AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators

Presentation

EUDAQ 1 & 2 for beam telescopes

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EUDAQ 1 & 2 for beam telescopes

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AIDA-2020 Third Annual Meeting
WP5: Data acquisition system for beam tests
Bologna, 24th April 2018

Contents

01 Introduction: Beam Telescopes

High-precision reference tracker
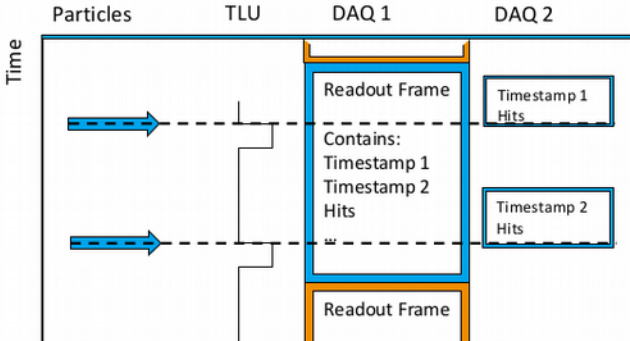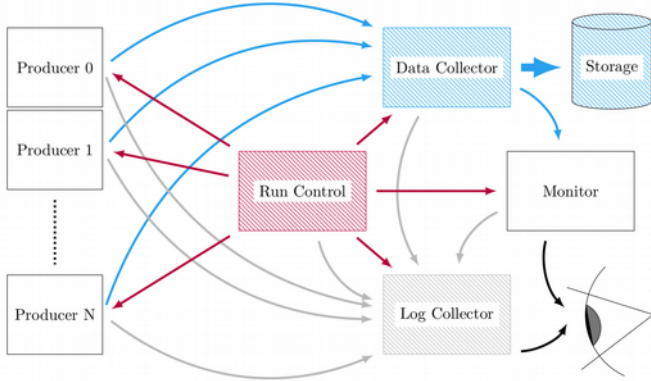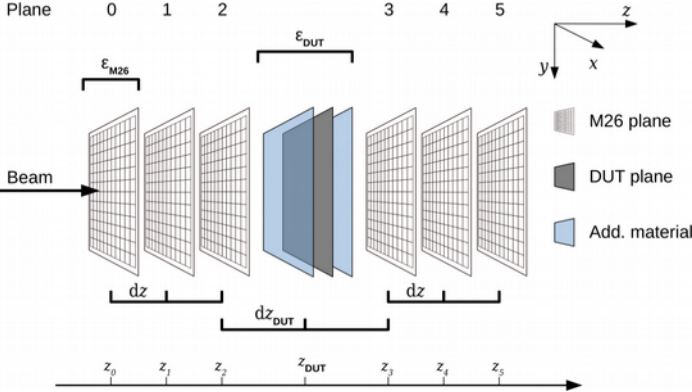
EUDET-type telescopes in a nutshell

- Mimosa26 based 6 plane telescope
  - → **Device Under Test (DUT) in between** (or behind)
  - → Response studies, efficiency, Lorentz angle, etc.

- Pointing resolution (> 1.8 μm) or
  angular resolution (> 0.03 mrad) @ 1-6 GeV/c
  - → **Material Budget (X0) imaging**

References

- **Portal & Manual & Description:** *telescopes.desy.de*

- **Performance & Reference Paper:** *H. Jansen et al to*
  https://doi.org/10.1140/epjti/s40485-016-0033-2
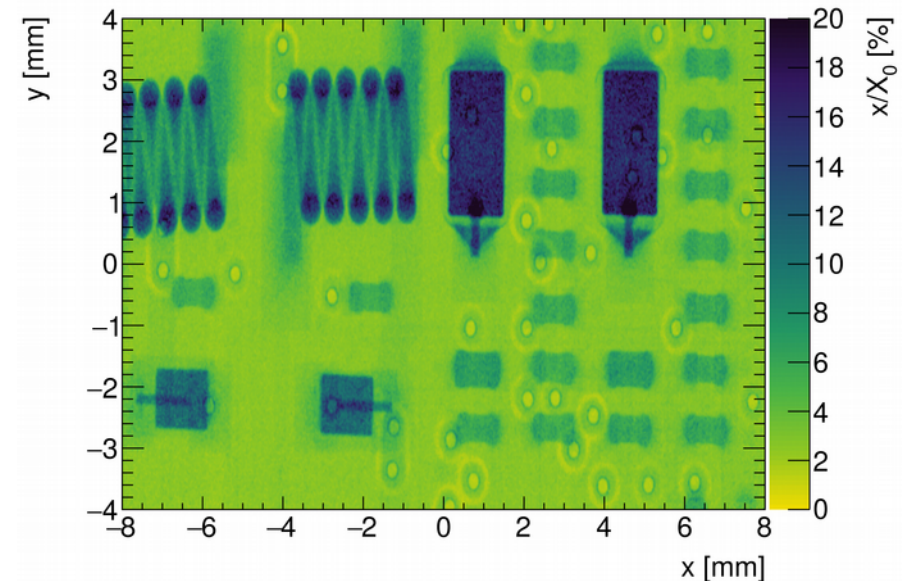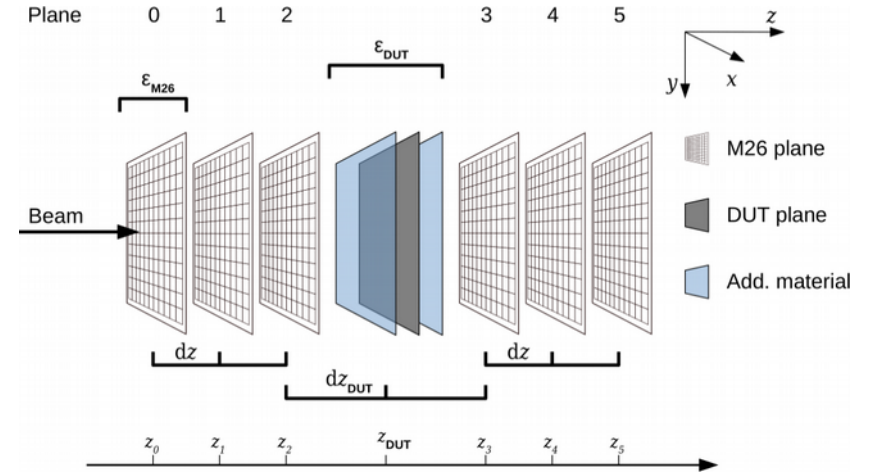
EoS of Petal of ATLAS Endcap upgrade, (Michaela Queitsch-Maitland)

01 Introduction: Common Beam Telescopes

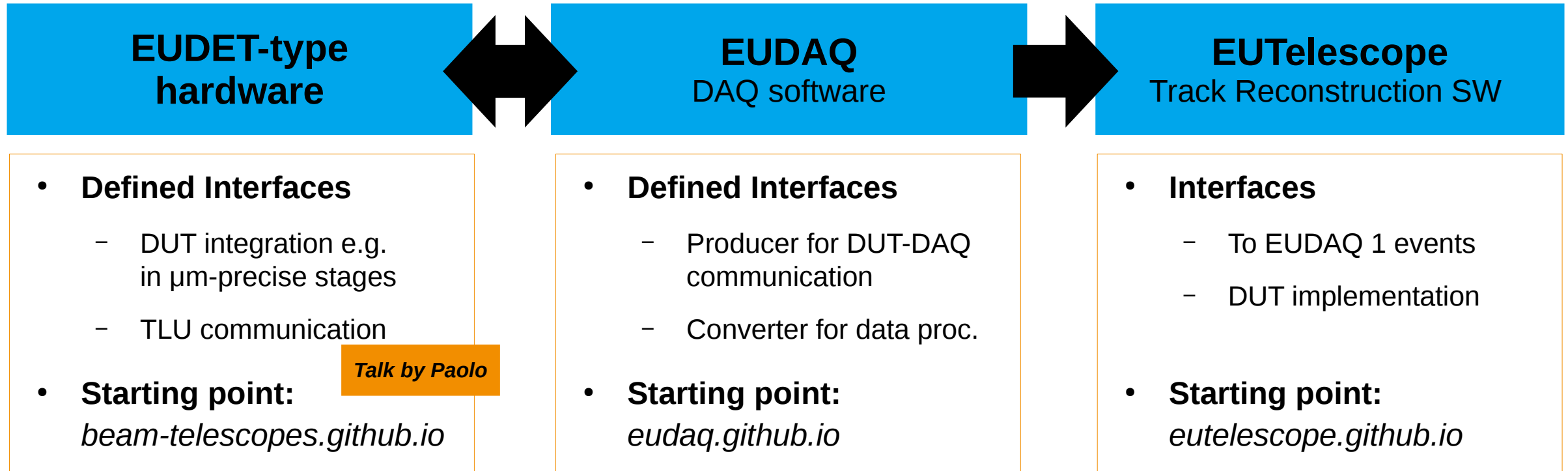**A common tool used by many different users from various experiments**

Today & User interfaces

- A workhorse for various (HEP) test beams: 7 copies at 5 different test beam facilities

- 3 pillars of EUDET-type telescope package: from data to results

Talk in WP15, 25.04., 14:35

| **EUDET-type hardware** | ⬌ | **EUDAQ** DAQ software | ➡ | **EUTelescope** Track Reconstruction SW |

EUDET-type hardware

- **Defined Interfaces**
    - DUT integration e.g. in µm-precise stages
    - TLU communication

    Talk by Paolo

- **Starting point:** *beam-telescopes.github.io*

EUDAQ DAQ software

- **Defined Interfaces**
    - Producer for DUT-DAQ communication
    - Converter for data proc.

- **Starting point:** *eudaq.github.io*

EUTelescope Track Reconstruction SW

- **Interfaces**
    - To EUDAQ 1 events
    - DUT implementation

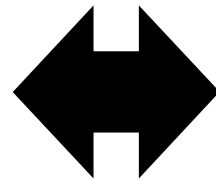- **Starting point:** *eutelescope.github.io*

02 EUDAQ software framework

An easy-to-use, top-level test beam DAQ

Data in from DUT DAQ:

- Producer

- Examples: TLU, Mimosa, FEI4, ...
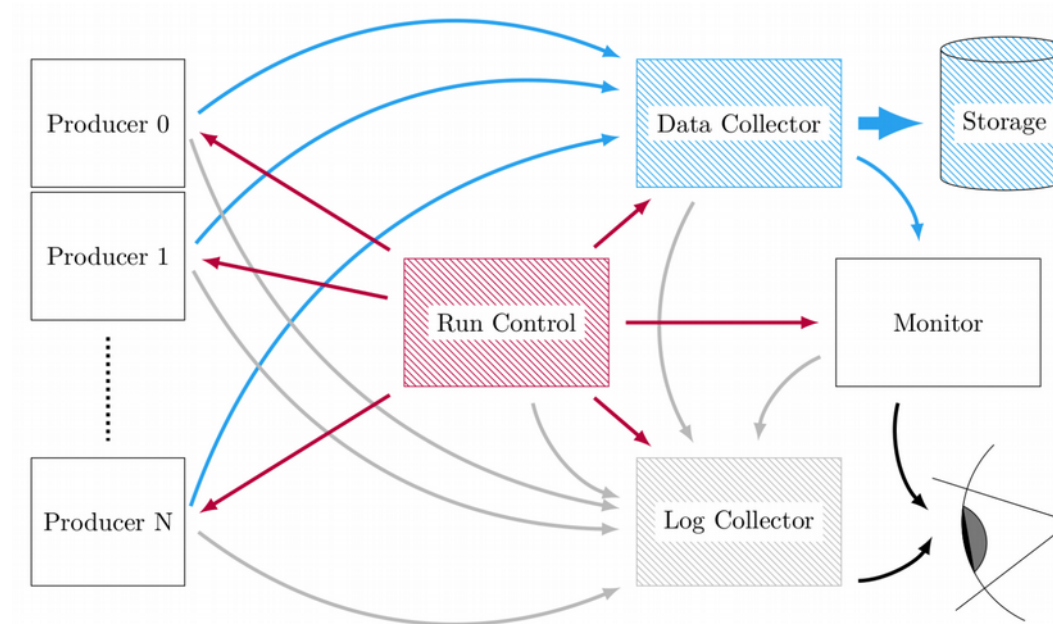
**Data out for monitoring or reconstruction:**

- Converter

- Examples: LCIO, ROOT, ...

Finite State Machine of Run Control:

- Connect → Initialize
- Initialized → Configure (or Re-initialize)
- Configured → Start Run (or Re-configure)
- Started → Stop Run
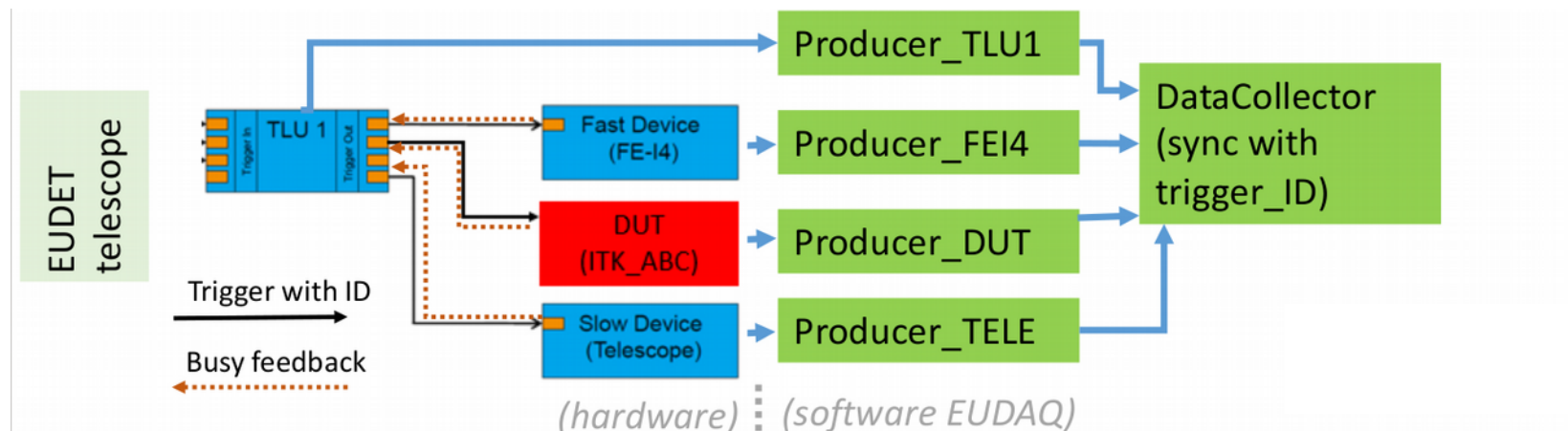- Stopped → Start next Run / Initilise / Configure / Reset

03 Data taking: EUDAQ 1 ("EUDET mode")

If not busy: One Trigger = One Event (incl. Multiple Tracks)

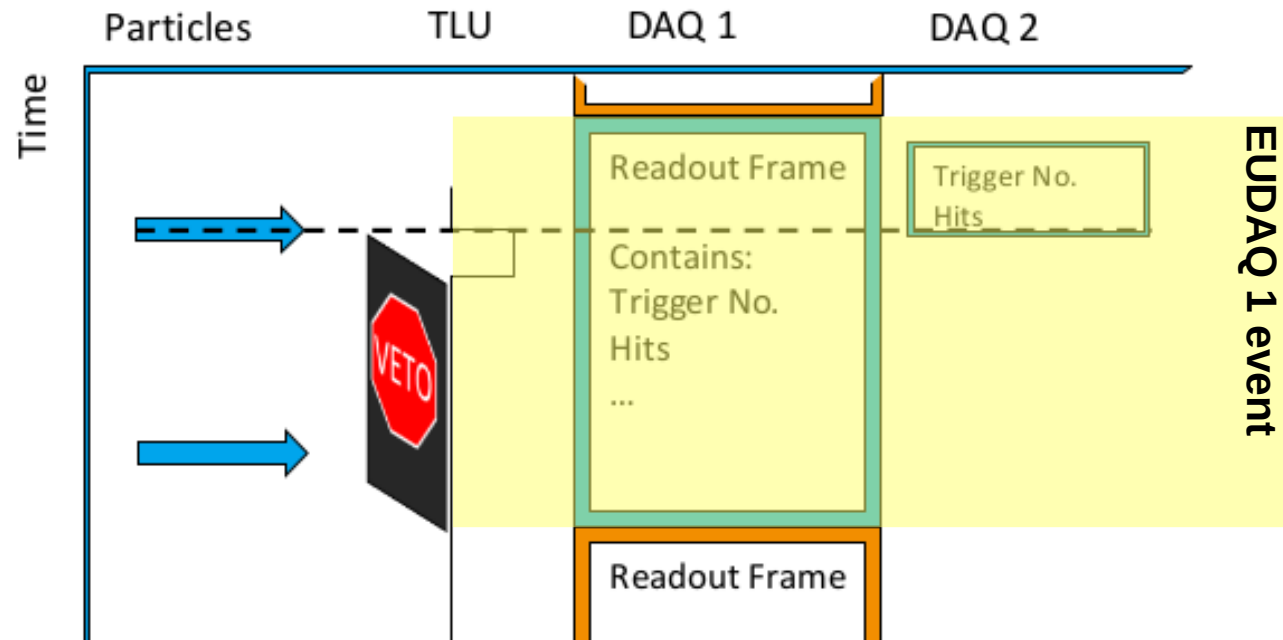| EUDET-type hardware	⟷	EUDAQ 1
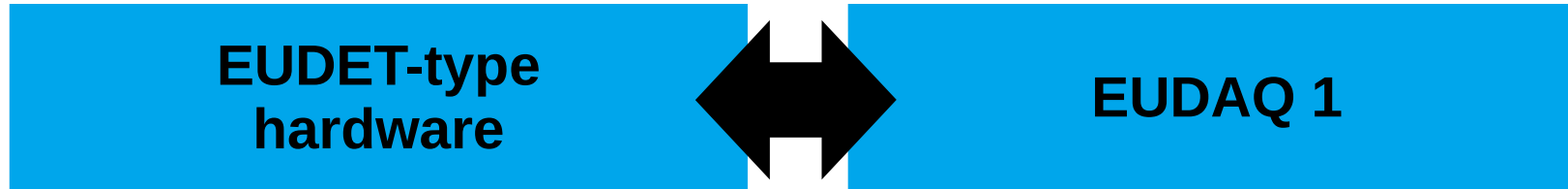
Strategy

→ trigger (ID) from TLU

→ busy for read-out from DUTs

→ one data collector

Exemplary setup for EUDET mode

03 Data taking: EUDAQ 1 ("EUDET mode")

If not busy: One Trigger = One Event (incl. Multiple Tracks)

Strategy

→ trigger (ID) from TLU

→ busy for read-out from DUTs

→ one data collector

Conclusions:

- Well-defined (EUDAQ 1) event definition
- One event has one track with high time resolution
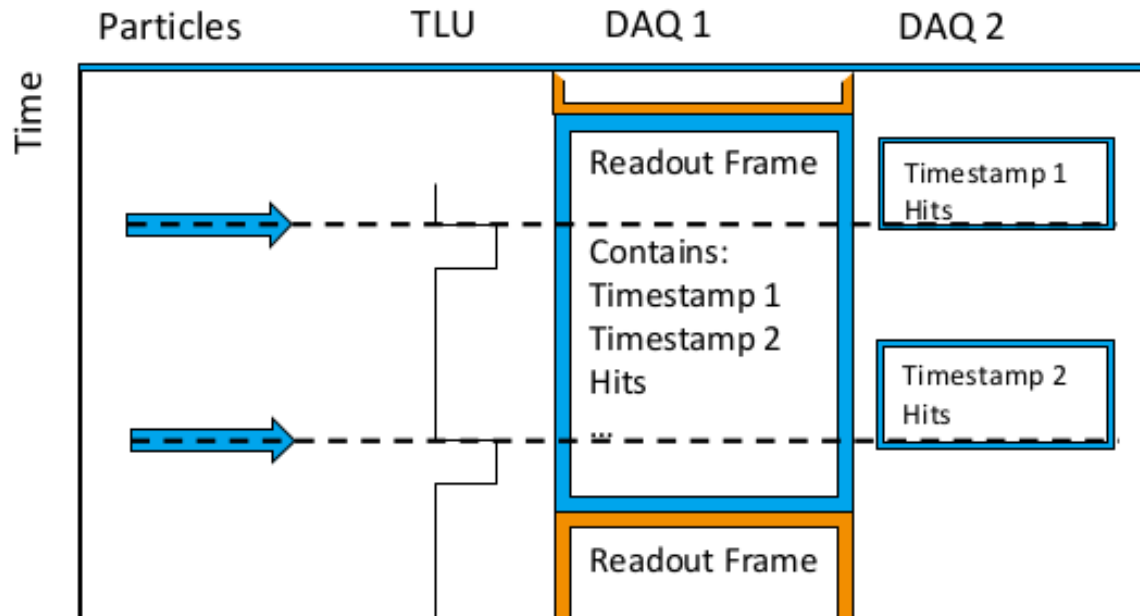- **Data taking rate is limited by the slowest device.**

EUDET-type telescope performance:

- MimosaDAQ
- EUDET TLU
- EUDAQ 1

~ 2 kHz trigger (= event) rate at beam conditions

03 Data taking: EUDAQ 2 and AIDA TLU ("mixed/AIDA mode")

**No busy → all particles → Higher Trigger Rate, more timing information**

Strategy

→ "all" triggers from TLU

→ (online or offline) synchronisation by Trigger ID (mixed mode) or by common clock and timestamps (Aida mode)

→ optional multiple data collectors and multiple connections

Conclusions:

- More flexibilty to match performance: **multiple data collectors → online or offline synchronisation**
- More Options: **EUDET, mixed or AIDA modes**
- **No general EUDAQ2 event definition possible → User-dependent definition**

03 For the telescopes: Mixed mode for MimosaDAQ

Rolling shutter !!!
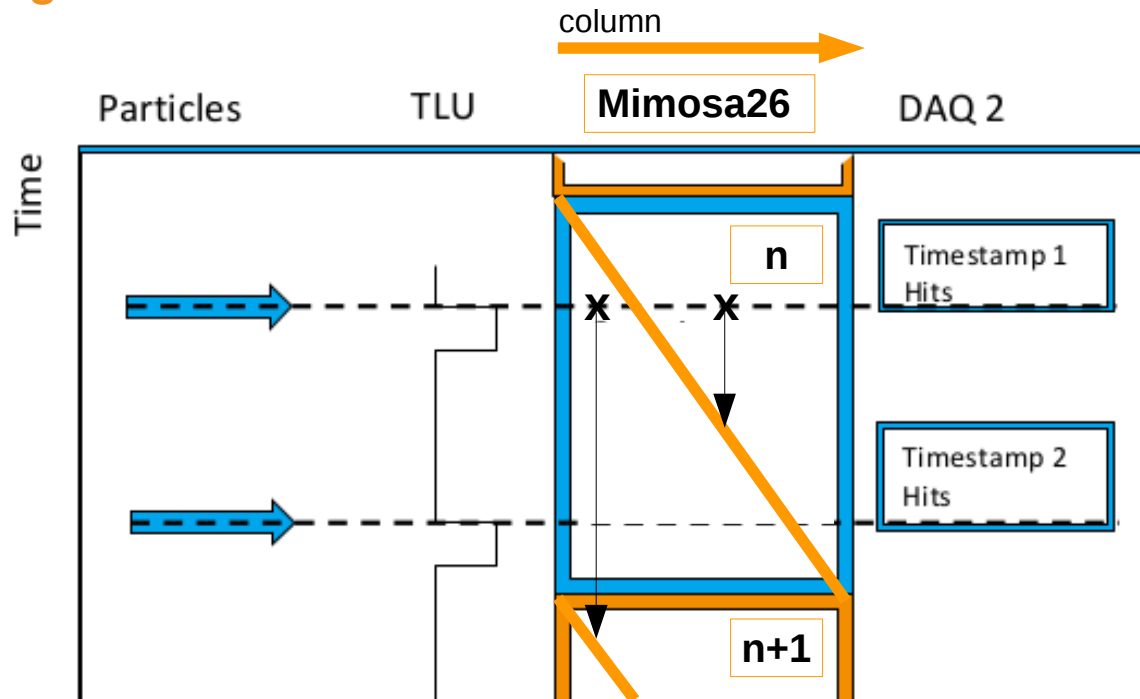
Mimosa26 read-out

- continuous ("self-triggered")
- rolling shutter ("line by line") (read-out time 115.2 µs/frame)

→ one hit is in frame **n** *OR* **n+1**

Current MimosaDAQ for EUDAQ2 and AIDA TLU

- FPGA implementation results in a triggered device: **one trigger → two consecutive frames**
- AIDA TLU in mixed mode reads out the Trigger ID for synchronization **and** ignore the MimosaDAQ busy
- Use fast DAQ2 information (e.g. FEI4) for **increasing time resolution of tracks**
- → **Ongoing: Event Merging (online/offline) AND track finding (EUTelescope)**

03 Data taking modes
Options and Status

#	Mode	Sync.	TLU	EUDAQ	Streams	DataCollector	Event building	Realizations
1	EUDET	global busy	EUDET	1	1	DataCollector	Online by DC	EUDAQ1
2	EUDET	global busy	both	2	1	EventnumberSync DataCollector	Online by DC	ATLAS ITK
3	EUDET	global busy	both	2	>1	DirectSaveDataCollector	Offline by ***EventnumberSync EventBuilder***	TORCH and telescope upgrade crew
4	mixed	Trigger ID	AIDA	2	1	***TriggernumberSync DataCollector*** (based on Ex0TgCollector)	Online by DC	Telescope upgrade crew
5	mixed	Trigger ID	AIDA	2	>1	DirectSaveDataCollector	Offline by ***Triggernumber SyncEventBuilder***	Telescope upgrade crew
6	AIDA	timestamp	AIDA	2	1	TimestampSync DataCollector	Online by DC	CALICE, BIF and CaliceTelDataCollector
7	AIDA	timestamp	AIDA	2	>1	DirectSaveDataCollector	Offline by ***TimestampSync EventBuilder***	*Talk by Katja*

03 EUDAQ Summary
Overview

EUDAQ 1 – robust

- *Centralized* **Data Taking** with EUDET TLU
  - One Data Collector
  - Synchronisation by (sub-) event number

- **Versions**
  - Latest release v1.8.0, April 2018
  - Development Branch: v1.7-dev → master-v1

- **Code**
  - One library
  - One thread
  - Component-based Structure

EUDAQ 2 – more flexible

- *Decentralized* **Data Taking** with AIDA TLU
  - Multiple Data Collector (and connections)
  - Online or offline synchronsiation by event number, Trigger ID or timestamps

- **Versions**
  - Latest release v2.1.0, Nov. 2017
  - Development branch: **master**

- **Code** *improvements*
  - Core Library, Converter Library, …
  - Producer abstraction (modules) and multi-threading
  - User-based file/folder structure

only change/update for users →

Acknowledgements to Andre Rummler (maintenance since v1.6) and Yi Liu (final realization and release of v2.0) et. al.

04 Summary & Outlook

Summary

- EUDET-type telescopes (incl. EUDAQ) are under constant upgrade

- EUDAQ2 and AIDA TLU can run in EUDET mode plus two new data taking modes

- User's code have not to be rewritten

  - Producer
  - Converter
  - (in EUDAQ2 maybe: Collector/Merger)

- **Manual on http://eudaq.github.io/ or in CDS: AIDA-2020-NOTE-2018-001**

Outlook

- Mixed Mode for Mimosa- (or rolling shutter-) based telescopes is tested at the moment

  - Data taking modes
  - Merging options
  - Reconstruction changes in EUTelescope

- EUDAQ publication (effort started at DESY)

- Remove EUDAQ dependency in EUTelescope

- Continouos Code improvements (e.g. TCP/IP lib.)

- New MimosaDAQ (MMC3) (effort started with U Bonn)

Backup

03 Locations: Data Collectors and Telescope modules

Code locations and module (name) examples

Data Collectors (today)

| main | module | std | **src** |

Name
- DirectSaveDataCollector.cc
- EventnumberSyncDataCollector.cc
- StdRunControl.cc
- SyncByEventnumberPS.cc
- SyncByTimestampPS.cc
- TimestampSyncDataCollector.cc

Example modules

| user | example | module | **src** |

Name
- Ex0Monitor.cc
- Ex0Producer.cc
- Ex0RawEvent2StdEventConverter.cc
- Ex0RunControl.cc
- Ex0TgDataCollector.cc
- Ex0TgTsDataCollector.cc
- Ex0TsDataCollector.cc

EUDET-type telescopes including Mimosa26/LV-DAQ, FEI4/USBPix, EUDET/AIDA TLU

| user | eudet | module | **src** |

Name
- FmctluProducer.cc
- MinitluProducer.cc
- NiProducer.cc
- NiRawEvent2LCEventConverter.cc
- NiRawEvent2StdEventConverter.cc
- TluProducer.cc
- TluRawEvent2LCEventConverter.cc
- TluRawEvent2StdEventConverter.cc
- UsbpixI4BRawEvent2LCEventConverter.cc
- UsbpixI4BRawEvent2StdEventConverter.cc
- UsbpixrefRawEvent2LCEventConverter.cc
- UsbpixrefRawEvent2StdEventConverter.cc

03 Example: user/eudet/...
Starting the Telescope and Configuration file

Starting

```
# Start Run Control
euRun

# Start Logger
euLog -r tcp://<rc_ip>

# Start TLU Producer
euCliProducer -n FmctluProducer -t fmctlu
    -r tcp://<rc_ip>

# Start Telescope Producer
euCliProducer -n NiProducer -t niproducer
    -r tcp://<rc_ip>

# Start two DataCollectors
euCliCollector -n DirectSaveDataCollector
    -t tlu_dc -r tcp://<rc_ip>
euCliCollector -n DirectSaveDataCollector
    -t ni_dc -r tcp://<rc_ip>
```

EUDAQ Config file

```
[Producer.fmctlu]
# Telescope at HDMI1
DUTMask = 0x1
# HDMI1 is reading out Trigger ID
DUTMaskMode = 0xFC
# EUDET or mixed mode to ignore busy at HDMI1
# DUTIgnoreBusy = 0x1 # yes (mixed)
DUTIgnoreBusy = 0x0 # no (full EUDET)
...
# Data collector – producer connection
EUDAQ_DC = tlu_dc

[Producer.niproducer]
...
# Data collector – producer connection
EUDAQ_DC = ni_dc

[DataCollector.ni_dc]
EUDAQ_FW = native
EUDAQ_FW_PATTERN = PATH/run$6R_ni_$12D$X

[DataCollector.tlu_dc]
EUDAQ_FW = native
```