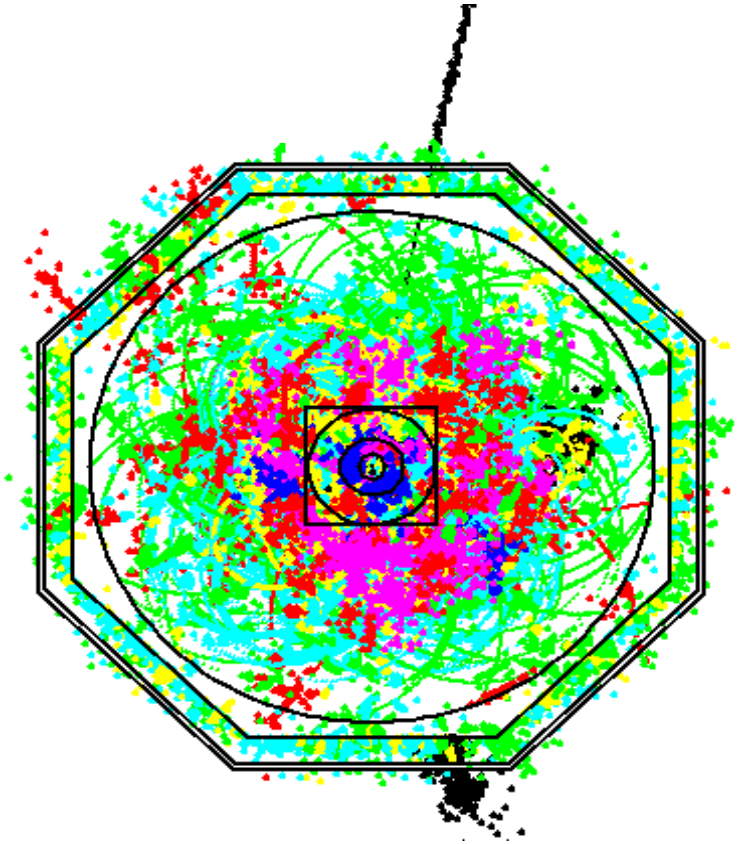
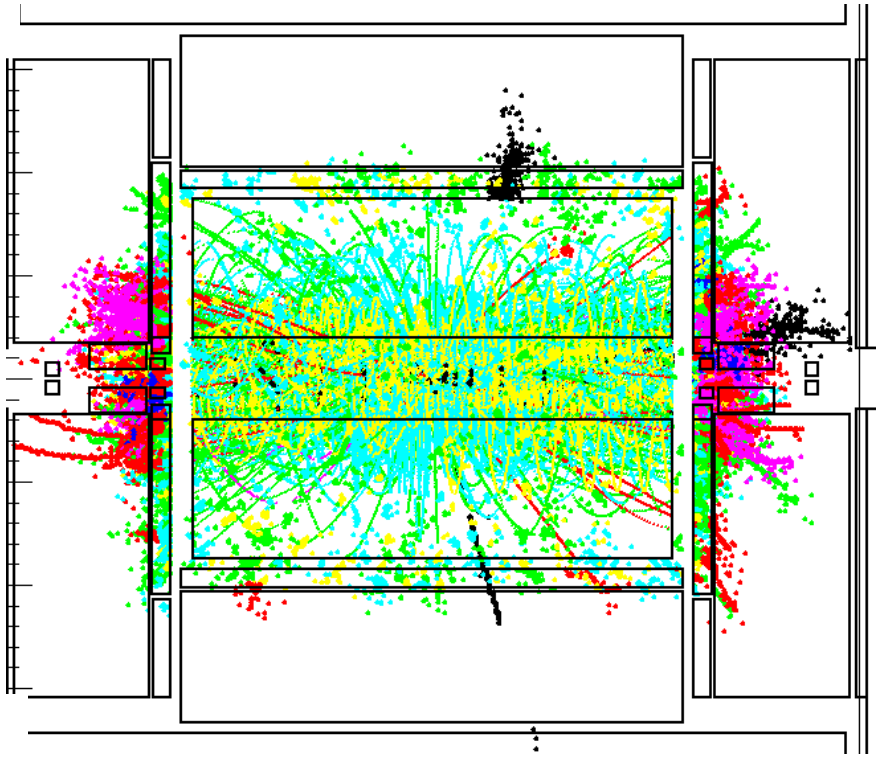
ILD Background WG

Mark Thomson





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+ input from Frank Gaede and Marco Battaglia

Background/Time-stamping

Guideline for the Plan of the detector groups

8. Simulate and analyze some reactions at 1 TeV, including realistic higher energy backgrounds demonstrating the detector performance.

★ **Heroic efforts for the LoI !**
- **But incomplete…**
- **Not fully integrated into a physics analysis**
- **In addition do not understand the time-stamping requirements for ILD**

⇒ **Impact on sub-detector design/technology**

★ **Only considered pair background**
- **other sources, e.g. gamma gamma → hadrons**

(see next page)

★ **Only looked at background in trackers**
- **what about calorimeters**

(see later)

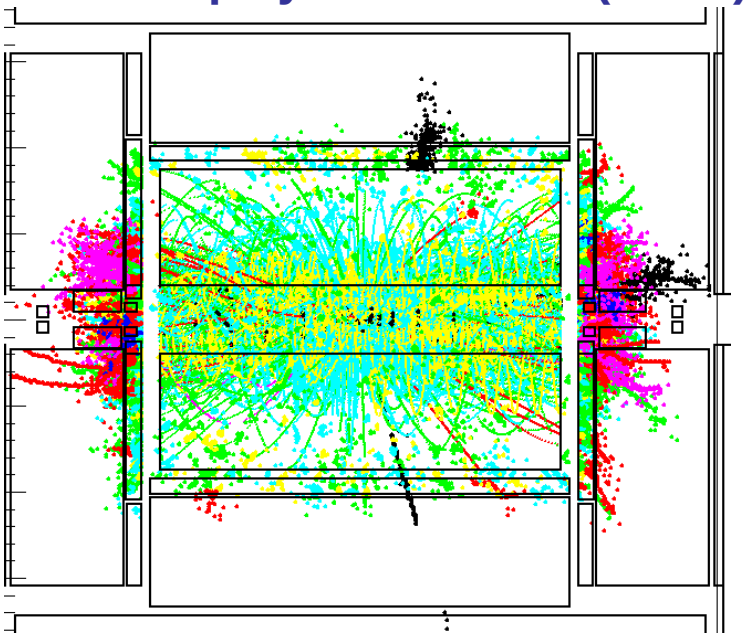
Two-photon → hadrons background at CLIC

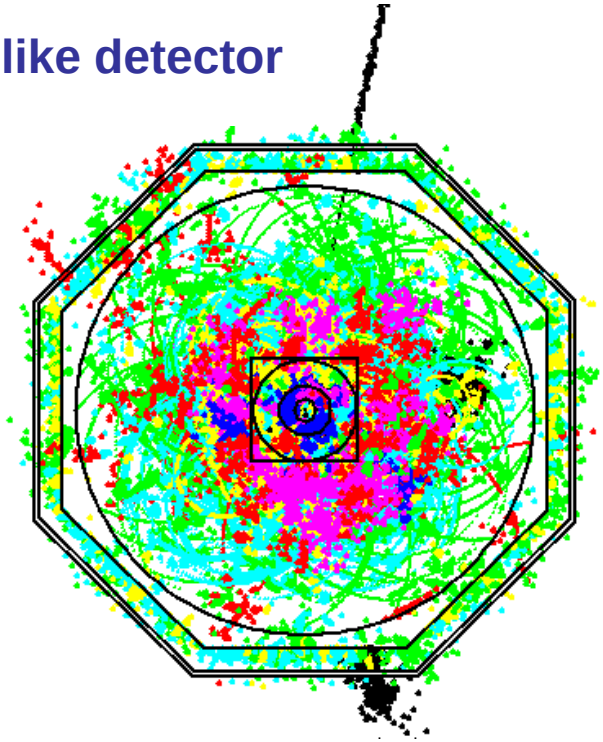
★**Preliminary** studies **(Battaglia,Blaising,Quevillon)** indicate significant two photon background for **3 TeV CLIC** operation

★Approx 13 particles per BX $(p_T > 0.15\,\mathrm{GeV}\ ,\ |\cos\theta| < 0.98)$

⇨ ~25 GeV visible energy per event

e.g. Event display for **150 BXs** (75 ns) in ILD-like detector





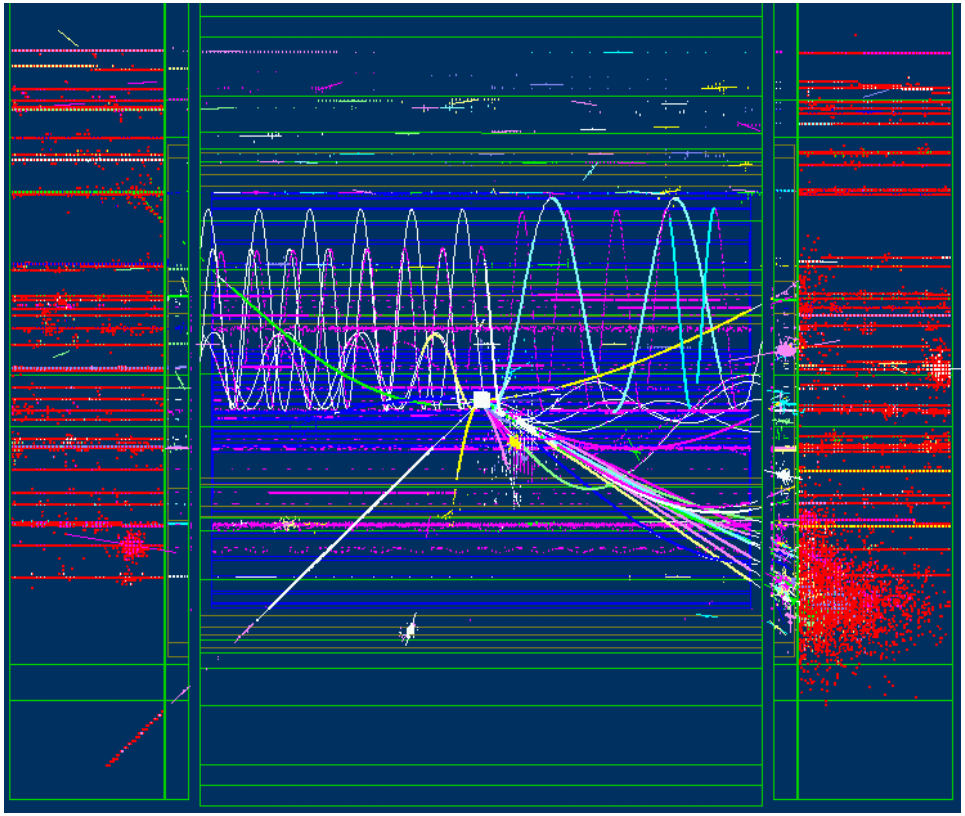
★ **NOTE:** integrated lumi in 1 CLIC BX ~ integrated lumi in 1 ILC BX

★ For ILC, cross-sections smaller and p_T of particles lower

★ BUT in ILD must consider VTX/TPC integration times

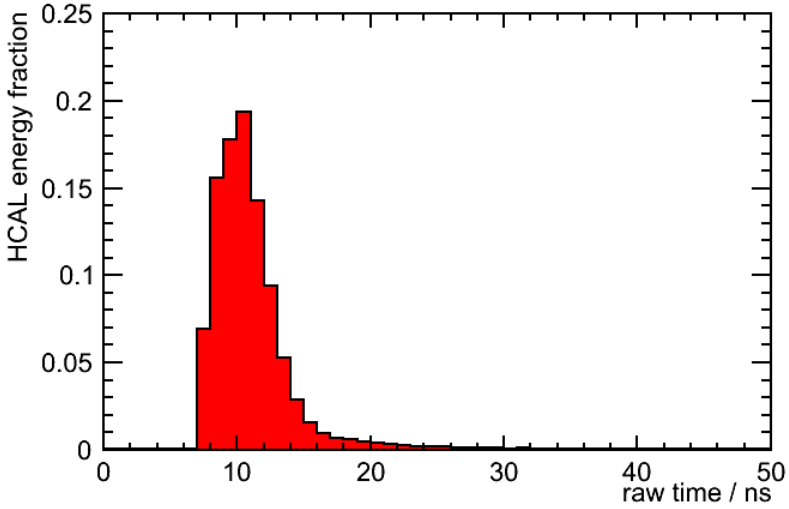
Beam Halo Muons at CLIC

- ★ Beam halo muons potentially important at CLIC
  - straight tracks in TPC not a big problem (removed by PatRec)
  - tracks in HCAL maybe more important…
    - potentially removed by timing + PatRec
  - but showers from Brems inside jets maybe impossible to remove
  - impact at ILC unlikely to be significant, but needs checking



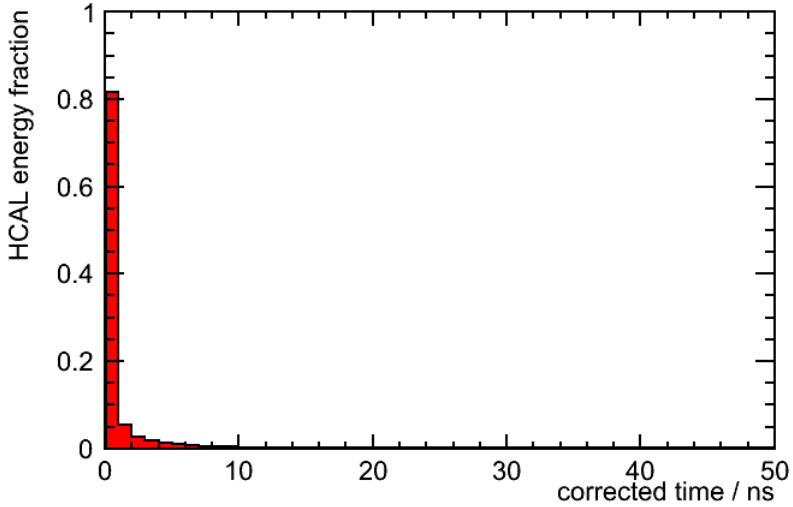
Time Structure in Calorimeters

- ★ First look at HCAL time structure in 250 GeV jets in ILD (no background)
- ★ Don't really trust MC – but probably gives some indication

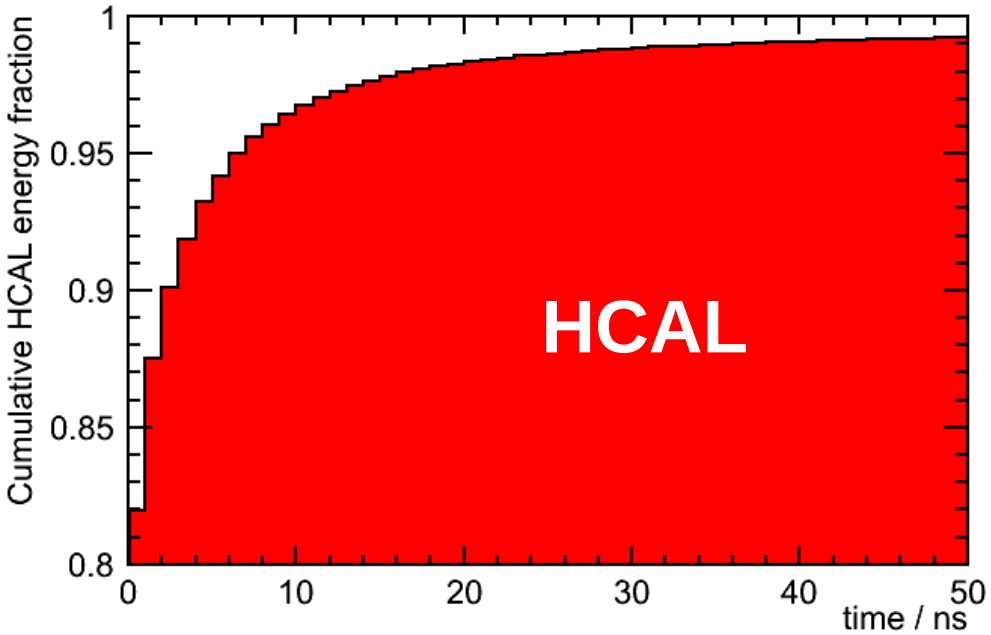


- Distribution dominated by time of flight to HCAL
- Long tail from low energy neutrons out to ~1 μs

- Correct for time of flight using hit position assuming propagates at speed of light
- Feasible (?) for ILC, triggerless readout
- In practice might correct in hardware at HCAL module level



Impact on time-stamping



- 95 % of energy in 10 ns
- 99 % in 50 ns

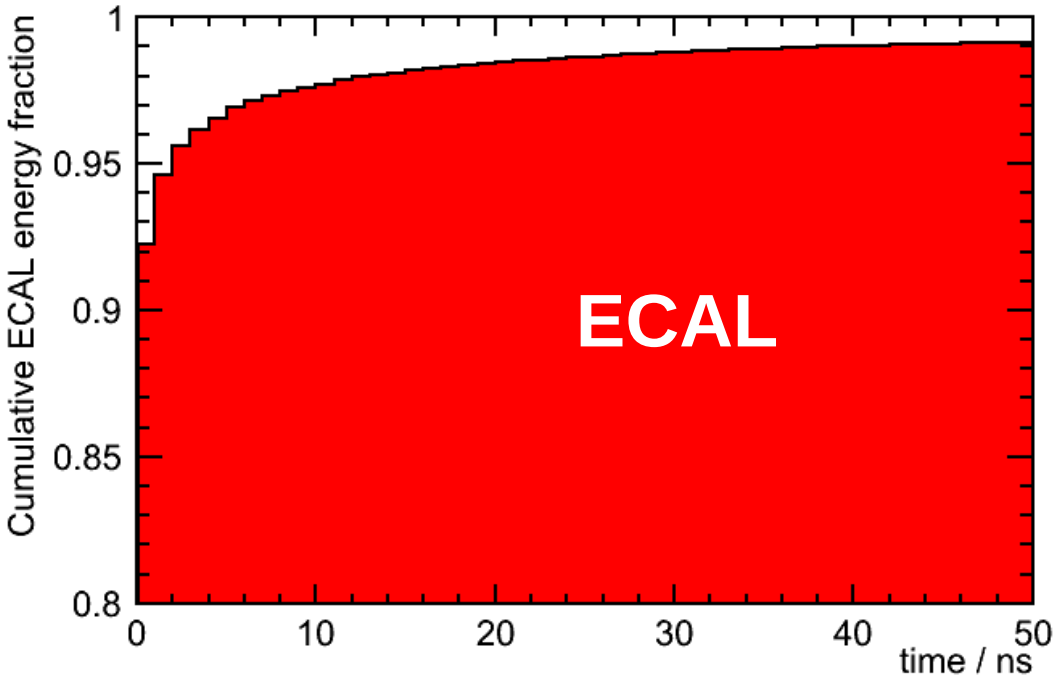
Comments:

★**ILC** has ~370 ns (RDR) or ~740 ns (SB2009) BX structure
- time structure unlikely to be an issue - **curlers reaching endcap?**
- time structure of hits from pair background could be different
  - timing cuts might help

★**CLIC** has 0.5 ns BX structure
- even with perfect time-stamping, probably integrate over > 10 BXs
- needs study – endcap region could be problematic
  - timing information in reconstruction might help

For completeness ECAL

- ★ Hits in ECAL arrive faster (photon component)
- ★ Suspect time structure dominated by curved tracks/loopers
  - needs checking



Background WG: Aims

High level: understand impact of background on ILD detector performance and time-stamping requirements

Several aspects:

1. Simulation of background sources: pair, gamma-gamma, beam halo muons, …
2. Refine background overlay infrastructure
3. Optimisation of reconstruction in presence of background
4. Performance studies

A few comments:

- ★ Should aim to provide tools to make inclusion of background in physics studies relatively straightforward
- ★ Not starting from scratch, building on previous work
- ★ Initially concentrate on software tools
  - make these applicable to ILC and CLIC

General simulation strategy

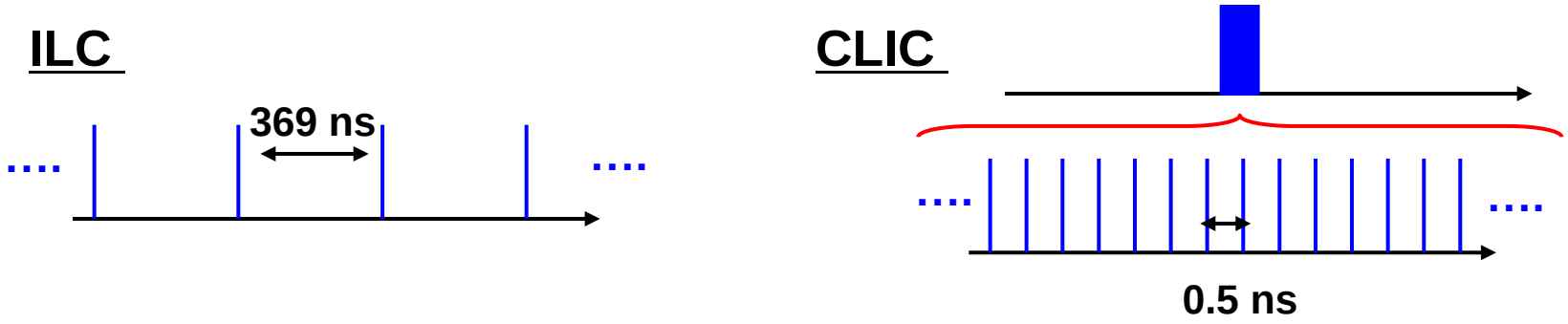
- **Two possible approaches to simulation**
  - Introduce background at Mokka stage, i.e. overlay STDHEP
    - For most backgrounds **extremely** inefficient
  - Introduce background in Marlin, i.e. overlay SLCIO
    - More efficient, simulate background samples only once
    - Equally correct
      - Mokka creates SimHits from energy depositions
      - SimHits can be merged/combined at overlay stage
- **Agreed:** all background treated by overlay at SimHit level, i.e. combine .slcio
- what background samples are needed?

1. Pair background
2. Gamma-gamma ➔ hadrons
3. Beam halo muons

Anything missing?

Overlay Strategy

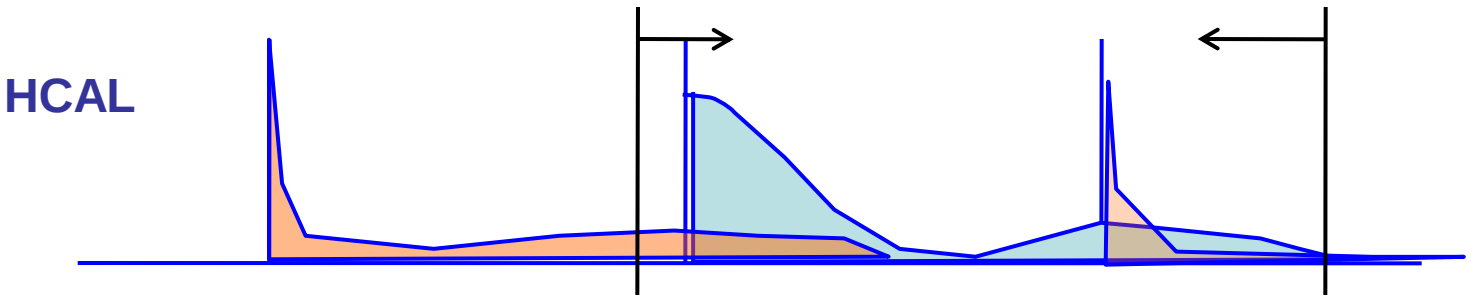
- **Requirements**
  - Needs to be easy to use – enable non-experts to perform studies
  - Needs to be "reasonably fast"
  - Needs to be flexible enough to cope with backgrounds in all sub-detectors (requirements/timing very different)
- **Timing I: need to cope with different time/bunch structures**



- **Timing II: need to cope with time structure in general, e.g.**
  - TPC filled in time (shifts in z)
  - Si integrates over N BXs
  - hadronic showers have slow neutron component
  - …

Proposal

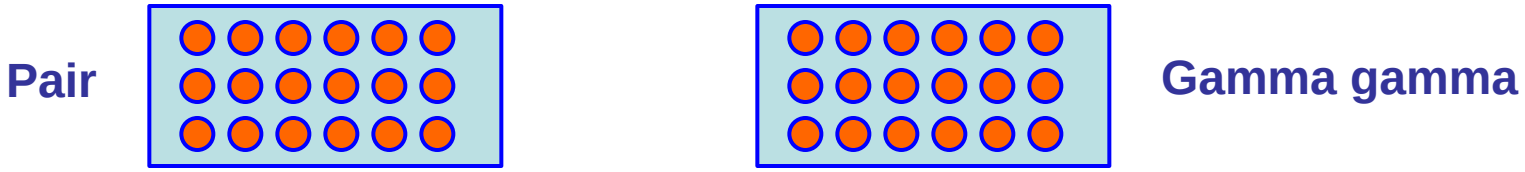
- ★ **All overlay performed in Overlay processor**
  - **i.e. not in the digitisers which would require passing LCIO background hits to digitisers (most would be thrown away)**
- ★ **Overlay processor(s)**
  - **Handle multiple background files .slcio (pair, muon, …)**
  - **Configurable at global level**
    - **e.g. specify BX separation in time**
  - **Include functions for overlay of different sub-detectors**
    - **some will be simple, others won't …**
    - **configuration to specify BX window required and timing cuts**



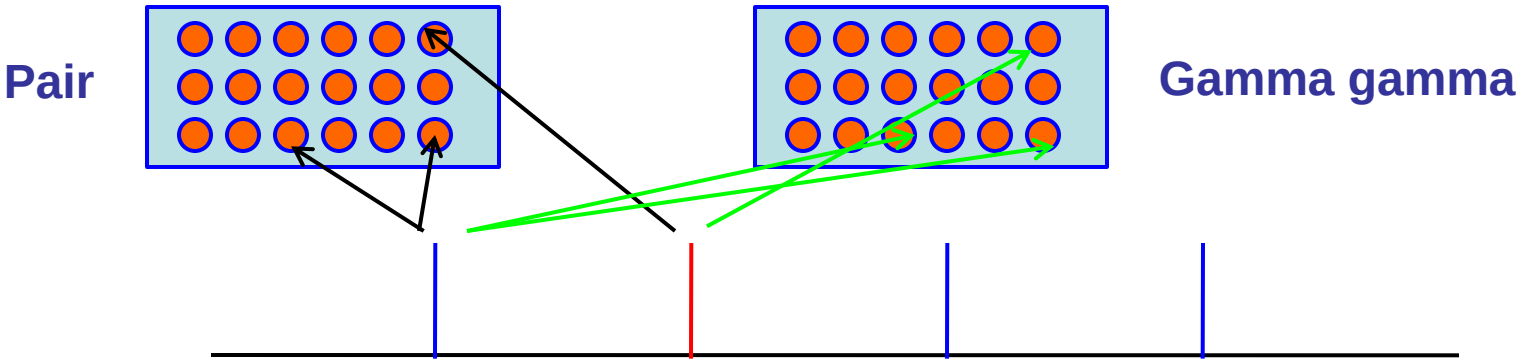
  - **Need to include hits from a range of BXs and then impose cuts**

The ATLAS approach

★ Store pool of background events in memory (for speed)



★ For each physics event BX0 assign entry(s) in pool to BXs needed



★ Pass pointers (and time-offsets) to sub-detector overlay functions
★ Selected BX range of interest and overlay relevant hits
★ Refresh fraction of pool, e.g. replace m out n events in memory

★ This is essentially what the current overlay processor does
  - except events are always accessed from disk

★ Agreed to stick with current ILD approach, unless proves too slow

Software Tasks

- ★ **OverlayProcessor**
  - Validate running multiple processors (one for each background type) works
  - Integrate missing sub-detectors, e.g. Calorimeters
  - Benchmark software performance, CPU, memory
- ★ **Unify configuration of sub-detectors in overlay processor**
  - Specify range of BXs for overlay, e.g. -50, +10 BXs
  - Specify assumed two hit separation in time, e.g. 10 ns
    - This is hardware dependent but in first instance make reasonable guess at pulse shape (probably not critical)
  - Specify timing cuts for hits to be passed to digitiser, e.g -5 ns, +100 ns
- ★ **Digitisers**
  - Timing cuts
- ★ **Prepare background samples**
  - We have pairs
  - Need: gamma gamma ➔ hadrons
  - Need: beam halo muons
  - Coordinate with CLIC on this

Where now?

- ★ We know what we want to do…
  - Just need to put names to tasks
  - Once technical aspects are solved, can start to study impact of background/timing requirements
  - Will then need to address reconstruction issues

That's all for now…