Measurement of angular correlations of jets in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector ($R_{\Delta R}$ analysis)

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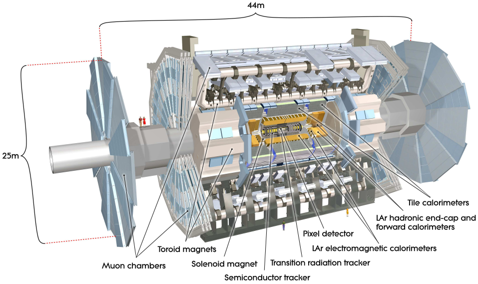
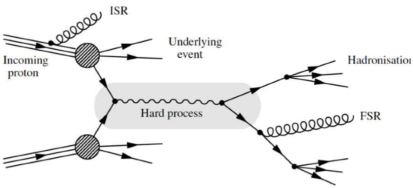
Overview

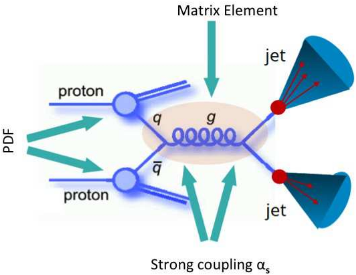
- Motivation
- Analysis phase space
- Trigger selection
- Experimental correction
- Results
- Summary



ATLAS is a general purpose detector at LHC

At hadron colliders, jet production is a dominant high p_T process.





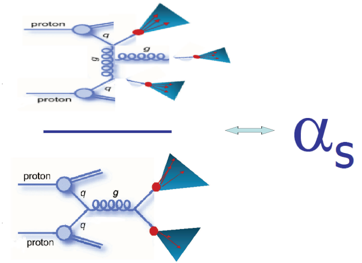
Studies of events with Multijet final state,

- Provide a direct test of pQCD calculations
- Constrain Parton Distribution Function (PDFs)
- Probe strong coupling constant α_s

Motivation: $R_{\Delta R}$ definition

$R_{\Delta R}$

In Multijet Production, a quantity $R_{\Delta R}$ is defined to study the angular correlations of jets with final goal of determining α_s.



Start with an inclusive jet sample,

- For each jet count the number of neighboring jets with $\Delta R < \pi$
- Add them and normalize by total number of jets
- "The average number of neighboring jets"

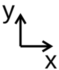
$$R_{\Delta R} = \frac{\sigma_{incl.jet}(with\ neighboring\ jets)}{\sigma_{incl.jet}} \qquad (1)$$

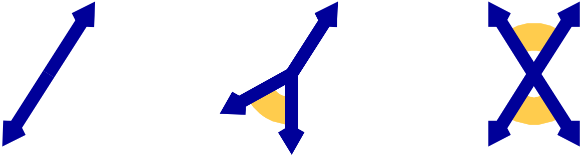
$R_{\Delta R}$ example

$R_{\Delta R}$ = average number of neighboring jets per jet

here: for $\Delta R < \pi/2$

in this example all jets have same (p_T, y)





2 jets	3 jets	4 jets
no neighbors within ΔR:	two jets have one neighbor each:	each of the four jets has one neighbor:
0 neighbors	2 neighbors	4 neighbors

if all events were like this	$R_{\Delta R} = 0$	$R_{\Delta R} = 2/3$	$R_{\Delta R} = 1$

$R_{\Delta R}$ definition

Three dimensional measurement

- Inclusive jet p_T
- Distance ΔR to neighbor jet in $(\Delta\phi, \Delta y)$

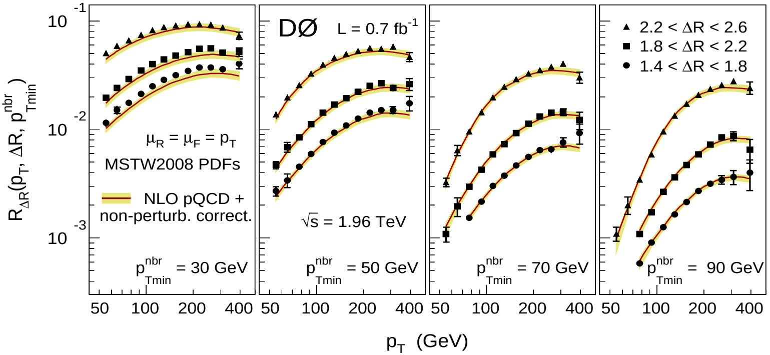
$$\Delta R = \sqrt{\Delta y^2 + \Delta\phi^2} \quad (2)$$

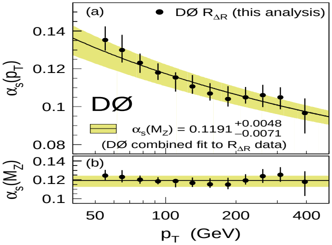
- p_{Tmin}^{nbr} : minimum p_T of neighbor jet

In a ratio measurement,

- Experimental uncertainties cancel to great extent
- Residual PDF dependance
- Systematic uncertainties due to choice of renormalization and factorization scales reduce
- Nonperturbative effects are reduced

D∅ results: Phys. Lett. B 718 (2012) 56, arXiv:1207.4957





Analysis Phase Space

Inclusive jets

- $|\mathrm{y}| < 1$
- $120 < p_T < 2000$ GeV

Neighbor jets,

- 3 ranges of ΔR : (1.4-1.8), (1.8-2.2), (2.2-2.6)
- p_{Tmin}^{nbr} : 70 GeV, 120 GeV, 200 GeV

Datasets and selection criteria

Data and MC

- 2012, 8 TeV data
- $\int L \sim 20\ fb^{-1}$
- PYTHIA8 dijet sample, Tune AU2, PDF: CT10

Event and jet selection,

- ≥ 1 primary vertex with ≥ 2 tracks
- Jet algorithm: anti-kT
- distance parameter R=0.6

Trigger studies: 99% efficiency point

Jet trigger Threshold [GeV]	2012 Int. Luminosity [pb-1]	99% efficiency point [GeV]
80	2.32	120
110	9.84	160
145	36.38	210
180	79.03	250
220	262.24	305
280	1168.48	390
360	20340	490

p_T Binning: 120, 160, 200, 250, 310, 390, 490, 620, 800, 1040, 1400, 2000 GeV

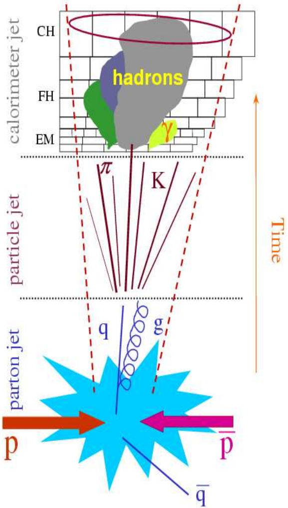
Correction for experimental effects

Initial results are measured at detector level

- Compared to LO MC with full-simulation of the ATLAS detector

These are corrected to particle level

- corrects the observed data for detector effects
- Allows detector independent comparison of results
- Easier comparison to MC



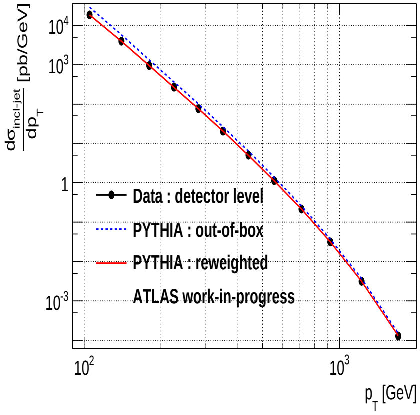
A jet analysis in stages

Correction for experimental effects

Can use "Bin-by-bin" correction,

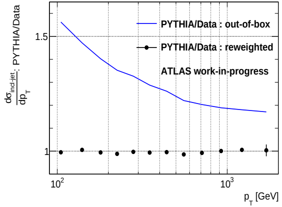
- If simulation could describe data
  - reweight PYTHIA(1) : inclusive cross section
  - reweight PYTHIA(2) : ratio $R_{\Delta R}$
  - study the dependance of corrections on the reweighting ($\rightarrow$ uncertainty)
- If migrations between bins are small (high purity, high efficiency)
  - p_T bins are adopted according to resolution
  - study purity and efficiency

Reweighting the MC to describe the inclusive jet cross section



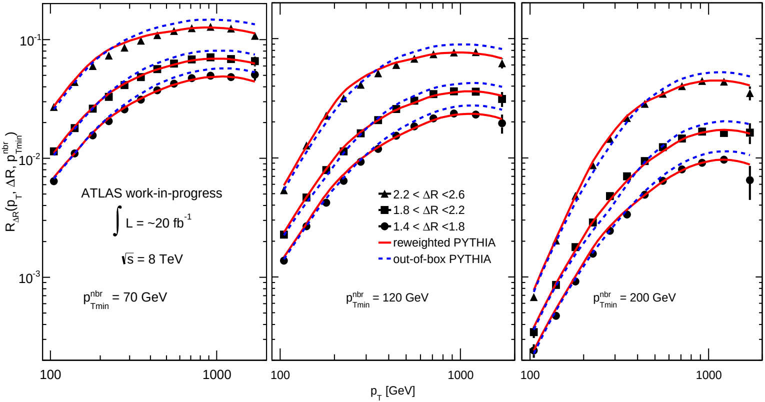
- This reweighting step corrects the denominator in the ratio $R_{\Delta R}$

- bin migrations depend on p_T slope
- Using MC in correction procedure requires MC to describe data



$R_{\Delta R}$: Reweighted PYTHIA compared with detector level data

After reweighting inclusive jet cross section the ratio $R_{\Delta R}$ is reweighted to describe data.



After MC reweighting: much improved description of data

Migration matrix, Purity and efficiency for inclusive jet cross section (denominator in $R_{\Delta R}$)

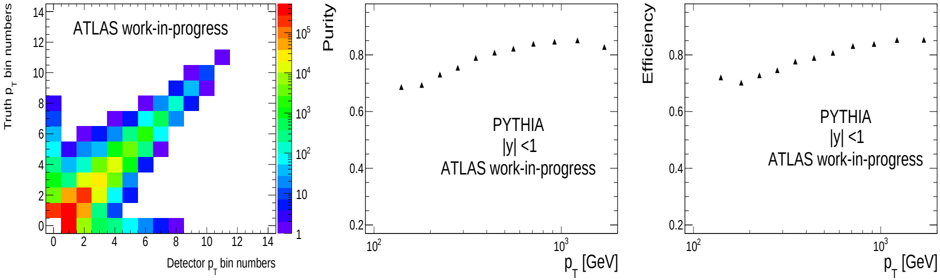
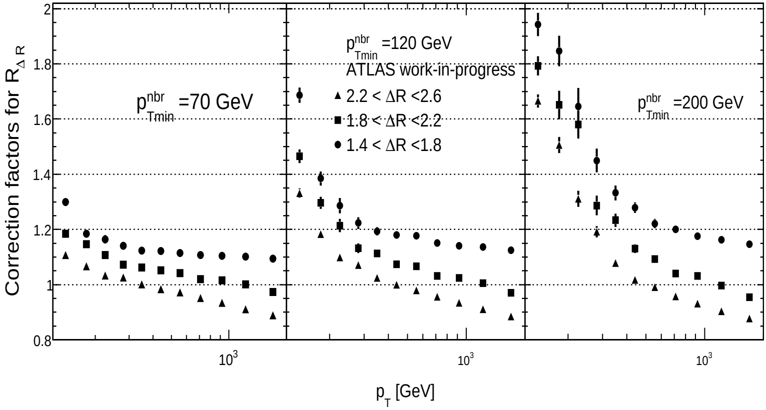


Figure 1: (a) Migration matrix (b) Purity (c) Efficiency

plot shows high purity and efficiency.

Correction factors are determined using reweighted MC

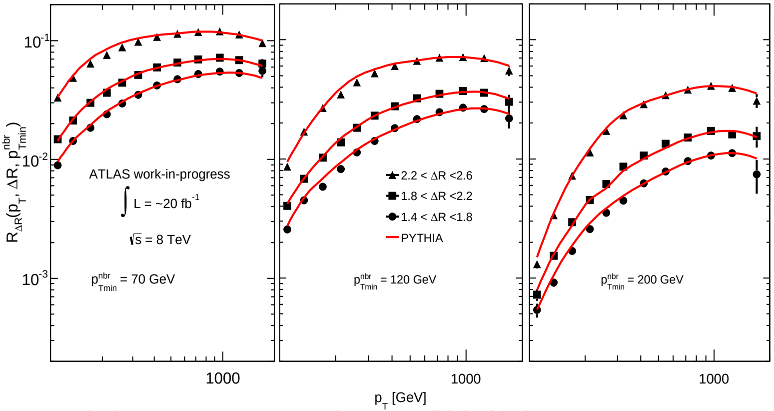
$$Correction\ \ factors = \frac{R_{\Delta R}(truth)}{R_{\Delta R}(reconstructed)} \qquad (3)$$



Correction factors are $<$ 1.2-1.4 | except in extreme regions

Corrected $R_{\Delta R}$

Detector level results are scaled by the correction factors.



Corrected data agree well with truth PYTHIA

Summary and conclusion

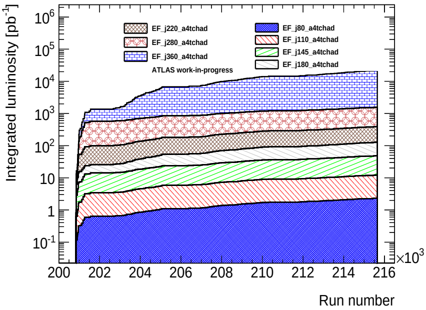
- The quantity $R_{\Delta R}$ is measured with 2012, 8 TeV data
- Extend the DZero measurement from 50-400 GeV to 120-2000 GeV

Plans ahead

- Experimental systematic uncertainties
- NLO calculation
- Non-Perturbative corrections
- The extraction of α_s

BACKUP SLIDES

Trigger studies



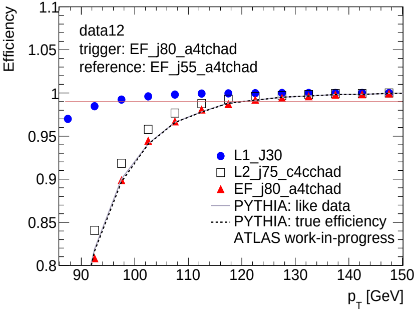


Figure 2: (a) Luminosity per trigger (b) J80 trigger efficiency

Single jet triggers used in the analysis.
Trigger efficiency calculated using bootstrapping technique

*Trigger nomenclature explained in the next slide.

Trigger nomenclature

ATLAS has three three levels of jet triggers. The trigger names at different levels are explained below.

- L1_J30 : Level 1 single jet trigger with transverse energy threshold of 30 GeV
- L2_j75_c4cchad : Level 2 single jet trigger, transverse energy threshold of 75 GeV, "c4" cone jet algorithm of radius 0.4, "cc" calorimeter cell energy is the input to the jet algorithm, "had" calibrated to hadronic energy level
- EF_j80_a4tchad : Event Filter jet trigger, transverse energy threshold of 80 GeV, "a4" anti-kT jet algorithm with distance parameter 0.4, "tc" topoclusters are input to the jet algorithm, "had" calibrated to hadronic energy level