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

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Neutron measurement for dd experiments in LHD is very useful to study high energy ion confinement peculiar to helical plasma physics. In the present study, we are aiming at design and preparation of comprehensive neutron diagnostic system suitable for LHD, in particular developing neutron emission profile measurement system using directional neutron detectors.

The following research subjects have been so far carried out;

1. An NE-213 organic liquid scintillation detector system was prepared as a versatile and reference neutron monitor with fast spectral unfolding procedure to derive dd neutron spectra from the measured data.
2. As one of the promising detector candidates for neutron emission profile measurement, a prototype of directional neutron detector based on recoil proton counter telescope geometry was fabricated and the basic performance was checked by using an accelerator DT neutron source.
3. The applicability of a diamond detector to measure charged particles produced from nuclear reactions was also checked through neutral particle measurement in LHD experiments.

In addition, we have also tried design consideration of a compact accelerator dd neutron source to realize in-situ calibration for neutron detectors installed on LHD and detection of a small amount of neutrons produced from hydrogen discharge plasmas in LHD.

This report mainly describes No.2 item, that is, the performance test results on the directional neutron detector for neutron emission profile measurement. The detection principle is based on a recoil proton counter telescope holding multichannel proton collimators between two plastic scintillators, as shown in Fig.1. The first scintillator, on which fusion neutrons are incident, serves as a recoil proton emitter as well as a trigger signal supplier to make coincidence with the second scintillator. By adjusting the solid angle of higher energy recoil protons to enter the second scintillator through the collimators, the detector counts can be sensitive to the direction of neutron incidence.

Fig.2 shows comparison results between experiment and calculation on the neutron incident angle dependence of detection efficiency for 14MeV neutrons, which seem to be comparatively in good agreement. In parametric survey of the detector specification to optimize its directionality, we have found that the angle resolution defined as a full width of neutron incident angles at a half maximum of detector counts would reach about 4 degrees at minimum around 45 degrees neutron incidence to the detector axis.

We are now making design consideration on a compact neutron emission profile monitor based on an array of the optimized directional neutron detectors.

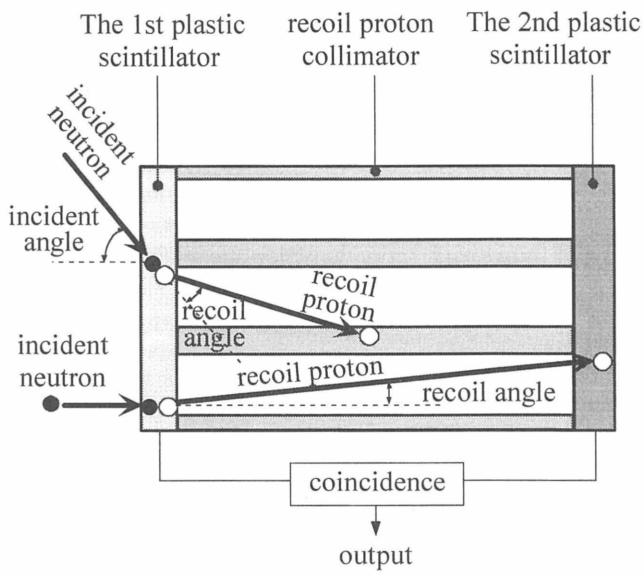

Fig.1 Concept of directional neutron detector

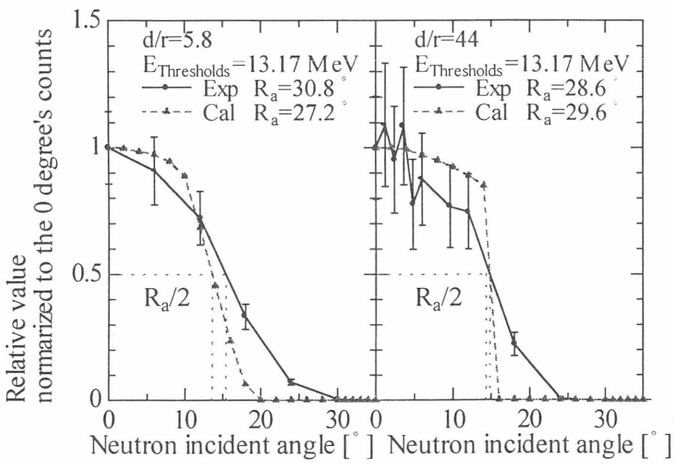

Fig.2 Neutron incident angle dependence of detection efficiency for 14MeV neutrons