AIDA 2020 / EUDAQ

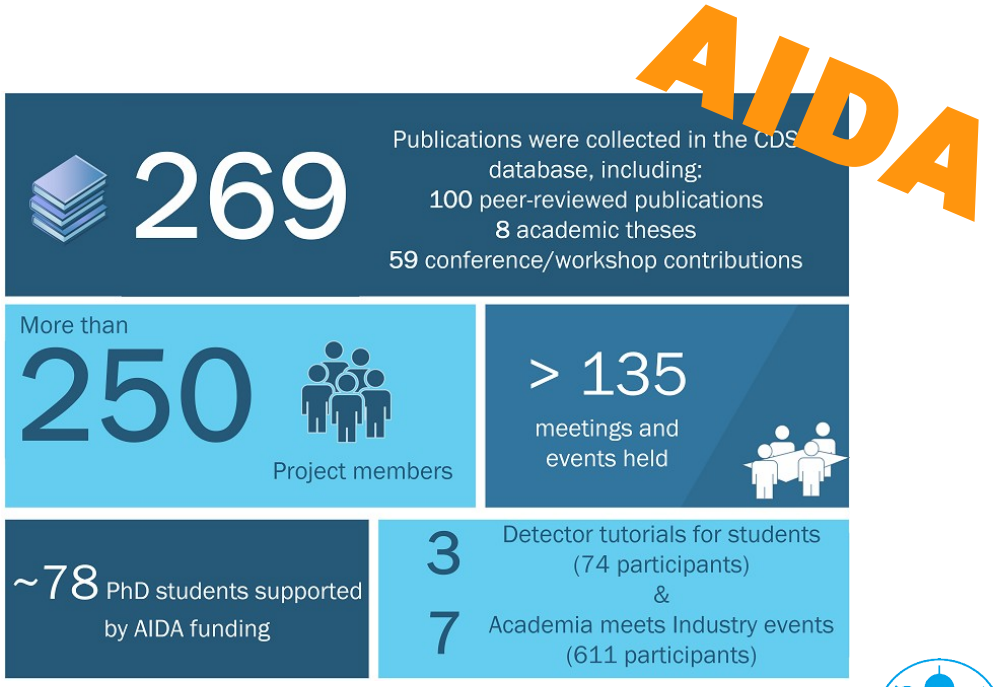
Ralf Diener, DESY

Overview

- AIDA 2020
  - Introduction and Overview
- DESY II Testbeam Facility
  - Facility, Plans, Infrastructure
  - Pixel Beam Telescopes
- EUDAQ
  - Overview
  - Use Cases

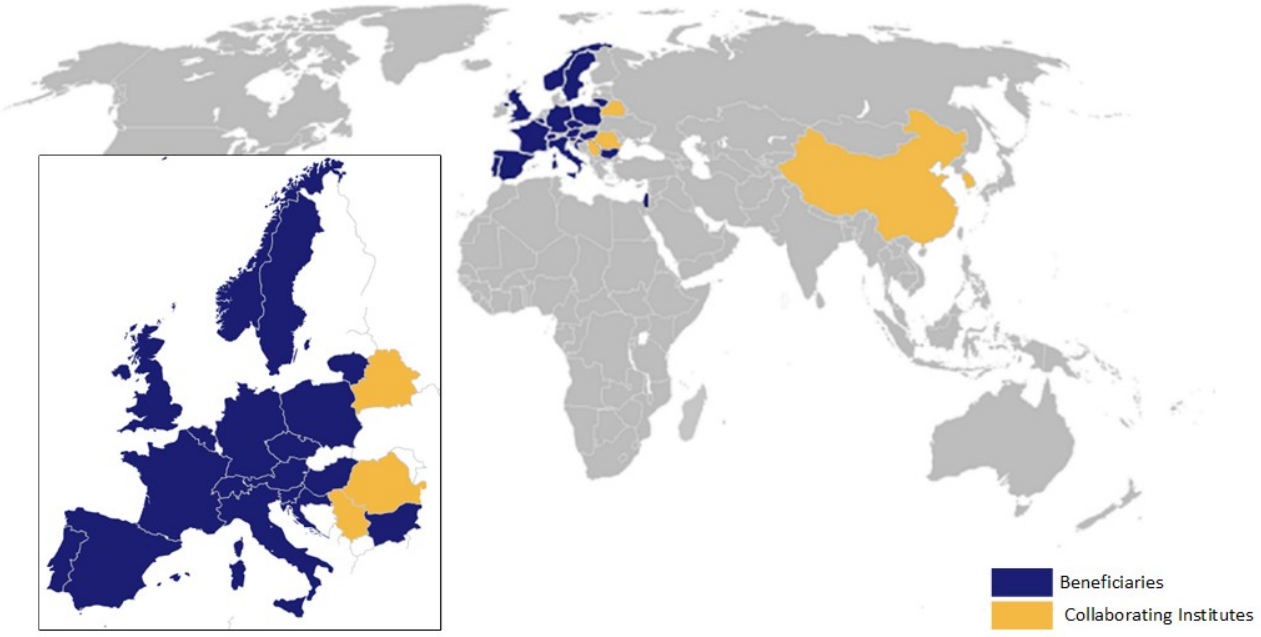
AIDA 2020 - Introduction

- AIDA: **A**dvanced European **I**nfrastructures for **D**etectors at **A**ccelerators
- Funded by the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement no. 654168
- Supports infrastructure to enable advanced detector development:
  - Development, support and improving infrastructure
  - Exploring novel detector technologies
  - Providing common tools and systems
  - Outreach, industrial relations and technology transfer
  - Runs from 5/2015 to 4/2019
- "Successor" of EUDET (2006-2010) and AIDA (2011-2014) programmes (similar but not the same scope)



AIDA 2020 - Members

- 38 beneficiaries (incl. DESY, KIT)
- 14 partner organizations (incl. HZDR), 7 collaborating institutes
- 24 countries and CERN



- Total budget 29.5 MEUR, including 10 MEUR from EC
- EC coordinating institute CERN
- Scientific coordination DESY

AIDA 2020 - Workpackages

- Topics organized in work packages
  - NA: Networking Activity
  - TA: Transnational Access
  - JRA: Joint Research Activity
- Covers mostly all steps in detector R&D life-cycle
  - New ideas
  - Simulation
  - Prototyping
  - Test measurements
  - Data analysis
  - Publication, technology transfer

No	Type	WP
WP1	MGT	Project management and coordination
WP2	NA1	Innovation and outreach
WP3	NA2	Advanced software
WP4	NA3	Micro-electronics and interconnections
WP5	NA4	Data acquisition system for beam tests
WP6	NA5	Novel high voltage and resistive CMOS sensors
WP7	NA6	Advanced hybrid pixel detectors
WP8	NA7	Large scale cryogenic liquid detectors
WP9	NA8	New support structures and micro-channel cooling
WP10	TA1	Beam test facilities
WP11	TA2	Irradiation facilities
WP12	TA3	Detector characterisation facilities
WP13	JRA1	Innovative gas detectors
WP14	JRA2	Infrastructure for advanced calorimeters
WP15	JRA3	Upgrade of beam and irradiation infrastructure

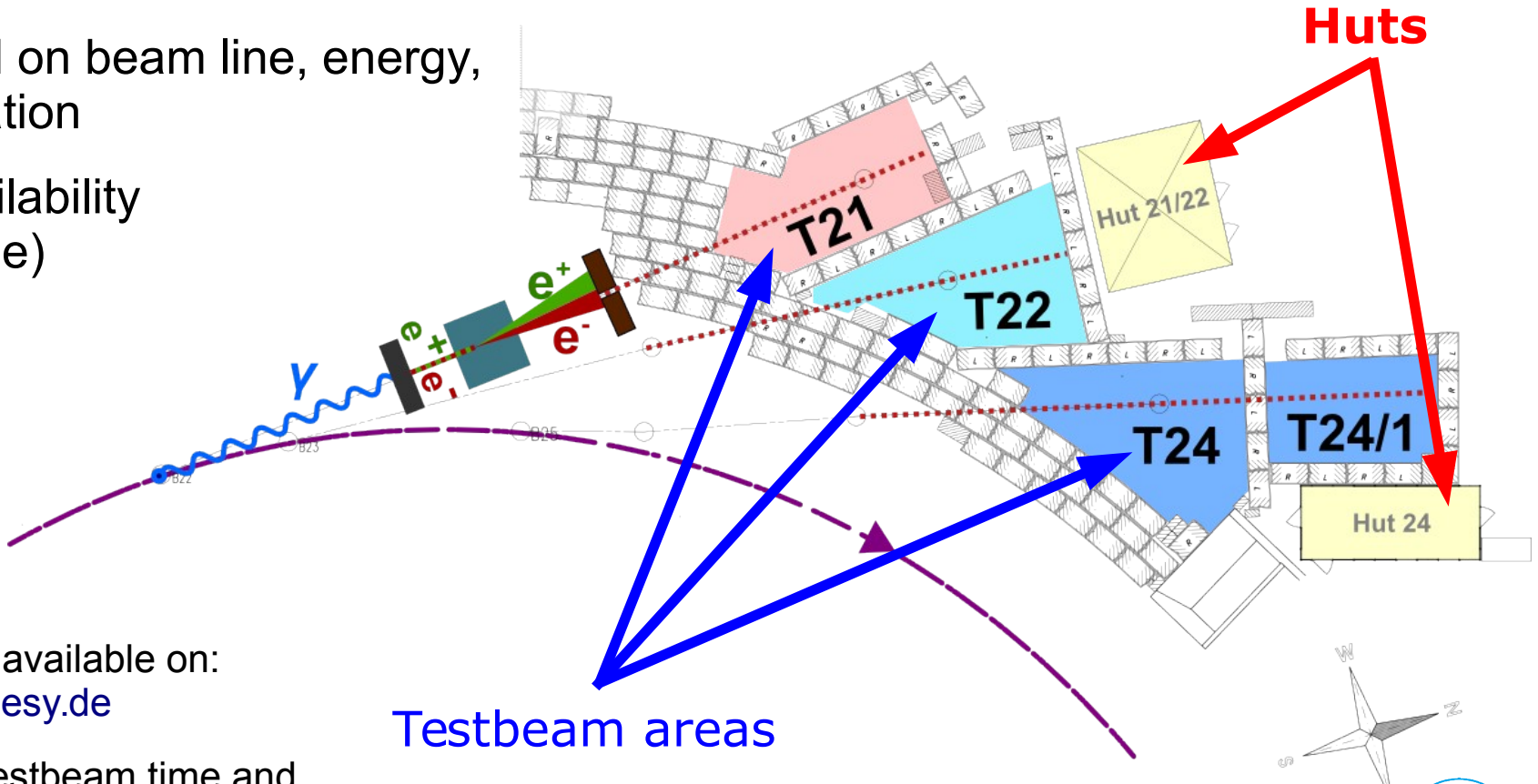
DESY II Testbeam – AIDA 2020

- AIDA 2020 supports the DESY II testbeam facility
  - WP5: NA4 - Data acquisition system for beam tests
    - EUDAQ development
  - WP10: TA1 - Beam test facilities
    - Transnational access
  - WP15:JRA3 - Upgrade of beam and irradiation test infrastructure
    - Common slow control for environmental conditions (temperature, pressure, humidity…)
    - Support for beam telescopes
    - Large area strip beam telescope inside 1T solenoid magnet

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)

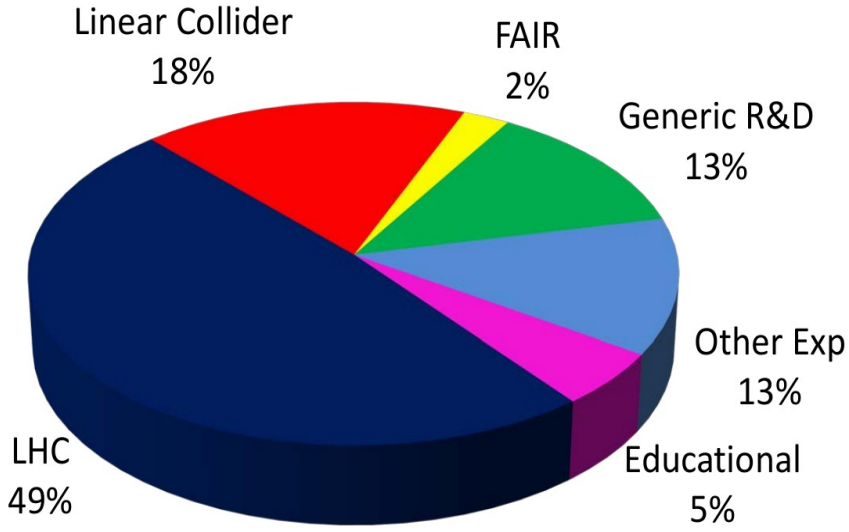
- Three individual beam lines, controlled by the user
  - Shutter, area interlock
  - Select particle momentum/collimation

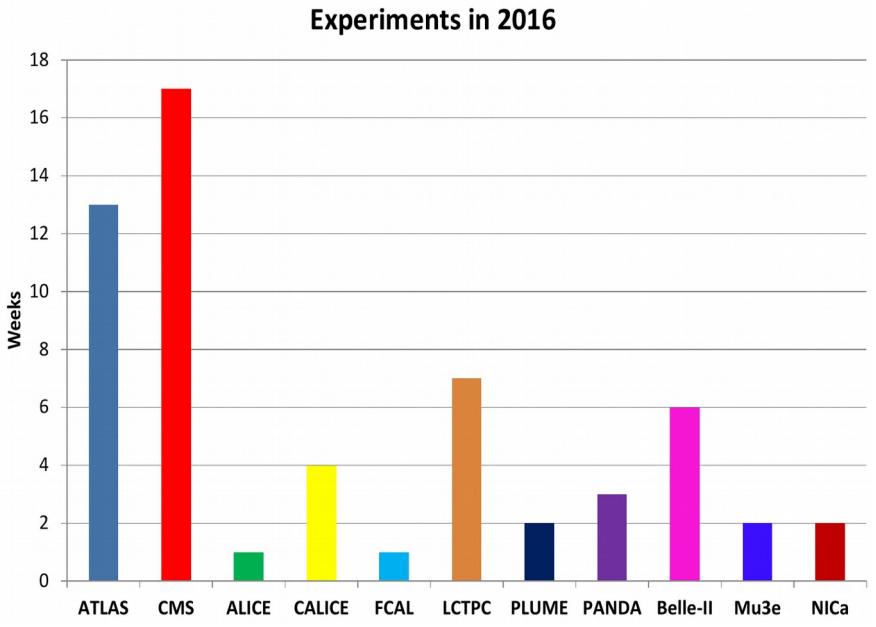


- More information available on: http://testbeam.desy.de
- Annual calls for testbeam time and other information: subscribe testbeam-info mailing list

DESY II Testbeam - 2016 / 2017

- Run 2016: Mar. 14 – Dec. 23
  - 105 weeks available, 67 allocated
  - 292 Users from 21 countries
    - 37 % new users, 47 % students
- Run 2017: Feb. 13 - Dec. 22
  - 4 week shutdown in July/August
  - So far 46 weeks requested by 24 groups
    - ~ 75 % LHC, ~ 80 % telescope requested



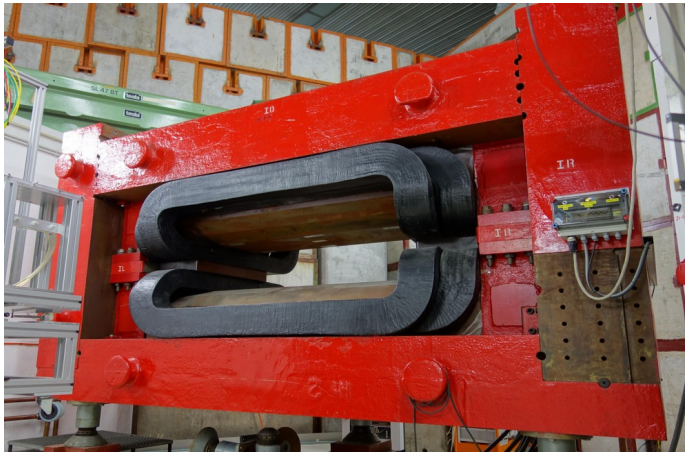


DESY II Testbeam - 4th Beam Line

- Current beam lines well used, but sufficient → additional of this type not needed
- Under study: 4th beam line using DESY beam directly (~10^{10} e^-/bunch, 12.5 Hz)
  - Electrons with max DESY II energy and/or high intensity
    - Studies with 6.3 GeV beam, high intensities (100 kHz or more)
    - Fan out + collimation: 10^{10} to 100 electrons/cm^2
  - Pion/muon beam (beryllium target): up to 4 GeV / O(10) pions per bunch
    - Extended test possibilities: hadronic calorimetry and particle identification
  - Electromagnetic irradiation (~ 10 X_0 tungsten target)
    - Intensive electromagnetic shower of electrons and photons with E < 1 GeV
- No influence on DESY II operations
  - Uses only dumped beam, extraction and beam line already installed (DORIS)
  - Needed: Small building/shielding/interlock, magnets, collimator, targets, ...
- Studies to establish the full feasibility, workshop planned for summer 2017
  - Demand and requirements of user communities, more details of planning

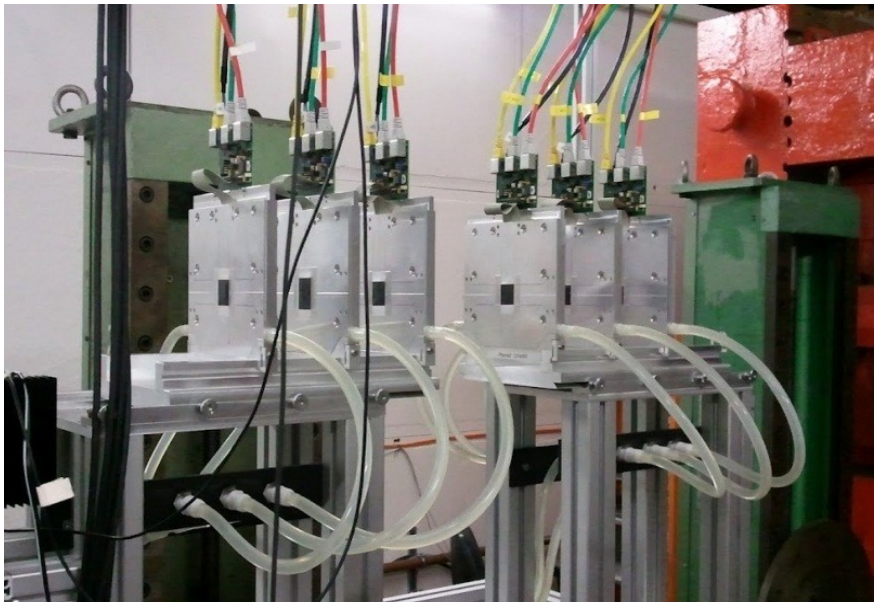
DESY II Testbeam - Infrastructure

- All the useful things:
  - 30 kg and 1 ton stages
  - 25 t crane
  - Patch panels: Ethernet, optical fiber, BNC, S-HV
  - IP cameras, dry nitrogen
  - Gas setup (incl. flammable gas) in 2 areas
  - Dipole magnet in TB 21
  - Superconducting solenoid (1 T)
    - Usable diameter ~ 75 cm
    - Wall: 0.2 X_0
    - Mounted on movable stage



DESY II Testbeam - Pixel Telescopes

- Complete Package:
  - Hardware, trigger, software, dedicated support crew
- 6 Layers pixel planes, 1x2 cm^2, 18 µm pitch
  - Dedicated stages to move/rotate Devices-under-test (DUT)
  - Both Arms adjustable for different DUTs
- Trigger rates up to 3 kHz
- Few micron tracking resolution
- High demand: requested by ~ 70 % of users in 2016
- "Copies" used worldwide at different test facilities: Users find familiar setup → quick start
- Uses EUDAQ and EUDET / AIDA mini-TLU



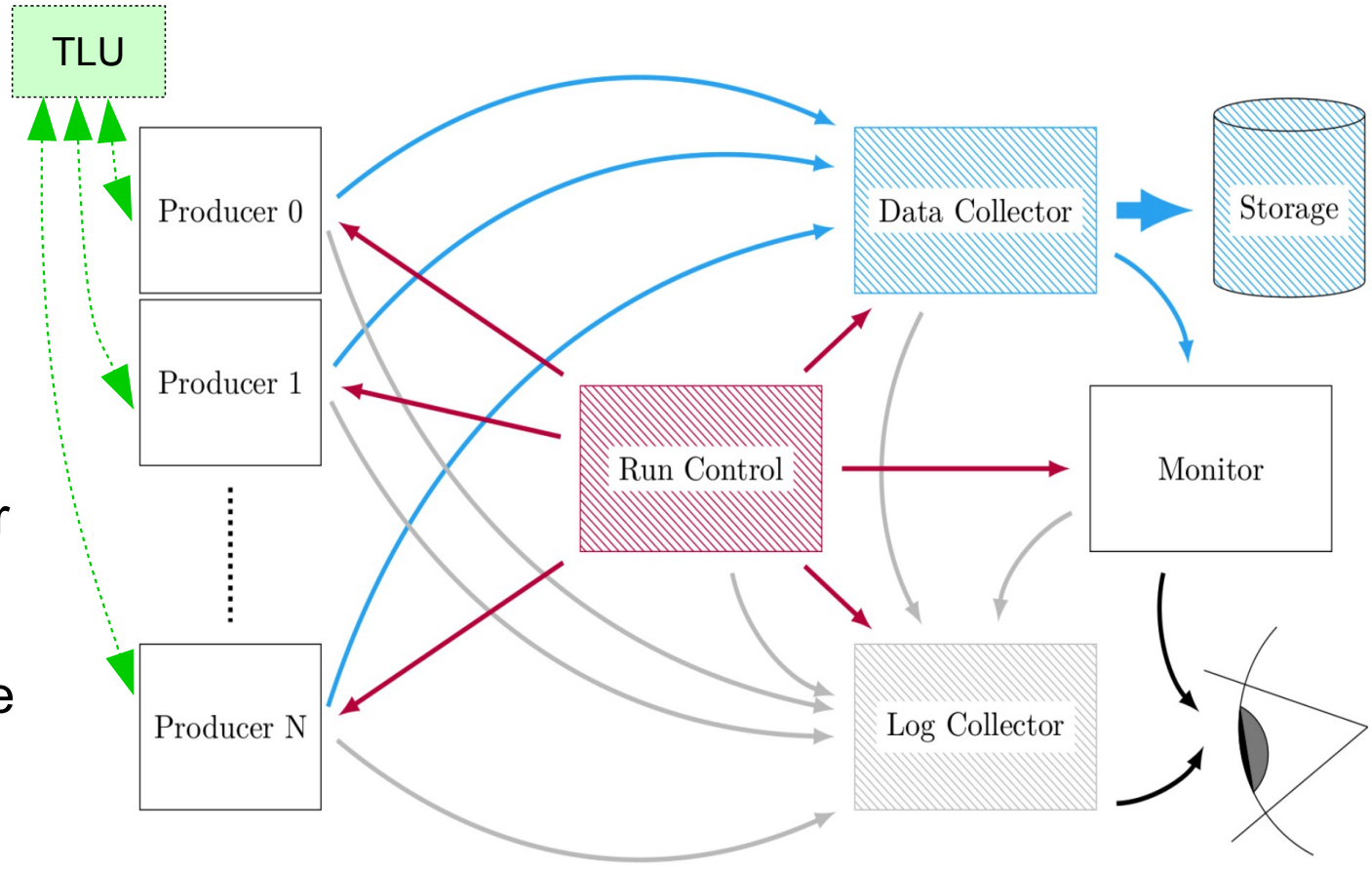
Name	Est.	Site
AIDA	2009/10	CERN, H6B, North hall (SPS)
ANEMONE	2011	Bonn, Germany
ACONITE	2012	CERN, H6A, North hall (SPS)
DATURA	2012	DESY, TB21
CALADIUM	2013	SLAC, ESA
DURANTA	2015	DESY, TB22
AZALEA	2016	CERN, T10, PS

EUDAQ - Introduction

- *"Testbeam"* DAQ: Generic framework for data acquisition started 2007
  - Provide generic DAQ for users: simplicity, not feature creep
  - Development to satisfy user needs, not focused on specific community
  - EUDAQ works as "*glue*"-DAQ:
    Integrate many different devices / different DAQs into one testbeam setup
  - DAQ control, data handling, storage, log collection, online monitoring
  - Components communicate via TCP/IP, can run on distributed machines
- Driving force: telescopes
  - Designed to also be generally useful for other systems
- Framework
  - Written in C++, designed modular and portable,
    OS independent: Linux, Mac OS X, and Windows
  - Data formats: RawDataEvent, StandardEvent, Converter: ASCII, ROOT, LCIO, …
  - Reconstruction and analysis possible with EUTelescope software:
    Generic Pixel Telescope Data Analysis Framework

EUDAQ - Working Principle

- Run control:
  - Central component in the network
  - Distributes IPs and port numbers
  - Distributes commands
  - Central interface to user
- Producers:
  - Skeleton provided, to be fleshed out by user
- Data collector:
  - Central online “event builder”: merges detector events in global EUDAQ event including cross checks, single data stream to disk → plugins for data conversion
- Central monitoring (events provided by data collector)
- Log Collector: collects messages from all network nodes in a single place



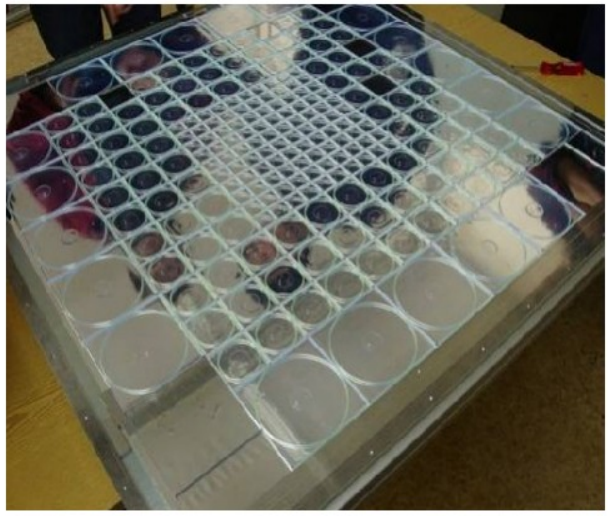
EUDAQ - Status

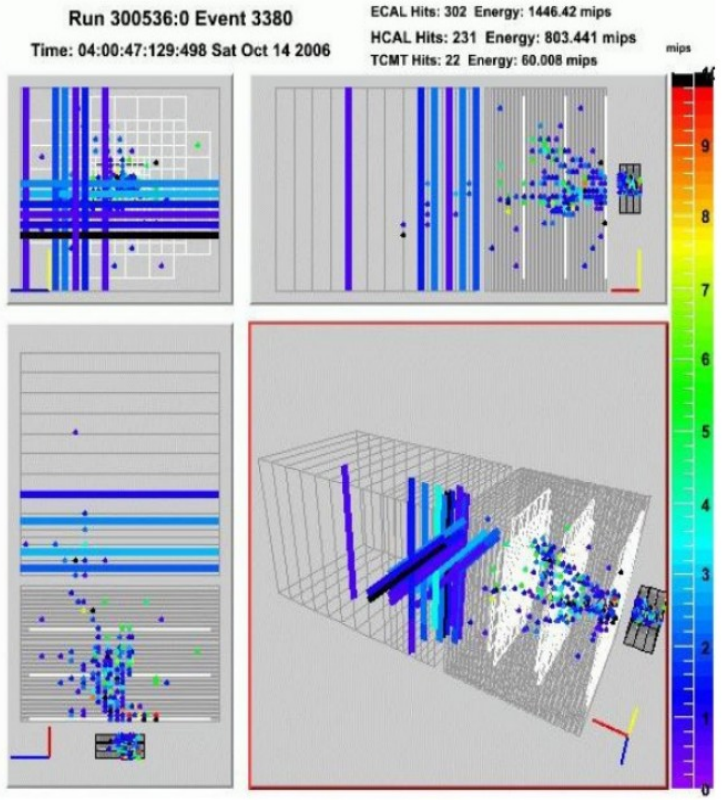
- EUDAQ 1.x: current working horse, maintained, currently release 1.7 in the work
- New major release upcoming: EUDAQ 2.0
  - Development to be even more versatile
  - Example:
    - EUDAQ 1.x: TLU Trigger signal with trigger ID distributed to all sub detectors
      → used to merge events
    - EUDAQ 2.0: In addition: TLU System clock distributed to all sub detectors
      → timestamp inserted into sub event and used to merge events
    - No waiting of faster sub detectors for the completed readout of slower detectors
      Offline merging based on timestamps, quasi “online” event building → monitoring

- Webpage: https://telescopes.desy.de/EUDAQ (incl. documentation and manual)
- GitHub repository: https://github.com/eudaq/eudaq (LGPL3)
- Users: Altro (Bonn), APIX (Atlas Pixels), Atlas (TRT), ClicPix (CERN), CMS Pixel (DESY), DEPFET (Bonn), FORTIS/SPIDER (Bristol), Mu3e (Heidelberg), PixelMan (Freiburg), SITRA (Santander), Taki (Mannheim), Timepix (Bonn), …, CALICE

AHCAL + Telescope

- CALICE Analog Hadronic Calorimeter (AHCAL)
  - Scintillator tiles with wave length shifting fibers, read out by SiPMs
  - Developed for particle flow approach: highly granular 3*3 cm^2 - 12*12 cm^2 tiles
  - Readout: 12 bit (analog), LabVIEW DAQ

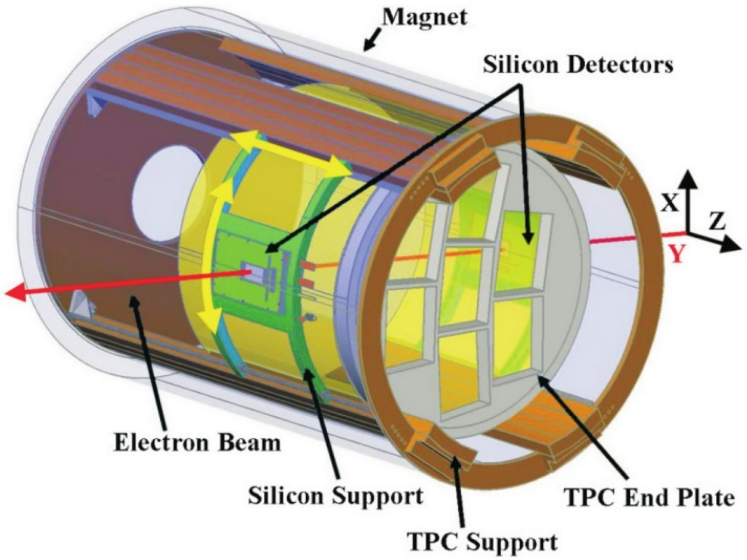


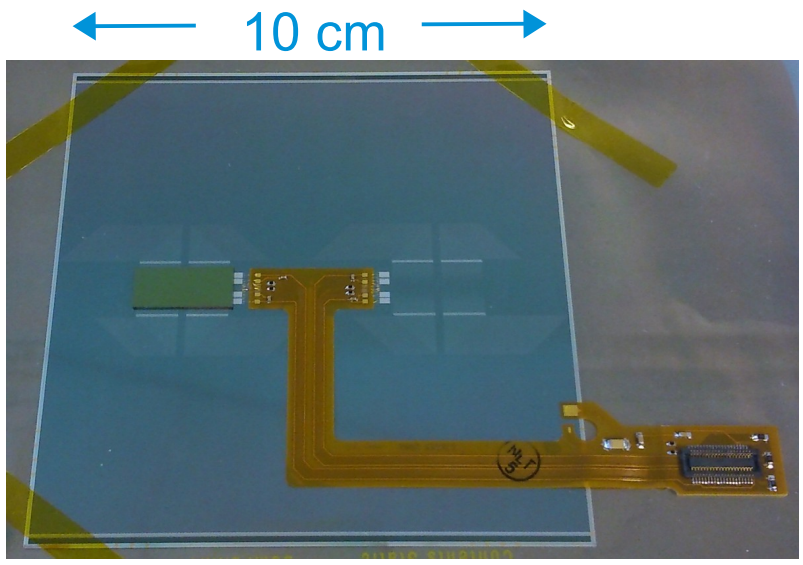


- Combined testbeam with telescope:
  - First goal: running combined √
  - Next steps: more efficient data acquisition
  - Future: measure response of scintillator tiles depending on position
- First test user of EUDAQ 2.0

Solenoid Large Area Beam Telescope

- An external Si tracker can provide
  - Reference tracks for incoming particles
  - Time projection chamber (TPC): Study of field distortions and momentum resolution
- Should be “simple and versatile” to be used by other groups during test beams
- Challenge: needs to fit in the limited space between magnet and TPC (~3.5 cm)





- Hardware chosen:
  - *SiD* strip sensors with 4K strips (pitch: 20µm), read out using 2 KPiX chips (incl. own DAQ)
  - Expected spatial resolution ~7-8um
  - Test system available
  - Sensors ordered (exp. early summer)
  - Will be integrated in EUDAQ

Summary

- European AIDA 2020 programme provides support for advanced detector development supporting all steps in detector R&D life-cycle

- DESY II testbeam facility
  - 3 beam lines with 1 to 6 GeV electrons/positrons, operated as a user facility
- Infrastructure: Test beam pixel telescopes
  - Highly demanded, success story used at many facilities worldwide

- EUDAQ:
  - Generic DAQ for users, aim on simplicity and easy integration of user DUTs
  - Next major release version 2.0 upcoming
- Use cases: combined test beams
  - Beam telescope and hadronic calorimeter ongoing
  - Planned: new telescope and combination with TPC

Additional Information

DESY II

- Radius: 46.601 m (circumference is 292.8 m)
- Bunch of about 10^{10} (electrons or positrons) injected from LINAC at 450 MeV
- Acceleration by eight 7-cell PETRA-type cavities
- Revolution frequency is 1 MHz, bunch length around 30 ps
- Acceleration/deceleration in sinusoidal mode; frequency of 12.5 Hz (cycle: 80 ms)
- Today: DESY II runs as pre-accelerator for PETRA
- Usual running conditions: acceleration to 6.3 GeV (maximum 7GeV)
- Extraction for PETRA every minute at 6.0 GeV