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Dependence of Fast-Neutron Imaging on Scintillators

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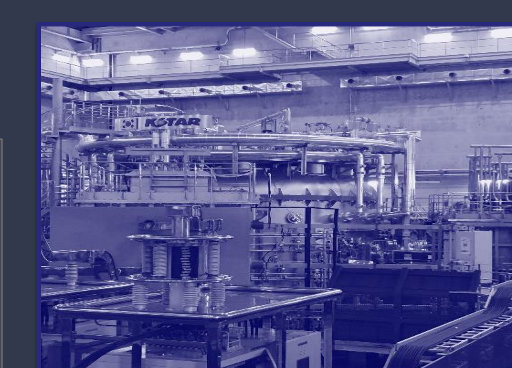
Fast-neutron imaging has emerged as a powerful non-destructive testing (NDT) method, particularly effective in scenarios where conventional X-ray or thermal neutron techniques are limited. This study explores fast neutron imaging using monoenergetic D-D fusion neutron sources, including a compact neutron generator and the KSTAR tokamak. Emphasis is placed on how different scintillator materials influence image quality, with implications for scientific diagnostics and industrial inspection. To evaluate the impact of four different scintillator materials on image clarity, spatial resolution, and signal-to-noise (SNR) using D-D fast-neutron sources.

Fast-Neutron Sources

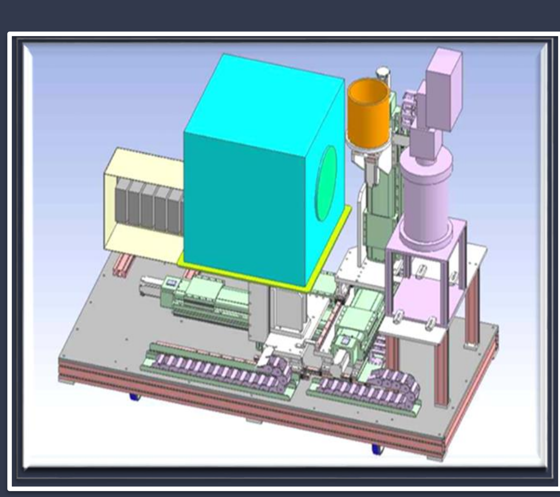
Compact D-D Neutron Generator with fast neutron flux of 1×10^8 n/sec in KFE

Portable D-D Neutron Generator with fast neutron flux of 1×10^7 n/sec



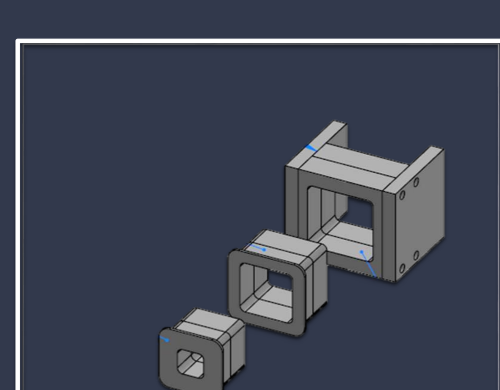
Pulsed D-D Fusion Neutron from the KSTAR Tokamak

Fast-Neutron Imaging System



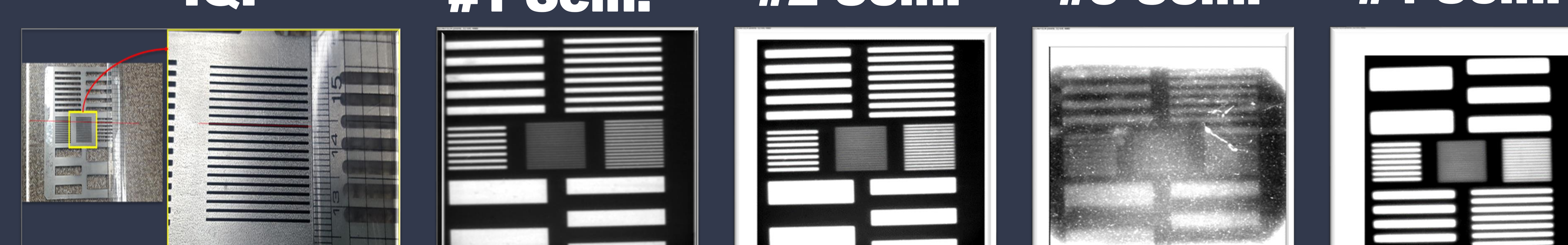
KFE Imaging system with D-D Neutron Generator

CCD Camera with scintillator holder



Neutron Beam Collimator

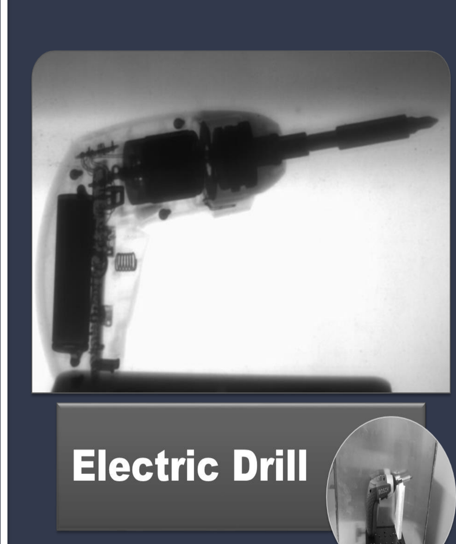
Scintillators Tested & Performance Analysis :



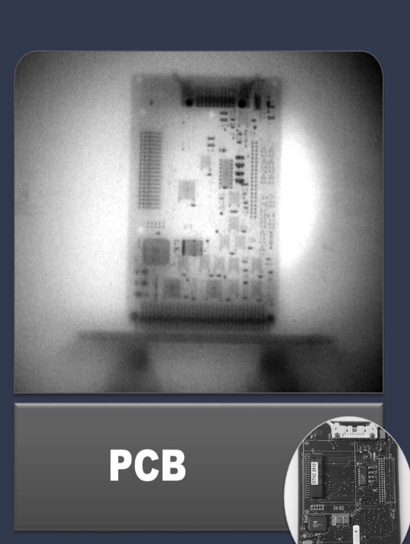
Four different scintillators were evaluated under identical exposure conditions using D-D fast neutrons. The experimental setup involved a CCD-based imaging system with a collimated beam and IQI (Image Quality Indicator) targets. No normalization was applied to the collected images to enable direct comparison. Key performance metrics included:

- Spatial resolution
- Image contrast
- Signal-to-noise ratio (SNR)
- Neutron detection efficiency

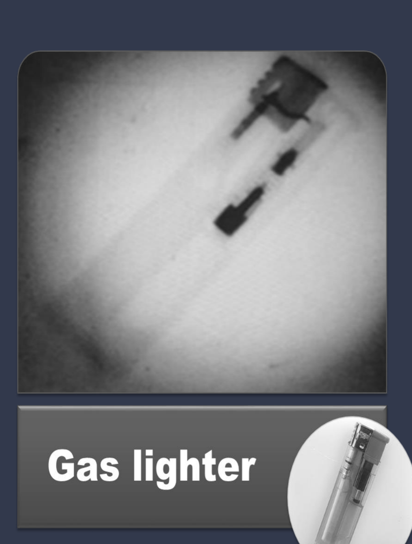
Fast-Neutron Image Gallery



Electric Drill



PCB



Gas lighter

a mug filled with water

(each image was not collected and normalized)

One scintillator produced notably sharper and clearer images, while the other three yielded higher SNRs but exhibited image blurring. This contrast is attributed to differences in:

- Light yield (affects SNR positively but may lead to optical diffusion)
- Decay time (faster decay improves image sharpness)
- Intrinsic spatial resolution of the scintillator material

These findings highlight the fundamental trade-off between image clarity and signal intensity in fast neutron imaging systems.

- Scintillator selection critically influences image performance in fast neutron imaging.
- Proper scintillator combinations enhance image quality and diagnostic reliability.
- Continued research into scintillator materials will support the advancement of fast-neutron imaging systems,
- This technology has strong potential as a reliable core method in industrial NDT, Fusion applications, and Hig-value material inspection.

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