"Preparation and commissioning of CMS for the run-II of LHC"

jean-louis Faure

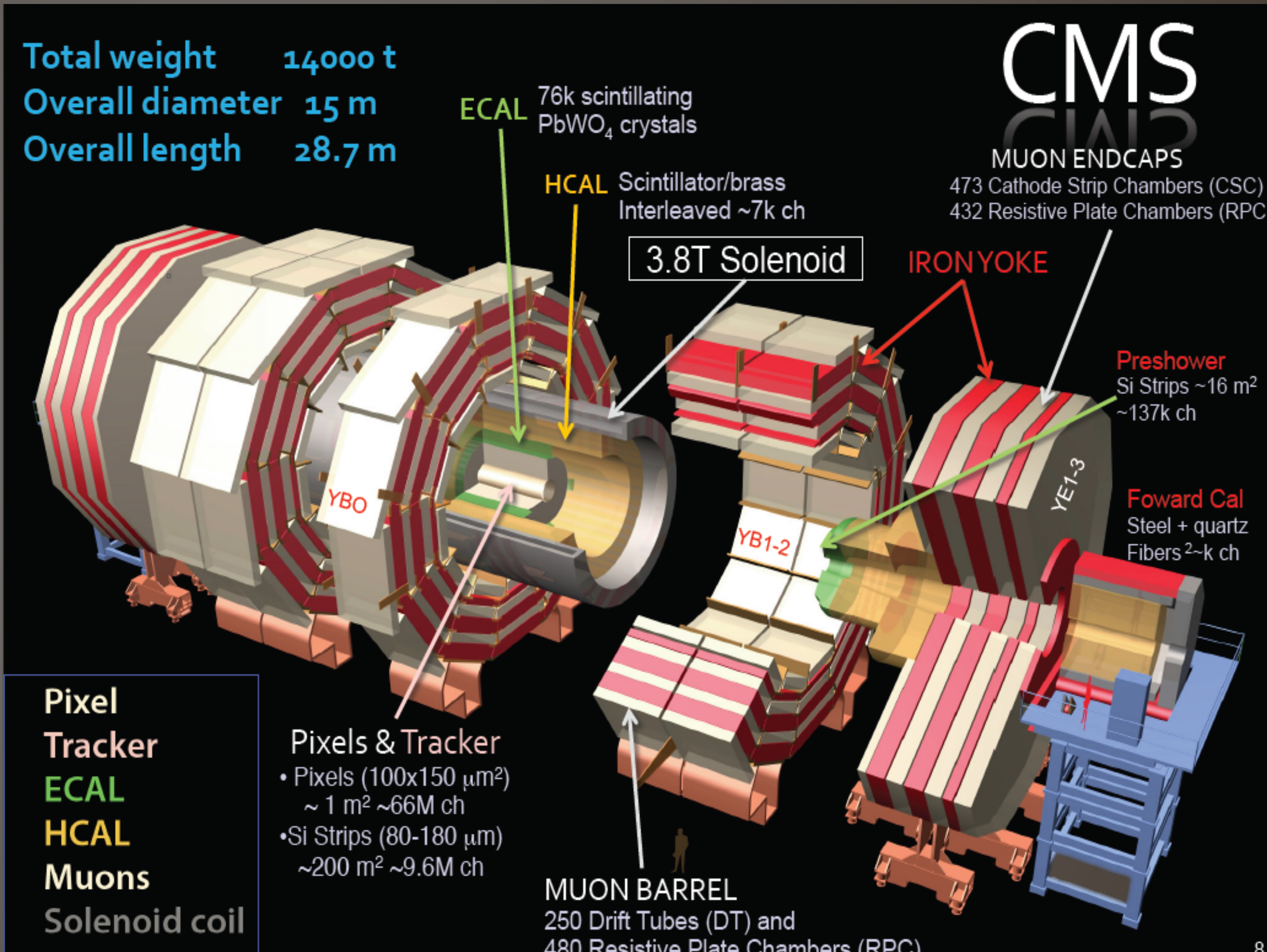
CEA-Saclay: DSM/IRFU/SPP

on behalf of CMS collaboration

in

13th Pisa Meeting on Advanced Detectors

The CMS Detector



CMS Upgrade Program

LS1 Projects
- Complete muon coverage (ME4)
- Improve muon operation (ME1), DT electronics
- Replace HCAL photo-detectors in Forward (new PMTs) and Outer (HPD→SiPM)
- BRIL
- Tracker operation at -15° C
- DAQ1 → DAQ2

Phase 2 Upgrades: Technical Proposal this fall
- Tracker Replacement, Track Trigger
- Endcap Calorimeter replacement
  Barrel ECAL Electronics upgrade
  Trigger/DAQ upgrade
- Tracker & possible endcap Calorimeter, Muon extension
  - From |η|=3 to |η|~4

Phase 1 Upgrades
- New L1-trigger systems (Calorimeter – Muons – Gobal) (ready for 2016)
- New pixel detector (ready for installation in 2016/2017 Year End Technical Stop)
- HCAL upgrade: photodetectors and electronics (HF 2015/2016 YETS, HB/HE during LS2)

- **Preparatory work during LS1**
  - **New beam pipe**
  - **Install test slices (*Pixel , HCAL, L1-trigger*)**

<u>Current LHC schedule</u>

LS1: January 2013 – December 2014 (24 mos)
Extended Year End Technical Stop (EYETS): December 2016-April 2017 (19 weeks)
LS2: July 2018 – December 2019 (18 mos)
LS3: January 2023 – June 2025 (30 mos)

CMS Upgrade Program In Elba Meeting

Talk of Fabio Ravera, Poster Paola Tropea

Talk of Davide Cieri
Talk of Geoff Hall

Poster Nicola Pozzobon

Gilles De Lentdecker, Ilaria Vai, Alice Magnani, Luigi Benussi

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Poster Pierluigi Bortignon

Poster Martin Lipinski
Poster Kavita Lalwani

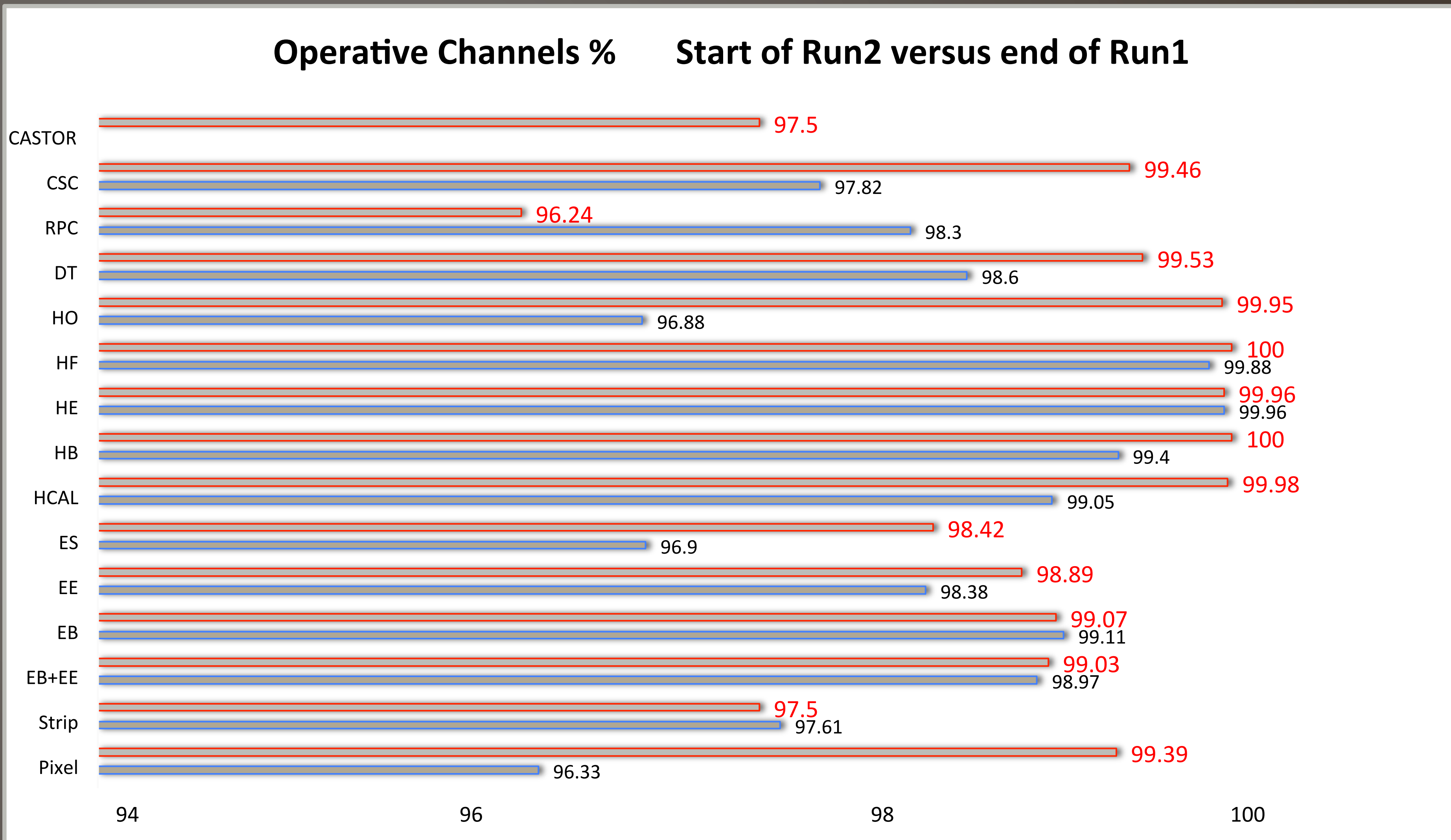
Poster: Sophie Mallows : Monte Carlo simulations of the radiation environment for the CMS Experiment

CMS during LS1

- **New detectors / components**
  - RPC: installation of new RE4 chambers
  - CSC: installation of new ME4/2 chambers and new on and off chamber electronics for ME1/1
  - Trigger: new hardware, moving on path to full trigger upgrade
  - DAQ: new DAQ2 (hardware and software) and new Trigger and Clock Distribution System
  - +New beam pipe with smaller diameter: prepare for new pixel detector
  - +New YE4 shielding

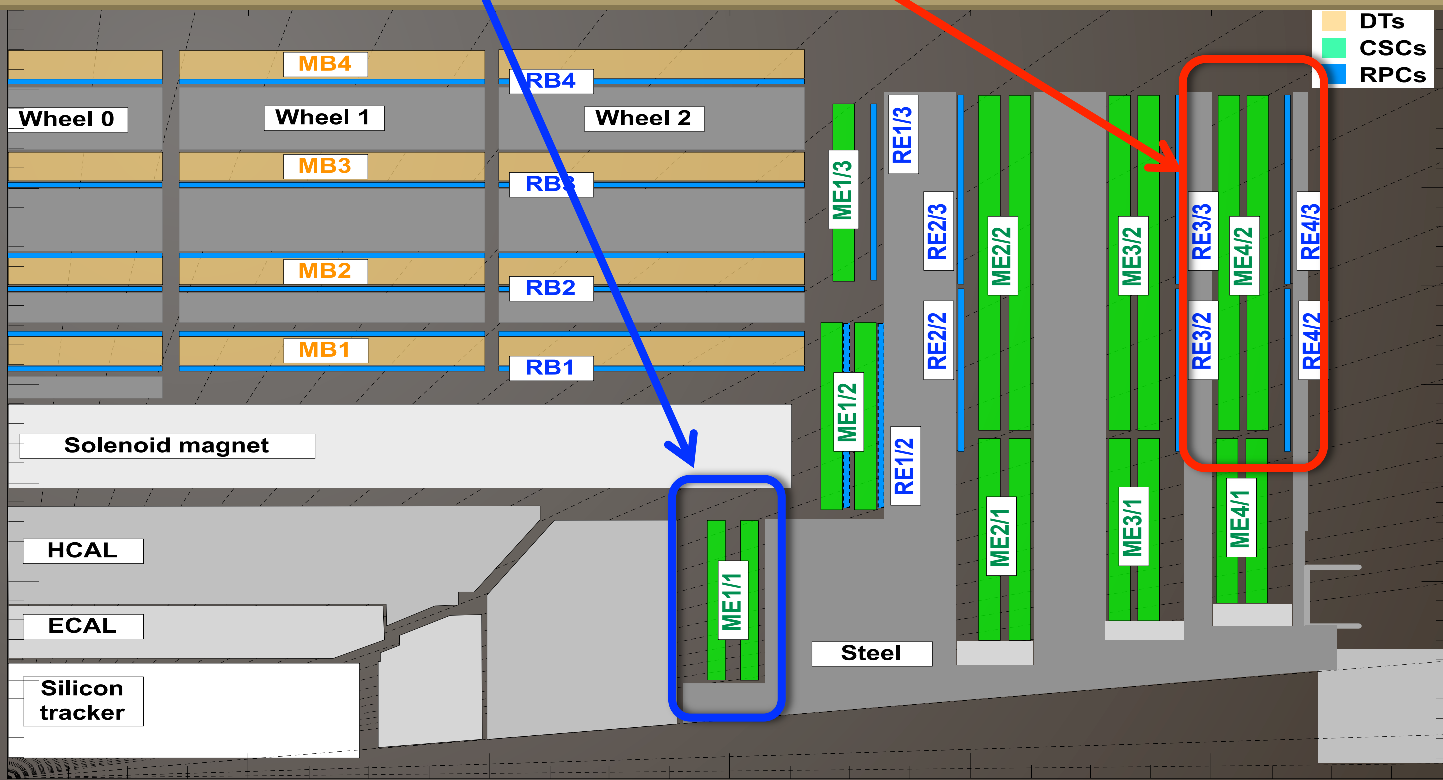
- **Detector repairs and improvements**
  - PIxels removed to repair faulty channels
  - Tracker sealing to operate at -20^{0}C (4C during run 1)
  - DT: readout electronics moved
  - HCAL: replacing HO HPDs with SiPMs, replacing HF PMTs, new Clock Control Modules
  - ECAL: new serial links for trigger, new laser, DAQ upgrades

General Consolidation



Muon System in Run 2

- CMS Muon System has three sub-systems: Drift Tubes (DT), Cathode Strip Chambers (CSC), Resistive Plate Chambers (RPC)
- Removal, revision, re-installation of ME1/1 chambers
- 4th muon station added: 72 (144) new CSC (RPC) chambers



Drift Tubes for Run2

250 chambers
172200 drift tubes

Chamber HV: 312 channels recovered

Chamber Minicrates: 3200 channels recovered

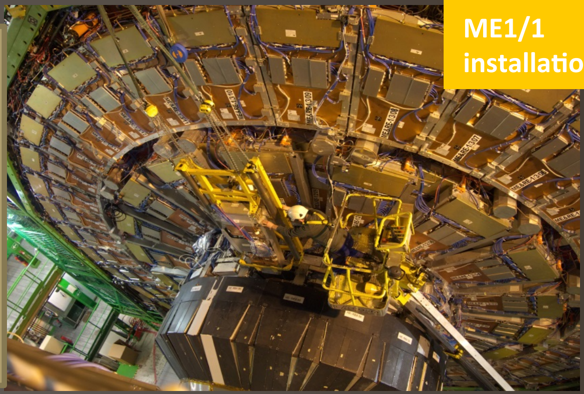
Sector Collector (Read-Out and Trigger) relocated out of UXC: installed 3500 optical links that make single outputs of all 250 chambers available in USC

CSC consolidation

ME1/1 refurbishment lab in SX5

ME1/1 chamber electronics upgrade

72 chambers extracted, refurbished and reinstalled in CMS.
Increase capacity for data rate and exploit full chamber segmentation in $2.1<|\eta|<2.4$ to enhance rate capability (including @ HL-LHC) and improve muon reconstruction



ME1/1 installation

Present system consolidation, maintenance and repair

Repair system faults from Run 1 –> recover highest efficiency. Improve system reliability (HV, LV, racks, detector infrastructure)

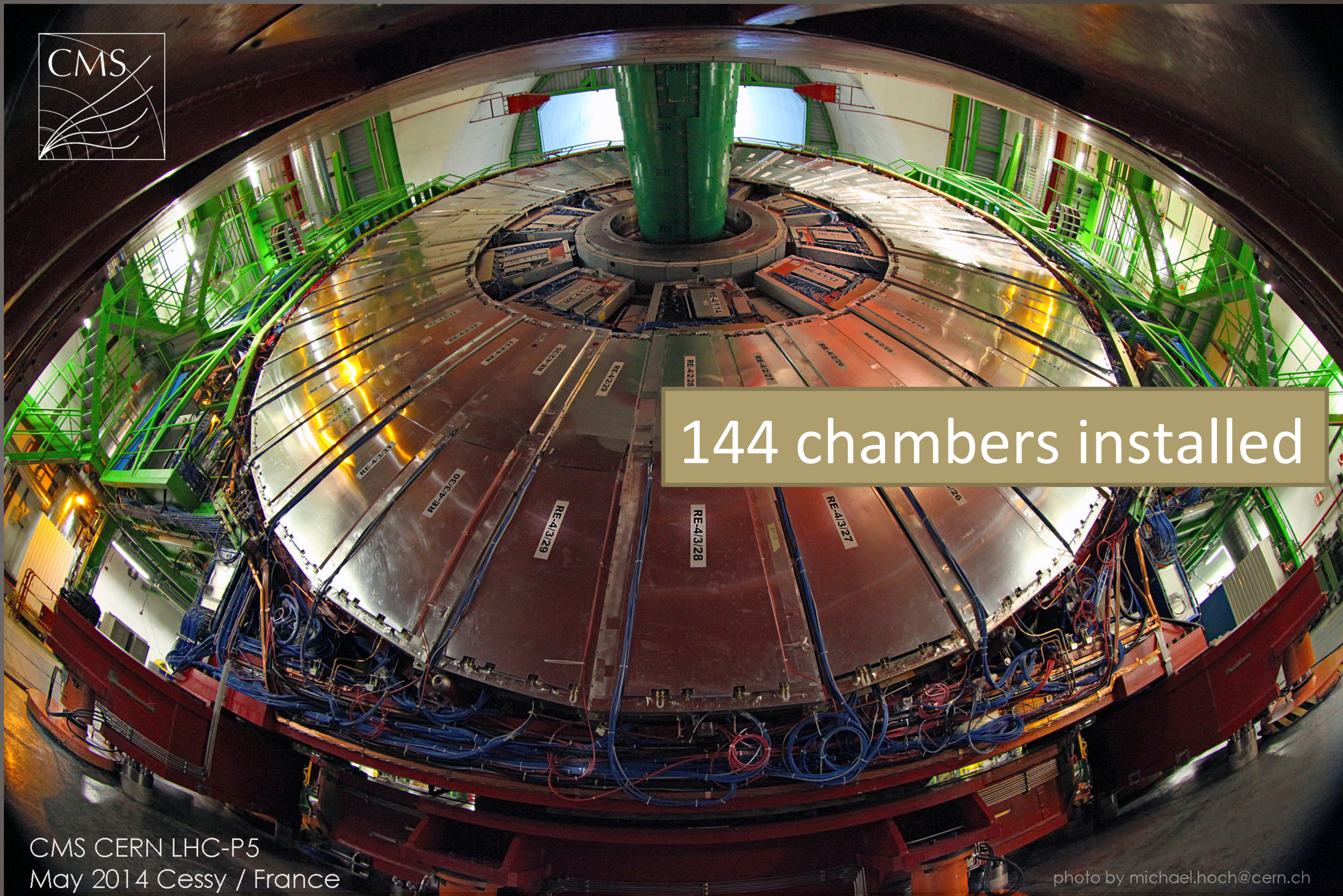
ME4/2 chamber factory in B904

Completion of station 4 (ME4/2 ring $1.2<|\eta|<1.8$)

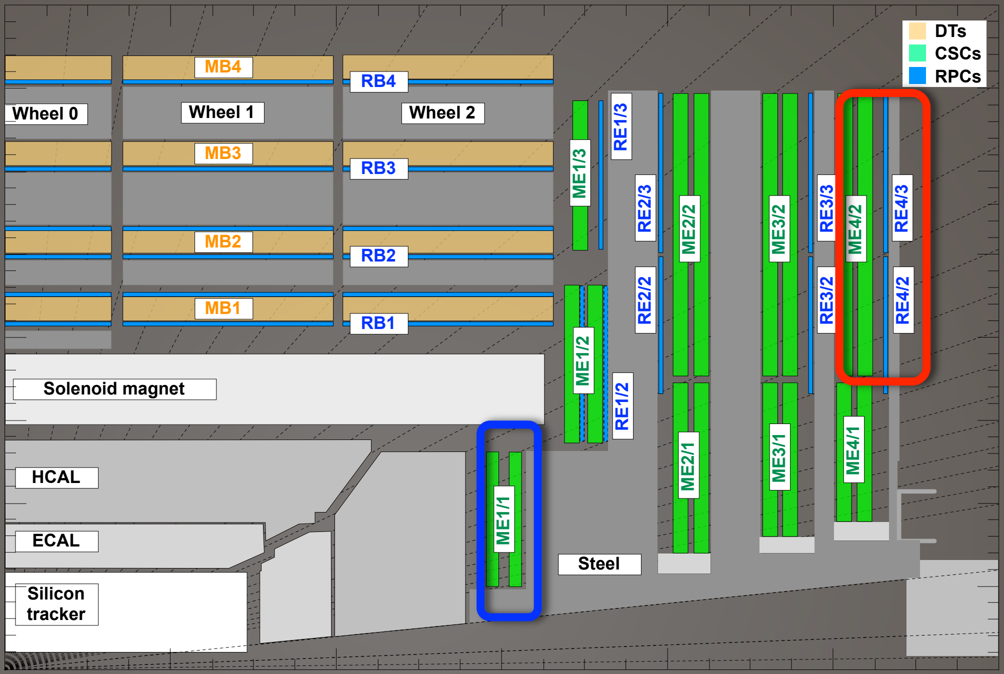
Re-establish 4-station redundancy over all $0.9<|\eta|<2.4$ range. Improve muon-ID efficiency and sustain high-Lumi L1 rates at a reasonably low pT threshold

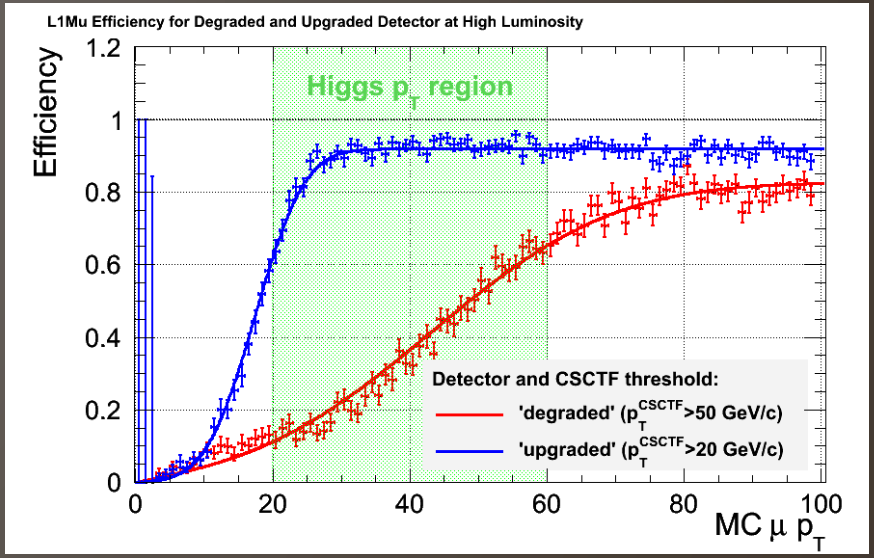
ME4/2 installation

RPC (RE4) for Run2



LS1: Muon performance improvements





Trigger performance: significantly lower threshold for same rate

CSC and RPC: ME4/2 ($1.25<|\eta|<1.8$)

More hits, lower rates

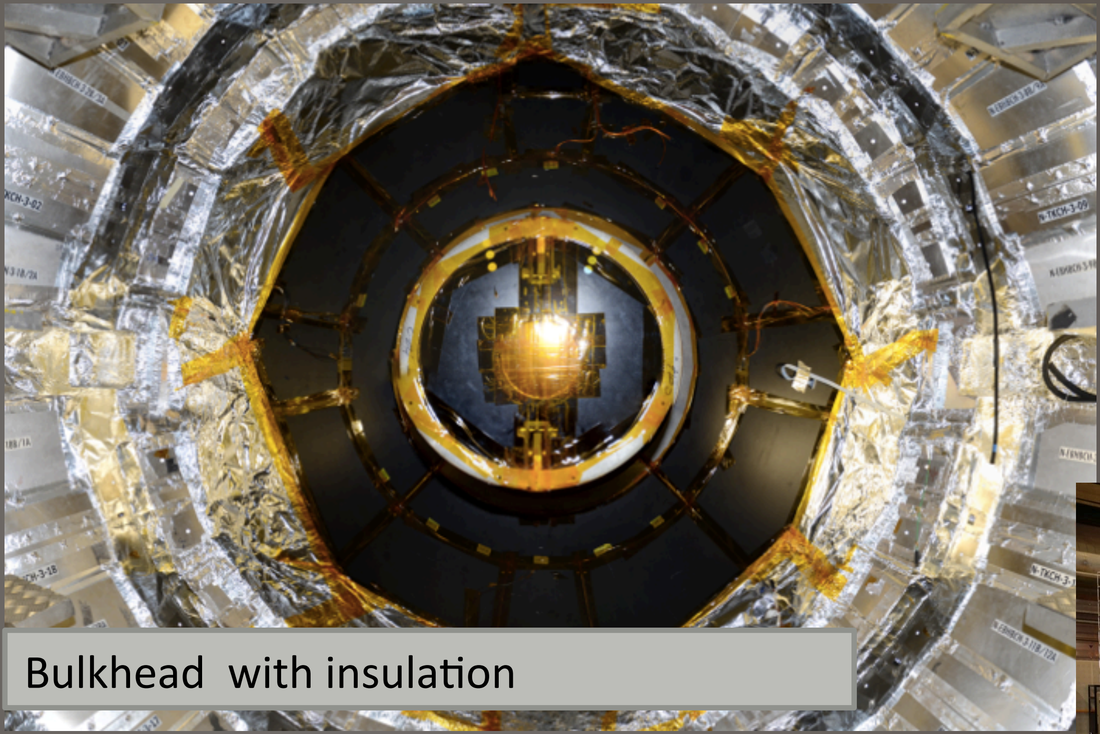
CSC: ME1/1 ($2.1<|\eta|<2.4$) new digital boards and trigger cards : higher strip granularity

Electronics reliability

DT: new trigger readout board and relocation of sector collector from UXC55 to USC55 (new optical links)

Tracker running cold (-20degrees)

Si tracker operation at -15 C commissioned (tested to -20), Pixel -20 C (tested -25)



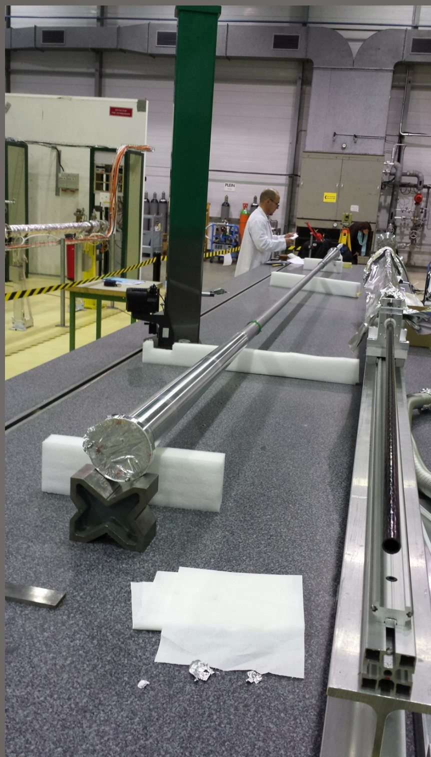
Bulkhead with insulation

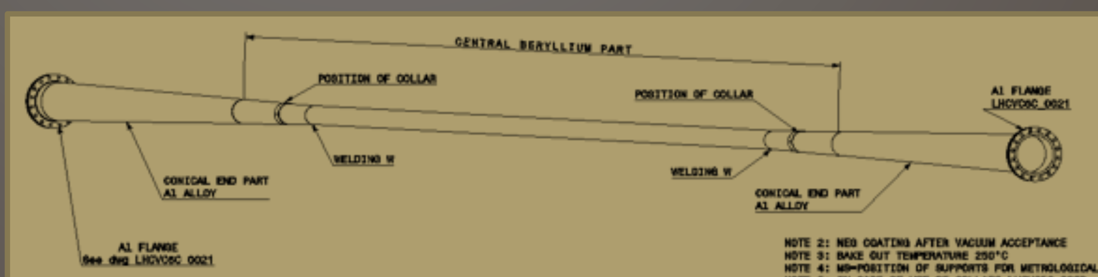
New dry gas plant

More detail in Poster of Lorenzo Viliani

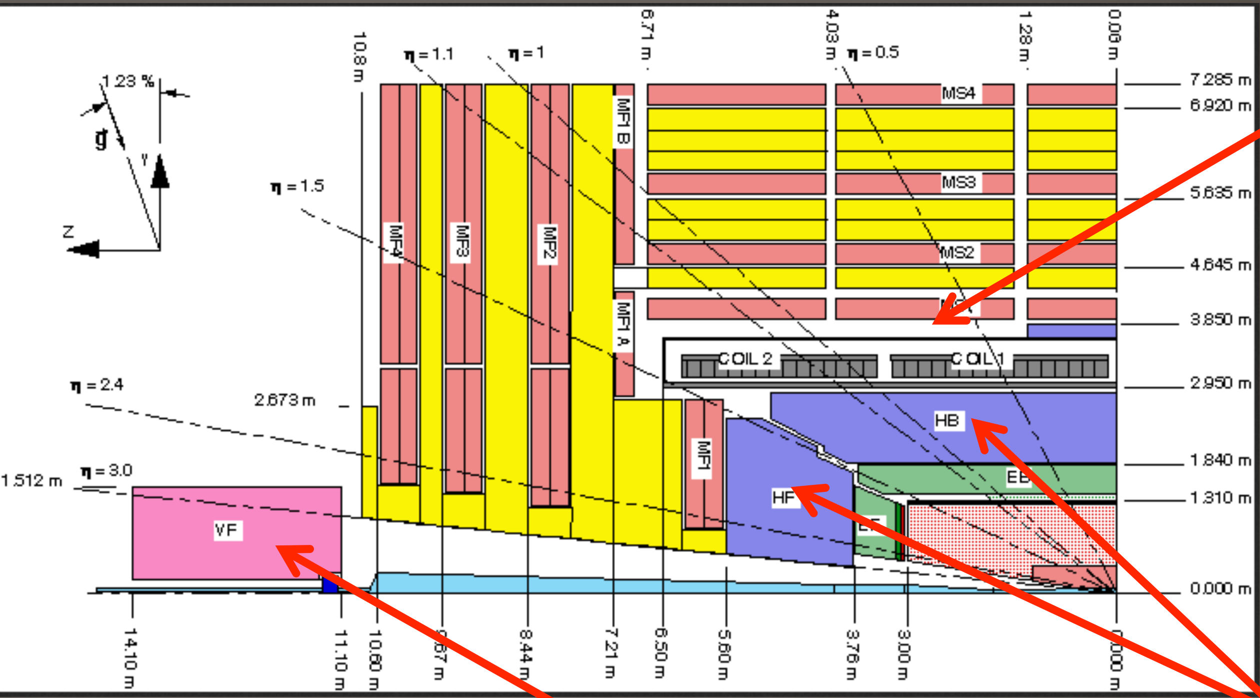
New beampipe

New reduced Diam. Pipe ready for installation of upgraded pixel in 2017

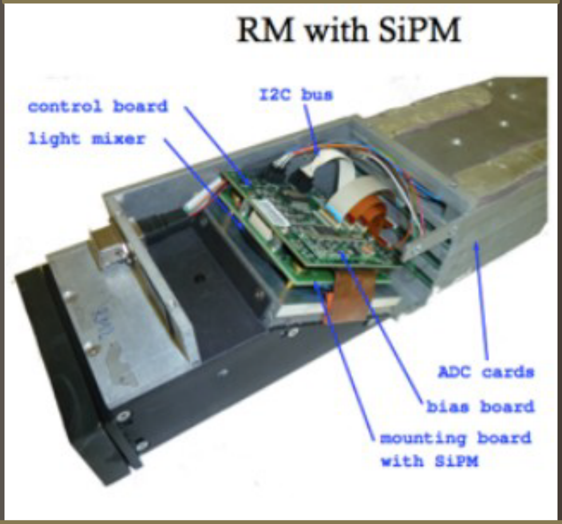




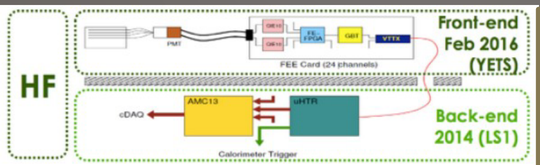
HCAL

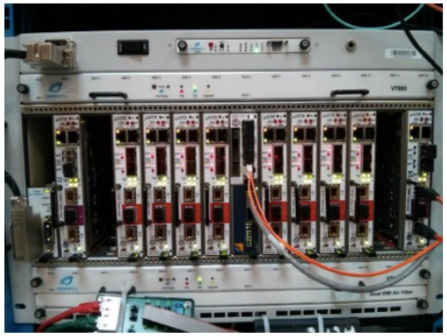


HO: replacement of HPDs by SiPMs



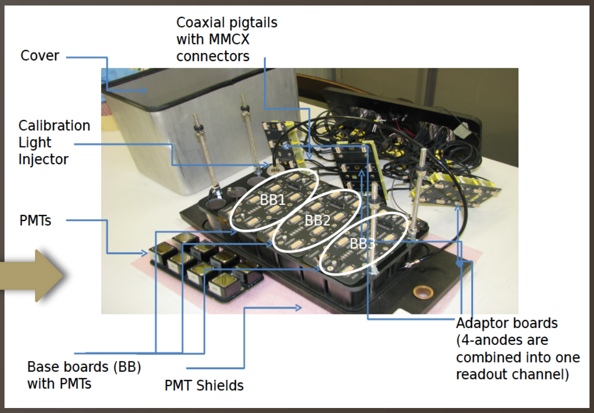
HBHE: control modules Replacement and misc repairs



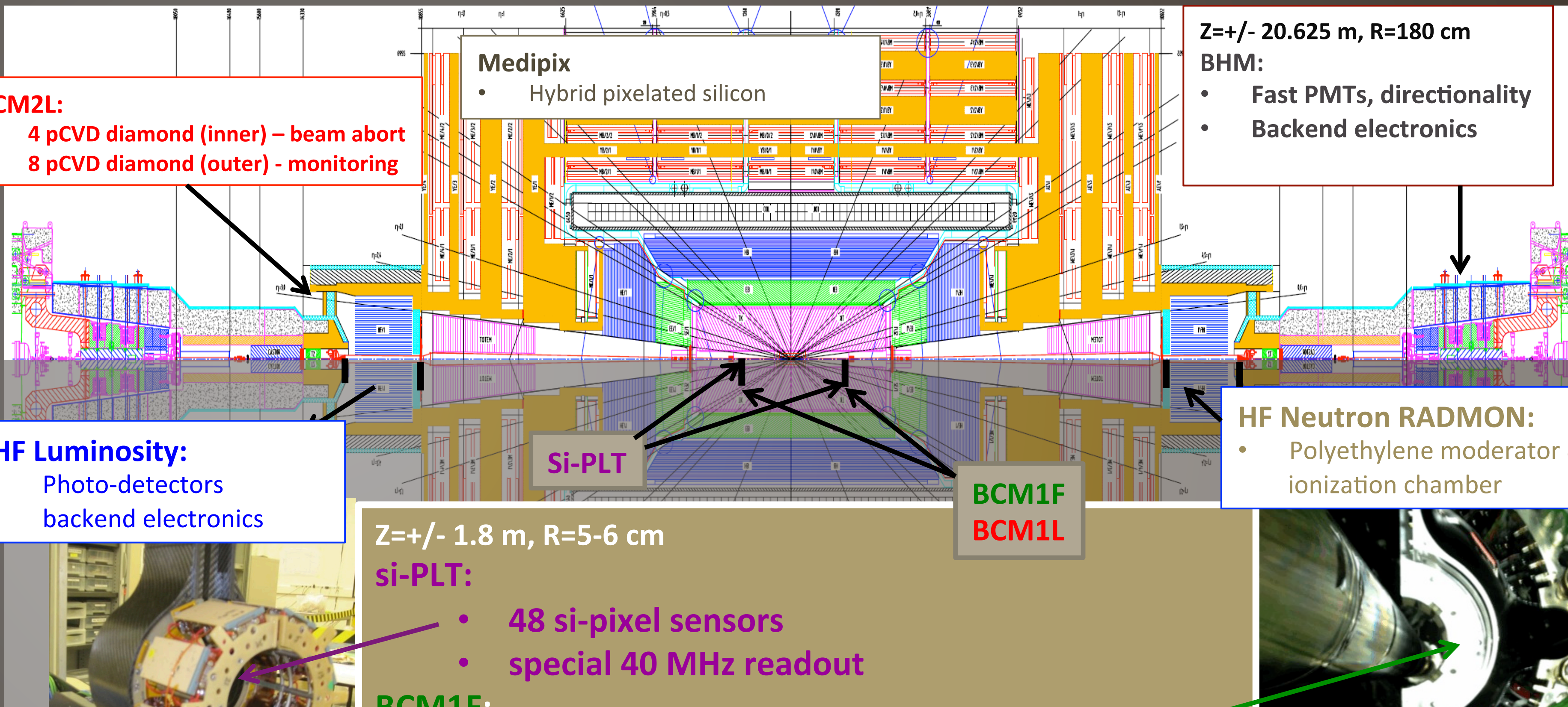


HF: switch to multi-anode PMTs and uTCA BE electronics

New Thin window, dual-.-anode to reduce Cherenkov noise from punch through muons



Beam Radiation Instrumentation and Luminosity
measure backgrounds, protect the experiment and measure luminosity



BCM2L:
- 4 pCVD diamond (inner) – beam abort
- 8 pCVD diamond (outer) - monitoring

Medipix
- Hybrid pixelated silicon

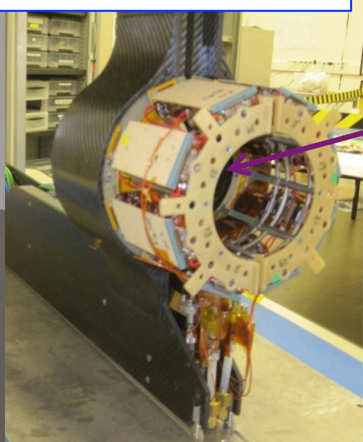
Z=+/- 20.625 m, R=180 cm
BHM:
- Fast PMTs, directionality
- Backend electronics

HF Luminosity:
- Photo-detectors
- backend electronics

Si-PLT

BCM1F
BCM1L

HF Neutron RADMON:
- Polyethylene moderator & ionization chamber

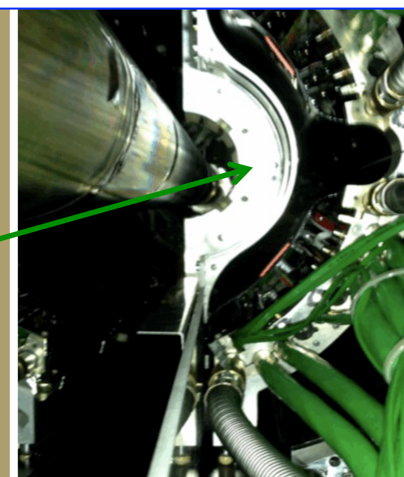


Z=+/- 1.8 m, R=5-6 cm

si-PLT:
- 48 si-pixel sensors
- special 40 MHz readout

BCM1F:
- 48 single crystal diamond sensors
- fast MIP counter, triggerless readout

BCM1L:
- 4 pCVD diamond – beam abort



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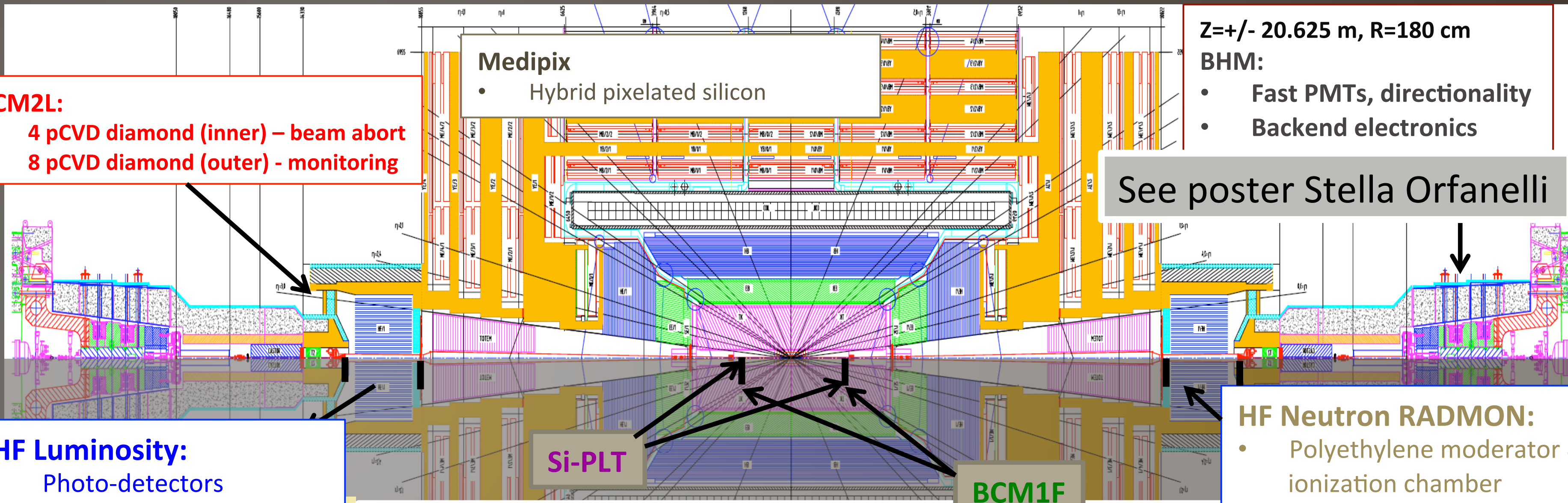

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- **Backend electronics**

See poster Stella Orfanelli

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- Photo-detectors
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BCM1F
BCM1L

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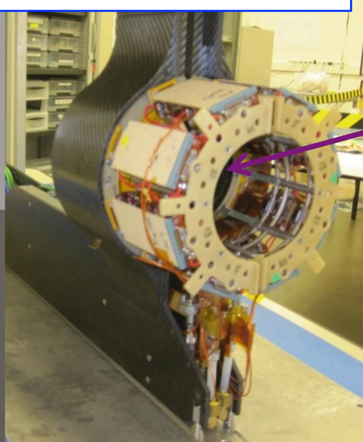

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See poster Andreas Kornmayer,

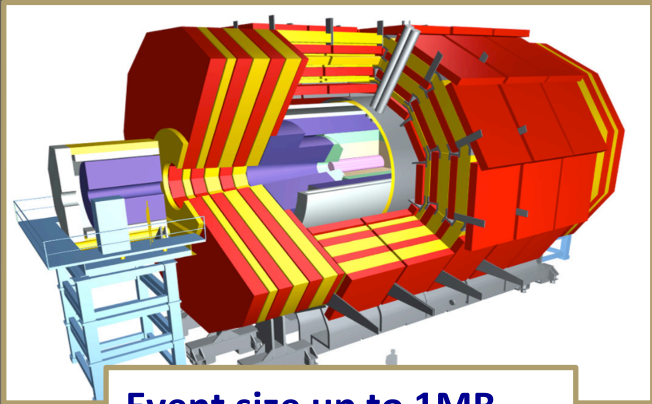
See poster Olena Karacheban

DAQ

&

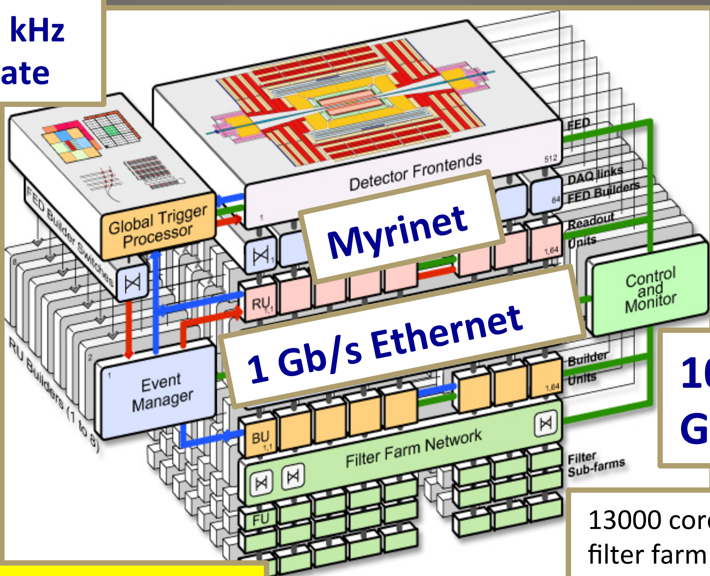
Triggers

DAQ1<------------------->DAQ2



Event size up to 1MB

100 kHz
L1 rate

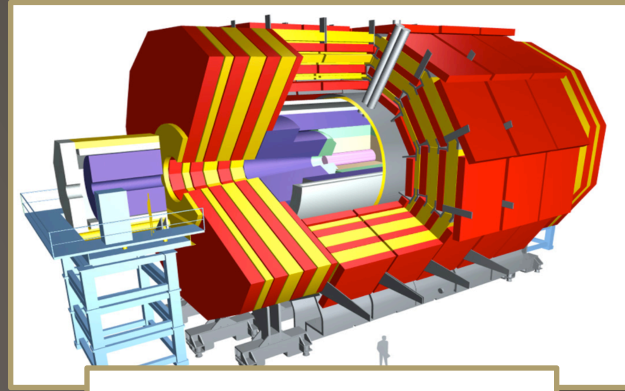


100 GB/s

13000 core filter farm

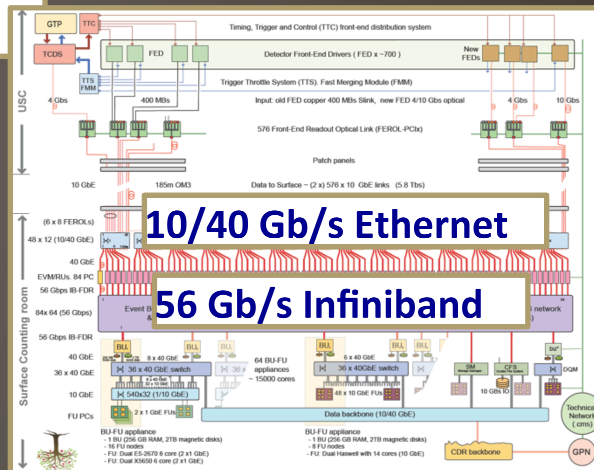
CMS DAQ 1

max. 1.2 GB/s to storage



Event size up to 2MB (large margin)

100 kHz
L1 rate



200 GB/s

15000+ core filter farm

CMS DAQ 2

~ 2 GB/s to storage

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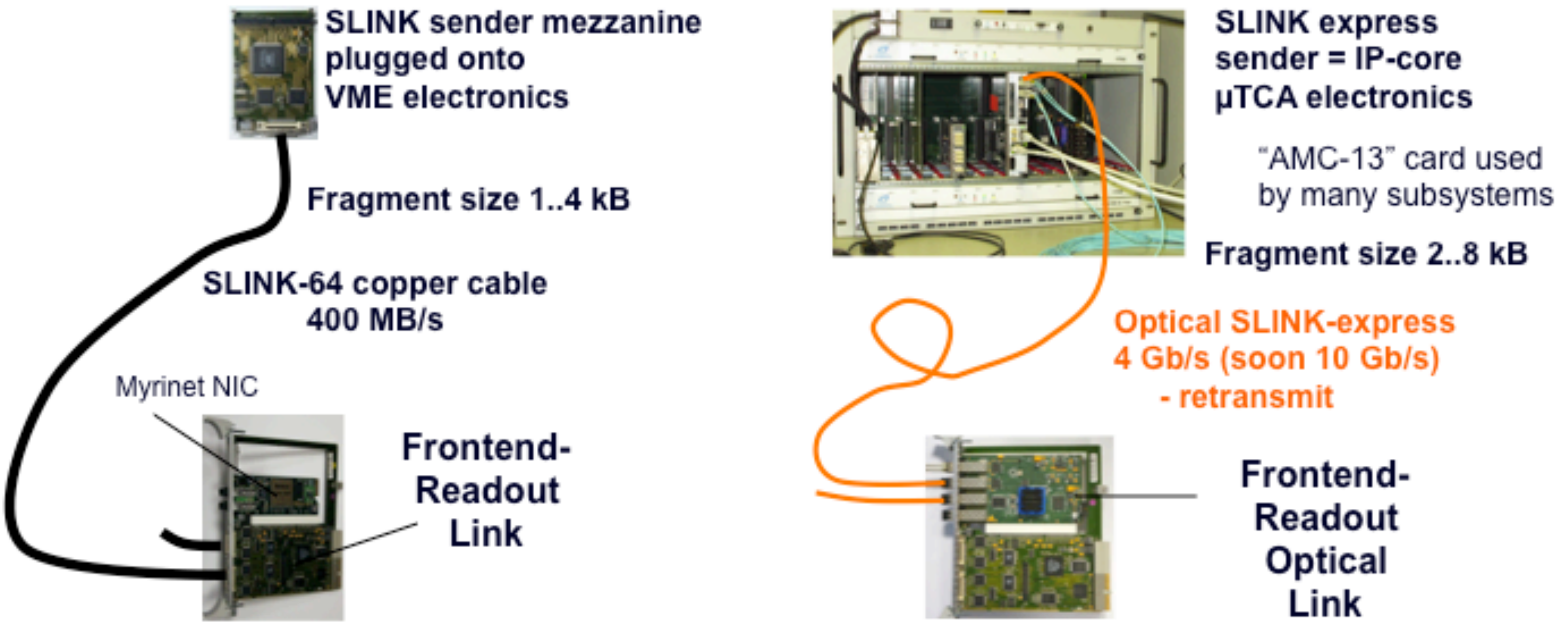
DAQ1<------------------->DAQ2

New or upgraded detectors in CMS

- Several detectors / online-systems being upgraded to cope with higher luminosity
- Increase of event size
- Readout electronics of upgraded systems based on µTCA

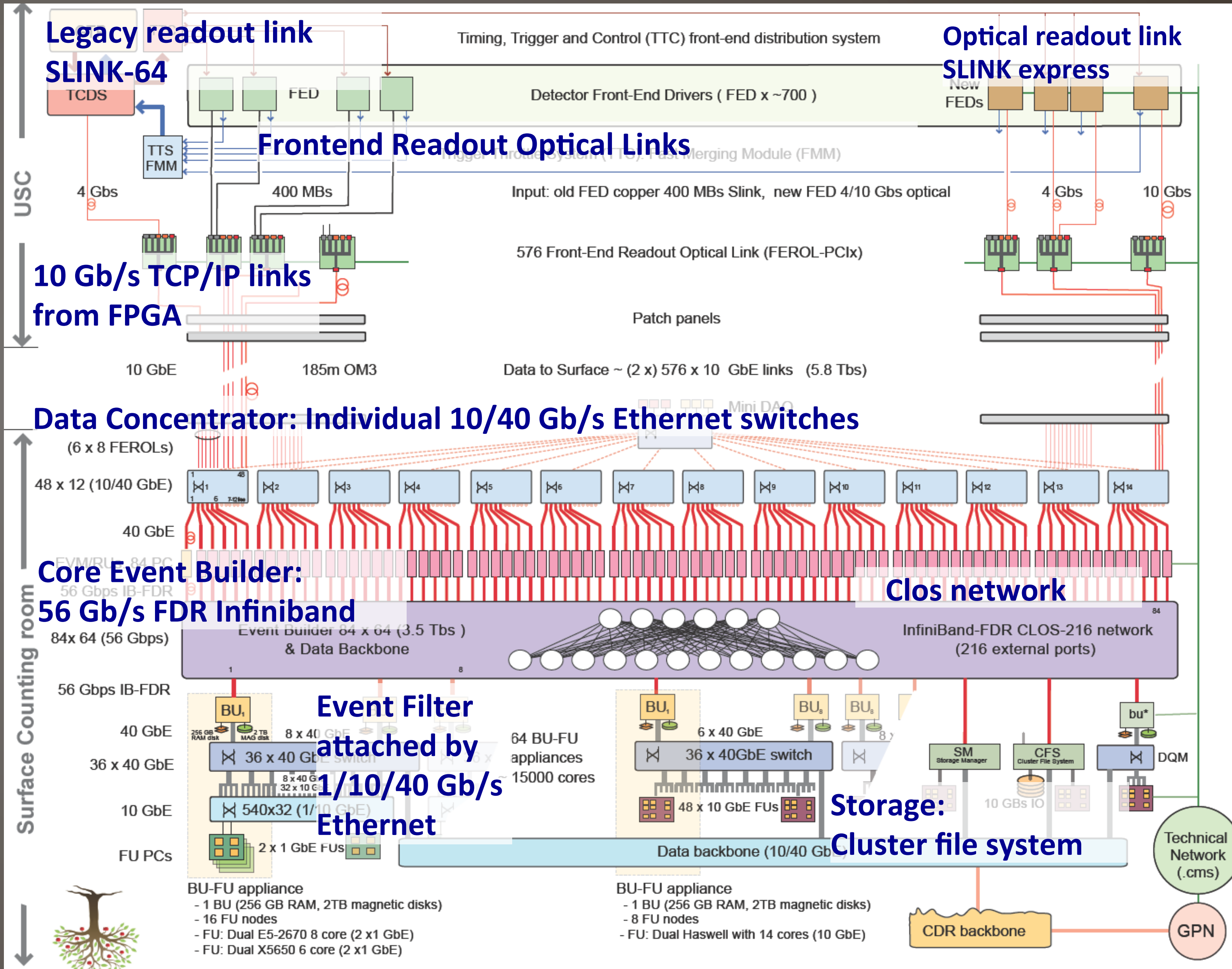
- 2014: New Trigger Control and Distribution System
- 2014: Stage-1 calorimeter trigger upgrade
- 2014/15: new HCAL readout electronics
- 2016: Full trigger upgrade
- 2017: New pixel detector and readout electronics



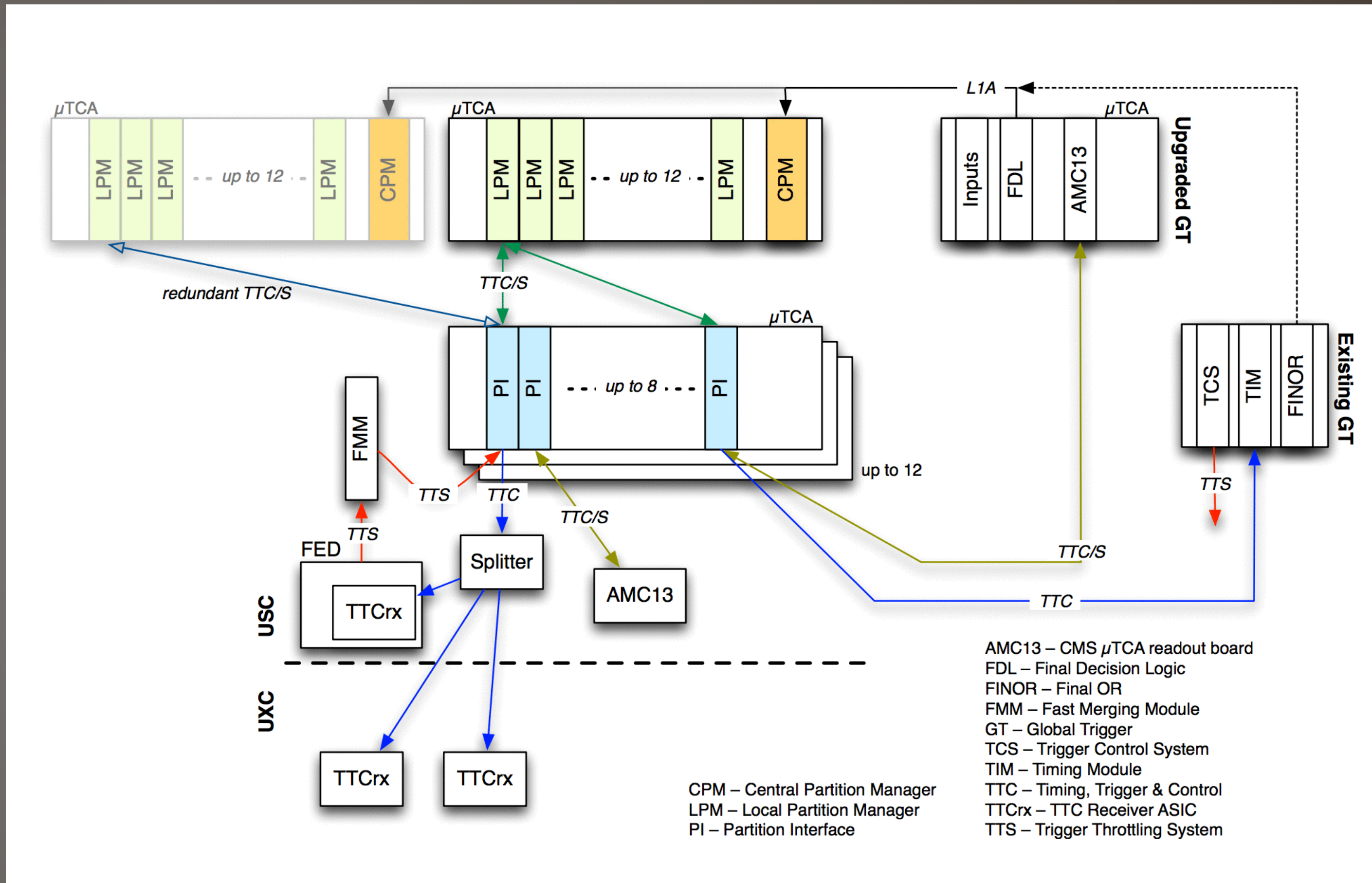
640 Legacy Links: SLINK-64
(600 after pixel upgrade)

+ 50 new Links: SLINK-express
(170 after pixel upgrade)

DAQ2 for Run2



new Timing and Control and Distribution System: TCDS



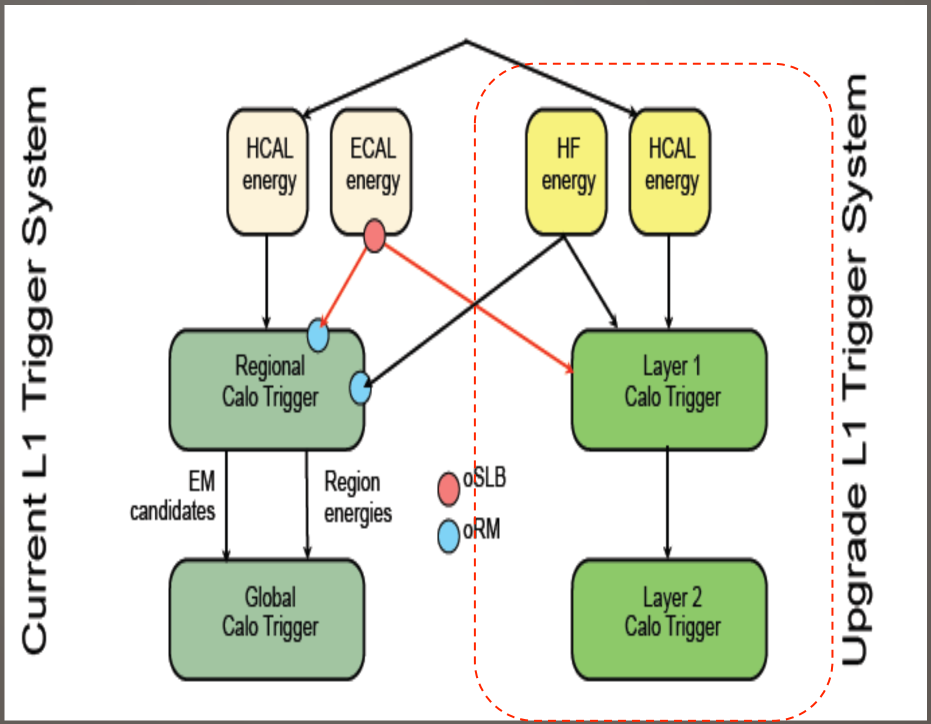
Motivation:

– New partitions required for upgrade and future detector

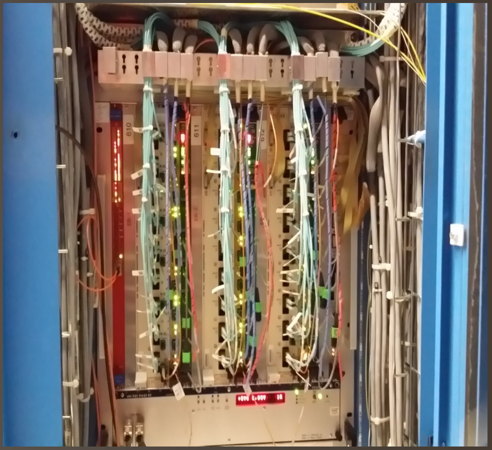
– Merging logically different components: L1 trigger and Timing and Control system

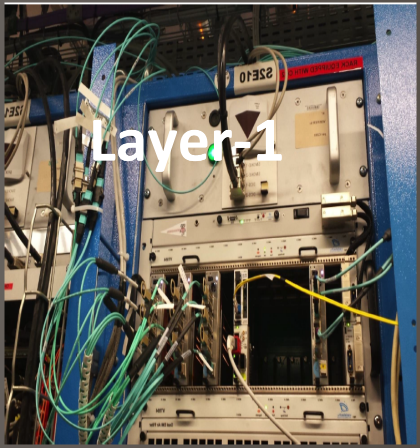
L1 Trigger Upgrade Calorimeters

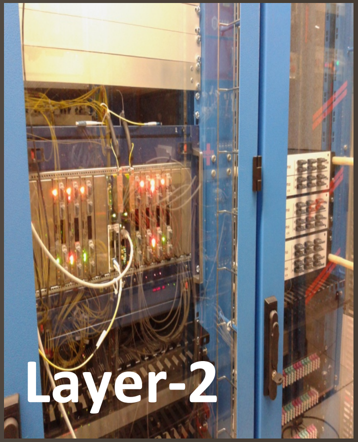
- **Upgrade to ECAL Level-1 trigger:** change links between ECAL Trigger Concentrator Cards (TCC) and Regional Calorimeter Trigger (RCT)



oSLB



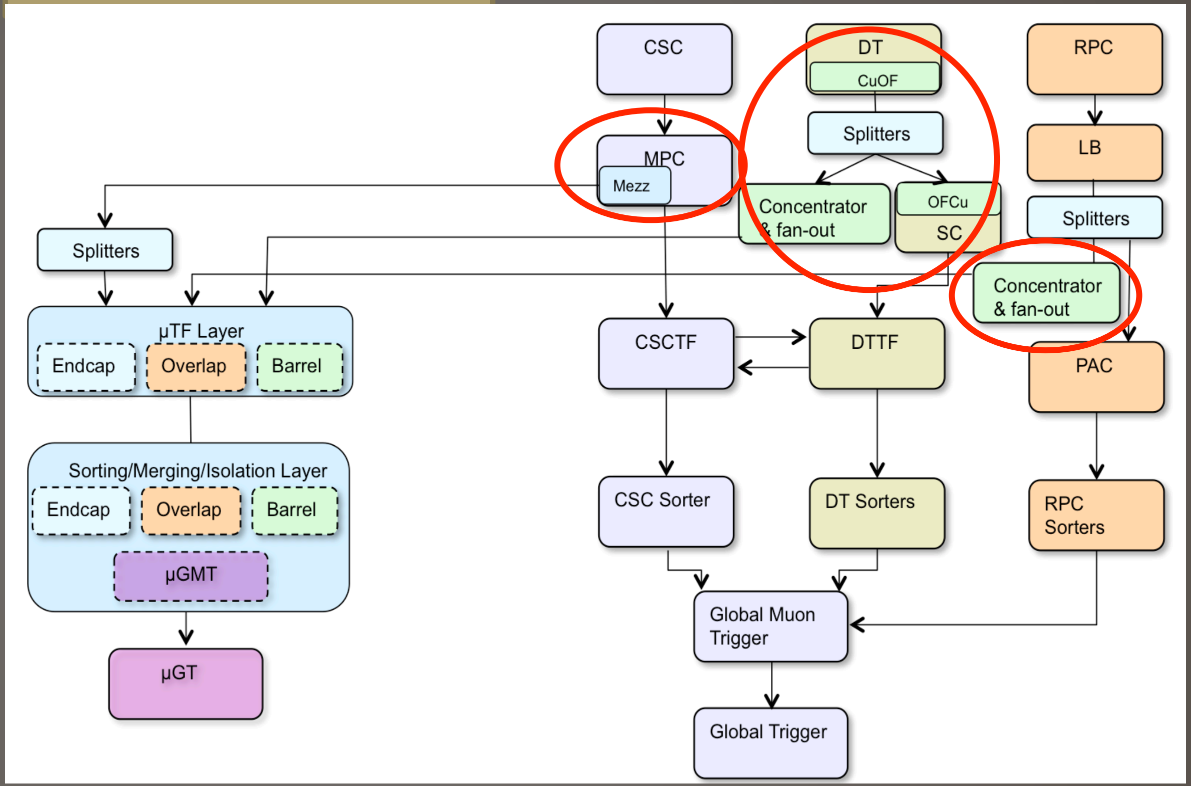


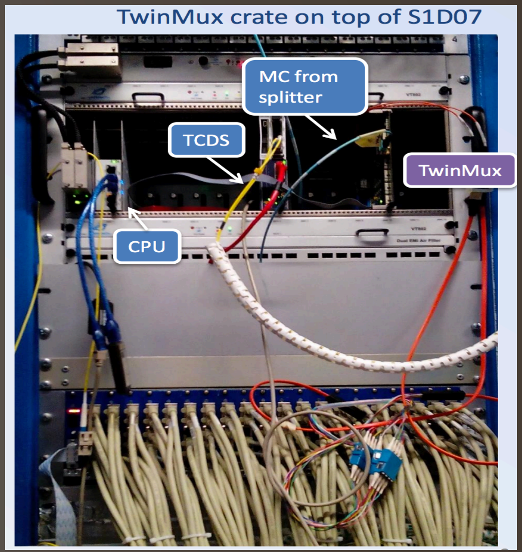


L1 Trigger Upgrade: Muon Trigger

New system

Legacy system





Also in Poster
Pierluigi Bortignon

- Build up new Muon Track Finders in 2015 and commission in parallel (ready for physics by 2016)
- Full split of CSC signals installed and tested
- Split a slice of the DT and RPC signals to commission the new trigger

Improvements of High Level Trigger [HLT]

8 TeV → 13 TeV
Factor ~2 in cross-section from the increased energy
Factor > 2 for multiple object triggers (due to combinatorial)

50 ns → 25 ns bunch spacing
Increased level of out of time pileup

Peak luminosity from ~7e33 cm-2s-1 to 1.4e34 cm-2s-1 Factor 2 in rate

Rate x 4 (at least)
In time pileup from <PU> ~ 25 (Run1) up to <PU> ~ 40 (Run2)
Out of time pileup has a much larger impact than at Run1

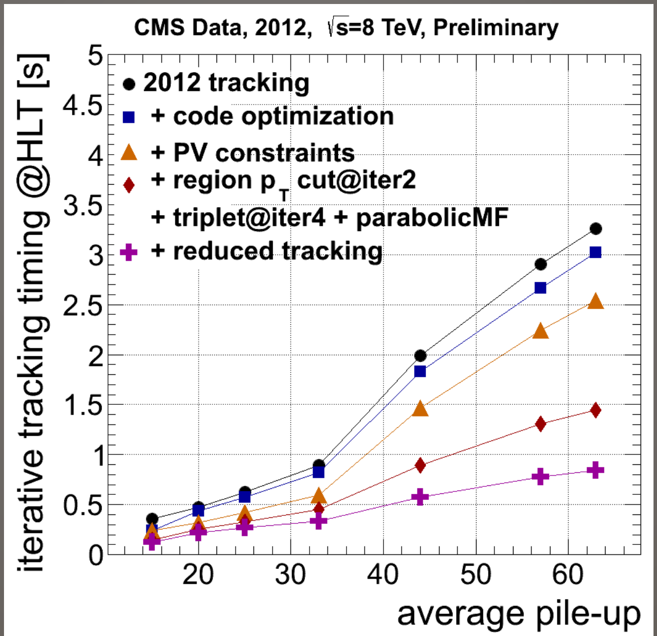
Reminder L1 ~ 100 kHz and HLT output rate ~1 kHz

Use of Particle Flow (PF) at the HLT level

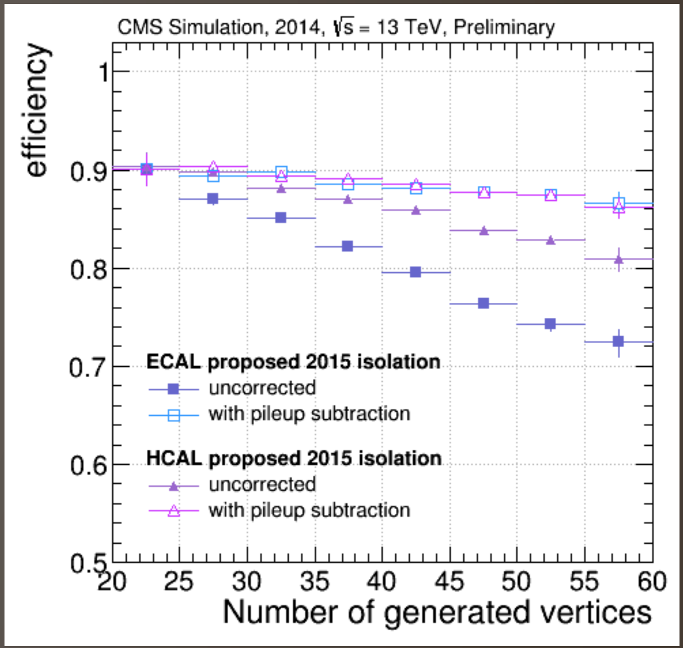
Major directions driving the developments were:
pileup mitigation, both for in-time and out-of-time pileup
improved efficiency for high-pt
general improvements to the algorithms building on experience in Run 1

Improvements of HLT exemple_1

Tracking improvements



Effect of **pileup subtraction** on the 2015 "PF cluster based" isolation, and comparison of performance with the one used at Run1



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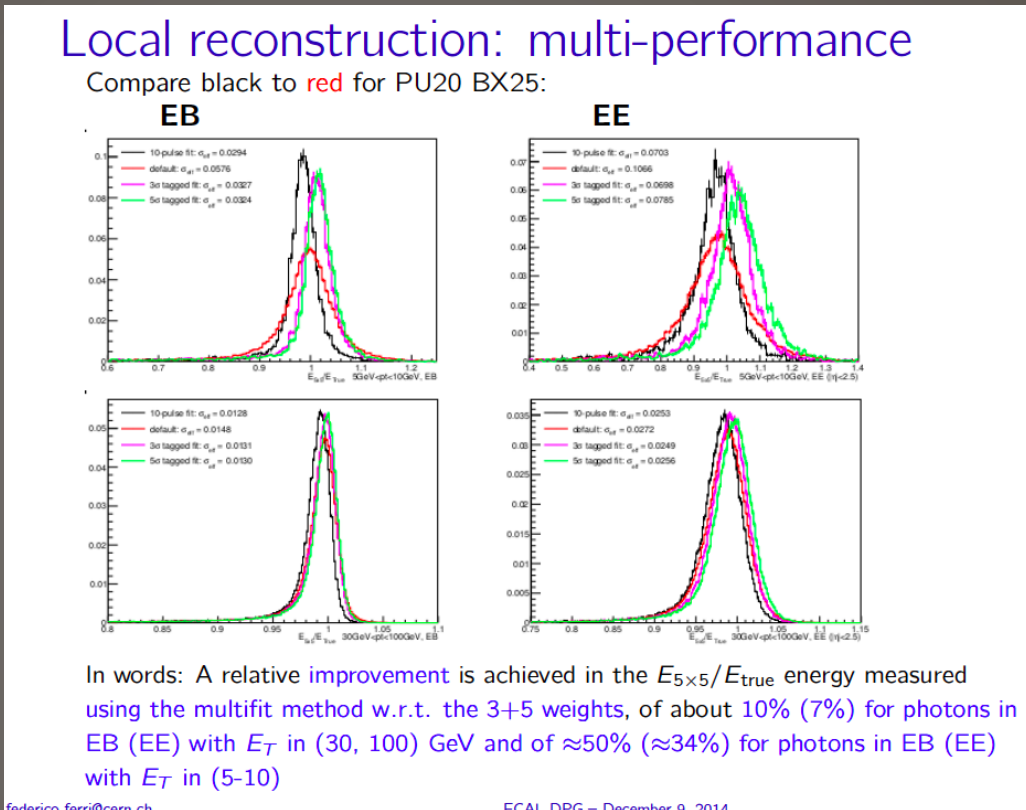
Improvements of HLT exemple_2



ECAL

New “multifit” method of local reconstruction validated on simulation and Run I data

- -Improved performance with high pileup
- -Will be used offline for 50ns & 25ns running; in HLT for 25ns running

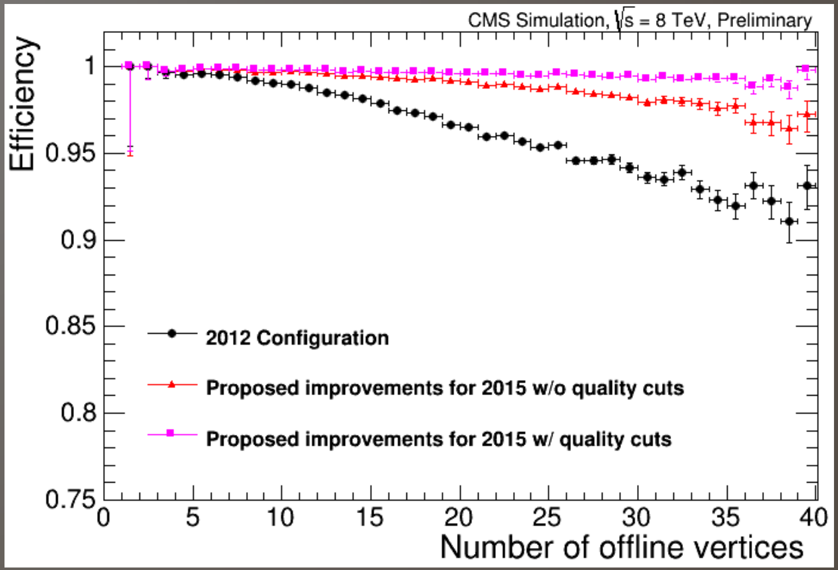
Improvements of HLT exemple_3 Muon

L1 updates for 2015

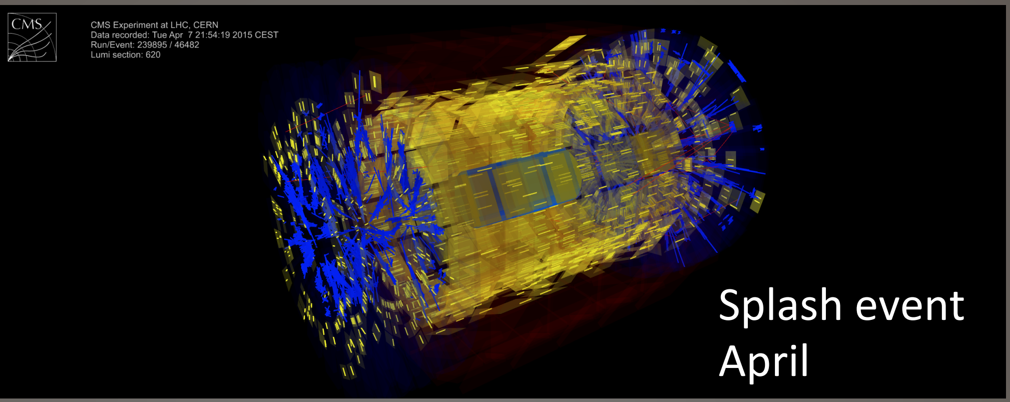
- Additional muon chambers in the endcaps
- Increased granularity of the CSC (endcap muon) readout

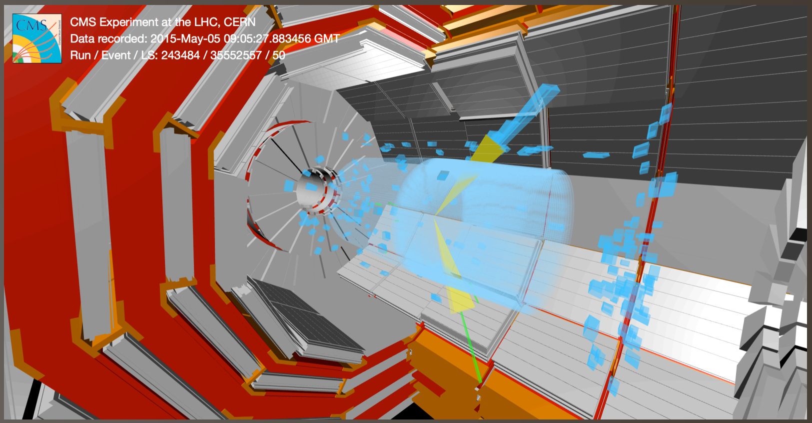
HLT

Main updates to the Level_3 algorithm for Run2:
- Use $\chi 2$ measurement to assign hits to tracker tracks
- Quality filters on tracker tacks become part of the L3



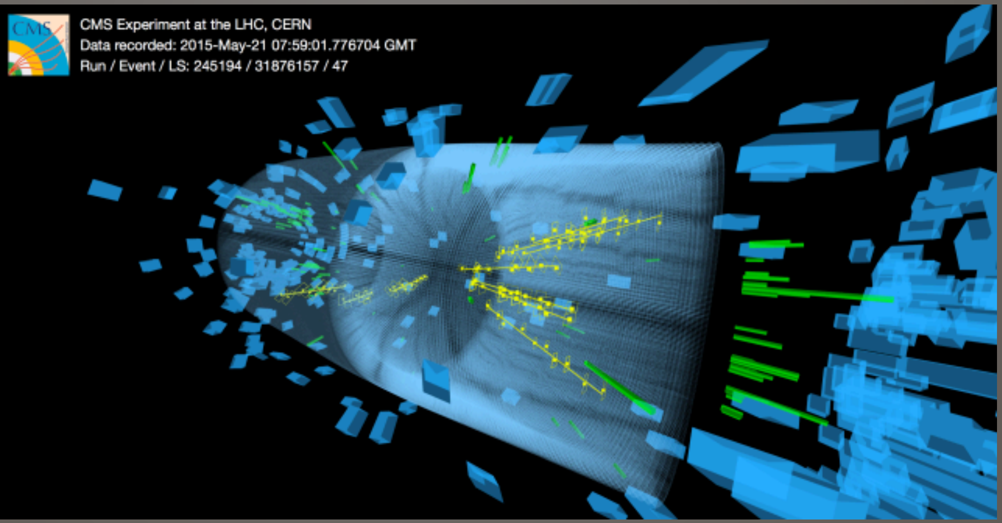
CMS READY FOR RUN 2





First low energy proton-proton collisions after LS1 (900 GeV)

This di-jet event produced from proton-proton collisions was detected in the CMS detector. The total energy is approximately 30 GeV in each jet.



13 TeV proton-proton collisions after LS1
May, 21th

Thank You & Stay tuned

Some Glossary

BRIL : Beam Radiation Instrumentation and Luminosity
BHM: Beam Halo Monitor
PLT: (Si) Pixel Luminosity Telescope
BCMxx: Beam Condition Monitor