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The LHD Neutron Diagnostics

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Neutron diagnostics have played an essential role in magnetic confinement fusion, in particular, in terms of enhancement of energetic-particle (EP) physics studies. To explore a new confinement regime utilizing isotope effects and obtain deeper understanding of EP-related physics in the Large Helical Device (LHD), the deuterium operation has been conducted in LHD since March, 2017. An integrated set of neutron diagnostic systems based on leading-edge technologies was established before the start of the deuterium operation [1]. In the first deuterium campaign, the system consisted of a wide dynamic range ex-vessel neutron flux monitor, a neutron activation system, a vertical neutron camera, scintillating-fiber detectors, and fast-neutron scintillation detectors. These have provided much new information, e.g., total neutron emission rate, i.e., global confinement of beam ions, effect of beam-ion-driven magnetohydrodynamic (MHD) instabilities on neutron emission profile, i.e., beam ion profile, triton burnup ratio, etc [2]. In LHD, enhancement of neutron diagnostics is steadily continuing. The second vertical neutron camera characterized by high-neutron-detection efficiency and high-time resolution has been operated since the second deuterium campaign and measured rapid change of neutron emission profile with higher accuracy. An ion cyclotron resonance heating (ICRH) antenna is now being installed for the next campaign. To prove production of high-energy tail of deuteron perpendicular to magnetic field and investigate confinement property of high-energy deuteron tail, an advanced neutron spectrometer called TOFED [3] is being constructed in the collaboration with Peking University, China. A single crystal CVD diamond detector will be also employed to measure secondary 14 MeV neutron. In this paper, current status of LHD neutron diagnostics and representative results will be described.

[1] M. Isobe et al., IEEE Transaction on Plasma Science 46 (2018) 2050.
[2] M. Isobe et al., Nuclear Fusion 58 (2018) 082004.
[3] X. Zhang et al., Nuclear Fusion 54 (2014) 104008.

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