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Improving TCAD simulation of 4H silicon carbide particle detectors

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Silicon Carbide (SiC) has several advantageous properties, making it an appealing detector material: the high charge carrier saturation velocity and breakdown voltage allow for a very fine intrinsic time resolution. The larger bandgap suppresses dark current, even for highly irradiated material, which omits the need for cooling and reduces power consumption.
TCAD simulations of SiC devices face several challenges. Several potential polytypes, its anisotropic nature, and ongoing improvements in manufacturing high-quality wafers have led to various contradicting material and model parameters. In addition, low charge carrier concentrations, a result of the wide bandgap, worsen convergence and increase computation times, necessitating adapted solver settings and error criteria as well as a thoughtful meshing procedure.

This talk presents our progress in designing and producing high-precision 4H-SiC particle detectors supported by TCAD simulations. It will review the available parameter sets and necessary physics models and discusses meshing strategies and convergence issues. Simulation results, such as I-V, C-V, and induced signals, are verified against measurements on prototype 4H-SiC p-in-n diodes.
We present a comprehensive study for a HV-optimized guard structure implemented in diodes and strip sensors of a wafer run currently being processed at CNM.
While Synopsis Sentaurus is well known and established in the HEP community, a recently initiated collaboration with the startup company Global TCAD Solutions (GTS) allows for further cross-checking and a more customized approach to build a sufficient simulation framework for 4H-SiC.

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