Jet physics in ATLAS

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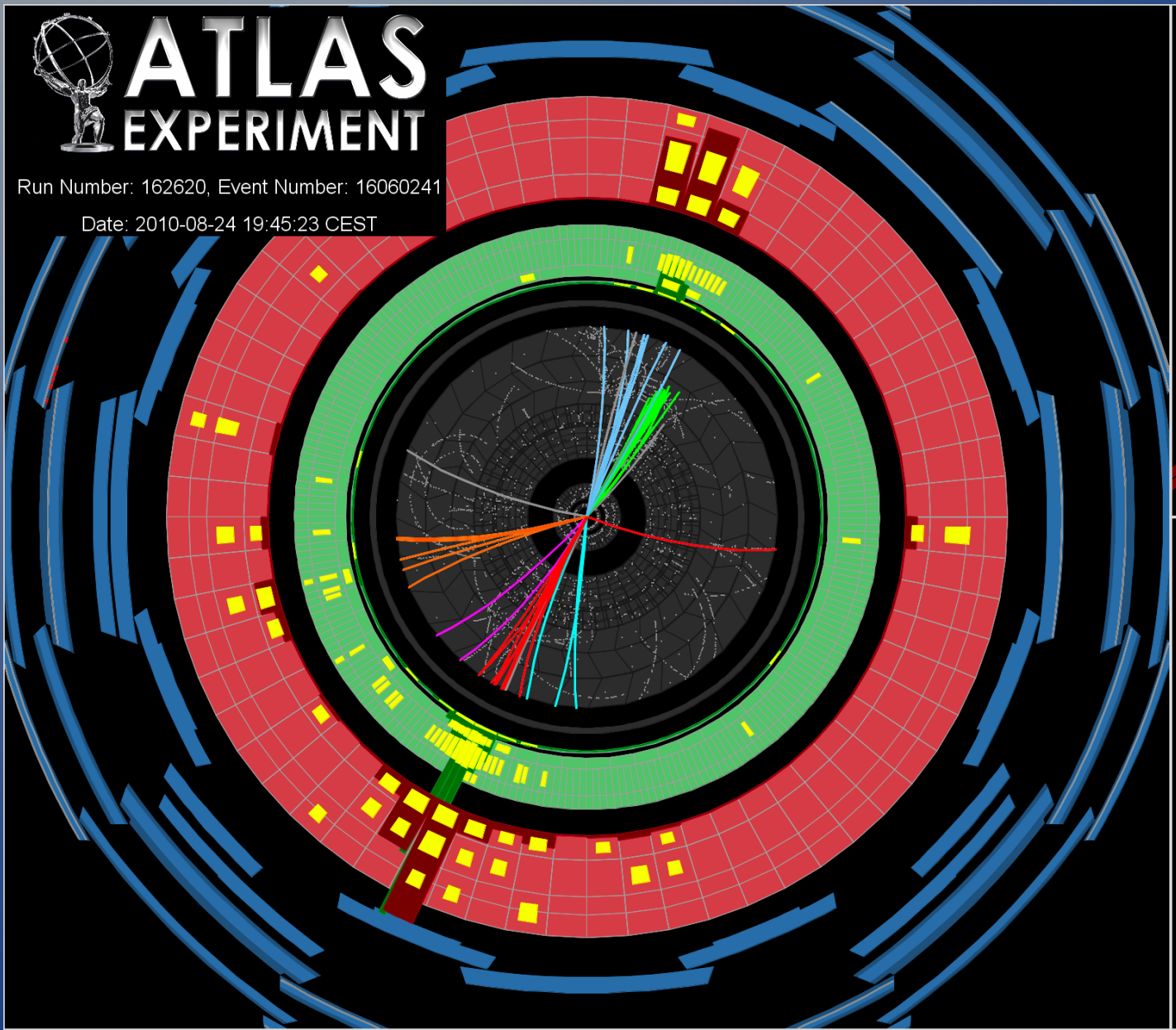
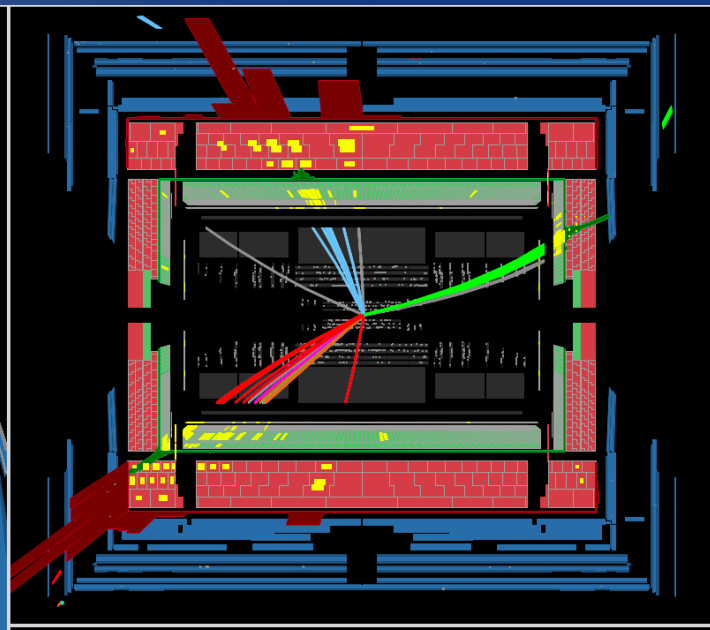
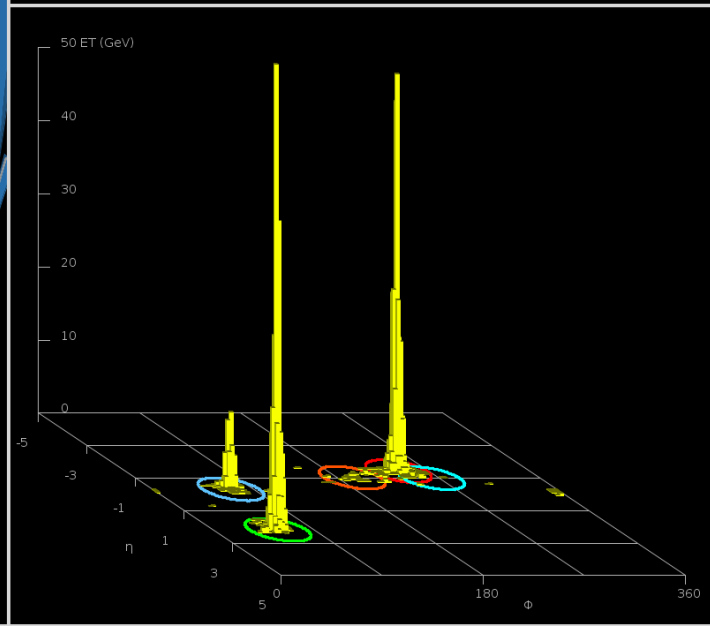






Outline

Triggering on jets
Calibrating jets
Inclusive measurements
Multi-jets
Testing hard radiation

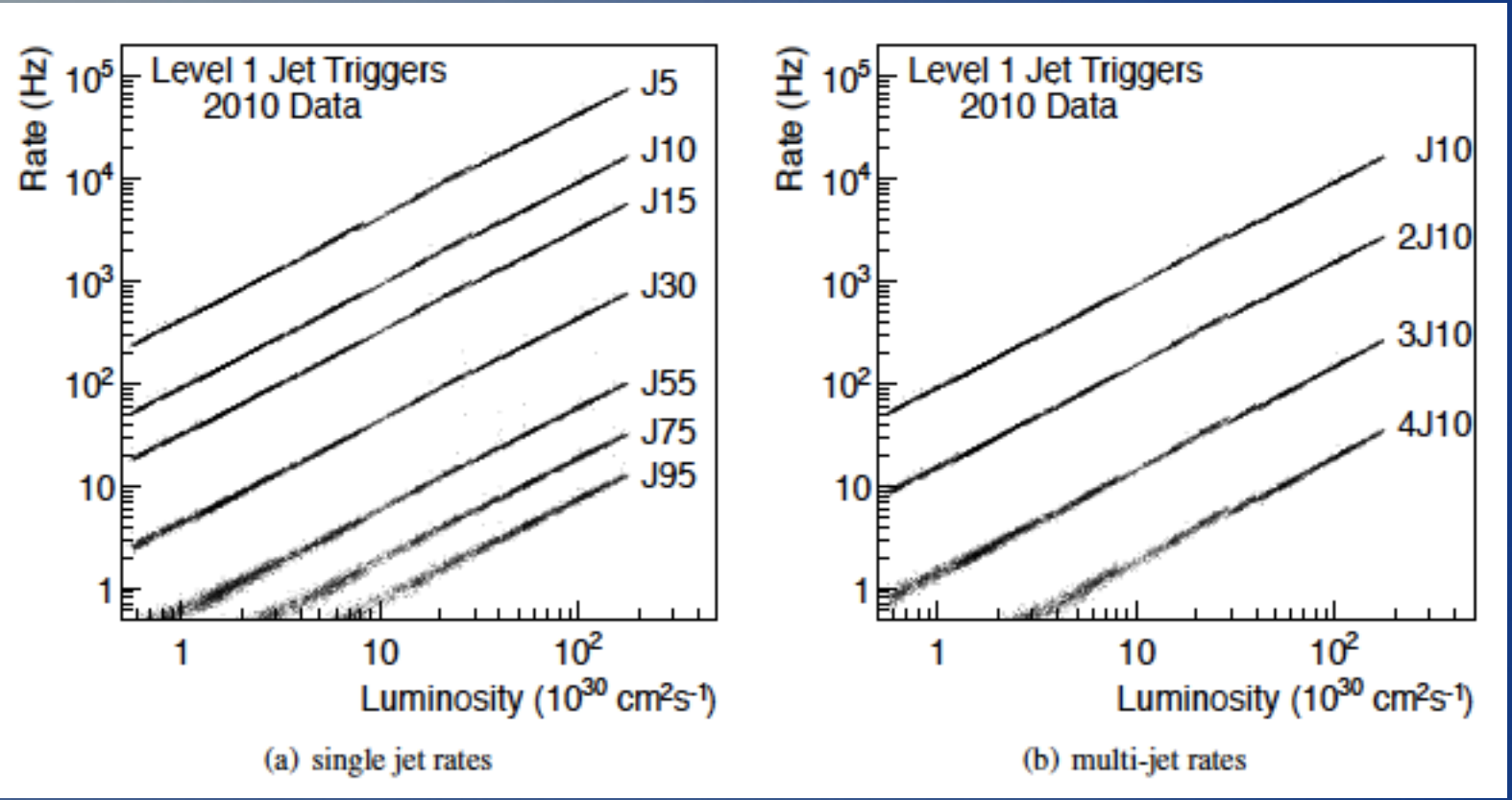
Triggering on jets

Trigger	L1 Name	Threshold (GeV) L1	L2	EF
Inclusive jets:				
EF_j10	L1_J5	5	7	10
EF_j20	L1_J10	10	15	20
EF_j40	L1_J15	15	30	40
EF_j80	L1_J30	30	60	80
Forward jets:				
EF_fj10	L1_FJ5	5	7	10
EF_fj20	L1_FJ10	10	15	20
EF_fj40	L1_FJ15	15	30	40
EF_fj80	L1_FJ30	30	60	80
Multijets:				
EF_2j10	L1_2J5	5	7	10
EF_2j20	L1_2J10	10	15	20
EF_3j20	L1_3J10	10	15	20
EF_4j10	L1_4J5	5	7	10
EF_4j20	L1_4J10	10	15	20
Summed Jet Energy:				
EF_je60	L1_JE60	60	N/A	N/A
EF_je100	L1_JE100	100	N/A	N/A
EF_je120	L1_JE120	120	N/A	N/A

Last year in Atlas we had a rich jet trigger menu, with inclusive jets, dijets, multijets, sum et; also topological triggers cutting on $\Delta\eta$ or $\Delta\Phi$ were used.

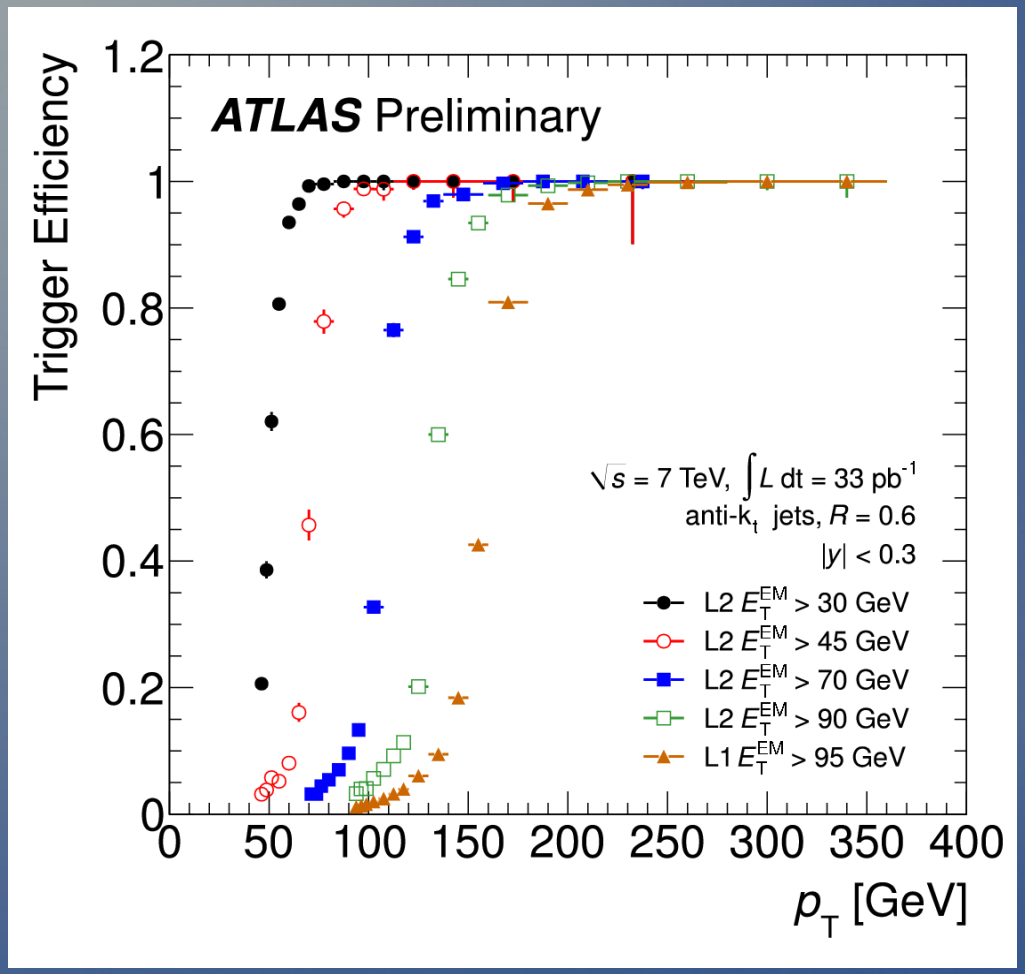
Menu is even more complicated this year, with asymmetric multijets, low-pt thresholds seeded by the random trigger and virtual thresholds

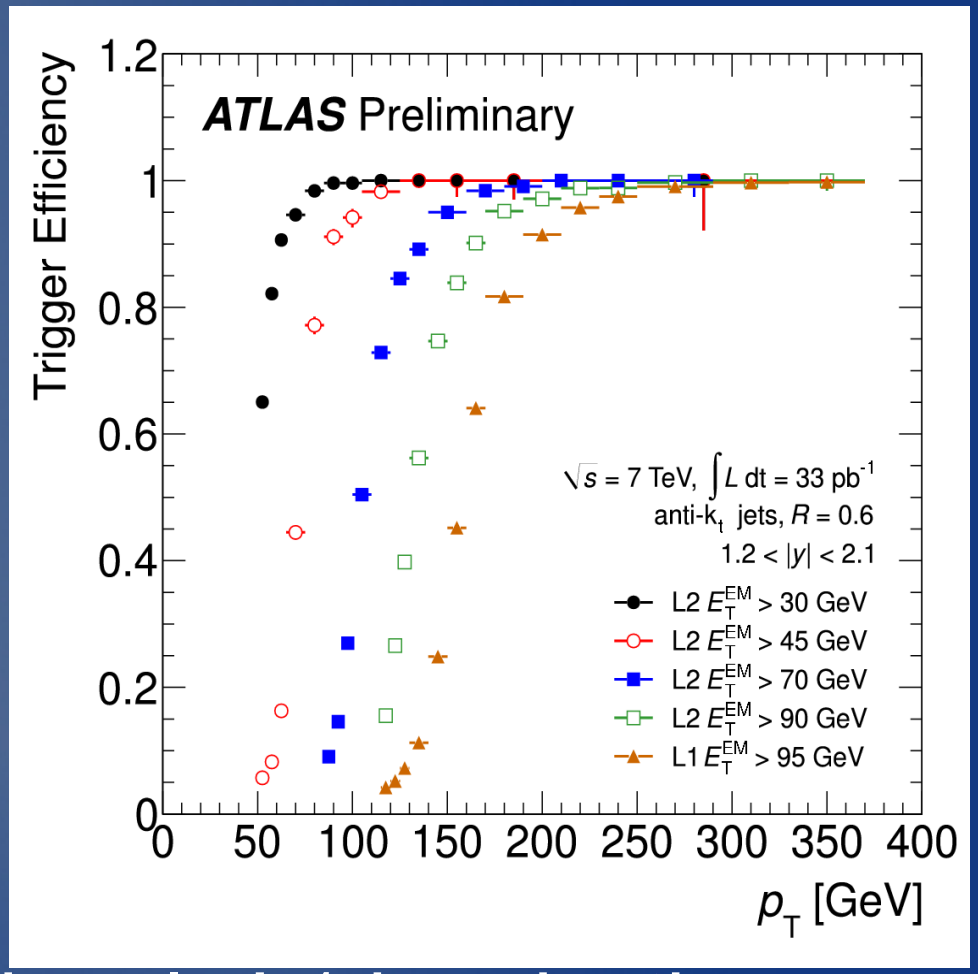
Rate behaviour



Rate for central inclusive and multijet trigger quite linear; pileup effects not yet seen

Central efficiencies

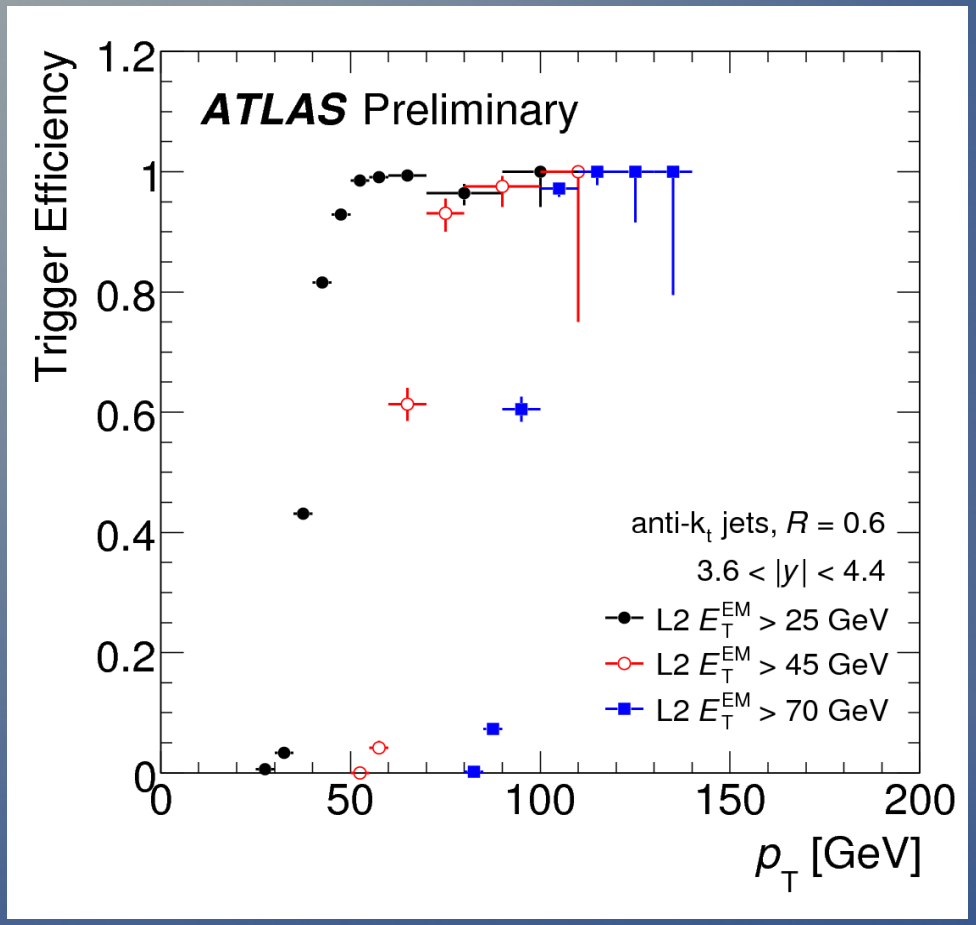


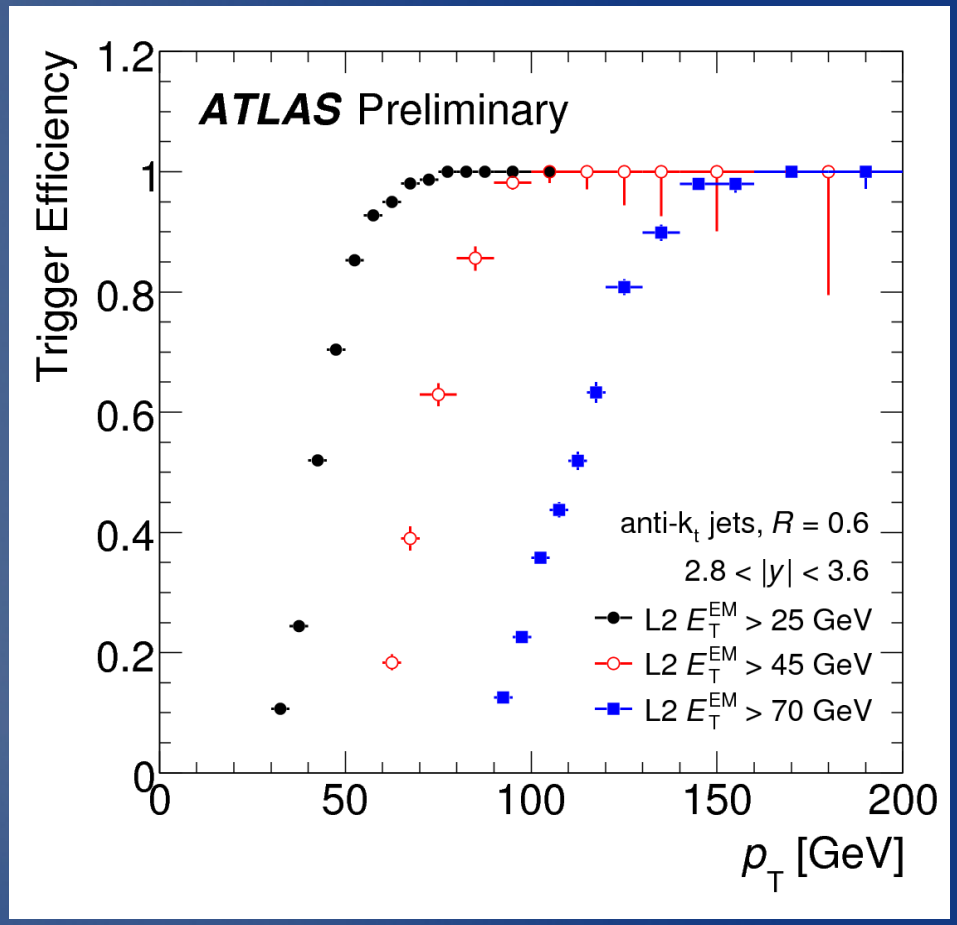


Atlas jet trigger was run with only L1 in rejection mode (but with all algorithms running for validation purposes) until the summer, then L2 was also rejecting. Last thresholds always in L1 only mode

Jet trigger was run at EM scale (no calibration)

Forward and transition efficiencies

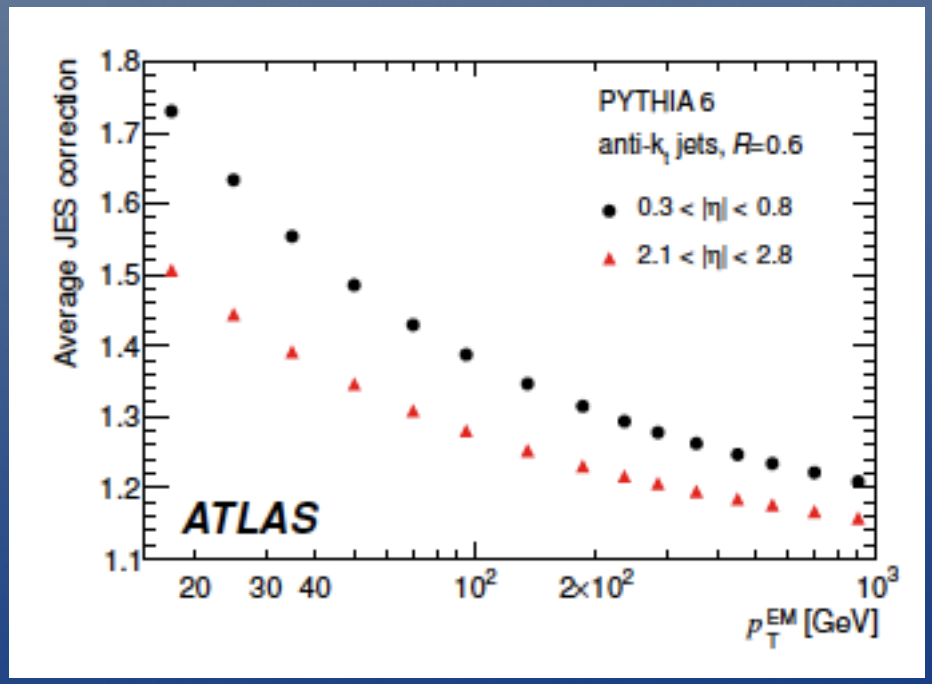




Turn-on in the forward region is sharper than for central jets (despite a dead cell); the transition region between central and forward is the most difficult

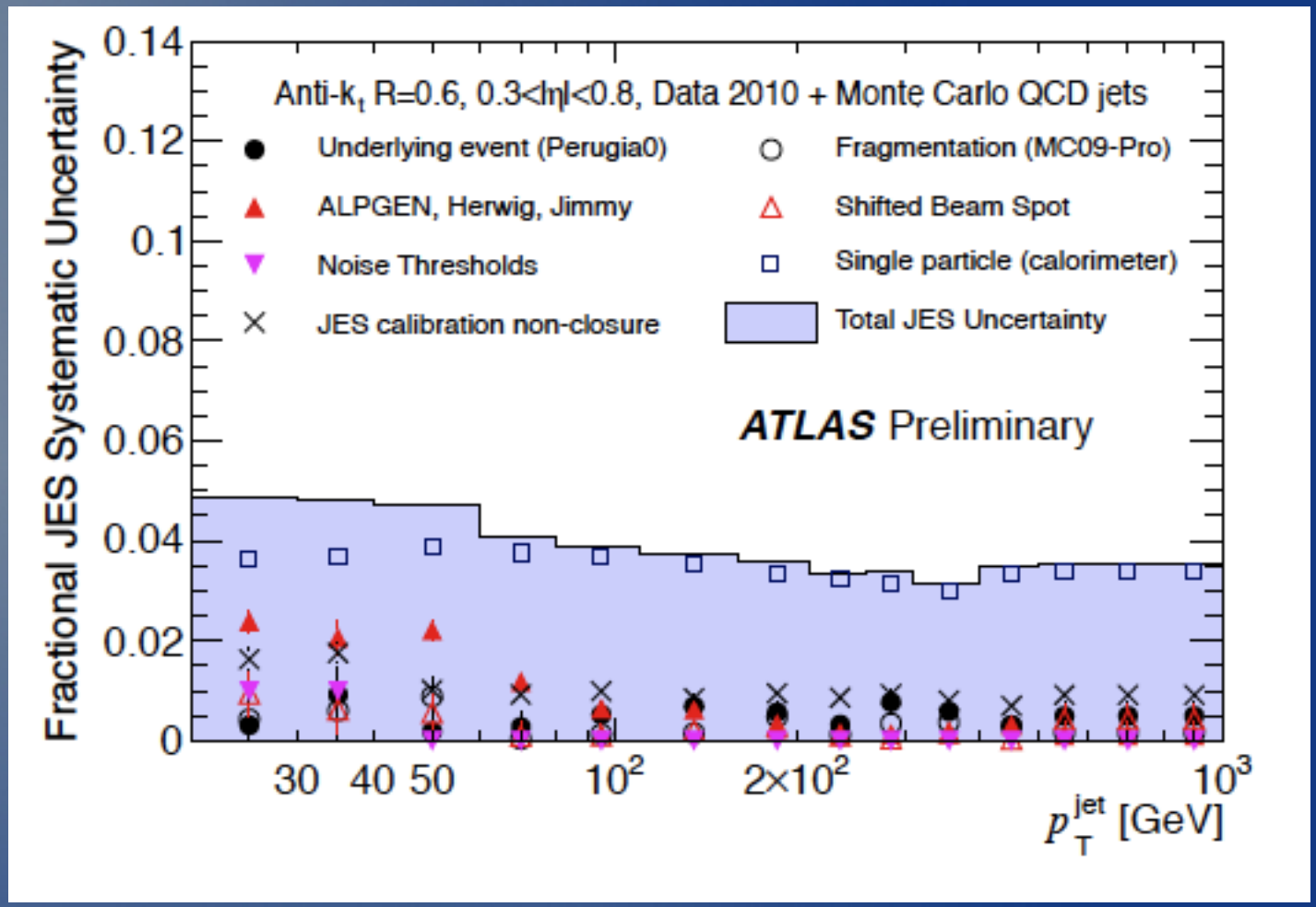
Energy scale calibration

In 2010, lacking enough statistics to perform a proper in-situ calibration with γ-jet balancing, calibration constants have been derived from MonteCarlo. For added stability, calibration constants were applied to the sum (em+had), not separately to the two components.



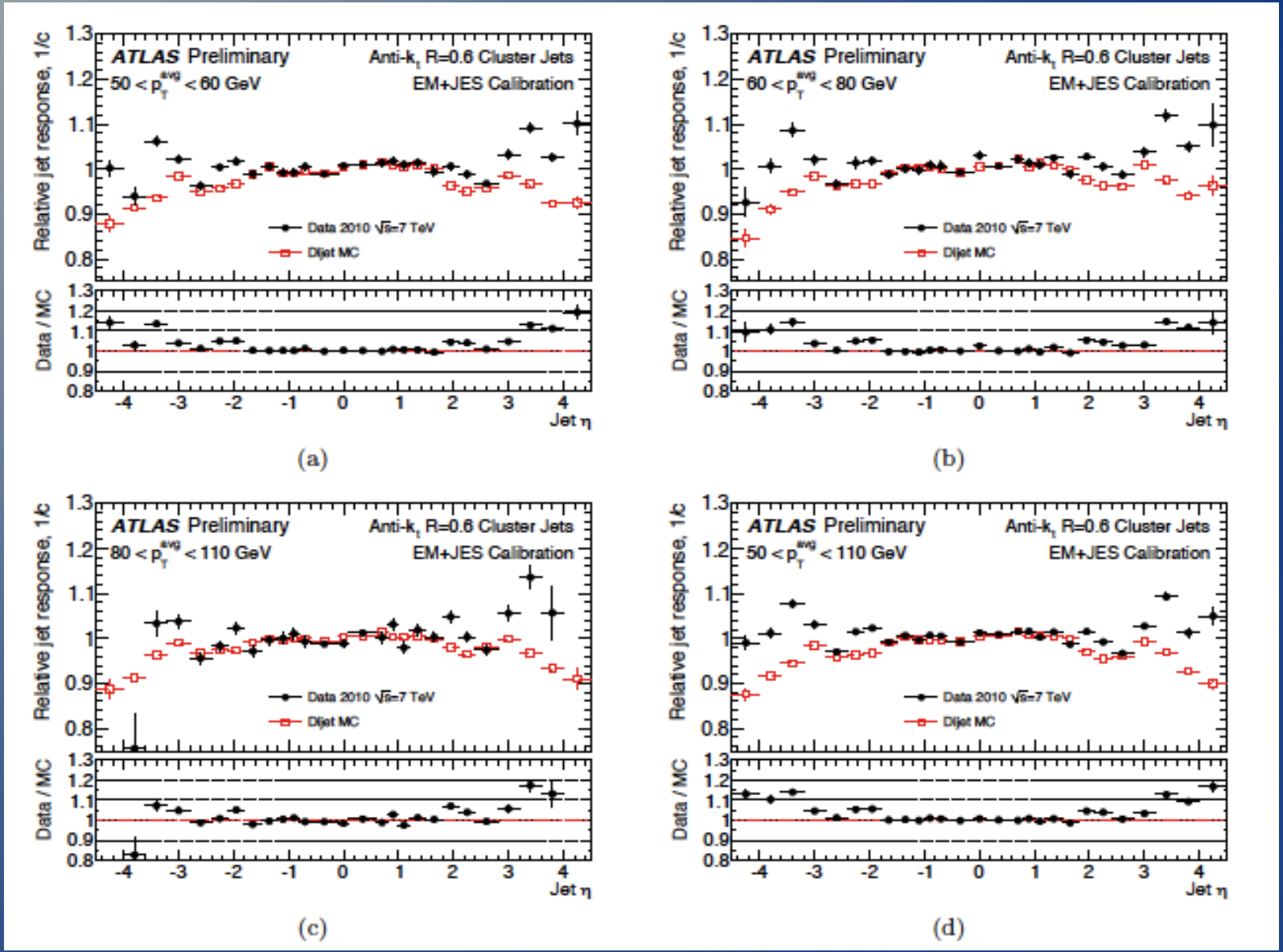
Correction factors depend on jet Pt and eta, and have been cross-checked with test-beam data, single-particle response and track jets. Also cross-checked with limited statistics using γ-jet and dijet balancing. A proper calibration accounting for the energy deposited in each calorimeter layer is underway.

Jes uncertainty



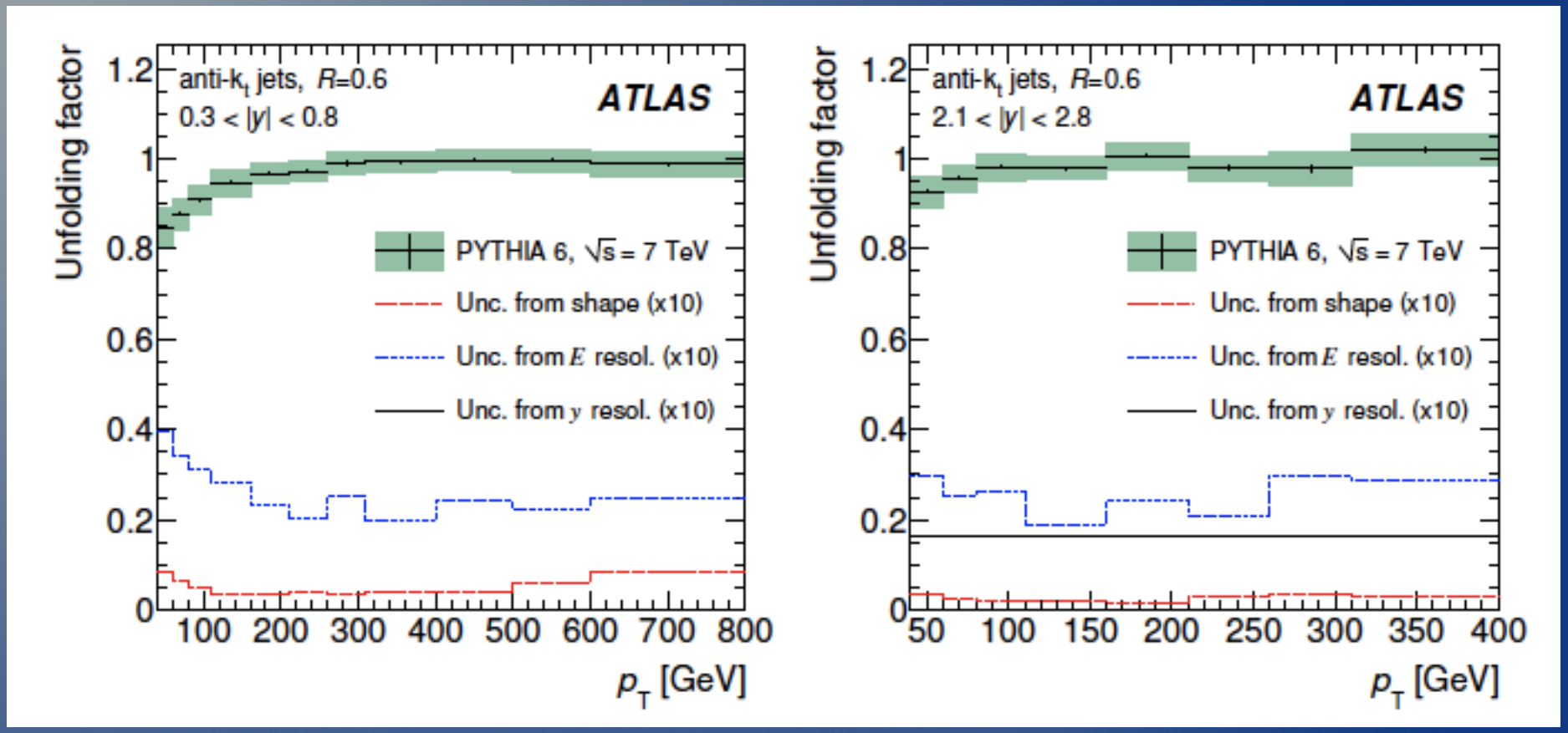
Largest source of systematics for any steeply-falling distribution, and a lot of effort to reduce it.
Already a factor 2 better than this summer's result
Dominated by statistics of single particle response

Forward JES calibration and (more) uncertainty



Without tracking, the only way to cross-check the JES in the forward region is central-forward jet balance, in the limit of vanishing third jet. Discrepancies O(10%) have been found, going in opposite directions between Pythia and Herwig showering. Additional systemetic uncertainties applied.

Correction for detector effects



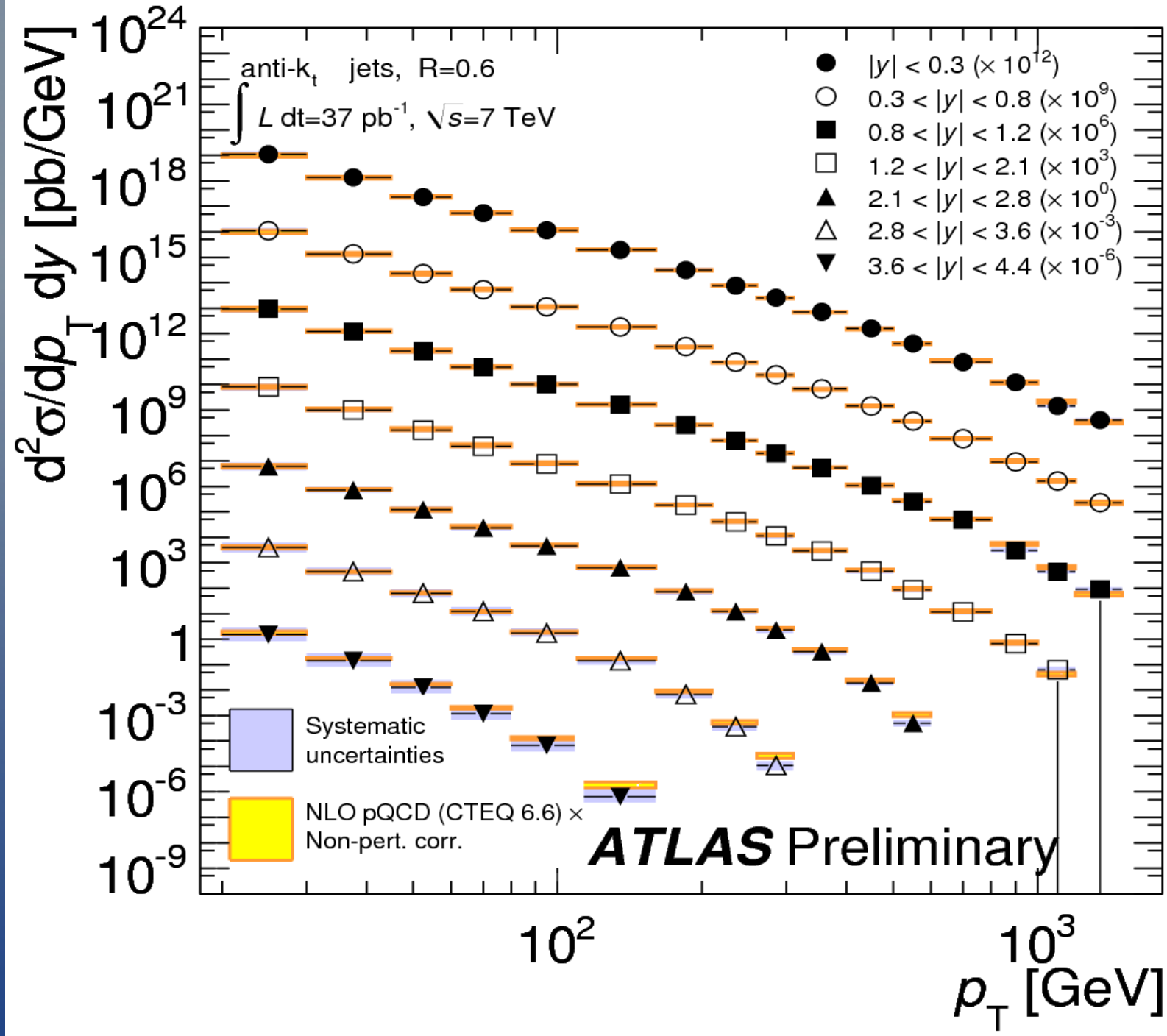
Results corrected for detector effects to be directly comparable with theory. Many techniques tested, so far still using bin-by-bin unfolding: in each distribution data is corrected by hadron/reconstruction level ratio in MC

A word on theory

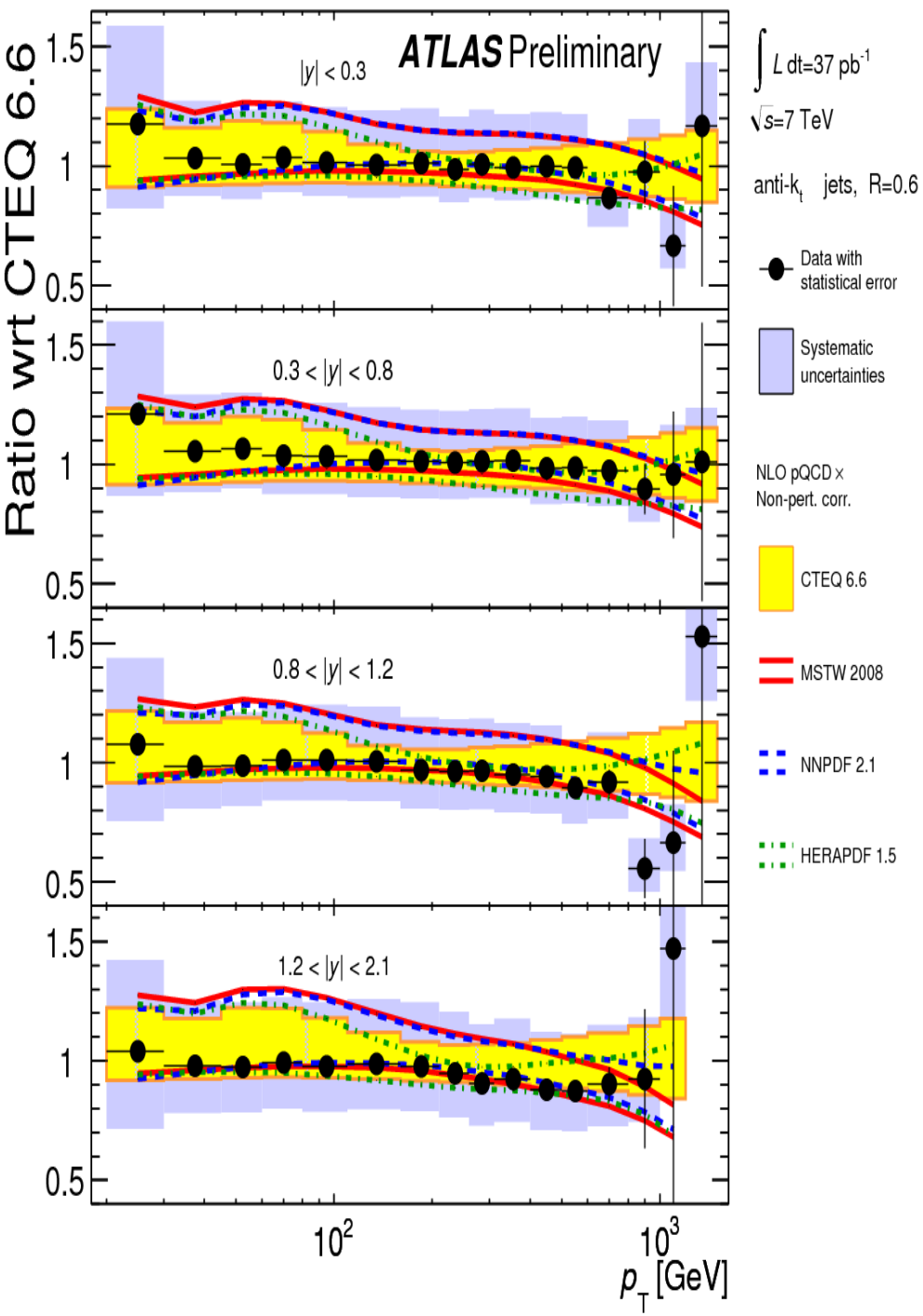
Jet production is the most common process at the LHC, and leads to an enormous number of diagrams at higher orders.

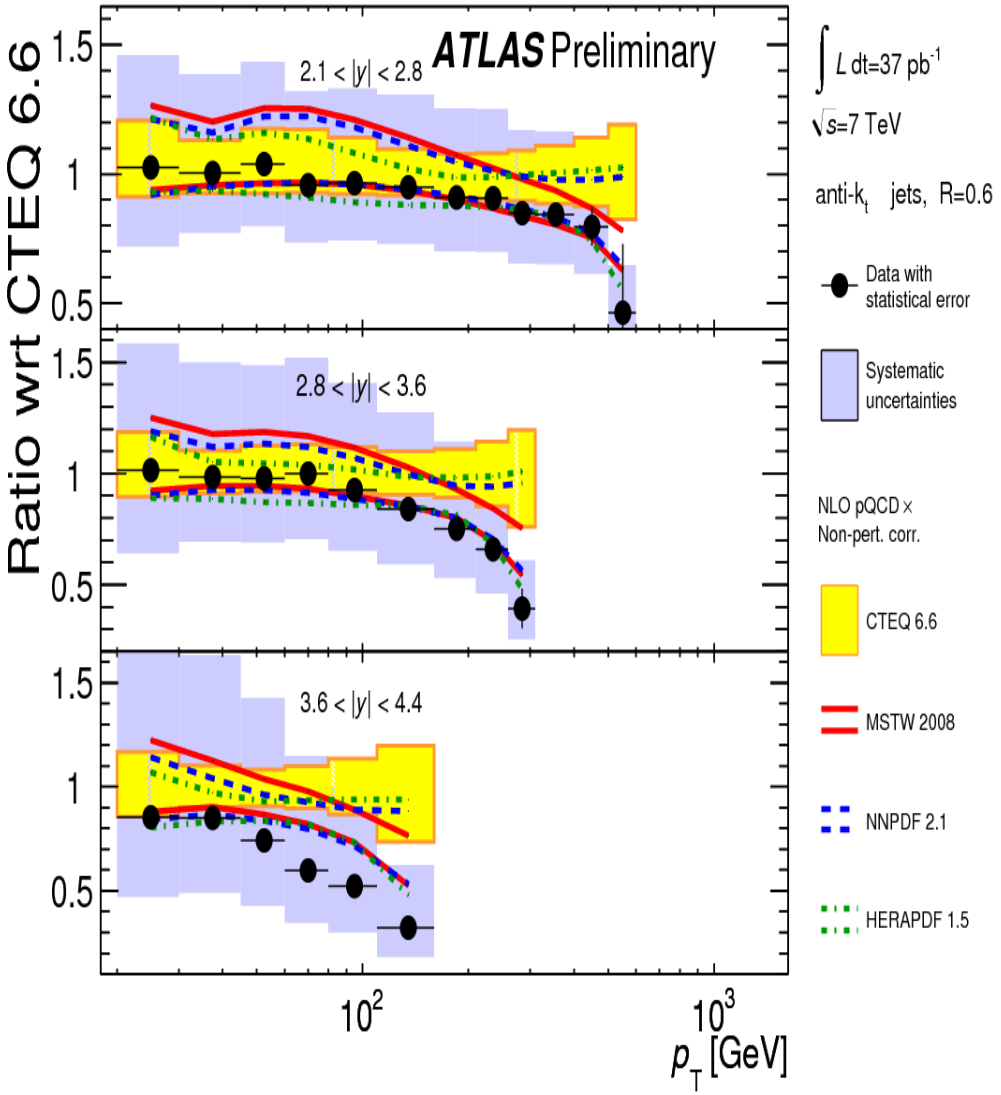
- LO generators like Pythia and Herwig have 2->2 process at matrix element, plus some leading logs terms to match with parton shower.
- A full NLO calculation for 2->2 and 2->3 parton processes available with NLO++, but no matching with PS. Partons are however clustered into jets, then soft corrections coming from unfolding
- ALPGEN contains 2->n LO matrix elements, so it should be well-suited for multiple final states
- POWHEG box now includes 2 parton final states at NLO, with matching to both Pythia and Herwig PS.
- HEJ is a new fully-resummed MonteCarlo for wide-angle emission of similar momentum partons. Recently interfaced to ARIADNE + Pythia, just used at parton level here

Inclusive jet cross section for antikt 06 jets after detector unfolding. Pt range from 60 to 1200 GeV, rapidity < 4.4

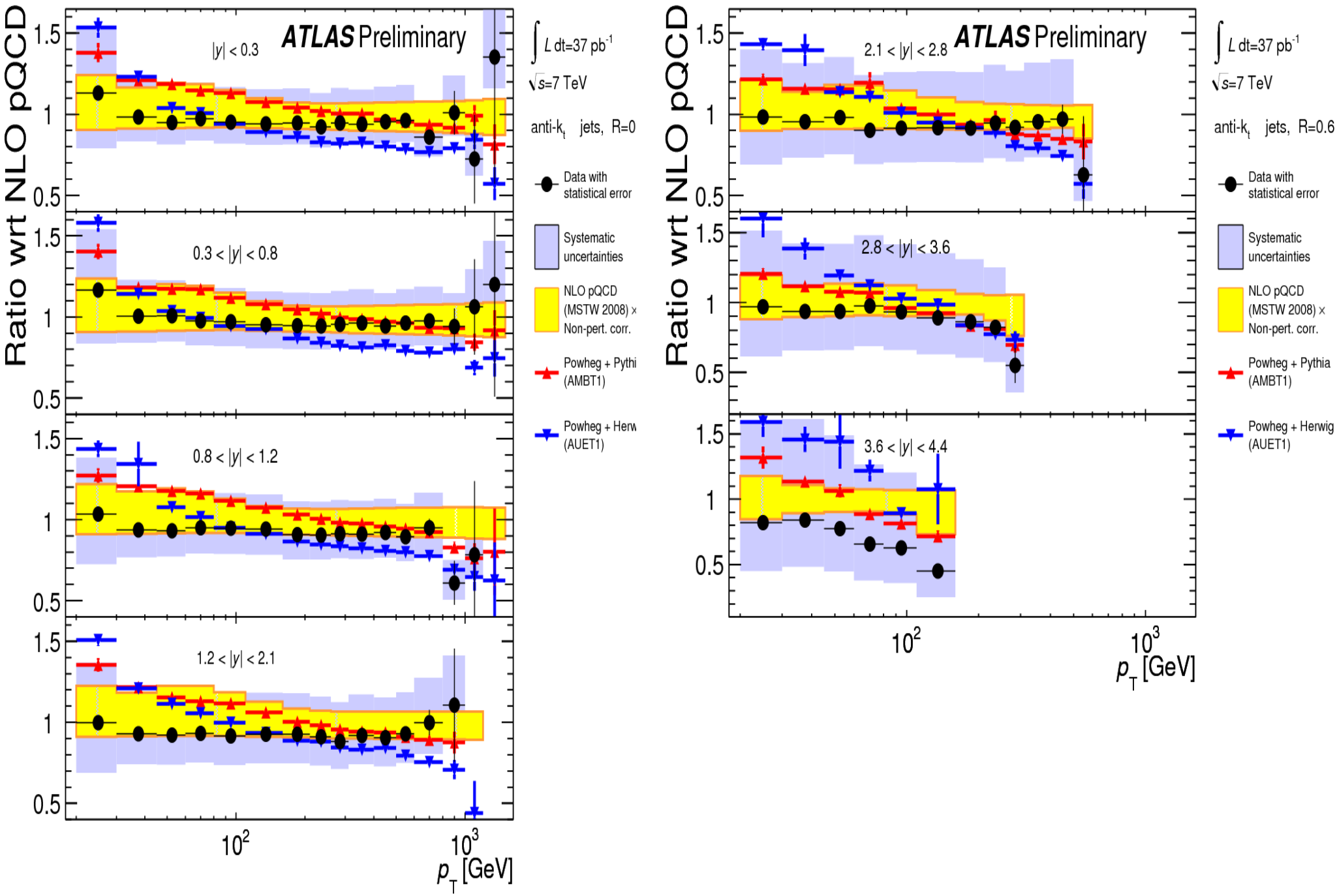


Ratios with theory (various Pdf sets)



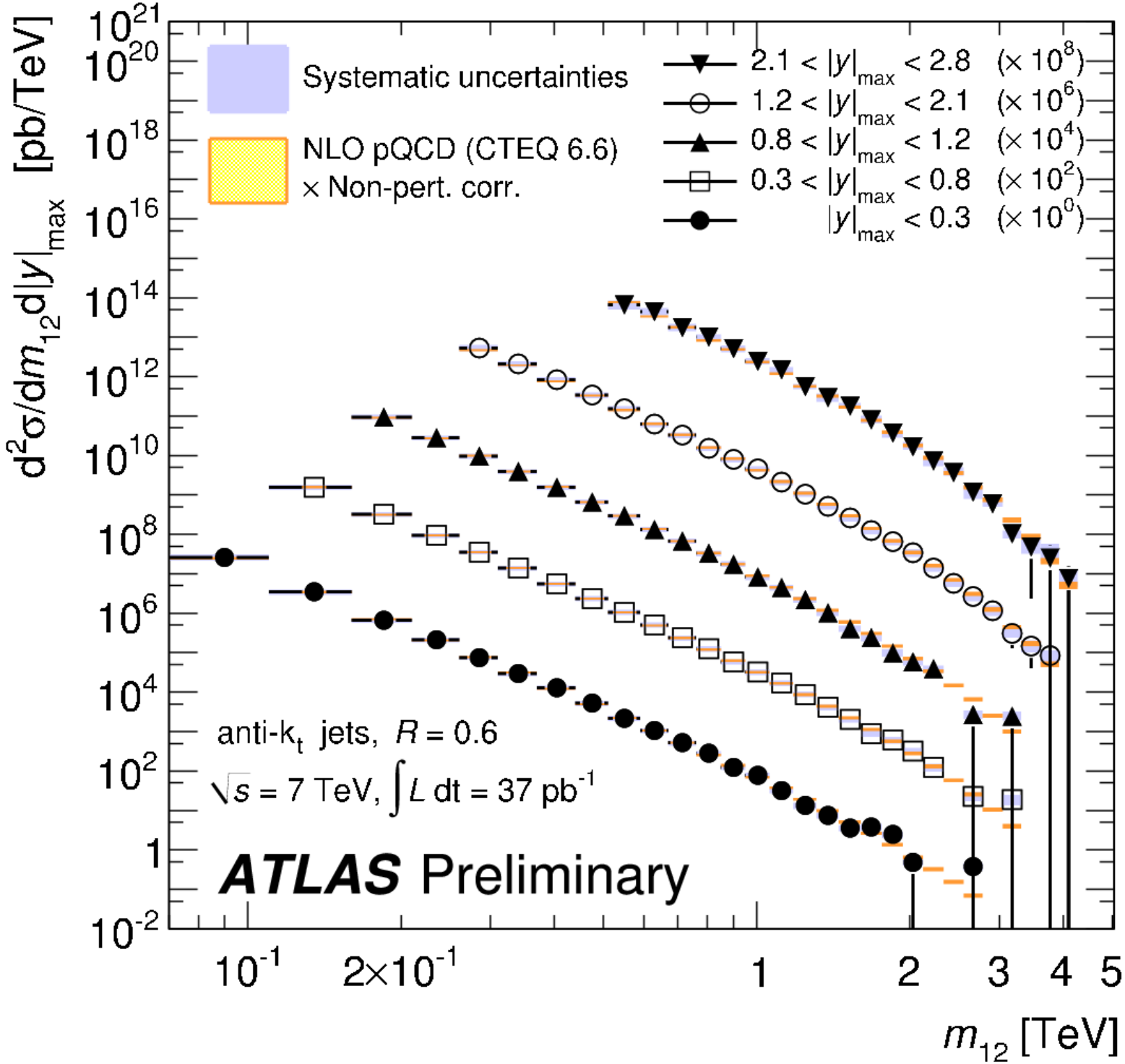


Ratios with Powheg (with different showers)



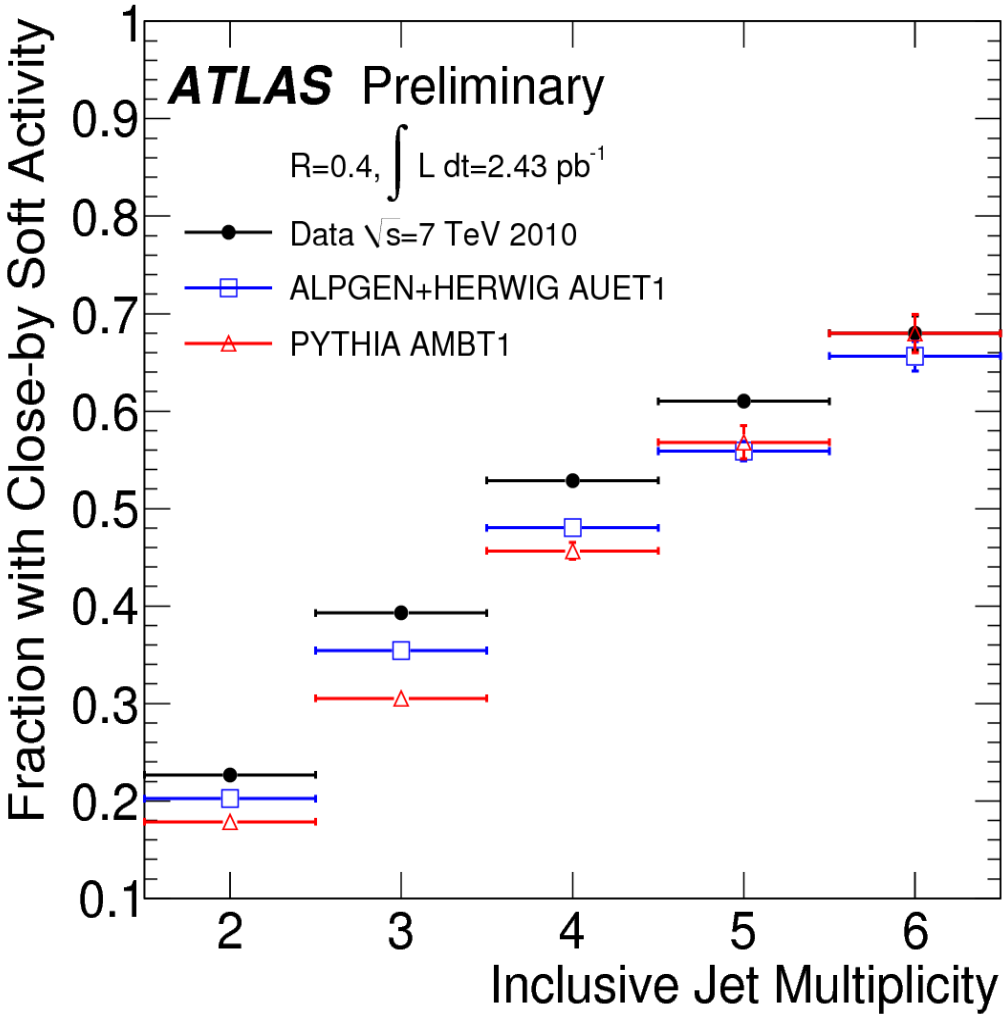
Dijet invariant mass

largest masses ~ 4 TeV, forward extension still under way



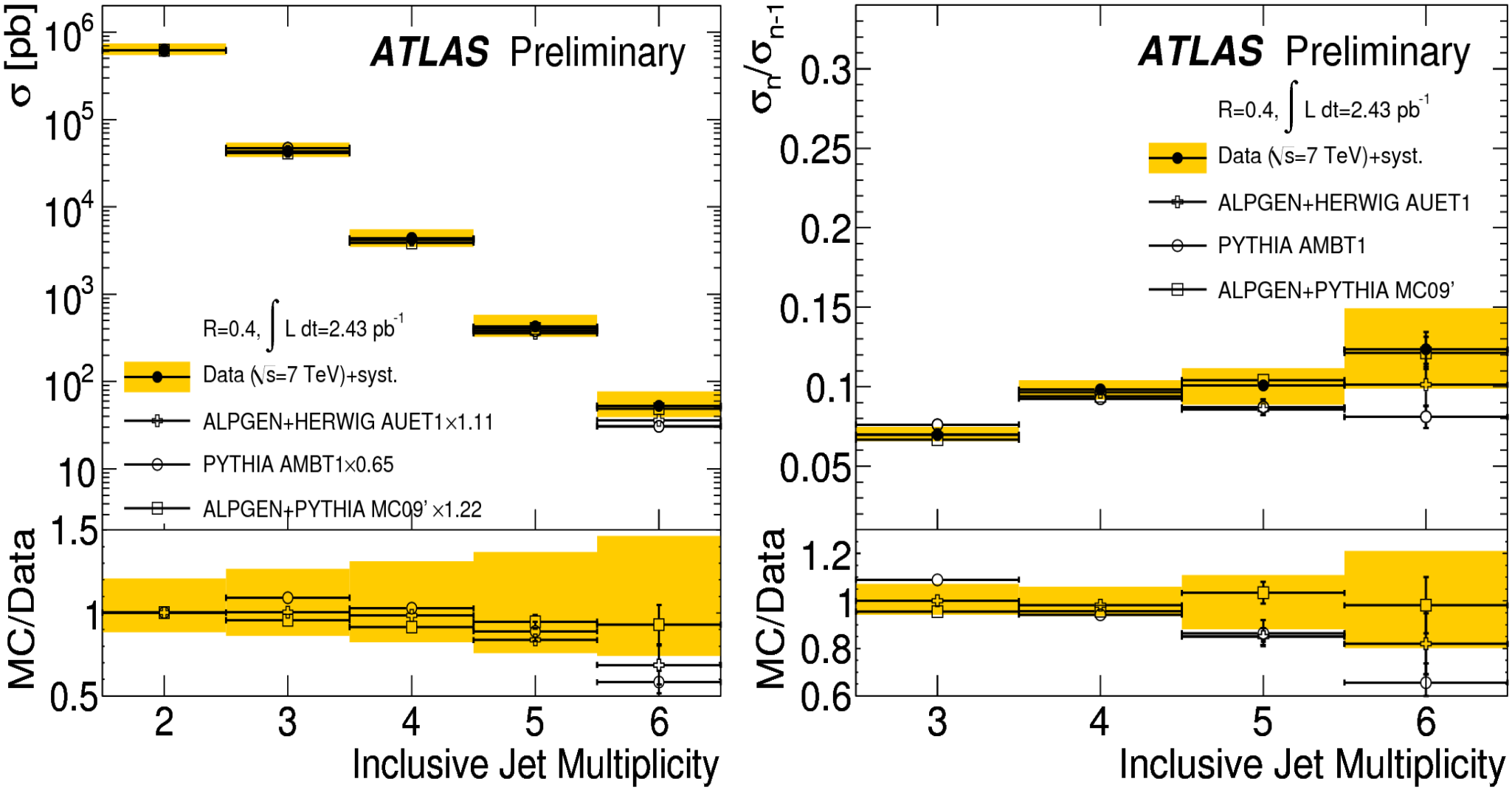
Multi-jet production

Not a trivial extension of the inclusive/dijet analysis: main systematics is migration between jet multiplicities, that depends on jet resolution and split-merging between nearby jets.



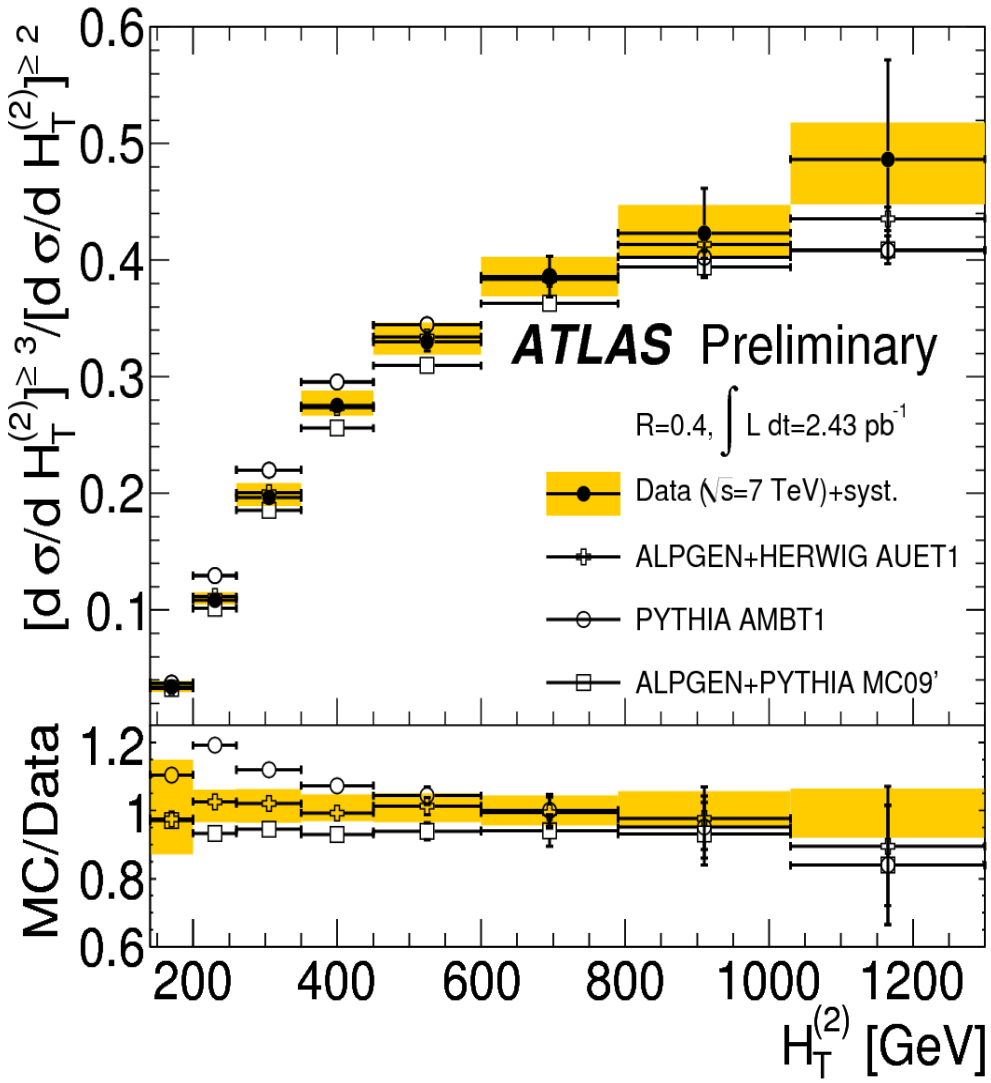
The fraction of events with another selected jet within 1.5 is better described by Alpgen; however, the full difference in bin migration is taken as systematic error

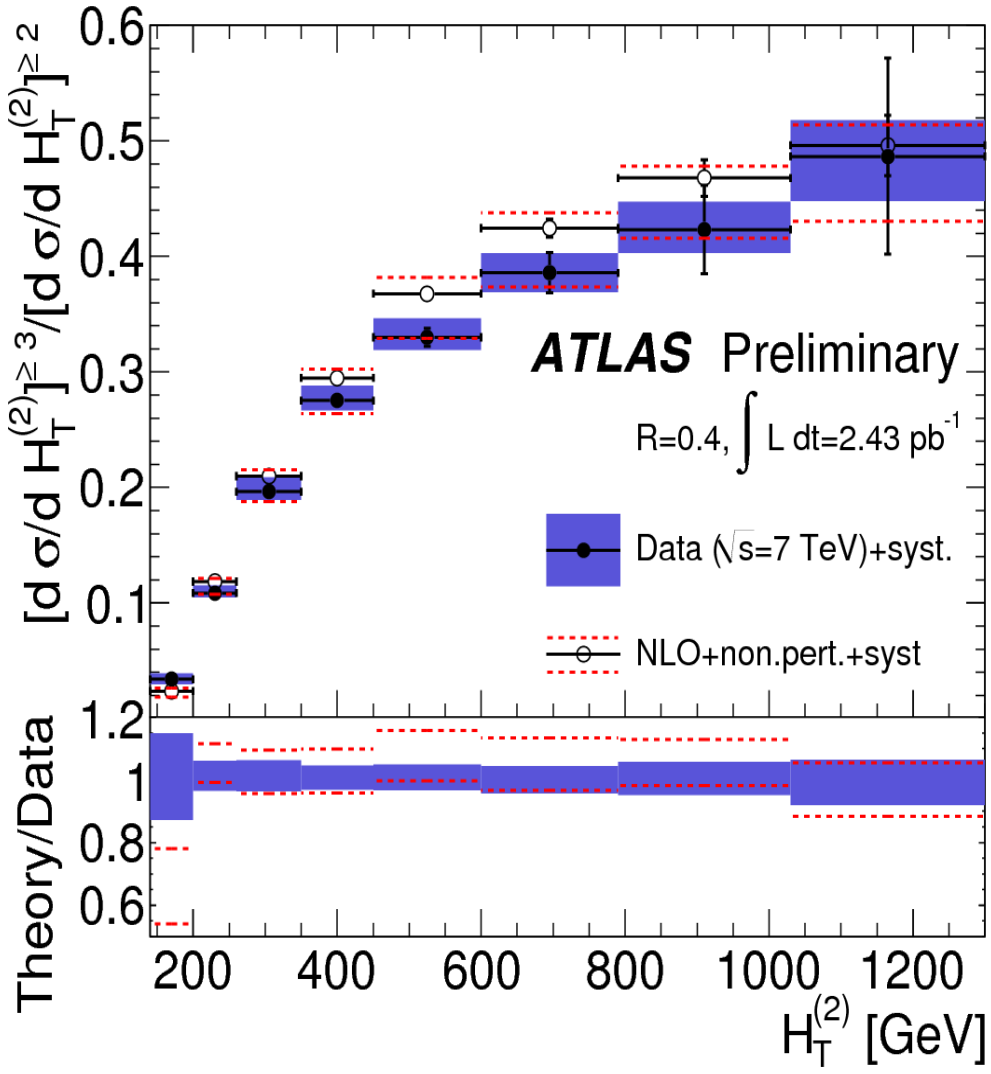
Cross sections and ratios (Berends scaling)



Data tend to agree better with Alpgen + Pythia, even if the large systematics due to the merging deserves better investigation

2- to 3- jet fraction vs HT

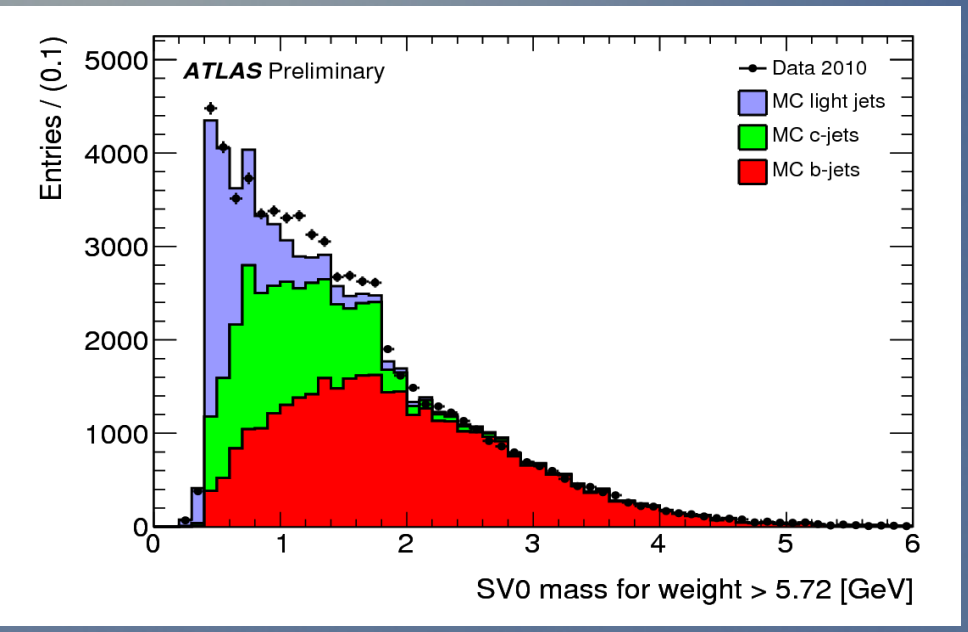


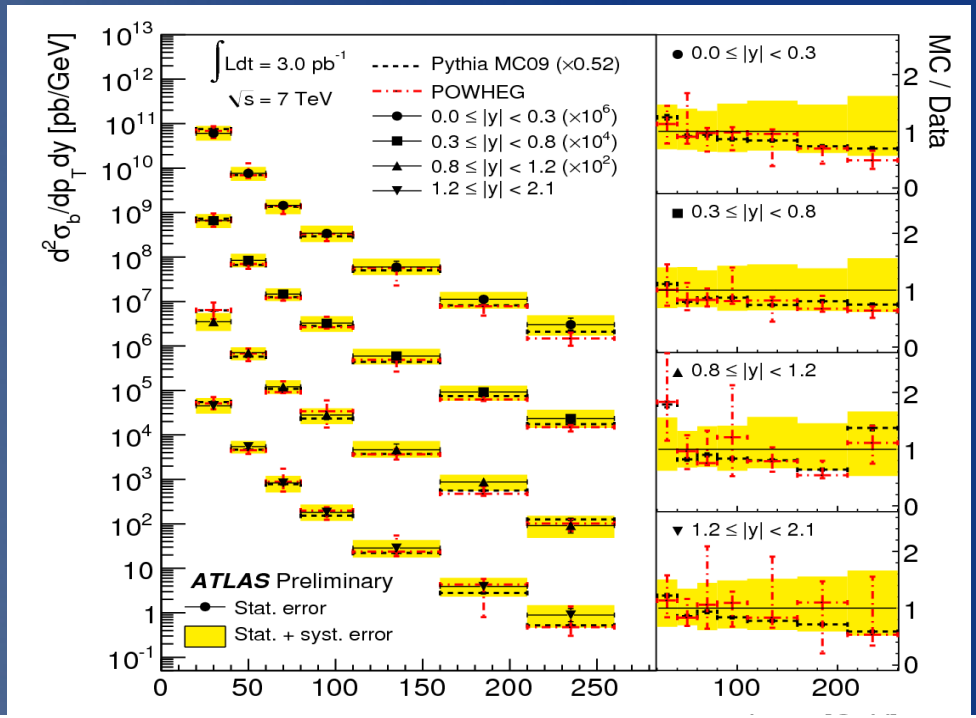


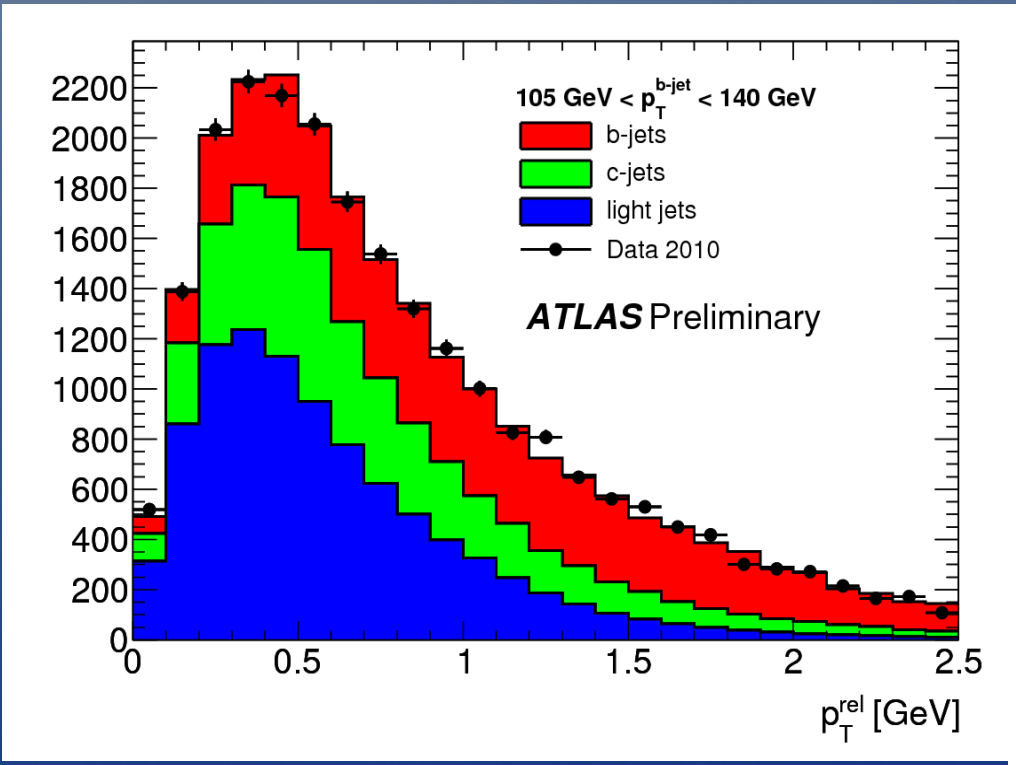
Largest discrepancy observed in the 2/3 jet ratio, so the distribution was looked at as a function of HT

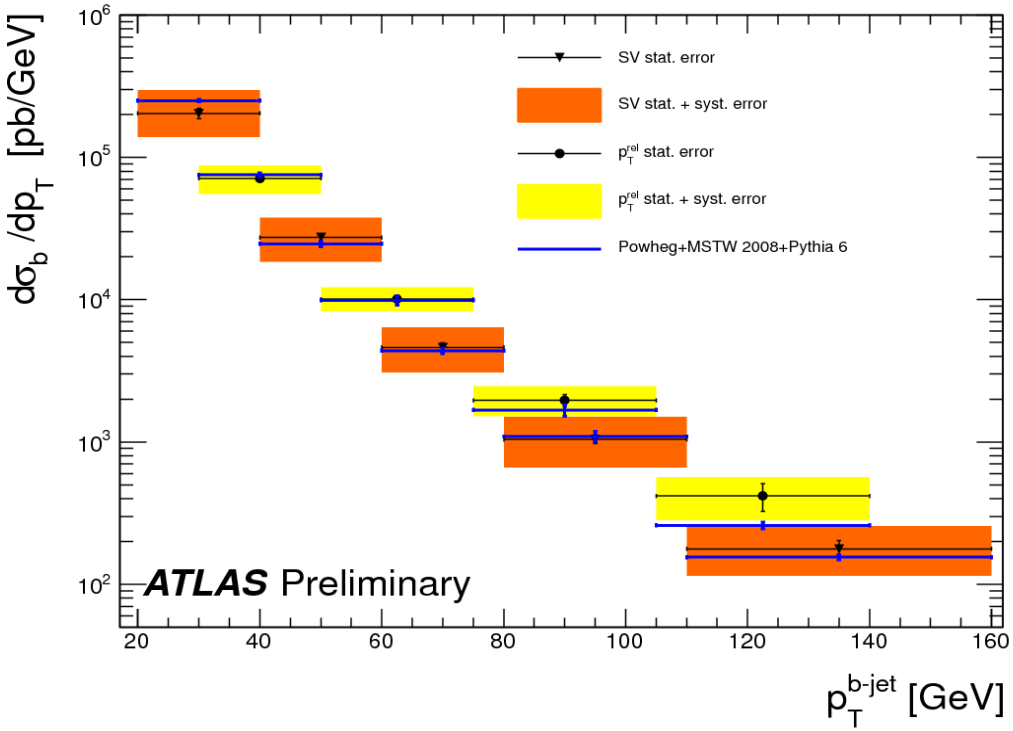
As expected, dominated by the low-energy region

B-jets from secondary vertexes and muons



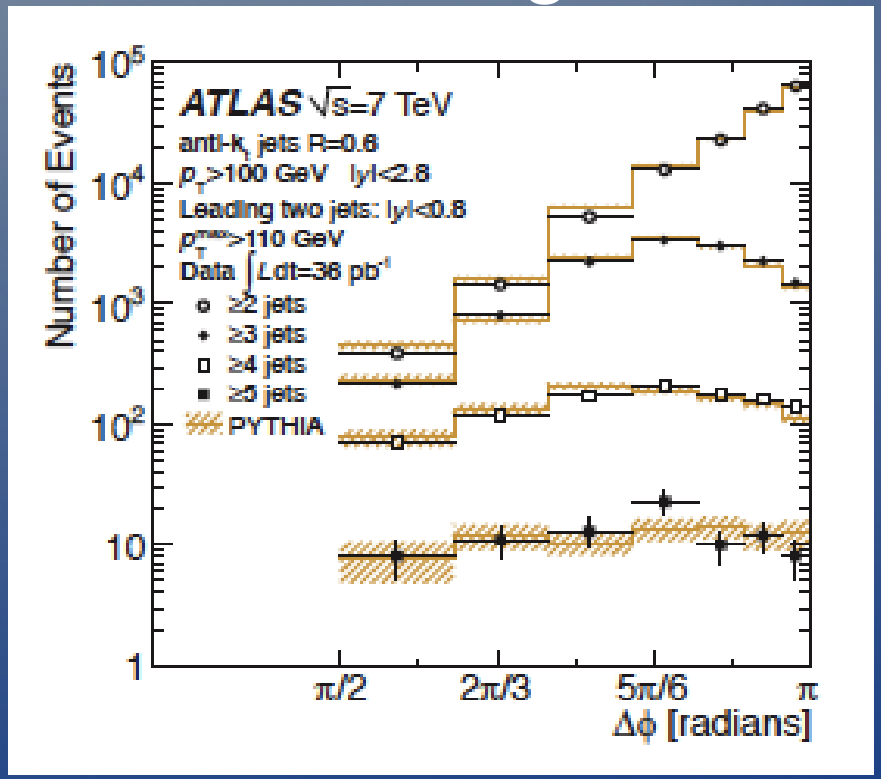


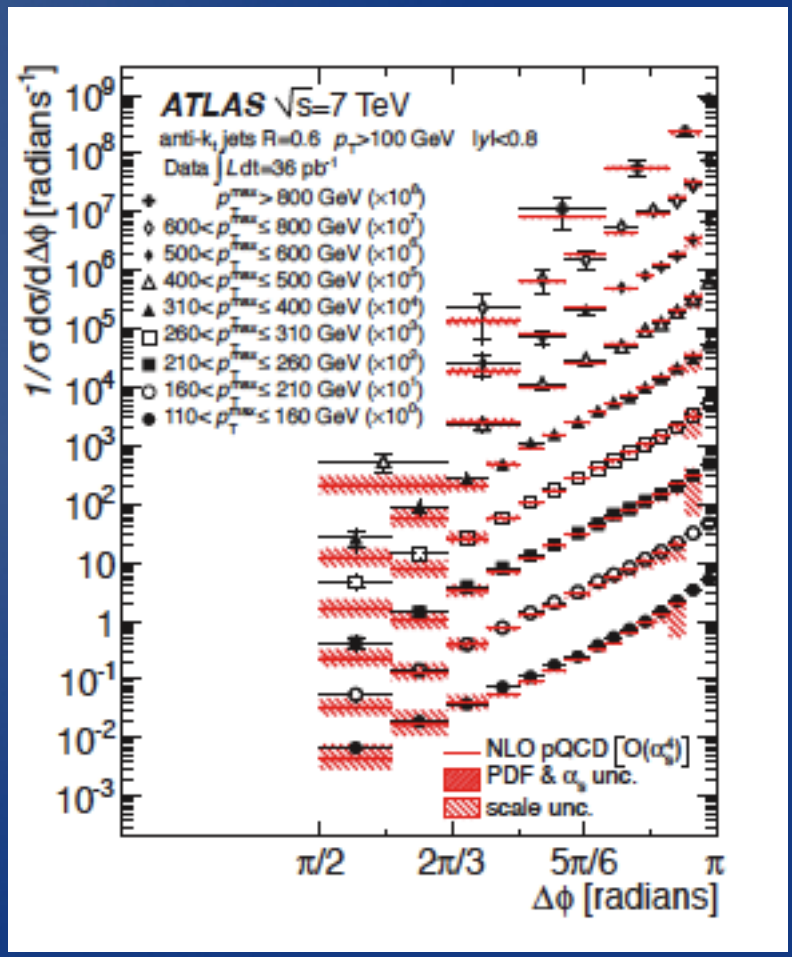




An indirect way to look at high orders: azimuthal de-correlation

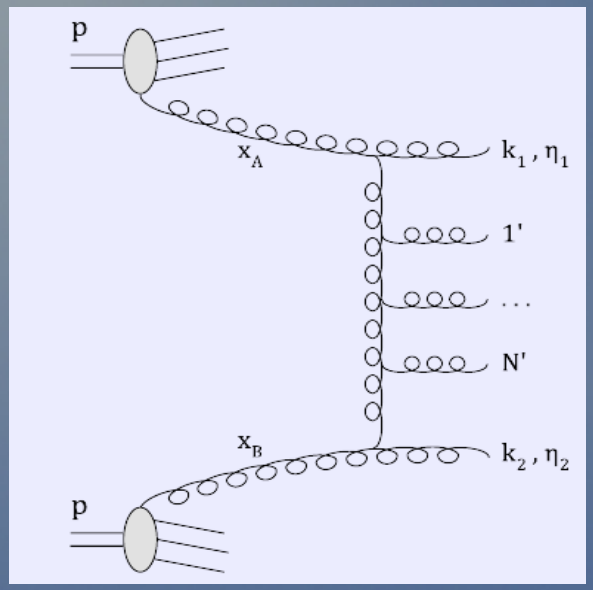
Pure dijet final states have to be back-to-back because of momentum conservation. Any deviation from that is an indication of higher-order terms

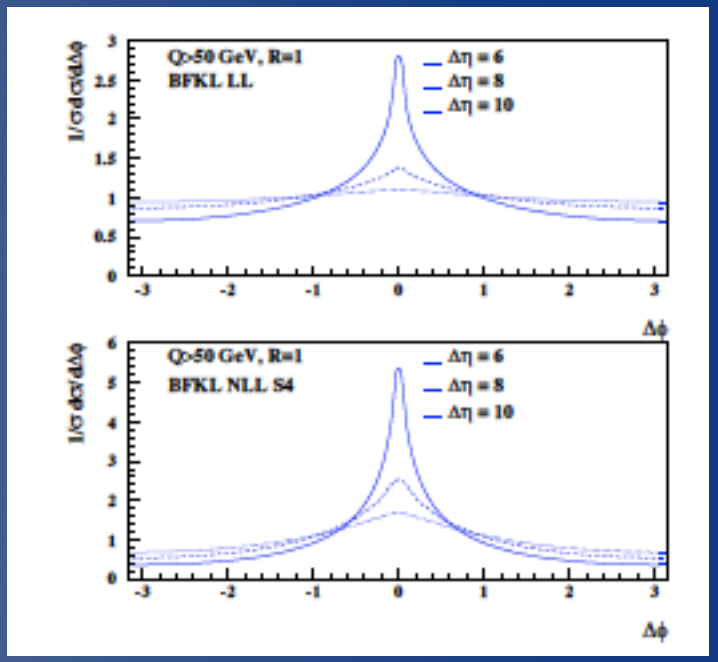


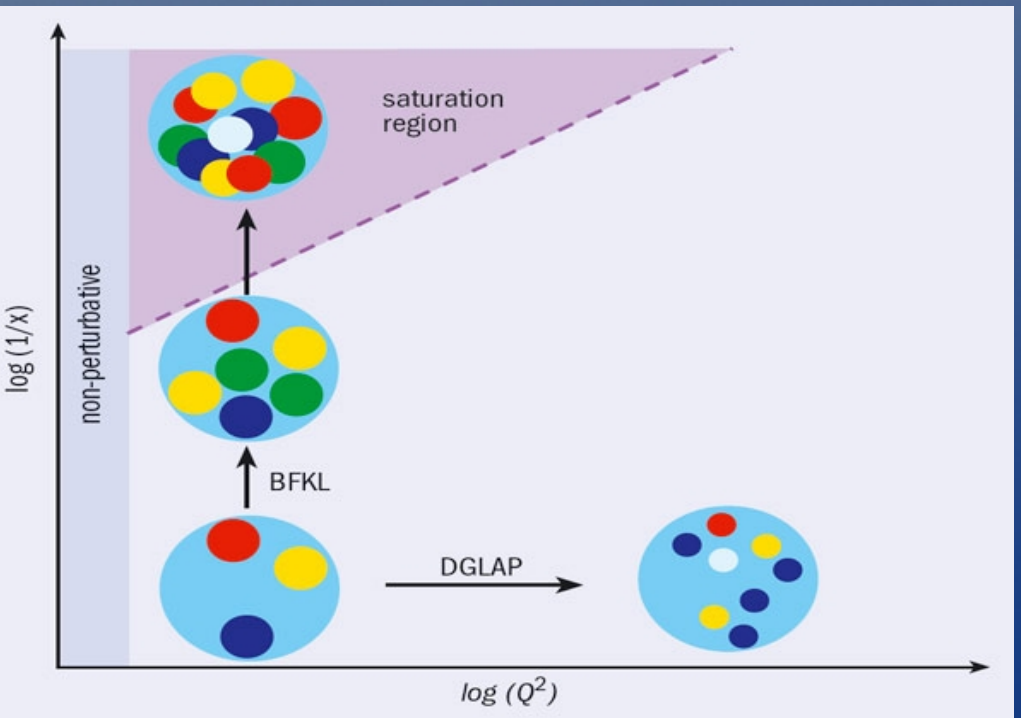


Comparison made with Pythia and NLO++
Only in central region

Mueller-Navelet jets and BFKL evolution







Forward-backward jets emit central minijets from gluon ladders, that will lead to extreme de-correlation at large Δη. Low-x behaviour should be better described by the BFKL equation (but still has to be demonstrated. Another way to look at all this is explicitly exploring what is in the gap

Measuring the jet veto

Which is the fraction, given two (possibly forward) jets, in which there is not a third jet between them?
This question is very much connected to the azimuthal de-correlation, to the 2/3 ratio, and in general to radiation from/between jets.

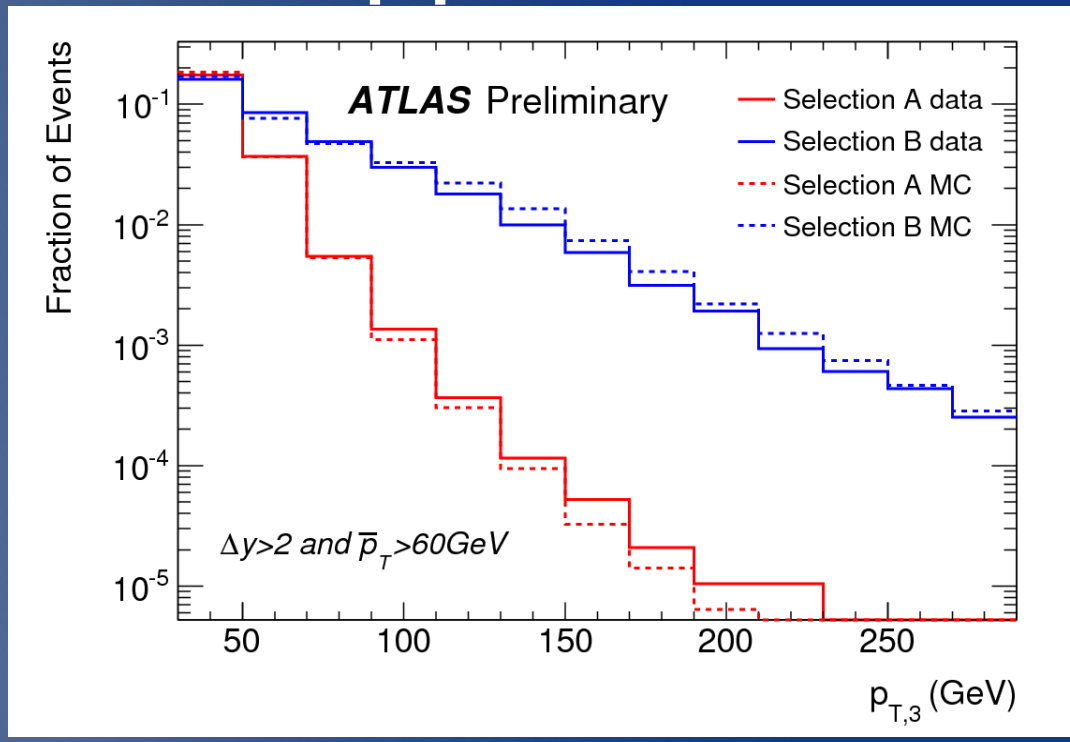
Two approaches to define “boundary jets”:

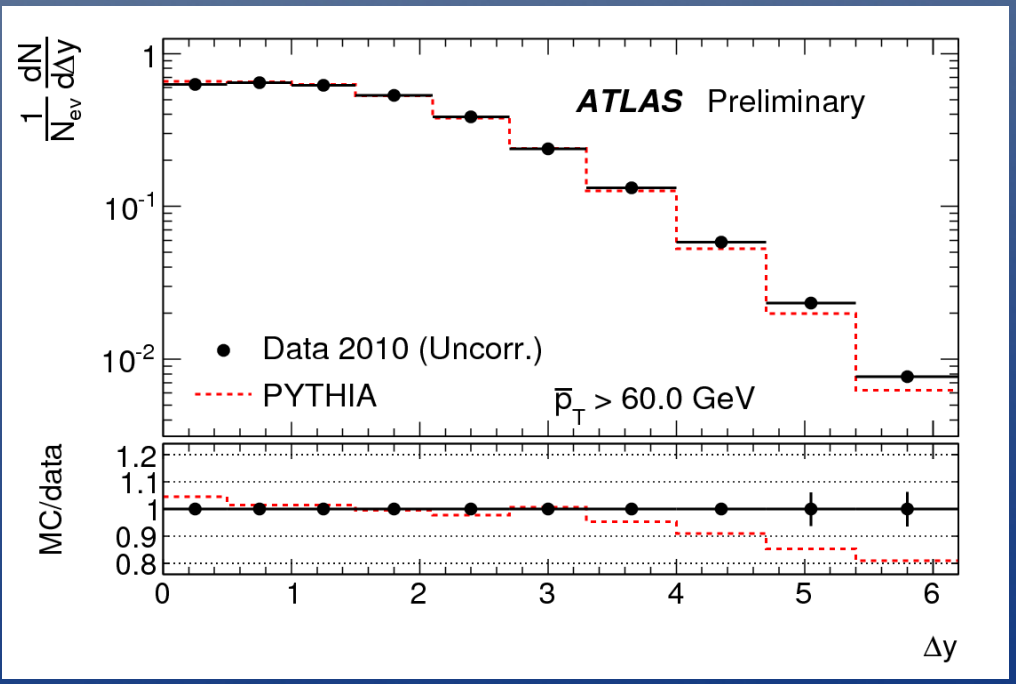
- A: The two leading jets in the event (probes high-Q^2 – DGLAP-like approach)
- B: The most forward and backward jets above a given threshold (gives larger gaps, should probe more BFKL-like dymanics)

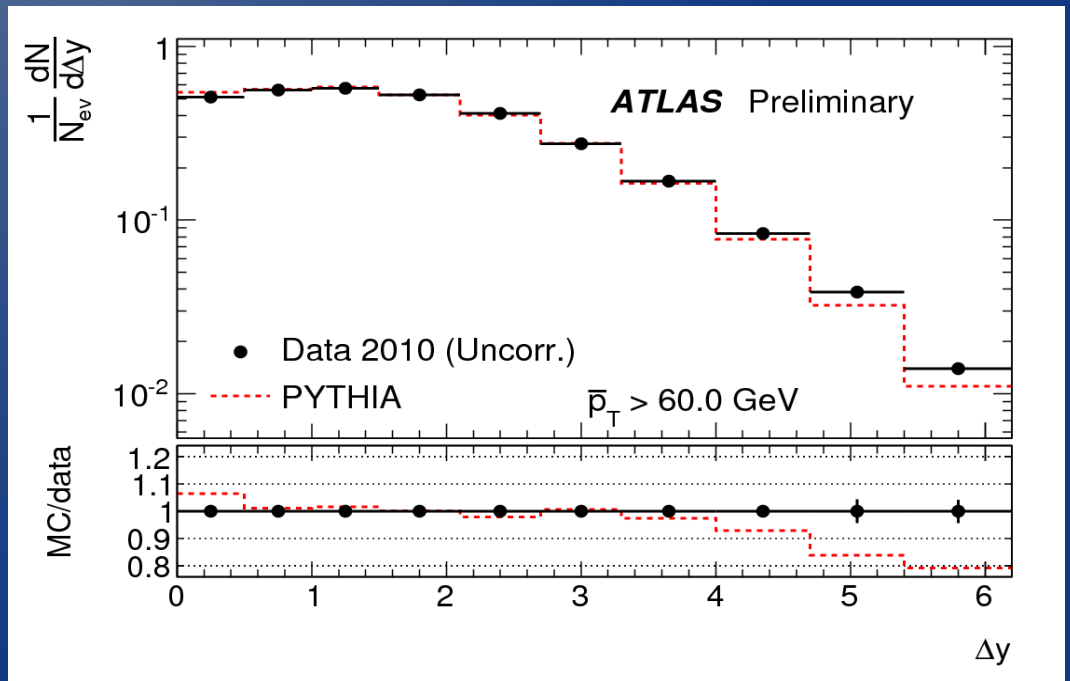
Testing ground for theory and experimental techniques to search for VBF Higgs

Kinematics for the two approaches

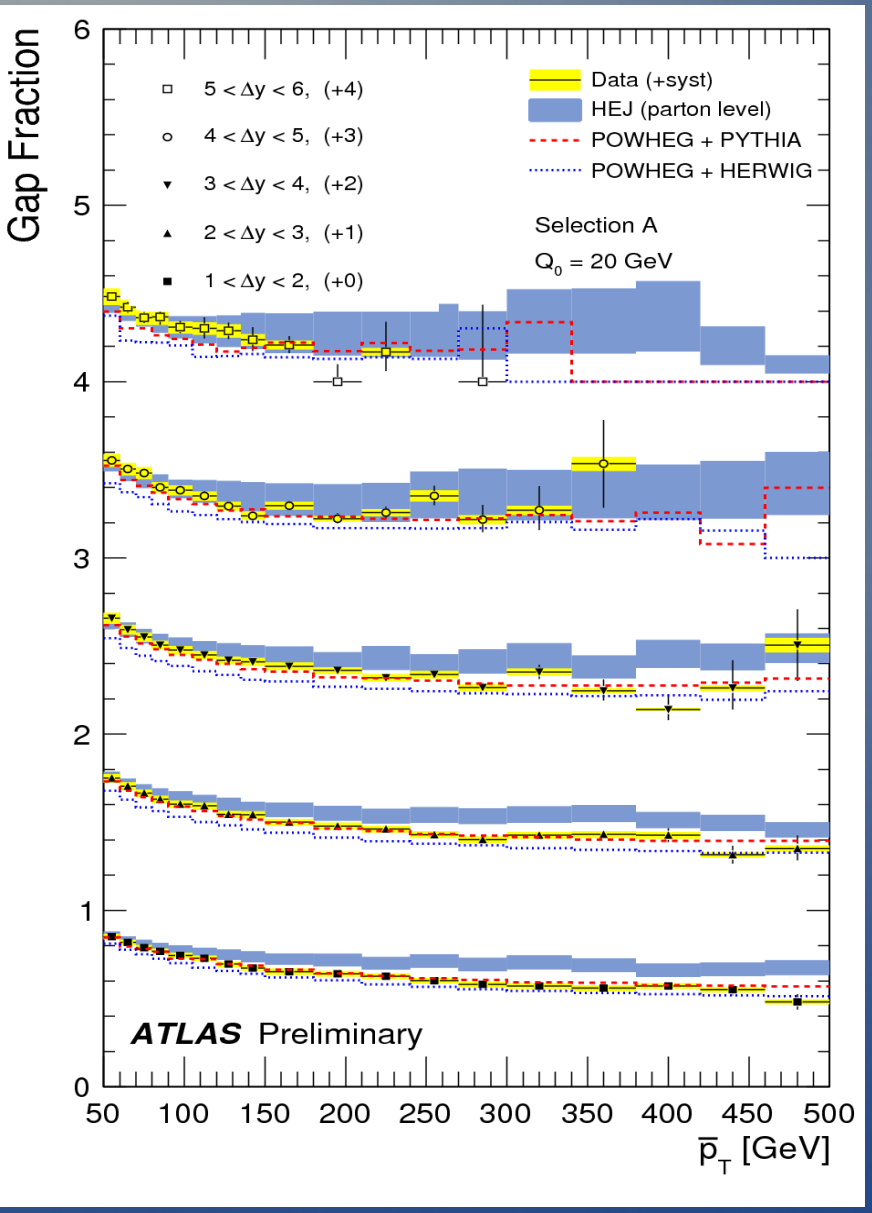
In “selection B”, the veto jet can also be the leading in the event, and is on average much harder than “sel. A”, and delta eta Is larger.
We require average Pt of two jets above 60 GeV, to be selected by inclusive trigger (shame on me)

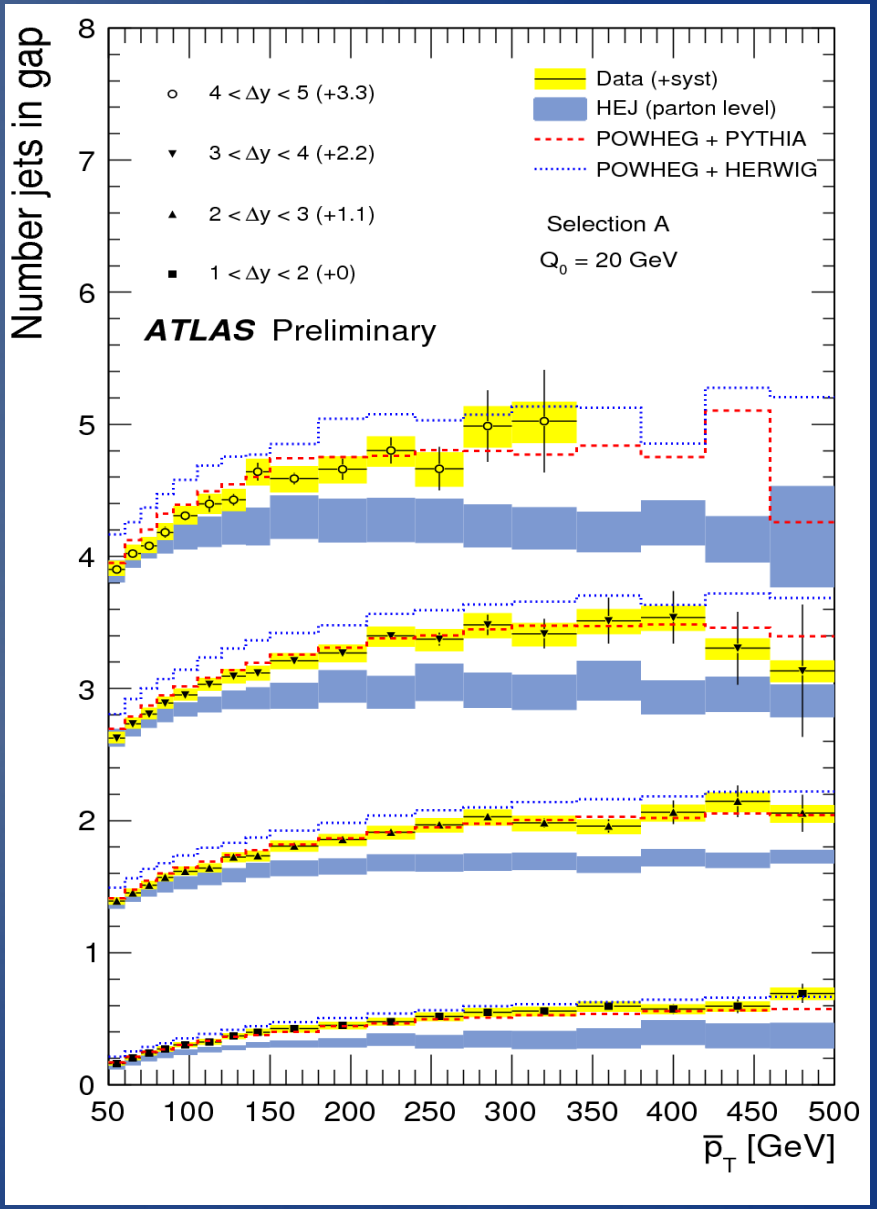






Jet activity vs Pt

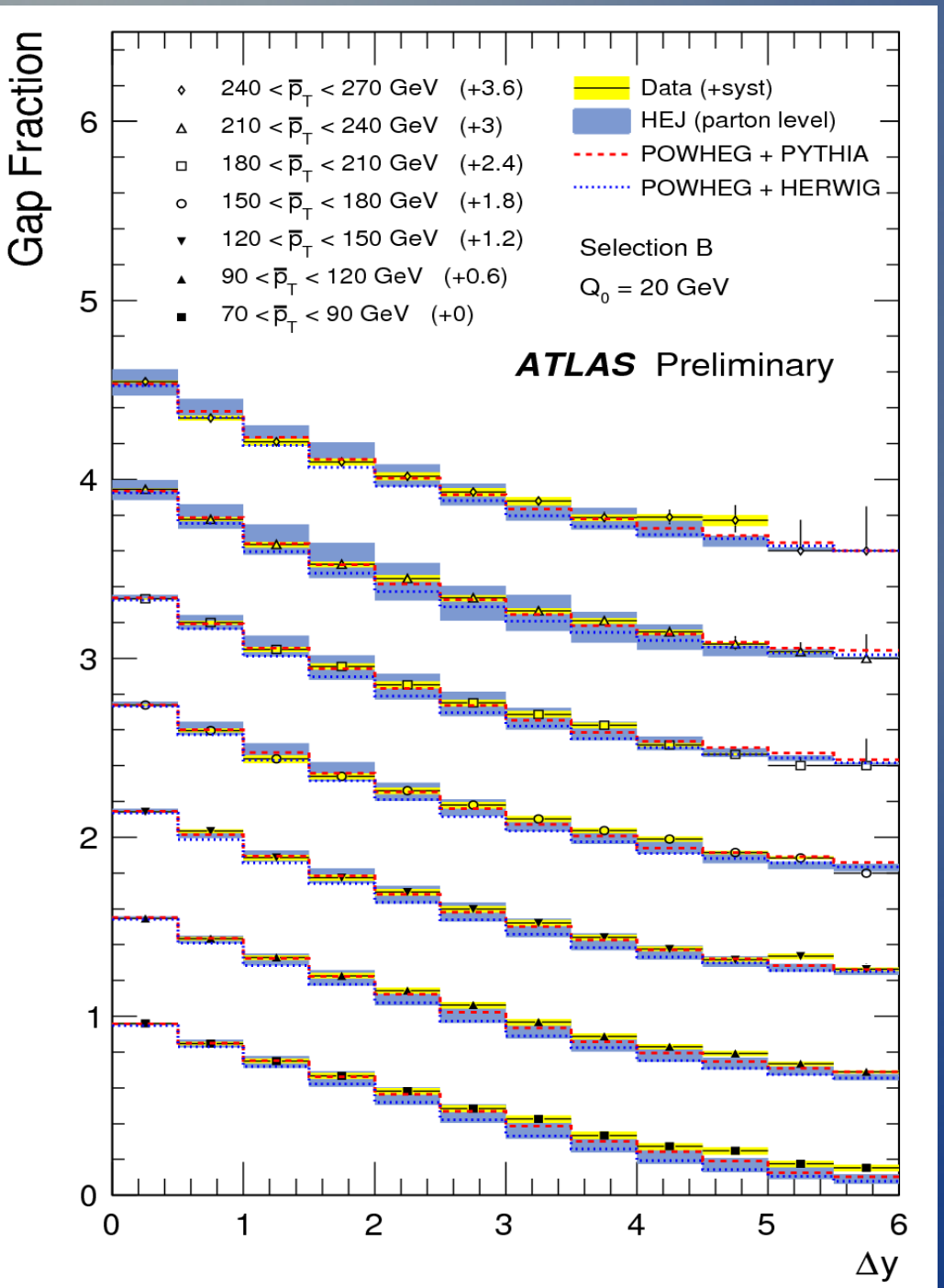


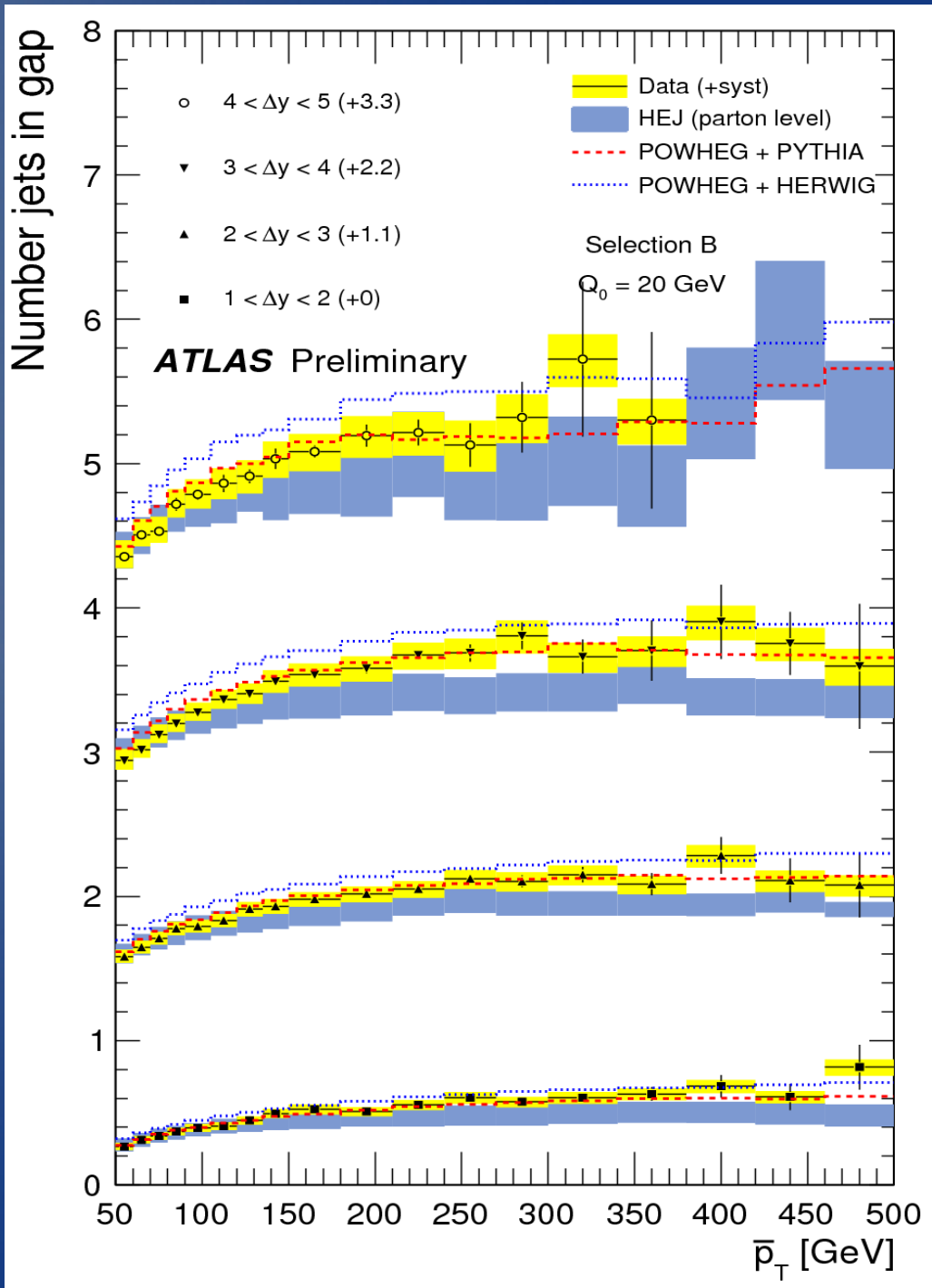


HEJ underestimates activity, especially when pT/Q0 gets large, since it assumes radiation has similar scale

Different predictions for Powheg showers larger than scale variation

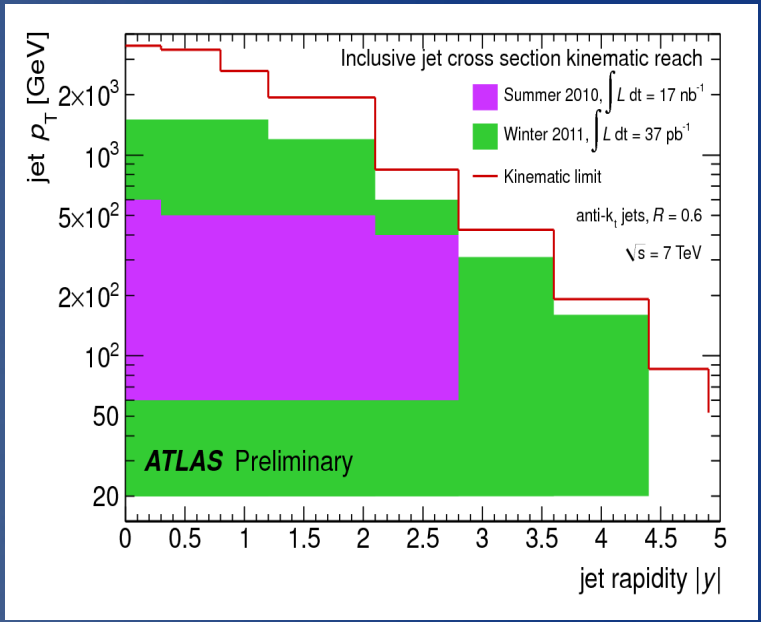
Gap fraction vs rapidity separation





Present/future prospects

Jets are complex objects, especially in the LHC environment ATLAS measured jet production in unprecedented kinematic regime, testing and constraining pQCD



Main physics drives in 2010 to continue for 2011:

- Pdf fits (inclusive and dijet cross sections)
- Global event shapes, multiple gluon emission (multijets)
- Radiation in dijet system (angular decorrelation, jet veto)
- Heavy-flavour jets
- Sub-jet structure

...enjoy the rest of the conference about the last point!