§2. Measurement of Electron Temperature of Up to 20 keV

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One of the main goals in the 5-th Experimental Run was to realize plasmas with electron temperatures exceeding 100 million centigrade. In order to achieve this goal, not only a high power ECH system but also reliable diagnostic tools to measure very high electron temperatures were required. To meet the latter requirement we paid much effort for improving the reliability and accuracy of the Thomson scattering system. As the electron temperature to be measured goes up and consequently the Thomson scattering spectrum becomes wider, an error in the spectral responsivities of a polychromator $\{F_j(\lambda); j=1,5\}$, with which the Thomson scattered spectrum is analyzed, introduces a larger error in the deduced electron temperature. The dominant causes of errors in $\{F_j(\lambda); j=1,5\}$ are: (1) the gradual change of the detector's ambient temperature and (2) the inaccuracy of spectrum calibration. As a countermeasure for (1), we regulate the temperature of the panel that is contacted to the detector housing by flowing temperature-regulated water from the start of the LHD experiment (1998). This countermeasure seemed at first to be effective, but its ability gradually dropped as water-mold living in the pipe increased and finally choked the pipe. This year we replaced all temperature-regulating system with newly designed one. To prevent the water-mold from increasing, we dissolved small amount of chlorine into the circulating water. Up to now, we have observed no evidence of the water-mold increasing in the water.

$\{F_j(\lambda); j=1,5\}$ are obtained by reading the electric output of each color channel while illuminating the entrance of the polychromators with the wavelength-resolved light source whose spectrum is known. The problem is that there is no wavelength-resolved light source whose spectrum is accurately known. As a light source we used a monochromator-tungsten-lamp combination whose output was calibrated by use of light detectors fabricated and calibrated at two different manufactures: Yokogawa and MeresGrio. For a wide range of wavelength the discrepancy between the output spectra measured by the two different detectors is within 5%, but at the longer wavelengths (λ >1000nm) and at the shorter wavelengths ((λ <800nm) the discrepancy become much larger. For a temperature less than 4 keV, which is the case for almost all the hitherto LHD discharges, the uncertainty of this level in $\{F_j(\lambda); j=1,5\}$ in the shorter wavelength does not cause a serious problem, but for electron temperature larger than 10 keV, this will cause a large error. Then other method is needed to further refine the accuracy of $\{F_j(\lambda); j=1,5\}$. As the second best method, we illuminated the entrance of the polychromator with a standard lamp light whose spectrum $B(\lambda)$ was calibrated at NIST and compared the outputs with the integration $\int d\lambda F_i(\lambda)B(\lambda)$. An example of the result is shown in Fig.1. For the most polychromators, the discrepancy between the measured value and the calculation are within 7%. The corresponding error in the deduced electron temperature is estimated less than ~ 7 % for Te< 20keV. An example of the high temperature profile thus obtained is shown in Fig.2.

As a reward for the effort to improve the temperature-regulation of APDs, the electron density profiles with the much improved data quality were obtained.

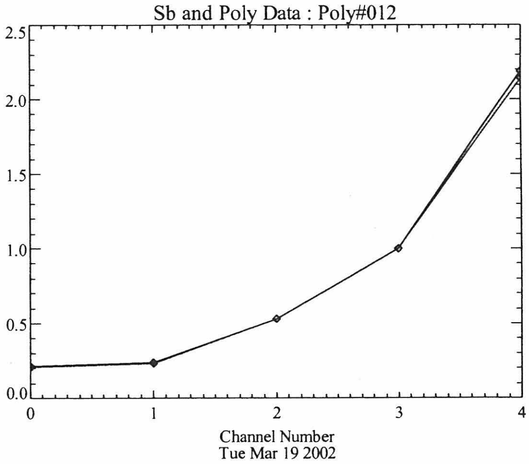

Fig.1. Comparison between the calculated and the measured signals from a polychromator illuminated by a black body radiation.

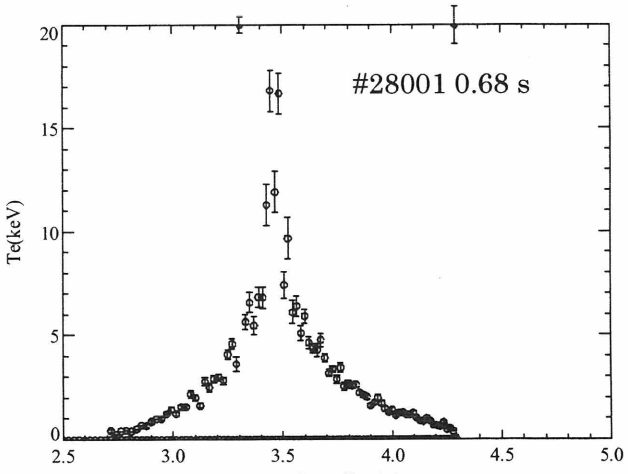

Fig.2. An example of a high electron temperature profile.