

Development of Scintillation Detectors for Energetic Particle Confinement Studies in Magnetic Confinement Fusion at National Institute for Fusion Science

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One of the key issues in sustaining fusion-burning plasmas is the confinement of energetic alpha particles produced by deuterium–tritium fusion reactions, which act as the primary heating source. Therefore, research on energetic particle confinement has been conducted in existing magnetic confinement fusion devices. National Institute for Fusion Science has been developing a variety of scintillation detectors to investigate energetic particle behavior in magnetic confinement fusion devices through measurements of neutrons, gamma rays, X-rays, protons, and hydrogen atoms.

During deuterium operation of Large Helical Device (LHD) from March 2017 to December 2022, stilbene and EJ-410 scintillators were used to measure the deuterium–deuterium (D–D) neutron emission profile [1], while an EJ-410 scintillator was employed to measure neutron flux with high time resolution [2]. EJ-301 and CLYC7 scintillators were utilized for D–D neutron spectrum measurements [3]. In addition, multiple BCF-10 scintillation fibers embedded in an aluminum substrate with honeycomb structure were applied to measure secondary deuterium–tritium neutrons at the ~1% level within a predominantly D–D neutron field [4]. In addition, LaBr₃:Ce detectors were installed to measure gamma rays emitted from the plasma [5]. ZnS:Ag scintillators were employed in magnetic spectrometers, fast-ion loss detectors [6], and imaging neutral particle analyzers [7] in LHD. At present, we are developing fast-ion loss detectors based on ZnS:Ag scintillators and hard X-ray detectors based on LaBr_{2.85}Cl_{0.15}:Ce (LBC) scintillators for energetic particle confinement studies in Compact Helical Device.

We will present the development and application of scintillation detectors utilized in magnetic confinement fusion research.

1. K. Ogawa et al., “Neutron Camera in Large Helical Device” *Journal of Fusion Energy* **45**, 7 (2026).
2. K. Ogawa et al., “Neutron Flux Measurement Using a Fast-Neutron Scintillation Detector with High Temporal Resolution on the Large Helical Device”, *Plasma and Fusion Research* **13**, 3402068 (2018).
3. S. Sangaroon et al., “Observation of significant Doppler shift in deuterium-deuterium neutron energy caused by neutral beam injection in the large helical device”, *AAPPS Bulletin* **32**, 5 (2022).
4. E. Takada et al., “Design Optimization of a Fast-Neutron Detector with Scintillating Fibers for Triton Burnup Experiments at Fusion Experimental Devices”, *Review of Scientific Instruments* **90**, 043503 (2019).
5. K. Ogawa et al., “Large Volume and Fast Response Gamma ray Diagnostic in the Large Helical Device”, *Plasma and Fusion Research*, **18**, 2402016 (2023).
6. K. Ogawa et al., “Observation of energetic-ion losses induced by various MHD instabilities in the Large Helical Device (LHD)”, *Nuclear Fusion* **50**, 084005 (2010).
7. W. Paenthong et al., “Design and initial results of the imaging neutral particle analyzer in large helical device”, *Review of Scientific Instruments* **95**, 083547 (2024).