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Advancements in Low Gain Avalanche Detectors (LGAD) performance study: latest results on very thin sensors and investigation of the new "double-LGAD"concept

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This presentation focuses on the specific R&D on the state-of-the-art Low Gain Avalanche Detectors (LGADs), aimed at improving their timing performance to meet the demanding requirements of future-generation experiments. In particular, the present study focuses on evaluating the performance of the first very thin LGAD prototypes produced by the Fondazione Bruno Kessler (FBK), with a thickness of 25 and 35 μm and the introduction of the new concept of "double-LGAD", which provides advantages in electronics and time resolution. The results of these studies will be followed by an overview of the next steps.

In preparation for Run 5 (2035) and 6, the ALICE Collaboration has submitted a proposal for a next-generation heavy-ion experiment, ALICE 3, to be installed at Interaction Point 2 during Long Shutdown 4. The new experimental apparatus will be entirely made of the most advanced silicon technologies and specifically designed to provide exceptional pointing resolution and excellent Particle IDentification (PID). In particular, the Time-Of-Flight system, which will play a key role in PID, requires an outstanding time resolution of 20 ps. Several silicon technologies are under investigation to achieve this goal, and, among them, LGADs have attracted particular interest.

Despite the impressive timing performance of LGADs, which are already planned to be used in many detector upgrades, the demanding requirements of future experiments, like ALICE 3, have motivated significant R&D efforts to further improve their time resolution. The current studies have demonstrated the potential of a thinner LGAD design to achieve better timing performance. Several results obtained with the first very thin LGAD prototypes produced by the Fondazione Bruno Kessler (FBK), including extracted characteristics, charge distributions and a comprehensive analysis of the timing performance will be shown in the presentation. Following these studies, the new concept of 'double-LGAD' was implemented and tested for the first time in a beam test setup, considering couples of LGADs, both with a standard thickness of 50 μm and the ones that belong to this new generation of thin sensors. This implementation generates a higher signal, which is advantageous for the electronics and results in improved time resolution. Different results for this innovative concept are here reported, followed by a comparison with single sensors. These studies will continue by considering thinner sensors, with a thickness of 15-20 μm, for which the laboratory characterization has already started, and monolithic LGADs based on CMOS technology.

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