

**AIDA** 2020

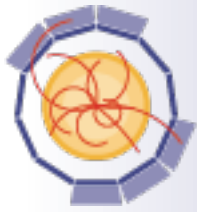
Advanced European Infrastructures  
for Detectors at Accelerators

# WP5: Data Acquisition System for Beam Tests

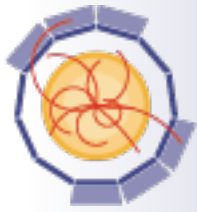
D. Cussans, on behalf of WP5



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654168.



- Introduction:
  - Aim of WP5: Common DAQ
  - Enhancements with respect to AIDA
- Status
  - Hardware – Trigger/Timing Logic Unit (TLU)
  - DAQ – EUDAQ 2
  - Data model –
    - mixing triggered, self-triggered, continuously integrating detectors
  - Data Quality Monitoring – DQM4HEP
- Project Planning
- Conclusion



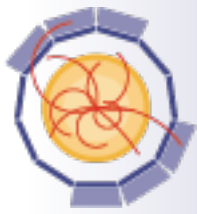
- Make software and hardware tools to make beam-test DAQ : Easier / Better / Nicer
- Focused on supporting Linear Collider R&D, but aiming to be general.
- A tool-kit for making DAQ systems
  - Inspired by XDAQ package
- Tools to build common DAQ systems from existing DAQ systems
  - Common run-control



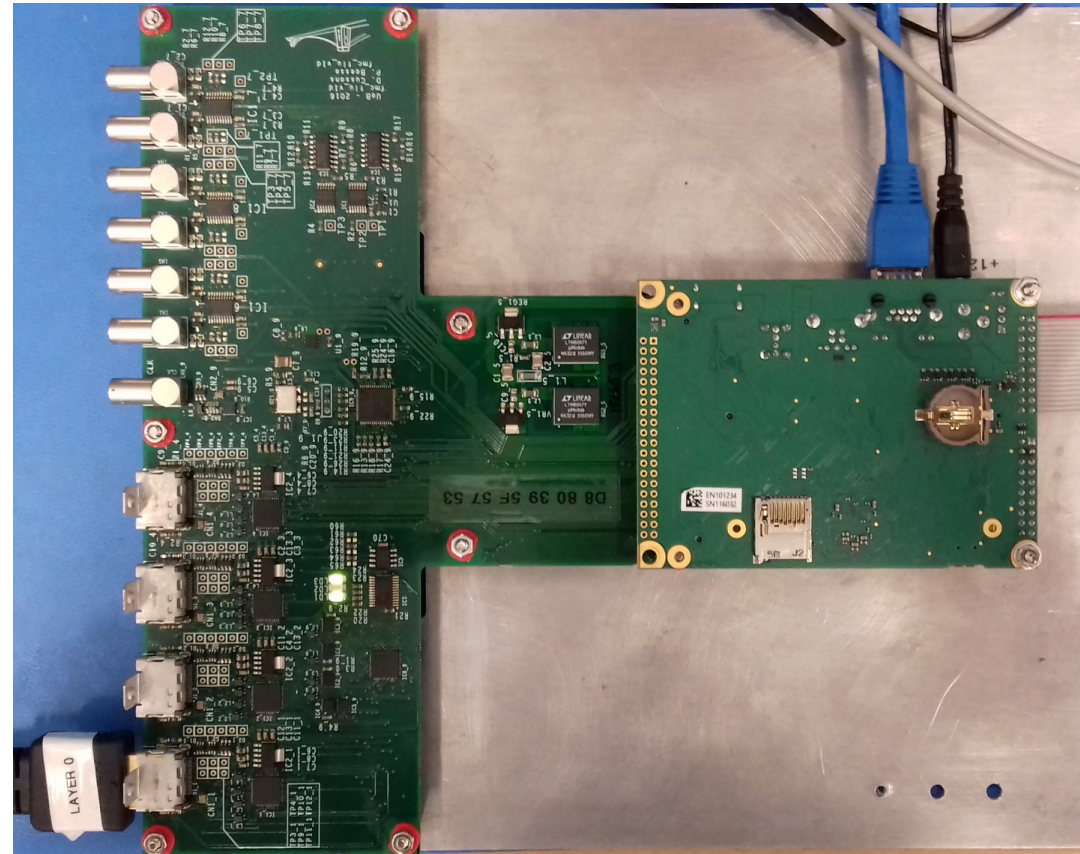
# AIDA<sup>2020</sup>

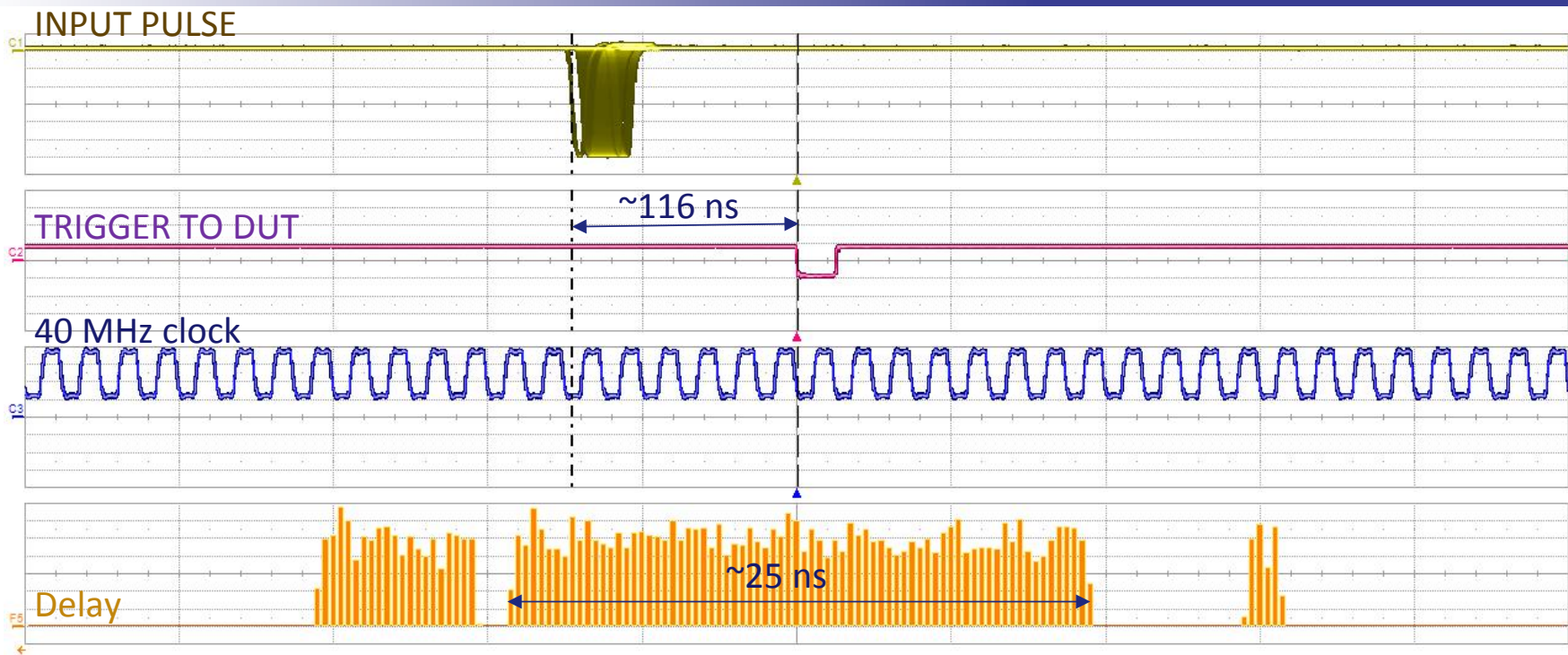
# Enhancements - Highlights

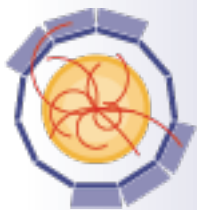
|                                | <b>AIDA</b>   | <b>AIDA-2020</b>   |
|--------------------------------|---|--|
| <b>DAQ software (EUDAQ)</b>    | Single data collector<br>Fixed FSM<br>Focused on beam telescope | Scalable data collector<br>Flexible state machine<br>General |
| <b>Data Model</b>              | Tag event with trigger number                                   | Tag event with trigger and/or timestamp                      |
| <b>Data Quality Monitoring</b> | Dedicated to pixel detectors                                    | Use DQM4HEP framework - general                              |
| <b>Hardware (TLU)</b>          | Aging FPGA family<br><br>4 trigger inputs                       | Current model FPGA<br>6 trigger inputs<br>Low jitter clock   |
| <b>Beam telescope</b>          | Trigger rate < O(10kHz)   | Trigger rate < O(1MHz)                                       |



- New hardware based on the successful miniTLU one
- More trigger inputs (4→6)
- Increased number of DUT (3→4)
- Multiple clock generation options
  - On-board oscillator
  - DUT
  - Differential LEMO
  - Highly configurable clock chip
- mini-HDMI → HDMI connectors
- Fast threshold discriminators for trigger detection
- Firmware ported to Xilinx series 7 devices
- Launching production in 2 weeks – contact us if interested in a unit





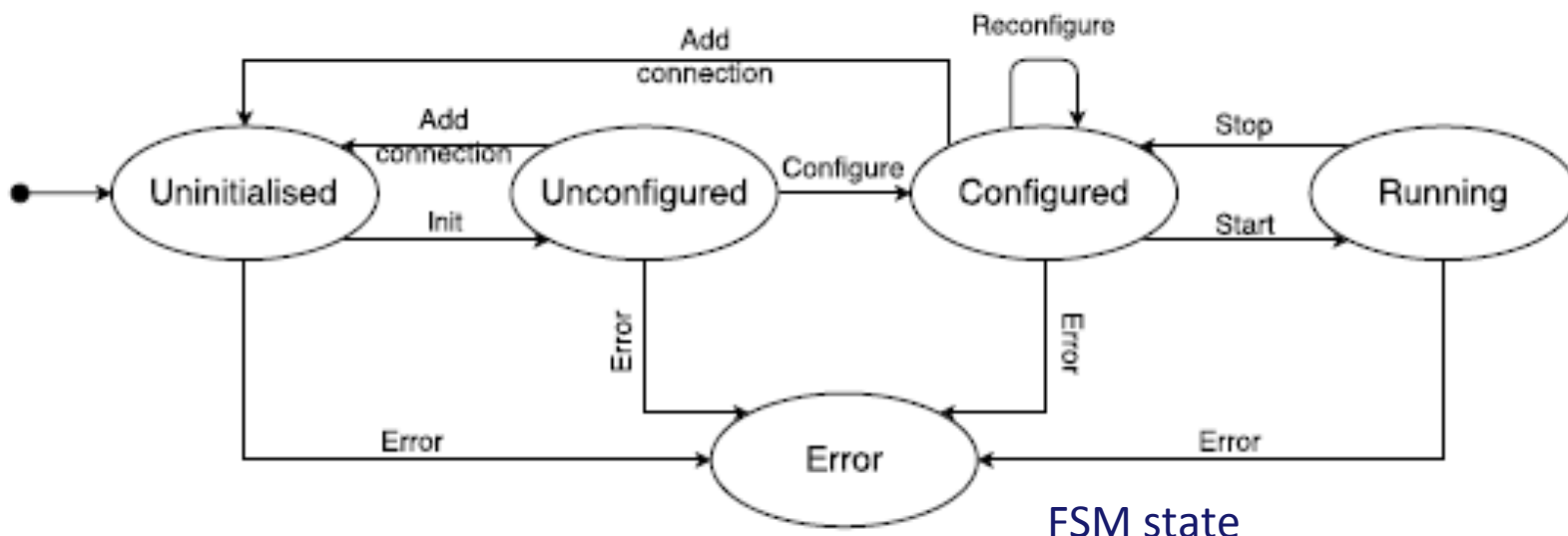


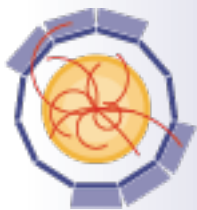
RunControl maintains a database about the address of clients and sends command to them.

- The Standard RunControl EUDAQ is enough for most user cases.

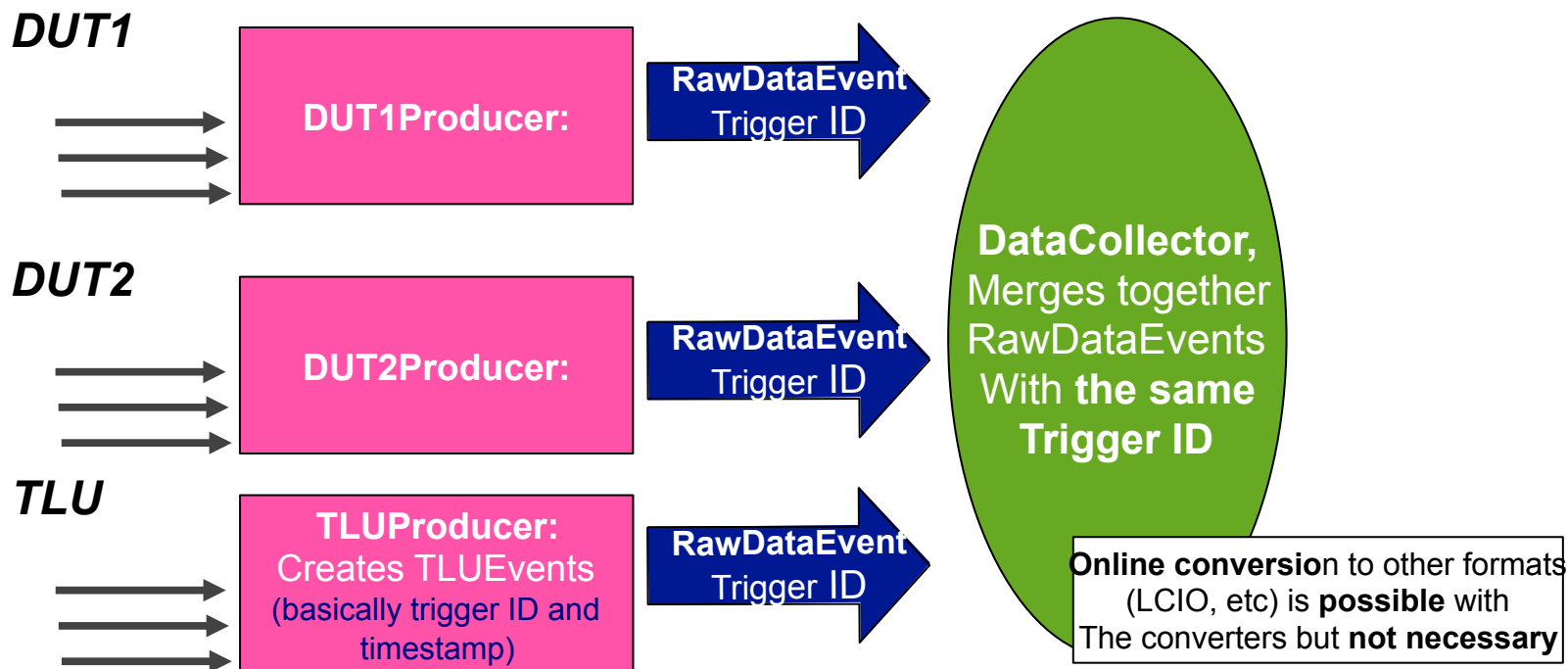
New in EUDAQ2

- QT GUI is decoupled from RunControl and EUDET-telescope
- User can reuse the GUI with their own RunControl without touch GUI code.
- Provide flexible to have dedicated RunControl to integrate with other DAQ system .
- The FSM states EUDAQ clients are checked by RunControl

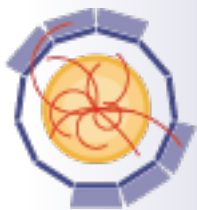




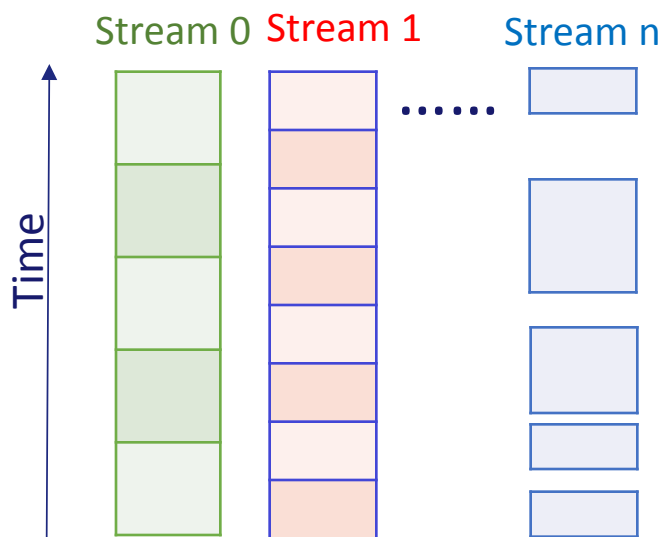
- **EUDAQ 1** philosophy : common readout frames in synchronization with trigger id driven by the TLU → trigger number and event number are the same !







Using only a trigger ID to merge multiple data sources inefficient when integration time is different ( externally triggered / self-triggered / continuous integration

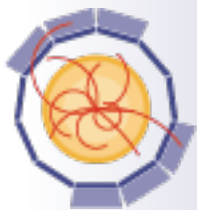


In generic case, sub events can arrives in any random time.



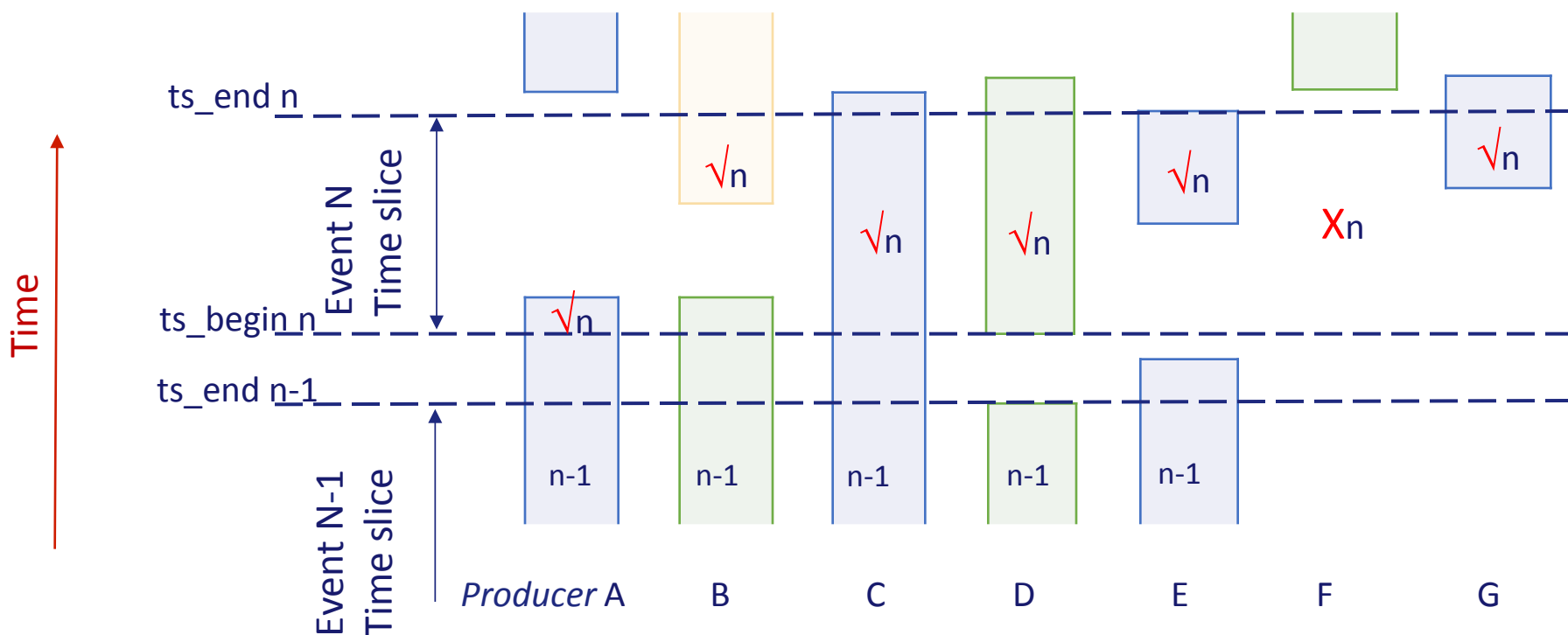
*How to defined a physical event?  
How to defined a valid trigger?  
Which detector is the trigger device?*

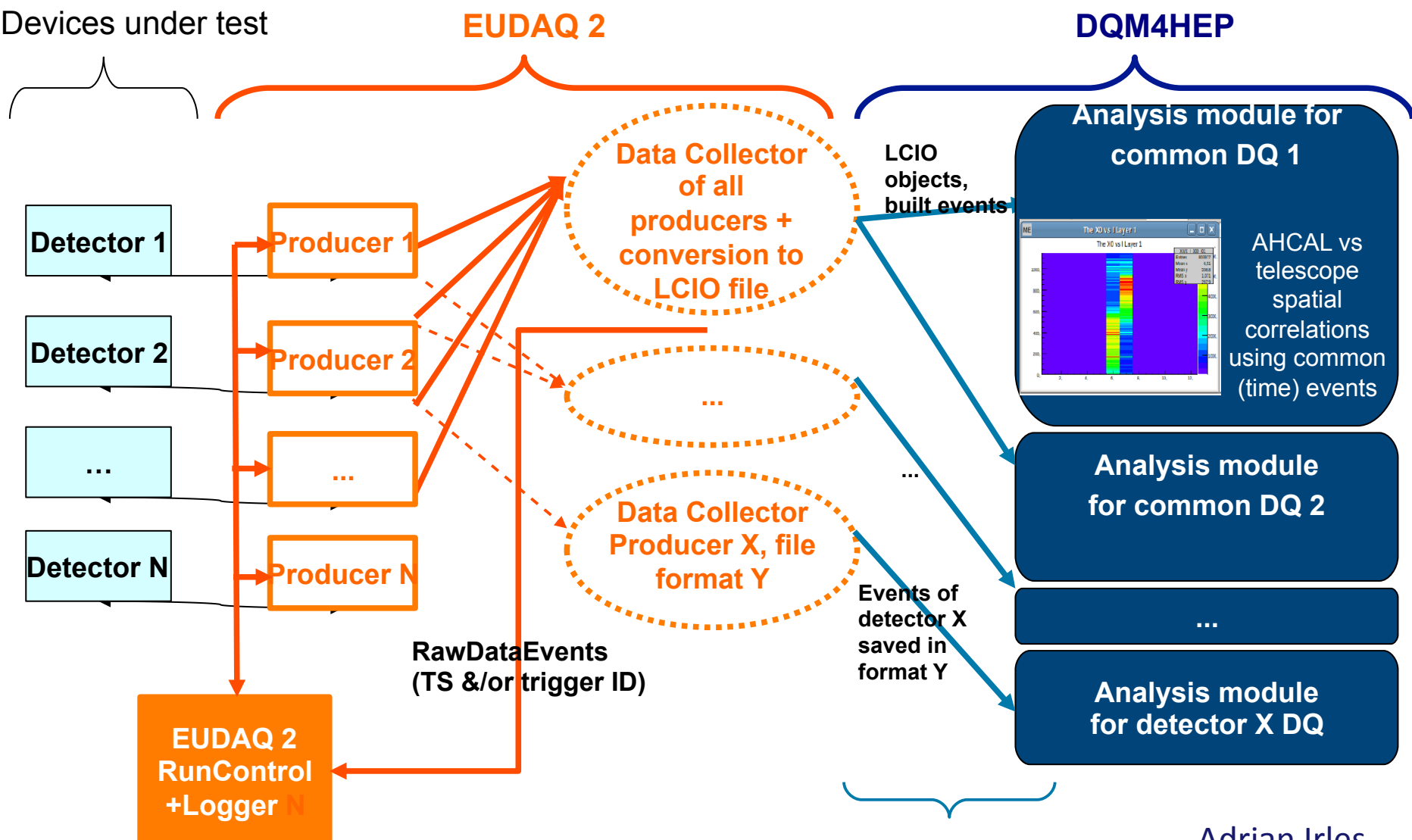
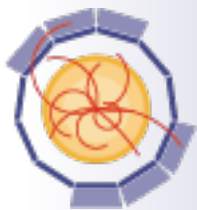
- Users can write their own event builder
- Generic DataCollectors for direct synchronization by timestamp and trigger number cases are provided. (next page)



- Time length of incoming Event is flexible.
- Time slice of merged event is variable
- All Producers are equal to each others
- Can cope with unmatched data (e.g. noise hits)

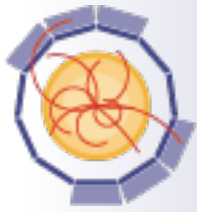
Event sync  
by Timestamp-pair



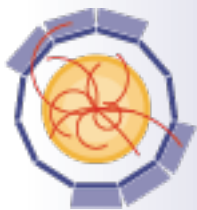


EUDAQ 2 – DQM4HEP interface (to be done)

Adrian Irles



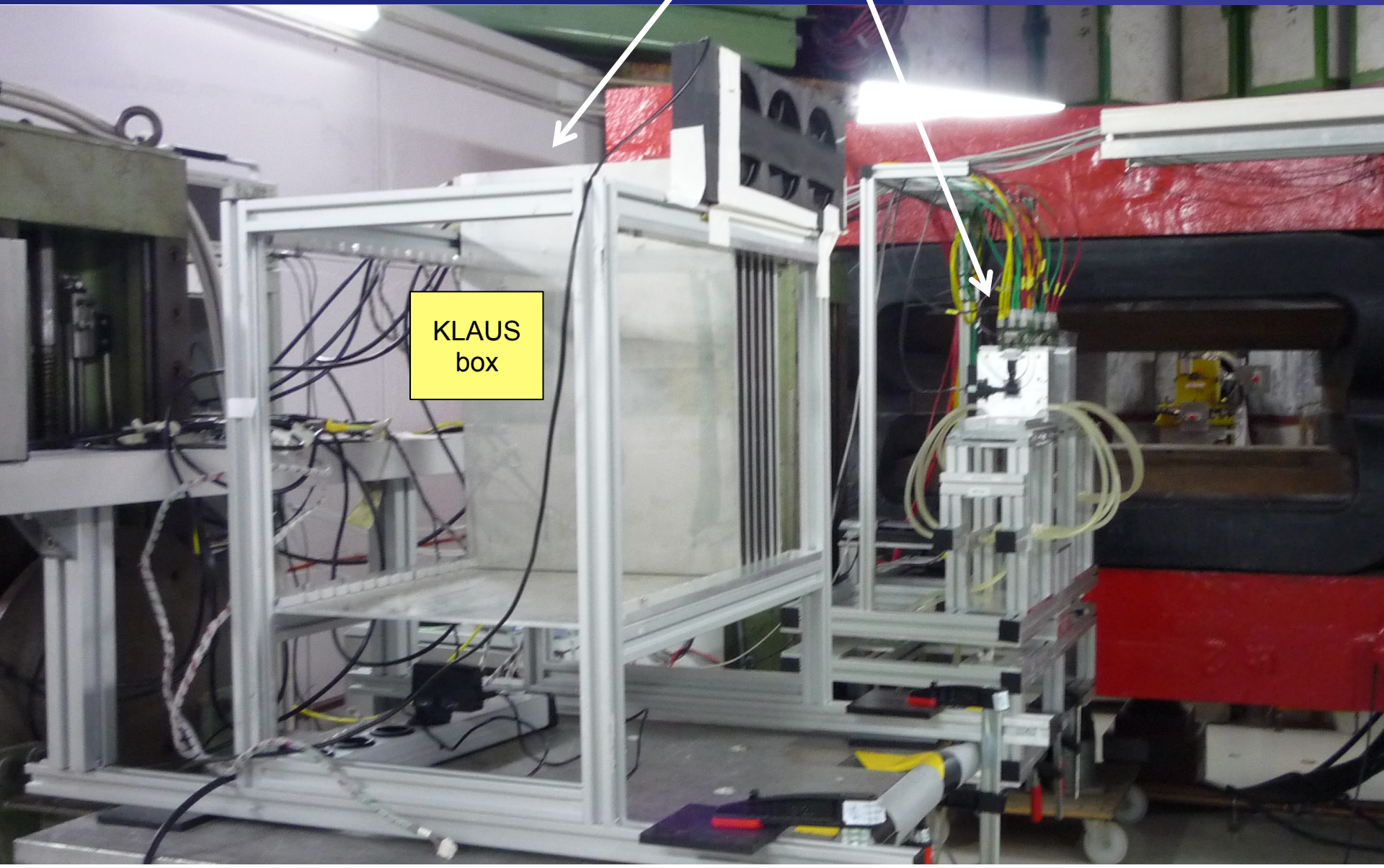
- Using DQM4HEP framework from IN2P3
- Interface to EUDAQ based system underway
  - Reading from files already works
  - Providing method for serialization of event data being developed
    - Will allow true online monitoring
  - Integration with EUDAQ run control underway
- DQM4HEP can also be used for environmental parameter monitoring for DESY test beam areas
  - See WP15.3.2



# AIDA

2020

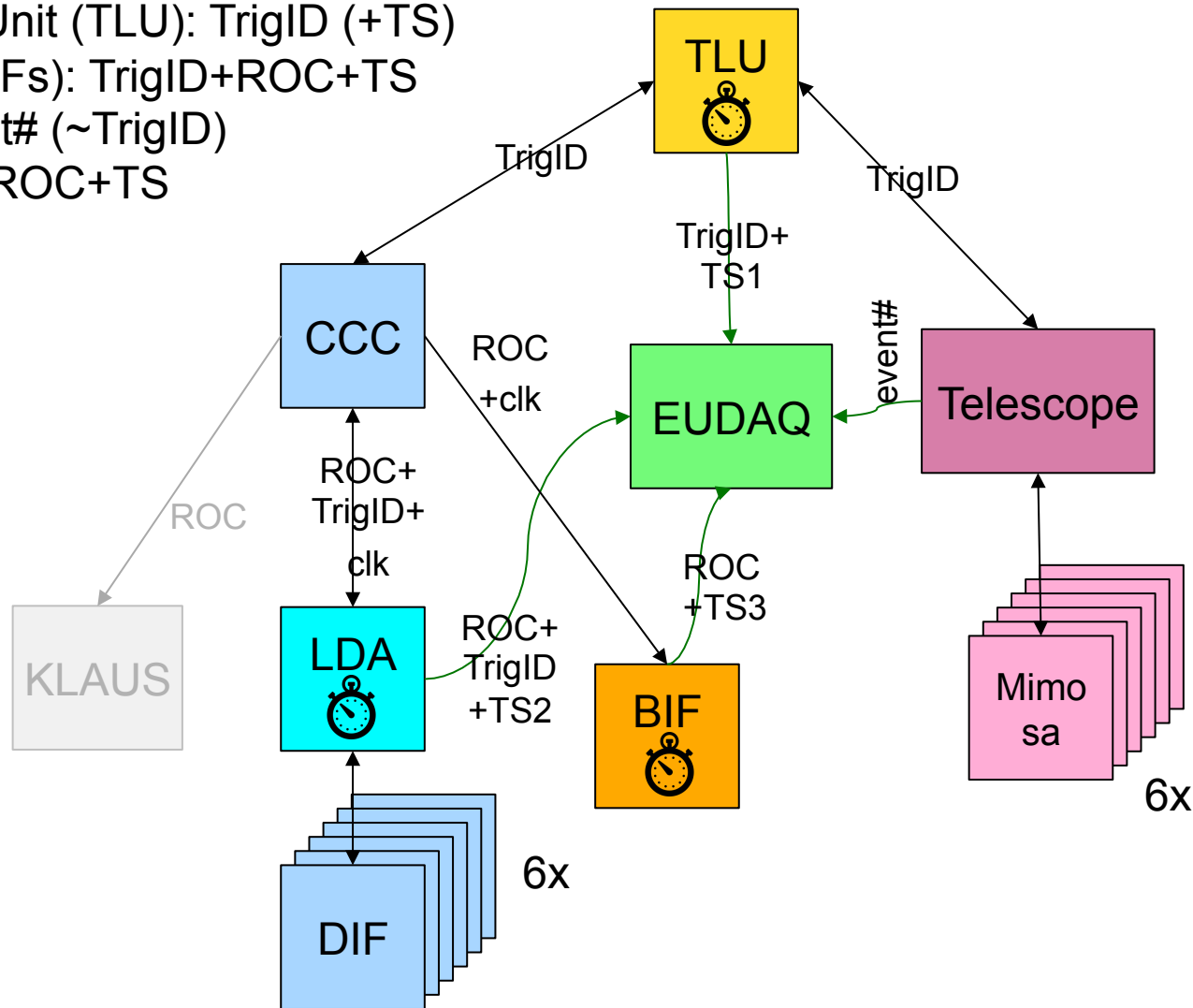
## CALICE AHCAL / AIDA Beam-telescope combined beam-test

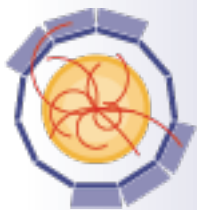


KLAUS  
box



- 3 Synchronizations: **TriggerID** or **Readout cycle(ROC)** or **TimesStamps(TS)**
- EUDET Trigger Logic Unit (TLU): TrigID (+TS)
- AHCAL (CCC+LDA+DIFs): TrigID+ROC+TS
- Beam Telescope: Event# (~TrigID)
- 2017: Mini-TLU (BIF): ROC+TS
- 2017: Klaus: ROC



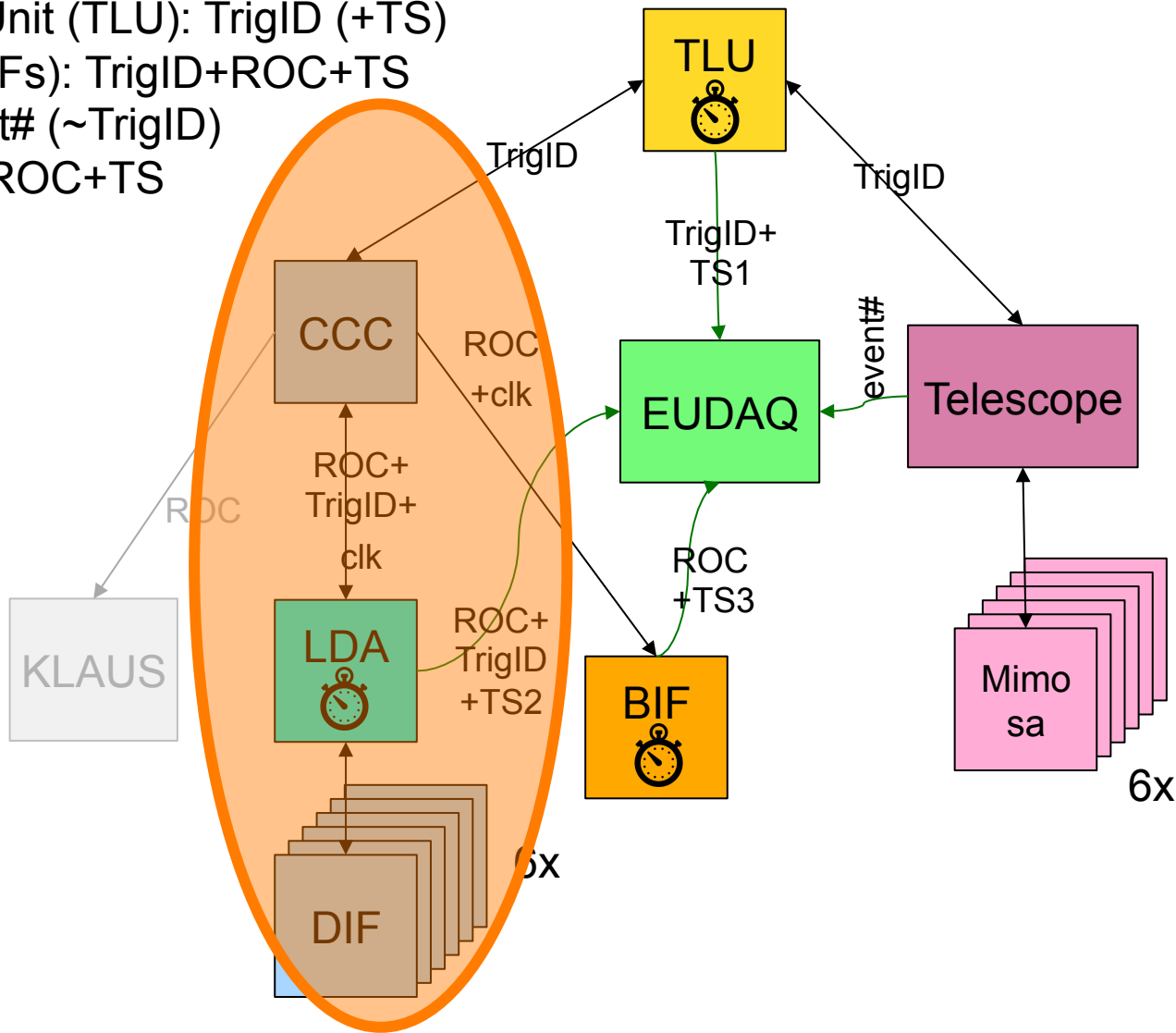


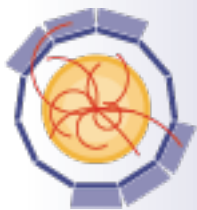
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2020

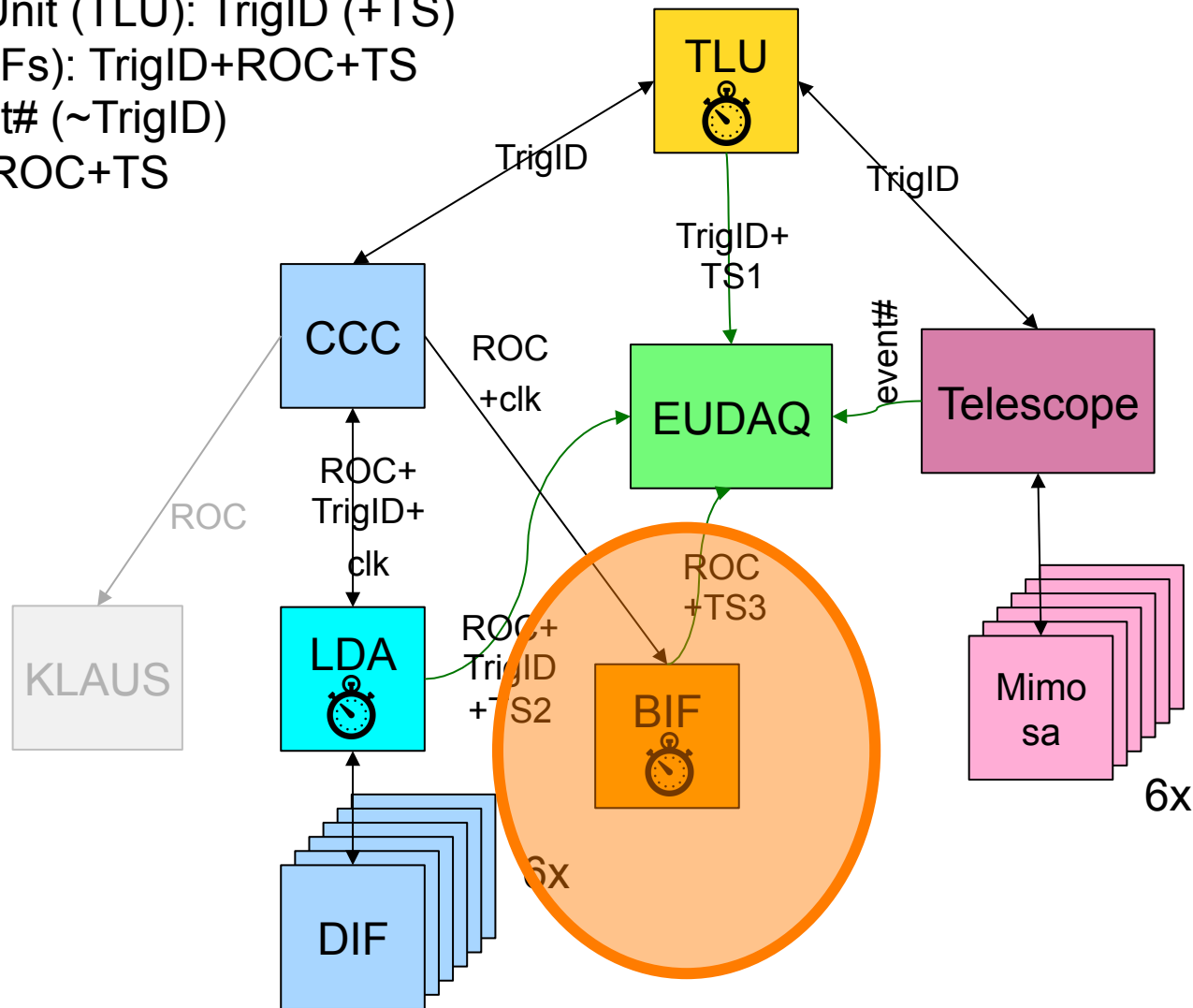
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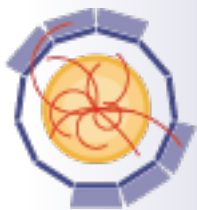




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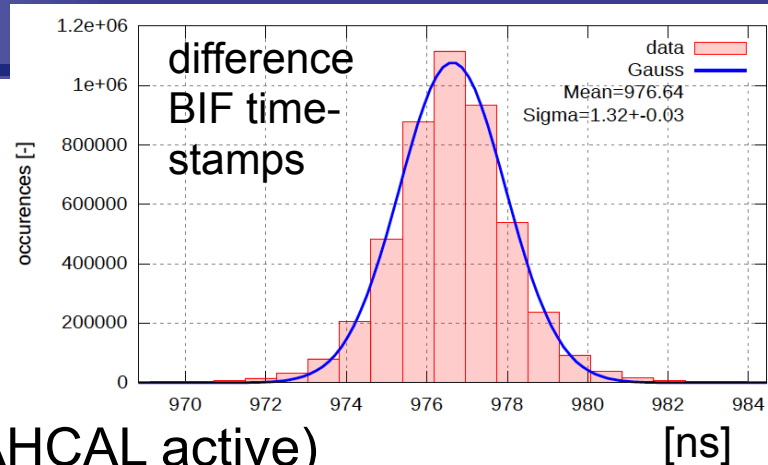


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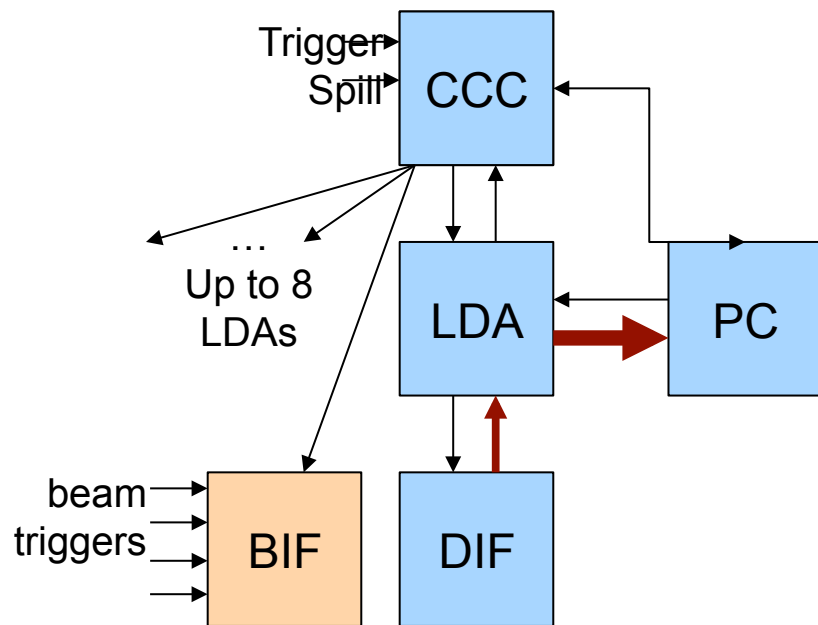
2020

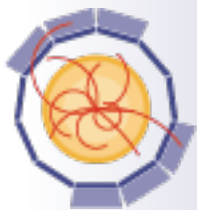
## BIF (Beam Interface): Timestamping external signals

- Modified firmware of the **AIDA mini-TLU**
  - **Receives AHCAL clock**
  - Knows AHCAL fast commands from HDMI
- Records timestamps from 4 inputs (lemo)
- + start&stop of acquisition
  - Estimated time jitter: 1 ns
- acquisition is gated (=records only when AHCAL active)
- Implemented in the “slave mode” - acts like another LDA/DIF



Jiri Kvasnicka , Katja Kruger



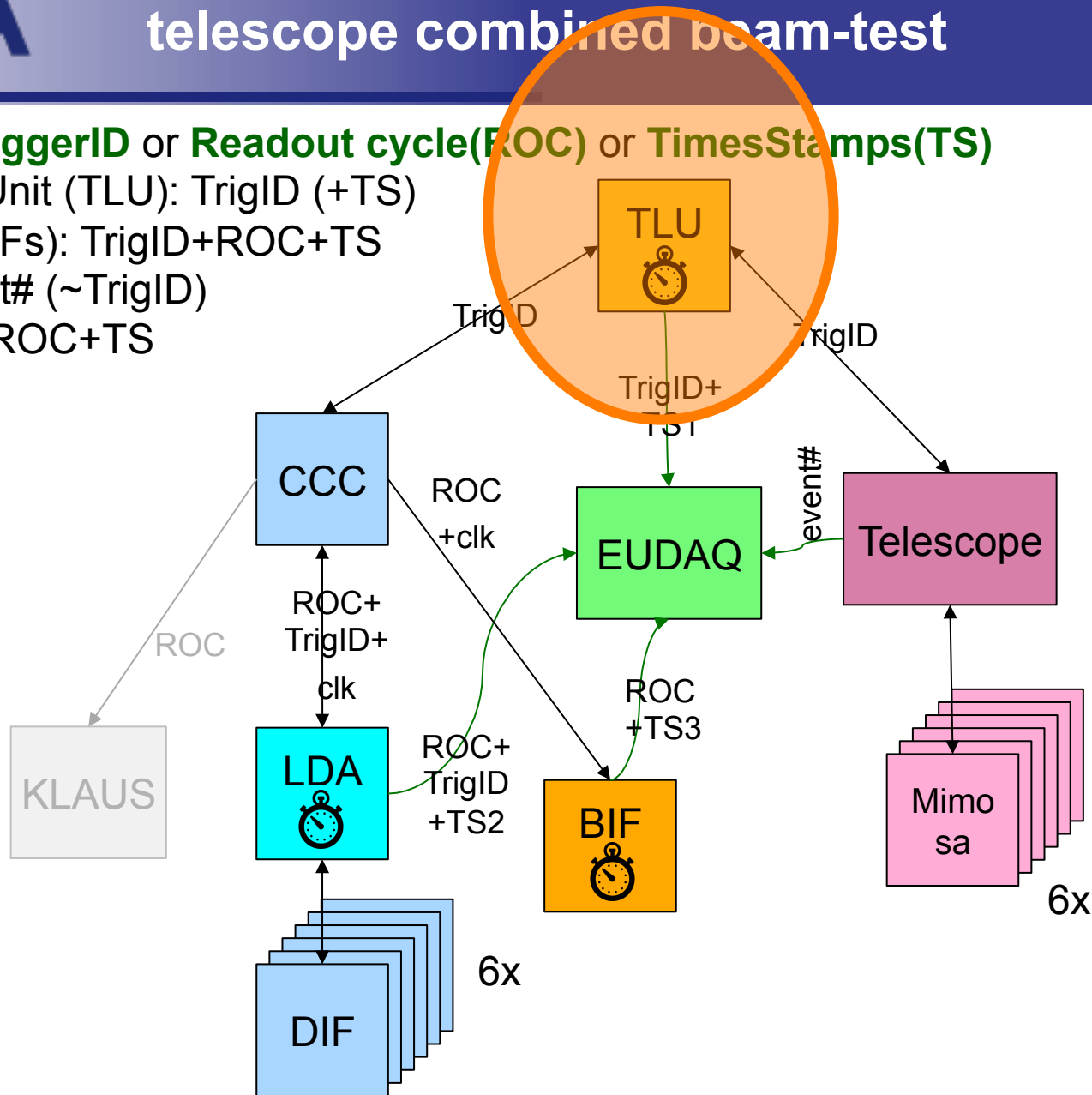


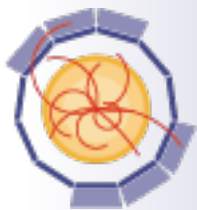
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2020

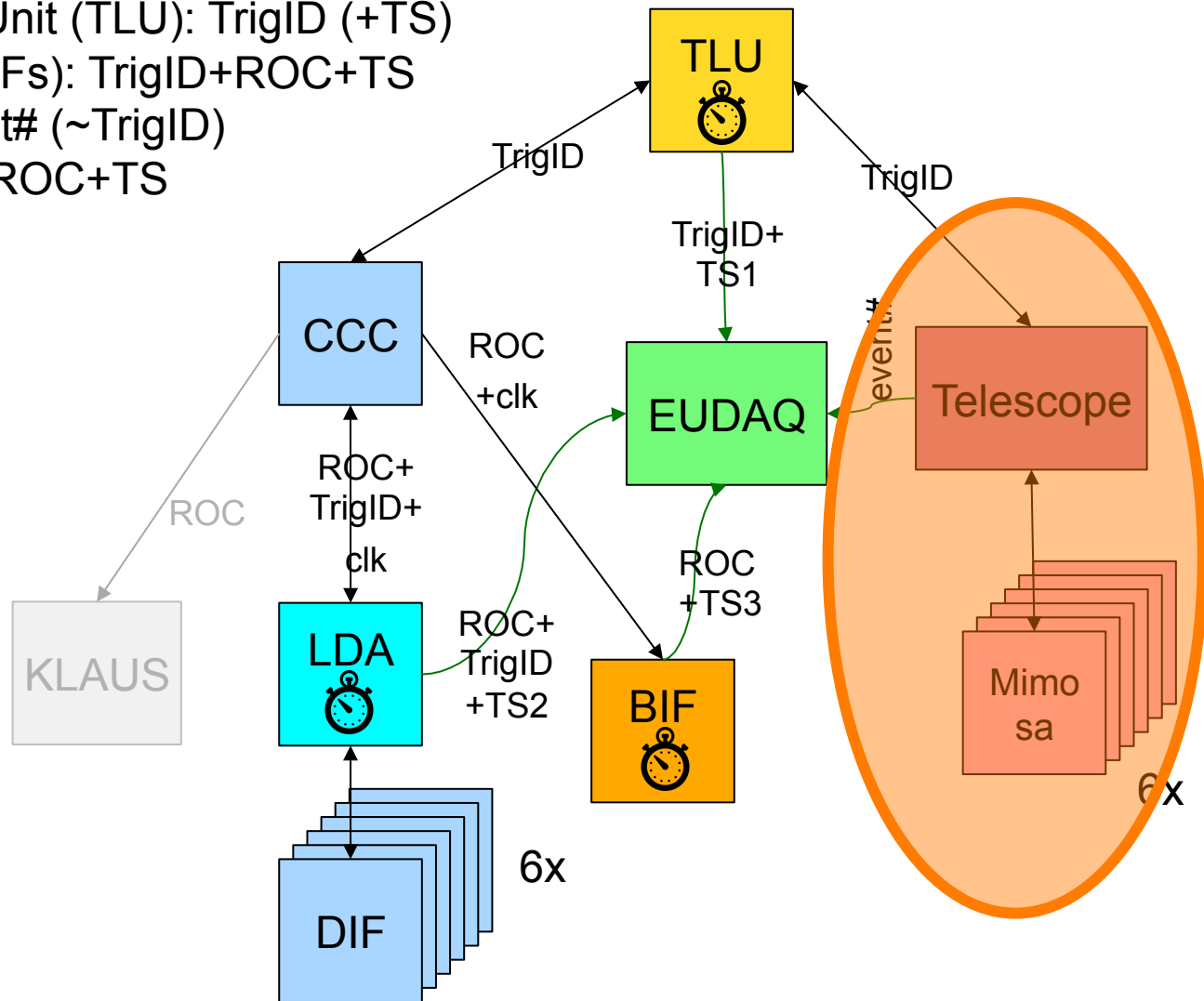
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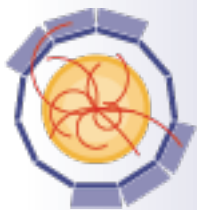
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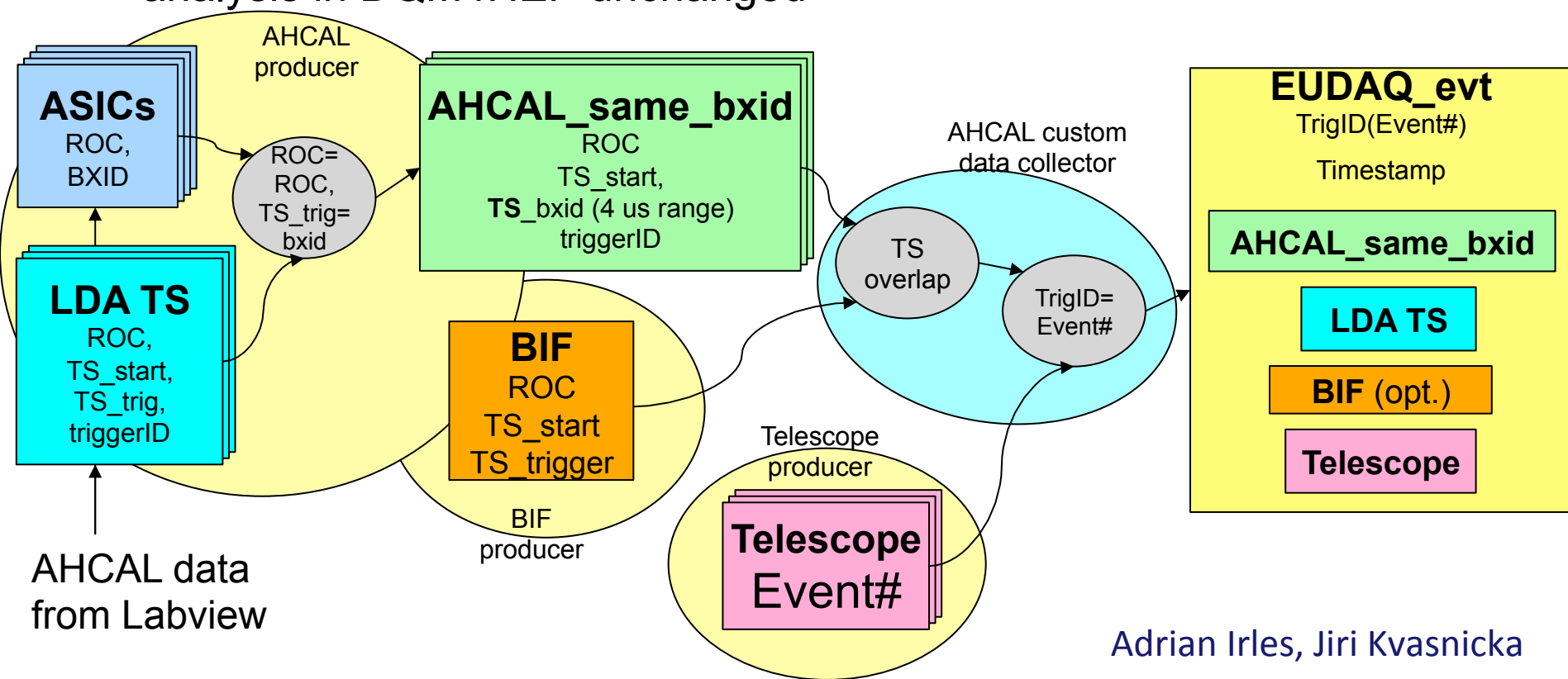
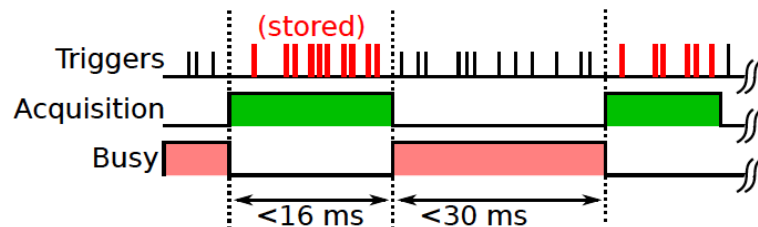


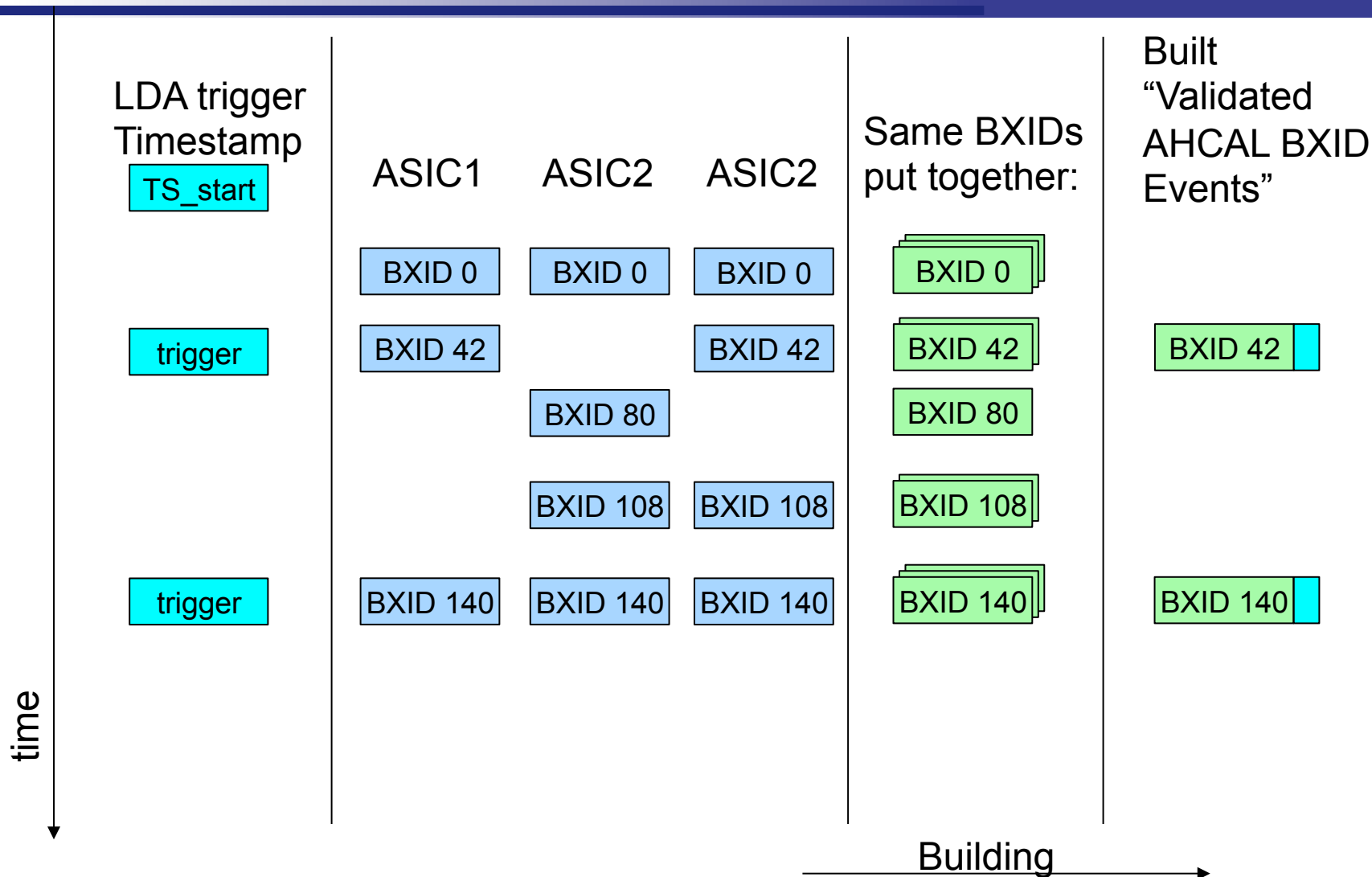
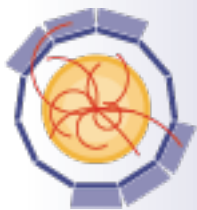
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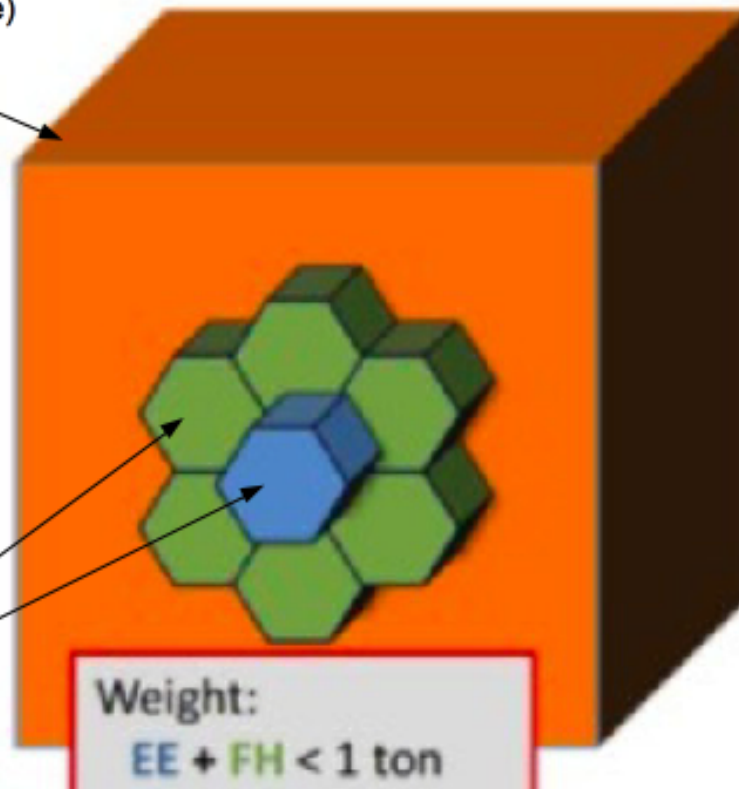
- > simple data collectors available in EUDAQ (triggerID sync / timestamp sync)
- > here event building is more complex
  - need a custom data collector
- > data format kept compatible with EUDAQ1
  - analysis in DQM4HEP unchanged





# Combined Beam Tests CMS HGCAL / CALICE AHCAL

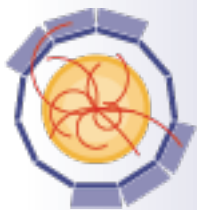
CALICE  
Highly granular analogue  
hadron calorimeter  
(with coarser absorber structure)



CMS  
EM Section and  
Front hadronic section

Combined readout system:

- Needs to synchronise externally triggered devices with internally triggered device
- Synchronisation will make **use of EUDAQ**
- Benefit from experience from AHCAL/Beam Telescope tests
- Testbeam planned for Summer 2017



- EUDAQ already used by ATLAS and CMS pixel beam test communities
- CMS HGCAL planning to use EUDAQ for combined beam-test with Calice AHCAL:

The screenshot displays the EUDAQ Run Control v1.6.0+5-gf75fd6 interface. The left pane shows the 'EUDAQ Log Collector' window with a log table. The right pane shows the 'Control' window with configuration and status information.

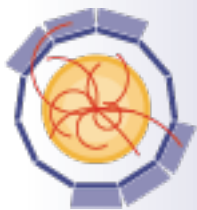
| Received     | Sent         | Level   | Text  | From            |
|--------------|--------------|---------|---|-----------------|
| 17:15:19.963 | 17:15:19.963 | 4-INFO  | Connection from LogCollector (128.141.89.141:35780)                   | LogCollector    |
| 17:15:52.009 | 17:15:51.808 | 4-INFO  | Connection from ProducerHGCal_RP1 (128.141.89.141:35790)              | LogCollector    |
| 17:15:52.009 | 17:15:51.908 | 4-INFO  | Connection from ProducerHGCal_RP2 (128.141.89.141:35791)              | LogCollector    |
| 17:15:52.009 | 17:15:52.009 | 4-INFO  | Connection from ProducerHGCal_RP4 (128.141.89.141:35794)              | LogCollector    |
| 17:15:52.110 | 17:15:52.109 | 4-INFO  | Connection from ProducerHGCal_RP3 (128.141.89.141:35796)              | LogCollector    |
| 17:16:33.677 | 17:16:33.676 | 4-INFO  | Configuring /home/daq/daq/hgcalSpecific/HGCalConf_GENERATED_B...      | RunControl      |
| 17:16:34.305 | 17:16:34.305 | 4-INFO  | Testing copying file to RPI number 1 with host address rpihgcal0...   | ProducerHGCa... |
| 17:16:34.362 | 17:16:34.362 | 6-ERROR | Command to copy exited with error code 65280                          | ProducerHGCa... |
| 17:16:34.377 | 17:16:34.377 | 6-ERROR | Command to execute script exited with error code 256                  | ProducerHGCa... |
| 17:16:34.377 | 17:16:34.377 | 6-ERROR | Could not configure RPI number 1                                      | ProducerHGCa... |
| 17:16:34.405 | 17:16:34.405 | 4-INFO  | Testing copying file to RPI number 2 with host address rpihgcal02     | ProducerHGCa... |
| 17:16:34.506 | 17:16:34.506 | 4-INFO  | Testing copying file to RPI number 4 with host address rpihgcal04     | ProducerHGCa... |
| 17:16:34.521 | 17:16:34.521 | 6-ERROR | Command to copy exited with error code 65280                          | ProducerHGCa... |
| 17:16:34.521 | 17:16:34.521 | 4-INFO  | Testing executing script on RPI number 4 with host address rpihgcal04 | ProducerHGCa... |
| 17:16:34.533 | 17:16:34.533 | 6-ERROR | Command to execute script exited with error code 256                  | ProducerHGCa... |
| 17:16:34.533 | 17:16:34.533 | 6-ERROR | Could not configure RPI number 4                                      | ProducerHGCa... |
| 17:16:34.610 | 17:16:34.610 | 4-INFO  | Testing copying file to RPI number 3 with host address rpihgcal03     | ProducerHGCa... |
| 17:16:34.736 | 17:16:34.736 | 4-INFO  | Command to copy file successful!                                      | ProducerHGCa... |
| 17:16:34.736 | 17:16:34.736 | 4-INFO  | Testing executing script on RPI number 2 with host address rpihgcal02 | ProducerHGCa... |
| 17:16:34.944 | 17:16:34.944 | 4-INFO  | Command to copy file successful!                                      | ProducerHGCa... |
| 17:16:34.944 | 17:16:34.944 | 4-INFO  | Testing executing script on RPI number 3 with host address rpihgcal03 | ProducerHGCa... |
| 17:16:35.192 | 17:16:35.191 | 4-INFO  | Command to execute script successful!                                 | ProducerHGCa... |
| 17:16:35.192 | 17:16:35.192 | 4-INFO  | Successfully configured RPI number 2                                  | ProducerHGCa... |
| 17:16:35.335 | 17:16:35.335 | 4-INFO  | Command to execute script successful!                                 | ProducerHGCa... |
| 17:16:35.335 | 17:16:35.335 | 4-INFO  | Successfully configured RPI number 3                                  | ProducerHGCa... |

The right pane shows the 'Control' window with the following configuration and status information:

- Control Config: /home/daq/daq/hgcalSpecific/HGCalConf\_GENERATED\_BY\_SCRIPT\_DO\_NOT\_MODIFY.conf
- Run: [Empty]
- Log: [Empty]
- GeoID: 0
- Status: Run Number: [Empty], Rate: [Empty], File Bytes: [Empty], TLU Status: [Empty]
- Events Built: [Empty], Triggers: [Empty], Particles: [Empty], Scalers: [Empty]
- Connections table:

| type         | name      | state           | connection      |
|--------------|-----------|-----------------|-----------------|
| LogCollector |           | OK Configure... | 127.0.0.1:56366 |
| Producer     | HGCal_RP1 | ERROR: Error... | 127.0.0.1:56378 |
| Producer     | HGCal_RP4 | ERROR: Error... | 127.0.0.1:56376 |
| Producer     | HGCal_RP3 | OK Configure... | 127.0.0.1:56374 |
| Producer     | HGCal_RP2 | OK Configure... | 127.0.0.1:56372 |

Tanmay Mudholkar , CMS



- ... including DQM tool

The screenshot displays three main windows from the EUDAQ system:

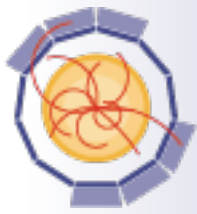
- EUDAQ Run Control v1.6.0+14-g74dedc4:** Shows control parameters like Config, Run, Log, and GeoID. Status indicates Run Number: 4, Rate: 996 B, and Events Built: 7. Connections table shows DataCollector, LogCollector, and Producer (RPI) are OK.
- EUDAQ Online-Monitor v1.6.0+14-g74dedc4:** Displays a tree view of sensors (Sensor 1-15) and hitmaps for Hexa 1, 3, 5, 7, 9, 11, 13, and 15. The hitmaps show hit distributions across the detector area.
- EUDAQ Log Collector:** Shows a log of system events, including connection messages and run preparation steps.

At the bottom right, a terminal window shows the command 'START RUN' and subsequent data submission logs, including error messages like 'The client socket is probably closed. break this thread'.

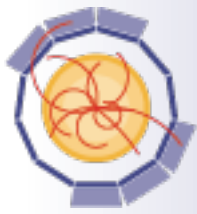
March 15, 2017

Andrey Pozdnyakov, CMS

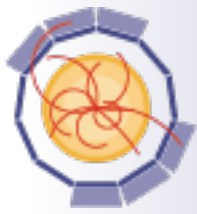




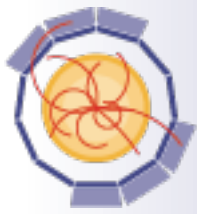
- D5.1 Interface Definitions ( M15 , Done ).
- D5.2 Trigger Logic Ready ( M30 ).
  - Testing prototypes
  - Will make modifications and produce TLUs for AIDA-2020 beam-lines.
    - Units are costing more than expected → Will have to have a tight definition of AIDA-2020 beam-line
    - Will manufacture TLUs for other users at “Cost price”
    - May add features to make TLU useful for DUNE as well → larger production run → Lower cost. (... and risk of design problems in final unit not borne by AIDA-2020 WP5 ... )
- D5.3 DAQ Software ( M30 ).
  - Basically, EUDAQ 2.0
- D5.4 , D5.5 Data acquisition hardware ( M30 )
  - Linked to D5.2
- D5.6 Common DAQ system used in combined beam tests ( M45 )
  - Already running combined beam tests between different Calo systems.
  - Integration of Silicon strip tracker progressing



- MS43 , M21 ( TLU Design ready ) reached.
  - Prototype TLU exists. Report written
- MS46 , M24 ( EUDAQ interfaces to other DAQs available. )
  - Reached after release of EUQDAQ 2.0
    - EUDAQ 2.0 release due this month.
    - Reaching milestone on time will be tight.
- MS47 , M24 ( Online event data model available. )
  - Linked with EUDAQ 2.0 release
- MS62 , M27 ( Development of run control ready )
  - Reached when EUDAQ 2.0 is released
- MS66 , M30 ( TLU ready hardware )
  - See D5.2
- MS67 , M30 ( Data quality tools ready )
  - Using DAQ4HEP tools ( Ete, Pingault , Mirabito. IN2P3 ) and enhancing integration with EUDAQ
  - Looks OK.



- MS68 ( Slow control system ready ) , M30
  - Linkage to WP15.3.2
  - Can use DQM4HEP framework
- MS80 (Common DAQ system ready for combined beam-tests) , M36
  - Already mounting common beam-tests between different ILC detector prototype DAQ systems.



- Common DAQ work-package exists to provide tools for beam-test users
  - Linkage with many AIDA-2020 work-packages ( e.g. , beam-line infrastructure , calorimeter )
  - Linkages outside AIDA-2020 – e.g. LHC groups using beam-telescopes.
- Work on
  - Hardware for synchronization (TLU)
  - Data model for in-homogenous detectors
  - DAQ Software (EUDAQ 2) – WP15.2
  - DQM Software (using DQM4HEP)
- .... going well. Expect to meet milestones on time ( or with only small delay )