Geant4 Release 8.0 Highlights

J. Apostolakis for G4

Outline

- Improvements in electron transport
  - Multiple scattering
- Developments in kernel
  - Geometry, particles
- Refinements, improvements in hadronics
- Physics Lists
- Migration of User code

- Complete list of scheduled features
  - http://geant4.web.cern.ch/geant4/source/planned_features.html
- Apologies for missing attributions and developments not included in this presentation

Review on Multiple Scattering

- Simulating energy deposition for thin layers precisely has required using very small cuts (slow)
  - medical applications, shielding, fine granular calorimeters...
- Users reported results that depended significantly on step limits and cut value
- An extensive investigation of cut/step limit effects was carried out, and concluded that:

Multiple Scattering process is very important

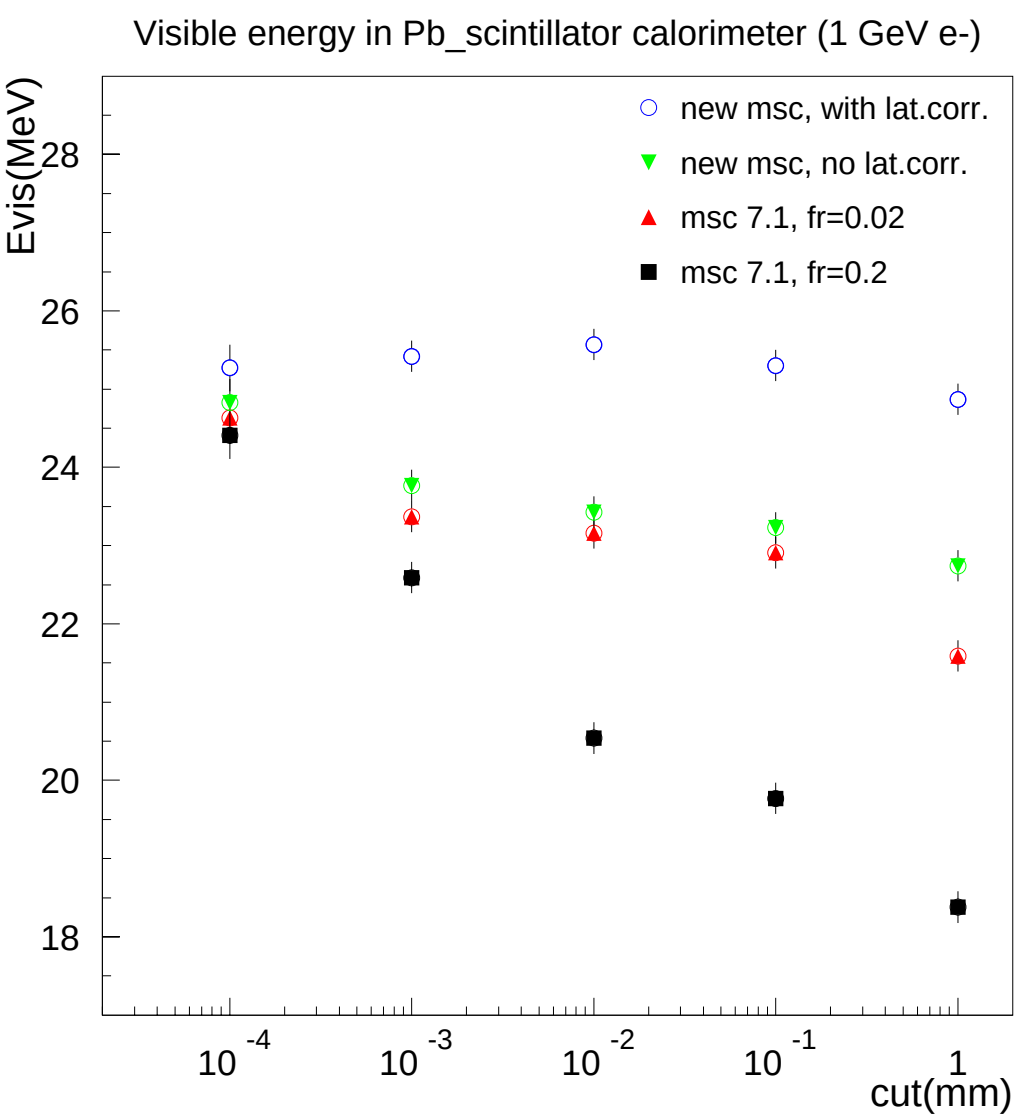
M. Maire, L. Urban

Upgrade of Multiple Scattering between 7.1 and 8.0

- Multiple Scattering process (MSC) performs these functions:
  - samples scattering angle after step
  - Samples lateral displacement
  - t <-> z transformations
    - Physical <-> geometrical step
  - Step limitation
- G4MscModel Improvements:
  - Introduced correlation between scattering angle and radial displacement
  - More precise calculation of geometry 'safety' before sampling 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
  - 2 steps in the start volume
  - 4 steps in other volumes it crosses,
- New method overrides changs
  - Restores values/results of 7.1
  - SetMscStepLimitation(false)
    - In G4VMultipleScattering

For further information please see M. Maire's talk
http://agenda.cern.ch/fullAgenda.php?ida=a057572

Motivation/First results of Upgrades



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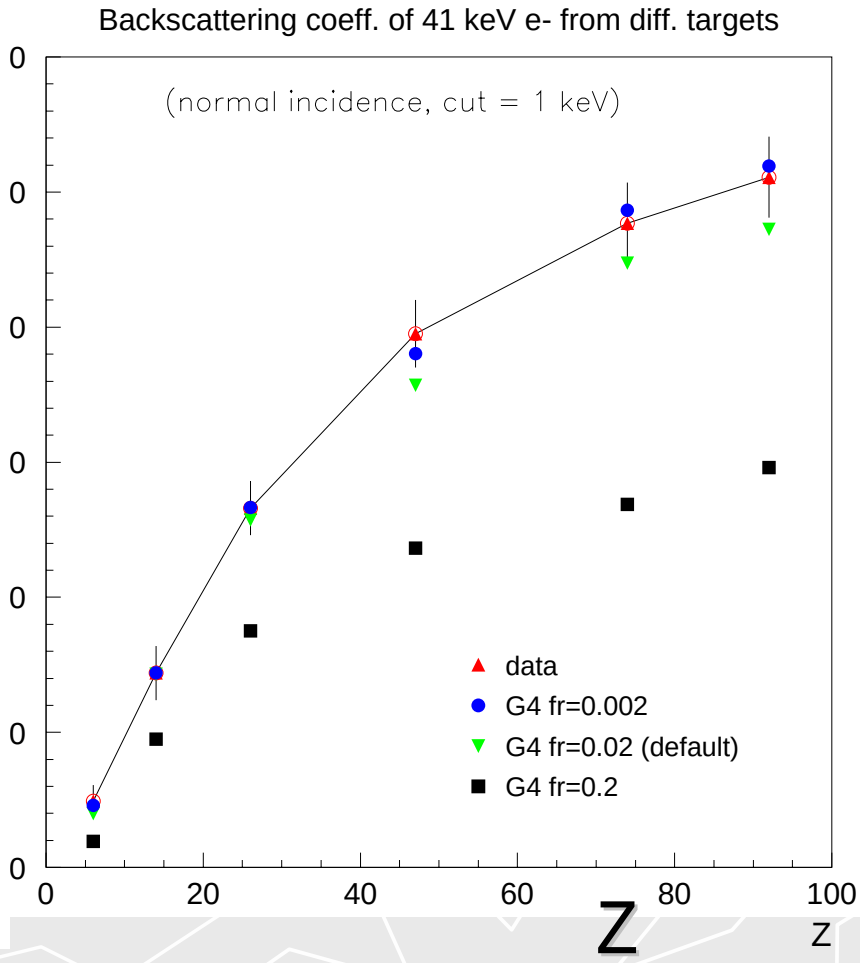
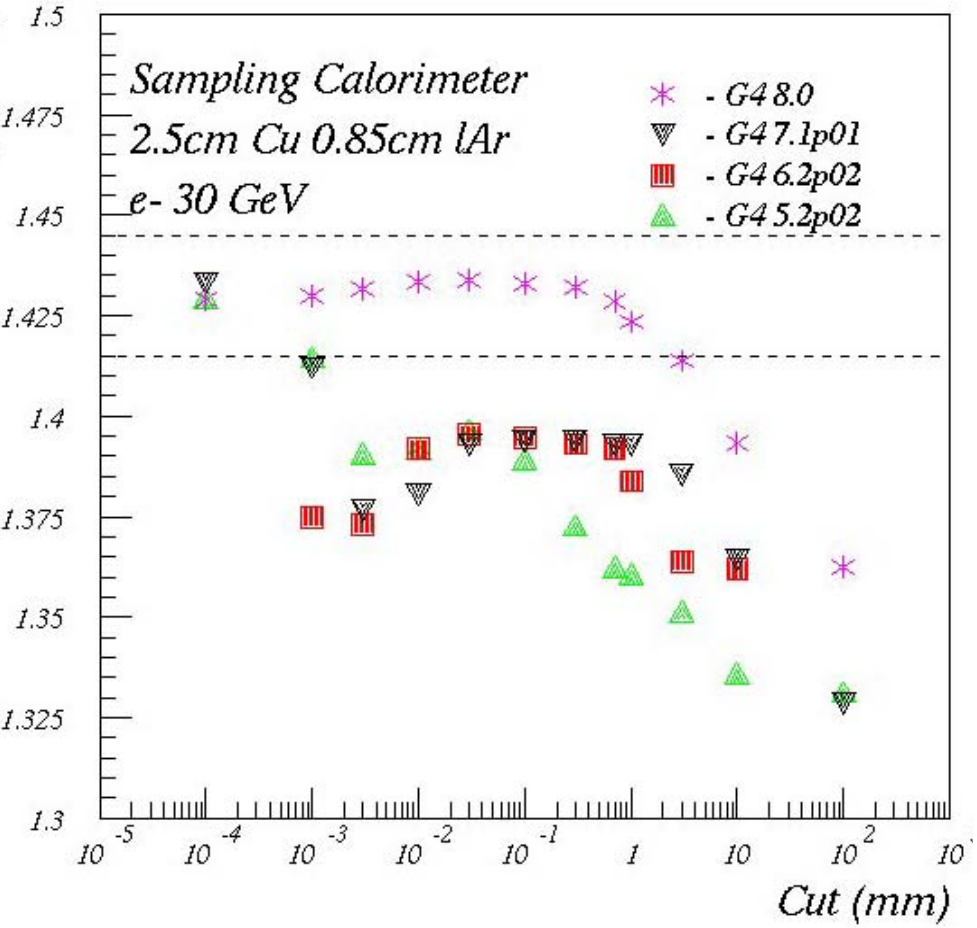
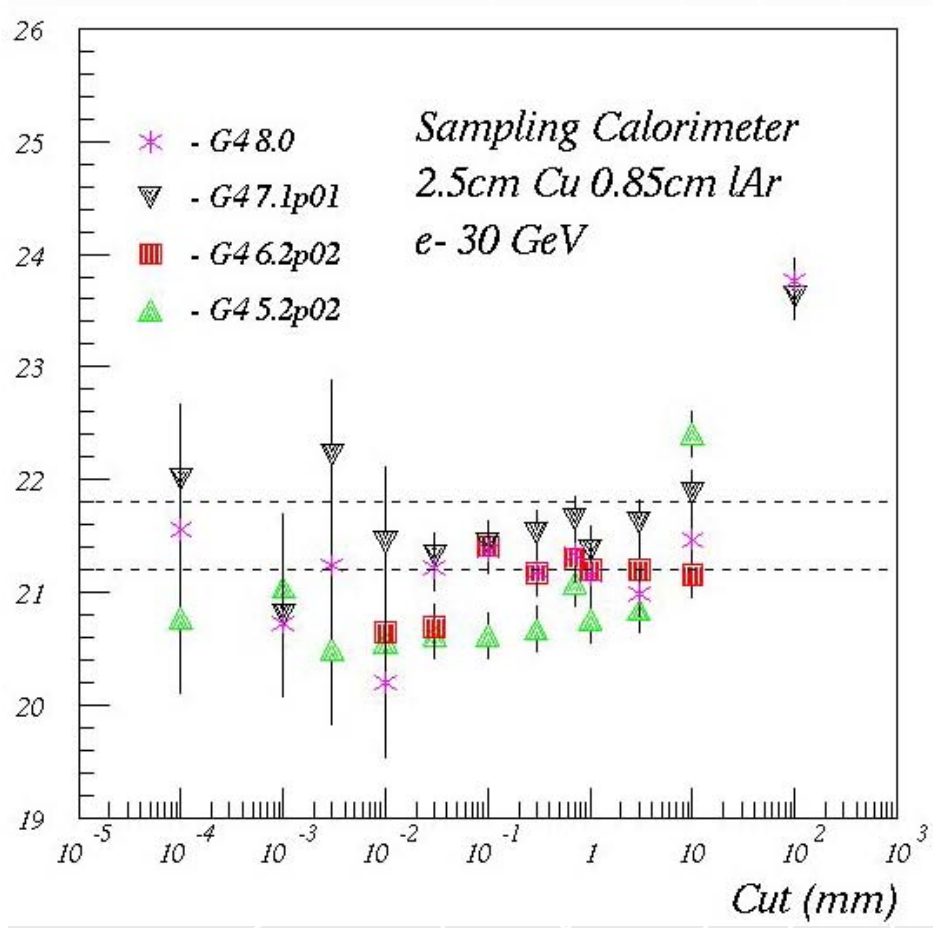


Atlas HEC : Cu(25mm)-lAr(8.5mm)

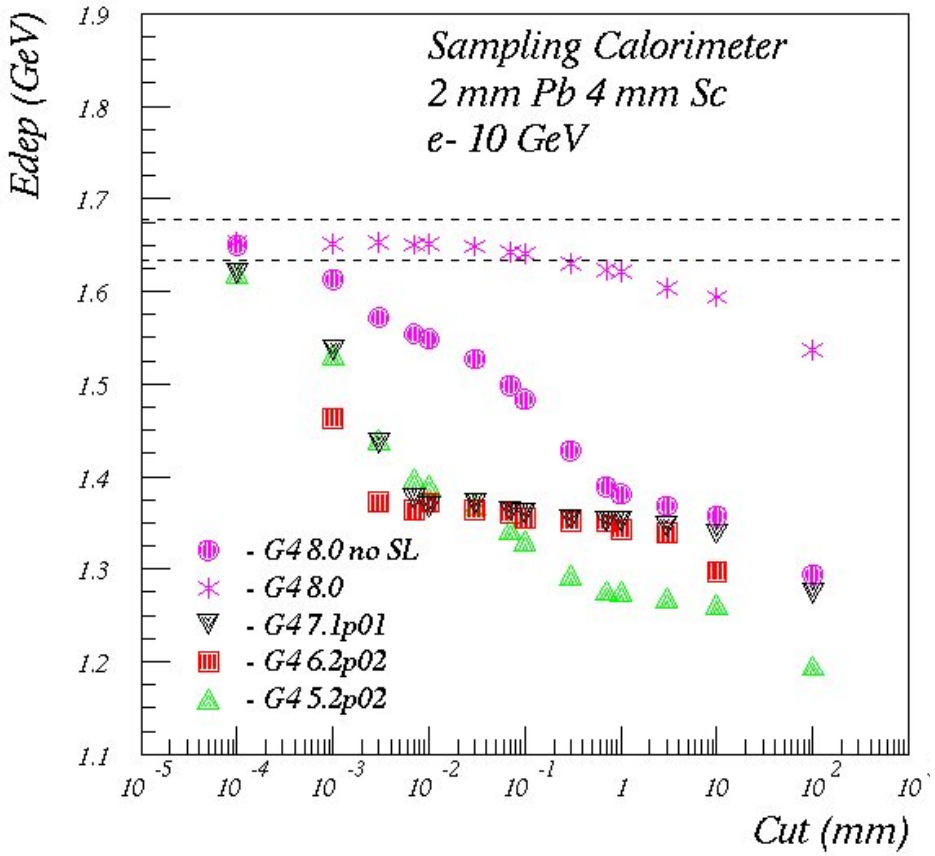
Energy Deposited (GeV)

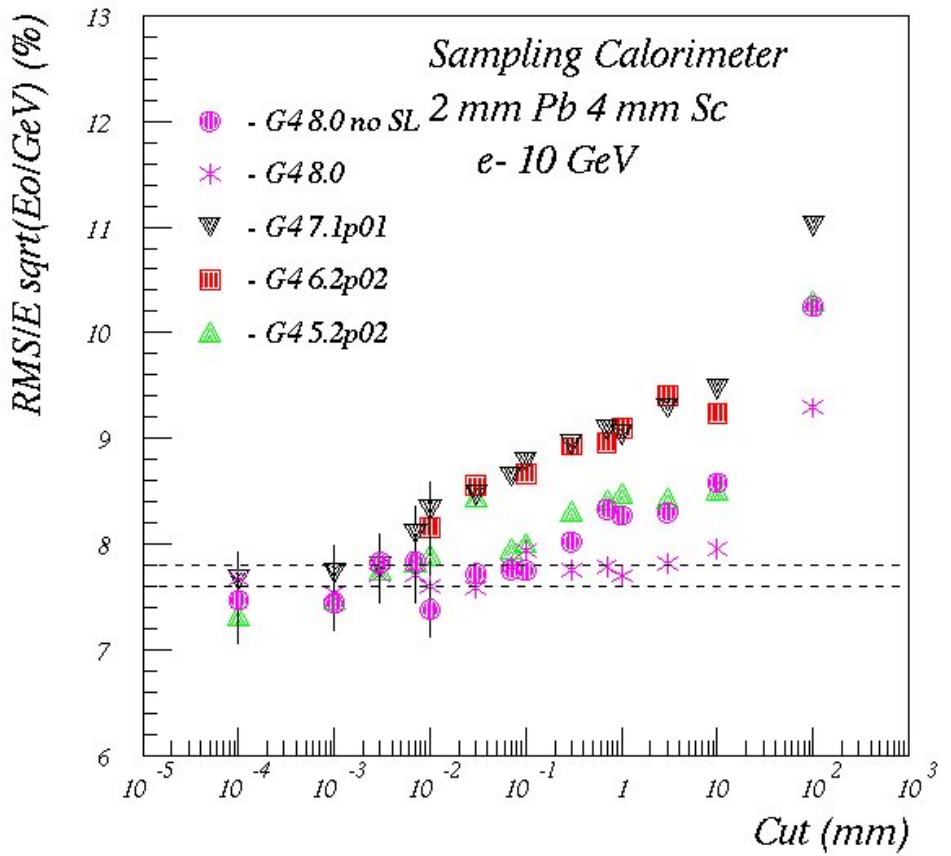


RMS/ (E * sqrt(E_0/GeV) (%)



LHCb : Pb(2mm)-Sc(4mm)





Geometry: solids and dynamical geometries

- Additional solids
  - Generic twisted trapezoid shape with different endcaps - (O. Link)
  - New ellipsoid (G.Guerrieri, INFN/Genova) 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:
  - Was used for G4ProductionCuts and G4VUserRegionInformation,
  - Can now create User Limits for Regions (7.1)
  - Now enabled its use with parameterisation / Fast Simulation
    - All these data members are optional

Nested parameterization

- In the past G4VPVParameterization::ComputeMaterial() method used to take only the copy number of the immediate physical volume
  - There was 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 is 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

Non-static particle definition

- In Geant4 8.0, all particle definition class objects are instantiated when GenerateParticle() method of physics list is invoked
  - Until now, most particle definition objects were static and the GenerateParticle() method ensured they were linked in the 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.
- Released 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 to store hits in their detectors (HEP experiments).
  - But is not convenient for radiation applications (Space/medical/HEP)
    - Where the main interest is scoring dose/flux.
- G4 8.0 introduces 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.

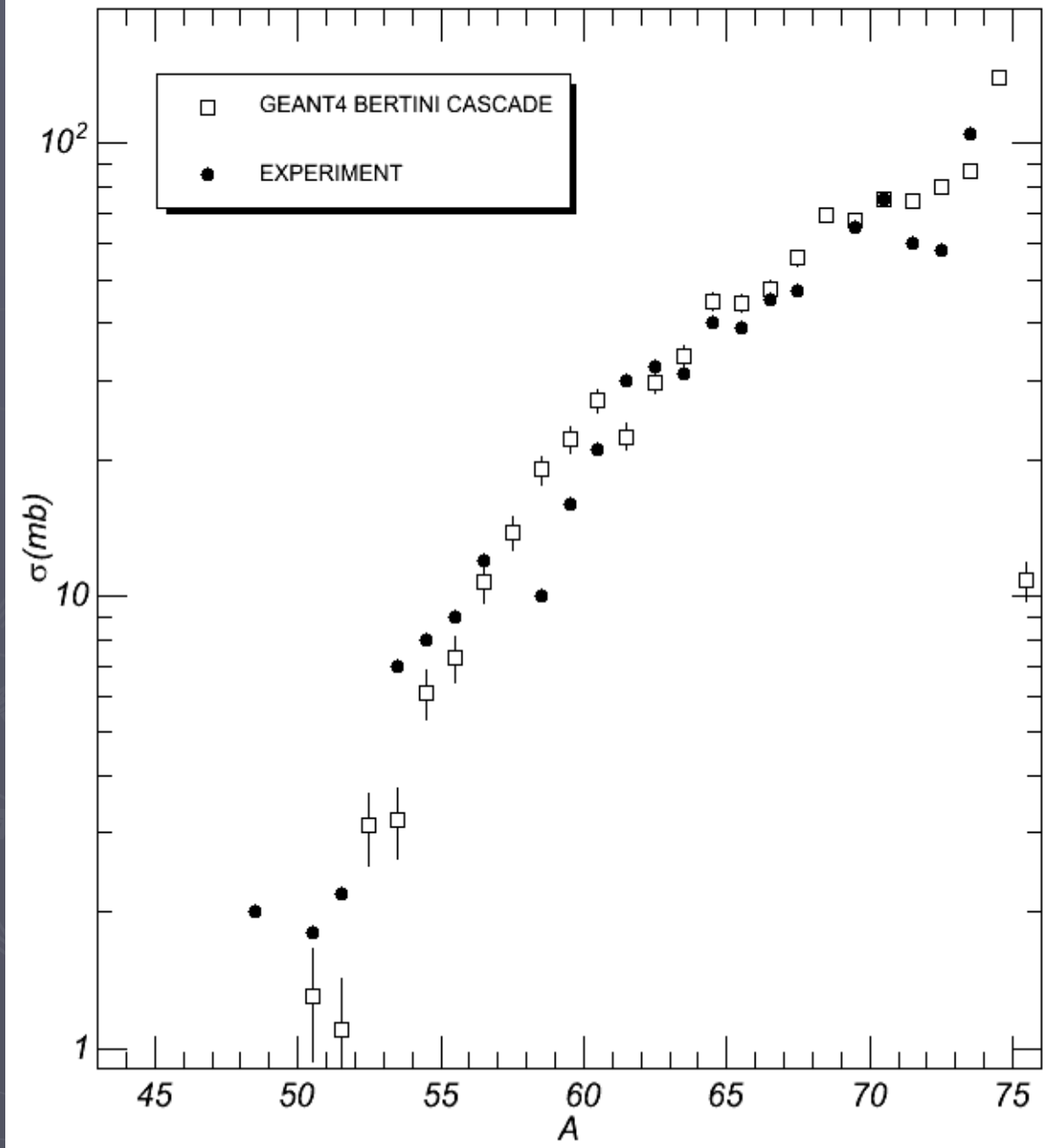
M. Asai for Run-Event WG

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

A. Heikkinen, D. Wright

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

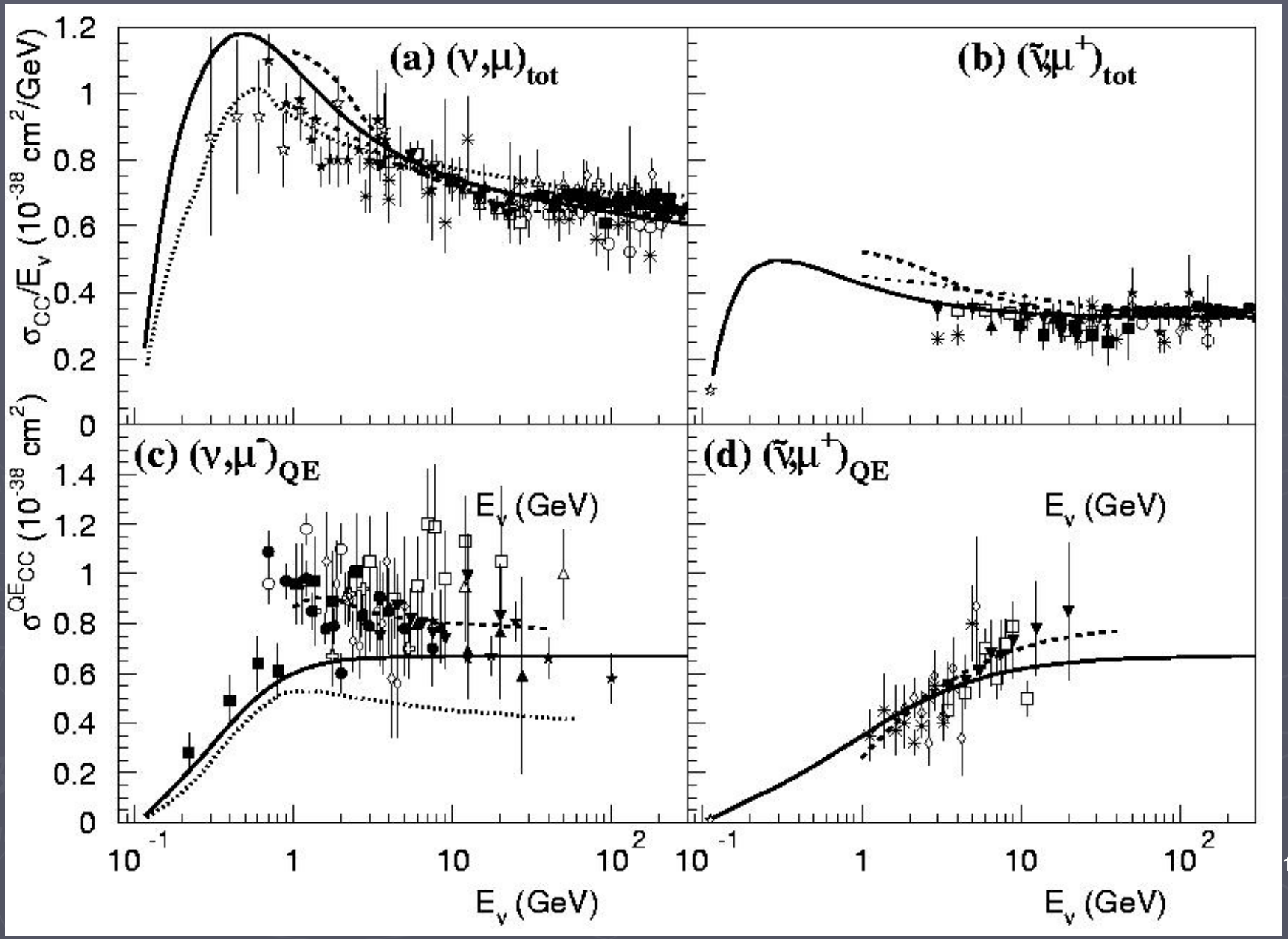


New Developments in CHIPS

- 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. Kosov

Neutrino-nuclear interactions for CNGS



Physics Lists

- Revised to work with Geant4 8.0
  - Co-work with particles revision
- Utilise EM(std) physics builders
  - Tested by EM(std) WG on HEP calorimeter setups
- Now γ-A interactions is default in all PLs
  - QGSP_GN is now QGSP, includes γ–nuclear
  - A few 'engines' suppressed
    - LHEP_GN, ..
- New variant with 'old' EM physics
  - QGSP_EMV uses multiple scattering with 7.1 parameters

Migrations

- Migrations:
  - Use of <sstream> instead of <strstream>
  - Support for CLHEP-2.0.X (compatible with 1.9.X series)
- Changes required in User Code
  - Fast parameterisation
    - Region replaces ‘envelope’.
  - Creating and instantiating physics lists : impact of the revised, "non-static", particle definitions
  - G4VProcess base class
    - StartTracking() now has argument const G4Track*

Summary

- Improvements in multiple scattering process
  - Addressing issues with ‘electron transport’
- Speedups for initialisation/navigation
  - Option to only re-optimise parts that change with run
  - New voxelisation options being studied for regular geometries
- Overlap checks at geometry construction
- Revised implementation of particles
  - Impacting advanced users, customizing
- Refinements in hadronic physics
- Improvements in visualisation, user interfaces, ...
- Migrations:
  - Use of <sstream> instead of <strstream>
  - Support for CLHEP-2.0.X (compatible with 1.9.X series)