Summary Parallel Session 8A

Technical aspects related to hadronic physics and remaining topics

Gunter Folger

CERN/EP/SFT

Overview:

- Aczel Regino Garcia Rios
  - Complete description of the 12C(n,n'3a) and 12C(n,a)9Be reactions in the High Precision neutron model

- Julia Yarba:
  - Technical Aspects of Varying Hadronic Model Parameters and Studying Sensitivity of Simulated Results

Complete description of the $^{12}C(n,n'3\alpha)$ and $^{12}C(n,\alpha)^{9}Be$ reactions in the High Precision neutron model

A. R. Garcia, E. Mendoza and D. Cano-Ott
Nuclear Innovation Unit – CIEMAT, Spain

R. Nolte
Physikalisch-Technische Bundesanstalt (PTB), Germany

GOBIERNO DE ESPAÑA · MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD · Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

"Complete description of the $^{12}C(n,n'3\alpha)$ and $^{12}C(n,\alpha)^{9}Be$ reactions in the High Precision neutron model", A. R. Garcia et al. | 22nd GEANT4 Collaboration Meeting, 27-29 of September, 2017, University of Wollongong, Wollongong, Australia.

Step 1	Step 2	Step 3		
$n+^{12}C \rightarrow n'+^{12}C^*$	$^{12}C^* \rightarrow \alpha+^{8}Be$	$^{8}Be \rightarrow 2\alpha$	(I)	… E_n>8.29 MeV
$n+^{12}C \rightarrow \alpha+^{9}Be^*$	$^{9}Be^* \rightarrow n'+^{8}Be$	$^{8}Be \rightarrow 2\alpha$	(II)	… E_n>8.81 MeV

Limitations of G4ParticleHP to describe breakup reactions

G4ParticleHP does not always provide a complete description of breakup reactions:

- Incomplete or missing evaluated data (e.g., angular distributions for $^{12}C(n,\alpha)^{9}Be$)
- Incomplete model implementation (e.g., breakup of $^{12}C^{*}$ in $^{12}C(n,n'3\alpha)$).

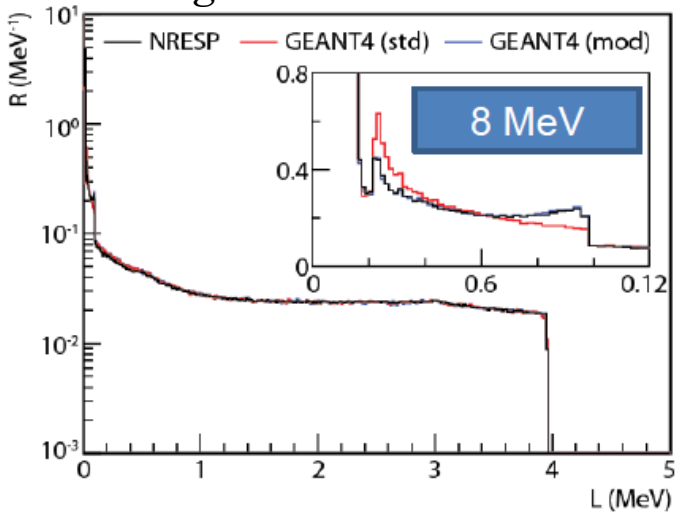
G4ParticleHPInelasticBaseFS

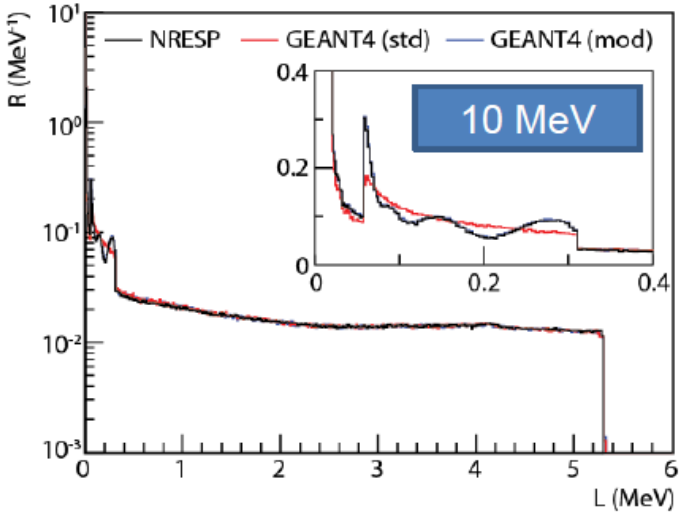
- Reactions with **MORE THAN ONE** particle and a residual nucleus in the final state.

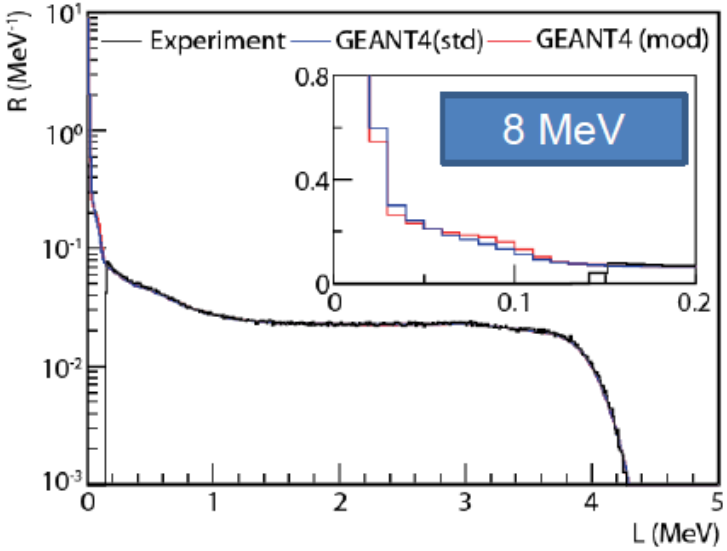
G4ParticleHPInelasticCompFS

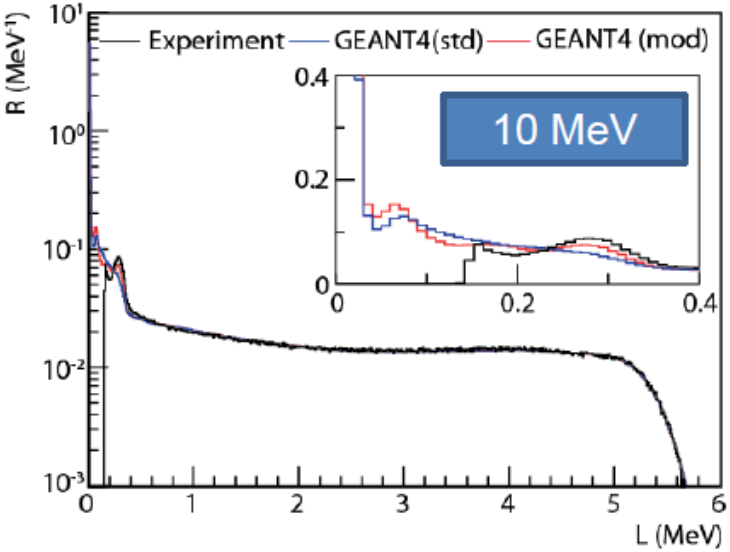
- Reactions with **ONLY ONE** particle and a residual nucleus in the final state.

Verification against NRESP code






Experiment
GEANT4(std)
GEANT4 (mod)
8 MeV
R (MeV⁻¹)
L (MeV)


Experiment
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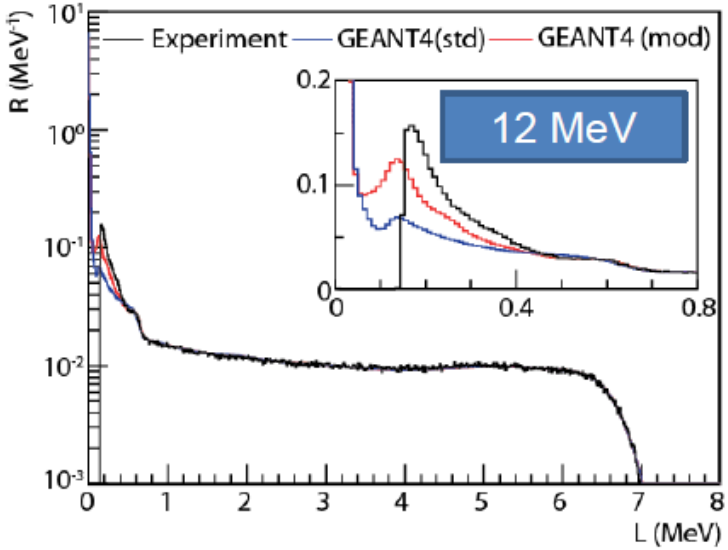
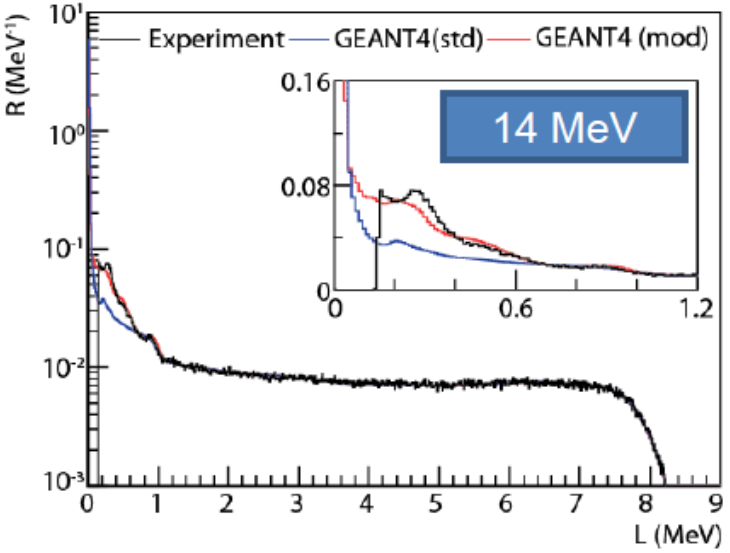
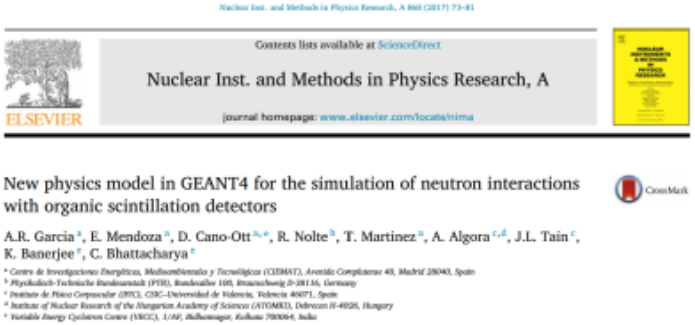
GEANT4 (mod)
10 MeV
R (MeV⁻¹)
L (MeV)


Experiment
GEANT4(std)
GEANT4 (mod)
12 MeV
R (MeV⁻¹)
L (MeV)


Experiment
GEANT4(std)
GEANT4 (mod)
14 MeV
R (MeV⁻¹)
L (MeV)

Conclusions

- Completed the description of neutron induced alpha production reactions on Carbon in the High Precision neutron model (G4ParticleHP), i.e., angular distributions for $^{12}C(n,\alpha)^{9}Be$ reaction and multistep breakup model for $^{12}C(n,n'3\alpha)$ reactions.
- Results verified against simulations with NRESP and validated against Time-Of-Flight measurements performed at PTB.
- Potential applications of this work extend beyond organic scintillation detectors, to other types of fast neutron detectors where carbon reactions require an accurate description, e.g., diamond detectors.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ELSEVIER

New physics model in GEANT4 for the simulation of neutron interactions with organic scintillation detectors

A.R. Garcia [a], E. Mendoza [a], D. Cano-Ott [a,*], R. Nolte [b], T. Martinez [a], A. Algora [c,d], J.L. Taín [c], K. Banerjee [e], C. Bhattacharya [e]

[a] Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Avenida Complutense 40, Madrid 28040, Spain
[b] Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, Braunschweig D-38116, Germany
[c] Instituto de Física Corpuscular (IFIC), CSIC-Universidad de Valencia, Valencia 46071, Spain
[d] Institute of Nuclear Research of the Hungarian Academy of Sciences (ATOMKI), Debrecen H-4026, Hungary
[e] Variable Energy Cyclotron Centre (VECC), 1/AF, Bidhannagar, Kolkata 700064, India

- These and other results (e.g., performance of the modified version of GEANT4 with different evaluated nuclear data libraries) already published.

  (See A. R. Garcia et al, NIM A 868, 73–81, 2017)
- Inclusion in next GEANT4 release already in progress (by Dr. Tatsumi Koi).

Technical Aspects of Varying Hadronic Model Parameters and Studying Sensitivity of Simulated Results

Varying model parameters requested 2 years ago

Challenge:

- how sensitive are Geant4 predictions to the variations of model parameters, and what uncertainties are associated with a Geant4 physics model, or a group of models, involved in simulation and optimization of a detector design

Three hadronic models now allow to vary parameters

PreCompound (since 10.3)
- 9 configurable parameters and 14 switches

Bertini (since 10.1)
- 11 configurable parameters and 5 switches

FTF(P) – work in progress, 1st configuration interface in 10.3.ref08
- "diffraction" part of FTF for now; baryon projectile as the 1st use case
  - "hadronization" part (string fragmentation) is left for later
- 18 configurable parameters and 4 switches

Using Professor Tuning Toolkit (I)

- "Scans" by a single parameter are a good starting point and give a reasonable feel what what parameters are "sensitive" and where
- However, understanding correlations of parameters in only possible in the multi-parameters space
- Hence, enters Professor: http://professor.hepforge.org
  - "Fundamentally, the idea of Professor is to reduce the exponentially expensive process of brute-force tuning to a scaling closer to a power law in the number of parameters, while allowing for massive parallelisation and systematically improving the scan results by use of a deterministic parameterisation of the generator's response to changes in the steering parameters." – from Professor's web site
  - A set of parameters $P_i=\{x_i , y_i , z_i ,...\}$ is a "point" in the multi-parameter space
  - Randomly sample multi-parameter space
    - For each P_i simulate data combinatorics: beam × energy × target …
    - Derived quantities are histograms
  - Each simulated (histogram) bin content is $f(P_i)$ - polynomial approximation
  - Fit experimental data with $f(P_i)$ to explore sensitivity and coupling of parameters

Summary

- As the configuration interfaces to Geant4 HAD models get expanded, we are in the processes of exploring sensitivity of simulated physics observables to the variations of model parameters
- This requires certain infrastructure run multiple variants of a model (or a physics list) and to collect outputs for further comprehensive analysis
- We have implemented a set of tools for this purpose
- Understanding correlations of parameters is an important task that requires analysis in the multi-parameter space and may involve multiple datasets
- We have implemented a set of interface tools to the Professor toolkit and are currently exploring how far we can go with it