Delphes card & FCC Software Framework

Zbyněk Drásal

CERN

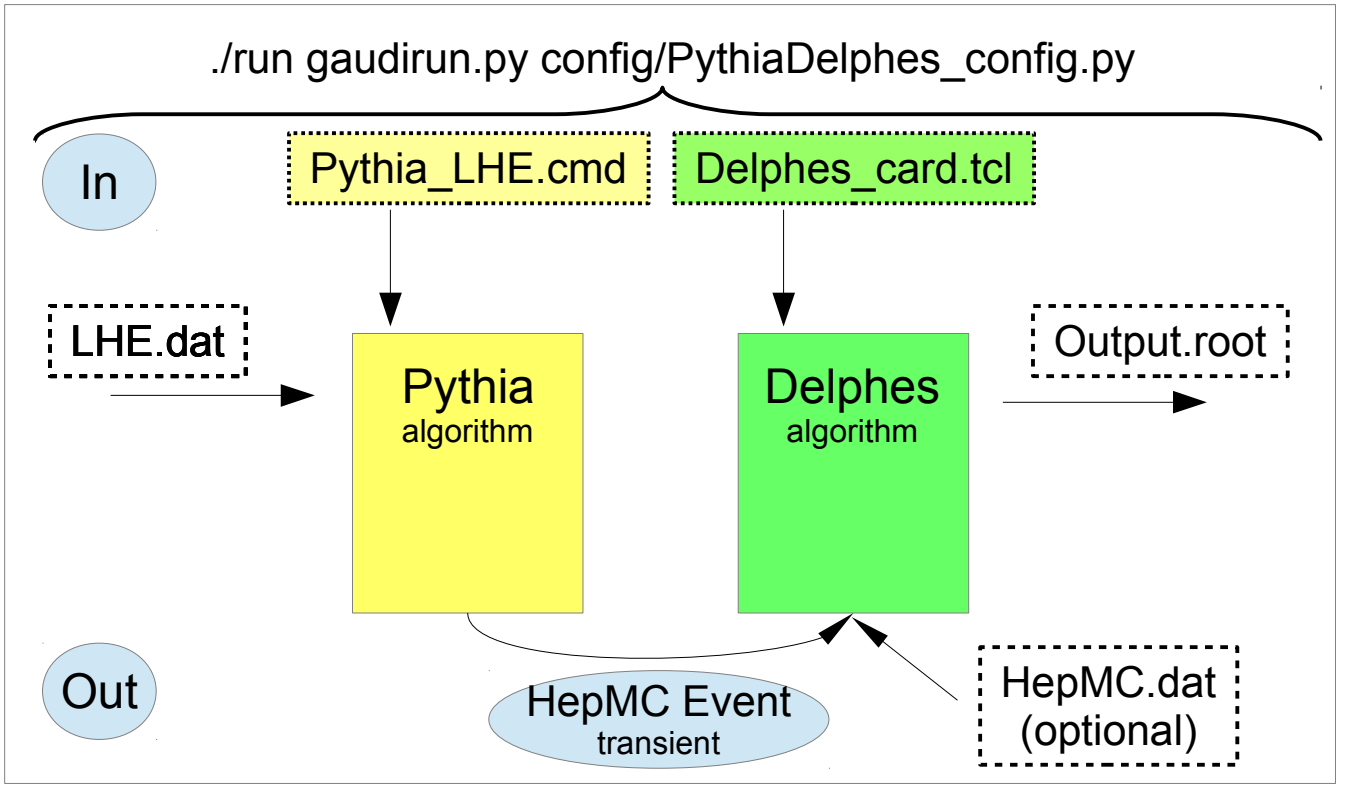
With: M. Mannelli, C. Helsens, W. Riegler, H. Gray & F. Moortgat

Overview

- How to use Delphes and simulate physics events within the FCC Software Framework?
  - Strategy & processing sequence
  - Input/Output data files
  - Configuration inputs
  - Tutorial
  - Example: pp → HH
  - Issues?
- Summary & Outlook

Strategy & Processing Sequence

- FCCSW → based on modular structure of Gaudi framework
- Strategy:
  - modularize Pythia & Delphes as Gaudi algorithms
  - use configuration files to control processing sequence



Pythia Input/Output Data Files

- Pythia Input:
  - The Pythia data input is required either through LHE (Les Houches Event) data file (from e.g. Madgraph, ...)
    → Already simulated Les Houches Events are processed by Pythia
    → Pythia performs MPI, ISR, FSR & hadronization
  - Or no input data file provided to Pythia
    → Pythia will simulate physics events & perform MPI, ISR, FSR, …
- Pythia Output:
  - The Pythia data output is through transient memory data store using HepMC event data format.
- **Comments:**
  - Current version of Pythia installed on **lxplus** supports LHE of version 1.0, not higher!
  - The newest Pythia version 8.205 does support all LHE versions!

Delphes Input/Output Data Files

- Delphes Input:
  - The Delphes data input is preferably from transient event data store
  - In principal, the input event can be read-in from HepMC data file

    → both inputs read-in through: `DelphesExtHepMCReader class`
- Delphes Output:
  - The Delphes data output is written out through the standard Delphes ROOT tree writer: `ExRootTreeWriter class`, so ROOT file is exported

FCCSW Configuration

- FCCSW configuration:
  - Run sequence of Gaudi framework controlled through a Python script
  - Use the following file: ${FCCSW}/config/PythiaDelphes_config.py
  - Variables to be arranged:
    - NEvents → events to be simulated
    - PythiaconfFile → Pythia configuration, called command, file (use either Pythia_LHEinput.cmd or Pythia_standard.cmd)
    - DelphesCard → Delphes TCL configuration file (use official Delphes card)
    - DelphesHepMCInFile → Delphes input file (use "" to read HepMC directly from Pythia, i.e. from transient data store)
    - DelphesRootOutFile → Delphes output file (define name of Delphes output file)
      If file not defined the data goes to transient data store → will be useful once the FCC event-data output is defined

Pythia Configuration

- Pythia configuration:
  - Control Pythia physics using command file → use the following files
    - ${FCCSW}/config/Pythia_LHEinput.cmd → read-in LHE file
    - ${FCCSW}/config/Pythia_standard.cmd
  - Variables to be arranged for LHE input:
    - PartonLevel:MPI = on/off → Switch on/off Multi-Particle-Interaction
    - PartonLevel:ISR = on/off → Switch on/off Initial-State-Radiation
    - PartonLevel:FSR = on/off → Switch on/off Final-State-Radiation
    - HadronLevel:all = on/off → Switch on/off Hadronization
    - Beams:LHEF = data/name.lhe → Define LHE event data file

Delphes Configuration

- Delphes configuration:
  - `${FCCSW}/config/FCChh_DelphesCard_*vXX.tcl`
    - Official FCC-hh Delphes configuration card
    - Defines detector characterization and sequence of Delphes modules to be executed.
    - All Delphes objects to be analyzed are written-out by Delphes internal module `TreeWriter`, via branches:

Array of particles in each event as `Particle` branch, each particle of `GenParticle` type:
`Branch Delphes/allParticles Particle GenParticle`

Array of electrons in each event as `Electron` branch, each particle of `Electron` type
`Branch ElectronEnergySmearing/electrons Electron Electron`

`...`

    - To analyze data, read the branches through `ExRootTreeWriter class` → follow add hoc tutorial for more details

HowTo? Tutorial

- For additional information follow the HowTo? tutorial at FCC Twiki page:
  - **https://twiki.cern.ch/twiki/bin/view/FCC/FccPythiaDelphes**

TWiki > FCC Web > CommonTools > FccSoftware > FccPythiaDelphes (2015-09-15, ZbynekDrasal)

FCC Pythia + Delphes Analysis (Tutorial)

Contents

Overview

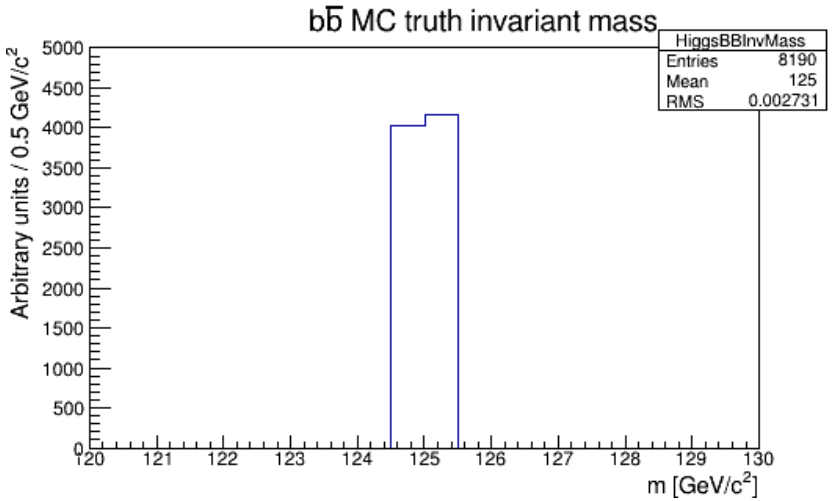
A small tutorial on how to study FCC-hh benchmark channels within the **FCCSW framework** with **Pythia** generator and **Delphes** simulation.

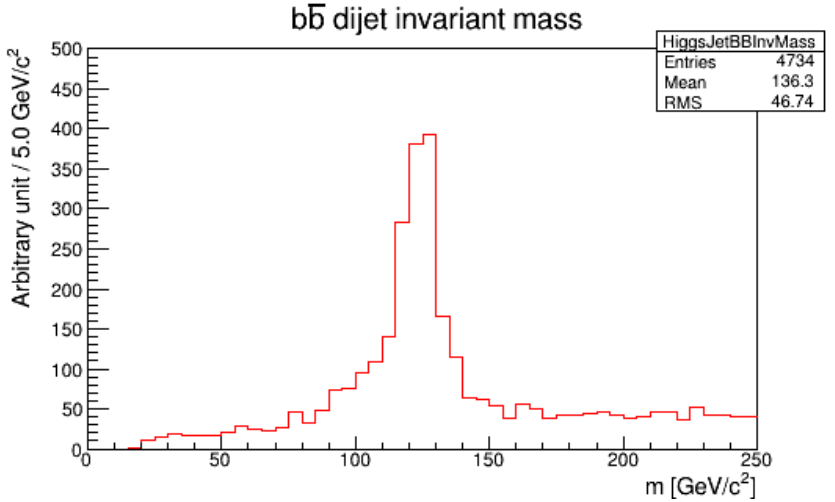
Input/Output:

- The Pythia input is required through LHE (Les Houches Event) data file together with a special Pythia config file or just standard Pythia config file.
- The Pythia output is through transient memory data store using HepMC event data format.
- The Delphes input is preferably from event data store, but can be in principal read-in from HepMC data file.
- The Delphes output is through Delphes ROOT tree writer, so via ROOT file.
- Support for FCC event-data format is under development --> will be available soon!

Example: pp → HH

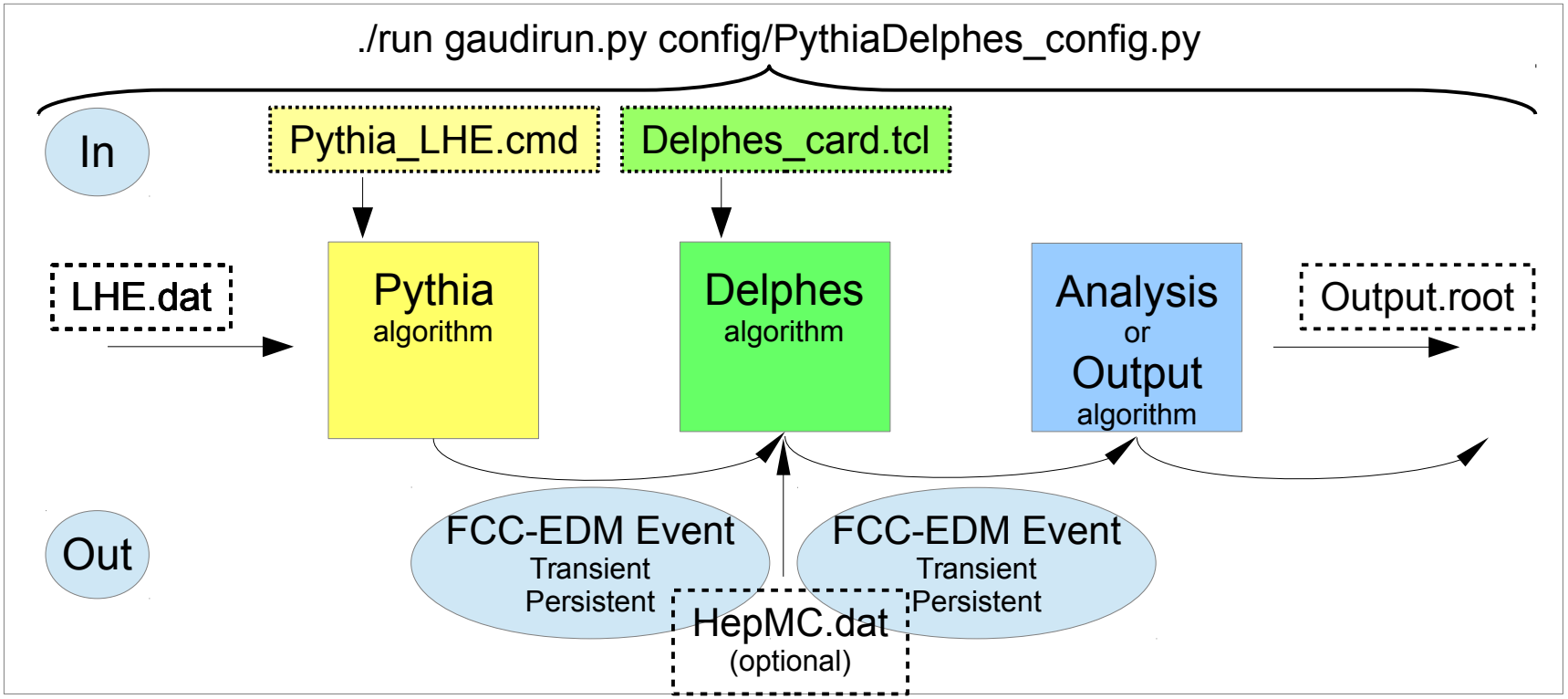
- Physics process: pp → HH , analyze events with H → $b\bar{b}$, draw inv. mass
  - Download LHE file (double higgs production) from:
    https://test-fcc.web.cern.ch/test-FCC/LHEevents.php
  - Use `PythiaDelphes_config.py` with `Pythia_LHEconfig.py` set as `PythiaconfFile`.
    - Set `nEvents` = 50000 , switch `MPI`, `ISR`, `FSR` on
    - Set the LHE file as an input in `Pythia_LHEconfig.py`
    - Use official Delphes card
    - Keep `DelphesHepMCInFile` = "", set `DelphesRootOutFile` = "DelphesOutput.root"
  - Use Particle branch to find b, $\bar{b}$ coming from Higgs and Jet branch with BTag=1 to find b-jets





Issues?

- Current approach provides full generator & simulator chain, but ...
  - Missing output to the official FCC event-data structure, i.e. EDM, (transient/persistent) → needs to be implemented, e.g. for official simulation campaign etc.
  - An interplay between end-users and software developers needed, to define possibly missing parts in the official FCC EDM!



Summary

- **Summary:**
  - Pythia & Delphes implemented as Gaudi algorithms into FCCSW framework (continue & extension of work by M. de Gruttola) → HepMC events kept in memory now (transient data store) → Pythia can be run in cooperation with Delphes within FCCSW now!
  - Pythia&Delphes Gaudi config script prepared: `PythiaDelphes_config.py`
  - Pythia starting configuration files arranged
  - Official Delphes card (for details see W.Riegler's presentation) included to the FCCSW
  - Ask for pull request to include all the changes within the official FCCSW release
  - Prepared tutorial on FCCSW Twiki for newcomers:
    https://twiki.cern.ch/twiki/bin/view/FCC/FccPythiaDelphes

Outlook

- **Issues & Outlook:**
  - Current approach doesn't allow to save in an efficient way e.g. Pythia output (HepMC files too large)

    → **Need for implementation of transient input/output using FCC EDM!**
  - Not an issue for physics analysis → Delphes ROOT output given → use ROOT to analyse data, but...
  - If one wants to organize e.g. an official campaign for simulation of benchmark channels, it makes sense to simulate Pythia outputs only → end-users might want to change Delphes configuration in order to understand an interplay between physics & detector performance ...