§17. Hard X-ray PHA System for Study on Energetic Electron Tail Formation in ECRH Plasma of Heliotron J

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1. Introduction

The Heliotron J is one of advanced helical devices, realizing quasi-ominigeneous (QO) property in the magnetic field configuration on the Boozer coordinates. In a Heliotron J type configuration, the non-axisymmetric bumpy ripples play an important role in the viewpoint of neoclassical confinement [1,2]. Because of this reason, the Heliotron J was designed to be flexible in changing the magnetic field configuration to explore an optimized configuration experimentally. The primary motive of this work is to reveal confinement property of energetic electrons in various magnetic field configurations through measurement of pulse height spectra of X-rays in low-density ECRH plasmas. Another physics target is as follows. After the electron fishbone instability during ECRH phase was observed in DIII-D[3], experimental and theoretical efforts are being made intensively to understand fast-electron-driven MHD instabilities such as electron fishbone and/or Alfvén eigenmodes in tokamak and stellarator [4-7]. The excitation of MHD instabilities is believed to be due to the precessional drift motion of energetic banana electrons produced by ECRH. Our X-ray PHA system is also thought to be valuable to study this kind of physics because it can provide the possibility to discuss the causality between energetic electron tail and excitation of those MHD modes.

2. Hardware description

A silicon (Si) semiconductor detector suitable for evaluating electron temperature through measurement of relatively low energy X-rays spectrum is being employed in the Heliotron J. A hard X-ray detector based on a cadmium telluride (CdTe) diode (Amptek inc. /XR-100T-CdTe) is employed for our purpose to detect X-rays originating from energetic electrons generated by ECRH. Because the atomic number of the CdTe detector is much higher than that of the Si detector, the CdTe detector is suitable for high energy X-ray measurement. The detection volume of CdTe is 3x3x1 m^3. The thickness of Be window installed in front is 4 mil. This detector has a flat sensitivity in photon energy up to 60 keV. In addition to the Be filter, we install a tungsten aperture system variable in its size (50 μm ~ 200 μm) in the outside of vacuum to operate the system under appropriate counting rate. The electronic circuit used here and a typical output pulse from a spectroscopic amplifier due to X-ray irradiation are shown in Ref. 8. The energy calibration of the system was already performed by use of two different γ-ray sources (^{133}Ba and ^{241}Am).

3. Current status

Installation of the CdTe X-ray detector and PHA data acquisition modules on Heliotron J was completed in FY2006. Figure 1 shows the detector installed on the Heliotron J device. The detector is placed near the corner part (in other words, the straight end) and views the plasma perpendicularly. This condition is good for our purpose because we are aiming at measuring distribution function of energetic trapped electrons. Also, effect of bumpy ripples on confinement of trapped electrons in the low collisionality regime is expected to be seen in the straight part of the Heliotron J plasma. We have confirmed true event pulses coming from the detector during discharges. However, we suffer from a noise issue during discharge at this moment and this has not been fixed yet. In FY2007, first, we are going to make an effort to suppress the noise level and then move to the experiment mentioned in Sec.1.

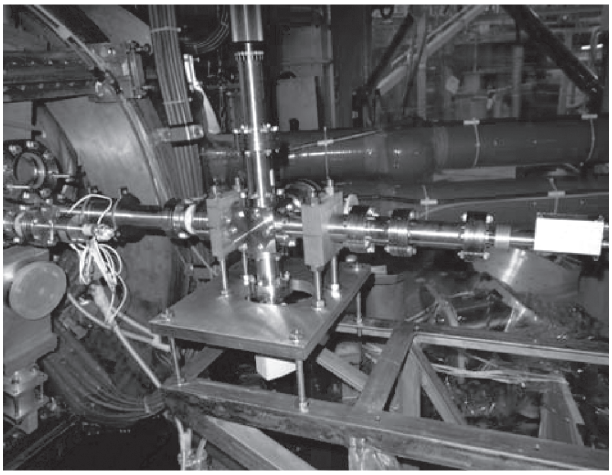

Figure 1 CdTe X-ray detector installed on Heliotron J.

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