New from the Geant4 Collaboration

Highlights of upcoming developments

J. Apostolakis for G4

Outline

- Improvements in electron transport
  - Multiple scattering
- Developments in kernel
  - Geometry, particles
- Refinements, improvements in hadronics

- Complete list of scheduled features
  - http://geant4.web.cern.ch/geant4/source/planned_features.html
- Apologies for missing items and missing attributions

Review on Multiple Scattering

- Simulation for thin layers requires precise simulation with small cuts (medical applications, shielding, fine granular calorimeters…)
- Cut dependence of the results and dependence of results from step limits were reported by users
- The investigation of cut/step limit effects have been carried out and the conclusion was following:

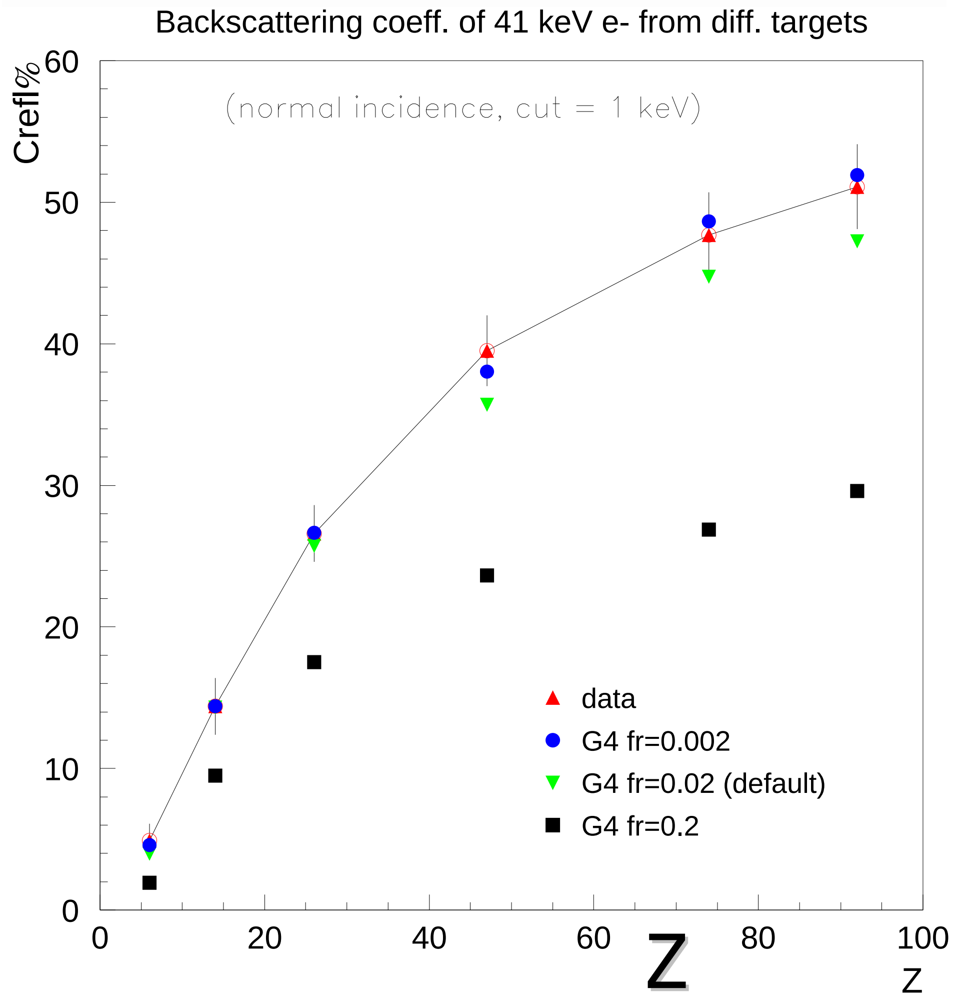
MultipleScattering process is very important

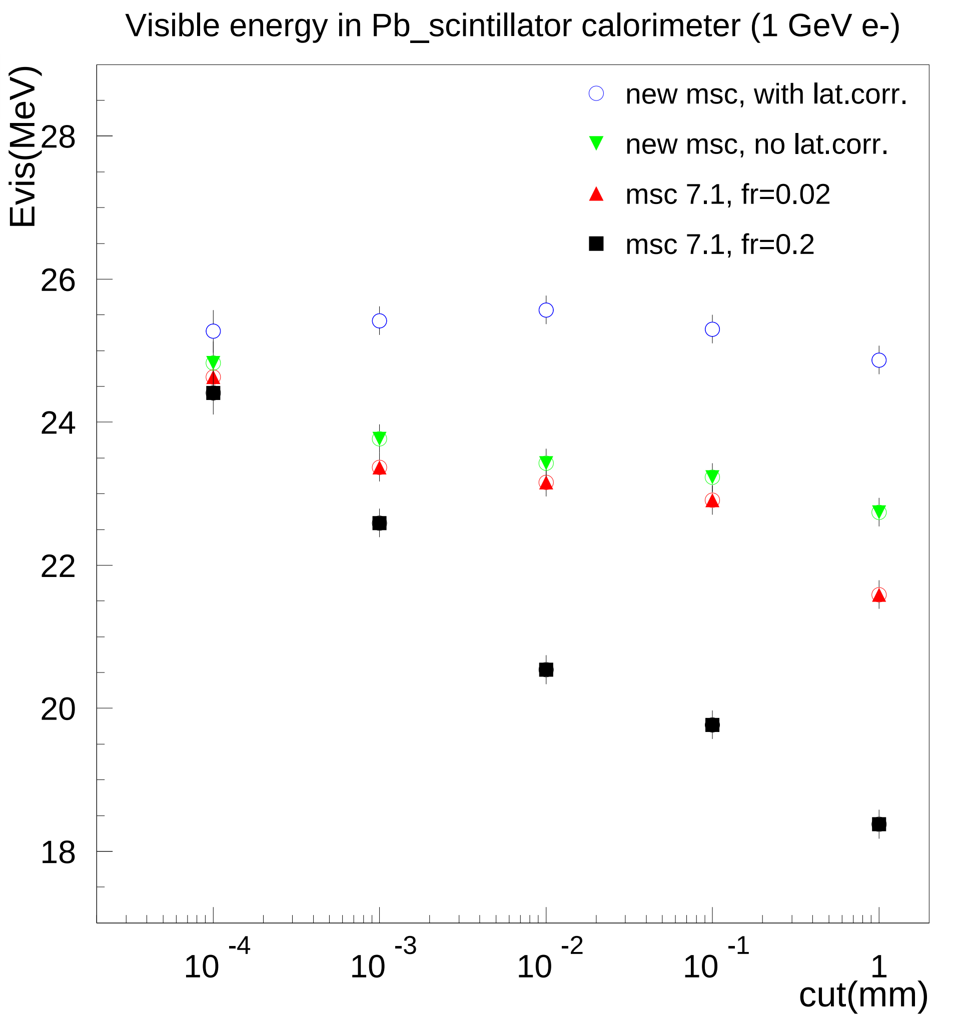
M. Maire, L. Urban

Upgrade of Multiple Scattering between 7.1 and 8.0

- MSC functions:
  - sampling scattering angle after step
  - Sampling lateral displacement
  - t <-> z transformations
  - Step limitation
- G4MscModel Updates:
  - Correlation between scattering angle and radial displacement is introduced
  - More precise calculation of safety before sampling of the displacement
- G4MultipleScattering updates:
  - step restriction not only after boundary with parameter facrange but also from the start of the track and from geometry (facgeom)
- Default values:
  - facrange = 0.02
  - facgeom = 4
- Defaults guarantees, at least, 4 steps in a volume if particle start outside, 2 steps if particle start inside
- G4VMultipleScattering update:
  - SetMscStepLimitation(false) method to overwrite defaults and to provide the similar results as in 7.1

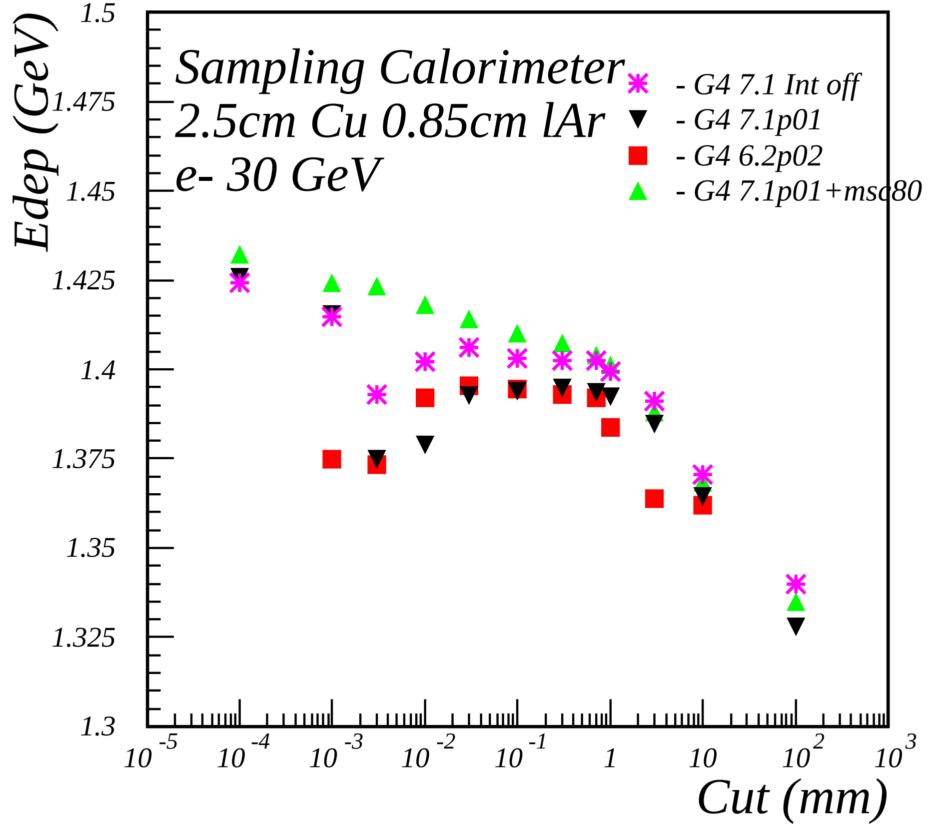
Motivation of Upgrades

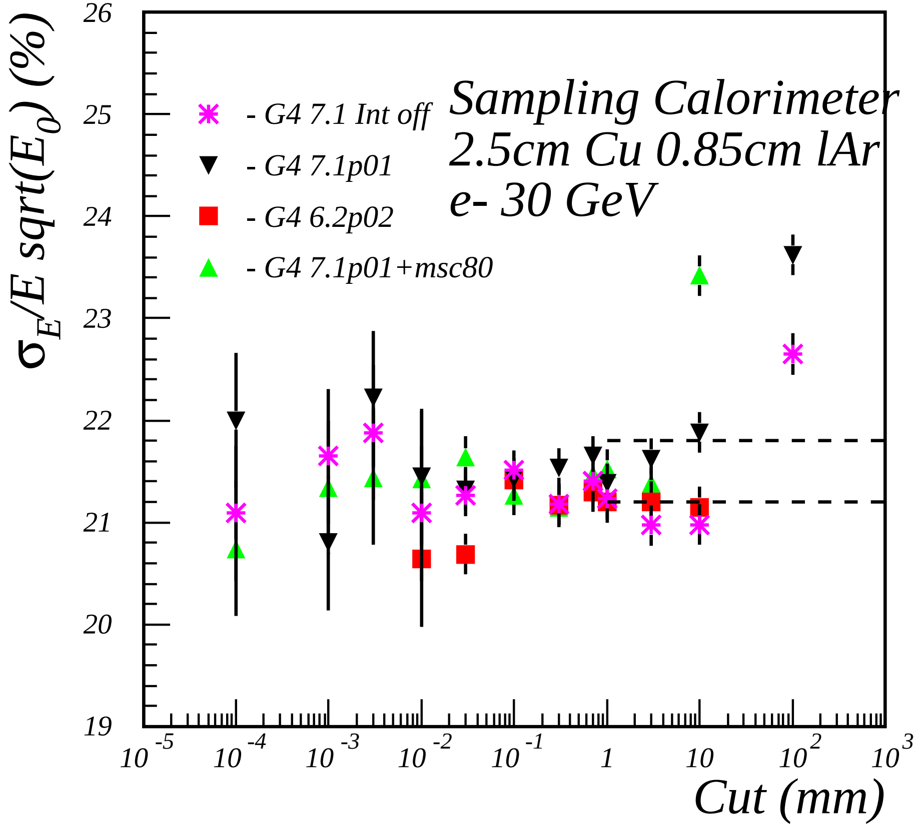




Z

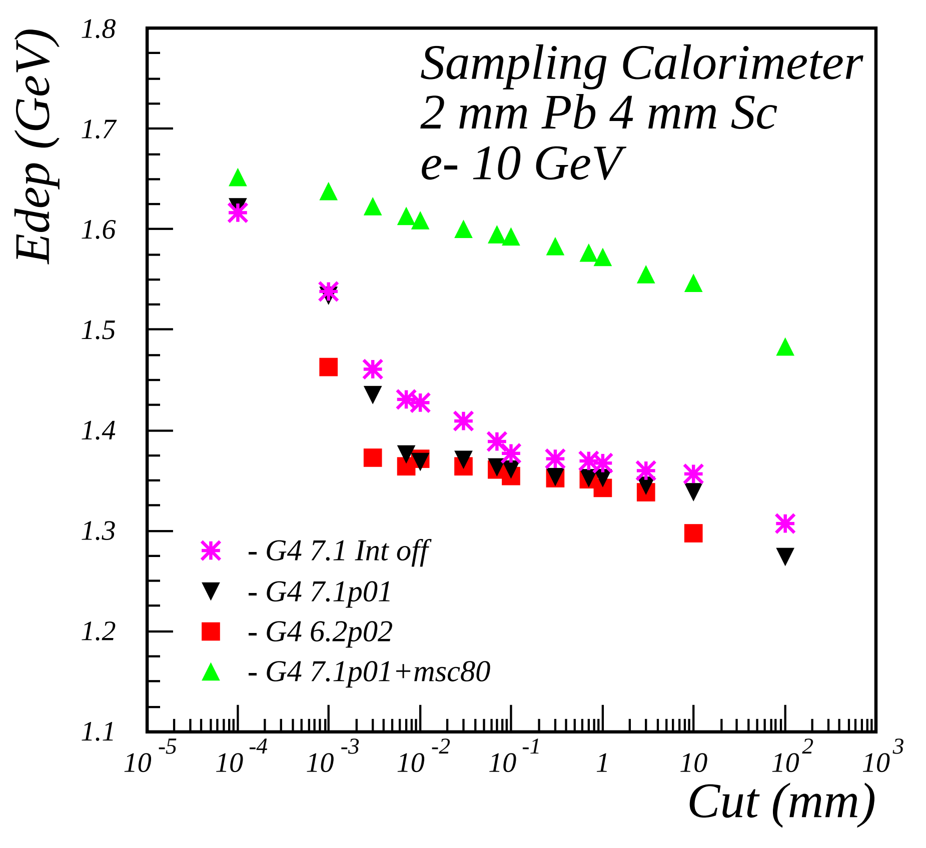
Multiple Scattering model upgrade

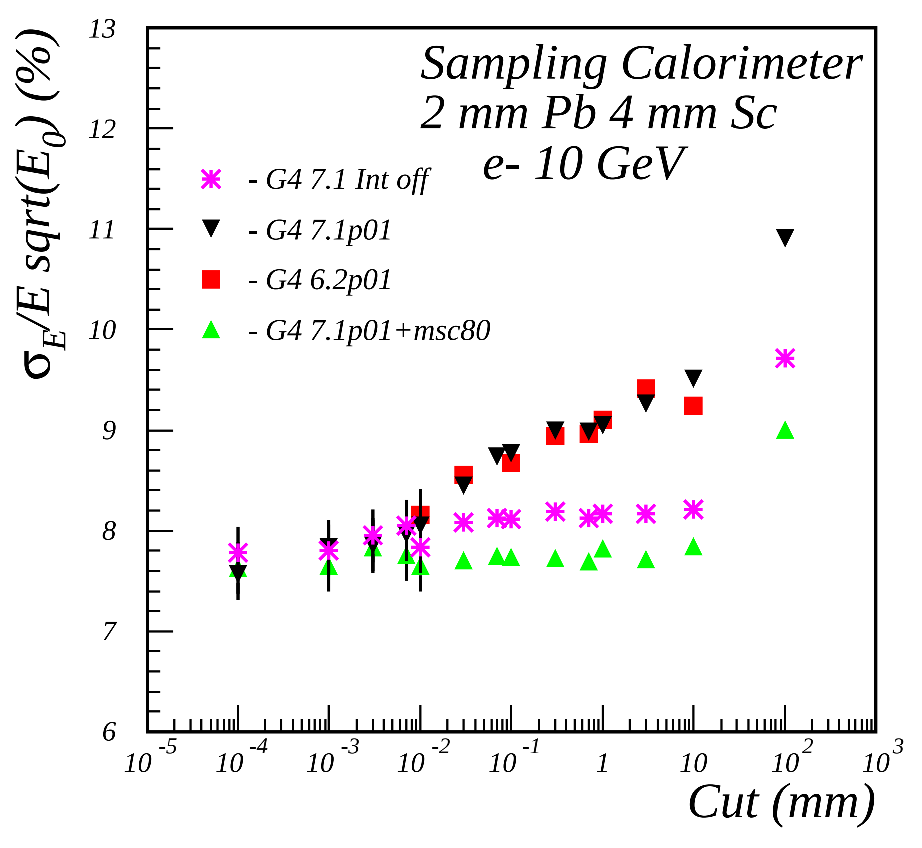




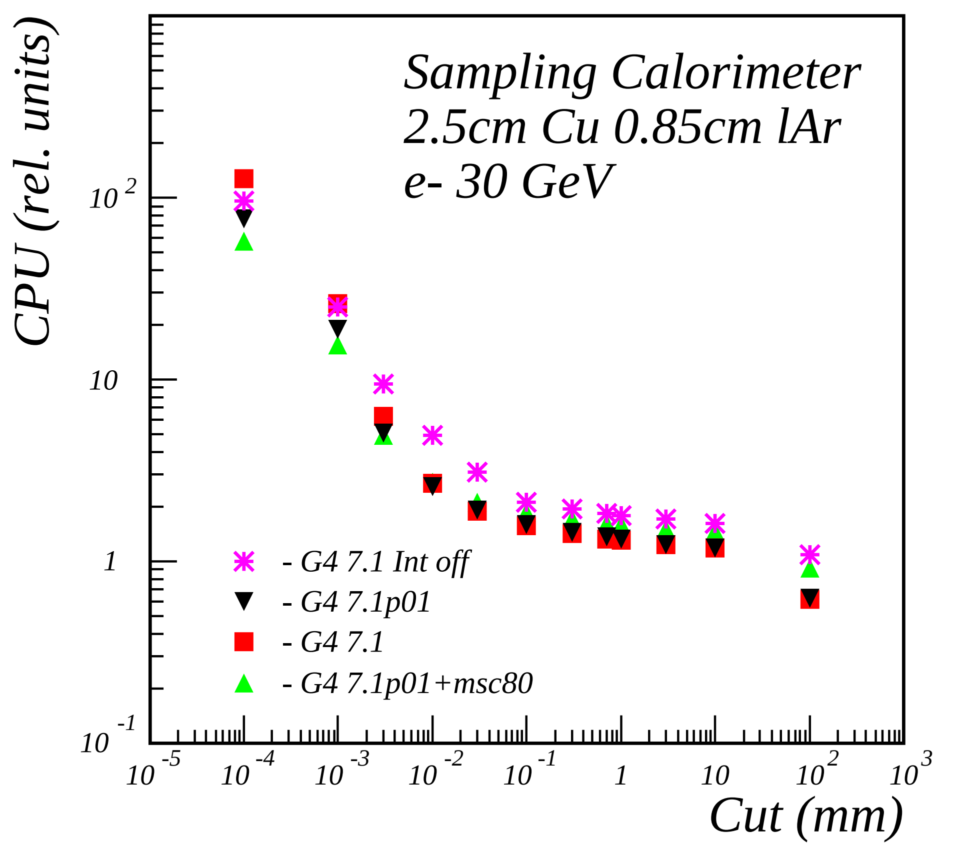
V. Ivantchenko, M. Maire, L. Urban

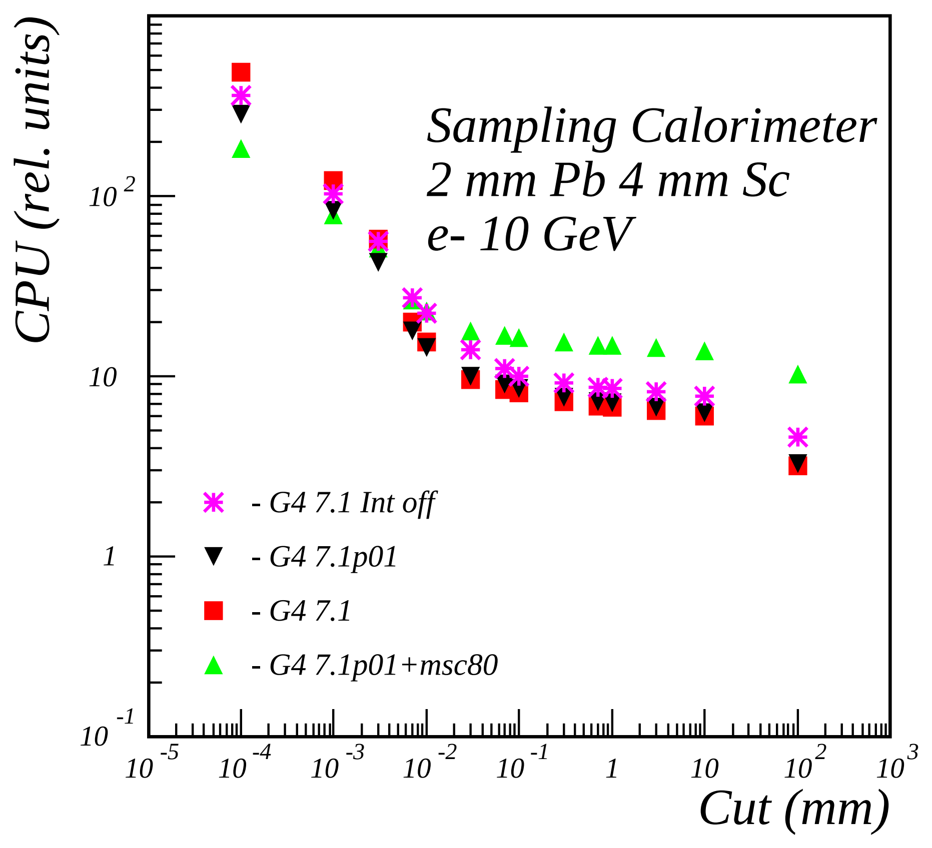
Multiple Scattering model upgrade





Multiple Scattering model upgrade (Preliminary Plots!)





Geometry: solids and dynamical geometries

- Additional solids
  - Generic twisted trapezoid shape with different endcaps - (O. Link)
  - New ellipsoid and elliptical cone (D. Anninos, CERN/Cornell)
  - Tetrahedron (M. Mendelhall, Vanderbilt Univ.)
- Testing and Improvements (O. Link, CERN)
  - Solid accuracy tests identified problems in torus, sphere (theta)
  - Fix in sphere and improvement of torus (new polynomial solver)
- Localized re-optimization for dynamic geometries
  - Change and re-optimize only part of a large geometry (G. Cosmo)
    - Enables lightweight initialisation for changes in dynamic geometries

Other new features in geometry

- Overlap detection at construction time
  - When a volume is placed it is checked optionally for 'overlaps'
    - If it overlaps sister volumes or protrudes from its mother
    - Points on its surface are sampled
    - An exception is generated if a point is outside the mother or inside a sister volume
  - Applicable for placement and parameterised volumes
- Extended use of G4Region. G4Region will have :
  - Was used for G4ProductionCuts and G4VUserRegionInformation,
  - Can create User Limits for Regions (7.1)
  - Now enabling its use with parameterisation/Fast Simulation
    - All these data members are optional.

Under development

- Optimized navigation for voxel phantom geometries
  - 'Dancing replicas' or Nearest neighbour navigation for regular parameterised volumes.
    - Investigating approaches used by users
    - Parallel discussion here (later report)
- Prototype of a parallel navigator
  - To enable improved use of parallel geometries
    - Mass/physics geometry, biasing geom, tallying, fast simul.
- Feasibility study and prototype for tunable tolerances

Non-static particle definition

- In Geant4 8.0, all particle definition class objects will be instantiated when GenerateParticle() method of physics list is invoked.
  - Until now, most particle definition objects were static and your GenerateParticle() method ensured they were linked in your executable.
- A side effect is foreseen if your physics list has physics processes/models as data members of your physics lists.
  - such processes or models may not been instantiated properly.
- Some currently provided "educated guess" physics lists
  - we will release revised physics lists to address this.
- What to do
  - In case processes/models are defined as data members, they are actually instantiated at the moment your physics list itself is instantiated, i.e. before GenerateParticle() method is invoked.
  - If you use your own copy/customized physics list you will need to migrate
    - For example if you derived from one of the "educated guess" physics list,
    - How to do this
      - define pointers for such processes/models as the data members, and make sure all processes/models are actually instantiated in your GenerateProcess() method.

Concrete sensitivity classes

- Till now Geant4 provided only an abstract class (G4VSensitiveDetector) for the user to define his/her detector sensitivity.
  - Various example detector classes are provided.
    - Good for HEP experiments, as primarily want to store hits in their detectors.
  - But it is not not convenient for space and medical applications.
    - Their interest is mainly scoring dose/flux.
- We will introduce G4MultiFunctionalDetector (a G4VSensitiveDetector). In it you can register concrete 'scorers' of G4VPrimitiveSensitivity to build a scoring detector as you need.
  - G4PSEnergyDepositionScorer, G4PSSurfaceFluxScorer, G4PSDoseScorer, G4PSTrackLengthScorer, etc. (class names are preliminary) will be provided.
    - We will continue working for additional primitive sensitivity concrete classes.

Concrete sensitivity classes

- Each G4VPrimitiveSensitivity class generates one hits collection per event. By registering more than one classes of G4VPrimitiveSensitivity, G4MultiFunctionalDetector generates more than one collections.
- G4THitsMap template class (an alternative to G4THitsCollection) will be introduced. It is also a derived class of G4VHitsCollection.
  - It is more convenient for scoring purposes. It does NOT mandate G4VHit concrete class to be stored, but for example a simple double value can be mapped with a copy number.
- New class G4VSDFilter will be introduced. It can be attached to G4VSensitiveDetector and/or G4VPrimitiveSensitivity to define which kinds of tracks are to be scored.
  - E.g., surface flux of protons of more than 1 GeV/c can be scored by G4PSSurfaceFluxScorer with a filter.
- Current G4Scorer and its related classes will become obsolete, but they will be kept with limited functionalities for a while for backward compatibility sake.

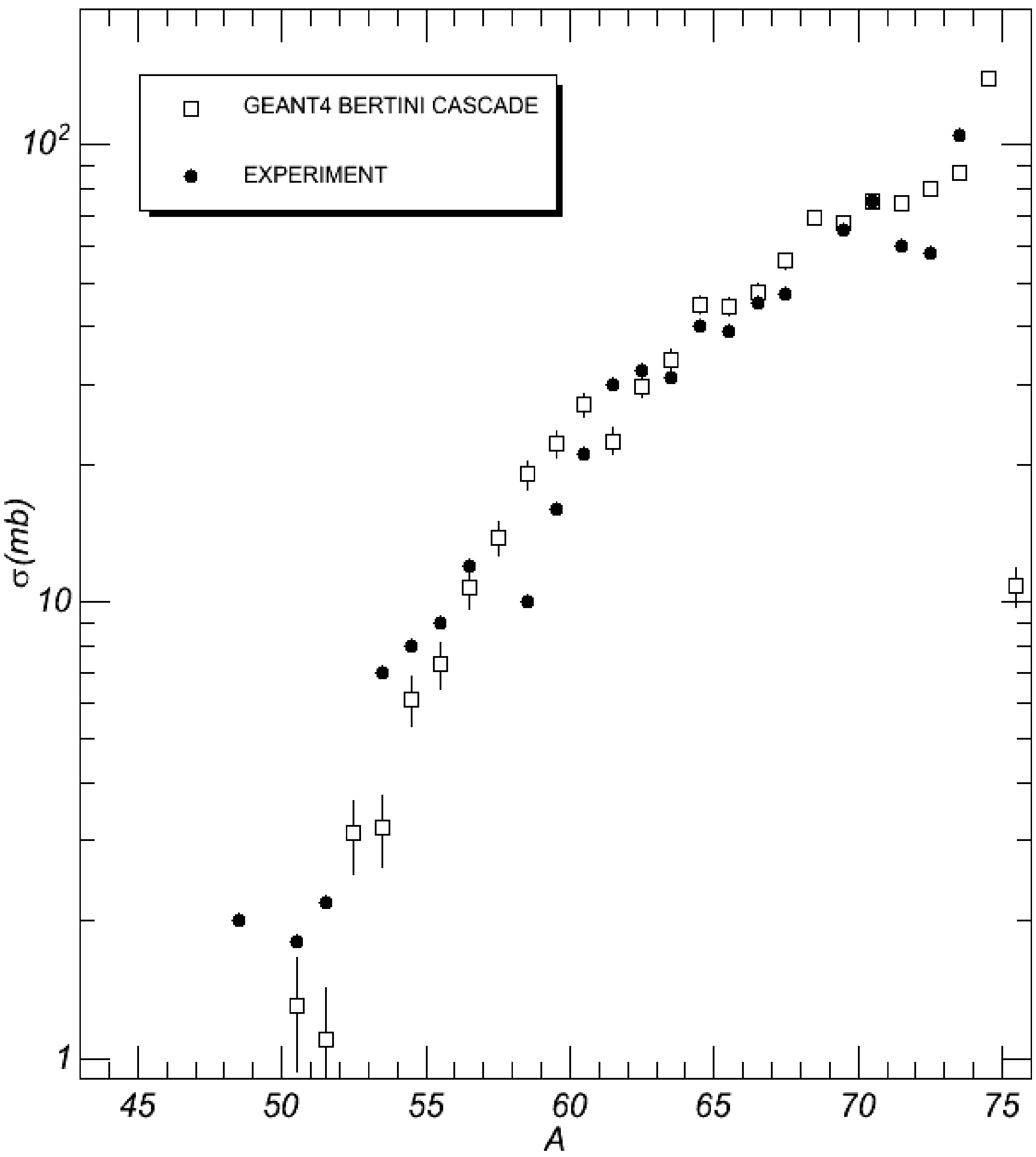
Nested parameterization

- Currently G4VPVParameterization::ComputeMaterial() method takes only the copy number of the immediate physical volume.
  - There is no way to get a copy number of its (grand)mother volume.
- To implement boxes in 3-Dimensional alignment with varying material (e.g. DICOM), one parameterization has to take care of three dimensions.
  - One big mother volume filled by one tiny cell with 3-dimensional parameterization
- With newly introducing nested parameterization, a touchable instead of naïve copy number will be provided to ComputeMaterial() method.
  - Material of a box can be indexed not only with the copy number of the immediate volume but also with copy numbers of its (grand)mother volumes.
  - The big mother box can be replicated twice in first and second axes, and then parameterized only along the third axis.
  - Performance improvement in both voxelization and navigation/tracking is foreseen.

Bertini Cascade

- Isotope production
  - Proton and neutron induced
- Elastic scattering interface for release 7.2
  - G4CascadeElasticInterface (for < 1 GeV)
- Kaon extensions
- Validation
- Optimization for speed, model tuning
- Ion-ion interactions (future)

MASS YIELD CURVE FOR $^{75}_{33}As$ WITH 380 MeV PROTONS

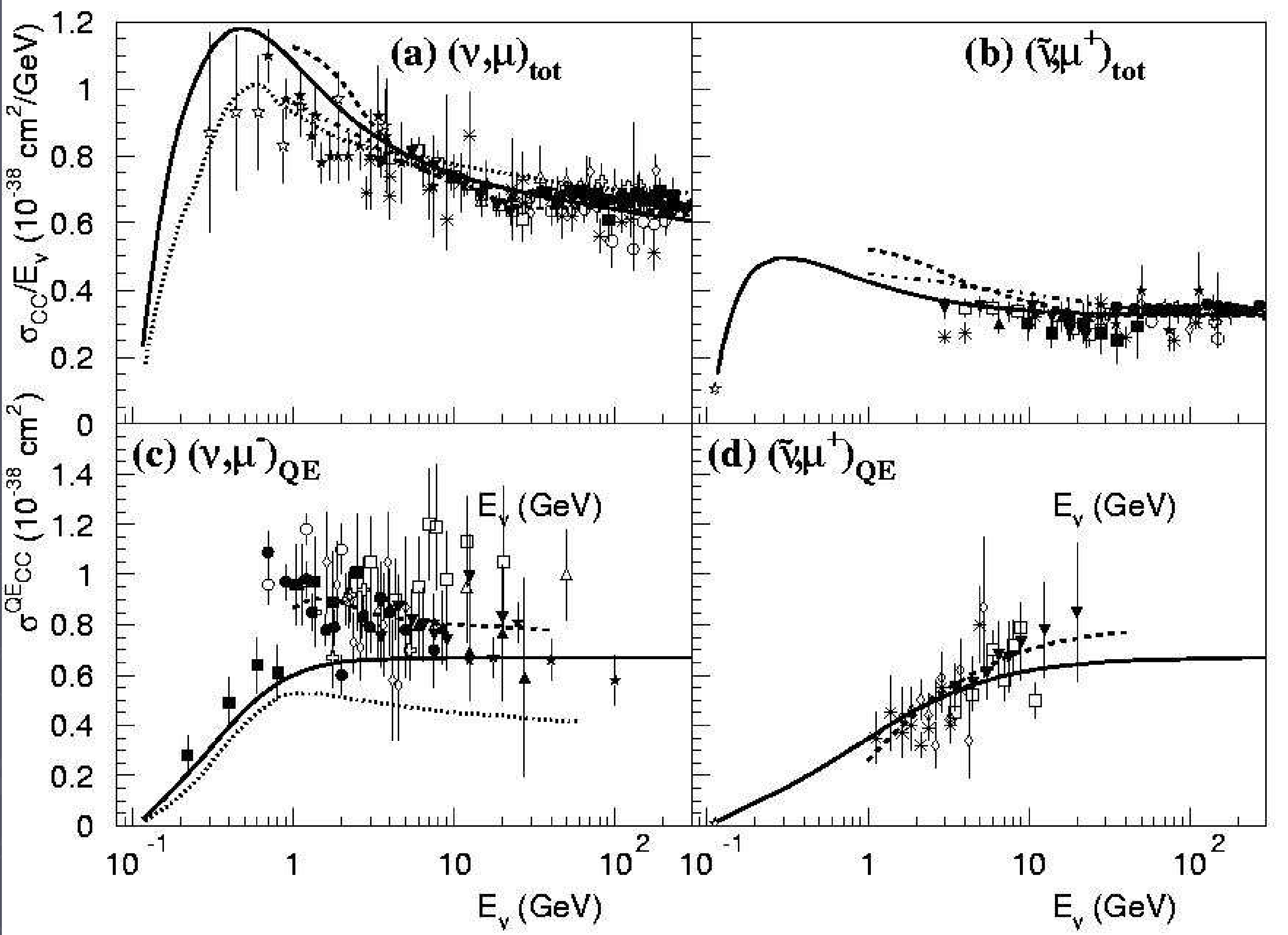


New Developments in CHIPS

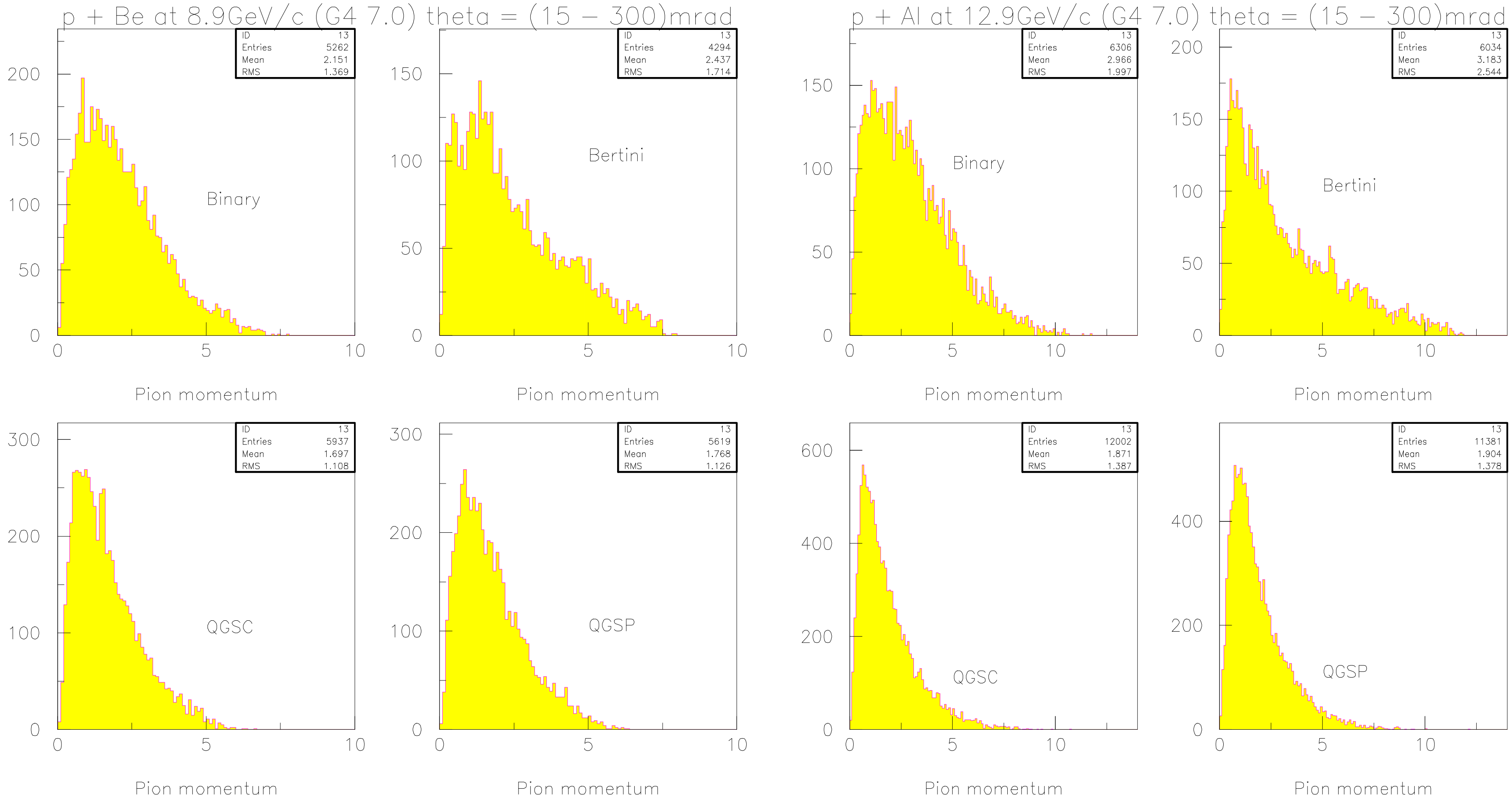
- G4QCaptureAtRest for nuclear capture of negative hadrons, muons, and low energy neutrons/antineutrons.
- Process level tests for comparison of simulated parameters with experimental data
  - Validation tests for at rest and in-flight (test19/test29).
- G4QCollision for photo- and lepto-nuclear reactions
  - with DIS simulation of neutrino-nuclear reactions.
- New fixed version of CHIPS for QGSC and FTFC.

M. Kossov

Neutrino-nuclear interactions for CNGS



HARP test: Pion production by protons of 8.9 GeV/c in Be and 12.9 GeV/c in Al G4 7.0



Summary

- Improvements in multiple scattering process
  - Addressing issues with 'electron transport'
- Speedups for initialisation/navigation
  - Only re-optimise parts that change with run
  - New voxelisation options being studied for regular geometries
- Revised implementation of particles
  - Impacting advanced users, customizing
- Refinements in hadronic physics
- Improvements in visualisation, user interfaces, …