Streaming Geant4 Simulations (GEMC)

Simulation proposal
Short, long term plans

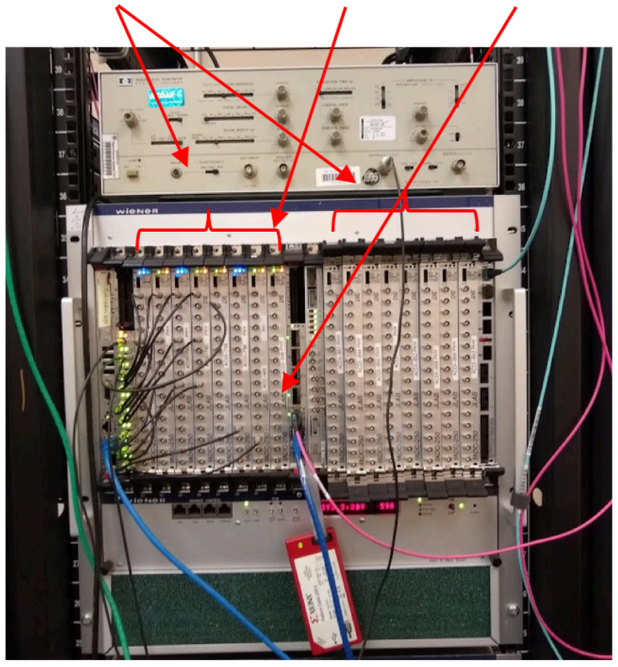
Maurizio Ungaro

CLAS12 Forward Tagger + Tridas

Beam On Test on an actual detector (CLAS12 Forward Tagger Calorimeter)

Streaming CODASRO from VTP

16x FADC250 Modules -> VTP -> 2x 10Gbps Ethernet -> PC

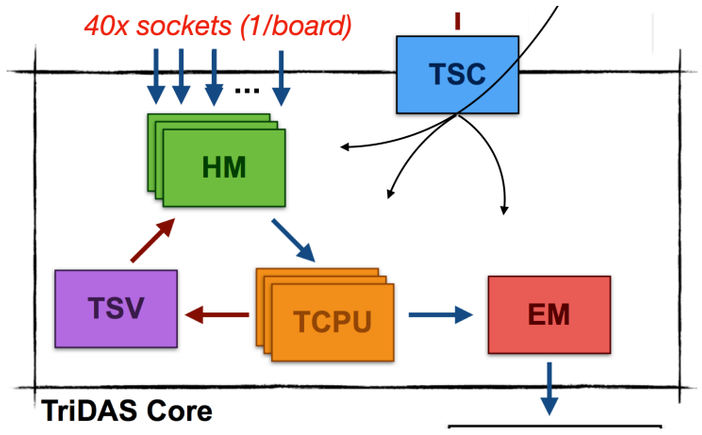


TCP

10/40GbE

CODA Translator to TRIDAS input

Tridas: Write Post Trigger File with continuous "real" analysis



Main Result: It's feasible.

Could send a stream of CLAS12 Data to the network

Could connect TRIDAS, and use actual reconstruction code

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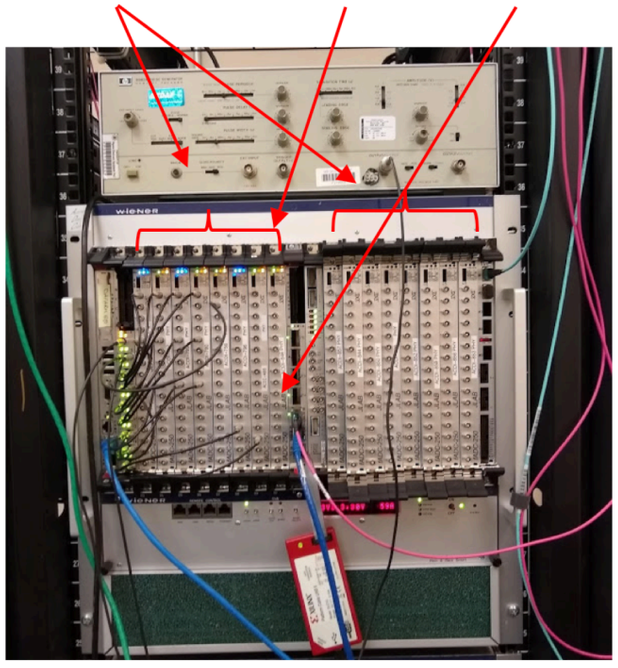

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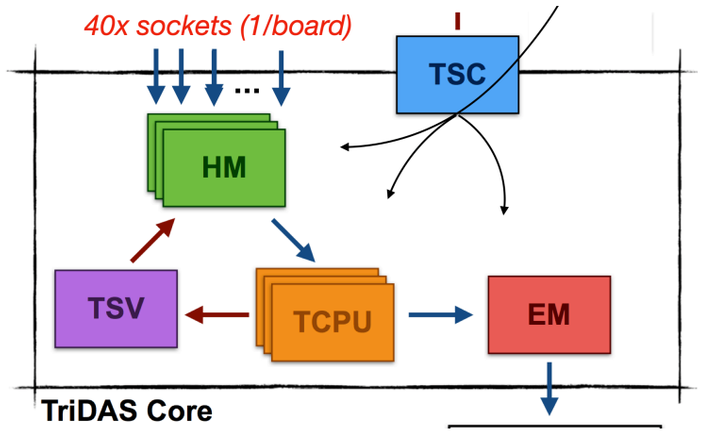


Many Challenges

Scaling to large detector system like CLAS12 or EIC:
Hardware & Software challenge.
TCP Transmission, events synchronization with downstream system.
Memory, CPU usage

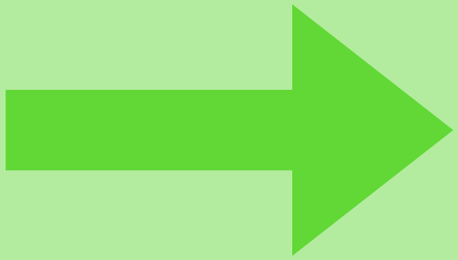
Streaming Geant4 Simulations Scope

Let's abstract the problem a bit

Continuous
DATA Stream

TCP

10/40GbE



Data Subscribers,
Analyzers

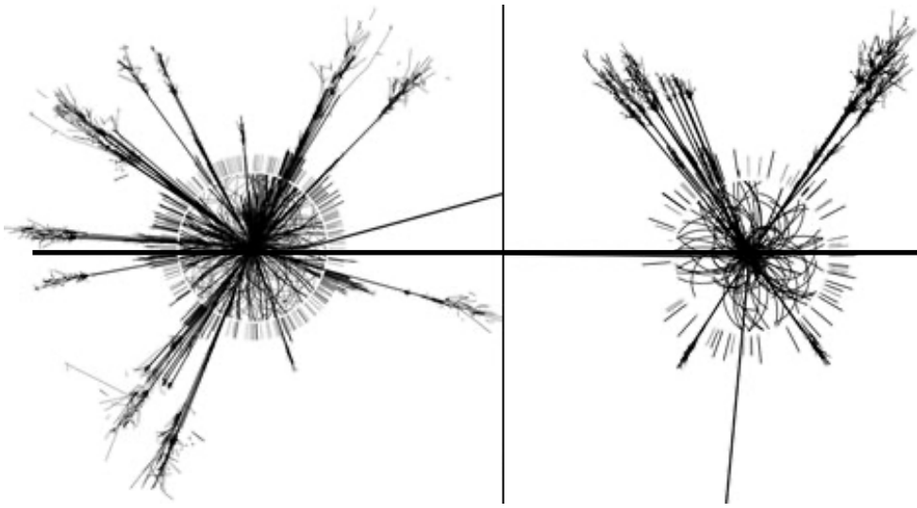
GOAL: Having simulated data that can replace the continuous data stream

the system should be transparent to the data source: experiment or simulation

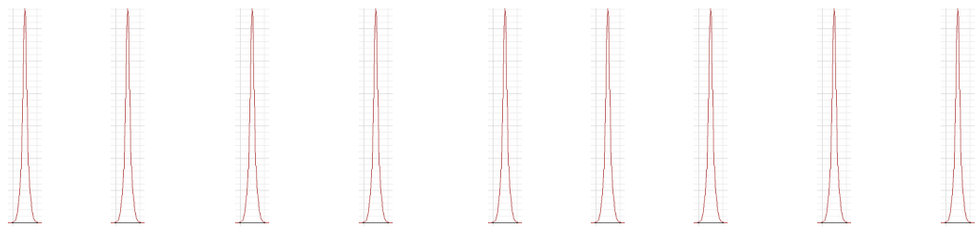
This will help addressing challenges on hardware, communications and software issues.

Streaming Geant4 Simulations Scope

generator: events are at absolute times t_i



time



beam structure (CEBAF: 4 ns)
for beam physics background
OR
actual data background merged

Geant4, Digitization

Continuous DATA Stream

Simulated data that can replace the continuous data stream

Streaming Geant4 Simulations Scope

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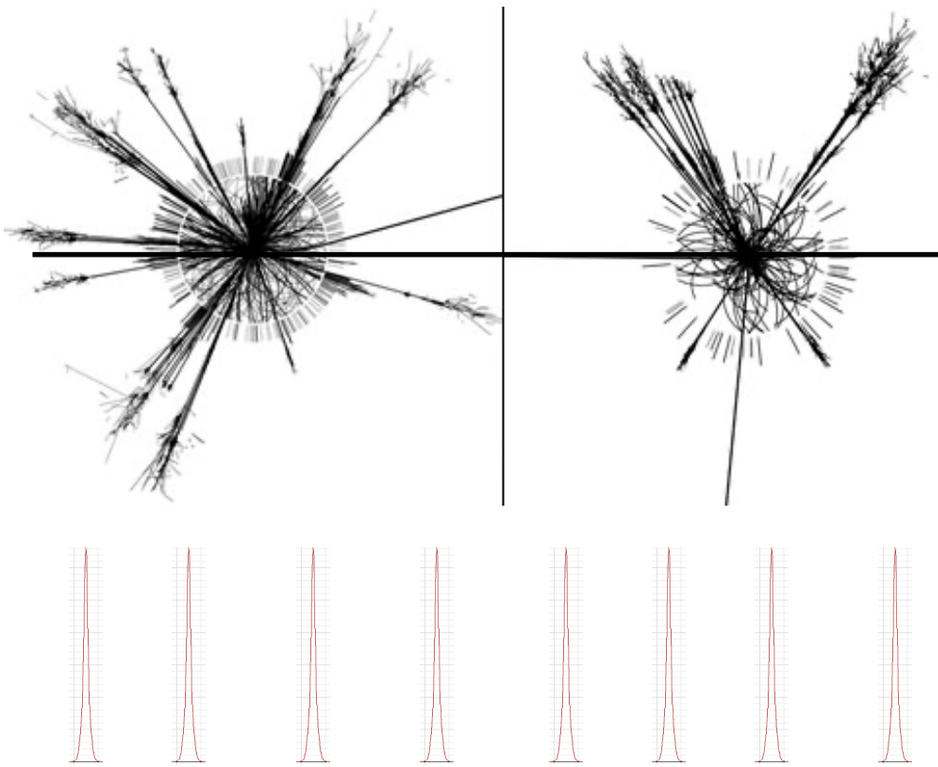

time

beam structure (CEBAF: 4 ns)
for beam physics background
OR
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Geant4, Digitization

No concept of “event”

Continuous DATA Stream

Simulated data that can replace the continuous data stream

Geant4 Streaming Challenges

- Geant4 is event-centric.
- Usually no event time window simulation.
- Usually no time-window of electronic simulations.
- Usually no Voltage vs time signal shape from a “hit”
- Usually no links between geant4 hit and electronic crate/slot/channel.

GEMC: GEant4 **M**onte-**C**arlo

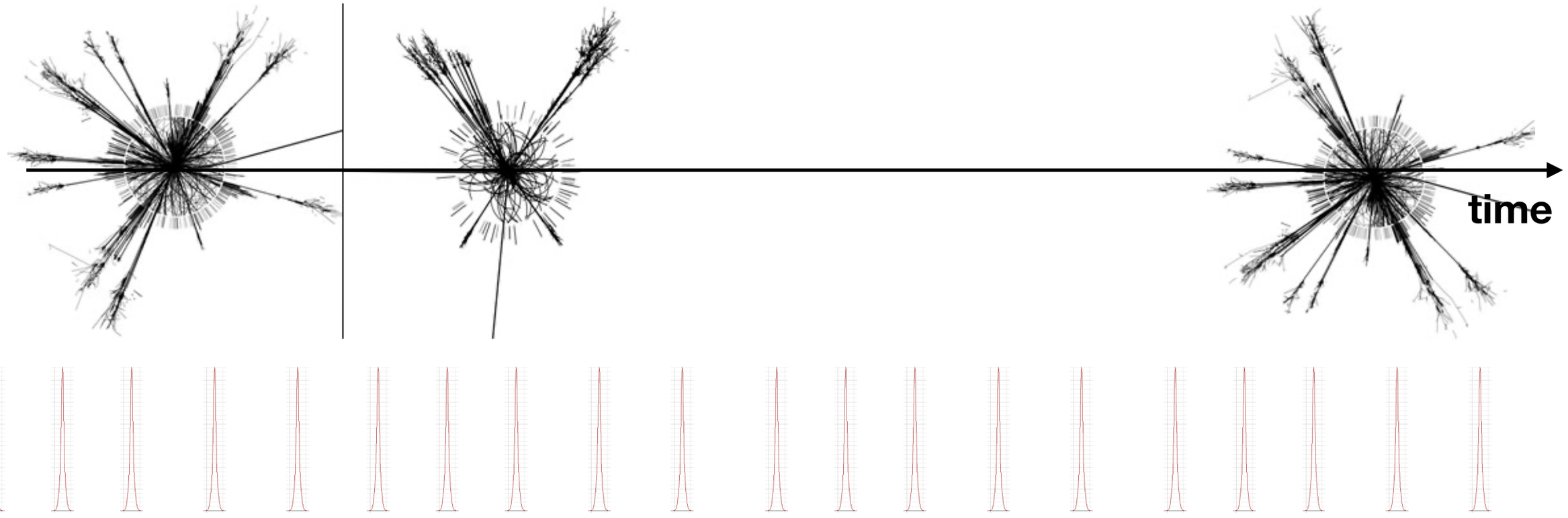
https://www.sciencedirect.com/science/article/pii/S0168900220300279

Event Time Window Simulation:

- beam structure: CLAS12: 124K e- in 250ns window in 4 ns bunches

- generator of events on top of that

TODO: add absolute time in the generators.



GEMC: GEant4 Monte-Carlo

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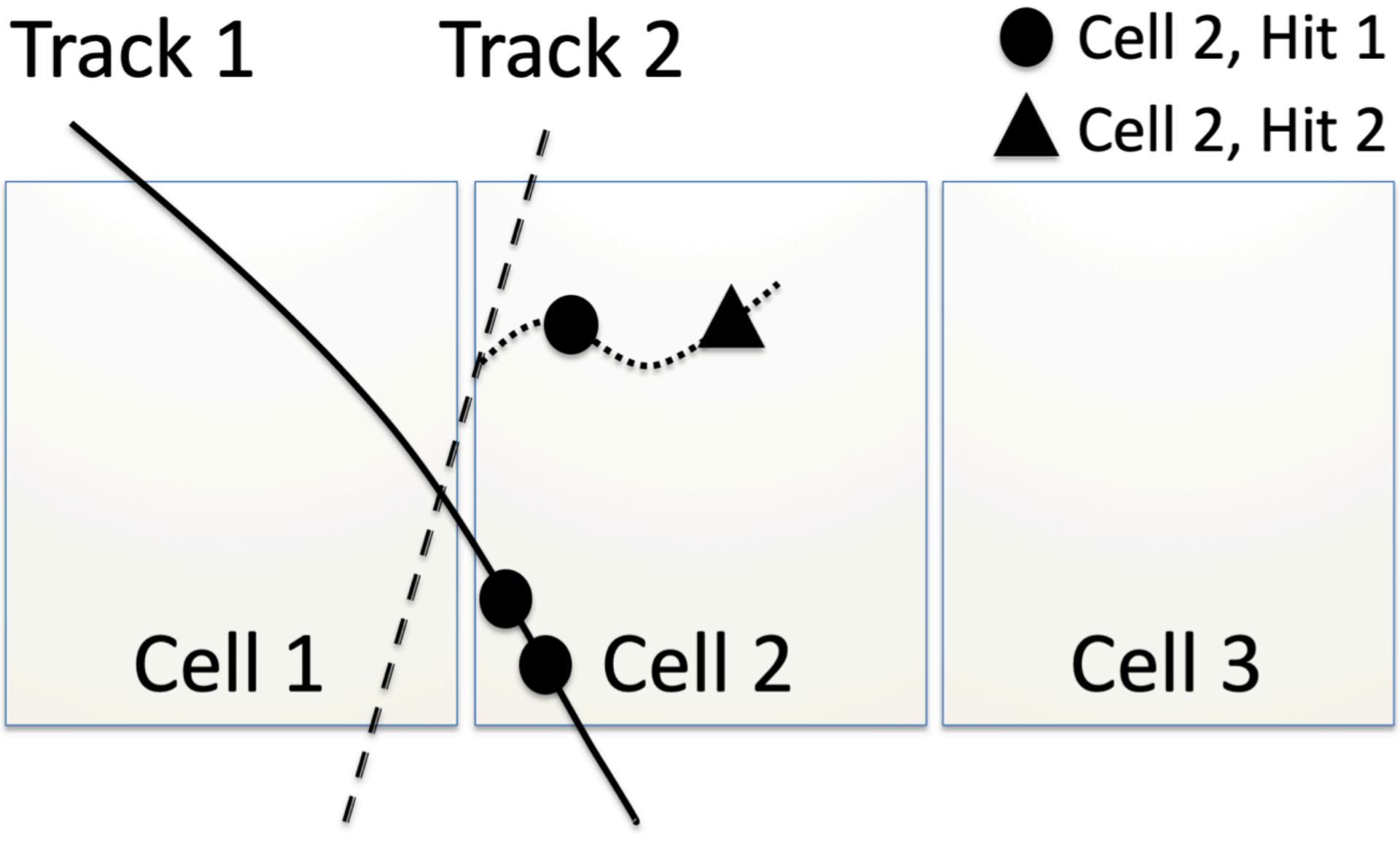
Time-window of each detector electronics.

Geant4 steps are analyzed and grouped based on their timing.
This mechanism is used to account for signals pile-up and can be extended.



GEMC: GEant4 Monte-Carlo

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Generic Link (framework library) between geant4 sensitivity and electronic crate/slot/channel.

```
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    </format>
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                      <uint32 count="1"> 0x00000003  </uint32>
                      <uint16 count="1"> 0x0004  </uint16>
                      <uint16 count="1"> 0x0005  </uint16>
                   </paren>
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             </paren>
             <paren>
                <uint8 count="1"> 0x04  </uint8>
                <repeat  n="1">
                   <paren>
                      <uint16 count="1"> 0x0002  </uint16>
                      <uint32 count="1"> 0x00000003  </uint32>
                      <uint16 count="1"> 0x0004  </uint16>
                      <uint16 count="1"> 0x0005  </uint16>
                   </paren>
                </repeat>
             </paren>
```

crate number

slot

channels

GEMC: GEant4 Monte-Carlo

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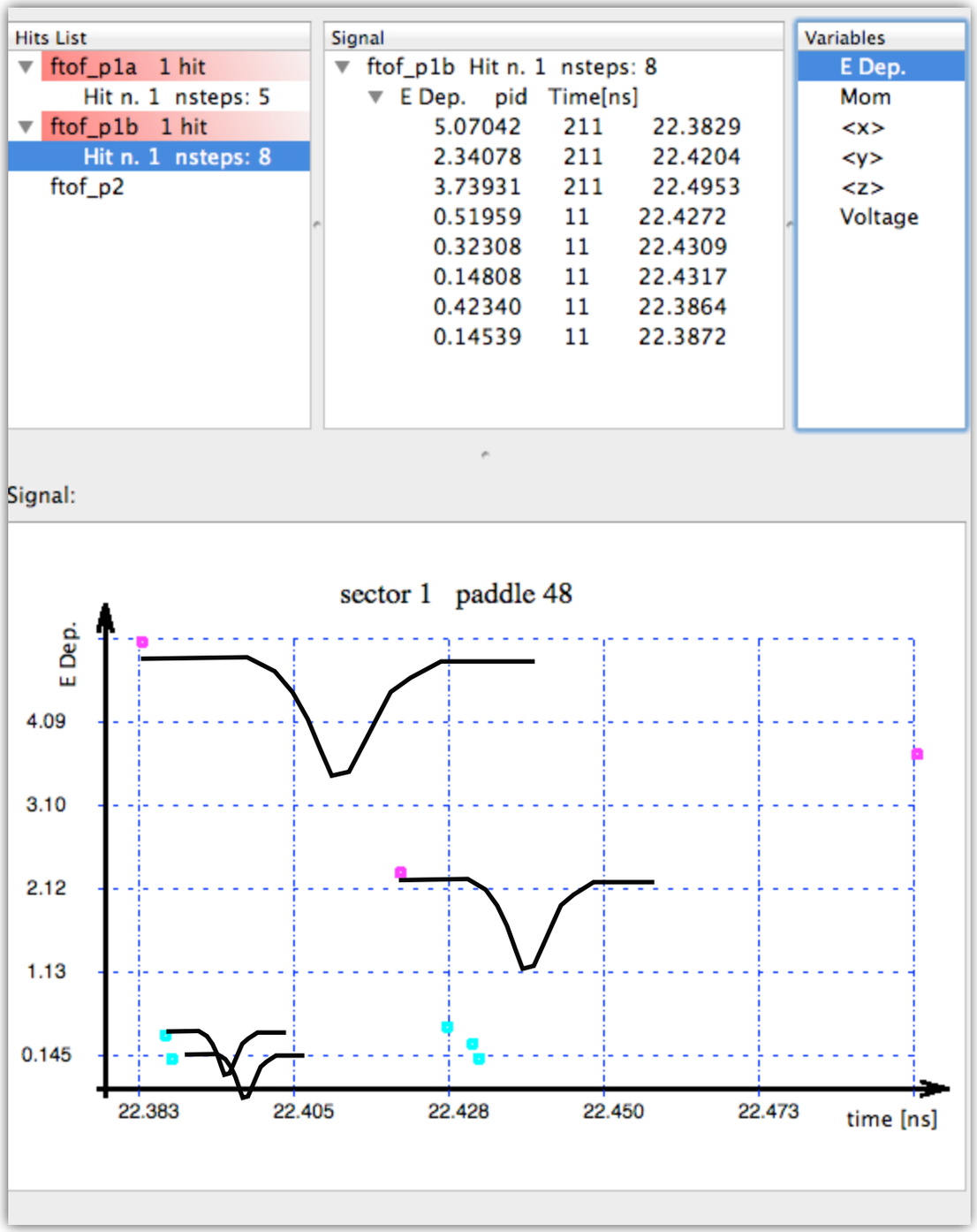
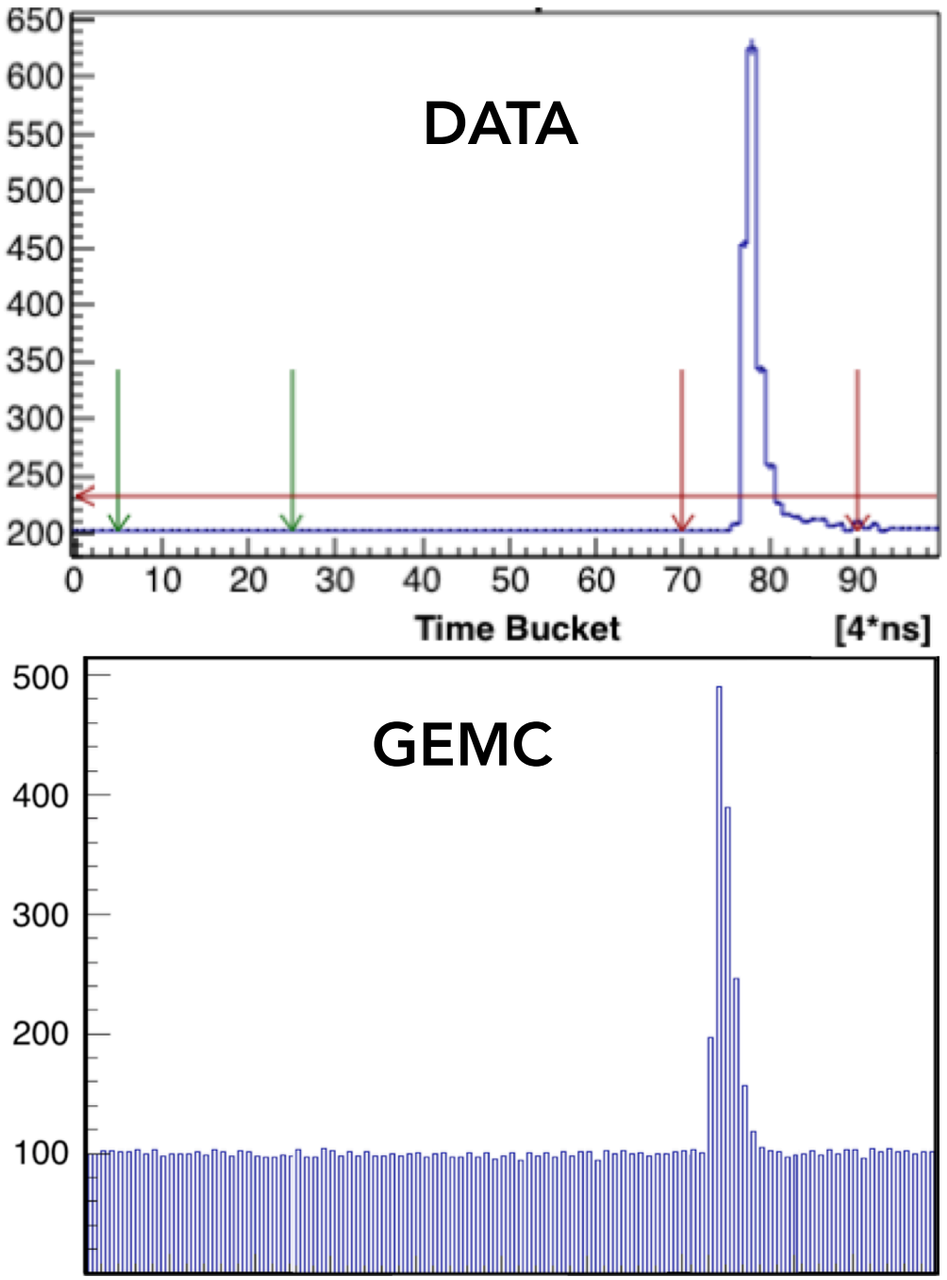
Voltage vs time signal shape from geant4 steps





Convolution with user-defined functions

GEMC for Streaming Readout

and getting around event-centrism: streaming buffers of data

Data structure:

1. common for both short and long term
2. structure / mechanisms may change later!

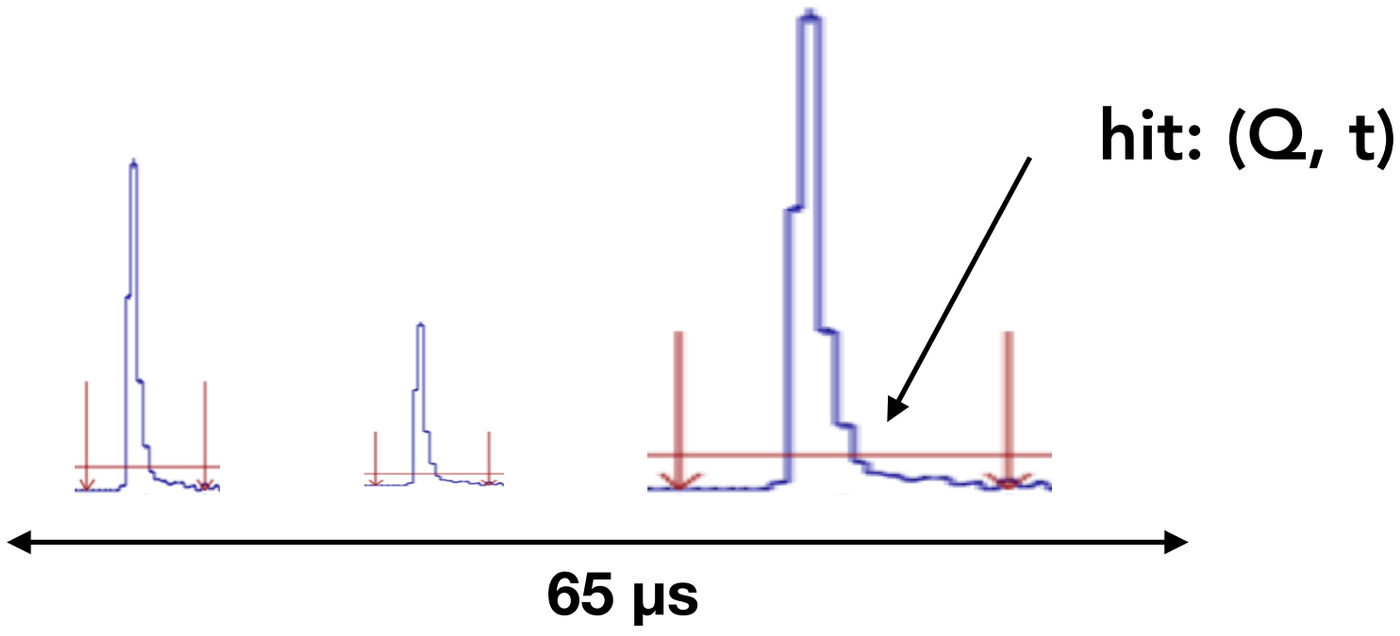
Proposal:

- one buffer / crate
- start with 1 crate of data (reproduce actual tests)
- use both high level ~CODASRO and low level actual CODASRO structure
- buffer integration time ΔT variable, can start with 65 μs
- GEMC will accumulate data into crate data buffers
- data in mode 3 but could be mode 1, mode 7

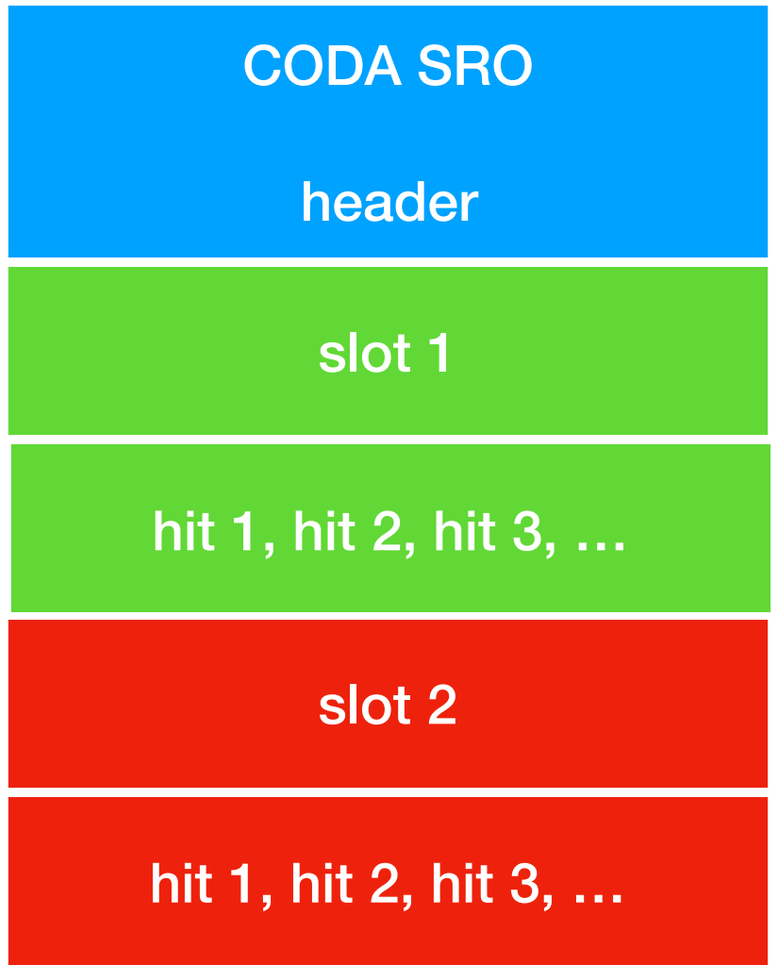
GEMC for Streaming Readout

and getting around event-centrism: streaming buffers of data

- use high level ~CODASRO structure
- buffer integration time ΔT variable, can start with 65 μs
- data in mode 3 but could be mode 1, mode 7



each 1 MHz data / crate
yields a buffer of 65 hits

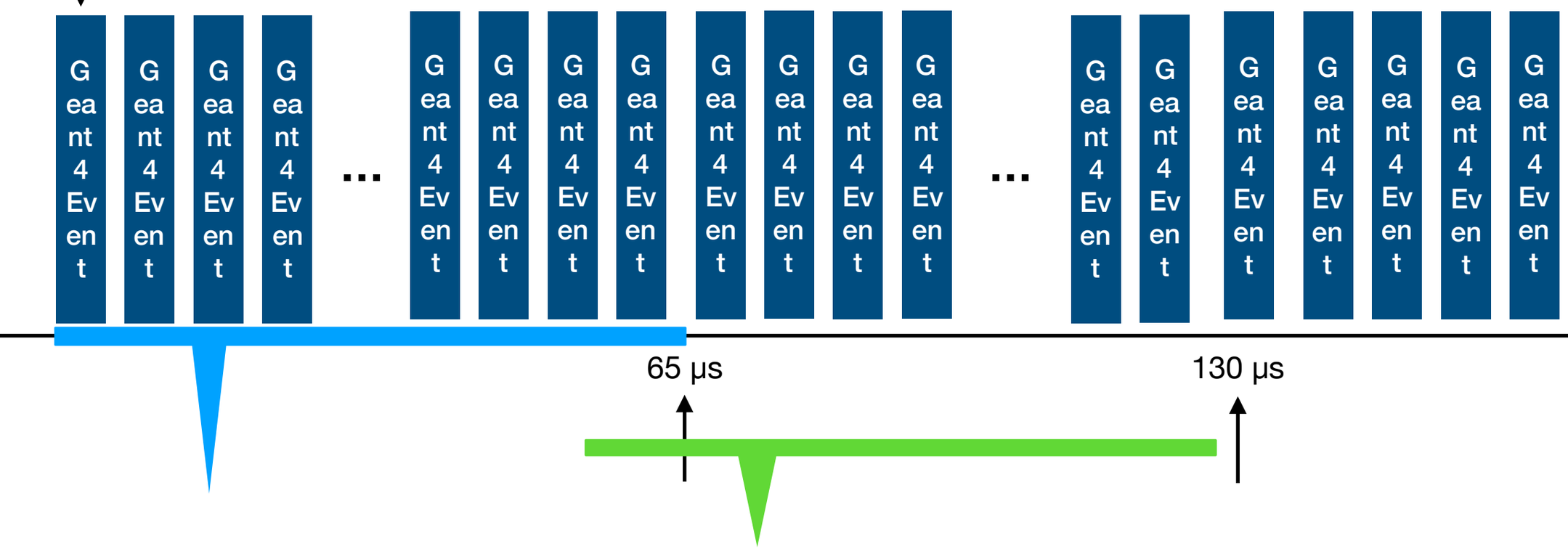


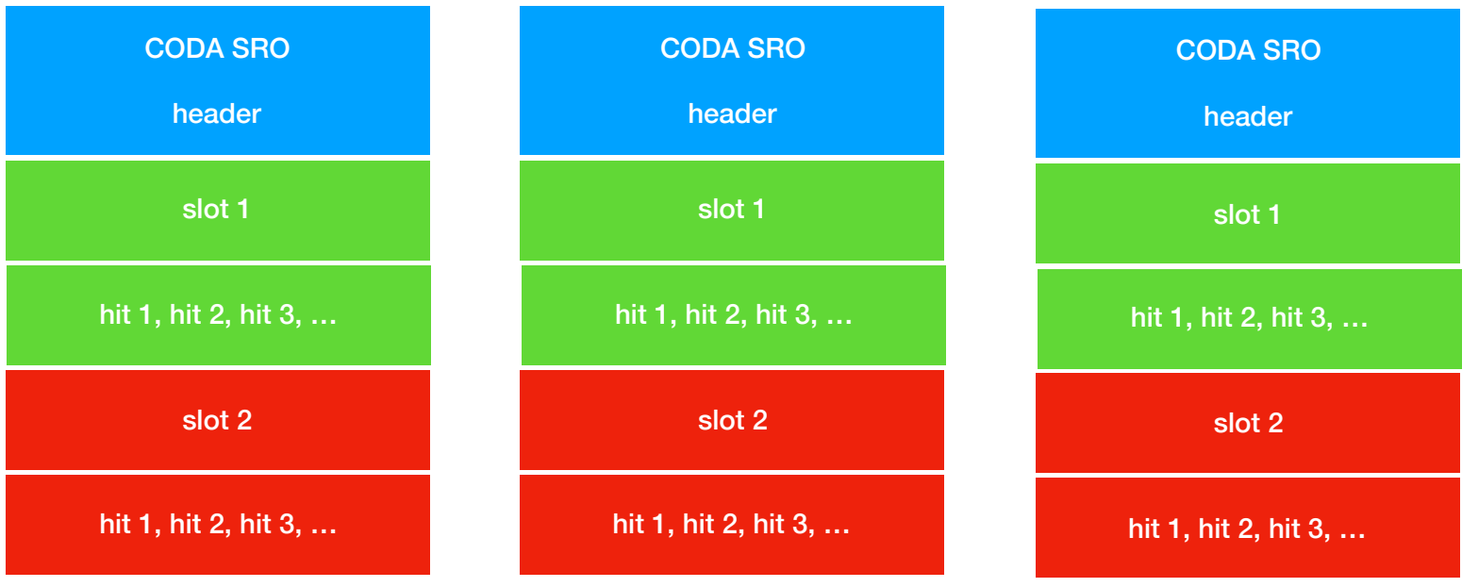
1 CODA SRO buffer

GEMC for Streaming Readout

getting around event-centrism

1 geant4 event is
(for example) 1 μs long





- events can end on future buffers

GEMC for Streaming Readout

Short term

- Design and implement high level CODA SRO and interface to actual CODA SRO structure

- Design and implement buffers of crate data

- Use a simple, existing detector geometry and demo buffer stream feasibility

GEMC for Streaming Readout

Long term

- Add crates, simultaneous buffers
- Keep compatibility with CLAS12 and EIC SRO efforts
- Simulate challenges of large scale detectors:
  - buffer synchronizations,
  - network glitches
  - large amount of data
  - crate malfunctions
  - etc

Summary

- streaming realistic simulated data will provide a workbench to address streaming readout challenges, for both CLAS12 and EIC

- geant4 limitations can be circumvented using GEMC

- Short terms and long terms plans to use GEMC to output buffers of data streams / crate