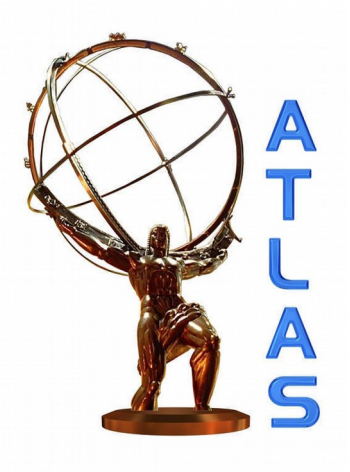
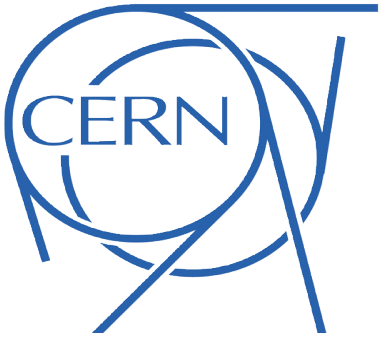
Recent QCD results from ATLAS





Tibor Ženiš
Comenius University Bratislava

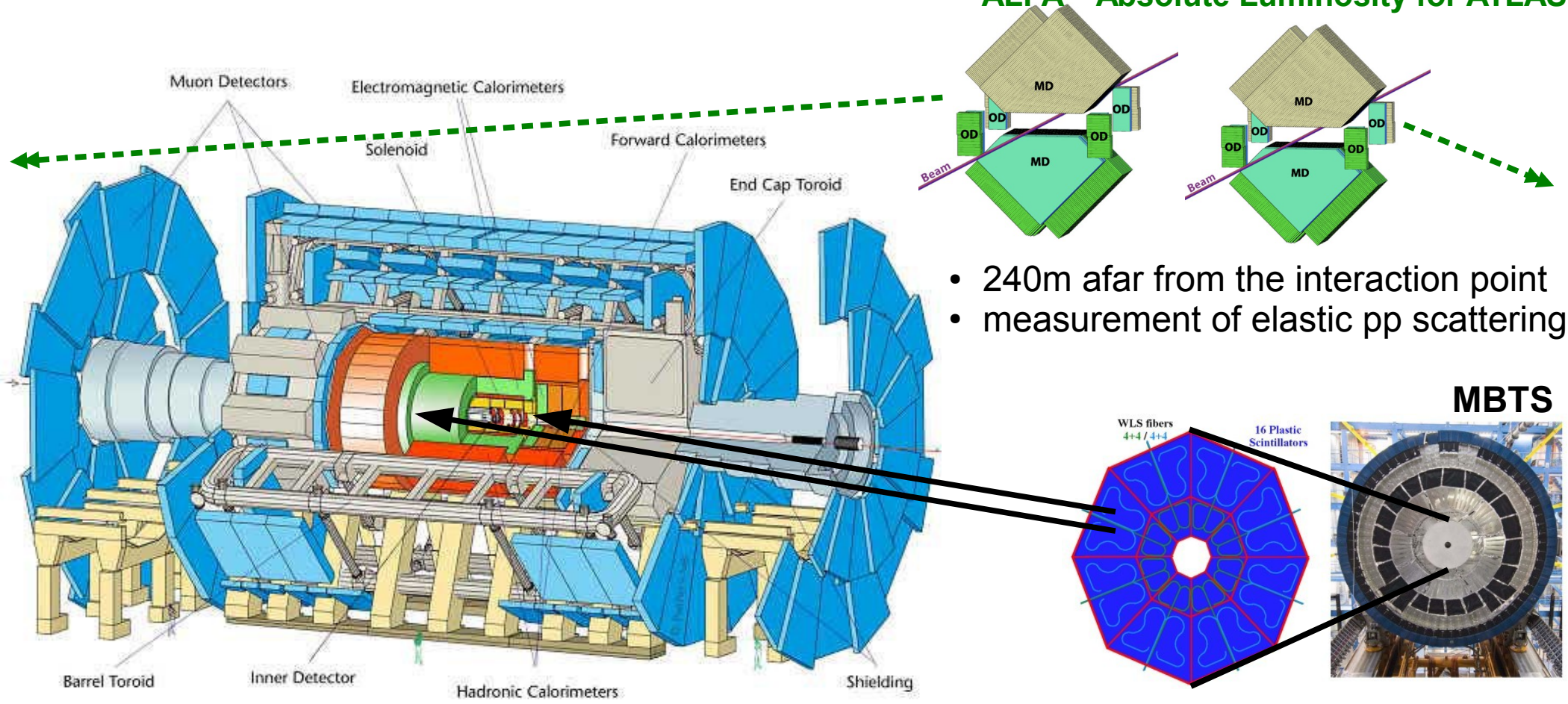
On behalf of the ATLAS collaboration

Overview

- Experiment ATLAS: Brief Description
- Samples of ATLAS QCD results
  - Measurements of underlying events
  - Total / elastic / inelastic cross-section
  - $\varphi(1020) \rightarrow K^{+} K^{-}$ cross section
  - Jet vetoes and azimuthal decorrelations in dijet events
  - Jet production cross sections
  - Inclusive isolated prompt photon cross section
  - Isolated photon and jet production cross section
- Conclusion

The ATLAS Detector

ALFA – Absolute Luminosity for ATLAS



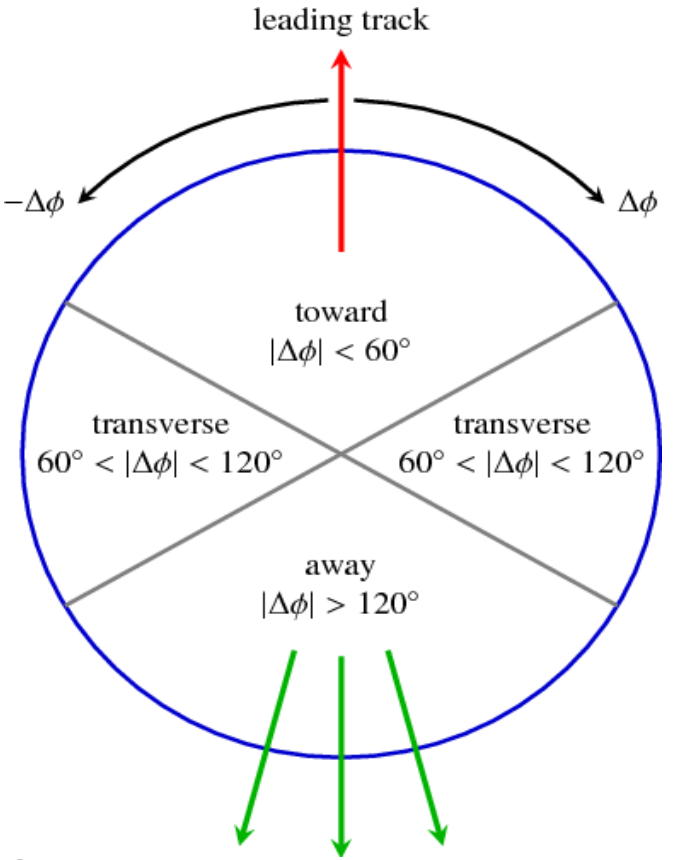
- 240m afar from the interaction point
- measurement of elastic pp scattering

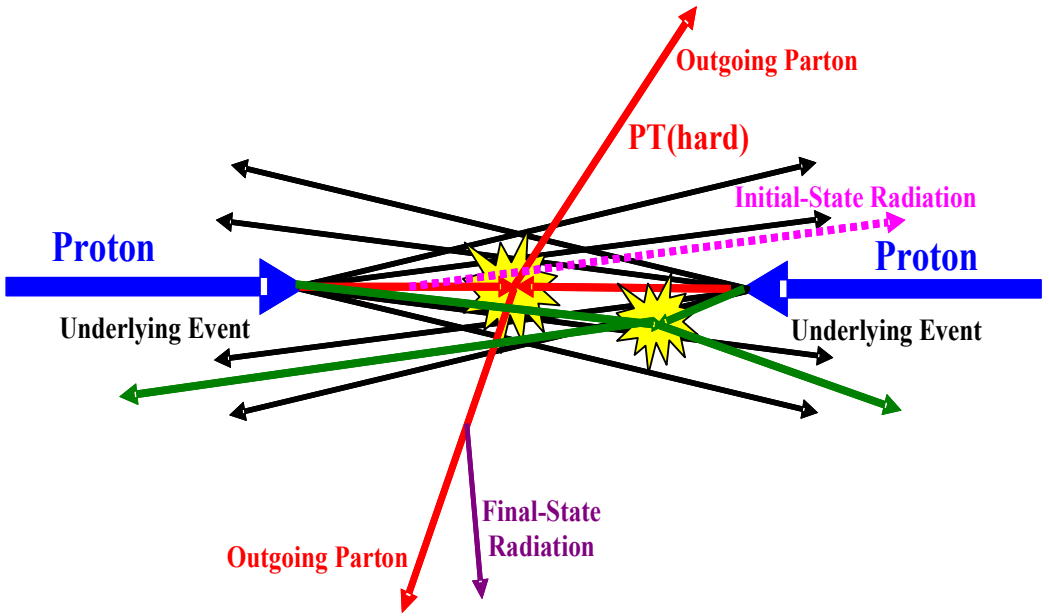
MBTS

- The key component of the ATLAS for direct inelastic cross section measurement and as a trigger for inelastic processes is the Minimum Bias Trigger Scintillator (MBTS)
  - is located in front of the Endcap calorimeters
  - consists from two rings of 8 counters on each side of detector
  - covers pseudorapidity $|\eta|$ 2.09 – 2.82, 2.82 – 3.84

Measurement of Underlying Events

- UE: soft processes accompanying hard parton-parton interaction in proton-proton collisions
  - no way to unambiguously distinguish between signals from the hard process and from the UE
- η, φ plane divided into regions around leading object (the highest p_T object):
  - $|\Delta\varphi| < 60°$ - **toward**
  - $60° < |\Delta\varphi| < 120°$ - **transverse**
    - **event-by-event distinguishing to "trans-min" and "trans-max" sides**
  - $|\Delta\varphi| > 120°$ - **away**

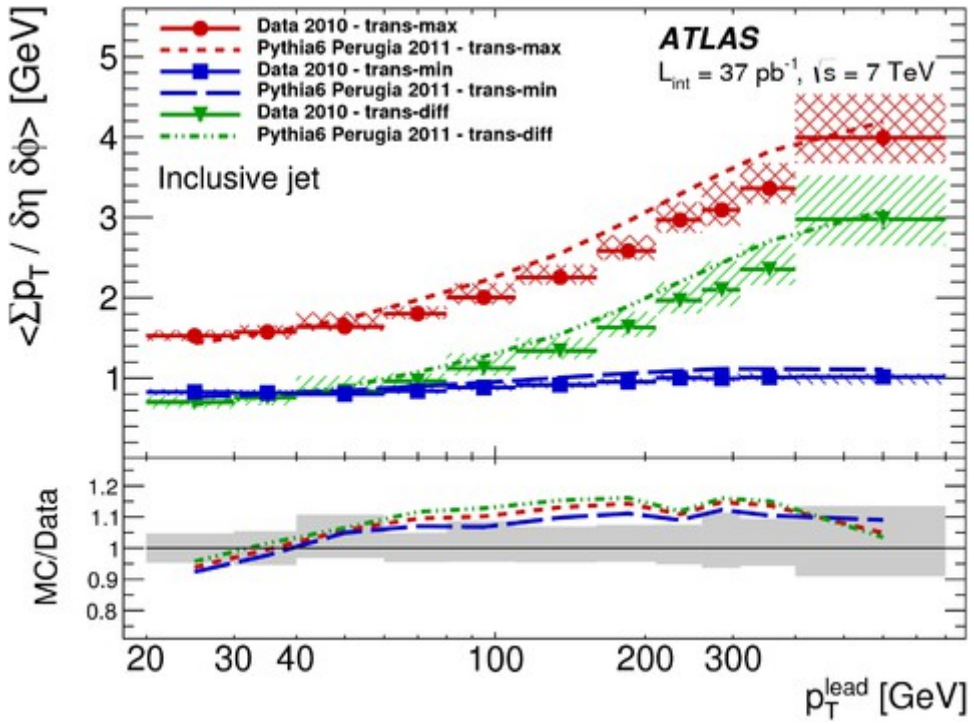


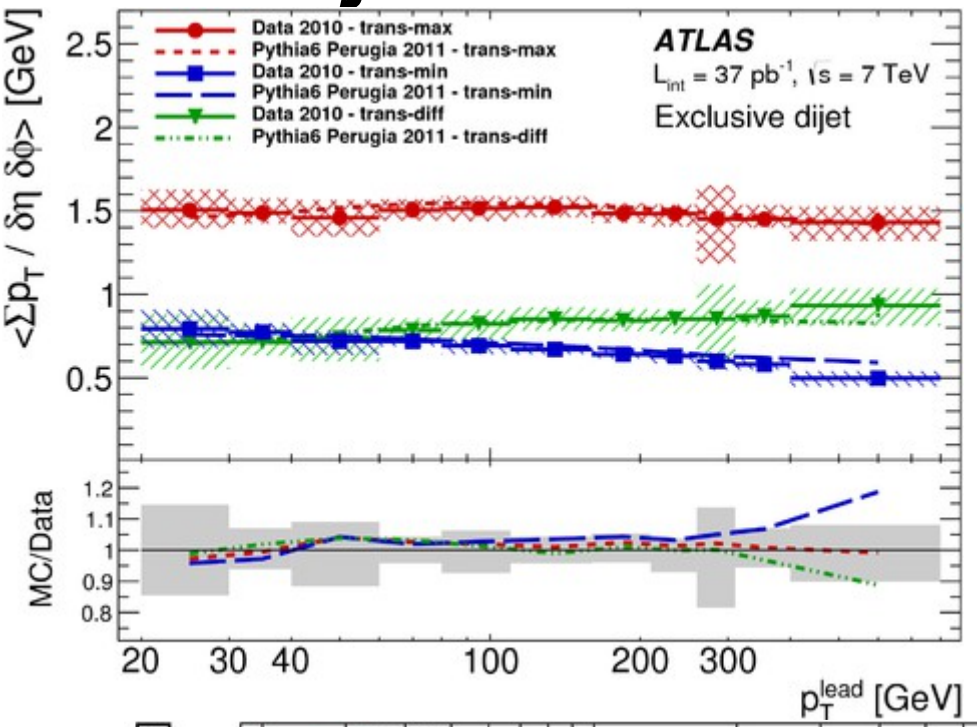


Observables:

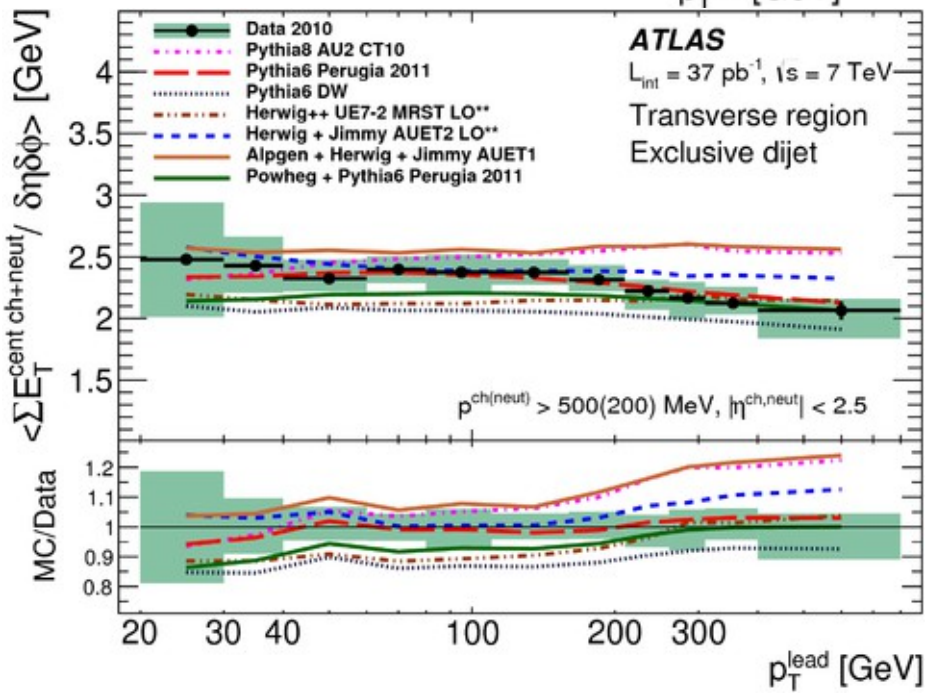
- charged particles multiplicity vs. p_T^{lead}
- scalar p_T sum vs. p_T^{lead}
- $\langle p_T \rangle$ vs. p_T^{lead}
- $\langle p_T \rangle$ vs. N_{ch}
- $\Delta\varphi$ distribution of multiplicity
- $\Delta\varphi$ distribution of p_T sum

Underlying event in jet events



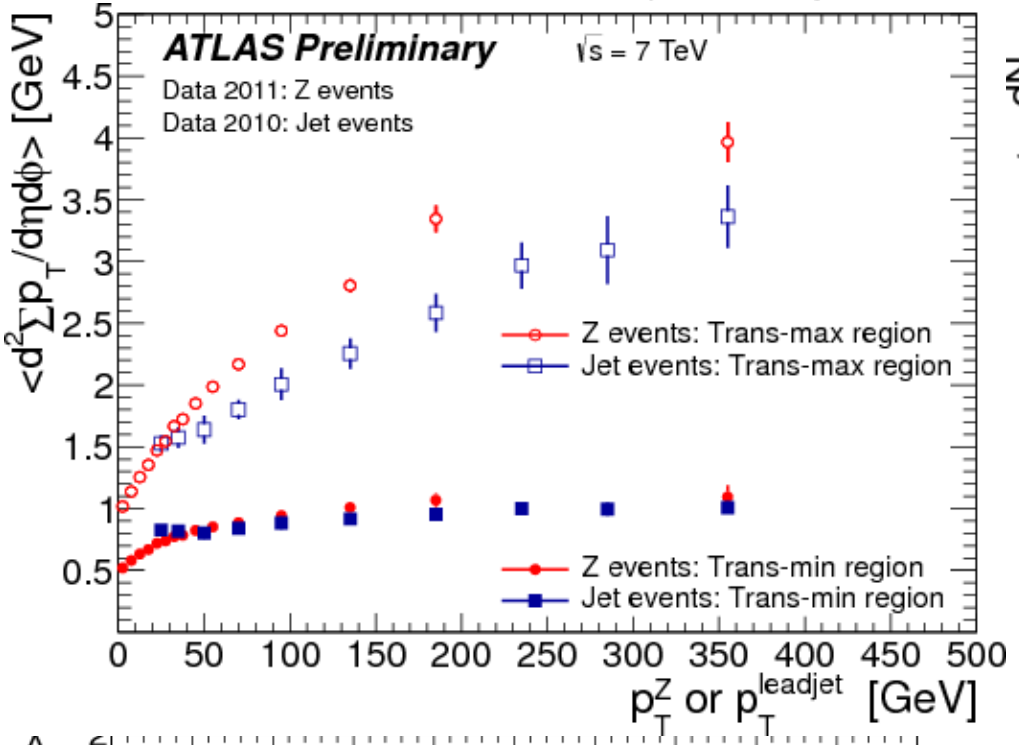


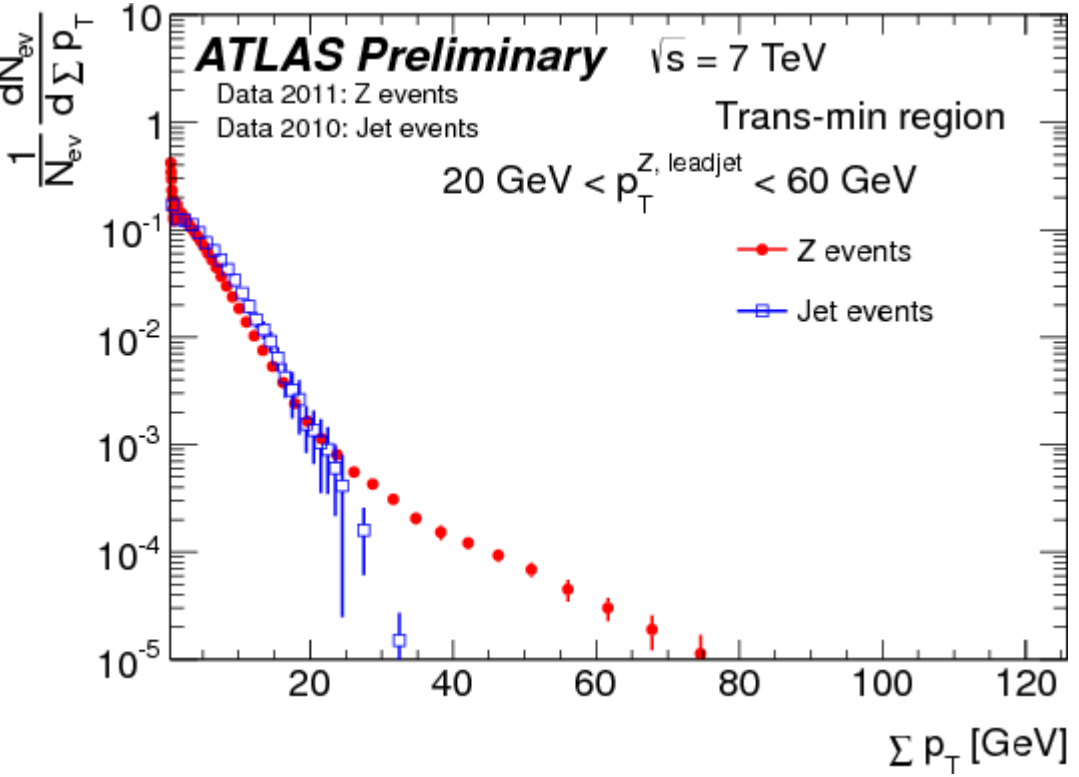
- Measurement of distributions sensitive to the underlaying event in QCD jet events
  - for inclusive jet (N >= 1) and exclusive dijet (N = 2) events
- 7 TeV data, 37 pb^{-1}
- The MC models reproduce most of the features of the underlying events
  - Need for further model tuning

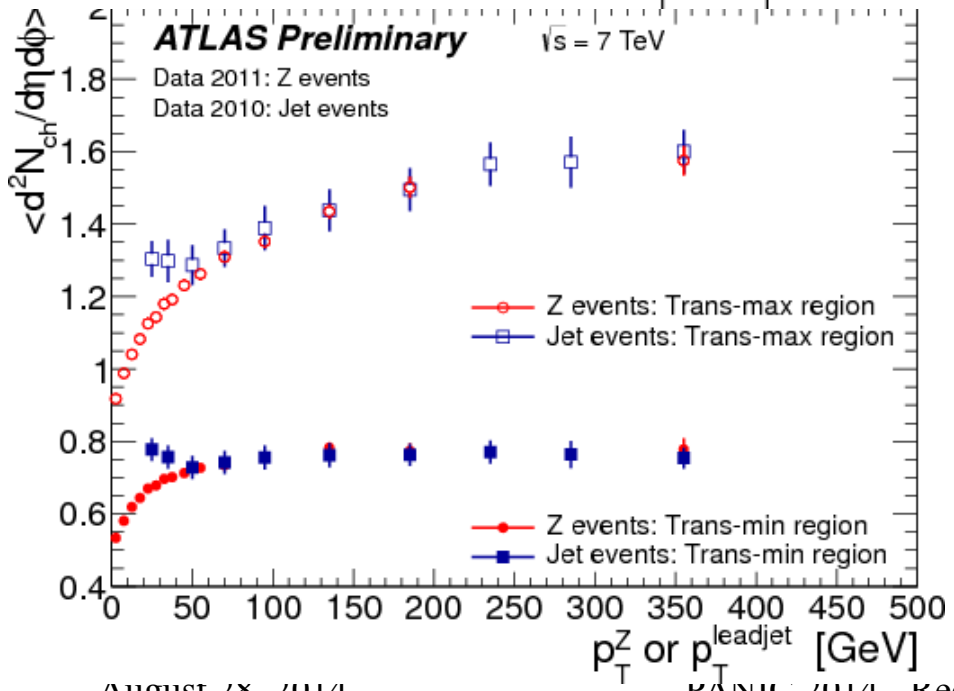


Eur.Phys.J. C74 (2014) 2965, arXiv:1406.0392

Underlying event in Z events





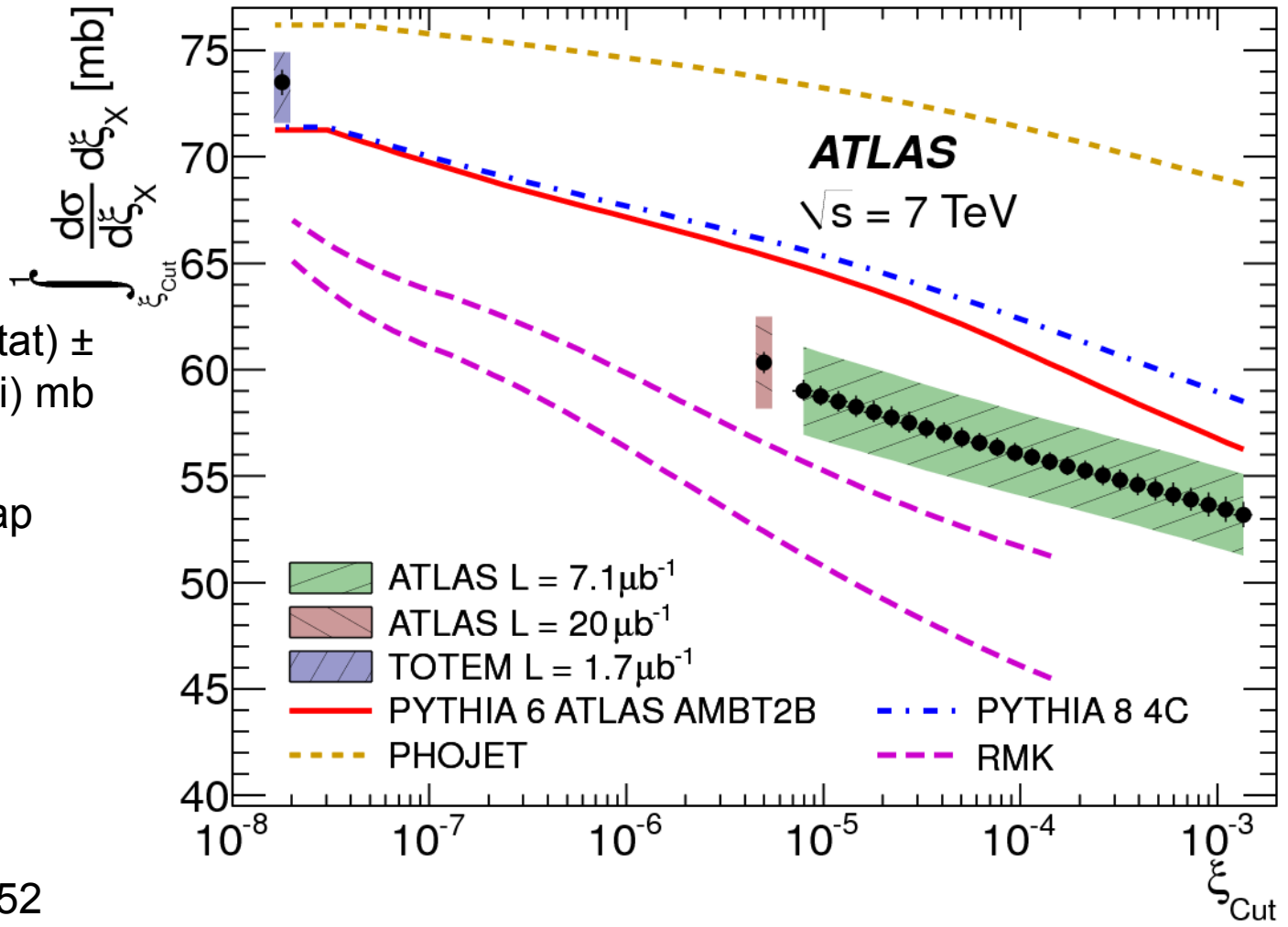


- $pp \rightarrow Z + X$, $Z \rightarrow e^+ e^- / \mu^+ \mu^-$
- Inclusive Z events
- Very similar to UE in inclusive jet events, up to kinematic selection bias as jets with $p_T^{jet} > p_T^Z$ are allowed in inclusive Z selection, hence the long Σp_T tail

ATL-COM-PHYS-2012-1295

Inelastic cross section using minimum bias events

- $\sqrt{s}$ = 7 TeV March 2010 data
  1.2e6 ev., 20.3 ± 0.7 μb^{-1}
- Acceptance region (MBTS)
  - $\xi = M_X^2 / s > 5 \times 10^{-6}$
  - $M_X > 15.7$ GeV
- $\sigma_{inel}(\xi > 5\times10^{-6}) = 60.3 \pm 0.05(stat) \pm 0.5(syst) \pm 2.1(lumi)$ mb

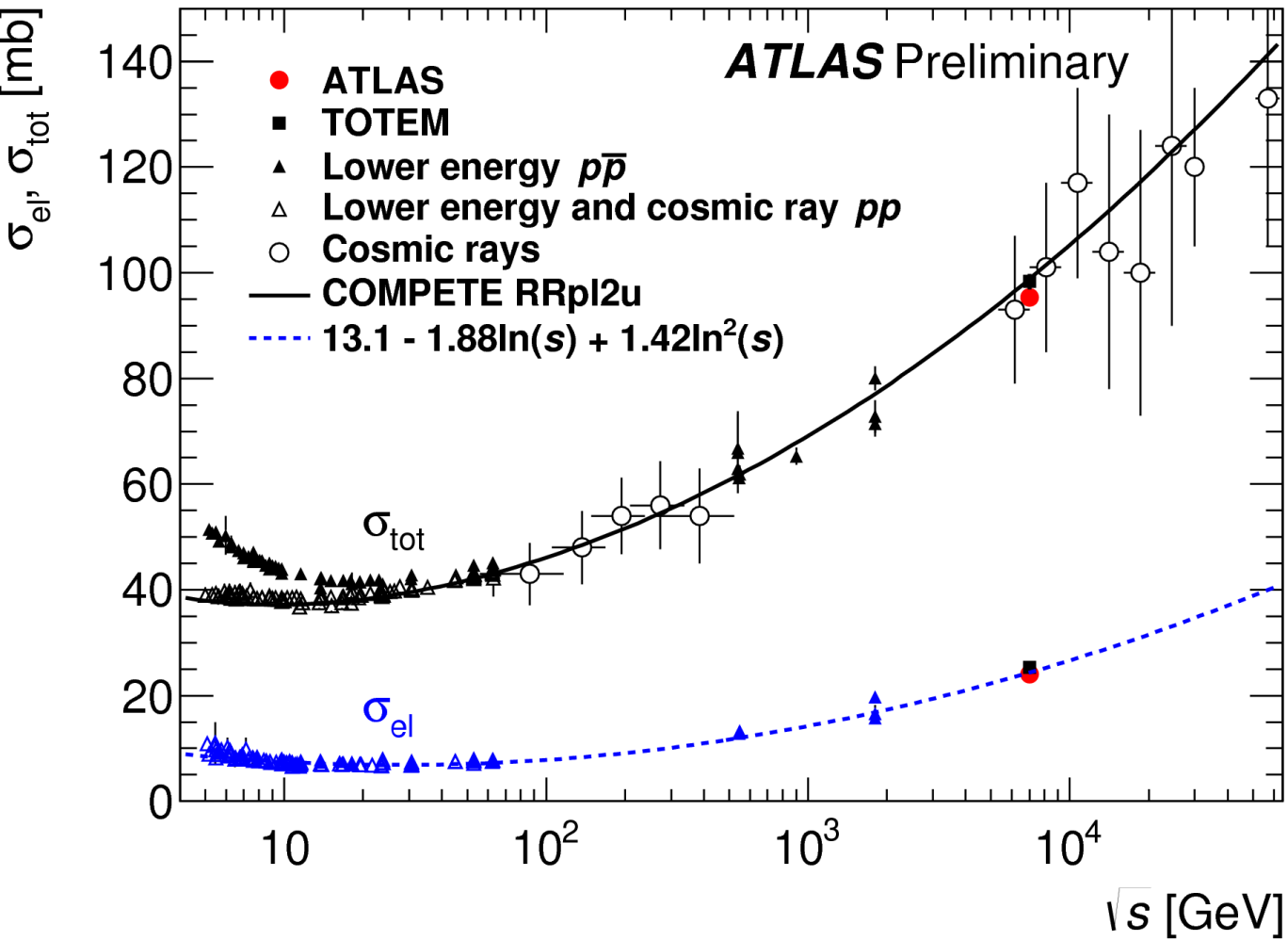


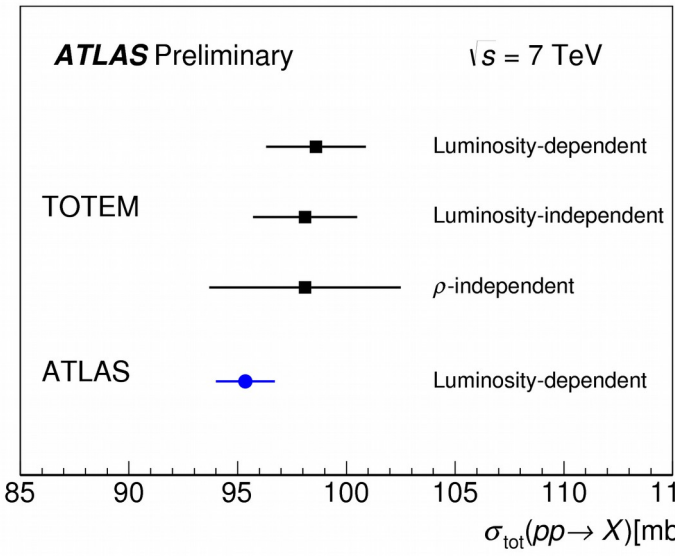
- Differential cross-section for gap size $\Delta\eta$
- $\sqrt{s}$ = 7 TeV March 2010 data
  7.1 ± 0.2 μb^{-1}
- Acceptance region
  - $|\eta| < 4.9$, $\Delta\eta < 8$
  - $\log_{10}\xi_{Cut} = -0.45\,\Delta\eta_{Cut} - 1.52$
- The results from both studies are consistent

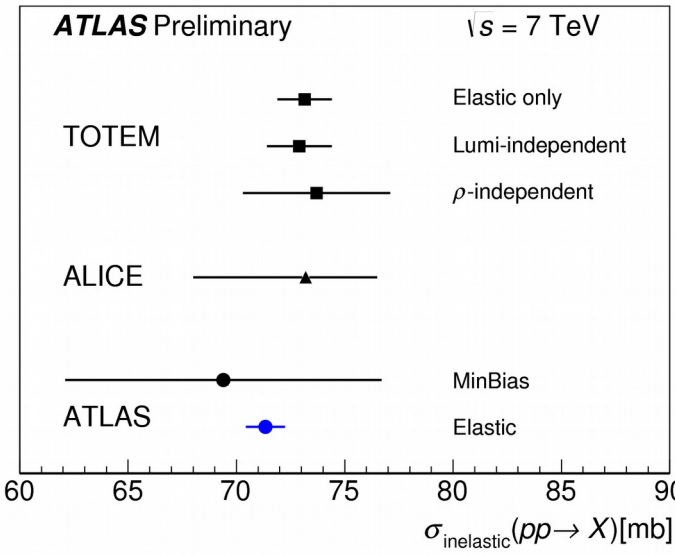
Nature Commun. 2 (2011) 463, arXiv:1104.0326

Eur. Phys. J. C72 (2012) 1926, arXiv:1201.2808

Total, elastic cross-sections with ALFA



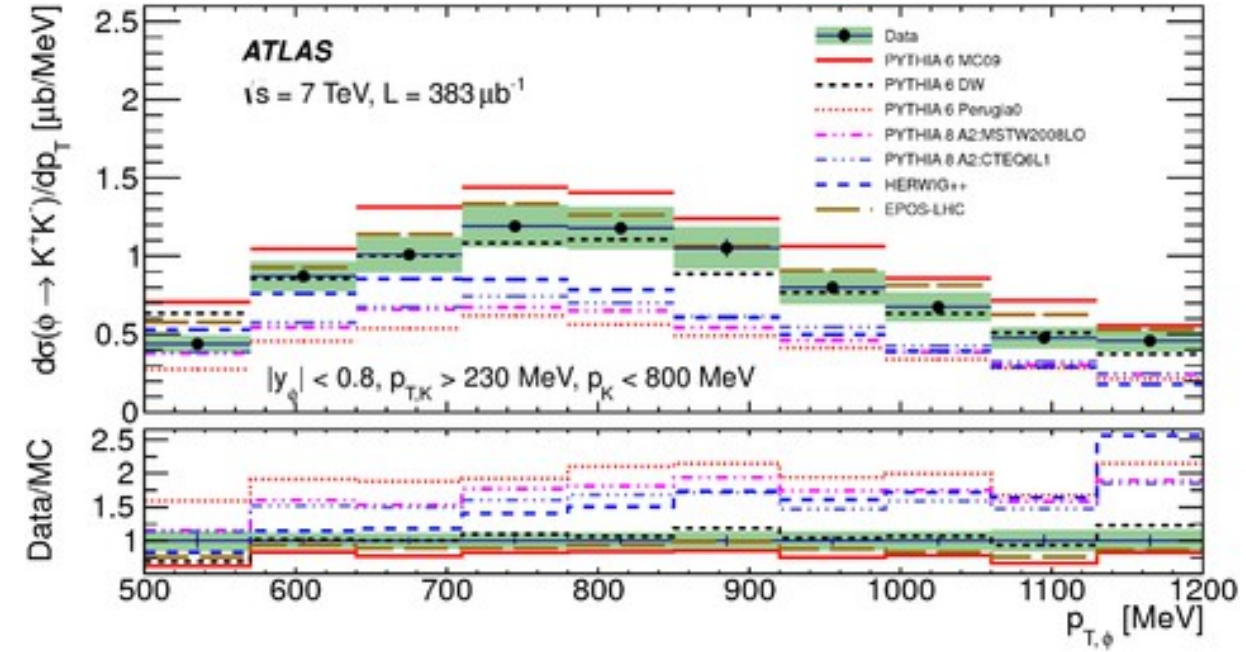


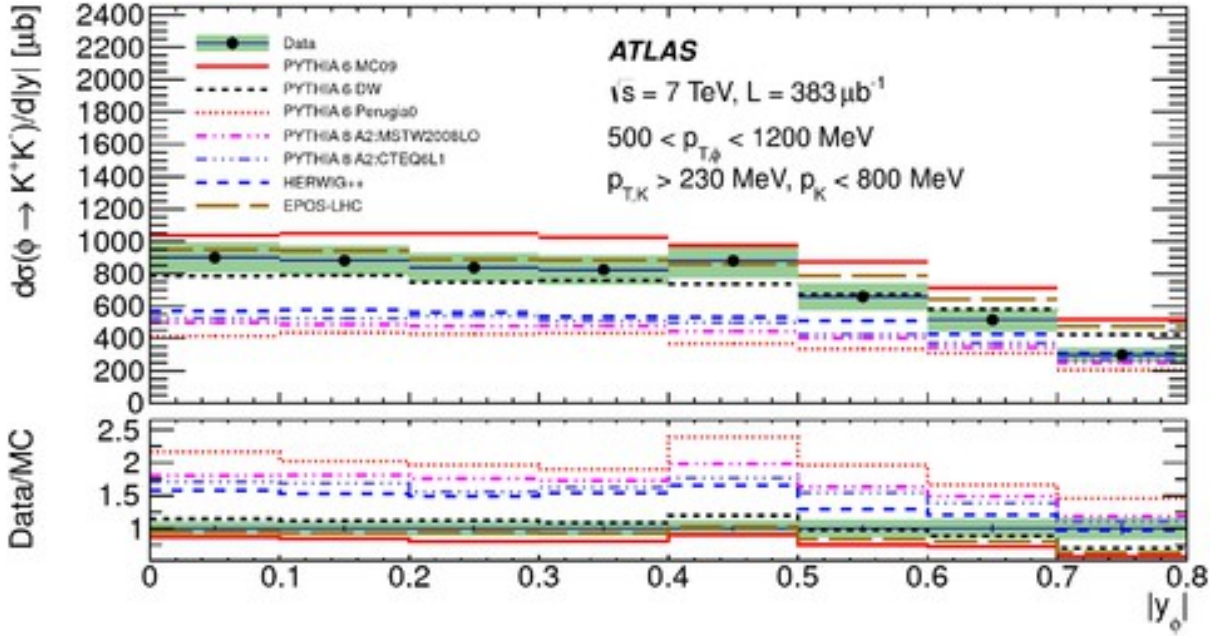


- 2011 7 TeV data 80 μb^{-1} with high β^* optics
- $\sigma_{tot}(pp \to X)$ = 95.35 ± 0.38 (stat.) ± 1.25 (exp.) ± 0.37 (extr.) mb
- The total cross section determined using the optical theorem

arXiv:1408.5778

$\varphi(1020) \rightarrow K^+ K^-$ cross section

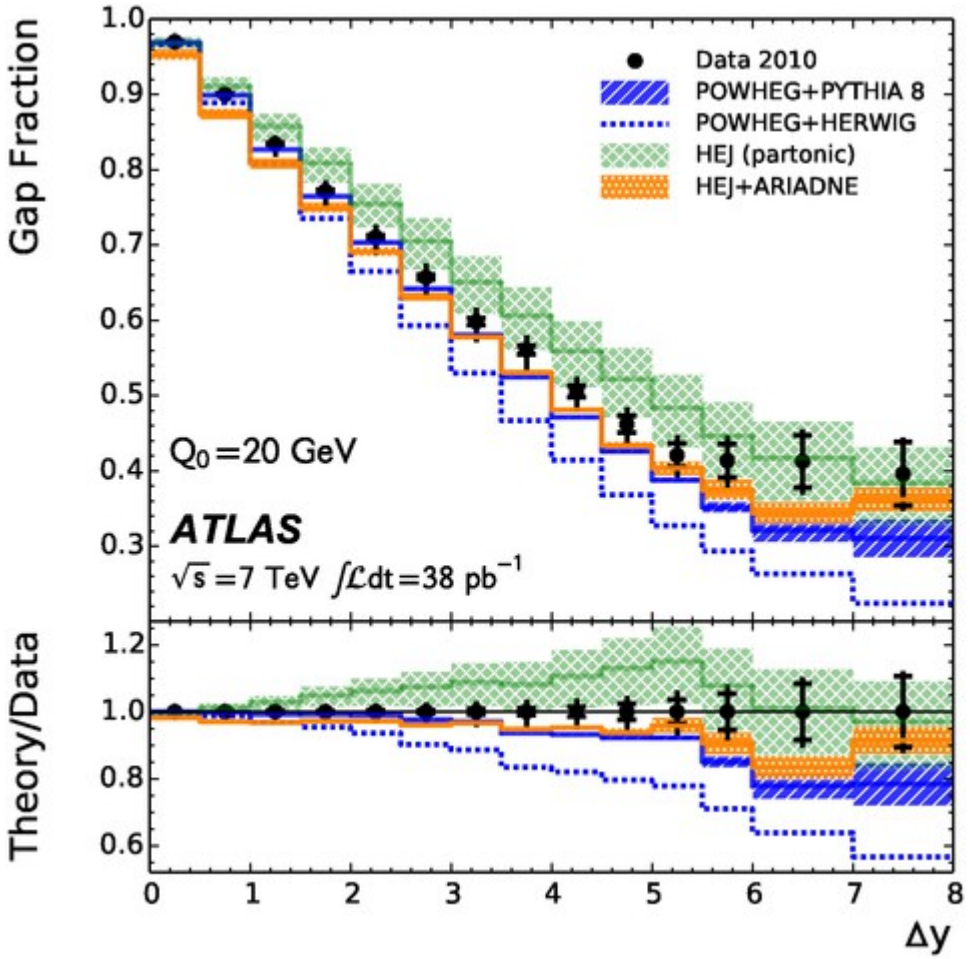


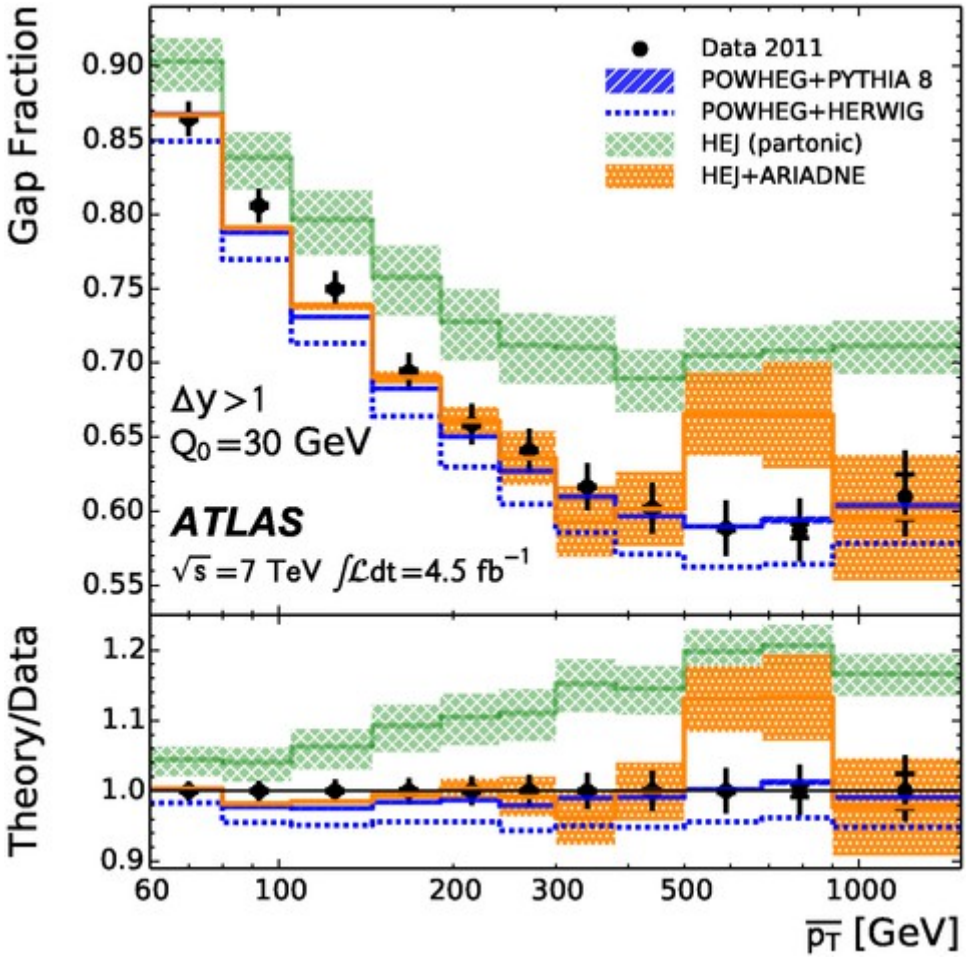


- Measurements of the $\varphi(1020)$-meson probe strangeness production at a soft scale Q = 1 GeV, which is sensitive to *s*-quark and low-*x* gluon densities
- Production of $\varphi(1020)$ mesons is also sensitive to fragmentation details
- The $\varphi(1020)$ measurements can constrain phenomenological soft hadroproduction models

Eur. Phys. J. C (2014) 74:2895, arXiv:1402.6162

Jet vetoes and azimuthal decorrelations in dijet events

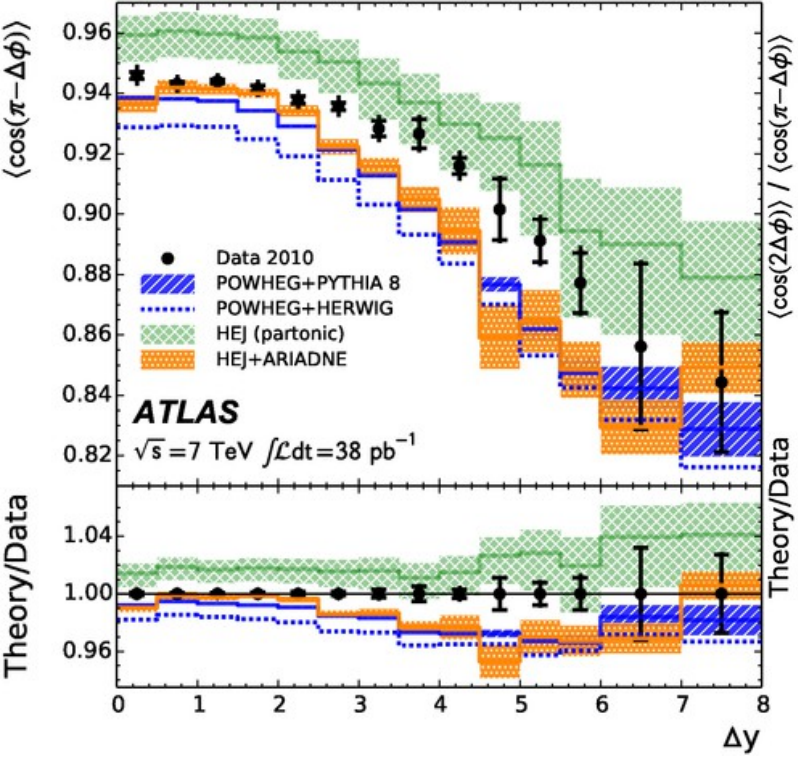


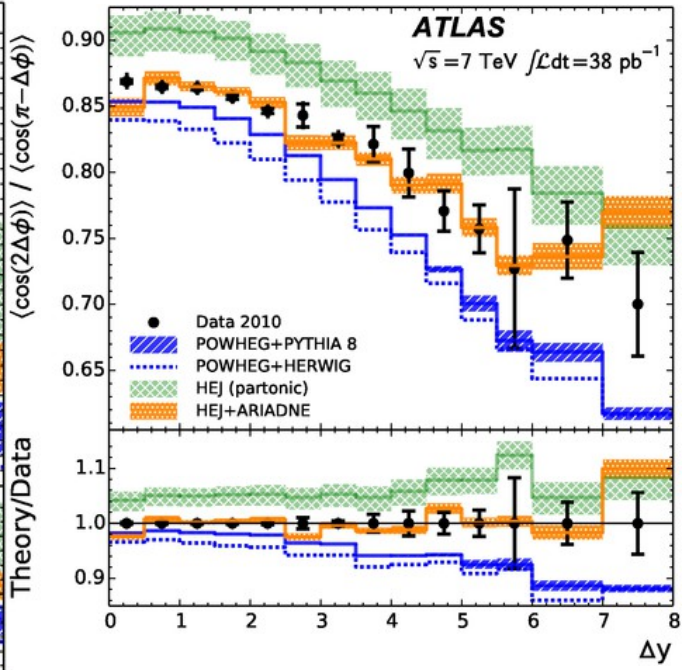


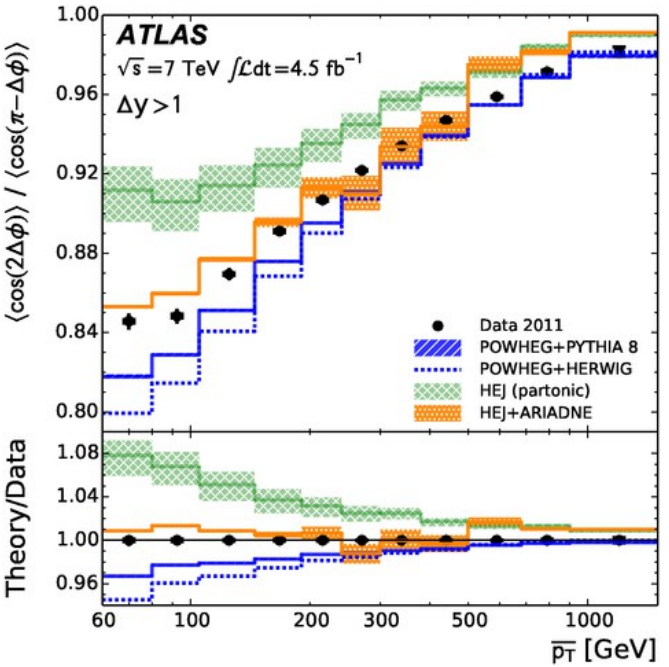
- Testing of perturbative QCD theoretical predictions in extreme regions of phase space
- In situations of large rapidity separation of jets or when a veto of additional jet activity is applied, higher order corrections become increasing important

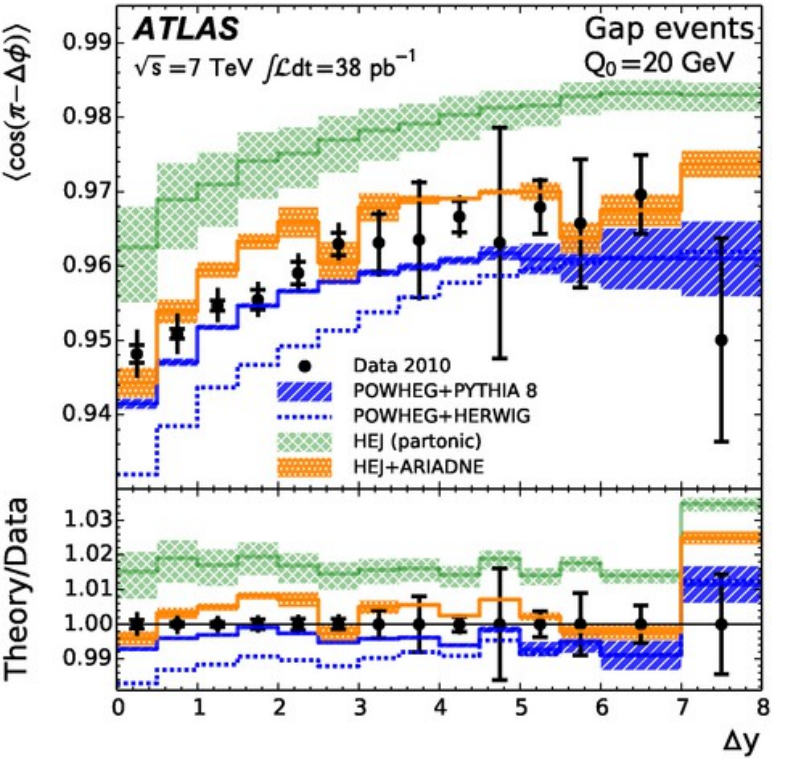
- The plateau at high $\bar{p}_T$ is qualitatively reproduced by theoretical predictions
- None of the theoretical models predicts the plateau at high Δy

arXiv:1407.5756





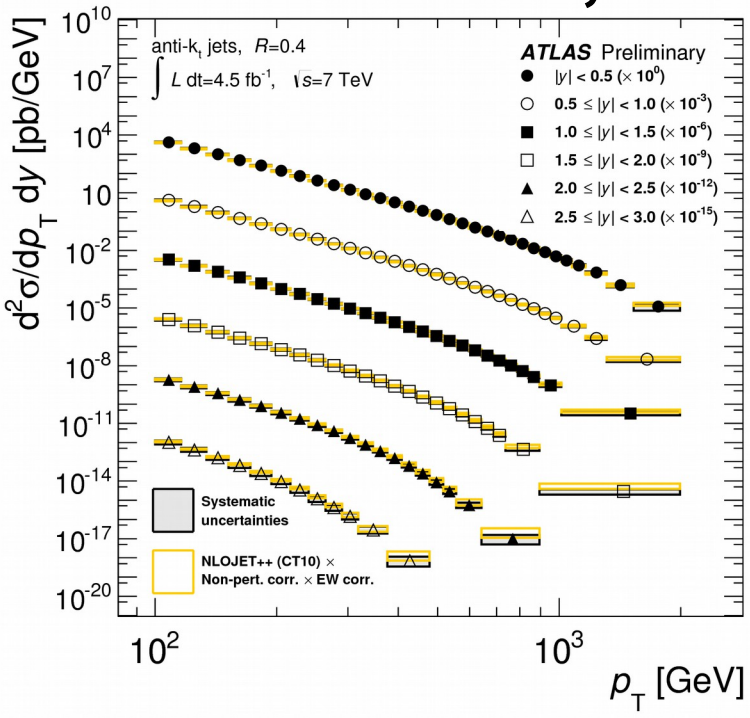


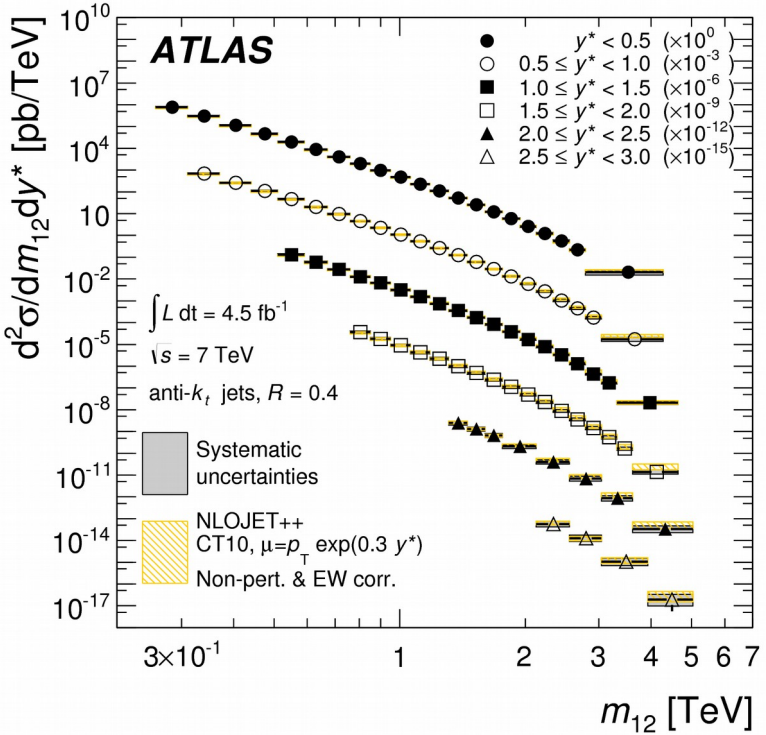


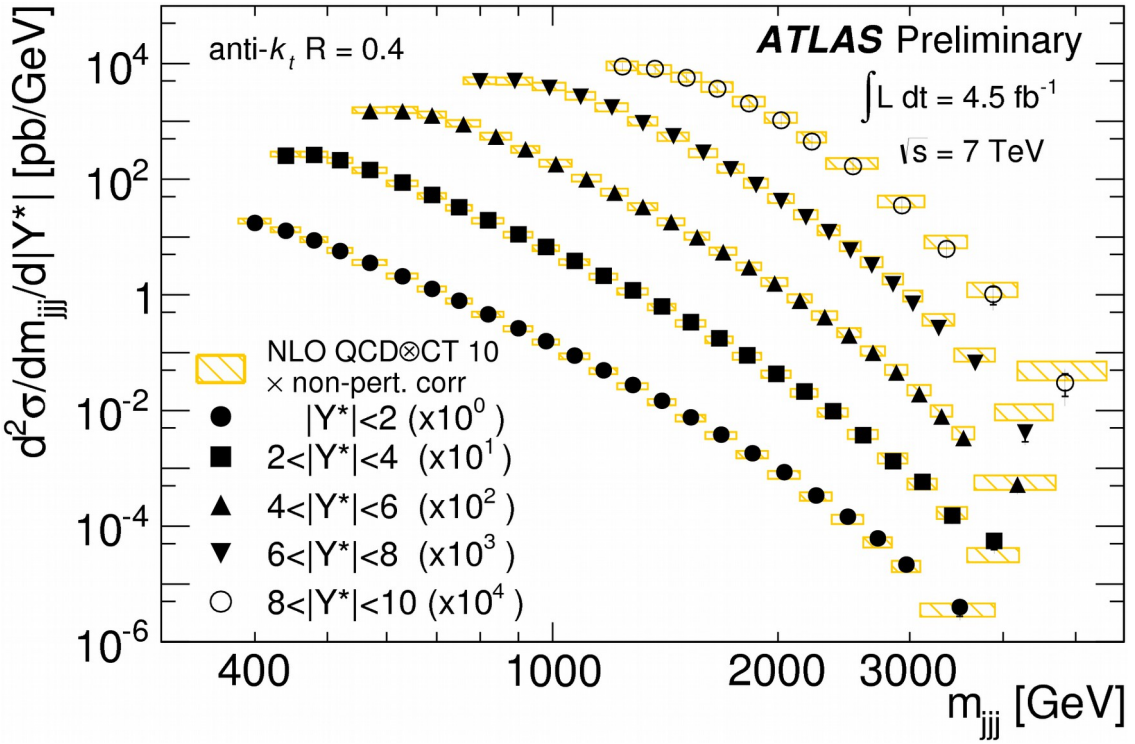
- Azimuthal correlations as a function of Δy and $\bar{p}_T$
- No theoretical prediction provide good agreement with data in all observables over the whole phase space
  - The largest differences are for low $\bar{p}_T$ and high Δy
  - The HEJ + ARIADNE prediction gives a good description of the data for both low $\bar{p}_T$ and Δy

arXiv:1407.5756

Inclusive, di- and three-jet cross sections





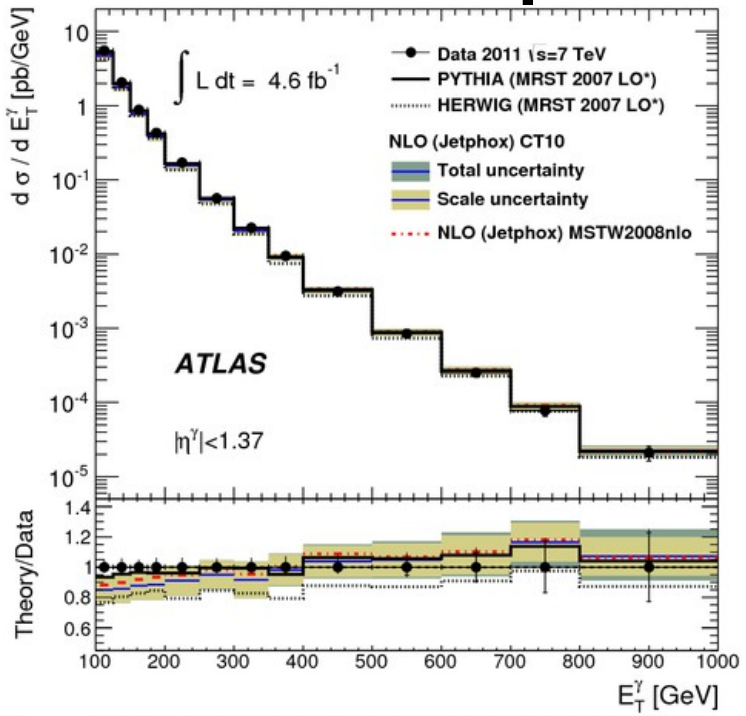


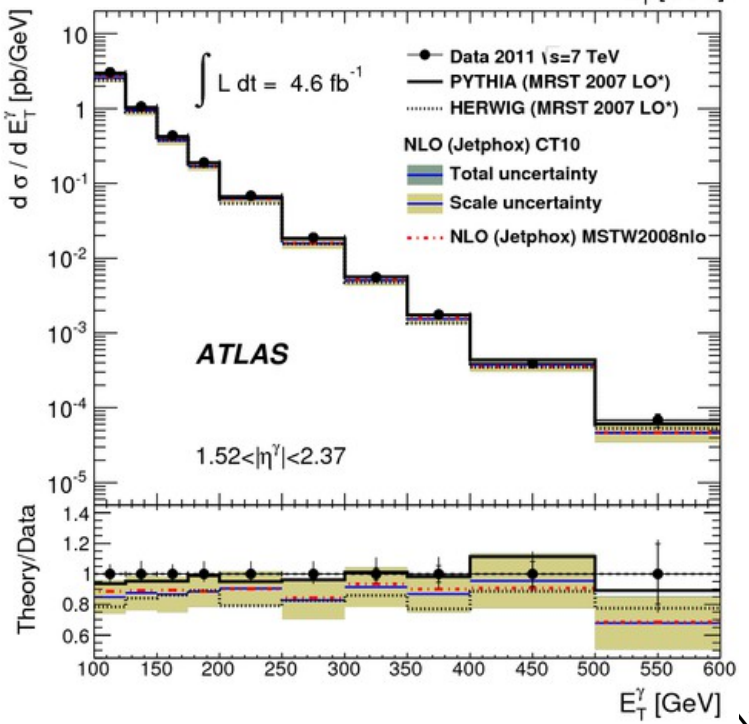
- 7 TeV ATLAS 2011 data, 4.5 fb^{-1}
- The measurements are corrected for detector effects to the particle level
- Good agreement is observed for the NLOJet++ theoretical predictions when using the CT10, NNPDF2.1 and MSTW 2008 PDF sets for the theoretical predictions

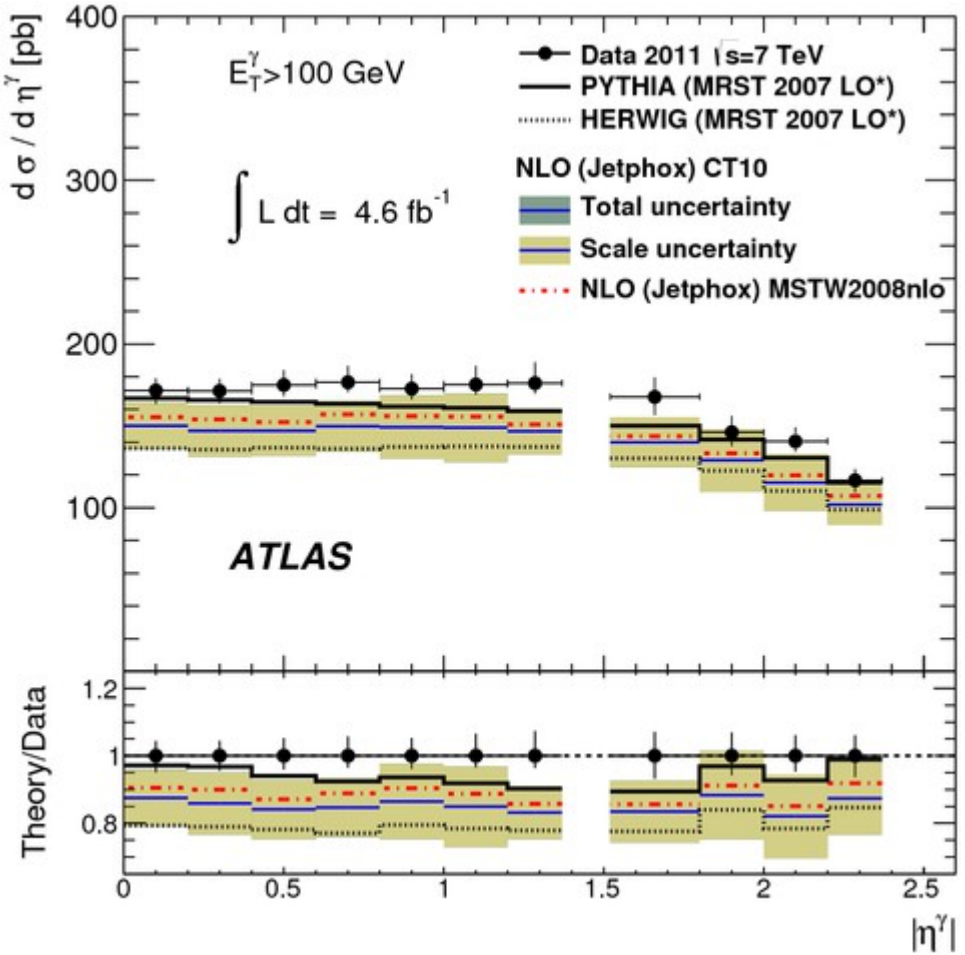
JHEP05(2014)059, arXiv:1312.3524

ATLAS-CONF-2014-045

Isolated prompt photon cross section



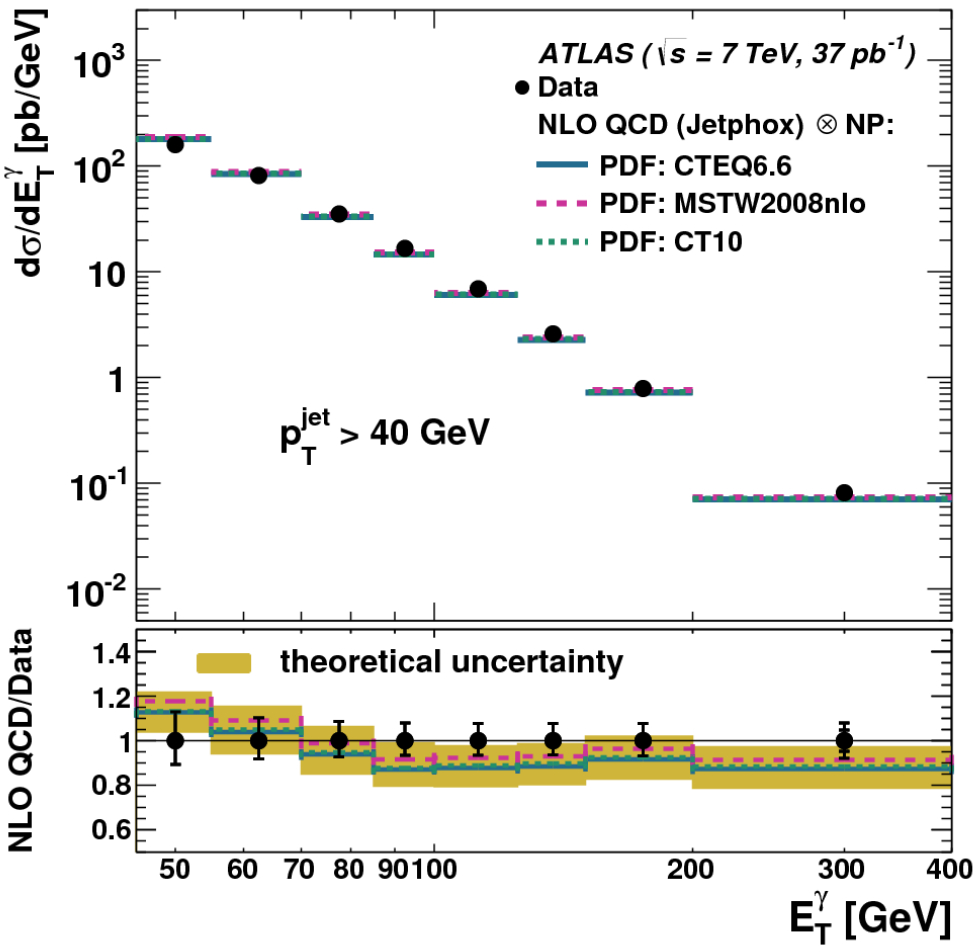


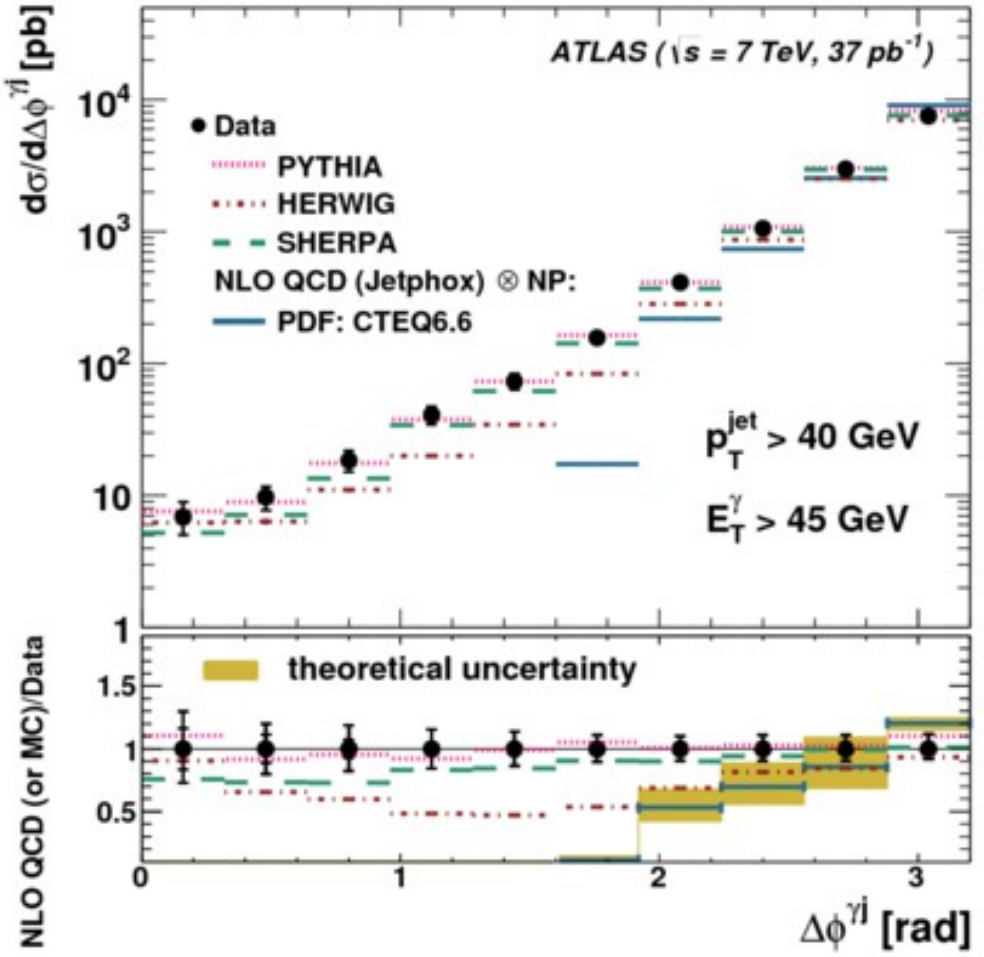


- The prompt photon production is sensitive to the gluon content of the proton ($qg \rightarrow q\gamma$)
- ATLAS data compared to LO parton-shower MC models and NLO perturbative QCD calculations

Phys. Rev. D 89, 052004 (2014), arXiv:1311.1440

Isolated photon and jet production





- The production of prompt photons in association with a jet in proton–proton collisions, pp → γ + jet + X, provides a testing ground for perturbative QCD in a cleaner environment than in jet production
- The NLO QCD calculations provide good description of the data, except of the azimuthal opening angle distribution of the cross-section

Nucl. Phys, B 875 (2013) 483-535, arXiv:1307.6795

Conclusion

- Various measurements sensitive to the soft and perturbative Standard model including total proton-proton cross section, characteristics of the underlying events, isolated prompt photon, photon and jet production cross sections were presented and compared to the theoretical expectations.
- The results are used or have a potential to test and tune PDF, phenomenological model parameters
- More ATLAS QCD results are available here: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/StandardModelPublicResults