Jet Energy Corrections for PUPPI Jets

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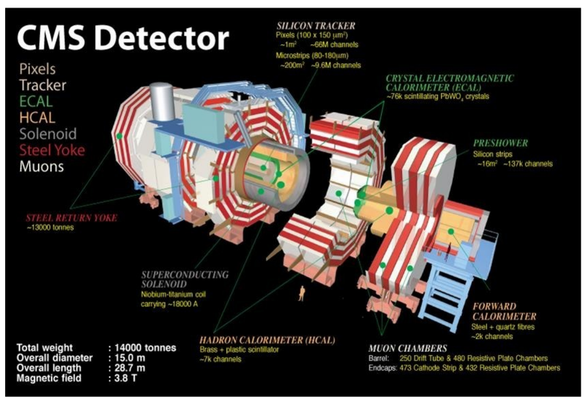
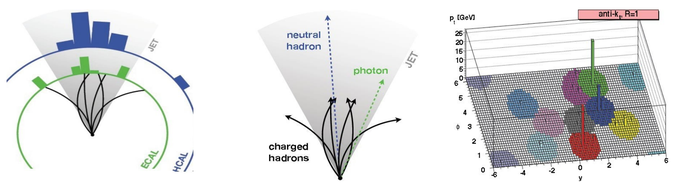
Introduction

- The Large Hadron Collider (LHC) is the world's most powerful particle accelerator.
- The CMS detector at LHC, consists of a superconducting solenoid which provides an axial field of 3.8 T.



PF Jet Reconstruction at CMS

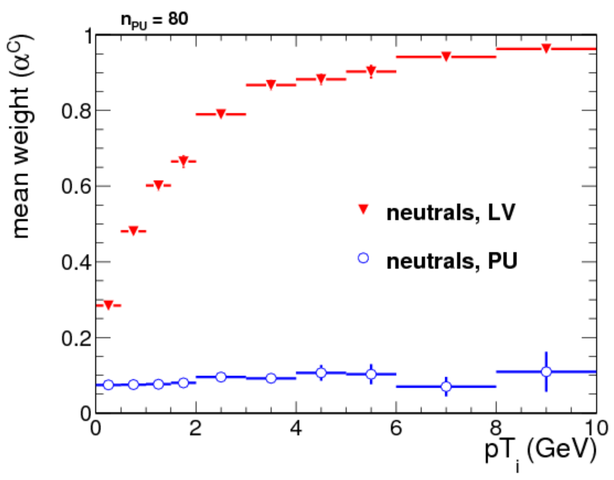
- Particle-Flow Jets: Clustering Particle Flow candidates[1] constructed combining information from all sub-detector systems.



- Anti-k_T clustering algorithm [2] with a cone R=0.4 (0.8) is then used which is infrared and collinear safe, geometrically well defined and tends to cluster around the hard energy deposits.
- Jets can be further classified based on different pileup reduction techniques:
  - PFCHS jets - Charged Hadron Subtracted (CHS) - : charged particles from non-primary vertices (pileup) are removed before clustering.
  - PUPPI jets : jets using inputs from the PUPPI algorithm.

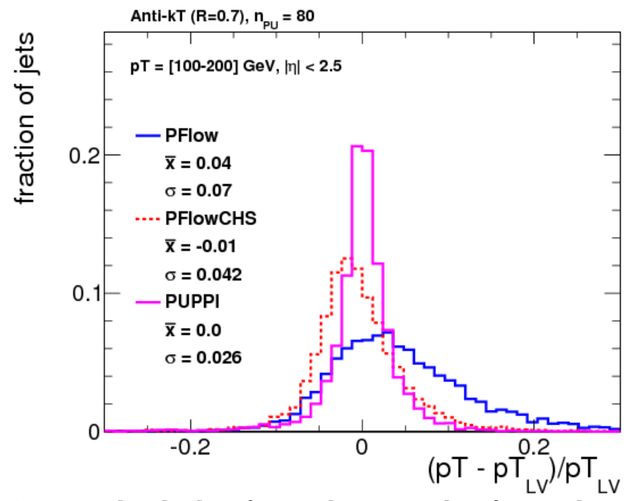
PUPPI algorithm

- In PUPPI Jets [3], each individual PF particle is weighted to account for the probability of coming from the leading vertex (LV) or pileup (PU) interactions. The weight rescales the particle four-momentum.
- This procedure leads to pileup-corrected PF jets



PUPPI Jets

- The jet p_T resolution of PUPPI for 80 pileup interactions is roughly 1.5 times better than PFlow CHS and 2.5 times better than PFlow.



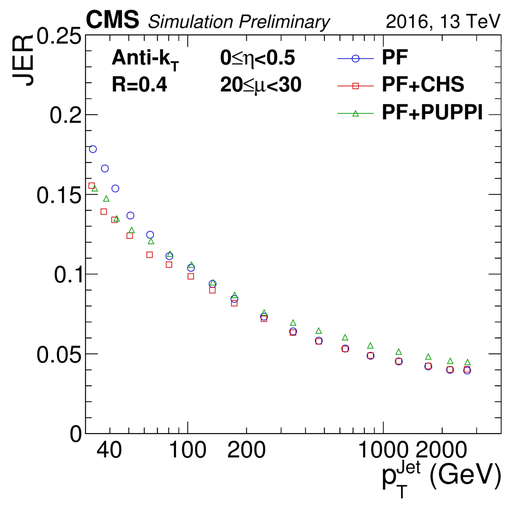
- Despite the lack of tracking in the forward region, PUPPI is able to identify pileup particles there as well using the discriminating variable α_i:

$$\alpha_i = \log \sum_{i \neq j, \Delta R_{i,j} < 0.4} \left(\frac{p_{Tj}}{\Delta R_{ij}} \right)^2$$

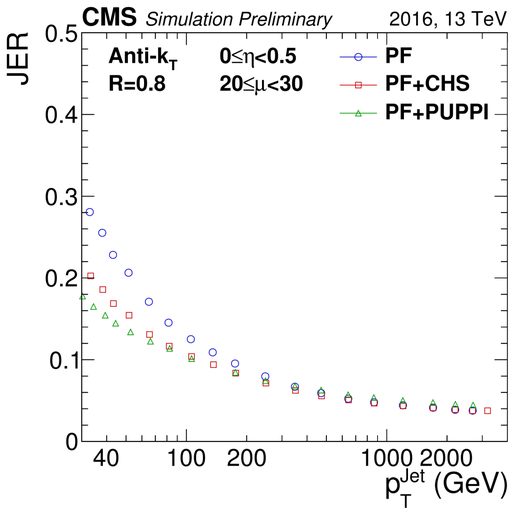
- i refers to the particle in question
- j are other particles
- p_{Tj} is the transverse momentum of the particle j
- ΔR_{ij} is the distance between the particles i and j on the η-φ plan

Jet p_T resolution

- For PF jets with a 0.4 cone-size, for 20-30 pileup interactions, the jet p_T resolution of CHS and PUPPI jets is similar [4].

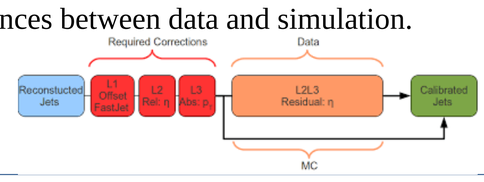


- For PF jets with a larger 0.8 cone-size, for 20-30 pileup interactions,PUPPI jets have better resolution than CHS ones [4].



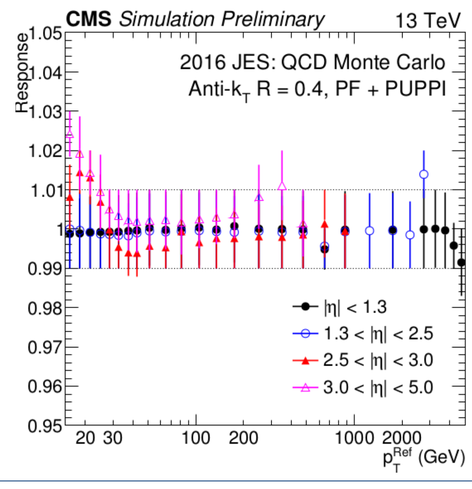
Jet Energy Corrections at CMS

- The energy of the jet that is measured at the detector level and the one that is obtained at particle level are different.
- This is why Jet Energy Corrections (JEC) to the measured jet energy are necessary in order to approximate, as best as we can, the jet energies at the generator (particle) level.
- L1 correction subtracts the average extra energy inside the jet cone due to pileup.
- L2 is a relative correction as a function of jet p_T and |η|, using balanced dijet events.
- L3 is an absolute correction using γ+jet events, Z+jets and multijet events.
- Baseline L2 and L3 corrections are obtained from simulation matching reconstructed with generated jets using dijet events. Then, residual ones are obtained from the data, using data-driven methods, to account for remaining differences between data and simulation.



JEC Performance on PUPPI Jets

- For PUPPI PF Jets only L2L3 corrections are needed.
- Generated and reconstructed jets spatially matched with ΔR <0.2. Jet response p_T^{reco} / p_T^{gen} then determined in fine bins of p_T^{gen} and |η|.
- Correction factor is the inverse of the mean response as a function of p_T^{gen} for each fine |η| bin.
- Then, we examine the closure of the derived MC Truth Corrections, by applying them in the same sample from which we derived them: corrected response is 1 ± 0.01.



Conclusions and Outlook

- Pileup per particle identification (PUPPI) is a very promising pileup-rejection method being implemented in CMS.
- PUPPI PF jets in CMS have improved jet pT resolution for low jet pTs where pileup plays an important role.
- PUPPI PF jets in CMS do not need pileup (L1) JEC corrections down to PF jet pTs of 15 GeV, due to successful pileup handling.
- Studies on PUPPI PF jets are ongoing to further improve their performance on CMS, as they will be becoming more and more important with the foreseen increase in instantaneous luminosity in Run III and HL-LHC.

References

1. Particle-flow reconstruction and global event description with the CMS detector, arXiv:1706.04965, JINST 12 (2017) P10003
2. The anti-k_T jet clustering algorithm, arXiv:0802.1189, JHEP 0804:063,2008
3. Pileup Per Particle Identification, arXiv:1407.6013v2, JHEP 1410 (2014) 59
4.