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Development of a neutron detector for nuclear data measurement using high-intensity neutron beam

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Highly precise neutron nuclear data is required in nuclear transmutation research of long-lived minor actinides (MA) in nuclear waste. In neutron capture cross section measurement, monitoring the number of the incident neutrons is necessary. However, in measurement with J-PARC/ANNRI, direct neutron monitoring system has not been employed. To make measurement with ANNRI more robust, an additional neutron beam monitor is required. Conventional neutron detectors cannot be used as a beam monitor at ANNRI because of two reasons, high counting rate environment and gamma-flash. The neutron flux at ANNRI is one of the highest in the world. Gamma-flash, an intense gamma-ray burst produced when the proton beam pulse bombards the spallation target, can paralyze a detector generally used in nuclear data measurement. In general, a semiconductor detector or an inorganic scintillator, which is adopted for a neutron detector, has relatively longer response time and is unsuitable for beam monitoring at ANNRI.
Therefore, a combination of a thin plastic scintillator and a ^{6}LiF foil was selected as a detection system, whose fast response enabled detecting neutrons at a high counting rate. Low gamma ray sensitivity of a thin plastic scintillator allows measuring fast TOF region without count loss or detector paralysis. The geometry of the ^{6}LiF foil, the plastic scintillator, and photomultiplier tube (PMT) was designed. The optimal thickness of the ^{6}LiF foil was determined with simulation codes, SRIM and PHITS. A ^{6}LiF foil was made by vacuum deposition method. A test detector system was built to study the feasibility of the method.
The detector system was tested under the high neutron irradiation condition at J-PARC /ANNRI. A neutron TOF spectrum was successfully measured without significant count loss or detector paralysis. A neutron energy spectrum was driven from difference of TOF spectrum with and without ^{6}LiF. The neutron spectrum was compared with a past neutron spectrum and good agreement was obtained. Statistic error was 0.68 % at 6.0 meV even though measurement times in this study was pretty short (~11 min).

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