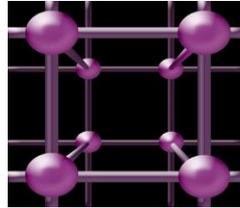


Lattice QCD with GPUs

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Understanding the structure and interactions of subnuclear particles represents the main challenge for today's nuclear physics. Theoretically, the behavior of subnuclear particles is described by Quantum Chromodynamics (QCD). Lattice QCD is a 4-dimensional discretized version of this theory that can be solved numerically.

We have several research areas. We study the structures of particles by placing them in an external electric field. A quantity called the polarizability is a measure of the rigidity of the particle. We measure interactions between two particles by placing them in a finite box and computing the so called scattering cross section. A peak in the scattering cross section is an indication of the creation of an intermediate particle. These quantities have been computed using GPUs.



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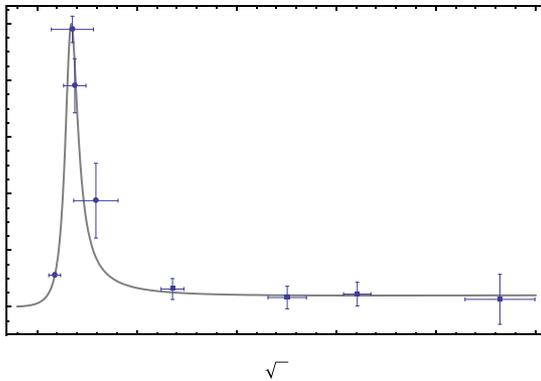
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Why GPUs?

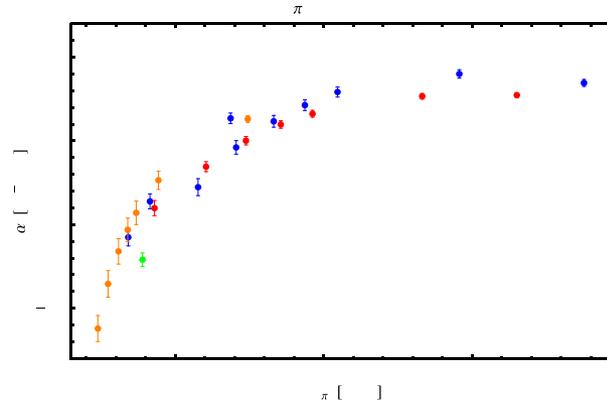
- Lattice QCD simulations require very large bandwidth to run efficiently. GPUs have 10–15 times larger memory bandwidth compared to CPUs.
- Lattice QCD simulations can be efficiently parallelized.
 - Bulk of calculation spent on one kernel.
 - The kernel requires only nearest neighbor information.
 - Cut the lattice into equal sub-lattices. Effectively use single instruction multiple-data (SIMD) paradigm.

Scattering



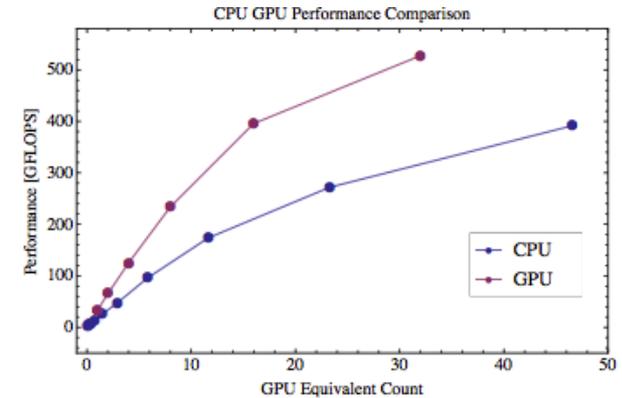
- Two particles are placed in a box and interact with each other
- Computational time: 100,000 GPU hrs

Polarizability



- An electric field is used to probe the internal structure of hadrons
- Computational time: 300,000 GPU hrs

Efficiency



Performance comparison between Keeneland's GPU cluster and Kraken's Cray XT-5 machine. The CPU core count is translated to GPU equivalent count by dividing the total number of CPUs by 22, which is the number of CPU cores equivalent to a single-GPU performance.

