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Neutron Diagnostics in the Large Helical Device

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Deuterium plasma experiment begins in the Large Helical Device (LHD) in March, 2017 in oder to to explore higher-performance plasmas in LHD and to gain a positive prospect toward an LHD-type fusion reactor. In the operation of LHD, neutron yield measurement is essentially required because neutron yield has to be managed in compliance with permitted neutron budgets. In terms of plasma physics, extension of energetic-particle physics can be expected in comparison with the hydrogen regime because neutrons dominantly produced by beam-plasma reactions become newly available as a signal to diagnose energetic-ion behavior. A comprehensive set of neutron diagnostics has been prepared toward the deuterium operation of LHD. These diagnostics consist of ex-vessel neutron flux monitor (NFM), neutron activation system (NAS), vertical neutron camera (VNC), scintillating-fiber 14 MeV neutron (Sci.-Fi.) detectors, neutron fluctuation detectors, and γ-ray detectors. The NFM on LHD consists of three detector sets. Each set has two different thermal neutron detectors, i.e., a fission chamber (FC) and a high-sensitivity thermal neutron detector. We have newly developed a digital signal processing unit (DSPU) for FC based on the FPGA by using leading edge technologies. The DSPU has both functions of pulse counting and Campbelling modes, providing a wide dynamic range up to 9.5×10^9 (cps). In situ calibration of NFM was performed in November 2016 by using a 252Cf neutron source of 800 MBq. To simulate a ring-shaped neutron source, we installed a railway along the magnetic axis position and ran a train loaded with 252Cf. As a result of this work, the calibration factor to evaluate total neutron emission rate (n/s) from pulse counting rate (cps) was obtained with the help of MCNP6 code. The NAS on LHD has two irradiation ends, which perform important roles in cross-checking neutron yield evaluated by the NFM and in investigating shot-integrated 1 MeV triton behavior through measurement of secondary 14 MeV neutron fluxes. The VNC plays an important role in studying radial beam ion transport induced by intrinsic magnetic field ripple and/or external magnetic field perturbation. A neutron collimator is essential for the VNC. Radially aligned eleven cylinders of 3 cm φ and 150 cm long embedded in a heavy concrete stack are embedded in the 200 cm concrete floor of the LHD torus hall. Our fast-neutron detector for the VNC is based on the stilbene scintillator and a leading edge fast digitizer equipped with the FPGA. The system was designed so as to realize wide dynamic range capability over 10^6 (cps), having automated n-γ discrimination capability by using the FPGA technology. Sci.-Fi. detectors are installed to study time-resolved 1 MeV triton confinement by measuring secondary 14 MeV neutrons. In addition to these, neutron fluctuation detectors are installed to follow rapid change of neutron flux due to MHD events. Also, CsI(Tl) detectors for γ-rays are prepared for verifying knock on ion-tail formation due to beam-injected fast protons. In this paper, overview of neutron diagnostics prepared for the LHD deuterium experiment, commissioning of these diagnostics, and initial measurement results are described.

Eligible for student paper award?

No

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