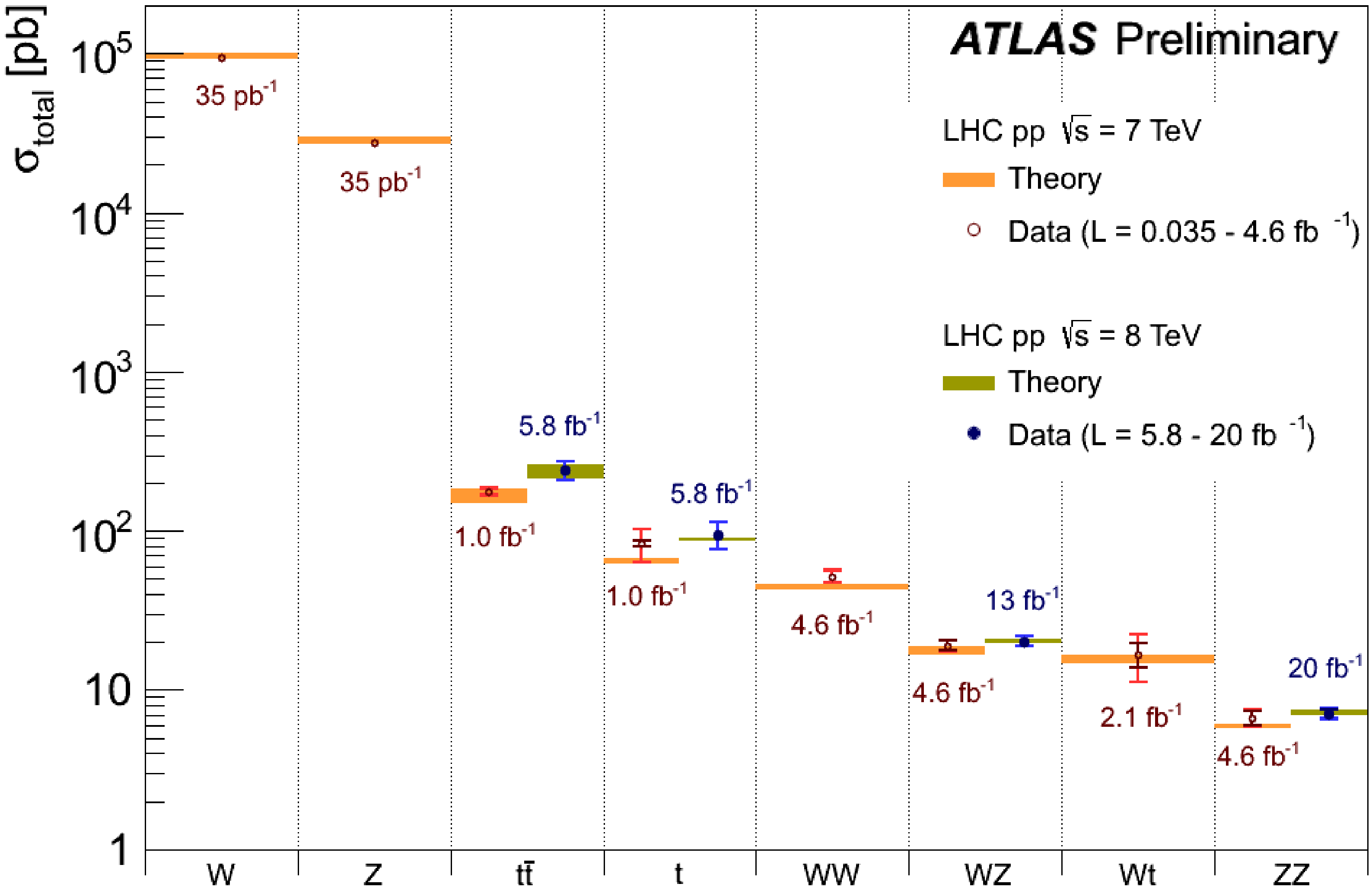
Measurements with PDF information from ATLAS

PDF4LHC meeting

Mark Stockton (McGill)
on behalf of the Atlas collaboration

SM results

- Atlas has measured many SM cross sections at both 7 and 8TeV



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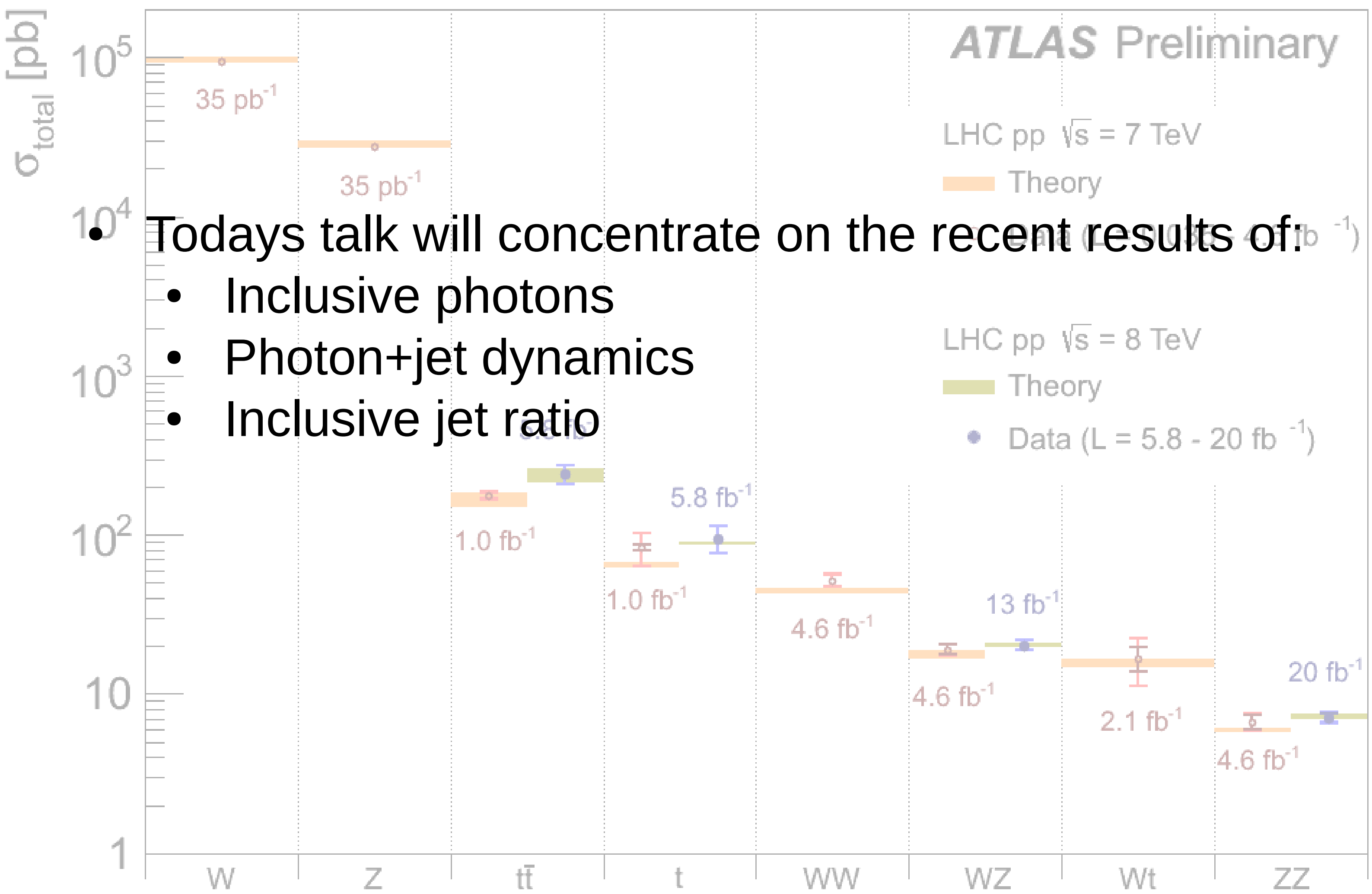
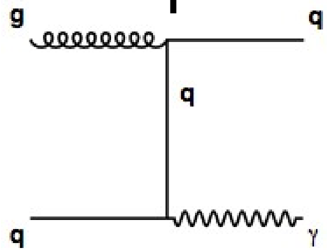


- Todays talk will concentrate on the recent results of:
  - Inclusive photons
  - Photon+jet dynamics
  - Inclusive jet ratio

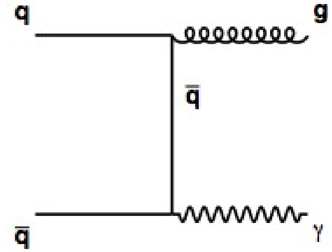
Photon production

- For single photon production there are three key processes

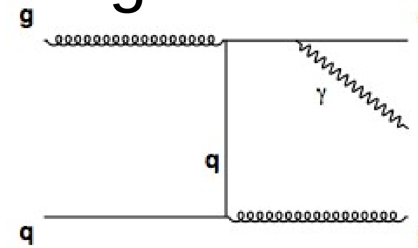
Compton



Annihilation

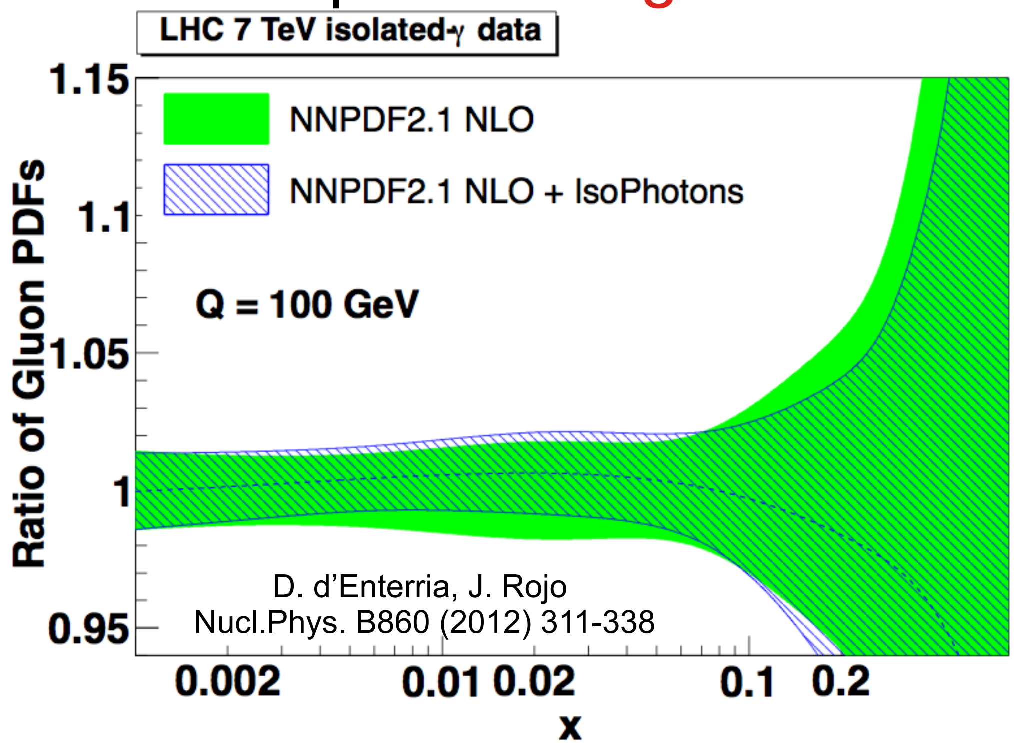


Fragmentation



- The Compton process allows us to probe the gluon PDF

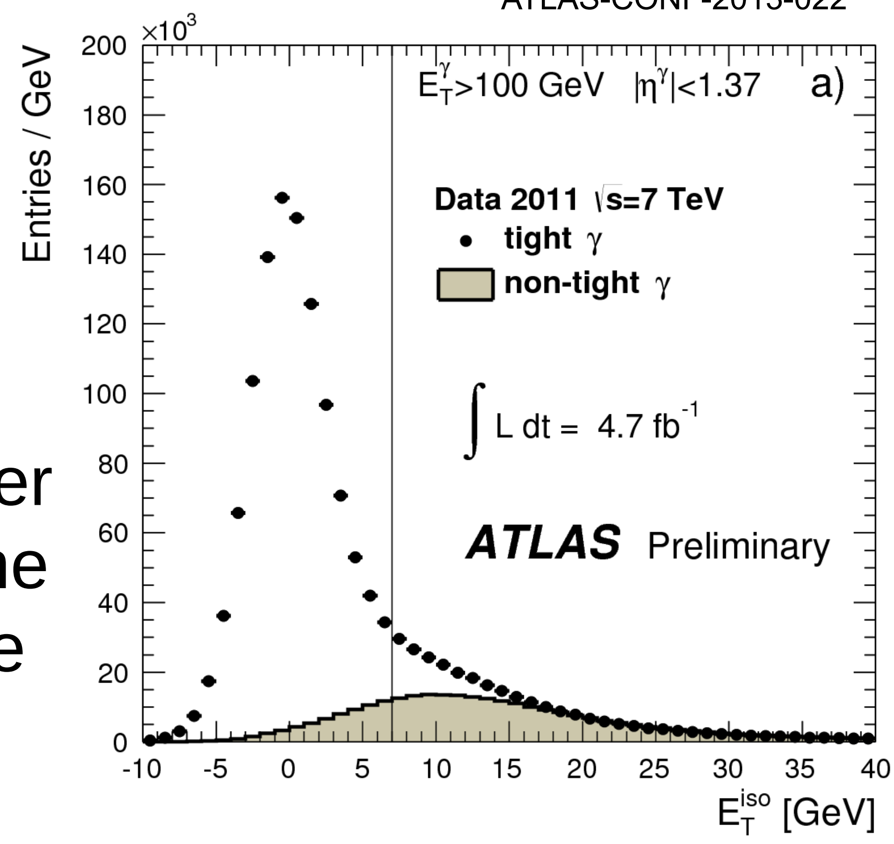
- The effect of this was already seen from the previous Atlas and CMS results



Latest measurement

- Previous LHC measurements covered the E_T range 15-400GeV
- New ATLAS result from 2011 data for the region 100-1000GeV
  - Specifically probing the region with the largest gluon PDF error

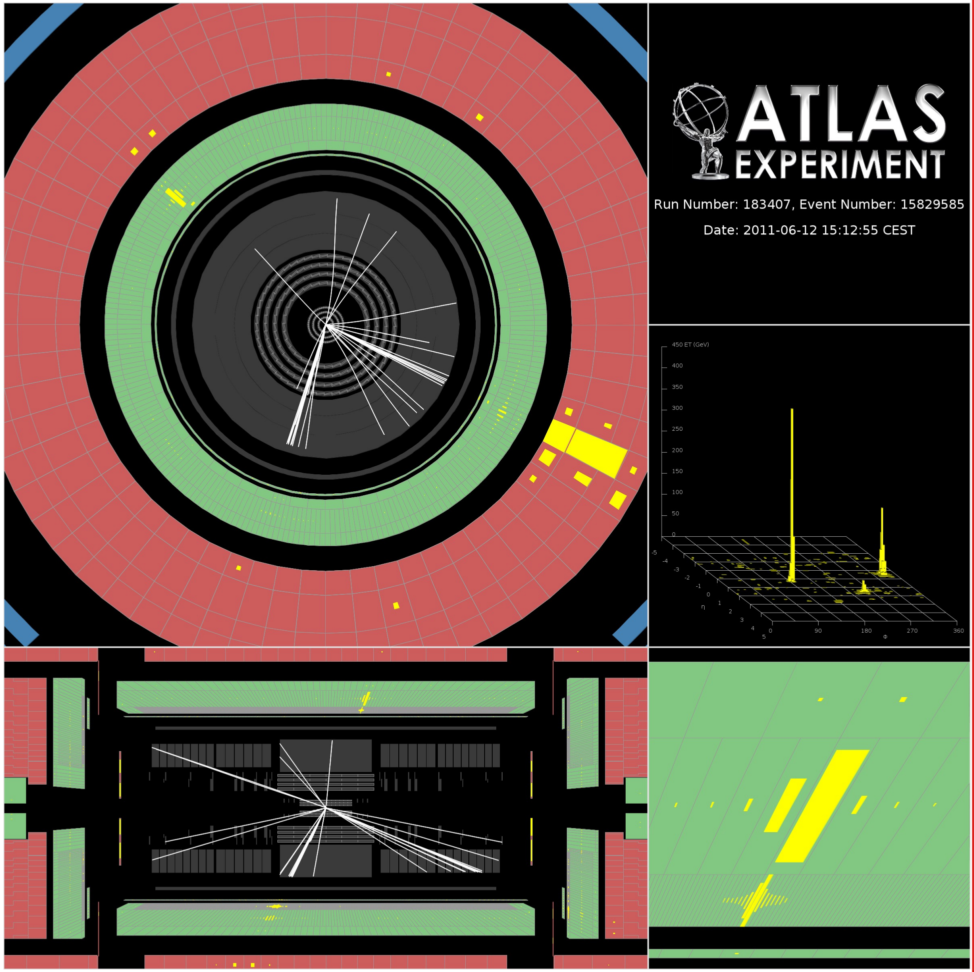
ATLAS-CONF-2013-022

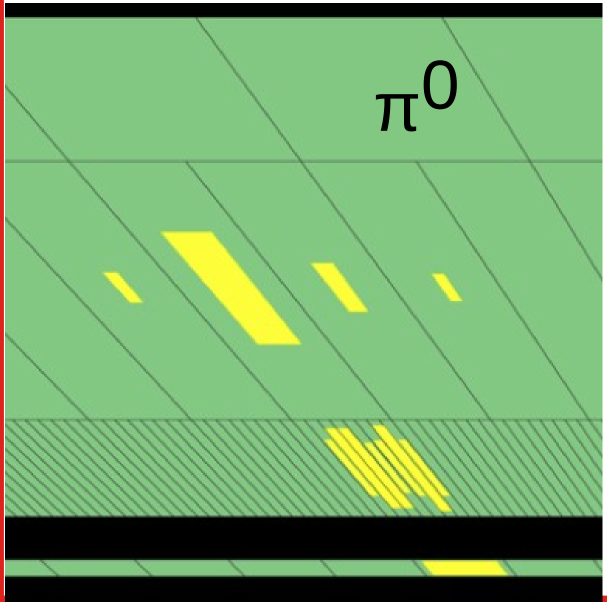


- As before require the photon to be isolated:
  - E_T^{iso} is the energy in a cone of 0.4
  - Expt: remove photon cluster
  - NLO: all partons in the cone
  - LO: all particles in the cone
- Apply a cut of E_T^{iso}<7GeV

Photon reconstruction

- Photons are reconstructed:
  - From EM calorimeter cells
  - No track → unconverted
  - 1&2 track matching for converted
- Right:
  - 960GeV photon candidate





- Main background is from π^0 in jets
- Use shower shape variables in first layer

Theory predictions

- NLO predictions are calculated using Jetphox
  - Includes the direct and fragmentation contributions

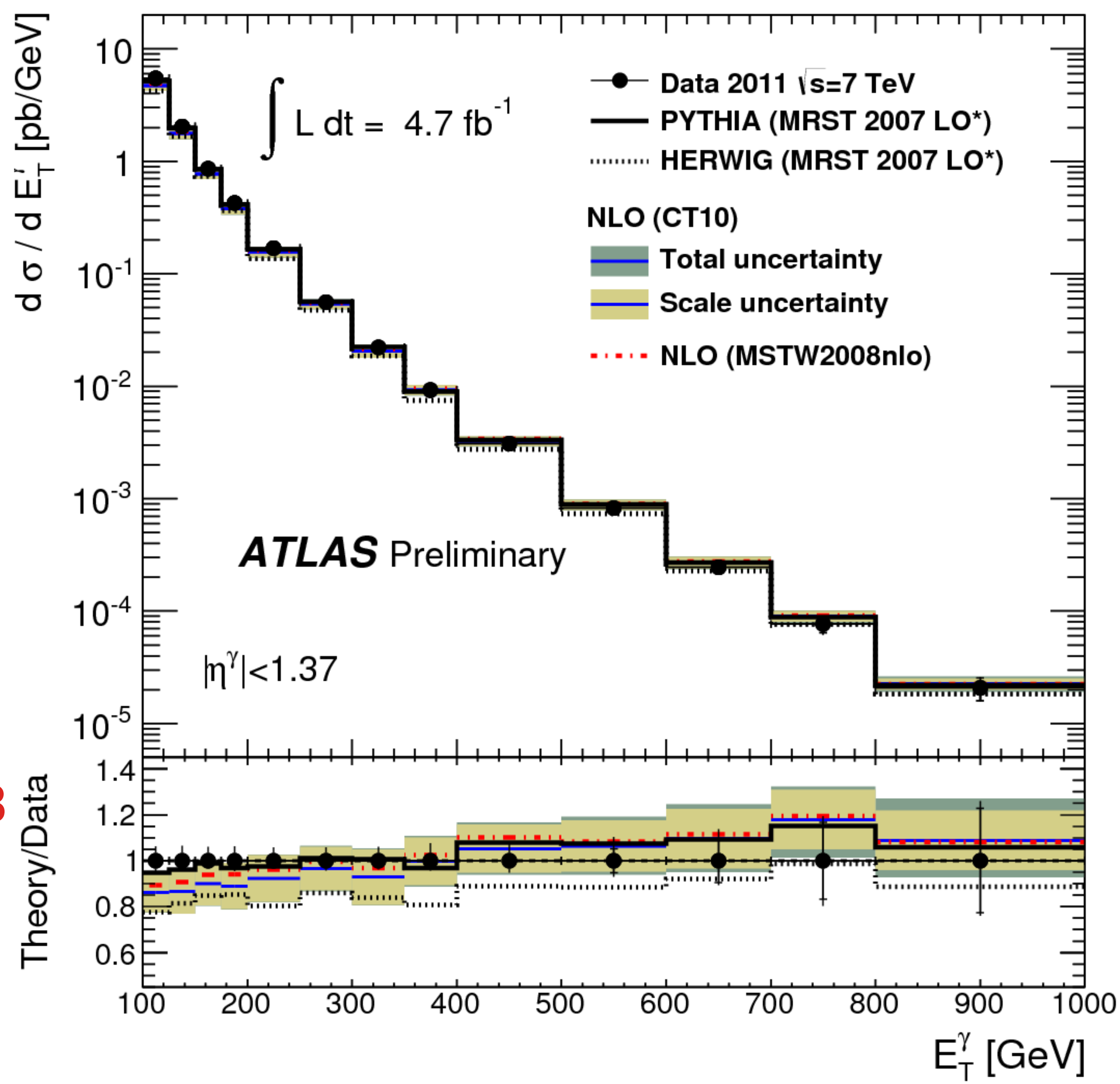
- Calculate scale variations
  - Vary coherently and independently (between 2 and 0.5 E_T)
- Calculate PDF and α_s uncertainties using LHAPDF
  - Gives a weight for each PDF eigenvector in the same event

- As expected its not fast and creates large ntuples
  - These can, and have, be used for fitting by using the PDF reweighting technique
  - However maybe more can be done to get a fast interface to the PDFs, e.g. APPLGRID ? FastNLO ?

Results (1)

- For region $|\eta|<1.37$
- Highest disagreement at low E_T
- From Jetphox the fragmentation contribution becomes negligible >500GeV
- Above 700GeV: large PDF uncertainties
- At low E_T 5% difference between CT10 and MSTW2008
- Pythia in good agreement, Herwig lower but within errors

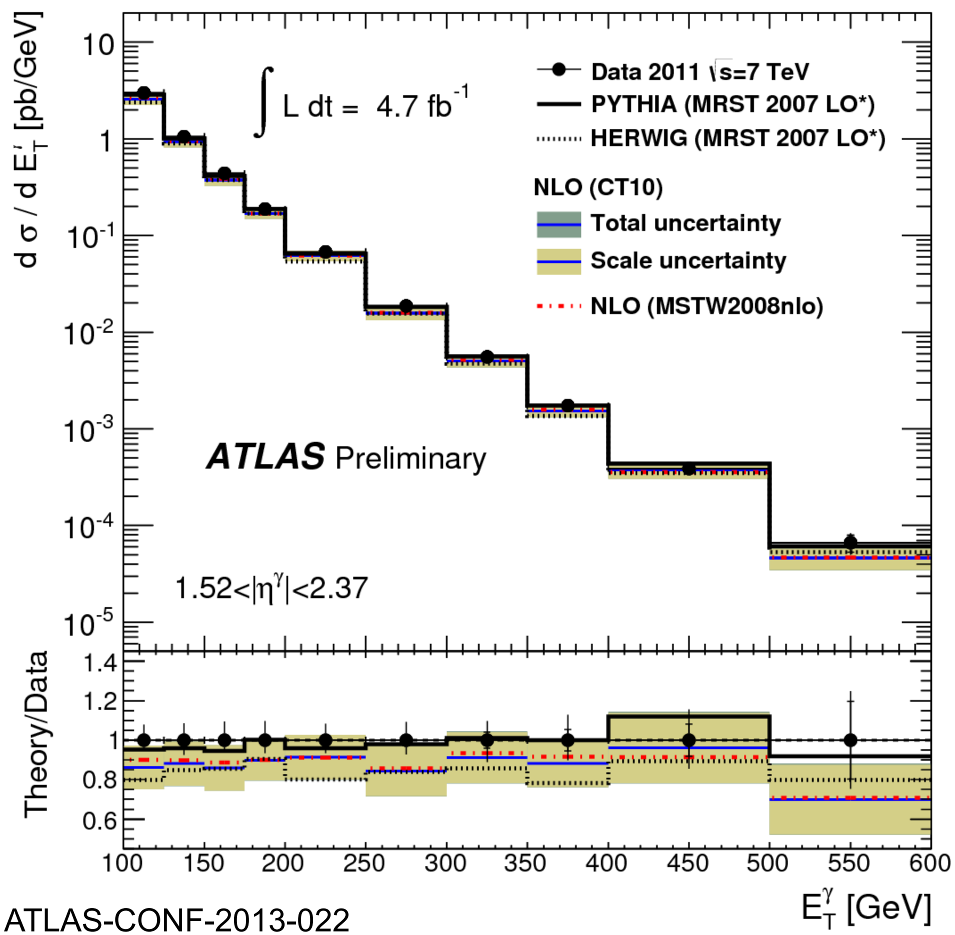
ATLAS-CONF-2013-022

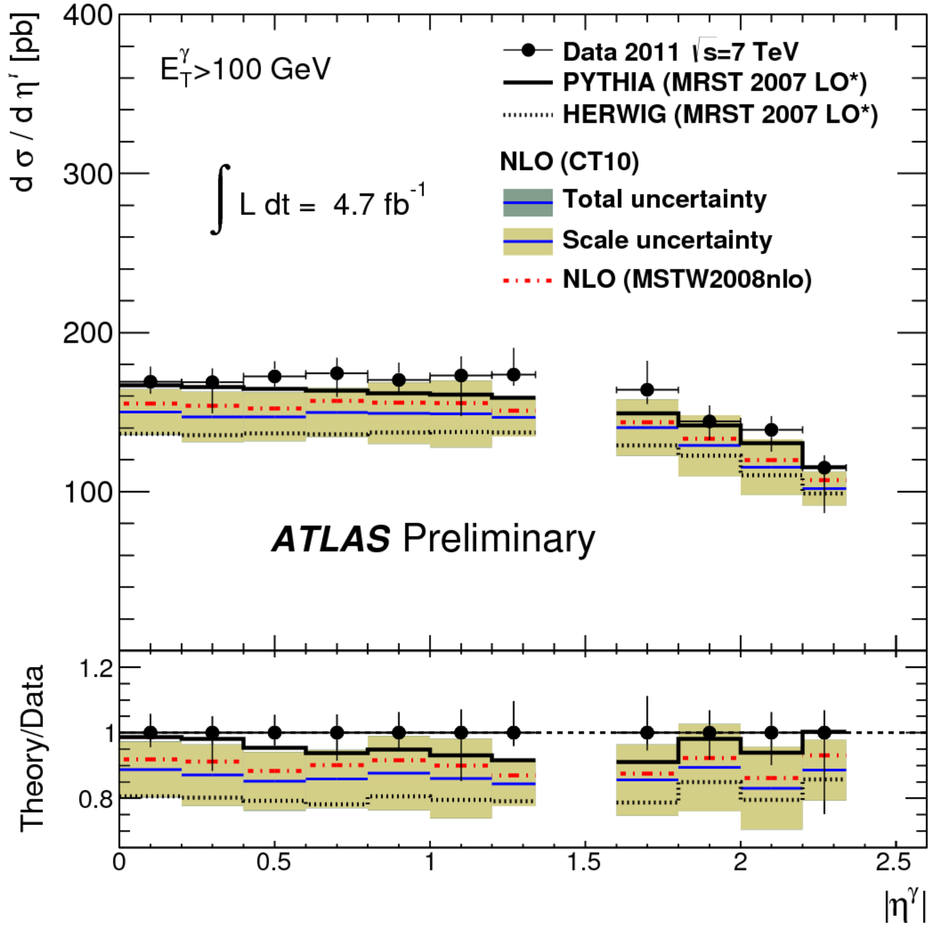


Results (2)

- Also measured:
  - Up to 600GeV for 1.52<|η|<2.37
  - As a function of η
  - Total cross sections

σ(pb)	|η|<1.37	1.52<|η|<2.37
ATLAS	234±2(stat)+13-9(syst)±4(lumi)	122±2(stat)+9-7(syst)±2(lumi)
CT10	203±25	105±15
MSTW	212±24	109±15



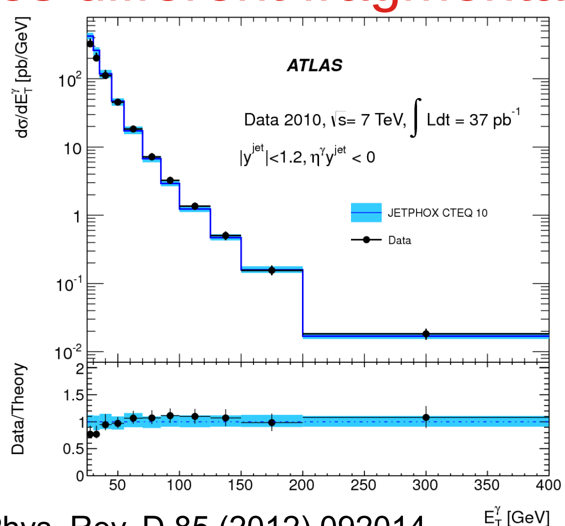


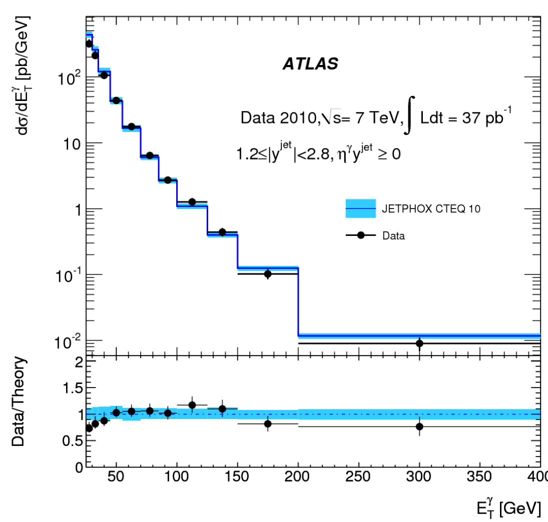
ATLAS-CONF-2013-022

Photon+jet

- The disagreement with theory could be totally due to fragmentation component
  - Hard to gain knowledge of this from the inclusive cross section
- Instead measuring a range of cross sections for the photon+jet system can provide different fragmentation contributions

- Existing ATLAS measurement: Phys. Rev. D 85 (2012) 092014
  - Cross section as a function of photon E_T in 2010 data
  - Investigating the same/opposite side nature of the photon/jet probes different fragmentation fractions





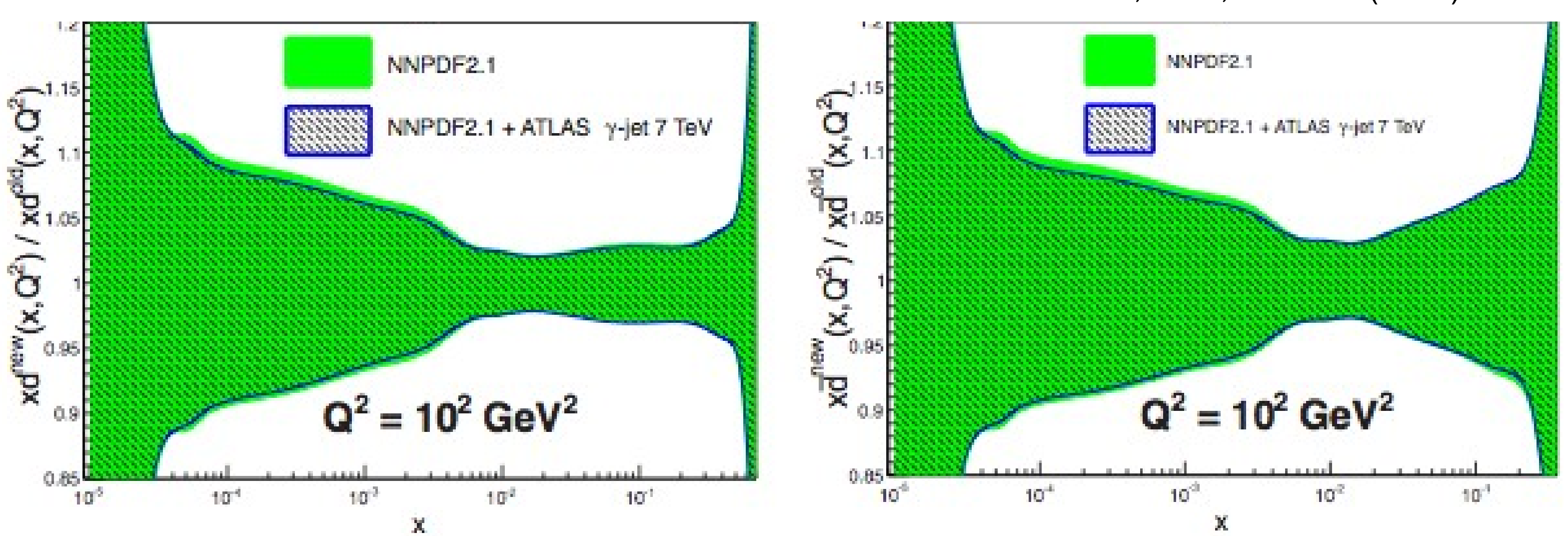
Phys. Rev. D 85 (2012) 092014

Photon+jet

- The disagreement with theory could be totally due to fragmentation component
  - Hard to gain knowledge of this from the inclusive cross section
- Instead measuring a range of cross sections for the photon+jet system can provide different fragmentation contributions

- Existing ATLAS measurement: Phys. Rev. D 85 (2012) 092014
  - Of course this measurement can also be used for PDF fitting
  - Demonstrated, with similar to techniques as inclusive result:

L. Carminati, et al., EPL 101 (2013) 61002



Photon-Jet dynamics

- New measurement: ATLAS-CONF-2013-023
  - Photon-jet dynamics, again in 2010 data

- As earlier: $|\eta^{\gamma}| < 1.37$ and $1.52 < |\eta^{\gamma}| < 2.37$
- Photon transverse energies $E_T^{\gamma} > 45$ GeV
- Isolation, again 0.4 cone, $E_T^{iso} < 4$GeV

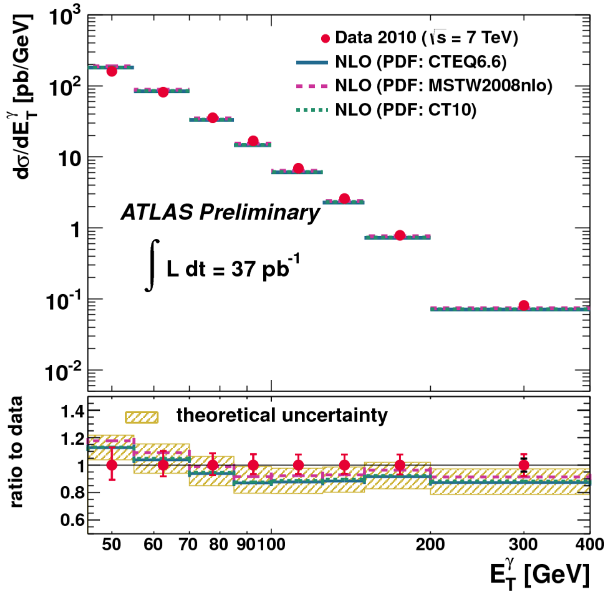
- Jets use the anti-kt algorithm with R = 0.6
- In the region $|y^{jet}| < 2.37$ and $P_T^{jet} > 40$ GeV

- Measure cross section for:

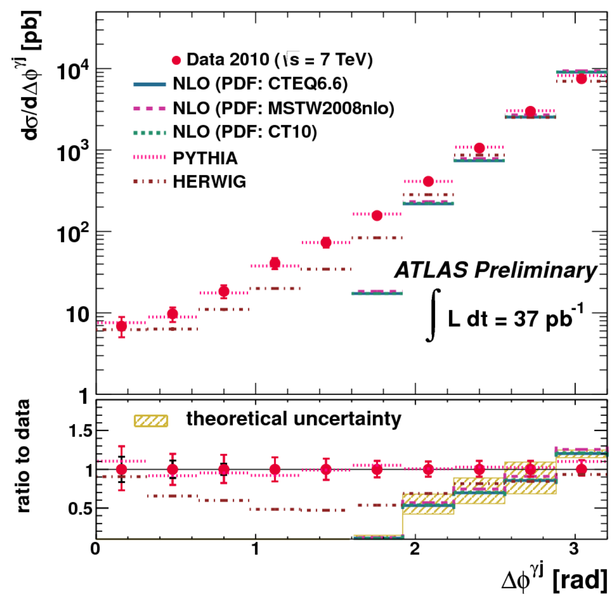
  E_T^{γ}, p_T^{jet}, $|y^{jet}|$, $\Delta\Phi^{\gamma j}$, $M^{\gamma j}$ and $|\cos\theta^{\gamma j}|$

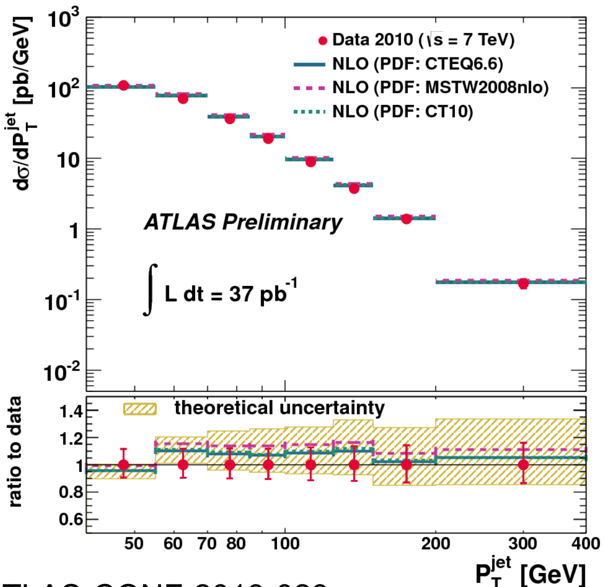
Photon-Jet dynamics

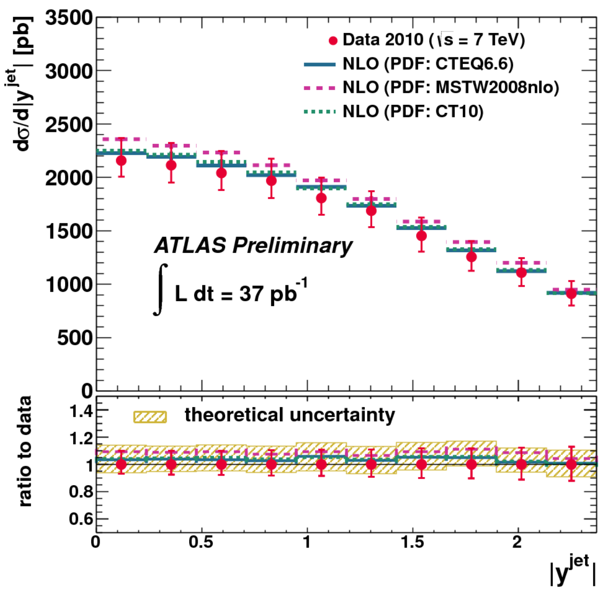
Mark Stockton

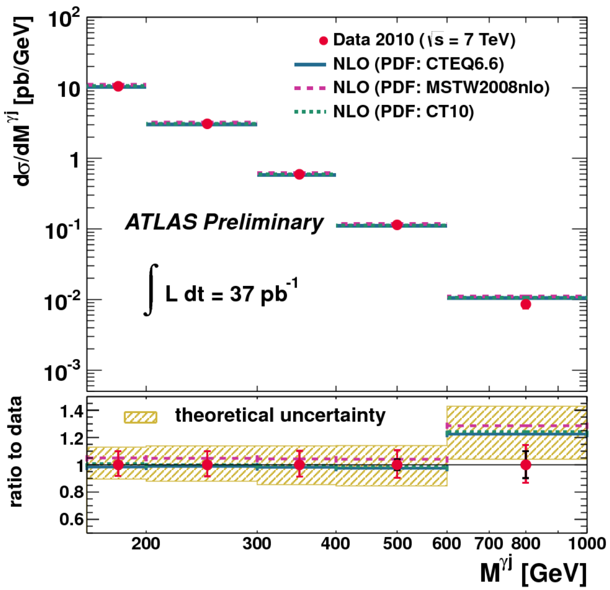


- Good agreement in most variables
- Same E_T^{γ} difference as prev results
- $\Delta\Phi^{\gamma j} > \pi/2$ for NLO → only Pythia agrees
- MSTW2008NLO again ~5% > CT10





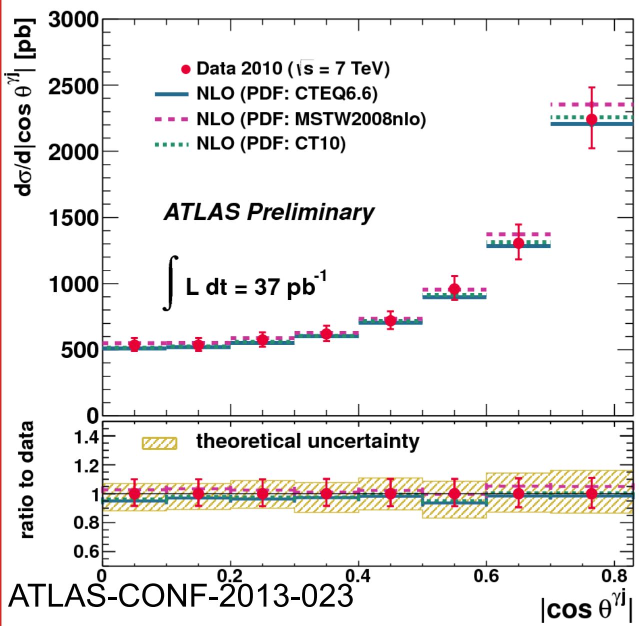




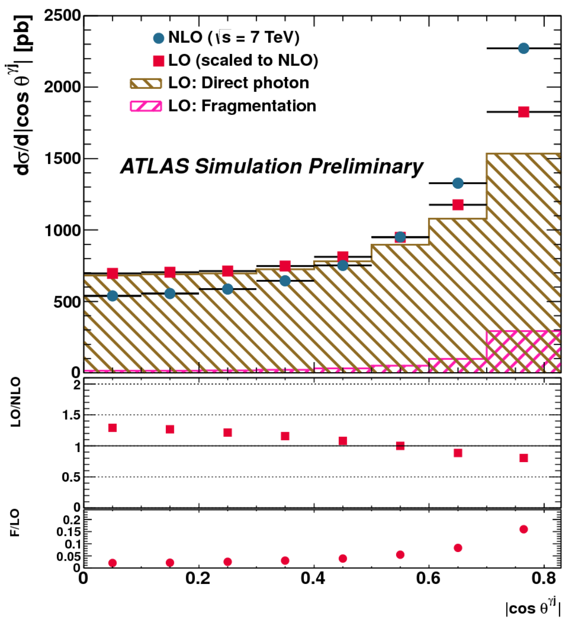
ATLAS-CONF-2013-023

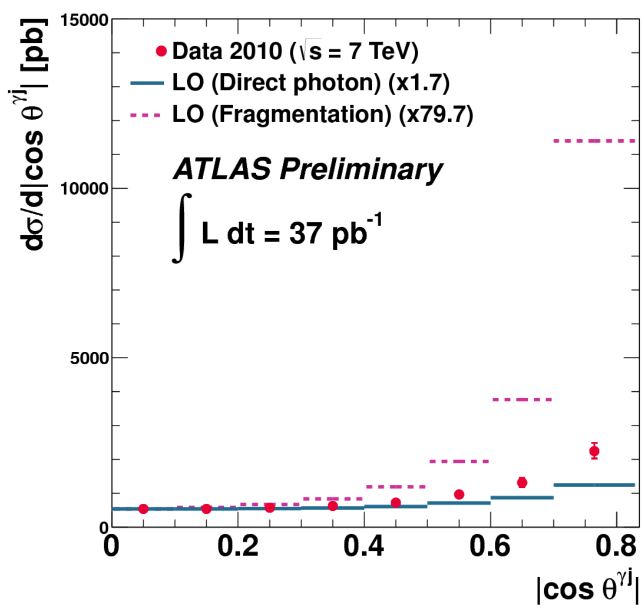
Fragmentation

- Measuring $|\cos\theta^{\gamma j}|$ shows good agreement to NLO
  - Apply extra constraints $|\eta^{\gamma}+y^{jet}|<1.185$, $M^{\gamma j}>161$GeV and $|\cos\theta^{\gamma j}|<0.83$ to remove any distortions due to the restrictions E_T^{γ}, η^{γ}, p_T^{jet}, y^{jet}
- NLO/LO shows dependence for this variable, and p_T^{jet}
- Region at high $|\cos\theta^{\gamma j}|$ most sensitive to fragmentation
  - Shape much closer to direct contribution (differ due to spin of exchanged particle)
  - Also can be investigated at low E_T^{γ}, p_T^{jet} and $M^{\gamma j}$



ATLAS-CONF-2013-023

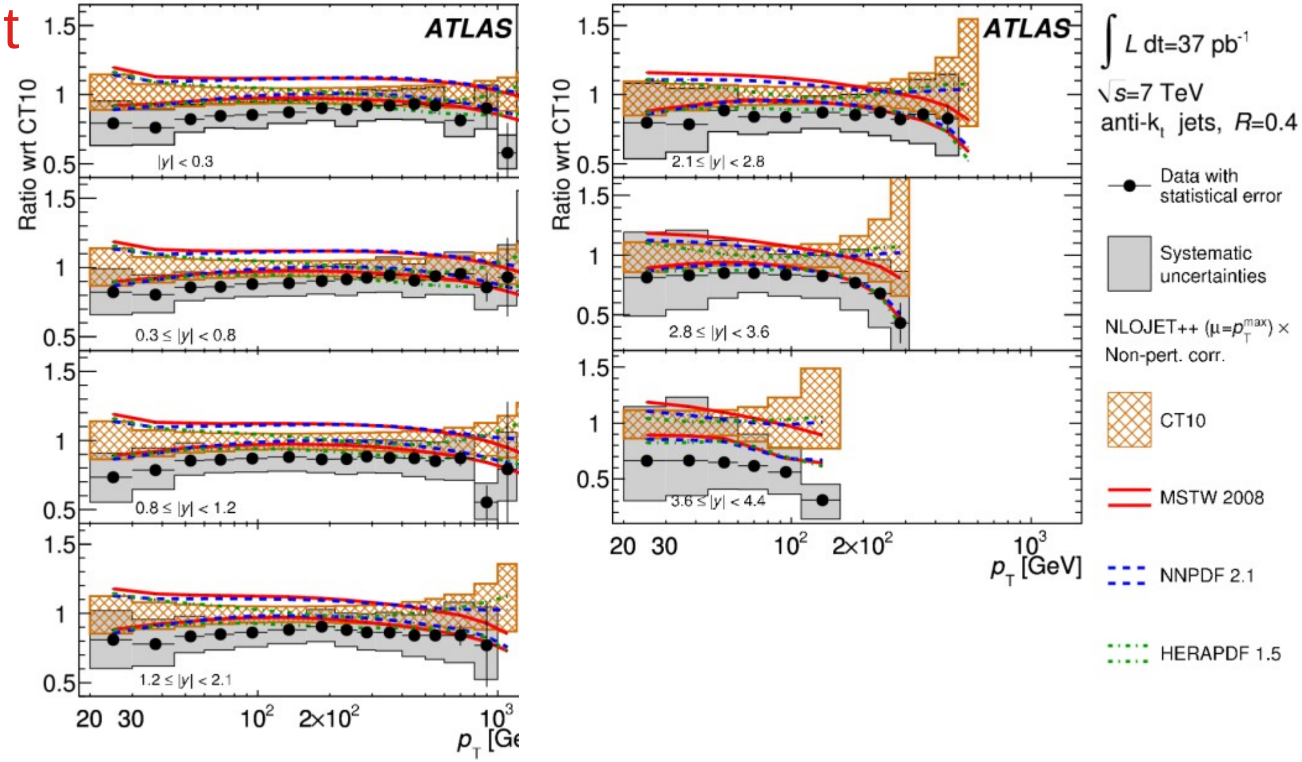




Jet production

- As with photon production probes the high x gluon PDF
- ATLAS 2010 result of inclusive jets:

Phys. Rev. D 86 (2012) 014022



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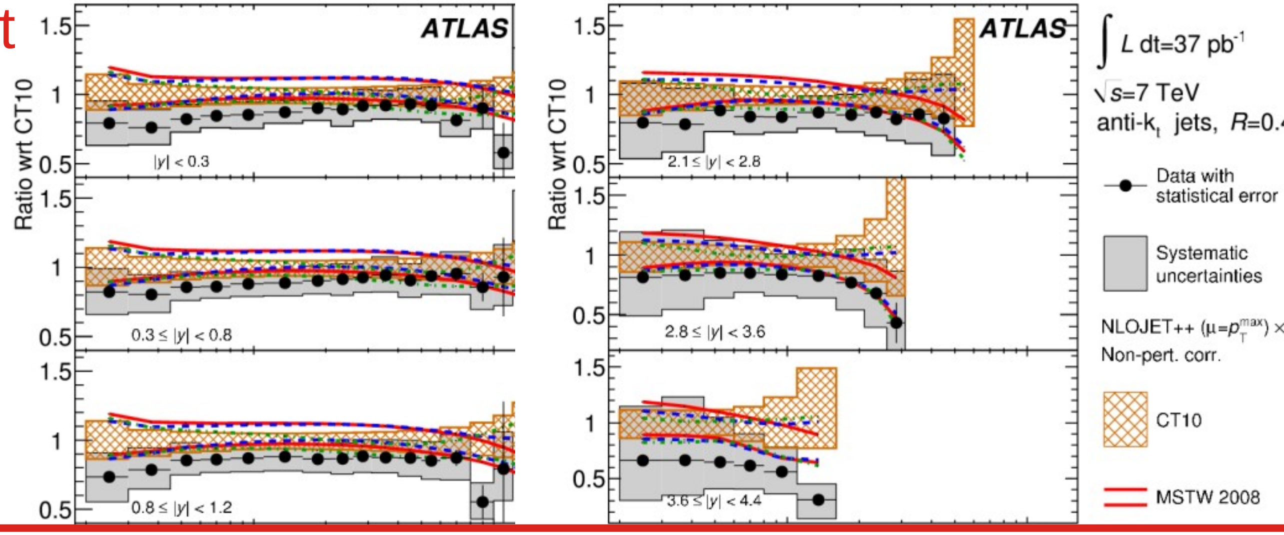
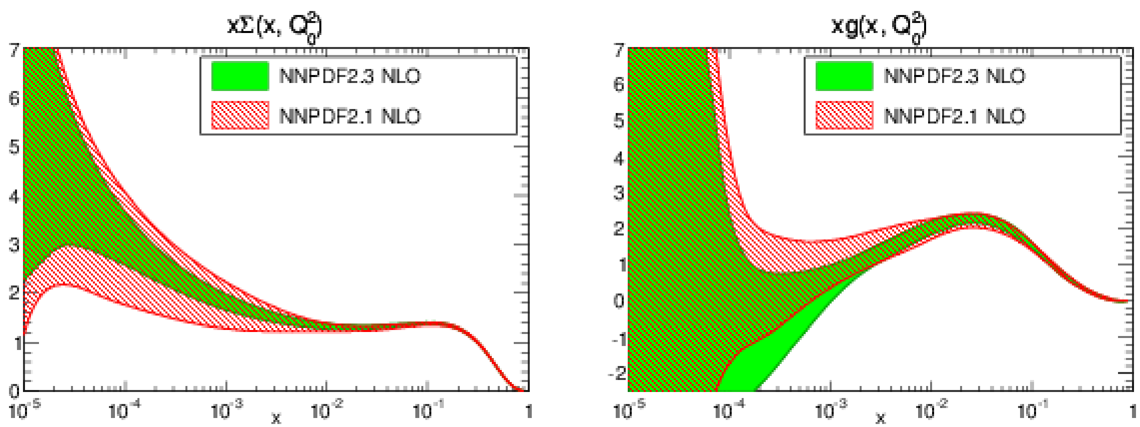


- Importantly these results include tables of correlated systematics
- Has led for the results to be included in NNPDF 2.3



NNPDF2.3 arXiv:1207.1303

Ratio to 2.76TeV

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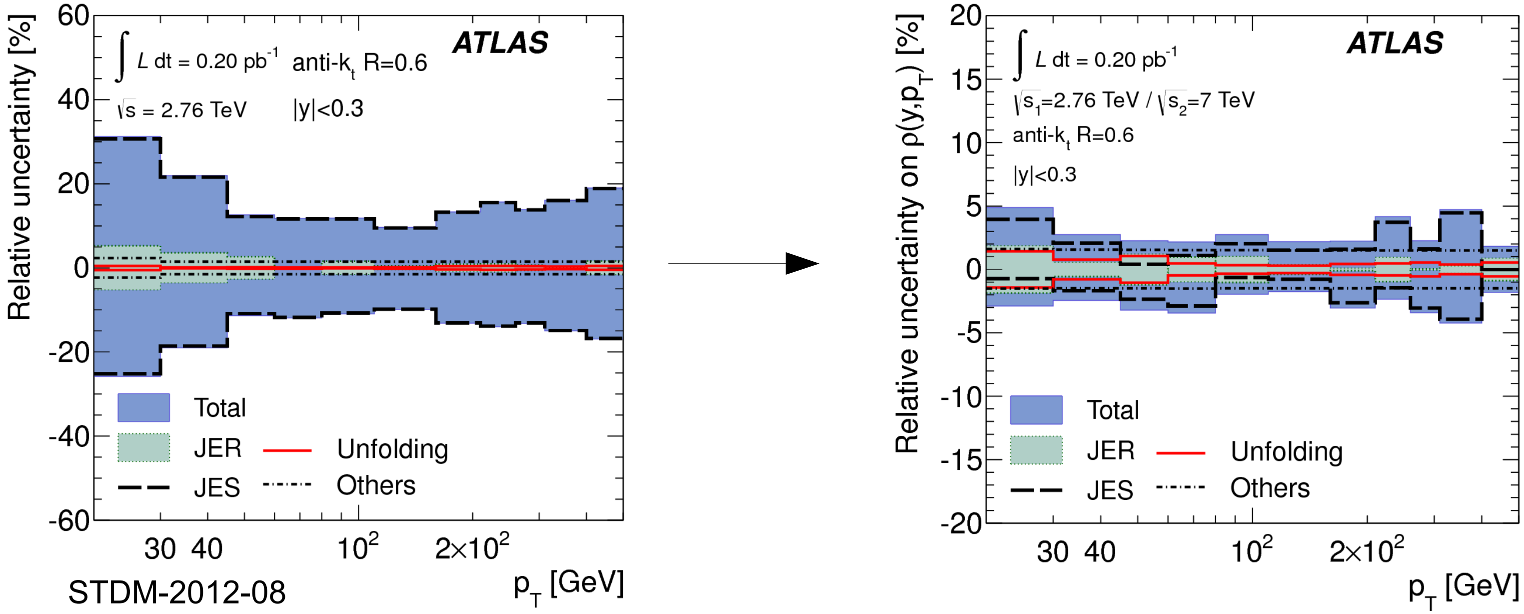
Mark Stockton

- To be able to provide better input want to reduce the experimental errors
- New measurement: STDM-2012-08
  - So new its not on arXiv yet...
  - https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PAPERS/STDM-2012-08/
- Measurement at 2.76TeV and comparison to 7TeV 2010 result on previous slides
  - 2.76TeV data is $0.2pb^{-1}$ from 2011
  - Jets use the anti-kt algorithm with R = 0.4 and 0.6
  - In the region $|y^{jet}| < 4.4$ and $20 < P_T^{jet} < 430$ GeV
- This is an update of ATLAS-CONF-2012-128
  - Includes updates to Powheg predictions, finalised luminosity and its systematics, χ^2 for PDF fit and extra PDF comparisons

Update post talk
ArXiv:1304.4739
Submitted to EPJC

Ratio to 2.76TeV

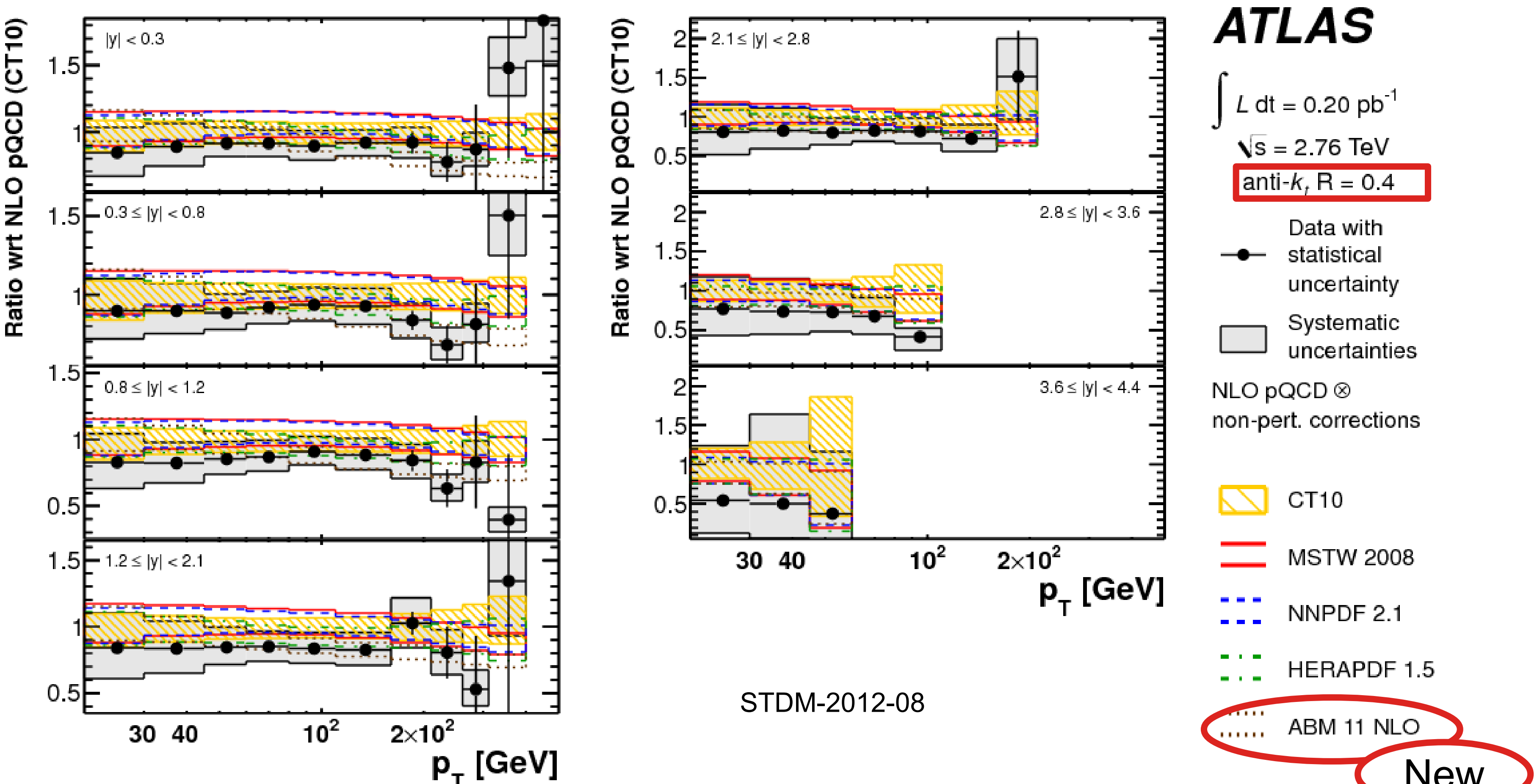
- To be able to provide better input want to reduce the experimental errors
- New measurement: STDM-2012-08
  - Measurement at 2.76TeV and comparison to 7TeV 2010 result on previous slides
- By measuring the ratio of the two results it cancels the largest experimental error coming from the jet energy scale (JES)
  - Only the trigger, jet selection, unfolding and lumi are uncorrelated



2.76TeV cross section (1)

McGill
Mark Stockton

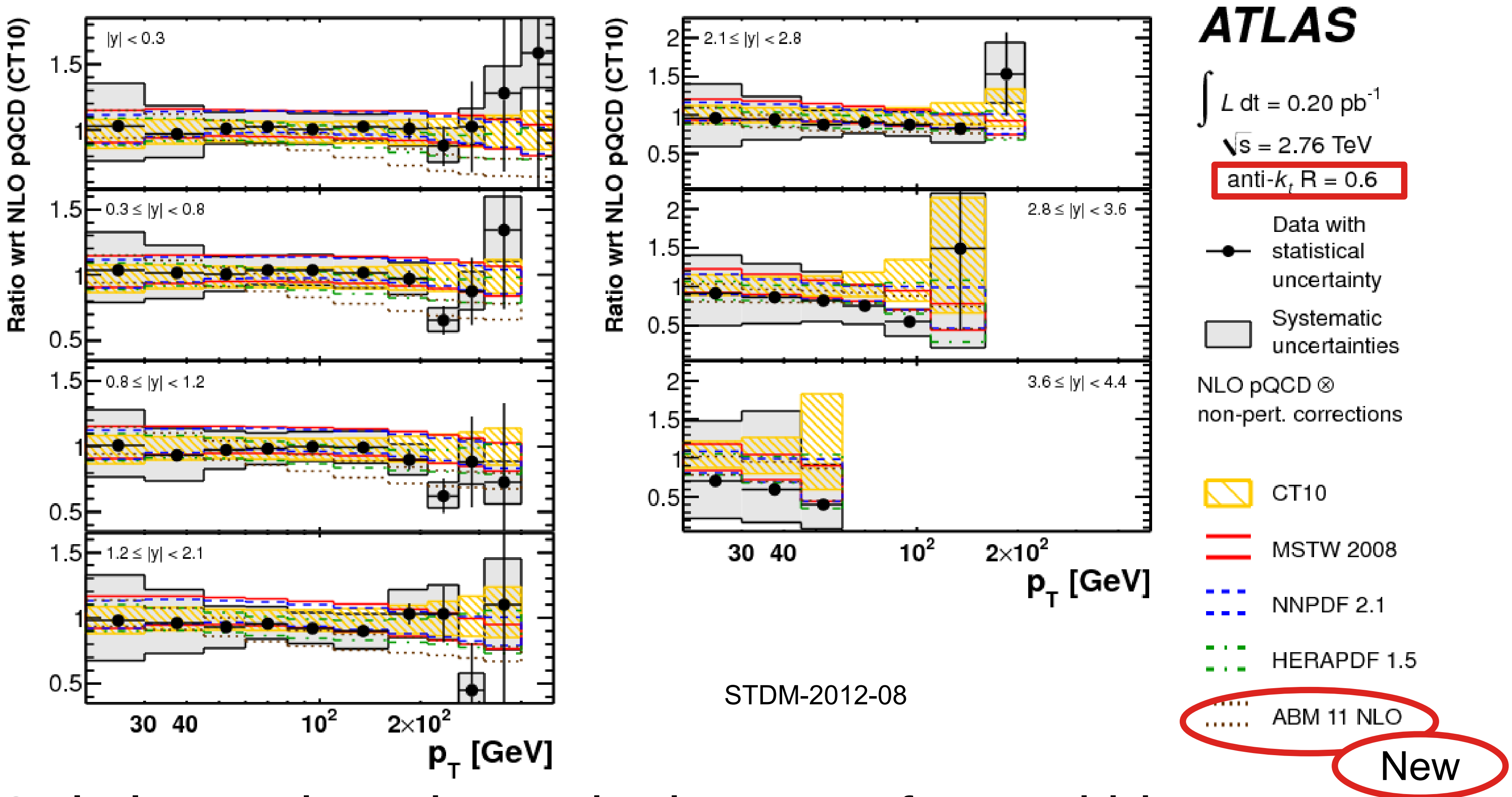
- First step is to measure the inclusive jet cross section at 2.76TeV following the same methods as for 7TeV



- Lower than theory in all bins, but agree within errors
- NLO predictions from NLOJET++

2.76TeV cross section (2)

- First step is to measure the inclusive jet cross section at 2.76TeV following the same methods as for 7TeV

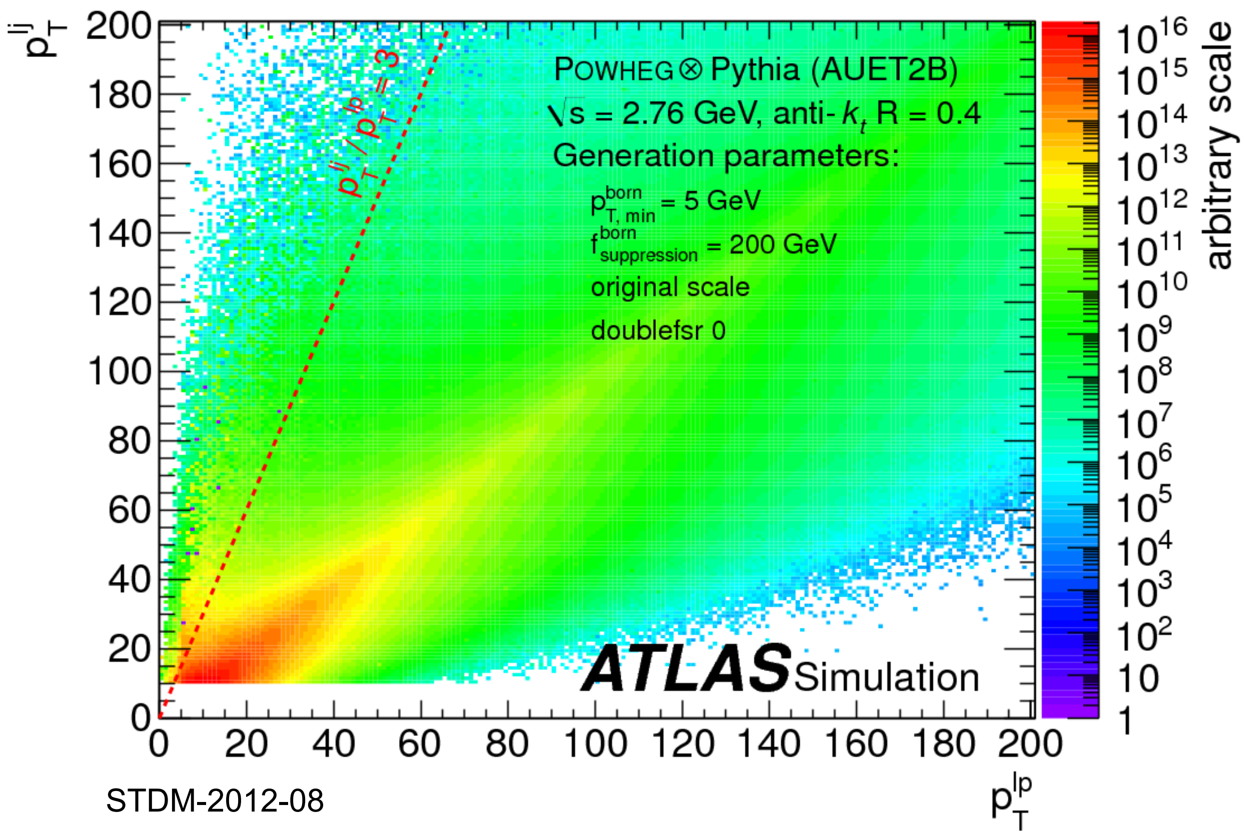


- Only lower than theory in the more forward bins

Powheg (1)

Mark Stockton

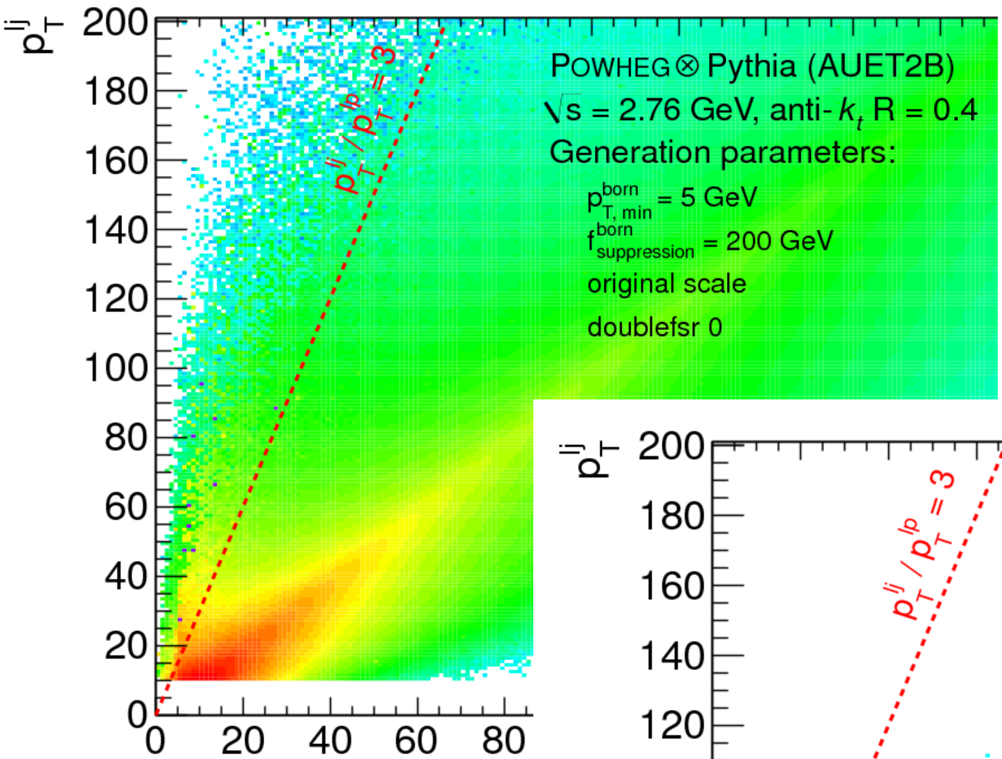
- The results are also compared to Powheg
- Observed a migration of events from low $p_T^{\text{leading parton}}$ to large $p_T^{\text{leading jet}}$
  - Example from AUET2B tune, also indicating the event cut $p_T^{\text{lead jet}} / p_T^{\text{lead parton}} > \kappa$ which was applied previously

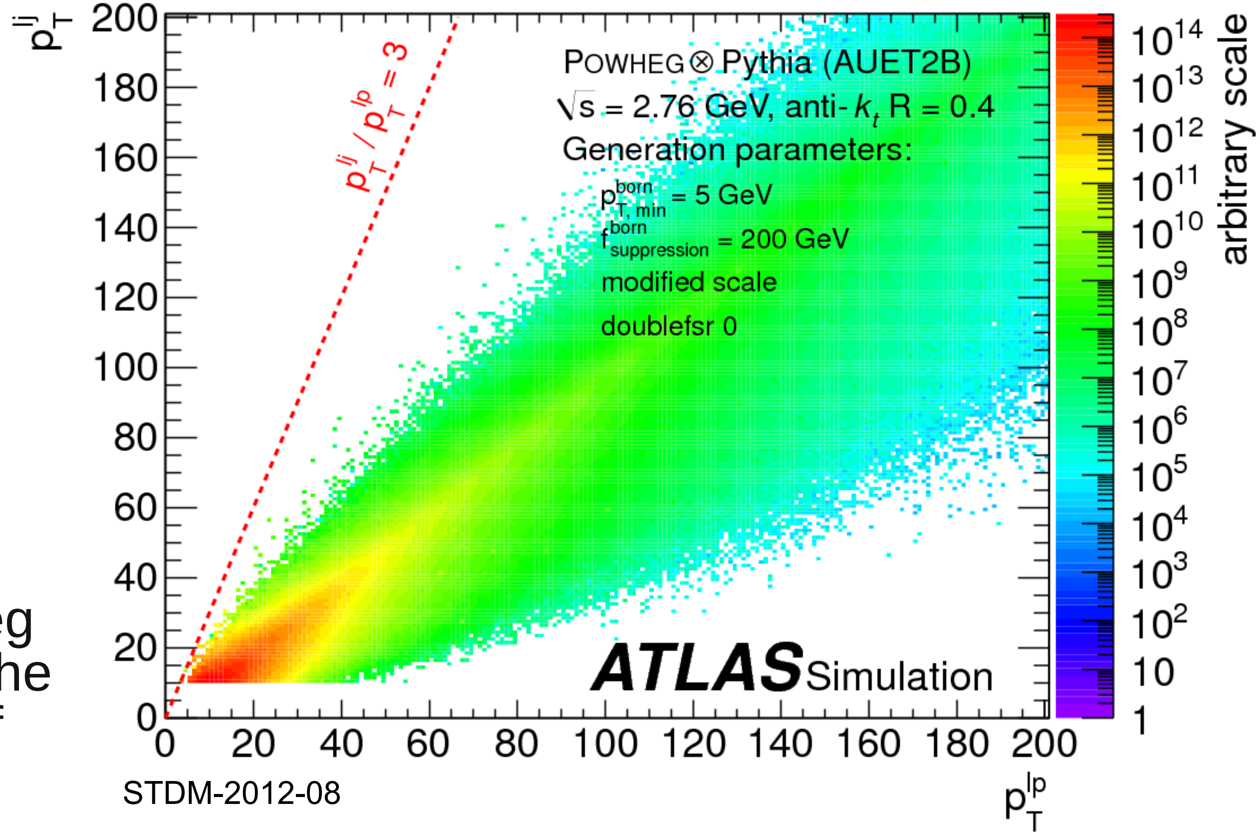


STDM-2012-08

Powheg (2)

- After input from Atlas to the authors a new version was released with modified matching scale:
- http://arxiv.org/abs/1303.3922





- Revision 2169
- Using the Powheg option doublefsr=1
- Origin is due to Powheg Box 1.0 not including the opposite p_T ordering of quark/gluon splitting

Powheg (3)

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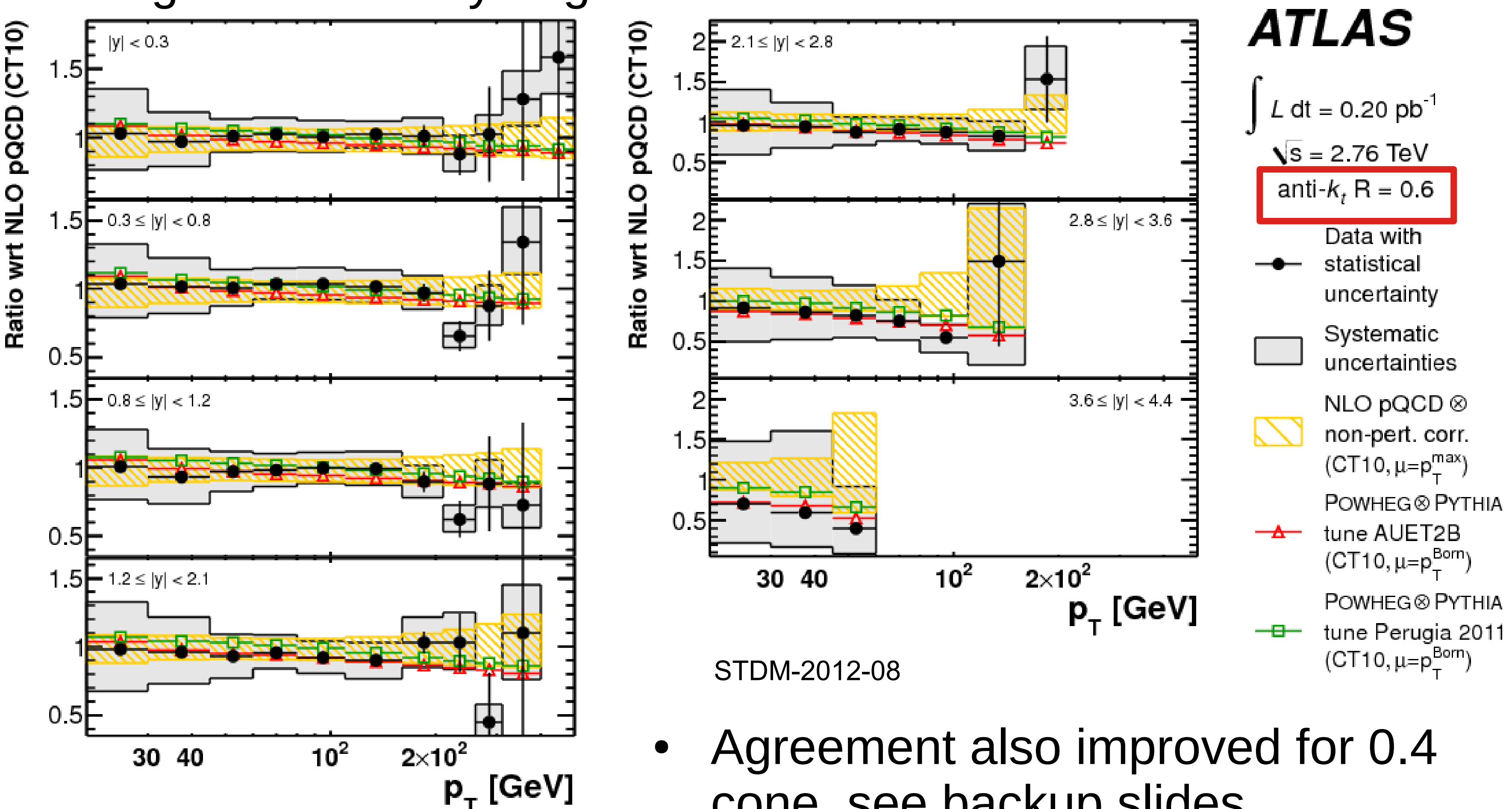
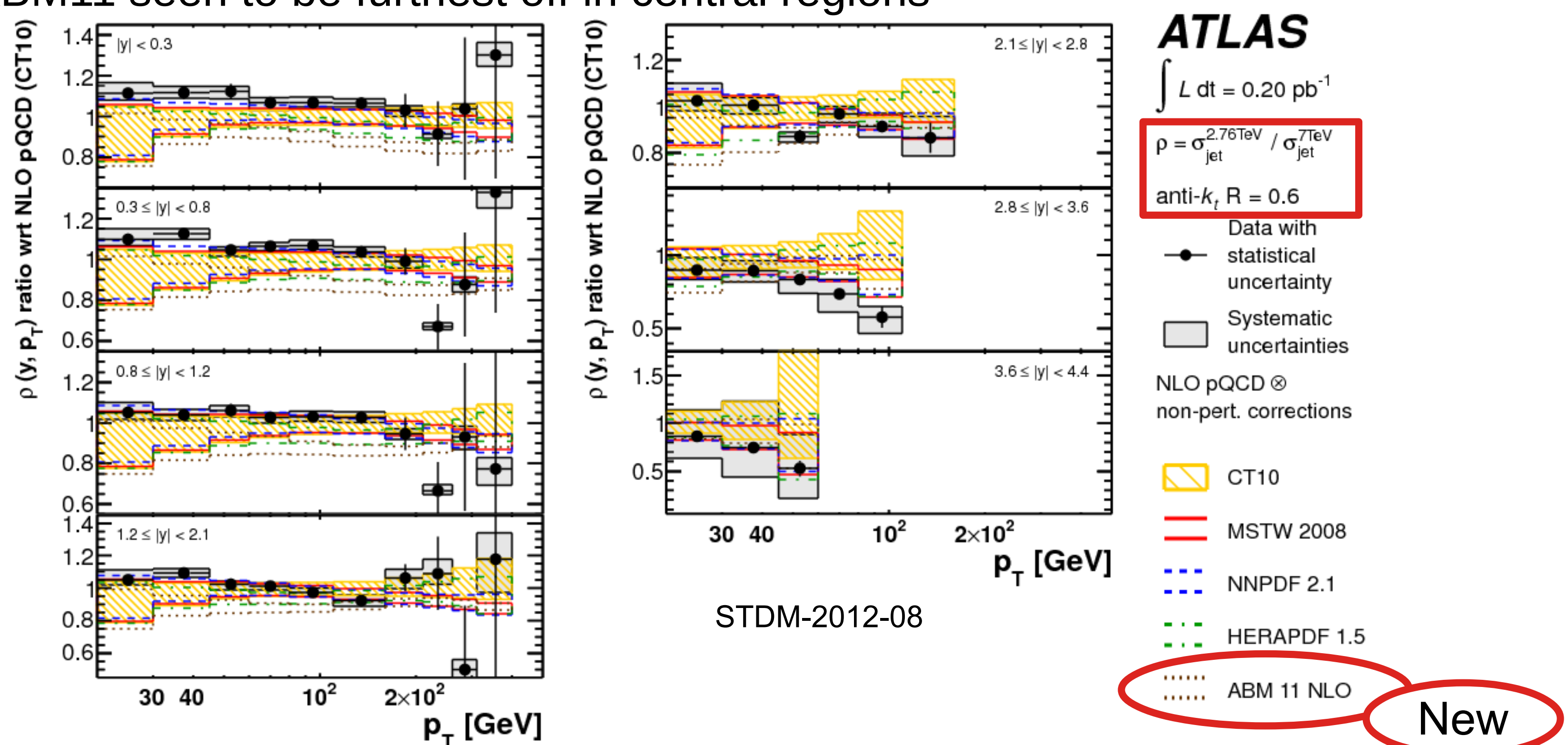
- This modified scale version is then used with two tunes and compared to the 2.76TeV cross section
  - Good agreement overall, especially in forward regions
  - Perugia consistently larger than AUET2B



- Agreement also improved for 0.4 cone, see backup slides

Ratio 2.76TeV/7TeV (1)

- The effect of the reduced uncertainties is plain to see in the ratio in p_T
  - In this case the theory cross section probes a different region of x and Q^2 due to the beam energy
  - Hence PDF uncertainties do not cancel, giving extra sensitivity
  - The ratio is also calculated as a function of x_T
- The measured points are slightly higher than the predictions in the central rapidity regions and are smaller in the forward rapidity regions
  - ABM11 seen to be furthest off in central regions



STDM-2012-08

Ratio 2.76TeV/7TeV (2)

McGill
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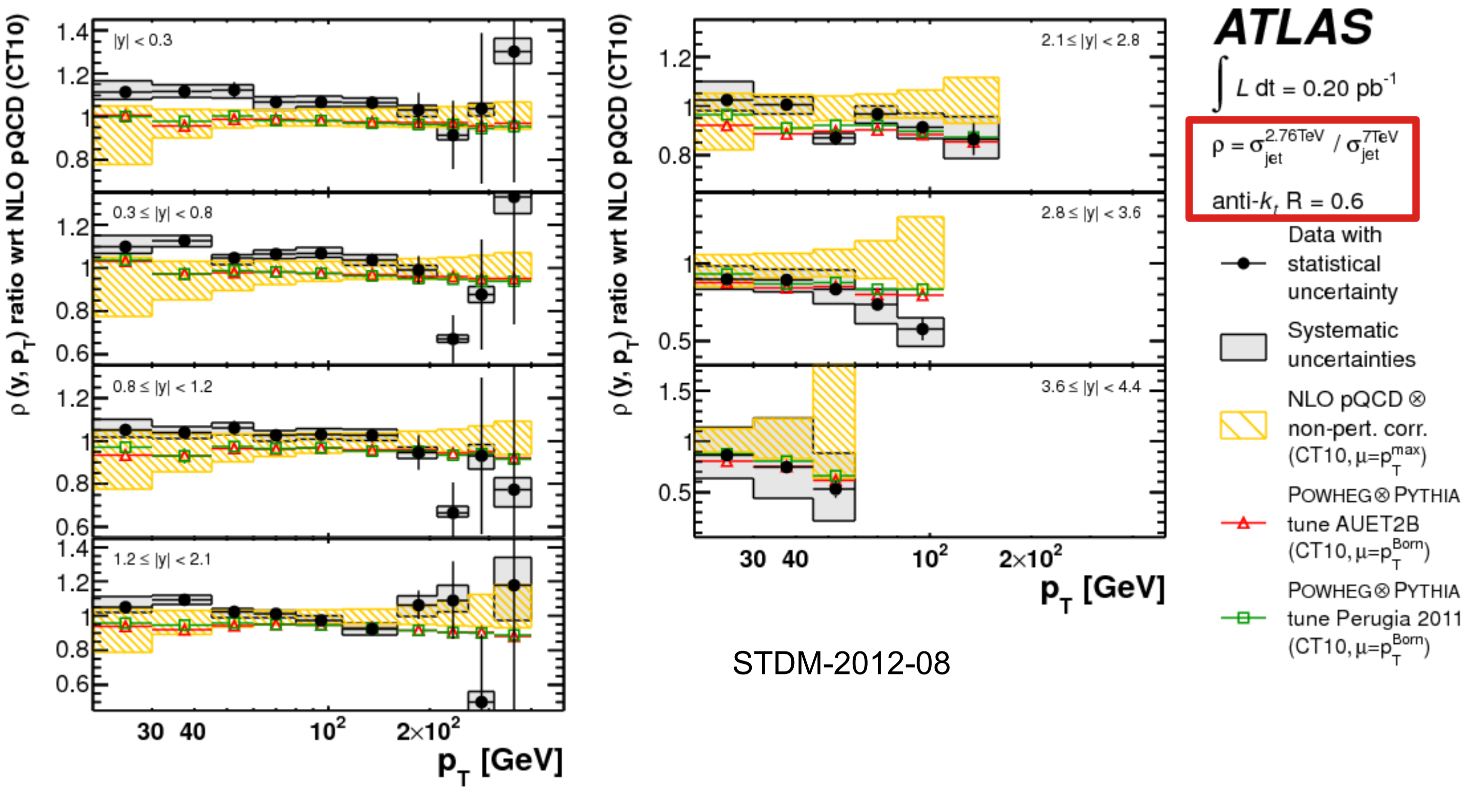
- The effect of the reduced uncertainties is plain to see in the ratio in p_T
  - In this case the theory cross section probes a different region of x and Q^2 due to the beam energy
  - Hence PDF uncertainties do not cancel, giving extra sensitivity
  - The ratio is also calculated as a function of x_T
- Again comparisons are made with Powheg, similar trends to NLO as there is a 10% difference in the central region, better agreement in forward region

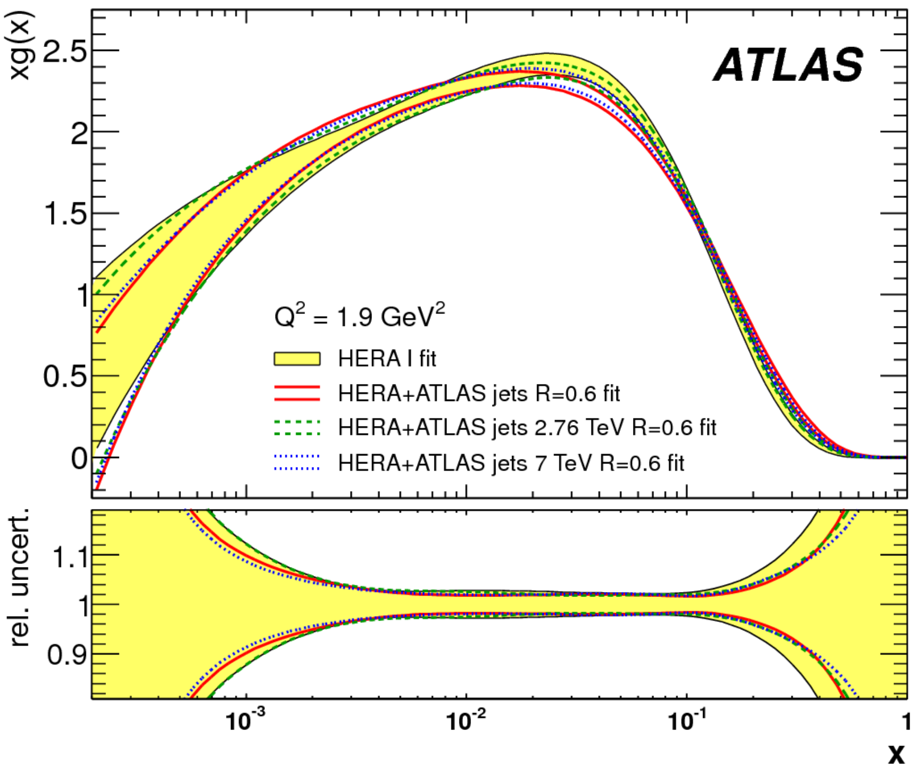


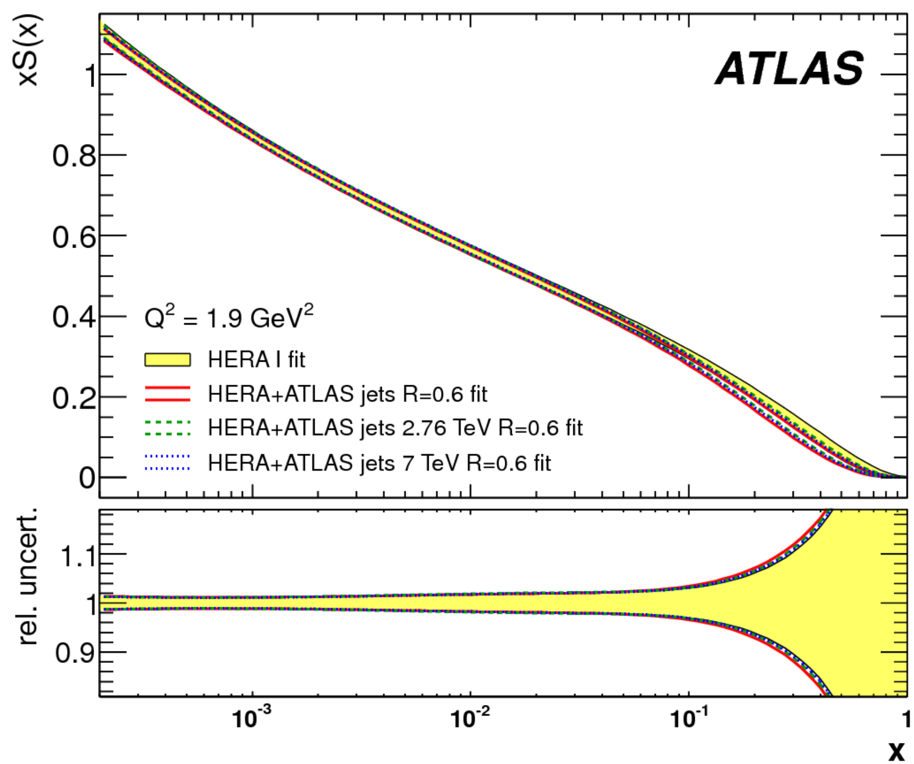
STDM-2012-08

PDF impact (1)

Mark Stockton

- The PDF impact is investigated using the HERAFitter package
- The gluon distribution becomes harder
  - Relative uncertainty is smaller at high x due to the higher central value
  - Points to sensitivity in the medium x region
- For sea quarks the distribution is softer
  - Again relative error slightly increased due to lower central value





STDM-2012-08

PDF Impact (2)

- χ^2 - New in the paper
  - The χ^2 are given separately for uncorrelated/correlated components
- Very good fit quality is found for both radius parameters
- The χ^2 values also show the pull of ATLAS jet data for both jet radius parameters, while the description of the HERA data is almost unaffected

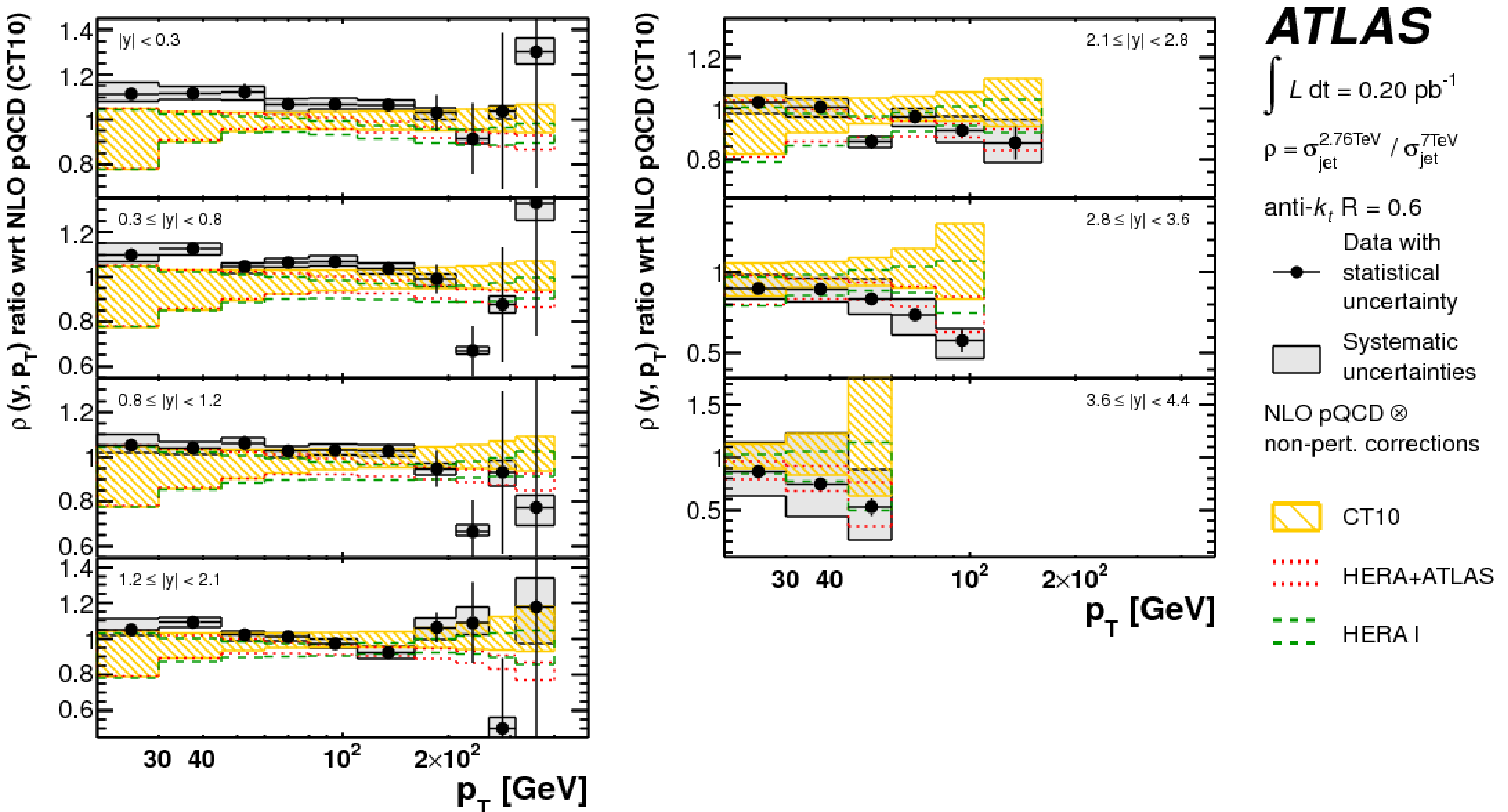
STDM-2012-08

input datasets	test dataset	χ^2_{uncor}	χ^2_{cor}	N_{points}
HERA	HERA	556	3.0	592
	ATLAS jets 2.76 TeV, $R = 0.4$	29	21	40
	ATLAS jets 7 TeV, $R = 0.4$	44		76
	ATLAS jets 2.76 TeV, $R = 0.6$	33	22	40
	ATLAS jets 7 TeV, $R = 0.6$	50		76
HERA ATLAS jets 2.76 TeV, $R = 0.4$ ATLAS jets 7 TeV, $R = 0.4$	HERA	562	3.6	592
	ATLAS jets 2.76 TeV, $R = 0.4$	27	19	40
	ATLAS jets 7 TeV, $R = 0.4$	33		76
	ATLAS jets 2.76 TeV, $R = 0.6$	29	13	40
	ATLAS jets 7 TeV, $R = 0.6$	41		76
HERA	HERA	557	3.1	592
ATLAS jets 2.76 TeV, $R = 0.4$	ATLAS jets 2.76 TeV, $R = 0.4$	20	7.4	40
HERA	HERA	559	3.4	592
ATLAS jets 7 TeV, $R = 0.4$	ATLAS jets 7 TeV, $R = 0.4$	28	14	76
HERA ATLAS jets 2.76 TeV, $R = 0.6$ ATLAS jets 7 TeV, $R = 0.6$	HERA	564	4.0	592
	ATLAS jets 2.76 TeV, $R = 0.6$ jets	29	12	40
	ATLAS jets 7 TeV, $R = 0.6$	40		76
	ATLAS jets 2.76 TeV, $R = 0.4$	26	18	40
	ATLAS jets 7 TeV, $R = 0.4$	32		76
HERA	HERA	558	3.2	592
ATLAS jets 2.76 TeV, $R = 0.6$	ATLAS jets 2.76 TeV, $R = 0.6$	21	4.9	40
HERA	HERA	560	3.6	592
ATLAS jets 7 TeV, $R = 0.6$	ATLAS jets 7 TeV, $R = 0.6$	34	9.4	76

PDF Impact (3)

McGill
Mark Stockton

- Using this newly created PDF, can see the impact at high y



STDM-2012-08

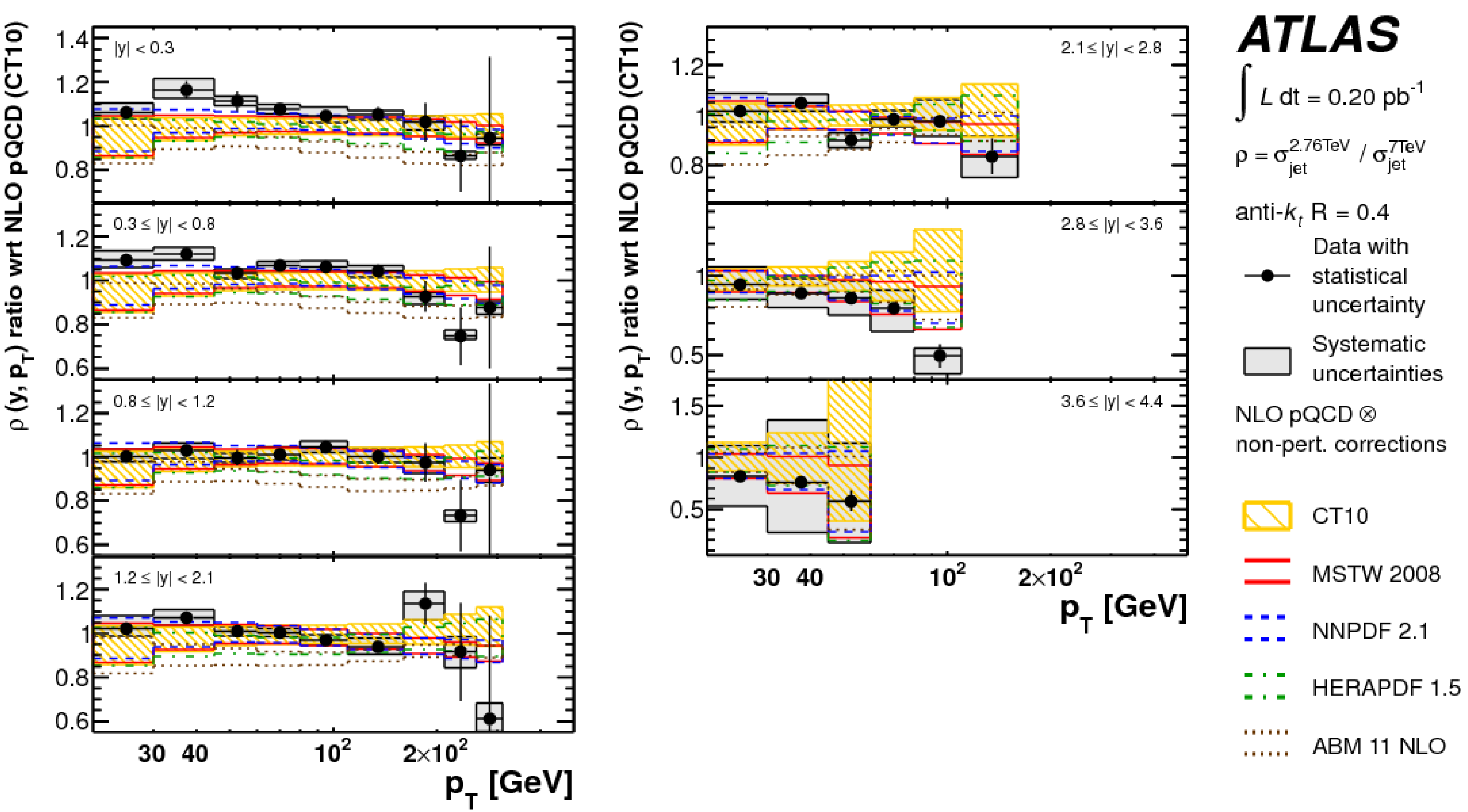
Summary

- ATLAS has made many SM measurements
  - This talk has only concentrated on some of the recent photon and jet measurements, but there are more results in these areas along with W, Z,...
- Have shown the results are already contributing to reducing the errors on PDFs
- Also presented how making ratios can dramatically reduce the errors
- To have the best impact on PDFs experimentally we also need to provide the details of the error correlations

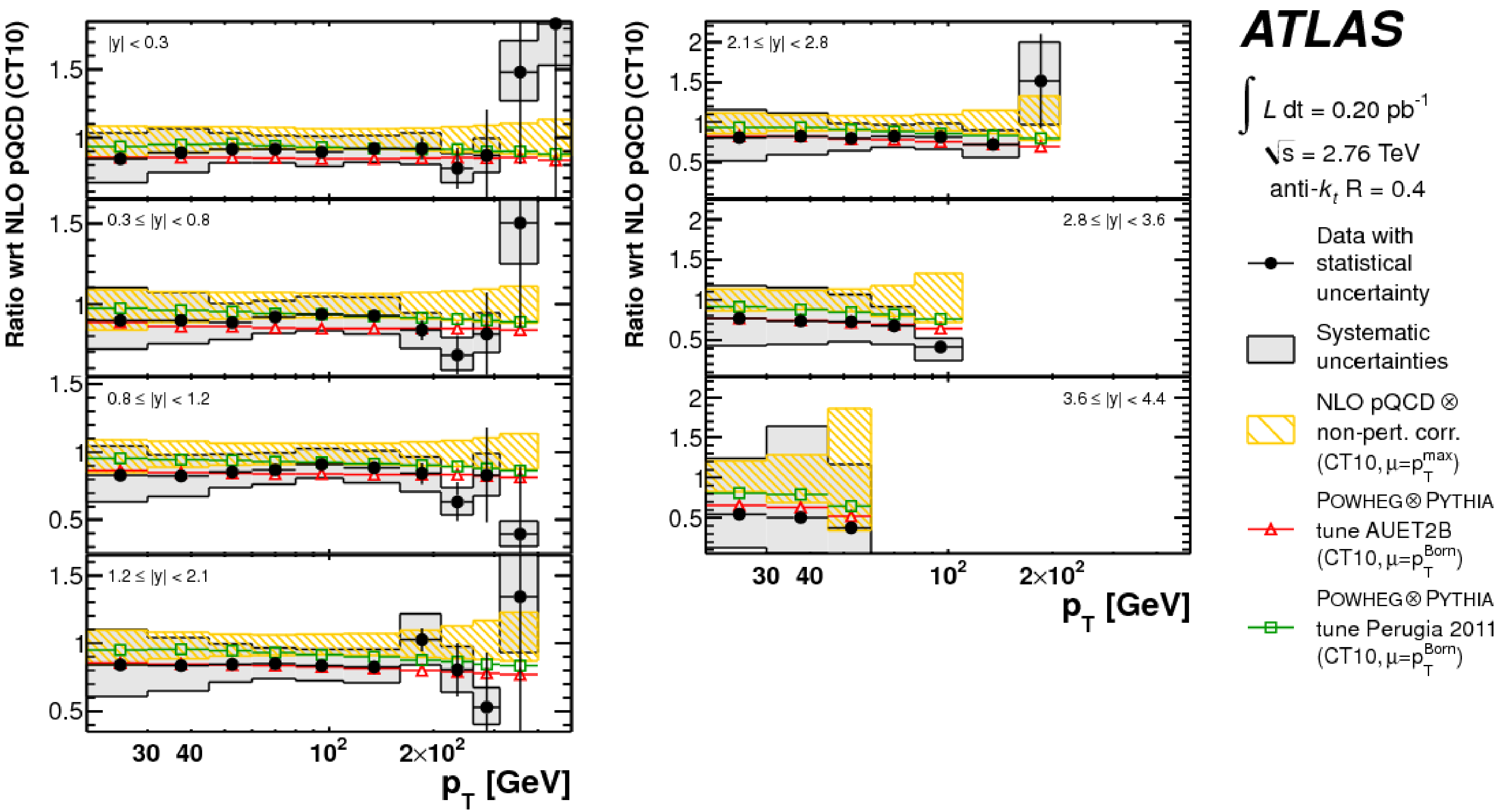
Backup

Mark Stockton

Ratio 0.4 results



Powheg 0.4 results (2.76TeV)



Powheg 0.4 results (ratio)

Mark Stockton