Towards a 20 ps timing detector with hybrid and CMOS monolithic LGADs for the future ALICE 3 experiment at LHC

In the dynamic realm of silicon detector advancements, the pursuit of consistently improved timing precision has witnessed remarkable progress. However, the ambitious requirements of next-generation experiments, along with the broader impact on various future scenarios, such as, for example, the FCC-ee, have motivated substantial and dedicated R&D to unlock their full potential. In the context of the future ALICE 3 experiment (planned to be installed at the CERN-LHC during LS4 in 2034-35), an intensive research program is actively addressing the challenge of identifying a 20-picosecond sensor technology for the Time-Of-Flight detector.
This talk will present key results and next steps in the development of both traditional and monolithic Low Gain Avalanche Detectors (LGADs and CMOS-LGADs).

Comprehensive studies were conducted on progressively thinner LGAD, testing the first 15 μm sensors ever produced by FBK (Fondazione Bruno Kessler), Trento, Italy. The results highlighted the potential of a thinner design for improved timing performance, and a resolution below 20 ps was achieved. To address the challenge of a small signal at the input of the front-end electronics, the novel double-LGAD concept was introduced and tested for the first time. Additionally, studies on the impact of particle incidence angle provided important insights for detector design. The results of this R&D campaign, which highlighted the outstanding performance of LGADs in the different layouts and led to sensors matching the ALICE 3 requirements, will be presented.

Furthermore, extending the LGAD concept to a CMOS technology has the potential to offer a transformative path forward. A CMOS-LGAD design would allow to combine precise timing and full-area coverage in a monolithic approach, offering a simpler and cost-effective assembly. The first CMOS-LGAD prototypes were produced in the third ARCADIA engineering run using the 110 nm technology of LFoundry and were tested for the first time. The first production batches, with low gain, served as a valuable reference for subsequent sensor optimization strategies. Following these developments, the most recent produced CMOS-LGAD, showing a gain up to 14, reached an intrinsic sensor time resolution of 75 ps. Latest results and next steps toward the 20-ps goal will be discussed.