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Simulation of Direct and Indirect X-ray Detectors Using Geant4: Advantages of Monte Carlo Methods

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X-ray detectors play a crucial role in various fields, from medical imaging to high-energy physics. This study focuses on the simulation of both direct and indirect X-ray detectors using the Geant4 toolkit, a Monte Carlo-based software widely used for particle-matter interactions. The direct detector simulation models the immediate conversion of X-rays into electrical signals, while the indirect detector simulates the conversion of X-rays to visible light, followed by an electronic signal generation.

In this work, we present a detailed comparison between direct and indirect X-ray detectors in terms of detection efficiency, spatial resolution, and signal-to-noise ratio, emphasizing the strengths of Monte Carlo simulations for modeling complex detector geometries and interactions. By leveraging the power of Monte Carlo techniques, we are able to precisely simulate photon interactions, charge transport, and the effects of detector materials and structures on performance.

The results demonstrate how Monte Carlo simulations can help optimize detector designs and enhance their performance for specific applications. Furthermore, the adaptability of Geant4 allows for custom detector configurations, making it an invaluable tool for advancing X-ray detection technologies.

Primary author: BENKABDI, Charaf Eddine (Radiations and Nuclear Systems Laboratory)

Presenter: BENKABDI, Charaf Eddine (Radiations and Nuclear Systems Laboratory)

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