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Offloading electromagnetic shower transport to GPUs: the AdePT project

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Several online and offline applications in high-energy physics have benefitted from running on graphics processing units (GPUs), taking advantage of their processing model. To date, however, general HEP particle transport simulation is not one of them, due to difficulties in mapping the complexity of its components and workflow to the GPU's massive parallelism features. Deep code stacks, with polymorphism, low branch predictability, incoherent memory accesses, and the use of stateful global managers are significant obstacles preventing porting Geant4 to GPUs. HEP computing will need to exploit more and more heterogeneous resources in the future, and our current inability to use GPU cards for detailed simulation of collider experiments limits the total performance available and raises costs, motivating R&D in this area.

The AdePT project is one of the R&D initiatives tackling this limitation and exploring GPUs as potential accelerators for offloading some part of the CPU simulation workload. We started one year ago with the ambitious goal of demonstrating a complete workflow working on GPU, having all the simulation stepping components: complete physics models describing the electromagnetic processes, magnetic field propagation in detector geometry, and code producing user hits data transferred from the GPU back to the host. The project is the first to create a full prototype of a realistic electron, positron, and gamma EM shower simulation on GPU implemented as either a standalone application or as an extension of the standard Geant4 CPU workflow.

Most of the original goals have already been achieved, and the prototype provides a platform to explore many optimisations and different approaches. We will present the most recent results and initial conclusions of our work, including a performance study comparing standalone and hybrid workflows on the CPU and GPU. We will describe the main features and components of the demonstrators developed in the AdePT project, the optimization process, and our preliminary understanding of the usability of GPUs for full simulation in HEP applications.

Significance

The work covers novel results about running general HEP simulation workflows on GPUs and in hybrid mode, a topic of major interest for the experiments.

References

https://indico.cern.ch/event/1019940/contributions/4301574/attachments/2224572/3767578/AdePT%20HSF%20Detector%20Sim%20group%

Speaker time zone

Compatible with Europe

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