Inclusive and Dijet Measurements in CMS and Their Relevance for PDFs

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(on behalf of the CMS Collaboration)

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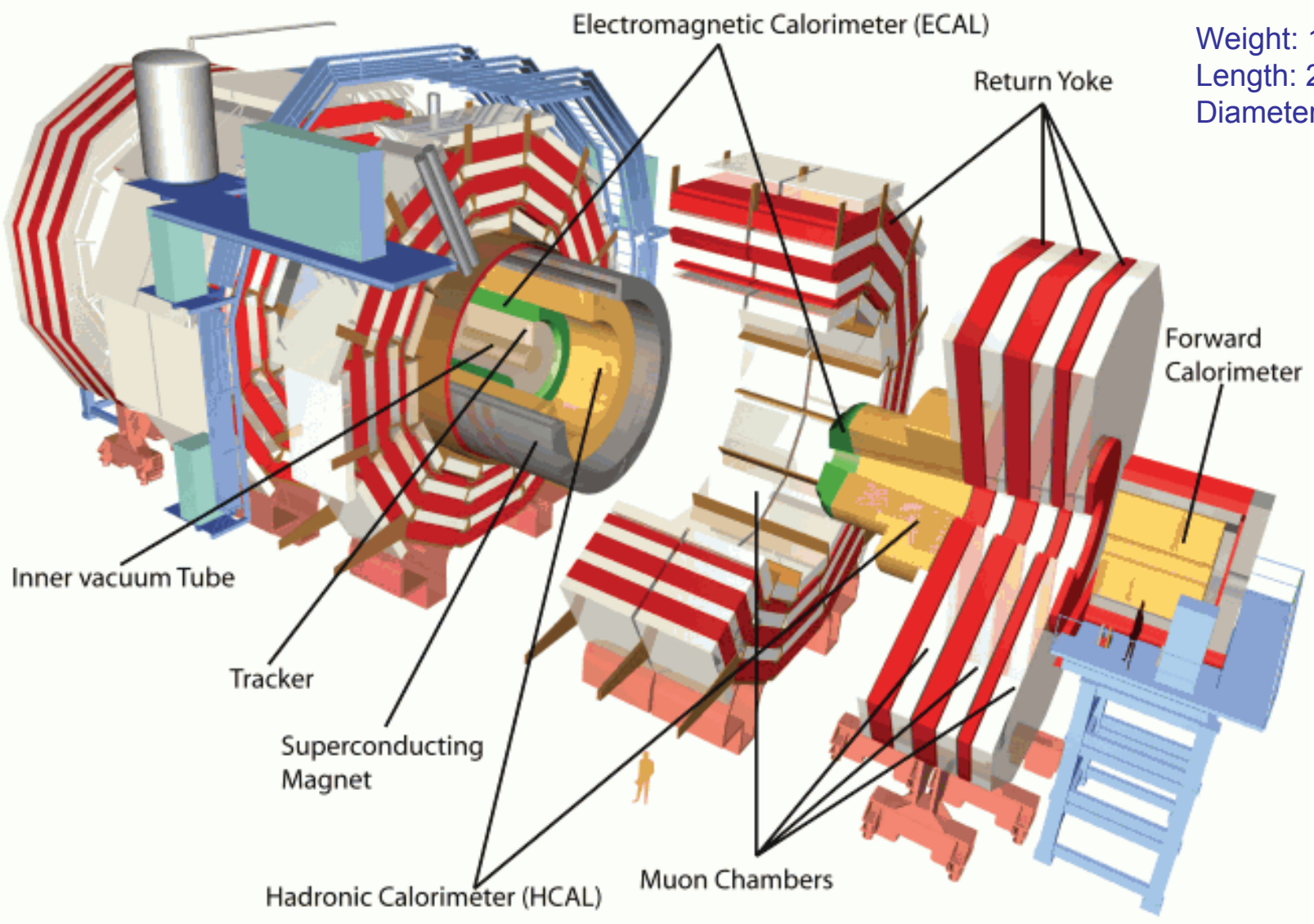
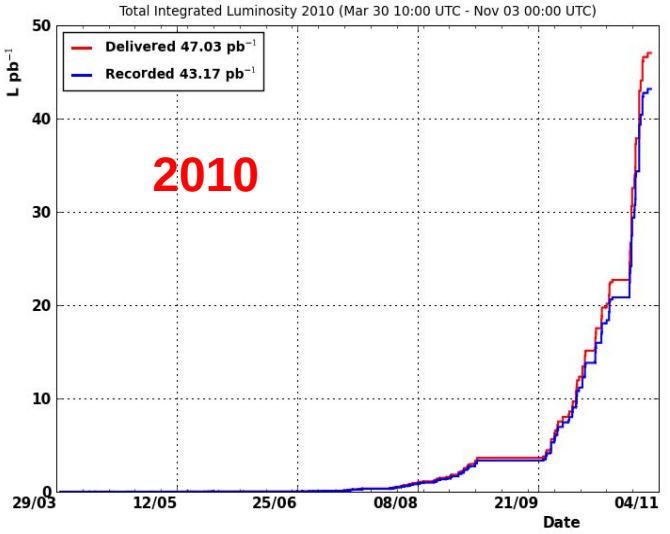
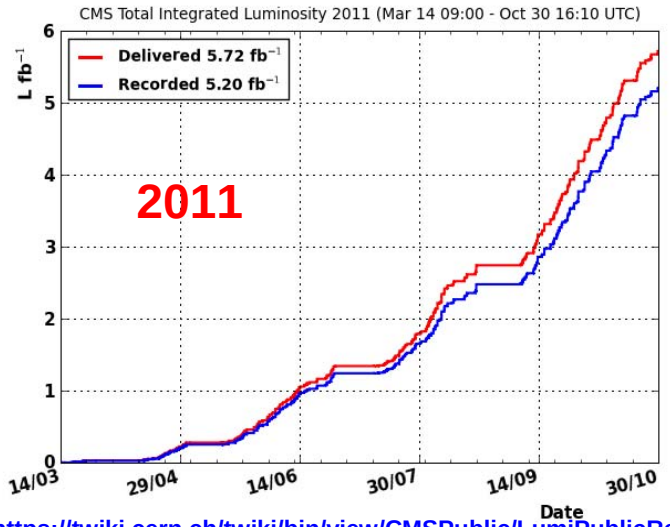
The CMS Detector



Physics Motivation

- Luminosity increased by a factor of 100
- Systematic uncertainties decreased by a factor of 2-3
- Jet p_T range extends from 0.1 TeV to 2 TeV
- Dijet mass range extends from 0.2 TeV to 5 TeV
- This measurements can be used to:
  - Test the pQCD
  - Constrain parton distribution functions (PDFs)
  - Differentiate between PDF sets
  - Look for possible deviations from the Standard Model

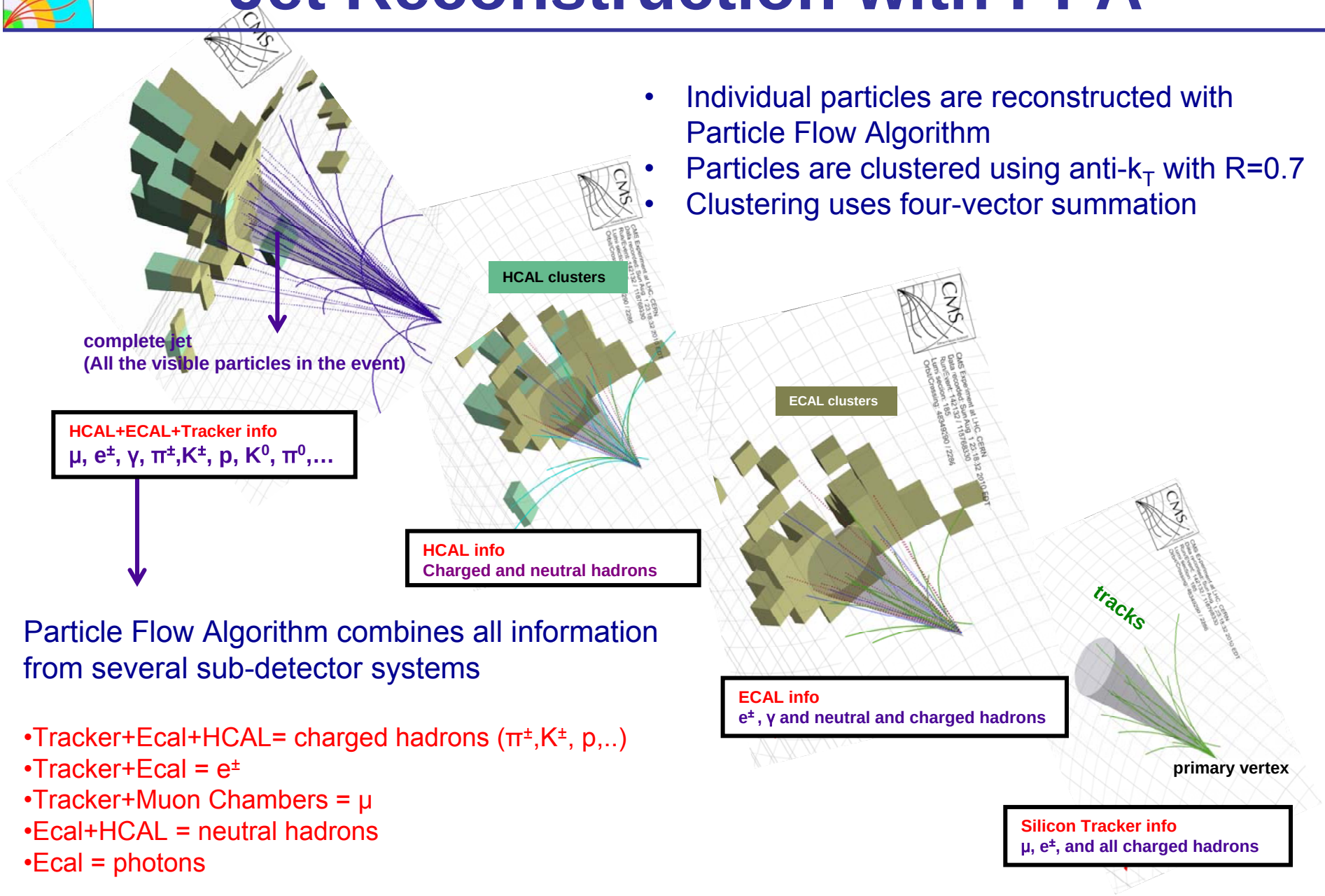




Ref:https://twiki.cern.ch/twiki/bin/view/CMSPublic/LumiPublicResults

Jet Reconstruction with PFA

- Individual particles are reconstructed with Particle Flow Algorithm
- Particles are clustered using anti-k_T with R=0.7
- Clustering uses four-vector summation



Particle Flow Algorithm combines all information from several sub-detector systems

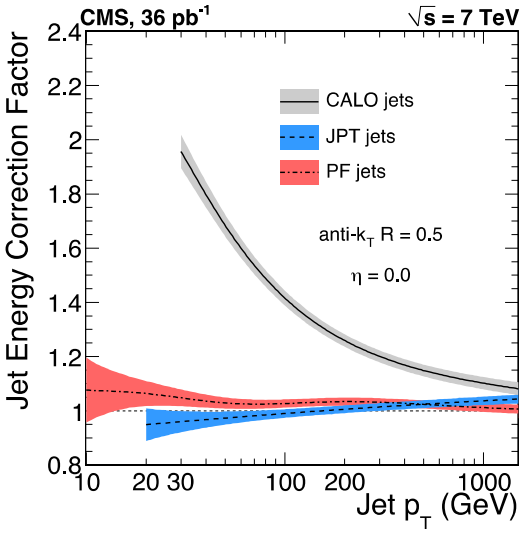
- Tracker+Ecal+HCAL= charged hadrons ($\pi^{\pm}$,$K^{\pm}$, p,..)
- Tracker+Ecal = $e^{\pm}$
- Tracker+Muon Chambers = μ
- Ecal+HCAL = neutral hadrons
- Ecal = photons

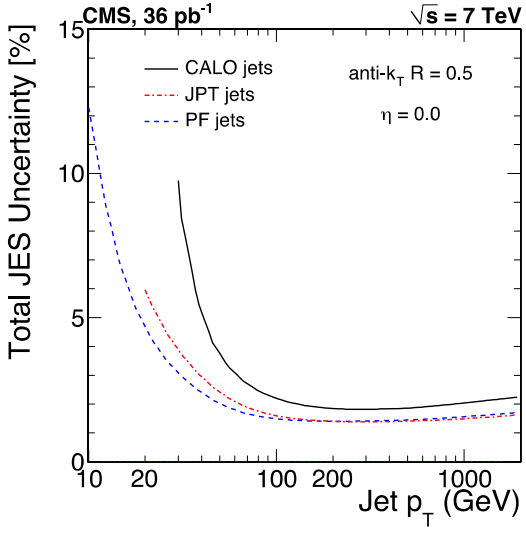
Event and Jet Selection

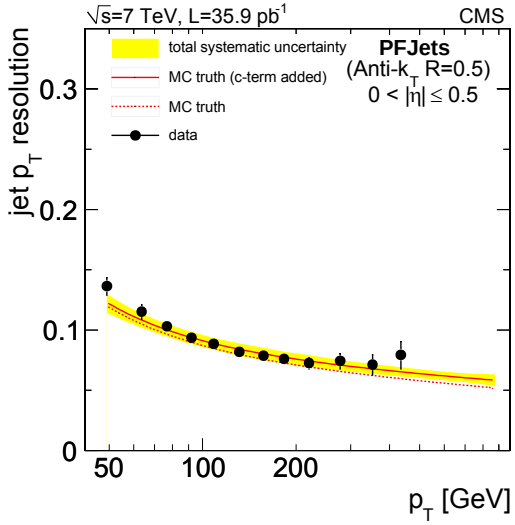
- A reconstructed vertex with at least 4 well reconstructed tracks
- At least one jet with $|y|<2.5$ for inclusive jet measurement
- At least two jets with $|y_{max}|<2.5$ for dijet measurement
- For both cases the jets are required to satisfy good quality identification criteria

- After applying the selection criteria we have a very clean data set and reject <<1% of our events

Jet Energy Scale and Resolution

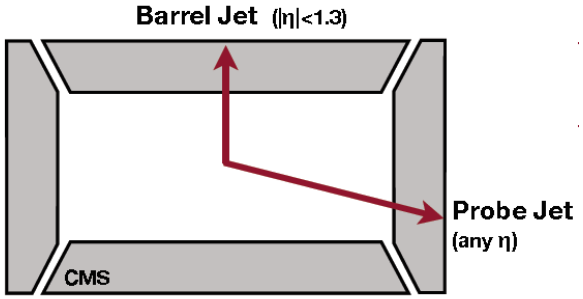






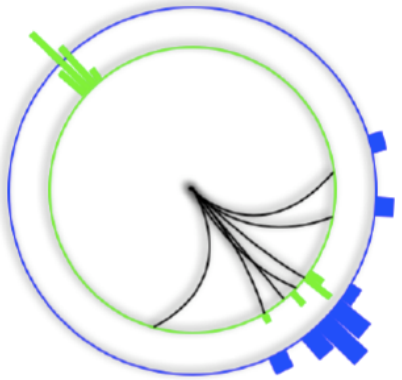
Data driven methods used

Dijet Asymmetry



Photon plus Jet Balance

γ+Jet events:



JINST 6 P11002, 2011

Experimental Measurement and Uncertainties

Measurement of the double-differential inclusive jet cross section

$$\frac{d^2\sigma}{dp_T d|y|} = \frac{1}{\varepsilon L_{eff}} \frac{N}{\Delta p_T \Delta|y|} \times C_{unsmearing}$$

N : number of jets in the bin
L_{eff} : integrated luminosity
ε : trigger and event selection efficiencies
Δp_T : transverse momentum bin width
$\Delta|y|$: rapidity bin width
C_{usm} : unsmearing correction factor

Measurement of the double-differential dijet cross section

$$\frac{d^2\sigma}{dM_{JJ} d|y|_{max}} = \frac{1}{\varepsilon L_{eff}} \frac{N}{\Delta M_{JJ} \Delta|y|_{max}} \times C_{unsmearing}$$

Data Unfolding

- Spectrum is corrected for detector smearing effects using Iterative Bayesian method (D'Agostini), as implemented in RooUnfold package

- The unfolded spectrum is compared to QCD predictions

Experimental Uncertainties

(and % impact on the cross sections)

- **Jet Energy Scale**
  10%-30% (dominant, but improved from 40%)

- **Luminosity**
  4% (improved from 11%)

- **Jet Energy Resolution**
  1%-3%

Non-Perturbative Corrections

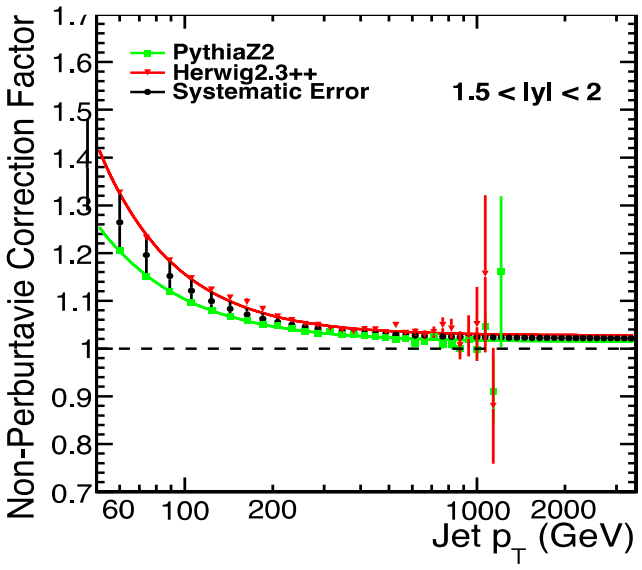
- We apply Non-Perturbative corrections to bring parton level calculations to particle level

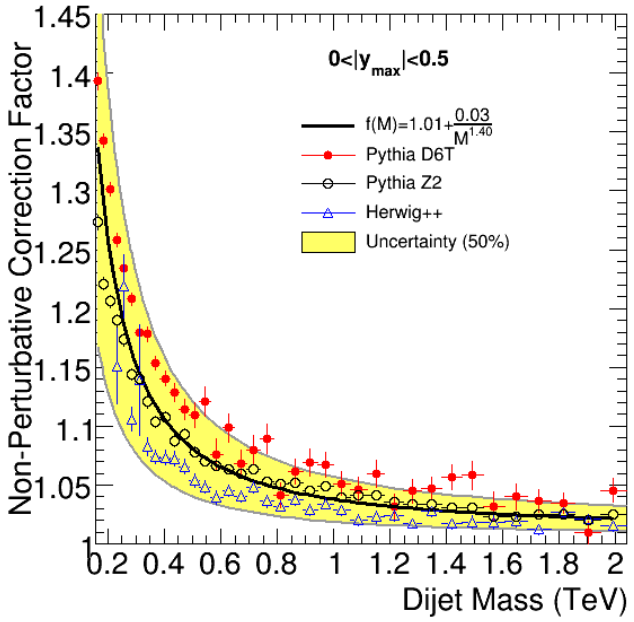
- NP corrections are derived from simulation and applied to NLO calculation to account for :

• Multi-parton interactions (MPI)

• Hadronization effects

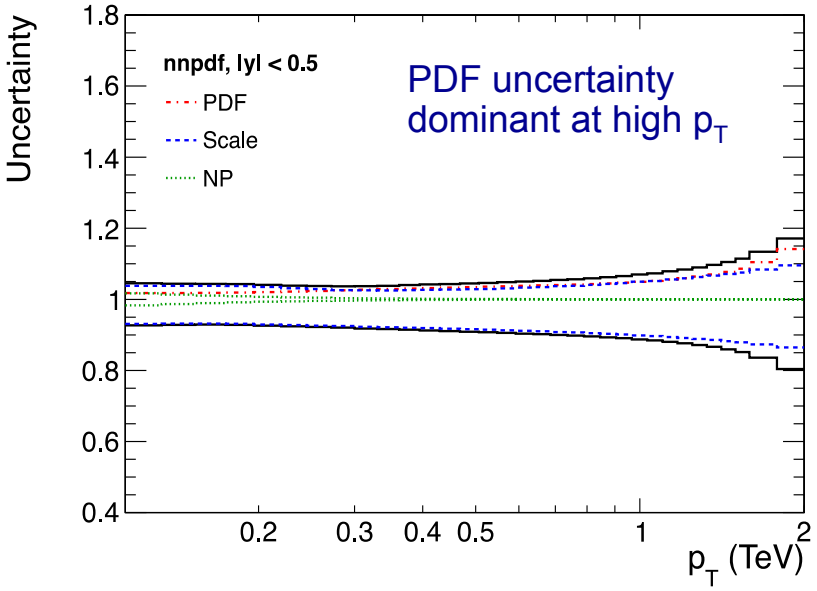
$$\text{NP correction} = \frac{\text{predictions with nominal settings}}{\text{predictions with MPI and Hadronization switched off}}$$

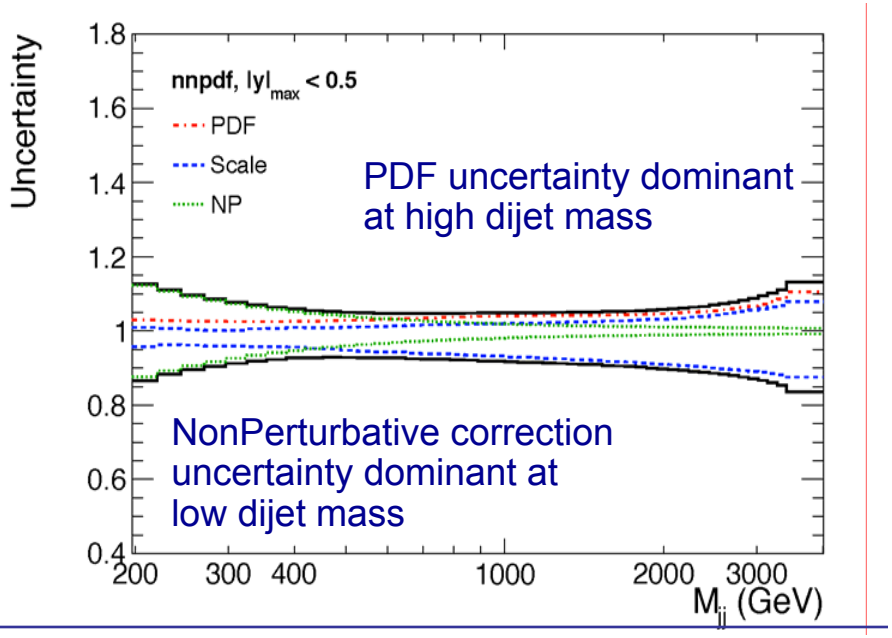




NLO Calculations and Uncertainties

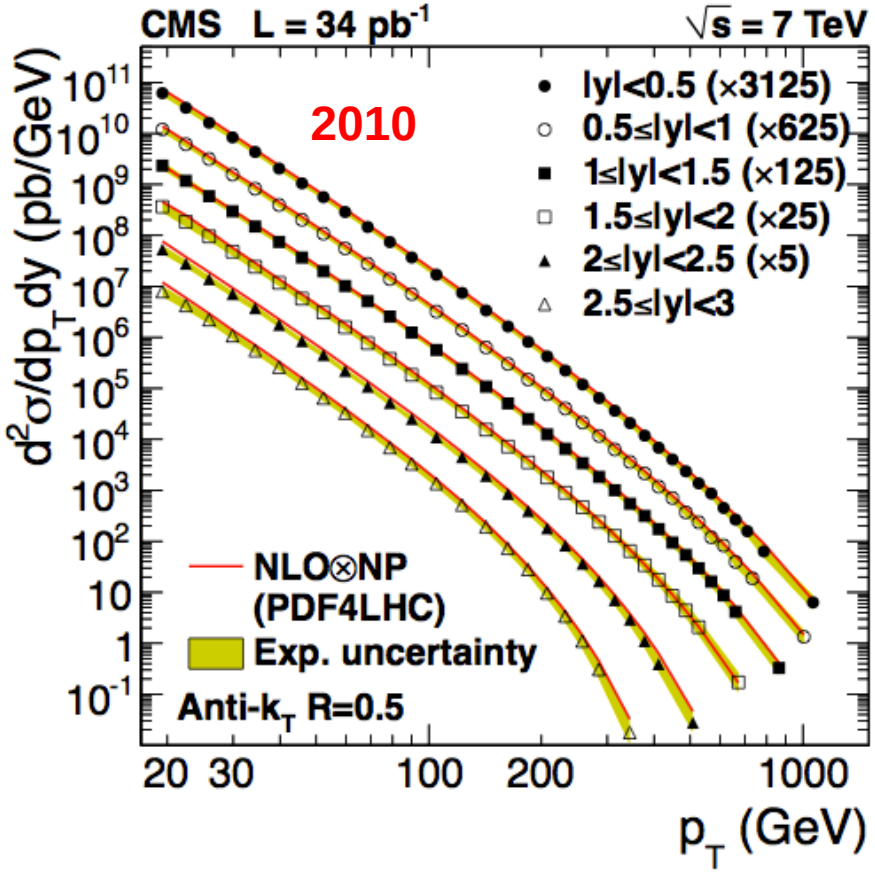
- The NLO calculations are derived using the NLOJet++ within the framework of fastNLO
- Renormalization and factorization scales, $\mu_R=\mu_F=p_{Tave}$ for the dijets (=p_T for the inclusive jets)
- The following PDF sets are studied for the NLO calculations
  - CT10
  - MSTW2008NLO
  - NNPDF2.1
  - HERAPDF1.5
  - ABKM09

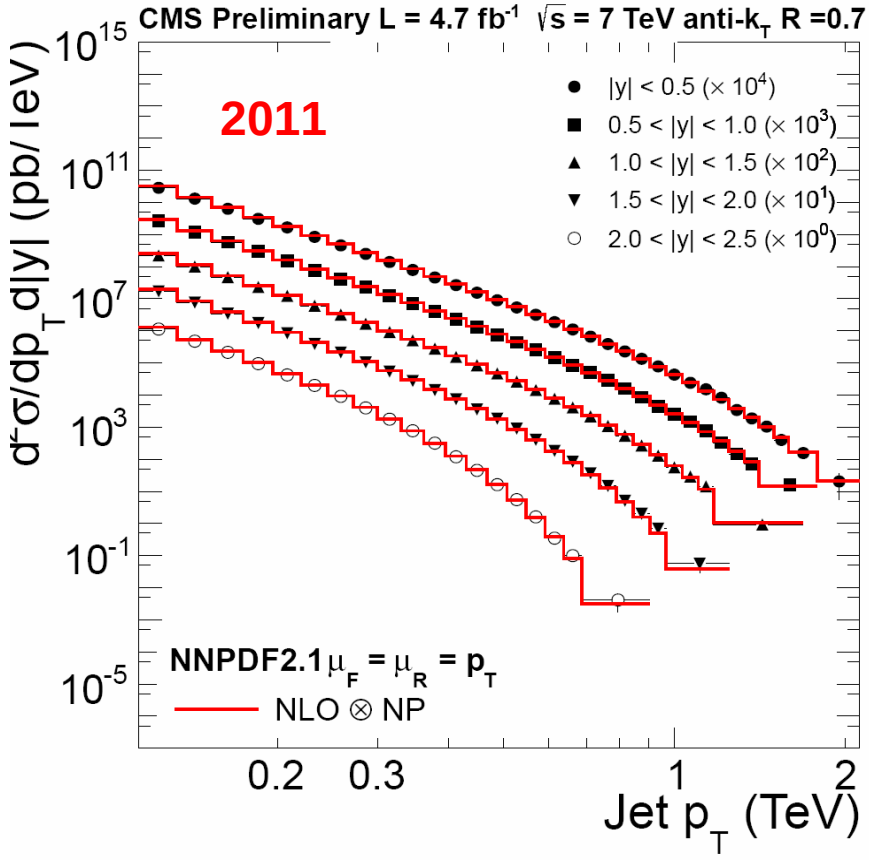




Inclusive Jet Cross Section

Unfolded double-differential cross sections as a function of jet pT compared to QCD prediction (NNPDF2.1 PDF set)

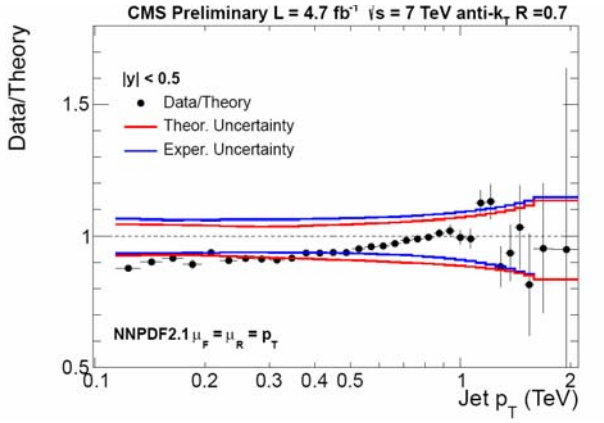


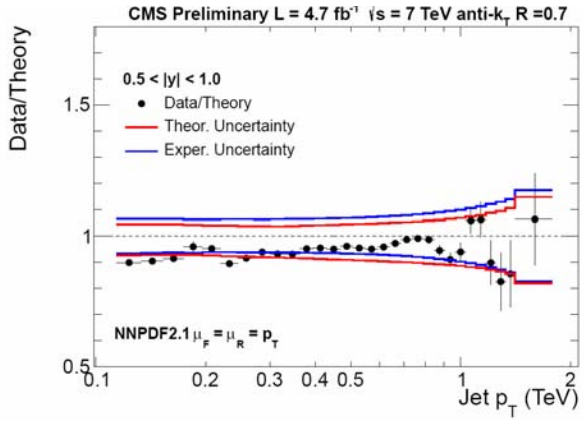


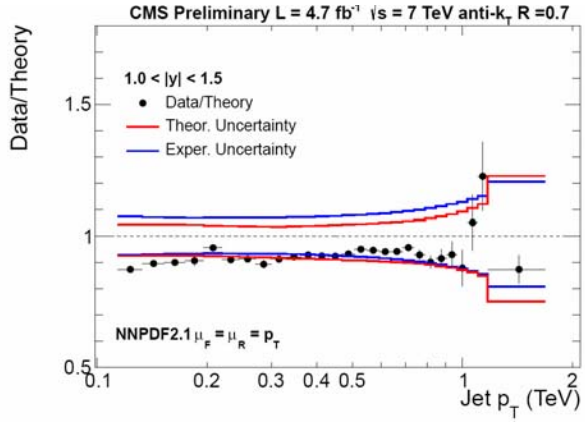
Phys.Rev.Lett.107:132001,2011

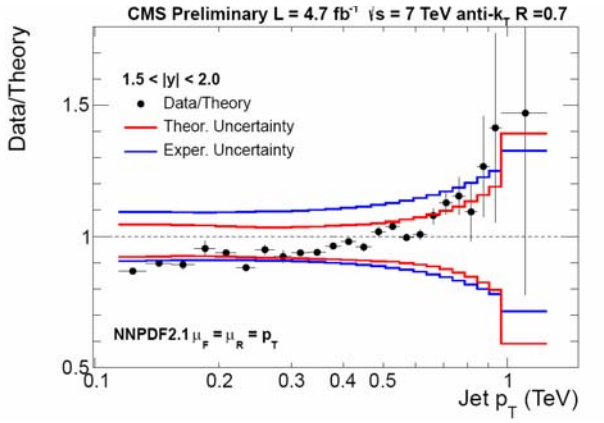
Inclusive Jet Cross Section

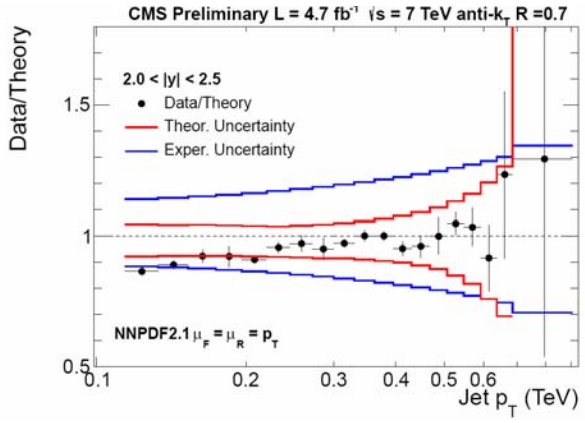
(Data and pQCD@NLO comparison for NNPDF2.1 set)







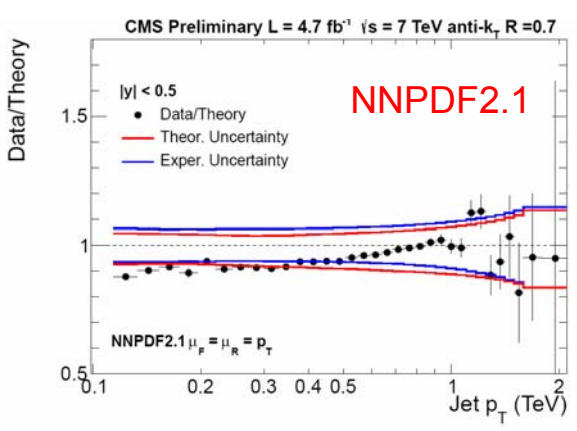


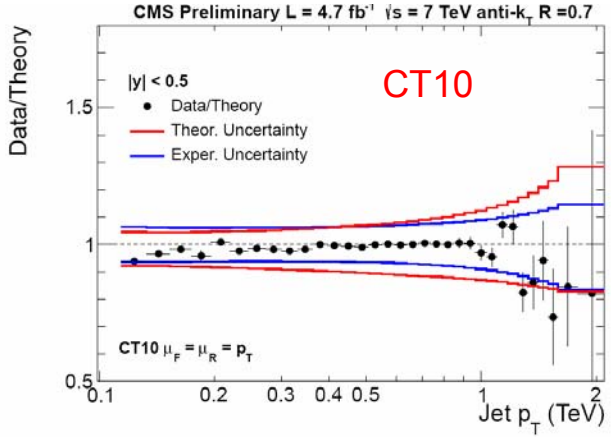


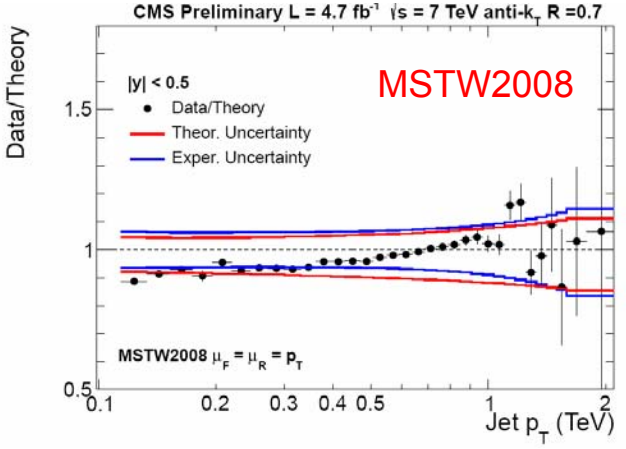
- pQCD@NLO and Data are in agreement within systematic uncertainties
- Theoretical and Experimental uncertainties are comparable at |y|<1.5

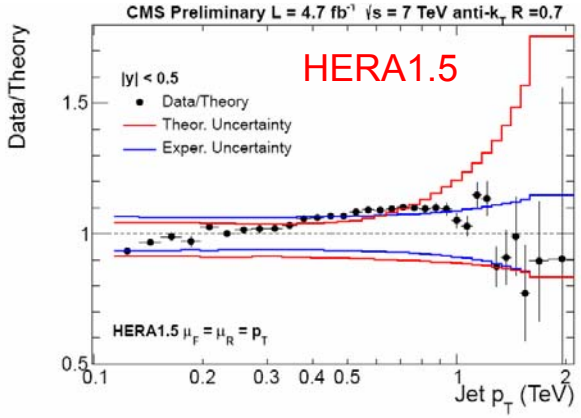
Inclusive Jet Cross Section

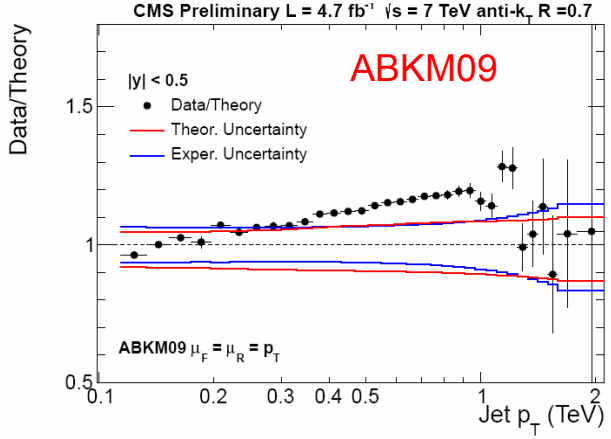
(Data and pQCD@NLO comparison for different PDF sets at |y|<0.5)







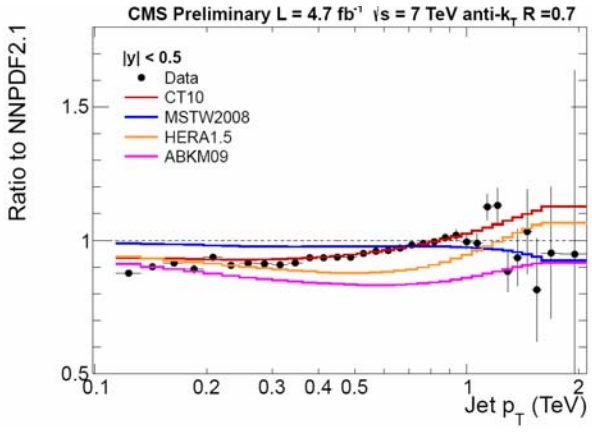


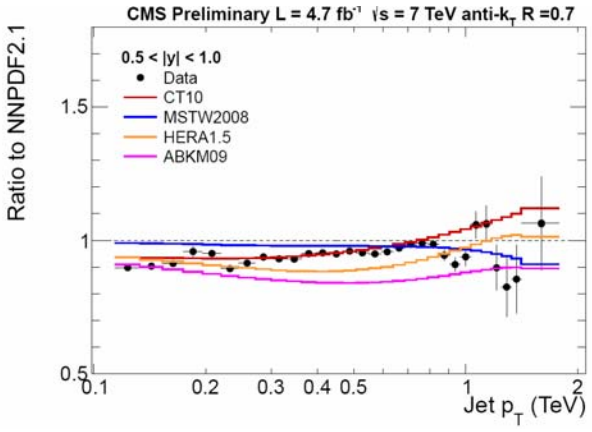


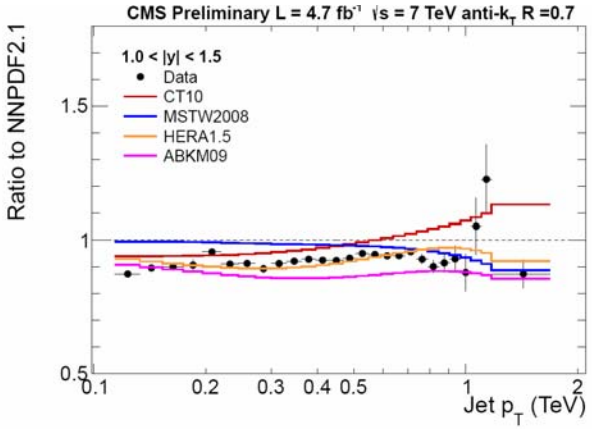
- All PDF sets are compatible with Data within systematic uncertainties
- Differences among the various PDFs are more pronounced at high p_T

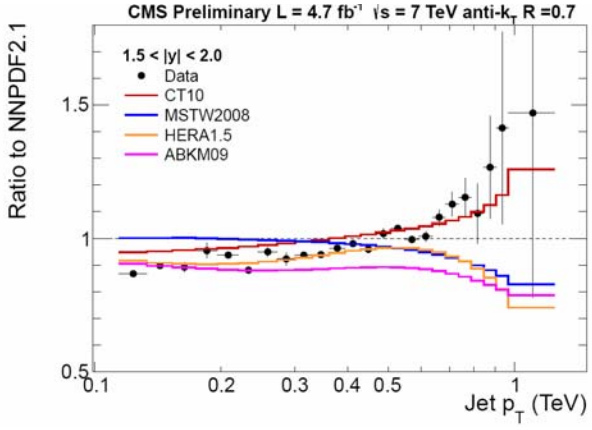
Inclusive Jet Cross Section

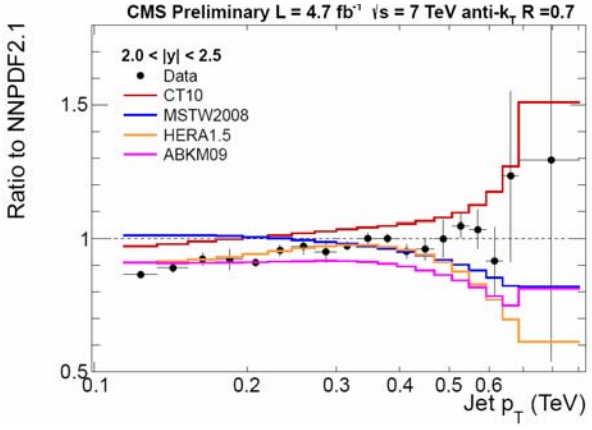
(Data and pQCD@NLO comparison for different PDF sets)







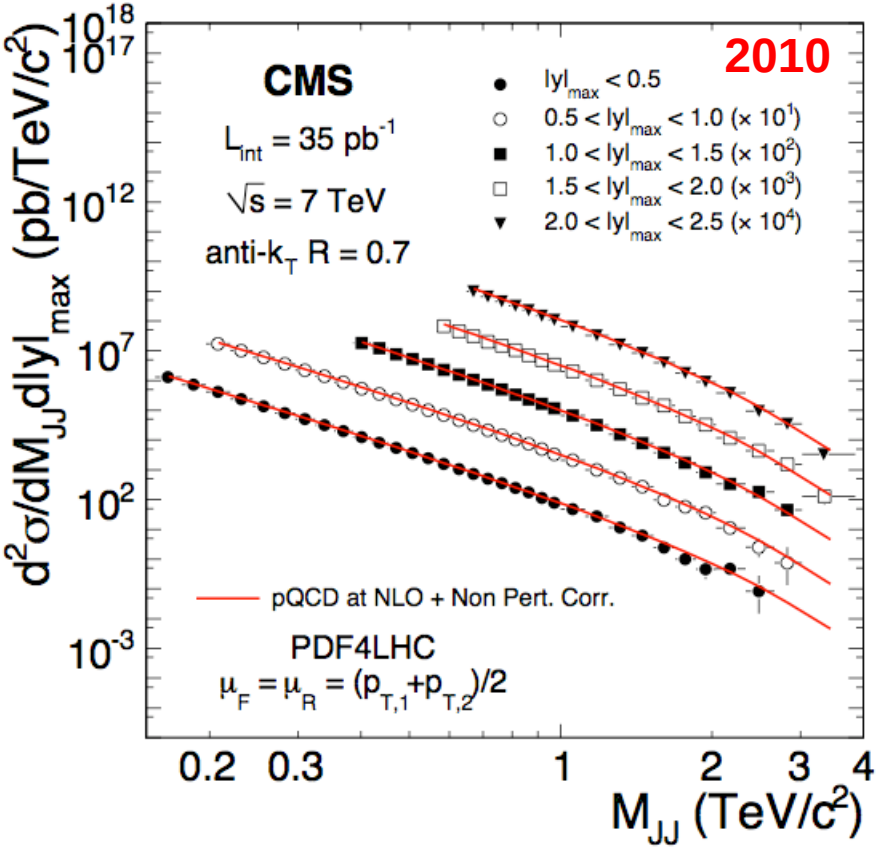


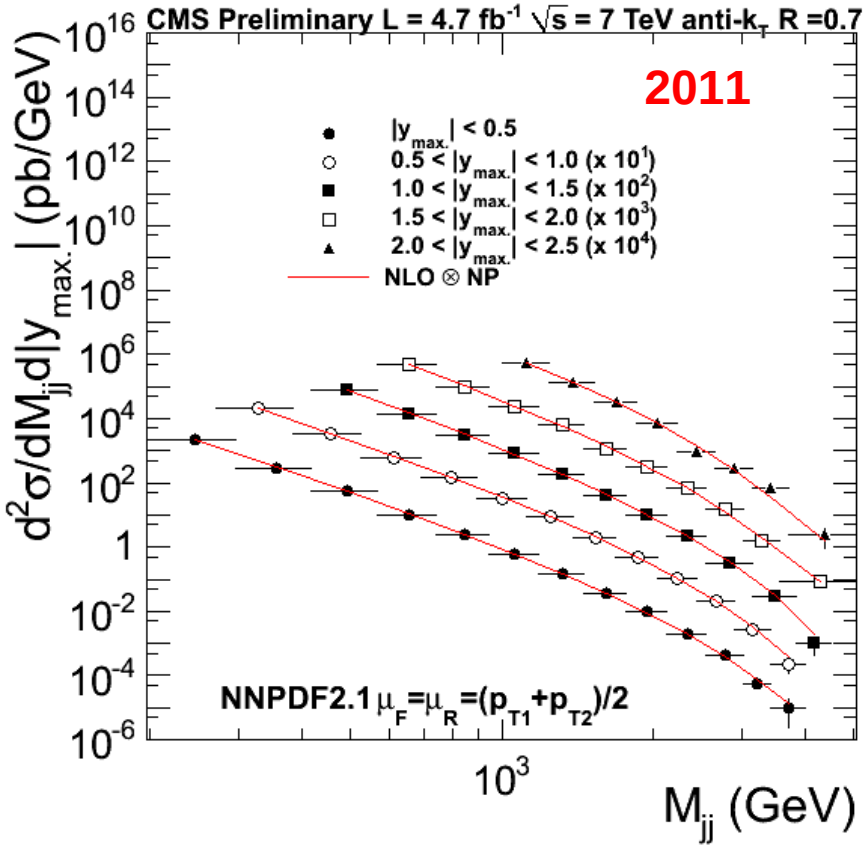


- Different trends seen for the different PDF sets
- Systematic study of uncertainty correlations are in preparation to decide which PDF set describes best the Data

Dijet Cross Section

The unfolded double-differential cross sections as a function of dijet mass compared to QCD prediction (NNPDF2.1 PDF set)

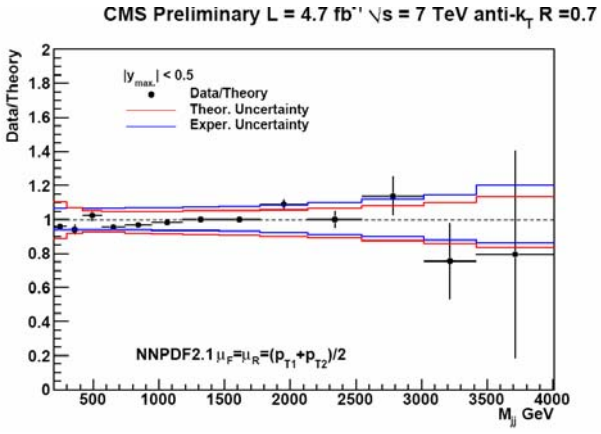


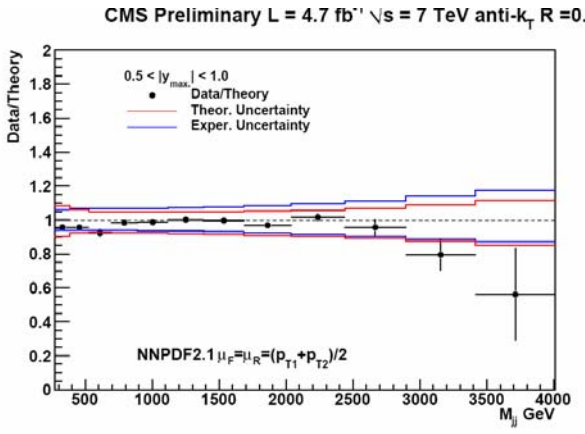


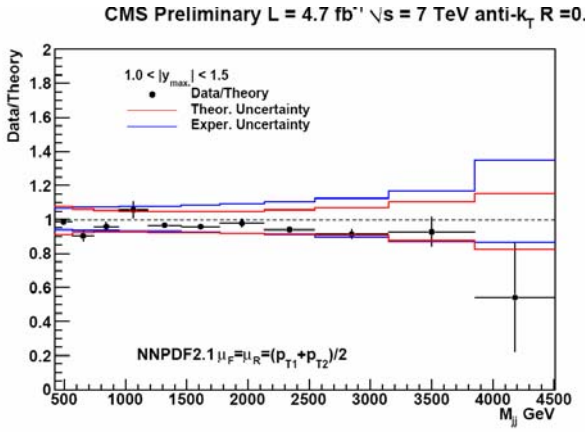
Phys.Lett.B700:187-206,2011

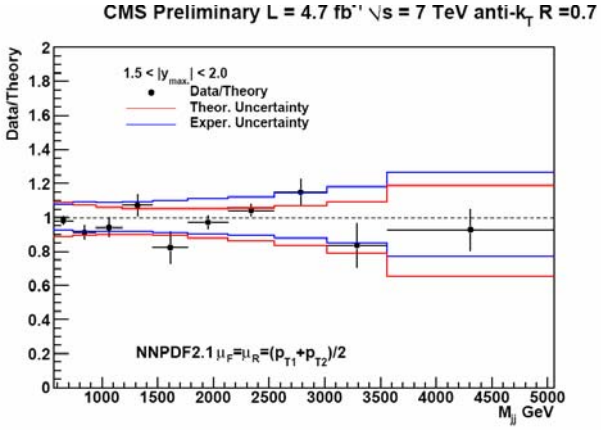
Dijet Cross Section

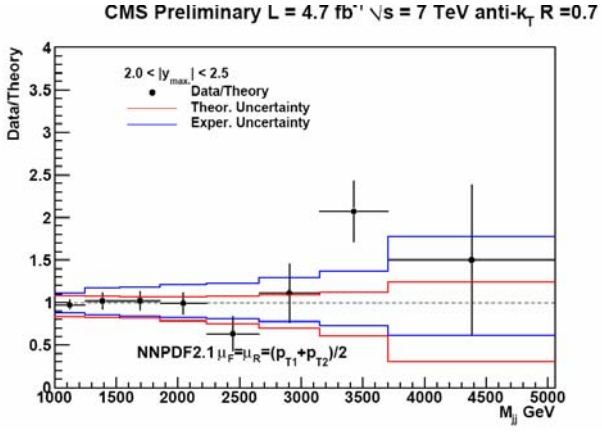
(Data and pQCD@NLO comparison for NNPDF2.1 set)







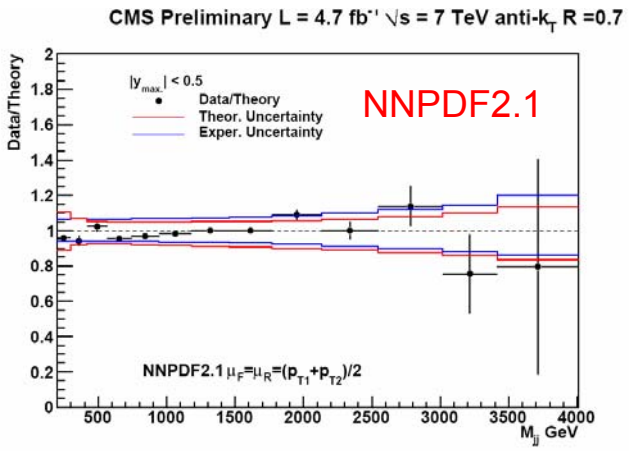


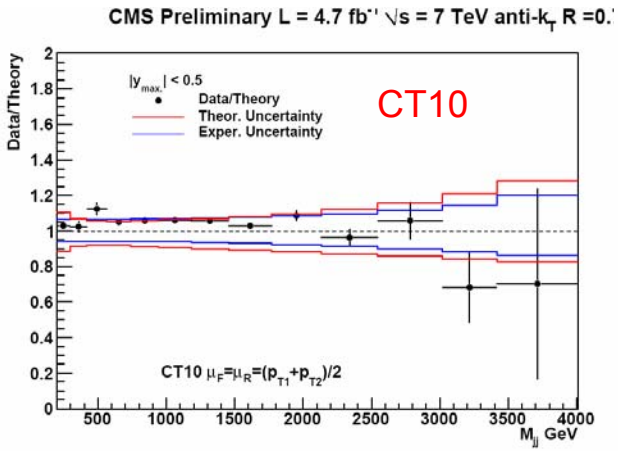


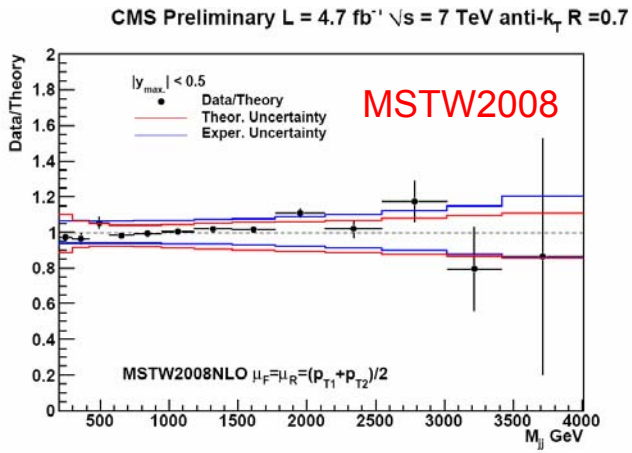
- pQCD@NLO and Data are in agreement within systematic uncertainties
- Theoretical and Experimental uncertainties are comparable

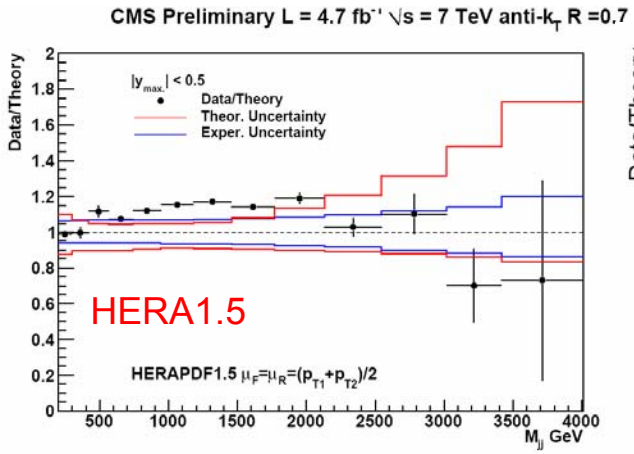
Dijet Cross Section

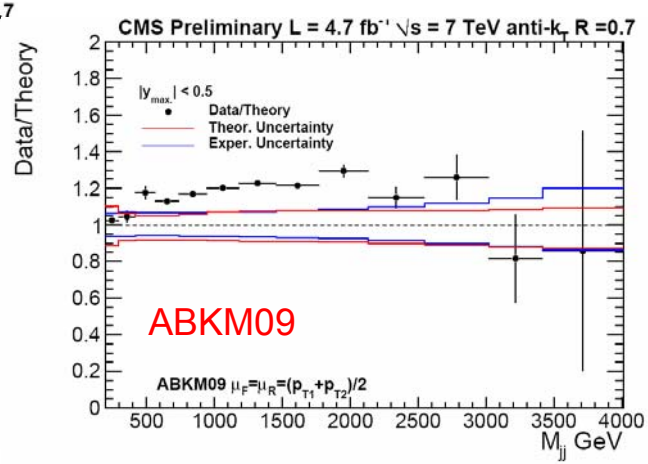
(Data and pQCD@NLO comparison for different PDF sets at |y|<0.5)







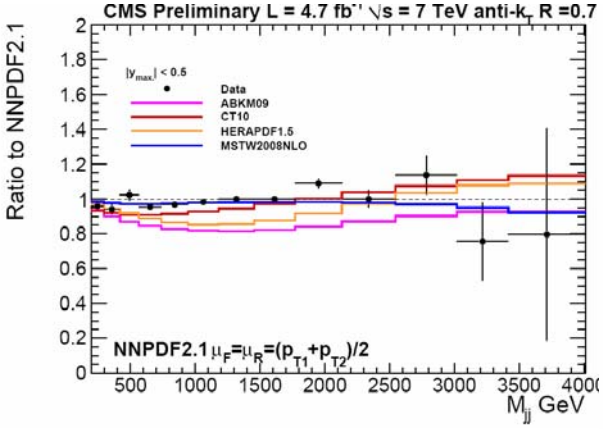


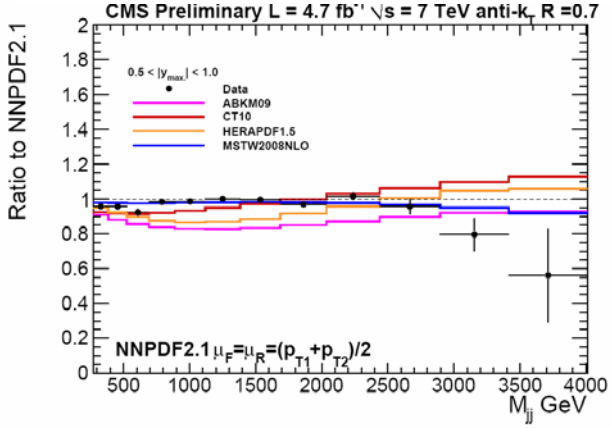


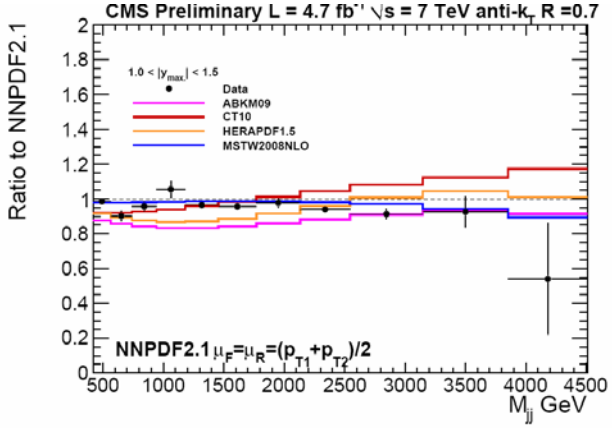
- All PDF sets are compatible with Data within systematic uncertainties
- Differences among the various PDFs are clearly present

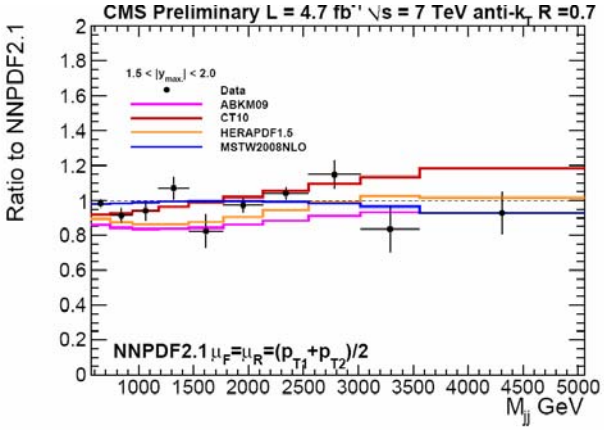
Dijet Cross Section

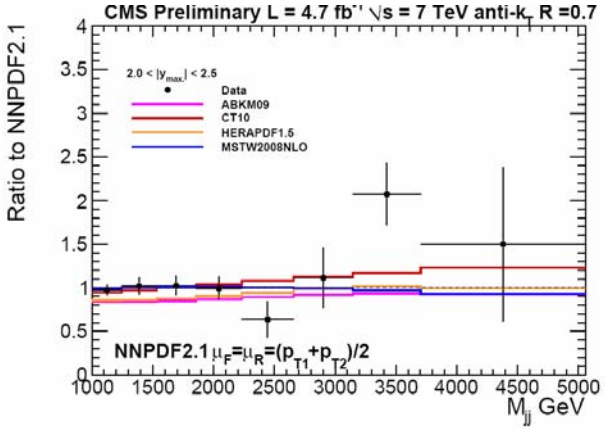
(Data and pQCD@NLO comparison for different PDF sets)











- Different trends seen for the different PDF sets
- Systematic study of uncertainty correlations are in preparation to decide which PDF set describes best the Data

Summary

- We have presented a measurement of the double-differential inclusive jet and dijet mass cross sections using **4.67 fb^{-1}** of proton-proton data collected at $\sqrt{S}$ **= 7 TeV**

- The measurement covers the inclusive jet p_T range from 0.1 to 2 TeV and the dijet mass range from 0.2 to 5 TeV in five rapidity bins, up to $|y|_{max} = 2.5$

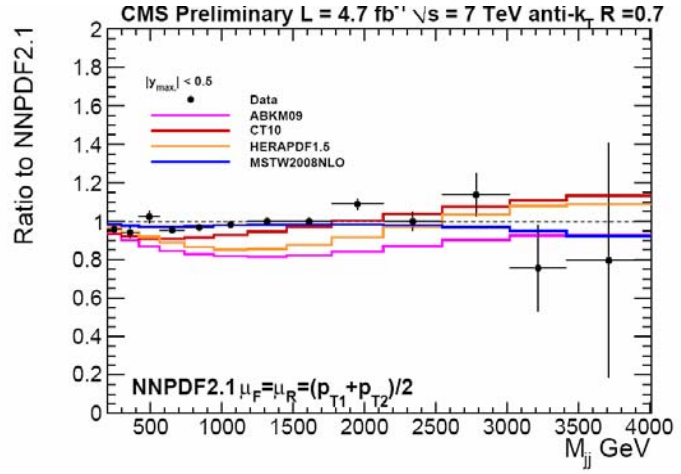
- The experimental and theoretical uncertainties are comparable
- The data are in good agreement with the theoretical predictions

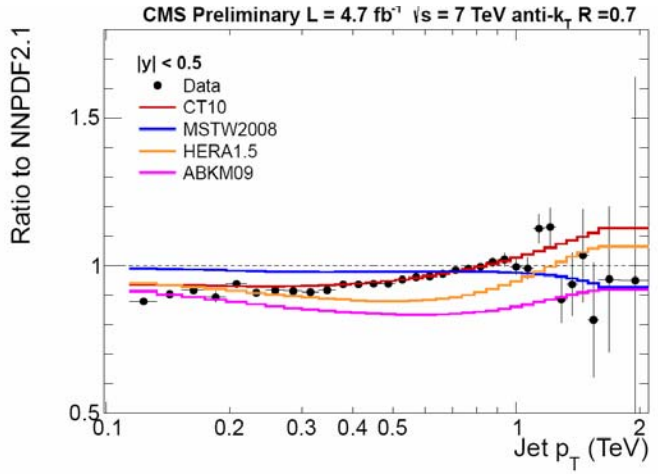
- All PDF sets are compatible with data within theoretical and experimental uncertainties

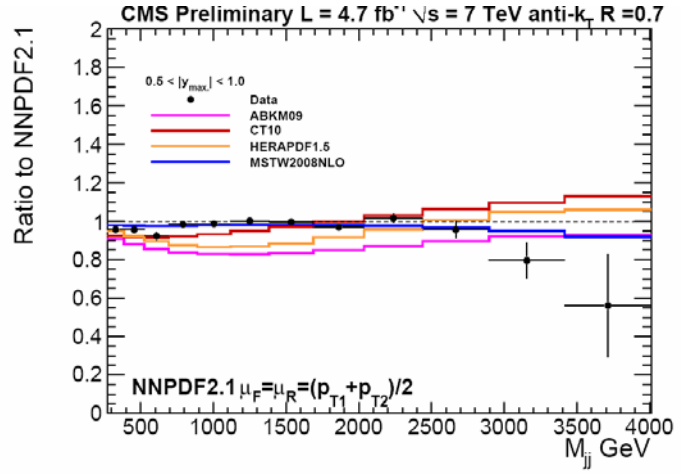
- Uncertainty correlations are in preparation and are going to be included in our publication

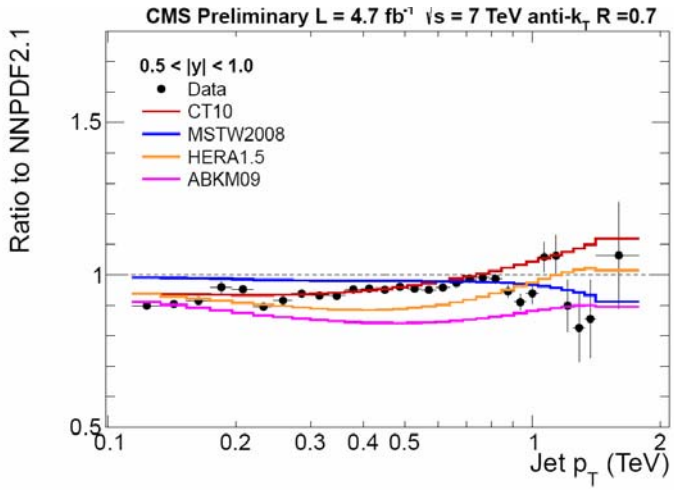
Backup slides

Data and pQCD@NLO comparison with various PDF Sets



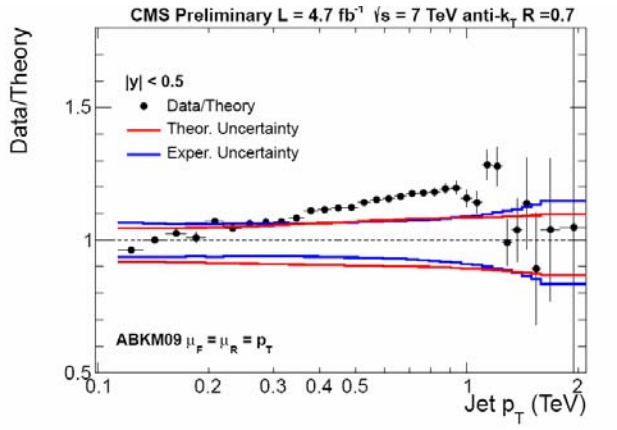


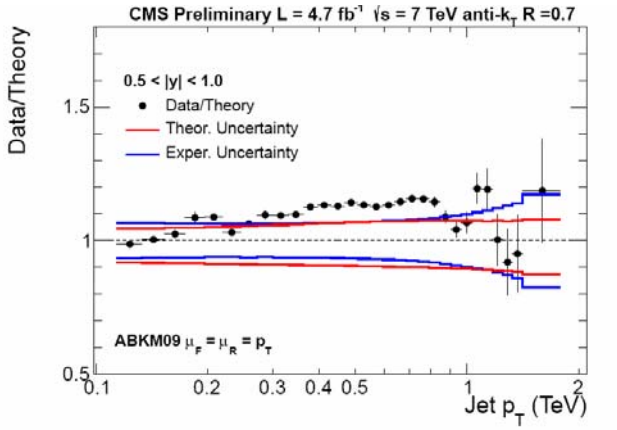


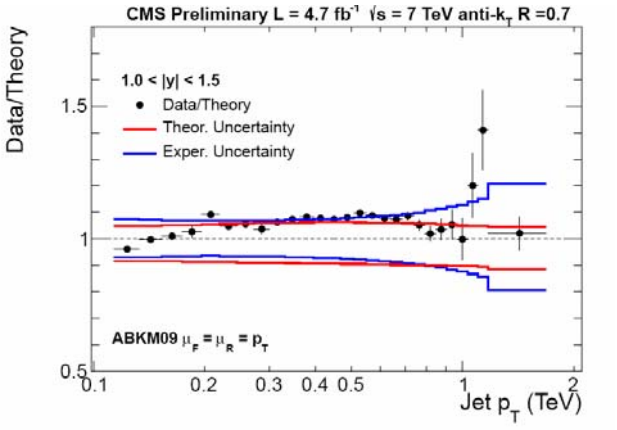


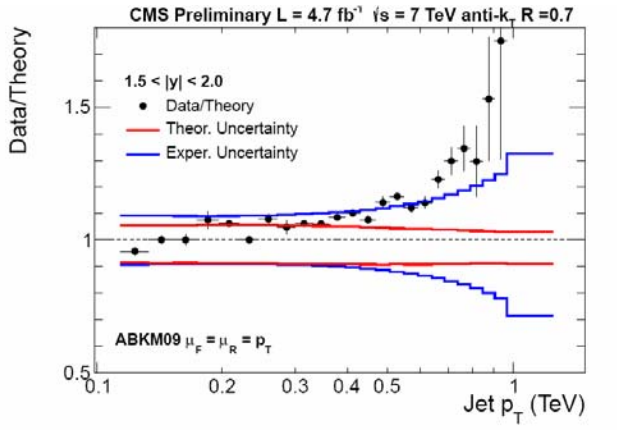
Inclusive Jet Cross Section

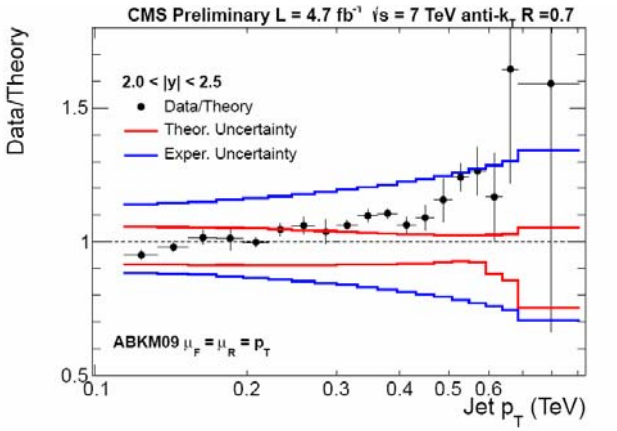
(Data and pQCD@NLO comparison for ABKM09 set)







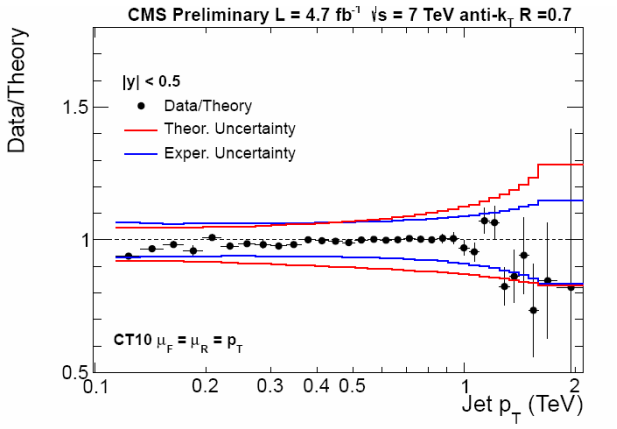


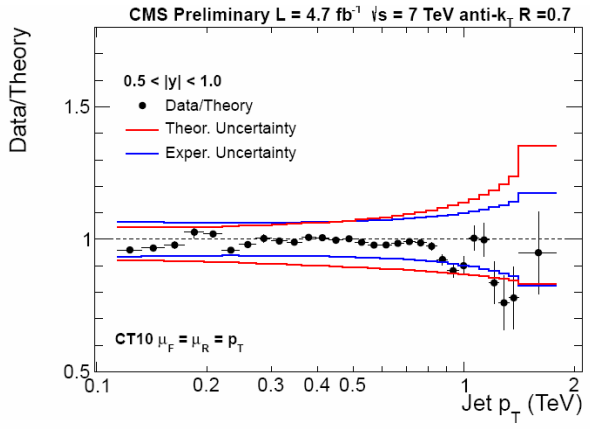


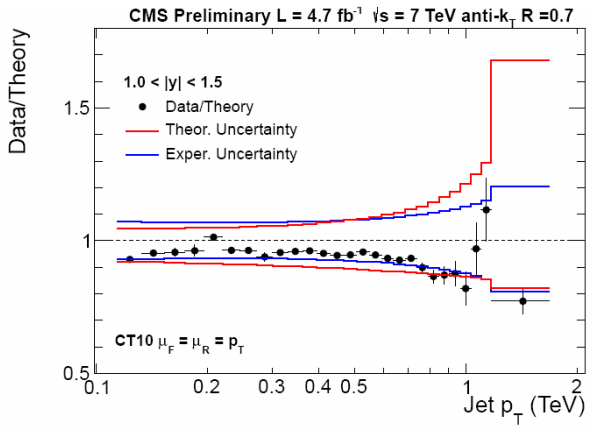
ABKM09

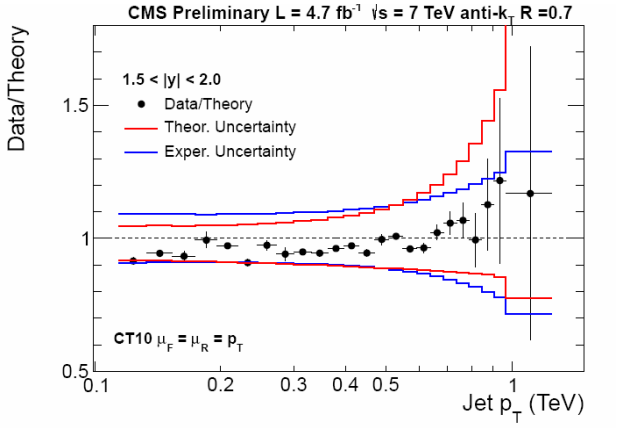
Inclusive Jet Cross Section

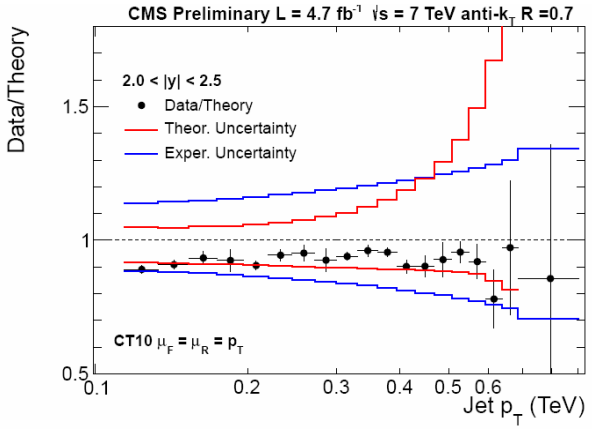
(Data and pQCD@NLO comparison for CT10 set)







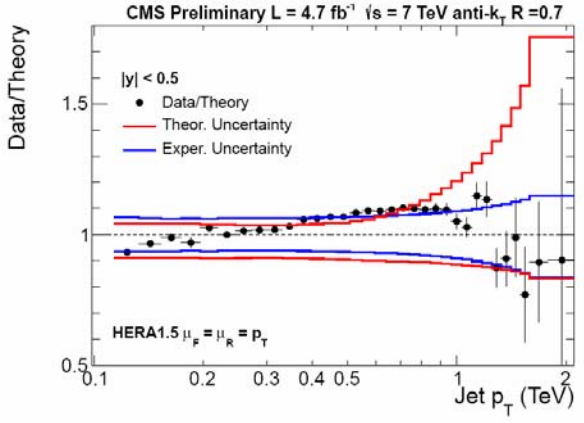


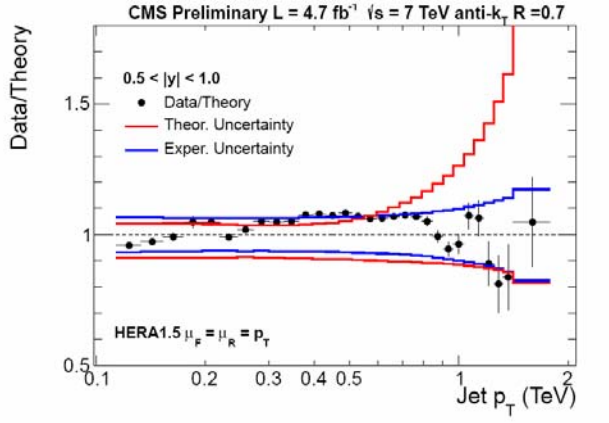


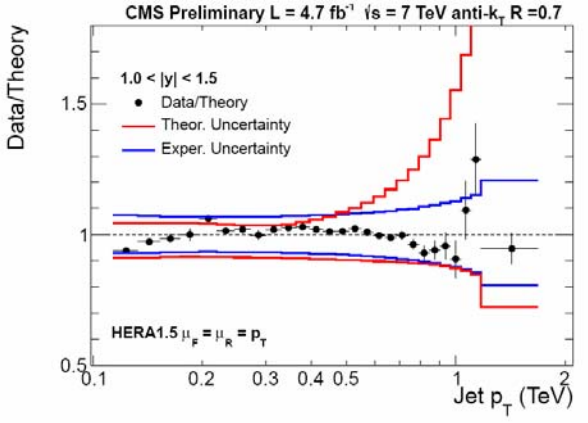
CT10

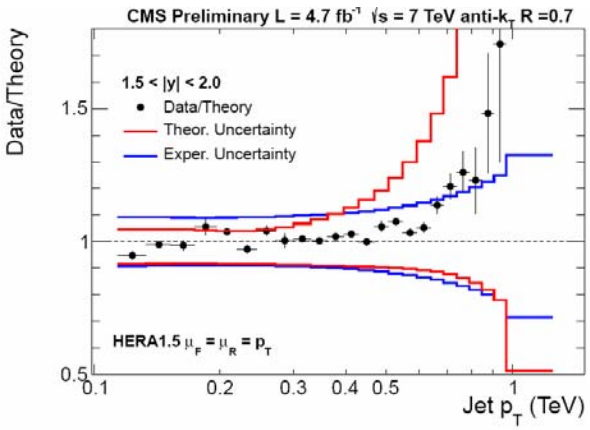
Inclusive Jet Cross Section

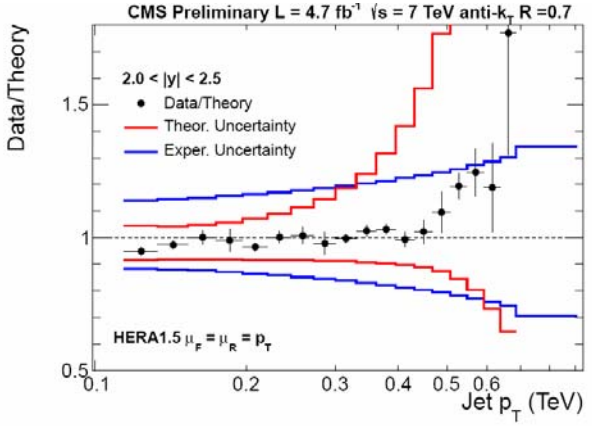
(Data and pQCD@NLO comparison for HERA1.5 set)







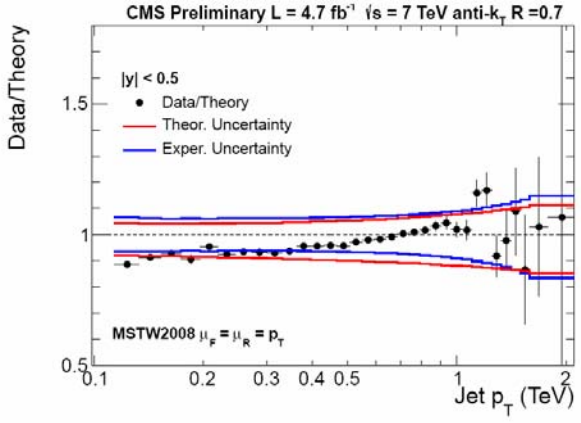


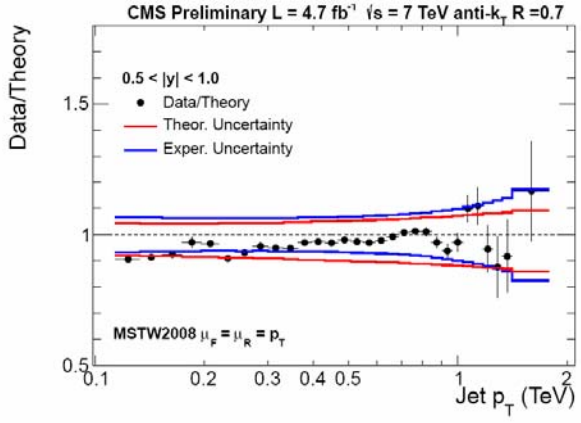


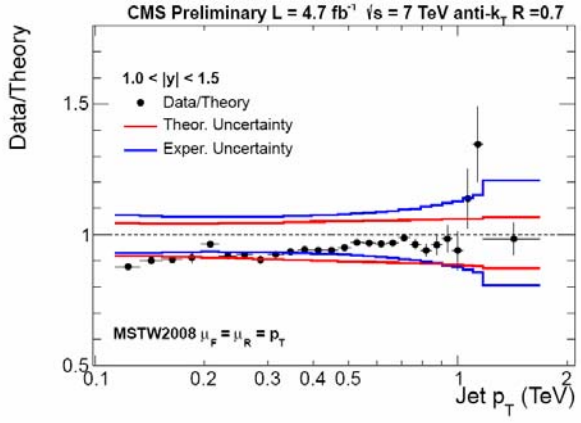
HERA1.5

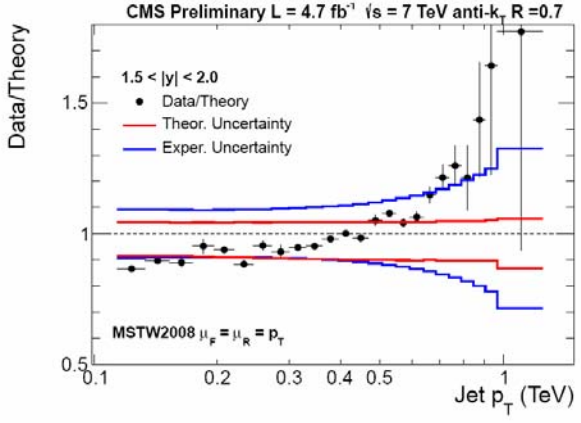
Inclusive Jet Cross Section

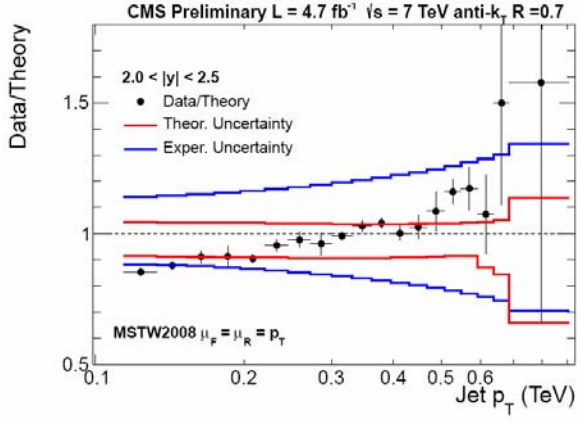
(Data and pQCD@NLO comparison for MSTW2008 set)







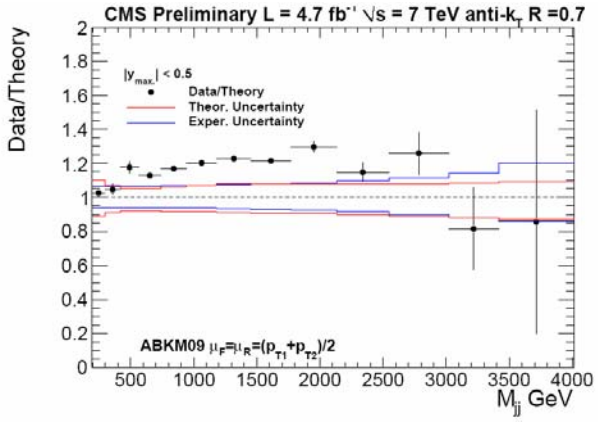


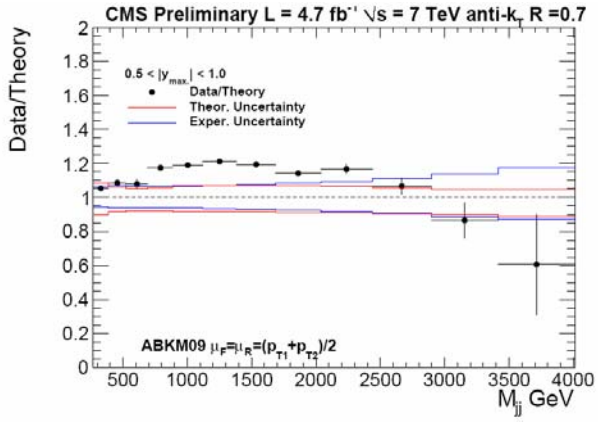


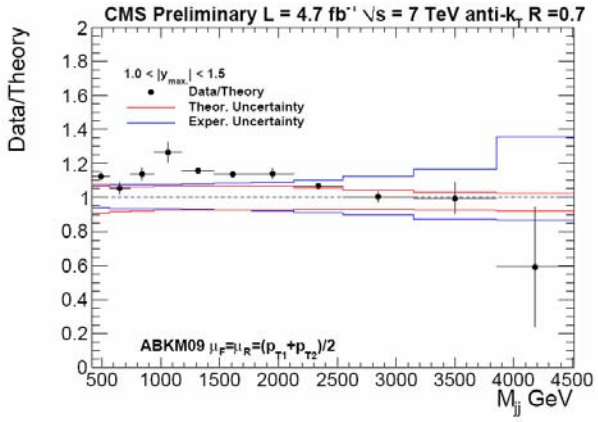
MSTW2008

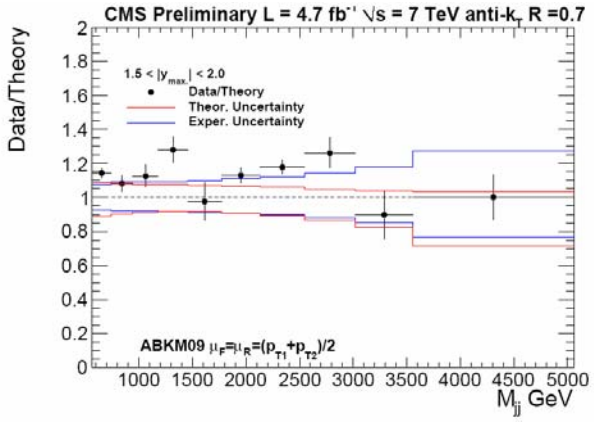
Dijet Cross Section

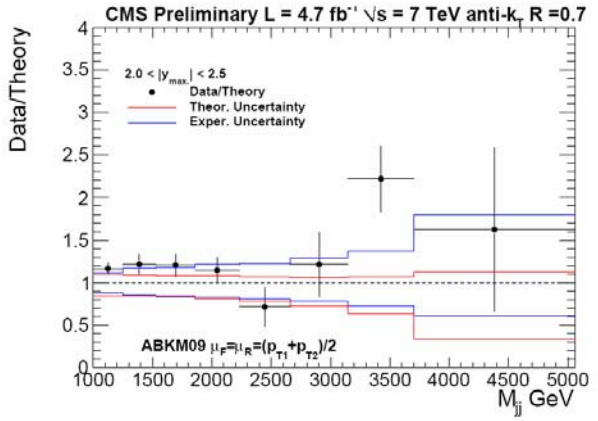
(Data and pQCD@NLO comparison for ABKM09 set)







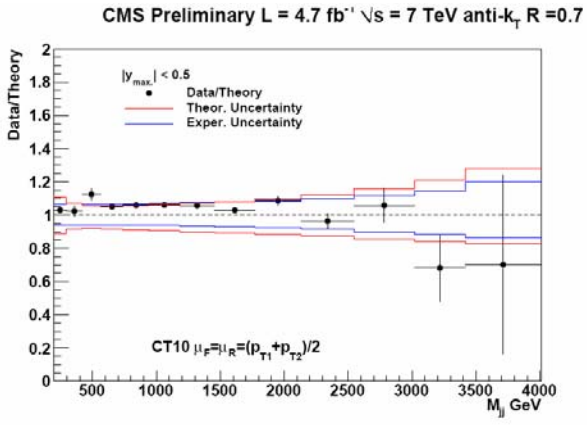


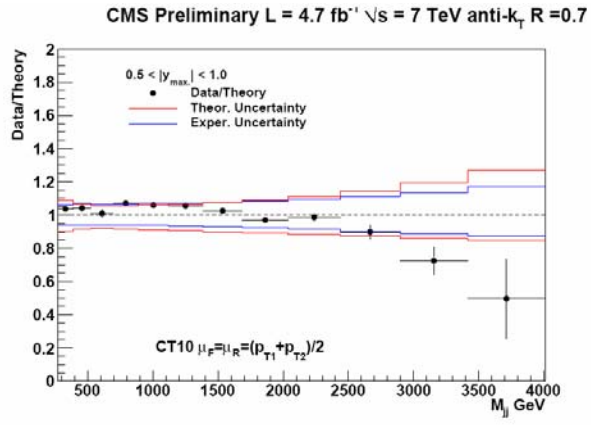


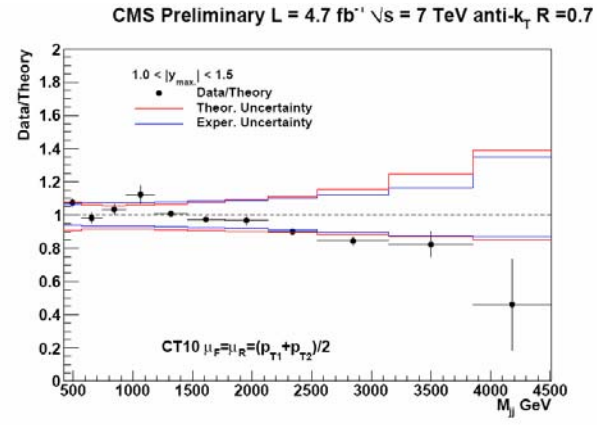
ABKM09

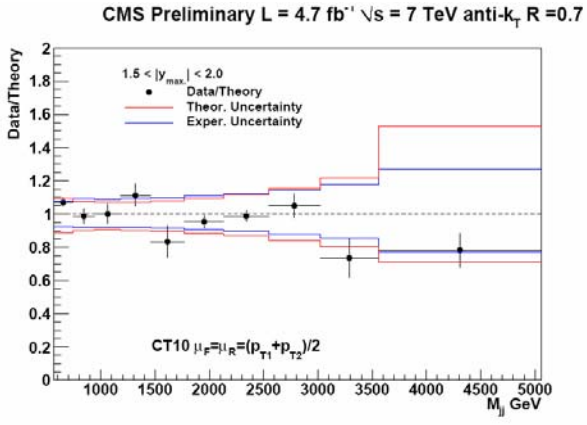
Dijet Cross Section

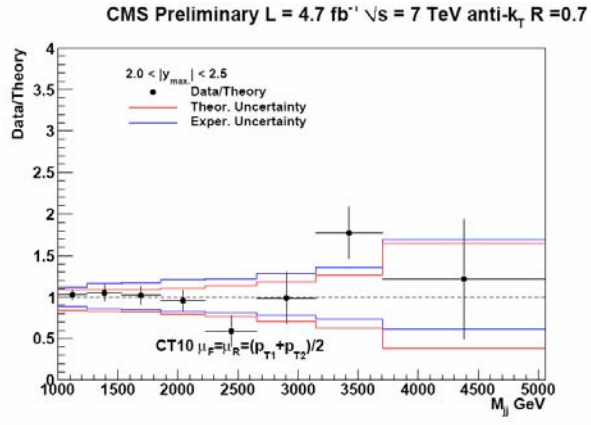
(Data and pQCD@NLO comparison for CT10 set)







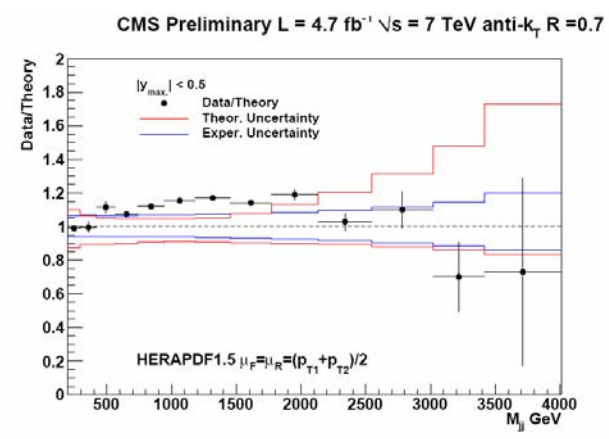


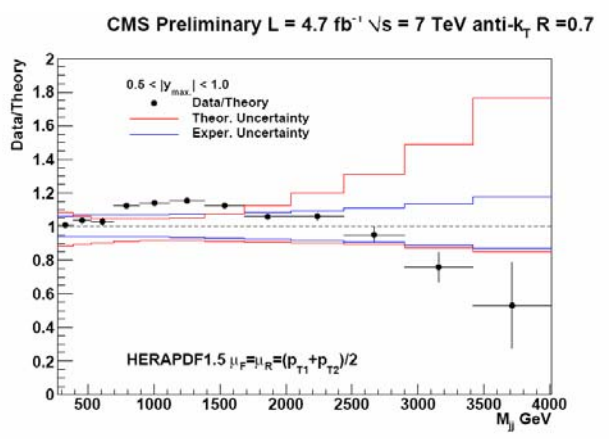


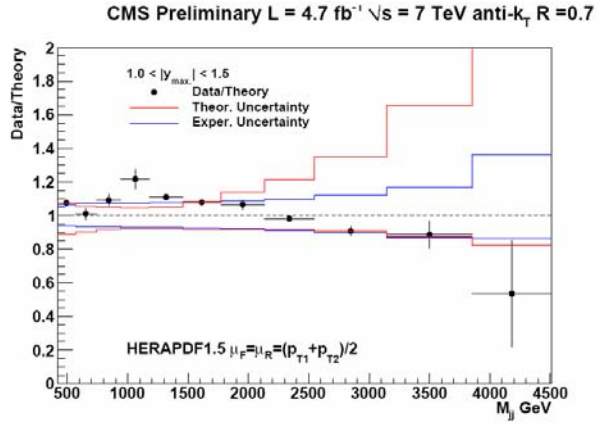
CT10

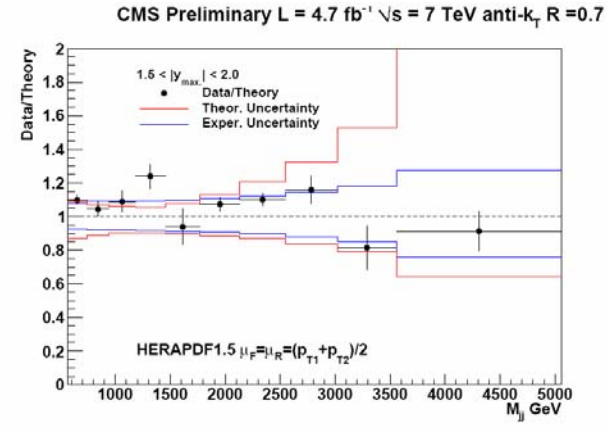
Dijet Cross Section

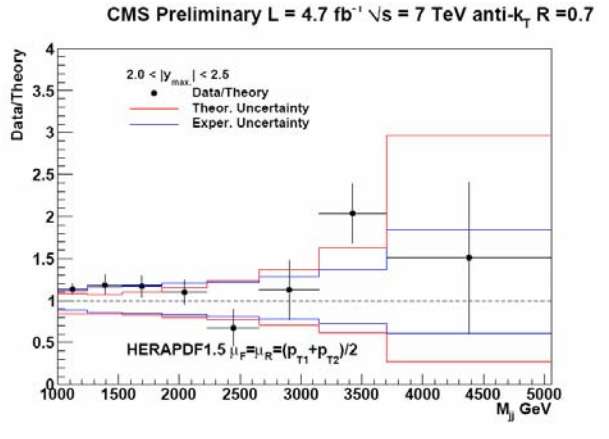
(Data and pQCD@NLO comparison for HERAPDF1.5 set)







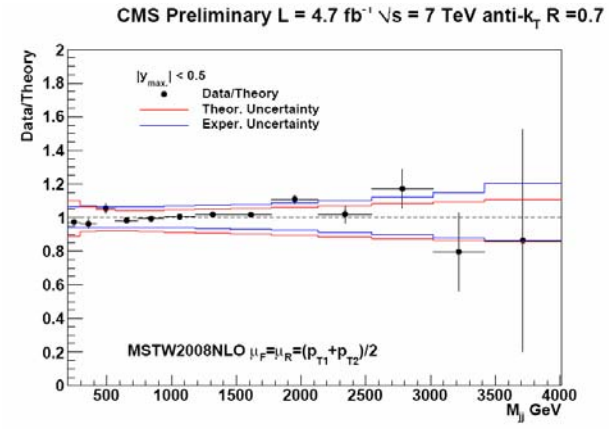


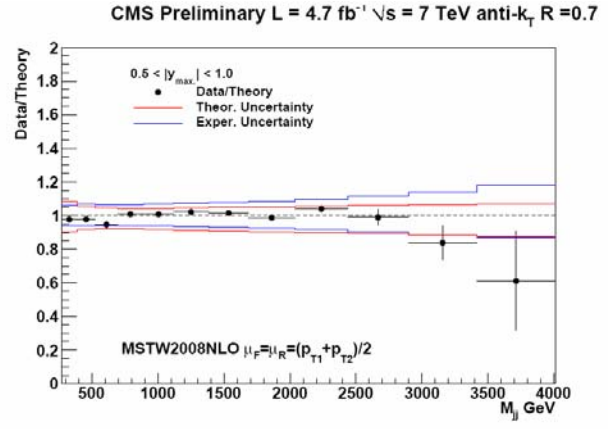


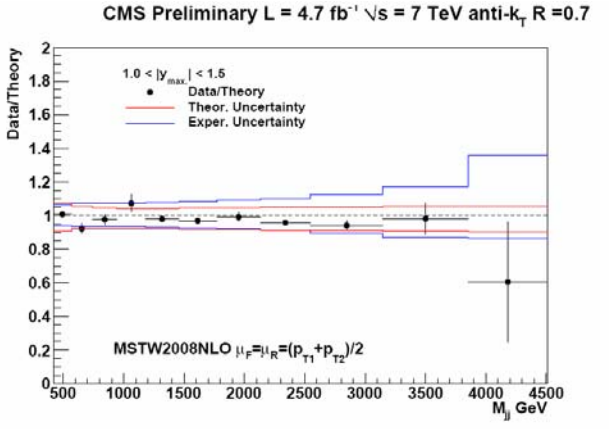
HERAPDF1.5

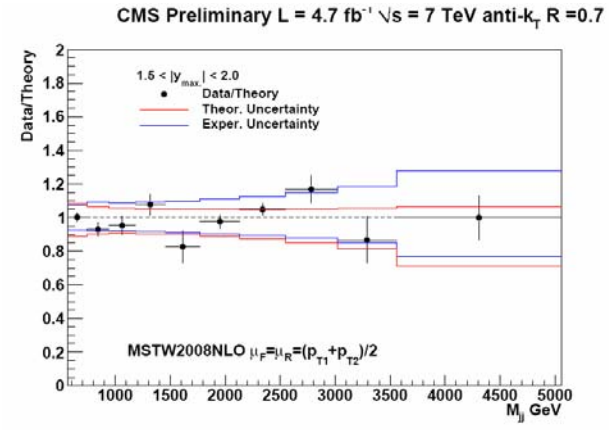
Dijet Cross Section

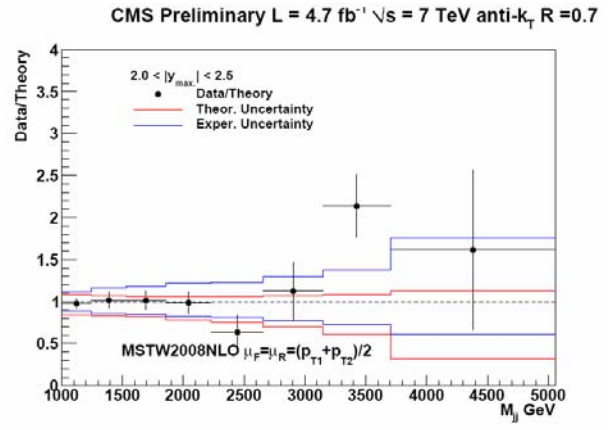
(Data and pQCD@NLO comparison for MSTW2008 set)











MSTW2008

Inclusive and Dijet Measurements in CMS and Their Relevance for PDFs

Georgios Mavromanolakis

University of Cyprus

(on behalf of the CMS Collaboration)

SM@LHC2012, 10-13 Apr 2012, Copenhagen, Denmark