§20. Development of 3-dimensional Electron Temperature Measurement System with High Time Resolution Using Soft X-ray Spectroscopy with Multi-layer X-ray Mirror

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It is necessary to measure basic plasma parameters with high time resolution in order to understand plasma physics. We have developed an electron temperature measurement system using soft X-ray spectroscopy. For spectroscopy we use a multi-layer X-ray mirror. The electron temperature is measured from soft X-ray energy spectrum. It is straightforward to measure the 3-dimensional electron temperature profile by tomography. The time resolution of this measurement system is determined by the band width of the detector and preamplifier circuit, which can be up to approximately 1MHz. So we can measure the electron temperature fluctuation.

Figure 1 shows a schematic view of the soft X-ray spectrometer with multi-layer X-ray mirror. The pin hole determines the sight line of each detector. The Be filter removes low energy emission and suppresses total reflection. Soft X-ray emission from the plasma is spectrally resolved by Bragg reflection ($2d\sin\theta = n\lambda$) at the surface of multi-layer X-ray mirror, and detected by the PIN diode array.

We use 924 eV ~ 1214 eV in this system as the energy range for spectroscopy based on reflectivity calibration of the multi-layer X-ray mirror (3% ~ 25% at 330 eV ~ 1250 eV, $2d = 66.7$ Å) and the sensitivity of the PIN diode (approximately 100% at 350 eV ~ 1250 eV), plasma parameters, and the structures around the port in CHS. Band width of the detectors and preamplifier circuit is 200 kHz. This system is installed the on equatorial plain in CHS. We measure the electron temperature with a space resolution of approximately 30 mm. After the measured soft X-ray intensity is corrected for reflectivity of the multi-layer X-ray mirror, sensitivity of the PIN diodes, and transparency of the Be filter, we obtain the electron temperature by spectrum fitting.

The result is compared with the electron temperature measured by Thomson scattering as shown in Figure 2. The electron temperature measured by soft X-ray spectroscopy with the multi-layer X-ray mirror system and the Thomson scattering system coincides within error bars.

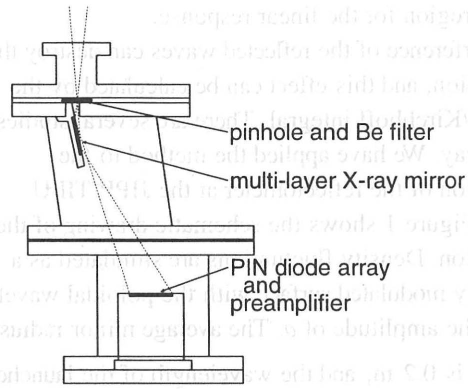

Fig. 1: Schematic view of the soft X-ray spectrometer with multi-layer X-ray mirror

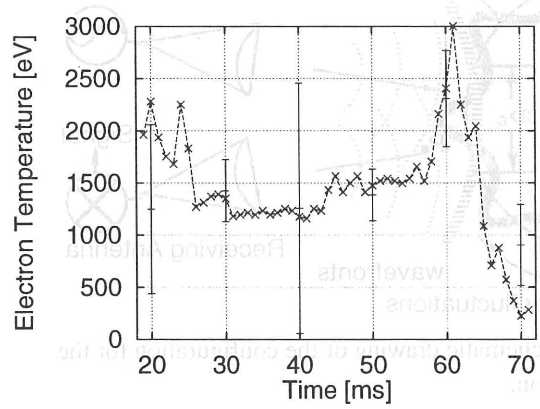

Fig. 2: Electron temperature measured by soft X-ray spectroscopy using the multi-layer X-ray mirror (dashed line) and by Thomson scattering (solid line with error bars)