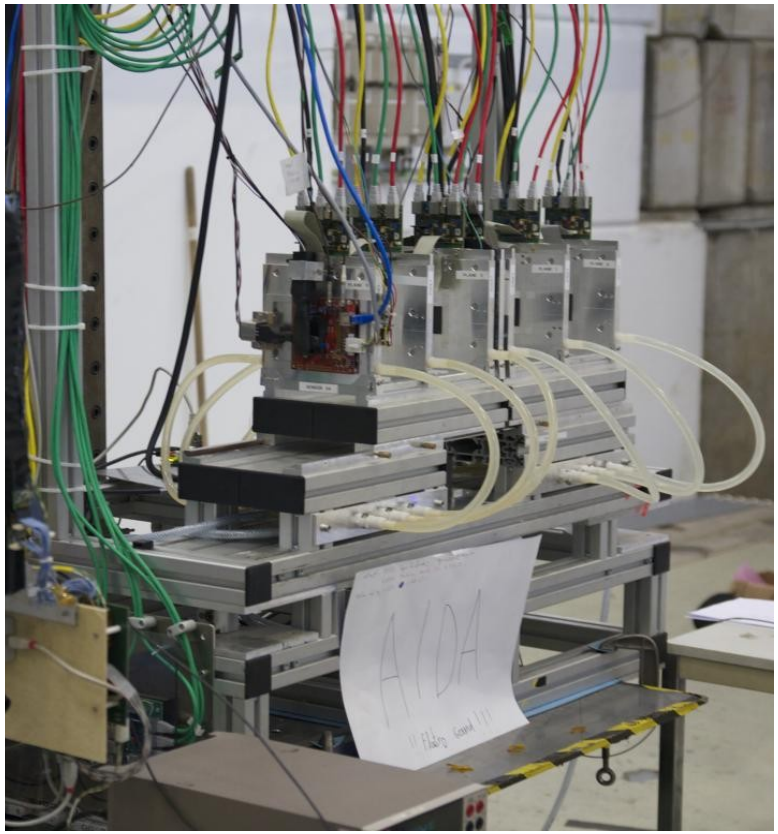


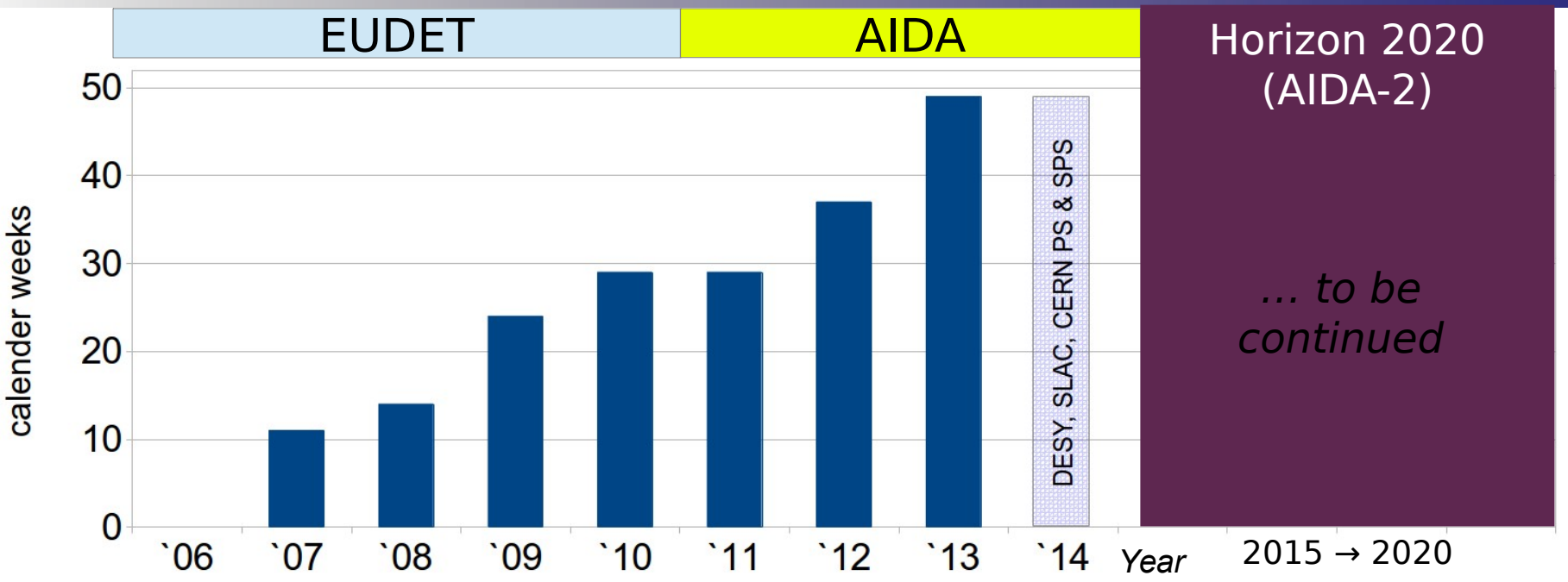
CERN PS T9, July-Sep 2014

Status of the AIDA telescope(s)

(and in specific the AIDA telescope at H6B)

Igor Rubinskiy
DESY, Hamburg (now UHH/CFEL)

An overview of the work of many people
contributed to the development
of the original EUDET telescope
and also of those who made the upgrade
to AIDA telescope possible



The EUDET telescope
– Mimosa26 sensors
CDS, ZS, binary, 18.4 μm square pitch

- the NI COTS readout system
introduced to replace VMEx64 and custom made electronics to solve scalability issues

Large Area Telescope: SALAT + quad FEI4

AIDA upgrades to EUDET telescopes
Trigger, DAQ integration, offline reco
Lite: TLU, EUDAQ, EUTelescope, FEI4 ROI

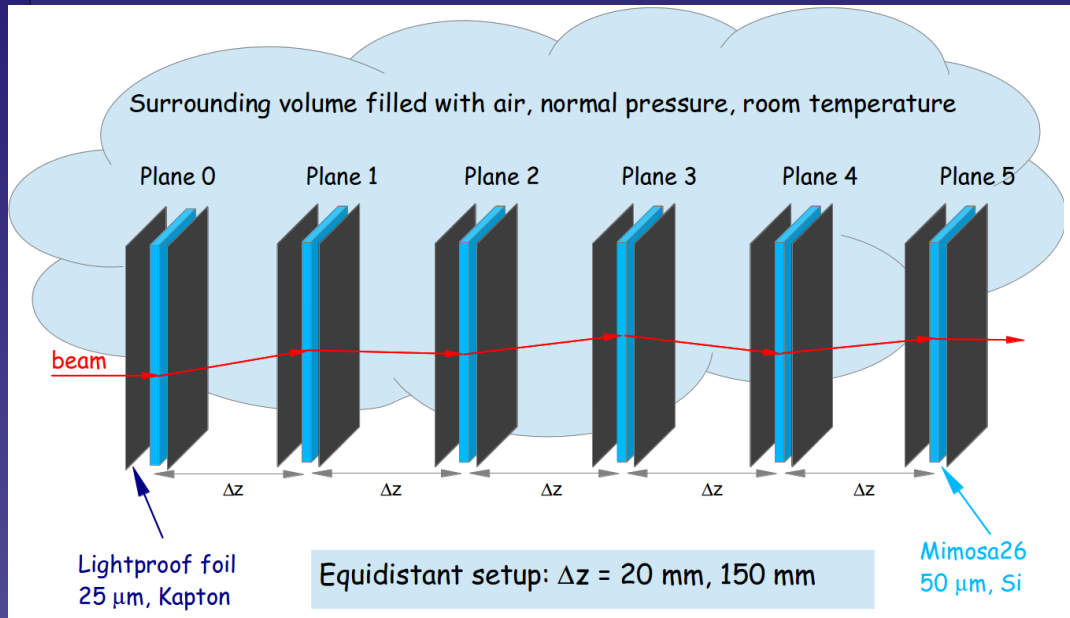
CALADIUM (for Carlton, Canada) (at FNAL)

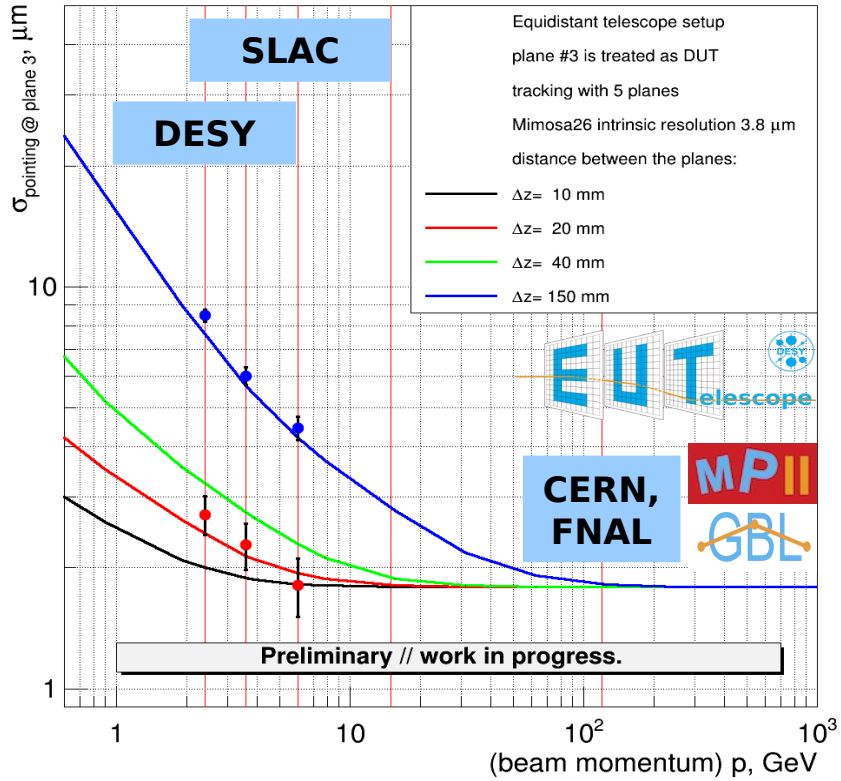
ACONITE (for ATLAS – world tour)

DATURA (for DESY at DESY II)

ANEMONE (for Bonn at ELSA)

6x Mimosa26 pointing resolution (EUDET telescope)





There are more
low energy beam facilities not
mentioned on this plot

The interplay between
– the telescope detector resolution,
– multiple scattering,
– distance between telescope planes
– distance to the DUT (track fit “passive” plane)
and their impact on alignment and tracking are well understood.

In many cases the R&D groups revise their DUT mechanics to get optimal track pointing precision on the DUT

AIDA WP9.3 objectives for upgrading the EUDET telescope

- Development of a versatile beam telescope able to characterize detector prototypes, satisfying the demanding requirements in terms of cooling infrastructure, read-out speed and precision
- Development of an off-beam infrastructure for the evaluation of thermo-mechanical properties of Vertex Detector prototypes

Task 9.3.1 Telescope

- This task builds on the telescope **infrastructure** developed as part of the EUDET.
- A versatile and modular pixel telescope is to be built using state-of-the-art pixel devices (**Timepix, ATLAS FE-I4 and Mimosa**) to meet the requirements of a broad user community. The telescope must provide a precise set of reference measurements and must be capable of LHC-speed response and time-stamping.
- CO2 cooling plant
- Common Offline Analysis Tools (EUTelescope based on ILCSoft/Marlin)
- DCS system

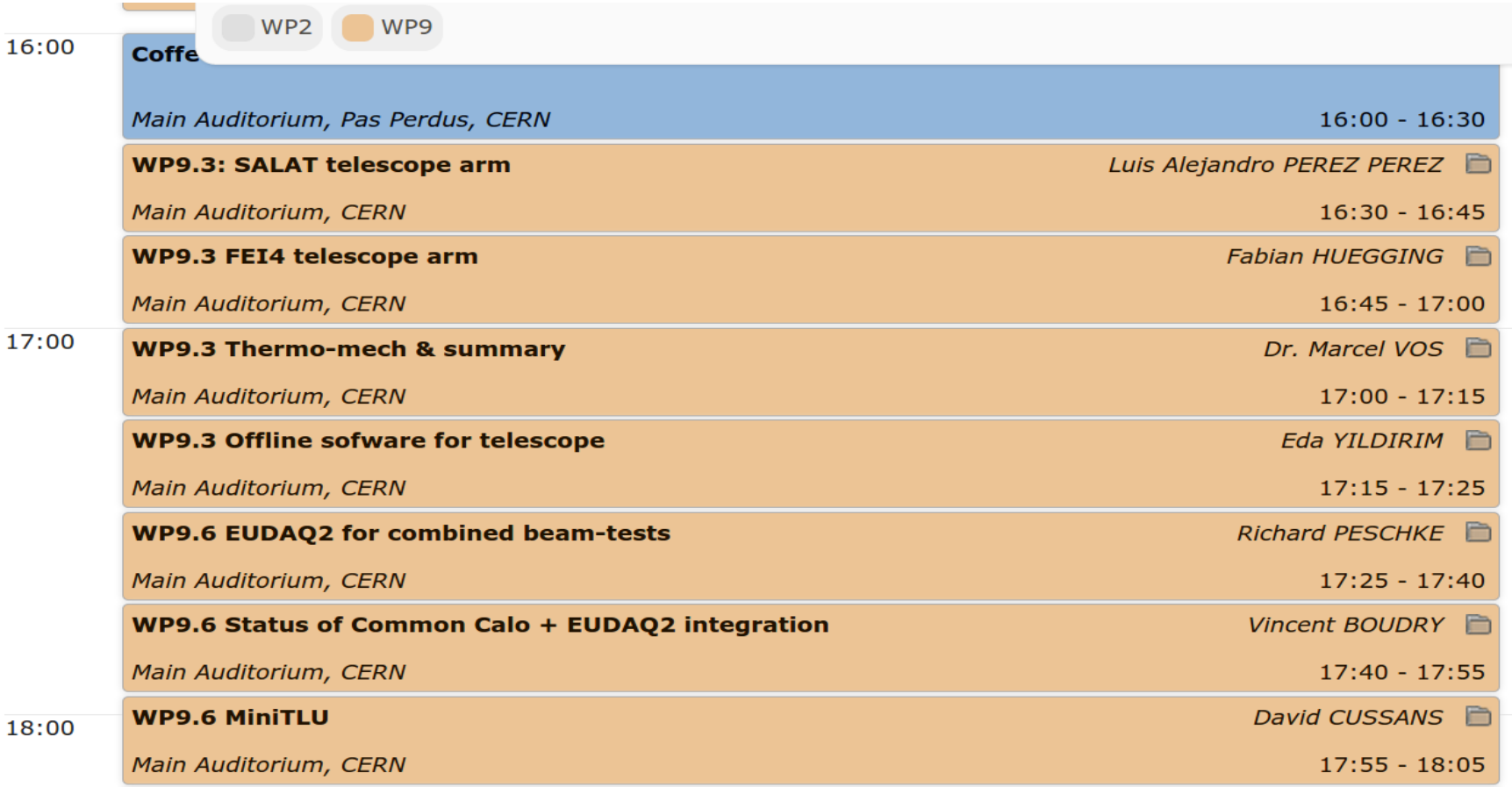
Task 9.3.2 Thermo-mechanical infrastructure

- Development of an infrastructure that allows to evaluate the thermo-mechanical performance of fully integrated detector prototypes under a realistic power load.

In short: AIDA is over!

The final AIDA annual meeting Dec.2014 slides are available here:

https://indico.cern.ch/event/342026/timetable/#20141210.detailed



Timepix LHCb group withdrawed from AIDA quite early in the project,
anyhow Timepix & Timepix3 was fully integrated with EUDAQ&TLU by CLICpix group

FEI4 as ROI and timestamping plane

Single FEI4 based plane used as Region Of Interest (ROI) for couple years now
- Proof of principle and usefulness in real TB demonstrated
- One Module: FEI4 based 3D module provided by IFAE Barcelona (-10V bias)
- One Readout: UsbPix + Burn-in-Card able to read up to 4 FEI4 modules
- Software: PyBar (Bonn Uni) [also works with STControl (Goettingen Uni)]
- further development steps are defined by User Feedback

as ROI
- tested by Bonn University in 2012 (talk by Theresa)

a Standalone FE-I4 telescope arm/ telescope
- Master Thesis by T. Obermann
- ATLAS IBL leftovers were enough to make FEI4 telescope replicas
  - Uni Geneva/CERN (talks by Bane, Francesco), ATLAS AFP/3D

Time-stamping (FEI4 data stream in DAQ “coarse” [x,y] with high t-resolution)
- implementation in progress ... and still has to be finished
  - in HW first, clock counter per trigger pulse implemented → in testing phase
  - eventually in offline reconstruction → match tracks with FEI4 hit (x,y,t)

ROI trigger with FE-I4 telescope arm

- ROI trigger successfully implemented into telescope hardware and software since 2012
- It is used by many groups: DEPFET, active CMOS etc. to increase trigger efficiency for small test chips
- for further details see AIDA technical note:
  - https://cds.cern.ch/record/1499551/files/AIDA-NOTE-2012-005.pdf

AIDA-NOTE-2012-005

AIDA

Advanced European Infrastructures for Detectors at Accelerators

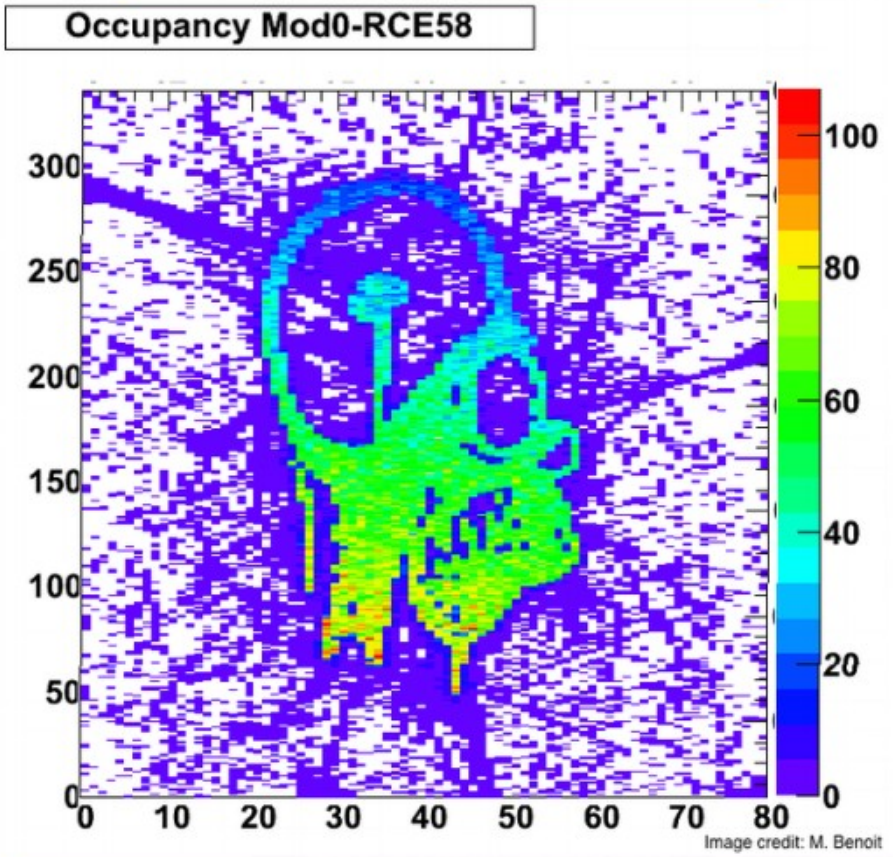
Scientific / Technical Note

Implementation of a Configurable FE-I4 Trigger Plane for the AIDA Telescope

Obermann, Theresa
et al

12 December 2012

Hitmap of ATLAS pixel detector in a muon beam with a selected region of interest



Published by M. Benoit on ATLAS twitter account:
https://twitter.com/ATLASexperiment/status/540178275948314624

EUDET TLU to miniTLU

Architecture improvement

- from one common trigger per one readout block per DAQ system
  - limiting factor is the slowest component in the whole system
- to common clock for all systems
- to a scheme where every single DAQ system should not be affected by other systems readout rate

Hardware improvement

- higher trigger rates: 1 MHz trigger pulses per second, 10 MHz bursts
- individual trigger timing resolution: course 6.25 ns, fine 0.8 ns (→ 50 ps?)

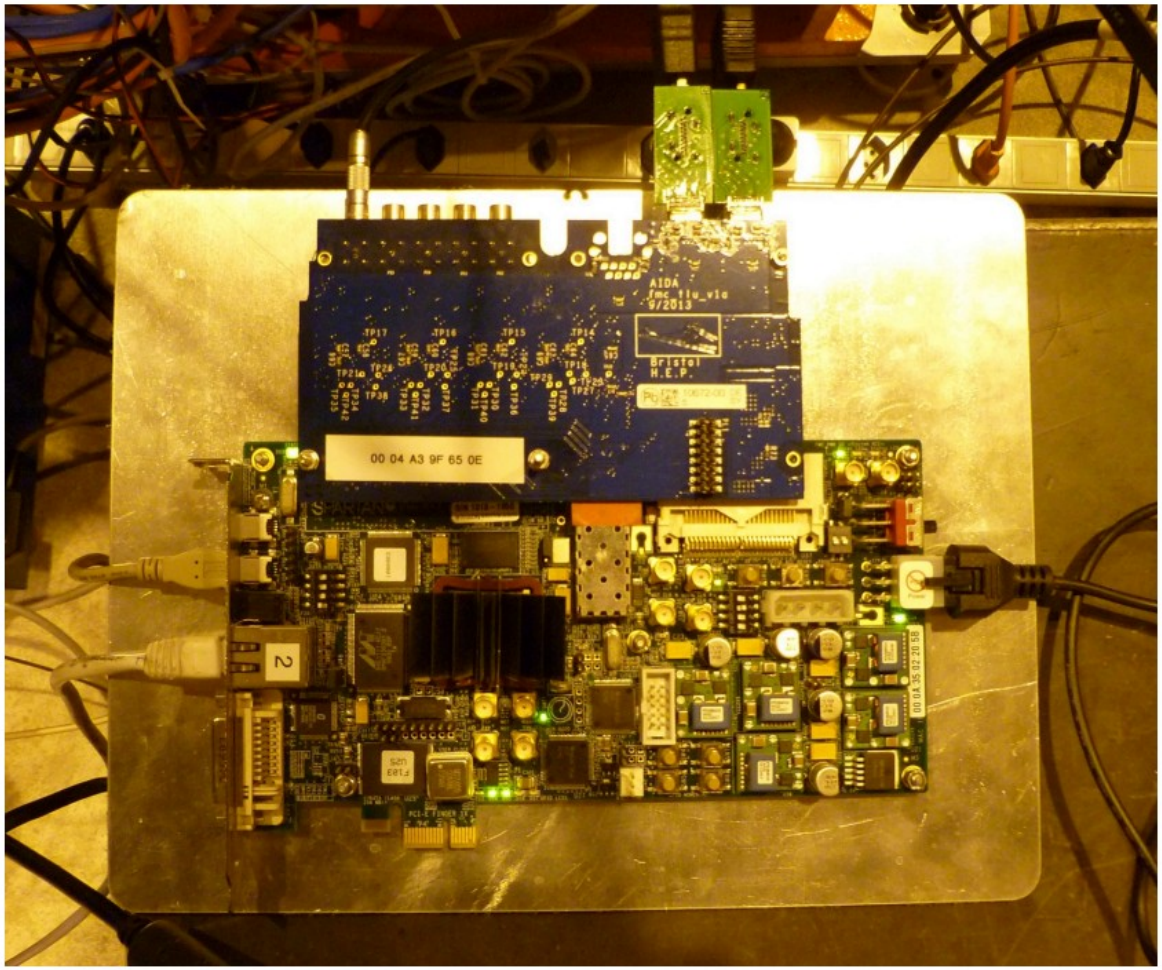
From the EUDET TLU:

- av. 0.5 MHz trigger pulses, sequencial triggers not closer then 800 ns
- different readout buffer architecture, User has to optimize the buffer readout frequency for any given track rate [in config file: ReadoutDelay = 0 //ms, up to 1000]
- timing resolution given by 48 MHz clock and PLL 8 (→ 2.6 ns)

Talk by David Cussans

EUDET TLU to miniTLU

- Currently only as boards bolted to plate
- Design for box in progress



- tested a lot in 2014
- HW interface:
  – RJ45 fanout board ✗
  – HDMI fanout board ✓
  – either or both w/ TTL fanout ✓ ✗ (HDMI to TTL yes)

Offline software

Talks: T.Bisanz, A.Morton, H.Perrey

Over the four years of the AIDA project the EUTelescope library (part of the ILCSoft package for testbeam tracking) has undergone a major revision:

Code refactoring:

- Removed obsolete code (out of 150 k lines of code!)
- compile time warnings strongly reduced
- consistent approach to the messages (errors, warnings, info levels)
- code comments

Redesign:

- New geometry layout of the telescope setup (still with ILCSoft Gear)
- Navigation between sensitive and non sensitive layers with new class EUTelGeometry based on ROOT::TGeo
- Revised basic element class EUTelGenericPixel (fits also strips)
- Clustering in non-standard pixel detectors with EUTelGeo (for L-type pixels, honeycomb, etc.)
- Pattern Recognition, Alignment, Tracking – with GBL+Millepede II libraries
- allows dead material layers and B-field presence
- Added one more package: Allpix for pixel/strip detectors digitisation models validation

Well defined Examples

- Introduced examples with reference data: Telescope only data, and with DUTs. Shows how the data processing flow should take place.

Nightly builds http://aidasoft.desy.de/CDash/index.php?project=EuTelescope

- For all examples nightly build tests are running and displayed with Aidasoft/Cdash, we get emails every morning about (un)successful changes to the repository

GitHub: Decentralized repository and version control https://github.com/eutelescope/eutelescope

- Improves branching, tagging, interaction between developers by really a lot (same for EUDAQ)

From EUDAQ v1.x to EUDAQ v2.0

See talk by R. Peschke

Going away from Central Data Collector
– to a decentralized scheme: every DUT DAQ can write it's own data as it likes
– the system becomes highly scalable

Moved to GitHub quite a long time ago
– https://github.com/eudaq/eudaq
– you are highly welcome to get registered and contribute!

Any EUDET telescope copy becomes an AIDA telescope with:
- new miniTLU triggering scheme (can be implemented in EUDET TLU FW too)
- upgrading to EUDAQ2.0 (beta exists, to be released soon)
- FEI4 for ROI and/or timestamping
- EUTelescope v1.0 (beta exists, to be released soon)

Detector Control System (DCS)

Build a Detector Control System for support of AIDA testbeam activities

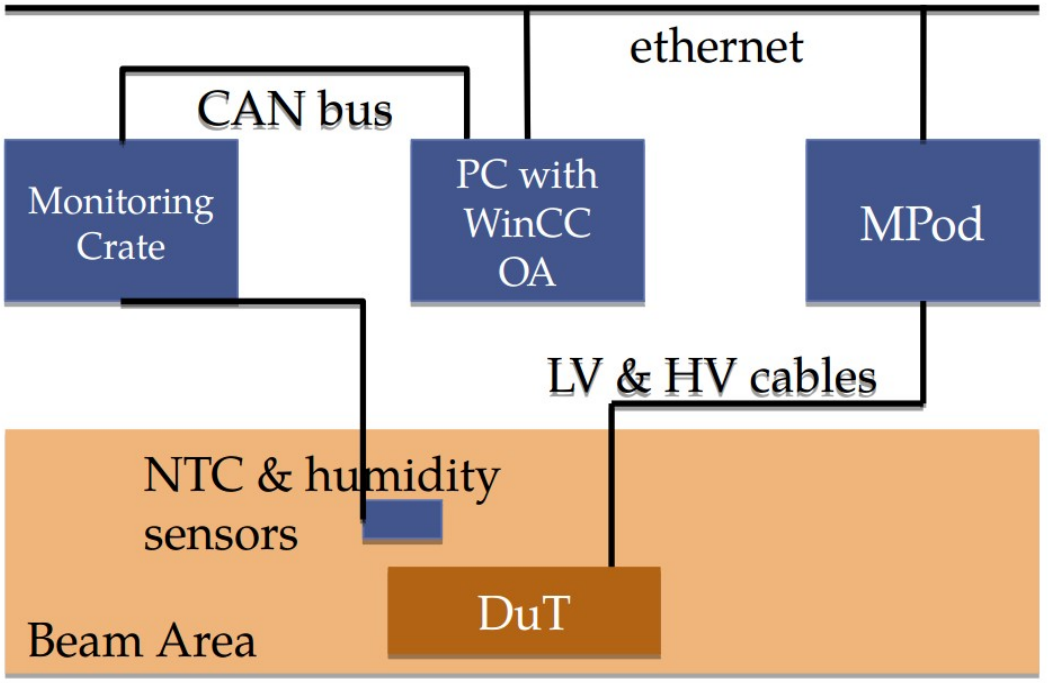
Supply HV + LV for DuT
Provide monitoring of:

- Environment
- Properties of DuT

Remote control/monitoring:

- Raise alerts
- Archiving of data

Transportable
Easy installation and configuration



Detector Control System (DCS)

- Individually floating 8 **HV** channels/module
- Channel control completely independent

Iseg HV module	Max. values	Resolution I ≥ 20 µA	Resolution I < 20 µA
EHS 8220n-F	2 kV 4 mA	4 nA	50 pA
EHS F2 05n-F	500 V 10 mA	10 nA	50 pA

MPV 8008LI Low voltage

- **LV** each up to 8V/5A, 8 floating channel
- Channels control completely independent

Monitoring

- 12 NTC for temperature monitoring
- 2 Honeywell humidity sensors HIH 4000
- 1 Four wire measurement e.g. PT100
- 4 digital outputs
- 32 ADC channel (6 bi-/unipolar ranges 25mV - 5V)

Detector Control System (DCS)

DCS-1 was delivered in spring 2012 (AIDA Wuppertal funds)
- in operation since then
- Firmware upgrades spring 2014
- Details in AIDA-2014-004

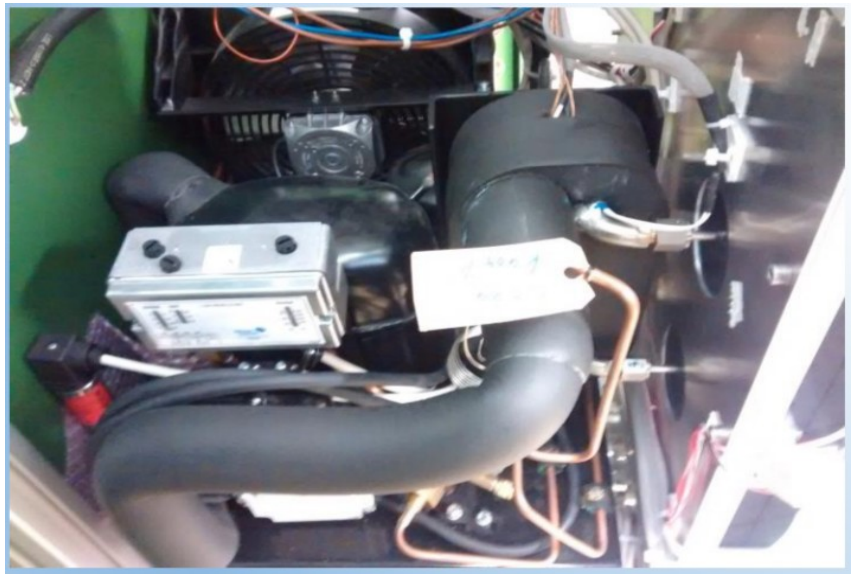
DCS-2 delivered in spring 2014 (ATLAS funds)
- first operation @ SLAC
- in operation since then
- Details in AIDA-2014-005

CO_2 cooling plant

Goal:
Easy to operate (ideally on/off, set temperature)
Mobile
For detector test and development (e.g. in a test beam or lab)

With Evaporative CO2 cooling:
Temperature range:
-30 to +20 degC
Cooling power:
- Few hundred Watts
(More power at the upper end of temperature range)
Several copies being made for various labs – one for AIDA telescope

CO_2 cooling plant



R404 Chiller inside

- Fully assembled and operational
- Few mechanical design changes being implemented

- Commissioning:
  - Needs to operate
    - long term,
    - safely,
    - with minimal training of users
- Takes time

CO_2 cooling plant

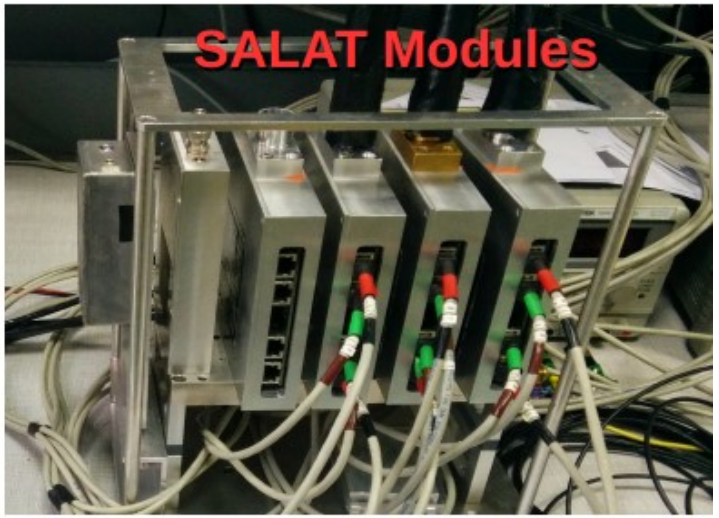
- Behind the Start and Temperature- settings panel, sit many sensors and controls
- Need a reliable system including under unusual circumstances (power failure, rapid heat load change, …)
- Current work:
    - Set up web interface
        - Useful for remote monitoring and control (e.g. control room running with cooler in a locked beam area)
        - Useful for commissioning:
            - Patience needed: you need stable running conditions, then change something, then wait to see response
            - Useful to be able to do this remotely

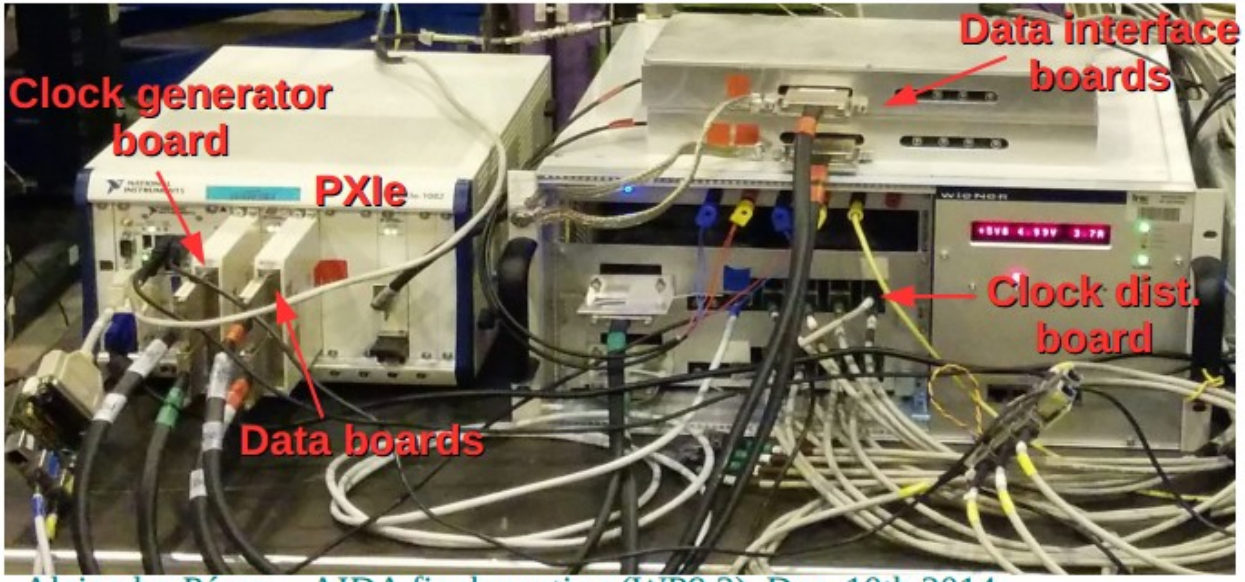
In the end, patience gets you a better product

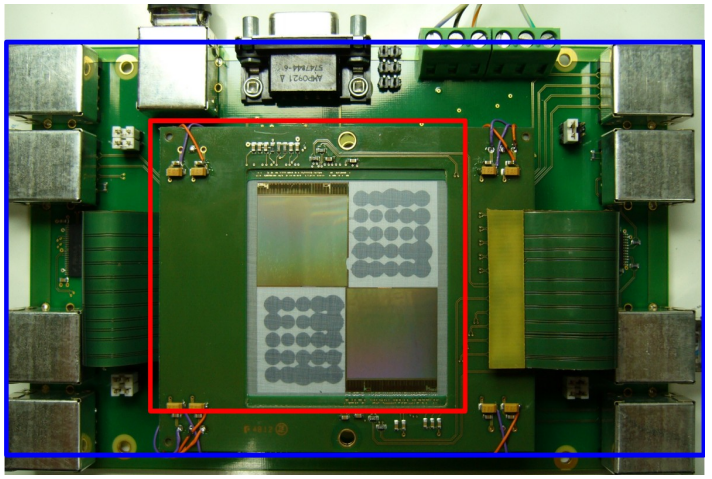
Large Area Telescope → SALAT (with Mimosa28 x4)

- **Possible delivery by the end of Jan. 2015: Hardware + Doc**
  - 4 (3 + 1 spare) operational modules characterized in beam at CERN in Nov. 2014
    - Mechanic support + PCBS (daughter + mother)
    - Beam test data analysis in advance stage

      ⇒ final results for beginning 2015
  - 2 Clock distribution + JTAG + data interface boards
  - Documentation (board and SALAT characterizations)
  - Details to be defined w.r.t. IPHC priorities emerging in the coming weeks



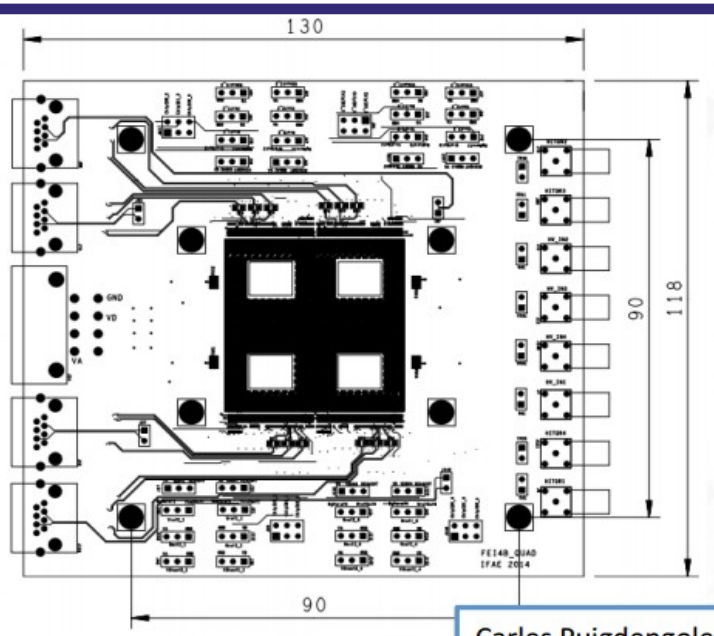




4x Mimosa28, 3.6Mpix on 15.3 cm^2
Resolution 3.5 um, eff. 99.9%,
Fake rate less 10^{-5}

Large Area Telescope → FEI4 quad plane

- Dedicated PCB for quad modules:
  - Each FE has a its HitOr output
  - HitOr inverted on PCB
    - require an extra power supply
  - Mechanics compatible with telescope
  - can be equipped with single chip or quad modules
  - Module(s) powered through on chip regulators
- Several PCBs built:
  - 1st equipped with bare FE-I4 chips for testing
  - 2nd is equipped with 2 single chip modules and tested at Barcelona
  - 3rd is being equipped with a quad module at Bonn



Carles Puigdengoles (IFAE)

Summary

Overall the project convergence is on time:

- most of the development work has been done on time
- all hardware components procurement & production is complete
- AIDA Telescope Lite – standard 6 Mimosa26, 1 FEI4, DCS, EUDET TLU, EUDAQ2 – commissioned at CERN SPS H6B beam area

The following delays in the subtasks:

- CO2 cooling plant – hardware is present and tested in parts, test runs and installation in H6B is missing → convergence in 2015

- miniTLU & EUDAQ2.0 – missing fanout board and beam test example
→ possible convergence early 2015

- Offline Infrastructure – missing data streams merging tool
→ will converge as the need pushes

- AIDA Telescope LAT – all HW in place, SbgDAQ-EUDAQ(2) layer missing
→ possible convergence before 31.01.15

Final AIDA telescope design

WP 9.3.1 Testbeam Telescope	
EUDAQ 2.0 + AIDA-TLU (common with WP8.6.2) - DESY + Bristol, LPNHE, Santiago d.C.	**95 %**
SALAT arm consisting of 3 SALAT planes - Strasbourg, IPHC	**99 %**
FEI4 single and quad planes for triggering and timestamping - Bonn & IFAE Barcelona	**95 %**
Offline software infrastructure **- DESY + non-AIDA institutes (Goettingen, Glasgow)**	**99 %**
CO2 cooling plant as general infrastructure **- NIKHEF & CERN et al.**	**80 %**
DCS as generic HV (LV) and Climate monitoring system **- Wuppertal**	**100 %**
WP 9.3.2 Thermo-mechanical deformations mockup **- Valencia et al.**	**99 %**