

# AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators

## Presentation

# Status of EUDAQ1 and EUDAQ2

Dreyling-Eschweiler, Jan (DESY)

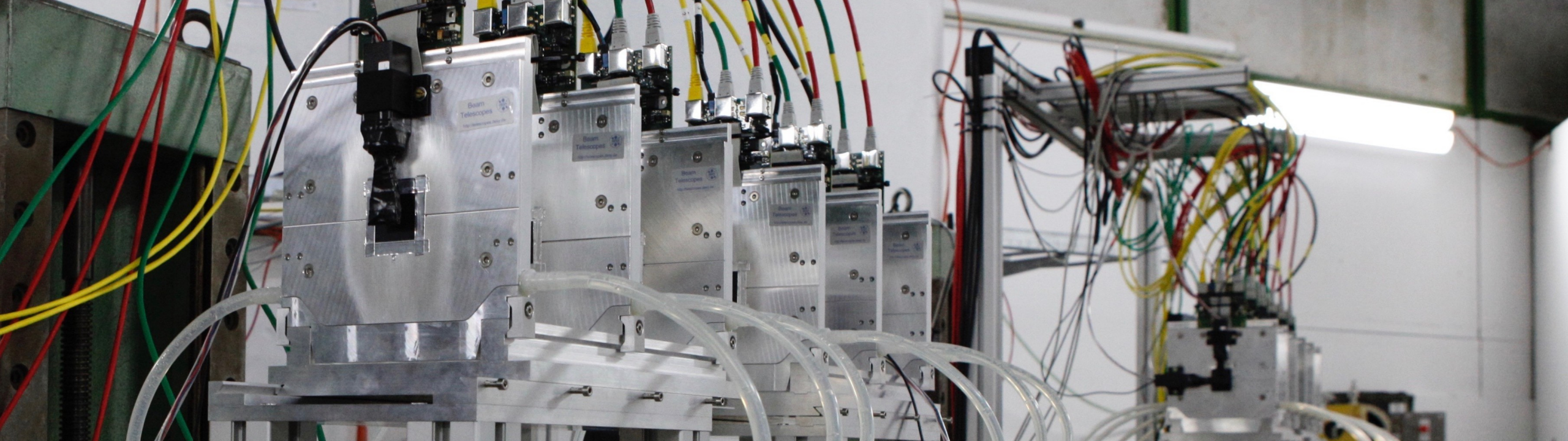
02 April 2019



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# Status of EUDAQ1 and EUDAQ2

Jan Dreyling-Eschweiler (DESY) for the telescope and test beam team

AIDA-2020 Fourth Annual Meeting  
WP5: Data acquisition system for beam tests  
Oxford, 2<sup>nd</sup> April 2019

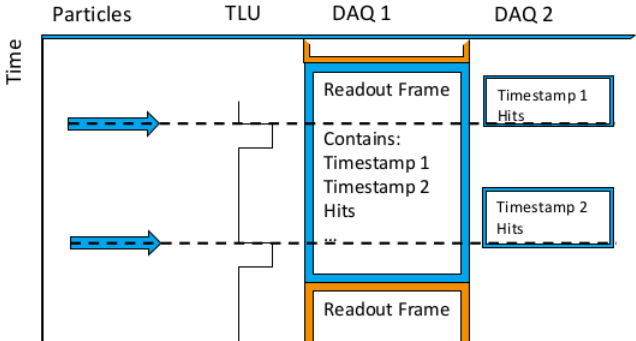
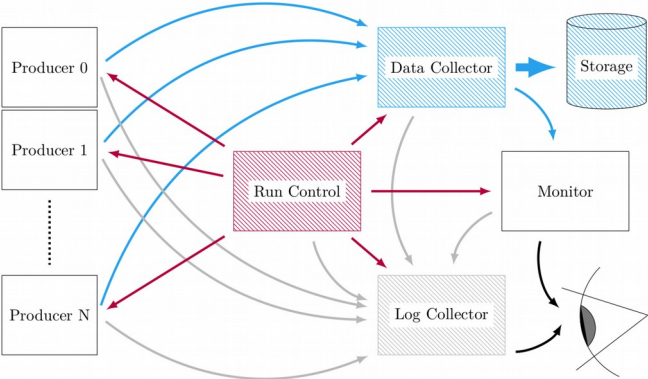
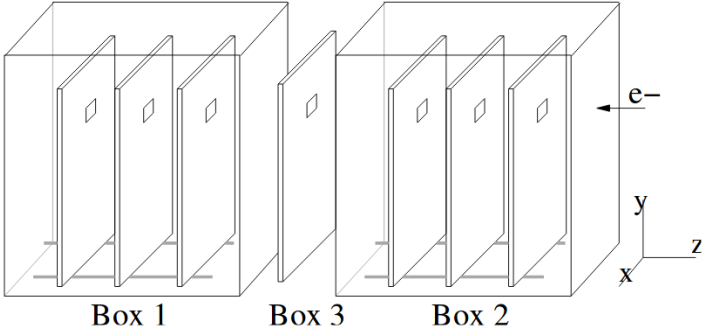
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## 01 Origin & Framework

## 02 Data taking modes

- Application example: EUDET-type telescopes
- EUDAQ 1 → centralized
- EUDAQ 2 → decentralized

## 03 Summary & Outlook



# Starting in 2006 with EUDET-type telescopes

Building up an infrastructure for European DETector research & development

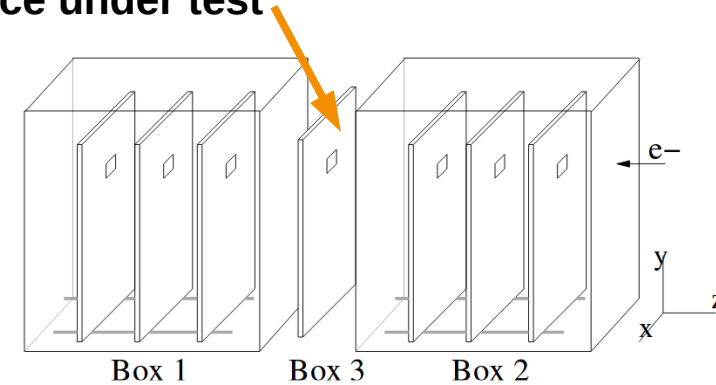
## Initial EUDET packages for beam telescopes DAQ

- Pixel Sensor (CNRS/IPHC Strasbourg) from Mimotel to **Mimosa26**
- Sensor DAQ (DESY, CNRS/IPHC) from EUDRB (VME64x) to **NI DAQ**
- Synchronization (Univ. of Bristol) trigger logic units: **EUDET TLU**
- **Common DAQ software** (DESY) **EUDAQ version 1**

Hardware

SW

DUT = Device under test



Talk in WP15,  
04.04., 10:50

Figure 5: Mechanical concept with three separate areas for the two reference arms and the DUT.

Ingrid Gregor (2007), EUDET-Report-2007-05

Tobias Haas (2006), <https://doi.org/10.1016/j.nima.2006.09.011>

## Strategy for Common DAQ

- Lightweight, top-level DAQ software with interfaces for specific device integration
- Synchronization using a simple trigger-busy communication protocol

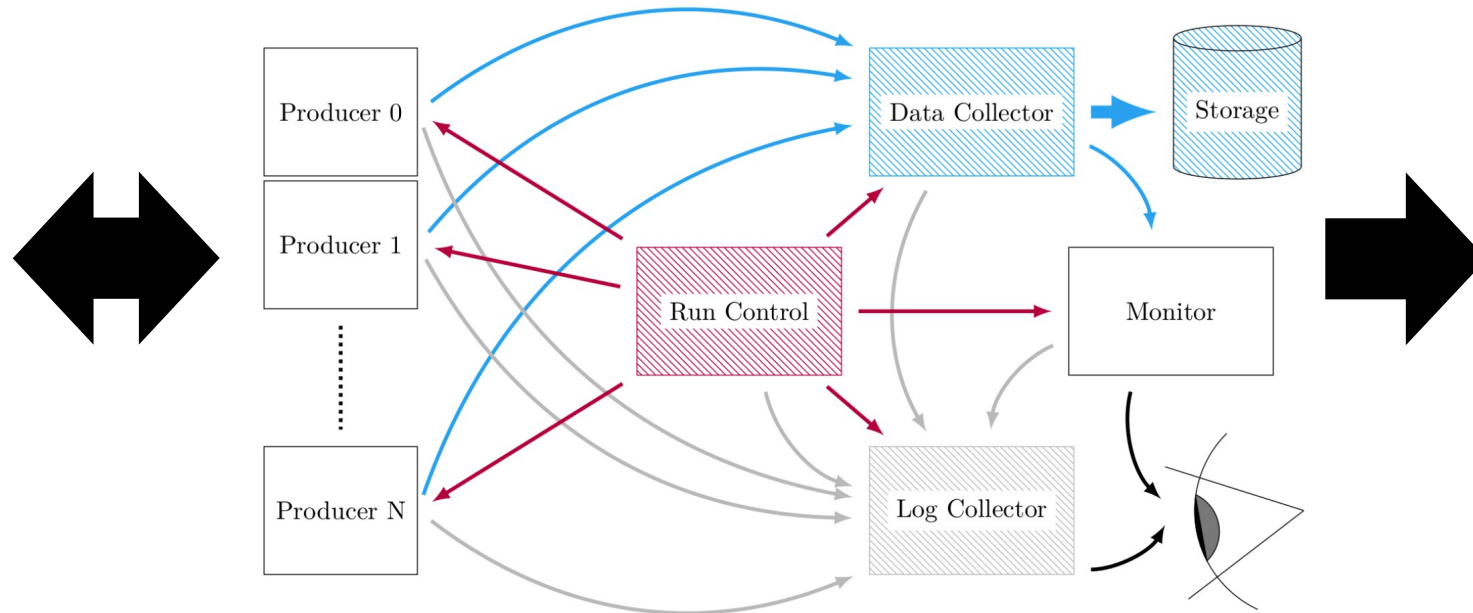
# EUDAQ software framework

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

EUDAQ

## Data in from DUT DAQ:

- Producer
- Examples: TLU, Mimosa, FEI4, ...



## Data out for monitoring or reconstruction:

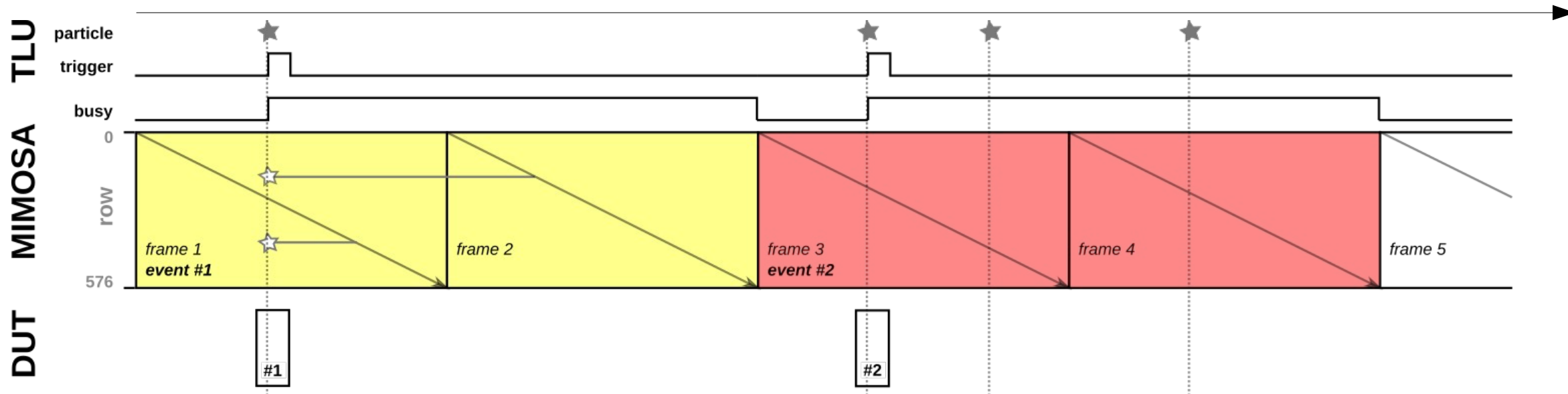
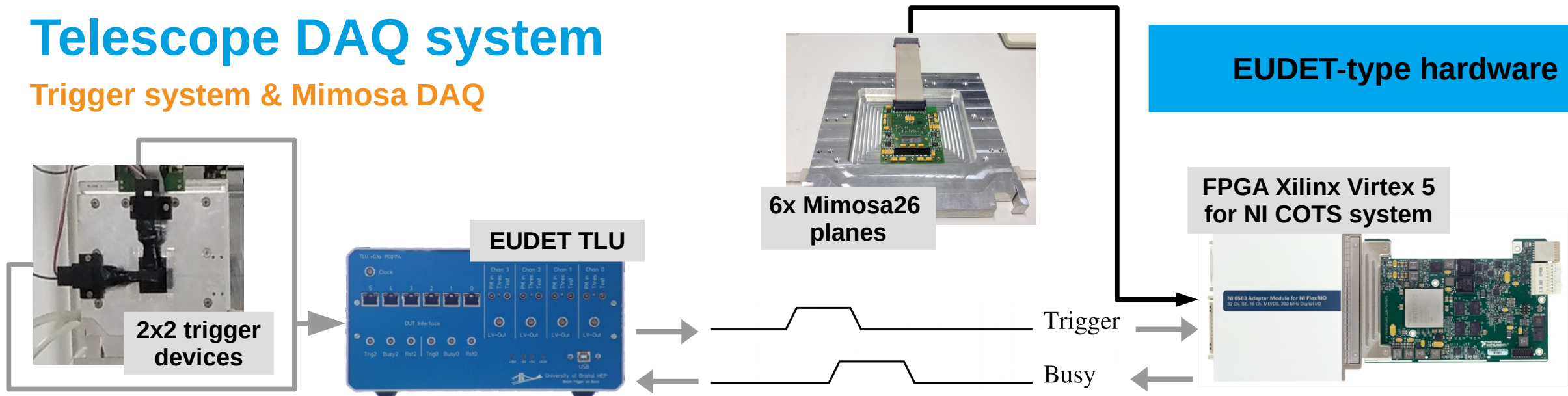
- Converter
- Examples: LCIO, ROOT, ...

## 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

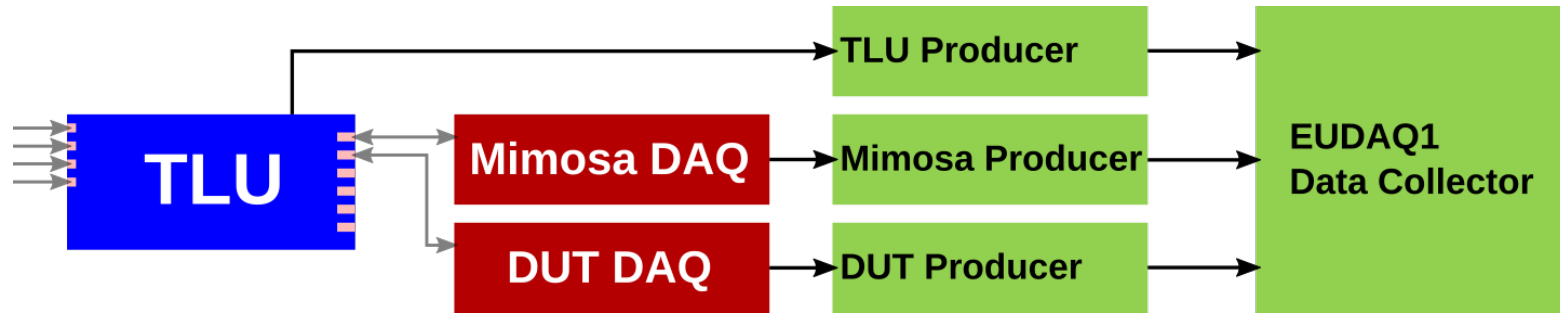
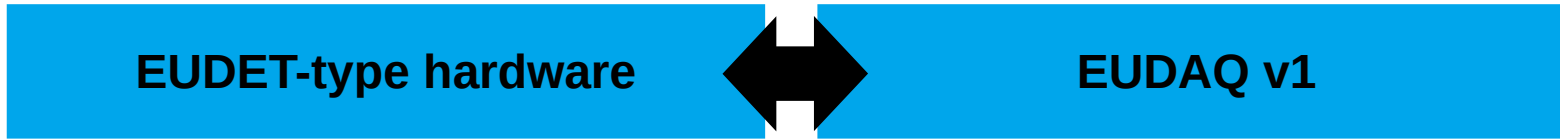
# Telescope DAQ system

## Trigger system & Mimosa DAQ



# Data Flow and Event Building

## Common DAQ for EUDET-type beam telescopes



**EUDAQ Data Collector**

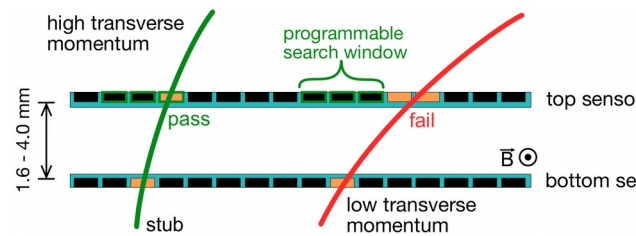
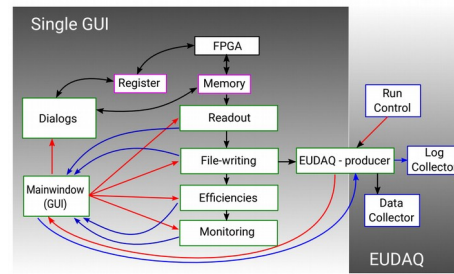
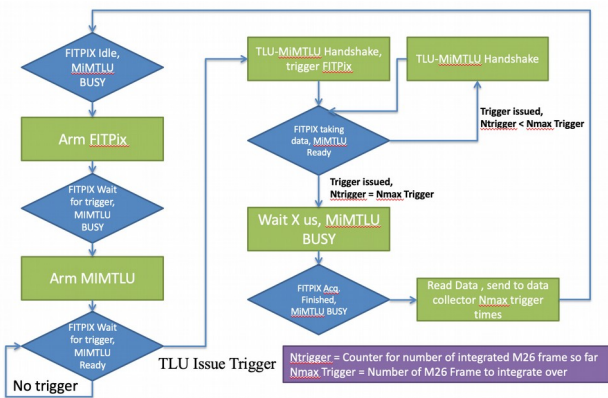
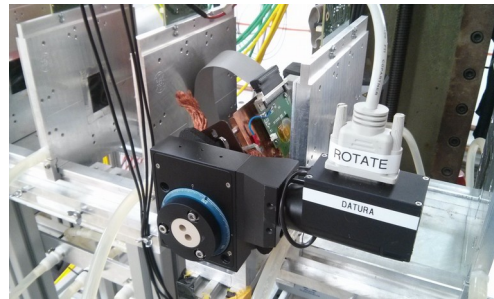
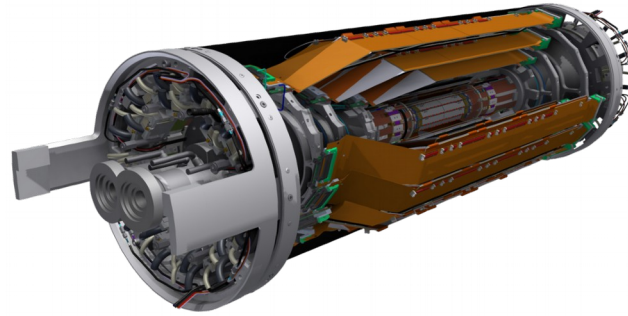
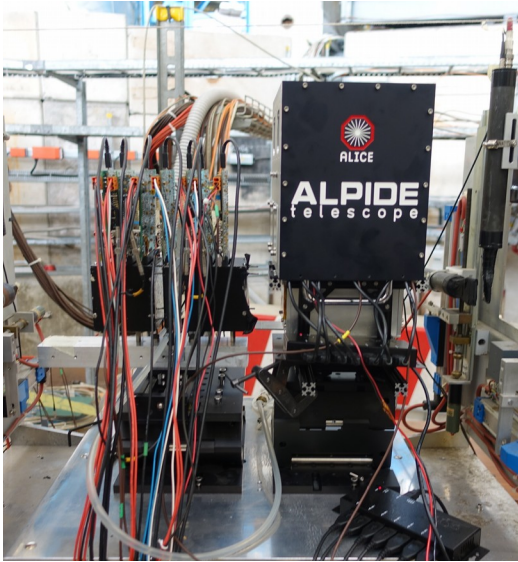
Evt. ID	TLU	DUT	Mimosa
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9
10	10	10	10
11	11	11	11
12	12	12	12
..	..	..	..

“**EUDET mode**”: One trigger = one read-out from all devices

- Event-based synchronisation for robust data-taking
- Unique event definition: **EUDAQ1 event**
- **But trigger rate is limited by the slowest device!**

# User evolution and examples

Many various and different applications



EUDAQ1 paper in editing phase:

Architecture and applications: ALICE ITS, ATLAS Itk, Belle II Vertex, CALICE, CLIC devel., CMS IT-PH1, CMS OT-PH2, CMS HGCAL, MIB, Mu3e devel., SiLab devel, outreach, ...

PREPARED FOR SUBMISSION TO JINST

## EUDAQ – A data acquisition software framework for common beam telescopes

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<sup>h</sup>Laboratoire de l'Accélérateur Linéaire (LAL), CNRS/IN2P3 et Université de Paris-Sud XI,  
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<sup>i</sup>Physics Department, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario, K1S 5B6, Canada

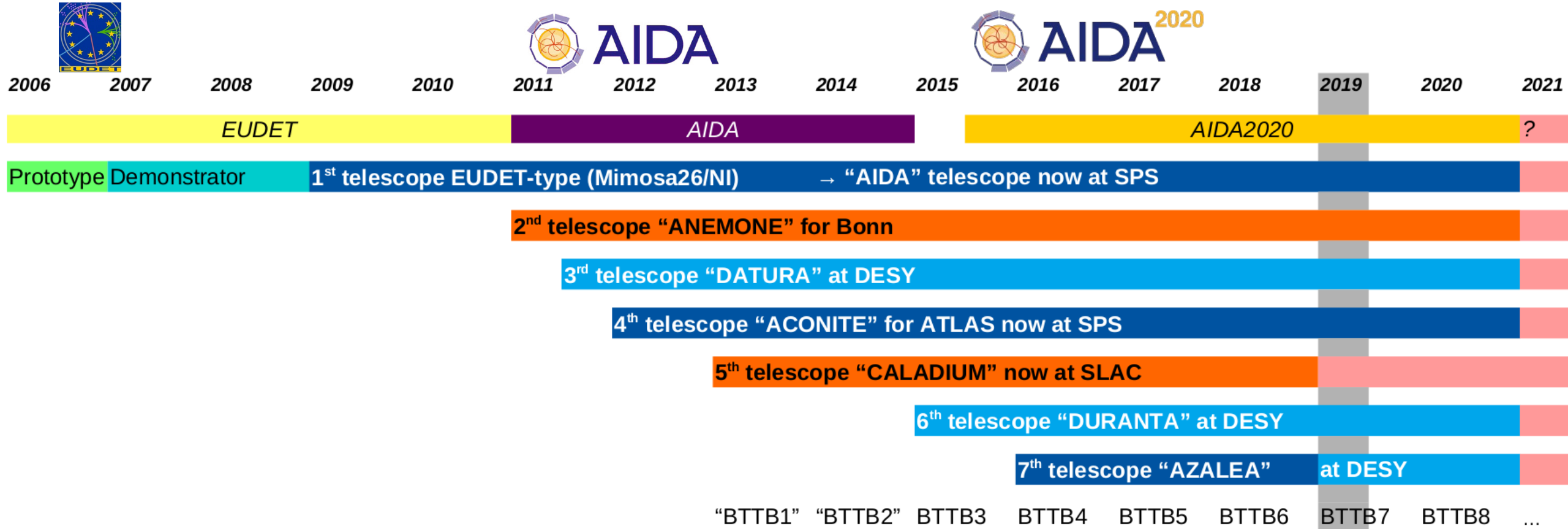
<sup>j</sup>Institute of Physics of the Czech Academy of Sciences,  
Na Slovance 2, 18221 Prague 8, Czech Republic

<sup>k</sup>Division of Nuclear Physics, Lund University



# Infrastructure evolution: 7 copies around the world

Same beam telescope at different beam lines



## EUDAQ v1

Development for version 2

EUDAQ v2

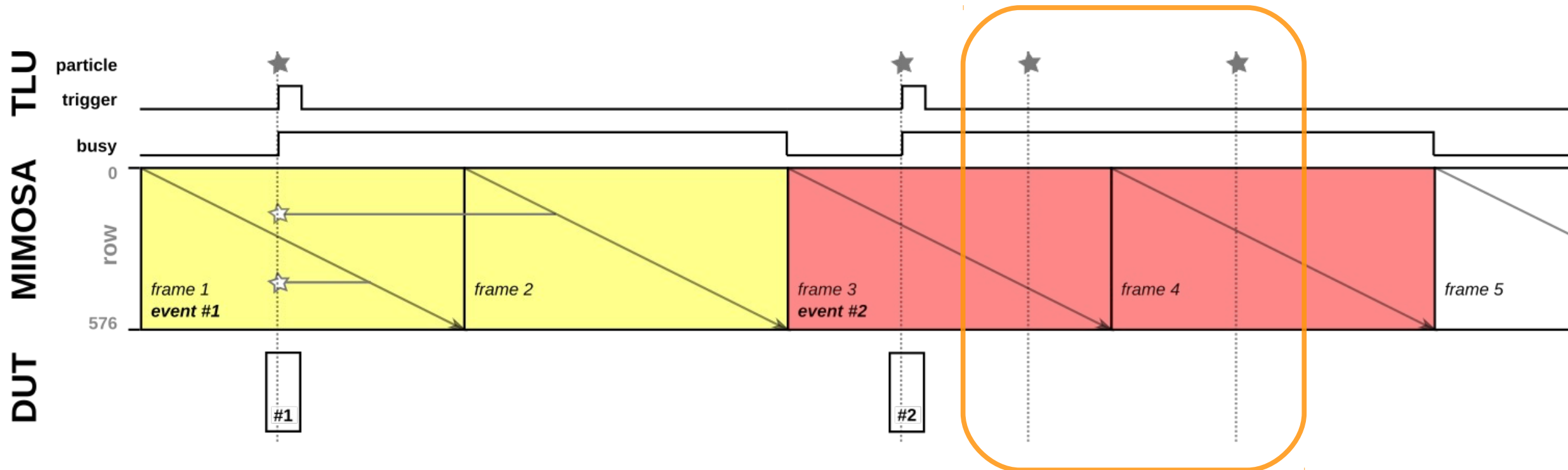
# Why a second version?

## 1) Higher trigger rates

### 1) Strategy for new mode

Allow **multiple** triggers within 1 telescope event

→ **ignore** busy from slow devices



# Why a second version?

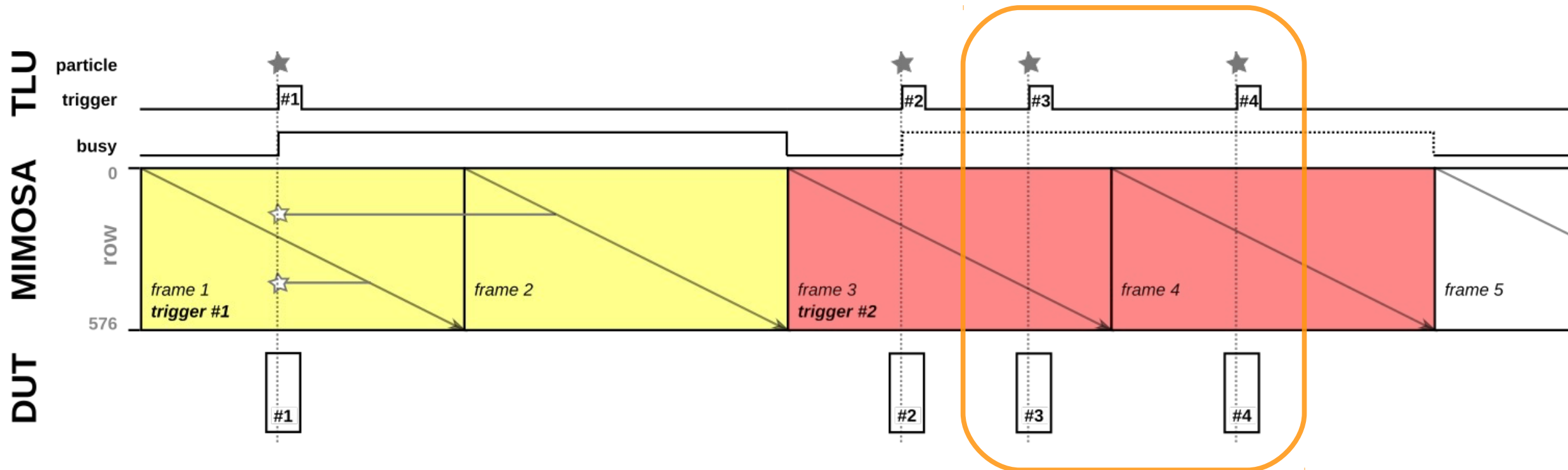
## 1) Higher trigger rates

### 1) Strategy for new mode

Allow **multiple** triggers within 1 telescope event

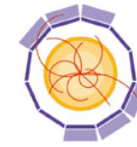
→ **ignore** busy from slow devices → no event-based sync.

→ synchronisation by **common clock or trigger ID**

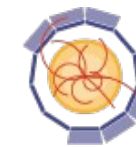


# Why a second version?

1) Higher trigger rates and 2) Common test beam DAQ



AIDA



AIDA<sup>2020</sup>

## 1) Strategy for new mode

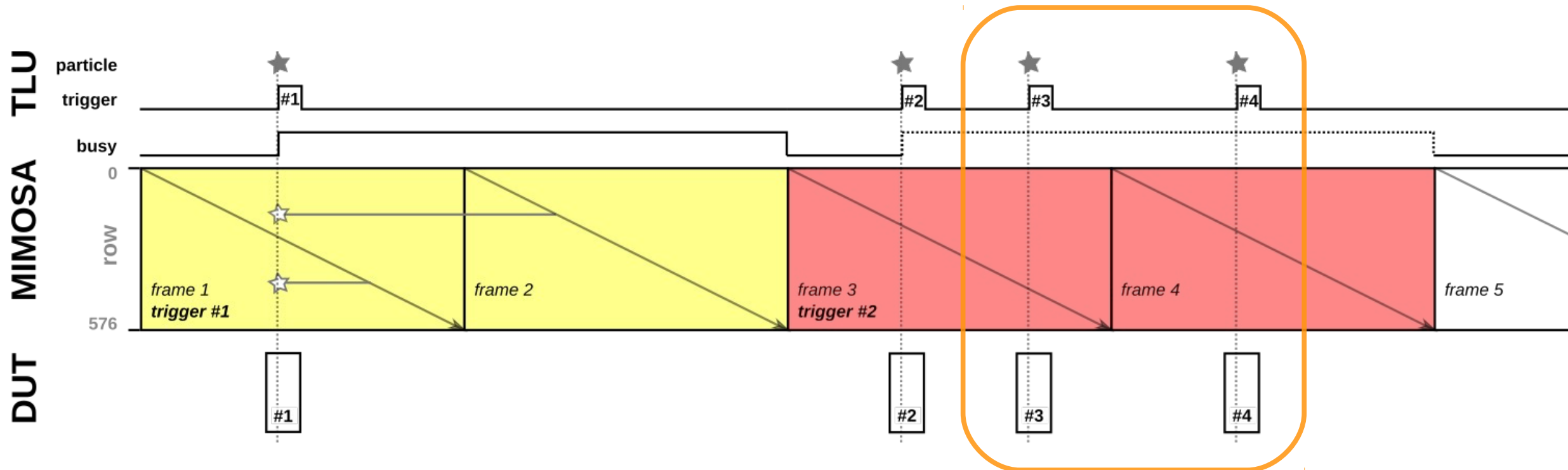
Allow **multiple** triggers within 1 telescope event

- **ignore** busy from slow devices → no event-based sync.
- synchronisation by **common clock or trigger ID**

## 2) Motivation for WP5 AIDA2020

Common DAQ software framework – not only tracker devices, also for calorimeter...

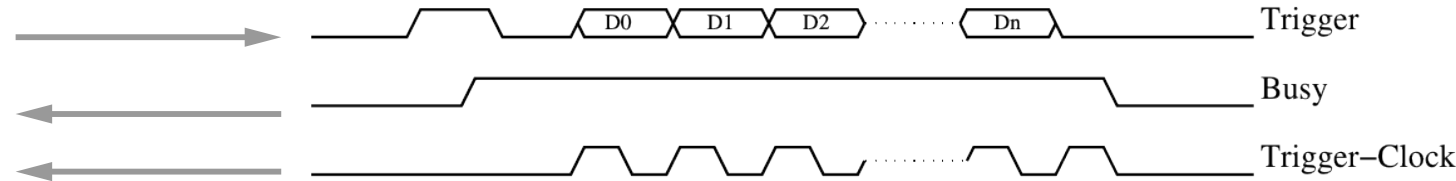
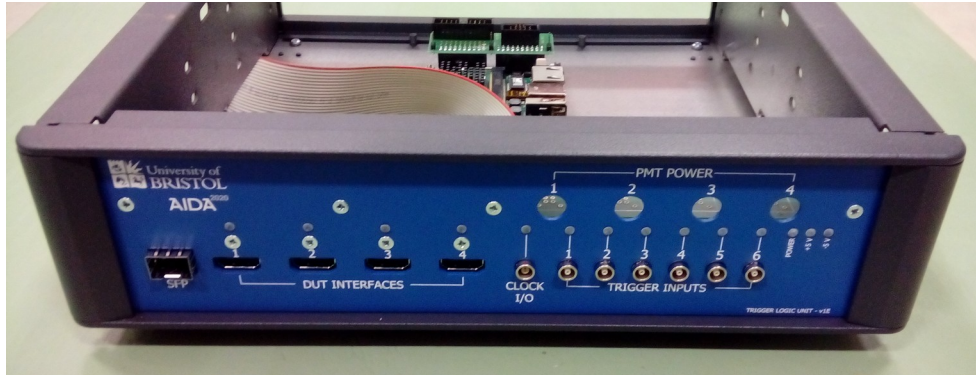
- **EUDAQ1** suitable candidate



# Telescope Upgrade: AIDA TLU ...

Talk by Paolo

New options meet reliable techniques



## “Trigger-data-handshake”

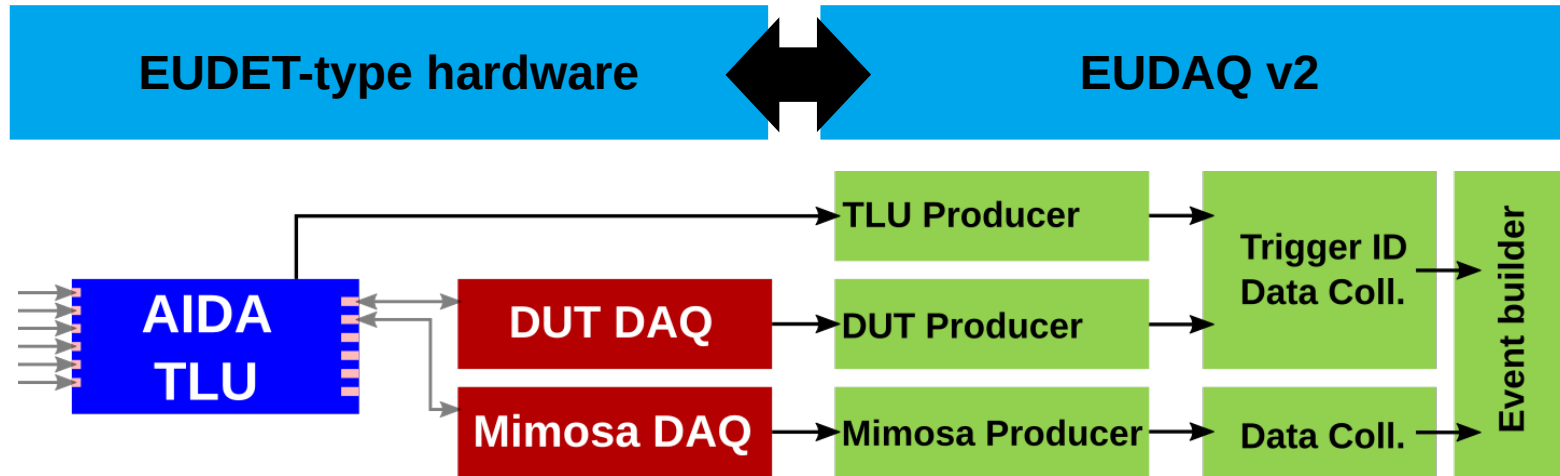
**AIDA TLU:** new options and faster

- New options: **Individual busy** & common clock option
- Backward-compatible (clock out **Trigger ID**)
- New FPGA Xilinx Artix: **1 MHz** maximum trigger rate
- 6x inputs for coincidence logic & 4x interfaces for DUT communication (HDMI)

- Trigger-busy communication
- Plus: device clocks out 15bit unique trigger ID on trigger line

# Telescope Upgrade: ... and EUDAQ2

## Independent data flow and event building



**EUDAQ 2 Sync. by Trigger ID**

Trigg. ID	TLU	DUT	Mimosa
1	1	1	1
2	2	2	1
3	3	3	1
4	4	4	4
5	5	5	4
6	6	6	6
7	7	7	6
8	8	8	6
9	9	9	9
10	10	10	9
11	11	11	9
12	12	12	9
..	..	..	..

“**Mixed mode**”: multiple trigger, not waiting for the slow devices

- Trigger ID-based synchronisation
  - New data collector options in EUDAQ version 2
- Event re-definition for analysis
  - e.g. EUDAQ1-like event by data duplication of Mimosa (duplicated track rejection after analysis)



# Telescope Upgrade: Results for “Mixed mode”

## Getting more timestamped tracks

E.g. 2 GeV/c test run at DESY II TB using the telescope and a fast reference plane FEI4

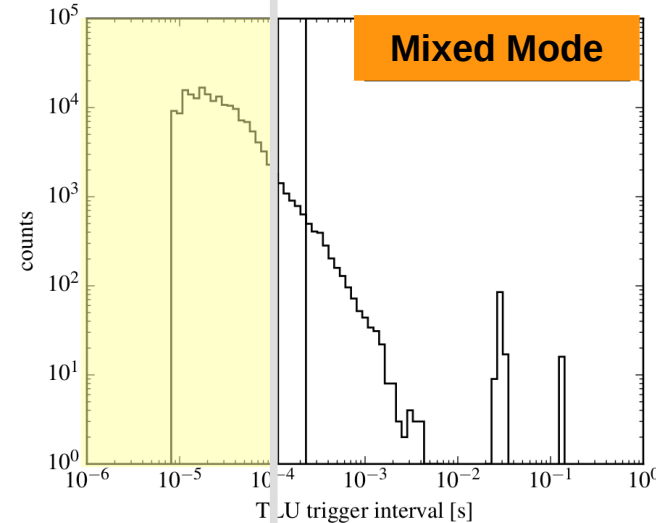
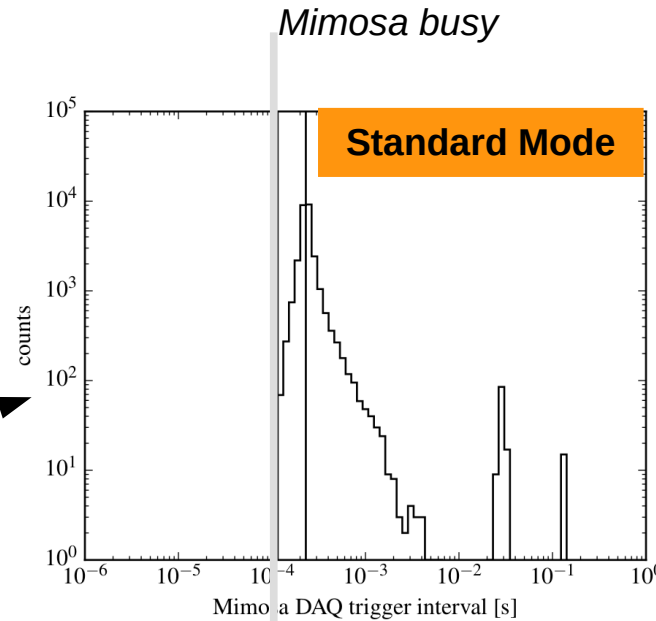
Mixed mode

Standard

EUDAQ 2 Sync. by Trigger ID

EUDAQ 1

Trigg. ID	TLU	DUT	Mimosa	Evt. ID
1	1	1	1	1
2	2	2	1	X
3	3	3	1	X
4	4	4	4	2
5	5	5	4	X
6	6	6	6	3
7	7	7	6	X
8	8	8	6	X
9	9	9	9	4
10	10	10	9	X
11	11	11	9	X
12	12	12	9	X
..	..	..	..	..



## Results & updated limits

- Trigger rate now limited by
  - busy time for clocking out trigger ID
    - here,  $8.8 \mu\text{s} = 115 \text{ kHz}$  (factor ~30)
- Timestamped tracks (with FEI4)
  - **all** tracks with high time resolution
    - **factor 5.5** at 2 GeV/c
    - factor 2.6 at 3 GeV/c @ DESY II TB
    - factor 1.1 at 5 GeV/c
  - potential factor 6.9 at 2 GeV/c
    - losing tracks due to 2-frame read-out

# EUDAQ version 1 and version 2

## Data taking

### EUDAQ 1 – robust

- **Centralized Data Taking** with EUDET TLU
  - One Data Collector
  - Online synchronisation by event number (unique event definition)

#### Data-taking modes of EUDAQ and EUDET TLU

Modes	Trigger comm.	Sync. by
EUDET	Global Trigger-Busy	Event ID

### EUDAQ 2 – more flexible

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

#### Available data-taking modes of EUDAQ2 and AIDA TLU

Modes	Trigger comm.	Sync. by
Standard/ EUDET	Global Trigger-Busy	Event ID/ Trigger ID
mixed	Individual Trigger-Busy	Trigger ID
Timestamp/ AIDA	Common Clock	Timestamps



# Realizations

## 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 <b>EventnumberSync EventBuilder</b>	TORCH and telescope upgrade crew
4	mixed	Trigger ID	AIDA	2	1	<b>TriggernumberSync DataCollector</b> (based on Ex0TgCollector)	Online by DC	Telescope upgrade crew
5	mixed	Trigger ID	AIDA	2	>1	DirectSaveDataCollector	Offline by <b>Triggernumber SyncEventBuilder</b>	Telescope upgrade crew
6	AIDA	timestamp	AIDA	2	1	TimestampSync DataCollector	Online by DC	CALICE, BIF and LYCORIS CaliceTelDataCollector
7	AIDA	timestamp	AIDA	2	>1	DirectSaveDataCollector	Offline by <b>TimestampSync EventBuilder</b>	CLIC

Talk by Katja

Talk by Mengqing

# EUDAQ version 1 and version 2

## Overview

### EUDAQ 1 – robust

- **Centralized Data Taking** with EUDET TLU
  - One Data Collector
  - Online synchronisation by event number (unique event definition)
- **Versions**
  - Latest release v1.9.1, Dec. 2018
  - Development Branch: v1.x-dev
- **Code**
  - One library
  - One thread
  - Component-based Structure

*only change/update for users* →

### EUDAQ 2 – more flexible

- **Decentralized Data Taking** with AIDA TLU
  - Multiple Data Collector (and connections)
  - Online or **offline** synchronisation by event number, **Trigger ID** or **timestamps**
- **Versions**
  - Latest release v2.2.0, Jan. 2019
  - Development branch: **master**
- **Code improvements**
  - Core Library, Converter Library, ...
  - Producer abstraction (modules) and multi-threading
  - User-based file/folder structure

# EUDAQ version 1 and version 2

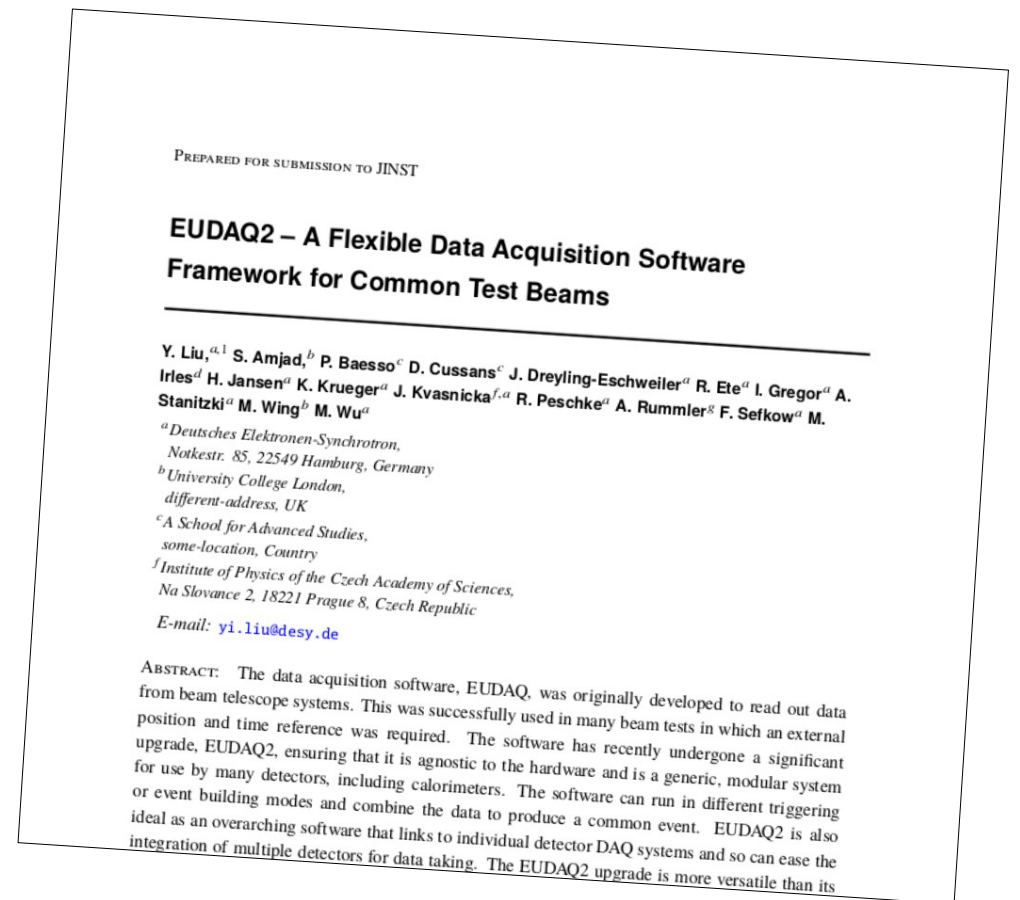
## Overview

### EUDAQ 1 – robust

- **Centralized Data Taking** with EUDET TLU
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- **Versions**
  - Latest release v1.9.1, Dec. 2018
  - Development Branch: v1.x-dev
- **Code**
  - One library
  - One thread
  - Component-based Structure *only change/update for users* →

### EUDAQ2 paper in draft phase:

Architecture and applications: EUDET-type beam telescope upgrade, ATLAS ITk strips, KPiX strip telescope (LYCORIS), CALICE AHCAL



# 04 Summary & Outlook

## Summary

- EUDAQ is under constant user-driven upgrade for beam tests
- 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)
- Code repo. & Manual: <http://eudaq.github.io/>

## Outlook

- EUDAQ 1&2 publications ongoing
- Continuous improvements
  - Repo. & code maintenance (CI, issue tracker, ...)
  - User-friendly implementations (Rate indicators, automatic scan options, ...)
  - Tackle the LogChannel limit (~10 producers)
  - Tackle the SendEvent-rate limit (~50 kHz)  
→ **Strategy for data-driven detectors**
- Ideas for Version 3
  - Modern TCP/IP library
  - Modern OnlineMonitor (DQM4HEP...)
  - ....

# Thank you

## Teams for common beam telescopes

- TLU: Paolo Baesso, David Cussans (Univ. of Bristol)
- EUDAQ1/2: Andre Rummler (CERN), Yi Liu, Lennart Huth, Thomas Daubney (DESY), and many user
- EUTelescope: Edo Rossi, Jan-Hendrik Arling, Cyril Becot, Xiacong Ai (DESY)
- MMC3: Yannick Dieter, David-Leon Pohl (Univ. of Bonn)
- Further support: Simon Spannagel, Maarten Van Dijk (CERN), Hendrik Jansen, Mengqing Wu, Marcel Stanitzki, Ingrid Gregor (DESY), WP5, WP15, and many more

## Contact

Deutsches  
Elektronen-Synchrotron

[www.desy.de](http://www.desy.de)







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Phone: 0049 (0)40 8998 2794

# 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		
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	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 FmctlProducer -t fmctl
-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.fmctl]
# 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
```



# Beam Telescopes

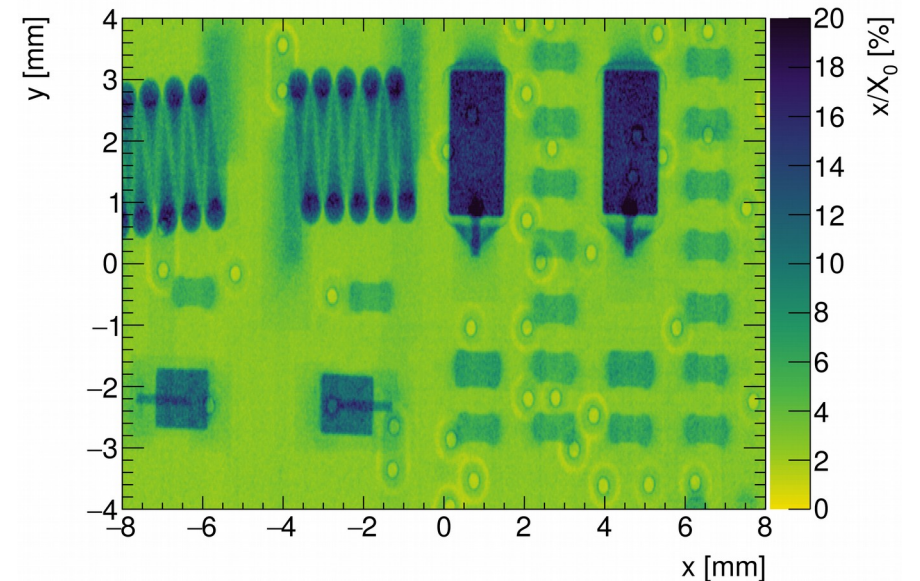
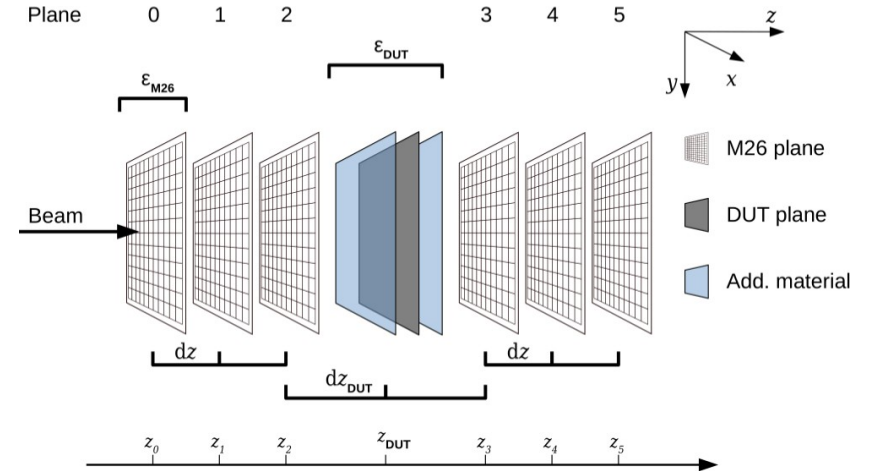
## High-precision reference tracker

### 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 ( $> 1.8 \mu\text{m}$ ) or angular resolution ( $> 0.03 \text{ mrad}$ ) @ 1-6 GeV/c
  - **Material Budget (X0) imaging**

### References

- **Portal & Manual & Description:** [telescopes.desy.de](https://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)

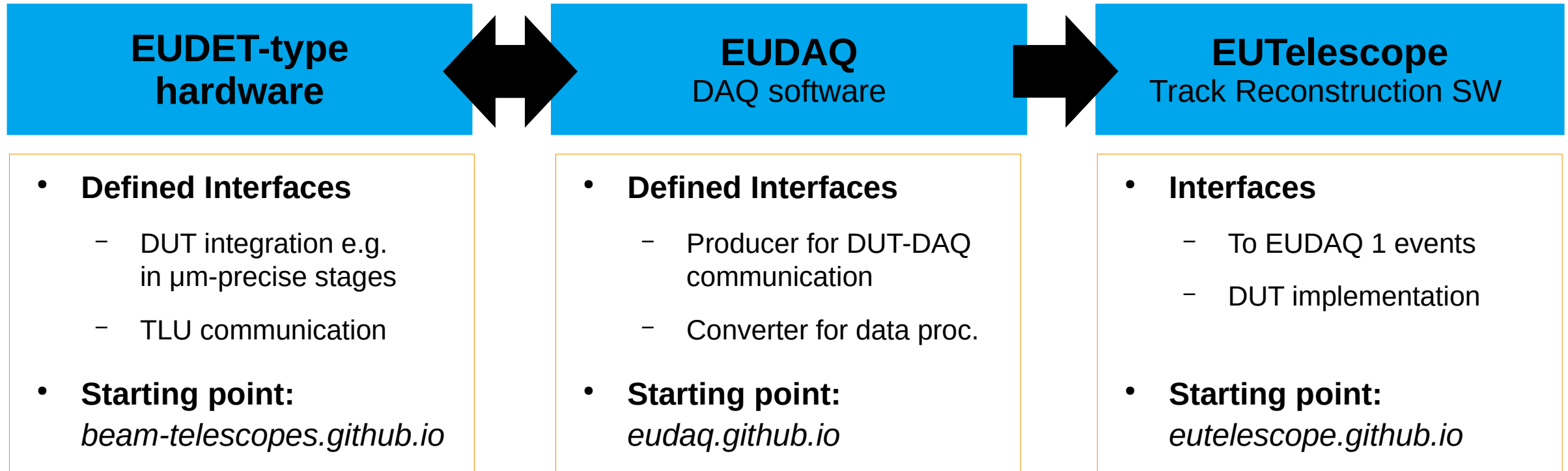
# Common Beam Telescopes

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



# EUDAQ telescopes family today

Documentation & Development different beam test beam facilities

Talk by Mengqing (Thursday)

Talk by Mengqing/Uwe

Talk by Ralf (yesterday)



Contact:  
Carsten Hast



**CALADIUM** @ SLAC in Stanford, USA



**DATURA** @ TB21



**DURANTA** @ TB22

**TB contact:**  
Ralf Diener,  
Norbert Meyners,  
Marcel Stanitzki  
**Telescope contact:**  
Hendrik Jansen, Jan Dreyling-Eschweiler



**AZALEA** @ PS, T10



**AIDA** @ SPS, H6B



**SPS/PS contact:**  
Henric Wilkens  
**Telescope contact:**  
André Rummler

Talk by Maarten (this morning)



**ACONITE** @ SPS, H6A

Talk by Alexander (this morning)

Talk by Dennis (yesterday)



**ANEMONE** @ BONN / ELSA

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**Telescope contact:**  
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