Level-1 Trigger Performance Studies
on the
CMS CSC Track Finder

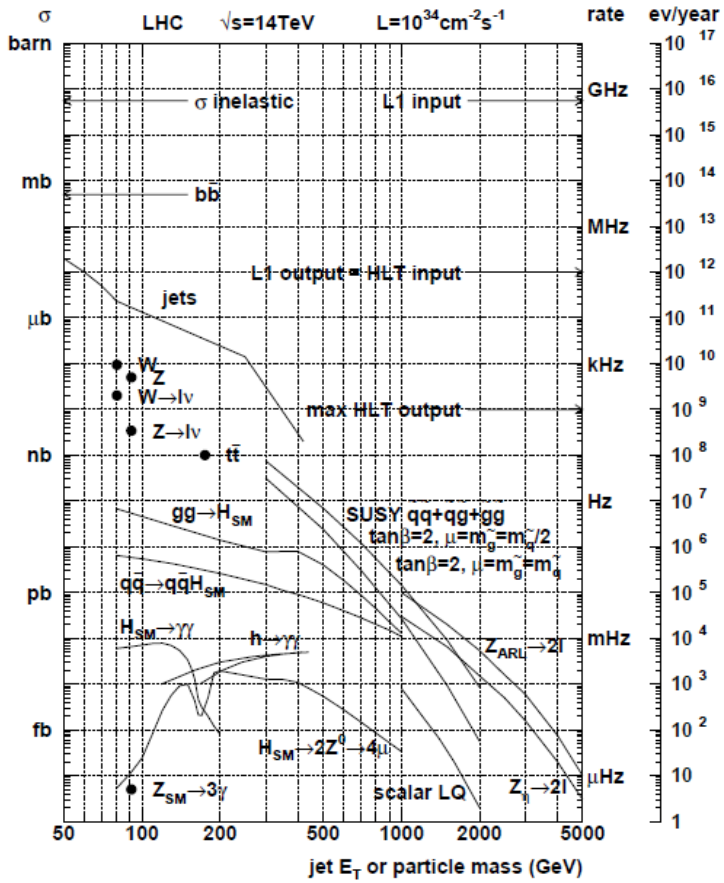
Alexander Ji
Stanford University

Supervised by:
Darin Acosta, Ivan Furic, Gian Piero di Giovanni
University of Florida

12 Aug 2010

Overview

The LHC: More Data Than You Can Handle



Source: CMS L1 Trigger TDR

- Goal is to explore rare physics: Higgs, Supersymmetry, Dark Matter
- Requires high luminosity ($10^{34} cm^2 s^{-1}$)
- Proton bunches cross every 25ns
- Generates **600 TB/sec** of data
- Most events are uninteresting

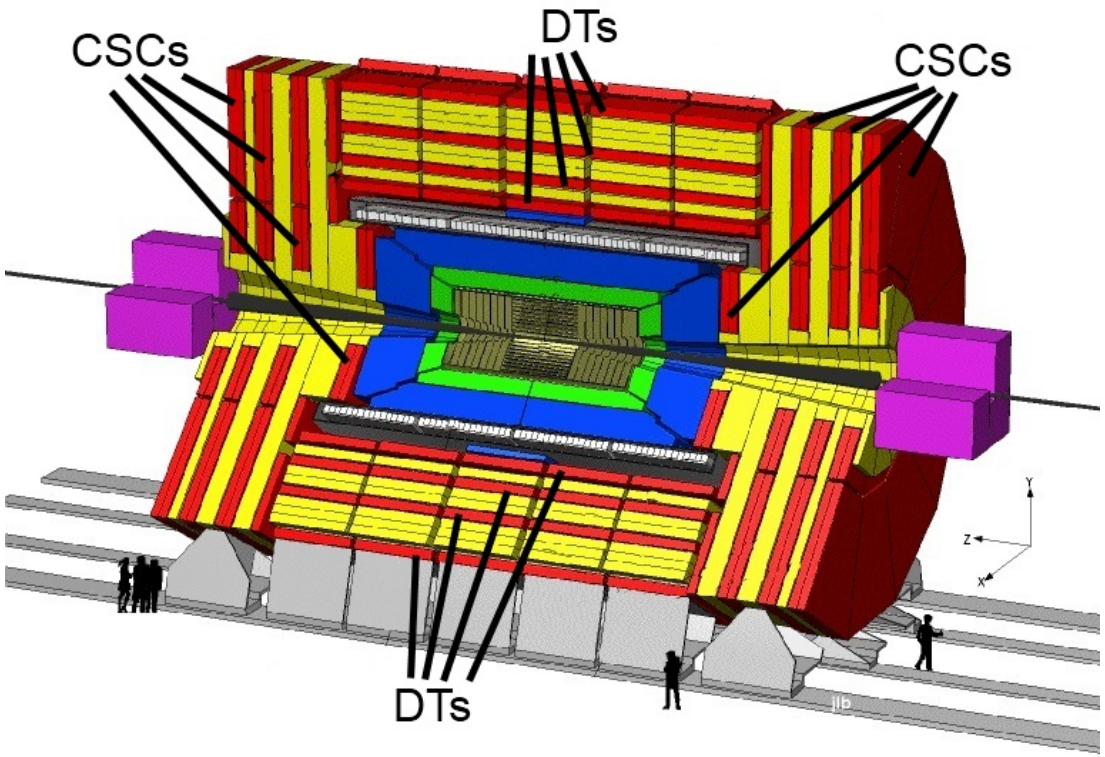
The Solution: Triggering!

- We *can't* and *don't want to* record all the data
- Use a trigger - "a system that uses simple criteria to rapidly decide which events in a particle detector to keep when only a small fraction of the total can be recorded" (Wikipedia)

The Solution: Triggering!

- We *can't* and *don't want to* record all the data
- Use a trigger - "a system that uses simple criteria to rapidly decide which events in a particle detector to keep when only a small fraction of the total can be recorded" (Wikipedia)
- The trigger must be *FAST* and *ACCURATE*
- FAST because of the 25ns clock
- ACCURATE because not accepting data means it's lost forever

The CMS Detector

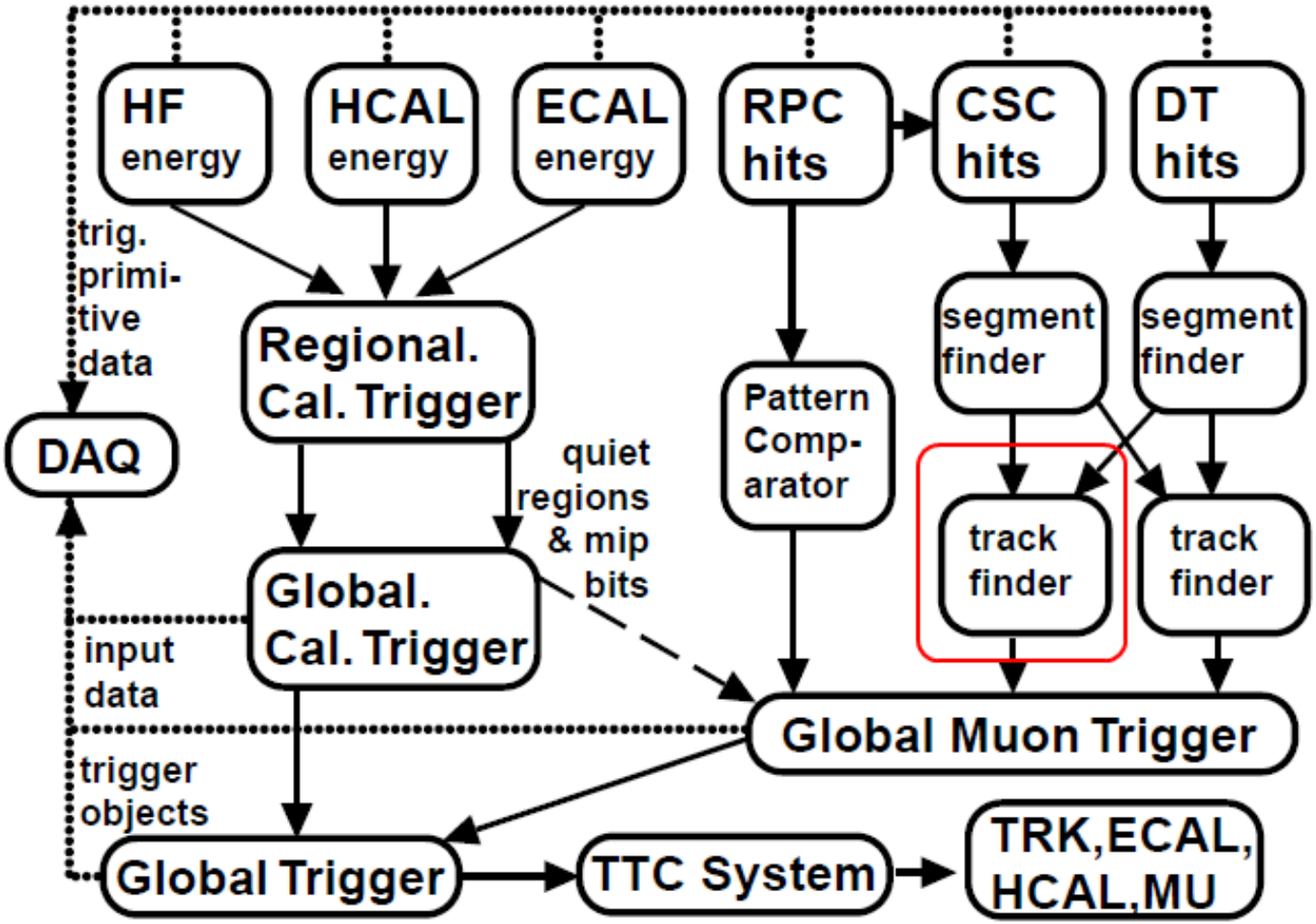


- Cathode Strip Chambers (CSCs): "endcaps"
- Drift Tubes (DTs): "barrel"

Source: http://ireswww.in2p3.fr/ires/recherche/cms/stephanie/images/CMS_3D.gif

The CMS Level 1 Trigger

Reduces events from 40MHz to 100kHz
(High Level Trigger reduces down to 100Hz)

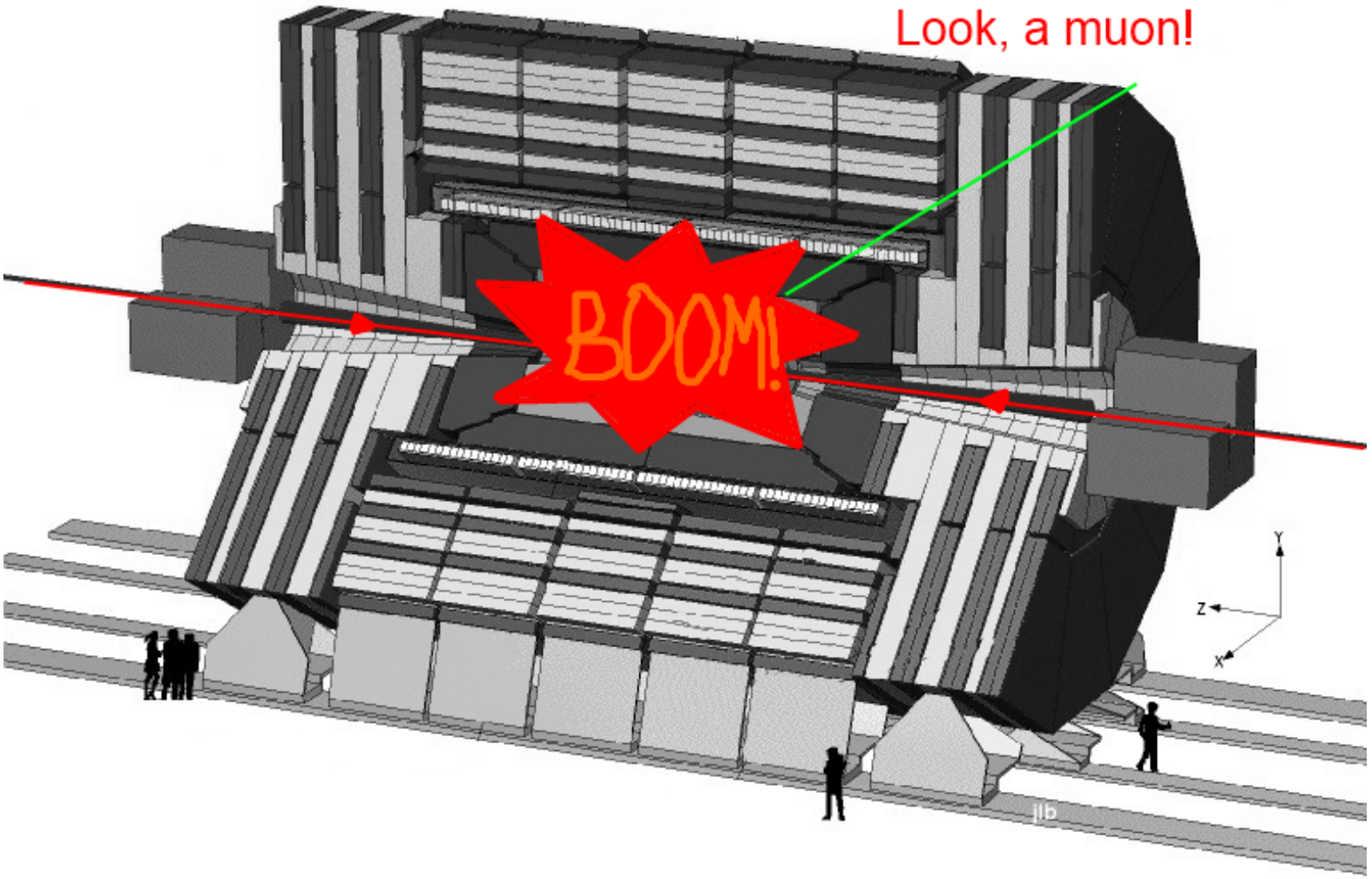


Source: CMS L1 Trigger TDR

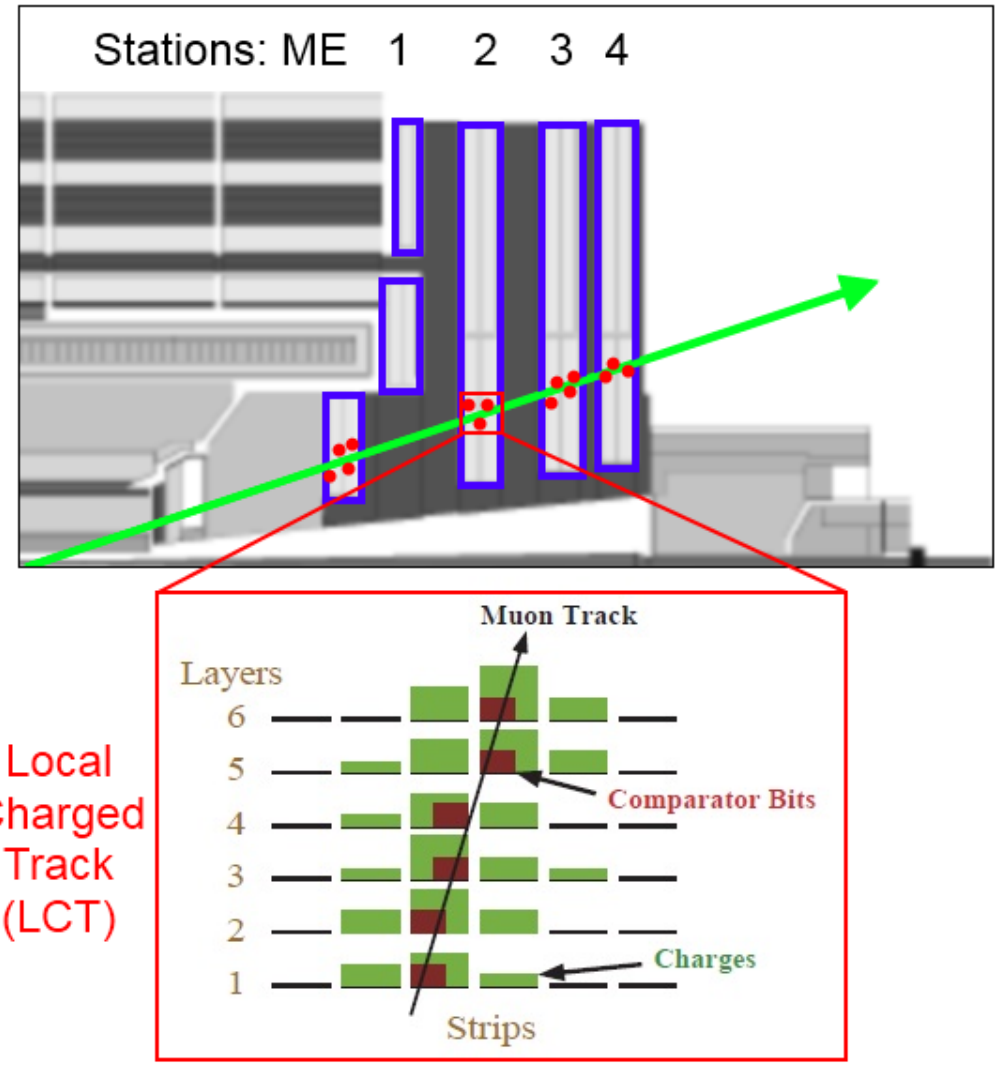
Detecting a Muon with Cathode Strip Chambers

Four Steps...

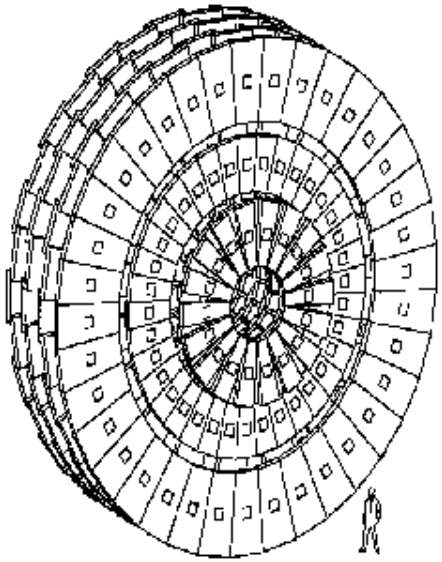
1. Beams Collide!

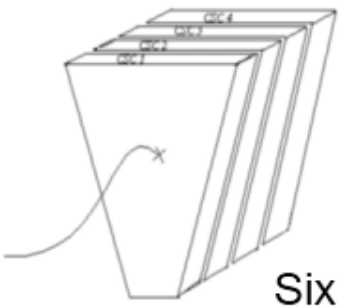


2. LCT Creation and CSC Geometry



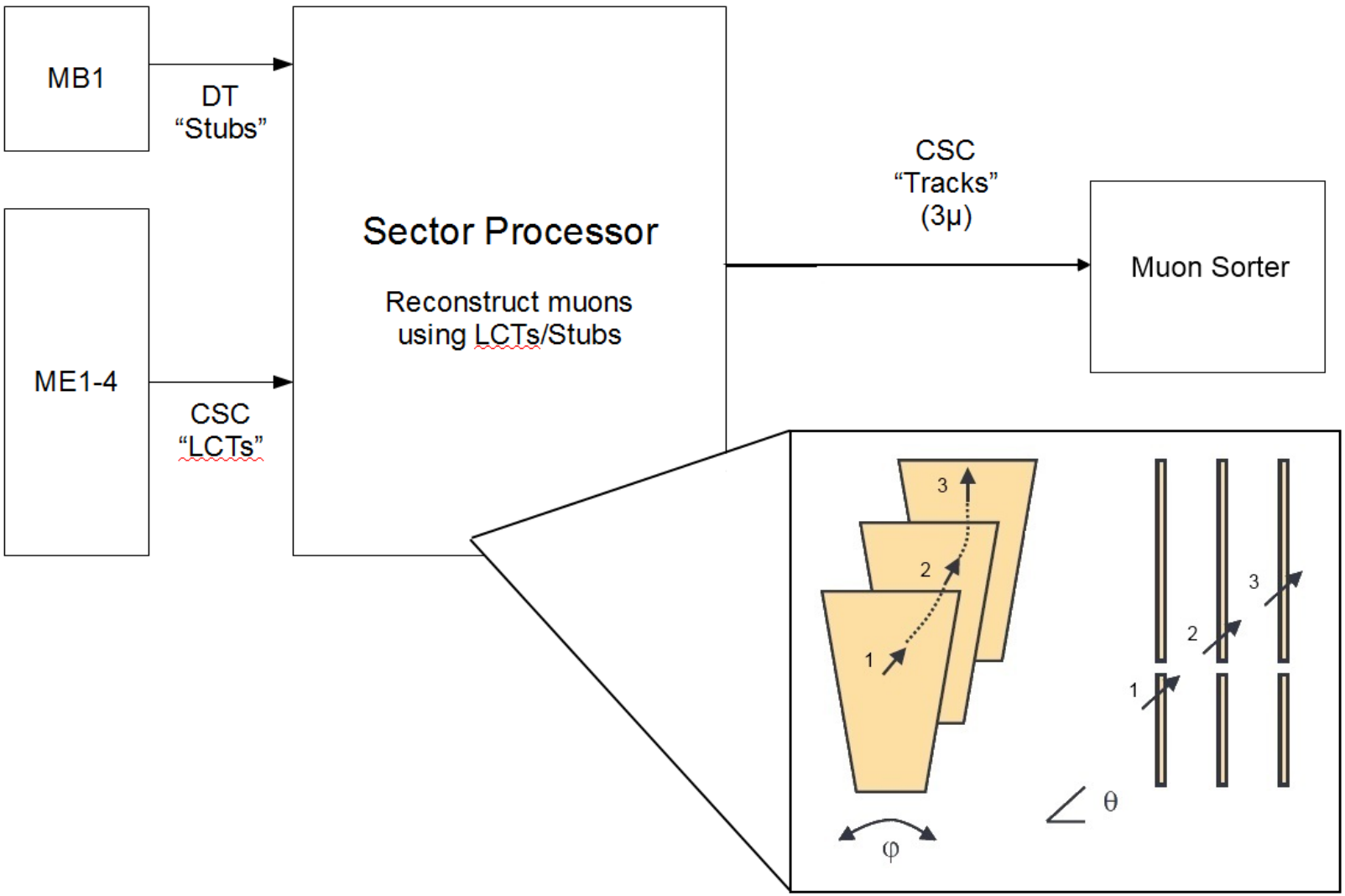
Local Charged Track (LCT)



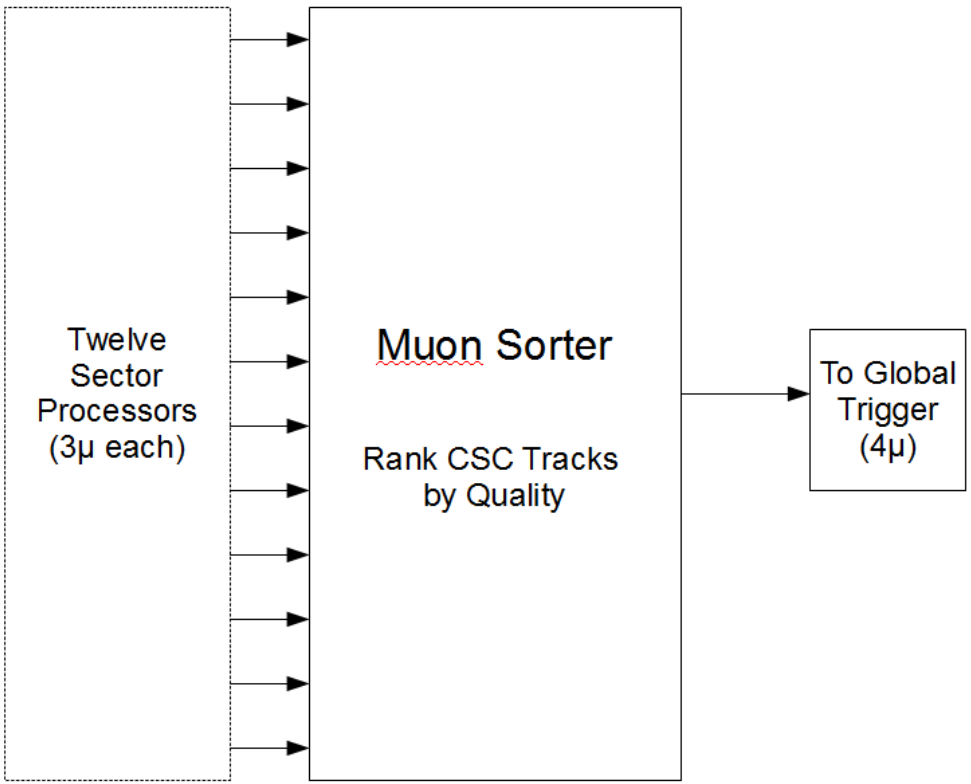


Six 60°Sectors in each endcap

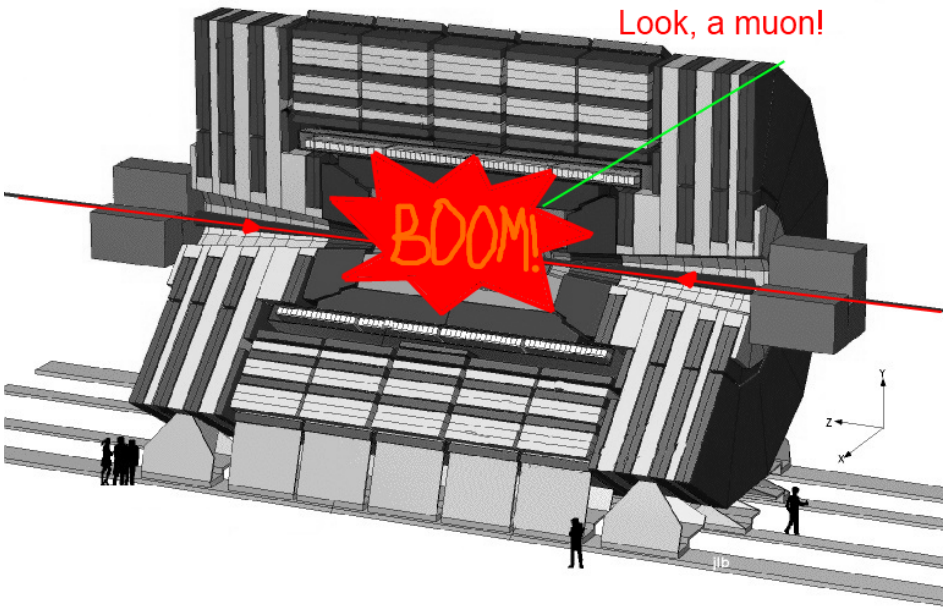
3. CSC Track Finder - Sector Processor

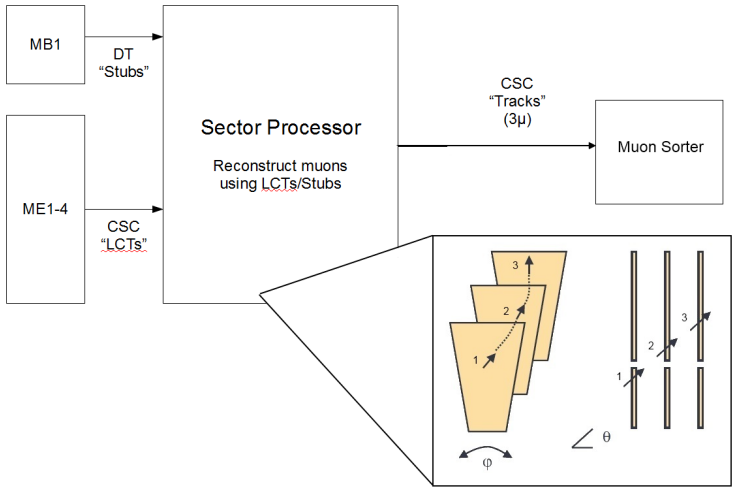


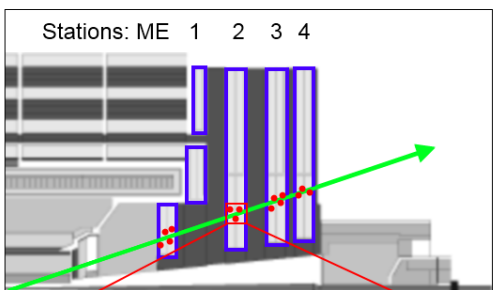
4. CSC Track Finder - Muon Sorter

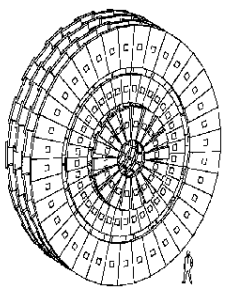


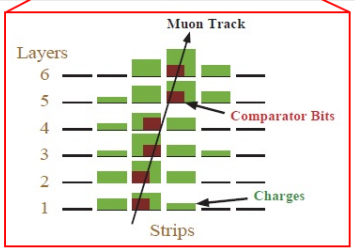
Repeat Every 25ns...



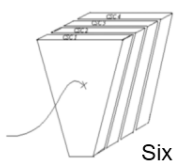




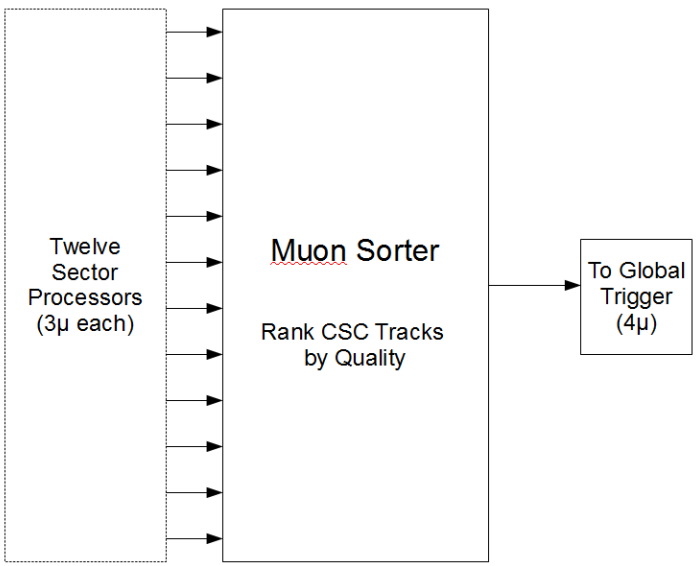




Local Charged Track (LCT)

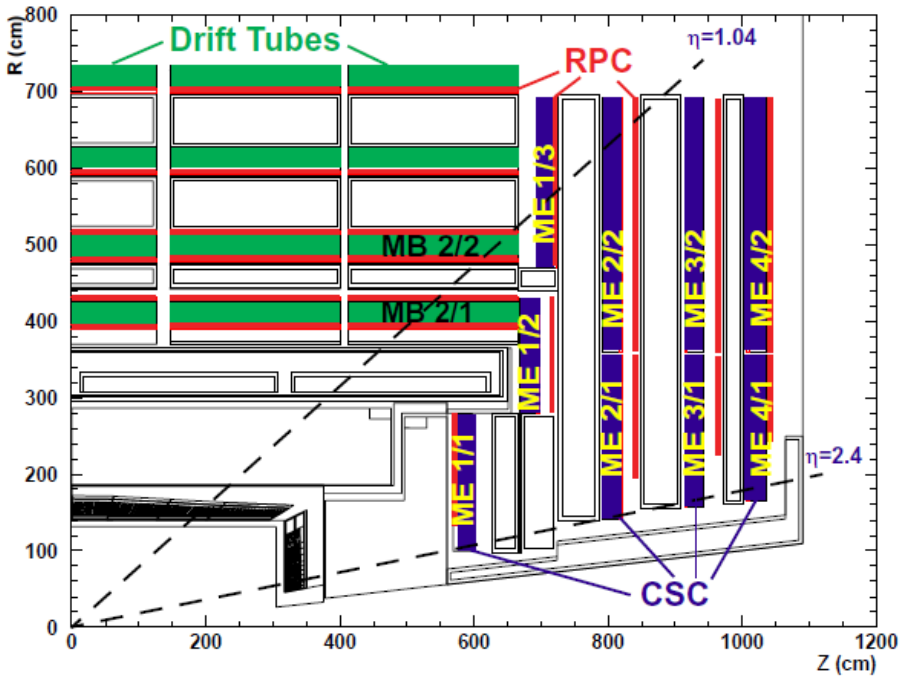


Six 60°Sectors in each endcap



Overlap Region Synchronization

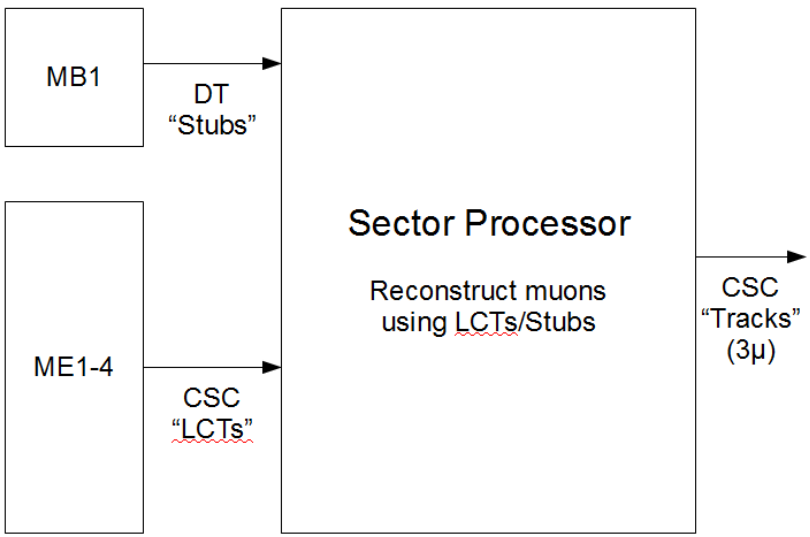
The Overlap Region



Source: CMS L1 Trigger TDR

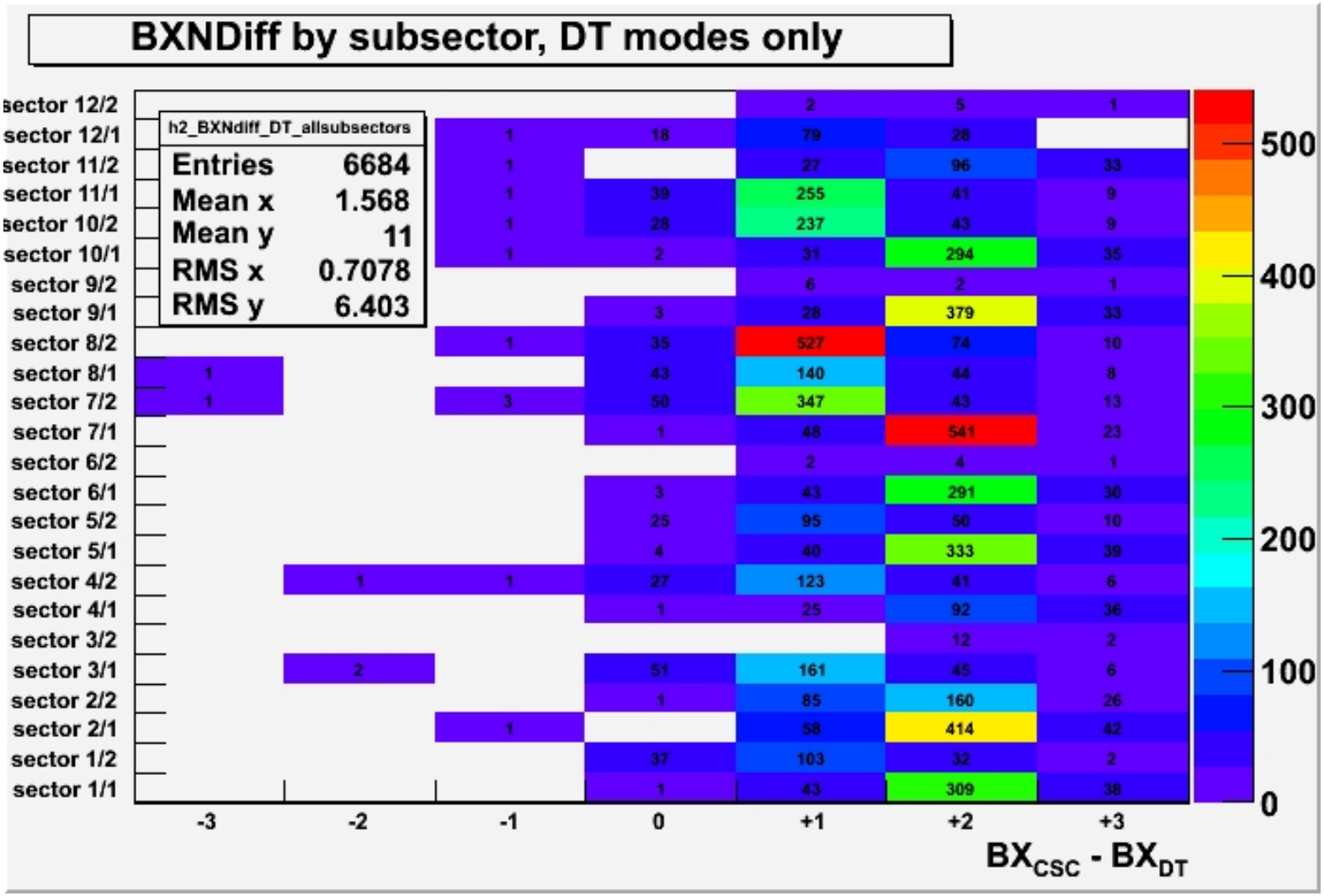
- DT and CSC Track Finders are independent
- A muon can pass through both regions
- Divide Track Finder responsibility at $\eta = 1.04$
- Share stubs and LCTs (we get stubs from MB1, they get stubs from ME1/3)
- Catching muons in this region is hard

DT Stub and CSC LCT Synchronization



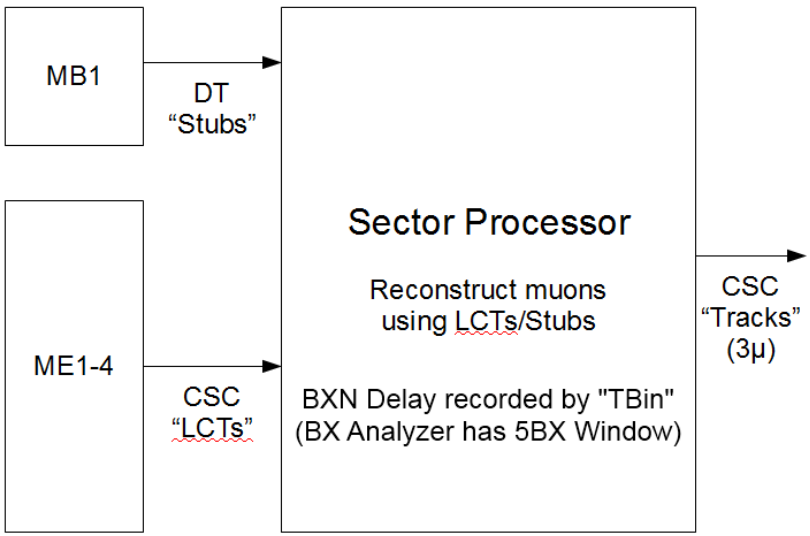
- Stubs and LCTs should arrive at the same time
- Compare stub and track Bunch Crossing Numbers (BXN)
- We want:
  $BXN_{CSC} - BXN_{DT} = 0$

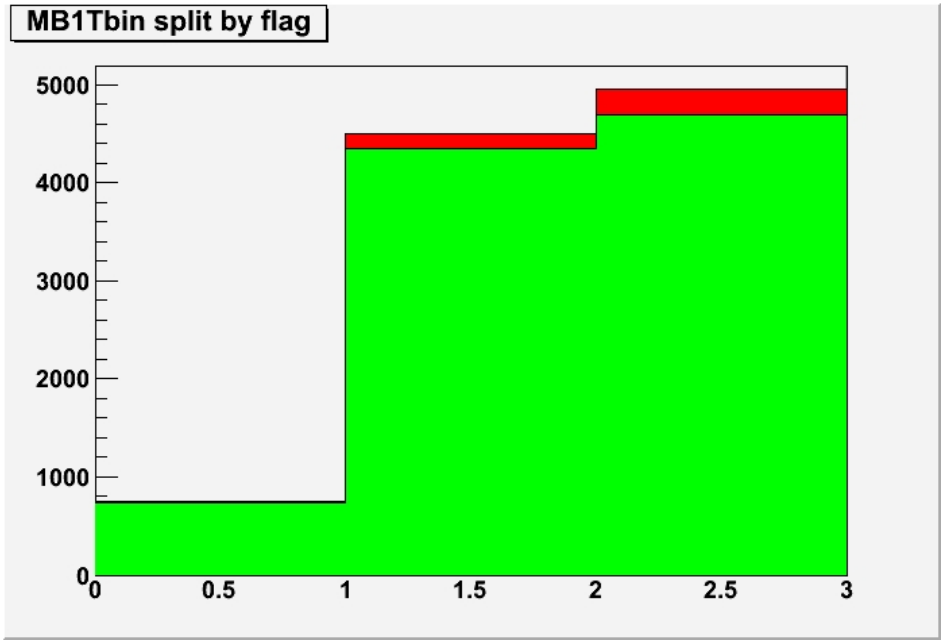
Unsynchronized DT Stubs



Not coming in synch...

Confirming Unsynchronized Stubs with TBin





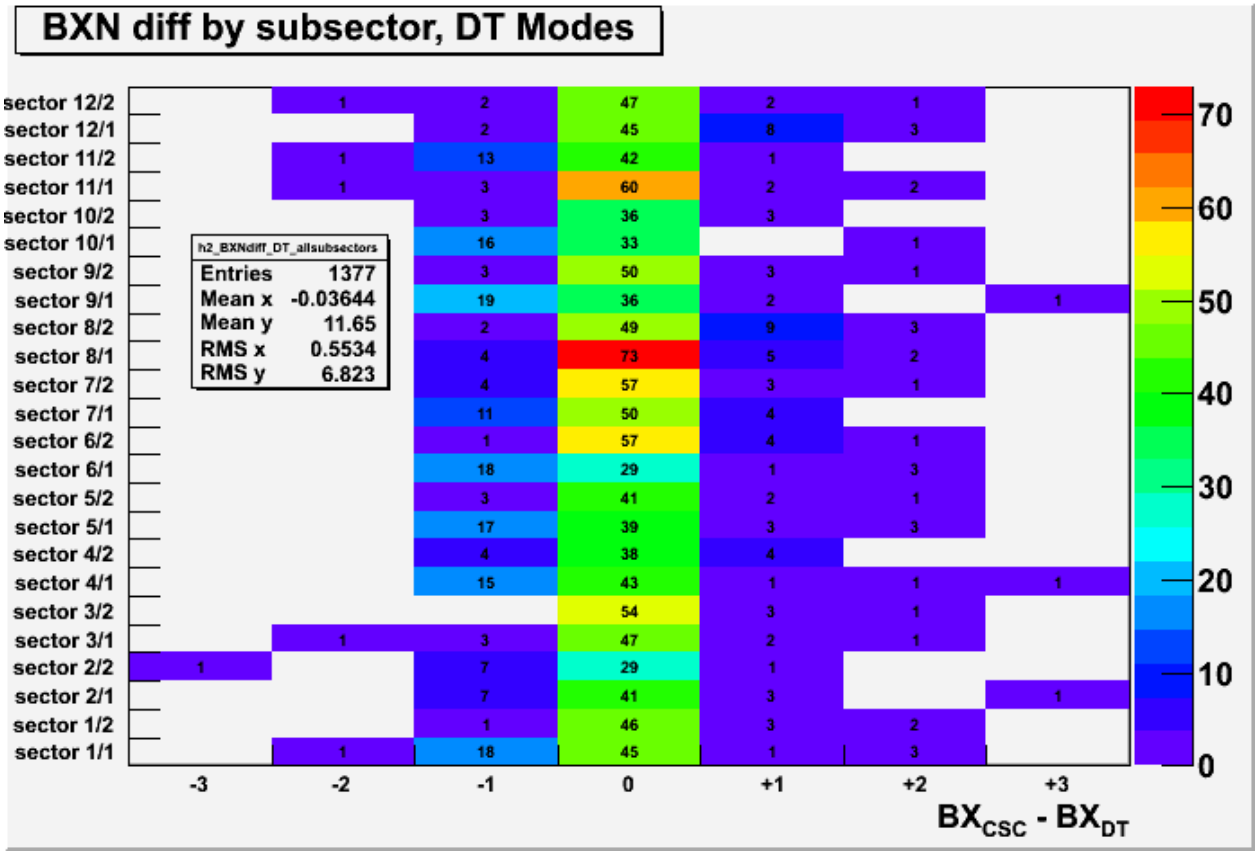
Confirms that DT stubs are being consistently delayed

Synchronizing the Stubs

20 Jul 2010: Anna applies delay to DT Stubs by subsector

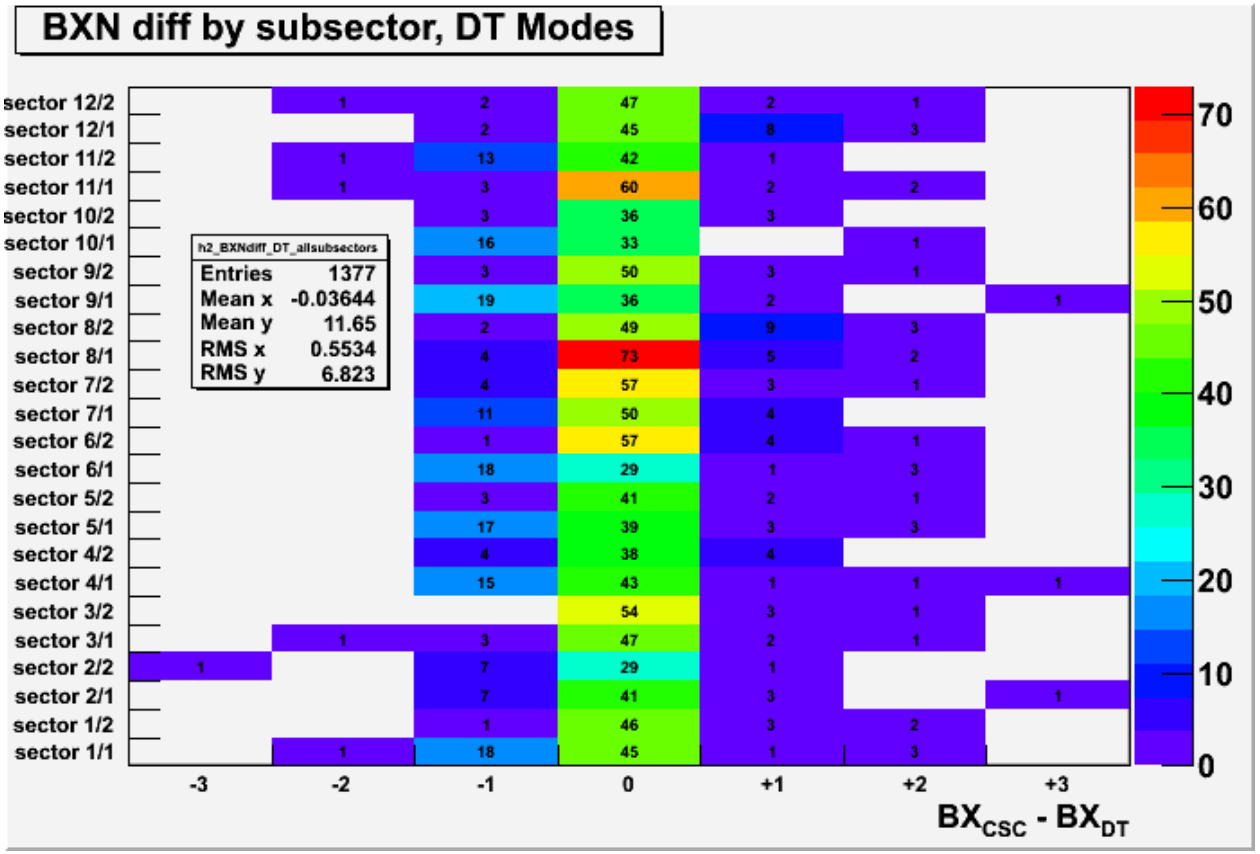
Synchronizing the Stubs

20 Jul 2010: Anna applies delay to DT Stubs by subsector



Synchronizing the Stubs

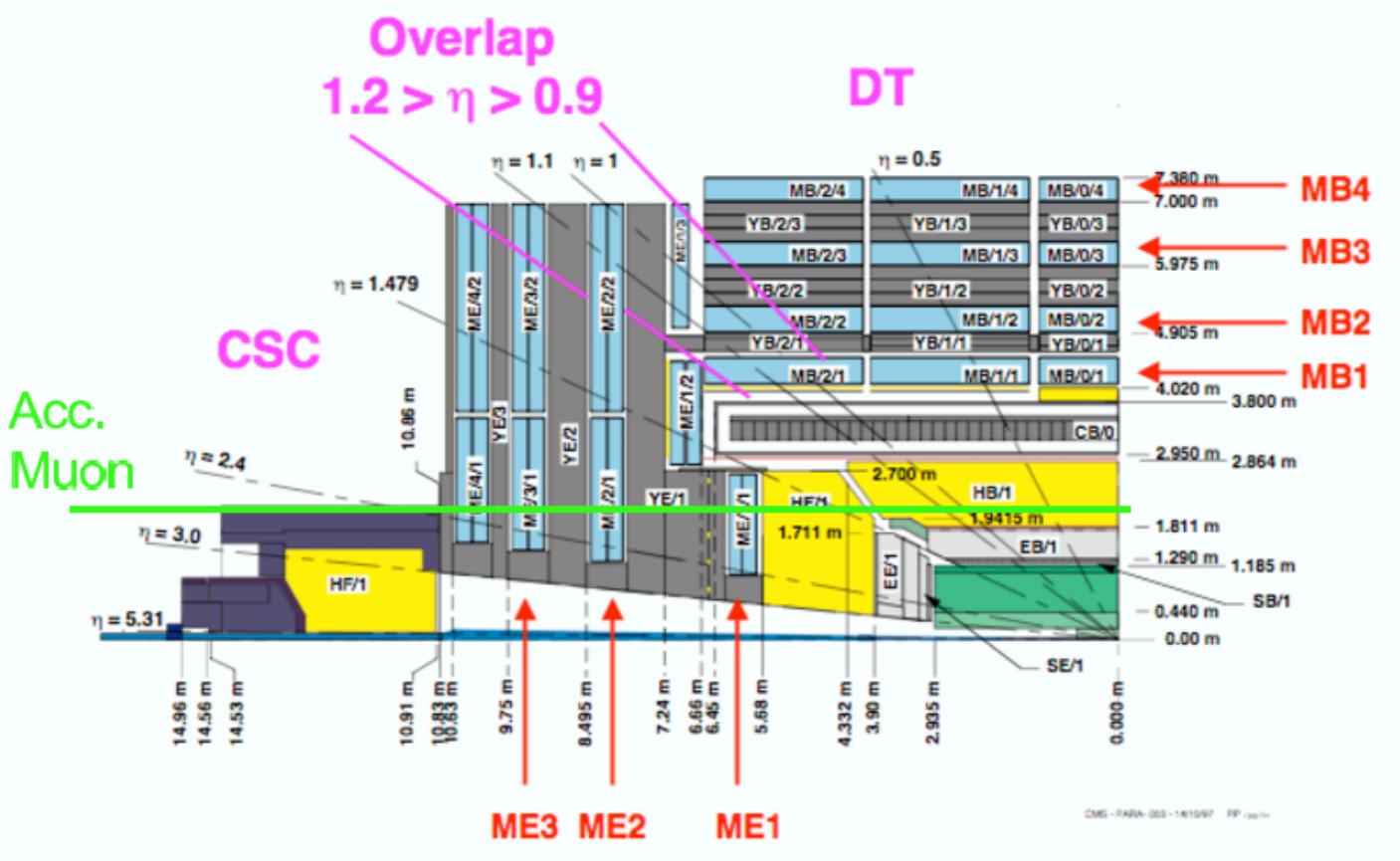
20 Jul 2010: Anna applies delay to DT Stubs by subsector



13 Aug 2010: DT synchronization monitoring code will be committed to CMSSW

Beam Halo Efficiency

Beam Halo Muons (aka Horizontal Muons)

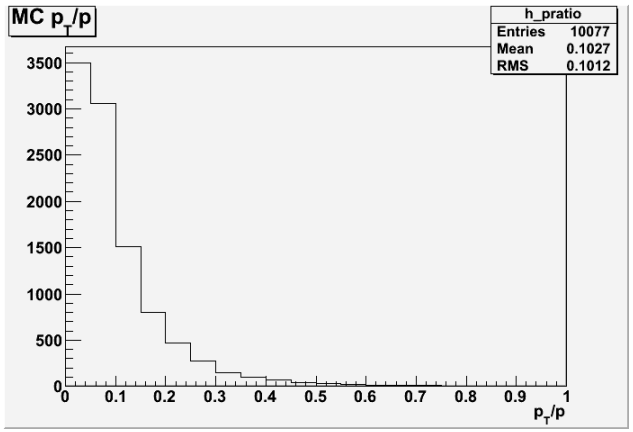


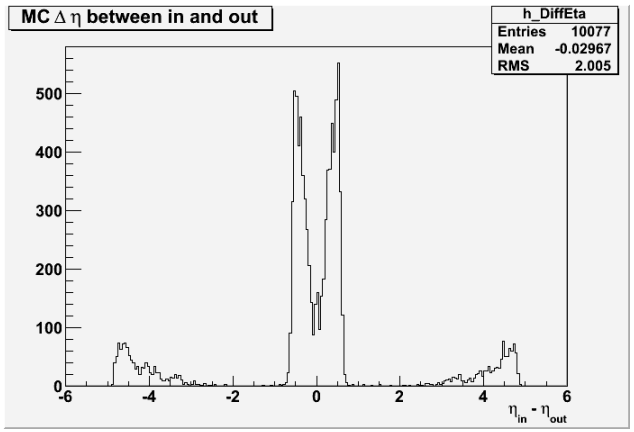
Source: CMS IN-2008/041

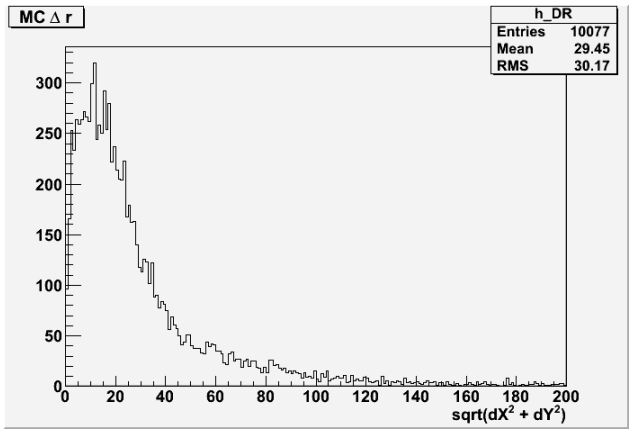
Halo Muons should rank quite low in the Muon Sorter!
Goal is to efficiently tag horizontal muons

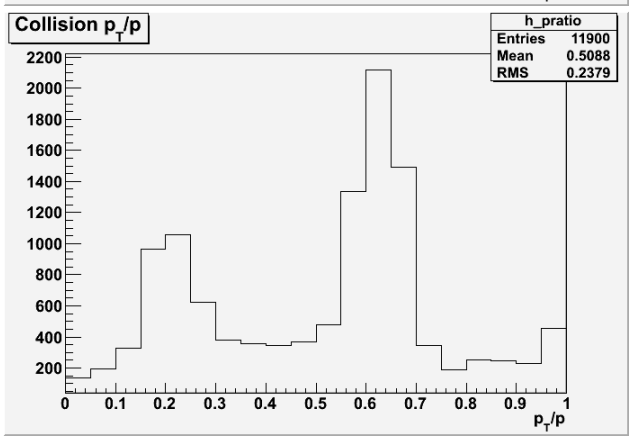
Horizontal Muon Cuts

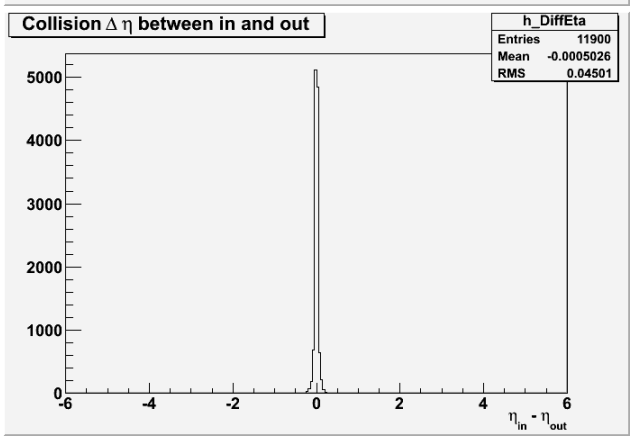
Comparing MC and Collisions RECO data

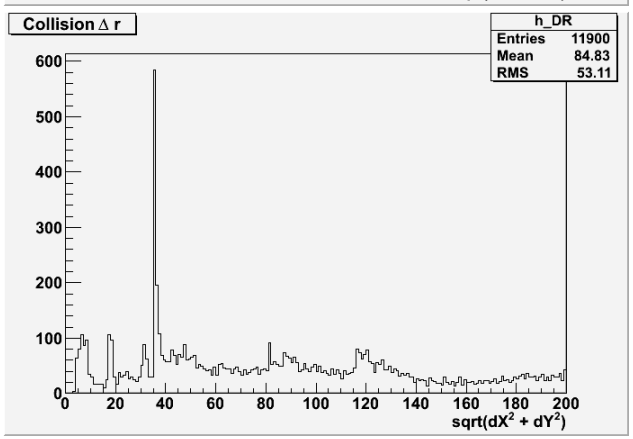












Cuts: $p_T/p < 0.15$, $\Delta\eta > 0.25$, $\Delta R < 30$

Calculating Beam Halo Efficiency

$$Eff = \frac{\text{Number of horizontal muons tagged as a halo muon}}{\text{Number of horizontal muons that could be tagged as a halo muon}}$$

- Identify horizontal RECO muons
- Find associated LCTs
- Find associated track and check to see if it's a halo muon

Code still has some bugs.

Conclusion

- DT Synchronization: Problem identified and fixed. Analysis code will be commited to CMSSW

Conclusion

- DT Synchronization: Problem identified and fixed. Analysis code will be commited to CMSSW
- Beam Halo Efficiency: Horizontal muon cuts established, efficiency code still buggy

Conclusion

- DT Synchronization: Problem identified and fixed. Analysis code will be commited to CMSSW
- Beam Halo Efficiency: Horizontal muon cuts established, efficiency code still buggy
- Triggering: important, difficult, and not exactly glorious

Acknowledgements!

- Darin Acosta, Ivan Furic, Gian Piero di Giovanni, Anna Kropivnitskaya, Khristian Kotov, Alex Madorsky, Laria Redjimi, Joe Gartner, and the rest of the CSCTF group
- Homer Neal, Jean Krisch, Steven Goldfarb, and University of Michigan
- National Science Foundation
- CERN
- All the other students

Questions?