§49. High-energy Particle Loss and its Influence on Plasma-wall Interaction in QUEST

Nagaoka, K., Osakabe, M., Takeiri, Y., Mahira, Y. (Kyushu Univ.), Ryokai, T. (Kyushu Univ.), Zushi, H. (Kyushu Univ.)

Energetic particle confinement is one of the key issues for steady state operation scenario in the thermonuclear fusion research, because the loss of energetic particle could give serious damage to the first wall in the vacuum vessel. In particular, the energetic particles accelerated by RF heating in ST (spherical torus device) tends to distribute outside of the bulk plasma. Recently, the localized loss of such energetic particles was observed on the first wall. The purpose of this collaboration is investigation of energetic electron behaviors and its loss mechanism to the wall in ST.

In order to observe energetic particle spatial distribution, a movable hybrid probe has been installed in QUEST (see Fig. 1). The hybrid probe is a directional probe to measure particle flux density and heat flux density. The sheath thermocouple is used as a electrode of an electrostatic probe. Therefore the particle flux density and the heat flux density can be observed simultaneously with high spatial resolution. The probe drive system has a two drive mechanism. The probe position can be changed by motor drive during the shot interval of the plasma operation, which is called as slow drive system. The probe position can be also changed during a plasma discharge using a compressed air drive system, called as a fast drive system. The heat flux was investigated for the first time, and the time evolution of the electrode temperature is shown in Fig. 2(a). The heat flux density is estimated by

$$q_{\mathrm{ext}} = \int \rho C \frac{\partial T}{\partial t} dV/S \quad [\mathrm{W/m^2}], \qquad (1)$$

where ρ is mass density, C is specific heat, V and S are volume and surface area of the electrode, respectively. The loss of heat flux from the electrode is neglected in this experiment, because the time scale of heat loss is much longer than the input flux, which can be seen by the gradient of the temperature increase and decrease in time (see Fig. 2(a)). The profile of the heat flux density observed with the hybrid probe is shown in Fig. 2(b). In this experiment, the last closed flux surface (LCFS) is located at the $R = 860$ mm, and the heat flux outside of the LCFS is considered to be mainly determined by energetic electrons. It is observed that the energetic electrons distribute 115 mm far from LCFS. The orbit calculation of energetic electrons with the energy of 10 keV was carried out. The detailed comparison of the energetic electron orbit with the observation was discussed by Mahira [1].

1) Y. Mahira, H. Zushi, K. Nagaoka, M. Osakabe, et al., Kyushu-Okinawa-Yamaguchi sectional meeting of Japanese Society of Plasma Fusion Research, Oita Univ. 17-18 Dec. 2011.

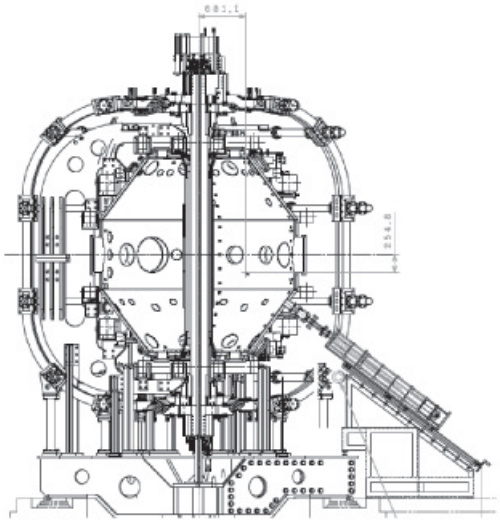

Fig. 1: Schecatic of QUEST and the hybrid probe system.

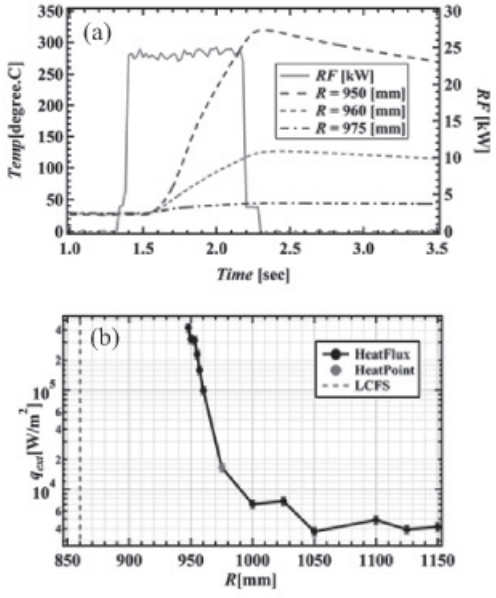

Fig. 2: (a) The time evolution of temperature increase of probe head. (b) The radial profile of power density measured by thermal probe.