Infrastructures and Installation of the Compact Muon Solenoid Data Acquisition at CERN

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on behalf of the CMS DAQ group
Outline

- Introduction
- Underground area
- Surface area
- What next?
• DAQ elements are installed at the experimental site both in the underground counting rooms (USC55) and surface buildings (SCX5).

• Elements installed in underground areas are in charge of collecting pieces of events from about 650 detector data sources and transmitting these event fragments to the surface elements. They also elaborate a smart back pressure signal that prevents the first level trigger logic of overflowing the front-end electronic (Trigger Throttling System).

• Elements installed in surface areas are in charge of full event building (a partial event building already takes place underground) and running the High Level Trigger algorithms. Events that pass these filters are stored locally and transmitted later to main CERN computing center.
CMS experimental site

Surface computer room

Underground Counting rooms
Underground DAQ elements

- 500 FRL cards receiving the data from one or two detector data sources
- 650 sender cards plugged on the detector readout card
- 650 S-link cables (total length 6 km) linking the senders with the FRLs
- 56 FMM cards, collects the status of every data sources and produce a back pressure
- 750 RJ-45 cables for TTS signals (total length 11 km)
- 500 Myrinet Network Interface Cards (NICs) plugged on the FRLs
- 6 Myrinet switches of 256 ports each
- 1000 optical patch cords connecting the FRL NICs with the switches (total length 38 km)
- 50 Compact PCI crates sub-divided into 60 logical crates to house the FRLs (some crates contain dual-backplanes)
- 60 crate controller PCs with their control cables (1.6 km)
- 30 opticables running between USC and SCX (216 fibers each, 200 m long)
DAQ racks types

Racks for electronic crates
(Front view)

- Tang. Fans 4U
- Filling plate
- Heat ex. 1U
- Chassis 6U
- Fan tray 1U
- Air guide 2U

Racks for computers
(Side view)

- Power distribution box
- Fans
- Air/Water heat exchanger
- Water inlet/outlet

Up to 44U usable space, 10 kW heat dissipation
Underground counting rooms

• The DAQ elements, the detector readout electronic and other services (i.e. High Voltage systems, Detector Safety systems) are located in a dual floor room, S1 and S2, having respectively the capacity of ~100 and ~160 racks of 60x90 cm².

• The rack assignment between sub-systems has been done in order to satisfy numerous constraints. Some of them are:
  – Number of racks for each function
  – Keep minimal the latency for trigger detectors and trigger logic
  – Maximum cable length for inter-rack cabling

• The final rack assignment was a very long iterative process (several years) and still some small changes/additions are requested!

• Once rack assignment “stable”, design and installation of the DAQ cable trays for inter rack communication
  – Trays located very close to false floor tiles to keep the cable length minimal
  – List of every single cable/fibers, labeling…
  – Keep track of the tray occupancy and add always a huge contingency…
DAQ racks in USC55 Lower floor

Data sources

- **DAQ PCs**
- **DAQ**
- **Tracker**
- **CSC muons**
- **CSC track finder**
- **Global trigger**
- **Cal. global trigger**
- **RPC trigger**
- **DT track finder**
- **DT**
- **Pixels**
- **Preshower**
- **Unassigned rack**

Underground control room

Lower floor

Last update: June 6, 2006
according to version 67 of official layout file
DAQ racks in USC55 Upper floor

Underground control room
Upper floor

Data sources

- DAQ PCs
- DAQ
- ECAL barrel
- HCAL HTR
- TOTEM
- TOTEM trigger
- CASTOR trigger
- Unassigned rack

Last update: June 6, 2006
according to version 67 of official layout file
USC DAQ installation schedule/status

- Rack welding in the counting rooms: Q3-Q4 2005
- CPCI crate controller PC install: December’05
- Cable tray installation and rack equipment: January’06
- Rack manifolds repair: up to July’06
- Copper cabling and electronic installation: Q3-Q4 2006
- Optical patch cords: 7 “big” days between November’06 and January’07
  - With the help of many DAQ group member from the software side!
- Optical cables installation: March-April’07 (External company)
- Test of every single elements/cables/fibers: Q1 2007
  - Broken: 2 FMM cables, one optical patch cord, 3 FRLs and 2 CPCI backplanes
  - All these items have been changed or fixed.

- Since April’07, all underground DAQ hardware is used for sub-detector commissioning
USC PC S2 area
Surface DAQ elements

• All DAQ surface elements are installed in SCX5 DAQ building
  – 640 Readout Unit/Builder Unit PCs, 2U server
  – 160 2U servers for services: data storage, DQM, databases, Run control…
  – 6 Myrinet switches of 256 ports each (the same than underground)
  – Storage systems
  – 6 Gigabit ethernet switches (256 ports each)
  – ~1200 Filter Unit PCs for 50 kHz trigger rate (June 2008)
  – Again ~1200 PCs for 100 kHz trigger rate (Sometime in 2009)

• The room has a total capacity of 170 racks (see layout) and 800 kW of cooling
  – The remaining racks will be used for the filter units when the LHC will ramp up in luminosity hence creating more data to analyse
DAQ building (SCX)

- Computer rooms
- Conference rooms / labs
- False floor
- Main Control room

Overall dimension: 
~ 14 x 30 m²

352 m², 
~6m height

165 m², 
~3m height

Data fibers and commodity networks from the pit
Rack layout in SCX5

RUBU racks  Servers/Storage/Switches  IT racks

Filter Units 100 kHz  2009…

Filter Units 50 kHz  June 2008

Contingency…
Why water cooled racks?

- Usually, plenum floors with forced cold air is used to cool down data centers
  - People do not like water close to PCs…

- With 10 kW/rack and 2kW/m2, air is no more efficient and requires a real storm
  - Hot spots are created what ever you do!

- Water cooled racks catch the heat at the very source, hence avoiding hot spots and giving a better usage of the floor space
Heavy computer science...
Force10 switches and RUBU rack
Myrinet switch and storage
What next?

- Commissioning in USC will continue with real detectors (November 2007)
  - Readout done from surface building very soon

- Central Control room installation (December 2007)

- 1200 Filter Unit PCs to purchase and install for June 2008
  - 50 kHz trigger rate capacity
  - Ready for first LHC collisions

- ~1200 Filter Unit PCs to purchase and install for 2009...
  - Depends on LHC program