GEANT-4 GPU Port:

Software Requirements Specification
Volere Template, Edition 16

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1 Project Drivers

1.1 Purpose of Project

Project Background
Currently running GEANT4 simulations that require many particle takes a long time to compute when run on the CPU. By running the simulation on the GPU the user should be able to see a significant speed up in computation times

Goal of the project
The goal of this project is to port the GEANT4 code to be able to run on the GPU.

1.2 Stakeholders

2 Project Constraints

2.1 Mandated Constraints

There are global constraints put in place by the existing software, the stakeholders, and the structure of 4ZP6. The project must be built upon the

existing GEANT4 code. The final product must be able to run any code/simulation that ran on the existing software. The software must run in parrallel on an NVIDIA GPU. Additionally, the final product needs to be completed by the end of April, 2016. If these global constraints are not met the final product is not acceptable.

2.2 Naming Conventions & Terminology

Throughout the document, "the project", "the product", and/or "the software" all refer to the modified GEANT-4 code that will run on a GPU. The "existing software" refers to the current GEANT-4 simulation program, including the modifications made by McMaster's Engineering Physics department to suit it to their needs.

Term	Description
GEANT-4	open-source software toolkit used by stakeholders to simulate the passage of particles through matter
GPU	graphics processing unit, well-suited to parallel computing tasks
CUDA	parallel computing architecture for general purpose programming, developed by NVIDIA

Table 1: Glossary

2.3 Relevant Facts and Assumptions

Facts

- GEANT4 is programmed using C++

Assumptions

- It is assumed that the user will have an understanding of particle physics
- It is assumed that the user will know how to use GEANT4

3 Functional Requirements

3.1 The Scope of the Work

3.2 Business Data Model & Data Dictionary

3.3 The Scope of the Product

The following table outlines the use cases for the product. Click the PUC # to go to its description. Descriptions of each PUC, referenced by PUC # are

PUC #	PUC Name	Actor(s)	Input/Output
1	Simulating Particles	Researcher	Simulation parameters (in), Distribution of particle's locations (out)

Table 2: Product Use Cases Summary

as follows.

1. The software will be used by researchers wishing to simulate large numbers of particles interactions with materials. The researcher sets simulation parameters, including the number of particles, their lifetime, and the material properties before running the simulation. On completion, the program gives back a map of where each particle travelled, so researchers can study where the particles are most probably to end up.

3.4 Functional Requirements

Req. #: 1	**Req. Type**: 3.4	**Use Case #**: 1

Description: Particle computations run on the GPU

Rationale: Design requirement, so that particle simulations run faster

Fit Criterion: Benchmarking a program before and after implementing the GPU code should show simulation speed ups by at least 30 times.

Priority: Very High **History**: Created September 29, 2015

Req. #: 2	**Req. Type**: 3.4	**Use Case #**: 1

Description: Changing existing projects to run with new GPU functions should be easy

Rationale: Design requirement, so that the user is able to easily run old projects with GPU code. This will also allow existing users to already know how to use the new code.

Fit Criterion: User should be able to fin and replace the names of their old functions with the new GPU functions. Upon recompilation of the project they should receive no errors.

Priority: High **History**: Created September 29, 2015

Req. #: 3	**Req. Type**: 3.4	**Use Case #**: 1

Description: Old projects should not be affected by the new code

Rationale: Design Requirement, don't want to break already existing code that works.

Fit Criterion: All old projects should be able to run exactly the same as before including the GPU library.

Priority: High **History**: Created September 29, 2015

Req. #: 4	**Req. Type**: 3.4	**Use Case #**: 1

Description: Running the GPU code on a computer that does not have a compatible GPU card should not cause the simulation to crash, just have simulation run on CPU like before.

Rationale: Want GEANT4 GPU projects to still be able to run on as many computers as possible.

Fit Criterion: Atleast 95% of all computers running non-Nividia graphics cards should still be able to run simulations

Priority: Medium **History**: Created September 29, 2015

4 Non-functional Requirements

4.1 Look and Feel Requirements

4.2 Usability and Humanity Requirements

4.3 Performance Requirements

4.3.1 Speed and Latency Requirements

Req. #: 5	**Req. Type**: 4.3	**Use Case #**: 1

Description: Decreasing the time it takes to run a simulation while maintaining identical results.

Rationale: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis.

Fit Criterion: Running a simulation with a given set of input parameters should complete significantly faster on the product as compared to the existing software. Both should have identical outputs.

Priority: Very High	**History**: Created September 27, 2015

4.3.2 Safety Critical Requirements

Req. #: 6	**Req. Type**: 4.3	**Use Case #**: 1

Description: Decreasing the time it takes to run a simulation while maintaining identical results.

Rationale: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis.

Fit Criterion: Running a simulation with a given set of input parameters should complete significantly faster on the product as compared to the existing software. Both should have identical outputs.

Priority: Very High	**History**: Created September 27, 2015

4.3.3 Precision of Accuracy Requirements

Req. #: 7	**Req. Type**: 4.3	**Use Case #**: 1

Description: Decreasing the time it takes to run a simulation while maintaining identical results.

Rationale: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis.

Fit Criterion: Running a simulation with a given set of input parameters should complete significantly faster on the product as compared to the existing software. Both should have identical outputs.

Priority: Very High	**History**: Created September 27, 2015

4.3.4 Reliability and Availability Requirements

Req. #: 8	**Req. Type**: 4.3	**Use Case #**: 1

Description: Decreasing the time it takes to run a simulation while maintaining identical results.

Rationale: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis.

Fit Criterion: Running a simulation with a given set of input parameters should complete significantly faster on the product as compared to the existing software. Both should have identical outputs.

Priority: Very High	**History**: Created September 27, 2015

4.3.5 Robustness or Fault-Tolerance Requirements

Req. #: 9	**Req. Type**: 4.3	**Use Case #**: 1

Description: Decreasing the time it takes to run a simulation while maintaining identical results.

Rationale: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis.

Fit Criterion: Running a simulation with a given set of input parameters should complete significantly faster on the product as compared to the existing software. Both should have identical outputs.

Priority: Very High	**History**: Created September 27, 2015

4.3.6 Capacity Requirements

Req. #: 10	**Req. Type**: 4.3	**Use Case #**: 1

Description: Decreasing the time it takes to run a simulation while maintaining identical results.

Rationale: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis.

Fit Criterion: Running a simulation with a given set of input parameters should complete significantly faster on the product as compared to the existing software. Both should have identical outputs.

Priority: Very High	**History**: Created September 27, 2015

4.3.7 Scalability Requirements

Req. #: 11	**Req. Type**: 4.3	**Use Case #**: 1

Description: Decreasing the time it takes to run a simulation while maintaining identical results.

Rationale: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis.

Fit Criterion: Running a simulation with a given set of input parameters should complete significantly faster on the product as compared to the existing software. Both should have identical outputs.

Priority: Very High	**History**: Created September 27, 2015

4.3.8 Longevity Requirements

Req. #: 12	**Req. Type**: 4.3	**Use Case #**: 1

Description: Decreasing the time it takes to run a simulation while maintaining identical results.

Rationale: Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis.

Fit Criterion: Running a simulation with a given set of input parameters should complete significantly faster on the product as compared to the existing software. Both should have identical outputs.

Priority: Very High **History**: Created September 27, 2015

4.4 Operational and Environmental Requirements

4.4.1 Expected Physical Environment

- The product shall be used by an engineering Physics professor, researcher or student
- The user will be sitting down in a temperature controlled environment

4.4.2 Requirements for interfacing with adjacent Systems

- The product shall work with the last four versions of GEANT4

4.4.3 Productization Requirements

- The product shall be distributed as a ZIP file.
- The product will be available on a public repo for users to download

4.4.4 Release Requirements

- Later versions of the product that have been patch will be available on the public repo

- Each release shall to cause previous features to fail.

4.5 Maintainibility and Support Requirements

4.6 Security Requirements

4.7 Cultural Requirements

NA

4.8 Legal Requirements

4.8.1 Compliance Requirements

NA

4.8.2 Standards Requirements

NA

5 Project Issues

5.1 Open Issues

5.2 Off-the-Shelf Solutions

5.3 New Problems

This section will be updated with new problems as they come along.

5.4 Tasks

Record of Proposed Project	September 18
Problem Statement	September 25
Requirements Document Revision 0	October 9
Proof of Concept Plan	October 23
Test Plan Revision 0	October 30
Proof of Concept Demonstration	November 16 - 27
Design Document Revision 0	January 1

Revision 0 Demonstration	February 1 - 27
User's Guide Revision 0	February 29
Test Report Revision 0	March 21
Final Demonstration (Revision 1)	Exam period
Final Documentation (Revision 1)	April 1

5.5 Migration to the New Product

5.6 Risks

5.7 Costs

All software used in the project is open-source and/or available for free. Existing hardware will be used for development, so there are no associated monetary costs.
Below are time estimates for each deliverable (as outlined in 5.4).

Task	Time	Rationale
Record of Proposed Project	6	Finished task in this amount of time.
Problem Statement	5	Finished task in this amount of time.
Requirements Document Rev 0	14	Finished task in this amount of time.
Proof of Concept Plan	4	Finished task in this amount of time.
Test Plan Revision 0	4	Finished task in this amount of time.
Proof of Concept Demo	4	Finished task in this amount of time.
Design Doc Revision 0	4	Finished task in this amount of time.
Revision 0 Demo	4	Finished task in this amount of time.
User's Guide Revision 0	4	Finished task in this amount of time.
Test Report Revision 0	4	Finished task in this amount of time.
Final Demo Revision 1	4	Finished task in this amount of time.
Final Documentation Revision 1	4	Finished task in this amount of time.

5.8 User Documentation and Training

- Function descriptions shall be provided for every new function.

- There shall be .txt file accompanying the project that will explain to the user the changes as well as how to use the new functions
- Users who know how to use GEANT4 should be able to easily use the new functions

5.9 Waiting Room

5.10 Ideas for Solutions