Streaming Geant4 Simulations

Project Overview

Opportunities to share enthusiasm/code/algorithms with existing ongoing efforts

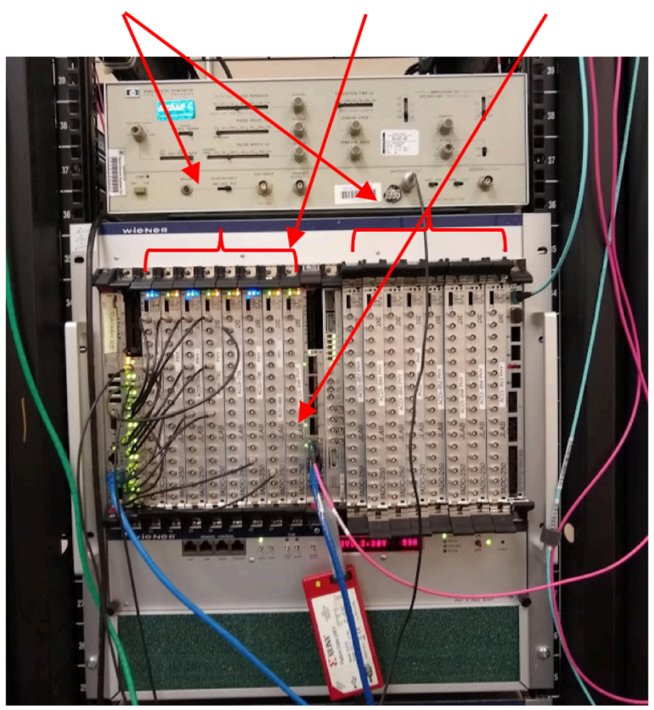
Maurizio Ungaro

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

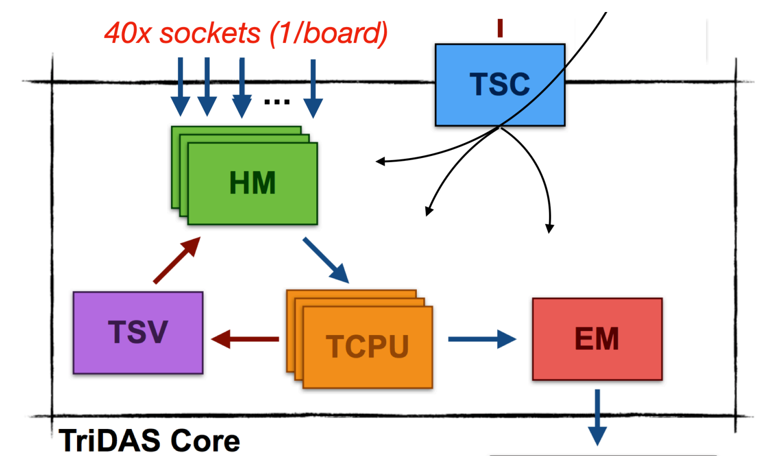


TCP

10/40GbE

CODA Translator to TRIDAS input

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



Many Challenges

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

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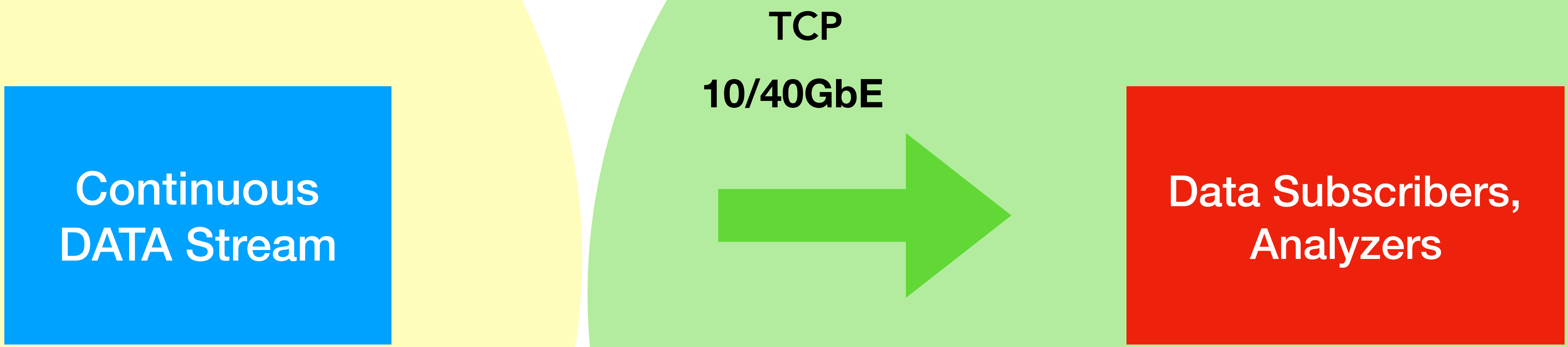
Streaming Simulations Scope

Data Source - Data Streaming



GOAL: Having simulated data that can entirely replace the data source

Streaming protocols / analysis systems should be transparent to the data source: experiment or simulation

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

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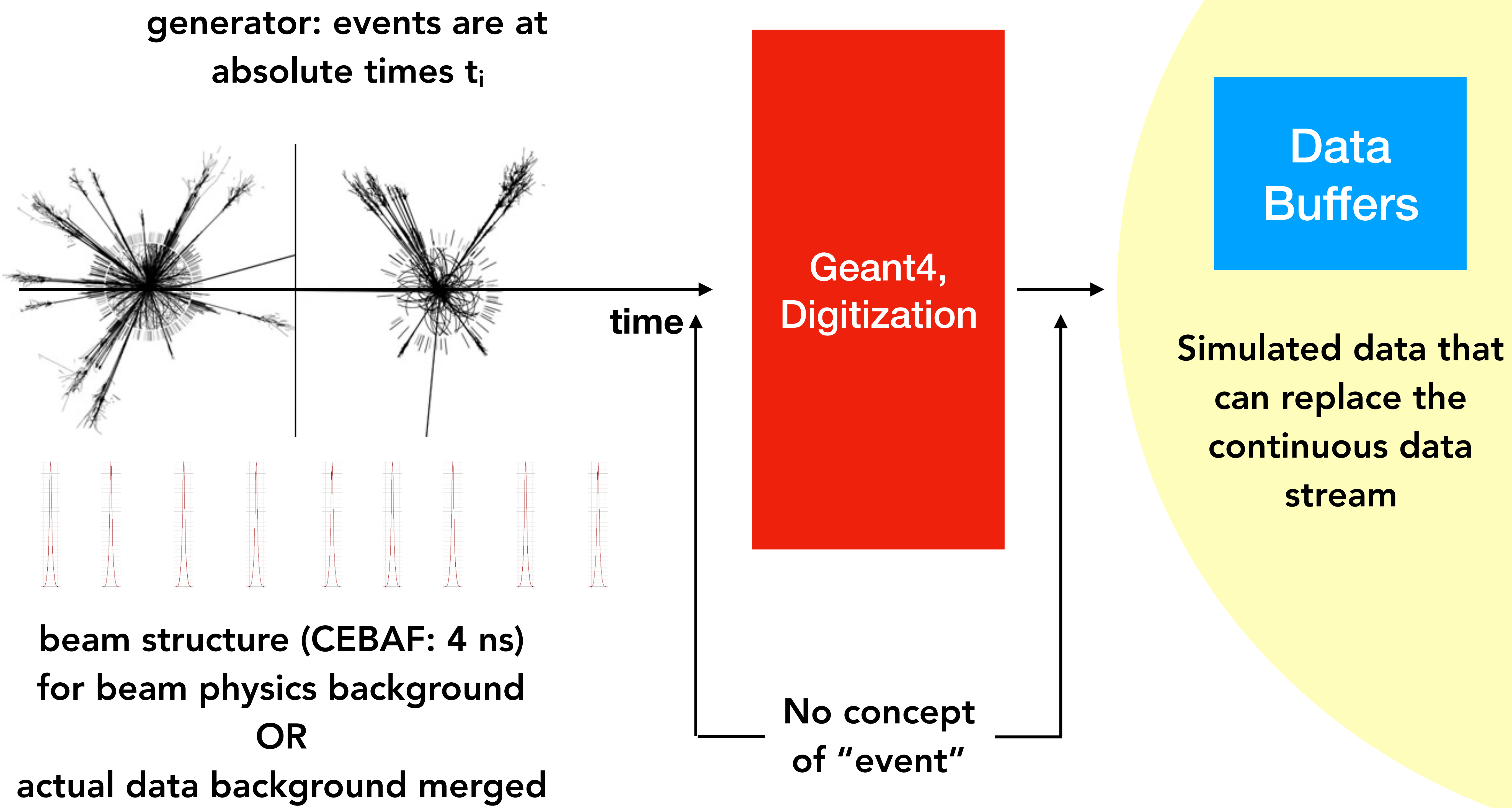
Streaming Geant4 Simulations Scope



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Geant4 Streaming Challenges

And opportunities for collaboration / sharing code and algorithms

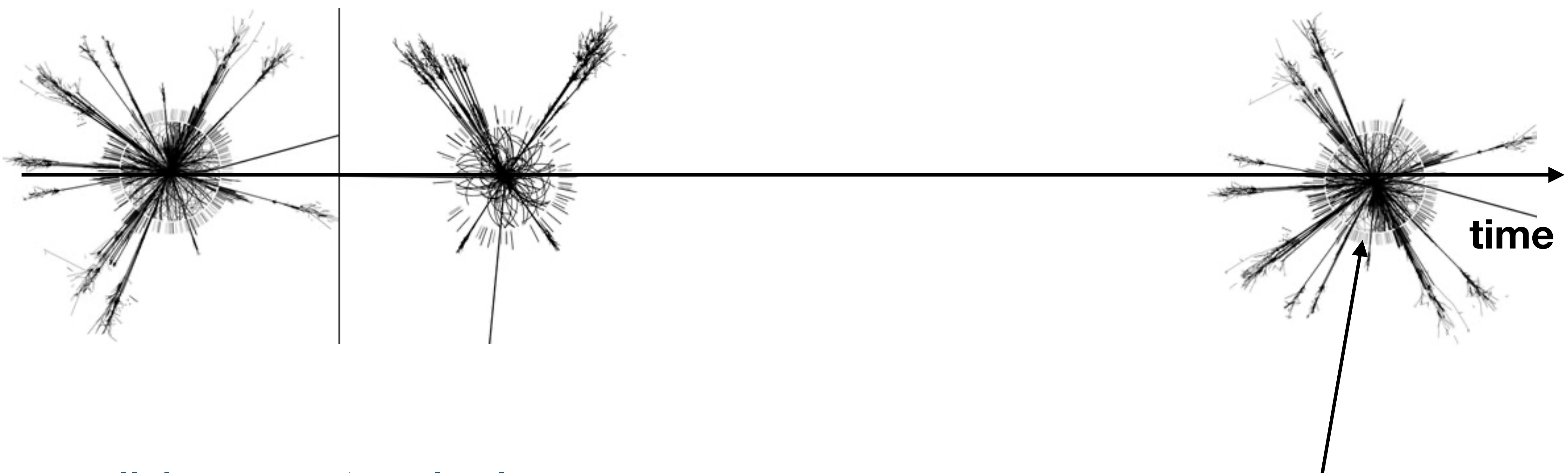
- **Generators "absolute timing", event time window simulation**
- **Intrinsic Time-Window of readout electronic**
- **Voltage vs time signal shape from a "geant4 hit"**
- **Link between geant4 sensitive identifier and electronic crate/slot/channel**
- **Geant4 event-centrism**

CLAS12 Geant4: GEMC: GEant4 Monte-Carlo

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

- **Generator absolute timing, event time window simulation.**

- beam structure: CLAS12: 124K e- in 250ns window in 4 ns bunches
- generator of events on top of that (middle of time window)



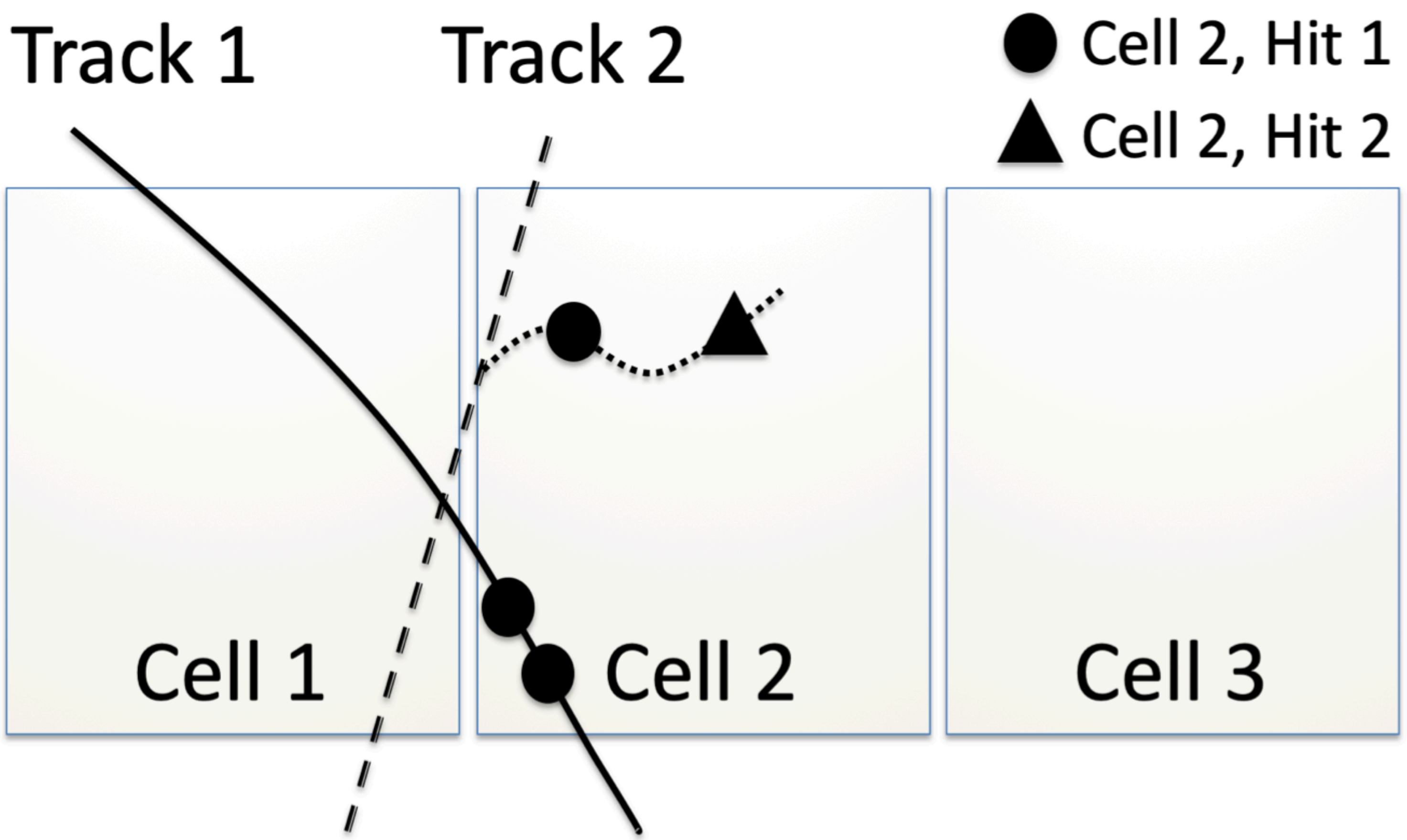
Collaboration / Code sharing opportunity:

- TODO: Library to convert cross section or weight to absolute event time T_e

CLAS12 Geant4: GEMC: GEant4 Monte-Carlo

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

- **Intrinsic Time-Window of readout electronic.**



Geant4 steps are analyzed and grouped based on their timing. This mechanism is used to account for signals pile-up, position of signals in time and more.

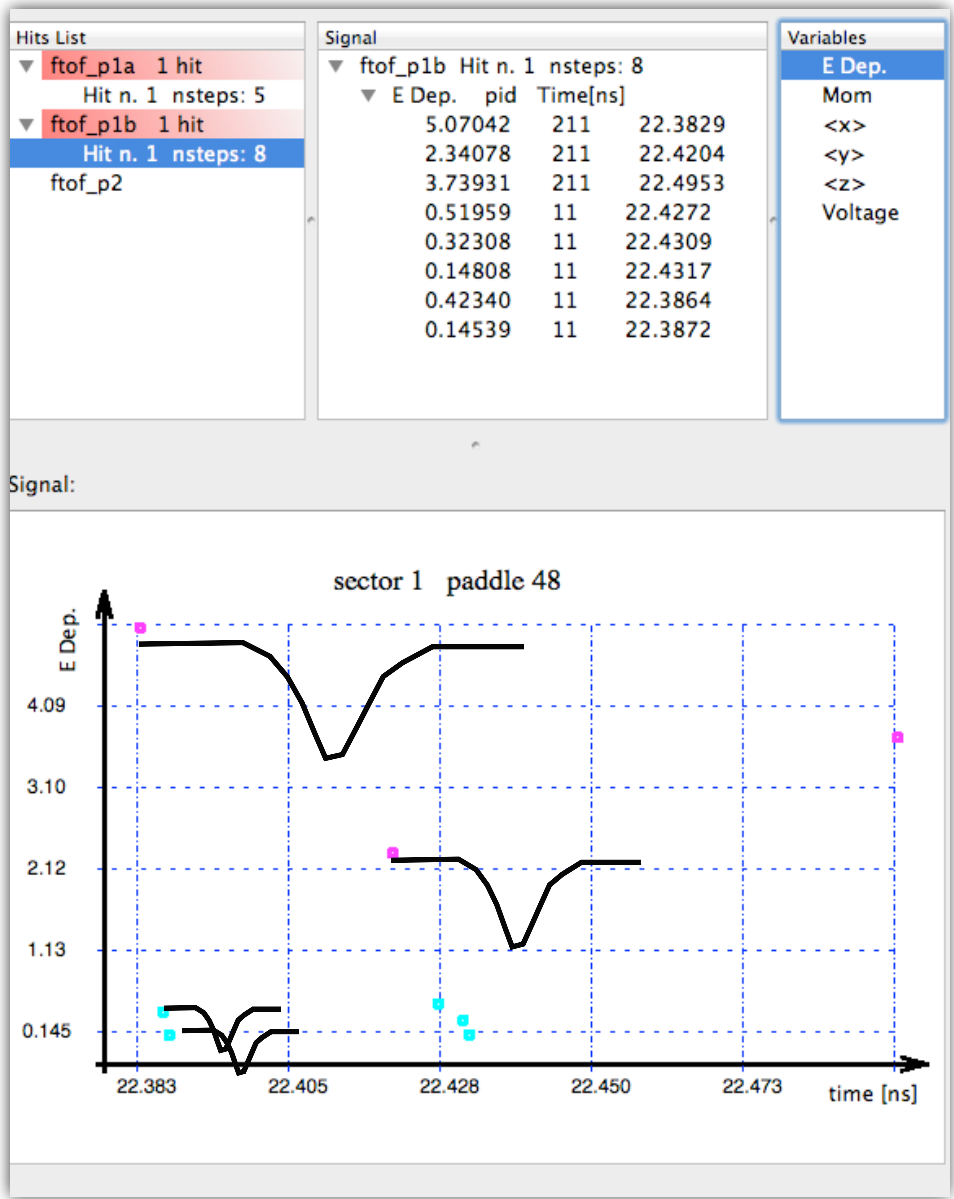
Collaboration / Code sharing opportunity:

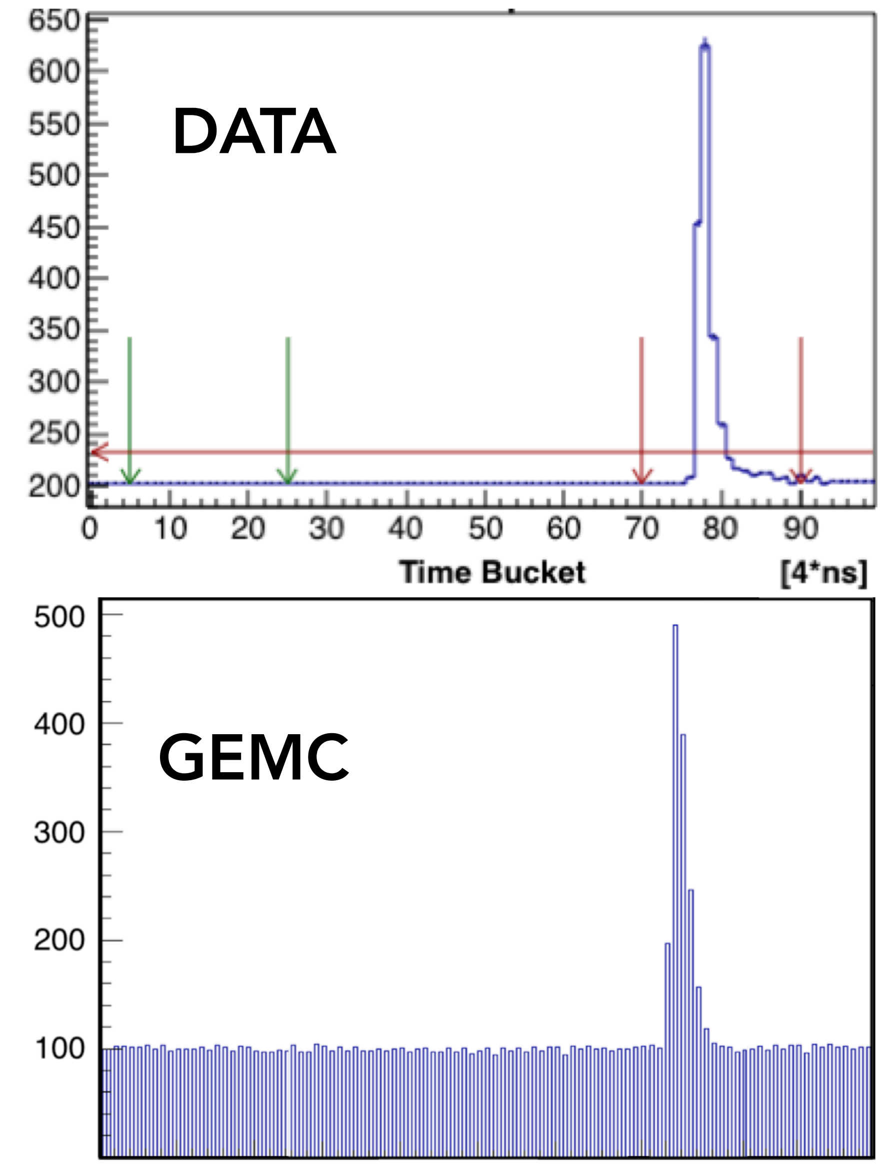
- Existing: “gtouchable” a library that collects Geant4 steps mimicking electronic time-window.

CLAS12 Geant4: GEMC: GEant4 Monte-Carlo

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

- **Voltage vs time signal shape from a "hit"**





Collaboration / Code sharing opportunity:

- Existing but not "general framework": library to convolute g4 steps with user defined function. This is work in progress at JLab.

CLAS12 Geant4: GEMC: GEant4 Monte-Carlo

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

- **Link between geant4 sensitive identifier and electronic crate/slot/channel.**

```
<composite data_type="0xf" tag="57602" padding="0" num="19" length="92" ndata="91">
  <comp>
      <format  data_type="0x3" tag="65" length="6" ndata="1">
         c,i,l,N(c,N(s,i,s,s))
      </format>
      <data  tag="66" num="67">
         <row num="1">
            <uint8 count="1"> 0x04  </uint8>
            <uint32 count="1"> 0x00000001  </uint32>
            <uint64 count="1"> 0x0000000000000001  </uint64>
            <repeat  n="4">
               <paren>
                  <uint8 count="1"> 0x03  </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>
               <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

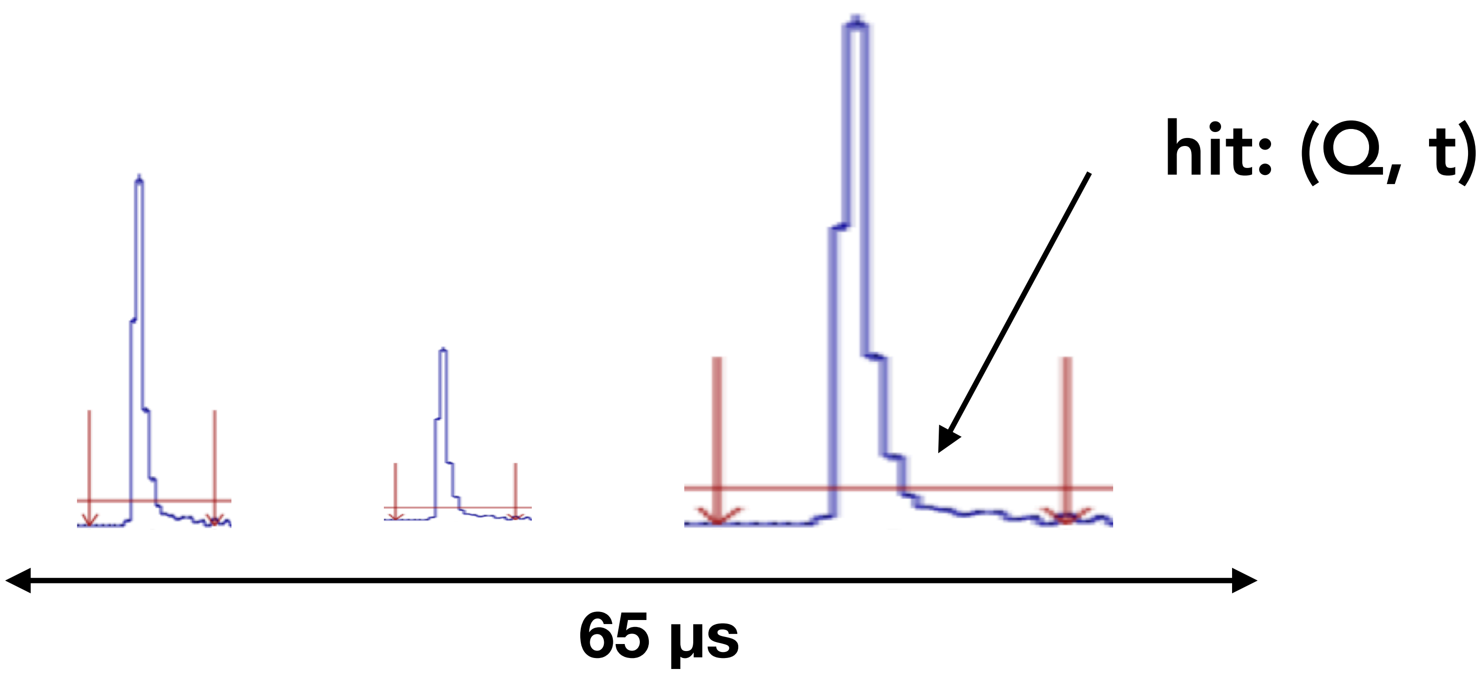
Collaboration / Code sharing opportunity:

- Existing: "translationTable" a library that links vector<int> (geant4 sensitive ID) to crate/slot/channel.

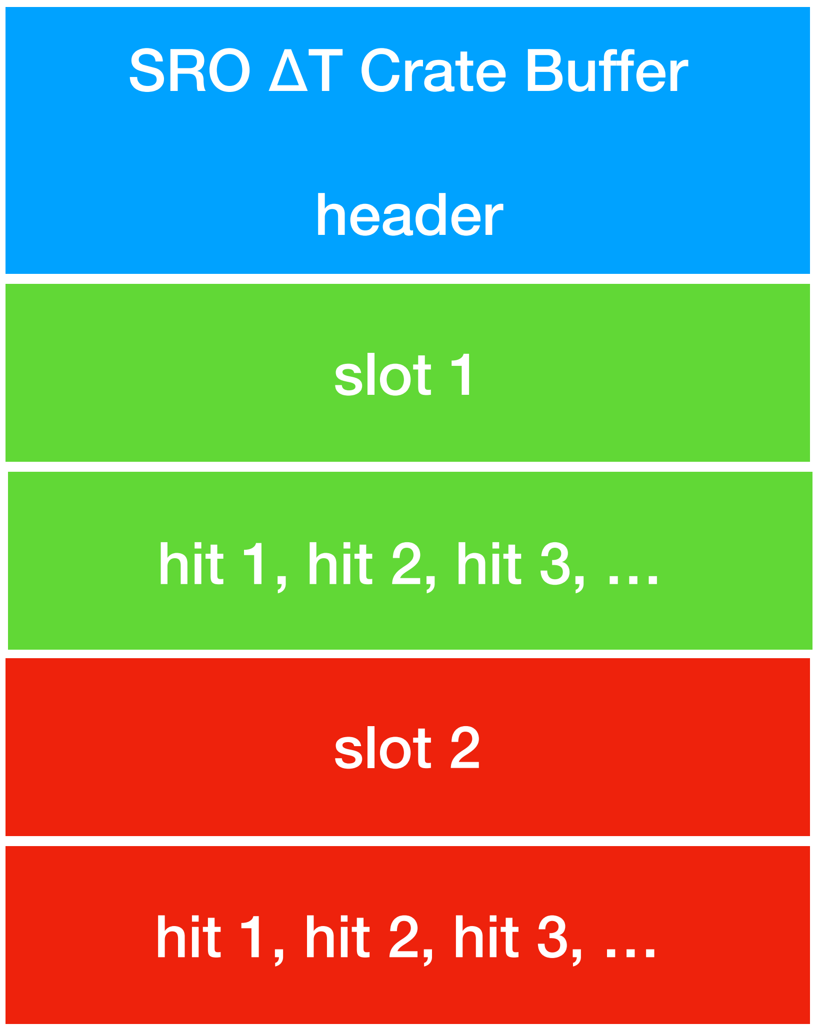
Simulations Streaming Readout

Getting around event-centrism: streaming buffers of data

- use high level buffer structure, filled from event**s** digitization
- buffer integration time ΔT variable, typically 10s of μs, collects several geant4 events



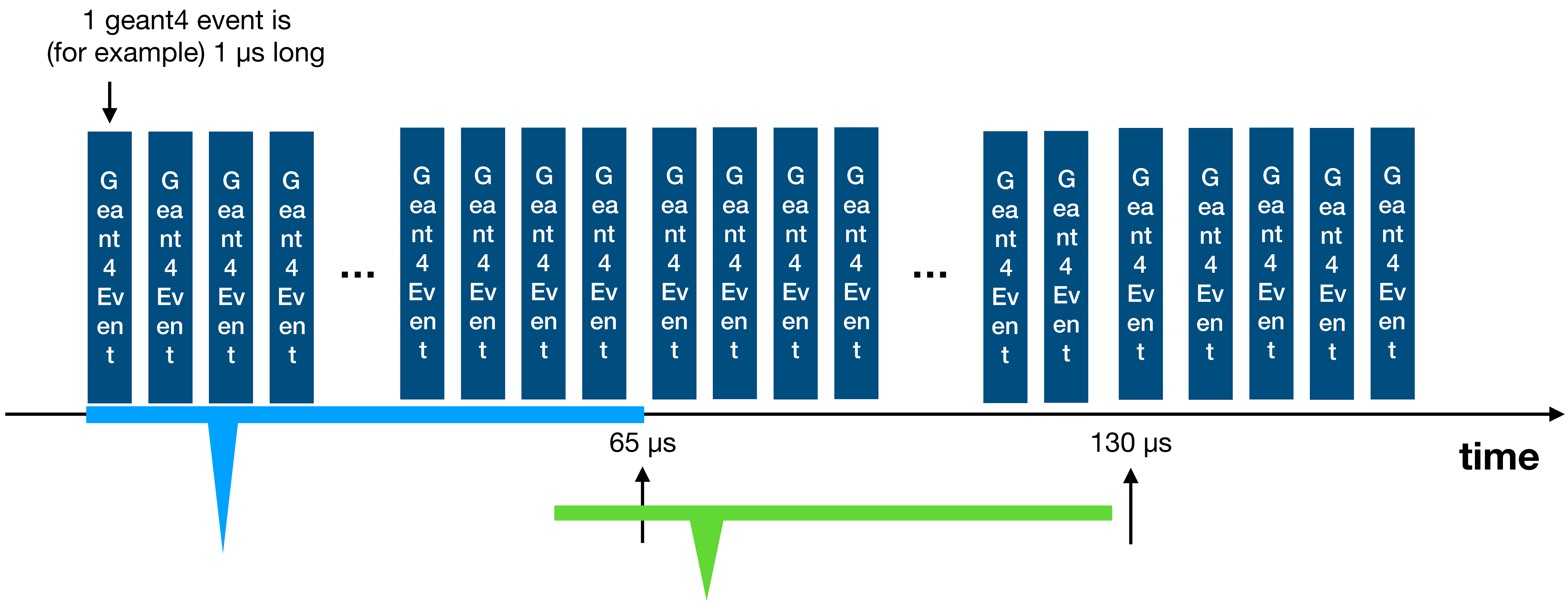
each 1 MHz data / crate yields a buffer of 65 hits

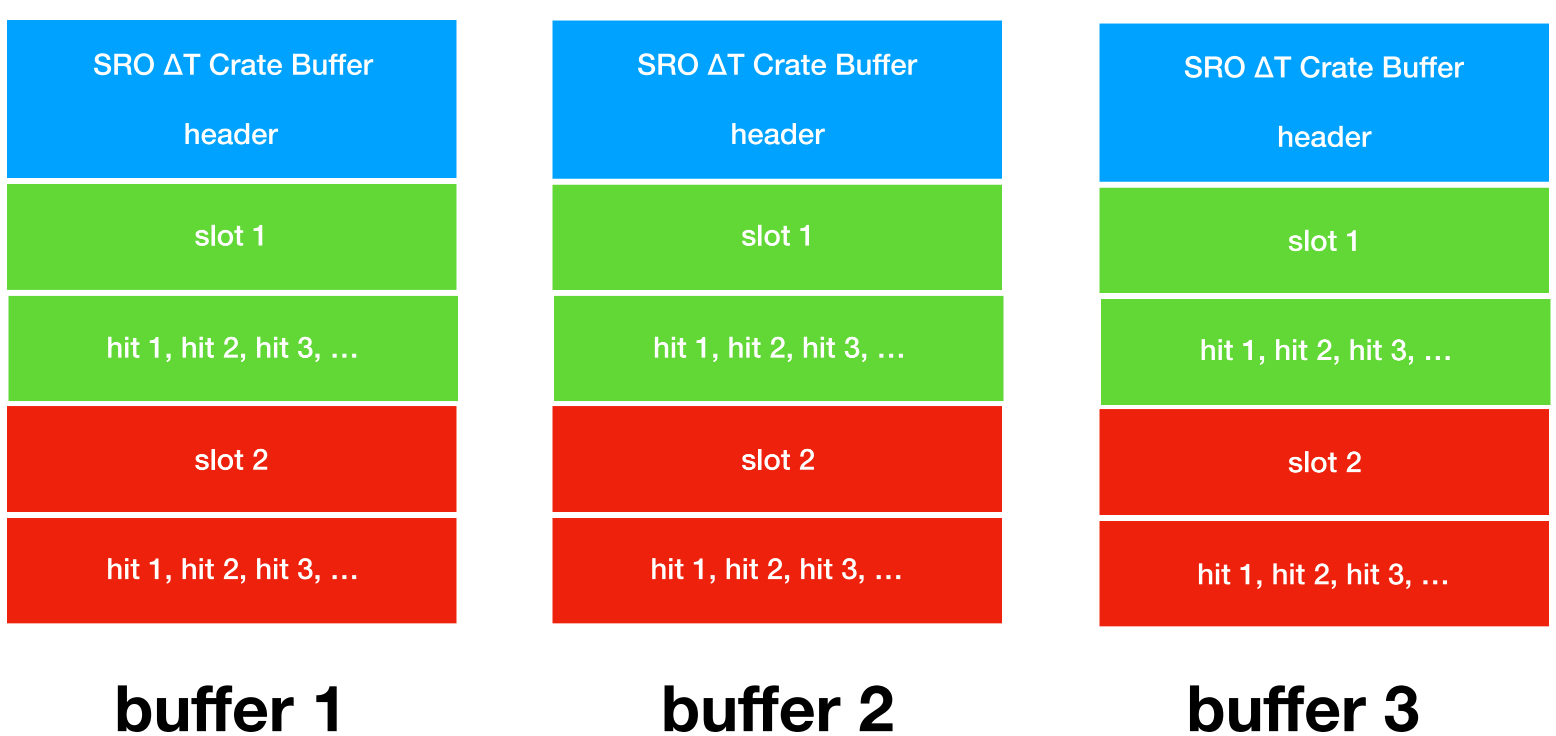


Crate Buffer Structure

Simulations Streaming Readout

getting around event-centrism





- Hits from a geant4 event can end on different buffers (propagation time, etc)
- Pile-ups are intrinsic in this scenario

Simulation Streaming Readout: a HL Buffer

Collaboration / Code sharing opportunity:

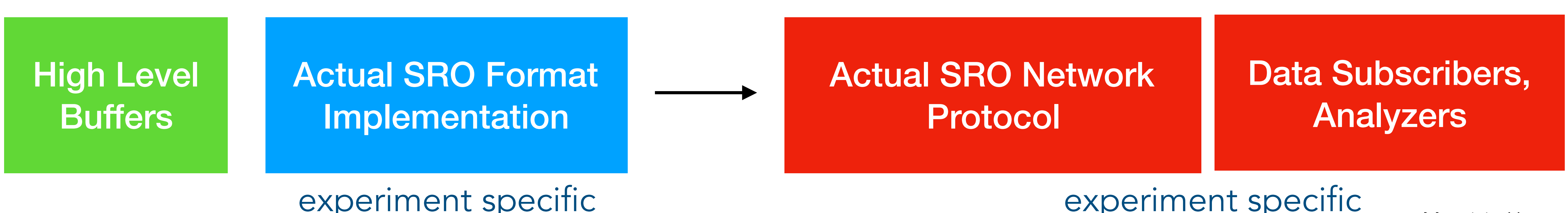
Design a define a “high level” buffer structure / protocol

- 1 Buffer / Crate
- 1 Buffer / Board

The buffers contains channels (absolute) time-ordered (either or):

- Wave packets raw data
- Integrated values (for example, mode 7 FADC)

The buffers include the physics / electronic noise, either geant4 produced or merged from actual data.



Summary: Streaming Readout plans at JLAB:

Short term

- Design and implement high level buffers. Collaboration / synergy highly desirable.
- Use a simple, existing detector geometry and demo buffer stream feasibility by replacing a real small detector source with simulation.

Long term

- Add multiples crates, simultaneous buffers streams. One buffer = 1 file on disk = 1 network stream.
- Support CLAS12 and EIC SRO efforts (actual buffer formats)
- Explore ML to speed up detector response
- Address details such as buffer timing in respect to signal shapes

- Simulate challenges of large scale detectors:

  ➡ buffer synchronizations issues
  ➡ network glitches
  ➡ large amount of data
  ➡ crate malfunctions

Always:

Explore collaboration / learn from / synergies with ongoing / mature efforts (see Jin Huang talk)