



Two Years into Transforming Geant4 for the Future



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Welcome to Fermilab

More than two years ago we started a journey together

- High Energy Physics institutions investigating ways to improve the computing performance of their software tools
- Advanced Scientific Computing Research funded institutions contributing their knowledge and tools to the same cause

Two scientific disciplines understanding each other's communities, organization, projects, work habits, goals

We grew into good colleagues, collaborators, friends

- Delivered low hanging fruit although most fruit is not hanging too low, as predicted
- Initiated R&D focused on new computing architectures and programming paradigms



Progress and Accomplishments

1. The successful integration of a team of experts from ASCR and HEP. Both sides learned the language and capabilities of the other side and got familiar with the details and needs of the project.
2. Formal code reviews of the existing implementation of the Geant4 electro-magnetic physics calculations, which resulted in noticeable improvement in performance and code quality.
3. Performance improvements of some computationally heavy operations by using memoization techniques in hadronic physics calculations.
4. Various localized improvements in the performance of both existing CPU and newly developed GPU code.
5. Tools and techniques leveraging existing ASCR products such as HPCToolKit and TAU, which were used to analyze the performance of both existing Geant4 code and the GPU prototype code.



Progress and Accomplishments

6. A Coprocessor Prototype that includes the simulation of physics process and the propagation of particles through electromagnetic fields on NVidia General Purpose GPU. The prototype is a demonstrator of basic functionalities of Geant4 on a GPU. A large body of Geant4 code was ported to CUDA, shows a promising performance speed-up and constitutes a test bench to investigate directions for optimization and rewrite of Geant4.
7. Code to simulate propagation of particles in electromagnetic fields designed from the ground up to take advantage of modern CPU, GPGPU and coprocessor's architecture.
8. Code to simulate physics processes designed from the ground up to take advantage of modern CPU, GPGPU and coprocessor's architecture.
9. Started development of a detector simulation framework with all the elements of the Geant4 toolkit, called the Geant Vector Prototype or GeantV, designed from the ground up to take advantage of modern CPU, GPGPU and coprocessor's architecture - in collaboration with CERN.



Today

Present progress on all the previously mentioned topics and discuss the next steps ...

(There is some uncertainty related to funding on the ASCR side ... some hope to revert this.)



Outlook

We have established a successful HEP-ASCR collaboration to transform Geant4 for the future

- Delivered low hanging fruit and initiated R&D for transformation to run on modern computing architectures under new software paradigms.
- Partnered with the principal foreign HEP laboratory, i.e. CERN, also with UNESP (Brazil).
- Opportunity to associate projects with initiatives such as the HEP Software Foundation (HSF) and the DOE Center for HEP Computing Excellence - collaborate on common software, optimize services, leverage resources.

Let's make every effort towards the continuation of our ASCR-HEP partnership and plan for success