Geant4 Hadronic Physics Group
Work Plan for 2020

1st version, 19 February 2020

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
  - A. Ribon
- Tuning and validation of charm production for **FTF** and **QGS**
  - A. Galoyan & V. Uzhinsky
- 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
  - A. Galoyan & V. Uzhinsky
- Improvement of elastic scattering for anti-baryons and light anti-nuclei
  - V. Uzhinsky

Hadronic String models (2/2)

- Review of the nuclear residual excitation energy in hadronic models
  - V. Uzhinsky
- 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
  - A. Galoyan & V. Uzhinsky
- Code and hadronic shower improvements of **FTF** and **QGS** models
  - A. Ribon
- Simulation of high-energy jets in FCC-hh
  - EPOS vs. Geant4 for hadron interactions at very high energy
    - 1 – 20 TeV
  - A. Ribon *in collaboration with* C. Helsens, L. Goukos, V. Volkl

Intra-nuclear Cascade models

- **Bertini** (BERT) model
  - Maintenance and user-support
    - M. Kelsey, Dennis Wright
  - Collisions with light targets
    - Dennis Wright
- **Binary** (BIC) model
  - Code review and maintenance
    - G. Folger
- **Liege** (INCL++) model
  - Maintenance and user-support
    - J-C. David, D. Mancusi, J.L. Rodriguez Sanchez
  - Maintenance of ABLA++ model and improvements in the production of hypernuclei
    - J.L. Rodriguez Sanchez

Precompound / De-Excitation models

- Maintenance and code improvements
  - V. Ivanchenko, J.M. Quesada
- 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
- V. Ivanchenko

Radioactive Decay model

- Maintenance and user support
  - Dennis Wright

- Maintenance of the database
- Add test in geant-val
- Add functionality of user spectrum definition for beta spectrum shape
- L. Desorgher

- Beta-delayed particle emission
- Superheavy elements
- L. Sarmiento

ParticleHP model

- Validation & Maintenance of ParticleHP
  - E. Mendoza & D. Cano (CIEMAT), H. Kumawat (BARC), Dennis Wright (SLAC)

- 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)
- E. Mendoza and D. Cano

ParticleHP model (*cont.*)

- Document the ParticleHP database format
- Create a tool to automatically change the charged particle cross sections adding user experimental data
- P. Arce

LEND model

- Update and release new version of LEND with new GIDI interface and updated data for December release
  - B. Beck, Douglas Wright
- Validation of LEND
  - J. Verbeke
- Bug-fixing in LEND
- Validation and improvement of gamma-nuclear models
  - Dennis Wright

NCrystal model

- Add new inelastic scattering models
- Integration of the code in Geant4
- X. Cai & T. Kittelmann

Hadron Elastic models

- Extend hadron elastic for heavy hadrons (i.e. charmed and bottom mesons and baryons) and use it in physics lists
  - V. Grichine , V. Ivanchenko
- Improvement and validation of the diffuse elastic model
  - V. Grichine

- 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
- V. Ivanchenko

Other Hadronic models

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

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 pbar 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
- V. Ivanchenko

Hadronic Validation and Testing

- Interfacing of tests 19, 23, 47, 48, 75 in geant-val
- Hadronic validation with BNL and MIPS data, and with the new high-granularity CMS test-beam
- 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, 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
- FNAL Team
  - S. Banerjee, K. Genser, R. Hatcher, S.Y. Jun, H. Wenzel, J. Yarba

Other Hadronic Validation activities

- Integration of the **n_TOF** target test into the validation tool
  - M. Cortes Giraldo
- Refinement of **TARC** validation (test15)
  - A. Howard
- Validation through test-beams (e.g. CMS HGCAL test-beam)
  - A. Zaborowska

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

- V. Ivanchenko