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ＬＨＤにおける総発生中性子計測と計測器校正
Neutron Flux Monitoring and Calibration of the Neutron Detectors in LHD

瓜谷章[1]，仲野裕次[1]，磯部光孝[2,3]，小川国大[2,3]，西谷建夫[2]，渡辺賢一[1]，山﨑淳[1]
A. Uritani[1], Y. Nakano[1], M. Isobe[2], K. Ogawa[2], T. Nishitani[2], K. Watanabe[1] and A. Yamazaki[1]

名古屋大学[1]、核融合科学研究所[2]、総合研究大学院大学[3]
Nagoya Univ.[1], NIFS[2], SOKENDAI[3]

Introduction

Deuterium plasma experiments (DD experiments) are in plan at the Large Helical Device (LHD) in NIFS. Deuterium thermonuclear fusion reactions generate neutrons with specific energy of 2.45 MeV. Neutron monitoring is quite important not only for evaluation of the plasma properties but also for the radiation safety managements. The neutrons will be measured by three fission chambers and a neutron activation method. It is necessary to calibrate the sensitivities of these neutron monitors in prior to the DD experiments. The *in situ* calibration will be done using a ^{252}Cf neutron source placed on a model train that will run on a circular railroad truck set in the LHD. There are some differences of conditions between the DD experiments and the calibration ones, as shown in Table 1. The influences of these differences on the sensitivities of the neutron monitors must be evaluated. In this work, the influences were evaluated using the Monte Carlo neutron transport code MCNP5.

Table 1 Differences of conditions between the DD experiments and the calibration ones.

	DD Experiments	Calibration
Neutron energy	2.45 MeV mono-energetic	^{252}Cf fission spectrum
Major Radius	~3.9 m	3.74 m
Minor radius	~60 cm	1 cm
Liquid He	exist	Not exist
Railroad	Not exist	exist

Monte Carlo Simulation

In MCNP, a geometry is defined with cells districted with many surfaces such as flat planes. Because no surface defining helical shape is prepared in MCNP, we have constructed an approximation model by dividing parts with a small angle in toroidal direction. We made the helical coil structure by rotating the poloidal position of coils. The LHD has a periodic structure with ten cycles (every 36 degrees). In other words, for every 18 degrees rotation in the toroidal direction, the coils rotate 90 degrees in poloidal direction. Figure 1 shows a schematic view of the LHD geometry used in the MCNP simulations. In this work, we adopted the simulation models with 360 divisions from a viewpoint of the simulation precision and the required calculation time.

Results of simulation

Figure 2 shows the neutron energy spectra at 500 cm from the equator and on the center axis of the LHD where the fission chamber will be placed. These two spectra are almost the same but there are slight differences. These slight differences cause the difference in the sensitivity of the fission chamber for DD and ^{252}Cf neutrons. The ratio of the sensitivities of the fission chamber at that position for DD and ^{252}Cf neutrons was 0.92±0.06.

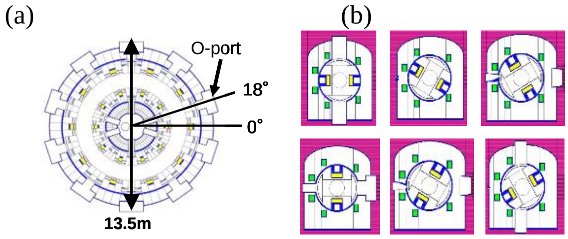

Fig. 1. Schematic view of the LHD geometry used in MCNP code. (a) Horizontal section on the equatorial plane of the LHD. (b) Vertical sections at different toroidal angle positions. Left upper figure; 0 degrees, left lower figure; 18 degrees. The helical coil structures gradually rotate.

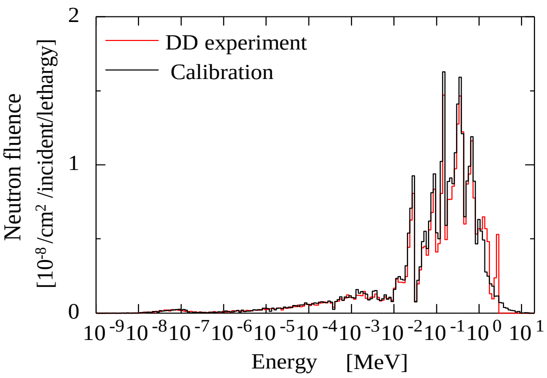

Fig. 2. Neutron energy spectra at 500 cm from the equator and on the center axis of the LHD.