FULL AND FAST SIMULATION FRAMEWORK FOR FUTURE CIRCULAR COLLIDER STUDIES

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Future Circular Collider

- 80-100 km circumference
- studied collider options:
  - hadron-hadron (FCC-hh)
  - lepton-lepton (FCC-ee)
  - hadron-lepton (FCC-he)
- goal 100 TeV for FCC-pp
  - more particles produced (×1.5 more than 14 TeV)
  - large detector (∼20 m x 50 m)
  - more pile-up events (∼1000 events)

http://fcc.web.cern.ch
Providing a flexible infrastructure

- different collider options
- several detector designs
- different accuracy, level of detail for
  - physics analyses
  - detector studies

What can be used?
- many specialised software solutions
- one flexible framework

SIMULATION

- event generation
- energy deposits
- hits
- digits
- reconstructed points
- raw data

RECONSTRUCTION

- particles
- tracks/clusters
- processing

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FCCSW - software common for all FCC collider options (hh, ee, eh) and experiments.

- common toolkits for event generation, simulation, ...
- easy to mix fast and full simulation
Non-FCC specific part is extracted to Gaudi+Geant4 simulation framework: Gaussino
Full simulation configuration

SIMULATION

- Interface
- physics list
- user actions
- DD4hep geometry

Geant 4

EDM
• detectors
- detectors (and readout structure in sensitive detectors)
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- step-by-step simulation
Full simulation

- detectors (and readout structure in sensitive detectors)
- step-by-step simulation
- sensitive detectors register particle passage
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• step-by-step simulation

• sensitive detectors
  register particle passage

• saving energy deposits
Configuration of fast simulation:

- configuration of Geant 4
- add parametrisation process
- add models that govern the particle (its lifetime, properties, energy deposits).
Fast simulation

- regions
  - envelope of tracker
  - sensitive detectors for calorimeters
Fast simulation

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  ◦ sensitive detectors for calorimeters

• parametrisation
  ◦ triggered by chosen particles in chosen regions
  ◦ if conditions not fulfilled: detailed simulation
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  - tracker:
    - particle momentum changed (smeared)
    - new exit position
    - tracks stored
  - calorimeter:
    - hits created
    - energy deposits stored
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region: calorimeters
region: tracker
Tracking detectors

- full sim
- simulation
- digitisation
- reconstruction
- tracks
- particles

σ may depend on:
- momentum
- particle type
- pseudorapidity

σ may come from:
- tkLayout, (originally for tracker layout CMS Upgrade studies)
- FCC software, awaiting tracker reconstruction: ACTS

tkLayout
fcc-tklayout.web.cern.ch

ACTS
acts.web.cern.ch
smearing resolutions $\sigma$
  
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Tracking detectors

- **full sim**
  - simulation
  - digitisation
  - reconstruction

- **particles**

- **fast sim**
  - smearing

- **tracks**

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**tkLayout**

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Tracking detectors

full sim

particles

fast sim

simulation

digitisation

reconstruction

smearing

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tkLayout

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ACTS

CHEP 2016, Track 2: 12 Oct 2016, 11:30
acts.web.cern.ch
Calorimeters

- full sim
- simulation
- particles
- digitisation
- reconstruction

a. GFlash library: existing in Geant 4
analytical parametrisation of shower profiles:
longitudinal (t) and radial (r, uniform in $\phi$)
b. frozen showers: library of presimulated showers
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b. frozen showers: library of presimulated showers
Parametrisation of the electromagnetic showers, using the original GFlash parameters

First tests with FCC-hh size calorimeters and single electron events...

Automation of the extraction of the parameters from full simulation currently being implemented
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Simulation in Geant 4

Currently

- possible to mix fast and full simulation within the same event
- event simulation entirely in hands of one framework
- first parametrisation models provided:
  - for tracking detectors:
    - p-dependent smearing
    - resolutions from external tools, e.g. tkLayout
  - for calorimeters:
    - GFlash parametrisation using original set of parameters

What next

- tools for extracting the parameters from full simulation
  - for existing models
  - within FCC software (same geometry)
- new parametrisation models:
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• FCC software is designed to be shared between accelerator options and all experiments

• Simulation important for both detector design studies and physics analyses

http://fccsw.web.cern.ch/fccsw/
Summary

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• Simulation important for both detector design studies and physics analyses

• Possibility to use in early studies Delphes ultra-fast parametrised simulation

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Summary

- FCC software is designed to be shared between accelerator options and all experiments
- Simulation important for both detector design studies and physics analyses
- Possibility to use in early studies Delphes ultra-fast parametrised simulation
- Integrated full and fast simulation within Geant 4

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