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Charge Diffusion Modeling and Pixel-level Differentiability in Monolithic Active Pixel Sensors

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Accurately simulating the response of monolithic active pixel sensors requires detailed technology computer-aided design simulations of the electric field inside the chip. This is used to model the electron propagation from their point of origin to potential collection. Specialized simulation software, such as Allpix², has been developed for this purpose. However, the electric field is often unobtainable due to the confidential nature of the chip's exact design properties. Further, such simulations are very time-consuming and difficult to differentiate, making them unappealing for end-to-end optimization pipelines.

In contrast, several analytical models for the charge collection process have been introduced, which do not require information about the electric field, but instead can be employed by fitting their parameters to match experimental data. We present a comparison of different approaches in terms of accuracy as well as differentiability of the models using data from an experiment with a small pixel telescope based on the ALPIDE sensor.

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