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

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In a spherical tokamak (ST), one of key issues for steady state operation is to establish a method of non-inductive current start up and sustainment. Electron cyclotron resonance heating (ECRH) is one of promising methods. In CDX-U, it has been first demonstrated that a plasma current I_p of ~1 kA was driven for 30 ms by 2.45 GHz radio-frequency (RF) traveling wave with RF power (P_{RF}) of ~8 kW. Subsequently, experiments to corroborate the validity of this method have been carried out in other ST devices, e.g. LATE [2], CPD [3] and TST-2 [4]. Currently, current ramp up experiments are being intensively conducted in QUEST by means of two RF wave systems at 2.45 GHz and 8.2 GHz. To reveal the role of suprathremal electrons in generating net plasma current during the non-inductive current ramp up phase, hard X-ray (HXR) diagnostic system was installed in 2009 in the framework of bidirectional collaborative research program between NIFS and Kyushu University.

QUEST is a medium sized ST device, having the major and averaged minor radii are 0.68 m and 0.4 m, respectively [5]. The toroidal magnetic field strength up to 0.29 T (at R=0.5 m) can be produced by eight toroidal field coils. Two RF waves at f_{RF} of 2.45 GHz (<P_{RF}=50 kW, CW operation) and f_{RF} of 8.2 GHz (<P_{RF}=200 kW, CW operation) are injected on the equatorial plane. Two semiconductor detectors, i.e. CdZnTe (3x3x2 m^3) and CdTe (3x3x1 m^3) of Amptek Inc. USA are employed to measure HXR. Arrangement of those two detectors on QUEST is depicted in Fig. 1. Two detectors are oriented in the opposite direction to measure both forward and backward emissions simultaneously. The tangency radii of sight lines for CdZnTe and CdTe are 0.372 m and 0.5 m, respectively.

Fig. 2 shows schematic drawing of the electronic circuit used for the HXR measurement. HXR-produced signal pulses from a preamplifier are fed into a spectroscopic amplifier (ORTEC 572). Shaped output pulses are transferred from the torus hall to the control room and time-resolved pulse height distributions are recorded by use of a multi-channel analyzer (MCA) module (Yokogawa Electric Co. WE7562). The MCA module is actually incorporated in the LABCOM data acquisition system and is remotely controlled from NIFS via SNET [6]. Prior to measurements, the energy calibration was performed using three different radioactive γ-ray sources, i.e. I^{129}, Cs^{137} and Co^{60}.

As an example of forwardly emitted HXR data, the HXR energy spectra as a function of P_{RF} (8.2 GHz) are shown in Fig. 3. It can be seen that the HXR spectrum depends on P_{RF} as expected, evolving as P_{RF} is increased [7]. Note that when P_{RF} was below 50 kW, an energy spectrum with a sufficient statistical accuracy was not obtained because of fairly low counts. In addition to the P_{RF}

scanning experiment, the build-up of the spectrum was investigated under different gas pressure and B_z conditions. Effort to understand the role of fast electrons on the non-inductive current ramp-up in QUEST is now being made.
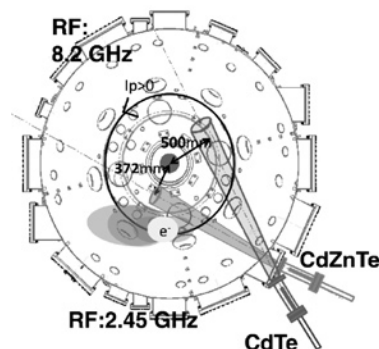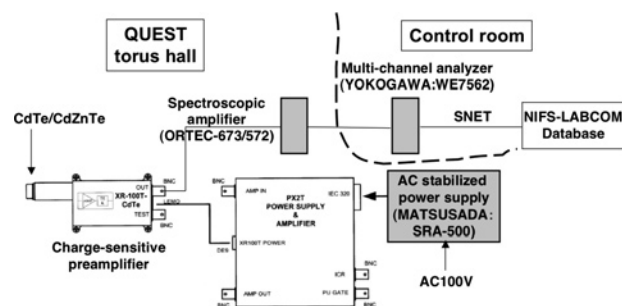

Fig.1. Arrangement of HXR detectors on QUEST.
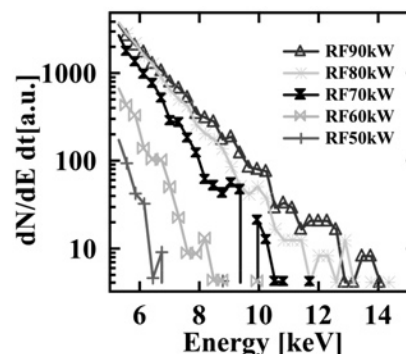

Fig. 2. Electronic circuit used for HXR detectors.

Fig. 3. HXR energy spectra as a function of P_{RF} (8.2 GHz).

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