GEMC for Streaming ReadOut

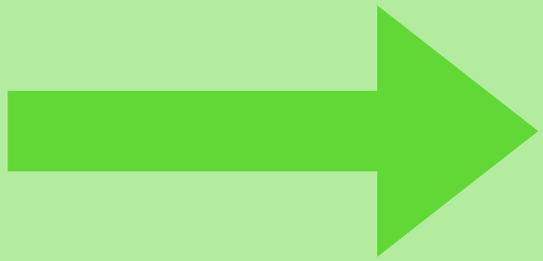
Plan Highlights:
from generated events to stream of data

Streaming Simulations Scope

Data Source - Data Streaming

Continuous DATA Streams

10/40GbE



Data Subscribers, Analyzers

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

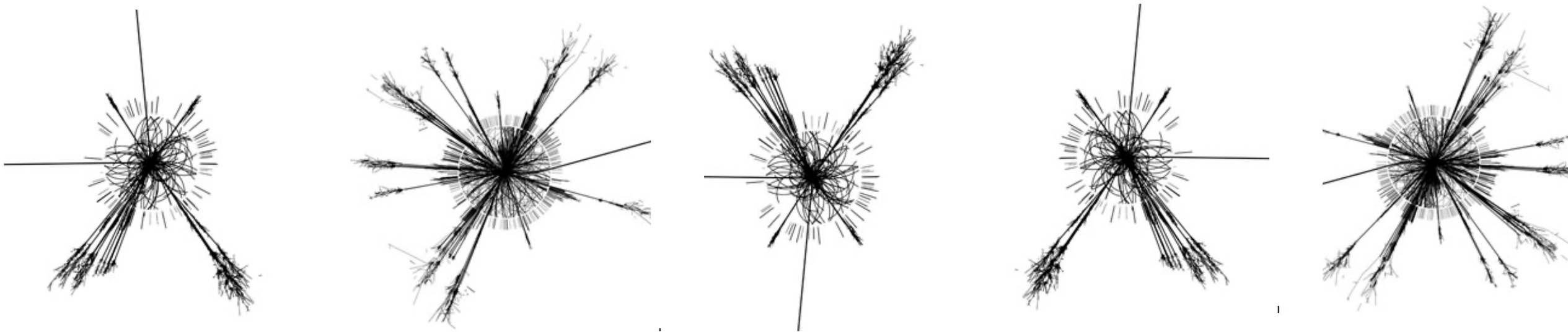
Streaming protocols / analysis systems should be transparent to the data source: experiment or simulation

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

Streaming Simulations Plan Highlights

- Event generators “streams”
- Working with Geant4 event blocks
- Streaming Readout Units
  - Voltage vs time signal shape from a “geant4 hit”
  - Sensitive identifier to crate/slot/channel
  - High level data format

Event generators “streams”: from here



10 11 12 13 14

Event Number

event header
list of particles
vertices
4-momenta
status

Event generators “streams”: to here

We want this w/o necessarily changing the event generators

Event generators “streams”: converter code

Input: Generated events that include cross section
Output: events with absolute times tags t_i

10.21 ns **54.82 ns** **135.23 ns**

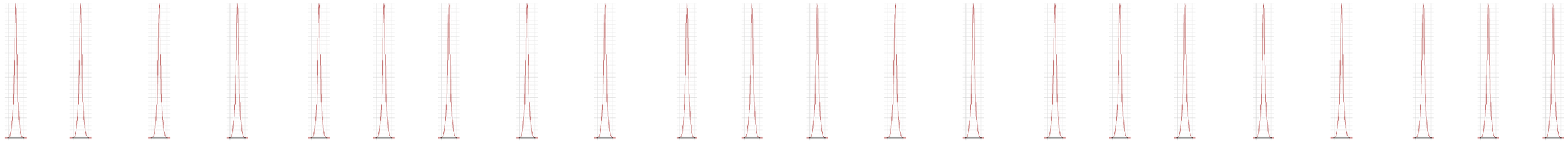
absolute time

event header
list of particles
vertices
4-momenta
status

Event generators “streams”: endgame

Input: Generated events that include cross section
Output: events at absolute times t_i

10.21 ns **54.82 ns** **135.23 ns**

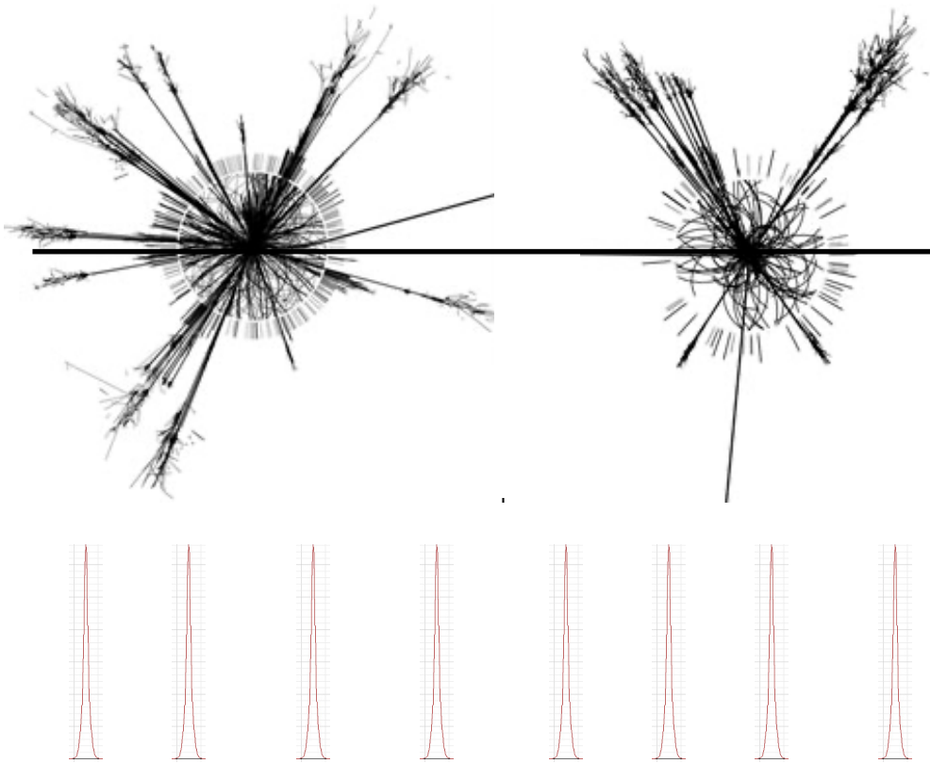


Bunched Beam on Target

absolute time

Streaming Geant4 Simulations Scope

generator: events are at absolute times t_i



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

time

Geant4, Digitization

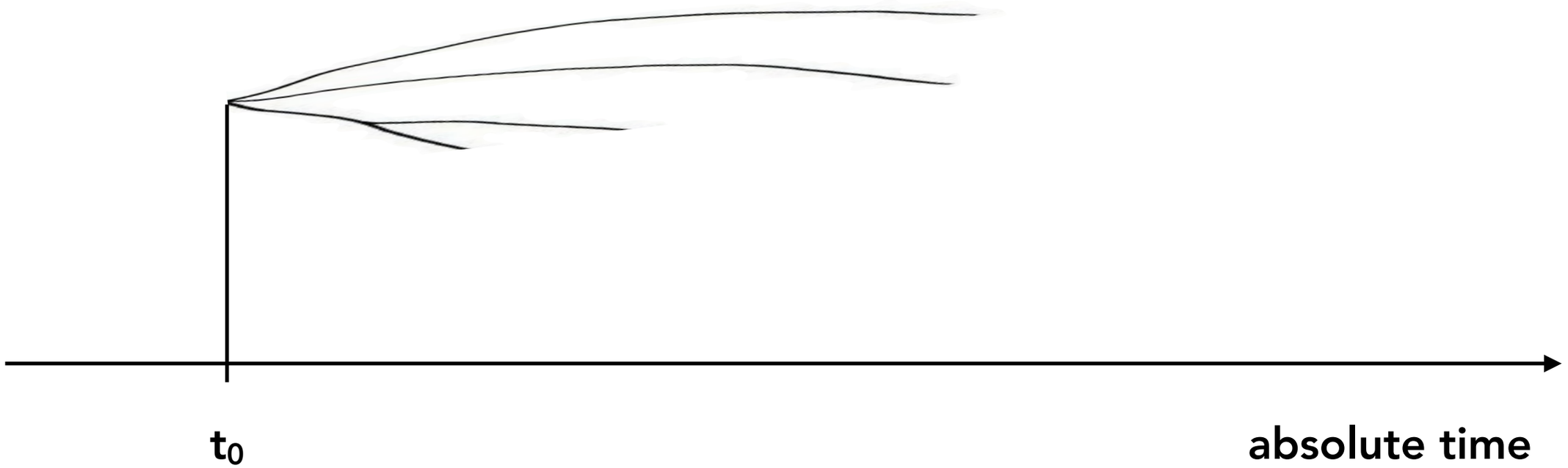
No concept of "event"

Data Streams

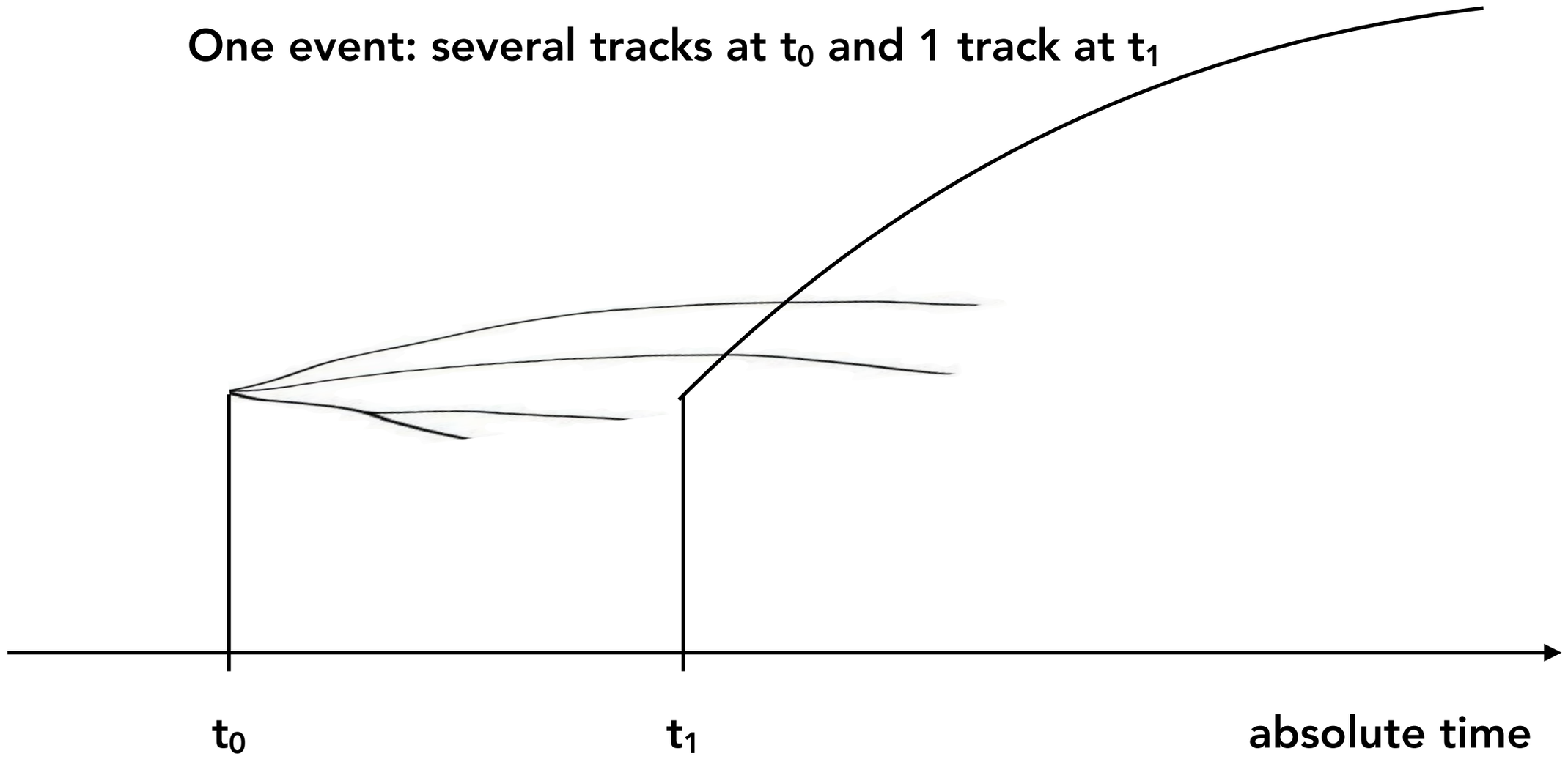
Simulated data that mimics continuous data streams

Event Time Dimension in Geant4 (GEMC)

One event: several tracks at t_0



Event Time Dimension in Geant4 (GEMC)



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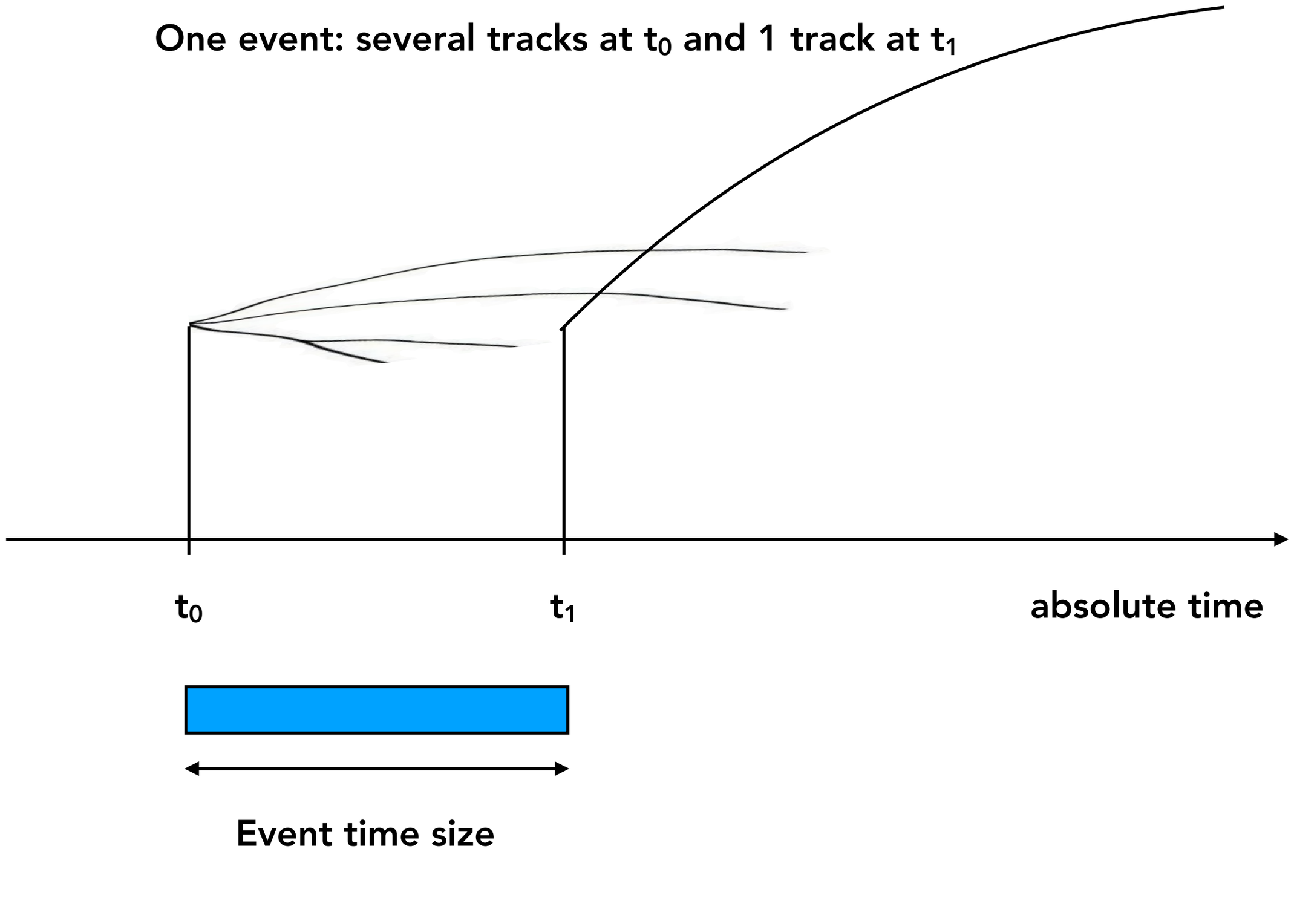

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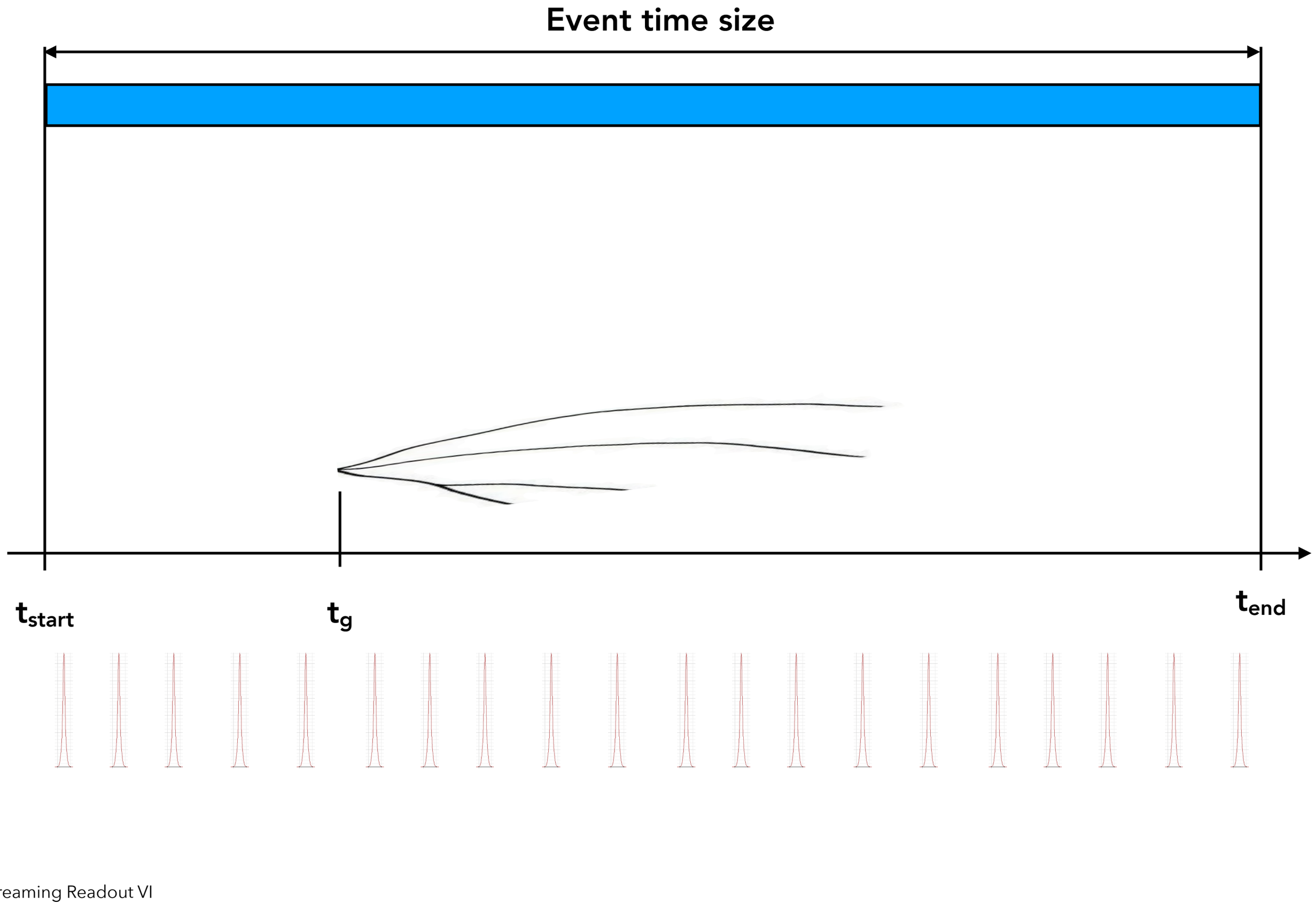

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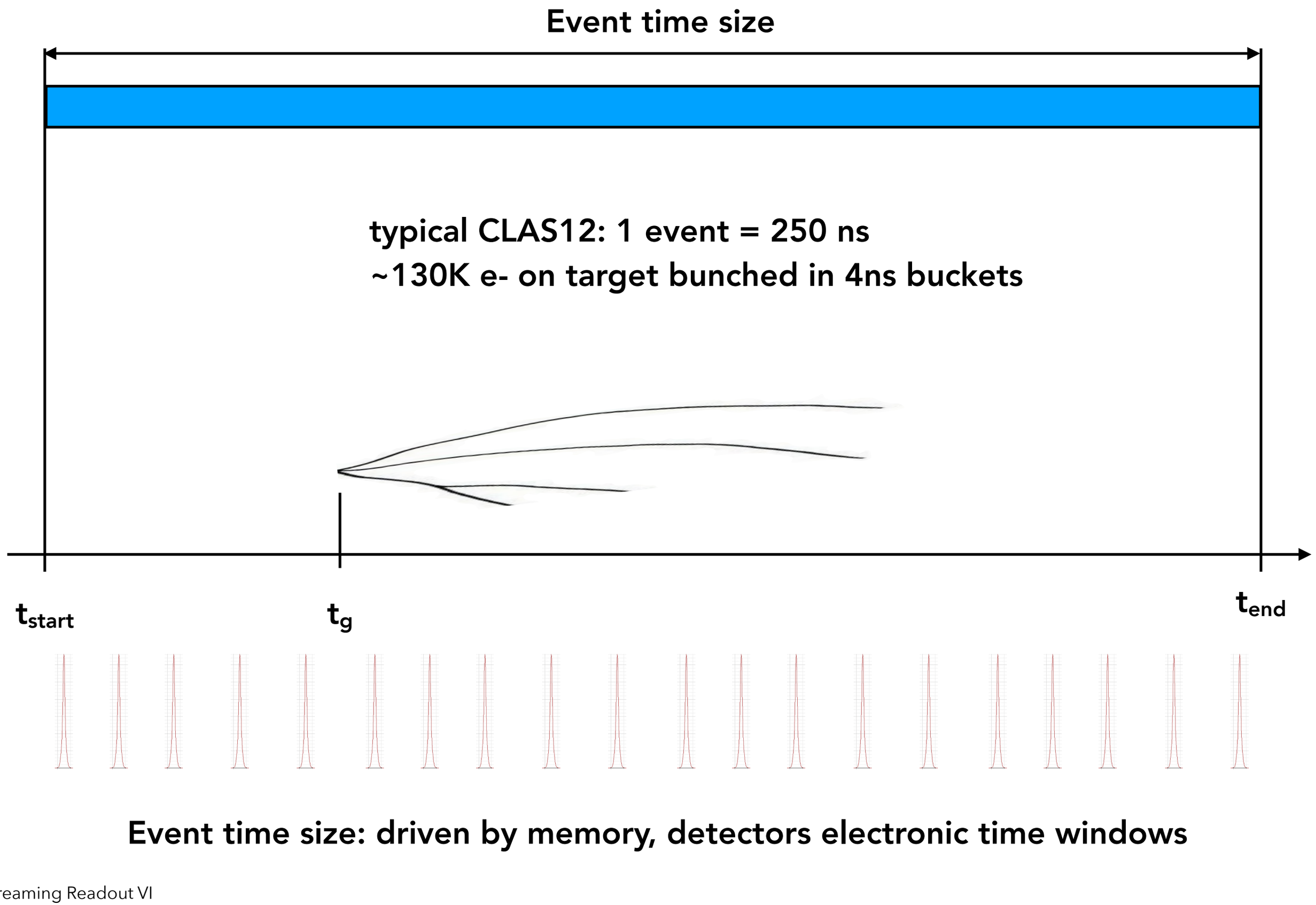
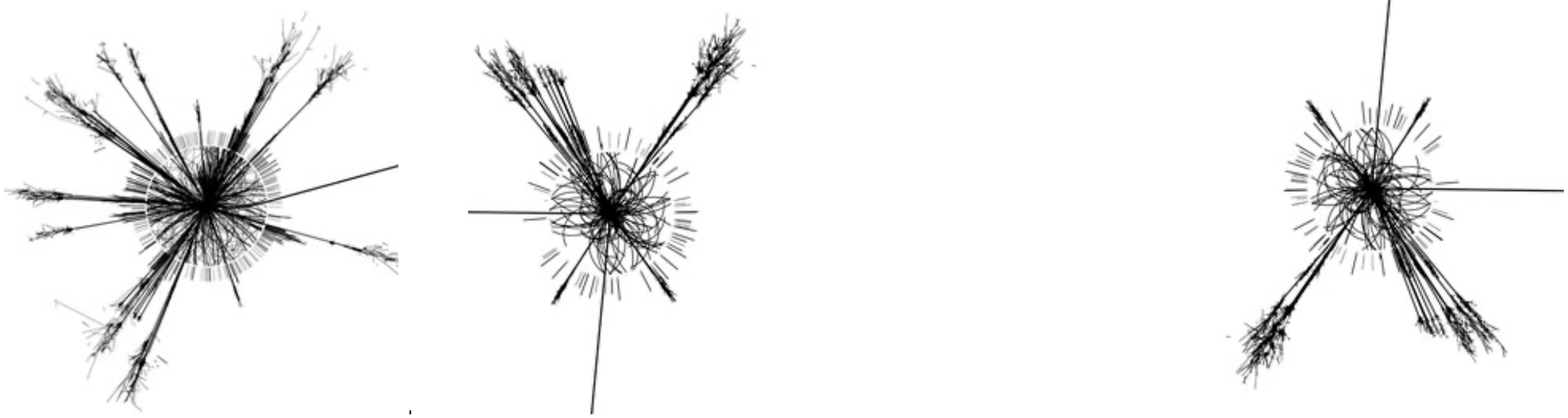
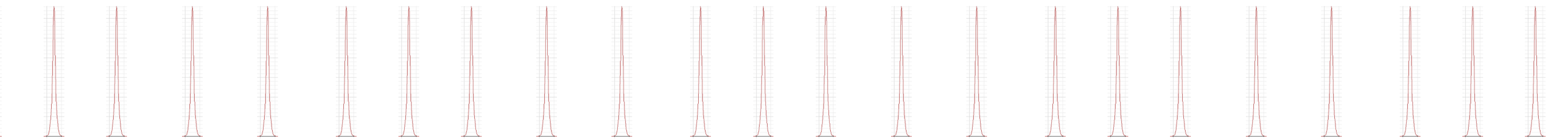
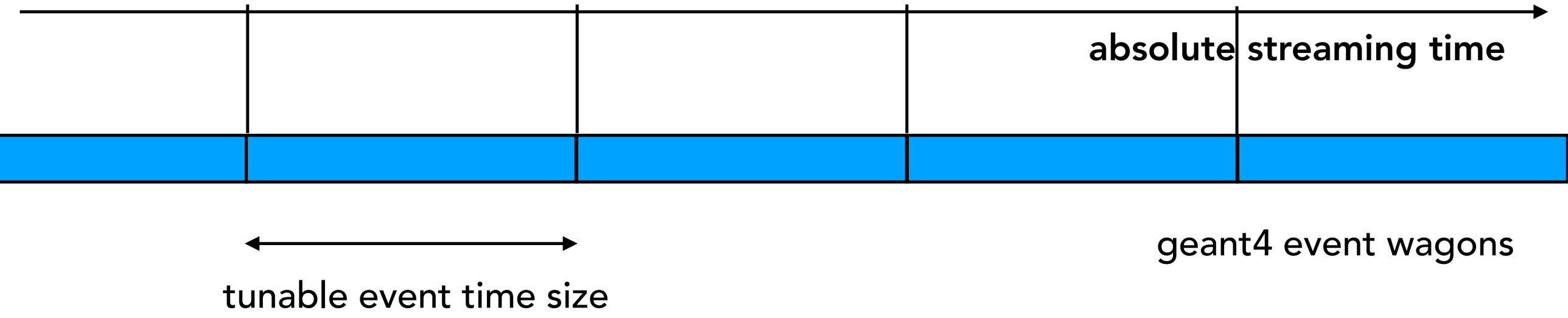


Event time size: driven by memory, detectors electronic time windows

Injecting Event generators “streams” in Geant4







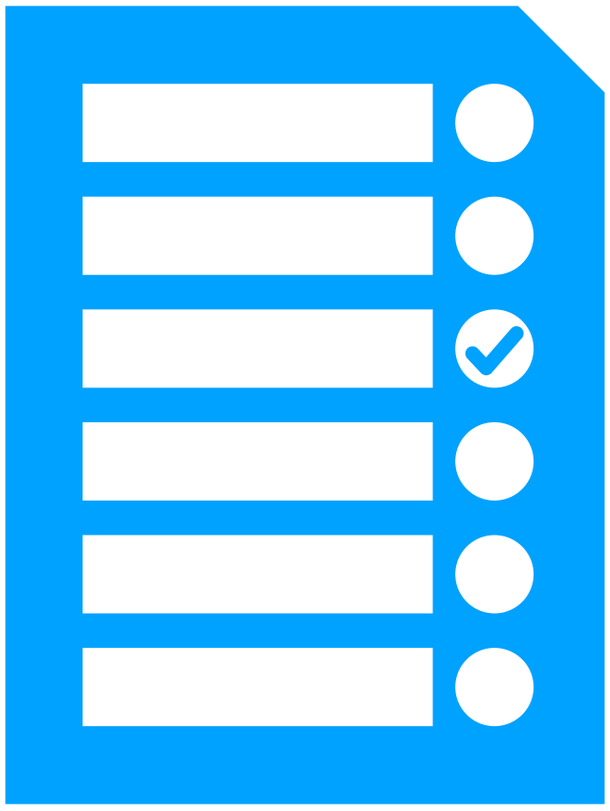
Natural mapping between absolute stream time and event number

Streaming Readout Unit (SRU)

Single detector electronic unit that organize hits, streams data

- Each SRU writes its stream to a file
- Each stream (file) to be broadcasted to the network

electronic address:
crate / slot / channel



FADC: one board or
one crate TP
DC Readout Board
VSCM
etc

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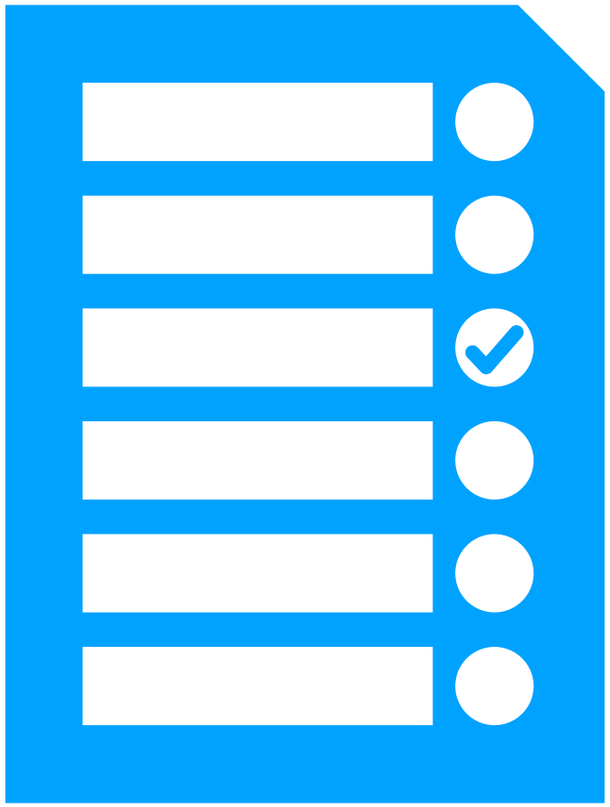

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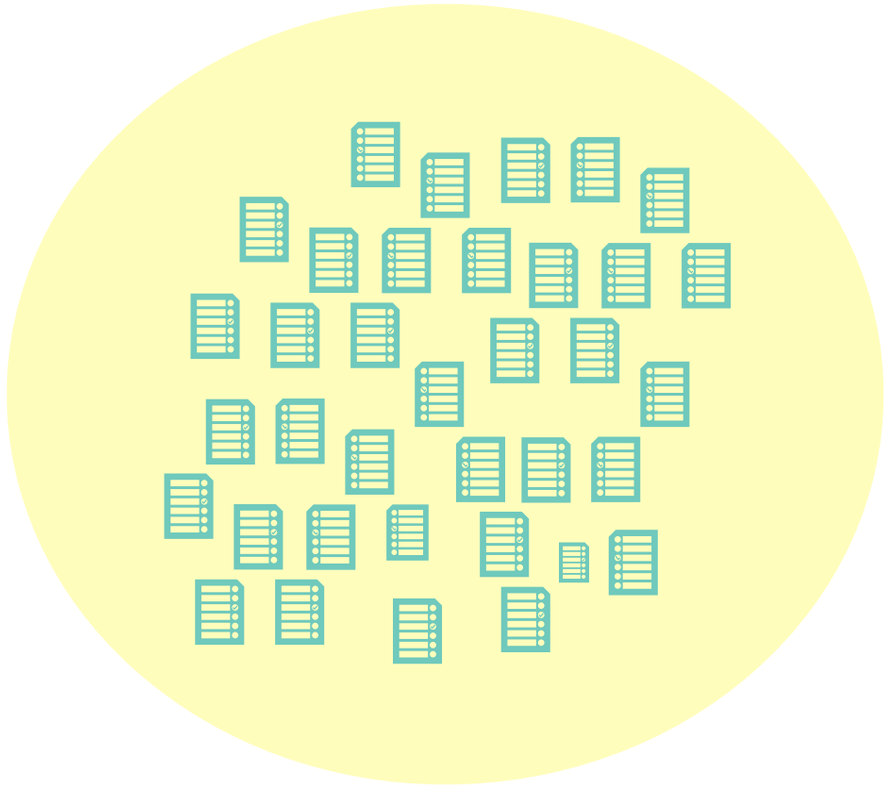


Continuous DATA Stream

Data Subscribers, Analyzers

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

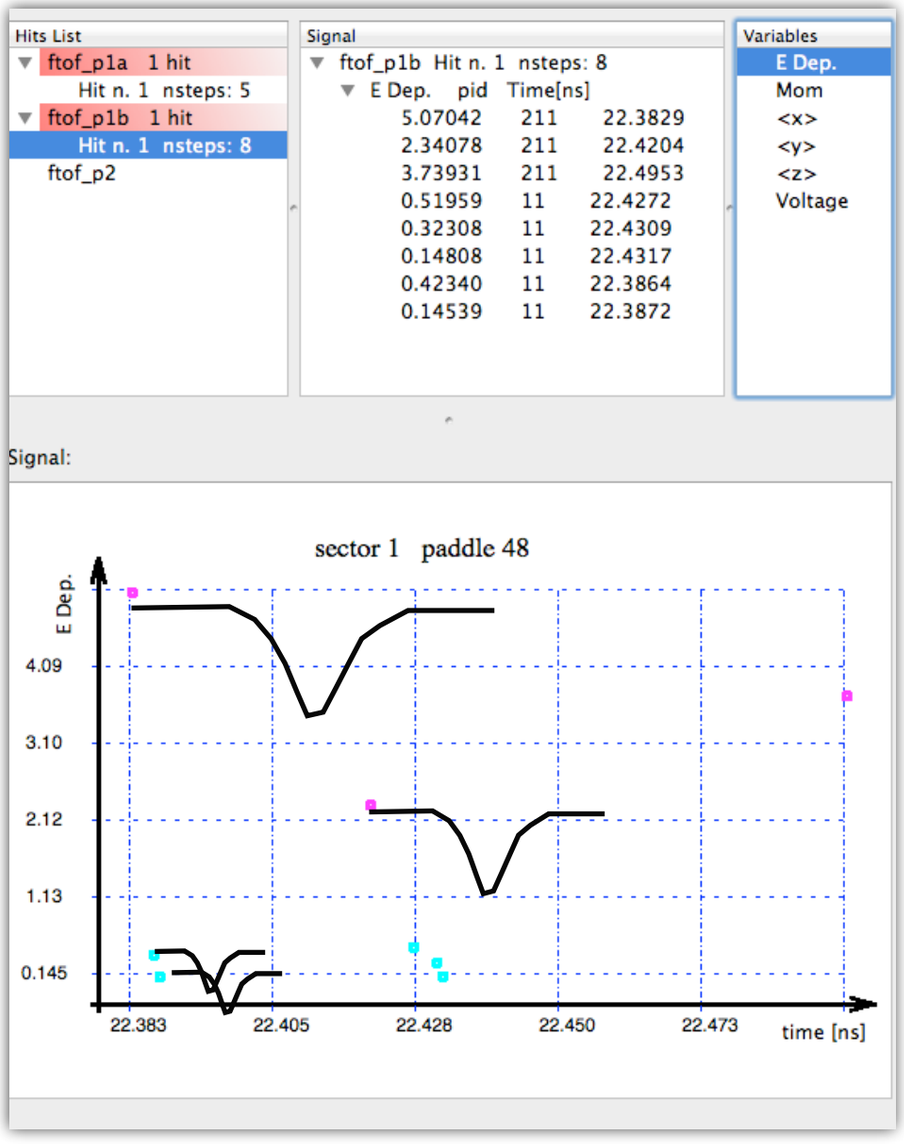
Collaboration / Code sharing opportunity:

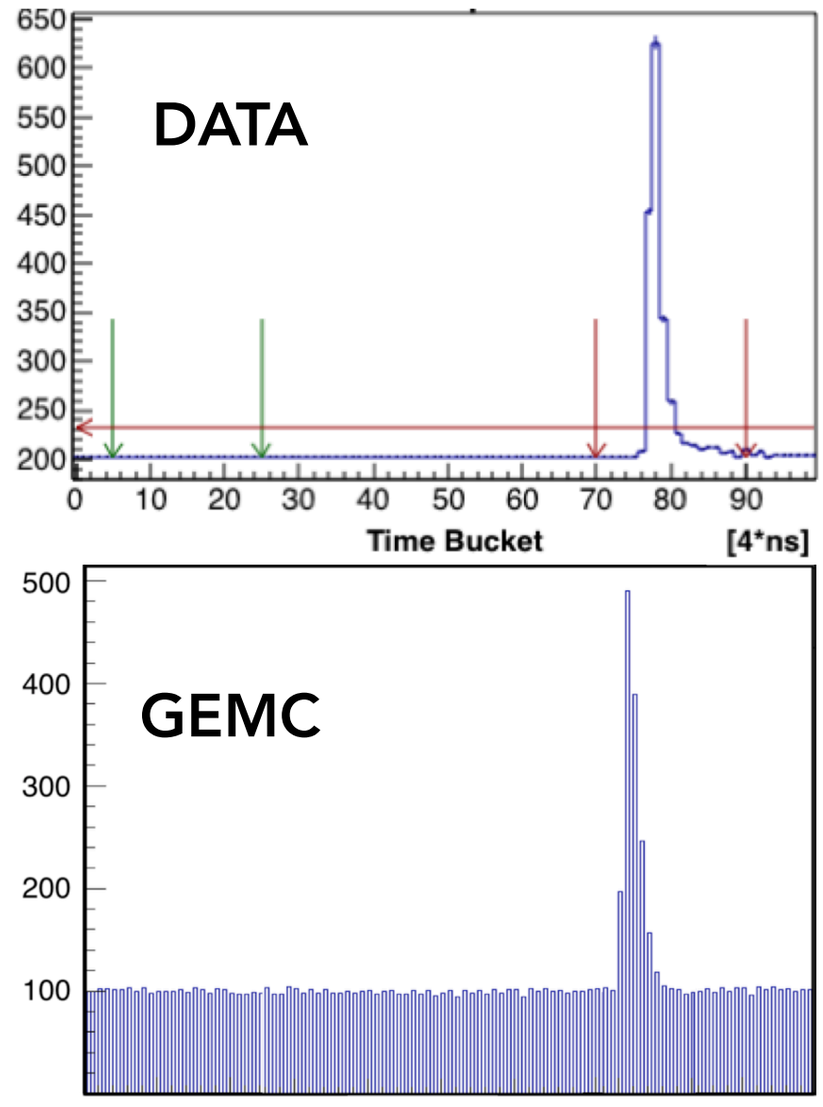
- Existing: “translationTable” library that links vector<int> (Geant4 sensitive ID) to crate/slot/channel.

CLAS12 Geant4: GEMC: GEant4 Monte-Carlo

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

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

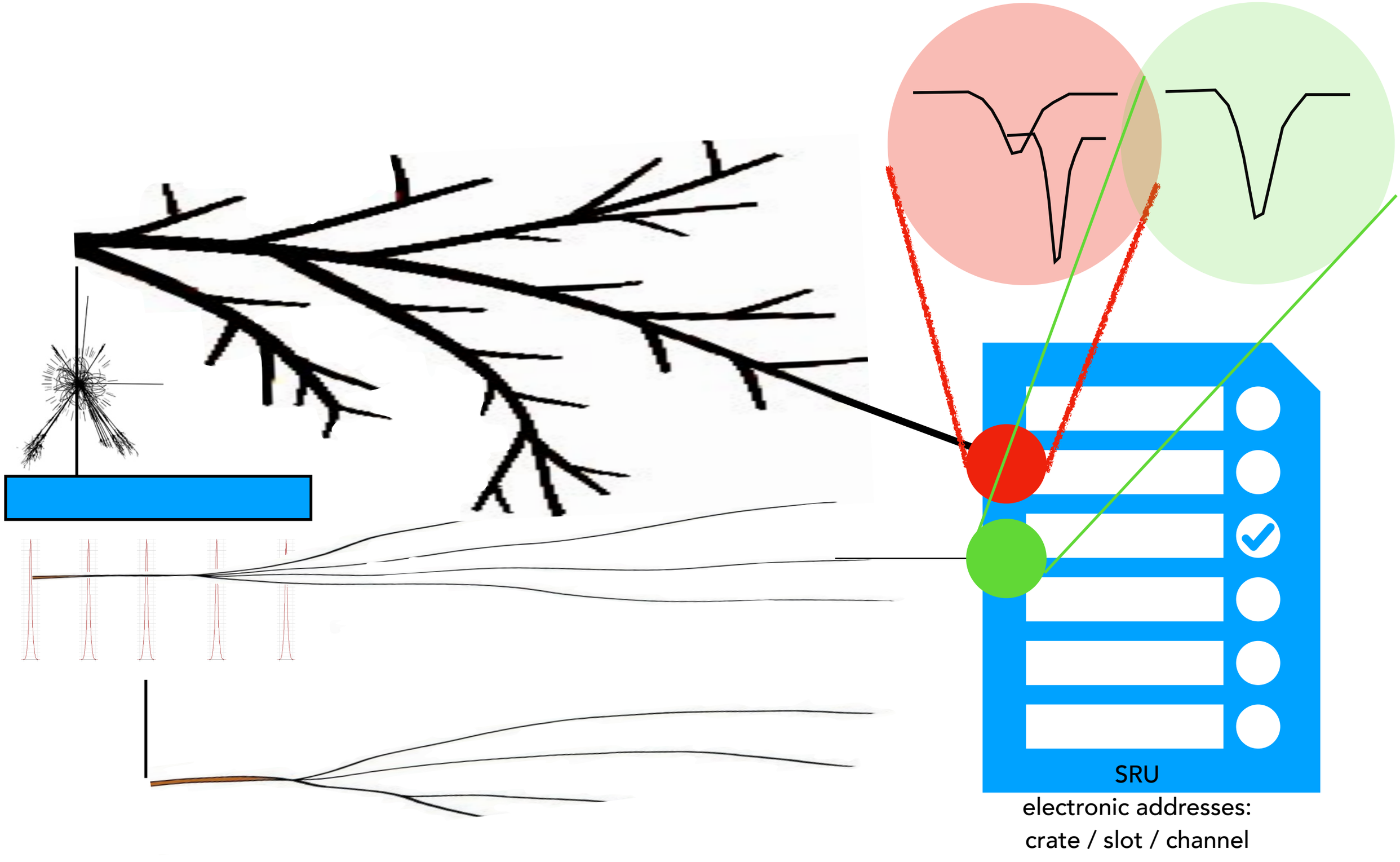




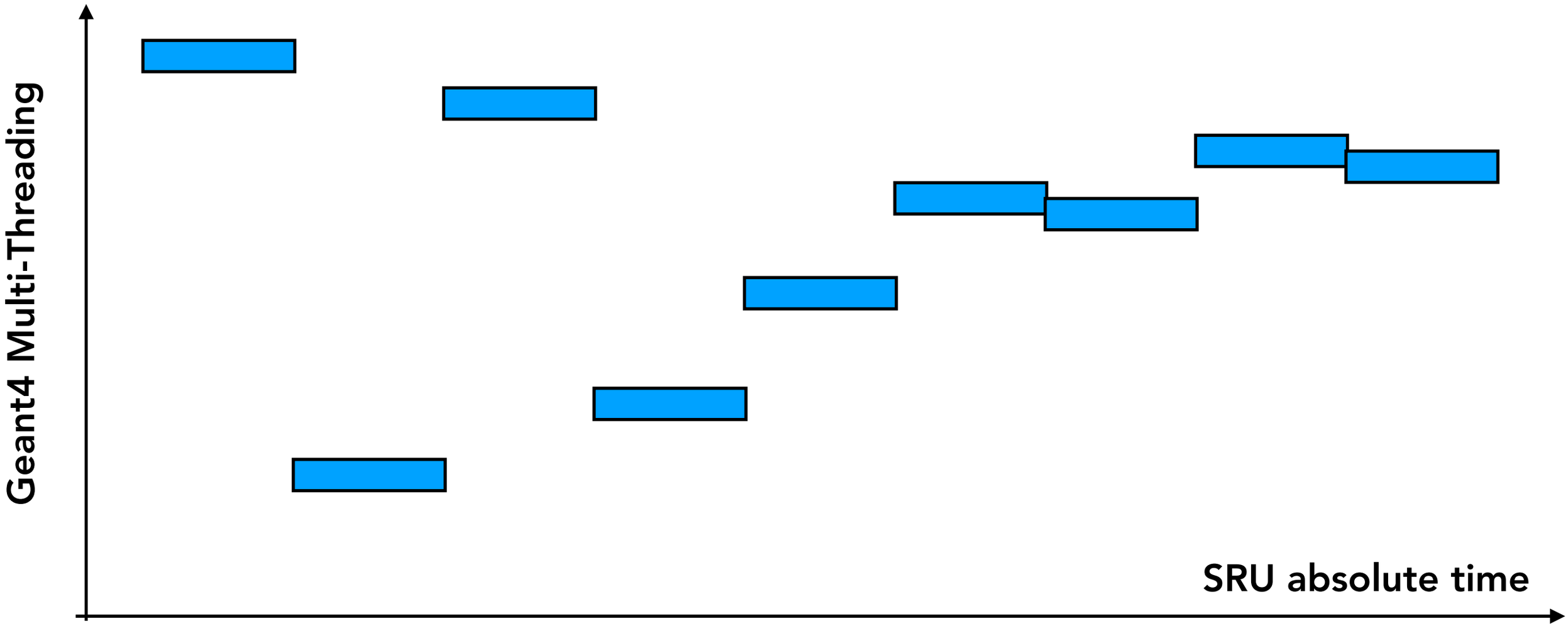
Collaboration / Code sharing opportunity:

- work in progress at JLab: library to convolute g4 steps with user defined function.

one event: Geant4 transportation + V(t) digitization



geant4 events as “times” goes by



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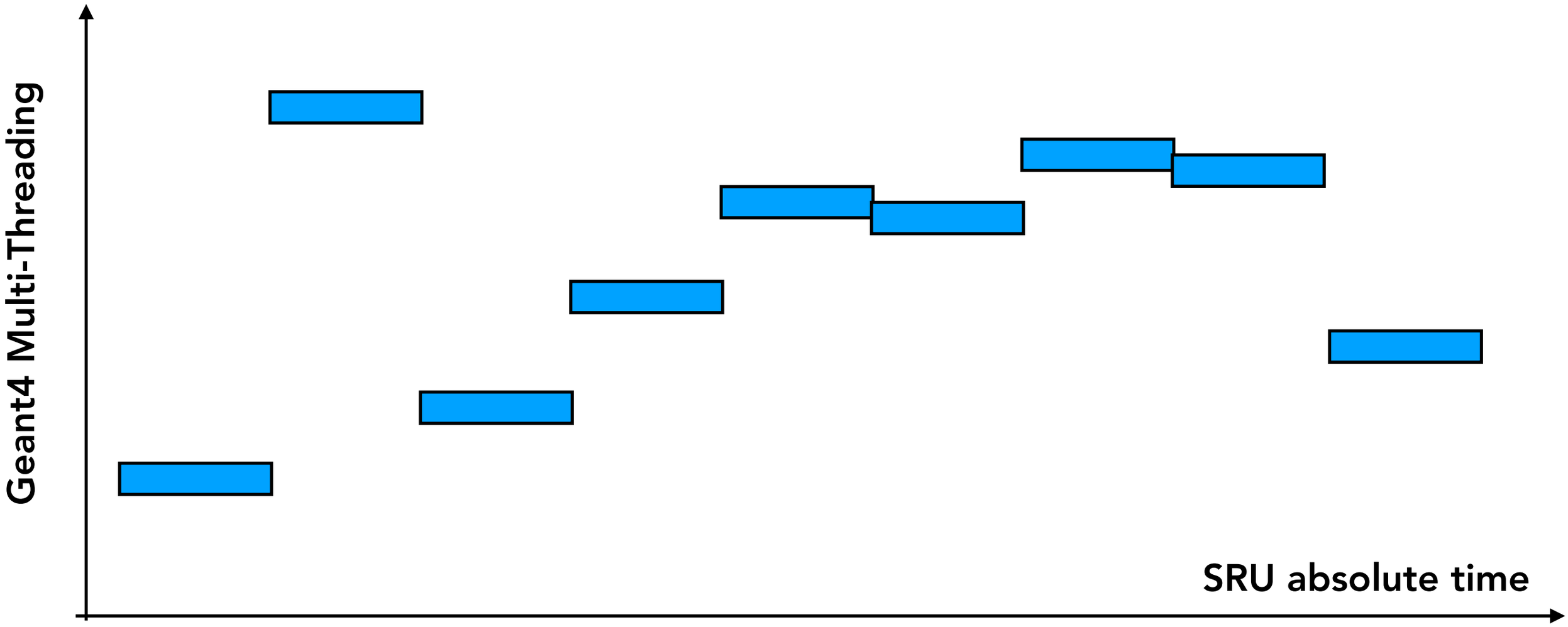

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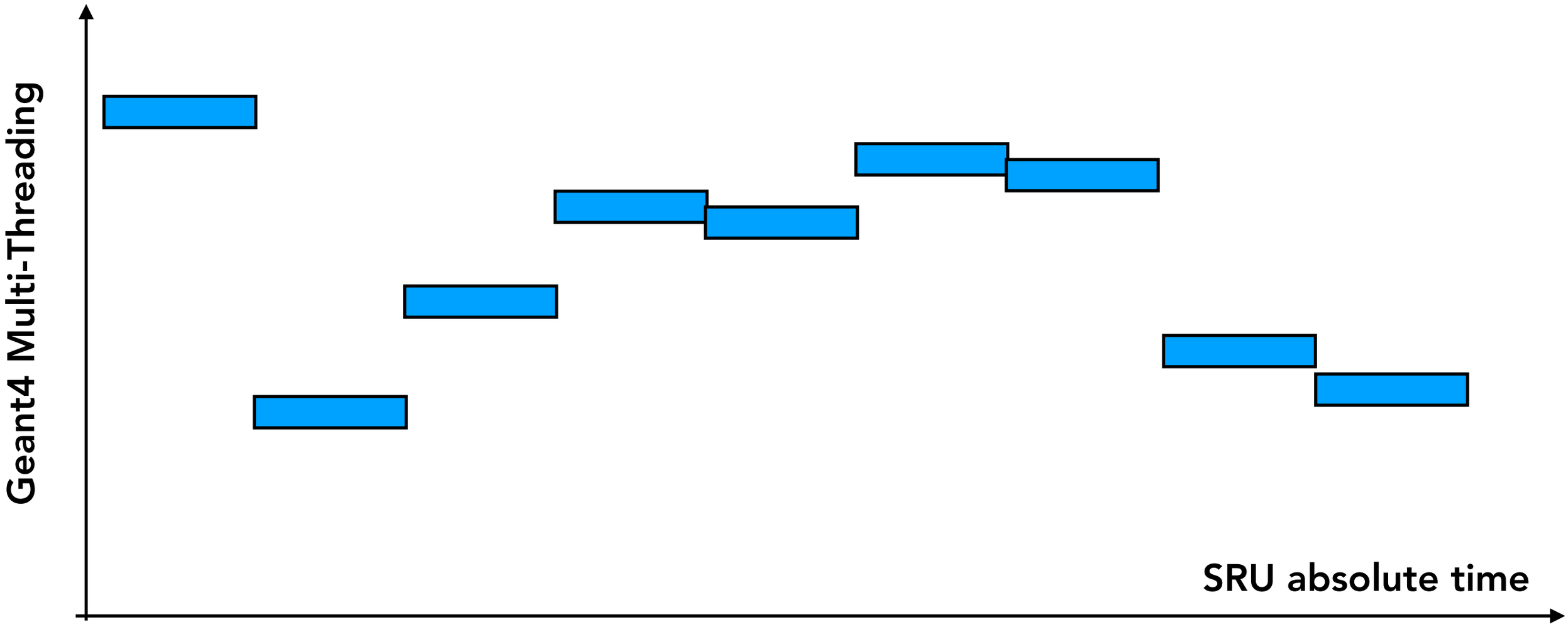
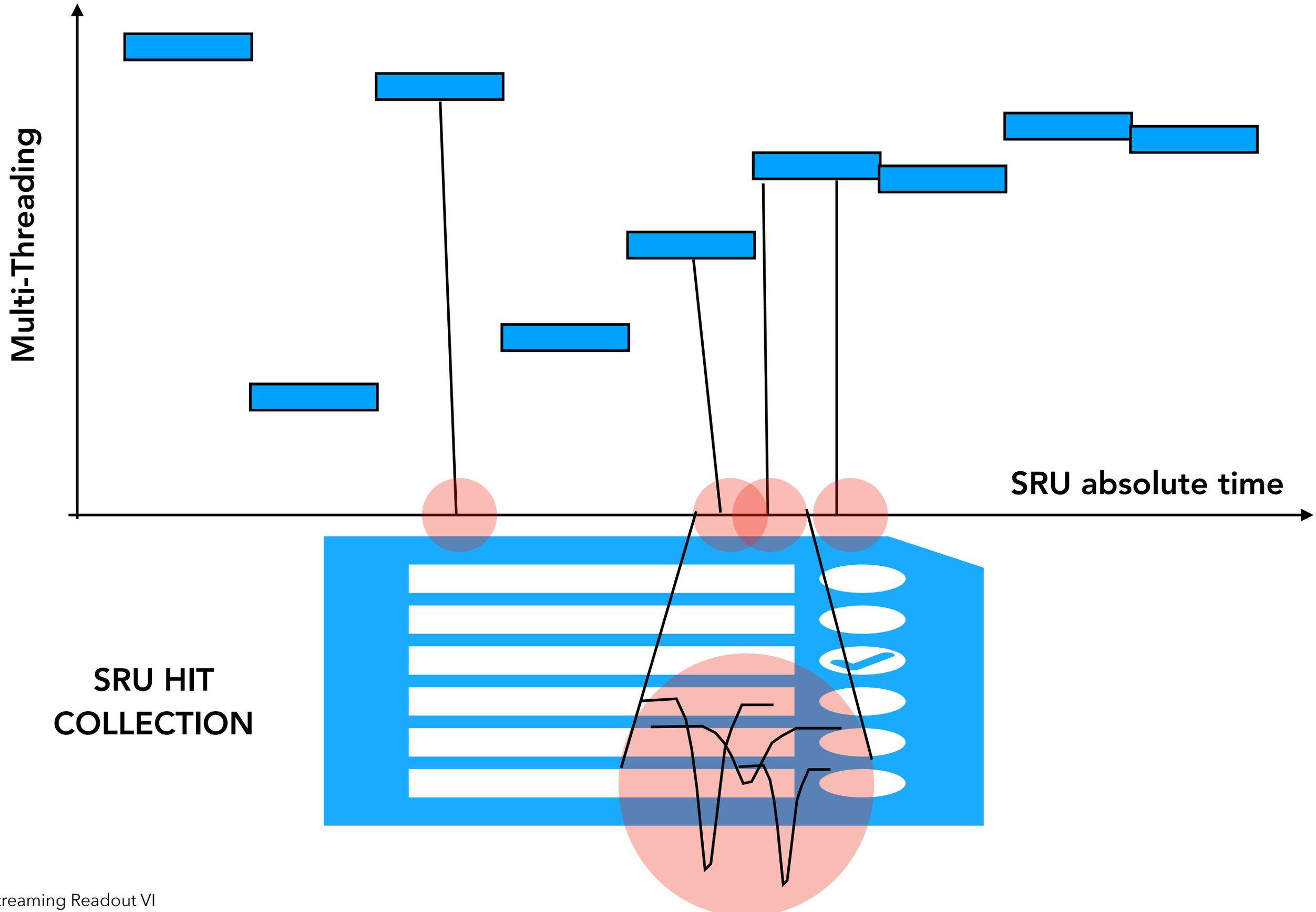


1 SRU hit collection: Geant4 transportation + V(t) digitization



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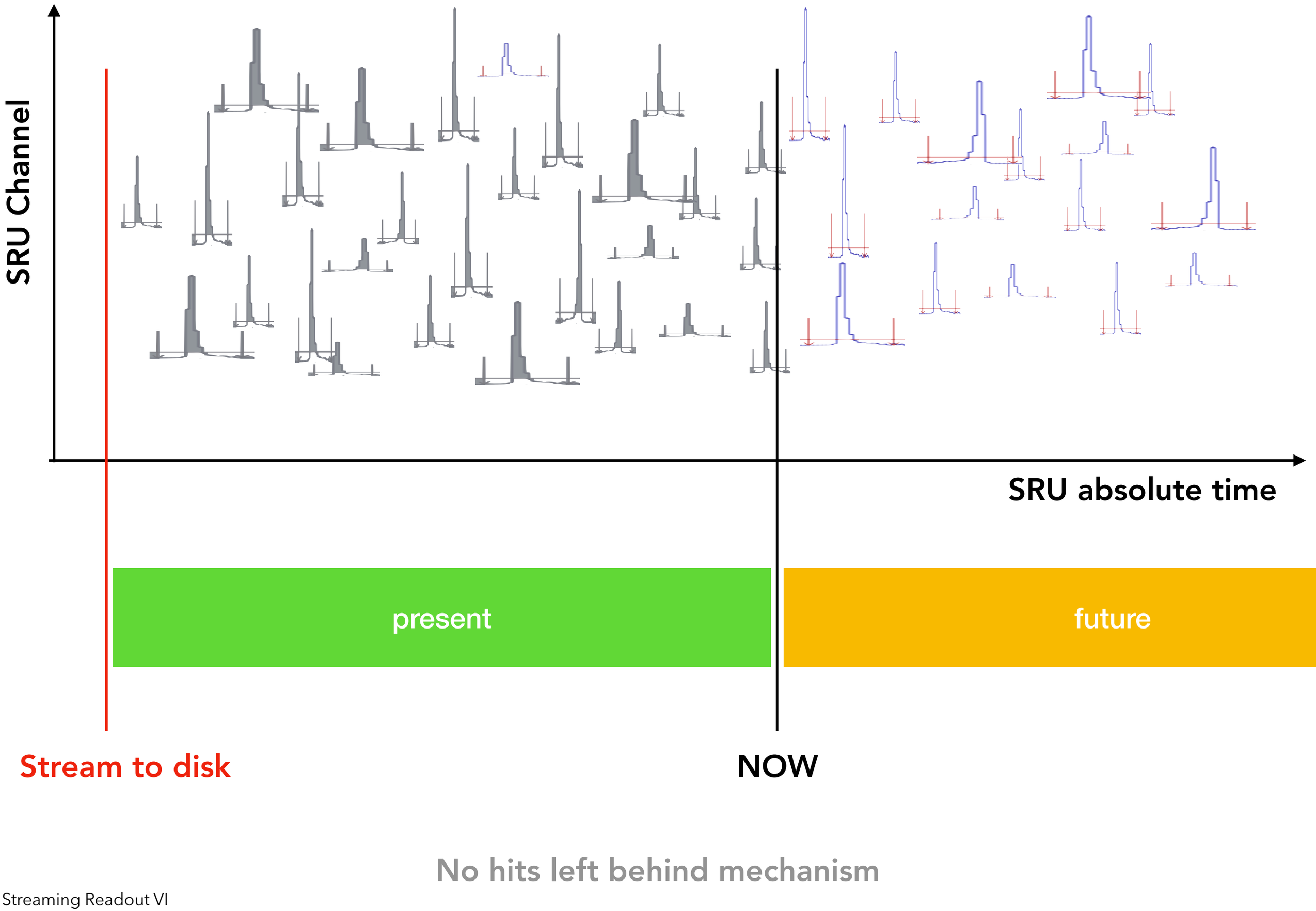
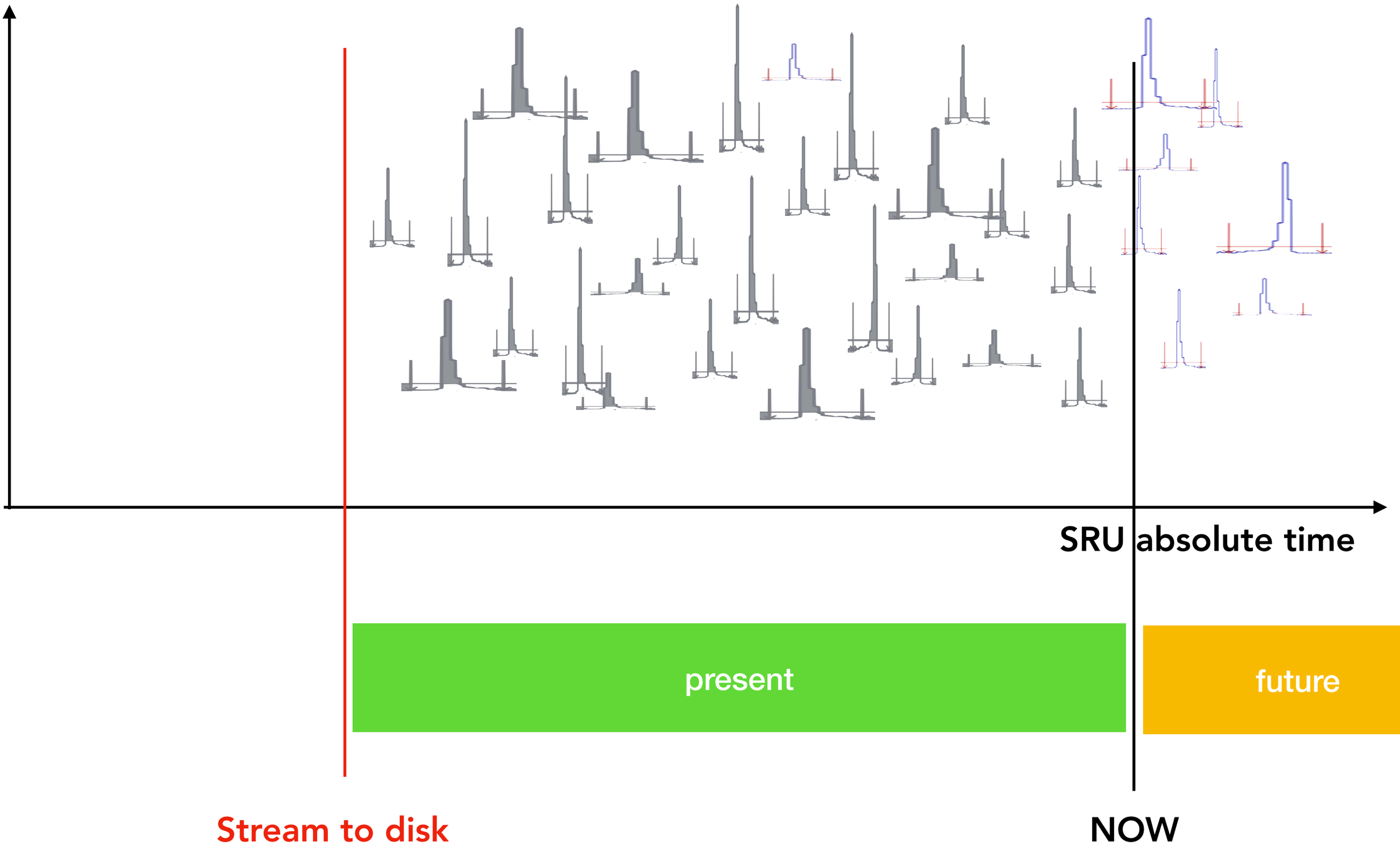


No hits left behind mechanism

1 SRU hit collection: Geant4 transportation + V(t) digitization



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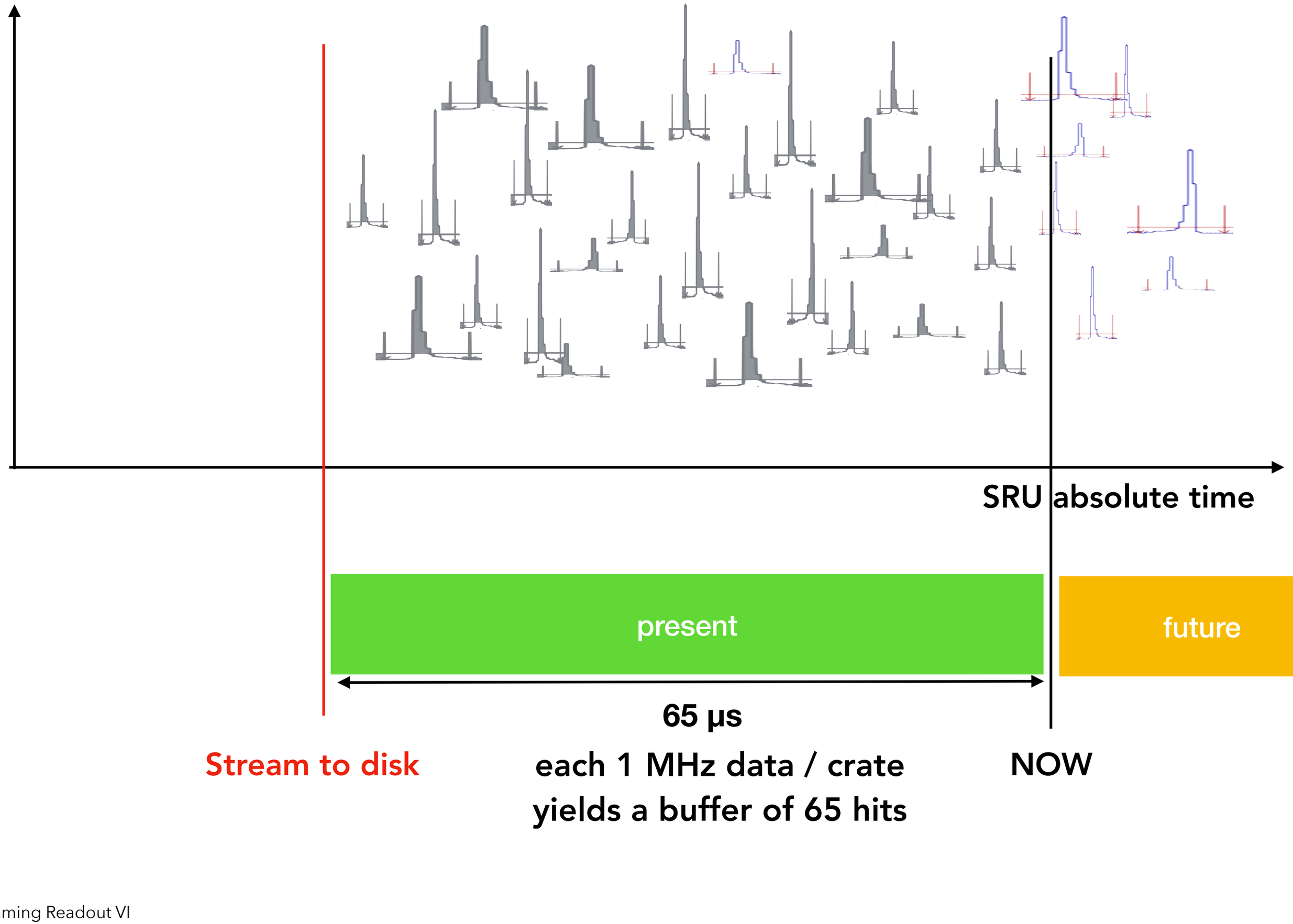


High Level Data Format

Collaboration / Code sharing opportunity:

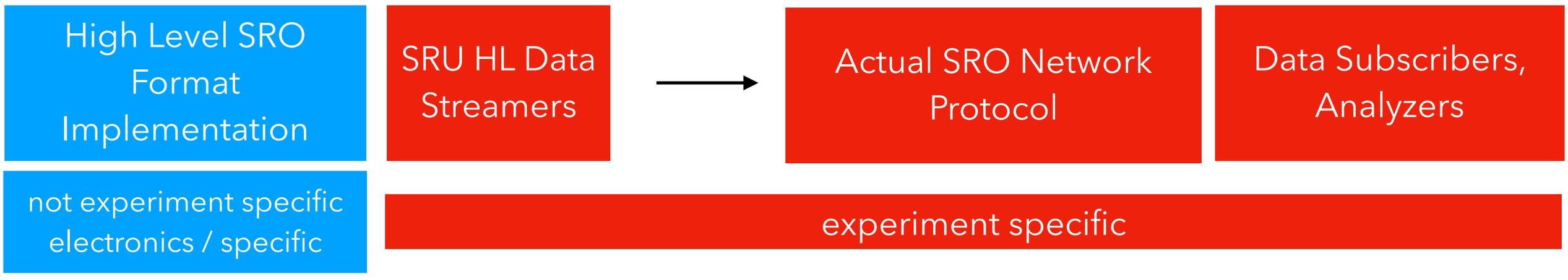
Design a define a “high level” data format. One file / SRU.

- 1 SRU Hit collection (data buffer) / Crate
- 1 SRU Hit collection (data 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.



Outlook

- Design and implement high level SRU format. Collaboration / synergy highly desirable.
- Use a simple, existing detector geometry and demo buffer stream feasibility by replacing a real small detector (one SRU) source with simulation.
- Add multiples crates, simultaneous buffers streams. One buffer = 1 file on disk = 1 network stream.
- Address details such as timing in respect to signal shapes

- Simulate challenges of large scale detectors:

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

Explore collaboration / learn from / synergies with ongoing / mature efforts