The JRA1 Final Telescope & some comments about EUDAQ

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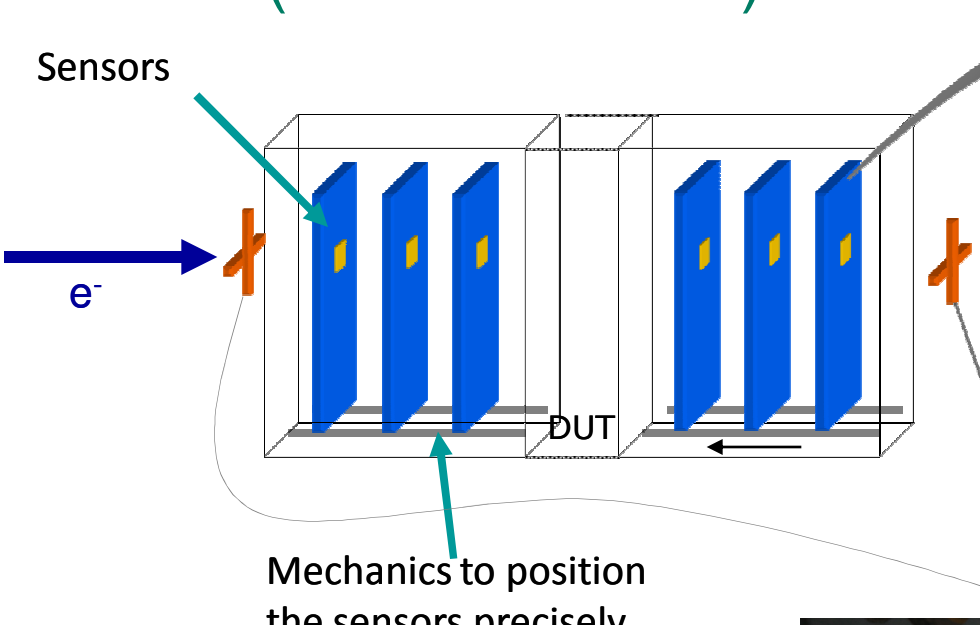
EUDET Annual Meeting 2009

- Final Telescope
- Usage of EUDAQ/EUTelescope
- Possible Upgrades to the 'final' Telescope
- Conclusions

Telescope Ingredients (Demonstrator)



ReadOut (EUDRB)

LVDS

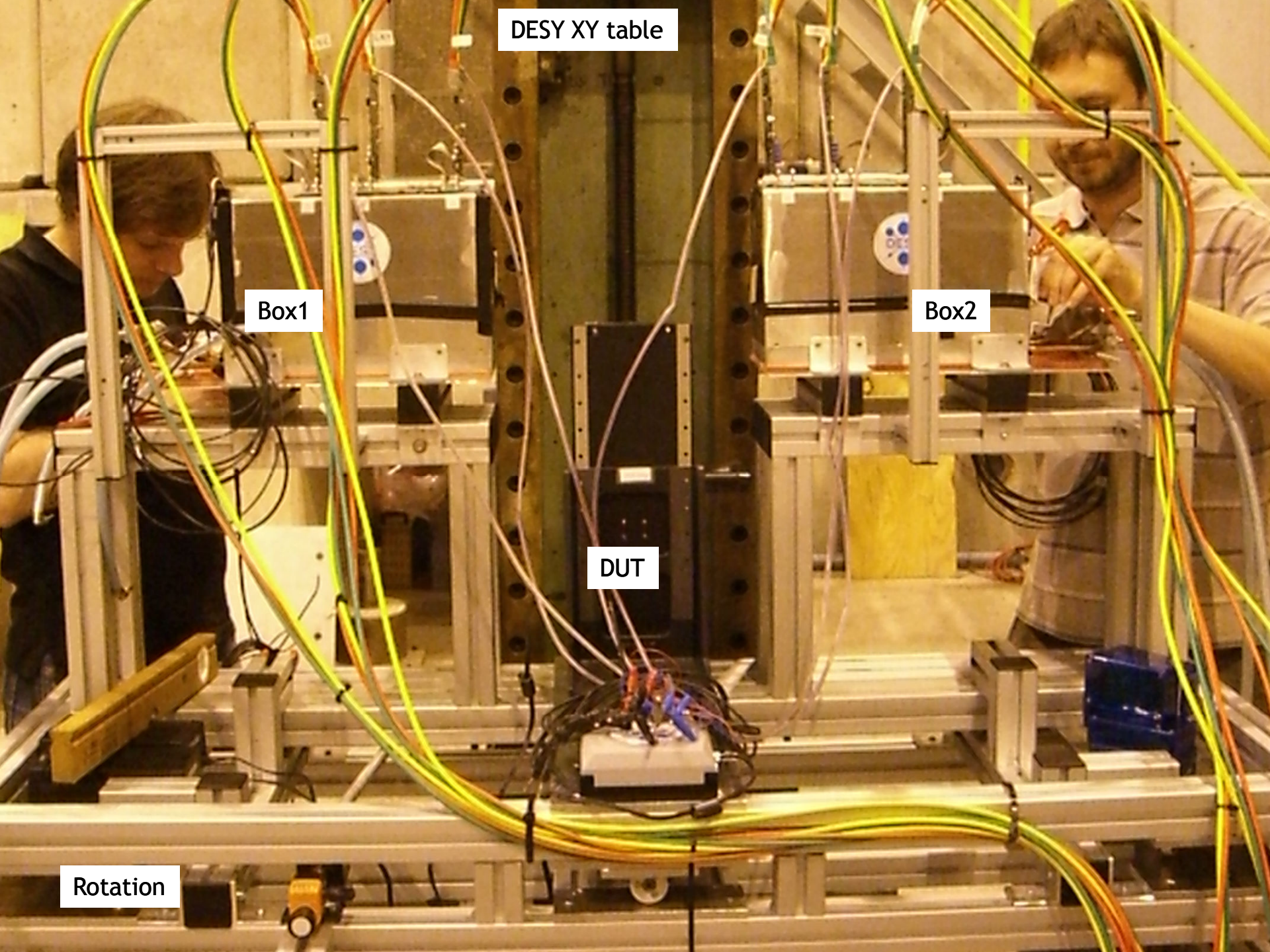
GBIT ETH

Trigger Logic Unit (TLU)

USB

EUDAQ

- ✓ Sensors
- ✓ Readout Boards
- ✓ EUDAQ
- ✓ Trigger Logic Unit
- ✓ Mechanics


DESY XY table
Box1
Box2
DUT
Rotation

Ingredients for the final telescope

Hardware

- 2 Crates with 3 EUDRBs
- TLU
- 6 Mimosa 26 (1x2 cm)

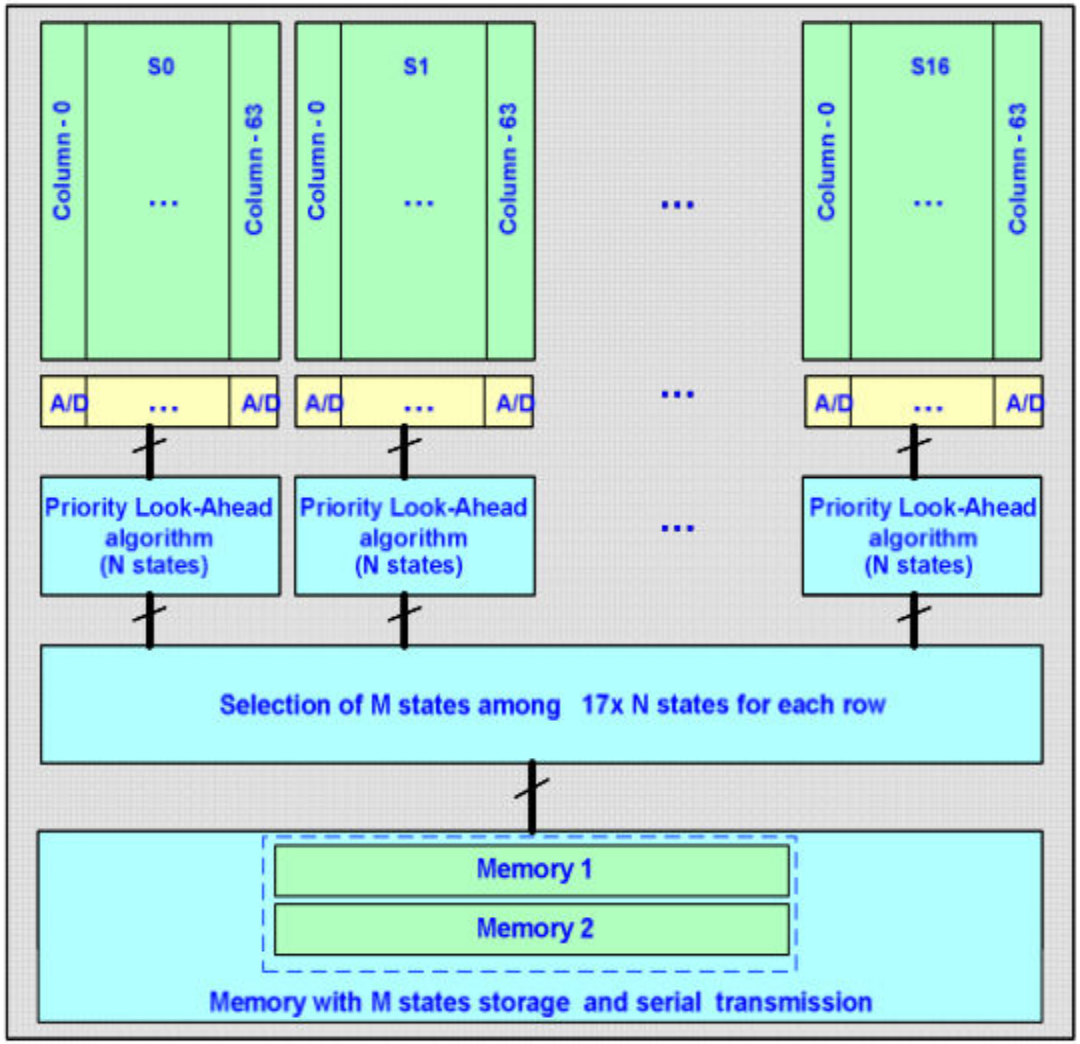
Software

- EUDAQ
- EUTelescope

Final Telescope Chip: TC/Mimosa 26

Submission in Nov 2008

- Mimosa-22 (binary outputs) complemented with zero-suppression (SUZE-01)
- Active surface : 1152 columns of 576 pixels (21.2 x 10.6 mm^2)
- Pixel pitch : 18.4 µm → 0.7 million pixels → σ_{sp} <3.5 µm ⇒ pointing resolution 2µm on DUT surface
- Integration time ~110 µs → 10^4 frames / second
- Throughput: 1 output at 80 Mbits/s or 2 outputs at 40 Mbits/s
- Needs adoption of readout electronics (EUDRB)

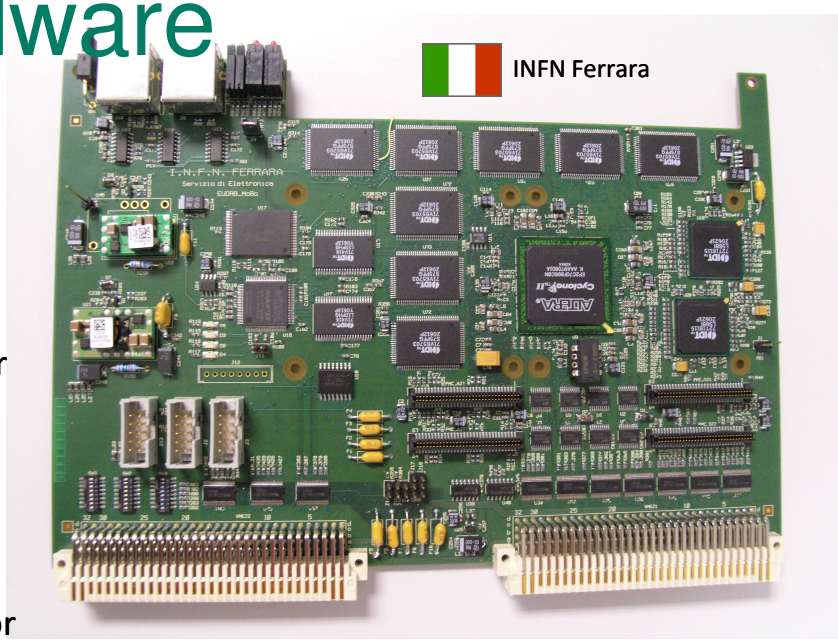


TC/Mi26 available/under test since March 2009

DAQ: Hardware

EUDET Data Reduction Board:

- Mother board with ALTERA CycloneII FPGA (clock: 80MHz) hosts core resources and Interfaces (VME64X slave, USB2.0, EUDET trigger bus)
- Analog Daughter card up to 20 MHz (4 channels)
- Digital daughter card drives/receives control signals for the detectors and features a USB 2.0 link
- NIOS II, 32 bit “soft” microcontr. (40Mz) for diagnostitics, pedestal+noise calculation and remote configuration
- Two readout modes: Zero Suppressed for normal data taking, raw readout of multiple frames for debugging or off-line pedestal and noise calculations

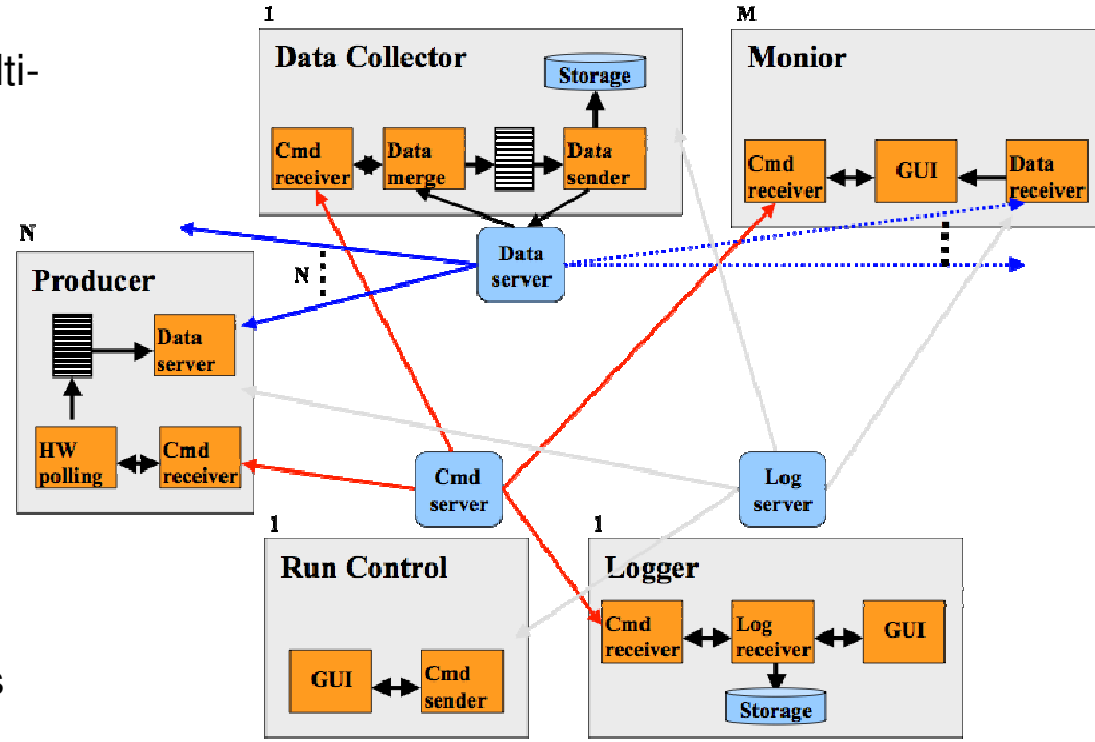


Trigger Logic Unit

- Two handshake modes
  - Simple handshake (Trigger/Busy/Reset)
  - Trigger data handshake incl. event number
- Timestamp and event-number via USB
- LVDS via RJ45, NIM and TTL via Lemo
- Inputs for four trigger signals (ANDed, ORed, VETOed)
- Internal trigger mode and scalers for testing
- Low voltage power supply for PMTs

DAQ: Software

- Platform independant (MacOSX, Linux, Windows)
- Object oriented, distributed and multi-threaded
- Highly modular, but light-weight
- DAQ Software is divided into many parallel tasks:
  - RunControl to steer the task
  - several Producer tasks read the hardware
  - one DataCollector task bundles events, writes to file and sends subsets for monitoring
  - Several Online - Monitoring tasks
  - Logger task allows to see what is going on



http://projects.hepforge.org/eudaq/

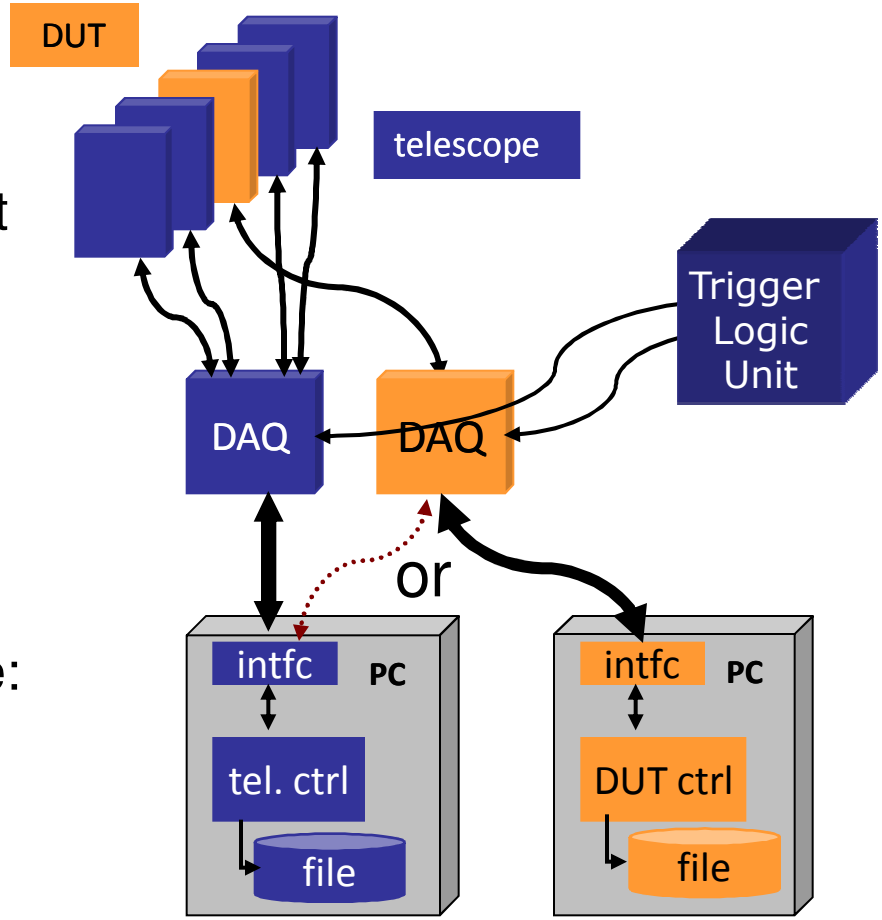
DAQ Changes - EUDRB & EUDAQ

EUDRB evolves with new sensors

- was successfully adapted to sensor Mimosa 18 (4x more pixels)
  (still with on-board zero suppression)
- Changes to readout the final telescope chip:
  - All done in firmware, no hardware modification needed
  - embedded M26 simulator operating in mode 0 (two channels @ 90 MHz)
  - the M26 interface operates at up to 90MHz
  - overlapping INPUT (frame acq.) and OUTPUT (VME readout) operations
  - interrupt-driven event read-out
  - 2e-SST block transfer (> 100MB/s burst rate)
  - leading word count in the output event data block

DAQ: Integration Concept

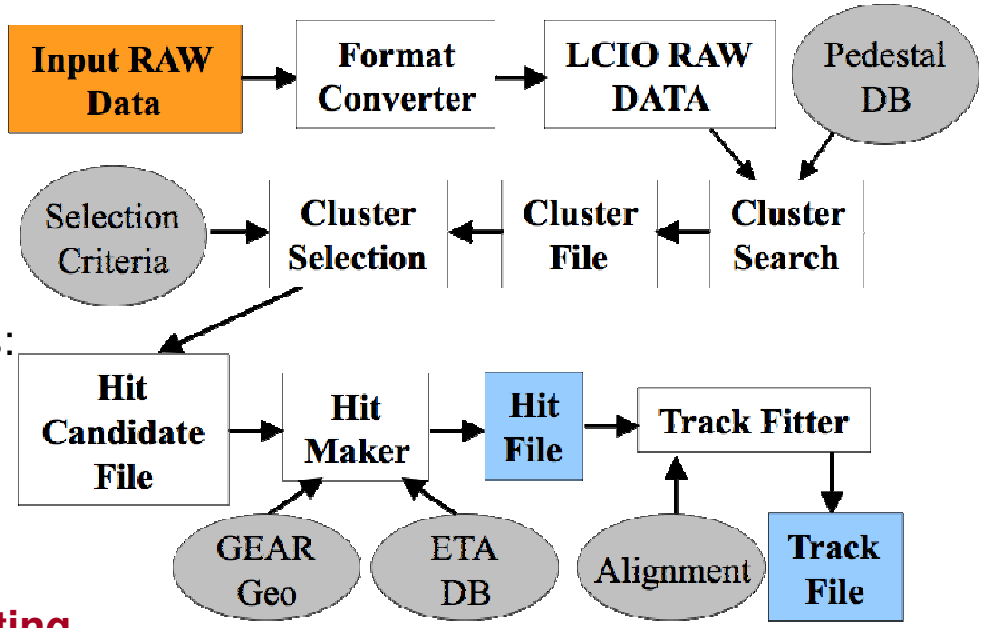
- How to integrate the DUT hardware with the EUDET beam telescope?
  - different groups with different detector technologies and different, pre-existing DAQ systems
- Use completely different hardware and DAQ for the DUT and the telescope
- Two levels of integration possible:
  - "easy" solution: at trigger level
  - full integration on DAQ software level



Analysis & Reconstruction Software

EUTelescope:

- Set of relevant high level objects (like tracks or space points) to characterize the DUT
- Histograms of important figures of merit.
- Based on available/tested software tools:
  - Single sensor analysis → **sucimaPix** (INFN)
  - Eta function correction → **MAF** (IPHC)
  - Track fitting → **Analytical track fitting** and straight line fitting
  - Alignment → **Millepede II**
  - Framework → ILC Core software = **Marlin + LCIO + GEAR + (R)AIDA + CED**
- Sticking to the ILC de-facto standard offers the possibility to easily use the GRID
- Each module is implemented in a Marlin processor
- execute all of them together, or stop after every single step



DAQ: Users & Producers

- Direct implementation into EUDAQ is now ‘standard’ and easy
- New ‘plugin’-Mechanism really makes life ‘even easier’
- Users are in general very convinced about ‘ease-of-use’ and fast implementation
- TLU is a real ‘seller’

Usage of EUDAQ

- Altro - Bonn (Martin Killenberg)
- APIX - Atlas Pixels (Georg Troska)
- DEPFET - Bonn (Julia Fourletova)
- FORTIS/SPIDER - Bristol (David Cussans)
- MimoRoma - INFN (Toto)
- MVD - DESY (Silvia Bonfanti)
- PixelMan - Freiburg (Uwe Renz)
- SITRA - Santander (Javier Gonzalez Sanchez)
- Taki - Mannheim (Christian Takacs / Ivan Peric)
- Timepix - Bonn (Martin Killenberg)
- Atlas TRT (Ilja Slepnev)

Usage of EUTelescope

- Depfet
- Atlas Pixels
- Atlas TRT
- And many more

There some groups (LHC) complain the ‘bulkiness’ of the framework for a testbeam environment

Upgrades to the final telescope

- New Mechanics
- TLU with tagging mode
- Fiber-Hodoscope
- ‘Ultimate’ Chip (2x2 cm)
- Commercial Readout

Upgrade 1: New Mechanics

- Improved mechanics under design with:
  - Easier access to the chips
  - Better cooling
  - Easier and better metrology

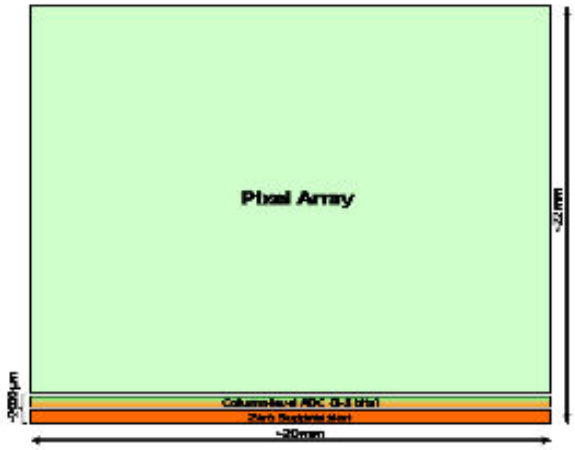
Upgrade 2: Fiber-Hodoscope & Tagged Mode

- Could get a hodoscope with 32+32 fibers of 1 mm^2
- This would help to run with high multiplicity to localize the triggered particle and improve alignment
- Would also be needed in the tagged mode, to have localization of the particles vs. time to match with faster DUTs
- Vincent Boudry could maybe provide us one (from CMS, where it is basically 'abandoned')
- Implementation and timeframe are under study.

Upgrade 3: The 'ultimate' chip

Ultimate EUDET BT

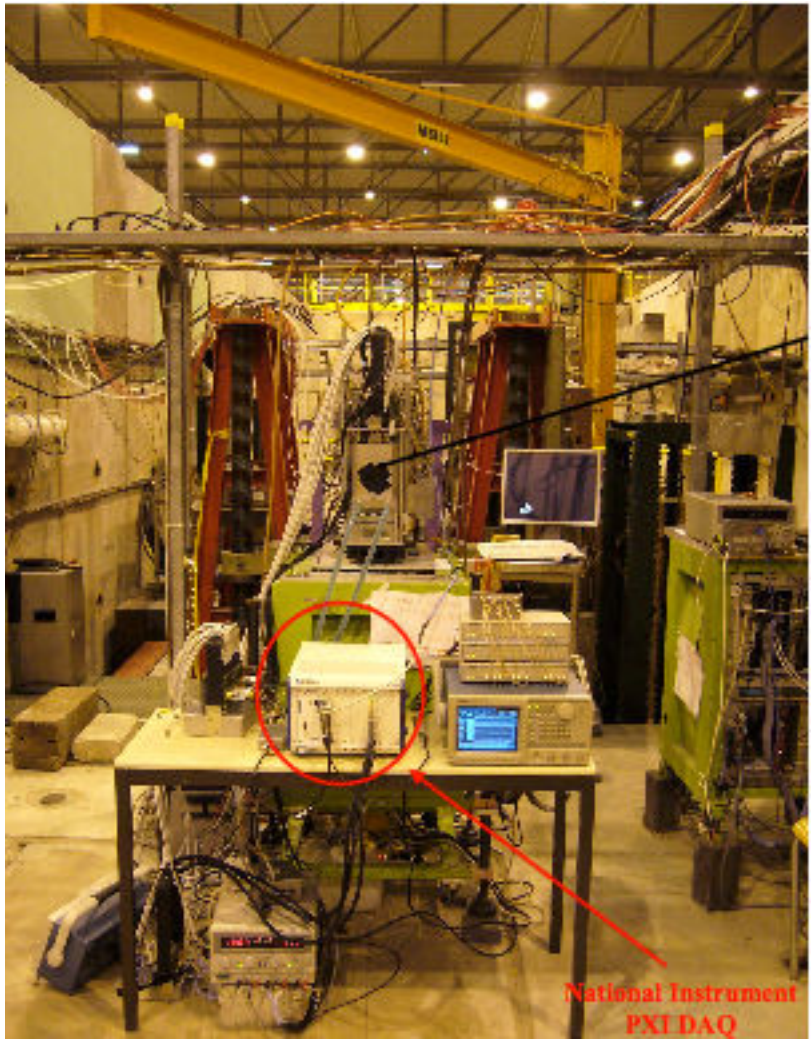
- **Main characteristics:**
  - pixel pitch: $18.4 \times 18.4\ \mu m^2$
  - 1088 columns of 10^3 pixels
    - $\Rrightarrow$ active area $\sim 20.0 \times 18.5\ cm^2$
      - $\Rrightarrow$ 1.7 times TC active area
  - in-pixel processing μ-circuits with improved tolerance to ionising radiation :
    - $\hookrightarrow \gtrsim 500$ kRad ($> 10^{13}$ pions/cm^2)
  - potentially $\sim$ twice larger in-pixel signal amplification
    - $\Rrightarrow$ improved SNR
  - read-out time $\lesssim 200\ \mu s$



- **Time line:**
  - design completed by February-March 2010 $\Rrightarrow$ foundry submission
  - sensor expected to be available for EUDET-BT commissionning in Summer 2010
  - no extra cost (masks funded by STAR collaboration)

Upgrade 4: 'Commercial' readout

- Current readout boards cannot be produced in big quantities.
- New readout based on National Instruments FlexRIO (PXI 7953R)
- Feasibility study performed by INRS together with NI
- Mainly as option for the 'copies' of the telescopes
- Will decide beginning of next year



Implementation Steps

Baseline (as it is running now)

- 2 VMEcrates with 3 EUDRBs
- 6 planes of Mi 26
- TLU in triggered mode

Step 1

- TLU in tagged mode (by summer 2010)

Step 2

- Additional Fiber-Hodoscope (by summer 2010)

Optional

- ‘Ultimate’ Chip and higher surface

In Parallel (needed for ‘other’ telescopes anyway)

- Implementation of ‘commercial’ readout

Conclusions

- Final telescope as specified for EUDET has been completed in September 2009 (Final Deliverable to EU)
- First users are emplyoing it since 1st of October and profit from 4-5x higher data rates (~1 kHz) compared to Demonstrator
- Will try to keep Demonstrator telescope alive in parallel at DESY (so 2 telescopes are available to users)
- Readout of the data is performed by nearly all users within the EUDAQ framework
- Analysis of the data is performed by part of the users with the EUTelescope framework
- Possible upgrades (corresponding to user demands) are under study
  - Tagged mode + Hodoscope
  - Bigger active surface
  - Copies of the telescope using a commercial readout