§34. Development of Neutron Diagnostic Systems for LHD Deuterium Experiment

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An accurate measurement of amount of DD neutrons generated in the LHD deuterium experiment is important for the safety limitation of the experimental plan, and for the evaluation of the heating efficiency and the heating mechanism. Neutron measurement can also provide additional information, such as ion temperatures, the thermo-nuclear fraction in the fusion reaction rate, degree of fast ion confinement, fast ion loss mechanism, *etc.*

In the present research collaboration, suitable arrangement of neutron detection systems and neutron detection places around LHD, and the calibration strategy for them are studied. So far, this work involves neutron transport study by using the MCNP calculation, and development various neutron detection system for (1) time-resolved emission measurement, (2) emission profile measurement, and (3) high-resolution neutron spectrometers.

Because each neutron detector has its individual energy response, *in situ* calibration experiments using a neutron source inside the vacuum vessel is needed. This calibration is supported by neutron transport code, such as MCNP (Monte Carlo N-Particle transport code, developed at the Los Alamos National Laboratory), while the input of helical shape into the calculation is quite challenging. In this annual year a 3D sector model of LHD was constructed as shown in Fig. 1, by averaging 6 cake-cut pieces of 6-degree each [1].

In general, neutrons are produced through thermonuclear (Plasma=Plasma) interaction), Beam=Plasma interaction and Beam=Beam Interaction. The expected neutron spectra are evaluated (Fig.2), for LHD deuterium experiment, showing that most of neutrons are produced through Beam=Plasma interaction. Therefore, the energetic ion behaviors on LHD can be studied by a neutron spectrometer which can resolve the slowing-down component in the spectra.

For application to the high-counting rate neutron measurement in the emission profile monitor, a digital signal processing (DSP) system was developed. In this study, digital data obtained from a stilben crystal detector of the profile monitor of JT60-U was used. Each neutron signal was analyzed to get the pulse height, total integrated pulse, fast and slow decaying components. Fig. 3 shows a 2D map in fast-slow space normalized with total. Neutrons are discriminated from γ-rays clearly [2].

[1] S. Yamamoto, et al., Proceedings of JSPF Annual meeting, Dec. 2008, **25-PD03**

[2] K. Ishii et al., 18th International Toki Conference (ITC18) December 9-12, 2008 Ceratopia Toki, Toki Gifu JAPAN, **P2-38**

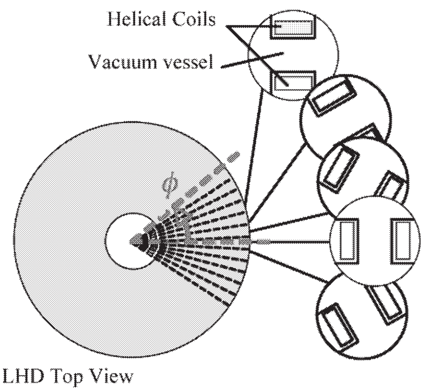

Fig. 1 The 3D sector model of LHD for MCNP calculation. One sector was divided into 6 cake-cut pieces of 6-degree each [1].

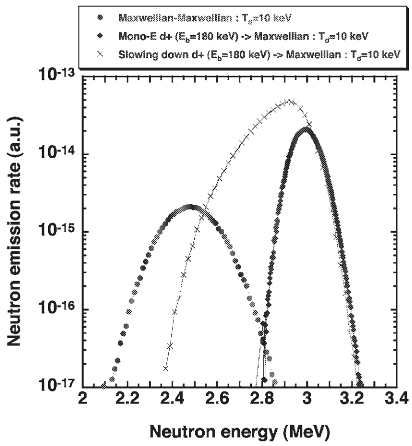

Fig. 2 The expected neutron spectra of forward viewing against the NBI on LHD deuterium experiment. Most of neutrons are produced through Beam=Plasma interaction.

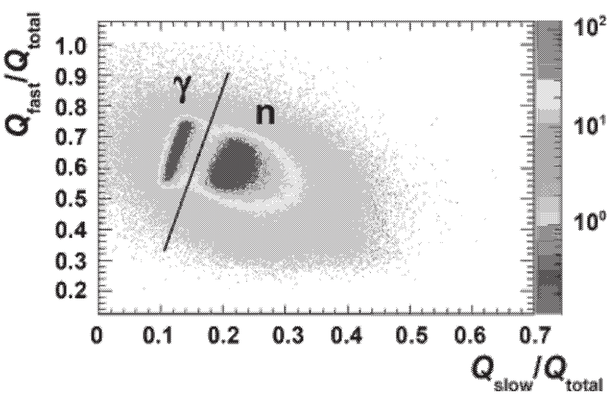

Fig. 3 A 2D map in fast-decaying and slow-decaying component space of event signals obtained by a DSP from a stilben crystal detector of the profile monitor of JT60-U [2].