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Development of gamma-ray detectors in high stray magnetic field for burning plasma tokamak (Remote)

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Measurement of alpha-particles and other fast ions which are born in nuclear reactions is of great importance to optimize the heating schemes for ITER and future fusion reactors. Gamma-ray spectrometers have been extensively used on tokamaks for studying the behavior of fast ions including fusion alpha-particles, and runaway electrons.

Gamma-ray diagnostics of Burning plasma Experimental Superconducting Tokamak (BEST) have been designed. However, the magnetic field is up to 1000 Gauss around the vertical gamma-ray detectors. And conventional photomultiplier (PMT) can't be used in such strong stray magnetic fields. Two new gamma-ray detectors have been developed: (1) LaBr3(Ce) scintillator integrated with a silicon photomultiplier (SiPM) which is insensitive to the magnetic field; (2) small-size LaBr3(Ce) crystal equipped with a liquid light guide (LLG) and Photomultiplier (PMT) for remote gamma-ray detection. The prototypes of the detectors have been fabricated and installed on EAST to validate their performance. The data acquisition system (DAQ) is fulfilled with a 14 bit and 400 MS/s digitizer and a PC. The DeGaSum code with advanced algorithms [1-2] is implemented to digitize and process signal pluses.

A good stability at high counting rates up to 106 /s is achieved with the SiPM-LaBr3 detector, which is very important in high performance plasma discharges. A good energy resolution is obtained of 4% at 662 keV. The counting rate can be up to 107 /s for the LLG-PMT-LaBr3 detector, and the energy resolution degrades not too much with an additional light guide, which shows a promising application in remote gamma-ray detection. With the scintillators and DAQ, bremsstrahlung from runaway electrons and gamma-rays were observed in EAST plasma discharges, and the detailed analysis is ongoing.

References
[1] A. Shevelev et al 2013 Nucl. Fusion 53 123004.
[2] E. Khilkevitch et al 2022 Nuclear Inst. and Methods in Physics Research, A 977 164309.

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