Inclusive Jets with CMS

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Introduction

- **Documentation of this analysis:**

- CMS PAS QCD-08-001
  Initial Measurement of the Inclusive Jet Cross Section at 10TeV with CMS

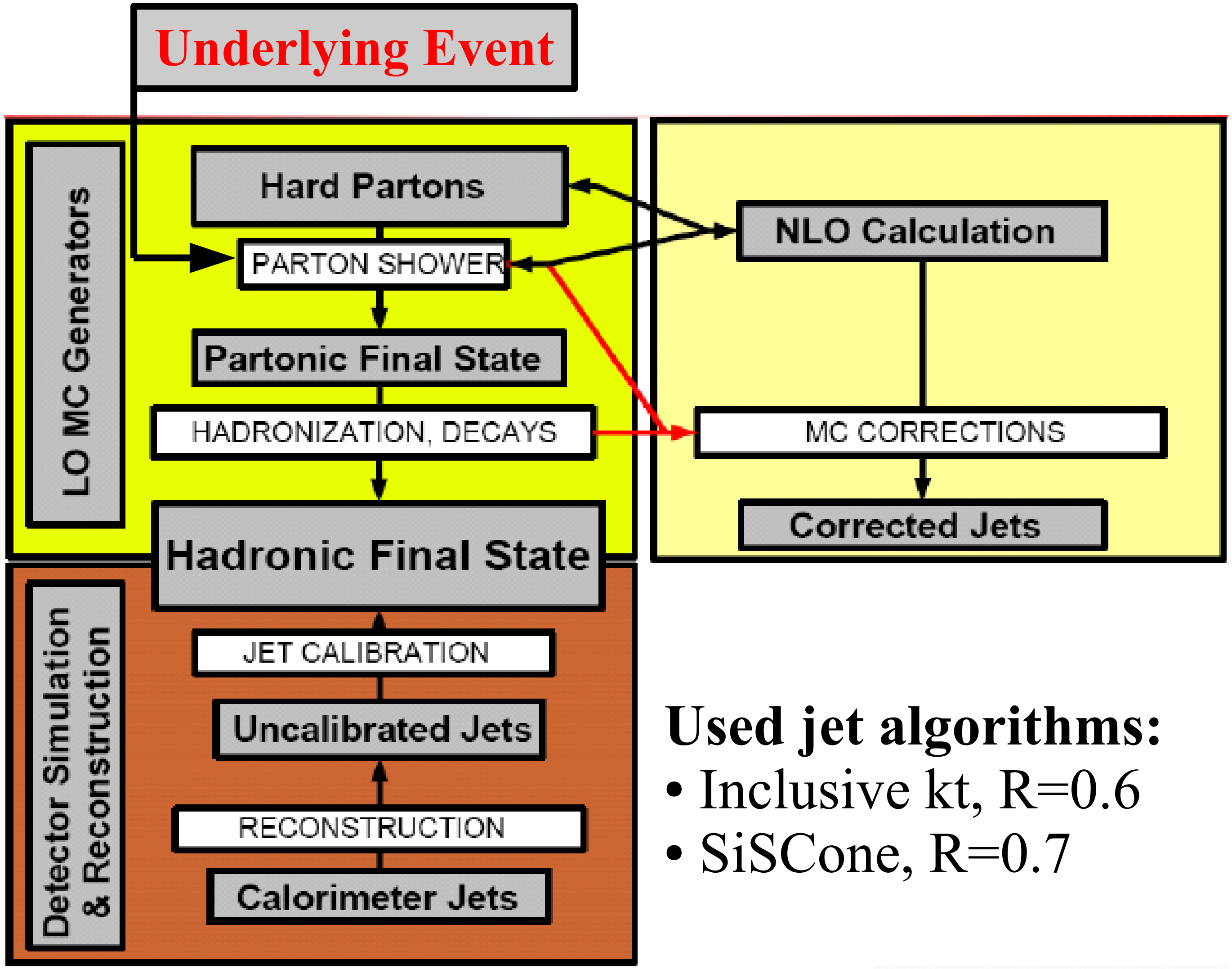
- All results in this presentation are approved by the CMS collaboration except explicitly noted

Introduction

Two-sided approach:
Derive particle jets from pseudo-data including corrections, resolution unfolding etc.

Compare to best theory model available:
NLO calculation plus non-perturbutive corrections

Consider all kind of uncertainties from PDF to JES and JER



Used jet algorithms:
- Inclusive kt, R=0.6
- SiSCone, R=0.7

Starting from Data

Observable: Differential Inclusive Jet Cross Section

$$\frac{d^2\sigma}{dp_T\,dy} = \frac{C_{res}}{L\epsilon}\frac{N_{jets}}{\Delta p_T \Delta y} \quad \text{with}$$

N_{jets} = Number of jets in a bin

L = Integrated luminosity

ϵ = Efficiency of clean-up cuts

C_{res} = Resolution unsmearing factor

Δp_T and Δy are p_T and y bin sizes

- **Data sets:**
  - Central MC production (Pythia 6.4 with tune D6T)
  - 10 TeV center-of-mass energy
  - Official absolute and realtive jet corrections from MC truth
  - Treated as data for this analysis
  - 10/pb of data are assumed

Pt binning motivated by resolution, Rapidity binning by detector geometry

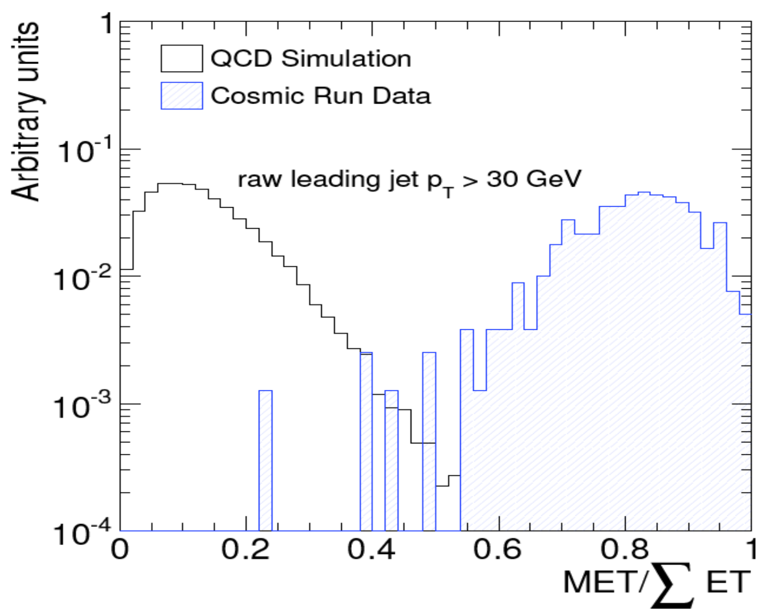
|y| min	|y| max	Expected reach	Detector part
0.00	0.55	1410 GeV	barrel
0.55	1.10	1327 GeV	barrel
1.10	1.70	1101 GeV	transition
1.70	2.50	846 GeV	endcap
2.50	3.20	507 GeV	transition
3.20	5.00	300 GeV	forward

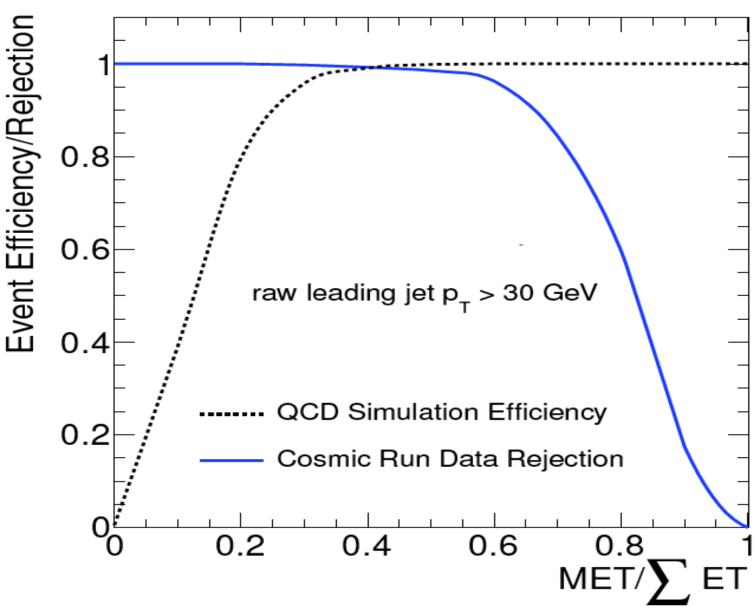
Reach: Last bin in which at least 1 jet is expected for 10/pb (Tevatron: ≈700 GeV)

Starting from Data

Event clean-up

• In events that include cosmic rays or detector noise, transverse momentum seems to be violated

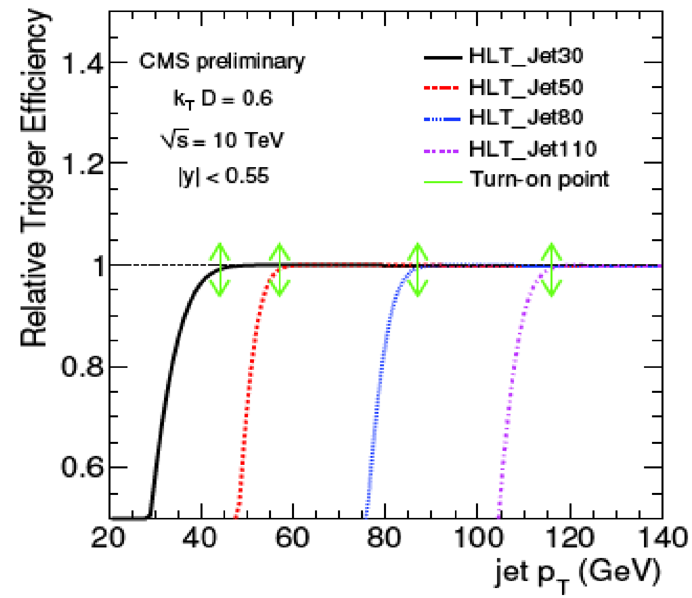




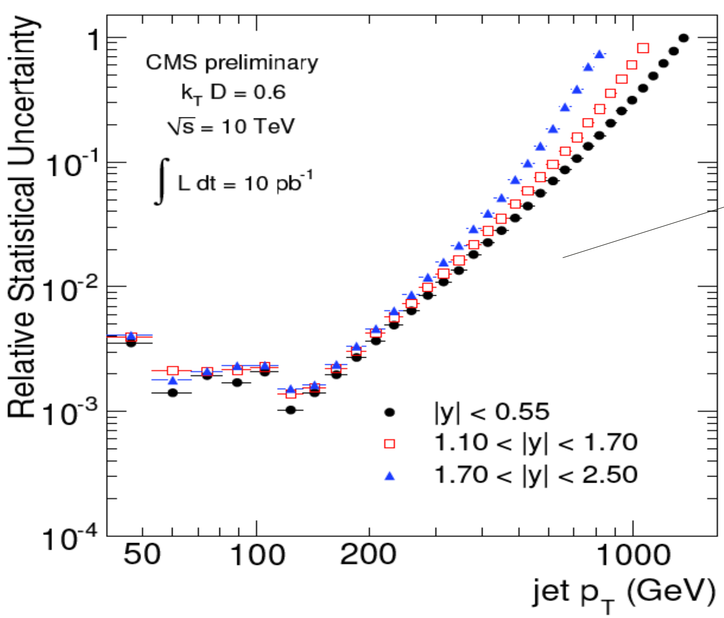
• Rejecting events with MET/ΣET > 0.3 reduces cosmic/noise "jet" events by over 99%, but throws away less than 1

Starting from Data

Construction of the Inclusive Jet Spectrum from trigger streams



- To each bin in pt, only one trigger stream contributes
- Identify trigger turn-on points from data where efficiency is 99% of subsequent trigger

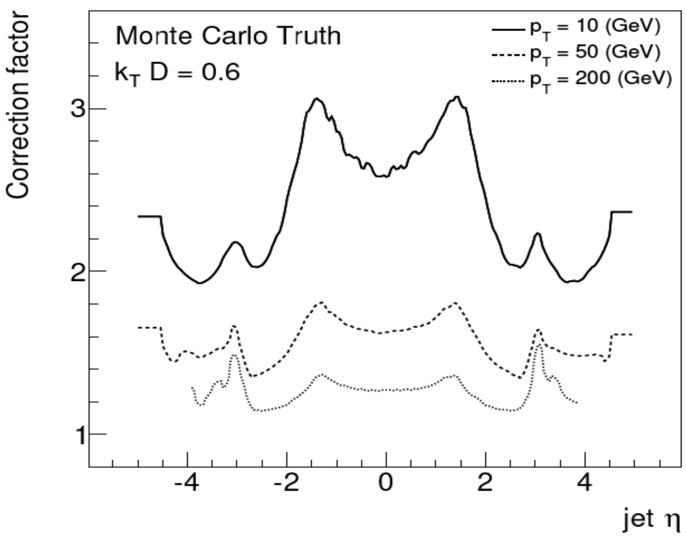


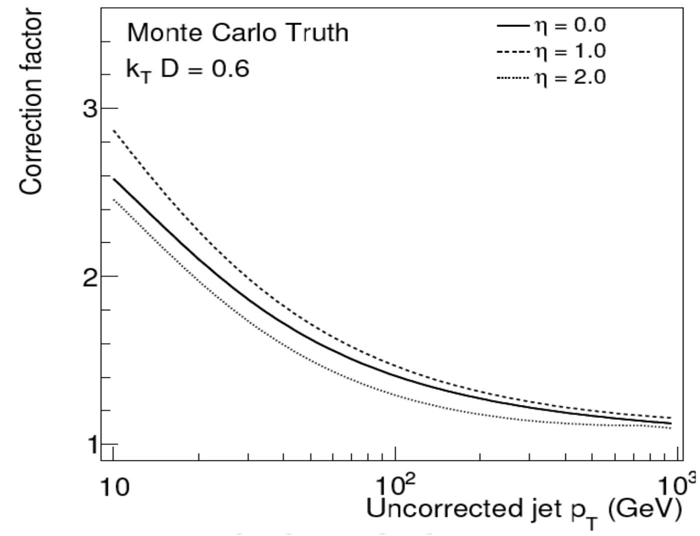
Expected statistical uncertainty for 10/pb of data taking into account trigger prescale

trigger	pre-scale
HLT_L1Jet15	10000
HLT_Jet30	2500
HLT_Jet50	50
HLT_Jet80	10
HLT_Jet110	1

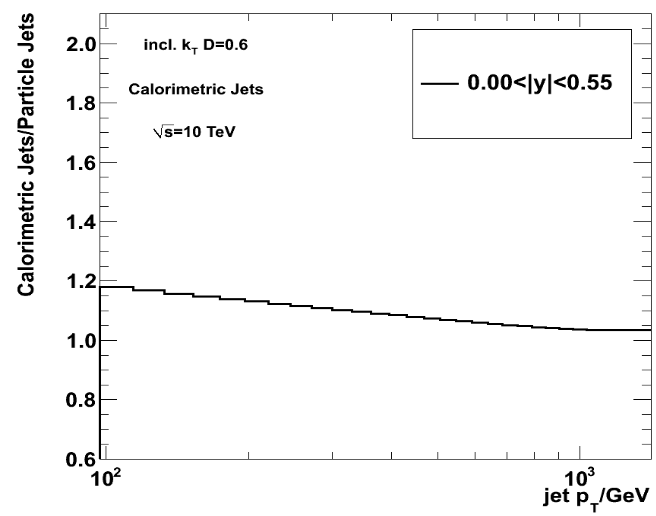
Starting from Data

Jet Energy Corrections





- Absolute and relative jet energy corrections as provided by the CMS JetMET group from MC for now
- Jet-by-jet basis, function of rapidity and pt
- Still yields a spectrum that is too hard → resolution unsmearing required



Starting from Data

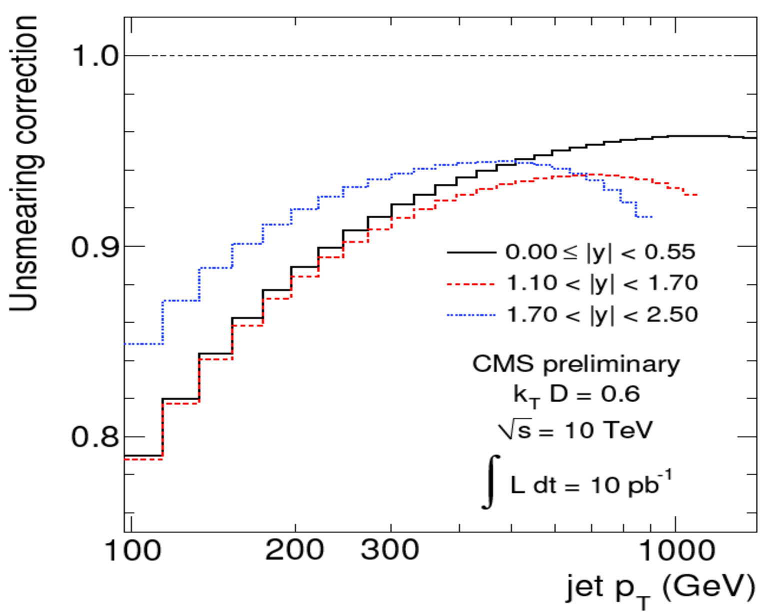
Resolution Unfolding

- Finite pt resolution leads to migration effects, observed spectrum becomes harder
- Ansatz function for the jet spectrum: $f(p_T) = N \cdot p_T^{-a} \cdot \left(1 - \frac{2\cosh(y_{min})p_T}{\sqrt{s}}\right)^b \exp(-\gamma p_T)$
- Gaussian fit of the jet energy resolution: $R(p'_T, p_T) = \frac{1}{\sqrt{2\pi}\sigma(p'_T)} \exp\left[-\frac{(p'_T - p_T)^2}{2\sigma^2(p'_T)}\right]$
- Ansatz function convoluted with resolution:

$$F(p_T) = \int_0^\infty f(p'_T) R(p'_T, p_T) dp'_T$$

- Correction calculated bin-by-bin:

$$C_{bin} = \frac{\int_{bin} f(p_T) dp_T}{\int_{bin} F(p_T) dp_T}$$

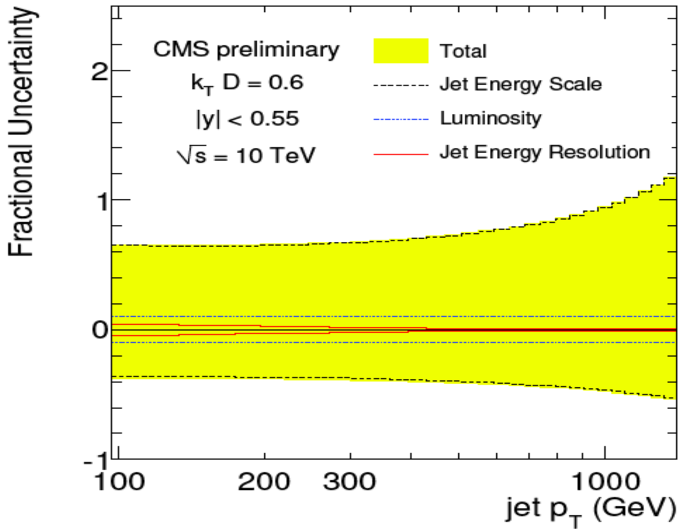


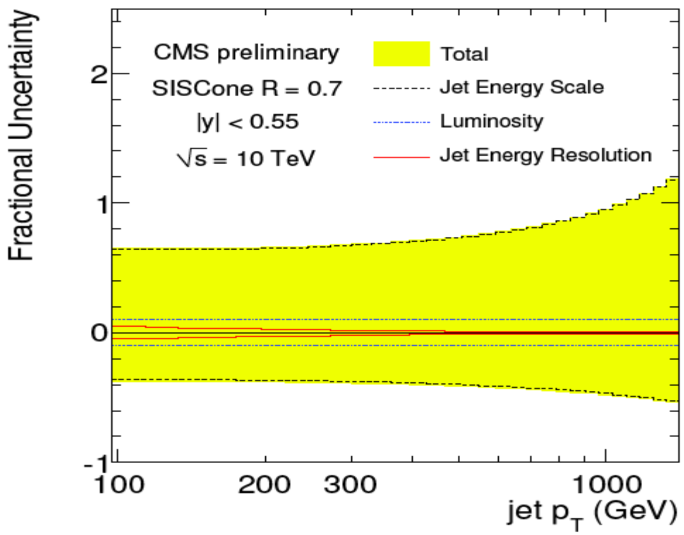
Starting from Data

Experimental Uncertainties

• Jet Energy Scale: 10% uncertainty on pt leads to 60-120% uncertainty in spectrum
• Luminosity: Assume 10% uncertainty
• Jet Energy Resolution: 10% uncertainty leads to 1-5% uncertainty in the spectrum after unfolding procedure

➔ **<u>JES by for the dominating uncertainty</u>**



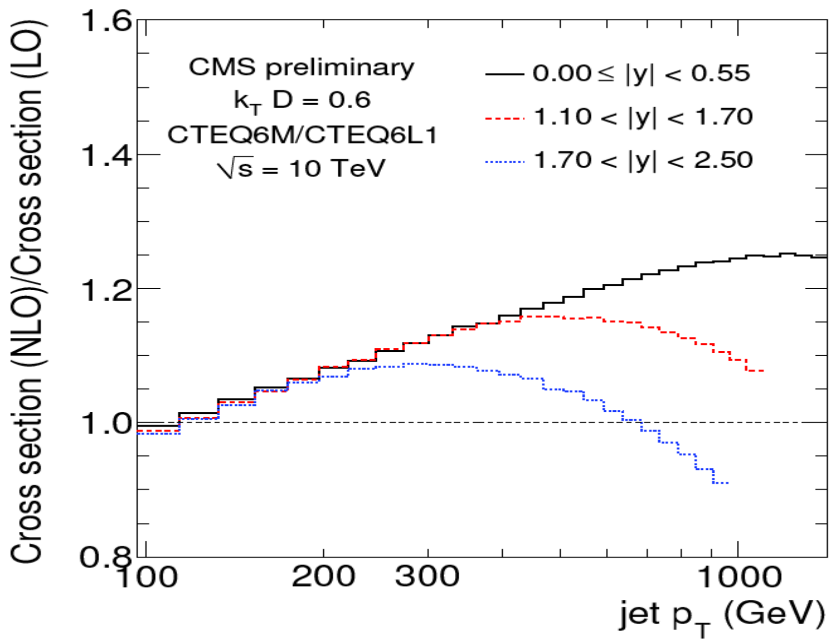


Starting from Theory

Overview

- Best theory calculations for inclusive jets are in NLO of pQCD
- Unfortunately no hadron level MC is available
- Best estimate: Use NLO calculation from NLOJET++ and fastNLO and correct for non-perturbative effects (method developed at Tevatron)
- Compare to pseudo data * K-factors

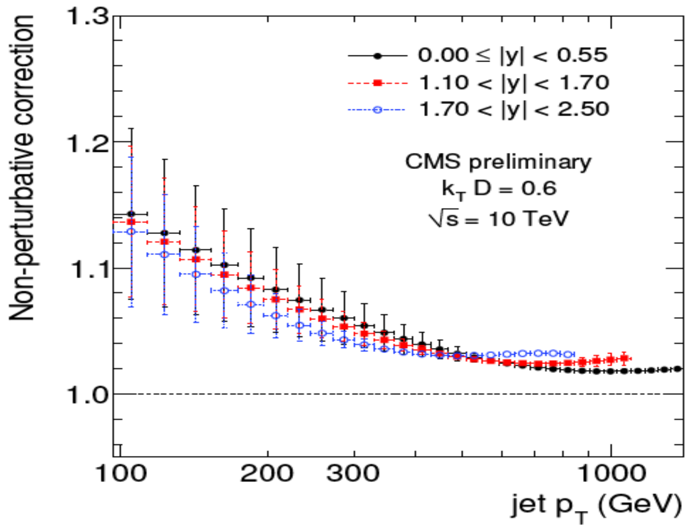
- K-Factors derived from NLOJET++
- FastNLO allows to vary PDF and α_s scaling
- Allows calculation of uncertainties



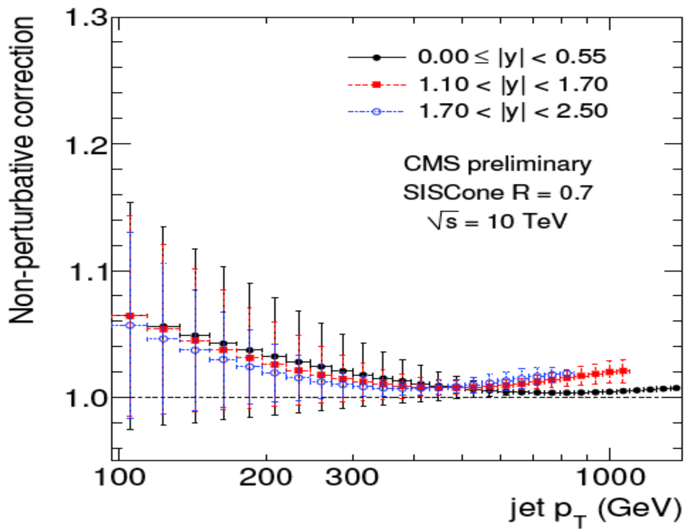
Starting from Theory

Non-perturbative corrections

• Non-perturbative corrections correct for the effects of hadronisation and multiple parton interactions (MPI)
• Initial and final state radiation are not corrected for as they are partly included in the NLO calculation



• Method:
Divide spectra of fully hadronised MC events with events without hadronisation and MPI
• Use both Pythia6 and Herwig++ to estimate systematic uncertainty

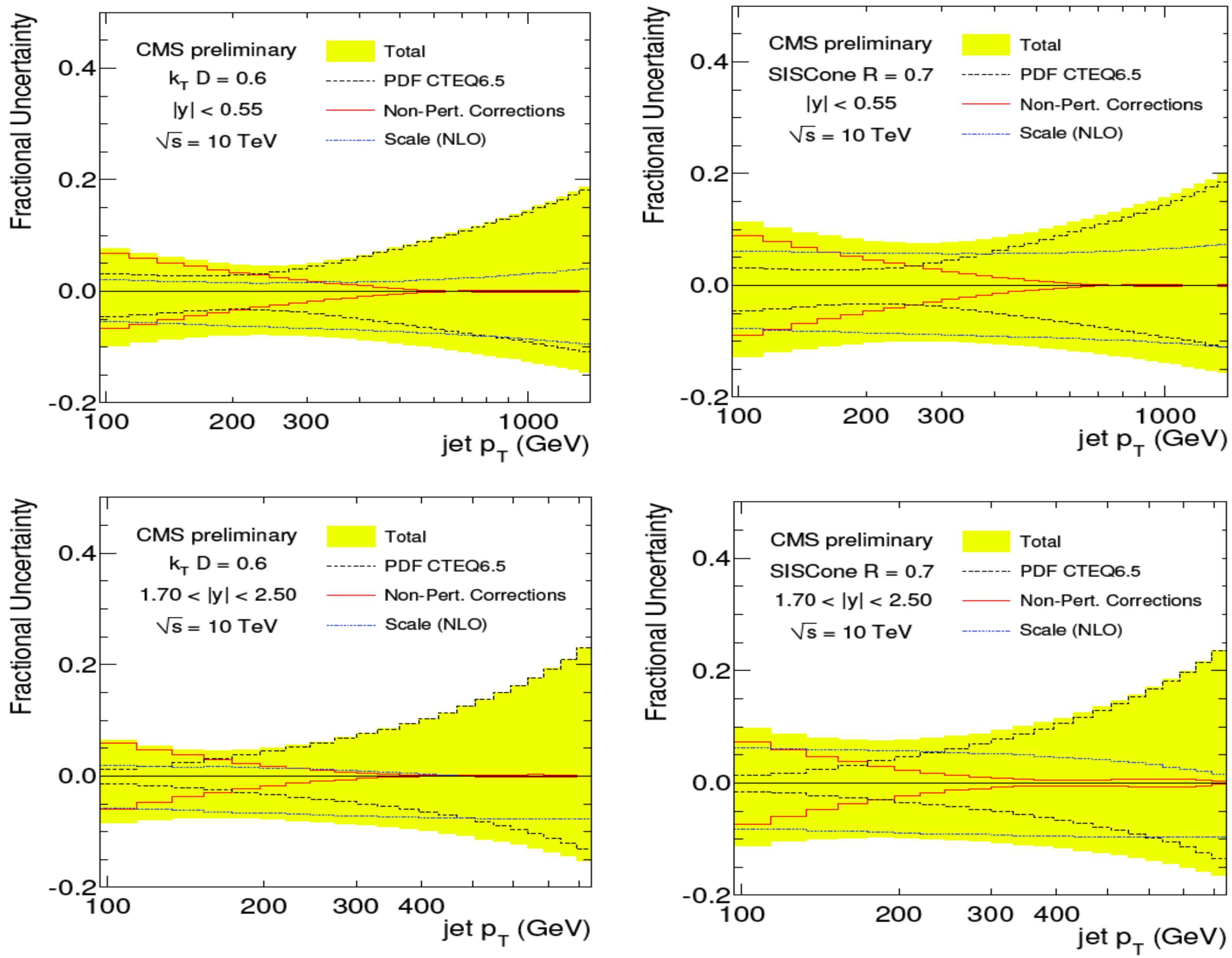


• Substantial differences between kt and SiSCone

Starting from Theory

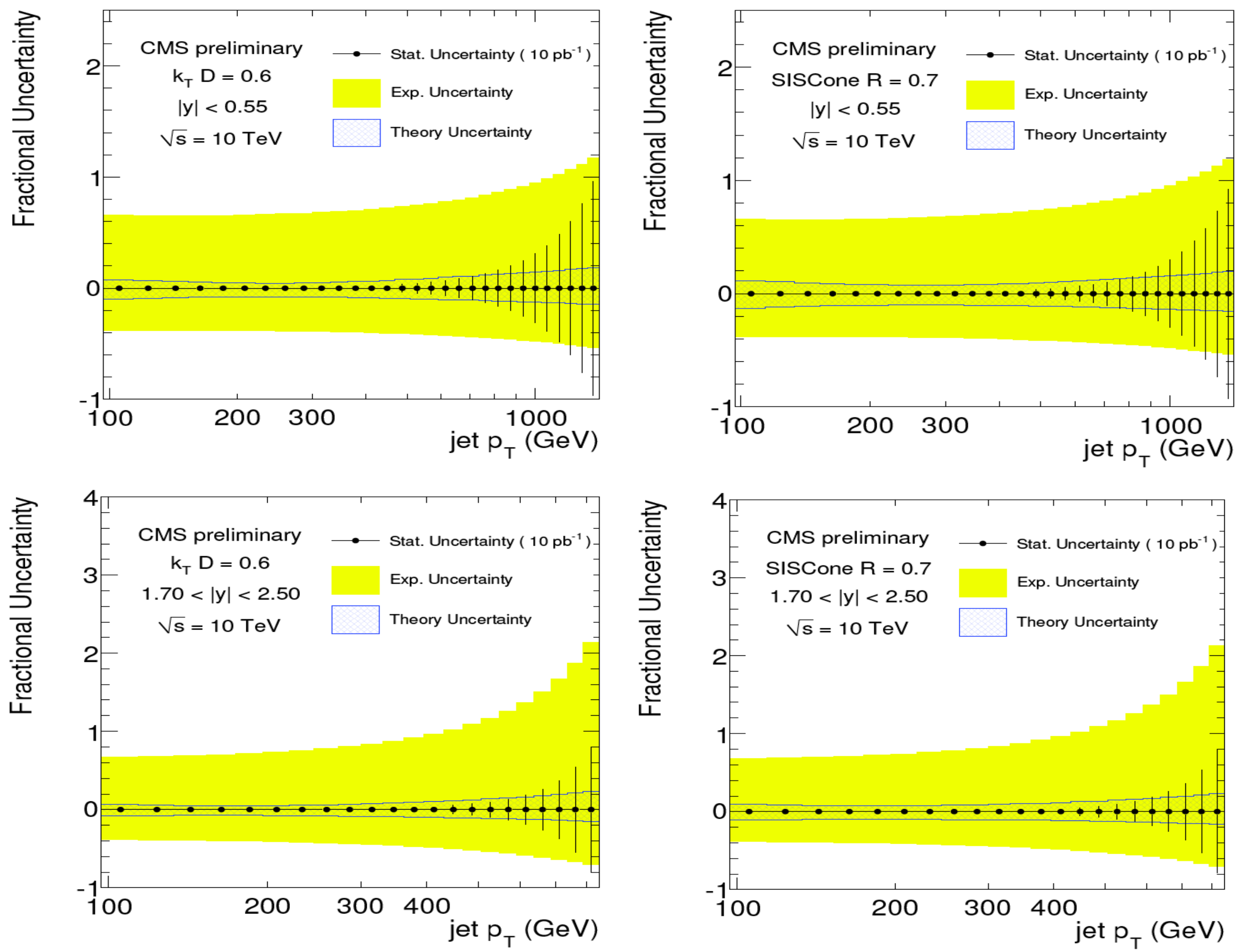
- For small pt, non-perturbative and scale uncertainties are dominating
- For large pt, PDF uncertainties take over
- Uncertainties are larger for SiSCone

Theory Uncertainties



The Big Picture

Combined Uncertainties



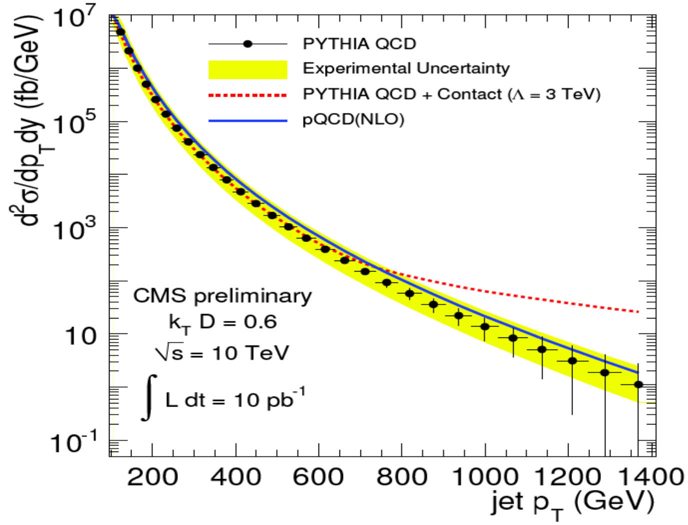
- Experimental uncertainties dominate

- Statistical uncertainties take over above 1 TeV

The Big Picture

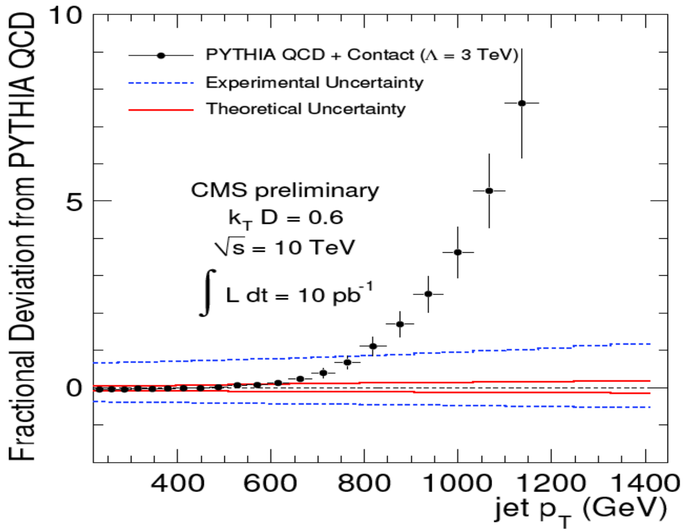
Sensitivity for New Physics & Summary

- Although uncertainties are huge, there is still discovery potential for large deviations like contact interactions



Summary:

- Plan for the first measurement of the inclusive jet cross section with 10/pb of data at 10 TeV
- Detailed study of experimental and theoretical uncertainties
- Extend reach of jet physics to the TeV scale
- JES is the limiting factor for this study



Plans & Outlook

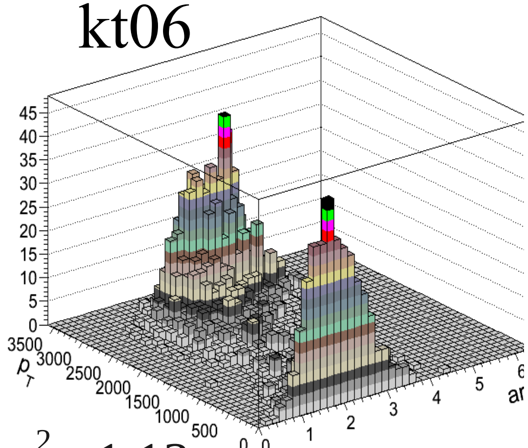
- Adjust to new beam energies (7TeV)
- Switch from SiSCone to anti-kt als default "cone-like" algorithm:

Non-perturbative corrections look more "kt-like", reduced systematical uncertainty

- Anti-kt makes in most cases perfectly cone-shaped jets with a defined jet area

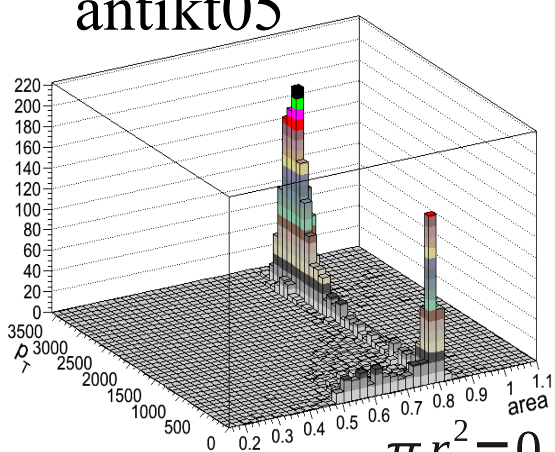
➔ New perspectives toward PU and UE subtraction and UE studies

kt06



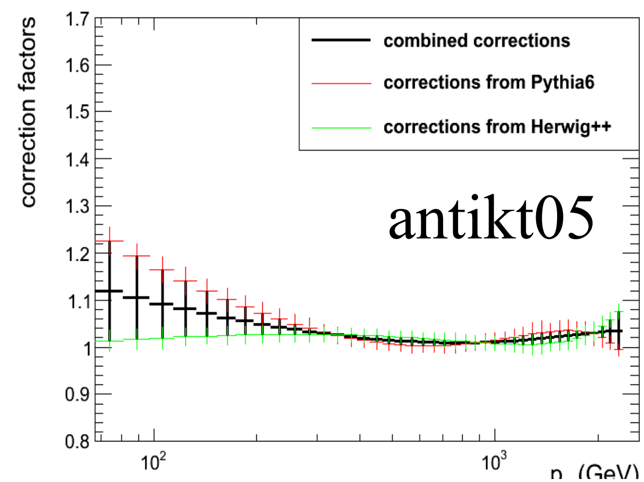
$\pi r^2 = 1.13$

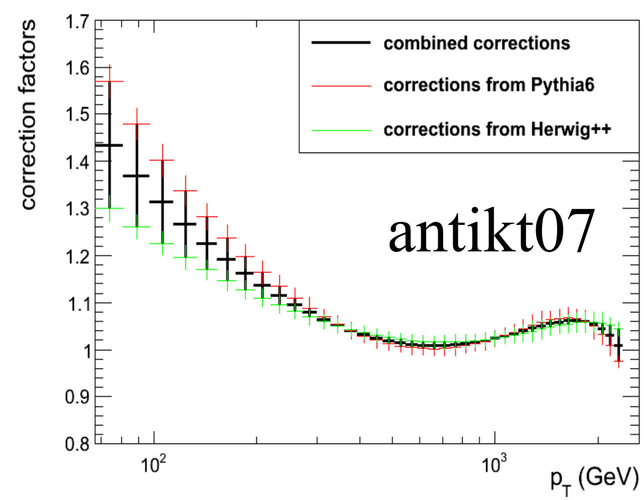
antikt05



$\pi r^2 = 0.79$

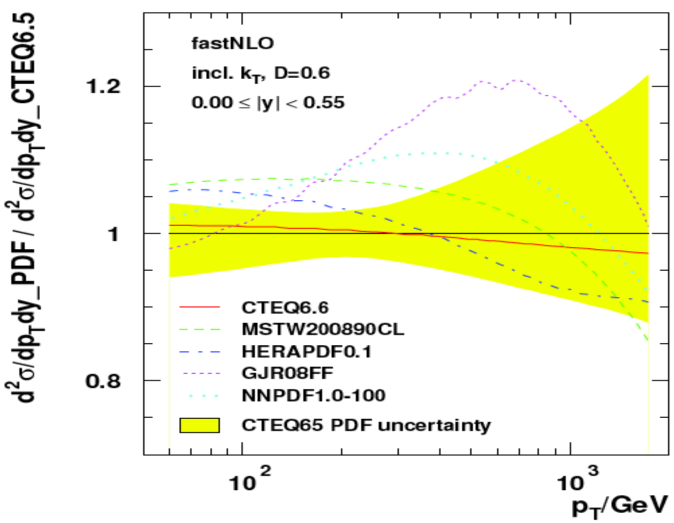
Non-perturbative corrections



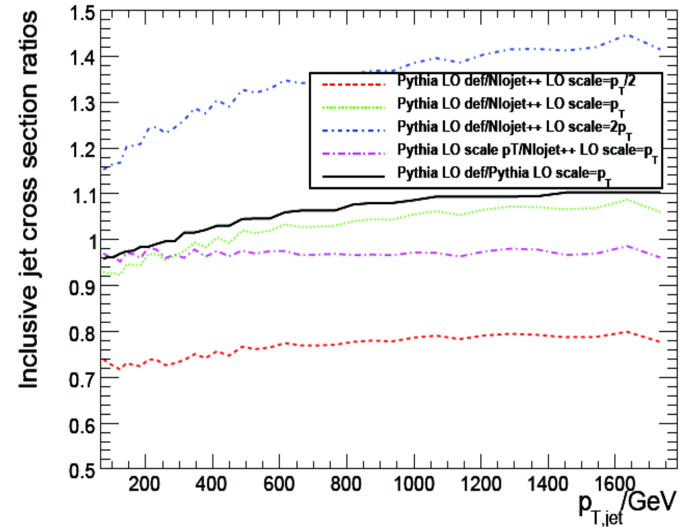


Back-up

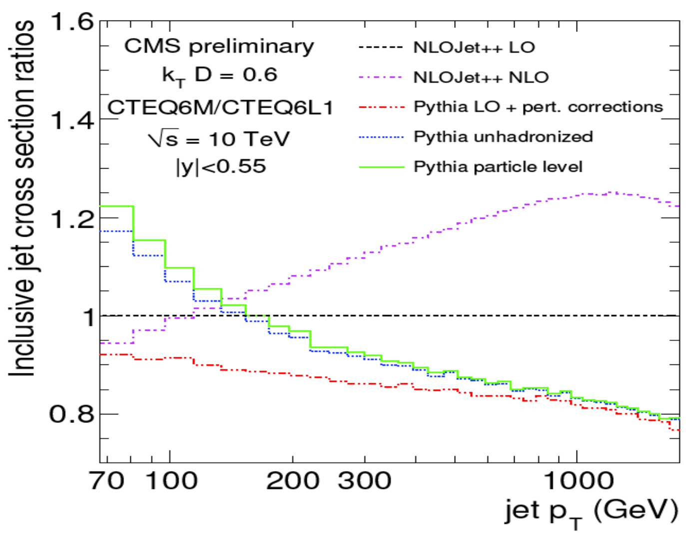
PDF uncertainty



alpha_s scale uncertainty



Comparison of NLO and Pythia



Sprectrum overview