Contribution ID: **5** Type: **Talk**

Sampling secondary particles in high energy physics simulation on the GPU

Friday, 12 September 2014 09:00 (30 minutes)

We present a massively parallel application for sampling secondary particles in high energy physics (HEP) simulation on a Graphics Processing Unit (GPU). HEP experiments primarily uses the Geant4 toolkit (Geant4) to simulate the passage of particles through a general-purpose detector, which requires intensive computing resources due to the complexity of the geometry as well as
physics processes applied to particles copiously produced by primary
collisions and secondary interactions. The combined composition and
rejection methods to sample secondary particles often used in Geant4 may not be suitable for optimal performance of HEP events simulation using recent hardware architectures of accelerated or many-core processors owing to the stochastic nature of the Monte Carlo technique. An alternative approach based on a discrete inverse cumulative probability distribution is explored to minimize the divergence in thread level parallelism as well as to vectorize
physics processes for spatial locality and instruction throughput. The inverse cumulative distribution of the differential cross section associated with each electromagnetic physics process is tabulated based on algorithms excerpted from Geant4 and a simple random sampling technique with a linear interpolation is implemented for GPU. Validation and performance evaluation with the alternative technique compared to the conventional composition and rejection method both on GPU and CPU are presented.

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Session Classification: GPU in Offline, Montecarlo and Analysis (3/3)