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Low material budget Detector-on-Flex Packaging for silicon radiation detectors

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Low material budget is a fundamental requirement in nuclear and space experiments, where every additional gram or unnecessary layer can degrade detector performance or limit deployment. This constraint significantly impacts the design of silicon detector systems, particularly in high-precision X-ray applications where minimizing attenuation and scattering is critical.

In this work, we present a lightweight and compact packaging solution developed in our laboratories, specifically aimed at addressing these challenges. The approach is based on direct integration of the silicon detector onto a commercial flexible printed circuit board (flex-PCB), which also hosts passive components for signal and power conditioning, a preamplifier stage, and a flat-flex cable (FFC) connector for seamless connection to back-end electronics. A tailored metal frame ensures both mechanical stability and efficient thermal dissipation.

Compared to traditional rigid PCB-based assemblies, this method offers multiple advantages: significantly reduced material in the detector's active area, an open backside for increased accessibility, shorter and lower-inductance interconnects, improved thermal expansion coefficient matching, and reduced thermally induced stress. These characteristics not only improve mechanical and thermal performance but also make the system particularly well-suited for scalable integration and rapid prototyping in constrained environments.

To validate the concept, a monolithic four-channel silicon drift detector (SDD) has been successfully packaged using this methodology. The resulting subsystem, optimized for low mass, thermal efficiency, and integration flexibility, will be presented as a practical solution for next-generation X-ray detection platforms.

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