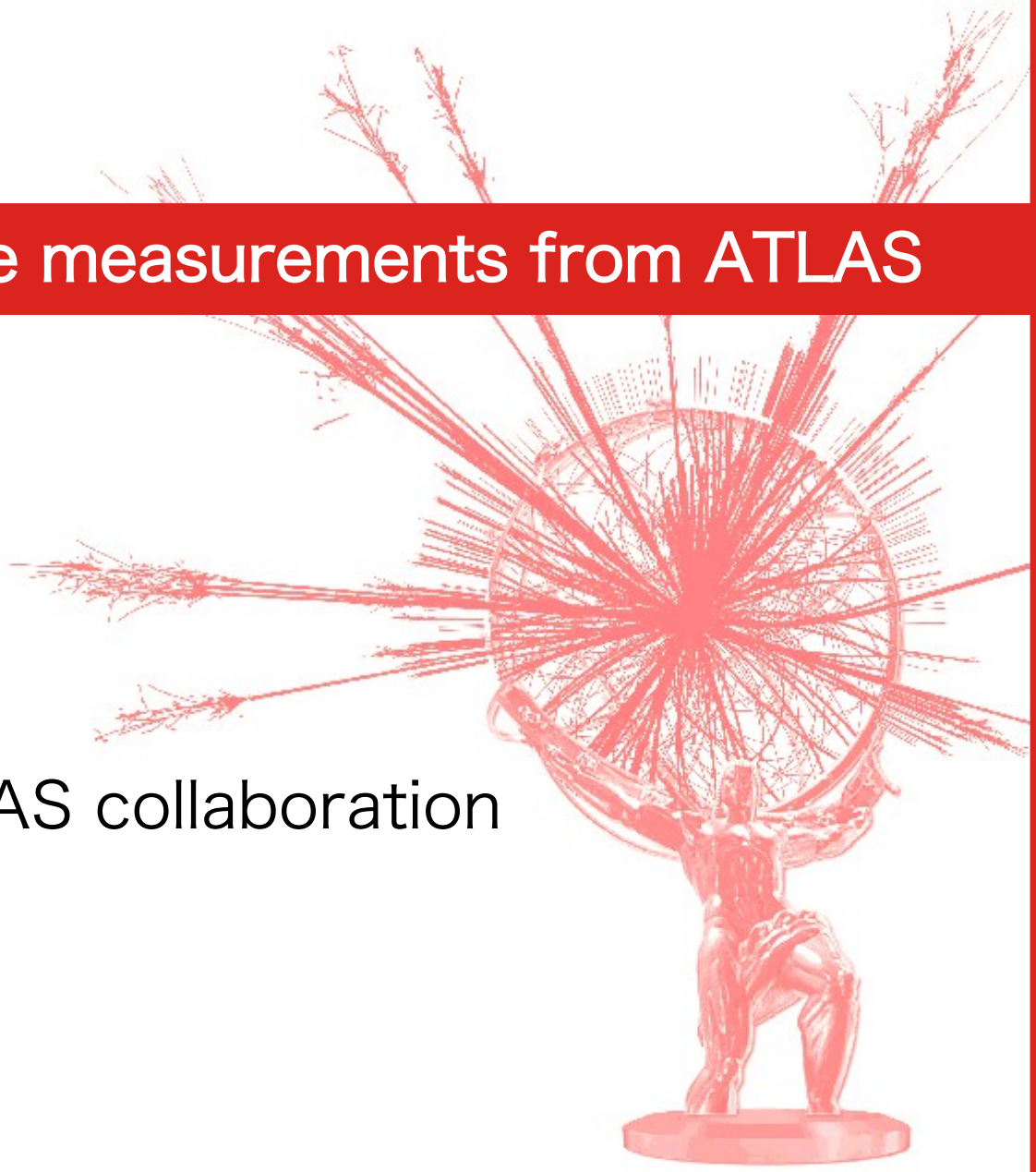
14 Mar

New PDF sensitive measurements from ATLAS



PDF4LHC

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on behalf of the ATLAS collaboration

Introduction

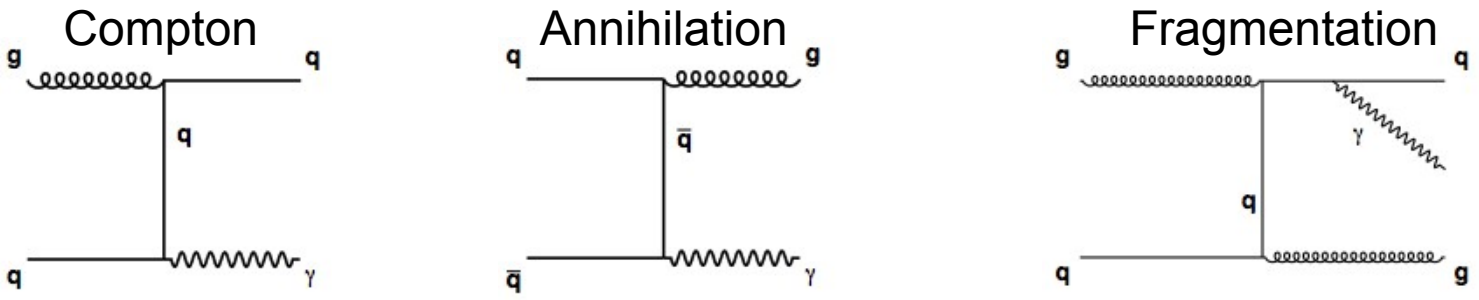
- Todays talk will focus on the brand new result on inclusive photons
  - This result is made using the 8TeV data
- The talk will also include a review of PDF studies related to photons at 7TeV

Year	Lumi	p_T range [GeV]		η regions	Isolation [GeV]
2010	880 nb^{-1}	15	100	0 < |η| < 1.81 excluding 1.37-1.52	3
2010	35 pb^{-1}	45	400	0 < |η| < 2.37 excluding 1.37-1.52	3
2011	4.6 fb^{-1}	100	1000	0 < |η| < 1.37	7
		100	600	1.52 < |η| < 2.37	
2012	20.2 fb^{-1}	25	1500	0 < |η| < 0.6	E_T dependent
		25	1100	0.6 < |η| < 1.37	
		25	650	1.56 < |η| < 1.81	
		25	650	1.81 < |η| < 2.37	

- References to ATLAS results shown:
  - 2010: Phys. Rev. D 83 (2011) 052005
  - 2010: Phys. Lett. B 706 (2011) 150-167
  - 2011: Phys. Rev. D 89, 052004 (2014)
    - PDF studies: ATL-PHYS-PUB-2013-018
  - 2012: STDM-2014-09

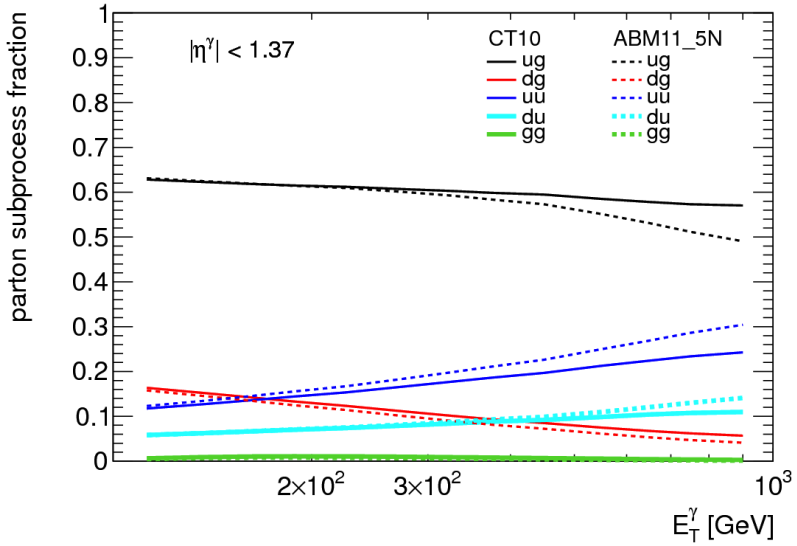
Inclusive photon production

- For single photon production there are three key processes



- At the LHC the Compton process dominates
  => Enables us to probe the gluon PDF

- At high E_T there is a smaller fragmentation contribution
  => Could provide a cleaner gluon PDF probe than jets

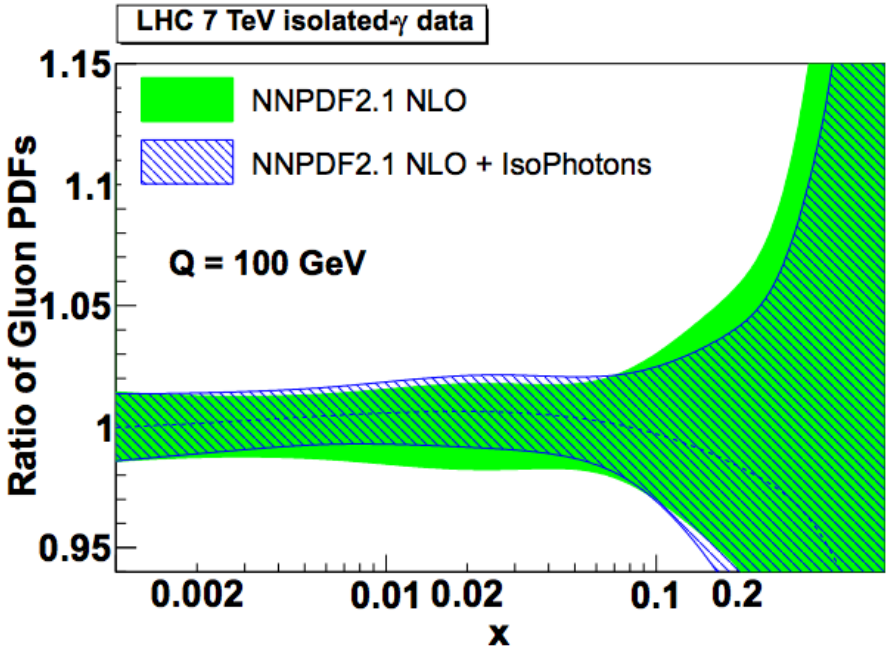


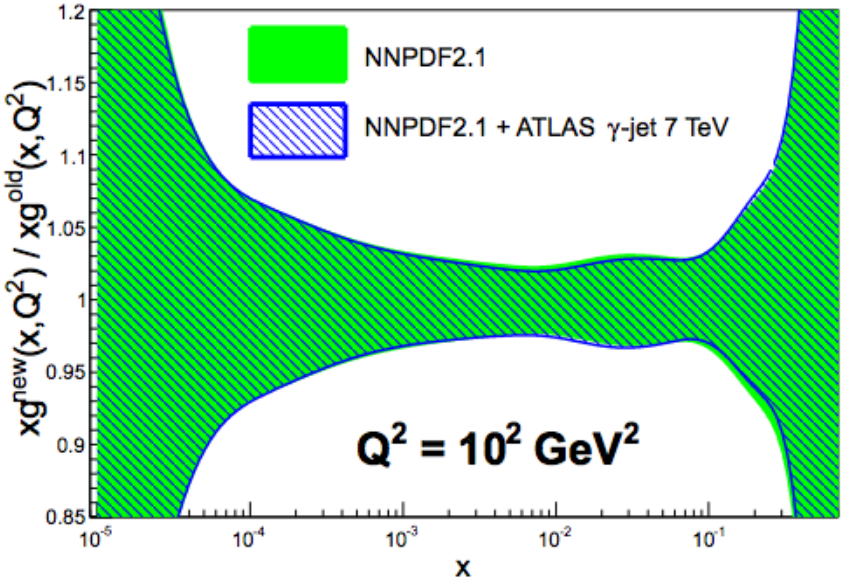
Existing PDF studies

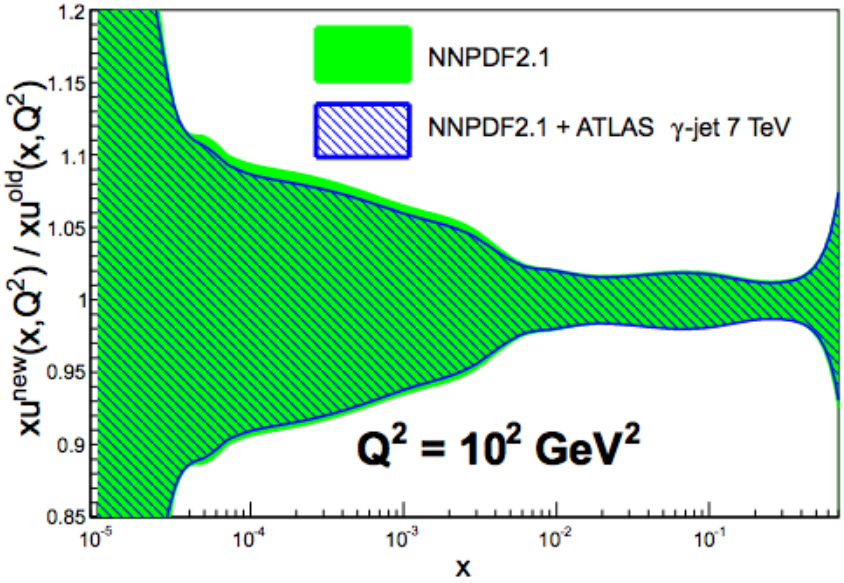
- Several recent studies have already shown the potential benefit of adding photons into PDF fits

- Right: 2010 Inclusive photon data
- D. d'Enterria, J. Rojo Nucl.Phys. B860 (2012) 311-338

- Below: 2010 Photon+jet data
- Using: Phys. Rev. D 85 (2012) 092014
- L. Carminati, et al.,
- EPL 101 (2013) 61002

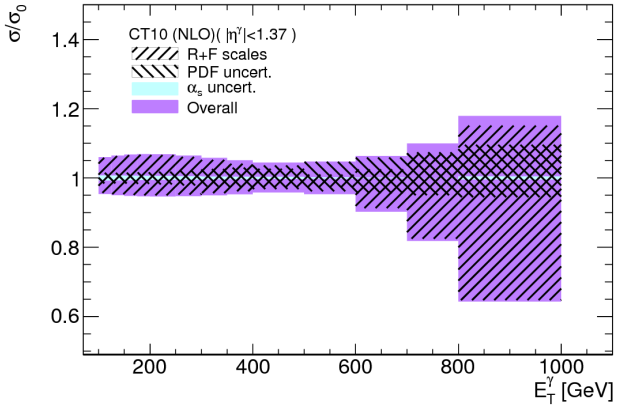


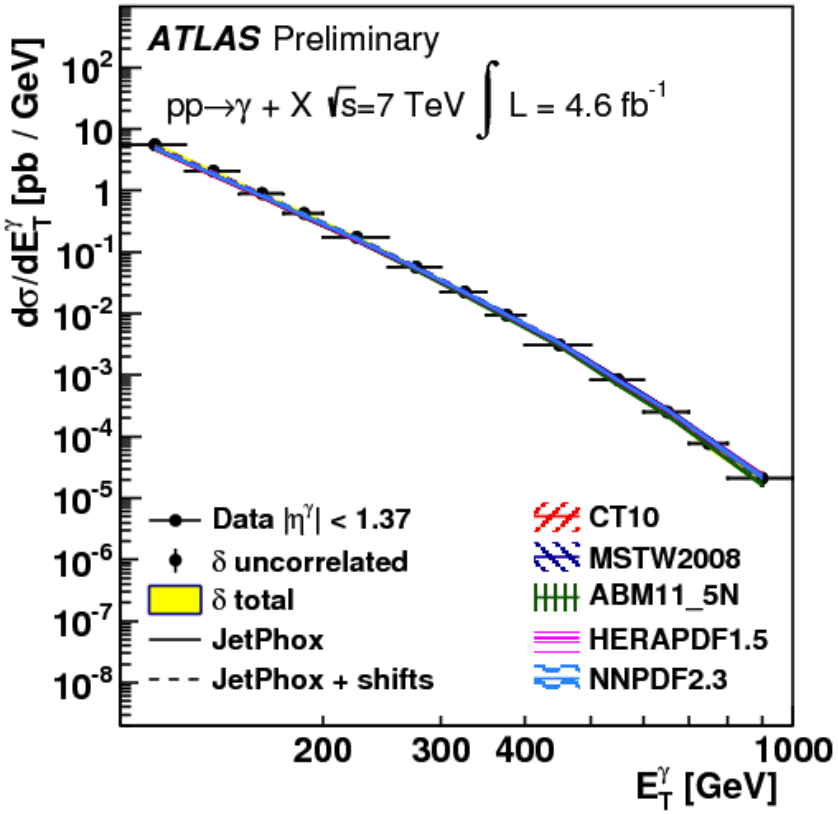


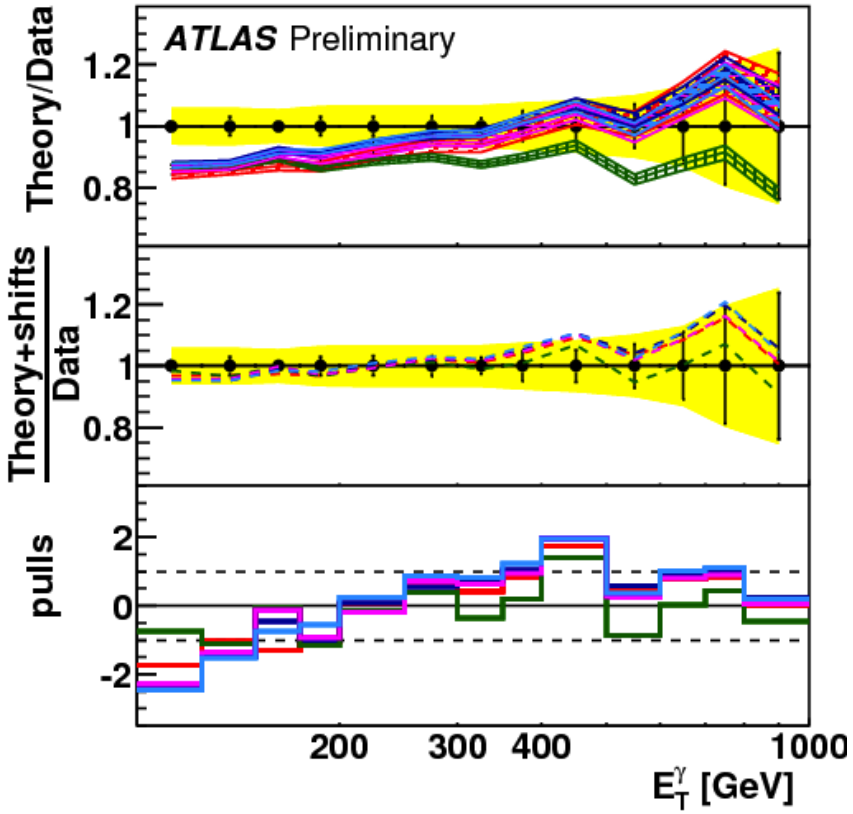


ATLAS PDF studies

- Study carried out to investigate PDF's
  - Using 2011 inclusive photon data
  - Compared PDF uncertainties
    - Scale uncertainty dominates
- Perform shape comparison to JetPhox/MCFM
  - Add k-factors to MCFM for fragmentation
- Best shape from ABM in central region
  - Others well within errors

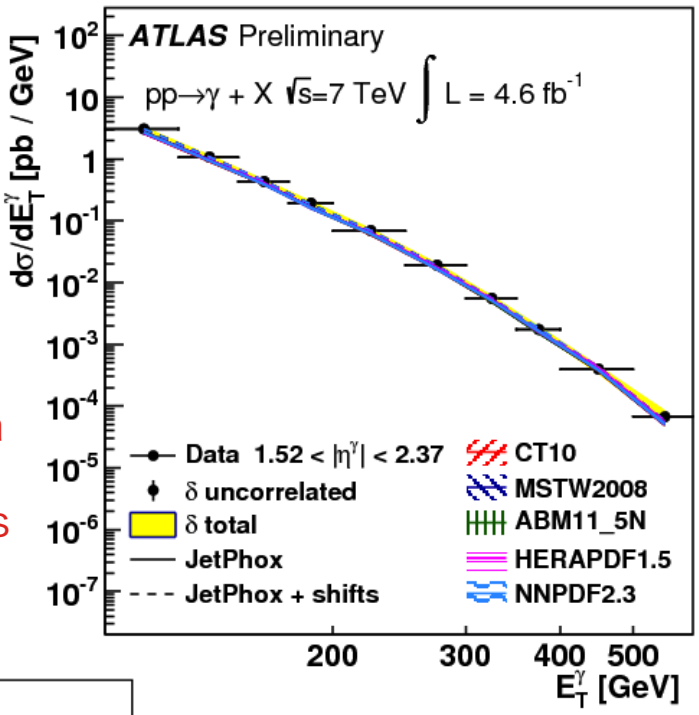


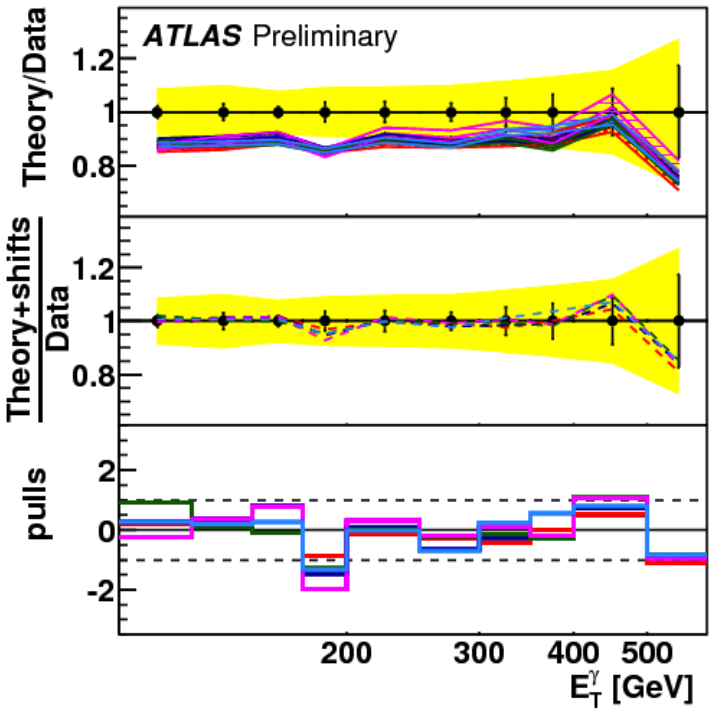


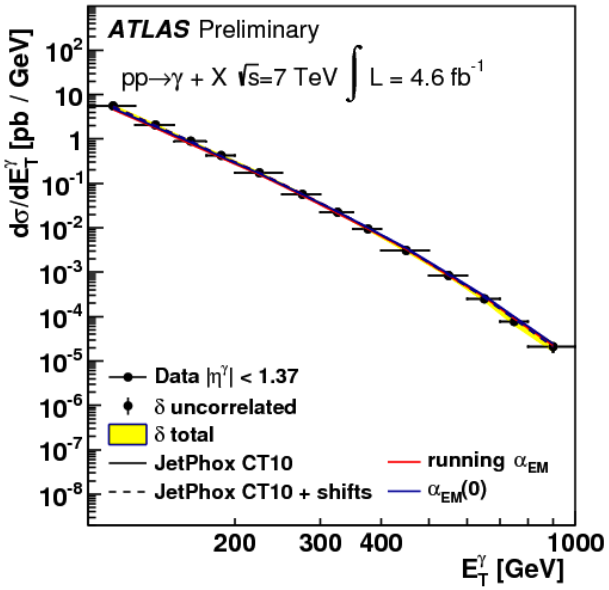


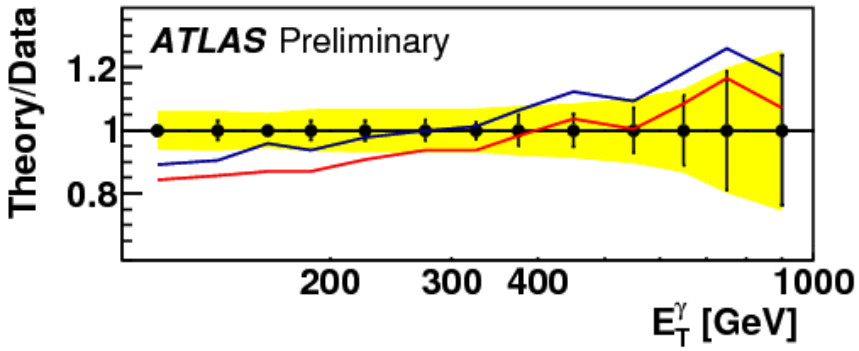
ATLAS PDF studies

- Less distinction of the PDFs for forward region
- Exp. Uncert are the main limitation on PDF impact from 7TeV studies









- Also compared using running α_{EM} to fixed, which is relevant for the latest comparisons to PeTeR

Photon Isolation

- Cross section is measured for isolated photons
  - Needed to reduce the fragmentation contribution
  - Also removes hadron background from meson decay

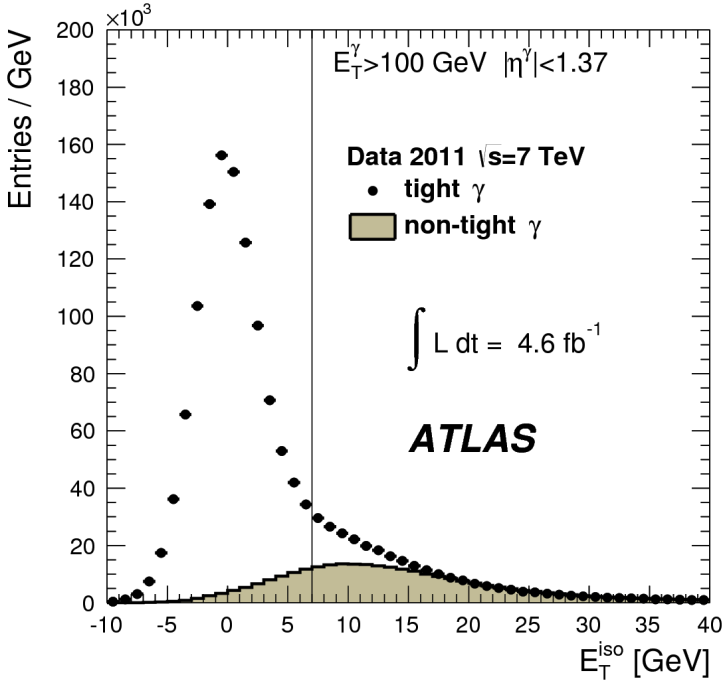
- Isolation is measured as the energy in a cone (R=0.4) around the photon
  - Experimentally we remove the photon cluster
  - At particle level it is the sum of energy from all particles, except muons+neutrinos
  - At parton level it is the sum of energy from all coloured partons
- Event-by-event ambient energy is also subtracted from the cone
  - To remove UE+pile-up

- Example on right from 7TeV analysis

- Requirement in 8TeV analysis is E_T dependent:

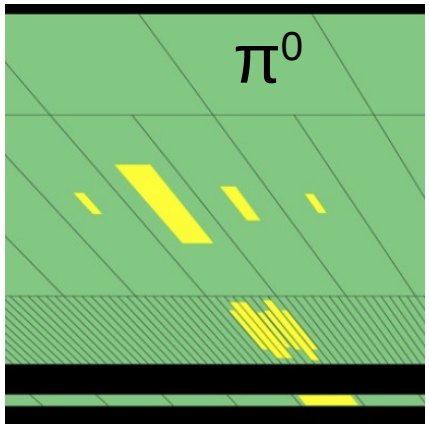
  $E_T^{iso} < 4.8\text{GeV} + 4.2 \times 10^{-3} \times E_T$

- Chosen to maintain high signal-to-background ratio
- Also avoids being too restrictive for NLO calculations



Photon identification

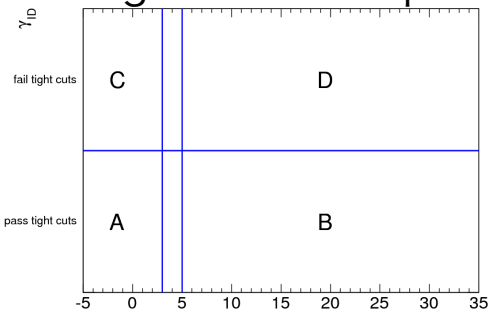
- Photons are reconstructed from EM calorimeter cells
  - Unconverted if no track, 1 and 2 track matching for converted

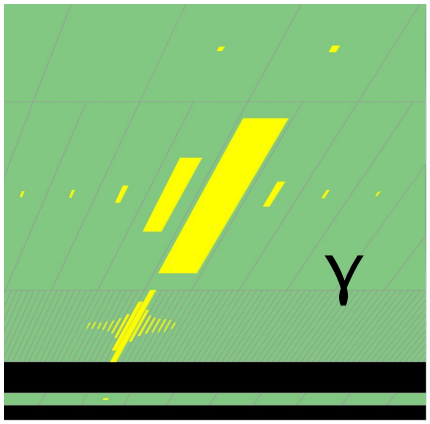


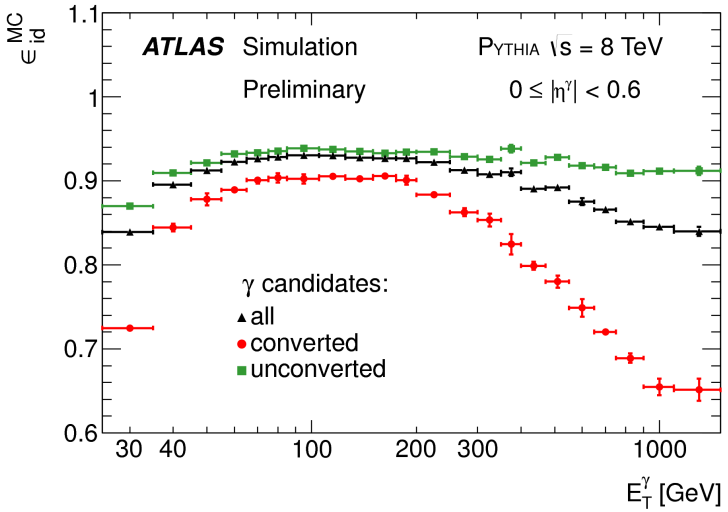
- Right 960GeV photon candidate (2011 data)
- Left MC example of a π^0

- Main background is from π^0's in jets
- Identify signal photons using shower shape variables

- ID and isolation used in 2D sidebands to workout remaining background



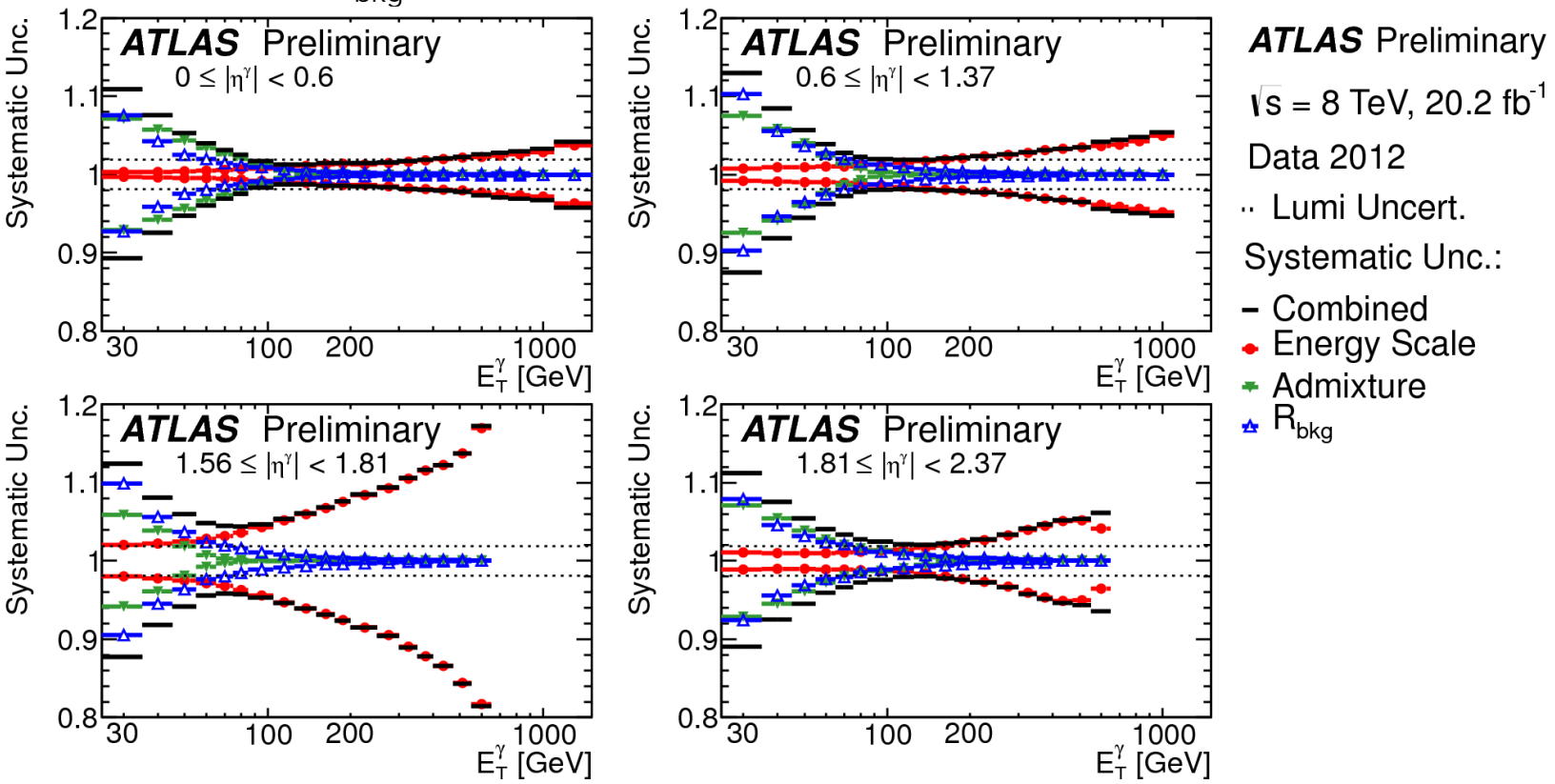




- Identification efficiency in 8TeV data
  - Calculated with Pythia
  - ε_{ID}= simulated photons passing identification / particle level photons
  - Similar result for unfolding correction factor
- Unconverted photons highly efficient
- Drop in converted photons at higher E_T affects combined efficiency
  - Due to difficulties to separate the two close-by tracks from the conversion, which then fail the tighter single track requirements.

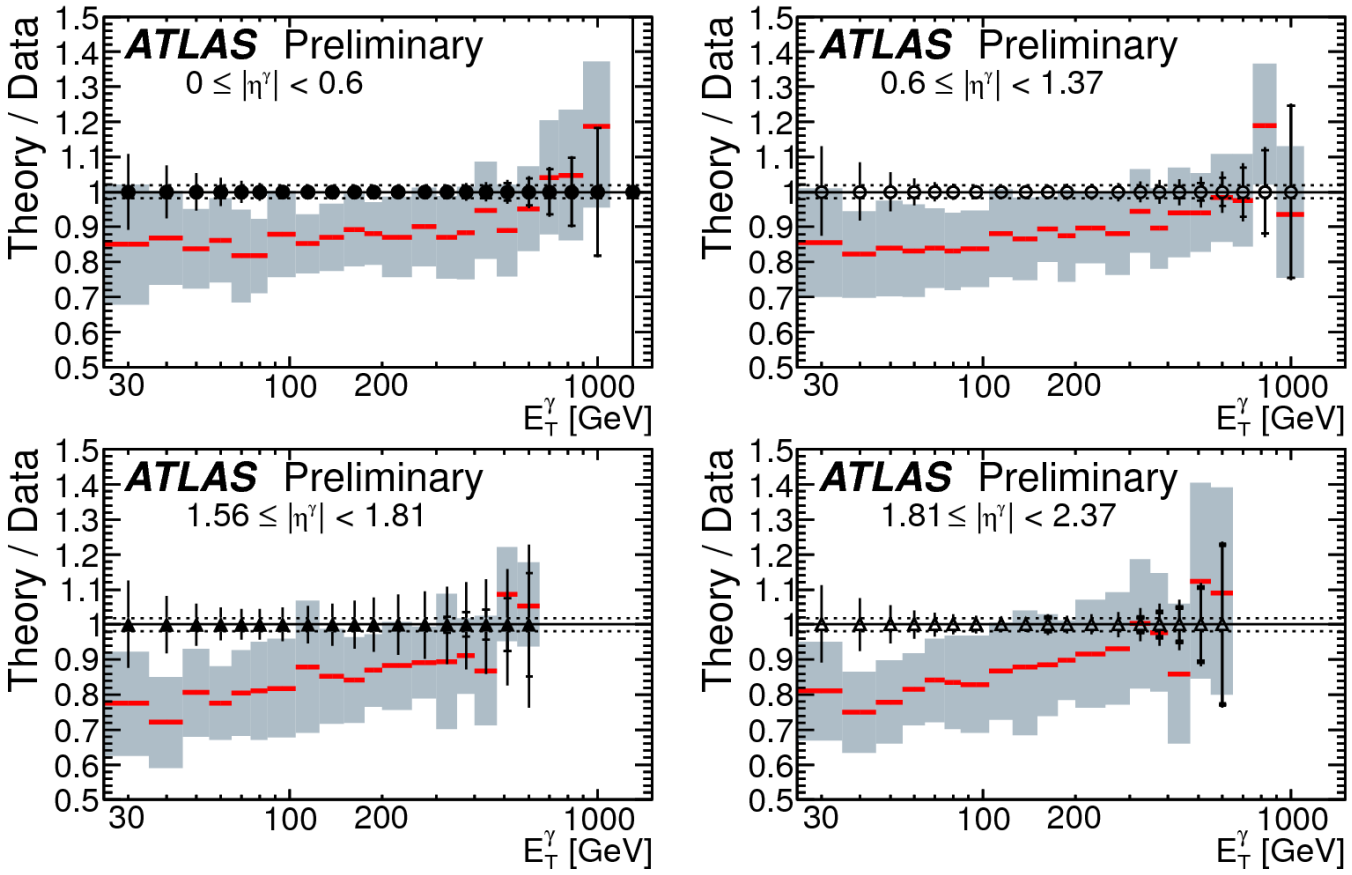
Systematics

- At high E_T the experimental uncertainty is mainly affected by the photon energy scale, but also a component from the photon ID efficiency
- At low E_T there are two main sources:
  - The mixture of fragmentation/direct photons in the MC samples - with the uncertainty obtained from performing a fit to find an optimal mix.
  - After the selection the remaining background is removed by a 2D sidebands technique - the assumption of the correlation of the background (R_{bkg}) is tested in a control region



Results - JetPhox

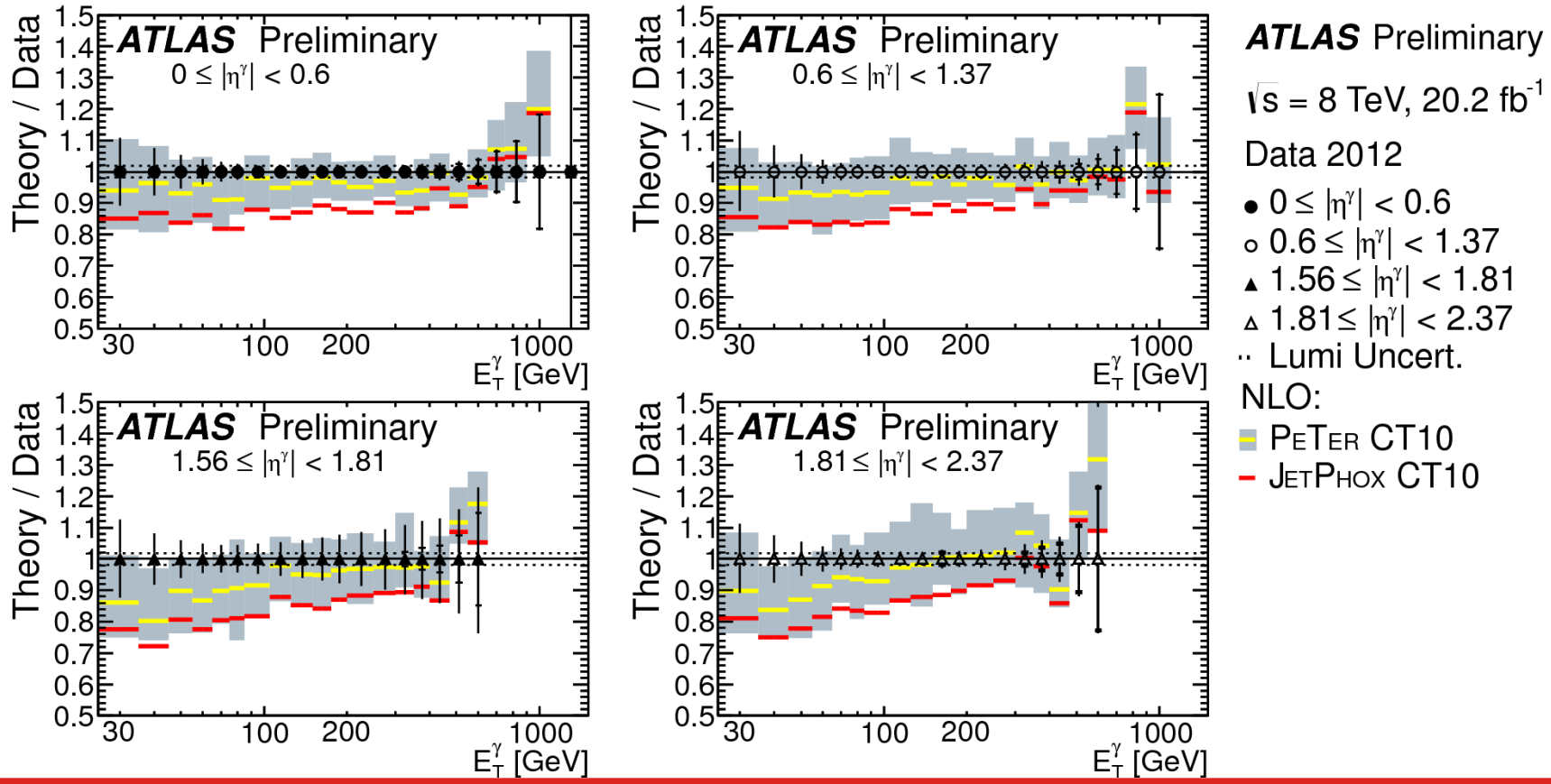
- Results are compared to Jetphox - NLO predictions direct+fragmentation
  - Scale uncertainty from varying the three scales by 2 around the nominal value (photon E_T), both simultaneously and independently
  - CT10 PDF +uncertainties used (others give similar results)
  - Uncertainty on α_s (0.118) by variation of ± 0.002
  - Additional hadronisation plus UE correction factors uncertainties



- Good agreement in shape
- Exp. uncert. far smaller causes disageement

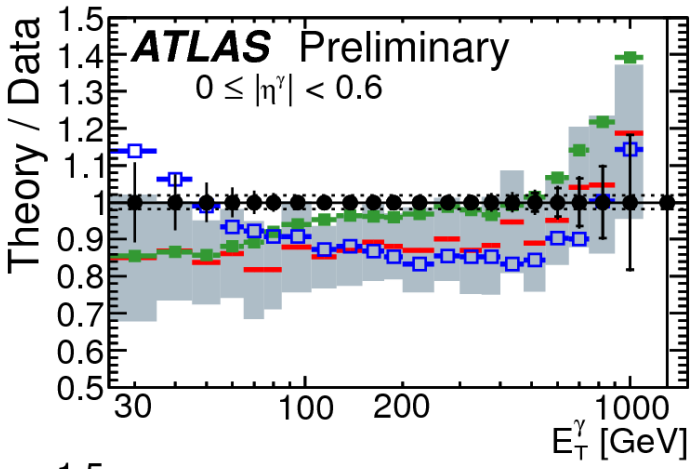
Results - PeTeR

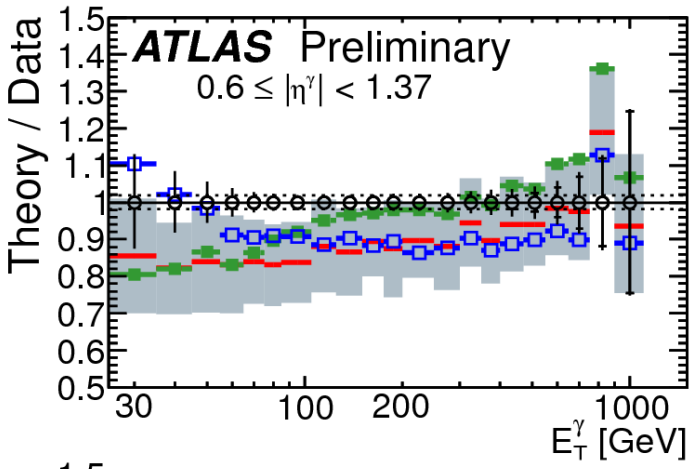
- PeTeR (NLO) includes the resummation of threshold logarithms
  - Based on JetPhox calculations
  - Use running α_{EM} as part of the electroweak Sudakov corrections
- Theoretical uncertainty is reduced (by 20%) and the agreement is much better over the entire phase space
  - Confirms the importance of the need for higher order predictions

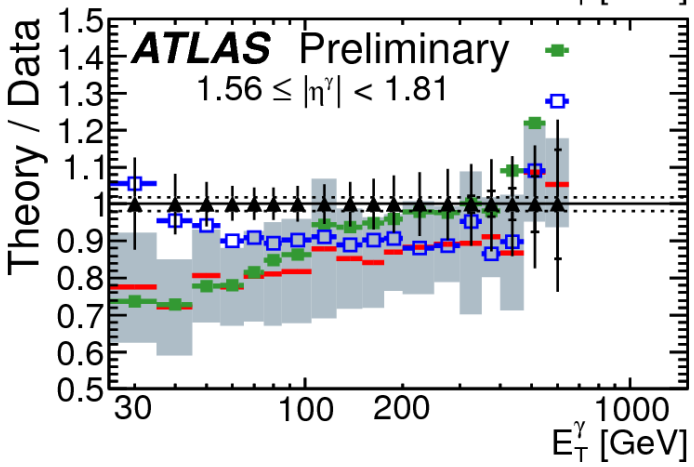


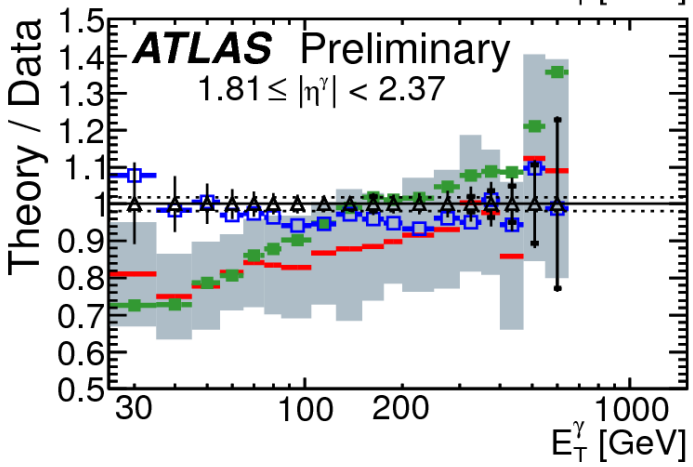
Results - LO

- Pythia is used in the analysis for the background subtraction, photon ID efficiencies and unfolding of the central value
  - Sherpa used for cross-checks/systematics
- Comparing their parton level predictions to the results:
  - Sherpa does well for most of the phase space
  - Pythia has a different shape at low E_T









ATLAS Preliminary

$\sqrt{s}$ = 8 TeV, 20.2 fb^{-1}

Data 2012

- ● $0 \le |\eta^\gamma| < 0.6$
- ○ $0.6 \le |\eta^\gamma| < 1.37$
- ▲ $1.56 \le |\eta^\gamma| < 1.81$
- △ $1.81 \le |\eta^\gamma| < 2.37$
- ·· Lumi Uncert.

NLO:

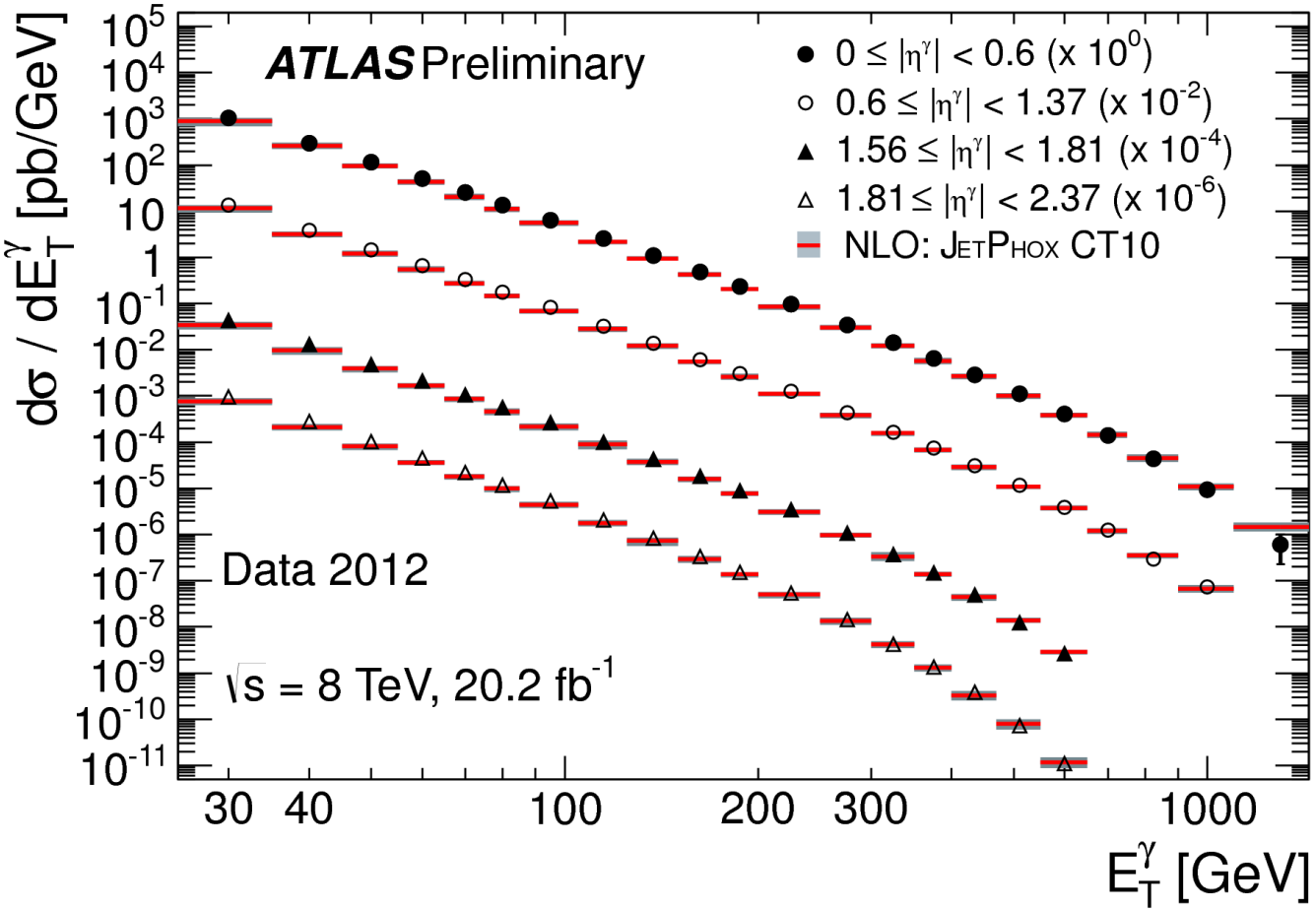
- JetPhox CT10

LO:

- Pythia
- Sherpa

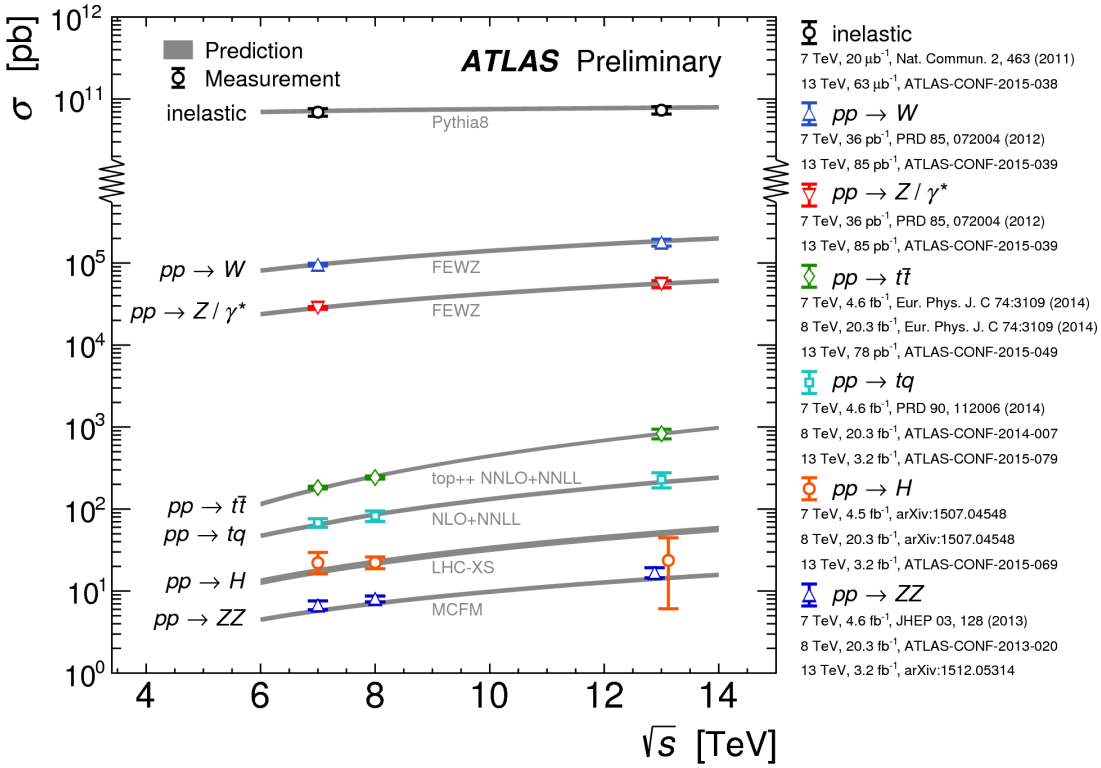
Results - summary

- The latest 8TeV measurement has the benefit of:
  - Uncertainties halved compared to previous ATLAS analyses
  - Covers the largest phase space to date
  - Compares to PeTeR - providing better agreement in the normalisation of the cross section and also reduced uncertainties
- Will make this a useful constraint once included in a global fit

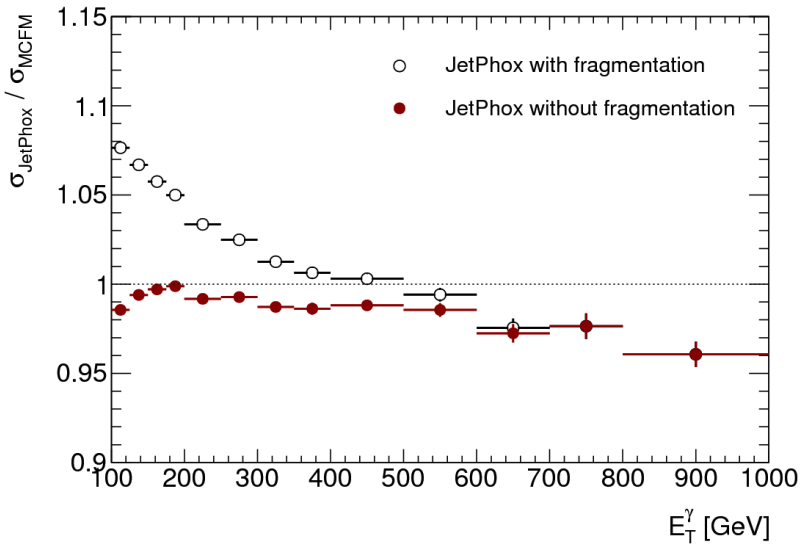


Summary

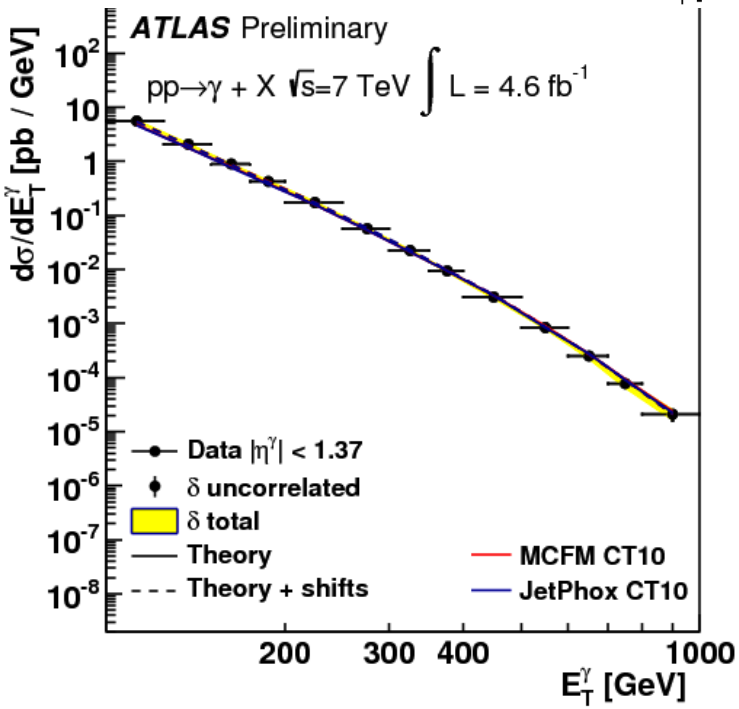
- 8TeV isolated inclusive photon results have been presented
  - Look forward to seeing the impact of adding into global fits soon
- Future:
  - ATLAS is working hard on many other PDF related topics
    - On both precision from run1 and the first run2 results
  - Coming soon will be new results from top, W, Z, high mass Drell Yan and jets

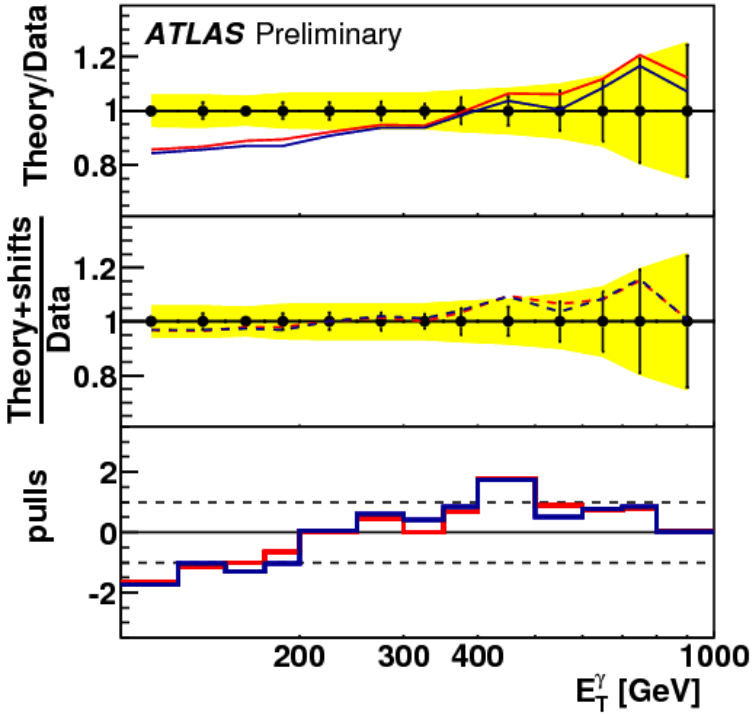


MCFM v Jetphox

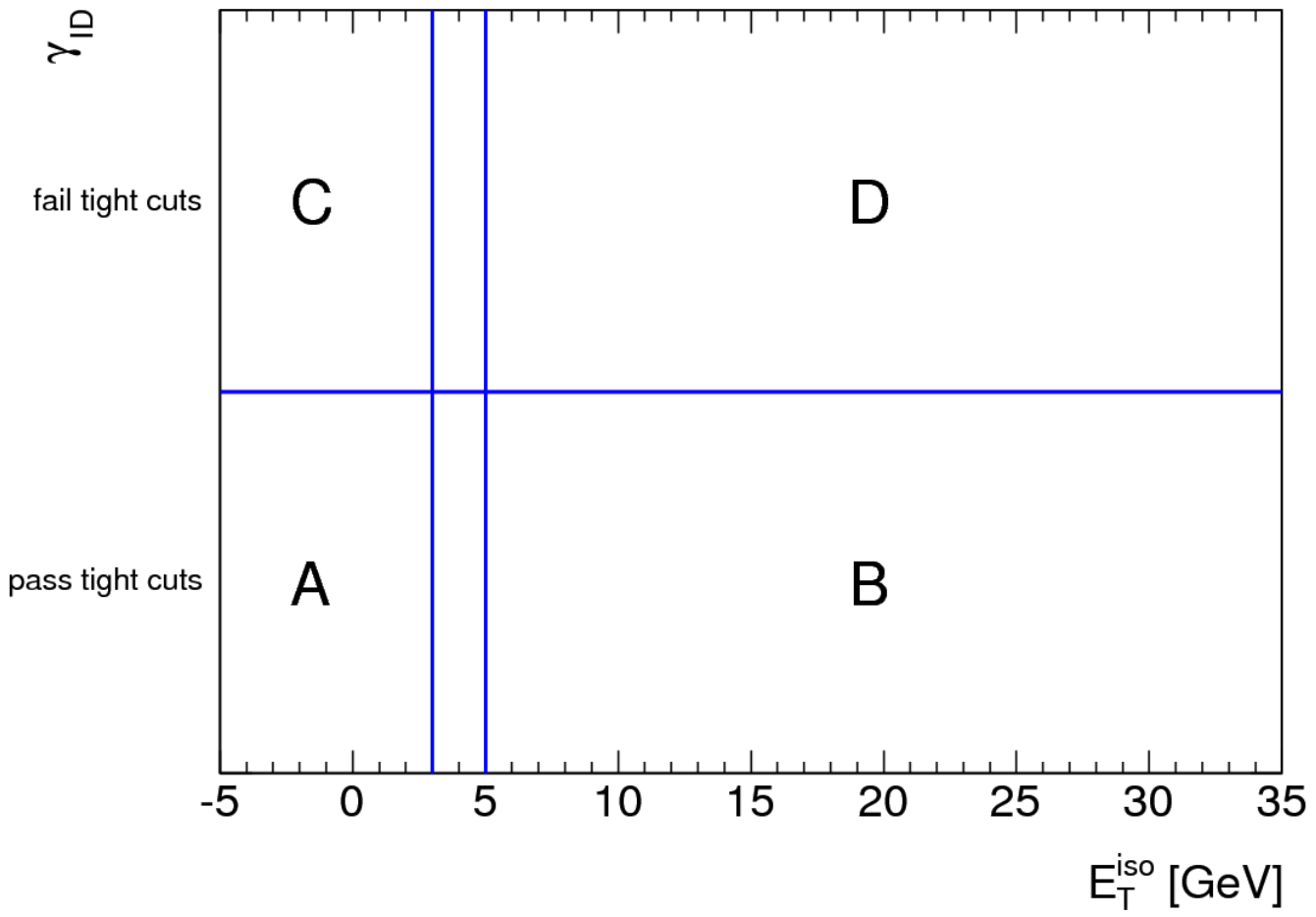


- MCFM used in the PDF study as can do fast reweighting of PDFs
- Comparisons made to Jetphox as this can do NLO fragmentation, only LO in MCFM
- Used k factors to add fragmentation to MCFM





Background


γ_{ID}
fail tight cuts
pass tight cuts
C
D
A
B
-5
0
5
10
15
20
25
30
35
E_T^{iso} [GeV]