Overview

- Let us see where we are and plan ahead
- $Z \rightarrow e^+e^-$ reconstruction:
  - Use "standard" electron selection, iso, id ...
  - Efficiency: extraction machinery in place (t&p) if we need
- Jets
  - Efficiency: Not an issue (~100 %) directly (caveat)
  - Resolution: presently available from MC, will obtain from data (using γ/Z+jet events)
  - JEC: available from MC, but data-driven correction obtained
  - Jet p_T cut: might need > 30 GeV/c. Will explain later ...
- Some thoughts on issues we have been ignoring so far
- Theory prediction

Summary of event selection

✓**Use standard *Egamma* POG electron Id**
✓**Use standard EWK electron isolation**

✦ $Z \to e^+e^-$ reconstruction

- $|m_{ee} - M_Z| < 10$ GeV/c^2
- Electrons
  - super cluster matched to track (*gsfElectrons*)
  - $p_T > 20$ GeV/c
  - within ECAL and tracker acceptance:
    $|\eta| < 1.4442$ (barrel) OR $1.56 < |\eta| < 2.5$ (endcaps)
  - loose isolation
  - "Robust Loose" electron id

✦ Jet

- Jet in the central region: $|\eta_{Jet}| < 1.3$

We can relax this given that we are going to take hit from JEC uncertainty anyway.

electrons

Z→e⁺e⁻: electron isolation criteria

Definition

Track isolation: $\sum_{0.015<\Delta R<0.3,\ p_T^{Track}>1.0} \left(p_T^{\text{track}}\right)$

ECAL & HCAL isolation: $\sum_{\Delta R<0.4} \left(E_T^{\text{RecHits}}\right)$

Veto

ECAL:

- Inner cone radius
  barrel: $\Delta R > 0.045$, endcaps: $\Delta R > 0.070$
- E_T threshold
  barrel: $E_T > 0.08$, endcaps: $E_T > 0.3$
- "Jurassic footprint removal"
  $0.02 < |\Delta\eta| < 0.5$ (both barrel and endcaps).

HCAL: None

These are default *Egamma* definitions

Cuts

Table 1: Isolation criteria for $\gamma^*/Z \rightarrow e^+e^-$ candidates.

	Track	Ecal	Hcal
Barrel	7.2	5.7	8.1
Endcap	5.1	5.0	3.4

EWK-09-004

$Z \rightarrow e^+e^-$: electron id

Definition

The *EGamma* POG defines the following four electron identification variables to discriminate between real and fake electrons:

$\Delta\eta$: difference between η of electron supercluster and electron track
$\sigma_{i\eta i\eta}$: electron super cluster resolution
$\Delta\Phi$: difference between Φ of electron supercluster and electron track
H/E : ratio of hadronic to electromagnetic component of the energy

Cuts

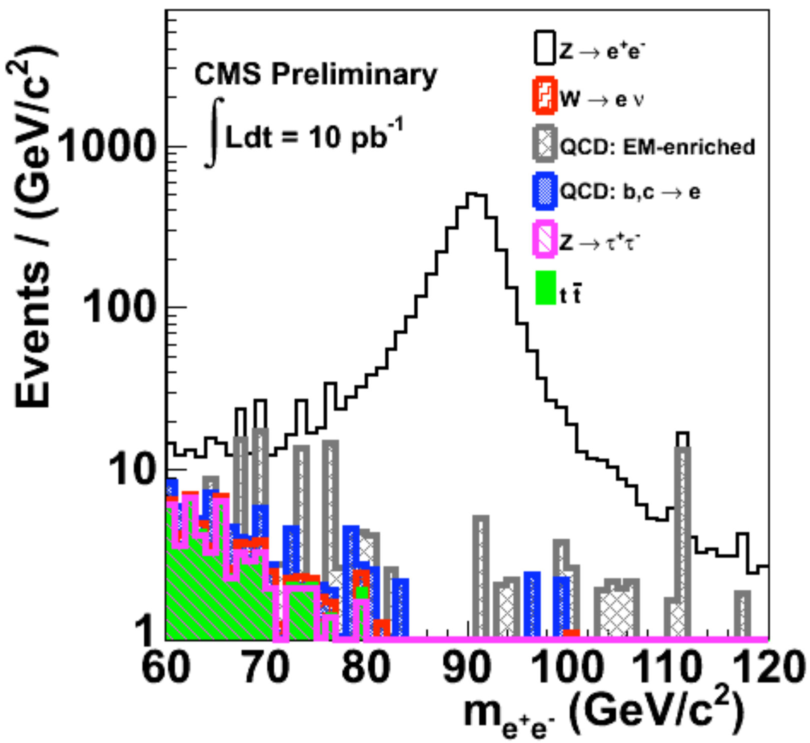
Variable	barrel	endcap
$\lvert\Delta\eta_{in}\rvert$	0.0077	0.0100
$\sigma_{i\eta i\eta}$	0.0132	0.027
$\lvert\Delta\varphi_{in}\rvert$	0.058	0.042
H/E	0.075	0.083

Standard *Egamma* POG electron ID
"Robust Loose"

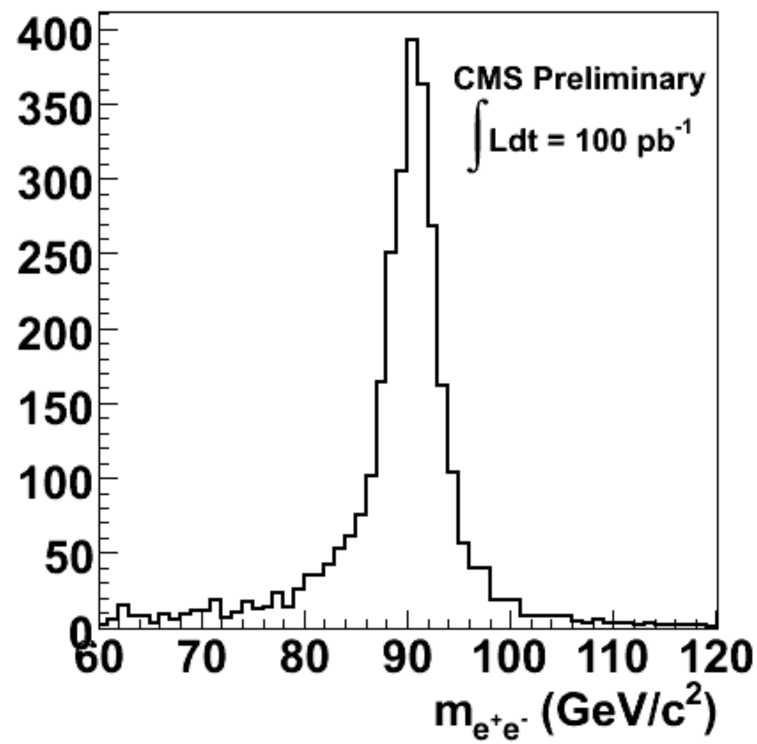
https://twiki.cern.ch/twiki/bin/view/CMS/SWGuideCutBasedElectronID

$Z \rightarrow e^+e^-$ signal and backgrounds

Signal & background



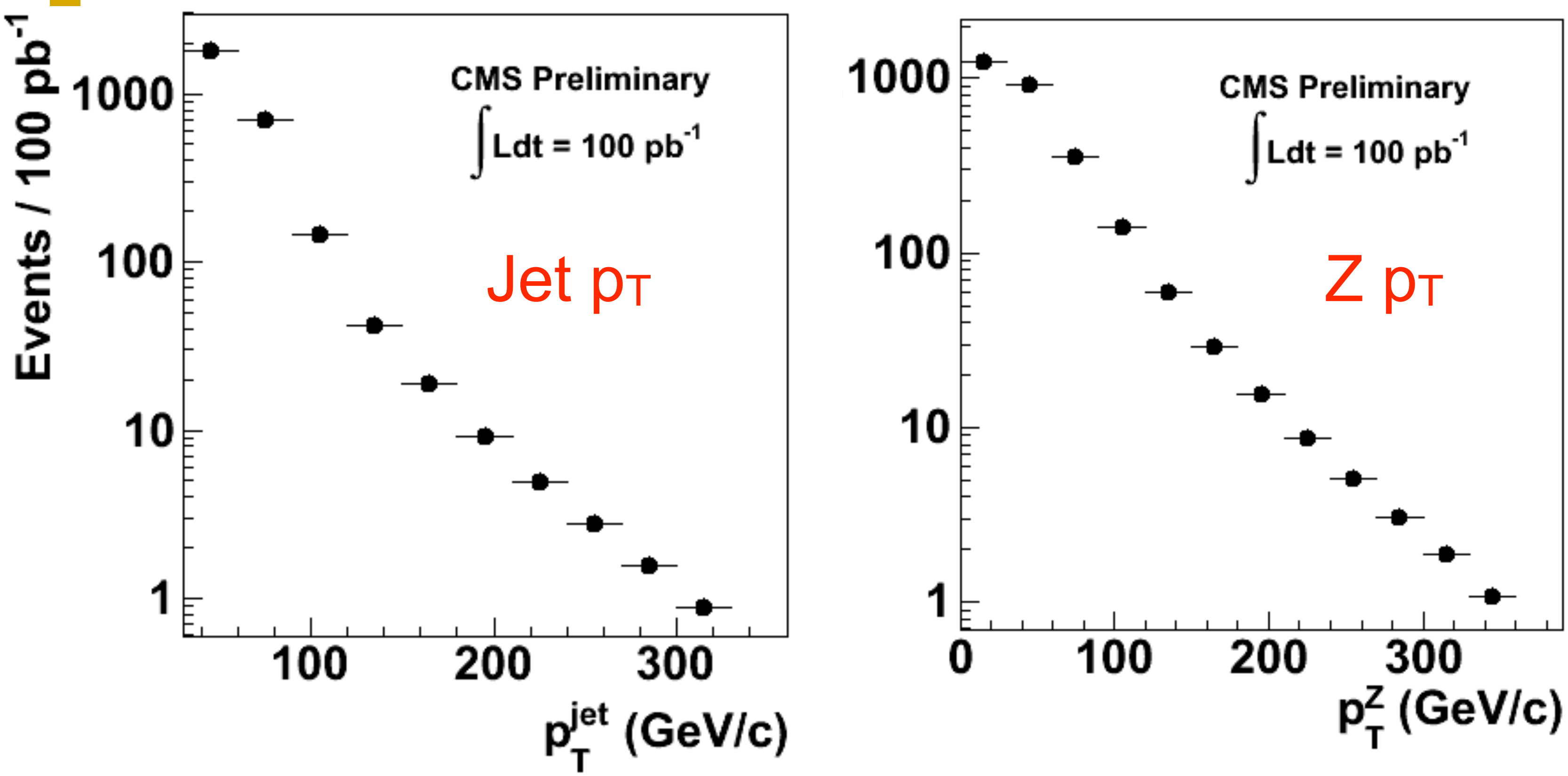
Reconstructed Z mass



- ✦Monte Carlo predicts less than 1% background contamination.
- ✦Will have slightly higher backgrounds in Zee+jets sample and in data.

Z + jets

p_T distributions of the Z and leading jet



✦We will have data up to p_T = 300 GeV/c.
✦Total events ≈ 2500 for 100 pb^{-1} at $\sqrt{s}$ = 10 TeV.

Background subtraction

✓**Progress on the "matrix/ABCD" method by Lovedeep**
✓**Updates from Lovedeep**

✦Background contribution is small (~ 10 % or smaller).

- if we screw up in background estimation by, say, 20% it will be 2 % additional systematic uncertainty
  - ➡This is negligible as we will see shortly
- This also means that we should not be spending too much time on backgrounds

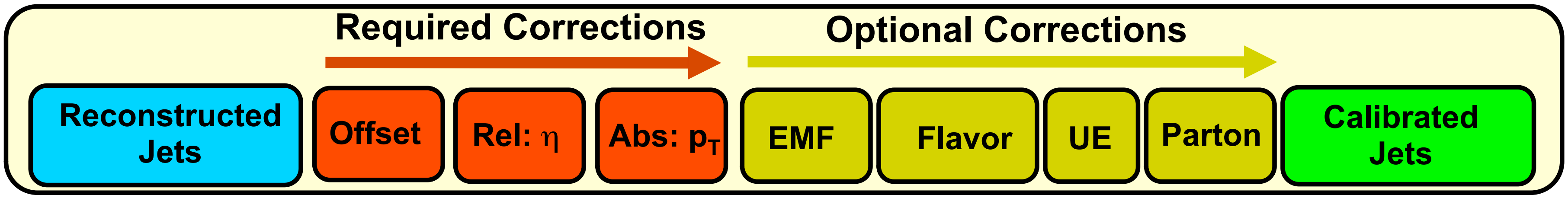
✦Both Tevatron experiments used template method to subtract background (taking shapes from MC)

✦In CMS (and also among Tevatron EWK/Top group), the "ABCD" method has gained popularity.

✦Depending on feedback from Lovedeep regarding how it works, we can decide to go for one method or another.

Jets

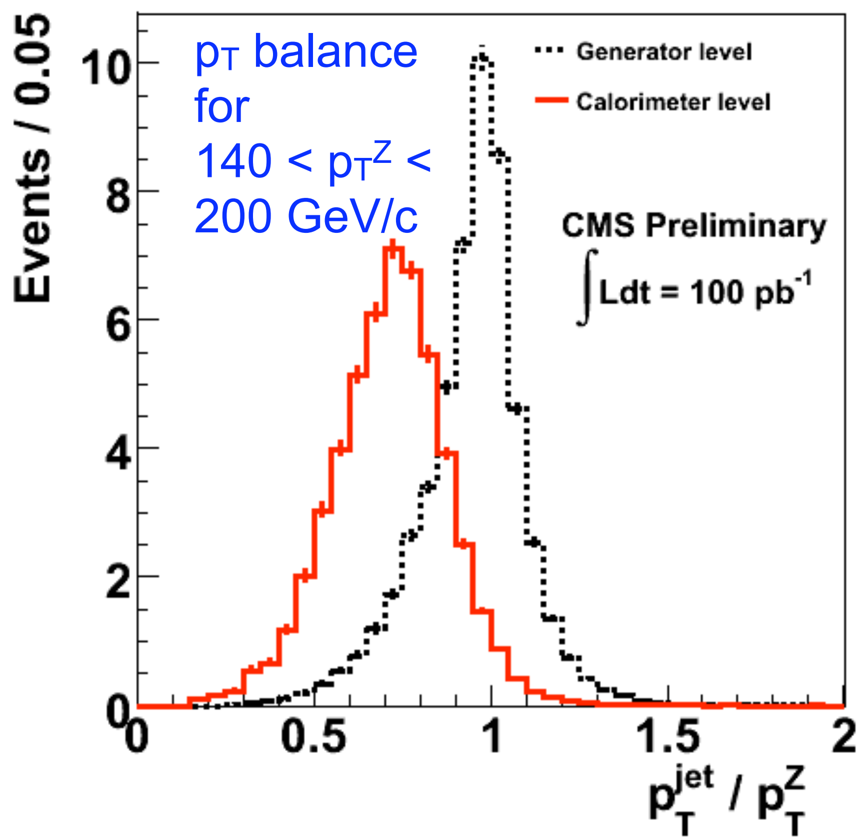
CMS plans for Jet Energy Correction

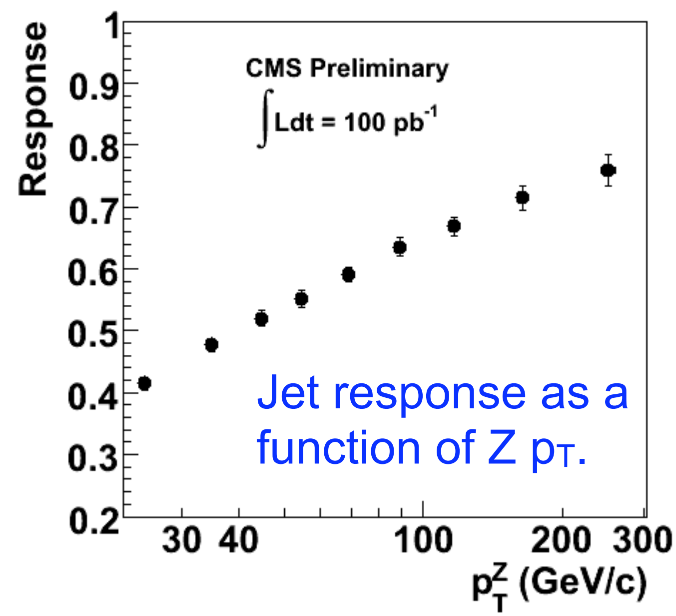


- CMS plans require the following jet energy corrections for most analysis
  - ➡ **Offset**: correction for pile-up and noise
  - ➡ **Relative**: correction for jet response vs. η relative to barrel
  - ➡ **Absolute**: correction for jet response vs. P_T in barrel
- The absolute correction will be measured ***in situ*** using p_T balance
  - ➡ In the three processes γ+jet, $Z(\rightarrow \mu^+\mu^-)$+jet, and $Z(\rightarrow e^+e^-)$+jet
- In Z ($\rightarrow e^+ e^-$) + jets analysis we will also need to apply flavor correction
  - ➡ **Flavor**: Z + jet events are rich in quarks. Quark jets have larger response than gluon jets which dominate QCD sample (the default flavor for CMS absolute correction)

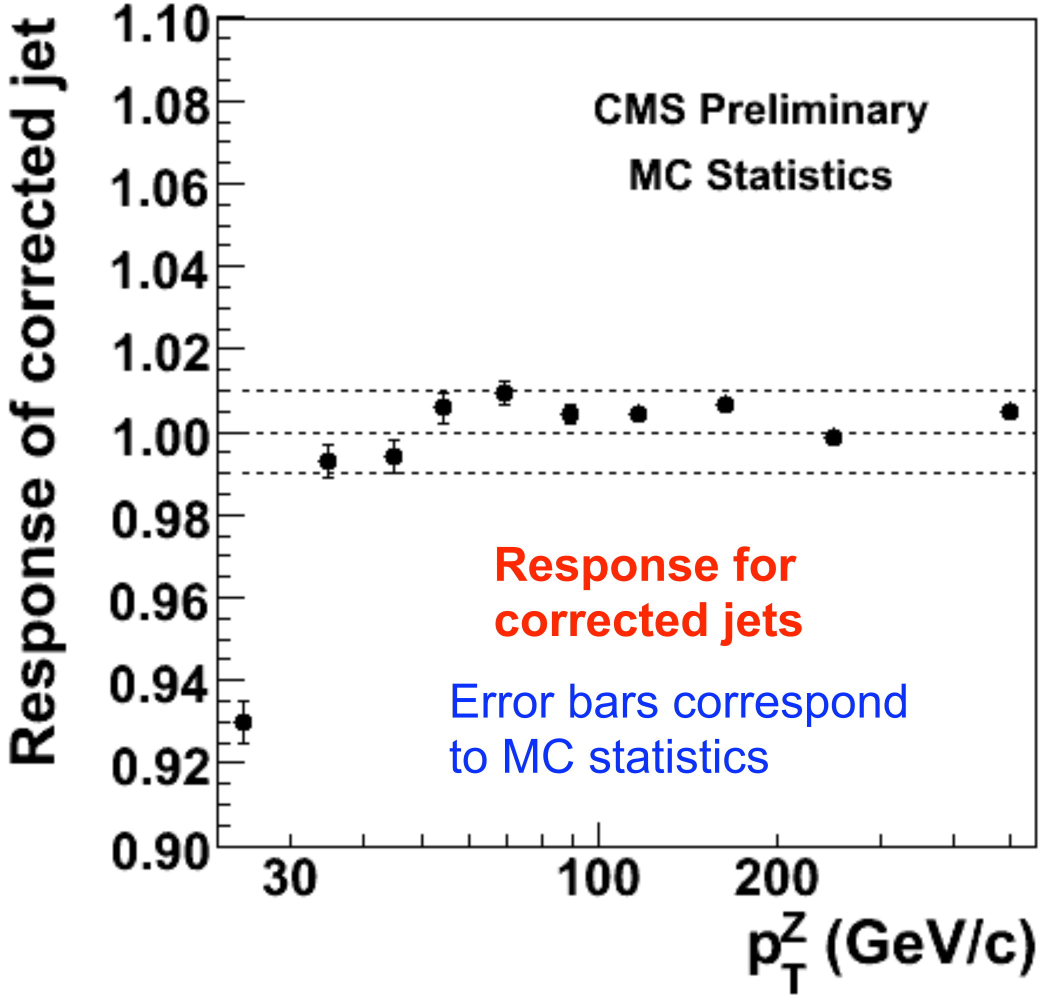
Understanding JEC: Z+jet p_T balance

- Jet response, p_T^{jet} / p_T^Z, peaks at:
  - 1 for Monte Carlo generated particle jets
  - < 1 for calorimeter jets
- The inverse of the jet response is the correction





Consistency check: response for corrected jets



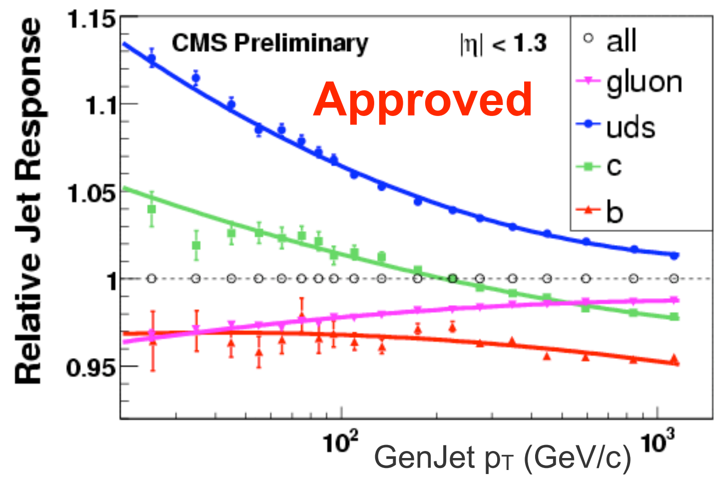
- ✦Obtain a good closure for $p_T > 30$ GeV/c. The response of the corrected jets is within 1% of unity.
- ✦Our method breaks down at very low p_T.
- ✦The first point shows the limit below which the method doesn't work. In this region the response distribution is highly non-Gaussian both before and after applying correction.

<u>Conclusion:</u> The method works well for $p_T > 30$ GeV/c.

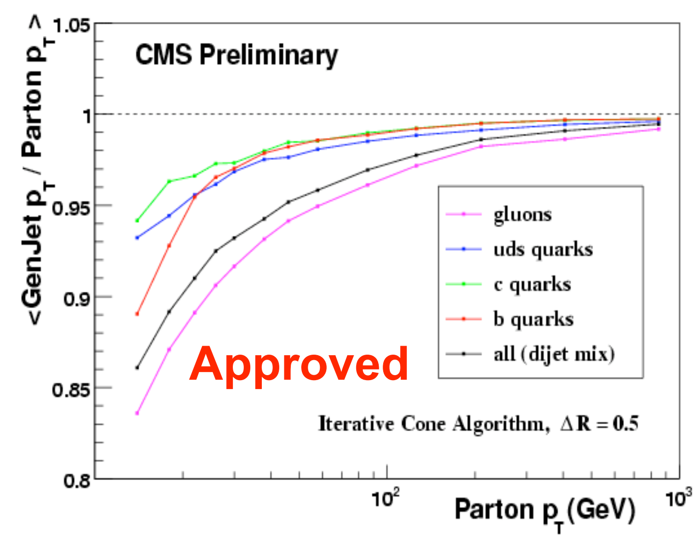
Flavor dependence

- γ/Z + jet events are rich in quarks
  - ➡ Quark jets have larger response than gluon jets which dominate many samples
- γ/Z + jet p_T balance corrects back to the parton level.
  - ➡ But the absolute correction is defined to be to the particle jet level
- The transformation function corrects for these effects using MC.
  - ➡ Makes the absolute correction applicable to the jet flavor mix of dijet events
  - ➡ Makes the absolute correction to the particle jet level, not the parton level

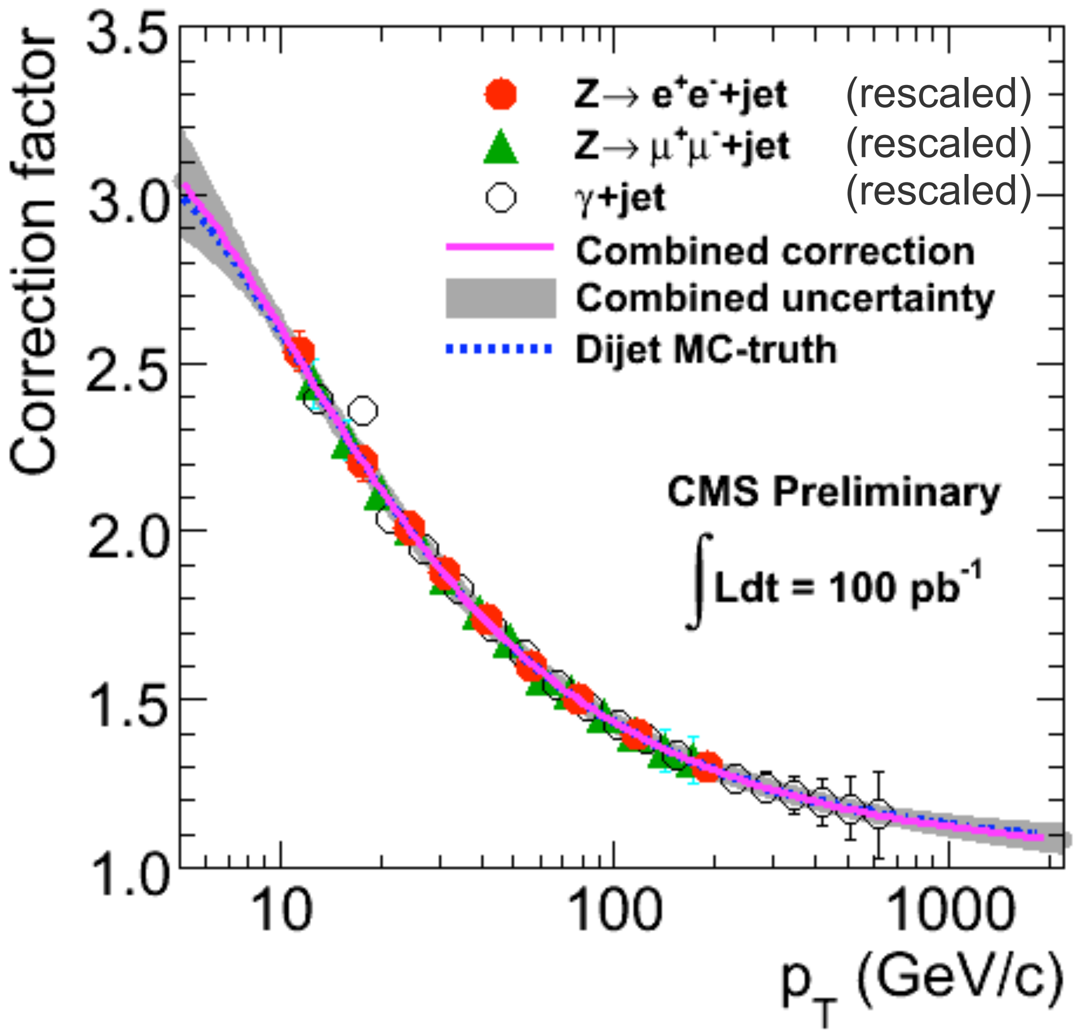
Flavor Corrections



Parton Corrections

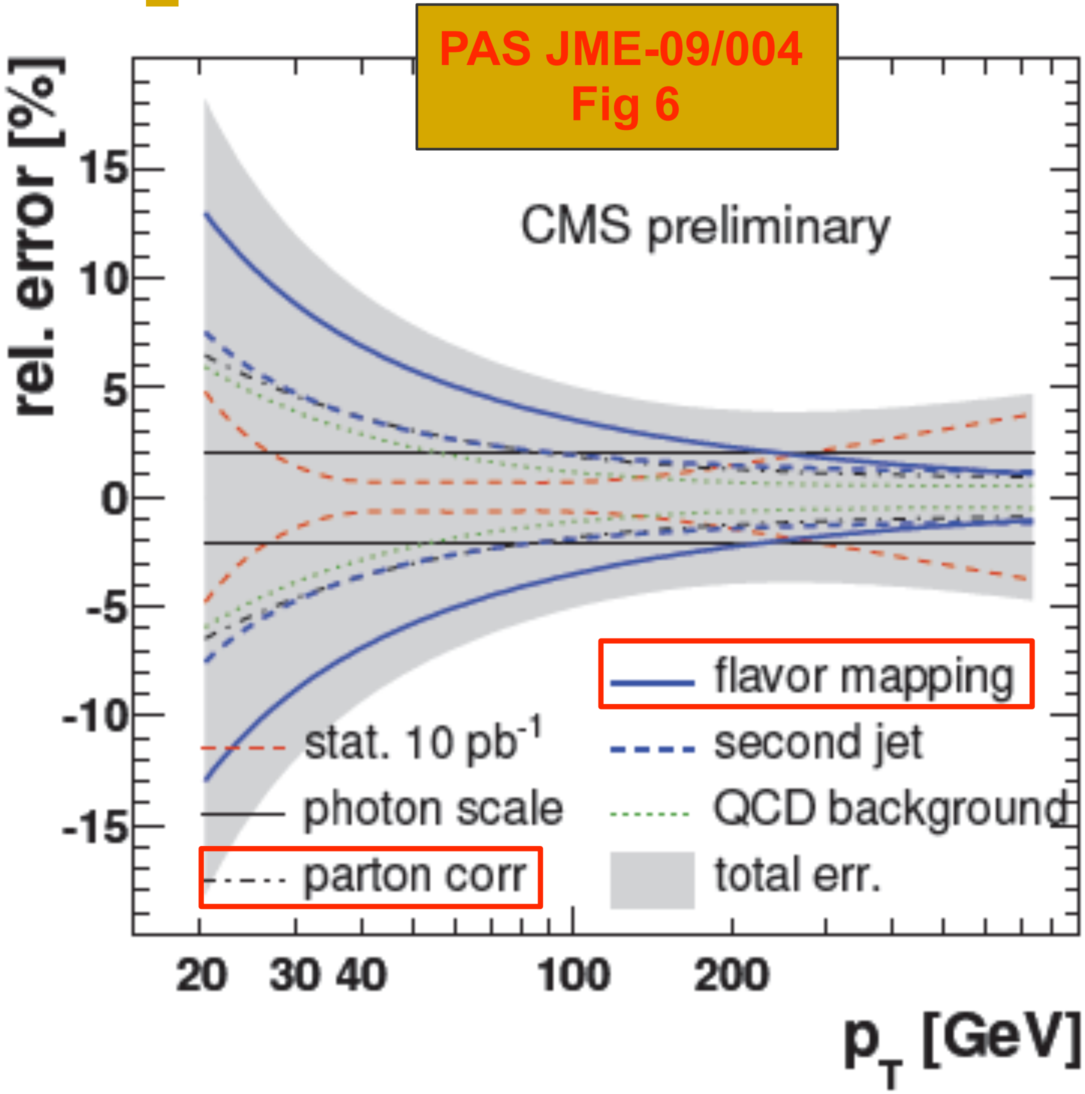


Combined absolute correction



- ✦QCD dijet can be used to extrapolate the correction beyond the region of data.
  - •Once the MC agrees with data in the region of overlap.
  - •Here they agree by construction.
- ✦If the real data disagrees with MC, then we will normalize MC curve to match data in the region of overlap.

Current estimates of syst error in JEC



Additional Syst errors

- ✦Syst. uncertainty from the closure test (~ 1%)
- ✦Uncertainties from the relative correction, and flavor correction (~4 − 5 %)

Other issues

Issues being ignored so far

- ✦To cancel lots of Z-related systematic uncertainties (including the Zee efficiency), we can normalize Zee+jets cross-section w.r.t. Zee cross-section
  - •See the D0 paper: arXiv: 0903.1748
- ✦We need to apply jet quality cuts
  - •At low p_T, fake jets can swamp the real jets
  - •In the past, EMF cut has been very effective: ECAL noise peaks at EMF=1, HCAL noise peaks at EMF=0
  - •We will get some help from JetMET group, but we should take some initiative as well
- ✦So far, we haven't thought much about comparison of our measurement with theory
  - •At least need LO, NLO, and NNLO prediction
  - •Need to understand and generate events using MCFM, MC@NLO, Serpa, ...
  - •Need to disentangle the effect of hadronization/showering: PYTHIA vs HERWIG etc. Also try w/o: ALPGEN