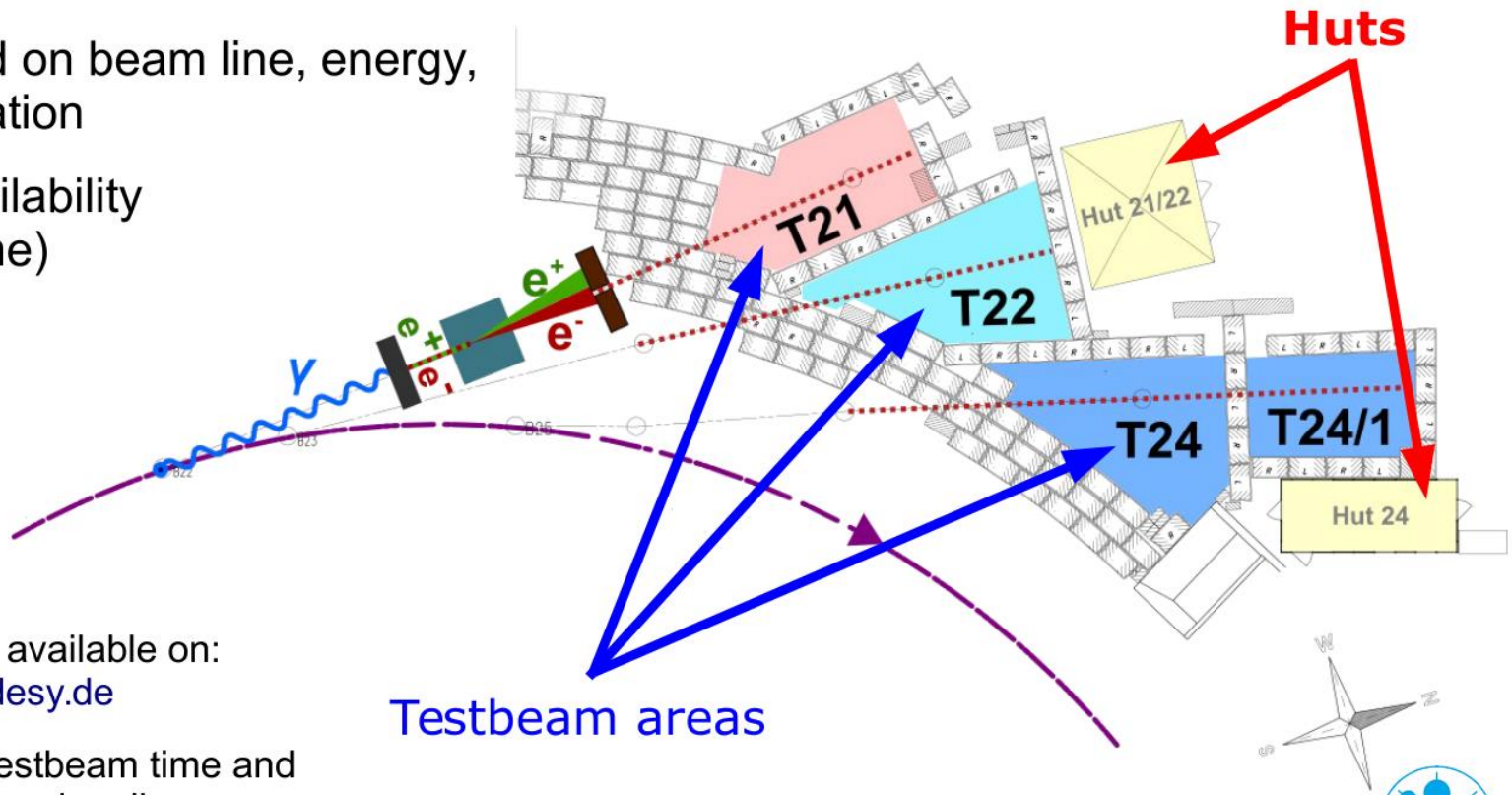
The EUDET telescopes: Status, Performance and Prospects

Lennart Huth for the Telescope Crew
BTTB8 Tbilisi, Jan 2020

DESY II Testbeam - Facility

- Facility fed by DESY II synchrotron
- Three thin, internal carbon fiber targets generate bremsstrahlung photons
- Conversion at target to e^+/e^- with energies up to 6 GeV
- Rates depend on beam line, energy, target, collimation
- Very high availability (~ 99 % uptime)

- Three individual beam lines, controlled by the user
  - Shutter, area interlock
  - Select particle momentum/collimation



- More information available on: http://testbeam.desy.de
- Annual calls for testbeam time and other information: subscribe testbeam-info mailing list

EUDET-type beam telescopes

- Mimosa26 based 6 layer telescopes
- Pixel Pitch of 18x18um^2
- Slow readout but excellent resolution
- Total size 2x1cm^2
- Provided in all three DESY test beam areas
- Shipped with EUDAQ2 and AIDA-TLU support
- Workhorse for many different groups
  - → Pixel/strip sensor studies
  - → Calorimeter studies
  - → Timing detectors
  - → Electron tomography
  - → Lorentz angle measurements
  - → ....

Telescopes around the world

AIDA-2020 managed

Self managed

EDUAQ

EUDAQ – A Data Acquisition Software Framework for Common Beam Telescopes

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EUDAQ2 – A Flexible Data Acquisition Software Framework for Common Test Beams

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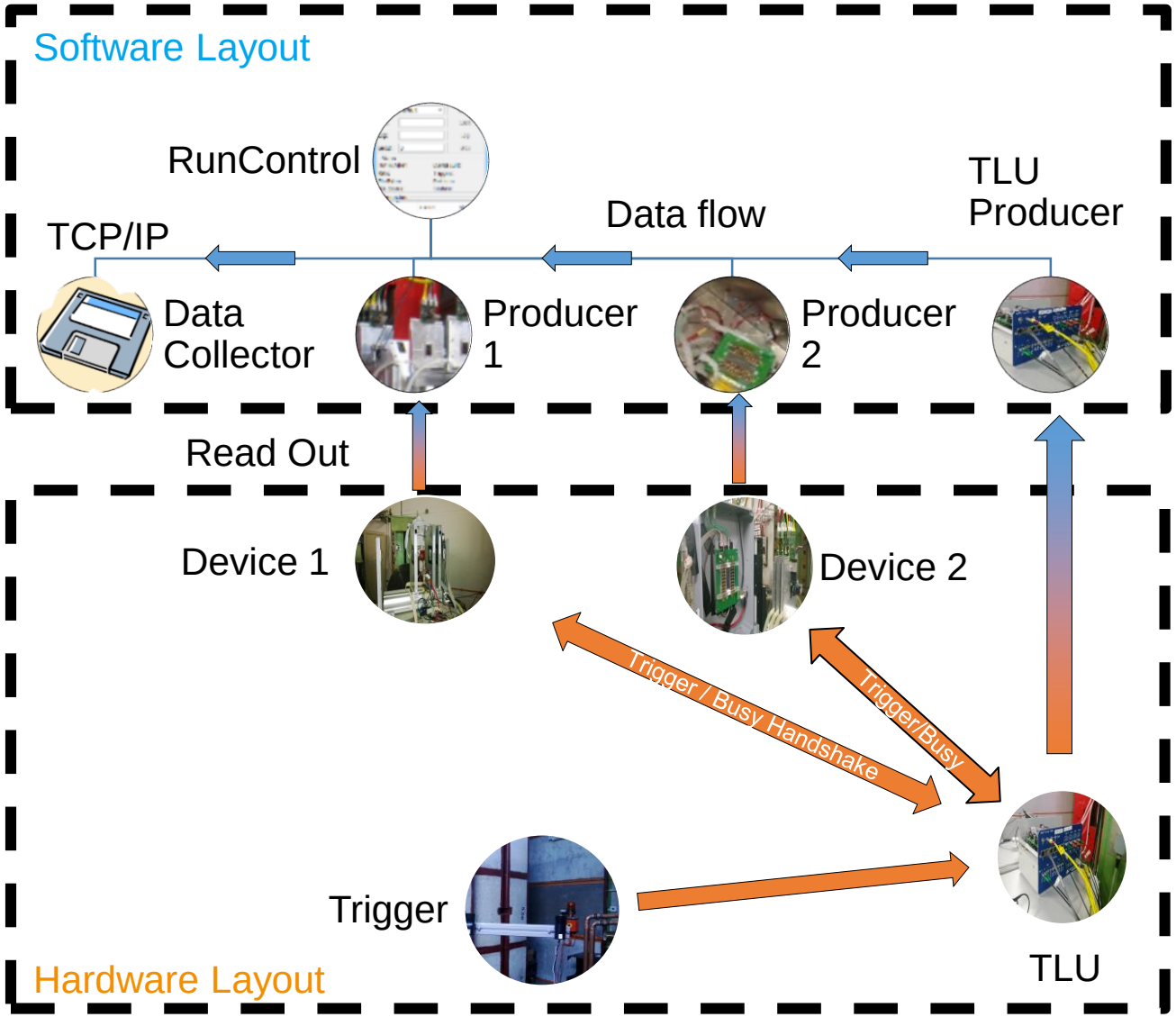
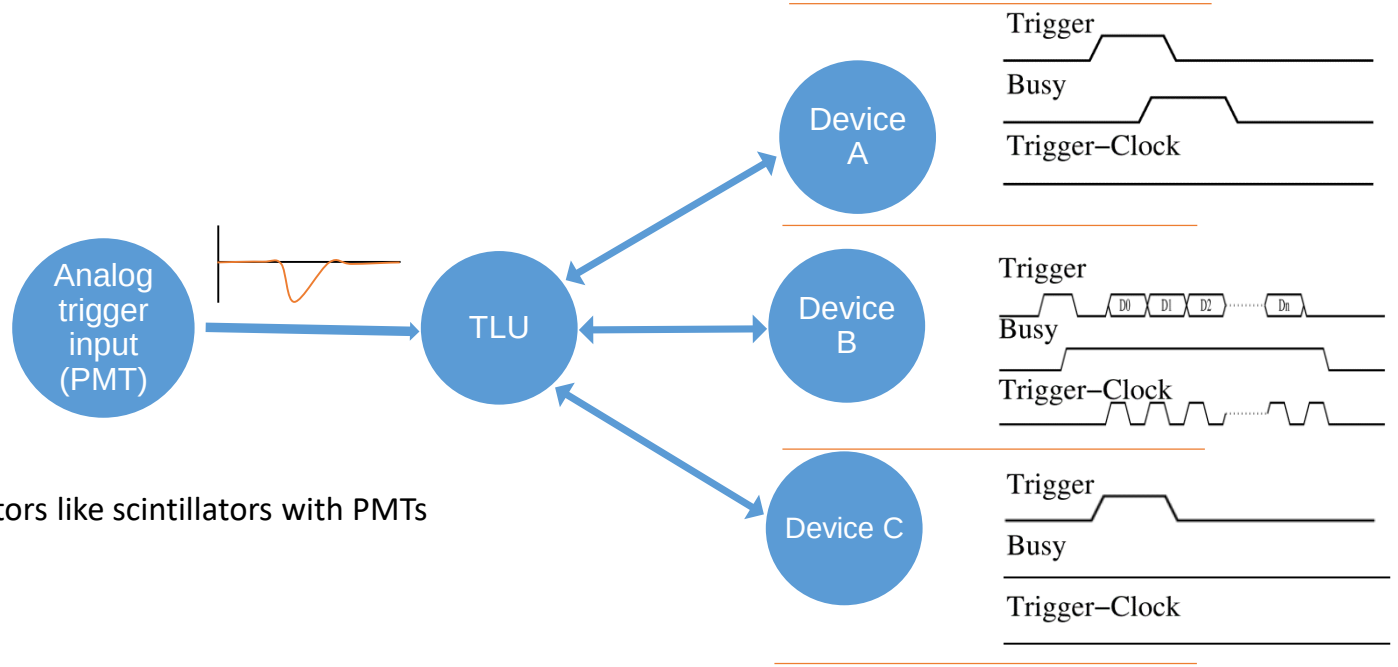
- EUDAQ is the de facto standard meta Data Acquisition System for beam test telescopes
- Reliable cross platform DAQ System
- In use for well over a decade
- Under active development from a large community from all over the world
- Ease of user device (Device Under Test DUT) integration is one of the main focus points

Test Beam Readout



- Divided into Hardware and software layer
- Hardware
  - Trigger Logic Unit (TLU) is the central authority
  - The TLU receives analog trigger signal and distributes a digital trigger system to all devices in the setup
  - It uses a trigger busy handshake
- Software
  - Distributed DAQ system (EUDAQ)
  - Consists of completely independent parts / programs such as:
    - Run Control
    - Data Collector
    - Producers
    -

Trigger Logic Unit (TLU)

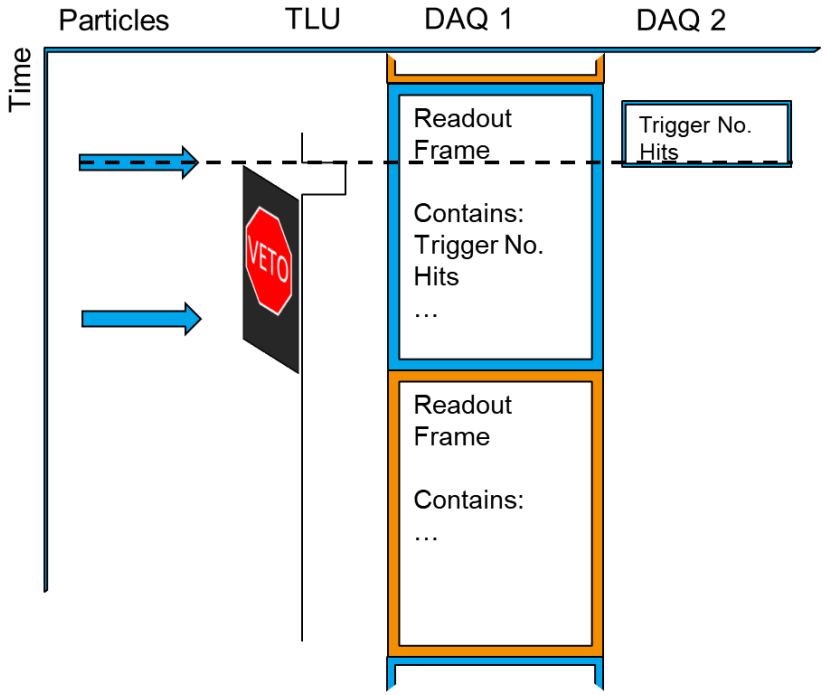


- Receives analog signals from fast particle detectors like scintillators with PMTs
- Converts the analog signal to a digital trigger
- Sends trigger to the devices
- Waits for the devices to finish their data taking
- Fully integrated into EDUAQ
- New Version of TLU (AIDA-TLU) is produced right now. If we want to have one we have to decide soon.

- Three types of handshakes
  - **Trigger/Busy Handshake:** Device sends a busy signal back. No new triggers can be issued during this time
  - **Trigger/Busy/Trigger-Data Handshake:** The TLU can send the TLU Trigger ID to the devices
  - **No handshake mode:** TLU just sends trigger without waiting for a response from the device

EUDAQ 1.x VS EUDAQ 2.x Readout Mode

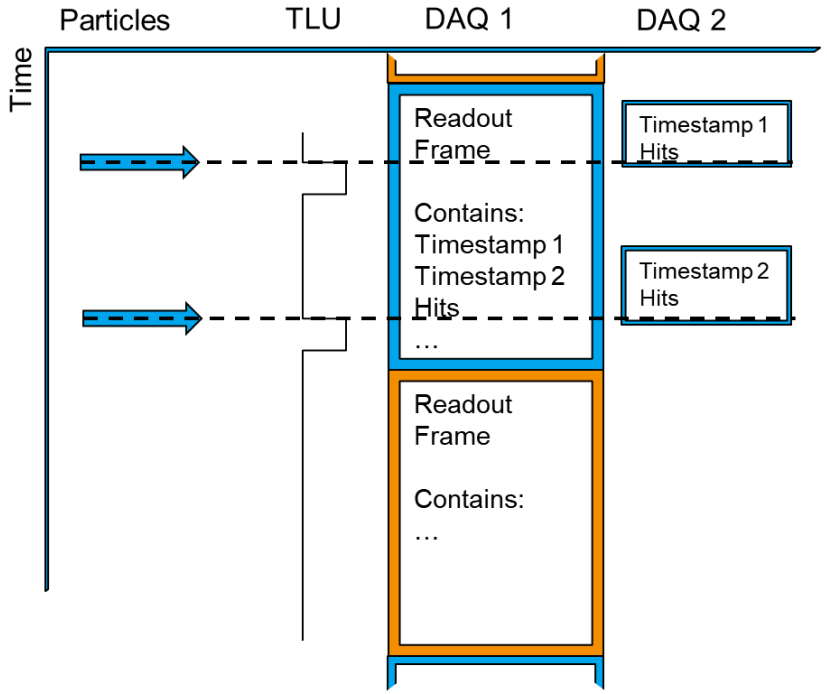
EUDAQ 1.x



Marked for write to Disk
Not Marked

- One trigger per read out frame
- Prevents the issuing of triggers for the whole time of the read out
- Slowest device limits the Event rate

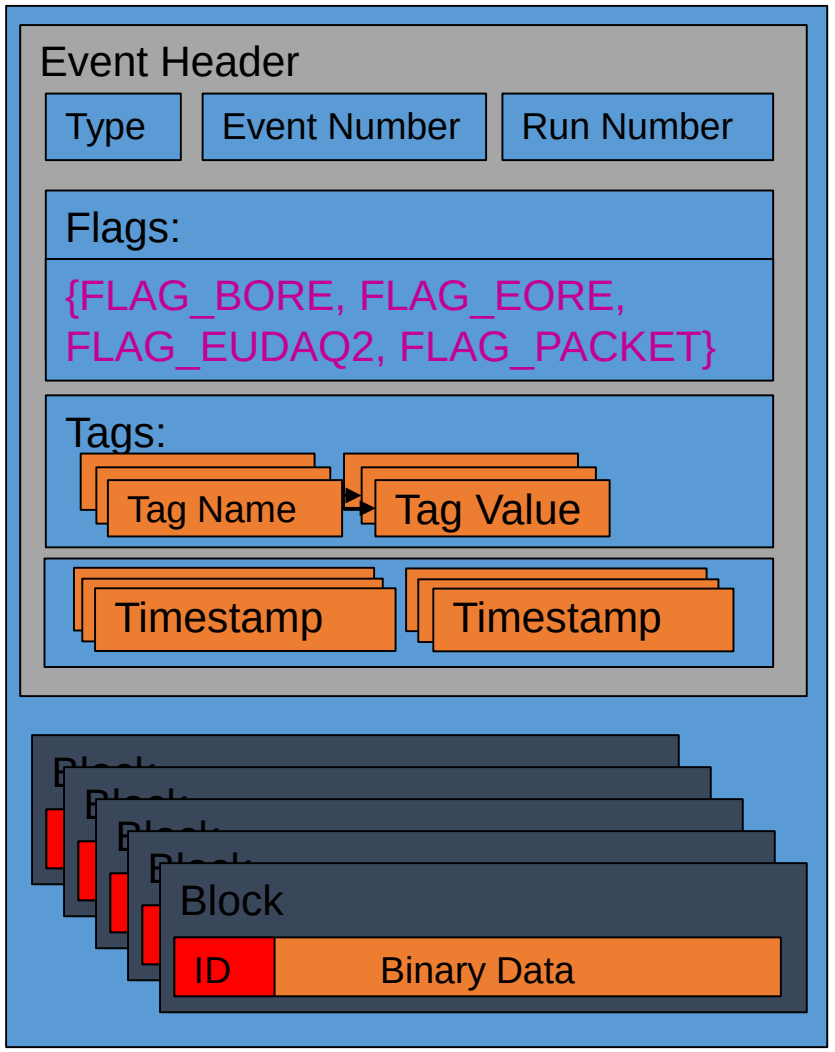
EUDAQ 2.x



Marked for write to Disk
Not Marked

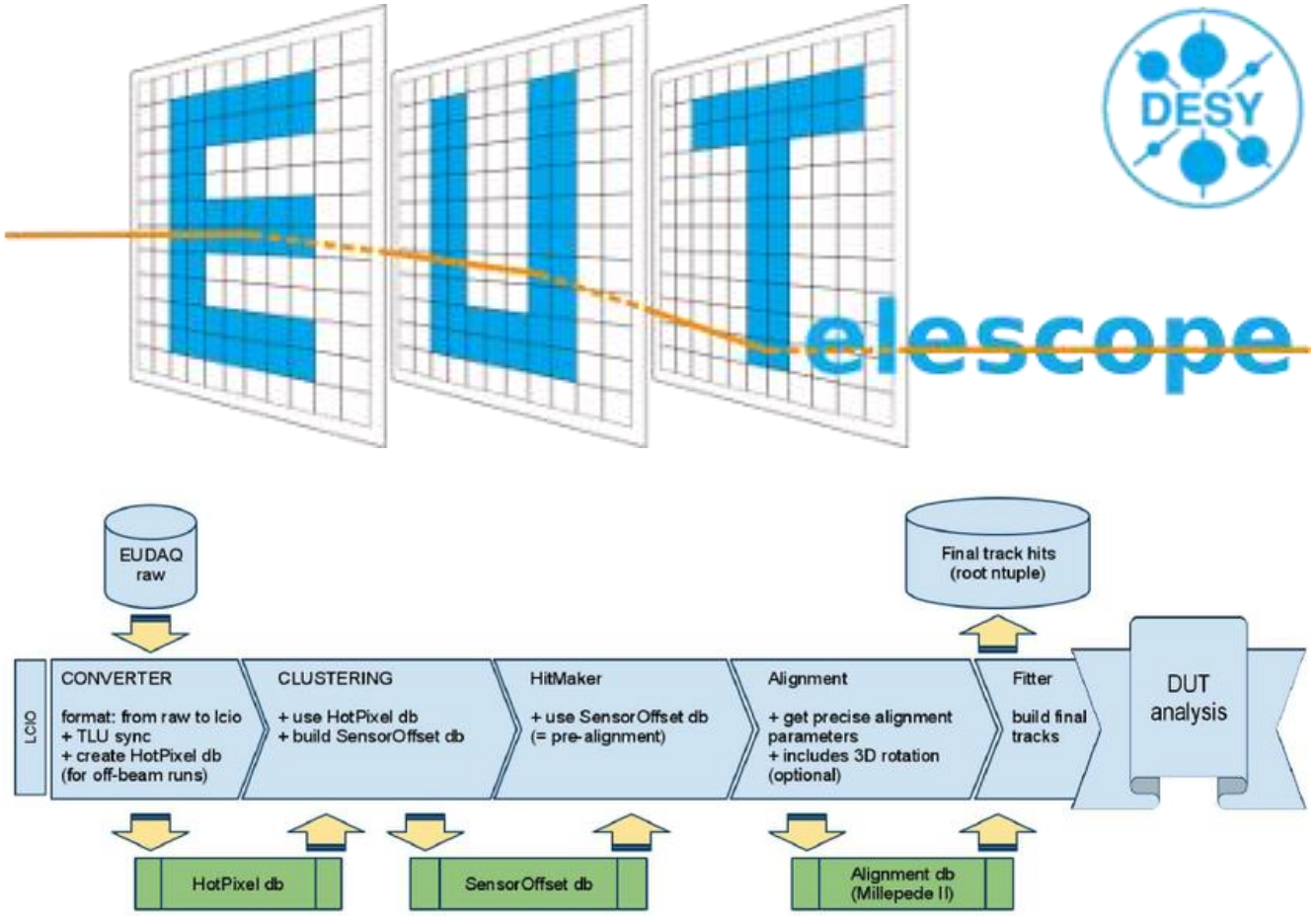
- Each Device can run at its own speed
- User can decide how to merge events
  - Event number Merging
  - Time stamp based merging

RAW Data Files



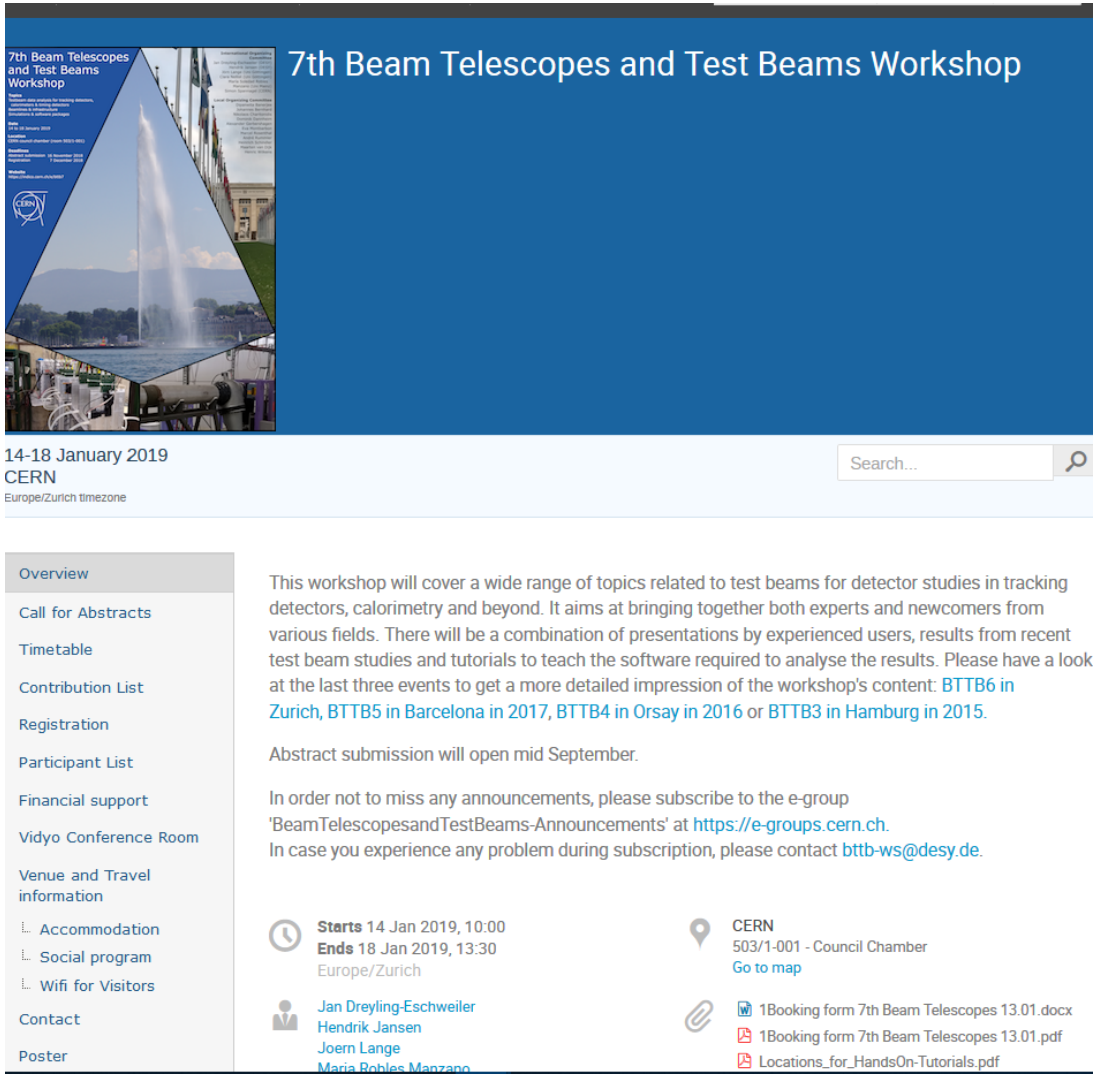
- Persistent Data Format
- Convertible to ROOT/LCIO
- Writing custom converter well documented
- Flexible
- No External Dependencies
-

EUTelescope



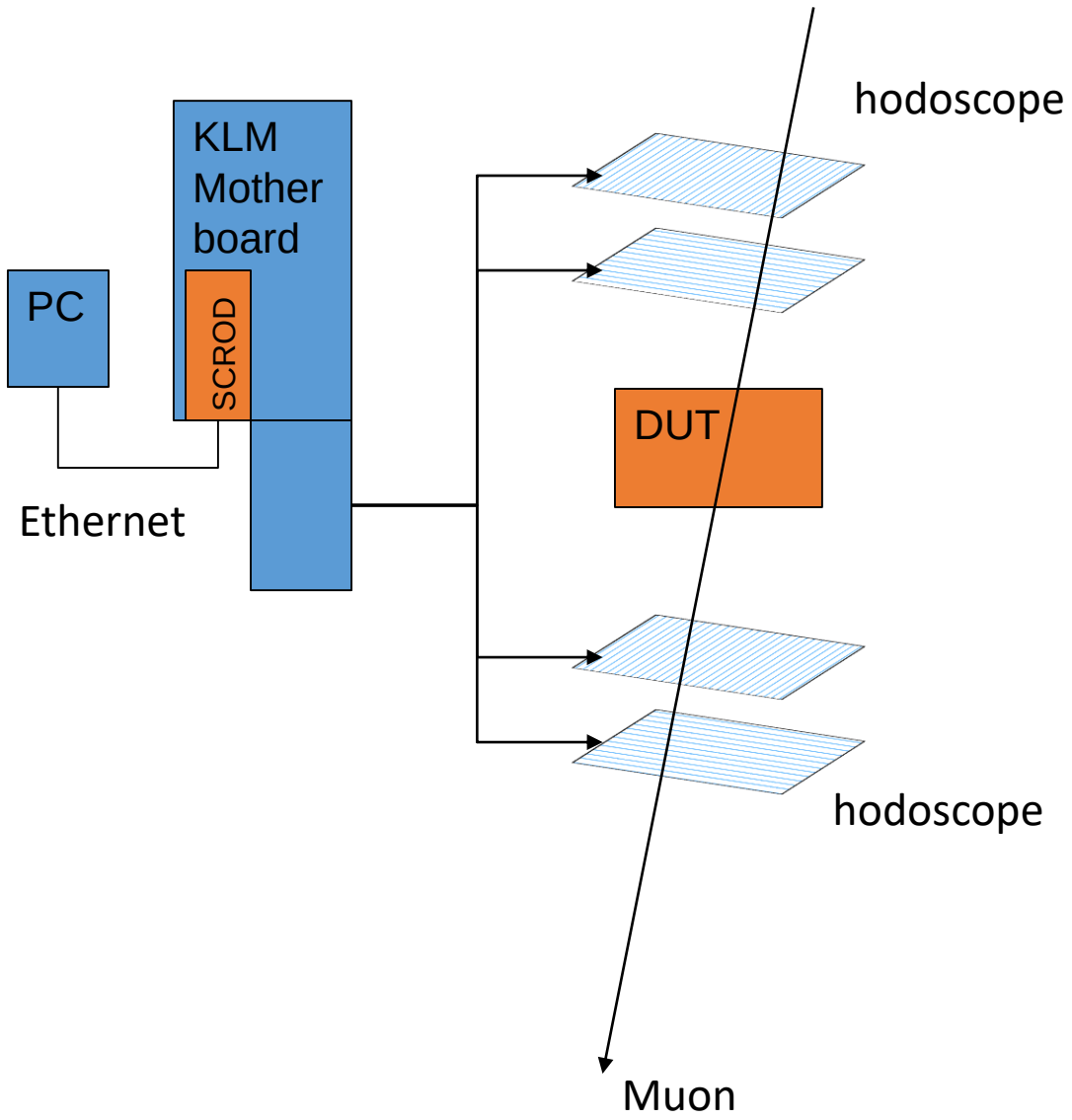
- EUTelescope is the analysis framework which is used for analyzing test beam data
- It is well integrated in the workflow
- Active development (many examples)
- Docker Images available
- It contains all the necessary tools for analyzing test beam data
  - Convert from EUDAQ format to its own LCIO format
  - Clustering: accumulating pixel responses to clusters
  - Hitmaker: converting Cluster information to 3d hits using geometry files
  - Aligment: Using Millepede II to improved Detector Geometry description
  - Track Reconstruction: uses varies algorithm such as General Broken Line Fitter (GBL)

Established Community with Annually Conferences (BTTB)



- Many detector communities are represented
- Active development for all components of the EUDET Test Beam Framework
- All core components are openly Developed on GitHub

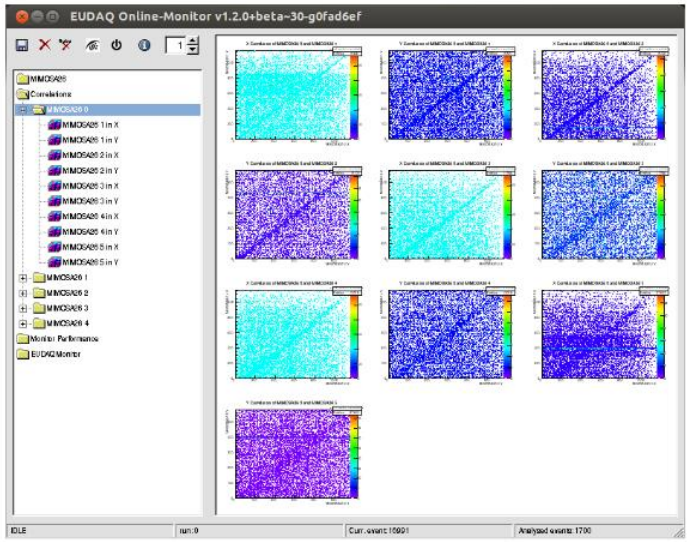
Hawaiian Muon Beam Line Setup (proposal)



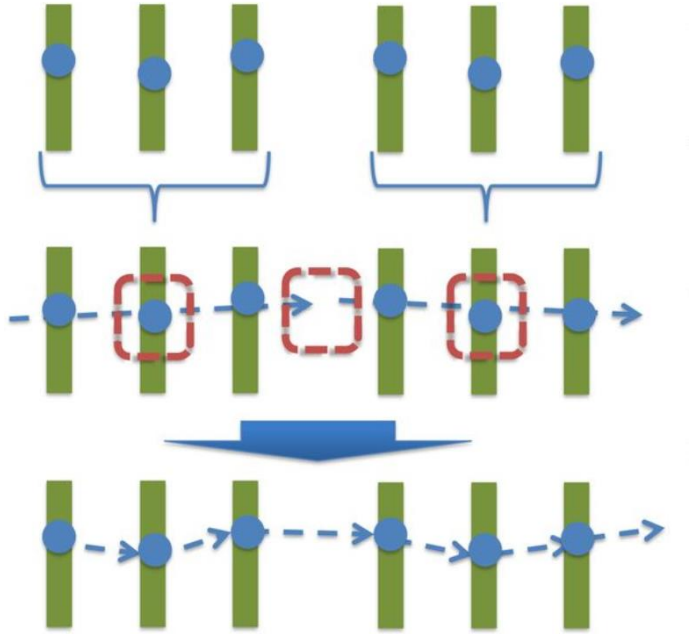
- Use KLM motherboard for the scintillator readout
- Use standalone Ethernet firmware for the SCROD
  - No FTSW
  - No PocketDAQ
  - No Copper
- Only Trigger Bit readout
- For the first version we should restrict ourselves to proven components
  - No new board design
  - No new chips
- **Let's get something working and then improve from there**

Milestones

Online Monitor



Track Reconstruction



- Readout Telescope
  - Ethernet Firmware
- Triggering System (TLU)
- DAQ Integration (EUDAQ)
- DQM Plots
  (Correlation plot / Online Monitor)
- Track Fitting (EUTelescope)
  - Residual Plots ➔ Pointing Resolution
- DUT Integration
  - Trigger Integration
  - DAQ Software Integration
  - DQM (Correlation plots etc.)
- Data Reconstruction
  - EUTelescope
- Data Analysis
  - EUTelescope/Root/BASF2/Python/Matlab