

# Geant4 - release 6.0

Highlights of major developments &  
improvements

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# Outline

- Relevant developments in Geant4 5.x releases
- Developments, Improvements and Fixes in 6.0
  - Kernel
  - Physics Processes
  - Physics Lists
- Major items for migration of users' code

## Caveat:

⌘ Details: <http://cern.ch/geant4/source/ReleaseNotes4.6.0.html>

⌘ Attributions are not mentioned

# Relevant developments in 5.0 - 5.2

## Geant4 5.0 (December 2002)

- Design review of geometry importance biasing & scoring module
- First version of “model-based” EM standard processes
- New theoretical hadronic models for the cascade energy range ( $100\text{ s MeV} - \sim 5\text{ GeV}$ ): Binary cascade and Bertini cascade

## Geant4 5.1 (April 2003)

- Addition of cuts per region

## Geant4 5.2 (June 2003)

- Improvements of cuts per region
- Performance optimization in field
- Testing and refinements to “model-based” EM standard processes
- Review of the pion reaction cross-sections

# Geant4 6.0 - general picture

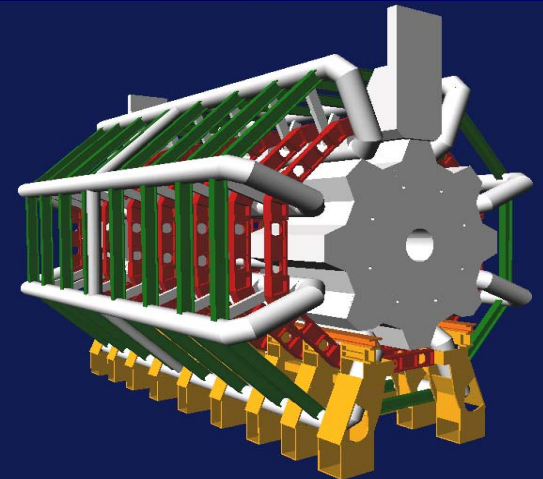
1. New **capabilities** in Geant4 6.0 for HEP
  - ⌘ Latest Physics lists distributed ‘inside’
  - ⌘ EM-std new ‘model’ implementation by default
2. Highlights of **improvements**
  - ⌘ to existing physics modeling & models;
  - ⌘ in physics process implementations;
  - ⌘ in functionality
  - ⌘ The high level of user feedback is reflected in developments, fixes & improvements

# Kernel: Run Manager

- Design review of the Run-Manager
  - ✓ Modularization
    - ✓ Separation of ‘mandatory behavior’ into `G4RunManagerKernel` class
  - ✓ Additional entries for event processing
    - ✓ Taking HEPMC events / track vectors
    - ✓ New mechanism for merging different kinds of primaries
  - ✓ Maintain link between pre-assigned decay products and corresponding primary particle
- New user “helper” classes
  - ✓ `G4StackChecker`, `G4VUserPrimaryVertexInformation`, `G4VUserEventInformation`, `G4VUserRegionInformation`, `G4VUserPrimaryParticleInformation`

# Kernel: Geometry

- Logical reorganization and restructure of modules
  - Code review to reduce internal dependencies
- Abstraction of **G4Navigator**
  - First level abstraction
  - Consolidation of the interface
- Addition of volume Divisions
  - *G4Box*, *G4Tubs*, *G4Cons*, *G4Para*, *G4Trd*, *G4Polyhedra*, *G4Polycone*
  - Extends capability of Replicas (offsets available)
- Solids:
  - New **G4Orb** shape
  - Review of ‘safety’ in Boolean & CSG solids
  - Fixes in **G4Sphere** for usage of ‘tolerance’
    - Review of algorithm for phi sections



# Kernel: Propagation in EM Field

- Ability to specialize integration accuracy
  - ❖  $\epsilon_{\min}$ ,  $\epsilon_{\max}$  now for each Field-Manager
- Choice of Field-Manager by track
  - ❖ e.g. more precise for muon or for tracks  $E > 5 \text{ GeV}$
- Ability to use variant Chord-Finder (5.2)
  - ❖ To enable possibility for performance improvement
- Fixes for missing intersections
  - ❖ Missing chord & repositioning in rare conditions
- Further usage of ‘safety’ in field propagator
  - ❖ Possibility to turn on/off the optimization

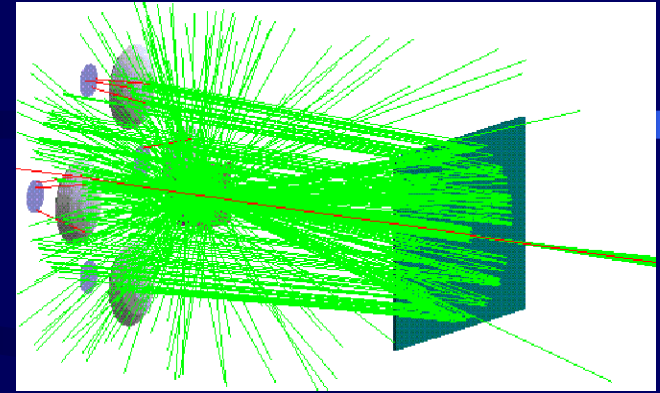
# EM Physics Processes

- New “model-based” EM standard physics processes are now the default
  - model approach for energy loss and MSC
  - we can more easily maintain and modify them
  - to enable the easy use of different models for a single process (e.g. ionization) in one application
  - previous user-interface unchanged
- The old (frozen) implementation is still available
  - with '52' postfix in the process class name



# EM Physics Processes & more ...

- Multiple scattering
  - Tuning for tail of angular distribution
  - Improvement for muons of  $E > 1 \text{ PeV}$
- Ionisation
  - Updated energy intervals, fluctuation models ...
  - Multiple scattering does not use table
    - Needed to ensure repeatability
  - Added PAI (Photon-Absorption-Ionisation) model
- EM low energy physics
  - New models (2BN, 2BS) for Bremstrahlung
  - New processes for electrons & positrons (a-la Penelope)
- Optical processes
  - New process for wavelength shifting
  - Adoption of **G4SurfaceProperty** class for materials



# Hadronic Physics: general

- Design iteration for hadronic framework
  - to allow for direct implementation of biasing at the framework level
- New implementations
  - leading particle biasing for any reaction
  - cross-section biasing for  $e^-/N$  and  $\gamma/N$  reactions
- Restructure of the hadronic code modules
  - simplification of the structure
- Fixed compilation warnings

# Hadronics: Cross Sections & Models

- *Binary cascade*:
  - included *pion projectiles*
  - added light ion reactions
  - improved transition to pre-equilibrium model
- *Bertini Cascade*: extended up to **10 GeV**
- *Scattering term*
  - extended for nucleon induced reactions to **8 GeV**
  - included s-wave absorption
  - pion induced reactions (up to **1.5 GeV**)
- Fixes to several models and robustness tests

# Hadronics: Improvements & fixes

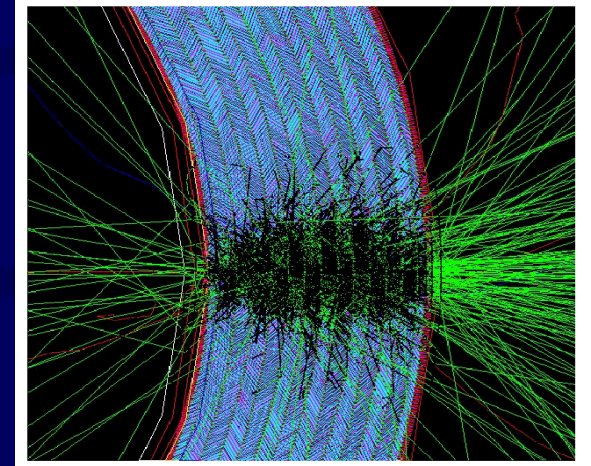
- Element selection in creating final state
  - fix for materials with many elements
  - now choosing isotope before calling model
    - using  $A^{2/3}$  cross-section approximation
- QGSM: improved meson splitting
- Added ion reaction cross-section
  - parameterizations from Shiver, Kox and Shen.
- Improved registration
  - of cross-section registration and models

# Hadronic Physics Lists

- The latest physics lists are now included
  - Ported from the latest version available for 5.2
    - Validation against use cases is underway
  - New version ‘with guarantees’
    - In first quarter 2004
- Physics lists and builders can be used:
  - As is, compiled in a ‘deployment’ directory
  - Altered (or additional/customized version) by user/experiment, in own installation

# Additional categories

- Visualization
  - Of ghost geometries for parameterization
  - New HepRep XML driver for HepRep 2
  - New visualization commands
  - Improved handling of auto-refresh at end of event/run
  - Removed obsolete OPACS driver.
- Biasing
  - First implementation of “weight-window” biasing technique
- Environments
  - MOMO Java tools are now included
    - GGE (Geometry editor), GPE (Physics editor)
- Examples
  - Reviewed and updated



# Major items for users' code migration

- Forced usage of touchable-history to retrieve information for the geometry hierarchy
  - Removed pointer to mother PV in `G4VPhysicalVolume`
- New default values (more accurate) for propagation in field
- ‘Non-magnetic’ fields require now their chord-finder and equation of motion initialized directly
- New interface for registration of cross-sections in hadronics, now registered directly with the process (\*)
- Exception handling enabled in hadronic physics (\*)
- Mandatory kernel functionalities of the run-manager are now grouped in the new `G4RunManagerKernel` class (\*)
- New data set for low-energy EM processes

*(\*) for advanced users*

# Established new releases & new features

- Established releases
  - End of June (minor release)
  - End of December (major release)
- Planning the new activities for 2004
  - taking into consideration requirements of all users including those from LHC experiments / LCG
  - Users' Technical Forum at CERN
    - February 5<sup>th</sup>, 15:00-17:30
    - Requirements collection and first-level prioritization



# Summary

- Geant4 6.0 includes
  - New features in the geometry modeler
  - New implementation of EM standard processes ‘model-based’
  - Improvements in hadronics models
    - Leading particle & cross section biasing
  - Source and configuration files for latest hadronic Physics Lists
  - See: <http://cern.ch/geant4/source/ReleaseNotes4.6.0.html>
- Geant4 is evolving
  - With the feedback from LHC experiments, BaBar and numerous other experiments and application domains.
  - Users’ Technical Forum at CERN on February 5<sup>th</sup> for collecting new requirements !

**Thanks** to all  
Contributors & Users