

Run 62063, Event 1534

The first LHC beam in CMS

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CIEMAT

On behalf of the CMS collaboration

Aspen Winter 09 - Physics in the LHC era



Outlook



- Brief description of CMS
- CMS preparatory activities
- The first beam in CMS
 - Events from beam shots onto collimators
 - Events from beam halo
- Conclusions

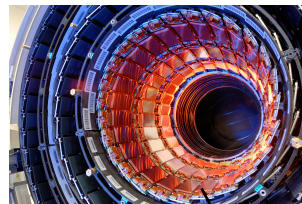
CMS detector for pp @ $\sqrt{s}=14\text{TeV}$



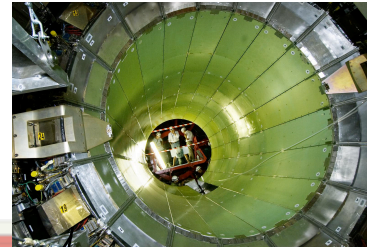
Pixels



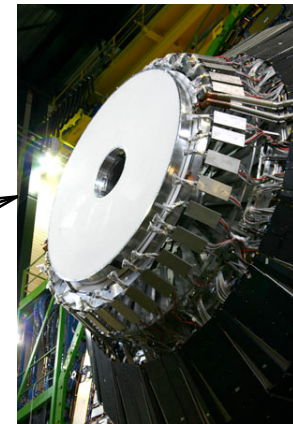
Silicon Tracker



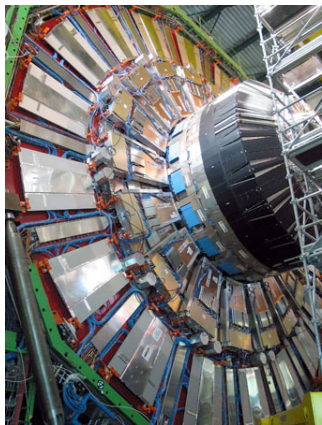
Electromagnetic calorimeter: ECAL



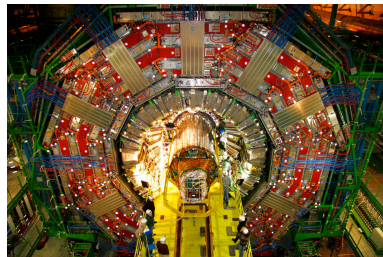
Hadronic calorimeter: HCAL



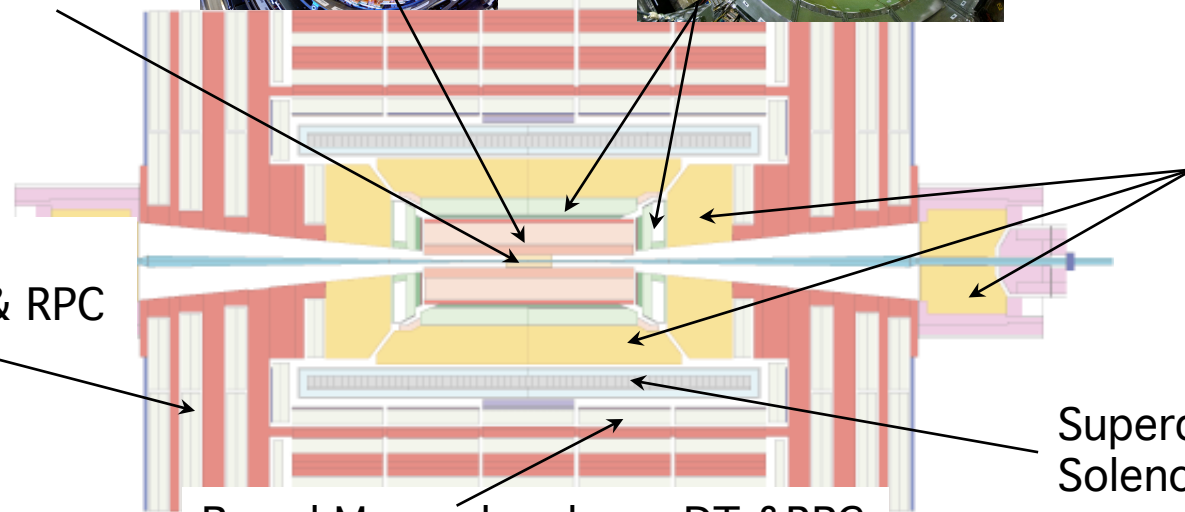
End Cap Muon chambers: CSC & RPC



Barrel Muon chambers: DT & RPC

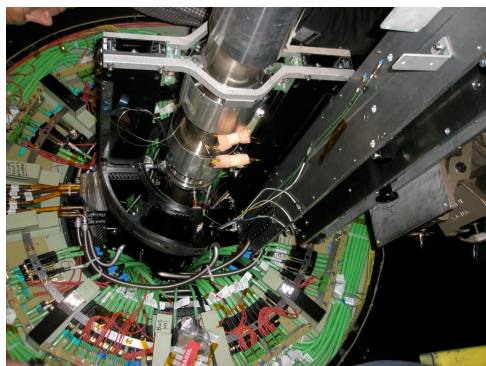


Superconducting Solenoid



Beam Radiation Monitors

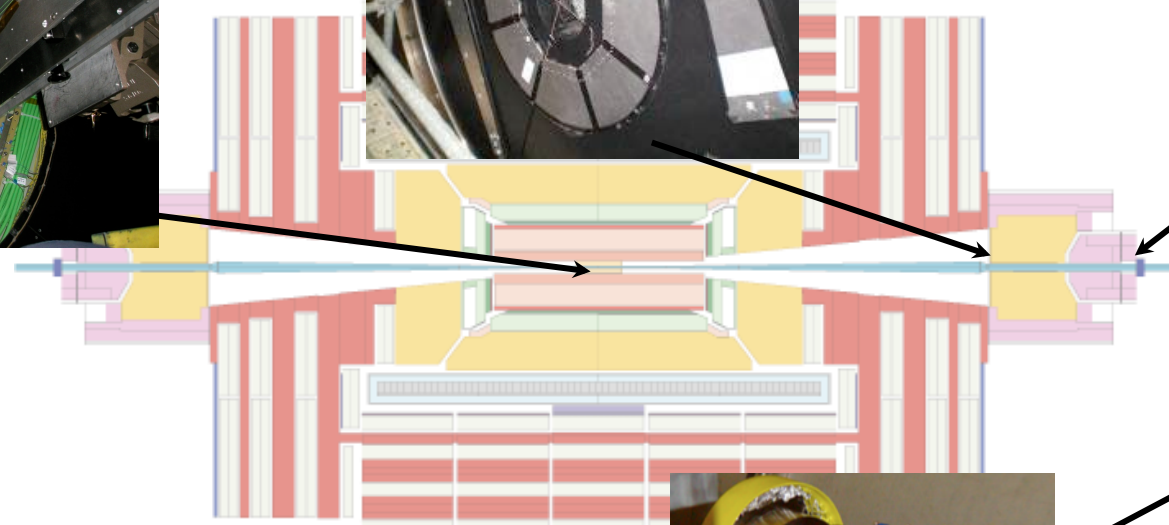
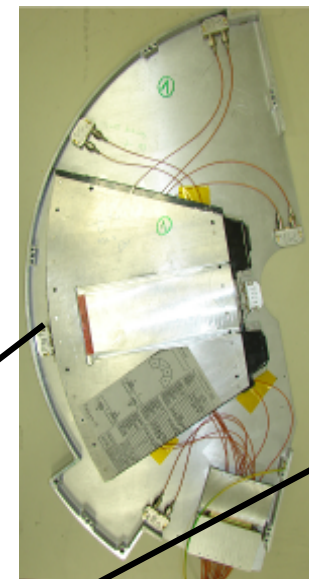
BCM1 L/F diamonds
 $Z = \pm 1.9\text{m}$, $r = 4.3\text{cm}$



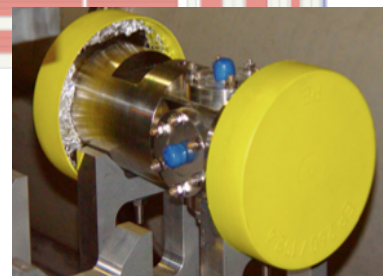
BSC1: scintillators
 $Z = \pm 10.9\text{ m}$, $r = 4.3\text{cm}$



BCM2 diamonds &
 BSC2 scintillators
 $Z = \pm 14.4\text{m}$, $r = 29\text{cm}$



BCM1 L/F and BCM2
 PROTECTION of CMS



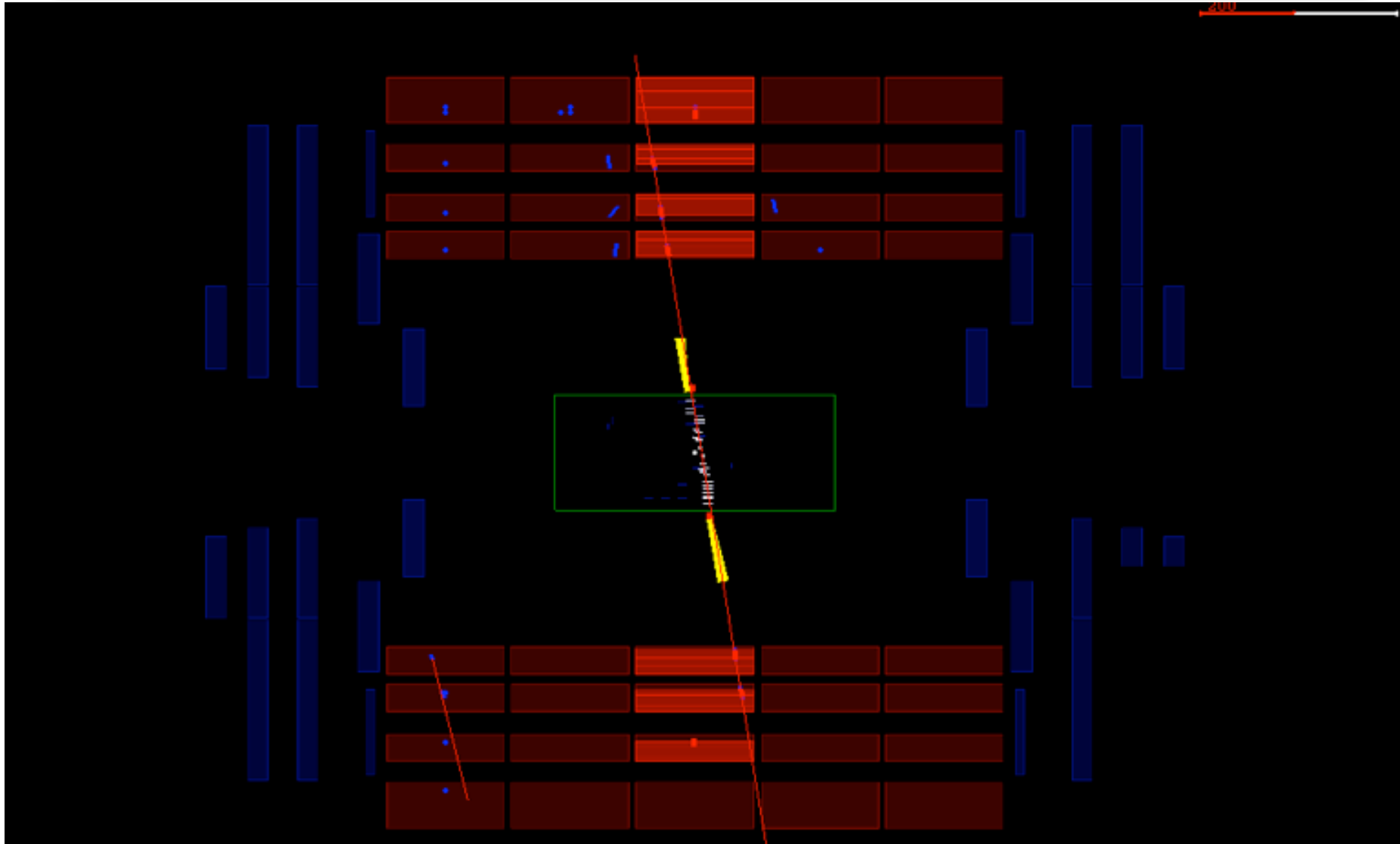
BPTX beam pickup
 $Z = \pm 175\text{m}$

CMS preparatory activities



- Detector commissioning with cosmic data in 2008
 - See K. Maeshima talk *The CMS detector its commissioning without beam*
- Since beginning of September 2008
 - All installed CMS sub-detectors in global readout routinely
 - All triggers operational
 - Stability of running with all CMS components was proved
 - Beam monitoring equipment ready and operational
 - Data flow working efficiently @ 50kHz
 - LHC clock and orbit signals tested

Cosmic event Aug08



CMS configuration @ LHC start up



- Pixels (barrel & end caps)
- Silicon Strip Tracker (barrel & end caps)
- Electromagnetic calorimeter (barrel & end caps NOT pre-shower)
- Hadronic calorimeter (barrel, end caps, outer & forward)
- Muons detectors: barrel, end caps, and Resistive Plate Chambers
- L1 trigger & DAQ

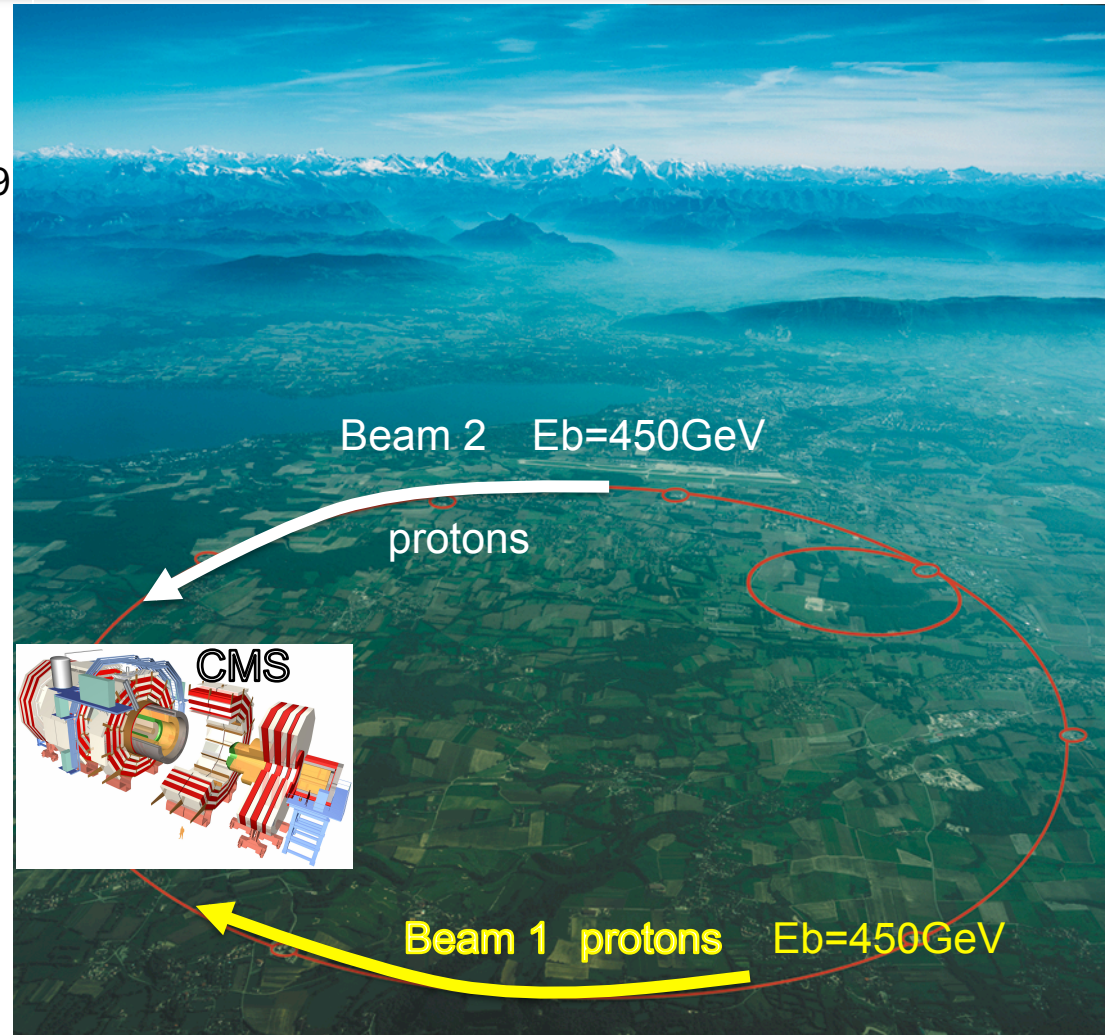
All installed detectors were in readout except one RPC end cap

Tracker and pixels switched OFF
Magnet OFF

First LHC beams in CMS

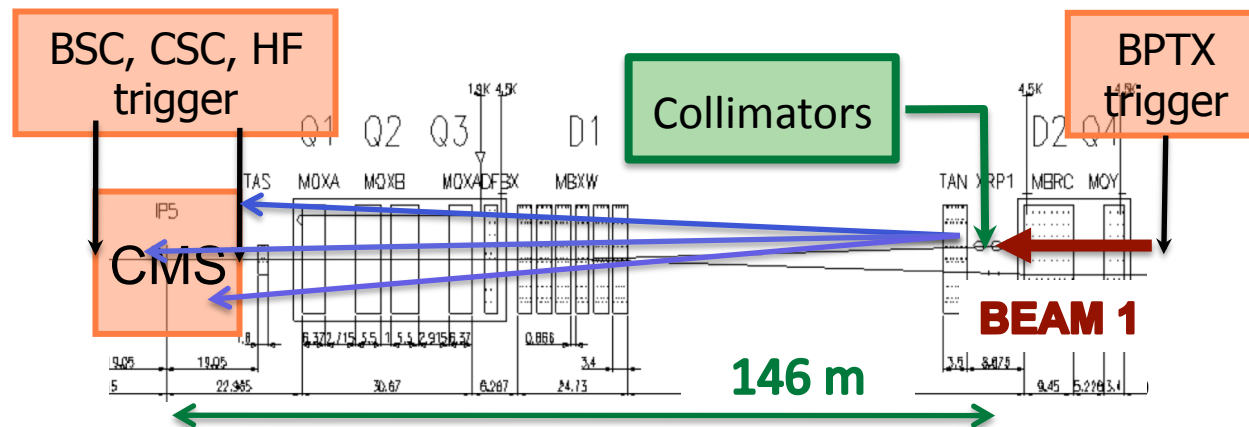
September 7-19th 2008

- Single beam shots of $2 \cdot 10^9$ protons onto collimators 150m upstream CMS
- Beam1 or beam2 circulating $\geq 10^{\text{th}}$ Sep
 - Beam halo events
 - Beam gas events
- We integrated ~ 40 hours of beam reaching CMS or going through



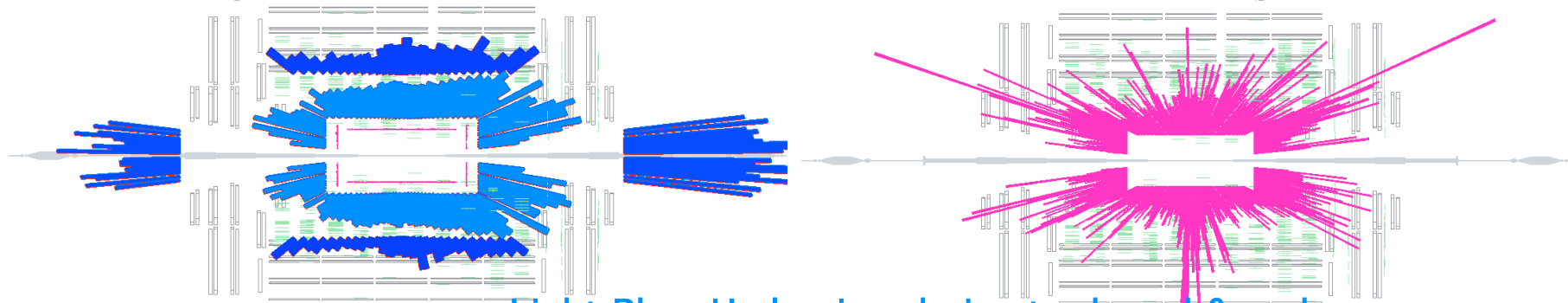
Beam onto collimators events

- Single shots of $2 \cdot 10^9$ protons of beam1 onto collimators
 - $\sim 150\text{m}$ upstream CMS
- Events were used for
 - Synchronization of triggers
 - BPTX beam pick up, Muon end caps, HF technical trigger, BSC
 - Previously done using cosmic muons
 - Internal synchronization of sub-detectors

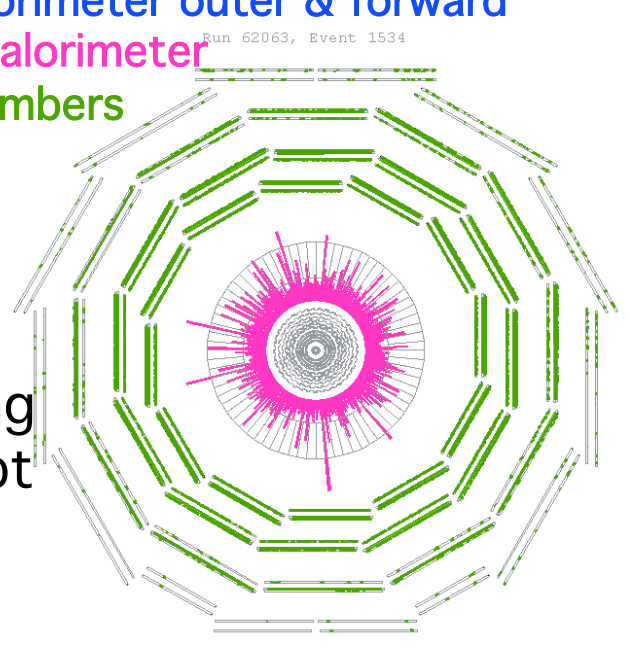
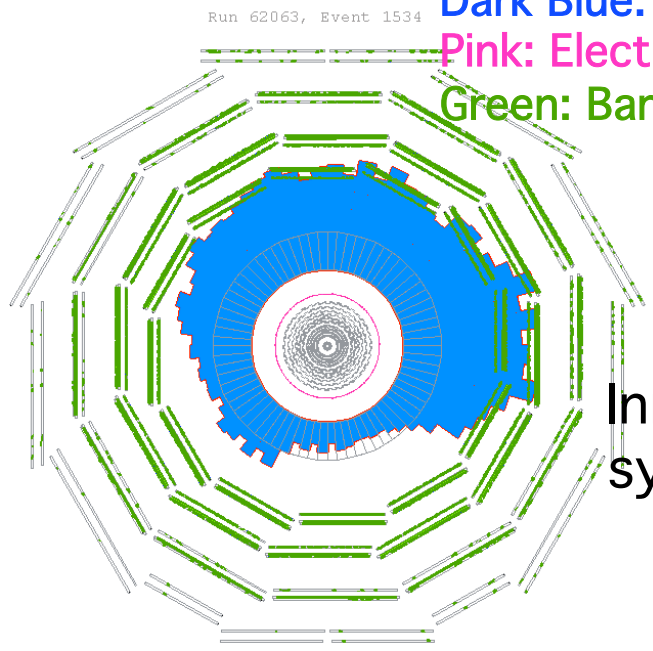


Beam onto collimators events

2.10^9 protons (one bunch) on collimators ~ 150 m upstream of CMS



Light Blue: Hadronic calorimeter barrel & end cap
 Dark Blue: Hadronic calorimeter outer & forward
 Pink: Electromagnetic calorimeter
 Green: Barrel muon chambers

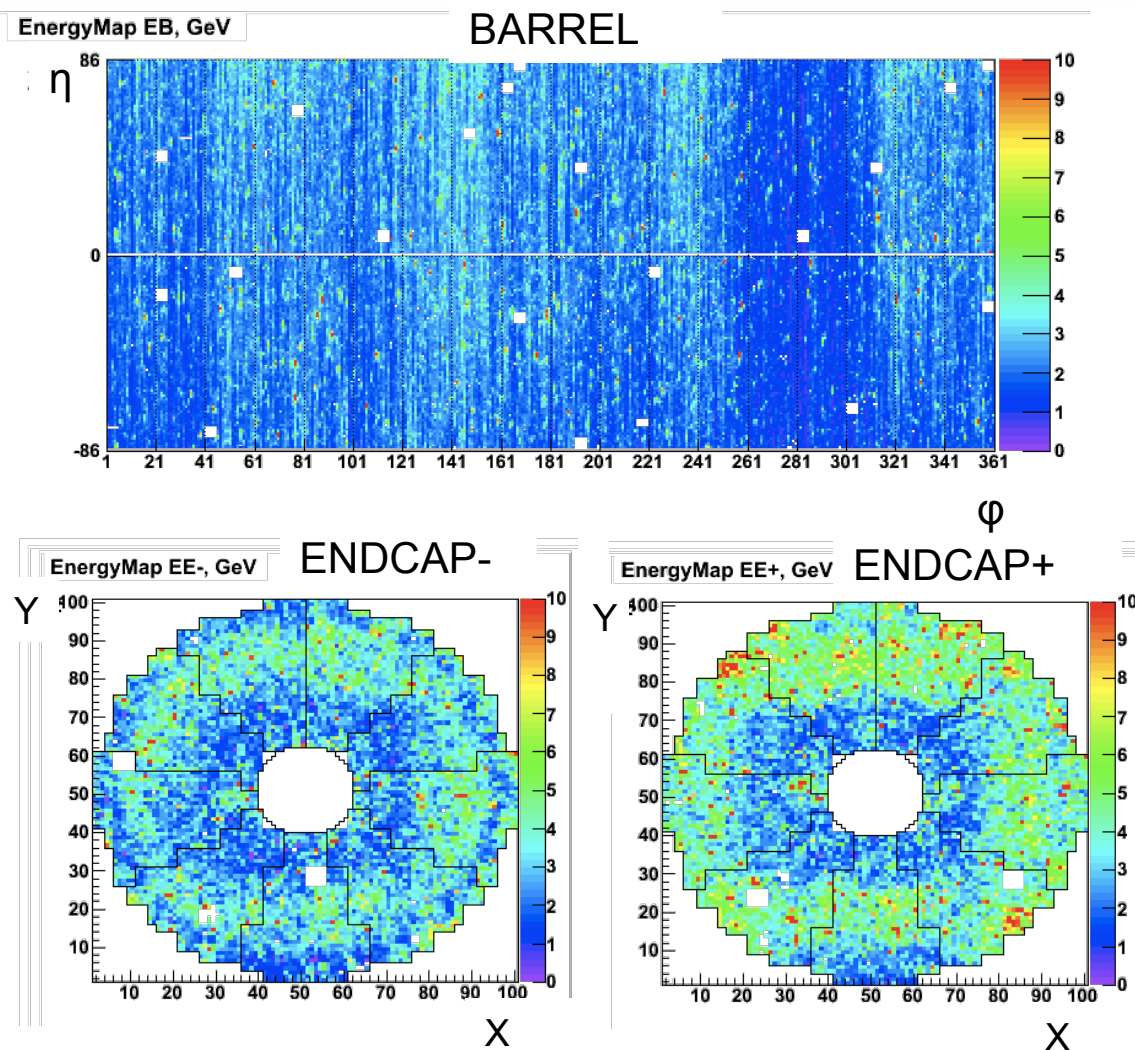


Inner tracking systems kept OFF

ECAL energy from collimator shots

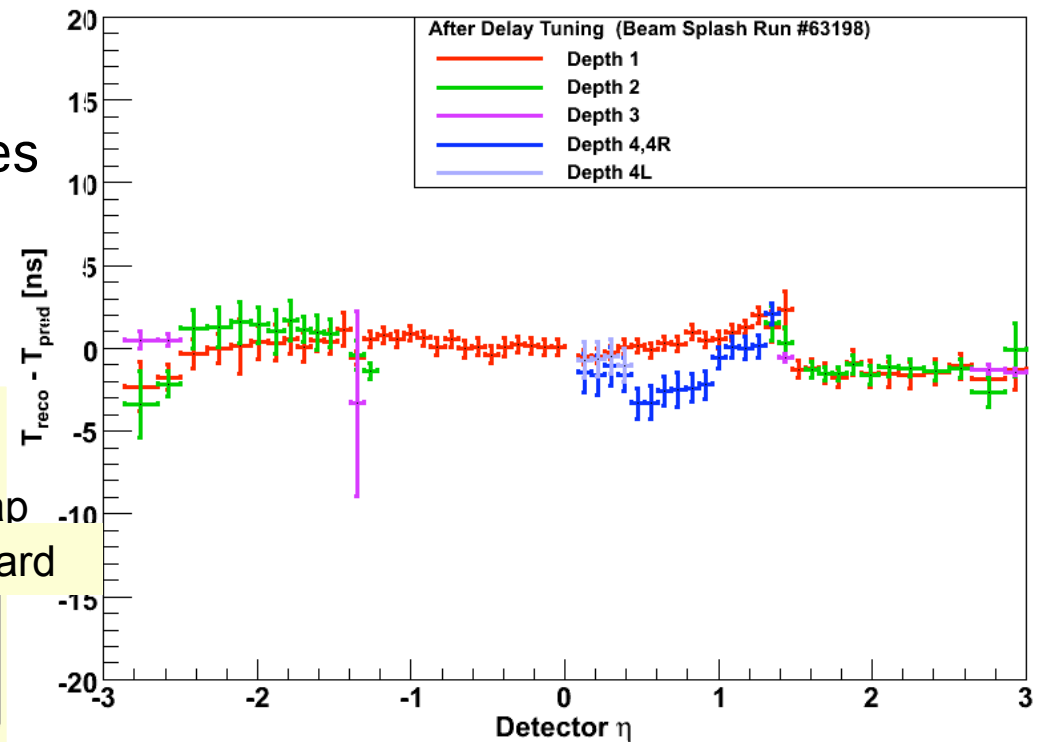
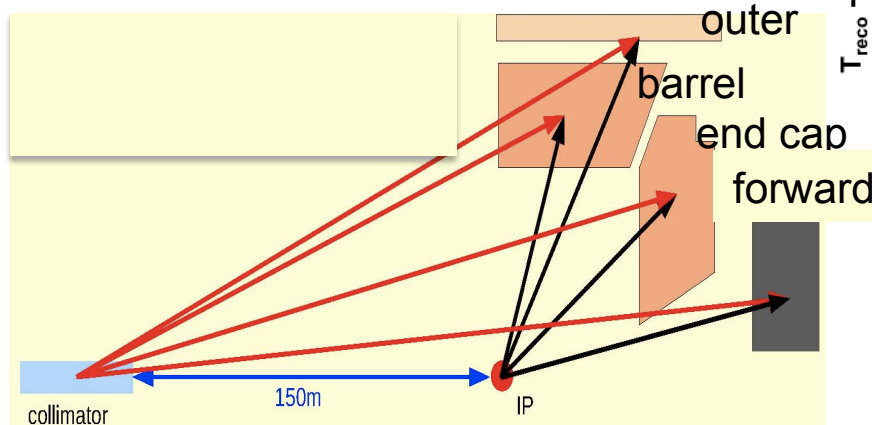
- 17 events where all active channels had >5 GeV
- Used for internal synchronization

End caps are not calibrated \rightarrow lower gain photodetectors nearest the beam pipe

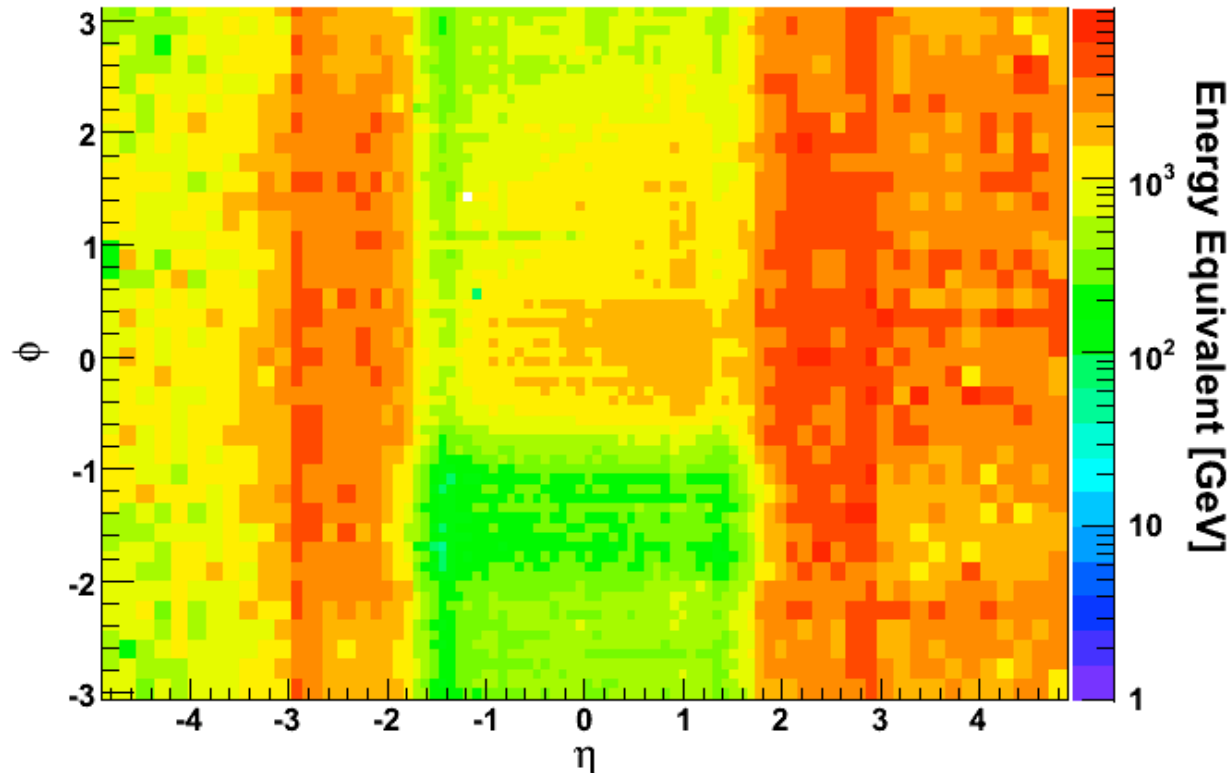


Synchronization of HCAL

- Using beam onto collimator events
- The time-of-flight differences are used to predict the hit times



HCAL energy from collimator shots



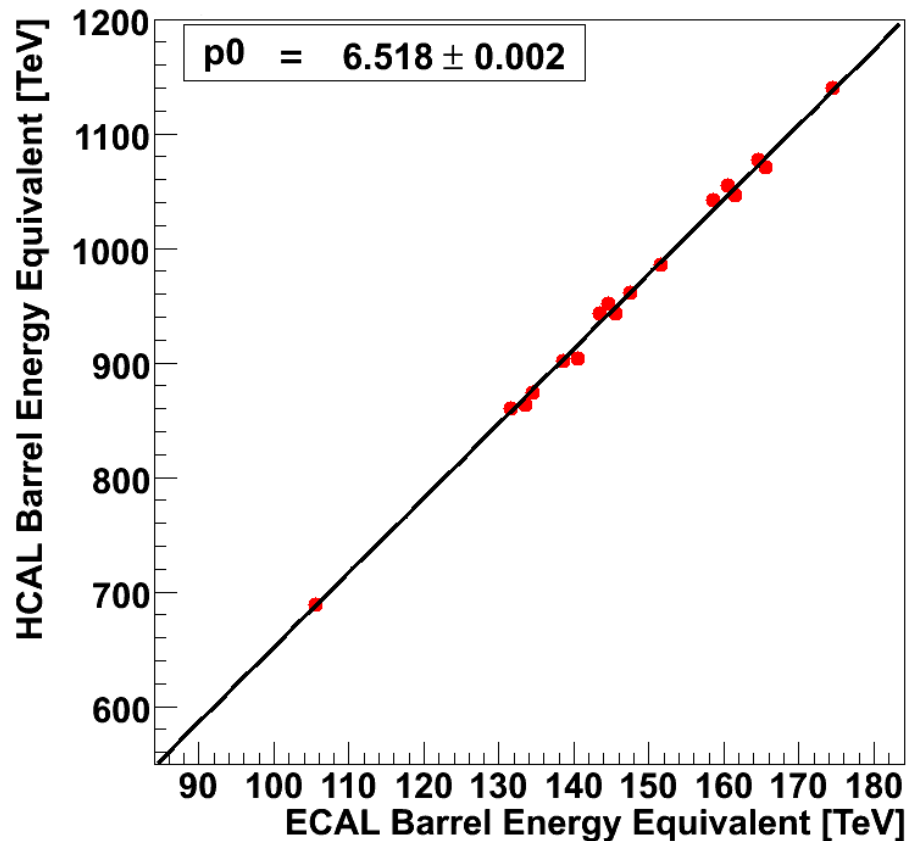
Energy is corrected by the

- Scintillator length in the barrel
- Cross sectional area of the tower in the end caps

Correlation of HCAL and ECAL



Using beam onto collimators events

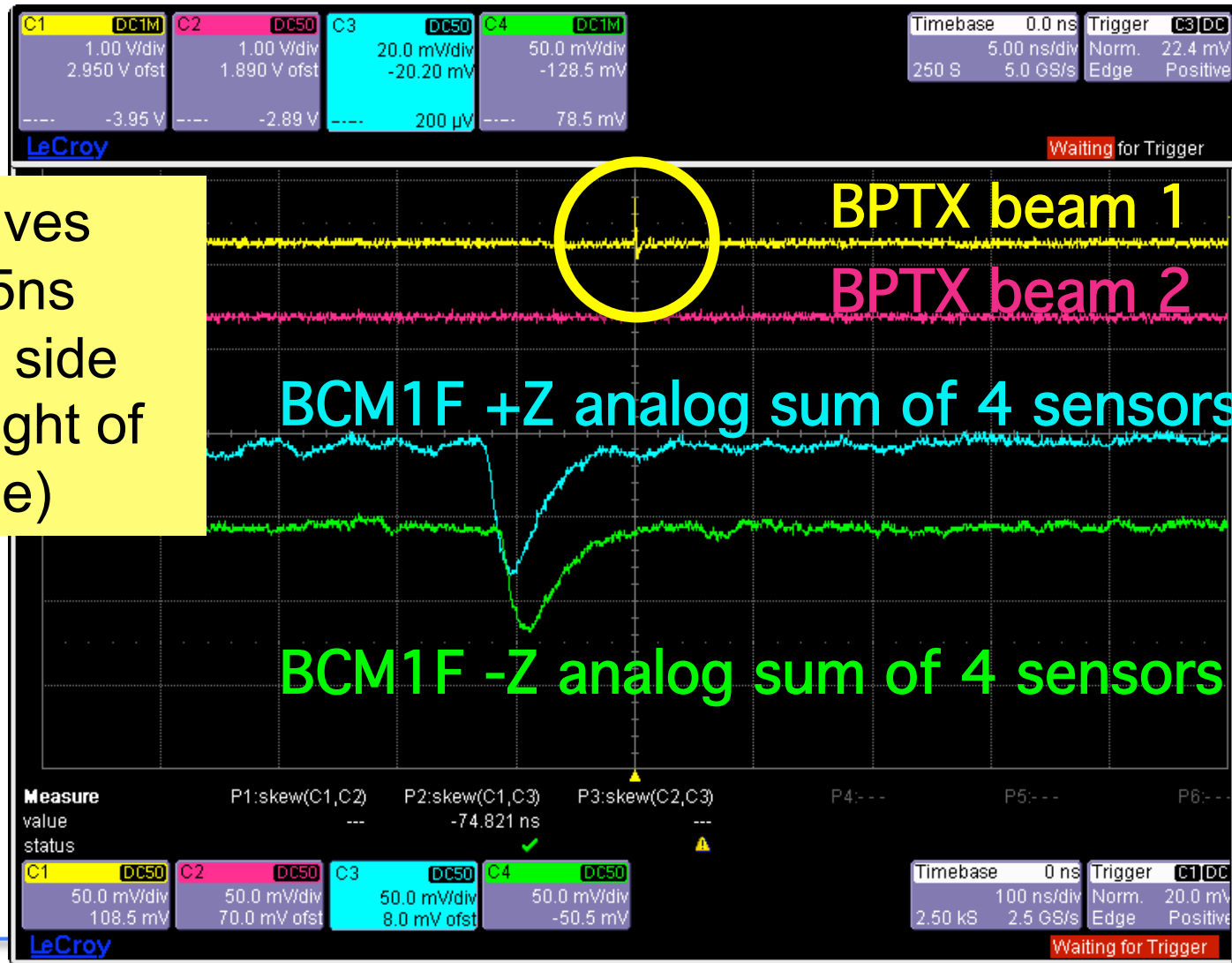


Large reconstructed energies due to huge number of particles reaching the detector $O(10^6)$ in each event

First circulating beam 10th Sep 08



+Z side gives signal ~15ns before -Z side (time of flight of the particle)

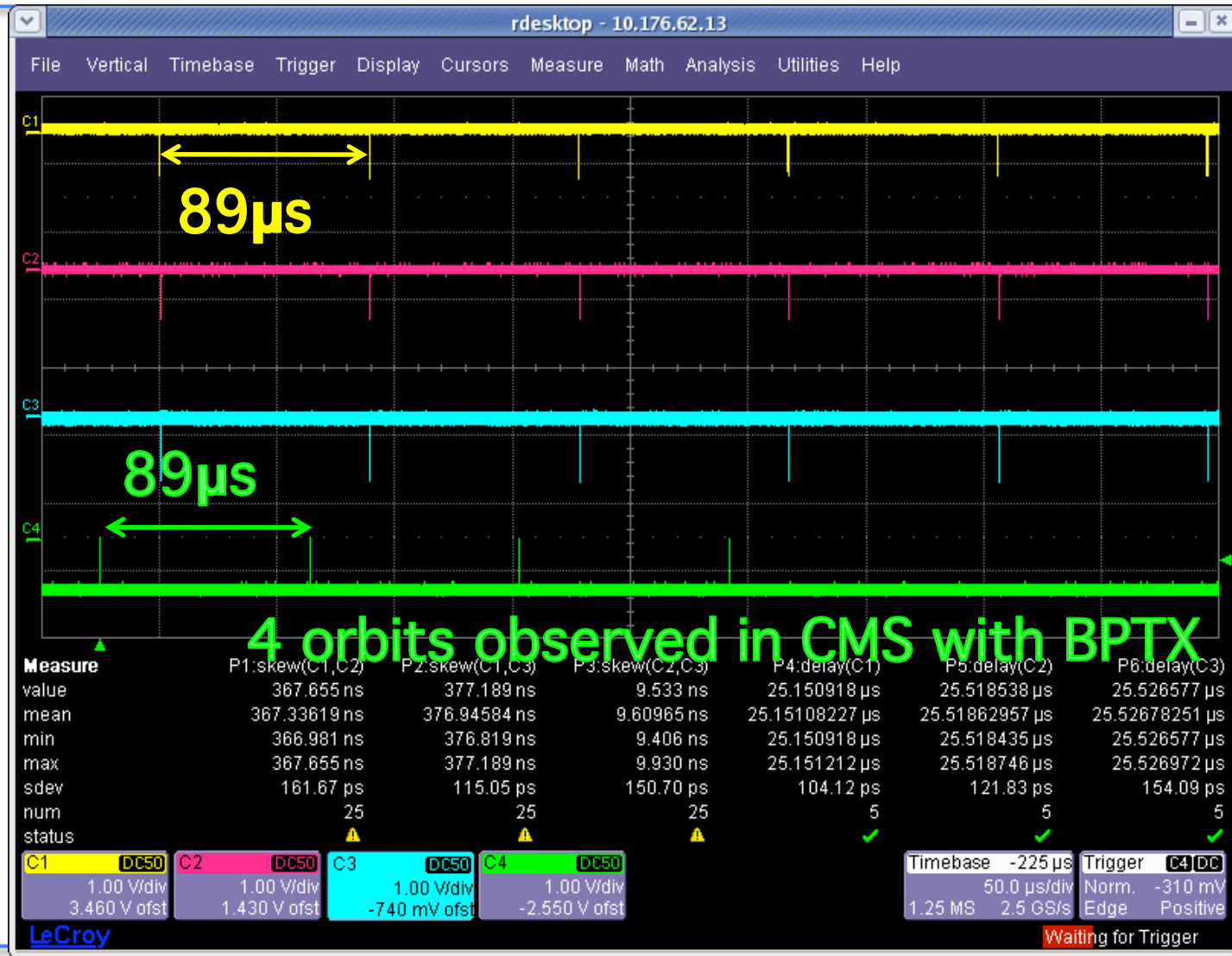


Multiple orbits



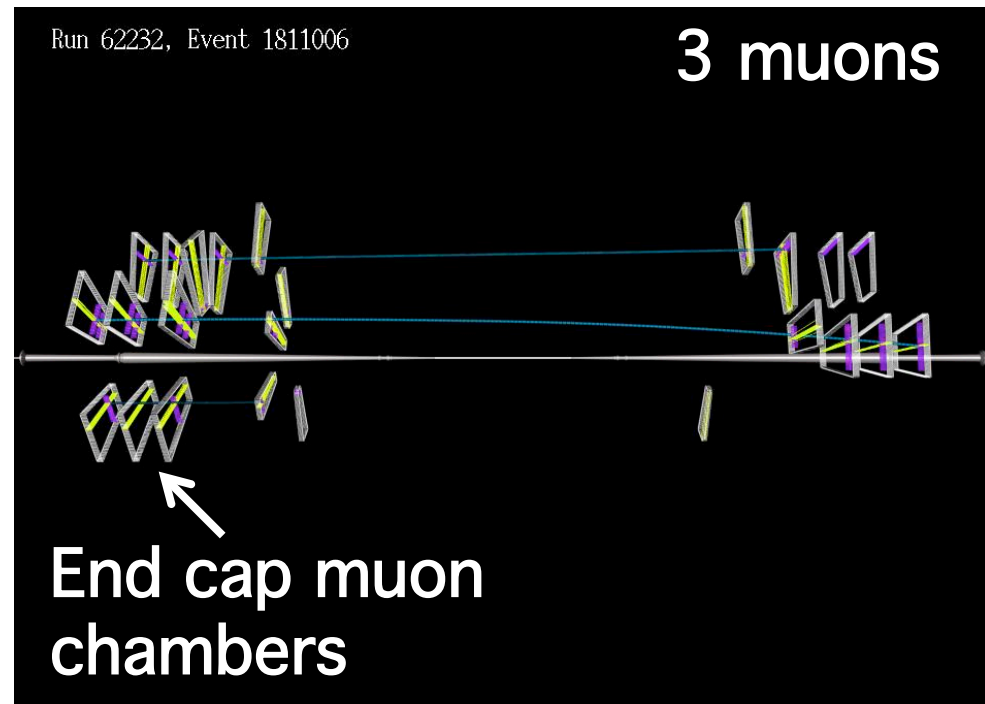
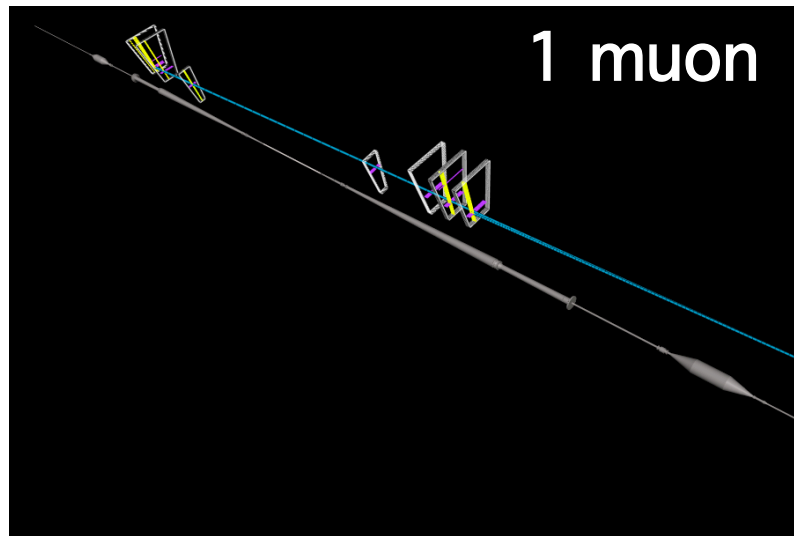
LHC orbit signals

CMS BPTX signal



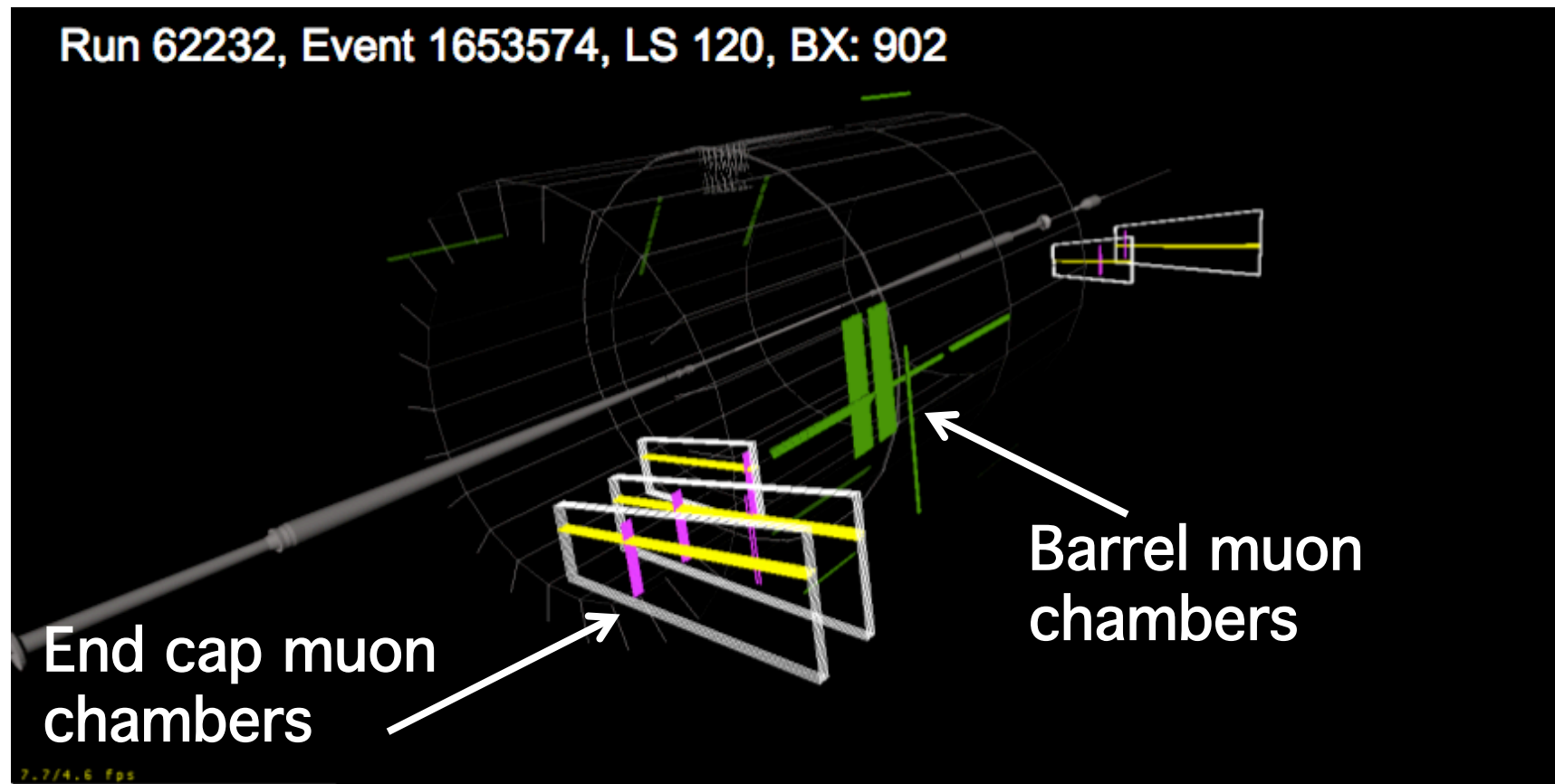
Beam halo muons

- Reconstructed in the end cap muon chambers
- Used for CSC alignment & synchronization
 - Results coming soon



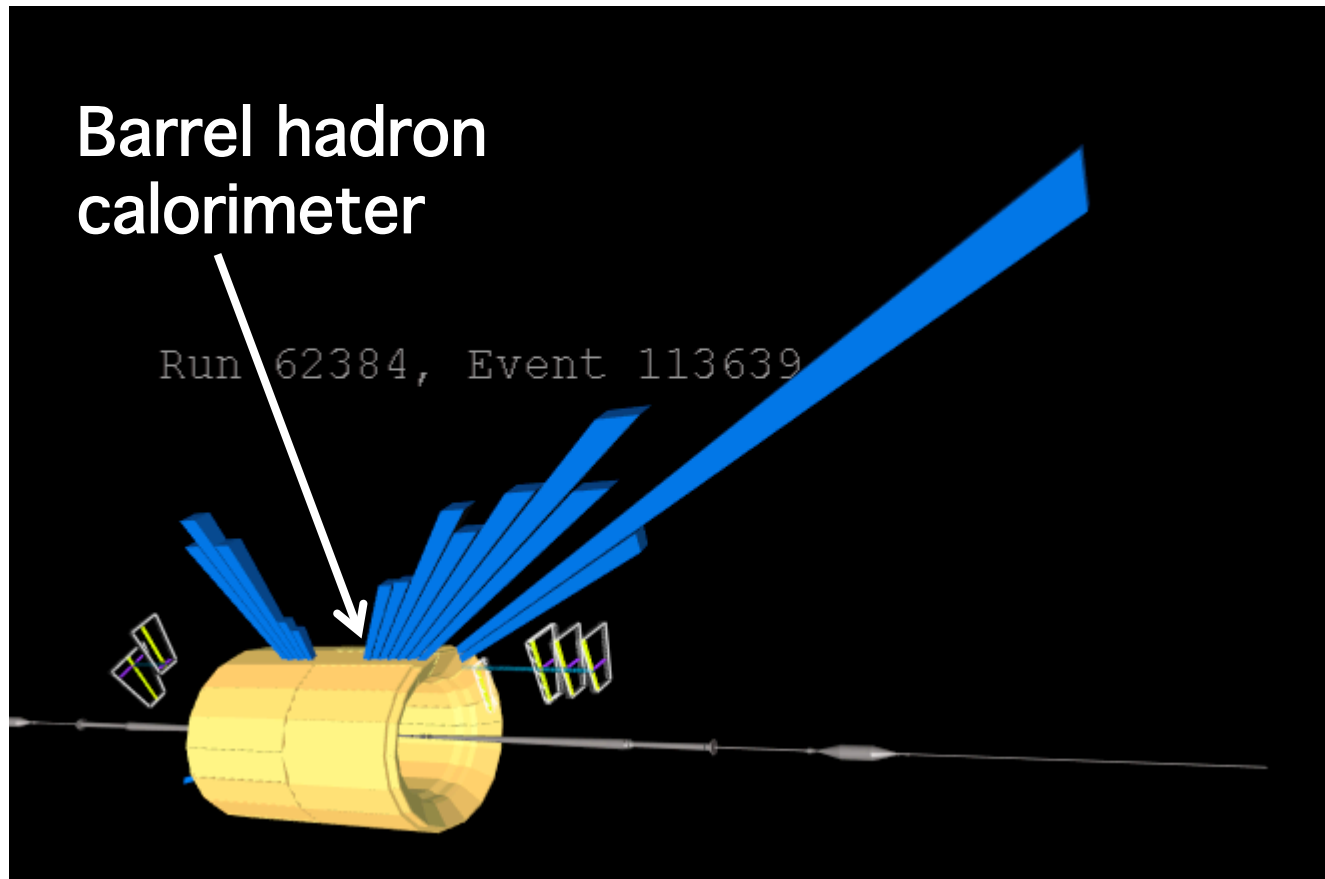
CSC and DT halo muon event

- Reconstructed in the barrel and end cap muon chambers

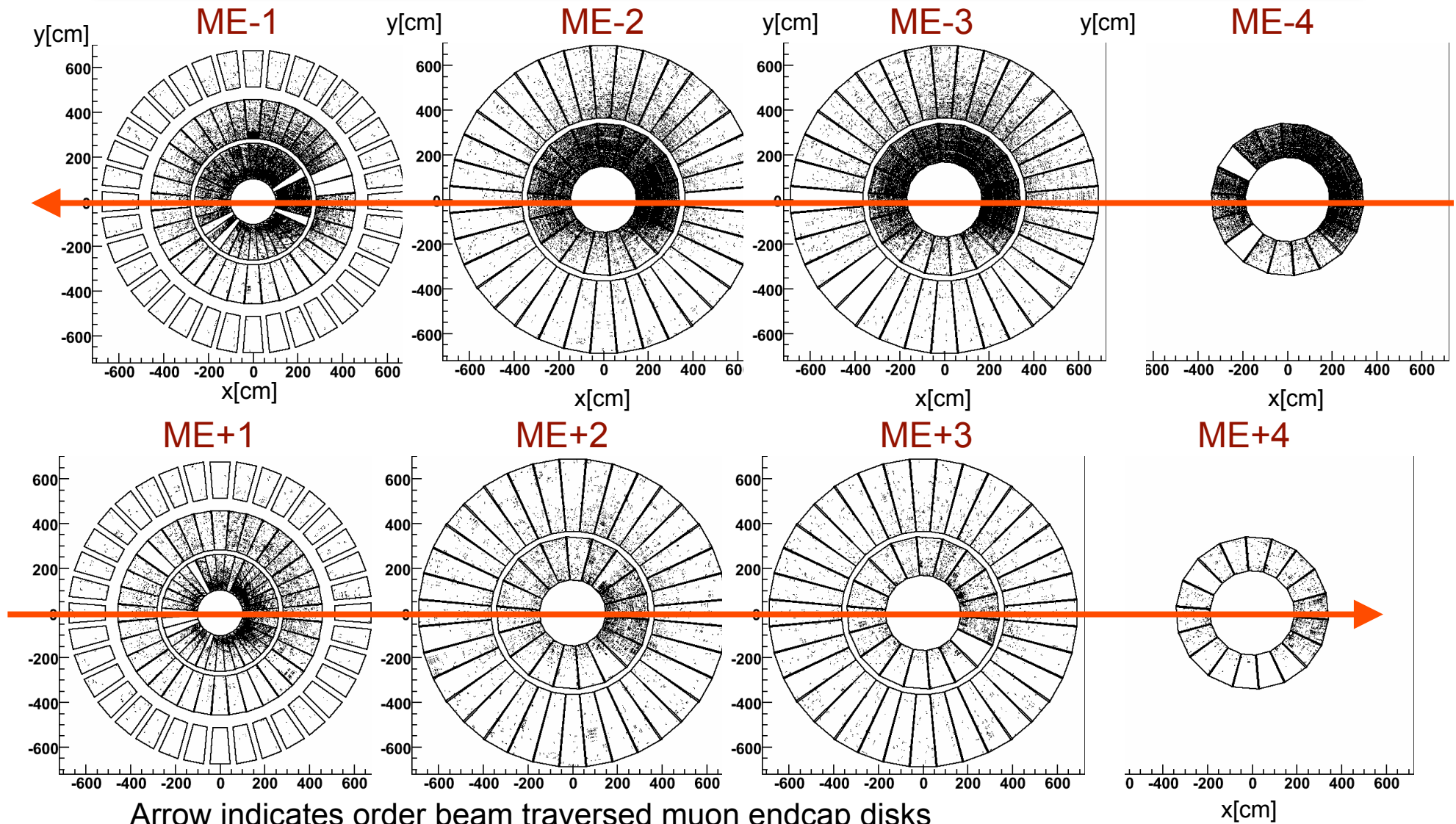


CSC and HCAL halo muon

- Reconstructed in the muon end caps and the barrel hadron calorimeter



Beam halo hits in muon end caps



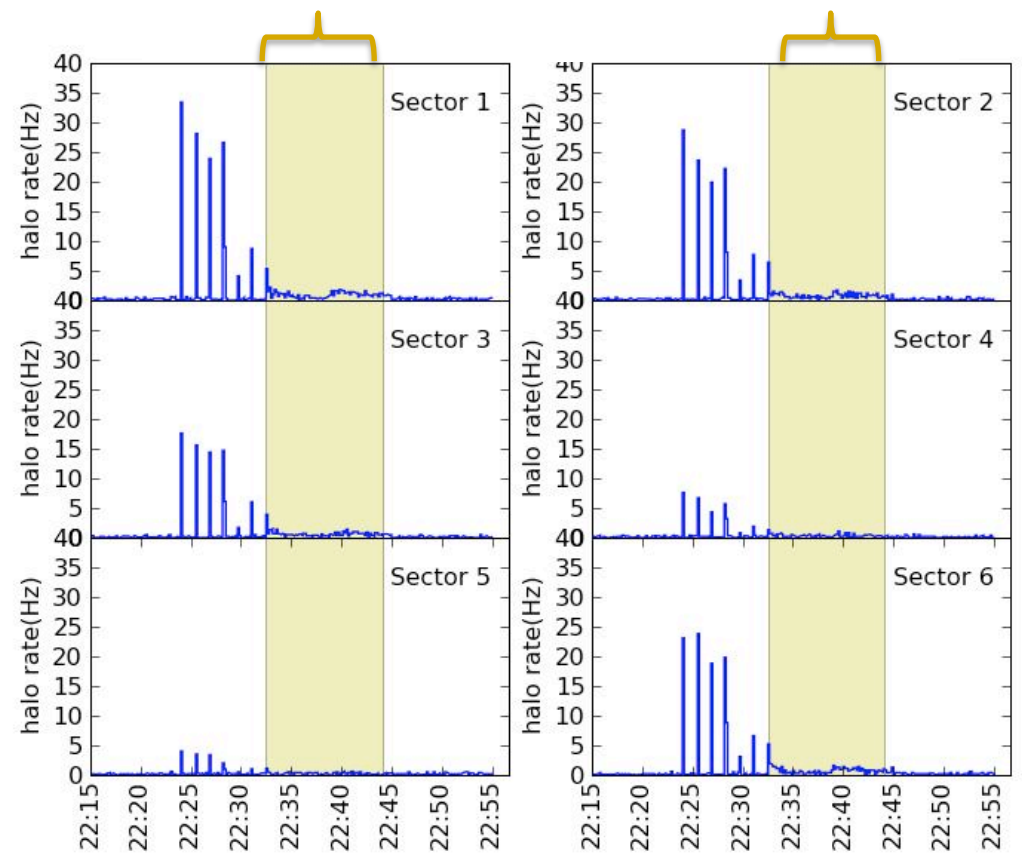
Arrow indicates order beam traversed muon endcap disks

Beam halo rates in muon endcaps

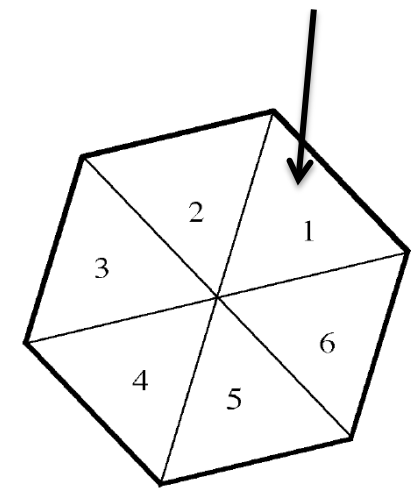
Online muon rate averaged over 10 second intervals

First beam capture ~10 min

Negative muon end cap



CSC trigger sectors viewed from the interaction point

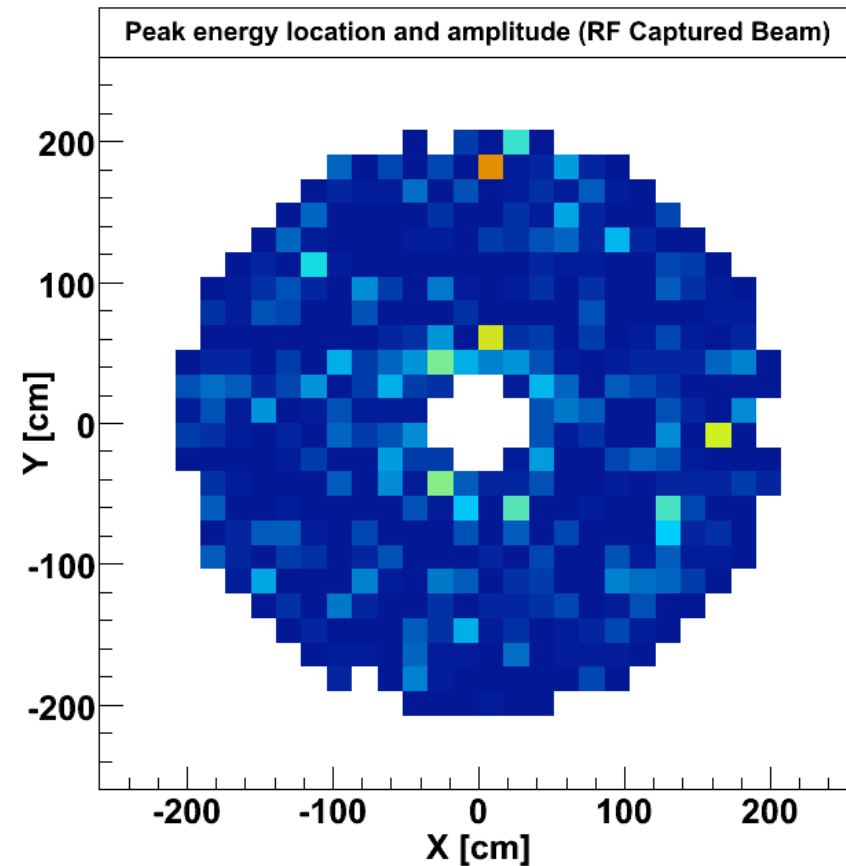
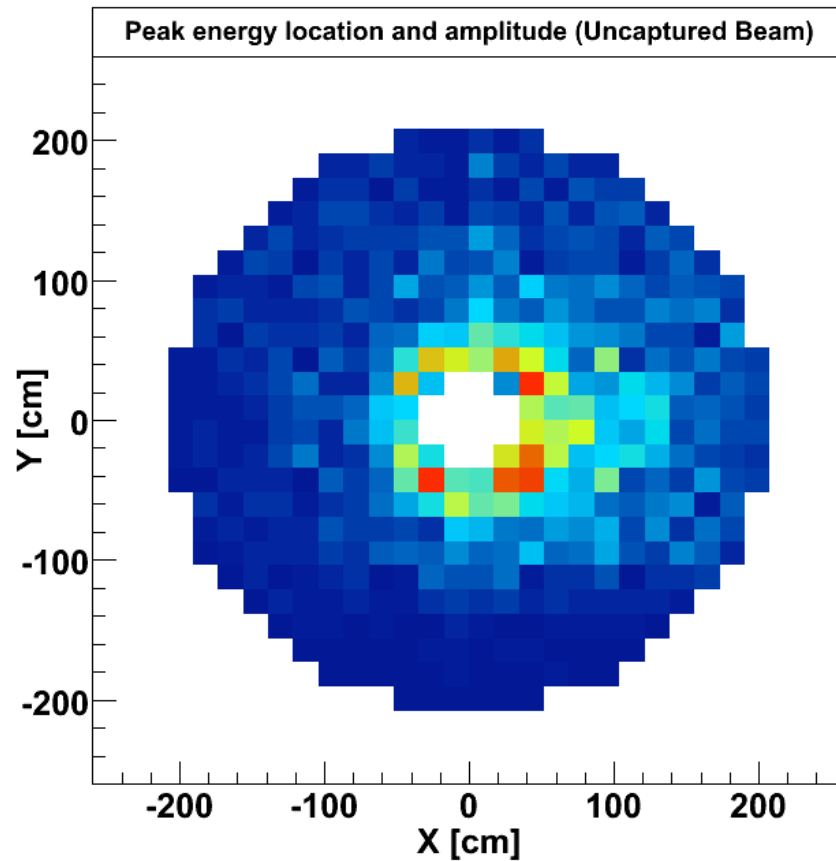


HCAL end cap energy

$4 \cdot 10^9$ protons in one bunch

Before beam capture

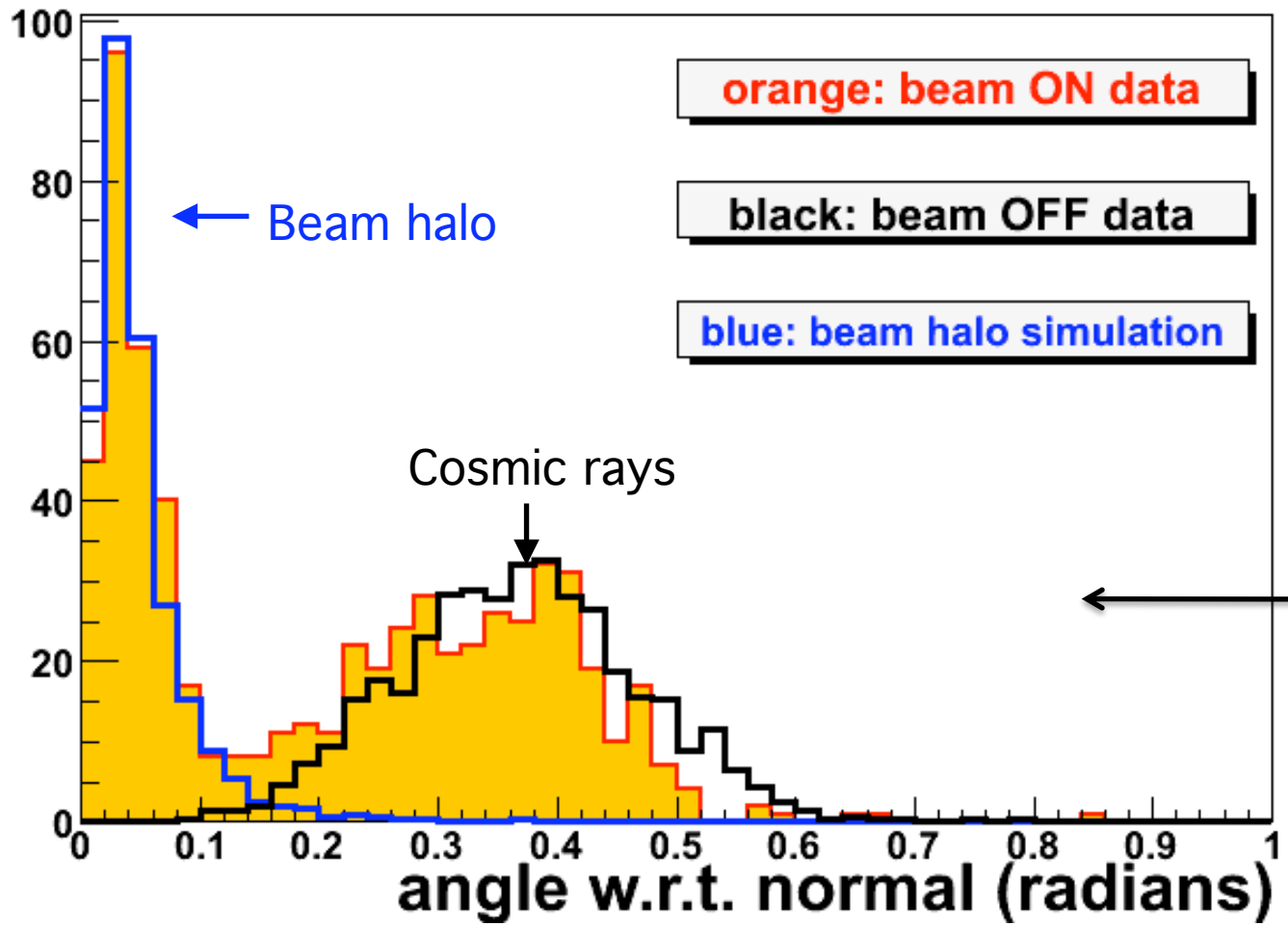
After beam capture



Beam halo: reconstructed tracks



beam halo data 12-Sep-2008



beam ON data:
combination of

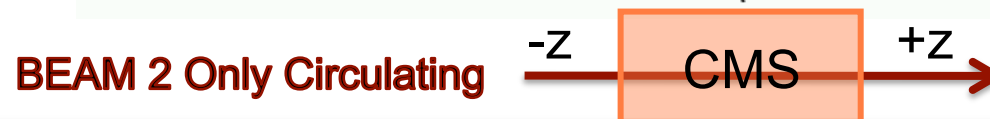
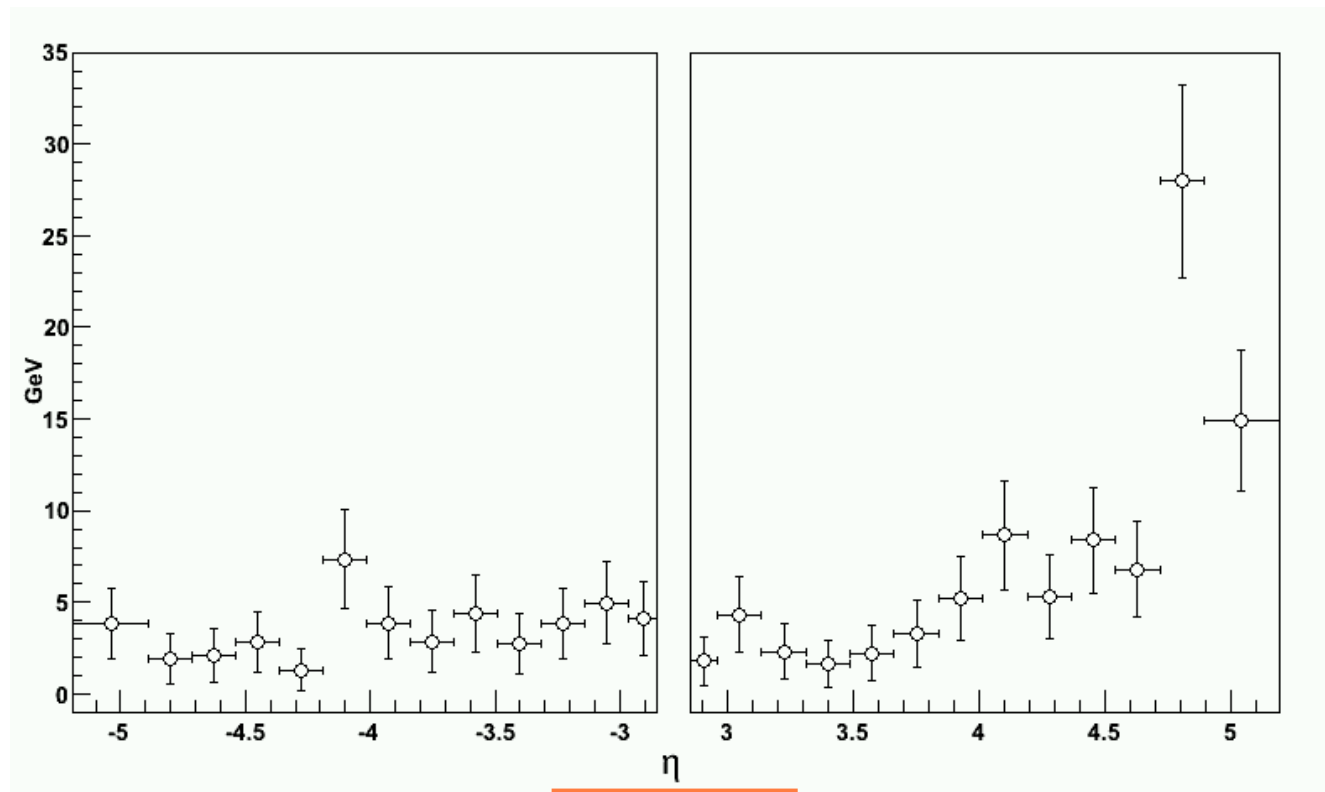
- beam halo
- cosmic rays

reconstructed
track angle
w.r.t. to the
normal to
transverse plane

Evidence for beam gas collisions



- Energy in the forward hadronic calorimeter HF



Conclusions



- After nearly 20 years of design and construction CMS started data taking with LHC beams
- All sub-detectors, online, offline, computing and analysis systems performed well
 - The solenoid and the tracker were off for beams
- Looking forward to the first collisions in 2009