CMS

Performance

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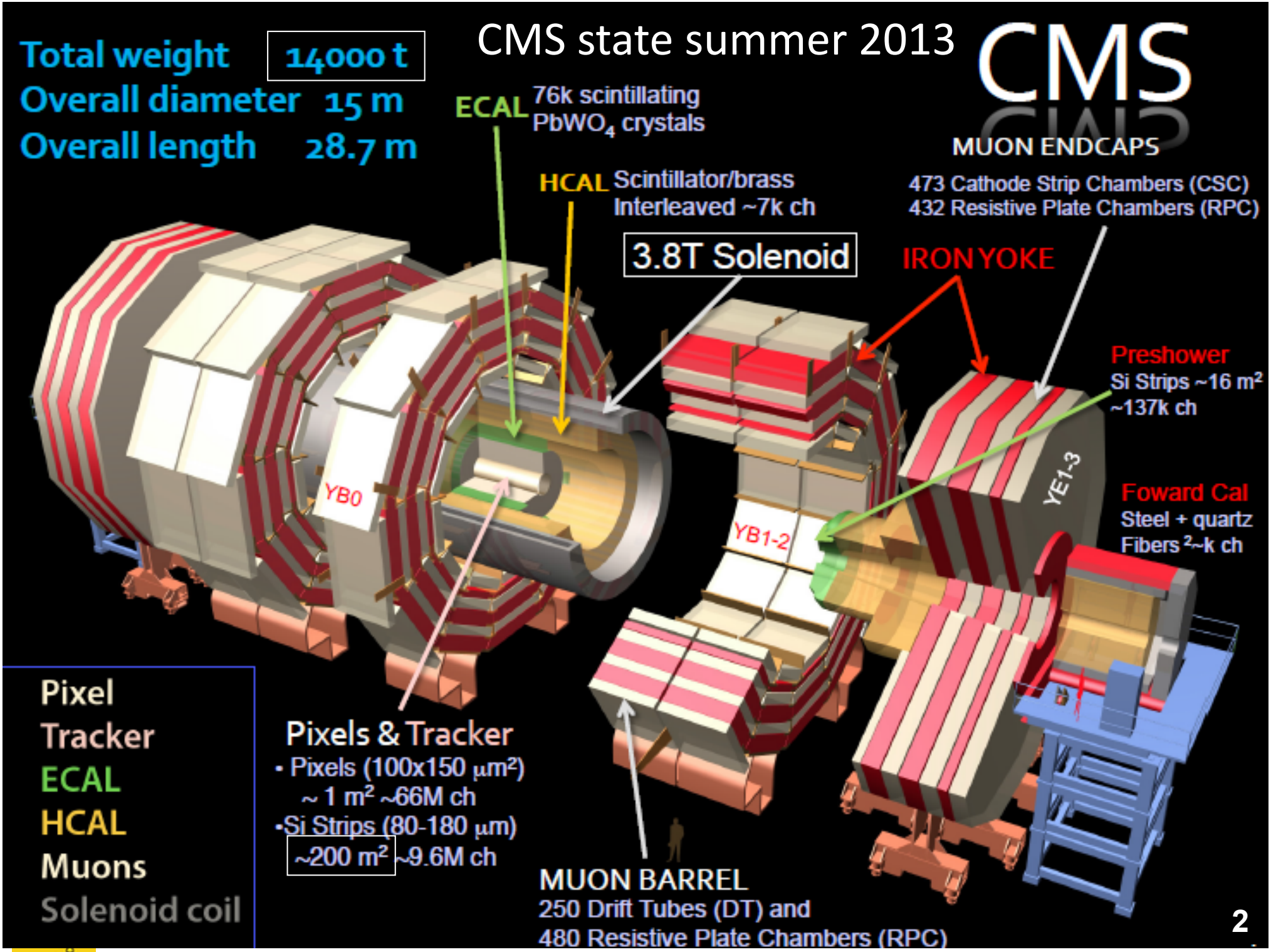
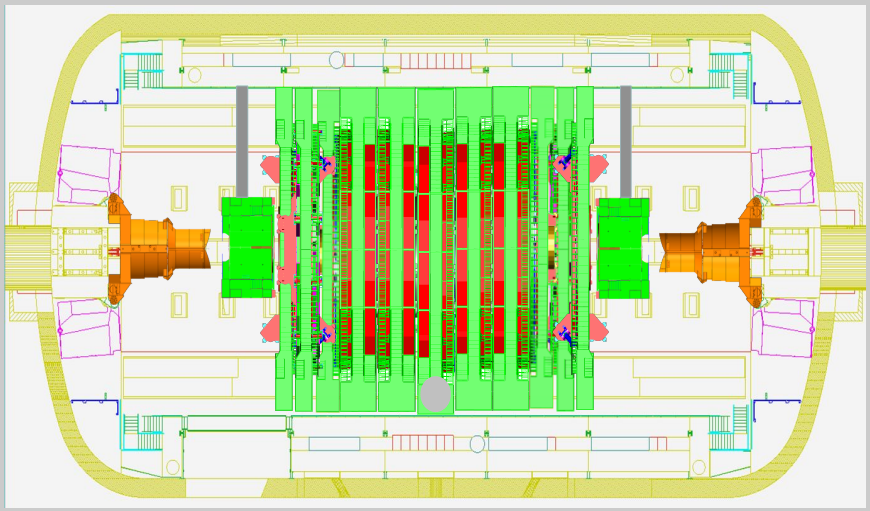
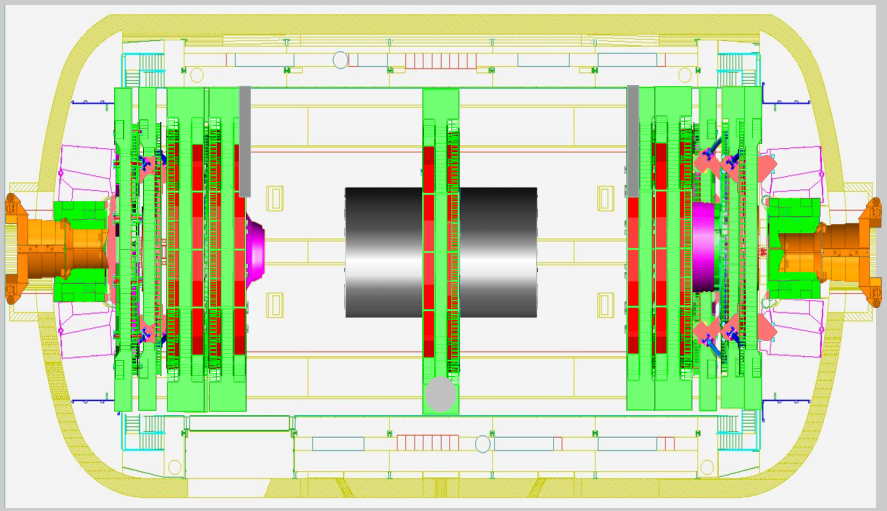
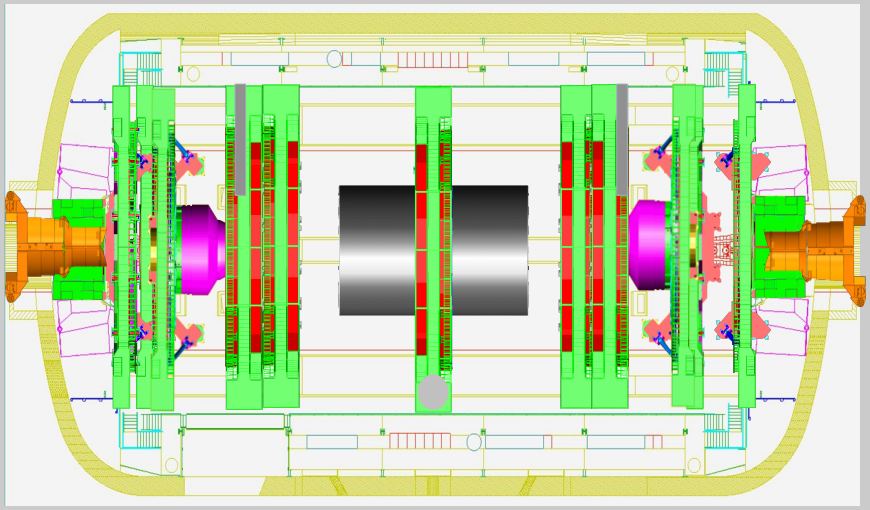
on behalf of CMS

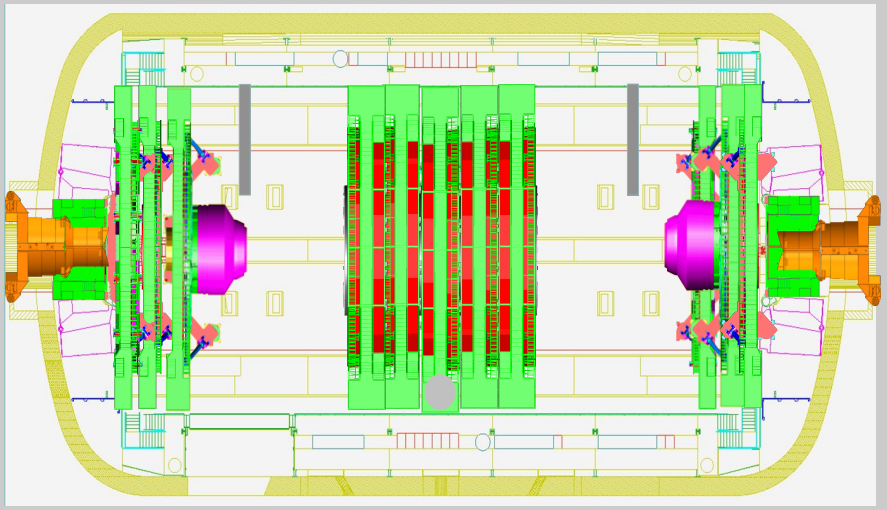

CMS state summer 2013
CMS
Total weight 14000 t
Overall diameter 15 m
Overall length 28.7 m
ECAL 76k scintillating $PbWO_4$ crystals
HCAL Scintillator/brass Interleaved ~7k ch
3.8T Solenoid
IRON YOKE
MUON ENDCAPS
473 Cathode Strip Chambers (CSC)
432 Resistive Plate Chambers (RPC)
Preshower
Si Strips ~16 m²
~137k ch
Foward Cal
Steel + quartz Fibers ²~k ch
YB0
YB1-2
YE1-3
Pixel
Tracker
ECAL
HCAL
Muons
Solenoid coil
Pixels & Tracker
• Pixels (100x150 μm²) ~ 1 m² ~66M ch
•Si Strips (80-180 μm) ~200 m² ~9.6M ch
MUON BARREL
250 Drift Tubes (DT) and
480 Resistive Plate Chambers (RPC)

Being compact helps to be (relatively) nimble.
LS1: A ballet with 1000 ton elephants



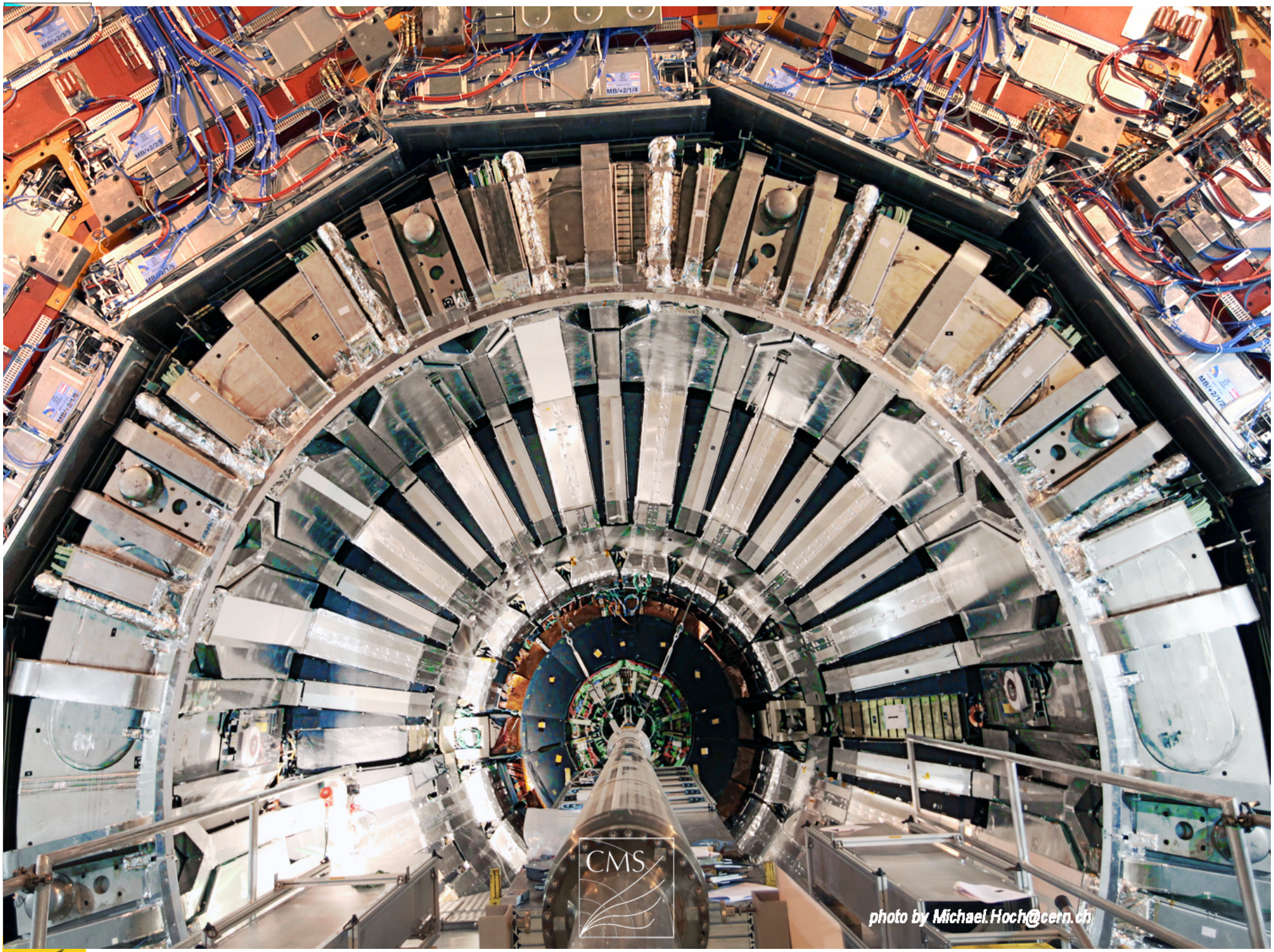


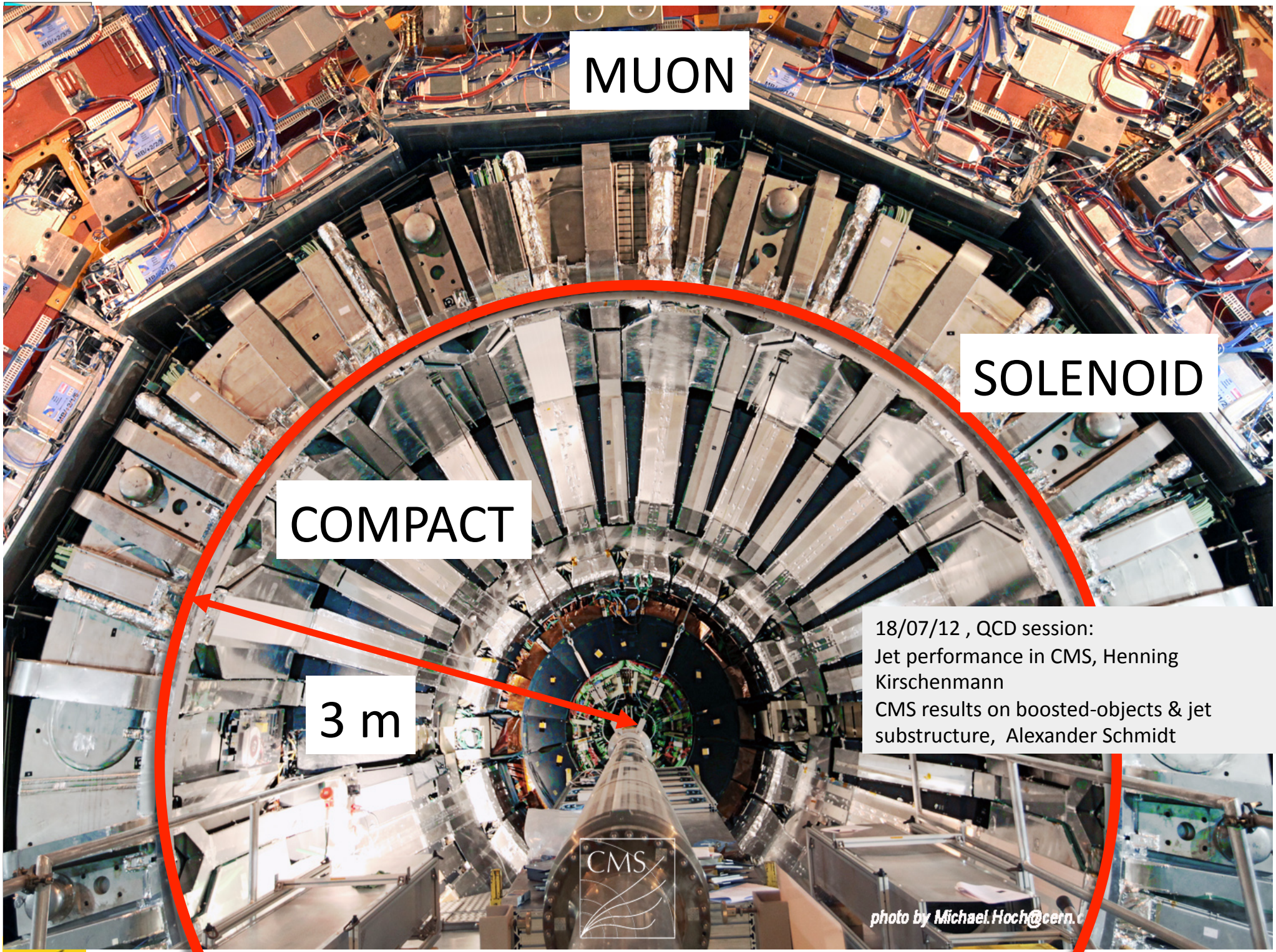




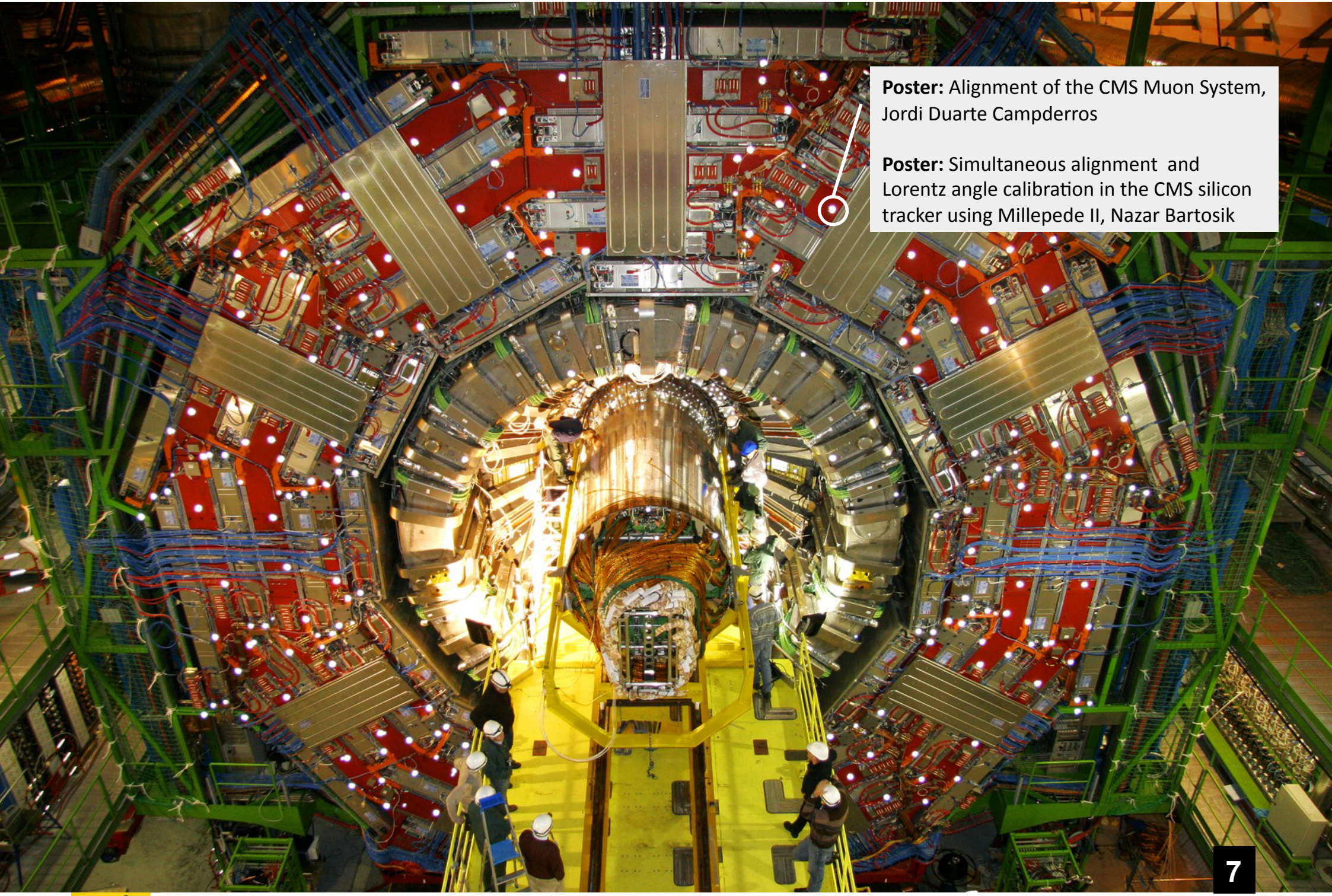
Qualitatively…
an impressive detector

1. All Si tracker
2. Calorimeters inside large 3.8 T, 3m radius solenoid
3. Hermetic up to 5.2 in rapidity
4. Muon detectors actually a rather precise gas tracker system covering a huge volume
5. 100 KHz readout rate (~1 MB event size)
6. Last but not least, photogenic


CMS
photo by Michael.Hoch@cern.ch



18/07/12 , QCD session:
Jet performance in CMS, Henning Kirschenmann
CMS results on boosted-objects & jet substructure, Alexander Schmidt



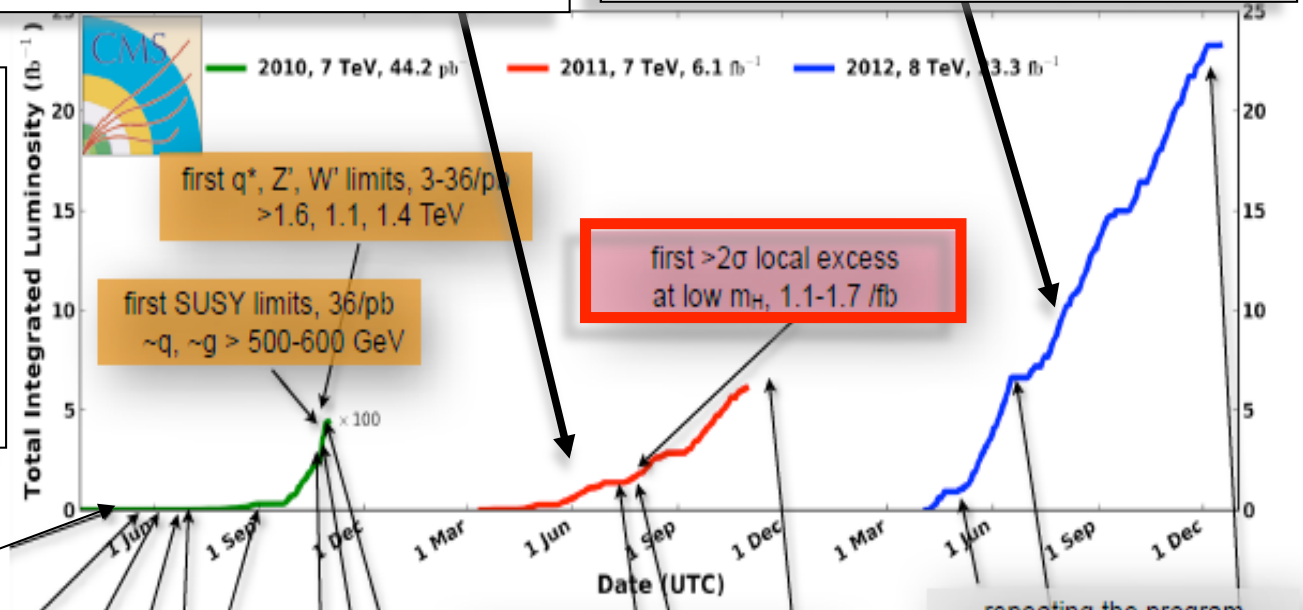
Poster: Alignment of the CMS Muon System, Jordi Duarte Campderros

Poster: Simultaneous alignment and Lorentz angle calibration in the CMS silicon tracker using Millepede II, Nazar Bartosik

Plenty of barrel muons in online display!

100 Khz barrel muons (all pt)

2009 running:
- Hard to see anything apart from min bias in the displays.
- Serious analysis to find muons in the barrel.



What a run!

first q*, Z', W' limits, 3-36/pb
>1.6, 1.1, 1.4 TeV

first SUSY limits, 36/pb
~q, ~g > 500-600 GeV

first >2σ local excess
at low m_H, 1.1-1.7 /fb

repeating the program
at 8 TeV

first MinBias / UE
studies, particle multiplicities

first top xsec, 3/pb
δ ~ 40%

first ZZ xsec, 1.1 /fb
δ ~ 40%

a new boson is
announced, 5 /fb

first incl. b x-section, 8/nb
δ ~ 15 %

first single top xsec,
t-chan., 36/pb
δ ~ 36%

going more differential,
e.g. Z/W + j,b,c

first incl. jet x-section, PF jets
60/nb δ ~ 20-30%

first significant limit on
$B_s \to \mu\mu$, BR<1.9x10⁻⁸

first m_{top}, 36/pb
Δ ~ 6.5 GeV

first incl. W/Z x-sections, 200/nb
δ ~ 4-6%, +11% lumi

first particle discovered
by CMS: Ξ_b

first WW xsec, 36/pb
δ ~ 40%
first limit on HWW

BSM searches continue,
limits pushed

first spin parity
analysis of the boson,
17 /fb

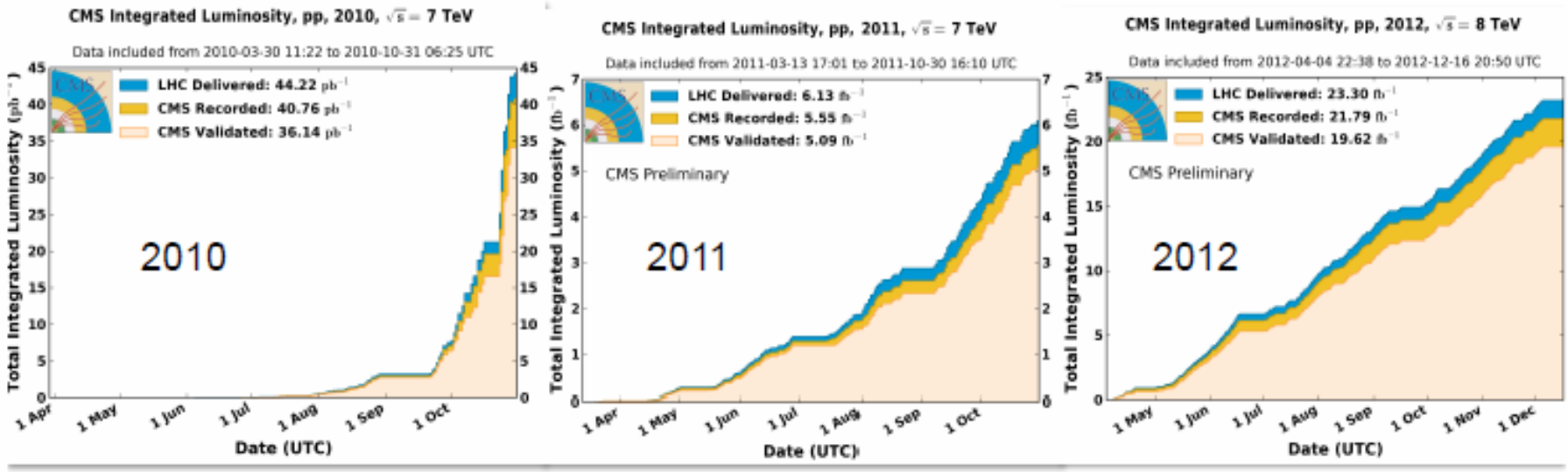
δ .. relative uncert Δ .. absolute uncert.

G. Dissertori

I. Redondo

Number of bottles / fb-1

People operating CMS

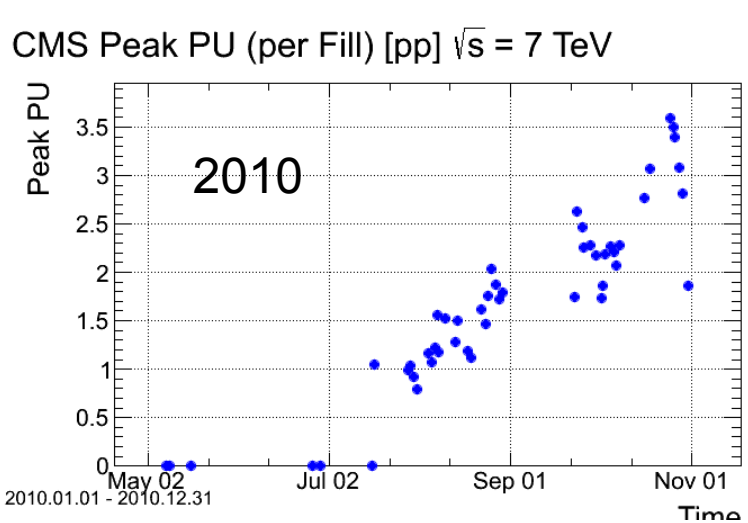


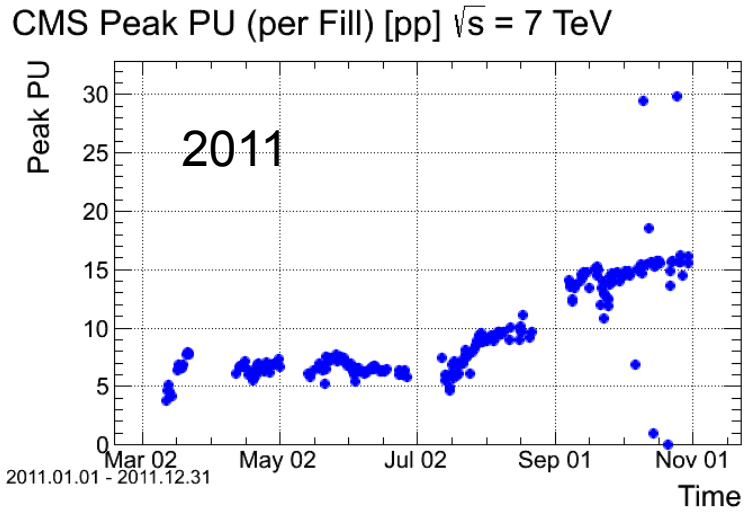
- Final refinements in automation during 2012
- Excellent data taking efficiency
  - Expertise did not fly away to the next collider (Where?)
- Data validated stable at 90 %

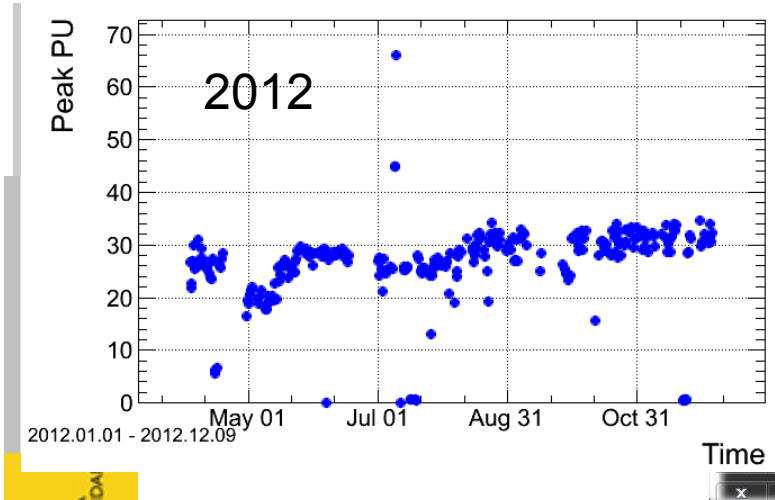
Period	√s [GeV]	Delivered luminosity [fb^{-1}]	Data taking efficiency [%]	Data validated [%]
2010	7	0.044	92.2	88.6
2011	7	6.13	90.5	90.1
2012	8	23.20	93.5	90.0

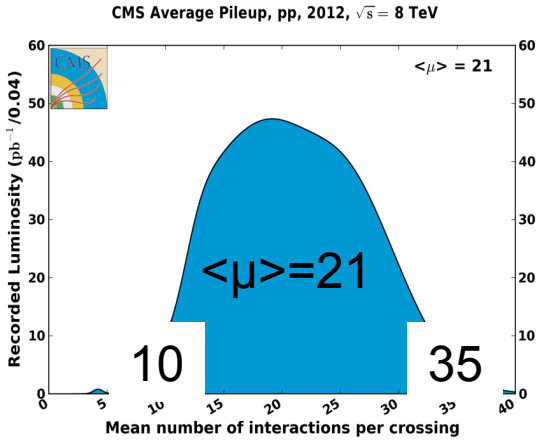
Event Pileup

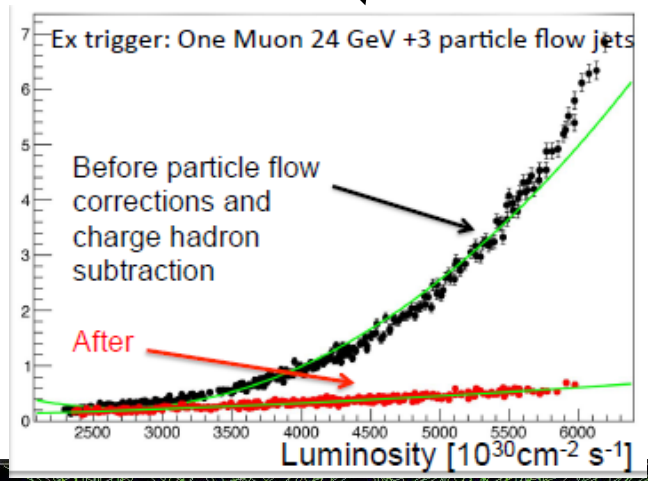
- Pileup increase forced CMS to adapt to varying data taking conditions
- From FW changes to trigger menus
- Offline algorithms (Particle flow) moved to HLT helped

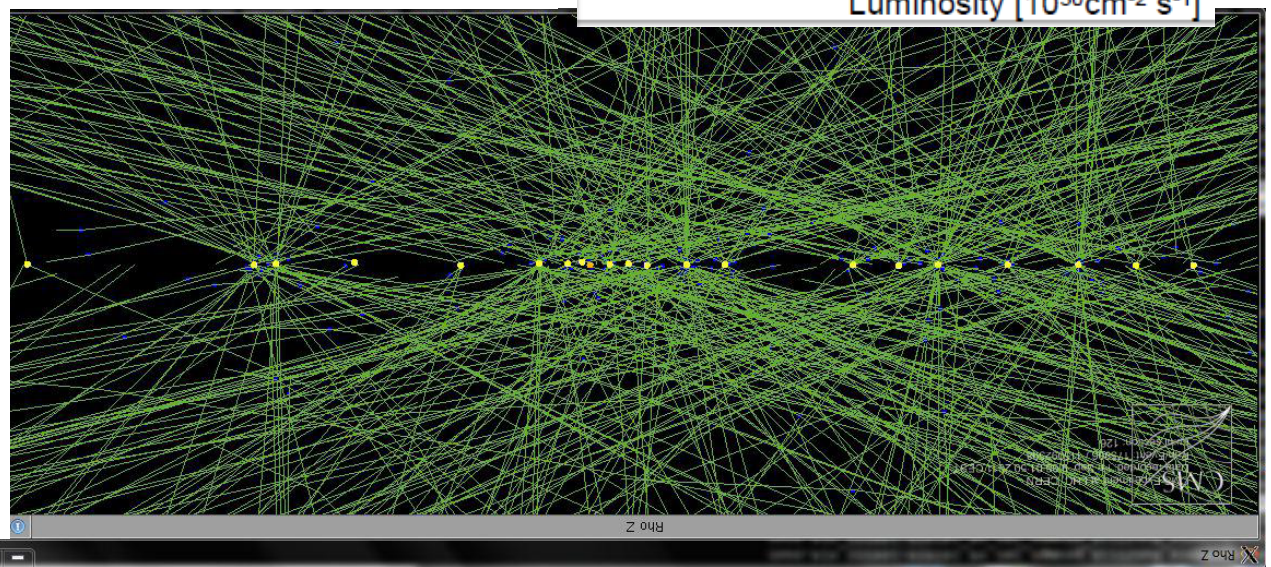




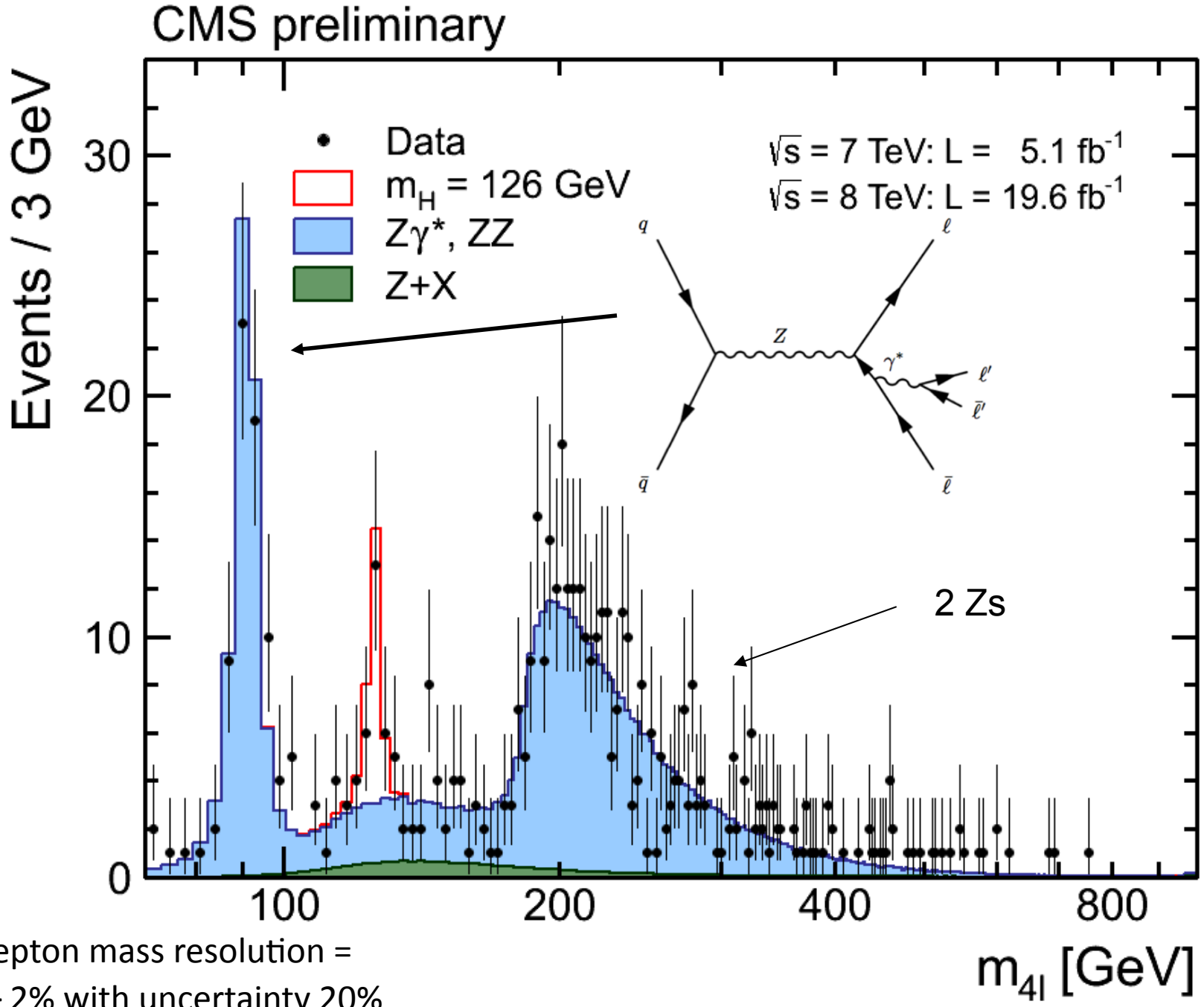






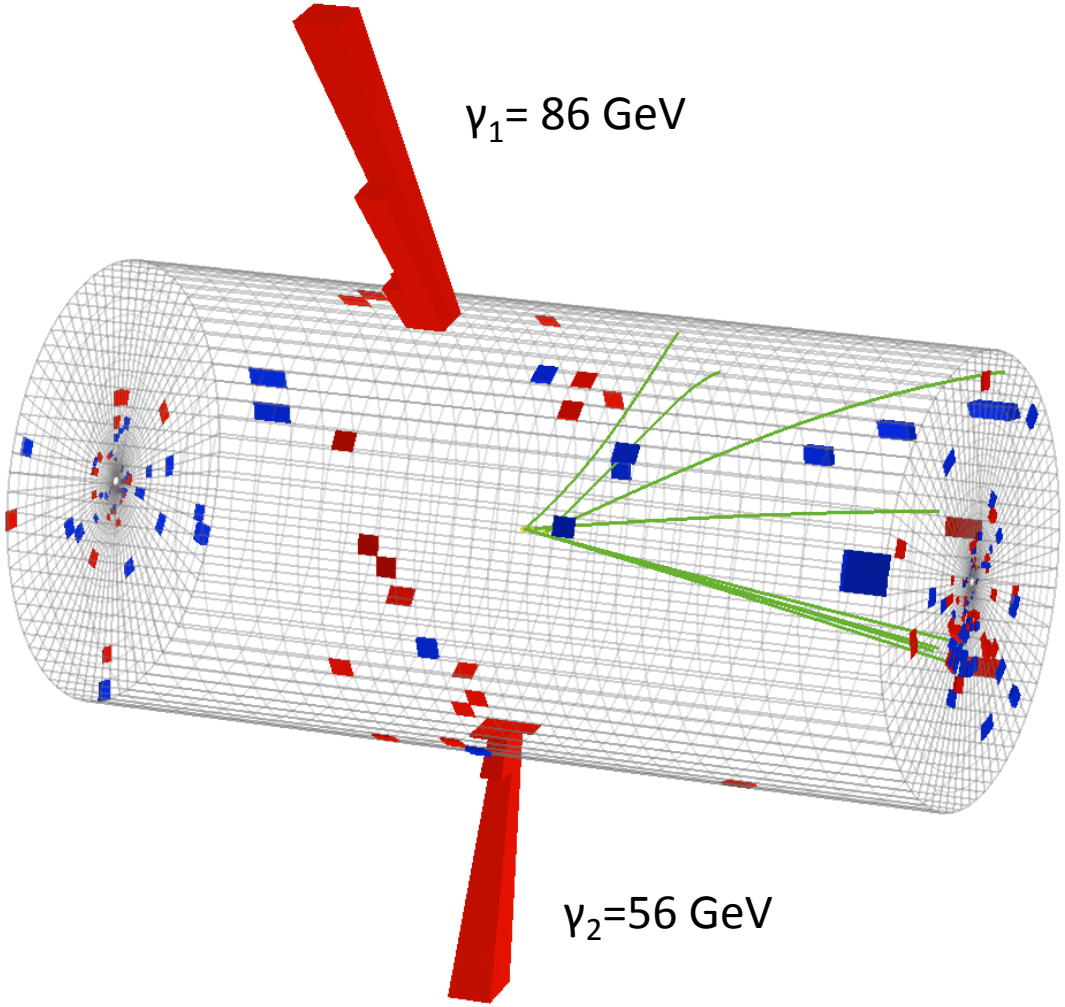


CMS in action: H->4 lepton

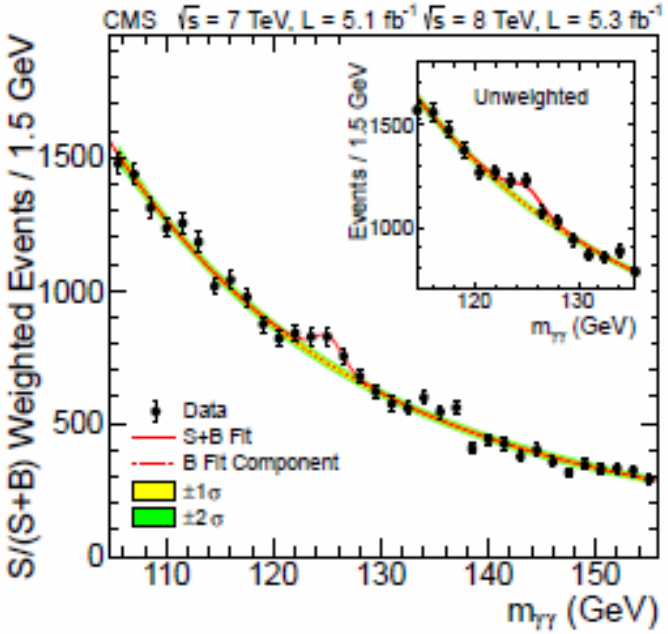


4 lepton mass resolution =
1 – 2% with uncertainty 20%

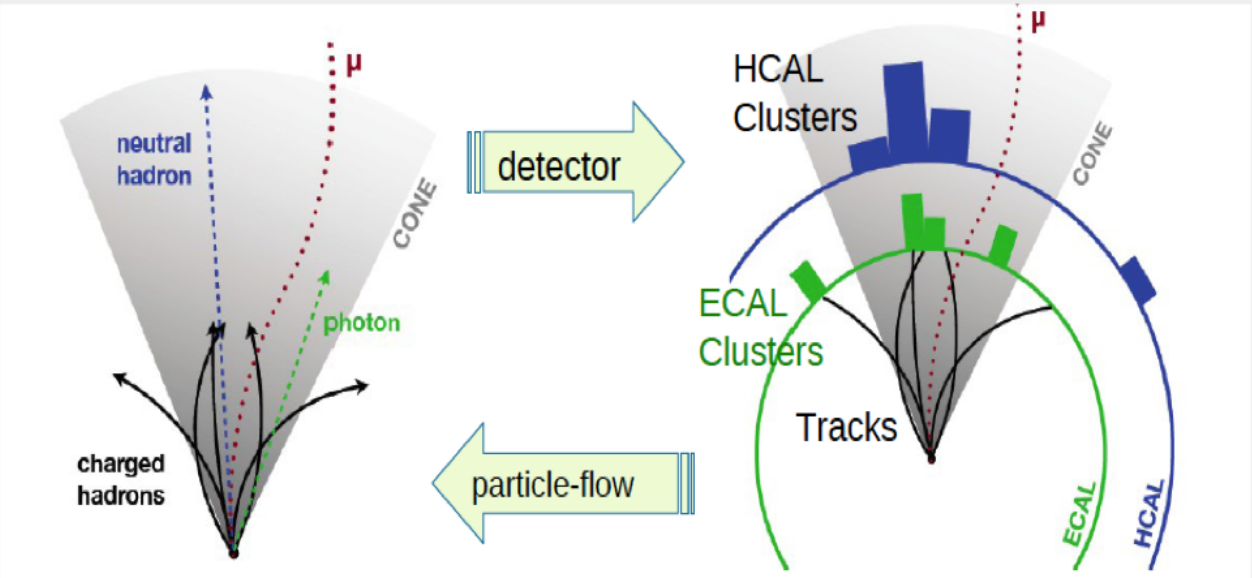
CMS in action: H->2γ



CMS Collaboration,
Phys. Lett. B716 (2012) 30-61



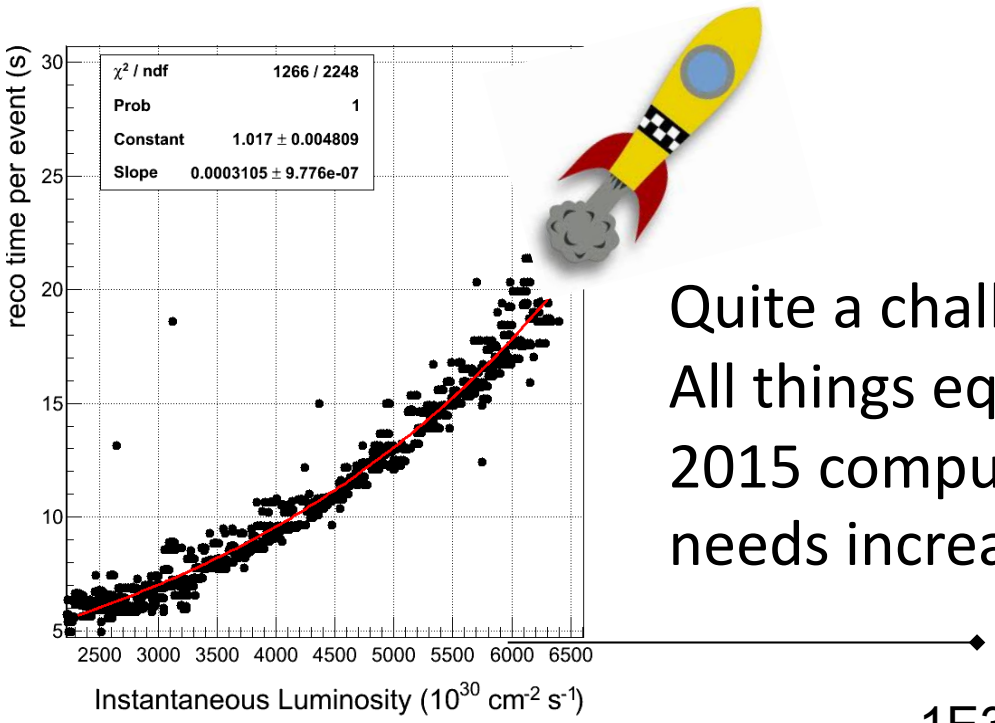
- A lot goes into those plots. Excellent:
  1. muon trigger and reconstruction
  2. electron trigger and reconstruction
  3. photon trigger and identification
  4. Tracking (and vertexing) is the backbone of the global event description
  5. and Massive computing resources
- And all that under a pile up of 20 vertex/crossing



- Charged particles well separated in large tracker volume & 3.8T B field
- Excellent tracking, able to go to down to very low momenta (~100 MeV)
- Granular electromagnetic calorimeter with excellent energy resolution
- In multijet events, only 10% of the energy goes to neutral (stable) hadrons

Computing and Data handling

- Improvements in the reconstruction code to cope with pile up
- Reconstruction time per event reduced by maintaining the physics performance.
  - Non-linear with PU ➔ explodes



Quite a challenge:
All things equal, 2015 computing needs increase x10

Reconstructed events
- 20 billion simulated events
- 12 billion data events

Data volume

More than 25PB moved to Tier-1s

70PB moved to Tier-2s

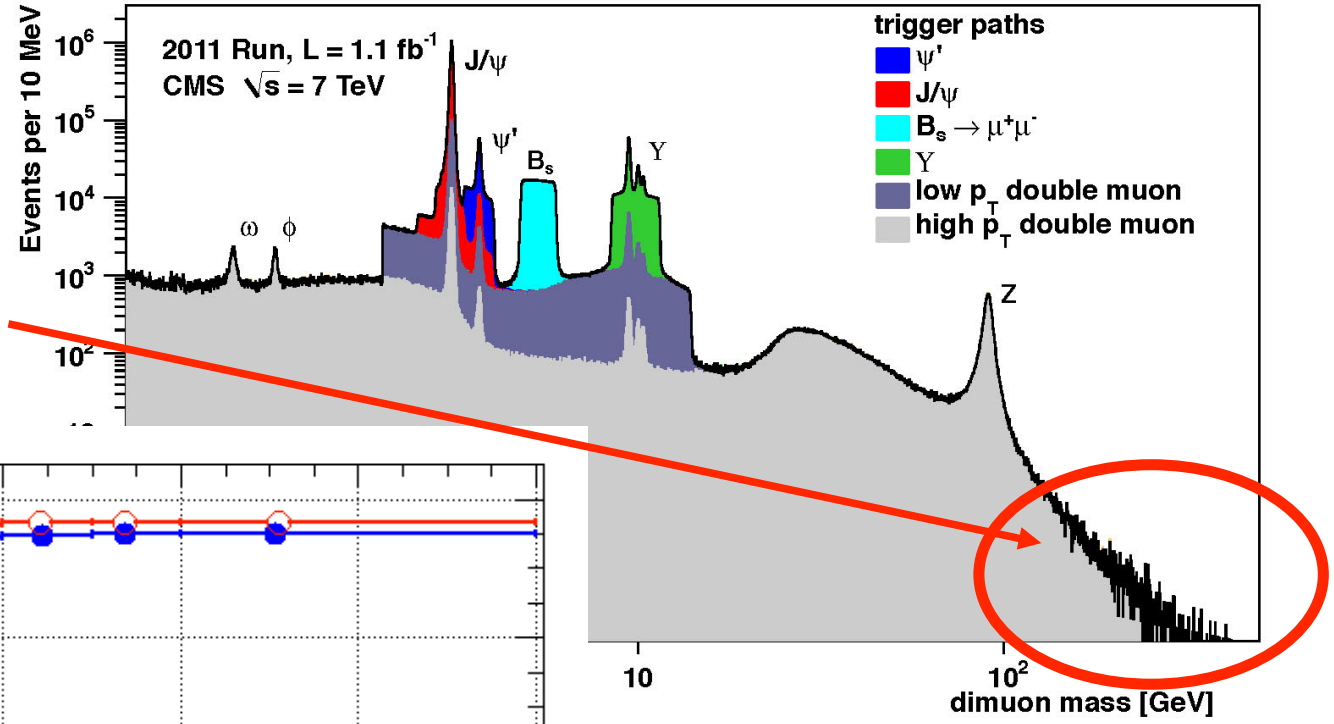
70M Grid processing requests submitted

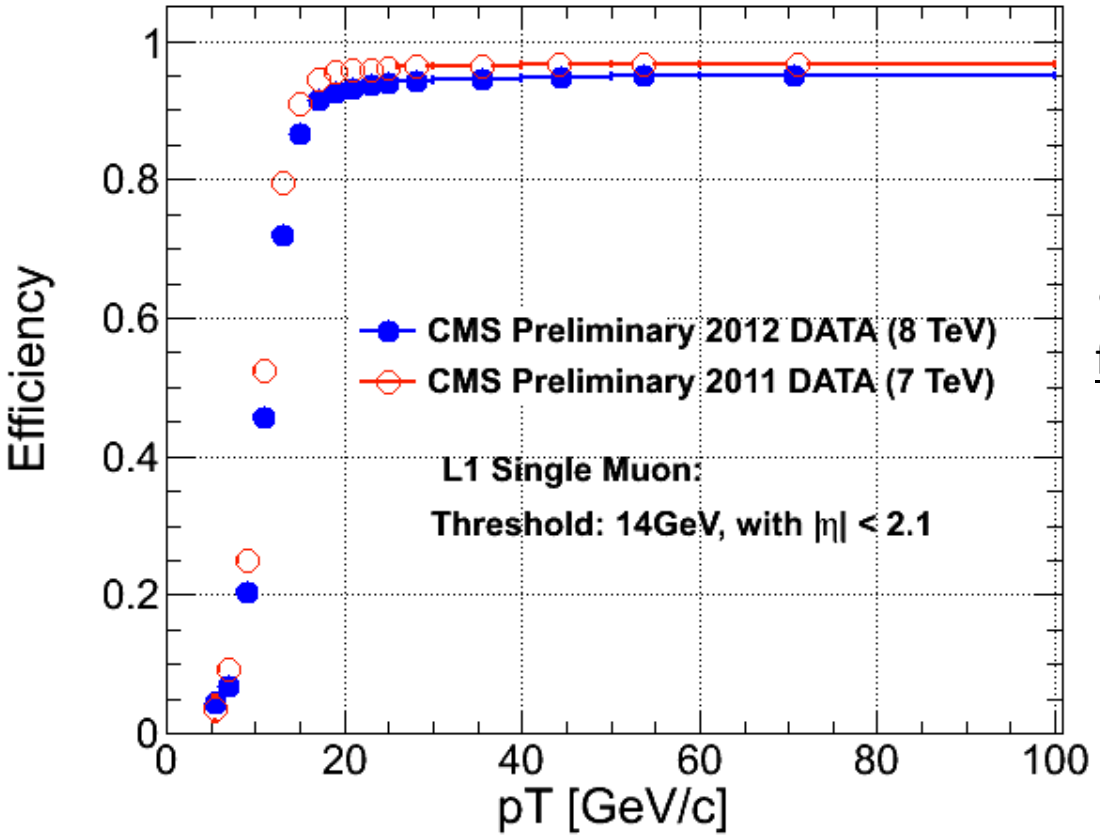
Poster: Data preparation for the Compact Muon Solenoid experiment

Roberto Castello

Excellent muon trigger and reconstruction

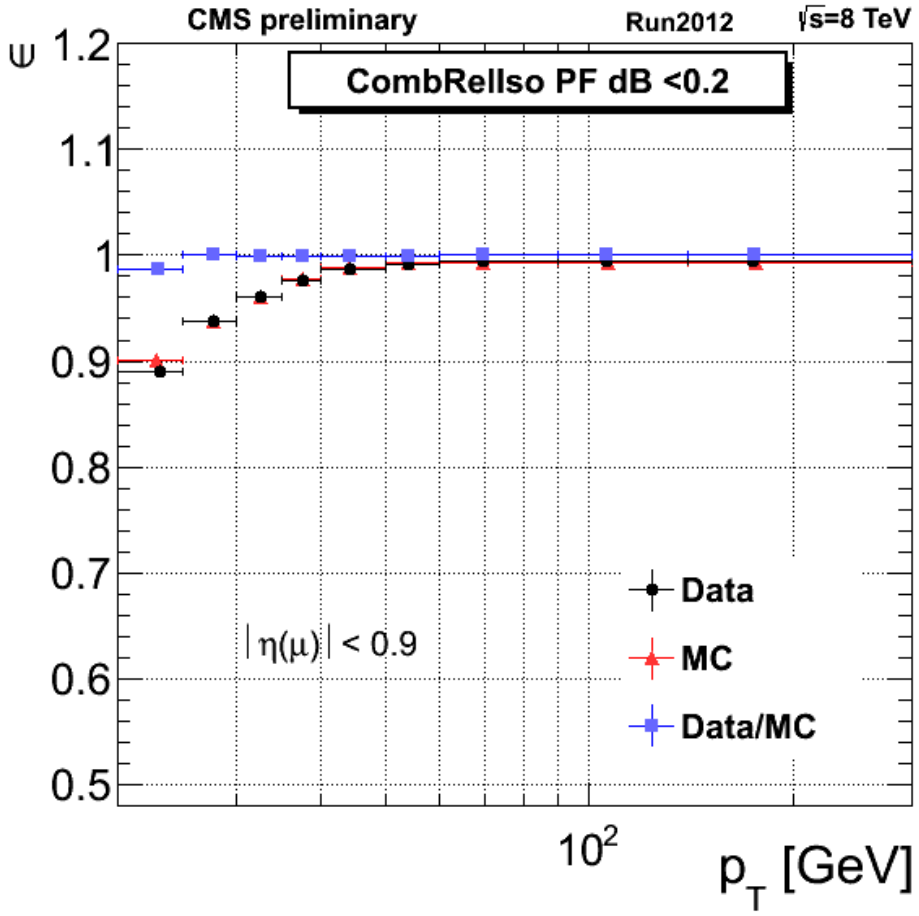
- An hadron collider makes the energy scan for you
- Resolution<1/2 % barrel,<6% endcap.
- Muon system resolution kicks in >100 GeV



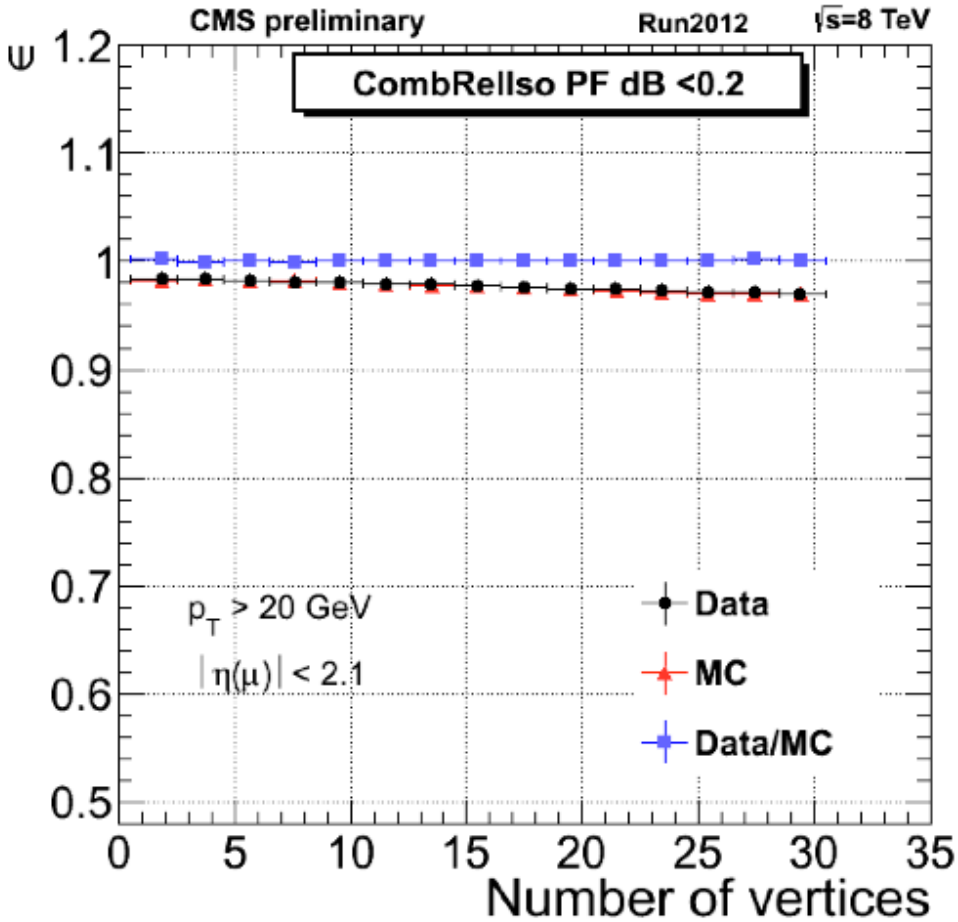


- ~<u>50% rate reduction in 2012, for few % efficiency</u>:
  - -Endcap Track Finder: tighter P_t assignment
  - -Better Global Muon Trigger P_t merging
  - -Improvement in Barrel-Endcap overlap Track Finding

Muon Isolation Efficiency



Eff>95 % @ pT>25 GeV

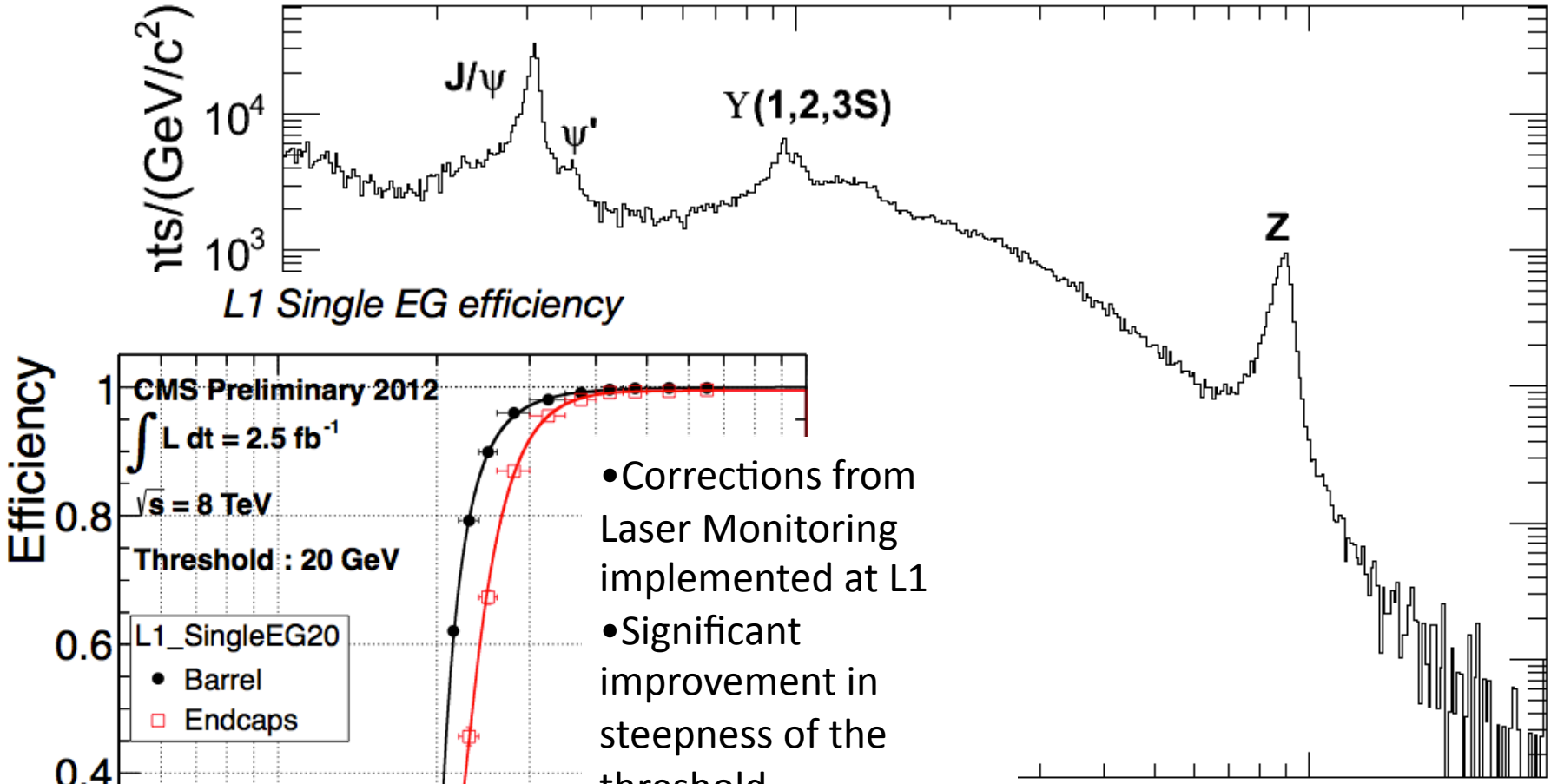


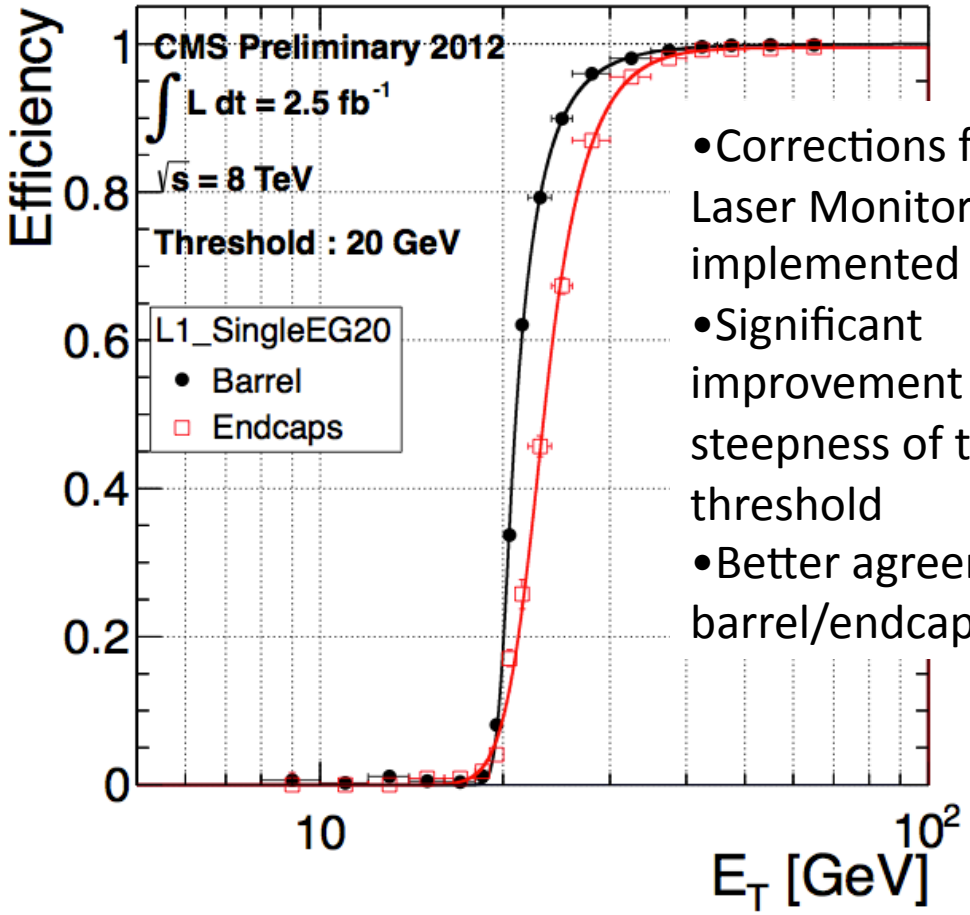
Rather flat vs. Pileup

Good description by the simulation

Excellent electron trigger and reconstruction

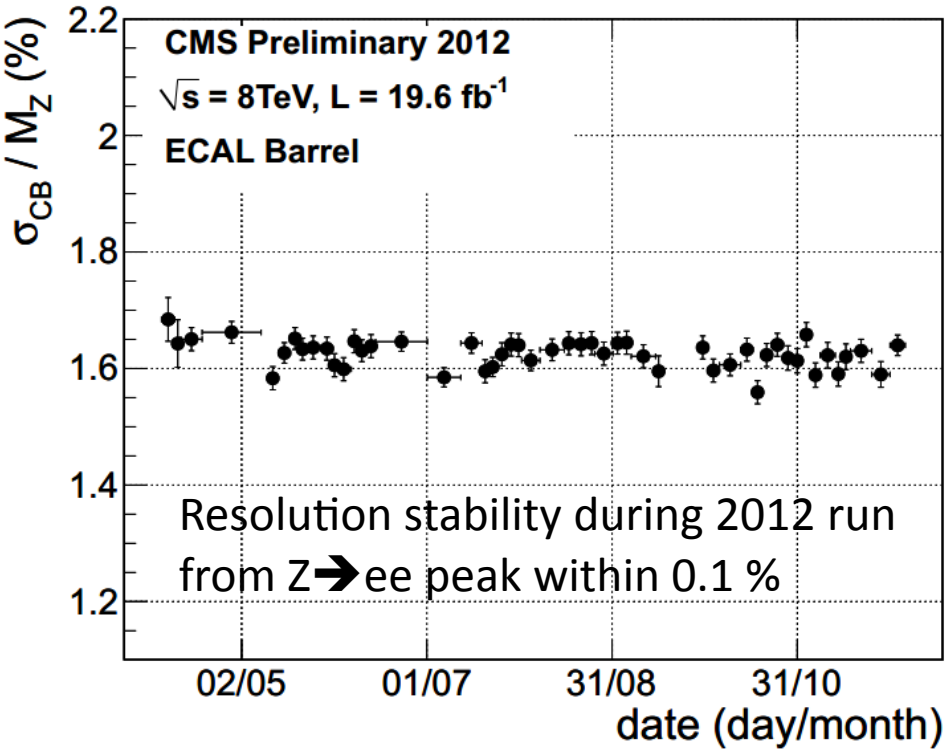
I. Redondo

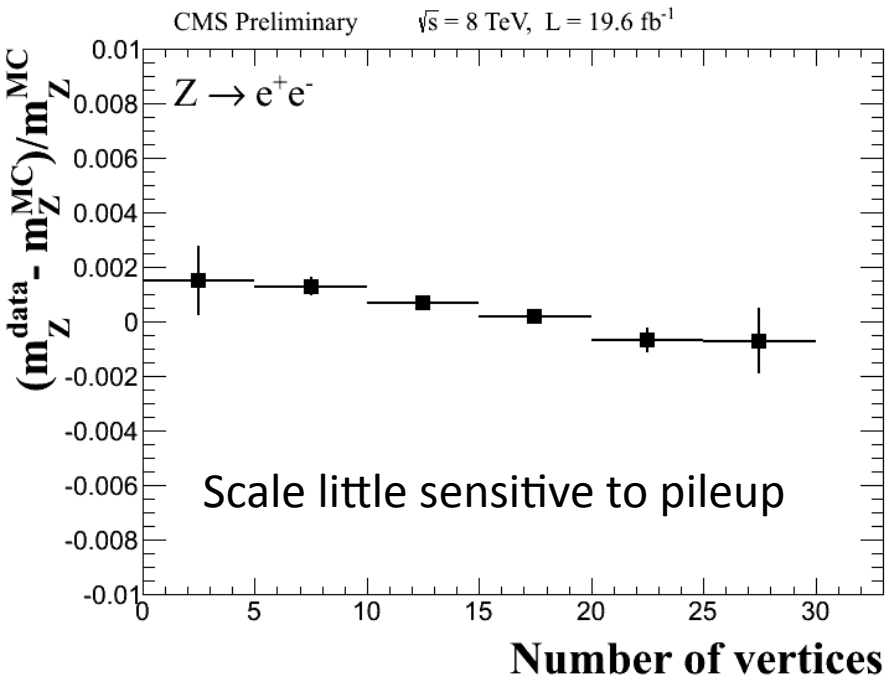




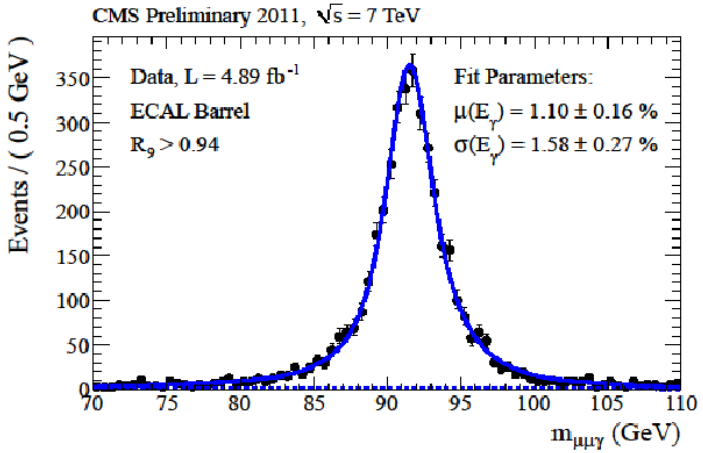
- Corrections from Laser Monitoring implemented at L1
- Significant improvement in steepness of the threshold
- Better agreement barrel/endcap

Excellent electron reconstruction



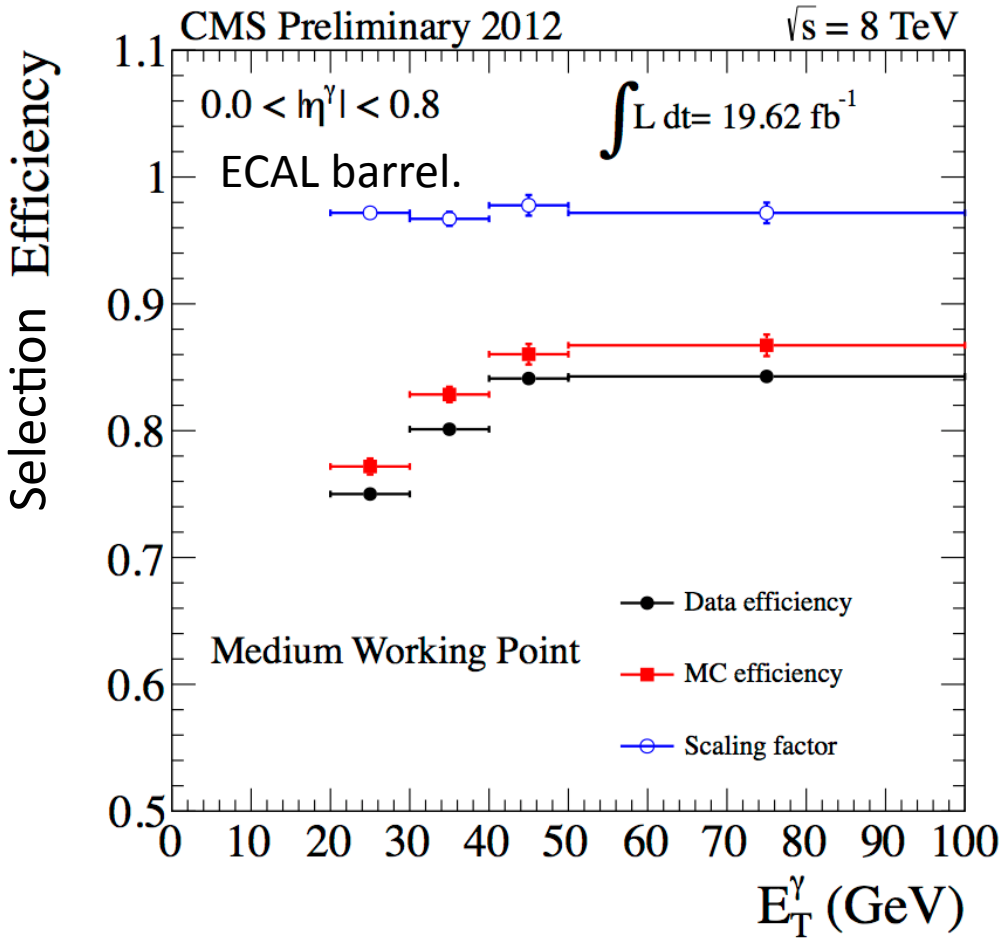


Scale also studied using Z➔μμ γ peak,
~99.6% pure source of photons.

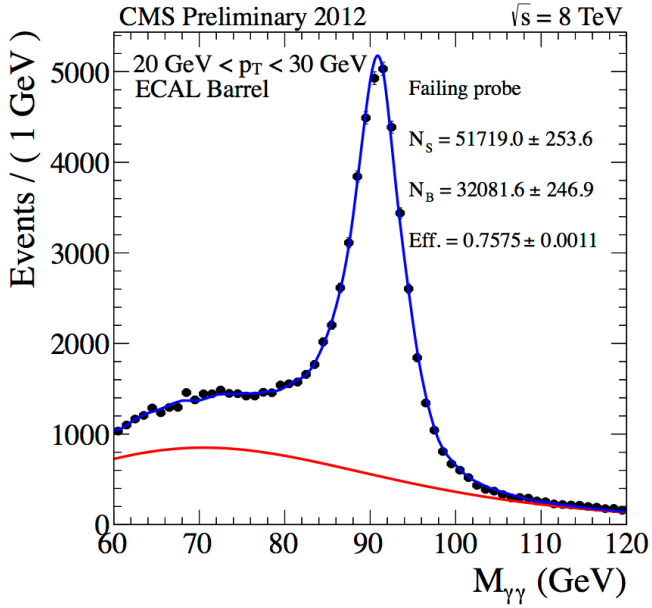


Photon Identification

Poster: Energy clustering, Calibration and Particle Identification with the CMS Preshower detector, Chiu-Ping Chang

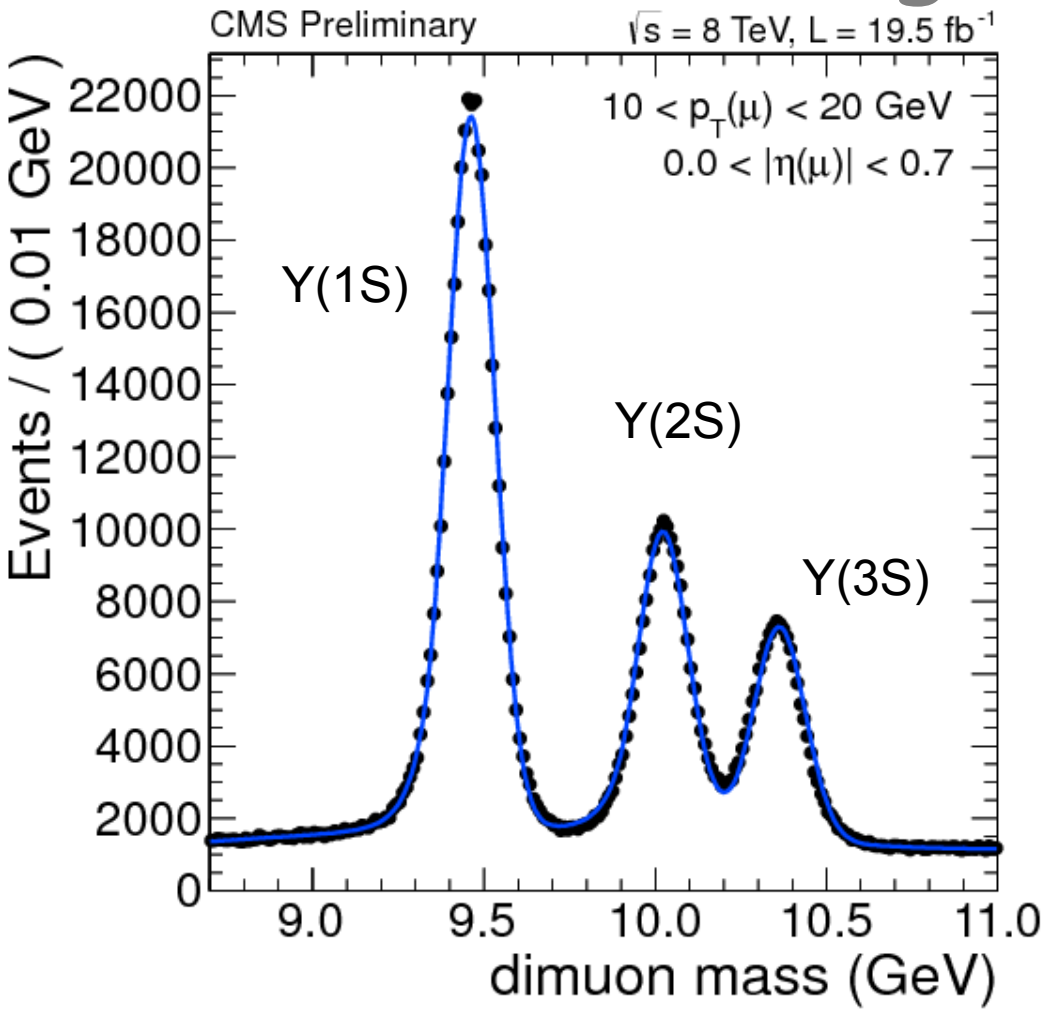


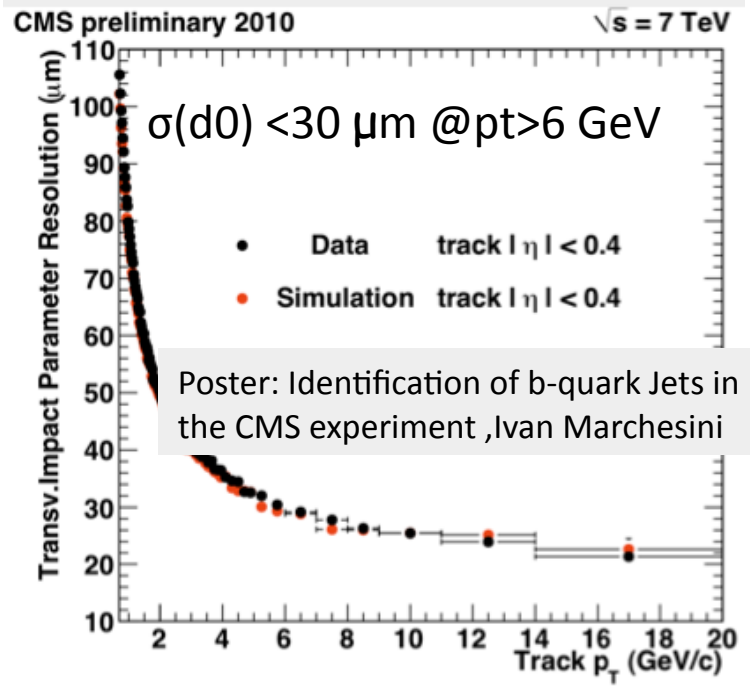
Total scale factor is determined by the product of the scale factor calculated using the **tag and probe** technique and the scale factor of the electron veto.



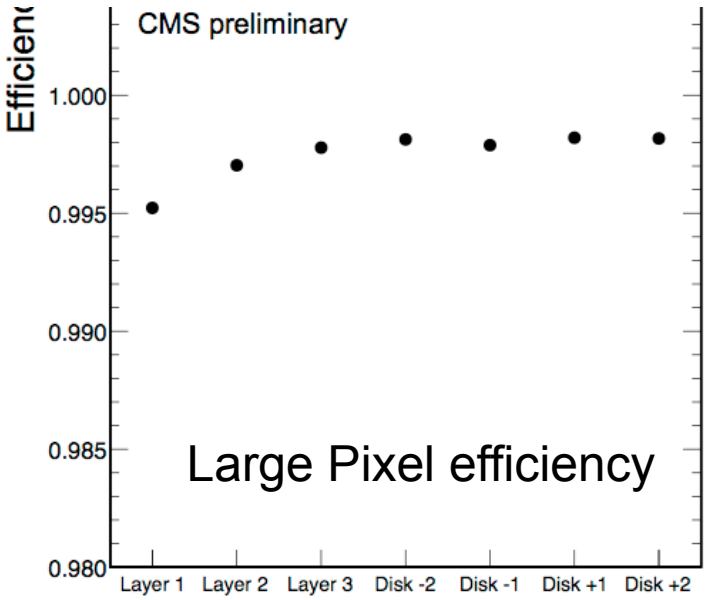
The **electron veto** scale factor is calculated in data and simulation by counting the number of passing and failing photons from **Z→μμγ** process.

Excellent Tracking and Vertexing

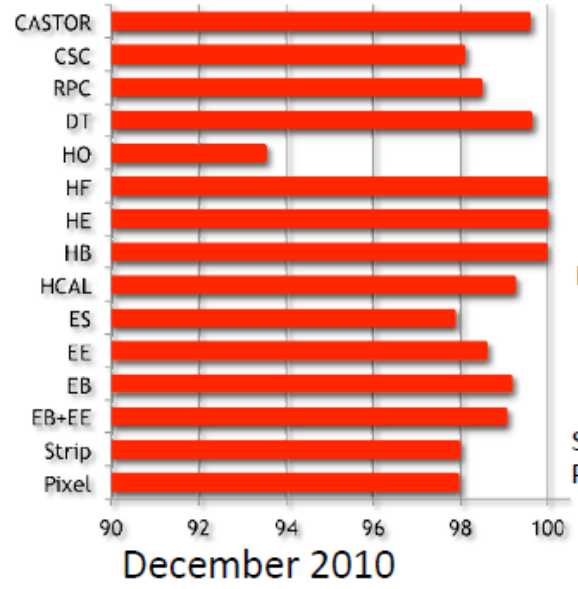


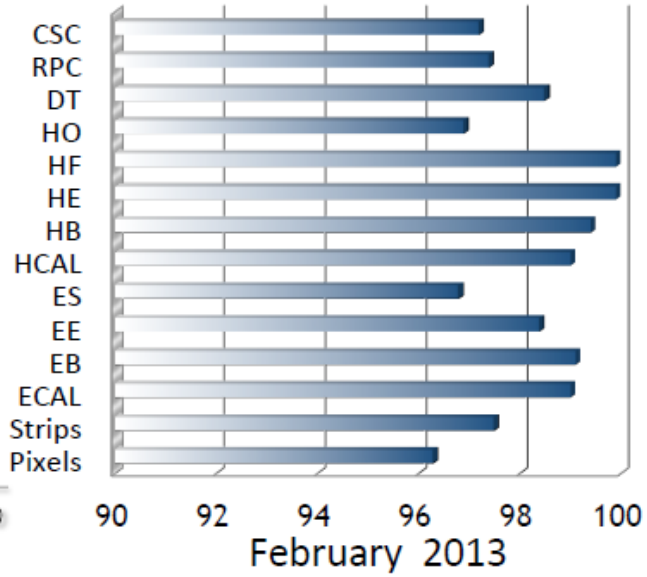


Poster: Identification of b-quark Jets in the CMS experiment ,Ivan Marchesini



- Strip Tracker with excellent tracking efficiency and resolution Δp/p~1% @ 100GeV
- Its high granularity is the the only way you can survive in High pileup or HI events.



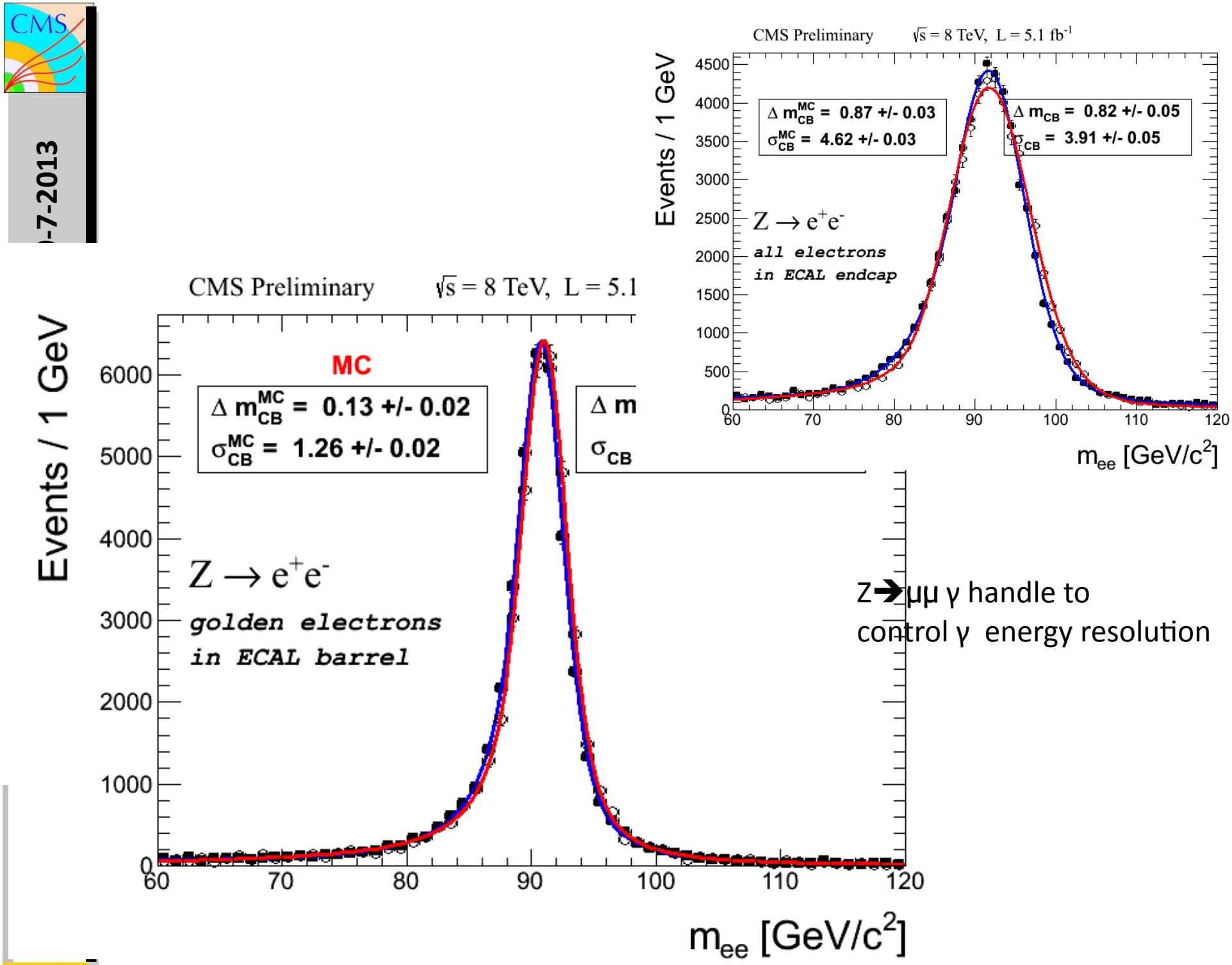


Detector is fully open for maintenance and upgrade

CMS Subsystem	CSC	RPC	DT	HCAL Outer	HCAL forw.	HCAL end.	HCAL barrel	HCAL	Presho wer	ECAL end.	ECAL barrel	ECAL	Strips	Pixels
% operational Feb 2013	97.2	97.4	98.5	96.9	99.9	99.9	99.4	99	96.8	98.4	99.1	99	97.5	96.3

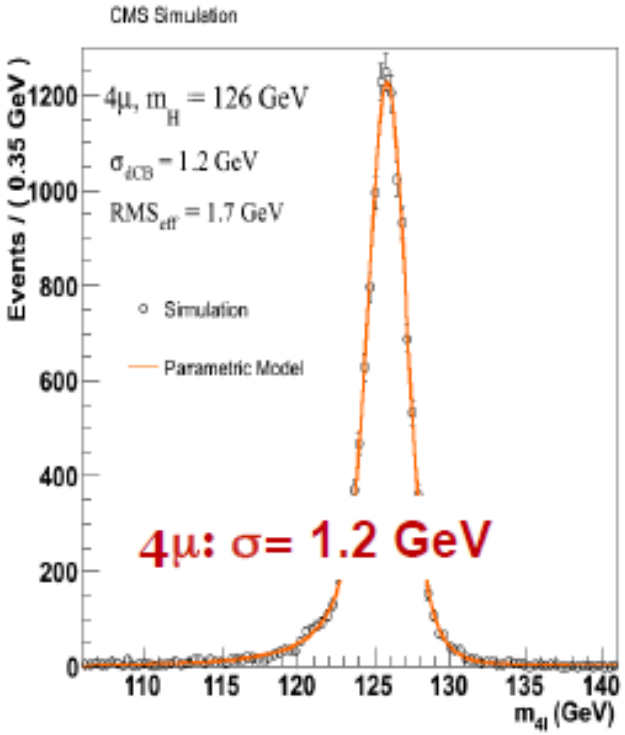
- Upgrade of the CMS Detector Costas FOUNTAS (16:00)
- Upgrade CMS Tracker Katja Klein (17:30)
- Upgrade of the CMS Muon S., Marcello Abbrescia (12:45)
- Upgrade of the CMS ECAL, Francesca Cavallari(9:45)

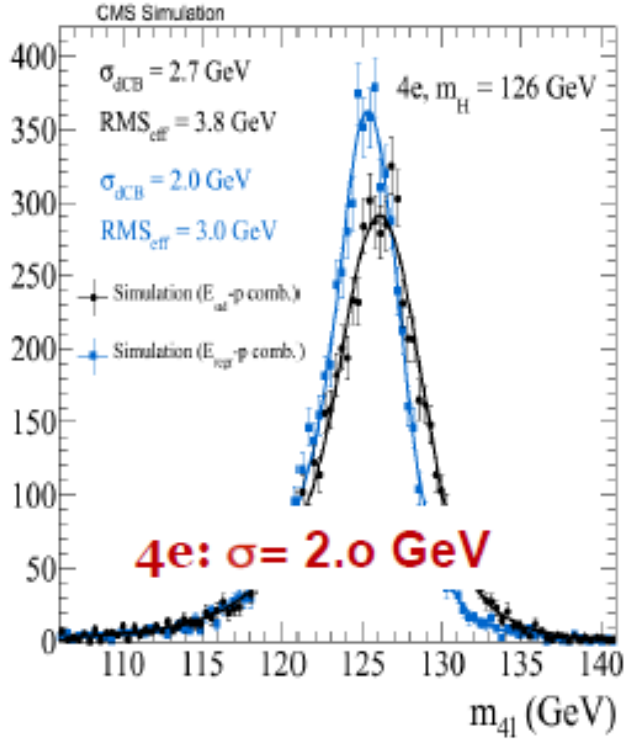
Backup

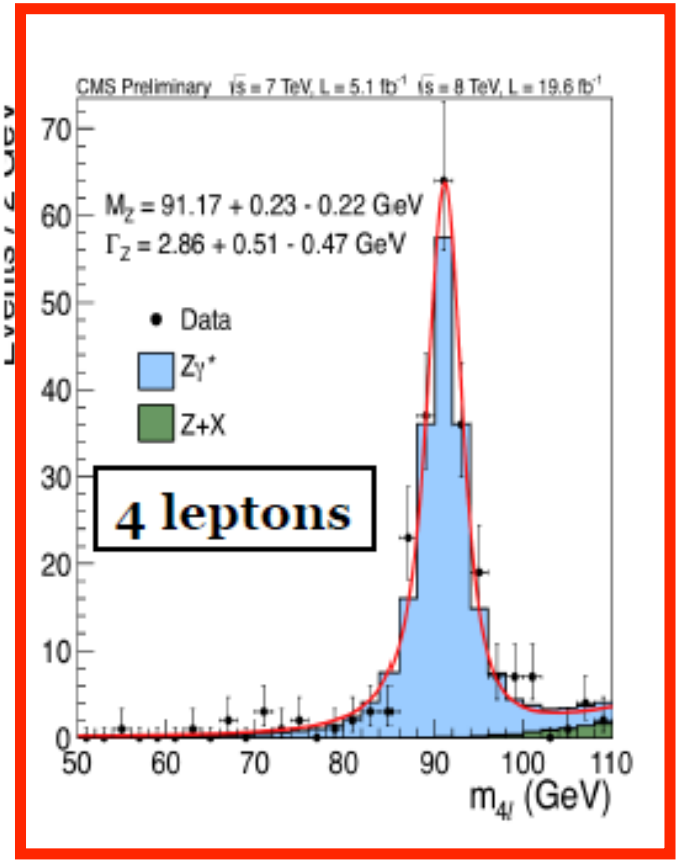


Z➔μμ γ handle to control γ energy resolution

4l mass resolution

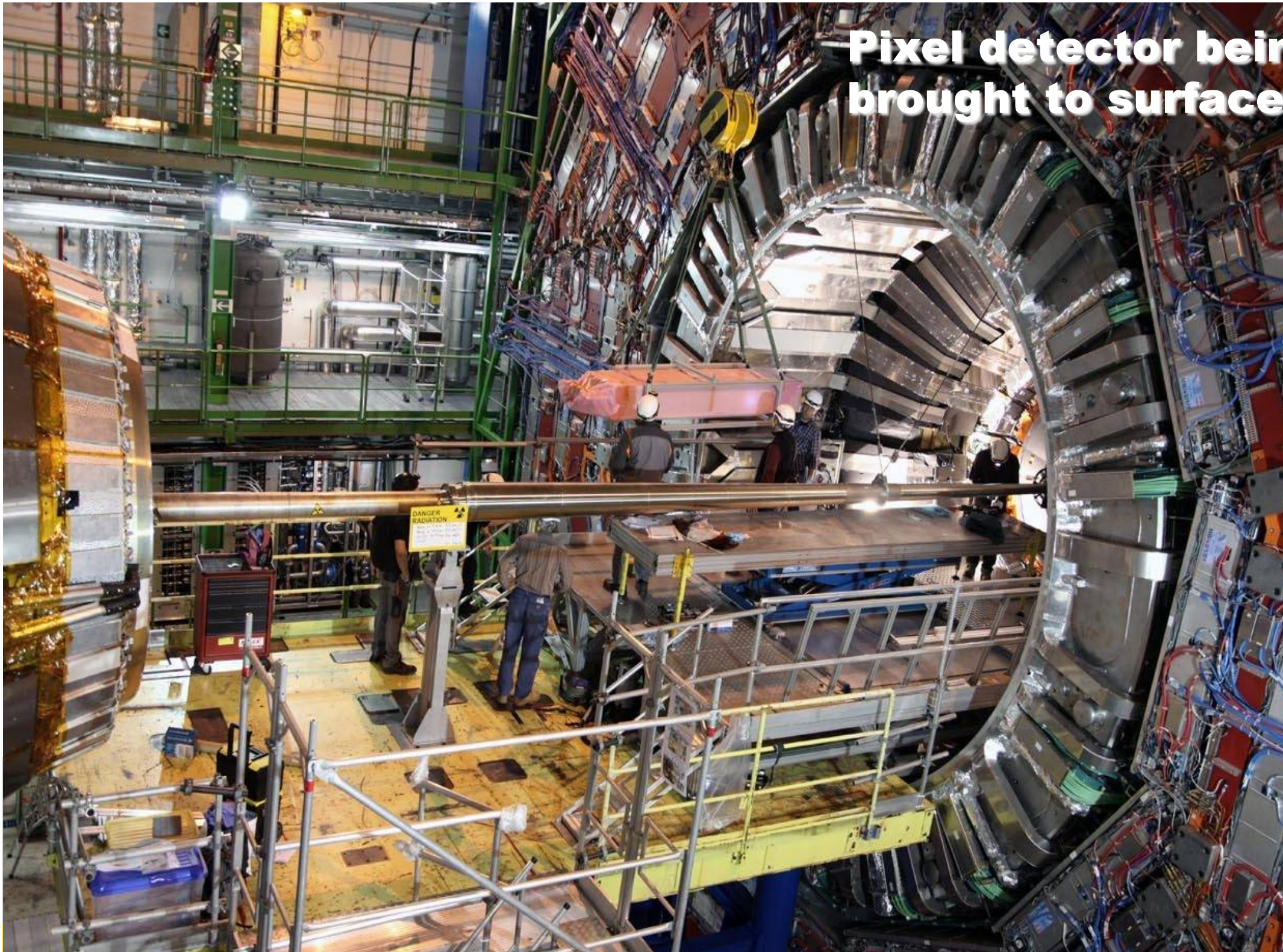


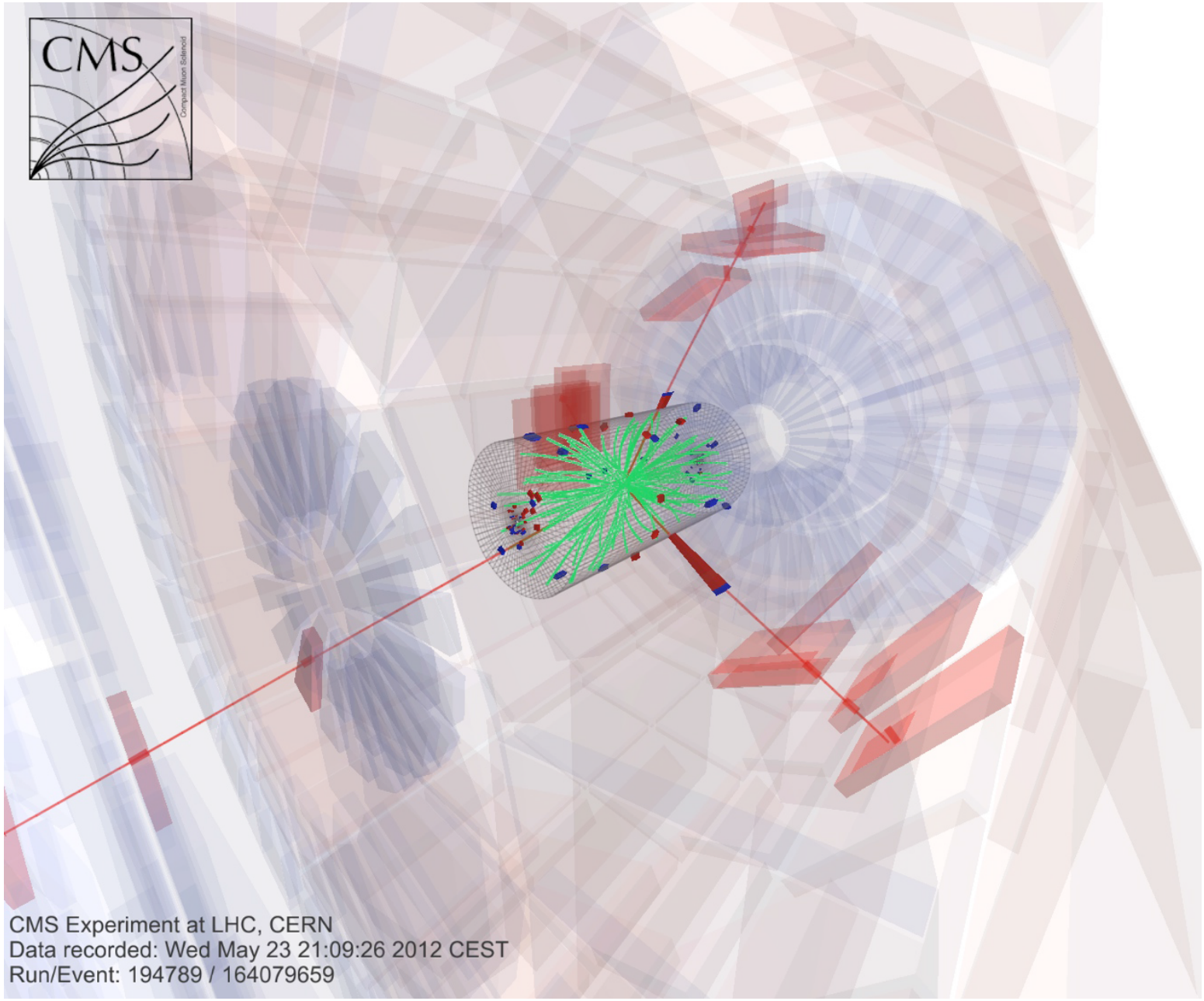




Data

4 lepton mass resolution = 1 – 2% with uncertainty: 20%



Pixel detector bein
brought to surface

CMS in action: H->4l candidate