V+jets MC predictions, Tevatron comparisons & LHC extrapolation: A look at PS generator dependence

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Context

- Vector Boson (VB) + Jets is a very important background at LHC.
- We now have NLO predictions up to W+3 jets which are in a very good agreement with measurements.
- For analyses we need hadronic final state event samples, which currently means LO ME-PS matched tools.
- We need to make sure these tools are reliable – we should compare to the available Tevatron data and NLO predictions.
- Even after doing this, there can be a large uncertainty in the extrapolation of the VB + Jets models to the LHC.

VB + Jets Measurements

- SM measurements are fundamental inputs to the successful modelling of SM backgrounds to searches.
- Tevatron has produced several VB + Jets measurements that can be directly compared against models:
  - Reduced model dependence
  - Detector unfolded
- We should make the best use of these results to constrain the predictions, but there can still be uncertainties in the extrapolation to the LHC…
- It is extremely important to make measurements of VB + Jets at the LHC as soon as data are available and in a fashion that facilitates direct comparison with the theoretical models.

Outline

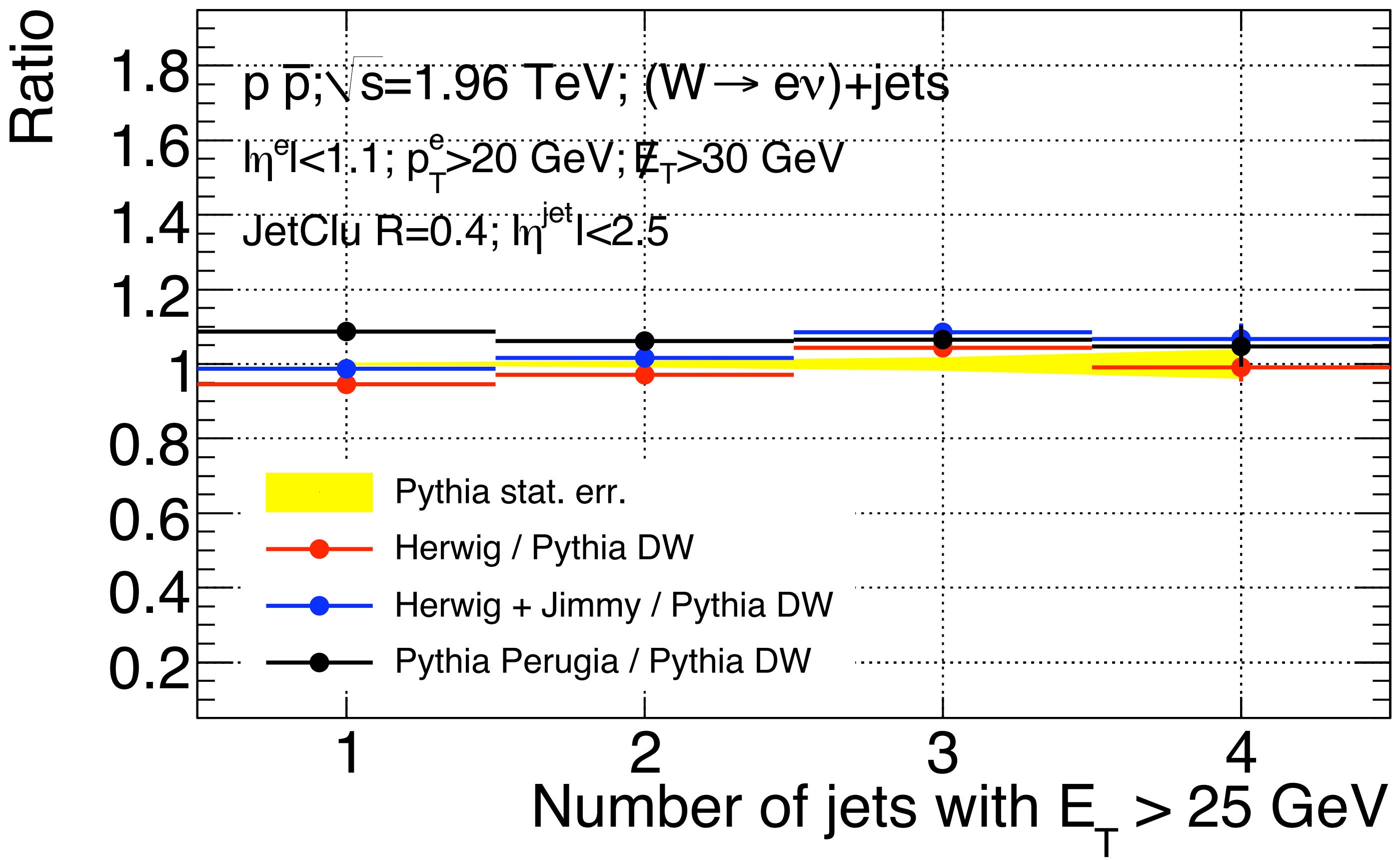
- We will examine the dependence of Alpgen ME-PS predictions on some PS Monte Carlo generators which have been tuned to describe soft, inclusive processes (MB,UE,Drell-Yan).
- We will show that the impact on VB + Jet predictions of different generator choices is significant.
- We will explore the level of agreement of these different models on some of the available Tevatron W/Z+Jets measurements.
  - These measurements have different observable definitions.
  - It is not obvious that a tune succeeding in one place will not fail somewhere else.
- We will show that using 2 models that well reproduce data at 1.96 TeV exhibit significant differences when extrapolated to 10 TeV.
- The exact results of these comparisons can be marginally dependent on the exact choice of observable (jet alg, cone size), but the conclusion is the same.

Dependence of VB + Jets Predictions on PS Generators

Generator Details

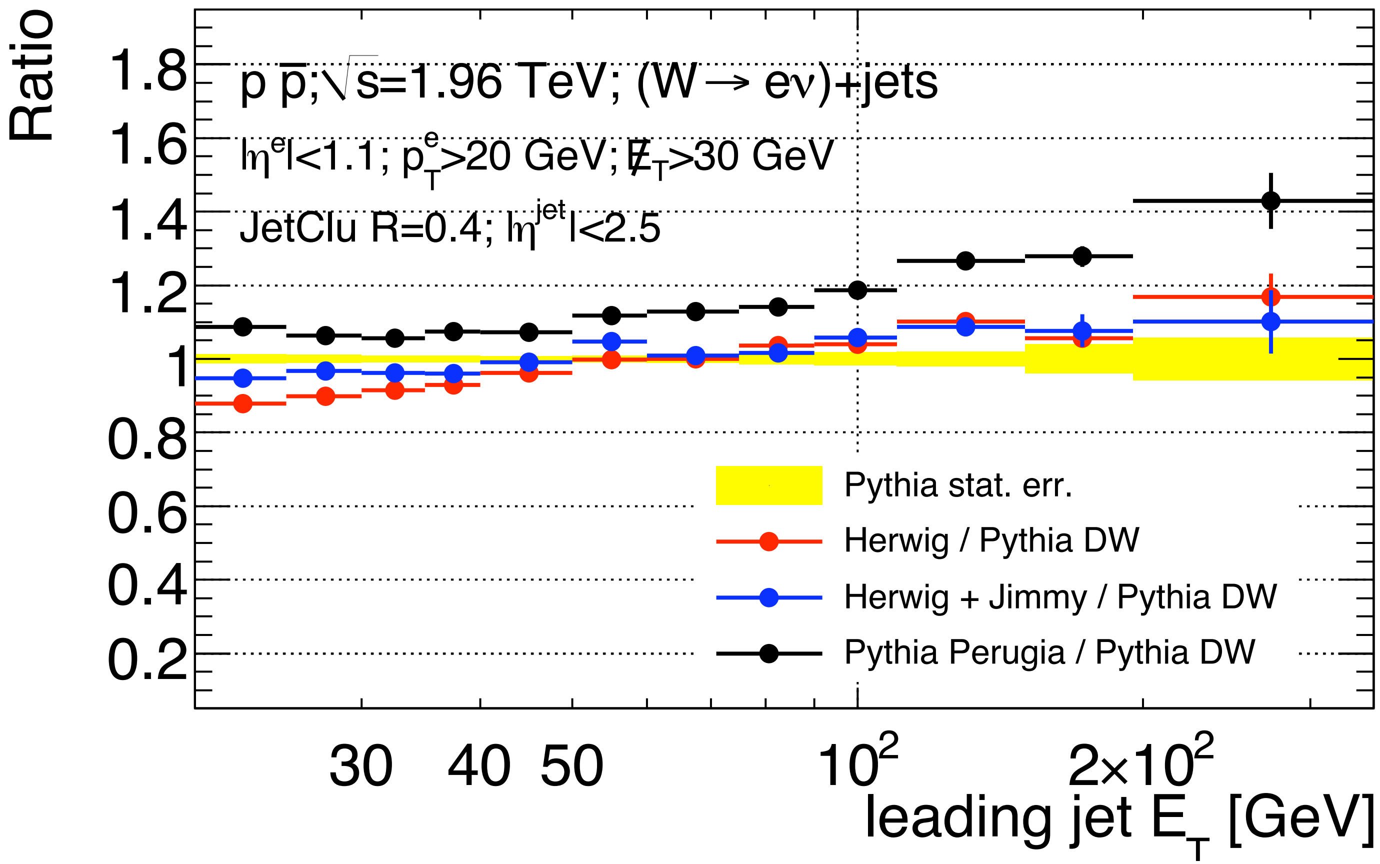
- All predictions use Alpgen v2.13 interfaced to a particular PS generator:
  - Pythia 6.4.21, “DW” tune (MSTP[5]=103) Old shower.
  - Pythia 6.4.21, “Perugia” tune (MSTP[5]=320) New shower.
  - Herwig 6.5.10
  - Herwig + Jimmy 4.1, ATLAS MC08 tune: JMRAD(73)=1.8, PRSOF=0, PTJIM = $2.8*(\sqrt{s}/1.8)^{0.274}$
- Alpgen parameters:
  - PTJMIN = 15 GeV, DRJMIN = 0.4, ETAJMAX = 2.5
  - ETCLUS = PTJMIN+5
  - PDF = CTEQ5L (CTEQ6L1 for Jimmy)
- We produce a combined 0parton – 4parton cross-section prediction at the stable particle (hadron) level (jets clustered using FastJet).

nJet Spectra Cone 0.4



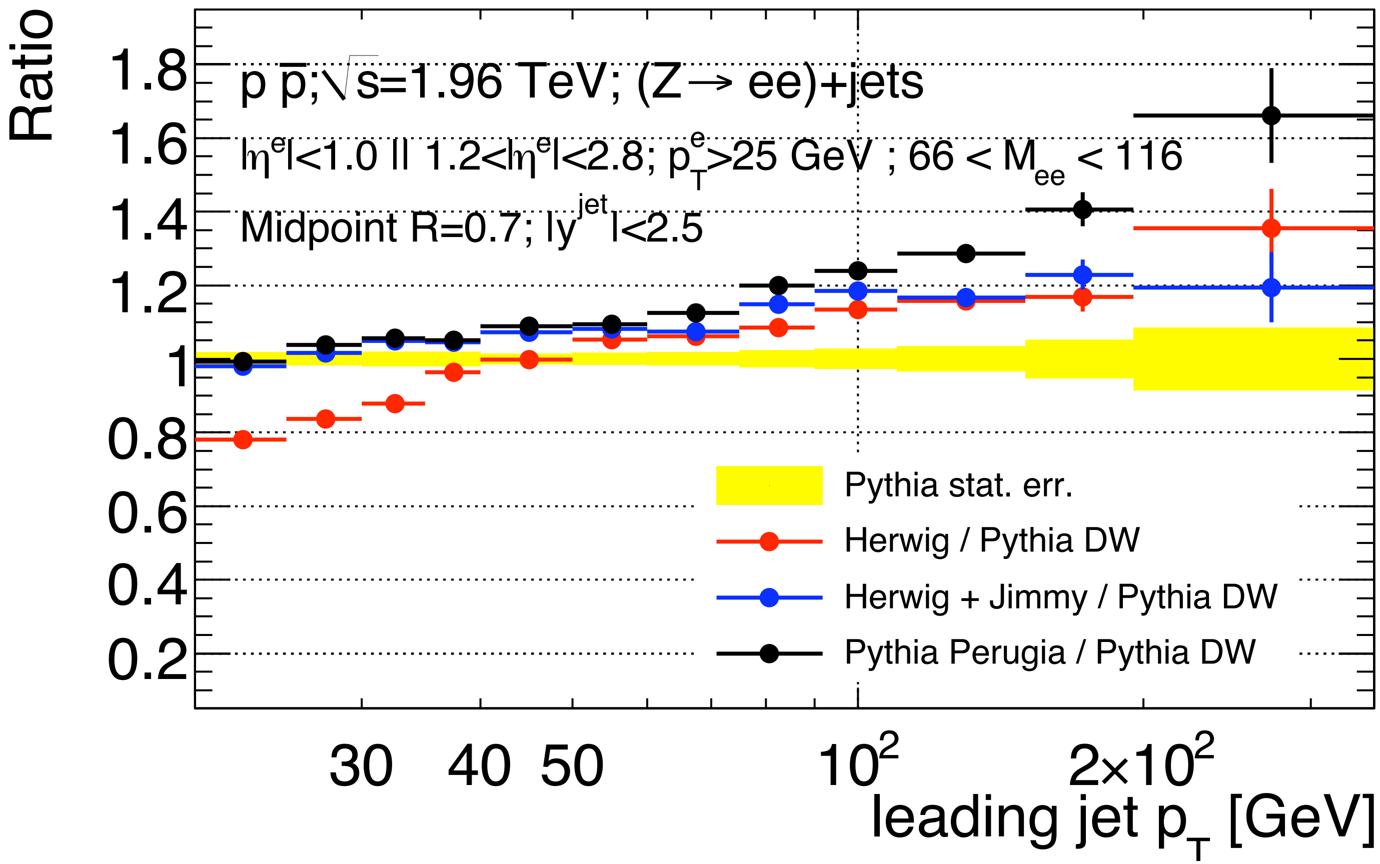
- Predictions agree to within 10% on rate of jets Et > 25 GeV.

W+Jets Lead Jet E_T Cone 0.4



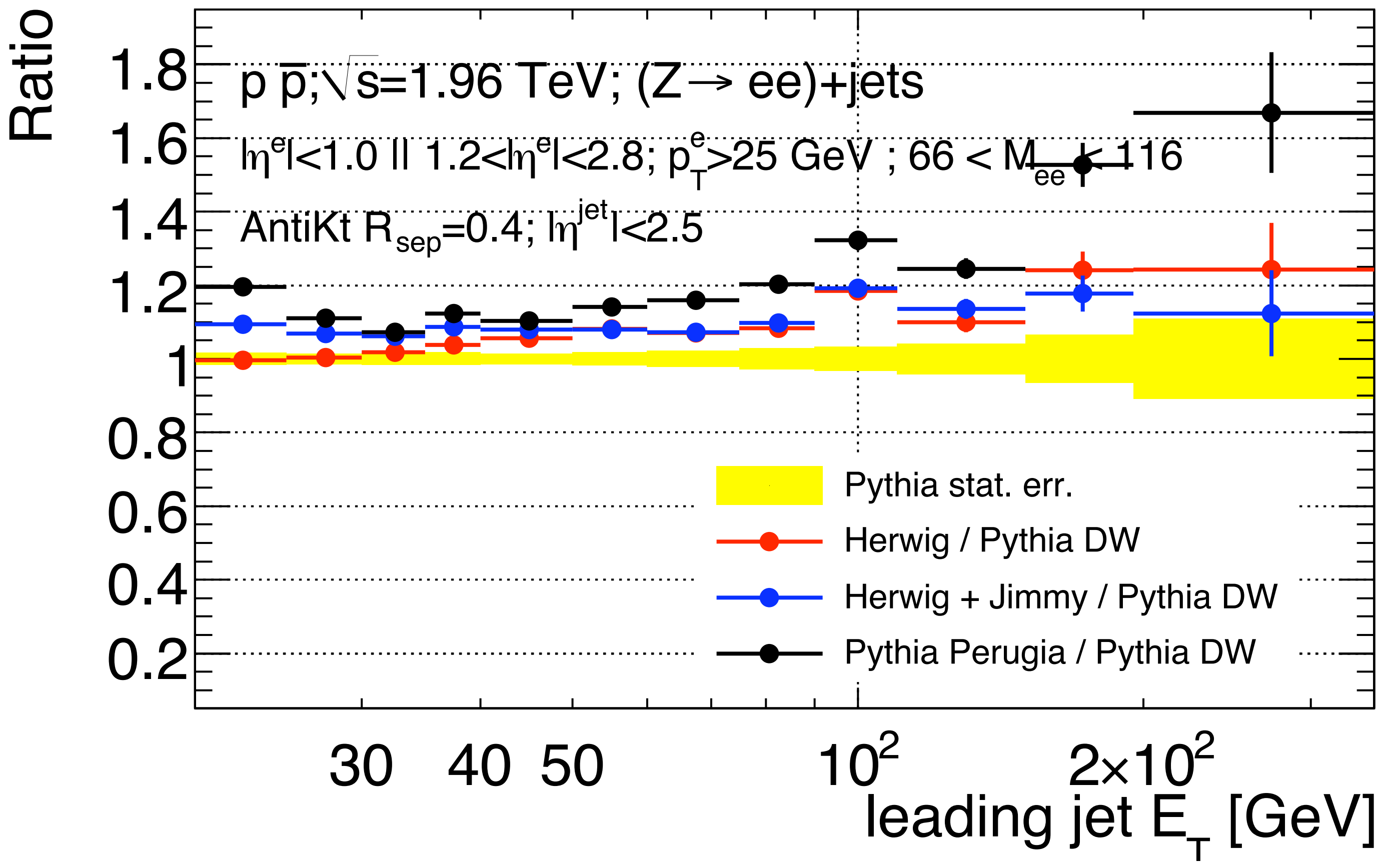
- Jimmy model improves Herwig-Pythia agreement at low E_T.
- Pythia-Perugia predicts a considerably harder jet spectra than DW or Herwig.

Z+Jets Lead Jet p_T Cone 0.7



- Jimmy model improves Herwig-Pythia agreement at low E_T.
- Pythia-Perugia predicts a considerably harder jet spectra than DW or Herwig.

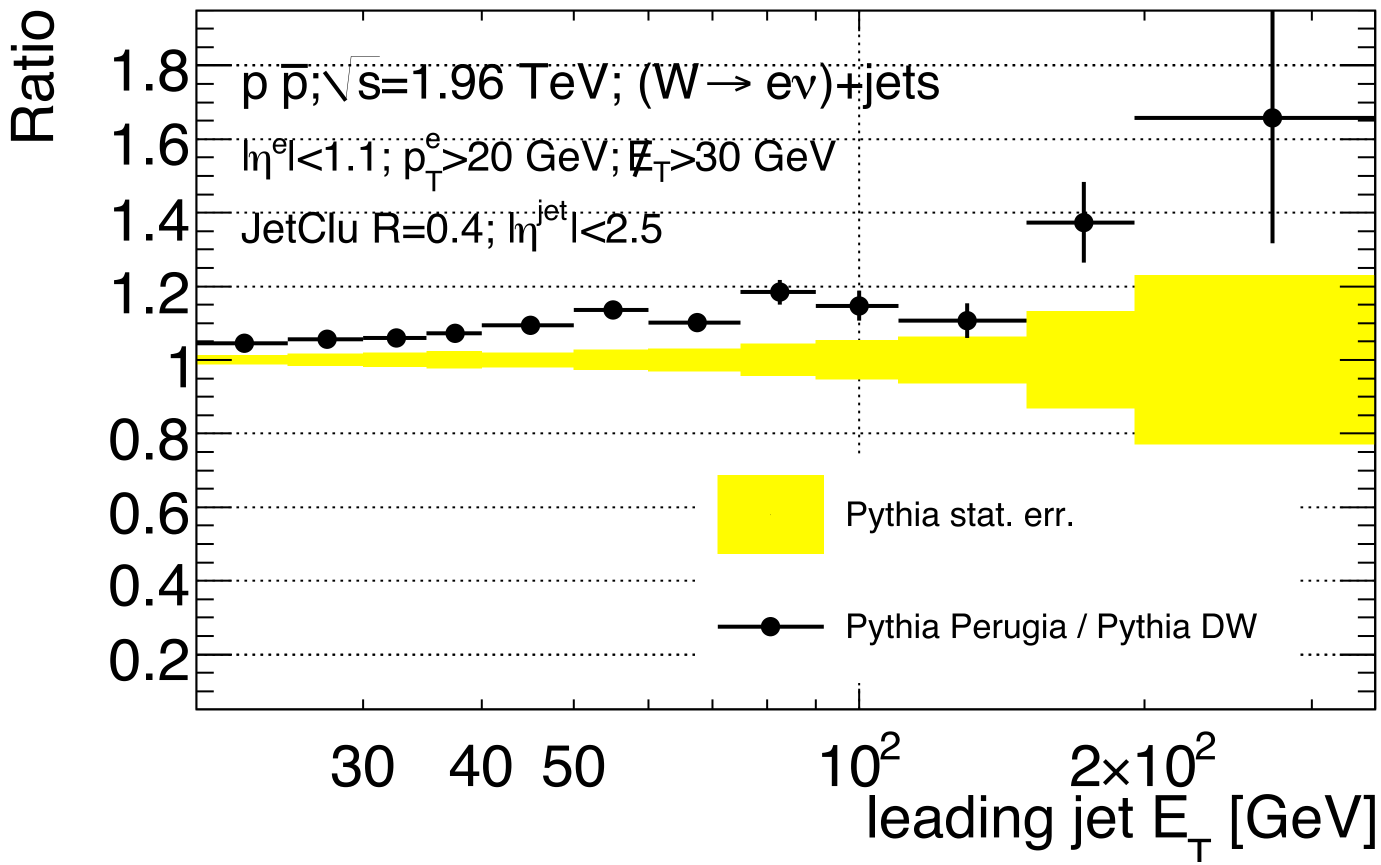
Z+Jets Lead Jet p_T AntiKt



- Pythia-Perugia predicts a considerably harder jet spectra than DW or Herwig.

Pythia 1p Standalone Prediction

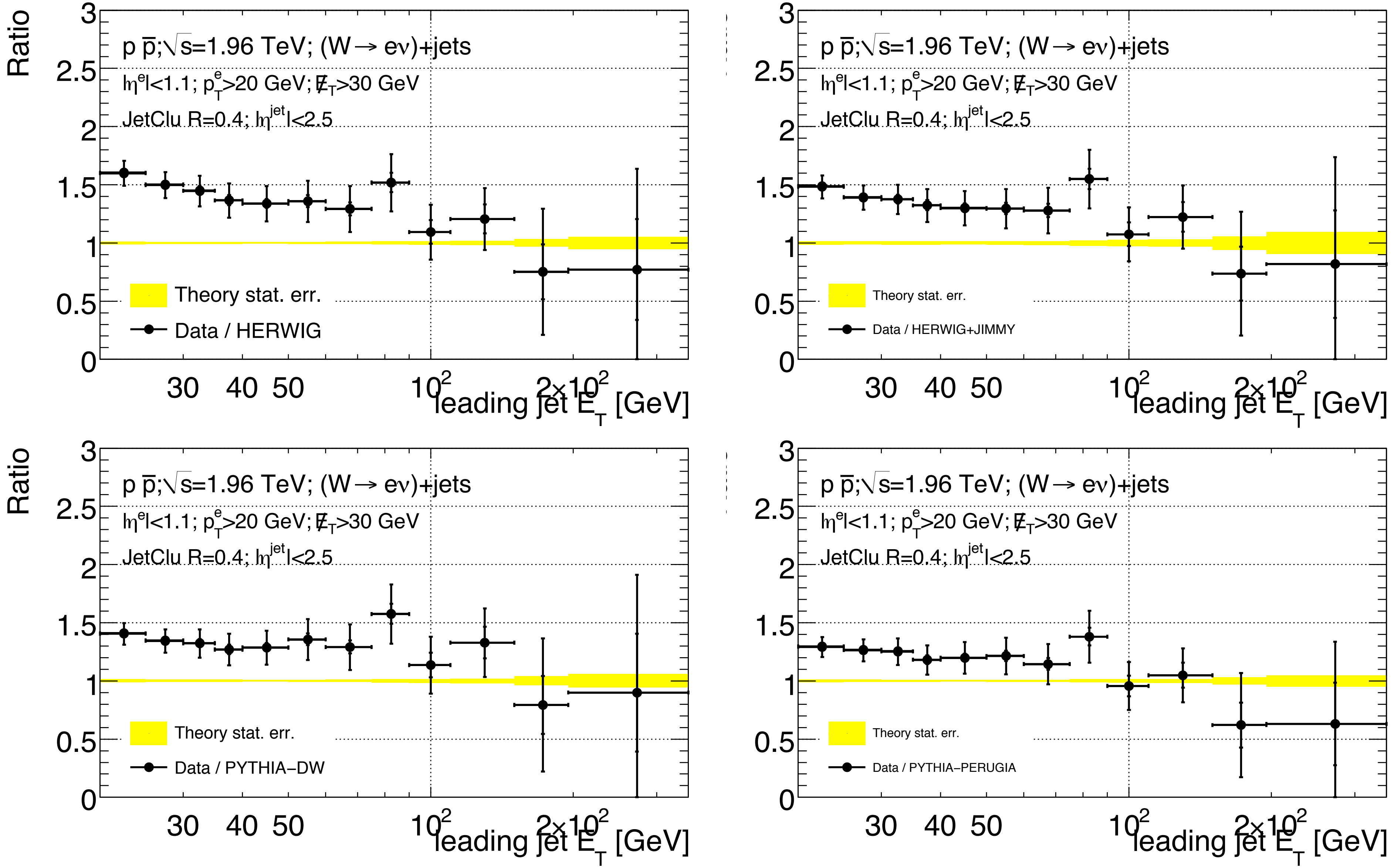
- In case you were wondering about ME and PS matching affecting the conclusions..



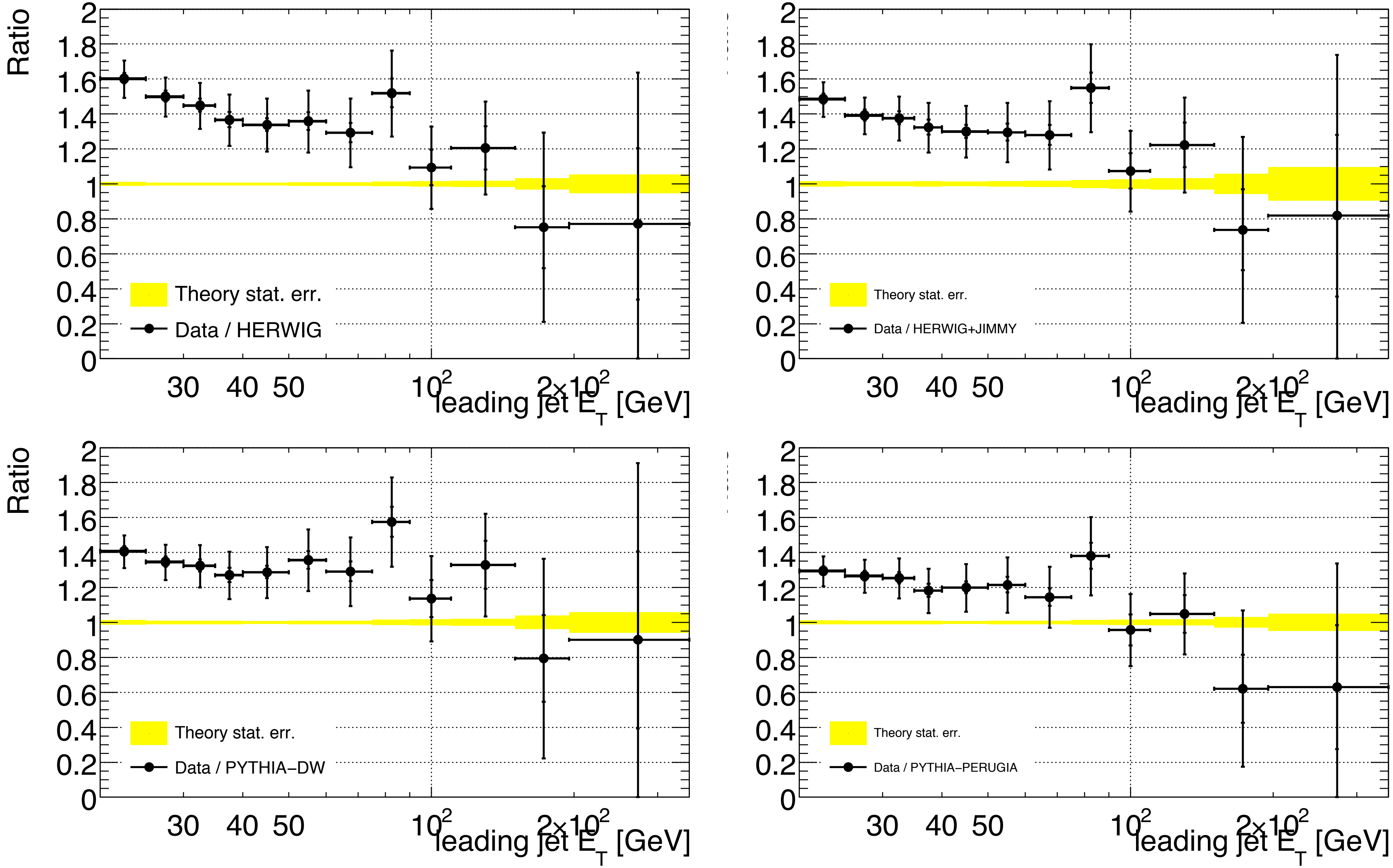
Comparisons to Tevatron VB + Jets Data

We see differences between the MC – does the data prefer one over the other?

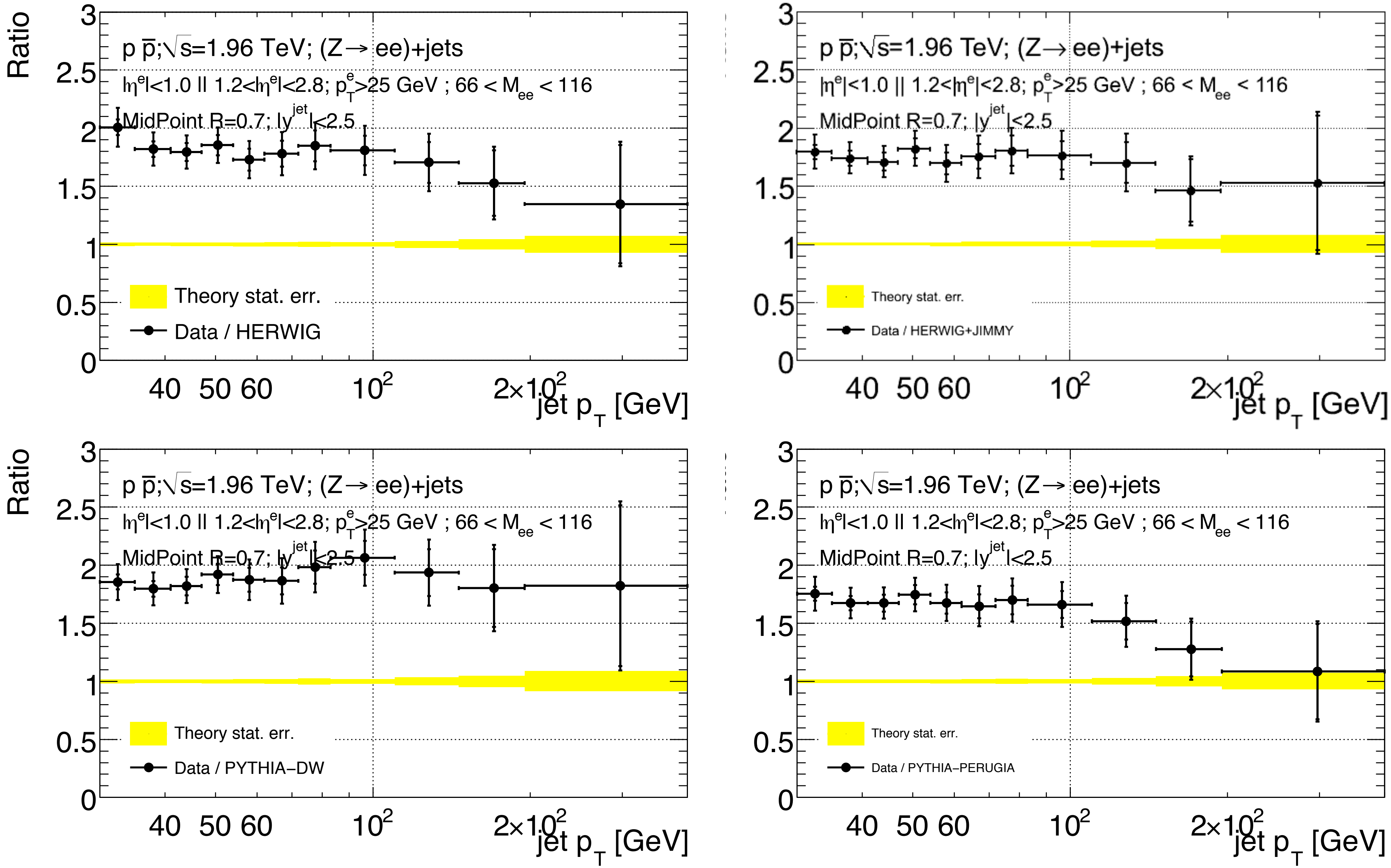
CDF W+Jets Lead Jet E_T



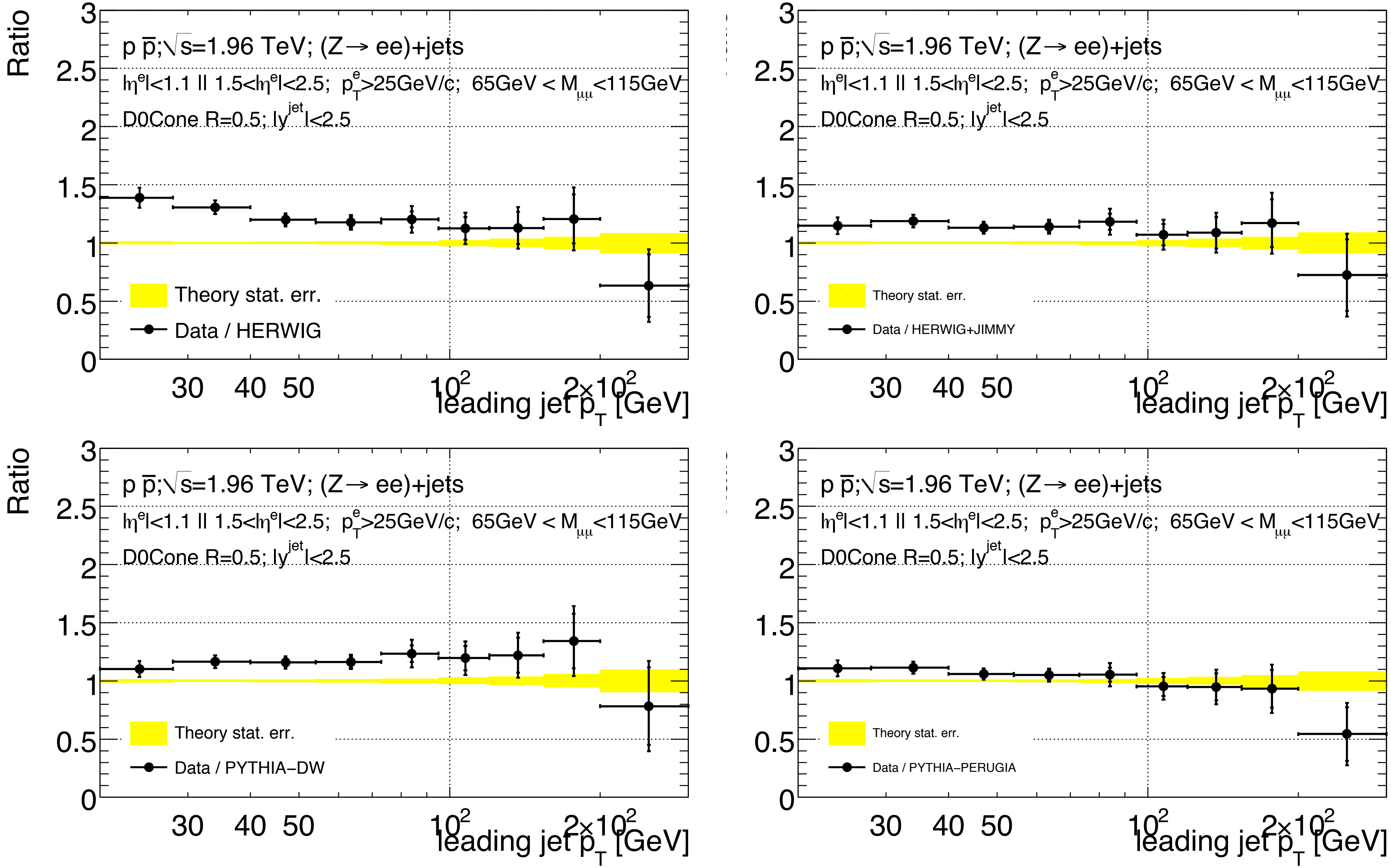
CDF W+Jets Lead Jet E_T ZOOM



CDF Z+Jets Inclusive Jet p_T

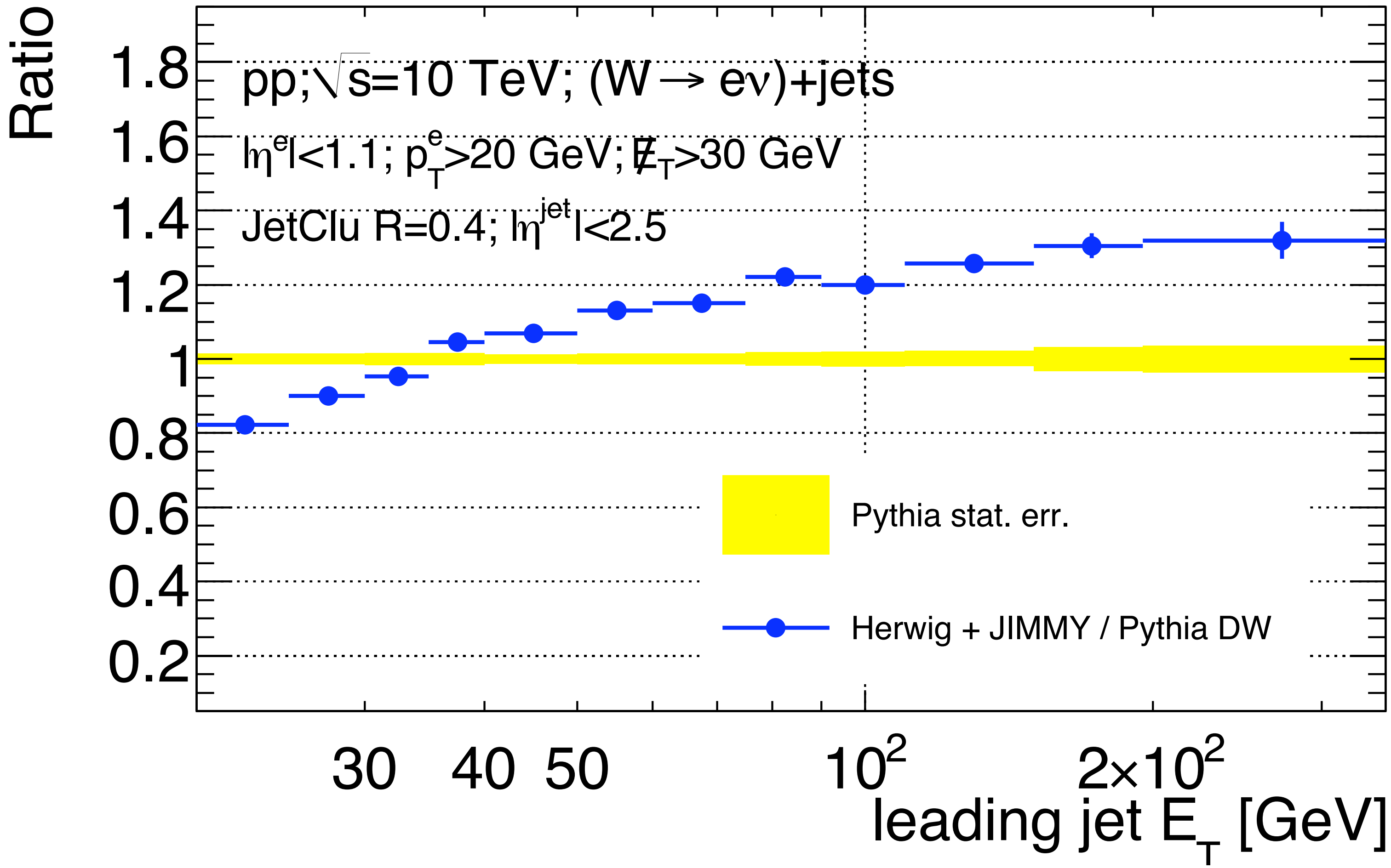


D0 Z→ee +Jets/$\sigma_{Z \rightarrow ee}$

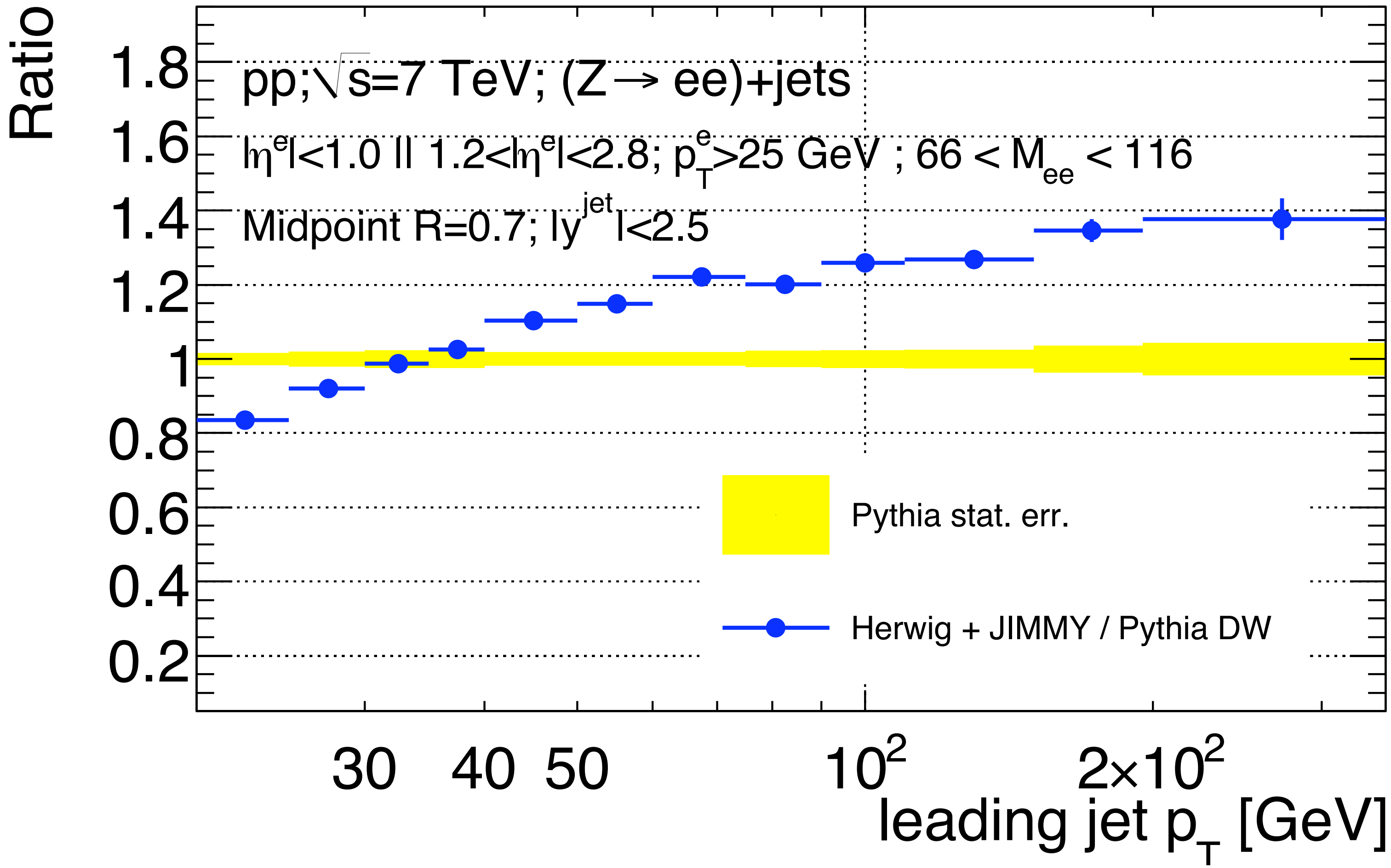


Extrapolation to LHC Energies

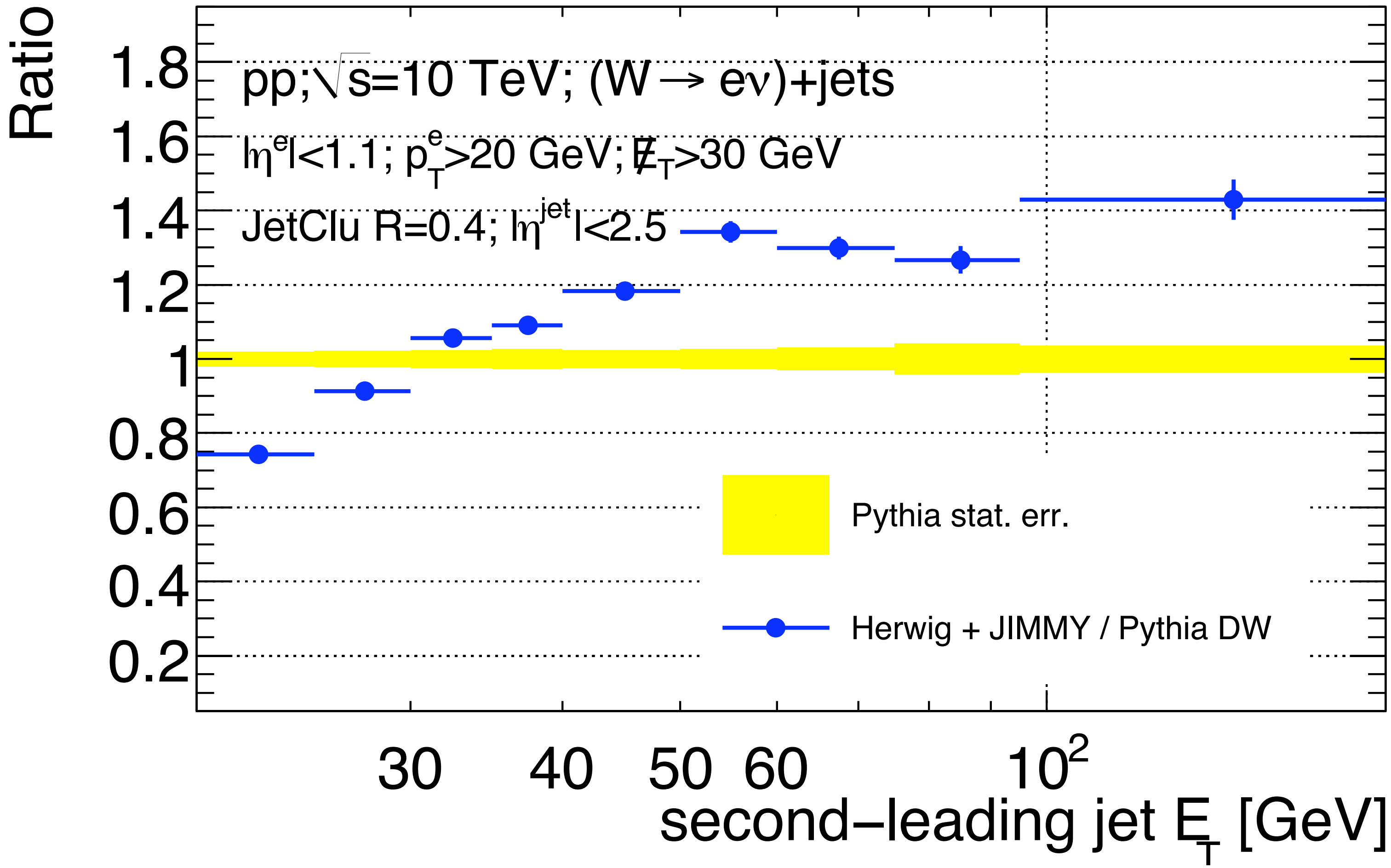
√s=10TeV Lead Jet E_T Cone 0.4



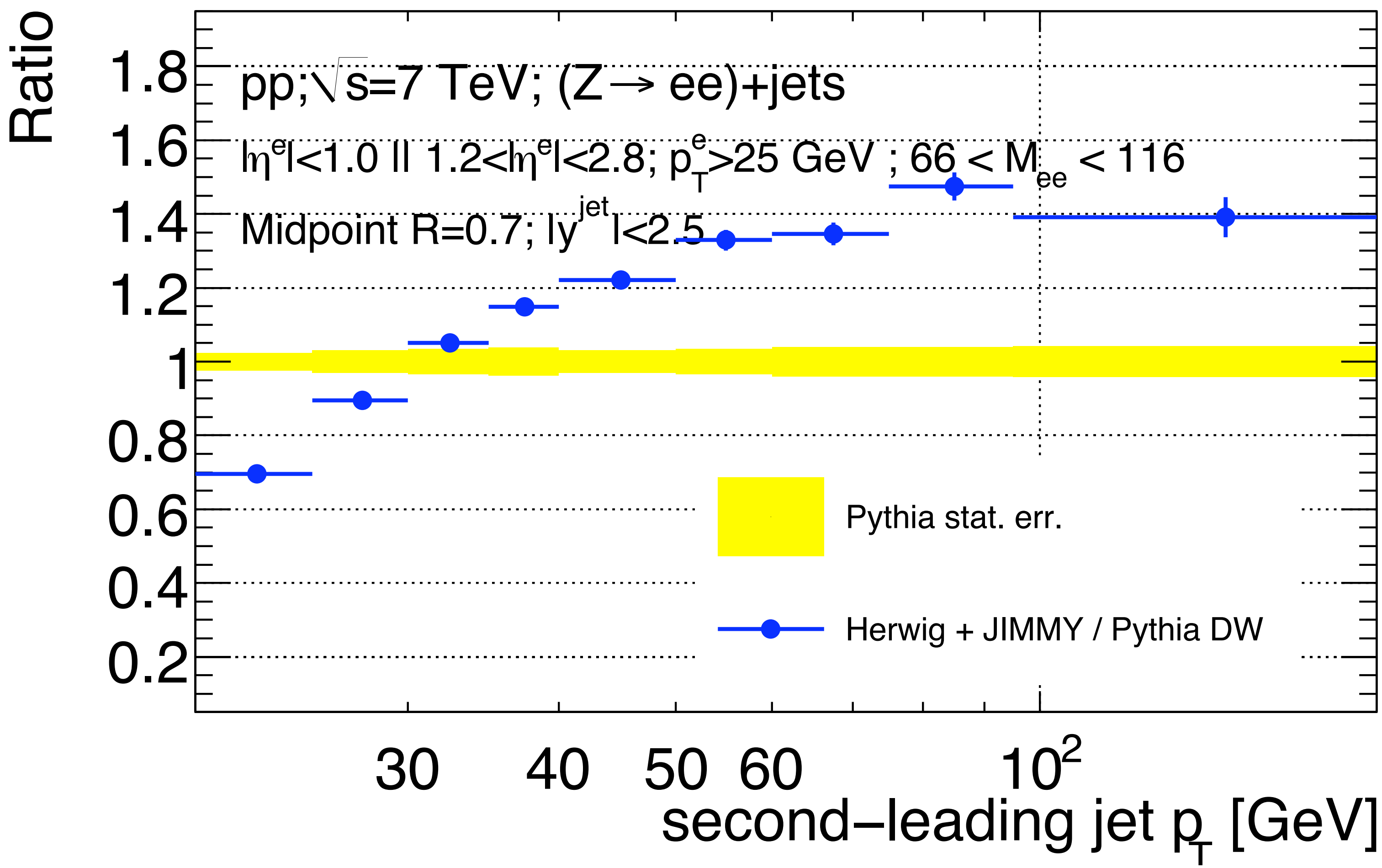
$\sqrt{s}$=7TeV Lead Jet E_T Cone 0.7



$\sqrt{s}$=10TeV Second Jet E_T Cone 0.4



$\sqrt{s}$=7TeV Second Jet E_T Cone 0.7



Conclusions

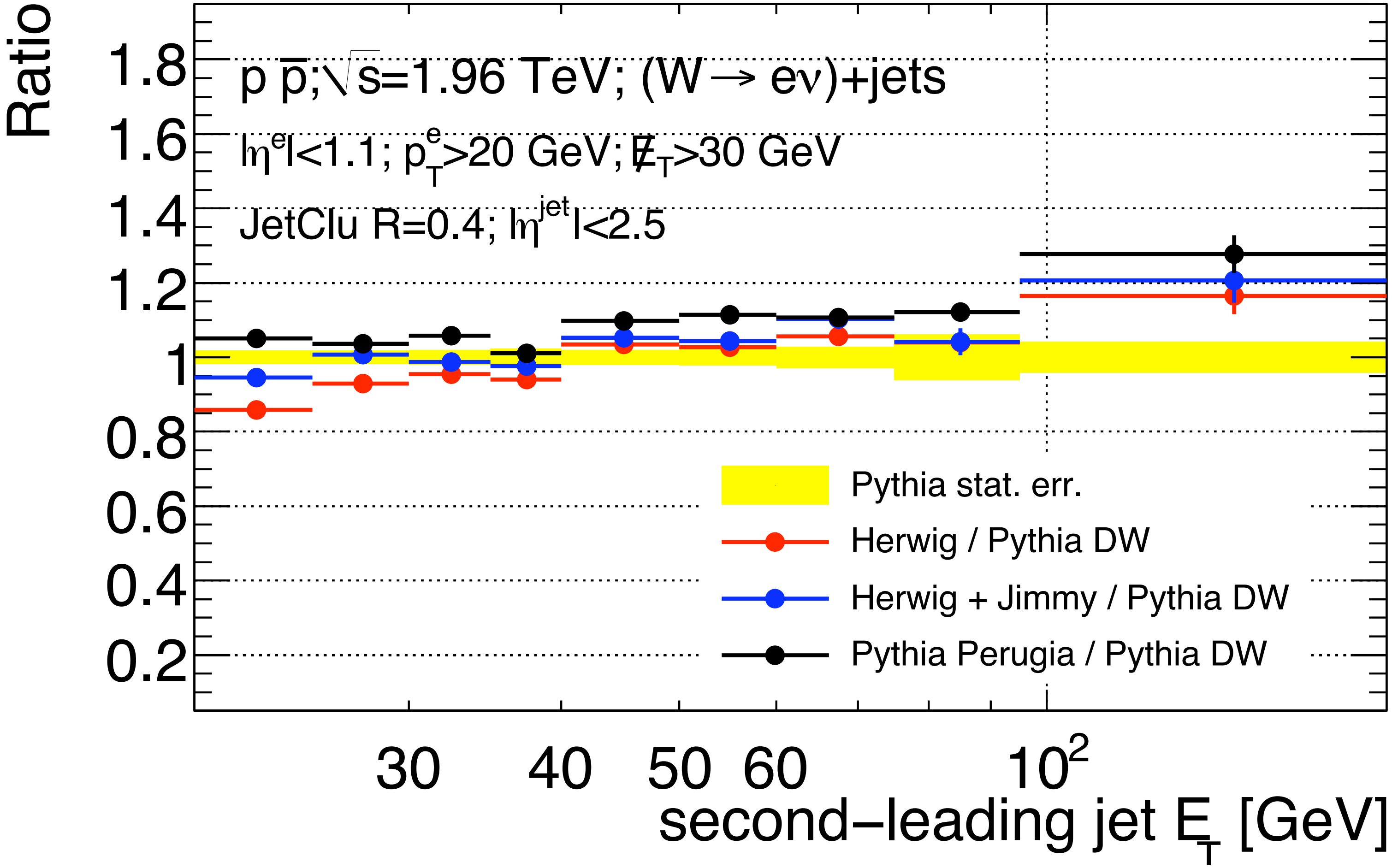
- We have learnt that the choice of PS model can have a significant impact on the predicted jet E_T spectra:
  - The underlying event tuning is important.
  - The choice of parton shower generator is important.
- Before 7 TeV VB + Jets measurements we should attempt to constrain MC tools with the available Tevatron results.
- The Tevatron results can provide important constraints:
  - Tuning on soft, inclusive processes is not necessarily sufficient to describe VB + Jets. For example, Perugia appears to be too hard.
- Tuned models that well reproduce Tevatron data result in dramatically different predictions at LHC energies.
- We need to repeat tuning efforts at the LHC, and in particular make direct measurements of VB + Jets for MC comparison.

Backups

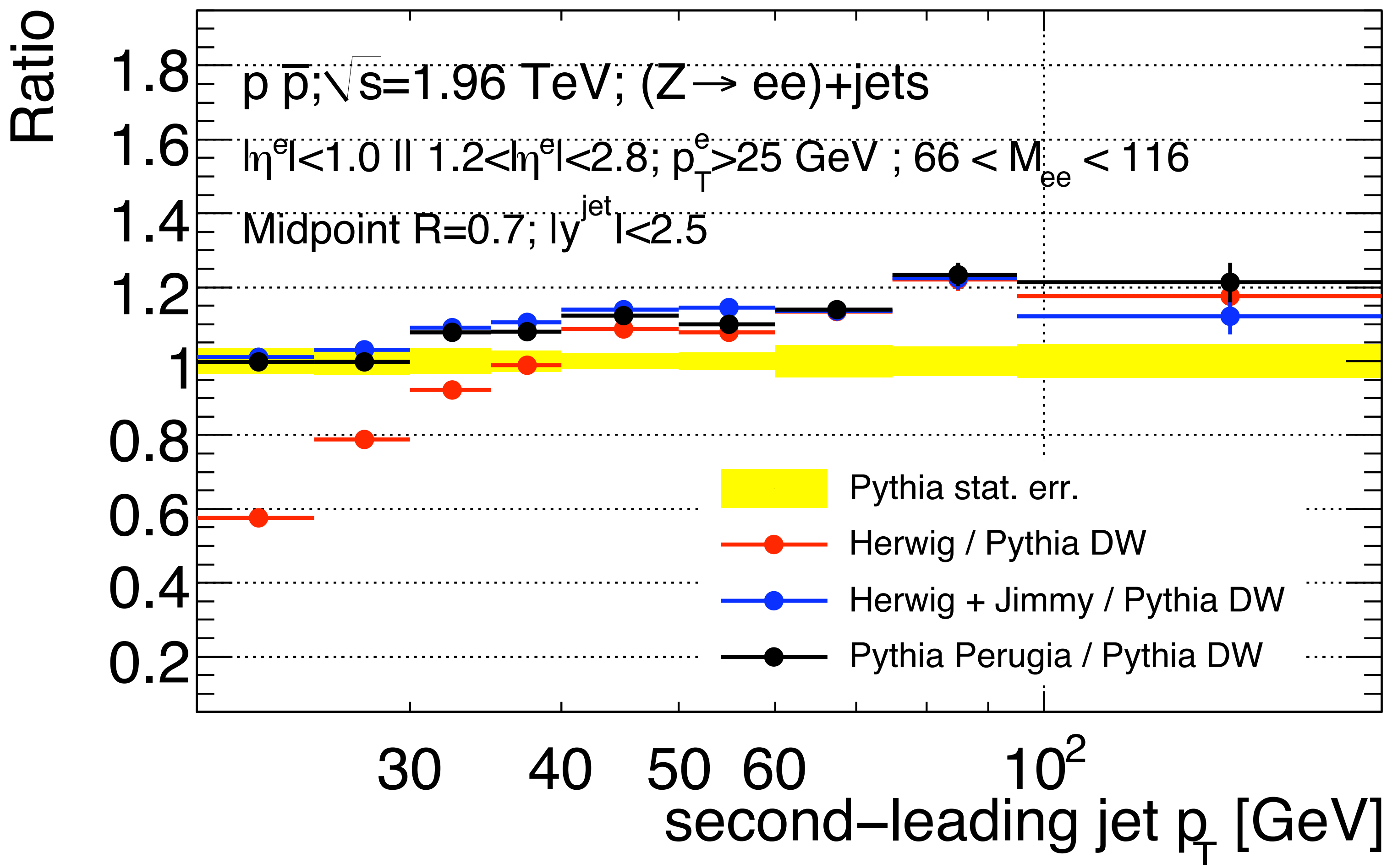
PYTHIA 6.4 Tunes

- PYTHIA-DW (Rick Field):
  - MSTP(5)=103.
  - Old (virtuality-ordered) PS and UE model.
  - ISR/UE tuned on CDF underlying event and Drell-Yan data.
  - UE energy dependence from Tevatron (630,1800,1960 GeV).
- PYTHIA-Perugia (Peter Skands):
  - MSTP(5)=320.
  - New (p_T-ordered) PS and UE – “interleved” ISR/UE model.
  - ISR/UE tuned on Tevatron minbias and Drell-Yan data.
  - FSR/Hadronisation tuned on LEP data.
  - UE energy dependence from UA5 (200,900 GeV), Tevatron (630,1800,1960 GeV).
- Tunes are supposed to be universal – have very similar energy scaling parameters (PARP(90)=0.25,0.26)

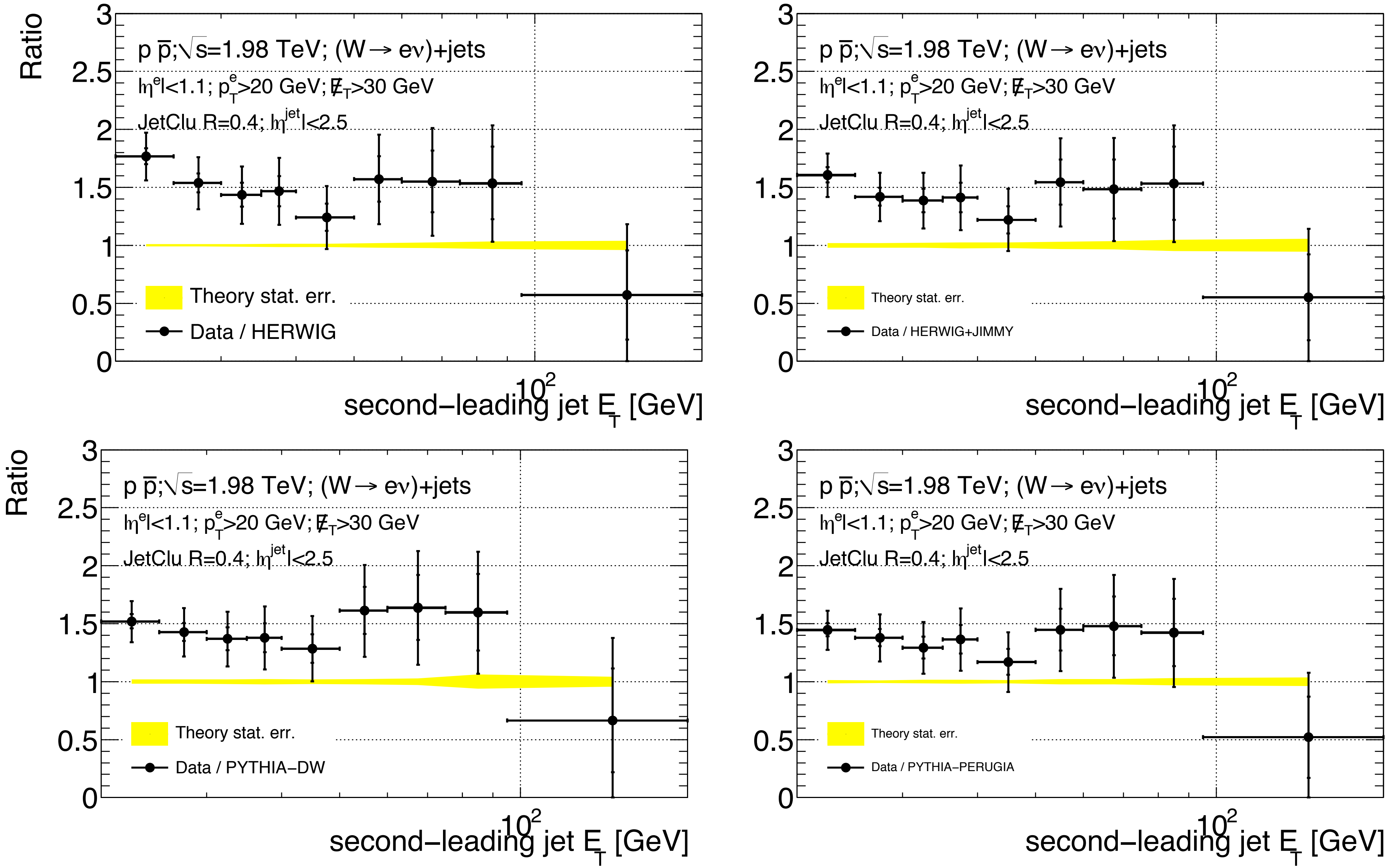
Second Jet Et Comparison



Second Jet Et Comparison



CDF W +Jets Second Jet E_T



D0 Z +Jets Second Jet E_T