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iactsim: a CUDA-accelerated simulation framework for IACTs

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Analyzing data from Imaging Atmospheric Cherenkov Telescopes (IACTs) requires large-scale Monte Carlo simulations of air showers and the detailed simulation of telescope optics and Cherenkov camera. Within the simulation of the telescope response, optical ray-tracing and camera electronics are the most time-consuming parts. Fortunately, these tasks involve many independent calculations (photon propagation and pixel response) that can be run concurrently. This makes them ideal candidates for acceleration using Graphics Processing Units, which have become widespread in both High Performance Computing systems and consumer hardware over the past decade due to their high parallel processing power and energy efficiency.

We have developed *iactsim*, a Python simulation framework, using CUDA to parallelize these specific tasks. *iactsim* is designed as a user-friendly and adaptable set of tools to support IACT performance evaluation, instrument design and data analysis. We have validated the framework capabilities by simulating the ASTRI dual-mirror optical system and its SiPM-based camera, confirming its effectiveness even in its early development stage.

Although it has been designed for IACT simulations, a key feature of *iactsim* is the separation between the optical ray-tracing and the camera electronics simulation. This modularity allows users to simulate the pixel response independently, using photon propagation results generated by external software (such as Geant4). As a specific application, we have used it to simulate the detection of Cherenkov photons induced by muons passing through the ASTRI camera protective window.

Here we present these ASTRI-specific use case studies, performance analysis and comparison with existing software.

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