

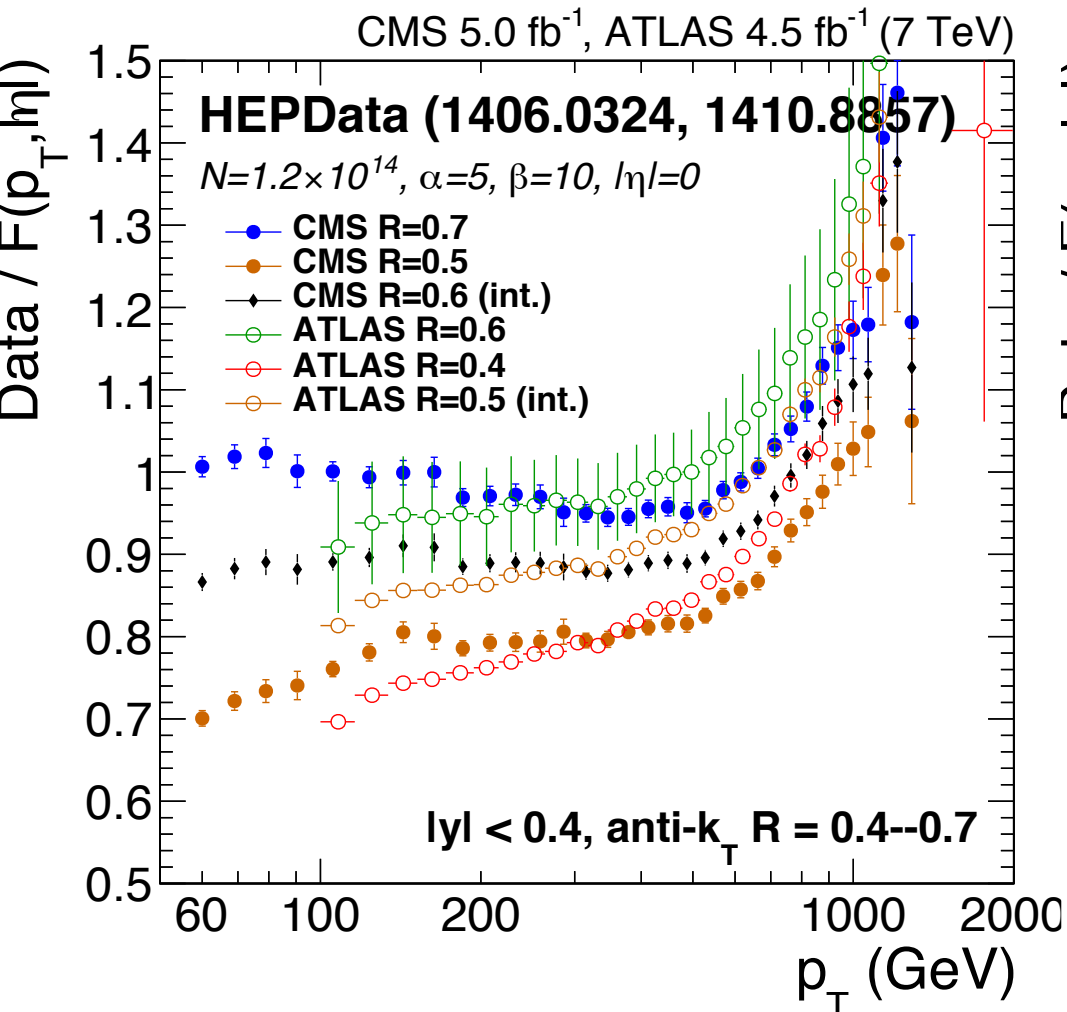
# Comparison of **CMS and ATLAS** **measurements of inclusive jets** (in 7 TeV data)

for the LHC Electroweak Working Group  
June 21, 2018

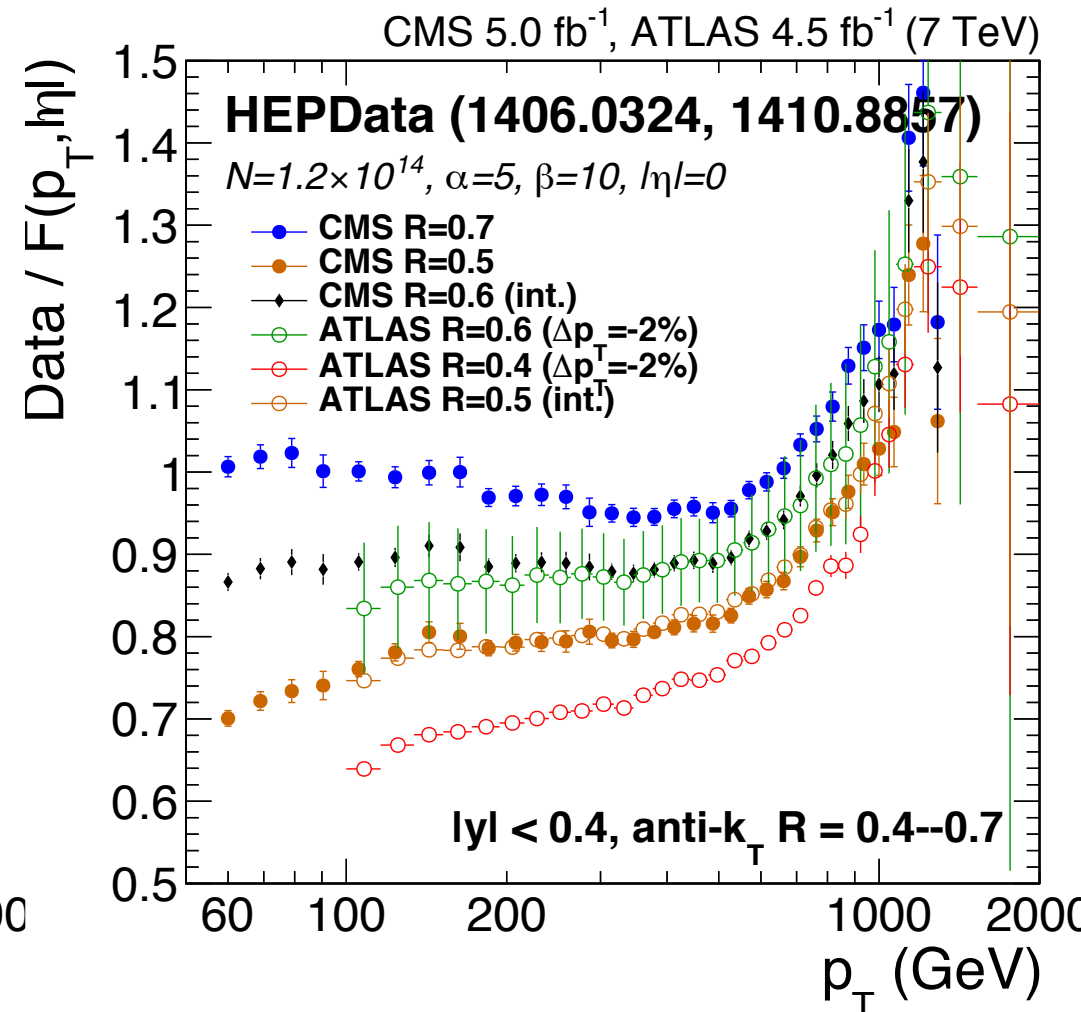
Mikko Voutilainen, U. Helsinki and HIP

- CMS and ATLAS have high quality jet data with  $R=0.4, 0.5, 0.6, 0.7$  from 2.76, **7**, 8, 13 TeV
- Combining data should reduce uncertainties and provide theorists a coherent reference set
- Benefit **global PDF** fits, understanding of **NNLO** predictions and **R dependence**

## nominal



## JEC shifted 2%



- Retrieved CMS and ATLAS 7 TeV (2011) data from HEPDATA, with stat and stat $\oplus$ syst
  - uncertainty sources provided differently, being worked into common format
- Interpolated R=0.4/0.6 and 0.5/0.7 spectra using **log(R)** scaling => **R=0.5,0.6** “common”
- Normalised by  **$F(p_T, \eta) = \iint N p_T^\alpha (1 - 2p_T \cosh(\eta)/\sqrt{s})^\beta dp_T d\eta$**  for plotting
- JEC uncertainty by far dominant => start by bracketing CMS/ATLAS difference as  **$\Delta_{JEC}$** 
  - known biases: FSR in  $p_T$  balance, response slope vs  $p_T$ , Pythia6/8 vs Herwig++

HEPData Search HEP Data

Browse all Aad, Georges et al.

Measurement of the inclusive jet cross-section in proton-proton collisions at  $\sqrt{s} = 7$  TeV using 4.5 fb<sup>-1</sup> of data with the ATLAS detector

The ATLAS collaboration

Aad, Georges , Abbott, Brad , Abdallah, Jalal , Abdel Khalek, Samah , Abdinov, Ovsat , Aben, Rosemarie , Abi, Babak , Abolins, Maris , AbouZeid, Ossama , Abramowicz, Halina

JHEP 1502 (2015) 153, 2015

<http://dx.doi.org/10.17182/hepdata.69343>

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Table 1

Data from Table 3  
10.17182/hepdata.69343.v1/t1  
Measured double-differential inclusive-jet cross section for the range 0.0 <math>\leq |\eta| < 0.5</math> and for anti- $k_T</math> jets with radius parameter...$

Table 2

Data from Table 4  
10.17182/hepdata.69343.v1/t2  
Measured double-

HEPData Search HEP Data

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Measurement of the ratio of inclusive jet cross sections using the anti- $k_T$  algorithm with radius parameters R=0.5 and 0.7 in pp collisions at  $\sqrt{s} = 7$  TeV

The CMS collaboration

Chatrchyan, Serguei , Khachatryan, Vardan , Sirunyan, Albert M , Tumasyan, Armen , Adam, Wolfgang , Bergauer, Thomas , Dragicevic, Marko , Erö, Janos , Fabjan, Christian , Friedl, Markus

Phys.Rev. D90 (2014) 072006, 2014

<http://dx.doi.org/10.17182/hepdata.68020>

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Table 1

Data from Figure 1a  
10.17182/hepdata.68020.v1/t1  
Inclusive Jet cross section with R=0.5 in the rapidity bin 0 <math>< |\eta| < 0.5</math>. The total uncorrelated...

Table 2

Data from Figure 1a  
10.17182/hepdata.68020.v1/t2  
Inclusive Jet cross section with R=0.5 in the rapidity bin 0.5 <math>< |\eta| < 1</math>. The total

Table 1 [10.17182/hepdata.68020.v1/t1](http://10.17182/hepdata.68020.v1/t1)

<http://www.hepdata.net/recc>

Data from Figure 1a

Inclusive Jet cross section with R=0.5 in the rapidity bin 0 <math>< |\eta| < 0.5</math>. The total uncorrelated uncertainty includes statistical one and systematic uncorrelated. The total systematic uncertainty includes all other sources, especially the luminosity uncertainty of 2.2%. The total error can be obtained as a quadratic sum of uncorrelated and correlated one. The NP correction can be used to scale theory prediction to compare to data at particle level.

cmenergies

7000.0

observables

D2SIG/DPT/DYRAP

phrases

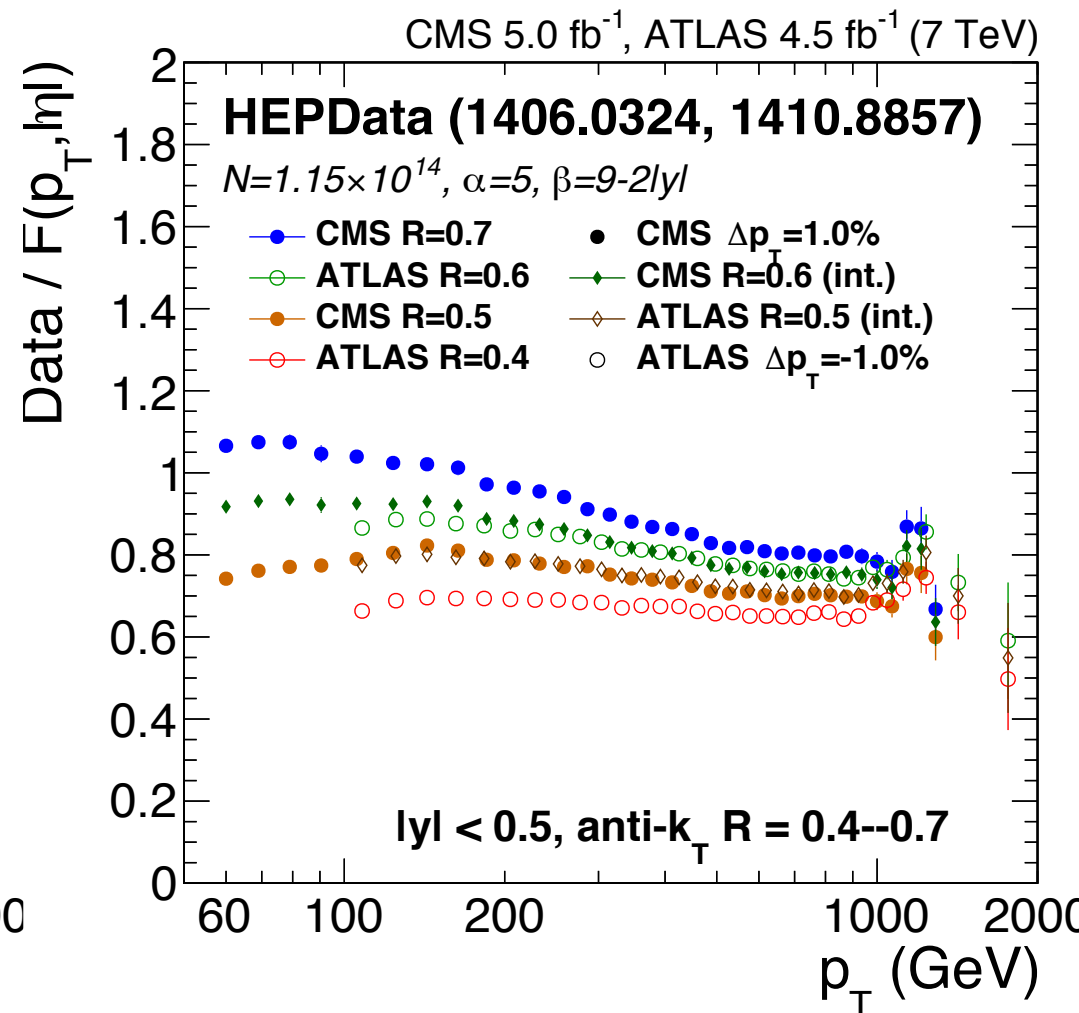
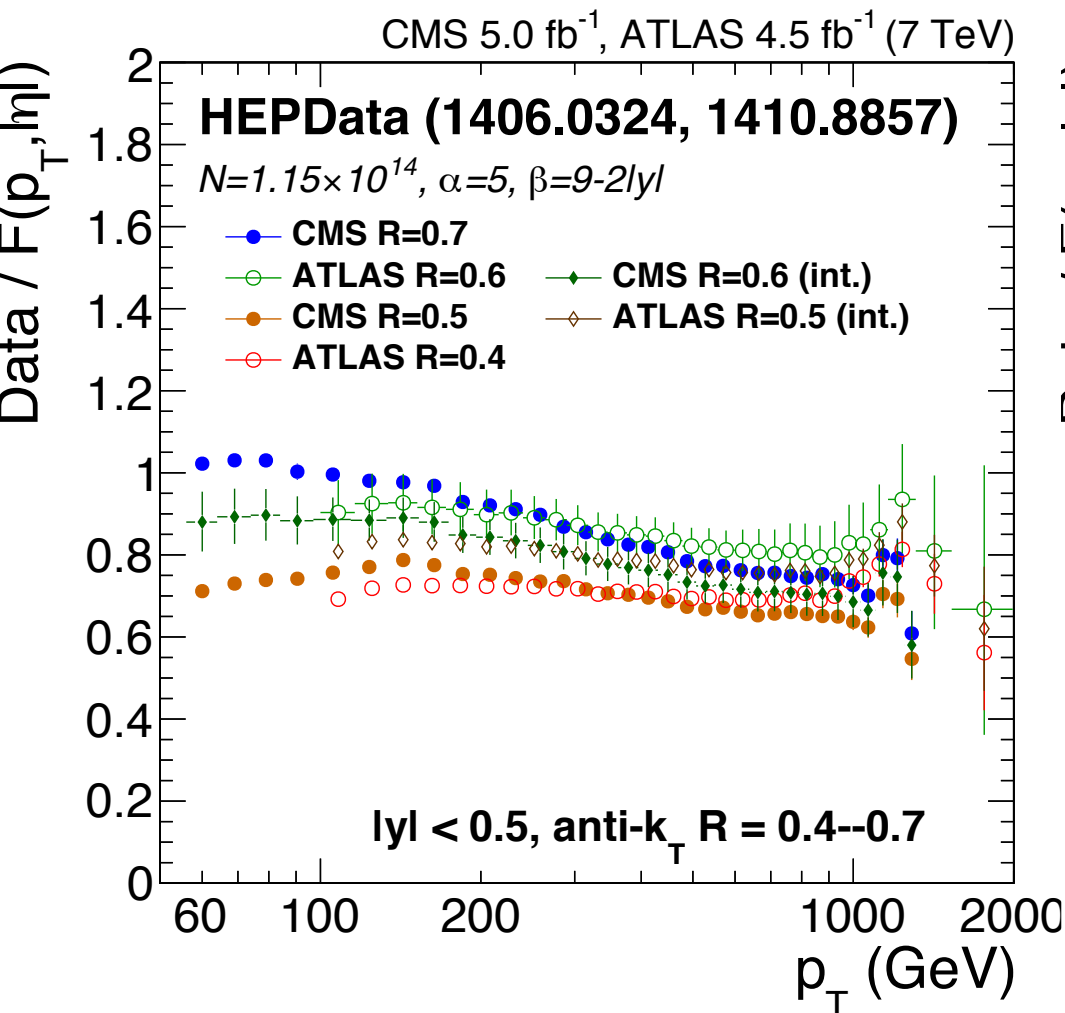
Inclusive

Double Differential

Transverse

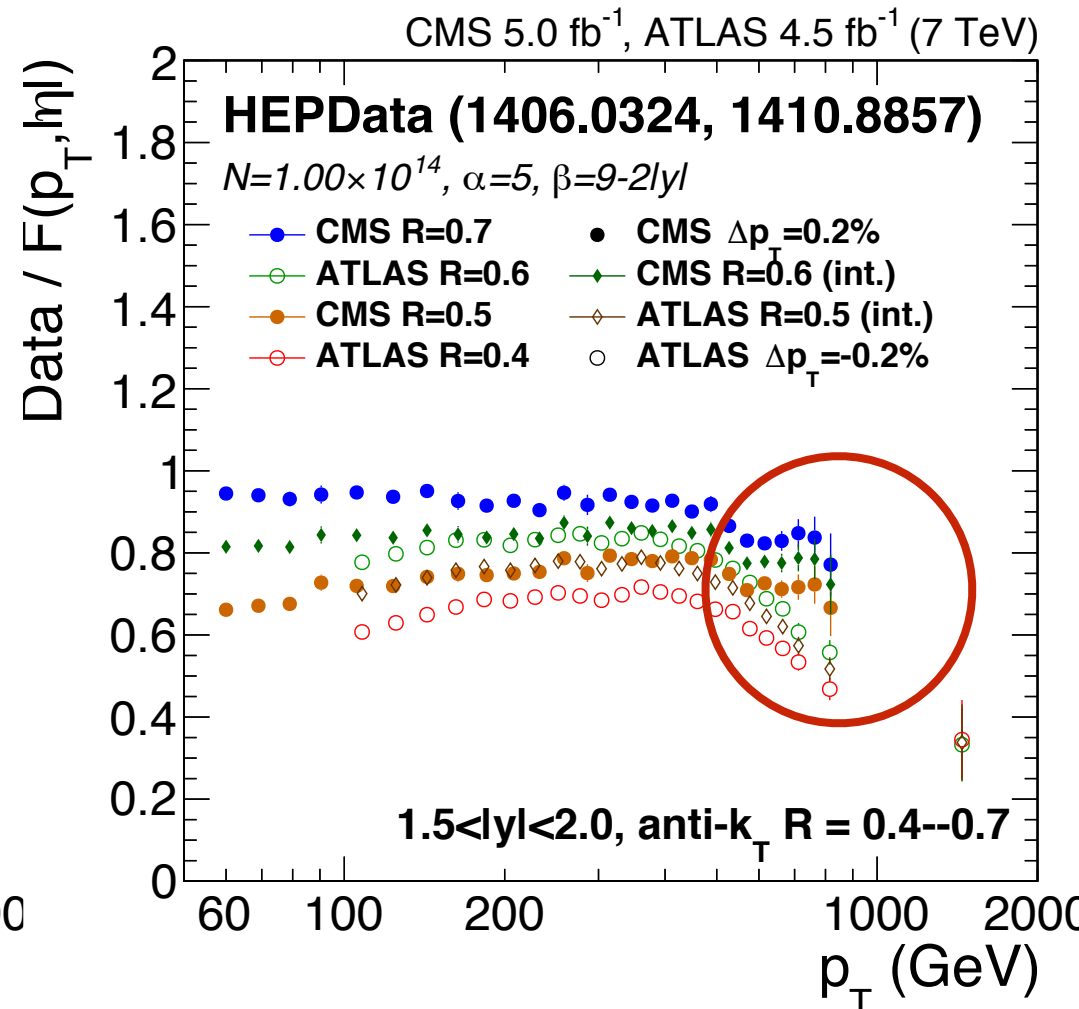
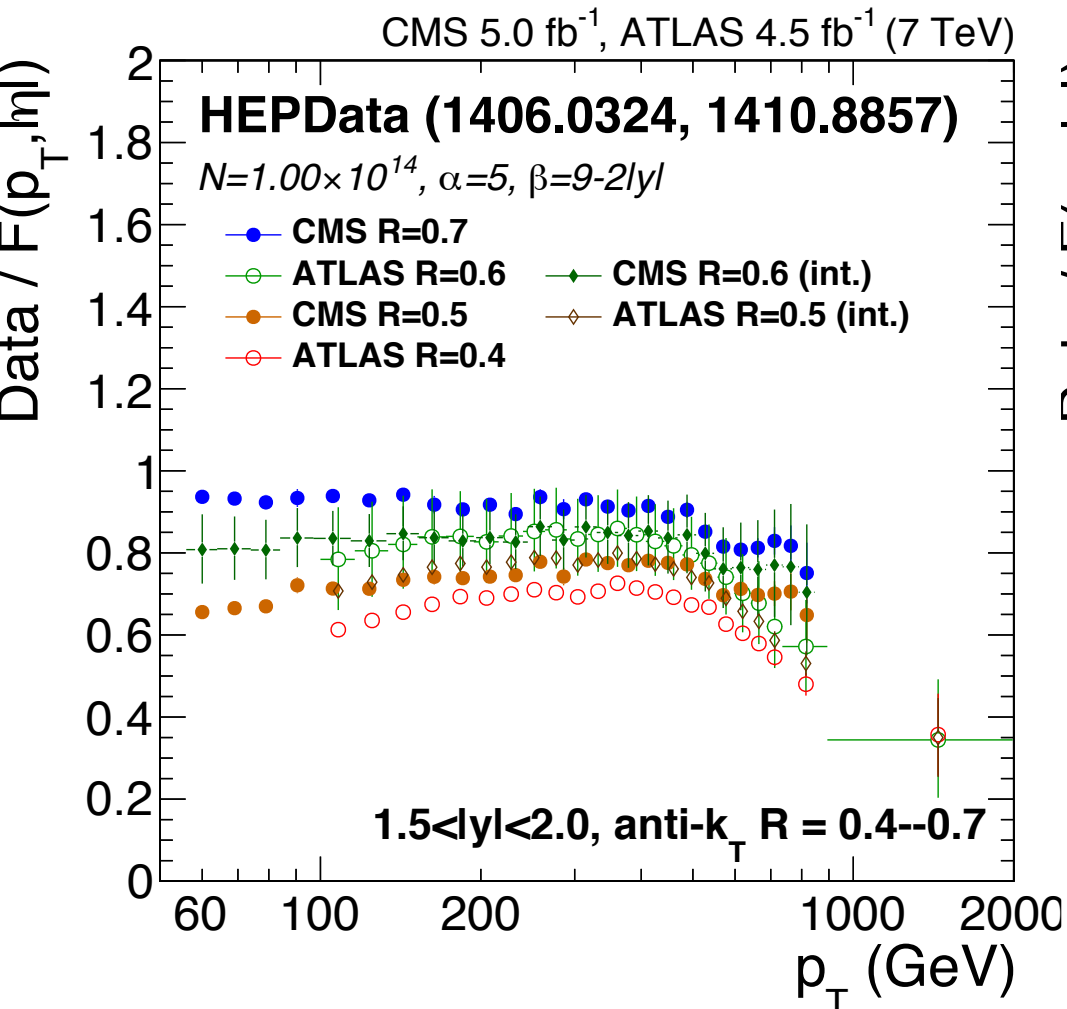
Rapidity Dependence

- Central rapidity in quite good agreement after CMS +1%, ATLAS -1% for  $\Delta JEC$
- Possibly tracked down to:
  - ▶ ATLAS FSR bias ( $p_T$  balance method used instead of MPF)
  - ▶ CMS  $p_T$  dependence (const fit due to lack of multijet and  $\gamma$ +jet statistics)

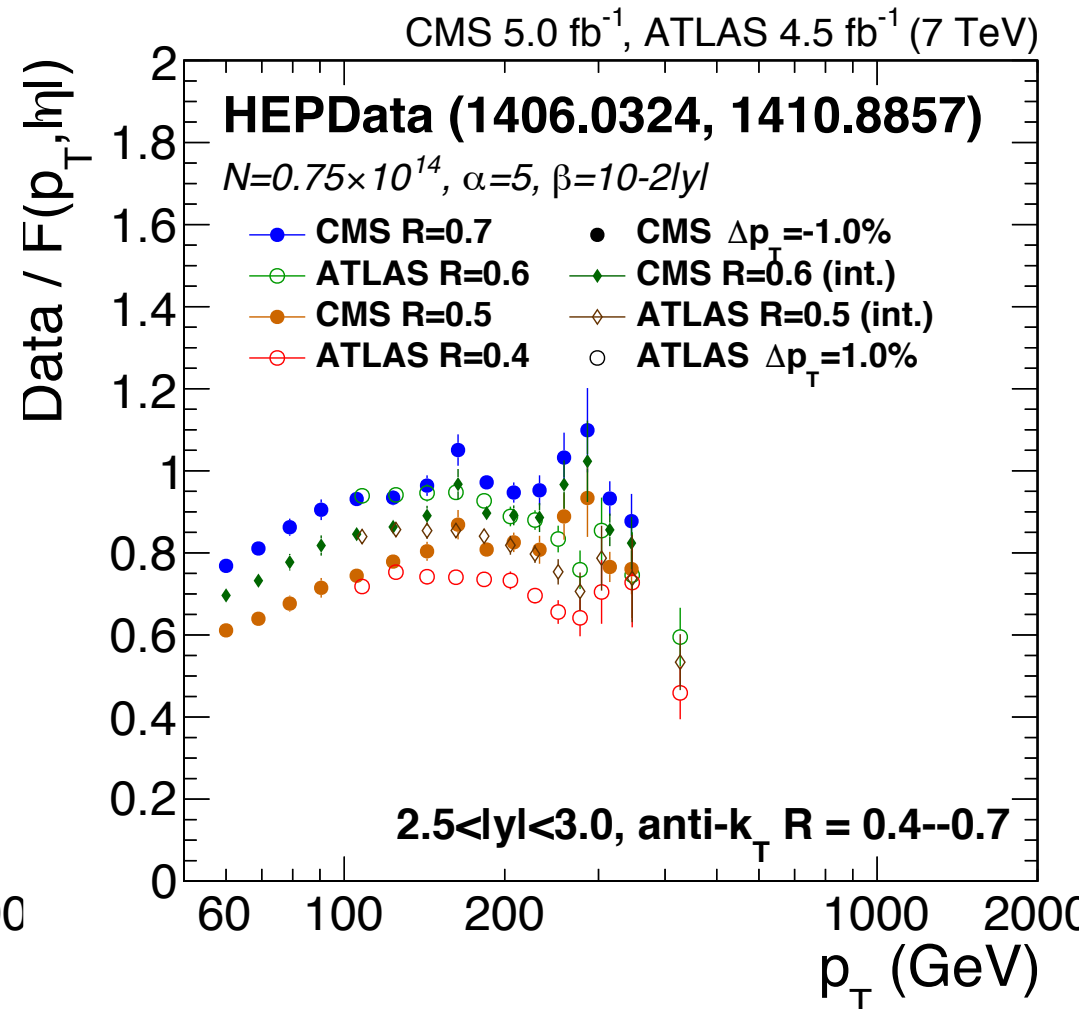
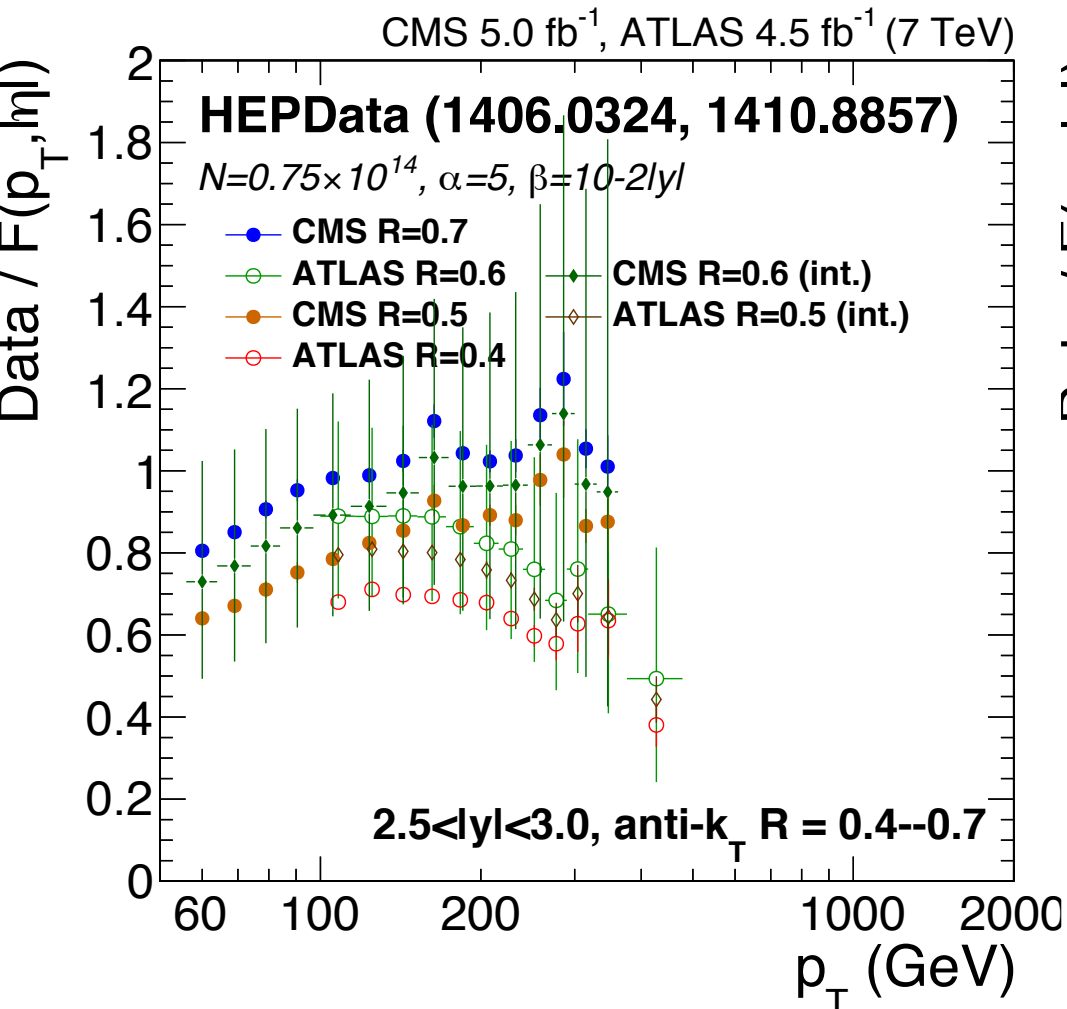


# 1.5 < |y| < 2.0

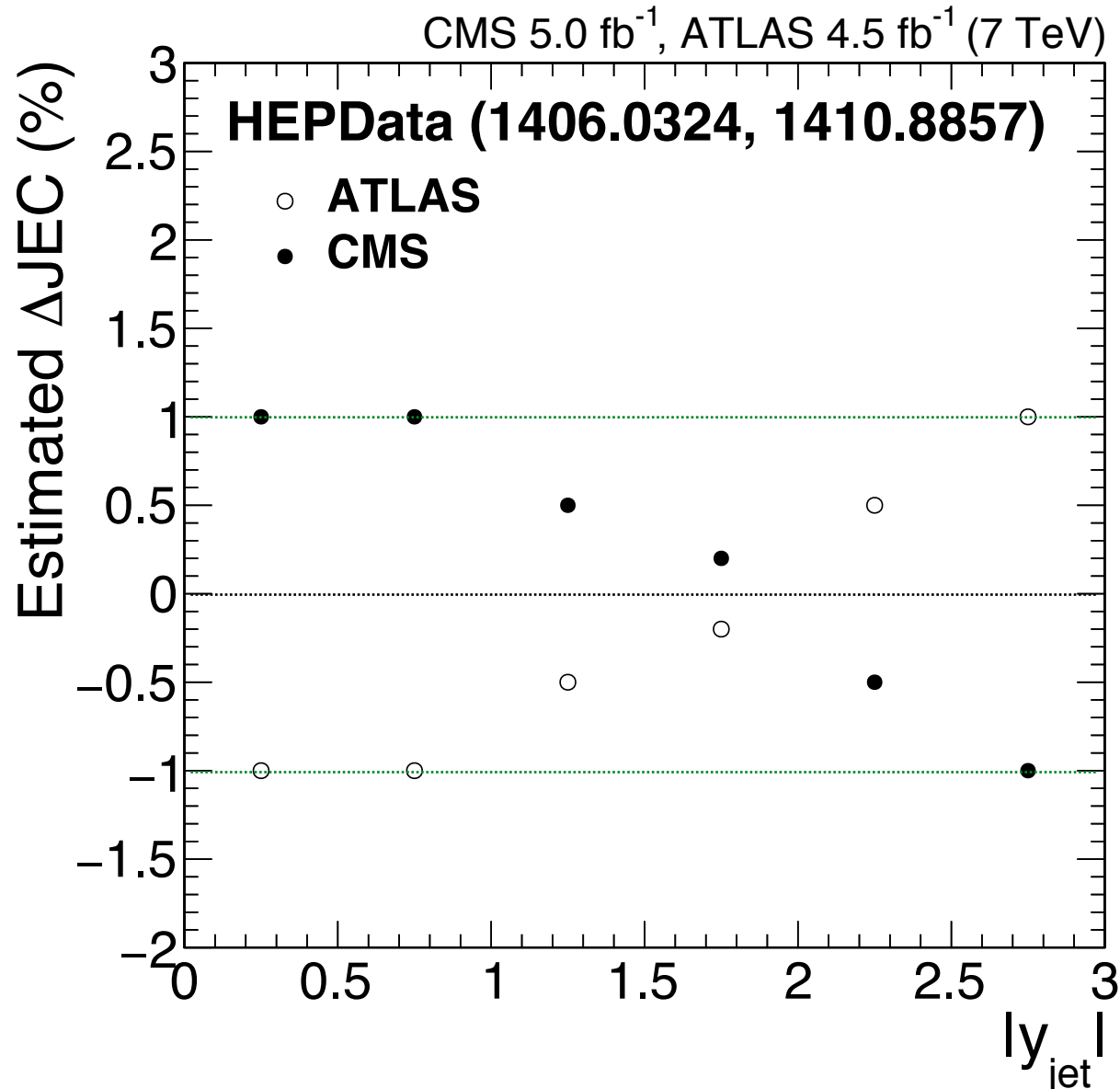
- Mid-rapidity 1.5 < |y| < 2.0 has big shape different at  $p_T > 500$  GeV
- Outside of direct Z/γ+jet reach, in barrel/endcap transition => detector effect (JEC/JER)?
- Global PDF fits have had large  $\chi^2/\text{NDF}$  for ATLAS data, could this |y| bin be the reason?



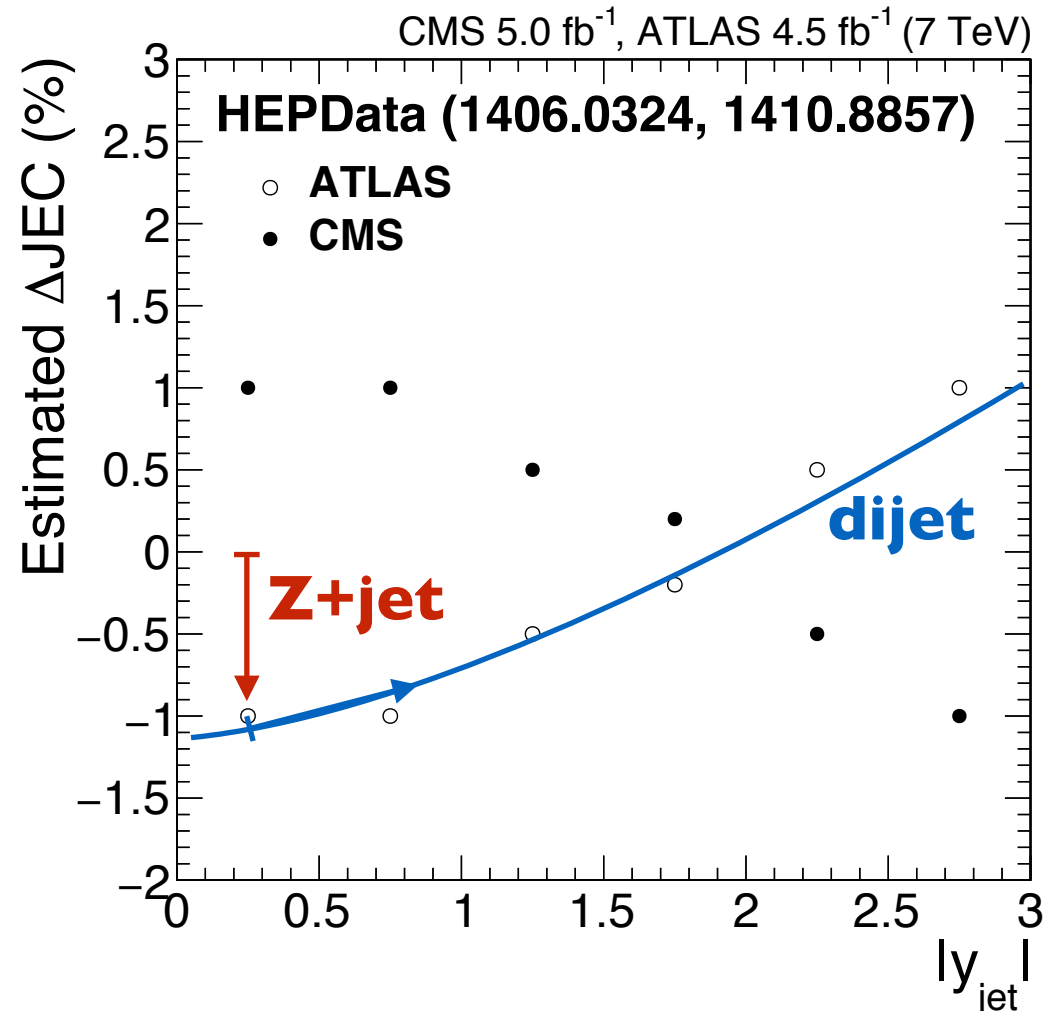
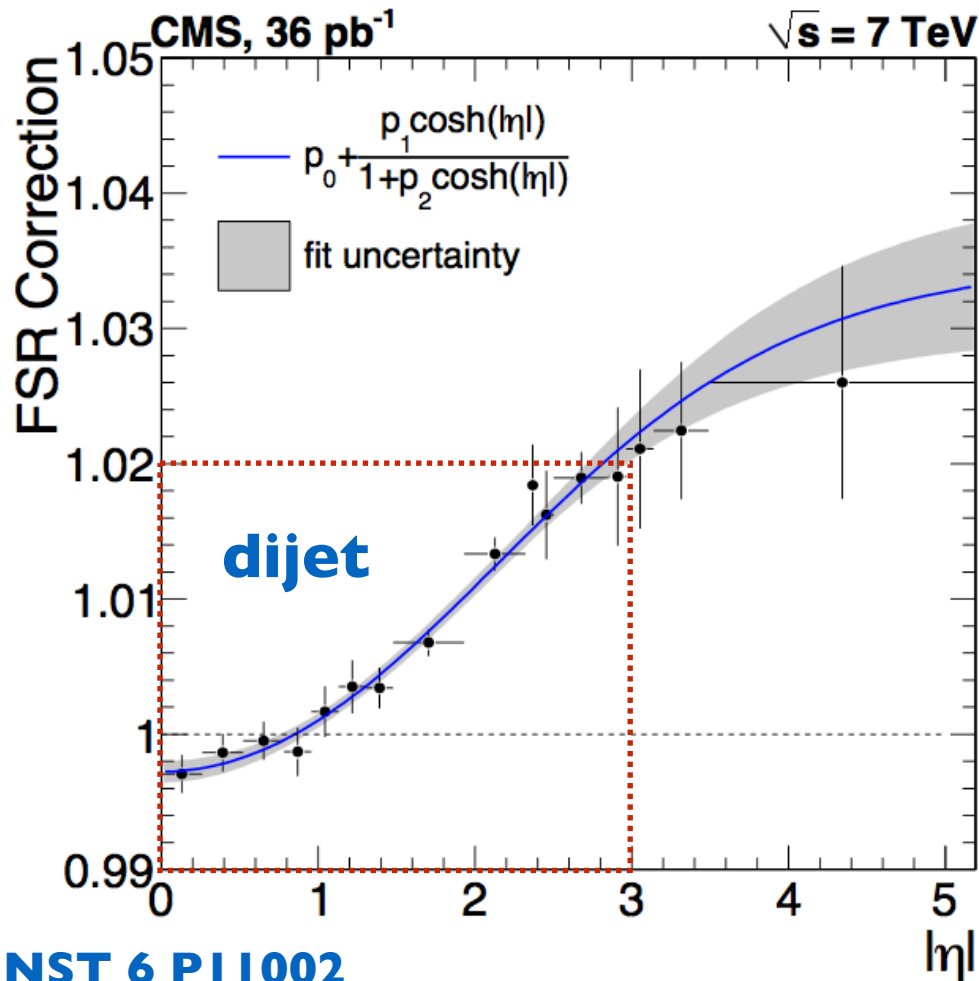
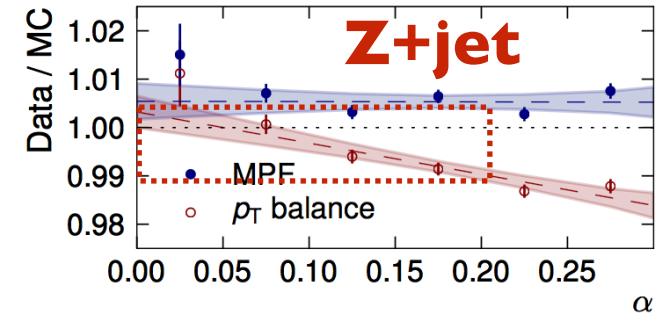
- Forward rapidity 2.5 < |y| < 3.0 in decent agreement, given large uncertainties
- $p_T \sim 200$  GeV compatible with CMS -1%, ATLAS +1%



- JEC variations  $\pm 1\%$ , well within systematic uncertainties of each experiment
- But possibly larger than either alone; estimated  $\Delta\text{JEC}$  as symmetric between CMS & ATLAS

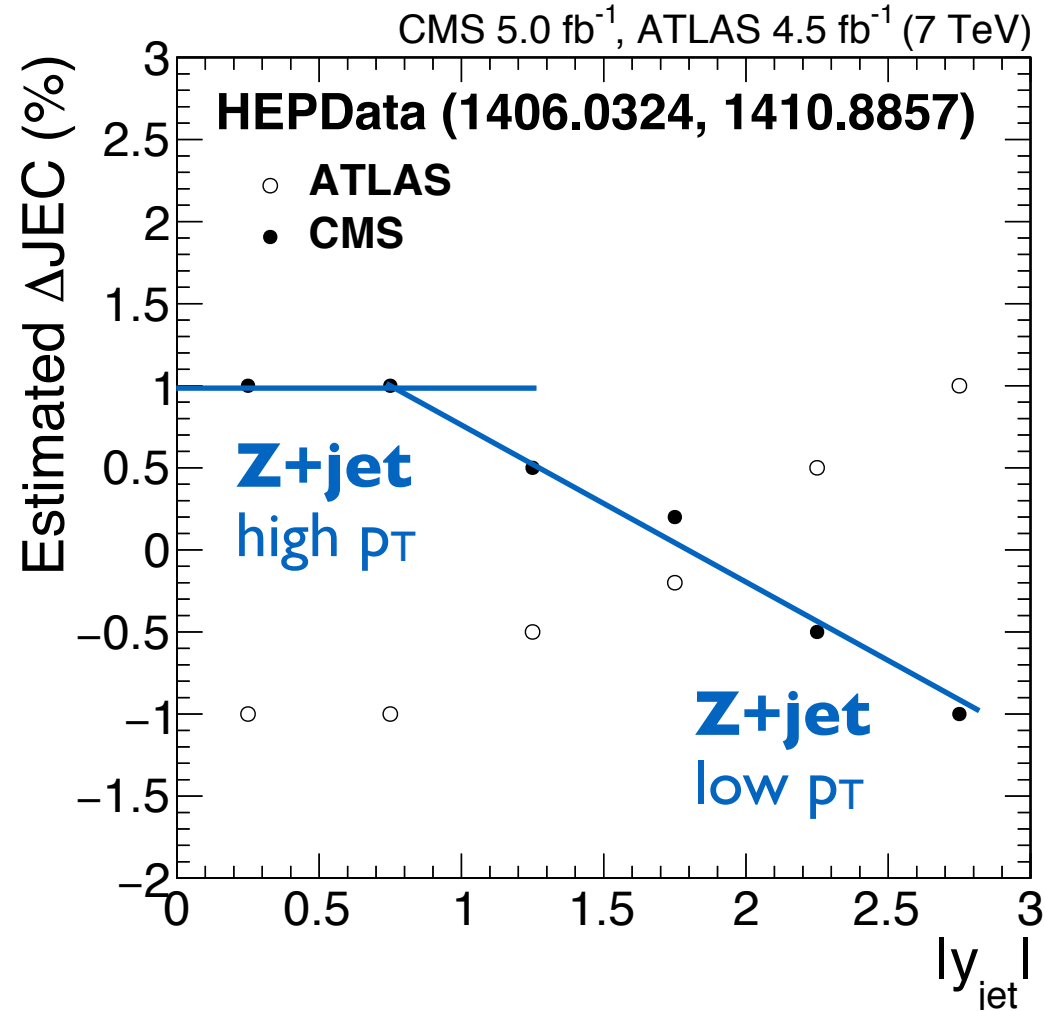
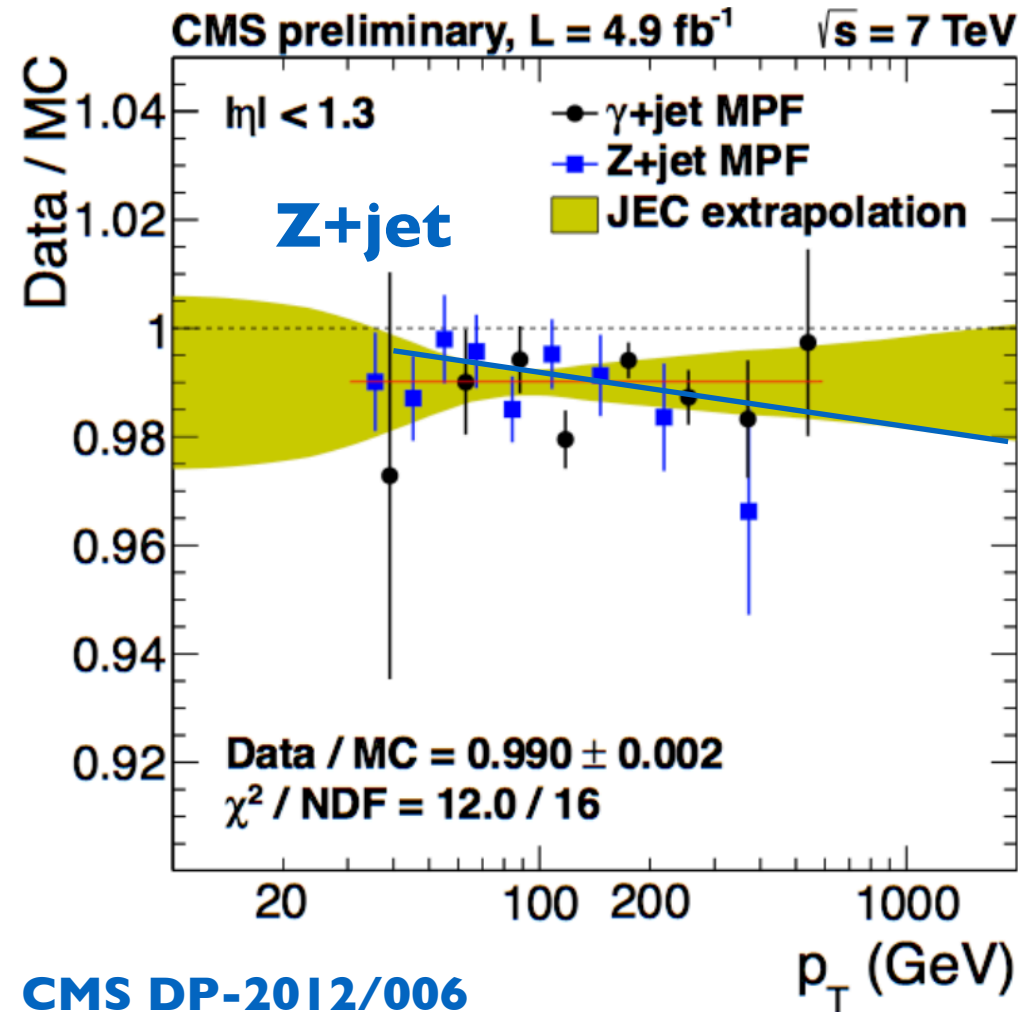
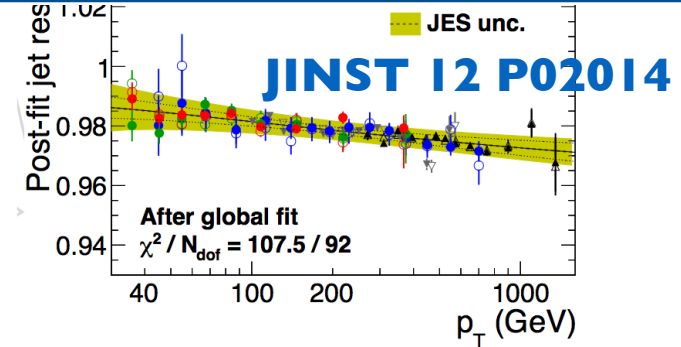


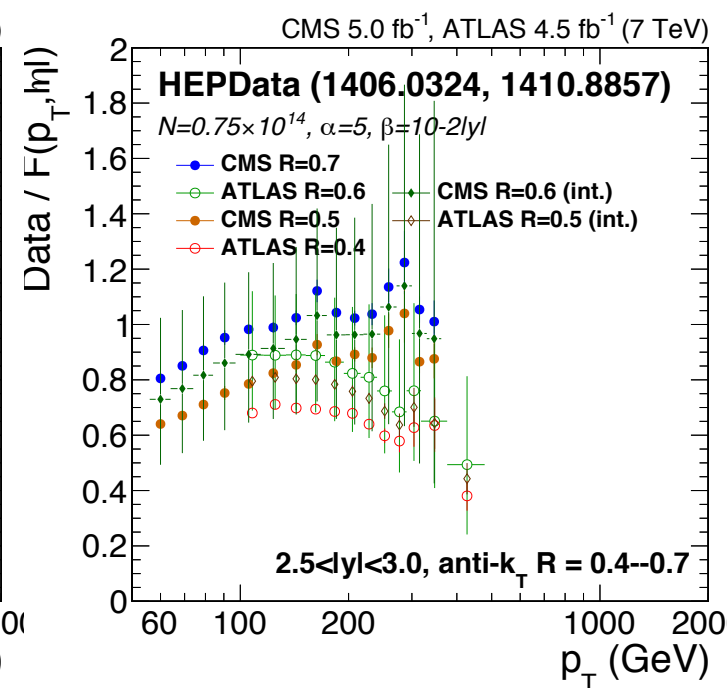
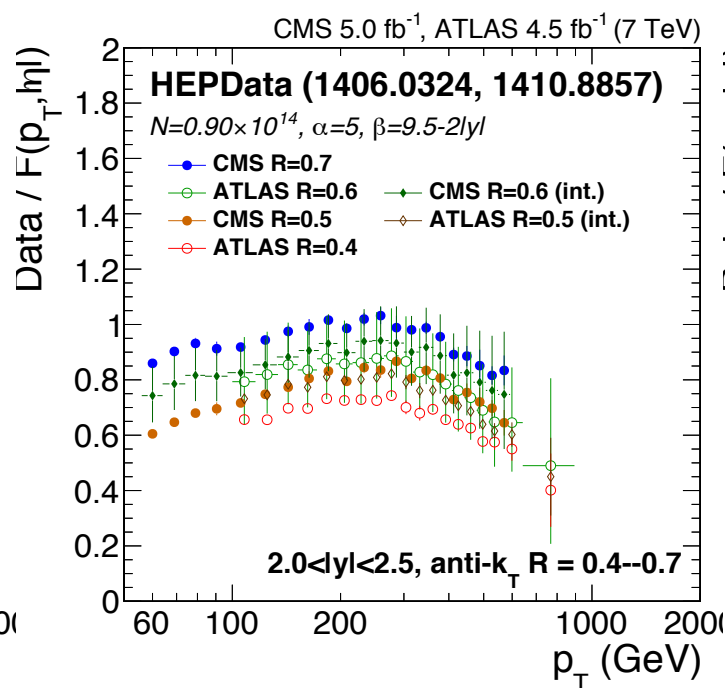
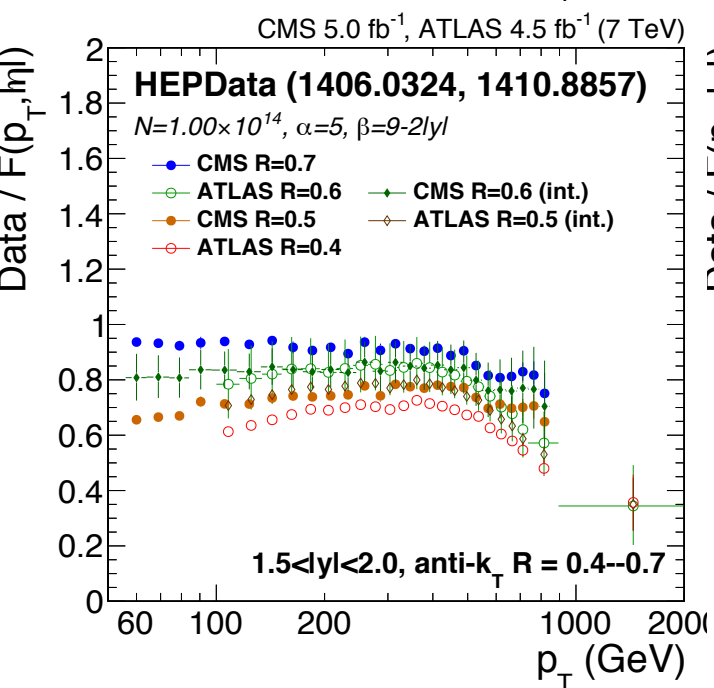
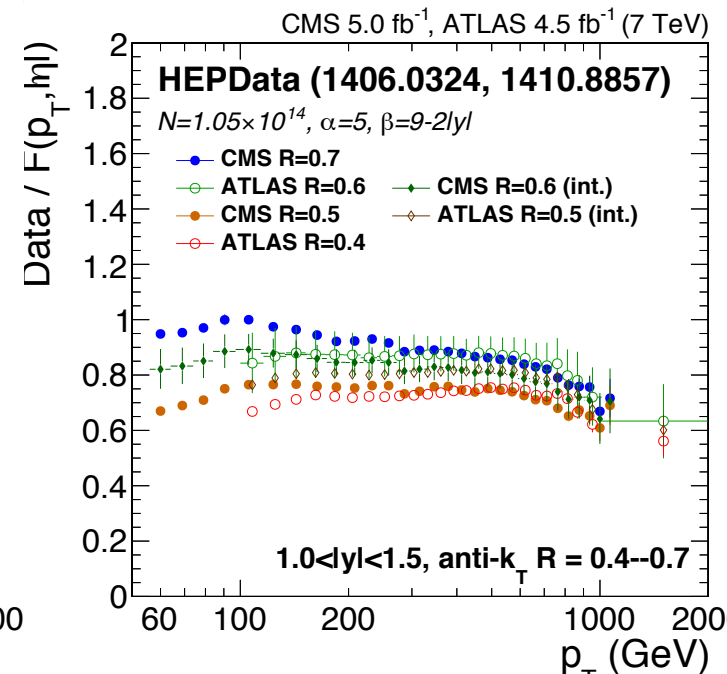
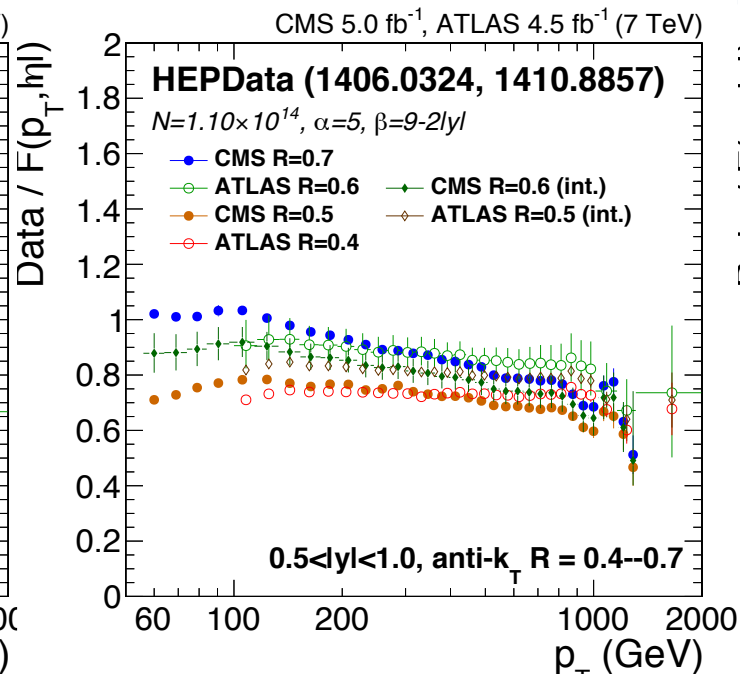
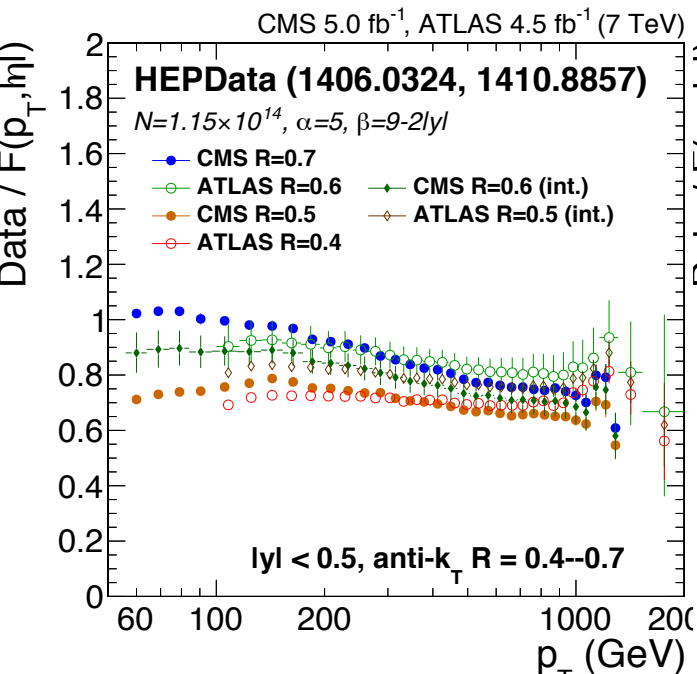
- ATLAS results fit hypothesis of residual FSR bias
  - ▶ CMS used MPF, while ATLAS used  $p_T$  balance at 7 TeV
  - ▶ -1% from Z+jet, +0% ( $|\eta|=0$ ) to +2% ( $|\eta|=3$ ) from dijet





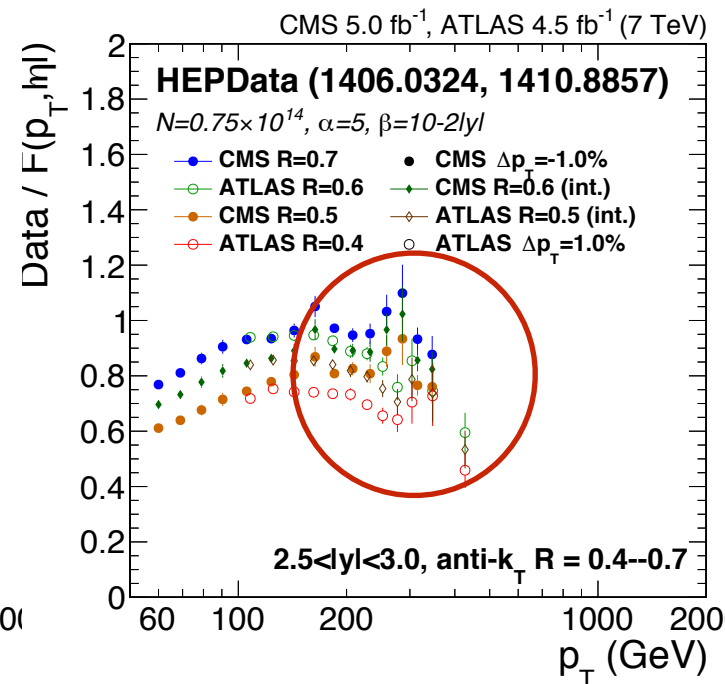
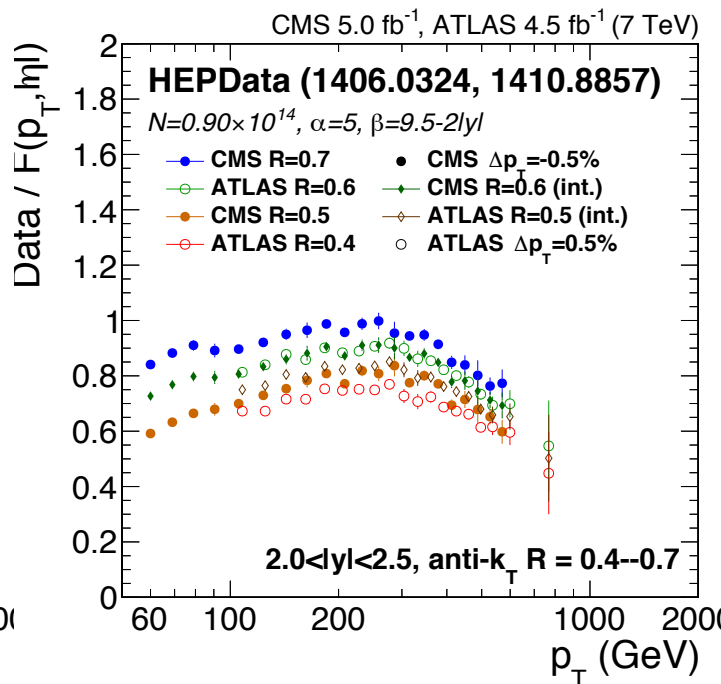
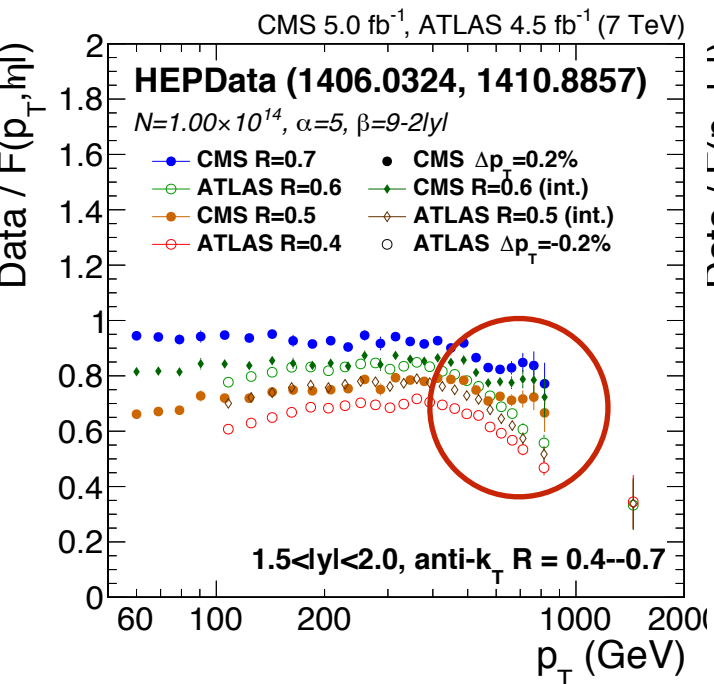
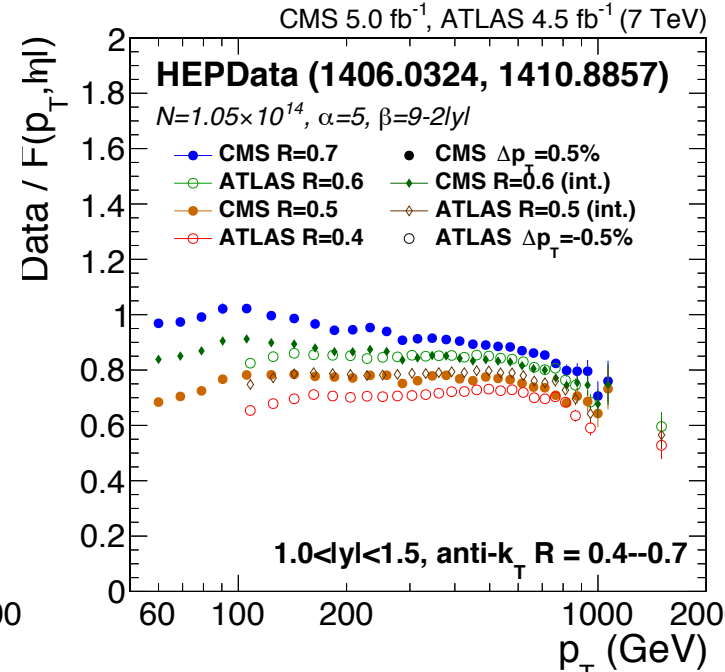
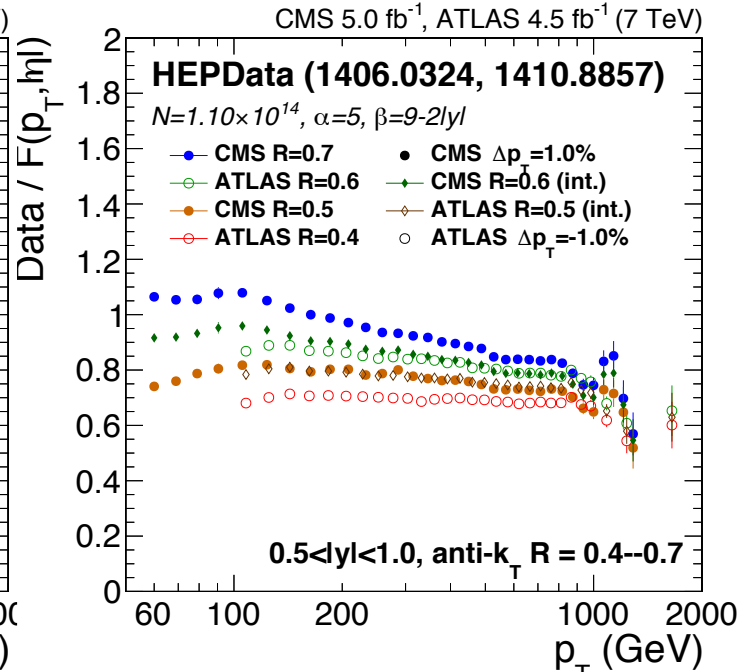
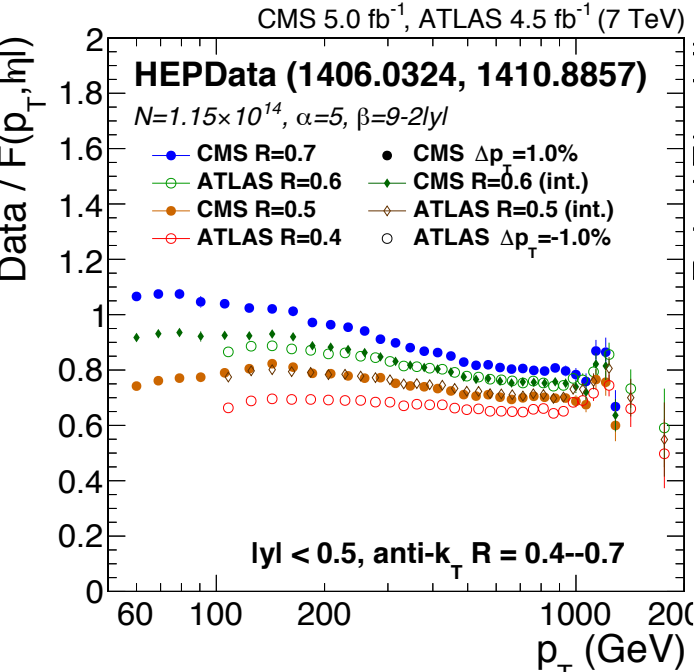
- CMS results fit hypothesis of residual Z+jet  $p_T$  dependence
  - ▶ 8 TeV data showed slope vs  $p_T$ , not enough statistics at 7 TeV
  - ▶ dijet balance: low  $|y| \Leftrightarrow$  high  $p_T$ , high  $|y| \Leftrightarrow$  low  $p_T$



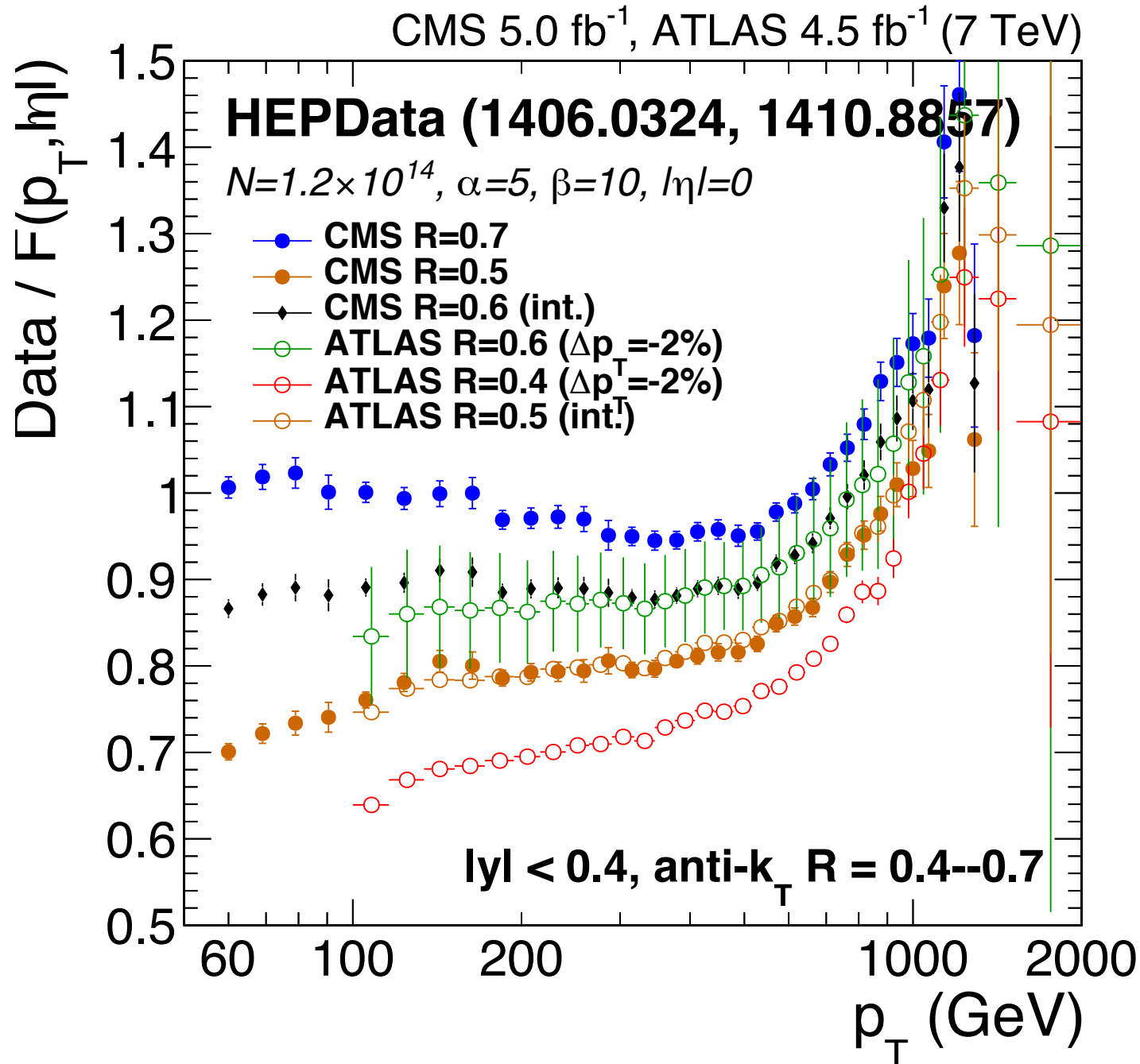




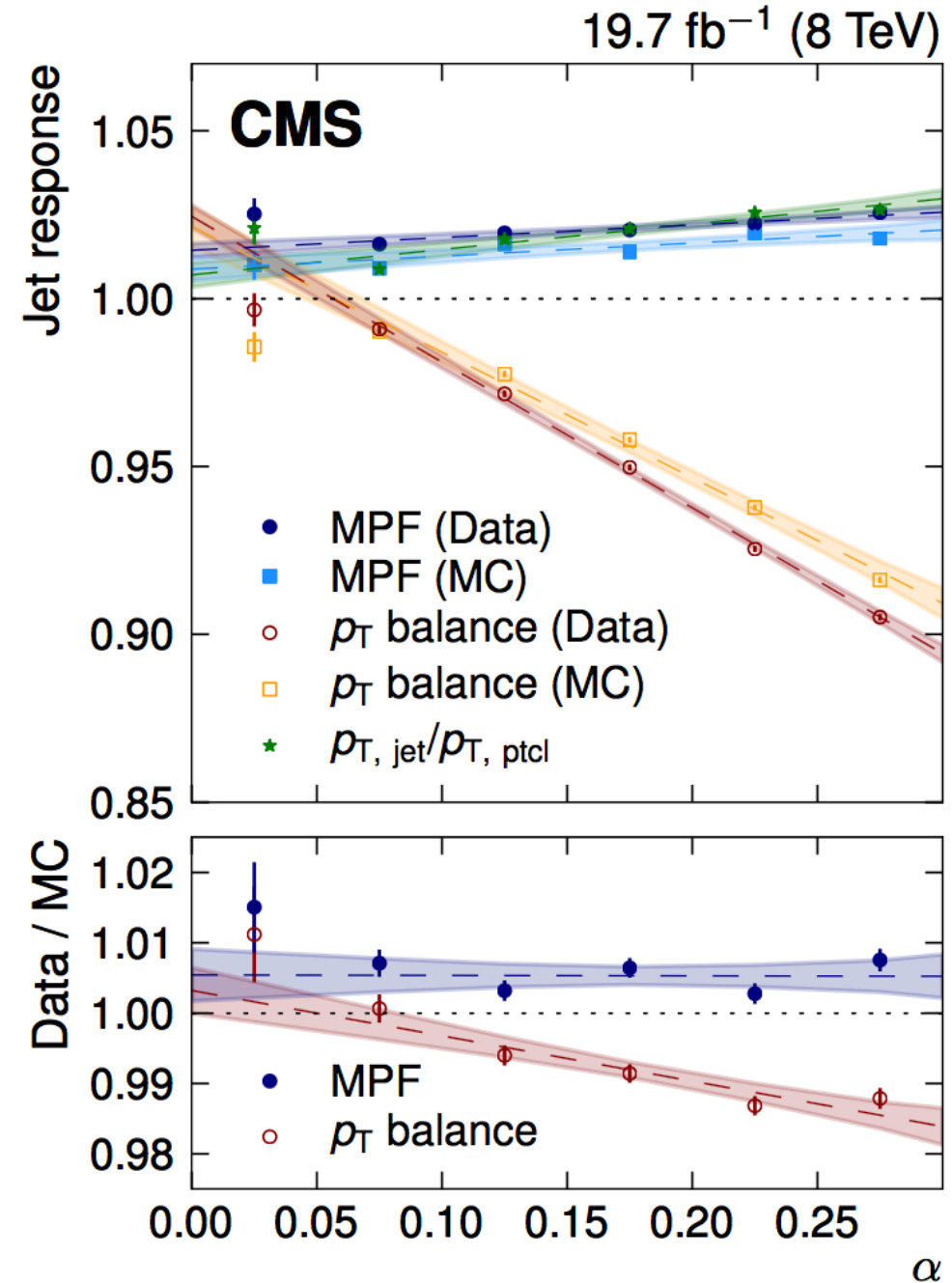
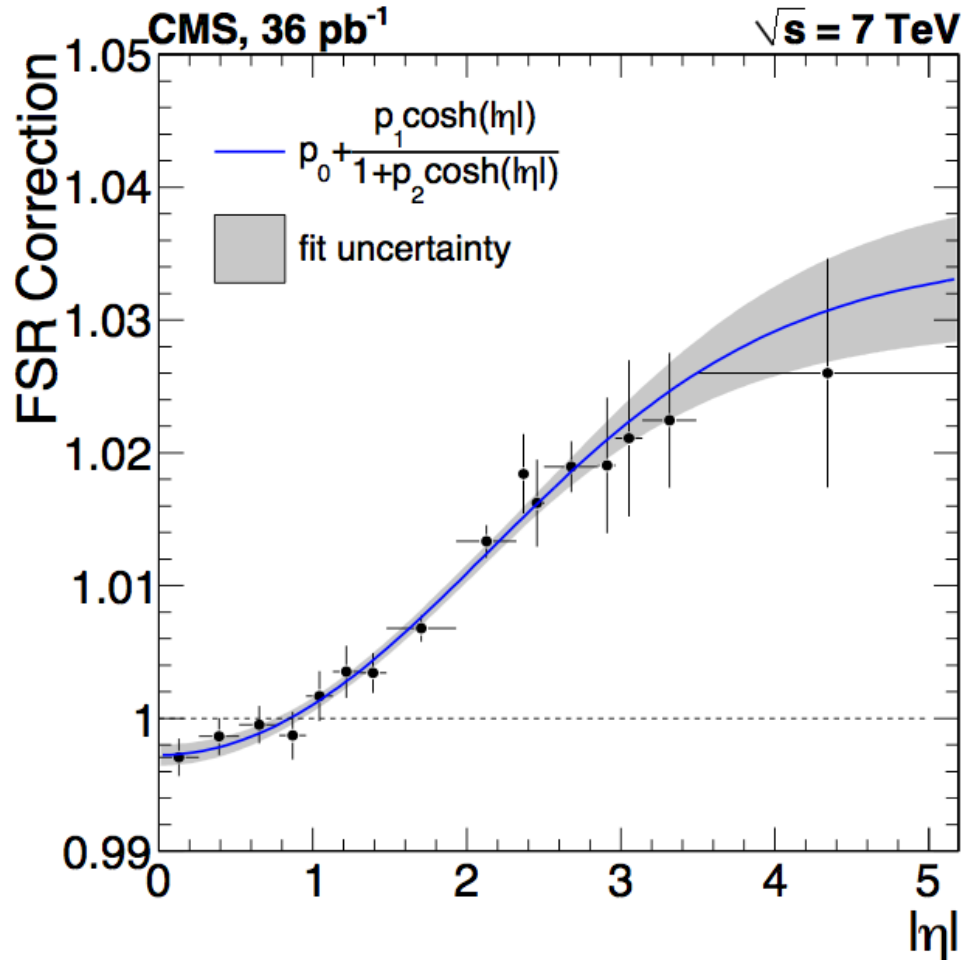
# All $|\eta|$ bins: after



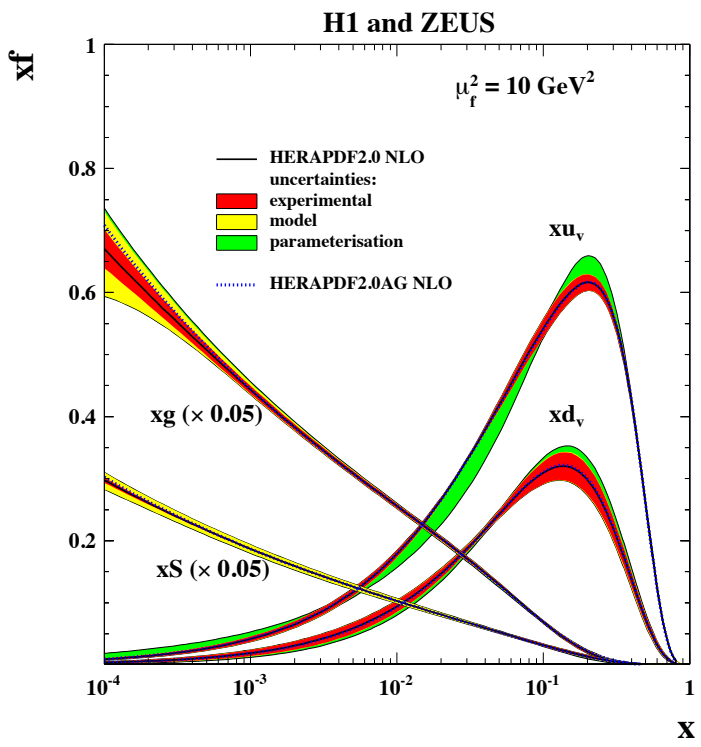
- Semi-direct comparison of ATLAS & CMS 7 TeV data
  - ▶ R difference by  $\log(R)$  interpolation
  - ▶  $p_T$  bin difference by  $F(p_T, \eta)$  interpolation
  - ▶  $d\sigma/dp_T$  difference by  $\Delta JEC$  (or unc. sources later)
- Combination of 7 TeV data looks feasible
- Even if we don't combine, there's a lot to learn about **JEC correlations**
- Before:  $m_t, m_W$ 
  - ▶ little sensitivity to  $p_T, \eta$  differential correlations
  - ▶ derived with very different and complex methods
  - ▶ observable not well defined at hadron level



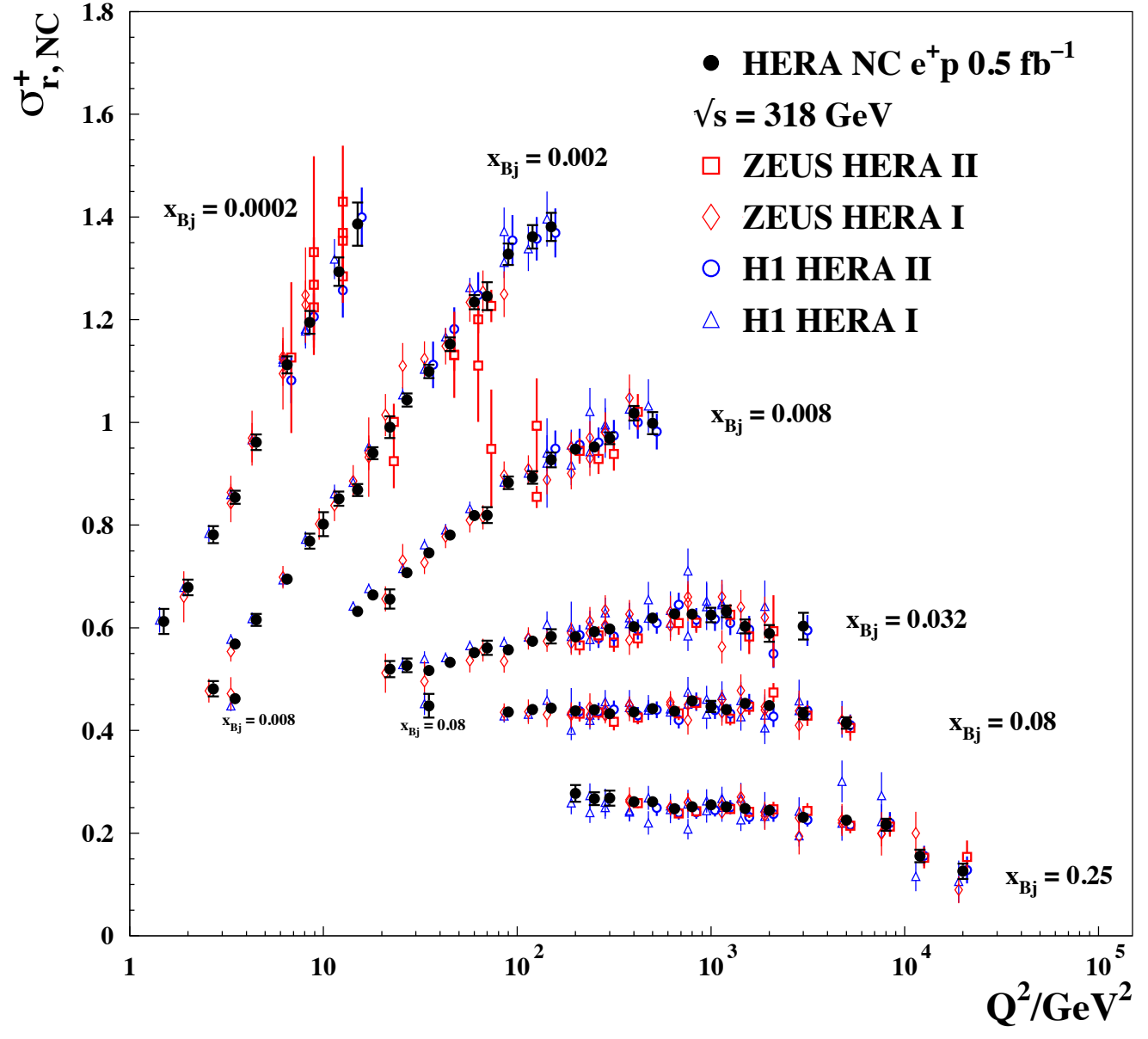
- Next step is to add nuisances and do  $\chi^2$  fit
  - ▶ compare uncertainties and study potential gains
  - ▶ investigate also 8 TeV data as available
- Check if existing nuisances have appropriate size and shape to account for FSR and  $p_T$  dep.



- To what level would we like to proceed with LHC combination/comparison?
- HERA (Zeus, H1) did it. How was it received?
- No **LHCPDF** without CMS and ATLAS combination?



## H1 and ZEUS



[arXiv:1506.06042](https://arxiv.org/abs/1506.06042)