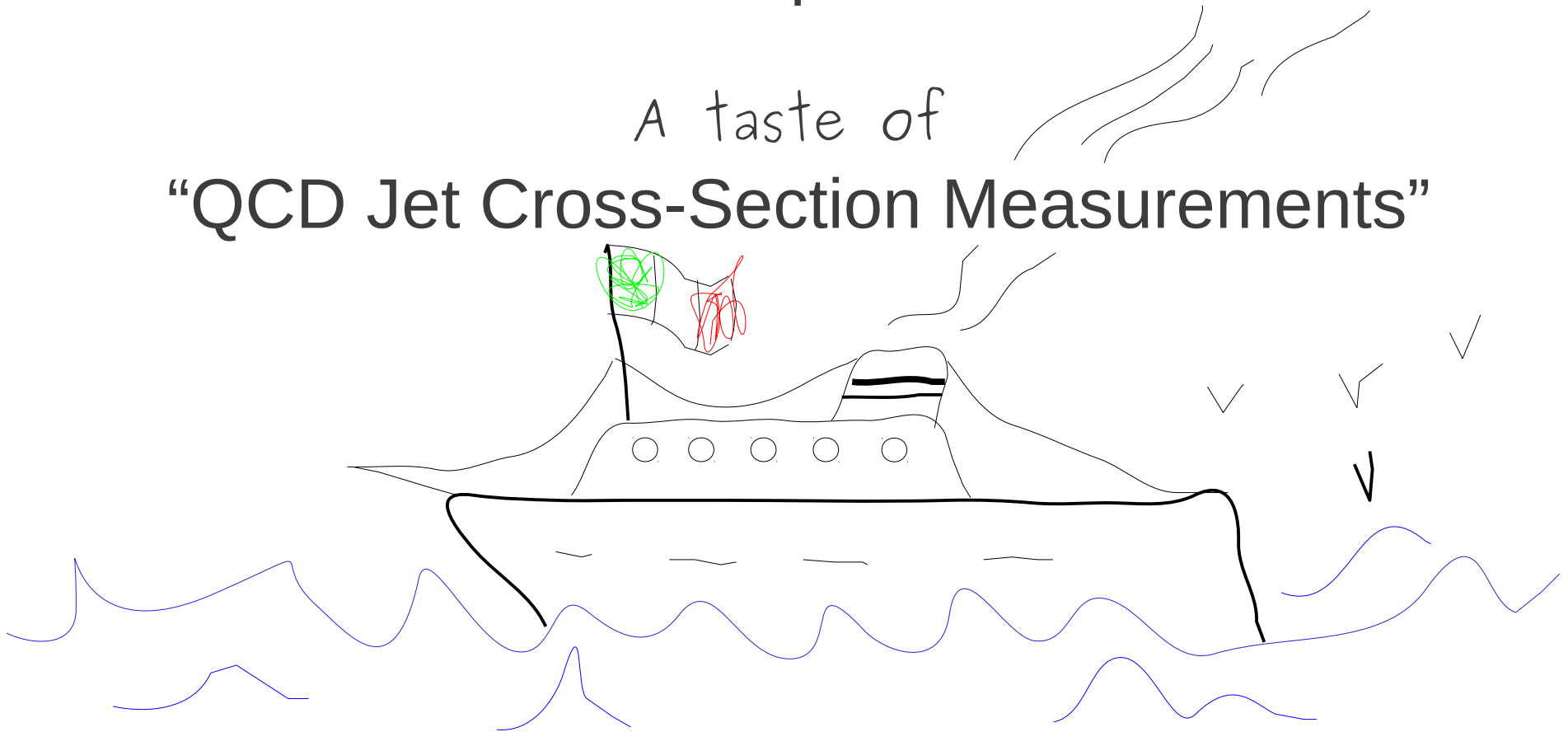


V ATLAS-Italia Physics Workshop ^{link}

Napoli

A taste of

“QCD Jet Cross-Section Measurements”



Zinonas Zinonos

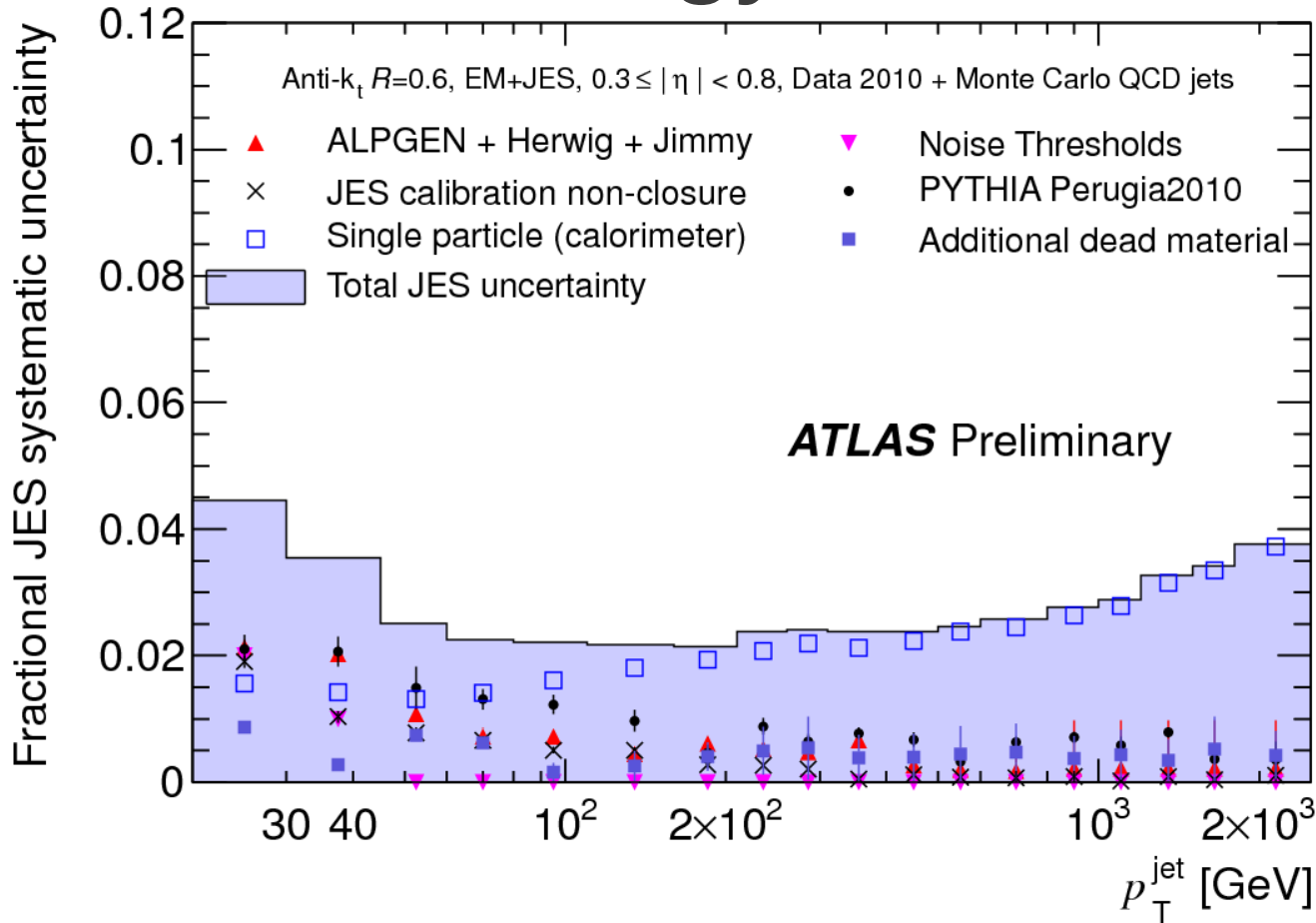
on behalf of the ATLAS Pisa Group

Overview

- * QCD jet production is the dominant high p_T process in pp collisions at LHC
- * ATLAS has successfully recorded and analyzed millions of such events at the highest energy regime ever achieved in laboratory
- * Jet performance and physics measurements are now in a very good shape and well reported in physics journals
- * The ATLAS Pisa group is strongly involved in these exciting QCD jet studies

Jet Energy Scale Uncertainty

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CONF note [link](#)

Central $\eta = [0.3, 0.8]$:

- JES < 2.5% ,
pT = [60, 800] GeV

- JES < 4.6 %
pT > 20GeV

Endcap ($0.8 < |\eta| < 2.8$),
Forward ($2.8 < |\eta| < 4.5$):

- JES < 4%, 6%
pT > 50 GeV

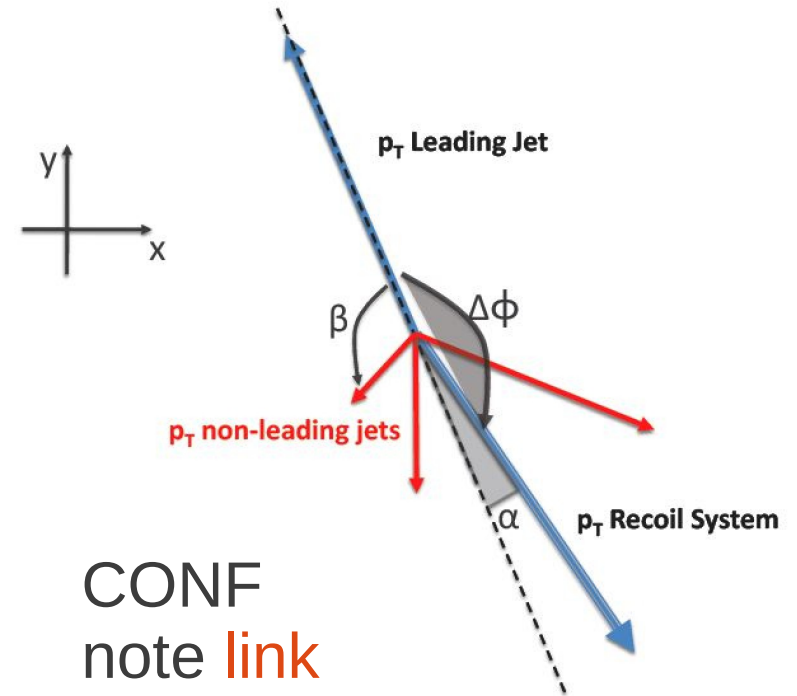
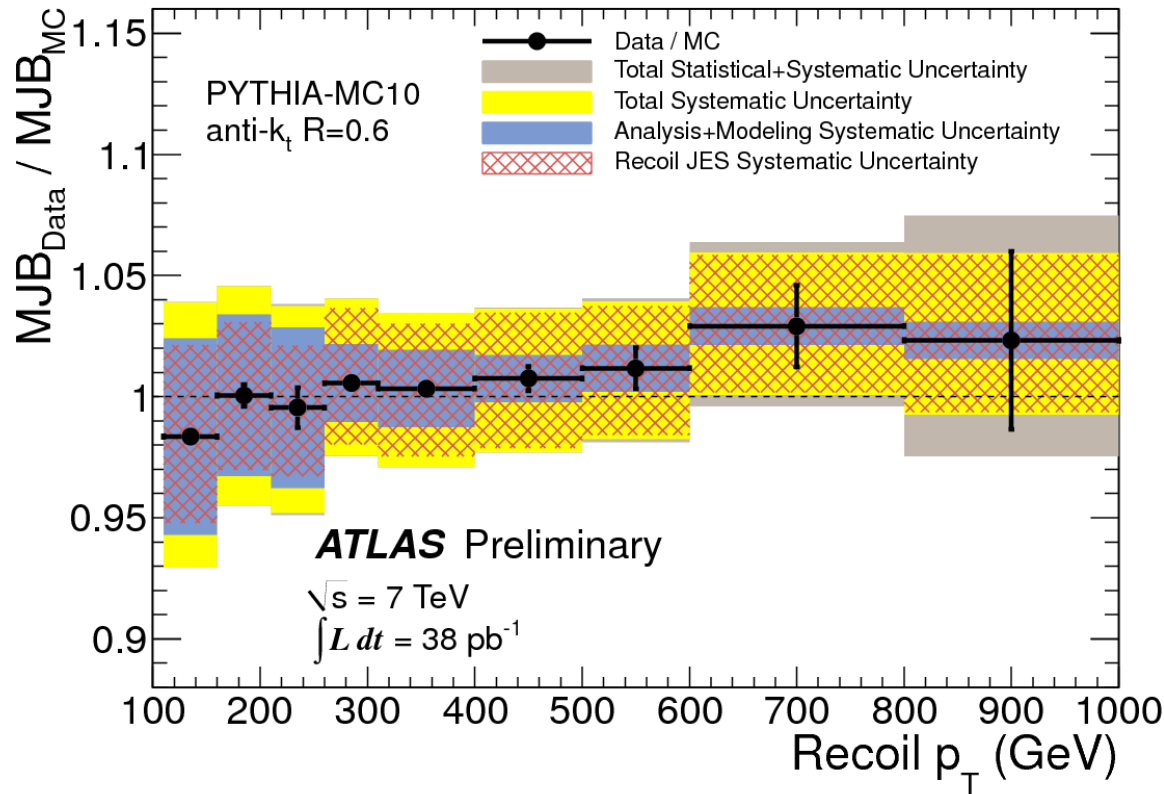
***Estimation:** Using a combination of in-situ techniques

- pT di-jet balance method [link](#)
- precise in-situ measurements of the calorimeter response to isolated single hadrons [link](#)
- extraction of the absolute electromagnetic energy scale of the calorimeters from the $Z \rightarrow ee$ analysis [link](#)

***Validation:** Using a multi-jet balance technique (MJB) [link](#)

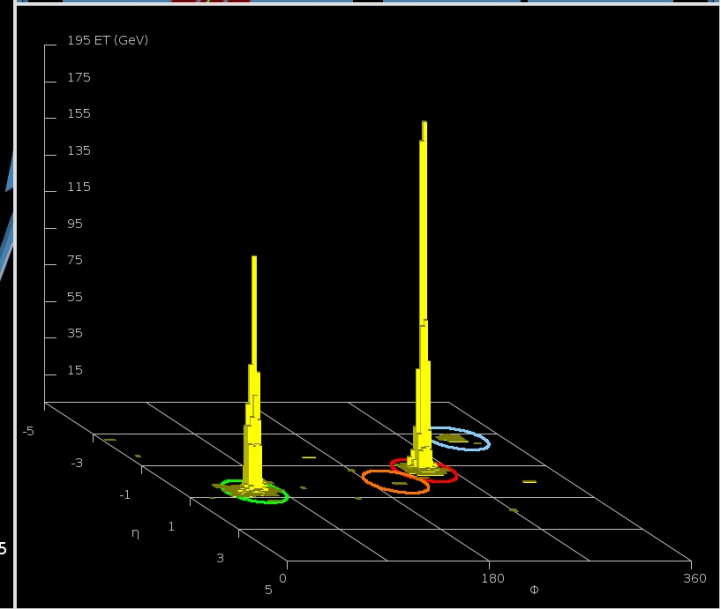
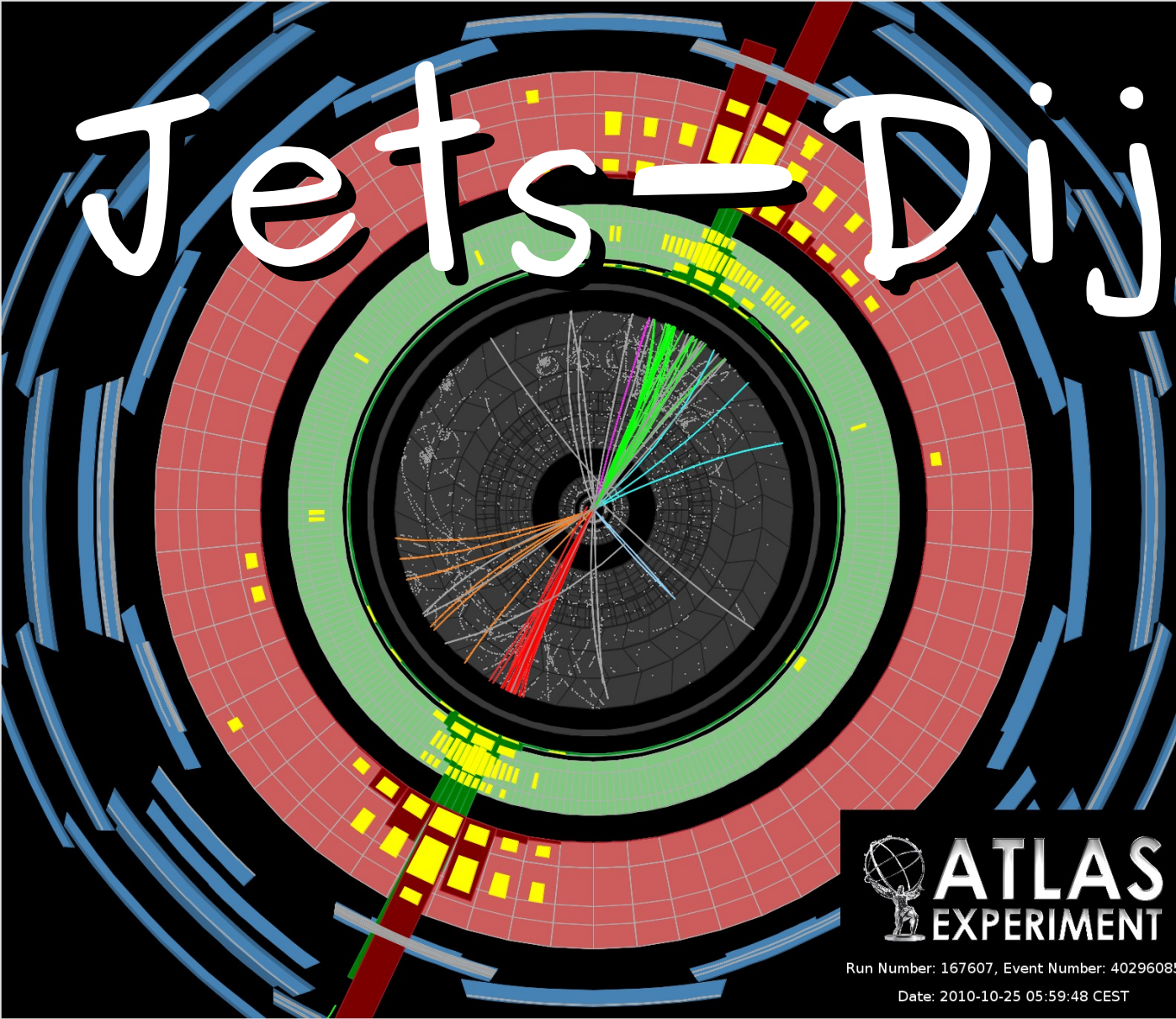
Jet Energy Scale Uncertainty

4/19



- * A multi-jet balance (MJB) technique has been developed to **verify** the energy scale of jets of very high transverse momentum
- * The leading jet is required to have significantly larger p_T than the jets of the recoil system
- * $MJB = |\mathbf{p}_T \text{ Leading}| / |\mathbf{p}_T \text{ Recoil}|$

Jets-Dijets



ATLAS
EXPERIMENT
Run Number: 167607, Event Number: 40296085
Date: 2010-10-25 05:59:48 CEST

Highest-mass central di-jet event collected during 2010. The two leading jets have $(p_T(\text{TeV}), y)$ of $(1.3, -0.68)$, $(1.2, 0.64)$ and an invariant mass of **3.1 TeV**. The missing ET in the event is **46 GeV**.

ATLAS' Jets in EPJ C Coverpage!

* First measurement with early data
at $L = 17 \text{ nb}^{-1}$



40 R C24

The European Physical Journal

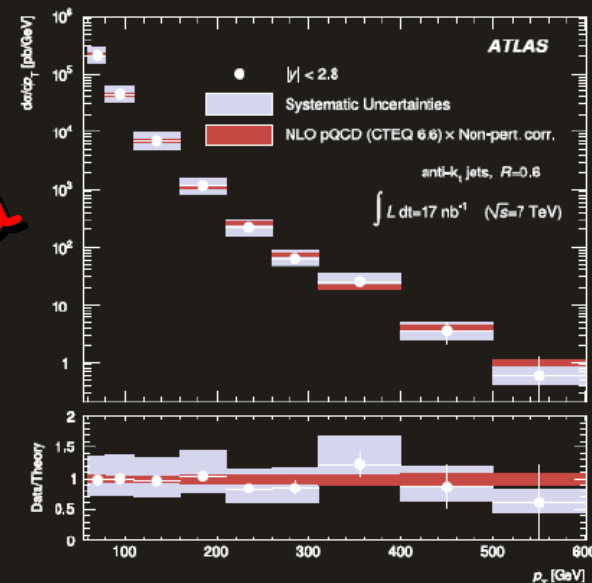
6/19
volume 71 · number 2 · february · 2011

EPJ C



Recognized by European Physical Society

Particles and Fields



Inclusive jet differential cross section as a function of jet p_T integrated over the full region $|y| < 2.8$ for jets identified using the anti- k_r algorithm with $R = 0.6$. The data are compared to NLO pQCD calculations to which soft QCD corrections have been applied. From the ATLAS Collaboration: Measurement of inclusive jet and dijet cross sections in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS detector

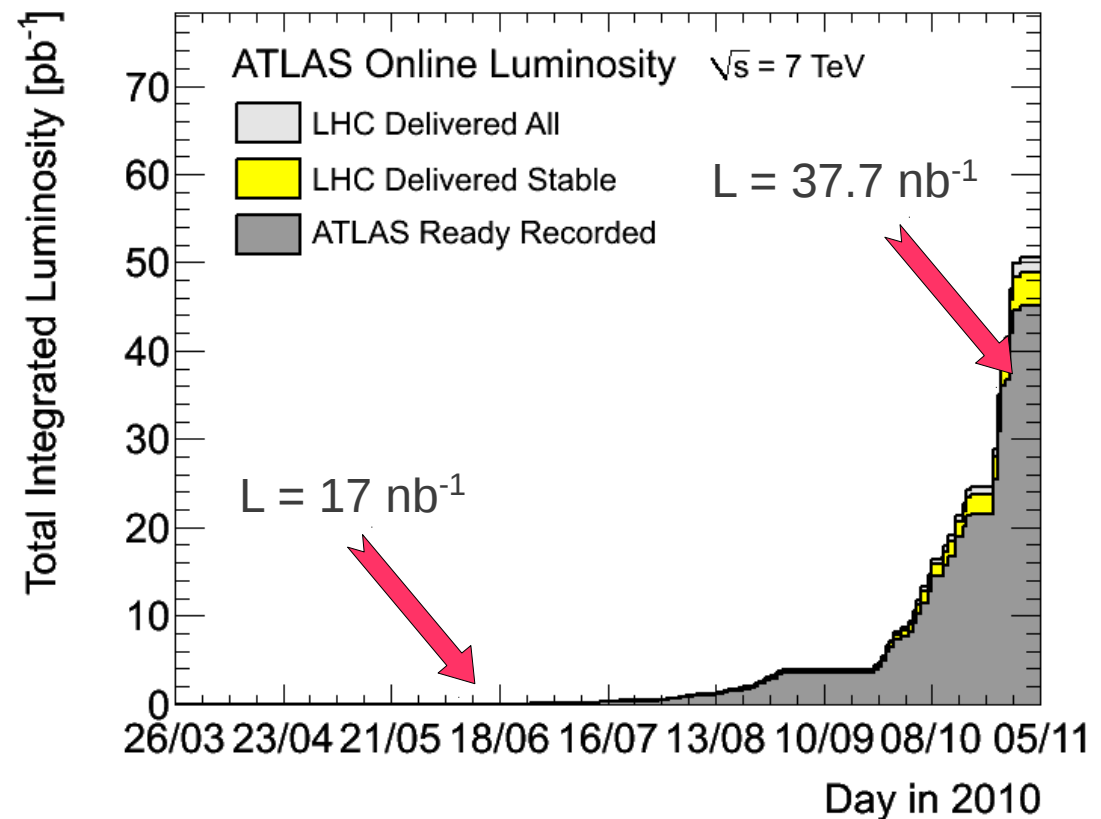


http://www.springerlink.com/content/043w31n6539157v2/fulltext.pdf

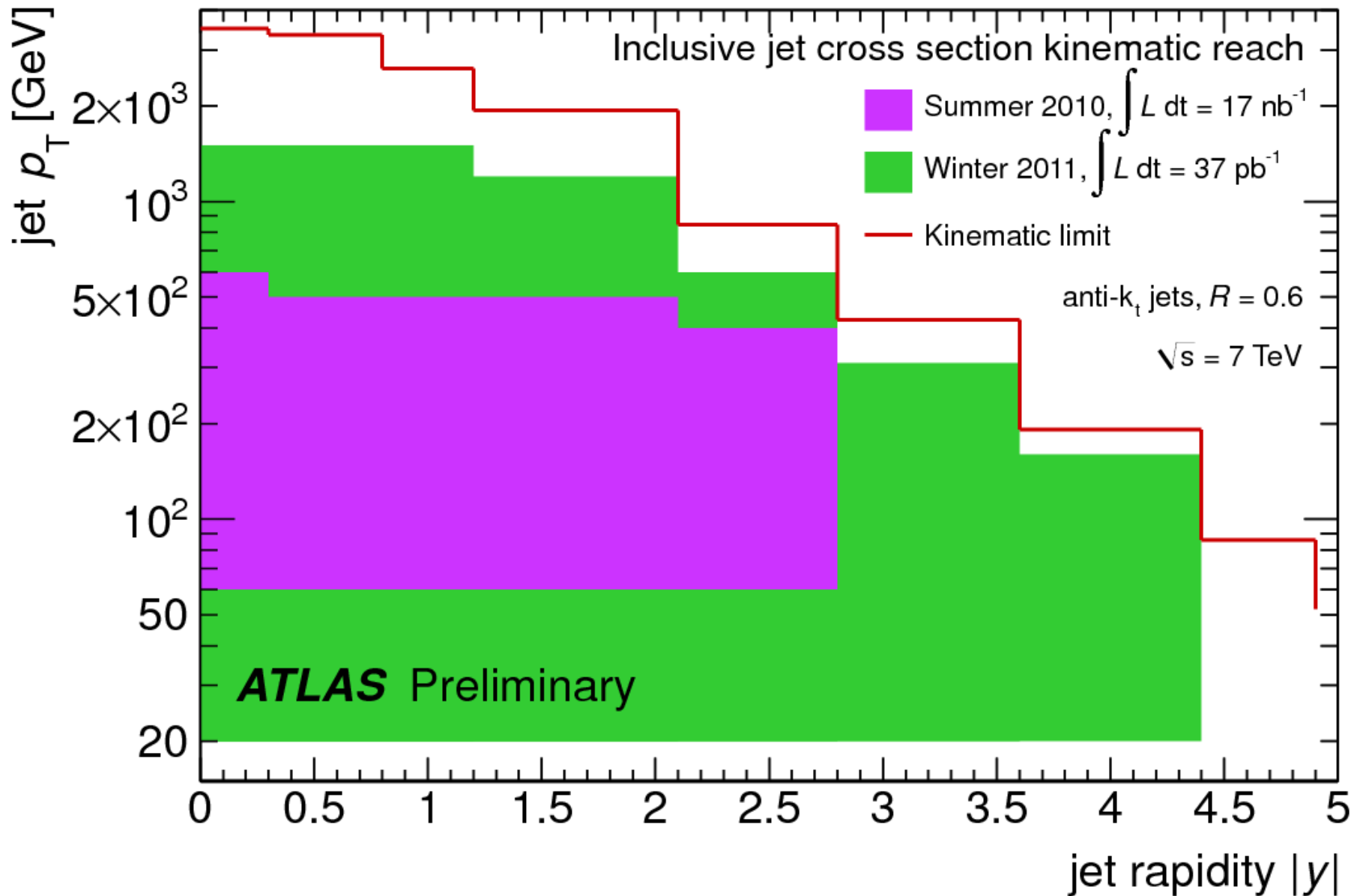
7/19

“Measurement of inclusive jet and dijet cross sections in proton-proton collision data at 7 TeV centre-of-mass energy using the ATLAS detector”

- * CONF Note (Moriond 2011) :
 - Public results [link](#)
 - CDS [link](#)
- * Full 2011 dataset – $L \approx 40 \text{ pb}^{-1}$
- * New kinematic limits searched and new significantly reduced experimental systematic uncertainties
- * 2nd paper foreseen in summer 2011

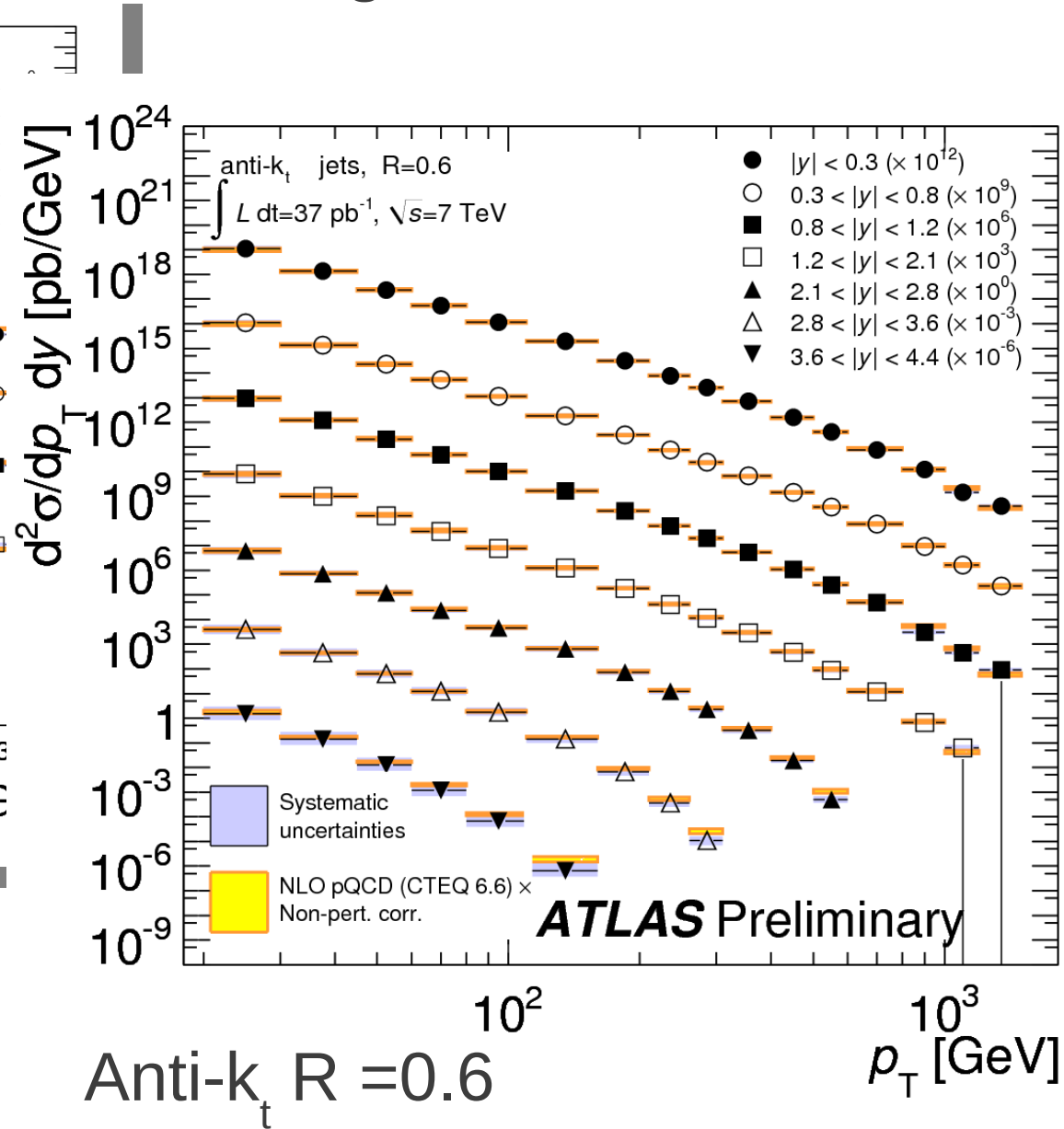
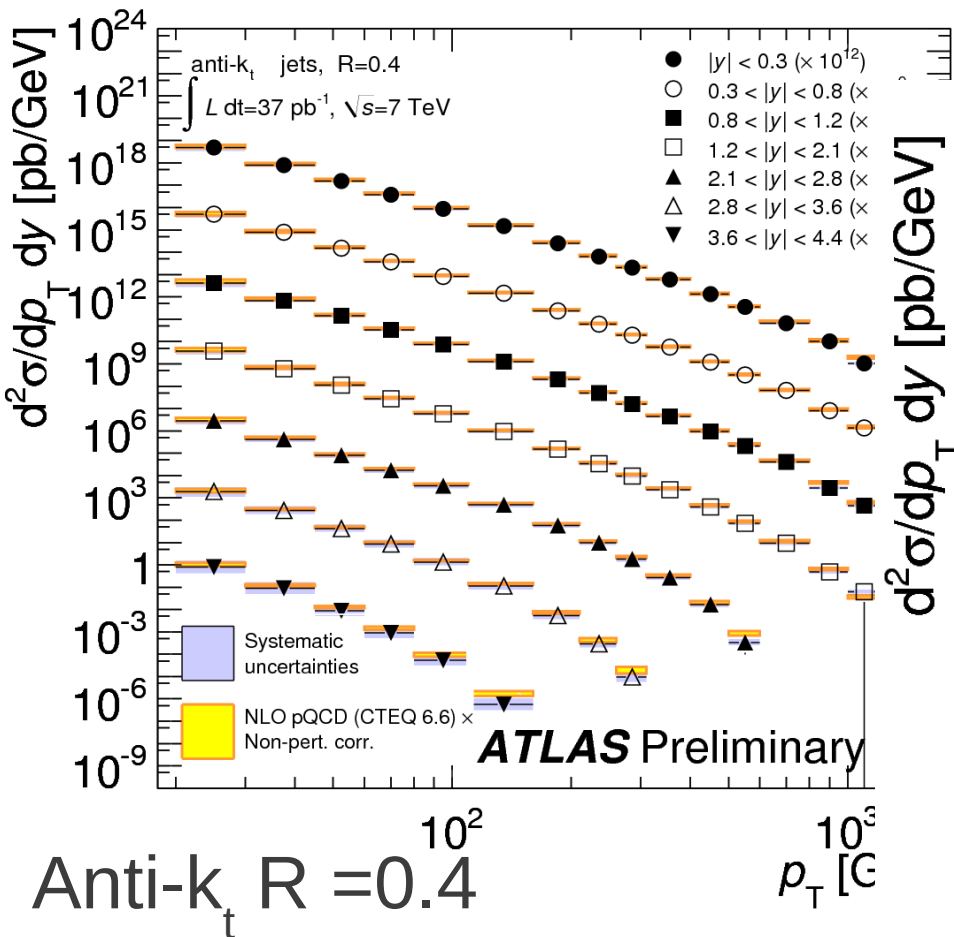


Reaching the phase-space boundaries



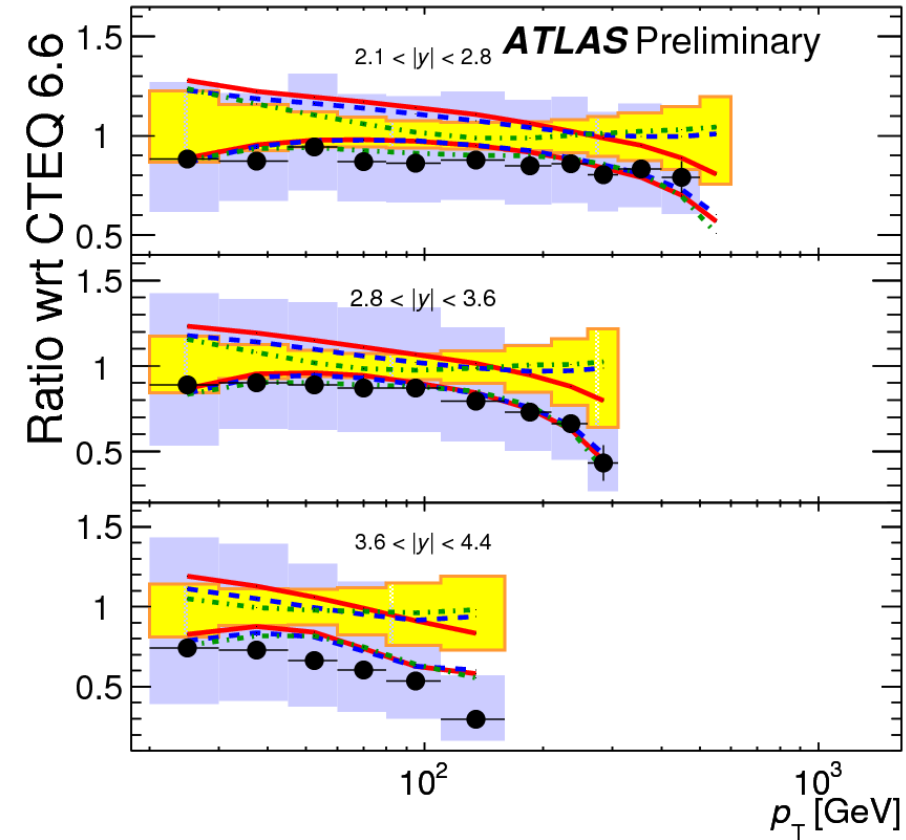
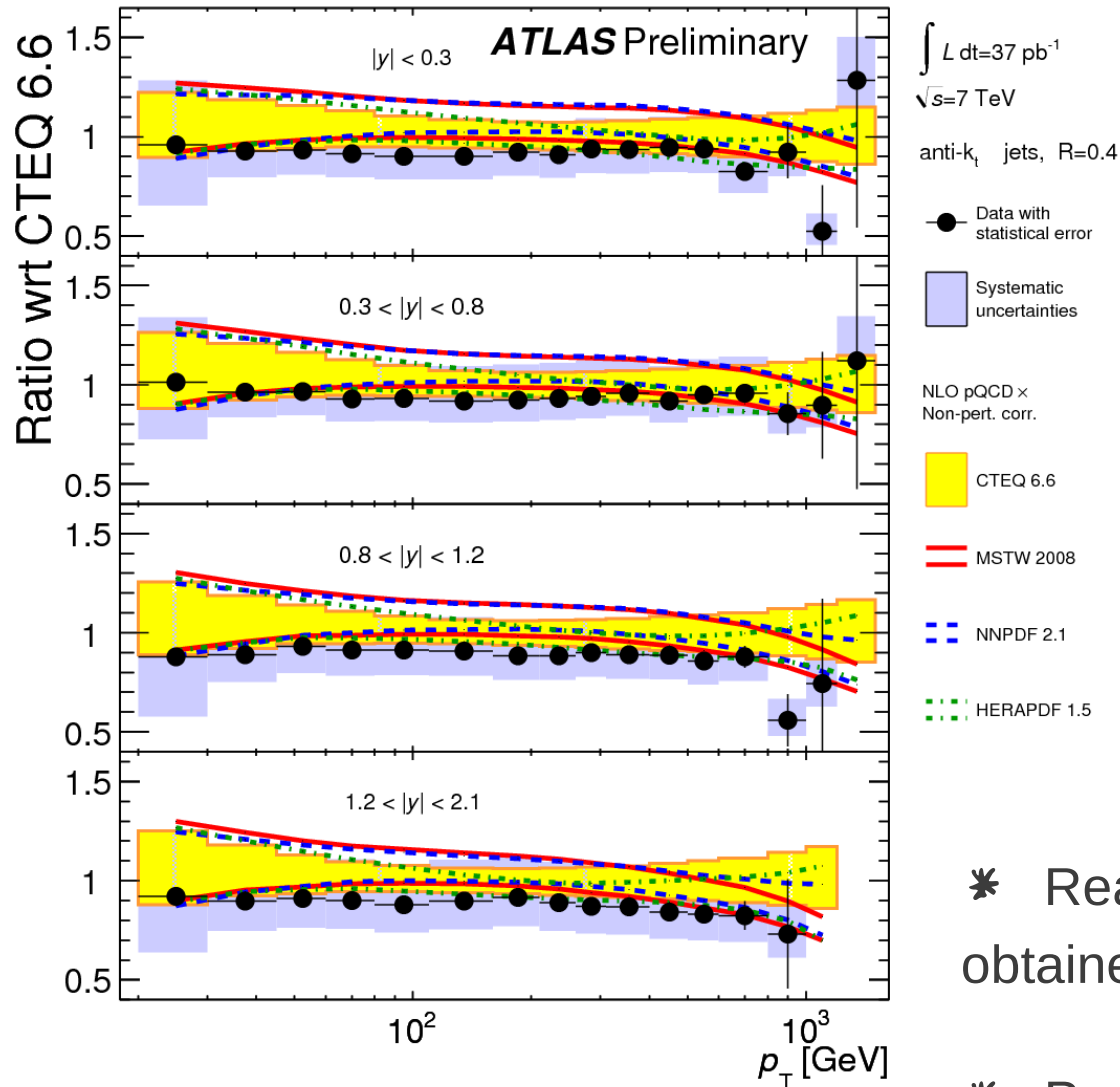
Inclusive jet double-differential cross section v_s jet p_T

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The data and theory predictions are in reasonable agreement within the experimental and theoretical uncertainties

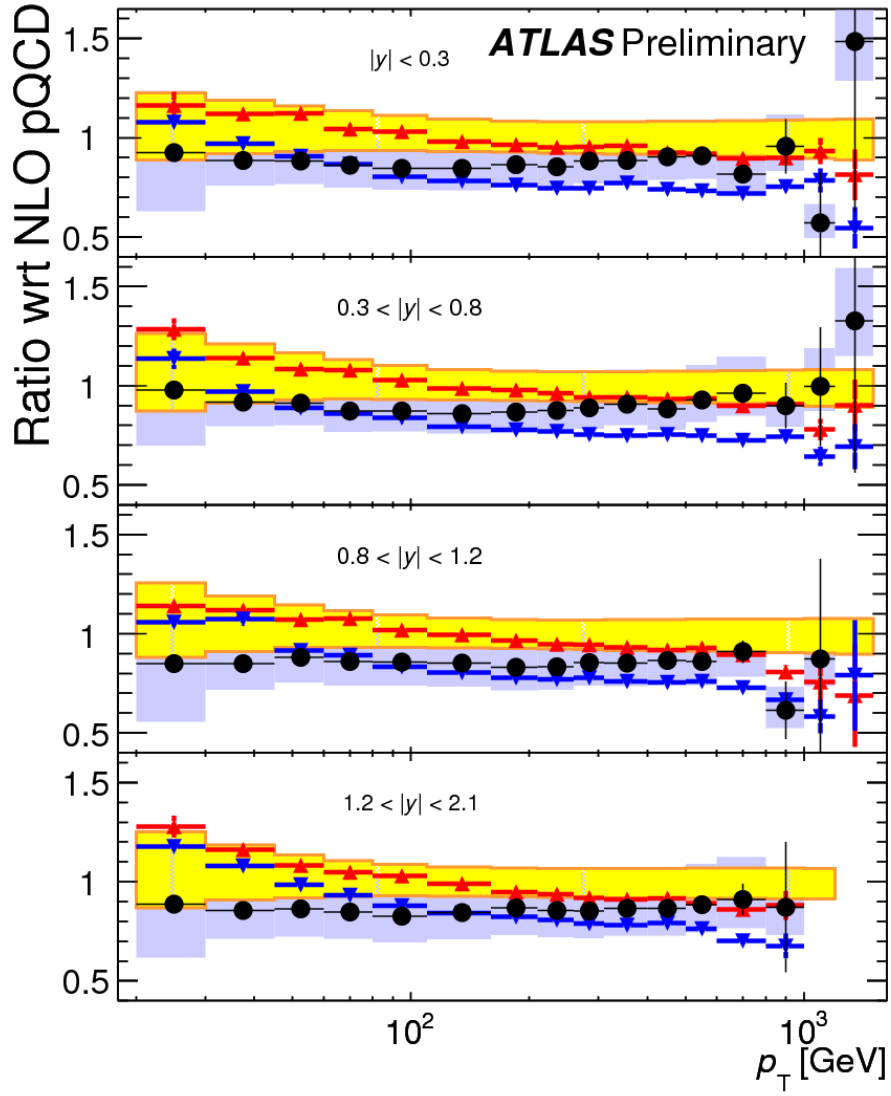
Probing PDFs at high x with Data



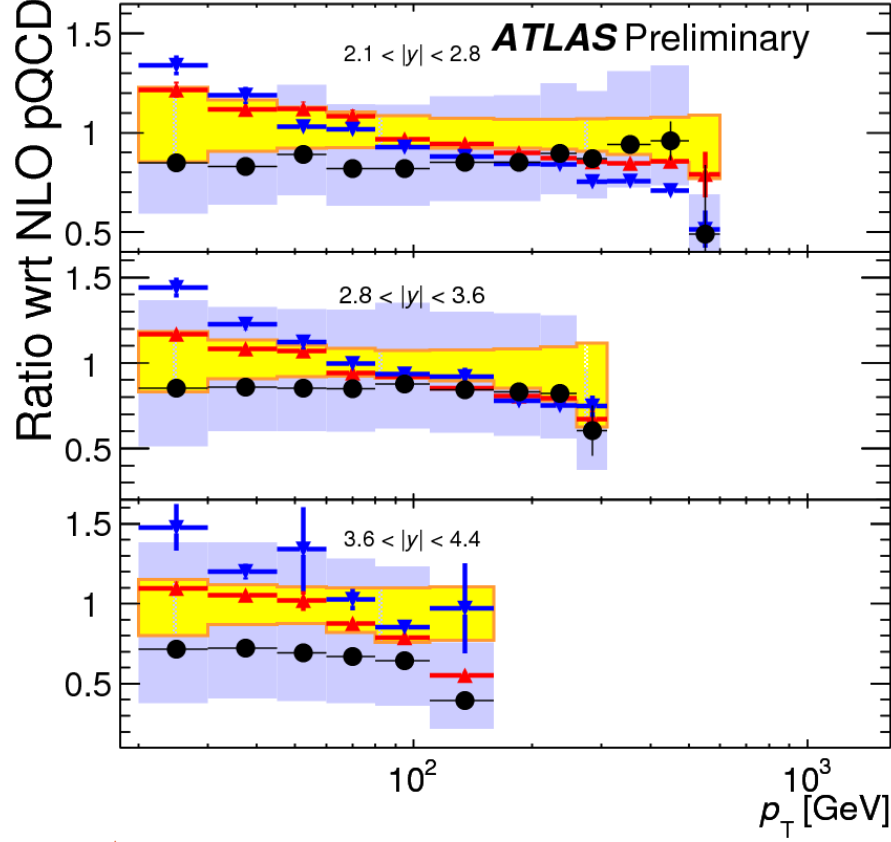
* Reasonable agreement with predictions obtained with different PDF sets

* Predictions using HERAPDF 1.5 appeared to follow the data most closely

Data and Theoretical Predictions



$\int L dt = 37 \text{ pb}^{-1}$
 $\sqrt{s} = 7 \text{ TeV}$
 anti- k_r jets, $R=0.4$
 ● Data with statistical error
 ■ Systematic uncertainties
 ■ NLO pQCD (MSTW 2008) × Non-pert. corr.
 ▲ Powheg + Pythia (AMBT1)
 ▼ Powheg + Herwig (AUET1)

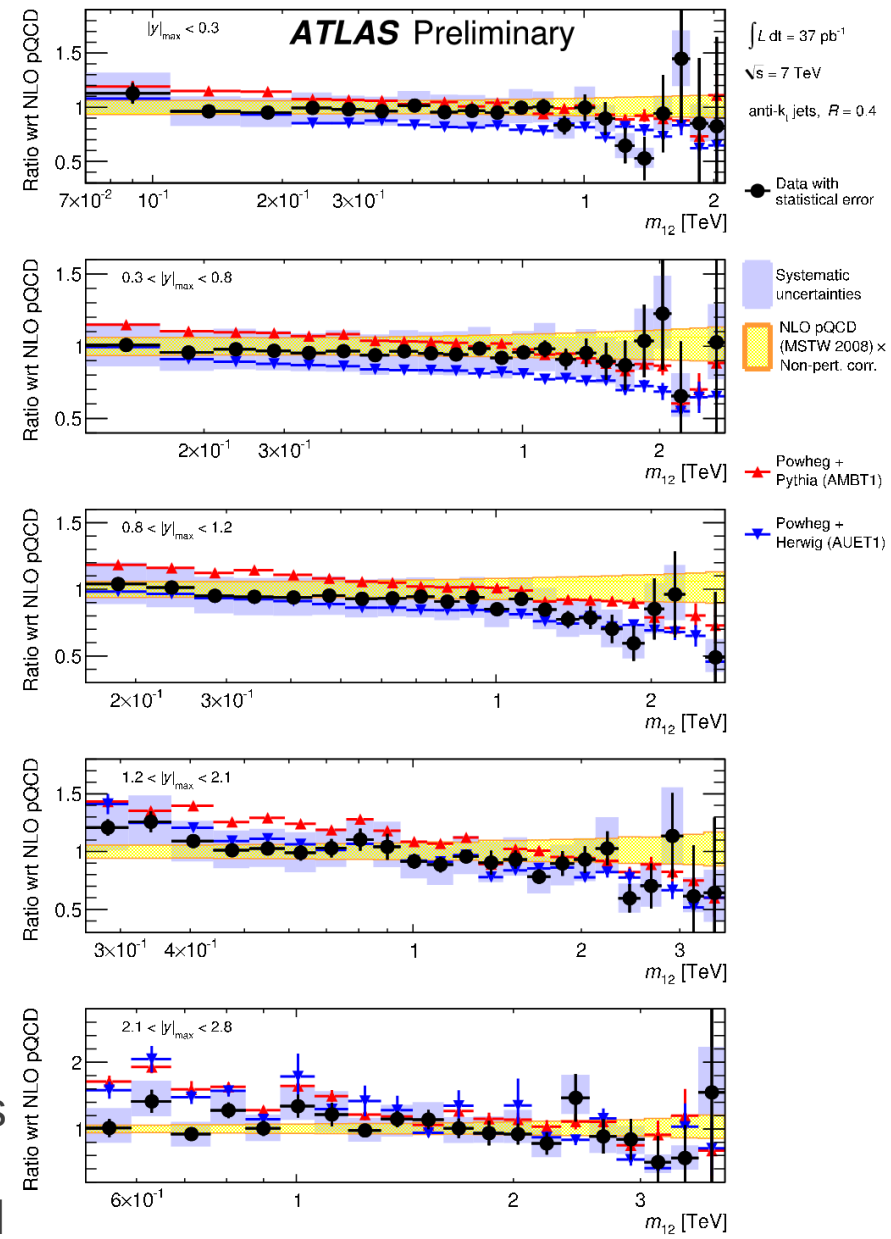
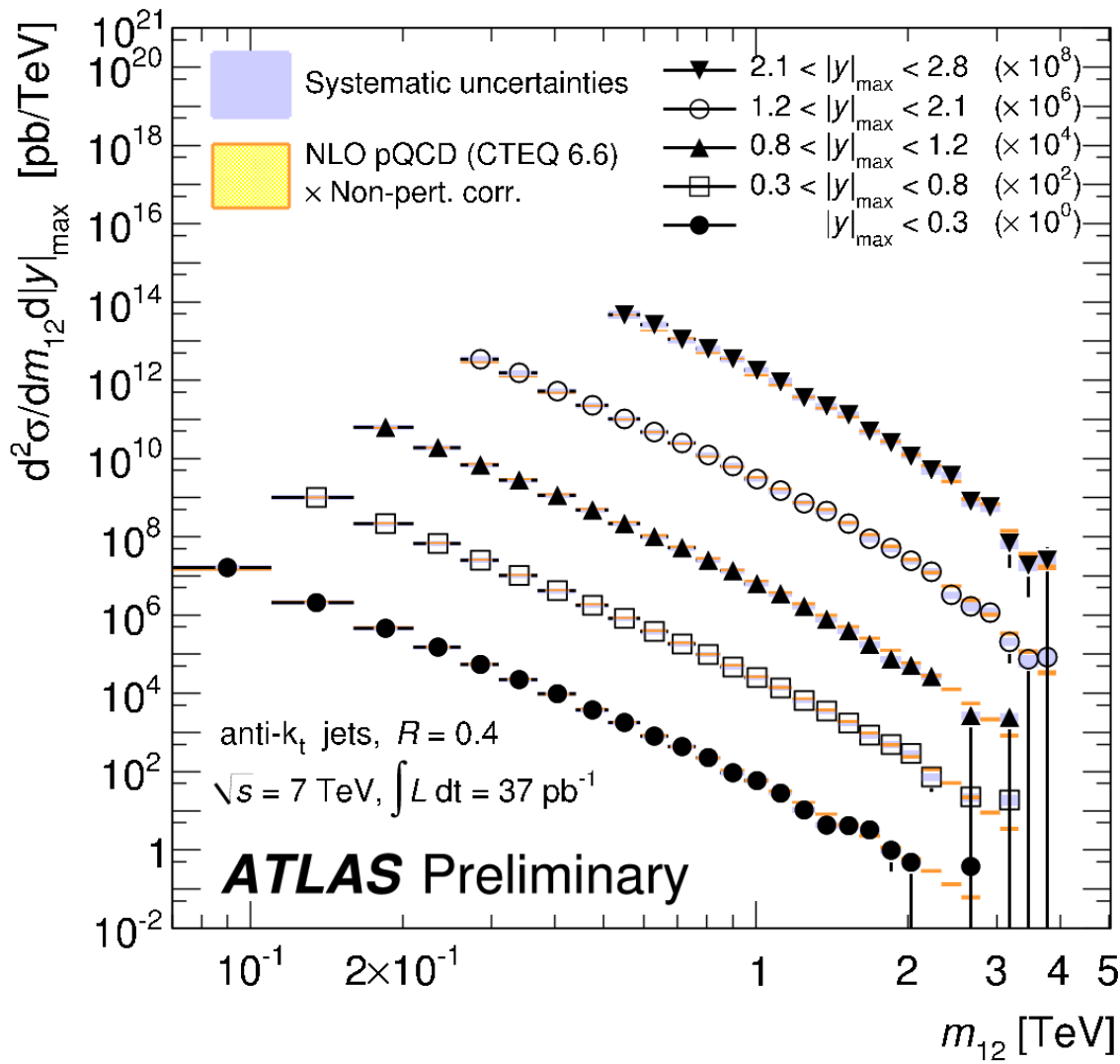


* POWHEG's *link* (NLO ME + PS) predictions (MSTW 2008 NLO) are consistent both with the data and with NLOJet++ within the present uncertainties

* The difference observed between the two predictions of POWHEG is coupled with the two different PS implementations

Dijet double-differential cross section vs dijet mass

12/19



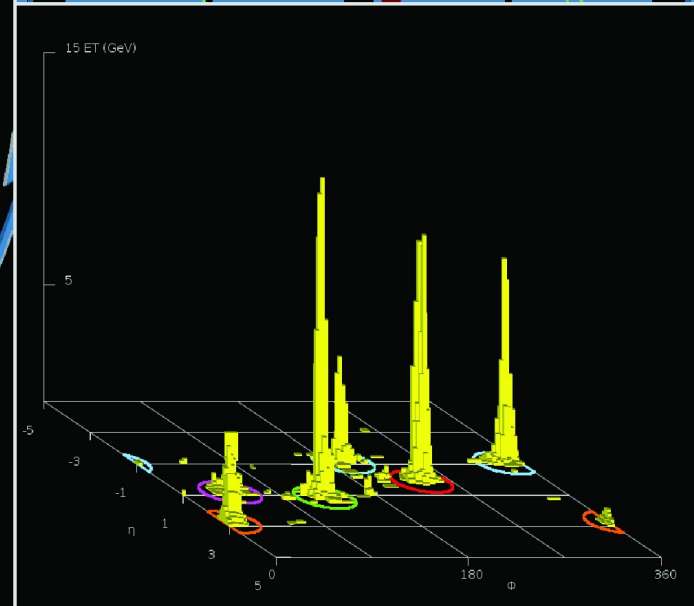
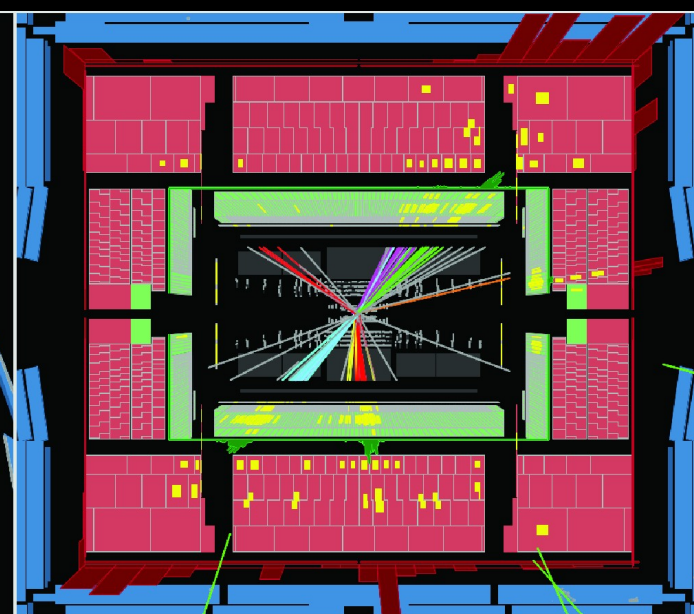
POWHEG's trend: systematically predicts higher cross sections at low dijet mass than the data and the NLOJet++ prediction regardless of the showering model

Multijets

 **ATLAS**
EXPERIMENT

Run Number: 161520, Event Number: 18445417

Date: 2010-08-15 04:53:16 CEST



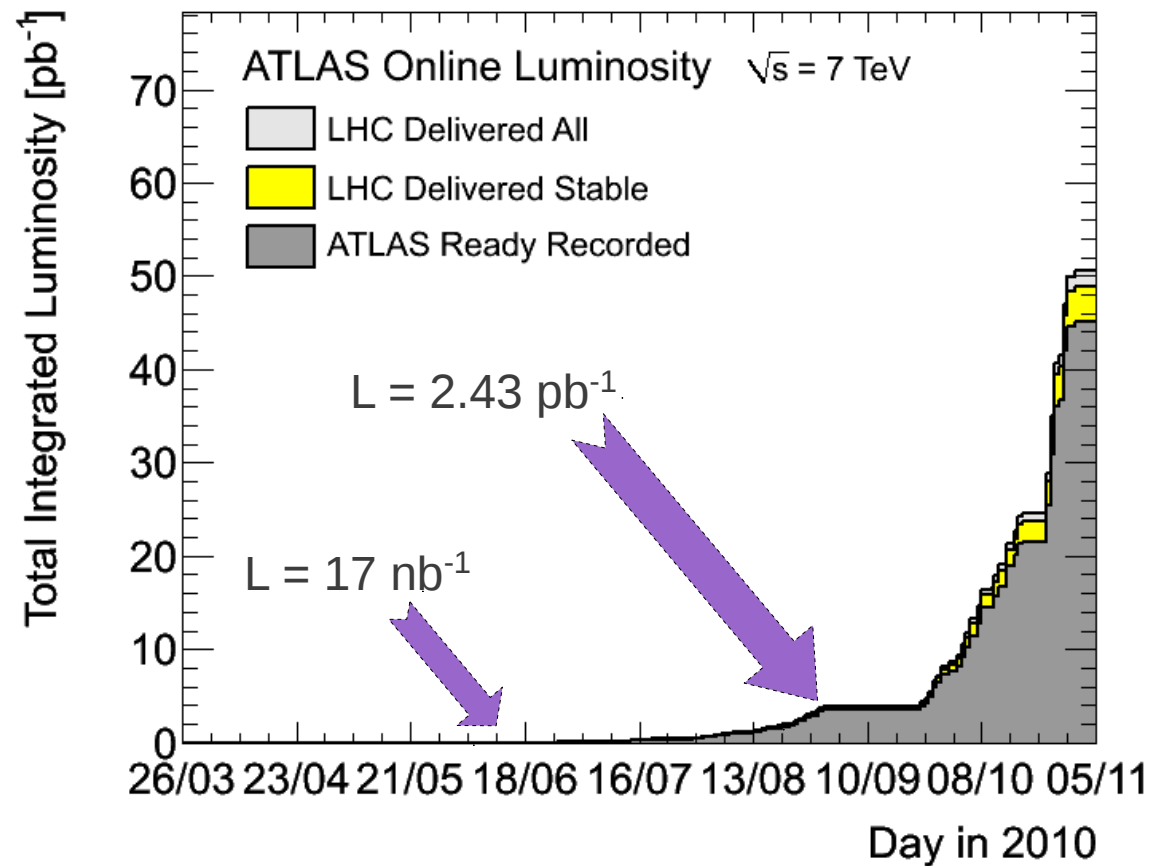
Event display of a **six-jet** event, reconstructed with the anti- k_t 0.4 algorithm, satisfying the multi-jet analysis requirements. The yellow towers represent the transverse energy deposited in the calorimeter projected on a grid of η and ϕ

“Measurement of multi-jet cross-sections in proton-proton collisions at 7 TeV center-of-mass energy” ^{14/19}

- * CONF Note (Moriond2011)
 - CDS note [link](#)
 - Public results [link](#)
- * Long and precise supporting note (~150 p.) [link](#)
- * Extensive use of 2-to-2 and Multi-leg ME MC generators
- * Paper in progress !

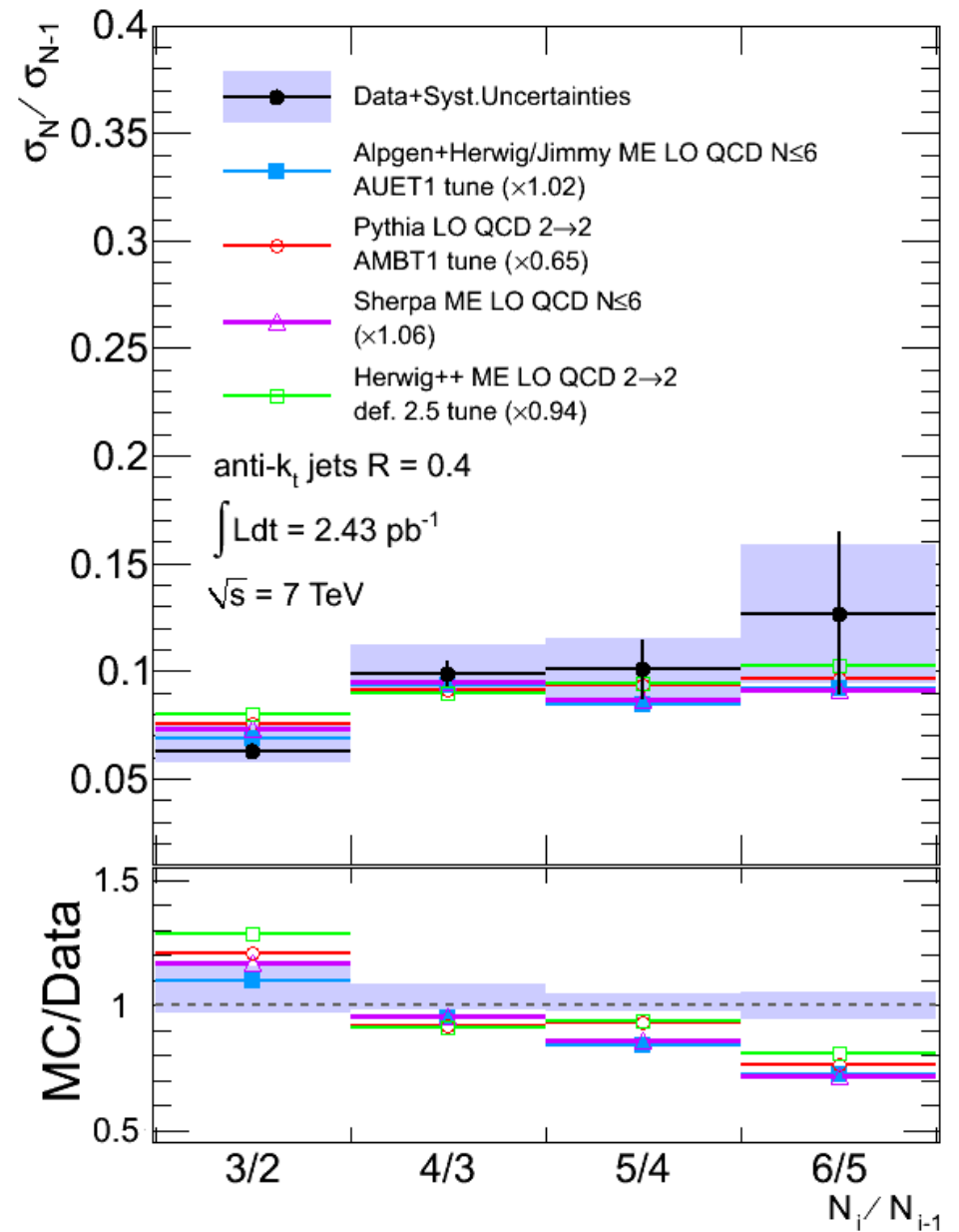
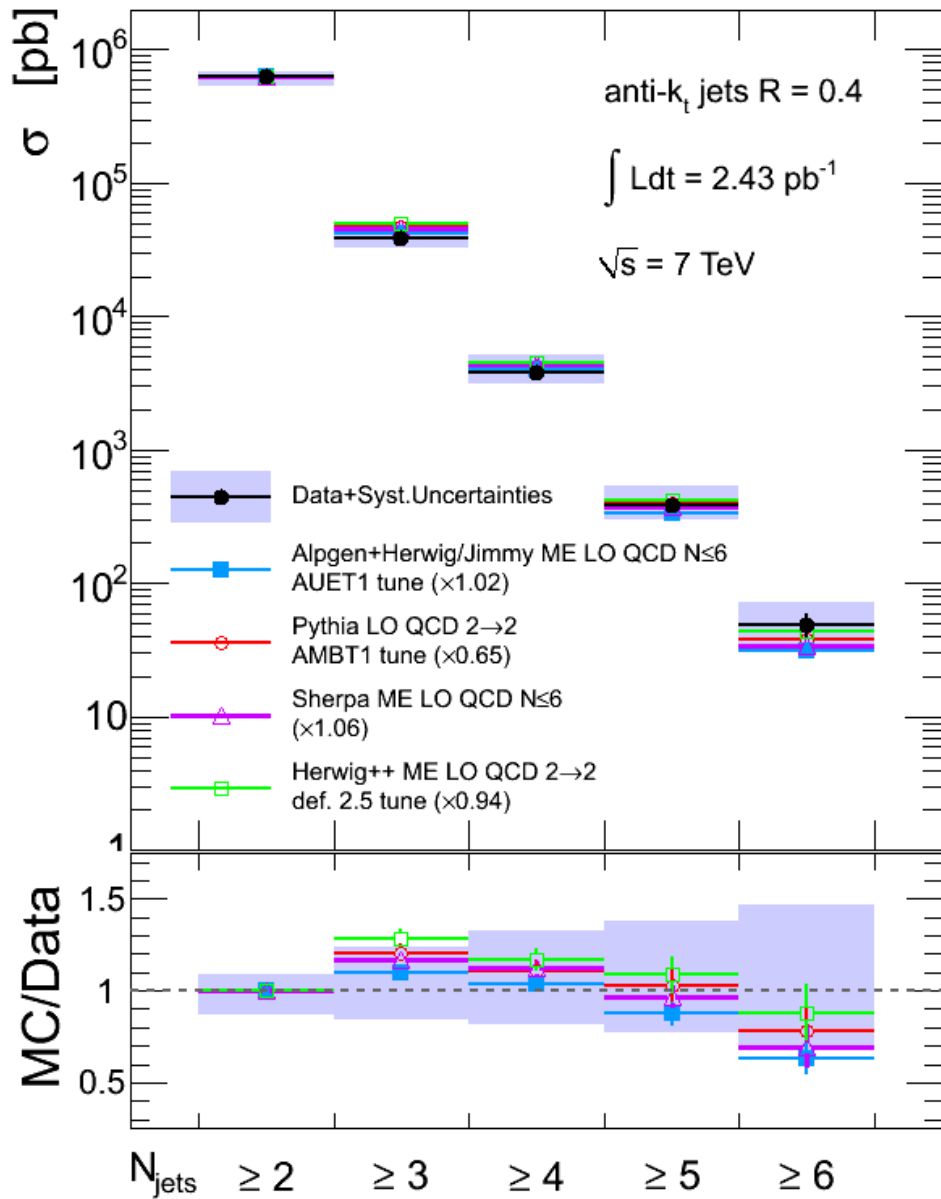
Analysis Highlights

- Usage of *multi-jet triggers*
- Fight Pile-Up with *JVF*
- Characterization of the multi-jet topologies
 - with multiplicity up to 6 jets
 - for jet p_T s up to 800 GeV/c
 - for event H_T up to 1.6 TeV

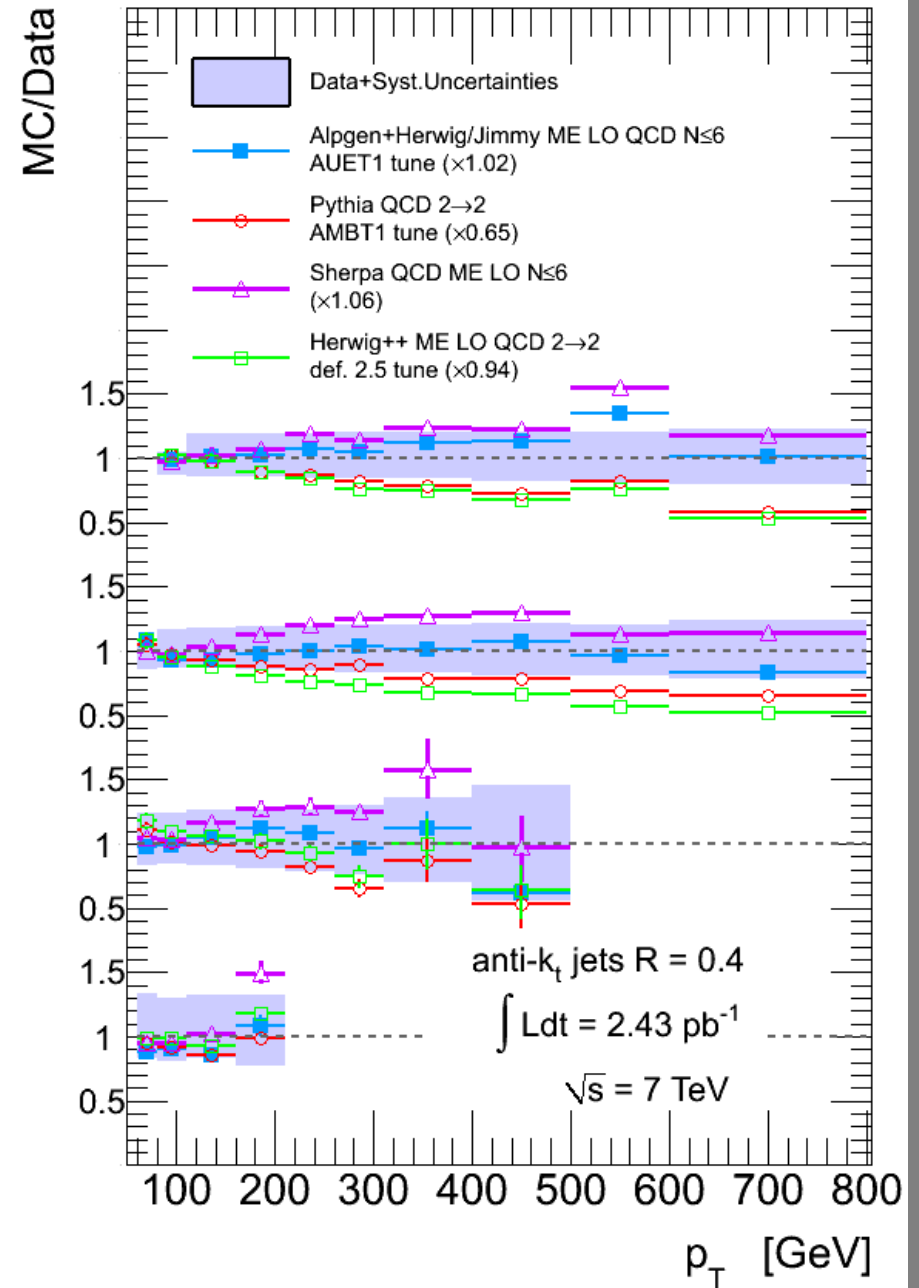
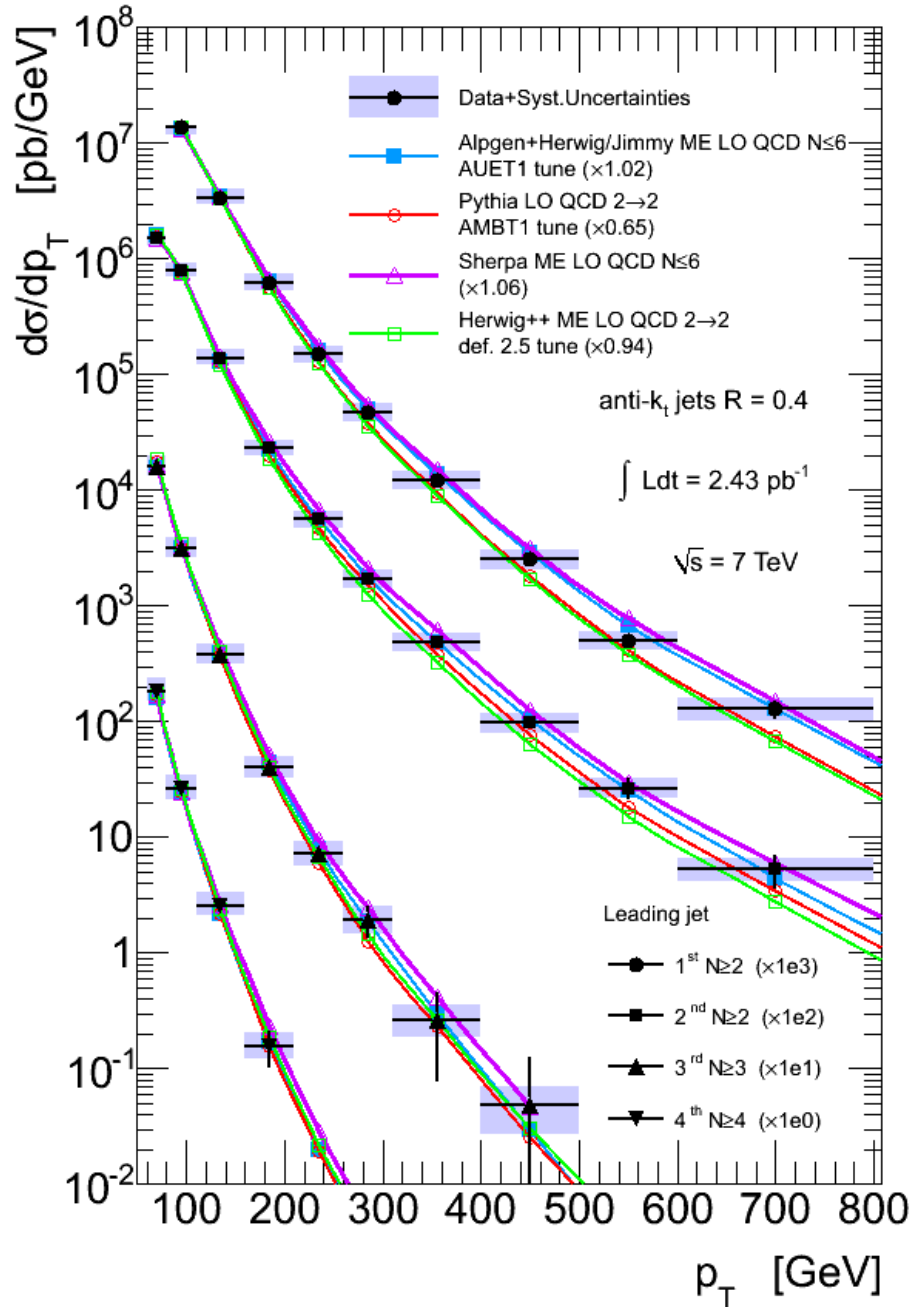


- Data comparison to $2 \rightarrow 2$ and $2 \rightarrow 6$ LO ME+PS Monte-Carlo simulations
 - PYTHIA 6, HERWIG++2.5 vs ALPGEN+HERWIG/JIMMY, SHERPA
- Test the pQCD predictions at NLO in high jet multiplicity events
- 3-to-2 cross-section ratios $-R_{32}$ - have reduced measurement uncertainties and comparable to the uncertainties of the LO and NLO theoretical predictions !

Inclusive Jet Multiplicity

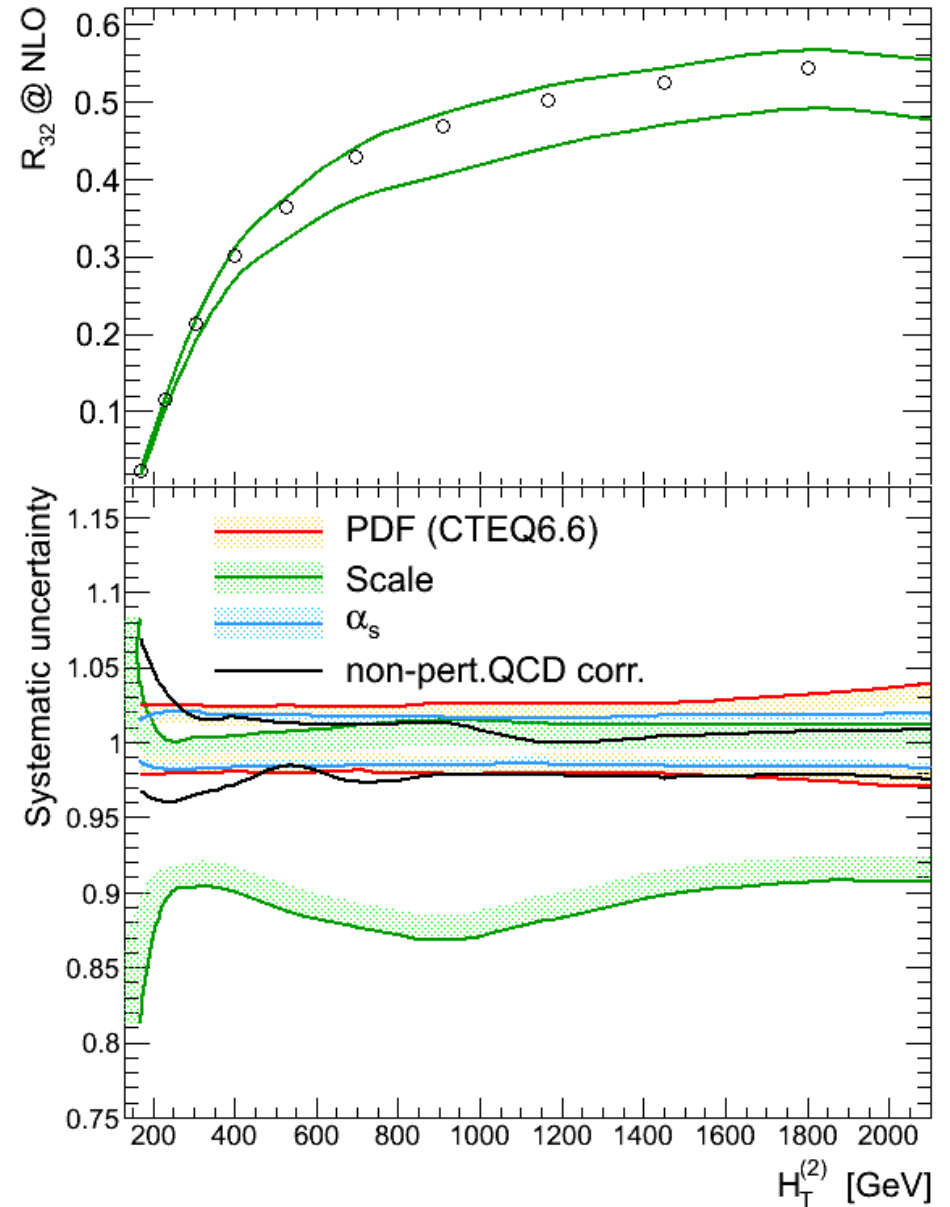
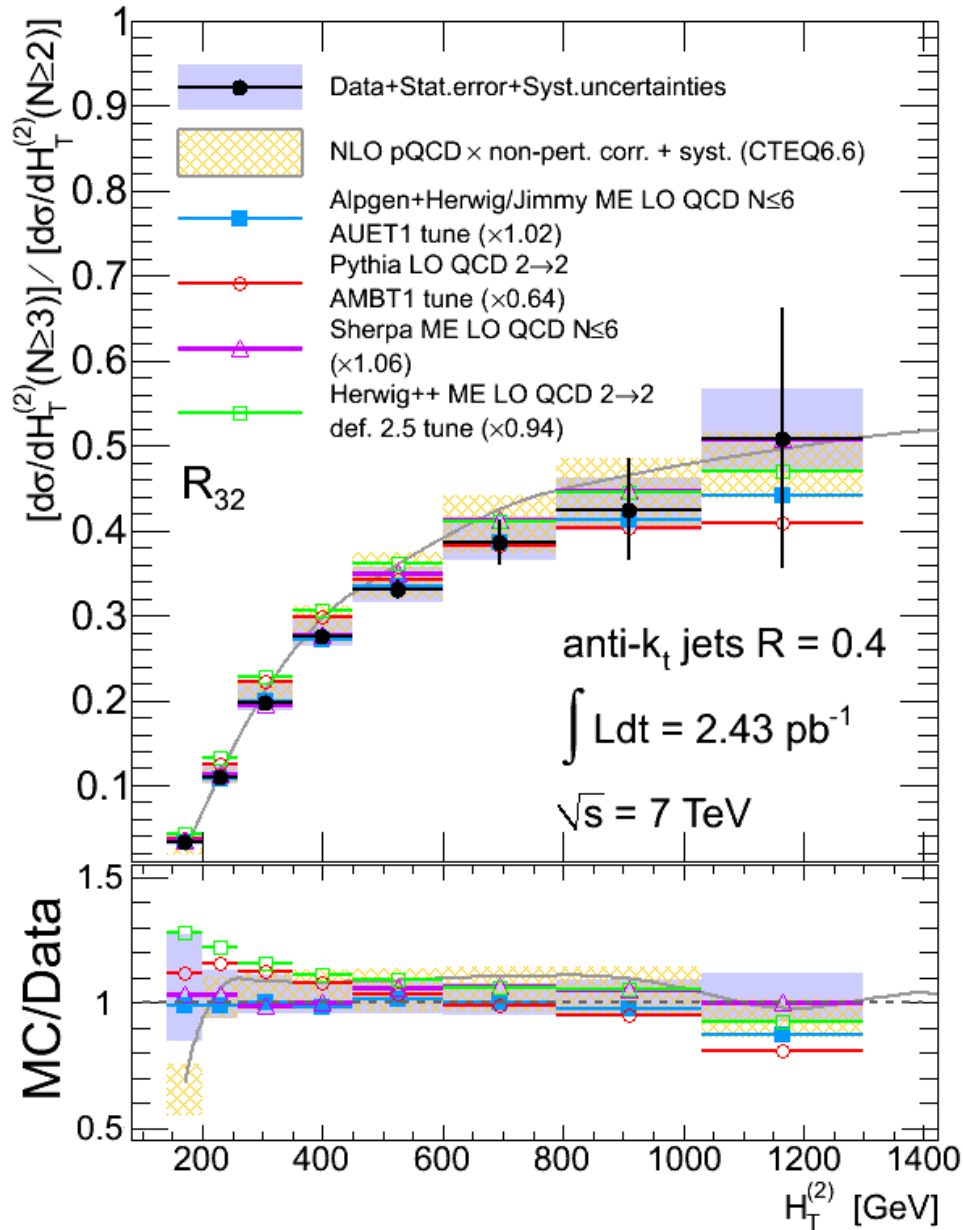


Differential Cross-Section v_s pT 17/19



R32 – a good α_s fit candidate

18/19



Future of QCD Jet Cross-Section Measurements

19/19

- **Jets:**
 - Detailed study of all the statistical and systematic correlations
 - Provide data for the PDF fits (first attempt to fit the ATLAS inclusive jet data is ongoing)
 - Make the AntiKt 4/AntiKt 6 cross section ratio, for the study of the higher order and non-perturbative QCD effects, and try to extend the analysis to different R
 - Measurement of the cross section at $\sqrt{s}=2.76$ TeV ongoing.
- **Multijets:**
 - Make use of the rich knowledge in the multi-jet analysis for background studies for many physics channels
 - Use more data to extend the kinematic region and explore further the η - ϕ phase-space
 - Precise measurements of the R32 variables as inputs to the α_s fit
 - Event shapes and Dalitz plots