§38. Performance Estimation of the LHD Neutron Flux Monitor by Monte Carlo Neutronics Calculation

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The neutron flux monitor (NFM) is one of the most important diagnostics in the LHD deuterium plasma experiment. In the LHD NFM, three ^{235}U fission chambers are used as wide range neutron detector, additionally ^{10}B counter and two ^{3}He counters will be used for very low neutron yield shot. Figure 1 shows a neutron detector using the ^{235}U fission chamber, where a 50-mm-thick polyethylene and a 1-mm-thick cadmium are used as a neutron moderator and a thermal neutron shield, respectively.

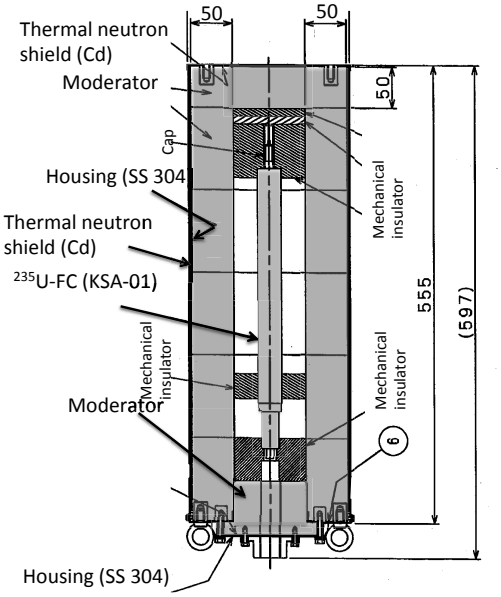

Fig.1. Schematic view of the neutron detector using a ^{235}U fission chamber.

Figure 2 shows an energy dependent seisitivity (response function) calculated by a MCNP Monte Carlo neutronics code, MCNP-6, with the 3-dimenstional model of the detector. The detector has rather flat sensitivity in the energy rage of 0.55 eV - 2.5 MeV, which is suitable to measure wide energy range neutrons with almost same sensitivity. Neutron energy spectra at the detector positions were calculated by MCNP-6 code with the 3-dimenstional model of LHD [1] as shown in Fig.3. Averaged neutron energy at the detector positions is ~0.3MeV, not 2.45 MeV, due to slowing down of neutrons by scattering with structural materials and super conducting coils. The detection efficiencies for neutrons generated in the LHD plasma, ε_{plasma}, were obtained from the neutron energy spectra and the response function as follows;

ε_{plasma} = 3.52 × 10^{-9}, 7.30 × 10^{-9} and 4.92 × 10^{-9} (counts/source neutron) for the top of LHD, 4-O port and 10-O port, respectively.

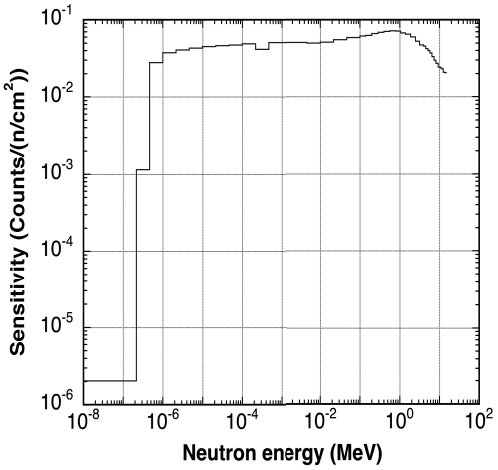

Fig.2. Response function of the neutron detector using the ^{235}U fission chamber.

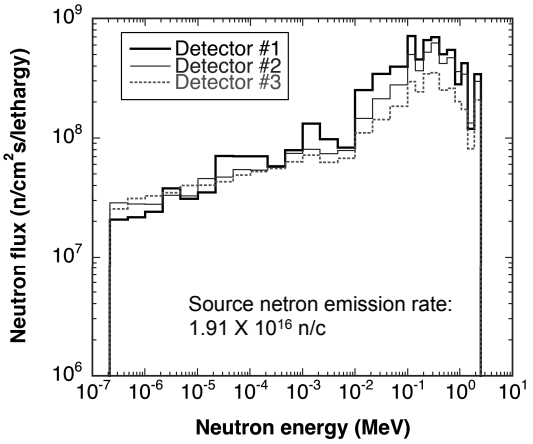

Fig.3. Neutron energy spectra at the detector positions.

An in-situ calibration of the LHD NFM is planed in November 2016, by ^{252}Cf neutron source rotating in the LHD vacuum vessel. The calibration is also simulated by the MCNP-6 calculation with the 3-dimenstional model of LHD excluding liquid helium in superconducting coils. The detection efficiencies for ^{252}Cf neutrons, $\varepsilon_{Cf\text{-}252}$, were;

$\varepsilon_{Cf\text{-}252}$ = 3.50 × 10^{-9}, 6.98 × 10^{-9} and 4.56 × 10^{-9} (counts/source neutron) for the top of LHD, 4-O port and 10-O port, respectively.

1) Nishitani, T. Ogawa, K., Nishimura, K., and Isobe, M.: Plasma and Fusion Research **11** (2016) 2405057.