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§69. Spatial and Velocity Space Measurement of Suprathermal Electrons to Study Non-inductive Plasma Current in QUEST

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One of key issues toward steady state operation in tokamaks is to establish methods of ramp-up and sustainment of non-inductive plasma current. In particular, in a spherical tokamak, a so-called ST, such as the QUEST, a space at the center column of the device is extremely limited. For the reason above, efforts have been made intensively to develop non-inductive start up scenario or technology by using radiofrequency (RF) in STs in the world. Aiming at revealing the role of suprathermal electrons in generating net plasma current during the non-inductive current ramp up phase, this project was initiated in April, 2009 in the framework of bidirectional collaborative research program between the National Institute for Fusion Science (NIFS) and Kyushu University, and continued to March, 2014 for five years. It should be noted that our project has contributed not only to the physics subject but also to education of a Ph.D. student. In this report, we look back over and summarize this project.

Hard X-ray (HXR) diagnostics system has been playing an important role in this project. In 2009, a single set of HXR detector system, i.e., a cadmium telluride (CdTe) detector, a main amplifier, an ADC unit for pulse height analysis, and a stabilized AC power supply were transferred from the NIFS to the QUEST site. We began to set up the system right after its arrival and measurement could be managed in that year. The development of HXR diagnostics has kept pace with the experimental cycle in the support of bidirectional collaborative research program. Finally, we have reached the system shown in Fig. 1. Each detector is scannable in its line-of-sight to measure time-resolved spatial- and velocity-distributions of suprathermal electrons generated by RF. The HXR system has been working at all times during the QUEST campaign.

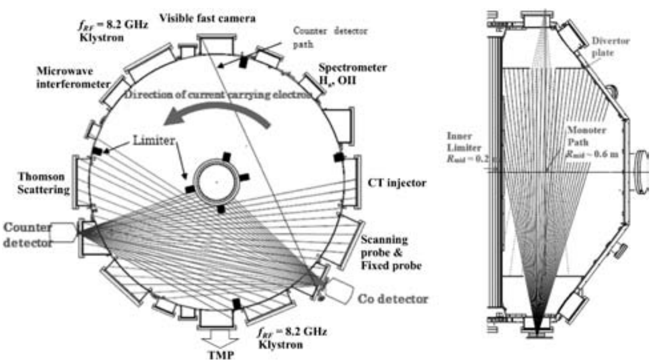

Fig. 1. Arrangement of hard X-ray detectors on the QUEST in the latter half of this project.

Our achievements for five years are listed in references [1-11]. Here, as an example, a result obtained from HXR detector system is shown in Fig. 2. Correlated with fluxes of generated hard X-rays Γ_{HX}, plasma current I_p driven by RF appears. It has been also observed that Γ_{HX} increases as increase (decrease) of RF power (gas pressure). In an open magnetic field configuration (OMFC), the mirror ratio M_{OMFC} also plays an important role in generating I_p. We have demonstrated that I_p ramp-up is feasible in high-M_{OMFC} configuration with high B_z where confinement of trapped suprathermal electrons is expected. Also, formation of inboard null configuration due to high β caused by increase of suprathermal electrons has been recognized.

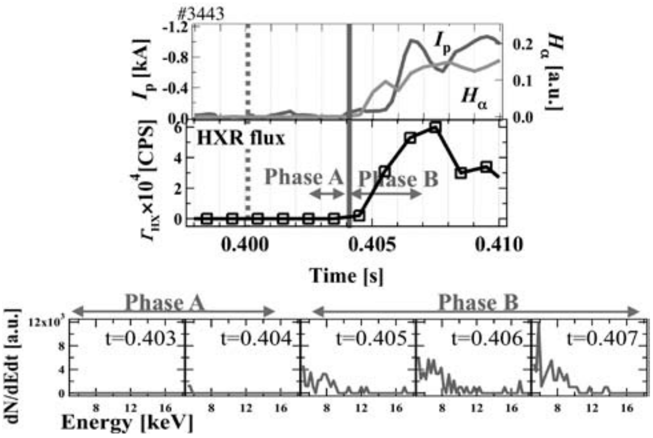

Fig. 2. Time evolutions of I_p, Hα light intensity, and hard X-rays in the I_p ramp-up experiment.

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