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Celeritas: evaluating performance of HEP detector simulation on GPUs

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Celeritas is a Monte Carlo (MC) detector simulation library that exploits current and future heterogeneous leadership computing facilities (LCFs). It is specifically designed for, but not limited to, High-Luminosity Large Hadron Collider (HL-LHC) simulations. Celeritas implements full electromagnetic (EM) physics, supports complex detector geometries, and runs on CPUs and Nvidia or AMD GPUs. Celeritas provides a simple interface to integrate seamlessly with Geant4 applications such as CMSSW and ATLAS FullSimLight.
Using EM-only benchmark problems, we show that one A100 GPU is equivalent to 32-240 EPYC CPU cores on the Perlmutter supercomputer. In a test beam application using the ATLAS tile calorimeter geometry and full hadronic physics simulated by Geant4, offloading EM particles to Celeritas results in a 3x overall speedup on GPU and 1.2x on CPU.
We will present the current capabilities, focusing on performance results including recent optimization work, power efficiency, and throughput improvement.

Significance

Heterogeneous architectures are increasingly more common, particularly within the TOP500 systems. LHC experiments such as ATLAS and CMS spend a significant amount of their computing budget on detector simulation traditionally done on CPUs. With the upcoming HL-LHC, the data complexity and quantity will significantly increase, challenging the current simulation software. This work will enable experiments to use GPUs for detector simulations.

References

https://indico.jlab.org/event/459/contributions/11818/

Experiment context, if any

ATLAS,CMS

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