Achievements:

It was verified that there was no low hanging fruit to harvest in the G4 code in what respects to improving its execution time performance. The CPU time distributions of the most consuming functions showed fractions in the 1-3% range. The ASCR and HEP (FNAL, SLAC) teams therefore followed the strategy to perform comprehensive reviews of entire sections of the G4 code such as the EM physics and the hadronic cross sections packages. These code and analysis reviews found opportunities for improvements, some requiring a modest development effort in localized code sections, with the potential to save on the order of 10% of the execution time of a typical HEP simulation application. These improvements, once implemented, would allow significant savings on computing infrastructure to the planned HEP experiments.

The FNAL team developed a first G4 based CUDA prototype running on GPU. This simple prototype includes only a few geometry shapes to model a simplified version of the CMS electromagnetic crystal calorimeter and most EM physics processes. Performance studies showed a GPU/CPU speedup of a factor of 20 when comparing a many cores GPU card to one CPU core. Redesign for optimal SIMT/SIMD performance is underway.

The FNAL simulation group has partnered with the CERN Software (SFT) group to explore opportunities for vectorization of the Geant4 components such as geometry, navigation, and physics. Preliminary work indicates speedups on the order of a factor of 3 for typical geometry functions. The GPU and vector prototypes are being integrated with the goal of evaluating the benefits of vectorization and parallelism in CPU/GPU hybrid systems.

The ASCR team instrumented Geant4 for profiling and tracing measurements using the TAU Performance System and the HPC ToolKit.

The HEP/ASCR teams met face-to-face on February 4th at Fermilab to discuss progress and plans. The vector prototype team held a face-to-face working week on January 21st -24th which will be followed by a second work meeting at CERN in early April.

First draft of a list of elements to include in a 2015 plan:

1st: Code reviews to identify areas for incremental improvement. Examples include EM and cross section packages in addition to a comprehensive review of the computational functions to manually improve expression evaluation and localized code transformation opportunities (common-sub expression elimination, procedure in-lining algebraic simplification).

2nd: Move from a set of experiments exploring the benefits of vectorization and parallelization to a full prototype that integrates all pieces of a detector simulation toolkit such as geometry, navigation, and physics.

3nd: Development and adaptation of tools for performance evaluation of the proposed prototype.