MC Truth and detector simulation programs Where are we?

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What is MC Truth?

- A single term to condense several concepts, requirements, functionality
  - Input to the detector simulation programs
  - Snapshot of interesting interactions during event processing
  - A link between detector response ("Hits", "Digits") and the original particles in the event
- While bits&pieces exist in the detector simulation programs (e.g. Geant) this functionality is not fully available anywhere

Input to the detector simulation

- The generator output (e.g. HepMC) contains all information needed for analyzing a physics event
- …still, detector simulation programs want to modify it…
  - Particles are eliminated (quarks, strings, stable particles outside the detector acceptance…)
  - Vertices are modified (primary/secondary vertices can be moved)
  - Vertices are merged
  - Decayed particles are "resurrected"
  - Events are merged ("pile-up")

Input to detector simulation (2)

- The original event is translated into “another” event that DS can swallow
  - HepMC::GenParticle→G4PrimaryParticle→G4Track
- In the process, it is quite hard to maintain a link to the original event, which allows backwards-navigation
- Need for an intermediate event representation (this is what the detector will see)
  - Not a connected tree, can we still use HepMC?

Event processing

- Detector simulation programs often used as "black boxes"
  - You input a physics event, out comes the detector response
- Need to gain some deeper insight, to "save" interesting physics processes that may occur at tracking time
  - Particle decays
  - Hard brems
  - Tracks entering/leaving a certain region of the detector
- (clashing requirements between DS and generators as far as long-lived particles are concerned)

Event processing (2)

- Need for an intermediate format to store event information
  - Particles, vertices, processes which generated them
  - Keep relationship with the parent particles
    - G4Track→HepMC::GenParticle?
- Mostly user-defined information/strategy
  - We do want to save hard brems in a tracking device, most certainly not in a calorimeter
  - Define "thresholds" to decide what to save, how, when…

Detector response and generated events

- It must be possible to associate hits (snapshots of a physical interaction in the detector) and the particle which produced them
  - For consistency checks
  - To verify the correctness of a reconstruction algorithm
- This can easily be realized for “primary” particles, how about secondaries?
  - Fool-proof implementation requires saving the whole simulated event – Out of question…
  - Need to implement strategy for primary-secondaries association that can be used from the hits viewpoint

Detector response and generated events (2)

- The actual detector response is simulated out of hits
  - Hits are merged into "digits"
  - The particle-hits association (1→1) is translated into a particle-digit association (Many→1)
- Events are merged into one bunch crossing at this level
  - Relationships must be conserved/rebuilt when the "truth" is re-shuffled
  - Do barcodes still work when events are merged? Or must they be re-arranged too?

Geant4 and MC truth

- No real interface to MC generators to start with
  - Kinematics provided by G4PrimaryParticles/Vertices
  - Only recently an interface to HepMC has been provided
- The HepMC::GenParticle→G4PrimaryParticle→G4Track chain makes backwards navigation hardly possible
  - Hits see G4Tracks
  - Hard to navigate from Tracks to primary particles
  - No link from primary particles to HepMC
  - Persistency IS a problem here!
- Stacking sequence in G4 makes it hard to foresee whether a track must be stored or not
- Need for a home-grown solution!

DS programs for LHC and MC truth

- All LHC collaborations are coming up with their implementation of a MC truth package
- This ranges from stop-gap solutions to complete re-implementations of the particle stack
- Different levels of satisfaction
  - The G4 users seem to be the most frustrated
- There is certainly room for common solutions

LCG – Common detector simulation infrastructure

- Common project set in place to provide unified simulation infrastructure that the LHC experiment can use
- Common definition of MC truth is the first item in the list of things to do
- Going through the requirements/design phase
  - Find a common base in terms of required functionality
  - To be implemented in SEAL/POOL
  - Maximize code re-use (why re-inventing the wheel if there is a wheel already)
  - Utilize existing components (e.g. HepMC) if these fit in the picture
- Aim at first implementation by the end '03