Hot Topics from CMS

(off the press)

Les Rencontres de Physique de la Vallée d'Aoste

La Thuile, 2010

Stéphanie Beauceron

on behalf of the CMS collaboration

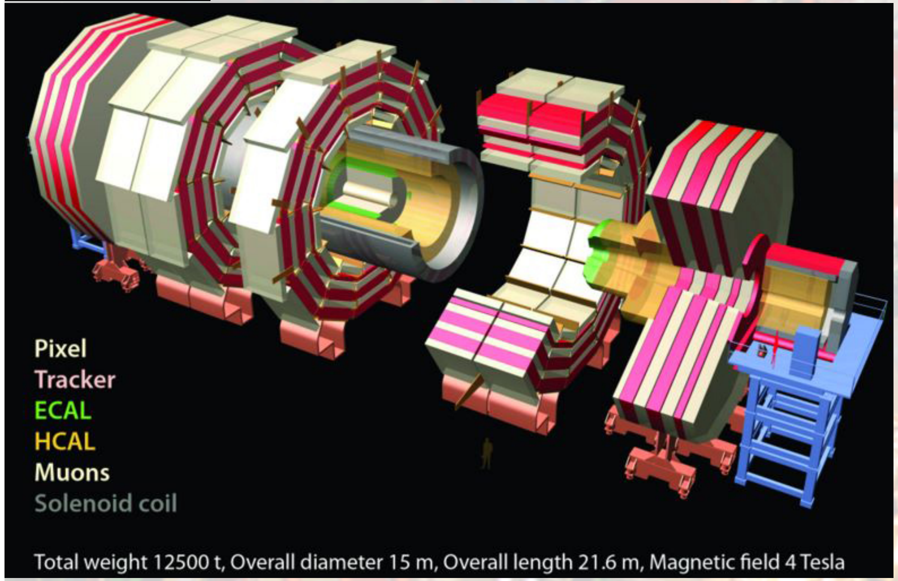
Courtesy of R. Tenchini

On the Road to Standard Model and Searches…

- Tracker, wonderful tool
- Ecal, control calibration
- Jets
- Missing E_T, a challenging variable
- Particle Flow algorithm, improvement all the way…

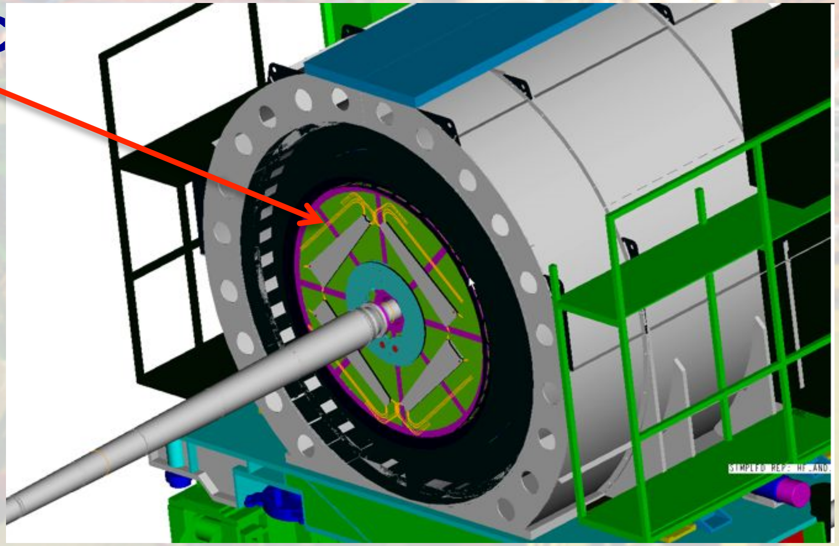
- Conclusion

CMS Data Recording



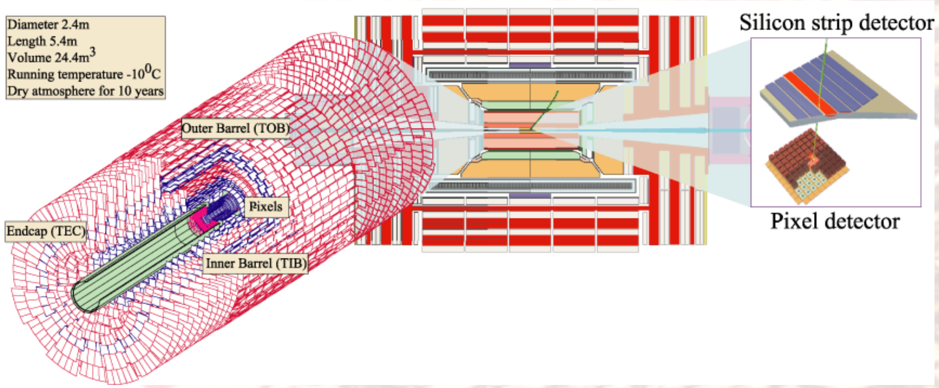
Data are recorded using High Level Trigger as a pass through (rate of collisions maximum 20 Hz)
➔ Record all events
➔ Mainly identify collisions events using Beam Scintillator Counter [BSC]

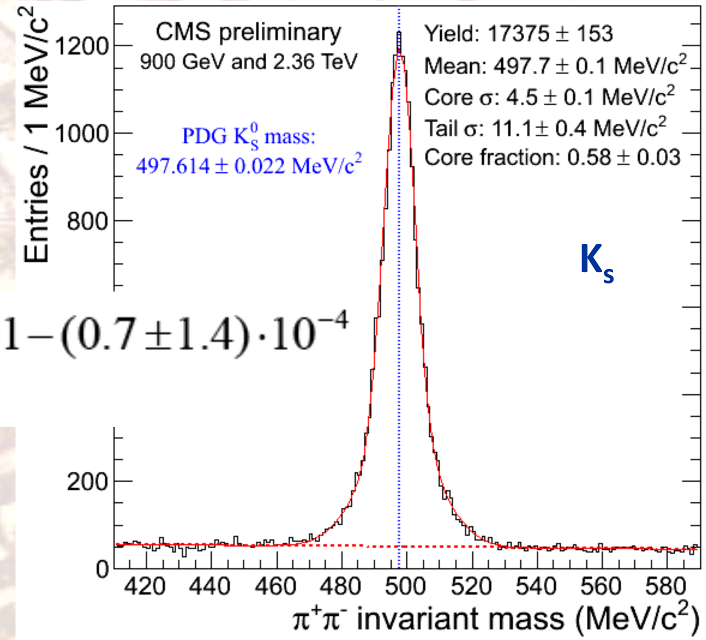
BSC



Luminosity recorded:
~10 μb^{-1} at 900 GeV
~0.4 μb^{-1} at 2.36 TeV

Tracking Quality





$$\frac{m}{m_{PDG}} = 1-(0.7\pm1.4)\cdot10^{-4}$$

Alignment from Cosmics data taken over summer 2009.

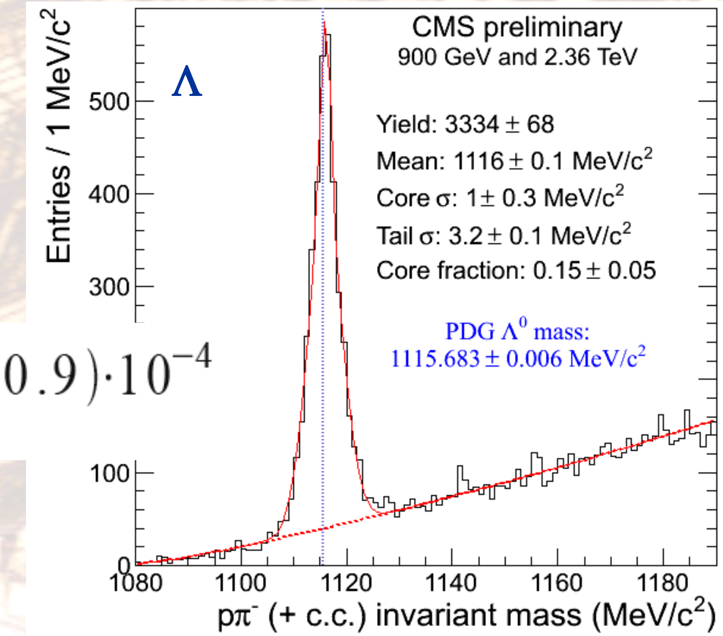
Selection:

Tracks with at least 6 hits

Normalized chi² < 5

impact parameter with beam spot > 0.5 sigma,

Both tracks at 1 cm of each other, oppositely charged



$$\frac{m}{m_{PDG}} = 1+(1.9\pm0.9)\cdot10^{-4}$$

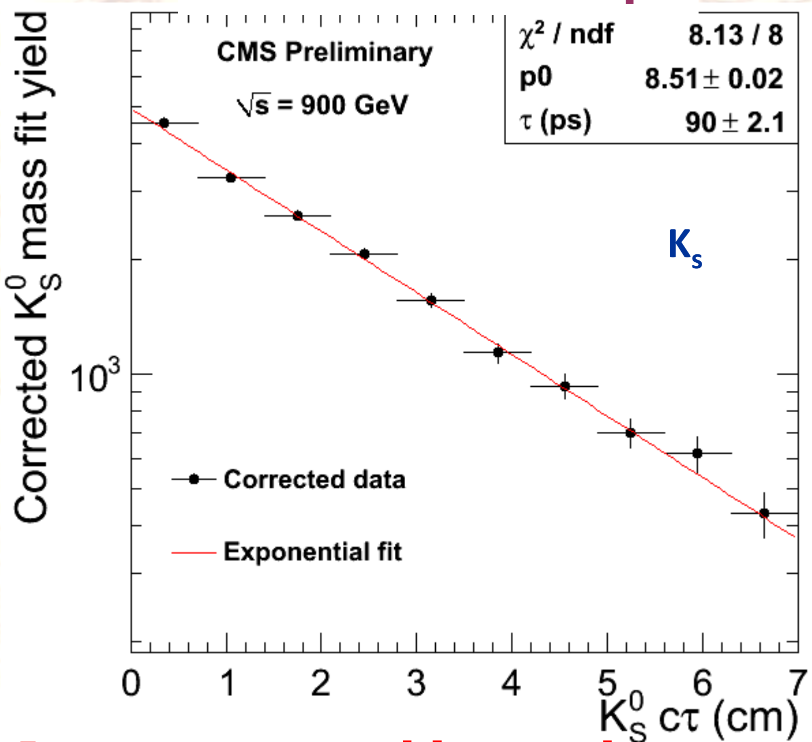
Lifetime

Monte Carlo is simulated with the same conditions as in data.

- Data and MC are split into bins of cτ and a fit for the yield is performed in each bin.
- Divide MC yields by true (exponential) distribution to obtain correction factor.
- Correct data and fit for lifetime.

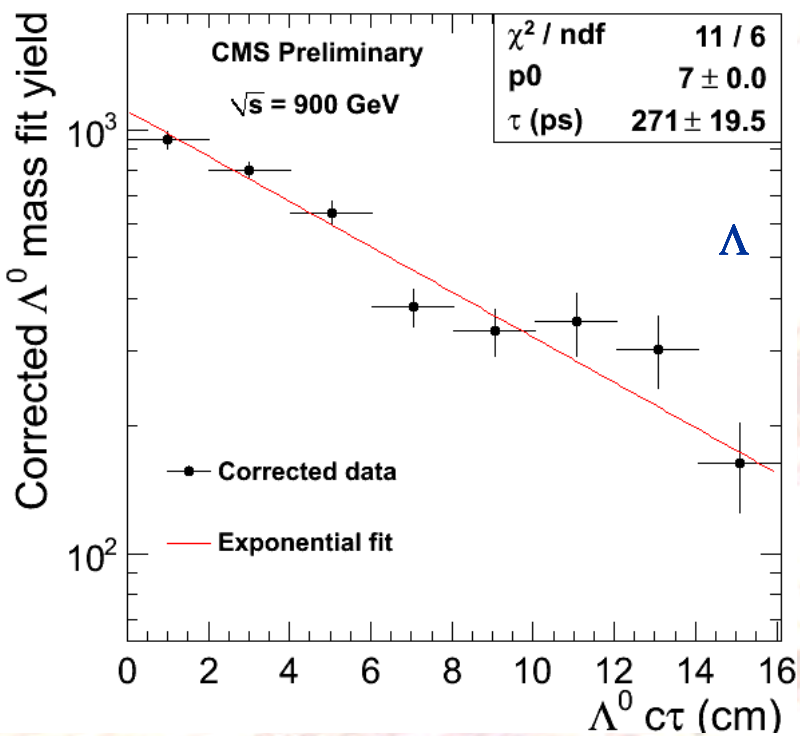
PDG: 89.53 ± 0.05 ps

CMS: 90.00 ± 2.10 ps



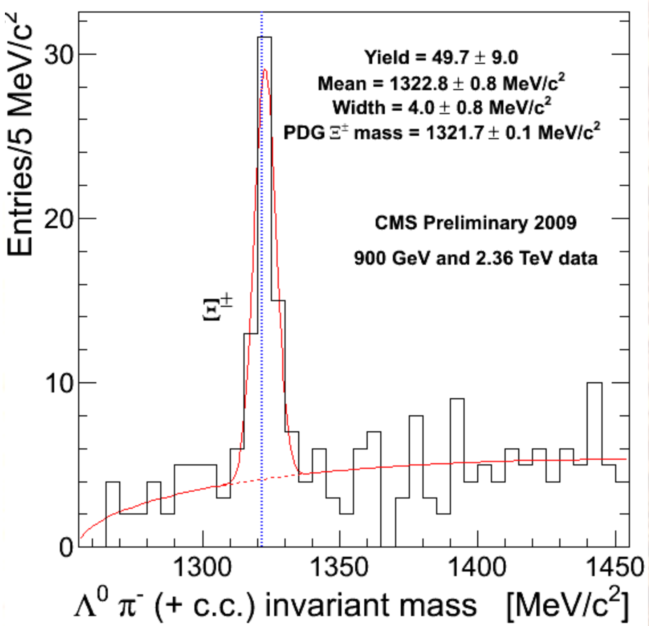
PDG: 263.1 ± 2.0 ps

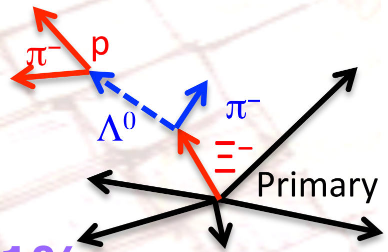
CMS: 271.0 ± 20 ps



➔ **accurate tracking and vertex simulation, even outside the beam region**

Tracking Results

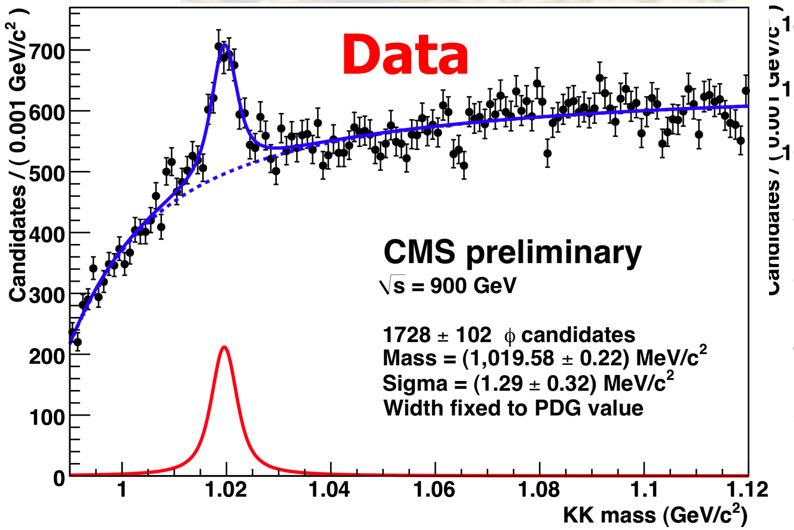


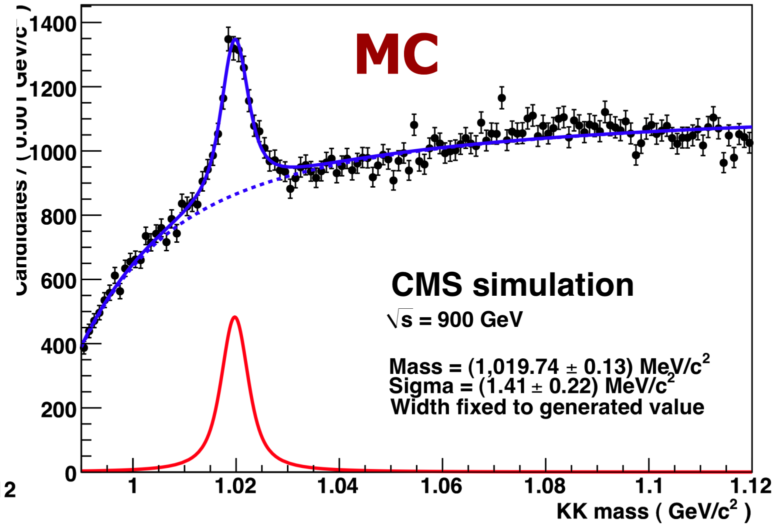


Selection for Ξ:
Lambda mass within 8 MeV
Lambda-pion vertex fit probability > 1%
Both pions have the same sign charge
3D impact parameter significance > 3 for all three tracks

Gaussian convoluted with Breit-Wigner

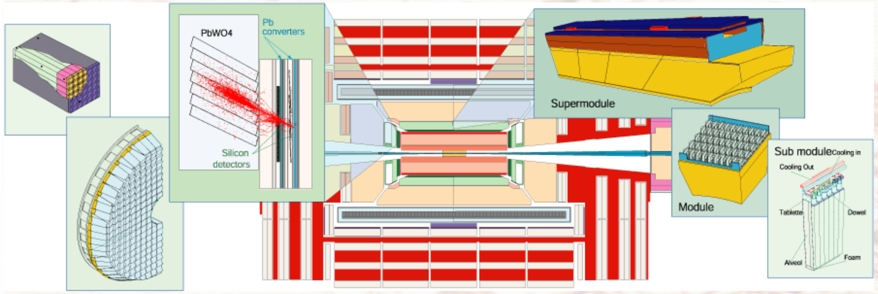
φ →KK:
Kaons with tracks ≥5hits, $\chi_{norm}^2 < 2$, d_{xy}<3mm, p_T>0.5 GeV
Particle ID:
p>1GeV OR
dE/dx inside kaon range



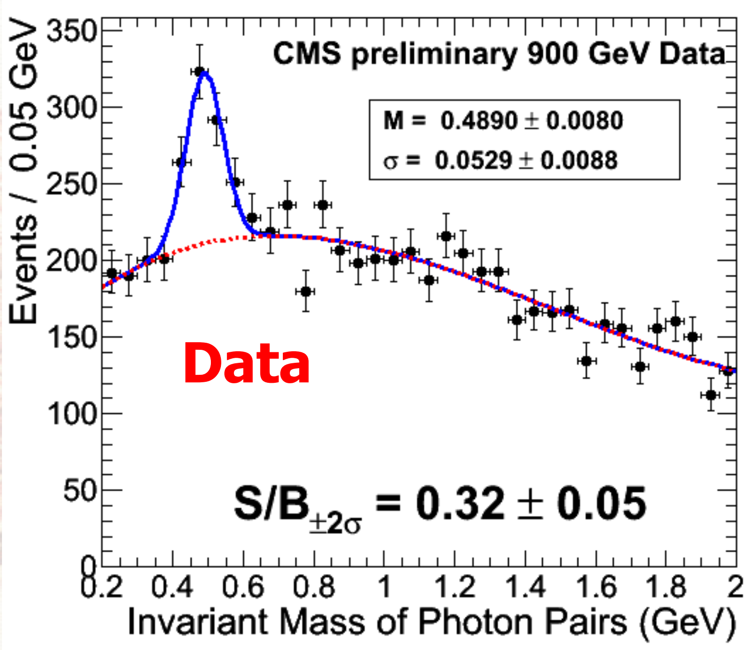


➔ Alignment of tracker system is well understood

Electromagnetic Calorimetry

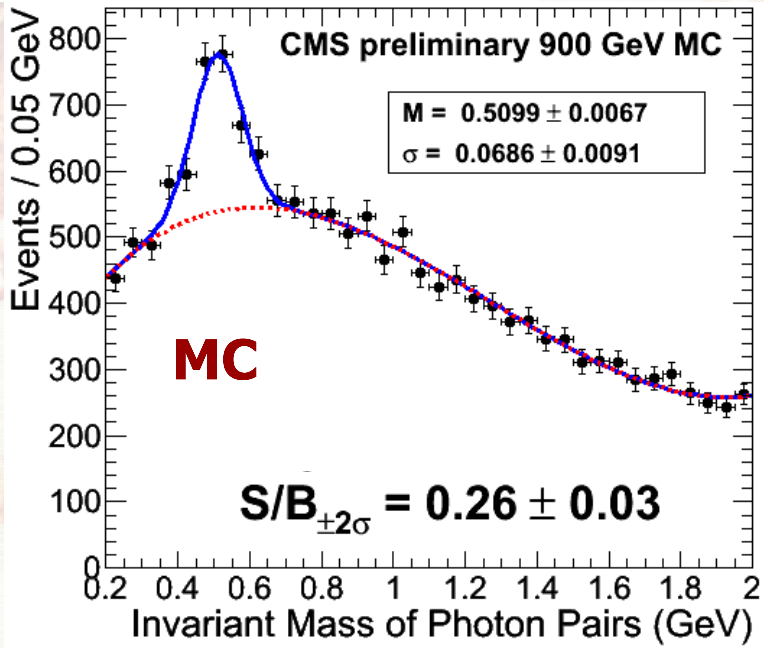


Precalibration from Test Beam period for ¼ of barrel + Cosmic running (~1-2% precision)



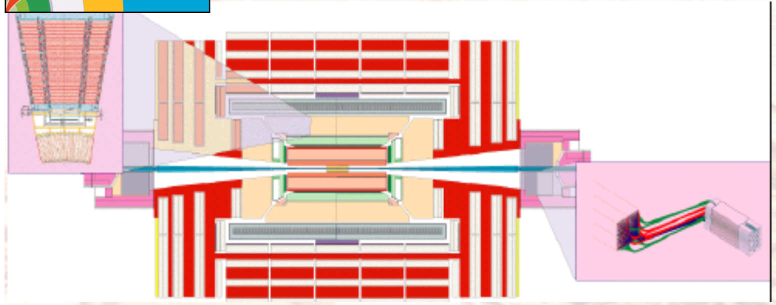
γ in barrel
- $E_T(\gamma)$>400 MeV;
- $E_T(\eta)$>2.0 GeV;
- S4/S9 > 0.85 (shower shape)

Mass and width compatible with MC
η yield scale as expected:
Data: N(η) / N(π^0) = 0.020 ± 0.003
MC: N(η) / N(π^0) = 0.021 ± 0.003

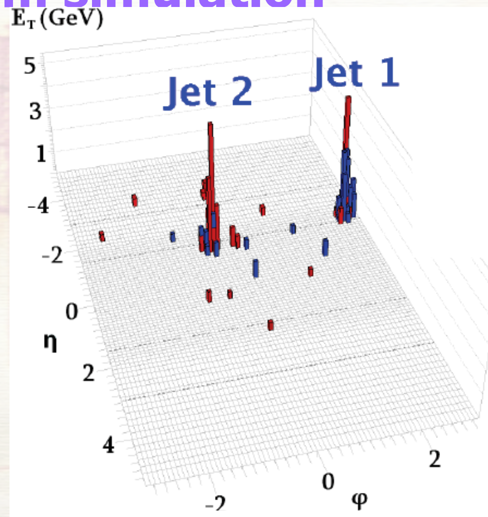


➔ Good agreement between data and MC

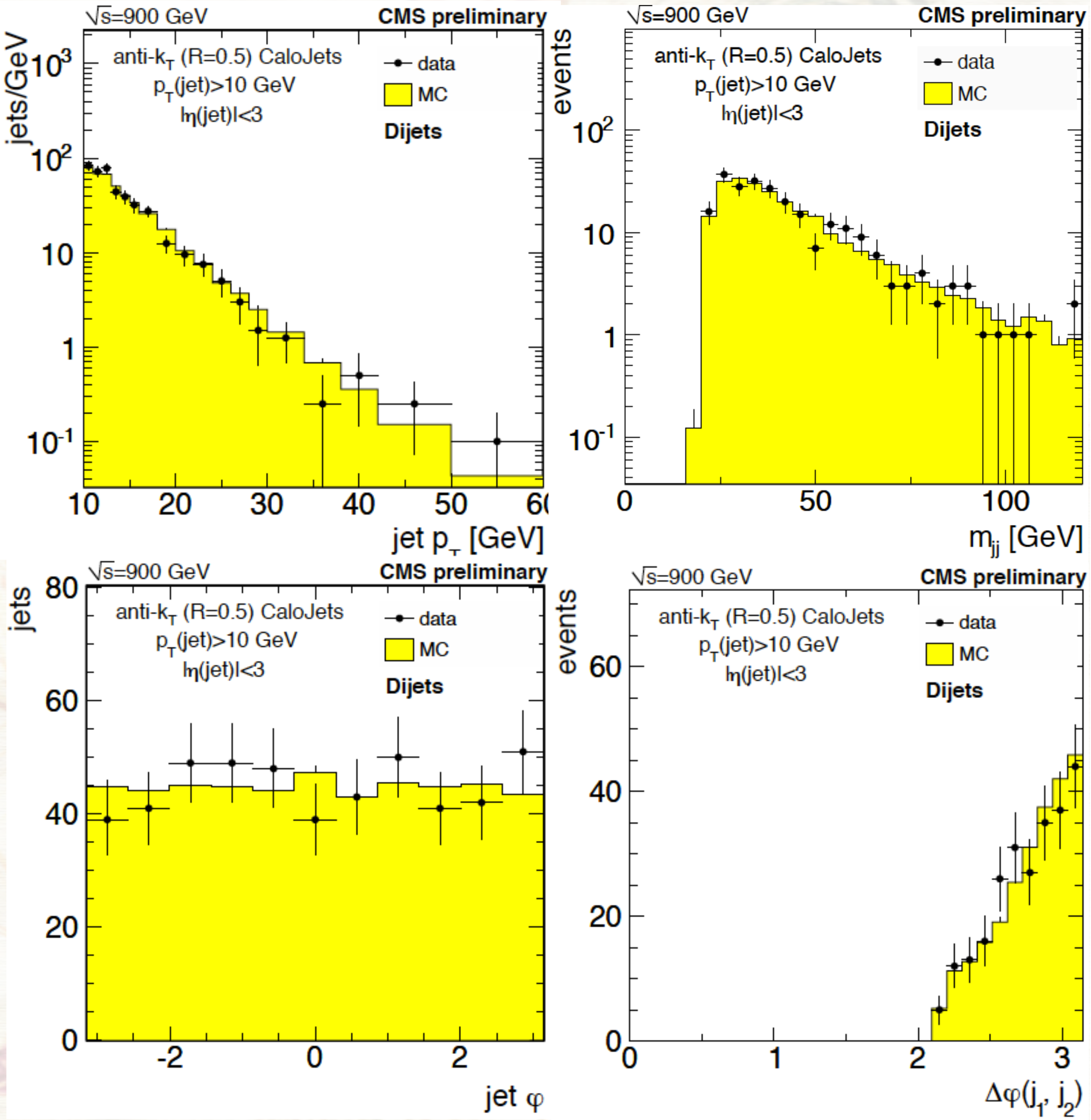
Calorimetry in Action



Jets reconstructed using Anti-KT R=0.5 algorithm
Di-jet analysis:
- P_T>10 GeV
- $|\eta|$<3.0
- $|\Delta\varphi(j1,j2) - \pi|$<1.0
- Jet Energy Scale corrections from simulation



run 124009: evt 10872958



Tracks + Calorimetry

Step #1: ZSP correction to jet #1

	p_T^{jet}	η	φ
Raw	**12**	0.27	2.5
ZSP	**16**	0.27	2.5

Step #2: "in-cone" tracks (purple, x2)

#	p_T^{trk}	E_{calo}	ΔE
1	4.2	−2.7	1.5
2	5.1	−3.2	1.9

Step #3: "out-of-cone" tracks (orange, x6)

#	p_T^{trk}	E_{calo}	ΔE
1	1.7	-	1.7
2	1.2	-	1.2
3	0.3	-	0.3
4	0.6	-	0.6
5	0.4	-	0.4
6	0.8	-	0.8

Step #4: efficiency

	ΔE
In-cone	0.1
Out-of-cone	0.4

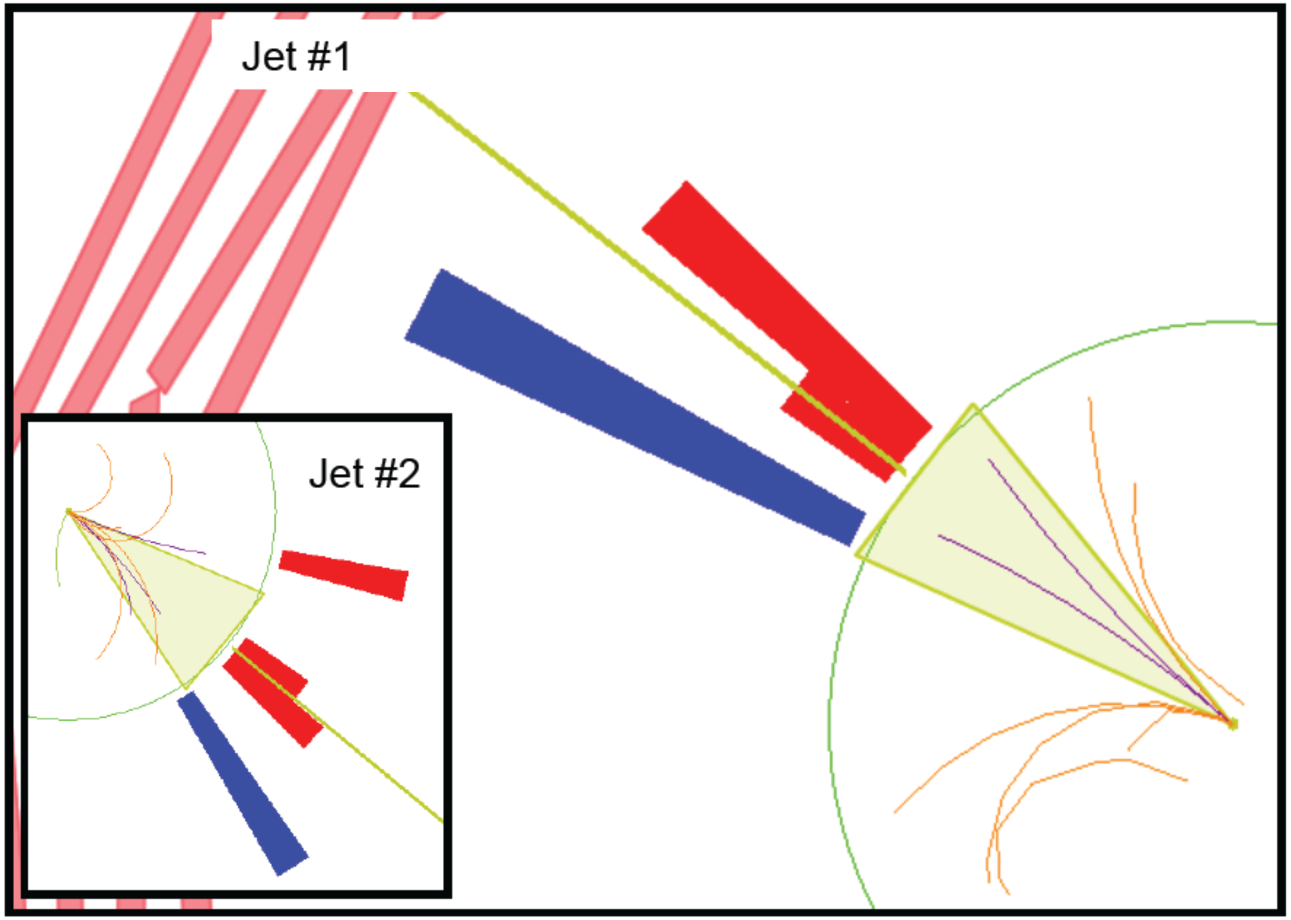
Corrected p_T for jet #1

	p_T^{jet}	η	φ
JPT	**24**	0.23	2.5

Direction correction

Δφ (uncorrected) = 3.1

Δφ (corrected) = 3.0



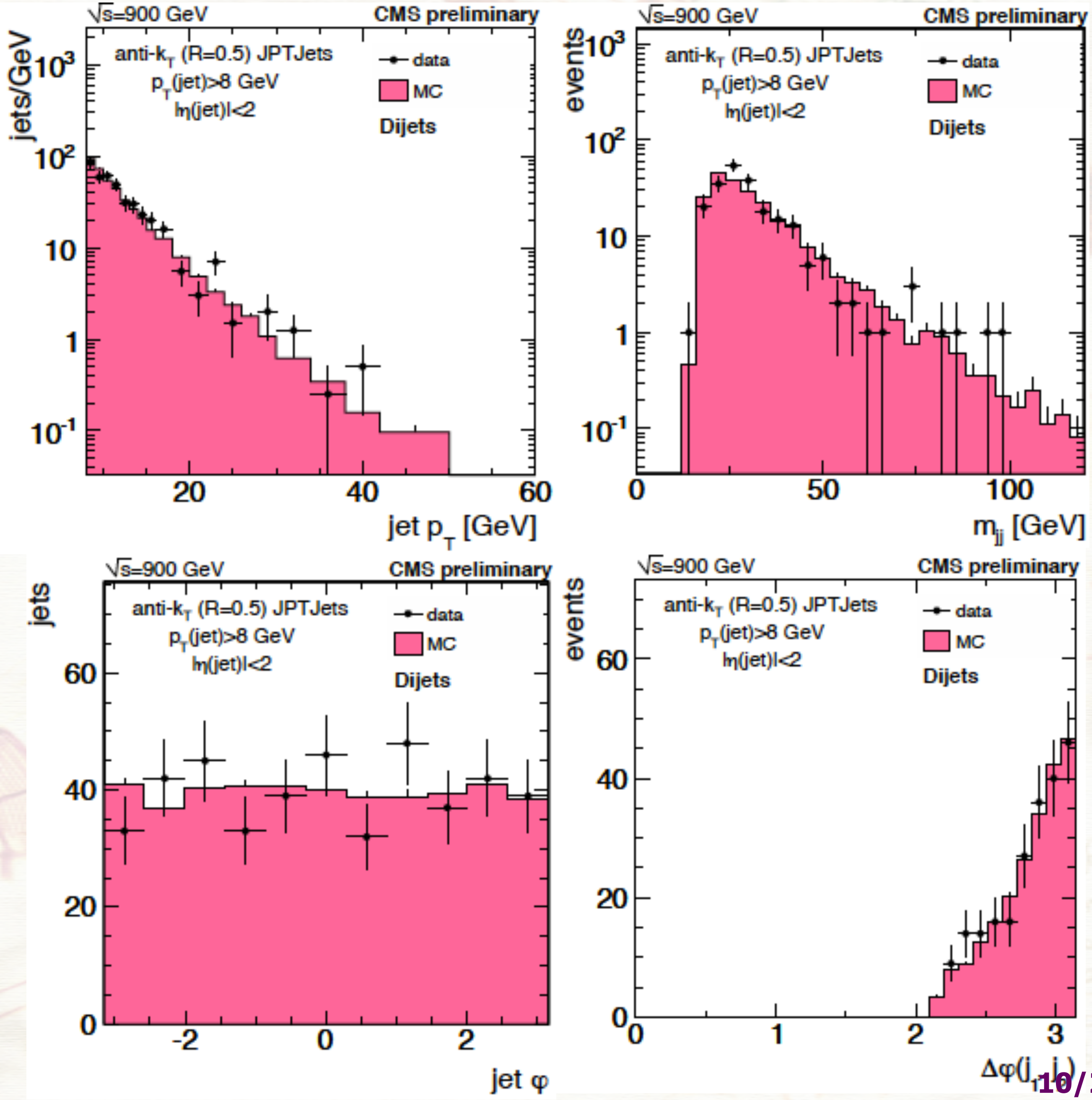
Corrected p_T of 24 and 25 GeV when including tracks.

Corrected p_T for jet #2

	p_T^{jet}	η	φ
RAW	13	2.0	-0.69
ZSP	17	2.0	-0.69
JPT	25	1.9	-0.55

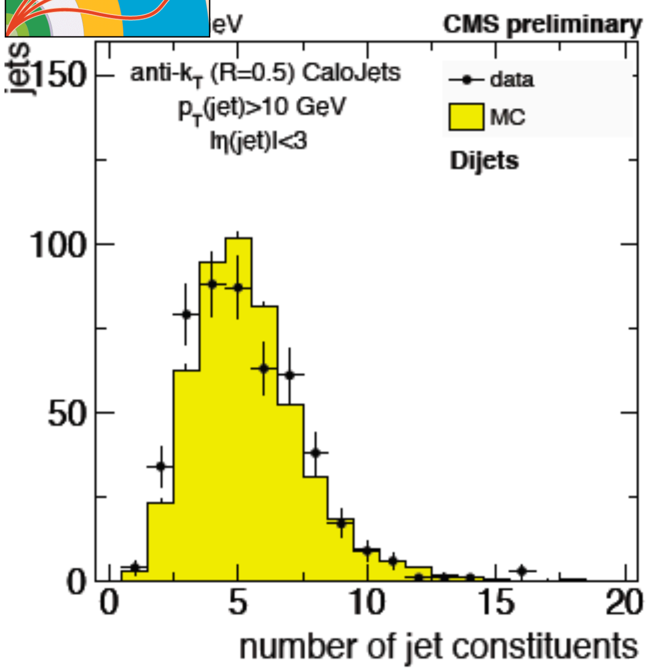
Jets + Tracks

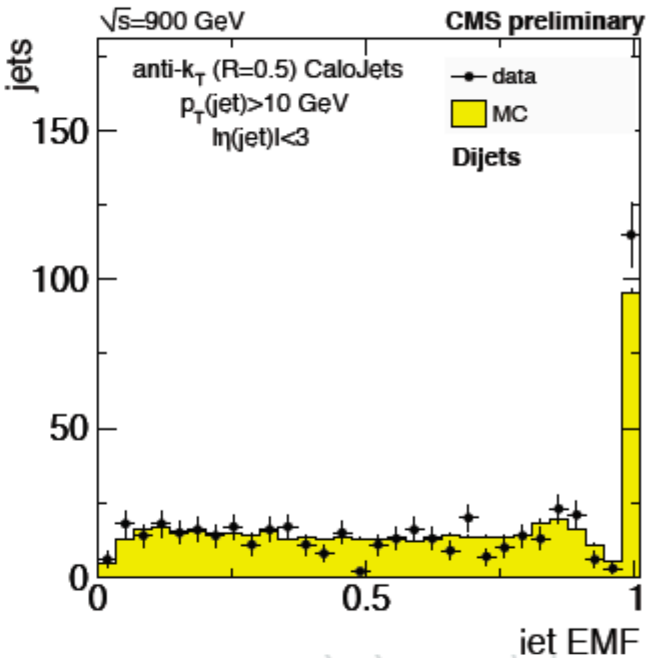
Jets reconstructed as Jets+tracks
Di-jets:
- $P_T > 8$ GeV
- $|\eta| < 2.0$
- $|\Delta\varphi(j1,j2) - \pi| < 1.0$



➔ Good agreement between data and MC and good agreement between calorimeter based jets and jets + tracks

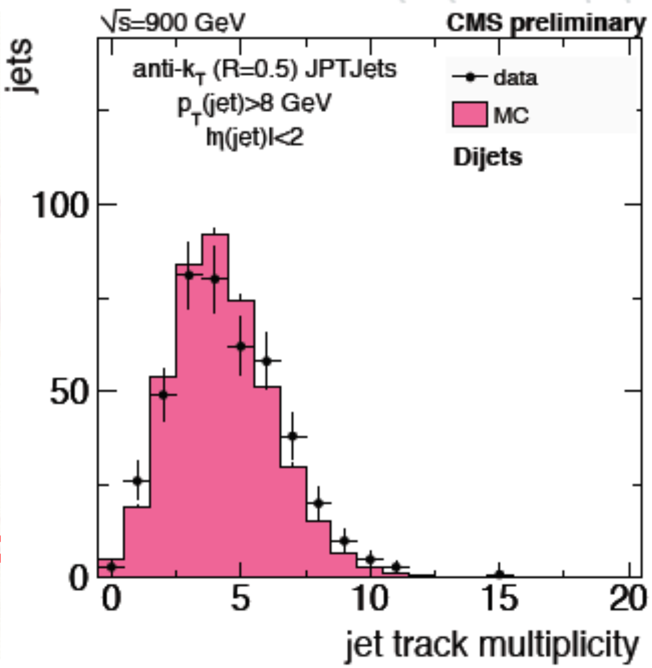
Jet Properties

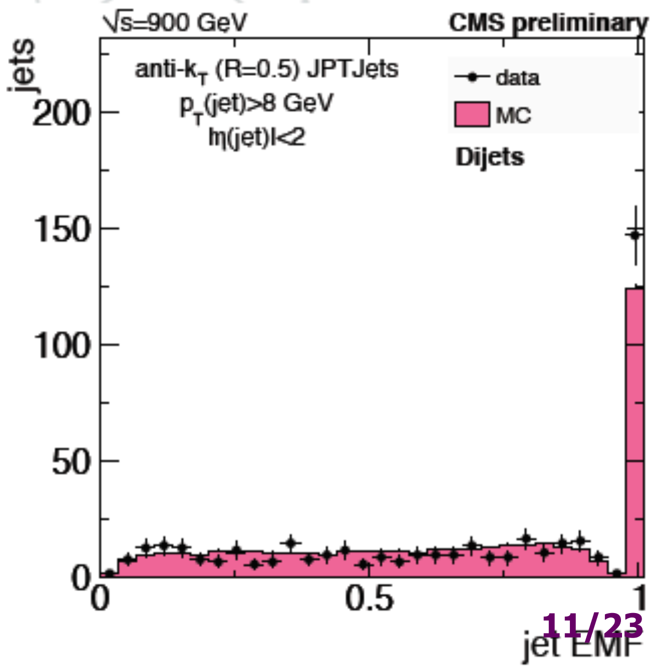




Jets reconstructed using Anti-KT R=0.5

Jets + Tracks

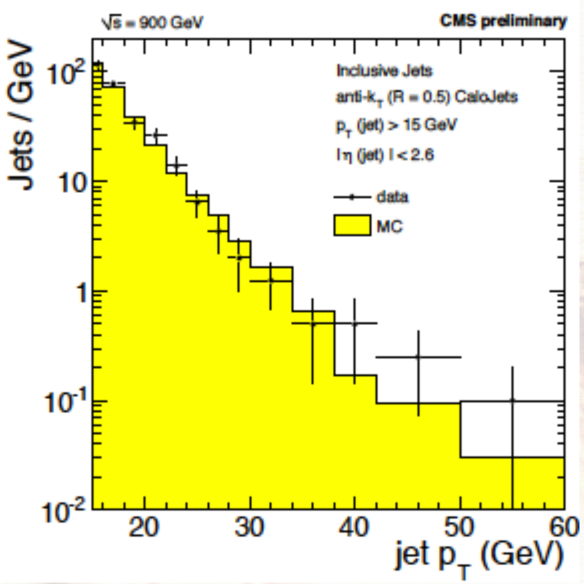


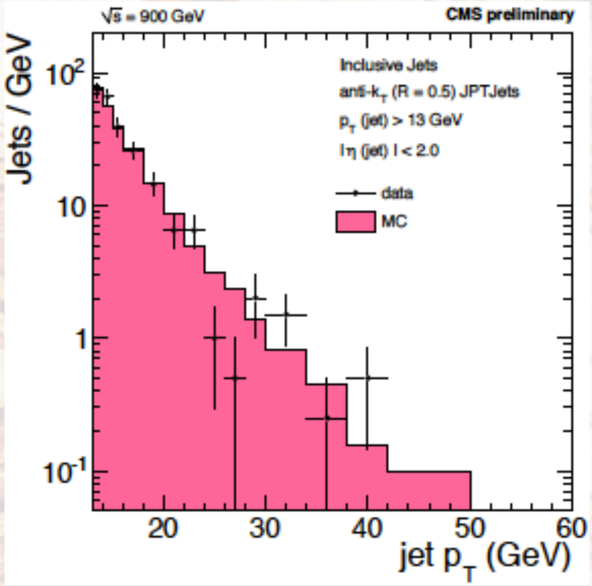


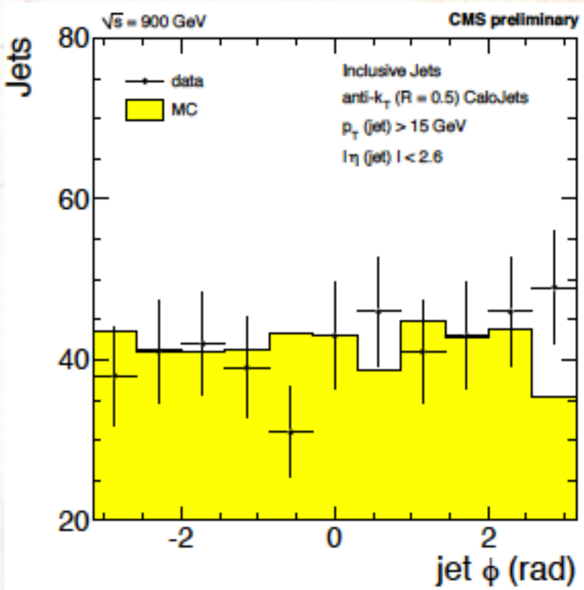
→ Good description of the variables
→ Clear understanding of jets, confident to look for high energetic jets…

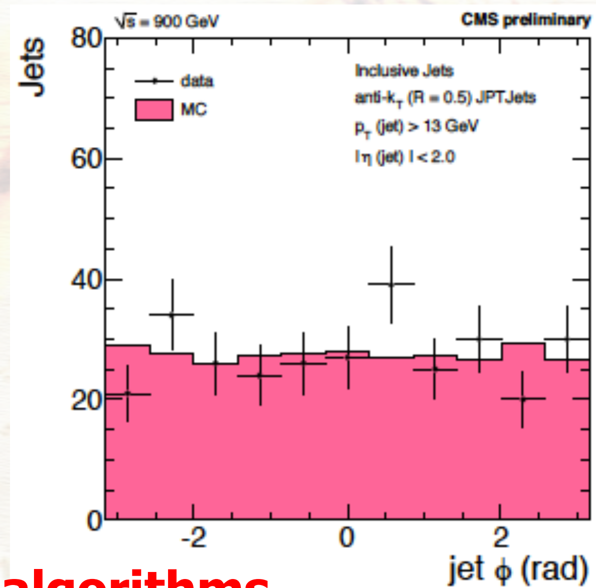
Inclusive Jets Analysis

	CaloJets	JPTJets
p_T^{min}	15 GeV	13 GeV
η^{max}	2.6	2.0







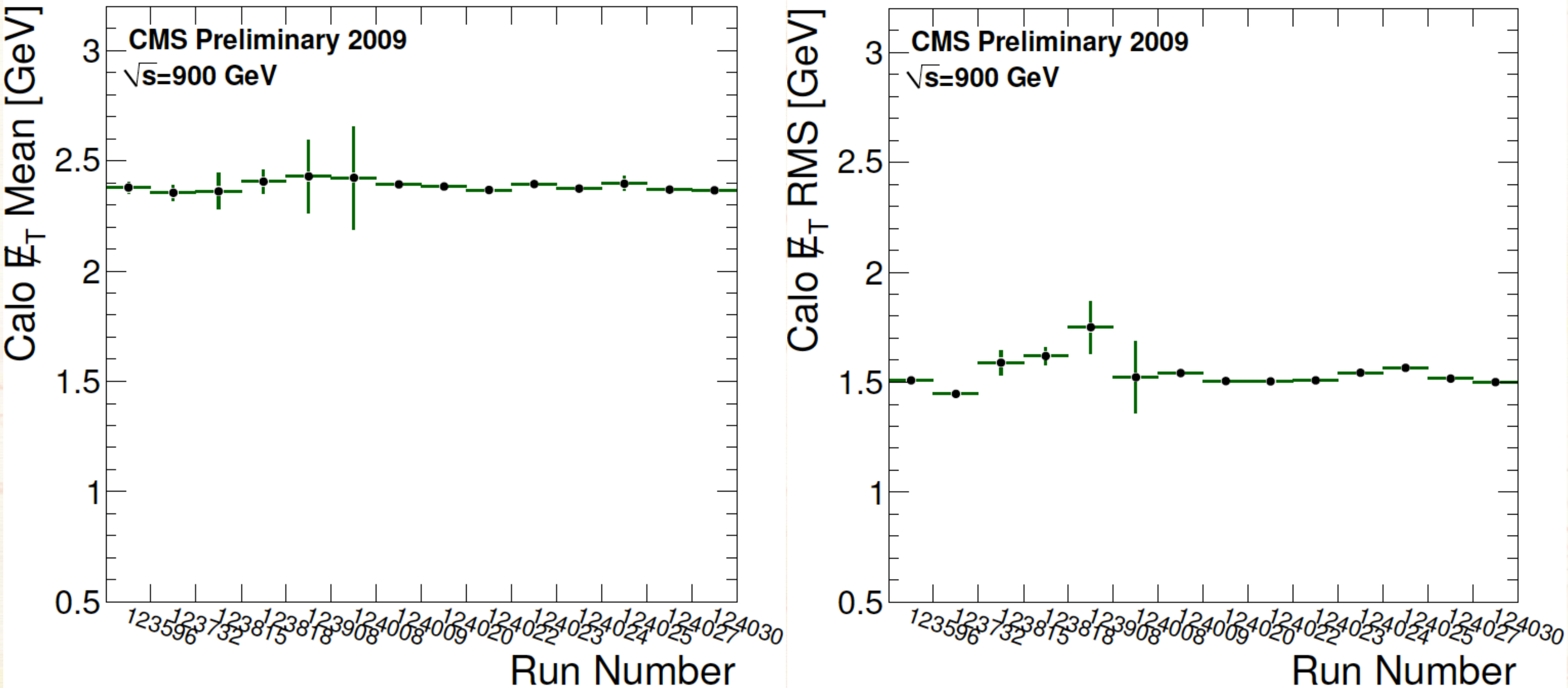


→ Good agreement for inclusive jets analysis for both algorithms

Missing E_T

Important variables for physics analysis but most challenging variable to understand
➔ Rely on good understanding of all the other objects.

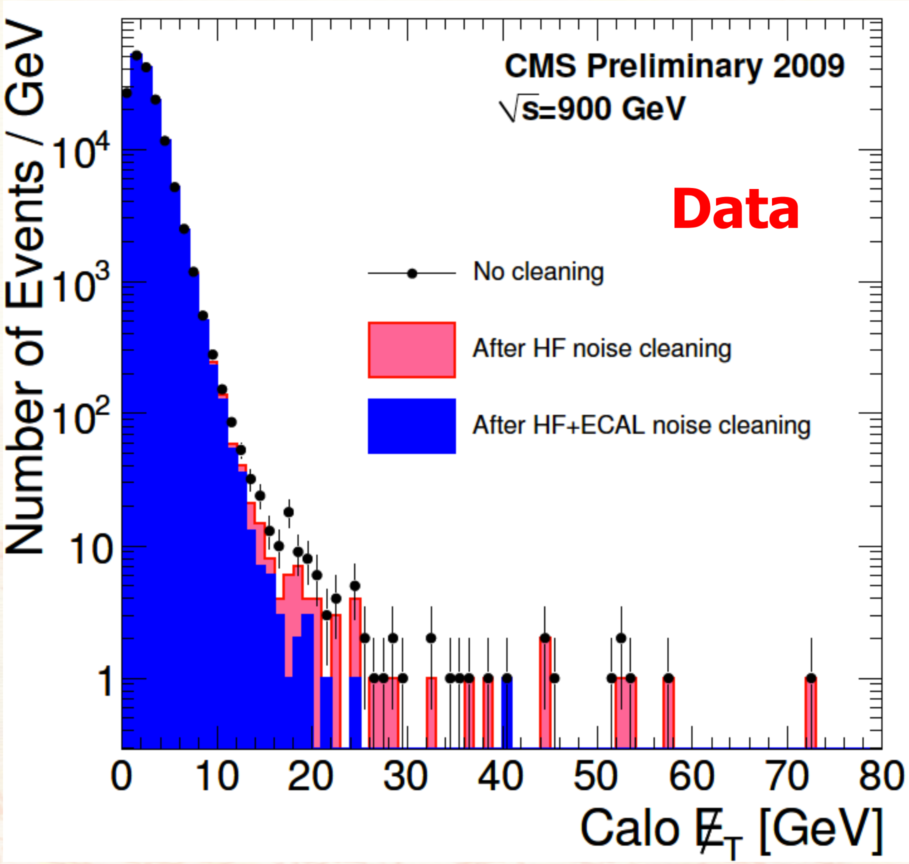
RAW Calorimetric ME_T

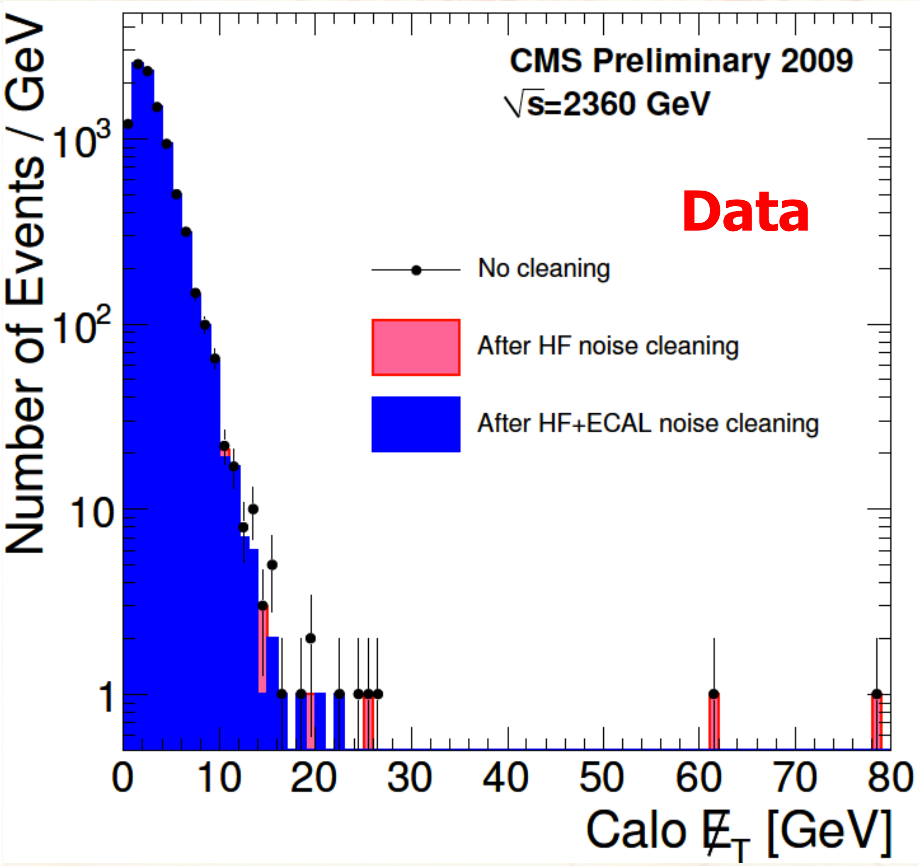


➔ Stability of calorimetric missing E_T calculation during the whole period of data taking.

Missing E_T

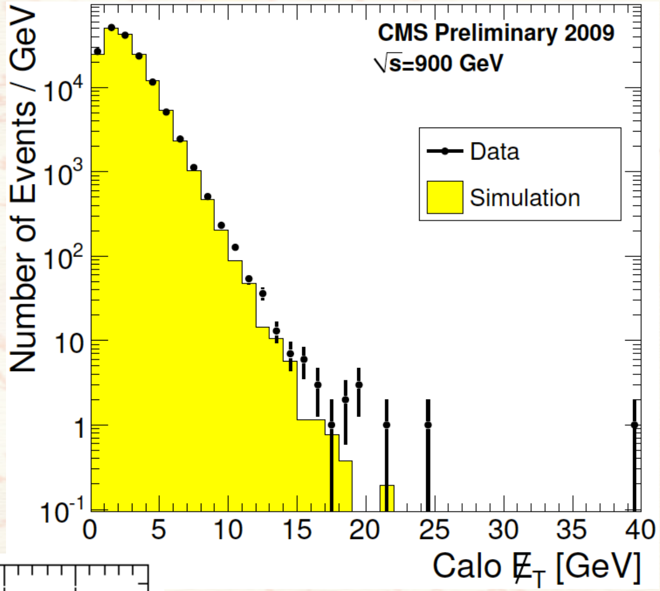
Cleaning of Missing E_T: (Events are not removed, only hot spot)
- **Noise in Hadronic Forward (particle hitting the PMT window)**
- **Noise in Hadronic Calorimeter [HB/HE] (specific pattern of channels)**
- **Noise in Electromagnetic Calorimeter (single Hot channel)**

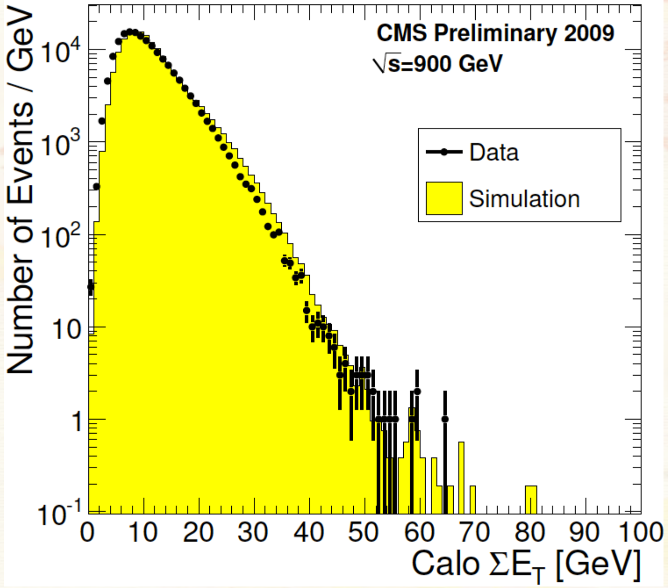


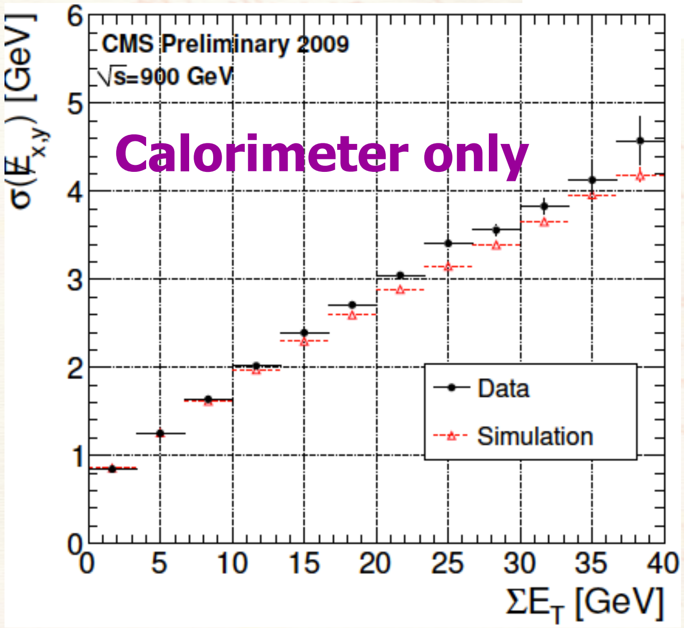


→ Clear understanding of the different noise behavior, cleaning procedures are in place

Missing E_T



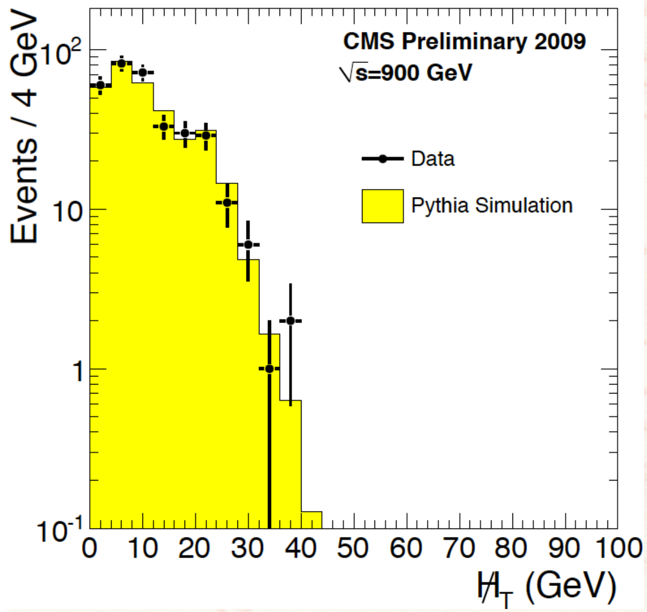


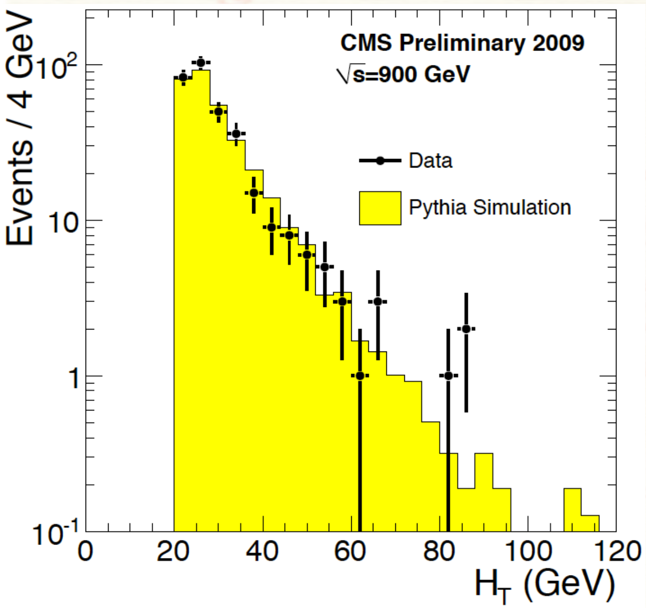


Good description of missing E_T variable and reasonable of Sum E_T

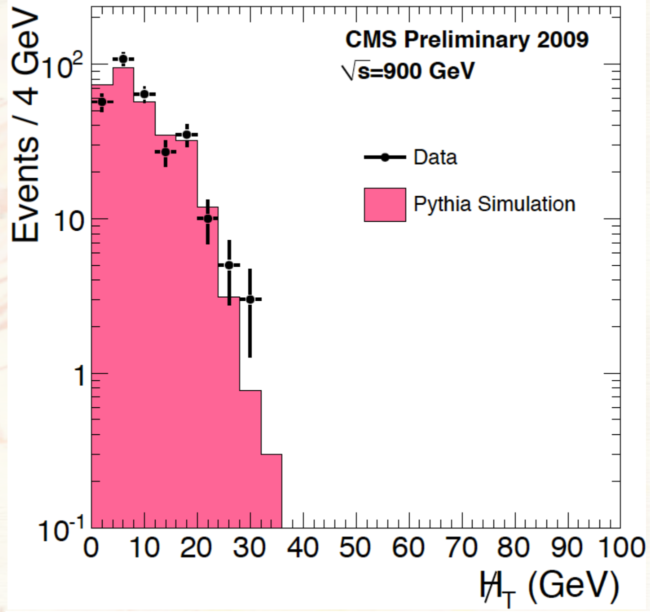
Agreement Data/MC on variables even if calibration of detector are not final

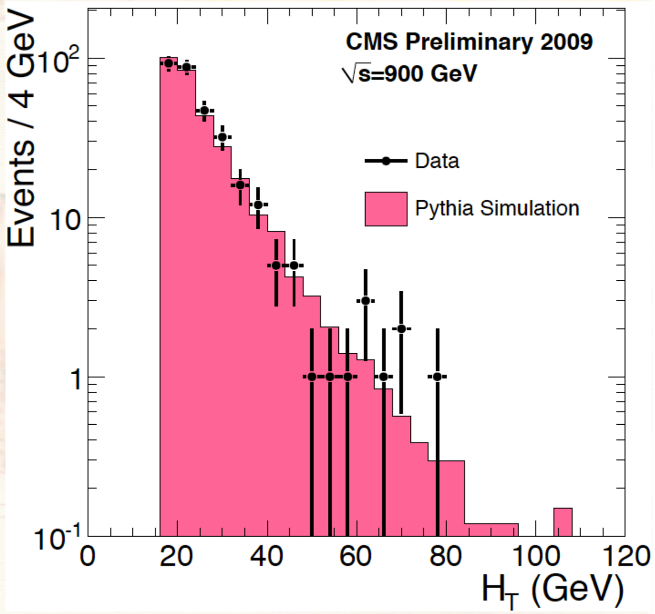
MH_T / H_T





$$MH_T = \left| - \Sigma \vec{p}_T(\text{jets}) \right|$$
$$H_T = \Sigma \left| p_T(\text{jets}) \right|$$





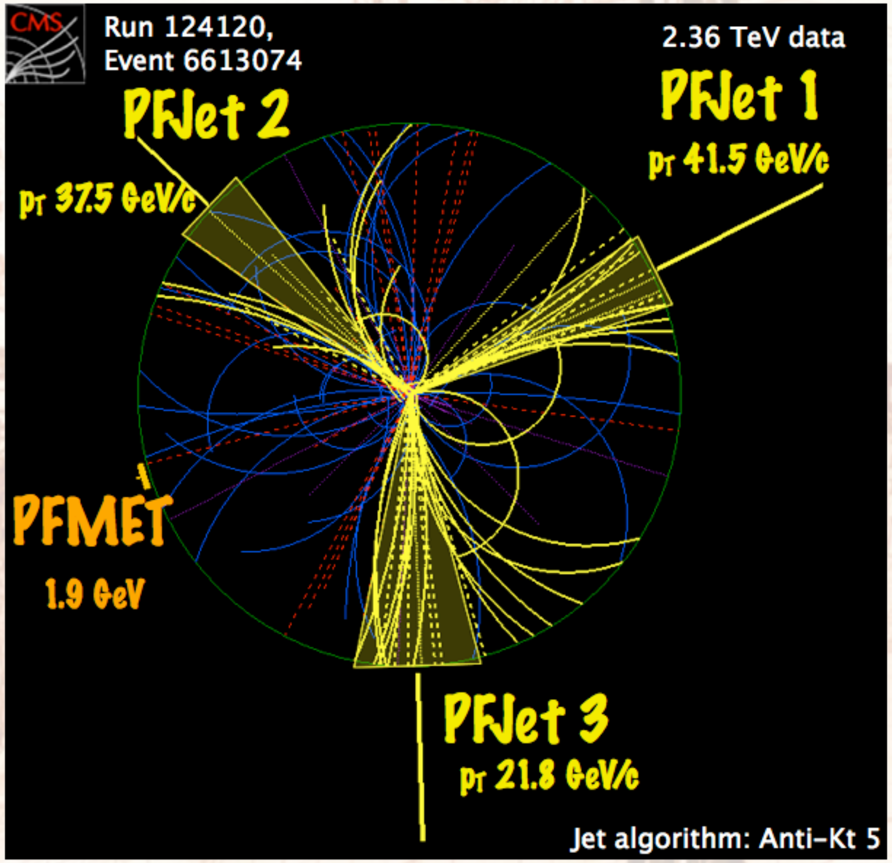
CaloJet

Tracks+Jet

Particle Flow Algorithm

Exploring the fine resolution and granularity of part of the CMS detector to improve the identification and resolution of reconstructed objects using Particle Flow Algorithms.

Principle: link track and cluster and cluster to cluster in fine grain



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

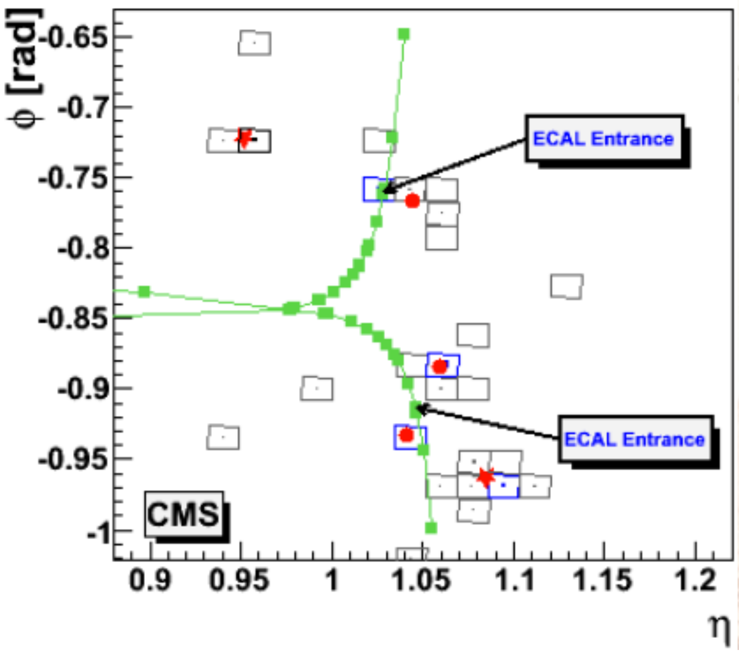
PFMET (1.9 GeV)

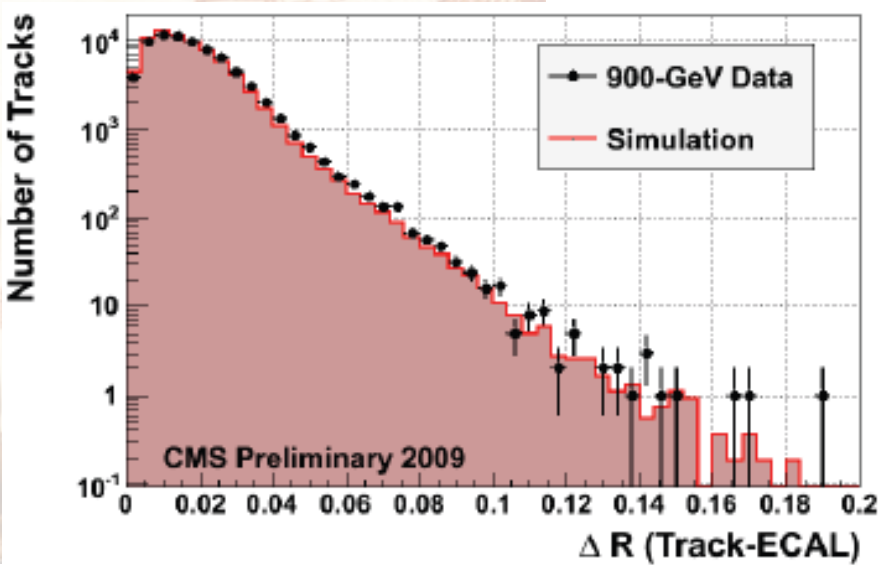
Multijet at 2.36 TeV

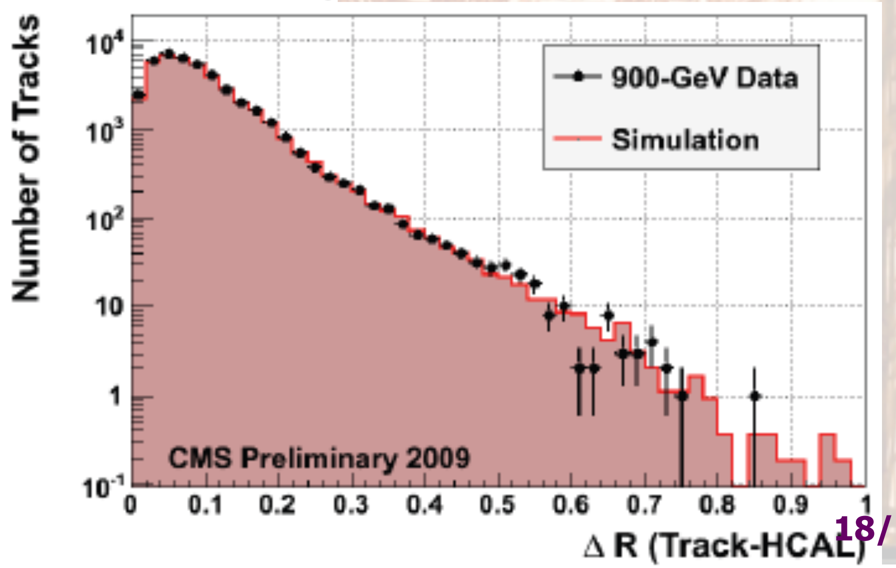
Particle Flow Commissioning

Need to establish track Ecal/Hcal cluster link:

P_T of tracks>1 GeV

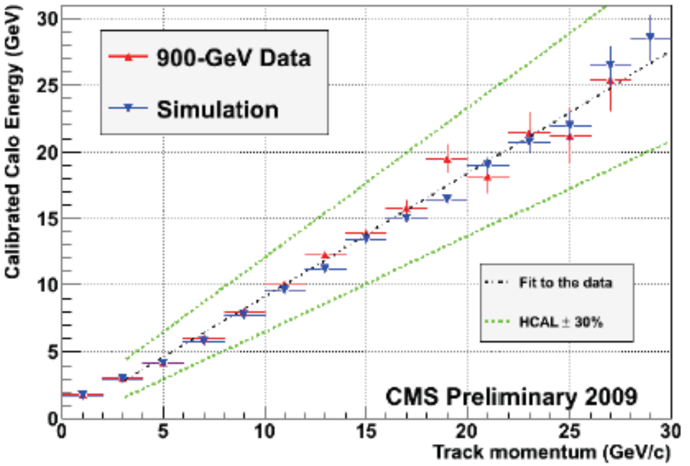






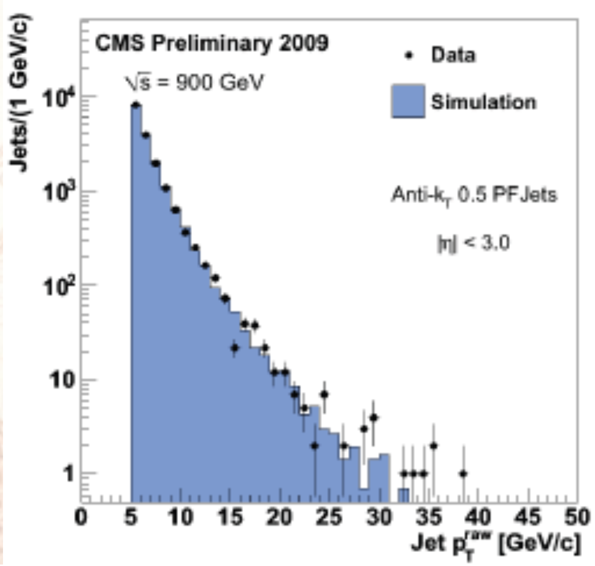
Particle Flow Jets

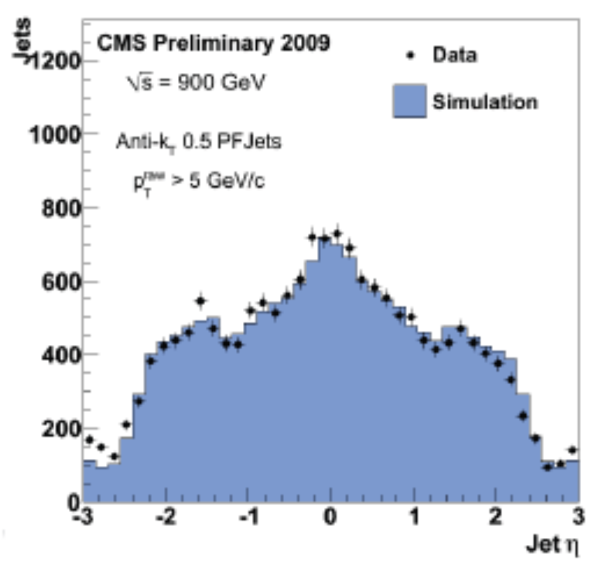
Charged Hadrons Calibration:

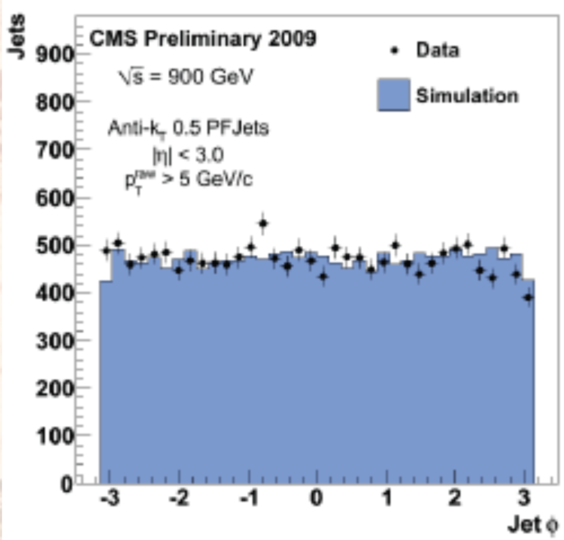


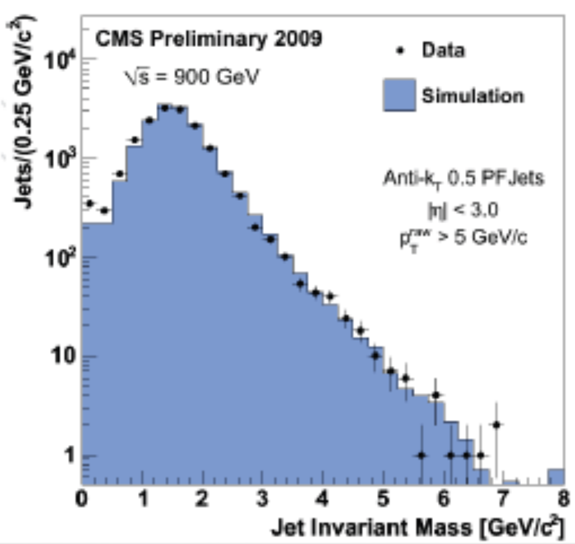
Calorimeter response to hadrons well simulated

Inclusive jet analysis:
$p_T^{raw} > 5$ GeV







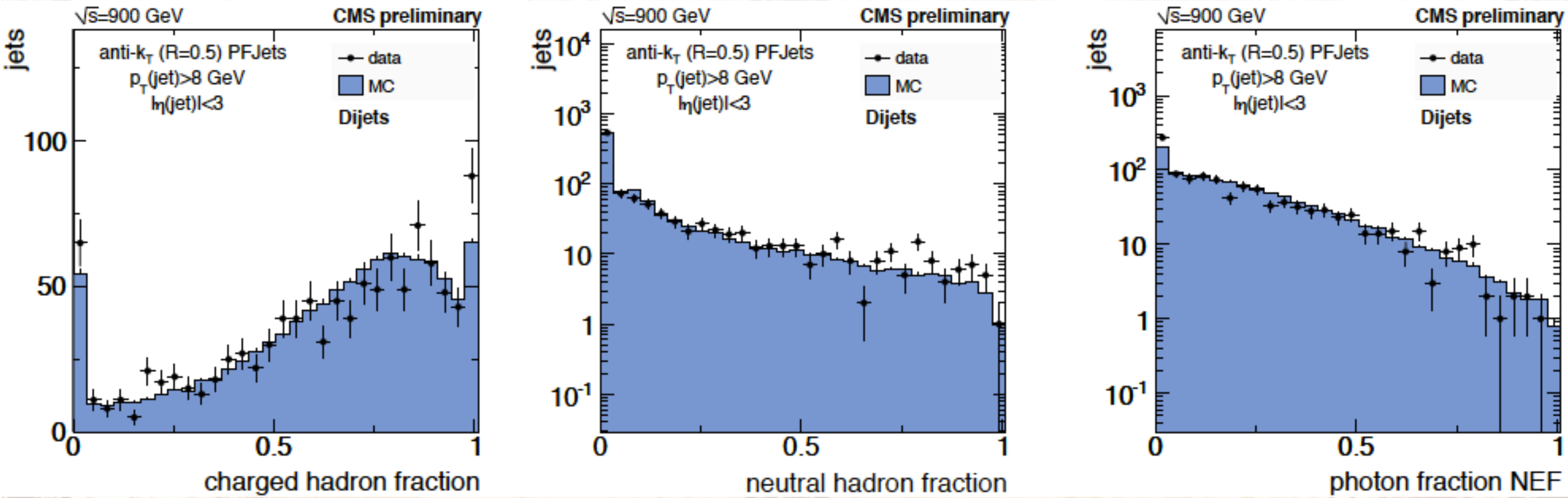


Particle Flow Jet Properties

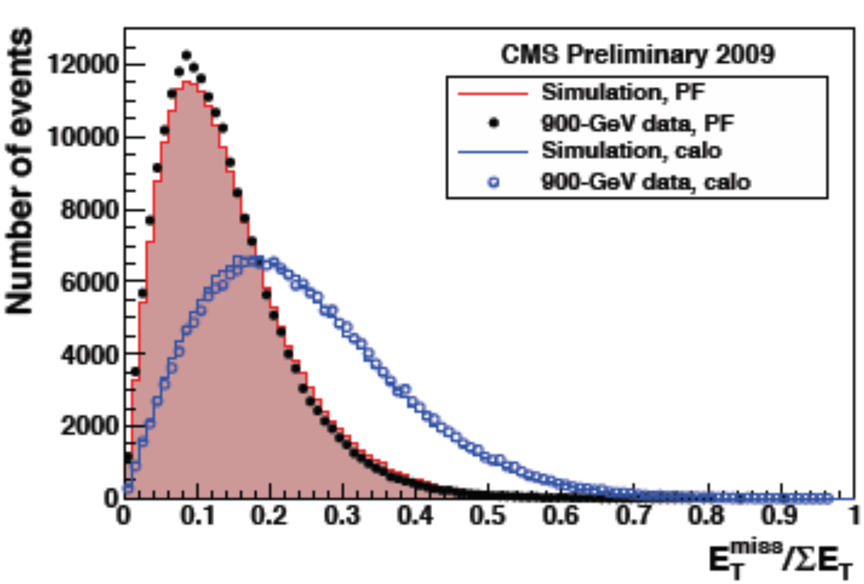
Jets reconstructed using Anti-KT R=0.5 algorithm from particle flow particles

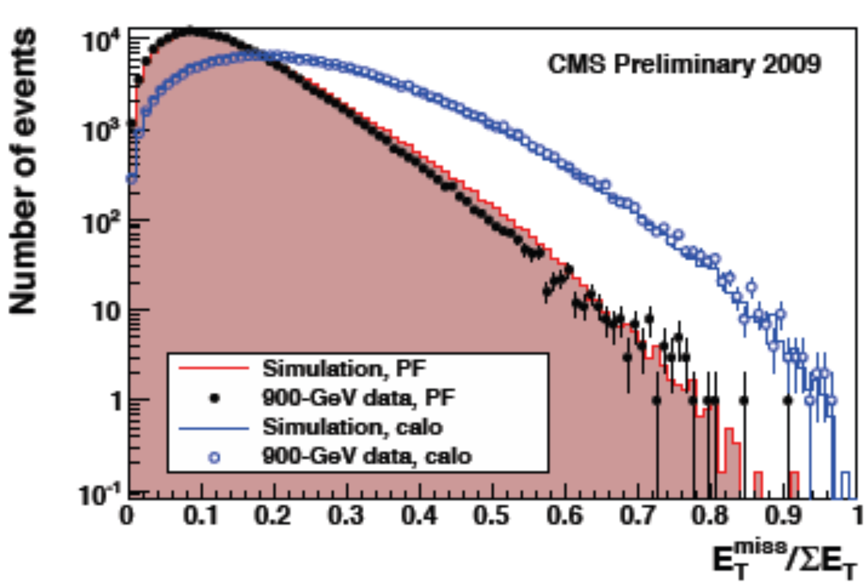
Di-jet analysis:

- P_T>8 GeV
- $|\eta|<3.0$
- $|\Delta\varphi(j1,j2) - \pi|<1.0$



ME_T using Particle Flow

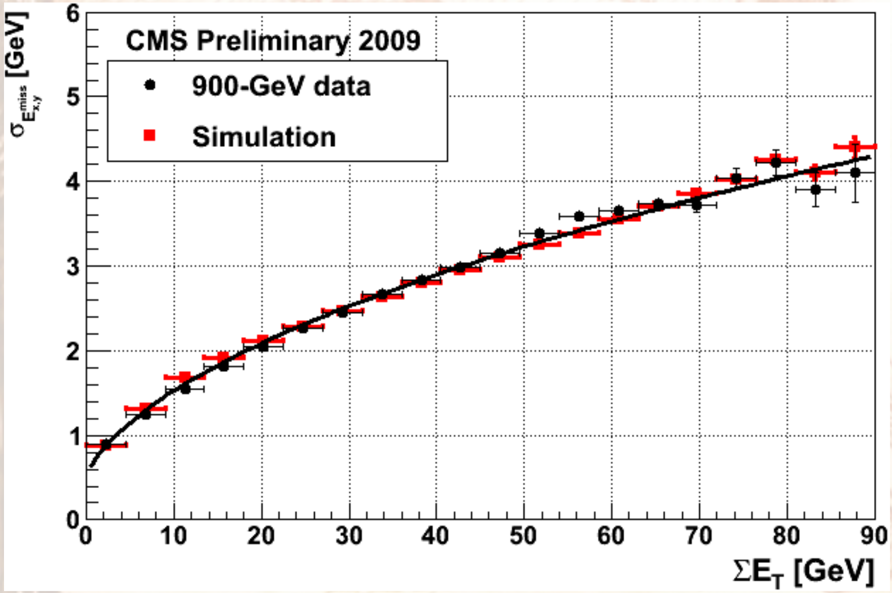




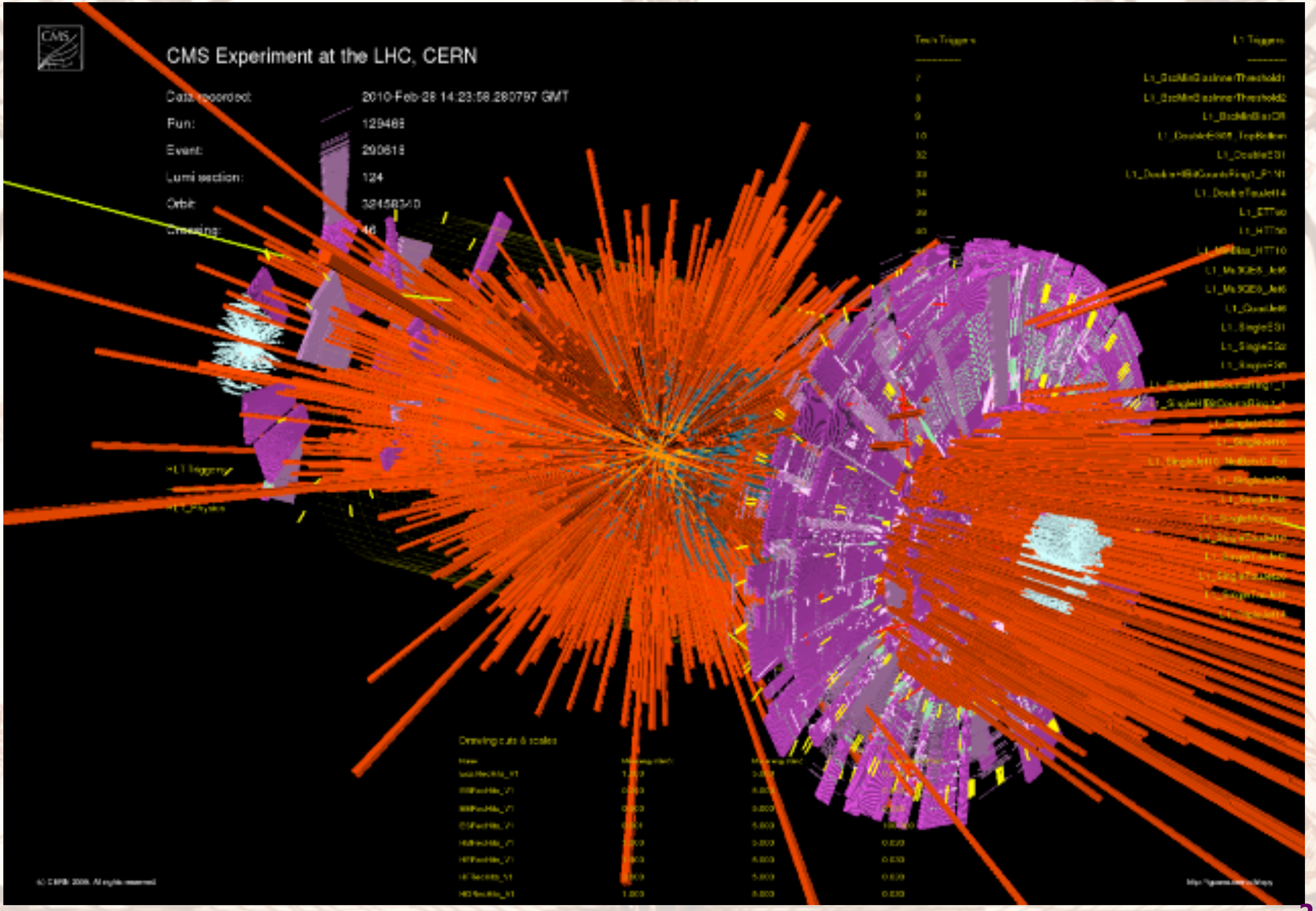
$SumE_T$ > 3 GeV
Particle-based ME_T relative resolution is about twice as good as for the CaloMET

$$\sigma(E_{x,y}^{\mathrm{miss}}) = a \oplus b\sqrt{\sum E_T}$$

a = 0.55 GeV
b = 45 % (PFlow)



And finally... CMS Back Alive!



Conclusion

From the first collisions day, a lot of results have been appearing very quickly
➔ Understanding and commissioning of the detector is in well advanced stage

Start to use complex algorithms with very few fine tuning
➔ Agreement with simulation is impressive all the way through

CMS is waiting for higher statistics of data and higher center of mass energy to start to perform searches

➔ By ICHEP, should start to see more Standard Model physics at 7 TeV and…

BackUp

AntiKt

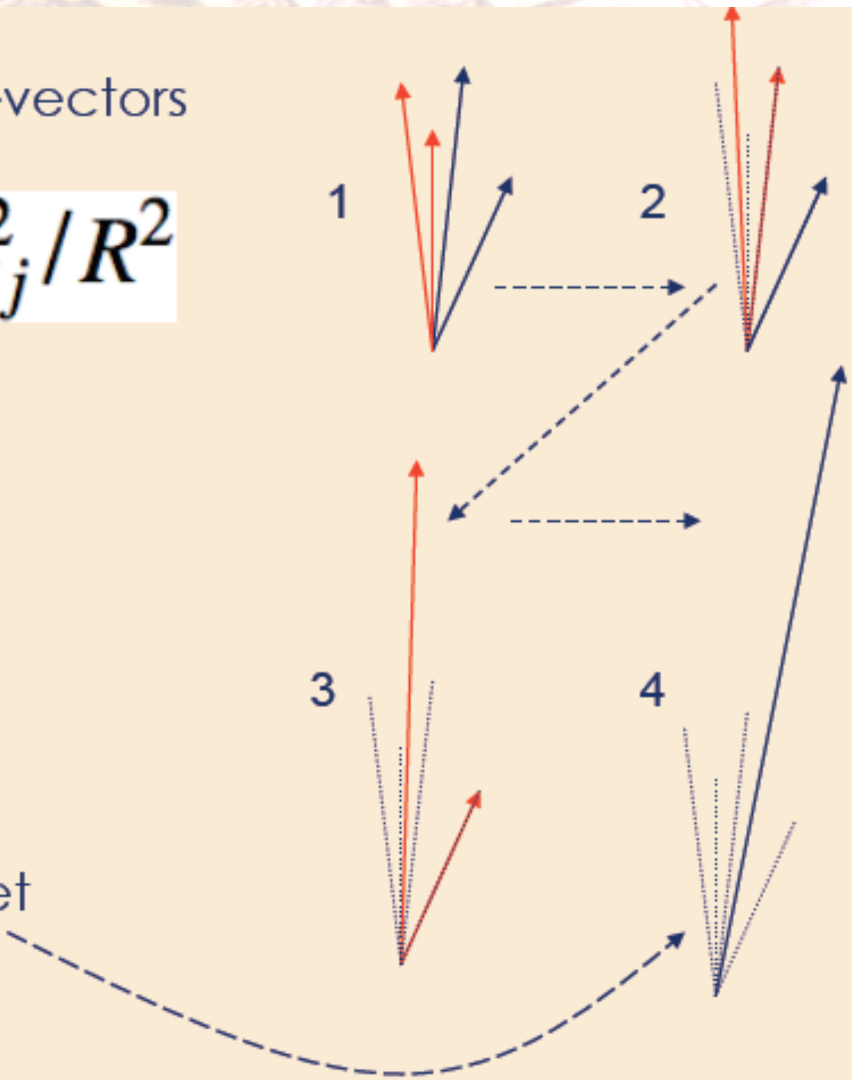
- Pairwise examination of input 4-vectors
- Calculate d_{ii}

$$d_{ij} = min(k_{ti}^n, k_{tj}^n)\Delta R_{ij}^2 / R^2$$

  - N = 2: k_T
  - N = 0: Cambridge Aachen
  - N = -2: anti-k_T
- Also find the "beam distance"

$$d_{iB} = k_{T,i}^n$$

- Find min of all d_{ij} and d_{iB}
- If min is a d_{ij}, merge and iterate
- If min is a d_{iB}, classify as a final jet
- Continue until list is exhausted



[1]: arXiv:hep-ph/9707323