§10. Progress in Preparation of Neutron Flux Monitor and Neutron Activation System for the LHD Deuterium Operation

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The Large Helical Device (LHD) has been operated 17 years, demonstrating high β, high ion and electron temperatures, and long pulse operation capabilities with hydrogen and/or helium gas. To explore higher-performance plasma, the LHD project will step into a new regime, i.e. deuterium plasma experiment[1] within two years. The deuterium experiment campaign will continue for nine years. Note that for the reason of radiation safety, annual neutron budget will be set and neutron yield has to be managed in each year. To execute this project as scheduled steadily and safely, a neutron monitoring system consisting of neutron flux monitor (NFM) and neutron activation foil system (NAS) is essentially required in terms of both plasma physics and radiation safety.

In the deuterium operation of the LHD, the neutron emission rate will change largely according to injection pattern of neutral beam (NB). It will also change rapidly within a time scale of beam ion's slowing down time after NB turn-off. For the reasons above, a fast-response NFM having wide dynamic range capability has been developed by using leading-edge digital processing technologies[2]. The maximum counting rate capability goes up to 5×10^9 cps in our system. In parallel to the development of NFM, we have characterized neutron field around the LHD in the collaboration with Nagoya University to choose neutron detector's sensitivity to thermal neutron and to search for the position suitable for installation of the detector[3-5]. As a result of these efforts, three ex-vessel NFMs were fabricated in FY2014 and were installed in the LHD in March, 2015. The LHD-NFM consists of three ^{235}U fission chambers (FCs) for middle and/or high-neutron yield shots. We also put one ^{10}B counter and two ^{3}He counters side by side with three FCs for low-neutron yield shots. Figure 1 shows the picture of a ^{10}B detector installed on the top of the LHD. Other two NFM detectors were installed at 4-O and 10-O ports. Preamplifiers were placed in the basement of the LHD torus hall to reduce effect of neutron irradiation. The digital signal processing system units for the ^{235}U fission chambers are shown in Figure 2.

In addition to the NFM, the NAS was also installed in March, 2015. The NAS will play an important role in assessing absolute DD neutron fluxes. This method is essentially insensitive to γ-ray. It will be employed for cross-check of neutron yield evaluated by the NFM[6]. The NAS of LHD has two irradiation ends. A metal foil is mounted in a small capsule (18.5 mmϕ x 40 mm) made of polyethylene. The capsule is launched from the station placed in the measurement room in non-radiation controlled area to the vicinity of LHD plasma by using a pneumatic rabbit system before a discharge. After a discharge, it goes back to the station and subsequently, absolute neutron flux is evaluated through radioactivity measurement by using a high-purity germanium detector. The total length from the station to irradiation end is 80 m for the 2.5-L port and 93 m for the 8-O port. The NAS is also going to be used for triton burn-up study to demonstrate MeV-ion confinement in the LHD.

Fig. 1. ^{10}B detector installed on the top of LHD.

Fig. 2. Digital signal processing units and interface unit for the ^{235}U fission chamber.

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