GEANT4 11.0.p03
& 2022 planned developments

kernel modules

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for the Geant4 Collaboration

Outline

- Fixes introduced in patch releases 10.7.4, 11.0.2 and 11.0.3
  - Kernel modules
- Review of planned developments for 2022
  - Kernel modules
  - Physics (see talk after this)

➢ *Detailed patch release notes:*

- **http://cern.ch/geant4-data/ReleaseNotes/Patch4.10.7-4.txt**
- **http://cern.ch/geant4-data/ReleaseNotes/Patch.11.0-2.txt**
- **http://cern.ch/geant4-data/ReleaseNotes/Patch.11.0-3.txt**

➢ *List of planned features for 2022:*

- **http://cern.ch/geant4/support/planned_features**

Bugzilla tickets addressed

#2204 – Wrong sampling of scattering angle of light ion off Hydrogen

#2346 – Mess in density effect data for hydrogen and helium

#2466 – Degraded accuracy of the energy loss fluctuation (G4UniversalFluctuation model)

#2468 – G4NDL/Capture/FSMF6 photon treatment

#2471 – Segmentation fault in G4OpBoundaryProcess

#2474 – Incorrect value of the mean excitation energy (I) of carbon (G4_C)

#2480 – In CMS FTFP_BERT_EMM electromagnetic response of the hadronic calorimeter is reduced

#2482 – Wrong setter called in G4OpWLS2

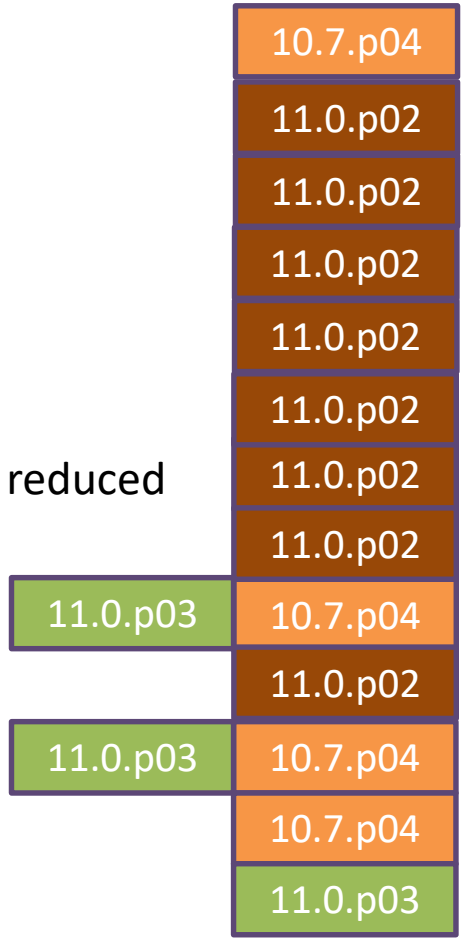
#2485 – geant4-config: wrong -I flag

#2486 – Extra warning/crashes when build compound materials in CMS

#2492 – /process/eLoss/StepFunctionIons does not work

#2495 – Problem dEdx and ranges for low-energy ions

#2502 – Crash during geometry test in multi-threaded simulation



Patches - Geometry & Persistency

- Solids/Boolean: 11.0.p02
  - G4UnionSolid: fix to add surface tolerance in Inside(p) for check on Z. Minor optimisation in constructors and in caching half-tolerance
- Management: 11.0.p03
  - Added protection in G4GeometryManager for Open/CloseGeometry() to be executed only by master thread
  - Addressing problem report #2502
- Navigation: 11.0.p02
  - In G4RegularNavigation, reset the zero step counter when a non-zero step is performed, to avoid aborted events
    - Based on GitHub PR#38 report
- Volumes: 11.0.p02
  - Extended getter methods in volumes/solids stores to optionally return the last-found object
- Persistency/ASCII: 11.0.p02
  - In G4GDMLReadMaterials, fixed default temperature to 20° C (NTP_Temperature)
  - Addressing the case of solid/volume name duplication when reading more than one GDML file

Patches - Global, Parameterisations, Run

- Global: 11.0.p02
  - In G4PhysicsModelCatalog, fixed typos in Bremsstrahlung models name
- Parameterisations: 11.0.p03
  - Fix in GFLASH to make the HitMaker compatible with command-based scorer
- Run: 11.0.p02
  - Fix in G4RunManagerKernel to check for correct state in the creation of the default exception handler

Patches – Materials, Particles

- Materials:

11.0.p02

  - Fixed density effect correction for liquid hydrogen
    - Addressing problem report #2346
  - In G4Material, reorganised AddElement(..) and AddMaterial(..) methods, to use temporary vector for allowing addition of the same elements during initialisation
    - Addressing problem report #2486
  - G4NistMaterialBuilder: fixed mean ionisation potential of carbon to NIST value
    - Addressing problem report #2474
- Particles:

11.0.p03

  - Fixes for transportation of hypernuclei and anti-hypernuclei

Patches – Digits_Hits, Configuration

- Digits_Hits:
  - Added missing virtual keywords in G4VScoringMesh

11.0.p02

- Configuration:
  - Updated extraction of include paths from VecGeom to use imported target property
    - Addressing problem report #2485

11.0.p03 10.7.p04

  - Fix for CPack on Windows

11.0.p02

2022 Planned Developments
Kernel

✔ In progress…

✔Achieved already either in 11.1-beta or development releases

Infrastructure

- Enhancements to Geant4 GitLab workflow ✔
  - Review use and integration of automatic performance monitoring tools
  - Additional Geant4Bot capabilities
- Modularization of Geant4 Libraries (global/granular/optional) ✔
  - Identify libraries/modules for merging, splitting, drop/add to a build
  - Profile modularization scheme to ensure performance is not affected
- Enhancements to build system ✔
  - Review mandatory and optional compiler flags needed to build and link to Geant4
- Optimization of Data Libraries
  - Simplify data library configuration/location
  - Review interfaces for data libraries, evaluate API and format changes
- Review need for dedicated sequential only build mode
  - Support sequential applications fully through Tasking Framework
- Move Geant4 web site to Jekyll with Git managed content ✔
- Migrate Geant4 Python module G4Py from Boost to pybind11 ✔
- Integration of automated performance monitoring ✔

Geometry & Transportation

- VecGeom
  - Prototype study on surface bounded volumes ✔
  - Support for single precision in data structures and navigation API ✔
  - Improved CUDA support and portability of SIMD-aware solids ✔
  - Handling of construction and run-time errors
  - Implementation of missing shapes/entities in GDML reader ✔
  - Code simplification, removal of unused API/backends
  - Adoption of Gitlab CI & extended platforms support
- Validation/consolidation of interface with navigator based on VecGeom ✔
  - Improve robustness of current interface/adapter to VecGeom navigator, testing & code integration
- Separate safety computation and its state from navigator
  - Loose coupling of navigator in computation of safety distances from geometrical boundaries
- Prototype navigation indexing class
  - An integer index identifying touchables & associated transportation process
- Alternative BVH navigator and optimization structure ✔
  - Navigation based on Bounded Volume Hierarchy (BVH) technique, either natively in Geant4 or through VecGeom

Magnetic Field & Biasing

- Magnetic Field
  - Addition of QSS integration methods (Quantized State Simulation) ✔
    - Alternative integration method which creates adapted polynomials and evaluates the limit of their validity
  - Review accuracy of boundary crossing in field (ALICE and CMS requirement)
  - Symplectic low/high order field integrators (GSoC HSF project) ✔
- Generic Biasing
  - Biasing of charged particle interaction occurrence
  - Prototyping of DXTRAN-like functionality
  - Extend generic biasing scheme for at rest case
- Reverse Monte-Carlo
  - Migration to multi-threading and improvements
  - Use of Reverse MC in parallel geometries

Fast Simulation & Analysis

- Fast Simulation
  - Modernisation of EM shower parameterisation ✔
  - Machine Learning studies on the current model, meta learning for real detector geometries ✔
  - Revision of Fast simulation framework
  - Revision of GFlash models ✔
  - Investigation on relevance of using a specialised tracking for triggering fast simulation
- Analysis
  - Support for multiple output types for n-tuples ✔
  - Addition of flexibility in resetting/deleting histograms ✔
  - Review support for writing same histogram/profile in a file several times (object versions)
  - Organisation of third-party code (HDF5, expat, zlib) in externals/g4tools ✔

Tracking, Run, Detector Response, Scoring & UI

- Tracking:
  - Redesign and implementation of G4ForceConditions
- Multi-threading & Tasking:
  - Reorganization of Run, Tasking and Event categories ✔
  - Sub-event level parallelism prototype ✔
  - Study on parallelisation of initialisation stage
- Scoring
  - Refinement of scorer functionalities and their drawing methods ✔
  - Support of IAEA phase space files for GPS
- UI
  - Change binding tool from boost-c++ to pybind11 ✔
  - Code updates to C++11/14/17 style

Visualisation

- OpenGL/Qt drivers:
  - Migration to Qt6 ✔
  - Improvements to toolbar in OpenGL Qt
  - Improvements on sceneTree
  - Fix issue with parametrized volumes ✔
  - Adapt to newer OpenGL versions, exploit new functionalities and replace deprecated calls such as glBegin/glEnd
- Open Inventor:
  - Refinements and extensions to the Open Inventor Qt Viewer ✔
  - Work on reference path to move through the geometry
  - Improved use/install of Coin library
  - Interaction OI viewer / UI Qt
- Other drivers:
  - Vtk driver: fully develop large renderings for medical applications
  - Improvements and further developments to native Qt3D driver ✔
  - Improvements and further developments to tools_sg (TSG) driver based on g4tools ✔
  - Provide 2min videos for each viewer
  - Development of visualisation solutions for iOS and Android devices

Novice & Extended Examples

- Development of a new example on polarisation
- New example for sub-event parallelism ✔
- New hadronic examples for monitoring particle fluence ✔
- Update of selected EM/hadronic examples with usage of G4Accumulable
- New example illustrating generic biasing for "DXTRAN" MCNP-like option and implicit capture
- New gflash parameterisation example for sampling calorimeter
- Porting of Geant4e and related example to multi-threading
- Medical & DNA
  - New radio-biology extended example
  - Validation and development with protons and He4 ions in molecularDNA example ✔
  - New example for the RBE/LET calculation
  - Microdosimetry spectra in a cylindrical domain at the specific water depth imitating silicon detector
  - New medical example for ultra-high dose rate
  - Inclusion of new cross-sections for gas materials in the "icsd" Geant4-DNA example
  - Add the possibility to use the SBS method in the DNA "scavenger" example
  - Implement DNA damage in plasmids with IRT
  - Extension to the DICOM reader to support RT Dose format
- Review of examples macros and tests (coverage of commands and use-cases) ✔
- Complete application of coding guidelines ✔

Advanced Examples

- Development of a specific example for proton tomography
- Further developments of in-silico experimental microdosimetry in the Radioprotection example
- Development of a mammography example
- Development of a SPring-8 synchrotron x-ray polarimetry example for testing low energy polarised gamma-ray physics
- New example showing how to import in Geant4 simulations IAEA Phase Space Files
- Code review, migration to C++17 and coding guidelines ✔
- Measurements of software metrics and statistical analysis over the examples

Thanks!