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# Flexible and Low-Material-Budget Packaging for Particle Detectors in Space

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This study presents an innovative approach to manufacturing flexible printed circuit boards (PCBs) with a low-material-budget stack, inspired by developments in the ALICE ITS1 and STAR tracker. The core of this method is the use of ultra-thin flexible cables, composed of aluminum and polyimide with thicknesses on the order of tens of micrometers, to establish connections between a sensor and its readout electronics. This design optimizes flexibility while minimizing the material budget around the sensor. The sensor interconnection is achieved through single-point Tape Automated Bonding (spTAB), an advanced alternative to traditional wire bonding, which is often unsuitable for non-planar integrations. This methodology was developed in collaboration with the University of Trento, the University of Turin, and the cleanrooms of Fondazione Bruno Kessler, and was validated within the SPES project (SuPErconducting Spectrometer for cosmic nuclear antimatter), funded by ASI. The proposed flexible PCB architecture offers significant advantages for satellite-based applications, as the minimized material budget reduces the impact of supporting electronics, ultimately enhancing experimental performance. To validate the packaging technology, a Monolithic Active Pixel Sensor (MAPS) chip, thinned to 50 µm, was integrated using this method. The resulting package consists of a flexible PCB made of Kapton and aluminum, with a two-layer architecture: one dedicated to power and digital communication and the other for grounding. The total stack thickness is approximately 100 µm, achieving a material budget X/X0 of about 0.06%. This work details the complete PCB manufacturing process, including rigorous quality assurance assessments via Plasma Focused Ion Beam (PFIB) and Scanning Electron Microscopy (SEM) imaging. Additionally, preliminary chip readout results and an analysis of sensor performance are presented. This research marks a significant step toward the adoption of this technology for space applications, demonstrating the successful integration of a MAPS detector and the viability of the proposed method. Finally, future directions, including steps toward space qualification, will be discussed.

## Eligibility for ”Best presentation for young researcher” or ”Best poster for young researcher” prize

**Authors:** LEGA, Alessandro (INFN); NOVEL, David

**Co-authors:** BELLUTTI, Pierluigi (FBK); Prof. BEOLE, Stefania Maria (Universita e INFN Torino (IT)); FACCHINELLI, Tiziano (Fondazione Bruno Kessler); IUPPA, Roberto (Universita degli Studi di Trento and INFN (IT)); PERINELLI, Alessio; RICCI, Ester (Universita degli Studi di Trento and INFN (IT))

**Presenter:** NOVEL, David

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