EURIZON Annual Meeting 2023

WP2 session

Central components of the CBM readout: Hardware and Software

- (m)CBM data Acquisition
- DAQ software components
- Online processing
- Controls

WP 2.2: Developments for the data acquisition chain, for data preprocessing and computing for mCBM and CBM at FAIR

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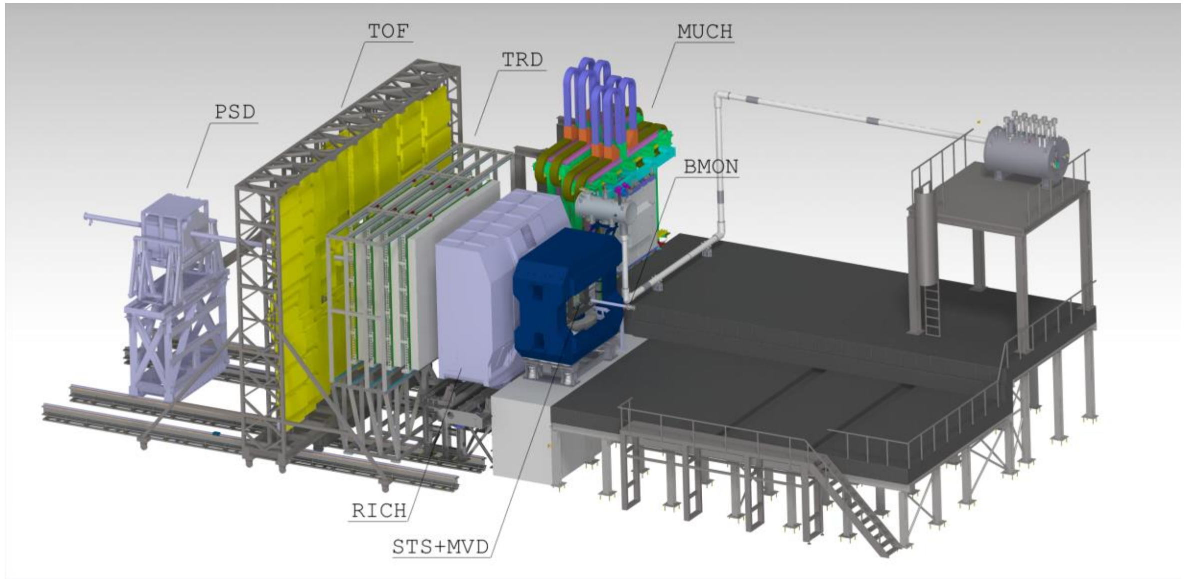
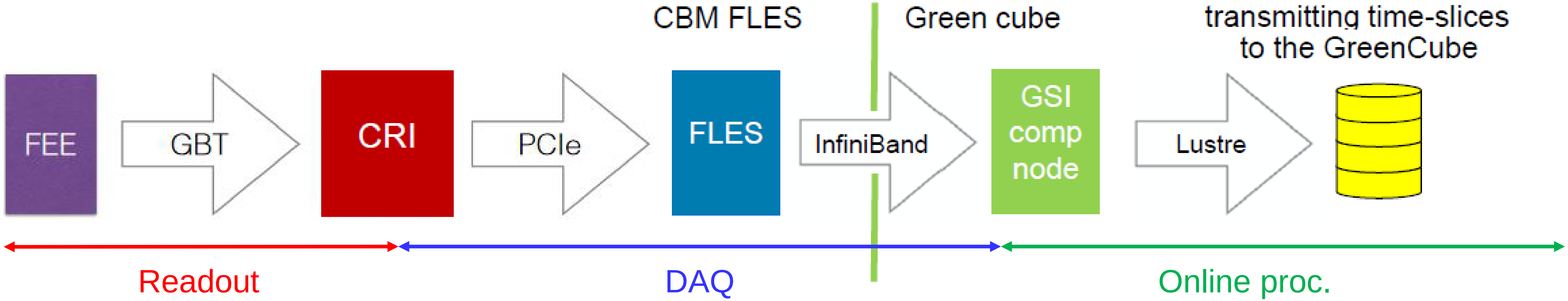
CBM data Acquisition



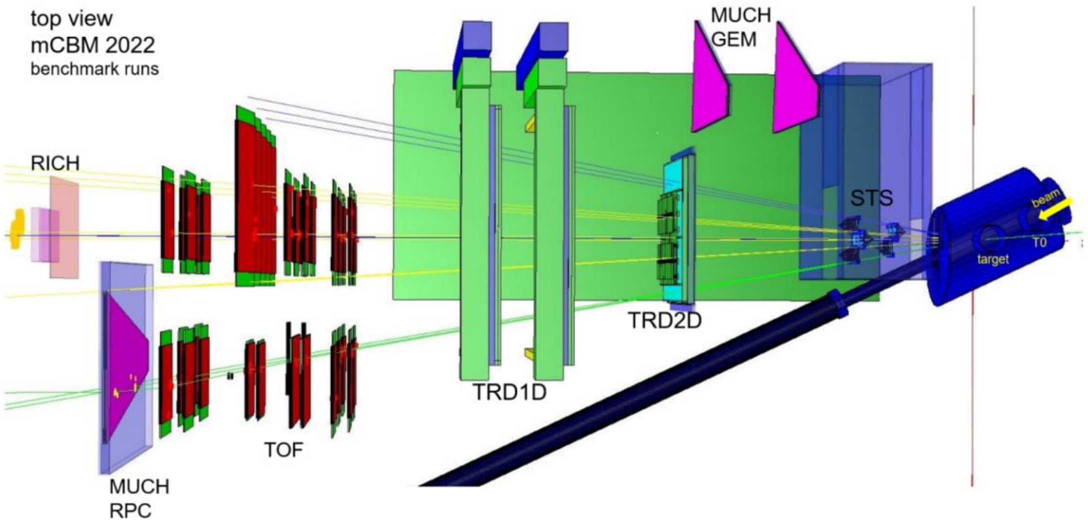
- 8 main detector systems
- Fully free-streaming acquisition (no HW trigger)
- Online processing computing farm in the GSI/Fair "Green IT Cube": O(100 k) cores

3 main stages:

- Readout chains: data generation and system specific transport
- DAQ: data organization and generic transport
- Online processing: data reconstruction and selection, archiving



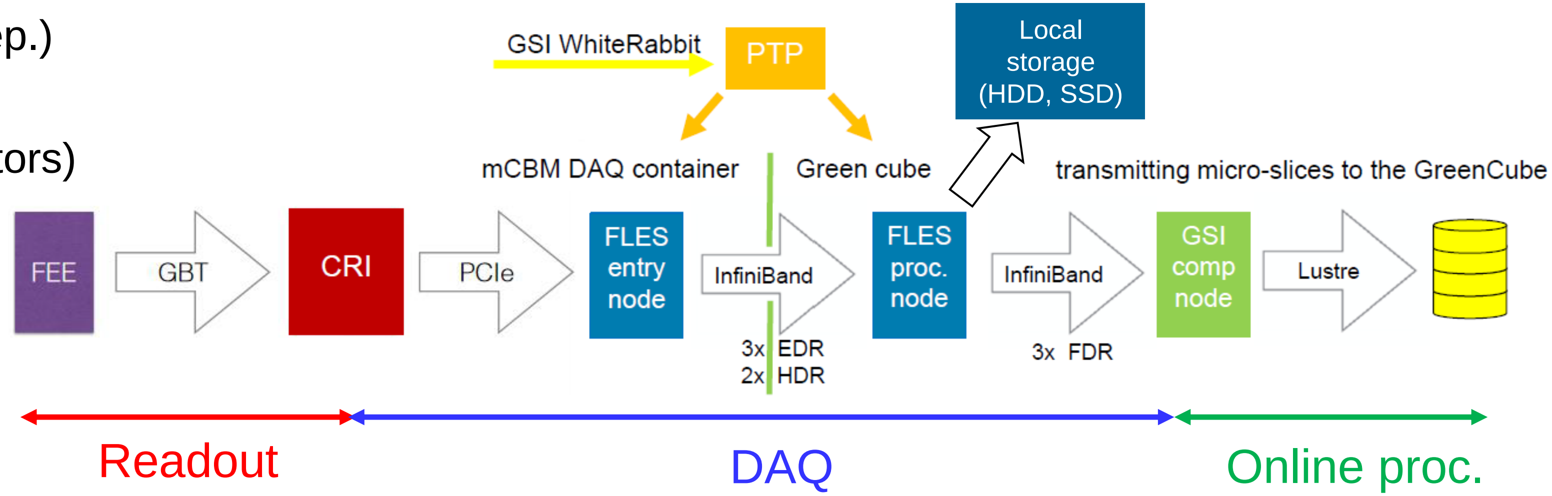
Prototype: mCBM (2nd phase, 2021-2022+)



- Permanent setup at GSI in dedicated cave
- SIS18 beamline
- Prototypes of 7 out of 8 CBM detector systems
- Up to 5 used at a time for physics analysis
- Reference measurement: $\Lambda \rightarrow p\pi^-$ decay
- Similar "HW/SW stress environment" as CBM
- O(100 TB) recorded in 2022 campaign

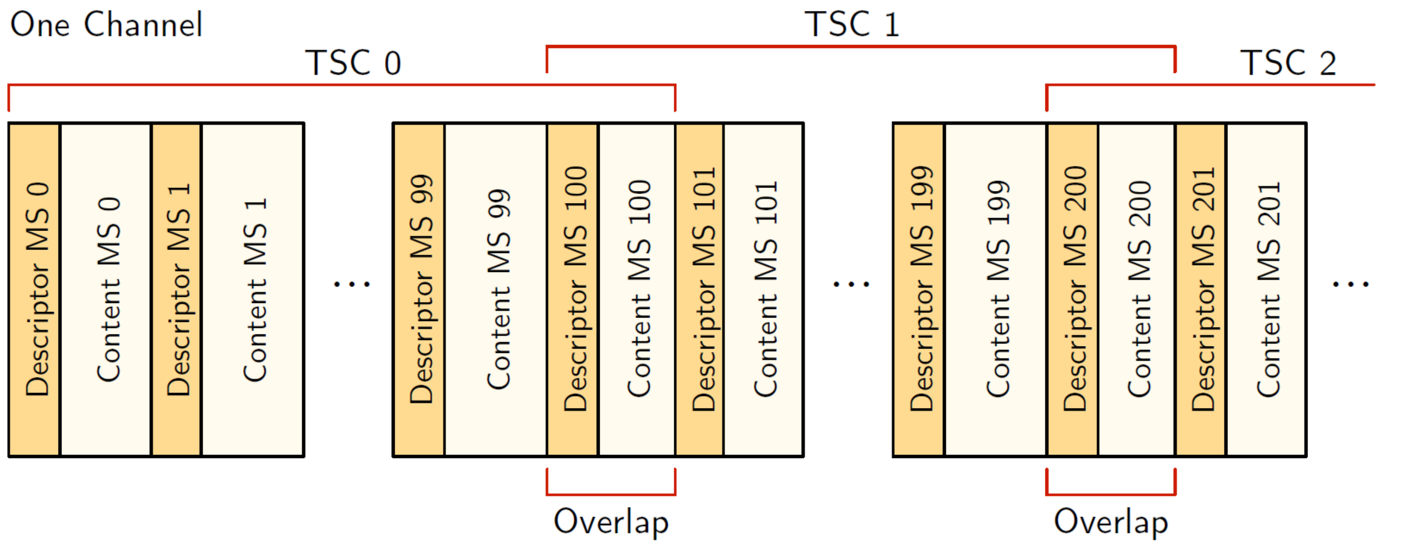
<u>Main differences to CBM in acquisition:</u>

- Reduced connectivity (3-10% CBM, detector dep.)
- Non final readout interface boards
- Evolving setup (each year closer to CBM detectors)
- In 1st and 2nd phases, no online data selection
- In 1st and 2nd phases, link from entry cluster to compute cluster not used in production
- Limited/prototype central coordination features

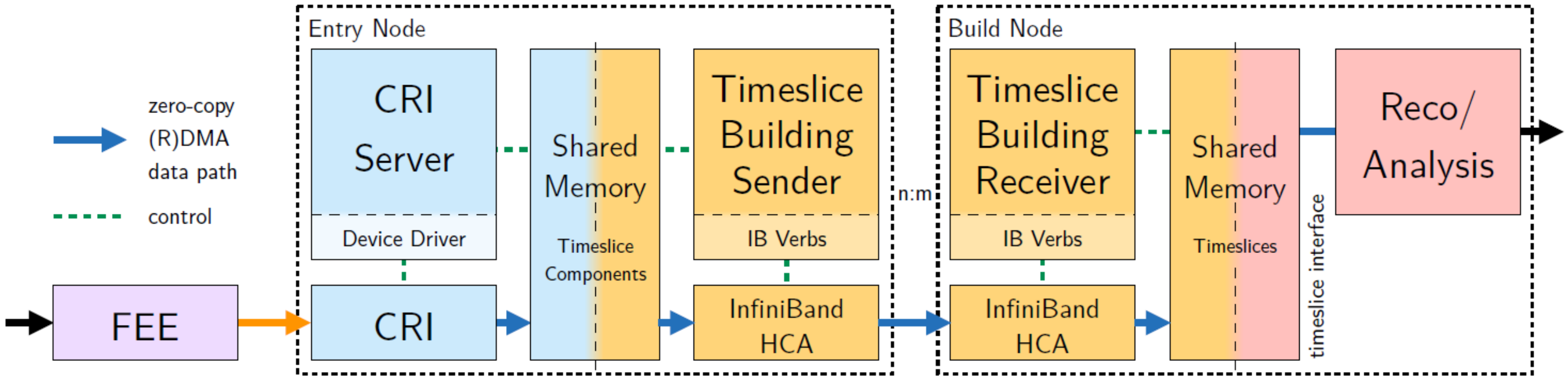


DAQ Software

- Data model:
  - microslices: self-contained blocks of data from a single source for a given period of time
  - timeslices: collections of microslices from multiple sources, overlapping over time
- FLES software (aka Flesnet):
  - Driver reading from CRI though PCIe
  - Timeslice builder sender/receiver
    - ⇒ Internal data transport & flow control
    - ⇒ Timeslice assembly



- mCBM specific FLES software:
  - Timeslice client
    - ⇒ Archiving of timeslices
    - ⇒ Publishing for monitoring
    - ⇒ Publishing for processing
  - InfluxDB + Graphana
    - ⇒ FLES monitoring



DAQ Software: operating mCBM in 2022

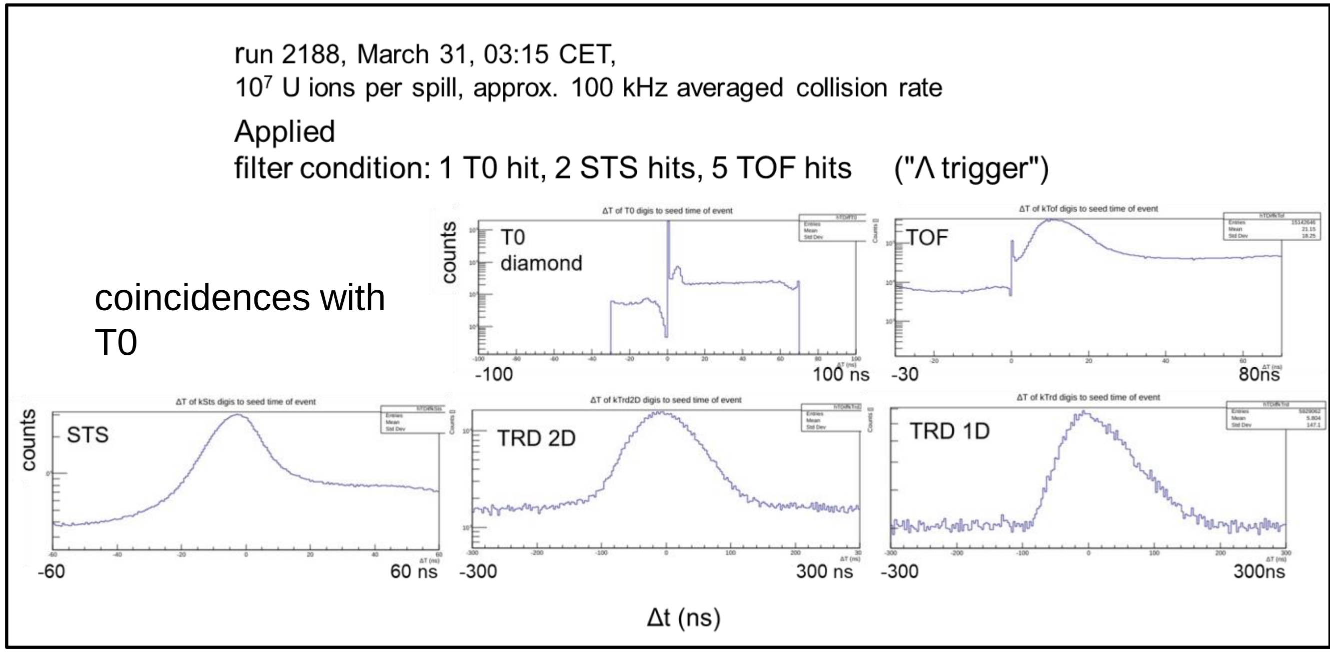
- No complete Experiment Control Software (ECS) available
- Additional layers added, with a CLI, to
  - Keep track of runs and their configuration
  - Start the cluster processes needed to perform the acquisition and archiving
  - Synchronize all systems before starting the readout
  - Enable/Disable data emission in a synchronized way for all systems

- Typical run sequence:
  - Ask detector shifts if they are ready and have their system configured
  - If needed, created a “configuration tag” selecting or excluding detector systems
  - Start the FLES run with a given recording/readout configuration tag
  - Common-start: re-synchronize the time counters of all participating systems, then communicate to all a common start point for data emission in future (5-6 s), strict for all
  - Monitoring of data rates in FLES, of data quality in data sample, …
  - Common stop: communicate to all system a common stop point for data emission in future, can be loosely obeyed
  - Stop the FLES run, which closes all processes in right sequence and archive some run logs

Online Processing: plans and mCBM

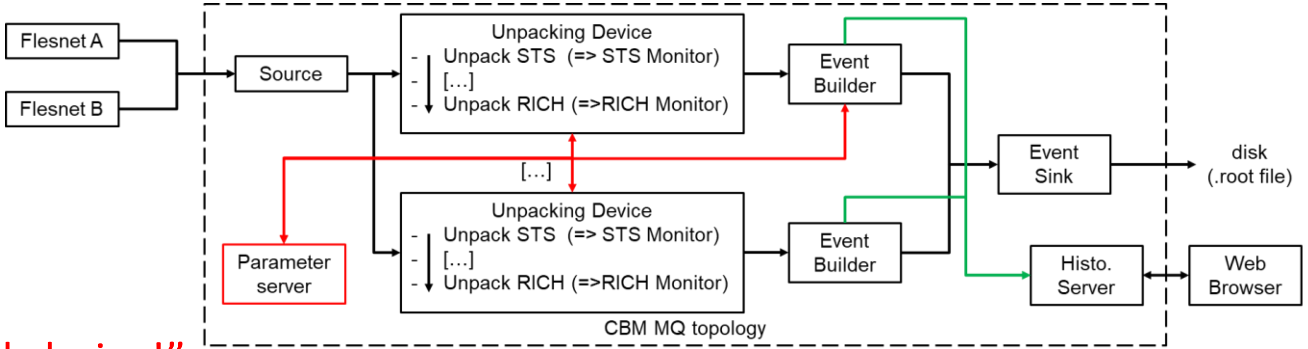
CBM plan

- Data unit for online processing = Timeslice
- Depending on physic cases
  - reconstruction from single detector to full setup tracking
  - event definitions may vary, ground for decision may not cover all signals
    - ⇒ "Event seeds" more than events
- Selection of data from looser time region around these event seeds for archiving
  - ⇒ allow more involved offline calibration if needed



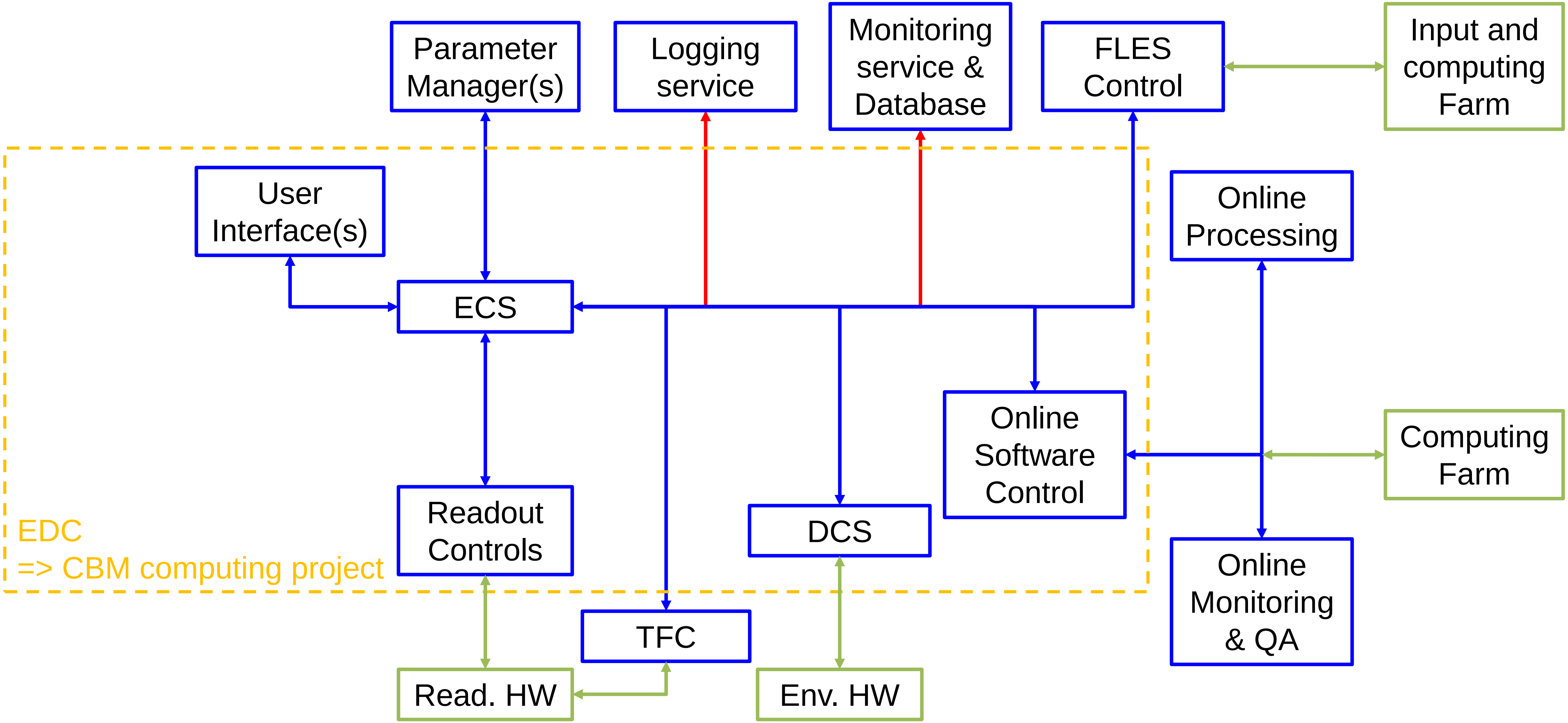
mCBM usage

- Bring stages of offline selection in FairMQ devices
- Online testing with coarse controls
- Used for 1st stage of mass offline analysis
- Now testing "replay" Online controls with ODC/DDS



⇒Disclaimer: "these solution are maybe/probably not our final choice!"

My main Worksite: Controls? EDC? ECS?

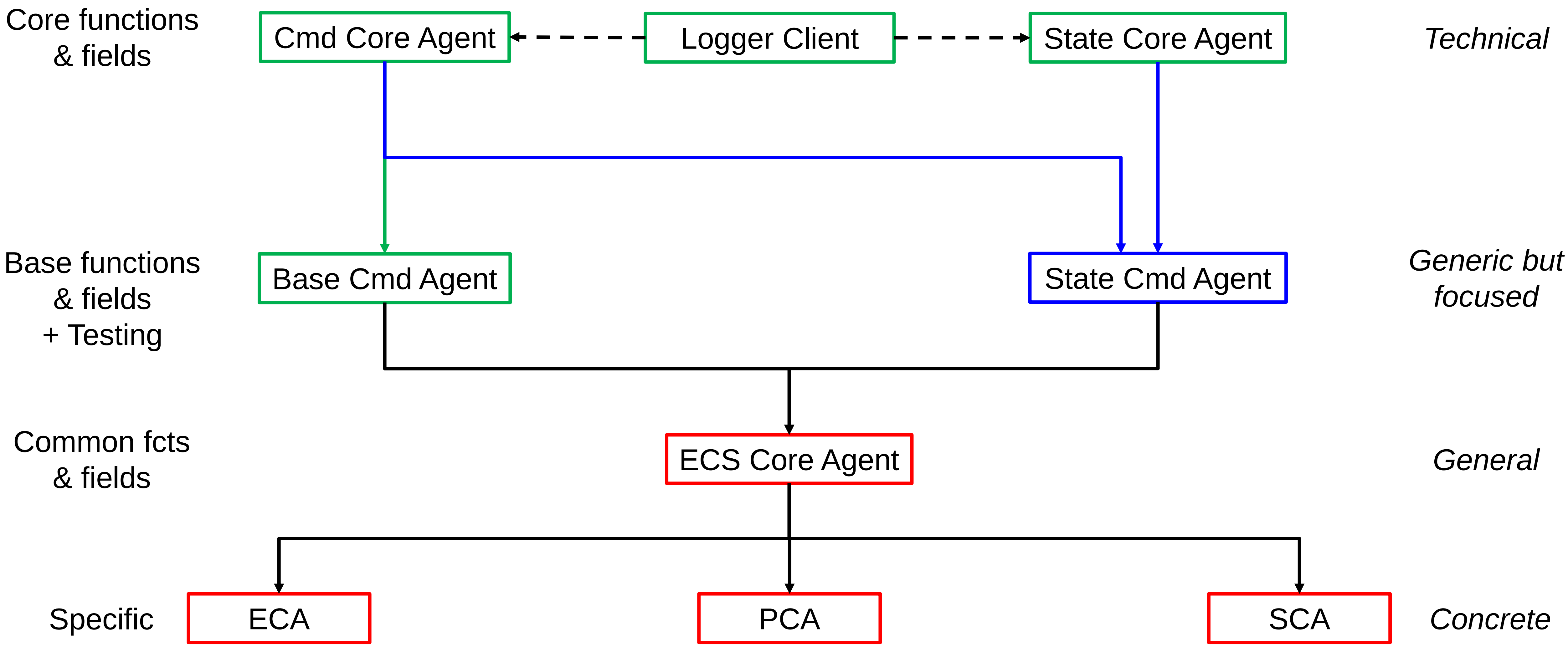


Readout controls

- C++ driver and low level management interfacing to the controls of the CRI FW and the full readout chain
  - “Device Control Agent” or DCA
  - At least one instance per entry node, at most one per CRI
  - Completely event (action) driven, from RPC calls by the controlling Python layer
  - Allows for atomic requests, queued requests and timed actions (e.g. periodic read for monitoring)
  - For now mostly providing low level register access
  - but later planned to hold most of the control logic to provide “atomic commands” and avoid access conflict
  - ⇒ Framework by FAIR colleague and system specific code by FPGA experts

- Python control libraries implementing the user interface
  - For now (2021-2022) also including most of the control logic and sending single register R/W requests
  - Later planned to mostly send “Atomic Command + parameters” , leaving register access to DCA
  - Based on client-server architecture to allow “common commands”,
    - e.g. asking all detector systems to (re-)synchronize
  - Currently stand-alone with either CLI interface or central scripts sending command to all systems
  - Will be the main interlocutor of the ECS agents controlling detector systems
  - ⇒ Framework by myself and system specific code either by me or detector experts

ECS: Modular concept



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Thank you for your attention

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For more information:

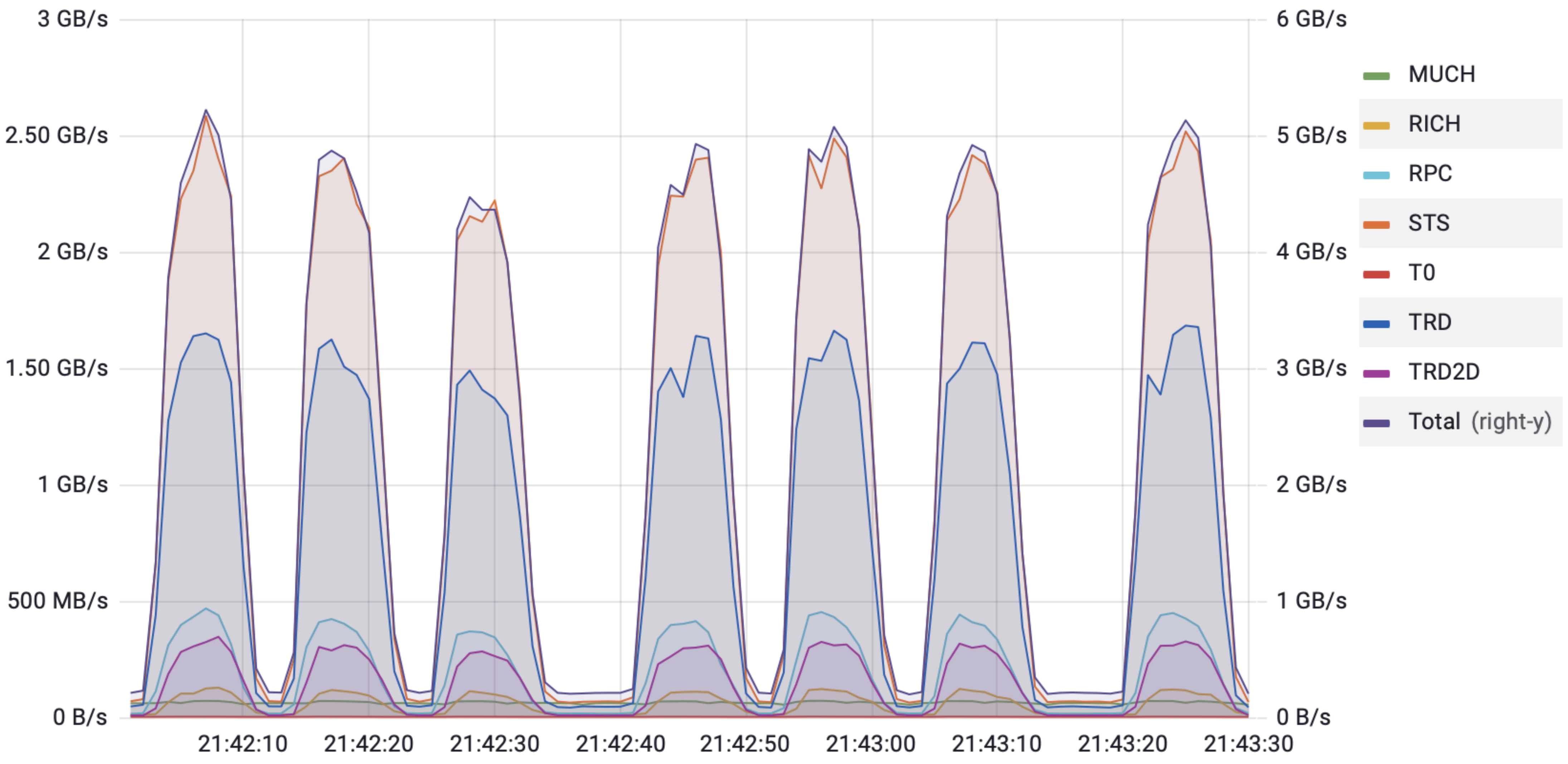
- *"Online Systems – Part I: DAQ and FLES Entry Stage", CBM TDR, currently under review and should be public sometime in 2023*
- *"CBM Progress Report 2021", 2022, https://repository.gsi.de/record/246663*
- *"mCBM proposal", CBM proposal to GSI G-PAC, 2017, https://repository.gsi.de/record/220072*

WP 2.2: Software for DAQ, Controls, Data analysis

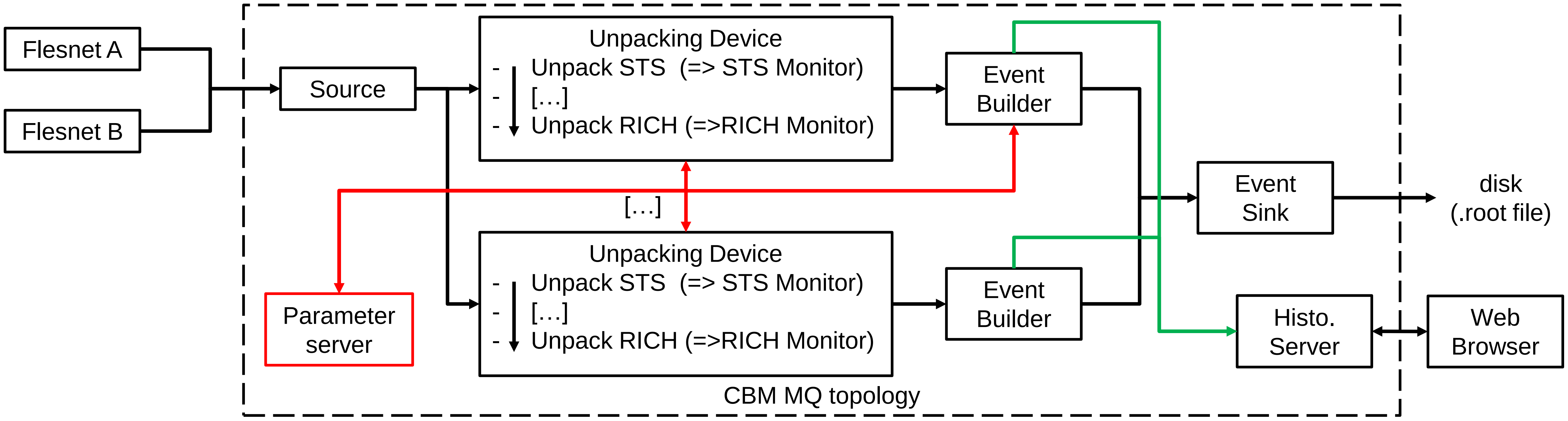
Assignee: P.-A. Loizeau

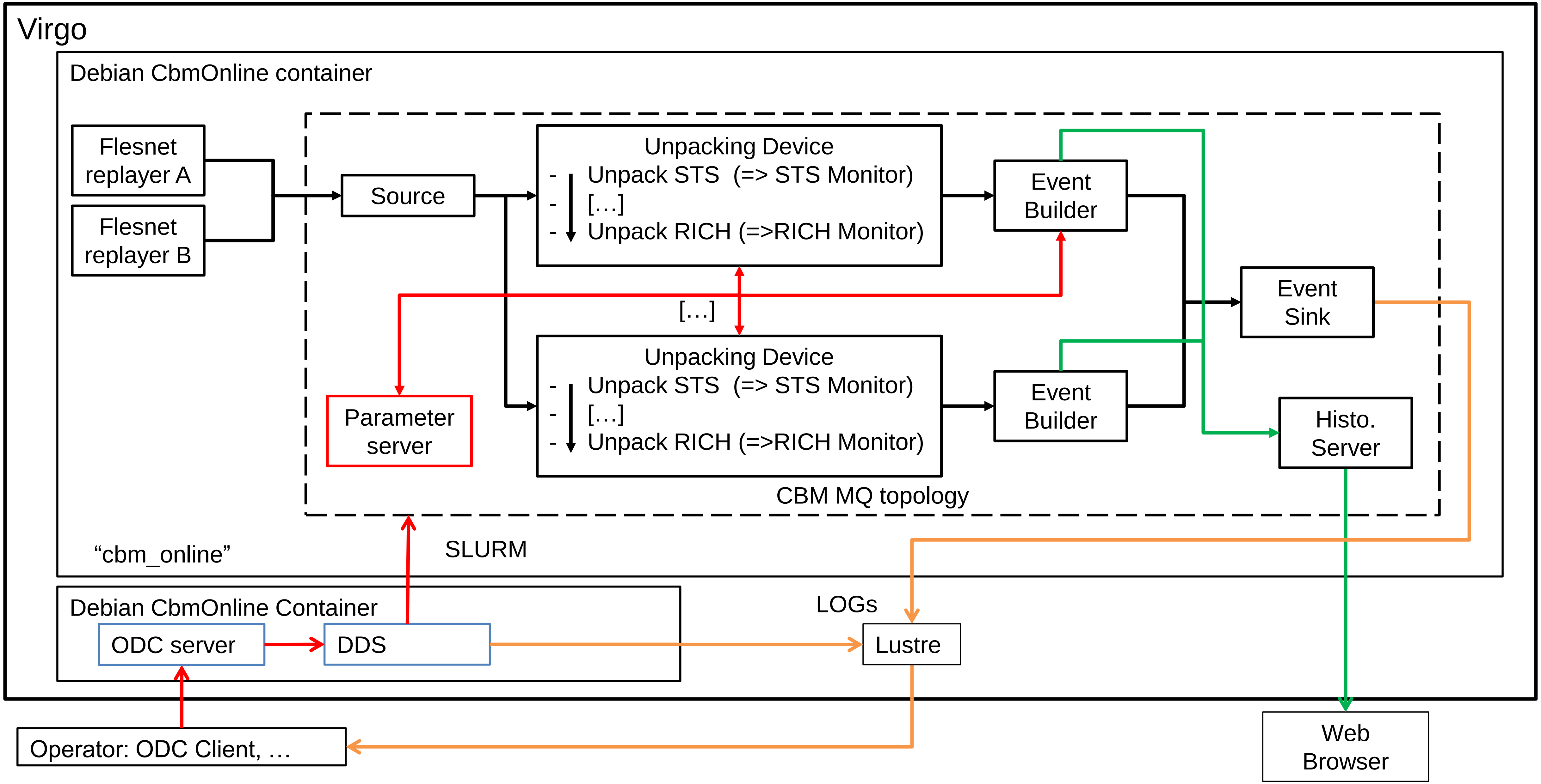
- Activities linked to WP2 in 2020-2022 period:
  - Finalization and support of the control SW for the AFCK based readout chain for the STS-XYTER (CBM STS laboratory, Kolkata CBM MUCH laboratory, mCBM 2020, BM@N tests)
  - mCBM
    - On-site support in the operation of the CBM DAQ prototype for mCBM 2020-21-22 campaigns
    - Development of a Python framework to control the CRI boards (High level part) and help for related detector-oriented developments, used for production in mCBM 2022 campaign
    - Development and support of online data monitoring tools for various mCBM detectors
    - Development and support of raw data unpackers and of event builders for mCBM
    - Test-deployment of these on the mFLES and Virgo clusters at GSI with the FairMQ framework to validate online processing concepts and test physical connections
  - Coordination of the “Experiment and Detector Controls” CBM computing project
  - Development of an “Experiment Control System” prototype for mCBM and CBM
  - General support and development with Cbmroot for CBM simulation and data analysis

Data rates in a mCBM DAQ high rate run (r2448)

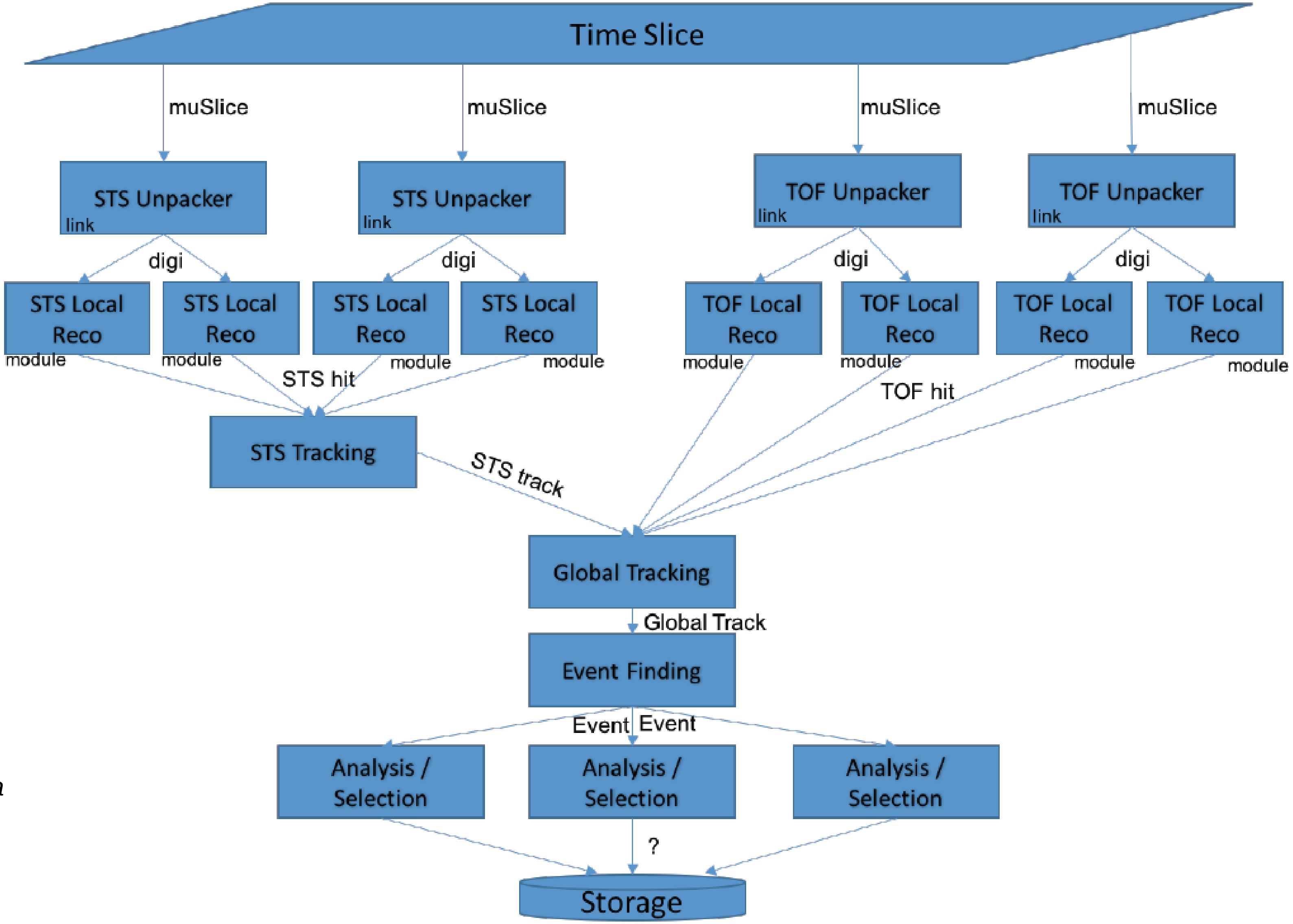


mCBM MQ test


Flesnet A
Flesnet B
Source
Unpacking Device
- Unpack STS (=> STS Monitor)
- […]
- Unpack RICH (=>RICH Monitor)
Event Builder
[…]
Unpacking Device
- Unpack STS (=> STS Monitor)
- […]
- Unpack RICH (=>RICH Monitor)
Event Builder
Parameter server
Event Sink
disk (.root file)
Histo. Server
Web Browser
CBM MQ topology


Virgo
Debian CbmOnline container
Flesnet replayer A
Flesnet replayer B
Source
Unpacking Device
- Unpack STS (=> STS Monitor)
- […]
- Unpack RICH (=>RICH Monitor)
Event Builder
[…]
Unpacking Device
- Unpack STS (=> STS Monitor)
- […]
- Unpack RICH (=>RICH Monitor)
Event Builder
Event Sink
Histo. Server
Parameter server
CBM MQ topology
"cbm_online"
SLURM
Debian CbmOnline Container
ODC server
DDS
LOGs
Lustre
Operator: ODC Client, …
Web Browser

Example: Simple CBM Process Graph (STS + TOF)



V. Friese
Theme Meeting on CBM
3rd February 2023, Jatni, India