§51. Study of Suprathermal Electron Behavior in Non-inductive Current Ramp Up Phase of QUEST Plasmas

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One of key subjects toward steady state operation in a tokamak is to establish a method of non-inductive current ramp up and sustainment. In particular, in a spherical tokamak (ST) such as QUEST, a space at the center column of the machine is fairly limited. For this reason, numerous efforts to develop non-inductive start up scenario by means of radiofrequency (RF) technology are being made intensively in STs [1-3]. This collaborative work was initiated in 2009 to reveal the role of suprathermal electrons (SEs) on the non-inductive current ramp-up by means of two RF waves at f_{RF} of 2.45 GHz and 8.2 GHz in QUEST [4,5]. To advance this study, the development of hard X-ray (HXR) diagnostics has kept pace with the experimental cycle.

In the first half fiscal year, our primary efforts were devoted to 1) the noise reduction of two HXR semiconductor detectors and 2) improvement of the collimator so as to determine the line of sight more precisely. The two detectors are oriented in the opposite direction to measure both forward (FW) and backward (BW) emissions at the same time. The collimator was upgraded along to the method by von Goeler et al. [6]. Subsequently, the ratio of FW emission to BW emission (*FW/BW*) was experimentally investigated in three different discharges, i.e. A: P_{RF}=23 kW, B_{z_Max}=18 G (#8017-8030), B:P_{RF}=31 kW, B_{z_Max}=26 G (#8081-8093), C:P_{RF}=36 kW, B_{z_Max}=26 G (#8139-8151). *FW/BW* as a function of I_p is shown in Fig.1. Asymmetry of HXR in the toroidal direction is recognized in the regime having closed magnetic flux surfaces. The FW emission goes over the BW emission after closed flux surfaces are formed at I_p of 3.5-4.0 kA and *FW/BW* linearly increases as I_p increases. This tells us that density of SEs having drift motion antiparallel to I_p increases as I_p increases.

To obtain deeper understanding for the role of SEs on the non-inductive current ramp-up, precise measurement of velocity distribution function of SEs is required since the net plasma current is supposed to be associated with its asymmetry in the toroidal direction. To measure the distribution function of SEs precisely, in the latter half year, we upgraded the HXR system so that it is capable of scanning observable domain from 0 to 50 degrees and from 130 to 180 degrees to the magnetic axis. The construction and installation of this system have been completed. The measurement of HXR is being performed with the upgraded system of which line of sight is scannable. Also, the HXR detector array consisting four detectors was newly prepared on the perpendicular diagnostic port. Arrangement of the upgraded HXR detector system is depicted in Fig. 2. QUEST is now equipped with the comprehensive HXR diagnosing system and the experiment to reveal the role of SEs on the non-inductive current generation is going to be accelerated.

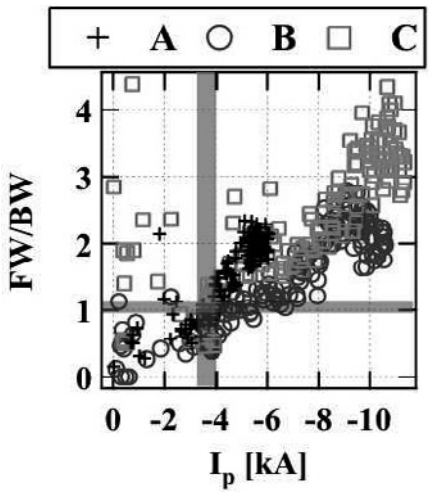

Fig. 1. Ratio of FW HXR emission to BW HXR emission as a function of net plasma current, I_p.

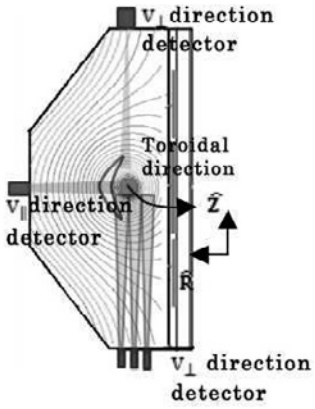

Fig. 2. Arrangement of the HXR detector system upgraded in 2010.

1) Maekawa, T. et al.: Nuclear Fusion **45** (2005) 1439.
2) Ejiri, A. et al.: Nuclear Fusion **46** (2006) 709.
3) Hanada, K. et al.: Plasma Science and Technology **13** (2011) 307.
4) Tashima, S. et al.: J. Plasma Fusion Res. SERIES **9** (2010) 316.
5) Tashima, S. et al.: 37th EPS Conference on Plasma Physics, P5.136.
6) von Goeler, S. et al.: Nuclear Fusion **25** (1985) 1515.