

# GEANT4 9.3 Highlights

Gabriele Cosmo & John Apostolakis, CERN PH/SFT  
for the [Geant4 Collaboration](#)

# Outline

- Major fixes and features to be included in the forthcoming release 9.3
  - Geometry & GDML
  - Materials, Particles & Generic processes
  - Physics
  - Visualization, UI
  - Configuration & Kernel
- If already available in 9.3-beta:  $\beta$ 
  - All 9.3-beta details in:
    - <http://geant4.cern.ch/support/Beta4.9.3-1.txt>
- List of 2009 planned developments:
  - [http://geant4.cern.ch/support/planned\\_features.shtml](http://geant4.cern.ch/support/planned_features.shtml)

# Highlights of release 9.3

# Geometry

- Revised implementation for curved surface solids with **Phi** sections: **G4Tubs**, **G4Cons**, **G4Sphere**
  - As part of code review 2009 for solids
- Implementation of generic divisions along **z** for polyhedra and polycones
- Interoperability of multiple navigators/geometries
  - Parallel navigation and activation of magnetic field, etc...
- Extension of **G4Region** to hold local magnetic fields

β

β

# Persistency

- GDML
  - Implemented **virtual layer** to allow customisation of the writer for user-extended schemas  $\beta$
  - Implemented ability to write **surface properties** associated to volumes and material properties  $\beta$
  - Implemented ability to handle '**assembly**' structures in reader
  - General code cleanup

# Global, Materials & Particles

- Reviewed implementation of physics vectors
  - Providing CPU improvement at initialisation
  - Further improvement to **Spline** interpolation
- Implemented migration of **ICRU-73** stopping power classes for materials to the **G4VIonDEDXTable** interface
  - **Access methods** of physics vectors have changed (vectors can also be identified via atomic number of material if material is pure)
  - Classes now deliver **mass stopping powers** instead of stopping powers per unit length
  - Removed dependency on **ICRU-73** material **densities**
  - New utility class **G4ExtDEDXTable** to handle **external** electronic stopping power tables for ions
- Added method **GetNuclearMass (A, Z)** in **G4NuclearProperty**
  - made obsolete class **G4NucleiPropertiesTable** (will be removed)

β

β

β

# Generic Processes & Parameterisations

- Integration of **Reverse Monte Carlo** for EM particles (e+/e-/ $\gamma$ )
  - Prototype of reverse EM tracking for protons
- Improved implementation of **G4VRangeToEnergyConverter**
  - **Faster** initialisation by a factor 2 to 3
- New method **ResetConverters ()**
  - Reduces memory waste after initialisation in **G4ProductionCutTable**
- Reviewed ionisation **potentials**
- Reviewed **density effect** parameterisations

# Electromagnetic physics - 1

- Standard EM models
  - **Frozen** version of default multiple-scattering model (`G4UrbanMscModel1`) from release 9.2
    - New tuning of multiple-scattering (development class `G4UrbanMscModel2`)  $\beta$  for central part and tail of the angular distribution
    - Added relativistic factor to Rutherford cross section and various developments for Coulomb scattering classes and `G4WentzelVIModel`
  - Simplified initialization of models and code cleanup  $\beta$
  - Modification in width correction in `G4UniversalFluctuation`, fixing step dependency for the correction on energy deposition  $\beta$



# Electromagnetic physics - 2

- Standard EM models
  - New Goudsmit-Saunderson multiple scattering model for electrons & positrons ( $e^-/e^+$ ) β
  - Fixed algorithm for selection of model by its energy range in G4EmModelManager to better treat energy-region overlap with low-energy models β
  - Gamma conversion with LPM effect
  - Addition of muon multiple-scattering model in Physics Lists
  - Physics lists with combinations of standard and low-energy models
  - Introduction of cut in range for recoil

# Electromagnetic physics - 3

- Optical processes
  - Inclusion of **Mie scattering** as a new optical photon physics process
  - Extension to the unified surface model to have both **specular** and **diffuse** components for the transmitted photons
  - New extended/optical example to exhibit **transmission** properties of optical fibers with circular and elliptical cross section

# Electromagnetic physics - 4

- Low-energy EM
  - Complete migration to 'standard-EM' design: added Bremsstrahlung physics according to Penelope and Livermore models; added **G4LivermoreIonisationModel**, first implementation of low-energy ionisation (**G4LowEnergyIonisation**) in the common design  $\beta$
  - New DNA processes migrated to the new design; new G4EMLOW-6.5 data set; made obsolete old cross-sections and final-state classes  $\beta$
  - Added **G4RayleighScattering** process to describe Rayleigh scattering and removed obsolete classes  $\beta$
  - Added new scaling algorithm, to obtain heavy ion stopping powers for ions not covered by **ICRU-73** report  $\beta$
  - Better **performance** from improved **G4LogLogInterpolation** class
  - Implementation of **polarized** photoelectric, gamma conversion and triple conversion models (gamma  $\rightarrow$  e<sup>+</sup> e<sup>-</sup> e<sup>-</sup>) ?

# Hadronic physics

- Models
  - Developments in **CHIPS** model to extend its applicability to all energies, particles and targets
  - Model precise sampling and ‘on-the-fly’ table preparation for **coherent\_elastic** module
  - Complete improvements to **pre-compound** model
  - Allow **carbon-ion** projectiles in **INCL** model
- Physics lists
  - New development physics-lists
    - **QGSC\_CHIPS** (**QGS** model with ‘EnergyFlow’ interface to **CHIPS** at all energies)
      - Interim **QGSC\_QGSC** (**QGS** model with interface to **CHIPS** at all energies, still using **LHEP** for neutrons)
    - **QGSP\_FTFP\_BERT** ( replaces LEP with FTFP for nucleon & pion projectiles)
    - **CHIPS** physics list ( completely replaces LEP, also for hyperons)
  - New physics-lists with special EM options (EMV, EMX, EMY)
  - Complete and validate INCL/ABLA physics list
  - Declared obsolete old unused configurations
- General cleanup of the hadronic code and speed-up study
- Review of physics models to identify and fix cases of event irreproducibility

β

β

β

β

# Visualization

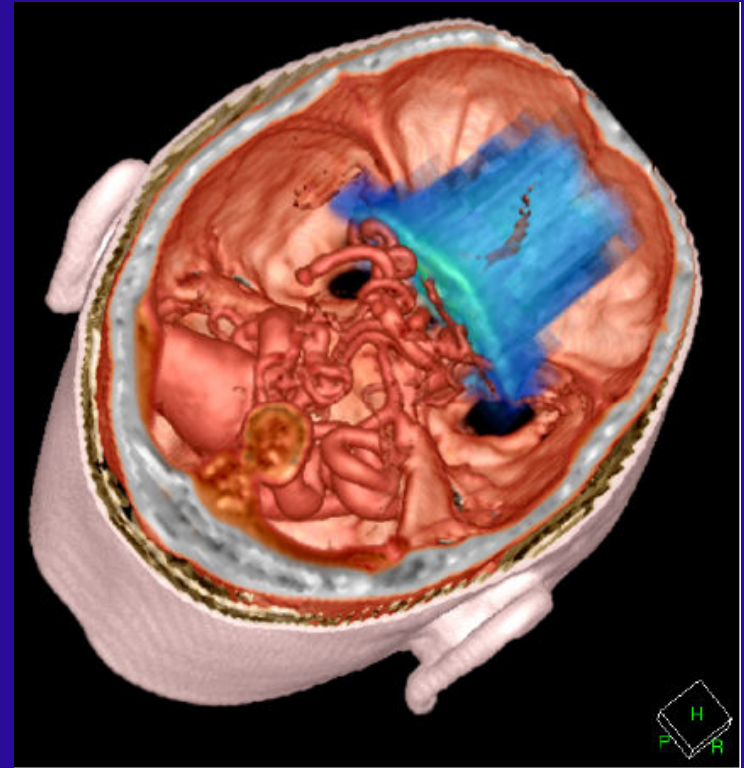
- Improved control over location and size of all GL windows
- Ability to make **high resolution PostScript** output (via **g12ps** option)
- Addition of initial Kinetic Energy to **trajectory** attributes
- Addition of "remaining energy" attribute to rich trajectory points
- New UI commands: `/vis/scene/add/title`, `date`, `logo2D`, `text2D`

β

# gMocren

Great tool available for volume visualization

- From JST/CREST project (Japan) to improve Geant4 for medical physics
- Able to visualize:
  - Volume data  
(including overlay of more than one set)
  - Trajectories
  - Geometry
- Runs on:
  - Windows and Linux
  - Mac will likely happen soon
  - Based on a commercial package but offered freely to all Geant4 users
  - <http://geant4.kek.jp/gMocren>
  - Installation is straightforward, follow the Download link on the above page
    - First run gMocren's one-click installer
    - Then, inside C:\Program Files\gMocren\gtk, you will find the one-click installer for gtk



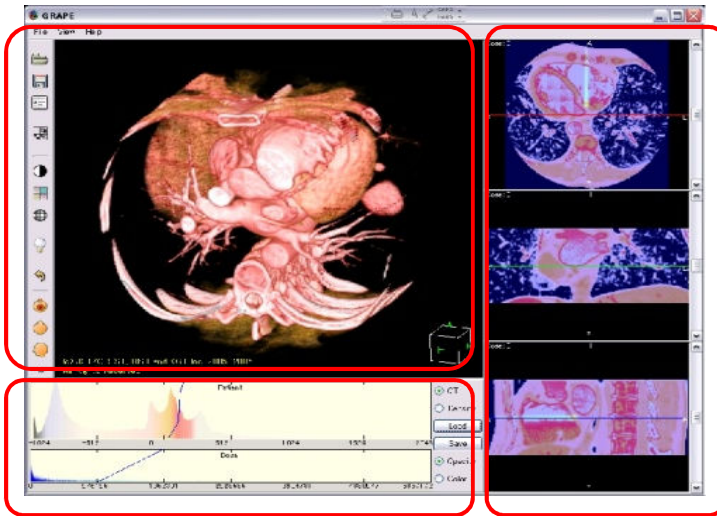
# gMocren : A Visualization Tool

<http://geant4.kek.jp/gMocren/>

*gMocren and utility software are freely available.*

3D (ray casting)

2D (MPR)

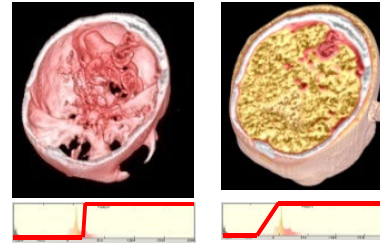


Opacity curve and color map editor

## Functionality Requirements:

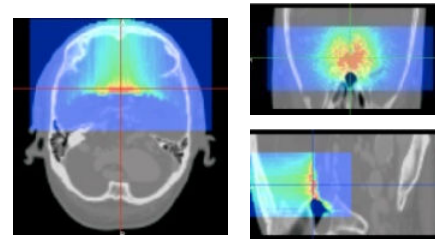
- To visualize
  - the modality image used by the simulation,
  - the calculated dose distribution and
  - the particle trajectories
- in an agreeable speed
- Transfer function editor
- Multi-platform

Opacity curve and color map editor



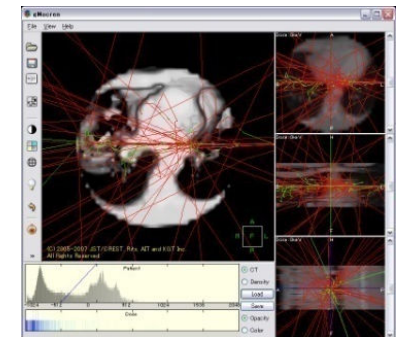
*free hand or templates with WW&WL editing*

Calculated dose distribution

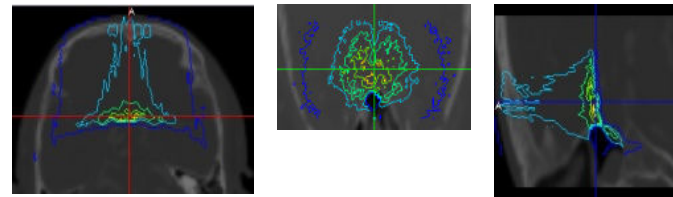


color mapping

Particle trajectories



Trajectory information in the simulation is available.



contour plot

## 9.3: more ...

- Interfaces/UI
  - New class **G4UIExecutive** for automatic instantiation of user interactive sessions, as done for visualization drivers
  - Enhancements to **G4VBasicShell** for better command completion in command line
  - Developments in Qt driver
- Error Propagation
  - Inclusion of pi+, pi- and proton in physics list
  - Added possibility to account for error deflation for 'smoothing'
- First prototype thread-safe/multi-core kernel (alternative code tree)
  - To be released in early 2010
- New and updated examples (advanced & extended)
- List of planned developments for the current year at:
  - [http://geant4.cern.ch/support/planned\\_features.shtml](http://geant4.cern.ch/support/planned_features.shtml)

β

β

β



# Platforms supported for 9.3

- Linux SL(C)5, gcc-4.1.2, gcc-4.3.X, 32/64 bits
- Linux SL(C)4, gcc-3.4.6, 32/64 bits
- MacOSX 10.5/10.6, gcc-4.0.1/gcc-4.2.1
- Windows/XP and CygWin Tools
  - Compiler Visual C++ 9.0 (Visual Studio 2008)
- Also tested: gcc-4.4.X, icc-11.X

# Thanks!