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Next-Generation Tracking System for Future Hadron Colliders

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The design of future high-energy and high-intensity hadronic machines, such as FCC-hh, relies on the ability of detectors to sustain harsh radiation environments while keeping excellent performances on tracking and tagging all the interaction products. In order to face the challenge, a vast R&D effort is required.

In this contribution, we propose a novel concept of tracking system, that combines the possibility to track particles up to fluences of the order of $5 \cdot 10^{16} \text{ n}_{eq}/\text{cm}^2$ together with a precise time information, $\sigma_t \sim 10 \text{ ps}$. For this purpose, Low-Gain Avalanche Diodes (LGAD) are the suited technology.

For the innermost, most irradiated portion of the detector, very thin sensors ($20\text{-}40 \mu\text{m}$) with moderate gain ($\sim 5\text{-}10$) can provide the required tolerance to the radiation. For such detectors, the internal gain mechanism of LGAD allows to provide the same amount of charge released by a particle passing $100\text{-}200 \mu\text{m}$ of standard PiN diodes up to $\phi \sim 0.5 \cdot 10^{16} \text{ n}_{eq}/\text{cm}^2$. Above those fluences, the thin doped layer responsible for the signal multiplication gets deactivated, but if operated at the proper bias voltage ($\sim 500 \text{ V}$) the signal multiplication happens inside the whole irradiated bulk volume.

Moreover, in the region of the tracker detector where the level of overall fluence keeps $\leq 0.5 \cdot 10^{16} \text{ n}_{eq}/\text{cm}^2$, LGAD with a geometry optimised for timing measurement can be used to provide precise position and timing information at the same time. Considering the current timing performances of LGAD under irradiation and assuming a $\sigma_t \sim 40 \text{ ps}$ from sensor + ASIC, the usage of track-timing layers alternated to tracking only layers can provide an ultimate $\sigma_t \sim 10 \text{ ps}$ per single track.

Primary author: SOLA, Valentina (Universita e INFN Torino (IT))

Presenter: SOLA, Valentina (Universita e INFN Torino (IT))

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