The electron density profile was normalized on interferometry measurements.

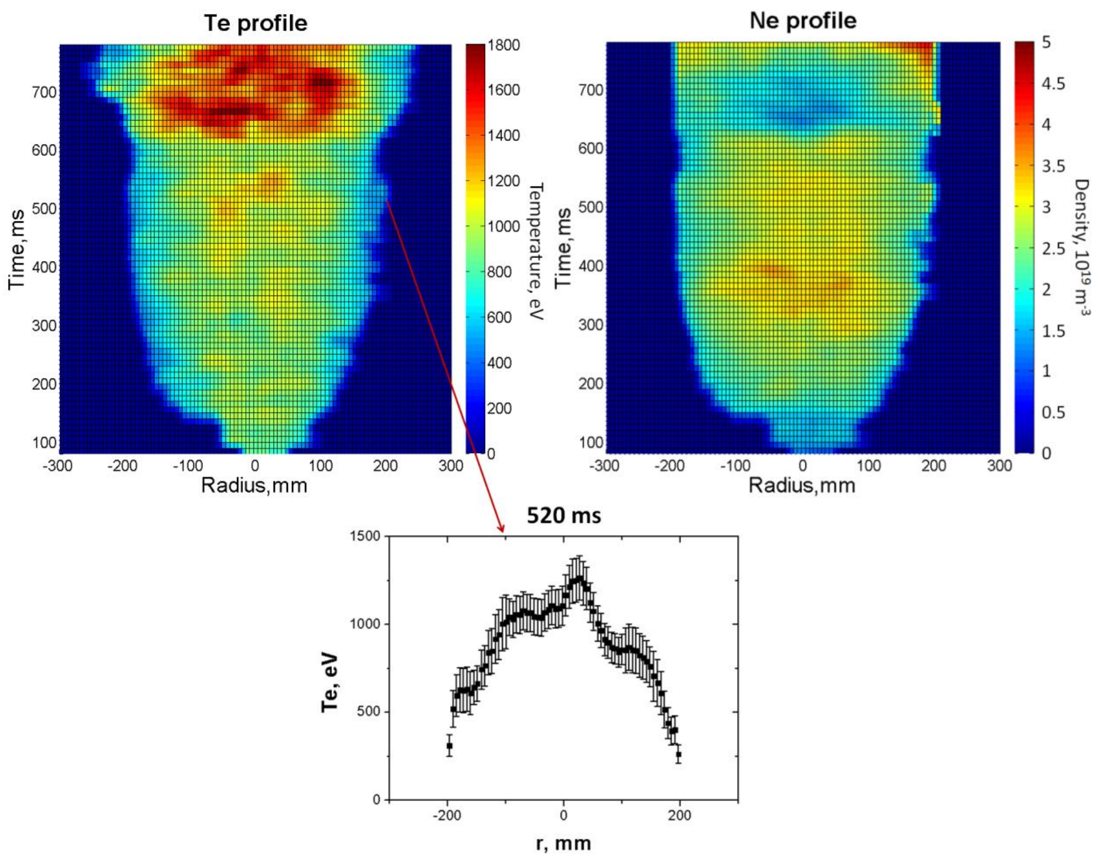

Fig. 3. Temporal evolution of the temperature profile in the T-10 tokamak discharge with an additional ECR heating and electron temperature profile with errors at 520 ms.

Conclusion.

At the T-10 tokamak was implemented Thomson scattering diagnostics working on the second harmonic of the 100 Hz Nd:YAG laser with television registration system. The diagnostics allows to provide measurement of electron temperature and density profiles with high spatial resolution and to obtain their temporal evolution during the tokamak discharge with 10 ms temporal resolution.

References:

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