Developments for Performance for Space Applications

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for the Geant4 Collaboration

ESA / ESTEC

Geant4 Review
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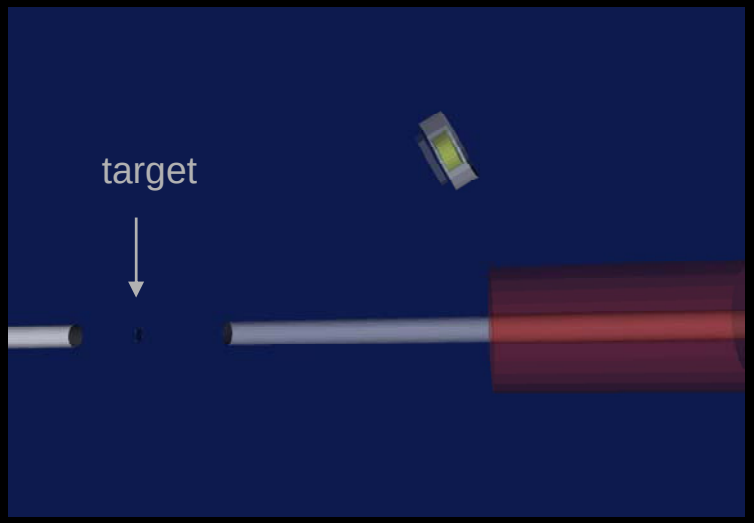
Geant 4

- Several application domains in which Geant4 performance can be an issue
  - Ground testing (accelerator, radioactive sources)
  - Space radiation environment spectra
  - Microdosimetry in big spacecraft structures
- Geant4 offers several variance reduction techniques (since several years)
  - Presented per application domain
- Single particle (no collective effects) → Parallel / distributed computing
  - Local cluster / GRID
  - TOP-C, DIANE, …
- Present developments →
  - More coherent VR framework to increase usability
  - Several new features (parallel geometries, more physics biasing, inverse MC, …)

Features by application domain (1/2)

Ground testing of space devices



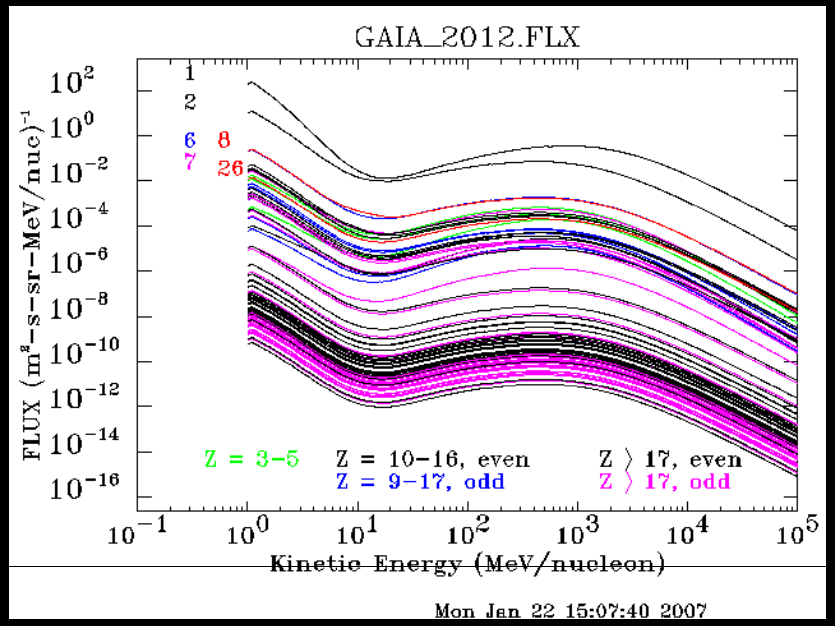
- Accelerators (thin target)
  - Cross section biasing
    - User implementations via G4VWrapperProcess
    - Hadronic physics
    - New Std EM developments
  - Forced interaction (implemented in HARP S/W)
- Radioactive sources (soft spectrum, shielded sensitive volumes, late activation products)
  - RDM built-in biasing options
    - Decay branching ratios / nuclear splitting
    - Observation time window
    - Fast beta decay (“fbeta”)

Features by application domain (2/2)

Geant 4

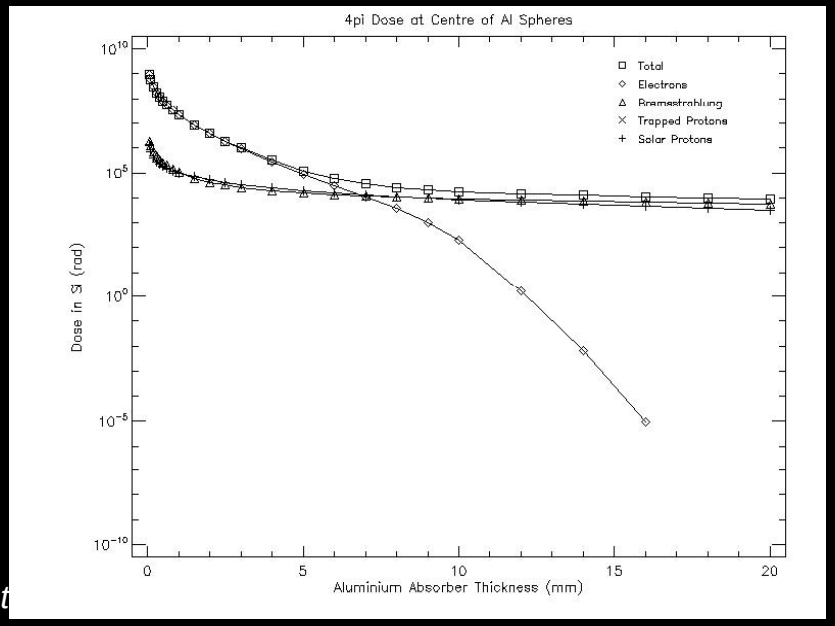
Space radiation environment spectra
e.g. cosmic ray / solar / trapped radiation

- Source biasing (GPS)
  - Position, Angular and Energy biasing
  - Multiple source biasing

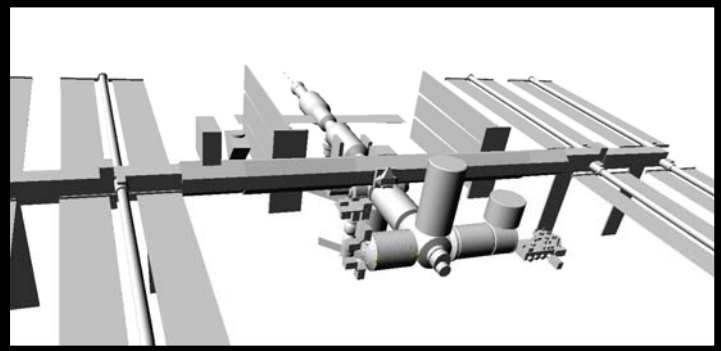


Big spacecraft structures (thick shield, micro-detectors)

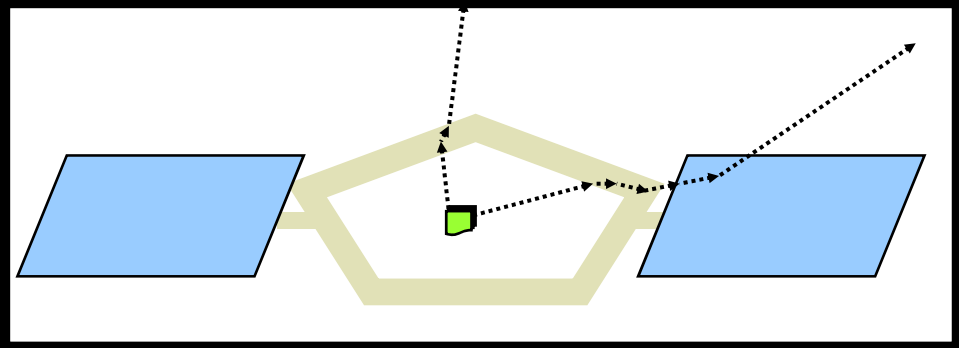
- Source biasing
- Geometry biasing
- Physics biasing
  (e.g. Brem splitting in e- environment)
- Inverse Monte Carlo



Geant4
Reverse MC



- Space Engineering essential requirement
- Microdosimetry (electronics) from space environment in big structures
- Up to 10^2 precise calculations in ~ 1 hour (or less)
  - Dose, Flux, Single Event Effects



- New transport equation, “adjoint” to the conventional “forward” transport equation
- Transport analogous to the forward one, but backward
  - successive points are higher in energy, earlier in time

Laurent Desorgher (Space IT) with ESA funding (REAT_MS 1 & 2)

Performance of the whole space application development cycle

Installation, migrations

- Layered software structure
  - CLHEP
  - GMDL
  - Histogramming

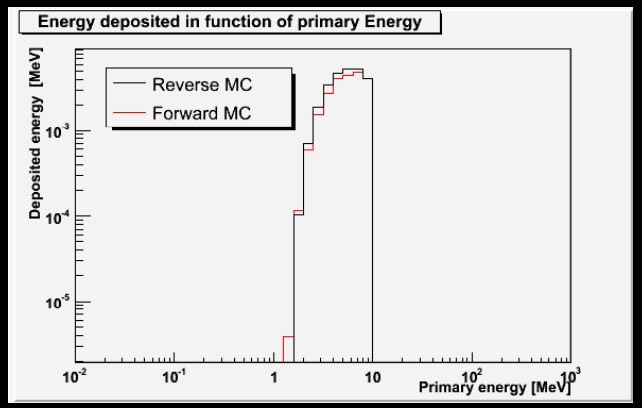
  Considering reducing number of dependencies

Geometry interfaces

- CAD (STEP)
  ESA REAT-MS project (QinetiQ + subcontr.)
- Tessellated solids (triangular/quadrangular facets)
  Up to 10^5 – 10^6 facets per model !
  Performance improvement under study (QinetiQ, ESA)
- GUI for geometry development (TRAD & eta_max, ESA)
  GDML output

Backup

Geant4 Reverse MC



Laurent Desorgher

Space IT and Uni. Bern

"Adjoint" technique [Kalos 1968]

- New transport equation, "adjoint" to the conventional "forward" transport equation
- Transport analogous to the forward one, but backward
  - successive points are higher in energy, earlier in time
- Suitable for Monte Carlo calculations
- Computations start at the detector and score at the source
- Possibility of computing doses at a point!

Feasibility study (REAT_MS 1)

- G4 RMC Prototype for fast e- dose computation
- Only continuous energy loss and simple multiple scattering
- Completed

Full implementation (REAT_MS 2)

- RMC in G4 for fast e- dose computation
- Backward simulation of :
  - e- ionisation with delta production, continuous energy loss and multiple scattering
  - Bremstrahlung, compton scattering, photo-electric effect
- In development - Release mid 2007

Proposed to be included in Geant4 release