Geant4 11.0.p01
&
Hadronic Physics Group
Work Plan for 2022

Alberto Ribon − CERN EP-SFT
On behalf of the Geant4 Hadronic Physics Working Group

Geant4 Technical Forum, 24 March 2022

Patch-01 of G4 11.0

- *hadronic / cross_sections /*

  - *G4ComponentAntiNuclNuclearXS* : correct computation of light anti-nuclei on hydrogen
    - Based on the isospin symmetry: properties of the reactions between anti-proton and light nuclei are equivalent to those between light anti-nuclei and hydrogen

- *models / coherent_elastic /*

  - *G4AntiNuclElastic* : fixed bug #2204 (rare cases of |cosϑ| > 1)
    - Correction in SampleInvariantT() method of the highest momentum transfer

- *models / inclxx /*

  - *G4INCLXXInterface* : fixed treatment of kaon0, anti_kaon0, kaon0L, and kaon0S
    - In current reference physics lists, INCLXX is never used for handling kaons, although it is capable of doing so, but at process-level or in custom physics lists one could observe crashes when trying to use INCLXX for neutral kaon projectiles. The change fixes this misbehavior.

No changes in hadronic showers observed with respect to G4 11.0

Hadronic Work Plan

Hadronic String models

- Validation of charm production for **FTF** and **QGS**

  - In proton-proton, proton-nucleus, antiproton-proton and antiproton-nucleus interactions

  and improvement of the decays of charmed hadrons using data of PDG

- Improvement of antiproton and light anti-ion annihilations in **FTF**

  - From at rest to hundreds GeV

- Validation of **FTF** nucleus-nucleus interactions

- Correct introduction of the formation time in **FTF** and **QGS**

- First extension of **FTF** for light hypernuclei and anti-hypernuclei projectiles

  - Aimed for a simple but reasonable approch, not expected to be accurate

- Continue the model parameter studies of **FTF**

- Technical investigation of using alternative sets of tuning parameters in **FTF**

  - For different projectile kinetic energies and/or projectile particle types

- Investigate the ~20% reduction in energy fluctuations

  - Observed in ATLAS HEC between Geant4 10.4 and 10.5 with **FTF**

- Code and hadronic shower improvements of **FTF** and **QGS** models

Intra-nuclear Cascade models

- Bertini-like (**BERT**) model

  - Maintenance and user-support

- Binary (**BIC**) model

  - Bug fixes and modernization of the code via new C++ features

- Liege (**INCLXX**) model

  - Maintenance and user-support
  - **Extension for antiproton**
  - **ABLA** : production of pionic nuclei, and their evaporation to pions

Precompound / De-excitation models

- Maintenance and user support
    - Probabilities of transitions may be improved and a number of bug reports resolved
- Implementation of a simple de-excitation treatment for light hypernuclei and anti-hypernuclei

Radioactive Decay model

- Maintenance and user support
- Maintenance of the database
- Improvement of the spectrum of beta decays

ParticleHP model

- Validation, maintenance and user support

- Improvement of the gamma-deexcitation in ParticleHP

  - Replace files in *$G4NDL/Inelastic/Gammas/* with corrected & consistent ones

  - Start using *G4PhotonEvaporation* in ParticleHP

- New G4NDL4.7 data library

  - New, extended thermal neutron data

  - New, corrected files in *$G4NDL/Inelastic/Gammas/*

- Implement an option that forces ParticleHP to respect event-by-event conservations

  - energy-momentum, baryonic number, *etc.*

- Extend ParticleHP model to higher energies

- Insert in Geant4 the NuDEX code (to generate EM de-excitation cascades)

- Create a tool to change the charged particle cross sections with user's ones

- Support for thermal scattering data + development of new variance reduction techniques

  - *e.g.* AMS and adaptive multilevel splitting

7

LEND model

- LEND, GIDI update
- Upgrade of MCGIDI

NCrystal model

Model for ~meV neutron scattering in crystals

- Update Geant4-NCrystal hooks for recent releases + MT support
- Thermal neutron scattering in liquids

Hadron Elastic

- Improvement in the elastic scattering of anti-baryons and light anti-nuclei on target nuclei

- Simple elastic scattering treatment for hypernuclei and anti-hypernuclei on target nuclei

Other Hadronic models

- Development and validation of neutrino / lepton – nuclear physics

- Muonic atoms, molecules, and catalyzed fusion physics

- Adoption of external decayers and maintenance of the related example
  - *examples / extended / eventgenerator / pythia / py8decayer*

- Use of Pythia8 as an external generator in Geant4

9

Hadronic Cross Sections

- Study low-energy corrections for light anti-ion nuclear cross sections

    - Aimed to better describe ALICE's recent measurements at low energies

- Extension of nuclear cross sections for light hypernuclei and anti-hypernuclei projectiles

- Provide full integral option for frequently used charged hadrons

    - $\pi\pm$, $K\pm$, p , $\bar{p}$

    - Take into account the variation of the hadronic cross sections of charged hadrons along a step, due to the energy losses by ionization

        – Already included and important in EM physics, might have some effect also in hadronic physics...

10

Hadronic Validation and Testing

- Integrating calorimeter test-beams for hadronic validation in *geant-val*

  - *E.g.* ATLAS HEC, CALICE Si-W ECAL, Dual Readout calorimeter, and others

- Use fixed-target data and calorimeter data for hadronic validation

- Hadronic validation of selected releases using fixed-target data

- Support, monitoring and documentation of physics lists with the focus on Intensity Frontier (IF) experiments

- Studying the sensitivity of the MC predictions to the variations of various parameters and development of needed infrastructure

- Validation of neutron physics with the TARC test

- New test case for thermal neutron transport

- New example for monitoring particle fluence

  - To avoid unexpected large changes in the evolution of Geant4

11