GEANT-4 GPU Port:

Software Requirements Specification
Volere Template, Edition 16

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Contents

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

The stakeholders that are currently involved with the project include: the project group, the supervisors of the project, as well as the McMaster Engineering Physics Department.

1.2a The Client

The client(s) for the project is the Dr. Buijis and his Grad Student Westly, representing the McMaster Engineering Physics Department.

The clients proposed the project because they have invested interest in running GEANT-4 simulations more efficiently.

They will be using the parallelized code to run and study nuclear simulations, and need the code to run much more quickly to obtain useful data.

1.2b The Customer

The customer in this case also includes the client; and as such they will be the part of the end-user group that we will cater to.

The customer is also other members of the Engineering Physics department who wish to run simulations using GEANT-4 as they also have use for the end product.

The users will want to run simulations with many particles and particle collisions, the optimization of the code will allow for them to do this in a timely fashion.

1.2c Other Stakeholders

The project group members hold stake in the successful completion of the project. If the project is done well, and the documentation is error free and concise, they are bound for high grades in their course.

Collaborators and users of the GEANT-4 project could be potential stakeholders, but only if after the project is completed, they accept our contributions to GEANT-4.

1.2d The Hands-On Users of the Product

Undergraduate and graduate students as well as professors in the McMaster Engineering Physics Department would be hands on users of the product.

1.2e Personas

Consider Matt Douglas, a graduate student in the Engineering Physics Department. Matt needs to see how a nuclear reactor would start given some specific starting conditions, and a close

to realistic number of particles. Matt isn't particularly fluent in C, but he can manage to change some starting variables. Matt inputs his desired number of particles and specific starting conditions into a GEANT-4 simulation. The simulation runs for several hours before Matt realizes that it might be too much for his software and hardware setup. He finds a version of GEANT-4 written for NVIDEA GPU's that claims to speed up a simulation on average 400x. He installs this version of GEANT-4 and attempts his simulation again. This time it takes only a half hour for his simulation to yield results.

The project will help not only graduate students like Matt, but undergraduates as well. It is a useful as a learning tool as well as for research projects.

1.2f Priorities Assigned to Users

Priority will be given to Wesley, the grad student that proposed the project to Dr. Buijis. He will be the first and main user of GEANT-4 after it is running in parallel.

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 as follows.

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

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

Placholder Text.

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. #: 1	**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. #: 2	**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. #: 3	**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. #: 4	**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. #: 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

4.3.6 Capacity 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

4.3.7 Scalability 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

4.3.8 Longevity 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

4.4 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