Geant4 Plan of Work 2021

Infrastructure, Kernel modules
Summary 2020

- Major achievements
- Excluding maintenance & support
- Presented also at last January Technical Forum
Releases

• Geant4 10.7
  • Patch releases: 10.6.p01, p02, p03

• New releases of VecGeom, v1.1.6 to v1.1.9

• Geant4 Monthly development releases

Courses

• Technical Training @ CERN on Geant4 [open to externals]
  • [Beginners Course](#), 21 - 23 January (new interactive format based on hands-on)
  • [Advanced Course](#), 28 September – 2 October (fully Virtual)
Highlights Infrastructure 2020
Updates to infrastructure

• Enhanced CMake configuration/build system
  • Enabled support of G4Py module activation at configuration
  • Simplified CMake scripts and new CMake “backend” to enable future modularisation of Geant4 libraries

• Geant4 Testing infrastructure
  • Added support for new systems/compilers configurations and LCG builds/views

• Improvements to GitLab workflow for patches and release management
  • Upgrade to new Jenkins version and system
  • Upgraded Geant4Bot to latest GitLab versions, allowing for quicker upgrades in future with GitLab CI, Docker and OpenShift pipelines
  • First prototype adopting GitLab CI
  • Improved notifications back to Merge Requests
  • Enlarged pool of shifters for monitoring daily testing

• Completed migration of Geant4 Web site to Drupal-8
Nightly integration testing, validation

• Simulation validation portal (geant-val.cern.ch)
  • Further development/improvement to the portal
    • Migrated to latest Angular version
    • Enhanced UI and more friendly representation/display of results
    • New web framework
    • New features: new static/JavaScript Root plots
    • Latex formula renderer moved from MathJax to KaTeX
  • Integrated new tests and benchmarks
Profiling & monitoring tools

- Better integration and new settings for TiMemory built-in profiling
  - Allowing for per-{run,event,track,step} profiling, to enable at configuration
- Geant4 performance regression testing and monitoring
  - Standalone application, with configurable parameters (GDML geometry, reference physics-list, particle-gun/generator input, number of threads/events)
  - Integration with CDash, Jenkins/GitLab-CI
- Added possibility to enable backtracing for debugging purposes
Geometrical Primitives

• Updated VecGeom library, VecGeom v1.1.9
  • Selection for enabling use made at configuration
    • [https://gitlab.cern.ch/VecGeom/VecGeom/tree/v01.01.09](https://gitlab.cern.ch/VecGeom/VecGeom/tree/v01.01.09)
  • Improved configuration settings
  • Ray-tracing using VecGeom CUDA backend on GPUs
  • Identified possible optimizations
    • Use of a global navigation index table with caching of transformations
    • Adoption of single precision in navigation
  • Bug fixes

• Improved speed for overlaps detection
  • Either through UI commands or at geometry construction
  • Improved algorithms for generation of random points on surface and computation of surface area and cubic volume on specific solids
Navigation & Field

• New templated field classes for equation of motion and selected steppers
  • Avoid virtual call for field and equation
  • Expected to provide a direct speedup

• Enhanced reporting from field drivers & debugging logs
  • New dedicated class G4DriverReporter
  • New **check-mode** for G4PropagatorInField and G4VIntersectionLocator
  • Adoption of new whiteboard for logging/debugging

• Further C++11 revision of geometry code

• Code optimization to G4Transportation class
Tasking in Geant4

• New tasking system (Beta version) as option in Geant4 10.7
  • Dedicated run manager (G4TaskRunManager) and factory (G4RunManagerFactory), enabling use of tasks for the event loop
  • Based on PTL (Parallel Tasking Library) package
    • C++11 library with internal thread-pool, task-groups and task-queue
    • Limited support of custom task-queues
  • Fully compatible with Intel/TBB, which can be selected at configuration

Parameterisations

• New general facilities based on Gflash
  • Facilitating multiple hit (energy & position) creation from fast simulation models
Workplan 2021

• *Program of work still under preparation*
• *Full version to be presented at next Technical Forum*
• *User support not taken into account*

(*) Carry over from 2020
Releases

• 2021 release of Geant4 - (all)
  • Overall planned features for inclusion to be published in March
  • Discussion at the next Geant4 Technical Forum

• Consolidated releases of VecGeom - (GA, GC, AG, GL, RS, ET, SW)
  • Including new developments for adaptation on GPUs
Infrastructure & Kernel

• Enhancements to Geant4 GitLab workflow - (GA, GC, GF, PM, BM)
  • Adaptation to new features in future versions of GitLab
  • Additional Geant4Bot capabilities

• Continue study on adoption of GitLab CI - (GA, GF, BM)

• Modularization of Geant4 Libraries (*) - (GC, BM)
  • Global/granular/optional

• Enhancements to build system - (GA, GC, GF, JM, BM)
  • Allow build/install of VecGeom and other core dependencies
  • Switch to C++17 as minimum requirement
  • Retirement of GNU Make build system – (GC, BM)

• Optimization of Data Libraries (*) - (GC, BM)
  • Simplify data library configuration/location
  • Provide C++ API for accessing/parsing data libraries
  • Optimize file access patterns and formats to minimize number of small files opened

• Investigate/review usage of "Unity" builds for Continuous/Nightly – (BM)

• Prototype of Geant4 web site based on Jekyll and Git managed content - (DK, GF, GrL, AZ)

• Migrate Geant4 Python module G4Py from Boost to pybind11 - (BM, UI developers)

• Integration of automated performance monitoring – (GA, BM)

• Simplification of custom allocator usage – (GC, JM, BM)

• Extend use of workspaces and task-based parallelism default in Geant4 (*) - (MA, GC, JM)
Testing & Validation

- Continuous integration of new physics (EM & hadronic) tests - (DK, GrL, IR, LP, GF)
  - Including calorimeter test-beams benchmarks
- Validation portal (geant-val.cern.ch) - (DK, GrL, IR)
  - Adoption of statistical analysis
  - Inclusion of more tests for MC generators
- Integration of new Geant4 tests with corresponding experimental data
Geometry & Transportation

- **VecGeom** - *(JA, GC, AG, MG, GL, RS, ET, SW)*
  - Optimised global navigation functionality on GPU
  - Improved CUDA support and portability of SIMD-aware solids
  - Support for single precision in data structures and navigation API
  - Summer student projects under definition

- **VecGeom solids default and interface with navigator based on VecGeom** (*-) - *(JA, GC, SW)*

- Separate safety computation and its state from navigator (*-*) - *(JA, GC)*
  - Loose coupling of navigator in the computation of the safety distances from geometrical boundaries

- Prototype navigation indexing class – *(JA, GC, AG)*

- Review adoption of workspaces for task-based parallelism - *(MA, GC, JM)*

- Revision of transportation processes(*) - *(MA, GC, JA)*
  - Specialized transportation processes for neutral and charged particles

- Addition of QSS integration methods (Quantized State Simulation) – *(JA)*

- Review accuracy of boundary crossing in field (*) – *(JA, DS)*
  - ALICE and CMS requirement
Tutorials / Schools / Workshop in 2021

• Technical Training @ CERN on Geant4
  • Beginners Course, proposed dates: 25-31 May
  • Advanced Course, proposed dates: 27 September – 1 October

• ESIPAP School in Archamps
  • Geant4 Tutorial, 8-9 February

• Geant4 Collaboration Workshop
  • IRISA Laboratory, Rennes (France), 20-24 September
People involved (*)

- Guilherme Amadio (GA), CERN
- John Apostolakis (JA), CERN
- Makoto Asai (MA), SLAC
- Gabriele Cosmo (GC), CERN
- Gunter Folger (GF), CERN
- Andrei Gheata (AG), CERN
- Mihaela Gheata (MG), CERN/ALICE
- Dmitri Konstantinov (DK), IHEP/CERN
- Grigory Latyshev (GrL), IHEP/CERN
- Guilherme Lima (GL), FNAL
- Jonathan Madsen (JM), LBNL Berkeley

- Pere Mato (PM), CERN
- Ben Morgan (BM), Warwick University/ATLAS
- Lorenzo Pezzotti (LP), CERN
- Witold Pokorski (WP), CERN
- Ivan Razumov (IR), IHEP/CERN
- Raman Sehgal (RS), BARC
- Dimitry Sorokin (DS), MIPT
- Evgueni Tcherniaev (ET), CERN
- Sandro Christian Wenzel (SW), CERN/ALICE
- Anna Zaborowska (AZ), CERN

(*) - List includes people outside SFT
- Most dedicating only few % effort (sum ~4 FTEs)