Geant4 10.6.p01
&
Hadronic Physics Group
Work Plan for 2020

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1st part: G4 10.6.p01

Patch-01 of G4 10.6 (1/4)

- cross_sections/
  - G4HadronInelasticDataSet : fixed wrong Gheisha cross section.
    Addressing problem report #2220
    - Does not affect the main reference physics lists
- management/
  - G4HadronicProcess : for charge check, assume that all final electrons
    come from internal conversion
- processes/
  - G4HadronElasticProcess : removed forgotten try/catch pattern for
    target isotope selection
- stopping/
  - G4MuonicAtomDecay : fixed Coverity warning by addition of G4Exception

Patch-01 of G4 10.6 (2/4)

- models/cascade/ (BERT)
  - G4CascadeCheckBalance : fixed outstanding problem of the interface with native pre-compound model, happening when in the default de-excitation, internal electron conversion gets enabled
    - Now BERP should work fine !
  - G4CascadeInterface : fixed memory leak by deleting ltcollider in the destructor
  - G4CascadeParamMessenger : ensure that Bertini-specific commands get added to "/process/had/cascade/" UI directory, instead of "/process/had/"

- models/parton_string/diffraction/ (FTF)
  - G4FTFParameters : fixed division by zero (Coverity report) due to wrong protection

Patch-01 of G4 10.6 (3/4)

- models/coherent_elastic/
  - G4ElasticHadrNucleusHE : for pi- and Z>1 reuse data structure computed for pi+ in order to reduce memory and CPU at initialisation; added new private methods to store/retrieve data tables. Co-works with new data-set G4EMLOW-7.9.1 . Fixed Coverity report. Switch to parameterized model based on kinetic energy and not momentum

- models/radioactive_decay/
  - G4Radioactivation::AddDeexcitationSpectrumForBiasMode() : fixed memory leak. Addressing problem report #2164
  - G4RadioactiveDecay, G4RadioactiveDecayBase : changed default verbosity from 0 to 1, and remove G4cerr wherever it occurs and replace it with G4Exception or G4cout. Increased verbosity thresholds in order to reduce printout size
  - *(Continue in the next page)*

Patch-01 of G4 10.6 (4/4)

(Continuation from previous page)

- G4BetaPlusDecay : changed sign of daughterZ argument in G4BetaDecayCorrections according to problem report #2199
- Fixed Coverity warnings in G4RadioactiveDecay and G4RadioactiveDecayBase
- Fixed uninitialized data in G4SFDecay

- models/lend/
  - Removed inclusion of amp_math header on Windows as it is not required

- physics_lists/lists/
  - LBE : updated cross-sections to avoid crashes caused by the removal of default Gheisha cross-sections, and to have consistency between elastic and inelastic cross-sections

2nd part: Hadronic Work Plan

Hadronic String models (1/2)

- Include heavy hadron nuclear interactions in physics lists
  - This requires also to deal with the decays of heavy hadrons in Geant4
- Tuning and validation of charm production for **FTF** and **QGS**
- Extension, improvement, tuning and validation of anti-baryon annihilations in the **FTF** model
  - From at rest to hundreds GeV
    - ALICE, CERN AD antiproton experiments, GAPS, Panda/GSI, *etc.*
  - Improve multiplicity of hyperon and anti-hyperon secondary production

Hadronic String models (2/2)

- Review of the nuclear residual excitation energy in hadronic models
- Development and validation of a coalescence model
  - Included in G4 10.6 a first version of coalescence for nucleus-nucleus collisions: to be improved, validated and extended for hadron-nucleus interactions
- Code and hadronic shower improvements of **FTF** and **QGS** models
- Simulation of high-energy jets in FCC-hh
  - EPOS vs. Geant4 for hadron interactions at very high energy
    - 1 – 20 TeV

Intra-nuclear Cascade models

- **Bertini** (BERT) model
  - Maintenance and user-support
  - Collisions with light targets
- **Binary** (BIC) model
  - Code review and maintenance
- **Liege** (INCL++) model
  - Maintenance and user-support
  - Maintenance of ABLA++ model and improvements in the production of hypernuclei

Precompound / De-Excitation models

- Maintenance and code improvements
- Complete, validate and release the new GEM model
- Tuning of evaporation probabilities
  - Special attention to α production in light fragment decay
- Add test on gamma production

Radioactive Decay model

- Maintenance and user support
- Maintenance of the database
- Add test in geant-val
- Add functionality of user spectrum definition for beta spectrum shape
- Beta-delayed particle emission
- Superheavy elements

ParticleHP model

- Validation & Maintenance of ParticleHP
- Investigate the CPU performance degradation with G4NDL4.6
- Implement an option that forces ParticleHP to respect event-by-event conservations (energy-momentum, baryonic number, *etc.*)
- Extend ParticleHP model to higher energies
- Implement a more detailed physics for organic neutron detectors up to 100 - 200 MeV
- Insert in G4 the NuDEX code (to generate EM de-excitation cascades)
- Document the ParticleHP database format
- Create a tool to automatically change the charged particle cross sections adding user experimental data

LEND model

LEND = Low Energy Neutron Data
GIDI = General Interaction Data Interface

- Update and release a new version of LEND with the new GIDI interface and updated data for the December release
- Maintenance and validation of LEND
- Validation and improvement of gamma-nuclear models

NCrystal model

Model for ~meV neutron scattering in crystals

- Add new inelastic scattering models
- Integration of the code in Geant4

Hadron Elastic models

- Extend hadron elastic for heavy hadrons (i.e. charmed and bottom mesons and baryons) and use it in physics lists
- Improvement and validation of the diffuse elastic model
- Interface for changing easily elastic models on top of any physics list
  - Maybe coupled with a similar interface for elastic cross sections
- Extend elastic scattering validation for antiproton and light anti-ions, and possibly improve these models

Other Hadronic models

- Development and validation of neutrino/lepton – nuclear physics
- Maintenance and investigation of possible extension of QMD model
- Muonic atom physics
- Explore the possibility of using Deep Learning to emulate a low-energy nuclear interaction model (BLOB) and to port it to GPU

Hadronic Cross Sections

- Improvement of elementary (hadron-nucleon) cross sections
  - Make class fully static (to avoid instantiation of it many times in each thread)
  - Extend tests to antiproton and gamma
- Verify and extend G4PARTICLEXS dataset
  - Evaluate data for light targets
  - Provide data for n , d , t , He3 , α on p , d , t , He3 , α needed for fusion
  - Add data for elastic scattering for proton and light ions
  - Add gamma cross sections
- Interface for changing easily cross sections on top of any physics list
  - Identify reliable alternatives to default hadronic cross sections
  - Allow user-defined cross section per element or per material

Hadronic Validation and Testing

- Interfacing more hadronic tests in geant-val
- Validation through test-beams, including the new CMS HGCAL
- Hadronic validation with BNL and MIPS data
- Studying the sensitivity of the MC predictions to the variations of various parameters, with the focus on models such as FTF , BERT , Preco and development of needed infrastructure
- Validation of interfaces of Geant4 hadronic models to be used by GENIE neutrino interaction code
- Integration of the n_TOF target test into the validation tool
- Refinement of TARC validation (test15)

Hadronic Framework

- Complete destruction of all hadronic objects at the end of a session
  - Provide correct destruction of ParticleHP models and cross sections
  - Simplified instantiation of hadronic string models
- Modernization of hadronic builders in physics lists
  - Hadronic cross sections and instantiation of final-state hadronic models should be done separately
  - Should not use thread-local data members
    - Builders should be simple classes used only at initialization to save to write the same code
- Setting 0 verbosity in hadronics via UI command
  - As it is already the case for EM physics