The WW story

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Based on 1407.4481 with Patrick Meade and Mao Zeng
1407.xxxx with Patrick Meade and Prerit Jaiswal.

Importance of WW

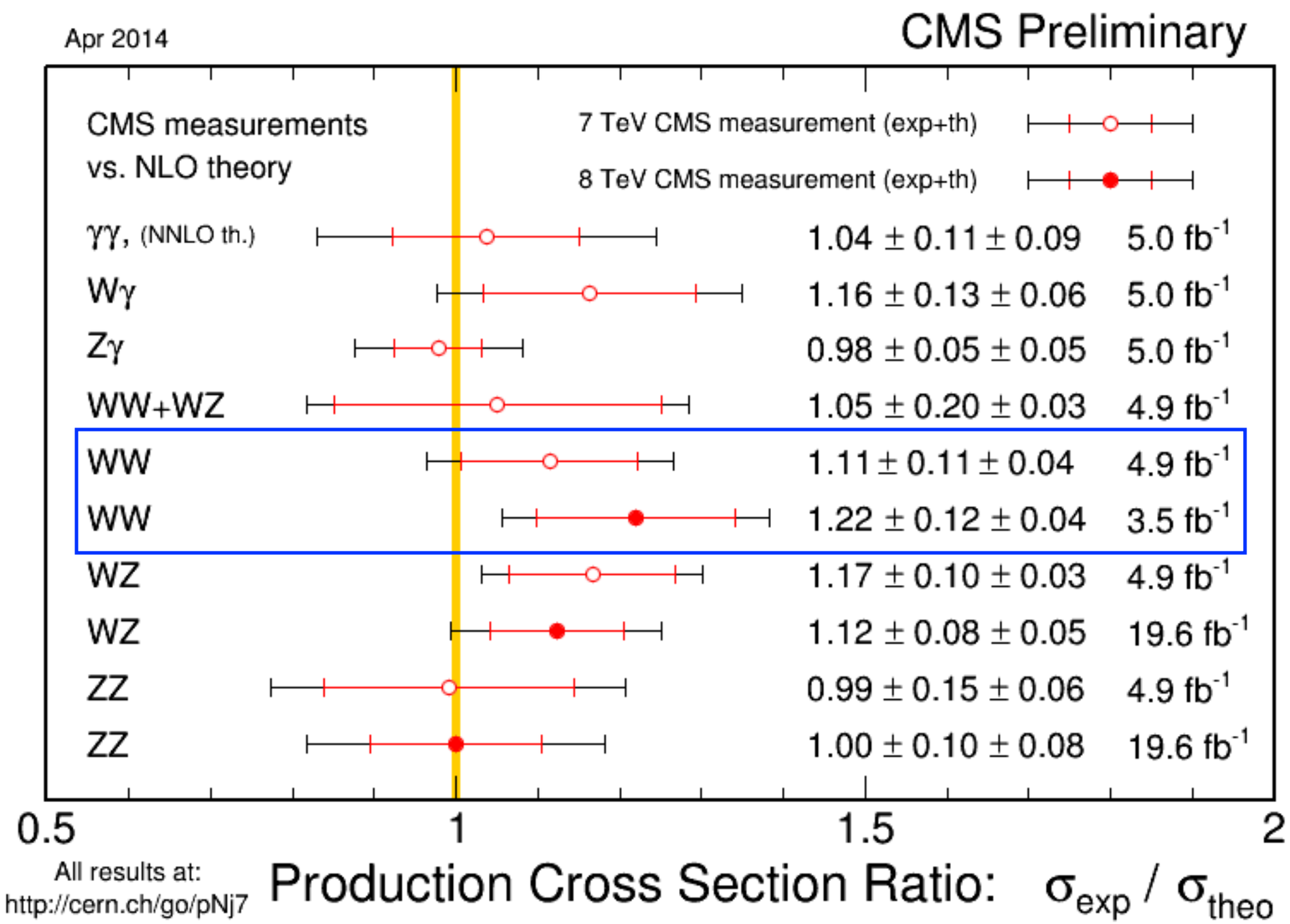
- LHC Era of Electroweak precision measurements
- WW is large background to H->WW. Higgs Precision Analysis
- WW huge background to many BSM searches

The WW Cross Section

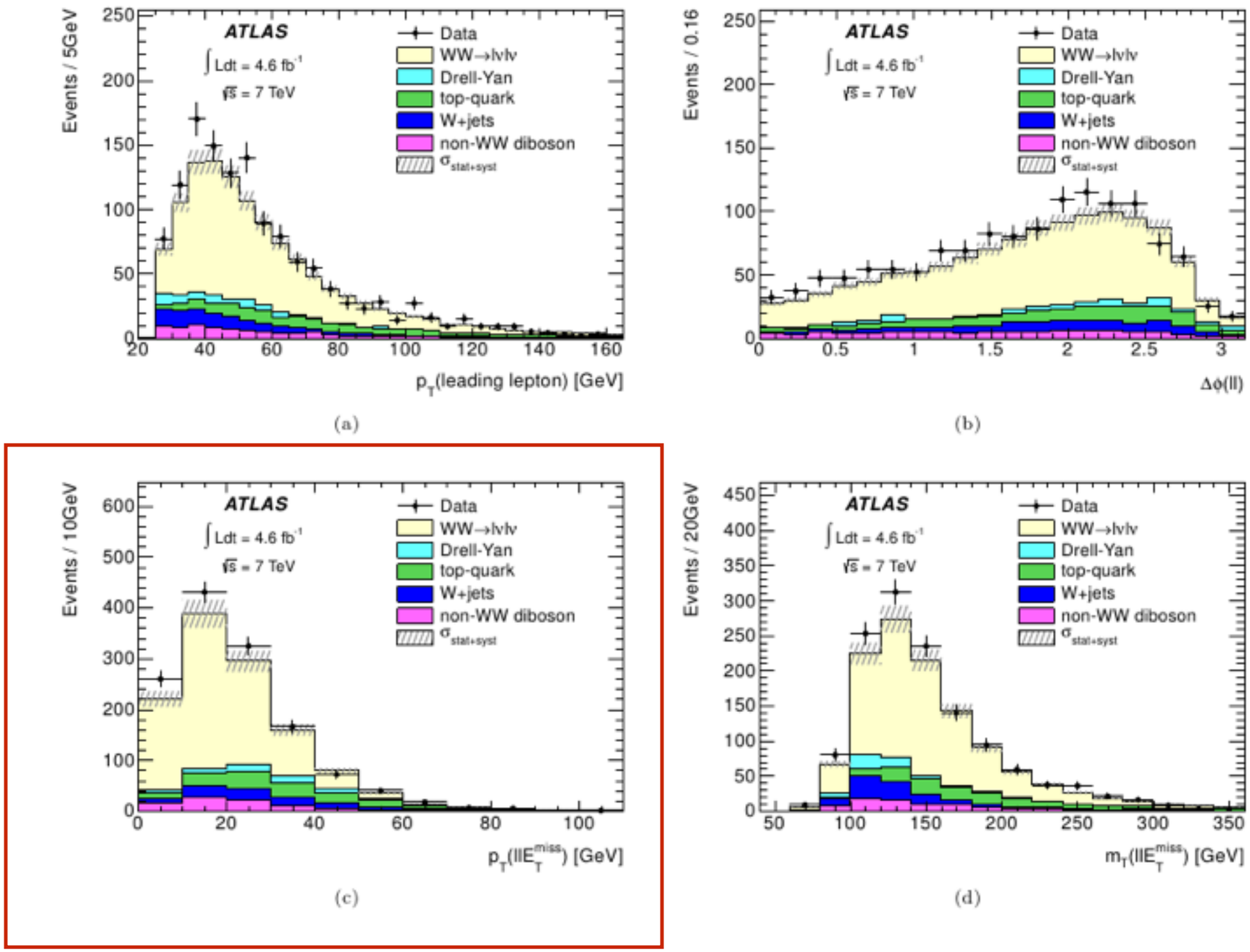
- WW decaying into opposite sign dilepton
- One of few channels with a Jet Veto
- Results available for ATLAS and CMS @ 7&8TeV
- Indirect Results also available as background to H->WW
- Both ATLAS and CMS routinely reported excess.

Experimental Results

Summary-CMS


Apr 2014
CMS Preliminary
CMS measurements
vs. NLO theory
7 TeV CMS measurement (exp+th)
8 TeV CMS measurement (exp+th)
γγ, (NNLO th.) 1.04 ± 0.11 ± 0.09 5.0 fb-1
Wγ 1.16 ± 0.13 ± 0.06 5.0 fb-1
Zγ 0.98 ± 0.05 ± 0.05 5.0 fb-1
WW+WZ 1.05 ± 0.20 ± 0.03 4.9 fb-1
WW 1.11 ± 0.11 ± 0.04 4.9 fb-1
WW 1.22 ± 0.12 ± 0.04 3.5 fb-1
WZ 1.17 ± 0.10 ± 0.03 4.9 fb-1
WZ 1.12 ± 0.08 ± 0.05 19.6 fb-1
ZZ 0.99 ± 0.15 ± 0.06 4.9 fb-1
ZZ 1.00 ± 0.10 ± 0.08 19.6 fb-1
0.5
1
1.5
2
All results at:
http://cern.ch/go/pNj7
Production Cross Section Ratio: σexp / σtheo

WW Excess in Differential Direction



Could Shape Be Important?

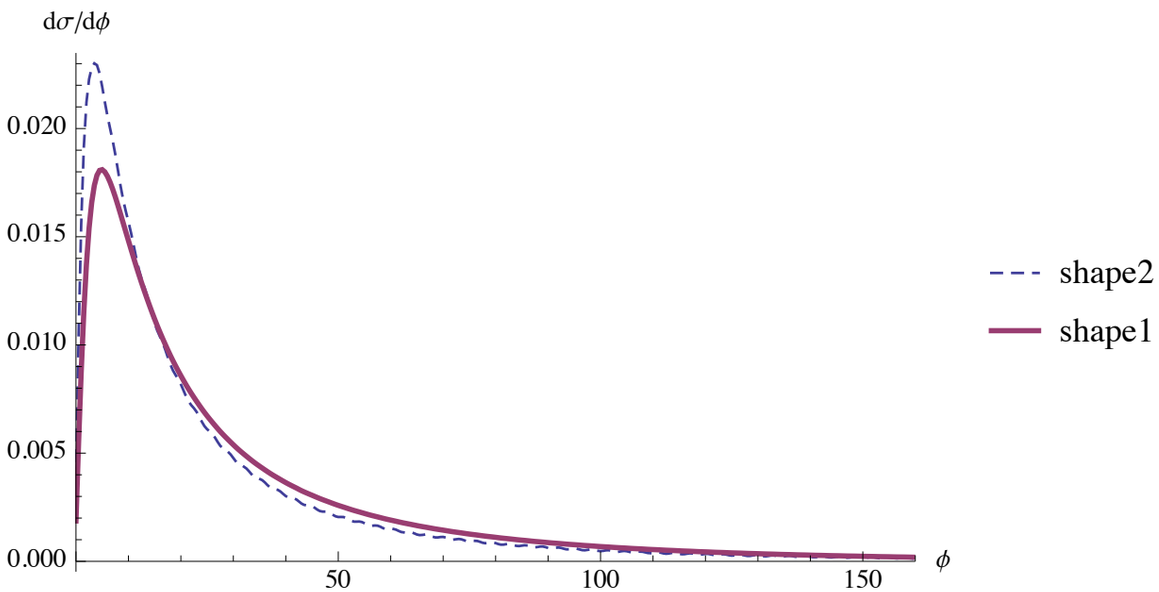
How is WW measured?

$$n = \sigma_{fid} L + n_{BG}$$

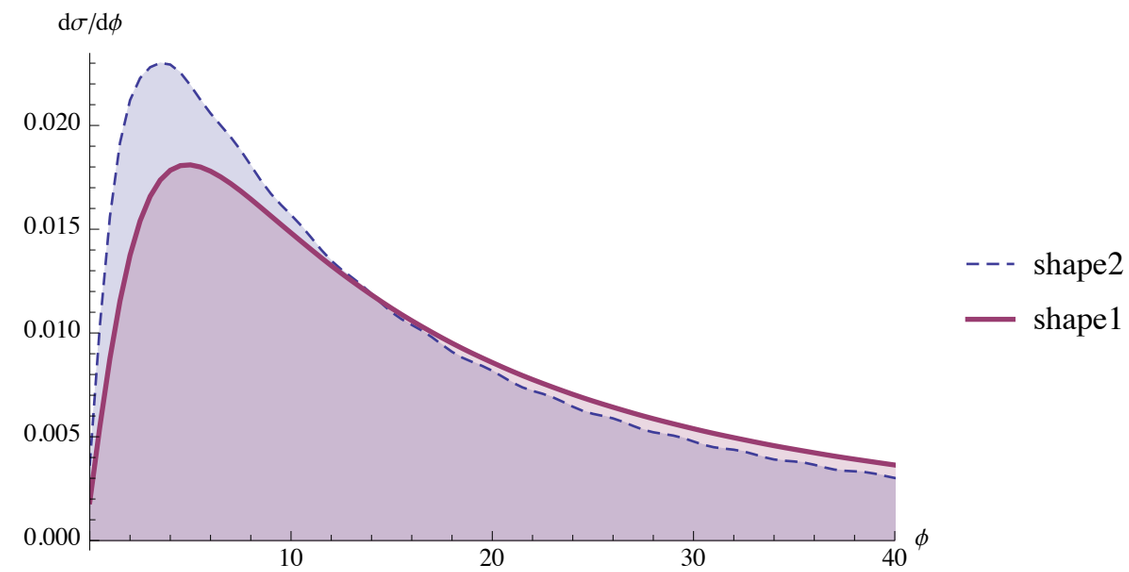
$$\sigma_{fid} = \sigma_{total} \epsilon . A . Br$$

- ϵ,A:efficiency and Acceptance.
- A captures the cuts placed.
- Jet-veto of 30GeV placed to reduce top background.
- σ_{fid} is unfolded with respect to ϵ and A to get σ_{total}

Can shape affect reported cross section?



Full Phase-space.
Both curves Normalized to unity.



Shape effect translates
to different
Fiducial cross-section

Theoretical Advances

- Total normalization effect complete NNLO calculation

NLO+gg:57.25pb(MCFM)
NNLO :59.84pb(T. Gehrmann et al. 1408.5243)

- Understanding higher order QCD effects to shape:

pT resummation and jet veto resummation

Need for Resummation

- In fixed order perturbation theory,

$$\hat{O} = \sum \alpha_s^n c_n + e_n$$

- valid only if c_n & e_n are well behaved

- often in problems involving two length scales,

$$c_n \backsim (Log^2(r))^n$$

- where r is the ratio of two scales.

- These large logs spoil perturbation theory

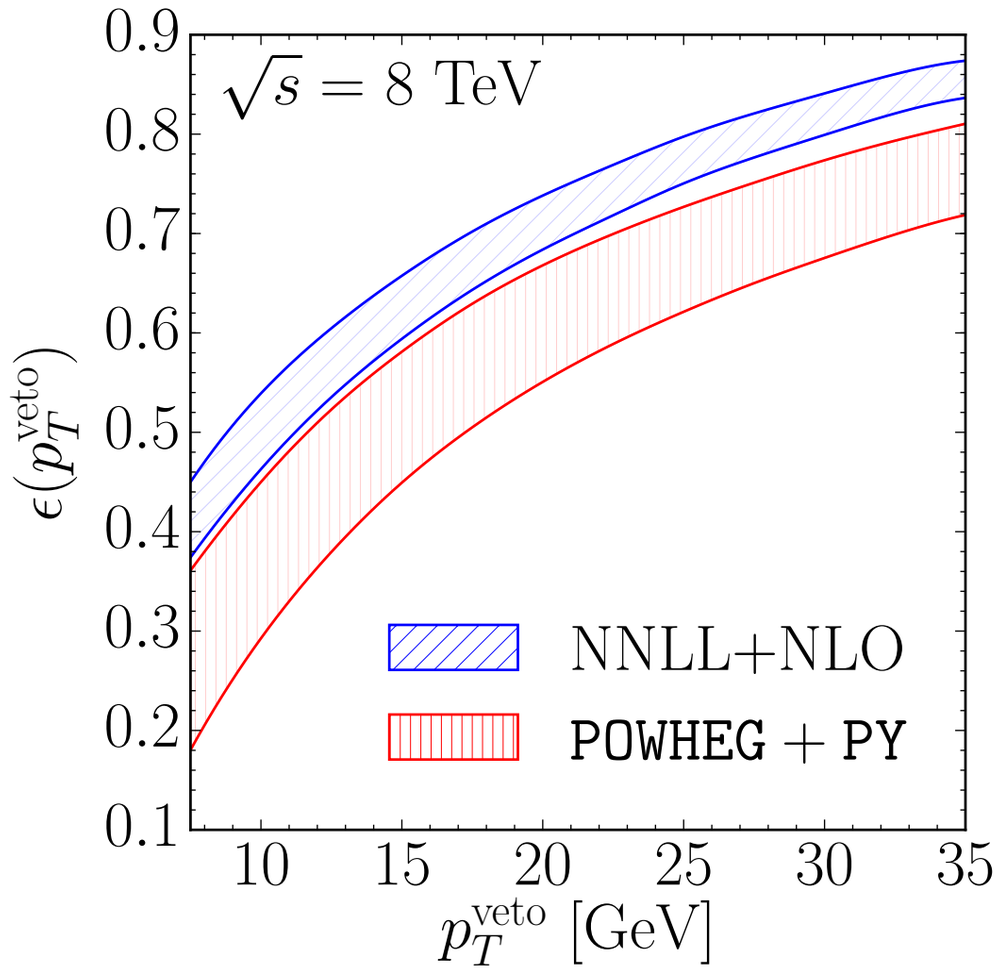
- Way forward:resumming these large logs

Jet veto vs pT resummation

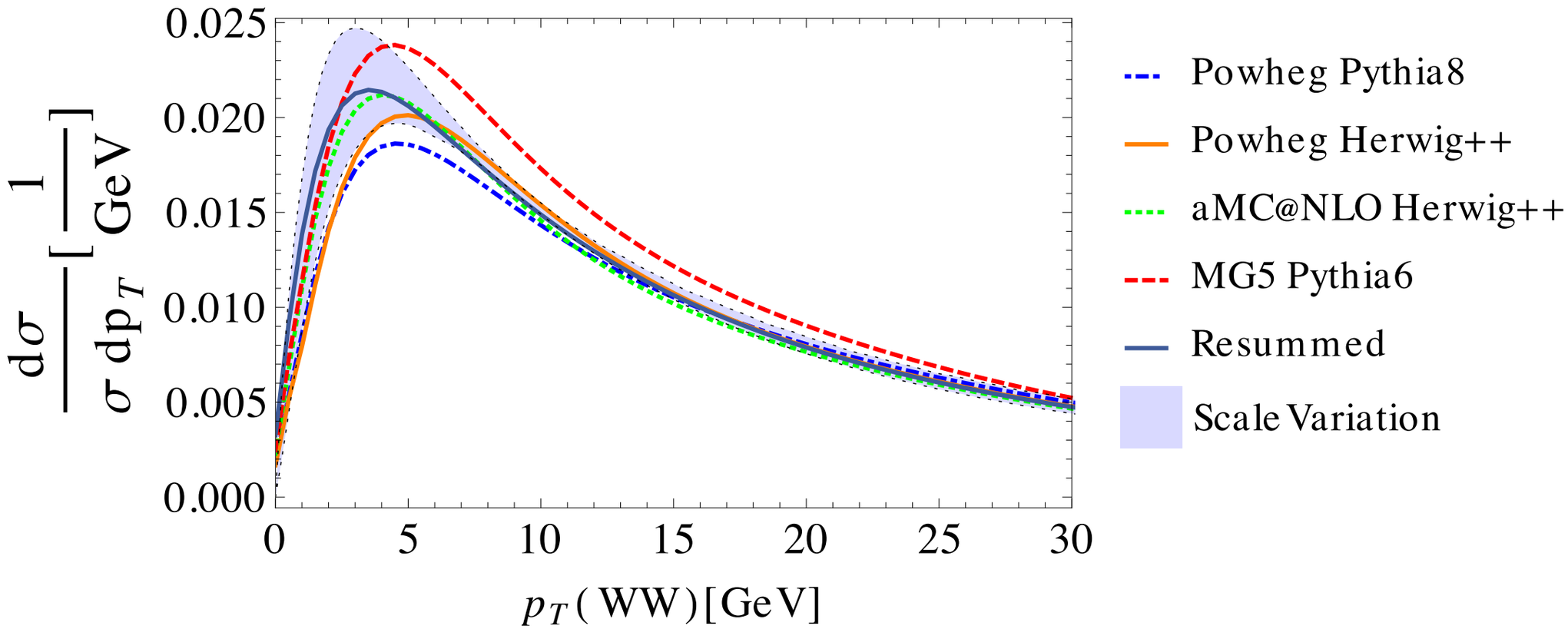
- Jet veto resummation: Log[pT(veto)/mWW].
- p_T resummation :Log[p_T/mWW]
- Transverse momentum of WW strongly correlated with jet pt.
- Whereas pT resummation gets the pT observable of WW right, jet veto resummation will predict the 0-jet cross-section.

Jet veto resummation results

Jaiswal,Okui (1407.4537)



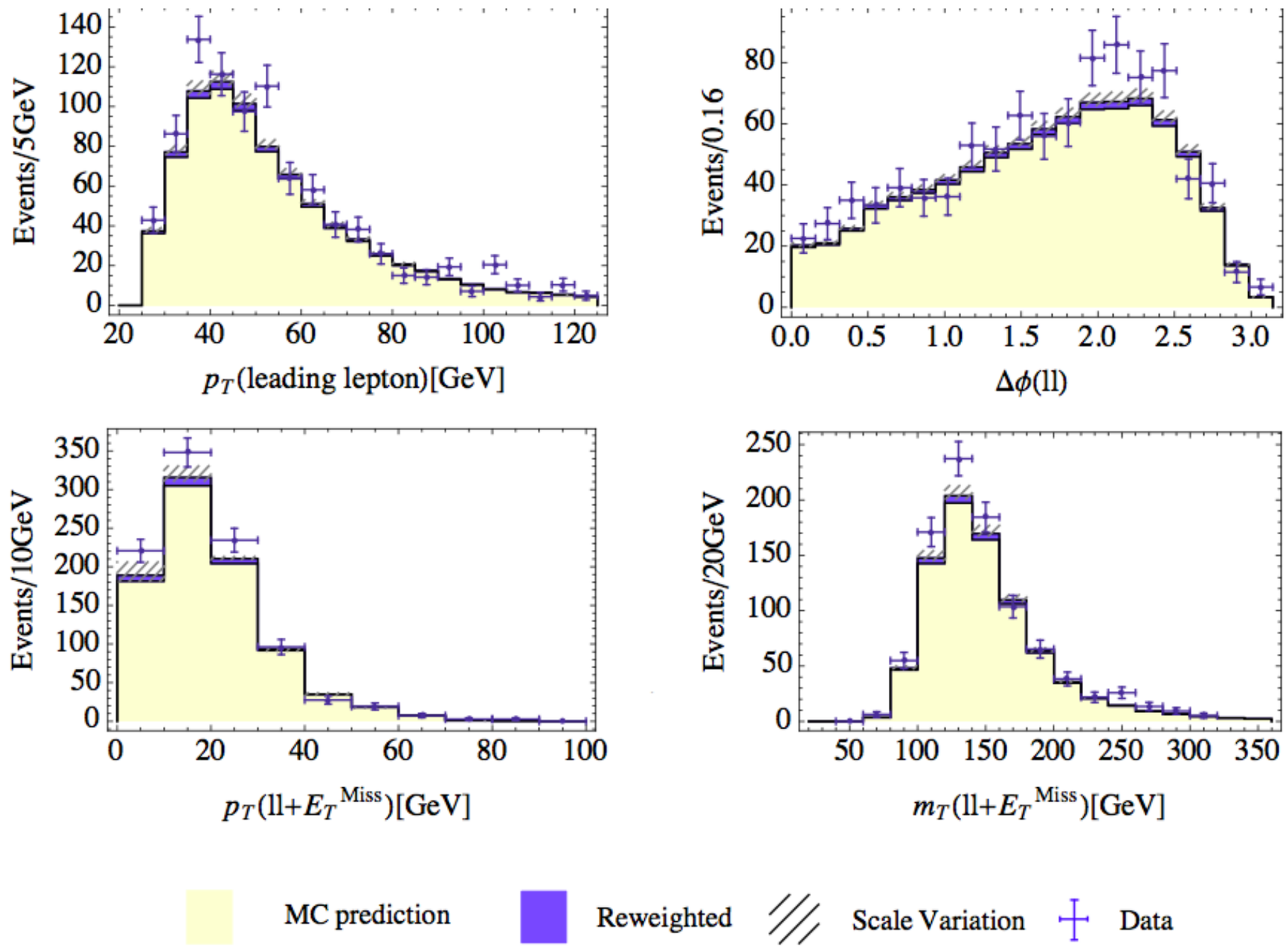
pT resummation results



Reweighting Procedure

- each event has a truth level pTWW.
- calculate reweighting function to make MC pTWW shape agree with resummation shape
- pass MC events through detector simulation.
- apply all cuts.
- Reweight with reweighting function
- compare events passing cuts before and after resummation reweighting.

pT resummation results contd



New CMS results

- full luminosity 8TeV, uses pT resummation reweighting.

Table 5: The W^+W^- production cross section in fiducial regions defined by requiring zero jets at particle level with varying jet p_T thresholds.

p_T^{jet} threshold (GeV)	σ_{0jet} measured (pb)	σ_{0jet} predicted (pb)
20	36.2 ± 0.6 (stat.) ± 2.1 (exp.) ± 1.1 (th.) ± 0.9 (lum.)	36.7 ± 0.1 (stat.)
25	40.8 ± 0.7 (stat.) ± 2.3 (exp.) ± 1.3 (th.) ± 1.1 (lum.)	40.9 ± 0.1 (stat.)
30	44.0 ± 0.7 (stat.) ± 2.5 (exp.) ± 1.4 (th.) ± 1.1 (lum.)	43.9 ± 0.1 (stat.)

- CMS(old) :69.9 ±7.0 pb
- CMS(new) :60.1 ± 4.8 pb
- NNLO theory:59.8 ±1.3 pb
- Old theory :57.3 ±1.0 pb

Analysis

- pT resummation easier to use:reweight MC events with respect to WW transverse momentum.
- Could pT resummation capture jet veto logs well?
- Jet veto resummation and pT resummation predict slightly different efficiencies
- Study needed to do an apples-to-apples comparison between the two resummation procedures.

Comparing jet-veto and pT resummation

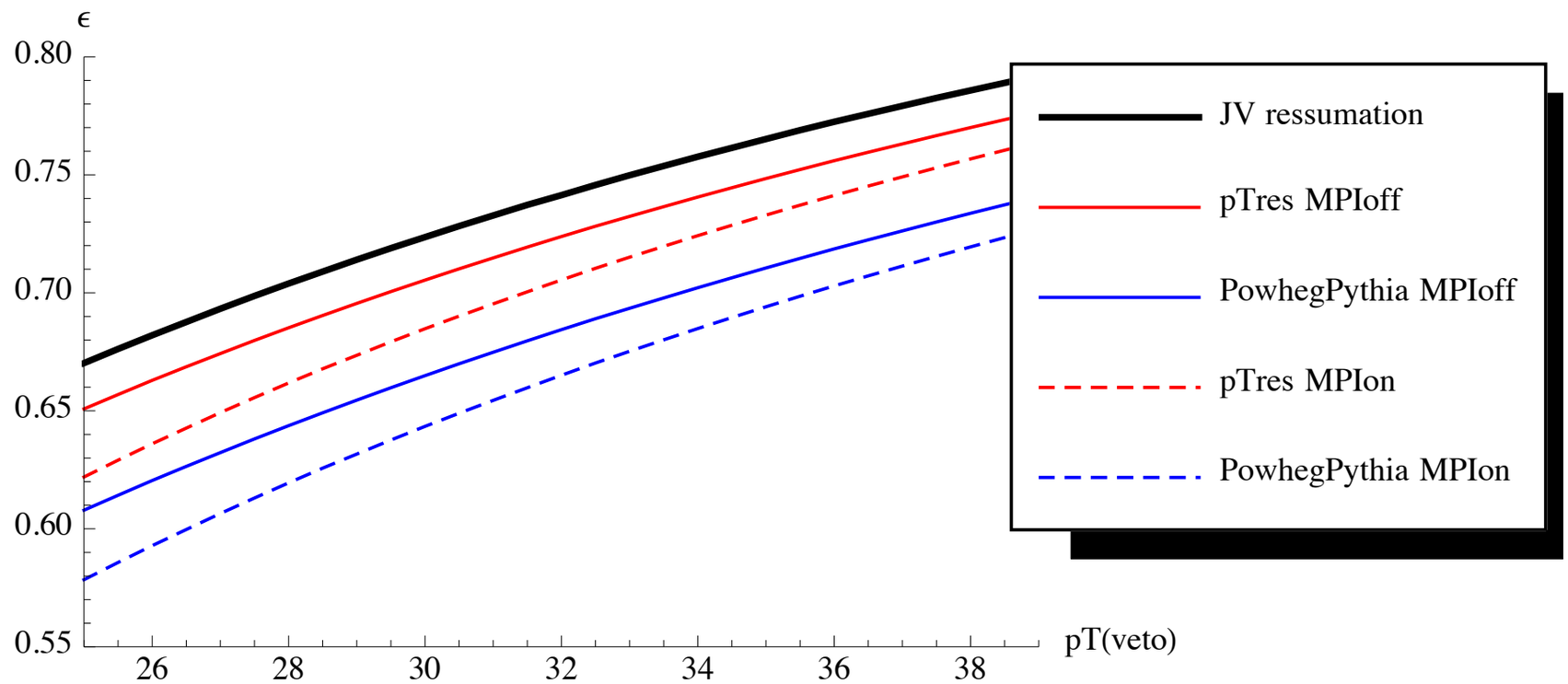
- Reweight MC generated 0-jet bin with jet veto resummation prediction.
- Then compare JV-resummation reweighted pTWW prediction with pT resummation.

- Reweight MC generated events with pT resummation(described before)
- Compare reweighted efficiency with jet veto prediction

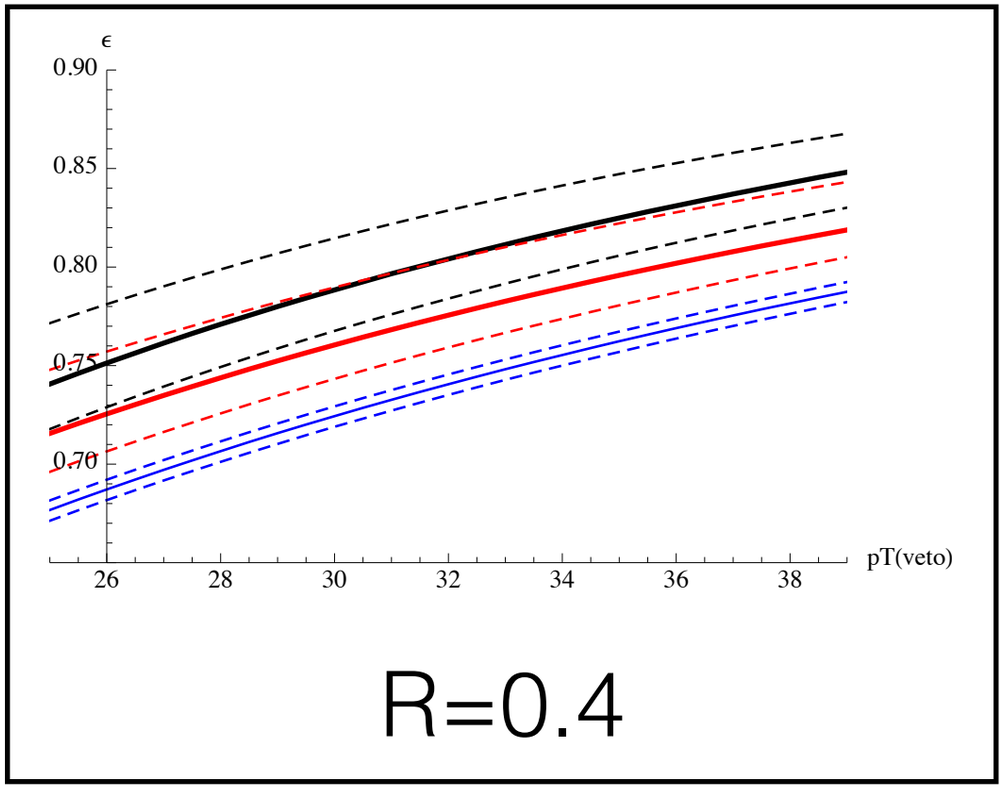
Aspects of study

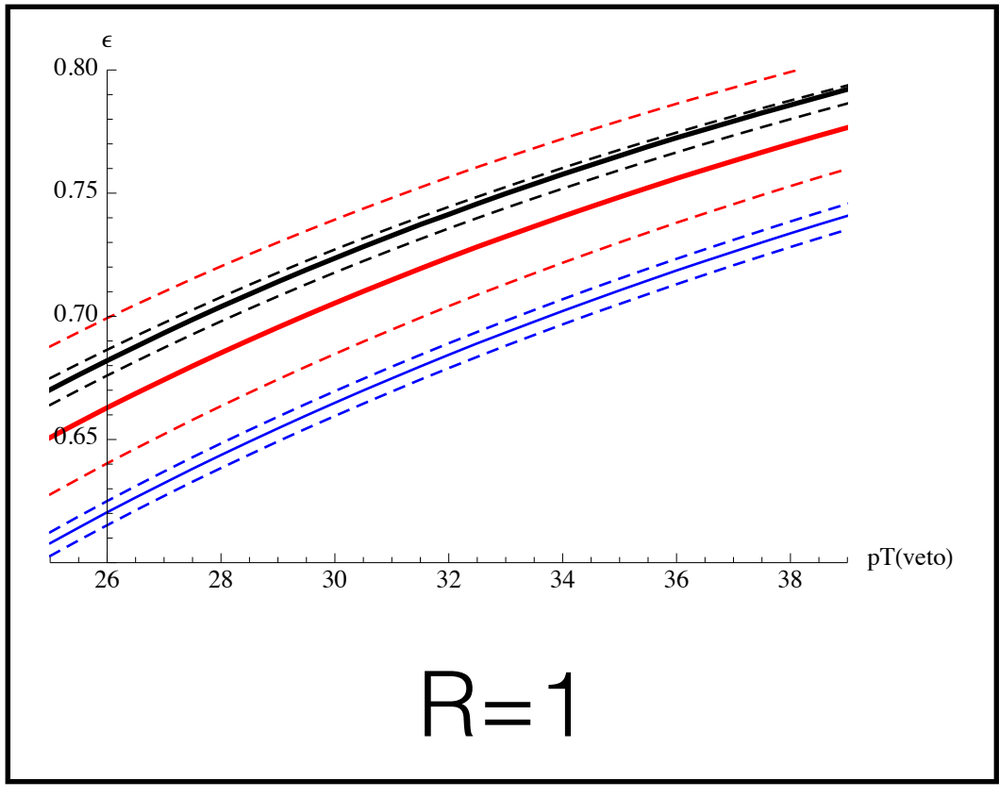
- MPI effects affect jet but not pTWW.
- What about Hadronization effects?
- expect pTWW and jet-veto resummation to agree better for larger R.

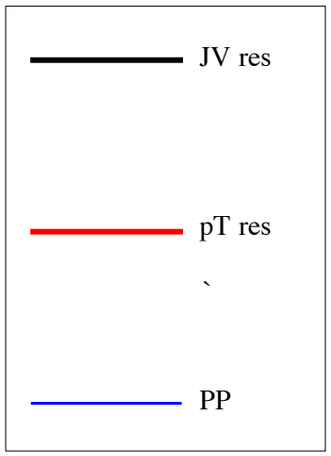
Results MPI off vs on



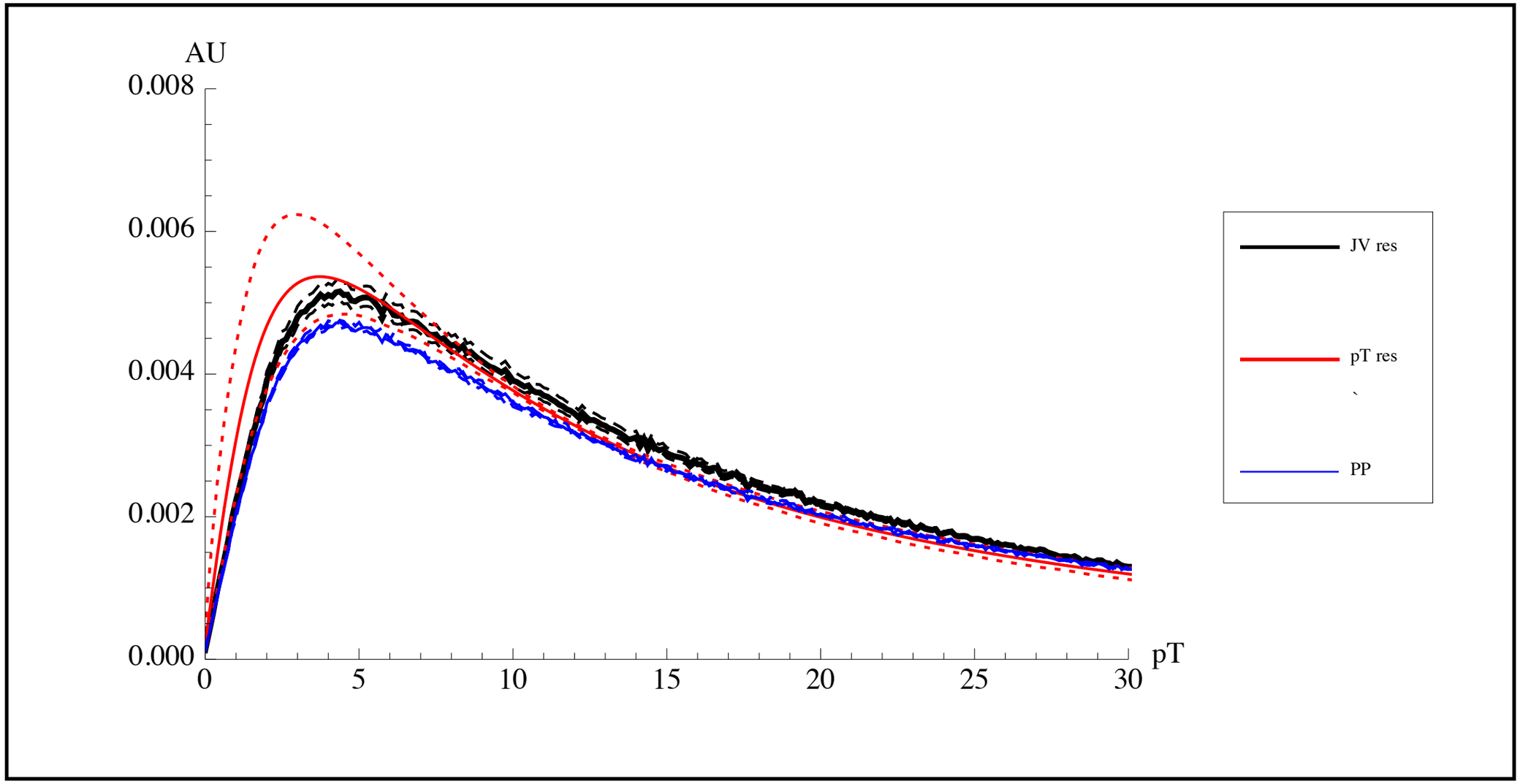
Results:R dependence







pT(WW) shape prediction



Conclusions

- JV and pT resummation consistent with each other
- Switching off MPI; agree better
- going to large R; agree better
- Yet Both cannot be done simultaneously

Outlook

- with knowledge of full NNLO matrix elements, we can take both pT and jet veto resummation to the next order, ie. NNLL+NNLO
- Joint Resummation
- Is it possible to decouple these effects and study them separately?
- NP effects
- Resummation scale.