Development of the HGTD Data Acquisition system

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on behalf of HGTD DAQ software team and USTC HGTD group

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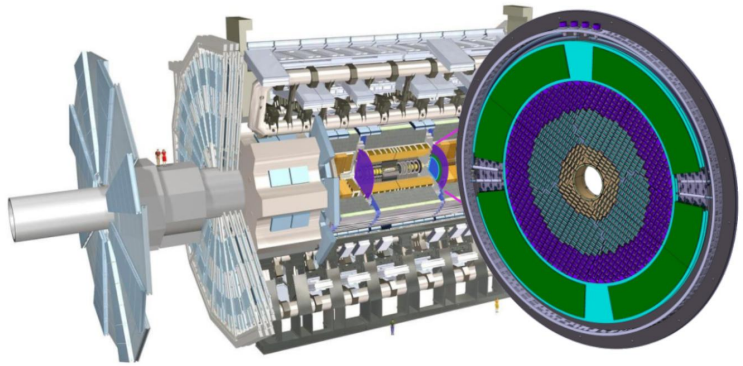
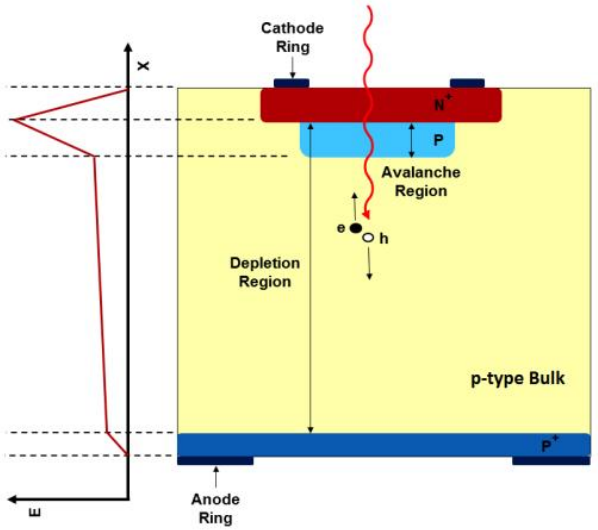
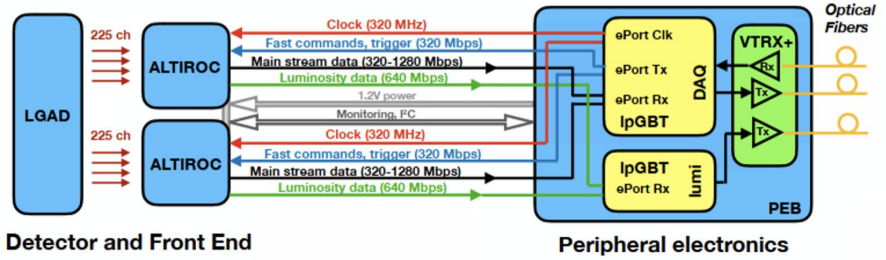
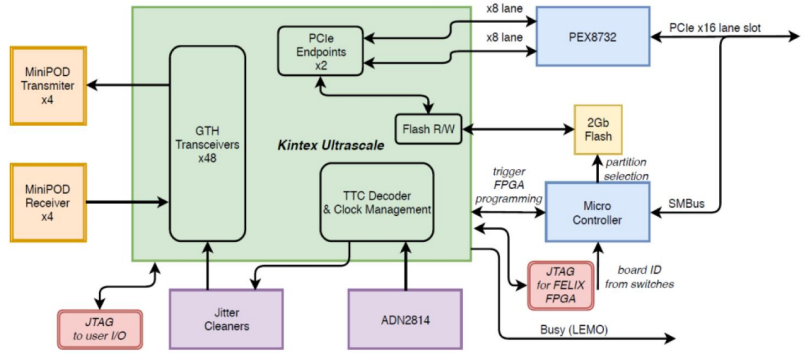
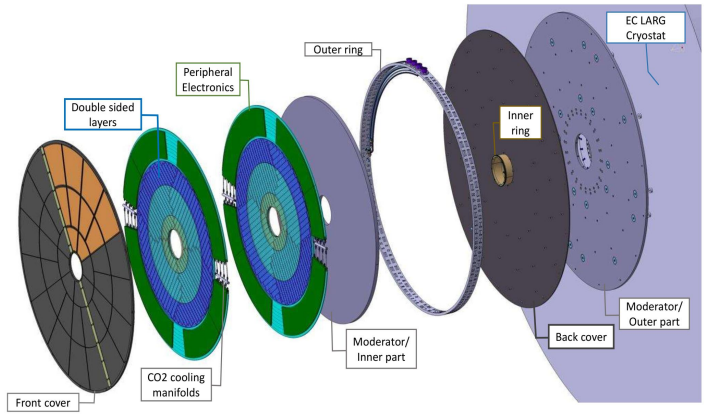
HGTD

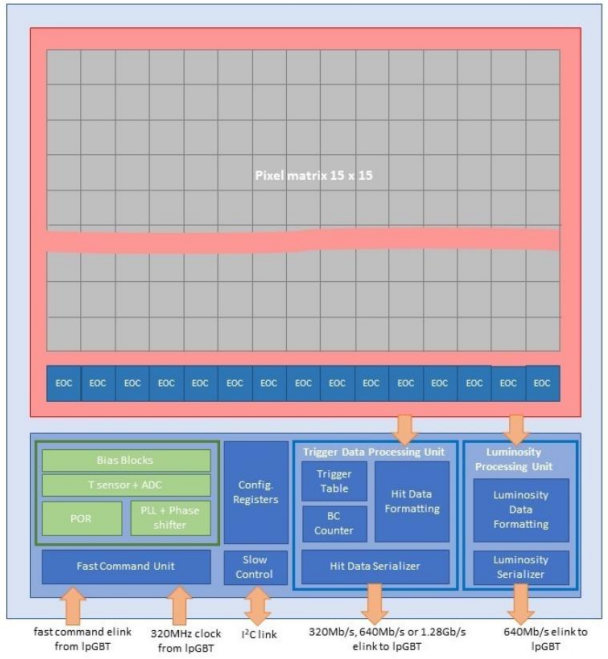






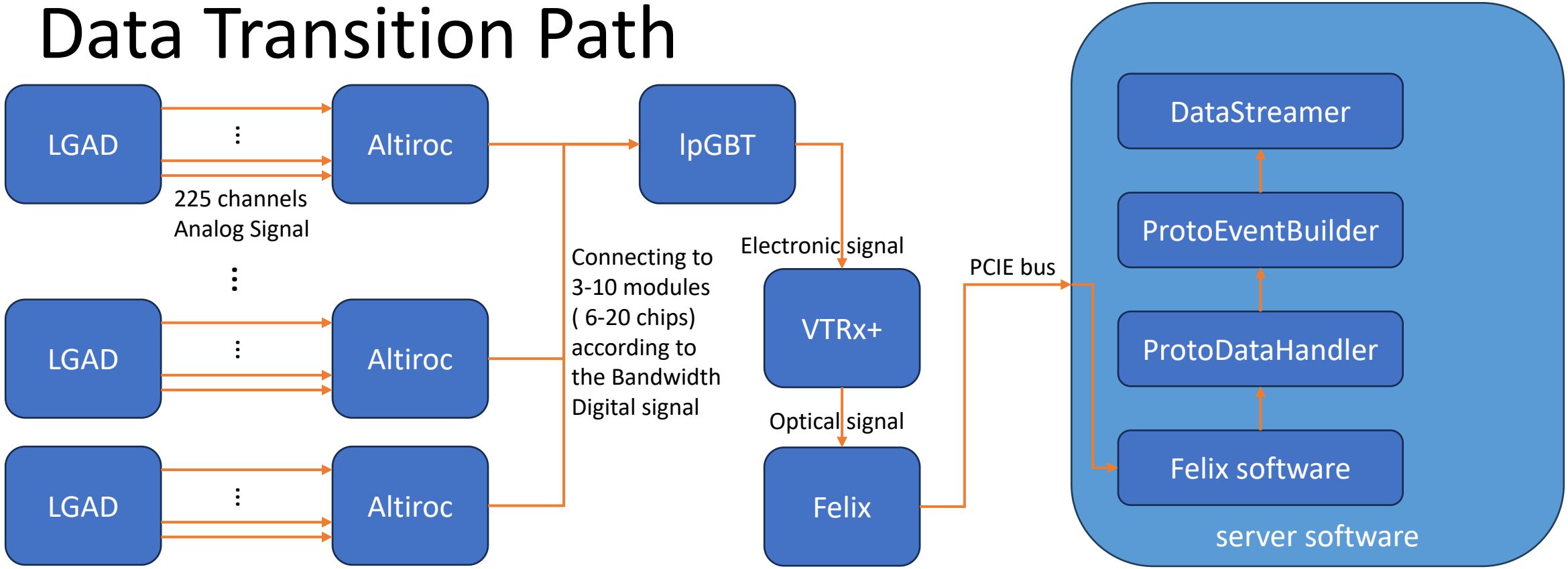






- The High Granularity Timing Detector (HGTD) will provide time information in the forward region.
- By using high-precision timing information, the increase of pileup interaction from LHC to HL-LHC can be mitigated powerfully.
- The sensor will be the Low Gain Avalanche Detector (LGAD).
- The front-end electronic ASIC is named ALTIROC.
- And the DAQ system for HGTD is currently being developed, based on the ATLAS phase II upgrade common back-end, e.g. lpGBT, VTRx+, Felix.

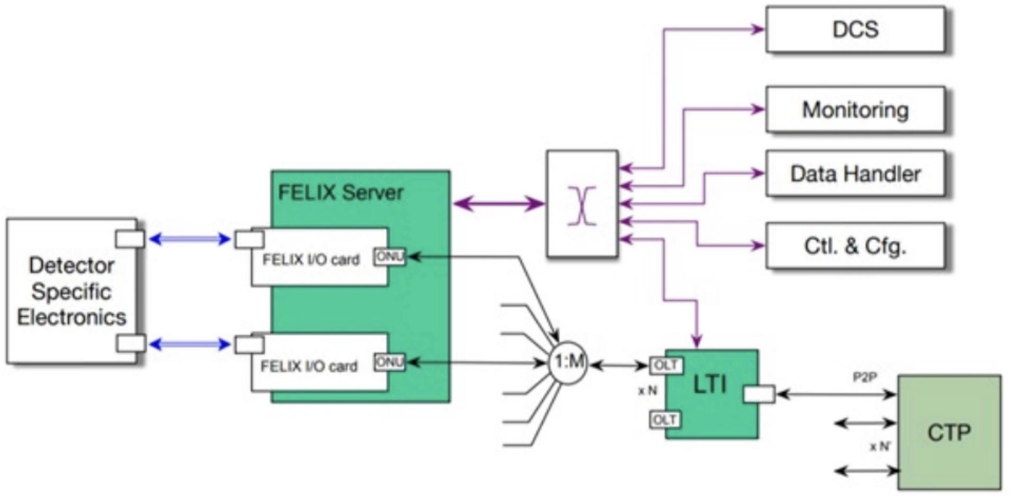
Data Transition Path



- When the charged particle passes through the sensor, the induced signal will be transferred to the Altiroc, where the signal get amplified, discriminated and digitalized.
- Then, the data will be passed to the lpGBT and VTRx+ on the PEB and converted to optical signal.
- Finally, the data will be received by the server through Felix IO card.

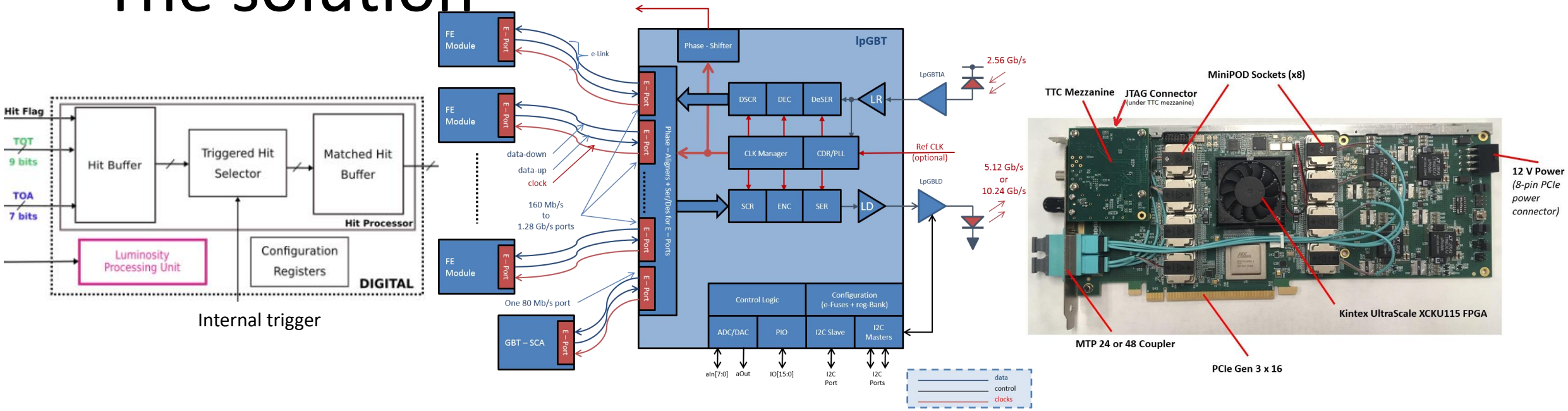
The requirement

	1.28 Gb/s	640 Mb/s	320 Mb/s	Luminosity	Total
Nb of module	1216	2976	3940	4192	8032 (Timing) + 4192 (Luminosity)
Total bandwidth	1556.48 Gb/s	1904.64 Gb/s	1260.8 Gb/s	2682.88 Gb/s	7404.8 Gb/s



- There are 225 channels on each ASIC, and only the data matches to a trigged BC will be readout to control the bandwidth to a reasonable range.
- According to the simulation, the modules at different radius face different flux, thus they need different readout bandwidth.
- But 8032 modules will still bring a very high bandwidth requirement.
- When so much data pass to the Felix and be distributed to different server, we need to find all data pieces and organize them into events through high-speed network.

The solution

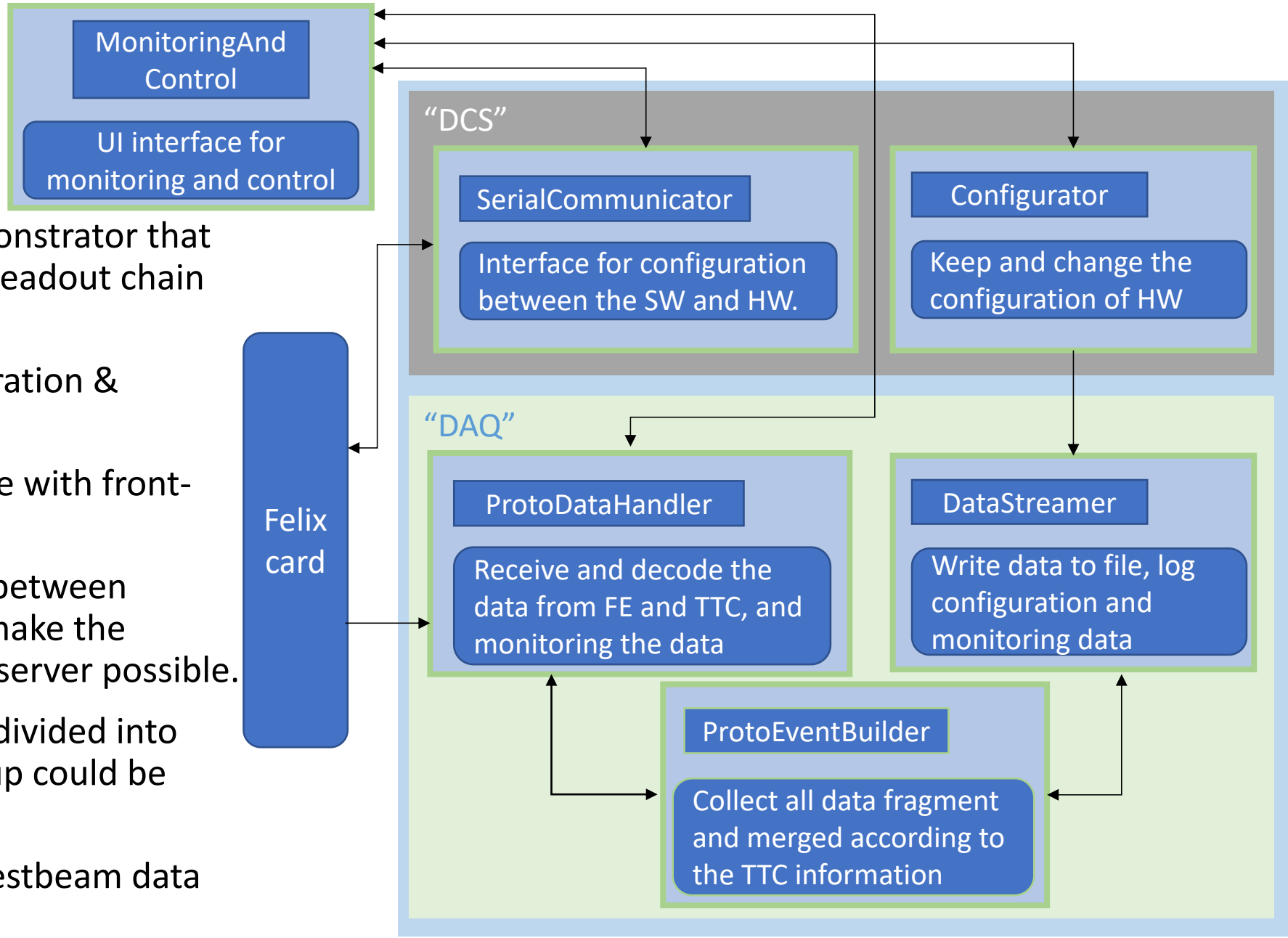


- For the ASIC, there will be a buffer that stores all the data, once the signal is higher than threshold. The depth of the buffer is decided by latency of the trigger, once receiving the trigger, the ASIC will organize the hits from all channels into a frame along with the BCID.
- The bandwidth of lpGBT reaches up to 10.24Gb/s , and it will collect data from several ASICs.
- The Felix transfer the digital signal from several lpGBTs to optical signal and its bandwidth reaches up to hundreds of Gb/s.
- A high-speed and robust software will take over the data handling, event building and recording, our talk will focus on this part.

Framework

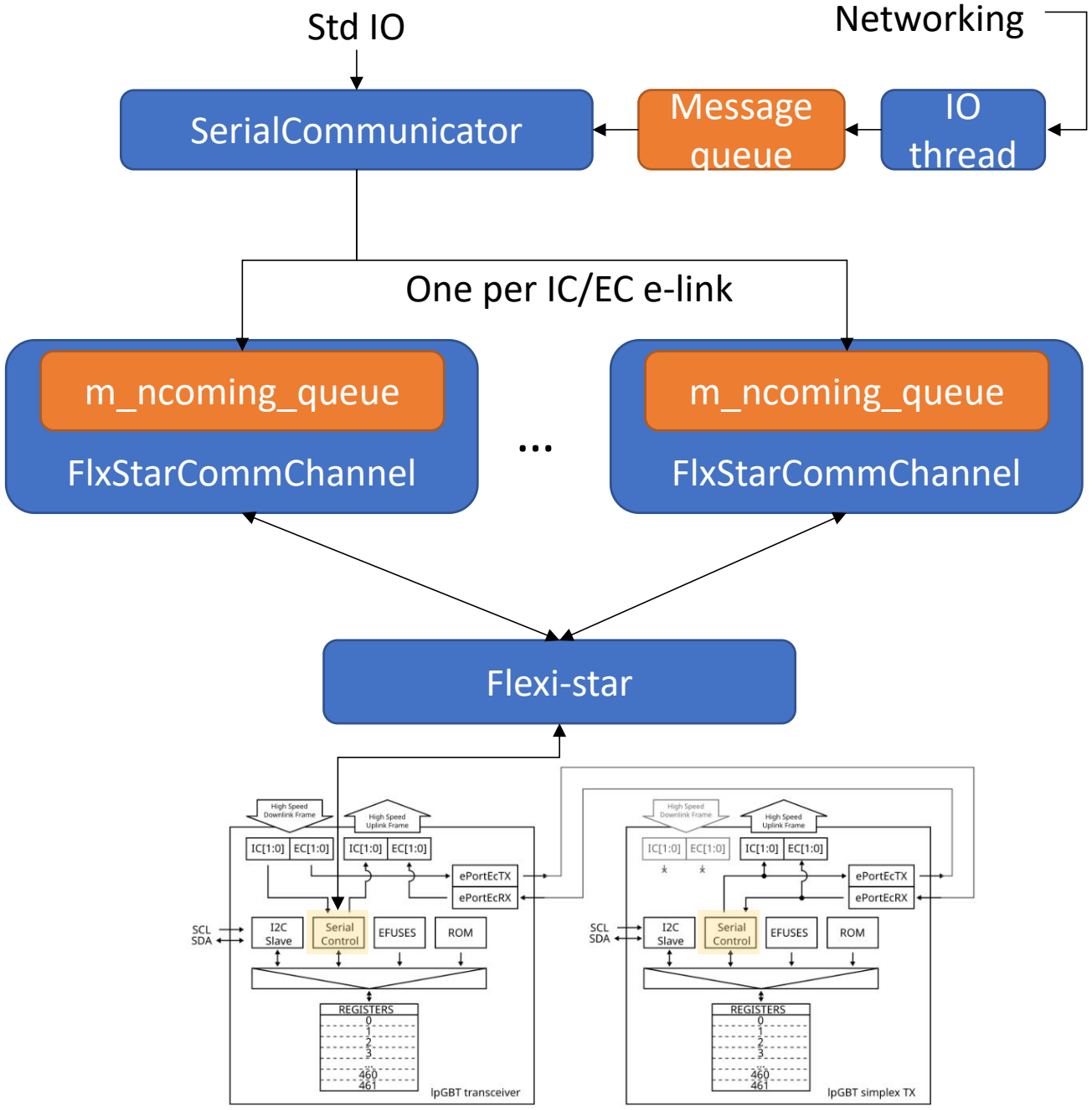
We are aiming to develop a demonstrator that will be used to implement a full readout chain using some TDAQ infrastructure.

- Targeting to develop a configuration & readout software.
- Using felix-star to communicate with front-end electronics
- Using TCP/IP to communicate between different components, which make the process of data from different server possible.
- Due to different functions are divided into different processes, the scale up could be relatively easy.
- Planning to be used in HGTD testbeam data taking.



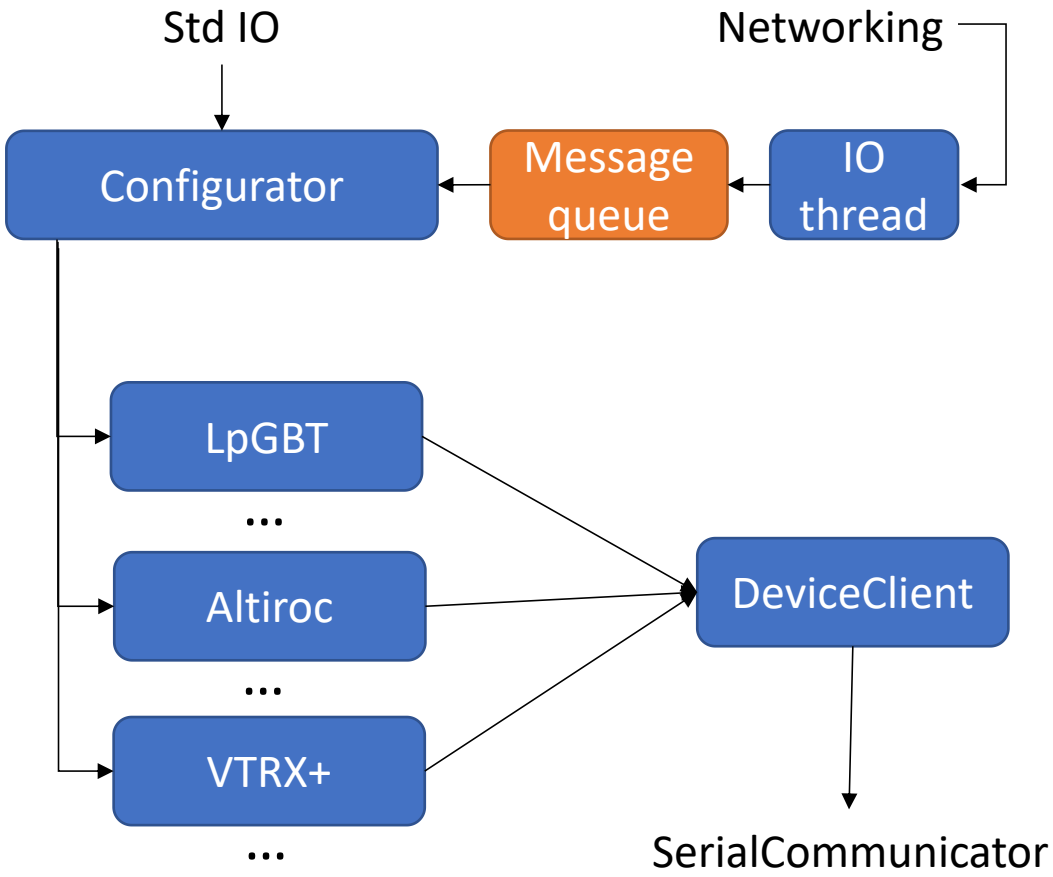
Serial-Communicator

- First of all, in DCS (Detector Control System), we need to configure all the front-end electronics. But there are too many components.
- There are so many Felix IO cards and so many lpGBTs, we need a package to help us find the correct one, so we create the SerialCommunicator package to serve as an interface.
- Two classes has been defined in this package.
  - SerialCommunicator, Works as a controller and distributes the corresponding messages to the different FlxStarCommChannels.
  - FlxStarCommChannel, The actual part communicates with the Felix card through the felix-star process, one for each lpGBT.



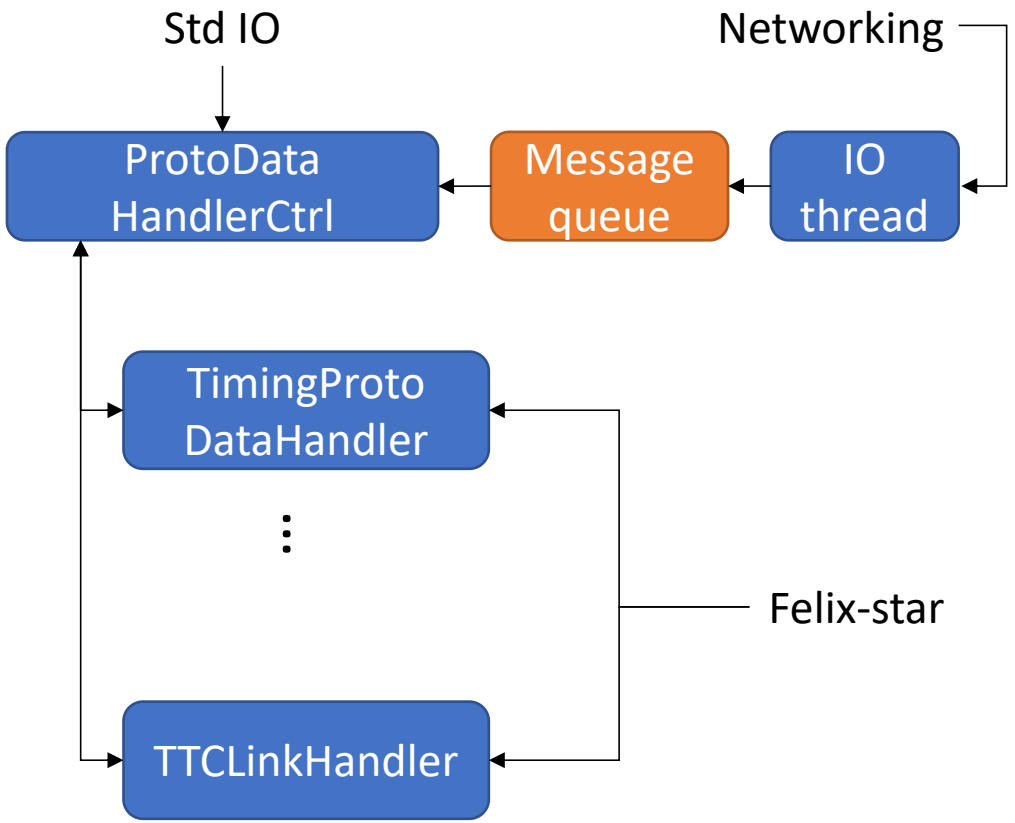
Configurator

- Now we know which link should be used, but there are different type of devices (lpGBT, Vtrx+, Altiroc) need to be configured, and there are tens or even thousands of devices of each type.
- We create the configurator package to help us record and change the configuration for each devices.
- During initialization, it instantiates objects according to the configuration files.
  - It will keep and forward changes to SerialCommunicator.
- Three types of classes has been defined in this package:
  - Configurator, controller to initialize and maintain all devices.
  - Devices (Altiroc, lpGBT, Vtrxp), used for recoding configuration and generate config command.
  - DeviceClient, forward config command.



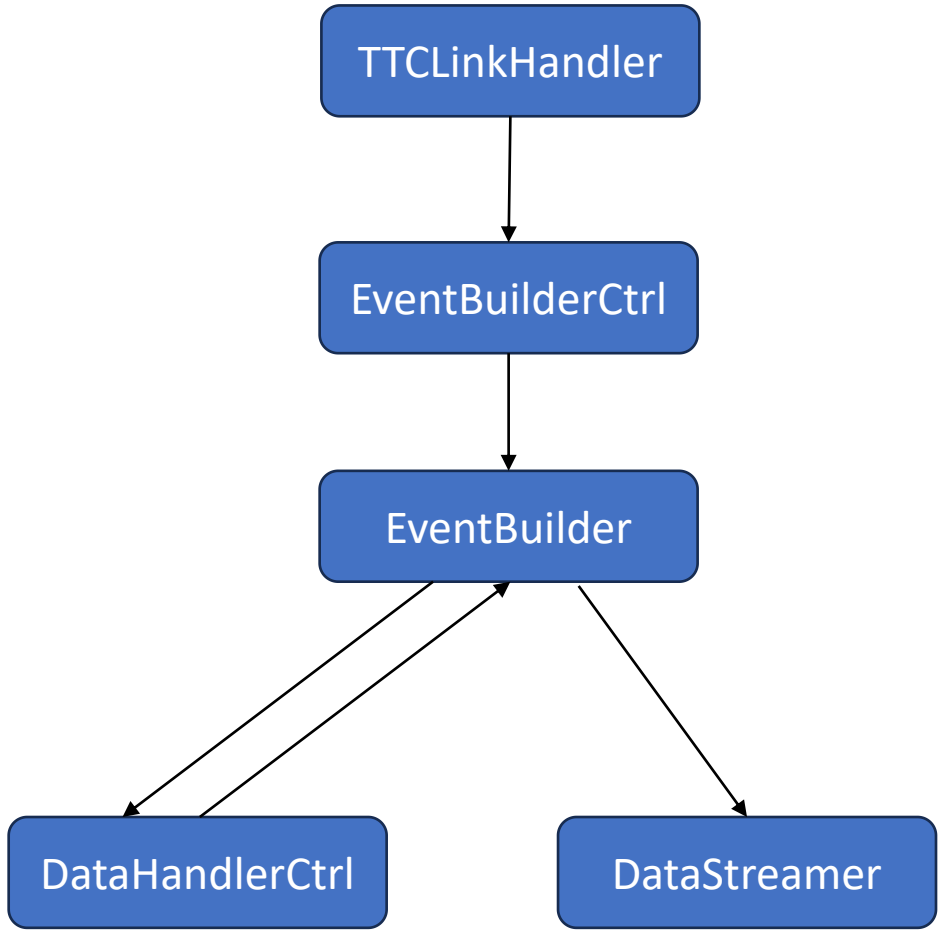
Proto-Data-Handler

- In DAQ, the data from Felix card is still encoded according to the Front-end electronics, we need a package to help us retrieve data from felix card and decode it to a more readable format.
- We implement the ProtoDataHandler to help us get data ready for the further process and storage.
- Four classes have been defined in this package:
  - ProtoDataHandlerCtrl: coordinate following components.
  - TimingProtoDataHandler: decodes data from Altiroc through Felix and transfers it to the EventBuilder.
  - TTCLinkHandler: decodes the data from TTC and forwards it to the Eventbuilder.
  - MonitoringObjects: create monitor plot.



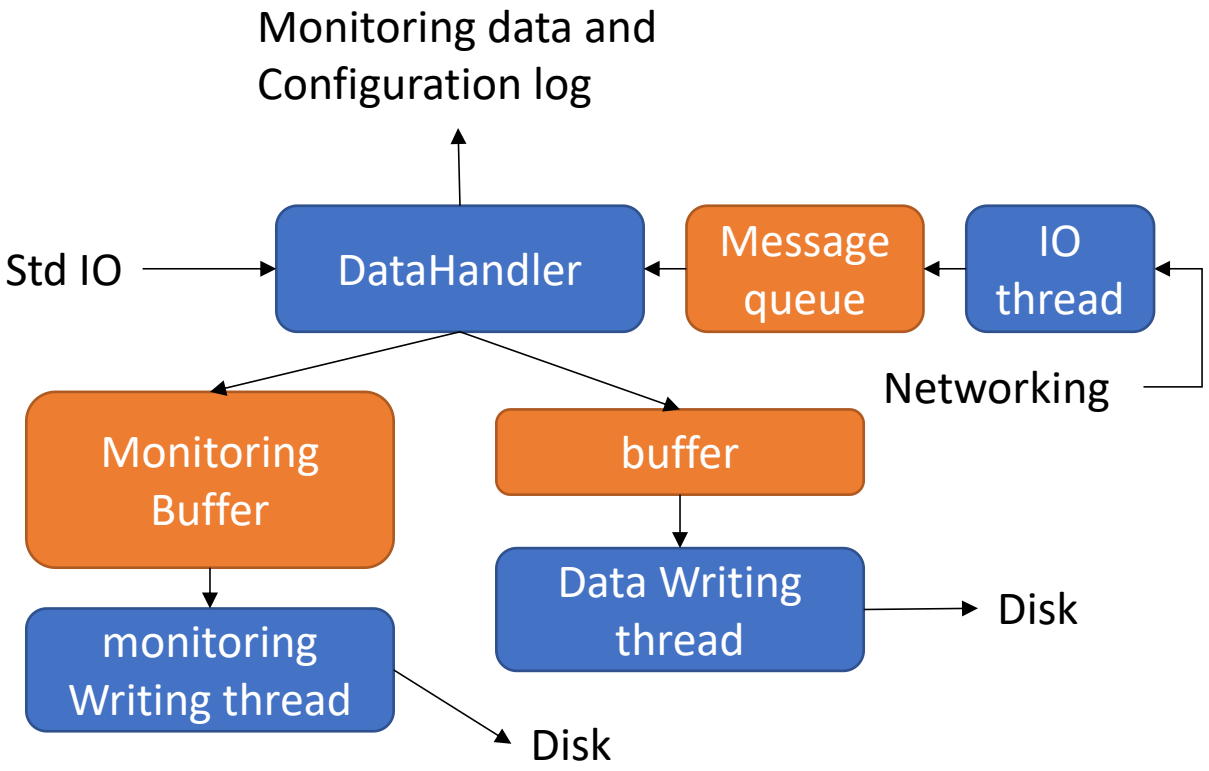
Proto-Event-Builder

- Then we need to organize data from ProtoDataHander into event, we implement the ProtoEventBuilder to find all the event pieces with same BCID.
- The EventBuilder will request data from DataHandlerCtrl with received BCID, to collect all the data frame with consistent BCID.
- The EventBuilder will organize these frame according to the Felix link ID, and tag event with both BCID and trigger id.
- The built event will be sent to DataStremer for permanent storage.

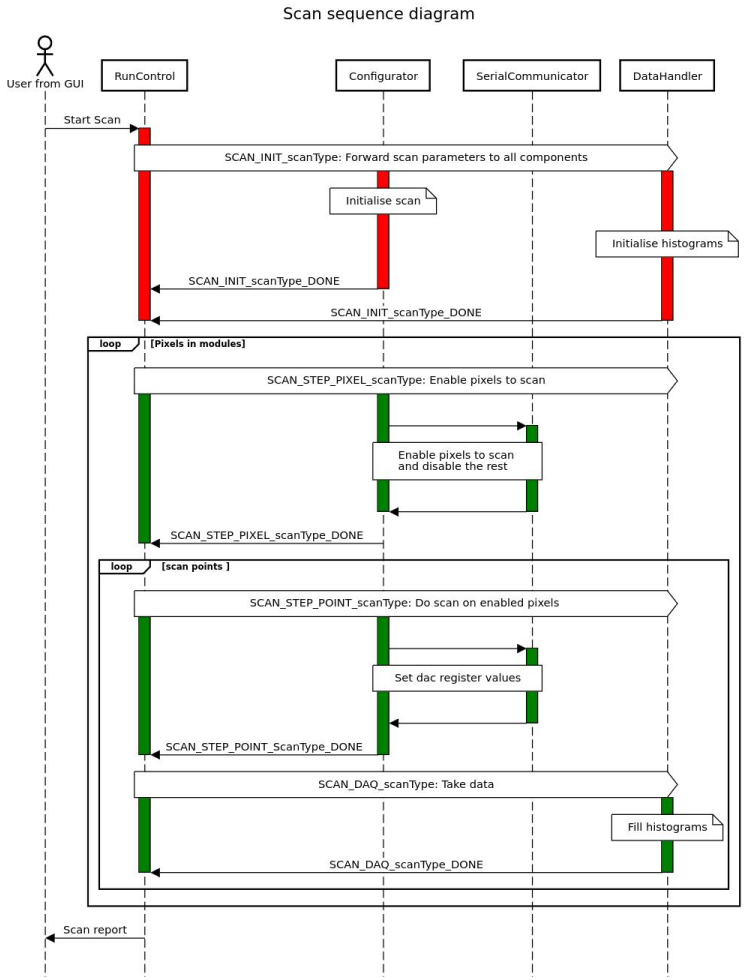


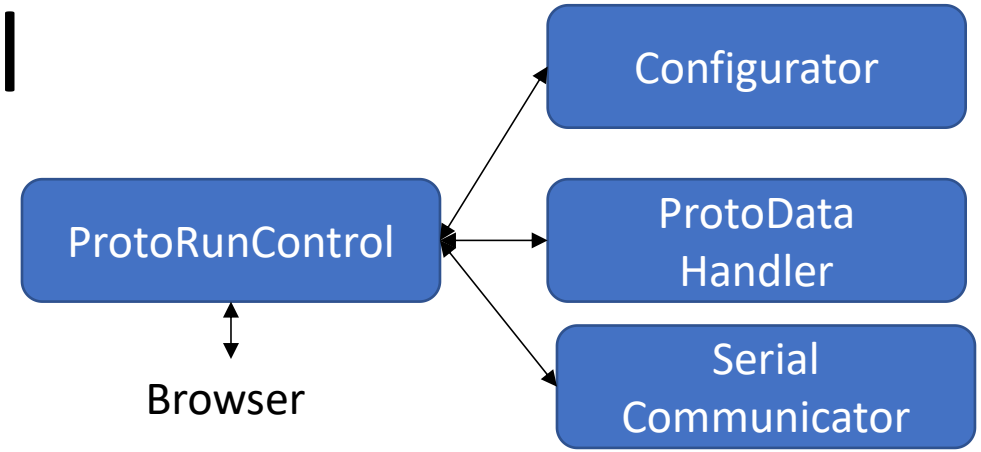
Data-Streamer

- We get timing data and monitoring data, and now we need a package to record these data in dedicated methods, which balance the accessibility and efficiency.
- The DataStreamer will be used for
  - Recording timing data.
  - Recording configuration changed for each process.
  - Recording register changed for all the hardware.
  - Recording the monitoring data.
- Now I use multi-threads and buffer design to,
  - Deal with the mismatch of IO speed for disk, memory and networking.
  - Responds to message or std IO promptly.
  - Different data type need different way for organization before storage, do this parallelly can improve the efficiency.



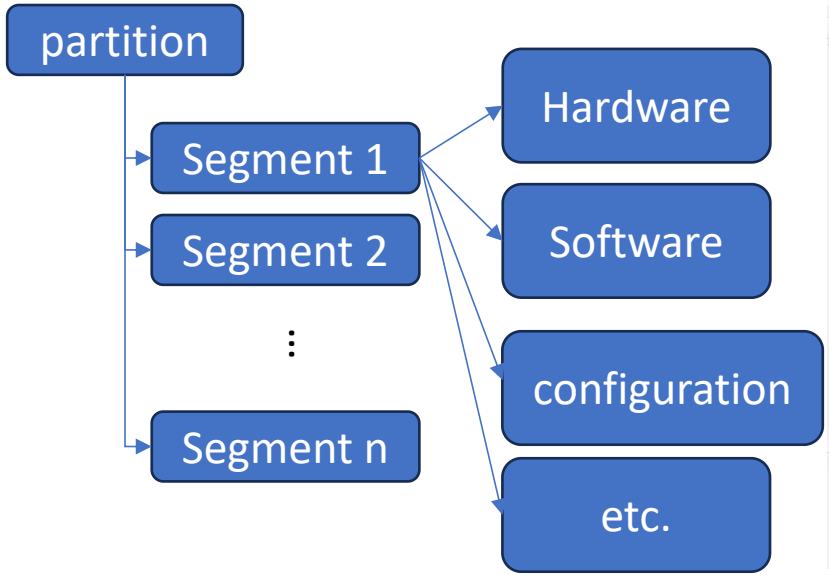
Monitoring-And-Control

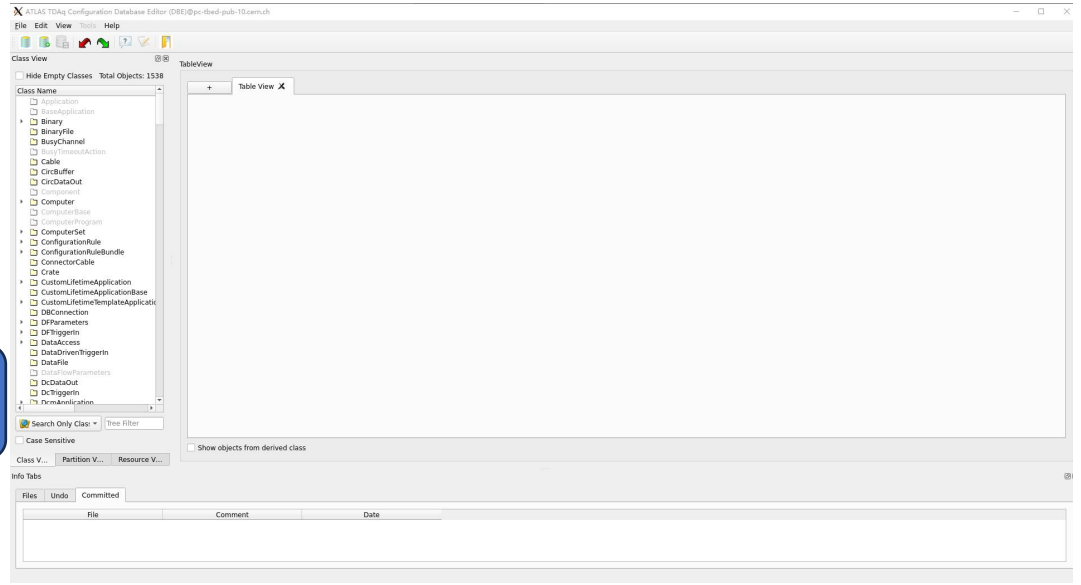


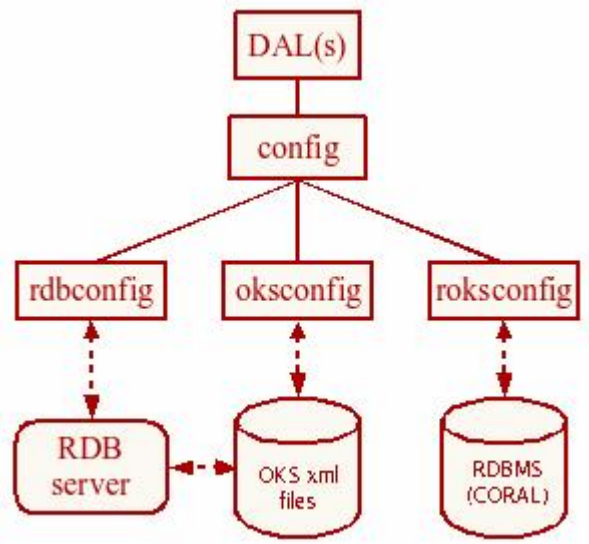


- To coordinate all the process, we need a package to control the state of each software.
- We also want to get out of communicating with these process through the indirect way like command line.
- We create MonitoringAndControl package.
- Works as an HTTP server to provide a web interface for control.
- This package will also monitor some signal from FE.

Partition, Segment and OKS database



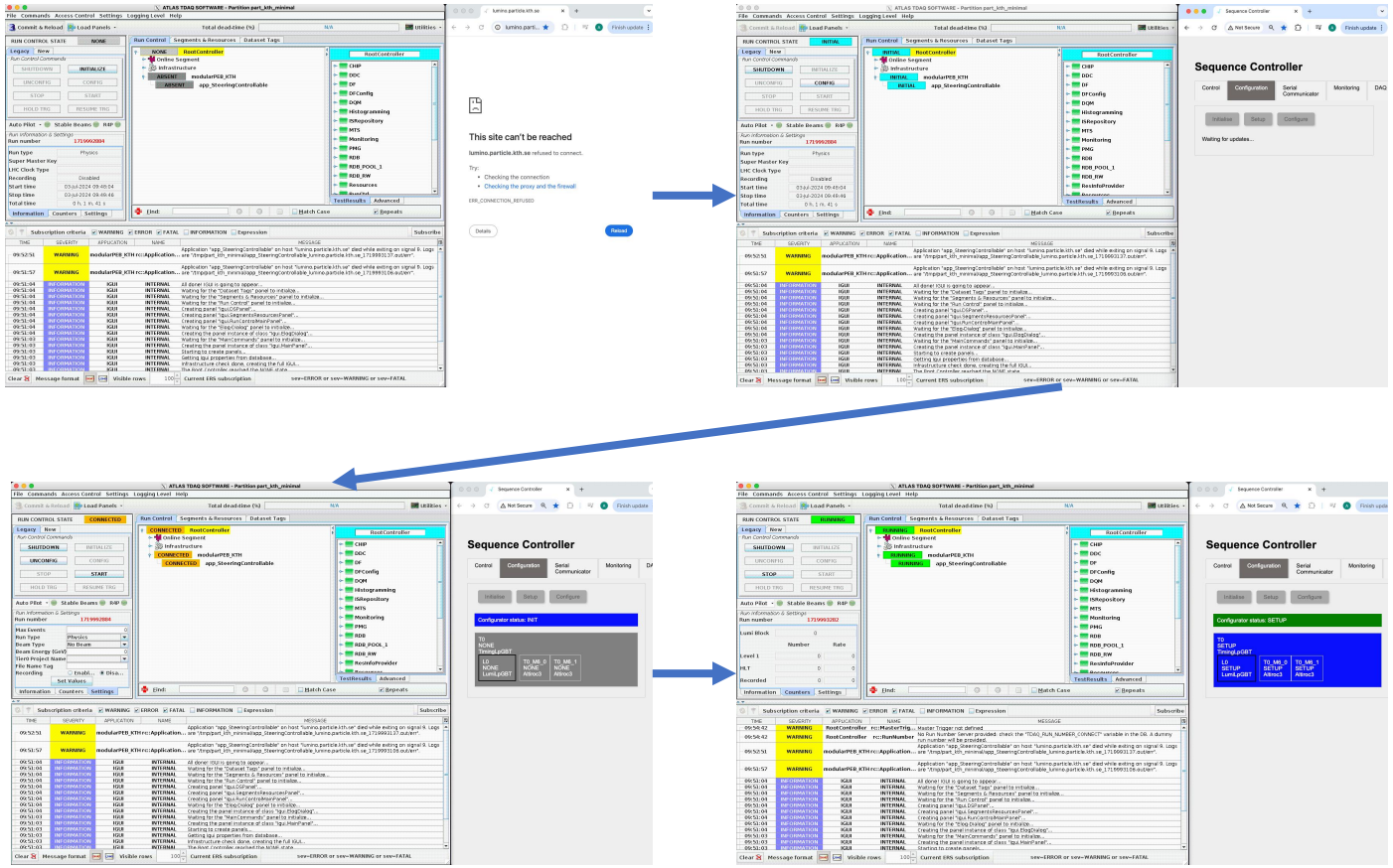




- As a part of ATLAS TDAQ system, the HGTD DAQ software need to be organized into partition
- The partition works as the root of other objects, this is the start point when raising an TDAQ system.
- Segment basically including all the configuration needed by an application. Every actual detector corresponds to a Segment.
- All the components needed in the ATLAS experiment running must be defined in the Object Kernel Support (OKS) database:
  - HW, including computer, network and so on.
  - SW, the software, the environment variable, the resources needed by process.

Partition demonstrator

- All the processes in the ATLAS DAQ system need to follow the Finite States Machine designed by TDAQ group, so that the process can be coordinated.
- We have setup the first partition and write the first process following the FSM requirement.
- This software can be coordinated by ATLAS. We will migrate all of our code to this form.



Summary and plan

- We have successfully readout and recorded the monitoring data to validate the readout chain.
- The basic functions of each components are well advanced and ready for the joint test.
- Basic TDAQ infrastructure for cooperation of processes set up.
- We have setup a demonstrator software follow the ATLAS FSM, and can already run within a partition coordinated by ATLAS TDAQ infrastructure!

- We are now trying to implement a full-chain demonstrator and use all the components to perform a scanning and tuning procedures of ASIC .
- We are also trying to use the ATLAS TDAQ infrastructure, using the OKS database to record all the executable and configuration files.
- Started discussion to work on configuration of SW ROD for HGTD.

Thanks for your attention!

Backup