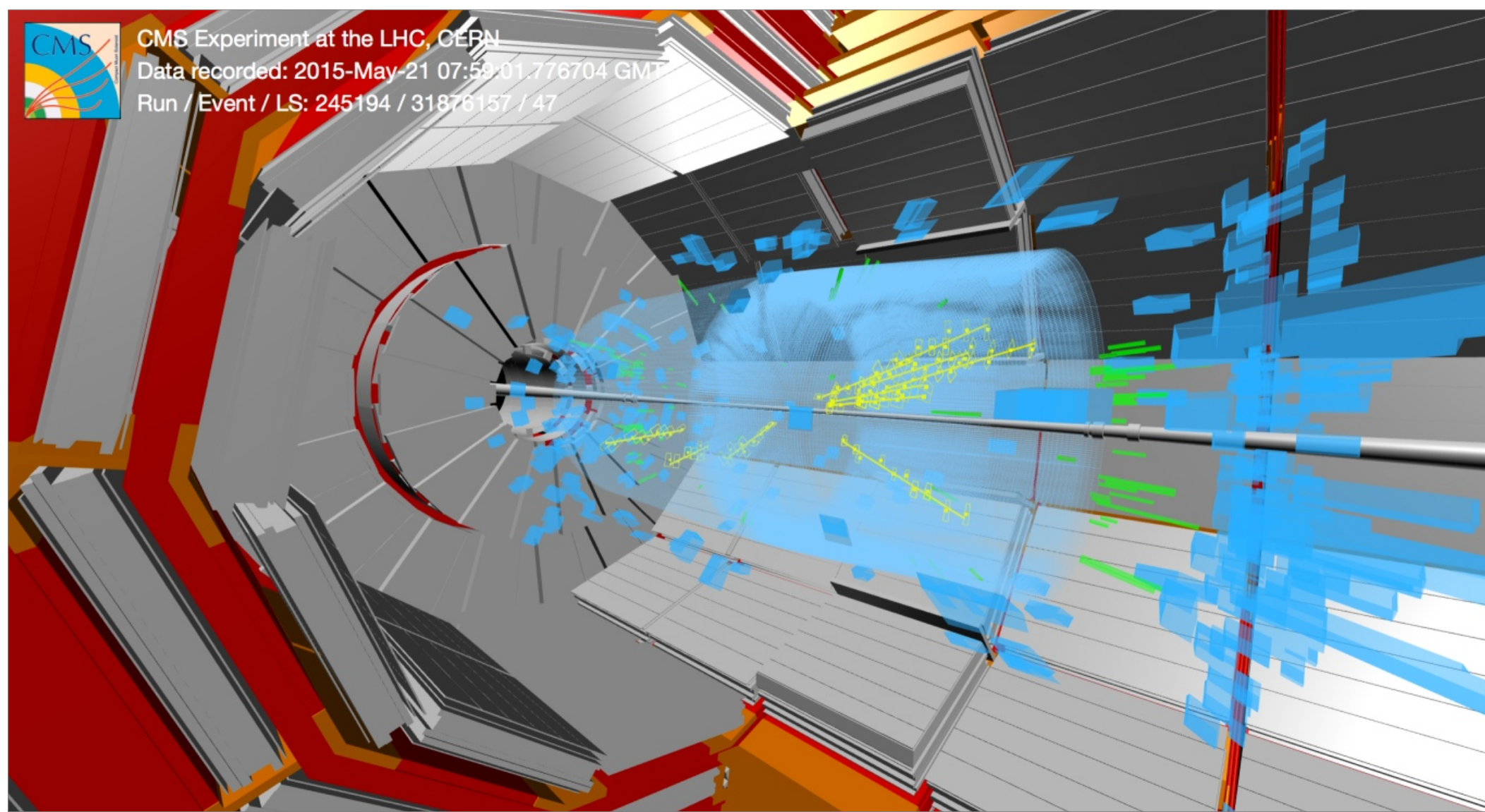




CMS Experiment at the LHC, CERN
Data recorded: 2015-May-21 07:59:01.776704 GMT
Run / Event / LS: 245194 / 31876157 / 47

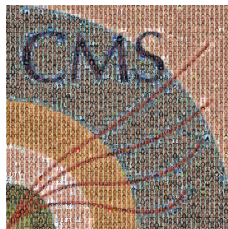


CMS Status Report

M.Bachtis (CERN)

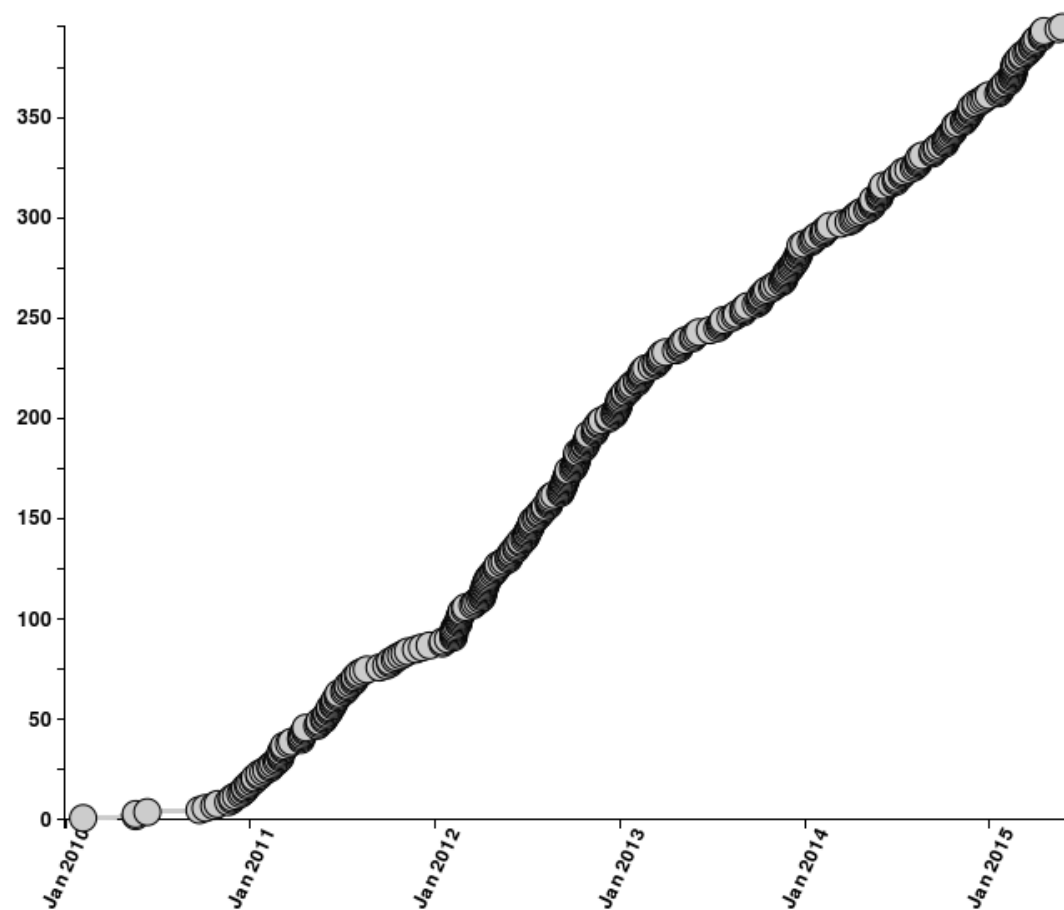
On behalf of the CMS collaboration

LHCC Open session, June 3rd 2015



Run I Physics

- 396 papers submitted
 - +23 on cosmic data
 - +47 in final state of review
- Large harvest from Run I data
 - Most ongoing Run I analyses → SM measurements
- Ready for Run II data analysis

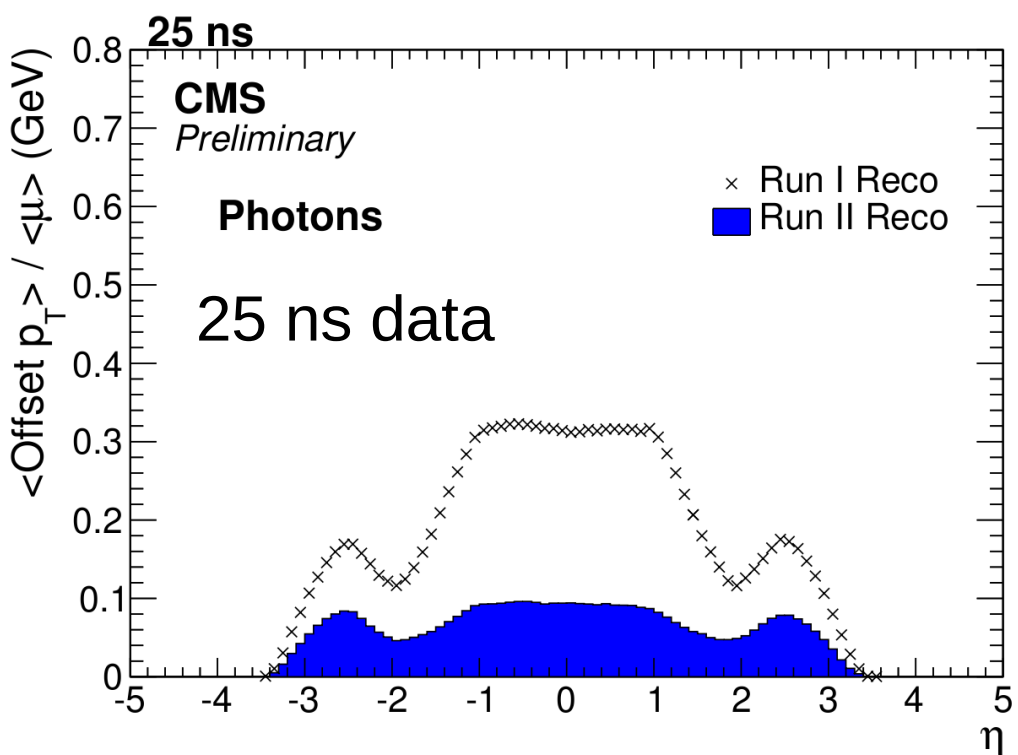
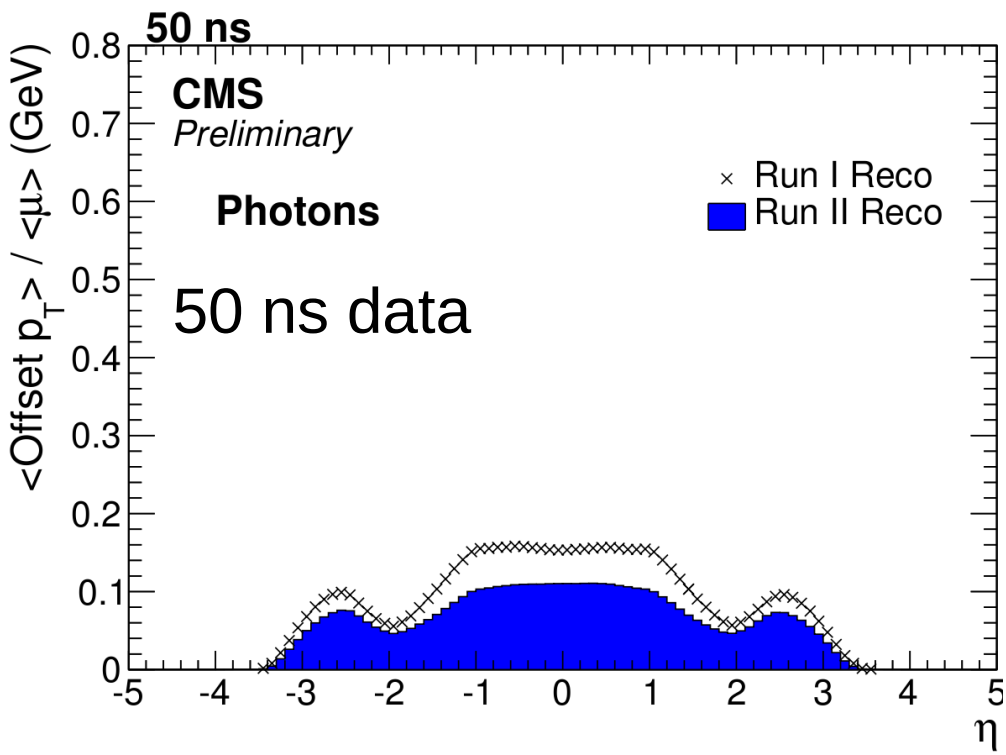
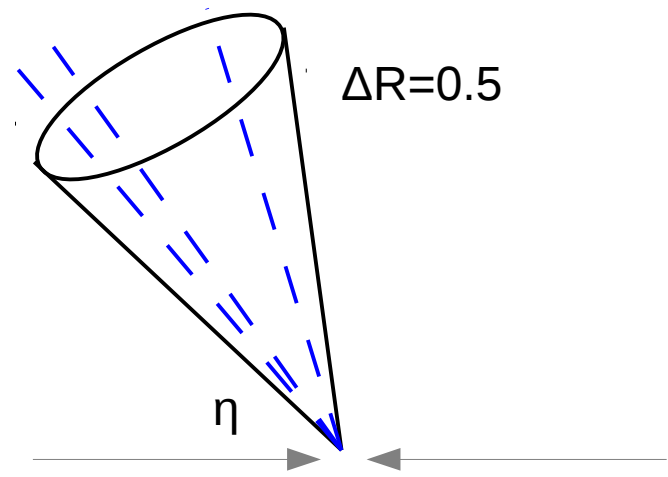


Reconstruction improvements for Run II

- Significant effort on algorithm improvements with emphasis on PU mitigation
 - Improvement on track reconstruction
 - Out of time PU mitigation in the calorimeters
 - Pulse fit in ECAL/HCAL to extract the in-time energy per cell
 - Revisiting of Particle Flow event reconstruction
 - A lot of ideas from the upgrade studies
- Improvements evaluated on 8 TeV data by re-reconstructing them with new algorithms
 - Organized Data to Data comparison workshop for Physics Objects

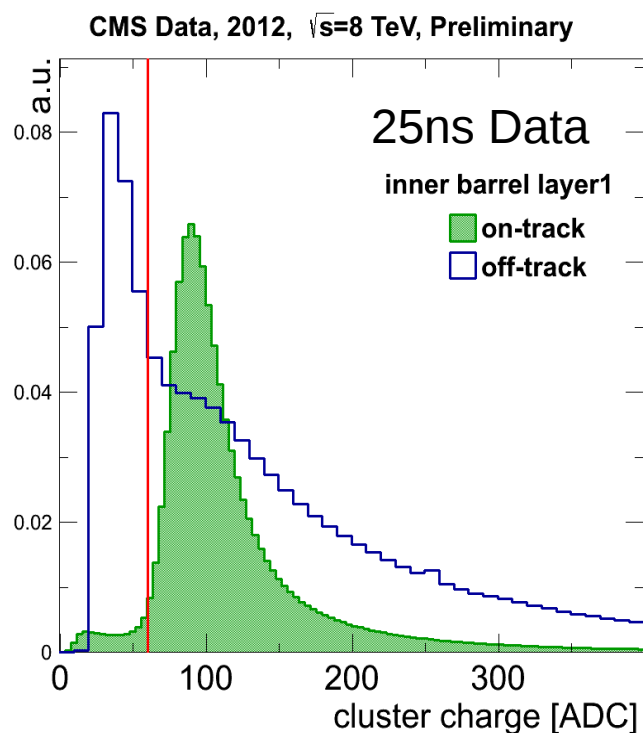
Out of Time PU mitigation in Calorimeters

- Summing particle energy in random cones in ϕ across η
 - Indicator of the PU energy to be subtracted for a given cone
- New reconstruction: bunch spacing independent

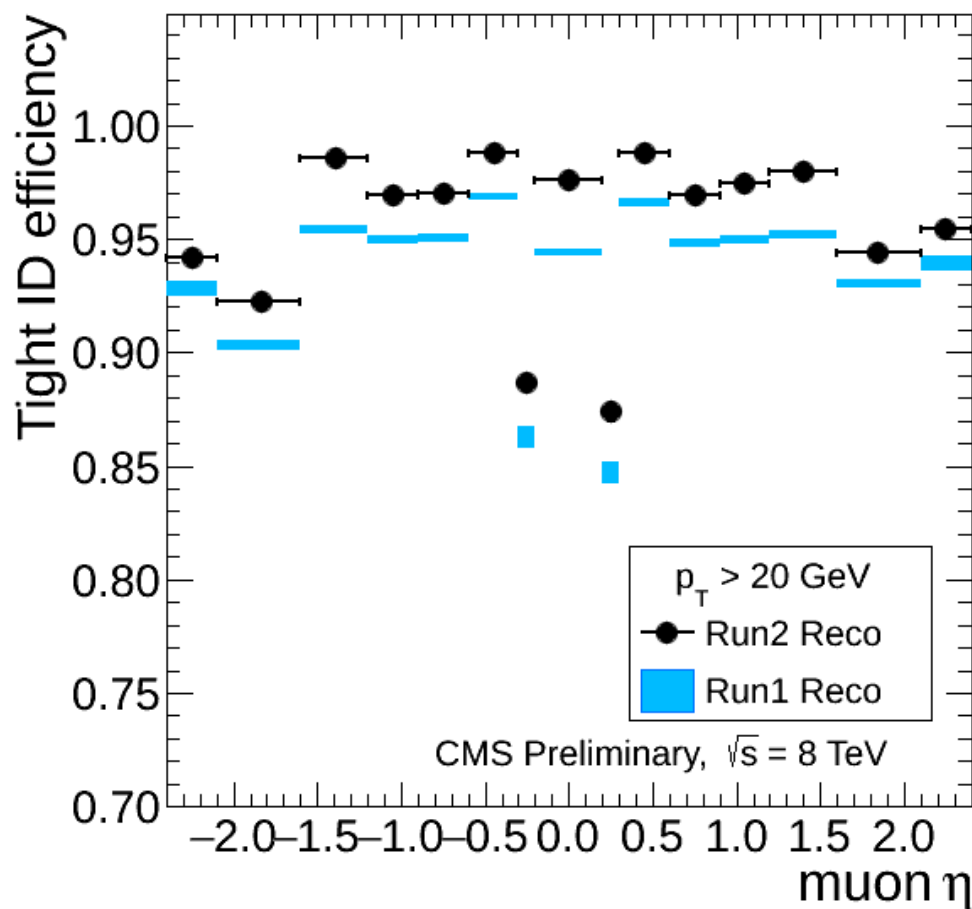


Tracking/Muons

- Improved track reconstruction
 - 2x faster at the same PU, lower fake rate
 - Improved track quality
 - Use of cluster charge to reduce OOT hits

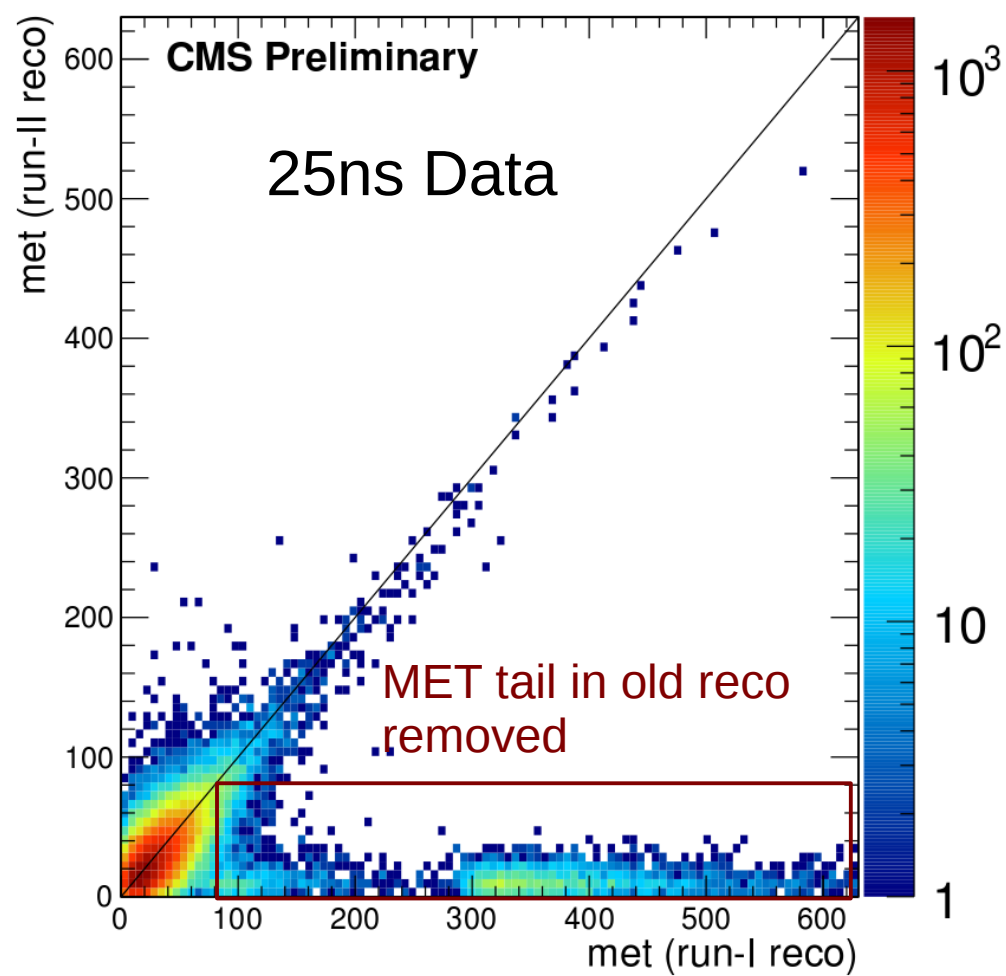
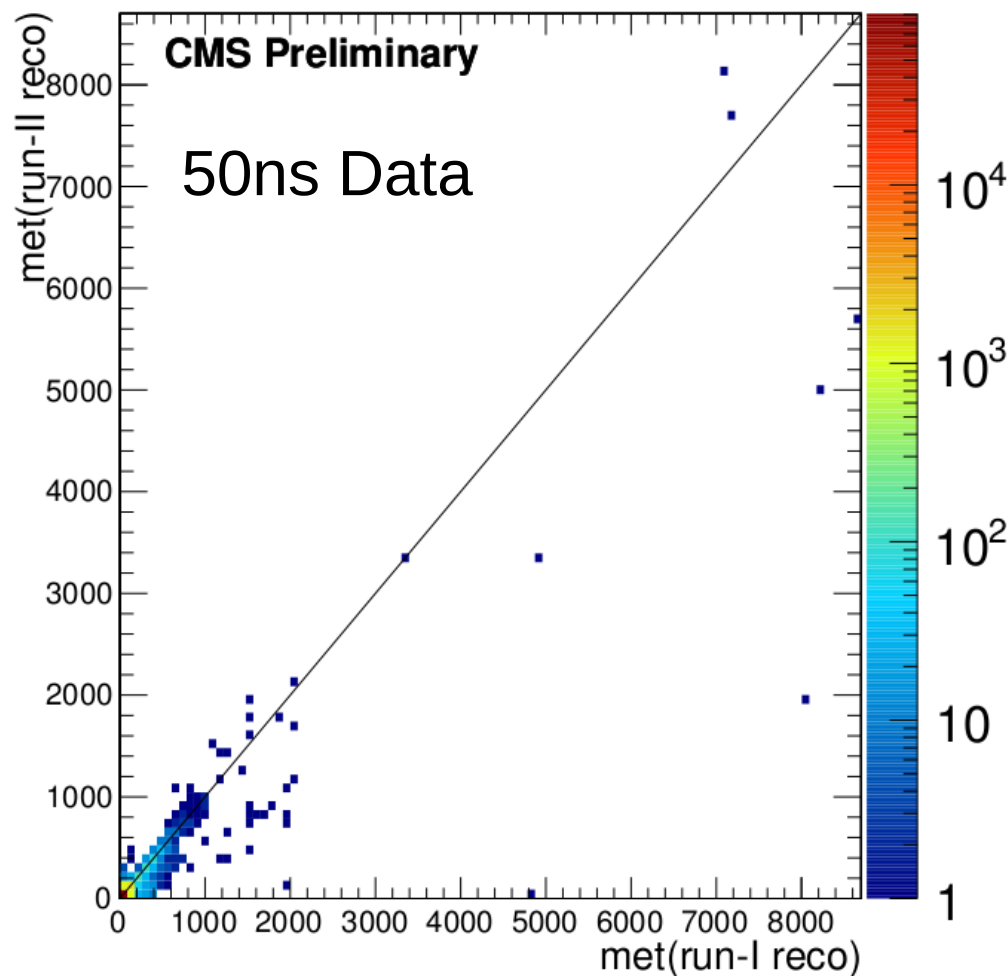


- New muon specific tracking
 - Recovering lost tracks (outside-in) and non associated hits (inside-out)



Tails of Missing ET

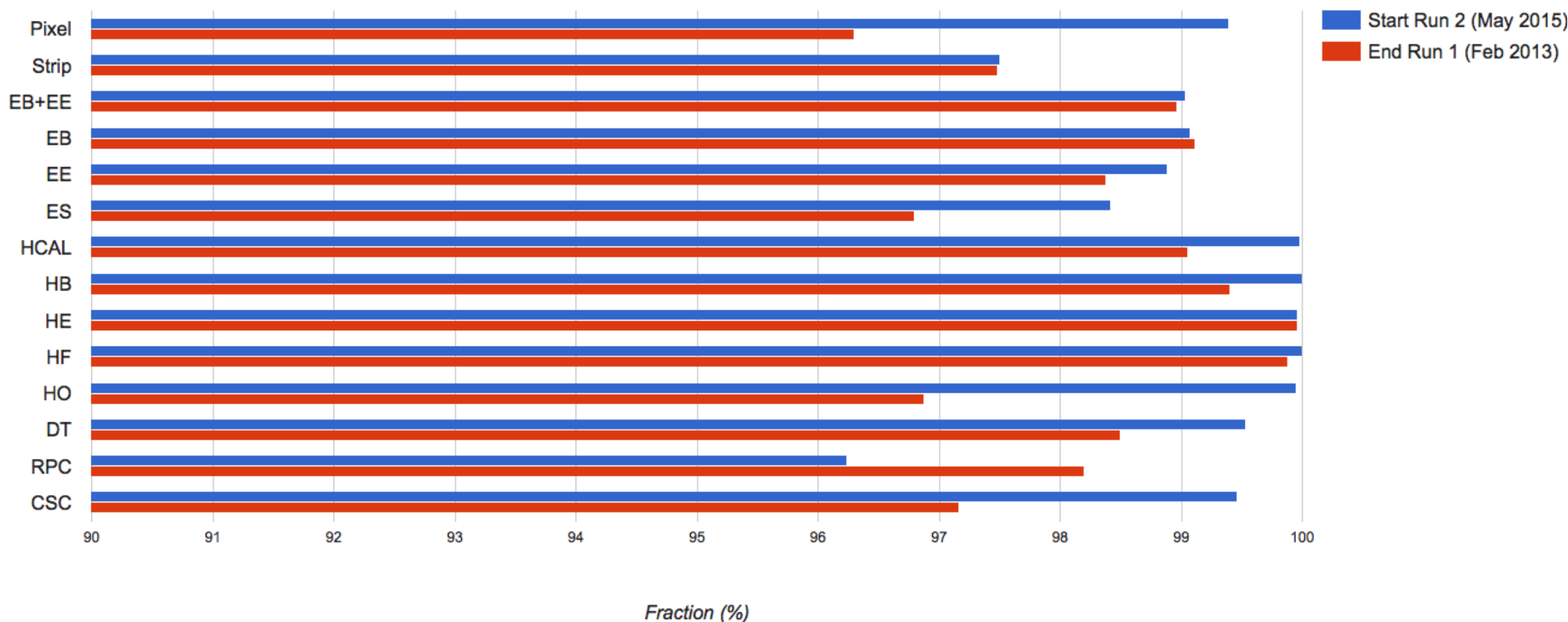
- Event by event comparison of E_T^{miss} between algorithms
 - Outliers reduced in Run II reconstruction in 50 ns data
 - Large tail of the Run I reconstruction removed in 25 ns data



Detector commissioning

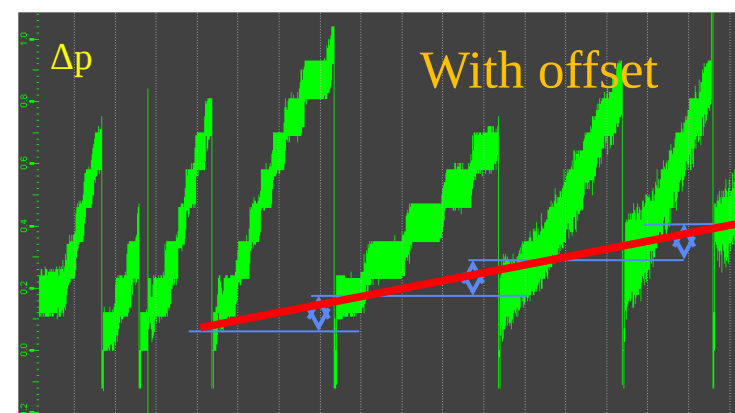
- All sub-detectors ready for data-taking
 - Active channel fraction higher than Run 1
- Now tuning the timing/synchronization using collisions

Active Detector Fraction Run 1 to Run 2



Status of the Magnet

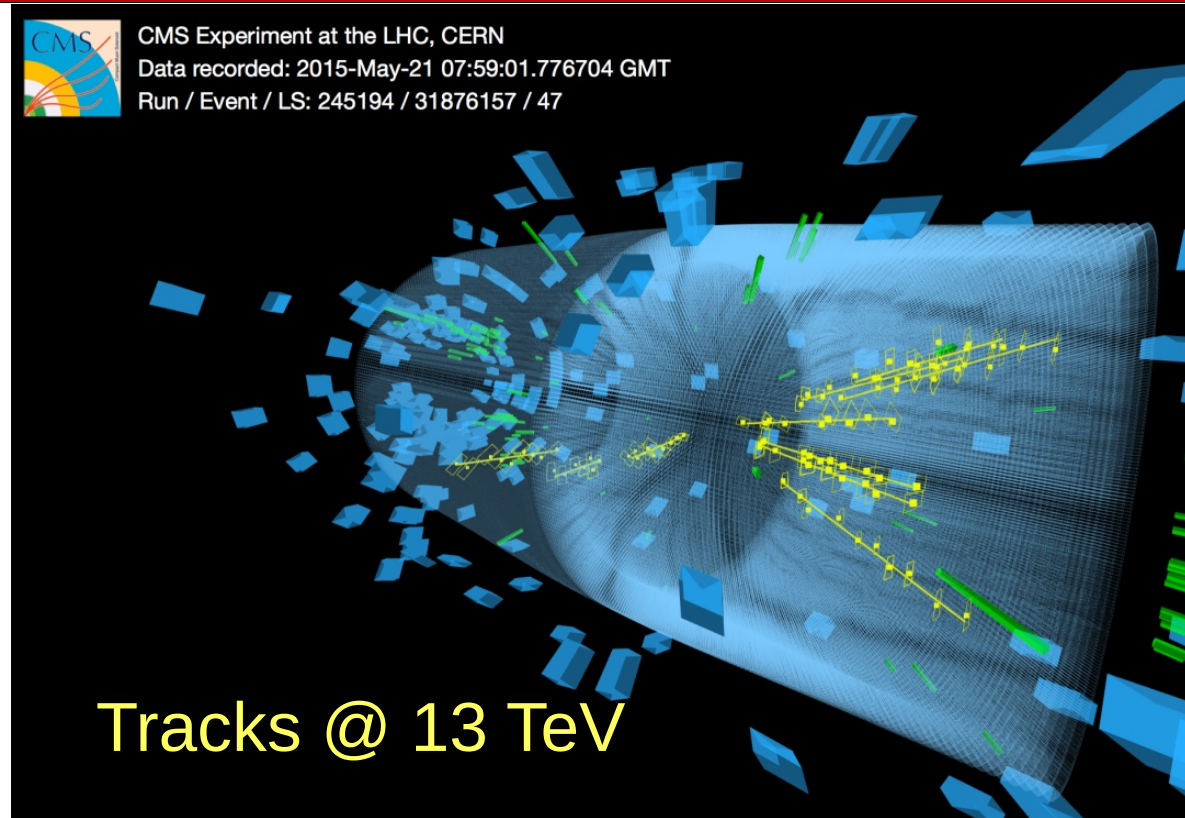
- Cryo cold box instabilities since March
 - Suspected oil contamination from compressor plant
- Three increasingly invasive campaigns of cleaning and replacement since Apr 1st
 - Many thanks to TE and EN departments for exceptional effort
- Cold box restarted on 30th May
 - Under close observation
- Decision on re-connecting the magnet imminent
 - If all goes well, operational ~8th June
- Precautionary preparations for comprehensive cleaning campaign
 - YETS 2015-16 or sooner



- Pressure drop across filter over several regeneration cycles
 - Offset indicates non-volatile pollutant

Tracker

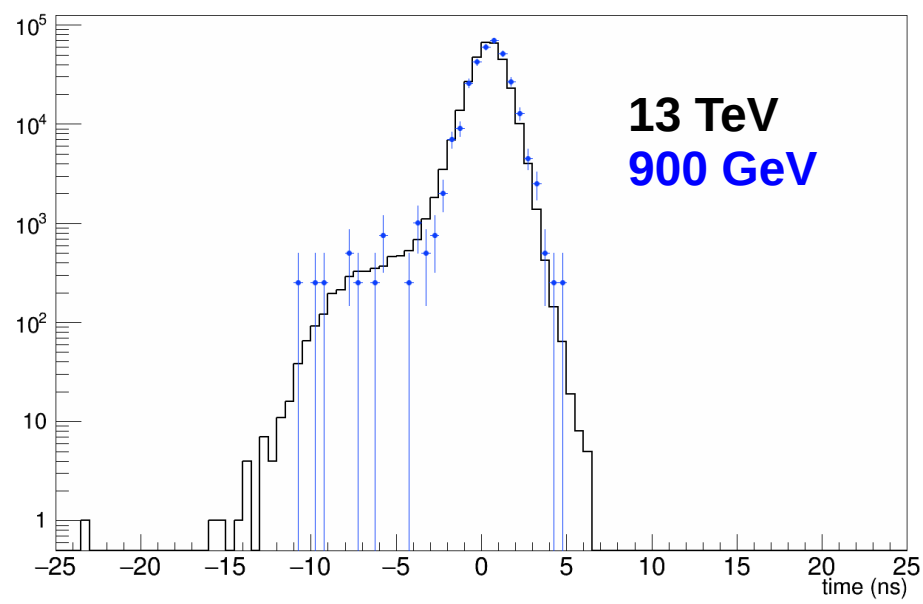
- Cosmic data needs for tracker alignment satisfied
 - Especially after re-inserting the pixel detector
 - Alignment achieved better than start of Run I



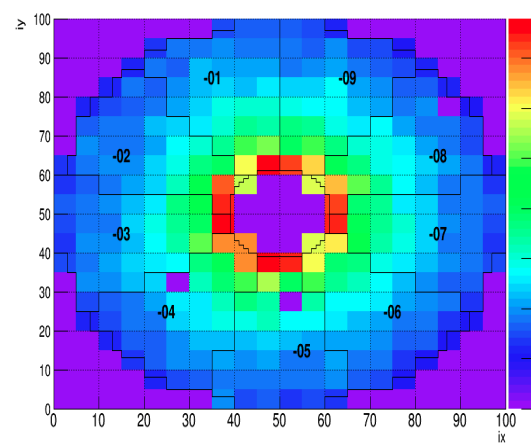
| | Min. required for tracker alignment | optimal | recorded |
|------|-------------------------------------|---------|-------------|
| 0T | 100h | 400h | 400h |
| 3.8T | 100h | 400h | 200h |

- All subsystems running smoothly
- Timed in for readout better than 1 ns
- 5 GeV ET e/γ trigger activated and timed-in
 - with Muons, HCAL, trigger
- Energy spectra in Barrel, Endcap and Preshower OK
- Already using π^0/η for calibrations

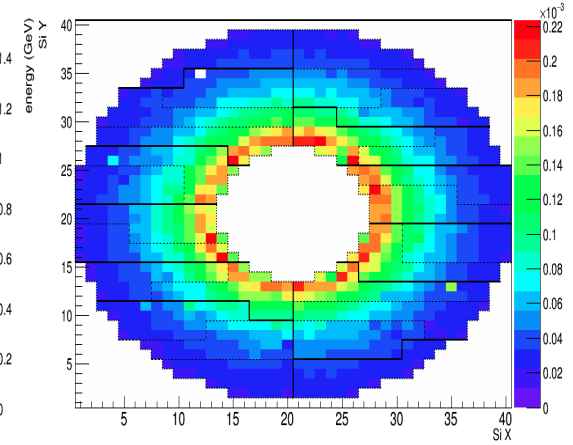
ECAL Barrel Readout Timing 2015



Endcap Energy

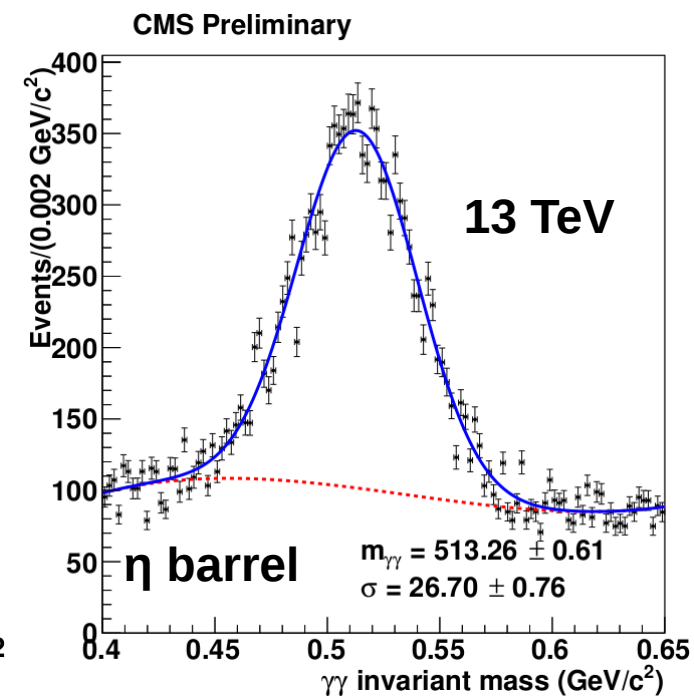
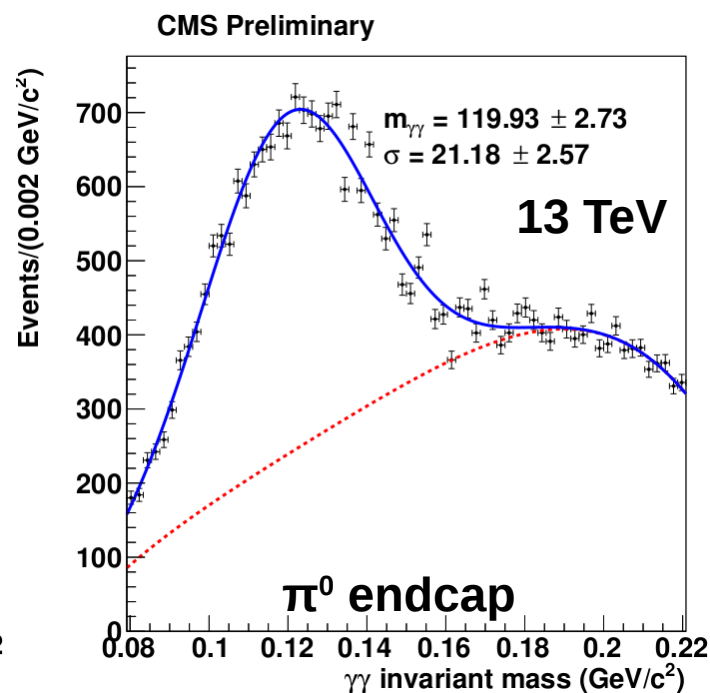
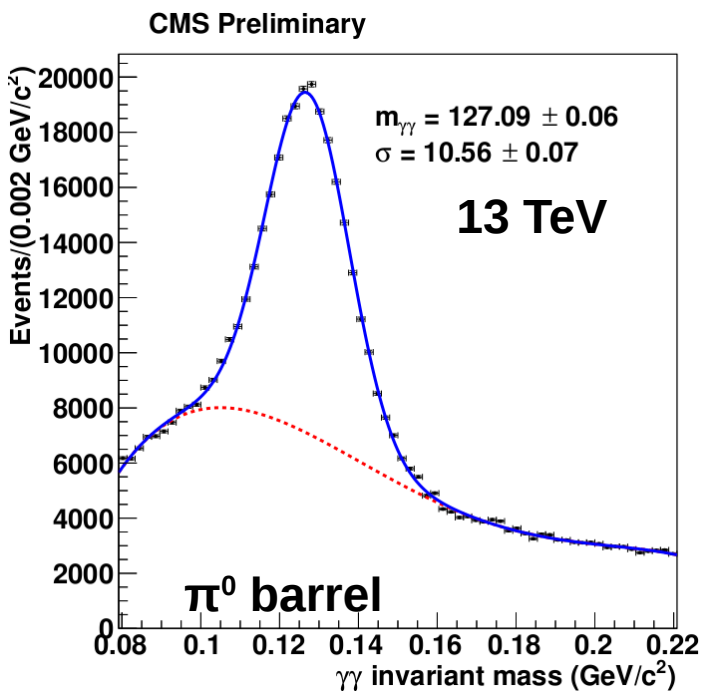


Preshower Energy

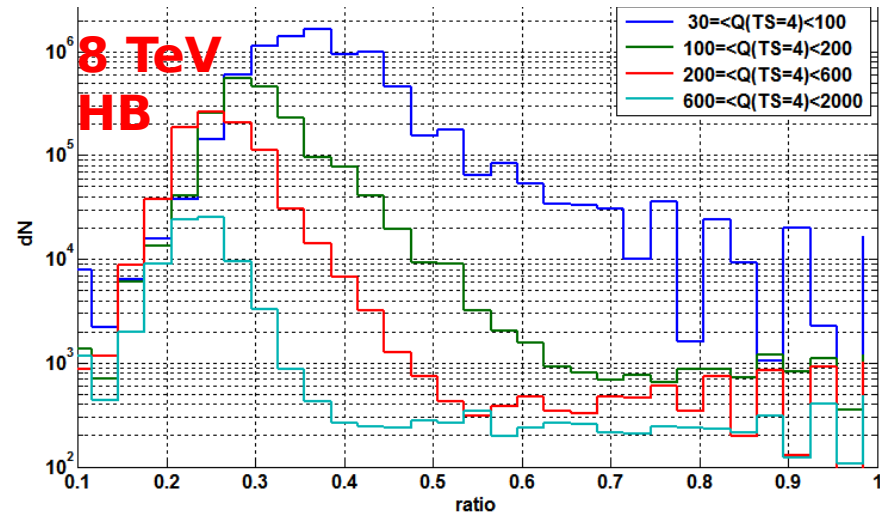
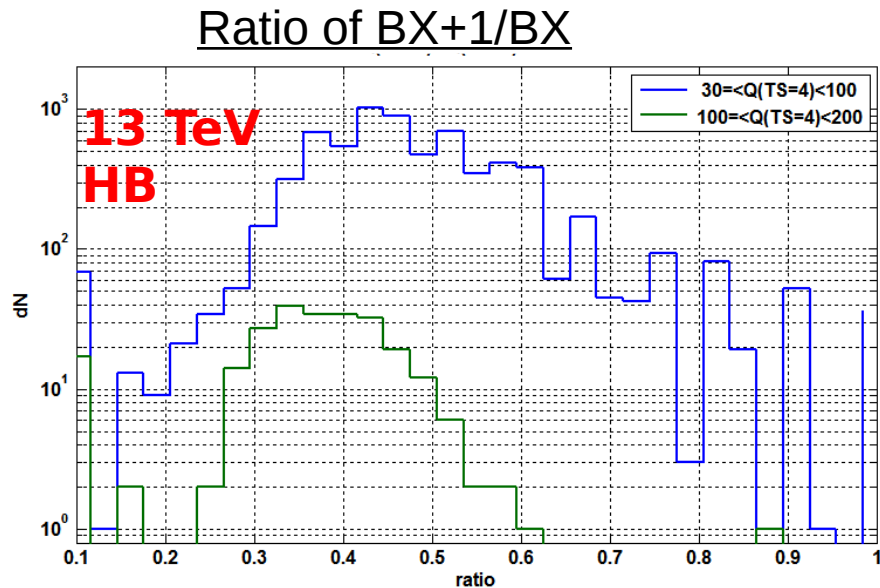


Monitoring of the di-photon spectrum

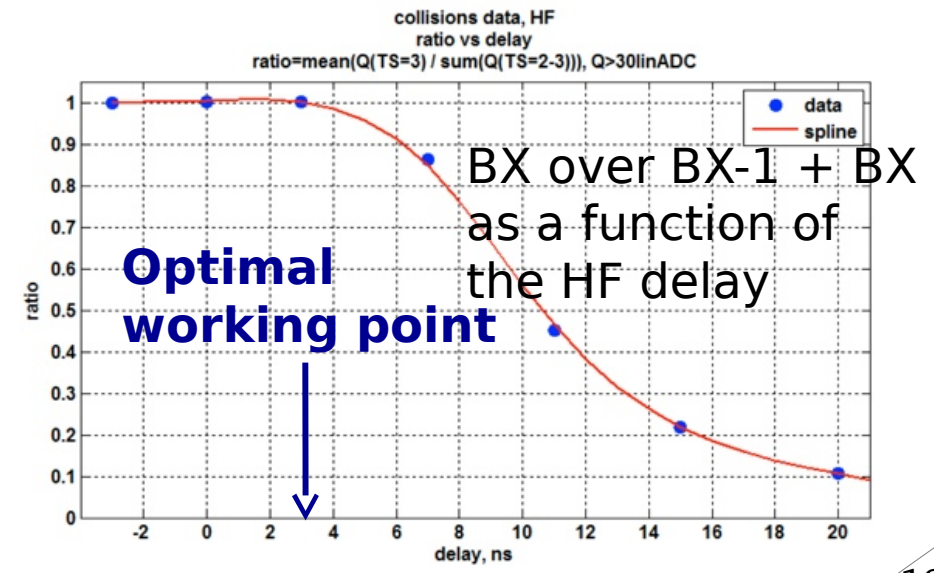
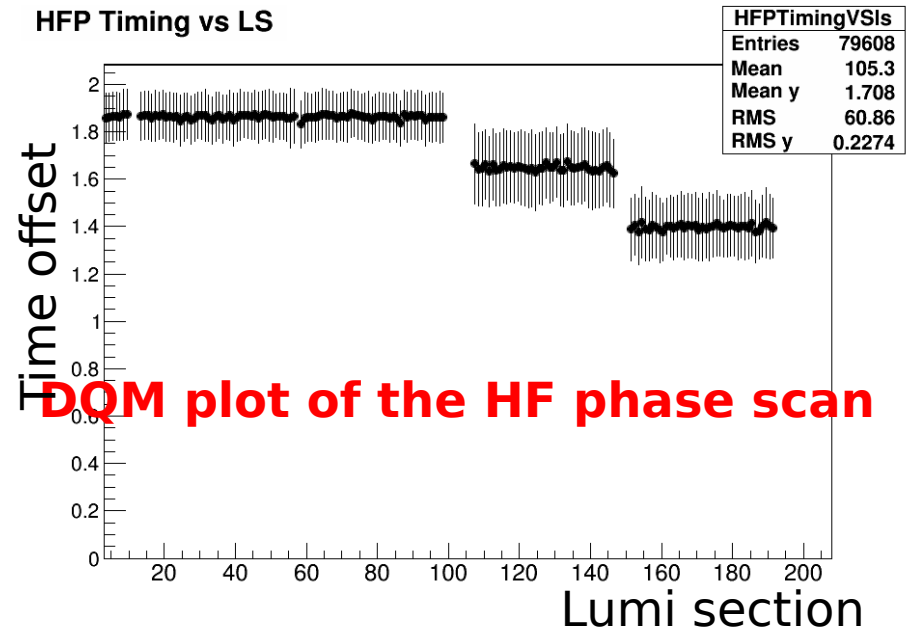
- Beautiful π^0 and η peaks – lots of statistics for calibration
 - Plots from data quality monitoring
 - Mean shifted since reconstruction/calibration not tuned



- HCAL timed in
 - Run I and Run II aligned within 2ns

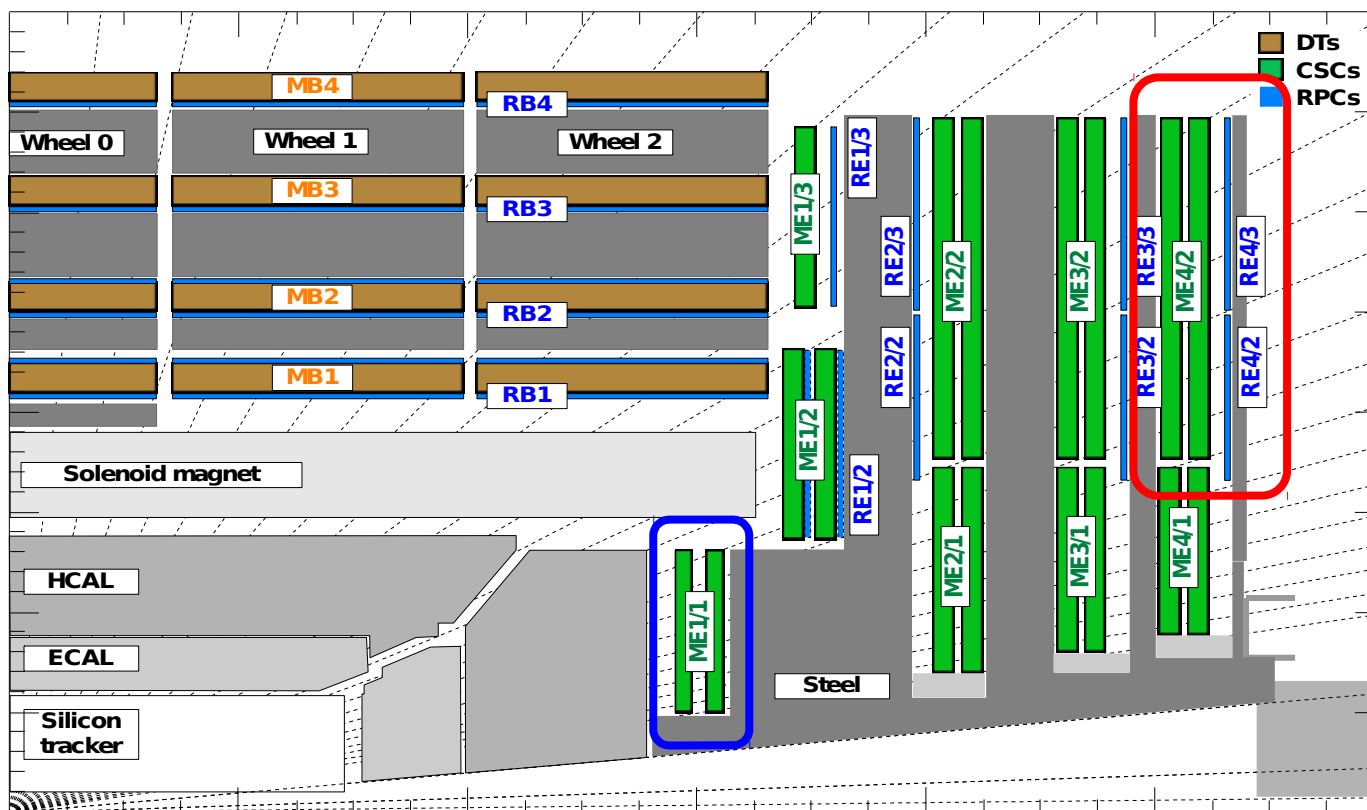


- Phase scans for the HF
 - Optimizing WP



Muon system in LS1

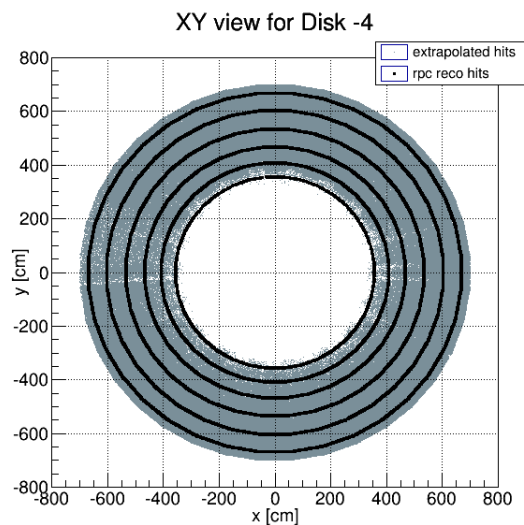
- Three technologies (Drift Tubes, Resistive Plate Chambers and Cathode Strip Chambers)
- Removal/Revision re-installation of ME1/1 chambers
- Fourth muon station in endcap added
- All detectors operational



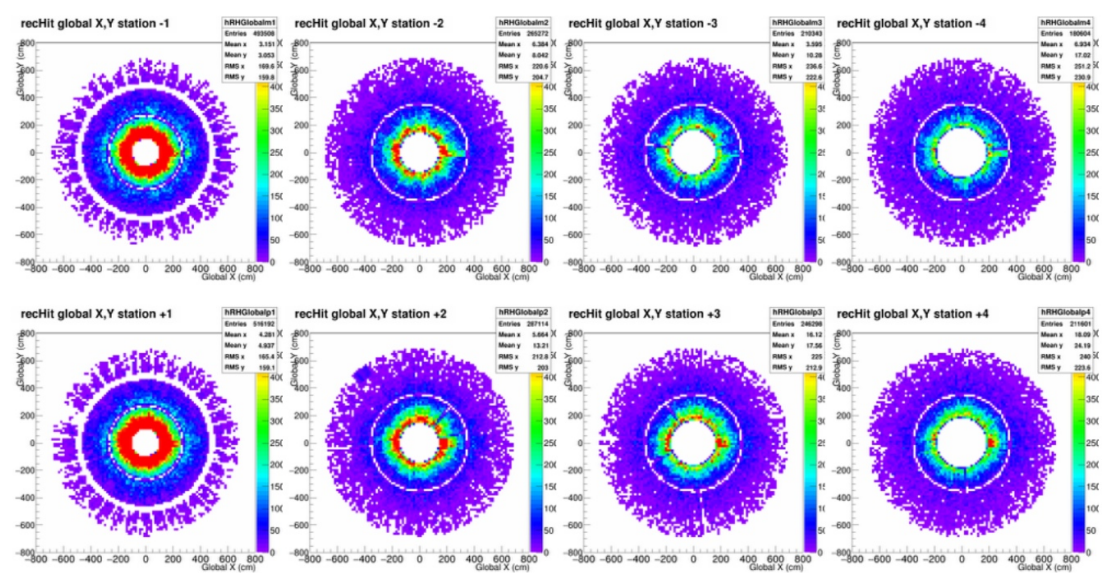
72 new CSC
144 new RPC

Muon commissioning highlights

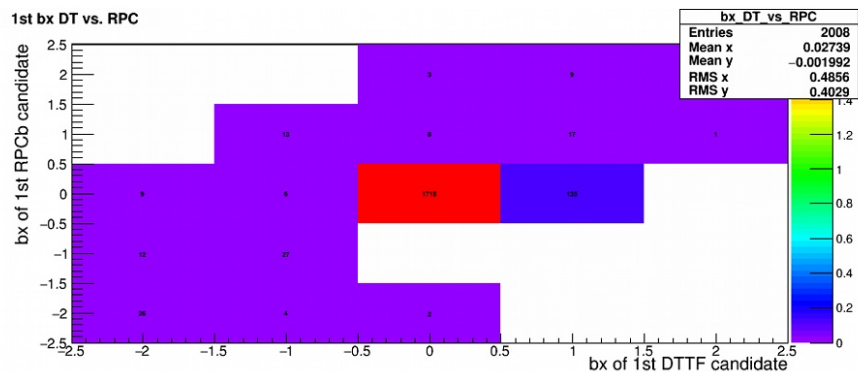
RPC Disk 4 hit map



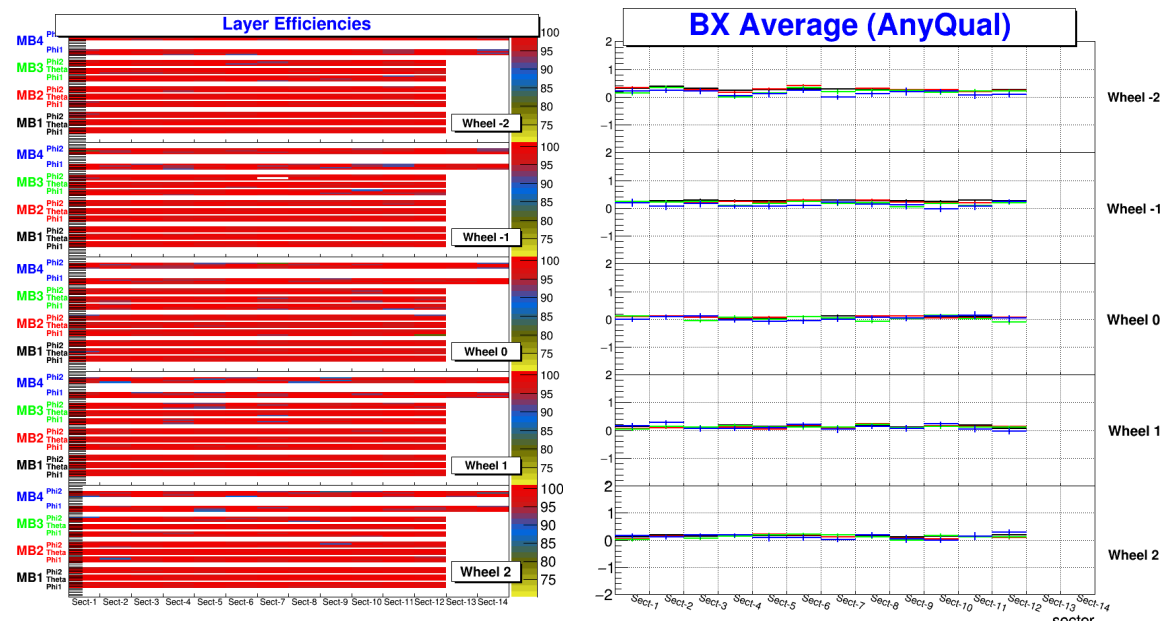
CSC Hit maps



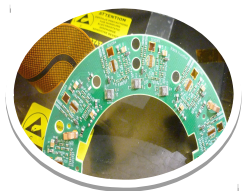
DT vs RPC trigger correlation



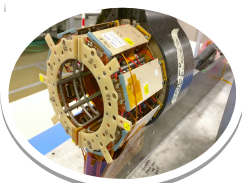
Drift Tube efficiency and Timing



New luminosity systems for Run II



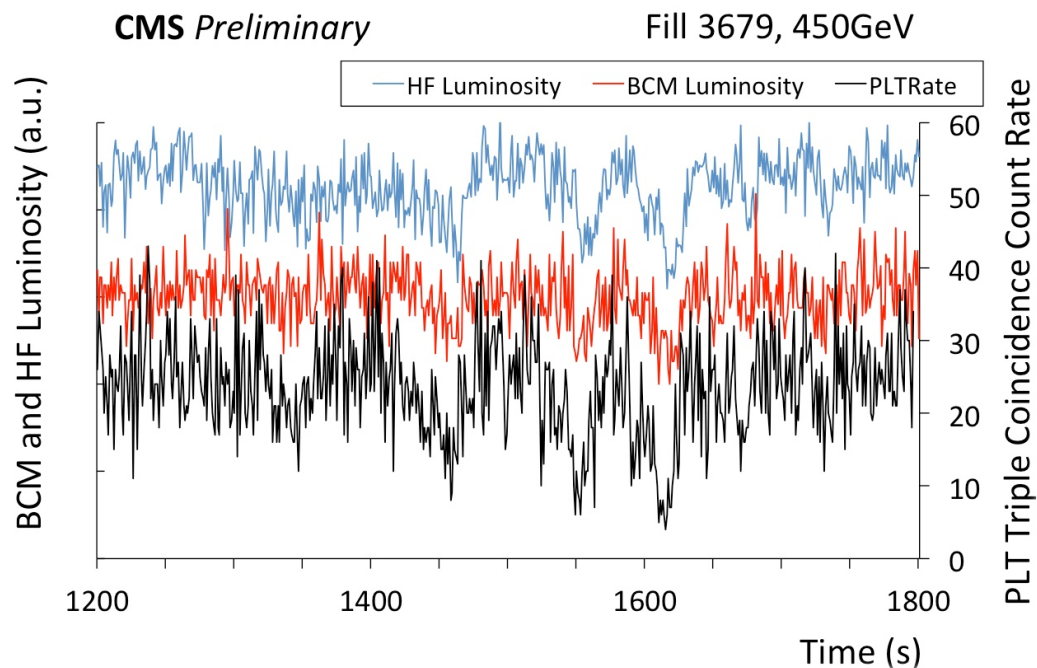
Fast Beam Conditions Monitor (BCM1F)



Pixel Luminosity Telescope

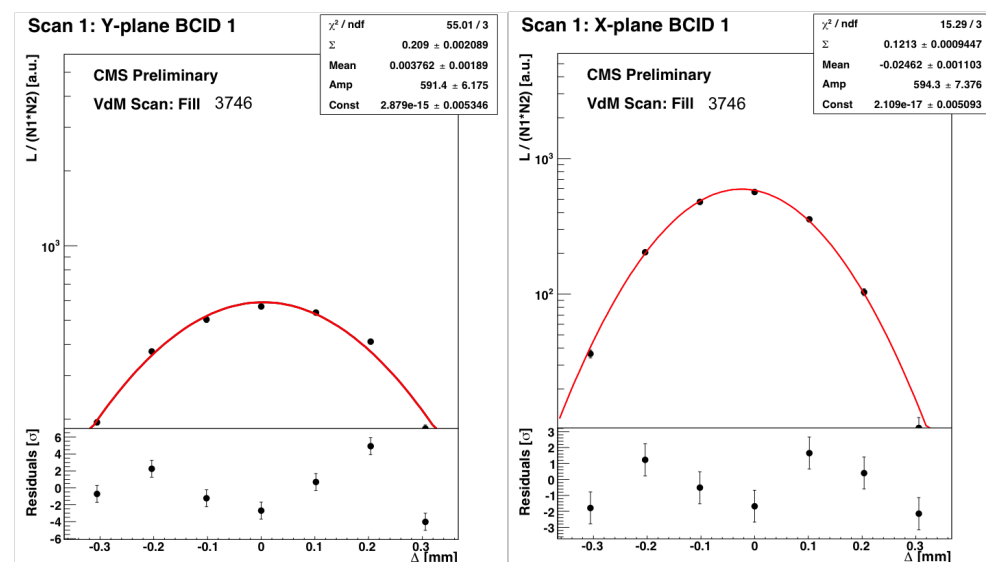


HF Luminosity



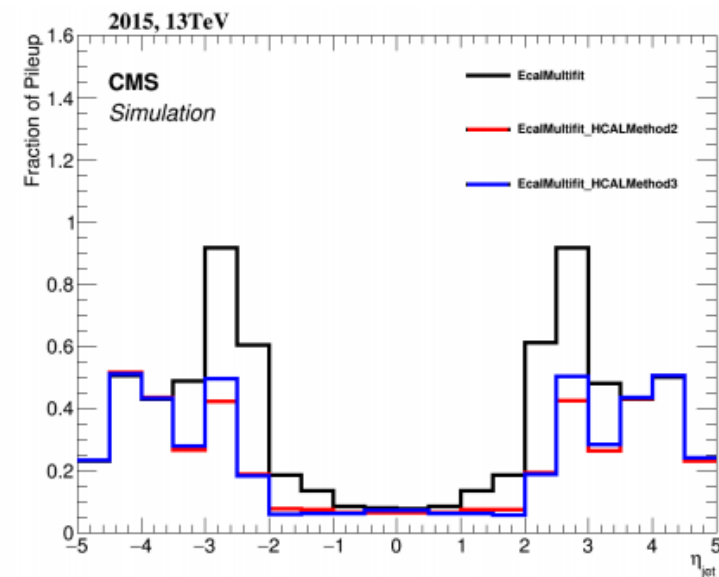
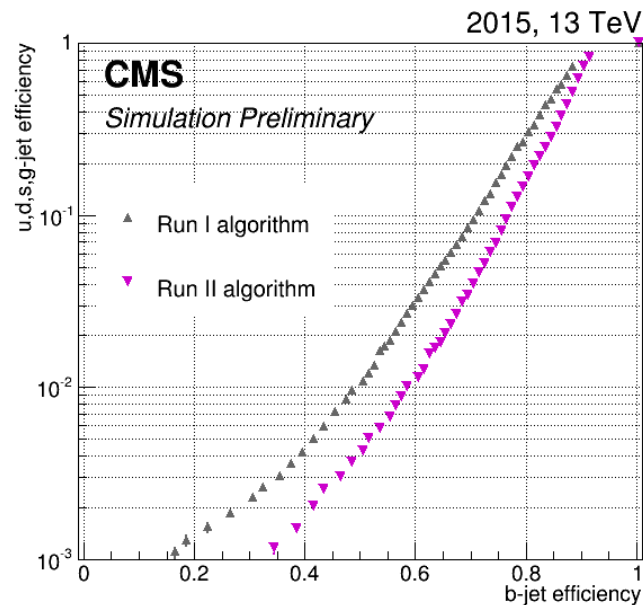
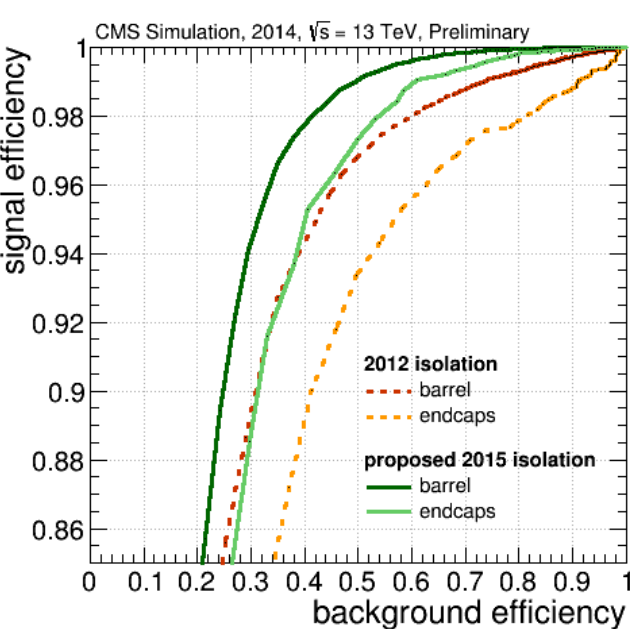
- Initial luminosity calibration

- MC estimation for each subsystem and vertex counting
- Commissioning of the VdM framework to be ready for dedicated VdM scans



High Level Trigger

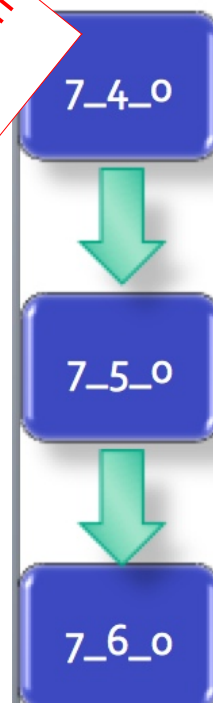
- Trigger menus in place for different scenarios
 - 50ns: Targeting peak luminosity of $5E33\text{cm}^{-2}\text{s}^{-1}$
 - 25ns: Targeting peak luminosities of $7E33\text{-}1E34\text{ cm}^{-2}\text{s}^{-1}$
- Major improvements in HLT algorithms to cope with new conditions
 - Including HLT specific OOT PU mitigation similar to offline



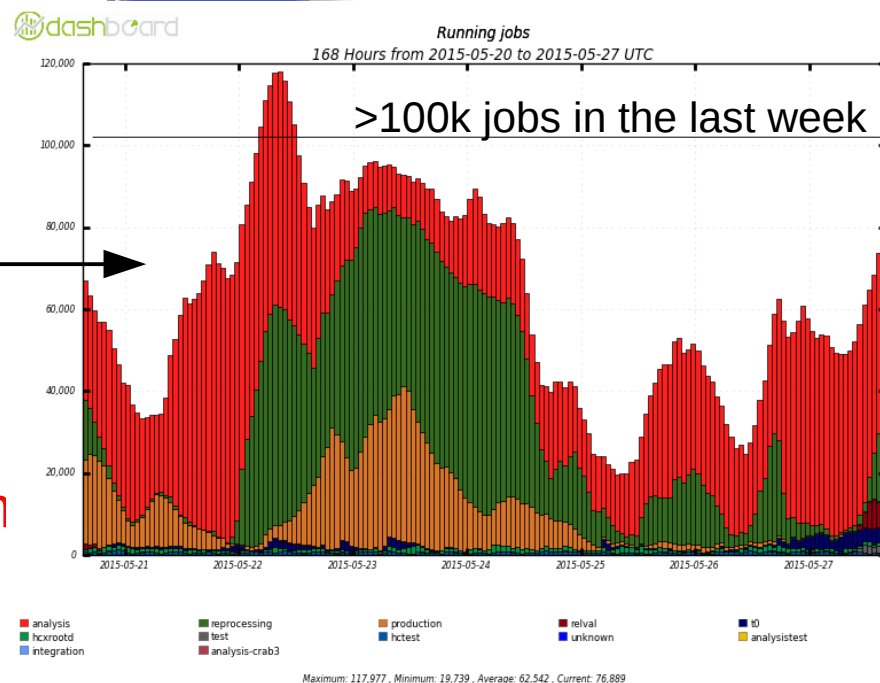
Software & Computing

- Significant Overhaul during the shutdown
 - Multithreading in simulation/reconstruction
 - Use of HLT farm for production when not taking data
 - Rework of GRID computing facilities towards increased flexibility and reduced time needed to produce analysis datasets
- Data Federation in T1/T2 sites
- One central Condor Pool
- Dynamic Data placement & Automatic clean up
- New Mini AOD format in production

In production



- Multi-threaded Reconstruction
- Date: March 2015
- Target: DIGI-RECO and Prompt Reconstruction for start-up
- Date: **June 2015**
- Target: DIGI-RECO and Prompt Reconstruction for 25ns
- Date: September 2015
- Target: End of year Re-RECO

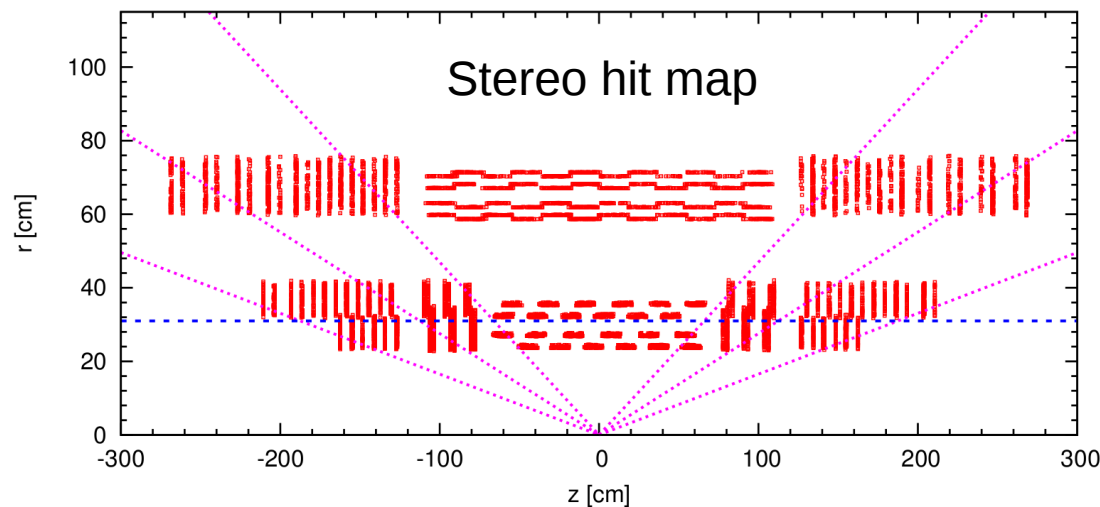


Physics @ 13 TeV

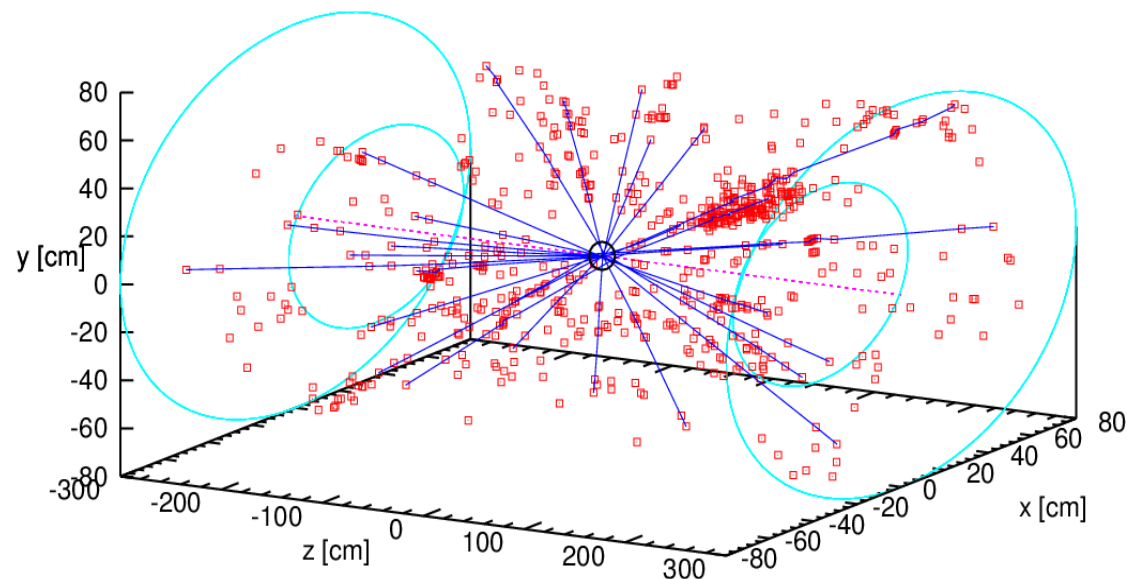
- First planned physics measurement: $dN/d\eta$, dN/dp_T
- Attempt to measure $dN/d\eta$ with “quiet beams” as a test
- Magnet was off ($B=0T$)
 - No momentum measurement
 - But can detect lower momentum tracks
- Pixel not in the run (not Stable Beams)
 - But can exploit the stereo layer hits in the tracker
 - Tilted sensor pairs by 5° giving 3D measurement

Two independent analyses

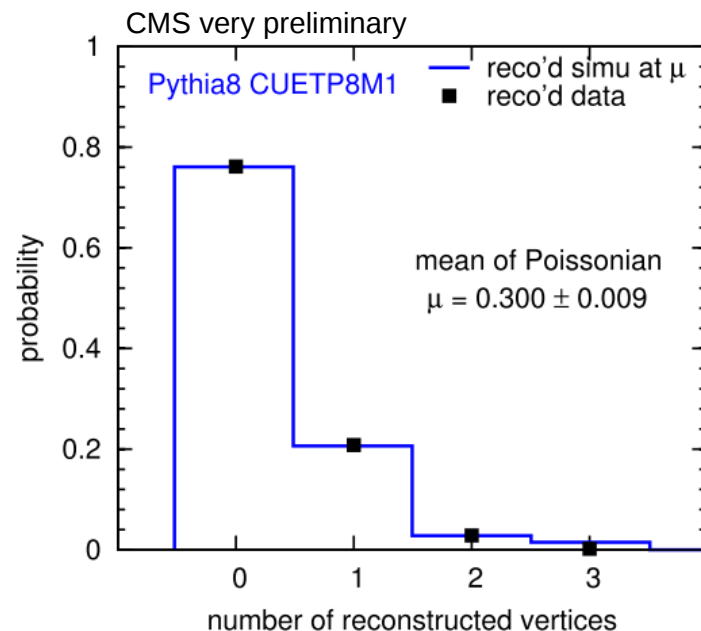
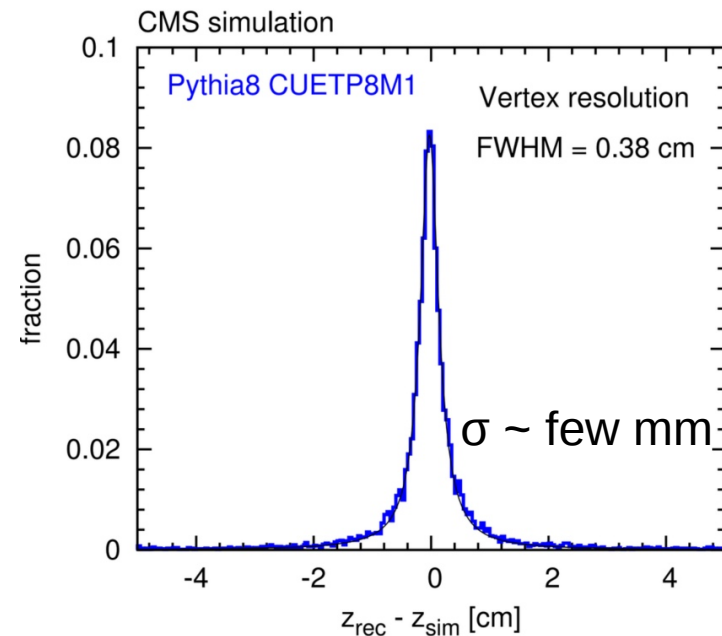
1. Using tracklets [vertex+ hit pair]
2. Using straight track reconstruction



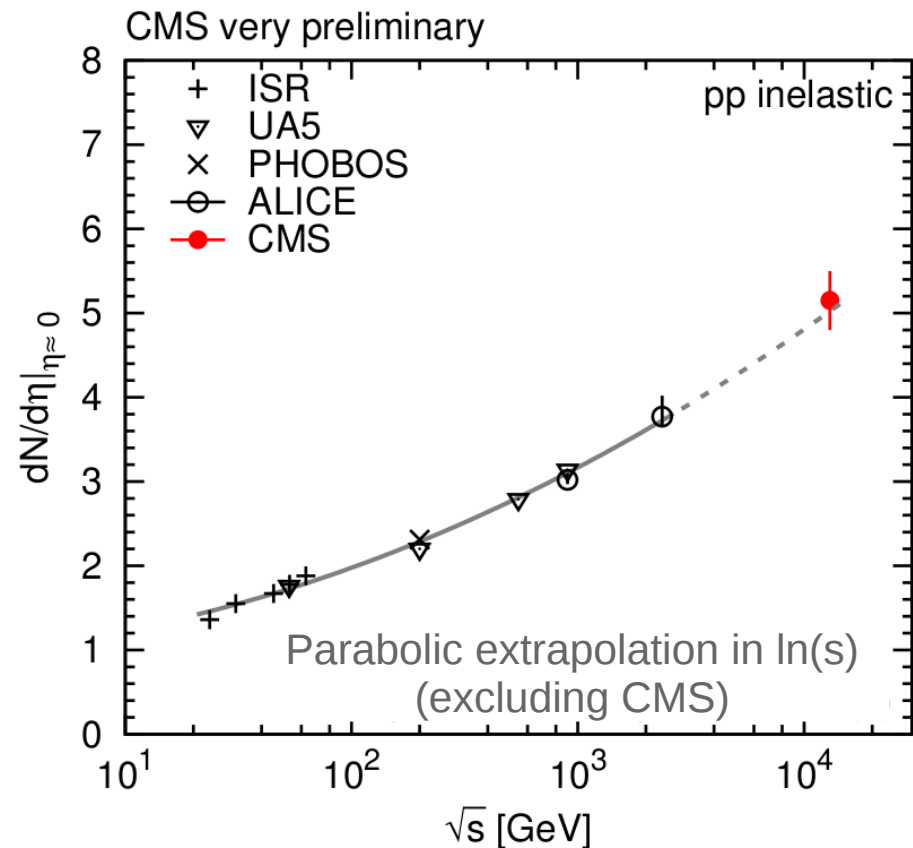
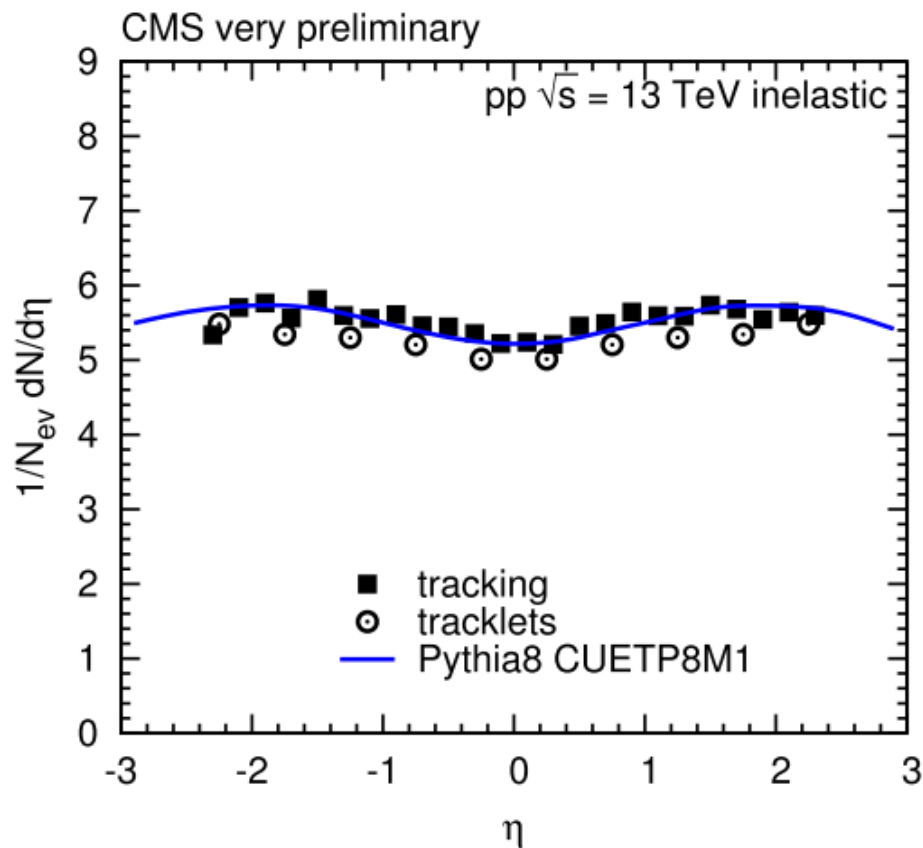
Tracking and PU estimation from data



- Iterative straight line tracking+ vertexing
 - Agglomerative clustering of strip hits
- PU estimation from data via vertex counting
- Track \rightarrow hadron correction by simulation (Pythia 8/Tune CUETP8M1)



Results



- Good agreement between tracking and tracklet analysis
 - Systematics of 6-8%
- Tune consistent with 13 TeV data
- Final result to be based on stable 13 TeV collisions

Upgrades

- Phase I upgrades progressing well
 - New Pixel Detector
 - L1 Trigger
 - HCAL HPD → SiPM
- Phase II technical proposal [submitted](#)

New Endcap Calorimeter

- Radiation Tolerant
- High Granularity
- 3D capability

Barrel Calorimeter

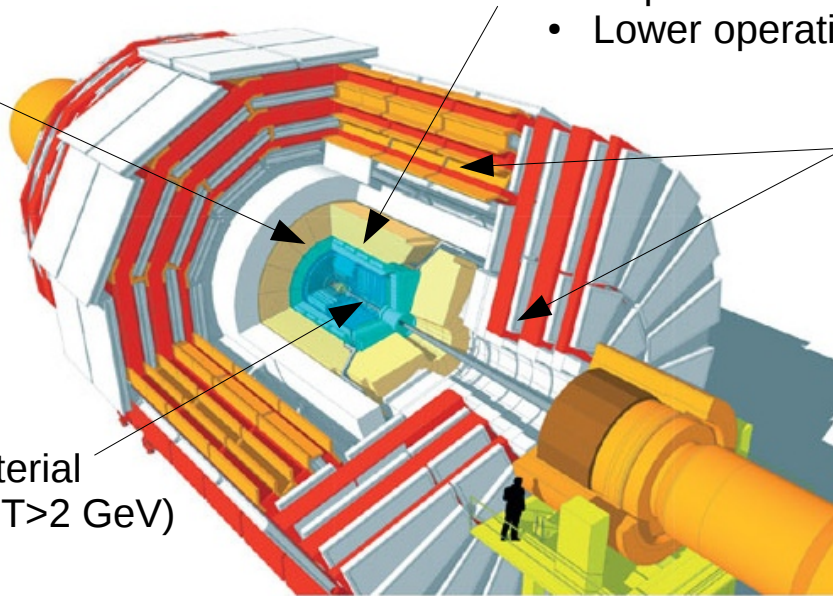
- Replace FE/BE electronics
- Lower operating temperature(8°)

Muon system

- Replace DT/CSC FE/BE electronics
- Complete RPC coverage In region $1.5 < \eta < 2.4$
- Muon tagging with GEMs for $2.4 < \eta < 3.0$

New Tracker

- Radiation tolerant – less material
- 40 MHz selective readout (PT>2 GeV) for track trigger
- Extend to coverage of $\eta \sim 3.8$

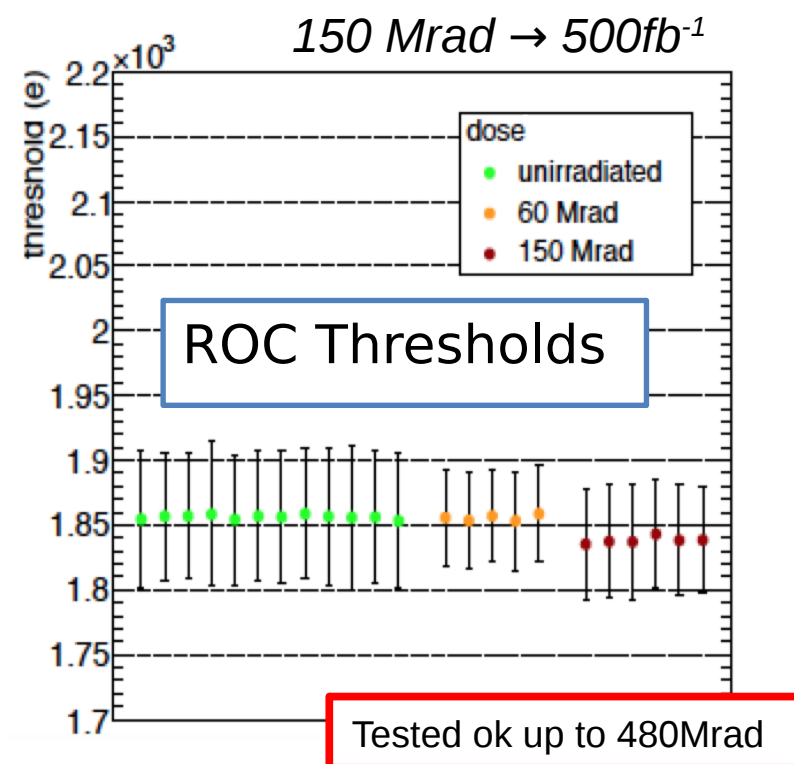


Trigger/HLT/DAQ

- L1 Track Trigger
- L1 Trigger: 12.5 μ s latency, 750 kHz output
- HLT output of 7.5 kHz

Phase I Pixel Upgrade Highlights

- Module components in hand and module production started
- Production of mechanics and supply tube / half shells started
- Lots of ongoing work on system tests
- At P5
 - 8 pilot modules installed/commissioned
 - CO₂ plant installed/commissionioned
 - CO₂ already flushed close to the detector
- On track for installation in YETS 2016/2017



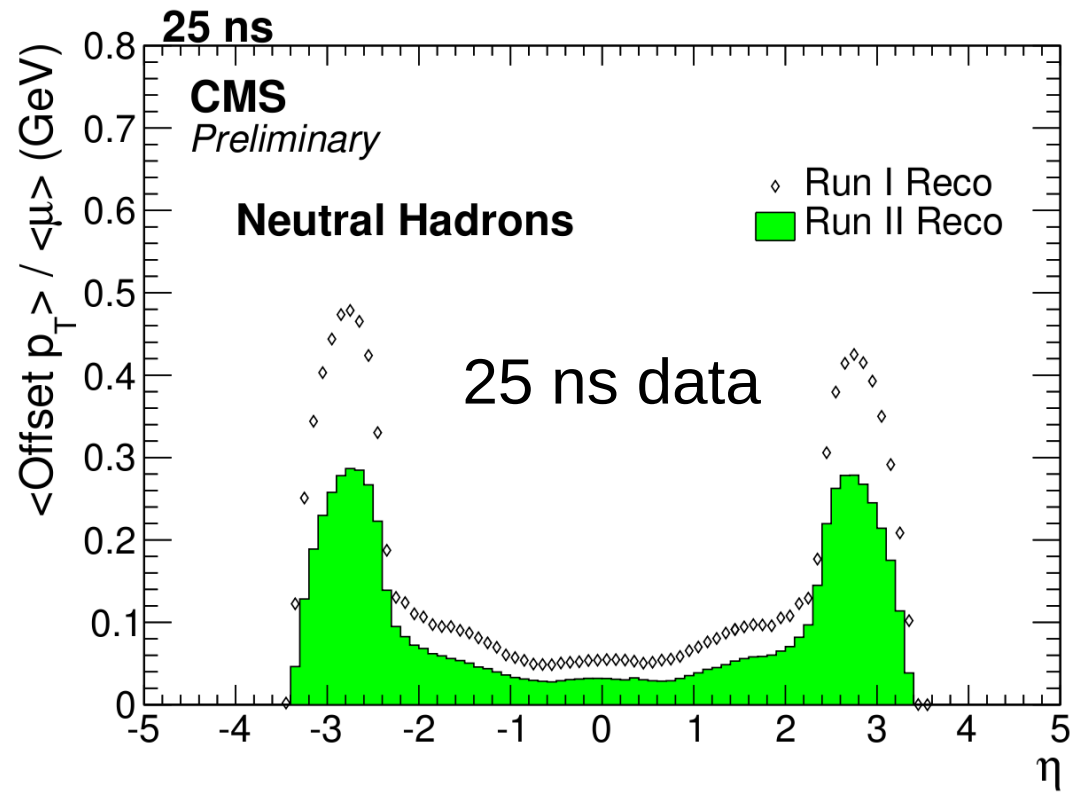
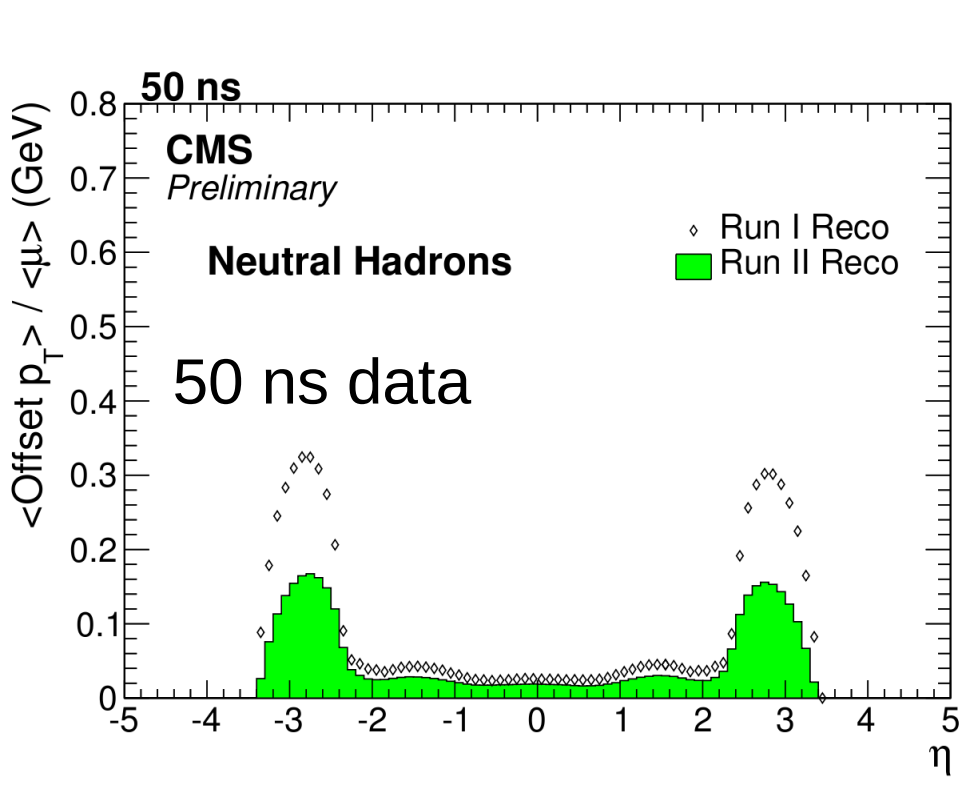
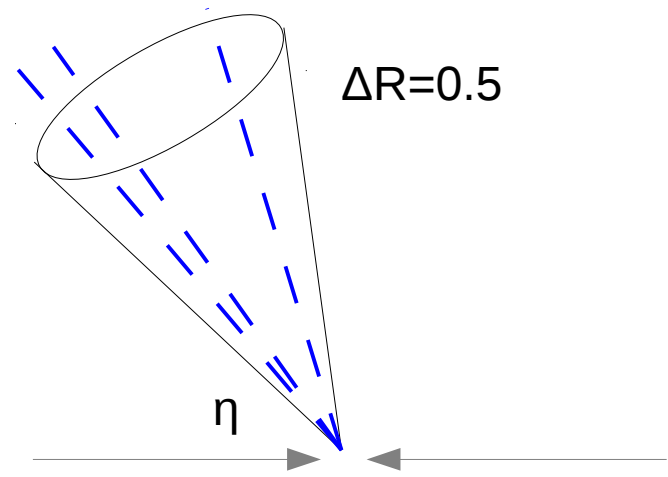
Summary

- CMS returns to discovery mode
 - Improved Detectors, Trigger and reconstruction algorithms
- Detector commissioning going very well
 - All systems operational
 - Magnet status to be monitored closely in the coming days
- First physics analysis @ 13 TeV in progress
- Road to the future paved
 - Phase I upgrades proceeding well
 - Phase II technical proposal submitted

Additional Material

Out of Time PU mitigation in Calorimeters

- Summing particle energy in random cones in ϕ across η
 - Indicator of the PU energy to be subtracted for a given cone
- New reconstruction: bunch spacing independent



Detailed Magnet status chronology

- The CMS magnet system ran normally with cosmic rays (CRAFT) 20 Mar-1 April
 - However signs of pollution in the cryogenic cold box already evident
 - Pressure drop across input filter to first expansion turbine over several cycles of regeneration with warm gas
 - Likely culprit: Breox lubricant from compressor plant
- 2 Campaigns of filter cleaning and change 1-10 Apr and 30Apr – 16 May
 - 1) Regeneration with cold box closed
 - 2) Filter replacement with cold box opened
 - Both unsuccessful
- Still see rapid clogging of heat exchangers and filters preventing sustained operation
- After discussing with CERN Technical Department heads and Director of Accelerators
 - Urgent programme of advanced diagnostics and change of built-in components

Actions over the last 2 weeks



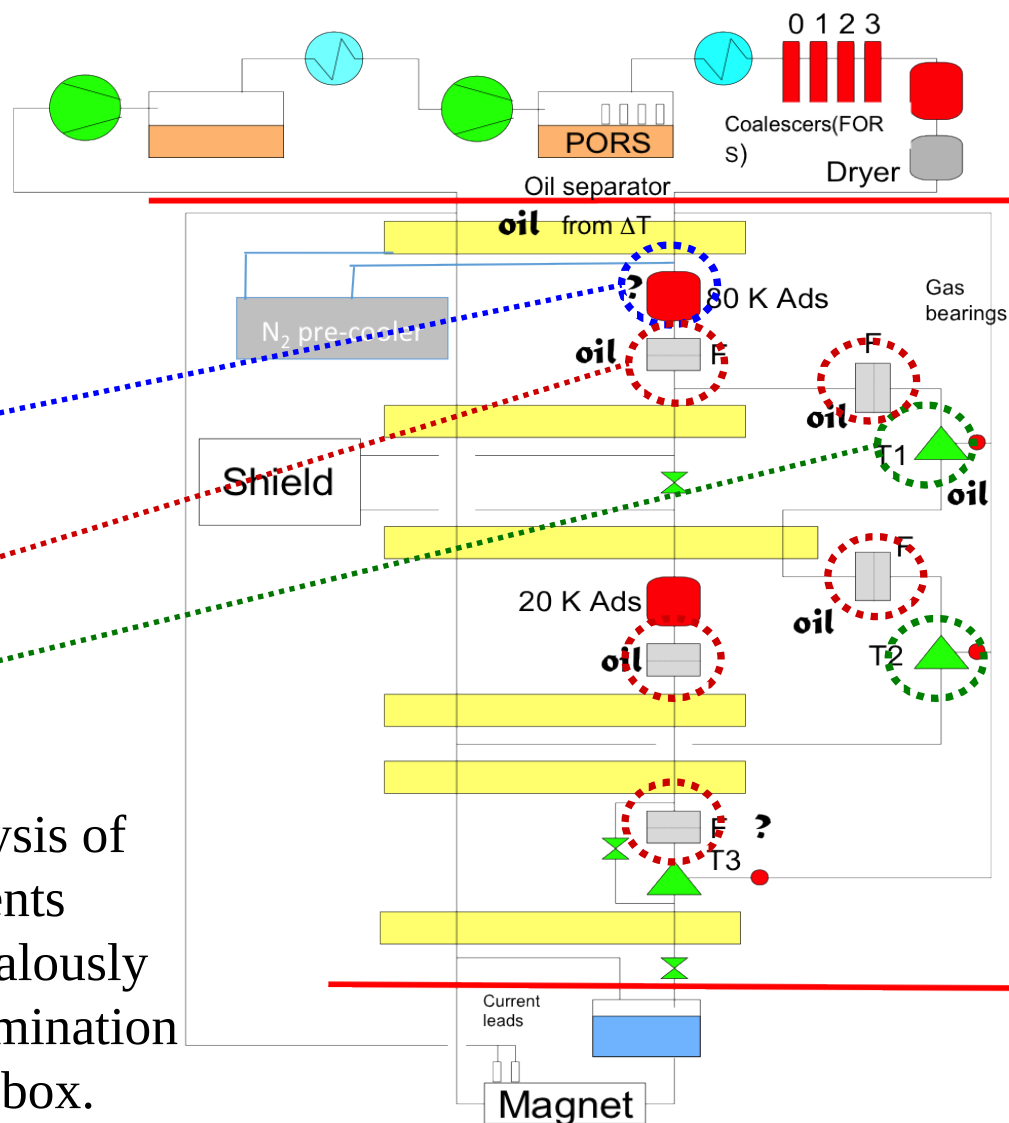
80K adsorber tank cut out - charcoal fill (60l) replaced



Tank re-welded in place.

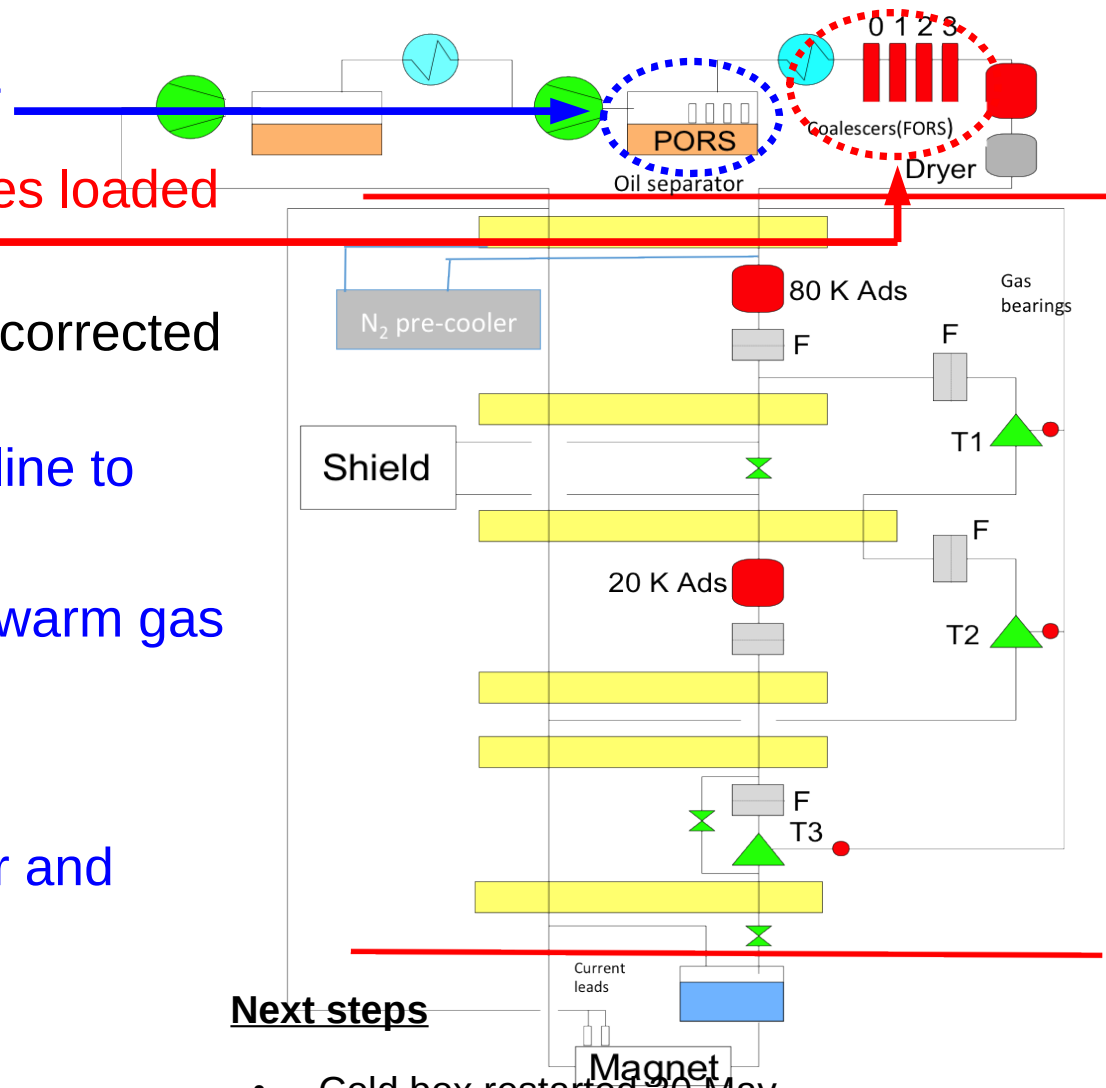
Filters and Turbines replaced or cleaned.

Visual/chemical analysis of all removed components consistent with anomalously large Breox oil contamination through most of cold box.



Likely diagnosis and next steps

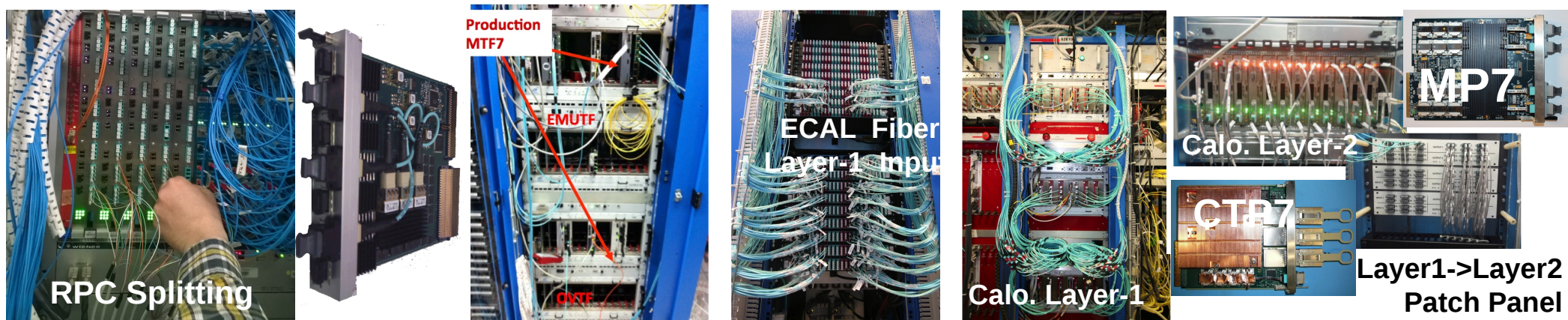
- Most likely cause of incident
 - Poorly functioning oil separator
 - + wrong coalescer cartridges loaded Nov 14
 - Maintenance mistake, corrected Feb 15
 - Contaminated 300m warm He line to cold box
 - Contaminated cold box during warm gas regenerations
- Implications/actions
 - Contamination of adsorber, filter and turbines
 - Replaced or cleaned
 - Contamination of heat exchangers
 - Mitigate with N2 pre-cooler
 - Contamination of thermal shield
 - Keep temperature below Breox m.p



Next steps

- Cold box restarted 30 May
- Decide 3/4 June whether OK to connect the magnet (TIP)
- Prepare thorough cleaning and He line replacement (est 13 weeks)
 - YETS 2015-16 or sooner

L1 Trigger for 2016



- In 2016: Full trigger upgrade as in TDR
- System will run in parallel with legacy in 2015 by splitting optical data paths from the detectors
 - Muon data paths splitting(DT/RPC/CSC) complete
 - ECAL data paths splitting completed and commissioned
 - HCAL data paths splitting will commence in next two weeks
- Calorimeter trigger hardware delivered and installed
- Production of MTF7 processor cards proceeding normally
 - First production card installed in USC-55

L1 Menu Highlights

- 50 ns: “legacy” L1 trigger
- 25 ns: “Stage 1” upgraded trigger

| Unprescaled object | Threshold @ 5E33, 7E33 (GeV) | Threshold @ 1.4E34 (GeV) |
|----------------------|------------------------------|--------------------------|
| Single muon | 16 | 25 (20er) |
| Double muon | 10, 3.5 | 12, 5 |
| Single electron | 25 | 40 |
| Single iso. electron | 22er | 30er |
| Double Electron | 15, 10 | 22, 10 |
| Single PFJet | 128 | 200 |
| Double iso. Tau | 36er | 44er |
| MET | 50 | 70 |
| HTT | 125 | 175 |
| Mu_EG | 12,10 and 5,15 | 20,10 and 5,20 |

Trigger rates estimated with Monte Carlo; Will be verified with data.

Total L1 rates:

89 kHz @ 5E33 (50ns)
82 kHz @ 7E33 (25ns)
93 kHz @ 1.4E34 (25ns)

“er”: eta-restricted

HLT Menu Summary

- 5E33 and 7E33 menus use the relaxed L1 seeds
 - Some paths have lowered thresholds/prescales

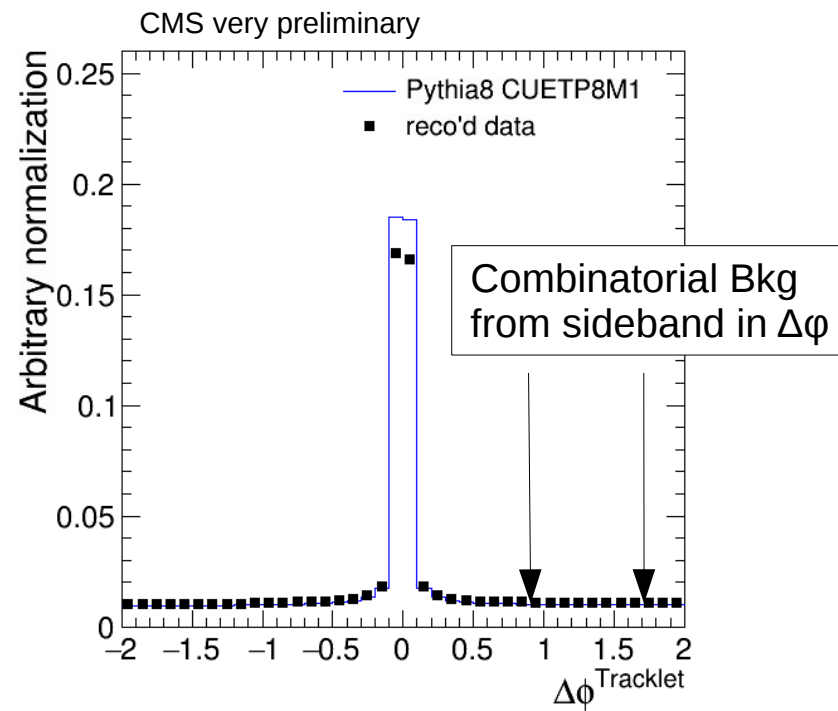
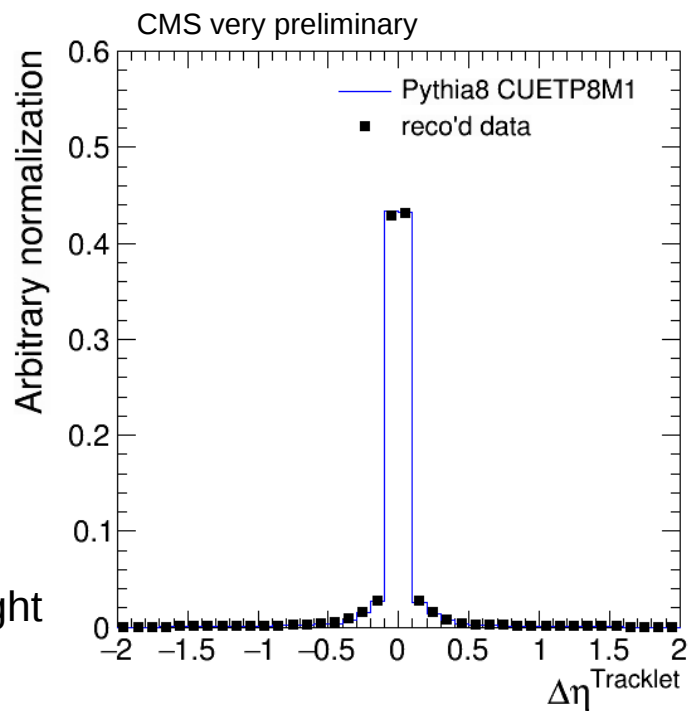
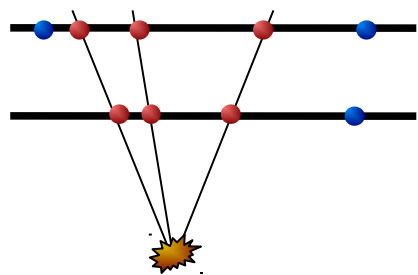
| Unprescaled object | Threshold @ 7E33 (GeV) | Threshold @ 1.4E34 (GeV) |
|----------------------|------------------------|--------------------------|
| Single muon | 50 (45er) | 50 (45er) |
| Single iso. muon | 20 (17er) | 27 (24er) |
| Double muon | 17, 8 | 17, 8 |
| Single iso. electron | 27 | 32er |
| Double Electron | 17, 12 | 23, 12 |
| Single Photon | 165 | 165 |
| Single PFJet | 450 | 450 |
| Double iso. Tau | 40er | 40er |
| MET | 170 | 170 |
| HTT | 800 | 800 |
| Mu_EG | 8, 17 and 17, 12 | 8, 23 and 23, 12 |

Rates for the 5E33 and 7E33 menus are ~800 Hz

Total rate for the 1.4E34 menu is within budget (~1.35 kHz peak rate) with recent improvements

CPU timing is also within budget with the upgraded DAQ farm

Tracklet reconstruction



- Charged particle multiplicity can be extracted from the height of the two-strip-cluster correlation peak

- Sharp correlation peak at $(\Delta\eta, \Delta\phi) = 0$ in 13 TeV data and PYTHIA8 MC simulation

- Corrected to charged hadron by PYTHIA8 (Tune CUETP8M1)

