§40. Development of Neutron Spectroscopy System for Deuterium Experiment on LHD

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In deuterium fusion plasma heated by neutral beam injection, 2.5MeV neutrons are emitted as accompanying products of DD reactions, which are mainly occurred as beam-plasma interactions. Thus, the neutron energy spectrum emitted from the deuterium plasma reflects the velocity distribution of fast ions in high temperature plasma. Toward LHD deuterium phase, the Associated Particle Coincident Counting neutron energy spectrometer: APCC-NES was installed at KSTAR and demonstrated the measurement of DD neutron energy spectrum.

APCC-NES is based on coincident detections of a scattered neutron and a recoil proton associated to an event of neutron elastic scattering. The incident neutron energy E_{in} is simply derived from the sum of the recoil proton energy E_{rp} and the scattered neutron energy. Therefore the system consists of three detectors: a thin plastic scintillator worked as an incident neutron target and ΔE detector for recoiled protons (called as a radiator), a Si surface barrier detector for recoiled proton detection (RPD), and a plastic scintillator for scattered neutron detection (SND). The scattered neutron energy is measured by time-of-flight (TOF) method between the radiator and the SND. For data acquisition of these detectors, the on-line digital signal processing was adopted in the APCC-NES.

Figure 1 shows the prototype APCC-NES system installed at J-port of KSTAR. The radiator and the RPD were set in the vacuum chamber. The collimator made of polyethylene containing ^{10}B was set in front of vacuum chamber makes the incident neutron beam having a diameter of about 2 cm. Output signals from the radiator and RPD were acquired by the DT5720B digitizer. The lengths of cables between amplifier and digitizer were 10 m. To reduce the electrical noise in each detector output, shielding box and tube were used and in addition a constant voltage constant frequency (CVCF) power supply was also installed.

Figure 2 shows the typical time trend of plasma current, NBI power, NFM, and outputs of the detectors of the APCC-NES system. Typical time trend of the counting rates of these detectors followed that of the NFM counting rate. Figure 3 shows the incident neutron energy spectrum obtained by recoiled proton telescope method: $E_{in} = E_{rp}/\cos^2\theta$ ($\theta = 20^\circ$) for coincident events between the radiator and the RPD. Here, background component due to chance coincident events (B) was subtracted from the one made by both coincident and chance coincident events (A). We successfully measured the neutron spectrum from KSTAR plasma.

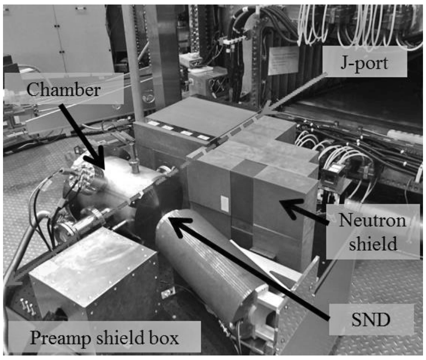

Fig. 1. Prototype APCC-NES system installed at J-port of KSTAR

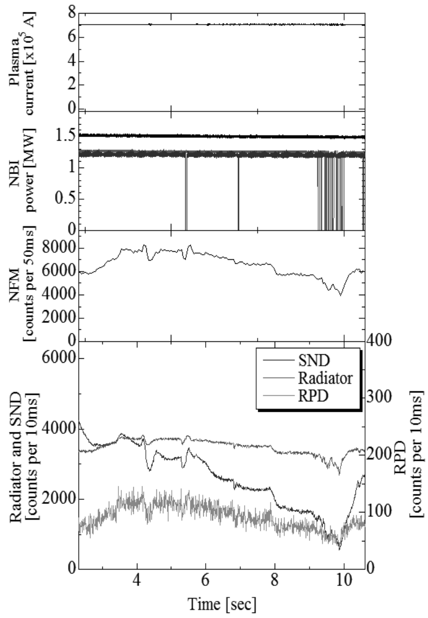

Fig.2. Typical time trend of plasma current, NBI power, NFM, APCC-NES detector in the KSTAR during 2014 experimental campaign (Shot No. 10576).

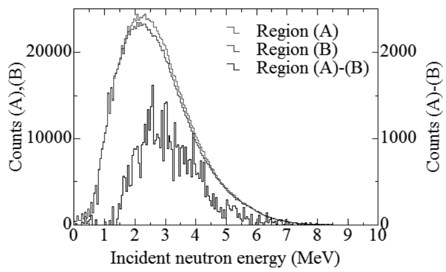

Fig.3. Neutron energy spectrum obtained by APCC-NES.

[List of Publications]

1) Y. Nakayama, H. Tomita, et al., "*Application of advanced nuclear emulsion technique to fusion plasma neutron diagnostics*", Physics Procedia, **80** (2015) 81-83.

2) Y. Nakayama, H. Tomita, *et al.*, "A Study of DD Fusion Neutron Measurement by Nuclear Emulsion Technique with Pinhole Collimator", KEK Proc., 2015-8, (2015) 44-49.