

# Performance of the CMS detector with first collision data

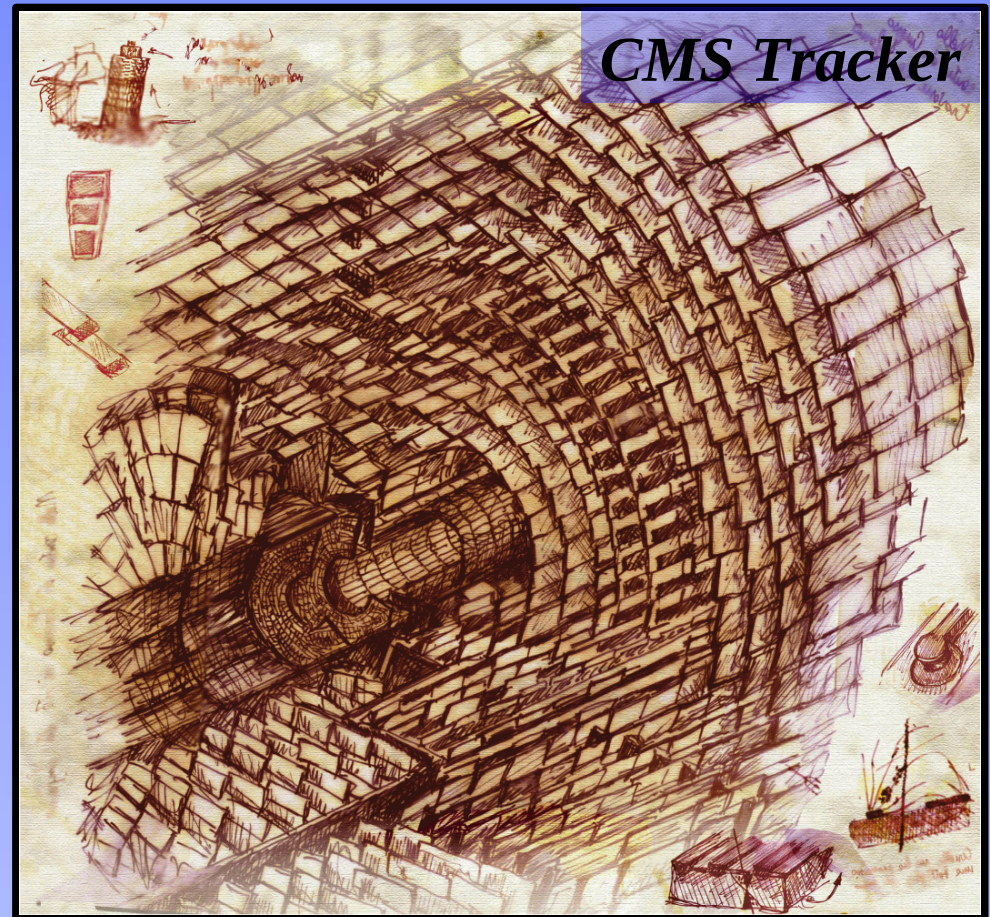
*On behalf of the whole  
CMS collaboration*



# Outline

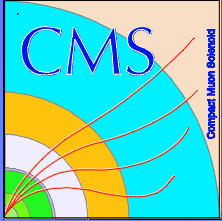


- Status of CMS calorimeters
- Status of CMS tracker
- Resonances
- Jet events
- Particle Flow
- Di-muon and b events
- Conclusions

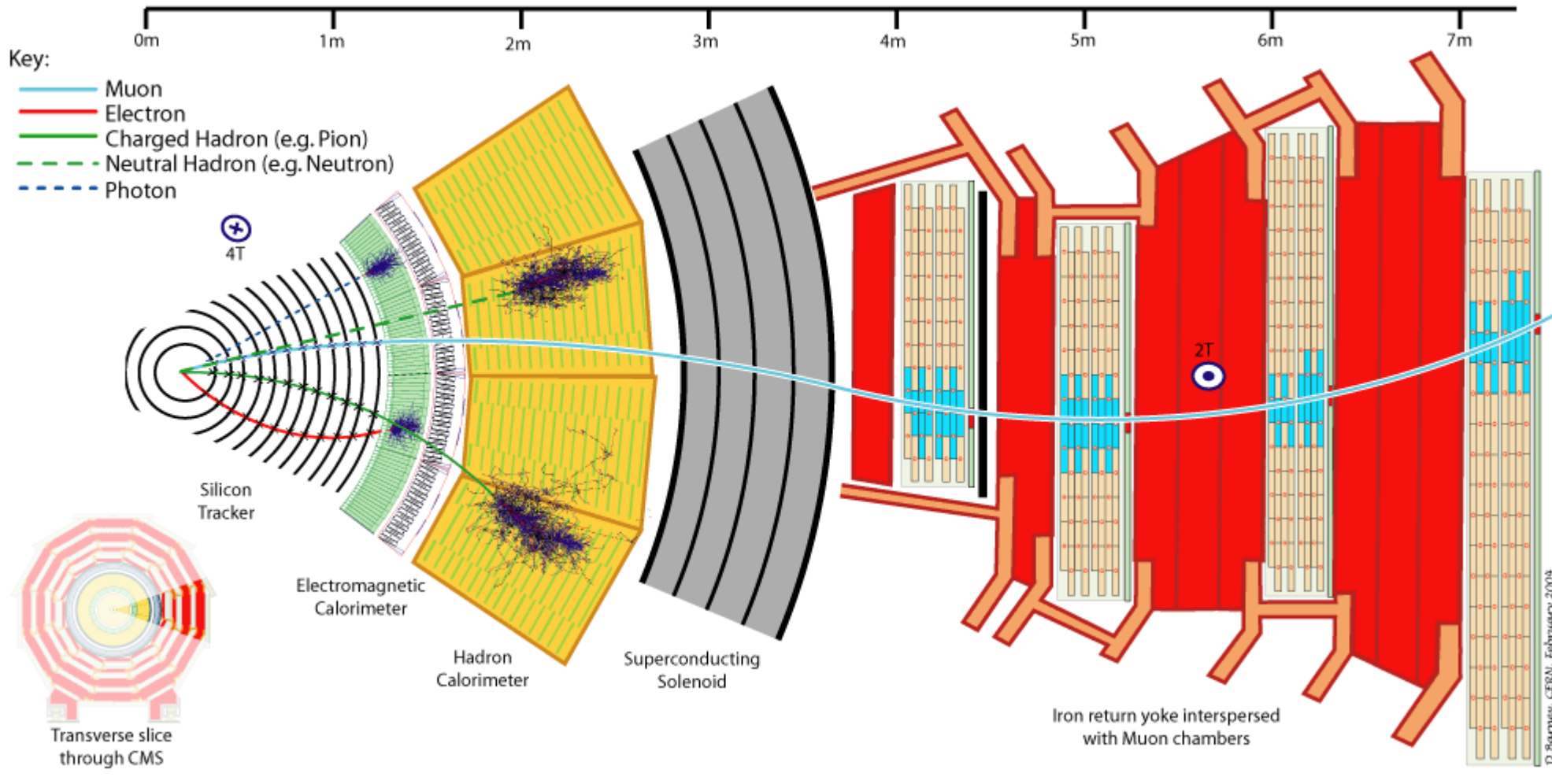




# Overview Of CMS

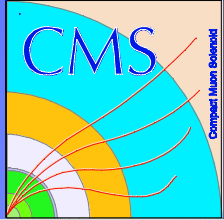


Compact Muon Solenoid





# Splash events



File Edit View Window Help

Delay 5.1s Run 121943 Event 164 Fri Nov 20 19:13:39 2009 CEST Lumi block id: 34

Event Filtering is OFF

Summary View

Add Collection

- ECal
- HCal
- Jets
- Tracks
- Muons
- Electrons
- Vertices
- DT-segments
- CSC-segments
- Photons
- MET

Views

Rho Phi

Rho Z

3D

Table

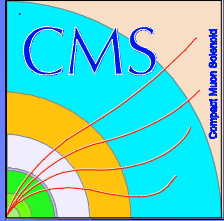
Collection	global	tracker	SA	calo	tr pt	eta	phi	matches	d0	d0 / d0Err	charge
70.2	false	false	true	false	-999.0	0.690	-2.437	0	-999.000	-999.000	1
64.9	false	false	true	false	-999.0	0.735	-2.683	0	-999.000	-999.000	1
42.5	false	false	true	false	-999.0	-0.200	-2.595	3	-999.000	-999.000	-1

loading event ...

**Splash events  
Tracker off  
20th November**

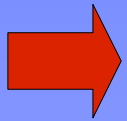


# Status of CMS Calorimeters

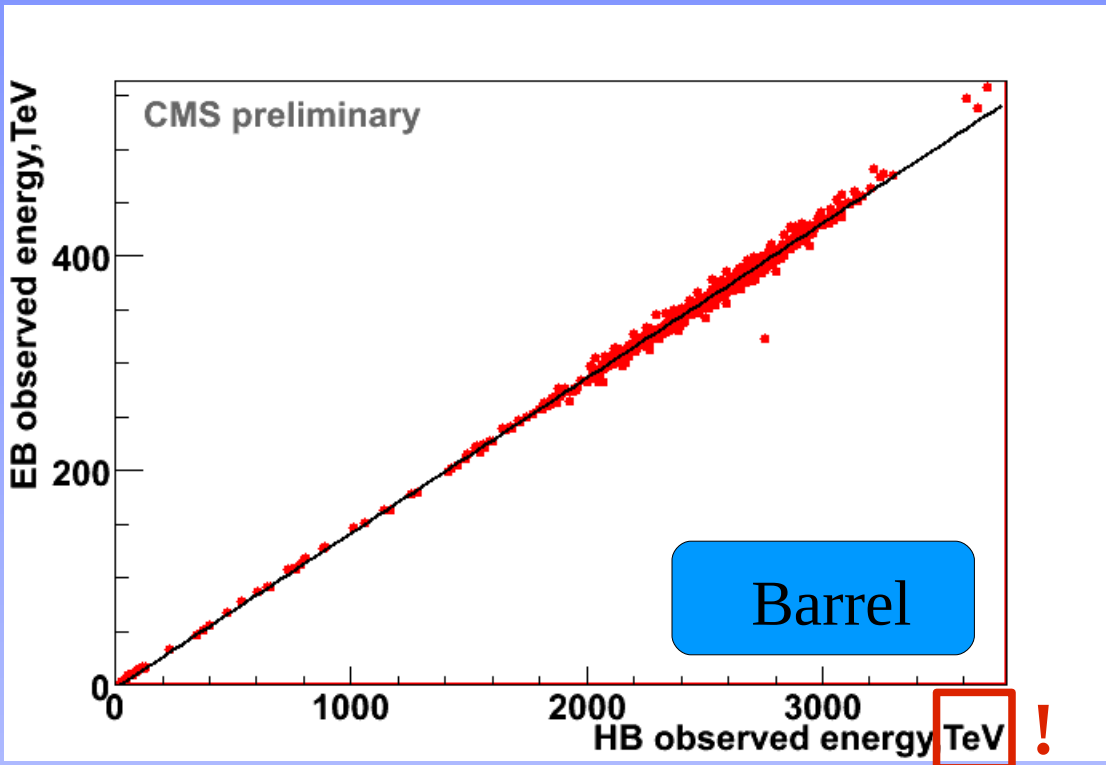
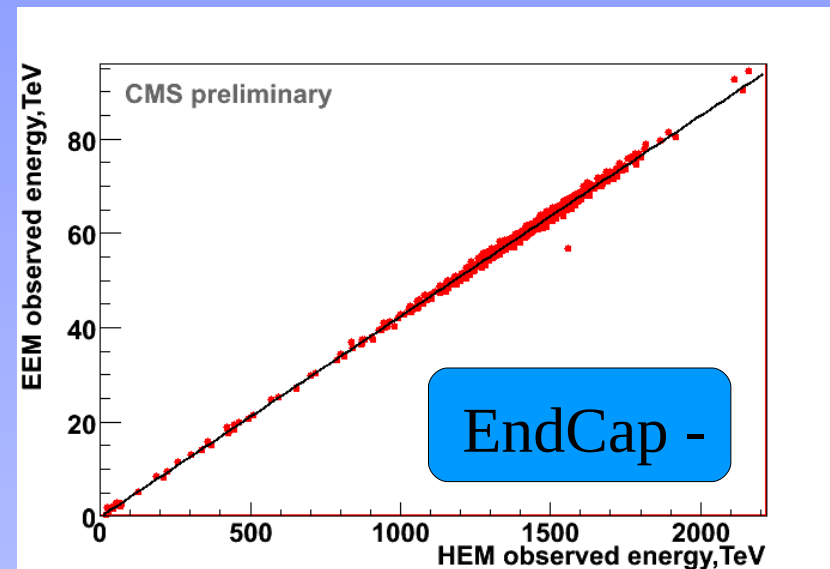
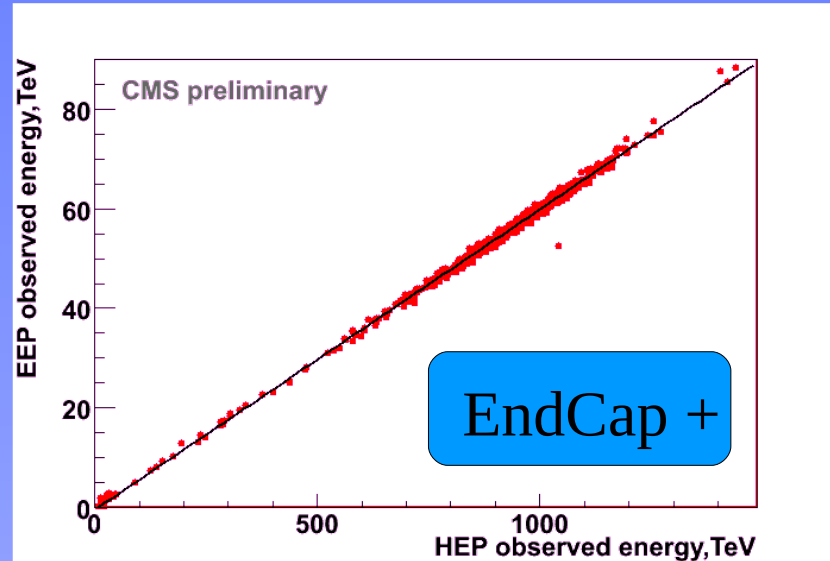


Before first beam fully circulating:  
~1k splash events, up to PeV scale !

Was used to commission ECAL & HCAL

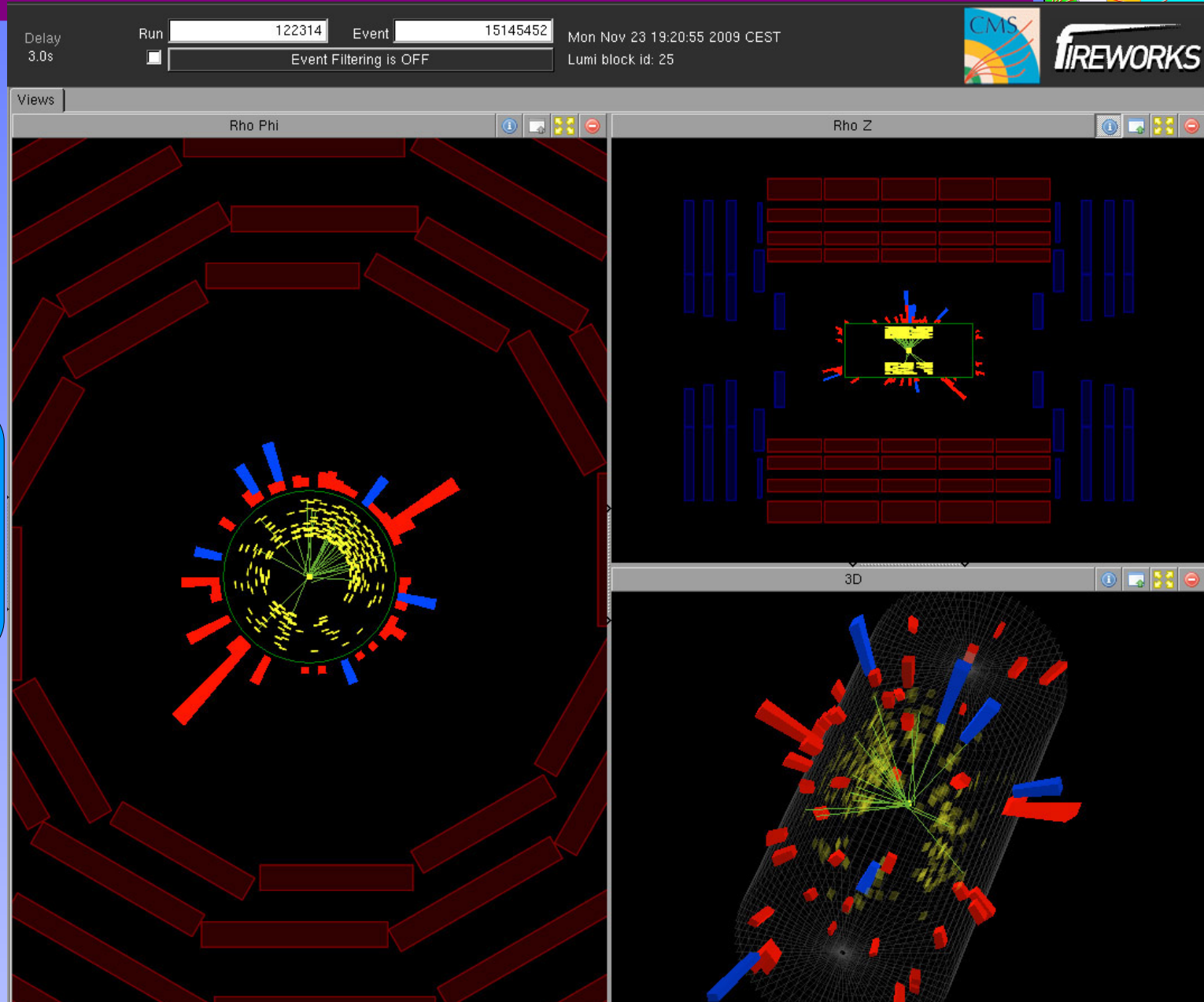
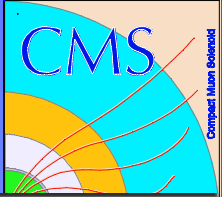


Good linear correlation between their  
measured energy





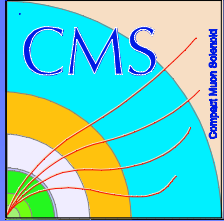
# Collision events



*First events  
23<sup>rd</sup> November*



# First Data



- We have logged about 87% of the luminosity CMS was given
  - Downtimes due to some subdetectors missing, powering up

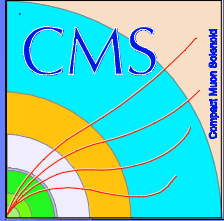
➔ CMS recorded about  $10 \mu\text{b}^{-1}$  at 900 GeV  
CMS recorded about  $400 \text{mb}^{-1}$  at 2.36 TeV

- We have collected about:

➔ 400 k events at 900 GeV  
10 k events at 2.36 TeV



# Status of CMS tracker

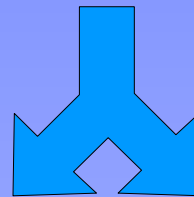
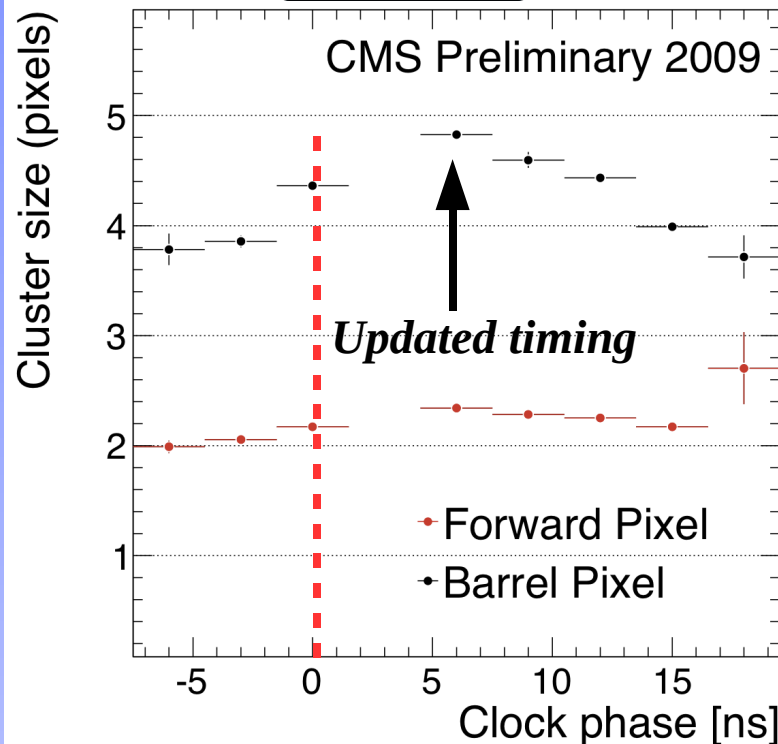


Pixel: 98.4% of channels in operation  
Strip: 97.2% of channels in operation

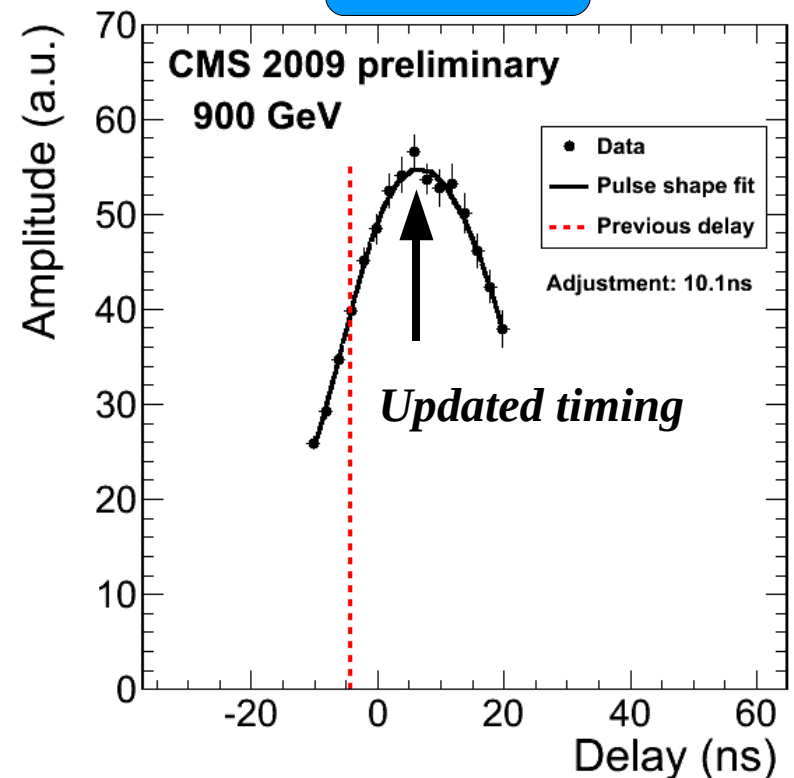
(HV & LV missing, cooling problems)

First collision runs were used  
to time the 2 detectors

**PIXEL**



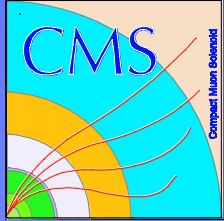
**STRIP**



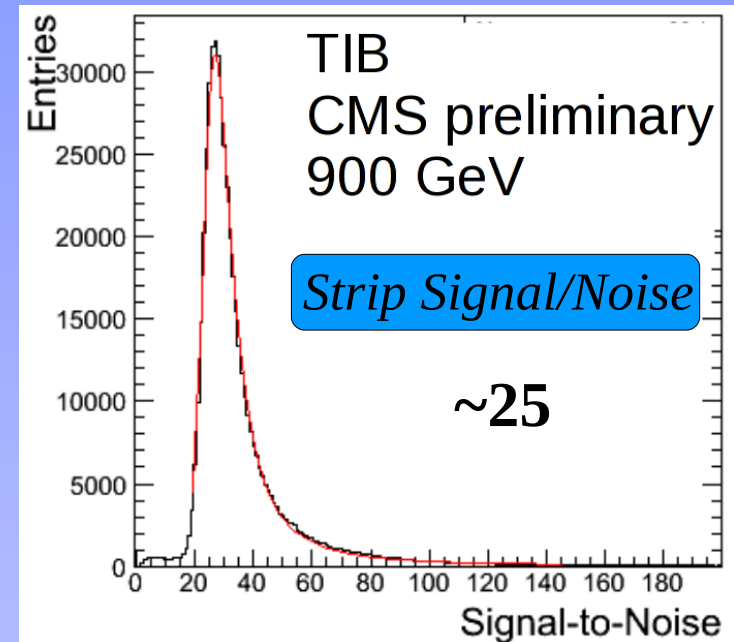
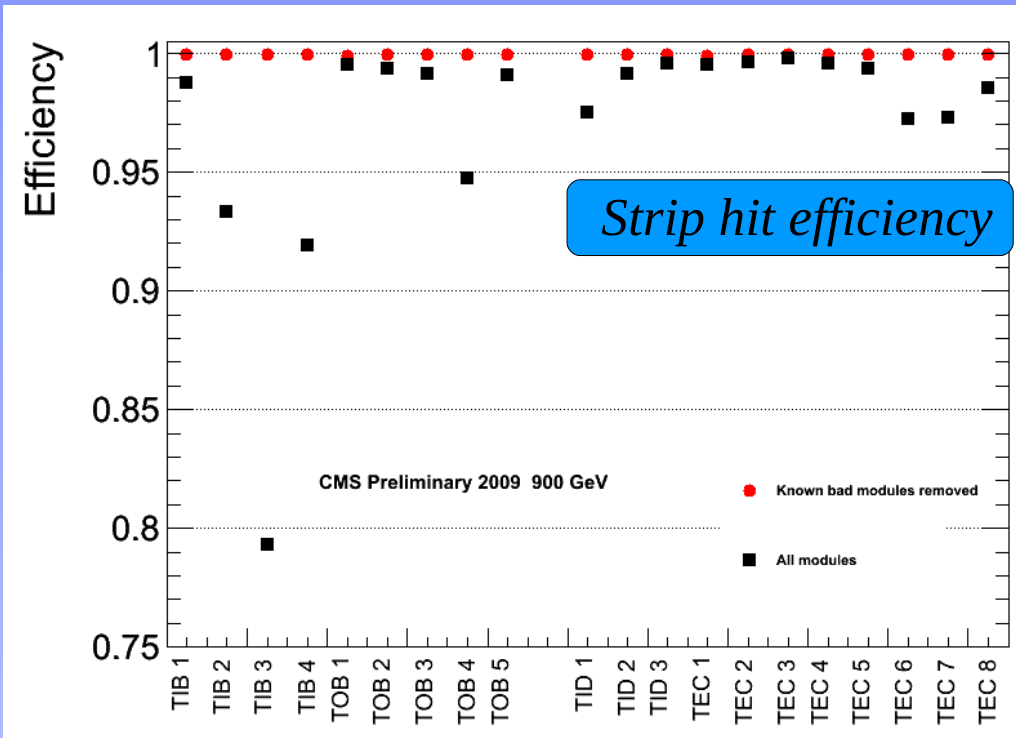
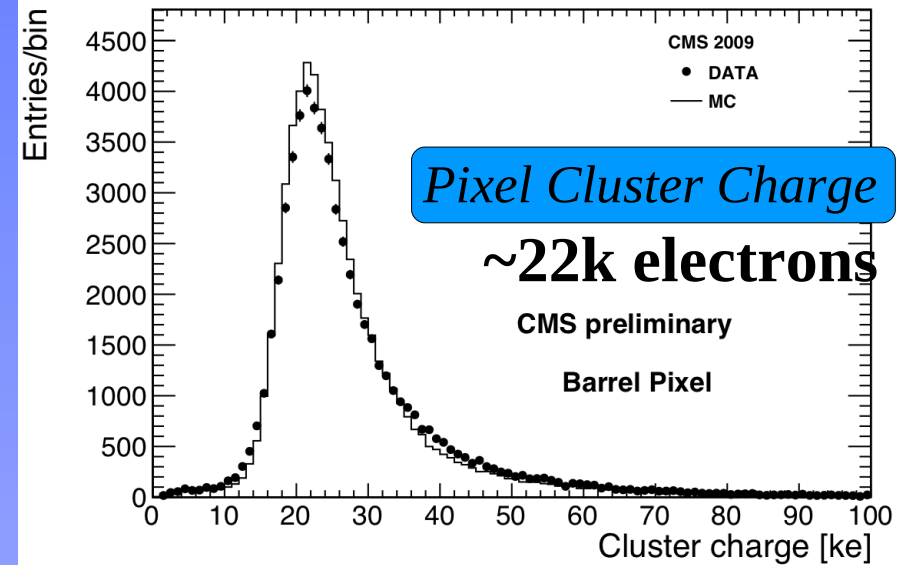




# Tracker performances

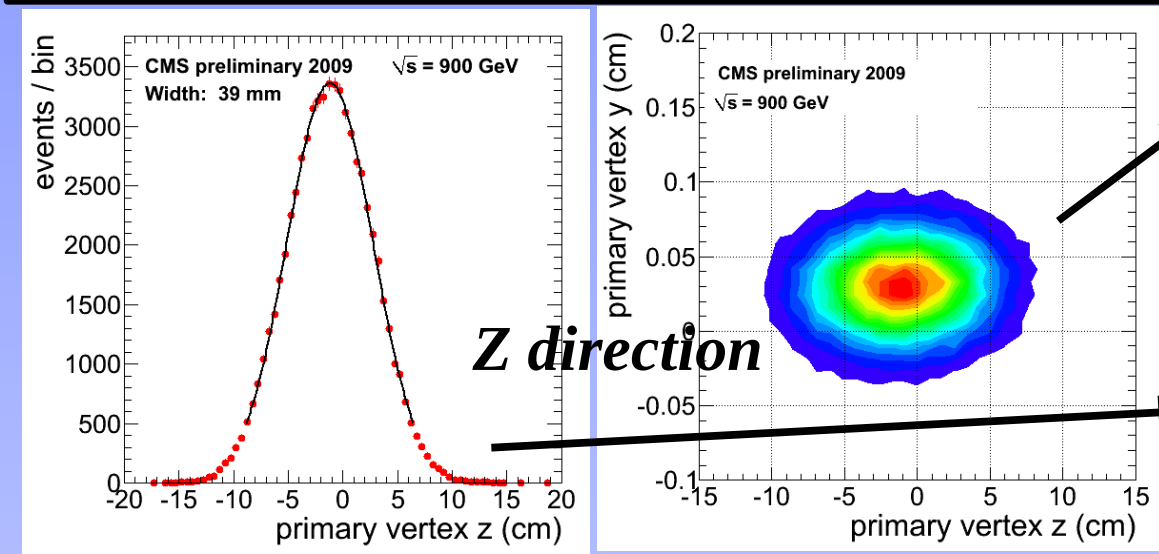
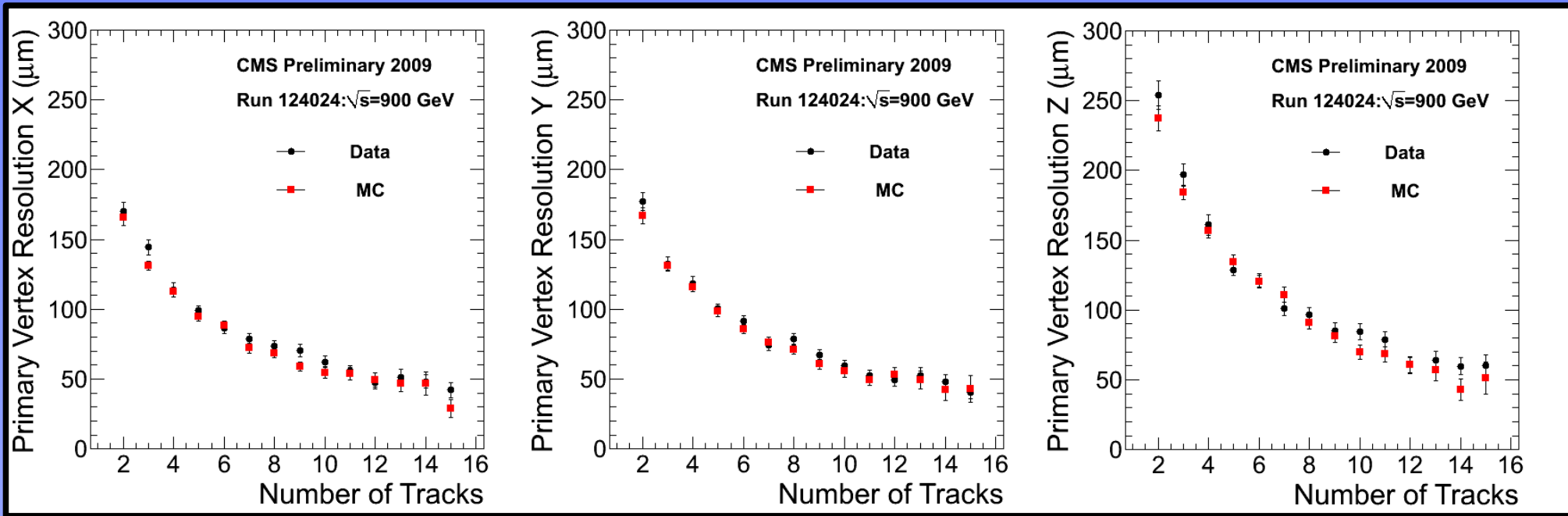
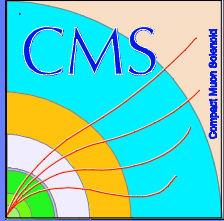


- Strip hit efficiency is very high for all layers/disks once bad modules are understood and removed
- Strip S/N always  $> 19$ , reaches 36 for part of the detector in peak mode
- Pixel Cluster charge agrees well with MC, mean charge deposit is  $\sim 22$ k electrons





# vertex/tracking performances

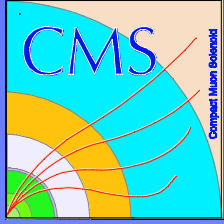


*Collision don't happen at our nominal detector center, was shifted by  $\sim 2\text{cm}$  in Z at the start*

Width in X : 0.22mm  
Width in Y : 0.25mm  
Width in Z : 39mm

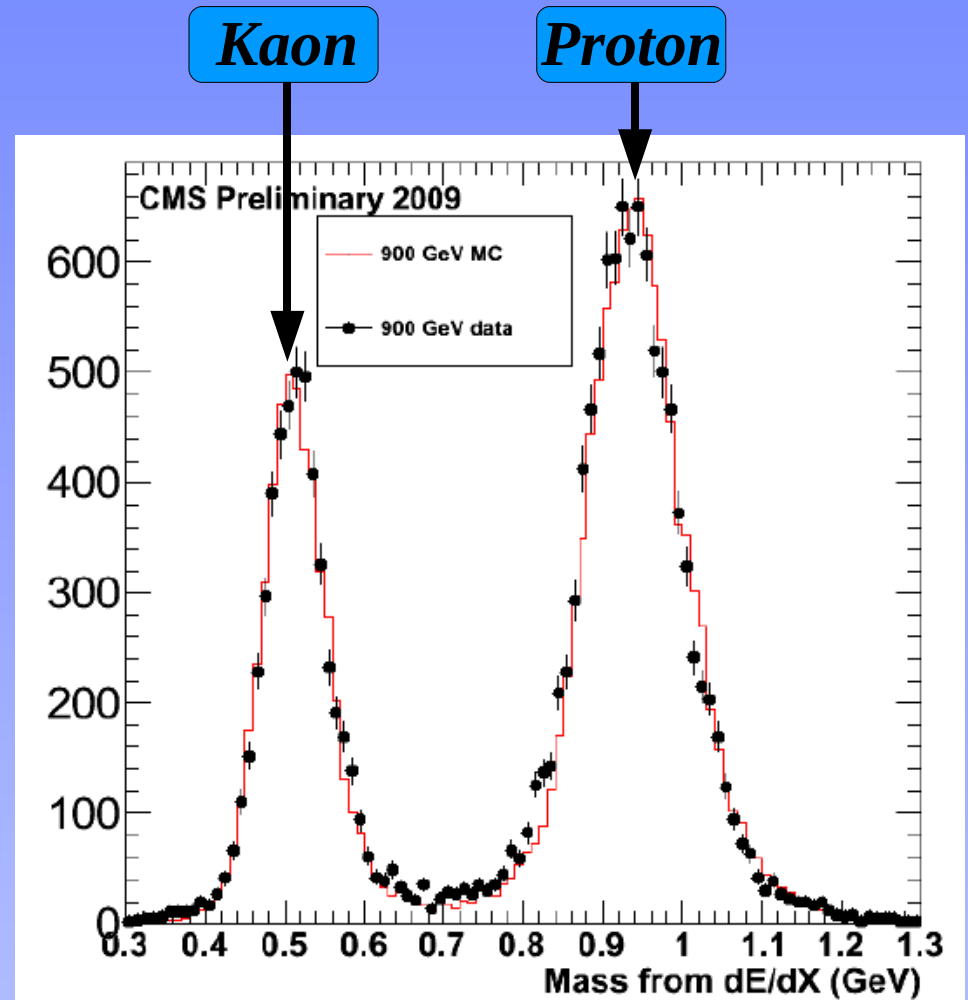
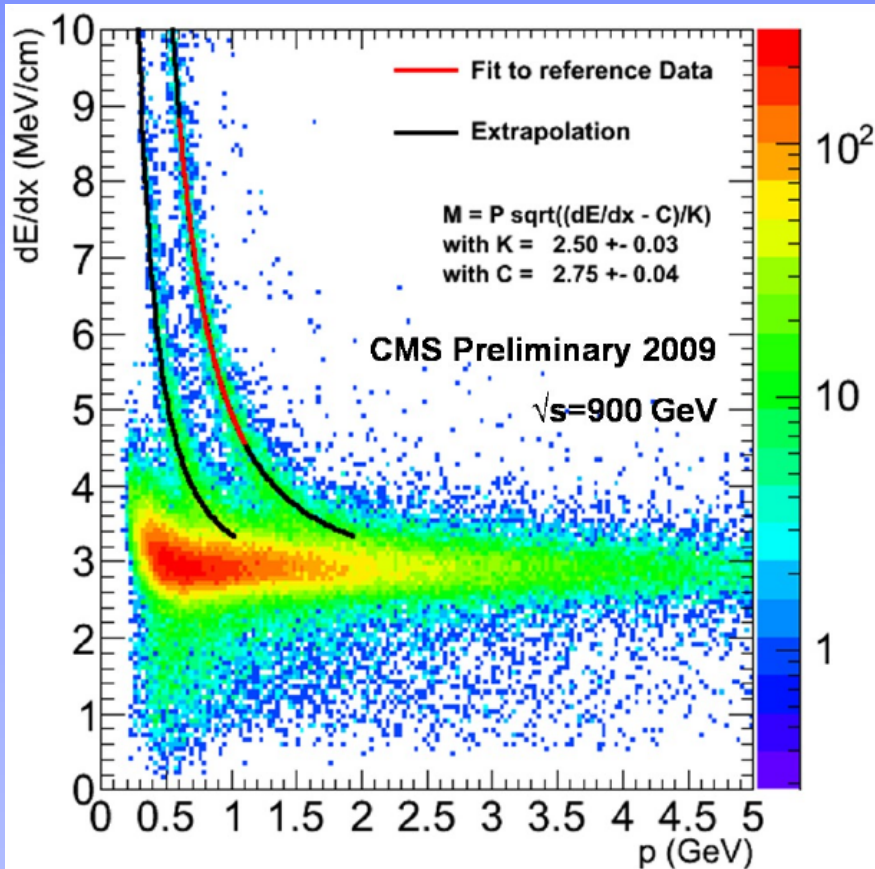


# Kaon and proton peak



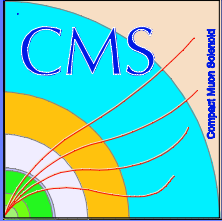
Use fit to reference data, then extrapolate the mass

➔ Peak of K and p clearly visible





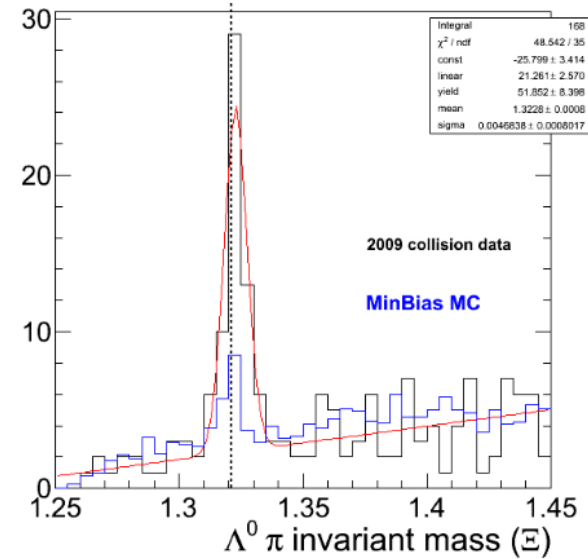
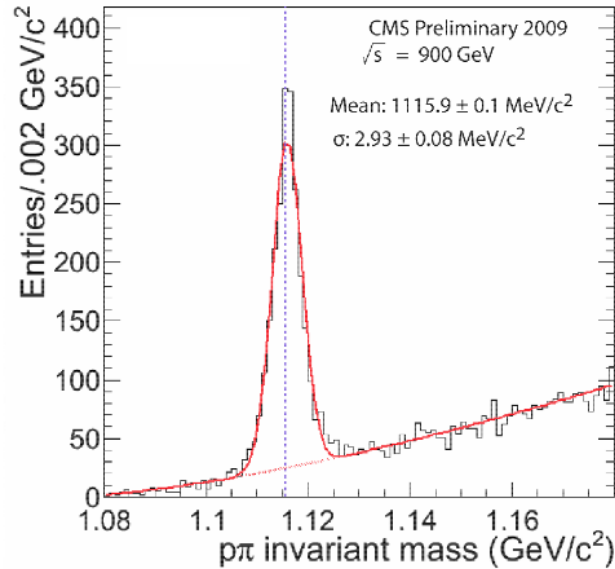
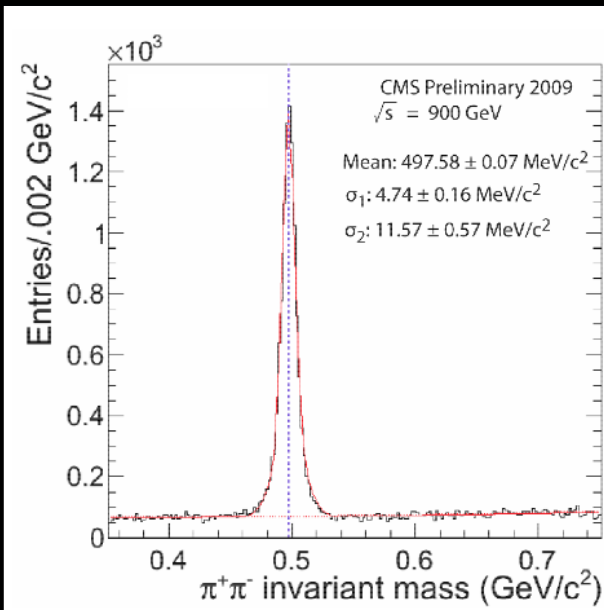
# Resonances



$K_s (\pi^+ \pi^-)$

$\Lambda (p\pi)$

$\Xi^- (\Lambda^0 \pi)$



$$\frac{m}{m_{DPG}} =$$

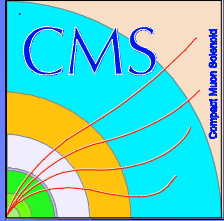
$$1 - (0.7 \pm 1.4) \cdot 10^{-4}$$

$$1 - (1.9 \pm 0.9) \cdot 10^{-4}$$

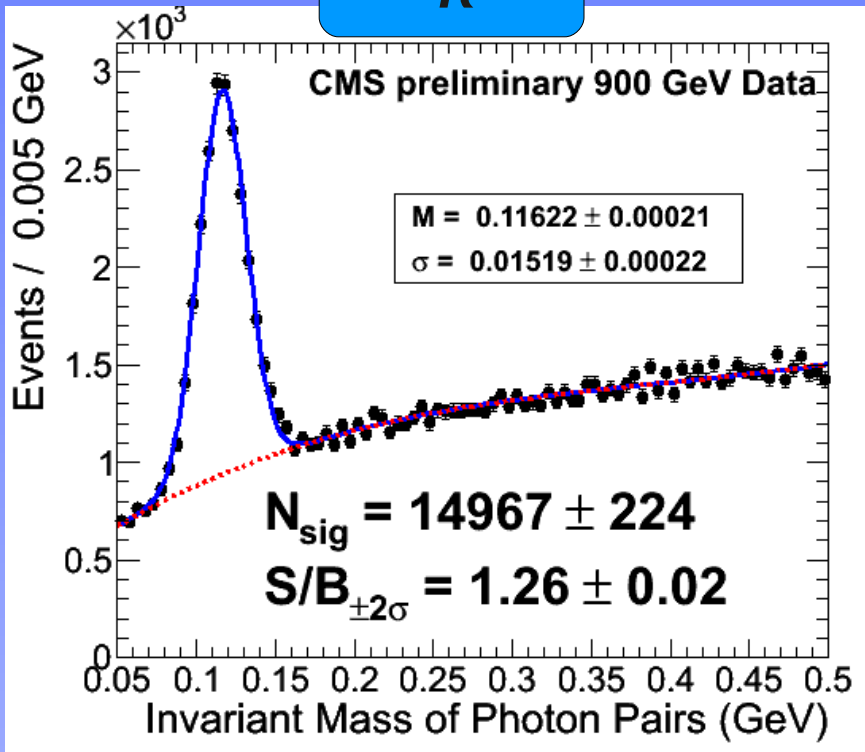
$$1 - (8.2 \pm 6.2) \cdot 10^{-4}$$



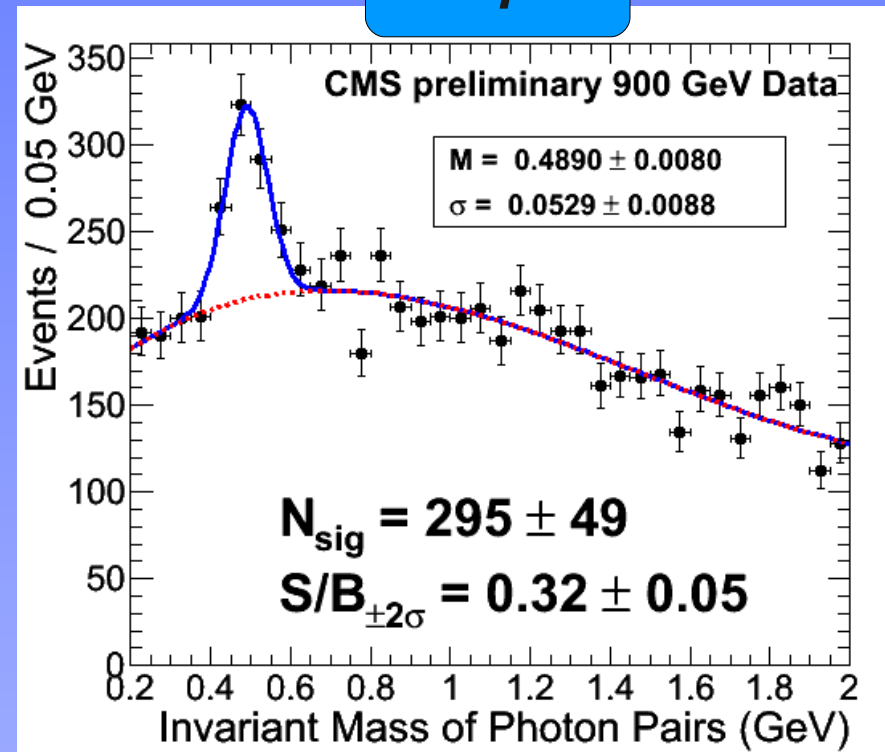
# Resonances (bis)



$\pi^0$



$\eta$



Collected about 30k of  $\pi^0$

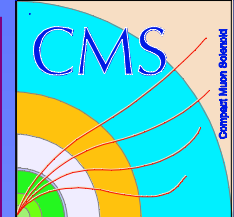
➡ Will enable starting of  $\pi^0$  commissioning

$\eta$  yield scale as expected :

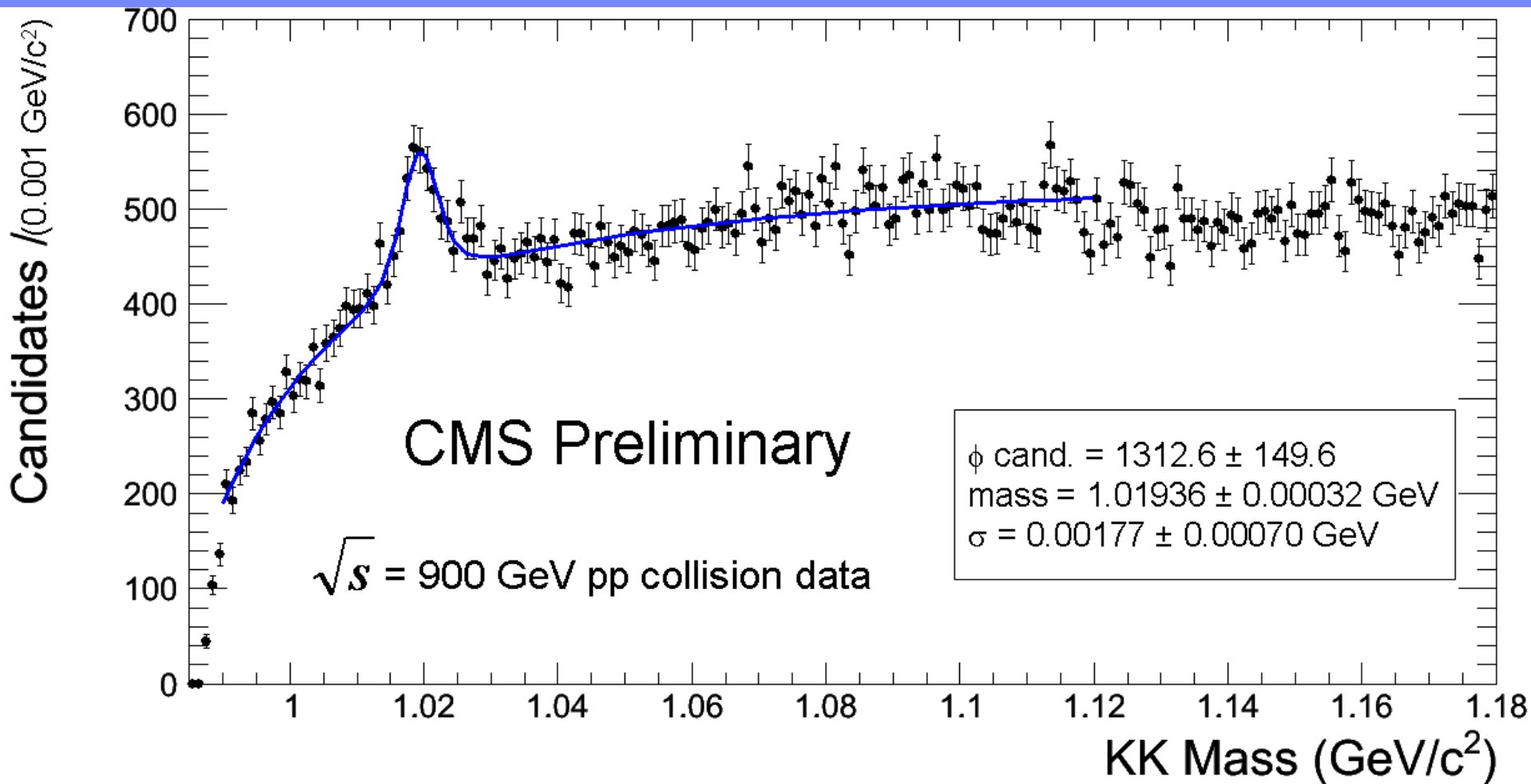
➡  $N(\eta) / N(\pi^0) = 0.020 \pm 0.003$



# Resonance (ter)

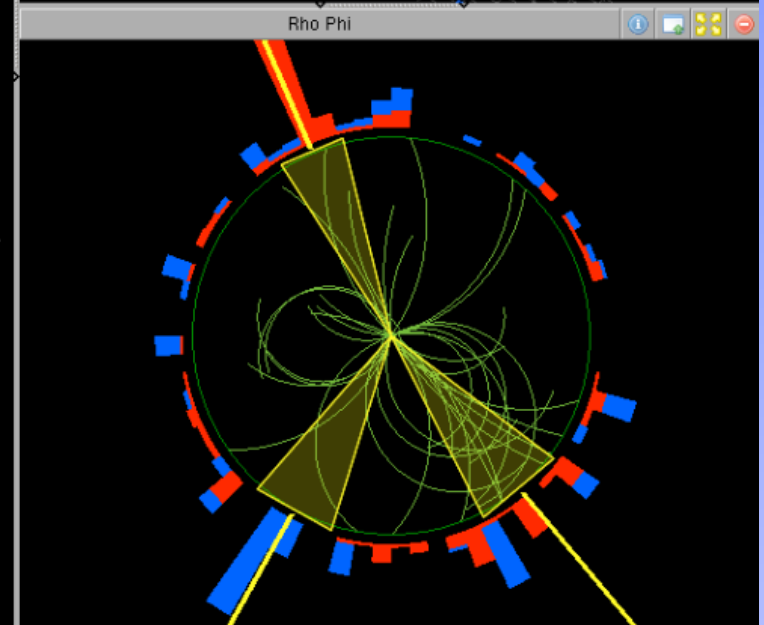
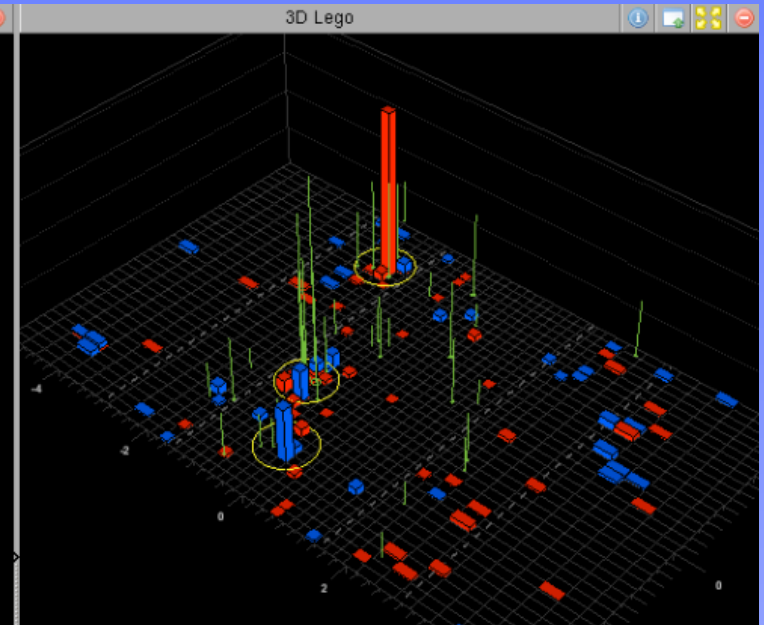
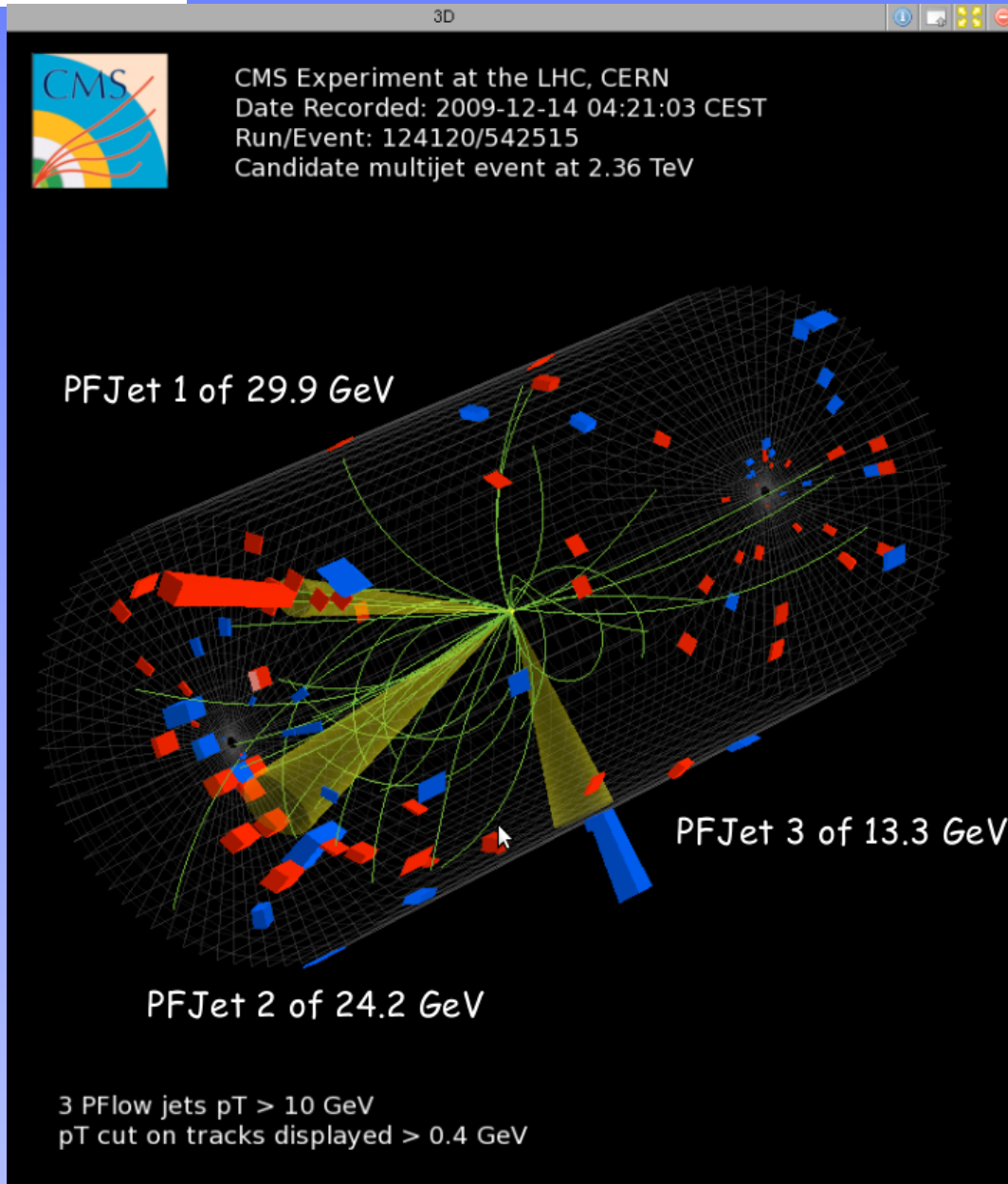
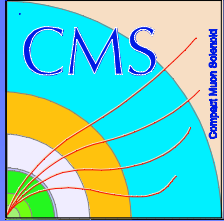


$\Phi \rightarrow KK$



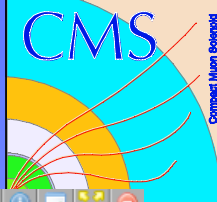


# Multijet event



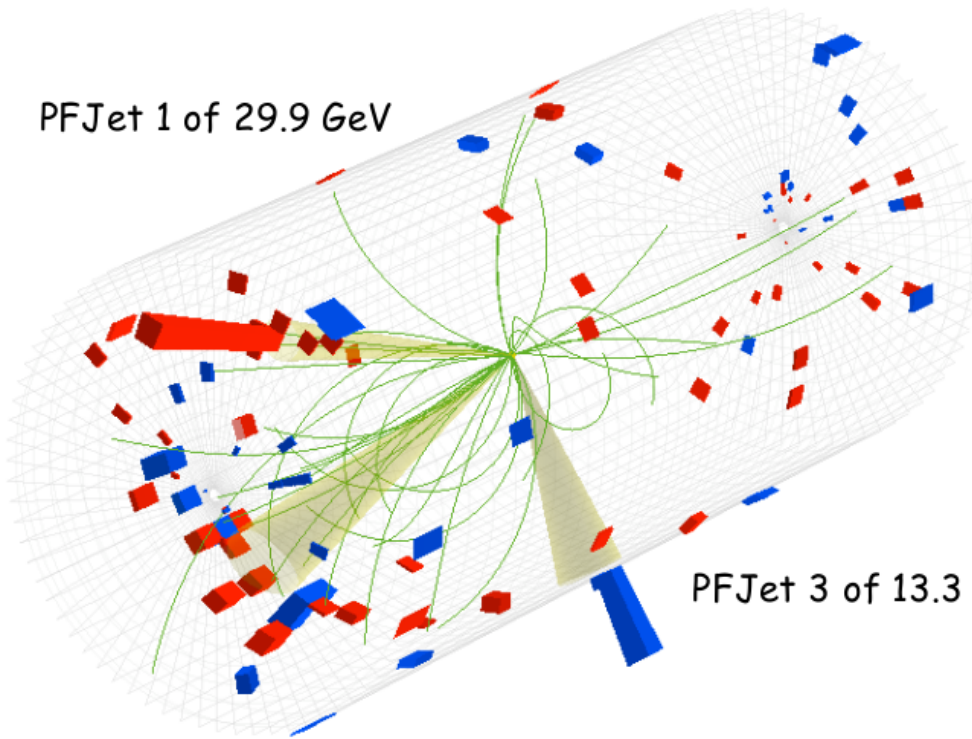


# Multijet event



CMS Experiment at the LHC, CERN  
Date Recorded: 2009-12-14 04:21:03 CEST  
Run/Event: 124120/542515  
Candidate multijet event at 2.36 TeV

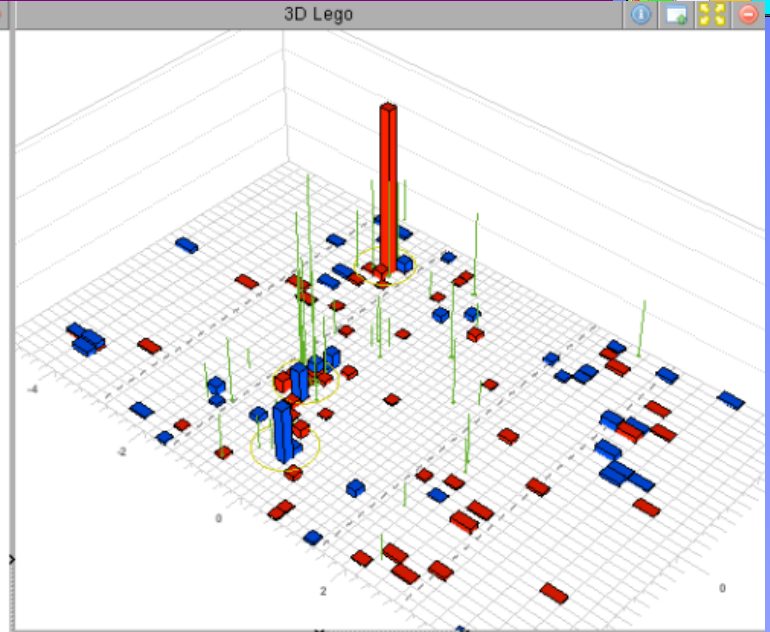
PFJet 1 of 29.9 GeV



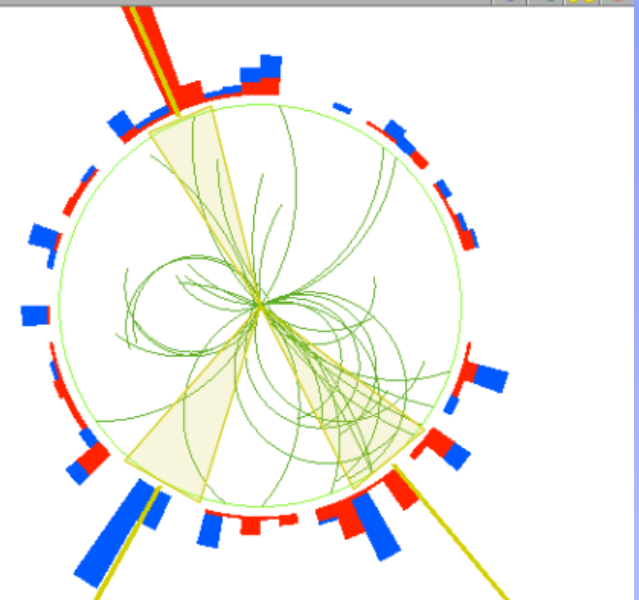
PFJet 2 of 24.2 GeV

PFJet 3 of 13.3 GeV

3 PFlow jets  $p_T > 10$  GeV  
 $p_T$  cut on tracks displayed  $> 0.4$  GeV



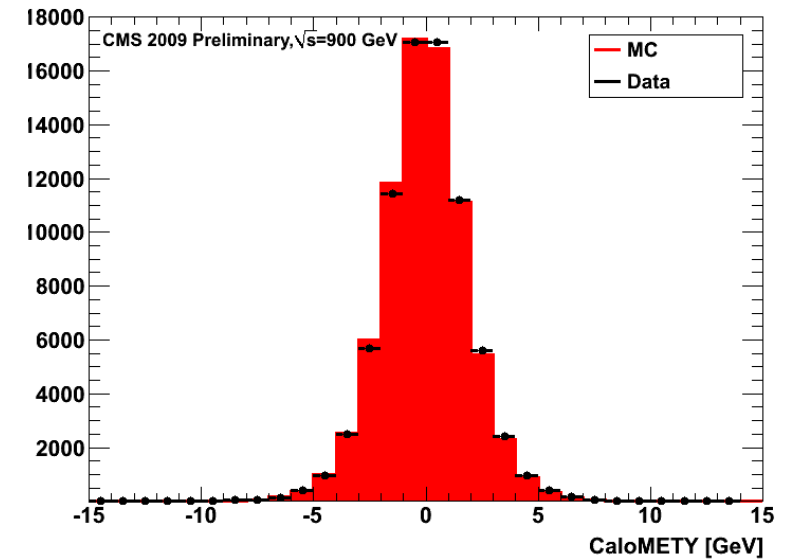
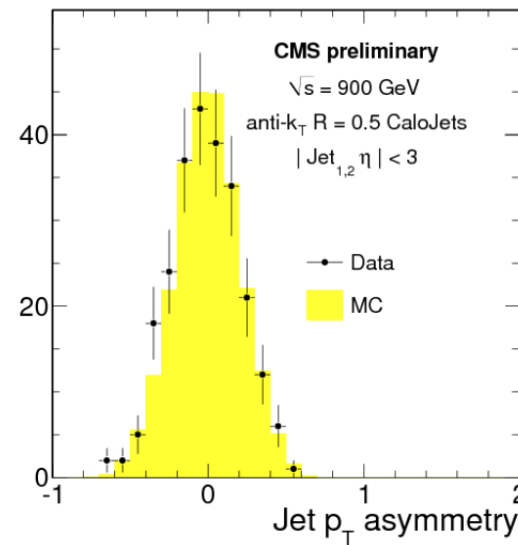
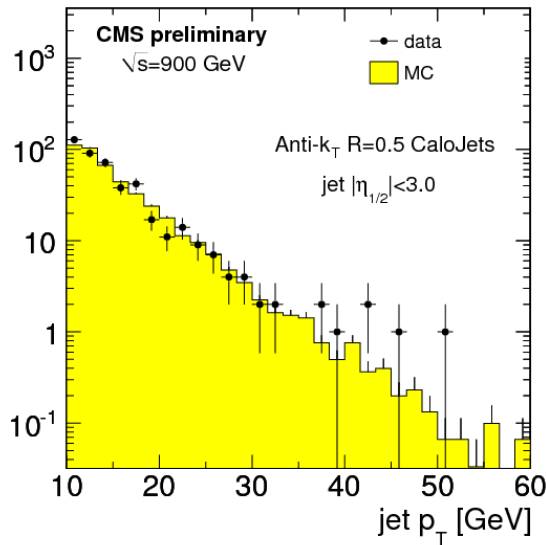
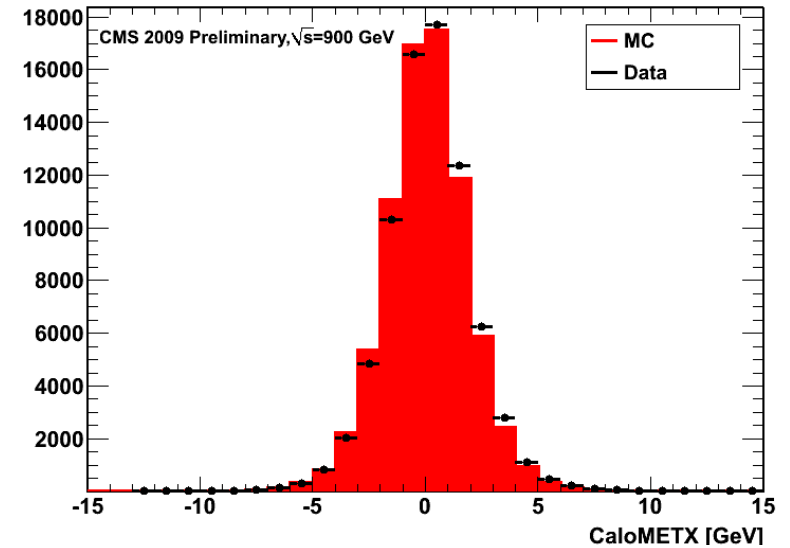
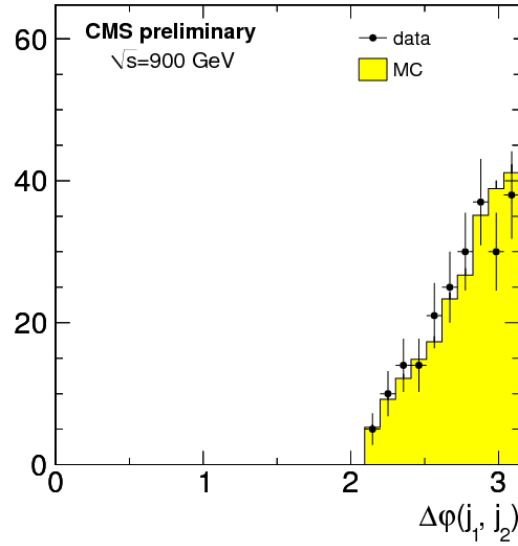
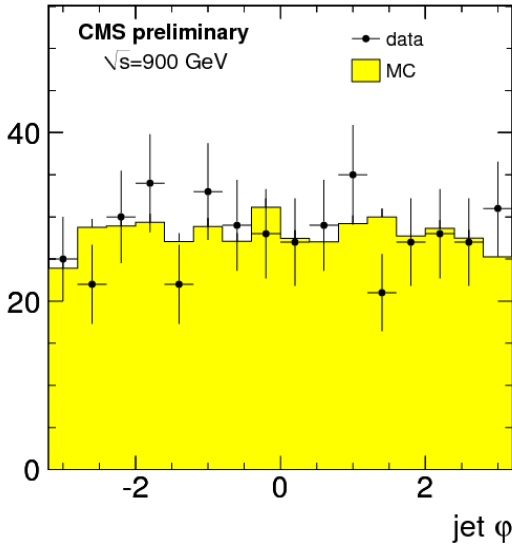
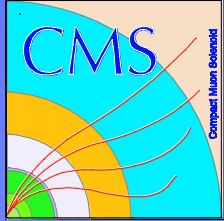
Rho Phi





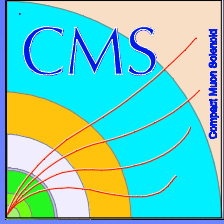


# Dijet Event





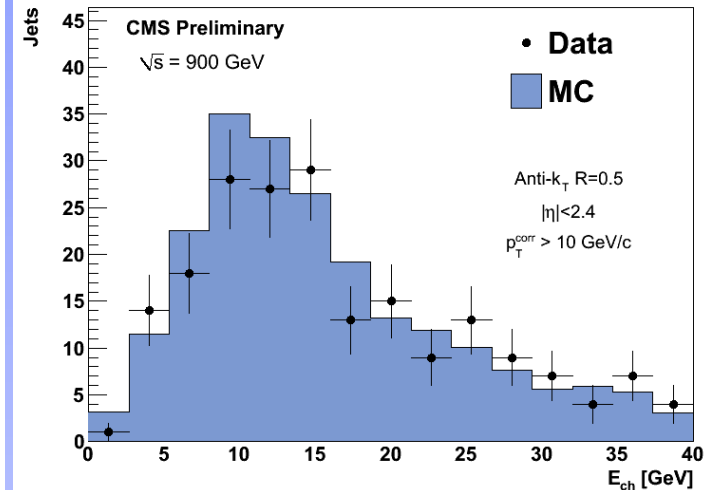
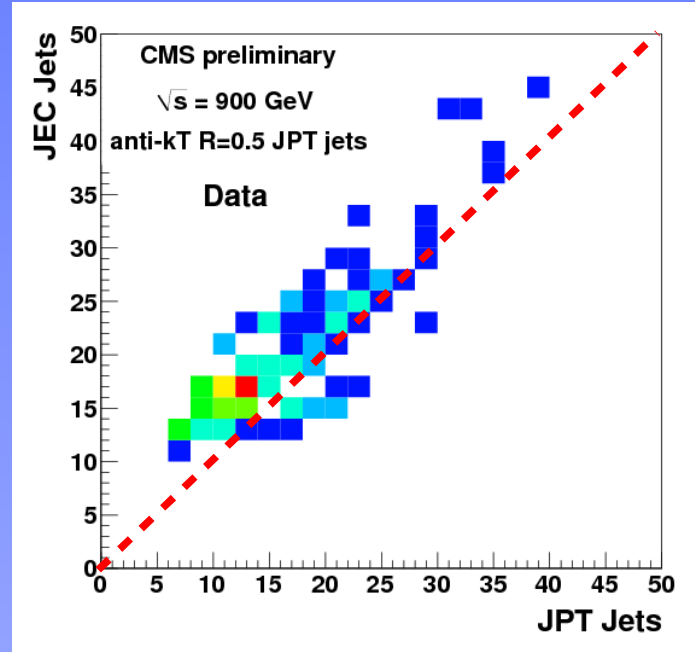
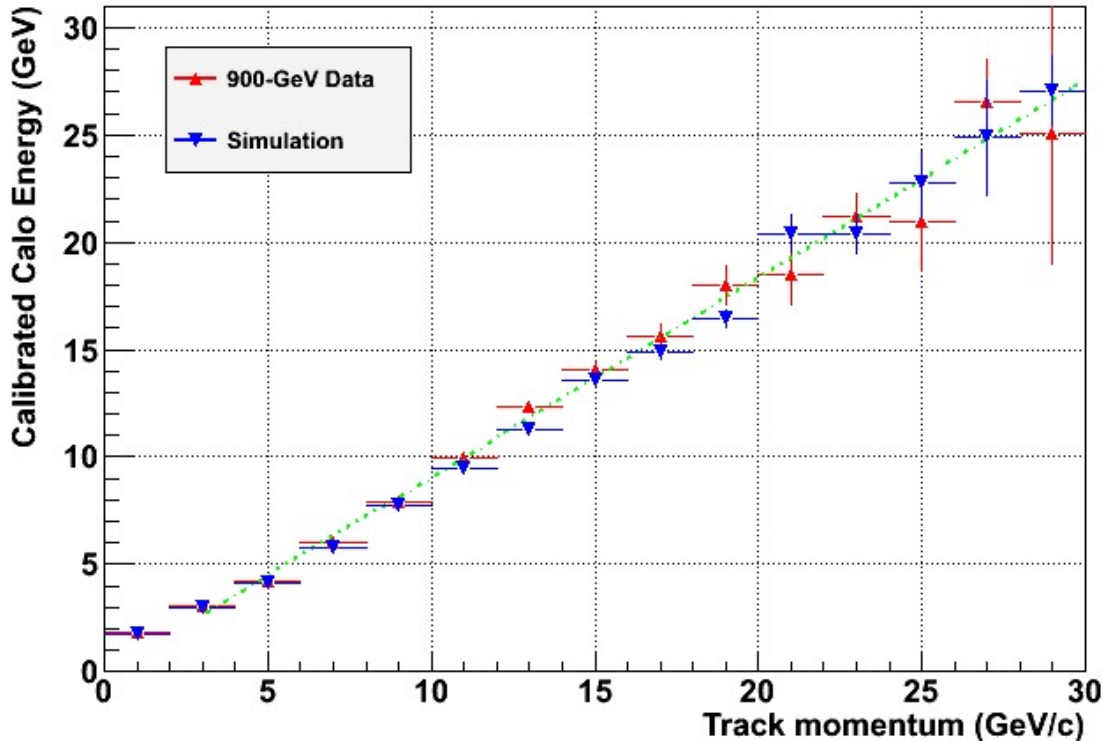
# Particle flow



PF combines tracking and calorimetry

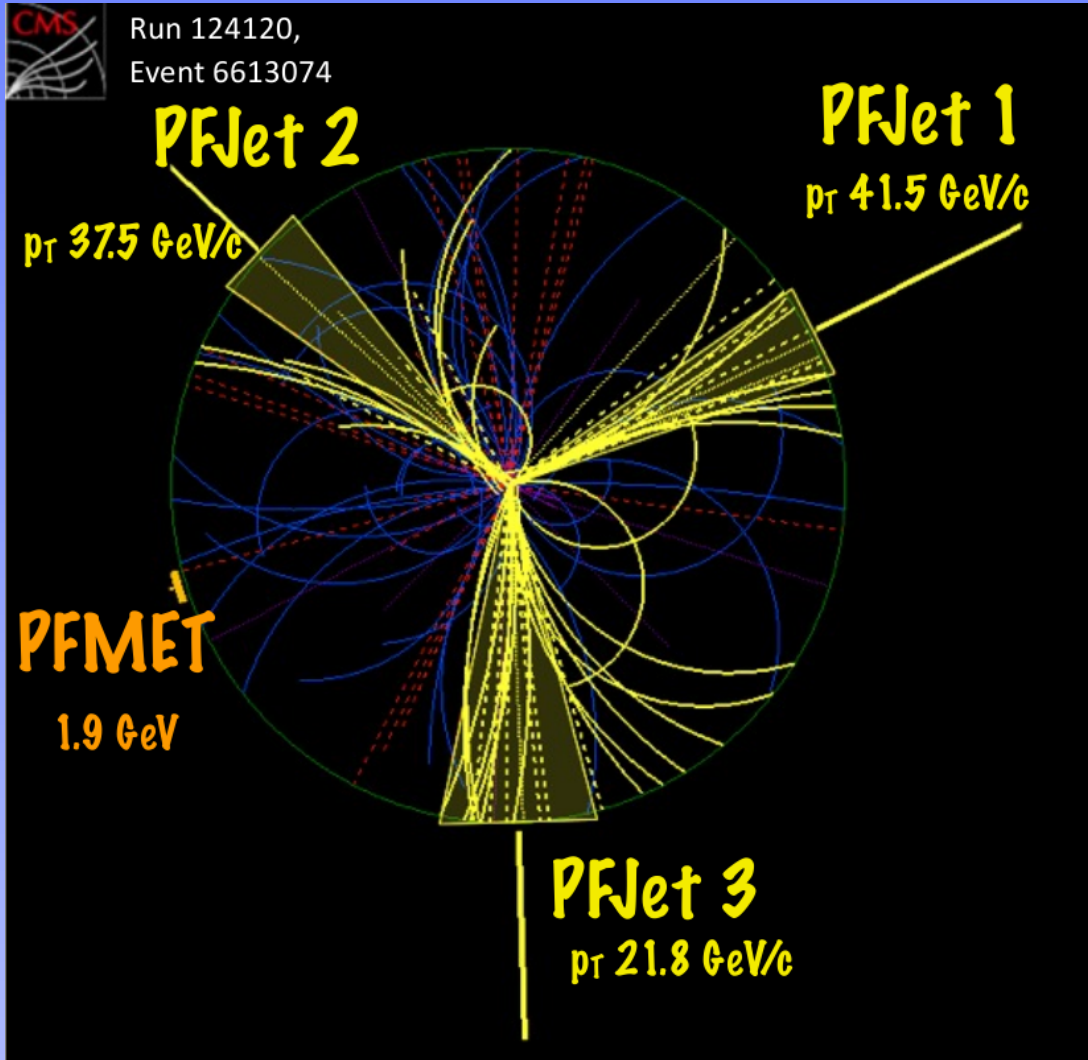
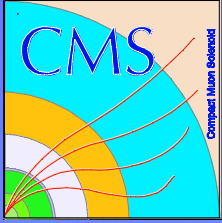
- Calo energy and track momentum are well correlated
- Slightly less jets when also using tracks (JPT) than just the calorimeter (JEC)

CMS Preliminary 2009





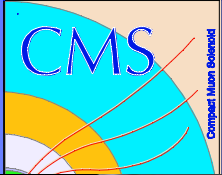
# Particle flow



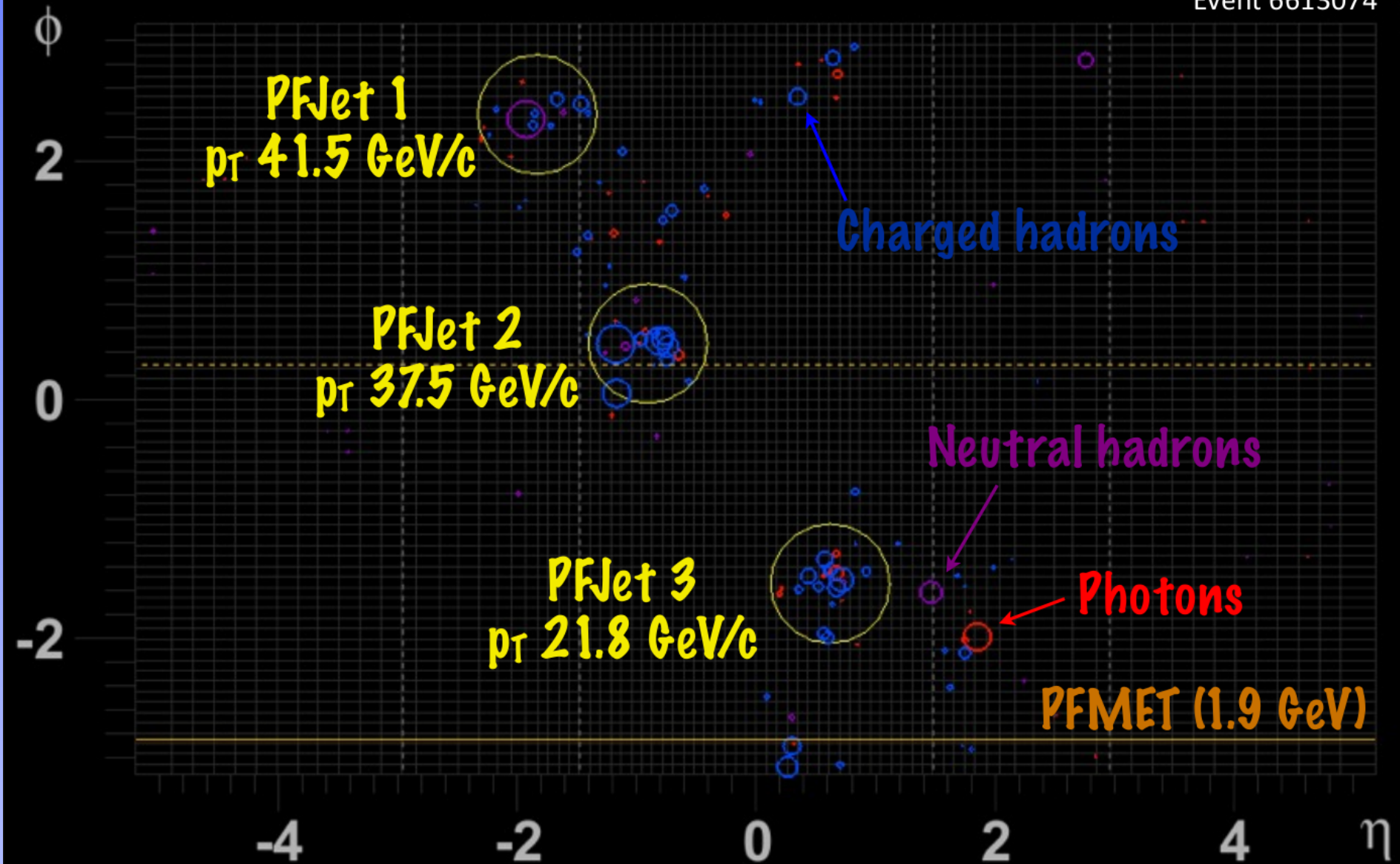
- PFJets with (uncorrected)  $p_T > 20$  GeV/c
- Particle inside the jet:
- Charged hadrons —————
  - Photons - - - - -
  - Neutral hadrons . . . . .
- Particles outside the jet:
- Charged hadrons
  - **Photons**
  - Neutral hadrons
- PFMET (1.9 GeV)**



# Particle Flow

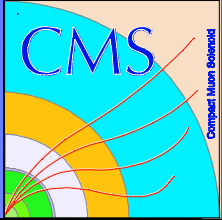


Run 124120,  
Event 6613074

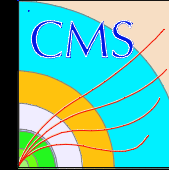




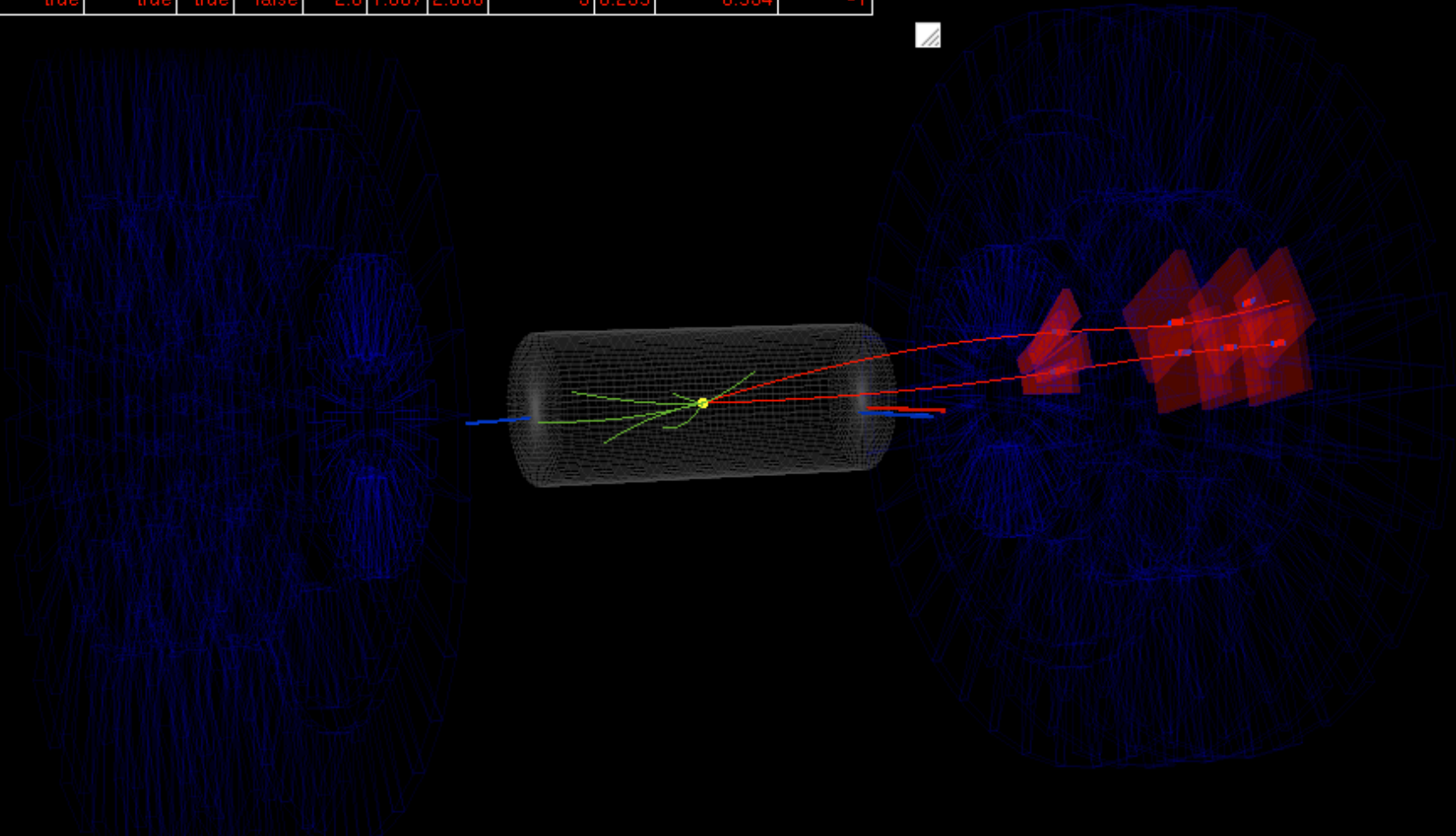
# Di-muons



$\nabla p_T$	global	tracker	SA	calo	tr pt	eta	phi	matches	d0	d0 / d0Err	charge
3.6	true	true	true	false	3.6	2.025	3.110	4	0.161	6.716	1
2.6	true	true	true	false	2.6	1.807	2.088	3	0.259	8.934	-1



Run: 124120  
event: 5686693



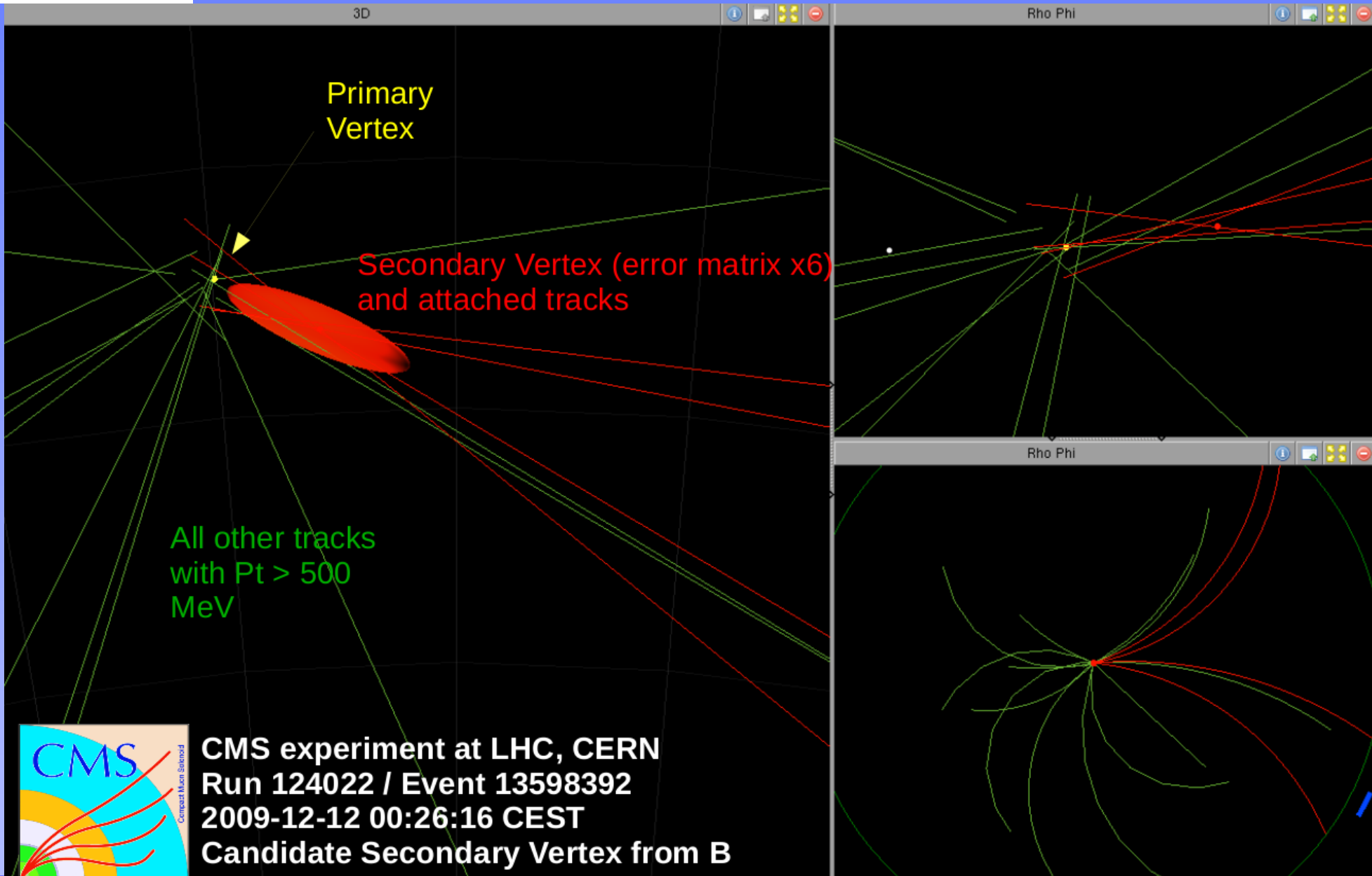
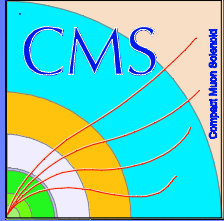
1<sup>st</sup> muon:  $p_T = 3.56 \text{ GeV}$

2<sup>nd</sup> muon:  $p_T = 2.56 \text{ GeV}$

$m(\mu\mu) = 3.03 \text{ GeV}$

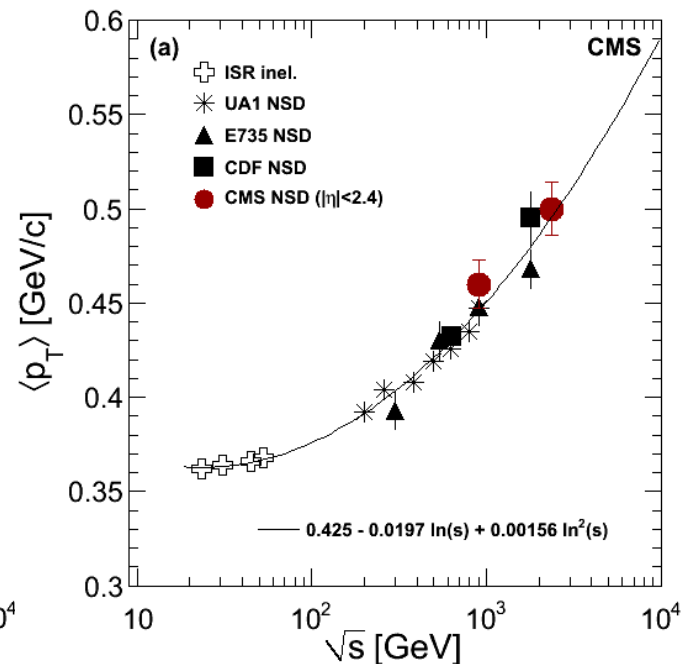
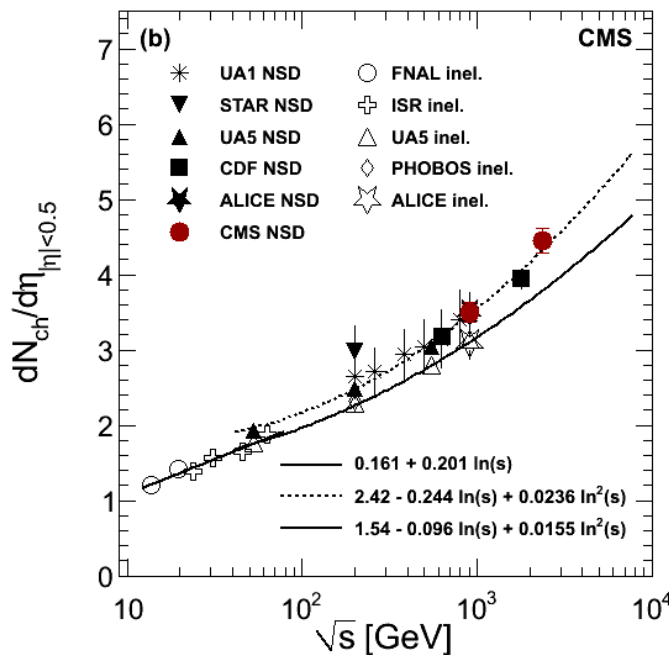
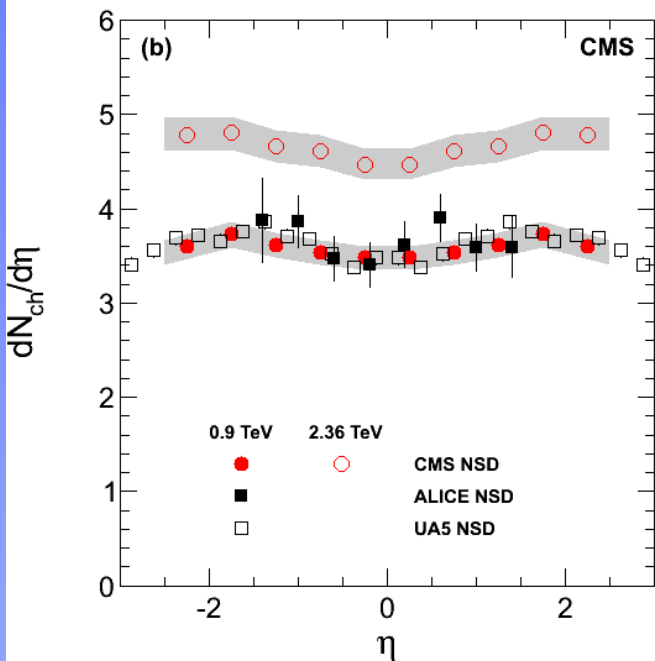
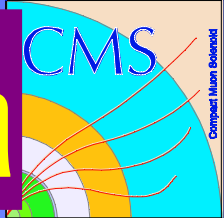


# B candidate





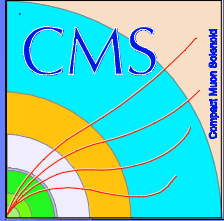
# First paper: $dN/dp_T$ and $dN/d\eta$



- First results to be published in CMS' first paper: ArchXiv:1002.0621v1
- Title: « *Transverse-momentum and pseudorapidity distributions of charged hadrons in pp collisions at  $\sqrt{s} = 0.9$  and 2.36 TeV* »
- Agrees well with UA5 and Alice
- Uncertainties are dominated by the systematics



# Future

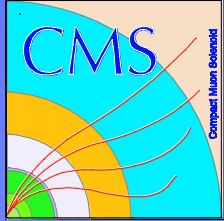


- During this winter shutdown, the detector has been reopened to let repairs take place.
- Is now closed, and ready for new data to come.
- At least 2 more physics papers will come in the next months:
  - One on the underlying events
  - One on the multiplicity
- Some detector papers are also being prepared.
- CMS is ready for higher luminosity and higher energy !



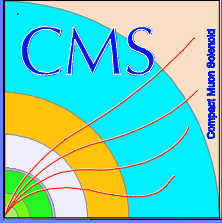


# Conclusions



- Everyone was very happy to (at last) have the first collision data, reward of many years of work.
- The extensive knowledge and experience acquired this last year during cosmic data taking has proven itself to be very useful for the operation of the CMS detector.
- Few hours after the first collisions, results were already showing up. There has been a lot of work done since, shown only partly here.
- The resonances observed show that though no further precision can be added to the measurement (yet), CMS performs extremely well !
- First CMS analysis has been published, will be followed by many in the near future.

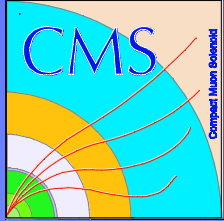
Hopefully this won't be the end,  
We are all eagerly waiting for the next step, at higher energy !



BACKUP



# Di-muon event



run: 124120 event: 5686693 in LS 19

dimuon mass 3.03217. Probab to come from same VTX: 90%

muon1 pt 3.56 eta 2.03 phi 3.11

muon2 pt 2.56 eta 1.81 phi 2.09

mu1 is Tracker Muon, is StandAlone, isCalo, isGlobal

Tracker mu normalized chi2: 0.47, UsedHits: 20

standAlone mu normalized chi2: 1.55, UsedHits: 23

Global Muon normalized chi2: 0.97, UsedHits: 43

mu2 is Tracker Muon, isStandAlone, isCalo, isGlobal

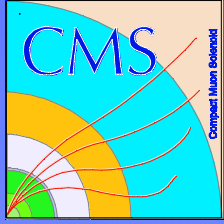
Tracker mu normalized chi2: 0.46, UsedHits: 21

standAlone mu normalized chi2: 38.88, UsedHits: 0

Global Muon normalized chi2: 0.46, UsedHits: 21



# B-candidate event



- Used SimpleSecondary Vertex b-tag on PFJet antiKt0.7
- EVENT: Run 124022, event 13598392, lum 87, bx 151, orbit 90785614
  - 18 tracks at PV, PV error (x:  $4.2\mu\text{m}$ , y:  $4.1\mu\text{m}$ , z:  $7.7\mu\text{m}$ )
  - 1 Anti-KT 0.7 PF Jet  $> 3\text{ GeV}$ :  $p_T = 10\text{ GeV}$ ,  $\eta = -1.42$ ,  $\phi = 0.20$
  - 8 tracks with 3 pixel hits, 1 track with 2 hits
  - All four tracks:

pt [GeV]	#px	#tot	$\chi^2/\text{ndf}$	$dz_{\text{sig}}$	$dxy_{\text{sig}}$	$IP3D_{\text{sig}}$	wgt in PV	$\sigma(\text{IP})$
● 1.11	2	9	16.1/23	-3.94	-0.08	3.82	0.036	$\sim 18\mu\text{m}$
● 1.26	3	9	17.4/19	-3.86	-2.60	4.21	0.001	$\sim 9\mu\text{m}$
● 1.39	3	9	38.6/25	1.47	2.68	2.87	0.427	$\sim 10\mu\text{m}$
● 2.04	3	14	16.5/33	1.72	0.27	1.56	0.920	$\sim 8\mu\text{m}$

–  $\chi^2/\text{ndf} = 1.67 / 5$

–  $m = 1.64\text{ GeV}$

–  $L_{xy}/\sigma = 0.12 / 0.019\text{ [cm]} = 6.6$

–  $L_{3D}/\sigma = 0.26 / 0.037\text{ [cm]} = 7.0$



# Dijet event

