

**AIDA**<sup>2020</sup>

Advanced European Infrastructures  
for Detectors at Accelerators

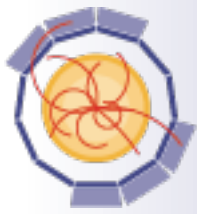
# WP5: Data acquisition system for beam tests

David Cussans (Bristol) on behalf of

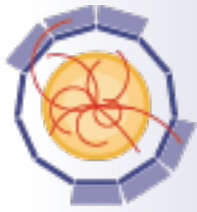
WP5 groups: University of Bristol, DESY Hamburg, Institute of Physics AS CR  
Prague, University of Sussex, University College London



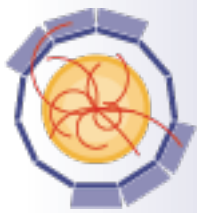
*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654168.*



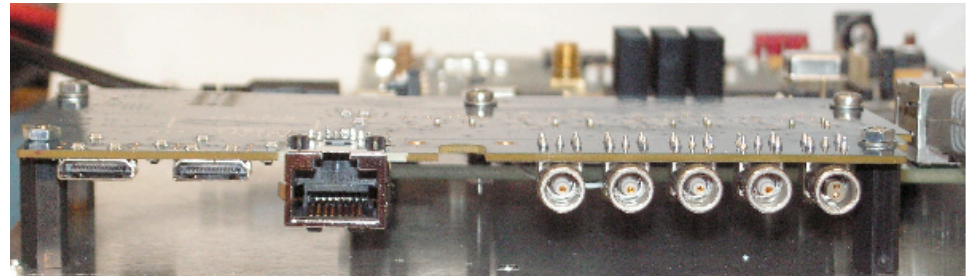
- **Overall concept of work-package**
- **Outline of tasks**
  - Task 5.1 Scientific coordination
  - Task 5.2 Interface, synchronisation and control of multiple-detector systems
  - Task 5.3 Development of central DAQ software and run control system
  - Task 5.4 Development of data quality and slow control monitoring
  - Task 5.5 Event model for combined DAQ
- **Requirements/status of detectors**
  - CALICE
  - TPC , Si reference tracker
  - FCAL
- **EUDAQ** (including beam telescope)



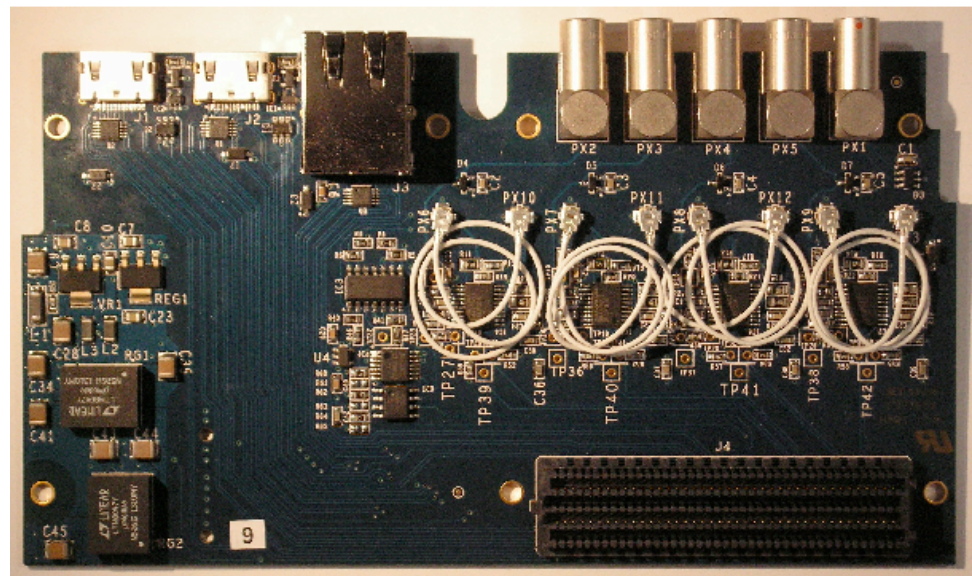
- **Provide a common data acquisition (DAQ) system for use by Linear Collider detectors in beam tests.**
  - Hopefully useful for LHC etc. as well, but focusing on Linear Collider
- **Priority: Run two or more detectors together in a common beam test.**
  - Should allow more physics and technical understanding to be extracted. Understand performance of detector and/or validation of reconstruction algorithms for individual and multiple detectors.
- **Clear and strong links with other parts of the programme**
  - software, detector development, test beam facilities.
- **Open**
  - hardware designs, firmware and software will be freely available.
- **Define standard interfaces**
  - Hardware , Software.
  - Follow standards and participate in combined beam test
- **Run control, data sanity and quality checks.**
- **Convert data to common format for ease of analysis.**
- **As a by-product, learn about a future Linear Collider DAQ.**

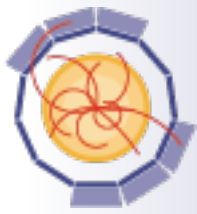


- Synchronize the data:
  - First step of any DAQ with multiple detectors
  - Use triggers and/or common clock
- Aim of WP5 hardware tasks:
  - Provide hardware standards
    - Clock/Synchronization/Trigger
    - Support existing standards
  - Provide hardware tools
    - Trigger Logic Unit (TLU)
      - Development of AIDA TLU
  - Provide support
- Responsible: **Bristol, UCL.**

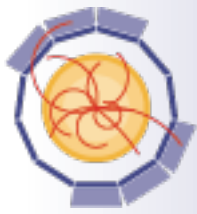


DUT0 (HDMI)   DUT1 (HDMI)   DUT2 (RJ45)   Trigger Inputs   Clock I/O

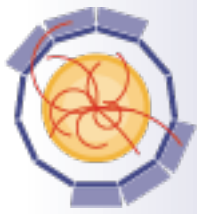




- **Link together data taking processes**
  - Use EUDAQ as a starting point:
- **EUDAQ Successfully used for beam telescope and the multitude of detectors it has been run with.**
  - Undergoing development (e.g. scalability) and supported.
- **Develop ability to link to pre-existing DAQ systems**
  - EUDAQ is currently a framework for writing DAQ.
- **Provide computing hardware for common DAQ.**
- **Tests of common DAQ system with single components.**
- **Use of common DAQ for combined beam tests with continued development and maintenance.**
- **Responsible; DESY, UCL, Bristol, Prague, Sussex.**

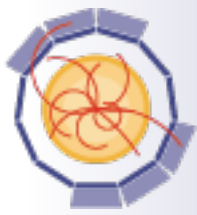


- **Framework for near-online checks of data quality**
  - individual detectors
  - Correlation between different detectors.
- **Framework for slow control systems of different detectors**
  - common and synchronised slow control monitor.
- **Continued development and maintenance of system.**
- **Responsible: Prague, DESY, Sussex, UCL.**



- **Extensive use of LCIO in Linear Collider Community**
- **Problem: LCIO not well suited to online data**
  - Developed for Monte-Carlo, where definition of event is clear. In a real detectors an “event” is often constructed later.
  - Doesn’t handle data from different detectors with different integration times
  - No method for serialization ( streaming over e.g. Ethernet ).
- **Work with WP3 on enhancements to LCIO to make it more suitable for use with online / beam-test data.**
  - May have to adopt a different approach if technical difficulties too great.



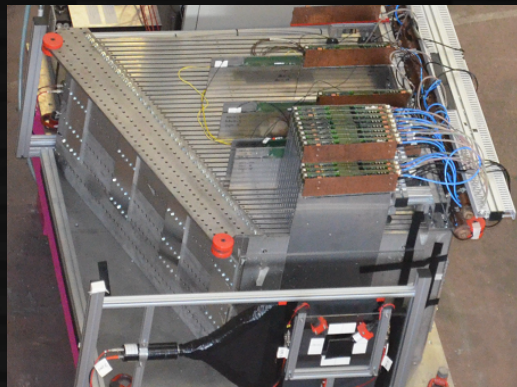


- **Diverse community**
- **Variety of DAQ systems**
- **Would benefit from common system**
  - Run a HCAL with an ECAL
  - Common interface would make different combinations easier
- **Need to interface central trigger/timing logic (TLU) with CALICE Clock and Control Card (CCC)**
- **Would benefit from common event building and monitoring frameworks**
- **Mature DAQ systems**
  - Use EUDAQ as central DAQ, rather than a framework to make a combined DAQ



# CALICE-DAQ introduction

- Three types of calorimeter being actively developed
  - Silicon ECAL
  - Scintillator strip ECAL / Analog HCAL
  - Semi-digital RPC HCAL
- Individual DAQ hardware and software
  - Conceptually based on UK(~2008) scheme



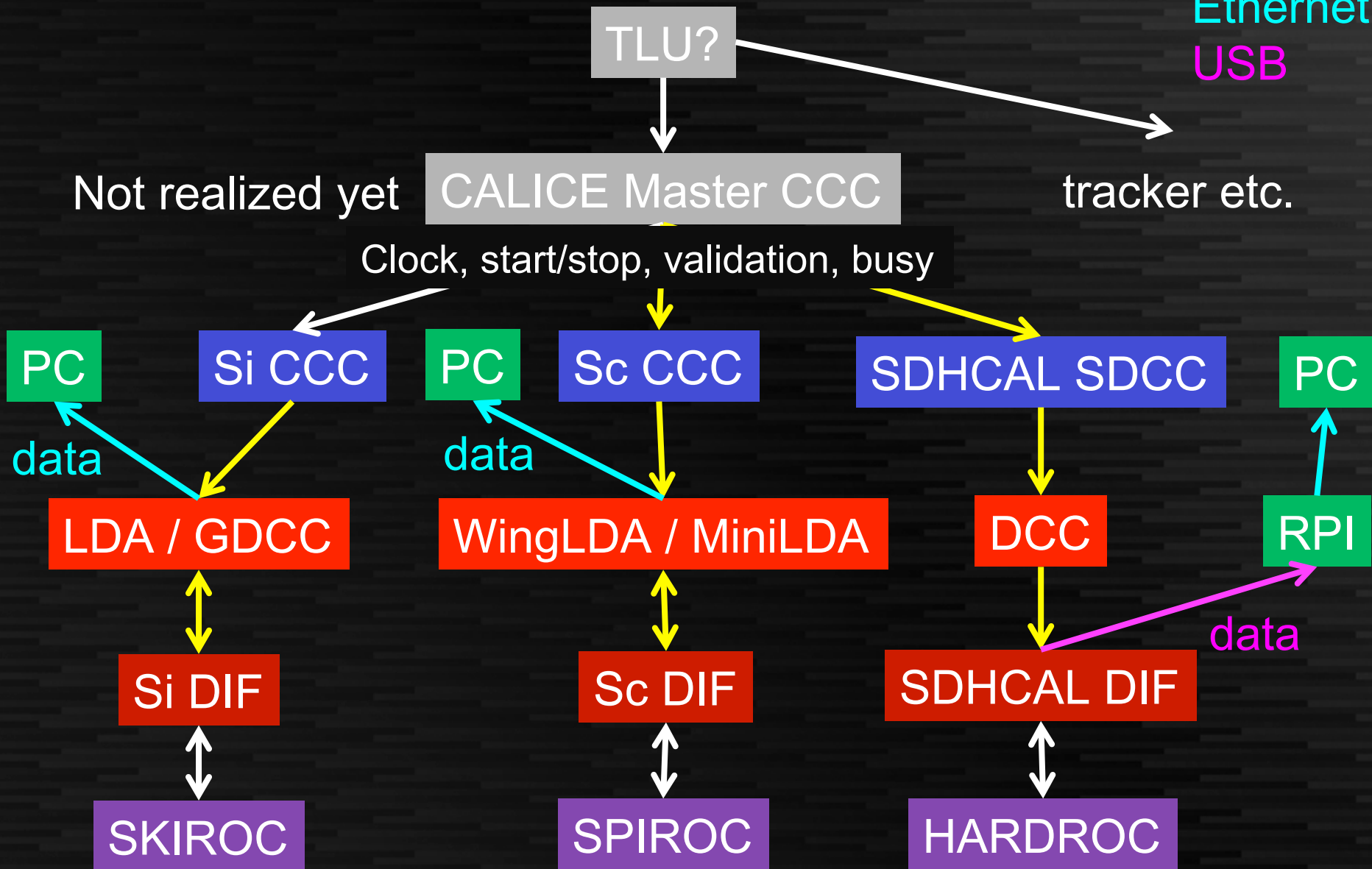
SiECAL (2012)

ScECAL+AHCAL (2014)

SDHCAL (2014)

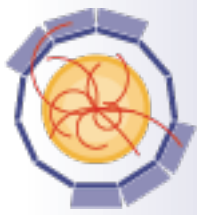
# CALICE DAQ Structure

HDMI  
Ethernet  
USB



# Targets of CALICE DAQ TF

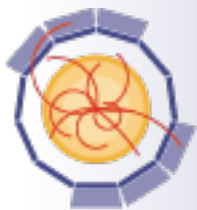
- Common DAQ
  - Common clock and acquisition cycle (AQC)
  - Synchronized data taking and event matching
  - Common run control
  - Interface to upper control (TLU)
- Combined testbeam
- Minimize total work by sharing tasks
- Currently 'minimal effort' basis
  - Acceptable combination with minimal effort



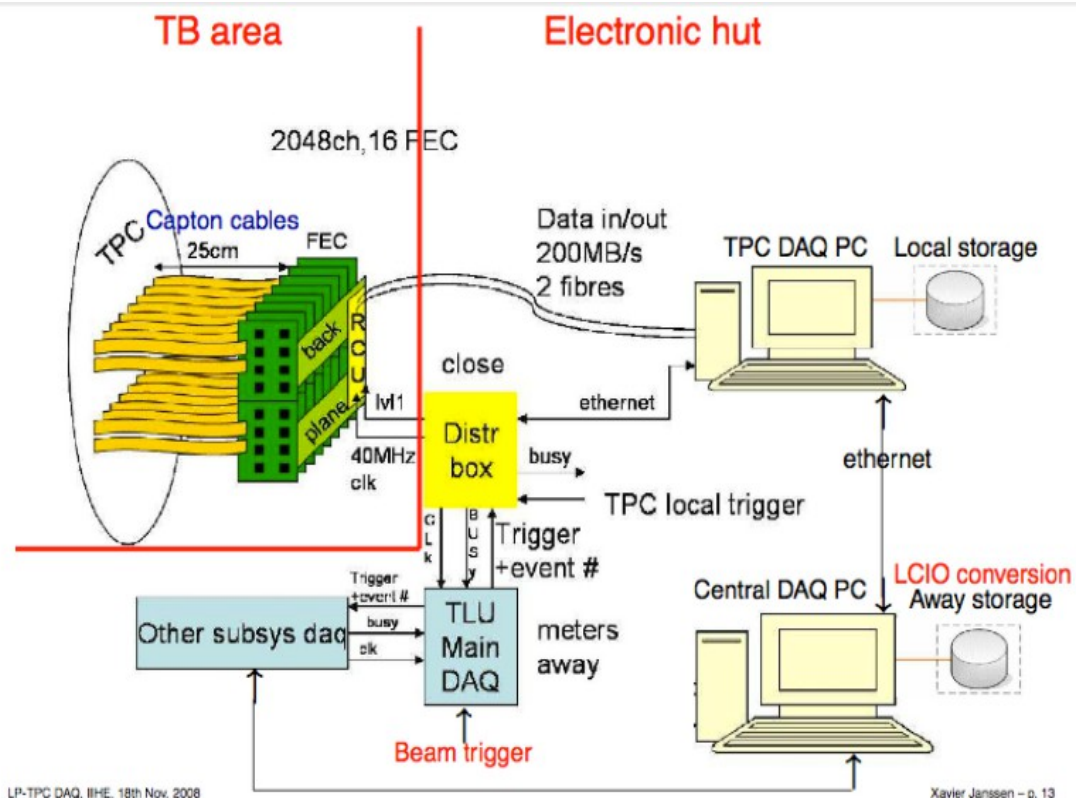
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# TPC + Reference Telescope (Dimitra Tsionou)

- **Diverse community**
- **Variety of DAQ systems**
- **Adding an external Silicon Reference Telescope**
- **Would benefit from common system**
  - Easier integration of reference telescope with TPCs



- Different DAQ used by the TPC groups using GEMs / Micromegas / InGrid
- GEMs: ALTRO electronics (Lund/CERN) based on Alice TPC
  - Plan to move to sAltro system (new readout chips,





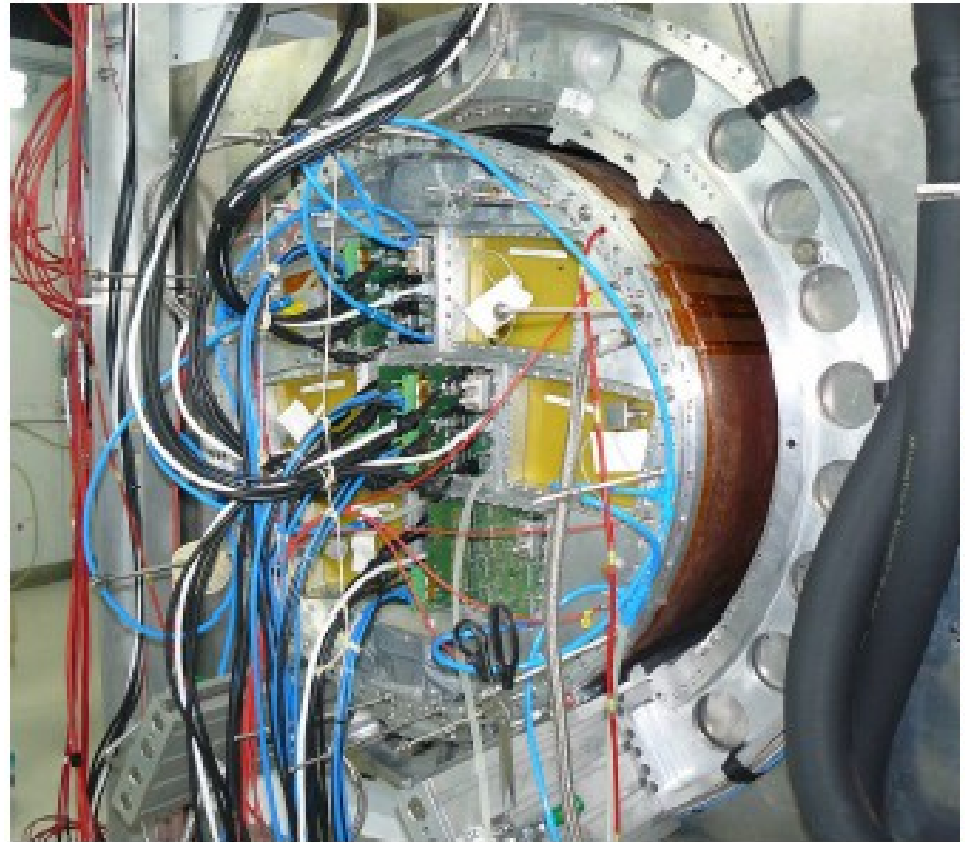


- **Micromegas: After electronics from T2K experiment**

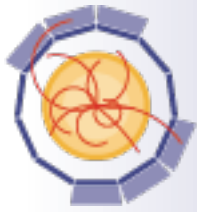
- Also tested Altro system in the past

- **InGrid: Timepix (Bonn)**

- Readout with Medipix (to be replaced by Scalable Readout System), acquisition and control with Pixelman



M. Lupberger, LCTPC 04/2015



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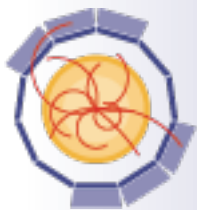
# TPC – Silicon Reference Telescope

- **Under Development**
- **In process of selecting sensor technology**
- **Then, will progress to DAQ**



- **Have experience of integrating to EUDET TLU**
- **Investigating Scalable Readout System ( SRS, RD51)**
  - Looks promising
  - Existing interface boards to e.g. APV25

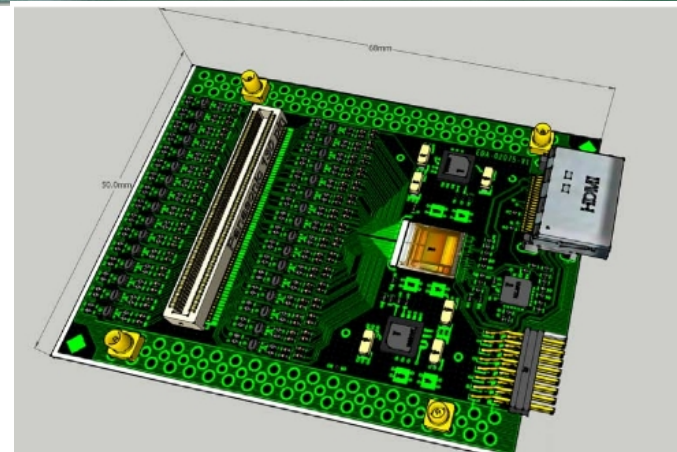
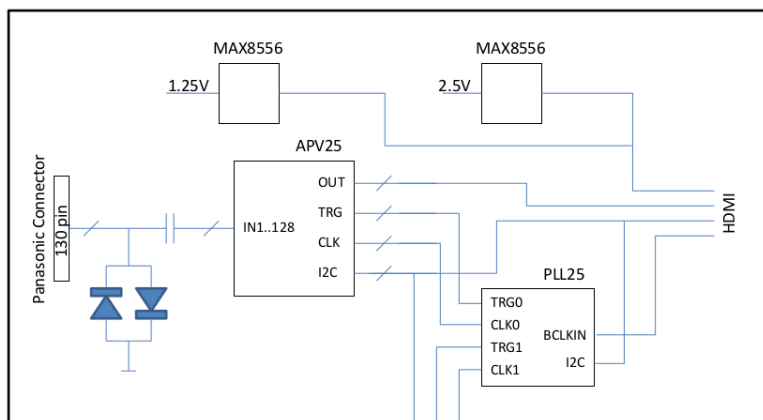




### • Test with SRS and APV 25

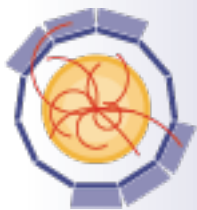
- Designed for CMS silicon microstrip detectors;
- 128channels;
- Shaping time (min): 50 ns;
- Range: 125 ke;

### • Small hybrid interfaces to SRS

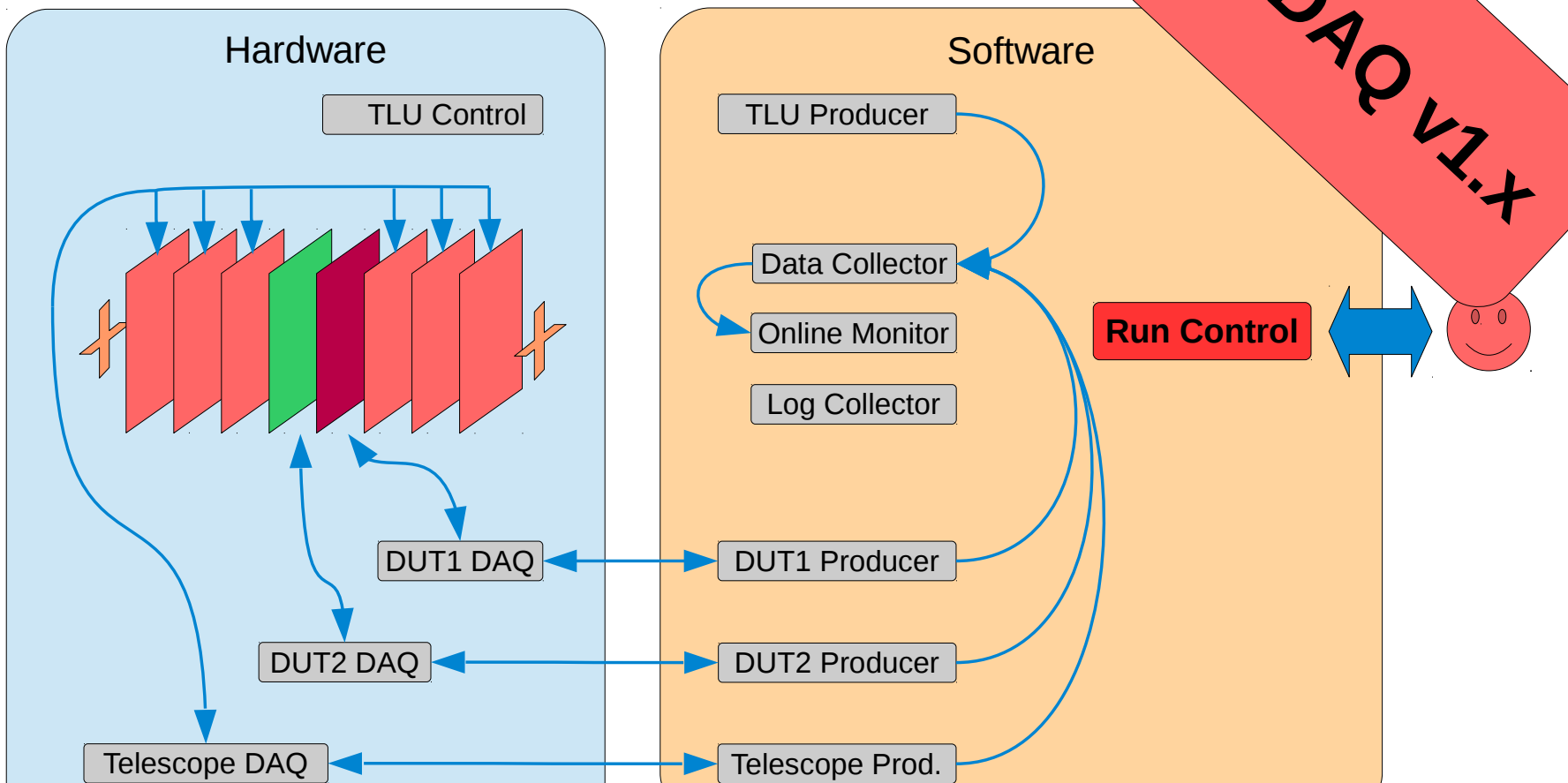


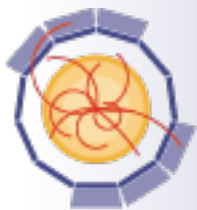


- **Framework for writing DAQ systems**
- **Developed for beam-telescope in EUDAQ**
- **Proved successful for telescope and others.**
- **Starting point for common DAQ in AIDA-2020**
- **Major development underway (EUDAQ 2.x)**
  - Scalable
  - Allows data from detectors with different integration times to be combined ( e.g. continuously integrating MAPS with triggered detectors)
- **Will also be supported by WP15 (Beam Test infrastructure)**
  - Hand over from existing maintainers (moving on)

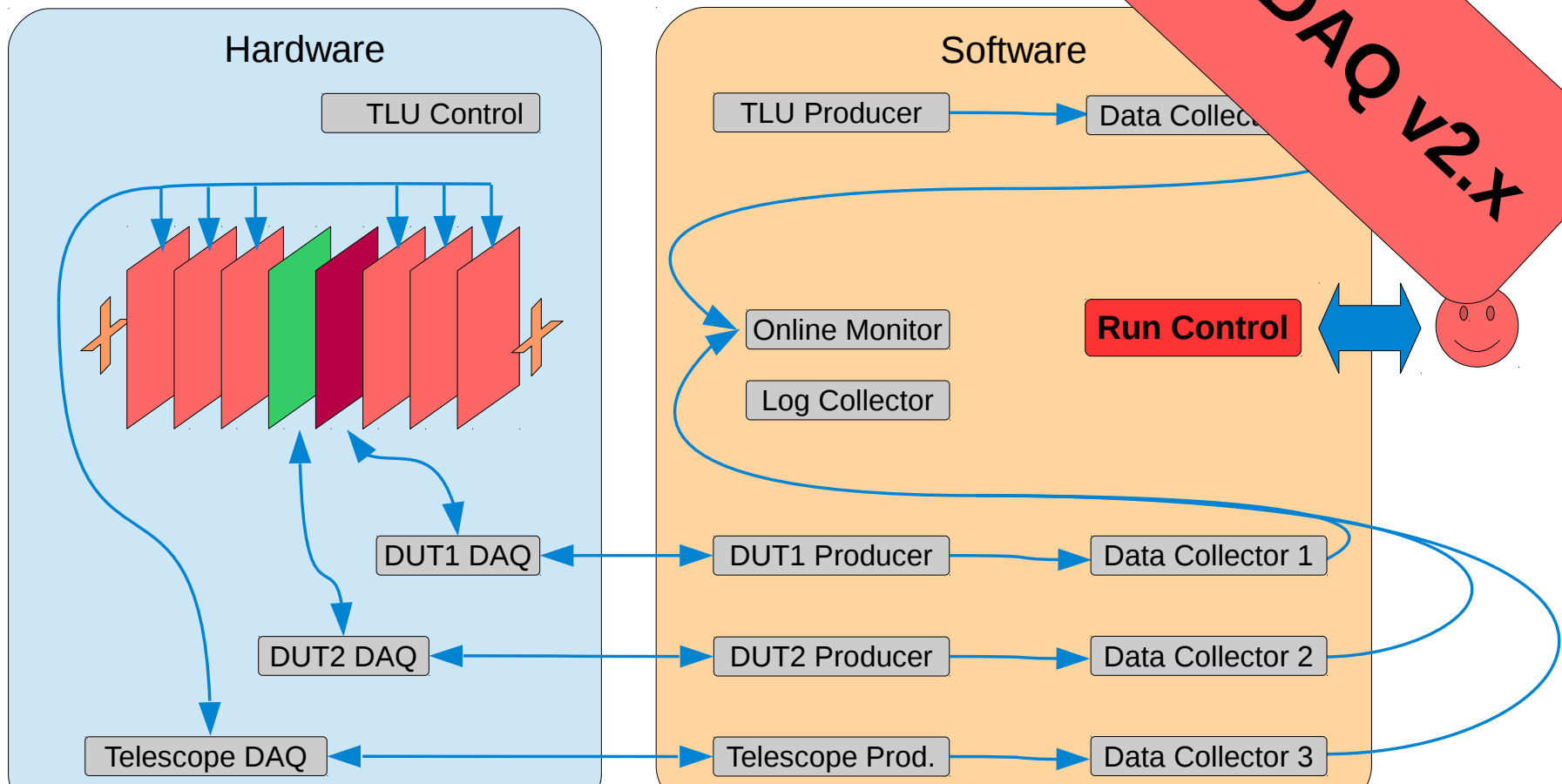


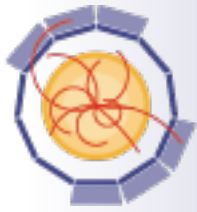
### Data flow



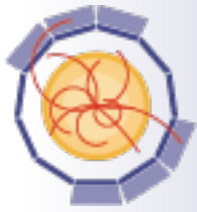


### Data flow





- **Add slow control functionality for monitoring/storage of beam energy, temperature, HV settings of the DUT, ...**
- **Use FE-I4 as trigger and track separation plane**
- **Maintain EUDAQ v1.x (single data stream)**
- **Finalise/maintain EUDAQ v2.x (parallel data streams)**
  - Existing developers leaving ( One this year, one next summer )
  - Knowledge transfer needed!
  - → EUDAQ Developers meeting, September in DESY.
  - N.B. Tools to build events from multiple files also useful for e.g. CALICE
- **Replace TLU by AIDA-TLU**



- **Starting work to create/develop interface standards and tools.**
  - Hardware , Software
- **WP5, Common DAQ has links to many other work packages – so communication vital**
  - Possible to manufacture technical compliance with milestones and deliverables but true success involves producing a useful things and having them used.