



Contribution ID: 390

Type: **Talk**

GPU-friendly surface model for Monte-Carlo detector simulations

Monday 21 October 2024 17:27 (18 minutes)

The demands for Monte-Carlo simulation are drastically increasing with the high-luminosity upgrade of the Large Hadron Collider, and expected to exceed the currently available compute resources. At the same time, modern high-performance computing has adopted powerful hardware accelerators, particularly GPUs. AdePT is one of the projects aiming to address the demanding computational needs by leveraging these heterogeneous compute architectures. While AdePT has successfully ported realistic detector simulations to GPUs using the VecGeom library, the complexity of geometry modeling emerged as a bottleneck. Thread divergence and high register usage were impeding the GPU performance. Therefore, a new, GPU-friendly surface-based model has been introduced in the VecGeom library that decomposes the divergent code of the 3D primitive solids into simpler and more balanced surface algorithms. In this work, we present the latest performance results, in particular on complex setups like the CMS Phase-2 geometry. Additionally, we explore techniques such as mixed precision and bounding volume hierarchies to further accelerate simulations.

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Session Classification: Parallel (Track 5)

Track Classification: Track 5 - Simulation and analysis tools