Phase 2 tracker in Fast Simulation at CMS
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Fast Simulation (FastSim)

CMS Simulation flowchart

- Simplified geometry, simplified material interactions and parametrization for energy deposition (Base 1)
- Simulation smoothing (template based smearing)
- Gen-aided fast tracking, standardised code and more RECO

Reconstructed Particles (same in Fast and FullSim)

SimHits

Gen Particles

Full Simulation (FullSim)

Phase 1 and Phase 2 geometry

- Phase 1 upgrade to prepare CMS detector for HL-LHC
- Phase 2 tracker is designed to be,
  - more radiation tolerant
  - efficient with reconstructing tracks with a high level of pileup (~140)
  - more radiation tolerant
- Need for new tracker to exploit the full potential of HL-LHC

Phase 1 tracker geometry (TPX)

- Outer Tracker
  - 1. TPX: Tracker Barrel Pixel layers
  - 2. TFPX: Tracker Forward Pixel layers
  - 3. TEPX: Tracker Endcap Pixel layers

- Inner Tracker
  - 1. TIB
  - 2. TOB
  - 3. TEC

Phase 2 tracker geometry (TFPX)

- Outer Tracker
  - 1. TBPS: Tracker Barrel PS modules
  - 2. TBB: Tracker Barrel double discs
  - 3. TEDD: Tracker Endcap Double discs

Defining Layers
- Layer’s parameters are extracted from full simulation and hardcored in fast simulation
- Tracker material is modelled with 27 nested cylinders in inner and outer tracker
  - sensitive layers
  - insensitive layers or dead materials (cable wires, gap etc)

Simulated Hits
- Generated particles are propagated in the CMS magnetic field
- Material interaction considered when the particles crossed each layer,
  - Electron bremsstrahlung
  - Charged particle energy loss by ionization
  - Multiple scattering of charged particle
  - Photon conversion
  - Nuclear interactions
- Particle interaction with tracker materials is defined by assigning interaction length in each layer

Reconstructed Hits
- No local reconstruction in tracker: no detailed information of charge deposition in layer’s modules
- Hits are reconstructed from simulated hits,
  - Gaussian smearing of ‘simhits’ in the strip modules
  - Position resolution template histograms extracted by PIXELAV in the pixel modules

FastSim Tracking

- Iterative tracking
  - Tracks are reconstructed in multiple iterations of the standard tracking
  - Initial iterations search for easiest tracks and displaced tracks are produced in subsequent iterations
  - Hits used in one iteration are hidden from the next non

Future Prospect

1. Tracking validation of phase 2 fastsim against phase 2 fullsim for zero pile-up
2. Make fastsim configurable for phase 0, phase 1, and phase 2 for users to use phase 2 geometry alongside current phase 1 geometry in fast simulation
3. Introduce pile-up and assess the tracking performance in phase 2 fast simulation

References
1. The Phase-2 Upgrade of the CMS Tracker, CERN-LHCC-2017-009 ; CMS-TDR-014