

What is in patch 1 for Geant4 Releases 8.2 ?

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Overview

- What issues led to creating the patch?
 - Problems reported in experiment test productions and other applications
 - ATLAS reported
 - New hadronic elastic and stopping models.
 - Several fixes and robustness improvements
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- Part 1: narrow focus on few, bigger issues
- Part 2: Numerous other improvements, fixes.

Motivation / hottest issue

- What issues led to creating the patch?
 - Problems reported in experiment test productions and other applications
 - ATLAS reported that ~70% events aborted when using QGSP
 - No failures when using QGSP_EMV
- Key issue: change in **geometry** and its use
 - Greater use from **multiple scattering**
 - Problems seen in simulation when geometry description errors (overlaps) are present.

Geometry

Description and Overlaps

Tools

Why new behaviour?

Geometry and physics

- The new multiple scattering process utilizes the Geometry Navigator to ‘see’ the next step
 - New in Geant 8.0. Enhanced in 8.1/8.2
- When there are overlaps and a field, problems have arisen
 - Up to ~70% events (QGSP, Atlas report) aborted due to a problem track.
- Identified overlaps in geometry description as an important trigger
 - Occur many times in same volume (not random!)
 - Inspection showed misidentification of volume due to this, and incorrect values of safety.

Identified weaknesses and risks

- Two weaknesses identified (when there are significant overlaps)
 - Field module's use of safety (overlaps bust it)
 - The safety is not 'single-valued'
 - Better protection against this added in field module (8.2p1)
 - New multiple scattering's intensive use of Navigator's ComputeStep stresses Navigator's 'protocol'
 - Results in un-forecast results
 - Improvements under preparation (another is previewed in February tag)
- Yet 'real' overlaps are a risk
 - Note: 'real' is my tag – I would place it probably > 10 microns
 - Even when tracks continue, overlaps can result in errors
 - Material used in physics (if overlaps are macroscopic)
 - Potential for larger number of steps at interfaces.

Related fixes & improvements

- Clear safety cached in field module for a new track – to protect against error from overlap
 - Implemented existing method `ClearPropagatorState()` `G4PropagatorInField` to clear track-dependent state (safety, zero-steps, loop flag. etc...).
 - `G4Transportation` now calls it for each new track
- When an event is aborted because the particle is stuck, the volume is checked
 - In `G4Navigator`, force call to `CheckOverlaps()` on the current volume before event aborts for a stuck track.

Overlaps and tools

- Overlaps
 - Is it an overlap or a coincident surface?
 - Tools to aid are key
- New tool provided in Geant4 8.2
 - Can be used when a volume is added or later
 - Useful for small number of volumes ($< \sim 10^{2-3}$)
 - Simple and robust
 - First version reports overlaps at all scales (to improve)
- Aware of open problem report in older tool
 - Starting to assess it and will then address it.
- A 'checking-mode' in G4Navigator is available
 - Reports a problem when it occurs during navigation;
- Are analyzing how to provide better tools
 - Expect first improvements by June 2007 release.

The 'future' of overlaps and their detection

- Try the Navigator's 'check-mode'
 - Assess its usefulness in large setup ... And improve?
- Further improvement needs:
 - Better tools to detect overlaps. Wish-list:
 - Robust, with user-tunable tolerance
 - Simple to use, exact, fast. (Challenging list!)
 - Improving the geometry description
 - Even in the presence of misalignment
 - Better understanding of the effect of overlaps on results
 - Are there other, not yet know effects ?
- I see more 'tolerance' for very small overlaps
 - and LOUDER reports about 'big' overlaps – that need to be fixed!

Small refinement(s)

- In CheckOverlaps() method of G4VPhysicalVolume: added verbosity flag
 - Request of Atlas (to avoid many OKs)
 - By default, verbosity is On.

De-excitation

- **Fission:** fixed probability to no longer be negative.
 - Now corresponds to Physics Reference Manual.
- **Evaporation:** added protection to exclude negative probabilities from the "competitive channel sum". Together with the fix below for fission this should only happen due to a precision error, but is protected nonetheless.
- These two fixes **affect** also
 - the **Pre-compound** model, and through this
 - the **Binary** Cascadewhich invoke these models.

Energy conservation fixes

- Corrected E-p non-conservation in QGS
 - In G4QGSMsplitableHadron, the smaller of the lightcone momenta q_+/q_- was ignored
- Bug in string hadronisation corrected (used for QGS model)
 - G4ExcitedStringDecay::EnergyAndMomentumCorrector():
 - correction used to stop even if not yet converged
- Visible change in average energy deposition
 - +1% in shower in test cases (100 GeV π projectile)

Energy deposition problem

- G4HadFinalState: corrected initialization of energy deposition.
 - Fix affects elastically scattered neutrons and probably most hadronic models.
 - Problem caused events in which the summed energy of final particles exceeds that of the incident particle
 - Visible especially in low energy neutrons.

Multiple scattering and the geometry

- Removed unnecessary call to location method of G4Navigator in G4UrbanMscModel
 - Added protection inside lateral displacement sampling against cases of $\text{TrueStepLength} < \text{GeomStepLength}$.

EM 'Standard'

- **G4UrbanMscModel:**
 - Fix in the single scattering code for heavy particles, now the code can be used with skin=1 e+/e- and for heavy particles as well.
 - Added protection inside lateral displacement sampling against cases of TrueStepLength < GeomStepLength.
- **G4MultipleScattering:**
 - fix to allow for reinitialisation of model parameters between runs.
- **G4VEnergyLossProcess**
 - Use SetEmModel(index) and added SetFluctModel() from in elonisation, hlonisation, ionlonisation, eBremstrahlung.

Protections

- Incorporated simple way to checks for NaN in build system
 - Continue to address any found
 - Address all reported by CMS/FNAL team in 2006, and others found independently
- Fission
 - fixed memory leaks in G4ParaFissionModel.

Fixed causes of NaNs

Sample fixes:

- Division by 0 in G4Quasmon and G4QNucleus and others
- In G4QElastic and in complicated event for the multi-projectile case
- In the (older) G4LElastic
- Division by 0 in G4QGSMSplitableHadron::SampleX().
- Protections against NaN values in Multiple scattering
 - sampling of theta when tau=0 in lateral displacement,
 - in ComputeTrueStepLength() for zero true length.
- In three G4NeutronHP classes

Most were infrequent – and a number were in variables that were not used in the particular case.

Yet these do reduce the occurrence of segmentation faults when using typical physics lists such as QGSC, QGSP, LHEP.

Other fixes

Fixes in solids (geometry)

- G4Polyhedra
 - Do not scale reducible-polygon in G4Polyhedra::Reset() method.
 - The 'original_parameters' structure offered as input through the accessors are always assumed to be already scaled by the ' $\cos(0.5 \cdot \text{phiTotal} / \text{theNumSide})$ ' factor.
 - *Addresses problem report #873.*
- In G4PolyconeSide::DistanceAway()
 - corrected the estimation of distance for the case of Phi sections.
 - *Addresses problem report #598.*

Summary

- Geant4 8.0, 8.1 and 8.2 include **improved**, new **physics** models:
 - Multiple scattering which is more stable when cuts are varied (optional, at 1.5-2x CPU cost)
 - Better elastic scattering, important for energy deposition in scintillators;
 - New microscopic models for stopping hadrons.
- Problem seen in production show **risks**, sensitive areas in user application and toolkit
 - Identified to be result of interaction of overlaps in geometry description, caching of safety in field module (fix: 8.2p1) and extra use of Navigator (soon)
 - Actions on geometry definition, overlap tools, navigator/multiple-scattering interface all needed (and underway)

Apologies for not including latest plots with versions 8.1, 8.2