Implementation of the free running format to the DAQ software

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Overview

- Description of the free running format
- Design of the trigger framework
- High level trigger implementation
- Integration with the DAQ system
- Additional tools

Description of the new DAQ format

- New data format includes a multi-layer structure of data
- Each layer has its purpose and encapsulates the lower layer (its children)

Epoch	• Encapsulates all the slices in a given time period
Slice	• Wraps all the images in a given time period
Image	• Wraps all the groups and hits with the same sampling frequency
Group	• Contains hits coming from one Source ID (can be nested in itself)
Data	• Carries information about a single hit
Additional Data	• Contains extended information about associated hit

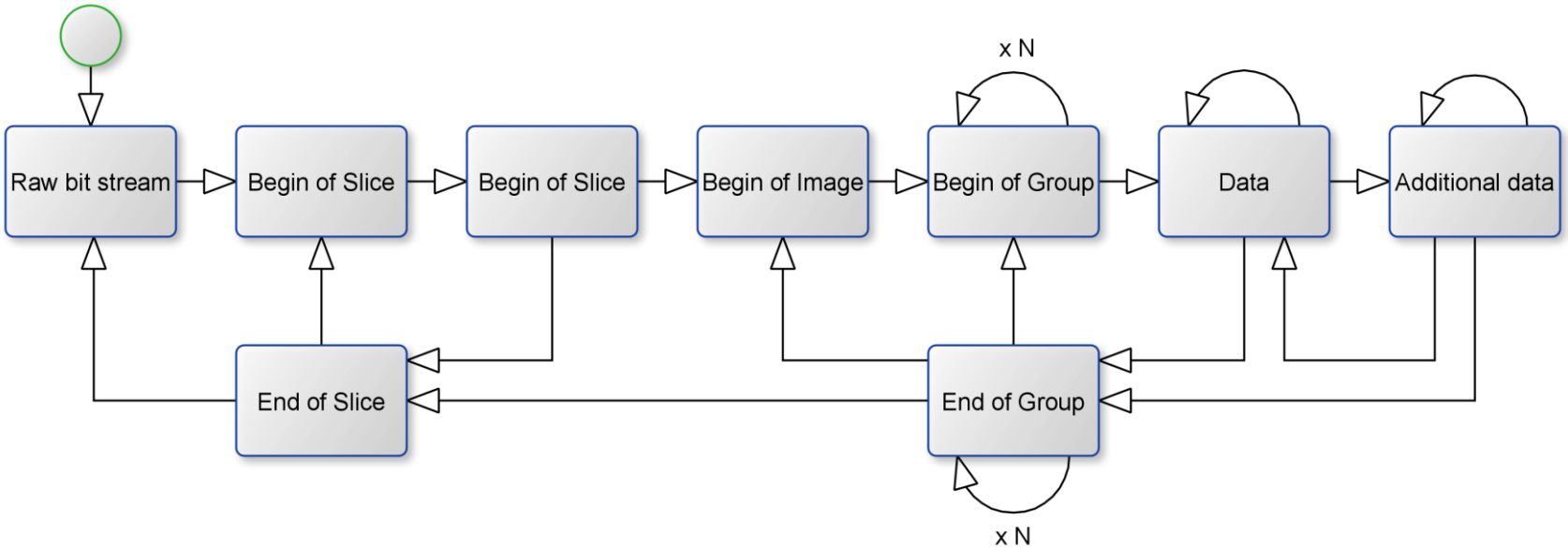
Structure of the free running format

- Data are aligned in atomic packages of the 32-bit size called „Data words"
- Every data word contains a control word indicating the type of data

Type of data word	Information included
Begin of Slice I	Number of Images in Slice, Slice number in Epoch
Begin of Slice II	Start time of Slice in Epoch
Begin of Image	Start time of Image in Epoch
Begin of Group	Source ID, View ID, First Hit time in Group
Data Word	Frontend ID, Channel ID, Hit time
Additional data	Any kind of data (29 bits)
End of Group	CRC checksum, 3 x bit flag
End of Image	Currently not used
End of Slice	CRC checksum, 3 x bit flag

Structure of the free running format

- State machine for validation of raw data streams
- Sequence of data words must follow the paths indicated below
- If any data stream has a different sequence, data are corrupted



Requirements for the trigger framework

Functional requirements

- Support of various triggering algorithms and triggering patterns (triggering rules)
- Adjustable trigger sensitivity
- Identification of regions of interest based on hit correlations
- Generating event candidates (list of images that comply with the triggering rules)
- Emulation of the hardware trigger
- Output for the CORAL (CSDigits)

Technical requirements

- Stand-alone framework – as few dependencies as possible
- Distributed computing for high performance
- Support for multithreading and NUMA balancing
- Reviewed code base (changes committed via pull requests)

Interface of the trigger framework

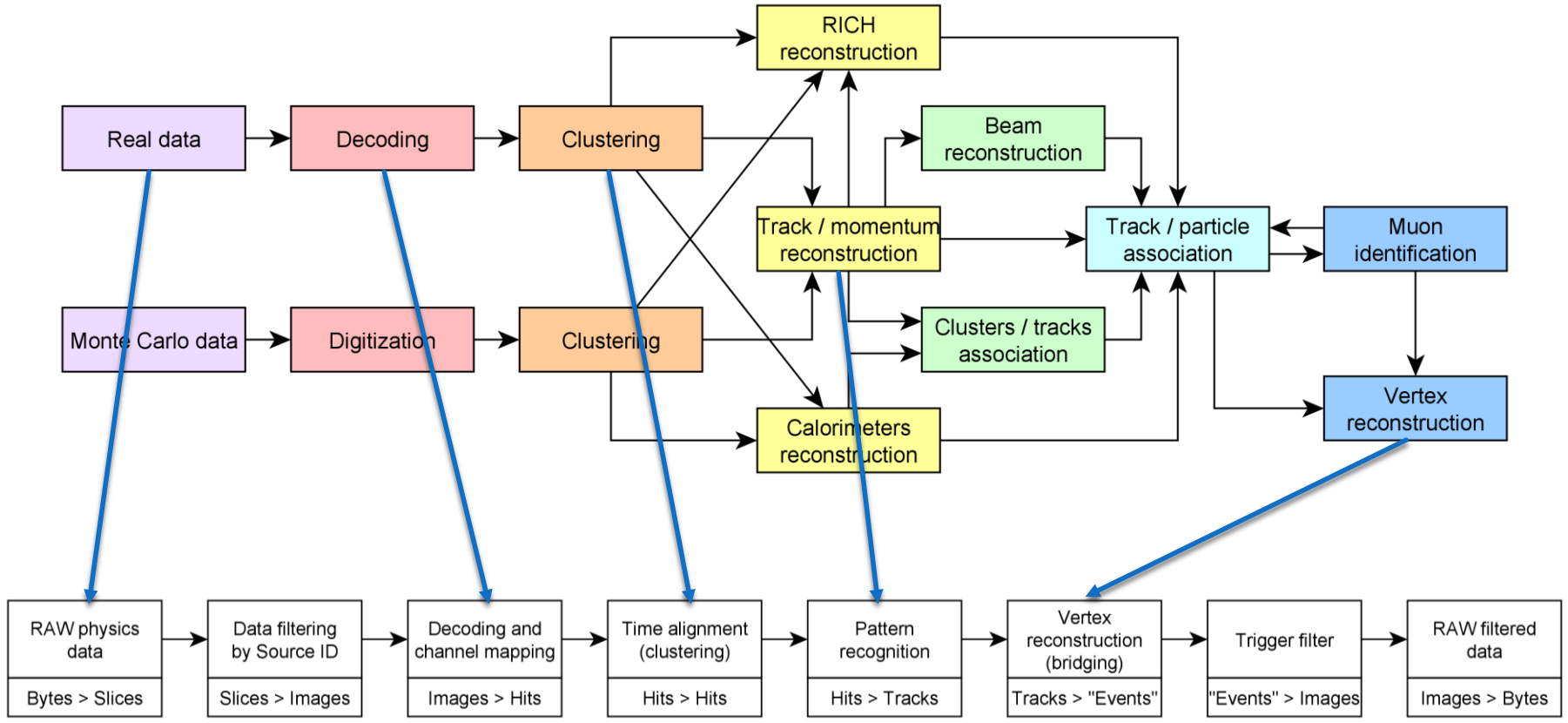
Inputs

- RAW data files from the DAQ
- Detector response simulations
- Detector descriptions (detectors.dat)
- Mapping files
- Triggering options

Outputs

- Event candidates (filtered RAW files)
- CORAL files (CSDigits)
- Monitoring information for monitoring tools

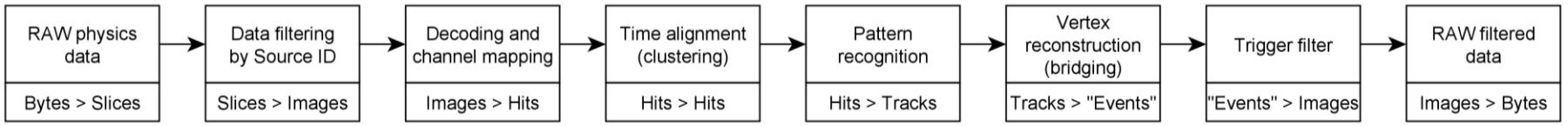
Reconstruction chain



Reconstruction chain

Steps that have to be taken in the reconstruction procedure:

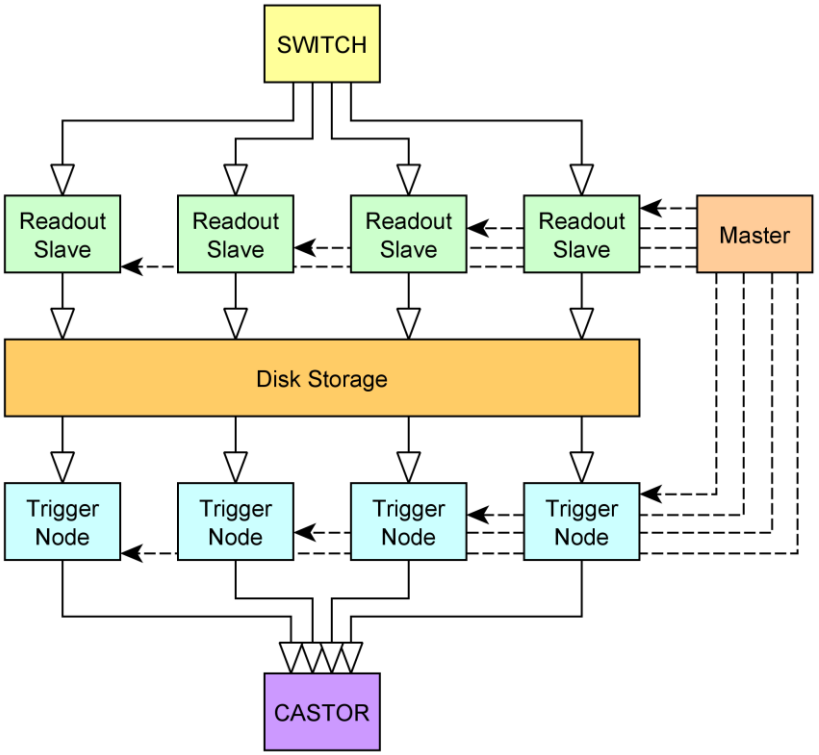
1. Reading RAW data – convert byte stream into slices
2. Data filtering by Source ID – extract trigger information from the slices
3. Decoding and channel mapping – change the transfer mapping into the physical mapping
4. Time alignment – find correlations between hits and justify hits in time dimension
5. Pattern recognition – convert hits into partial tracks (se)
6. Vertex reconstruction – join projections into the full particle tracks
7. Filtering – data containing event candidates are passed through



Possible integration scenarios

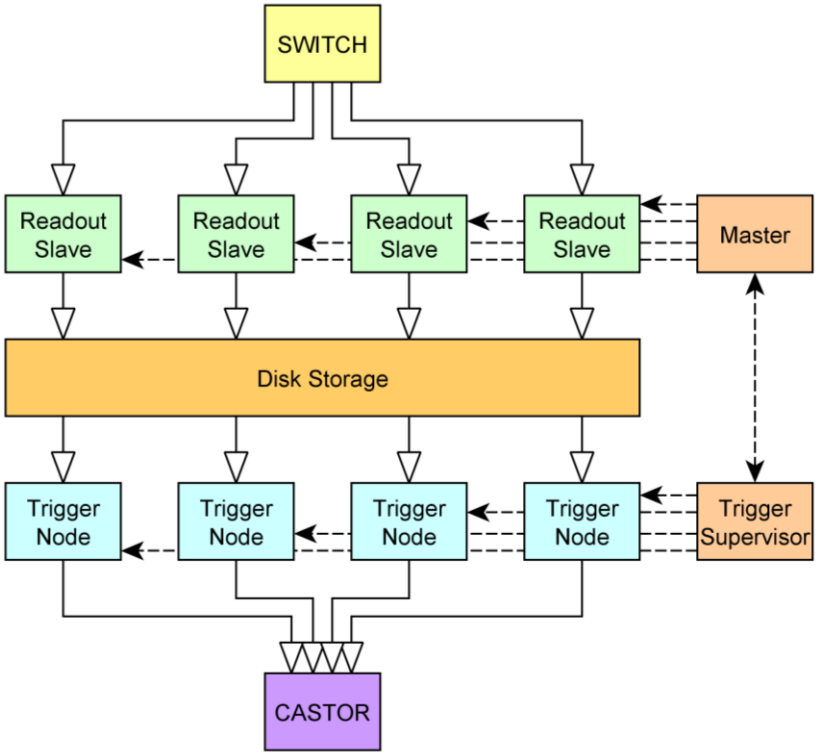
- Scenario 1 : Common master
- Scenario 2 : Independent trigger supervisor
- Scenario 3 : Common master interfacing through the database
- Scenario 4 : Independent trigger supervisor using the database

Scenario 1 : Common master



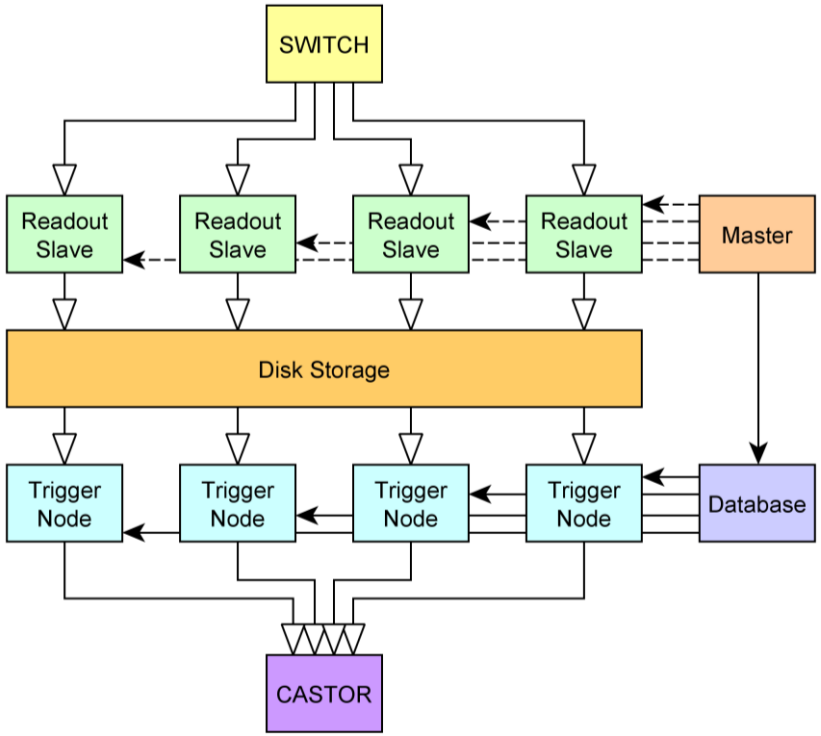
- After successful readout, the Master notifies trigger nodes about RAW data waiting for the triggering
- Trigger Nodes directly fetch RAW data from the Disk storage and initiate the triggering procedure
- Notification about successful completion is sent back to the Master

Scenario 2 : Independent trigger supervisor



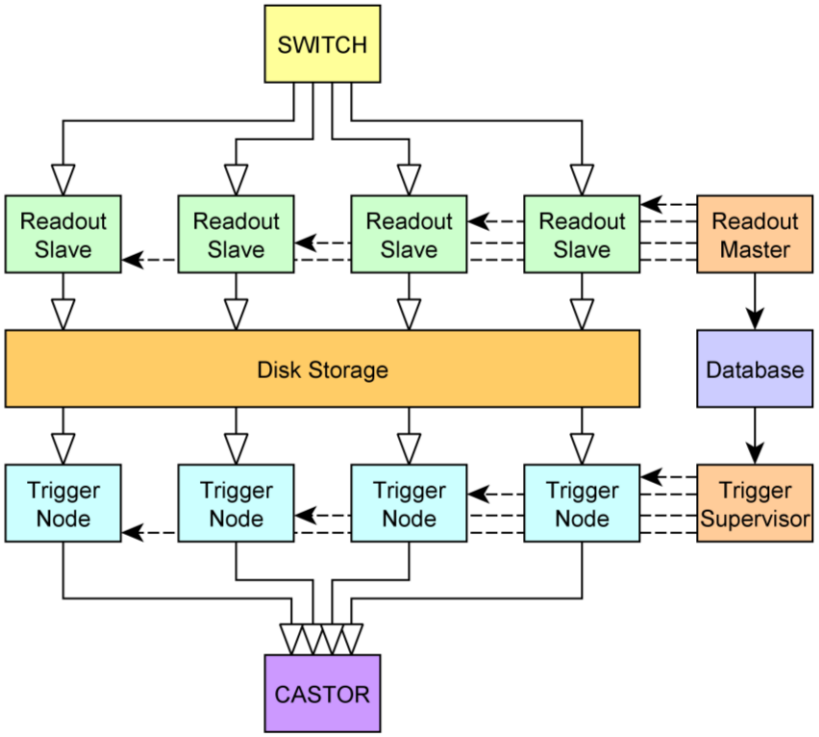
- After successful readout, the Master sends meta information about RAW files to the Trigger Supervisor
- Trigger Supervisor distributes this information to Trigger Nodes
- Trigger Nodes fetch RAW data directly from the Disk storage and initiates the triggering process

Scenario 3 :
Common master interfacing through the database



- Master saves meta information about RAW files to the database
- Trigger Nodes regularly check the database for new data
- Trigger Node directly pull RAW data from the Disk storage and immediately initiates the triggering procedure

Scenario 4 :
Independent trigger supervisor using the database



- Master saves meta information about RAW files to the database
- Trigger Supervisor accesses the database checking for new data and notifies Trigger Nodes about new data
- Data are directly transferred from the Disk storage to Trigger Nodes
- Trigger Supervisor initiates the triggering procedure on Trigger Nodes

Common features for all scenarios

- At first, RAW data are stored on the disk storage
- Then, they are directly transferred to the trigger nodes and „filtered"
- Filtered data are sent to the CASTOR storage

- The DIALOG interface is used for communication between Master <–> Slaves and Supervisor <–> Nodes
- Access to the database is always direct, i.e. using the SQL client

High level trigger dependencies

- Qt framework – the base framework of the DAQ
- DAQ structure file – taken from the RCCARS, must be converted into the library
- DIALOG – library providing communication with the DAQ
- ROOT – may be needed for advanced calculations in some modules

Modules of the trigger framework

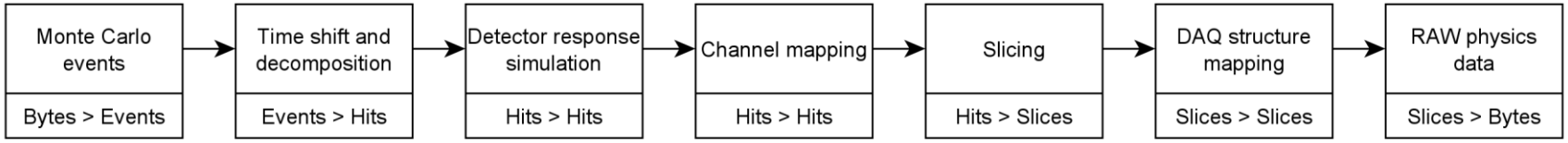
- HLT Node process – main triggering software running on Trigger Nodes
- HLT Supervisor process – manages Trigger Nodes and distributes the load
- **Data Generator** – tool producing artificial data in the new format
- CLI Data Generator – command line interface to the Data Generator
- **Data Browser** – tool for browsing chunks of data
- CLI Data Browser – command line version of the Data Browser
- Monitoring tools – not yet defined
- Configuration tools – not yet defined

Other tasks related to the new DAQ format

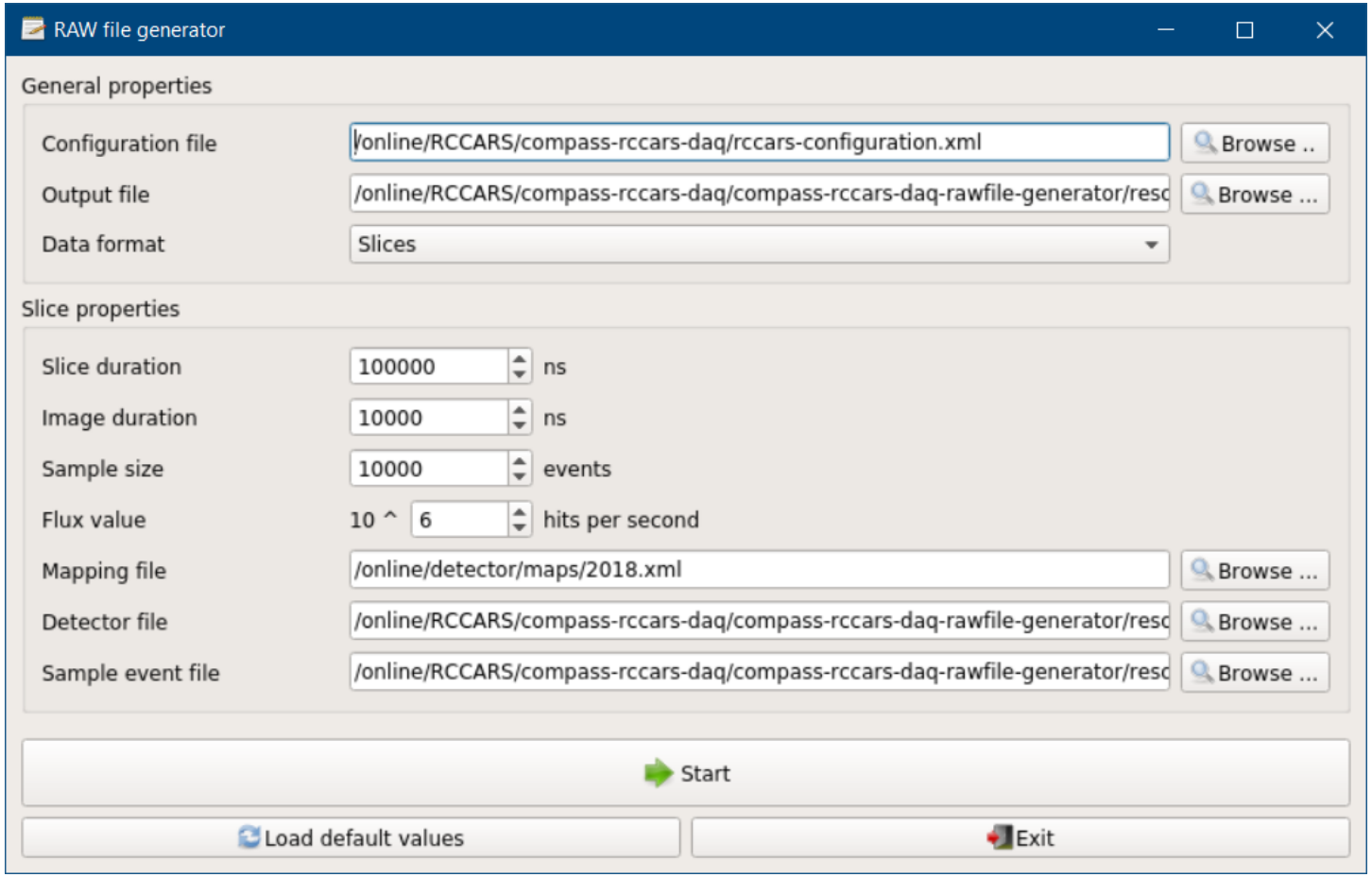
- Design and implementation of trigger configuration tools
- Design and implementation of trigger monitoring tools
- Modification of the Slave Readout process (work in progress)
- Modification of user interfaces, e.g. GUI, Logbook, etc.
- Adaptation of monitoring tools, e.g. COOOL, MurphyTV, etc.
- New database design
- Installation of new hardware

Data generator

- Data Generator is already implemented and **partially** operational
- Utilizes a straight pipelined structure (see picture below)
- The only missing part is the Detector Response Simulation, which is also the most important part
- It must be created in a cooperation with detector experts (hits -> signals)
- This part will be exploited also in the triggering procedure
- Inversed relation is required also for triggering (signals -> hits)



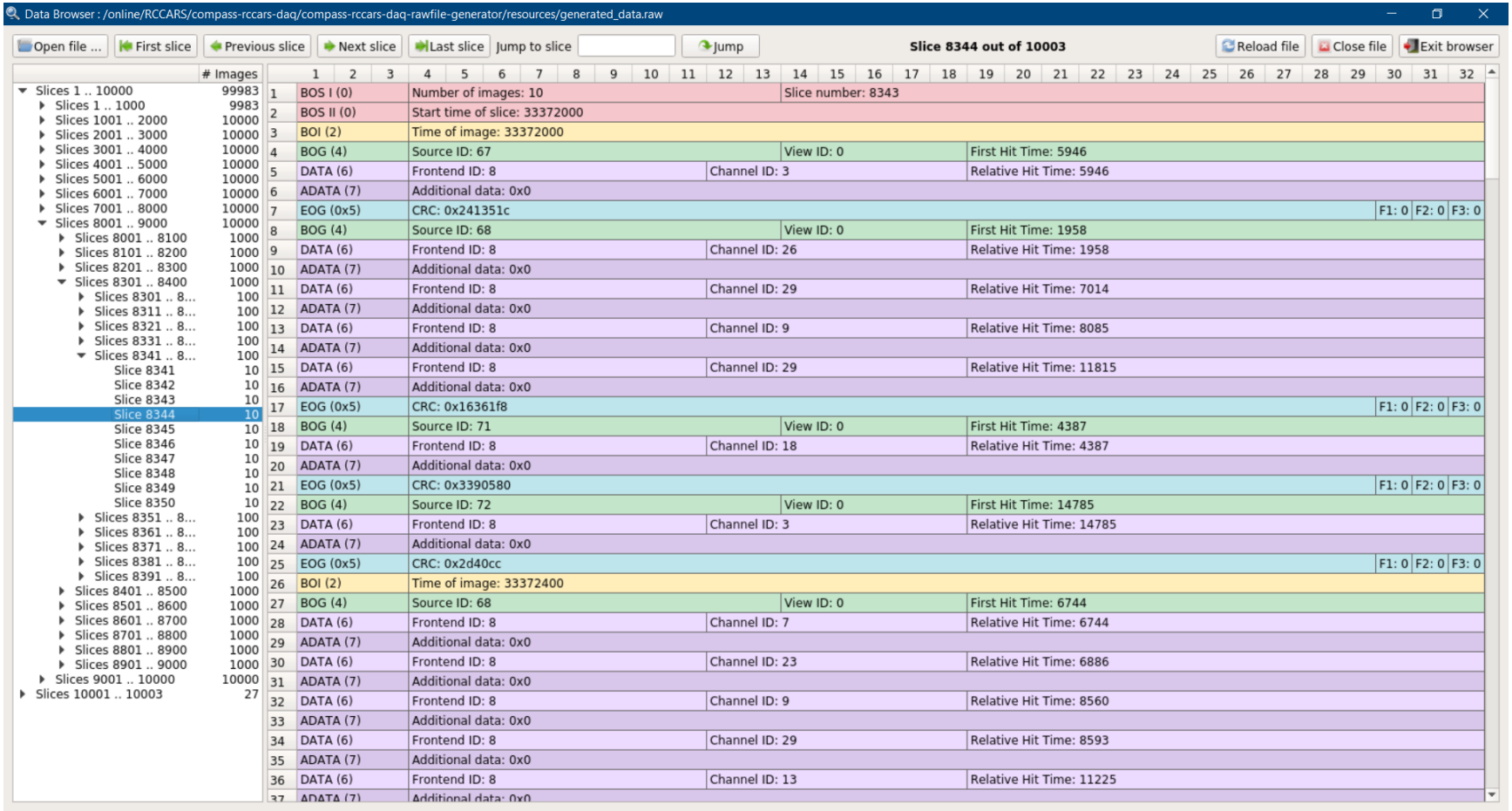
Data generator GUI



Data browser

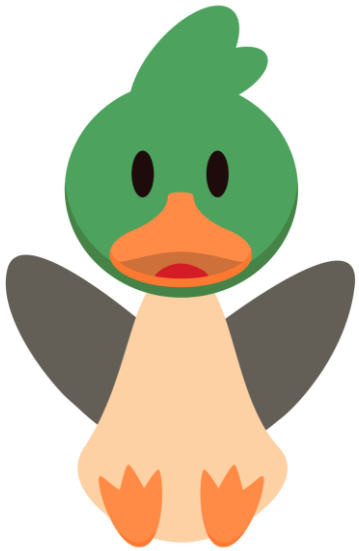
- Tool for browsing RAW data files
- Supports files up to several GBs
- Provides visualization of data words
- Additional useful features can be added – structure validation, statistics, histograms, etc.

Data browser



Summary

- Common goal is to implement the free running format and the high-level trigger system
- To accomplish such task, an advanced framework is required
- The trigger system will create a separate and independent ecosystem capable of emulation of the hardware trigger
- Interface with the current DAQ system must be also designed and implemented
- Many support tools (that are currently in use) must be modified as well
- Any available help would be highly appreciated
- It is a challenging task, but we are on our way



Thank you for your attention