§5. Development of Neutron Diagnostic Systems Leading to Extended Physics of Energetic Particle Confinement in LHD

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We have been developing the following neutron measurement systems and related items for D-D burning plasma experiments, especially for study of high-energy particle physics.

1) The combined neutron transportation code consisting of MCNP, FIT3D-DD and GNET.
2) The neutron flux monitor and the signal processing unit for neutron counters.
3) The artificial diamond neutron energy spectrometer.
4) The neutron profile monitor using scintillating fibers and the digital signal processing unit for discrimination of neutrons and gamma rays.
5) The neutron profile monitor using stacked nuclear emulsions.
6) The neutron energy spectrometer using recoil proton detector.

In this report, we describe the tentative results of 1) and 4) among the above items because of the limitation of writing space given.

i) The combined neutron transportation code

We checked the influence on differences between DD plasma experiments and in-situ calibration experiments in neutron energy spectra, source distribution, presence of helium coolant and calibration source supporting structures by using Monte Carlo calculations. Figure 1 shows the difference in the neutron fluence distribution near the O-port of LHD between the DD experiments and in-situ calibration. The calibration source supporting structures, such as a railroad of a source transport train, can reduce 4% of the neutron fluence near the O-port. The count difference in the fission chamber neutron monitor between the both experiments is less than 10% because scattering neutrons are dominant near the neutron monitor position and the neutron energy spectra have little difference.

We also studied the confinement of 1MeV tritons, which was produced by the D-T fusion reaction using GNET code. It was found that about 20% of tritons were lost by the prompt orbit loss and 70% were by the stochastic orbit loss. Figure 2 shows the velocity space distribution of tritons produced by D-T fusion reaction.

ii) The digital signal processing unit for discrimination of neutrons and gamma ray

The neutron profile monitor (NPM) stably operated at a high-count-rate for deuterium operations in the LHD has been developed. The NPM consists of three parts: a multichannel collimator, an eleven-scintillation-detector (a stilbene coupled with a photomultiplier) and a digital-based data acquisition system. The entire neutron detector system was tested using an accelerator-based neutron generator in Fusion Neutronics Source in JAEA. This system stably acquired the pulse data without any data loss at high-count-rate conditions up to $8x10^5$ counts per second. Figure 3 shows an example of the neutron-gamma ray discrimination.

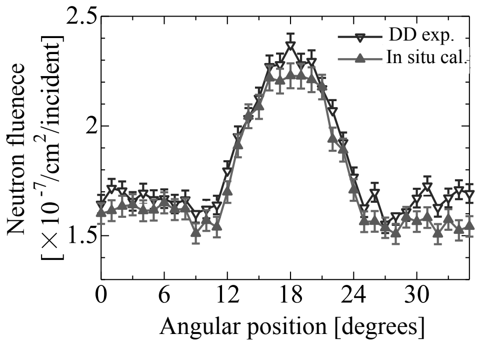

Fig. 1 Neutron fluence distribution near the O-port of LHD.

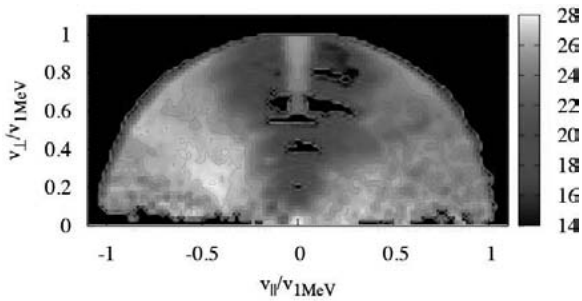

Fig. 2 Velocity space distribution of tritons produced by D-T fusion reaction.

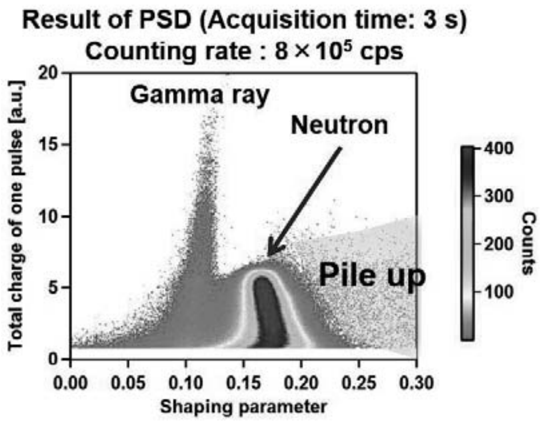

Fig. 3 An example of the neutron-gamma ray discrimination.