

AHCAL + beam telescope testbeam with EUDAQ2



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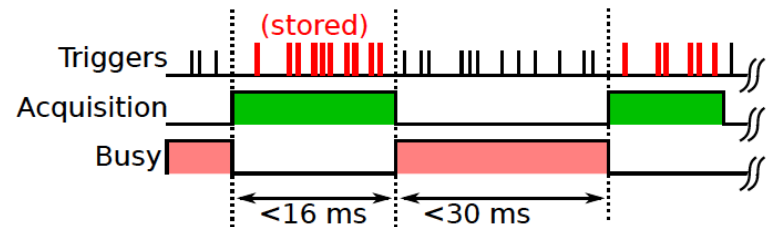
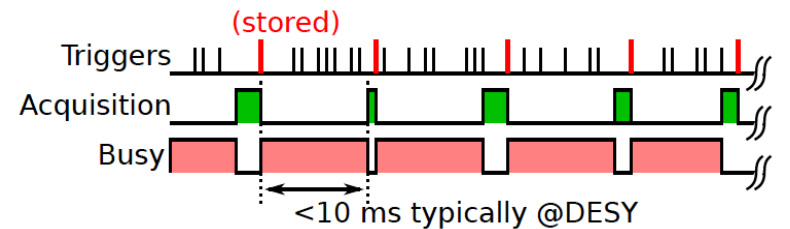
Overview

- Introduction: AHCAL and beam telescope synchronization
- Involved detectors
- Event building
- Testbeam experience (Debugging)
- Data quality and Performance
- Summary & next steps



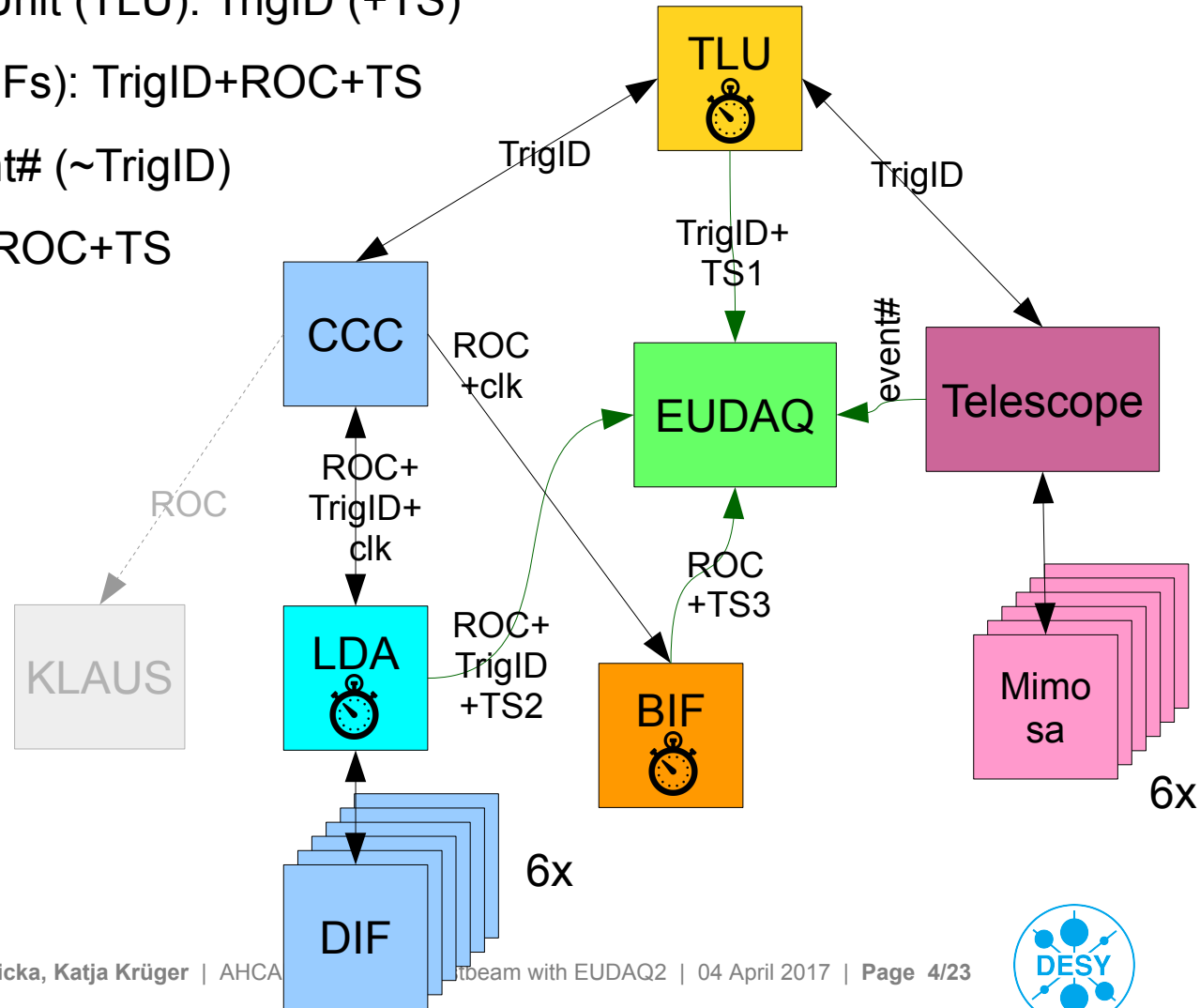
AHCAL and Beam Telescope Synchronization

- Main Problem: **synchronization of different concepts**
- AHCAL:
 - Self-triggered, ILC spill-oriented (Acquisition cycle / Readout cycle oriented)
 - More particles within the spill
 - Considerable dead time during readout
- Telescope:
 - Externally triggered
 - When triggered, 2 rolling shutter frames (115us) are sent as 1 event
- **Synchronization approaches:**
- Only 1 trigger per acquisition cycle
 - testbeams Oct + Dec 2016
 - EUDAQ1
- More triggers per acquisition cycle
 - testbeam Feb 2017
 - EUDAQ2
 - Event building necessary

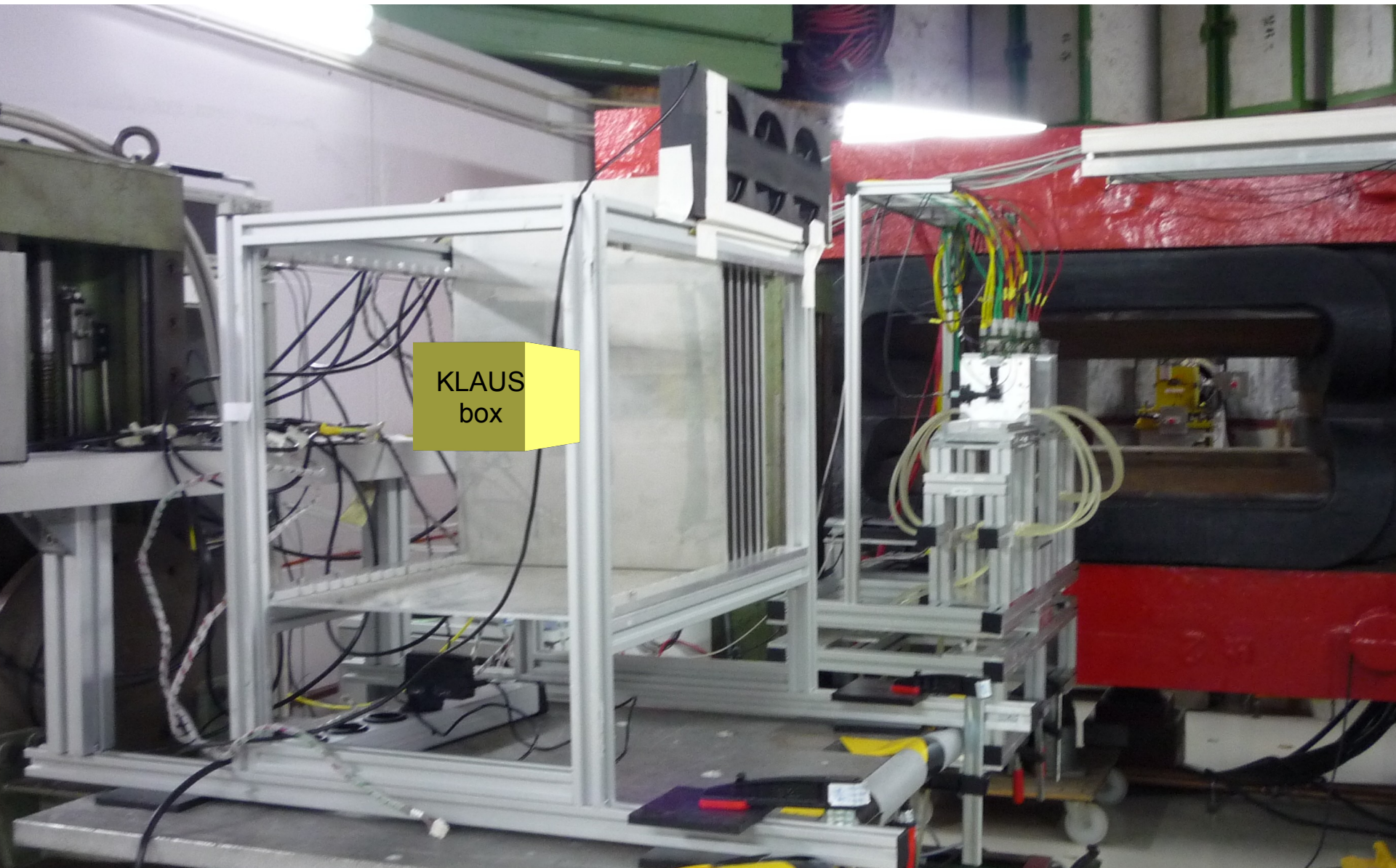


Involved detectors: why is it difficult to combine data?

- 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



Setup February 2017

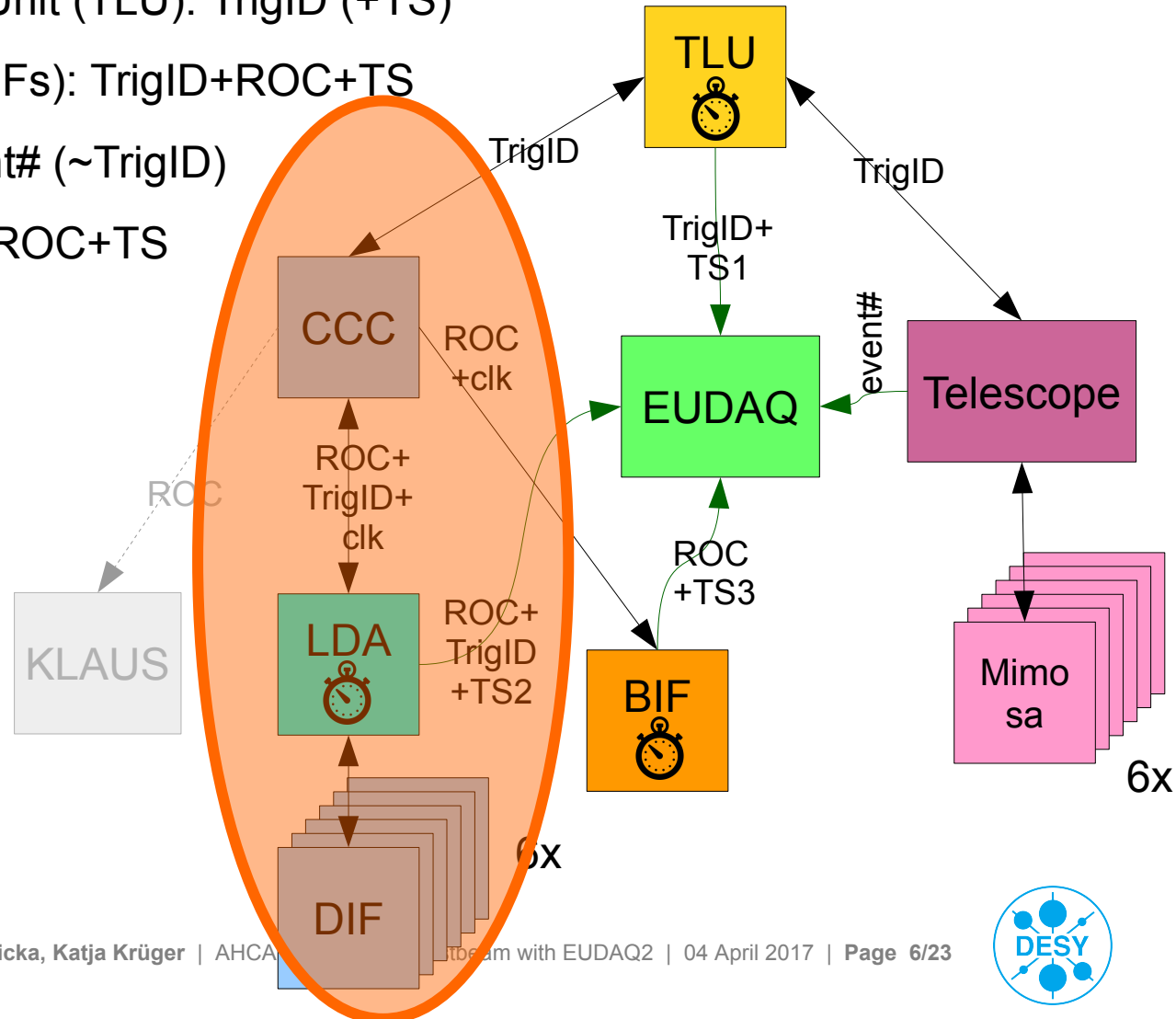


KLAUS
box



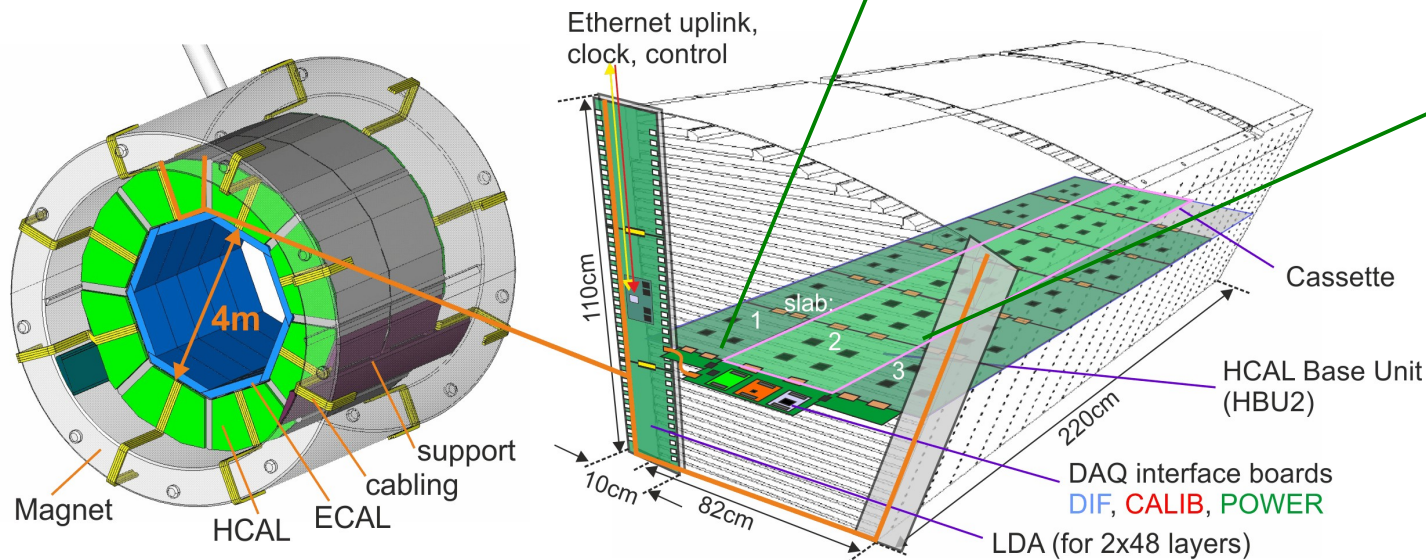
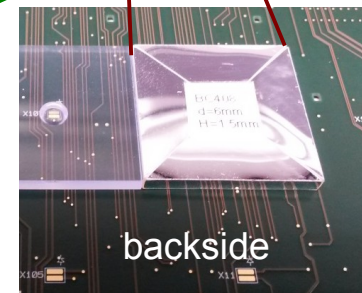
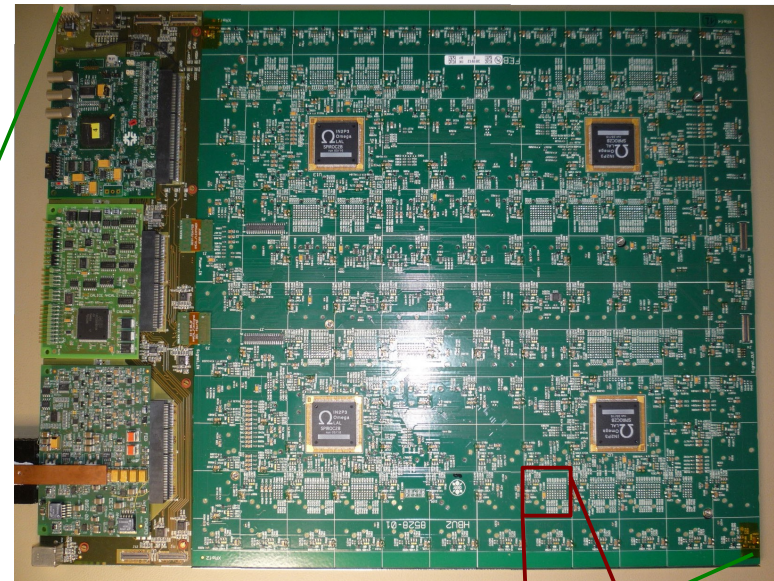
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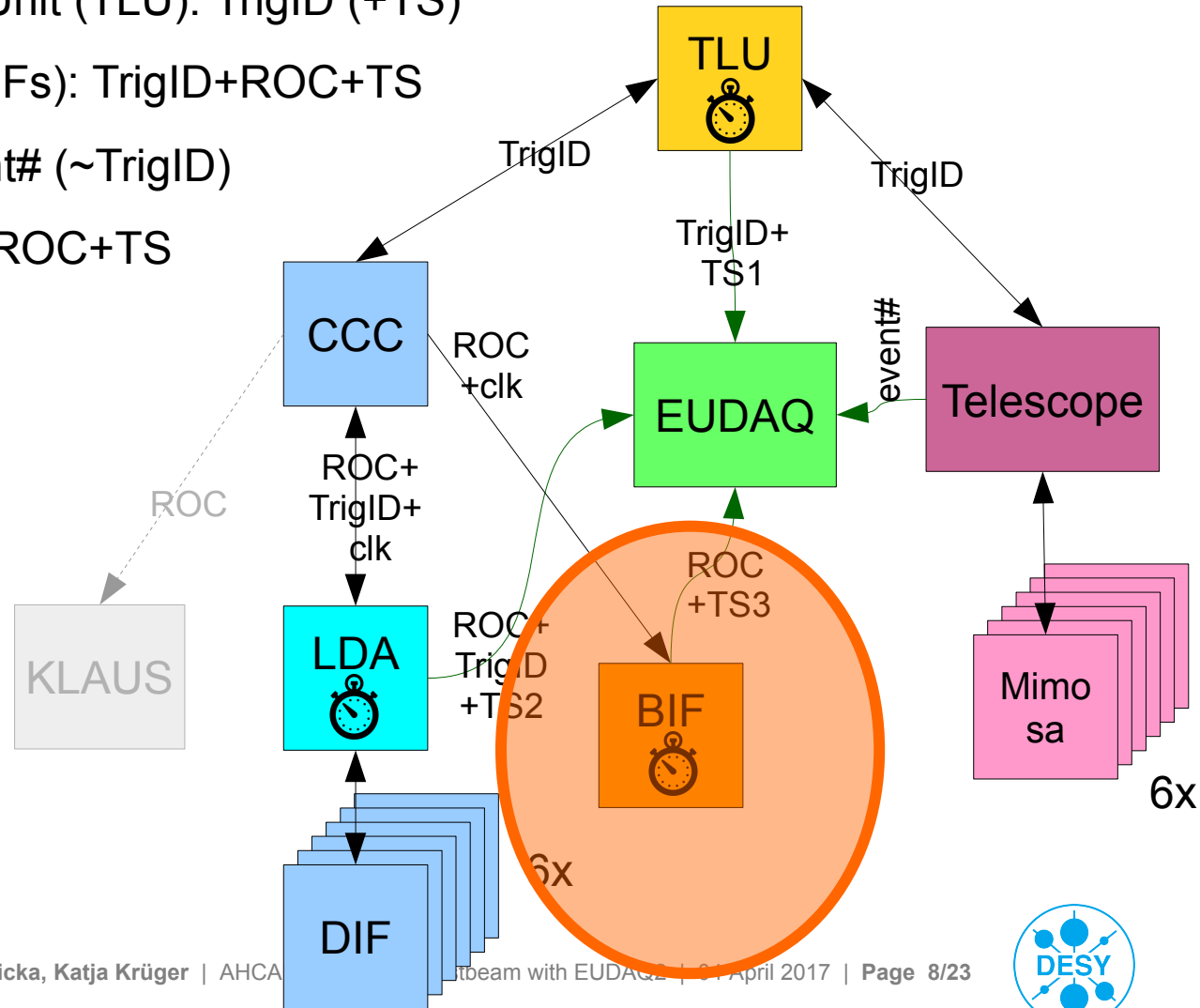
AHCAL

- HBU (HCAL Base Unit)
 - 36x36 cm²
 - 12x12 Scintillator tiles (3x3x0.3cm each)
 - Individual SiPM per scintillator tile
 - 4 ASICs (each 36 input SiPM channels)
- one set of interfaces (DIF, ..) per layer
- in this testbeam: 6 layers of 1 HBU



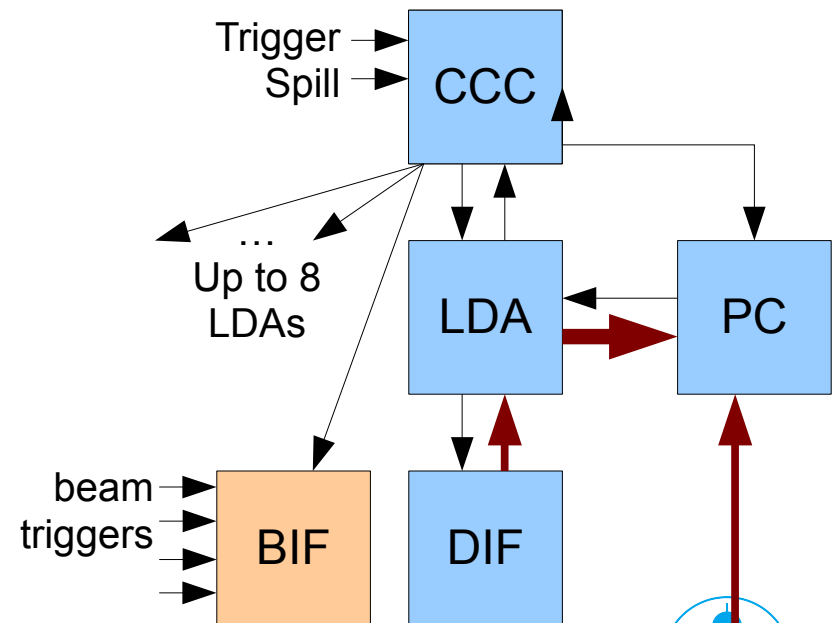
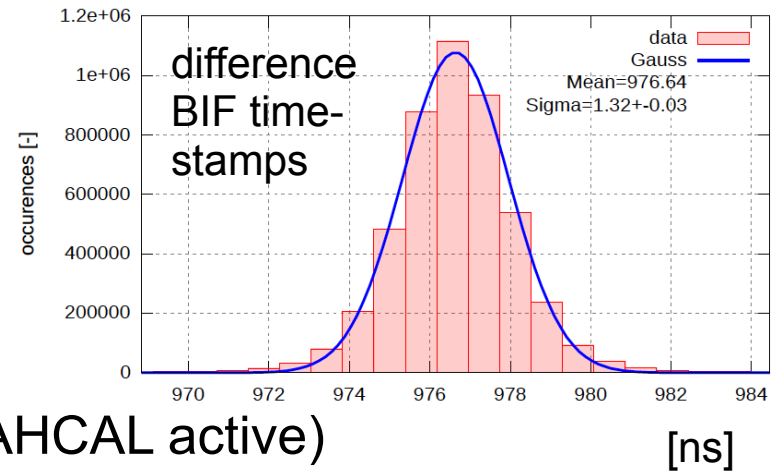
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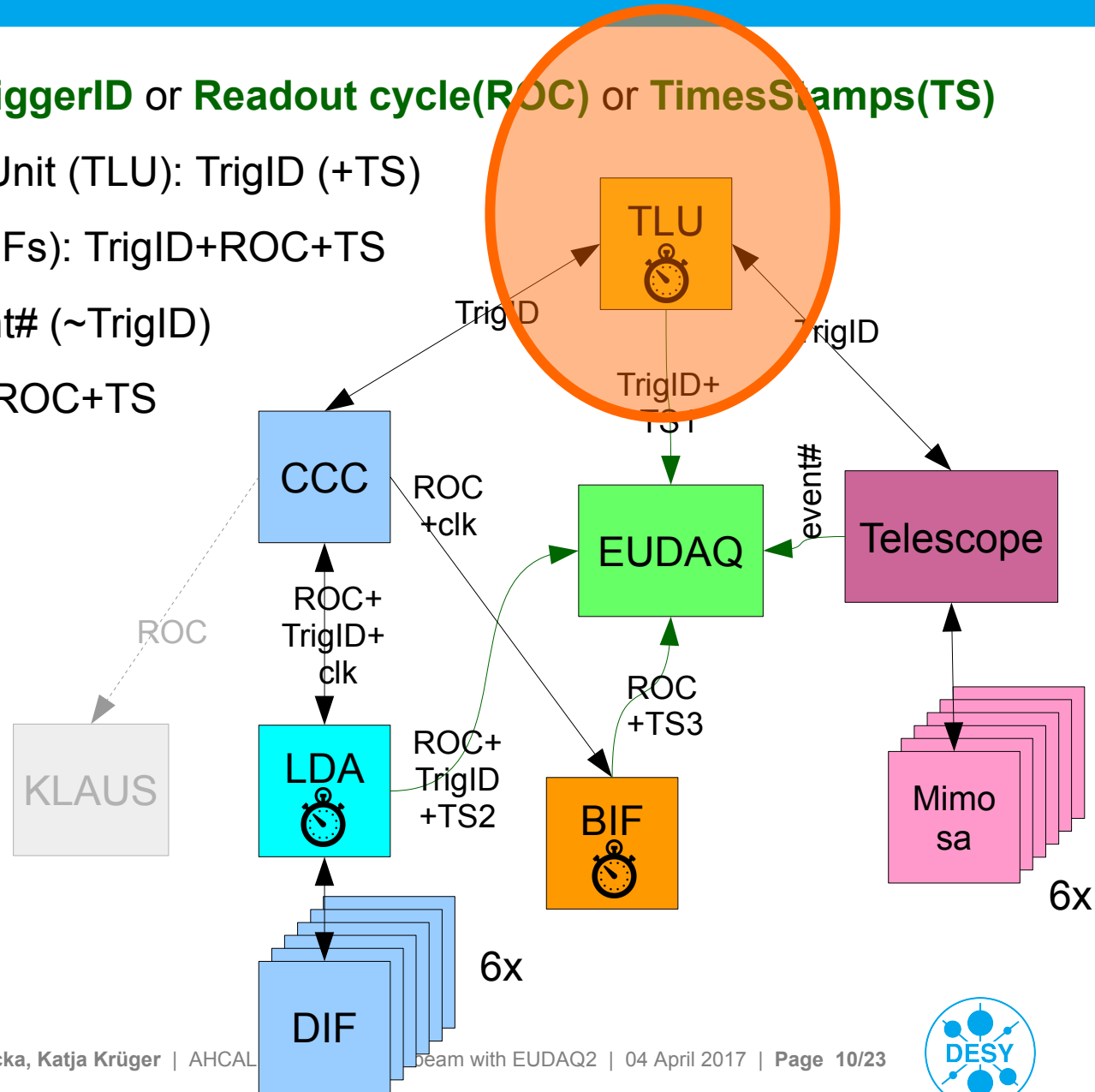
BIF (Beam Interface): Timestamping external signals

- Modified firmware of the **AIDA mini-TLU**
 - **Receives AHCAL clock**
 - Knows AHCAL fast commands from HDMI
- Records timestamps from 4 inputs (Iemo) + 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



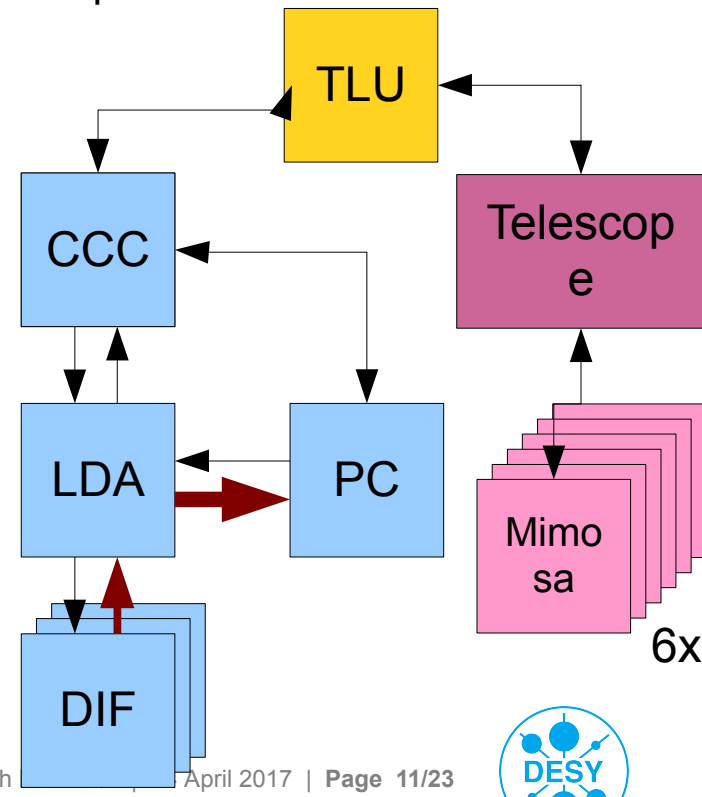
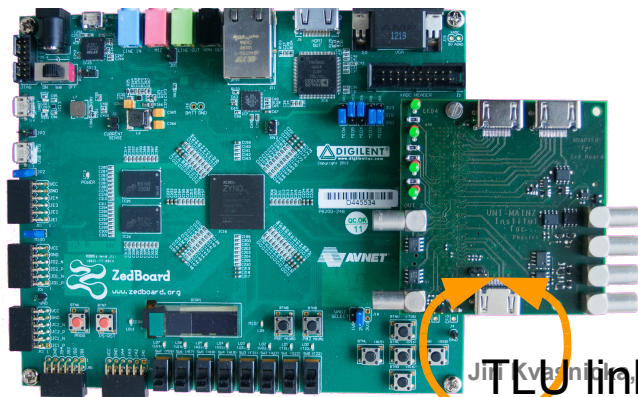
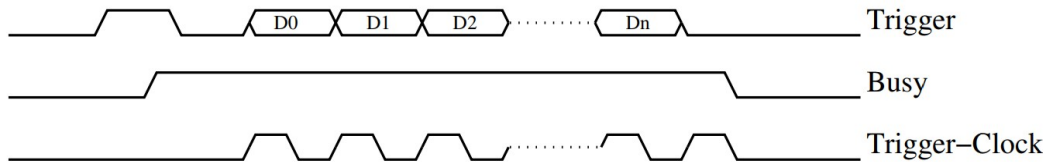
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TLU and triggerID

- EUDET TLU: a Trigger Logic Unit
 - Connects to 4 PMTs
 - Deliver triggers to DUTs (up to 6)
 - Telescope needs it → we have to use it
- CCC modification: **added a TLU interface**
 - Handles the triggers from TLU and triggerID clockout protocol
 - additional busy signal treatment (towards TLU)
- TLU and CCC have independent clocks



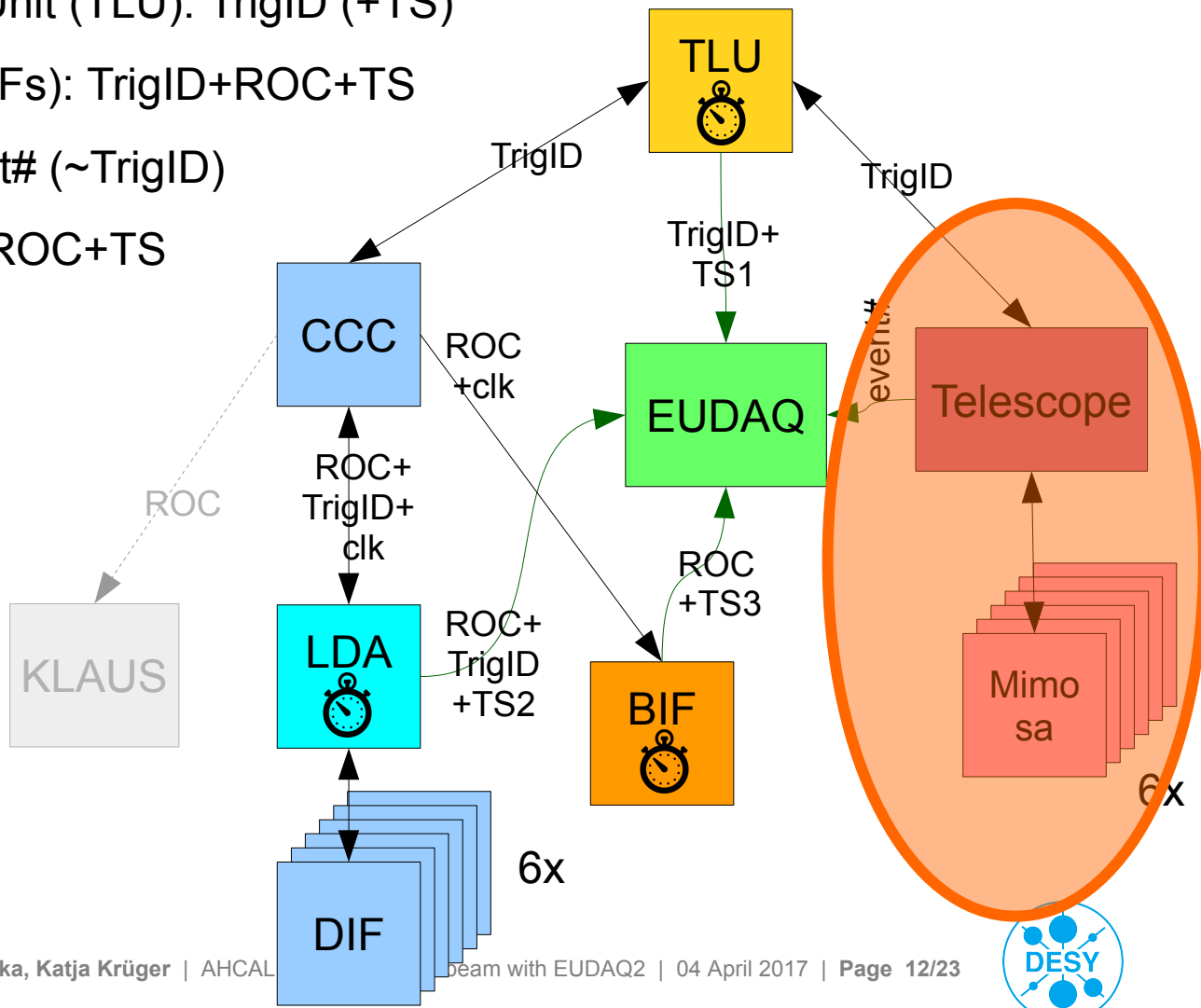
TLU link

am with



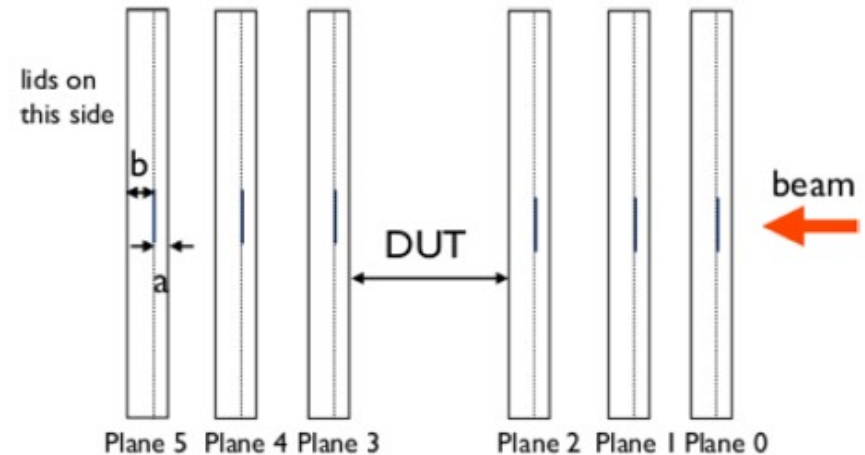
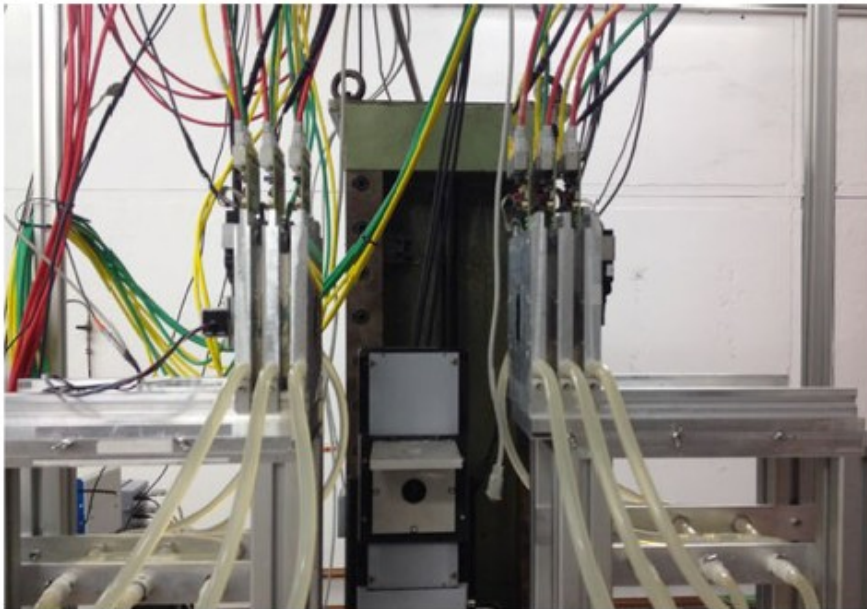
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Mimosa26 pixel telescope

- 6 planes, each 576x1152 pixels (**10.6 x 21.2** mm²)
- Unconventionally, AHCAL sits 3m behind
- Continuous rolling shutter (115 us)
- When trigger comes, data from 2 frames are sent
 - 1 “event” per each trigger



$a=2.65\text{mm}$
 $b=12.35\text{mm}$



Testbeam Setup in February 2017: putting it all together

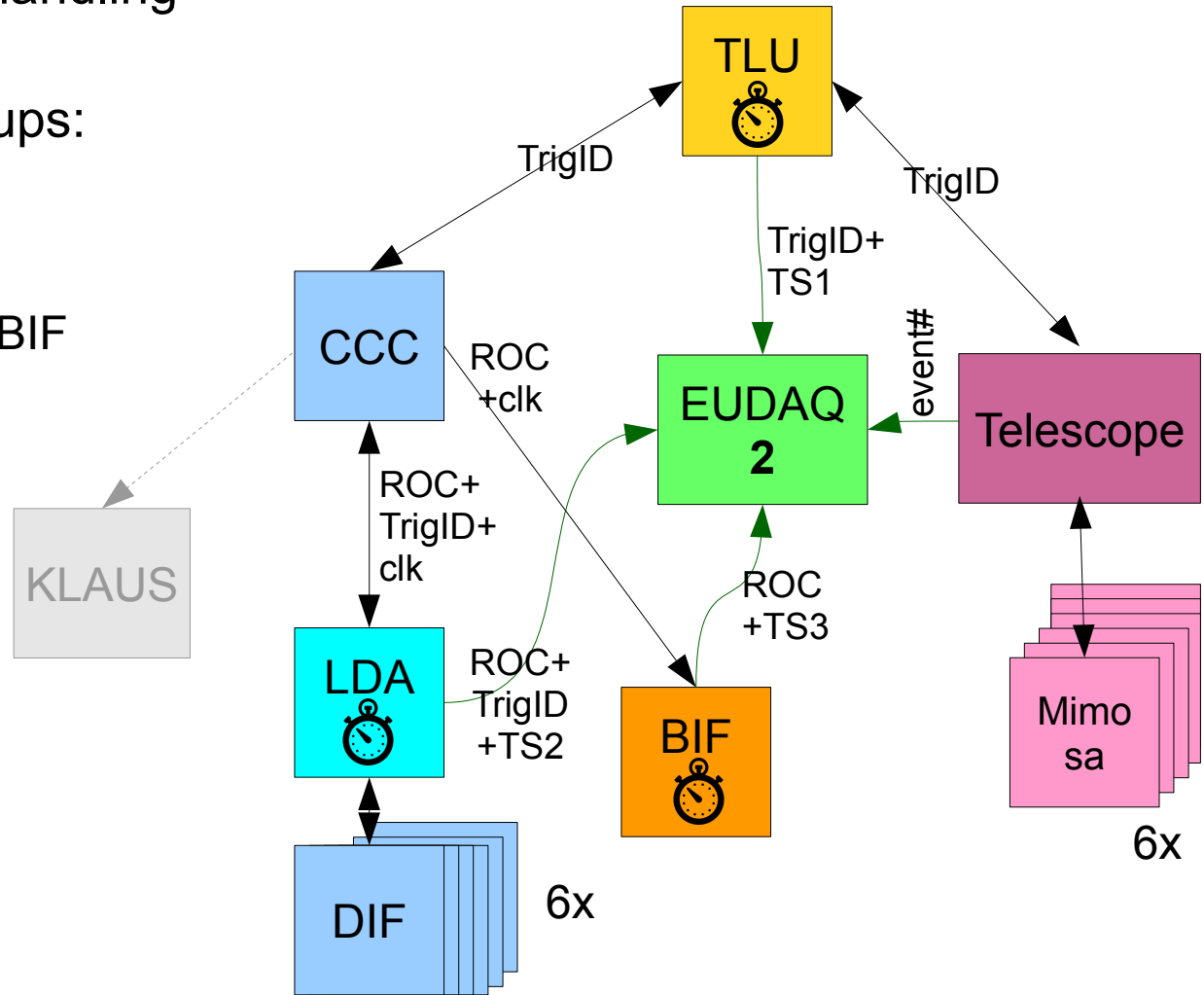
> TLU is master device handling busy signals

> independent clock groups:

- TLU
- telescope
- CCC + LDA + DIFs + BIF
- KLAUS

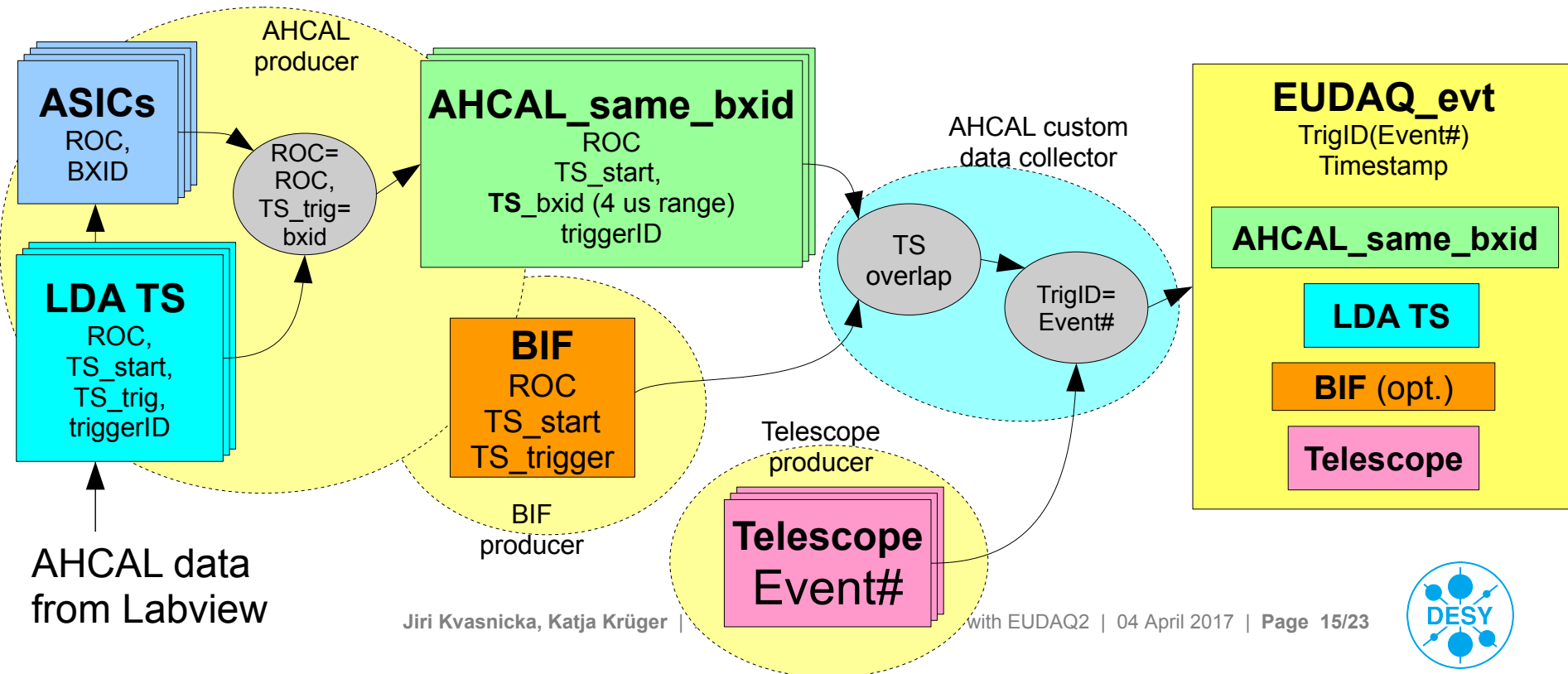
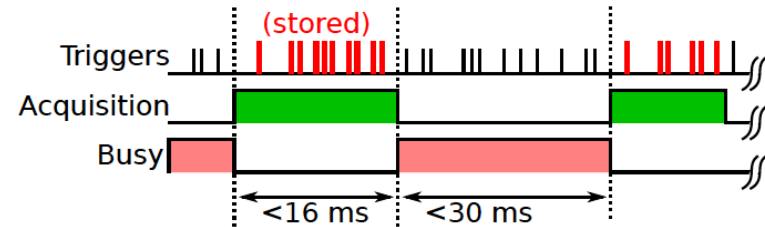
> new components

- readout scheme
- EUDAQ2
- AHCAL producer
- telescope producer
- TLU producer
- data collector

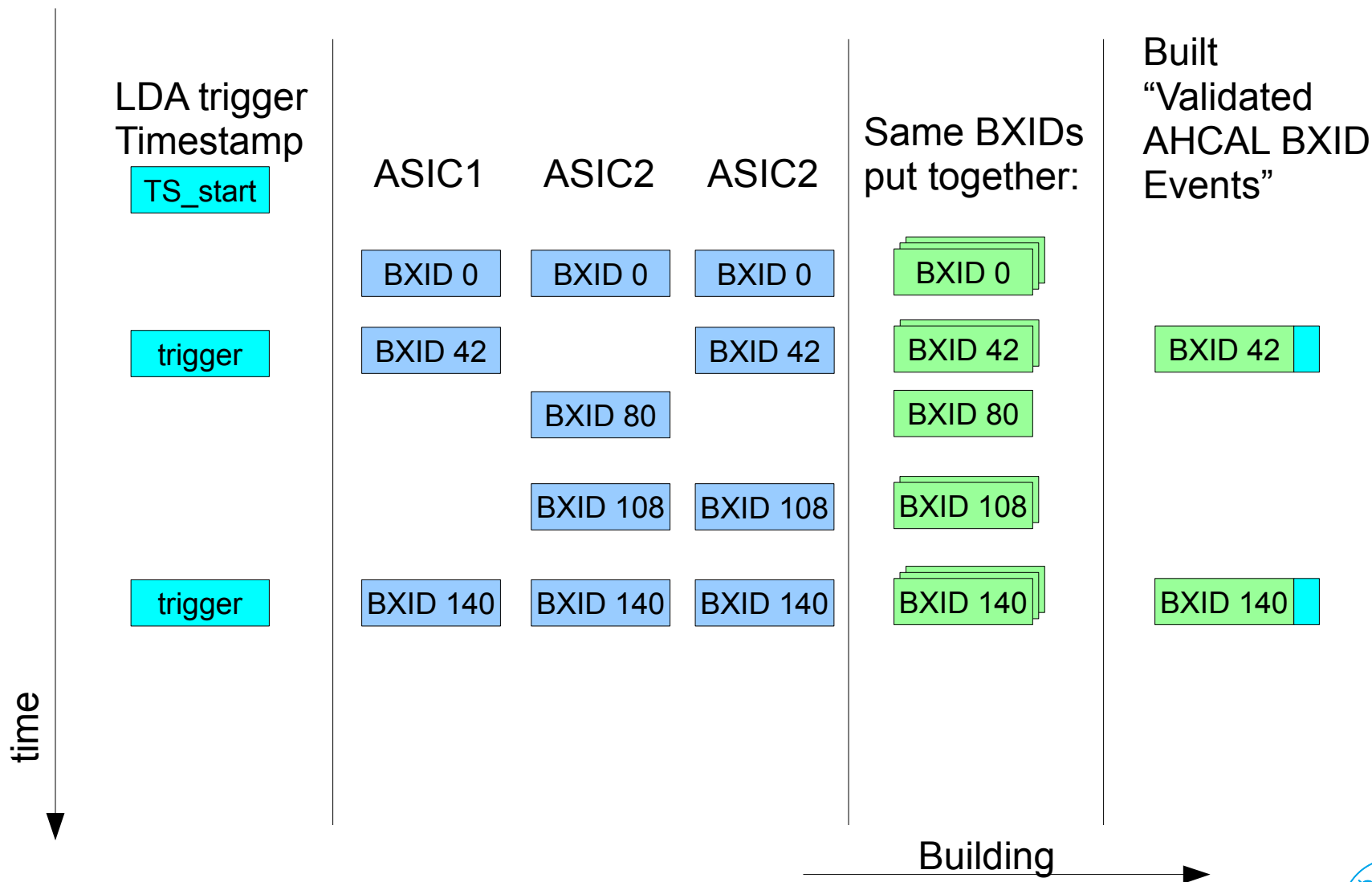


EUDAQ2: New event building

- > 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

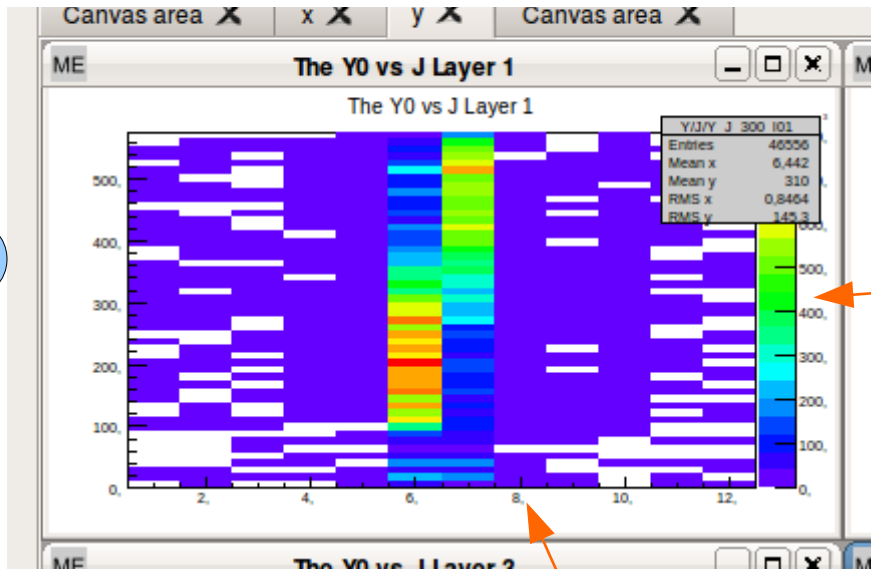


Event building of AHCAL

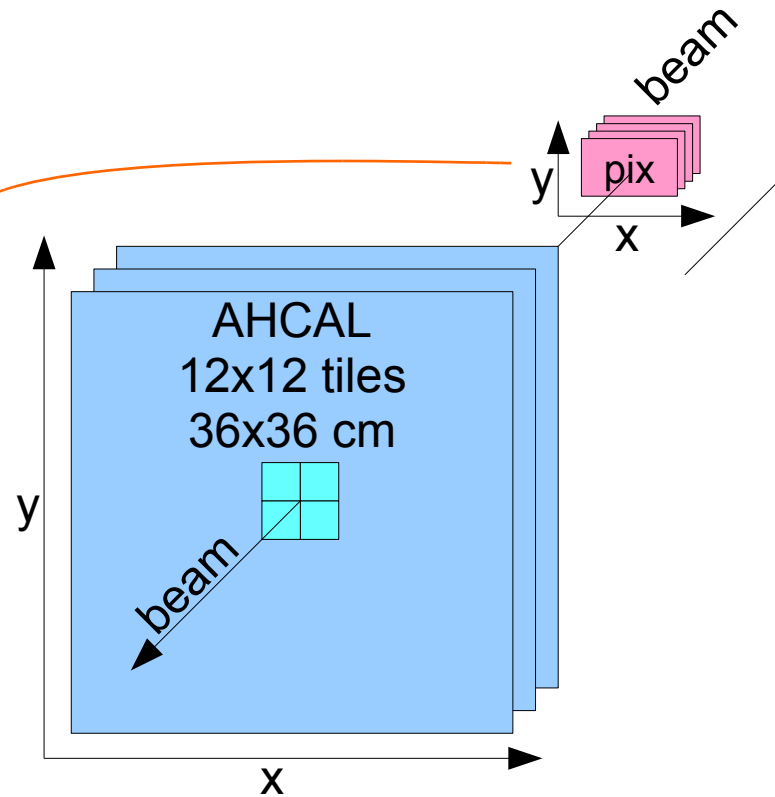


How to check that AHCAL and telescope are synchronous

- We look at the spatial correlation of x and y axes of:
 - Pixel telescope (1x2 cm)
 - Ahcal (36x36 cm, 3cm granularity)
- Beam aims at corner between 4 tiles

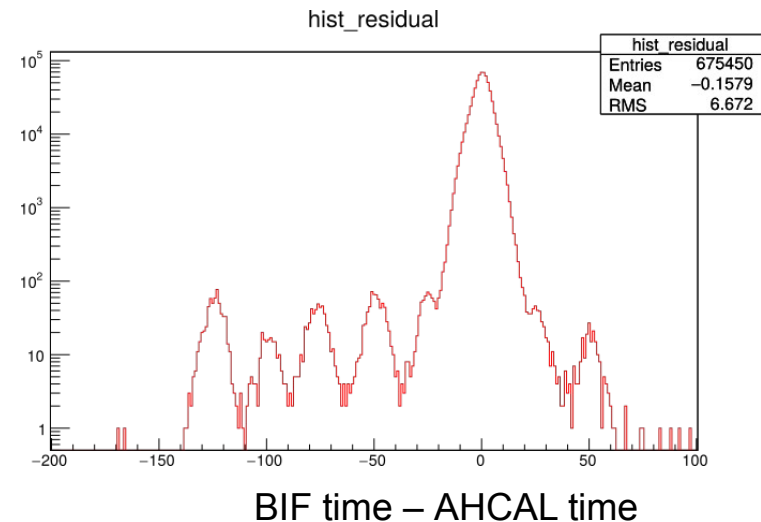
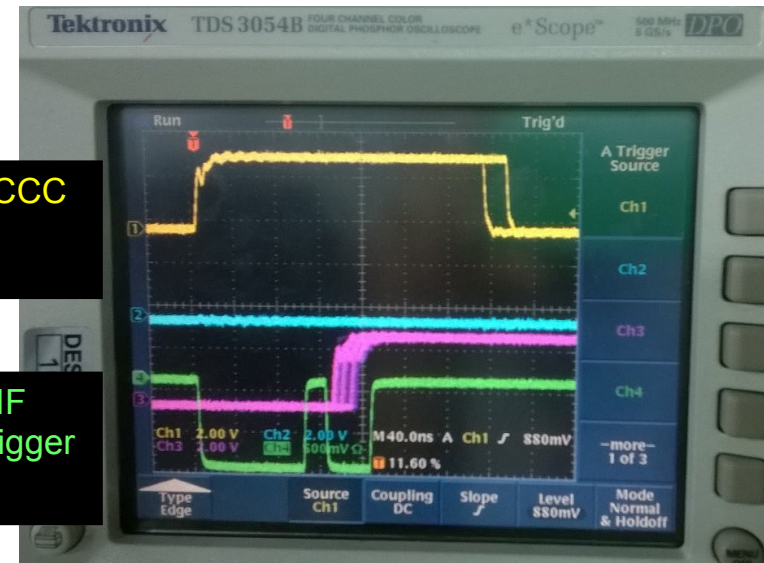


Dec 2016



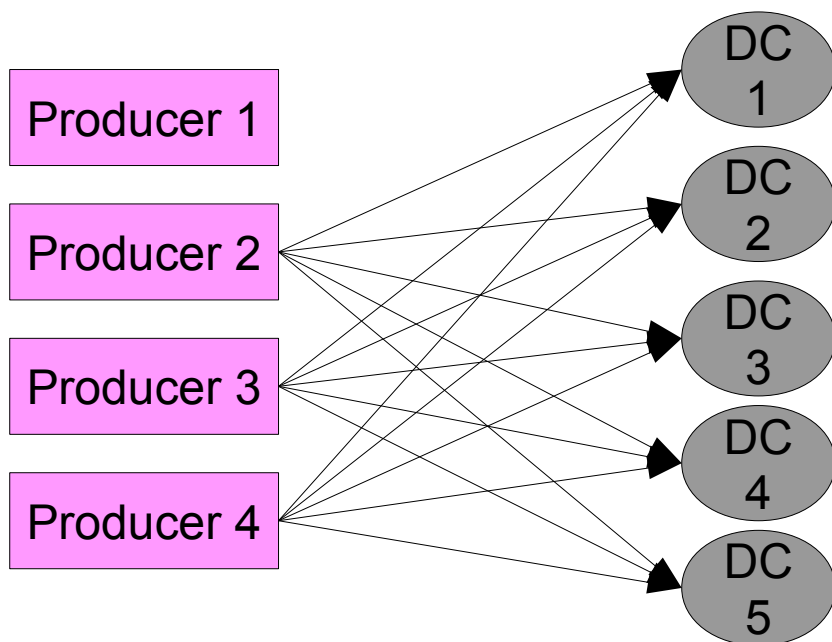
Difficult journey towards correlated events

- multiple changes at once
- intensive debugging required
 - TLU “features”/bugs
 - could all be filtered in CCC/EUDAQ/software
 - will be corrected in new AIDA-2020 TLU (?)
 - EUDAQ2 software
 - not correctly emptying queues at run end
 - fixed, EUDAQ2 frozen, ready for further tests
 - CCC firmware
 - BIF not fully synchronous with AHCAL
 - can be corrected in software, will be fixed in firmware



Difficult journey towards correlated events

- essential tools in debugging:
 - multiple data collectors in EUDAQ allowed testing of several configurations at the same time



The screenshot shows the 'eudaq Run Control v1.5.1+523~g116e10a' window. It features a control panel with fields for 'Config' (set to '/opt/yi/achal_tel_all.conf'), 'Run', 'Log', and 'GeoID' (set to '0'). Buttons for 'Load', 'Config', 'Start', 'Stop', 'Log', and 'Terminate' are visible. Below the control panel, a 'Status' section displays real-time data: Run Number: 45595, Events Built: 6612, Rate: 256.502 (342.602) Hz, Triggers: 6306, File Bytes: 0 B, Particles: 55306, and TLU Status: 00,14,20,--,--,-- (2,1) Scalers: 27688, 21025, 7134, 8509. The 'Connections' section contains a table with columns for type, name, state, and connection.

type	name	state	connection
DataCollector	dsdc1	OK: Started	tcp://192.168.21.1:33268
DataCollector	dtelp4	OK: Started	tcp://192.168.21.1:33266
DataCollector	dtelp3	OK: Started	tcp://192.168.21.1:33264
DataCollector	dtelp2	OK: Started	tcp://192.168.21.1:33262
DataCollector	dtelp1	OK: Started	tcp://192.168.21.1:33260
DataCollector	dtelm1	OK: Started	tcp://192.168.21.1:33258
DataCollector	dtelm2	OK: Started	tcp://192.168.21.1:33256
DataCollector	dtel	OK: Started	tcp://192.168.21.1:33250
LogCollector		OK: Started	tcp://192.168.21.1:33247
Producer	caliceahcalbif...	OK: Started	tcp://192.168.21.100:45250
Producer	Calice1	OK: Started	tcp://192.168.21.100:45244
Producer	ni	OK: Started	tcp://192.168.21.1:33254
Producer	TLU	OK: Started	tcp://192.168.21.1:33251

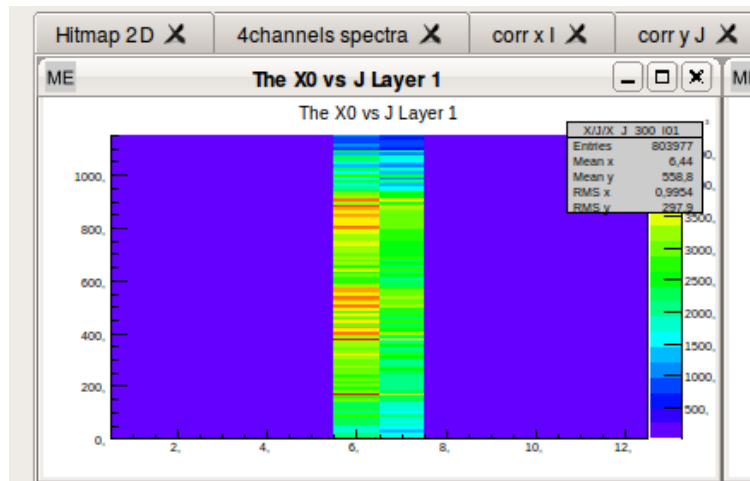


Difficult journey towards correlated events

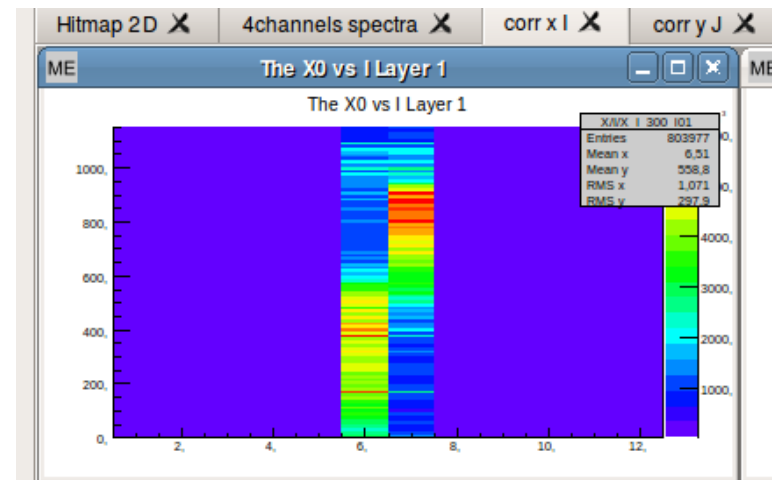
> essential tools in debugging:

- multiple data collectors in EUDAQ allowed testing of several configurations at the same time
- DQM4HEP monitoring of spatial correlations telescope hits vs. AHCAL hits

Uncorrelated

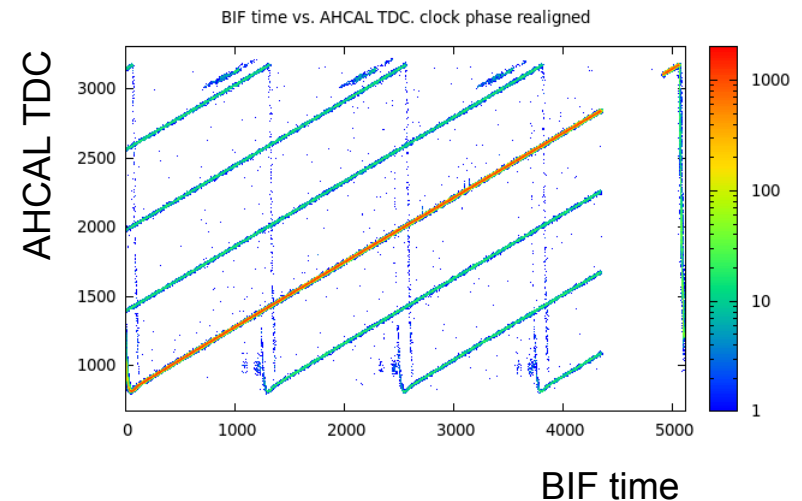
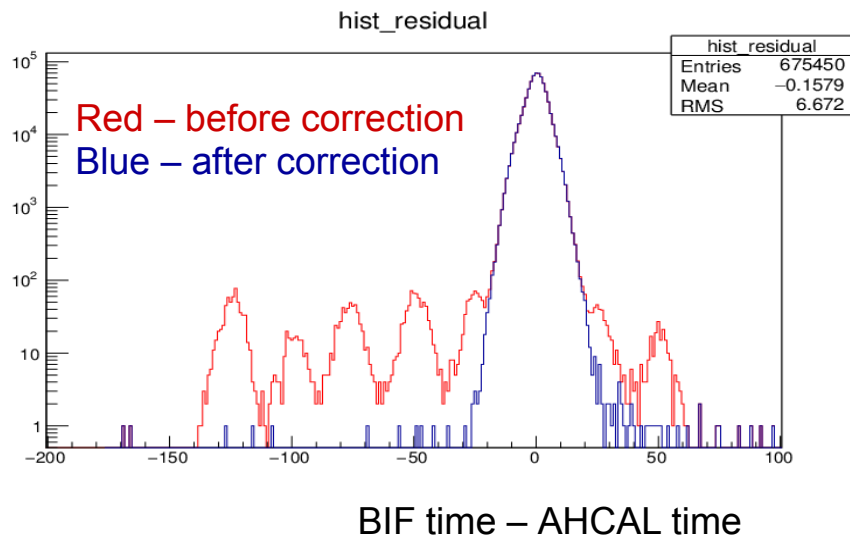


Correlated



Data quality

- spatial correlations observed between telescope and AHCAL hits
- time correlations observed
 - between LDA timestamp (25ns) and AHCAL hits
 - between BIF timestamp (~ 1 ns) and AHCAL hits
- correlations remaining stable over long runs and many runs
- obtained sustained event rate of 450 to 500 Hz (before: ~ 100 Hz)



Performance

- Data rates increased significantly after disabling 4th TLU PMT
- Main difference between 2016 and 2017: possibility of having more triggers per ROC
- No performance drop with 7 DataCollectors
- DQM4HEP faster than DAQ (process ~1k trigs/s)
- File sizes:
 - 2016 (run00445): 20k ROCs, 18k evts, raw 125MB, slcio 87 MB
 - 2017 (run45333): 2.8kROCs, 20k evts, raw 38MB, slcio 34 MB

	Cycles/s	Triggers/s
AHCAL + Tel 2016 2 GeV	~90	~80
AHCAL + Tel 2016 5.6 GeV	~50	~25
AHCAL + Tel 2017 2 GeV 1 tile	37	450
AHCAL + Tel 2017 2 GeV center	27	535
AHCAL + Tel 2017 5.6 GeV	34	240

← corner of 4 tiles from 4 asics



Summary and next steps

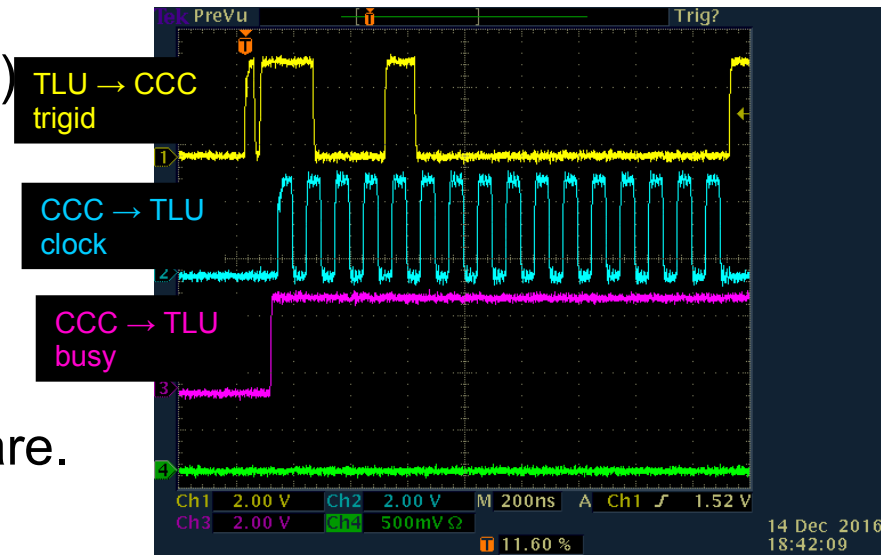
- combined AHCAL + BIF + telescope testbeam
 - proof-of-principle of efficient common running of externally triggered and auto-triggered detectors
 - first EUDAQ2 test with a calorimeter
 - profiting from multiple data collectors and DQM4HEP
- next application: CMS HGCal + AHCAL testbeam in July 2017 at SPS
 - HGCal: externally triggered; started to use EUDAQ1
 - AHCAL: auto-triggered





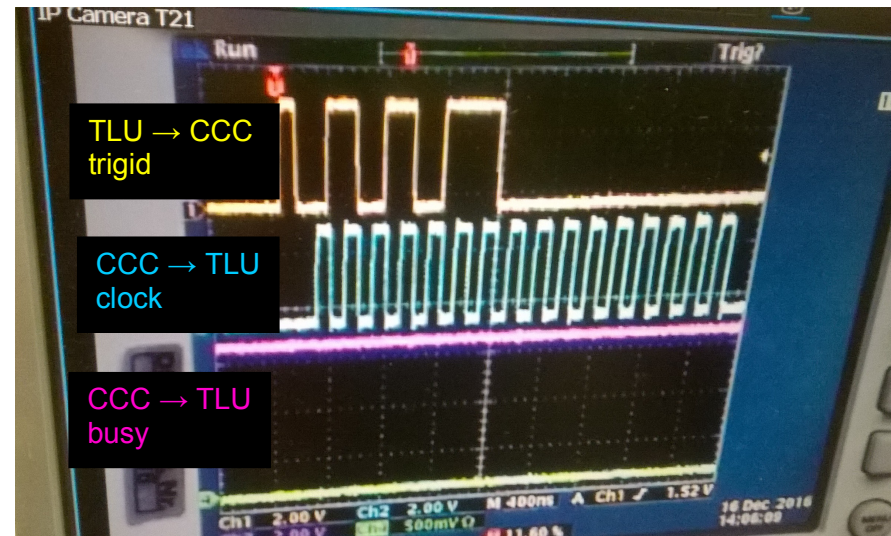
1st & 2nd problem:

- Run crashes after 16k triggers (events)
- Workaround: Don't take long runs!
- TB Dec2016: checked by scope
- Problem found: **A TLU glitch**
 - Happens with TriggerID>16k
- Understood, filtered out in CCC firmware.
 - => **Fixed in December**



- Event desynchronization in EUDAQ
- We saw trigger number “jumps”
- Problem found: TLU busy violation
- Understood, filtered in EUDAQ
 - => **Fixed in December**

All TLU Bugs!

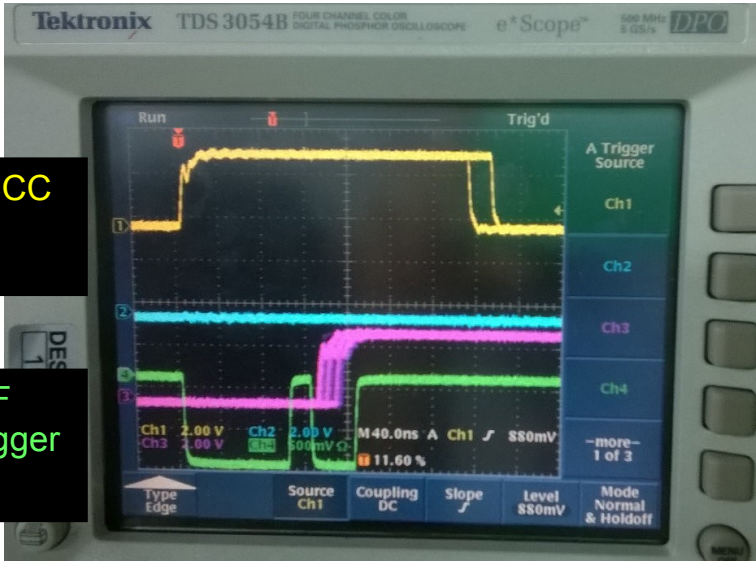


3rd problem: “dual” time correlation of BIF vs. AHCAL

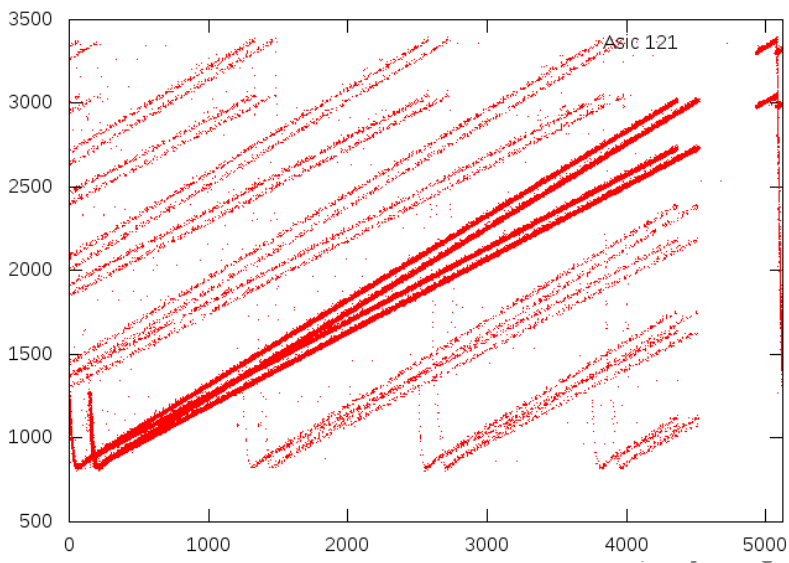
- 2x more events from BIF
- Time correlation artifacts observed
- Checked TLU output with scope
- Problem: **another TLU glitch**
 - 20 ns glitch makes the 2nd trigger
- Easily filtered in software. **Fixed**
- TLU bug, again

TLU → CCC
trigid
protocol

TLU → BIF
“single” trigger

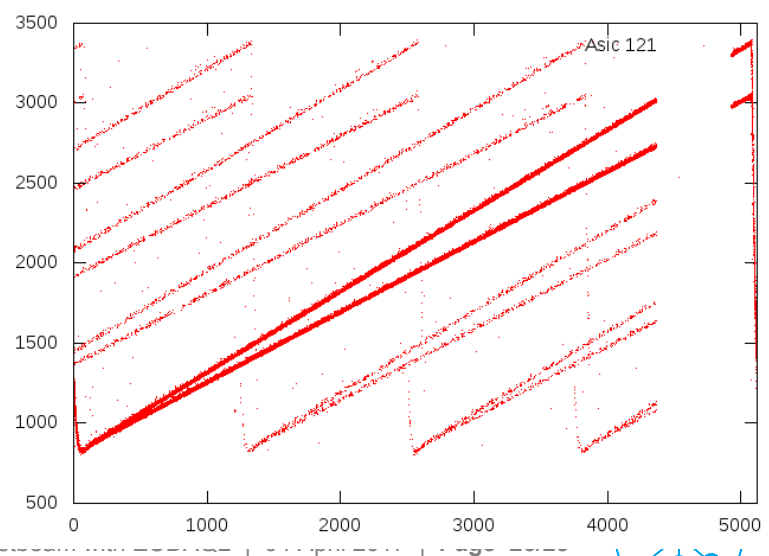


correlation of BIF triggers (from TLU) and AHCAL TDC



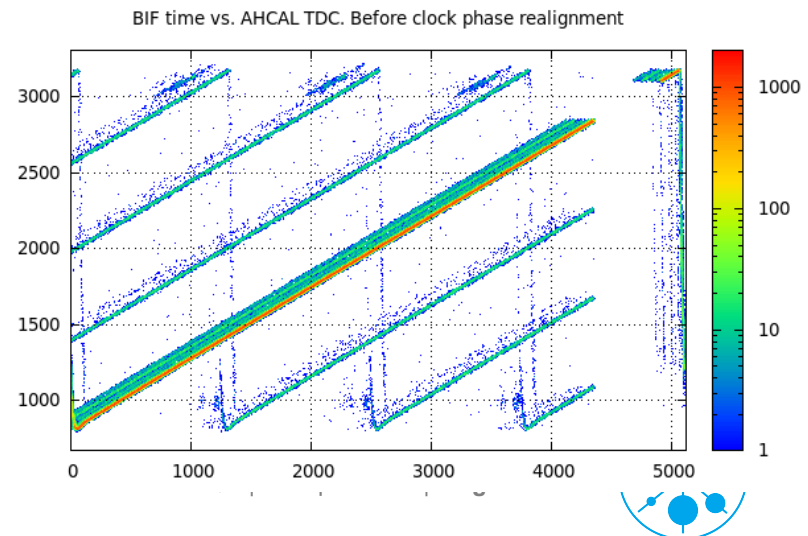
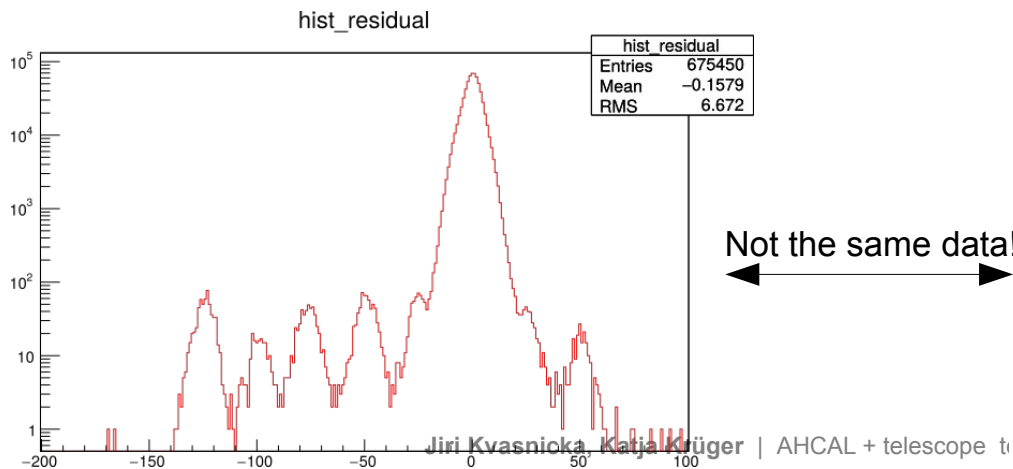
SW filter

correlation of BIF triggers (from TLU) and AHCAL TDC



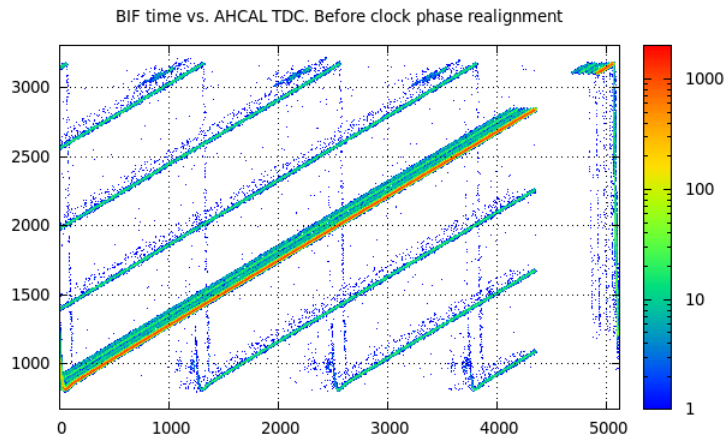
4th problem: weird BIF vs AHCAL time difference spectrum

- Yuji observed a weird spectrum in May2016 data:
 - Time difference between BIF time and AHCAL TDC (after calibration)
 - 1 big peak expected
 - Visible only in logscale, need some statistics
- Peak distance 25 ns, 8 peaks → immediate **suspect**: the 40 → 5MHz conversion in DIF.
- Similar problem observed in TB 2017: the raw correlation of BIF time and AHCAL TDC
 - 8 shadows observed – same problem as Yuji found before TB
- Complicated answer. Simply: **BIF gets wrong “start acquisition” signal .** Sometimes. But can be corrected offline

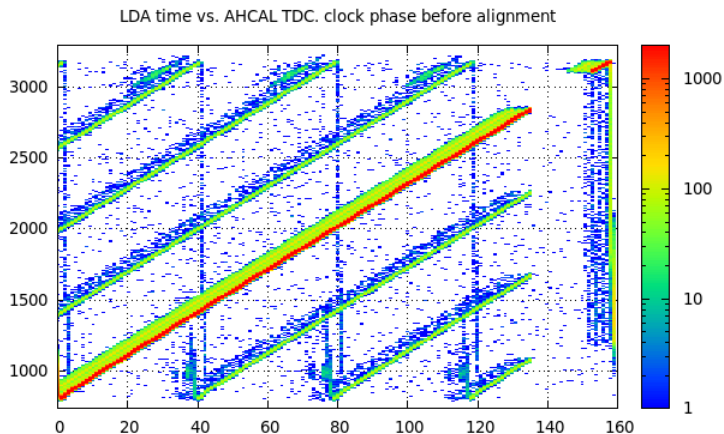
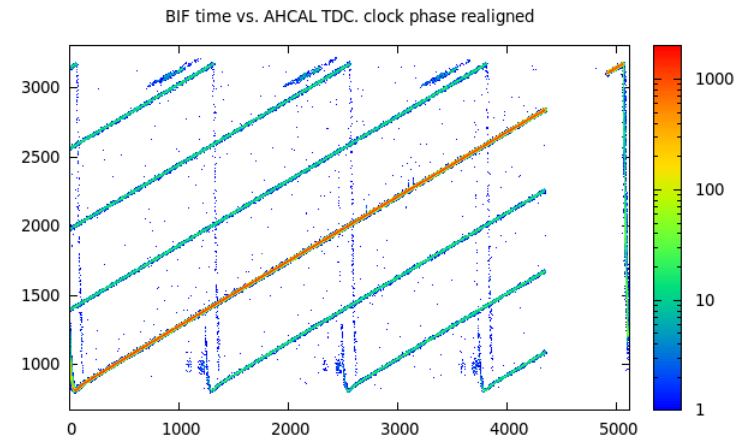


4th problem solution: BIF & AHCAL Time correlations

- Fix works for: (summary plots for whole week of data taking)
 - BIF_time vs. AHCAL_TDC
 - LDA_time vs. AHCAL_TDC



Start acq
realignment



Start acq
realignment

