

Jet energy corrections in CMS

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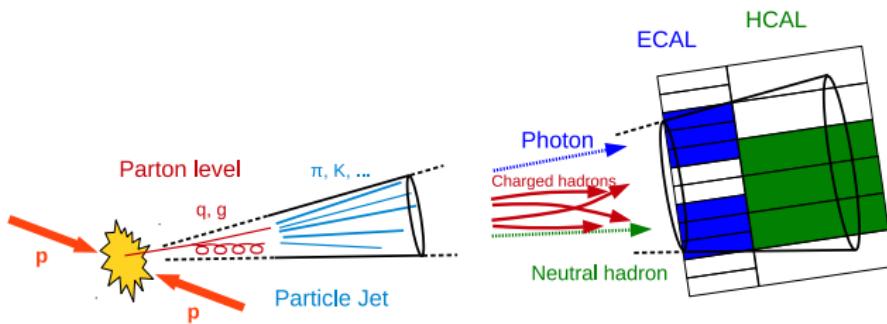
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Universität Hamburg

Vienna JetMET workshop, 25 Aug 2014

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 - Summary

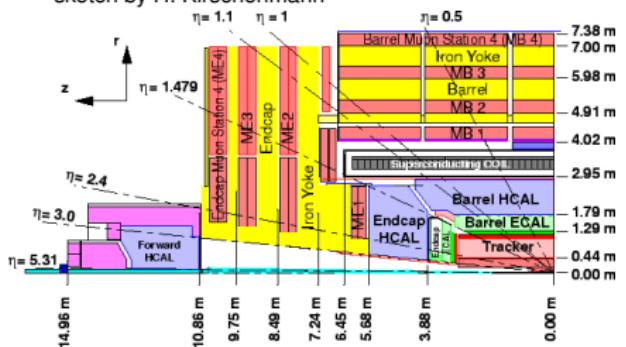
Jets at CMS



jet energy
corrections:

reconstructed jet →
particle level (no ν),
GenJet

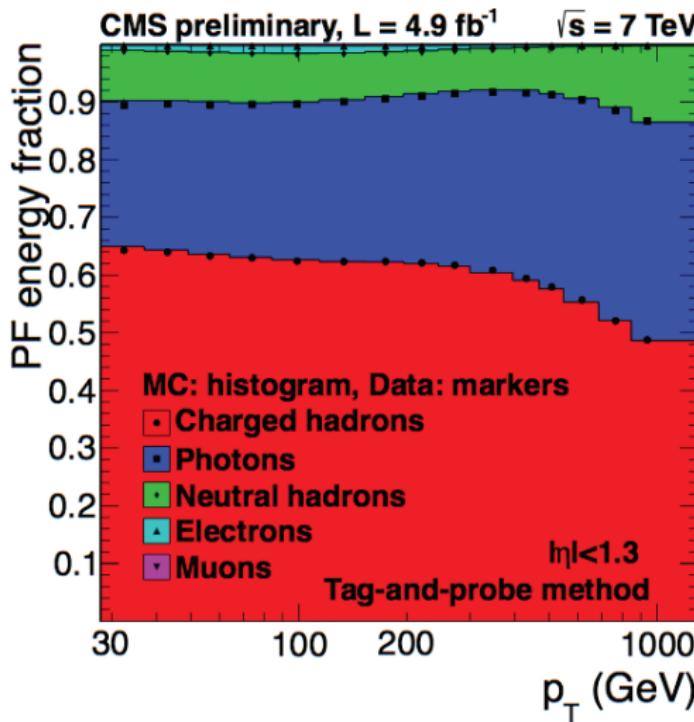
sketch by H. Kirschenmann



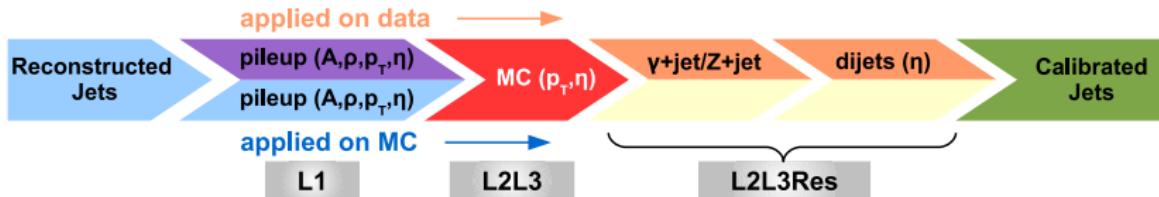
Jet types:

- anti- k_T jets with $R = 0.5$ and 0.7
 - clustered from PF particles
 - optional: removal of charged particles from pileup (CHS)

PF Jet Composition



Jet Energy Corrections

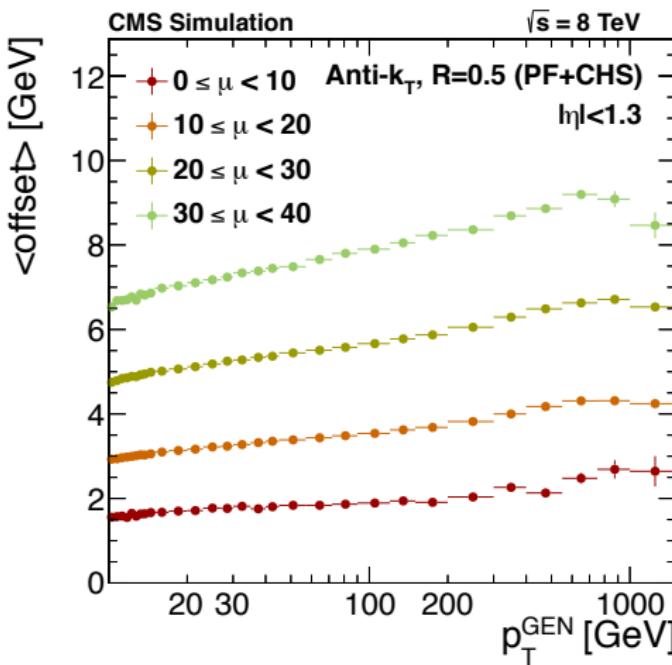


sketch by H. Kirschenmann

Factorized Approach:

- offset (L1): removal of pileup and electronic noise
- relative and absolute MC (L2L3): correction to particle level jet response
- (only for data) residual: correct for differences between data and simulation

Pileup Corrections from Simulation (L1)

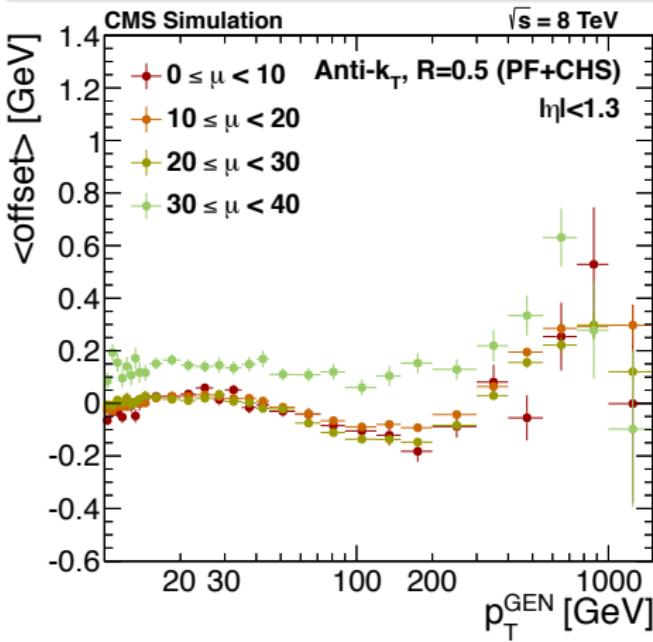


- same simulated QCD dijet events **with** and **without** added pileup
 - match reconstructed jets between samples based on particle level

CMS DP-2013/XXX

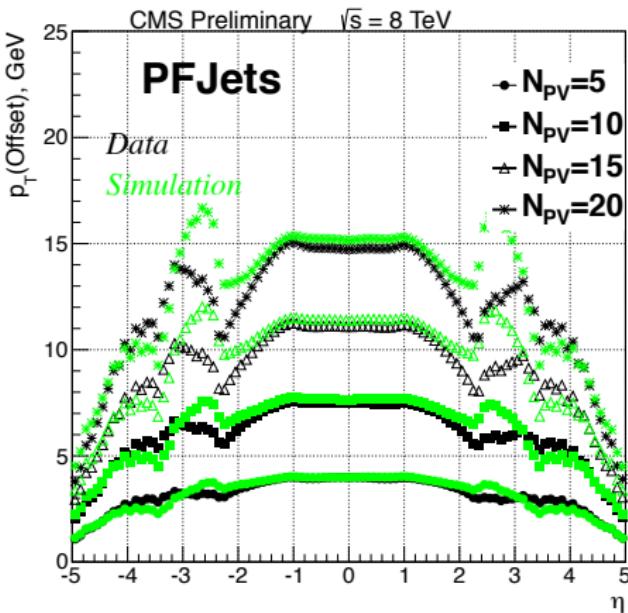
Pileup Corrections from Simulation (L1)

Remove offset as function of ρ , A , η and p_T (area-median approach)



Pileup Corrections for Data (L1)

Look at energy deposited in random cones in zero-bias data and ν MC sample



CMS DP-2013/033

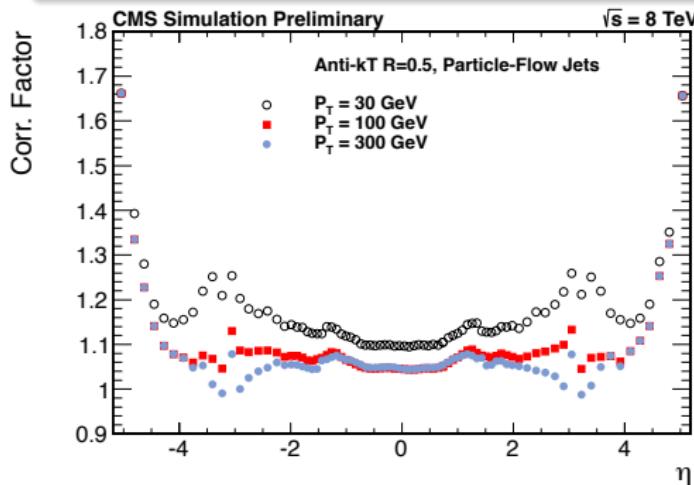
Jet energy corrections in CMS

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Corrections from Simulation (L2L3)

- find response in particle level p_T and η on simulated QCD dijet events with pileup after L1
- invert to find $C(p_T, \eta)$ for the L1 corrected reconstructed p_T

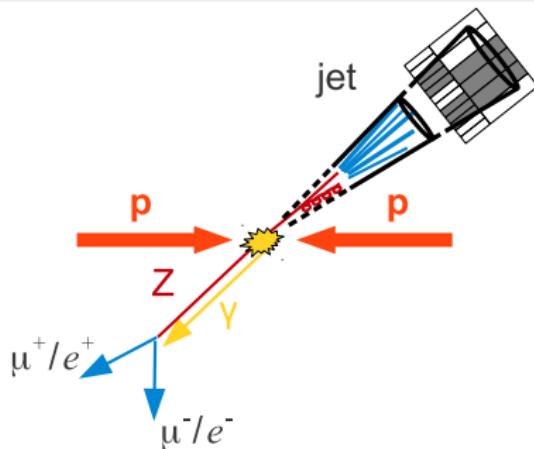


More details:

talk by A. Perloff:
"MC truth corrections and cone sizes"
tomorrow 4:15 pm

Corrections for Scale in Barrel Region (residual)

Measure absolute scale from balance with well measured reference object and compare simulation and data

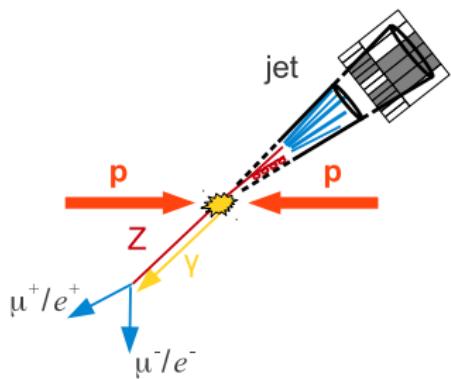


Channels:

- $Z(\mu\mu) + \text{jet}$
- $Z(ee) + \text{jet}$
- $\gamma + \text{jet}$
- (multijet events)

sketch by H. Kirschenmann

Corrections for Scale in Barrel Region (residual)



sketch by H. Kirschenmann

Observables:

- relative p_T of next-leading jet:

$$\alpha = \frac{p_{T,2nd\ jet}}{p_{T,tag}}$$

- p_T balance:

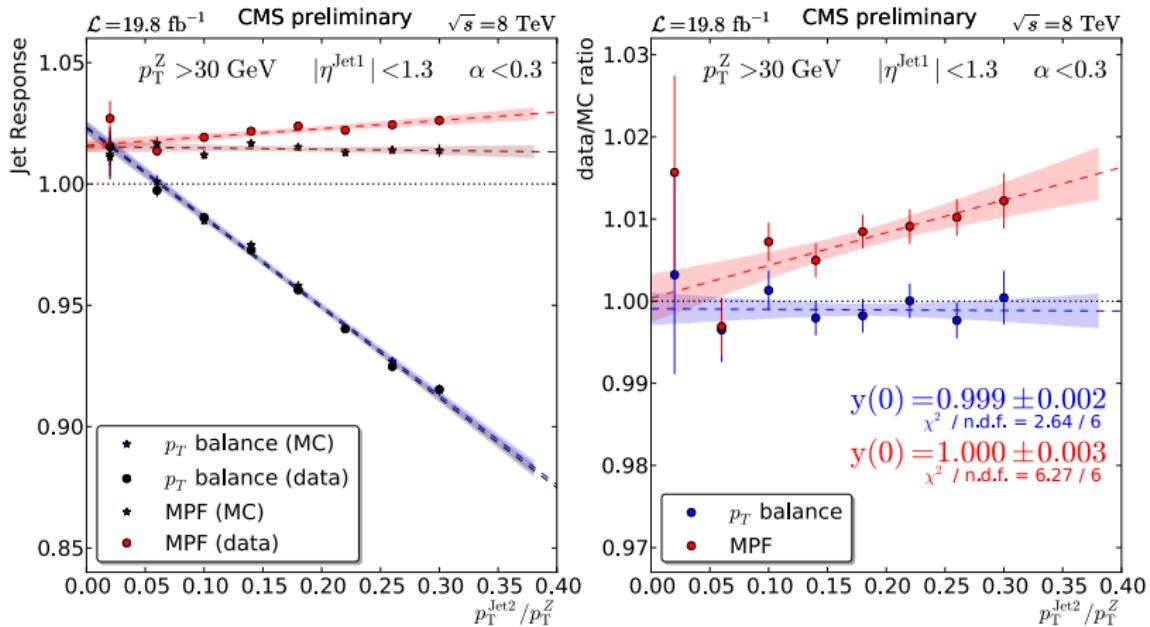
$$R_{probe} = \frac{p_{T,probe}}{p_{T,tag}}$$

- MPF:

$$R_{probe} \approx R_{MPF} = R_{tag} + \frac{\vec{E}_{T,\text{miss}} \cdot \vec{p}_{T,tag}}{(\rho_{T,tag})^2}$$

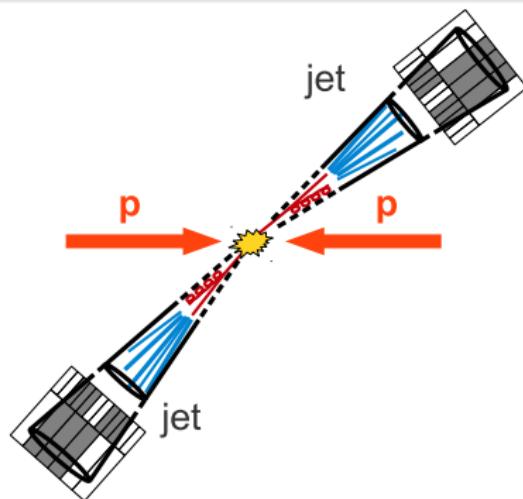
Scale in Barrel Region from Z+jet

Extrapolate to "no second jet" (pushes average p_T to ~ 150 GeV)



Relative Corrections for Data (residual)

Use dijet events to link other η regions to barrel



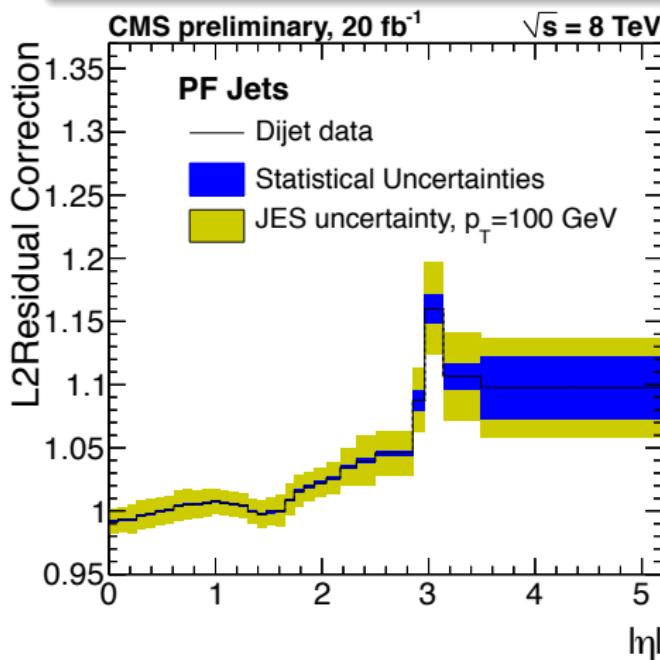
sketch by H. Kirschenmann

Selection:

- use special triggers on average p_T of dijet system
- tag jet within barrel region
- two highest p_T jets:
 - pass jet quality cuts
 - $\Delta\varphi(\text{tag}, \text{probe}) > 2.7$
 - $p_T^{\text{ave}} = (p_T^{\text{tag}} + p_T^{\text{probe}})/2$
- cut on $p_{T,\text{rel}}^{\text{3rd jet}} = \frac{p_{T,\text{rel}}^{\text{3rd jet}}}{p_T^{\text{ave}}}$

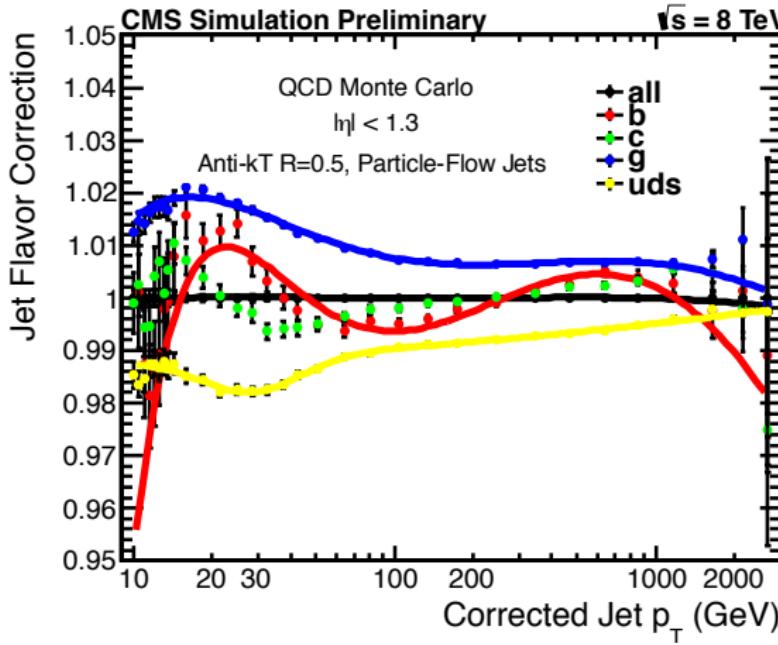
Relative Corrections for Data

extrapolate to "no third jet" (pushes with trigger average p_T to ~ 300 GeV)



- look at relative response from asymmetry or MPF
- take ratio data/MC at $\alpha = \frac{p_T^{\text{3rd jet}}}{p_T^{\text{ave}}} < 0.2$
- correct with a factor k_{FSR} to $\alpha = 0$
- correction as function of p_T, η

Optional: Corrections for Jet Flavor (L5)



Usually taken care of by comparing data to MC

Sources of Uncertainties

Uncertainties on data-derived corrections

statistical and systematic uncertainties on:

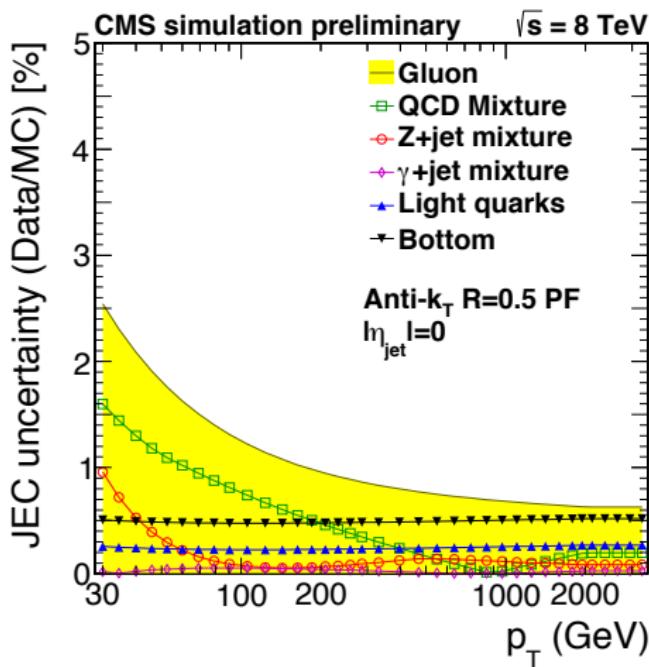
- scaling of pileup correction (η, ρ)
- relative corrections (η, p_T)
- absolute corrections (scale in barrel)

Uncertainties not constrained by data

uncertainty on modeling of:

- jet- p_T -dependence of pileup
- absolute scale at low or very high p_T (extrapolation)
- change of calorimeter scales with time
- different jet flavors

Uncertainty due to Jet Flavor

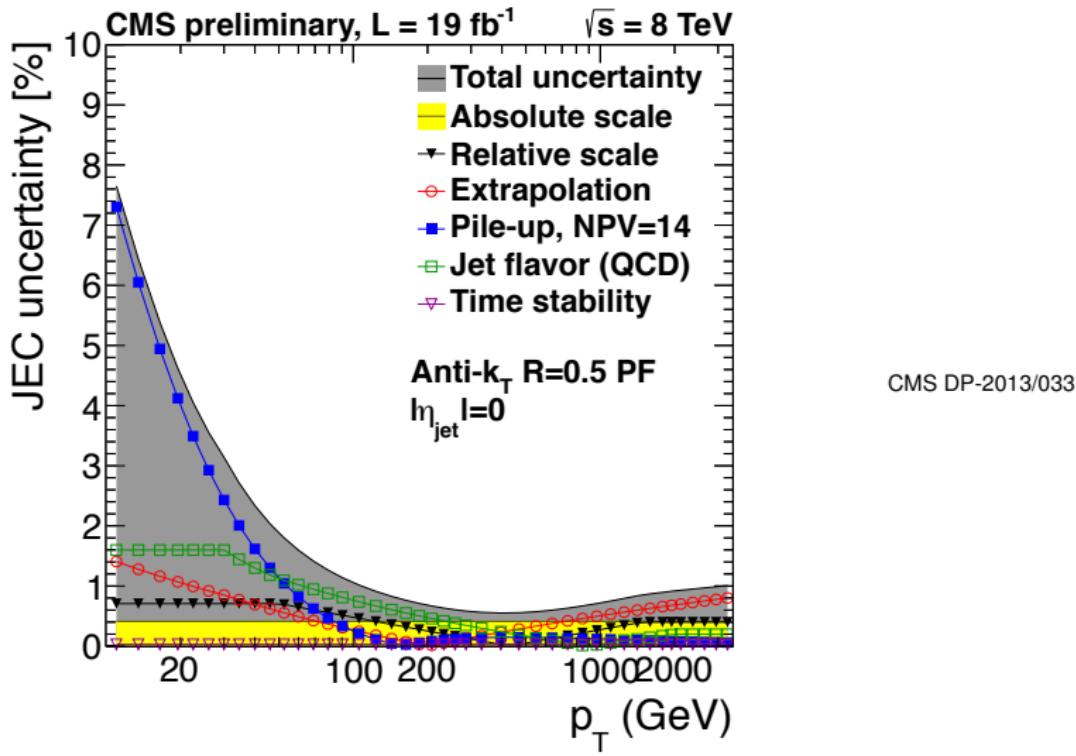


hadronization uncertainty

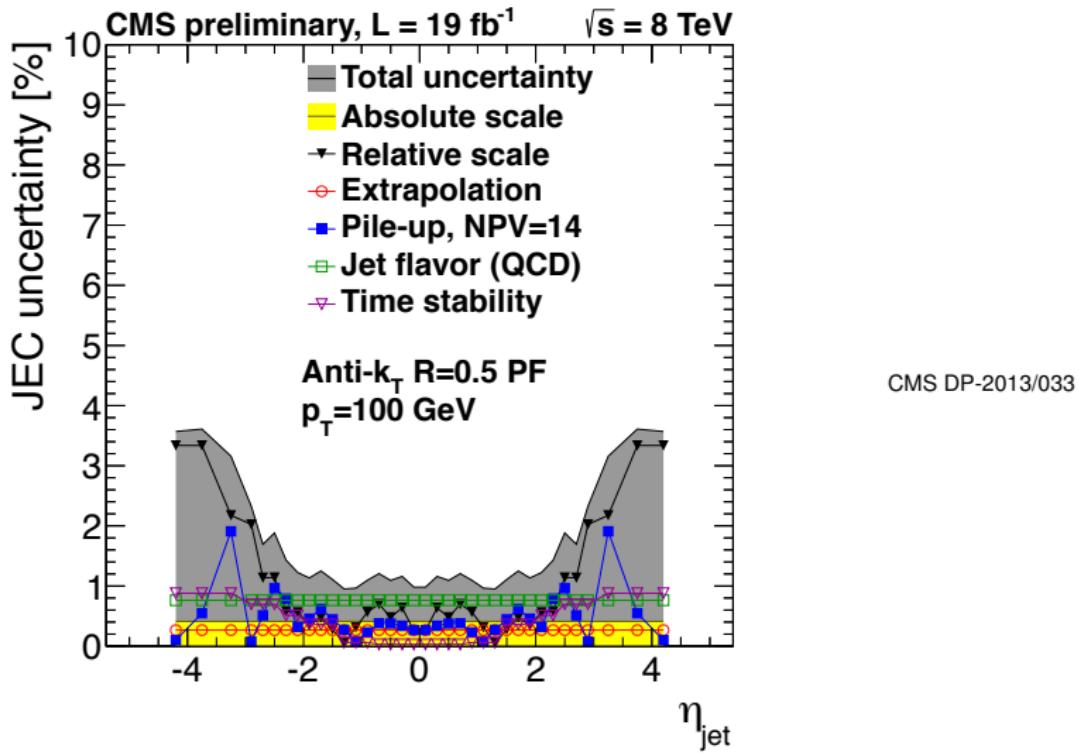
- constrained for flavor mixture as in Z+jet
- other flavor: take uncertainty from Pythia/Herwig
- for b quarks: $\sim 0.5\%$ or 320 MeV on m_t (excluding ν)

CMS DP-2013/033

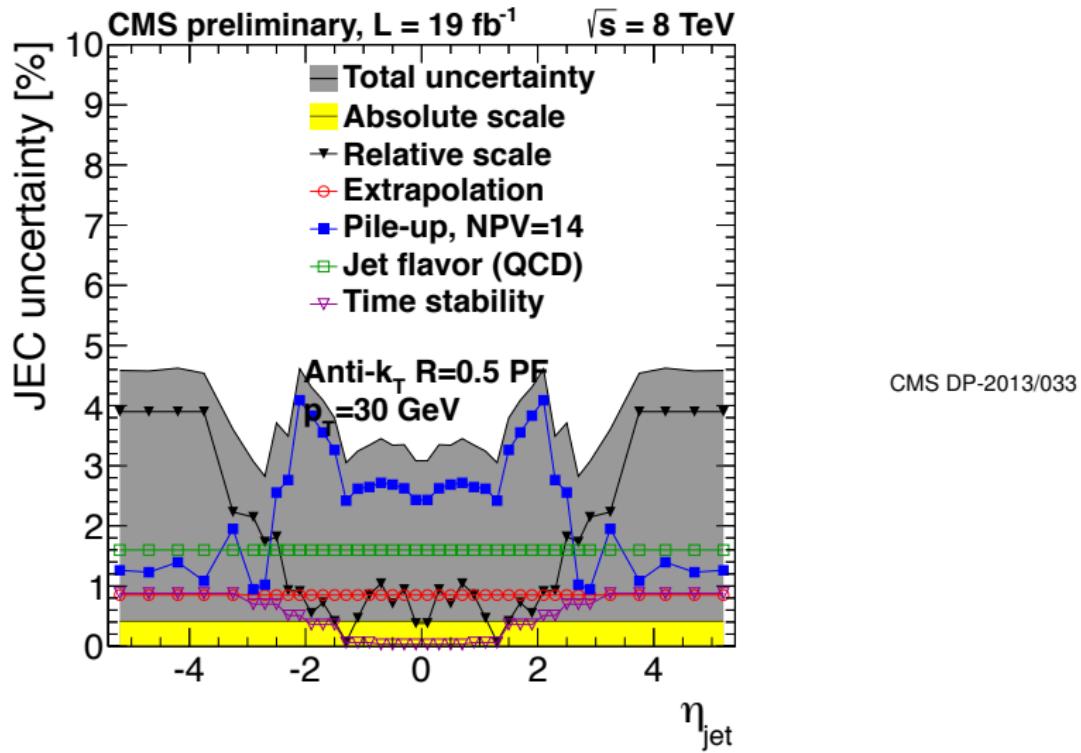
JEC Uncertainties



JEC Uncertainties

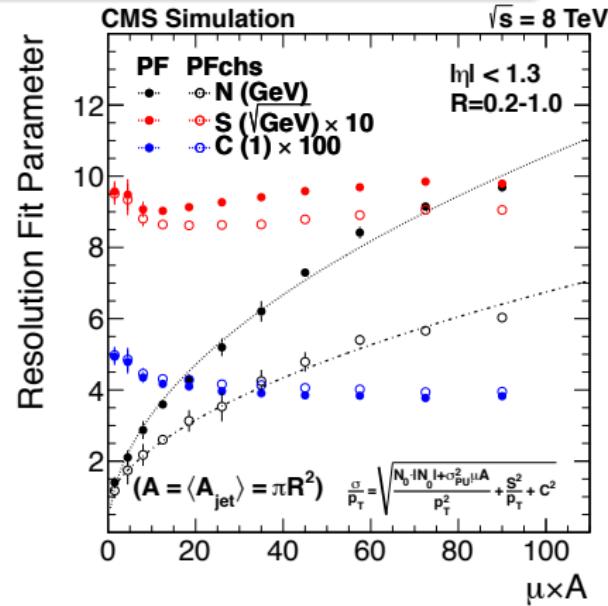
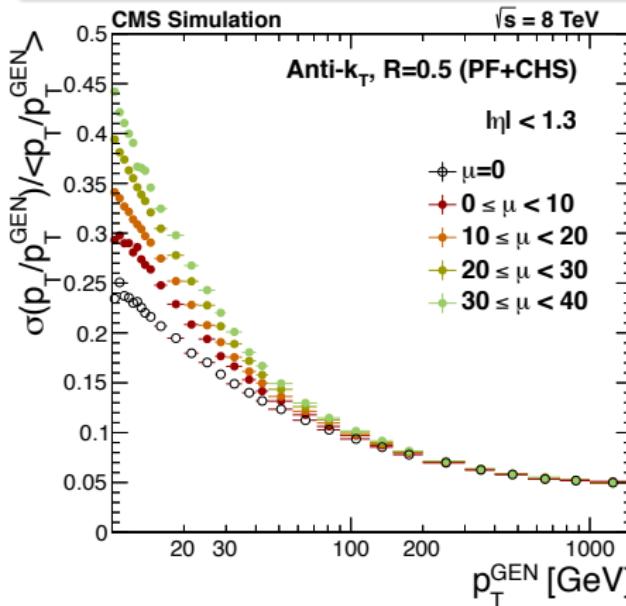


JEC Uncertainties



Jet Energy Resolution in Simulation

$$\text{PF jets: } \frac{\sigma(p_T)}{p_T} = \sqrt{\text{sgn}(N) \left(\frac{N}{p_T}\right)^2 + \frac{S^2}{p_T} + C^2}$$

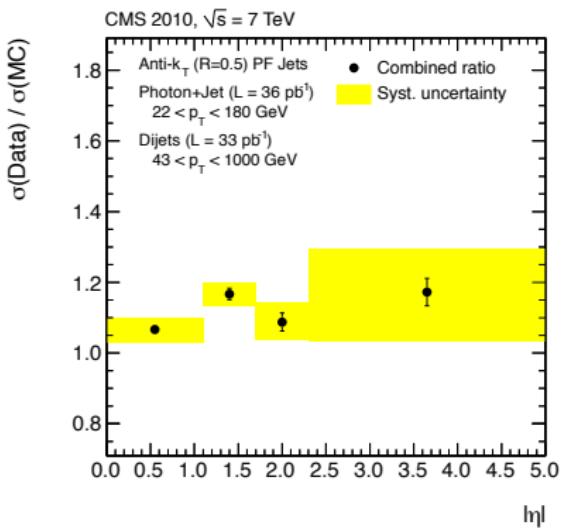
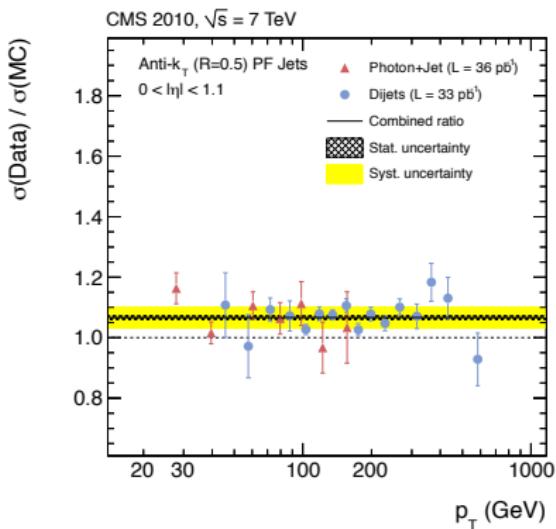


DP-2013/XXX

Jet Energy Resolution: Data/MC

use same techniques/samples as for residual corrections

2011 numbers: impact on $m_t \sim 260$ MeV



JINST 6 P11002

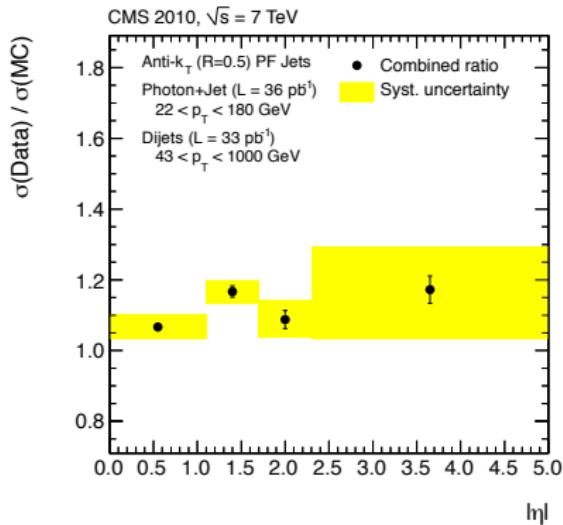
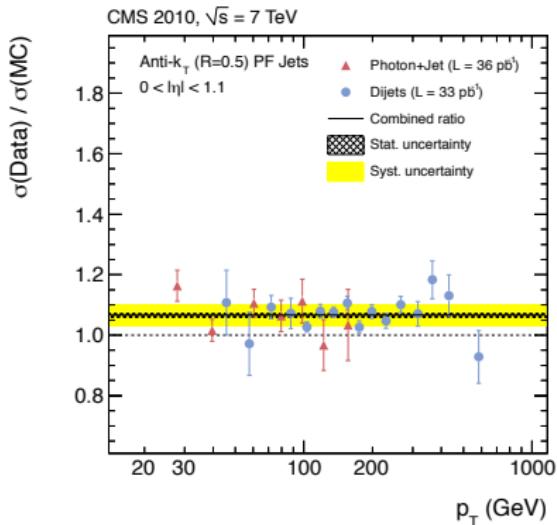
Jet Energy Resolution: Data/MC

New results:

talk by K. Goebel:

"Measurement of the jet transverse momentum resolution"

tomorrow 3:50 pm



Summary and Outlook

Summary:

- corrections for data needed for pileup, scale, and resolution
- jet energy corrections for "average" analyses know up to 1% level
- uncertainties classified for LHC combinations together with ATLAS

Outlook:

- new results on corrections, resolution, and validation of flavor response public soon
- barrel scale correction p_T -dependent using Z/γ +jet **and** multijets talk by A.-L. Pequegnot, "High-pt JECs with multijets", Tu 5:05 pm
- for run 2:
 - new jet cones, need first set of corrections for data quickly
 - cover large p_T range
 - constrain further uncertainties from data