§33. A Study on Neutron Emission Profile Measurement Using Directional Neutron Detectors

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In the present study, we are aiming at design and preparation of comprehensive neutron diagnostic system which is suitable for DD plasma experiments at LHD, in particular developing neutron emission profile measurement system (or neutron camera system) using directional neutron detectors during three years started from 1998.

The main results in 2000 are summarized as follows; We have prepared four kinds of candidate neutron detectors for the LHD neutron camera, which are an NE-213 organic liquid scintillator (adopted at JET), an NE-451 ZnS(Ag) scintillatior with a recoil proton emitter (adopted at TFTR), a stilbene organic crystal scintillator (adopted at JT-60U) and an original directional neutron detector based on recoil proton counter telescope geometry, respectively. The performance tests of these detectors have been made with neutron beams extracted from the fast neutron source reactor 'YAYOI' in the University of Tokyo and the intense DT neutron source of FNS in JAERI.

As an example of the results, Fig.1 shows a linearity of count rates from NE-213 and NE-451 detector systems to the YAYOI reactor power, which gives an important information on dynamic range for the neutron camera, including its detection efficiency and signal to noise ratio.

The stilbene detector with a fast neutron/gamma-ray discrimination circuit, which is now under preparation, will be expected to expand the dynamic range and in some case, to derive temporal DD neutron spectral change from the measured pulse height data.

As for the directional neutron detector, the main results have been published in Ref.1), which concluded that it would be useful as a complementary detector to mitigate the spatial constraints on conventional neutron camera systems.

To make neutronic design consideration for neutron measurement at LHD, we are developing a calculation model with the Monte Carlo neutron transport code 'MCNP'. The calculation model mainly consists of the vacuum vessel, simplified helical coils and a part of the experimental building. A preliminary calculation has been done for a poloidal cross section geometry of the 4.5-L port, where a multi-channel neutron collimator made of polyethylene will be installed under the floor for neutron emission profile measurement. To achieve the spatial resolution around 100 mm at the plasma center, it is necessary to set up 12 channel collimators, each of which has 12 mm in diameter and 1500 mm in length. Fig.2 is an example of calculation results of DD neutron spectra through a central collimator showing a good ratio of 2.45 MeV peak to total neutron spectrum. However, it has been found that the peak to total ratio comparatively depends on the calculation model, which means the necessity of more detailed modeling.

A simulation of in-situ calibration experiment for a neutron flux monitor has been also tried to estimate an accuracy of total neutron yield (or fusion power) measurement, relating to the development of a compact accelerator DD neutron source and a high sensitive neutron yield monitor.

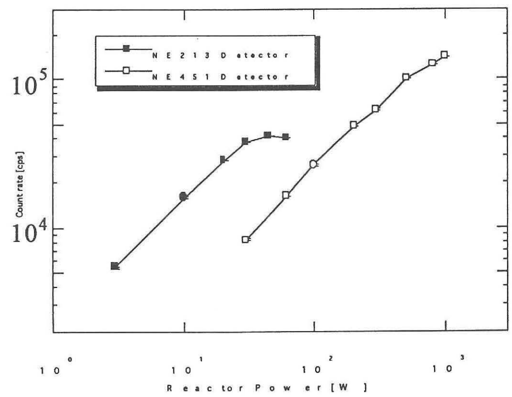

Fig.1. Linearity of count rates of NE-213/NE-451 neutron detectors and reactor power of 'YAYOI'.

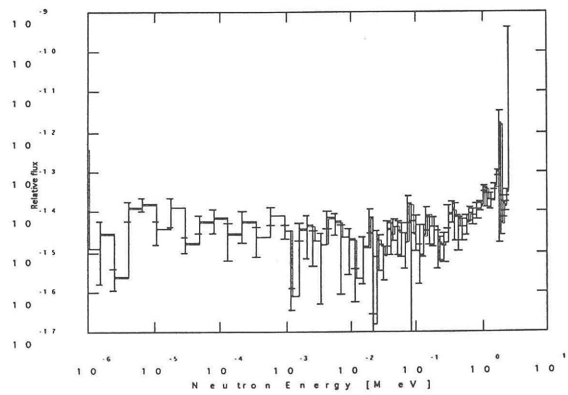

Fig.2. Calculated DD neutron spectrum through a collimator installed at the 4.5-L port of LHD.

Reference
1) Iguchi, T. et al., Fus. Technol., 39(2), (2001) 1147.