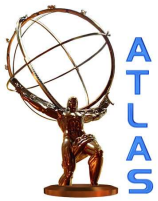


Inclusive jet cross section in ATLAS

(on behalf of the ATLAS collaboration)

Pavel Starovoitov

CERN

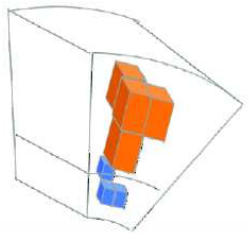
11-04-2011

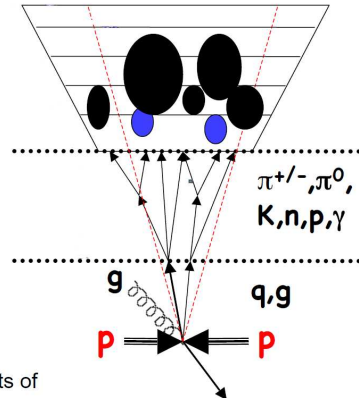
The researcher is supported by Marie Curie Incoming International Fellowship of the European Commission's 7th Framework Program under contract number PIIF-GA-2009-236320

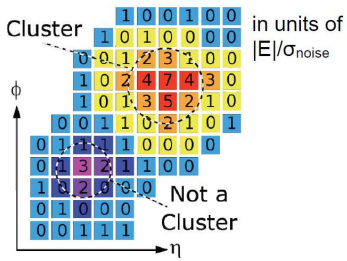
Outline

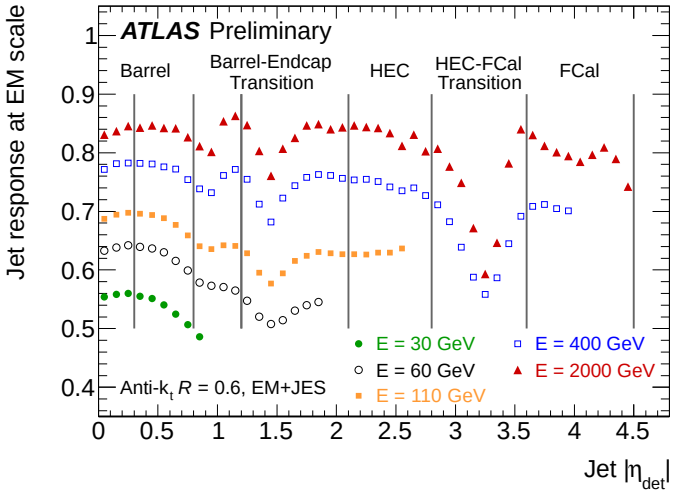
Jet reconstruction

- particles deposit their energy in calorimeter cells
- cells $\xrightarrow{Alg}$ 3D topoclusters
- 3D topoclusters $\xrightarrow{anti-k_t}$ jets

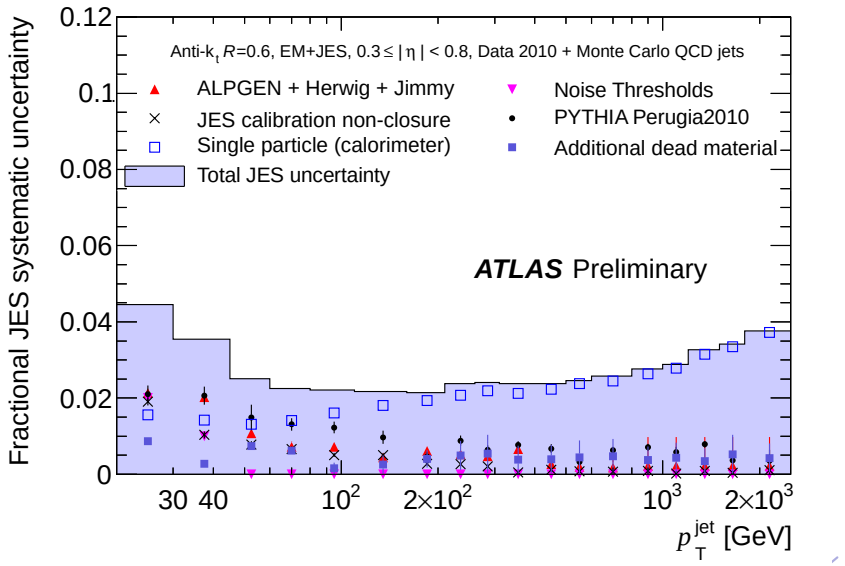




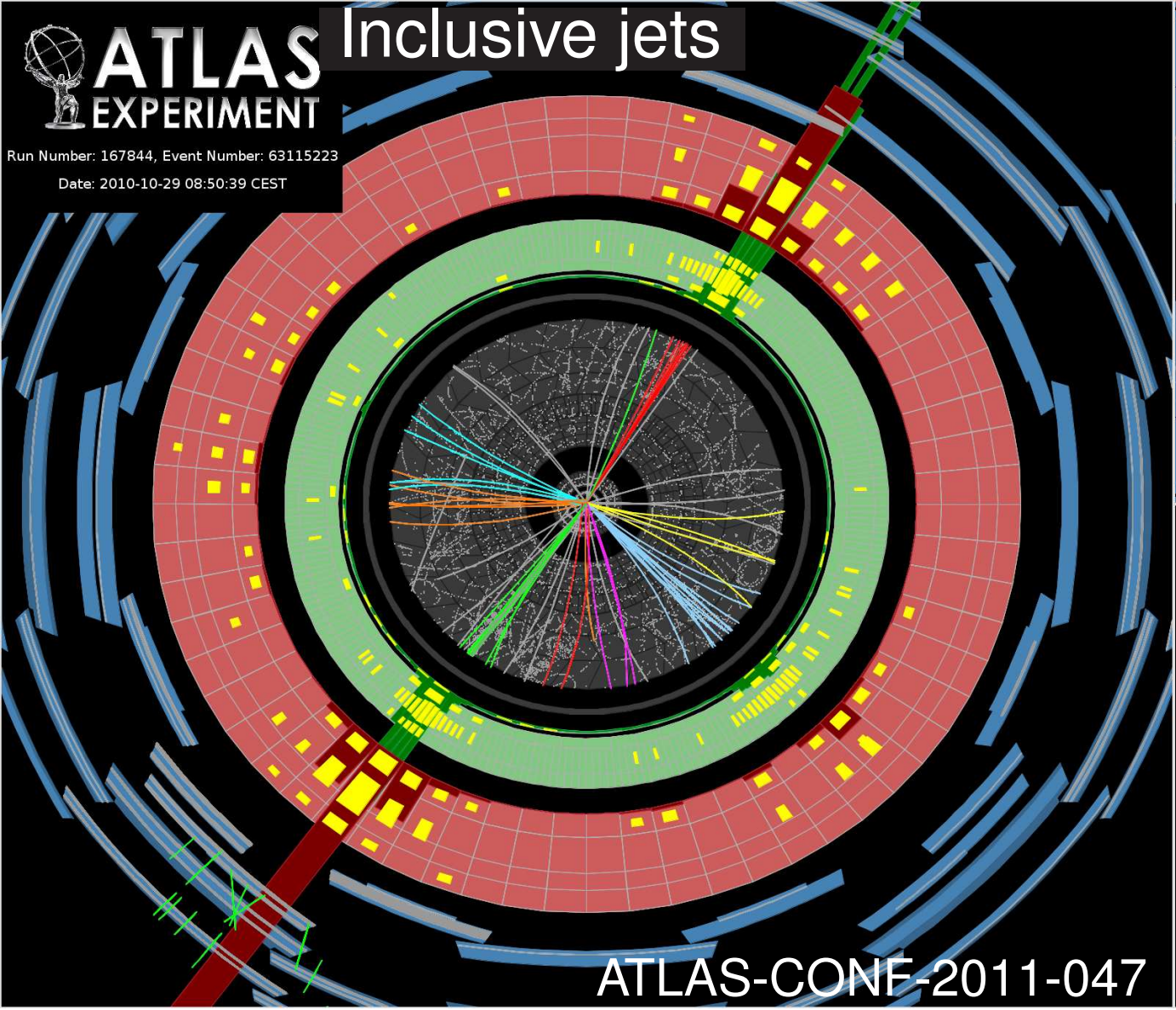


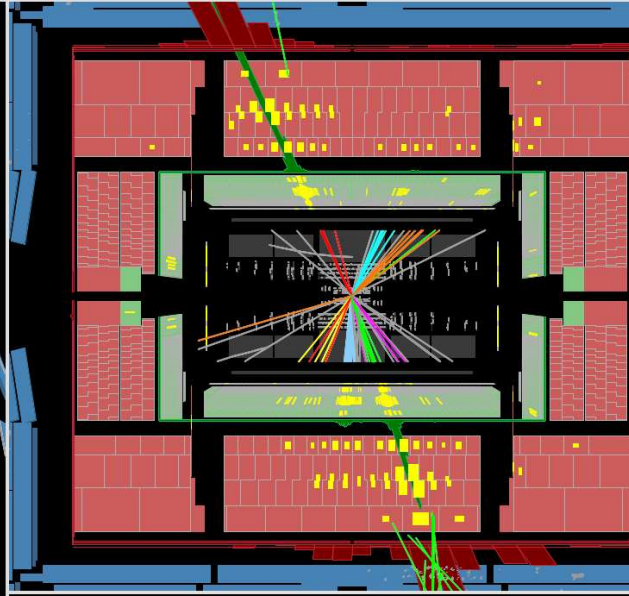


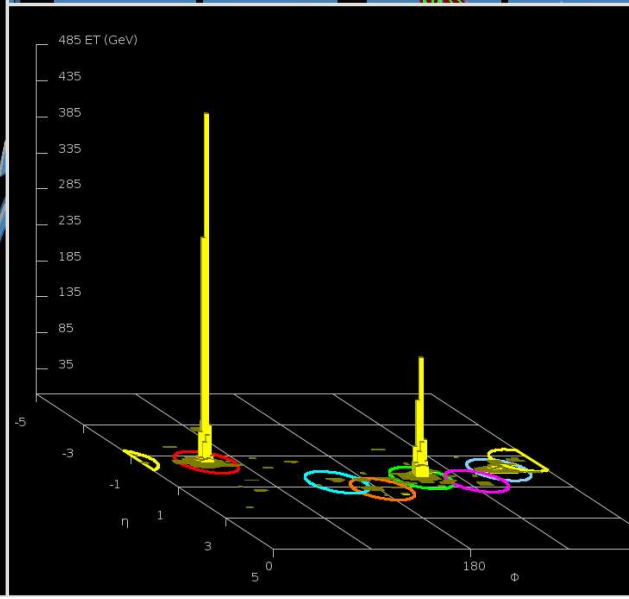
- EM+JES calibration restores response
- JES uncertainty :
  - single hadron response
  - η-intercalibration



Inclusive jets

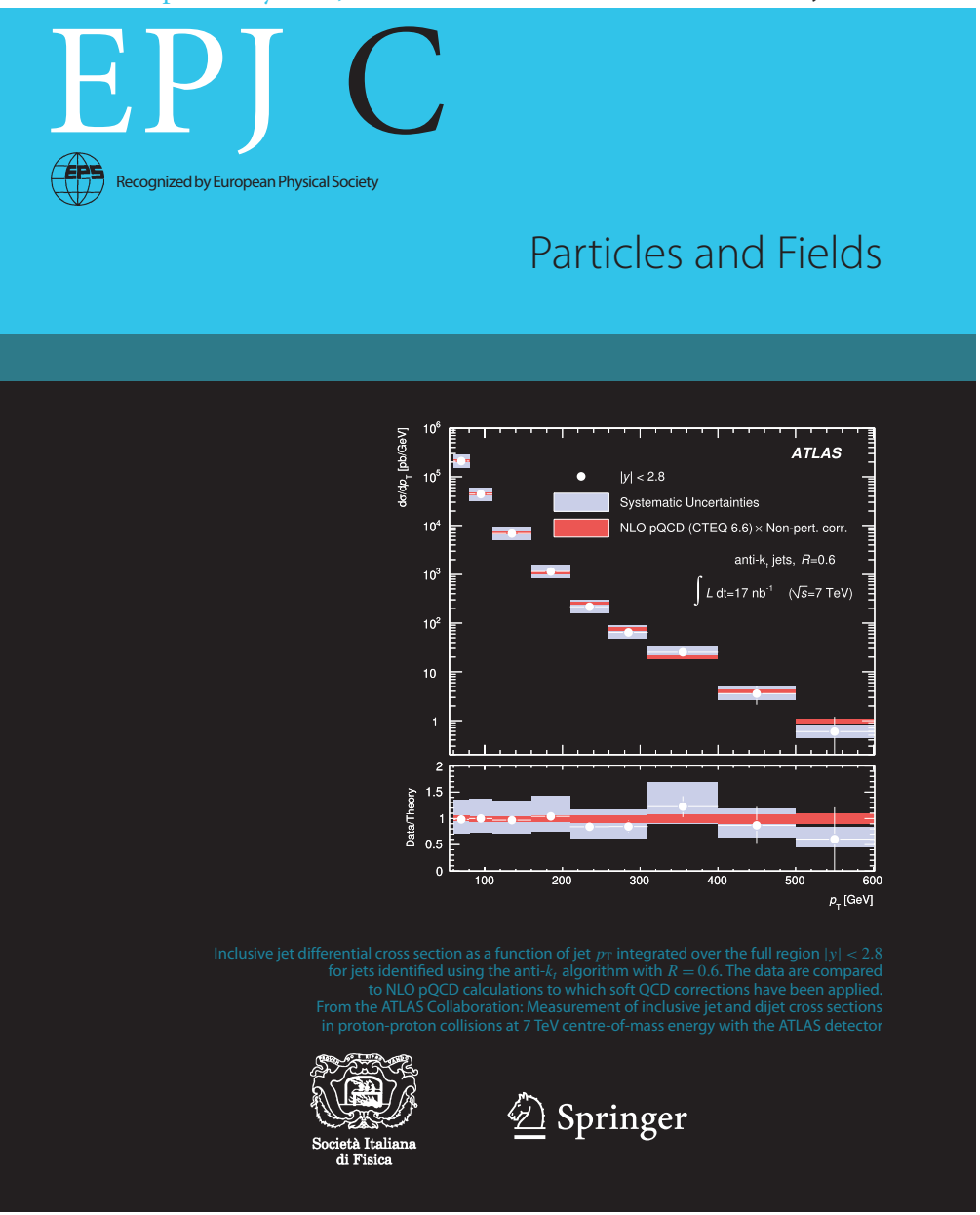






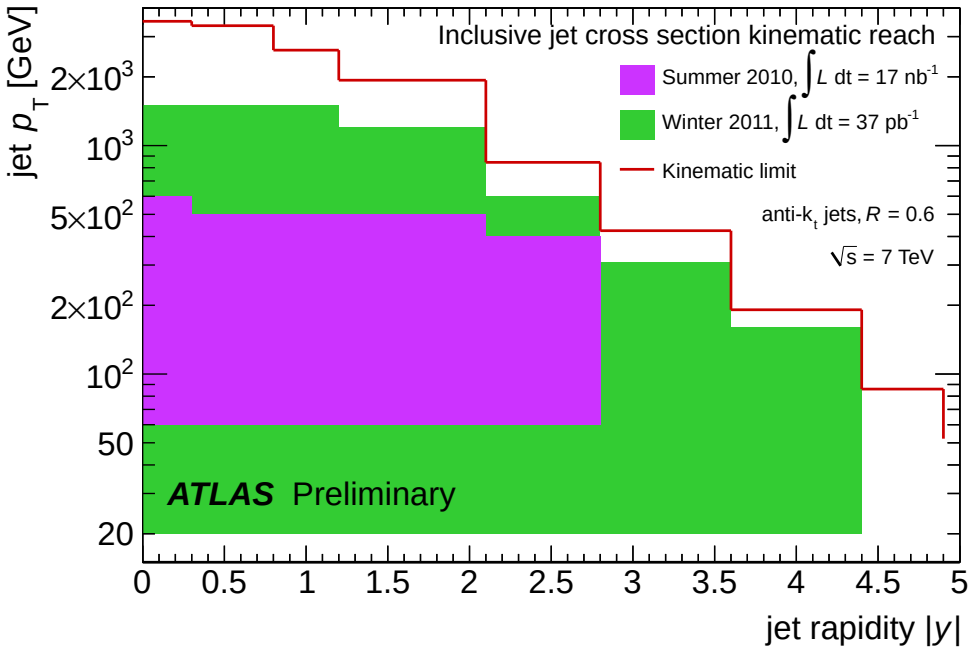
The two leading jets are central high-p_{T} jets with an invariant mass of 2.8 TeV. They have (p_{T}, y) of (1.5 TeV, -0.58) and (1.0 TeV, 0.44), respectively. The $E_{\mathrm{T}}^{\mathrm{miss}}$ in the event is 310 GeV.

Inclusive jets. Introduction

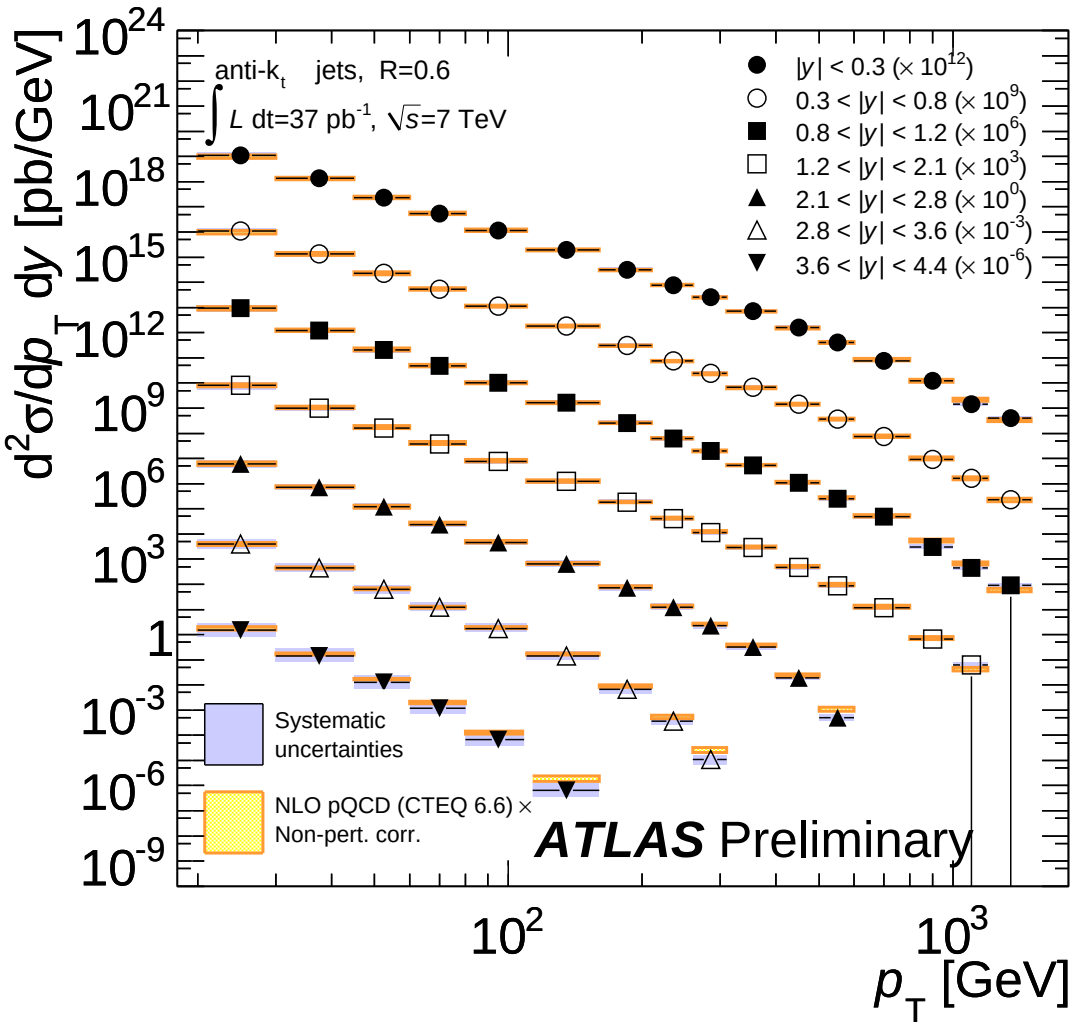


Update since Summer 2010

- $p_T > 60$ GeV$\rightarrow$ $p_T > 20$ GeV
- $|y| < 2.8 \rightarrow |y| < 4.4$
- $\mathcal{L} = 17$ nb^{-1} $\rightarrow$ $\mathcal{L} = 37$ pb^{-1}
- new (small) JES uncertainty



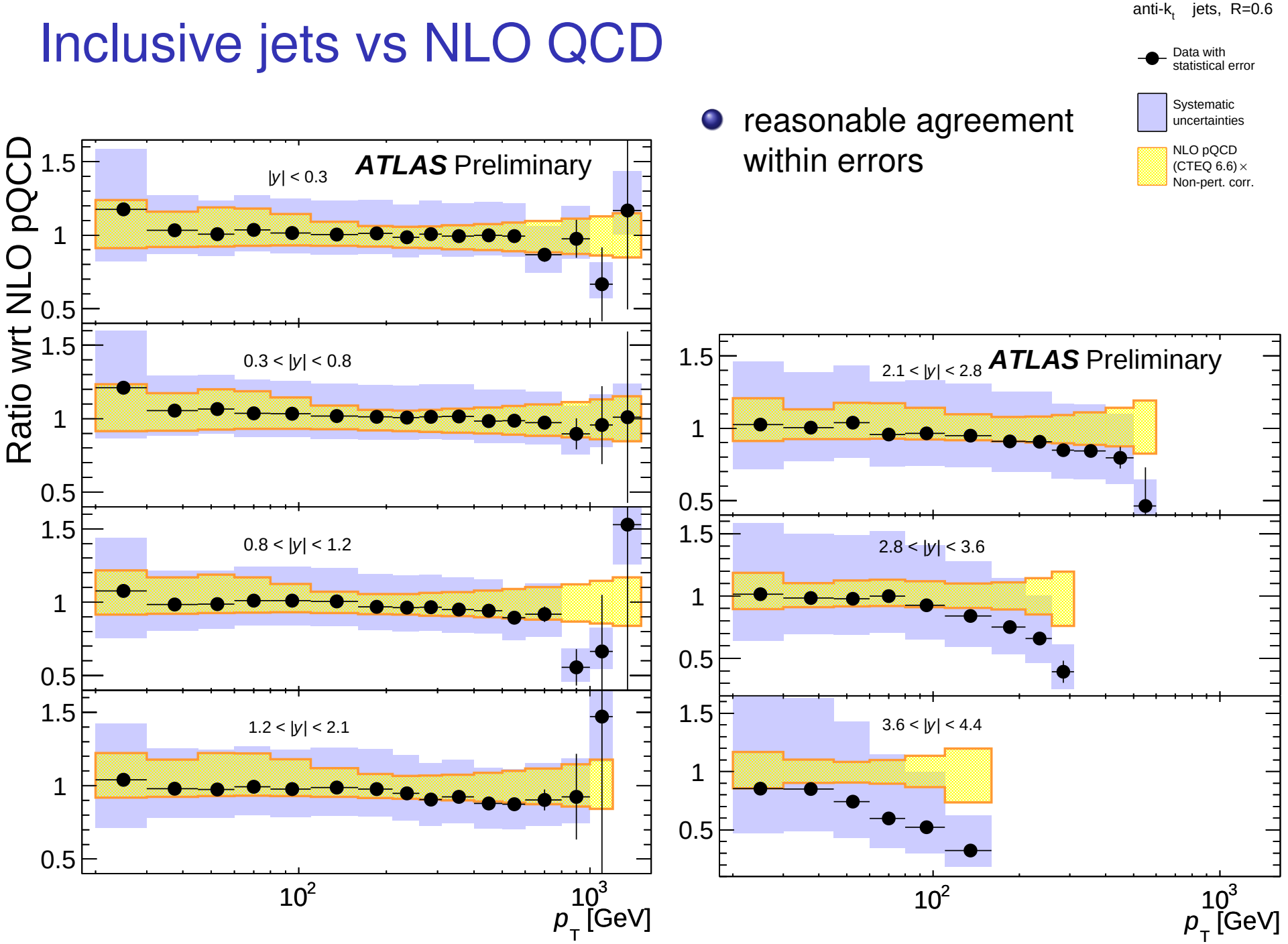
Inclusive jets



- two orders of magnitide in p_{T} $20\mathrm{GeV} < p_{\mathrm{T}}^{jet} < 1.5\mathrm{TeV}$
- seven rapidity bins $-4.4 < y^{jet} < 4.4$
- pQCD corrected for non-perturbative effects
- good agreement with theory over 7 orders of magnitude

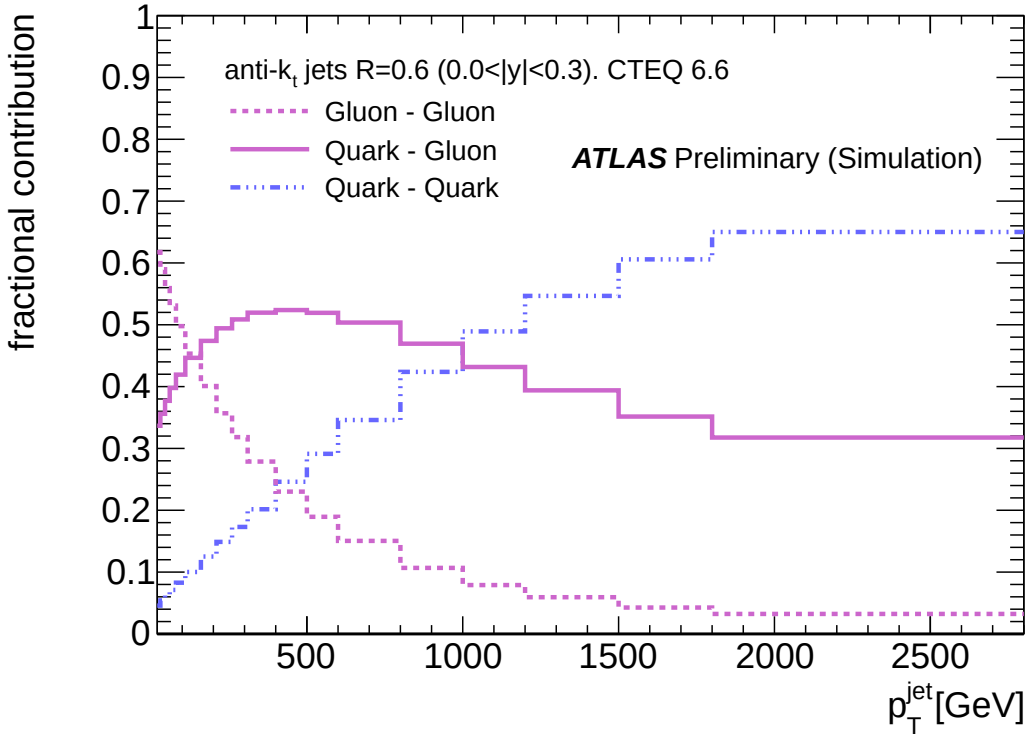
Inclusive jets vs NLO QCD

- reasonable agreement within errors



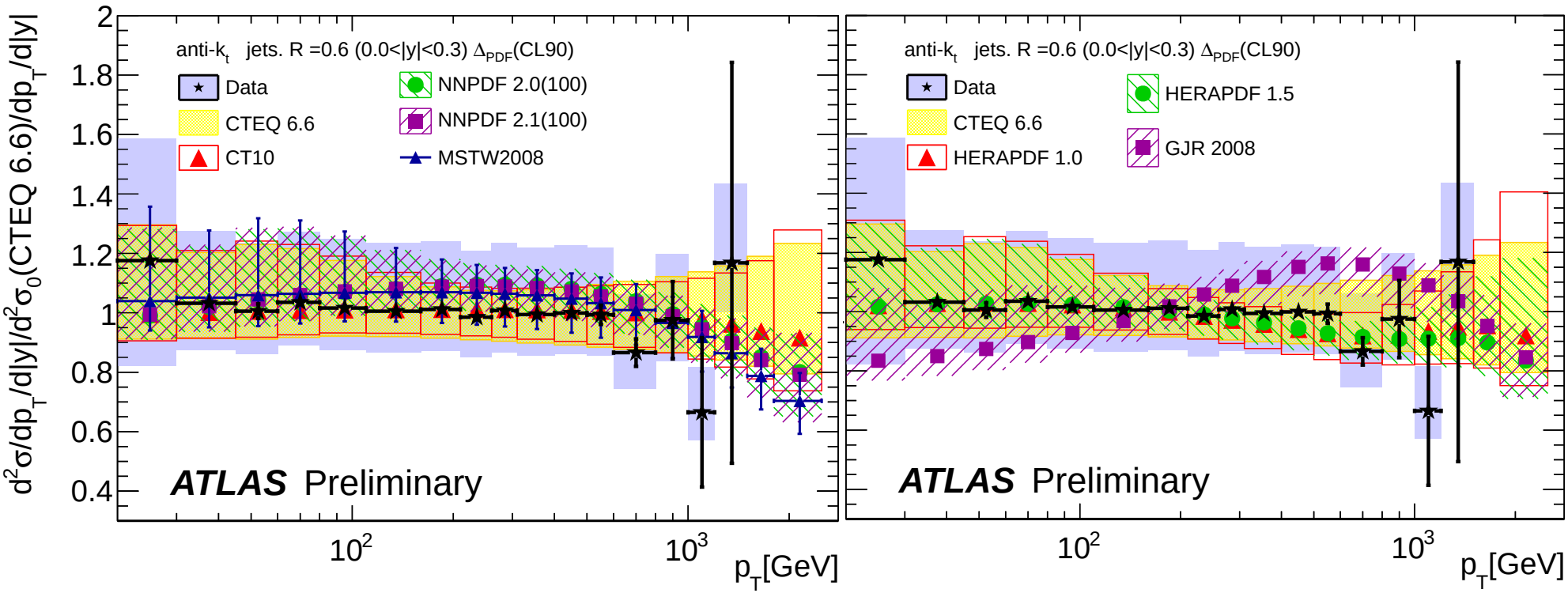
Inclusive jets in the $|y| < 0.3$

- the gluon-gluon subprocess falls quickly from $\sim 60\%$ to $\sim 5\%$ for jet $p_{\mathrm{T}} \geq 1.5$ TeV
- The quark-gluon scattering grows from 35% to 50% for jet $p_{\mathrm{T}} \sim$ 400–500 GeV and it slightly decreases to 30% at high p_{T}.
- the quark-quark subprocesses are very small at low jet p_T, but it is dominant at high p_T.



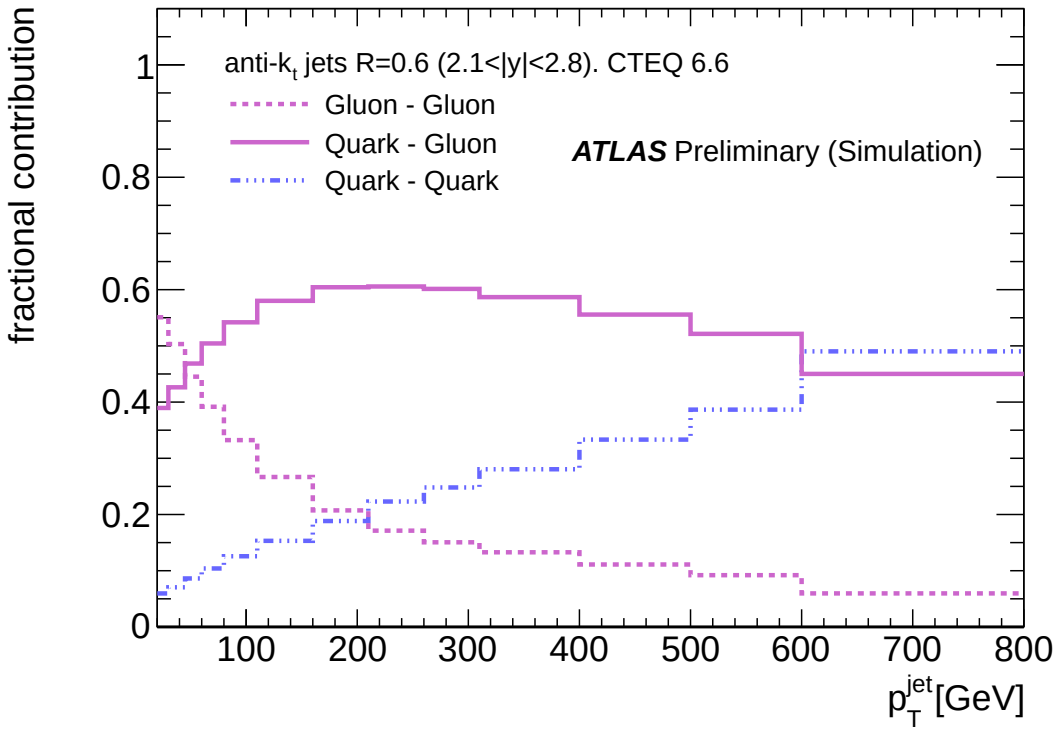
Inclusive jets in the $|y| < 0.3$

- CT10 is lower at high p_{T} than CTEQ 6.6
- NNPDF2.0 $\sim$ NNPDF2.1
- HERAPDF 1.5 has smaller incertainty HERAPDF 1.0 for high p_{T}.
- GJR compartible with data, but have a different shape



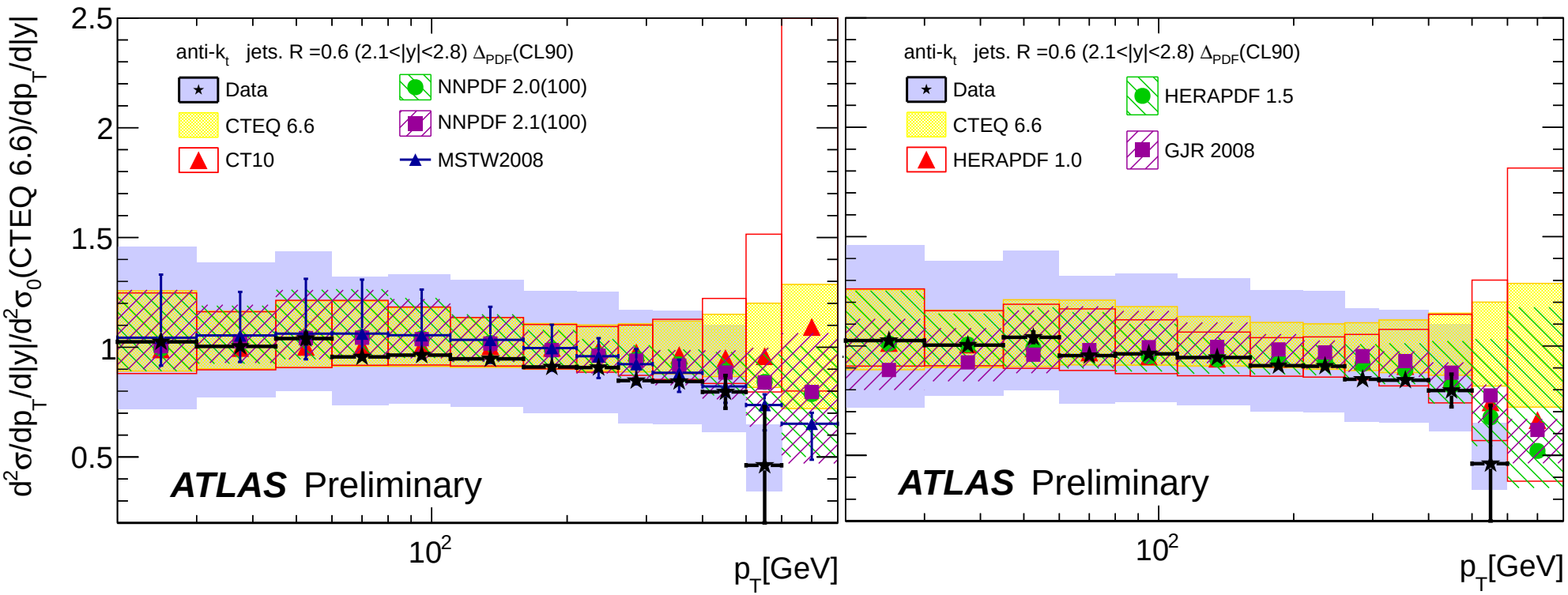
Inclusive jets in the $2.1 < |y| < 2.8$

- the gluon-gluon subprocess falls quickly from $\sim 55\%$ to $\sim 5\%$ at very high p_{T}
- the quark-gluon scattering grows from 40 to 60% up to jet $p_T \sim 250$ GeVand falls down to $\sim 40\%$ at high p_{T}'s
- the quark-quark scattering slowly grows from 5% at very low p_T to 45% at very high transverse momentum.



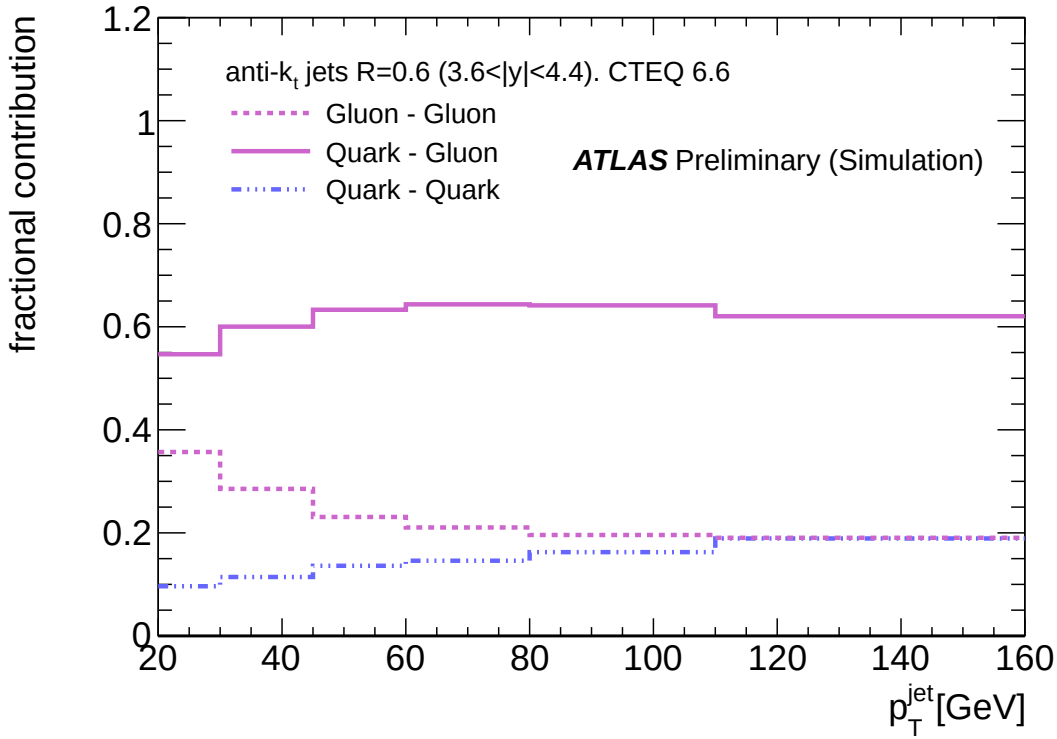
Inclusive jets in the $2.1 < |y| < 2.8$

- CT10 uncertainty is much higher at high p_{T} than CTEQ 6.6
- NNPDF2.1 unceertainty is a bit higher than NNPDF2.0
- HERAPDF 1.5 has smaller incertainty HERAPDF 1.0 for high p_{T}.
- GJR and MSTW are compartible with data



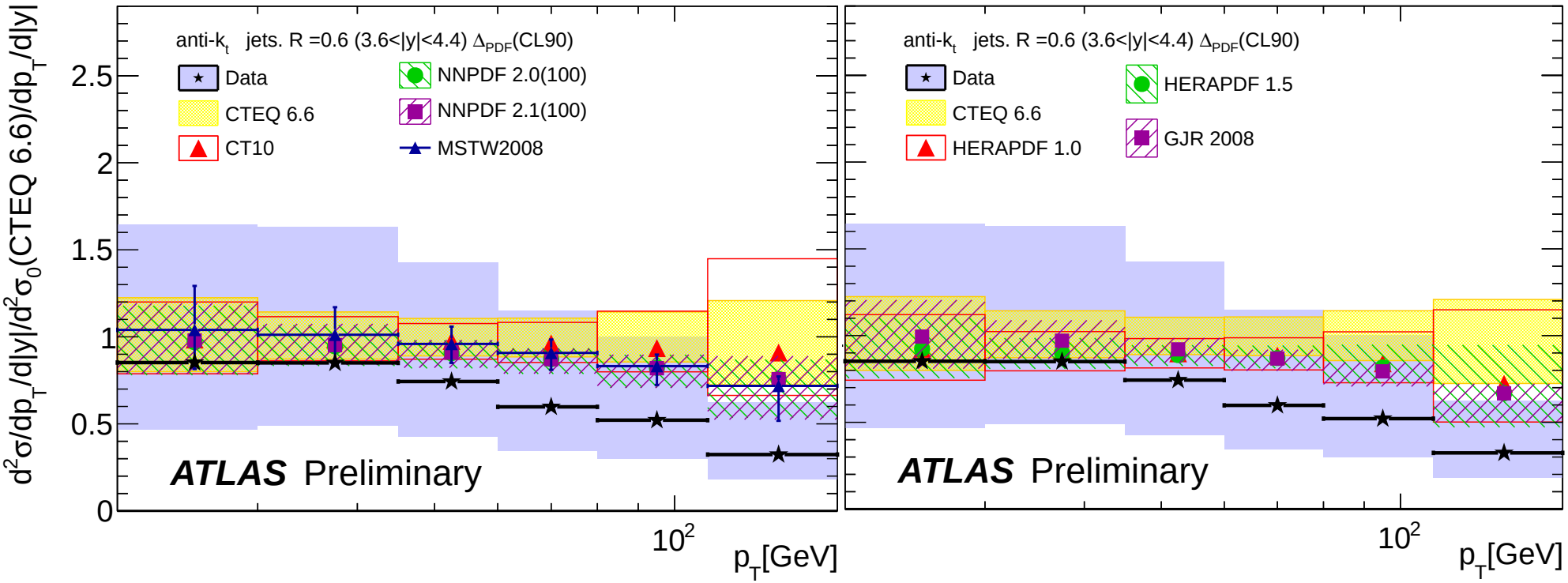
Inclusive jets in the $3.6 < |y| < 4.4$

- the quark-quark contribution is nearly flat and amounts to 15%
- the gluon induced processes contribute almost 85% to the cross section



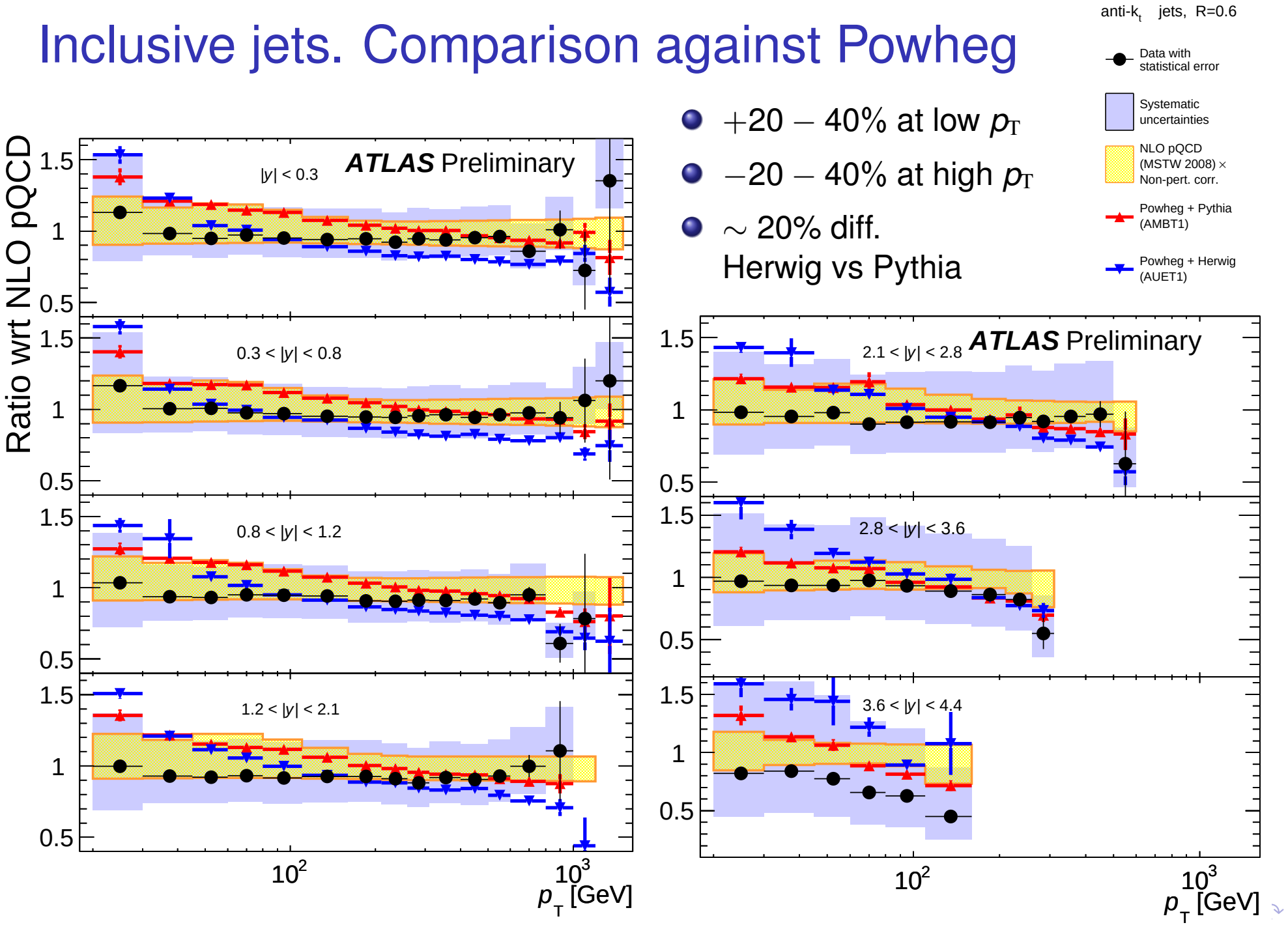
Inclusive jets in the $3.6 < |y| < 4.4$

- CTEQ 6.6 and CT10 are incompatible with data at high p_{T}.
- all PDFs predict larger cross sections



Inclusive jets. Comparison against Powheg

- $+20-40\%$ at low p_T
- $-20-40\%$ at high p_T
- $\sim 20\%$ diff. Herwig vs Pythia



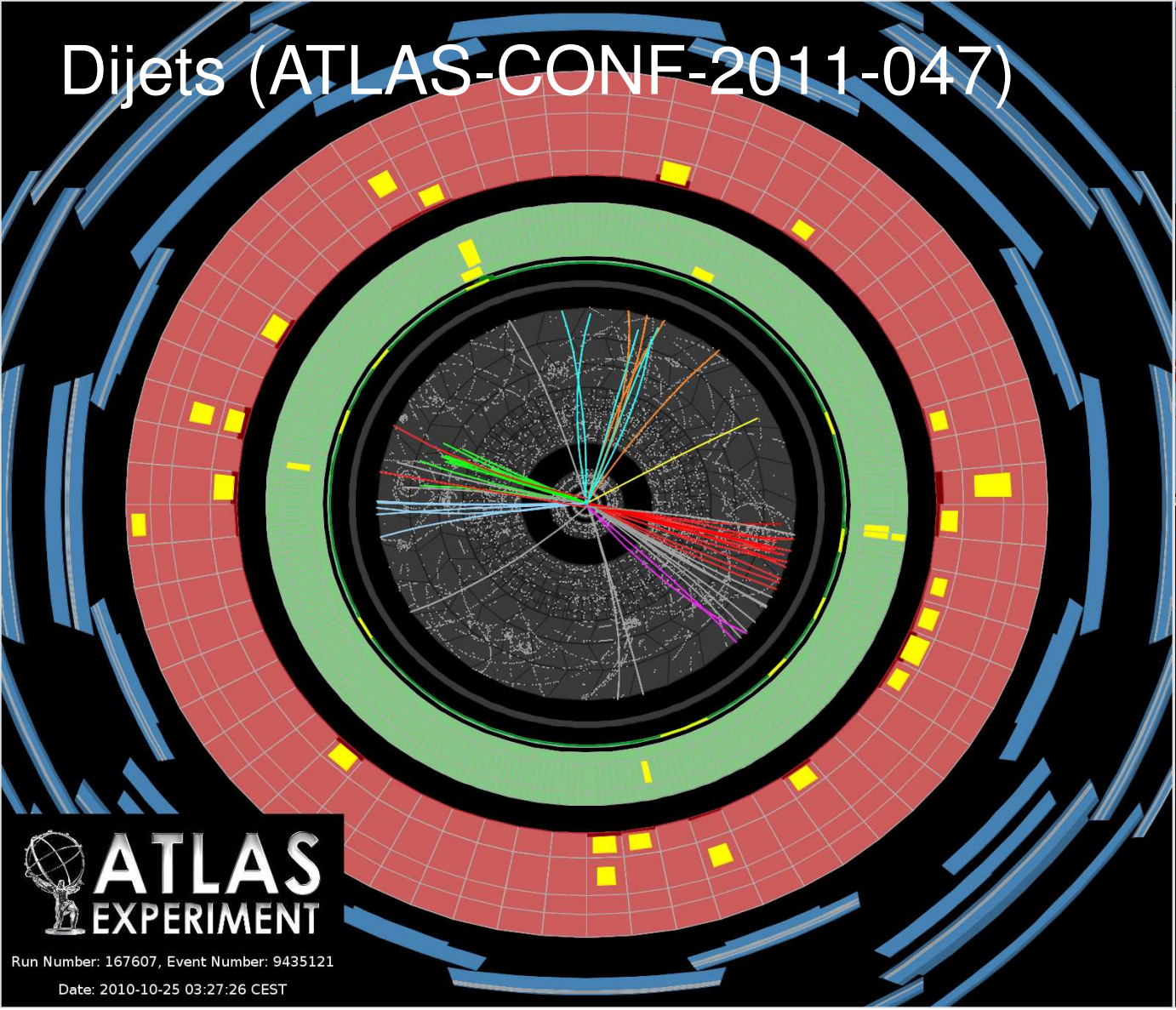
Inclusive jets. Summary

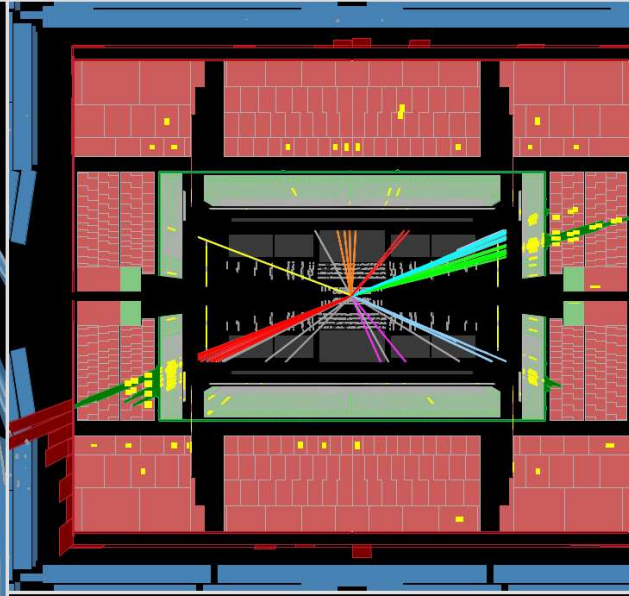
- Cross section measurements for inclusive jet production as a function of jet p_{T} have been presented.
- The largest systematic uncertainty for this measurement arises from the jet energy scale
- The data have also been compared with the NLO QCD predictions obtained with different PDF sets
- The data have also been compared with the NLO+PS Powheg prediction, using the MSTW 2008 NLO PDF set.

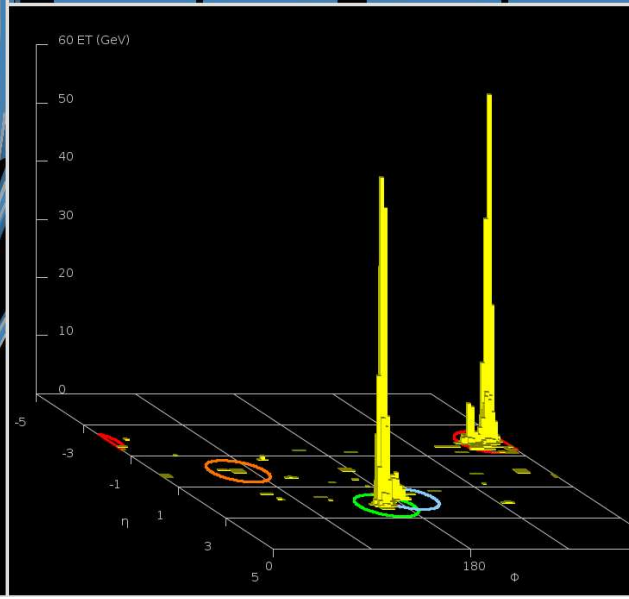
Table: Summary of systematic uncertainties on the inclusive jet cross section measurement for representative p_{T} and y regions for anti-k_t jets with $R = 0.6$.

p_{T}[GeV]	$\lvert y \rvert$	Abs. JES	Unfolding	Cleaning	Trigger	Jet Rec.
20	2.1-2.8	$^{+40\%}_{-30\%}$	20%	0.5%	1%	2%
20	3.6-4.4	$^{+80\%}_{-50\%}$	20%	0.5%	1%	2%
100	< 0.3	10%	2%	0.5%	1%	1%

Dijets (ATLAS-CONF-2011-047)

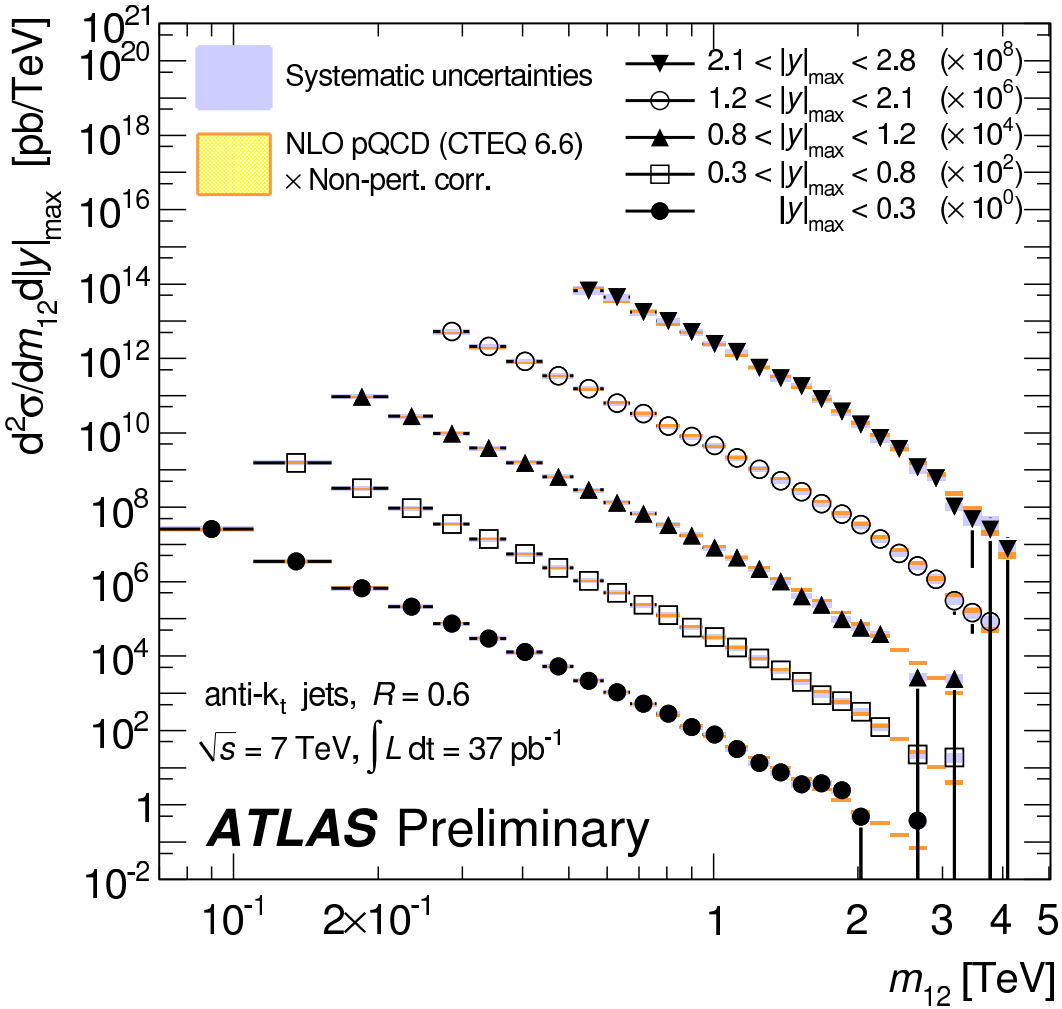






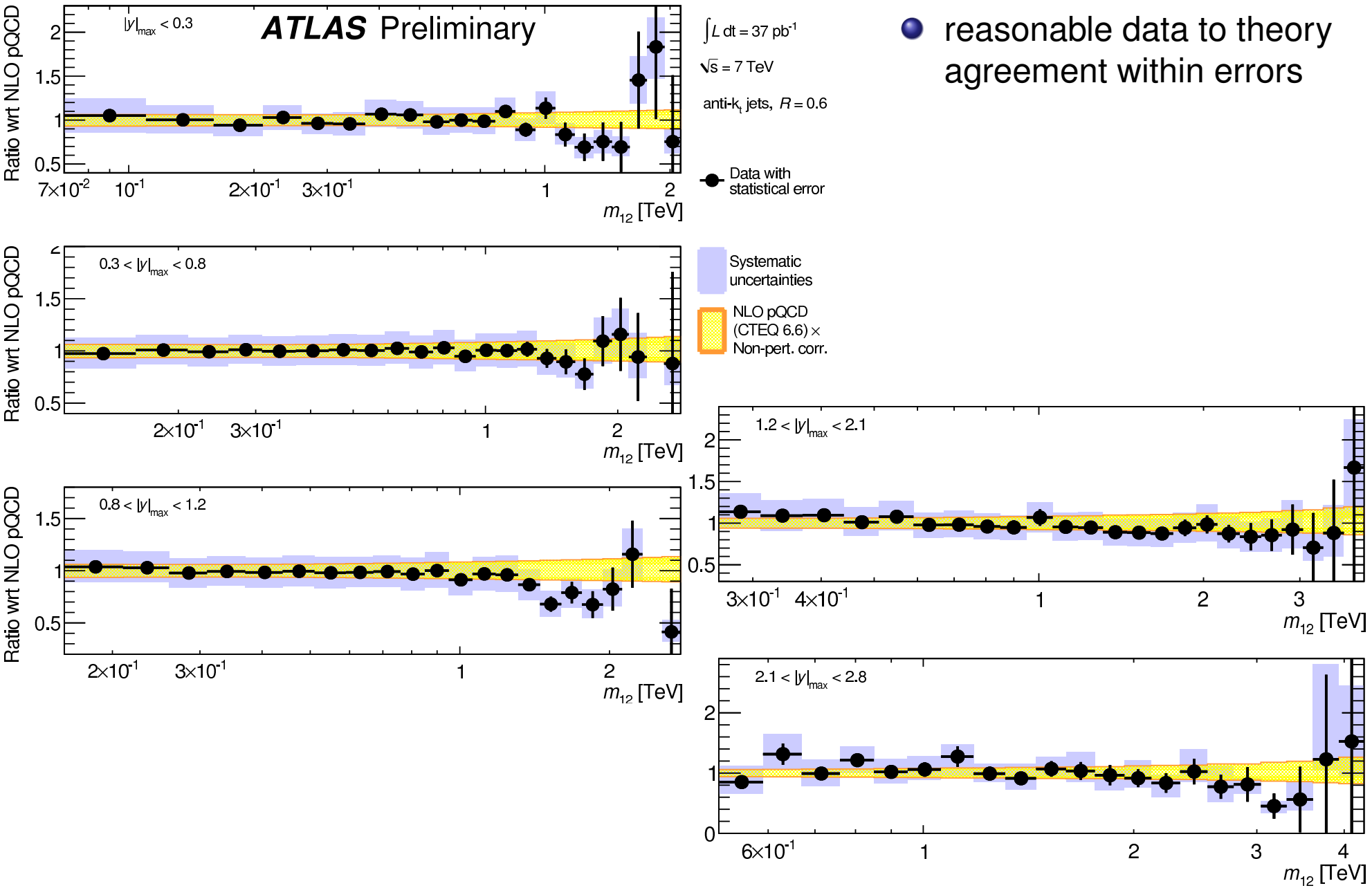
The two leading jets in a forward-backward dijet system produce an invariant mass of 4.0 TeV. The two leading jets have (p_T, y) of (510 GeV, -1.9) and (510 GeV, 2.2), respectively. The E_T^{miss} in the event is 31 GeV.

Dijets



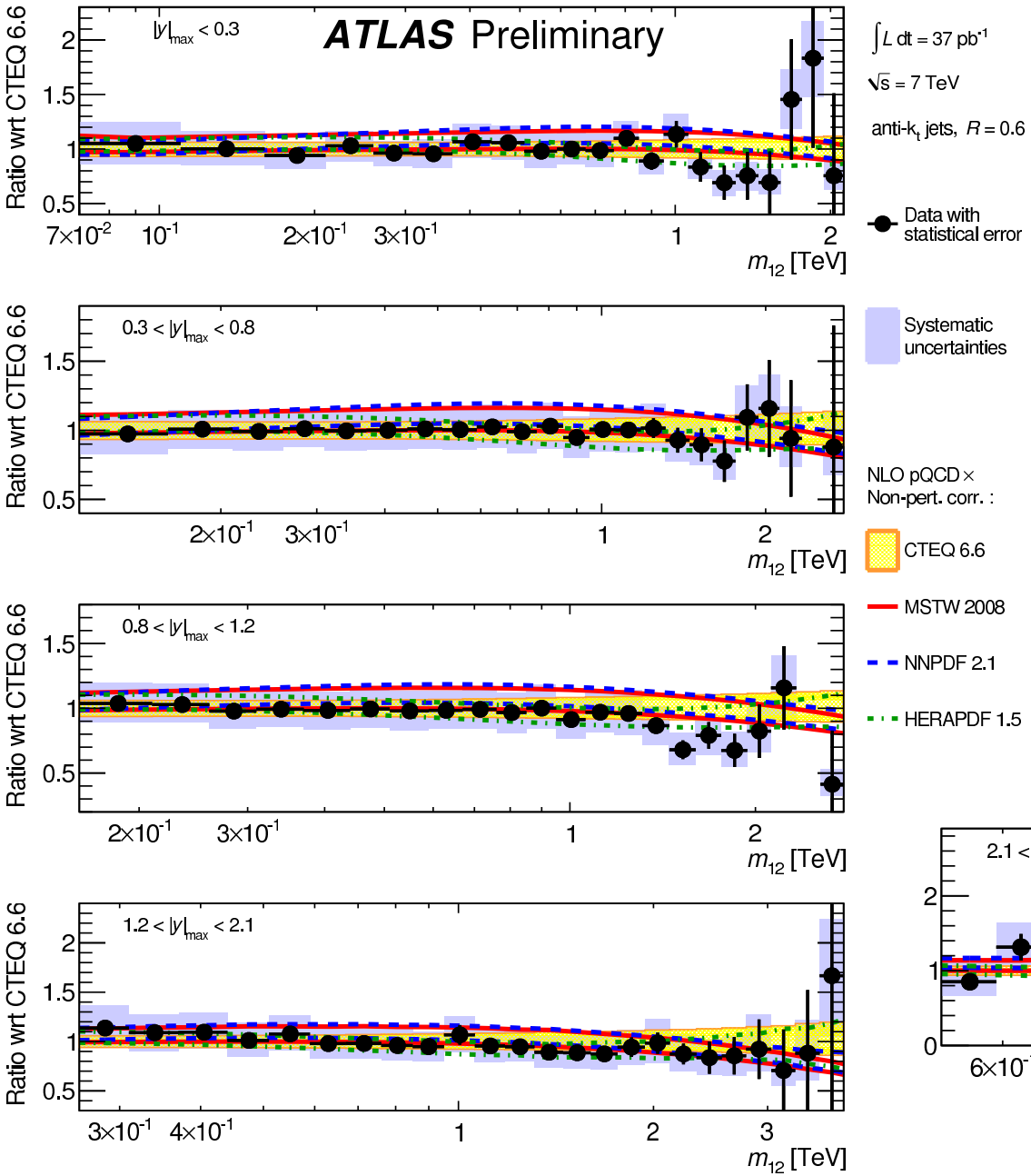
- leading jet $p_{\mathrm{T}} \geq 30$ GeV
- subleading jet $p_{\mathrm{T}} \geq 20$ GeV
- $30\mathrm{GeV} < m_{jj}^{dijet} < 4.1\mathrm{TeV}$
- 5 rapidity bins
  $-2.8 < y^{jet} < 2.8$
- NLO QCD corrected for non-perturbative effects

Dijets vs NLO QCD

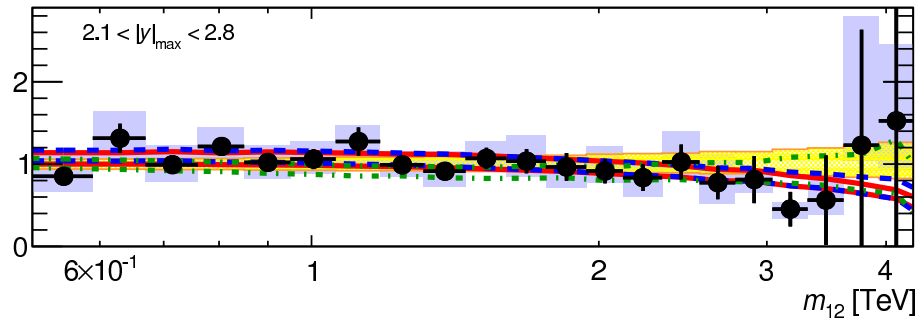


- reasonable data to theory agreement within errors

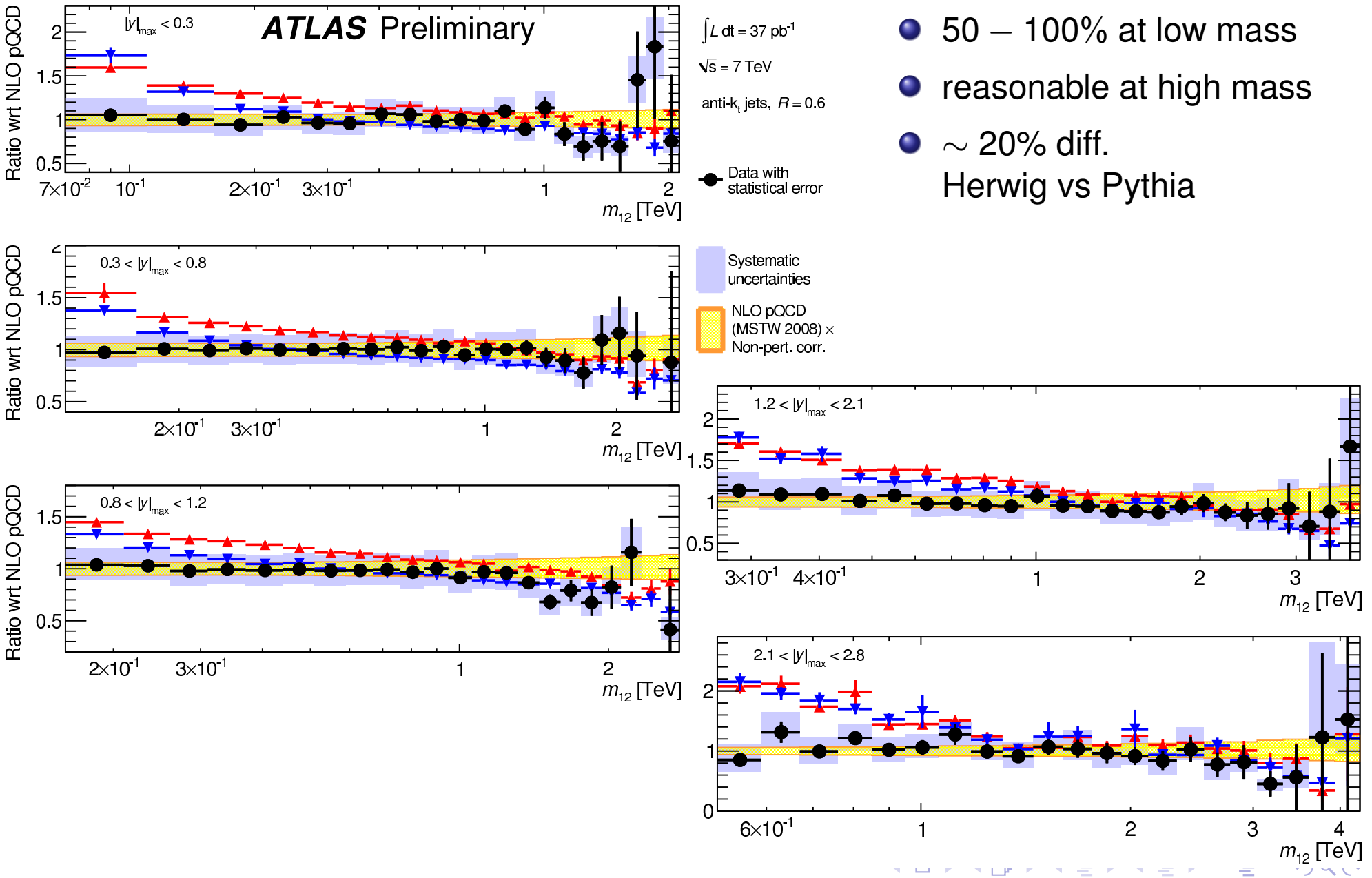
Diiets vs PDF



- boundaries of the theory uncertainty bands for various PDF sets are shown
- Predictions using HERAPDF 1.5 follow the data most closely



Dijets vs POWHEG



- 50 – 100% at low mass
- reasonable at high mass
- $\sim$ 20% diff.
  Herwig vs Pythia

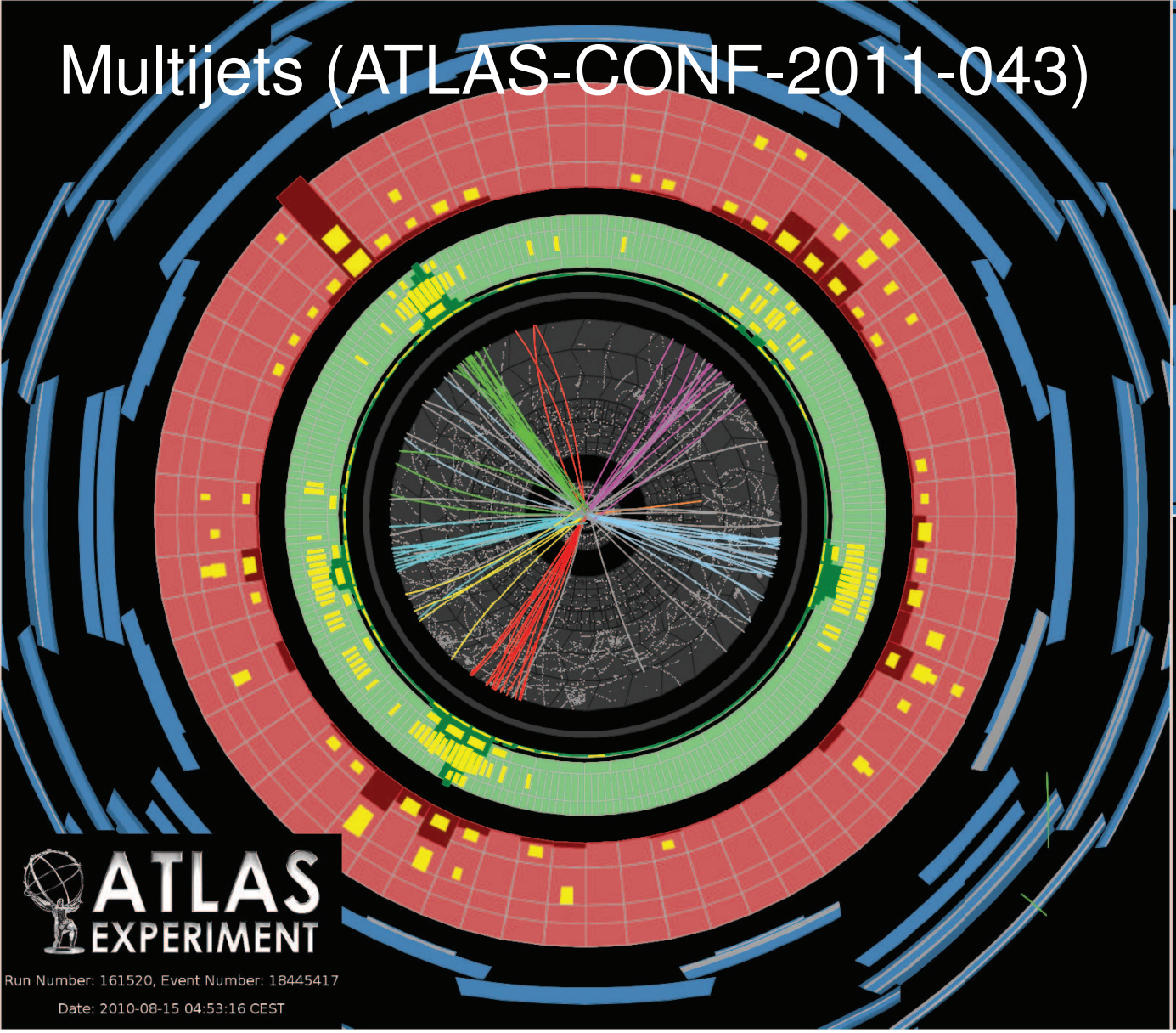
Dijets. Summary

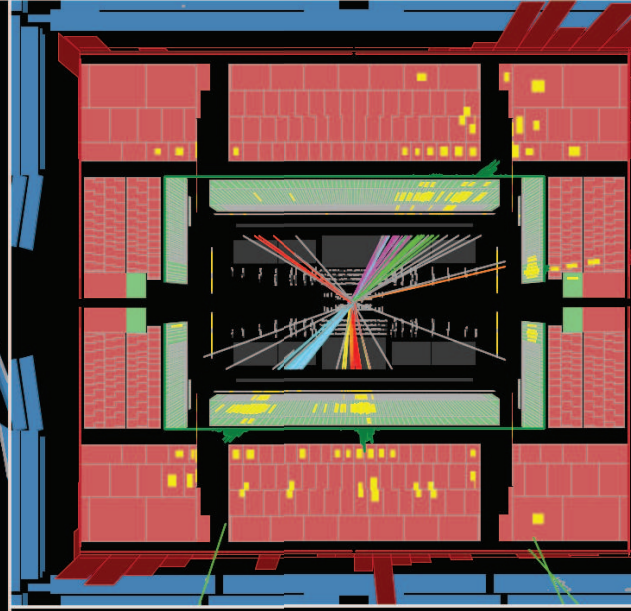
- Cross section measurements for dijet production as a function of the invariant mass of the two leading jets have been presented.
- The largest systematic uncertainty for this measurement arises from the jet energy scale
- Experimental and theoretical uncertainties are of the similar size.

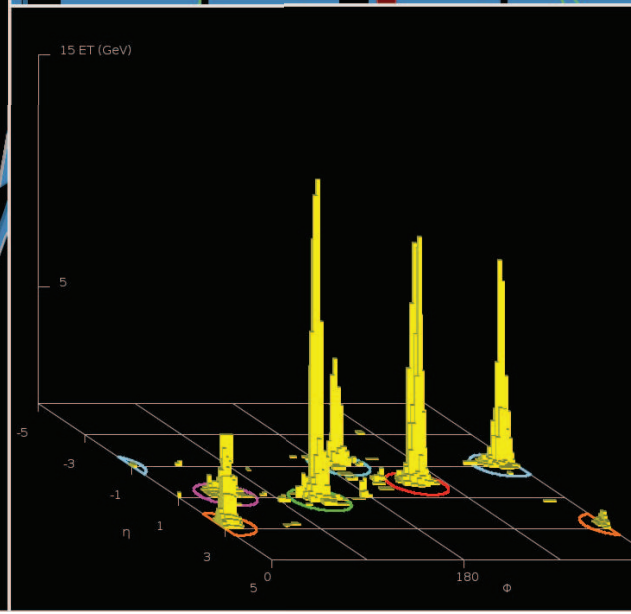
Table: Summary of systematic uncertainties on the dijet mass cross section measurement for representative dijet mass m_{12} and maximum rapidity $|y|_{\max}$ regions.

m_{12} [GeV]	$\lvert y\rvert_{\max}$	Abs. JES	Rel. JES	Unfolding	Cleaning	Trig.	Jet Rec.
60	2.1-2.8	$^{+30\%}_{-20\%}$	10%	10%	0.5%	1%	2%
200	< 0.3	10%	0%	5%	0.5%	1%	1%

Multijets (ATLAS-CONF-2011-043)

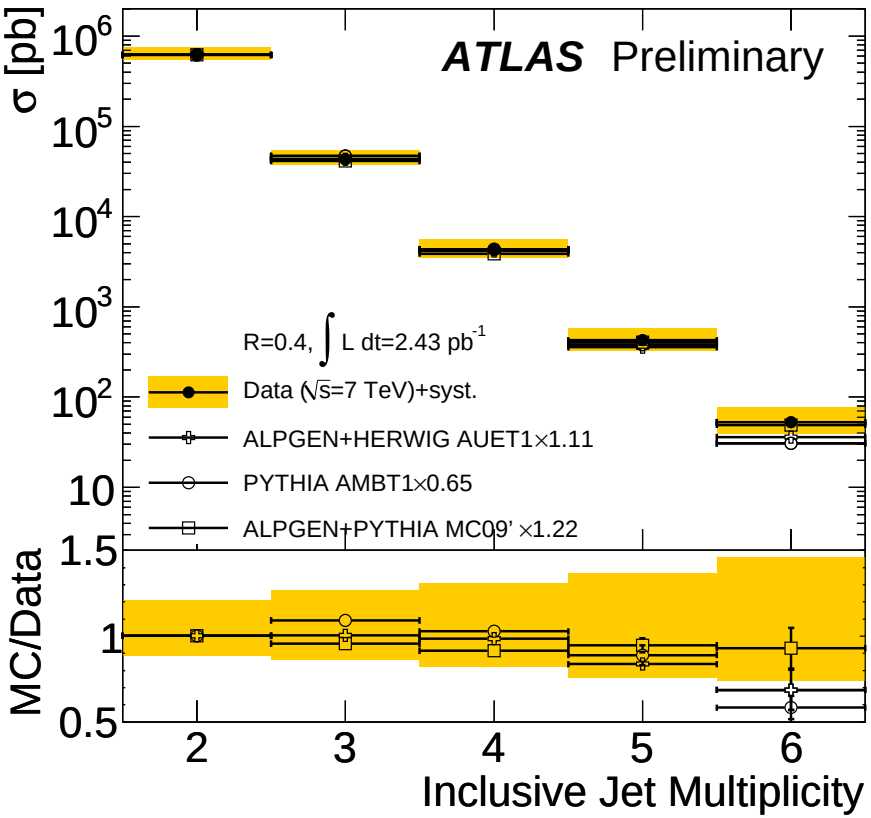


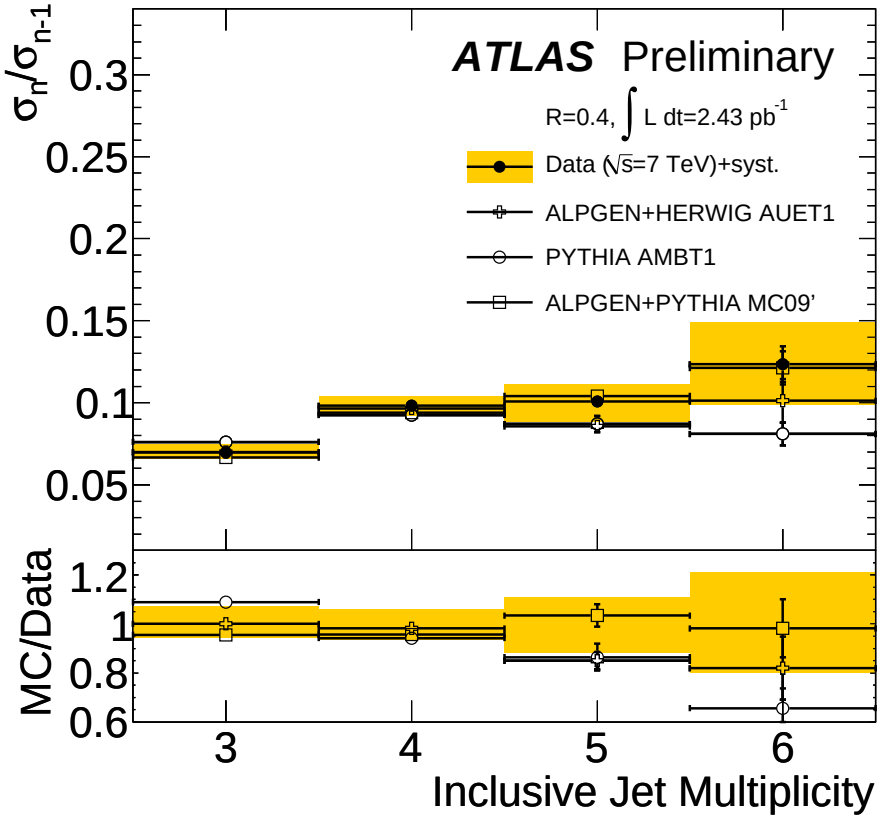




Event display of a six-jet event. The towers in the bottom right figure represent transverse energy deposited in the calorimeter projected on a grid of eta and phi.

Total inclusive jet cross section as a function of multiplicity

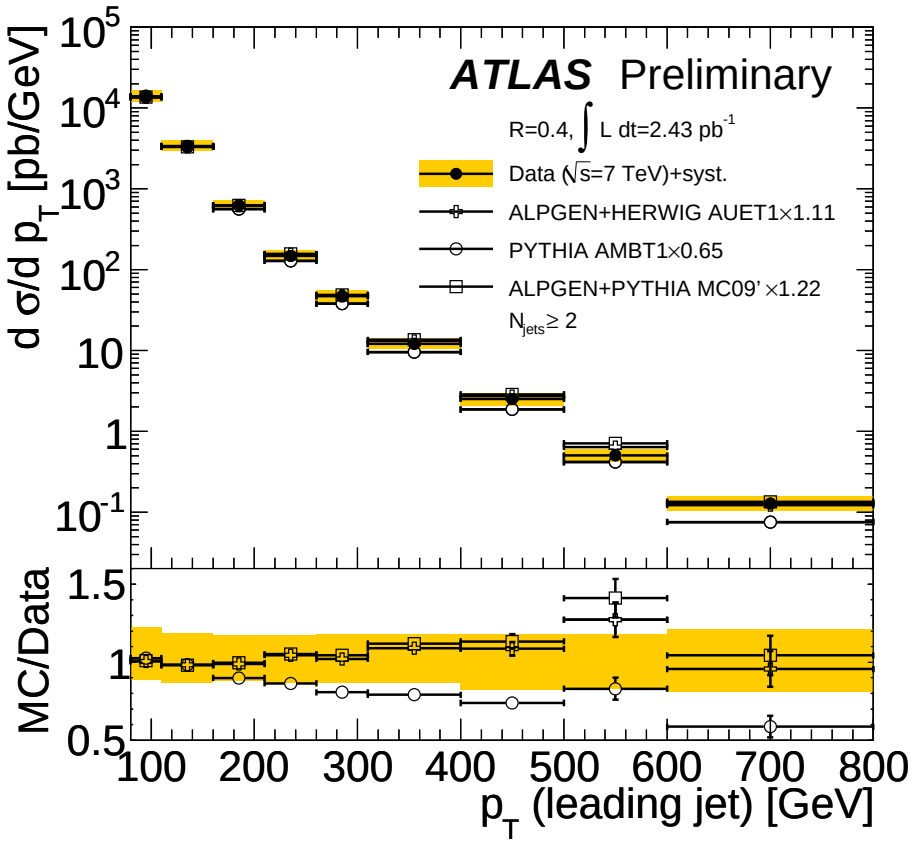


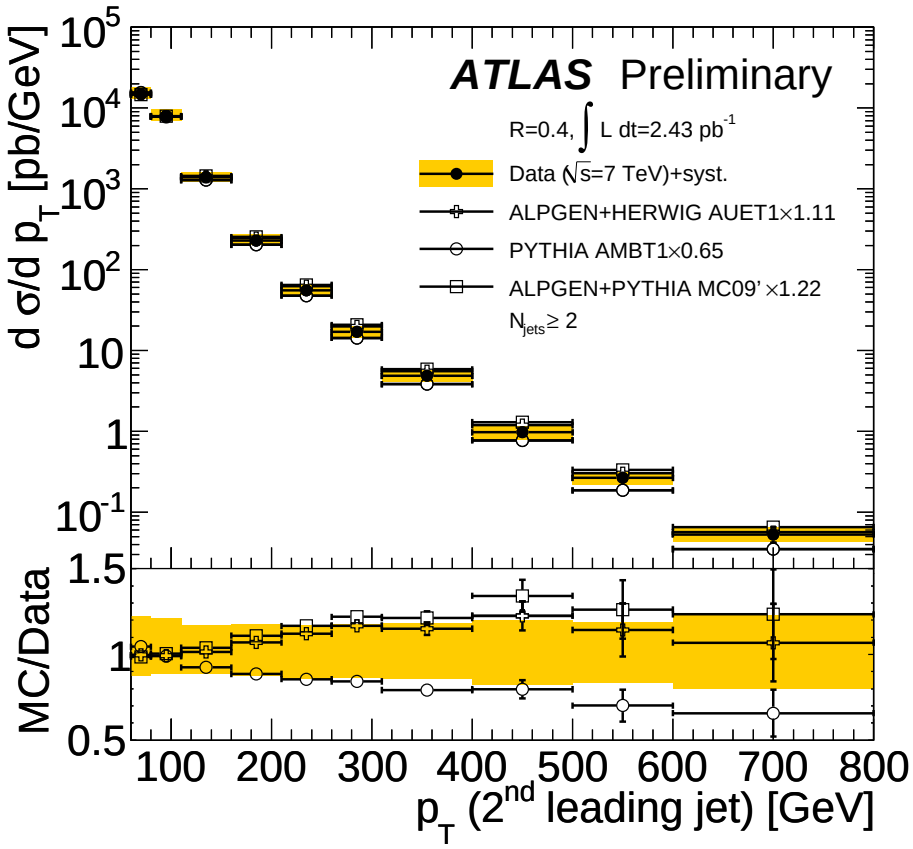


systematic uncertainty in $\sigma(n_{jets})$ is dominated by JES.
JES and unfolding systematics are comparable in $\sigma(n_{jets})/\sigma(n_{jets}-1)$

Cross section as a function of *i*-th leading jet p_T (1,2)

$|y^{jet}| < 2.8$, $P_T^{jet} > 60$ GeV, $P_T^{lead.jet} > 80$ GeV

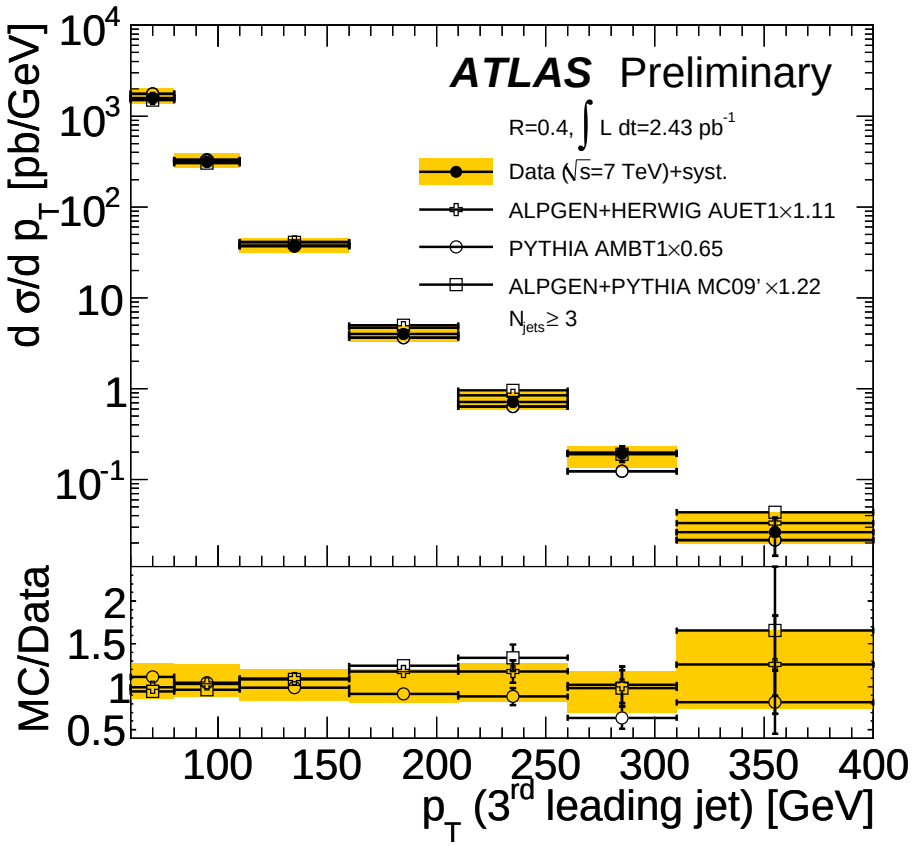


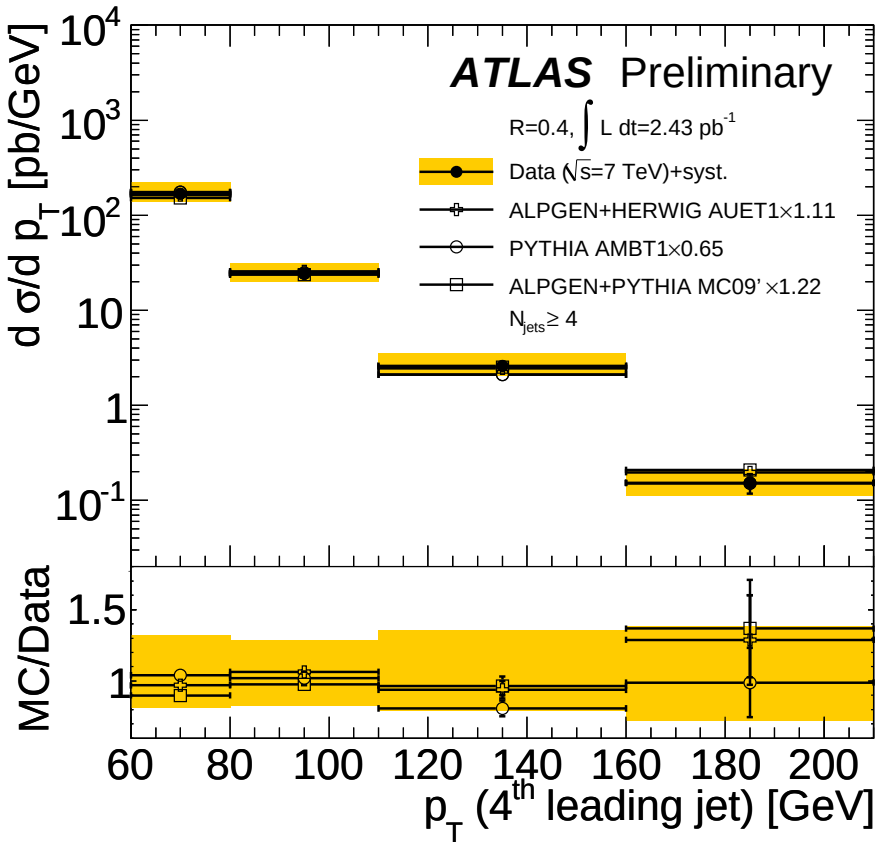


$|JVF| > 0.7$ (fraction of charged particle p_T coming from event vertex)

Cross section as a function of *i*-th leading jet p_T (3,4)

The jet energy scale systematic uncertainty is the dominant uncertainty in the measurement.

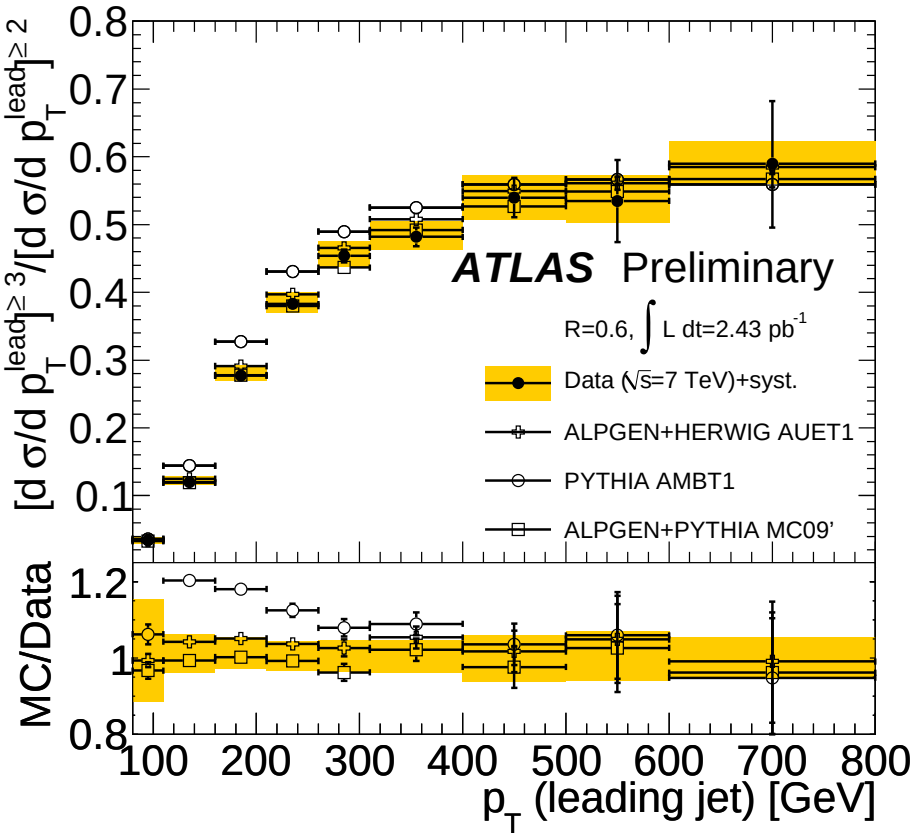


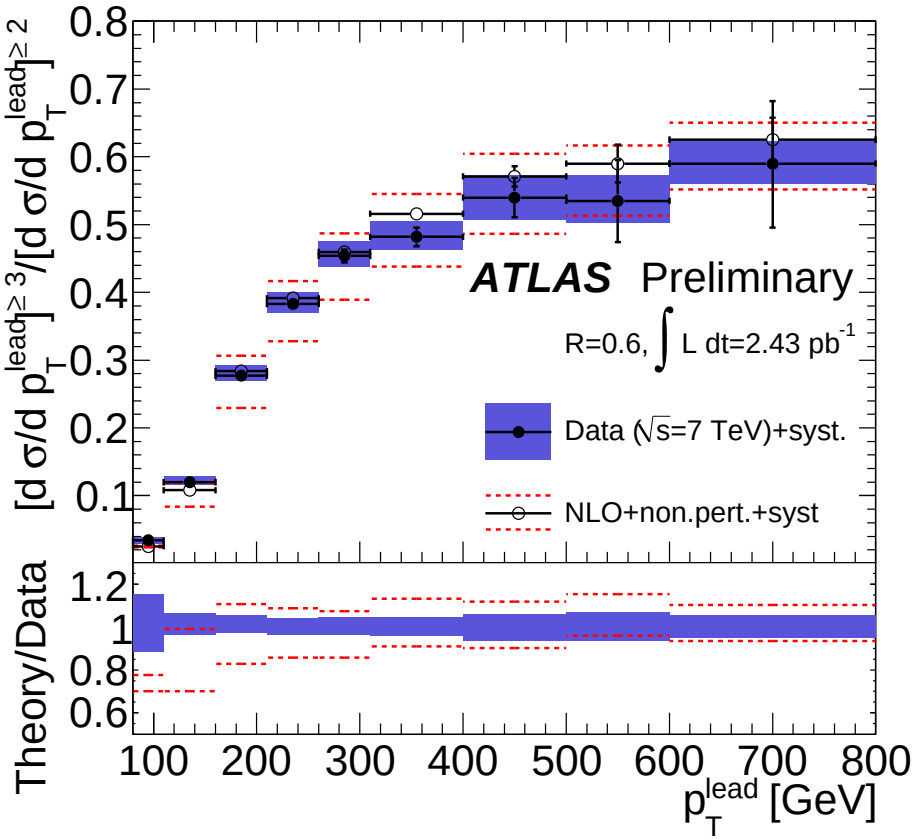


The ALPGEN+HERWIG AUET1 and ALPGEN+PYTHIA MC09 Monte Carlo simulations are in agreement with the data within the systematic uncertainties.

Three to two jet cross section ratio

The systematic uncertainty ($\sim$ 5%) is dominated by the systematic uncertainties in the unfolding correction $\rightarrow$ possibility to constrain PDFs and α_s





The ALPGEN+HERWIG AUET1 describe the data within systematic uncertainties.

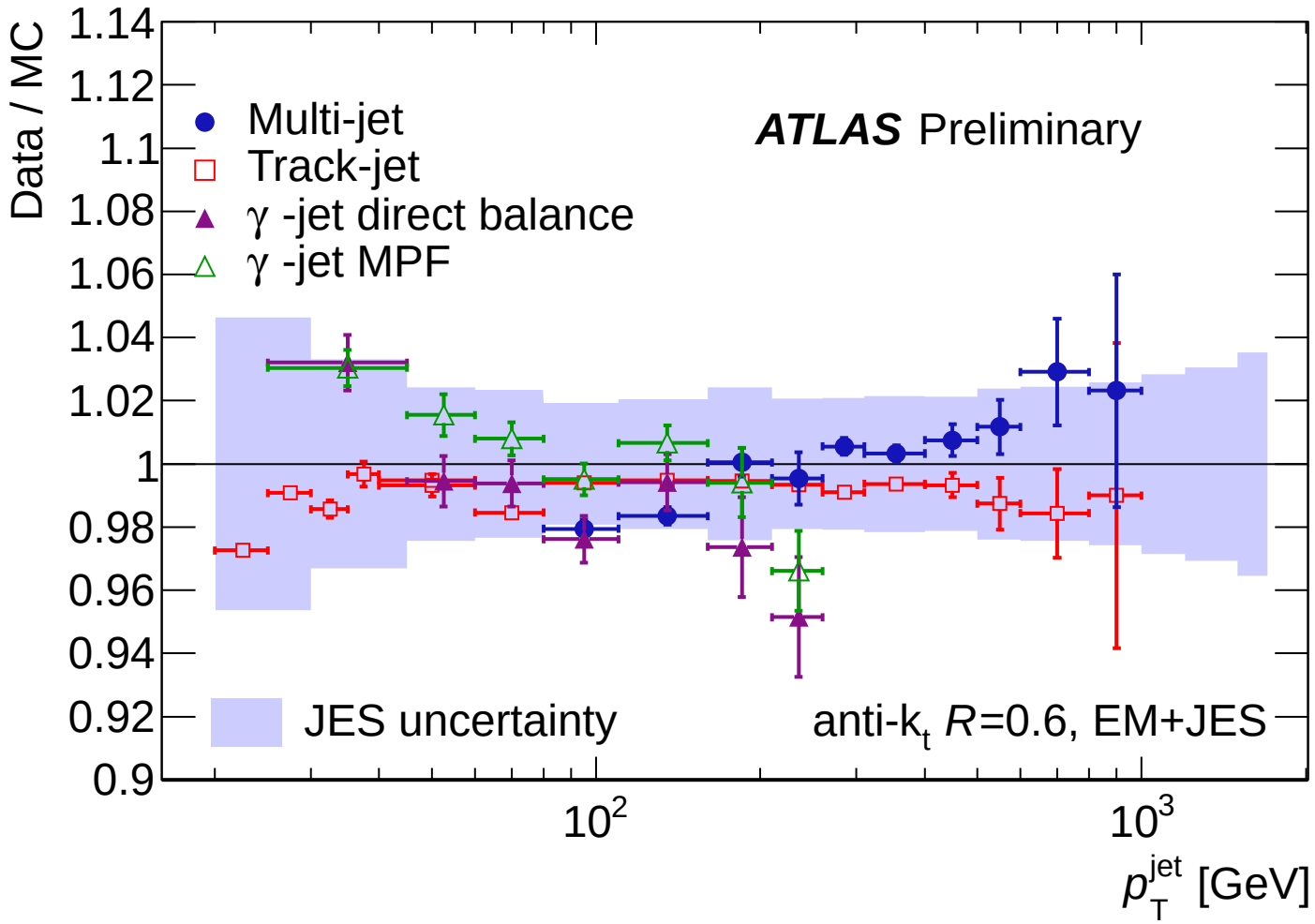
The shape descriptions from PYTHIA AMBT1 do not describe the data well.

Conclusions

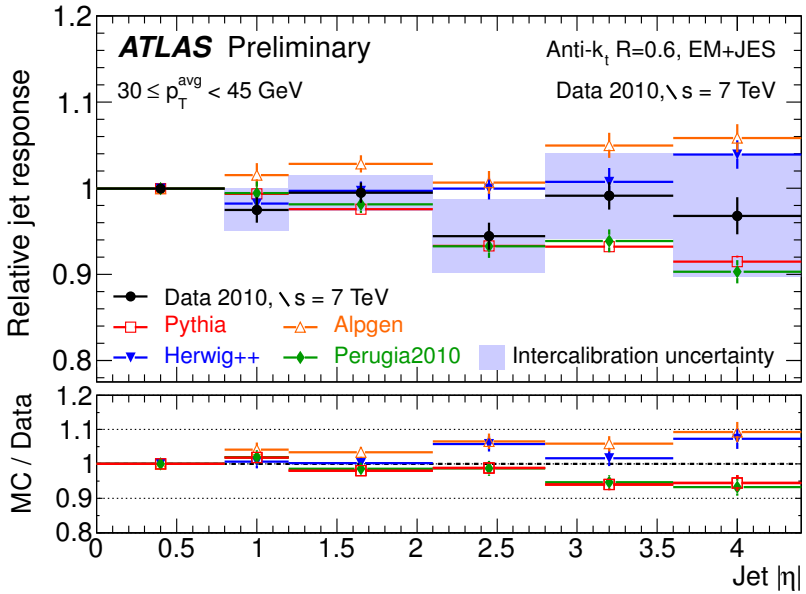
- Single inclusive jet and dijet production
  - The agreement of the NLO perturbative QCD predictions with the measurements extends over several orders of magnitude.
  - The data were also compared to several parton distribution function sets.
  - The experimental uncertainties achieved are similar in size to the theoretical uncertainties in some regions of phase space.
- multijets
  - ALPGEN generally describes the shapes well, whether the HERWIG or PYTHIA parton showers are used
  - PYTHIA LO+PS does not describe the shapes of some of the studied distributions
  - A measurement of the three to two jet cross section is described by both ALPGEN and a NLO pQCD calculation, albeit with a significant discrepancy in the lowest p_{T} bin.

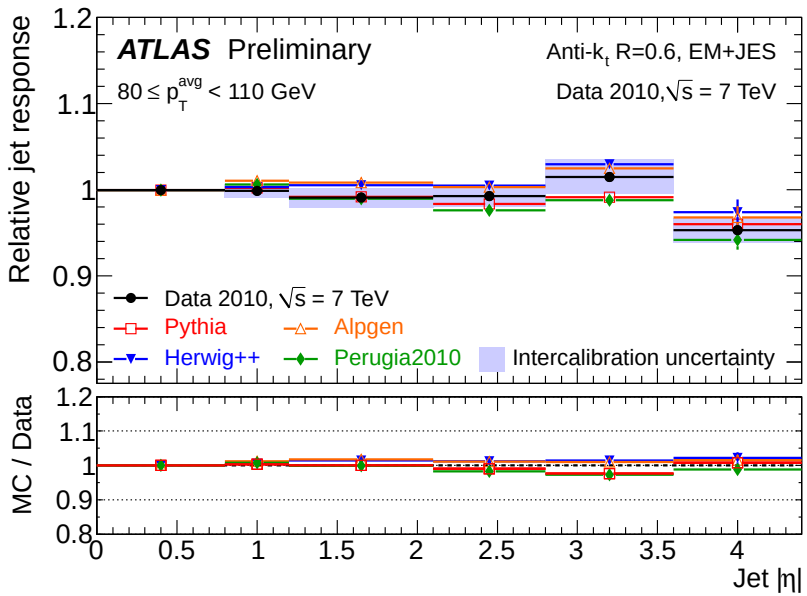
BACK-UP

JES uncertainty valiadtion

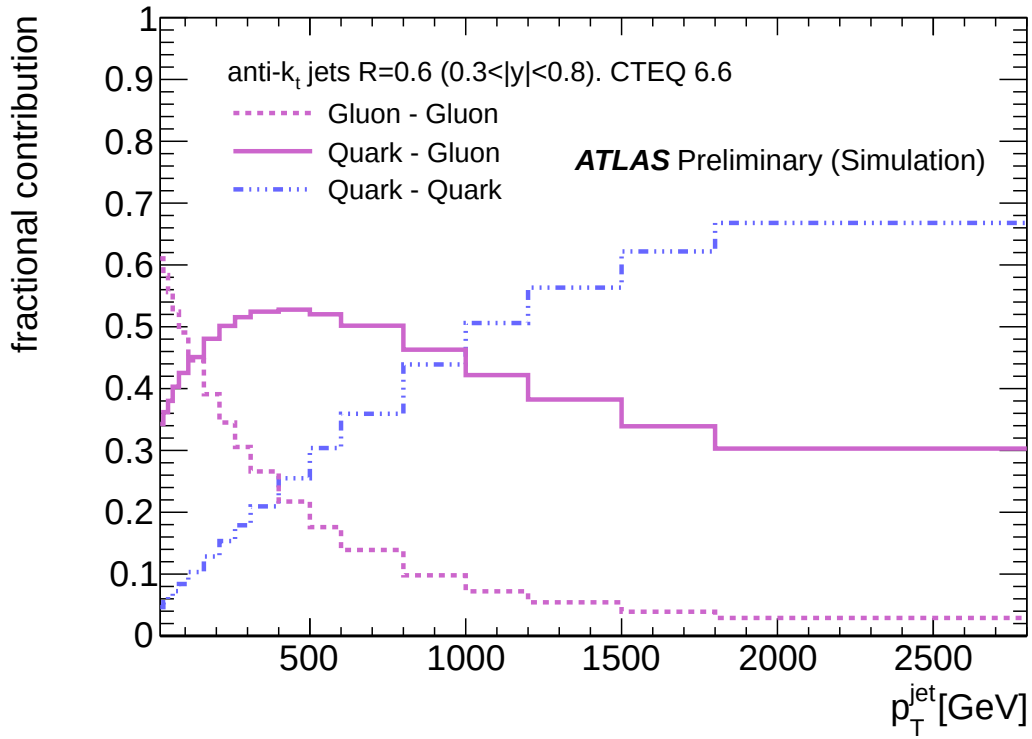


Eta intercalibration uncertainty

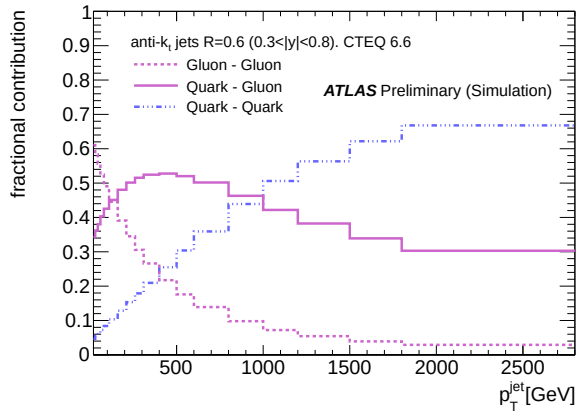


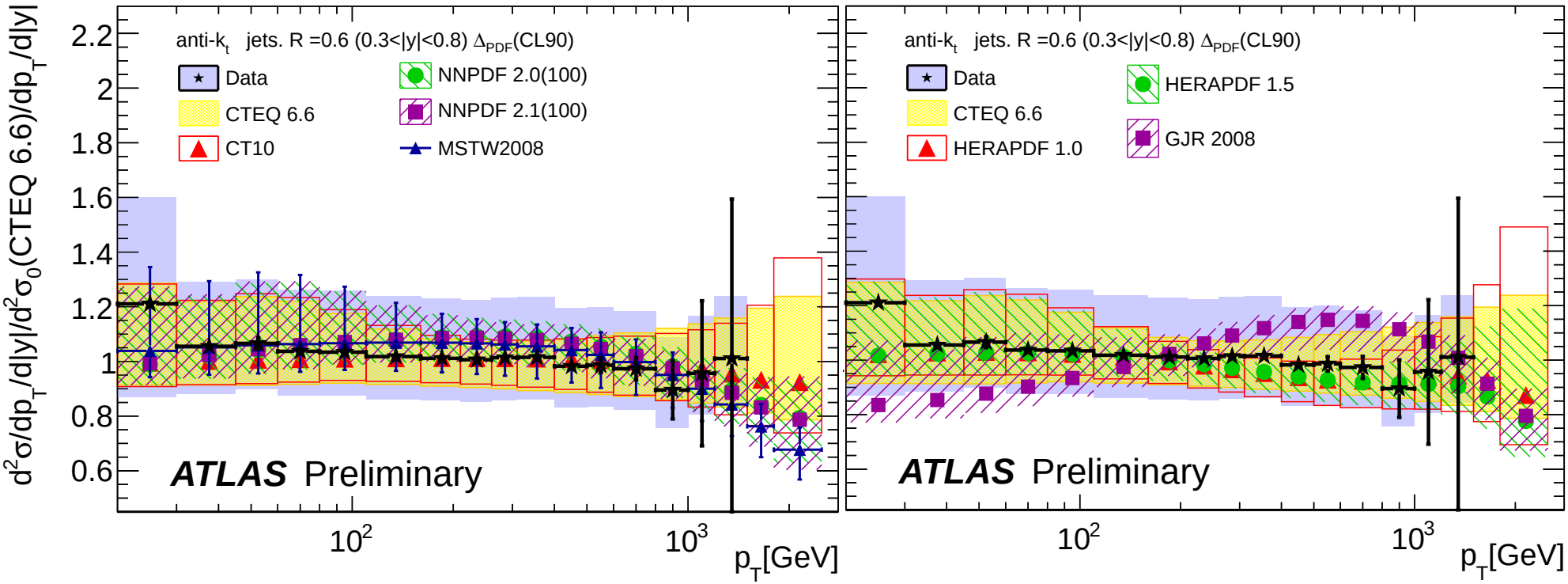


Inclusive jets in the $0.3 < |y| < 0.8$

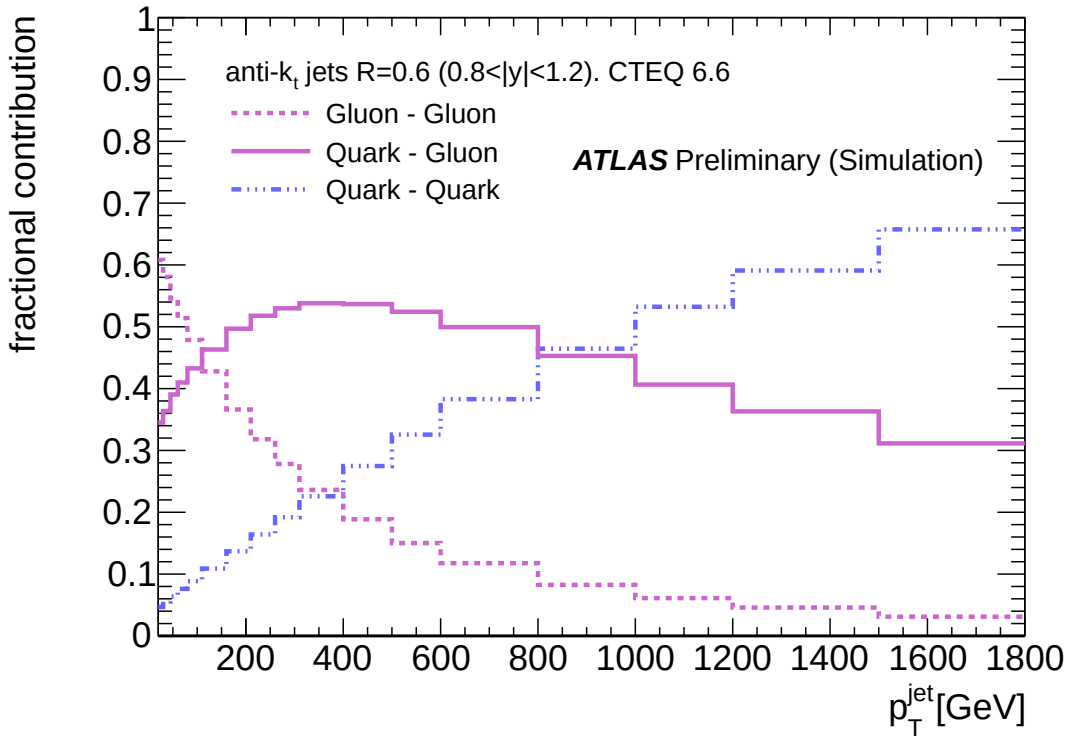


Inclusive jets in the $0.3 < |y| < 0.8$

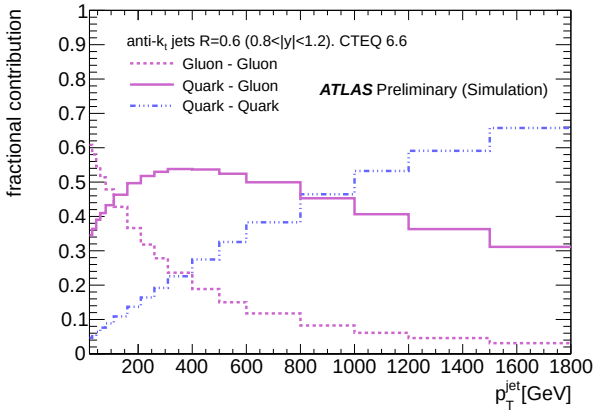


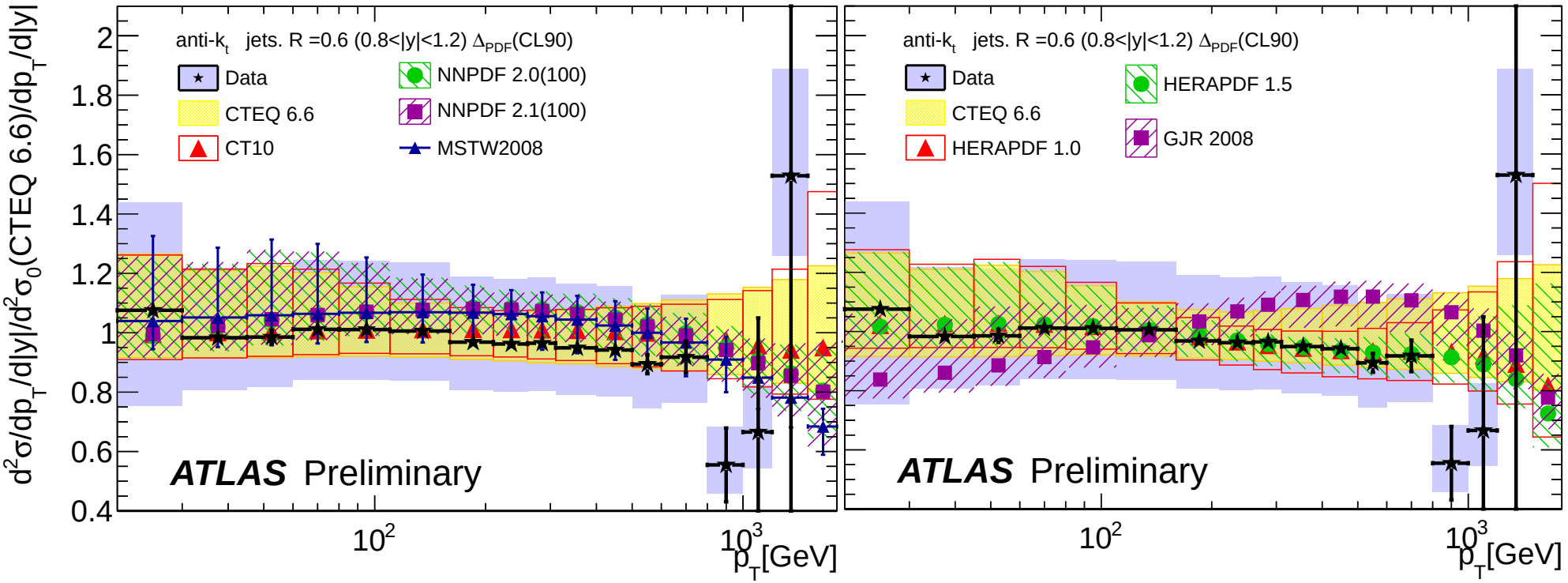


Inclusive jets in the $0.8 < |y| < 1.2$

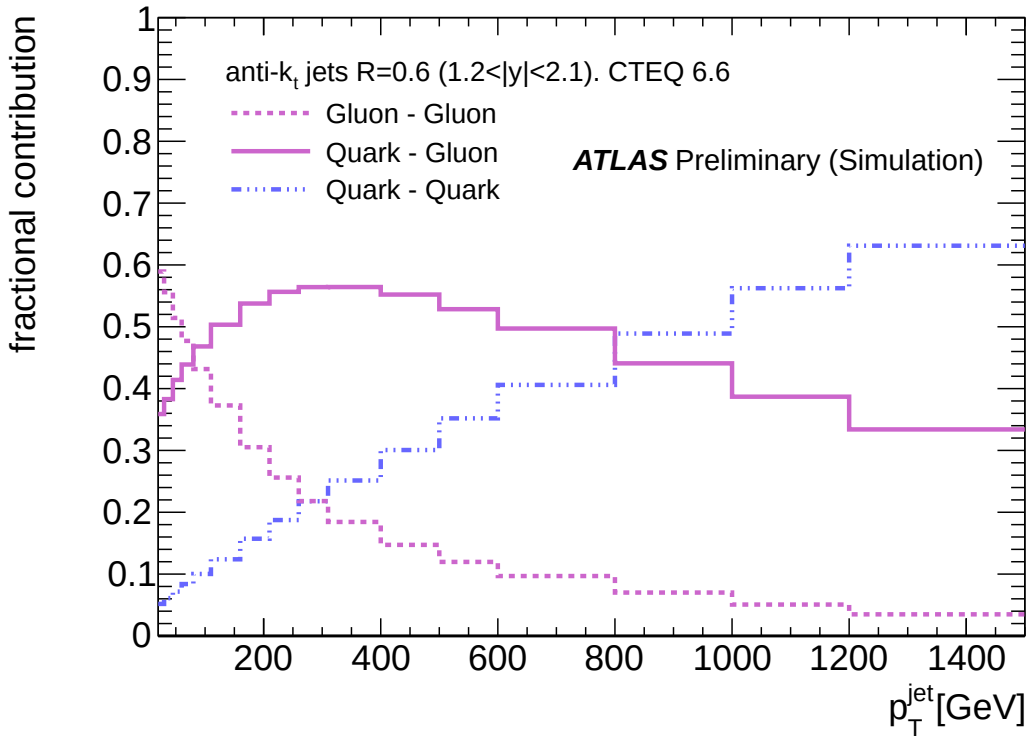


Inclusive jets in the $0.8 < |y| < 1.2$

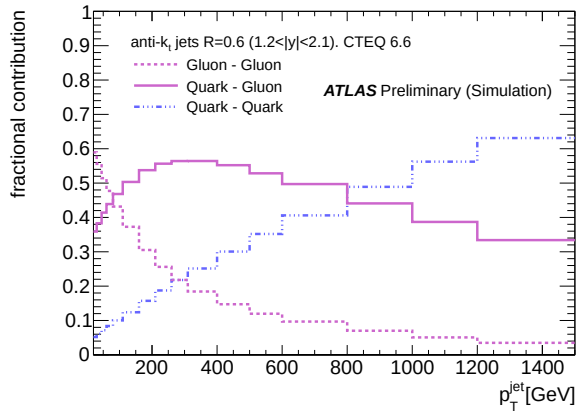


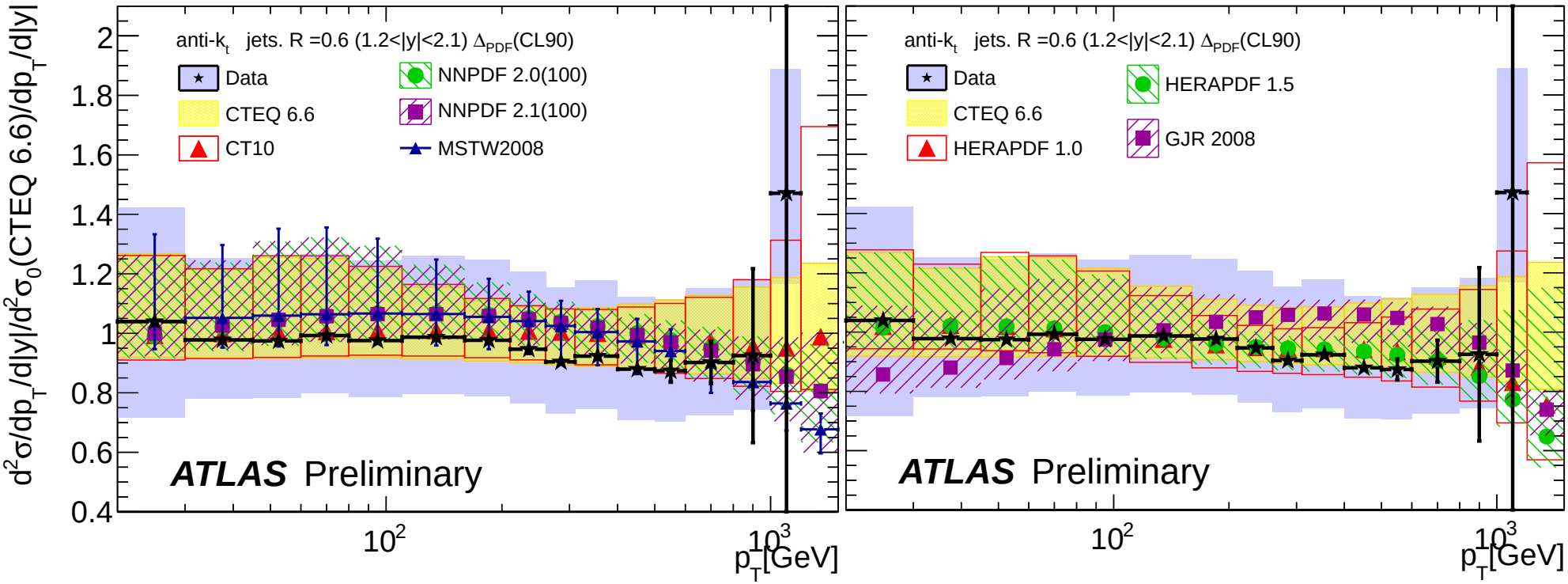


Inclusive jets in the $1.2 < |y| < 2.1$

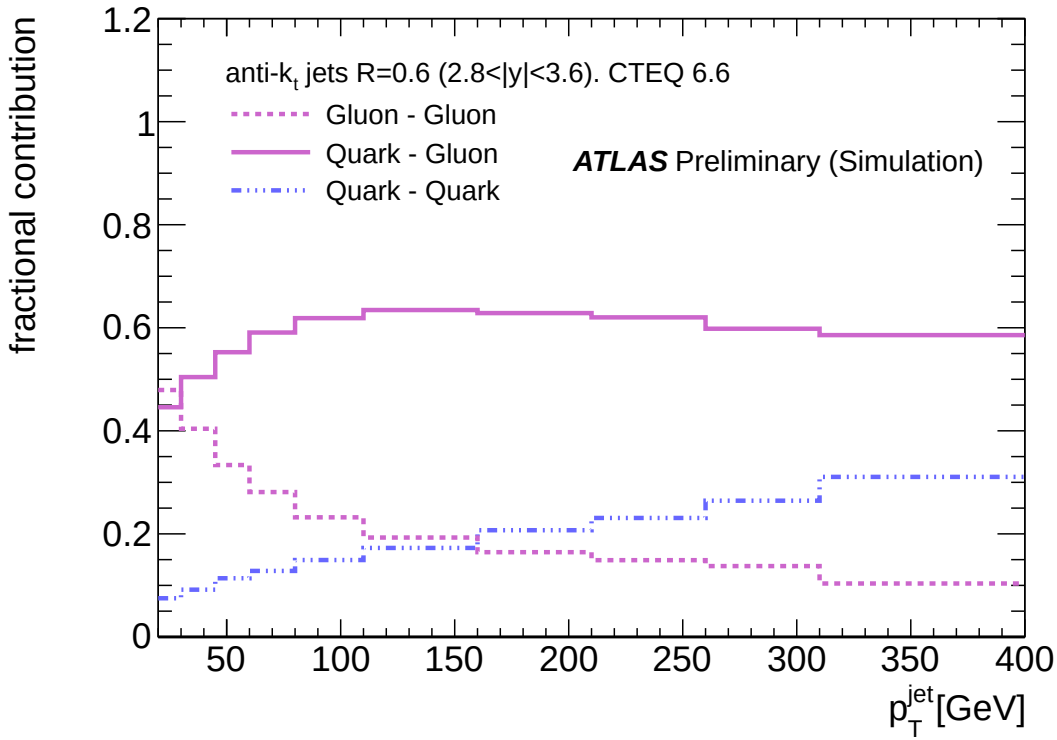


Inclusive jets in the $1.2 < |y| < 2.1$

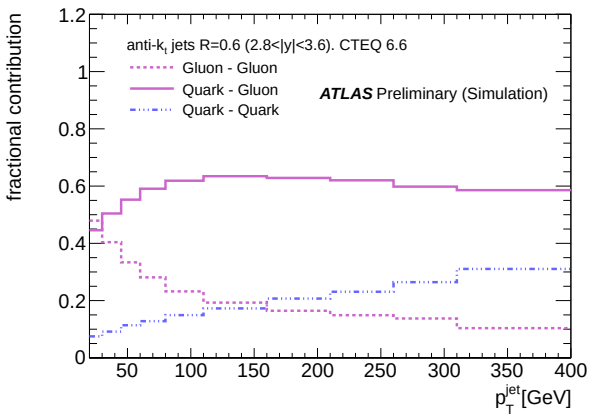


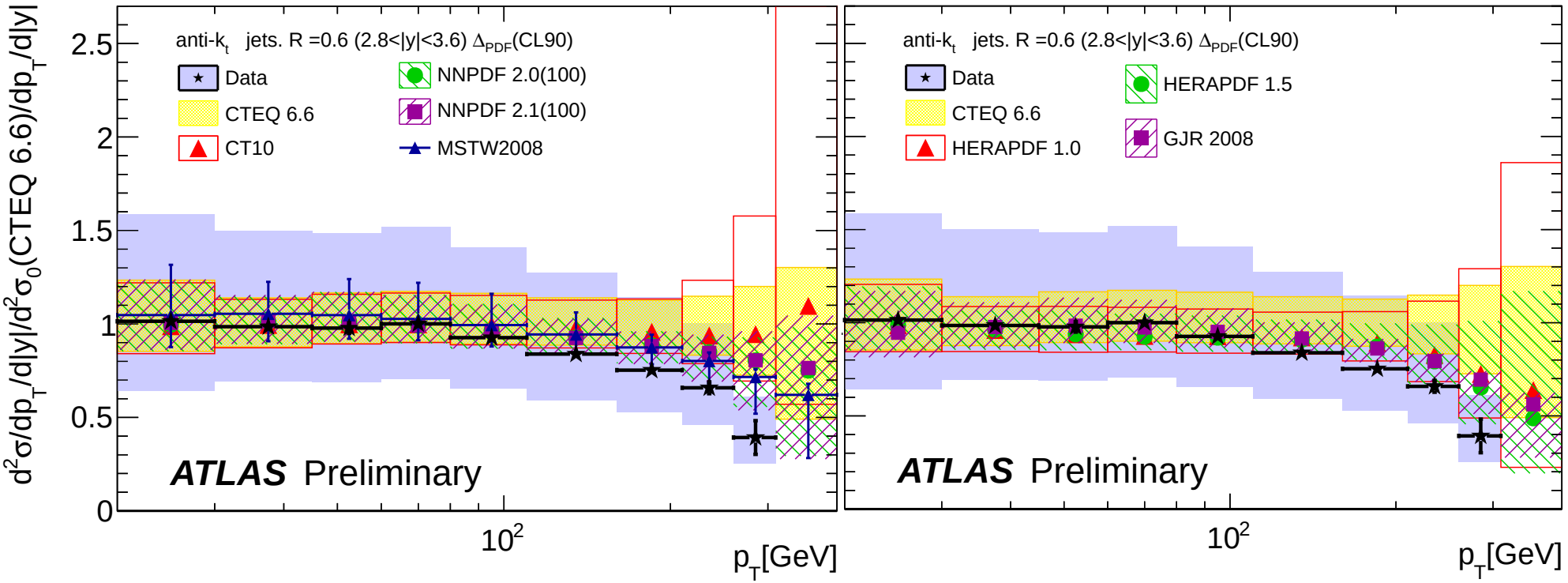


Inclusive jets in the $2.8 < |y| < 3.6$

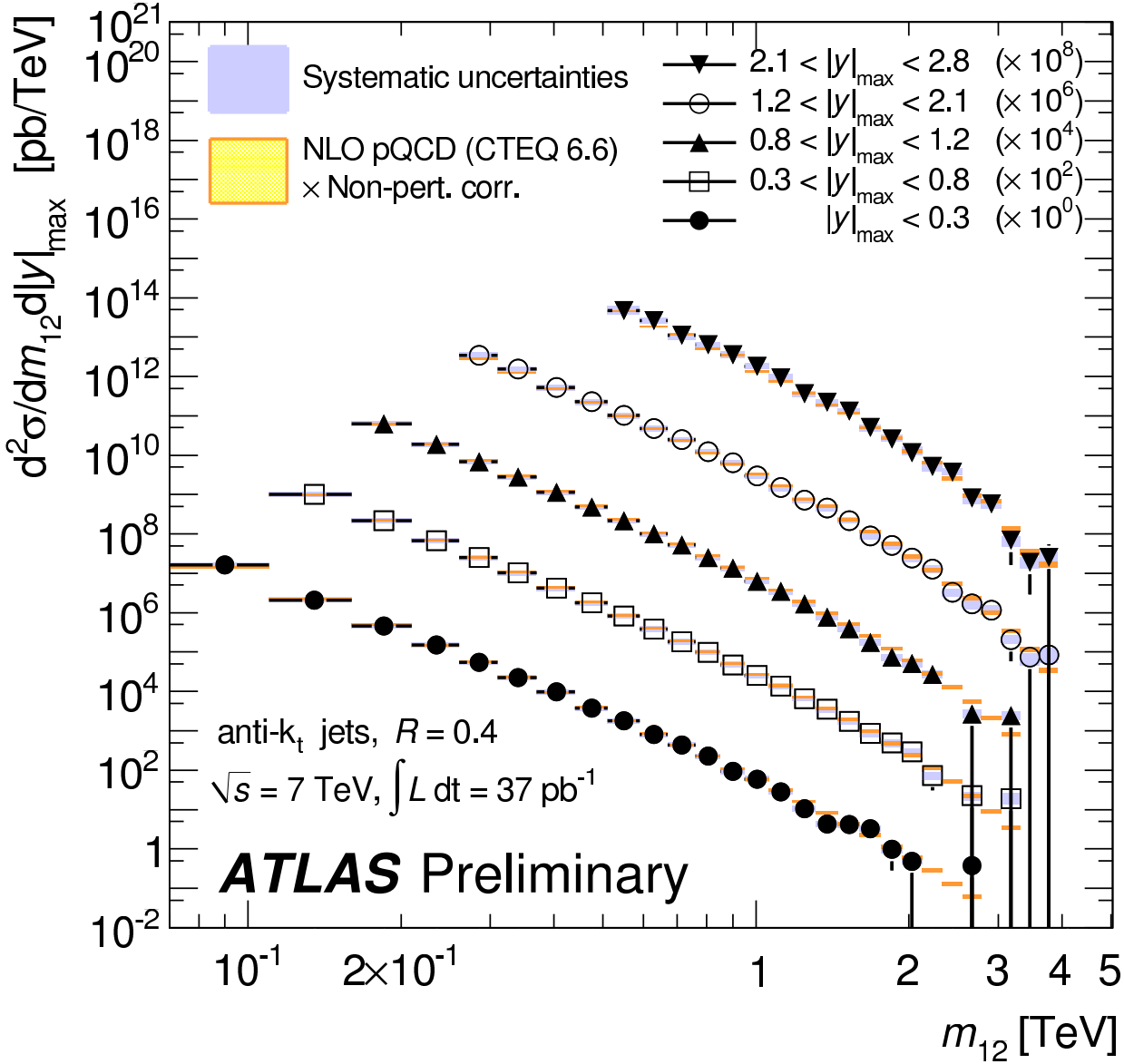


Inclusive jets in the $2.8 < |y| < 3.6$

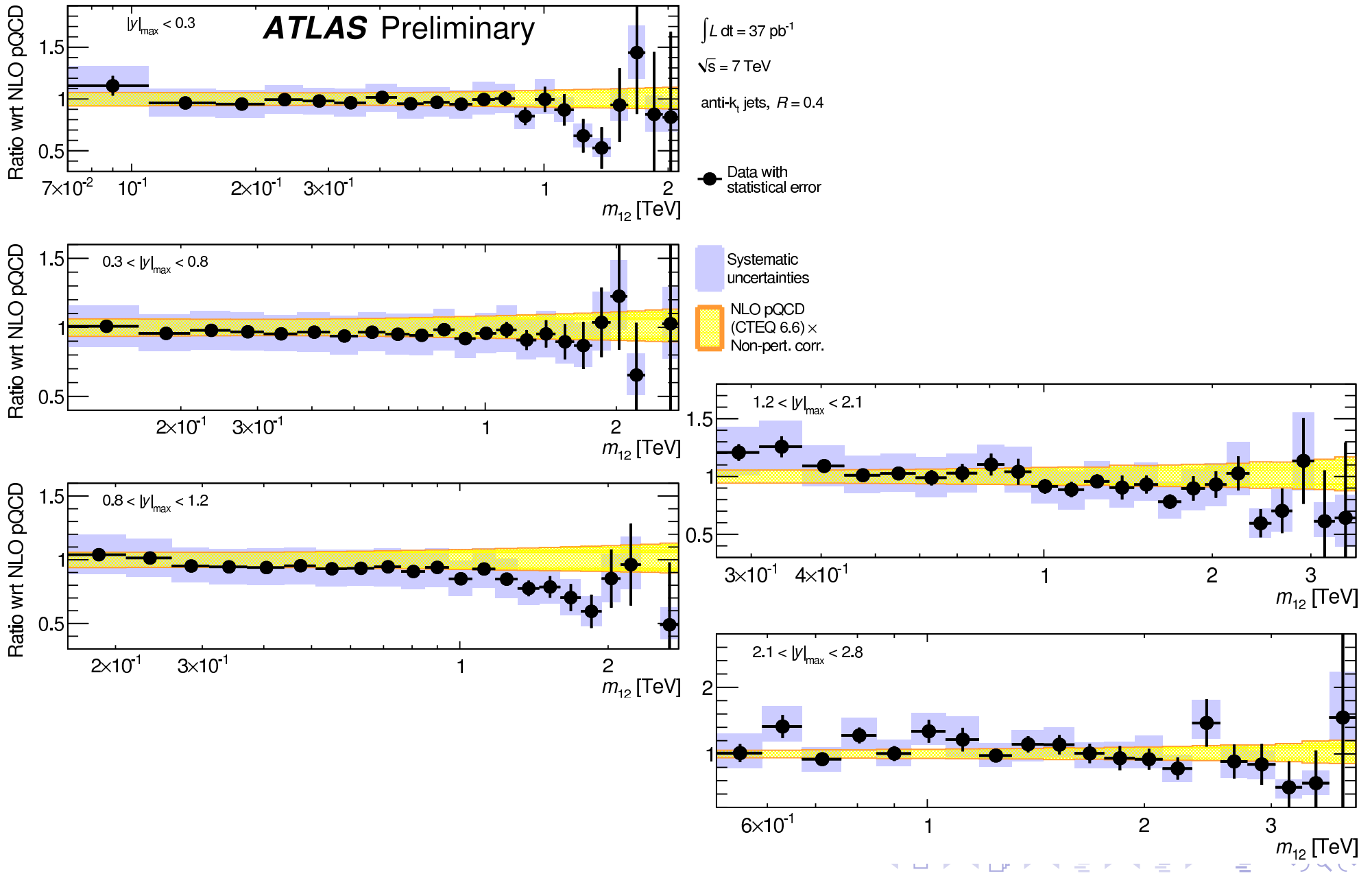




Dijets (R=0.4)


Systematic uncertainties
NLO pQCD (CTEQ 6.6)
× Non-pert. corr.
2.1 < |y|max < 2.8 (× 10^8)
1.2 < |y|max < 2.1 (× 10^6)
0.8 < |y|max < 1.2 (× 10^4)
0.3 < |y|max < 0.8 (× 10^2)
|y|max < 0.3 (× 10^0)
anti-kt jets, R = 0.4
√s = 7 TeV, ∫L dt = 37 pb-1
ATLAS Preliminary
d2σ/dm12d|y|max [pb/TeV]
m12 [TeV]

Dijets (R=0.4) vs NLO QCD



Multijets(R=0.4). 3/2