Efficient BIB overlay considerations

Ideas for a future-proof workflow

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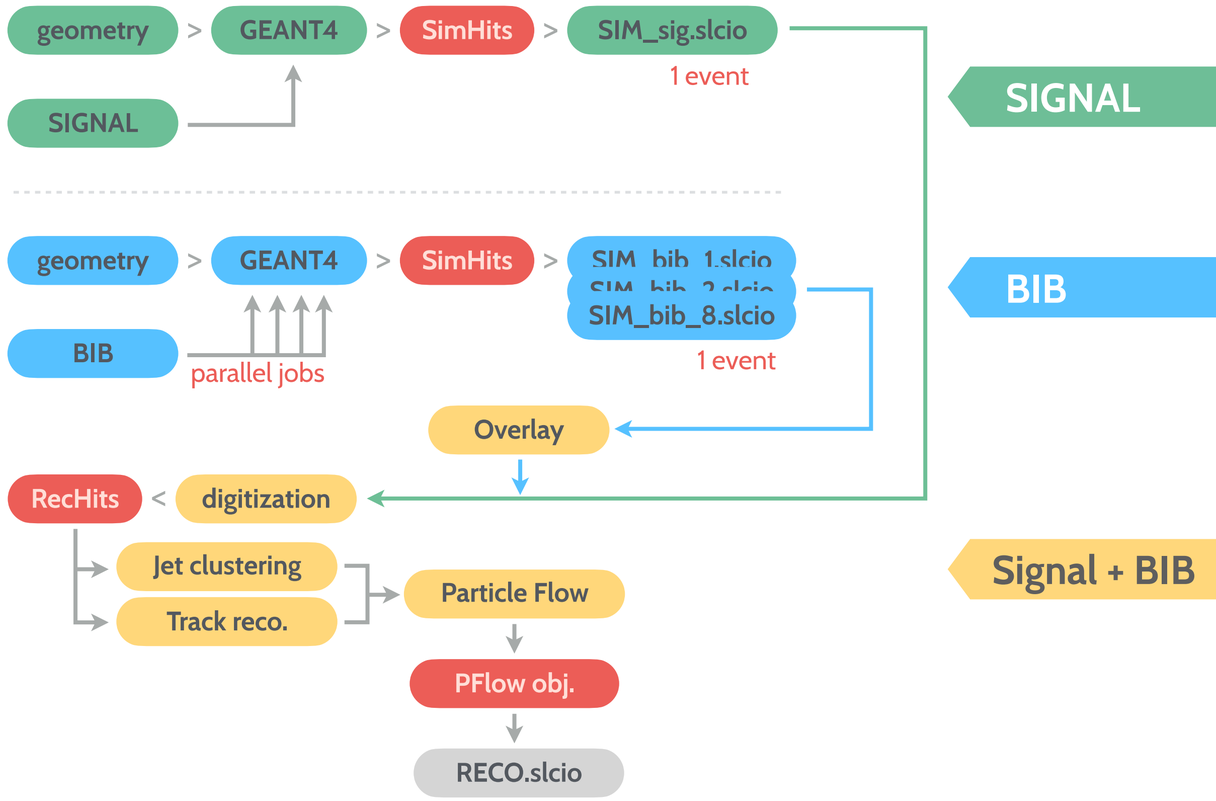
Current full-simulation workflow

At the moment our simulation workflow looks like this:



GEANT4 simulation of Signal: straightforward and fast

GEANT4 simulation of BIB: long (1 day), but done only once

↳ 1-10 reusable events: ~6×10^8 SimHits/event

Overlay of BIB: performed in each event before digitization

↳ sensitive to the # of BIB SimHits and merging logics

Great performance improvement was obtained by preselecting BIB SimHits based on digitization time windows

Less I/O, RAM and CPU time spent on reading and merging of irrelevant SimHits: (very rough numbers)

- RAM: 24 GB → 8 GB *(to hold all SimHits of a single event in memory)*
- CPU time: 10 minutes → 5 seconds (to select and merge hits within the time windows of interest)

Both simulation steps can be further optimised to produce higher statistics of BIB events (to avoid statistical biases)
+ less computations for constructing a single Signal+BIB event (to enable large-scale physics analyses)

GEANT4 simulation

At the moment we use BIB provided by MAP:

- **list of stable particles with a fixed weight = 1/23** → randomised in azimuthal angle
  ↳ 360M particles have to be simulated in GEANT4 to obtain 1 complete BIB event

Soon we'll use BIB simulated in FLUKA:

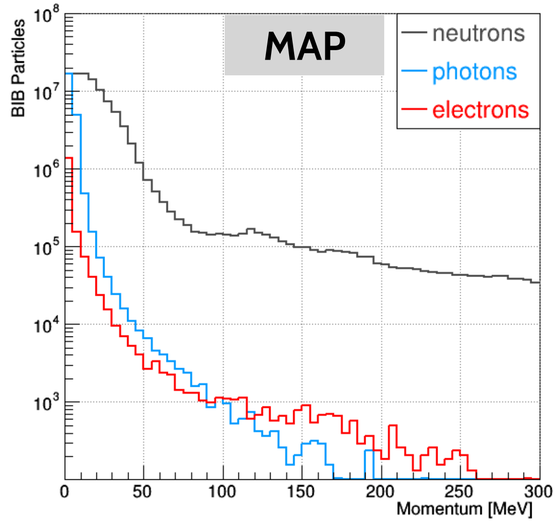
- **list of stable particles with variable weights depending on particle type and kinematics**
  ↳ the distributions will have to be sampled for creating actual input to GEANT4

Very high flux of particles allows to apply *Russian Roulette* sampling (used in CMS)

- **simulating only a fraction of the most abundant particles (photons, neutrons)**
  assigning weight ≥1 to the corresponding energy deposits
  ↳ can dramatically increase simulation speed in ECAL/HCAL (the most demanding part)
- **weights and energy/time thresholds have to be carefully chosen**

Less processing and less individual SimHits stored on disk

↳ **more BIB events available for a random Overlay**



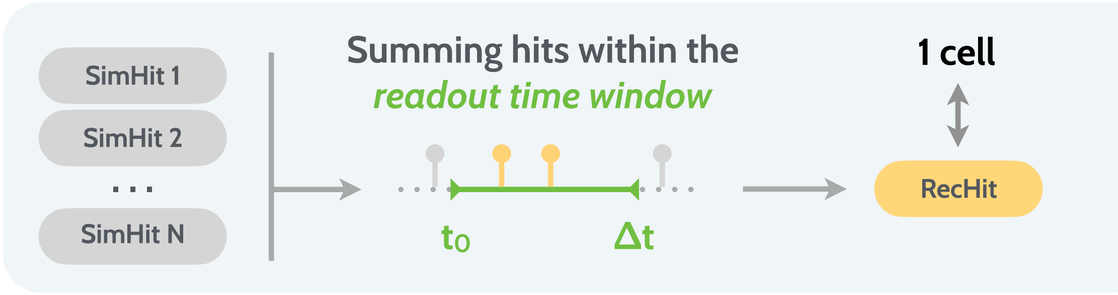
Overlay optimisation

Individual BIB particles are relevant in the Tracker region:

- **very small pixel size,** down to 50×50 μm
- **cluster-shape** → particle-type is important
- **precise timing** → pile-up effects are important

Only combined energy deposits relevant in the Calorimeter region:

- **large cell size,** at least 5×5 mm
- **timing granularity is coarser**
- **BIB distribution is fairly uniform**



Merging of individual energy deposits in calorimeter SimHits can be done before digitization → 1 hit/cell

↳ **only detector effects applied at the digitization step → less I/O, RAM and CPU processing**