Other ATLAS Jet Measurements

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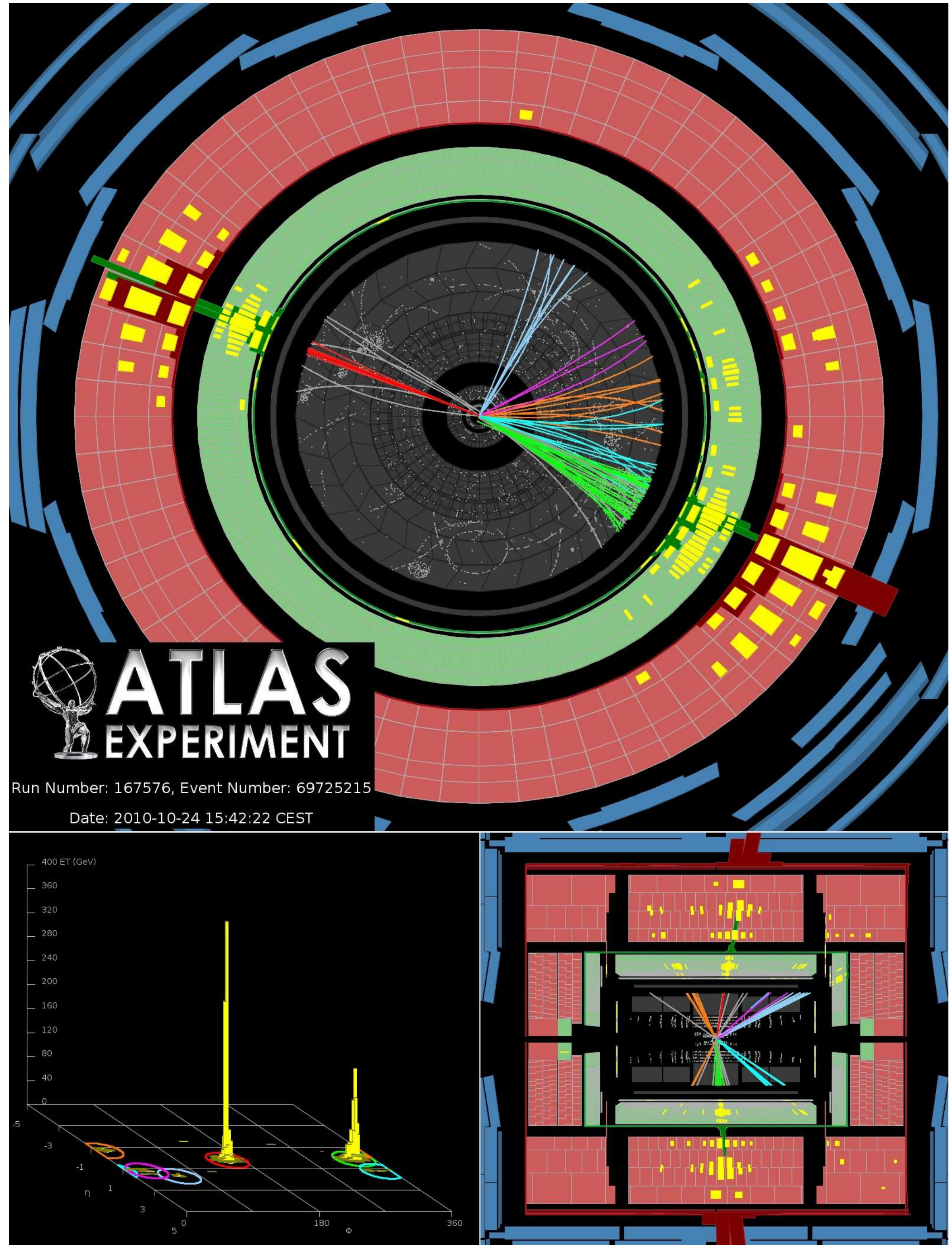
Jets as Hard Probes

High p_T dijet production provides a powerful probe of the hard scatter

- precision tests of pQCD
- constraints on parton distribution functions
- sensitivity to the presence of new physical phenomena
  - dijet resonances
  - quark compositeness
  - large extra dimensions



Jets as Hard Probes

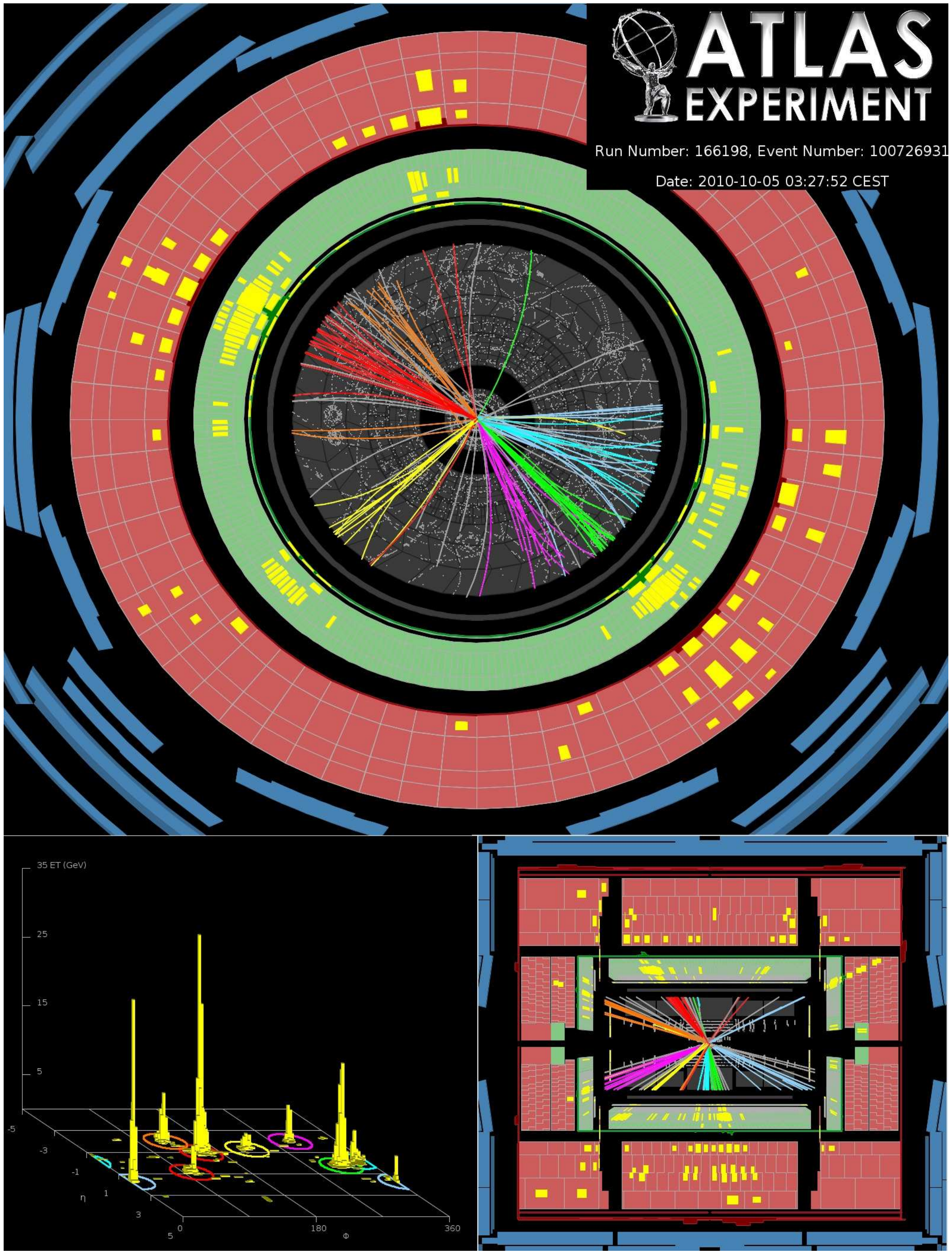
High p_T dijets are also a key probe for understanding activity in the rest of the event...

- azimuthal angle between leading two jets
- radiation between two leading or two most forward jets

... and within the jet

- jet shapes

These measurements test pQCD calculations and constrain phenomenological models.

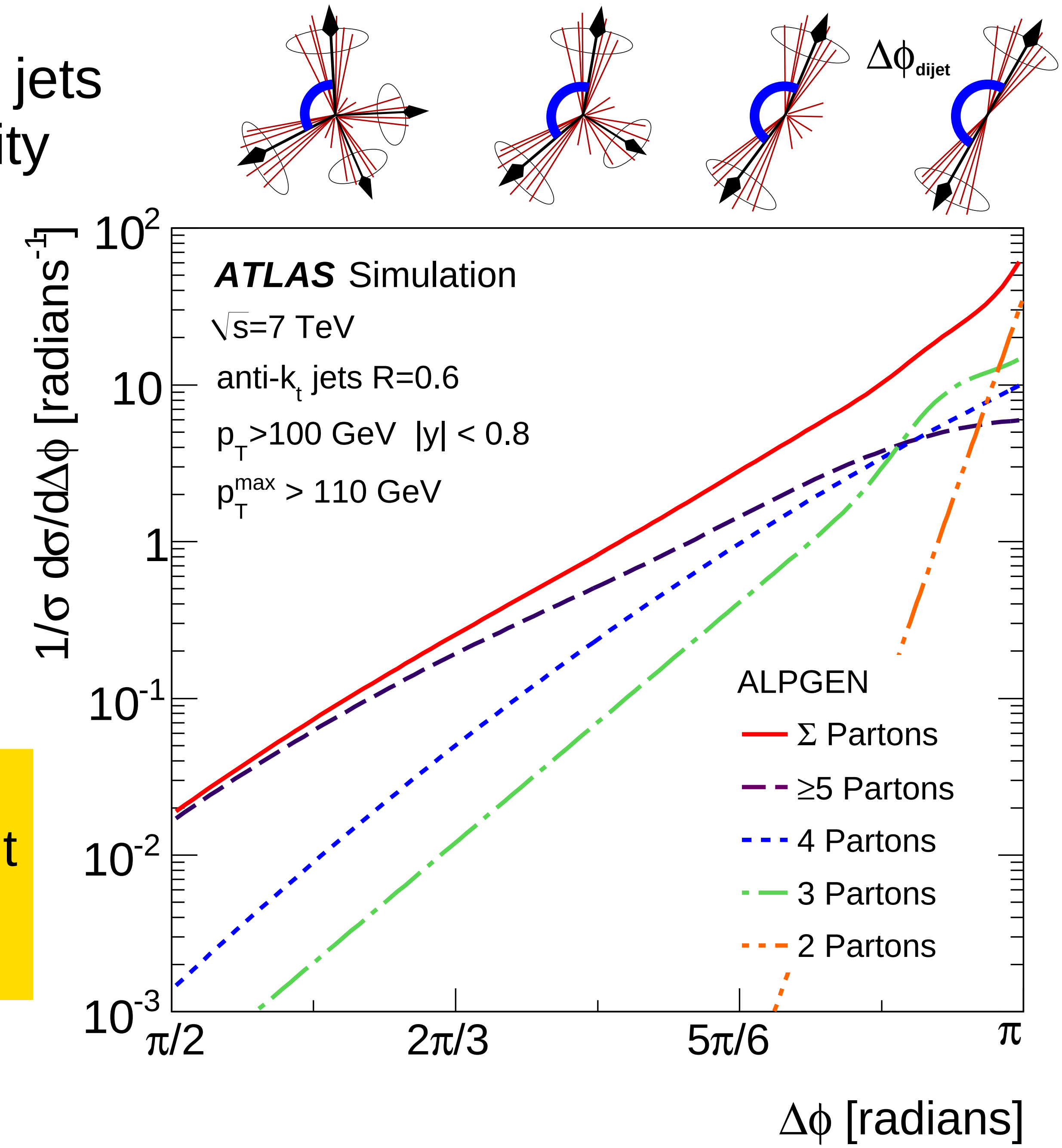


Azimuthal Decorrelations

$\Delta\phi$ between the leading two jets in an event reflects the activity in the rest of the event

- *soft* radiation causes *small* decorrelations
- *hard* radiation, such as from the presence of additional jets, can cause *large* decorrelations

$\Delta\phi$ tests pQCD calculations for multijet final states without requiring the measurement of additional jets

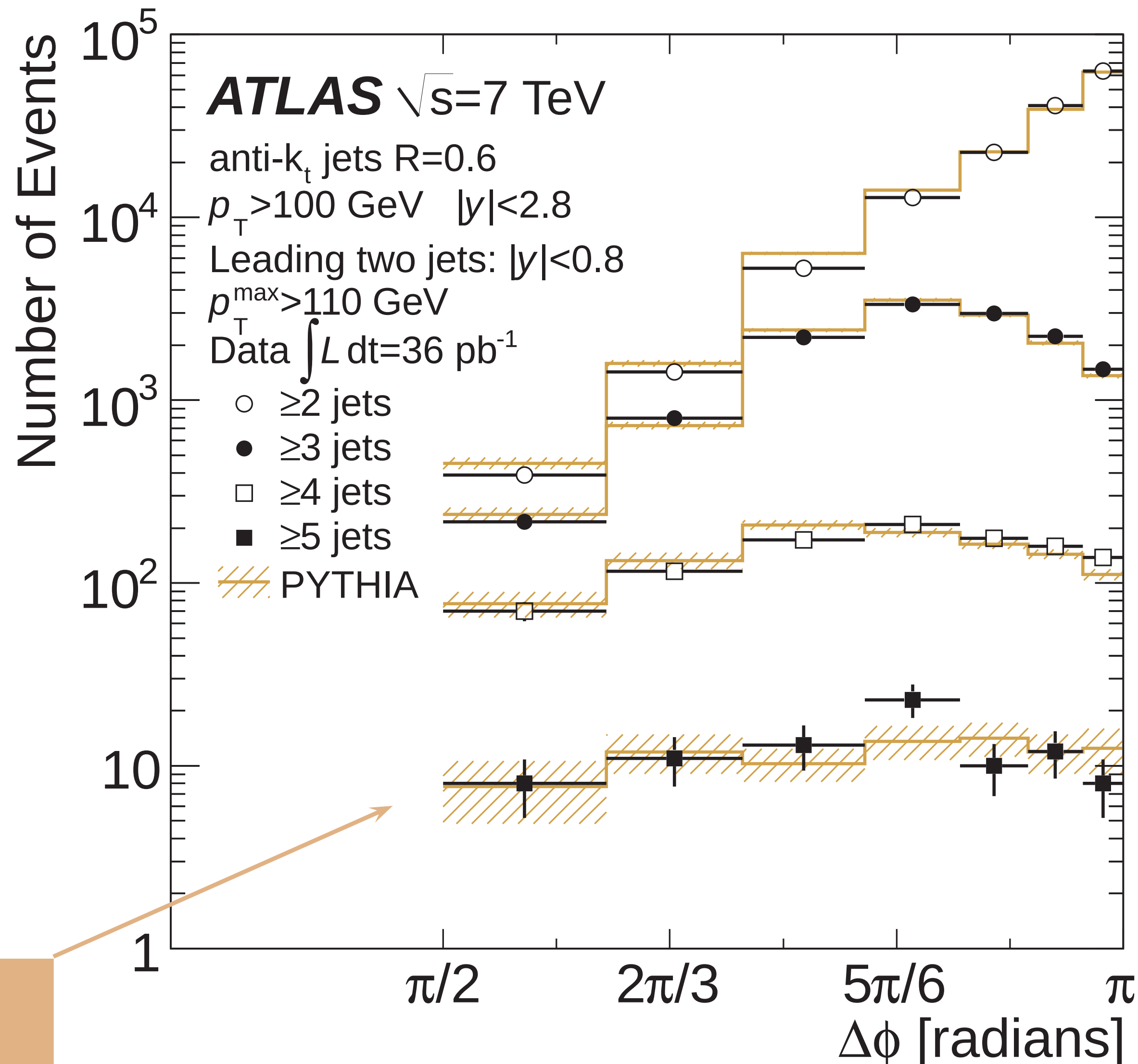


Azimuthal Decorrelations

Measure normalized dijet differential cross section:

$$\frac{1}{\sigma}\frac{d\sigma}{d\Delta\phi}$$

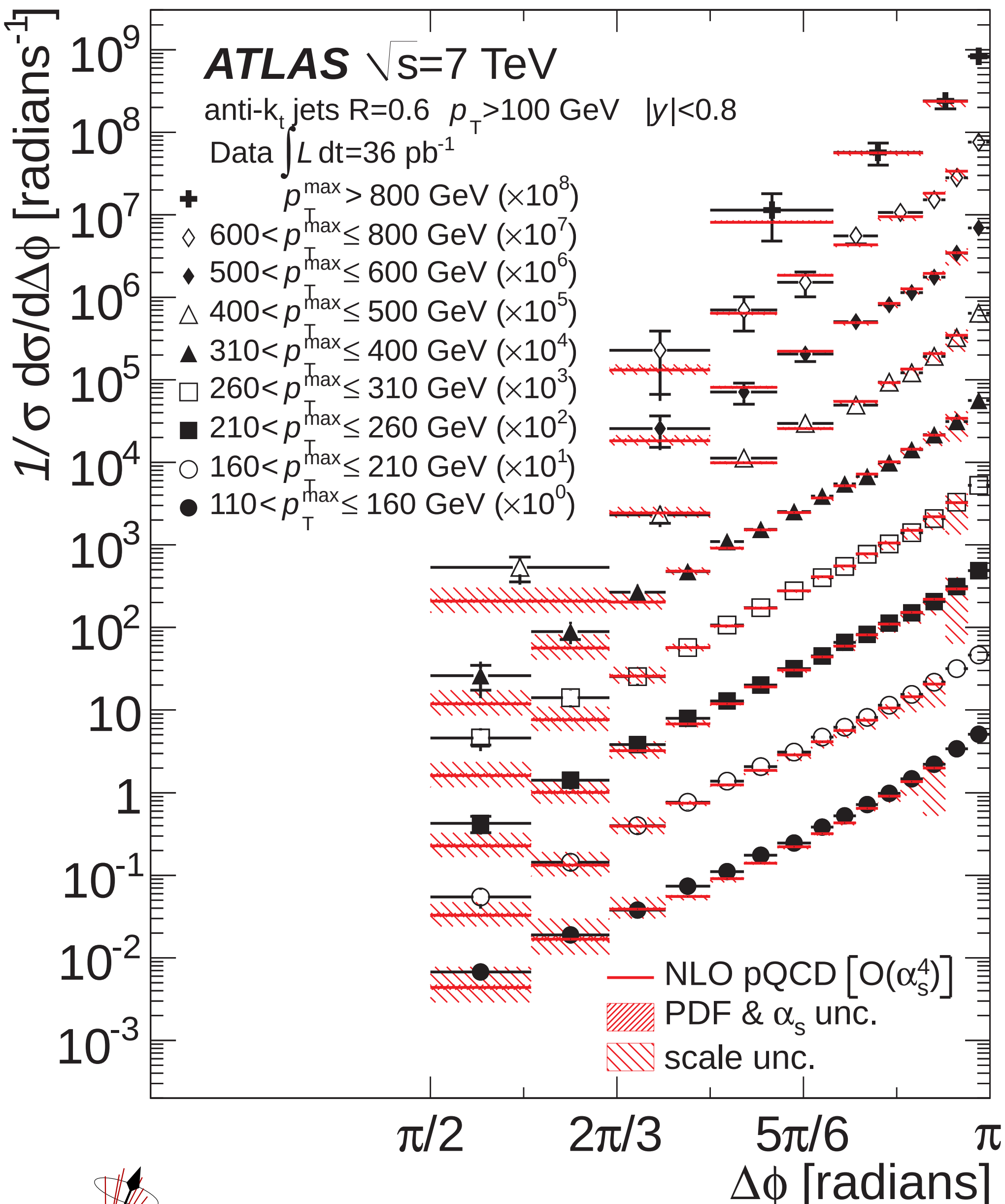
- anti-k_T jets with $R = 0.6$
- jet $p_T > 100$ GeV
- leading two jets $|y| < 0.8$
  acceptance out to $|y| < 2.8$
- cross section normalized separately for each p_T^{max} bin

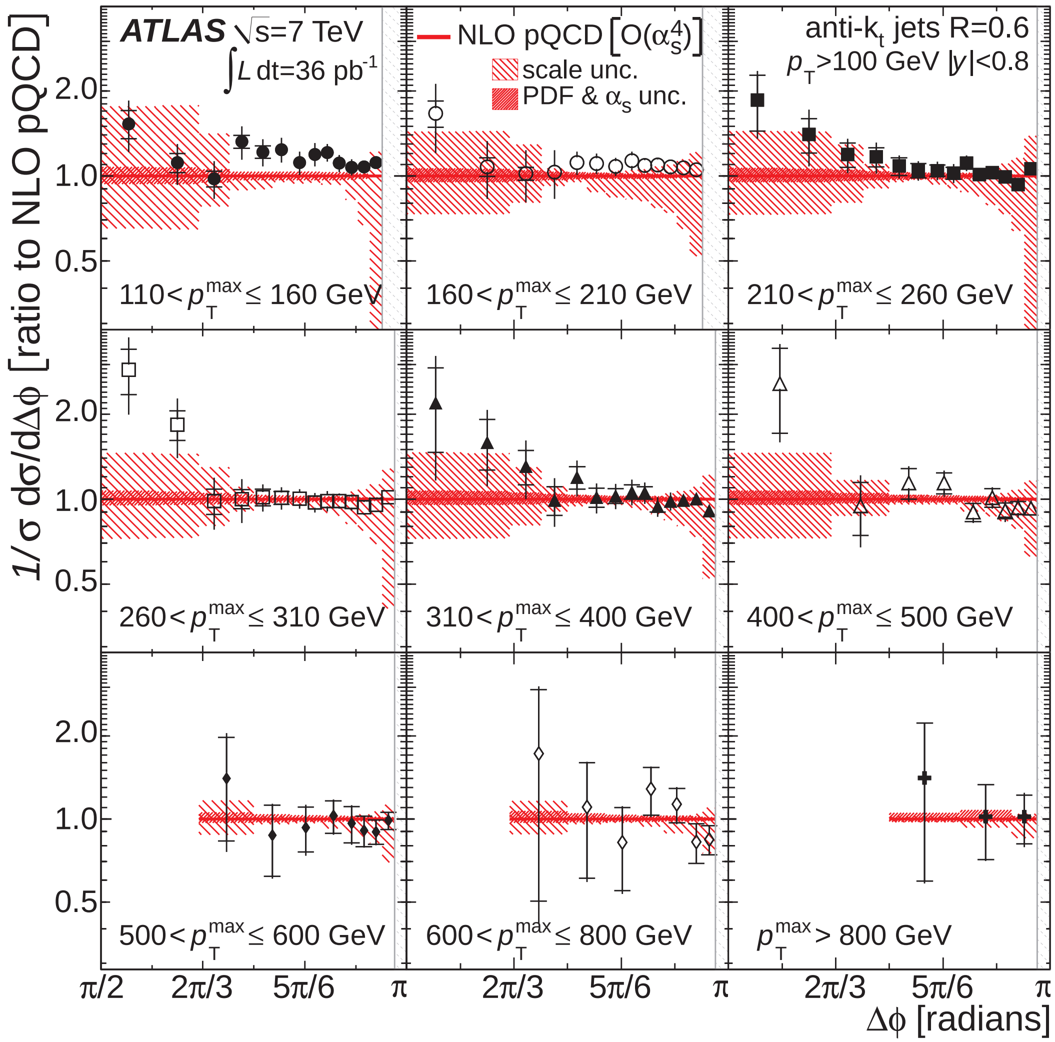


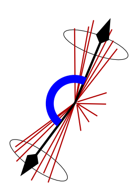
85 events have 5 jets with $p_T > 100$ GeV

arXiv:1102.2696 [hep-ex]
(accepted by PRL)

NLO pQCD Theory Comparison







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scale uncertainty large where NLO pQCD dominated by real $\mathcal{O}(\alpha_s^4)$ diagrams

comparison excluded where NLO pQCD diverges ($\Delta\phi \to \pi$)

Event Generator Comparison

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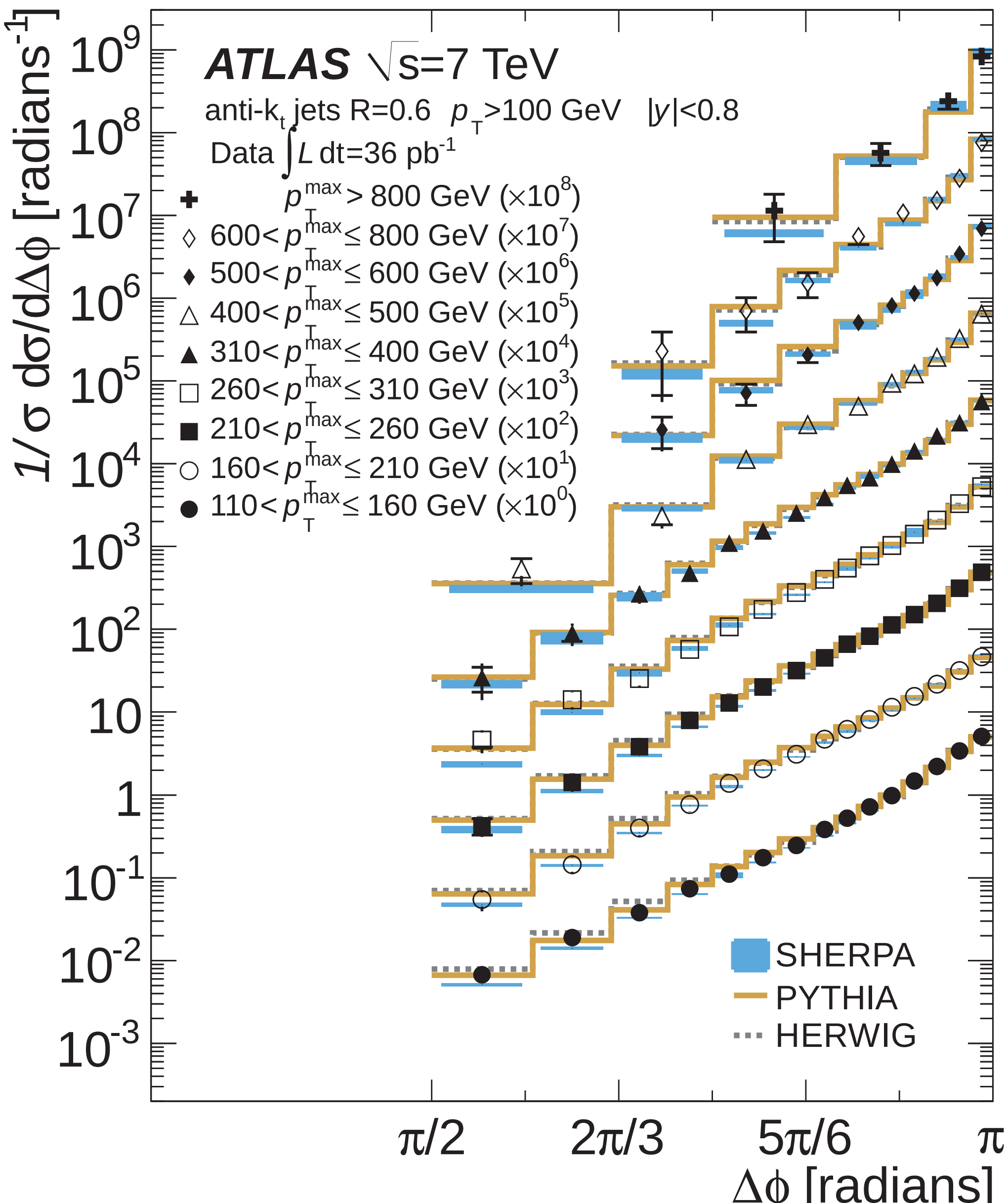

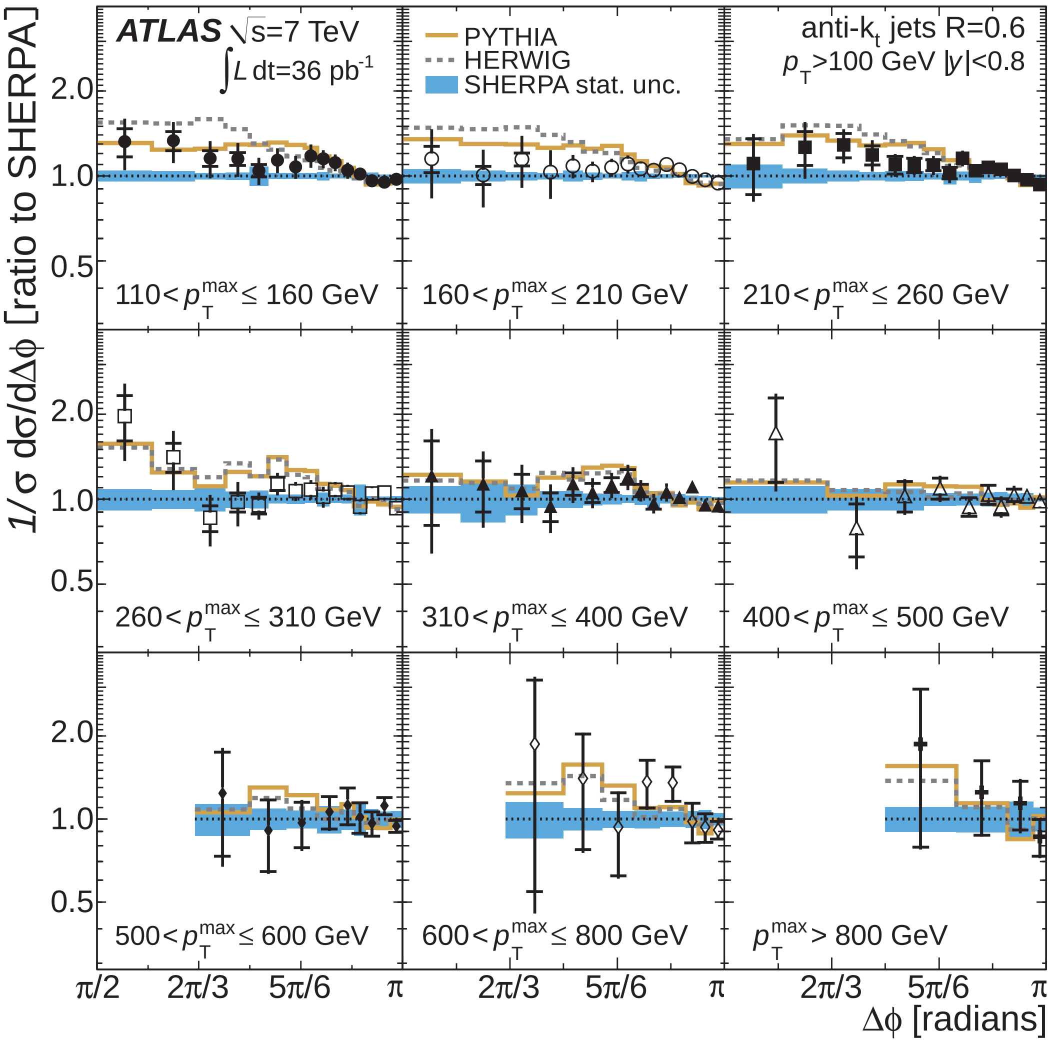

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Event Generator Comparison

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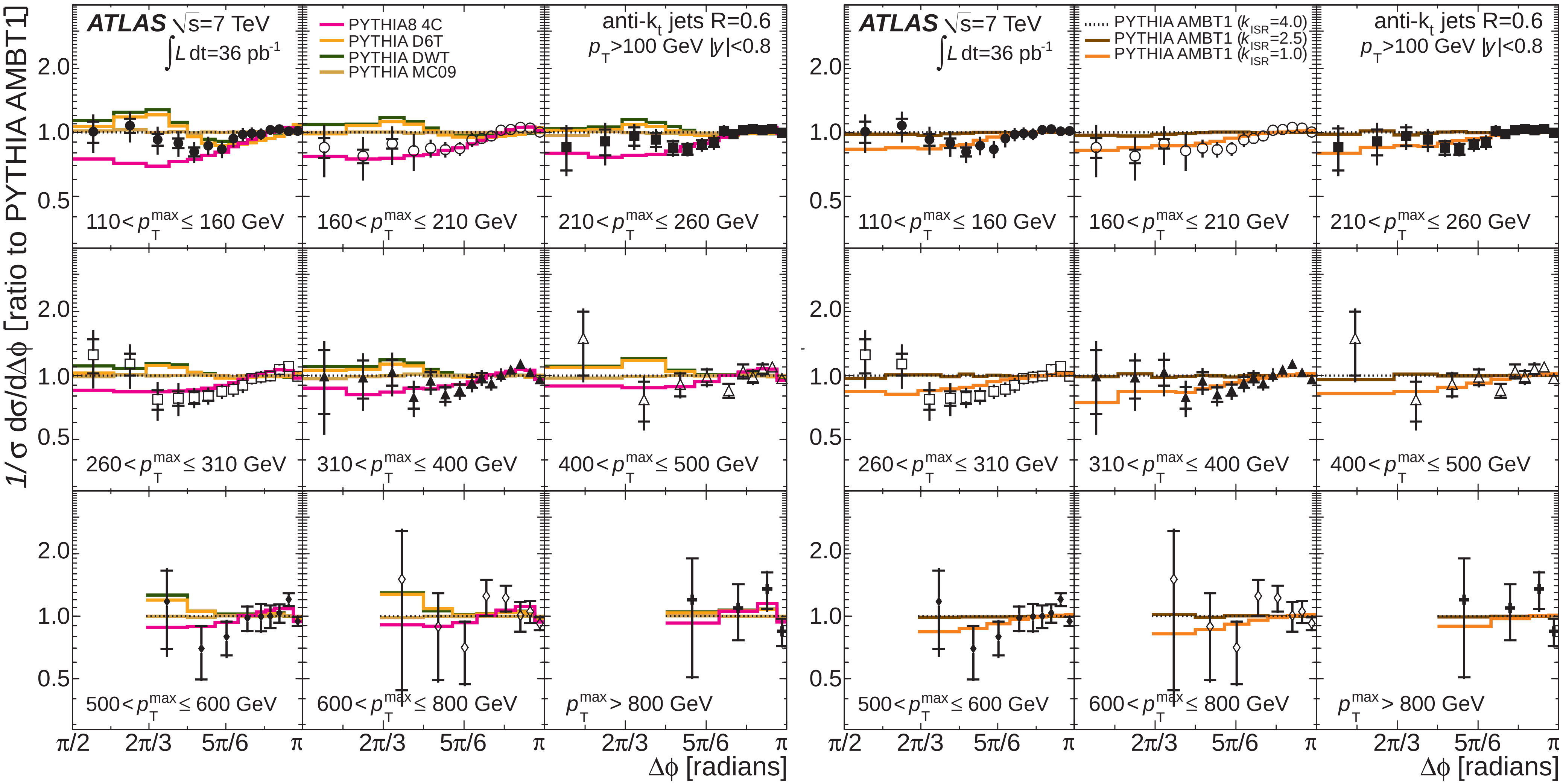

arXiv:1102.2696 [hep-ex]
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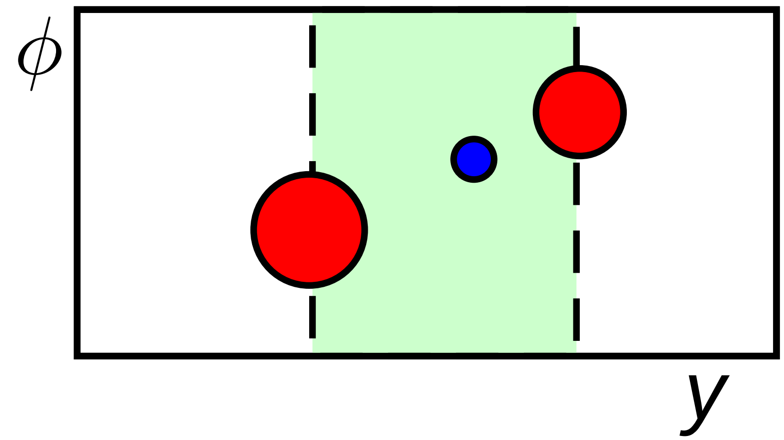
Dijet Production with Jet Veto

- Measure the hard radiation in the rapidity interval between two jets:
  - sensitive to BFKL dynamics
  - sensitive to wide-angle soft-gluon radiation
  - color-singlet exchange
- This measurement also probes theory predictions and experimental techniques relevant for VBF Higgs searches.



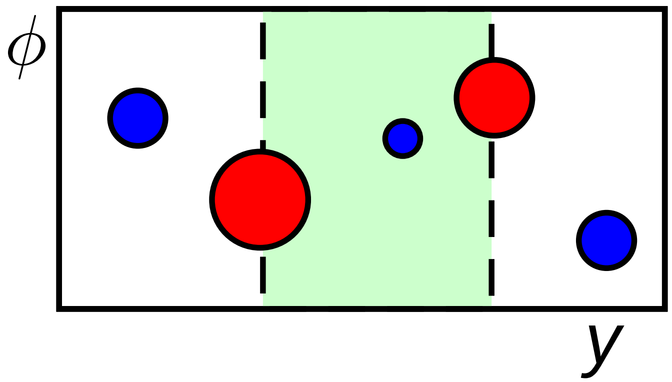
this is different than the traditional “rap gap” measurement focused solely on color-singlet exchange

Boundary Conditions

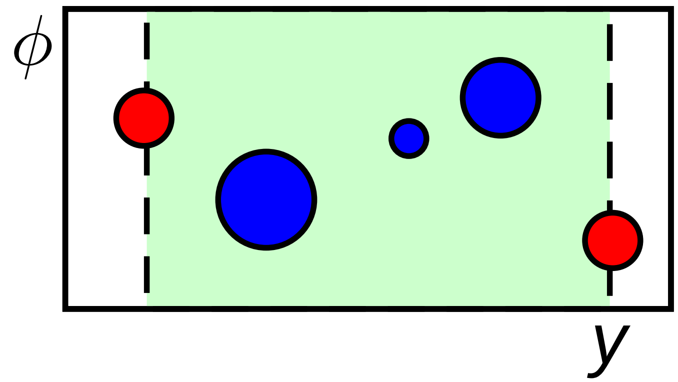
Event Selection:

- anti-k_T jets with $R = 0.6$
- boundary jets require $p_T > 20$ GeV and $|y| < 4.5$
- $\langle p_T \rangle$ of boundary jets > 50 GeV
- veto jet $p_T > 20$ GeV
- single interaction-vertex events

Selection A
boundary jets have highest p_T
increased sensitivity to wide-angle soft-gluon radiation



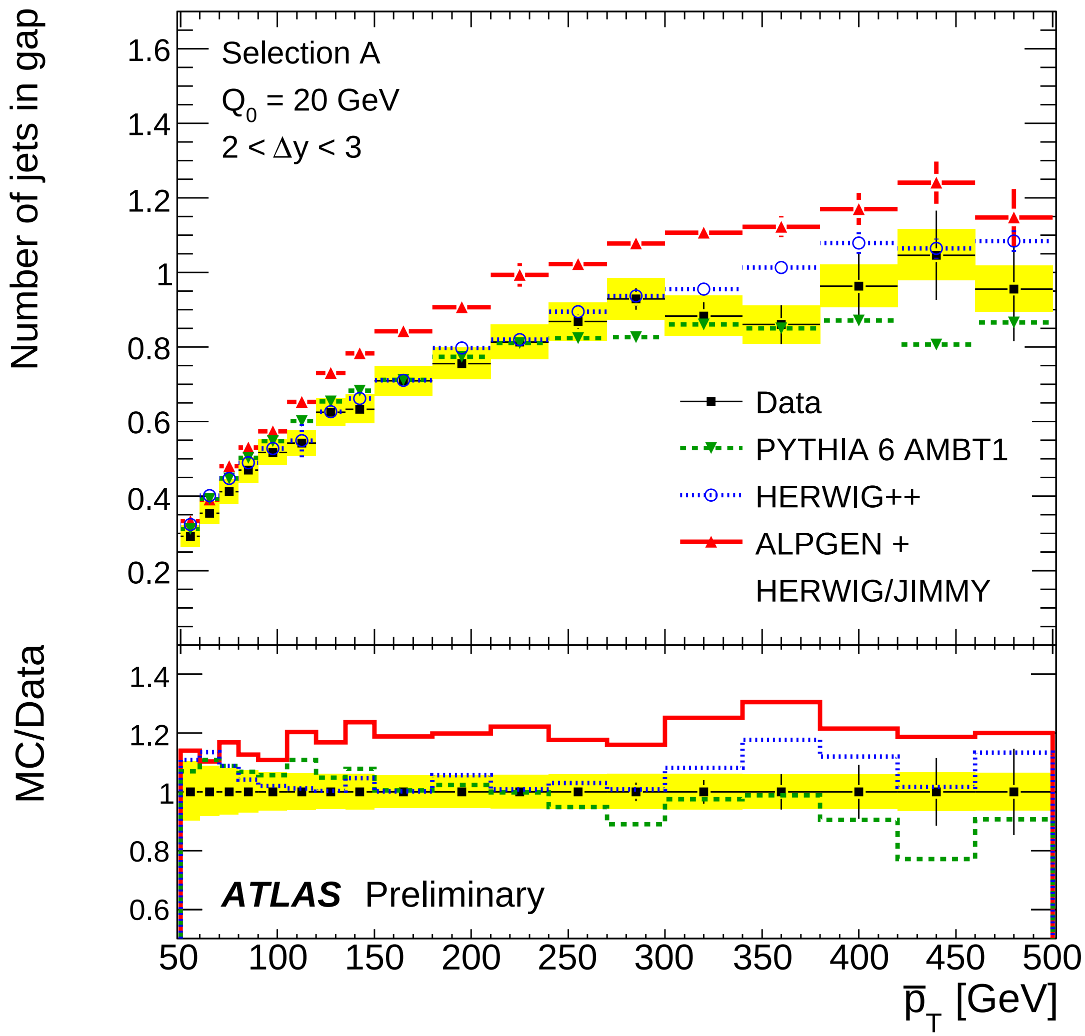
Selection B
boundary jets have most forward y
increased sensitivity to BFKL dynamics

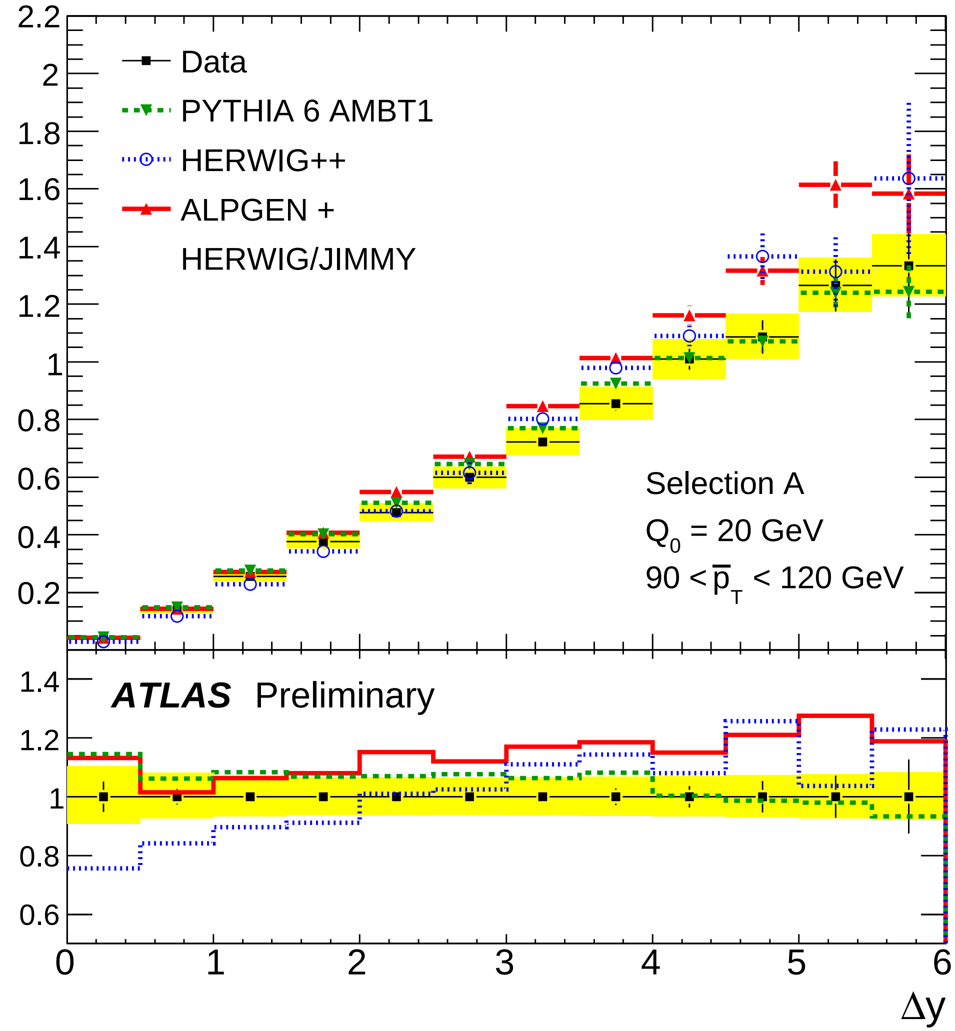


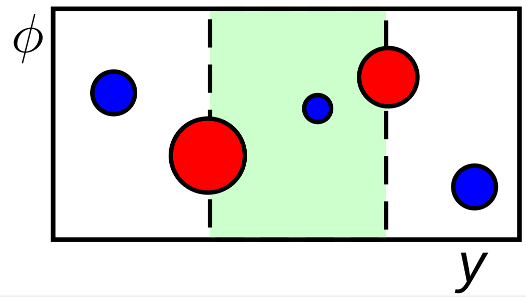
Observables (in $\langle p_T \rangle$ and Δy):

- Mean Jet Multiplicity: between boundary jets
- Gap Fraction: fraction of events without jet in gap

Jet Multiplicity







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Jet Multiplicity

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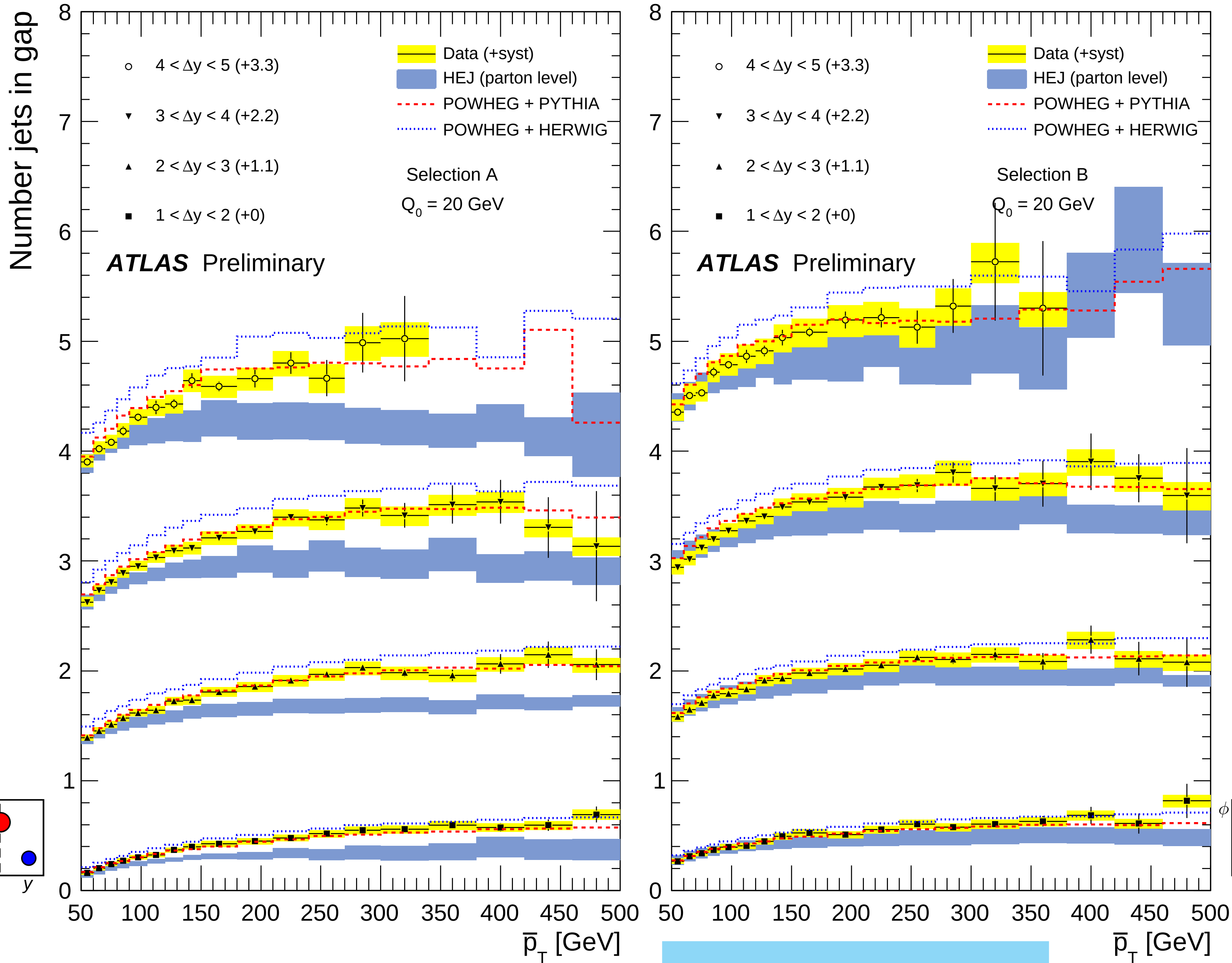

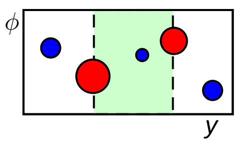

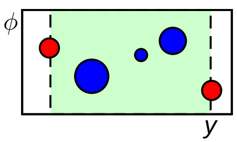

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Gap Fraction

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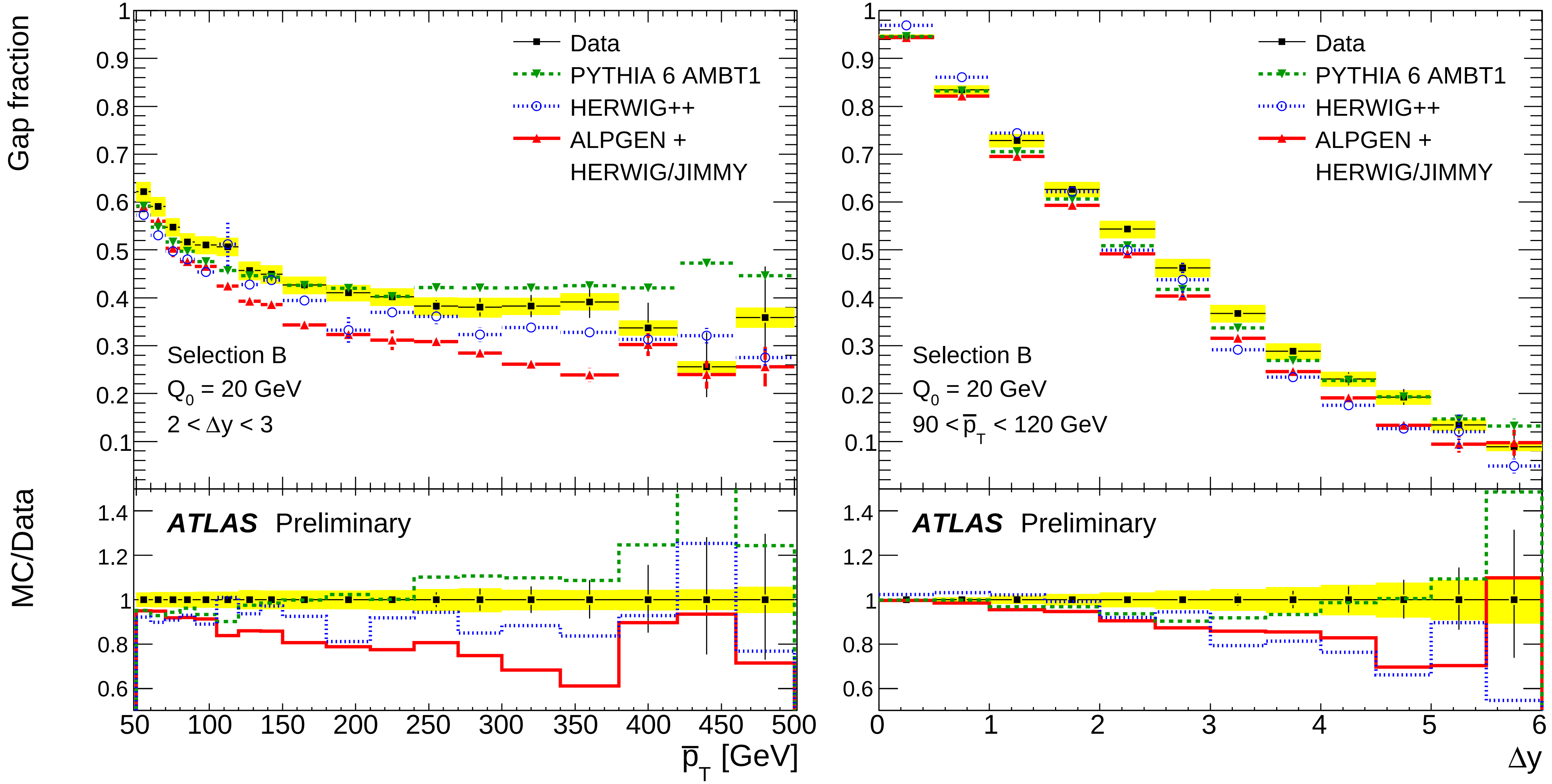

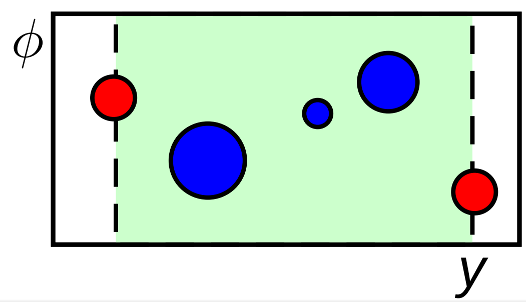

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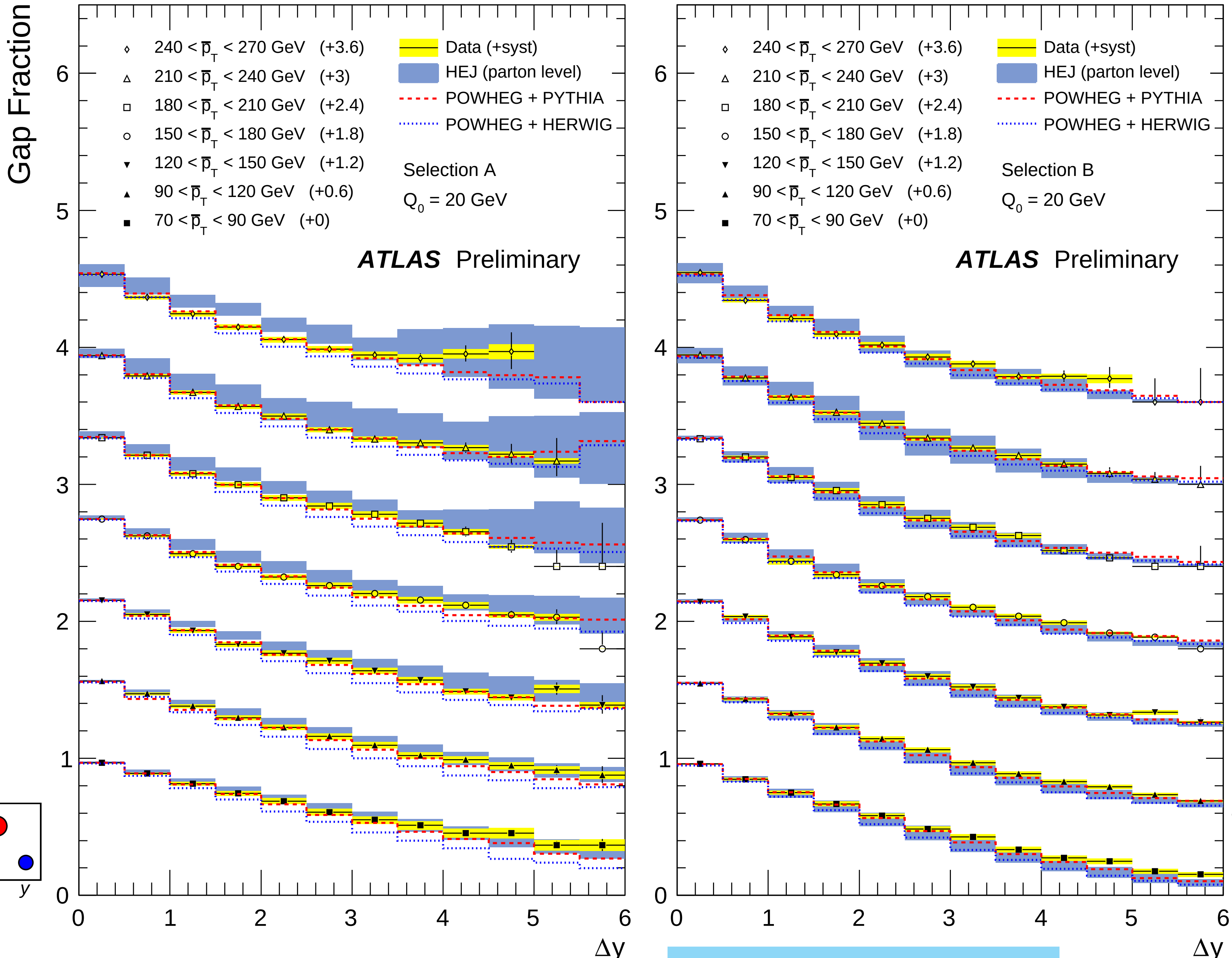
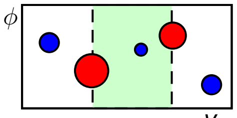
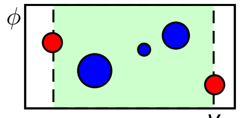
Gap Fraction







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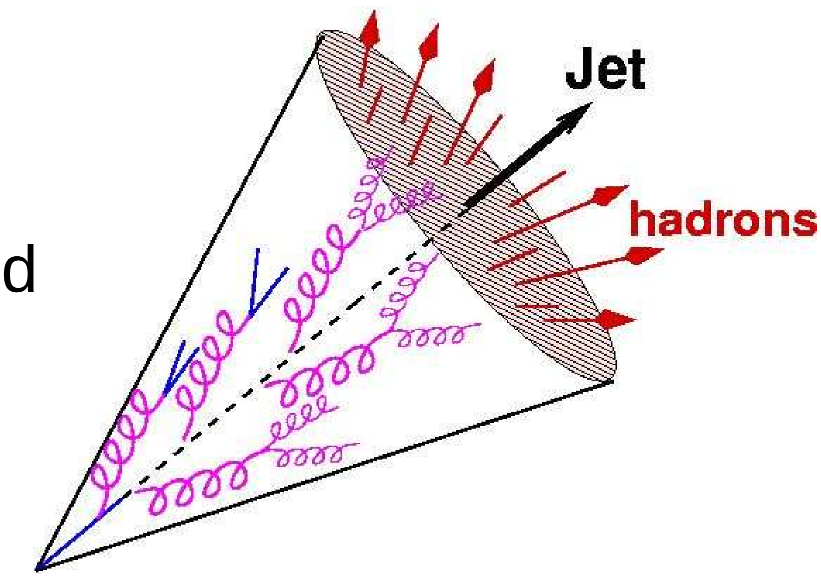
Jet Shapes

- Parton showers evolve until they hadronize at $Q \approx \Lambda_{\mathrm{QCD}}$
- The shapes of high-p_T jets are dictated more by multi-gluon emission than by the fragmentation process
- Measurements of jet shapes:
  - are sensitive to the mixture of quark & gluon final states and to the running of α_s
  - test parton-shower models
  - are also sensitive to the jet algorithm and to the underlying event

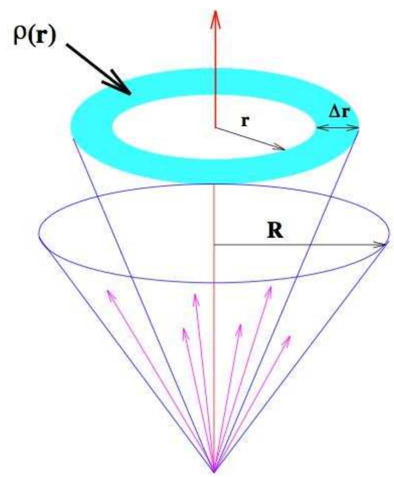


gluons radiate more than quarks so gluon-initiated jets tend to be broader than quark-initiated jets

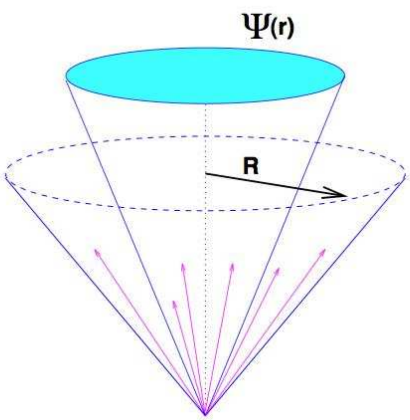
Jet Shapes

Event Selection:

- anti-k_T jets with $R = 0.6$
- jet $p_T > 30$ GeV and $|y| < 2.8$
- single interaction-vertex events

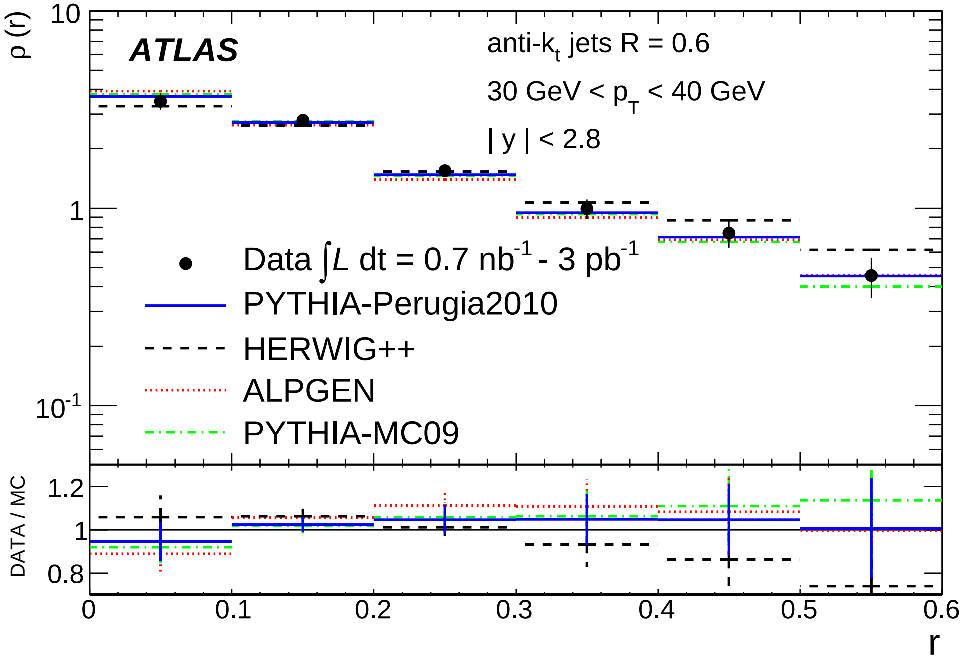


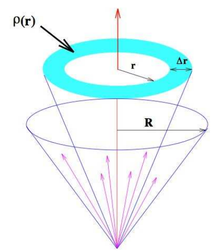
$$\rho(r) = \frac{1}{\Delta r}\frac{1}{N^{\text{jet}}}\sum_{\text{jets}}\frac{p_T(r-\Delta r/2, r+\Delta r/2)}{p_T(0,R)}, \quad \Delta r/2 \leq r \leq R - \Delta r/2$$

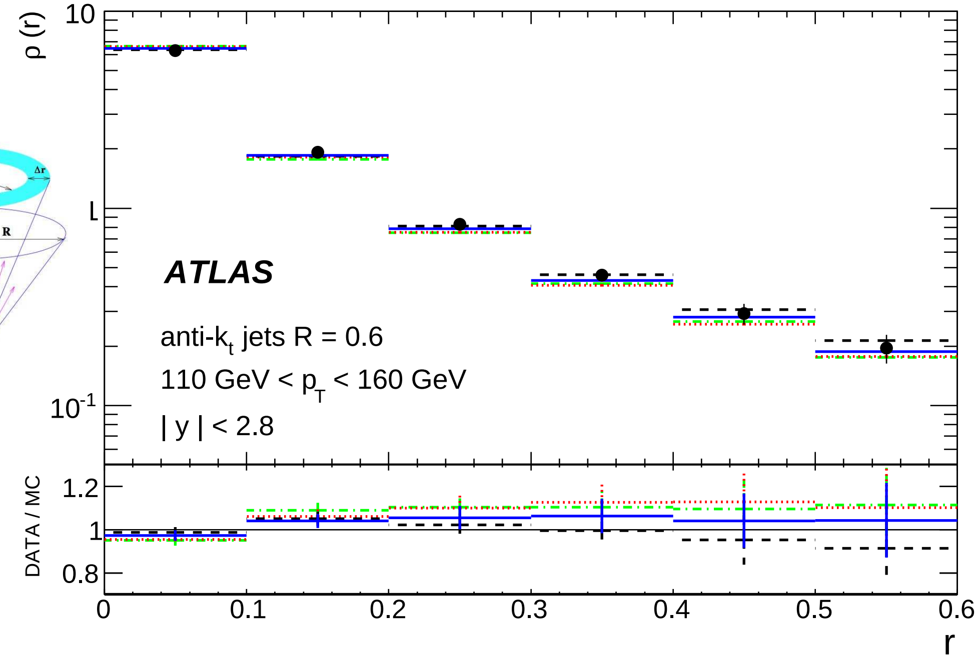


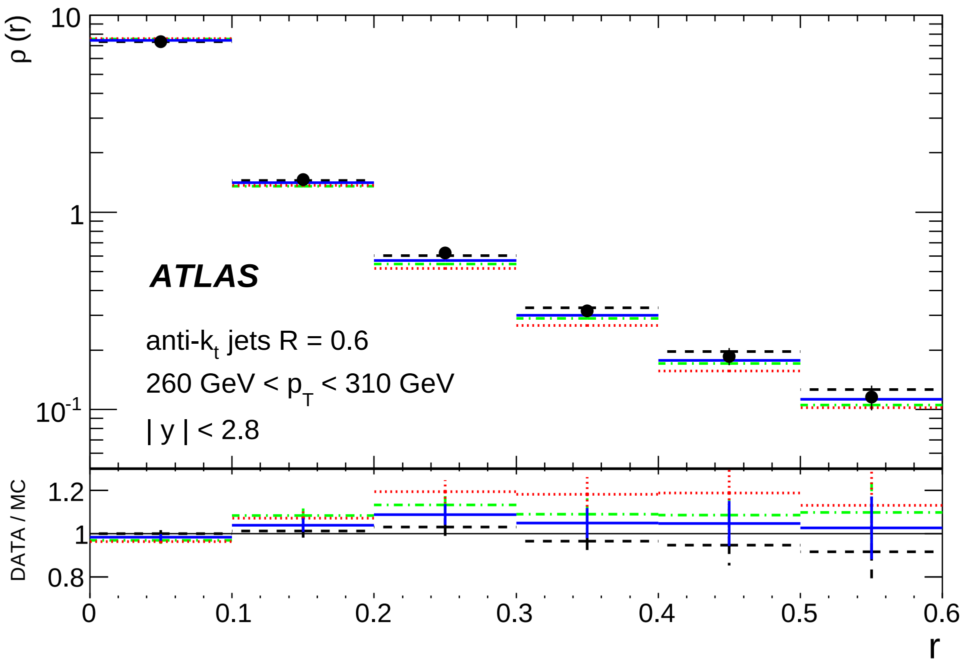
$$\psi(r) = \frac{1}{N^{\text{jet}}}\sum_{\text{jets}}\frac{p_T(0,r)}{p_T(0,R)}, \qquad 0 \leq r \leq R$$

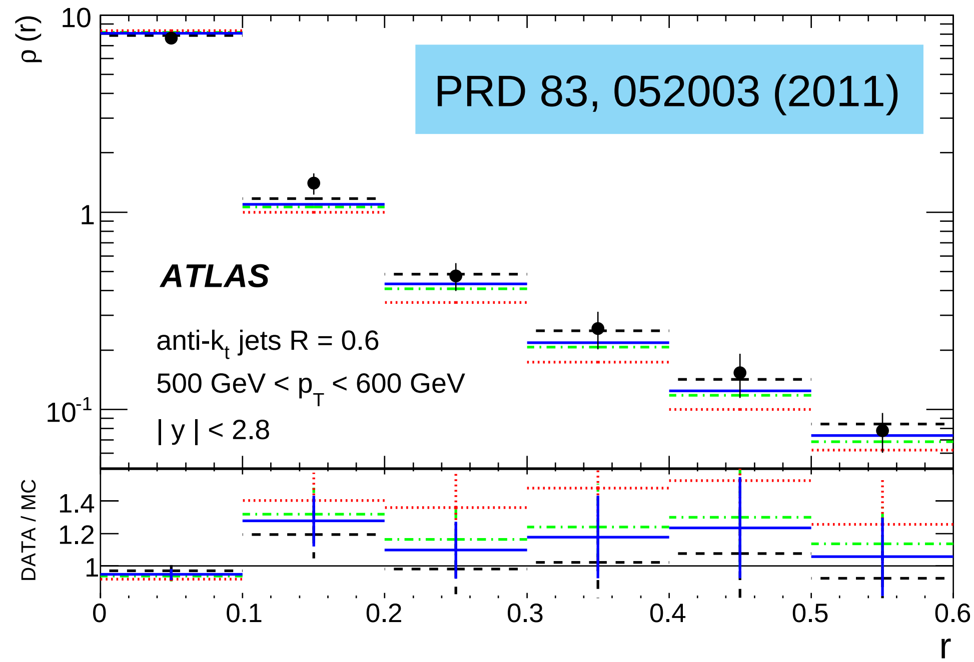
Differential Jet Shapes



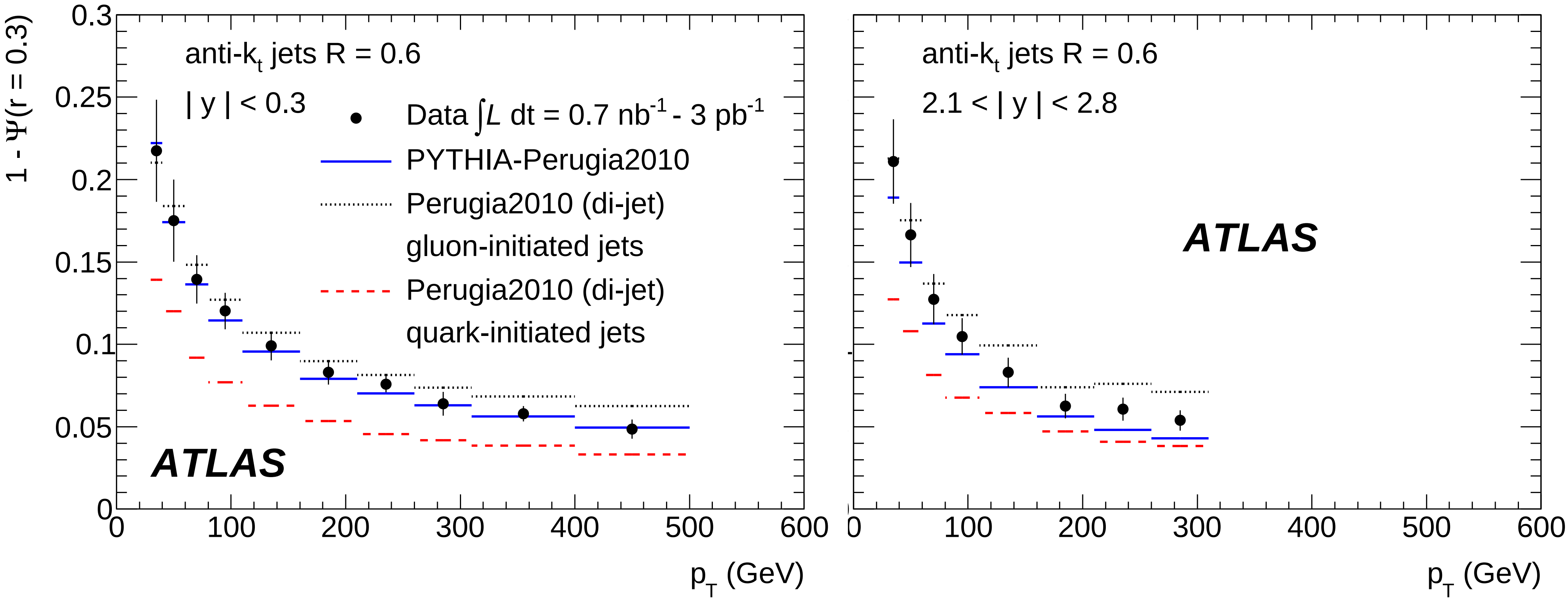


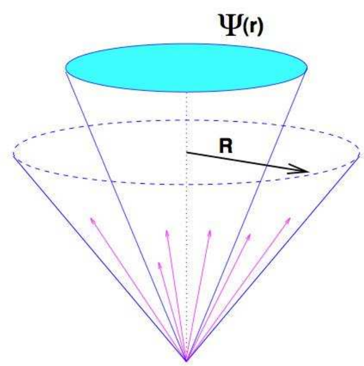






Integrated Jet Shapes





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Integrated Jet Shapes

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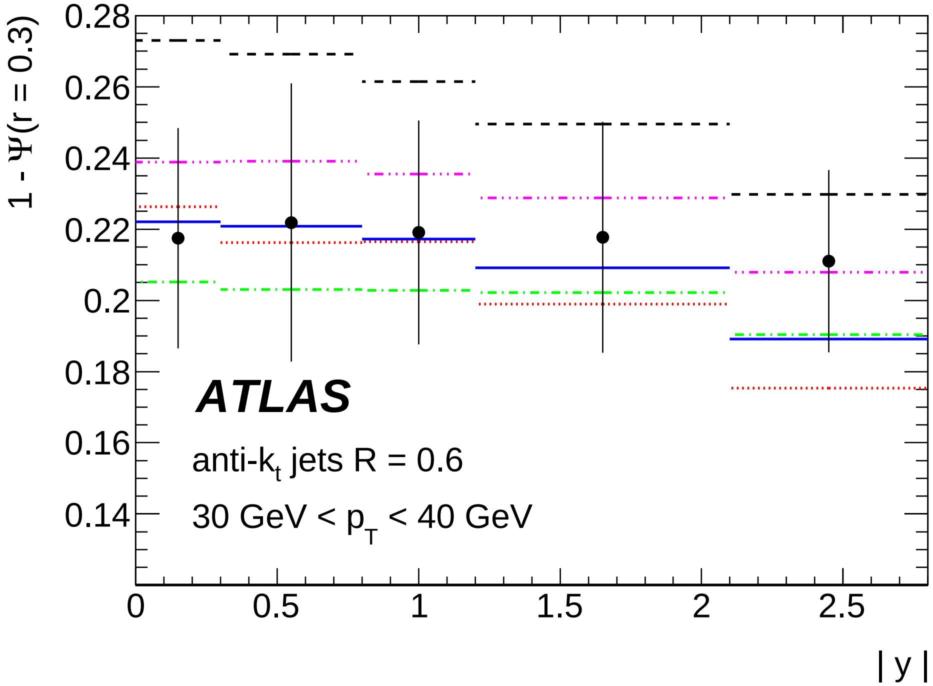
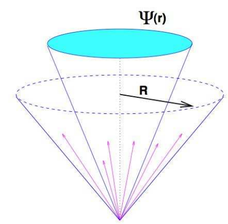
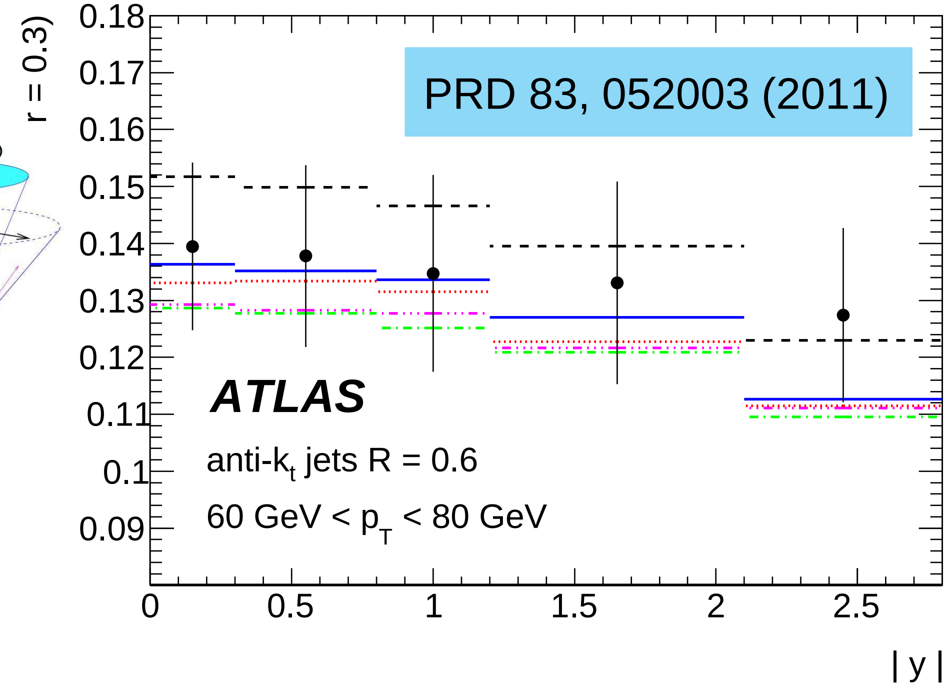
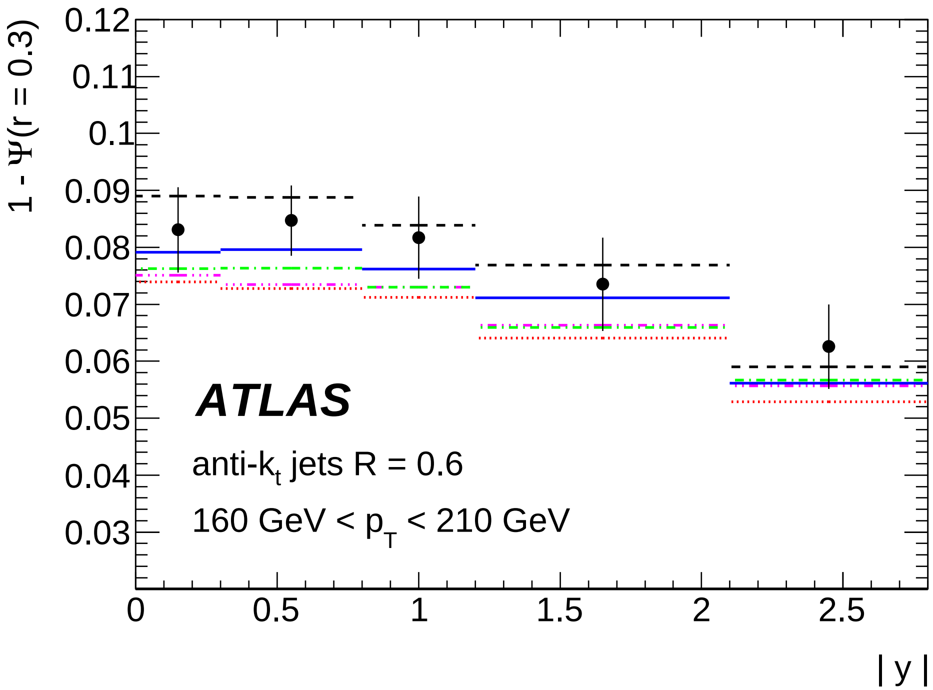
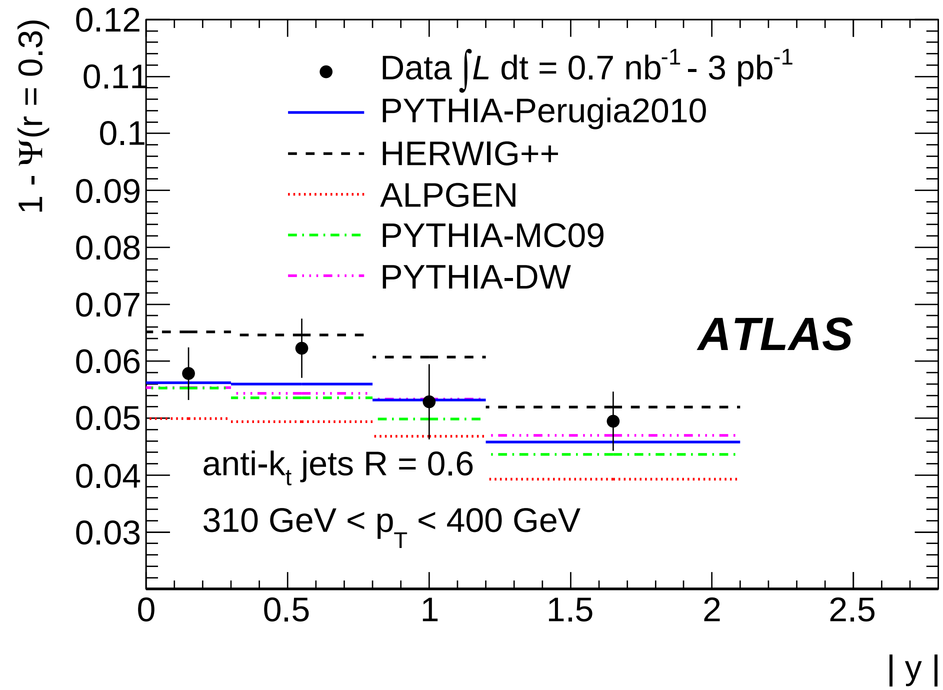




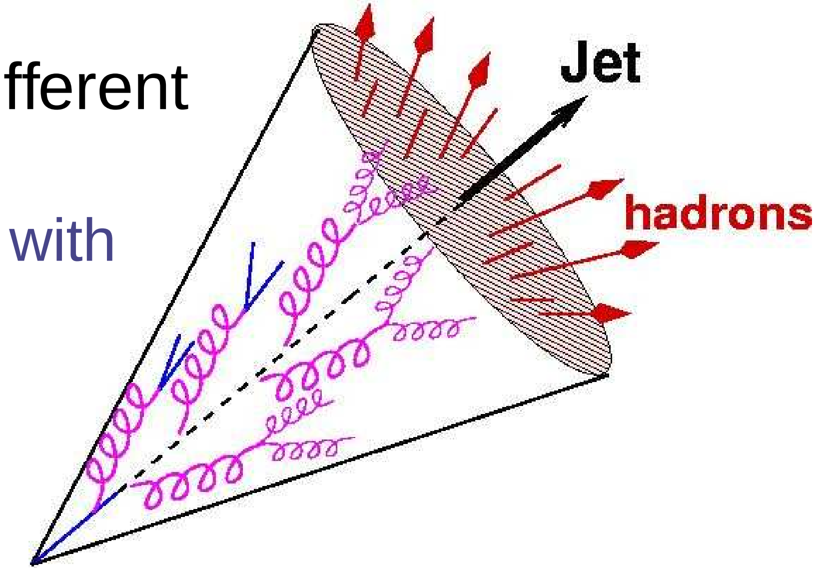


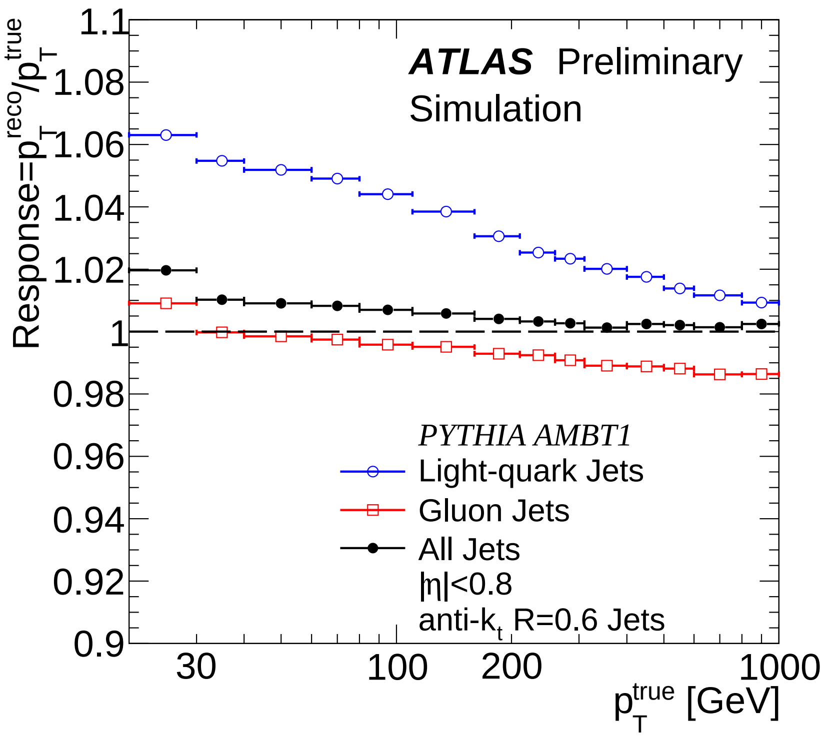


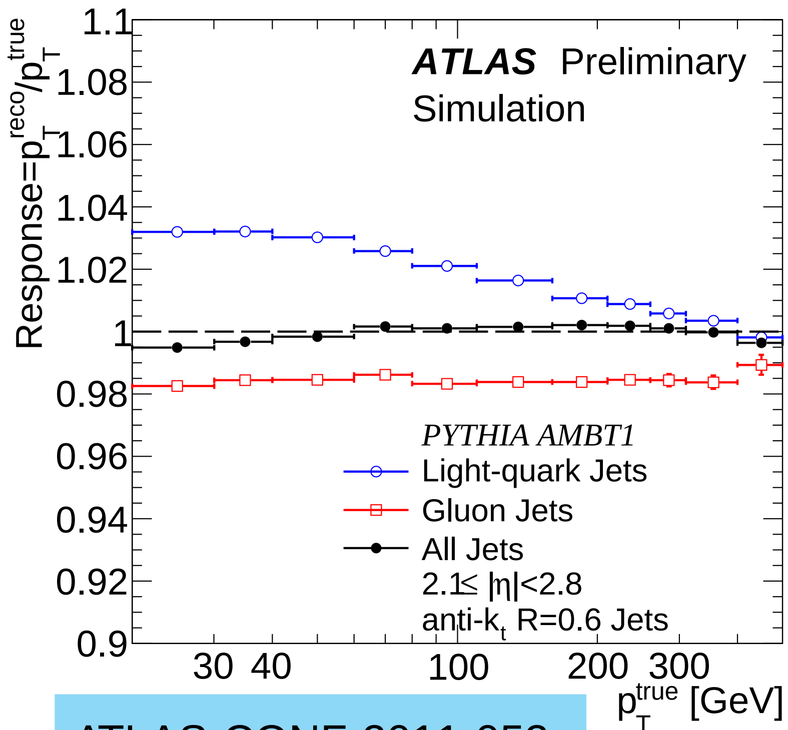


Jet Response

- Quark- and gluon-initiated jets have different calorimetric response
  - gluon-initiated jets tend to be broader, with more lower-momentum particles, than quark-initiated jets
  - these effects are being incorporated into the jet energy calibration







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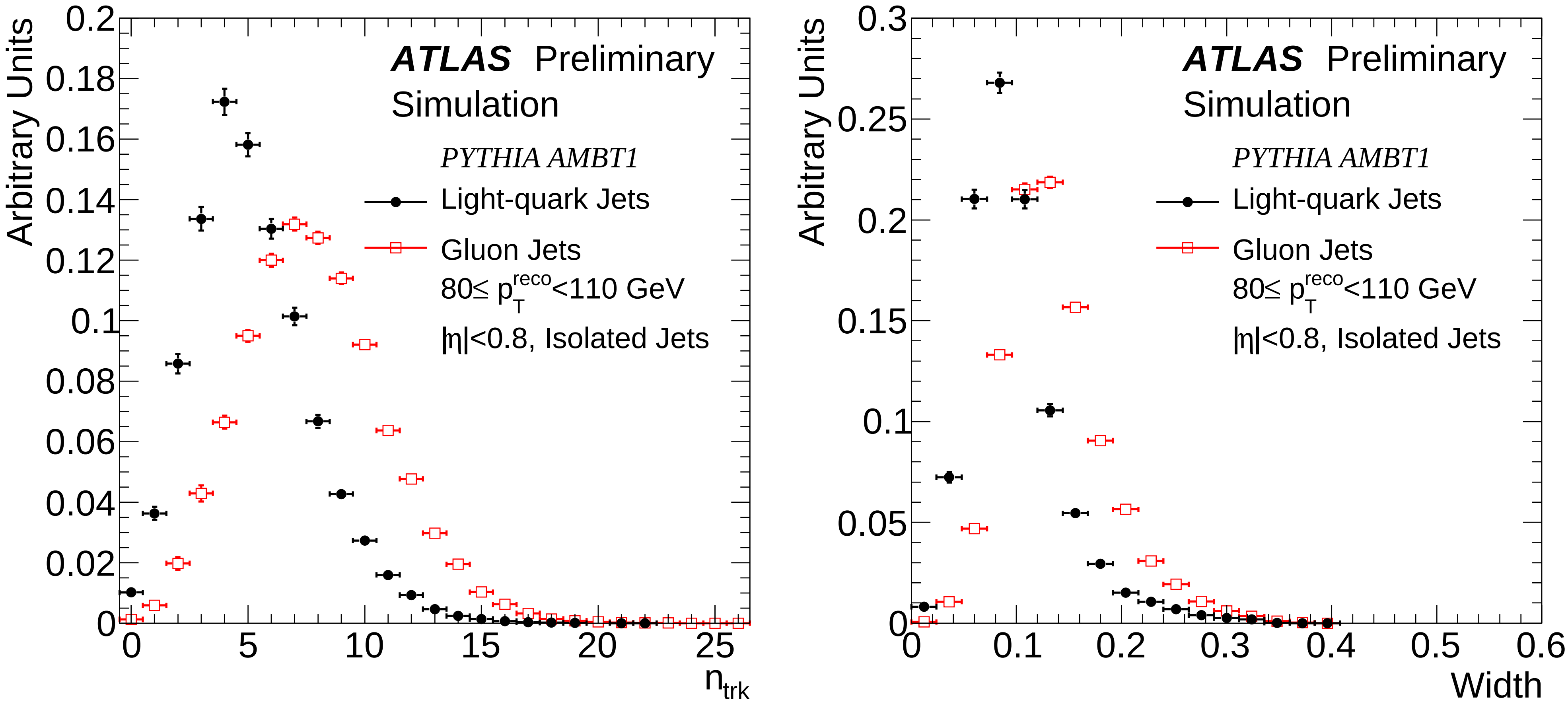
Event Selection:

- anti-k_T jets with R = 0.6 (and also R = 0.4)
- jet $p_T > 60$ GeV and $|y| < 2.8$
- single interaction-vertex events



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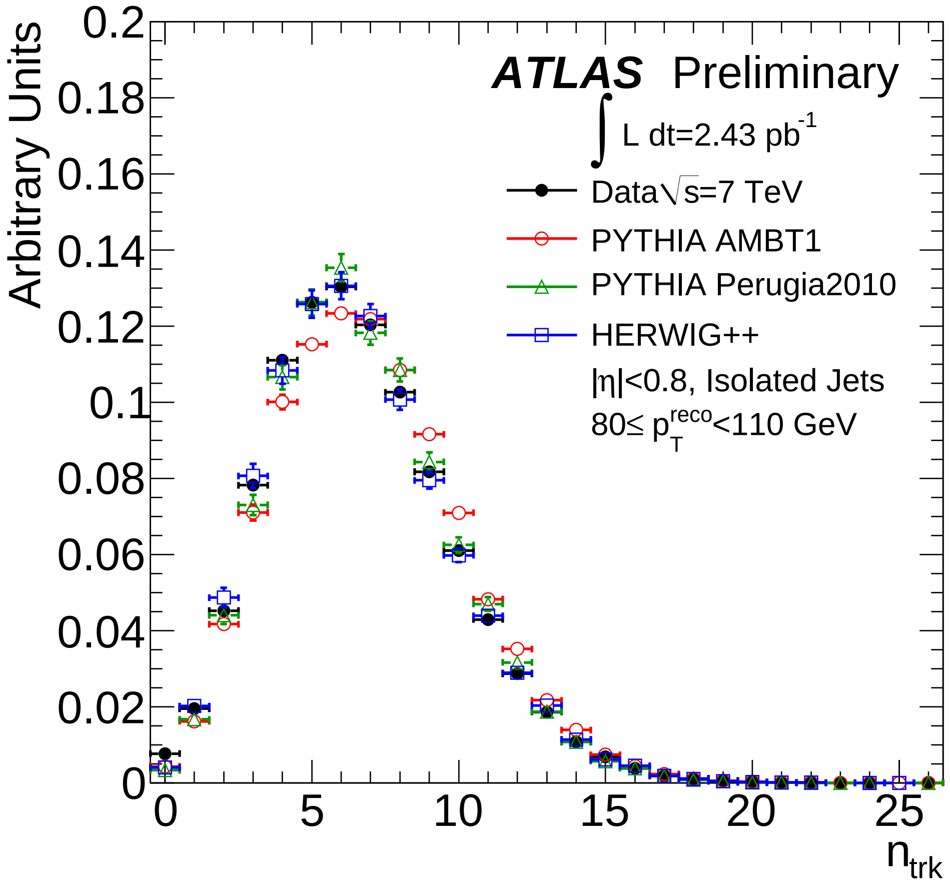
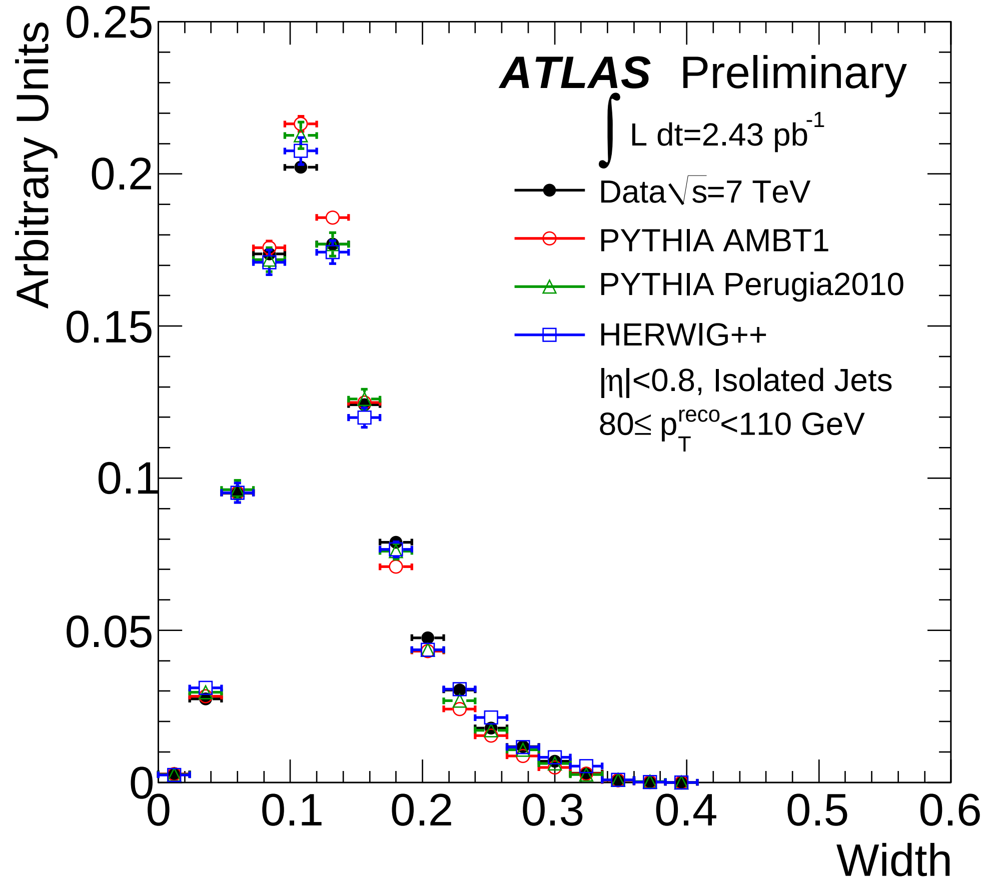
Fitting the Jet Response





Heavy-flavor fraction has been fixed to that of the event generator.

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Fitting the Jet Response

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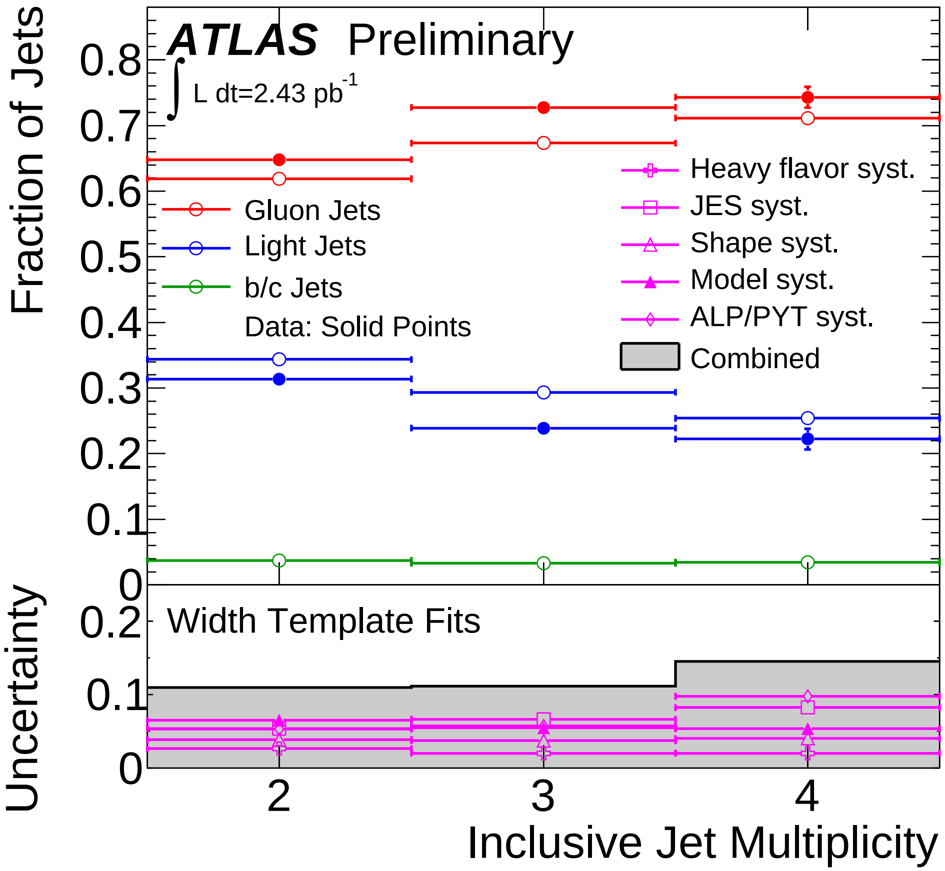

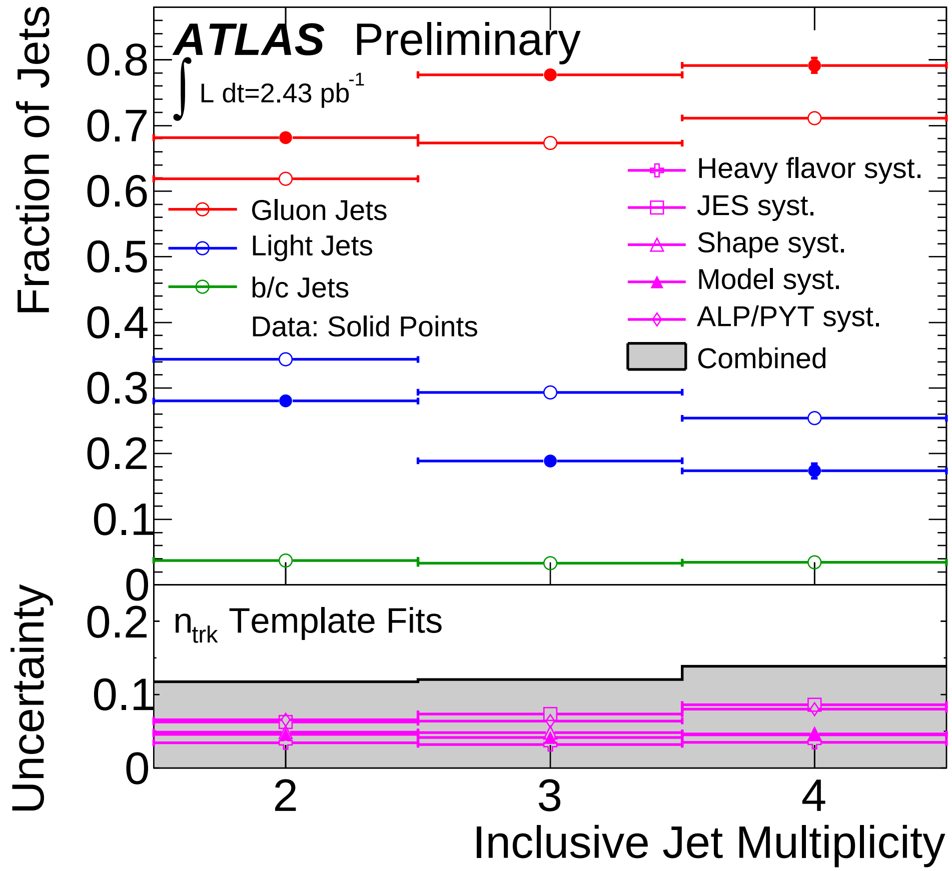

Results fit to data are closed markers (●) while results from simulation are open markers (○).

Heavy-flavor fraction has been fixed to that of the event generator.

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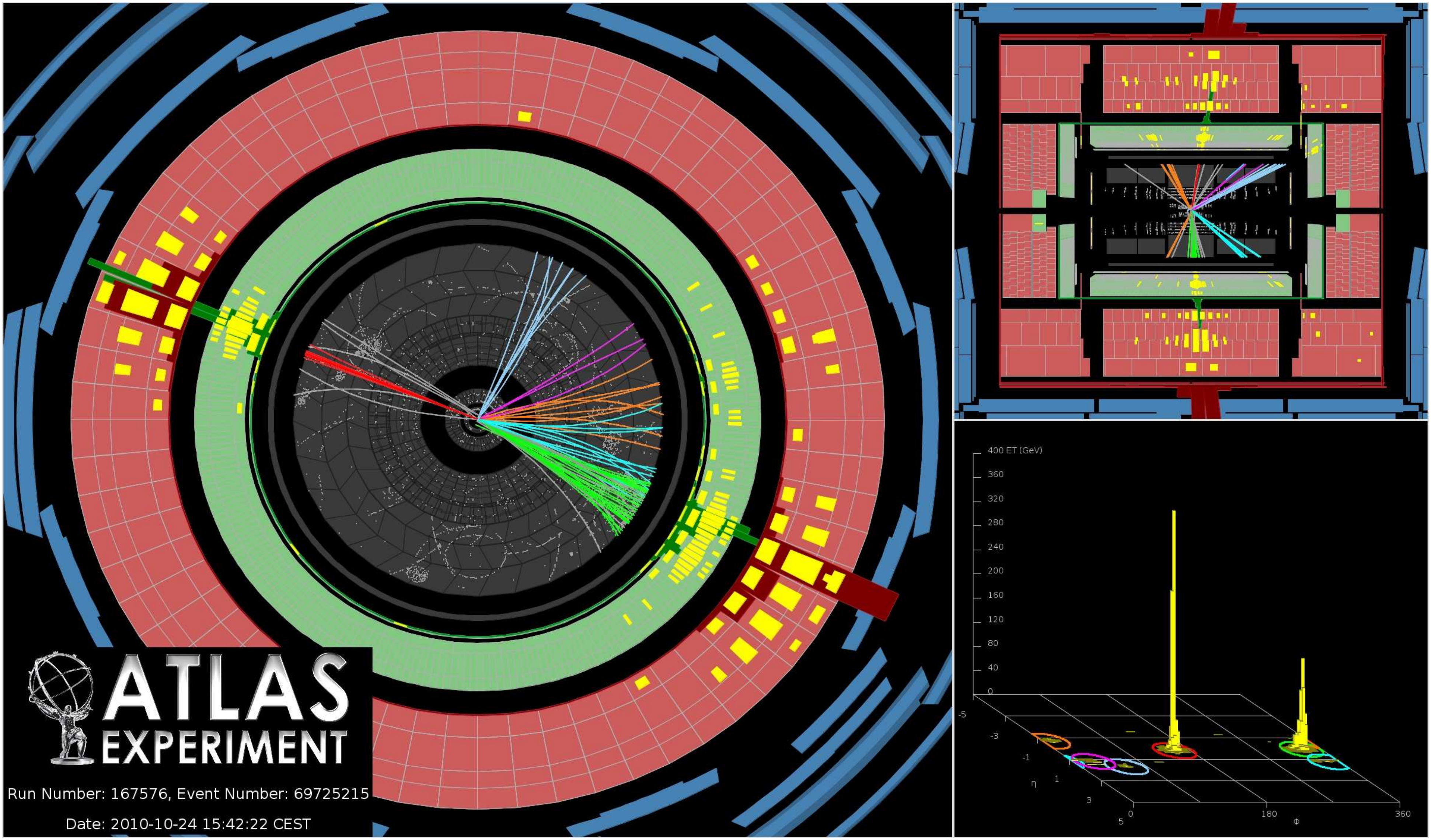
Summary

- Dijet Azimuthal Decorrelations
  - reflects the activity in the rest of the event
  - described by NLO pQCD, ME+PS (SHERPA), and tuned event generators
- Jets located in the rapidity intervals between boundary jets
  - sensitive to BFKL dynamics and wide-angle soft-gluon radiation
  - gap fraction and mean jet multiplicity described by PYTHIA and POWHEG+PYTHIA
  - HERWIG and ALPGEN+HERWIG predict too much activity between jets
  - p_T dependence not described by HEJ (not interfaced with PS)
- Jet Shapes
  - narrow with increasing p_T and y (quark/gluon mixture & running of α_s)
  - described by PYTHIA–Perugia2010 but less so by other tunes or event generators
- Jet Response
  - systematic uncertainties associated with the jet energy calibration can be reduced by including jet-shape information
- These results test important aspects of pQCD and will benefit global efforts to produce phenomenological tunes for the event generators.

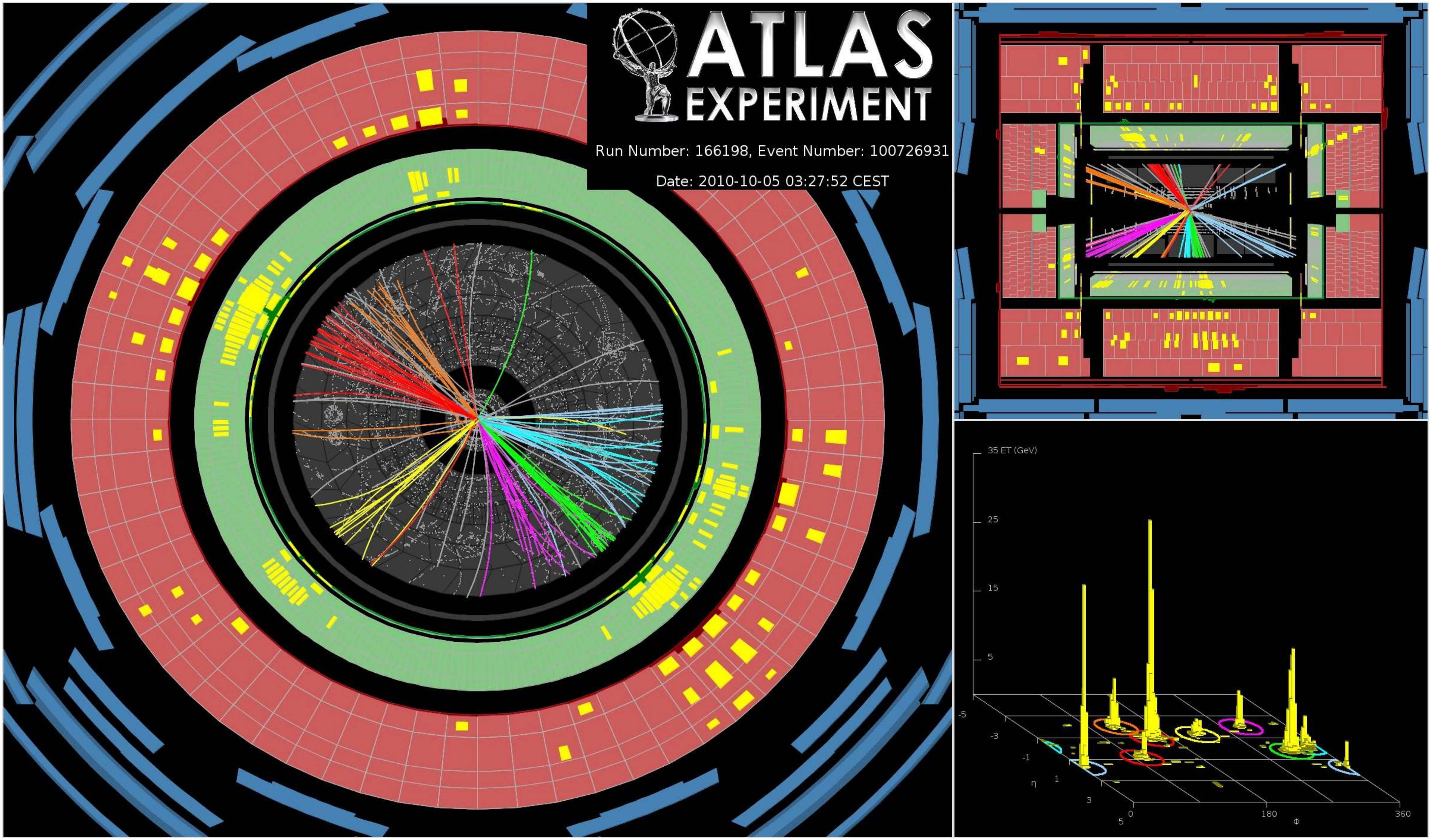
Backup

Event Display



Jet 1 p_T: 1.3 TeV (η = 0.2, ϕ = 2.8)
Jet 2 p_T: 1.2 TeV (η = 0.0, ϕ = $-$0.5)
$\not{E}_T$ = 42 GeV

Event Display



Jet 1 p_T: 290 GeV ($\eta = -0.9$, $\phi = 2.7$)
Jet 2 p_T: 220 GeV ($\eta = 0.3$, $\phi = -1.9$)
$\not{E}_T$ = 21 GeV $\sum E_T$ = 890 GeV

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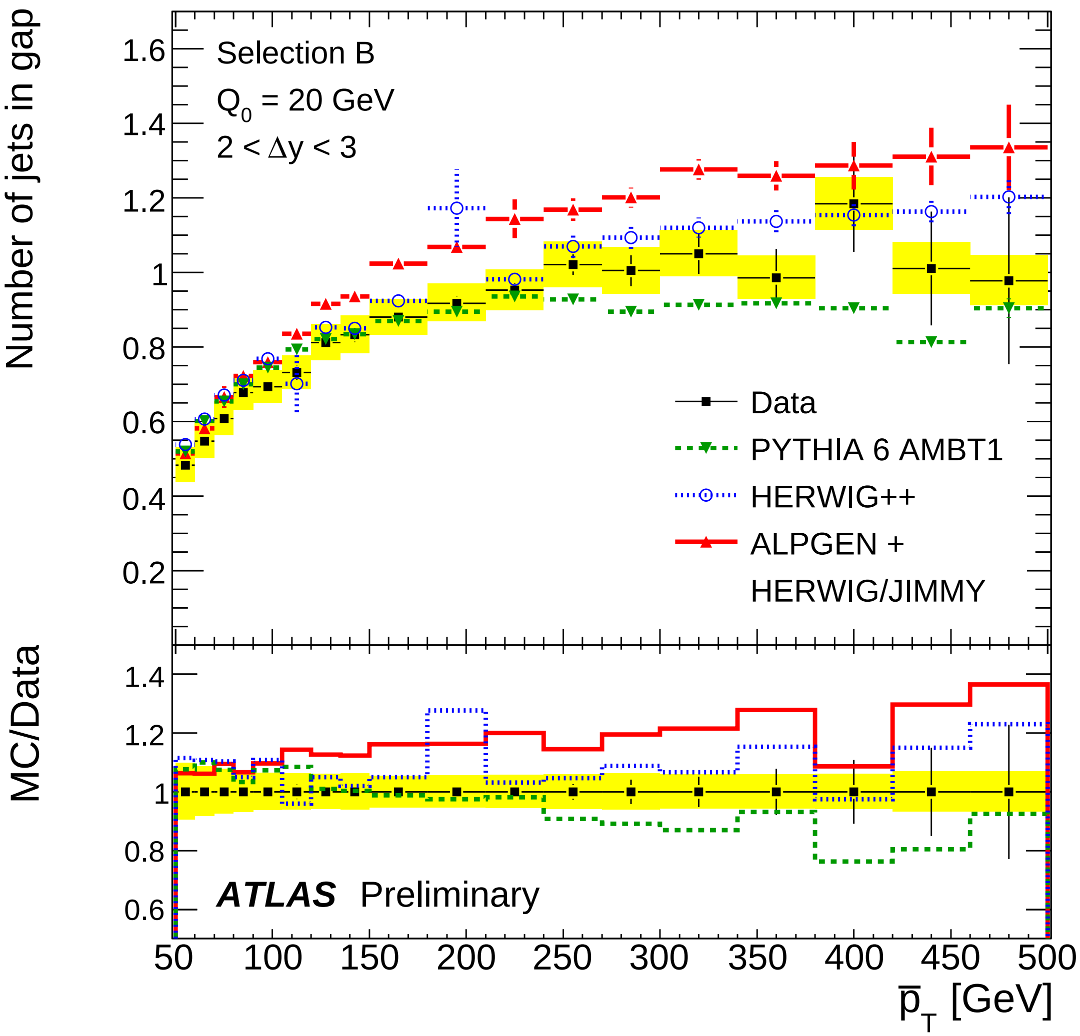

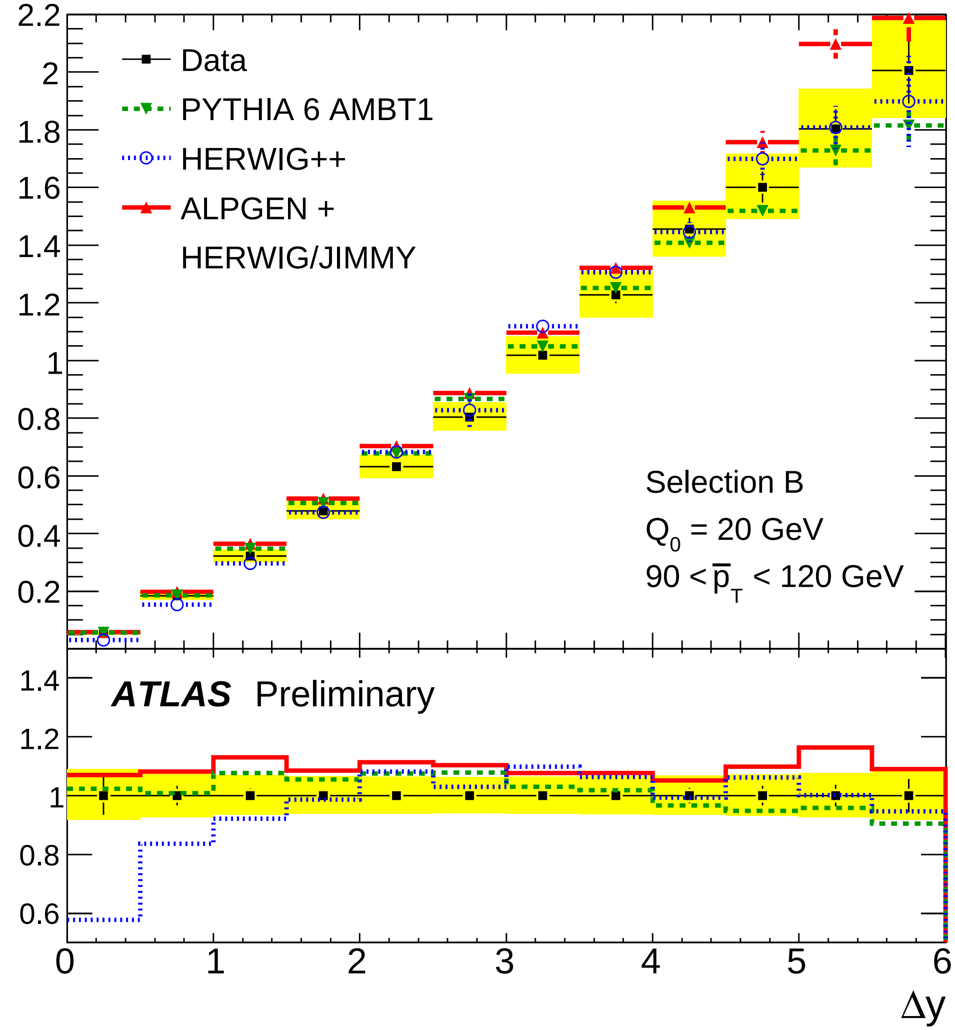

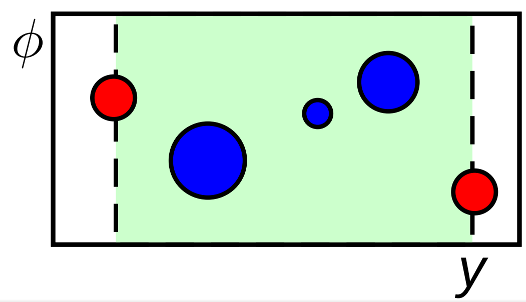

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Jet Multiplicity

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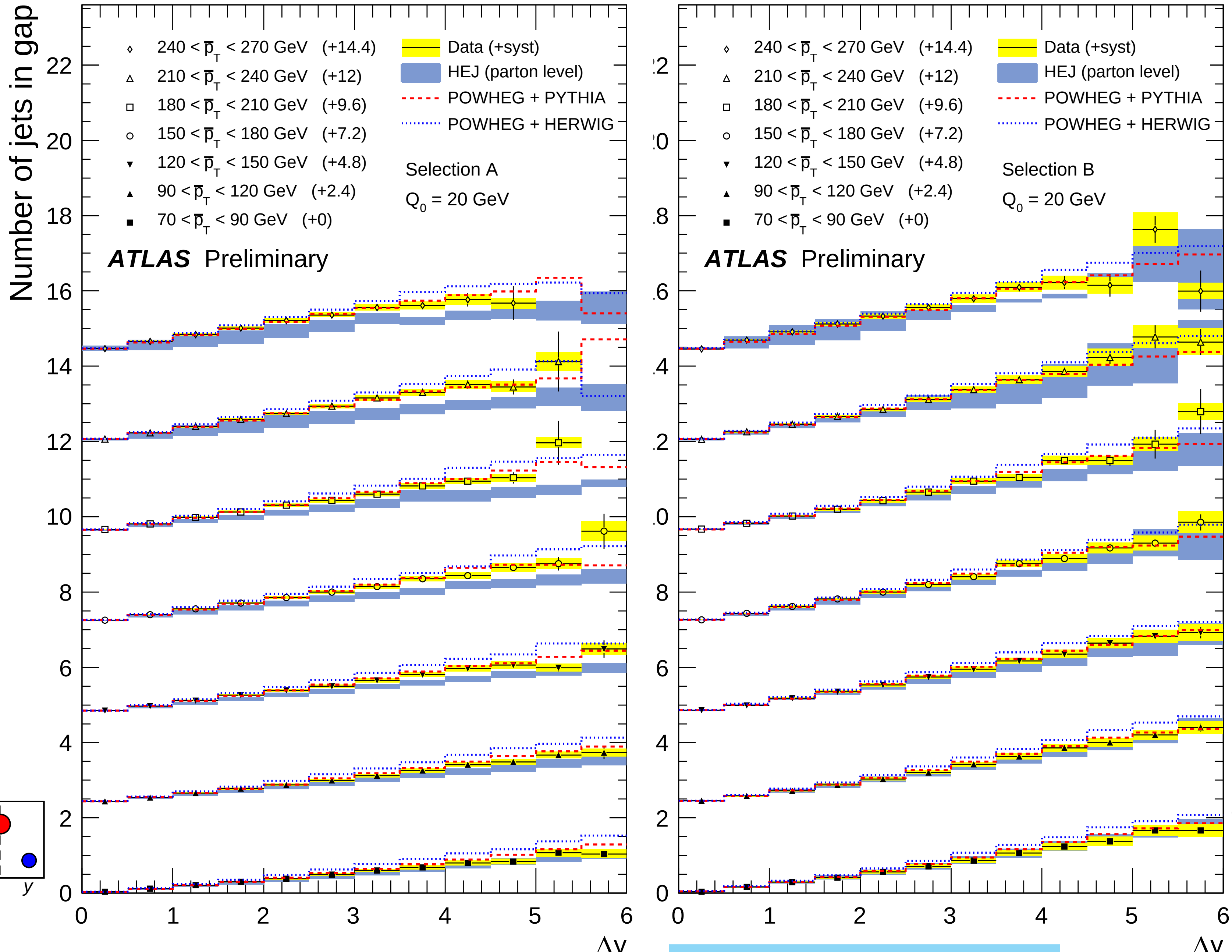

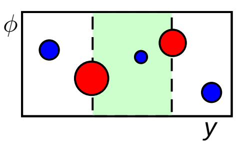

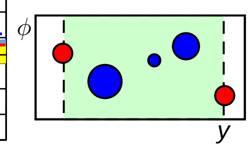

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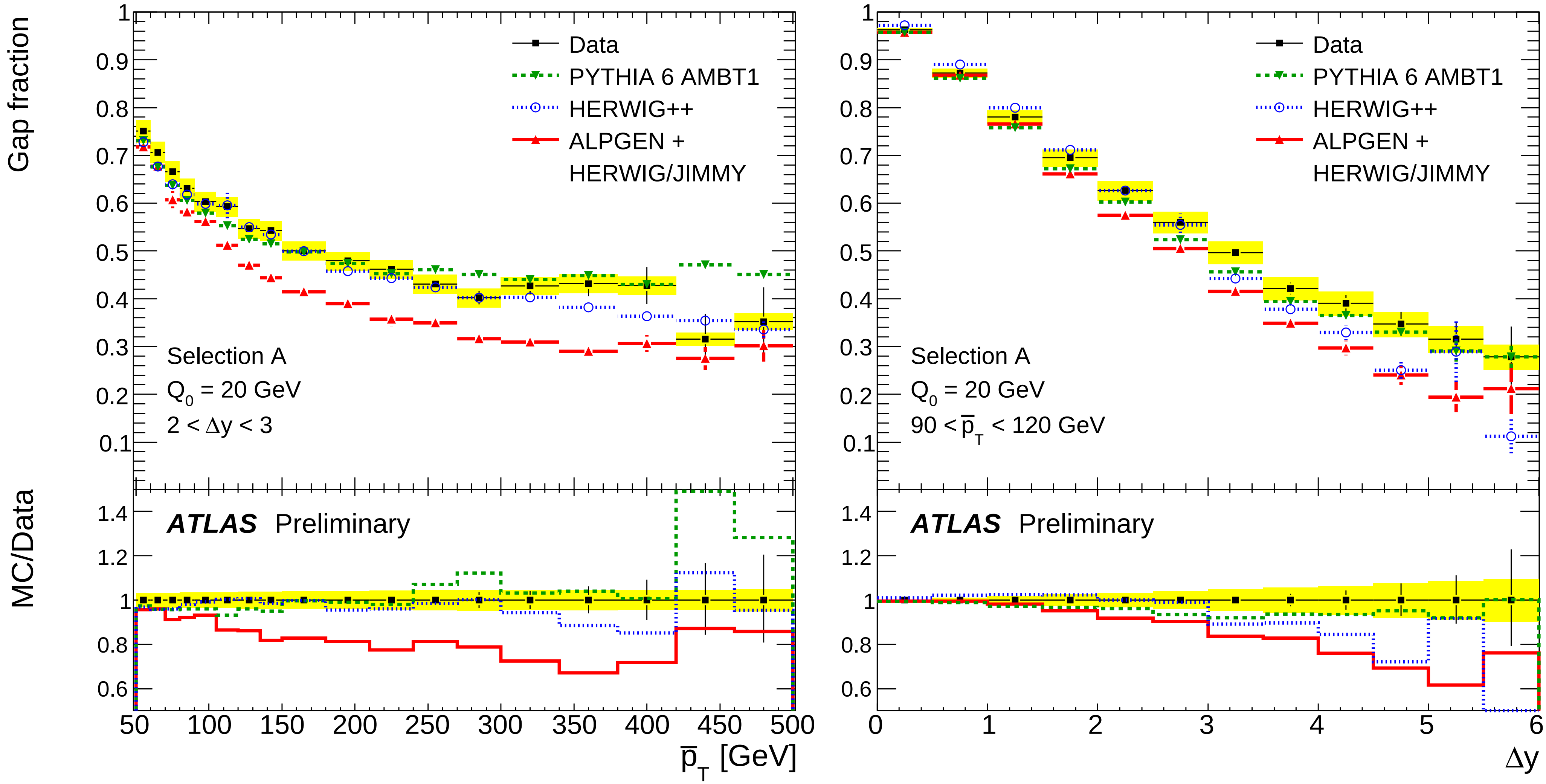
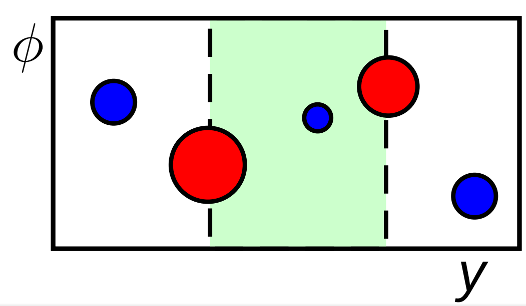
Gap Fraction





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Gap Fraction

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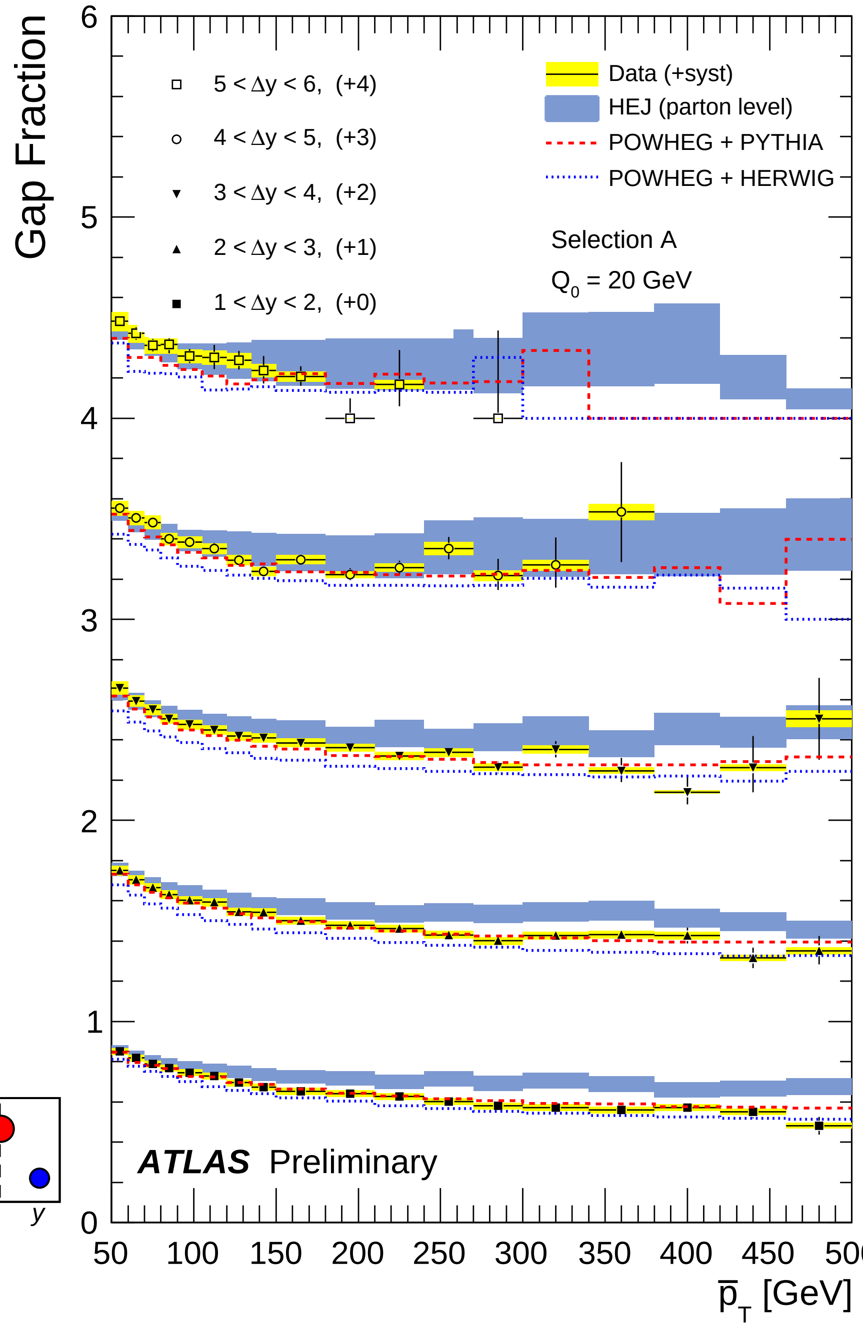

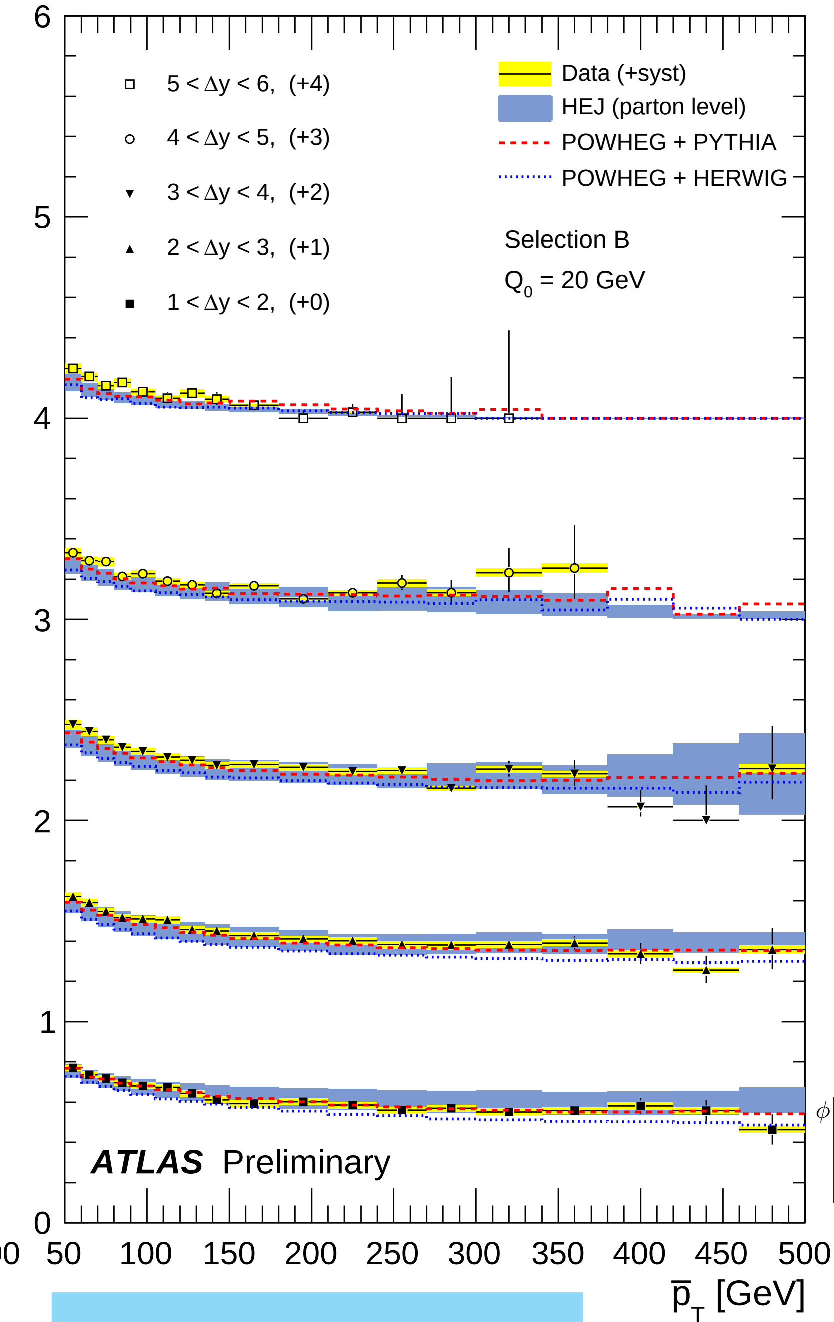

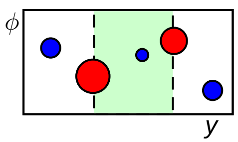

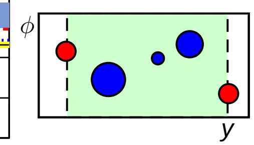

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