Contribution ID: **39** Type: **Poster**

Experimental determination of charge carrier transport models for improving simulation of the HR GaAs:Cr detectors response

Wednesday 29 June 2022 17:34 (1 minute)

The response study of Timepix3 [1] (256 x 256 pixels, pixel pitch 55 µm) with 300 µm and 500 µm thick HR GaAs:Cr [2] sensors was continued with particle beams at the Danish Centre for Particle Therapy in Aarhus, Denmark and at Super-Proton Synchrotron at CERN. The detectors were irradiated at different angles with protons and pions of energies ˜200 MeV and 120 GeV/c, respectively.

By performing measurements at grazing angle (as e.g. done in [3]), we extracted the charge carrier transport properties, i.e., the charge collection efficiencies and the charge carrier drift times as a function of the interaction depth, and measured the dependency of the electron and, for the first time, the hole drift velocity on the electric field. The latter one was found to be well described by a linear function. Moreover, we studied the dependence of the charge cloud size on the interaction depth (see Figure 1). Here, a good agreement was found with the Ruch model. All measurements were done for different detector assemblies to estimate systematic differences between them and to generalize the results.

The experimental findings were implemented into the Allpix2 simulation framework [4] and validated by comparison of measurement and simulation for various X- and ɣ-ray sources in the energy range from 5.9-122 keV (see Figure 2). Several approaches for charge carrier propagation were applied and the areas of their applicability were discussed.

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Session Classification: Poster