CMS Muon Trigger upgrade

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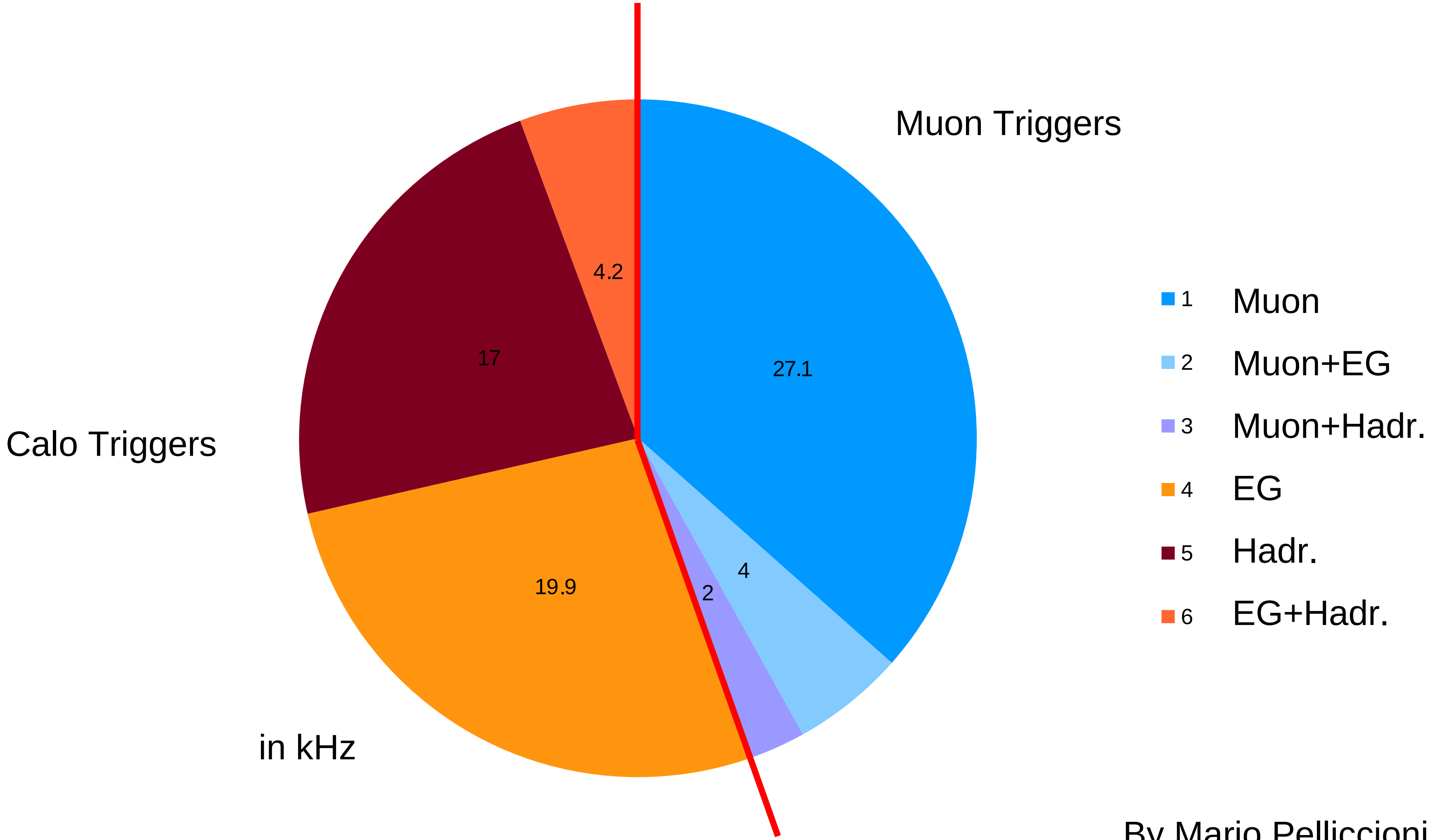
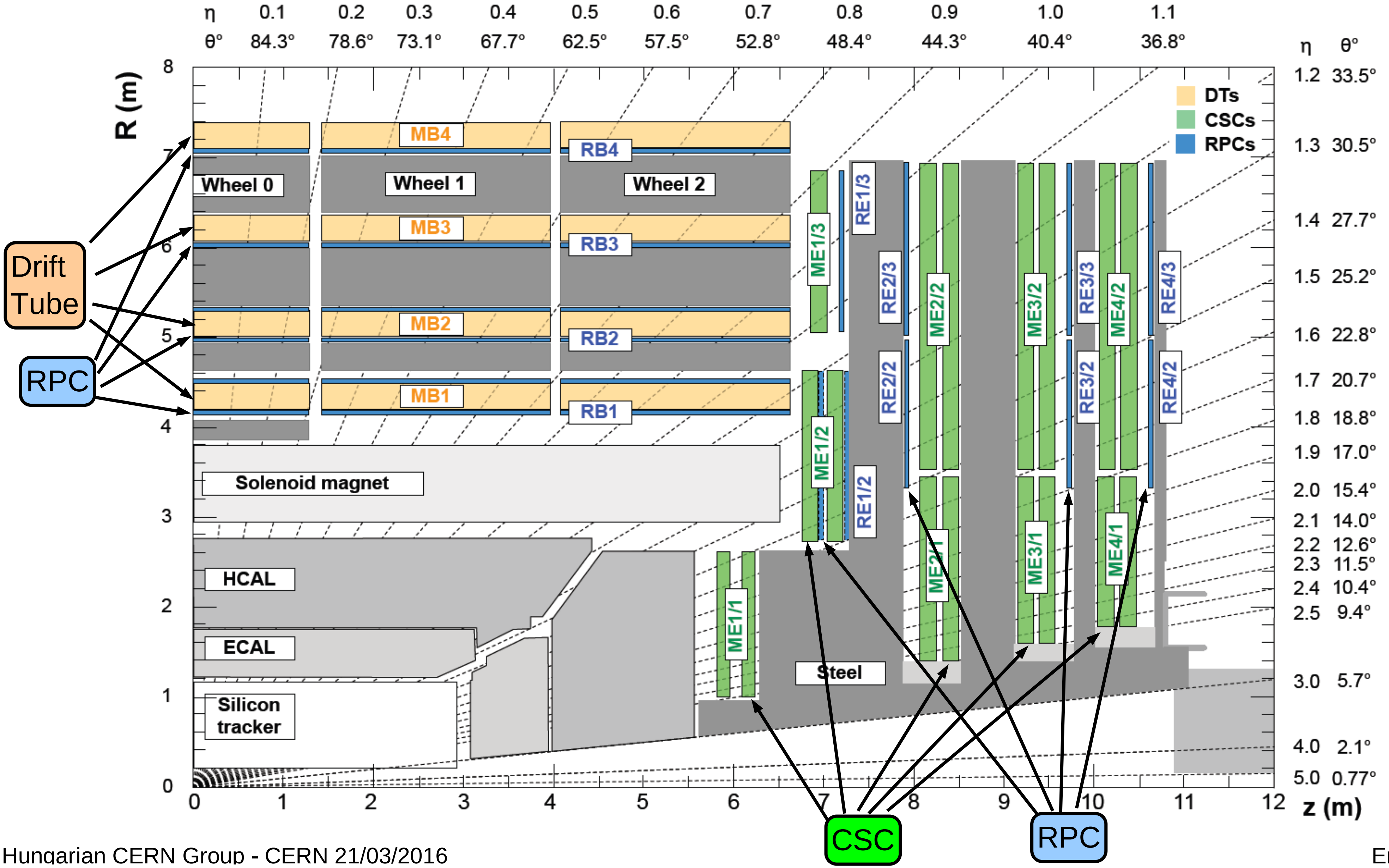
Trigger statistics



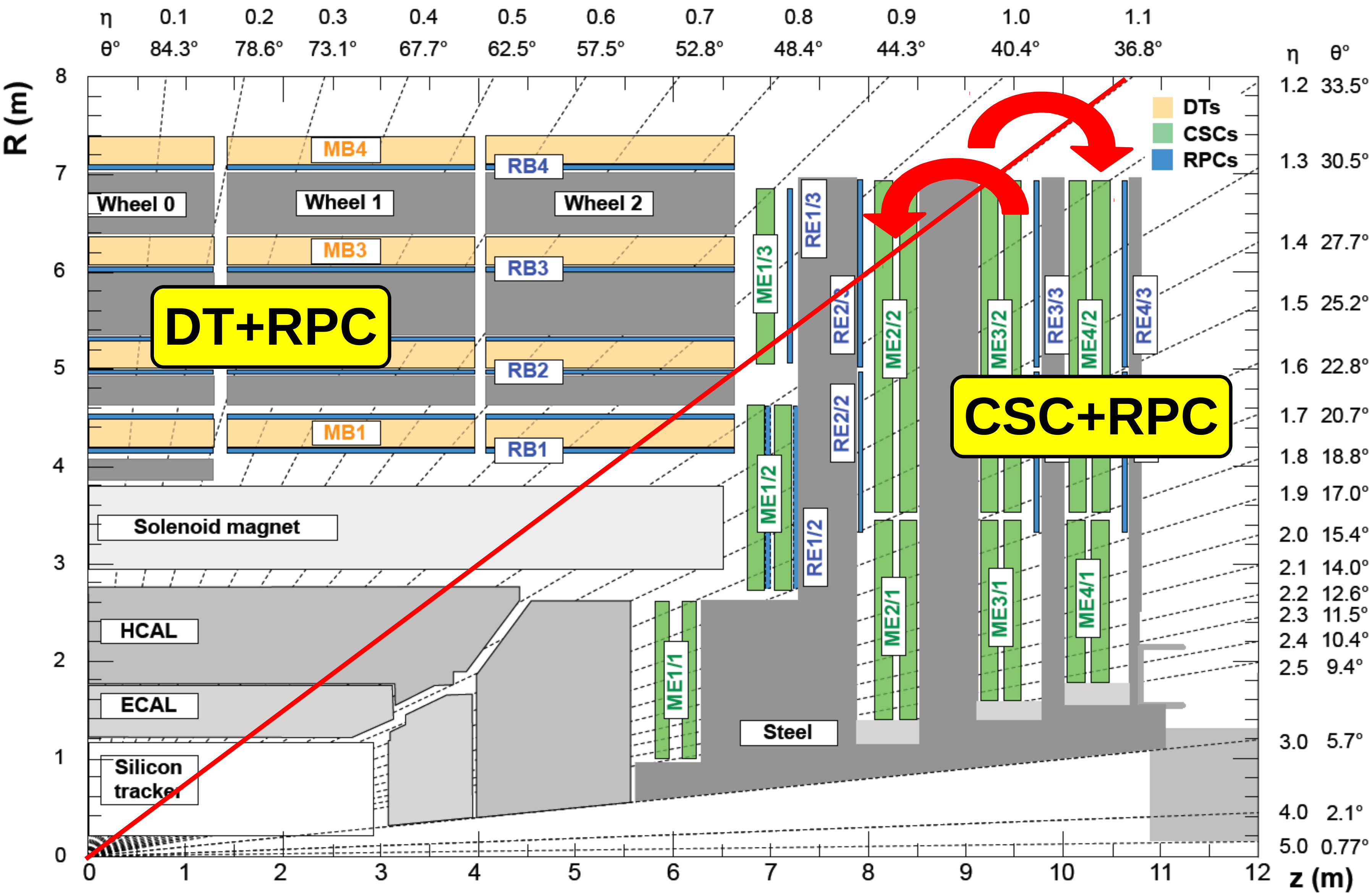
By Mario Pelliccioni

External-, Technical- and Random Triggers not represented here

Muon Detectors at CMS

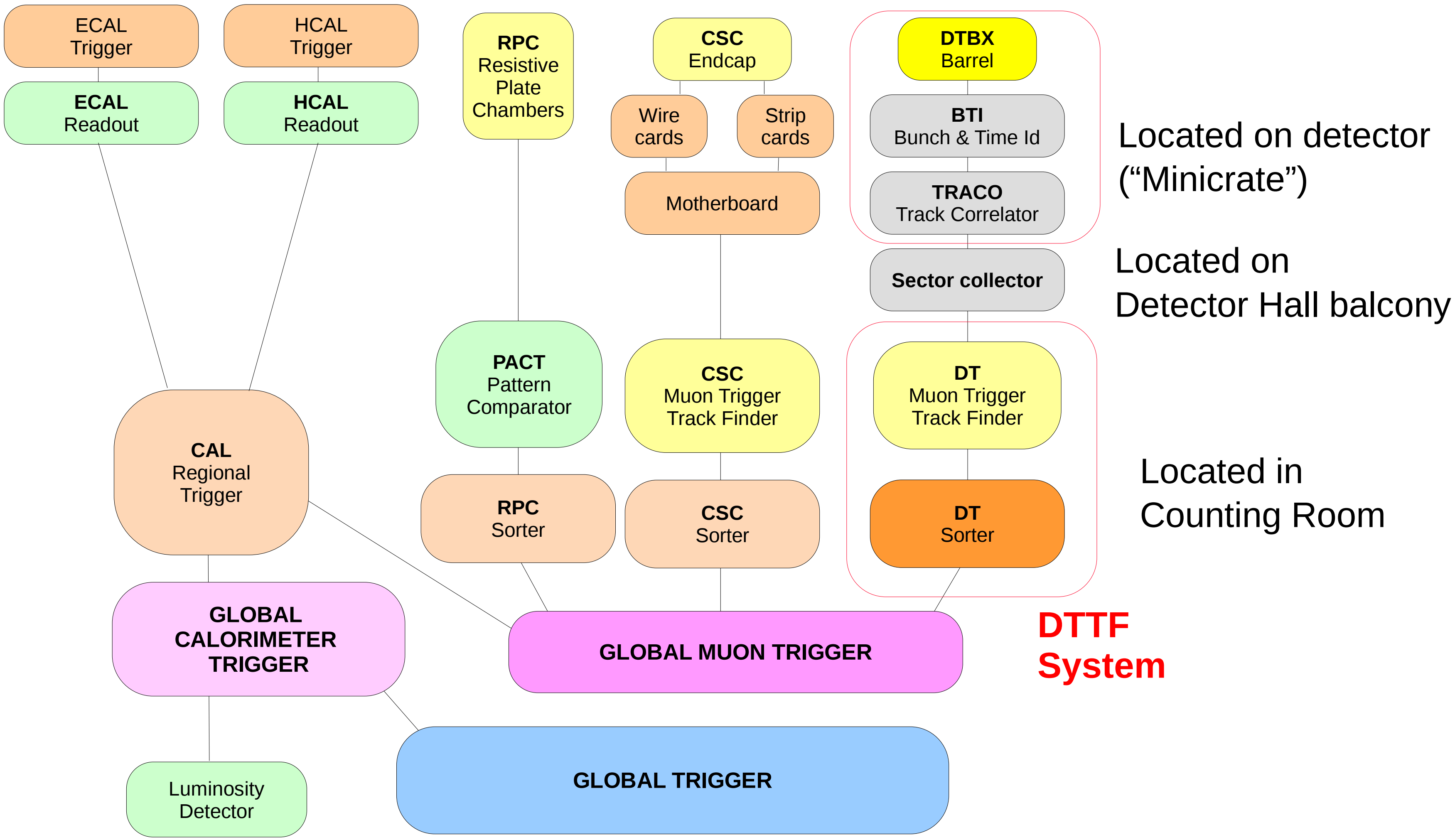


Old Muon Trigger: detector based



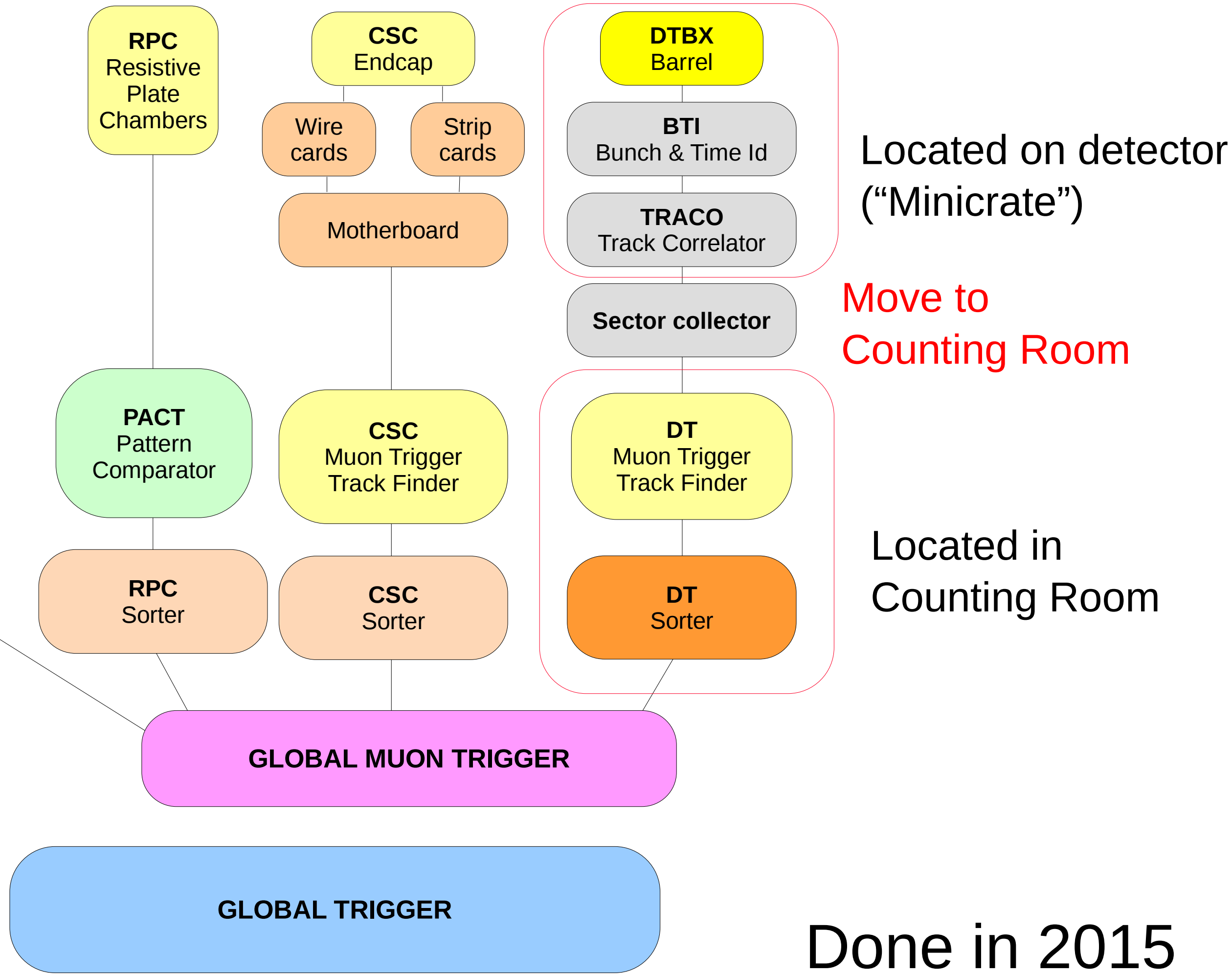
Data Exchange to find crossing Muons

“Legacy” Trigger Blocks



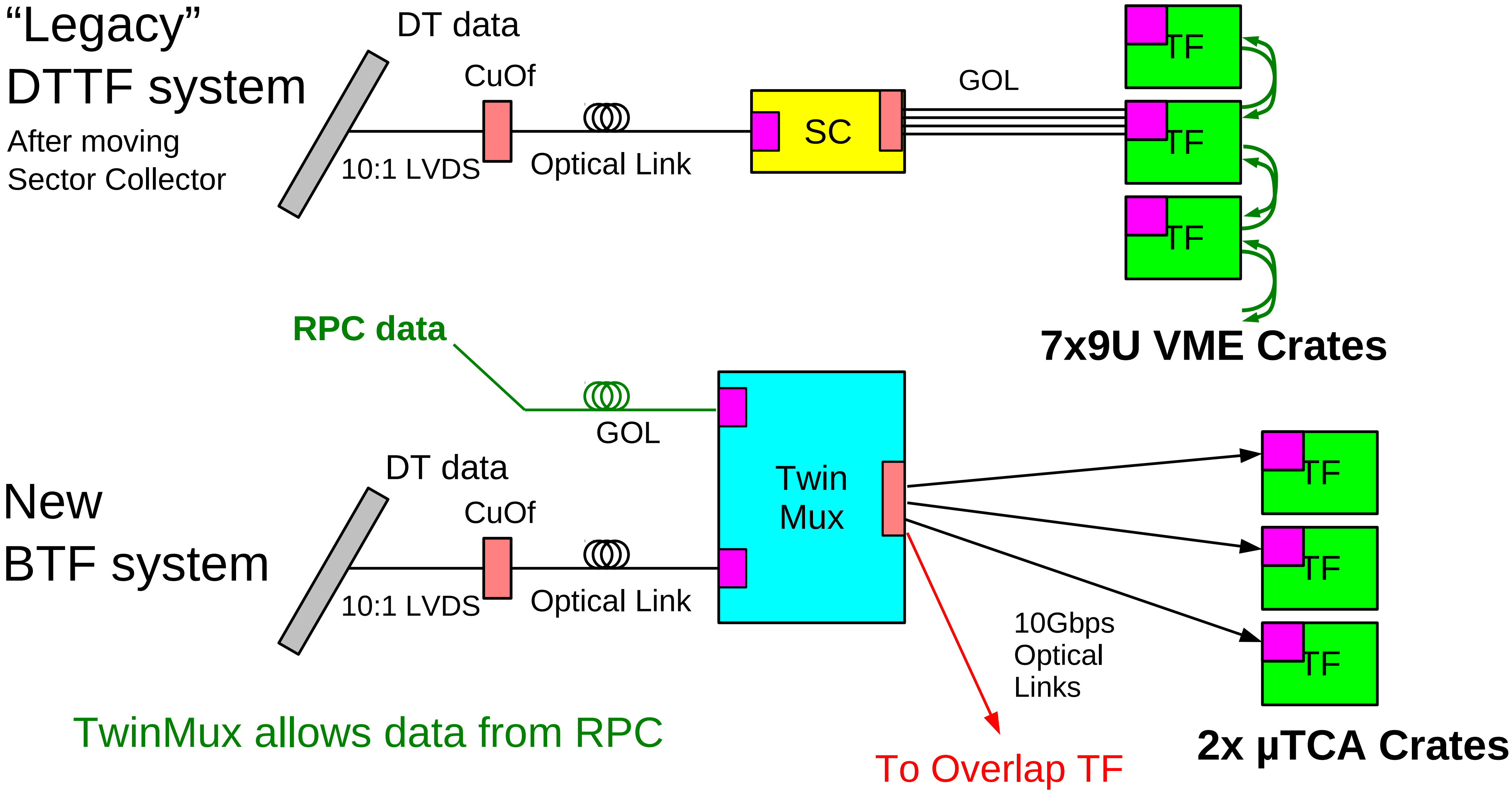
First Step: move Sector Collector

- Sector Collector
  - VME-based
    - With special components
    - Magnetic field (fans)
    - Radiation
  - Failure not to fix!
    - Only at next access time
    - Crate Failure: full Wheel missing!
  - Two Board failures after start, no problems later
- Replaced by simple Copper-Fiber transmitters
  - Speed: downgrade
    - 1.2Gbps => 480kbps
- Sector Collector in Counting Room
  - Increased Latency!



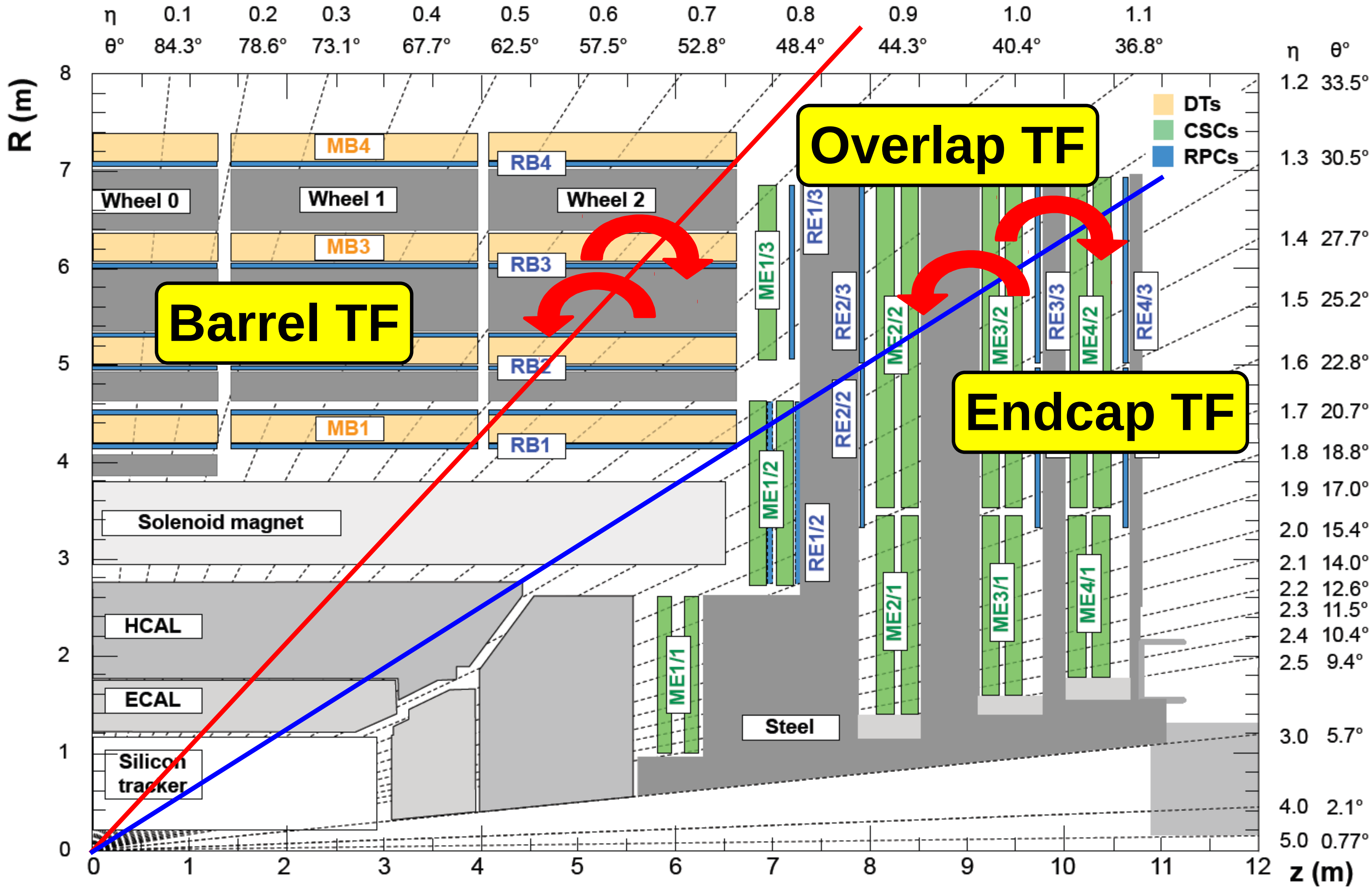
Done in 2015

Replace SC by TwinMux, DTTF by BTF



New task distribution

Track Finders allocated by Eta region, rather than by detector



Data Exchange to find crossing Muons remains

Actually no data exchange but fanout

Goals for the reorganization

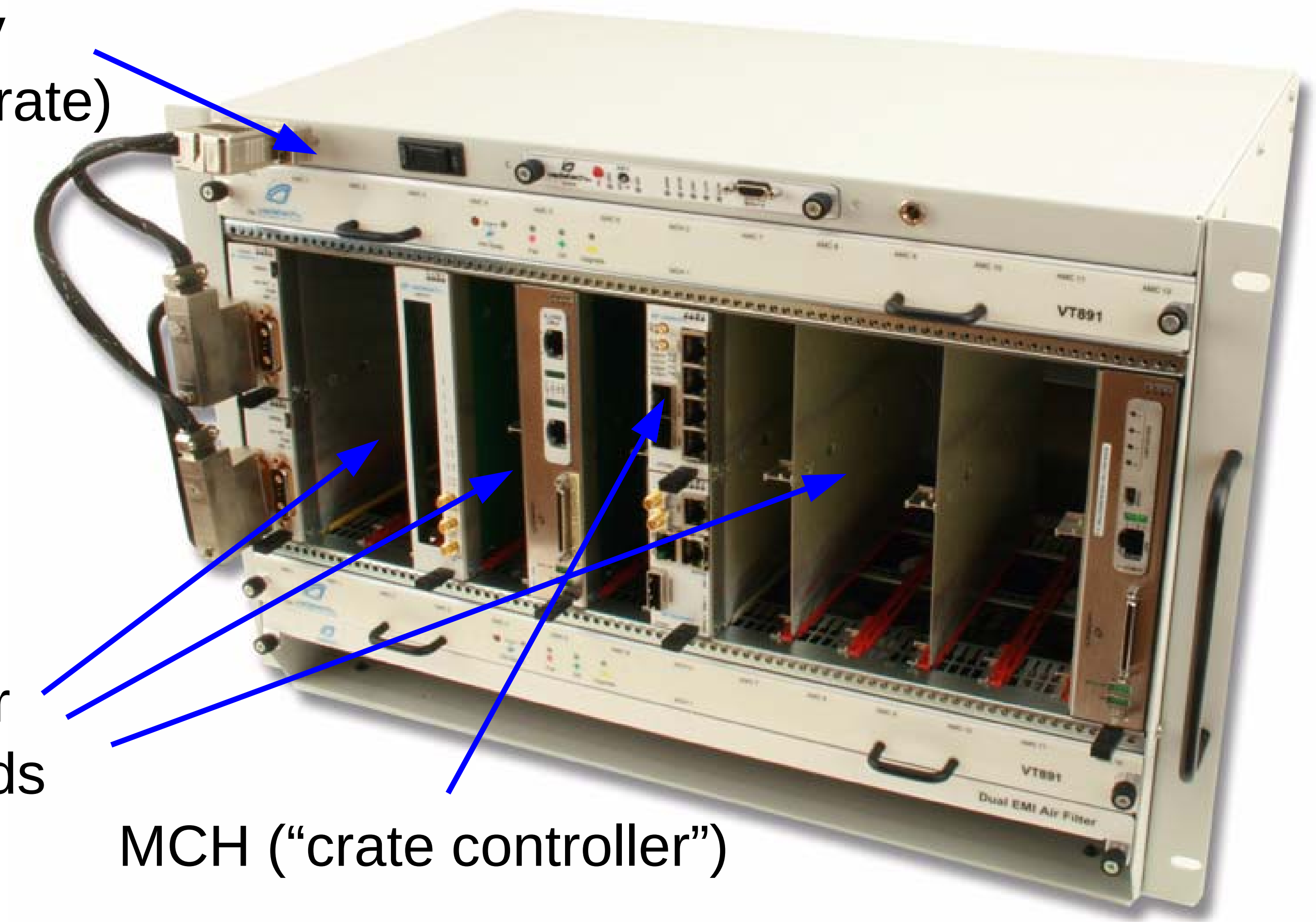
- Track Finders now combine data from different detectors
  - Detector or Link failure does not result in missing region
  - When Trigger Objects available from both, TF can take the better one
  - Better spacial coverage
  - Resolution might increase
- Problem areas
  - Trigger Objects are very different
    - To use them they need to be transformed to a common format
      - Loss of information in some cases
  - Latency chain is very different, must be leveled
- In the Barrel
  - RPC and DT: different features
    - RPC: good timing, less spatial resolution, noisy
    - DT: sometimes poor timing, good spatial resolution, noise is no problem
  - When combining, no gain in detector Gaps – both have the gap at the same area
  - Starting position: use RPC data
    - to confirm DT timing
    - to form Track Segments when DT data is not available

Technology Achievements

- New technology – replace VME
  - No VME support any more, industry already changed to newer technologies
  - High-speed serial Data Links (10Gbps – indeed 9.6Gbps with internal resync)
    - Less connections – more bandwidth
    - Increase data security – but increase latency due to serialization-deserialization
  - Highly integrated FPGAs
    - Less components
    - Overall costs did not decrease
  - Unified Crate technology
    - µTCA – a telecom technology
    - Not only Crate and Board, but Power distribution and Slow Control in the Standard
    - Many superfluous features
      - Actually little use of hi-speed backplane Lanes – except DAQ output
      - Hot swapping
      - Redundancy (Power and Control)
  - Ethernet control
    - Down to Board level
      - All Boards have unique IP numbers, MCH (the Crate Controller) acts as Router
    - System separated from Internet because of security reasons

Vadatech VT891 µTCA Crate one solution – the other one is Schroff

Power Supply (Schroff separate)



Place for 12 Boards

MCH (“crate controller”)

Others than expected from a telecom standard technology, no full compatibility among vendors!

Hardware

- The idea was: common hardware for CMS Trigger
  - Instead of this CMS Trigger uses 3 different Boards (TwinMux is the 4th)
  - All contain one big FPGA, many Hi-Speed Links (up to 72)
  - Not even the Control is common
    - IPbus and PCIexpress
- MP7 – developed by Imperial for Calorimeter Trigger
  - Barrel Track Finder
  - Global Muon Trigger
  - Global Trigger
- MTF – developed by Florida
  - Overlap Track Finder
  - Endcap Track Finder
- Timing and DAQ readout common for all CMS trigger blocks
  - AMC13 – developed by Boston
- Board Control over Ethernet
  - IPbus
  - PCIexpress

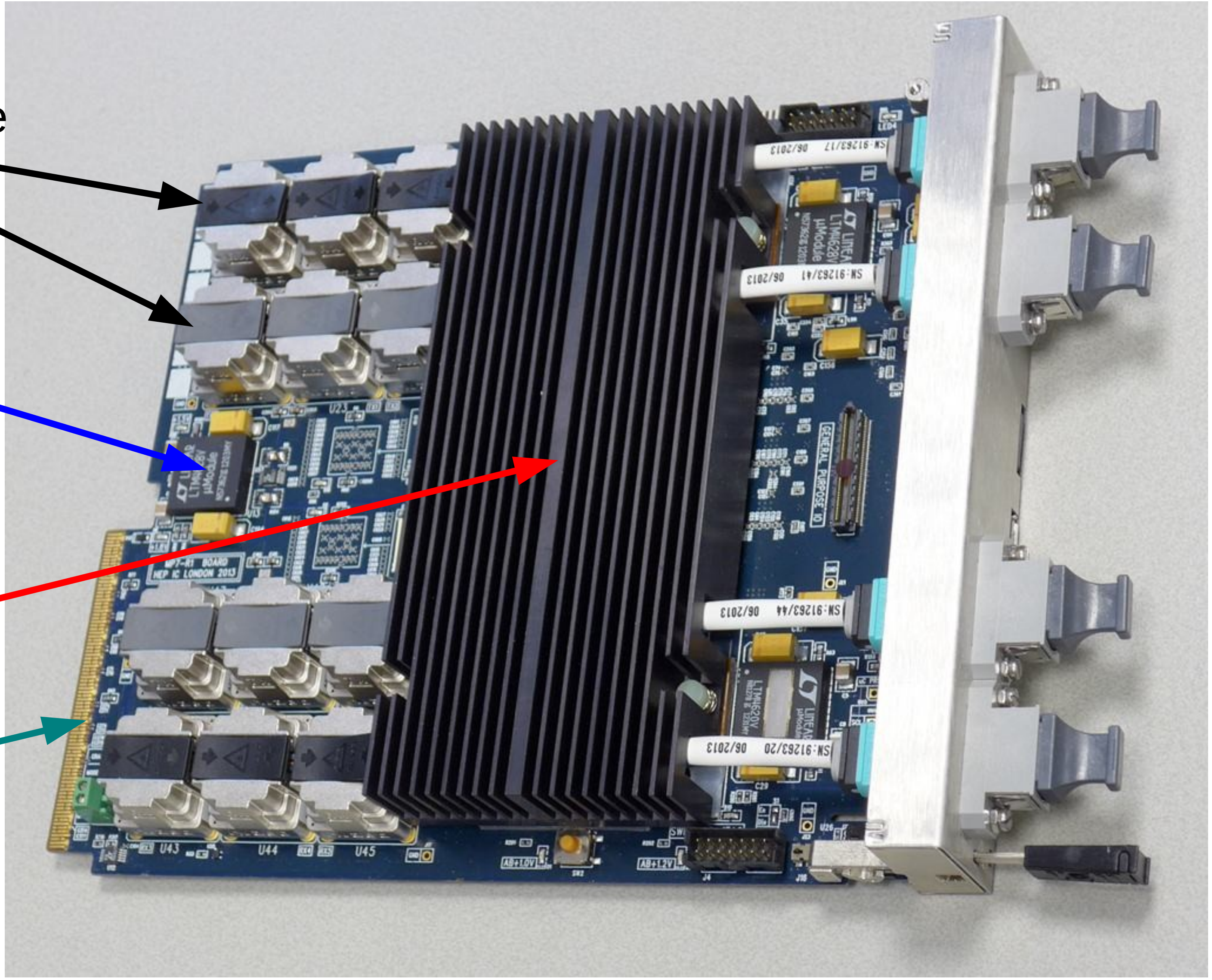
MP7 Board (Imperial)

MiniPod
Fiber Interface

MMC chip

Xilinx
XC7VX690T

µTCA
Bus
connector



72 x
10Gbps
Inputs

72 x
10Gbps
Outputs

Firmware development

- MP7 – common F/W blocks
  - Clocking
    - Several programmable Clock sources
    - Synchronized with LHC Clock
  - IPbus
    - Internal Registers accessible by Ethernet => IP packets
    - Possibility to upload and activate new Firmware
  - Timing and fast Control
  - DAQ
  - Link I/F
    - Functional tests using Link Buffers as Pattern Memory
- Board functionality, algo as “payload”
  - Trigger data inputs and outputs connected to HiSpeed Links
  - Control as IPbus branch
  - DAQ output interface is not part of the “payload”
    - Common Link I/F connected

Muon Trigger Blocks 1.

- Endcap Track Finder
  - Uses MTF7 Board
  - RPC hits received, too
  - Basically Pattern Matching method
    - Large amount of individual Patterns, placed in a huge memory
    - Memory needs to be loaded as part of the Configuration
    - PCIexpress connection for upload
- Barrel Track Finder
  - Uses MP7
  - RPC data formatted as DT Track Segments for unified handling
  - Algo as before – Extrapolation, Linking, Parameter Assignment
  - Assignment algorithm refined – we expect suppression of false Hi-Pt assignment
  - Sorting only in “Wedge” level – no Barrel Sorter
- Overlap Track Finder
  - Uses MTF7 Board
  - Pattern Matching using “Golden Patterns”
  - Re-formats DT Track Segments to patterns

Muon Trigger Blocks 2.

- Global Muon Trigger
  - One single MP7 Board
  - Accepts 3x36 Muon candidates from all Track Finders
  - Performs Ghost Busting – also based on Track Addresses
    - Ghosts: muon candidates from different Trigger components, indeed the same Muon
    - Not only geometrical parameters, as before
- Global Trigger
  - Uses MP7 Boards
  - Combination of Calo and Muon Trigger data
  - If number of Trigger algos increase, GT can be extended by additional Boards
  - As it was already the practice with the legacy system, now extended:
    - Firmware can be adapted to Trigger algorithms
    - Software tool prepares algos
      - Also checks feasibility
    - After compilation new firmware will be loaded into GMT FPGA
      - Check resources, timing
    - Software applies algo in the Emulator

Software

- Trigger Supervisor is dead, long live SWATCH
  - New Framework, built from scratch
- Components
  - Infrastructure (all in Scientific Linux)
    - PCs, S/W installation, networking
    - Process Control
  - System Control
    - Subsystem Control integrated into SWATCH
    - Run Control
  - Database
    - Subsystem parameters
      - Run parameters, setup parameters
    - Database edit
    - Shared between run system, Emulator and HLT
  - Monitoring
    - On-line data
    - Visualization
    - Limits, alarms (not yet implemented)

Plan B?

- Considered from beginnings – extremely hard task
  - Many H/W and S/W components, multi-level interactions
  - Different interconnections
    - hard to connect components of the legacy system with new ones
  - Every extra solution requires man-power to develop and implement
- As last year Calo trigger already used new technology, one possibility would be to keep legacy Muon Trigger with new Calo Trigger
  - Global Trigger should be legacy, as new GT can not accept legacy trigger data
- In December 2015 decision made for new Muon trigger
  - All DT Trigger Links reconnected to TwinMux – this is 2-3 Weeks work
  - TwinMux theoretically can send data to legacy DTTF – never tested
- New Global Trigger should be extended to receive legacy data
  - As “external trigger”
  - How the DAQ readout works?
- Control Software not compatible – run both in parallel?
  - Database, Emulator, Configuration?

No practical way back – new system MUST work

LHC timetable