Constraining the jet energy scale in CMS with photon+jet events

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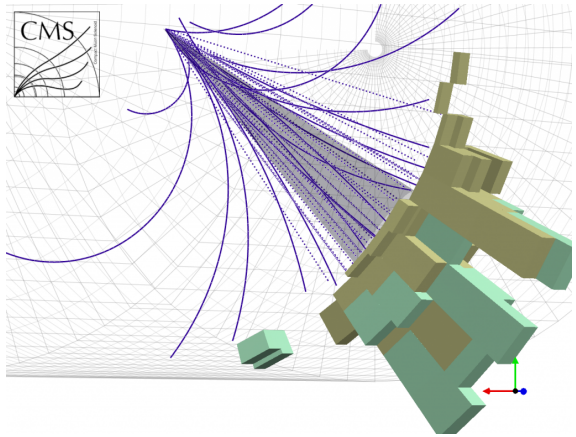
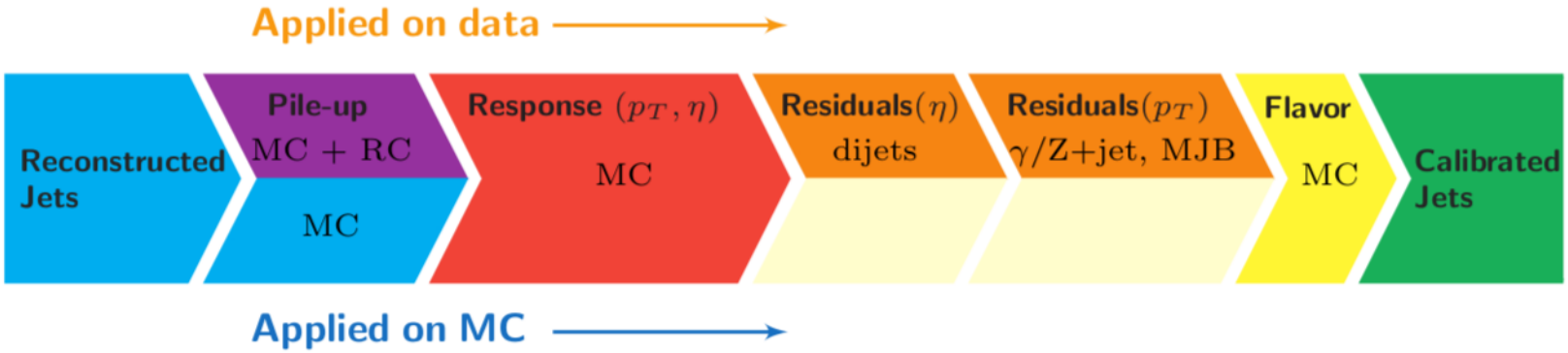
Jets physics

- Jets :
  - Stream of collimated particles from hadronisation of high energy quarks and gluons produced in proton-proton collisions at the LHC.
  - Intrinsic interest: important test of QCD
  - Jets are integral part of most analyses and are important tools for new physics searches.
  - Jets are complex and varied objects: a lot of activity within CMS to calibrate them
  - All following results for Anti-kT with DR=0.5 [1], other algorithm or R values are also used in some cases

- All material taken from JINST 12 (2017) P02014 [2]

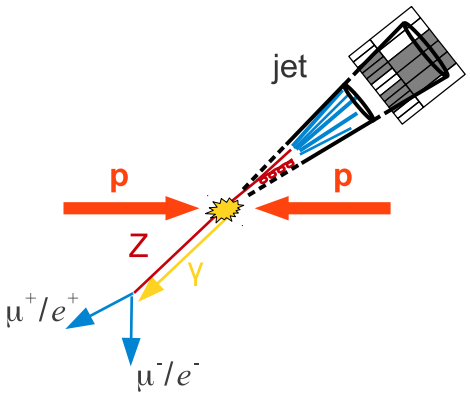


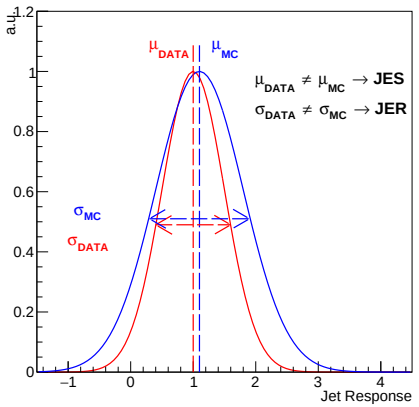
Jet energy corrections (JEC)

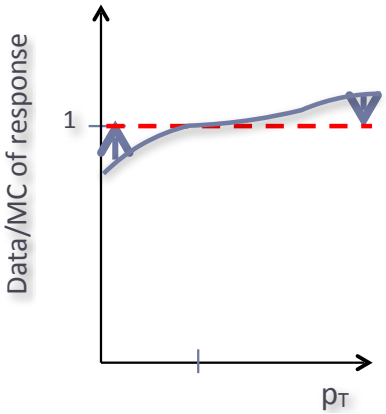


- Offset due to pileup : Substraction of pileup contribution in the jets.
- MC truth correction: correct for the non uniformity of the detector in η and p_T with Monte Carlo samples.
- η residual correction : correct for data/MC differences VS η .
- p_T residual correction: correct for data/MC differences VS p_T . Three channels : $Z + jets$, $\underline{\gamma + jets}$ and multijets.

Jet energy corrections with $\gamma + jets$ events

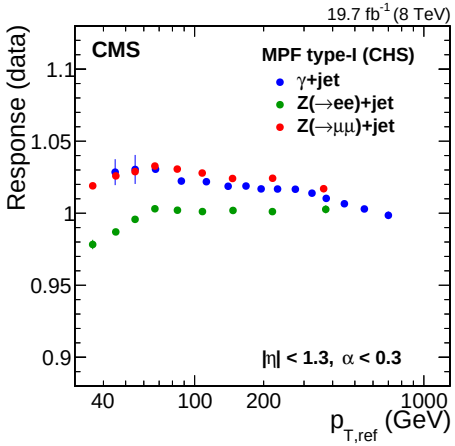


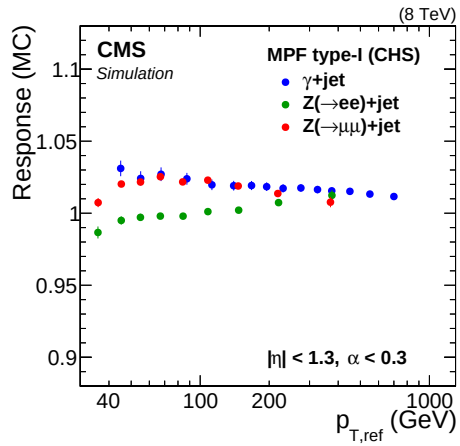


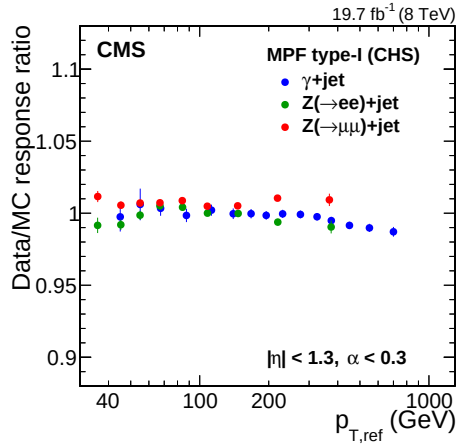


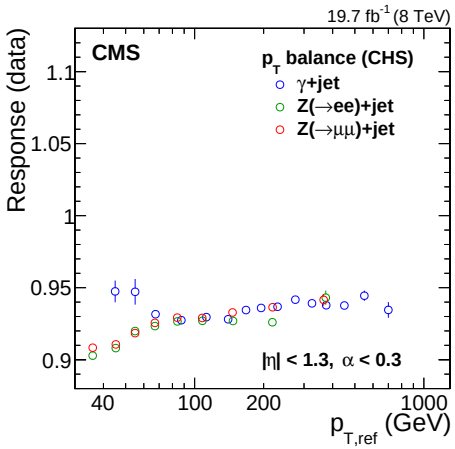
- Event selection :
  - Standard quality selection for photon and jets
  - Photon and jet requested back to back.
  - No real Missing transverse energy.
- Two jet responses definiton :
  - $R_{balancing} = \frac{p_T^{1^{st}\,jet}}{p_T^{\gamma}}$
  - $R_{mpf} = 1 + \frac{\not{E}_T \cdot p_t(\vec{\gamma})}{p_t(\vec{\gamma})^2}$
  - We define : $\alpha = \frac{p_T^{2^{nd}\,jet}}{p_T^{\gamma}}$ and we extrapolate to $\alpha \to 0$.

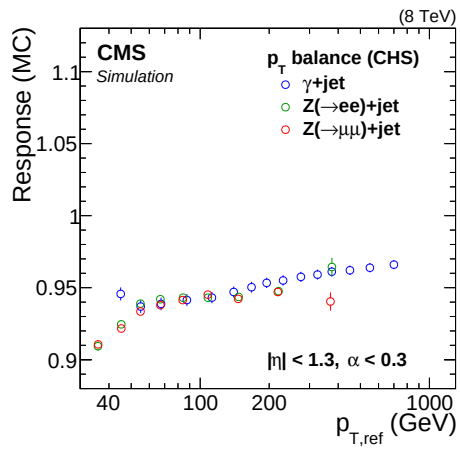
Responses for the 8TeV data

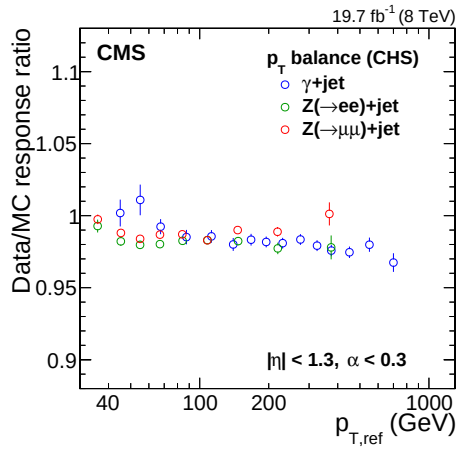






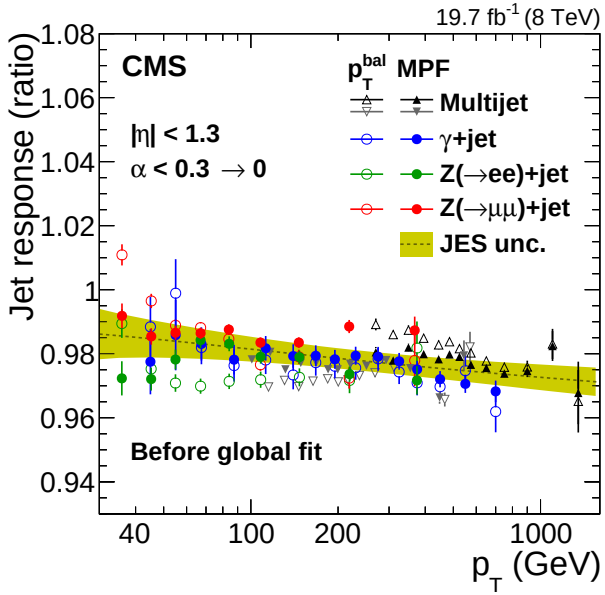


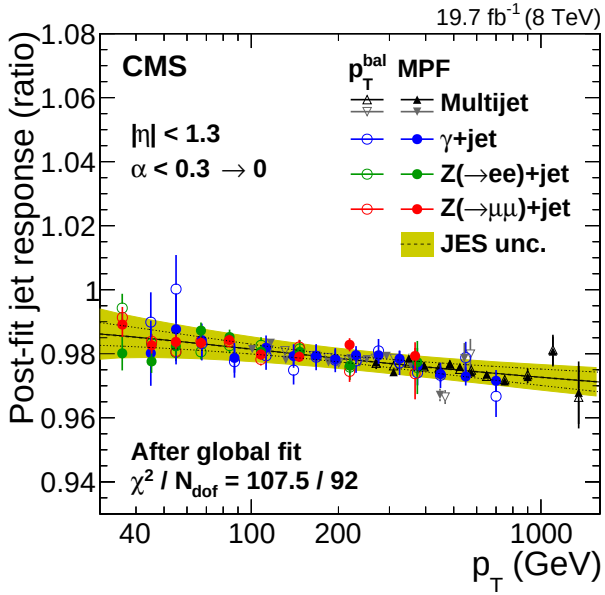




- Good agreement between Z and $\gamma + jets$
- We extract residual energy scale factors to account for differences in jet energy scale in data and MC using these ratios.

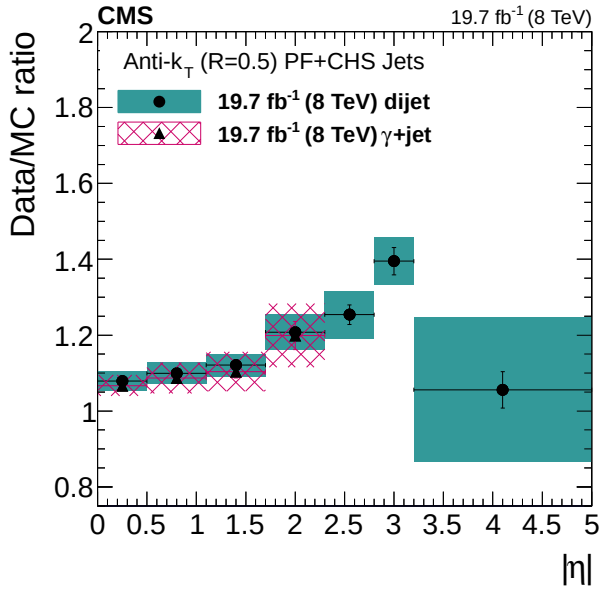
Global fit





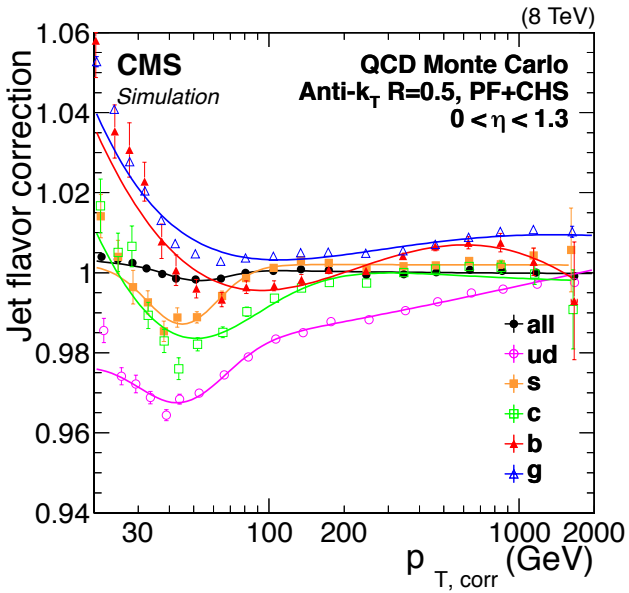
- $\gamma + jets$ is combined to other channels into a global fit.
- Each channel has it own p_T range where it is the most effective.
- Each channel has their own uncertainties that are taken into account in the global fit via nuisance parameters.

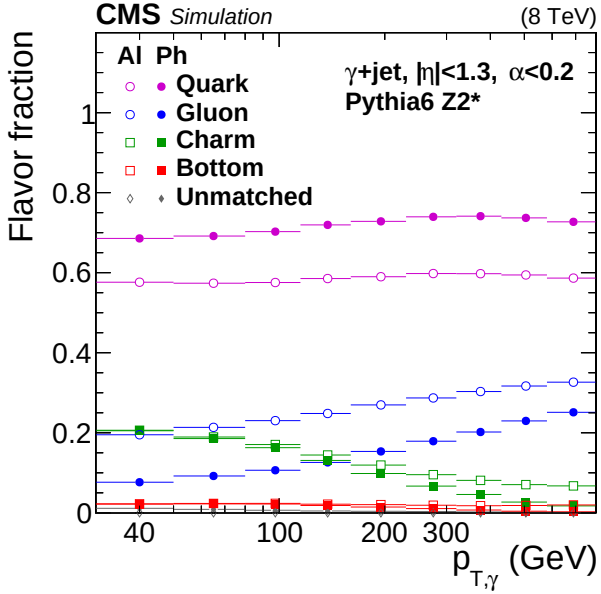
Jet Energy resolution (JER) study with $\gamma + jets$

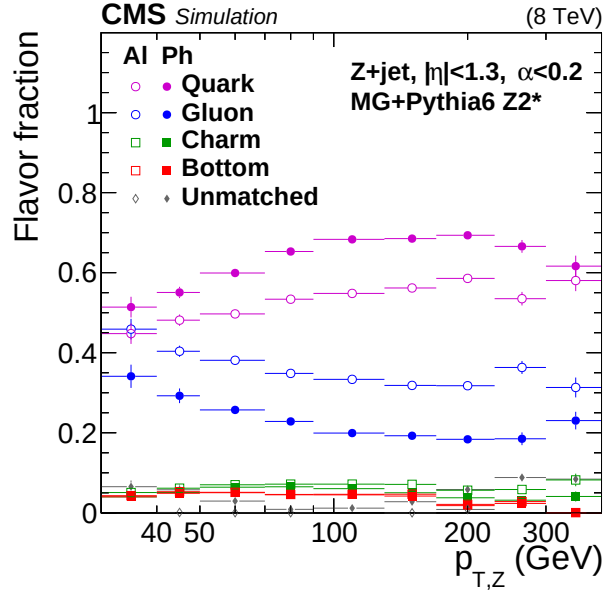


- The JER scale factors are used to smear the MC resolution to match that measured in data.
- The extraction is similar to the JES but taking the width of balancing distribution.
- Many analyses are very sensitive to the JER, their extraction is of major interest.

Jet flavor fraction







- The jet flavour is defined in term of parton flavor (the jet is matched to the closest gen-parton from the hard scattering)
- The jet flavour composition is different in each channel.
- Residual flavor correction have been extracted with MC samples
- Data have also different flavour fractions, it could be possible also to extract these corrections not only for MC sample but also for data.

Summary

- In the CMS experiment, $\gamma + jets$ events have been used to constrain the Jet Energy Scale and Resolution.
- JES and JER are extracted from events with no real ME_T and a photon as a reference object.
- The correction are extracted via the combination of different channels.
- In many analyses, jets are the first source of uncertainties. In this context, a better characterisation of the JES and the JER allow to reduce these uncertainties.

References

1. M.Cacciari, G. P. Salam, and G. Soyez "The anti-k_t jet clustering algorythm" JHEP 04 (2008)063, arxiv:0802.1189
2. http://iopscience.iop.org/article/10.1088/1748-0221/12/02/P02014/pdf

Backup

The LHC and the CMS detector

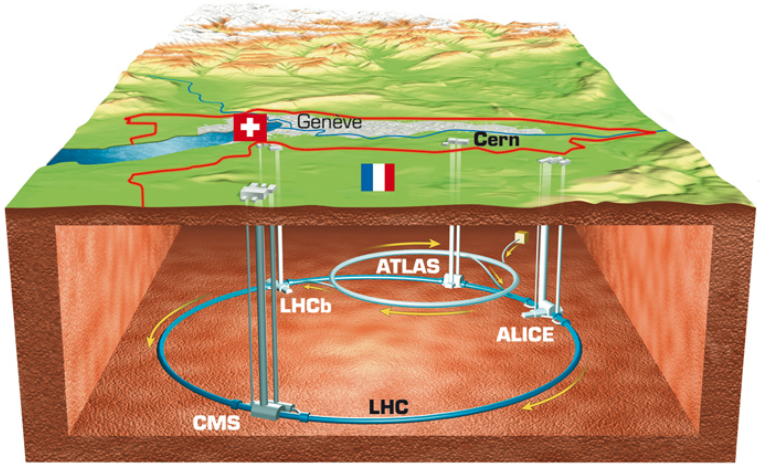


Figure: The LHC

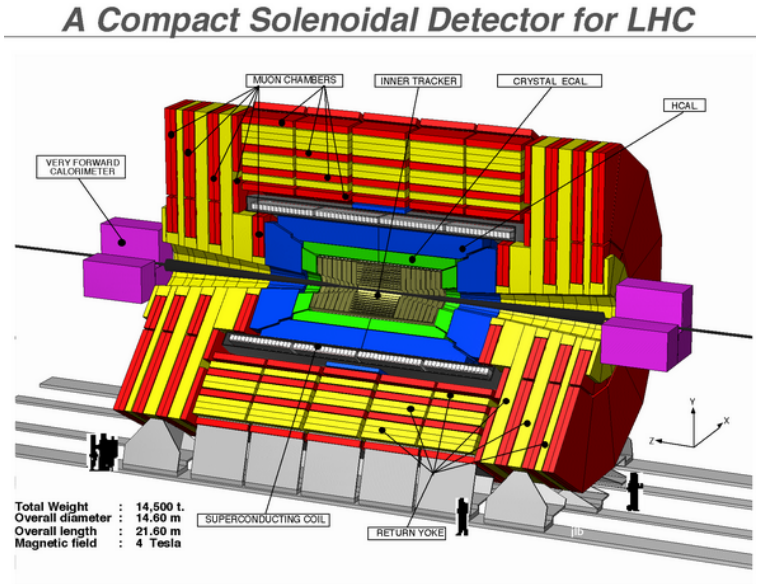


Figure: CMS

- Accelerate proton beams and collide them at a center of mass energy of 13 TeV.
- Multi-layer detector optimised for Higgs physics and a variety of new physics searches.
- PF reconstruction: optimally combine informations from different subdetectors to reconstruct and characterise the particles created in the collisions.