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Compensated LGAD –An innovative design of thin silicon sensors for very high fluences

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Future high-energy and high-intensity colliders, such as the Muon Collider or the FCC-hh, require precise particle tracking in space and time up to very high fluences, above 10^{16} 1 MeV equivalent n/cm^2 or even an order of magnitude higher.

To design future tracker detectors able to operate in very harsh radiation conditions, it is necessary to manufacture new sensors which provide excellent tracking and timing performances.

We will present an innovative silicon sensor concept which profits from the saturation of the radiation effects observed at high fluences, uses thins sensors, which are intrinsically less affected by irradiation, and internal multiplication of the signal up to the target fluences.

This breakthrough is possible thanks to a new concept of the implant responsible for signal multiplication in Low-Gain Avalanche Diodes (LGADs) obtained through the compensation of p- and n-type dopants. This new strategy is more resilient to radiation, as both acceptor and donor atoms will undergo deactivation with irradiation, but if properly engineered, their difference will remain constant. Therefore, the compensated LGADs will empower the 4D tracking ability to a fluence of 10^{17} 1 MeV equivalent n/cm^2 and above.

To achieve our target, a close interconnection with the modelling of the radiation effects is straightforward and state-of-the-art Technology CAD tools will be exploited. Present models need to be extended to unexplored regions of fluences to drive the detector engineering for the experiments of the future.

The first batch of compensated LGADs was released by FBK at the end of 2022. Sensor characterisation and signal analysis before and after irradiation will be presented and discussed. Possible improvements to the present design will be envisaged, and the next steps, guided by the modelling, will be introduced. The path to extend the validity of the present models to very high fluences will be enlighted.

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