CMS Detector Performance

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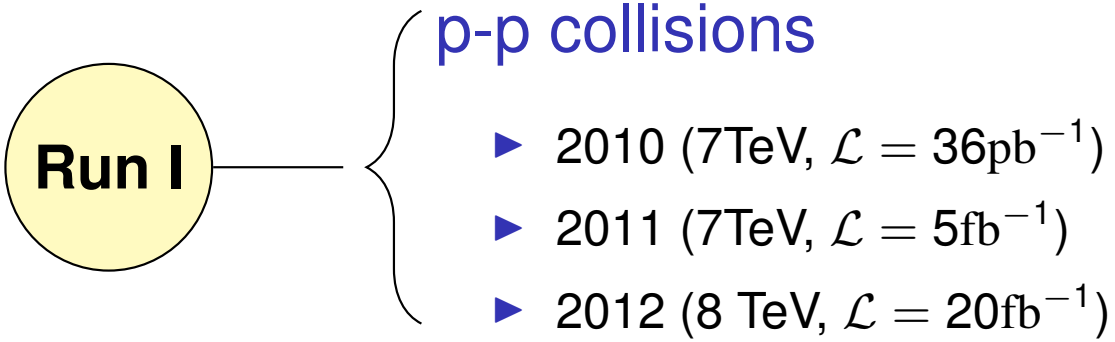
on behalf on the CMS Collaboration

University of Minnesota

ICNFP August 26, 2015

From Run I to Run II



$$N = \sigma \cdot \mathcal{L}$$

From Run I to Run II

Run I

p-p collisions

- 2010 (7TeV, $\mathcal{L} = 36\text{pb}^{-1}$)
- 2011 (7TeV, $\mathcal{L} = 5\text{fb}^{-1}$)
- 2012 (8 TeV, $\mathcal{L} = 20\text{fb}^{-1}$)

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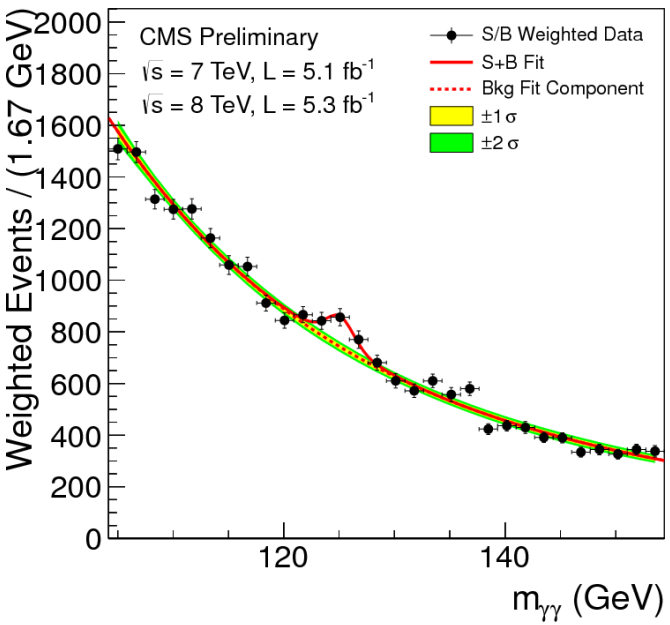
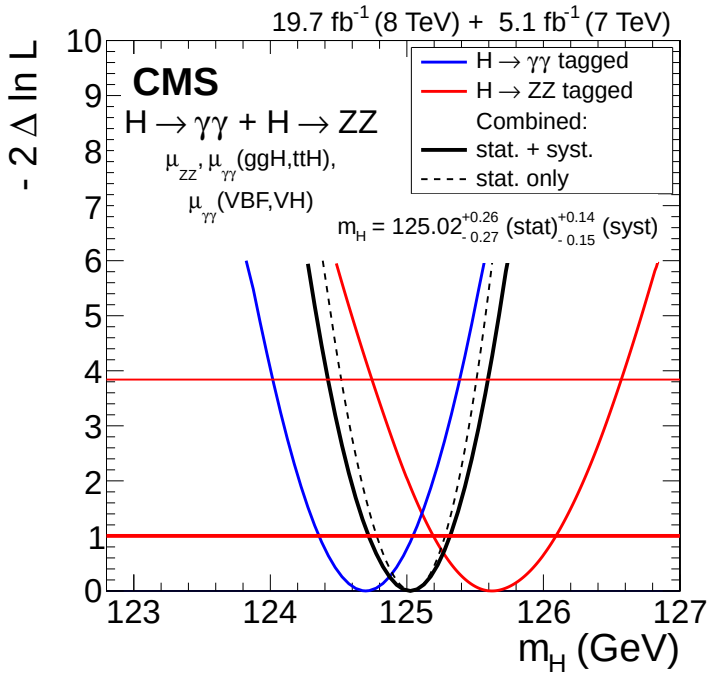




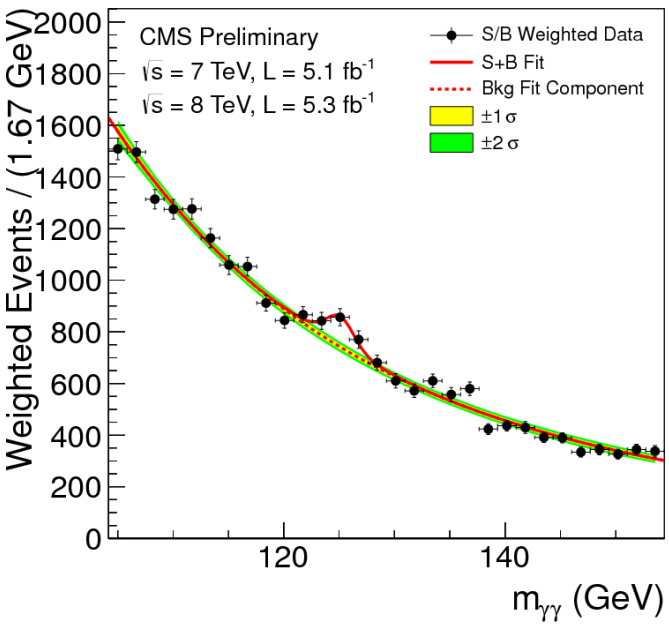
Higgs discovery
Jul 2012 (10fb^{-1}) → Higgs mass
Dic 2014 (Run I data)

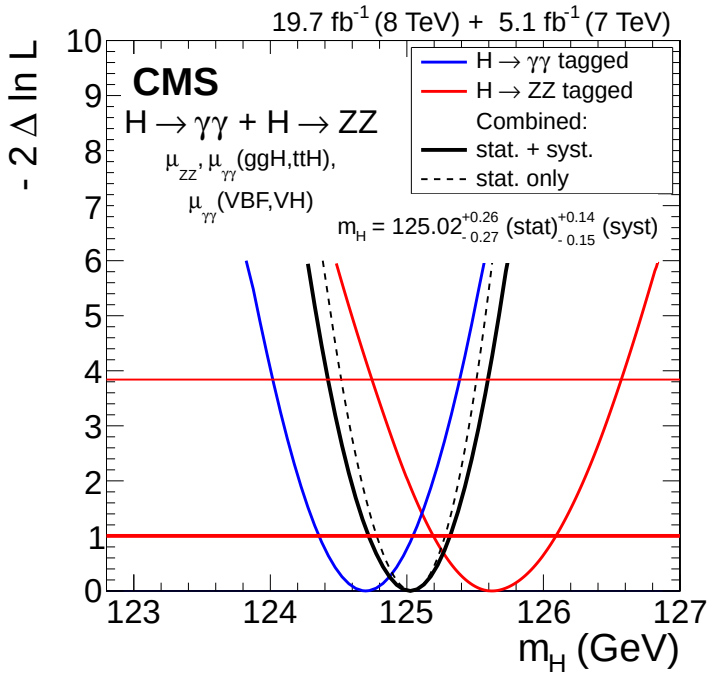
From Run I to Run II

Run I

Results possible thanks to:

- Very well calibrated detectors
- Established reconstruction algorithms and corrections for final state particles





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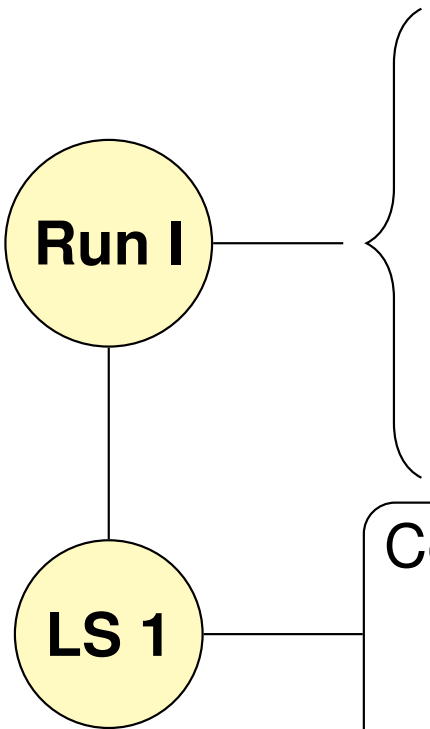
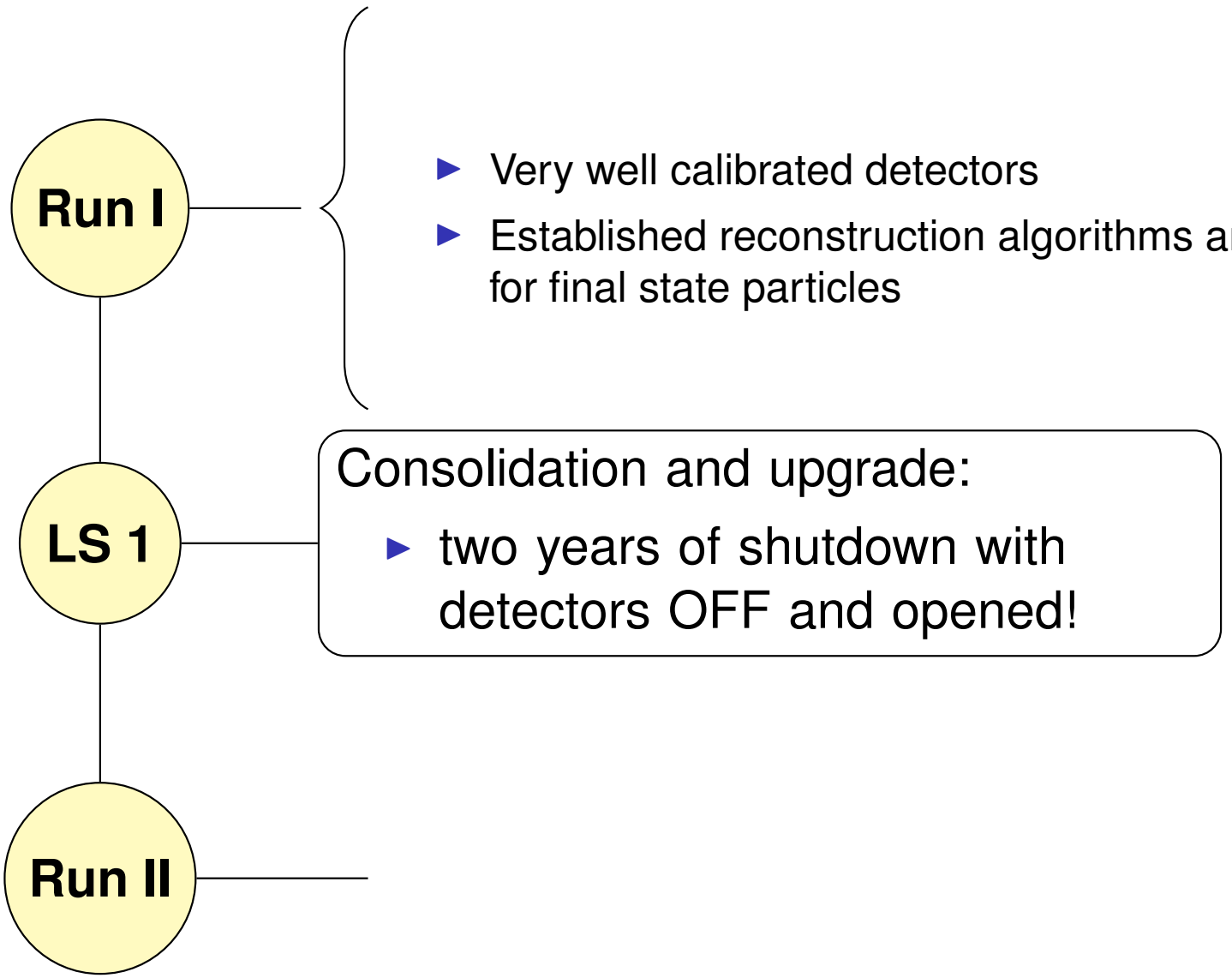


- Very well calibrated detectors
- Established reconstruction algorithms and corrections for final state particles

Consolidation and upgrade:

- two years of shutdown with detectors OFF and opened!

From Run I to Run II



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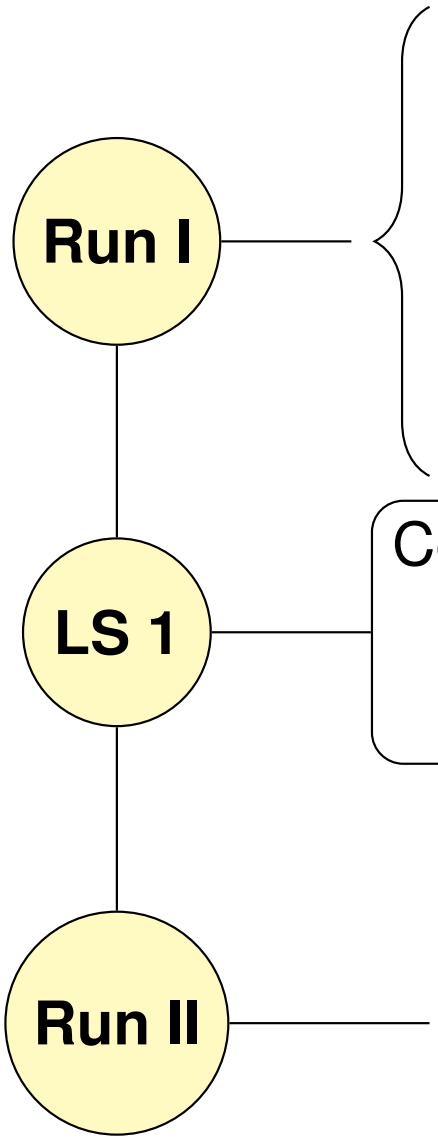


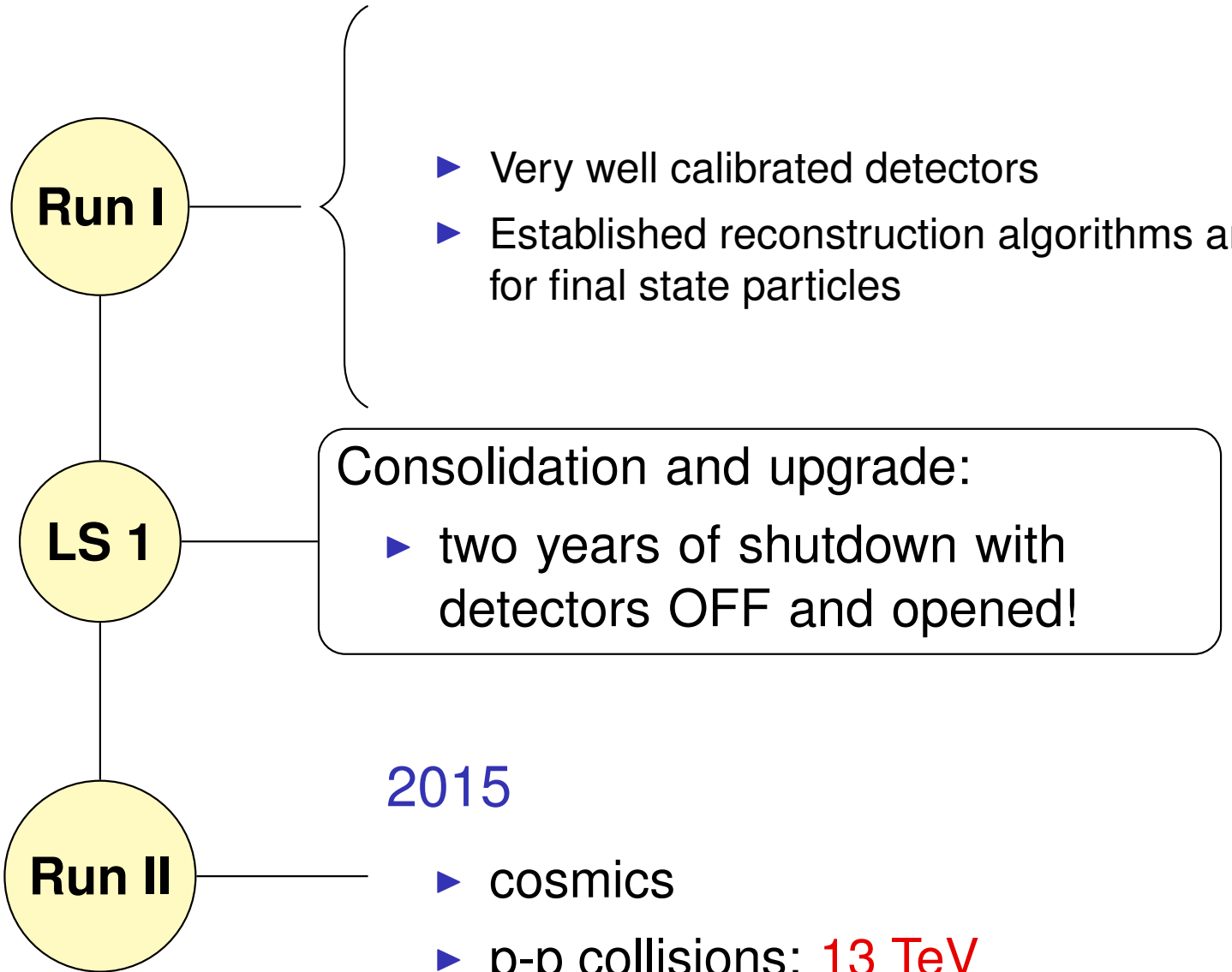
- Very well calibrated detectors
- Established reconstruction algorithms and corrections for final state particles

Consolidation and upgrade:

- two years of shutdown with detectors OFF and opened!

- New center-of-mass energy: 13 TeV
- Higher instantaneous luminosity: up to $1.4 \times 10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Increased number of collision events (PU): up to 40
- Different bunch spacing (collision rate): 50ns (20 MHz) $\rightarrow$ 25ns (40 MHz)

From Run I to Run II



From Run I to Run II (2)

Done/on going activities

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- Re-commission all sub-detectors (after two years OFF)

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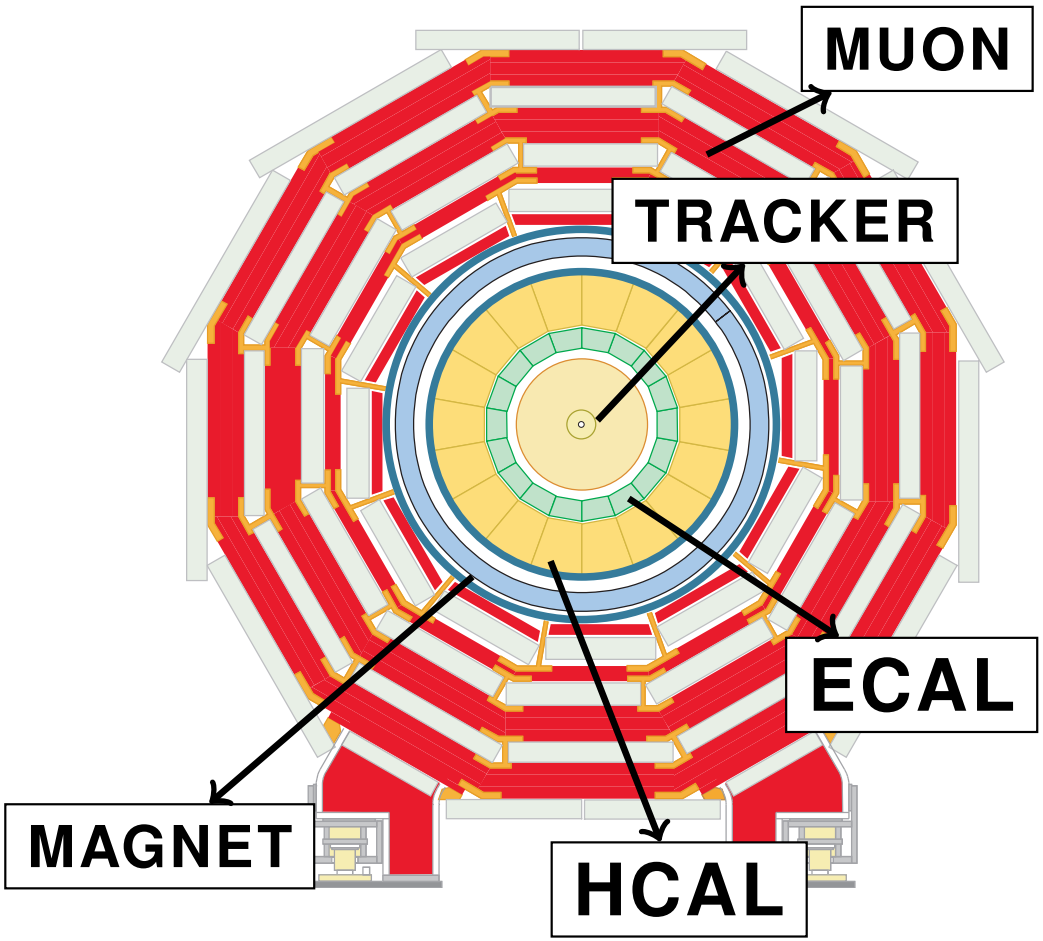
From Run I to Run II (2)

Done/on going activities

- Re-commission all sub-detectors (after two years OFF)
- Re-align and re-calibrate sub-detectors (detector opened)
- New/improved PU robust algorithms for final state particle reconstruction

CMS Detector



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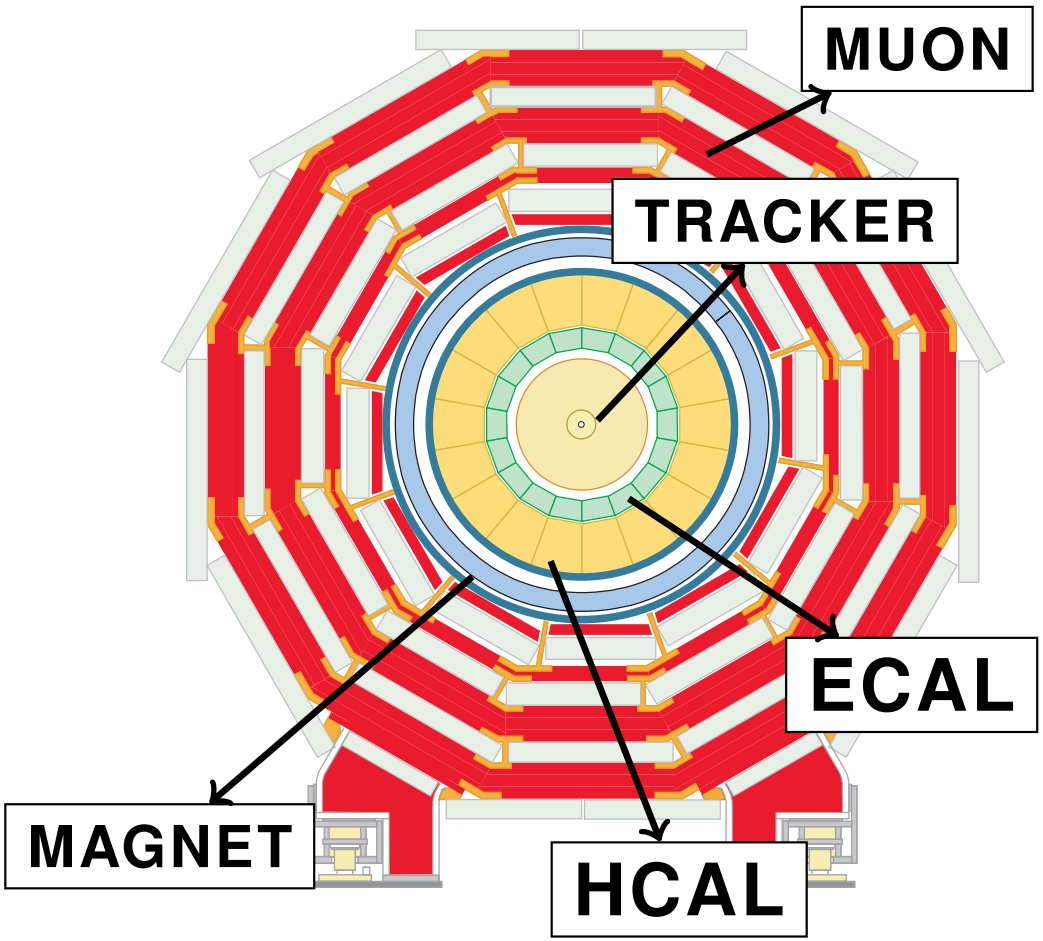
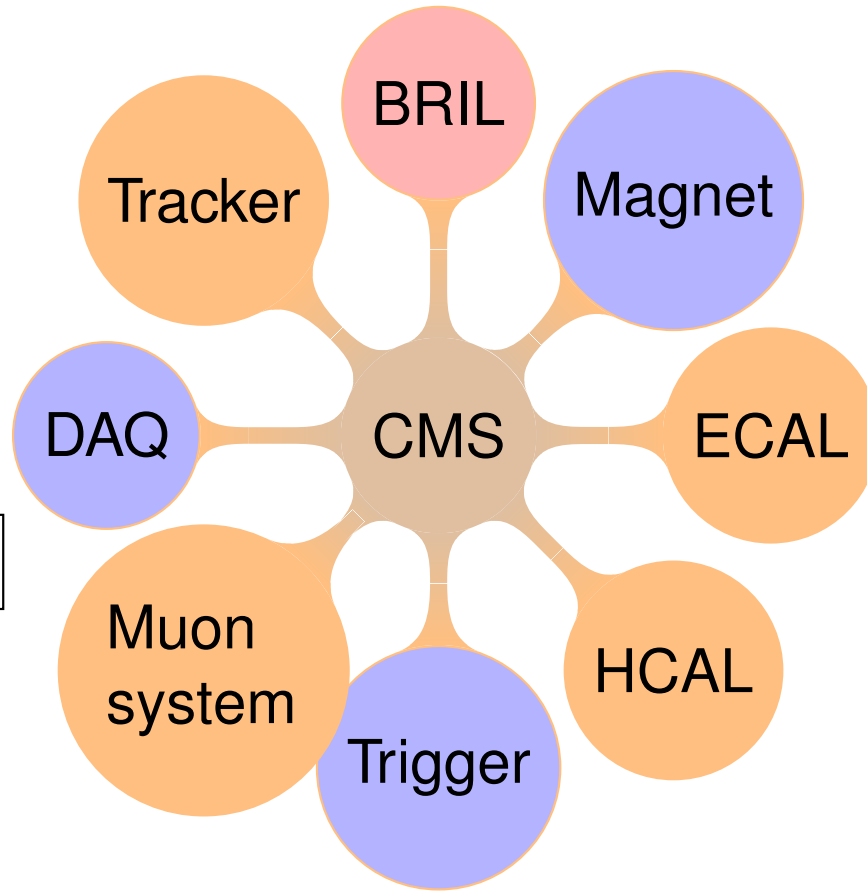
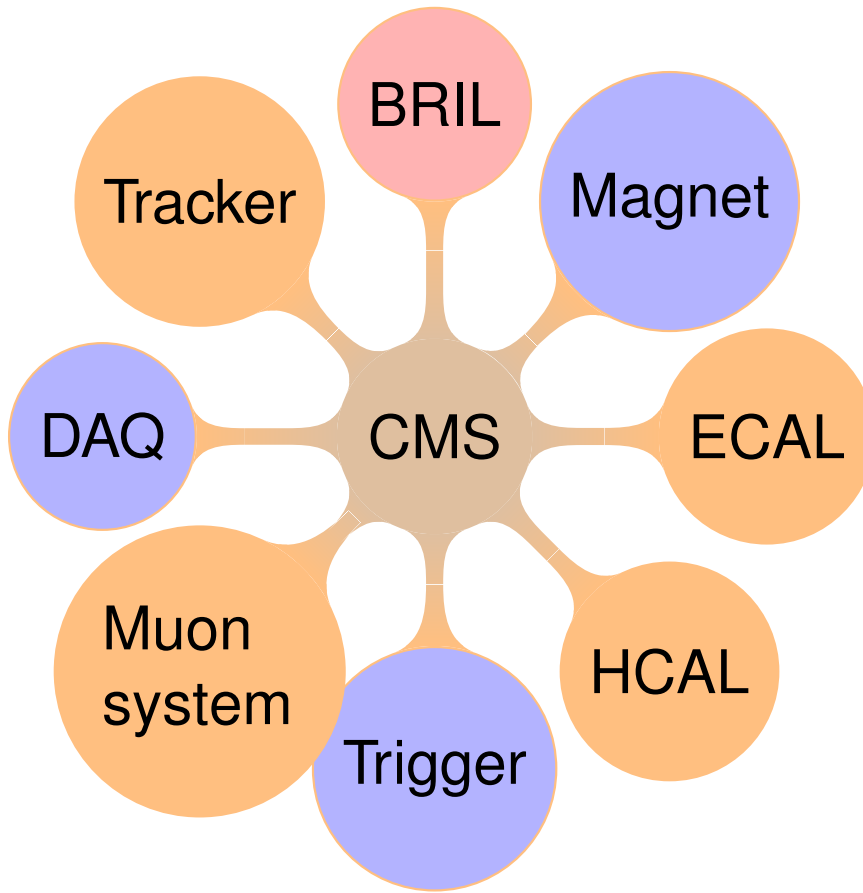




CMS Detector

CMS global performance depends also on subsystems that are not properly sub-detectors:

- Magnet
- DAQ
- Trigger



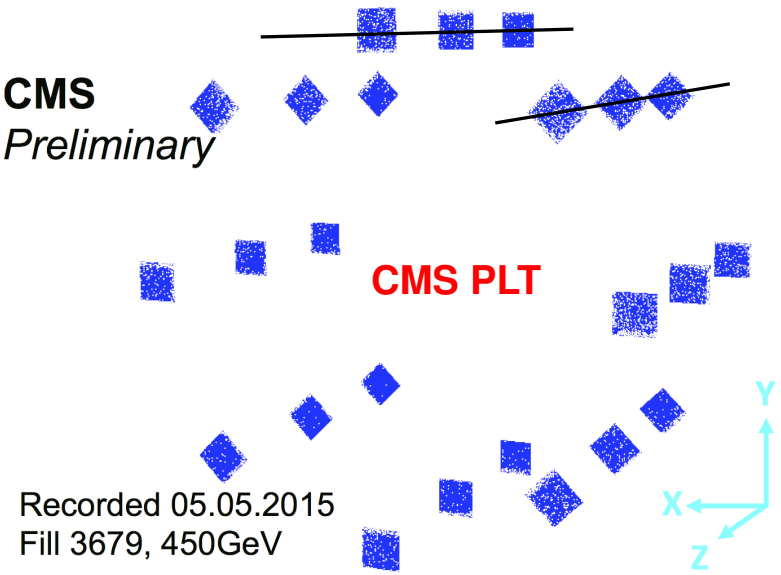
Beam Radiation Instrumentation and Luminosity

BRIL

- Several detectors (all commissioned)
  - Estimation of uncorrelated systematic uncertainty

BCM1F (online)
already used in Run I
based on number of MIPs

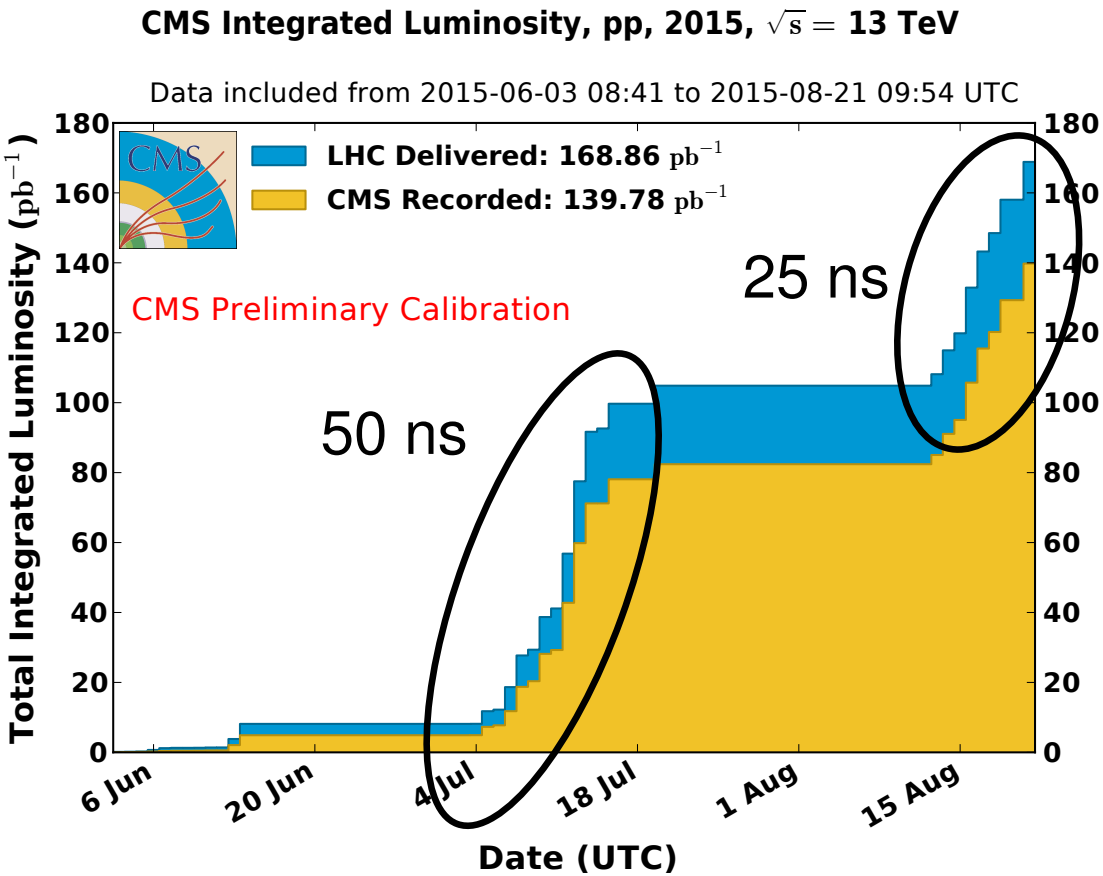
HF (online)
already used in Run I
based on occupancy



Pixel Luminosity Telescope (online): New for Run II, rate measurement based on occupancy

CMS Pixel Detector (offline)
Reference Luminometer, based on Pixel Cluster Counting, 2.6% precision achieved for 2012 Data

Luminosity Measurement



- In 2012, ultimate precision achieved after elaborate effort: 2.6% uncertainty

Trigger

Two stage trigger system:

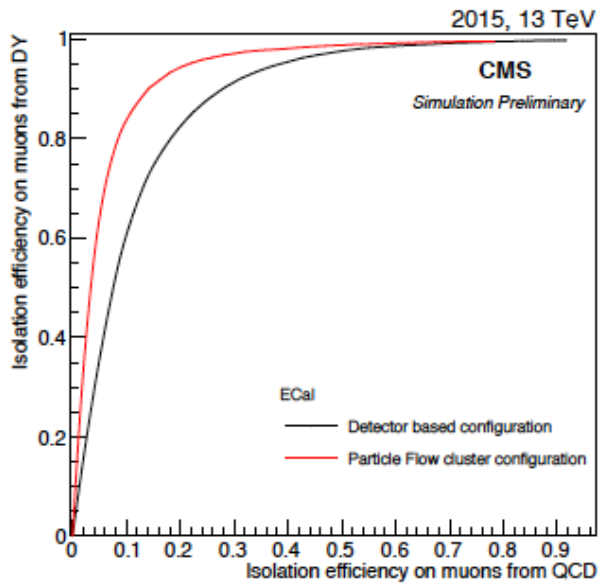
CMS (40 MHz) → L1 (100 kHz) → HLT (1 kHz)

- Improved algorithms -25% time needed to process 1 event
- Particle Flow algorithm now also at HLT

  $\rightarrow$higher PU w.r.t. Run I need dedicated PU mitigated algorithm

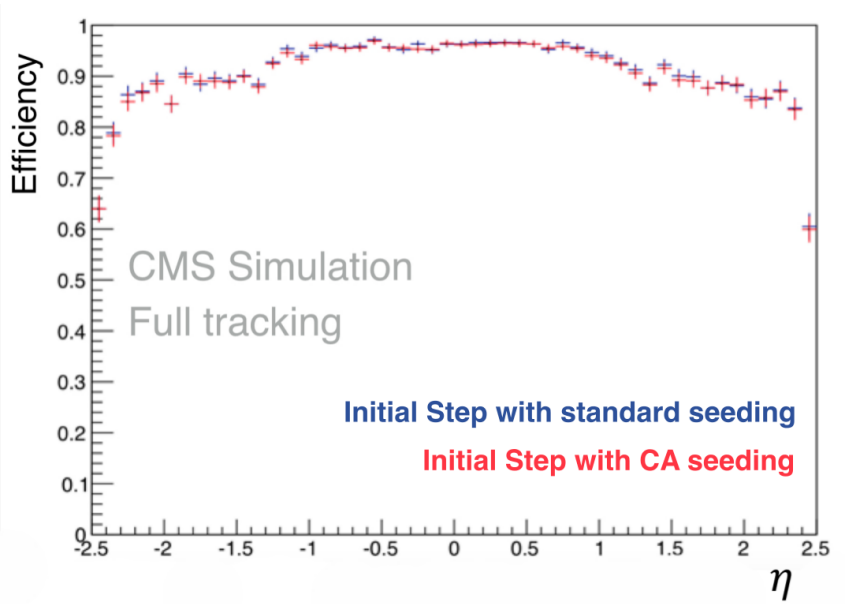
- Some detector conditions were unknown at startup:

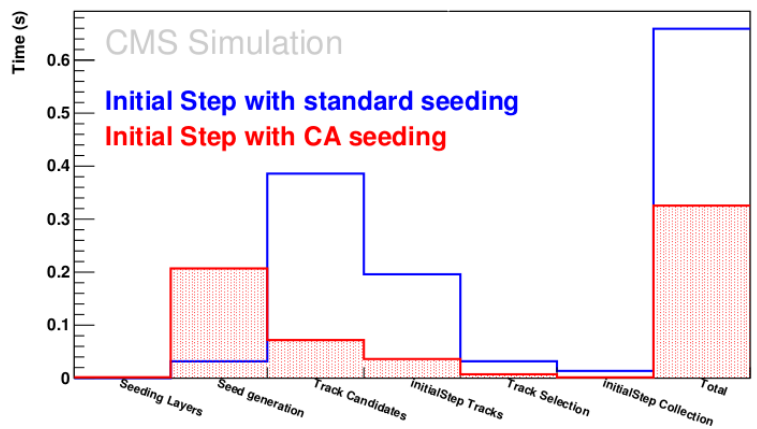
  need data to align and calibrate the detector again (e.g. $400\mathrm{pb}^{-1}$ for ECAL)
  - Trigger selection optimized on MC simulation at 13 TeV
  - Very loose selection criteria



Tracker

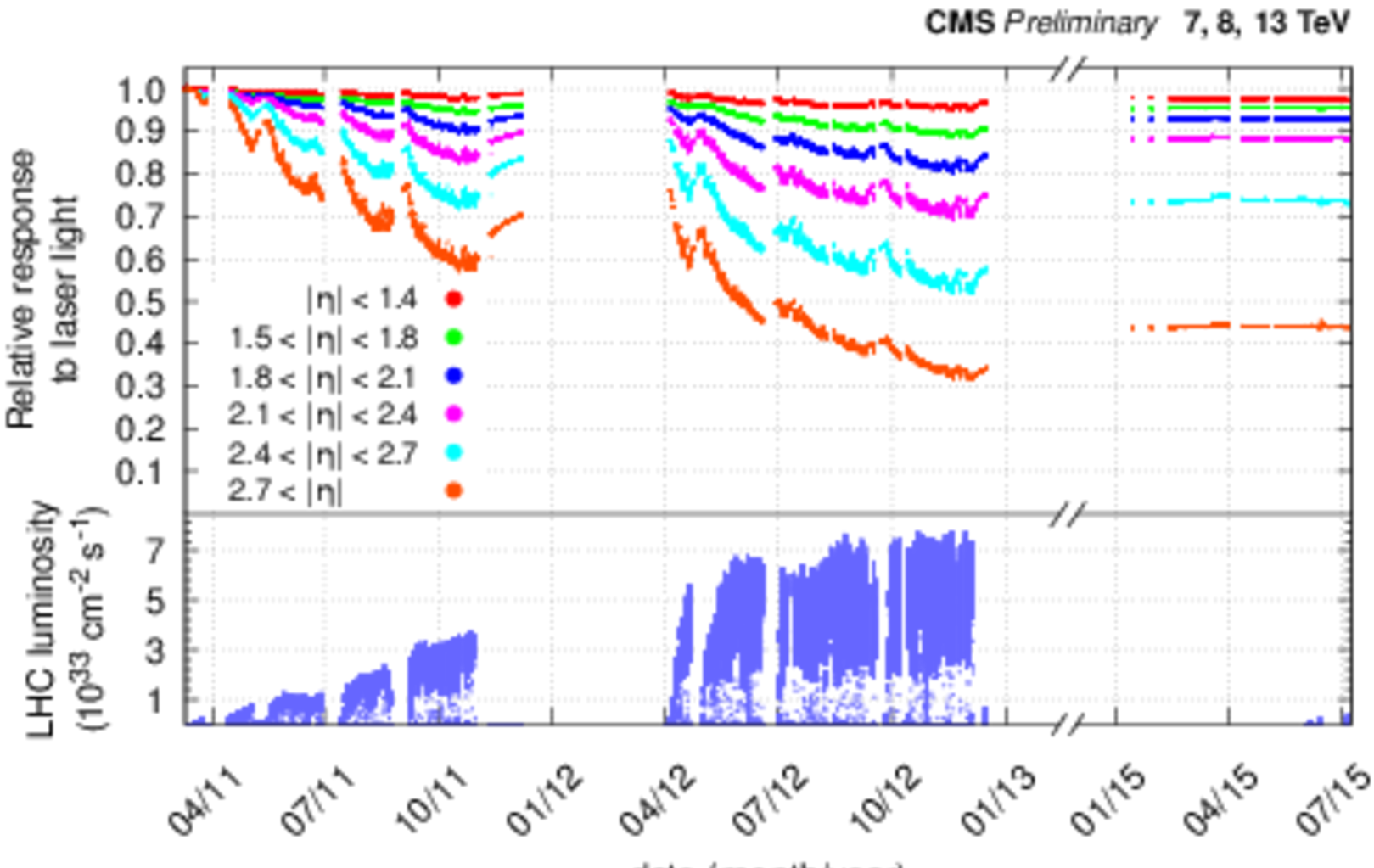
- Now operating at $-15°C$
  $\rightarrow$ calibration needed
- Removed completely and re-installed
  $\rightarrow$ alignment needed
- Full alignment and calibration performed using cosmic data and first collisions
- Improved tracking algorithm
  - Reduced time in tracking, same efficiency $\rightarrow$ crucial for tracking in trigger when at high luminosity





ECAL

- Fully operational (recovered 1% not working channels)
- Recovery of response during LS1: laser monitoring system
  - Need more data for precise alignment and energy calibration



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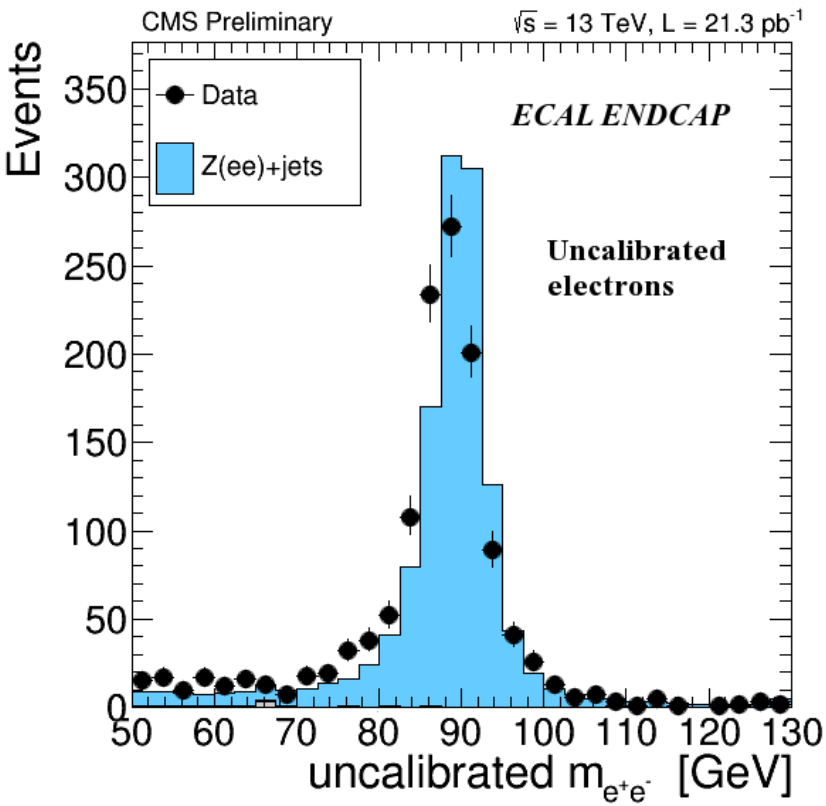
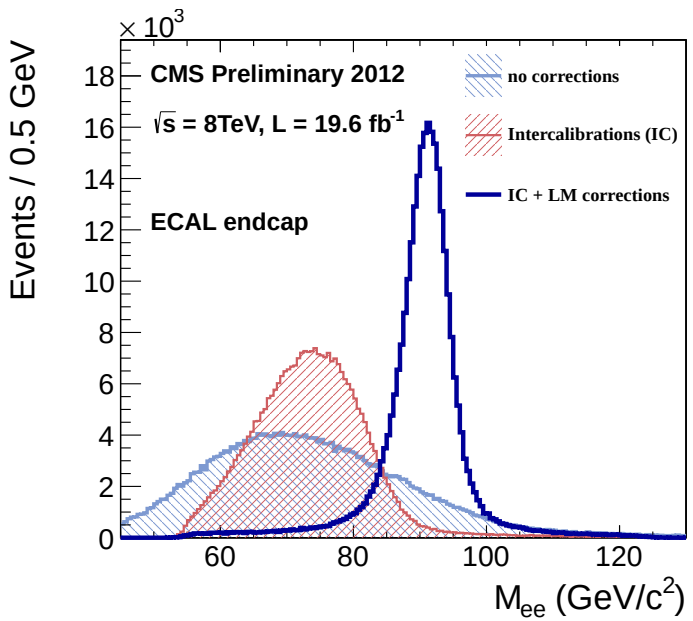
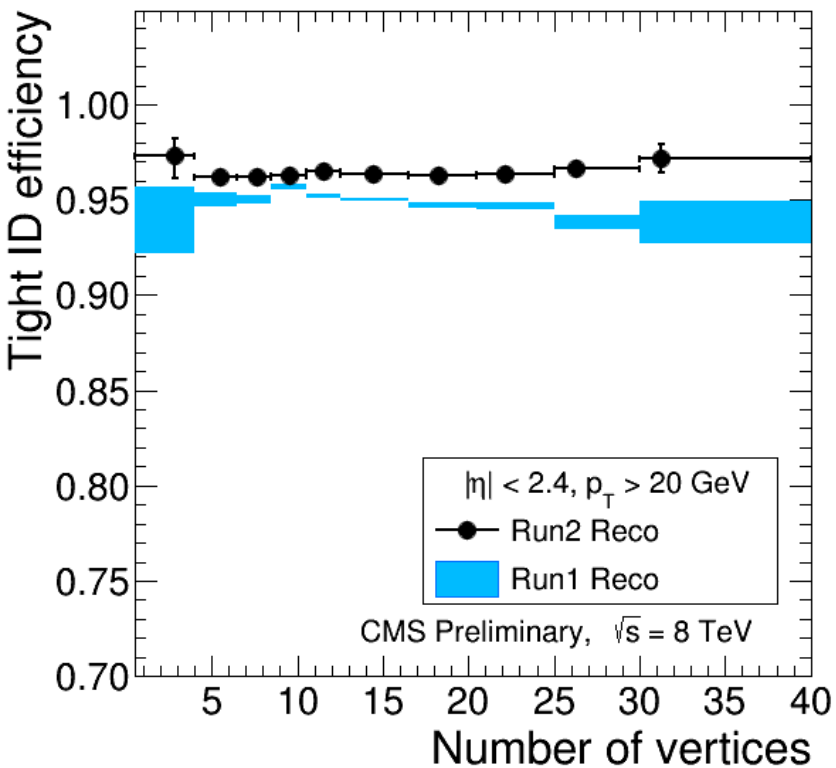
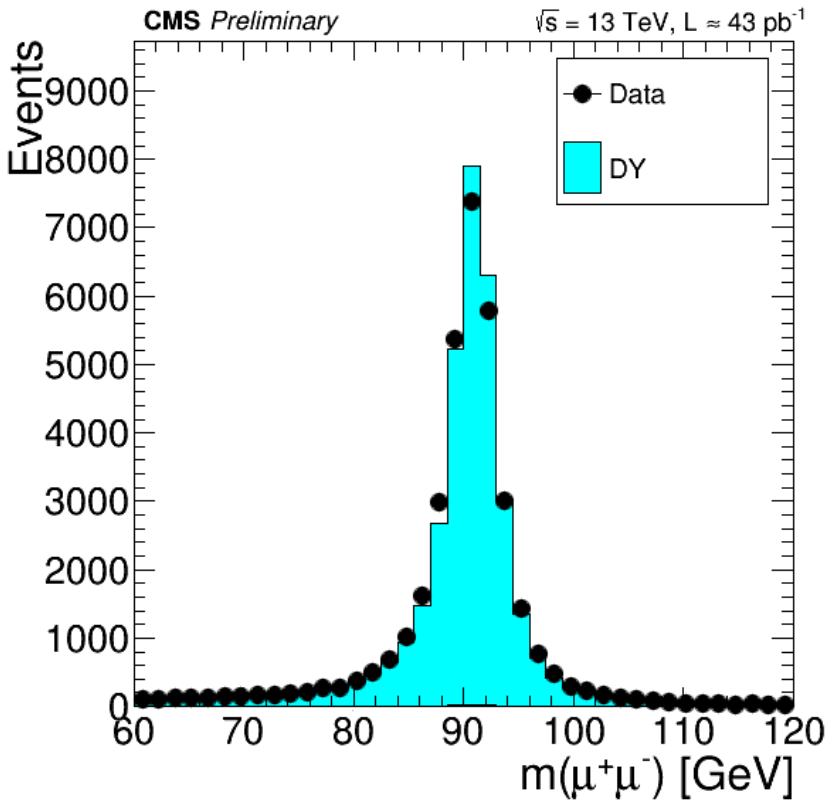




Muon

- New module installed during LS1
- Alignment performed using cosmics data and first collisions
- Improved muon reconstruction $\rightarrow$ 1-2% especially at high PU





Magnet

- Magnet at full field (3.8 T) on 19th of March for first time after two years
- Cosmic rays data collected for detector alignment at 3.8 T
- Cryogenic system encountered several problems during operation
  - Still under investigation $\rightarrow$ long work expected
  - CMS now continously running with full field for limited periods ($\sim$ 1 week)

Summary

- Broad experience from the past Run I
- Once more at the **energy frontier** (13 TeV) with **unprecedented conditions**
- Still at the **beginning of new era**
- Very preliminary alignment and calibration
  $\rightarrow$ already good quality data

The CMS Detector is performing well and we expect to be able to exploit its full potential collecting and analyzing the new data.

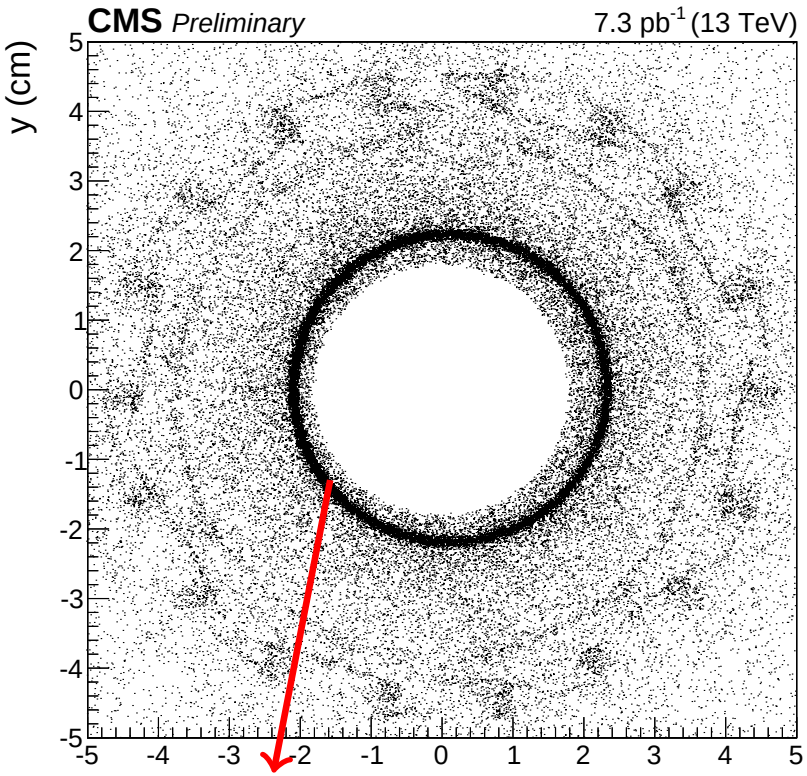

Thanks to all people involved in online operations (LHC and CMS)...
CHAMPION
DELL

. . . that made Run I a success and make Run II a reality

Thanks

Backup

Preliminary Tracker Material Measurements



Nuclear Interaction for Run2015B data at 13 TeV, (x, y) plane, zoomed in the beam pipe region, for the barrel part ($|z| < 20\text{cm}$). Beam Pipe is shifted from the central value of the detector. Grey circle with radius around 3.7 cm corresponds to the Pixel Shield. Structure with radius around 4.2-4.7 cm corresponds to the 1st layer of the Pixel. White circle with radius 1.8 cm corresponds to the reconstruction cut for the nuclear interaction.