Adaptable data-processing for HEP computing frameworks

https://indico.fnal.gov/event/52666/contributions/231769/attachments/153101/198580/SCDProjects_LDRD_Knoepfel.pdf

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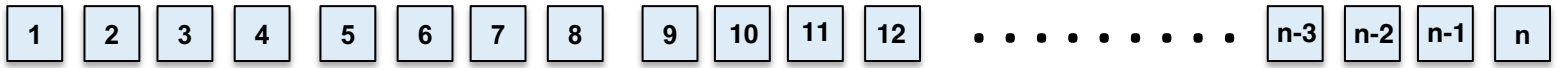
DUNE pre-collaboration meeting

9 May 2022

Processing complications (1)

- The collider physics approach to data processing

  Existing computing frameworks process data in rigid ways



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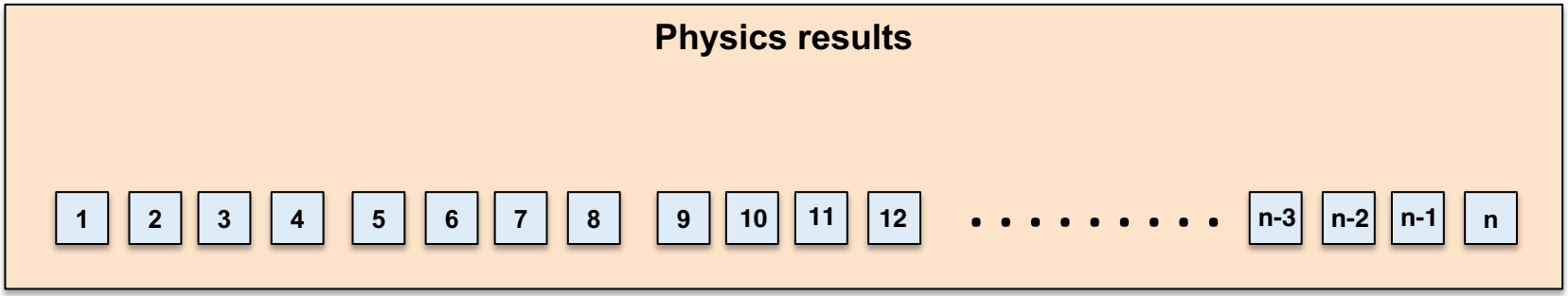

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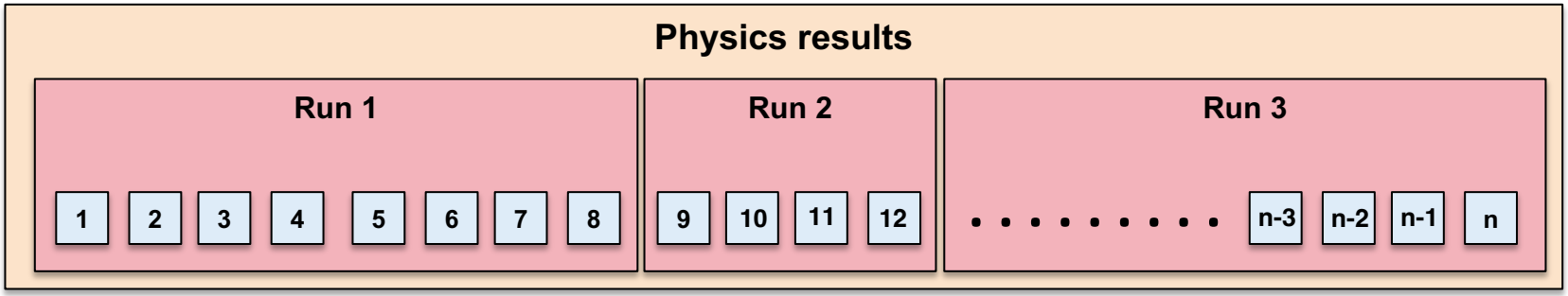

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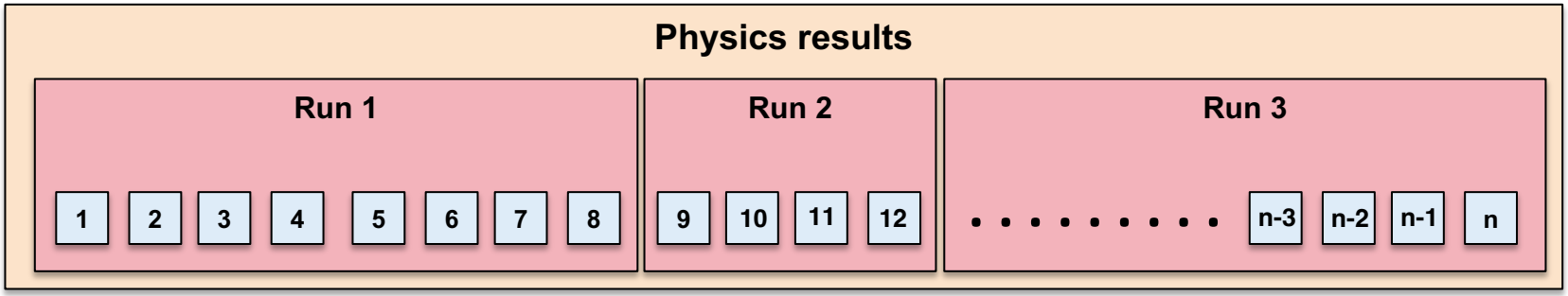

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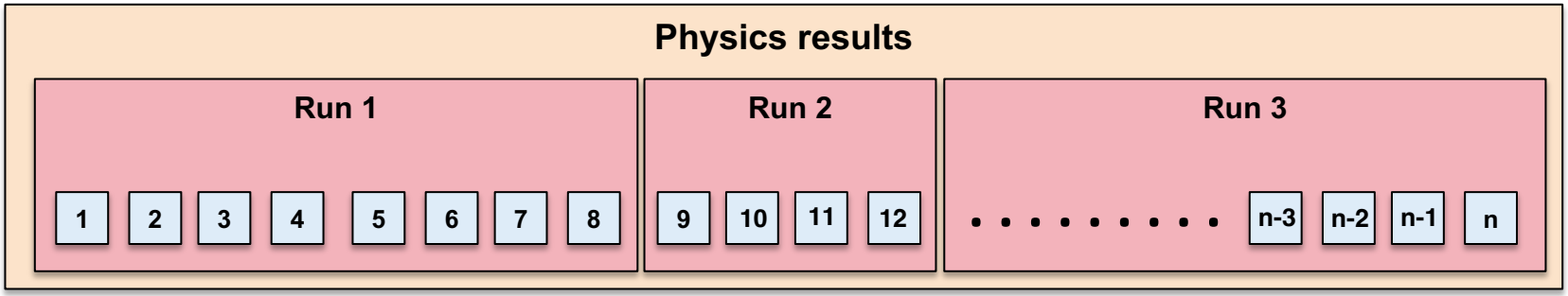

  Physics results are obtained by analyzing the data as a whole

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  Data-processing frameworks set these hierarchies “in stone”

- **This approach does not work well for DUNE.**

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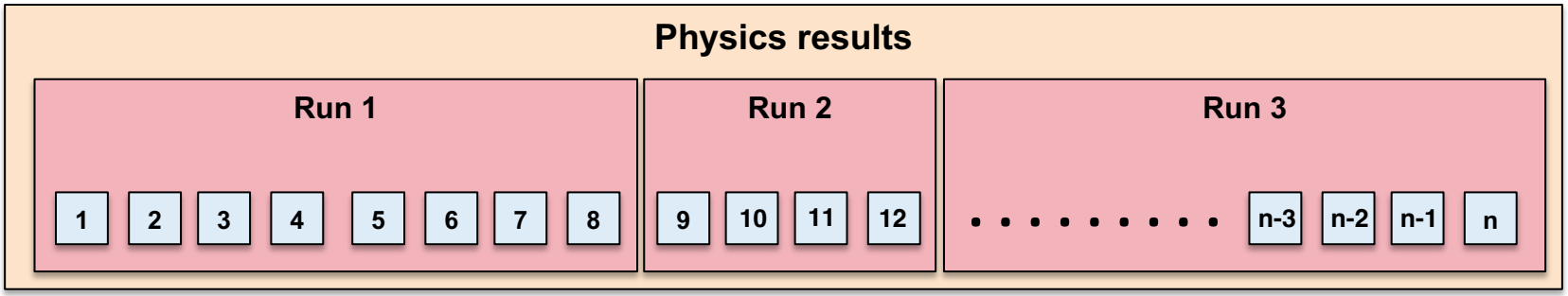
Processing complications (2)



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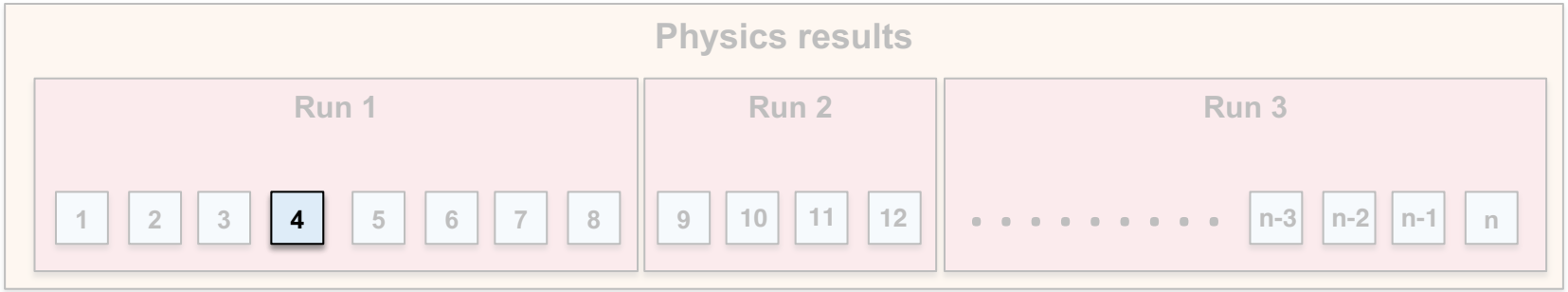

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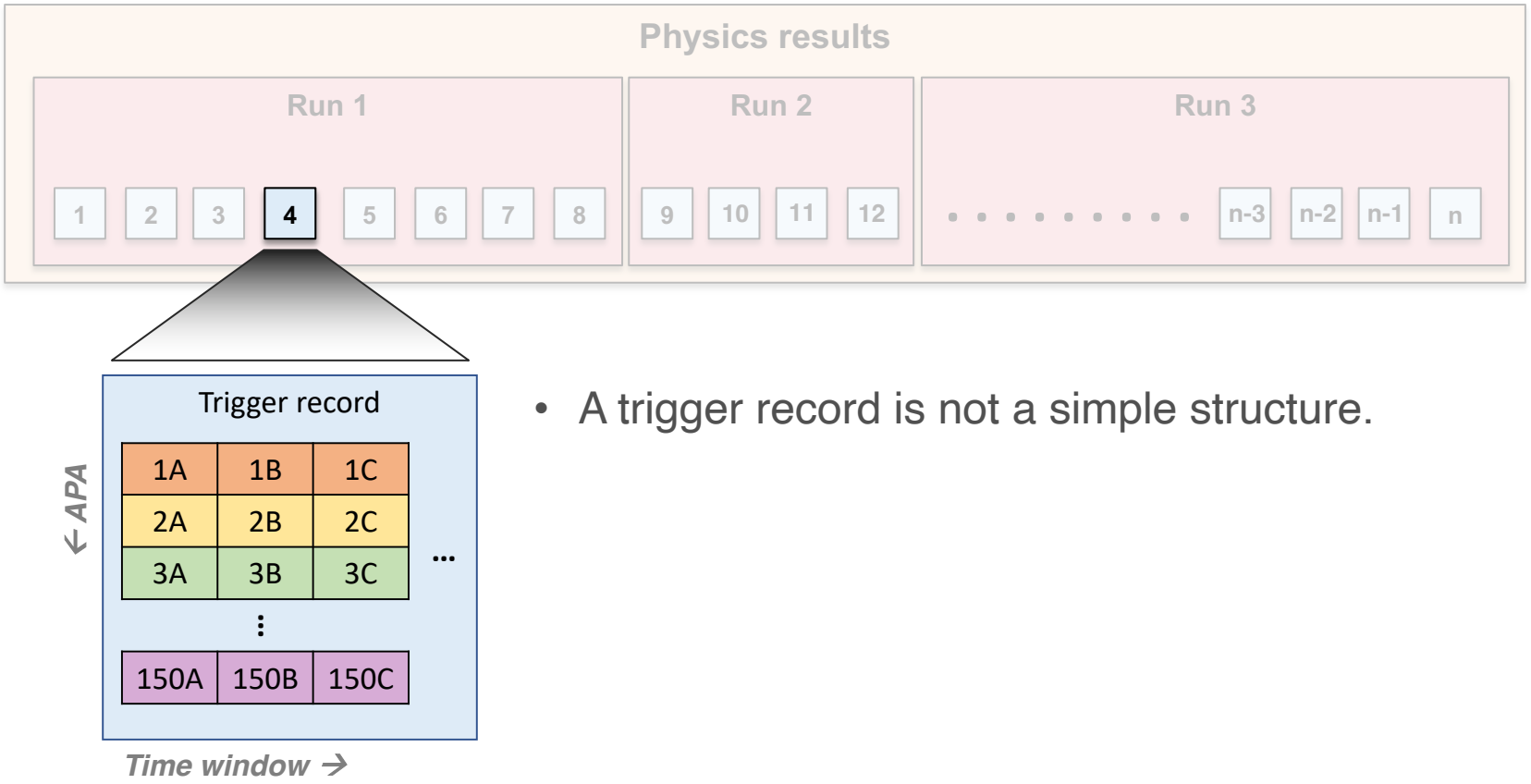

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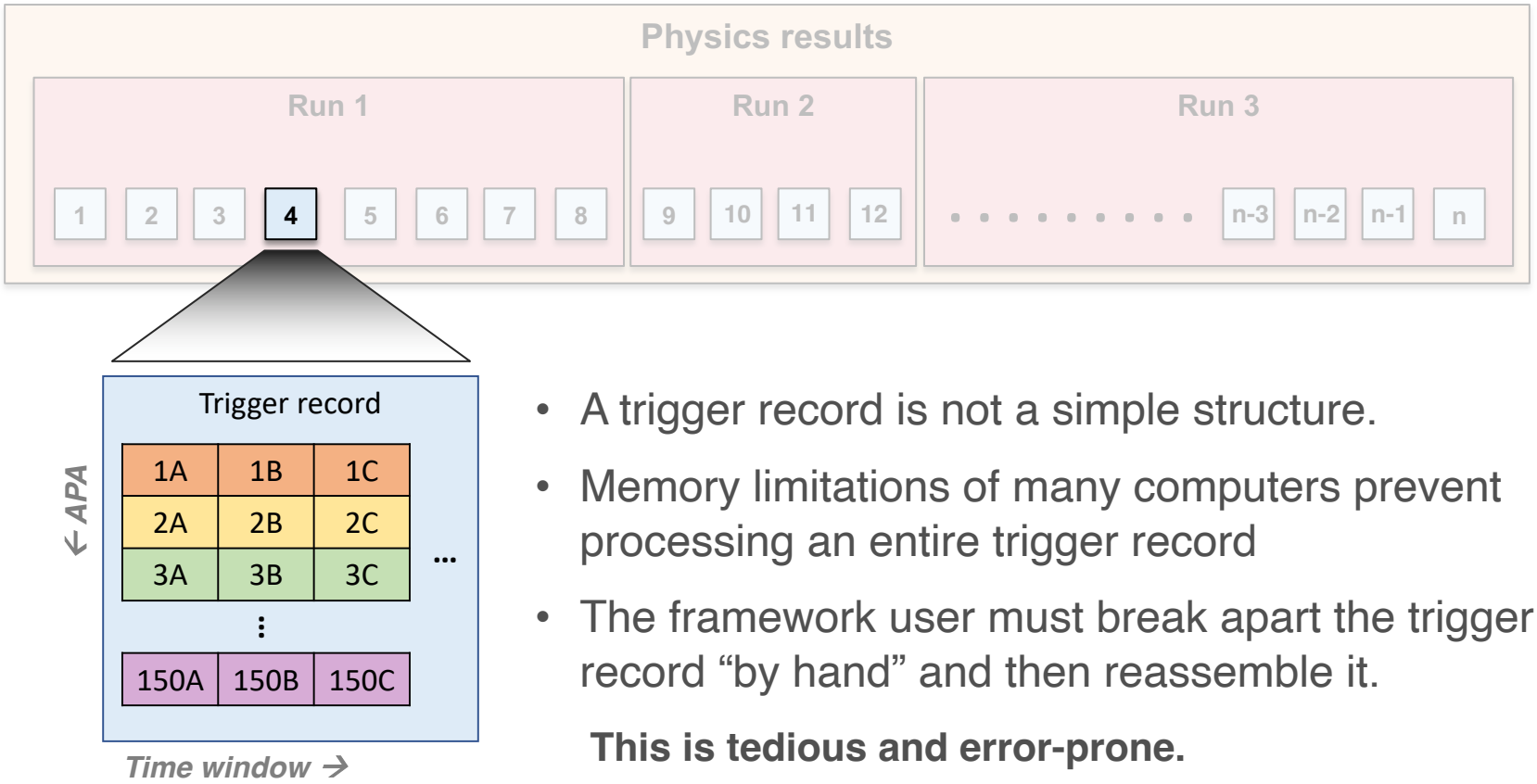

- A trigger record is not a simple structure.
- Memory limitations of many computers prevent processing an entire trigger record
- The framework user must break apart the trigger record “by hand” and then reassemble it.

This is tedious and error-prone.

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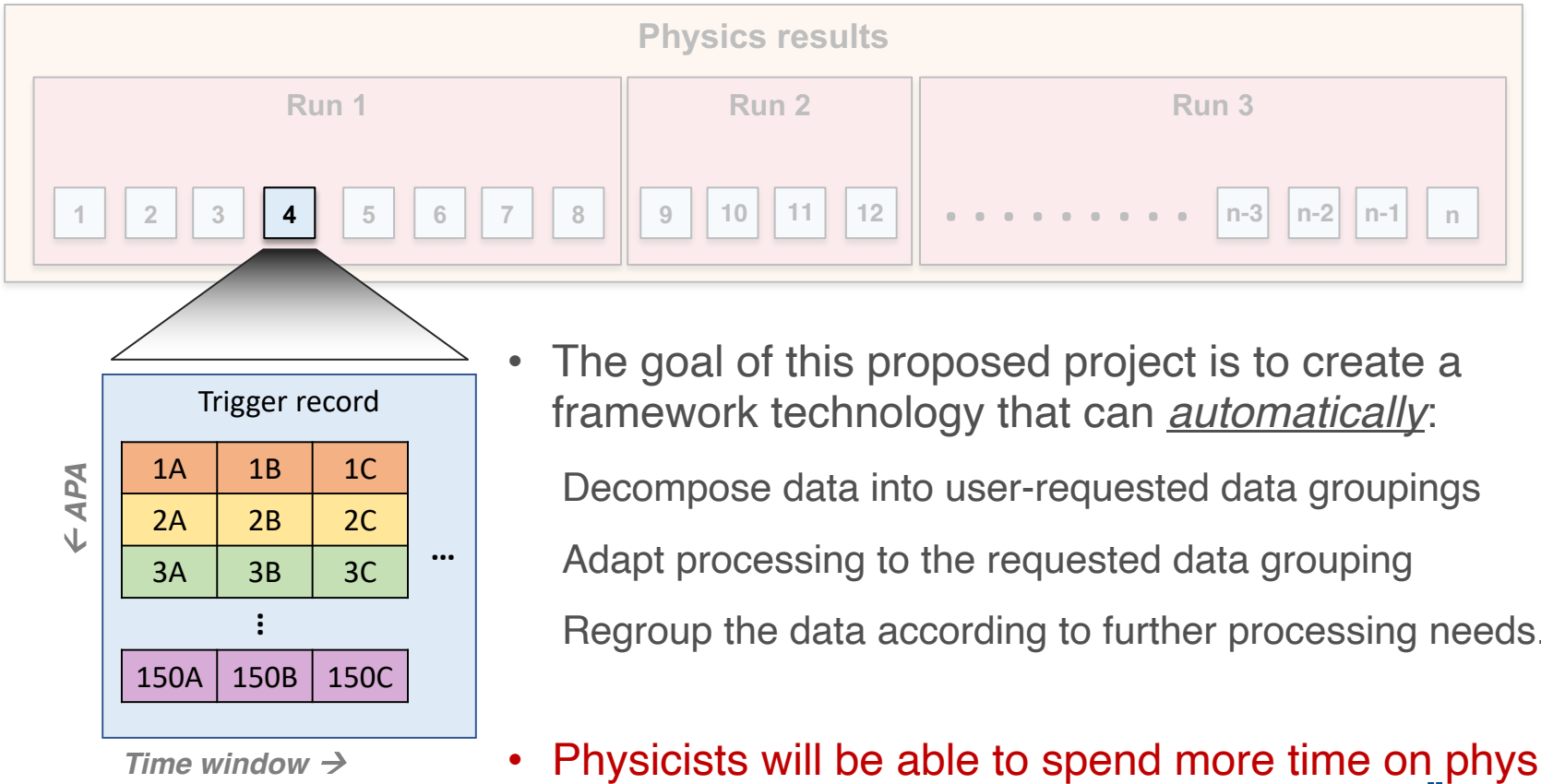
Processing complications (2)



- The goal of this proposed project is to create a framework technology that can *automatically*:
  - Decompose data into user-requested data groupings
  - Adapt processing to the requested data grouping
  - Regroup the data according to further processing needs.
- Physicists will be able to spend more time on physics.

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Establishing expectations

- **Goal of LDRD is to explore solutions for DUNE's framework needs**

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- ***However…***

  The scope is broader than just DUNE.

  I request DUNE's ideas/guidance, but the project is still self-directed.

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- Prototype package https://github.com/knoepfel/meld

  It will change ***a lot*** in the months ahead.

Meld

External software	Provided by Spack or system
Building and testing	CMake
Configuration	CLI11 + Boost JSON (probably Jsonnet later; not FHiCL or Python)
Plugin handling	Boost DLL
Task scheduling	Intel oneTBB (yes, MPI is on the table)

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Meld already supports:

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Meld does not yet support:

- Bookkeeping/metadata
- I/O system
- Serializing for a specific resource

The basic idea

- The framework should support experiment-defined processing levels.

  Inheritance-based modules don't necessarily work well.

- `meld` uses template metaprogramming to process data of the "right type".

  This may change.

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```
#include "meld/core/module.hpp"
#include "meld/utilities/debug.hpp"
#include "test/data_levels.hpp"

#include <chrono>
#include <iostream>
#include <thread>
#include <typeinfo>

namespace meld::test {
  struct run_only_module {
    void
    process(run const& r, concurrency::unlimited) const
    {
      using namespace std::chrono_literals;
      std::this_thread::sleep_for(1s);
      debug("Processing ", r.name(), ' ', r, " in run-only module.");
    }
  };

  MELD_REGISTER_MODULE(run_only_module, run)
}
```

Issues to address

- Looking through DUNE's workflow
- **Finding: It's not clear yet what the data flow should look like.**

  Does the concept of a "path" still make sense? *Probably*

  What's the best scheduler for the various use cases? *Under exploration*

  What does it look like in code to "reassemble" a trigger record without blowing the memory budget? *Don't know yet*

- I am working through these types of issues.