Measurement of the differential dijet mass cross section in proton-proton collisions at √s = 7 TeV in CMS

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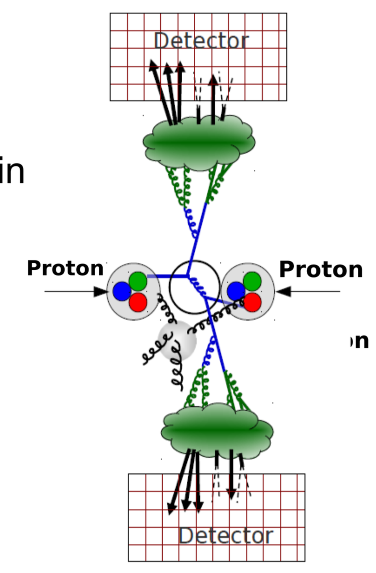
Motivation



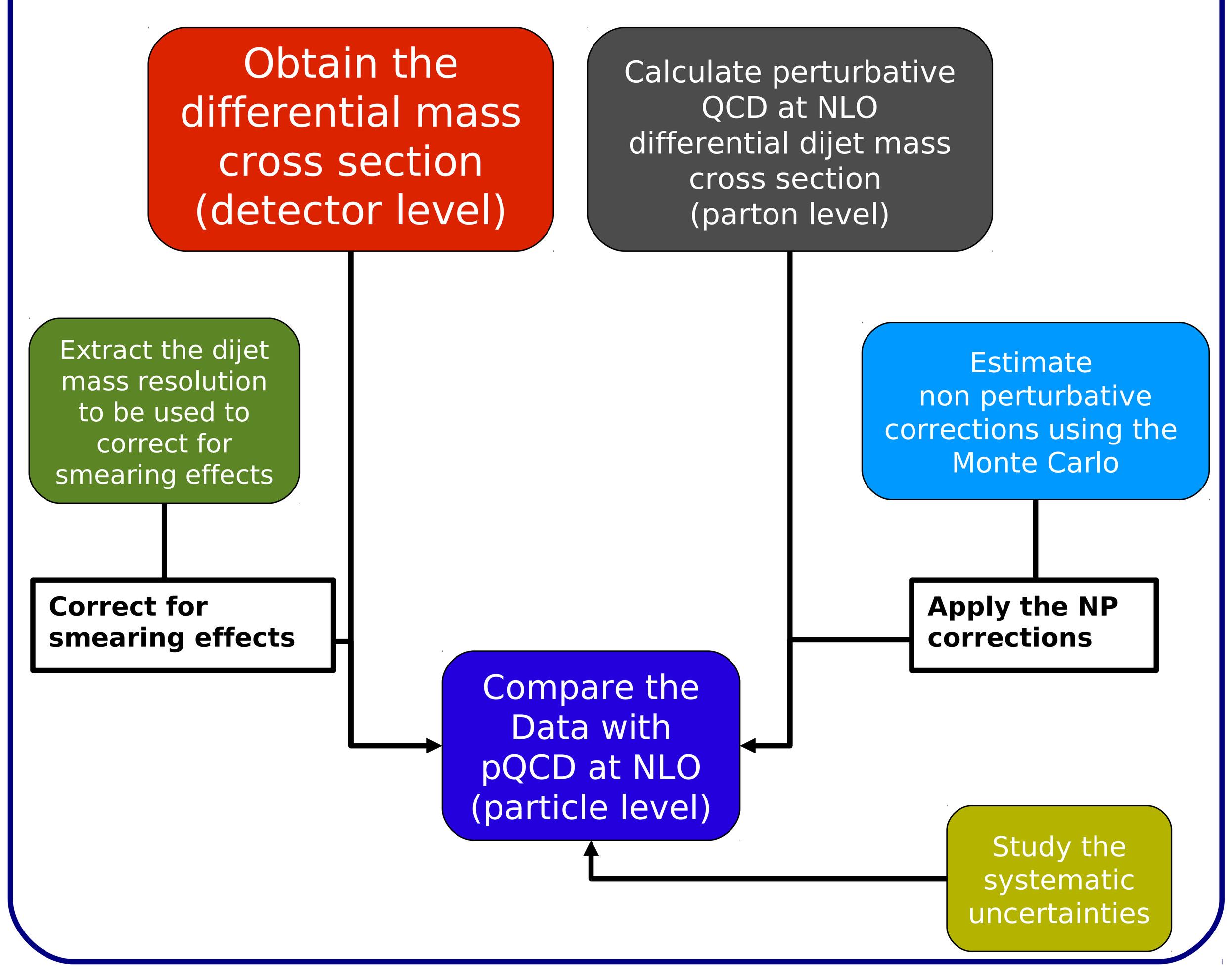
In proton-proton collisons, events with two energetic partons (quarks or gluons) arise from parton-parton scattering. We observe this outgoing parton pair as two hadronic jets (dijets) in the detector. The dijet mass spectrum predicted by Quantum Chromodynamics (QCD) falls smoothly and steeply with increasing dijet mass. In this study the double-differential dijet mass cross section is measured:

$$\frac{d^2\sigma}{dM_{JJ}d|y|_{max}}$$

as a function of the dijet invariant mass, in the bins of rapidity.

The mass reach goes beyond any previous measurement due to the high center of mass energy of *pp* collisions at LHC. This cross section measurement confronts the QCD predictions at an unexplored kinematic regime. It can be used to test the predictions of pQCD,to constrain the parton distribution functions (PDFs), and check for deviations from the standard model

Analysis Strategy



Event Selection

The analysis was performed with the data collected by CMS detector in 2010 and correspond to an integrated luminosity $\mathcal{L}$ = 36 pb^{-1}

1.) Requires at least two jets reconstructed with anti-kT PF (Particle Flow) algorithm with the cone size parameter R=0.7

2.) Rapidity of two leading jets must satisfy $|y|_{max}$=max($|y_1|$,$|y_2|$)<2.5

To remove possible non-collision backgrounds or instrumental noises; events were required to have a reconstructed primary vertex within |z|<24 cm and at least 4 tracks associated with this primary vertex. For jets, PF JetID criteria which requires at least two particles in a jet, one of which is a charged hadron, was used.

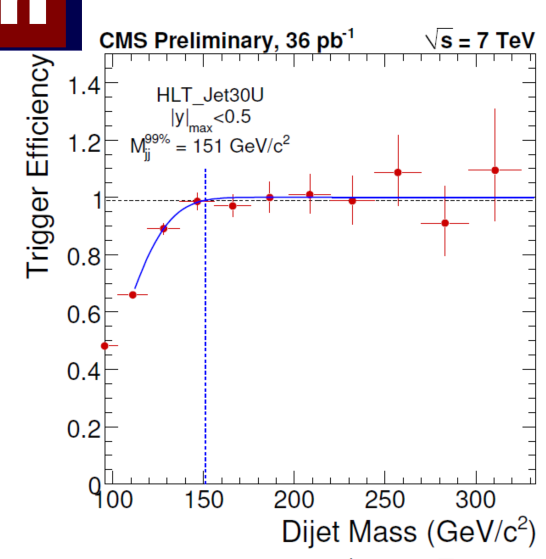
Spectrum Construction

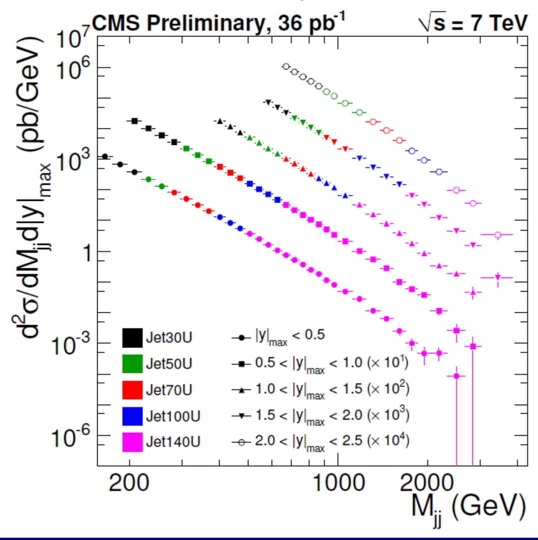
For each rapidity bin, the dijet mass spectrum from all data samples are properly combined with respect to the HLT Jet trigger efficiency. The efficiency for each data sample for a given HLT path is calculated according to the formula below:

$$\epsilon_A = \frac{\mathcal{L}_B}{\mathcal{L}_A} \cdot \frac{N_{TriggerA}}{N_{TriggerB}}$$

Trigger Efficiency Table

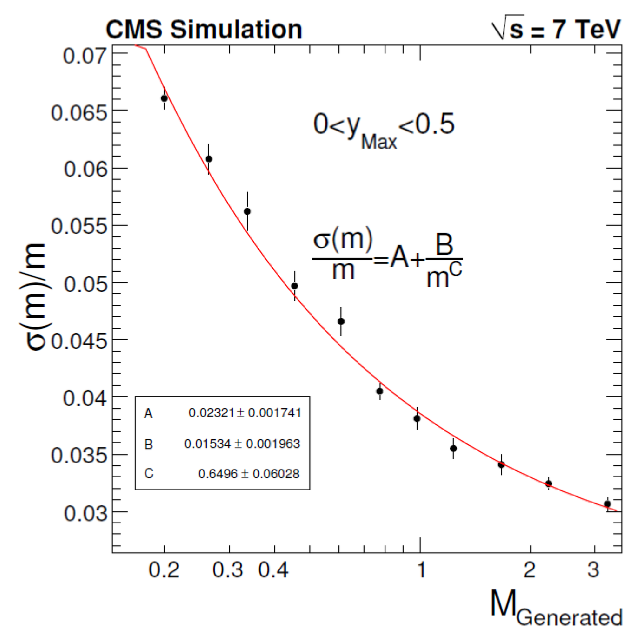
YBIN	Jet30U	Jet50U	Jet70U	Jet100U	Jet140U
0.0-0.5	156 GeV	220 GeV	270 GeV	386 GeV	489 GeV
0.5-1.0	197 GeV	296 GeV	386 GeV	489 GeV	649 GeV
1.0-1.5	386 GeV	489 GeV	649 GeV	838 GeV	1058 GeV
1.5-2.0	565 GeV	693 GeV	890 GeV	1058 GeV	1607 GeV
2.0-2.5	649 GeV	890 GeV	1246 GeV	1687 GeV	2231 GeV

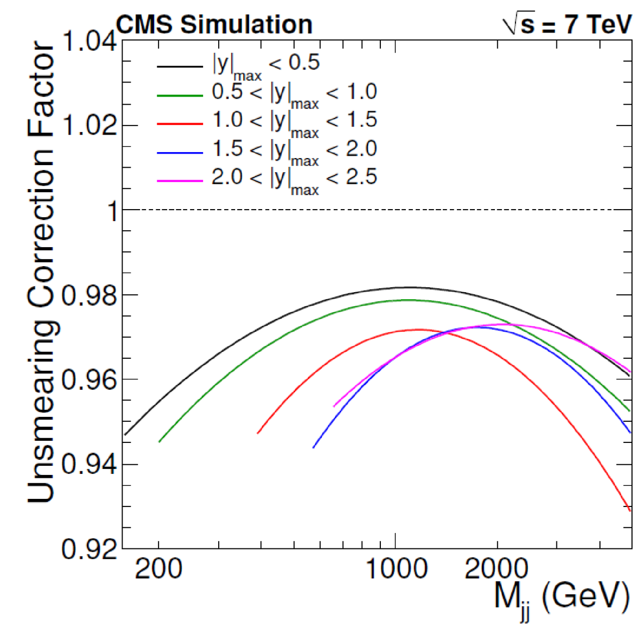




Dijet Mass Resolution and Corrections for Smearing Effects

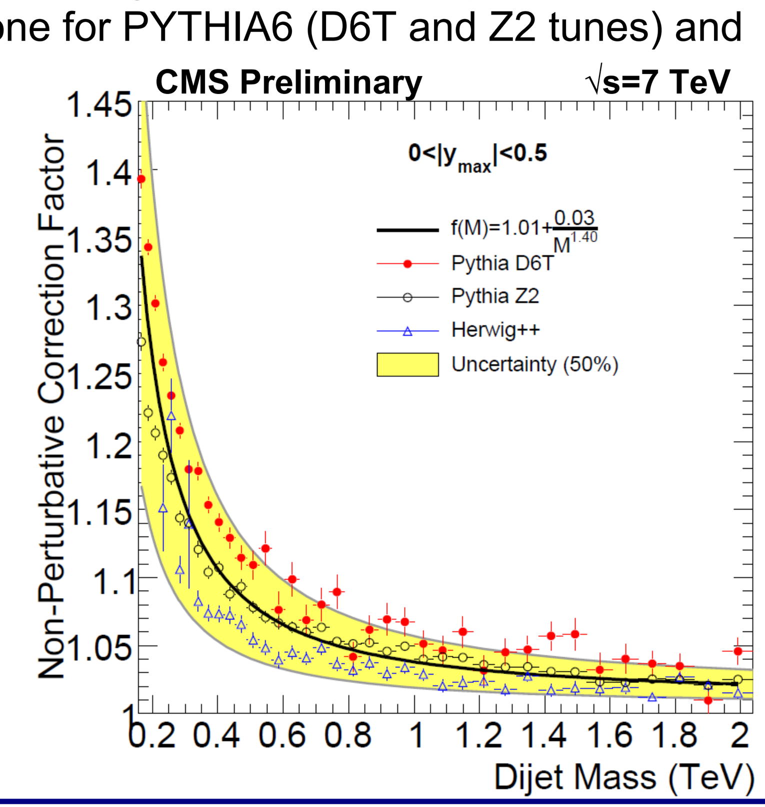
- A "forward smearing" technique via a toy MC was adopted to study the correction for smearing effects.
- M_{jj} values generated according to spectrum predicted by PYTHIA6 then smeared with a Gaussian function centered at M_{gen} and the σ is determined from the relative resolution parametrization.
- N_{true}/N_{Obs} ratio is used as a multiplicative bin-by-bin correction factor.
- Systematics studied by varying the spectrum slope and the resolution





Non-Perturbative Corrections

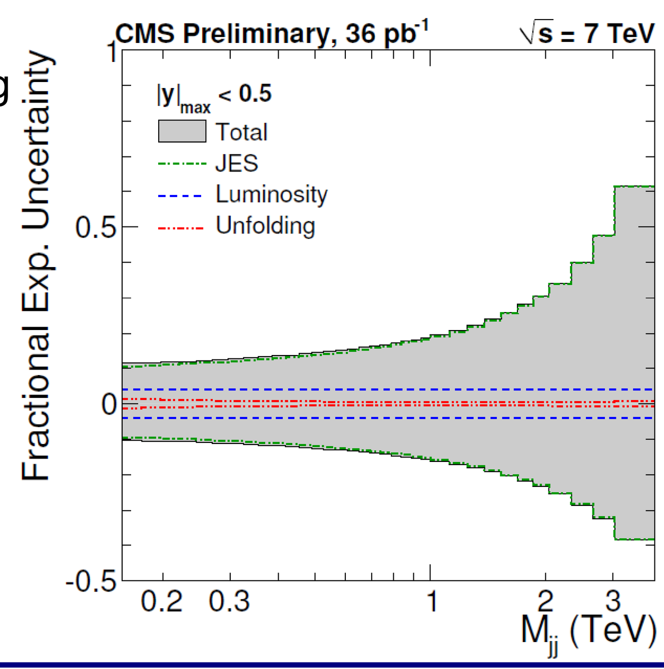
Non-Perturbative corrections were derived and applied to NLO calculations to account for multi-parton interactions(MPI) and the hadronization effects. This can be achieved by switching off the MPI and the hadronization and not switching off (the default) them in the MC event generator programs, then taking the ratio of two spectra. The routine above was done for PYTHIA6 (D6T and Z2 tunes) and Herwig++



Systematic Uncertainties

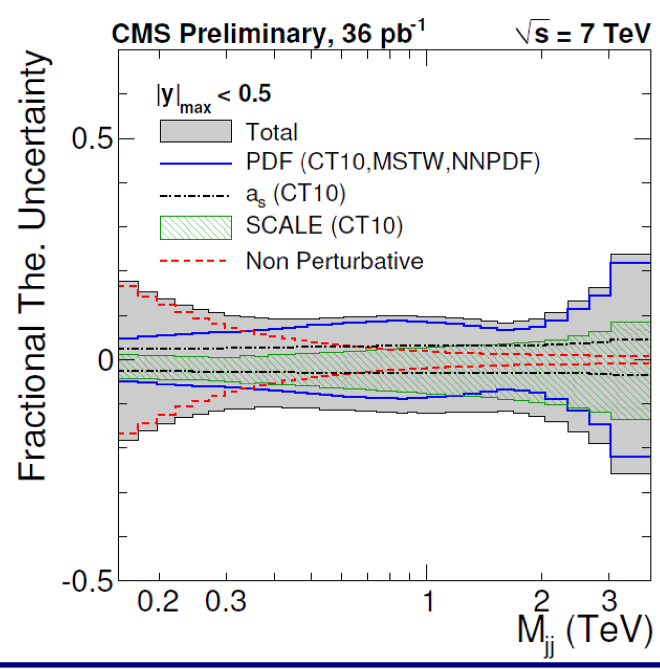
Experimental Uncertainties

- 3 to 5 % PF JES Uncertainty becomes the dominant source of the experimental uncertainty when it is propagated into the double-differential dijet invariant mass cross section
- Another source of the experimental uncertainty is on the measurement of the total integrated luminosity and it is estimated to be 4%
- The uncertainty coming from the unsmearing correction is due to the CMS detector simulation which affects the resolution and the mass spectrum



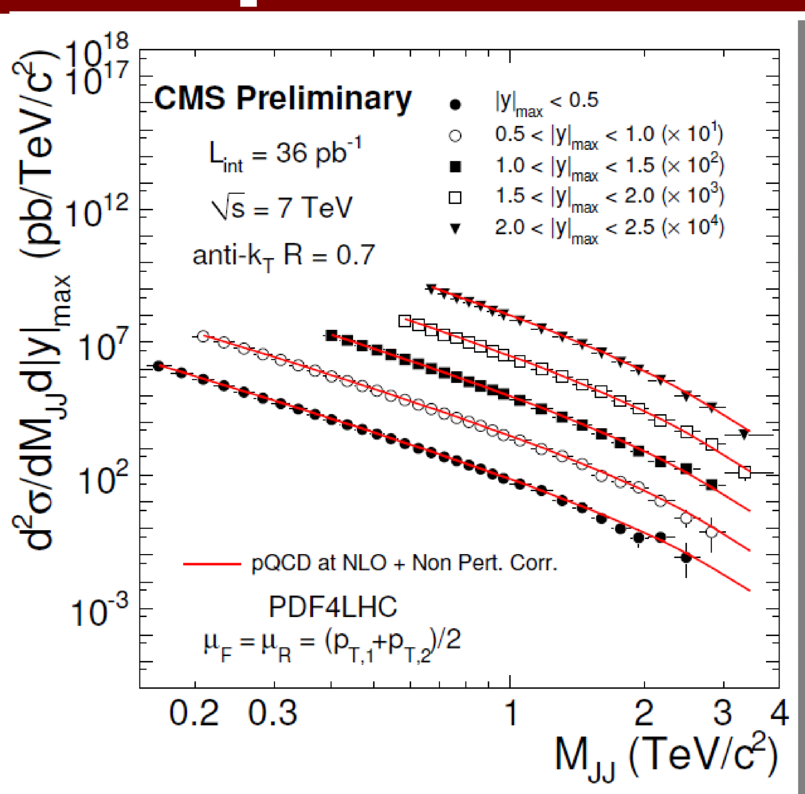
Theory Uncertainties

- The PDF uncertainty is estimated according to the PDF4LHC prescription through the variation of the CT10, MSTW2008NLO and NNPDF2.0 PDF sets
- Maximal deviation of the six point variation is used to estimate the renormalization and factorization scale uncertainties (μ_R/p_T^{ave} , μ_F/p_T^{ave})=(1/2, 1/2), (2, 2), (1, 1/2), (1, 2), (1/2, 1),(2, 1)
- The non-perturbative correction uncertainty is estimated as half of the NP correction deviation from unity

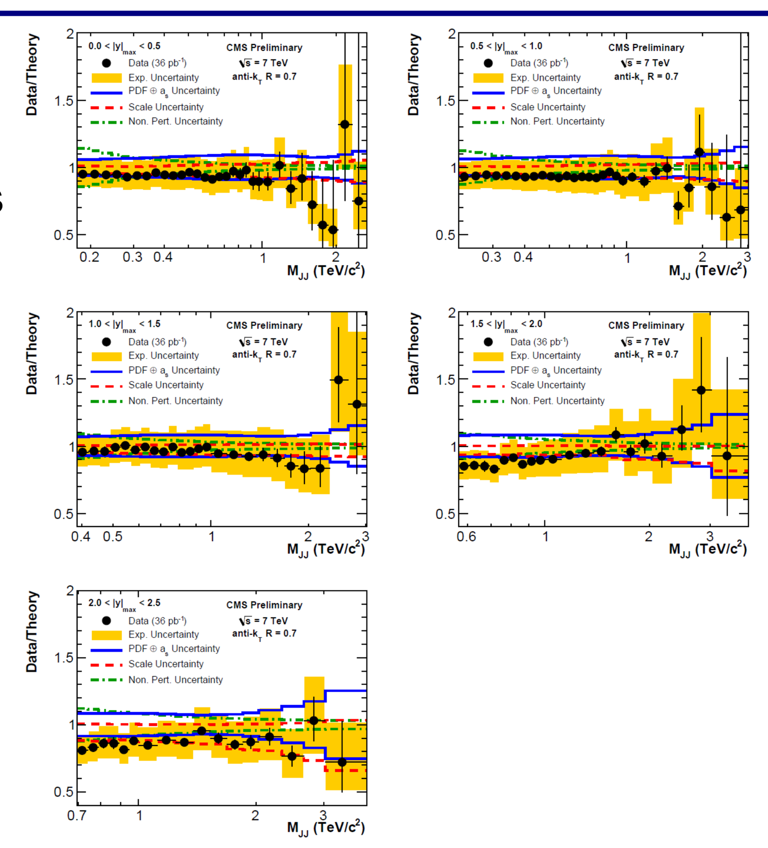


Result and Comparison to the Theory

Measured double-differential dijet production cross section (points) as a function of the dijet invariant mass, in bins of $|y|_{max}$, compared to the theory prediction (lines).
The error bars represent the statistical uncertainty of the data.



Ratio of the measured double differential dijet production cross section over the theory prediction in the different rapidity bins. The solid band represents the experimental systematical uncertainty and is centered around the points. The error bars on the points represent the statistical uncertainty. The theoretical uncertainty is shown as lines centered around unity.



Conclusion

Using 36 pb^{-1} from proton-proton collisions at √s = 7 TeV, collected with the CMS detector, the measurement covers the mass range from 0.2 TeV/c² to 3.5 TeV/c² in five $|y|_{max}$ bins, up to $|y|_{max}$ = 2.5.
The data are in good agreement with the theory prediction, indicating that QCD describes accurately the parton-parton scattering in this kinematic regime.

Reference : CMS AN 2010 / 278, CMS PAS QCD-10-025