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#2-279 Si-microstrip LGAD detectors for cosmic-ray space-borne instruments

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Silicon microstrip (Si-µstrip) sensors are employed in most of current space detector tracking systems for charged cosmic-rays, such as the DAMPE satellite detector or the AMS-02 detector onboard the ISS. As they allow for large-area coverage with contained electronic channels and power consumptions, they are ideal sensors for high-energy physics applications in space-borne instrumentation, and are planned to be instrumented in envisioned follow-up cosmic-ray space-borne missions such as the AMS-100 or the ALADInO next-generation magnetic spectrometers.

The efficiency of such systems is however already currently impacted by "backsplash" particles generated from downstream calorimeters, which can degrade tracking efficiency by tens of percent, especially at energies approaching 1 TeV.

One potential solution to overcome this limitation and enable new measurement approaches in next-generation instruments is the development of 5D tracking systems, which provide charge, time, and three-dimensional coordinate measurements for each layer of the tracker. This approach integrates the 3D-spatial coordinate and charge |Z| measurements with layer-resolved timing information, to: i) enable improved track finding; ii) provide a redundant and independent time-of-flight system to standard scintillator based detectors; iii) remove spurious tracker hits; iv) contribute independent particle ID information to transition radiation detectors (TRDs) or calorimeters. A key benchmark for timing resolution in next-generation space detectors is a timing accuracy below 100 ps, while a finer resolution of less than 50 ps could allow to achieve additional break-through objectives such as precise isotope separation that could allow groundbreaking sensitivities in understanding cosmic-ray physics and searches for heavy nuclear antimatter in cosmic-rays.

Such performances are already well within the capabilities of pixel LGAD systems developed for accelerator physics application. However, this level of performance in space applications requires significant reduction in readout noise and further advances in front-end electronics and consumption to comply with the stringent requirements of space operations.

LGAD-based tracking systems are primarily being developed for high-energy and high-intensity collider detectors, where timing resolution below 30 ps and spatial resolution on the order of 10 micrometers are required. These developments position LGAD as an optimal candidate for 5D tracking devices in large-scale detectors. In space, radiation hardness requirements are largely less demanding than those for high-intensity collider experiments. However, the integration of LGAD microstrips, currently available in O(cm^2) area, to O(m^2) area detectors necessitates careful consideration on capacitance noise and power consumption.

To address these challenges, in the context of the Pentadimensional Tracking Space Detector project (PTSD) we are investigating and developing an innovative concept of LGAD Si-microstrip instrument based on a detector capacitance mitigation design. The integration of LGAD and standard Si-µstrip sensors in a serial readout architecture will allow for a combination of two-dimensional coordinates and timing measurements, while minimizing the detector capacitance. A breadboard laboratory model will validate the requirements and space qualification of LGAD Si-microstrips. In this contribution, the status of R&D activities which are currently progressing will be presented.

In addition, a conceptual flight-demonstrator is being designed to be housed in a 3U CubeSat platform. This demonstrator will serve as a proof-of-concept for 5D tracking in space and will open new diagnostic opportunities for cosmic-ray and gamma-ray detection. The successful development of LGAD Si-microstrip based 5D

tracking will enable sensitivities to perform ambitious objectives otherwise hardly achievable in the next generation of space-borne cosmic-ray instruments, paving the way for future discoveries in particle astrophysics.

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