EP-SFT R&D Activities

IT R&D advisory group meeting, 22 September 2021

Introduction

❖ The group **develops and maintains common scientific software** for the physics experiments in close collaboration with the EP experimental groups, the IT department and collaborating HEP institutes

  ❖ Geant4, ROOT, Gaudi, Key4hep, CernVM, …

❖ The group provides a **common infrastructure and expertise** to the CERN experiments (e.g. LCG software stacks >400 packages)

❖ Started an **R&D program** to embrace new hardware and software architectures to cope with HL-LHC computing requirements

Simulation

❖ Ongoing R&D along 3 axes:

  ❖ Improvements to the Geant4 CPU implementation

  ❖ Fast simulation with traditional parametrization and ML

  ❖ GPU-based prototypes participle transport

❖ **G4HepEm**: specialized stepping/tracking for EM physics in Geant4

❖ **AdePT**: Demonstrator for EM physics transport simulation on GPUs

❖ **FastSim**: seamless integration of classical parametrization (GFlash) and ML generative models

ROOT

❖ Fast-path from **RNTuple** to analysis results:
million events / second into histograms, for actual analyses

  ❖ New I/O formats, faster compression algorithms, lossy compression, object stores, etc.

❖ With convenient, multi-threaded, distributed compute model: **RDataFrame**

  ❖ Implicit multi-core, distribute computing, bulk-processing multiple events, elastic resource allocation, etc.

❖ High-throughput **ML training** out of RDataFrame / RNTuple

❖ High-performance **ML inference** of ONNX models

❖ **RooFit**: PDFs with vectorization and CUDA, auto-differentiation

❖ WebGUI + Graphics

CernVM-FS

❖ Seamless container image ingestion

 ❖ Automatically ingestion them in /cvmfs/unpacked.cern.ch

❖ Kubernetes-native publisher

 ❖ Publishing to gateway services from ephemeral writable shell

❖ Client performance improvements for very large applications (e. g. Tensorflow)

R&D on Experimental Technologies (WP7)

❖ Turnkey software stack (**Key4Hep**)

  ❖ Flexible and modern software stack, ready for physics studies for experiments at future colliders

❖ Faster simulation

  ❖ Machine learning based fast, generic, simulation techniques

  ❖ Embraced within the SFT simulation activities

❖ Efficient Analysis

  ❖ Design data structures and interfaces to support very high throughput analysis

  ❖ Embraced within the ROOT activities

❖ Reconstruction at high pileup (**ACTS**)