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TCAD and charge transport simulations of MAPS in 65nm for the ALICE ITS3

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The Inner Tracking System 3 (ITS3) is the new vertex detector proposed for the upgrade of the ALICE experiment at CERN planned for the LHC long shutdown 3. It will consist of bent, wafer-scale monolithic pixel sensors manufactured in the TPSCo 65 nm process, reducing the material budget to an average of 0.9%X0 and the innermost layer's radius to 19 mm. These improvements will double the impact parameter resolution at 1 GeV/c transverse momentum. In the context of this upgrade, several sensor prototypes designed in a 65nm technology were produced and tested. A significant aspect of this characterization involved laboratory measurements using radioactive sources, with the 55Fe source being extensively employed. The study of these spectra enabled the evaluation of the charge collection performance of these chips, playing a crucial role in validating this technology for ITS3.

While the radiation hardness requirement for ITS3 (1013 1 MeV neq cm−2) has been fully met, higher levels of irradiation result in a degradation on the 55Fe spectra which remain to be not entirely understood. Irradiation can have various counteracting effects on silicon sensors, such as carrier trapping and doping reduction. In view of future designs, it is crucial to understand the role these effects play in the performance degradation.

To comprehensively understand this, simulating the charge transport mechanisms within these sensors is of fundamental importance. The 55Fe X-ray spectrum is used as reference for these simulations because its precise reproduction is very sensitive since it is not affected by large Landau fluctuations that are inherent to MIPs.

To achieve this kind of simulation, TCAD tools were utilized to model the electric field within the sensor, and Garfield++ was employed to simulate the charge transport and collection mechanisms.

This presentation will highlight the importance of these simulations and the tools employed. It will showcase the algorithms used to simulate the x-rays response and present comparisons with data for both non irradiated and highly irradiated chips.

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