Running GEANT4 Functions on a GPU
Discussion of Results

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Overview

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Brief Project Overview
Explanation of Terms
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Purpose

Brief Project Overview

Take an existing particle simulation toolkit - GEANT4 - and have some functions run on a GPU device to improve performance.

Definition: GEANT4

GEANT4 is

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What is GEANT4

- Geant4 is a toolkit that is meant to simulate the passage of particles through matter.
- It has been developed over the years through collaborative effort of many different institutions and individuals.
- Geant4 has many different applications, including applications in high energy physics, space and radiation, medical.

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What is GP-GPU

- General purpose graphic processing unit computing is a re-purposing of graphics hardware
- Allows GPUs to perform computations that would typically be computed on the CPU
- If problems are suitable to mass parallelization

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Easily Enable/Disable GPU Acceleration
Impl. 1: Existing Module in GPU Memory
Impl. 2: Add New GPU-Accelerated Functions to Interface
Accuracy / Testing

Easily Enable/Disable GPU Acceleration

- Old projects can be run using GPU acceleration with out having to change anything
- No new functions to learn

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Accelerating Module on GPU

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Why G4ParticleHPVector

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Two Implementations

- Run everything on the GPU
- Only select functions run on GPU

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Completely on GPU

- The vector is stored exclusively on the GPU
- $+$ Do not have to maintain a copy of the vector on the CPU
- $+$ Do not have to maintain the hashed vector
- $+$ Reduces how much is being copied to the GPU
- $-$ All functions are run on the GPU

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Implementation – Times

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Implementation – `GetXSec`

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Implementation – `SampleLin`

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Performance Results Summary

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Performance Results – `Times`

- Multiplies each point in vector by factor

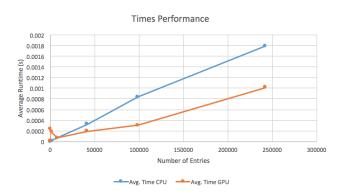Figure: Runtime vs. Number of Data Points – `Times`

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Performance Results – `GetXSec`

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Performance Results – `SampleLin`

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Performance Results – System Tests

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Impl. 2: Add New GPU-Accelerated Functions to Interface

+ Only functions that run faster on the GPU are implemented

+ Not forced to run functions that run slowly on GPU

− Will have to maintain two copies of the vector

− More copying the vector to and from the GPU

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Performance Results Summary

- Most functions slower on GPU until ~10,000 entries
- Most *commonly-used* functions significantly slower on GPU
    - Lots of data accesses
- Many problems in vector class not well-suited to parallelism

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Performance Results – `GetXSeclList`

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Accuracy

Testing

Summary of Results

Recommendations