GEANT4 Updates for 9.5 Release

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AARM Simulation Workshop
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GEANT4 9.5 Release

GEANT4 9.5 Release is scheduled for 2 December 2011

Many changes and improvements, both internal and external

This talk will focus on low-background/underground requests

- Requirements from LBE Community
- Improvements to radioactive decay models
- Improvements to neutron production
- Deployment of new μ-nuclear process
- Plans for direct γ-nuclear process
- Optical photon tracking

Requirements From LBE Community

- √ Forbidden-transition beta decays (database)
- √ Photo-evaporation models and data
- √ Neutron production in muon-induced showers
- √ Optical reflection models, precision data
- – (α,n) reactions below 10 MeV
- – Neutron production from muon capture
- × Populate metastable nuclear states by neutrons

D. Wright, G4 Collaboration Meeting, Sep 2011

Radioactive Decay Models

Improvement to beta-decay spectral shape, including ^{210}Bi

- 1st, 2nd, 3rd unique forbidden transitions
- Nuclear size information, nuclear angular momentum
- Different energy dependence shifts mean β energy
- Improved Fermi function

Improved IC in photo-evaporation, using data from Nudat2

- Automated script to download Nudat2 to GEANT4
- Conversion coefficients from data where available
- Validation suite for G4RadioactiveDecay

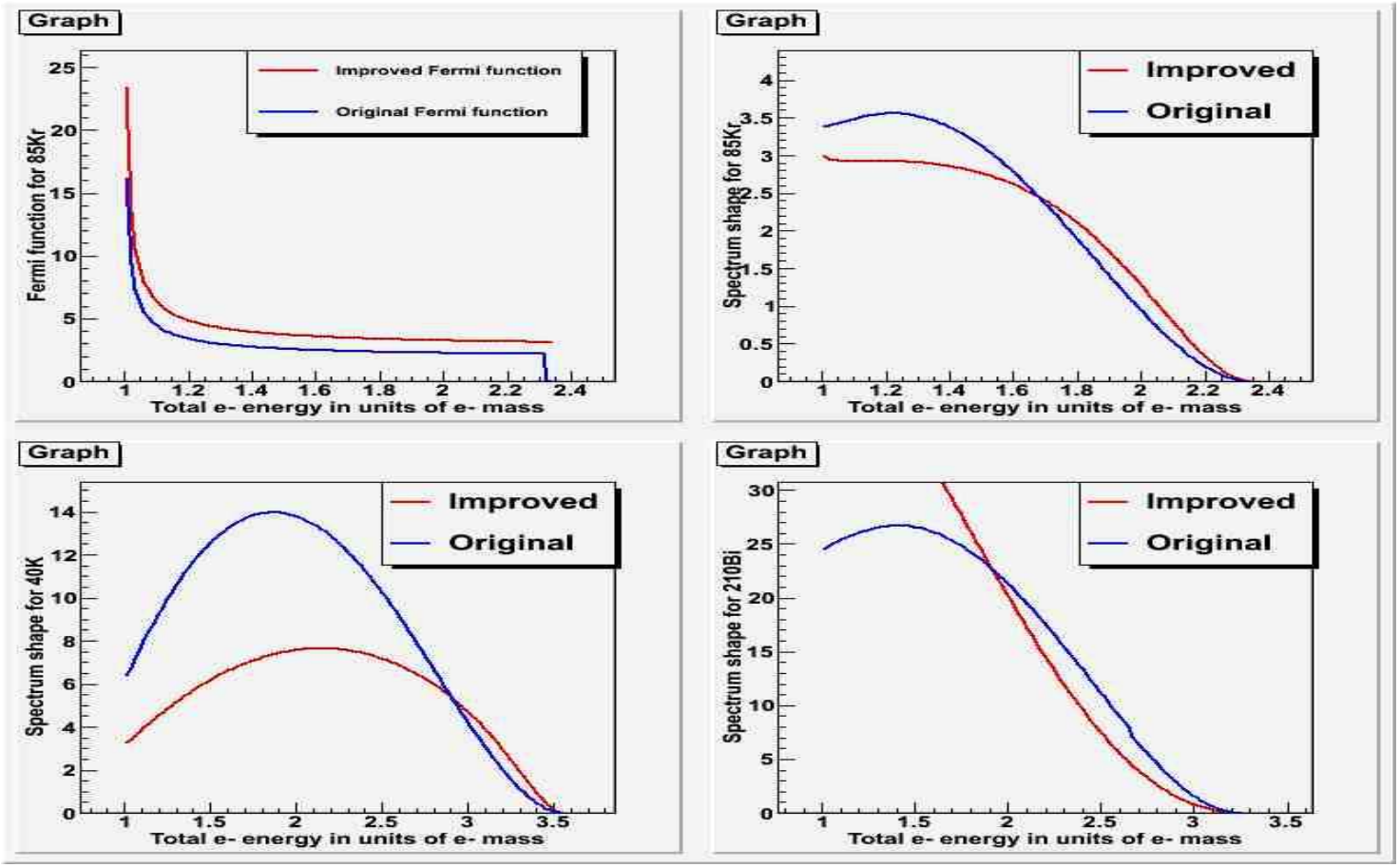
Extension of G4RadioactiveDecay for Z>100, A>250

- Users may load private database files with macro commands
- Also need to support IC for Z>100 (*G4AtomicShells*)

L. Desorgher, G4 Collaboration Meeting, Sep 2011

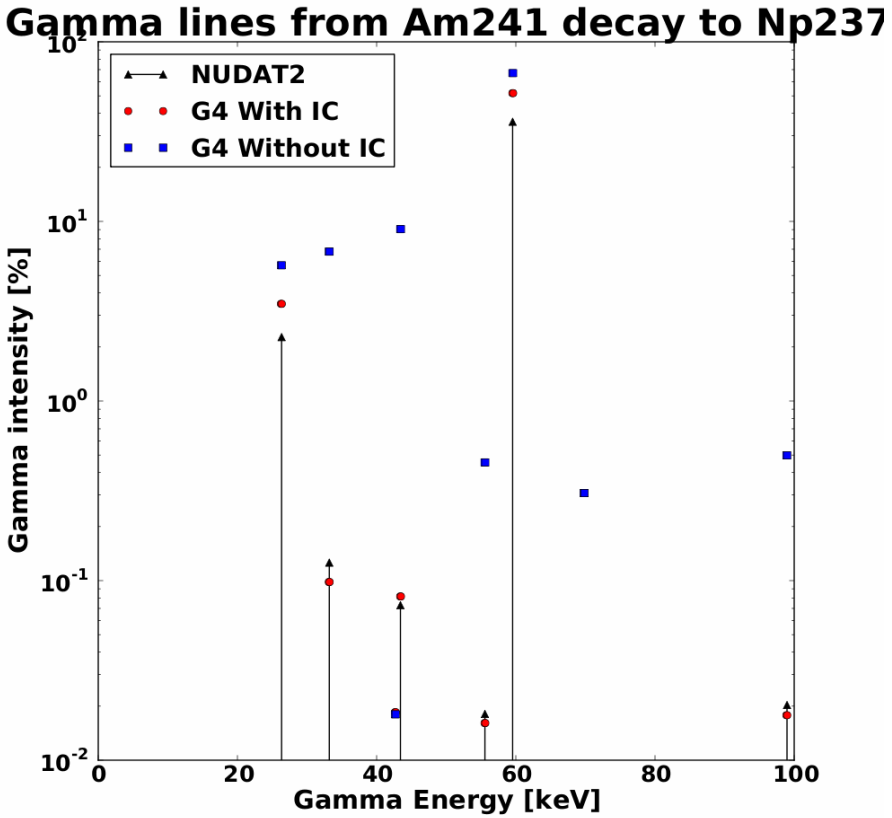
Forbidden β Transitions

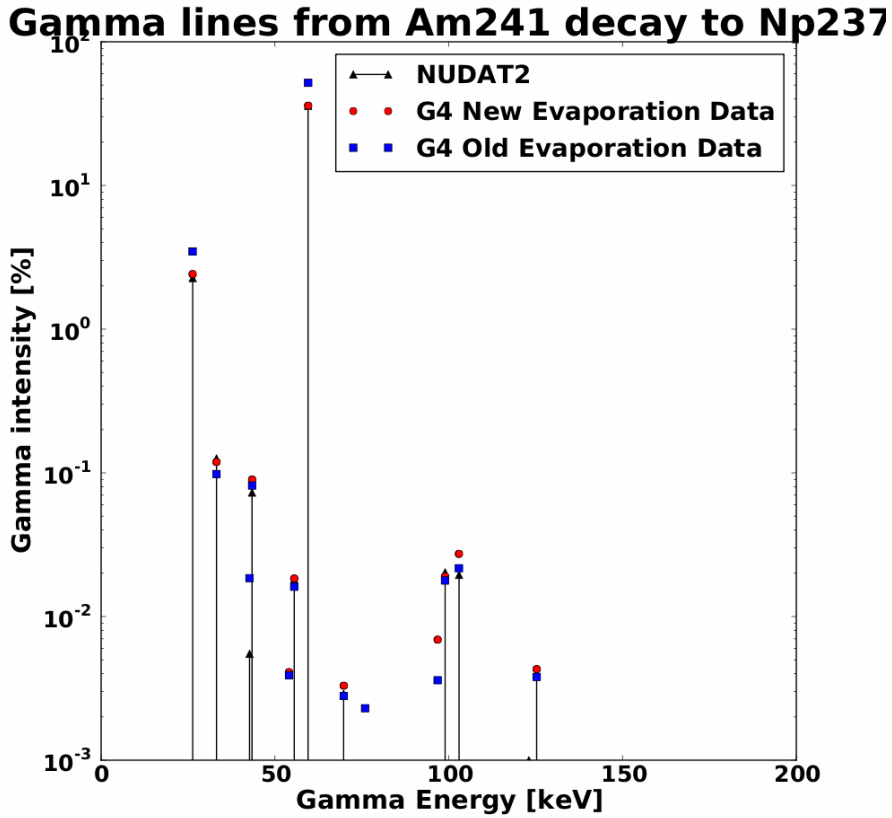
Blue: G4 9.4 Red: G4 pre-9.5



Internal Conversions

Black: Nudat2 Blue: G4 9.4 Red: G4 pre-9.5





Neutron Interactions

Bugs found in some **NeutronHP** internal classes have been fixed

Latest G4NDL includes ENDF-VII.0 and JENDL-4.0

- New ENDF-6 neutron data format now readable by GEANT4
- G4NDL data files will be distributed by IAEA
- Validated "isotope-by-isotope" against MCNPX

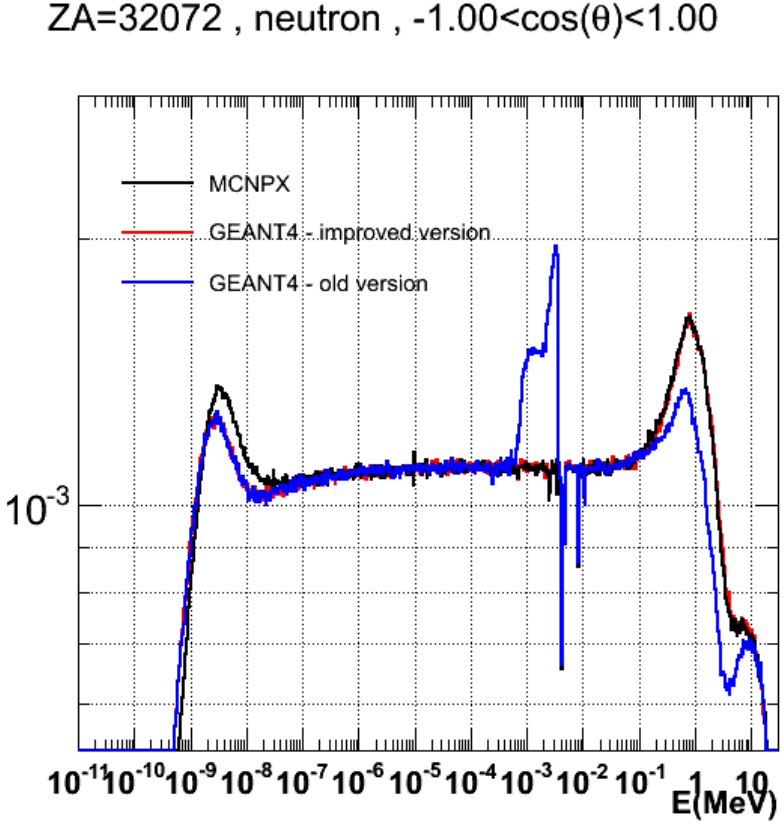
Use of new LEND data format (replaces ENDL, ENDF)

Inelastic model will use database for energies of final-state nucleons and light ions (p,n',d,t,^{3}He,α)

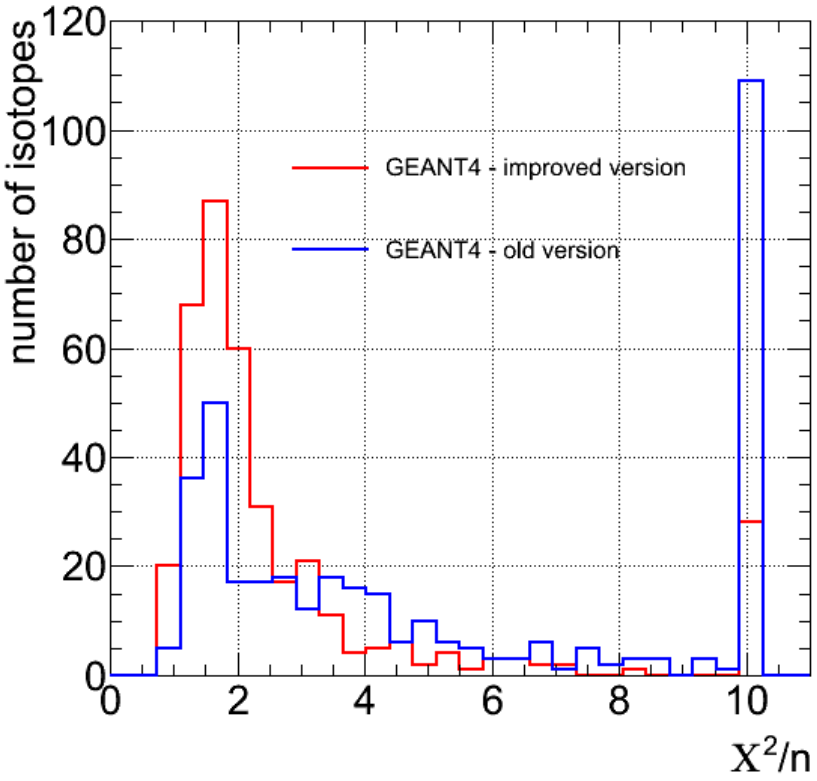
G4NeutronHP

Black: MCNPX Blue: G4 9.4 Red: G4 pre-9.5

^{72}Ge (n,n') Spectrum



All isotopes χ^2 vs. MCNPX



Improving (α,n) Spectra

"ChargedParticleHP" derived from **G4NeutronHP**

Use ENDF-VII, TENDL, IAEA medical database for p,d,t,... on (A,Z)

Physics lists configured analogously to NeutronHP

Validation will be by comparison to MCNP

Not ready for 9.5 release; expect to deploy with 9.6 (2012)

P. Arce, G4 Collaboration Meeting, Sep 2011

μ-Nuclear Interactions

Projectile muon exchanges virtual photon with nucleus

Virtual photon "converted" to pion, passed to existing intranuclear cascade models (Bertini, FTF)

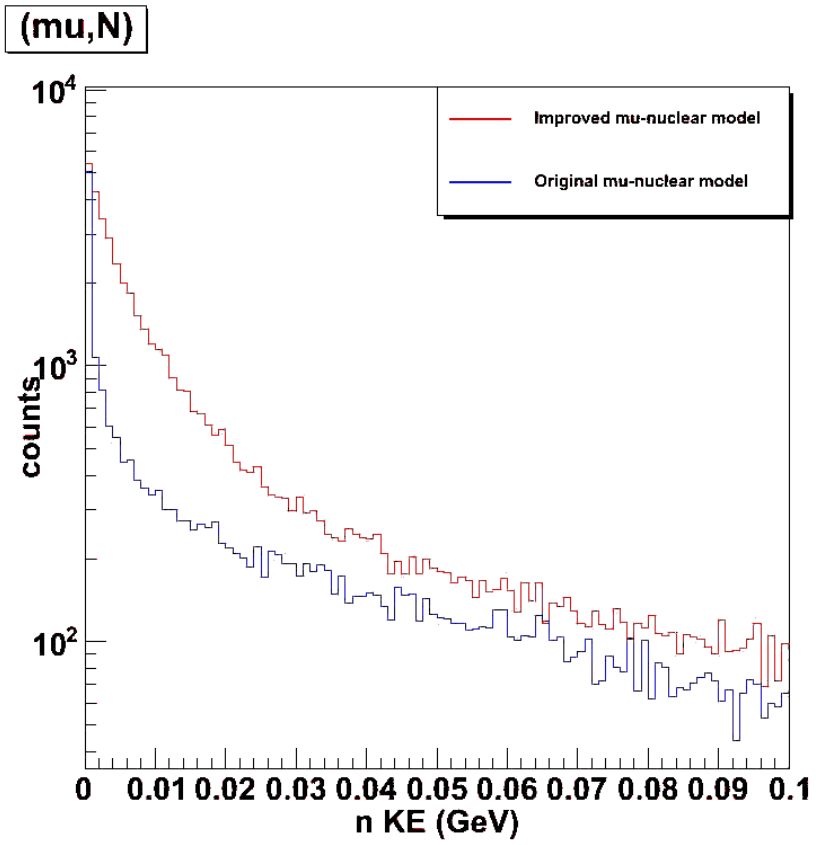
Neutron production increased over entire spectrum: better match to data, other codes

Inclusive cross-section tables unchanged

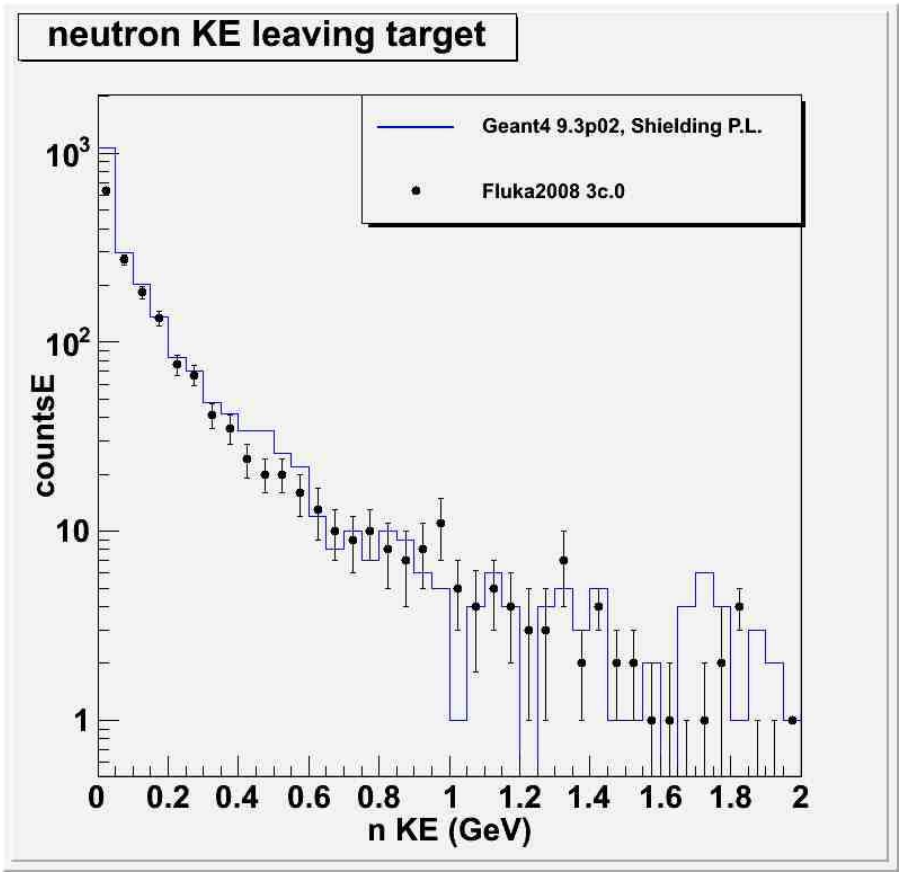
D. Wright, AARM Workshop, February 2011

μ-Nuclear Interactions

Blue: G4 9.4 Red: G4 pre-9.5



Comparison with FLUKA



γ-Nuclear Interactions

Direct photon-nucleus interactions are in development for GEANT4 9.6

Photon projectile to intranuclear cascade model (Bertini)

γ-p, γ-n final states up to 8 pions, $E_\gamma < 32$ GeV

Parametrized angular distributions still in development

Other final-state tables do not include photons

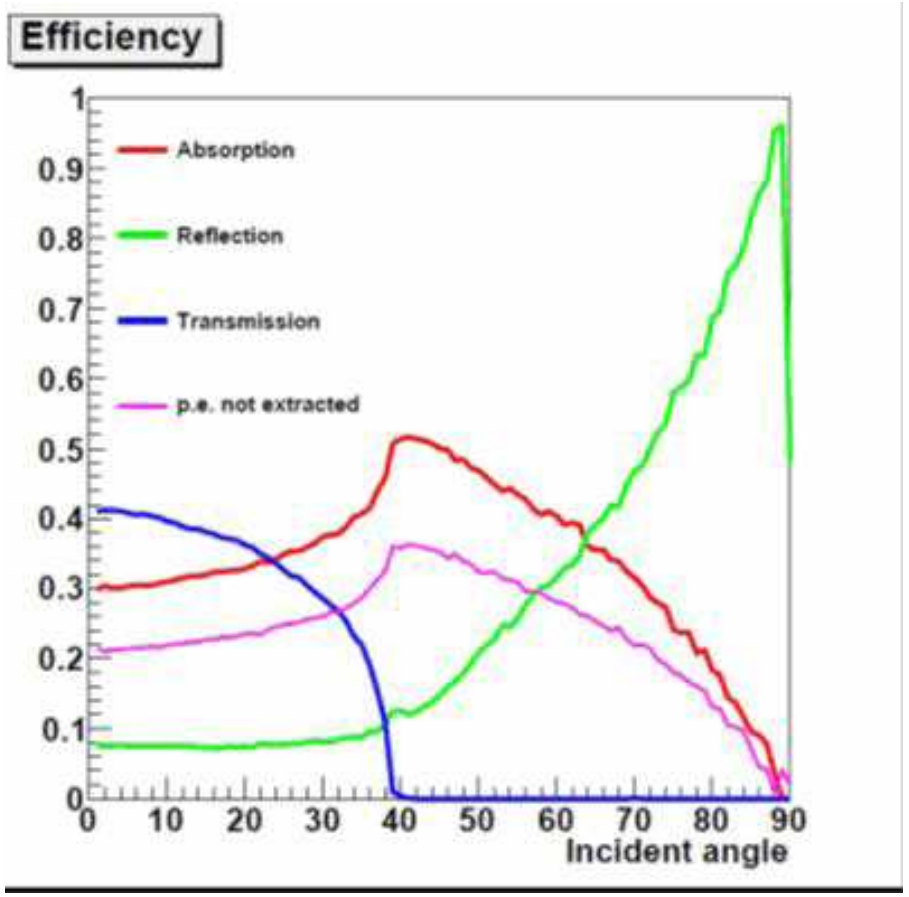
Will replace existing *G4PhotoNuclearProcess* in 9.6 (2012)

Optical Photon Tracking

Angular dependence of processes at optical boundaries

Calculated using complex refractive index for quartz at 175 nm

Wavelength dependence will be included in 9.5 release



K. Abe, G4 Collaboration Meeting, Sep 2011

Summary

Many requirements from LBE to GEANT4 are either

- $\surd$ satisfied (pending validation) for 9.5 (Dec 2011)
- – in development, aimed at 9.6 (Dec 2012)

Metastable nuclear states are not handled consistently in GEANT4 or in evaluated databases

Will require substantial development work