§6. Development of an Apparatus for Hard X-Ray Measurement in LHD

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In order to measure hard x-ray, an apparatus has been developed and installed on a horizontal port of Large Helical Device. The apparatus consists of a germanium detector, a collimator, a data acquisition system, filter-exchanging system controlled by a computer. The detector is calibrated by measuring Kα lines of metallic impurities. The energy resolution is approximately 400 eV at 5.6 keV. The divergence of the collimator is 8.9 mrad, and the diameter is 5 mm. The apparatus has been successfully operated, since copper shields and vibration dampers prevent the detector from giving rise to systematic error in signals as is shown in Fig.1.

The apparatus is equipped with two filters. The first filter is a 1-mm-thick aluminum plate and the second one is a 1-mm-thick SUS304 plate with a 0.5-mm-diameter hole. Figure 2 shows a total transmission rate of the filters. As is shown in the figure the transmission is modulated in the soft x-ray region due to the hole to measure soft x-ray.

With the apparatus has been obtained hard x-ray emitted from plasma heated by Electron Cyclotron Heating. Figure 3 shows a typical spectrum observed with the apparatus. A calculated spectrum is also indicated. The first peak in the lower energy region is the soft x-ray emitted from the bulk plasma. The higher energy part of the spectrum is supposed to be high-energy tail emitted from high-energy electrons. The density of high-energy electron can be estimated, since ion density and $Z_{\text{eff}}$ are eliminated from fitting between the experimental result and the calculation in the both energy region soft x-ray and hard x-ray.

Fig.1. The illustration of the apparatus for hard x-ray measurement.

Fig.2. Transmission rate of x-ray

Fig.3. The typical spectrum obtained by the apparatus. The spectrum is summed over 4 fixed shots. The solid squares represent observed results and the solid circle calculated results for fitting.