Parallel 4A: Hadronics Developments

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for the Hadronics Working Group

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Summary

Several processes/models introduced or improved this year

- Nucleus-nucleus interactions in FTF and INCL++
- BERT: Gamma and muon, N-N angular distributions
- Muon capture, decay-in-orbit, and cascades
- Nucelar de-excitation (PreCompound, evaporation)
- Radioactive decay expanded tables, isomer states
- NeutronHP, ParticleHP

Discrete isomeric states introduced as particles (G4Ions)

Hadronic framework is MT-compatible, optimization needed

Isomer States

Replaces direct use of excitation energy

Supports MT with “limited” set of pre-created particles

Uniform definition for excited states across processes

Reduces/eliminates internal, temporary G4Ions use

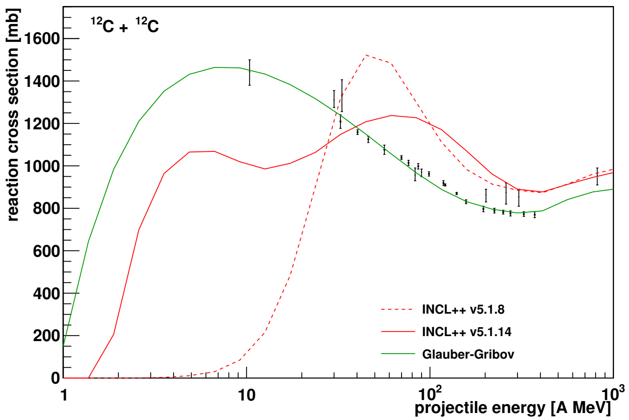
Nuclear-nuclear Interactions

Fritiof (FTF) String Model

- Handles two-nucleus input, two-fragment output
- Interfaces to Binary Cascade and PreCompound
- Energies from 3∼4 GeV/A up to RHIC supported
- Important tool for RHIC Beam Energy Scan program (BES)
- LHC validation poor (quark-gluon plasma)

Liege Cascade (INCL++)

- Significant tuning against data
- Improved small-cluster cross-sections (from INCL 4.6)
- Extend validity to 10∼15 GeV (2014)
- Plan to reintroduce ABLA(++)

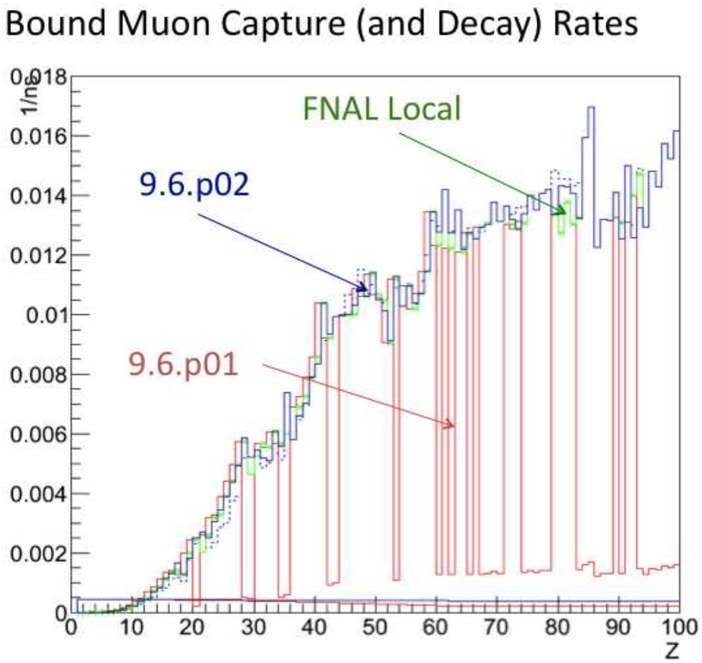


Davide Mancusi, CEA

Muon Stopping and Capture

Muon capture and decay-in-orbit substantially rewritten

- New, improved rate tables vs. Z,A
- Improved capture rate calculation
- Decay rate calculation vs. Z_{eff}
- **AlCap** data will be used after 10.0
- Capture ⇒ secondaries via BERT



Krzysztof Genser, FNAL

Dennis Wright, SLAC

PreComp, De-Excit, PhotonEvap

Improvements for multithreaded compatibility

- Removed statics, reduced singletons, improved memory usage
- Finalized migration to integer Z and A
- Replaced internal radom interface with G4 standard

Introduced production of isomer level states

- Generates correct de-excitation gamma spectra (user queries)
- Important for nuclear physics and medical applications
- "Long"-lived (1 μs) secondaris exposed to tracking
- Photon Evaporation needs code review, optimization, memory reduction

José Manuel Quesada Molina, U Sevilla

Vladimir Ivantchenko, CERN/G4AI

Particle HP

Replicates NeutronHP for inelastic scattering of "low" (E<200 MeV) energy particles (γ, n, p, d, t, ^{3}He, α)

Extensive validations against existing databases, other codes

- Cross-sections, secondaries, energy spectra
- TENDL Web data
- *G4PARTICLEHPDATA* vs. Job output
- G4 vs. MCNP (*Note: G4 does not interpolate tables*)

Reproduces NeutronHP exactly with neutron projectiles

Ready for release – should go into toolkit?

Pedro Arce Dubois, CIEMAT

Backup Slides

Isomer States

Through 9.6, G4Ions created with any (double) excitation

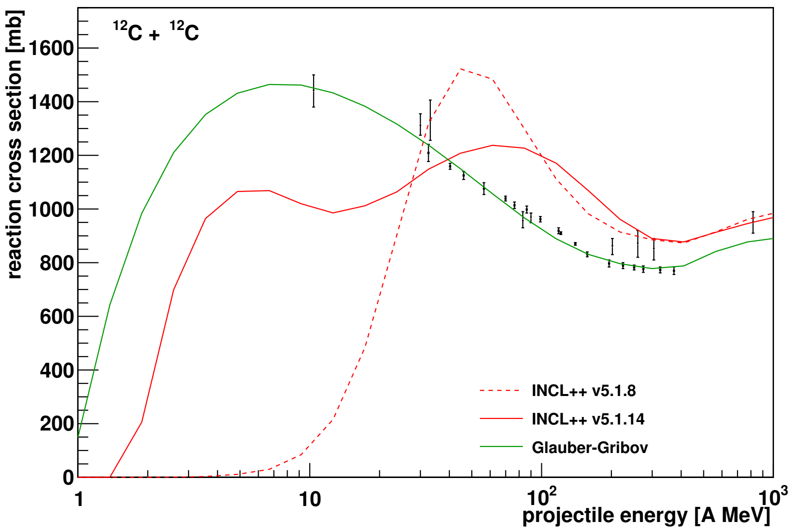
- Cascade models end up with excited residual nuclei
- Radioactive decay goes to excited final state
- Capture/absorption/quasi-elastic excites target

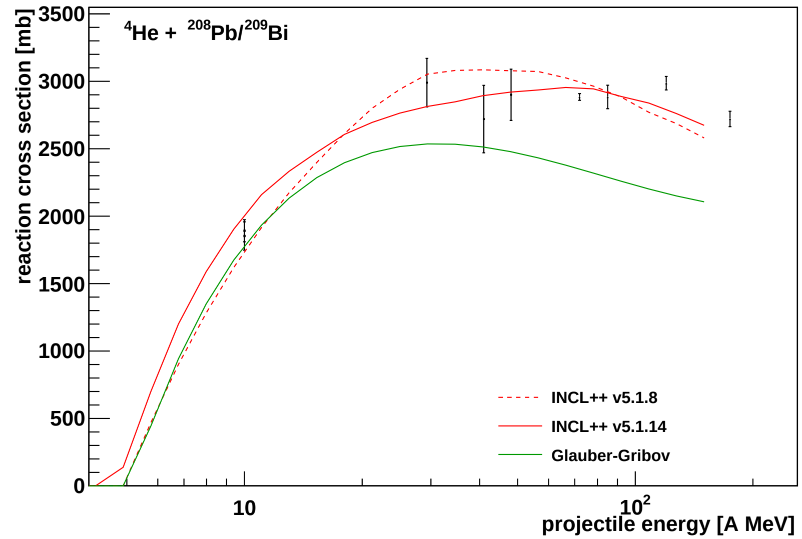
With MT, minimize writing to shared G4IonTable "on the fly"

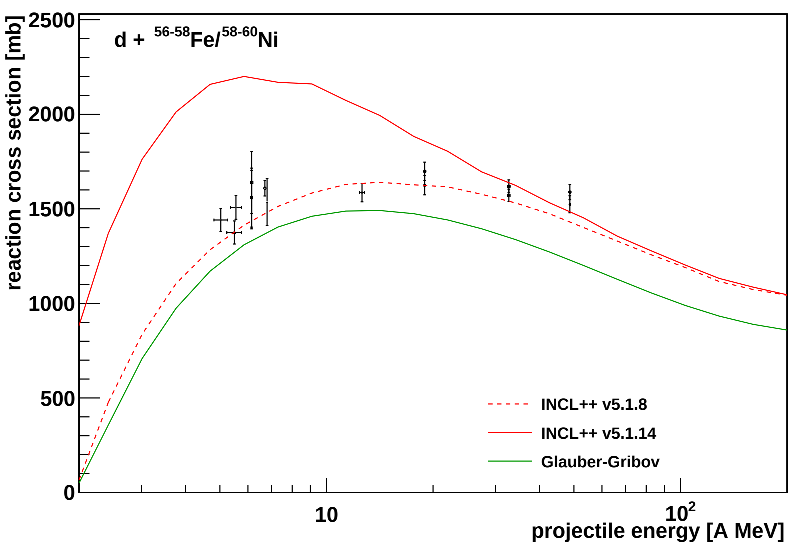
G4Ions with **known** (tabulated) excitations will be pre-created

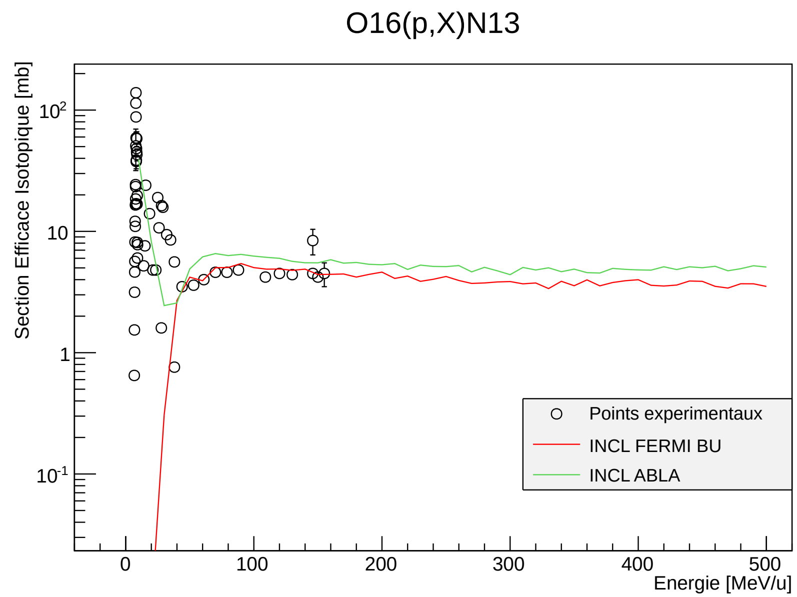
- Measured isomer states from photo-evaporation tables
- Finite (short, 1 ns) lifetime to limit quantity
- Labelled with integer level number, not double energy
- Energy value is internal, identical for all processes
- Accessible to all threads

Liege Cascade (INCL++)









Davide Mancusi, CEA

BERT Cascade

Most of 2013 Work Plan implemented

- New angular distributions for two-body final states
- Stopping/capture of muons with generated cascade
- Projectile emplacement, forced interaction validated

Addressed thread safety and re-optimizing for MT

Remaining items from 2013 Work Plan

- Enable post-cascade clustering for light-ion production?
- Use PreCompound as default for all de-excitation?
- Continuing struggle with “better” nuclear model parameters

Michael Kelsey & Dennis Wright, SLAC

Radioactive Decay

`G4RadioactiveDecay` (RDM) fully MT compatible

Nuclide decay tables now stored in map local to RDM

- No longer coupled to particle definition
- Master (static) map and local (per-thread) maps created

On-demand creation of ions (isotopes) still supported

RadioactiveDecay and PhotonEvaporation databases

- updated to ENSDF August 2012
- Versions 4.0 and 3.0, respectively

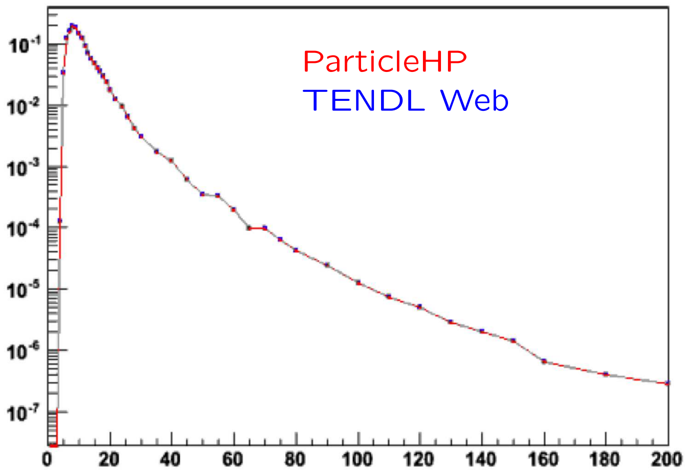
Re-design of RDM is required ($>$10.0 development)

- Internal conversion
- Correct gamma multiplicity

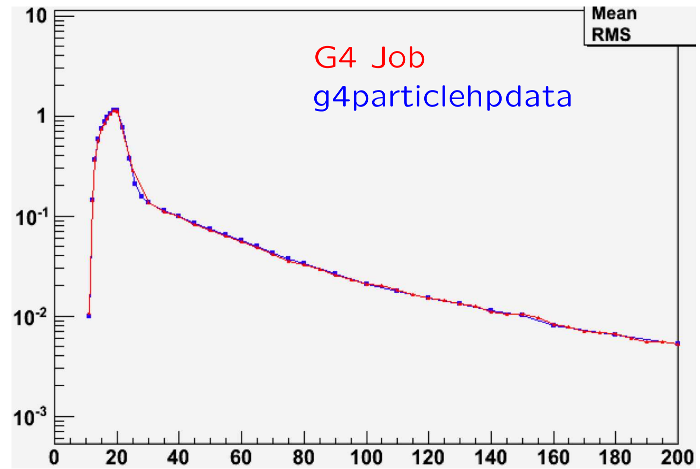
Dennis Wright, SLAC

Particle HP Validation

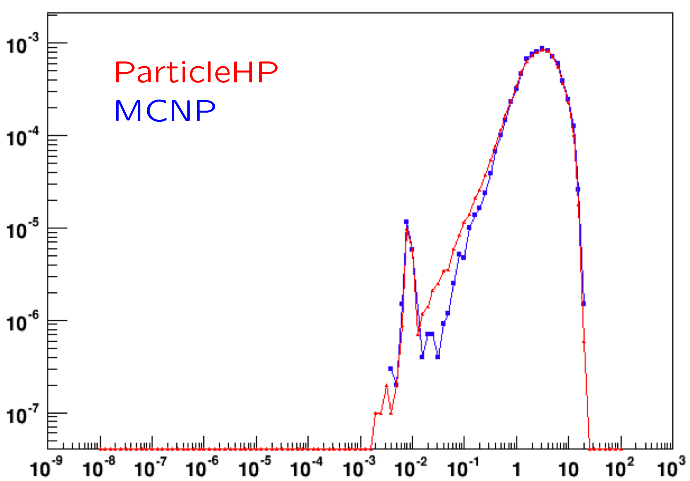
$^{14}N\ (p,\alpha)\ ^{11}C$



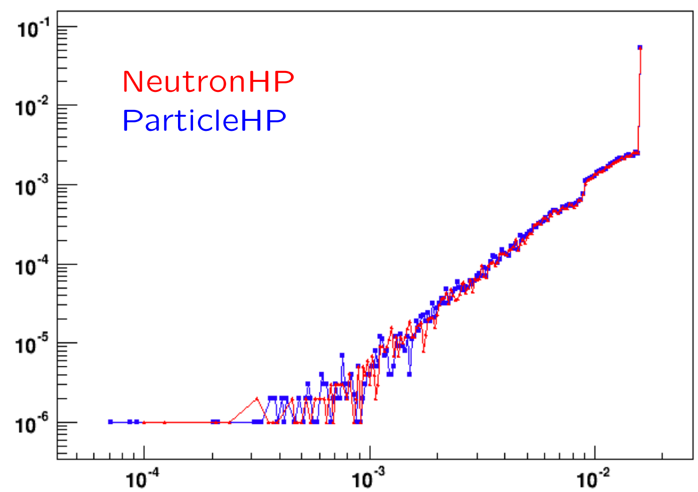
$^{208}Pb(p,2n)\ ^{207}Bi$



$^{18}O(p,n)\ X$



$^{27}Al\ (n,n)\ X$



Pedro Arce Dubois, CIEMAT