JRA1-DAQ: Accommodation of the M26

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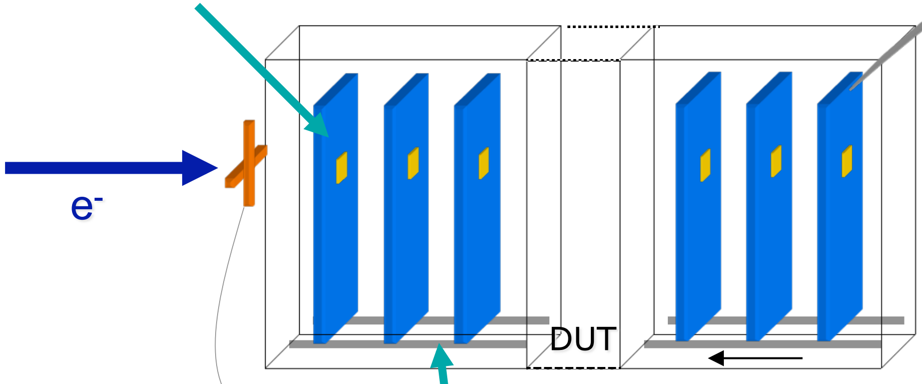
Outline

- Overview
- The Pixel Telescope
- MAPS – the 'binary' M26
- DAQ Changes
- Next Steps
- Outlook & Conclusions

EUDET

Telescope Ingredients (Demonstrator)

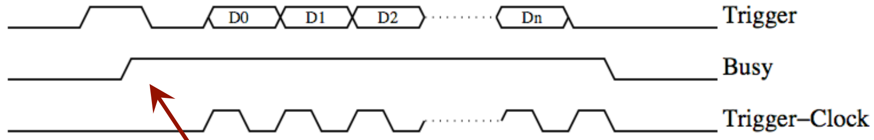


Trigger Logic Unit (TLU)

EUDAQ

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

DAQ Hardware: TLU



Busy acknowledges the Trigger

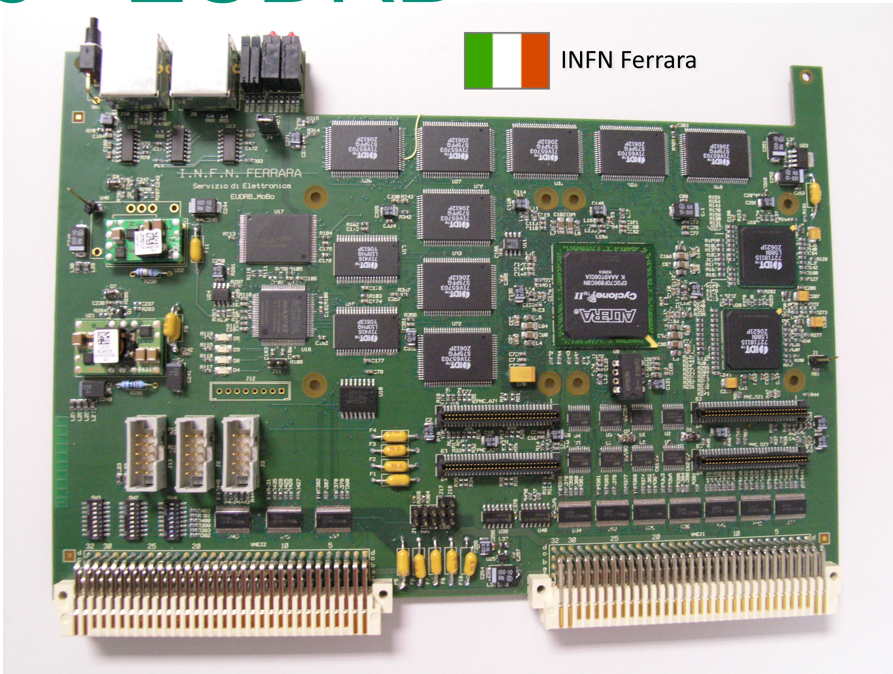
Trigger Logic Unit

- 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 (Software-Selectable)
- Inputs for four trigger signals (ANDed, ORed, VETOed)
- Internal trigger mode and scalers for testing
- Low voltage power supply for PMTs
- Special needs for special demands:
  - Low Jitter mode (for TPCs etc.)
  - ‘LHC’-users: increased timestamp resolution, central clocking

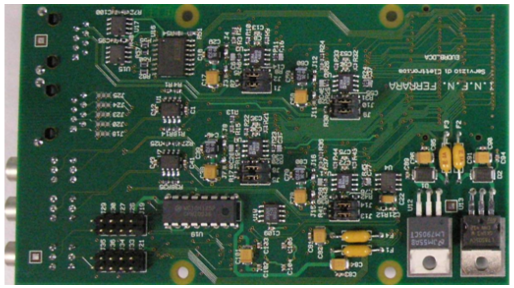
DAQ Hardware - EUDRB

EUDET Data Reduction Board:

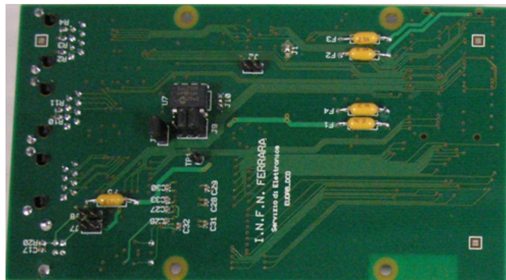
- Mother board with ALTERA CycloneII FPGA (clock: 80MHz) hosts core resources and Interfaces (VME64X slave, USB2.0, EUDET trigger bus)
- 2 Daughter cards (analog + digital)
- NIOS II, 32 bit "soft" microcontr. (40Mz) for diagnostitics, pedestal+noise calculation and remote configuration
- Two readout modes: Zero Suppressed for normal data taking, raw readout of multiple frames for debugging or off-line pedestal and noise calculations



Analog Daughter card based on the successful LEPSI and SUCIMA designs clock rate up to 20 MHz

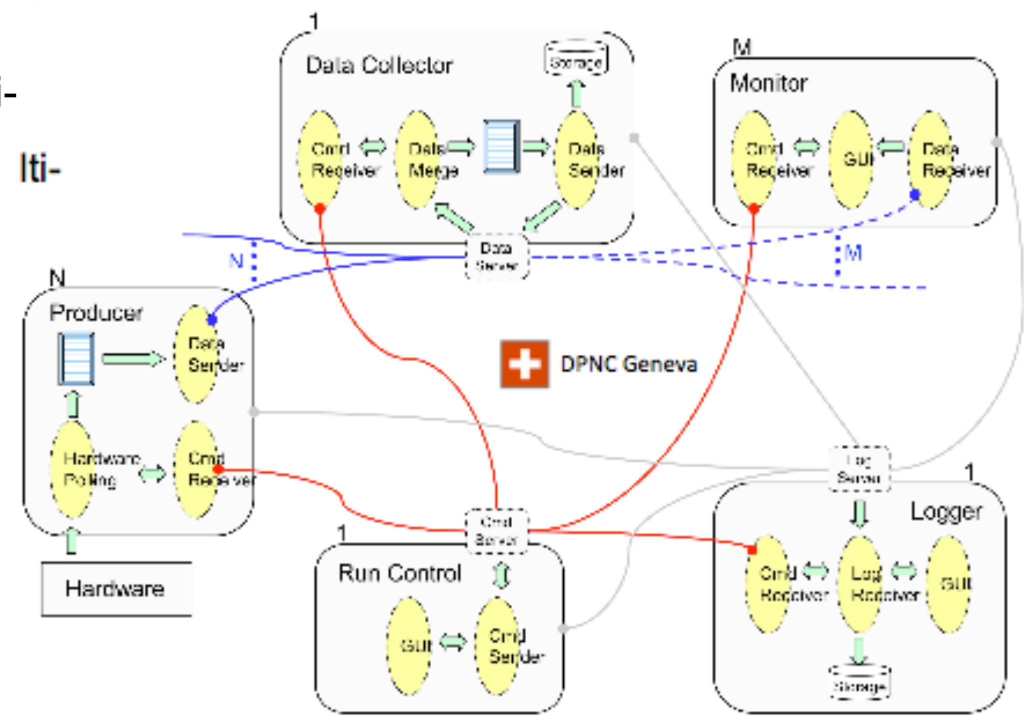


Digital daughter card drives/receives control signals for the detectors and features a USB 2.0 link



DAQ: Software

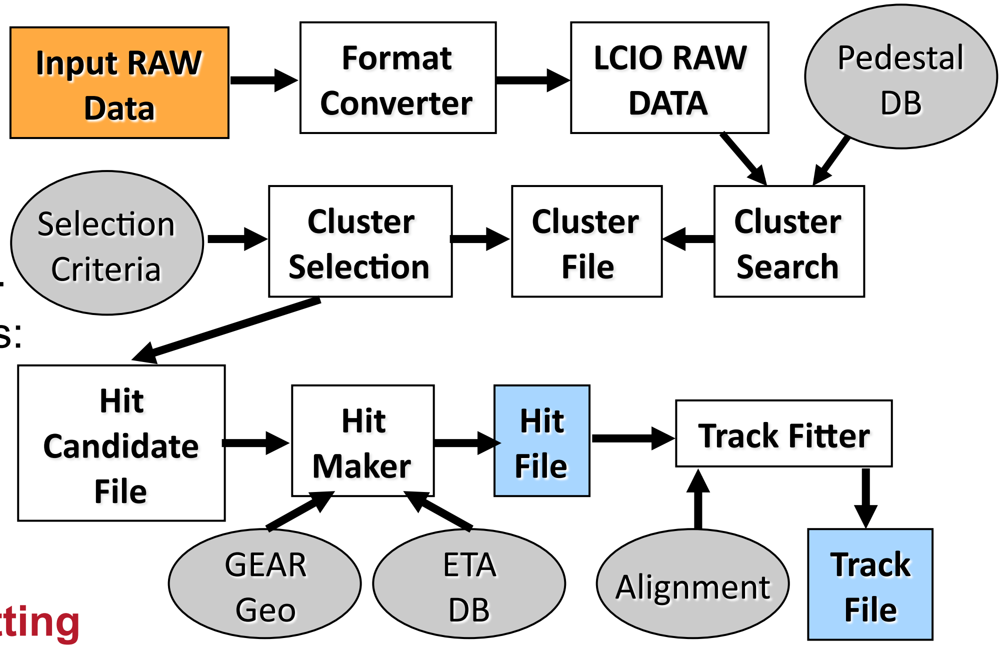
- Platform independant (MacOSX, Linux, Windows)
- Object oriented, distributed and multi-threaded
- Highly modular, but light-weight
- DAQ Software is divided into many parallel tasks:
  - RunControl to steer the task
  - several Producer tasks read the hardware
  - one DataCollector task bundles events, 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/

Analysis & Reconstruction Software

EUTelescope:

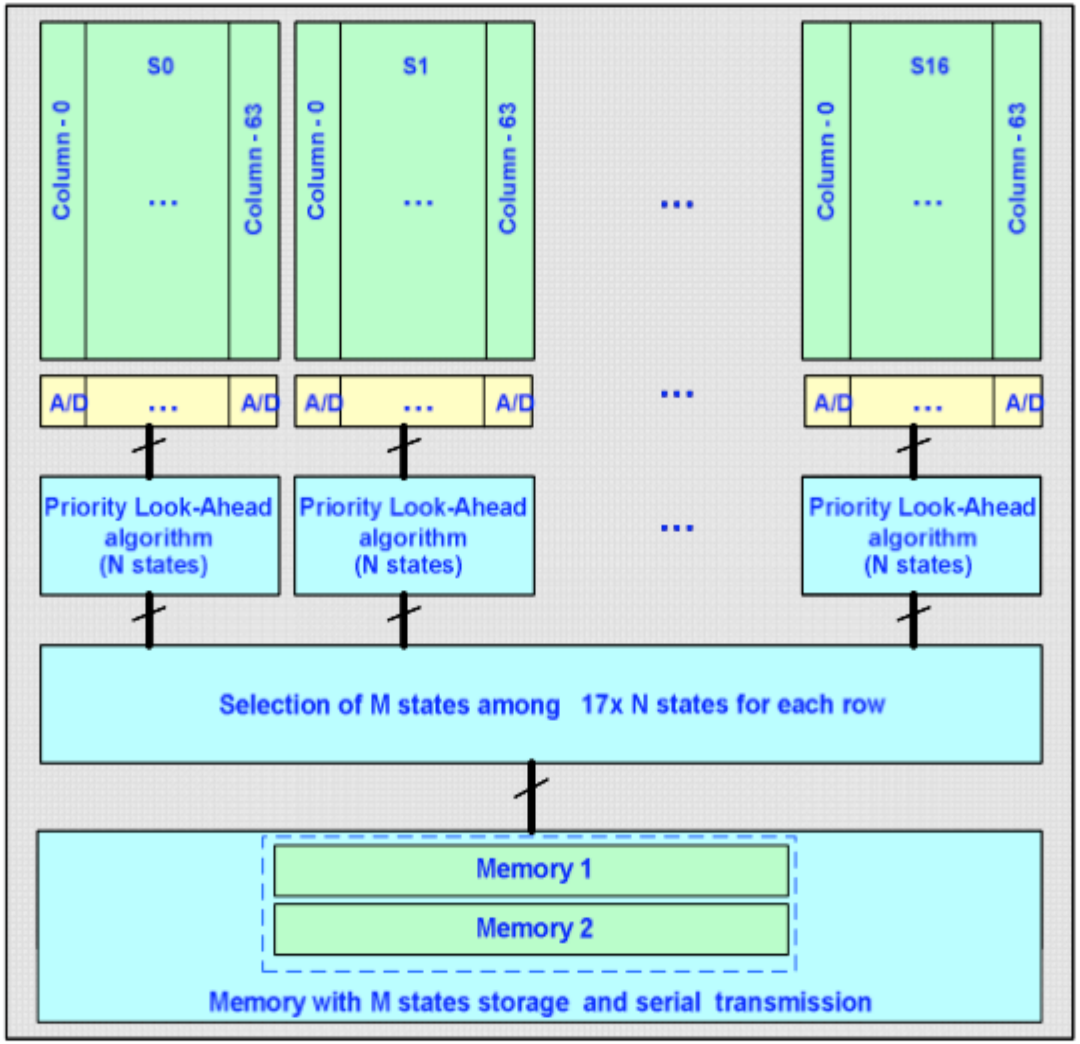


- Set of relevant high level objects (like tracks or space points) to characterize the DUT
- Histograms of important figures of merit.
- Based on available/tested software tools:
  - Single sensor analysis → **sucimaPix** (INFN)
  - Eta function correction → **MAF** (IPHC)
  - Track fitting → **Analytical 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

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 (21.2×10.6 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 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

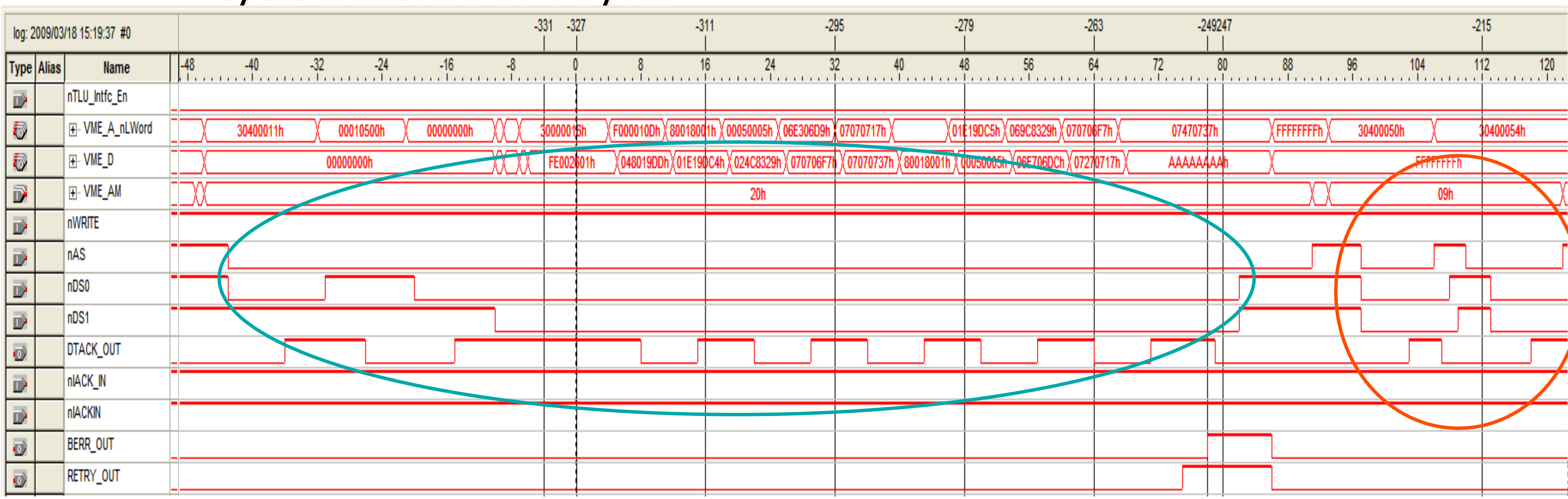
EUDAQ needs only minor changes

- modified EUDRBProducer to handle Mi-26 and 2eSST commands
- modified Converter to handle Mi-26
- small modifications to the RootMonitor (new decoding)

DAQ Changes - VME driver

2eSST transfer and Tsi148 driver 'features':

- CPU breaks 2eSST block transfer into many "atomic" transfers.
- atomic transfers allow 128 cycles (VME spec), but CPU never schedules more than 8 cycles thus making the transfer inefficient due to the overhead of the 3 address phases at the start of each "atomic" cycle.
- And worse: calling 2eSST block read within Tsi148 does not only provide block read!
- Example: Read 88 bytes, you get a block read of 80 bytes and 2 single cycle transfers of 4 bytes



DAQ Changes - VME driver speed

Performance (current Demonstrator, Mimotel)

- 6 EURDBs (~4kB each), no 2eSST, polling only, busy cleared by CPU: 200-300 Hz (2008: 50 Hz only)

Expected Performance (with Mi-26 simulator)

- Readout of one EUDRB, fixed event size of 2112 bytes,
  90 MHz: 4.88 kHz (theoretical limit 5 kHz)
- Readout of 3 EUDRBs, 4144 bytes: 1.1 kHz
  - Tested with internal trigger up to 1 kHz in June
  - EU goals 'achieved'

Next Steps

Run of full telescope with M26

- Modifications of Hardware will start tomorrow
- Real testing of full telescope will start at Sep, 9
- Aims:
  - Test of noise behavior at different clock speeds
  - Test of readout speed under beam conditions
- My dream:
  - Readout all frames and run the telescope tagged instead of triggered
  - Could be achieved with low pixel clock and around 2 kHz of DAQ rate (hard!)

Outlook & Conclusions

- Main changes for M26 are in firmware (and hardware)
- Software framework flexible enough to adapt to M26
- 3 M26 have been run successfully as DUT in June (analysis is still ongoing)
- Telescope will be changed to M26 ‘now’
- Full results will be shown at Annual Meeting in Geneva