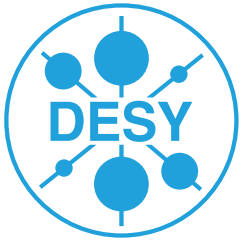
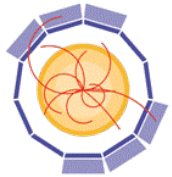
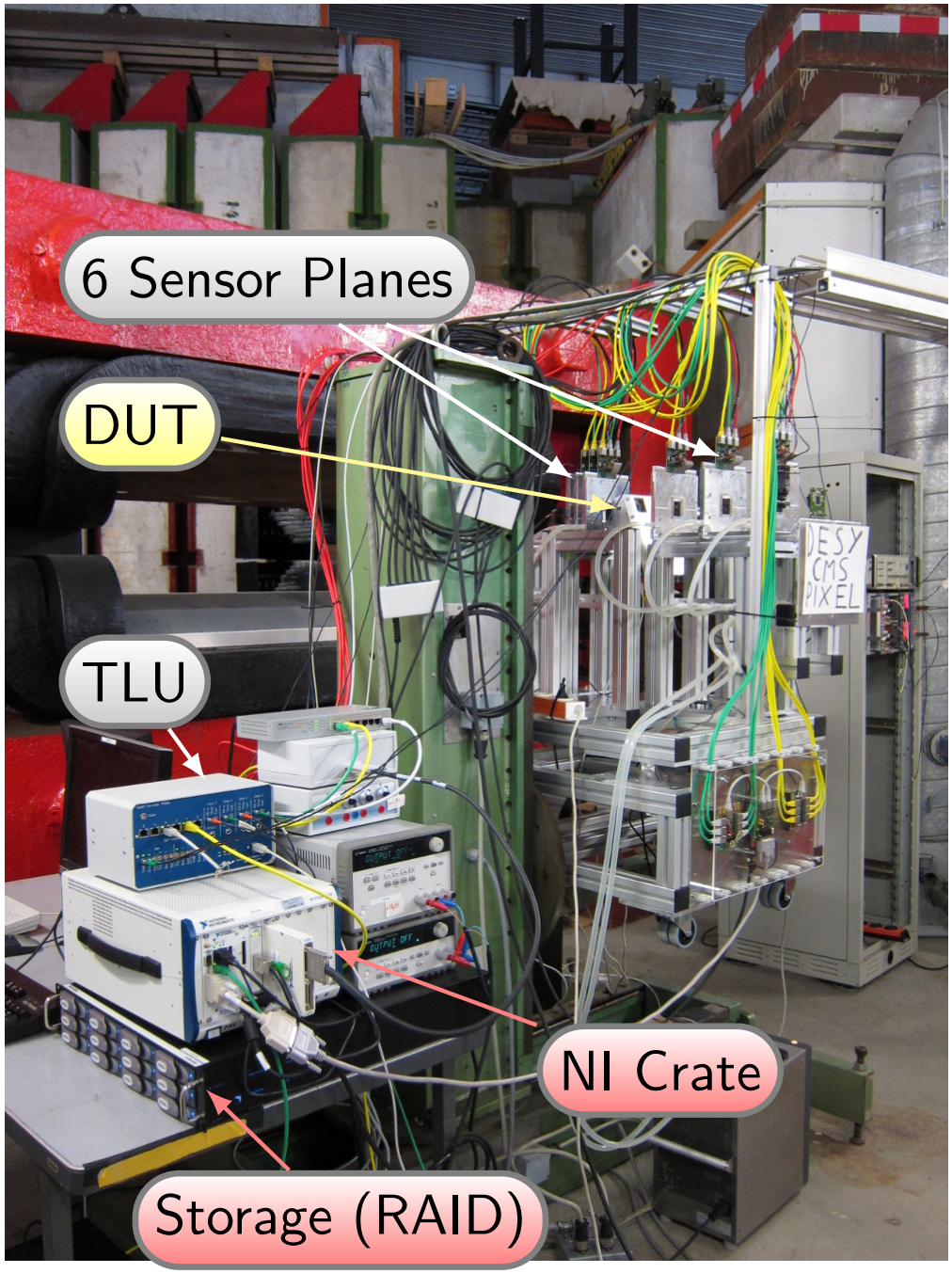


AIDA

# DAQ of the Mimosa-based AIDA Pixel Telescope for High-Rate Beam Tests

Hanno Perrey



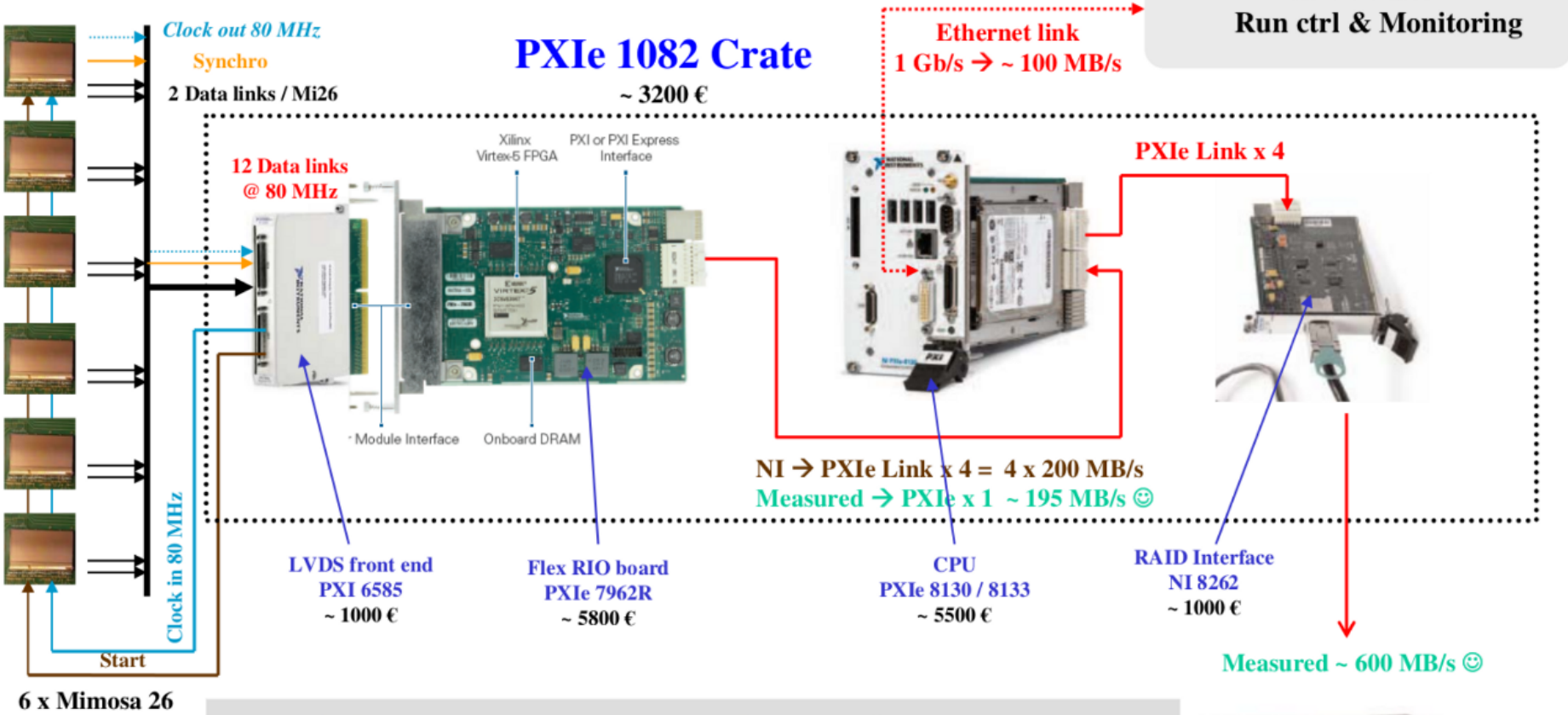

# Datura Telescope at DESY: Hardware Group Picture

- 6 planes with Mimosa26 sensors
- Precise and flexible mechanics
- Central DAQ components:
  - Trigger logic unit (TLU)
    - ★ see previous talk by Alvaro Dosil Suarez
  - National Instruments Crate: 8-Slot PXI Express Chassis

# Upgrade of the DAQ in 2011

Much faster than previous system
⇒ ready for the future

**DAQ (15,5 k€) → Crate + Flex RIO + CPU + RAID (Option)**




**DAQ development Done & Used in Beam Test**

- Telescope 6 x Mimosa 26 = 12 links @ 80 MHz = 120 MB/s
- Telescope 6 x Ultimate = 12 links @ 160 MHz = 240 MB/s

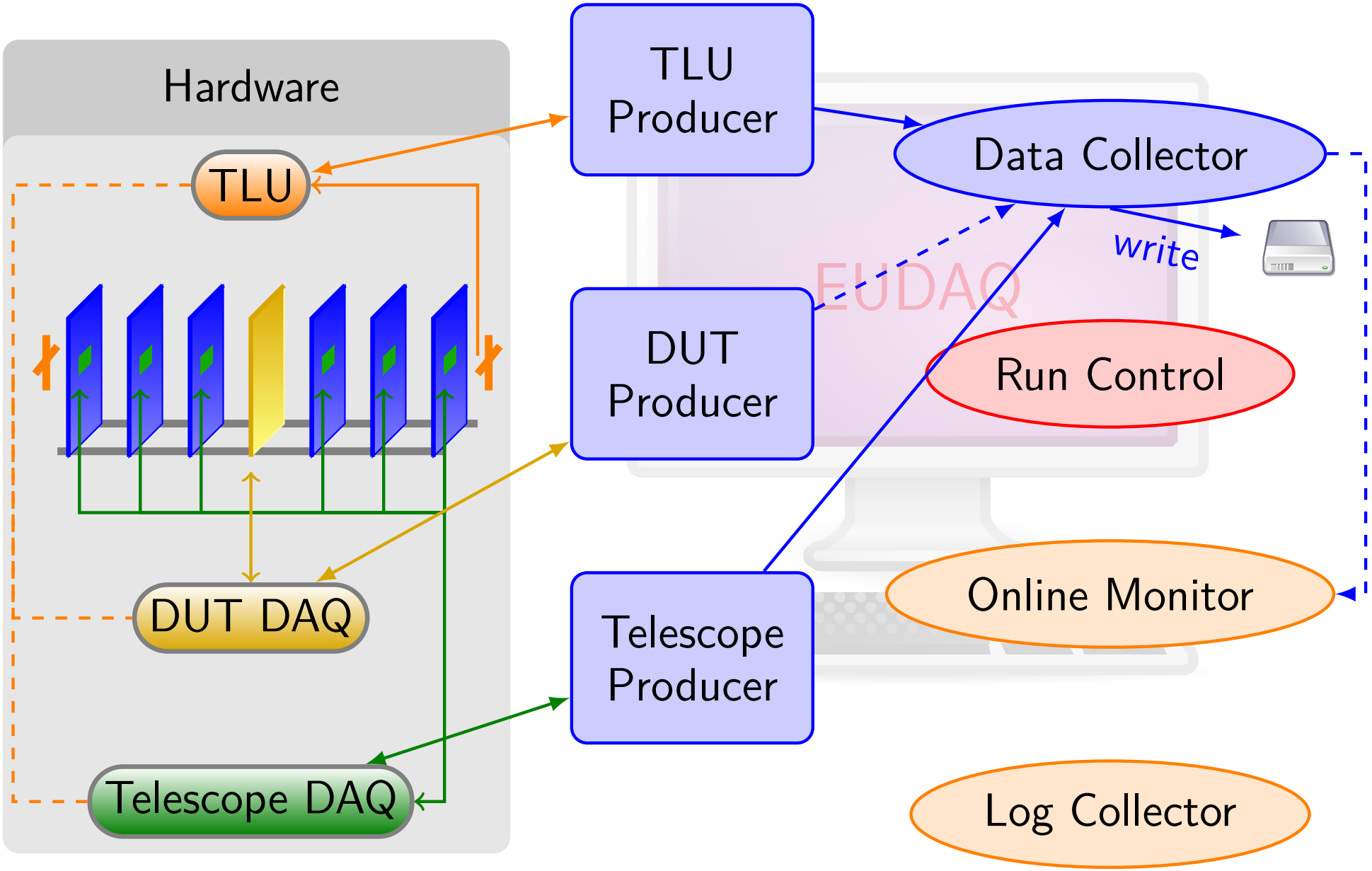
RAID Disk - 3 TB
HDD 8264
~ 4500 €

System set up by Strasbourg, connection to EUDAQ done by DESY

# Features of the EUDAQ Software Data Acquisition System

- Generic framework for data acquisition
- OS independent: Linux, Mac OSX, (Windows)
- Allows full integration of device under test (DUT) independent of its technology including pre-existing DAQ systems
- very Modular and flexible design
- DAQ control via GUI, but CLI interface also available
- Online Data Monitoring
- Hardware interaction performed by *producers*,
  data assembled and stored on disk by *DataCollector*
- Already in use by many groups:
  Altro (Bonn), APIX (Atlas Pixels), Atlas (TRT), CMS Pixel (DESY), DEPFET (Bonn), FORTIS/SPIDER (Bristol), MimoRoma (INFN), MVD (DESY), PixelMan (Freiburg), SITRA (Santander), Taki (Mannheim), Timepix (Bonn),
  ... and more (NA62, Alfa, Alice, etc.)

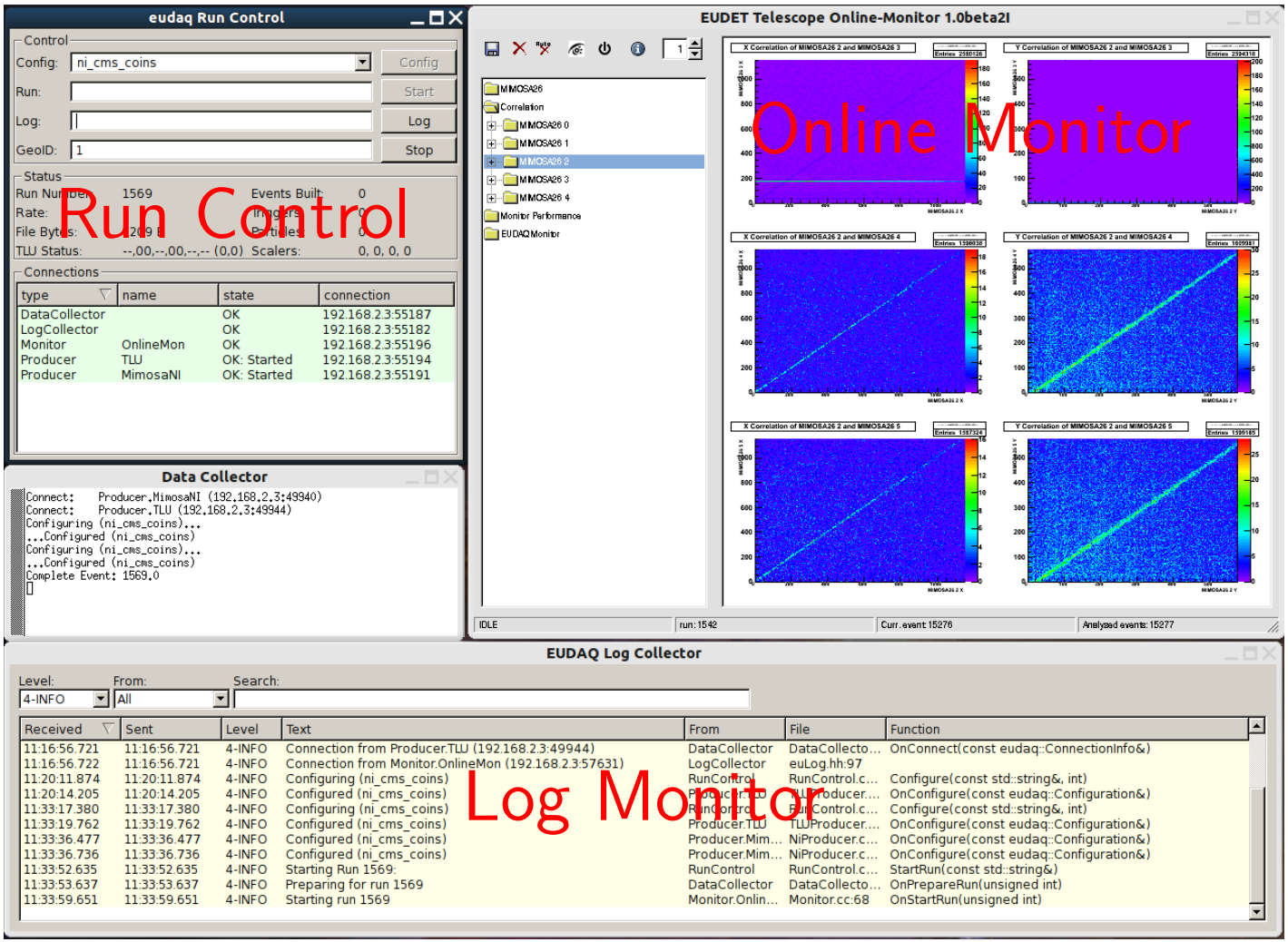
# The EUDAQ Architecture



# Running EUDAQ

- All components communicate via TCP stack

→ Components can be run on different networked machines



## EUDAQ Data Formats:

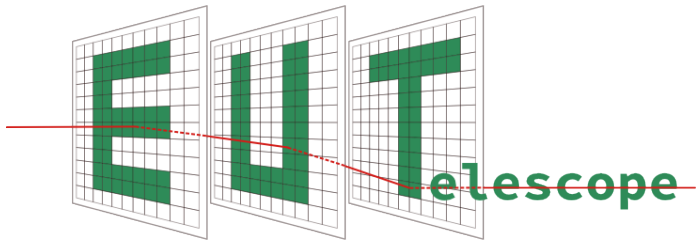
- RawDataEvent
  - Generic container for unaltered, encapsulated detector response
  - Data input: raw block of memory or vector
  - Storage of additional information possible
- Alternative: StandardEvent
  - Decoded detector data
  - Can be read by e.g. the Online Monitor

## DUT Integration into EUDAQ

- DUT Producer
  - Talks to the DAQ hardware, receive events from there
  - Receives commands from Run Control
  - Sends data to the Data Collector (RawDataEvent or StandardEvent)
- DUT DataConverterPlugin
  - Convert the specific native detector data into StandardEvents
  - Needed e.g. for online monitoring of the DUT

⇨ Full integration: detector data sent and decoded on each trigger

# EUTelescope Analysis Framework




- library of processors running in ILCSoft's Marlin application framework
- step-wise transition from single pixel array to 3D coordinates of fitted tracks in global frame
- uses LCIO data format, conversion through EUDAQ or separately

## Version 0.8 recently released

- improved user experience: easier installation & use, extended documentation & support
- many fixes and some new features as well

Major code refactorization in progress: improve usability & maintainability

# The road toward a high-rate beam pixel telescope

## What does *high rate* mean for Mimosa-based telescopes?

- Mimosa sensors: dead-time free, continuous read-out (115 µs/frame)
- Current setup: one trigger per frame ($\rightarrow$ max. rate $\sim 10\,\mathrm{kHz}$)
- High-rate: one trigger per particle (max. trigger rate $\mathcal{O}(100\,\mathrm{kHz})$

## Disclaimer to following slides

Not all points settled yet and details certainly still under discussion

# Preparing DAQ Hardware & Firmware for High Rates

- FlexRIO & PXIe bus of NI chassis already capable of handling continuous read-out of 6 planes of Mimosa26 or MimAIDA
- LabVIEW code running on NI host (used for frame packaging) requires some optimization: currently too CPU intensive for full MimAIDA operation
- larger data volume of MimAIDA would saturate TCP/IP communication $\rightarrow$ need to write directly to RAID

$\rightarrow$ requires modifications to EUDAQ...

# Preparing the DAQ Software for High-Rate Beam Tests

## Moving to one-trigger-per-particle

- Define data structures in EUDAQ with range of trigger-numbers and/or time-stamps
- backward-compatible: allow both new and old data structures
- Modify EUDAQ to LCIO conversion to cope with new data format
- Modify EUDAQ monitoring

## Move to multiple data streams

- Separate data writing and event building

→ integrate systems with very different DAQ & readout concepts

- allows higher data throughput
- challenging for full online monitoring – might not be feasible
  - full data possibly unavailable until end-of-run
  - time consuming merging of data streams (might require full tracking)
- need sophisticated event building → could be done offline

→ immediate offline DQM to complement simplified online mon. ?

# DQM and Analysis of High-Rate Data Using EUTelescope

- EUTelescope already well established for test beam data analysis
- Framework could be extended to allow prior processing of data before merging data streams
- principally suited for elaborate/complicated merging schemes
- Last EUTelescope release simplified user experience already

→ with setup simplified sufficiently, automatic processing and reconstruction for immediate offline DQM feasible

- some effort necessary to avoid data duplication across events

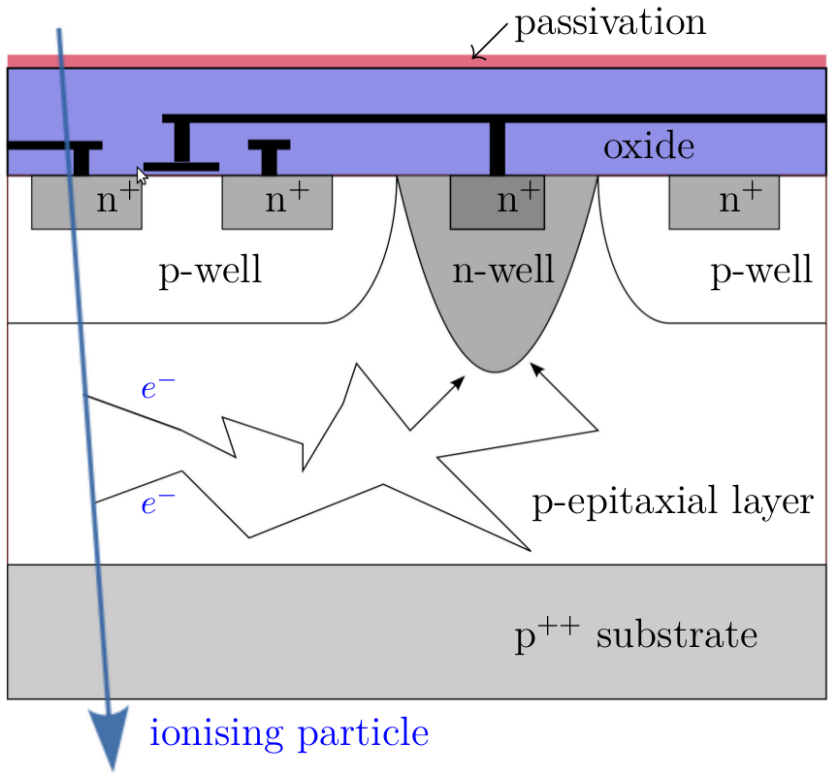
# Summary

- Pixel telescope hardware DAQ already well under way toward high-rate capabilities
- DAQ and analysis software frameworks both are flexible and modular and can be extended to process high-rate data; however some work needed!
- The one-trigger-per-particle concept requires data format and (minor?) architectural changes in EUDAQ
  - need to be careful not to break existing DUT producers!

# Overview Backup Slides

# Mimosa26 Sensors

- by IPHC (Strasbourg) & IRFU (Saclay)
- MAPS – Monolithic Active Pixel Sensor
- signal processing µ-circuits integrated on sensor substrate
- Pixel size: $18.4\,\mu m^2 \times 18.4\,\mu m^2$
- Excellent ($\approx 1\,\mu m$) spatial resolution
- Readout in rolling shutter mode
- At 80 MHz $\rightarrow$ 112.5 µs per frame
- No dead-time, continuous readout
- Digital readout
- On-pixel amplification
- 1 discriminator per column width
- Built-in data sparsification
- Current version of Mimosa26:
  - High resistivity epitaxial
  - Back-thinned down to 50 µm



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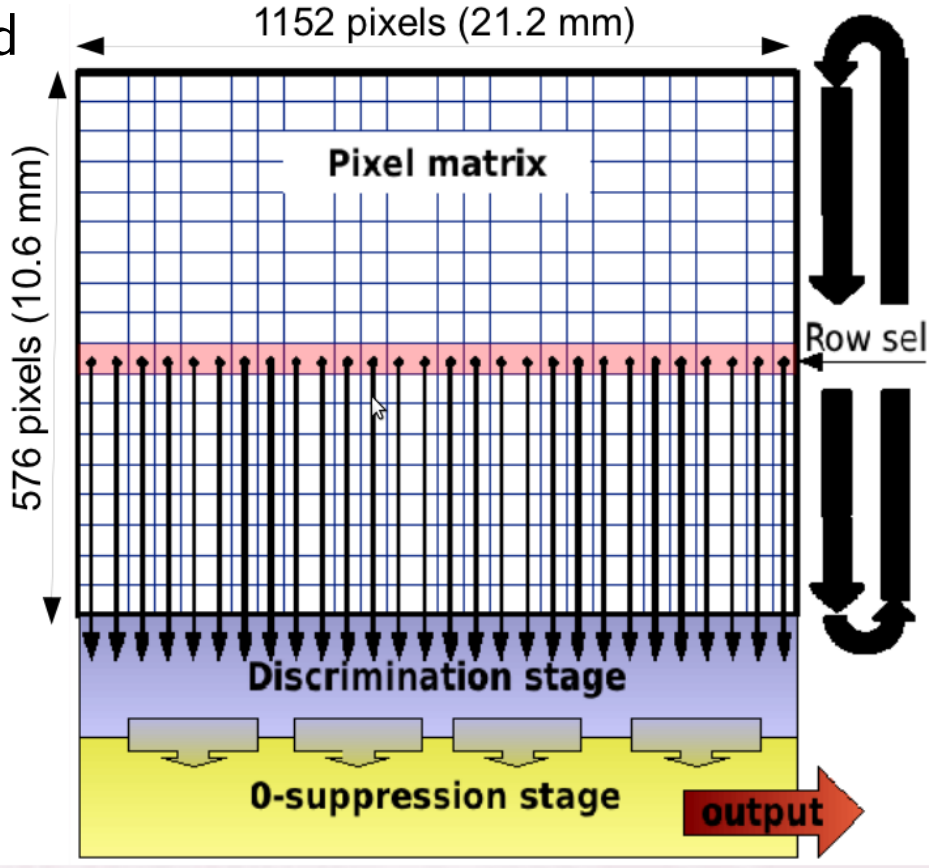
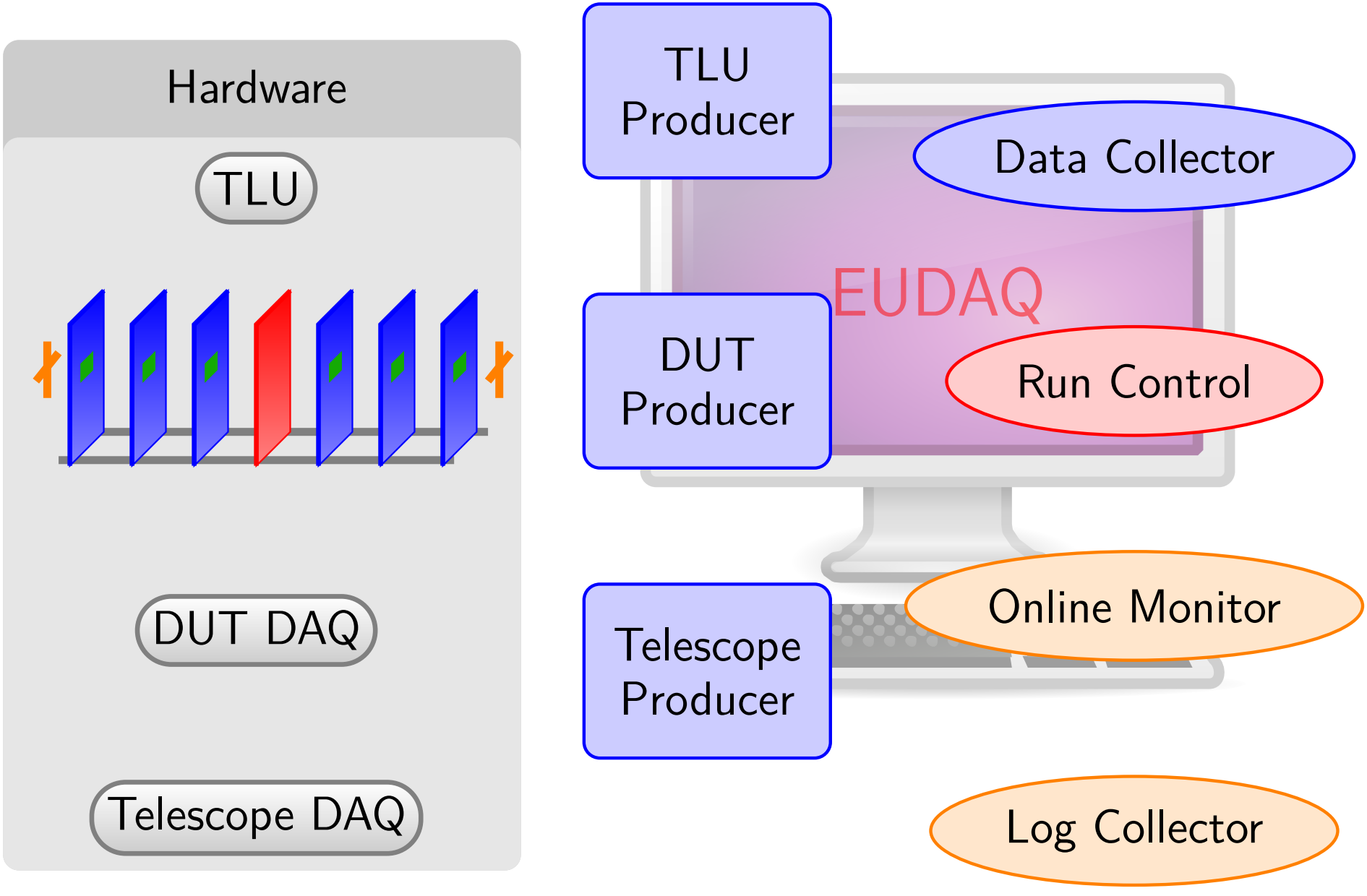


# The EUDAQ Architecture



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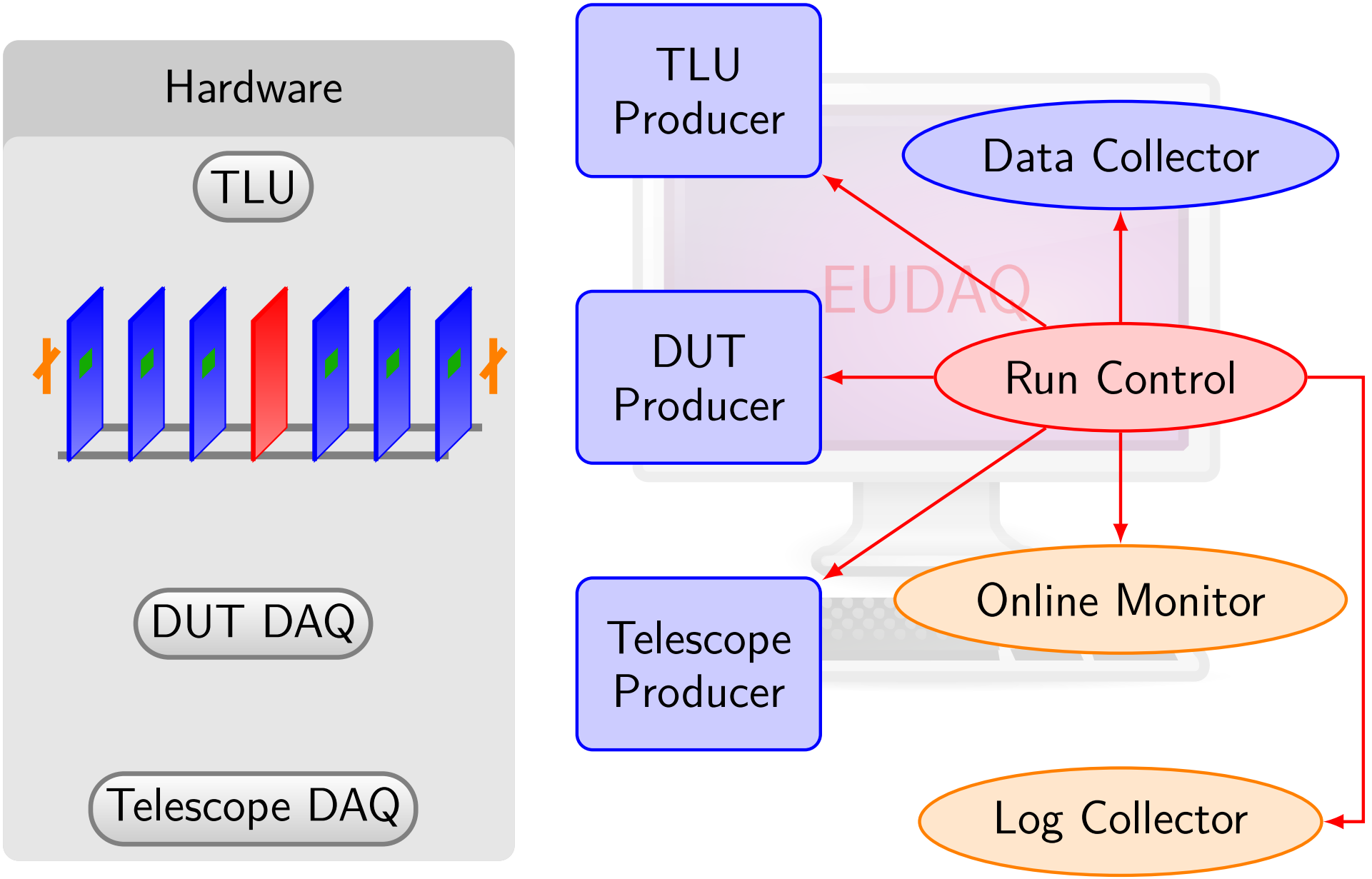

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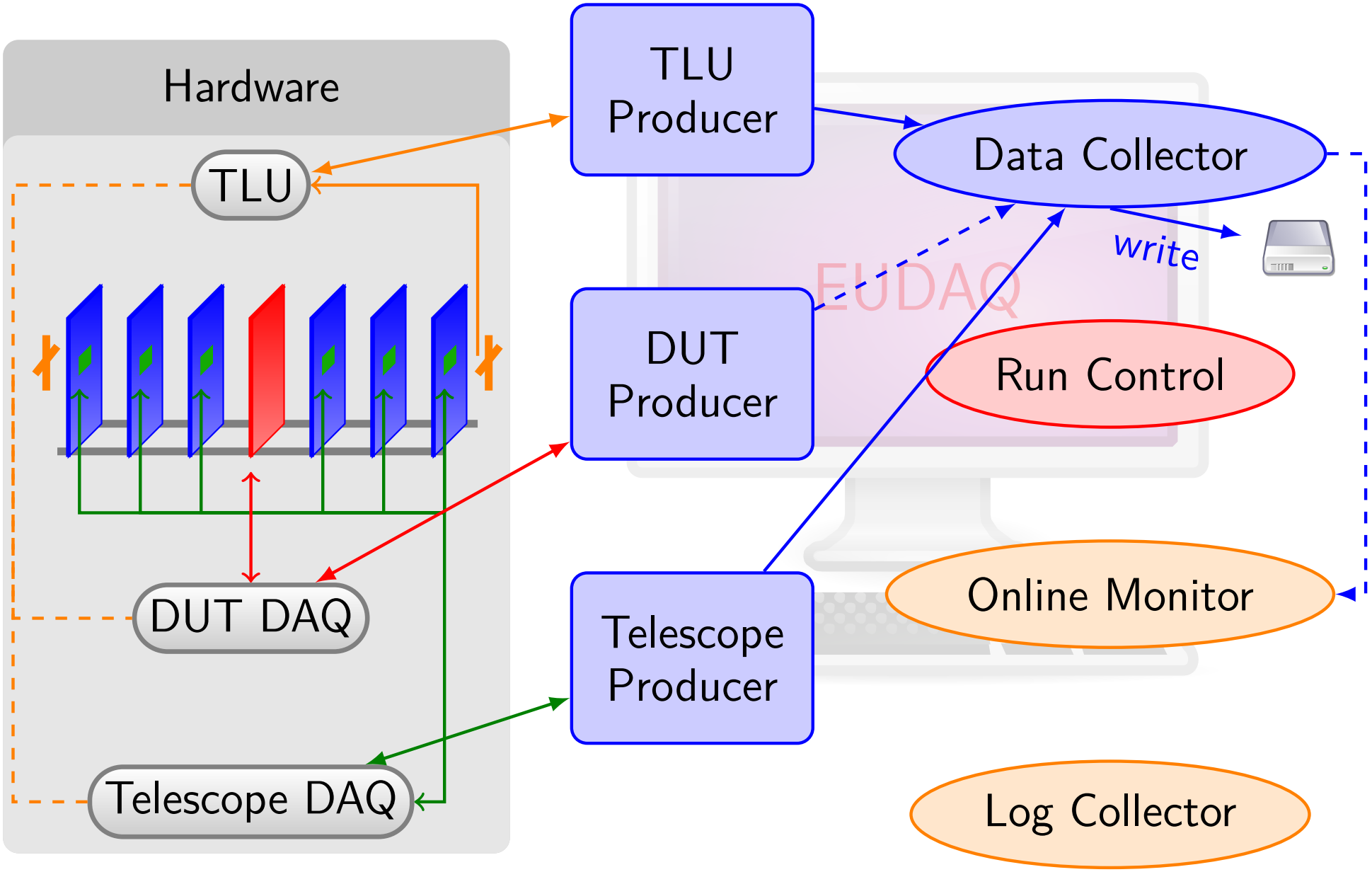

# The EUDAQ Architecture