PRINCETON UNIVERSITY

Possible hadronic work items

V. Ivanchenko CERN & Princeton University

Geant4 Hadronic group meeting

18 January 2023

Proposed work items

- Reduction of use of environment variables
- Neutron general process
- Hadron elastic process
- Neutrino processes
- Update of HP package
- Update of de-excitation module

- Disclaimer: *I am proposing personal work plan, which may be completed only with the help of other developers/users of Geant4 hadronics*

Reduction of use of environment variables

- There is issue #139 created by S.A.L. Fernandez:
  - https://gitlab.cern.ch/geant4/geant4-dev/-/issues/139
  - Excessive use of *getenv* inside Geant4
  - In the discussion Ben Morgan support the idea of needed improvements
  - I personally do not fully understand the problem but intuitively agree that excessive calls to *getenv* may be a problem, for example, at supercomputers
- A significant reduction of number of calls to *getenv* is implemented
  - !3388 – for hadronic/management
    - There were 5*Nprocesses*Nthreads calls – now only 5
  - !3396 – for hadronic/cross_sections
    - From 5 to 1
  - G4LEVELGAMMADATA is called only once
  - !3389 – for electromagnetic/utils
  - !3393 – for standard EM
- It is proposed to complete this work
  - Check radioactive decay and HP
  - Fix low-energy EM and DNA classes
  - I would propose to drop two variables:
    - G4HadronicProcess_debug – use verboseLevel instead
    - G4HADRONIC_RANDOM_FILE – useless, because cannot be used for debugging

Neutron general process

- G4NeutronGeneralProcess has been releases in 11.1
  - It was design in the similar style of G4GammaGeneralProcess
  - It provides few % speed-up in preliminary tests (even in CMS)
  - It provide statistically the same results as the default neutron physics
  - It gives 0% speed-up in special build of CMSSW
- There are 2 merge request with fixes/improvements
  - !3368 – optimized neutron general process
  - !3401 – fixed hadron elastic process
  - They are proposed for the patch to 11.1
- Further analysis of efficiency of the method should be performed in 2023
  - To establish G4GammaGeneralProcess we spent 3 years

Hadron elastic process

- G4HadronElasticProcess is one of the key processes for hadronic physics
  - Applied on each hadron/ion
  - Affect hadronic shower shape
  - Inherit of G4HadronicProcess
- In the release 11.1 the integral approach was introduced to hadron inelastic
  - Not for hadron elastic but computation of step limit is done inside the base class
- !3401 – fixed several problems of hadron elastic
  - Allowing integral approach
  - Removed obsolete try/catch constructions
- Coherent charge exchange process is a part of coherent elastic
  - This model exist inside Geant4 but was never ready for use in production
  - Inclusion of such model may affect hadronic response and should be tried
- Number of improvements are proposed to be implemented inside G4HadronElasticProcess
  - Introduce an option of coherent charge exchange model
  - Balance projectile diffraction and charge exchange
  - Extend validation samples for the charge exchange (may be summer student)

Neutrino processes

- Vladimir Grichine have been developing neutrino-nuclear processes and currently we have
  - 4 process classes
  - 16 model classes
  - 6 cross sections
  - There are some problems with biasing
- It is proposed to optimize the design for neutrino physics in collaboration with V. Grichine
  - Introduction/improvement of base class(es)
  - Attempt to reduce duplications
  - Evaluate biasing method
  - Review physics constructor for neutrino

Update of HP package

- Particle HP code is used widely in various applications
  - Nuclear physics
  - HEP
  - Medical physics
  - Other applications
- There are concerns to CPU performance and code quality
  - Essential for HEP and medicine
- It is proposed to review and clean-up HP sub-library
  - Technical clean-up
    - Apply clang-tidy code format
    - Introduce C++11 elements in the code
    - Remove unused obsolete code
    - Review usage of HP parameters
  - Improve handling of the data
    - Modify G4PhysicsVector in order to speed-up HP data access
    - Add extra parameters will be needed
  - Introduced an option to use native gamma de-excitation module
  - It is expected not to touch any aspect of HP physics except de-exitation

Update of de-excitation module

- De-excitation module in Geant4 11.1 was improved
  - Significant part of bug reports are fixed
  - Most part of remaining bug reports depend on data
  - Agreement between data and MC prediction is on the same basic level
- It is proposed to continue development for the de-excitation module
  - Evaluate Fermi BreakUp model
  - Evaluate alternative GEM model
  - Evaluate multi-fragmentation model
  - Help for model improvements and validation is required