# Jet reconstruction, jet production measurements and determination of $\alpha_s$ at the LHC

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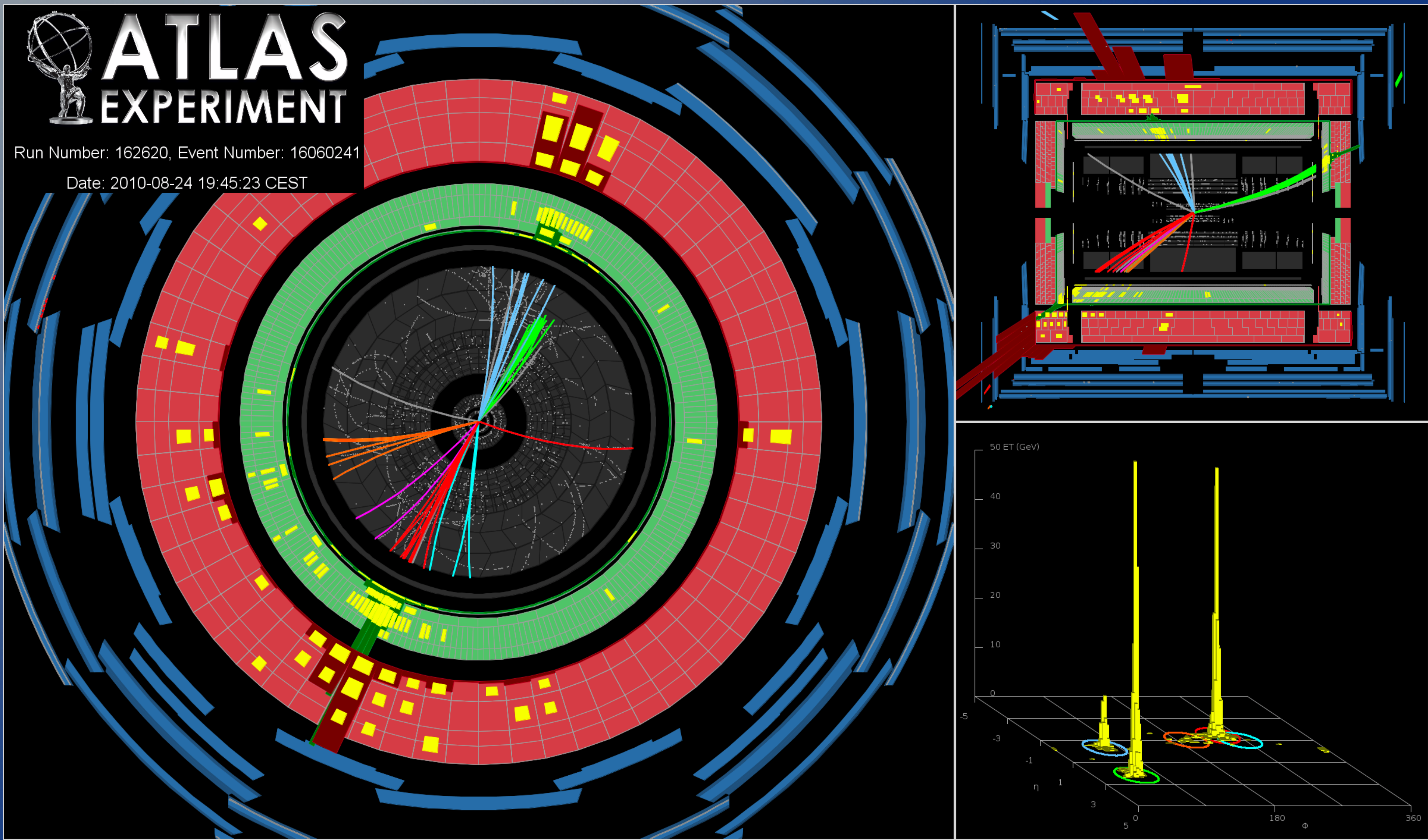
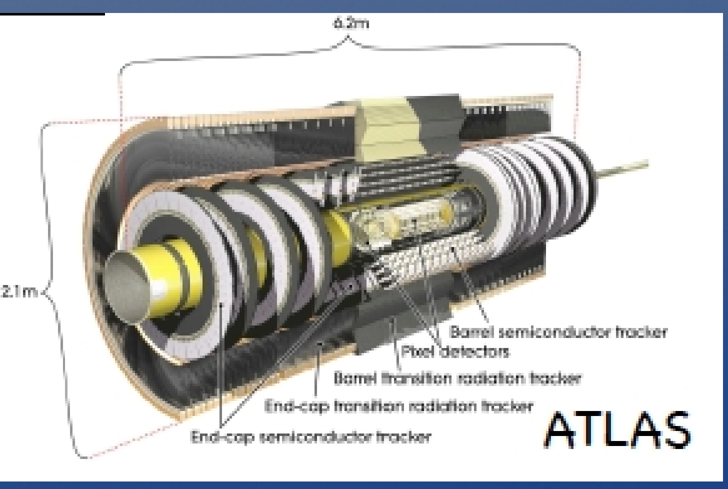
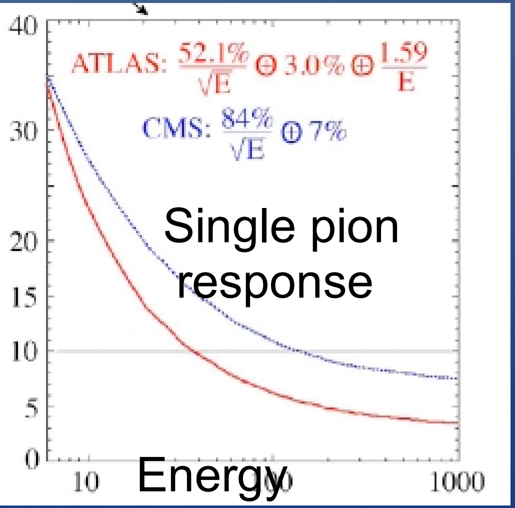
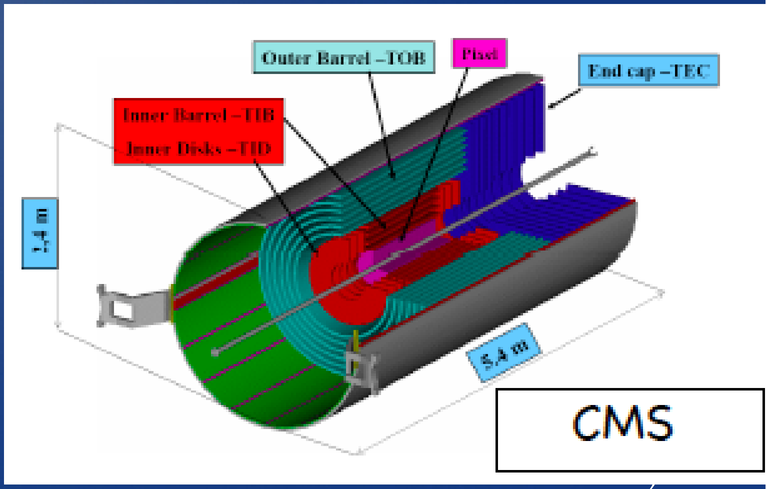


# Detector performances for jet reconstruction: ATLAS vs CMS

| | ATLAS | CMS |
|---|---|---|
| Magnetic field | 2 T solenoid<br>+ toroid: 0.5 T (barrel), 1 T (endcap) | 4 T solenoid + return yoke |
| Tracker | Silicon pixels and strips<br>+ transition radiation tracker<br>$\sigma/p_T \approx 5 \cdot 10^{-4} p_T + 0.01$ | Silicon pixels and strips<br>(full silicon tracker)<br>$\sigma/p_T \approx 1.5 \cdot 10^{-4} p_T + 0.005$ |
| EM calorimeter | Liquid argon + Pb absorbers<br>$\sigma/E \approx 10\%/\sqrt{E} + 0.007$ | $PbWO_4$ crystals<br>$\sigma/E \approx 3\%/\sqrt{E} + 0.003$ |
| Hadronic calorimeter | Fe + scintillator / Cu+LAr (10λ)<br>$\sigma/E \approx 50\%/\sqrt{E} + 0.03$ GeV | Brass + scintillator (7 λ + catcher)<br>$\sigma/E \approx 100\%/\sqrt{E} + 0.05$ GeV |






η coverage: 2.5 for trackers, 4.9-5.0 for calorimeters

# Jet reconstruction in ATLAS

3-dimensional topological clusters in the calorimeter are locally calibrated and combined with the anti-kt algorithm (D = 0.4, 0.6).
Calibration constants from Monte Carlo and test-beam data;
Tracking only used to establish systematics from double ratio, and to count vertices for pileup correction

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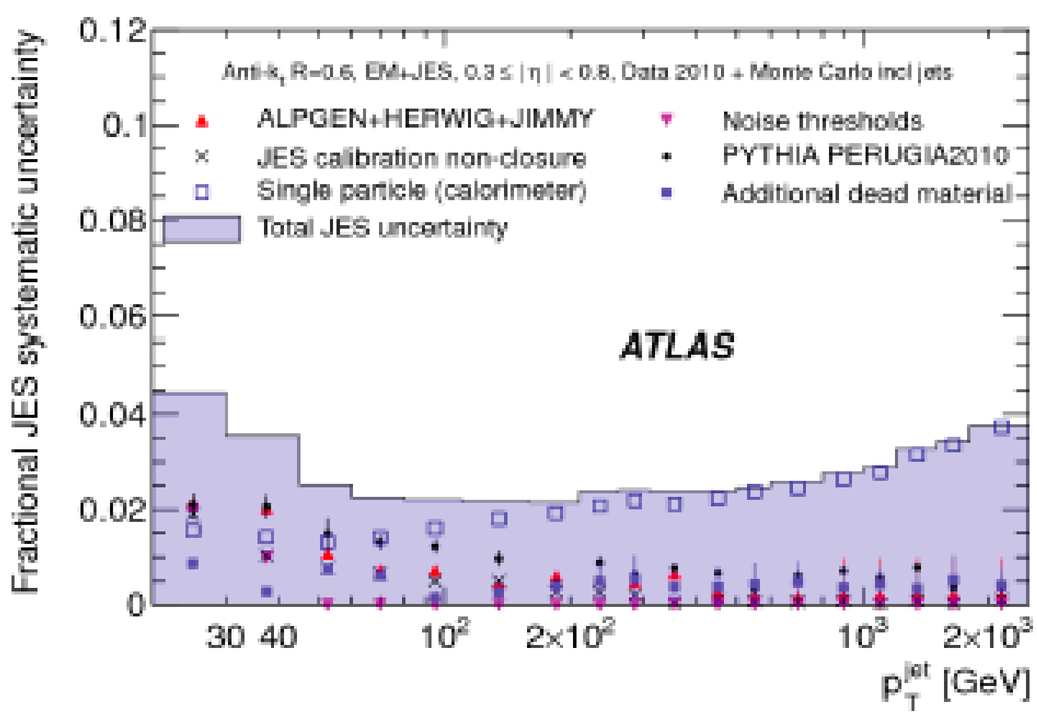



Systematic uncertainties from detector and modeling, validated in situ with γ-jet and dijets

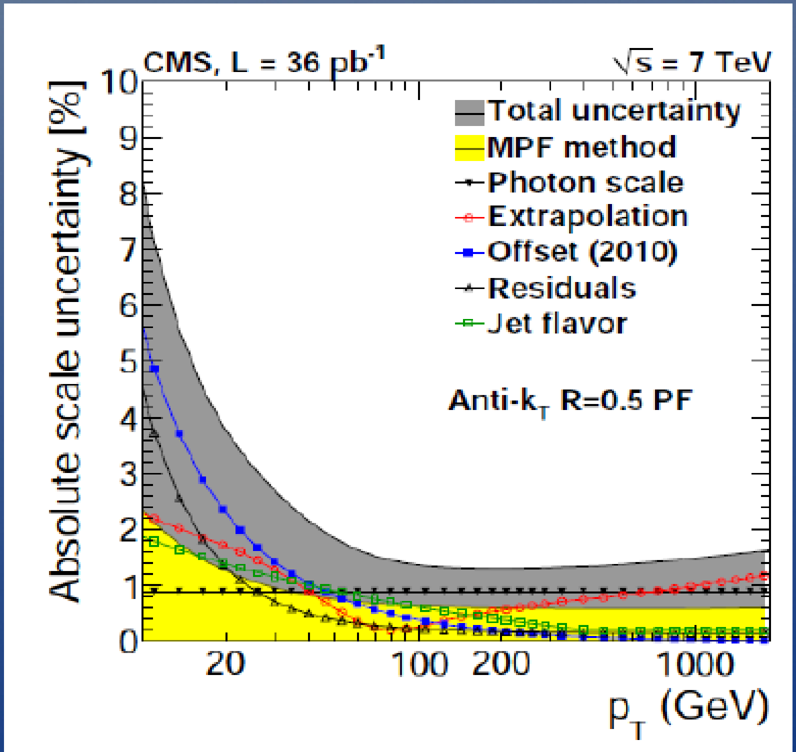
# Jet reconstruction in CMS

Larger jets (D=0.5, 0.7) and more use of tracker: input to jet reconstruction is a particle flow object (e, mu, tau, gamma, $h^+$, $h^0$)

Jets corrected by several factors:

$$p_\mu^{cor} = \mathcal{C} \cdot p_\mu^{raw}. \qquad \mathcal{C} = C_{\rm offset}(p_T^{raw}) \cdot C_{\rm MC}(p'_T, \eta) \cdot C_{\rm rel}(\eta) \cdot C_{\rm abs}(p''_T)$$

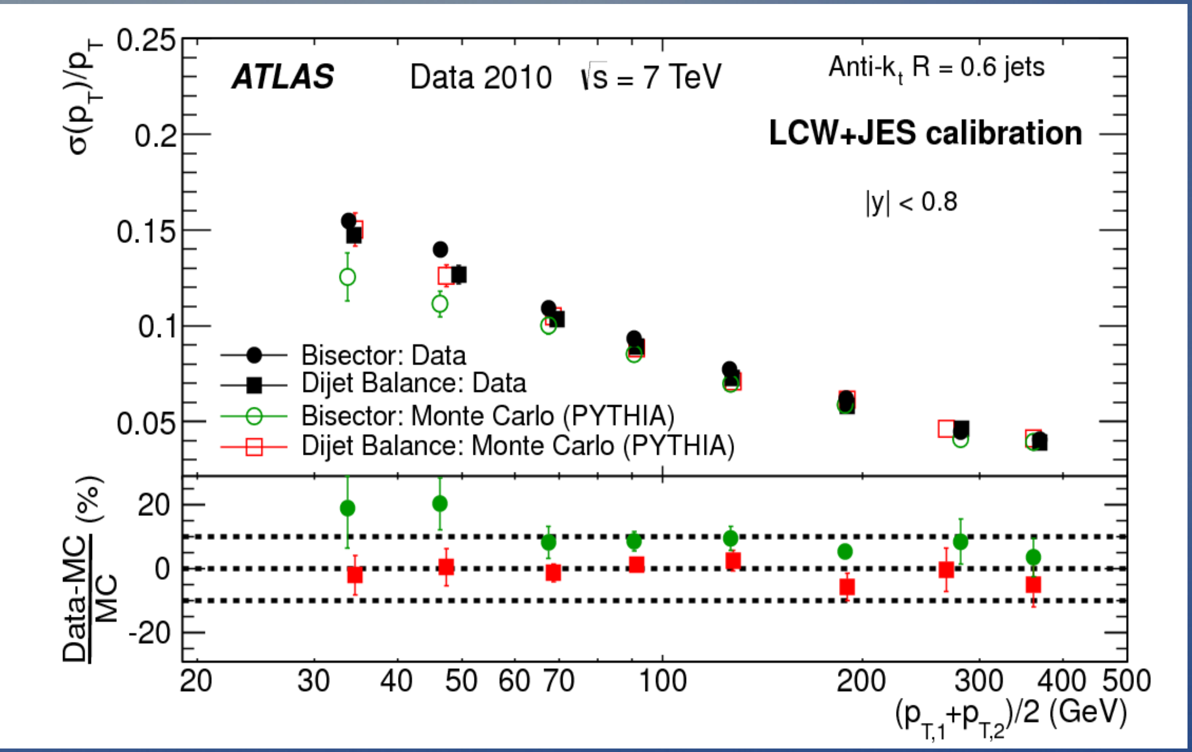
Accounts for pileup, MC-based factors, position inhomogeneities, residual difference from in-situ techniques (γ-jet, Z-jet)

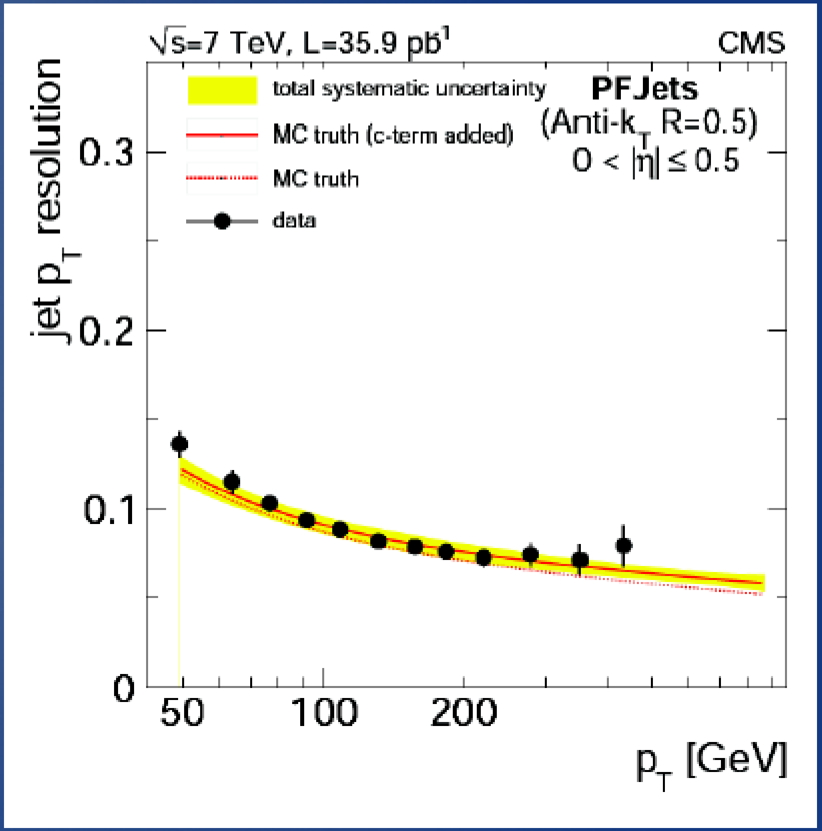



Residual uncertainties from photon JES, relative η response, pileup, extrapolation for balance

# Jet resolution

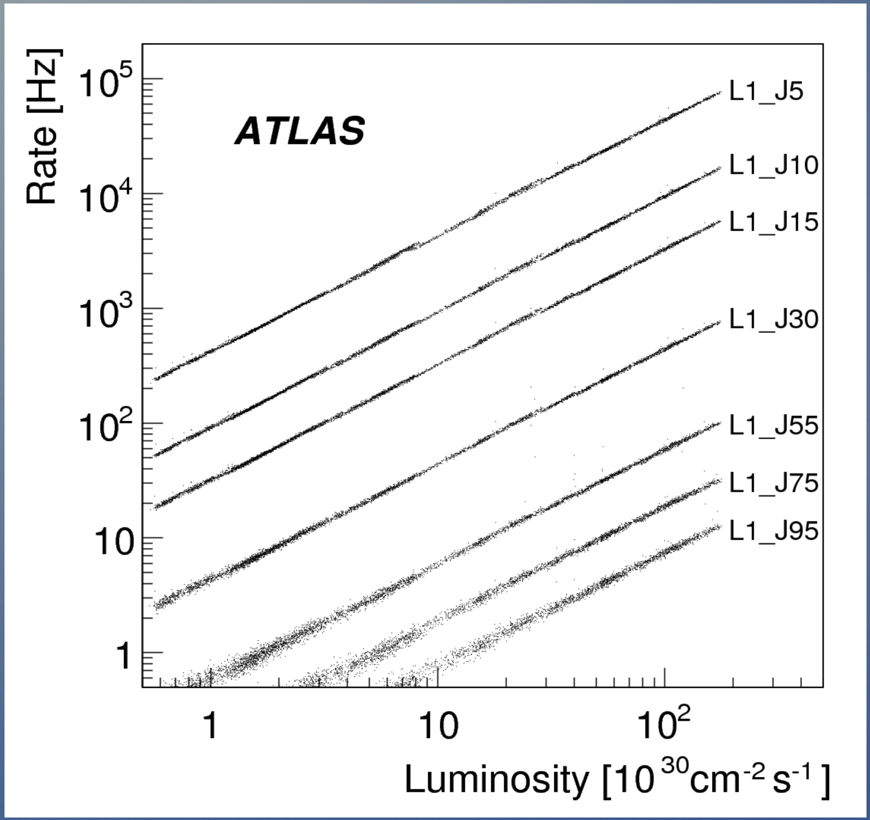
Measured in data using dijet balance and bisector (ATLAS); similar performance between the two detectors

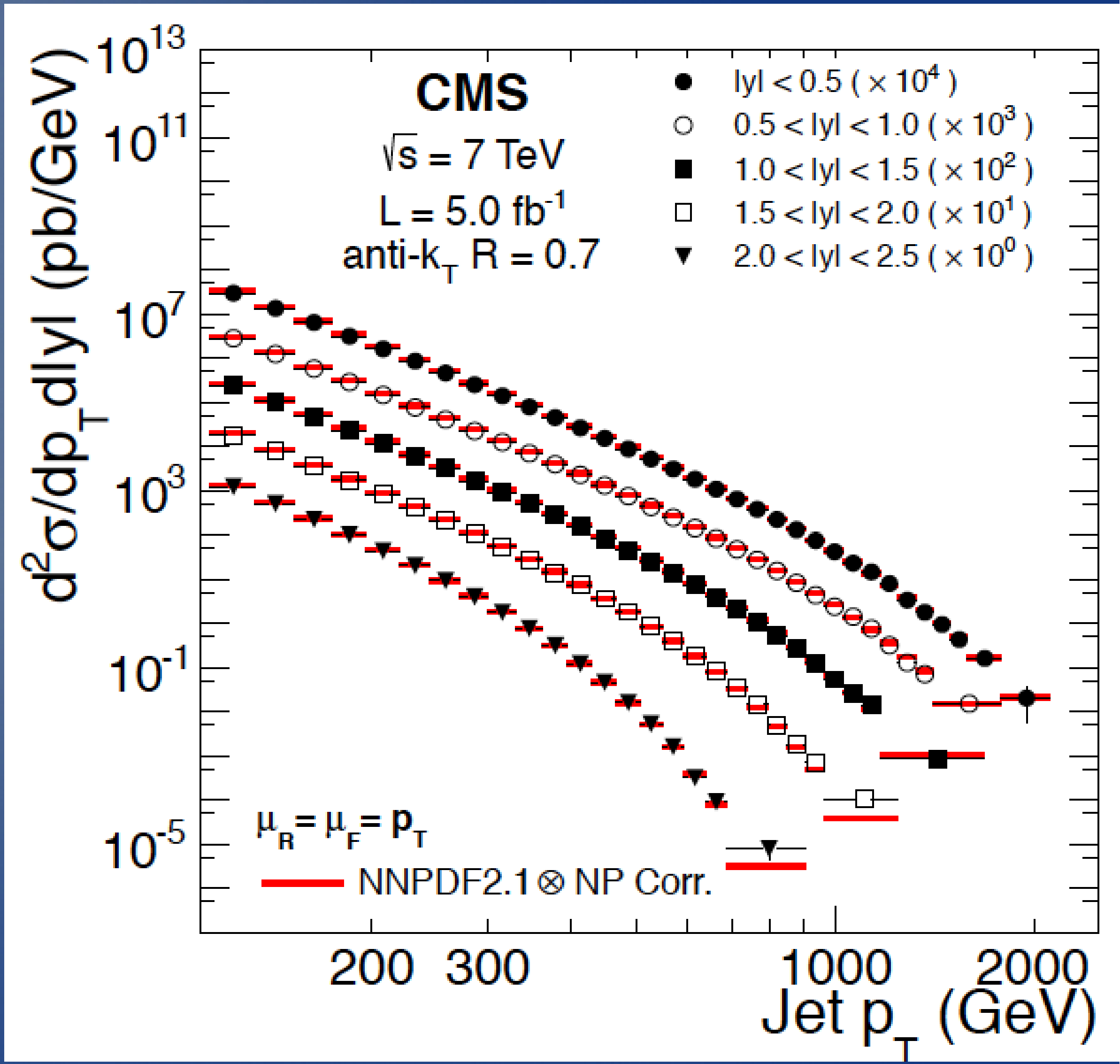



O(10%) resolution for 100 GeV jets

# Inclusive jet cross-section



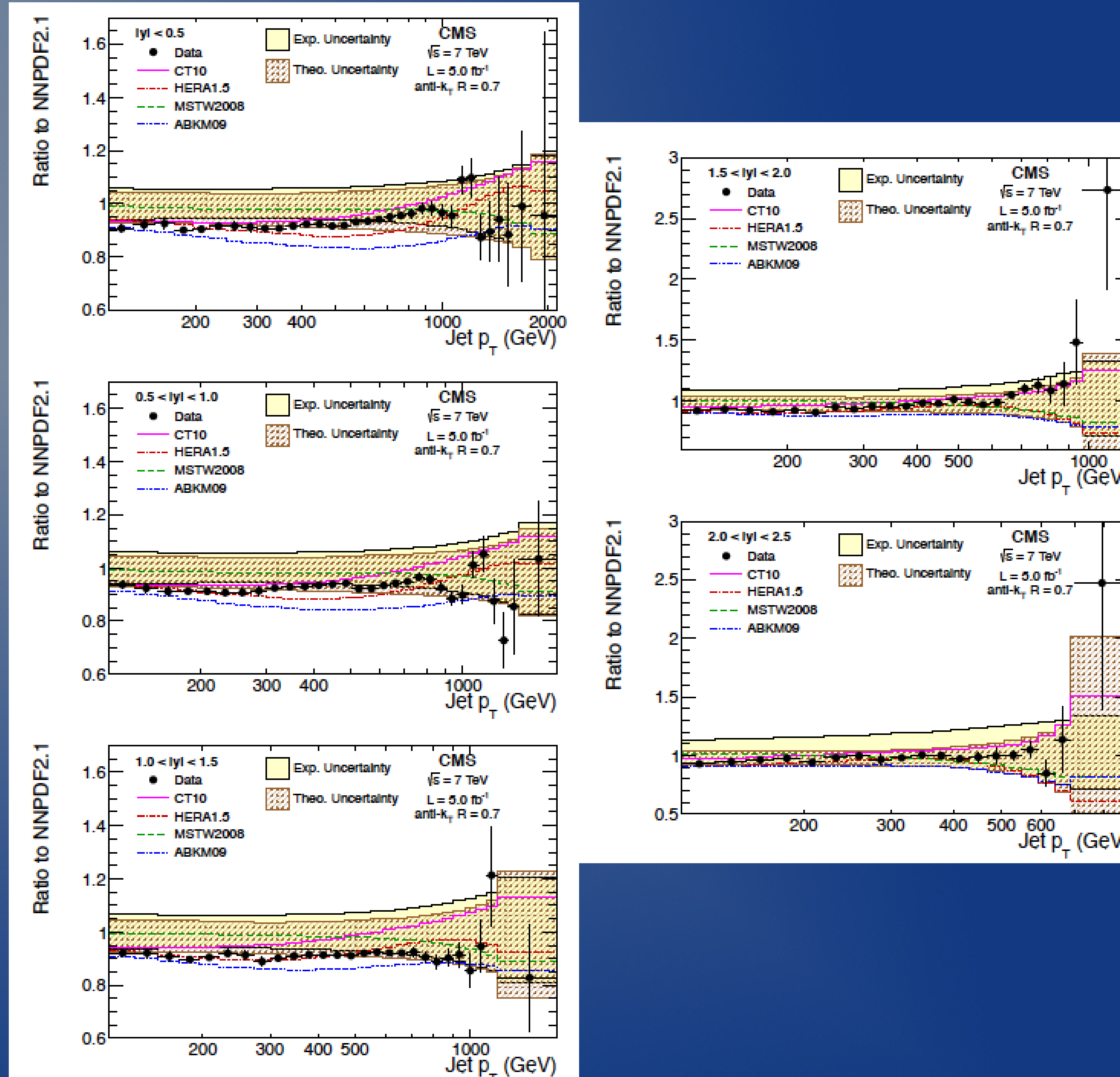

Jet production is the most common process at the LHC, and can be measured over several orders of magnitude.

NLO QCD can be tested over a wide range, and sensitivity to PDF's (derived before LHC data) can be strong

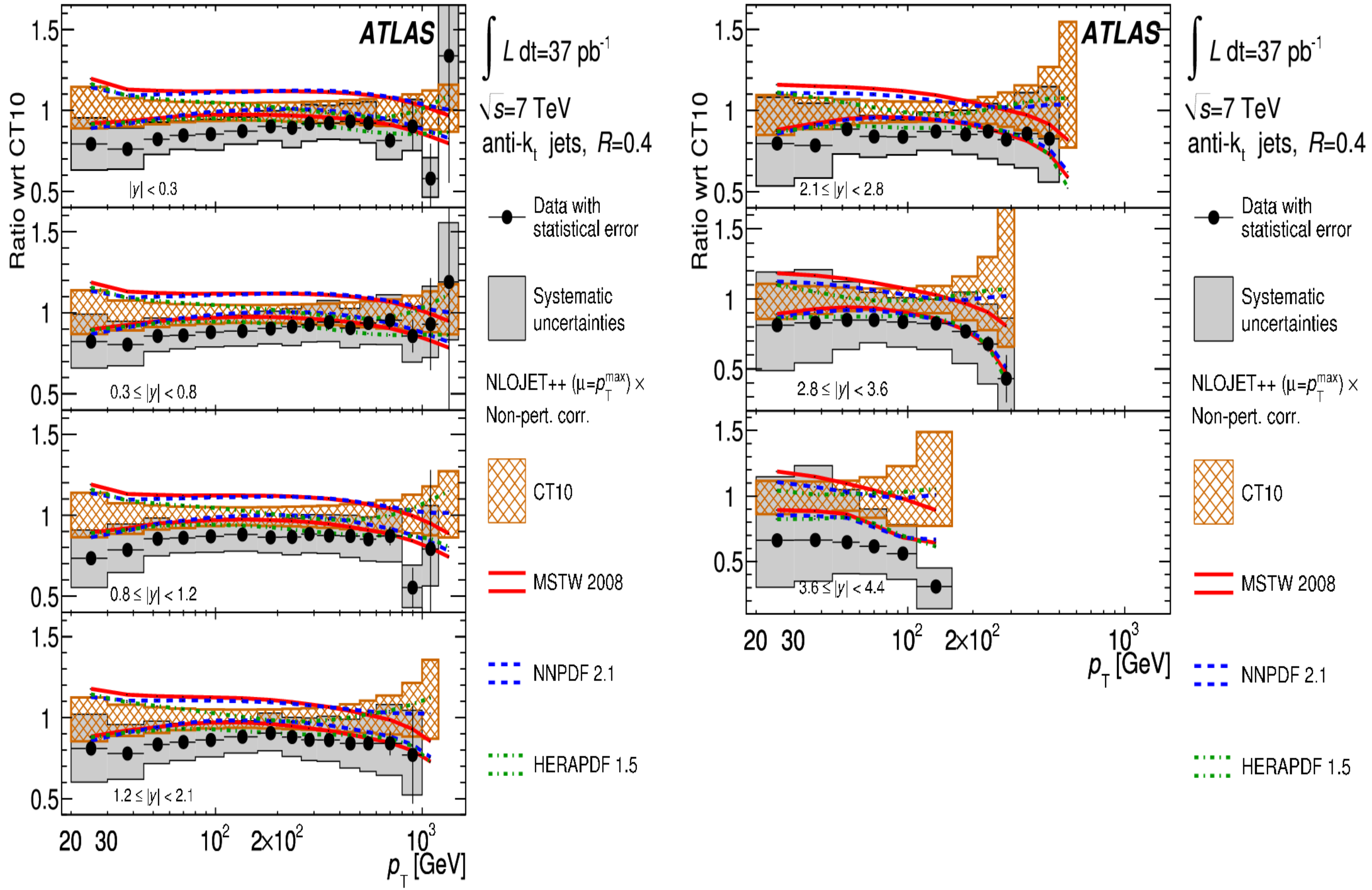
# New CMS result on 2011 data

Up to η<2.5
Agreement with most PDF sets, will publish correlation matrix soon

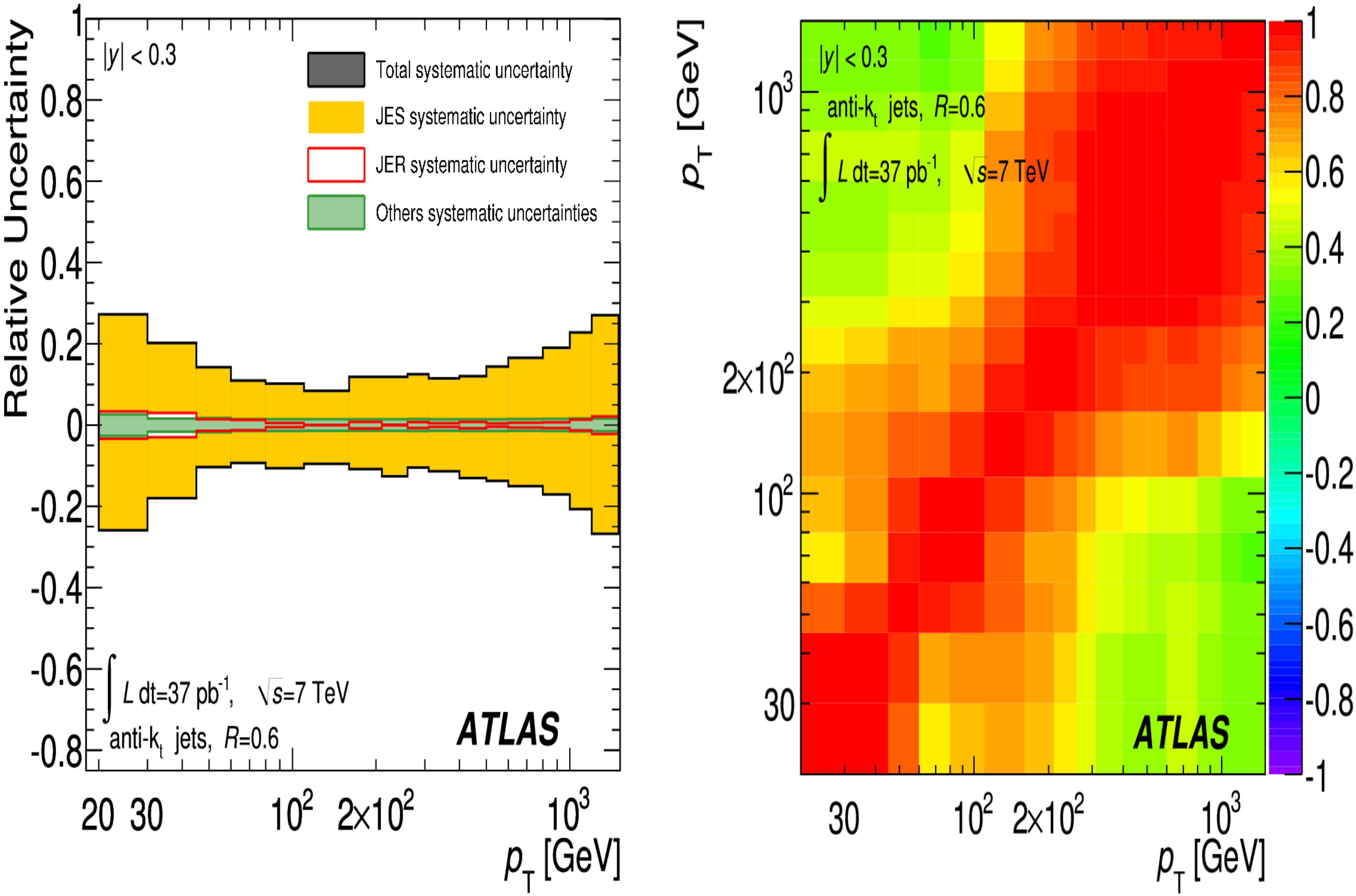
Precision comparable to PDF difference



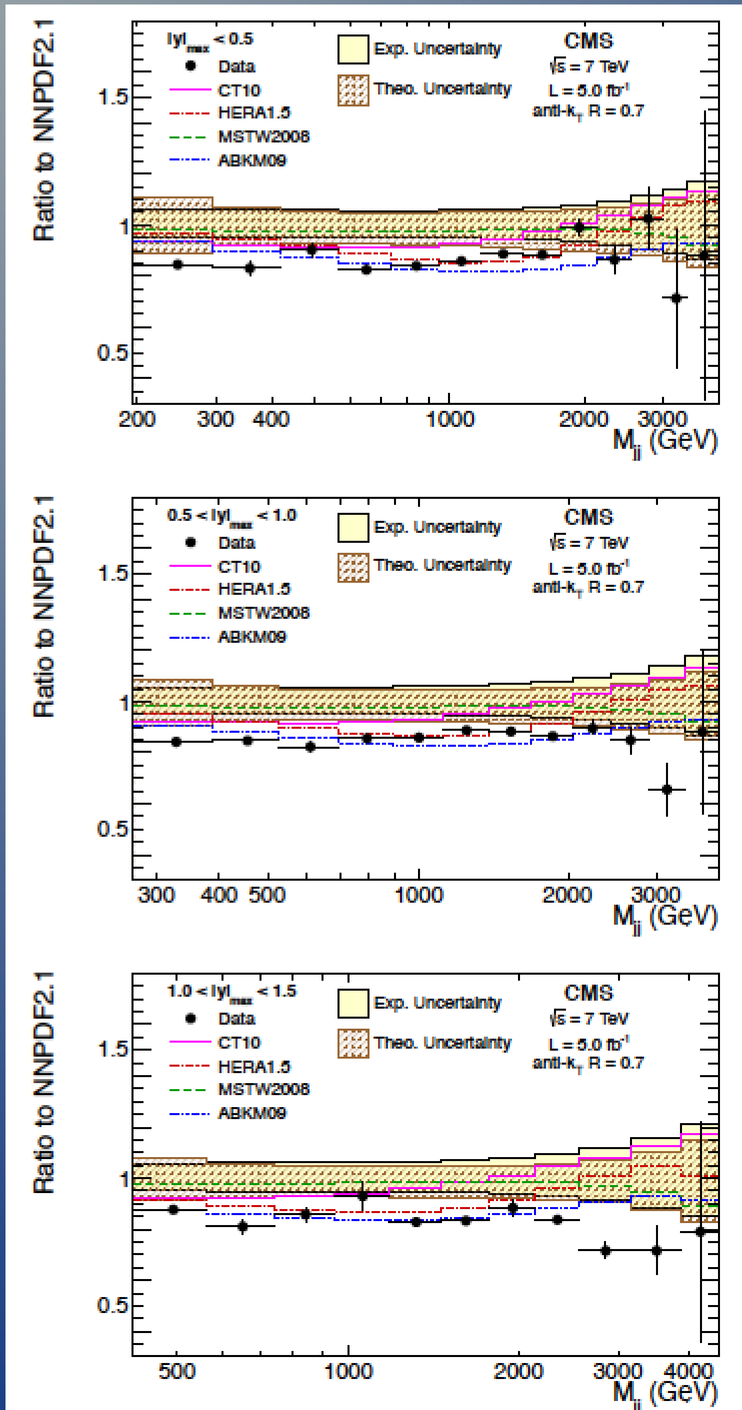
# ATLAS 2010 inclusive result

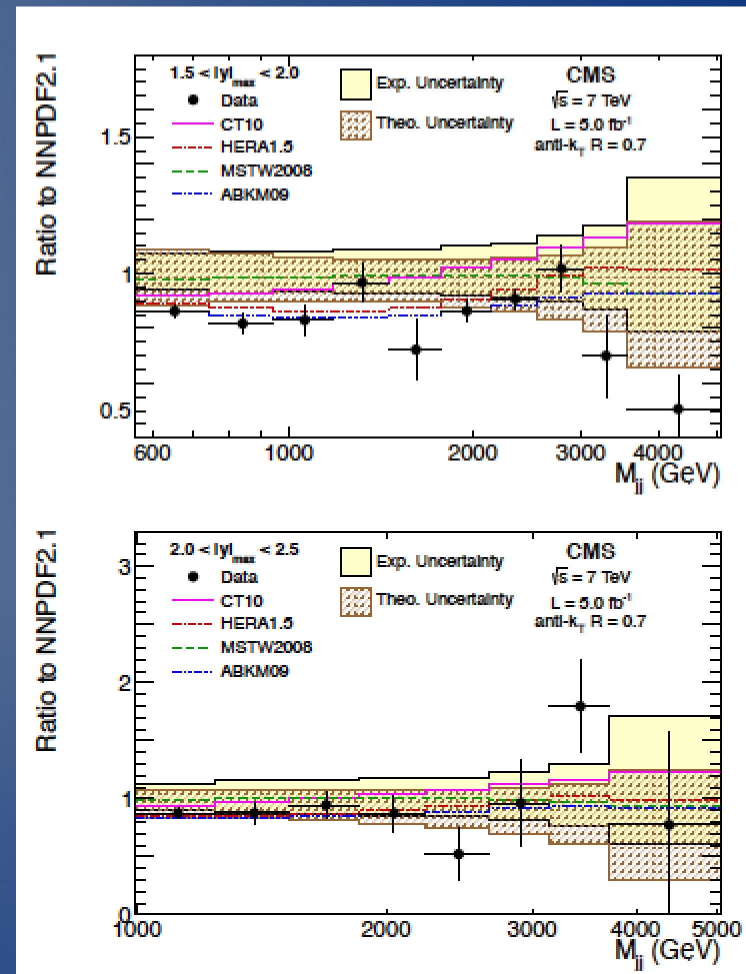


# Systematic uncertainties: magnitude and correlations



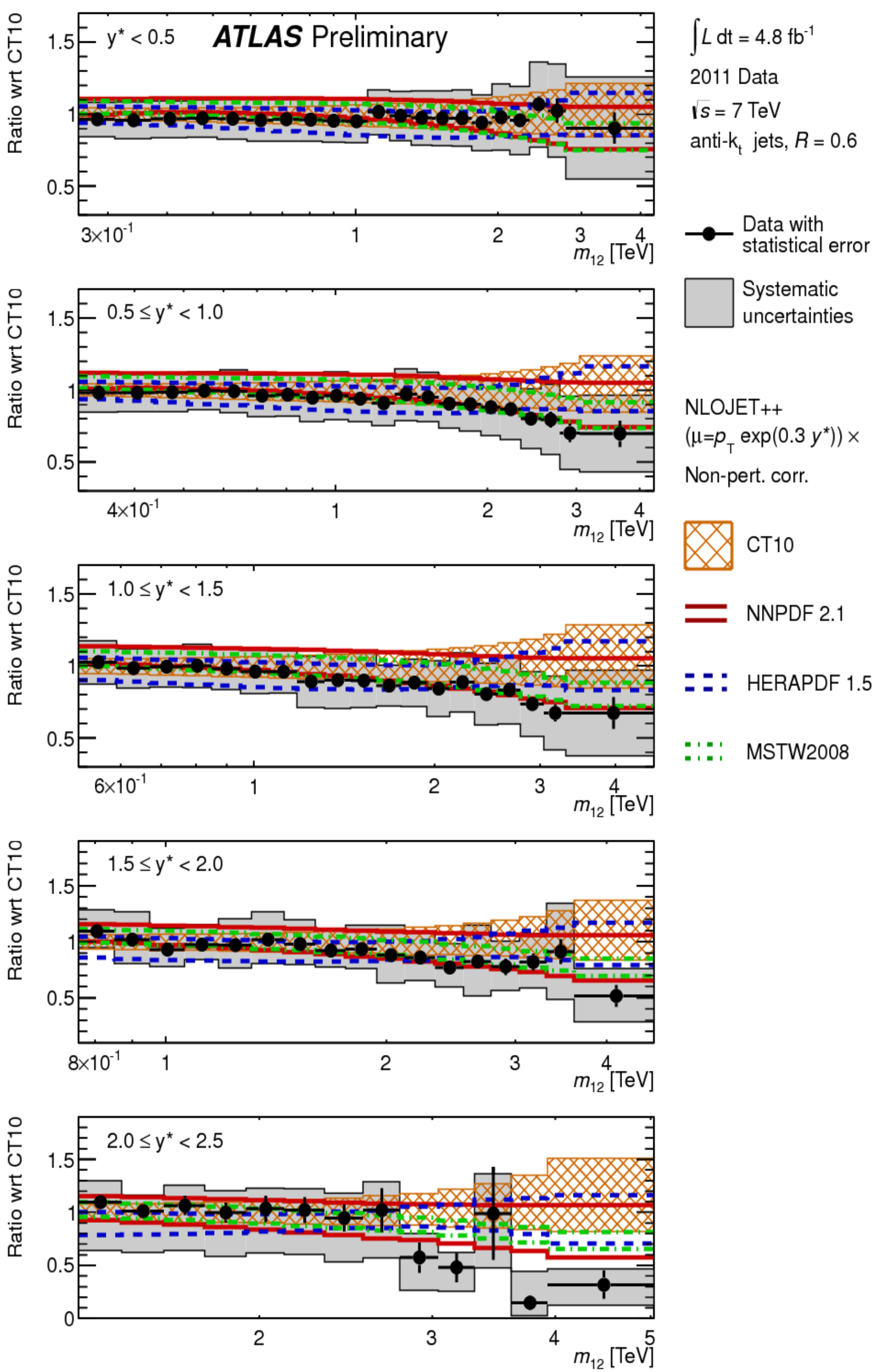
# CMS 2011 dijets

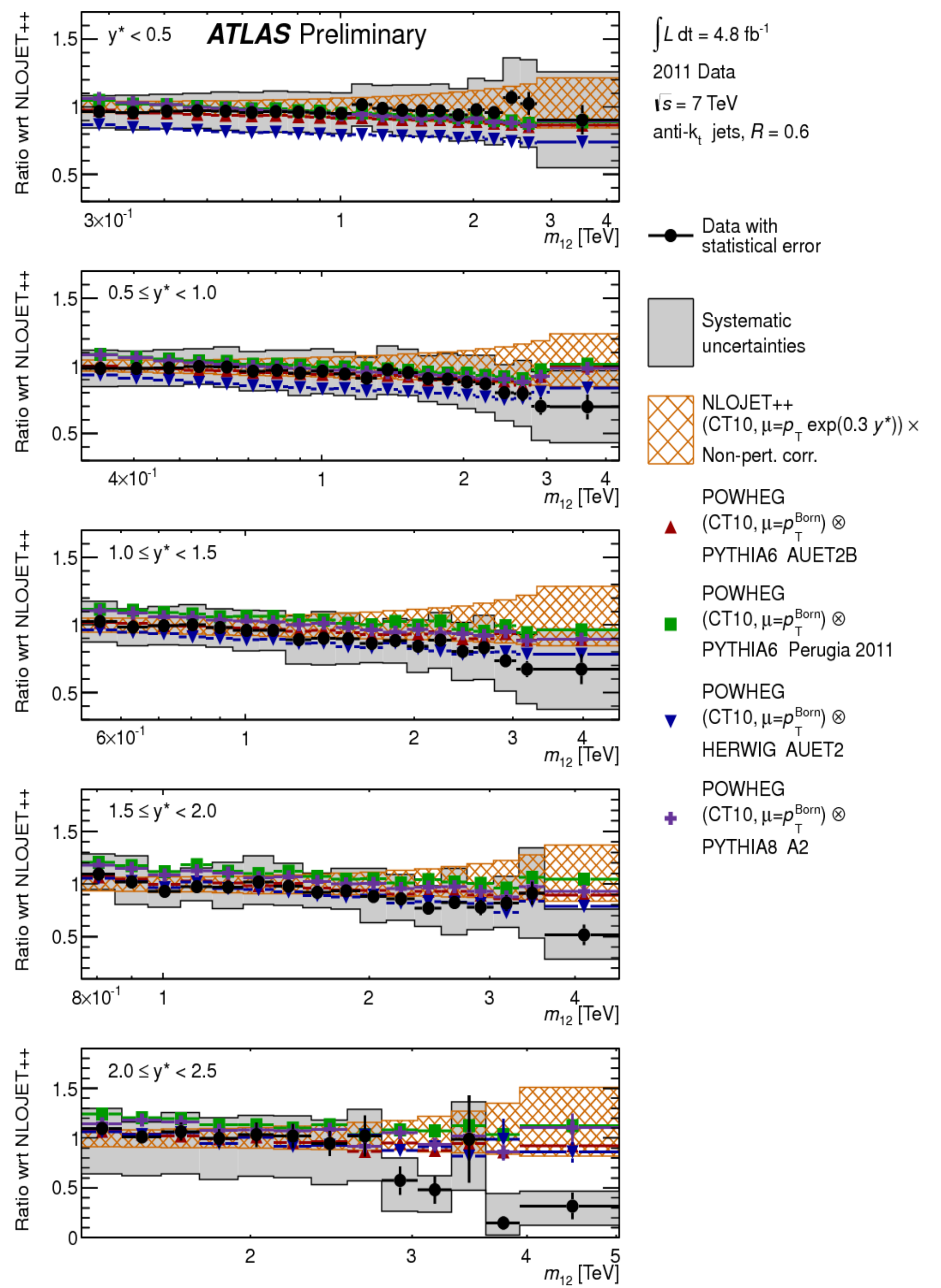


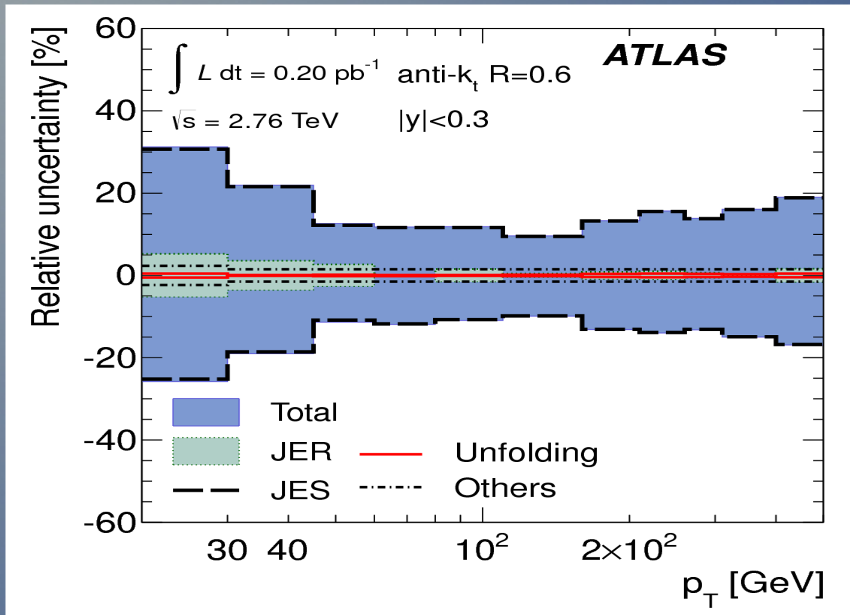

Cross-section in bins of $y_{max}$ ; start to see discrepancies with some PDFs

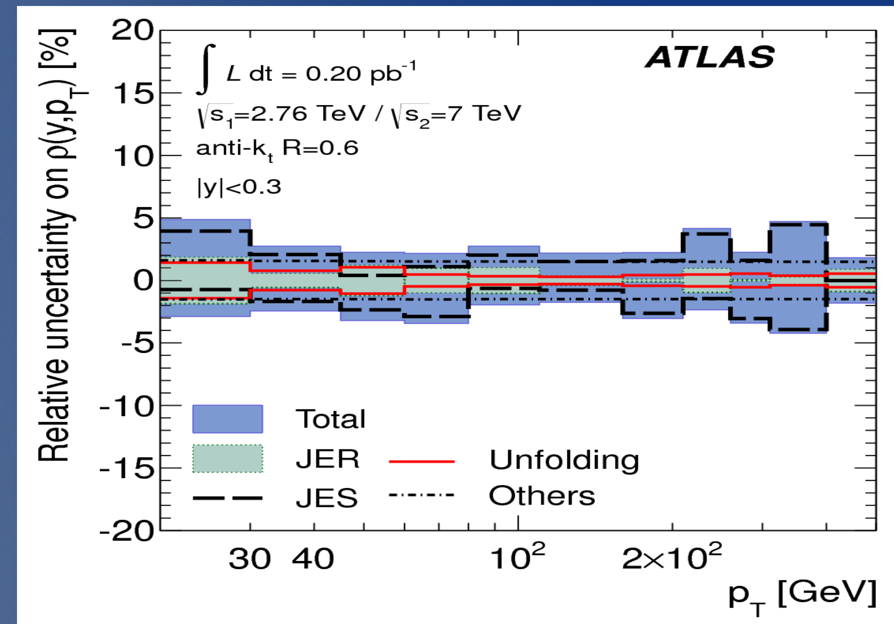
# Atlas 2011dijets: comparisons with PDF's



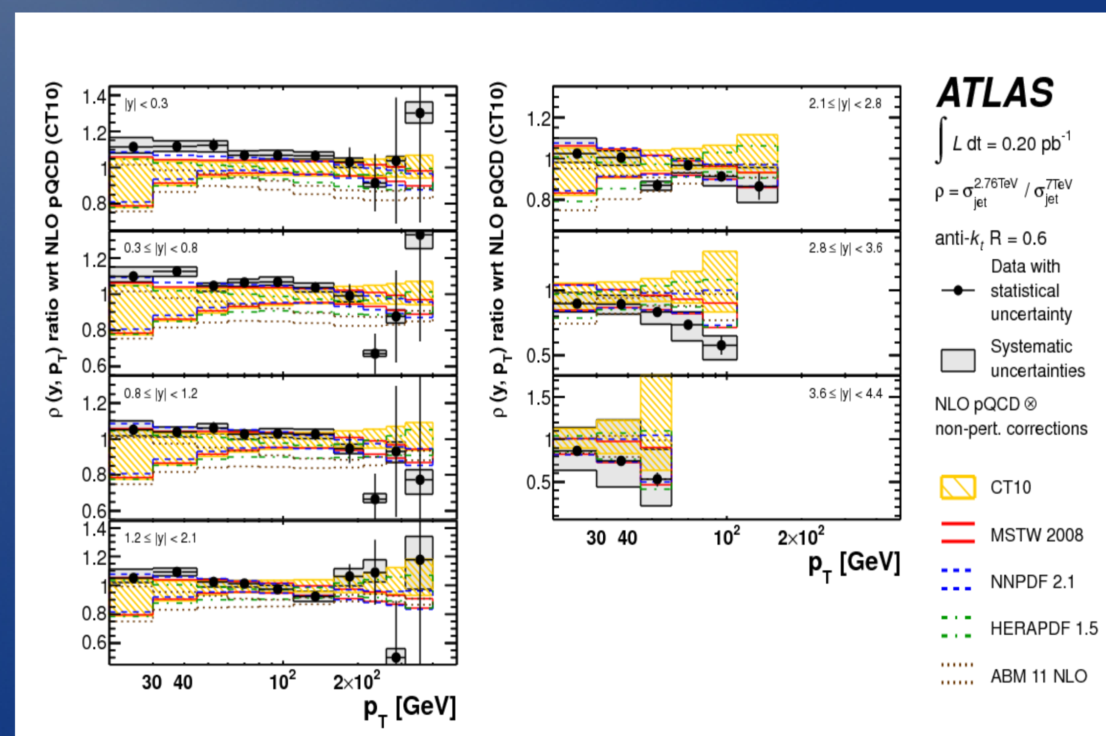



# Ratio between 2.76 and 7 TeV x-sections



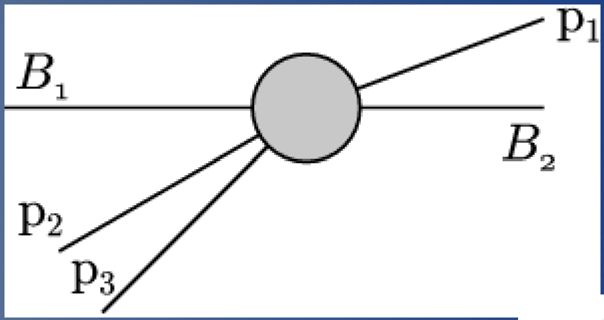



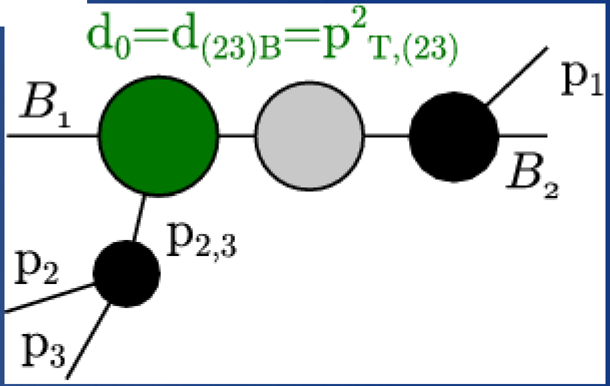

JES is the main systematics of inclusive measurements, limiting their impact on PDF determination. The LHC has delivered small data samples at 2.76 TeV, so a ratio of the inclusive cross-sections between the two CoM cancels most of the JES systematics and gives better constraints to PDF's.

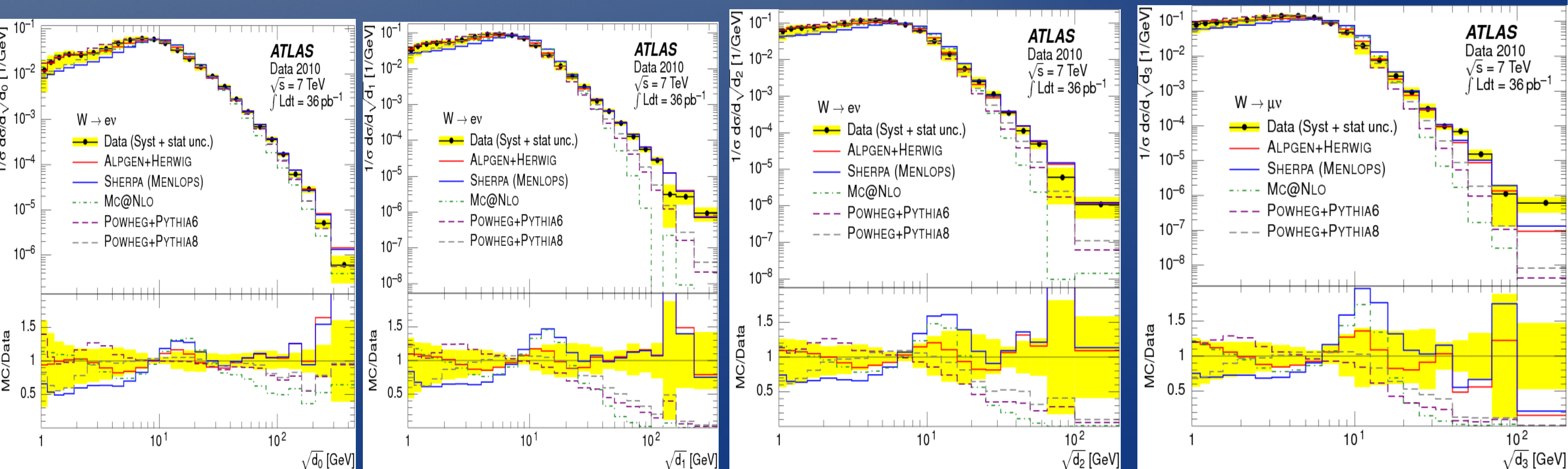


# Probing showering models: Ysplit in kt

Kt splitting scale compared to several models in W->l v + n jets. Multileg generators better at high values of y than pure NLO ones

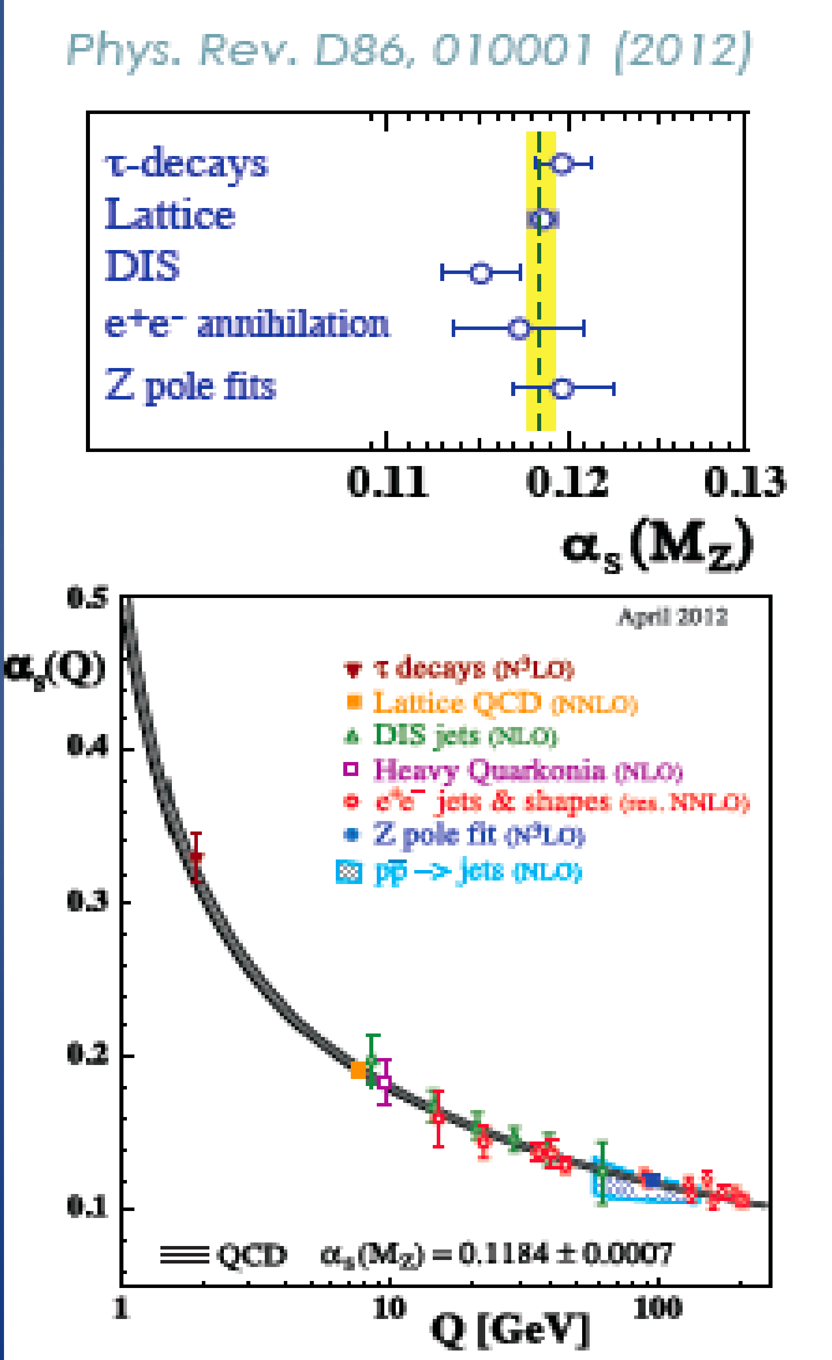


# Measuring $\alpha_s$

Only free parameter of QCD (apart form quark masses)
It affects cross-sections, branching fractions and gluon emission probability, it has been measured at various scales and propagated through the RG equations.
Predicting the correct running of $\alpha_s$ is a very stringent QCD test

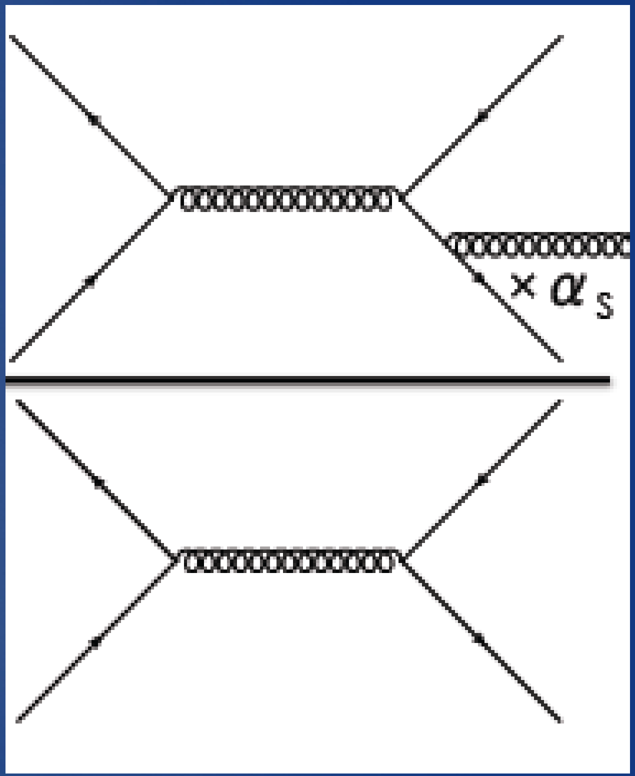


# Variables for $\alpha_s$ measurement

$\alpha_s$ directly influences emission of hard gluons, so rate of events with 3 hard jets. Ratios can reduce uncertainties:

$$R_{3/2}\left(p_T^{\text{lead}}\right) = \frac{d\sigma_{N_{\text{jets}}\geq 3}}{dp_T^{\text{lead}}} \bigg/ \frac{d\sigma_{N_{\text{jets}}\geq 2}}{dp_T^{\text{lead}}}$$

$$N_{3/2}\left(p_T^{\text{all jets}}\right) = \sum_i^{N_{\text{jets}}} \frac{d\sigma_{N_{\text{jets}}\geq 3}}{dp_{T,i}} \bigg/ \sum_i^{N_{\text{jets}}} \frac{d\sigma_{N_{\text{jets}}\geq 2}}{dp_{T,i}}$$

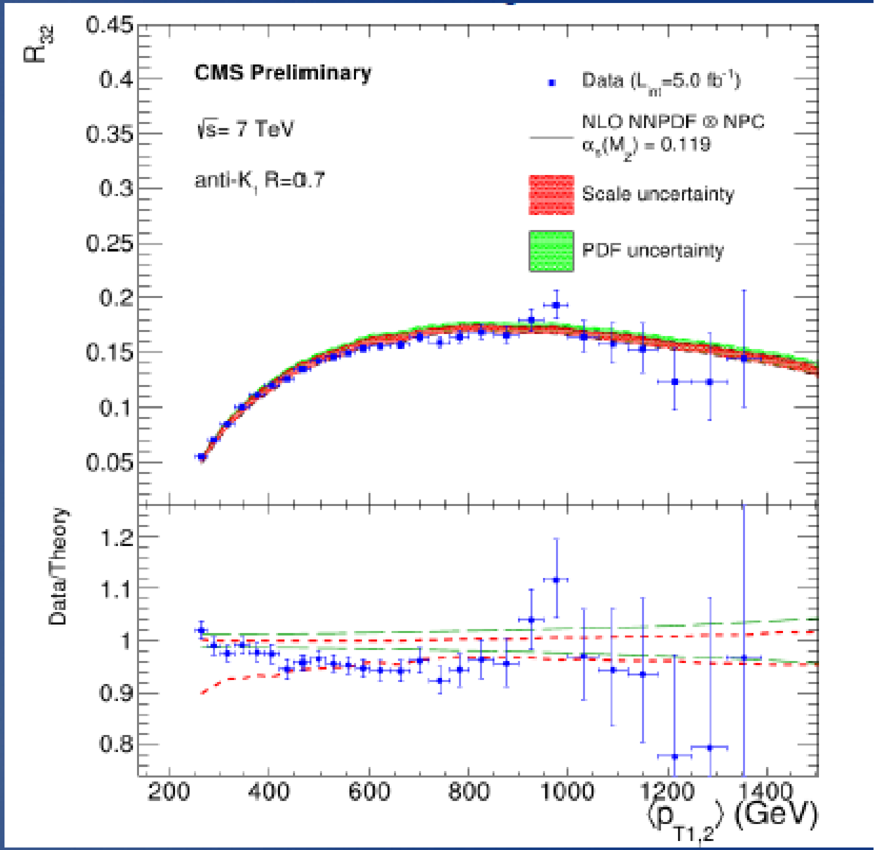


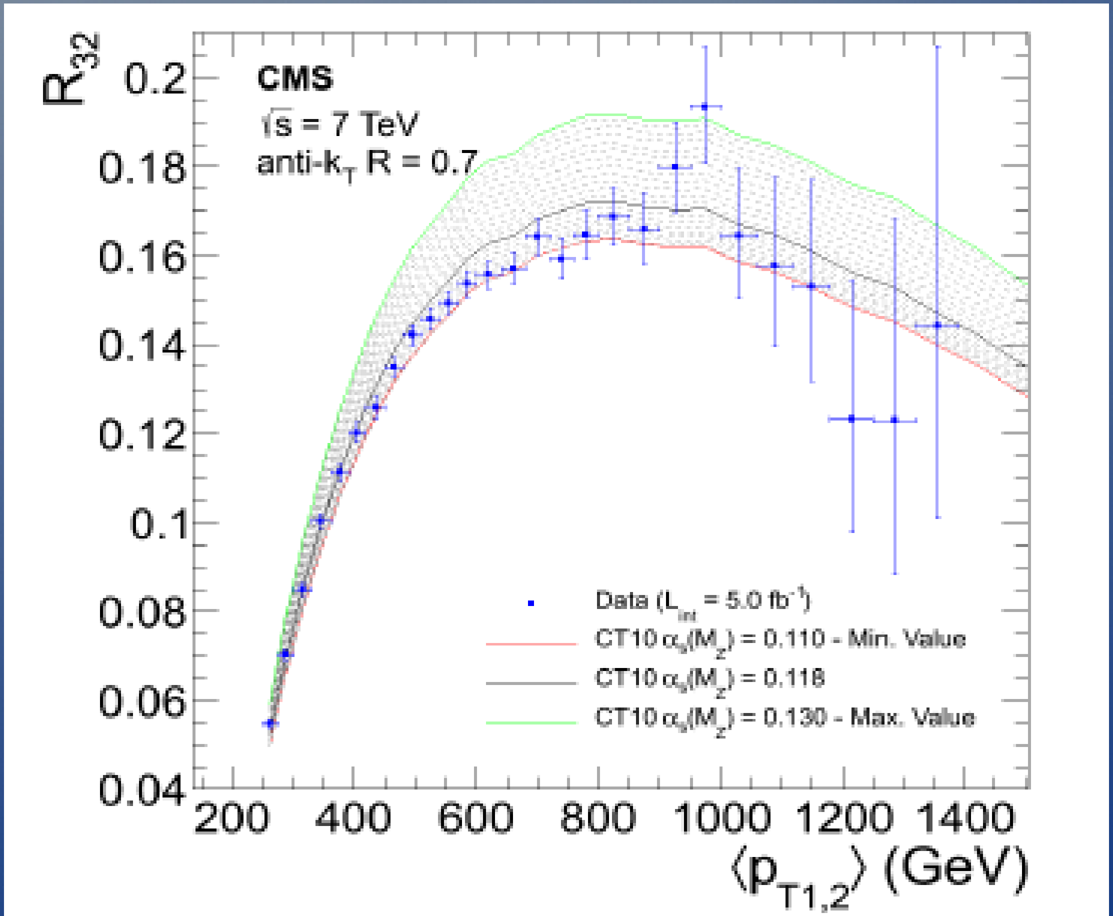
# $R_{32}$ from CMS (2011 data)

As a function of average Pt(1,2)

$p_T$ > 150 GeV, |y|<2.5

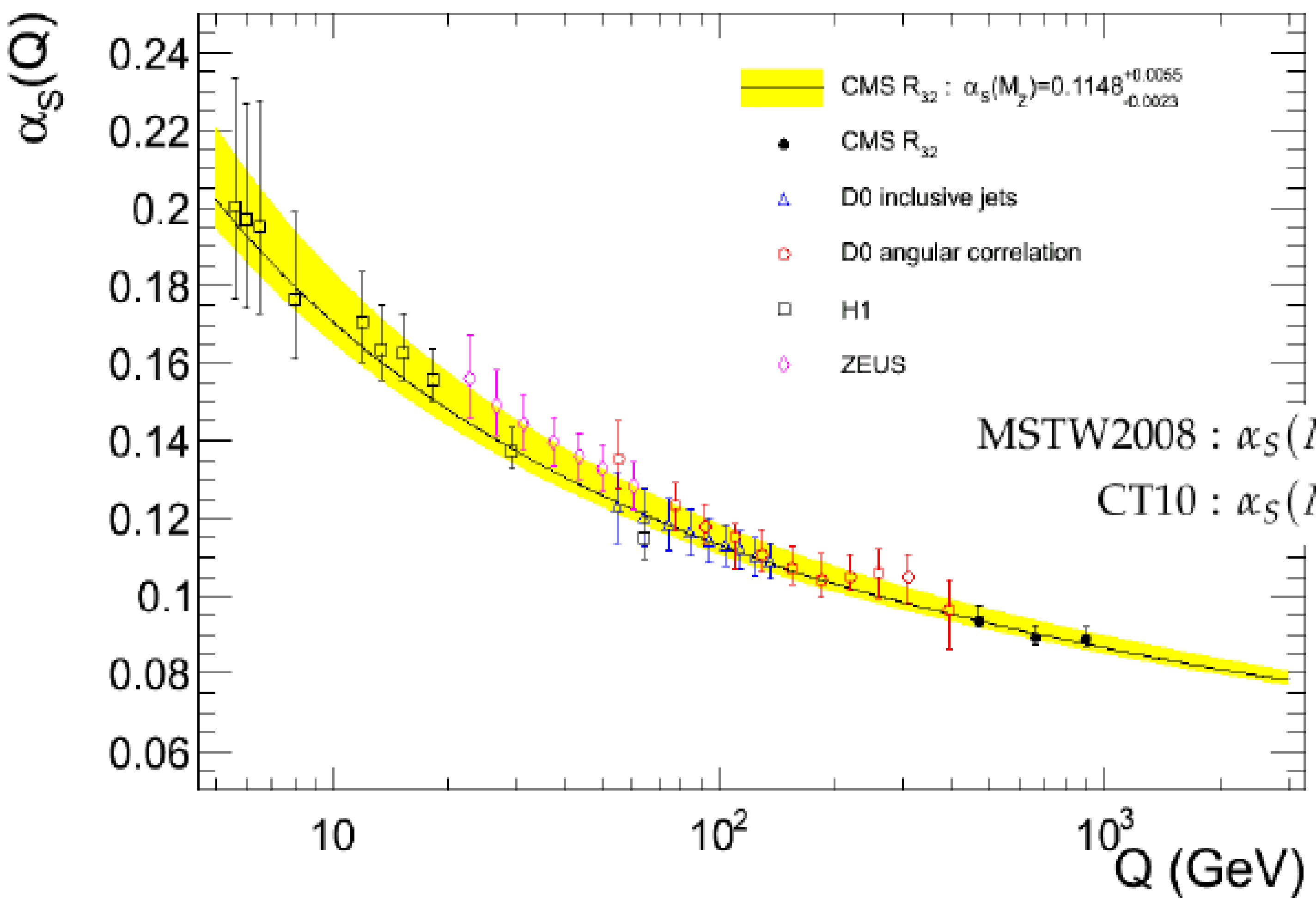
CMS-QCD-11-003




Compared to NLOJet++ interfaced to PDF's with different values of α.

# $\alpha_s$ from $R_{32}$ in CMS



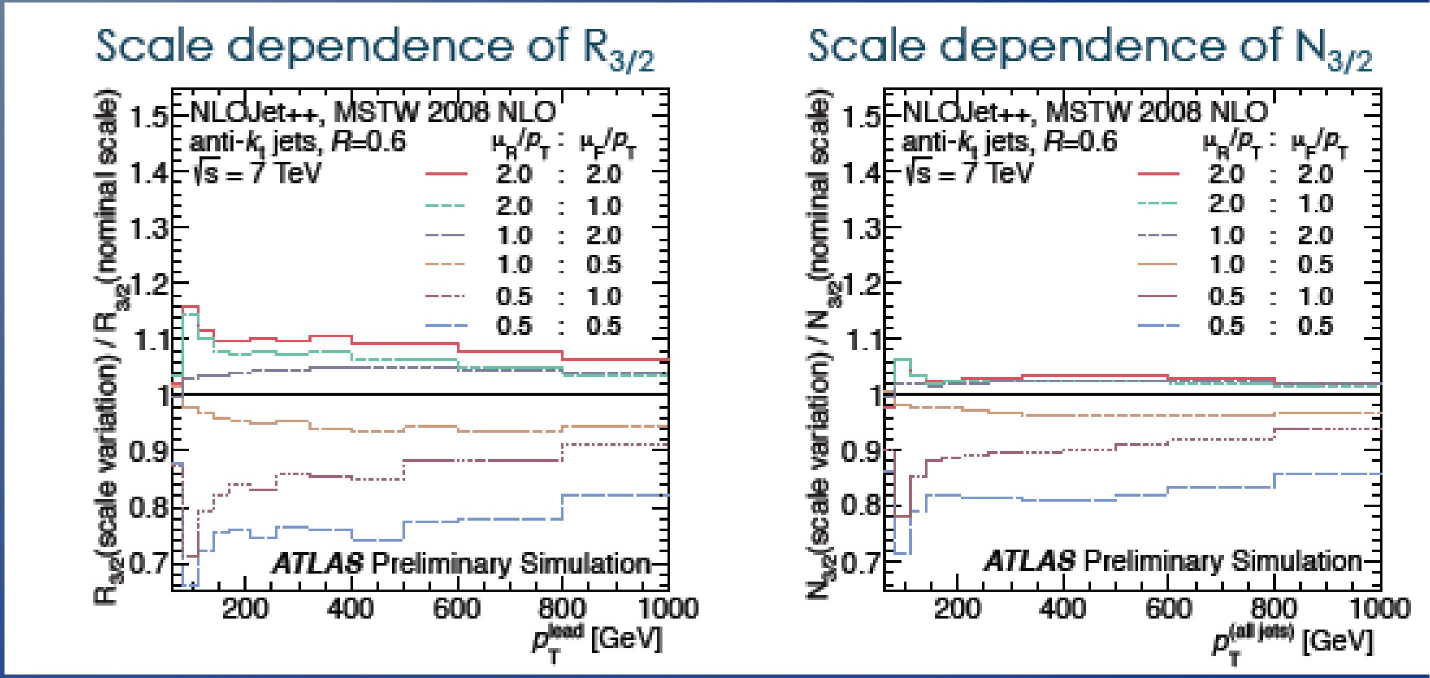

$$\text{MSTW2008}: \alpha_S(M_Z) = 0.1135 \pm 0.0096(exp.)$$

$$\text{CT10}: \alpha_S(M_Z) = 0.1130 \pm 0.0080(exp.)$$

$$\alpha_s^{NNPDF}(MZ) = 0.1148 \pm 0.0014\ (\text{exp.}) \pm 0.0018\ (\text{PDF})\ ^{+0.0050}_{-0.0000}\ (\text{scale})$$

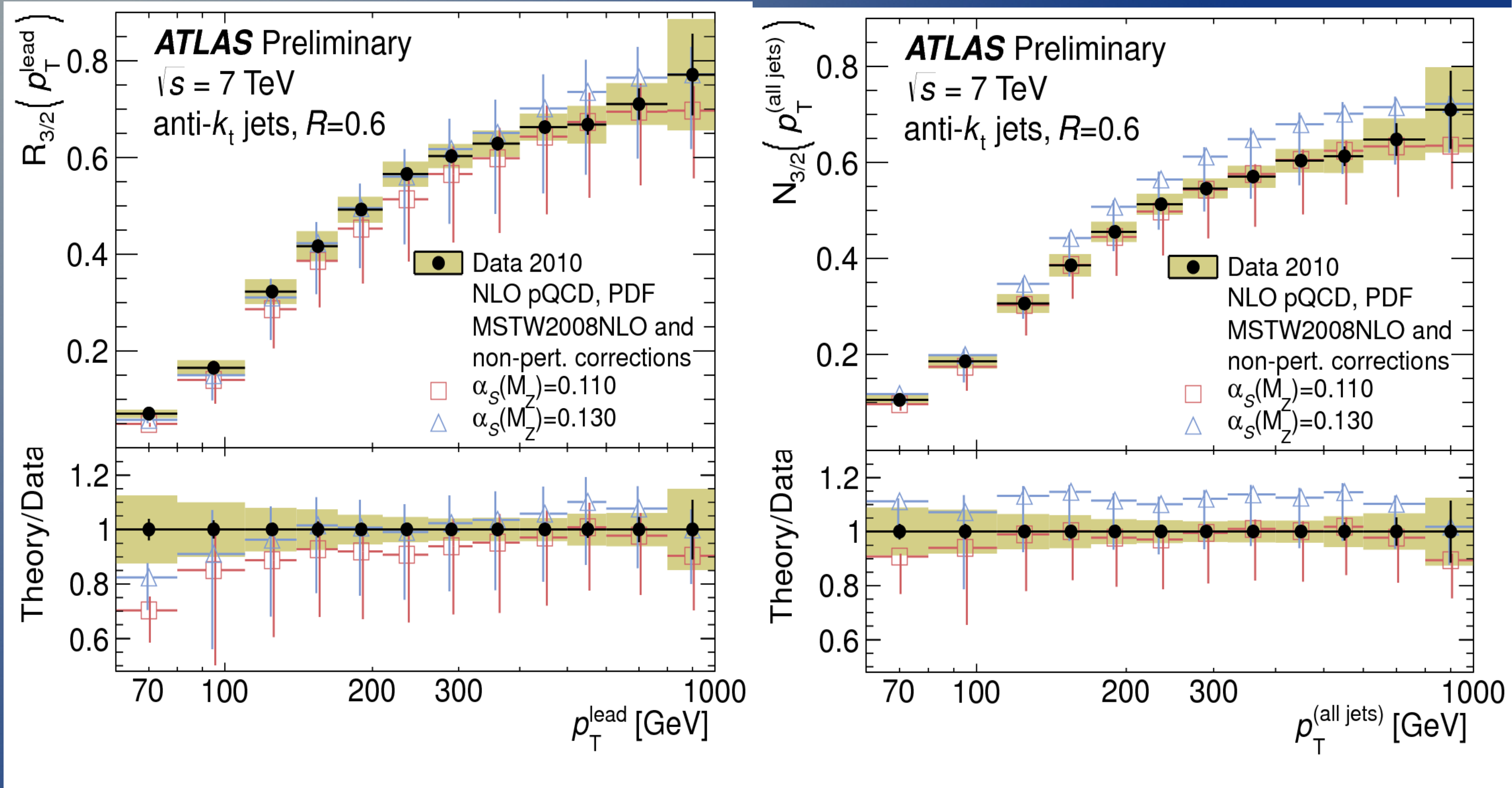
# Choice of variable for the ATLAS measurement

ATLAS studied the scale dependance of the two variables : for R the scales are leading jet $p_T$, for N are the $p_T$ of each jet




$N_{3/2}$ was found out to be more stable against scale variations, and was used in the measurement

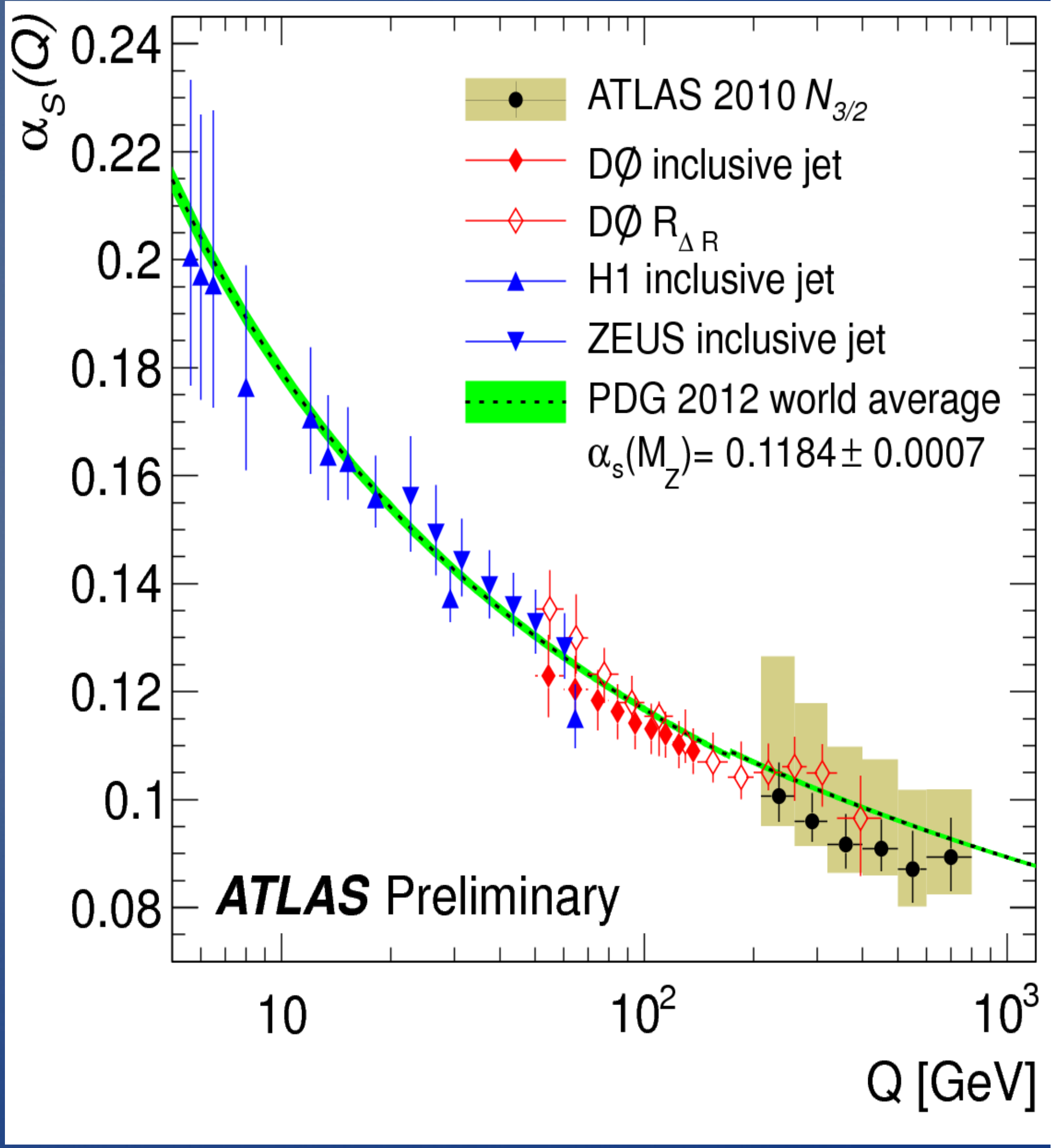
# ATLAS result on 2010 data




Theory errors include scale, PDF and non-perturbative corrections

# ATLAS $\alpha_s$ extraction

$\alpha_s$ is extracted from a $X^2$ fit to the NLOJet++ predictions with NP corrections. Correlations between systematics included as nuisance parameters; theoretical uncertainties considered as offsets. Final result, propagated to $M_Z$:




$$\alpha_S(M_Z) = 0.111 \pm 0.006(\text{exp.})^{+0.016}_{-0.003}(\text{theory})$$

# Conclusions

- Could only rapidly flash some results, full list growing every day in
https://twiki.cern.ch/twiki/bin/view/AtlasPublic
http://cms.web.cern.ch/org/cms-papers-and-results
- QCD is now a precision domain, and it is important to perform proper unfolding of the data to particle level, and publish all uncertainties and their correlations
- Higher precision and the more sophisticated statistical analysis of the next measurements will challenge even more the spectacular agreement with predictions observed so far

# ATLAS 2010 result: Powheg