Monte Carlo truth in the ATLAS detector simulation programs

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Outlook

- What is MC truth ?
- Tracks
- Processes
- Strategies
- Defects and shortcomings

What is MC truth?

- Snapshot of the event from the generator
- (simplified) snapshot of the event in the detector simulation
- A way of connecting hits to tracks
- A way of knowing what went into the detector
- A trick to understand the physics which went on in a detector
- Many other things (it really depends whom you're talking to)

Several kinds of truth in ATLAS

- Truth from the generator (physics event)
- Truth from the simulation (selected interactions/processes in certain regions of the experiment)
- Track records and recorders (basically scoring surfaces which register all particles which go through)
- Calibration hits (not discussed here)

Truth from the generator(s)

- Exchange format is HepMC
- All generators in use are “equipped” with a interface into HepMC
- Events are read in the Detector simulation and modified
  - Vertex spread
  - Acceptance cuts
  - …
- It is a requirement that the original event be preserved along the software chain

Truth from det. simulation

- We decided to use HepMC for storing the truth from simulation for consistency reasons (and to avoid persistency issues)
- The event from the generator (GEN_EVENT) is copied (TruthEvent) and subsequently dropped.
- TruthEvent's vertices are shifted according to the (expected) experimental distribution
- TruthEvent is the only event source which is used by the detector simulation
- Processes and interactions which occur in the detector simulation will be saved in TruthEvent

Requirements on truth

- It must be possible to save snapshots of physics processes which occur in the detector
- It must be possible to customize the truth strategies on a volume/subdetector basis
- It must be possible to set cuts/parameters which determine which processes are saved
- The truth event must be navigable
- The truth event must be connected
- Vertices in the truth must correspond to physics processes

Some more thoughts

- Not all detectors require to point back to the truth
  - Calorimeters vs. trackers
- Pile-up makes the problem much more severe
  - A “bunch crossing” is naturally much, much bigger than a single event from the generator
- Hits from “background” may or may not be associated to a track
- There isn’t a single strategy for the truth
  - Different simulation streams may satisfy different requirements

A word on tracks

- Primary tracks
  - From the generator, they can be found in GEN_EVENT
- Regenerated primaries
  - Primary tracks which underwent a physical interaction which was saved in the truth
- Registered secondaries
  - Tracks which were produced in a physical interaction which was saved in the truth
- Secondaries
  - Tracks which were generated in a physical interaction which was NOT saved in the truth

Primaries, regenerated primaries and registered secondaries are followed by the truth mechanism, secondaries are NOT

How does it work?

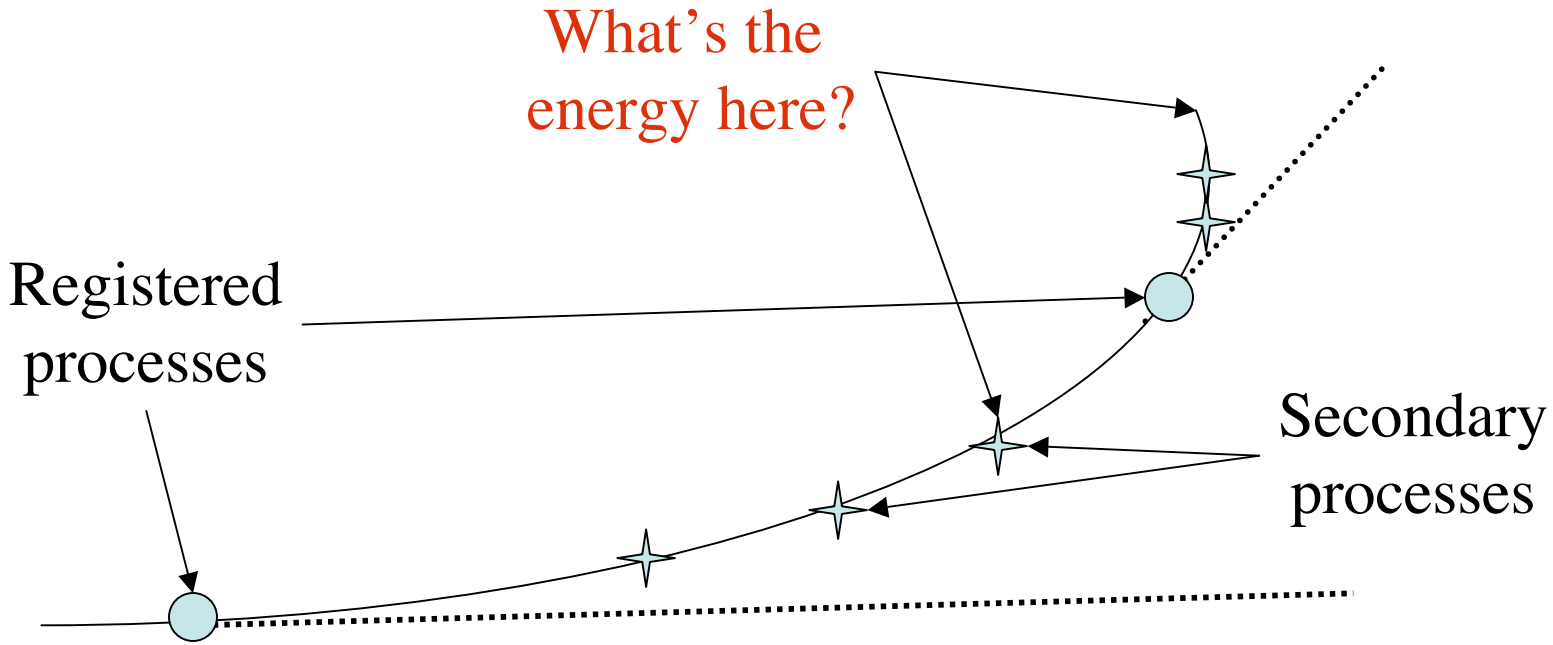
- “Strategies” are defined to deal with physics processes (e.g. brems) and associated to volumes
  - Plug-ins
  - Configurable
  - Shareable (can be applied to more than 1 volume)
- Strategies interrogated at every interaction (if at least 1 new track is produced) for those tracks which are “eligible” to the truth
- When a strategy triggers, the interaction vertex is stored and tracking can continue
- Using barcodes to categorize particles:
  - Barcode <100000 for primaries
  - Barcode >200000 for registered secondaries
  - Barcode >1000000*N for regenerated primaries

Practically (in G4)…

- Customized trajectories are created for "eligible" tracks
  - Take care of running the strategy machinery
  - They are destroyed as soon as the track is killed
- Helpers can be used (from the strategies) to decide what to do in rather generic terms
- Ineligible tracks are not followed by the truth mechanism at all (for performance reasons)
  - This saves us time for instance in the shower development

Shortcomings

- Once a track is declared “secondary” there is no way of following its history anymore
- Some problems with “energy conservation”



“Geometrical” truth

- “Which tracks enter the muon system/LAr calorimeter?”
- Too heavy to use the same mechanism as for the “physical” truth
- We use special hits collections and scoring planes
  - “TrackRecord”
  - Particle type, barcode, position, momentum
- Used by reconstruction algos
- Can be used for simulating separately different regions of the detector
  - Calorimeters can be simulated independently from the IDET

Summary

- We have a system which
  - Works
  - Fulfills the requirements (until now)
  - Is easily expandable
  - Does not add any complication in the software system
- We are reasonably satisfied
- Only real problem that we can see is that requirements from physics and detector groups are often conflicting and we can't accommodate them all