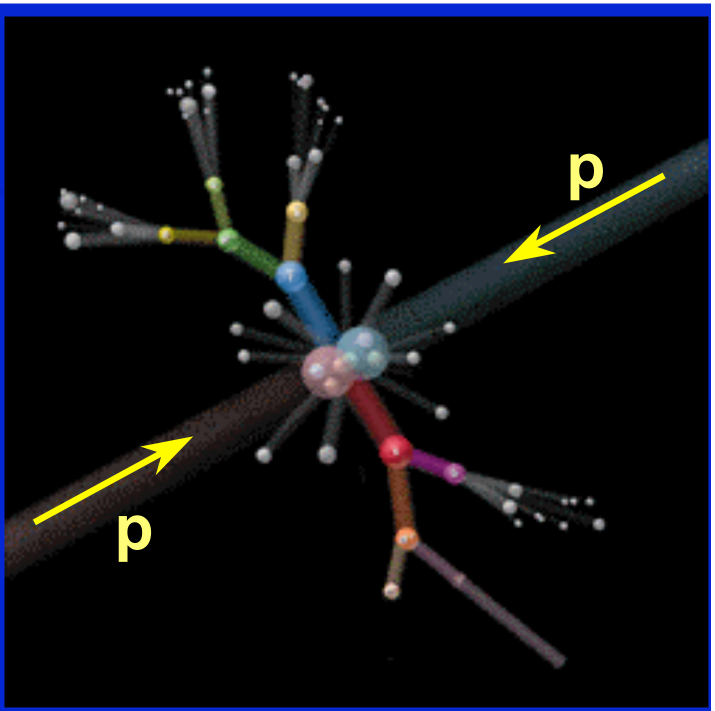
QCD measurements from minimum bias to jets

Maria Jose Costa, CERN
On behalf of the ATLAS Collaboration

Physics at the LHC, Cracow 2006

Contents

Introduction



- At LHC pp collider, essentially all physics will arise from quark and gluon interactions (small & large transfer momentum):
    - Hard processes (high pT): well described by perturbative QCD
    - Soft interactions (low pT): require phenomenological models.

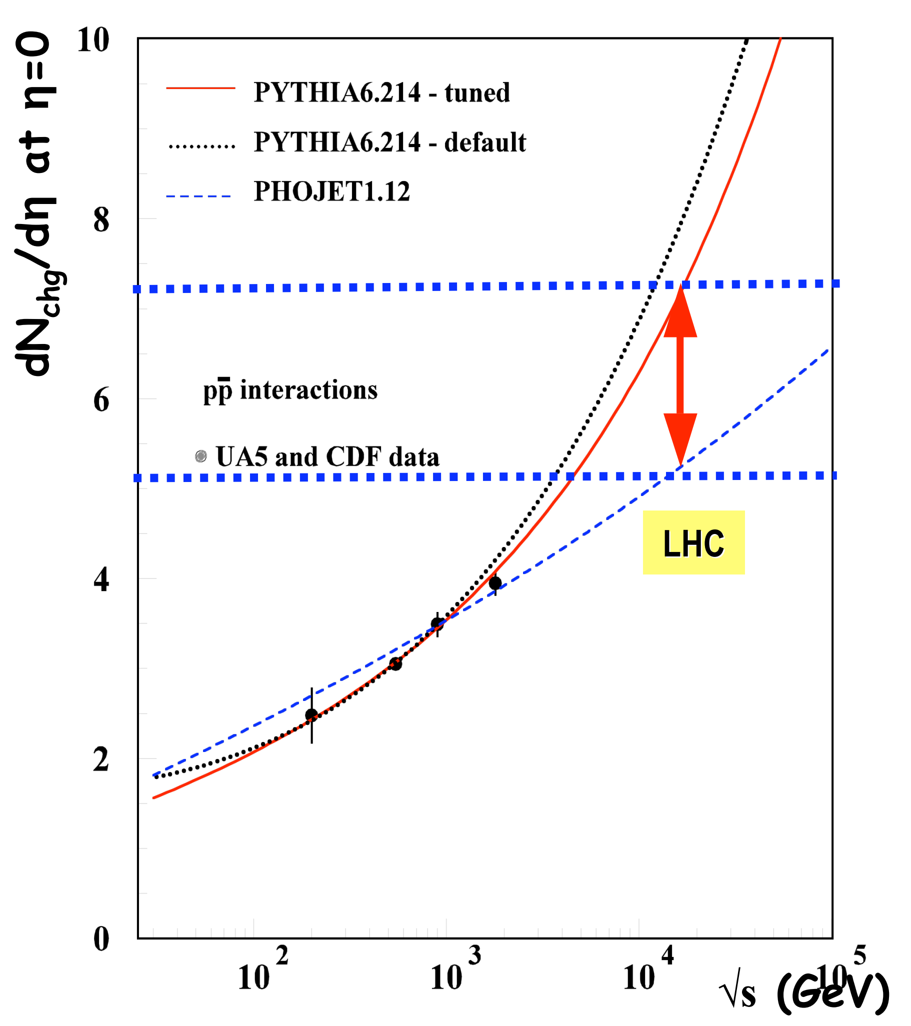
    Dominant processes at LHC! (minimum bias)

- Detailed understanding of QCD is important for understanding:
    - A particular channel which might indicate interesting phenomena
    - The background surrounding such channel

- QCD can be precisely tested in a wide energy range.

Minimum bias

A. Moraes, Dawson, C. Buttar



PYTHIA models favour $\ln^2(s)$
PHOJET suggests a $\ln(s)$ dependence

- *MC comparisons to data from ISR, SPS and Tevatron have been performed as well as extrapolations to LHC.*

Comparison of predictions for minimum bias event generators and consequences for ATLAS radiation background
Moraes, Dawson, Buttar
ATL-PHYS-2003-013

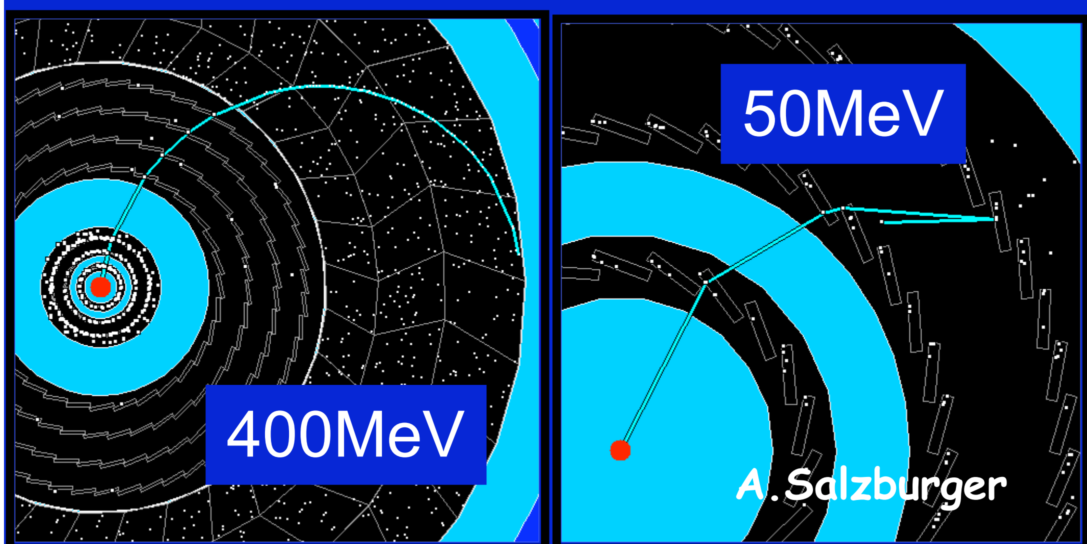
Minimum bias and underlying event: Towards the LHC
Dawson, Buttar, Moras
Czech.J.Phys.:54 (2004)

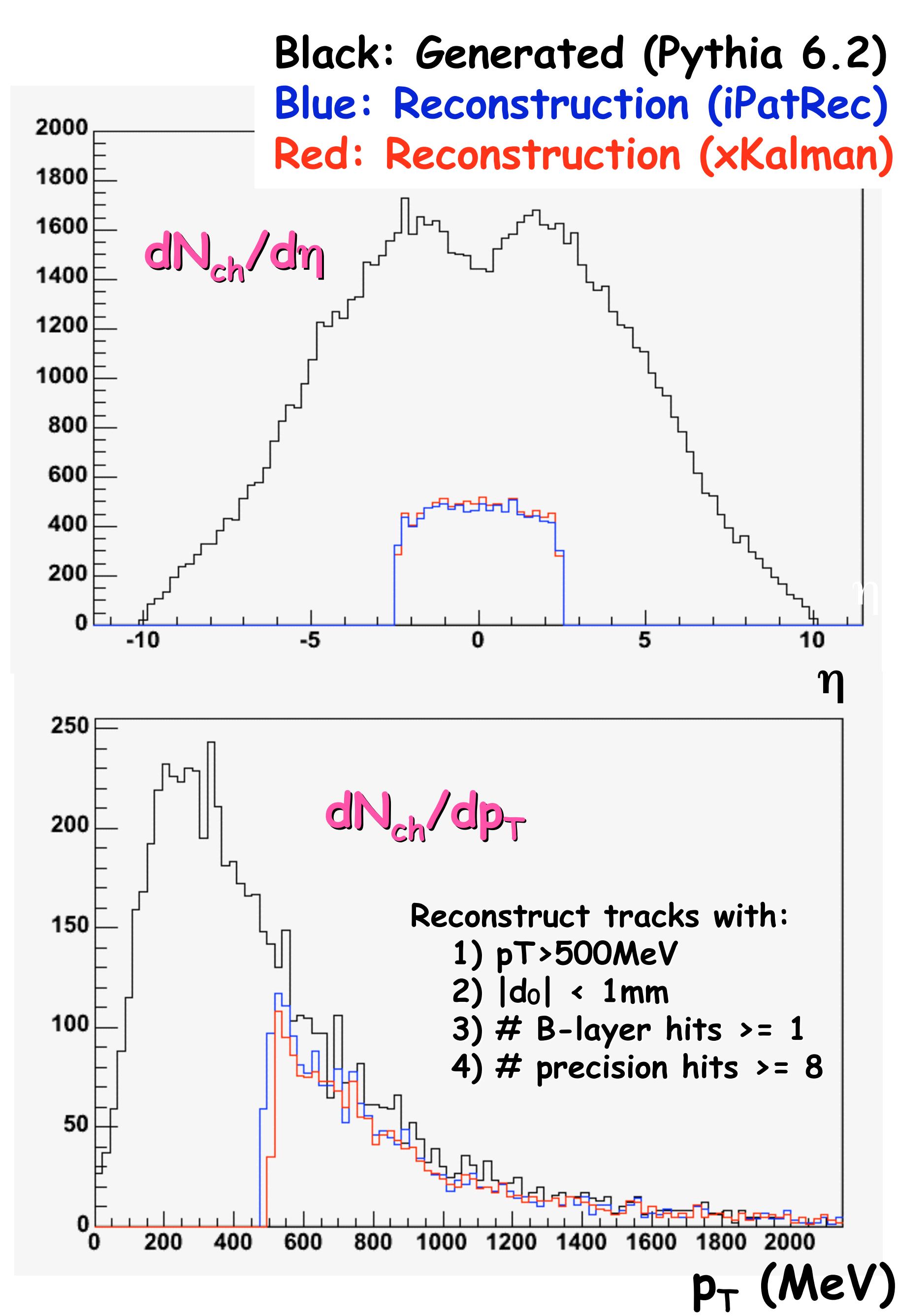
Prediction for Minimum bias and the underlying event at LHC energies
Moraes, Buttar, Dawson
ATL-PHYS-PUB-2005-007

- *How well can we make these measurements with the first ATLAS data?*

Minimum bias

- Only a fraction of tracks reconstructed by Inner Detector due to:
  - limited rapidity coverage $|\eta| < 2.5$
  - p_T cut-off of 0.5 GeV
  - → Tracking is sensitive to soft tracks
  - → Dedicated search tuned for soft particles will be used

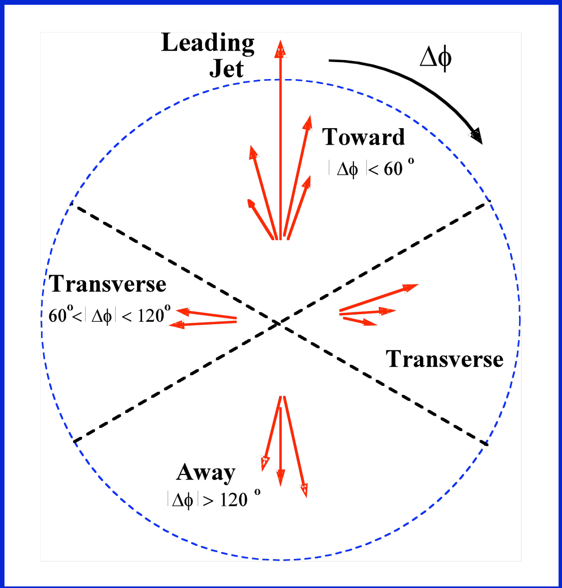


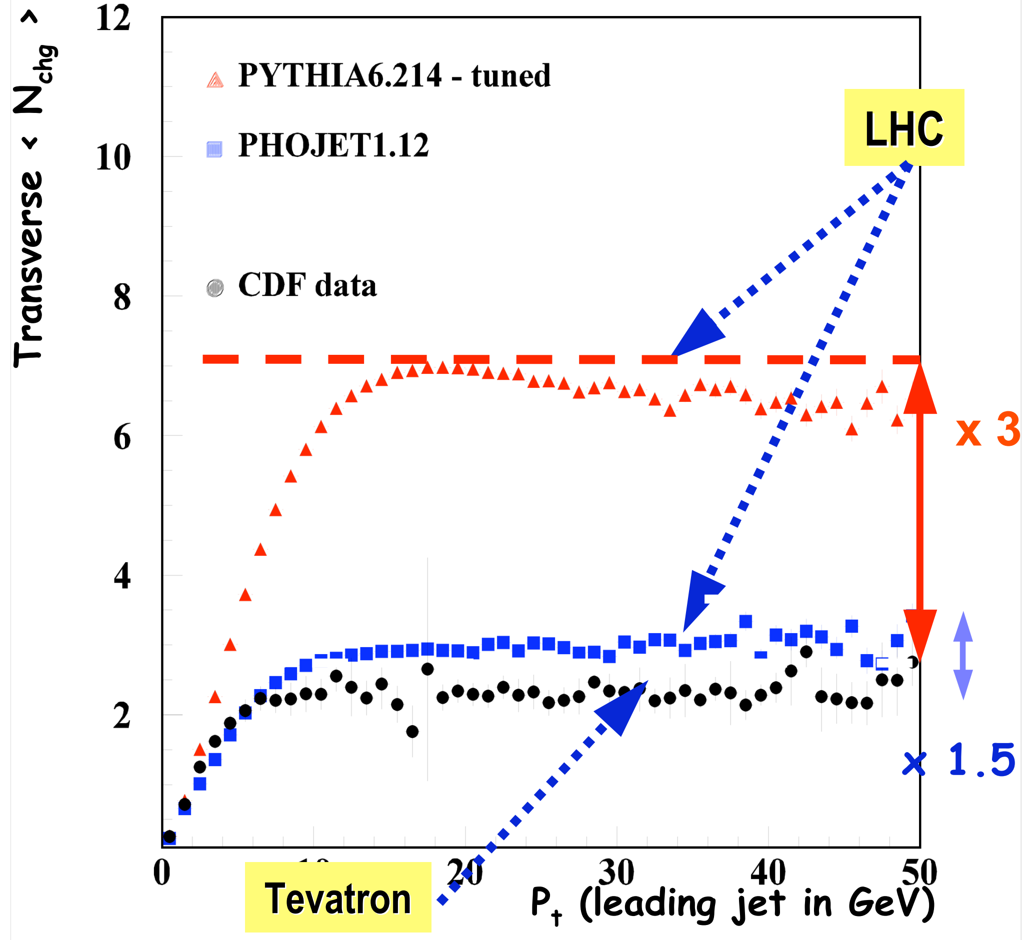


Underlying event

A. Moraes, Dawson, C. Buttar

- The UE has hard (multiple semi-hard parton scattering) and soft components (beam-beam remmants)





- Extrapolation of UE to LHC depends on:
  - Multiple interactions
  - Radiation
  - PDFs

$dN_{ch}/d\eta$ (MB) ~ 7
$dN_{ch}/d\eta$ (UE) ~ 30 (Pythia 6.214)
~ 15 (PHOJET 1.12)

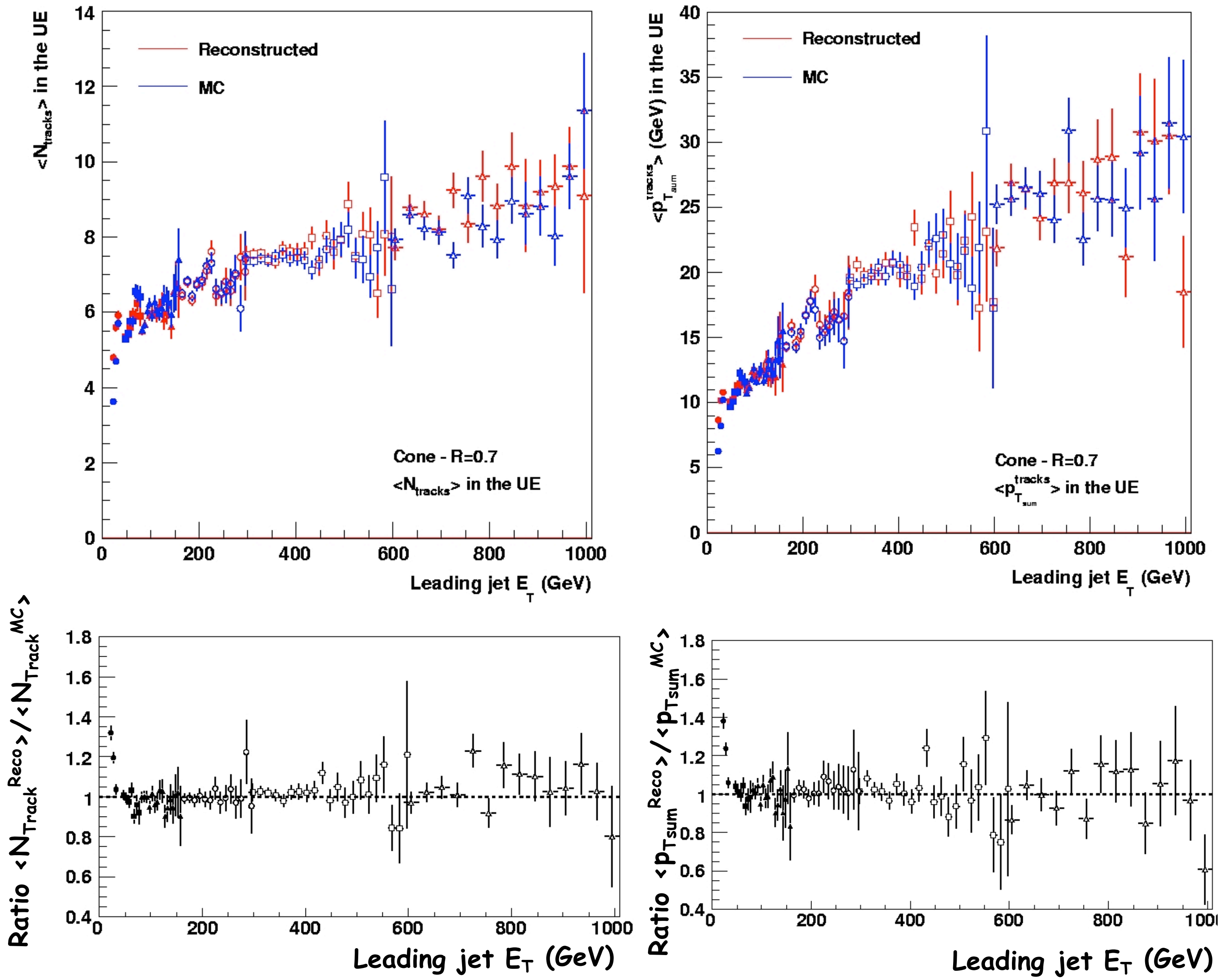
Underlying event

Selection of UE

$N_{jets} > 1$
$|\eta_{jet}| < 2.5$
$E_T^{jet} > 10$ GeV

$|\eta^{track}| < 2.5$
$p_T^{track} > 1$ GeV/c

Reconstructed track distributions for the UE reproduce the MC event generator predictions

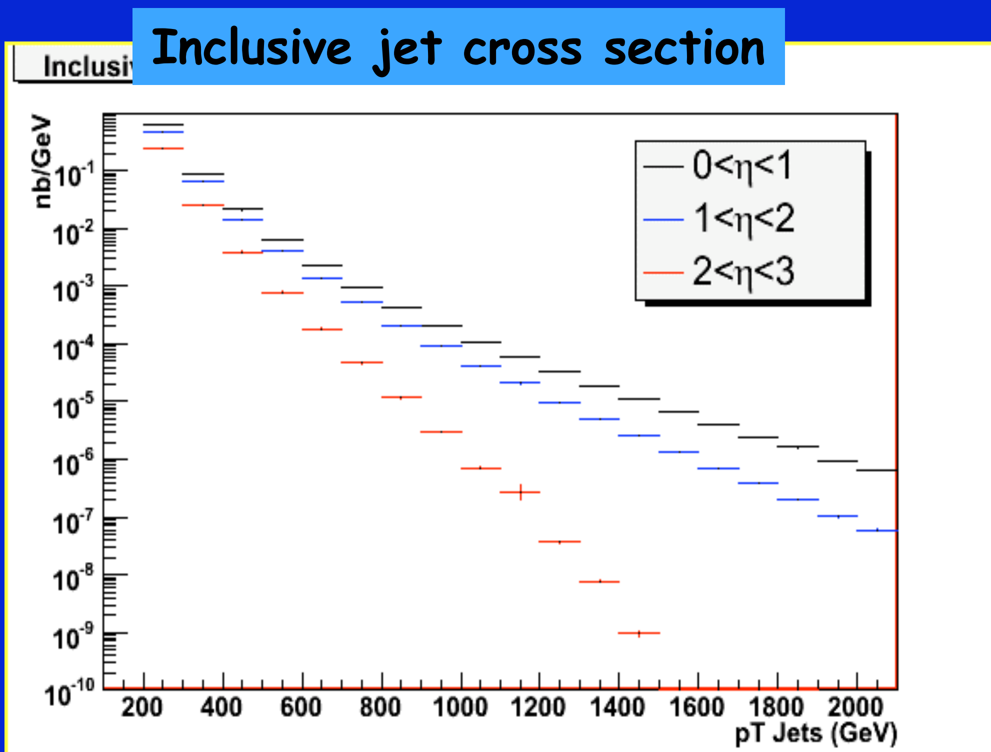


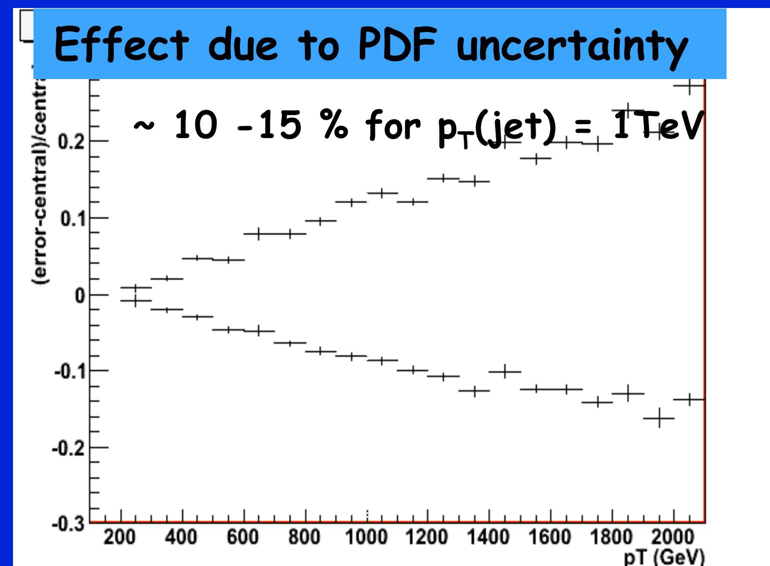
D.Clements, T.Carli, C.Gwenlan,
C.Buttar, A.Cooper-Sarkar, M.Sutton

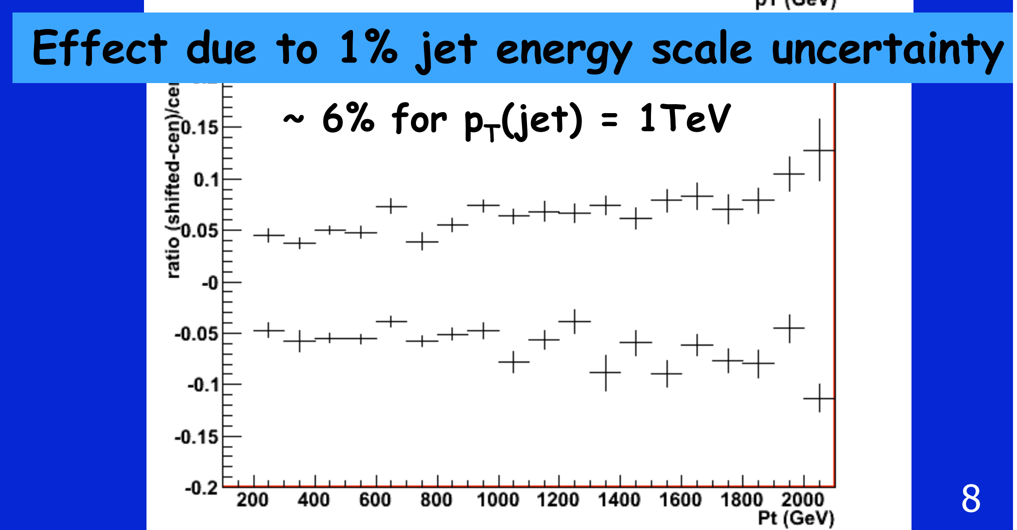
Inclusive jet cross section

- Measurement dominated by systematics

- This measurement can be used to:
  - constrain PDFs
  - look for new physics
  (e.g. quark compositeness)



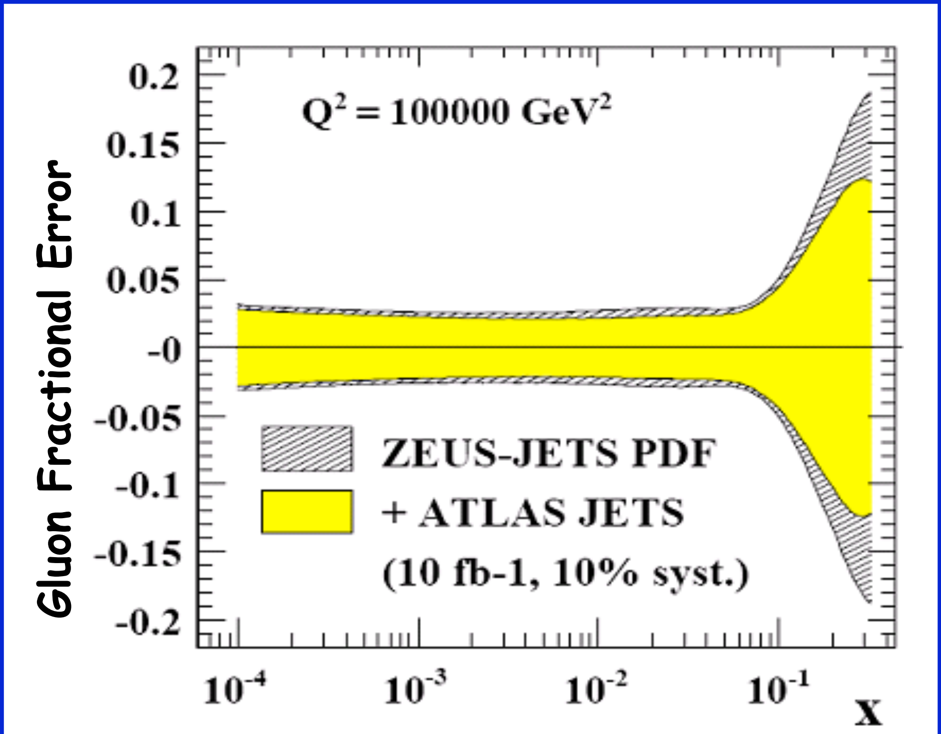




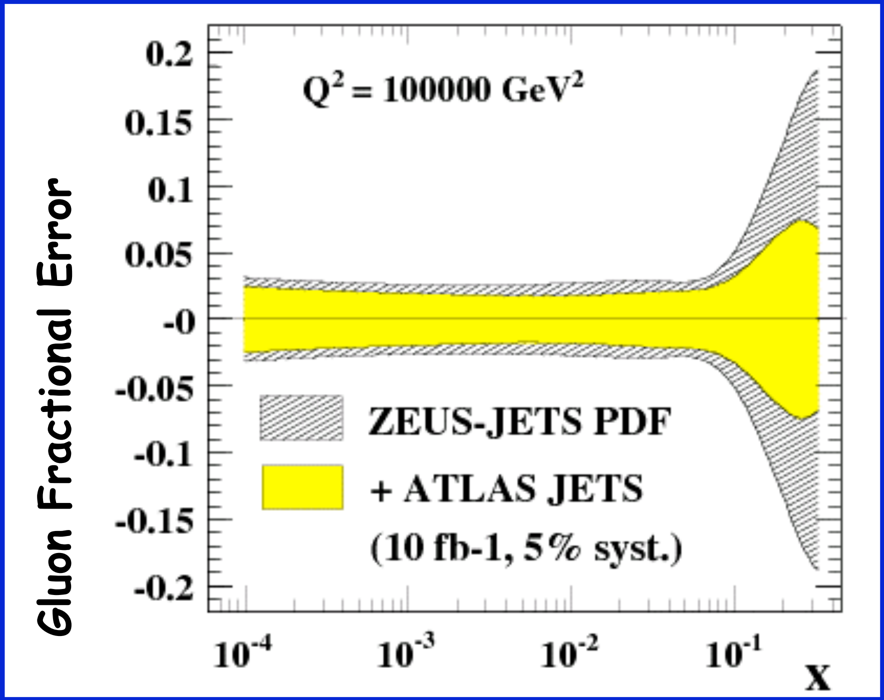
Inclusive jet cross section

- ATLAS pseudo-data for $0<\eta<1$, $1<\eta<2$, $2<\eta<3$ up to pT = 3 TeV was used in a global (ZEUS) fit to assess the impact of ATLAS data on constraining PDFs

- Preliminary results suggest that ATLAS data can constrain the high x gluon.



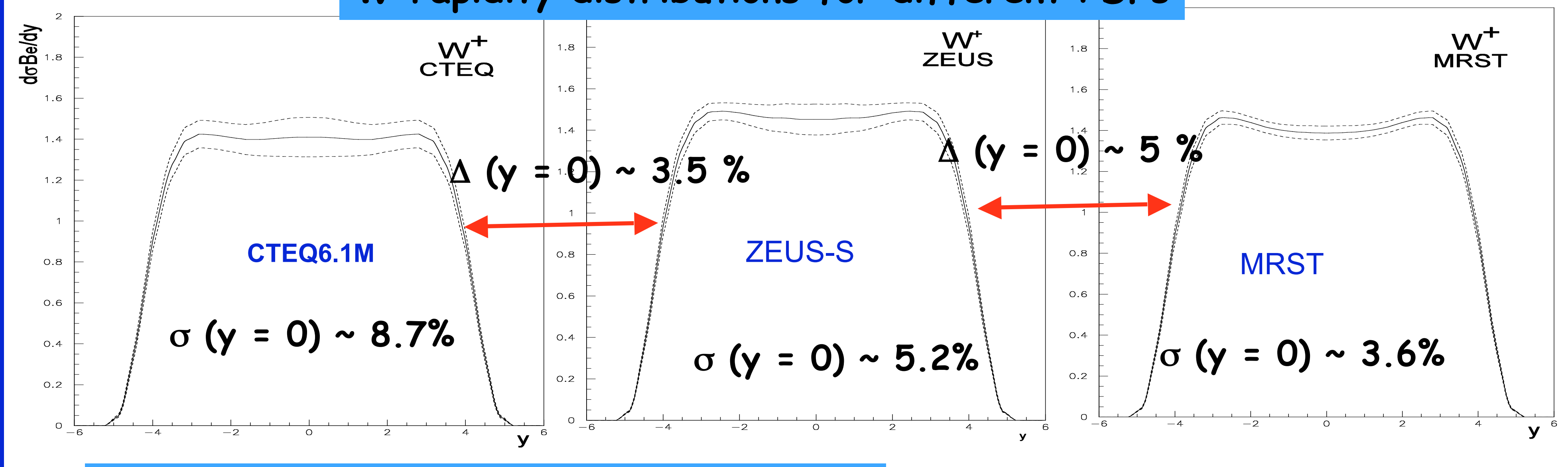
- Increasing statistics from 1fb-1 to 10 fb-1 (= 1 year of low lumi data taking) leads to small improvements.
- Decreasing systematic errors leads to a significant improvement.



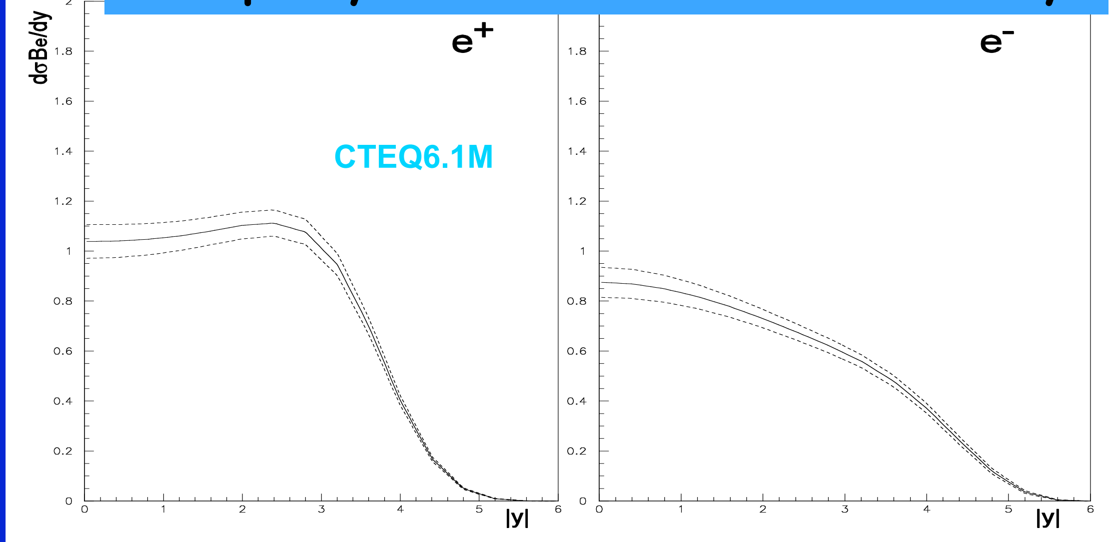
A.Tricoli, A.Cooper-Sarkar

Gluon PDF from W rapidity

W rapidity distributions for different PDFs



e± rapidity distributions from W± decays

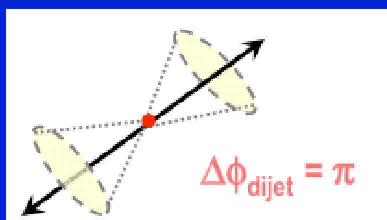


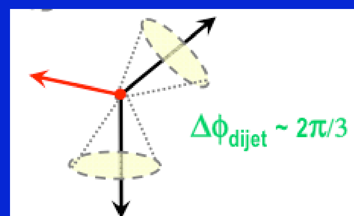
- Uncertainties on the W (or e±) rapidity distributions are dominated by the uncertainties on gluon PDF.
- Effect of including ATLAS psedo-data (1M assuming 4% uncertainty) in global PDF fits: Low-x gluon shape parameter λ $-0.119 \pm 0.046 \rightarrow -0.181 \pm 0.030$

A.Moraes

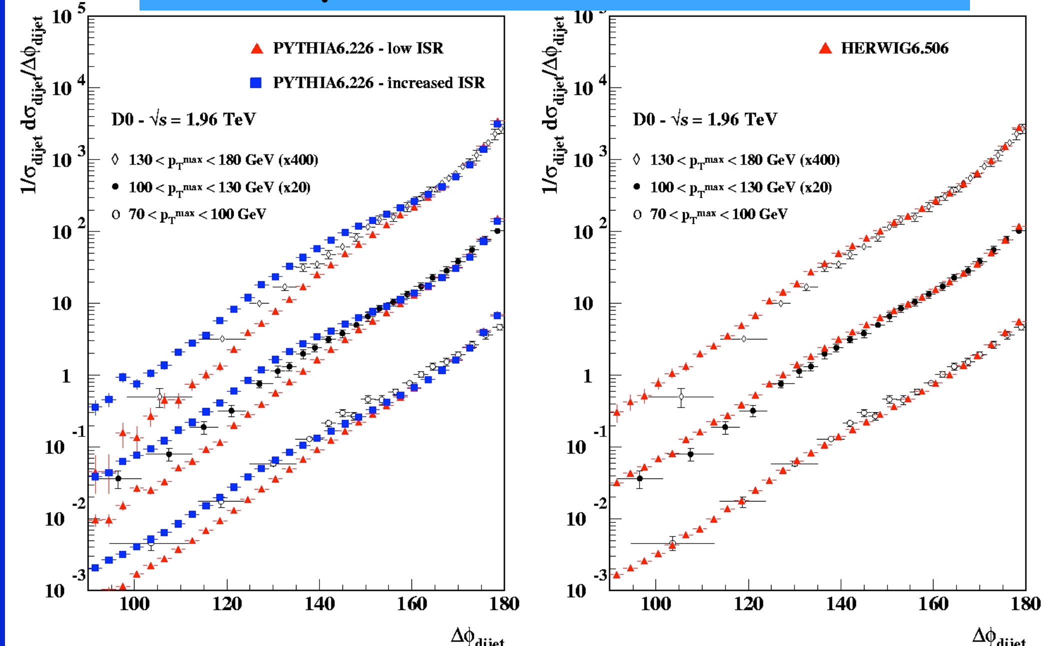
Dijet azimuthal decorrelations

- Early measurement to benchmark generators

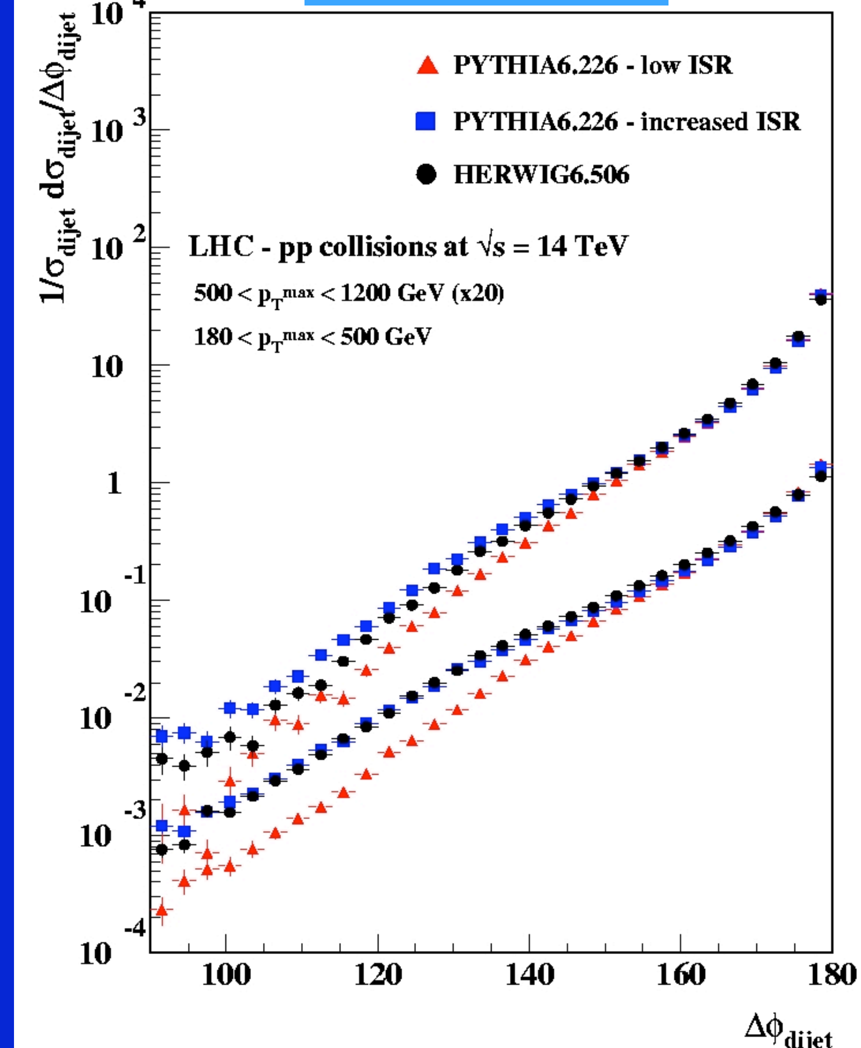




MC comparisons with D0 measurement



LHC predictions

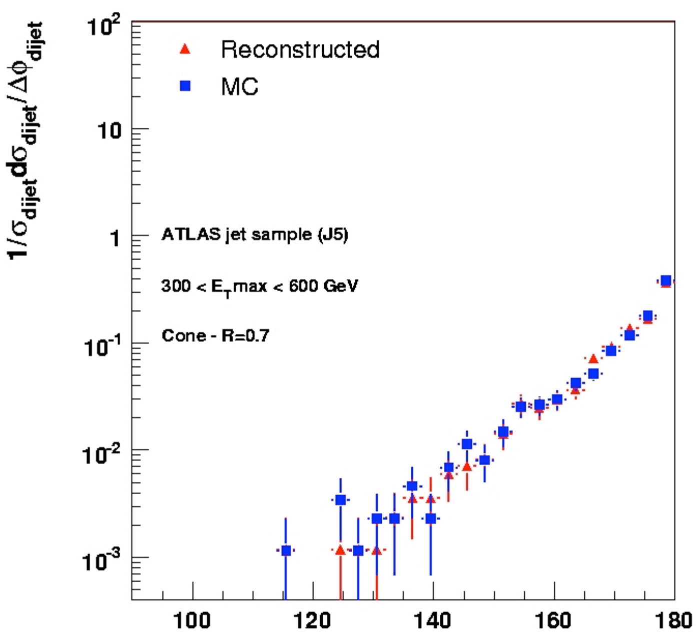


Dijet azimuthal decorrelations

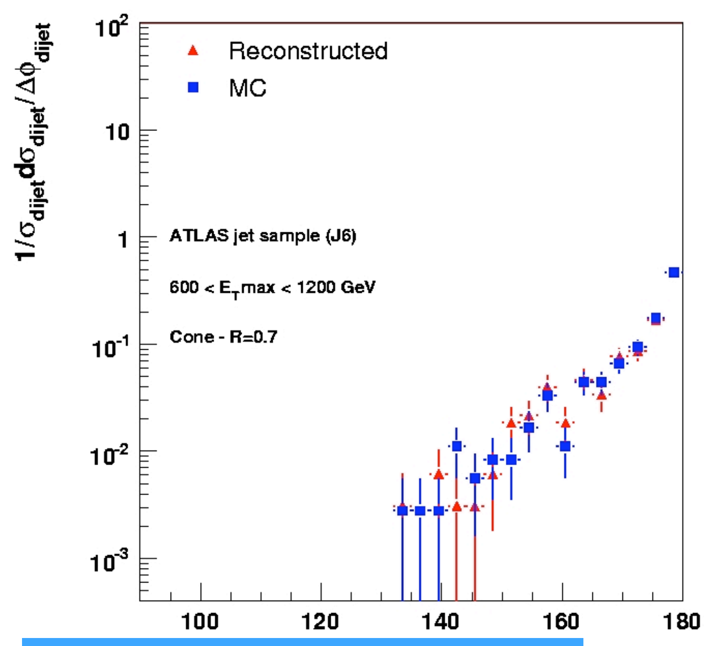
Reconstructed dijet azimuthal decorrelations

Dijet Event Selection

Cone jet algorithm (R=0.7)
N_{jets} = 2
$|y_{jet}|$ < 0.5
E_{Tjet2} > 80 GeV



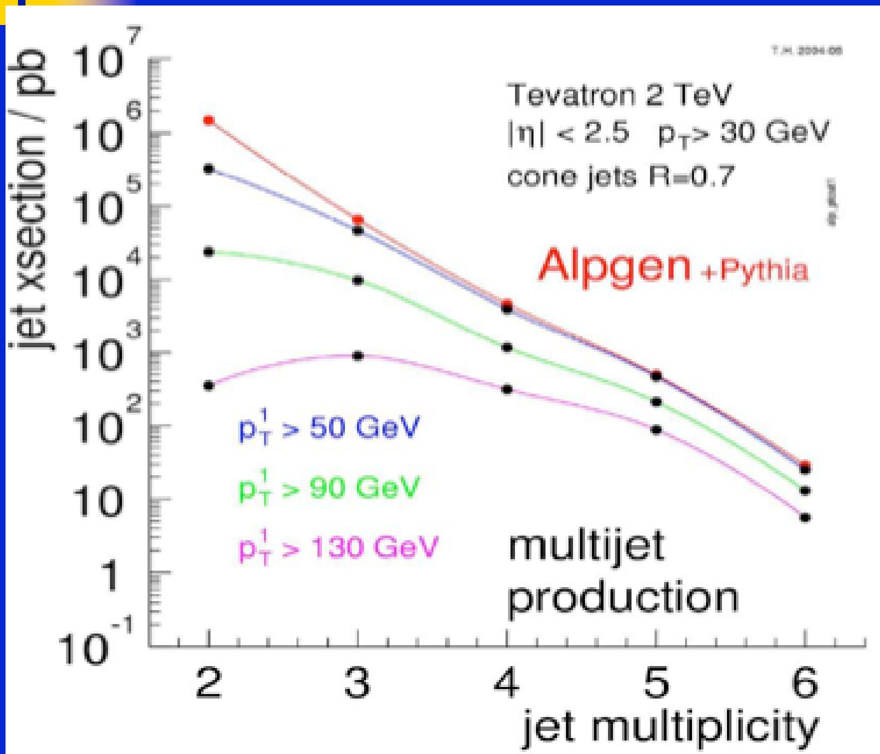
$300 < E_T^{MAX} < 600$ GeV

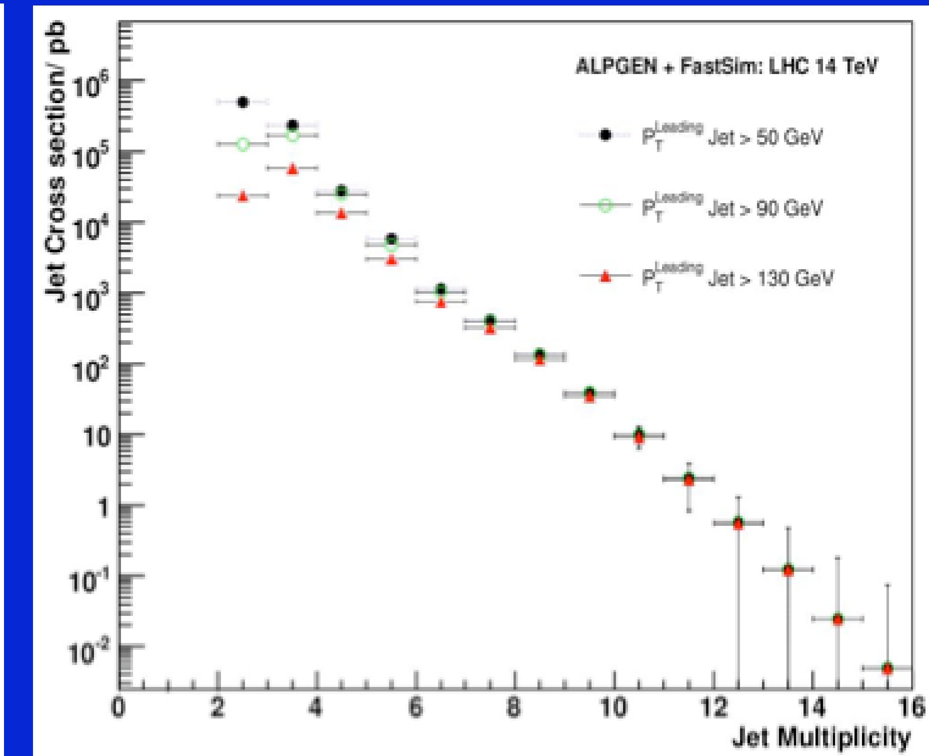


$600 < E_T^{MAX} < 1200$ GeV

S.Padhi

Multi-jet production



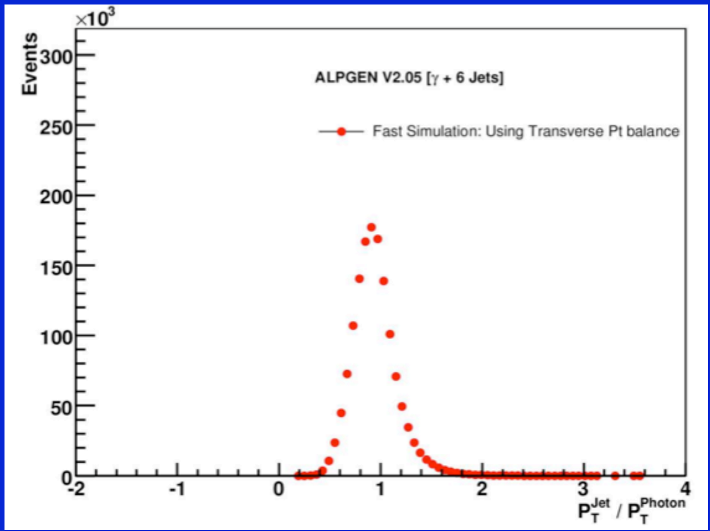


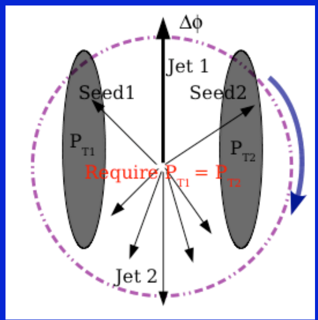
- Jet cross section still huge for E_T > 130 GeV
  - Important background (top, Higgs, SUSY, …)
  - Can be used to calibrate the detector (using inclusive top, W+jets, Z/γ+jets for jet energy calibration)

Multi-jet production

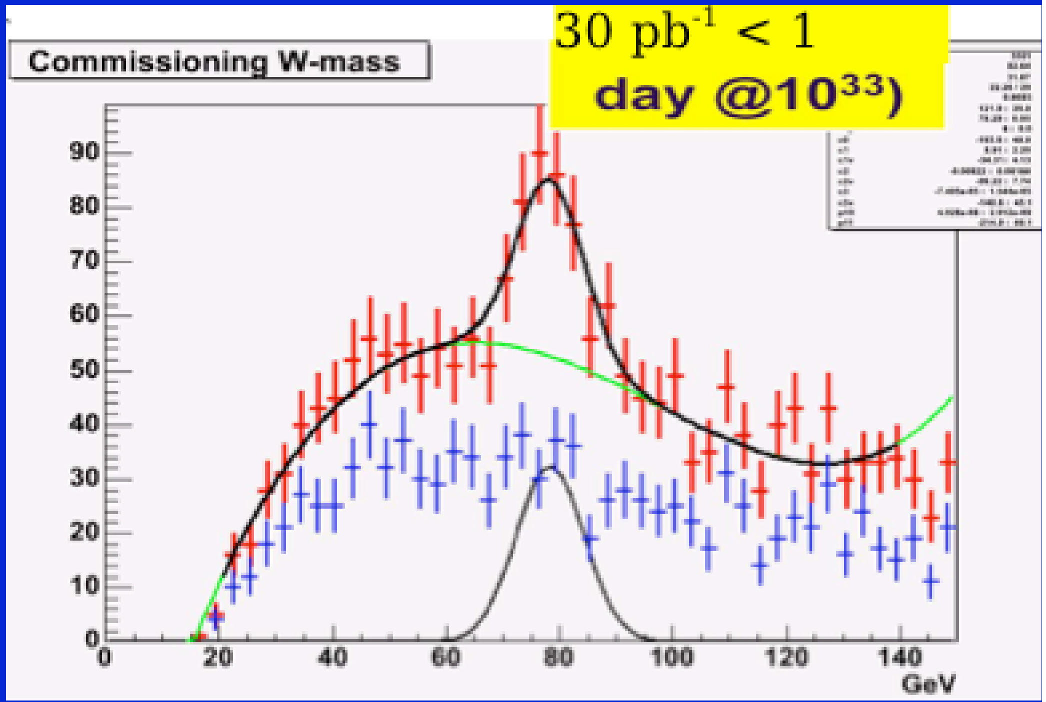
Detector calibration (jet energy scale)

- The jet energy scale can be recovered based on Z^0+Njets or γ+Njets





W can be identified in top events with no b tagging →
Useful for absolute jet energy calibration



Conclusions

- A good understanding of QCD is essential for physics at LHC

- Minimum bias & underlying event:

  - Monte Carlo generators have been tuned in order to have a good description of MB & UE events distributions.
  - But they give different predictions for LHC
  - Studies to perform these measurements in ATLAS have started

- Jet physics

  - Inclusive jet cross section measurement in ATLAS could help on constraining gluon PDF at high x

  (low x gluon PDF can be constrain from W rapidity measurements instead)
  - Studies to measure dijet azimuthal decorrelation in ATLAS have been done
  - Jets can also be used to calibrate the ATLAS detector.