Community White Paper Simulation

V. Daniel Elvira (Fermilab)
John Harvey (CERN)

Scope

- Full and Fast simulation applications of HEP experiments (detectors, beam lines):

  MC truth, geometry, particle propagation in materials and fields, physics modeling, pileup, digitization, analysis/monitoring tools

- Software and physics support, training

(Outside scope: generators, event visualization, propagation/ manipulation of beams through accelerator lattice (i.e. LHC), space or medical applications)

Scope – detail

- Handling of MC truth information
- Geometry description software tools (DDL, interface to CAD), geometry description
- Navigation, error transport (GEANE)
- Explore random number generator options – fast, guarantee reproducibility in the world of parallel computing
- Modeling of pileup
- Readout modeling (digitization)
- Physics models of particle interaction with matter, decay tables, evaluation of systematic uncertainties associated to physics models
- Physics validation (unit tests, thin target experiments, test beam experiments, in-situ)

Scope – detail

- Generic detector-independent Fast Sim framework
- Fast Sim tuning to Full Sim, test beam, experiment data
- Modeling of neutrino beams from proton-target
- Neutrino-nucleus interaction (GENIE)* and interface with nucleus de-excitation and hadronic shower (Geant4)
- Low energy neutrons, modeling of shielding
- Computing performance monitoring (profiling, instrumentation code to measure in what functions, what particles, what energy ranges the time is spent)
- Software training and support

* Some overlap with generators group

Challenges

1. Improving computing performance
   - Geometry library optimization/vectorization (i.e. VecGeom)
   - Explore options to reduce digitization time (vectorization?)
   - Continue work to exploit benefits of vectorization, SIMD, data locality in modern architectures (CPU, GPU, coprocessors)
     - ➢ Develop prototype application for complex experiment and demonstrate 2-5X CPU gain
   - Continue tests of simulation applications in HPC

Challenges

2. Improving physics accuracy
   - Improve, re-implement physics models
   - Validate physics models for LAr
   - Extend hadronic physics for the FCC energy frontier
   - Improve Full-Fast Sim agreement to expand Fast Sim use
   - Shower library development
3. Pileup handling (I/O and local bandwidth issues)
4. Find areas of commonality across experiments for Fast Sim, Geometry tools, …, etc

CWP Simulation Plan

Hold a series of meetings (once a month) on different topics – recruit and invite experts

- First meeting (February 27th) on Computing Performance
  - ✓ Reports by ATLAS, CMS, LHCb, ALICE, neutrino and muon experiments
  - ✓ Geant4 modules take between <10% (neutrinos) to ~50% (LHC) of all computing resources
  - ✓ MC Simulation in general takes up to 85% of total resources
  - ✓ In conversations on a common set of metrics for apples-to-apples comparisons focused on phase 2 detectors (ATLAS-CMS)
  - ✓ Next: recruit volunteers to write this up

CWP Simulation Plan

Hold a series of meetings (once a month) on different topics – recruit and invite experts

- Second meeting (March 27th) on Fast Simulation
  - ✓ GeantV team will present ideas on embedded Fast Sim framework with automated mechanism for fast and precise tuning, and ML techniques to replace complex physics algorithms
  - ✓ ATLAS and CMS are also scheduled to report
  - ✓ Neutrinos (Laura Fields): DUNE only experiment with fast MC, developed for the reason that they do not have a working reconstruction
- Third meeting (April) on Hadronic Physics, Fourth meeting …

John Harvey and Daniel Elvira to discuss organization of simulation section writing next week (last week of March)

Material

San Diego workshop, first meeting on Computing Performance (2/27/2017), second meeting on Fast Sim (3/27/2017)

- San Diego Simulation and summary sessions

https://indico.cern.ch/event/570249/sessions/217045/#20170124 (Simulation session)

https://indico.cern.ch/event/570249/sessions/214768/#20170126 (Summary)

- Meeting on Computing Performance

https://indico.cern.ch/event/615703/

- Upcoming meetings material in same parent indico url