Readout Challenges

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Outline

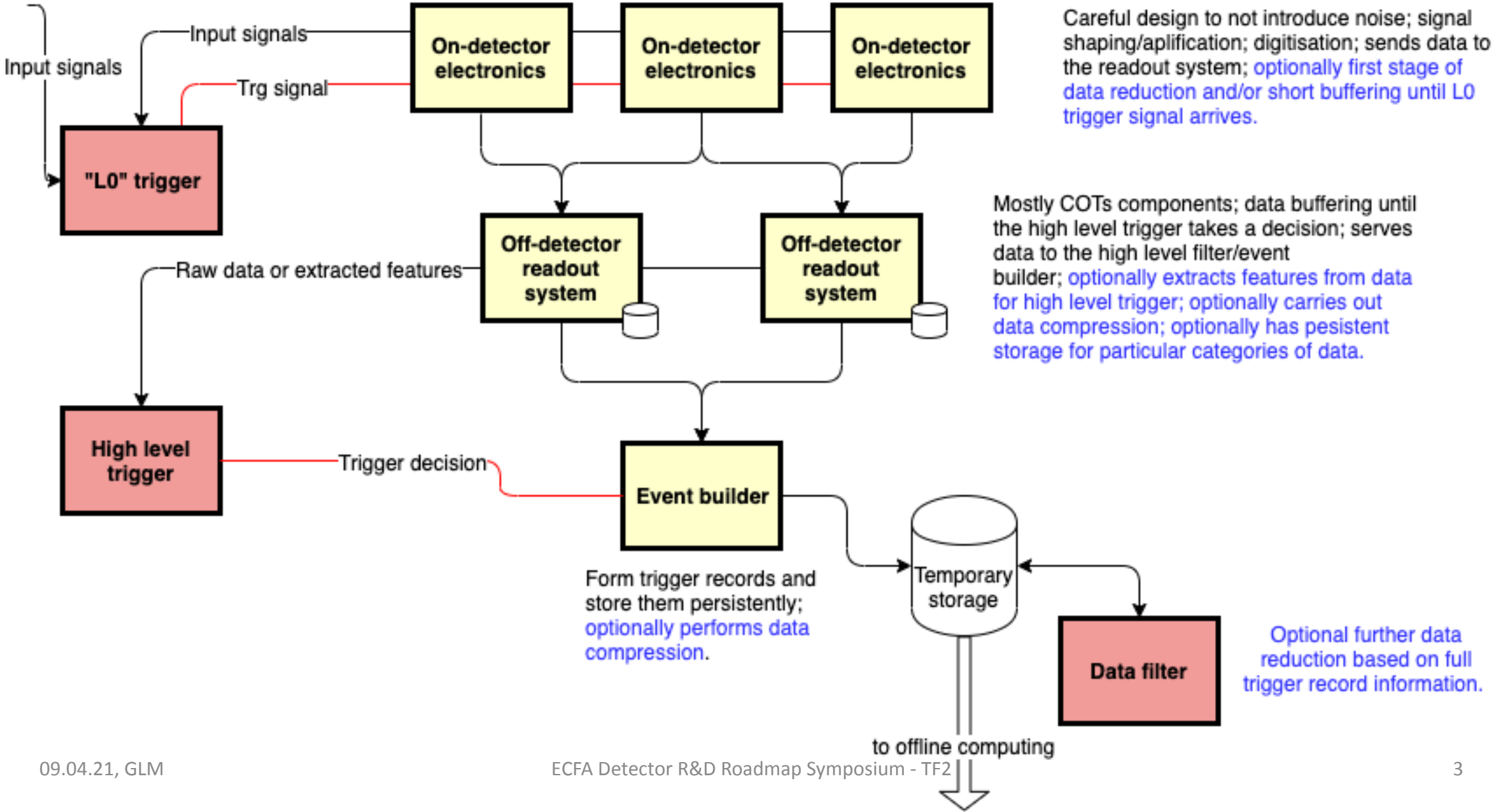
Trigger and DAQ for liquid detectors

The Trigger/DAQ dilemma: when/where should data be reduced?

DUNE as an example of a mixed approach

A glimpse into the future

A “standard” Trigger / DAQ system



Trigger/DAQ in liquid (neutrino) detectors

Large detectors producing very large volumes of data (1-10 TB/s range)

Mixture of fast (light) and slow (charge) signals

- Except if only fast signals are used, the L0 trigger approach is not well suited

Mixture of localised and distributed “events”

- For some physics signals the complete view of the activity in the detector is needed to select the data, e.g. SNB

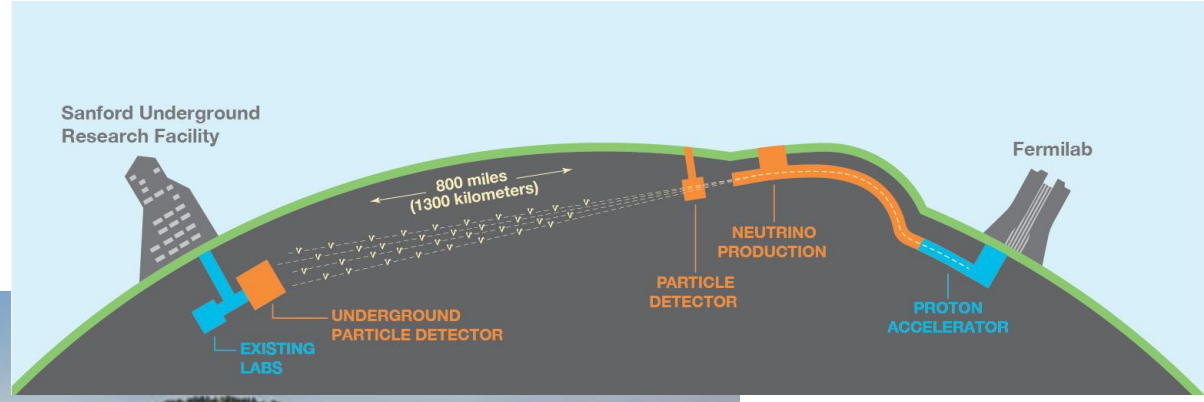
Mixture of interactions with known (beam) and unknown time and direction

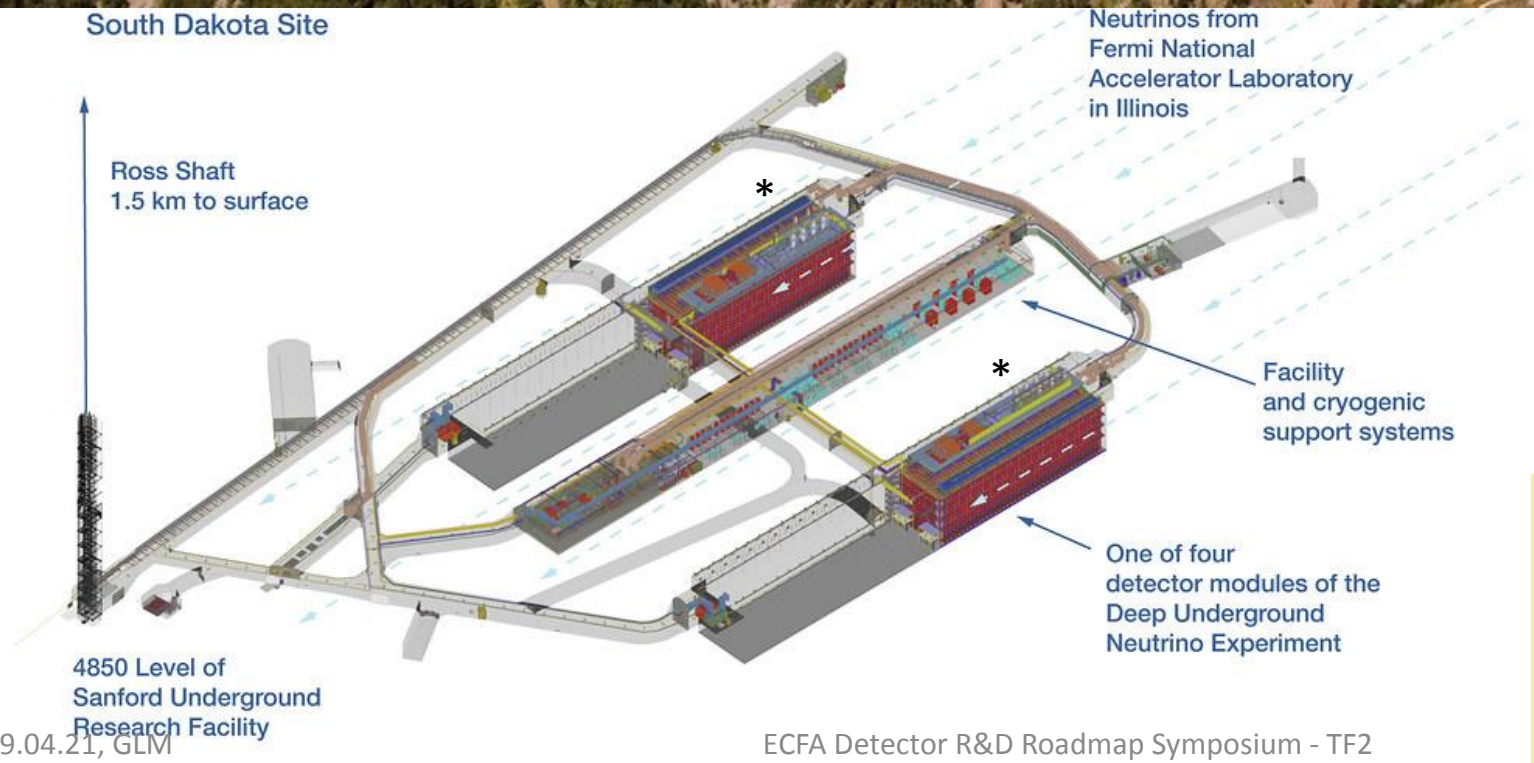
The Trigger and DAQ dilemmas

- What data shall be retained?
- Where/when should data be selected?
- Where/when should data be compressed?

- An almost continuum of valid answers exists, but the community tends to polarise around two schools of thought (see TF7)
  - Reduce data as early as you can and minimise the size of the downstream system (the hardware fans)
  - Transfer as many data as you can to the downstream part of the system to allow for more sophisticated data selection (the software fans)

DUNE – Distributed DAQ





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- Event builder, storage
- Data filter
- GPS antennas and receivers
- Computing infrastructure

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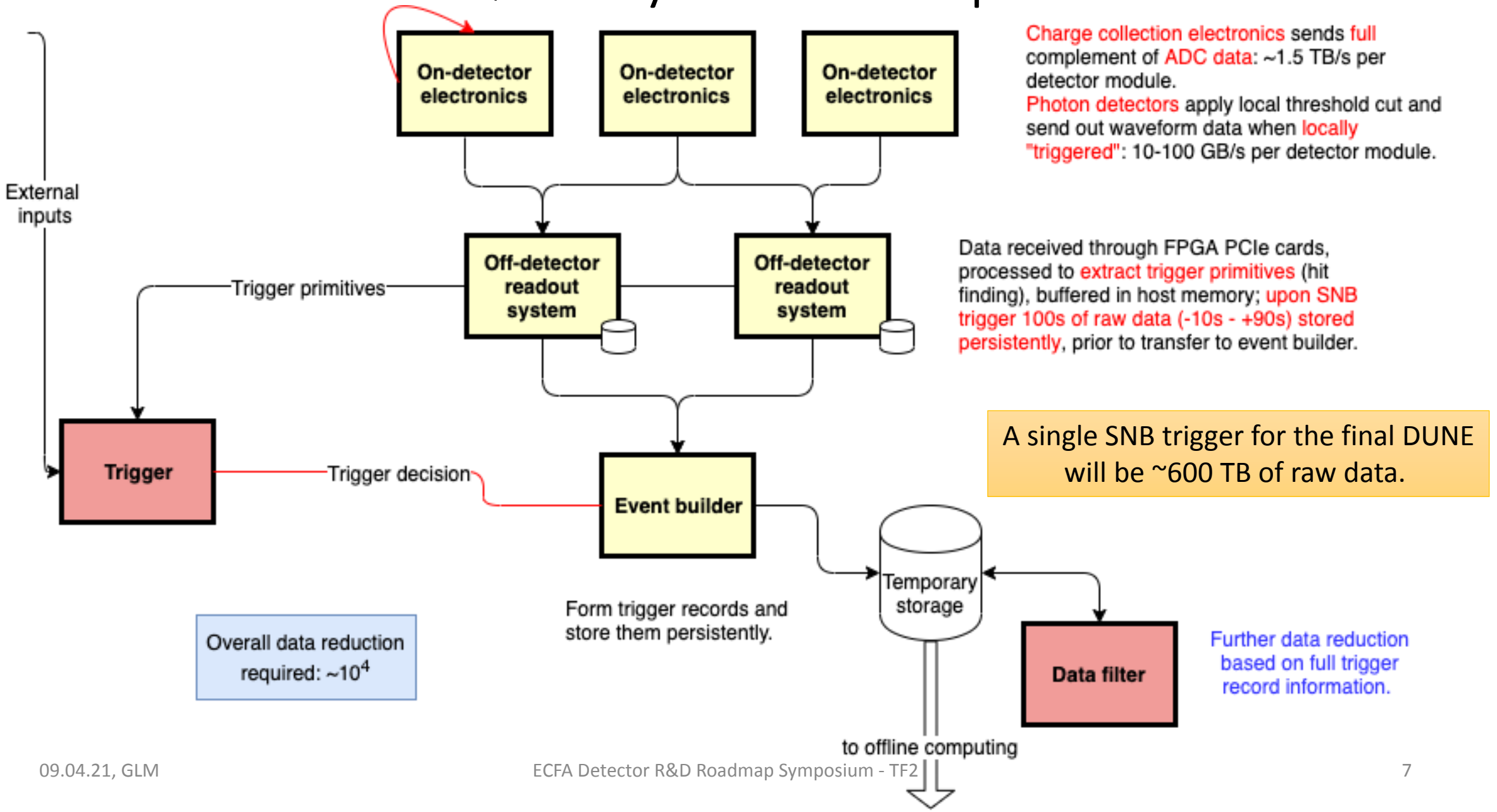
- Timing system
- HW signals interface
- Readout
- Trigger

The DUNE DAQ - a hybrid example



Architecture choices

- Readout the full complement of digitised charge collection data;
- Locally trigger the photon detectors and send digitized waveform data around those triggers to the DAQ;
- Carry out distributed processing of data (hit finding) in the readout to extract so called trigger primitives (firmware + software);
- Base the trigger decision on trigger primitives;
- Provision a high bandwitdh and fully redundant network connecting readout and event builder as well as high performance storage in order to trigger generously and apply further selection/compression in the data filter;
- Provide fast local storage in the readout, to rapidly persist SNB candidates.

Is this the right choice?

- Decisions have been taken balancing:
  - Wish to exploit future progress in computing world (hardware and software)
  - Limitations of power at SURF
  - Budget
- Is it a waste to not carry out processing for charge collection data in the on-detector electronics?
- Do we loose data selection power by basing ourselves on the “classically” extracted hits instead of introducing very early on in the chain more sophisicated machine learning techniques?
  - Alternative still an option
- Do we have all the handles to react to the real detector behavior that we will discover at turn on?
- Would it be better to send more data to offline computing and let data center infrastructure “clean up” the data?

Summary and outlook

- The “philosophical” questions around design choices for large trigger and data acquisition systems for liquid detectors are the same that apply for other types of experiments (see TF7)
  - Augmented by the vast spectrum of physics signatures that are typically studied
- Techniques that up to recently were considered “offline” domain are becoming interesting for online data selection
  - Need to find the good balance between keeping the DAQ system robust and predictable, i.e. “simple”, and the wish of making the perfect data selection
- Those questions animate the DAQ communities and are driving interesting R&D, ranging from concentrating the full intelligence in the on-detector electronics to pushing all data to data-center like falicities in which any modern data processing technique can be explored.
  - Time will tell if there really is a “better” solution