The fast Thomson scattering system for a transient electron temperature and density measurement in LHD

Ryo Yasuhara [1], Hisamichi Funaba[1], Hiyori Uehara[1], Daniel den Hartog[2]
[1] National Institute for Fusion Science
[2] Wisconsin Plasma Physics Laboratory, University of Wisconsin-Madison
e-mail(speaker) yasuhara@nifs.ac.jp

Laser Thomson scattering systems are one of the most reliable diagnostic tools for evaluating electron temperature and density distribution in fusion plasmas. However, the high pulse energy laser systems required as probe beams for Thomson scattering systems have repetition rates of only a few 10 Hz to 100 Hz due to the heat generation limitation of the laser medium. Therefore, it was impossible to measure spatial changes in electron temperature and electron density profiles in transient plasmas on the order of milliseconds, such as the abration of hydrogen pellets, plasma collapse, and rapid heating of plasmas by heating devices.

In this work, we have achieved the high-time resolution Thomson scattering system for measuring plasma electron temperature and density up to 20 kHz. This system consists of an ultra-high repetition rate laser operation in a time shorter than the thermal diffusion time of the laser medium by using 1) an originally designed Q-switched Nd: YAG laser oscillator with a full width at half maximum of 20 ns and 2) a flash lamp power supply using IGBTs. By using this laser system and a proprietary analog-to-digital converter, the electron temperature and density distribution of the LHD plasma was measured at 70 spatial points, with a repetition rate of 20 kHz (50 μs intervals), 100-time frames, and a temporal resolution of 20 ns per time. [1] This result is far superior to the repetition rate and the number of events obtained with conventional Thomson scattering measurements, multi-pass methods, and intracavity. Measuring transient and sudden events that could not be observed directly before is now possible, such as hydrogen pellet dissolution [1], plasma collapse [2], ECH rise as shown in Fig.1, and transient MHD phenomena.

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References

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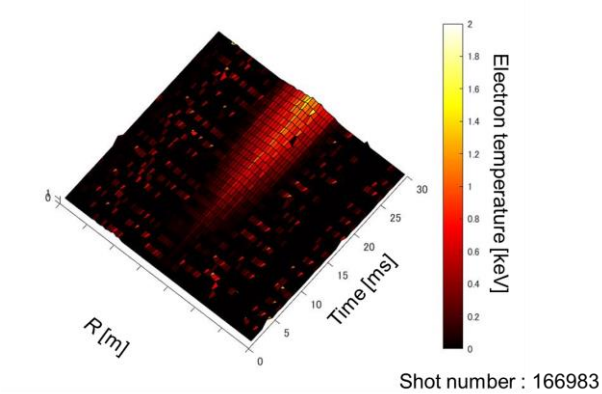

Fig. 1 Highly time-resolved measurement of plasma start-up by ECH heating by the fast Thomson scattering measurement.