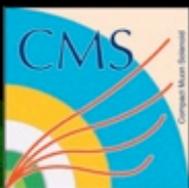


CMS Commissioning and Upgrades



CMS Experiment at the LHC, CERN

Data recorded: 2010-Mar-30 11:04:37.067645 GMT(13:04:37 CEST)
Run: 132440
Event: 3111007
Lumi section: 139
Orbit: 36243167
Crossing: 1

Event Display of the First 7TeV Collision

HLT Triggers:

- HLT_Activity_PixelClusters
- HLT_Activity_EcalREM
- HLT_L1Jet6J
- HLT_L1SingleForJet
- HLT_L1SingleForJet_NoBPTX
- HLT_L1SingleTauJet
- HLT_L1SingleTauJet_NoBPTX
- HLT_MinBiasBSC
- HLT_MinBiasBSC_NoBPTX
- HLT_MinBiasBSC_OR
- HLT_MinBiasHcal
- HLT_ZeroBiasPixel_SingleTrack
- HLT_MinBiasPixel_SingleTrack
- HLT_MinBiasPixel_DoubleTrack
- HLT_SplashBSC
- HLT_L1_BscMinBiasOR_BptxPlusORMinus
- HLT_L1_BscMinBiasOR_BptxPlusORMinus_NoBPTX
- HLT_L1_HFTech
- HLT_L1Tech_HCAL_HF_coincidence_PM
- HLT_HFTThreshold10

Drawing cuts & scales

Name	Min energy (GeV)	Energy scale (GeV)
EBRecHits_V2	0.250	1.000
EERecHits_V2	0.800	1.000
ESRecHits_V2	0.001	100.000
HRRecHits_V2	0.750	0.001
HERecHits_V2	0.750	0.001
HFRRecHits_V2	3.000	0.005
HORecHits_V2	3.300	0.005

Francisco Yumiceva (Fermilab)
for the CMS Collaboration

<http://lqanpa.cern.ch/ispv>

The CMS Detector



Electromagnetic Calorimeter

76k scintillating PbWO4 crystals

Hadron Calorimeter

Scintillator tiles/brass interleaved

Muon Barrel

Drift Tubes(DT) and Resistive Plate Chambers(RPC)

Muon End-Caps

Cathode Strip (CSC) and Resistive Plate Chambers(RPC)

Hadron Forward Calorimeter

Quartz fiber/iron

Pixels & Tracker

- Pixels
 - 100x150microns,
 - 66M channels
- Silicon Microstrips
 - 9.6M channels

3.8T Solenoid

Iron Yoke

Total weight 12500 t, Overall diameter 15 m, Overall length 21.6 m, Magnetic field 4 Tesla

CMS Timeline



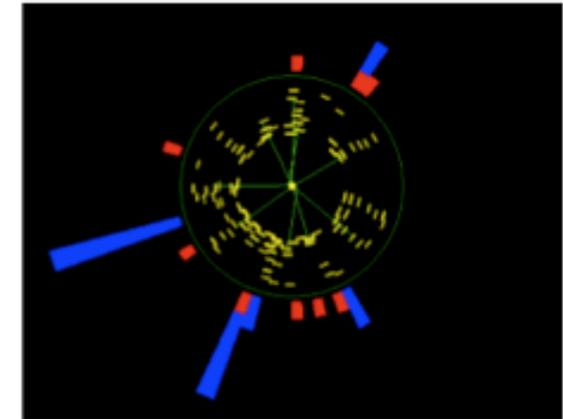
September 2008

First beam splashes in CMS



July 2009

Repairs in the LHC finished

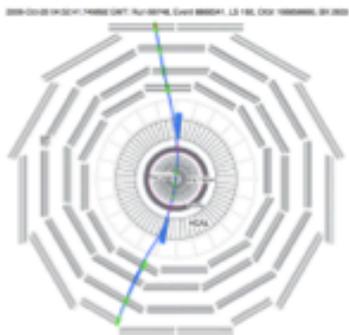


December 2009

First 900 GeV and 2.4 TeV collisions

2008

Cosmic data taking with 3.8 T field



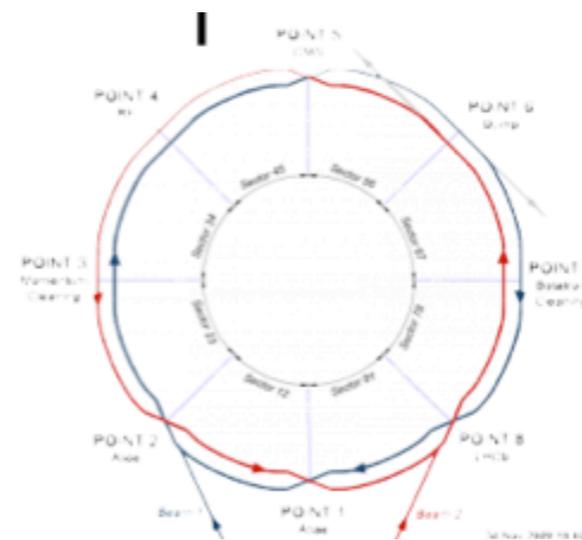
September 2008

Magnets incident, set back the LHC for a year



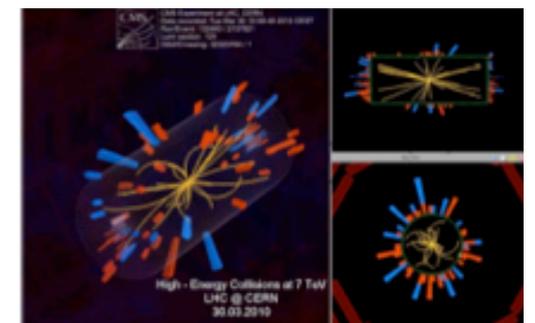
November 2009

CMS sees two circulating beams



March 2010

First 7 TeV collisions



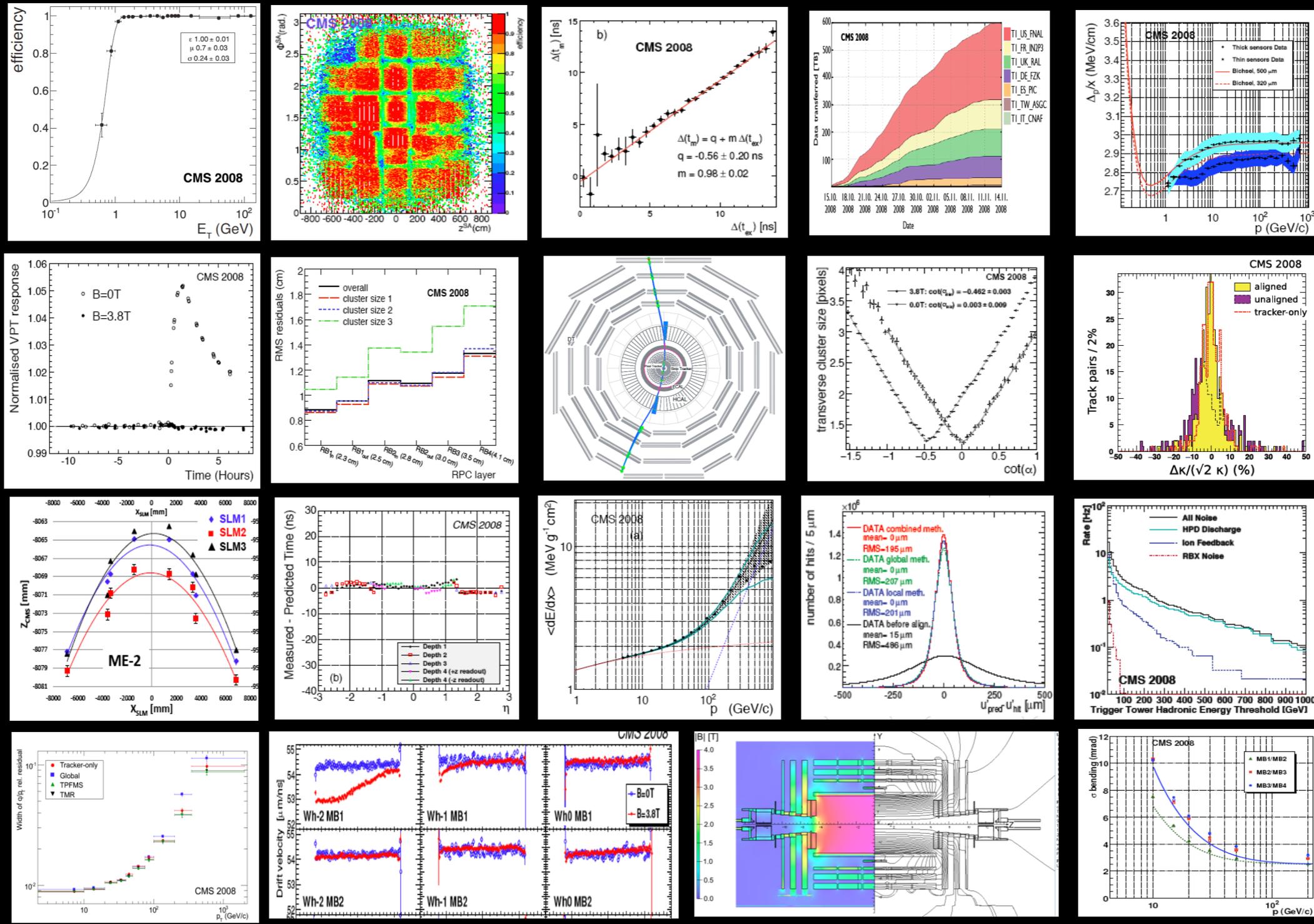
Data Collected so far

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- Cosmic ray data 600M events
 - 23 publications on detector performance (Journal of Instrumentation)

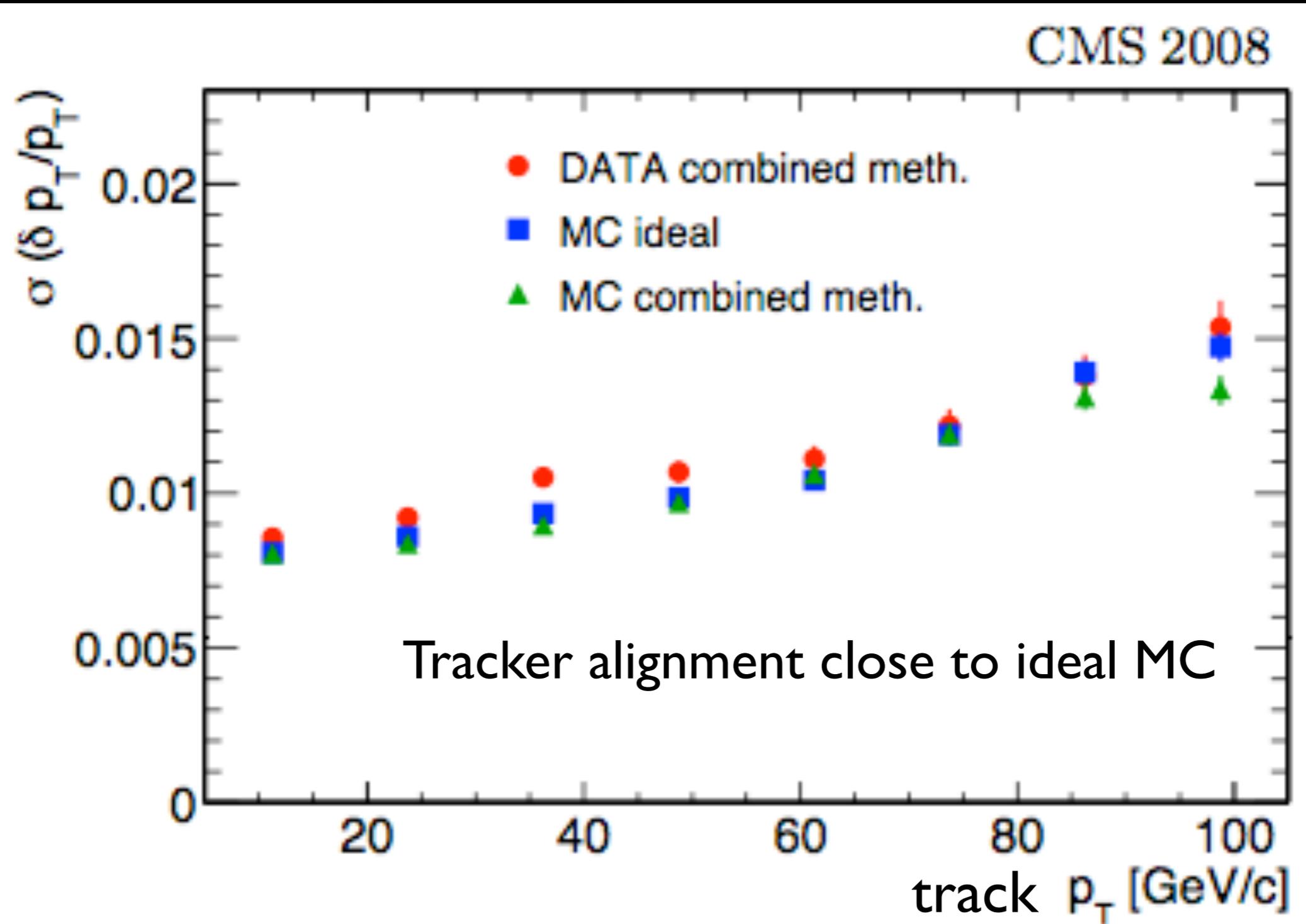
Data Collected so far

23 (Cosmics) Papers published in JINST



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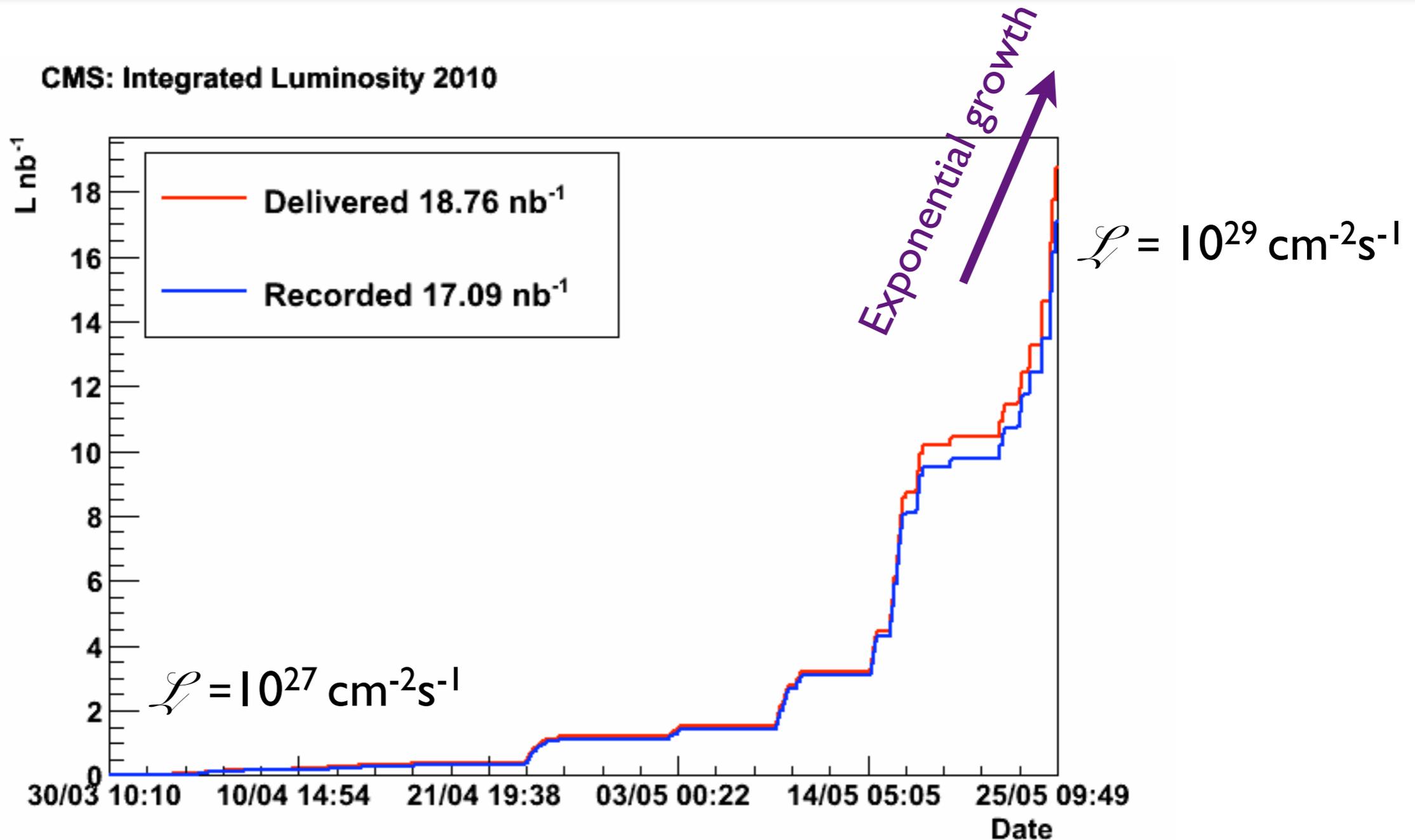
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- 7 TeV Collisions (Mar 30, 2010 onwards) $> 17 \text{ nb}^{-1}$

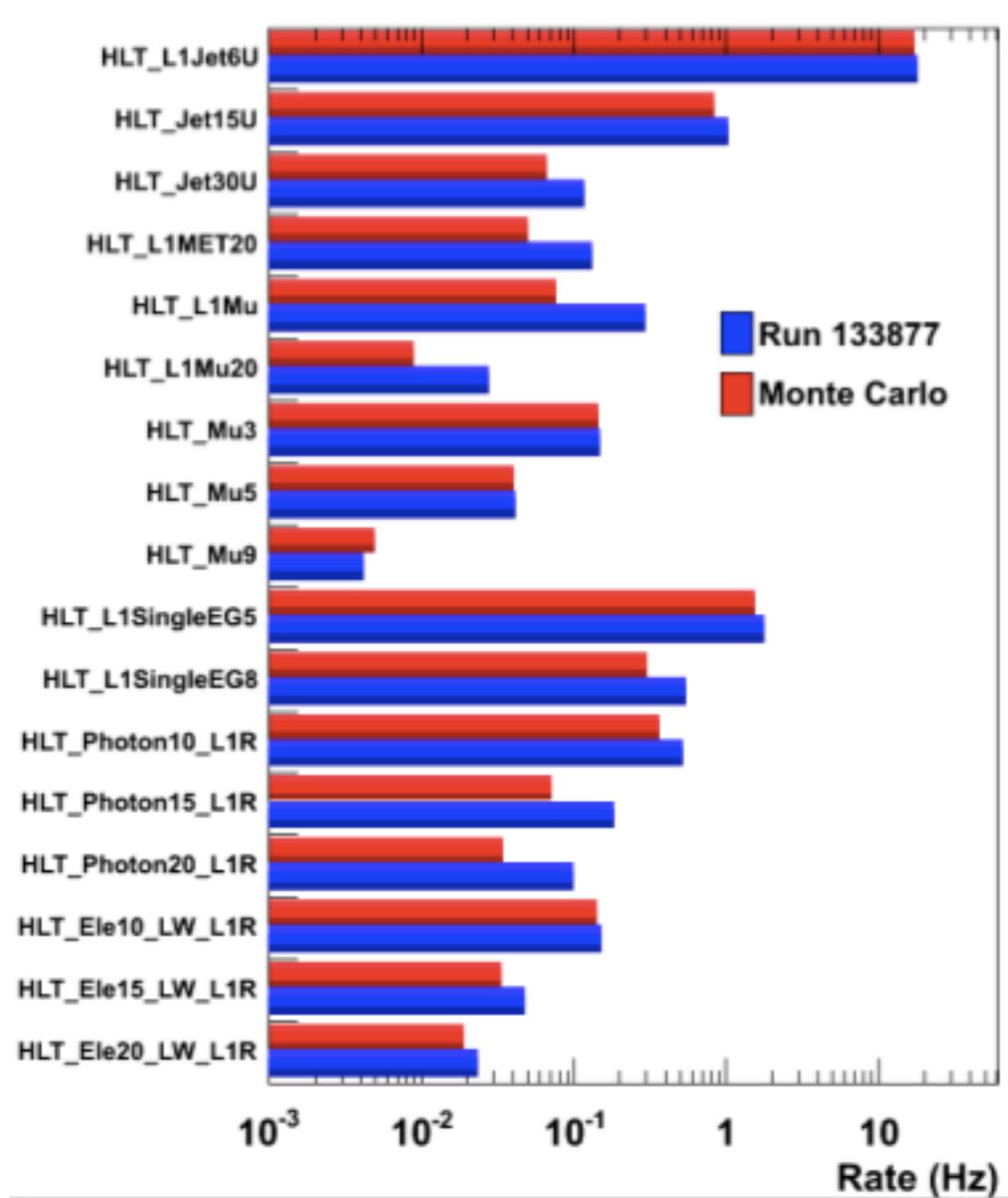
Integrated Luminosity at 7 TeV Collisions



91% overall data taking efficiency in the first 2 months!!

High Level Triggers

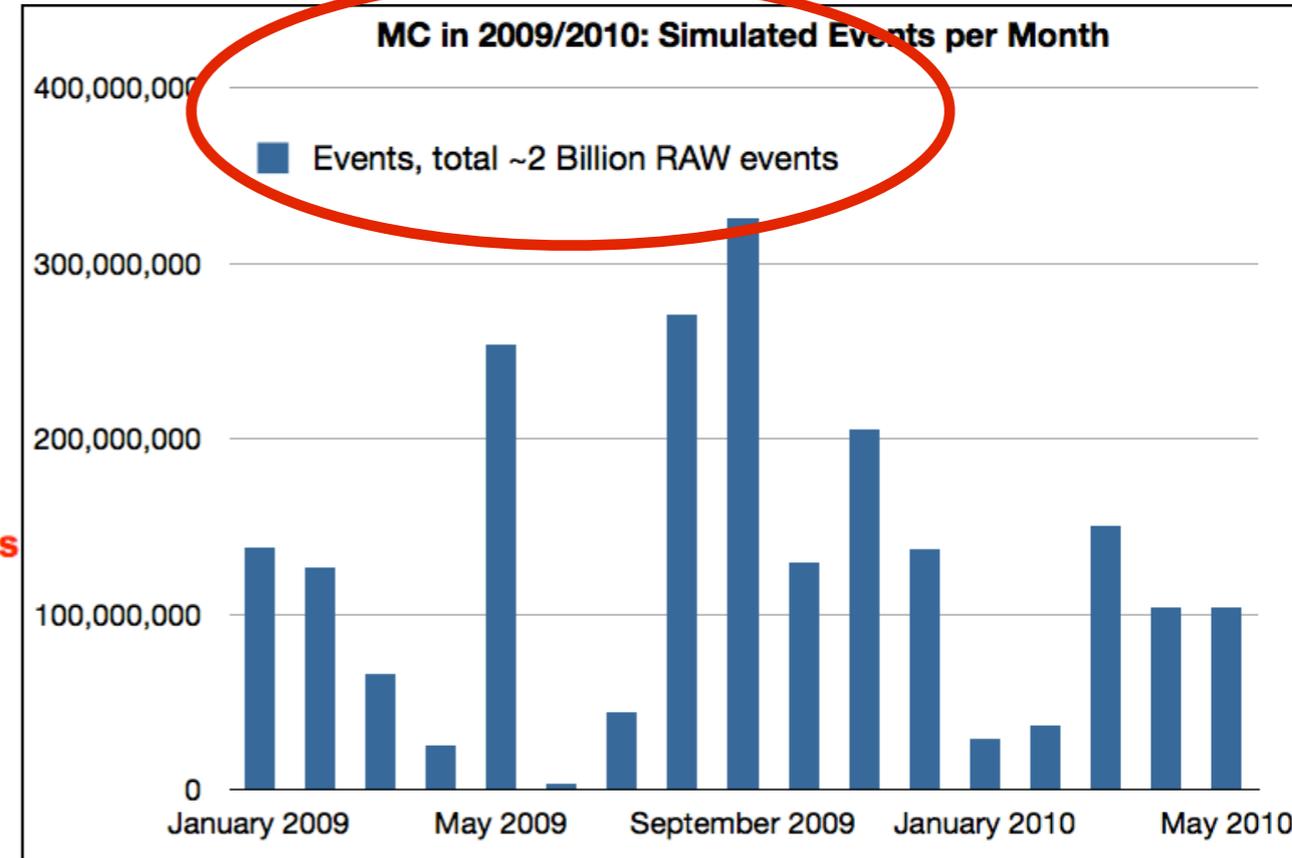
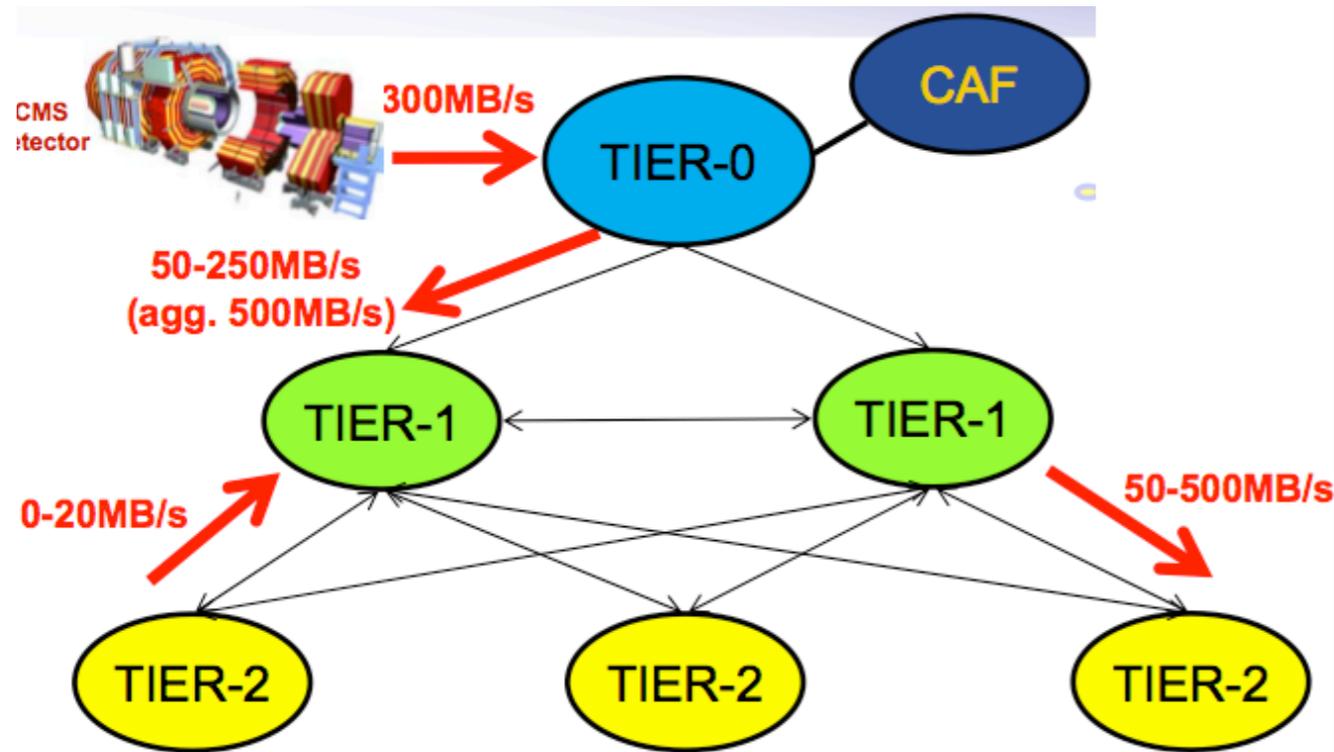
HLT Triggers



High Level Triggers Rates
Data/MC comparison

Working as expected

CMS Computing Model



Tier-0/CAF
at CERN

part of resources shared
with other experiments

7 Tier-1s

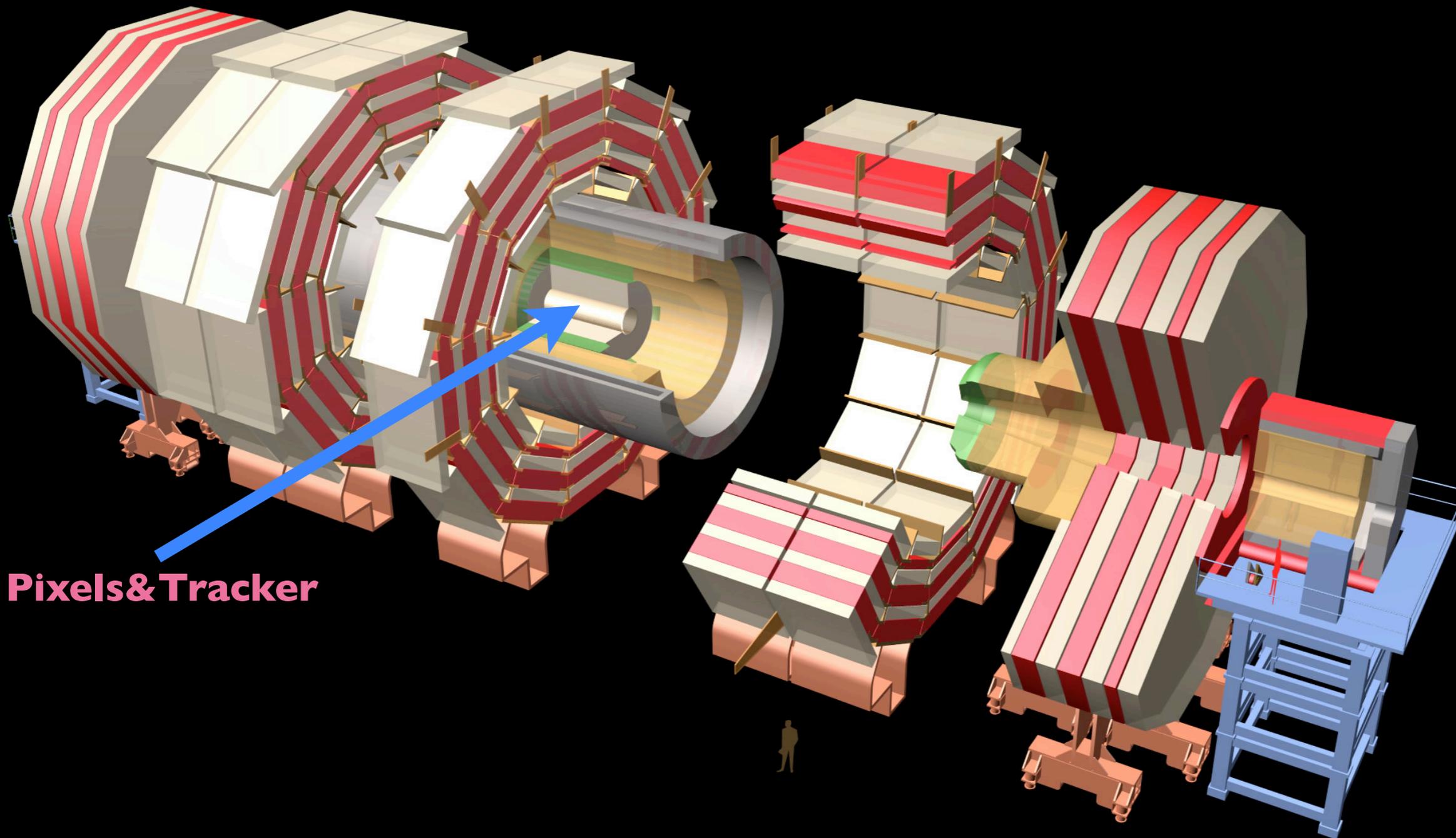
**FNAL (US), INFN (IT), FZK (DE),
IN2P3 (FR), RAL (UK), ASGC
(TW), PIC (ES)**

~50 Tier-2s

large contribution
from US Universities

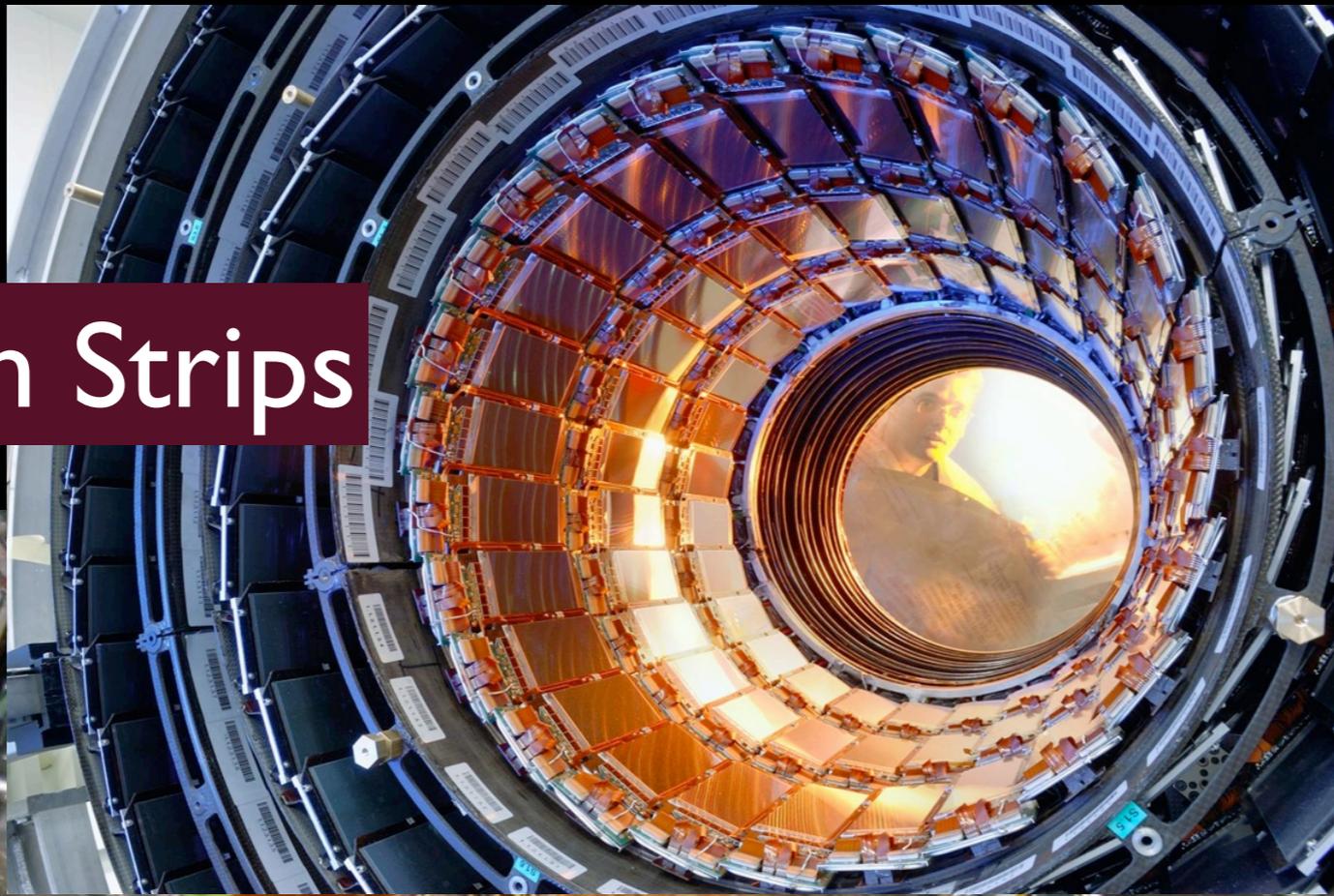
Computing is performing well.
Fermilab plays an important role in CMS data operations

The CMS Detector

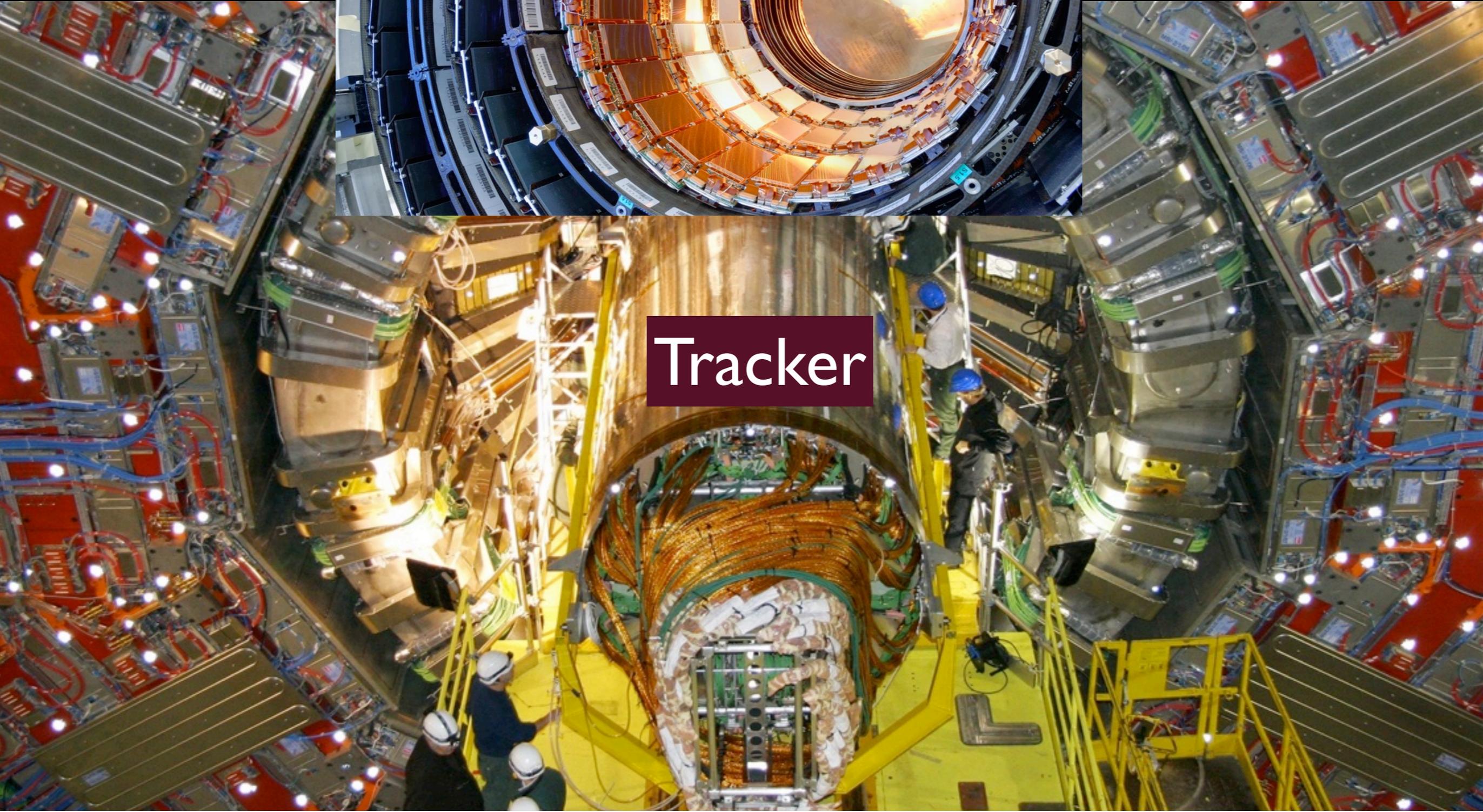


Pixels & Tracker

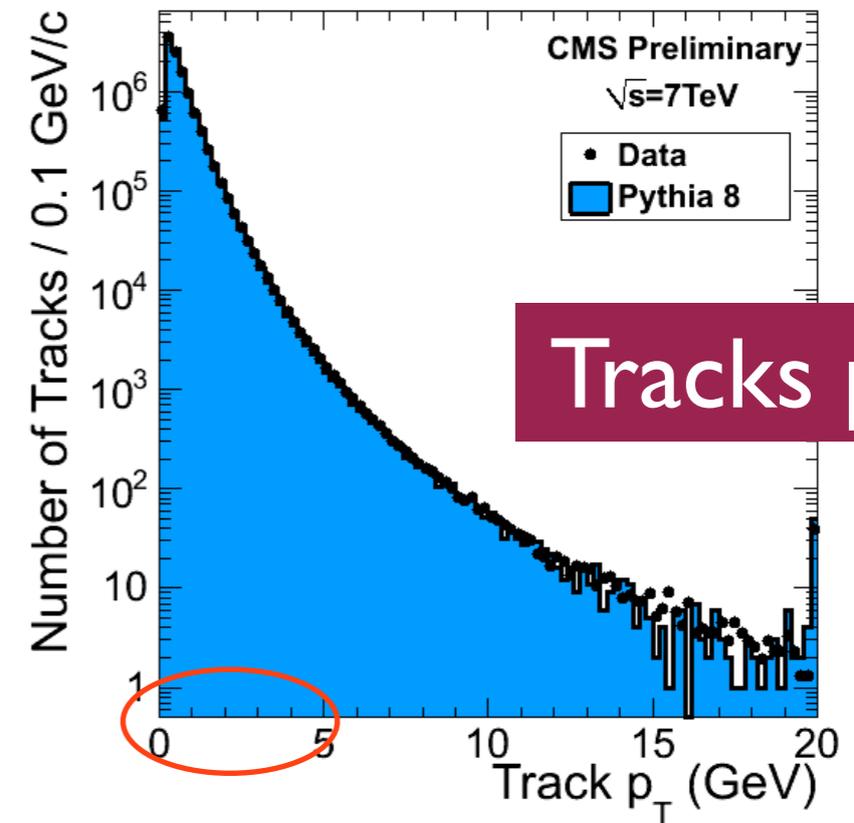
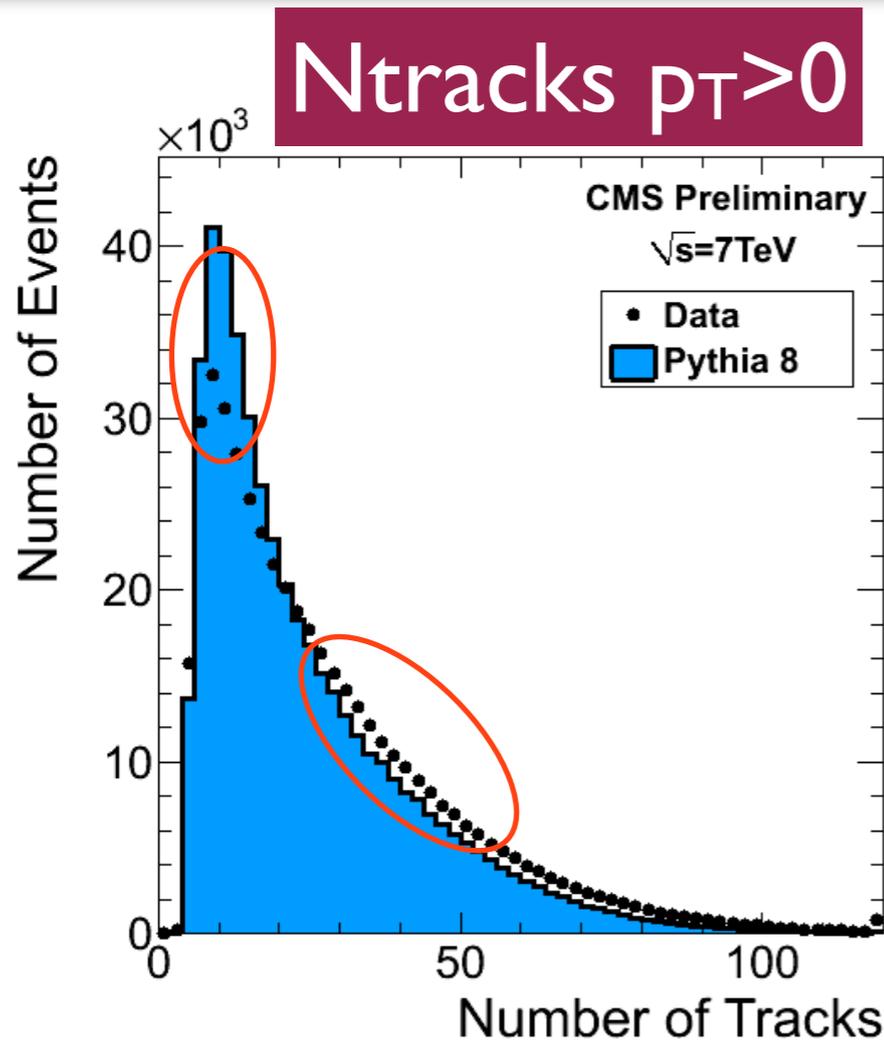
Silicon Strips



Tracker

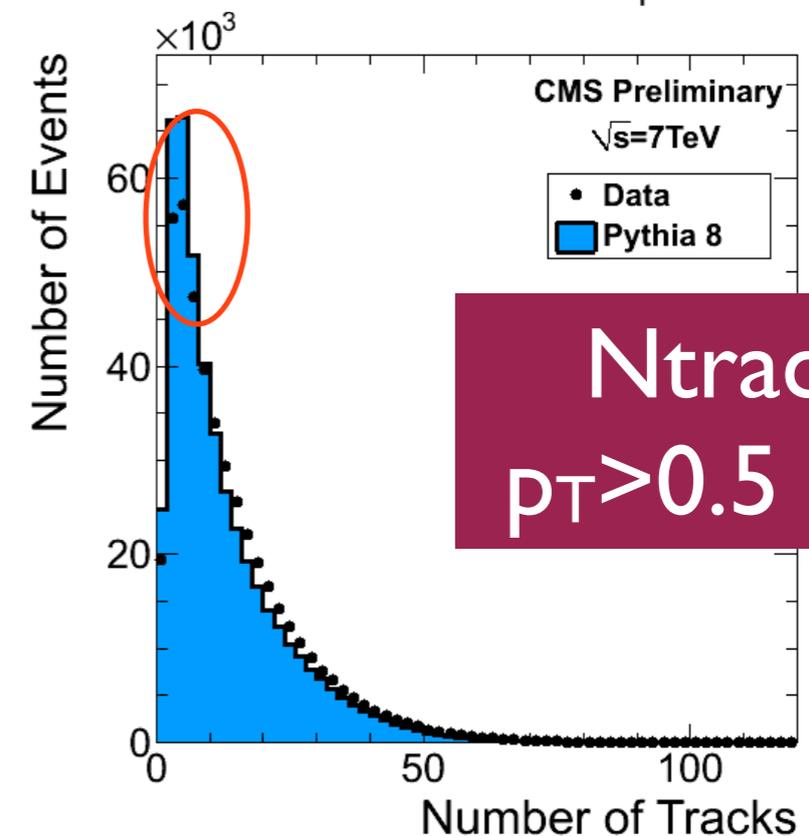


Reconstructed Tracks

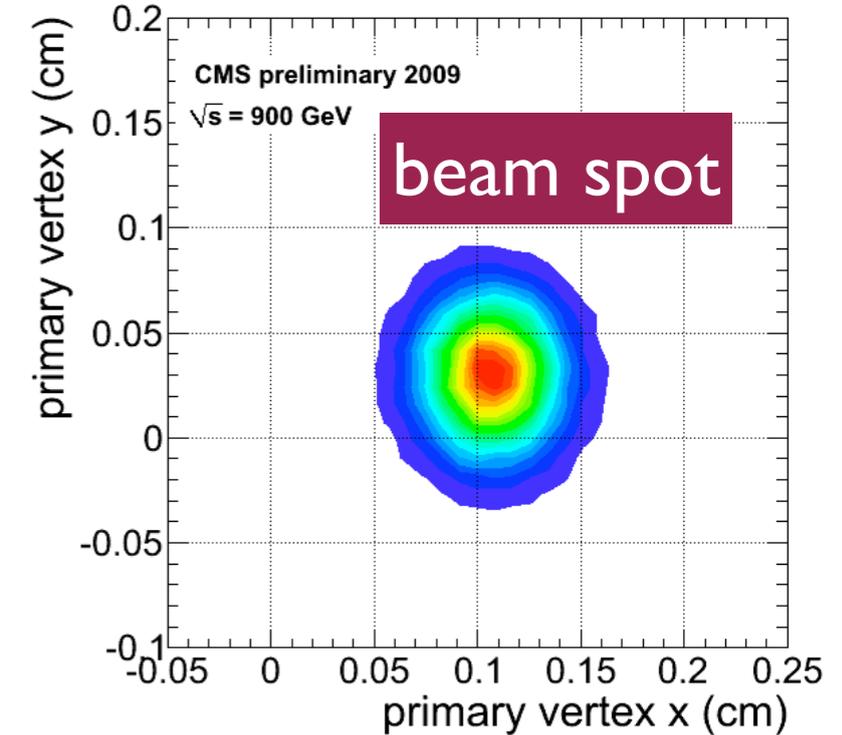
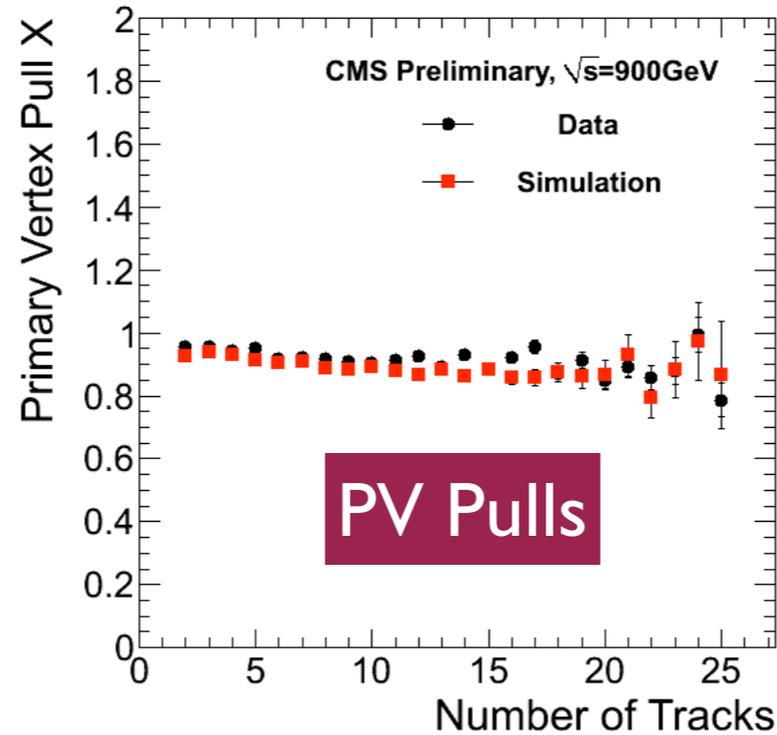
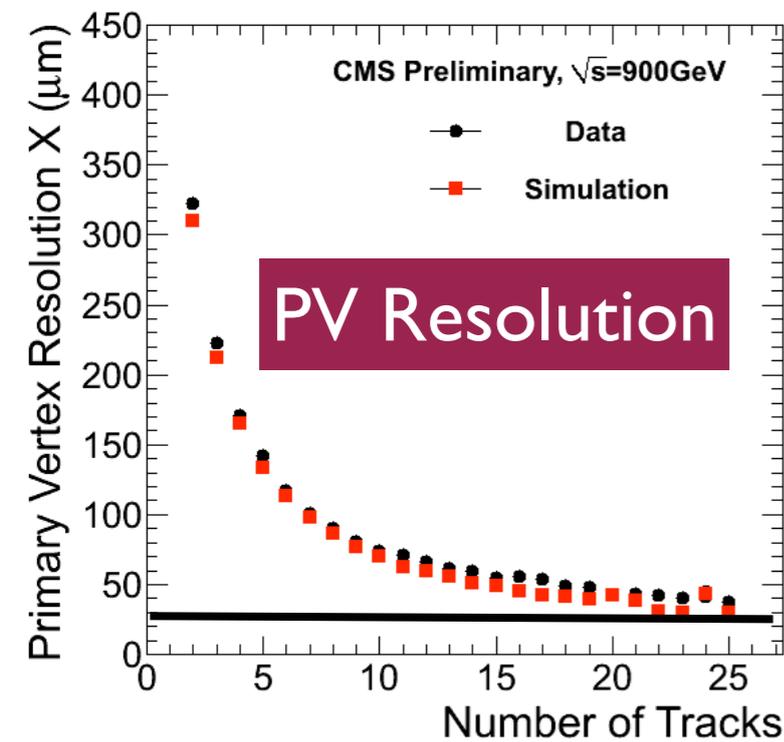


Differences between data/MC come from low p_T tracks

Track Multiplicity sensible to MC tuning.



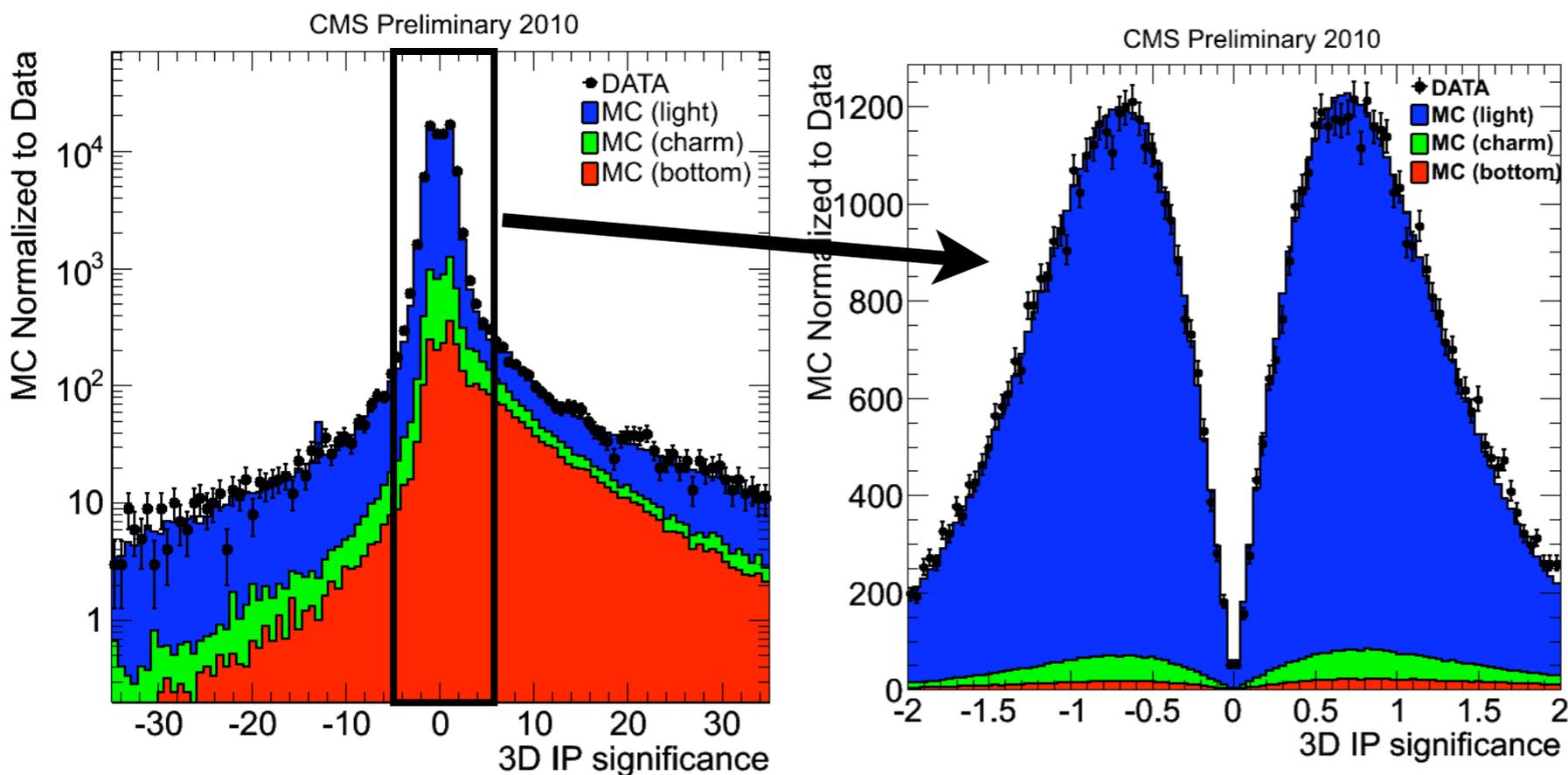
Primary Vertex Reconstruction



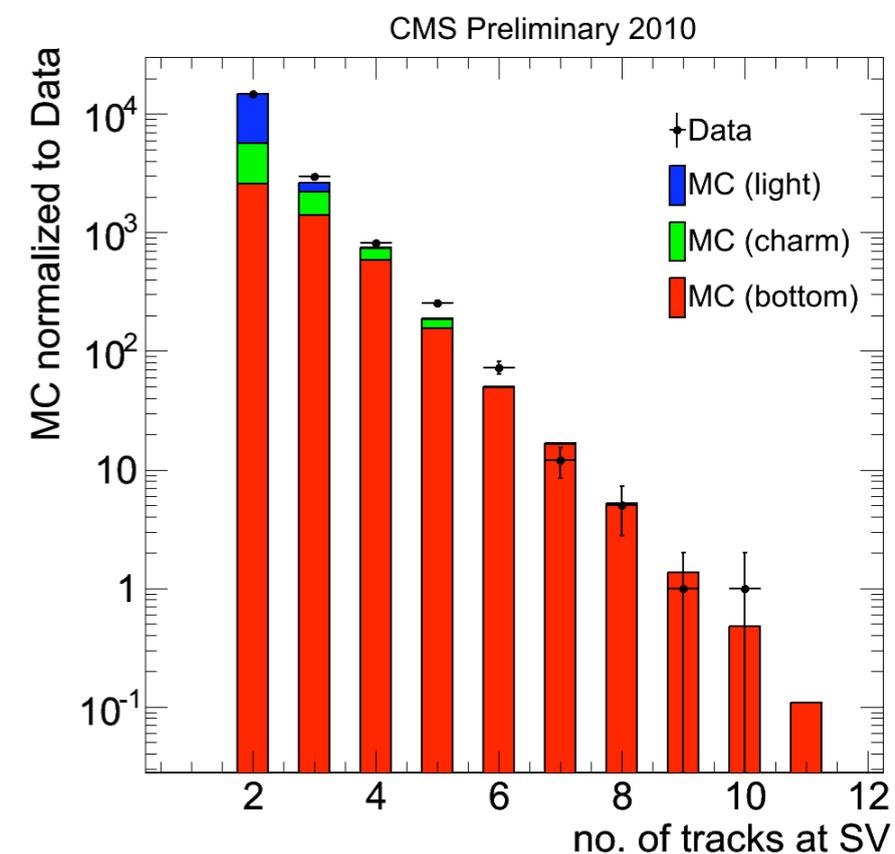
Well understood uncertainties in tracking/vertexing
Primary vertex resolution well modeled in simulation

Already can do b-tagging!

Impact parameter significance

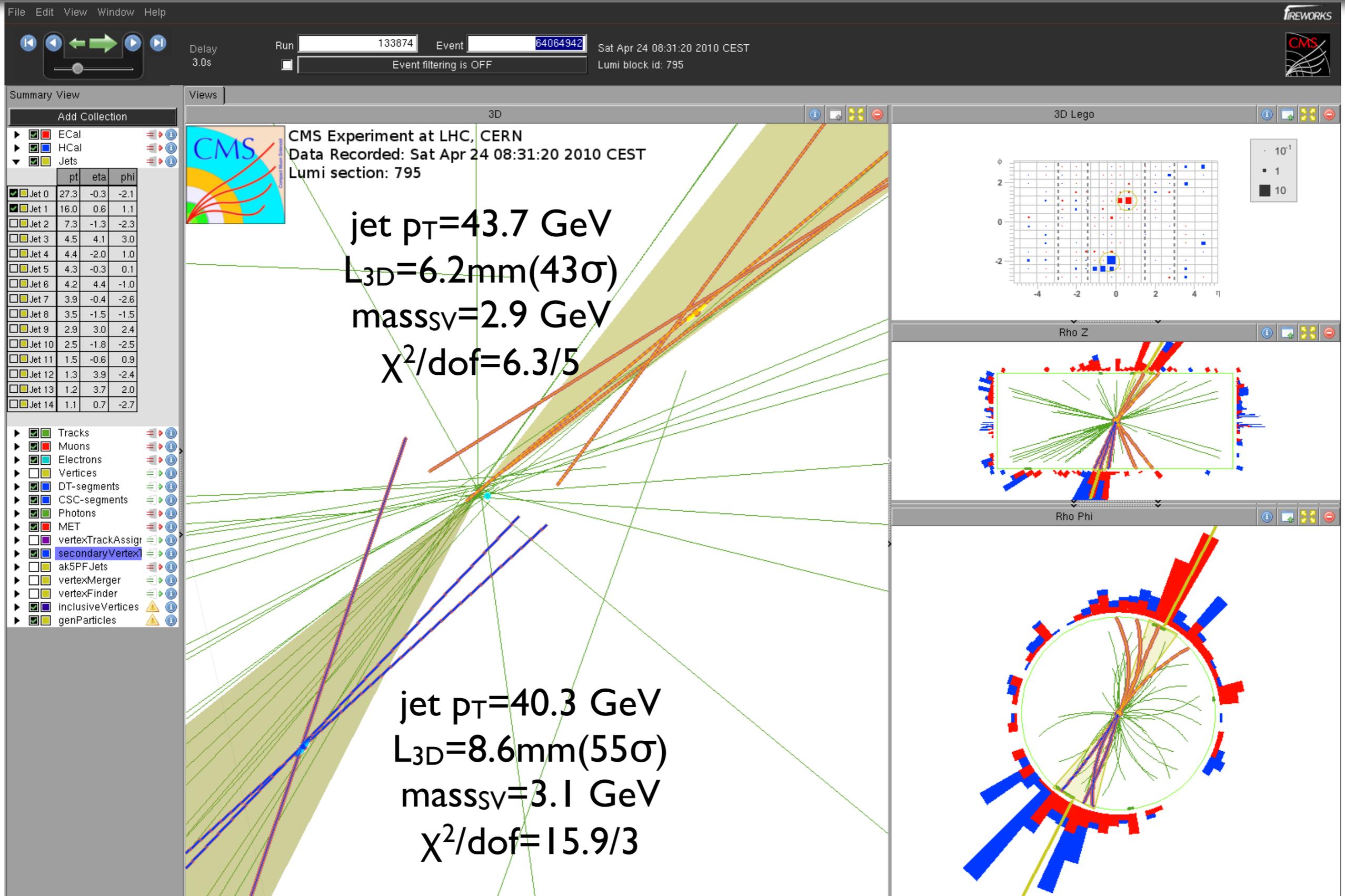


Track Multiplicity at secondary vertex

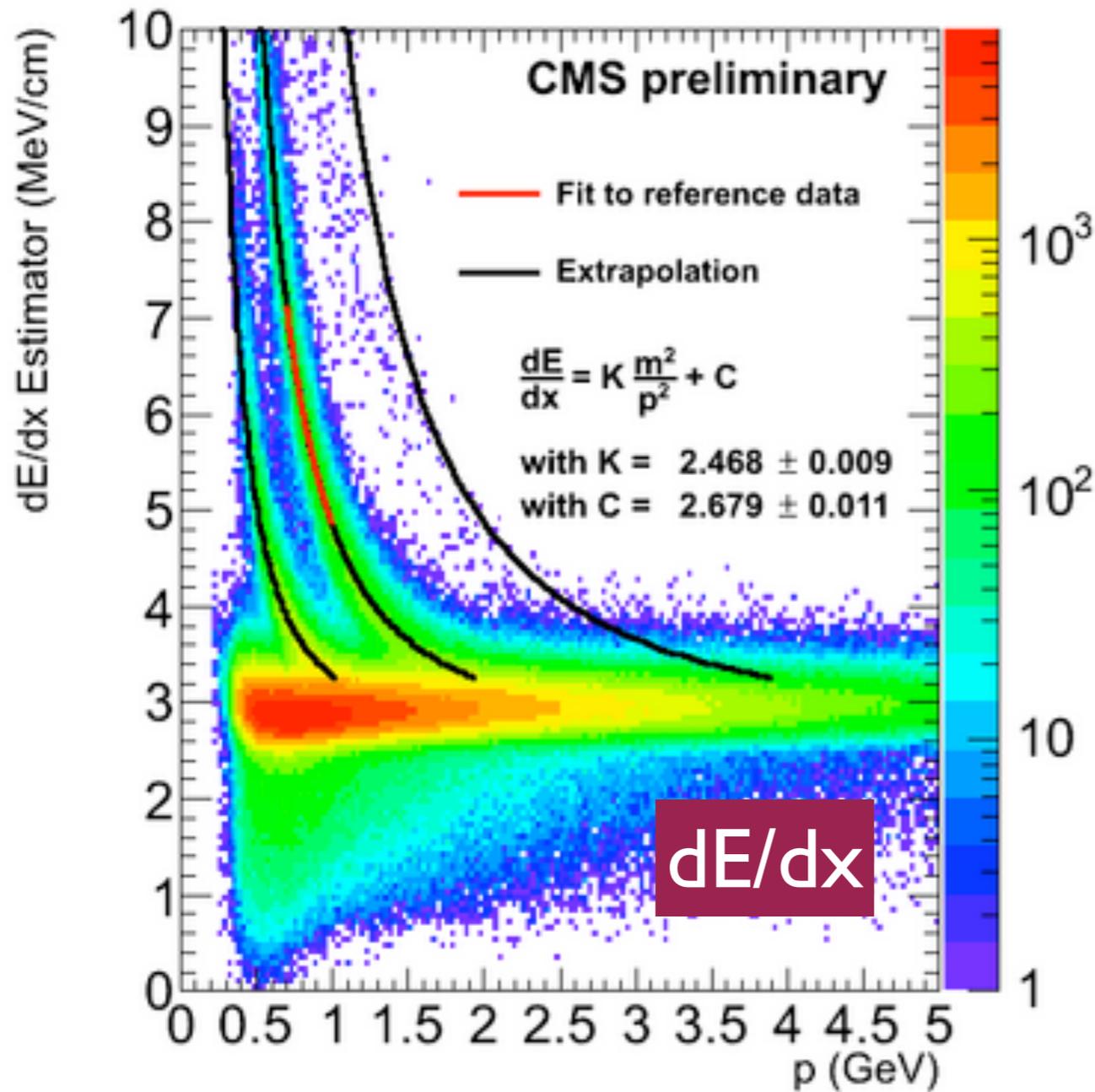


Very good agreement observed for b-tagging discriminators

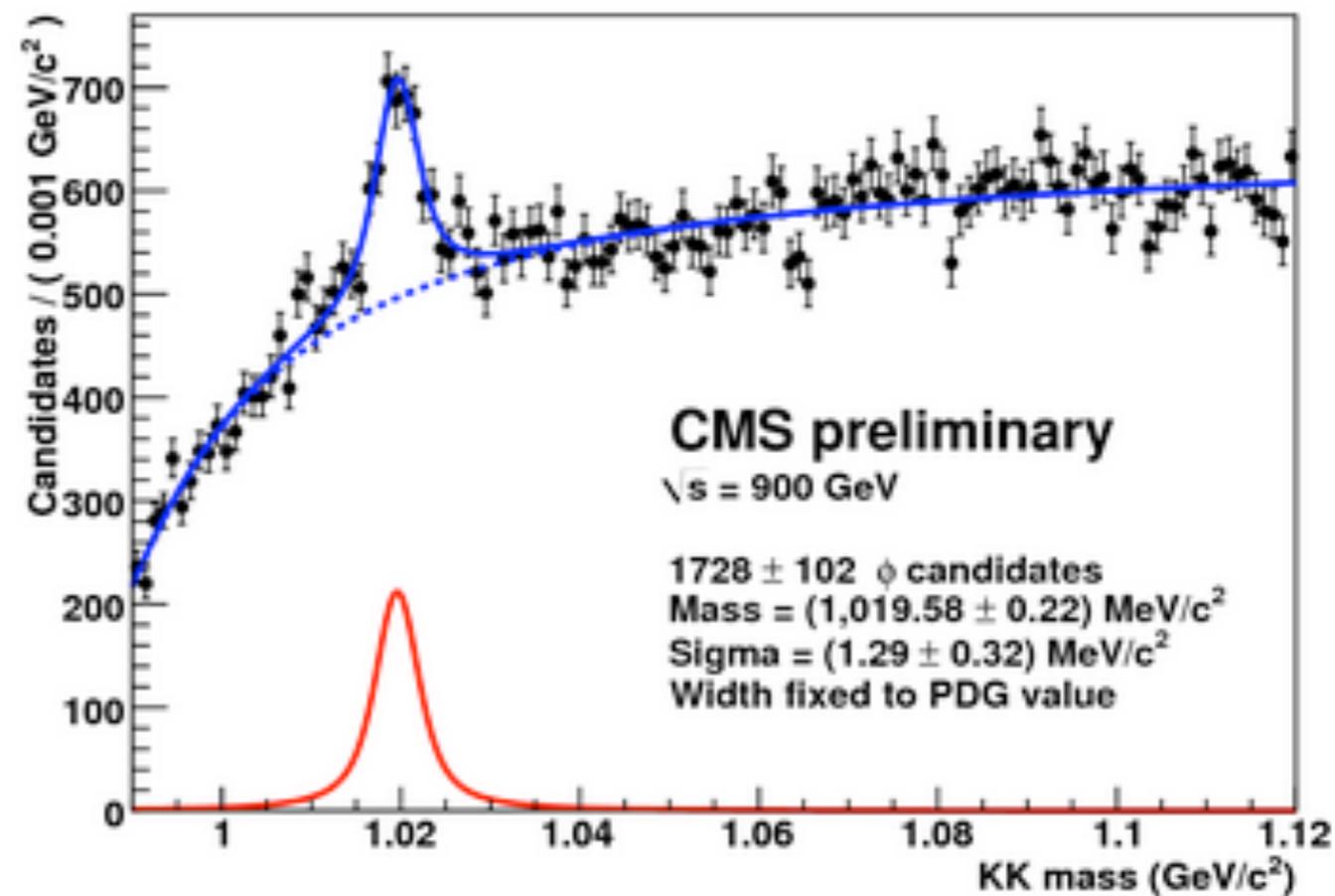
Event Display of a double b-jet candidate



Tracker dE/dx

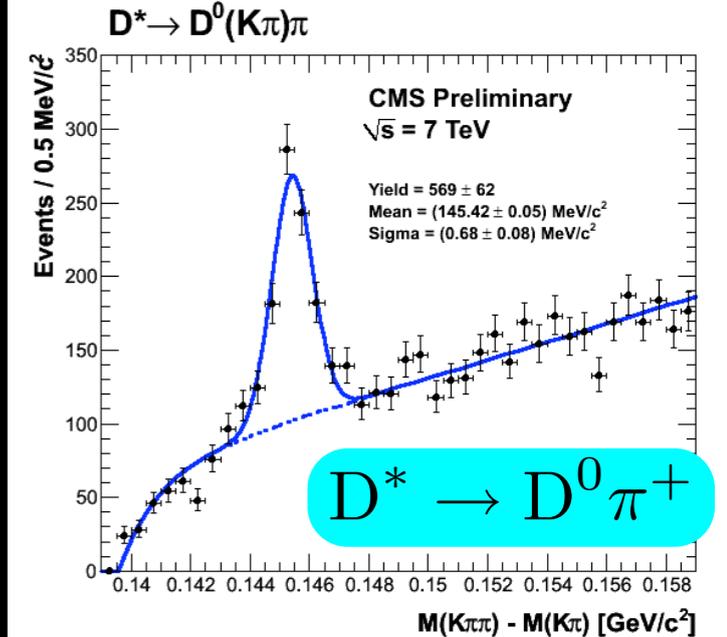
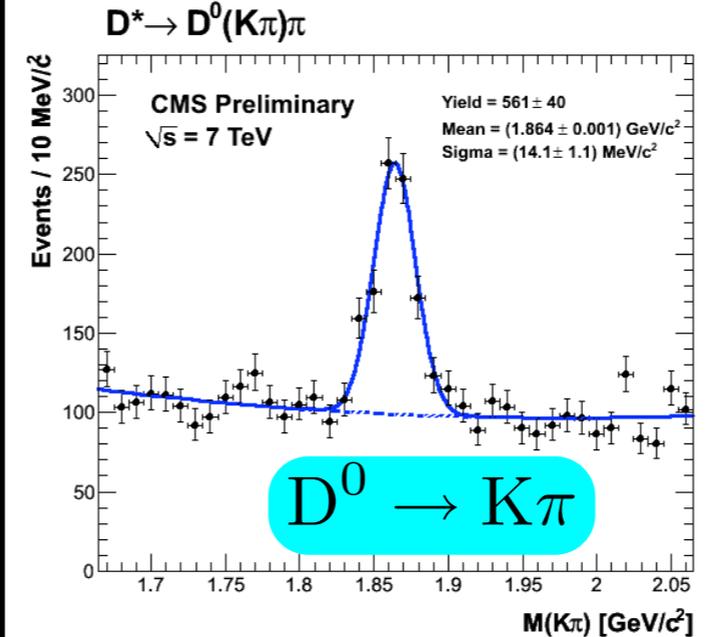
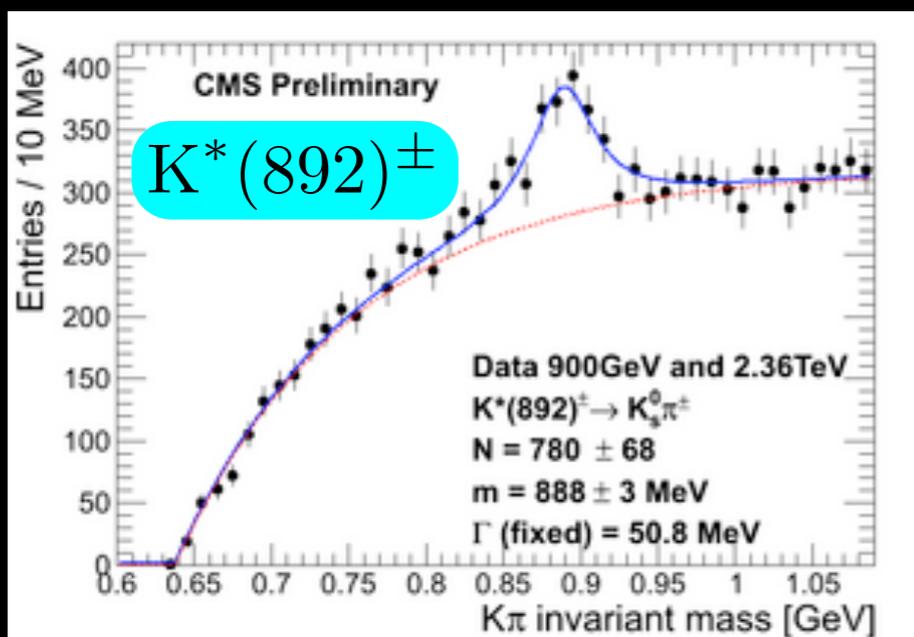
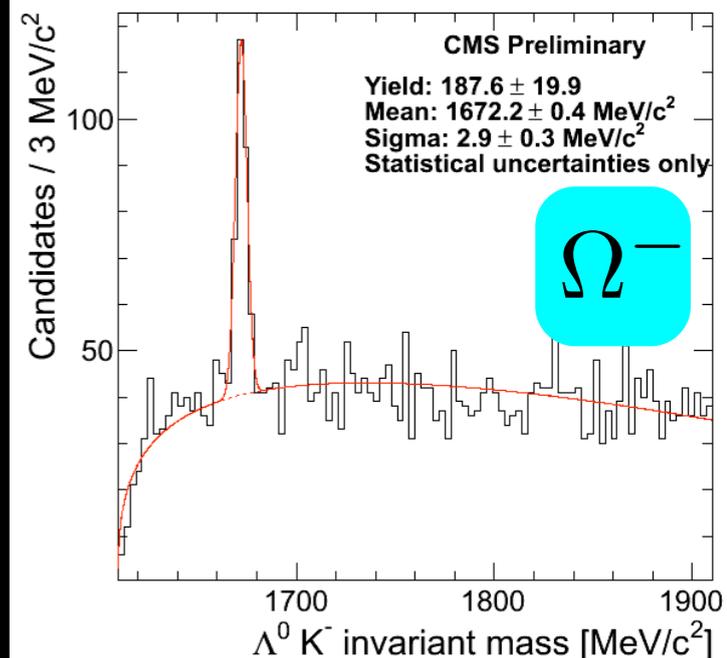
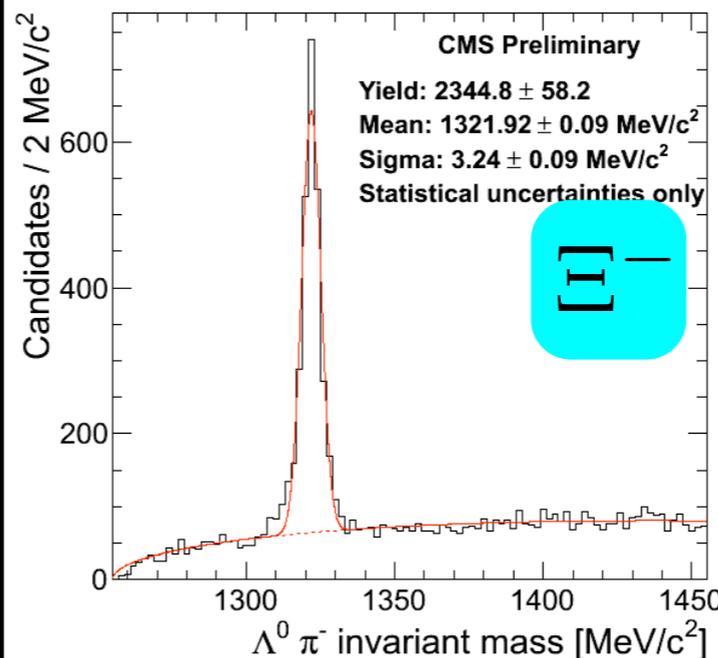
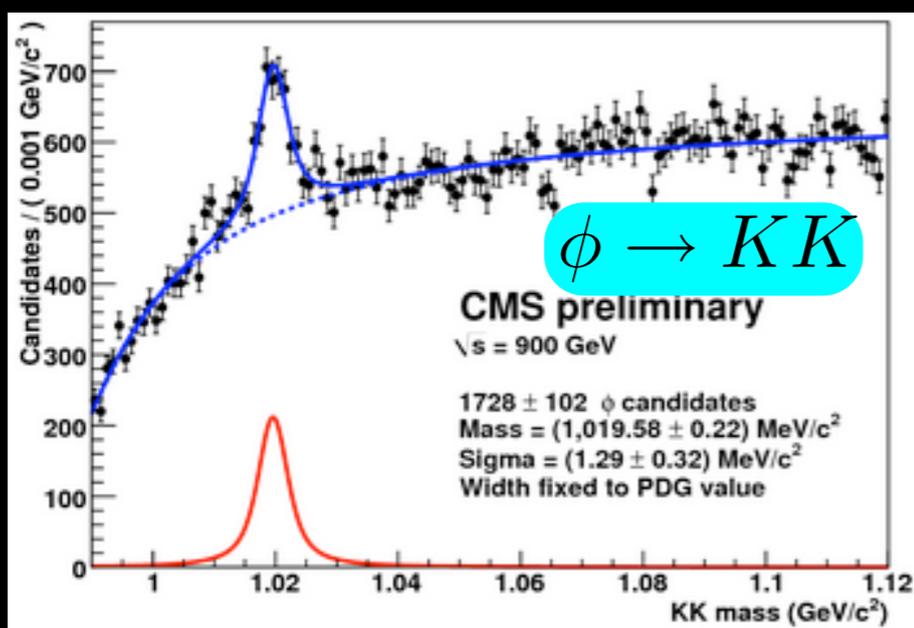
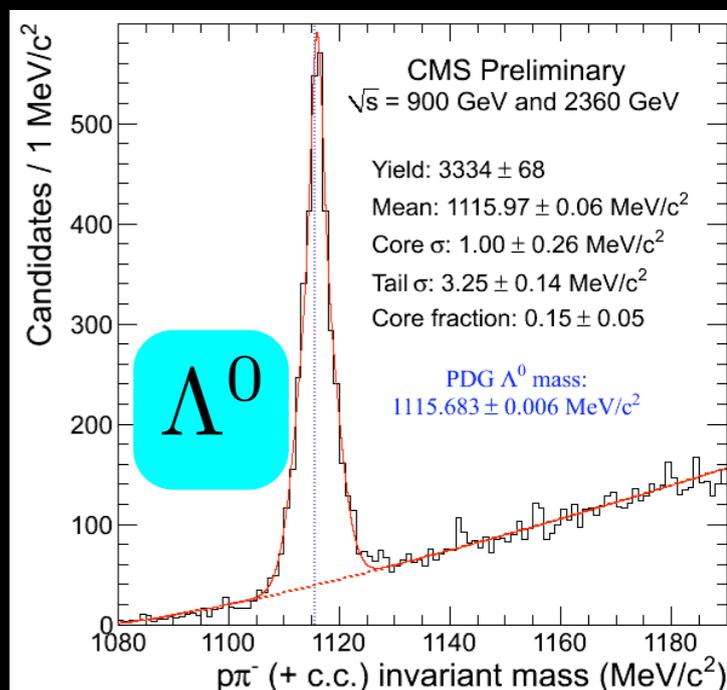
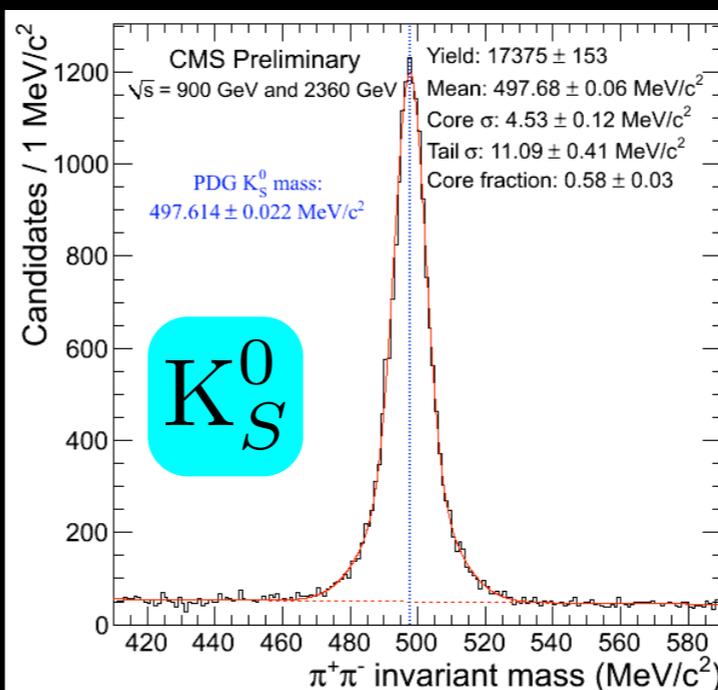


$$\phi \rightarrow KK$$

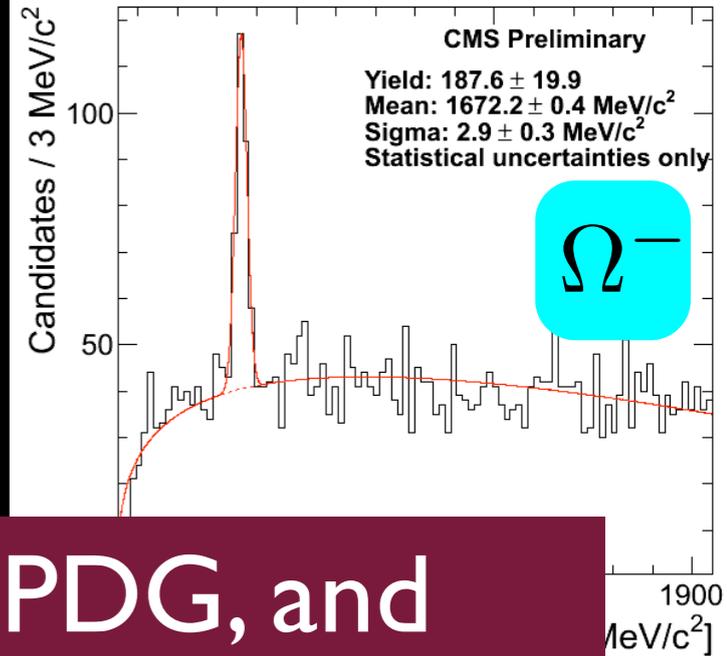
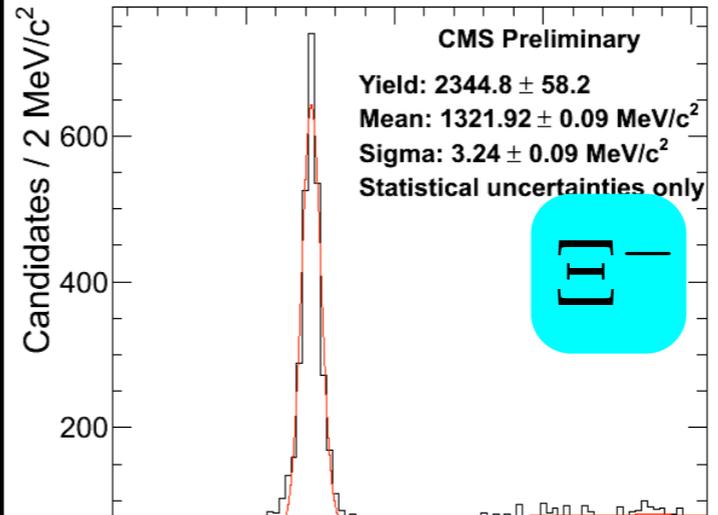
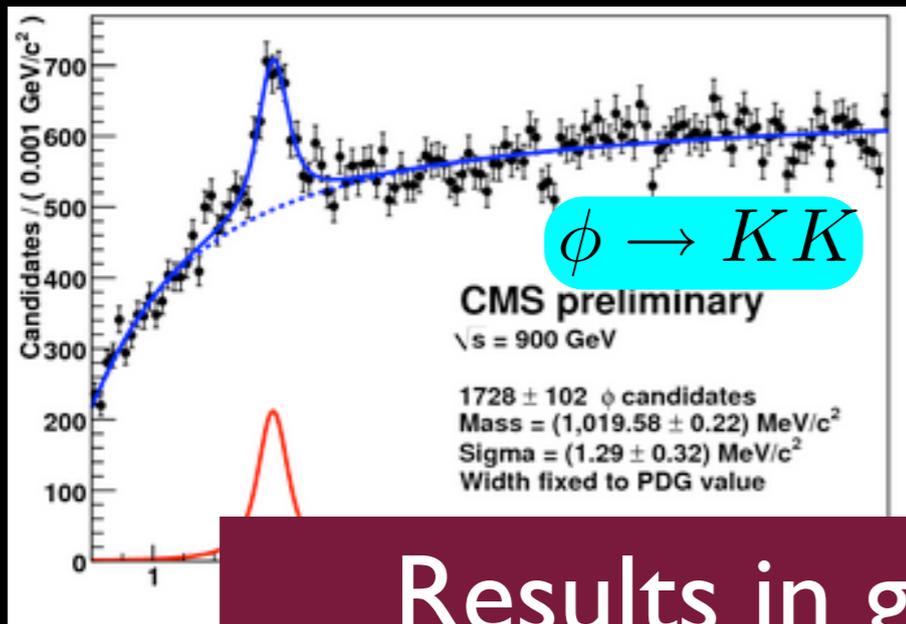
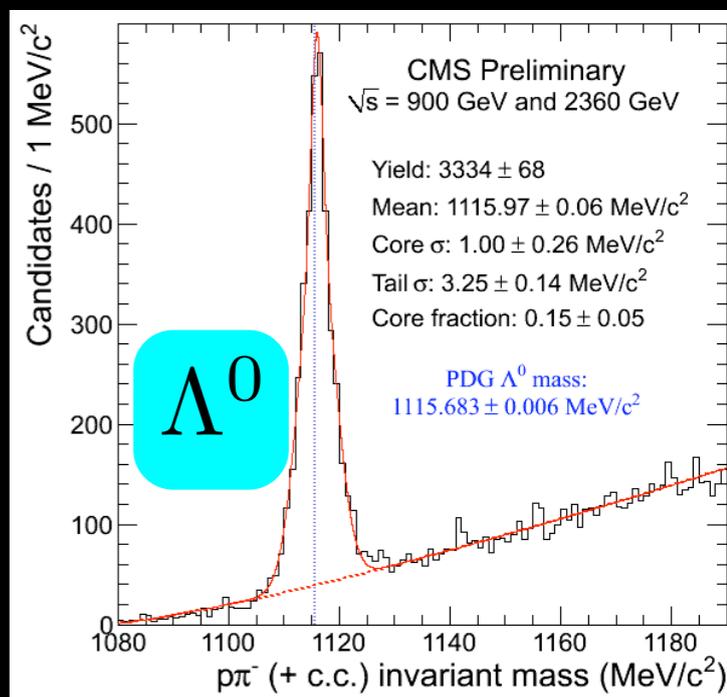
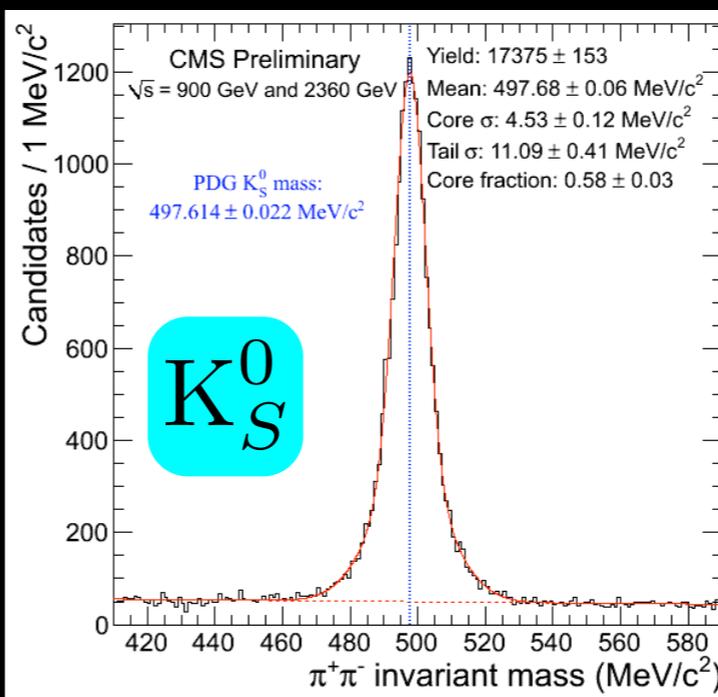


Particle Identification with dE/dx

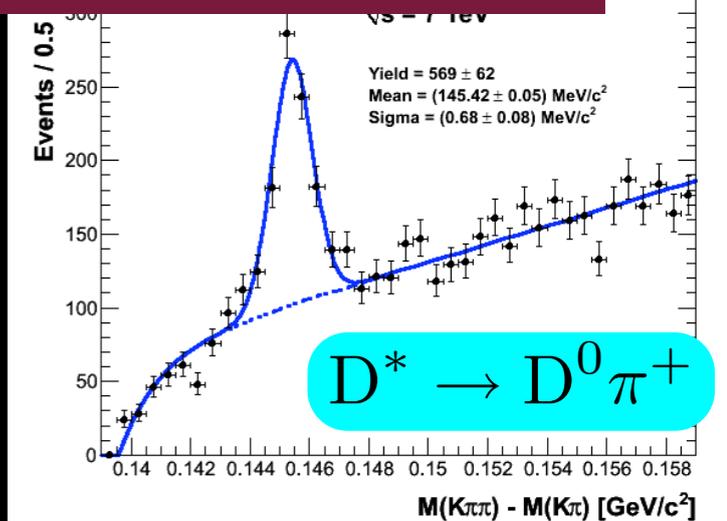
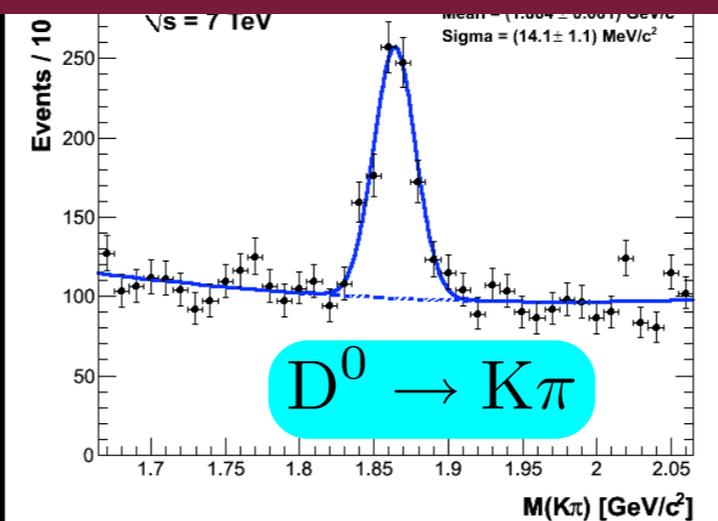
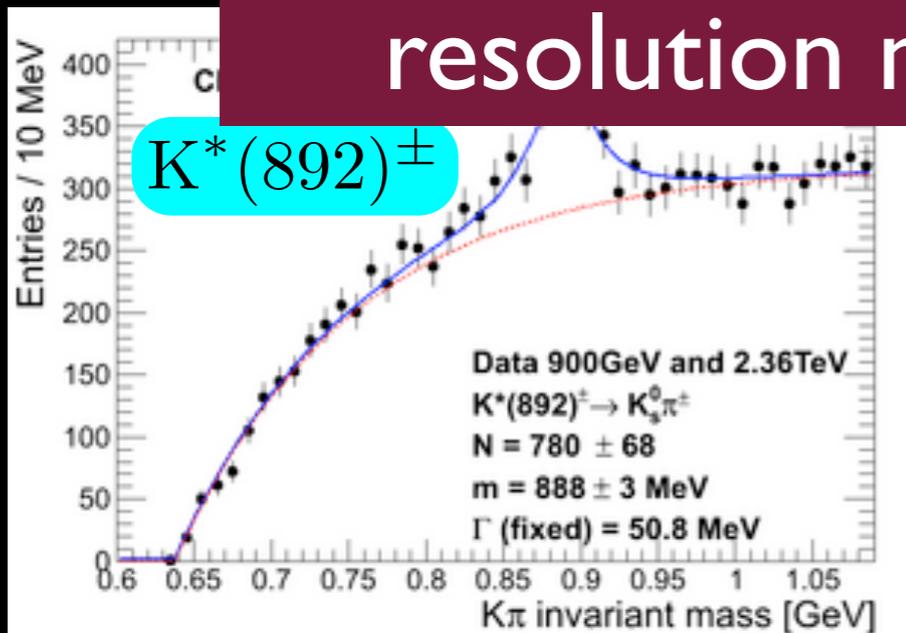
Rediscovering The Standard Model



Rediscovering The Standard Model



Results in good agreement with PDG, and resolution matches well between data/MC

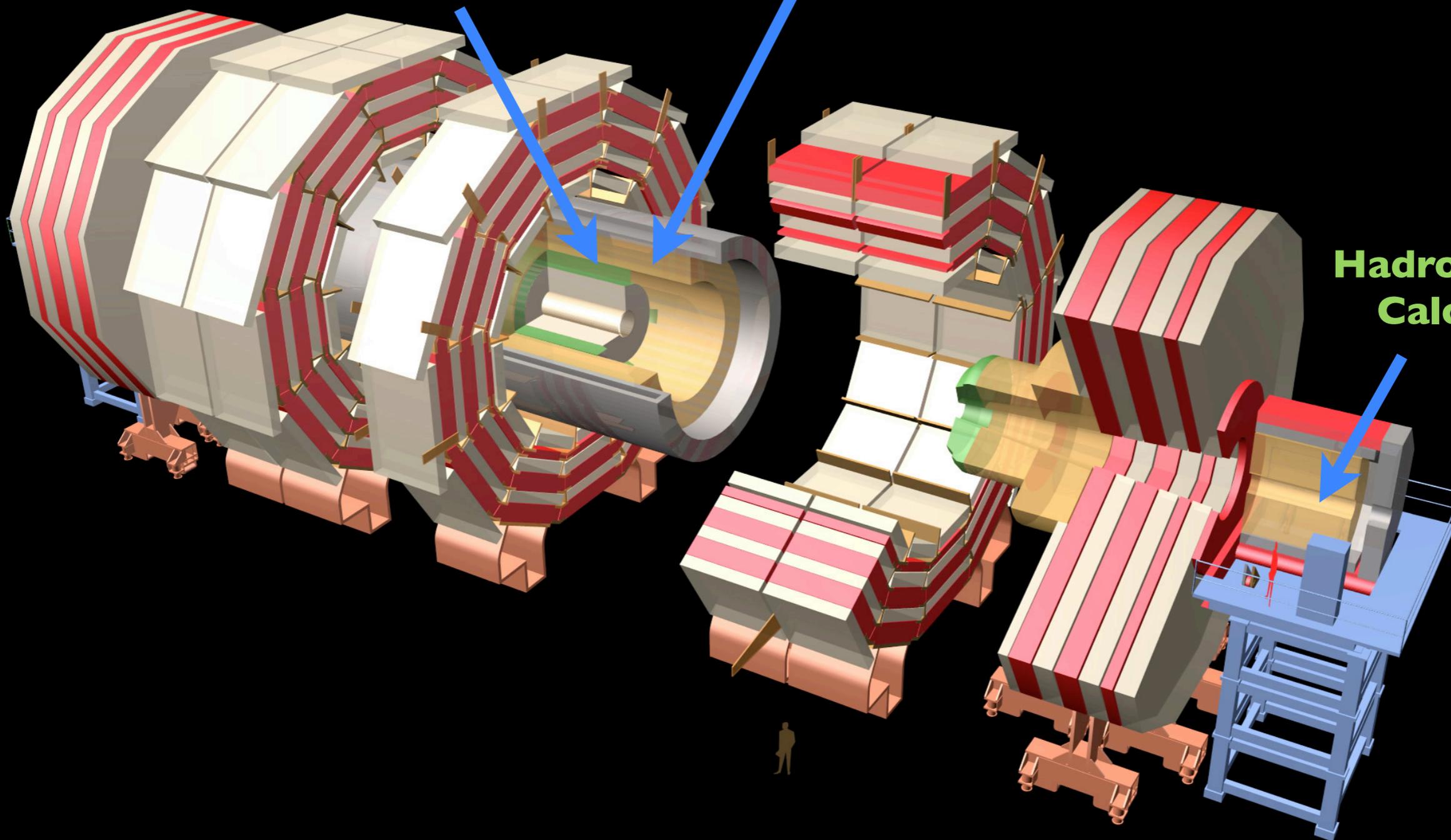


The CMS Detector

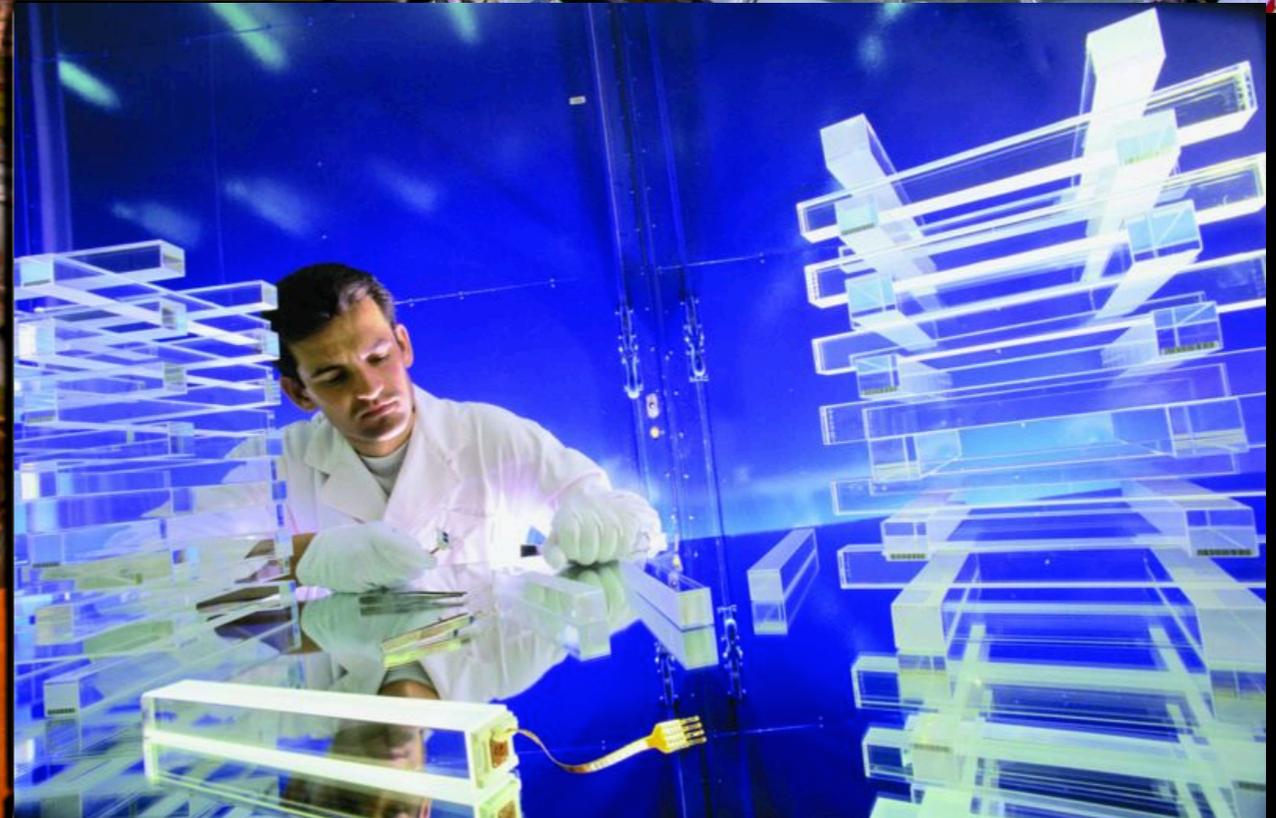
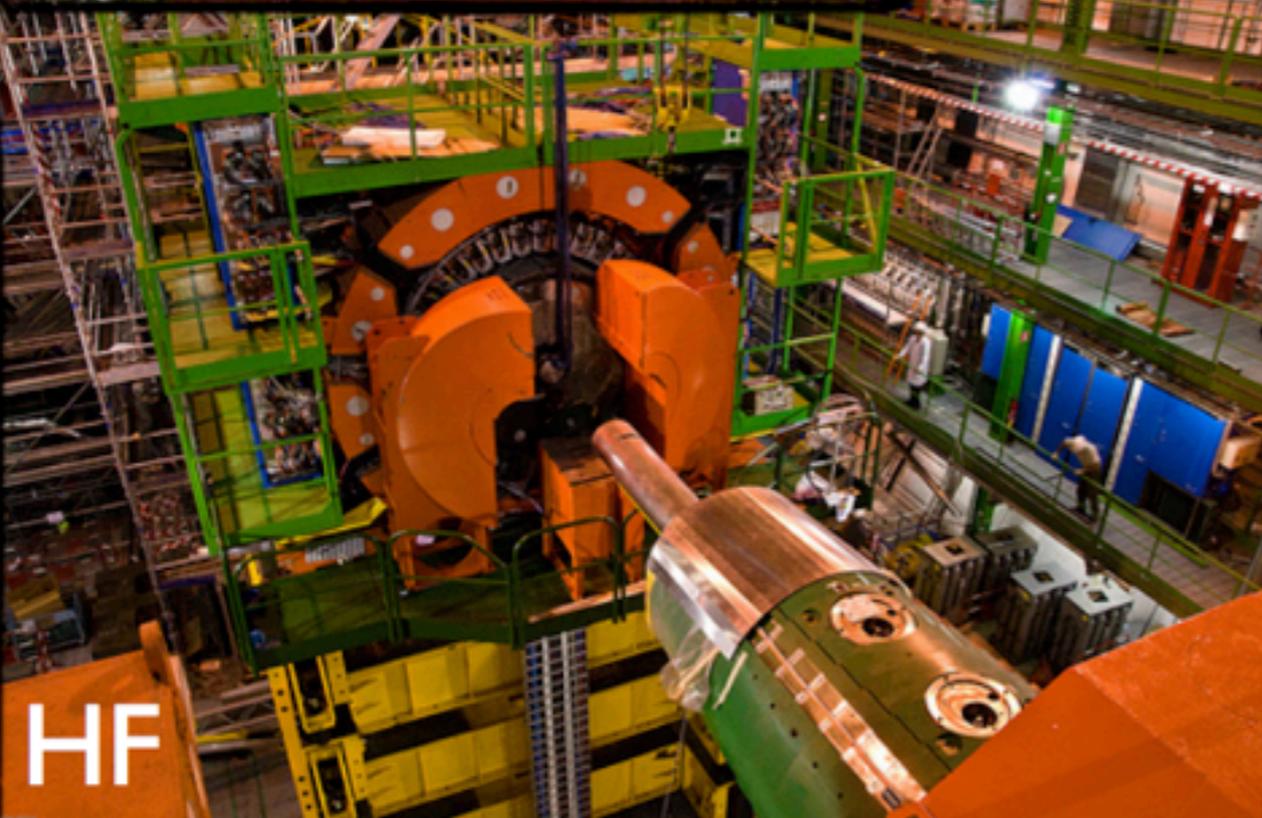
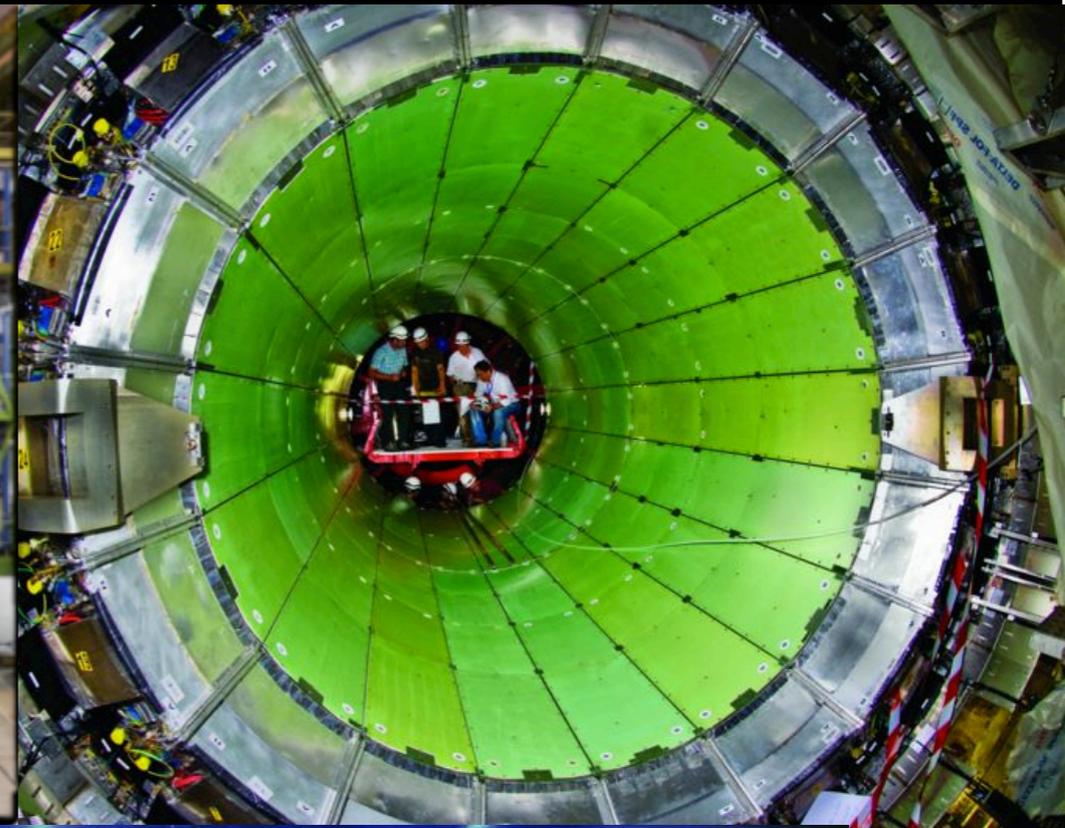
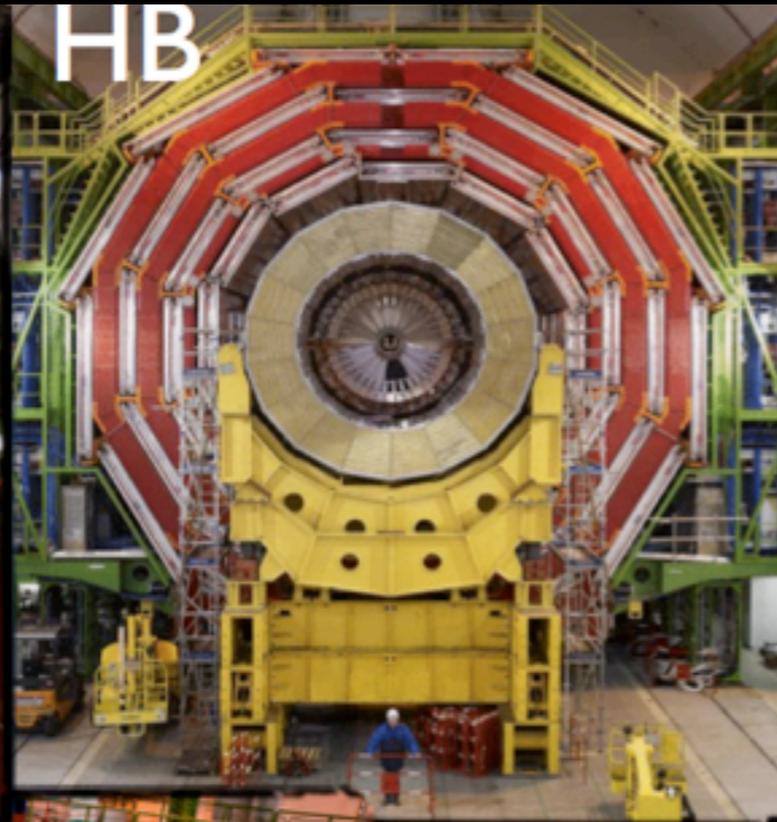
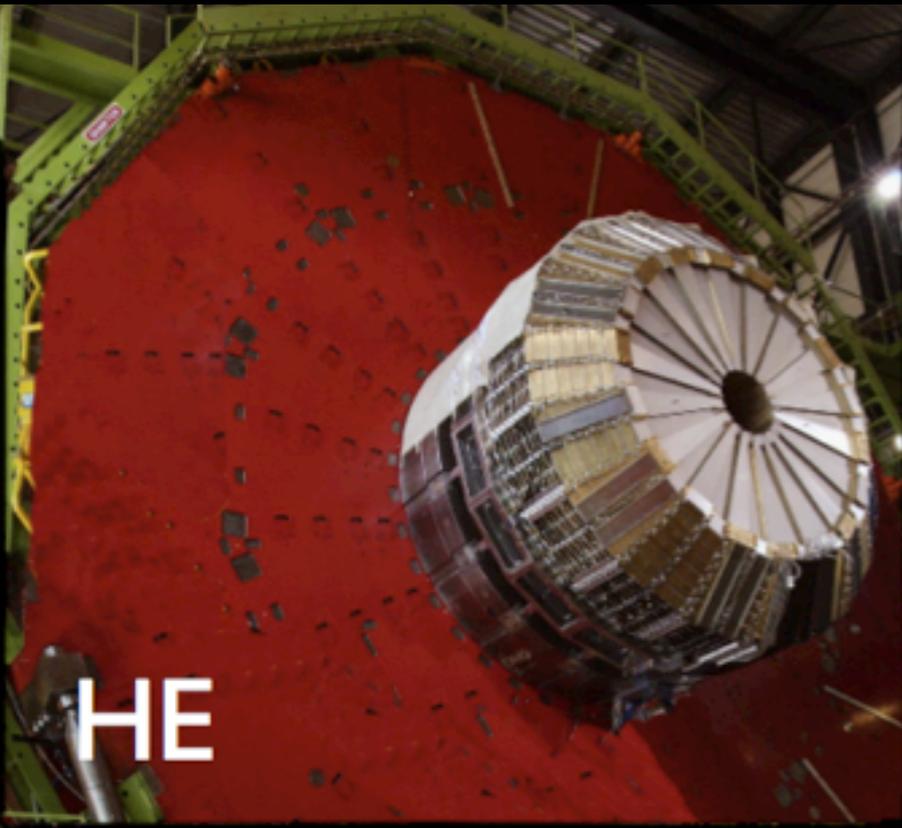
**Electromagnetic
Calorimeter**

**Hadron
Calorimeter**

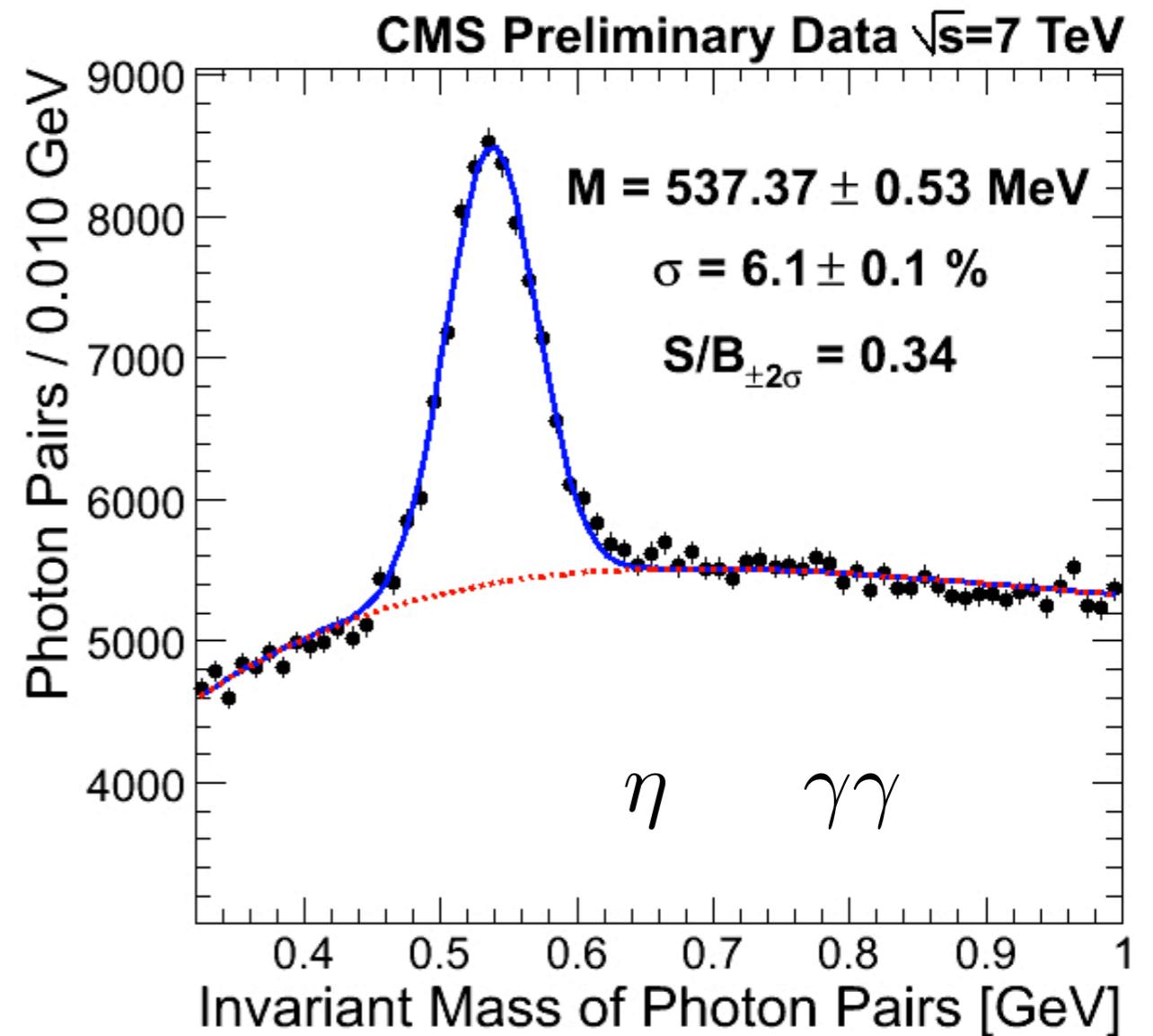
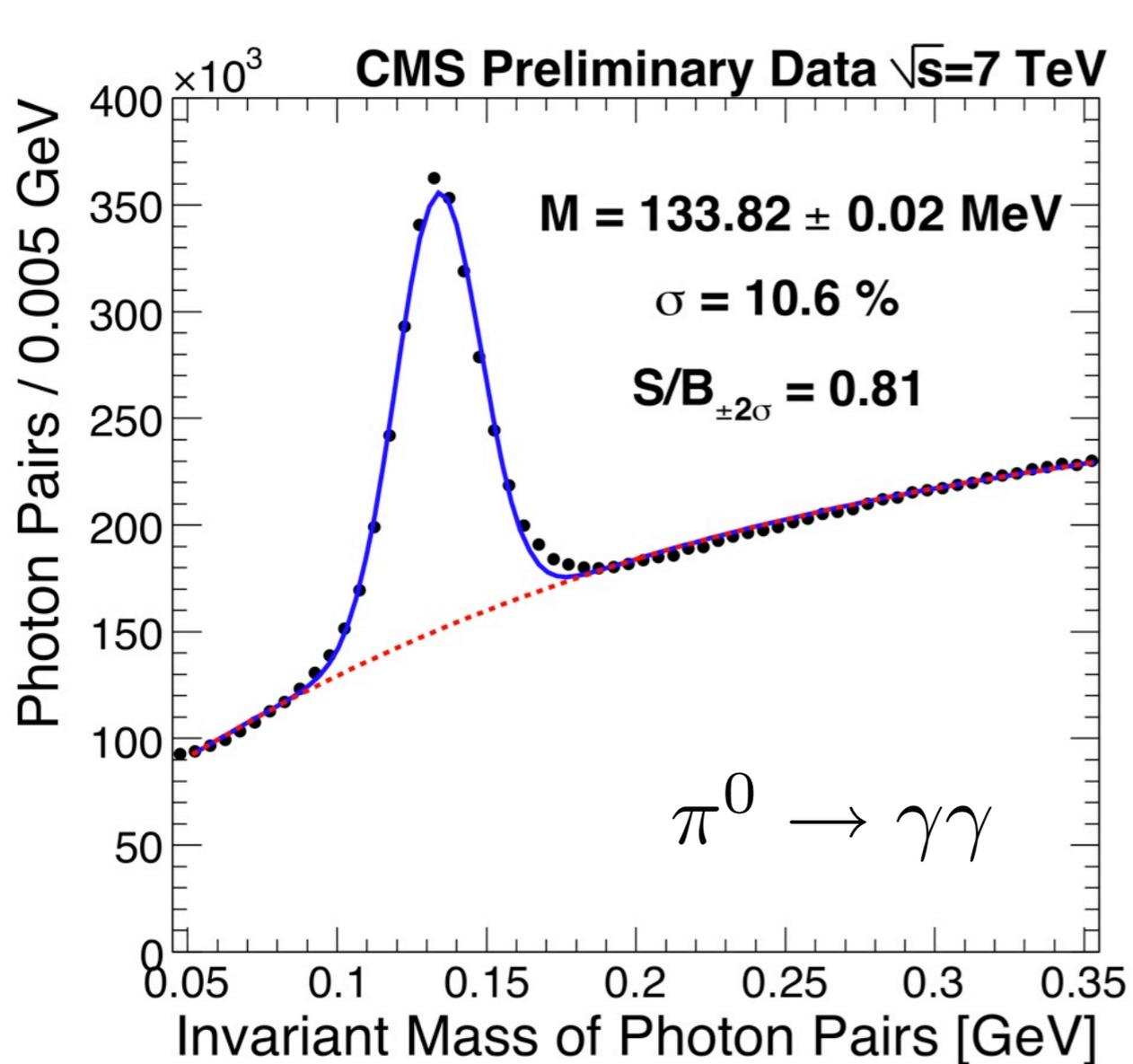
**Hadron Forward
Calorimeter**



Hadron and Electromagnetic Calorimeters

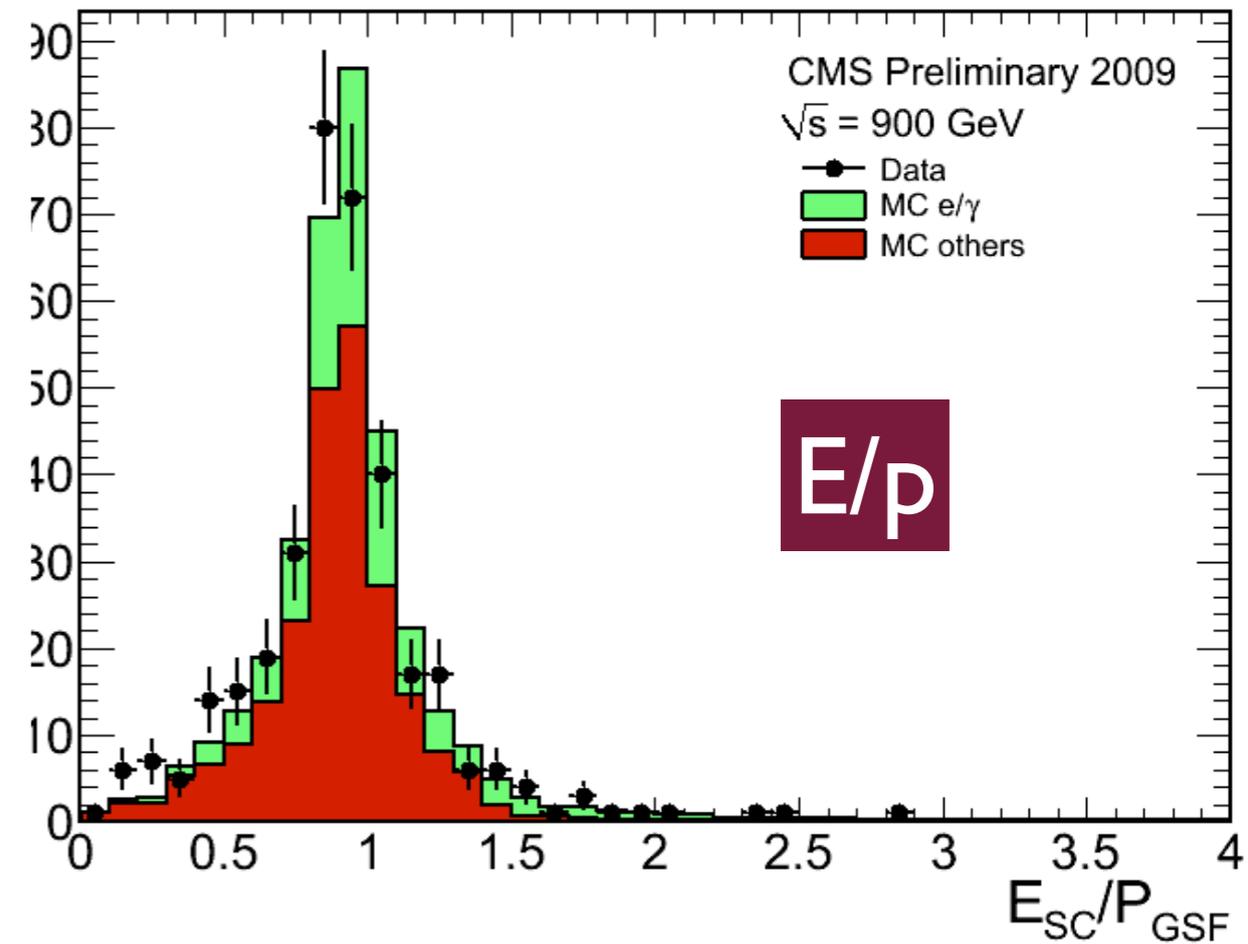
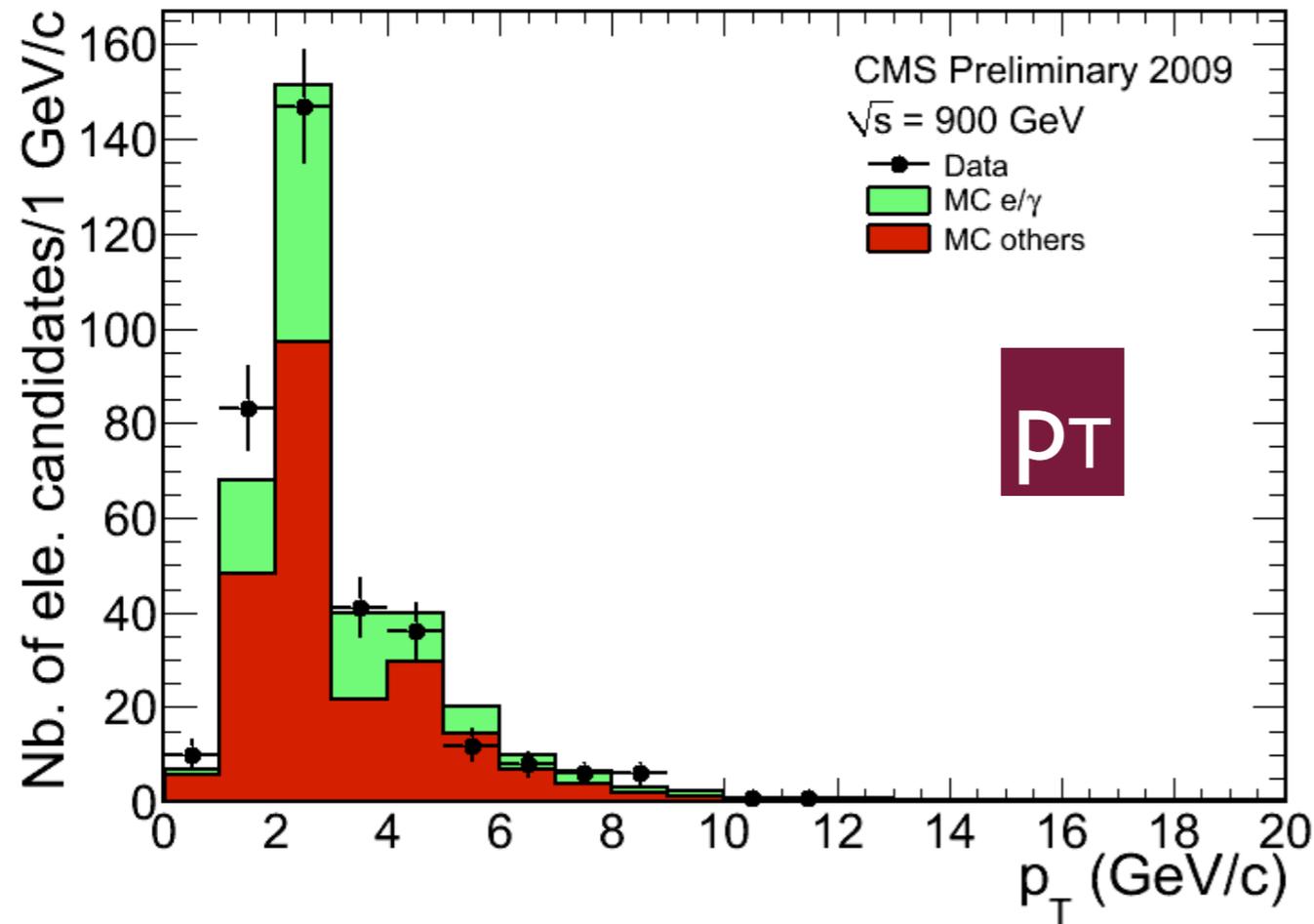


Electromagnetic Calorimeter Calibration



Agreement on energy scale at ~ 1 % level (width well model)
pi0 sample to improve further calibration and monitoring

Electron Candidate Reconstruction



No electron Identification applied.
Low p_T region dominated by Tracker reconstruction
high p_T by Electromagnetic Calorimeter

Jets! Jets! Jets!

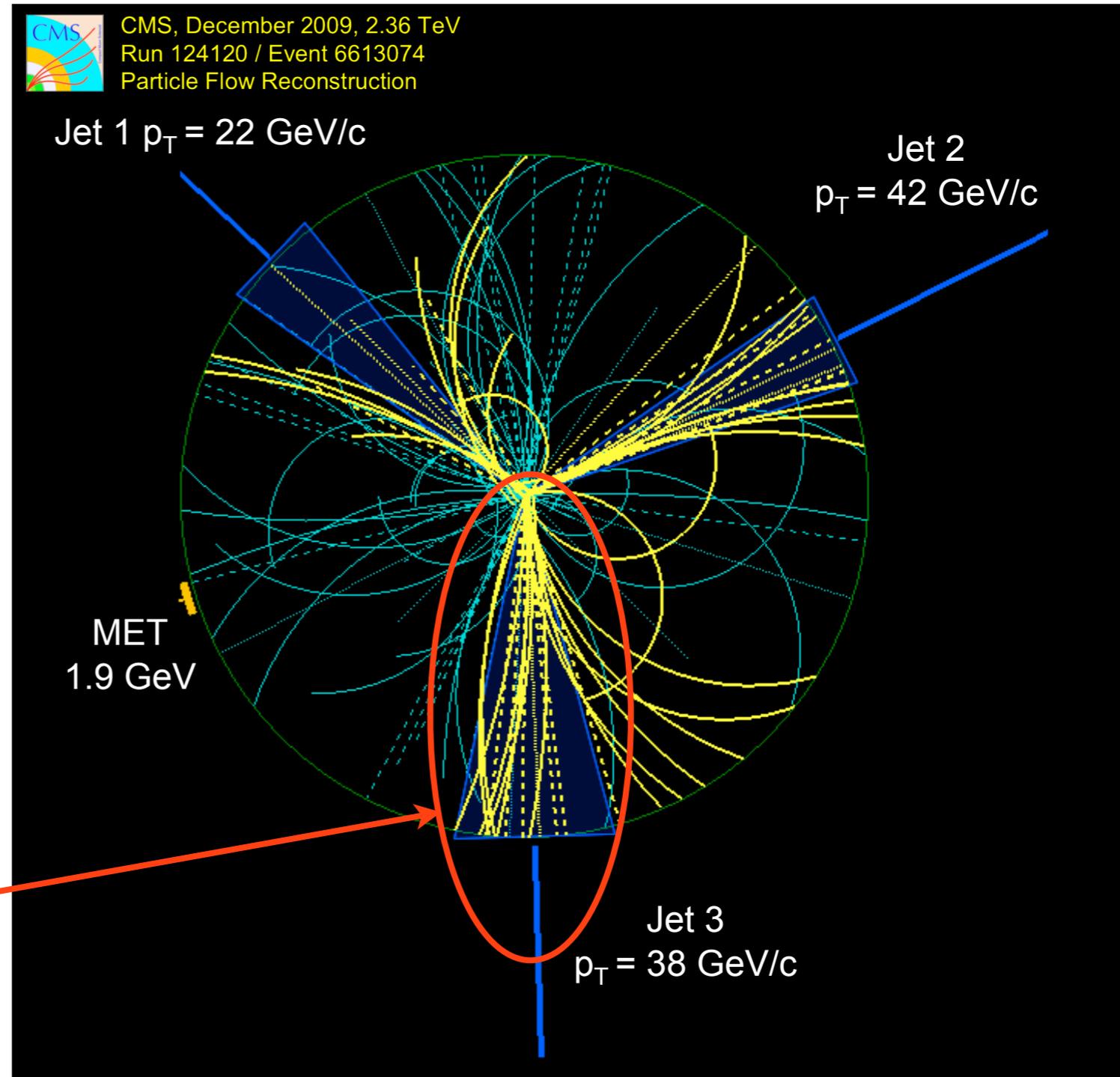
Default Jet Algorithm:
anti-kT, R=0.5

Three different Jet
Reconstruction methods:

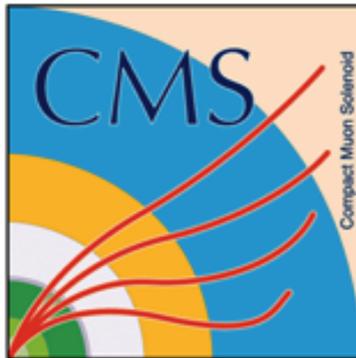
Calorimeter Jets:
Based in calorimeter tower.

Jet-plus-tracks Jets
a posteriori corrections to
calorimeter using tracks

Particle flow Jets
a priori use of tracks and
calorimeter
Identify charged hadrons,
photons, electrons, neutral
hadrons

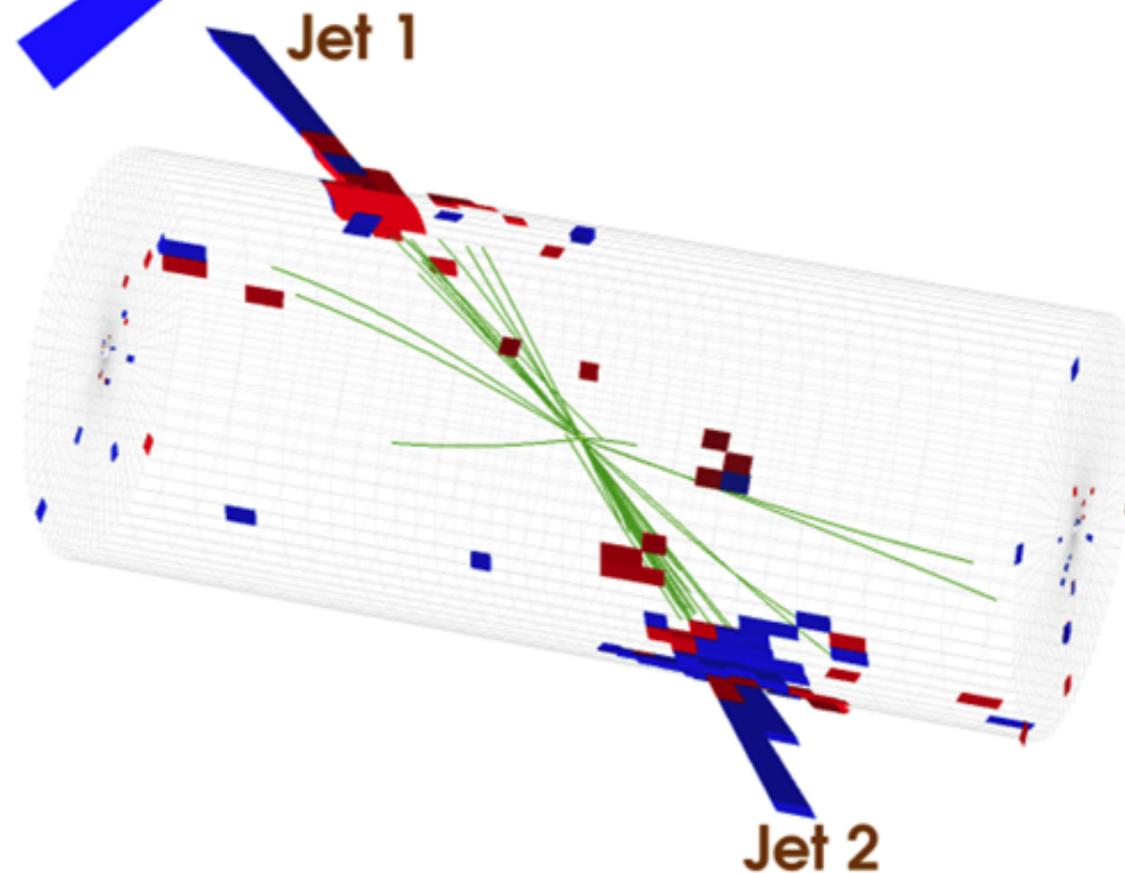
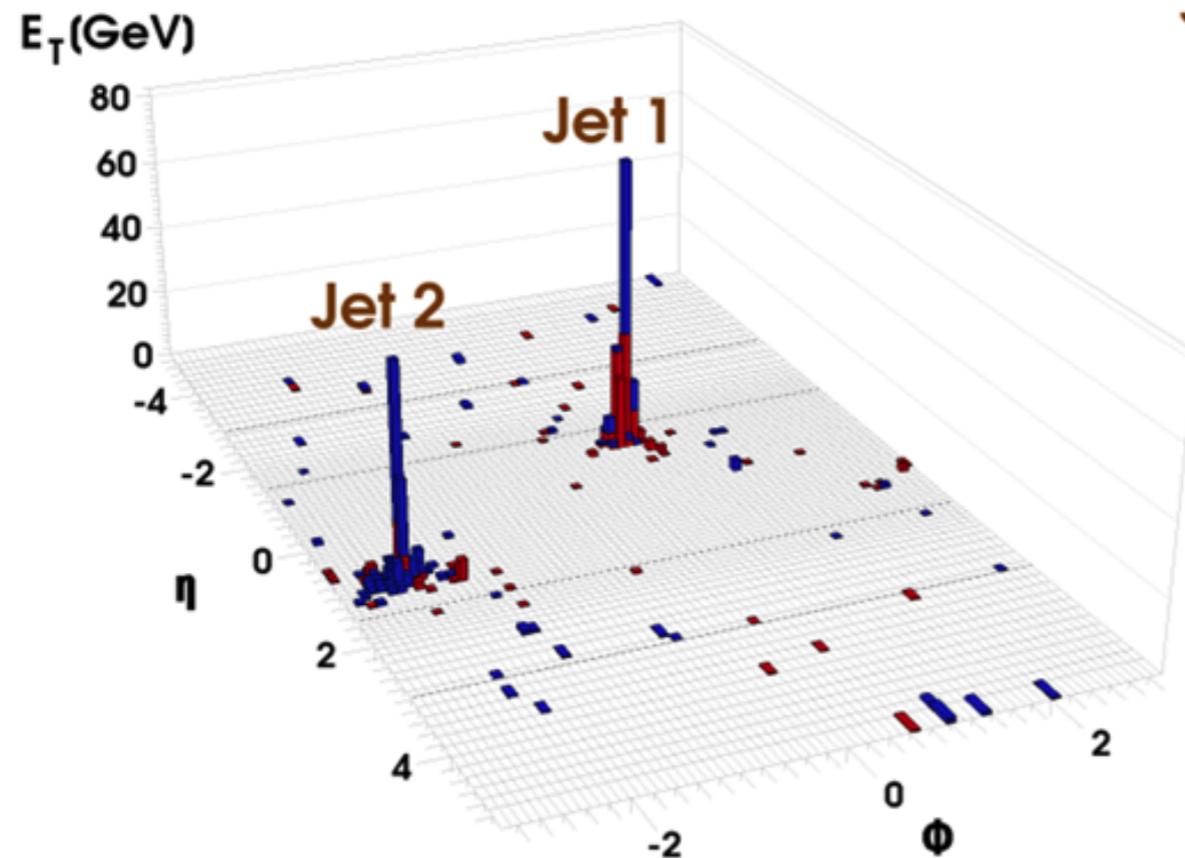
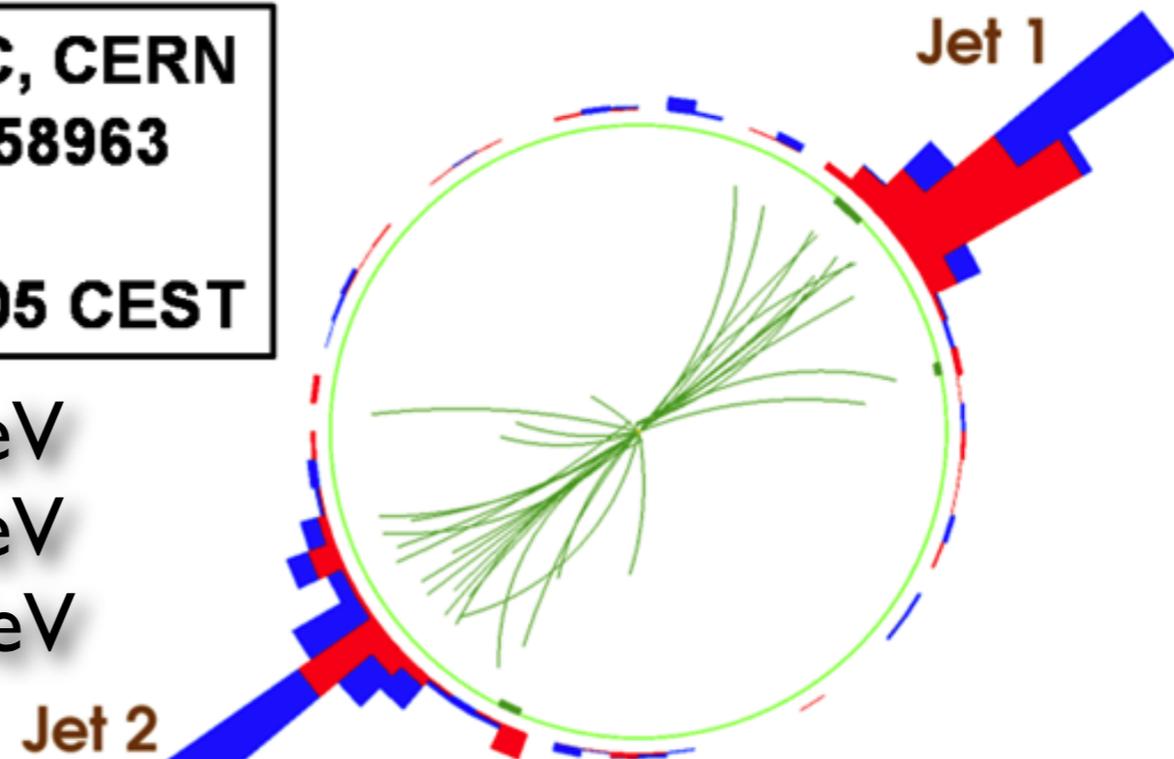


High-mass dijet at 7 TeV



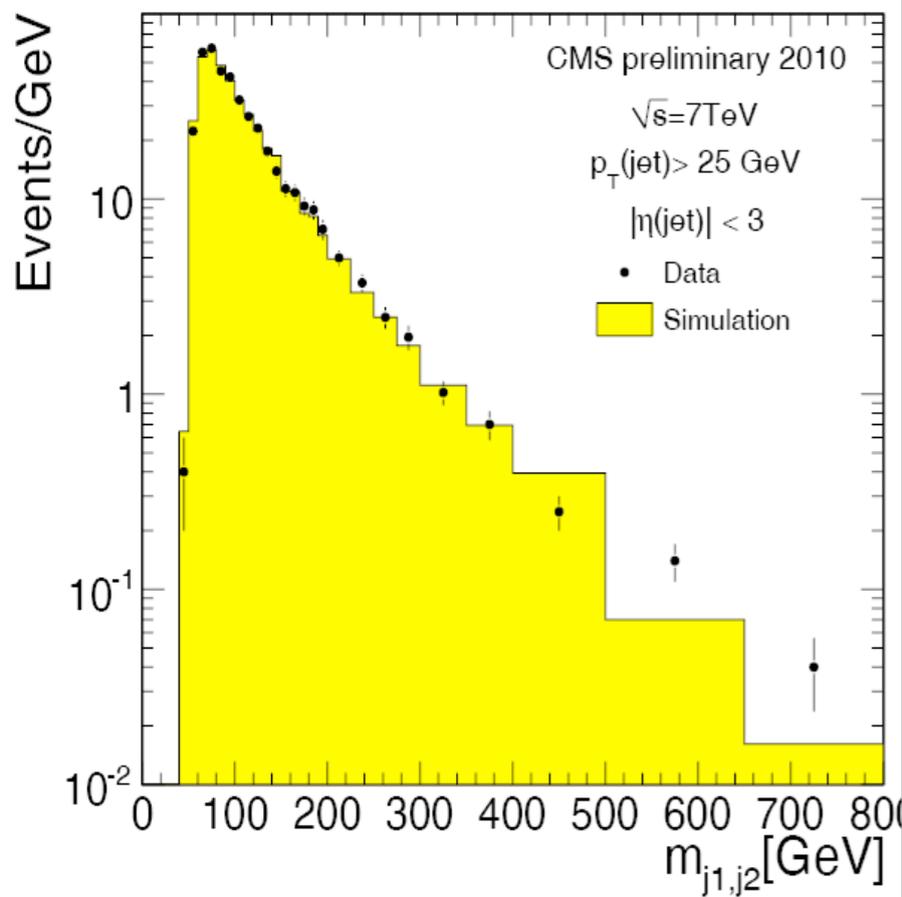
CMS Experiment at LHC, CERN
Run 133450 Event 16358963
Lumi section: 285
Sat Apr 17 2010, 12:25:05 CEST

Jet 1 p_T : 253 GeV
Jet 2 p_T : 244 GeV
Dijet mass : 764 GeV

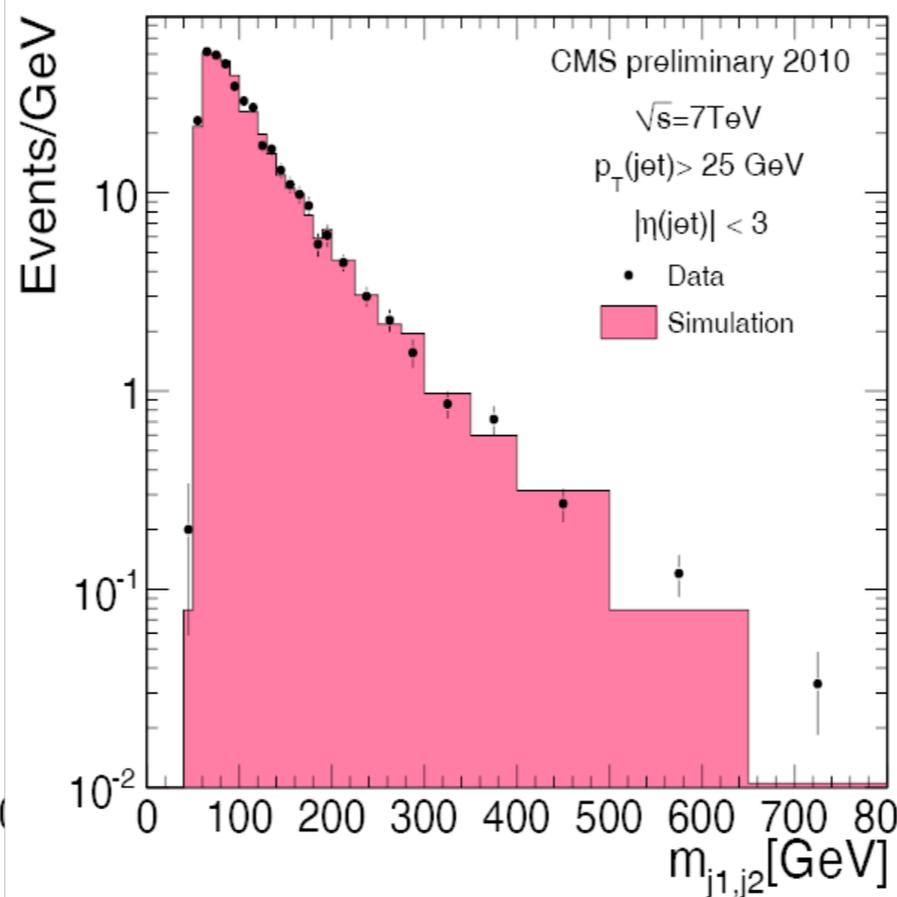


Dijet mass for different type of jets

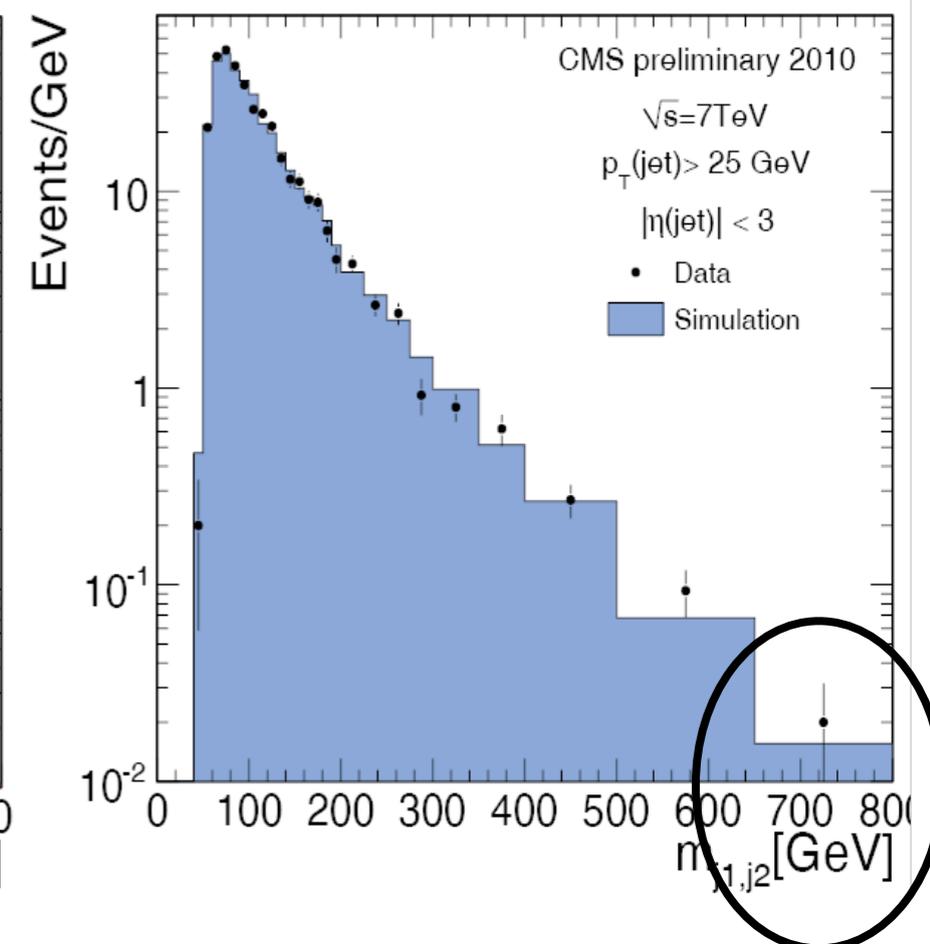
Calorimeter jets



Calorimeter+Tracks jets



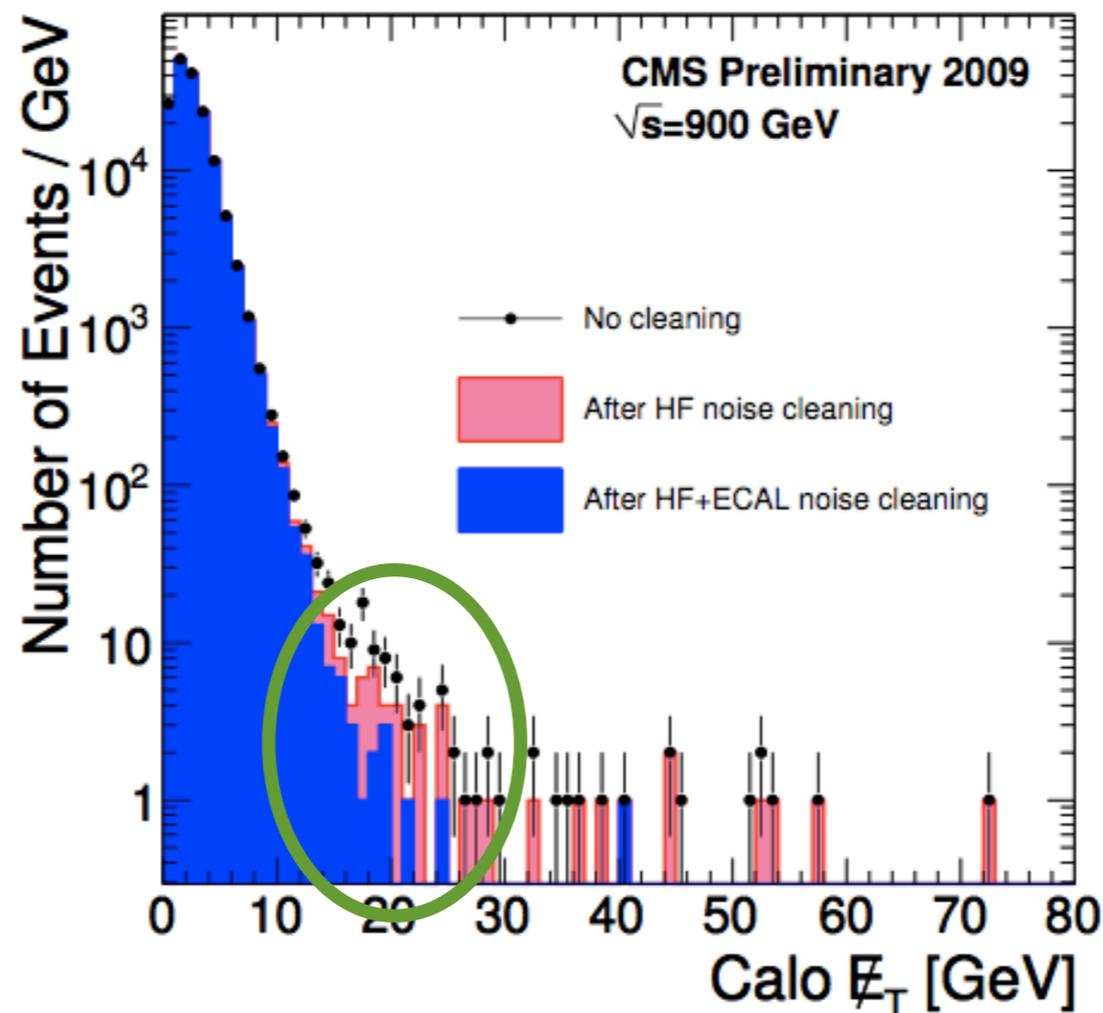
ParticleFlow jets



Reconstruction consistent between the three jet reconstruction methods

Already reaching $\sim 1\text{ TeV}$

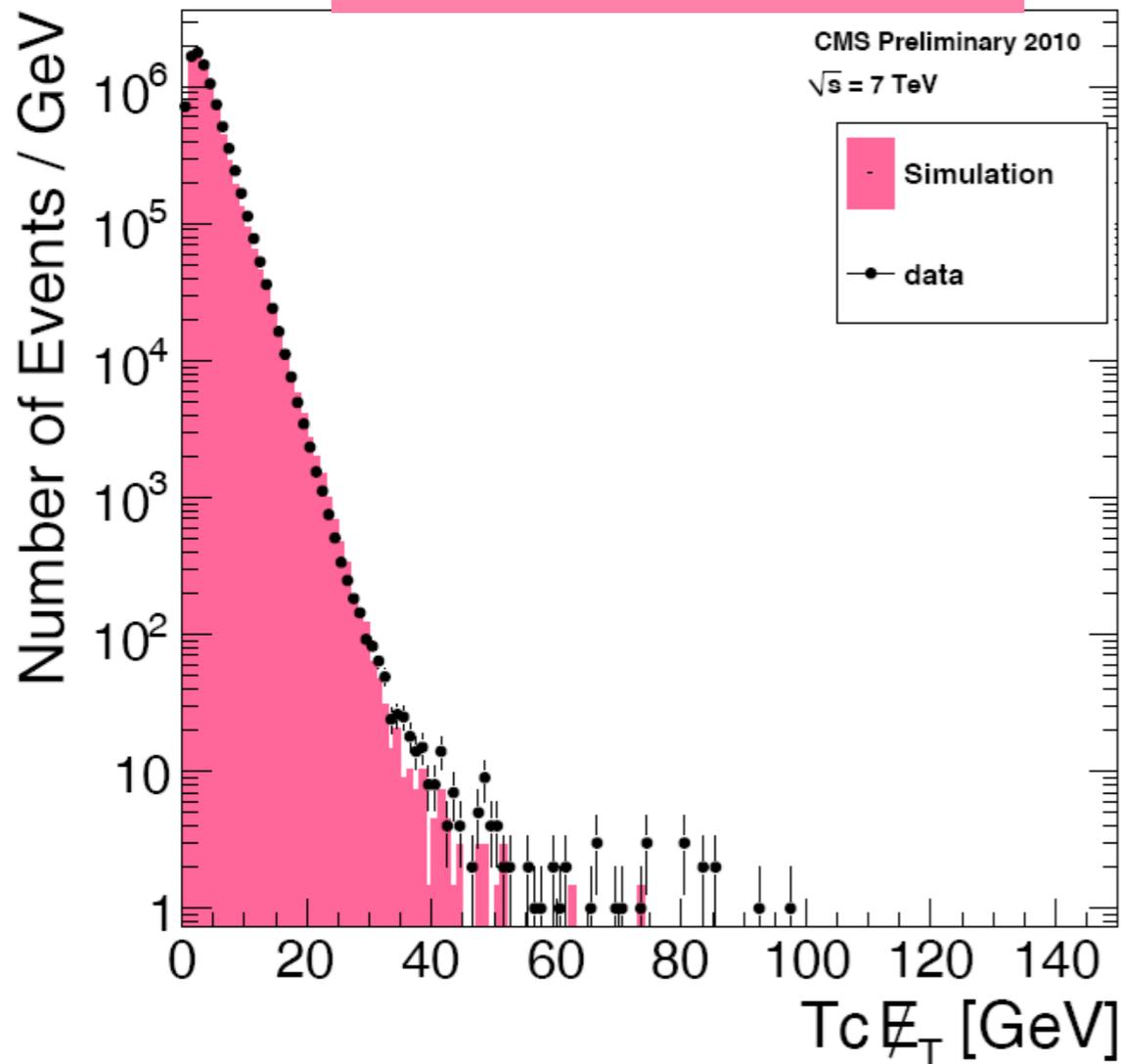
Anomalous Noise Clean-up



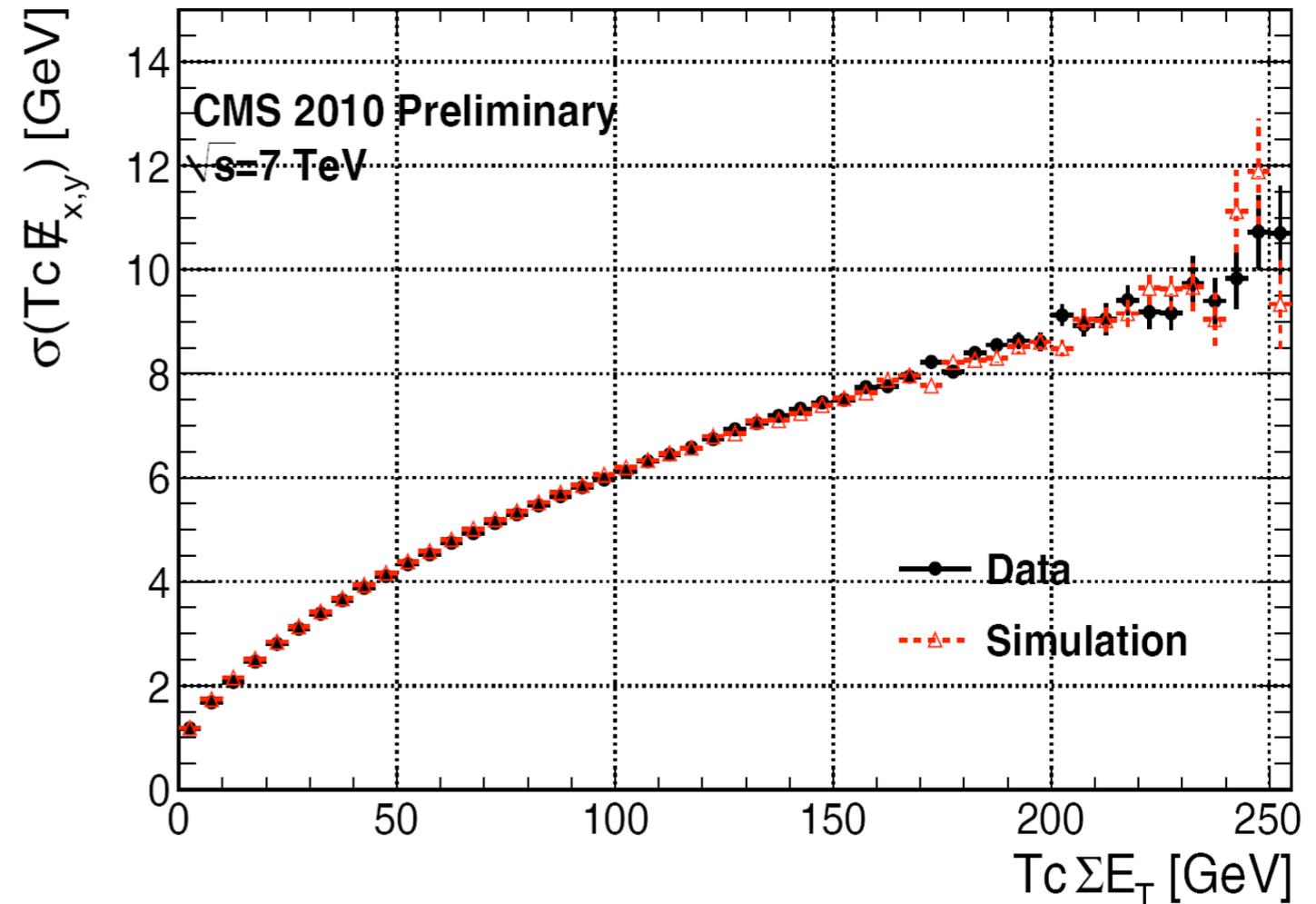
- Missing E_T is a good variable to show the effects of the noise clean-up.
- Only filters for HF and ECAL noise has been applied in these plots.
 - Events in the tail are reduced.
- Detail studies to understand and filter noise are underway
 - Take advantage of detector timing and topology selection.

Missing E_T

Track Corrected MET

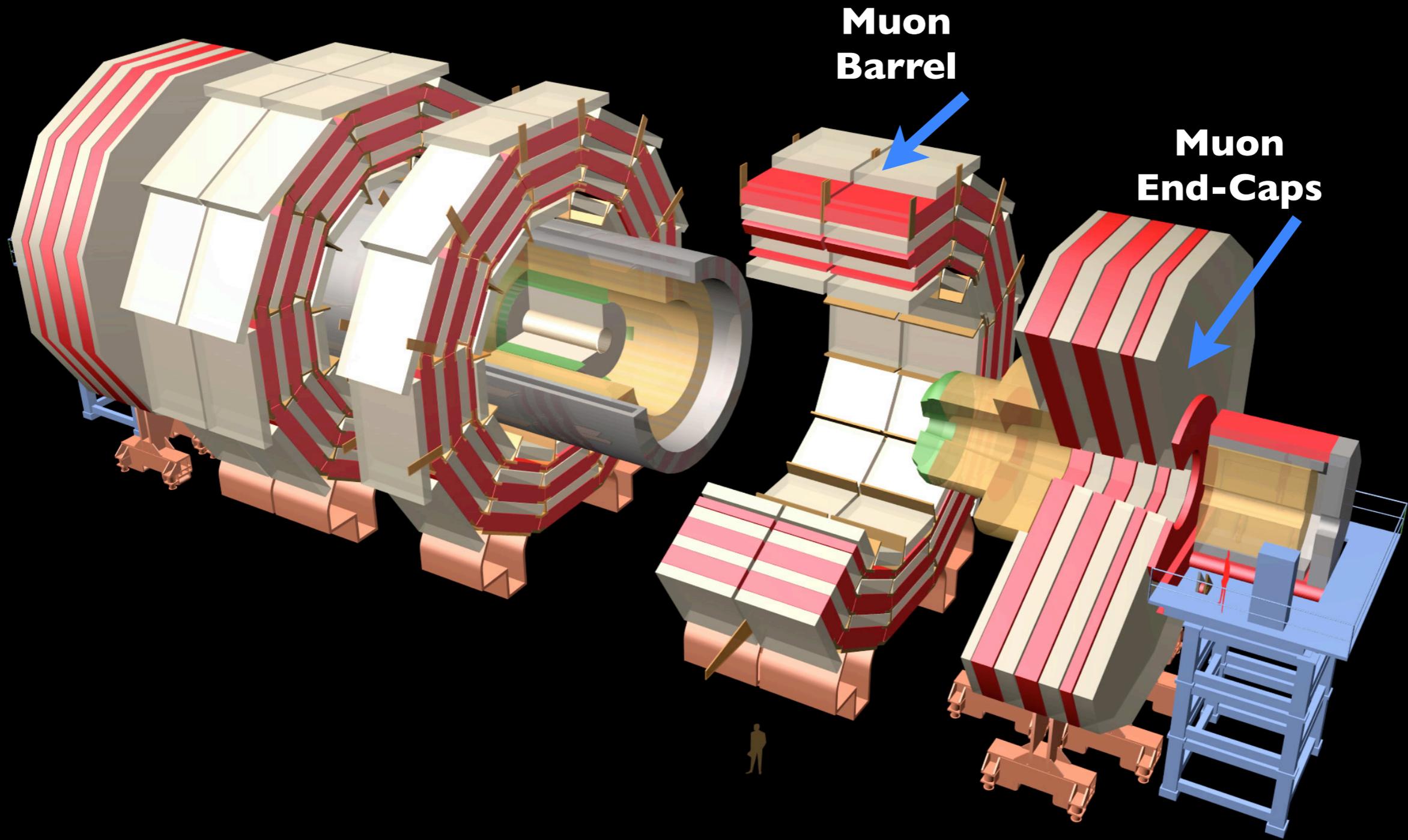


MET Resolution

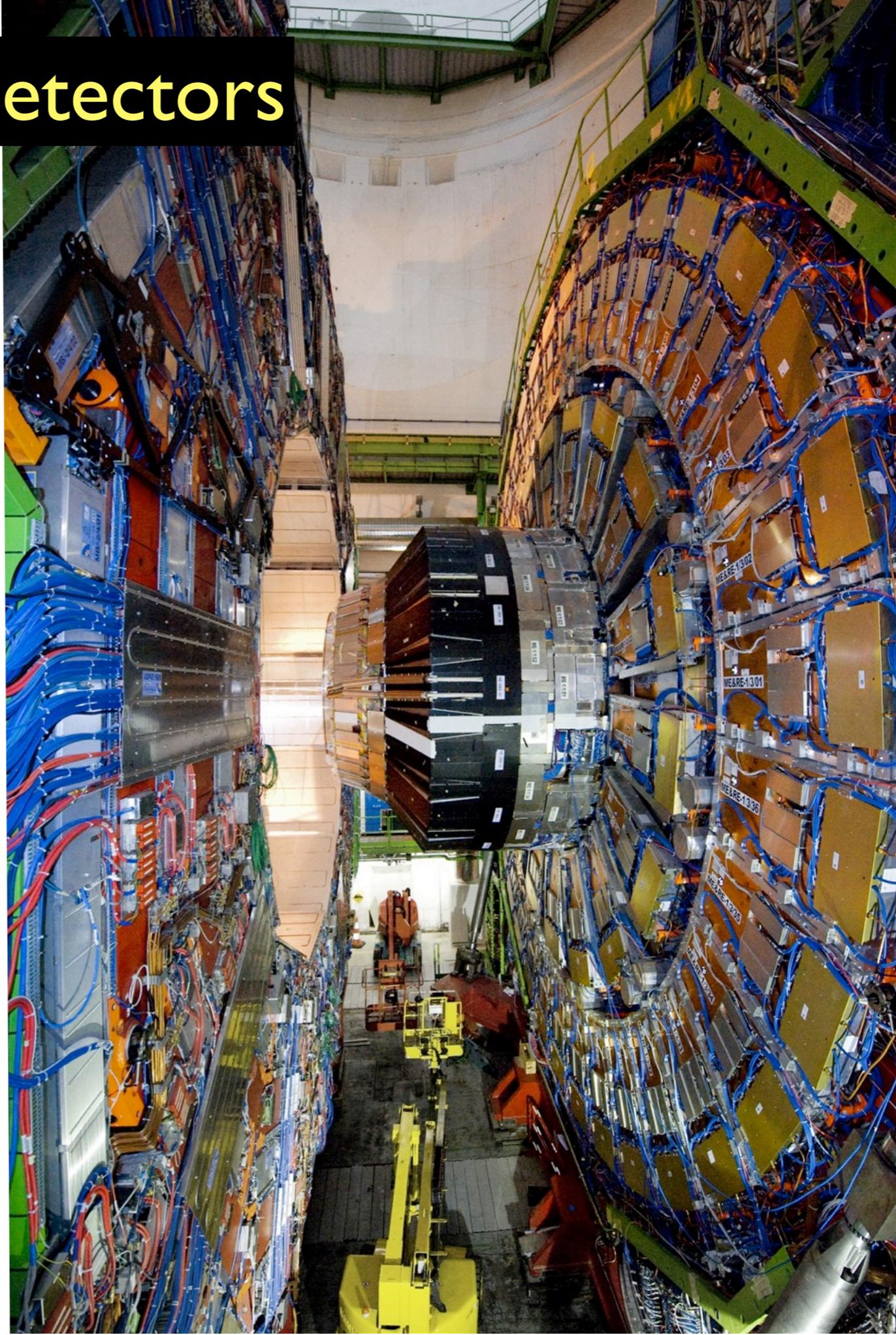


- Core of MET distribution is well-described.
- $\text{Sum}E_T$, MET very dependent on Pythia tunes.
- MC tuning is underway.
- All MET methods (calo, track, particle flow) are in agreement.
- Resolution agrees well between data/MC.

The CMS Detector

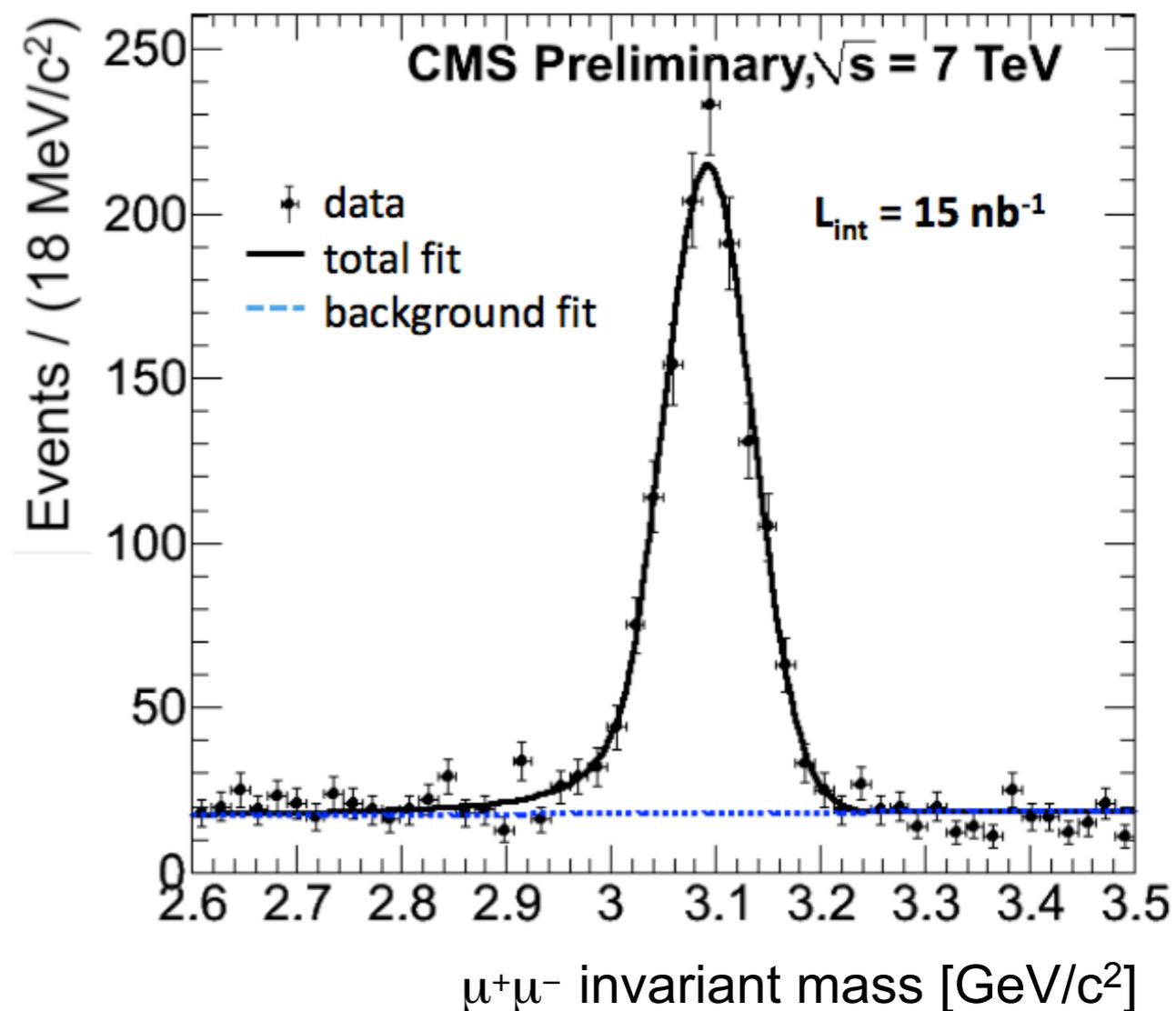
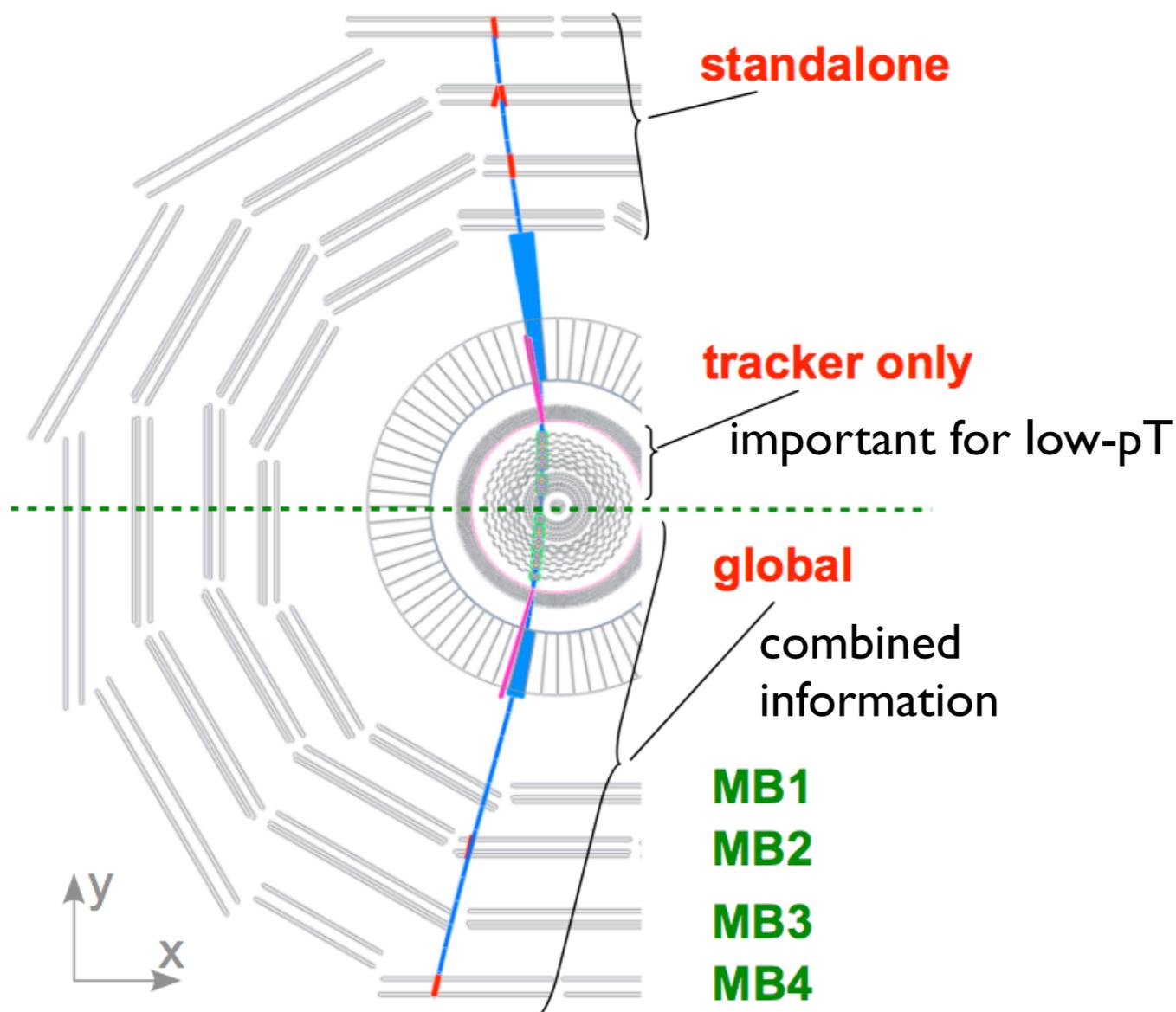


Muon Detectors



Di-Muon Reconstruction

$$J/\psi \rightarrow \mu^+ \mu^-$$

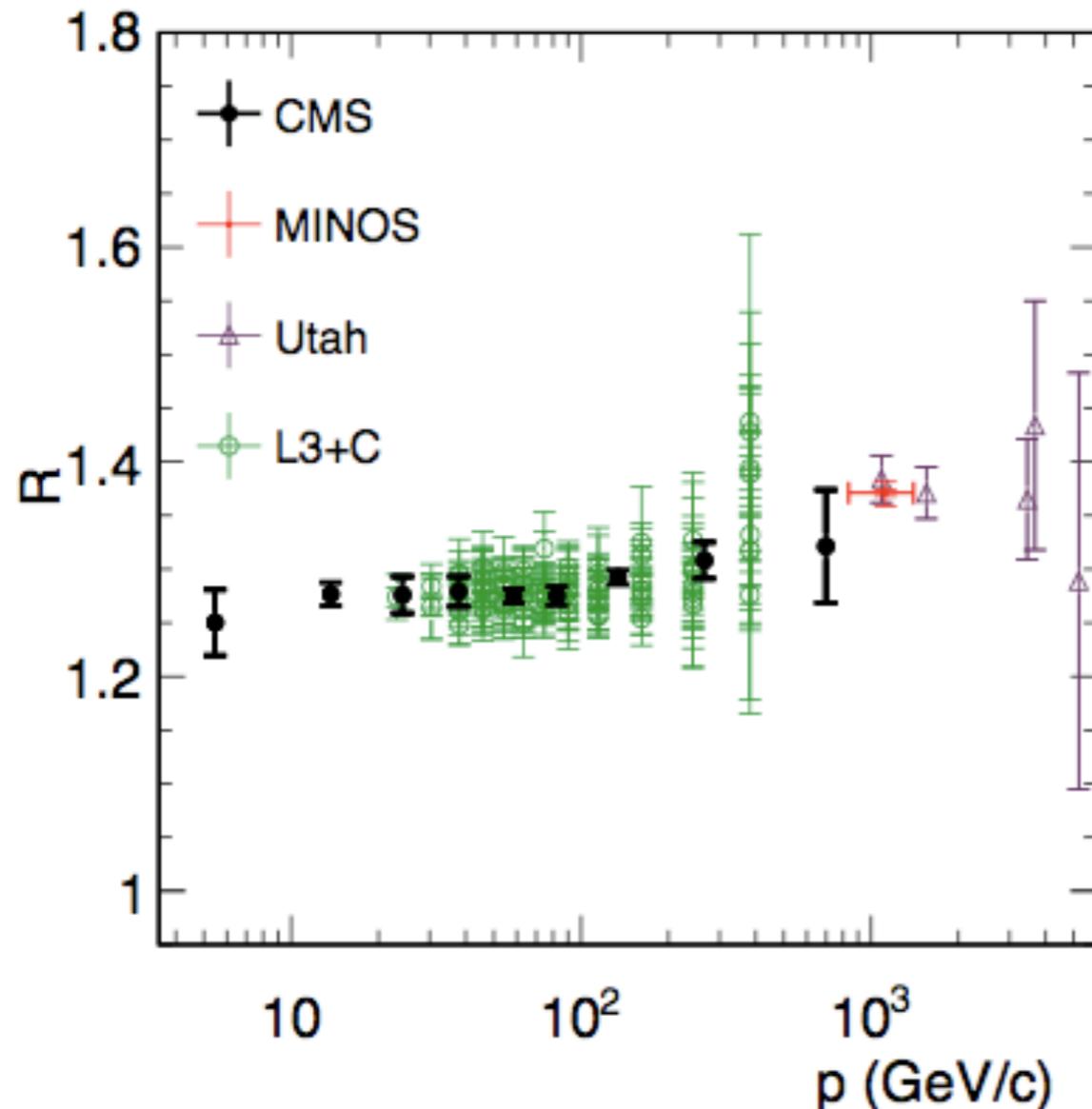


Signal events: 1230 ± 47
 Sigma: $(42.7 \pm 1.9) \text{ MeV}$
 M_0 : $3.092 \pm 0.001 \text{ GeV}$
 S/B = 5.4 ($M_0 \pm 2.5\sigma$)
 $\chi^2/\text{ndof} = 1.1$

Measurement of Muon Charge Asymmetry

Charge ratio of atmospheric muons

CMS 2006-2008 preliminary



Most precise measurements
to date below 850 GeV

This measurement implies a good understanding of:

- Muon reconstruction in large momentum range
- Muon Level I trigger efficiencies
- Muon tracking alignment

Submitted to Physics Letter B

looking into the future ...



CMS Plans for Upgrades

■ Motivation:

- LHC will deliver high luminosity collisions $\mathcal{L} > 10^{34} \text{ cm}^2\text{s}^{-1}$, at high rate (50 ns bunch spacing)
- Radiation damage to detectors
- Detector improvements

■ Timeline for upgrades during major LHC shutdowns:

- 2012 ($\mathcal{L} > 10^{33} \text{ cm}^2\text{s}^{-1}$, at 13/14 TeV)
 - Replace Calorimeter sensors, finish last wheel muon end-cap, replace beampipe, new beam monitoring
- 2016 ($\mathcal{L} > 10^{34} \text{ cm}^2\text{s}^{-1}$, at 13/14 TeV)
 - New pixel system, finish replacement calorimeter sensors
- 2020 ($\mathcal{L} \sim 4\text{-}5 \times 10^{34} \text{ cm}^2\text{s}^{-1}$)
 - Replace tracker, trigger

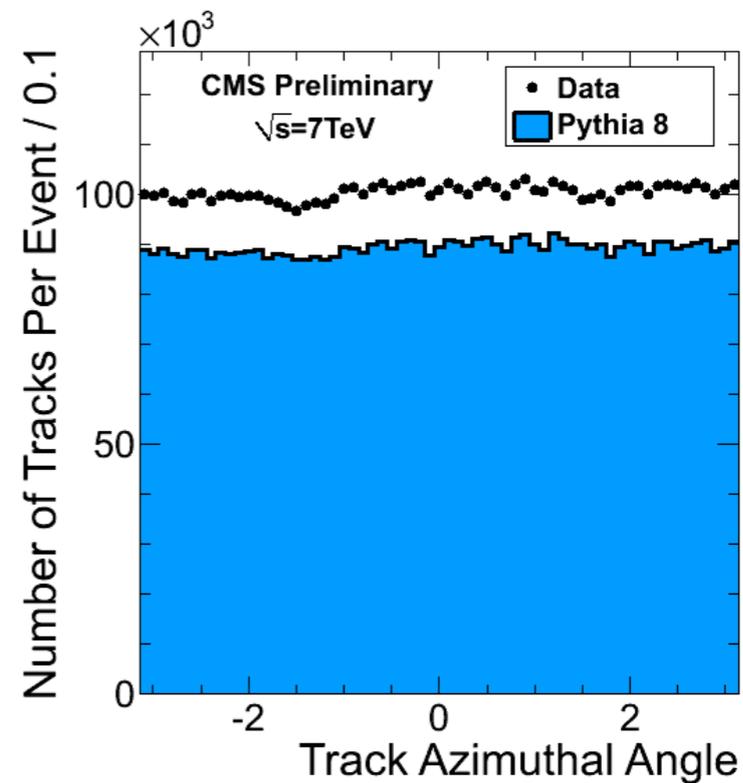
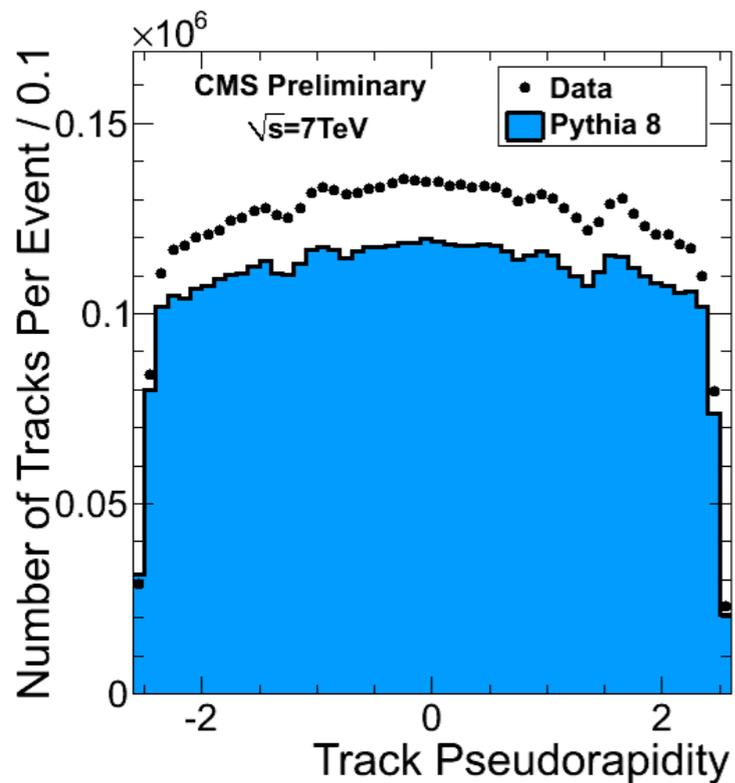
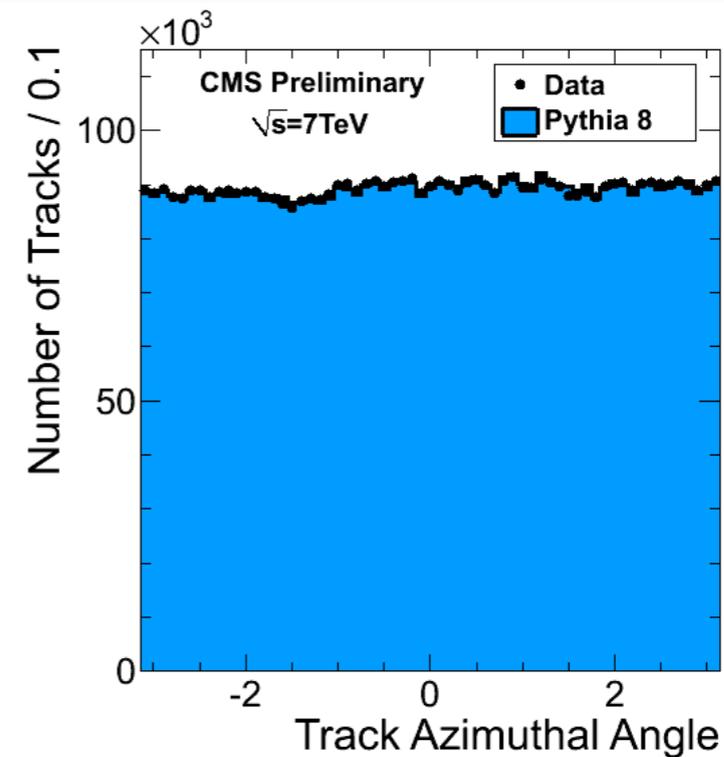
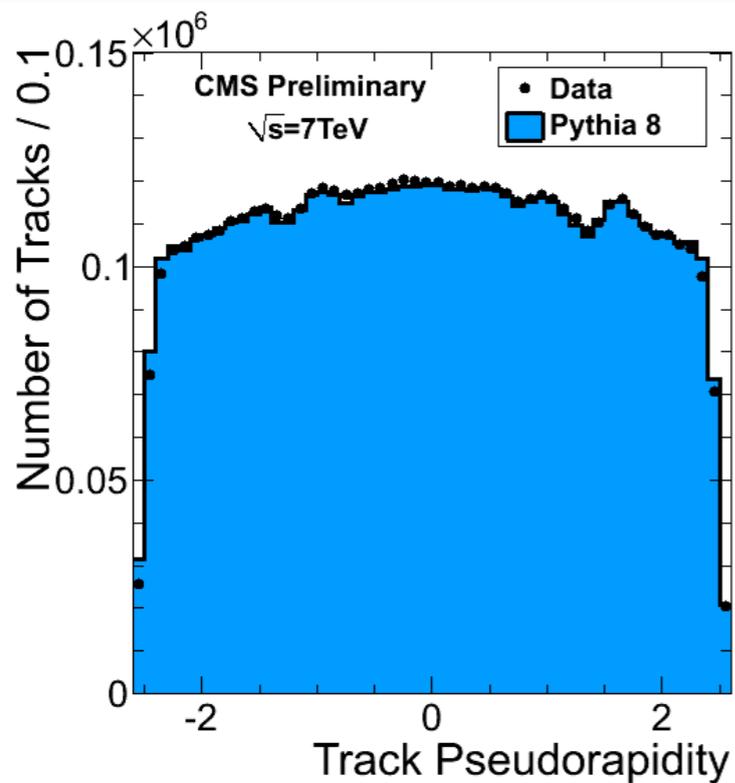
■ All these upgrades have major impact in physics.

■ Revised plan for CMS upgrades in preparation (draft TDR in June)

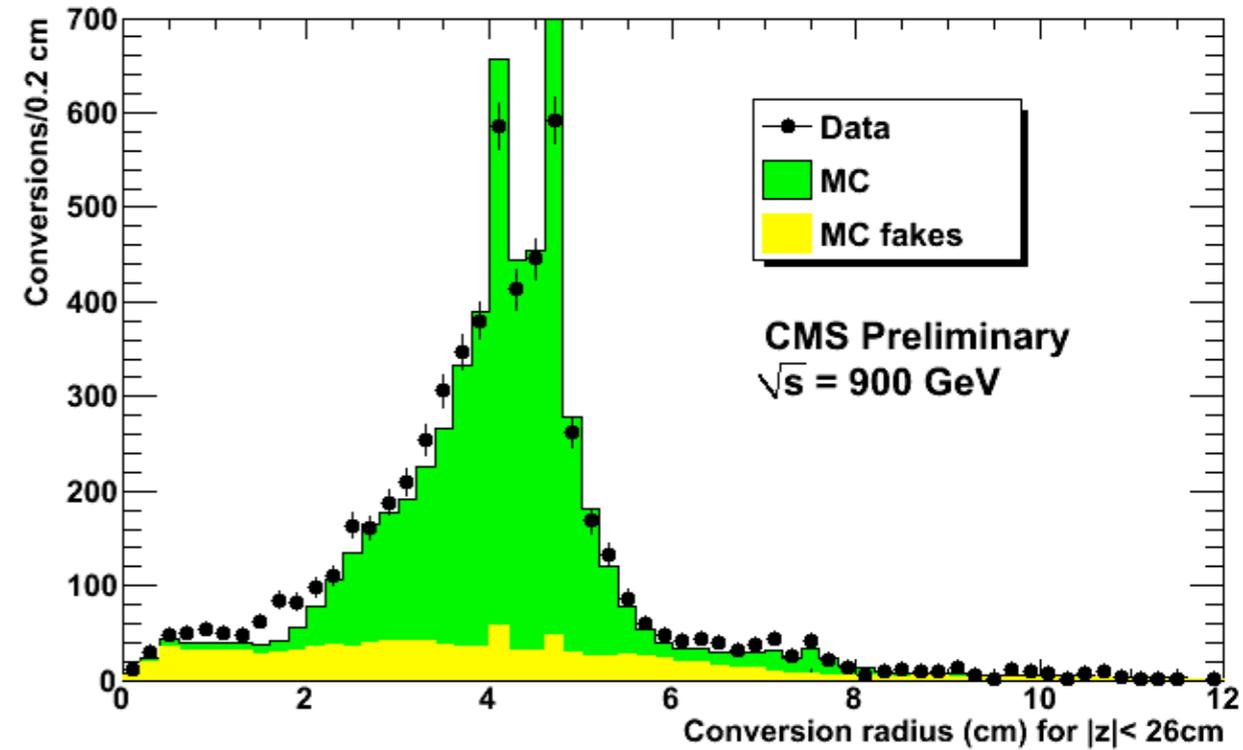
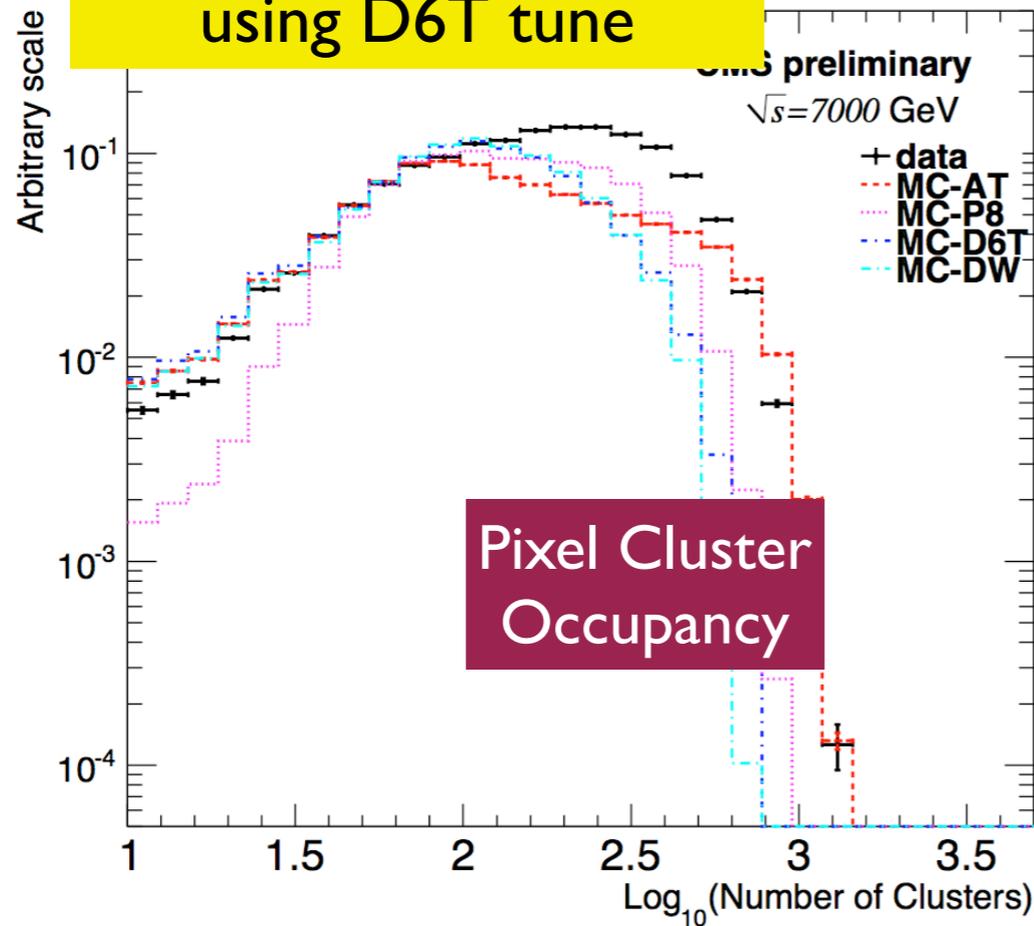
Summary

- The CMS detector profited from the extensive cosmic data taking in 2008 and 2009 for commissioning
 - Very good alignment, precise knowledge of B-field, operations, calibrations.
 - Performance plots were delivered in hours, and extensive analysis done in days!
- CMS is in very good shape:
 - > 98% of its components are operational
 - very good data taking efficiency > 90%
 - Reasonable well simulation of detector. Improvements are ongoing.
- CMS is ready for discoveries
 - stay tuned for new results very soon!

Backup slides

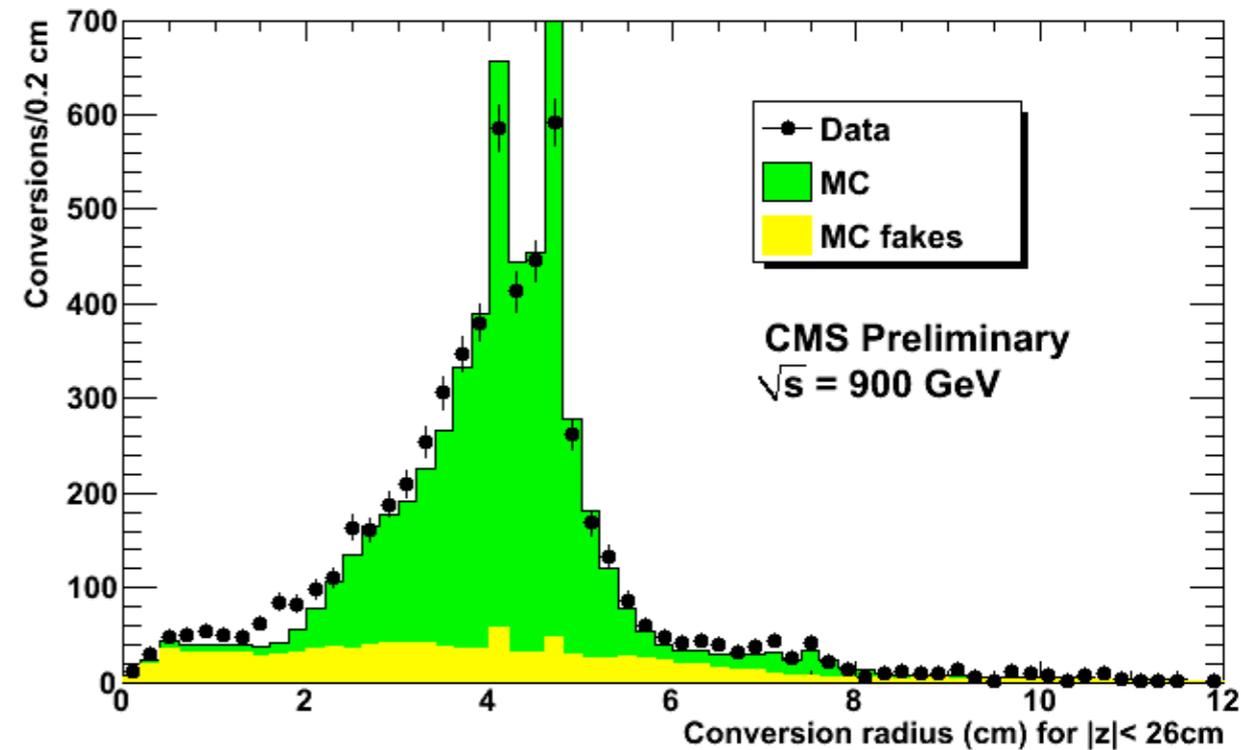
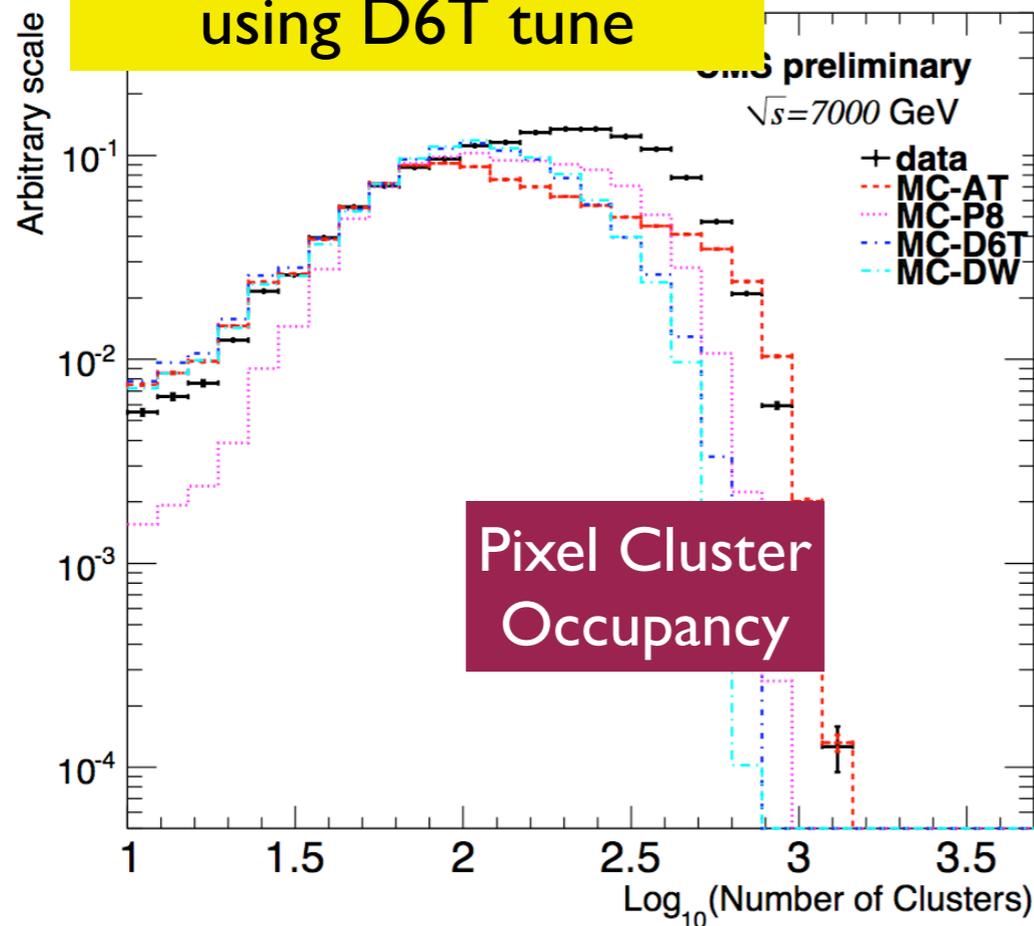


discrepancies are due to imperfect MC modeling. Currently using D6T tune



Material Estimation
Conversion vertices

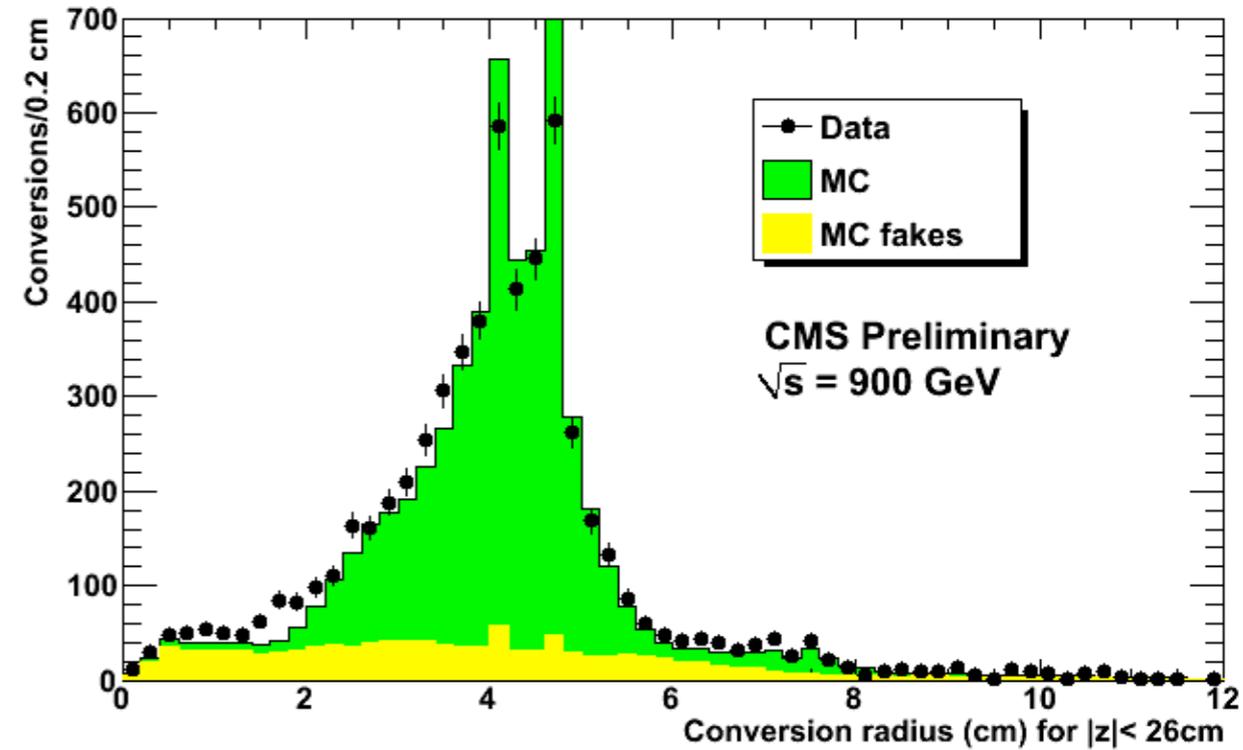
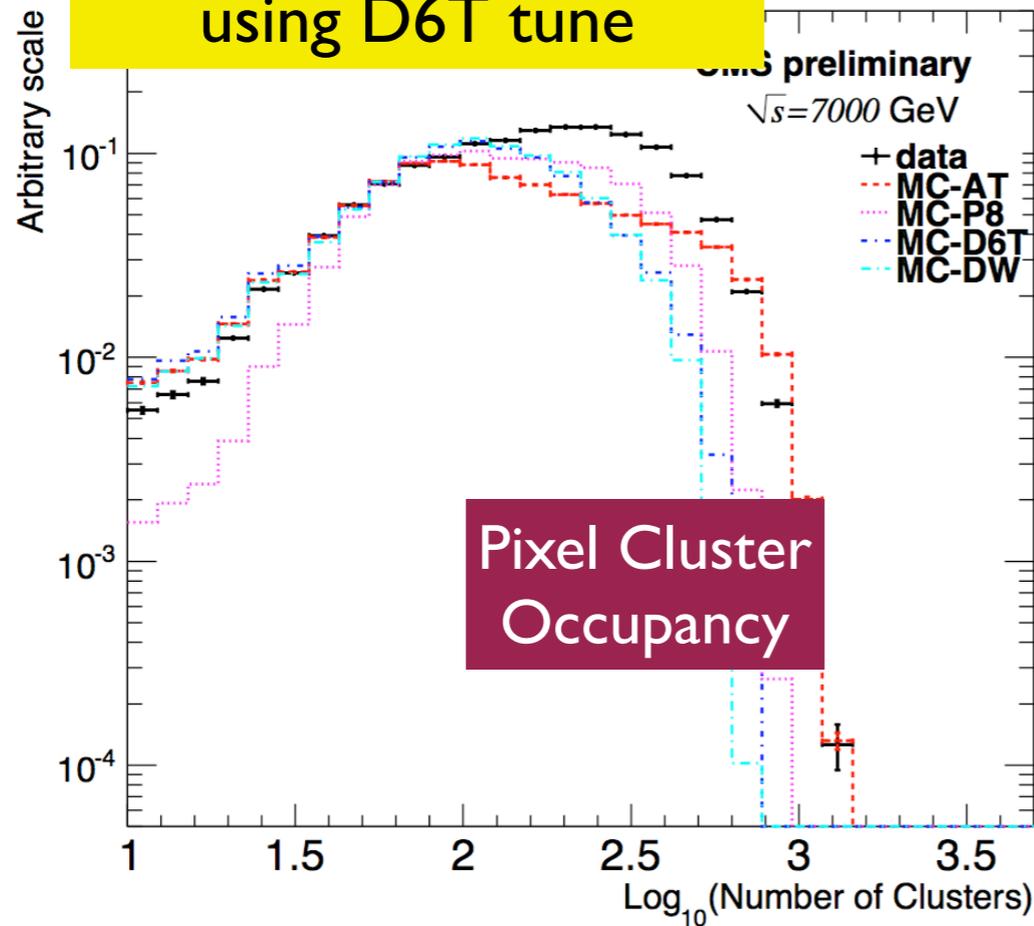
discrepancies are due to imperfect MC modeling. Currently using D6T tune



Material Estimation
Conversion vertices

Already very good tracker alignment and a very good understanding of the tracker material

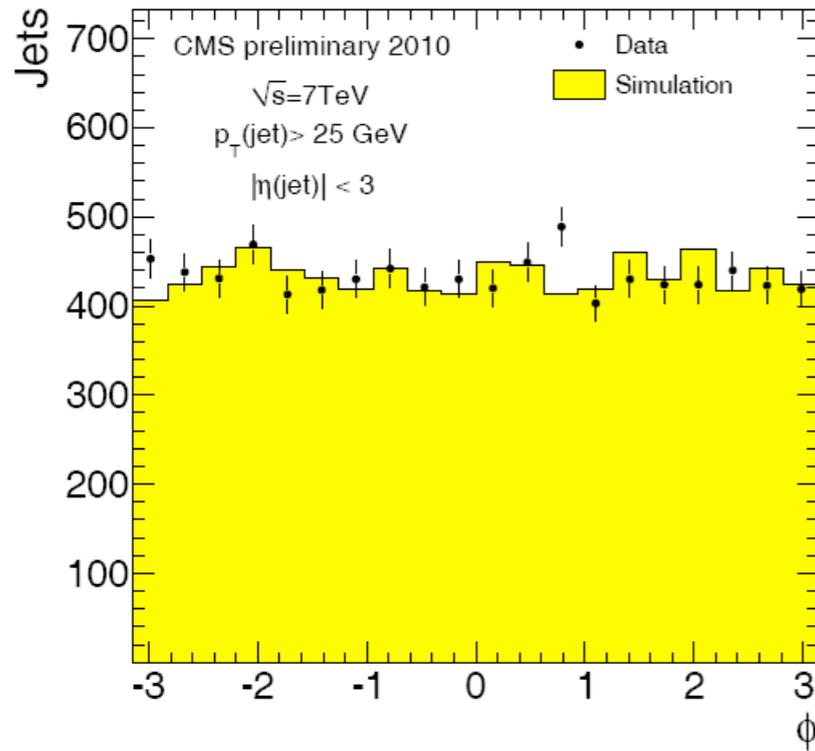
discrepancies are due to imperfect MC modeling. Currently using D6T tune



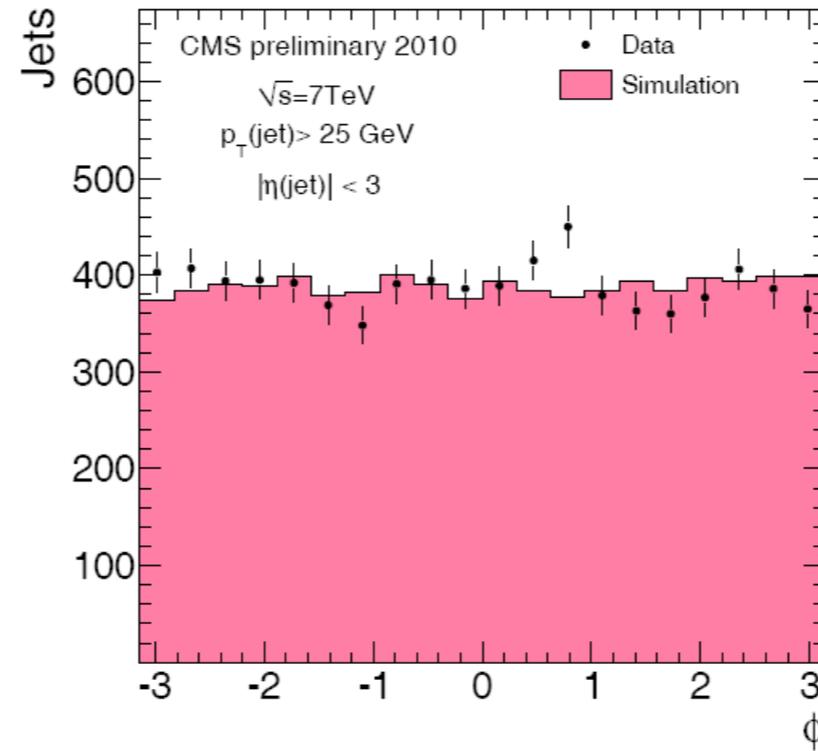
Material Estimation
Conversion vertices

Inclusive Jet Reconstruction

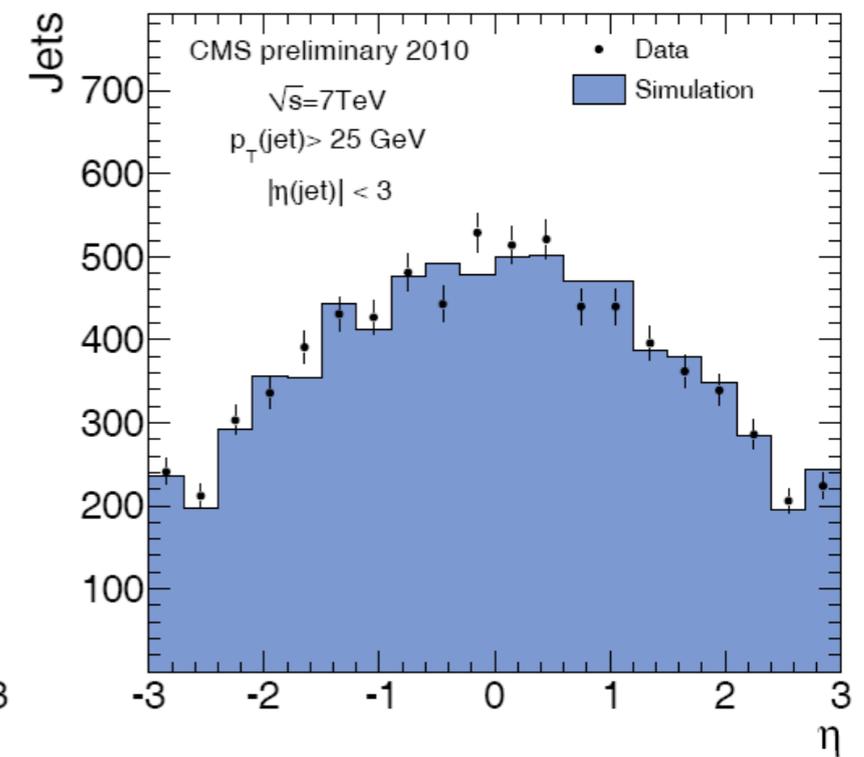
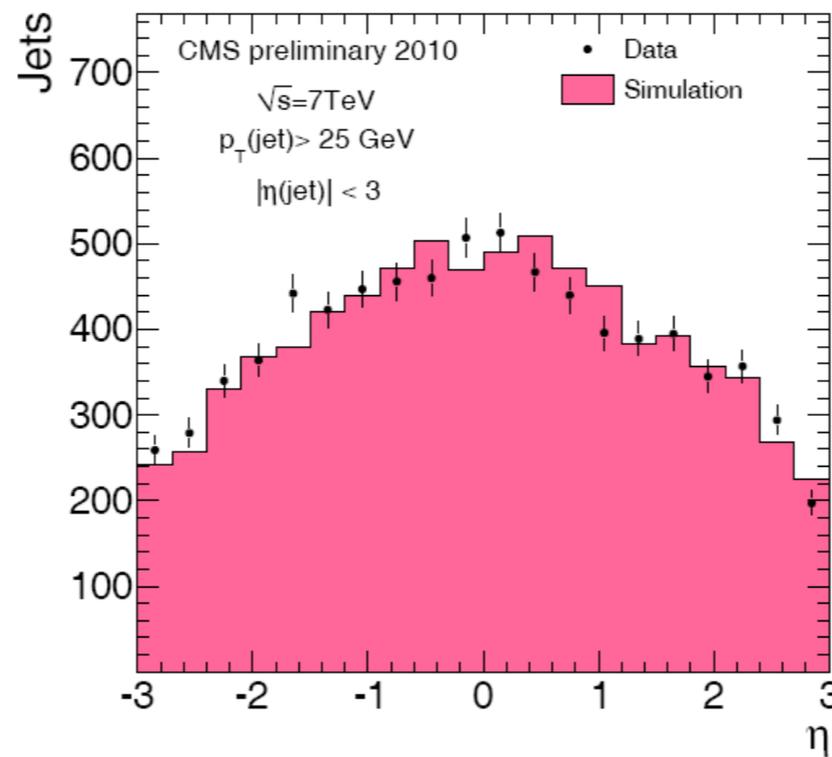
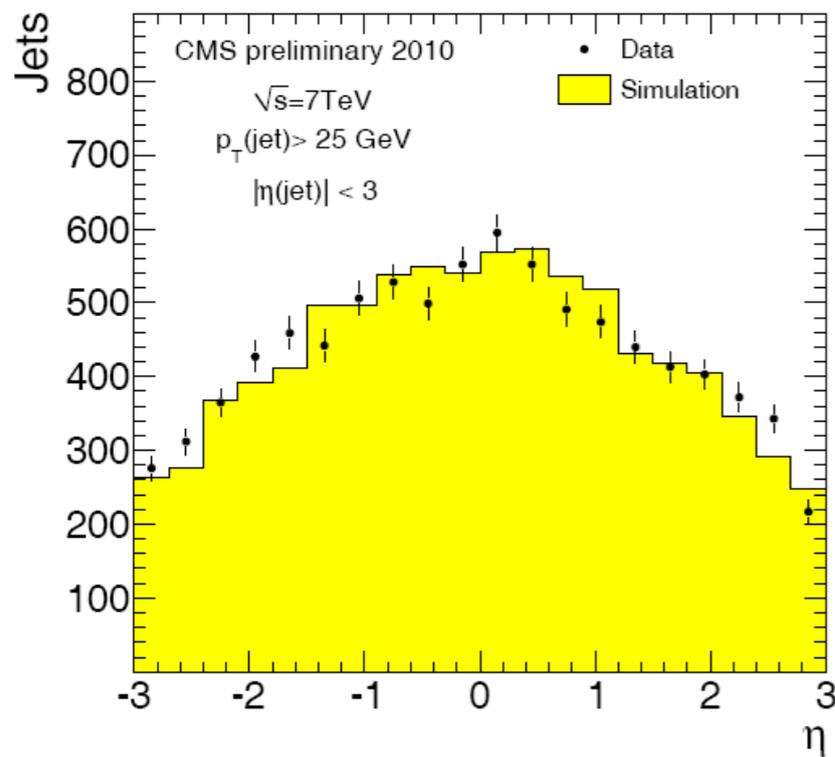
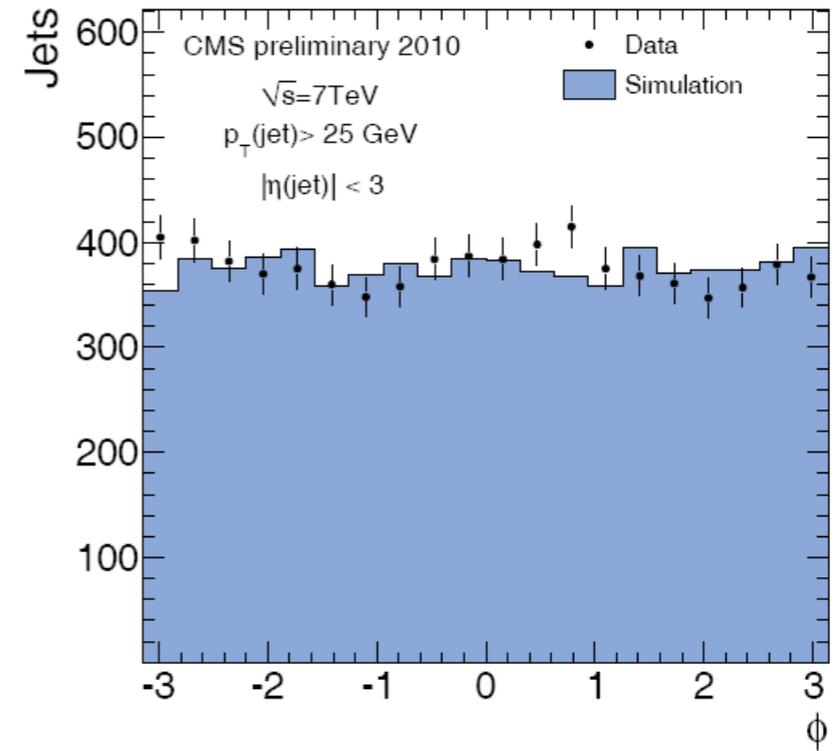
Calorimeter jets



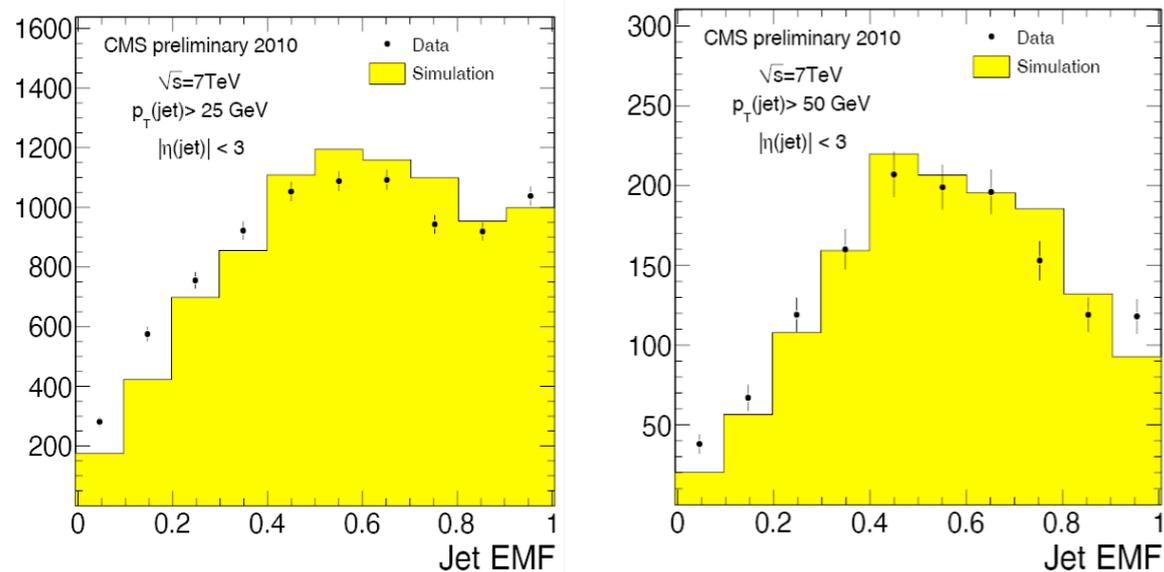
Calorimeter+Tracks jets



ParticleFlow jets



Calo jets



PF jets

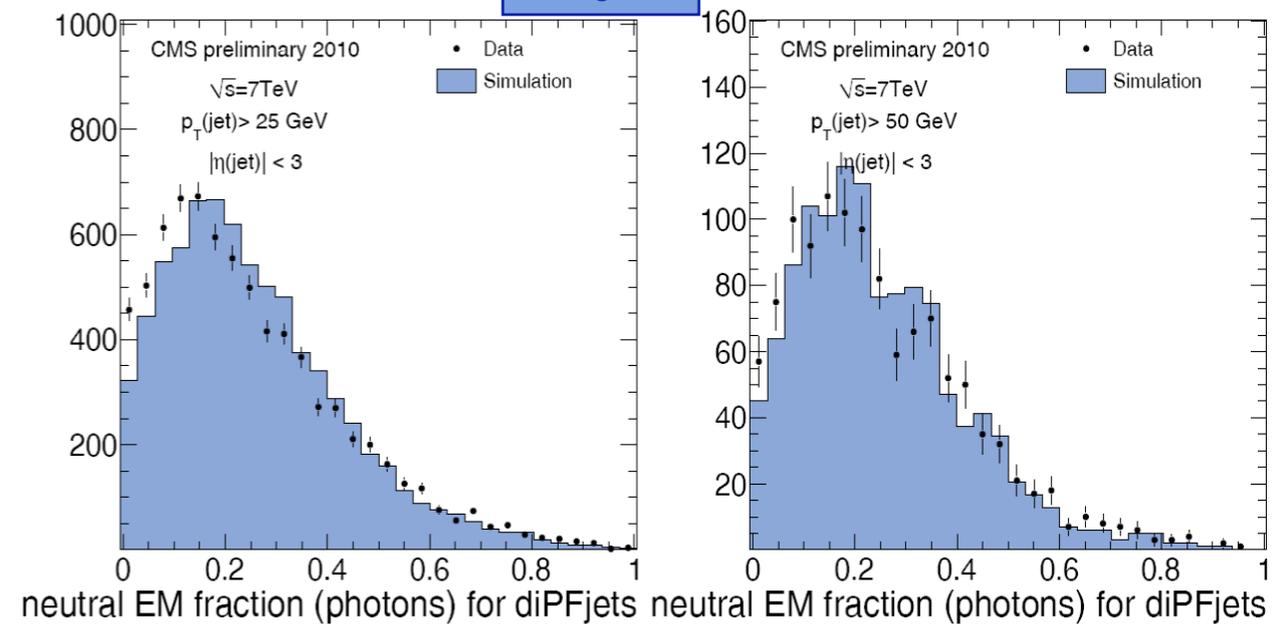


Figure: Fraction of di-jet energy contributed by electromagnetic calorimeter deposits (*EMF*) for a p_T cut of 25 GeV and 50 GeV.

Figure: Data vs MC: neutral electromagnetic fraction (photons) for diPFjets for a p_T cut of 25 and 50 GeV.

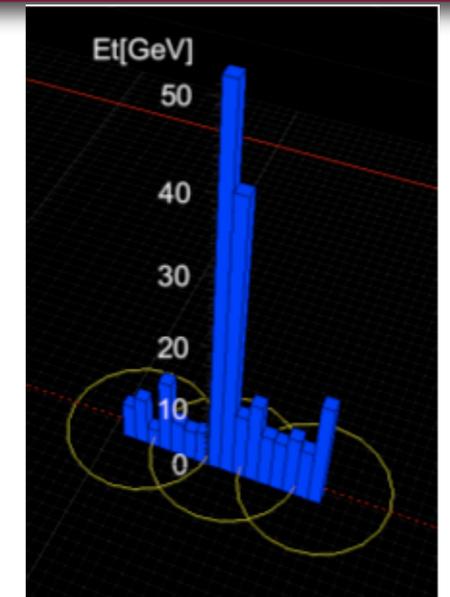
- General agreement. Small data excess at low EMF seems to be reduced at larger p_T values

Anomalous Noise in Calorimeters

■ Hadron Barrel(HB) and end-caps(HE) calorimeters

- Source: Hybrid photo-diodes(HPDs)
- Appear in 1-72 channels
- Caused by ion feedback, noise and discharges in HPDs
- Random ~10-20 Hz

HPD



■ Hadron Forward calorimeter (HF)

- Source: photo-multipliers (PMT) window
- Appear in 1 channel
- Caused by Cherenkov light by particles going through PMT glass

PMT



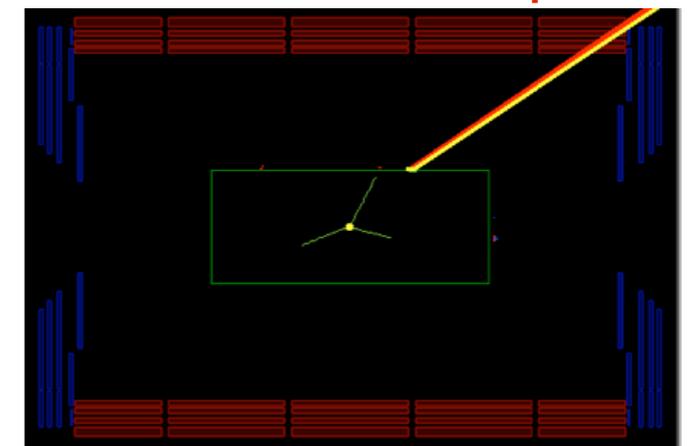
■ Electromagnetic calorimeter (ECAL)

- Appear in a single crystal
- In time with collisions but wider spread
- Caused mostly by deposits in avalanche diodes (APDs) by highly ionizing secondary particles

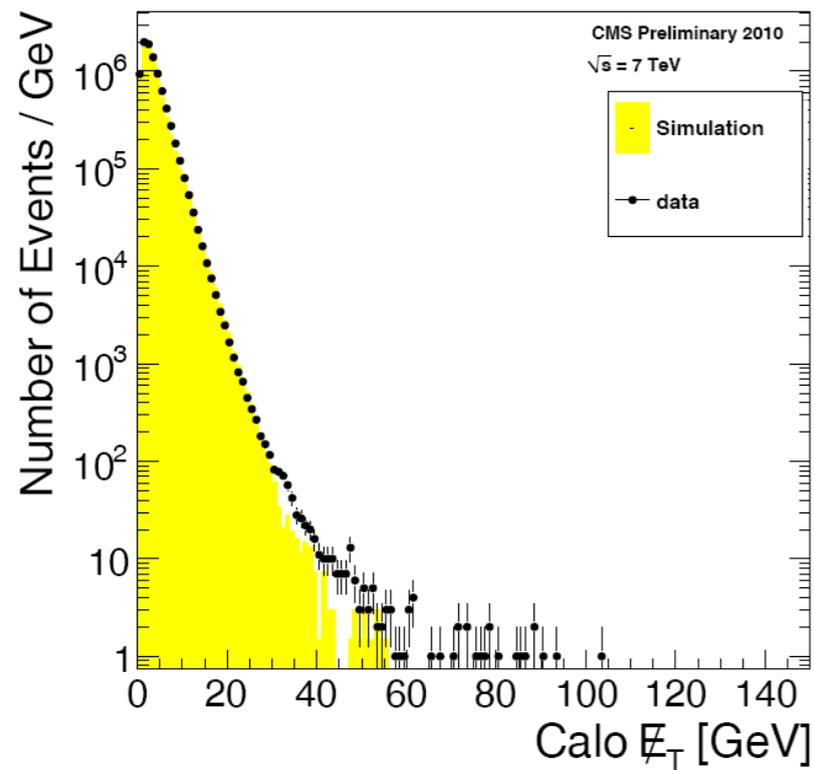
APD



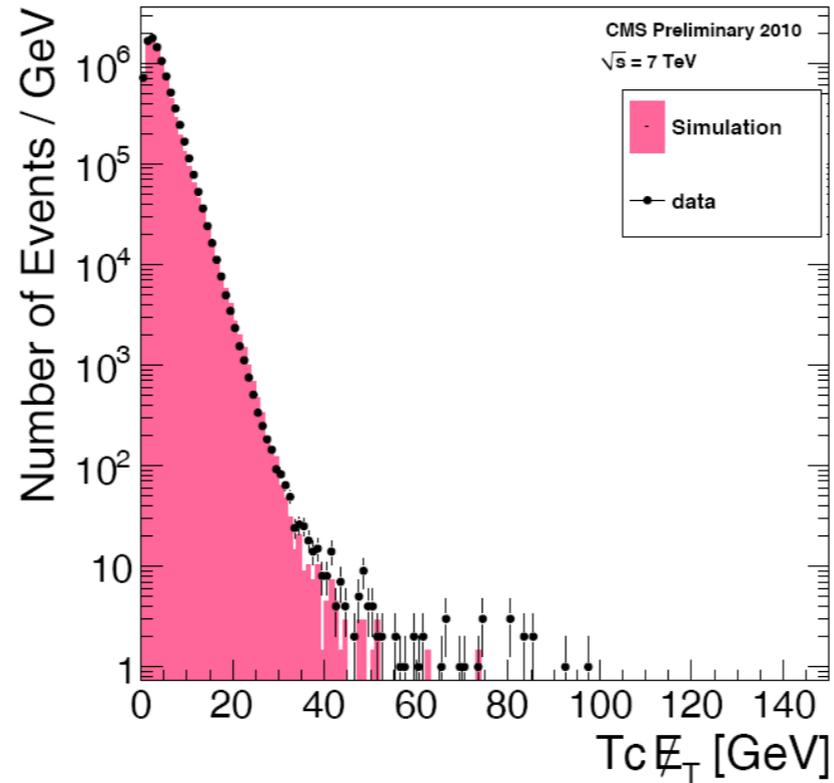
ECAL "Spikes"



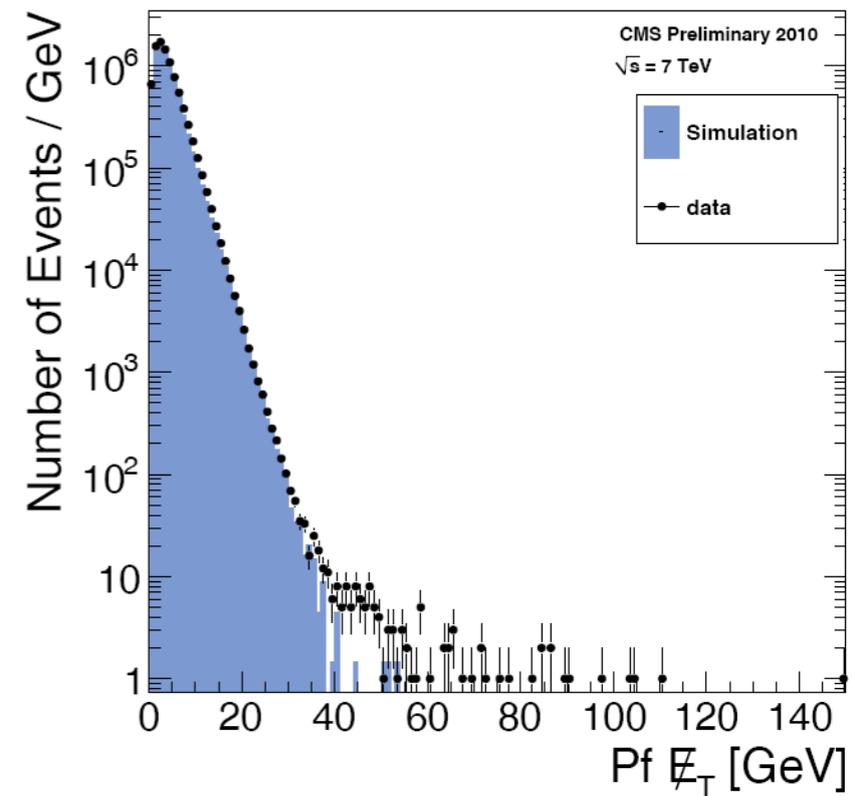
Calo MET



Track Corrected (TC) MET

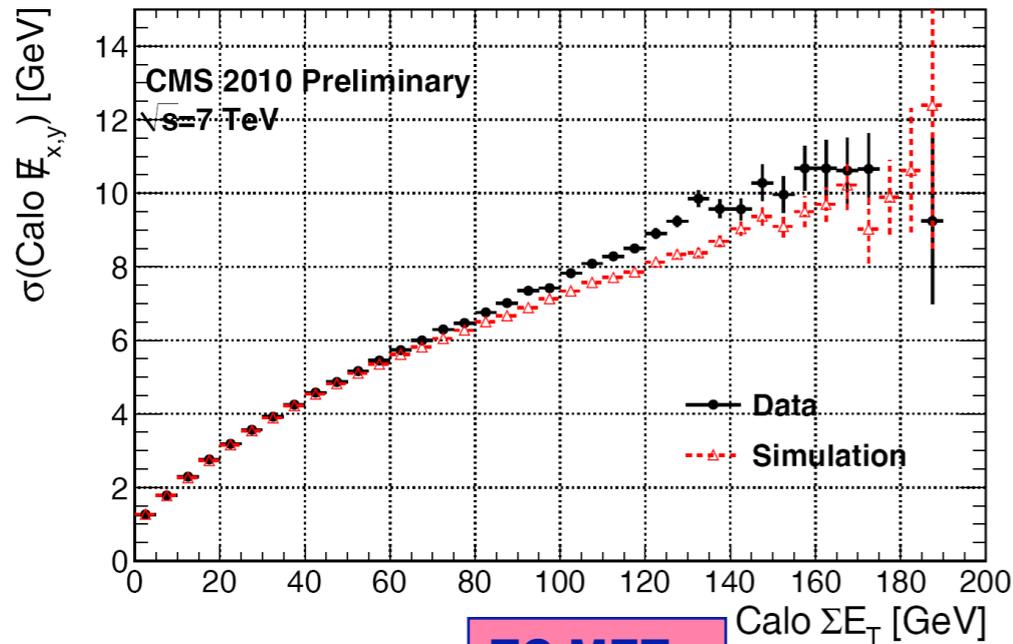


PFlow MET



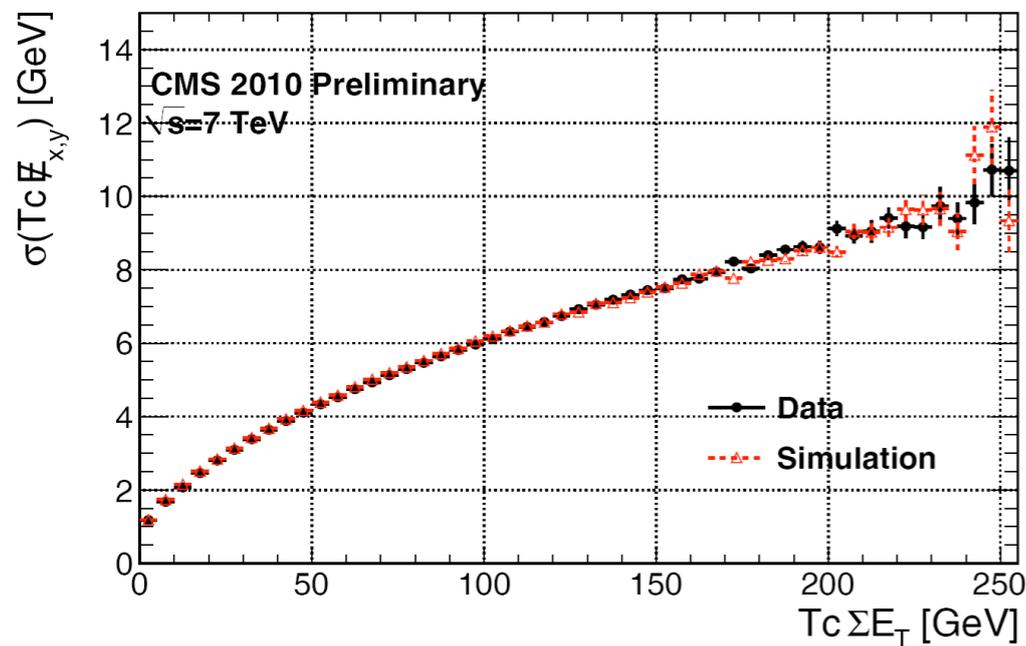
MET Resolution

Calo MET



variables in
x and *y* axes are for
uncorrected MET

TC MET



PF MET

