

MC & Tools Experimental Summary

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Les Houches - Physics at TeV Colliders - 2019



Outlook

- ▶ Jet activity in Vector Boson Fusion Z and W production
- ▶ MC variations: “case study”

Jet activity in VBF Z and W production

Physics motivation:

- VBF topology is becoming increasingly important for LHC measurements
- Standard candle for VBF H and VBS
- New measurements available for vector boson fusion and scattering
- New Theory/MC developments trying to improve the description of the process

Many recent activities:

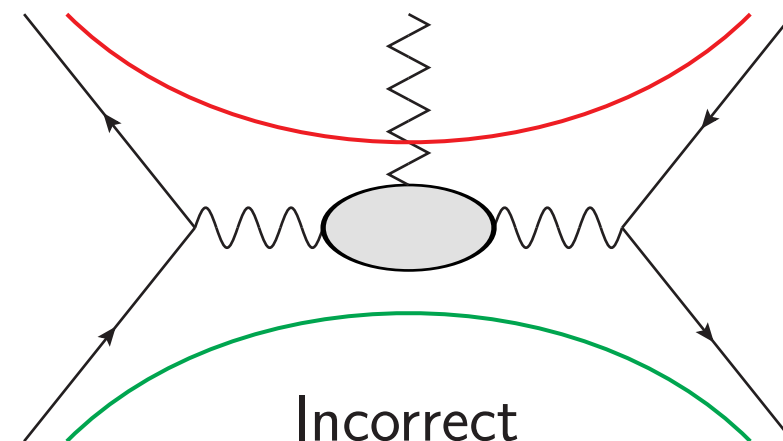
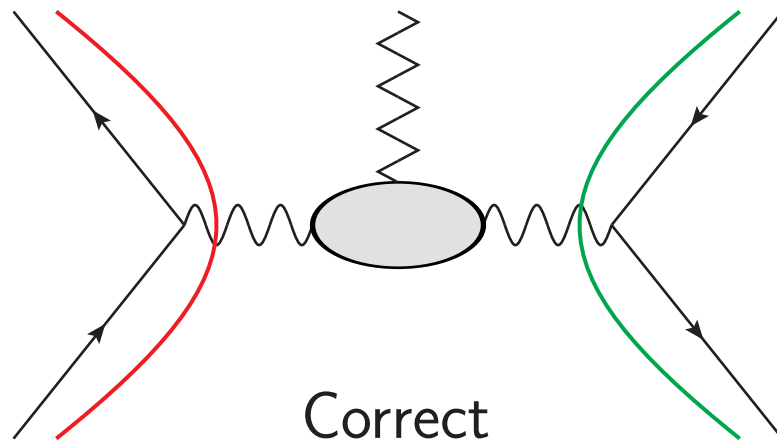
- VBS WZ LO study at LH 2017
- VBSCan same sign WW NLO study ([arXiv:1803.07943](#))
- Multi Boson LHCEWWG ATLAS-CMS comparison
- EW corrections starting to be available ([arXiv:1904.00882](#), [arXiv:1906.01863](#))

Yet, experimental
results are
unclear...

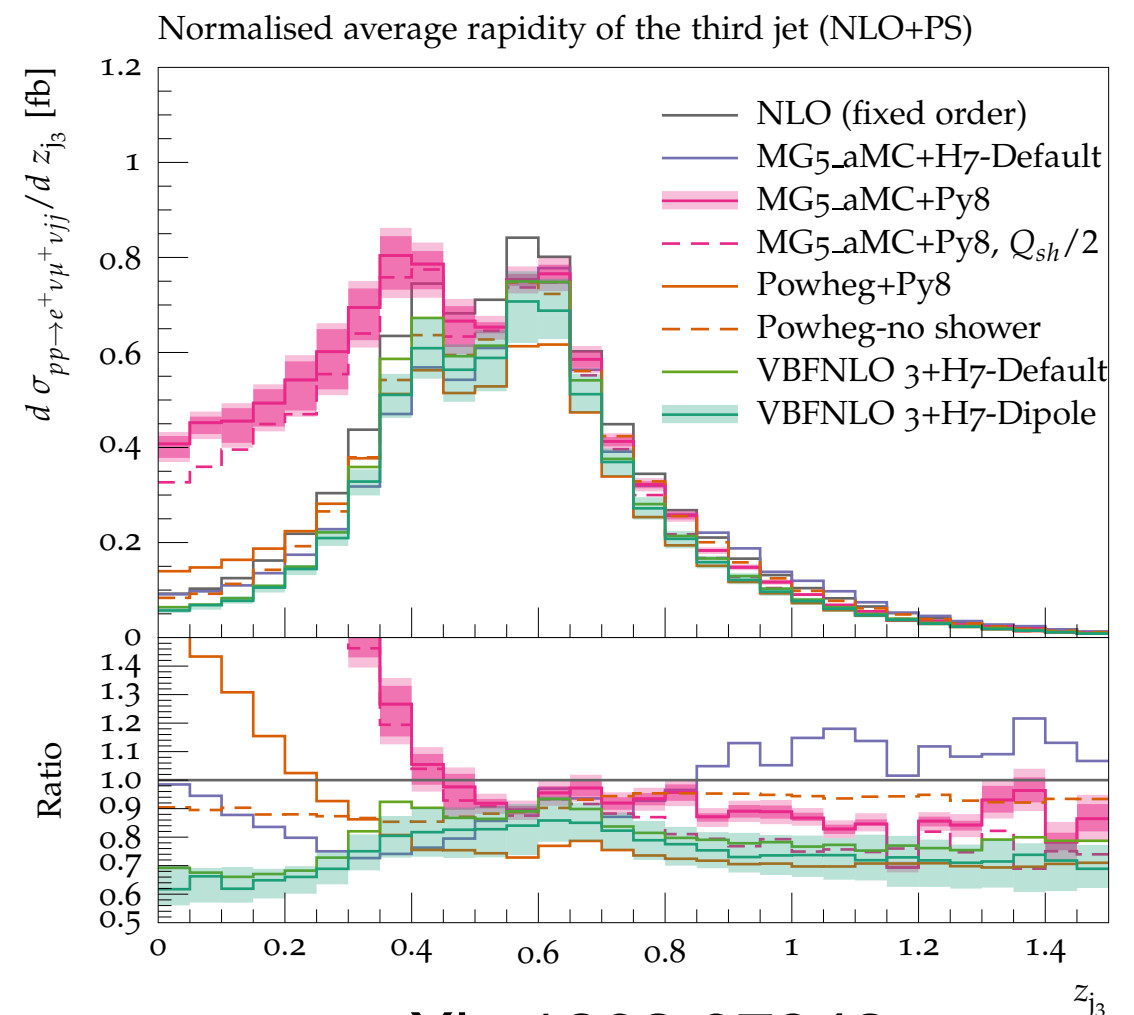
Process	Experiment	Obs. (fb)	Pred. (fb)	Obs. ratio	Region
EW WZjj	ATLAS	$0.57^{+0.16}_{-0.14}$	$0.321^{+0.13}_{-0.11}$	$1.77^{+0.49}_{-0.43}$	ATLAS SR
	CMS	—	$1.25^{+0.13}_{-0.11}$	$0.82^{+0.51}_{-0.43}$	CMS tight SR
WZjj (EW+QCD)	ATLAS	$1.68^{+0.25}_{-0.25}$	$2.15^{+0.65}_{-0.44}$	0.78	ATLAS SR
	CMS	$3.18^{+0.71}_{-0.63}$	$3.27^{+0.42}_{-0.35}$	$0.98^{+0.22}_{-0.20}$	CMS tight SR
QCD WZjj	ATLAS	—	—	$0.56^{+0.16}_{-0.16}$	ATLAS CR
	CMS	—	$18.6^{+0.31}_{-0.25}$	~ 1.02	CMS tight CR

Third jet and Parton Shower

Possible issue with color flow in VBF-like topology:



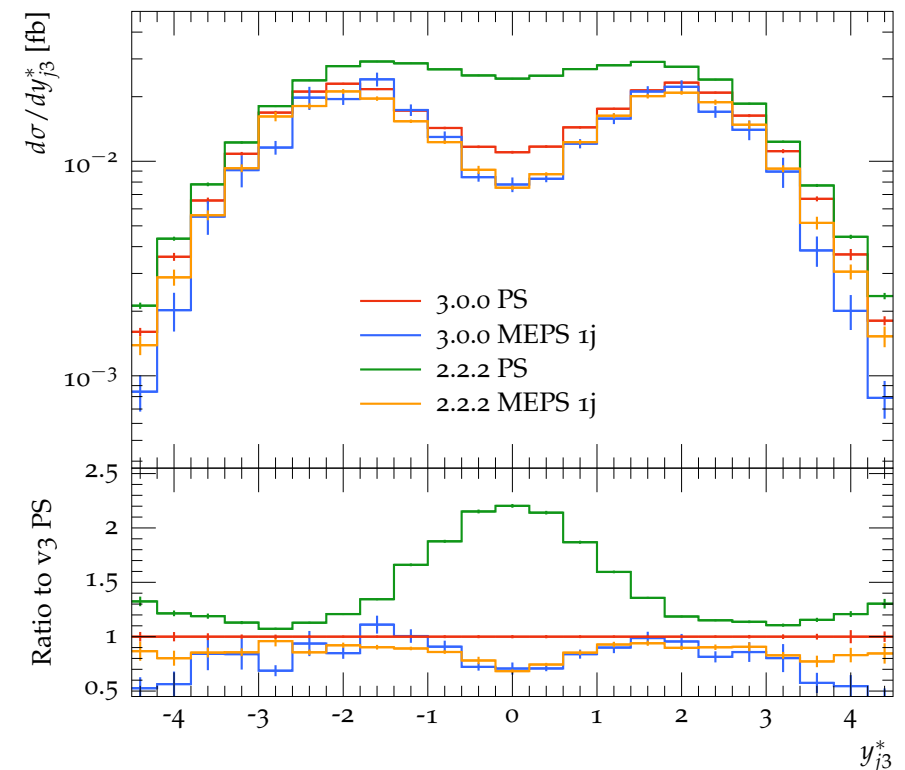
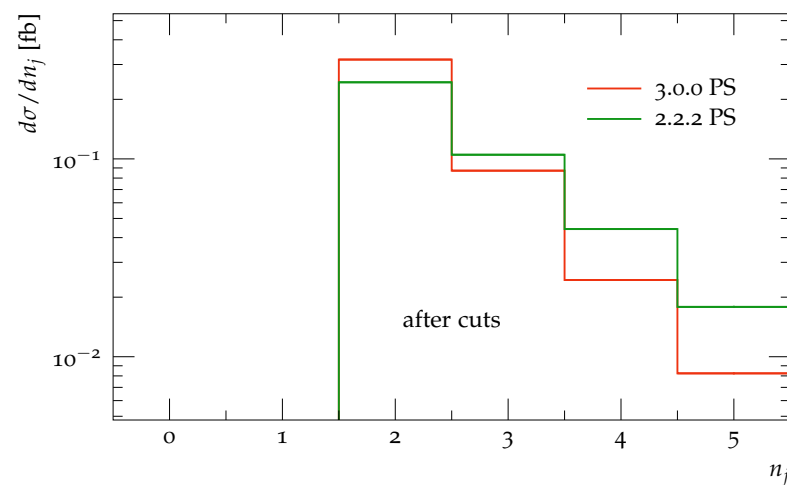
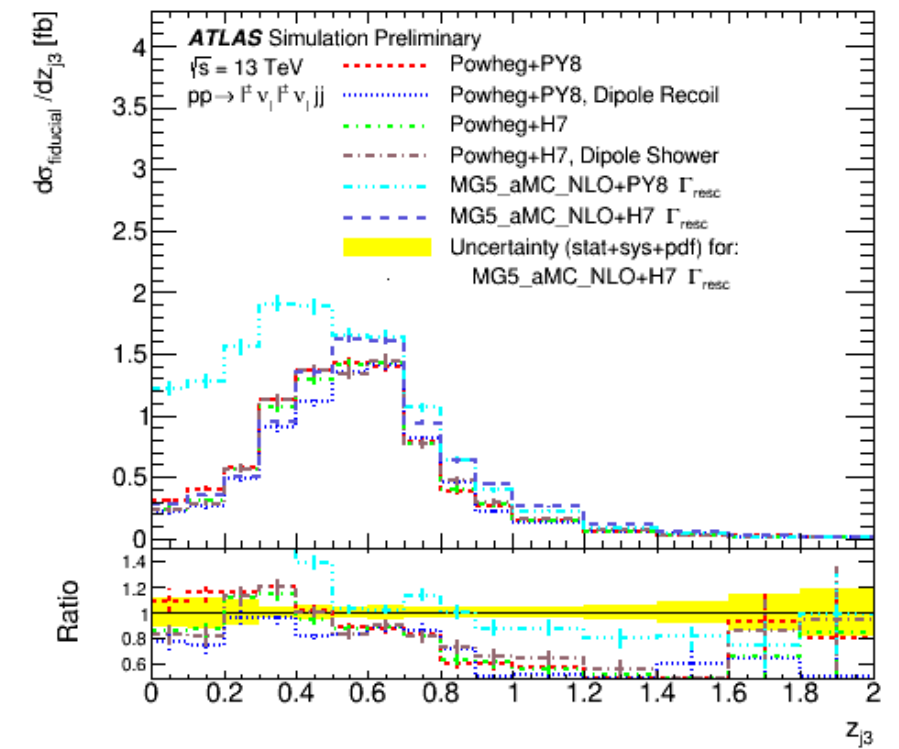
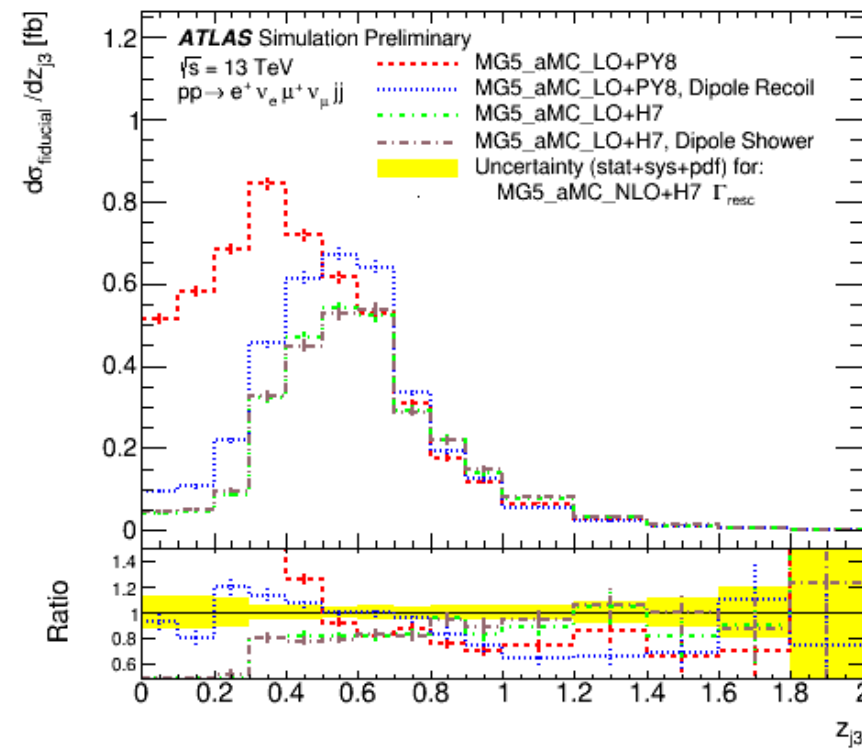
Several studies done in W^+W^+ showing disagreement on the third jet, even at NLO



Third jet and Parton Shower

Both Pythia and Sherpa recently provided a “fix” for the color flow

ATL-PHYS-PUB-2019-004



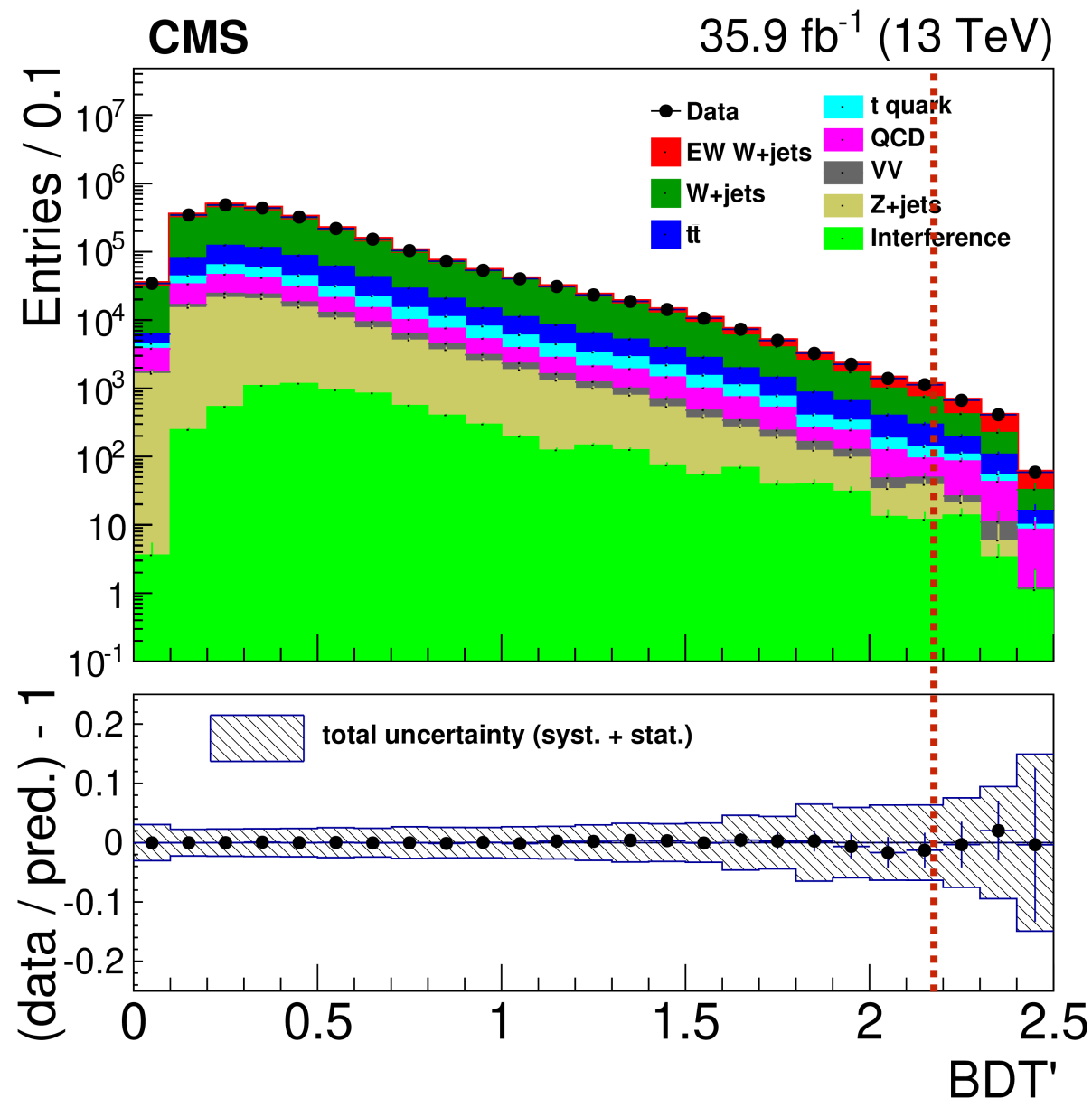
Sherpa 3.0.0 vs 2.2.2

S. Höche, MBI Workshop, Ann Arbor, 2018

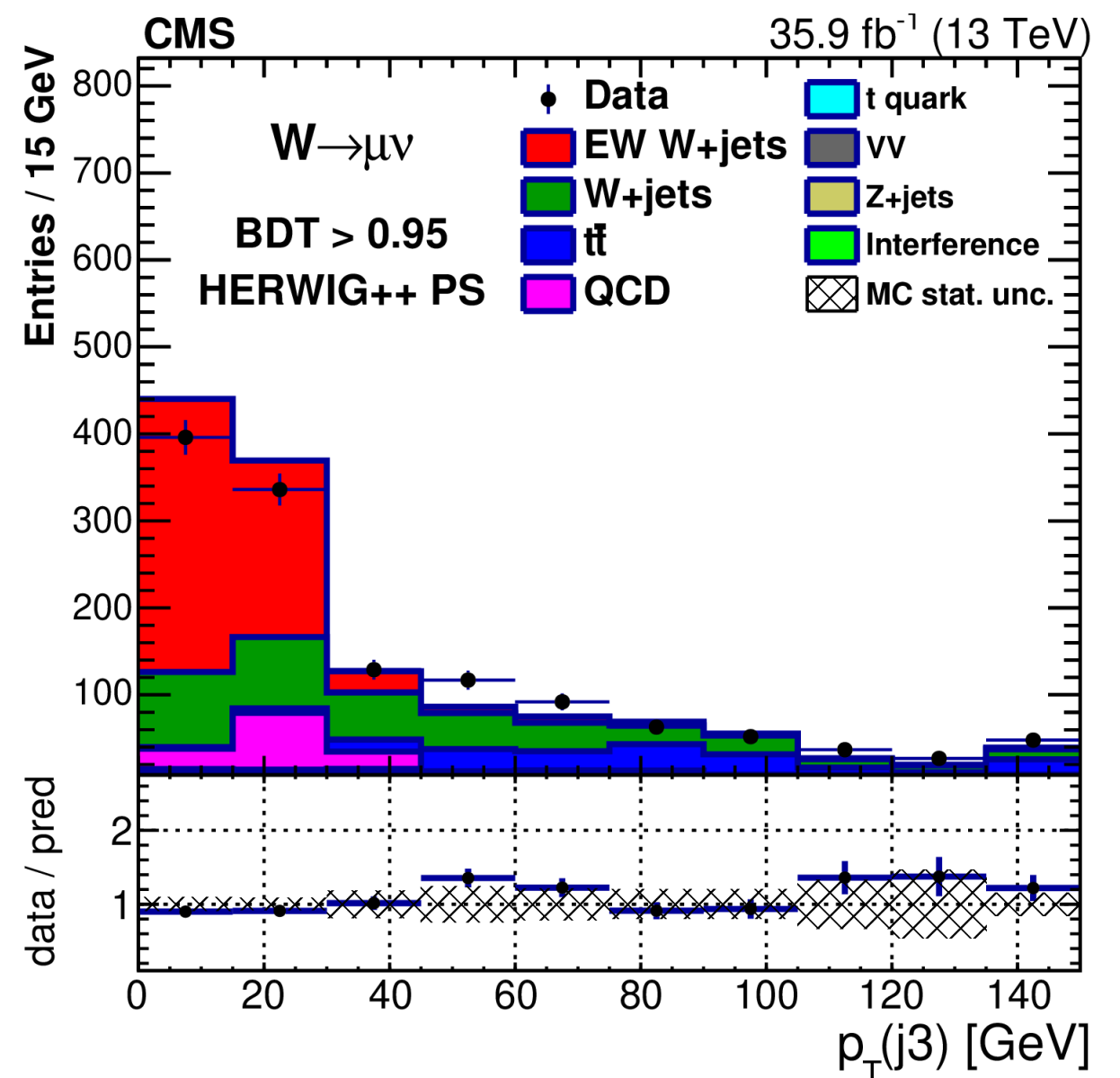
Jet activity in VBF W

CMS measured the jet activity in the rapidity gap in a signal region selected with a BDT

- ▶ in the signal region about same amount of EWK and QCD Zjj or Wjj
- ▶ the BDT is based on m_{jj} , $\Delta\eta_{jj}$, z^* , quark/gluon likelihood (QGL)



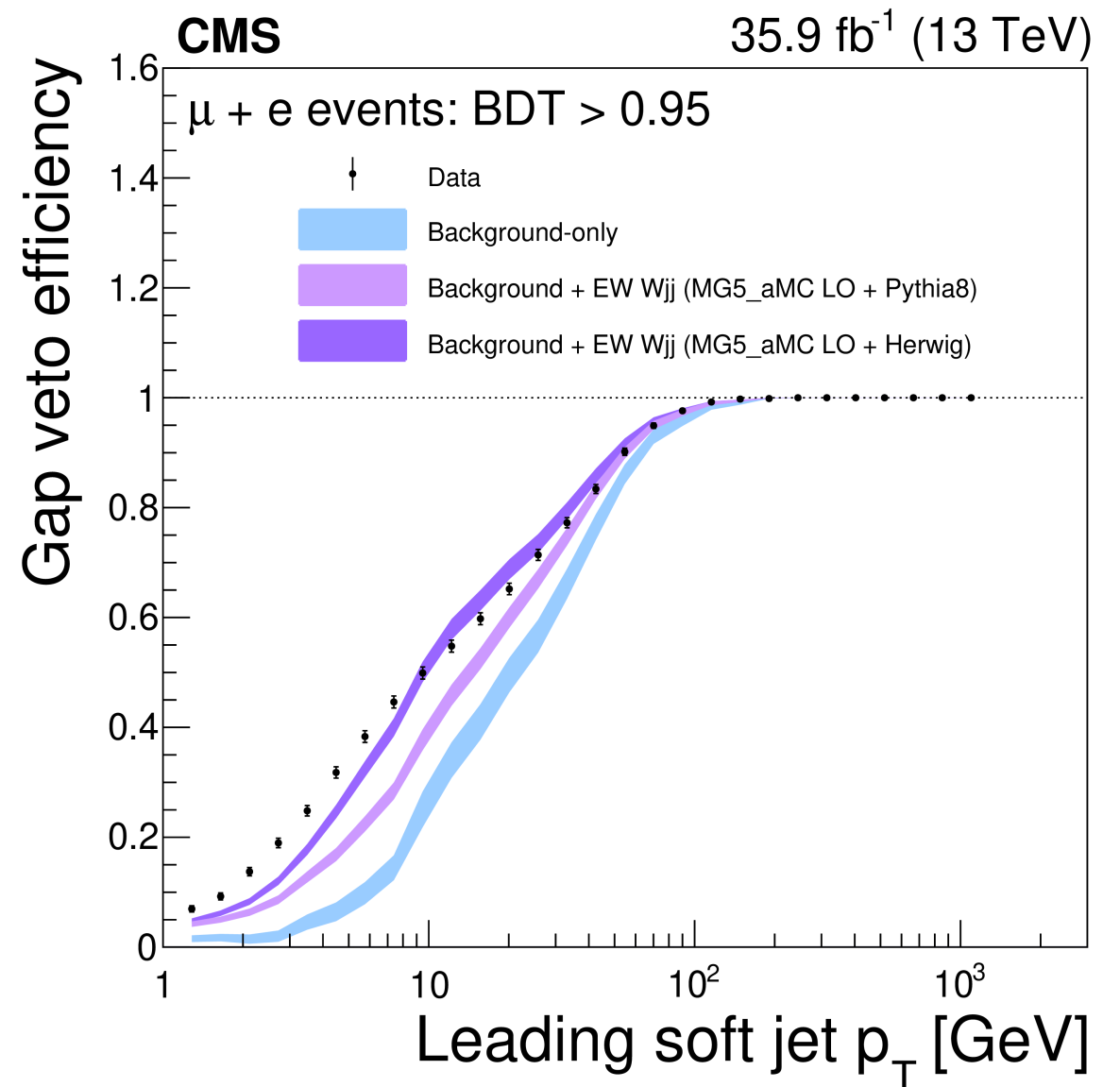
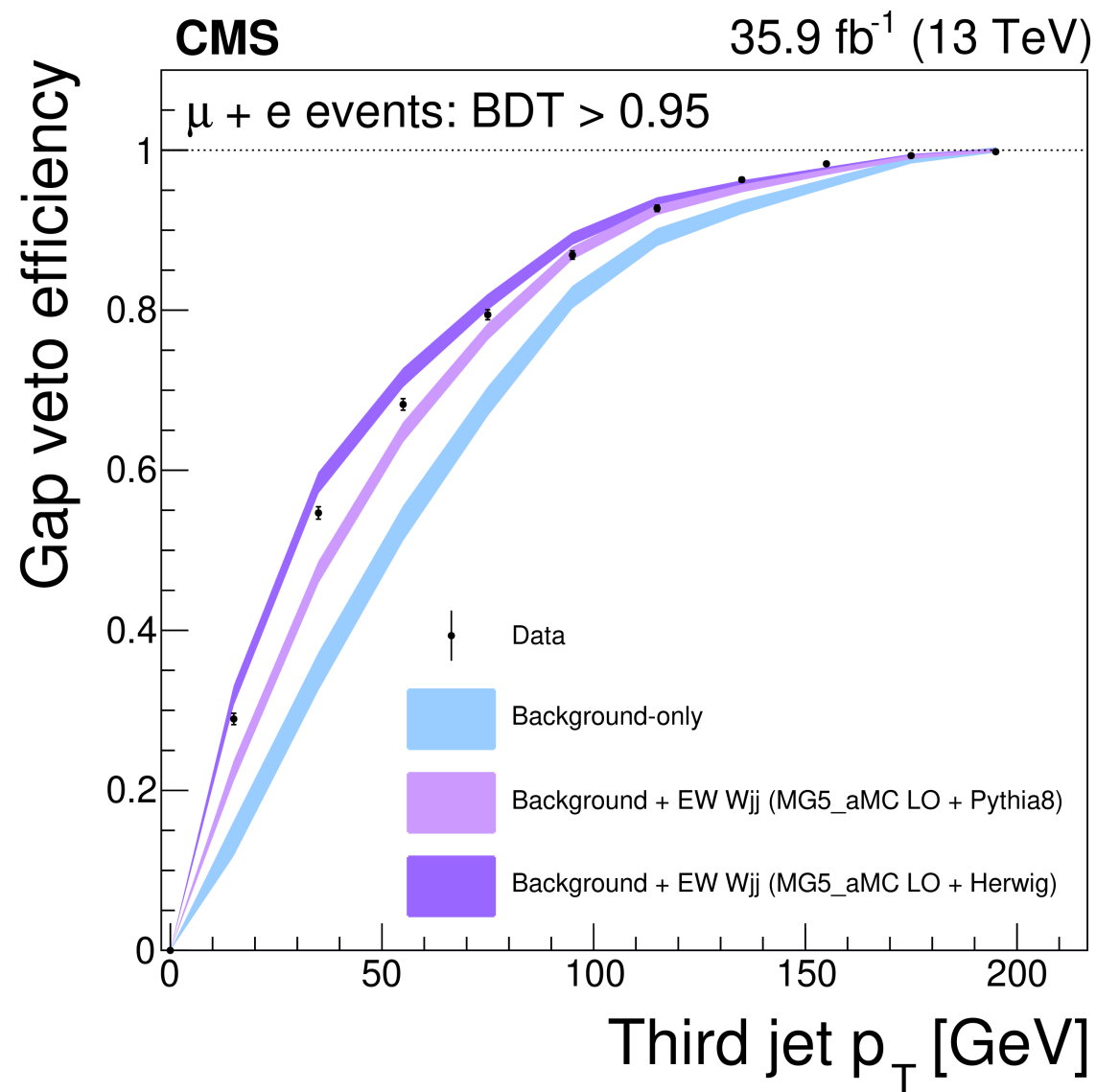
arXiv:1903.04040



Jet veto efficiency

Clear disagreement between MG+Pythia and data

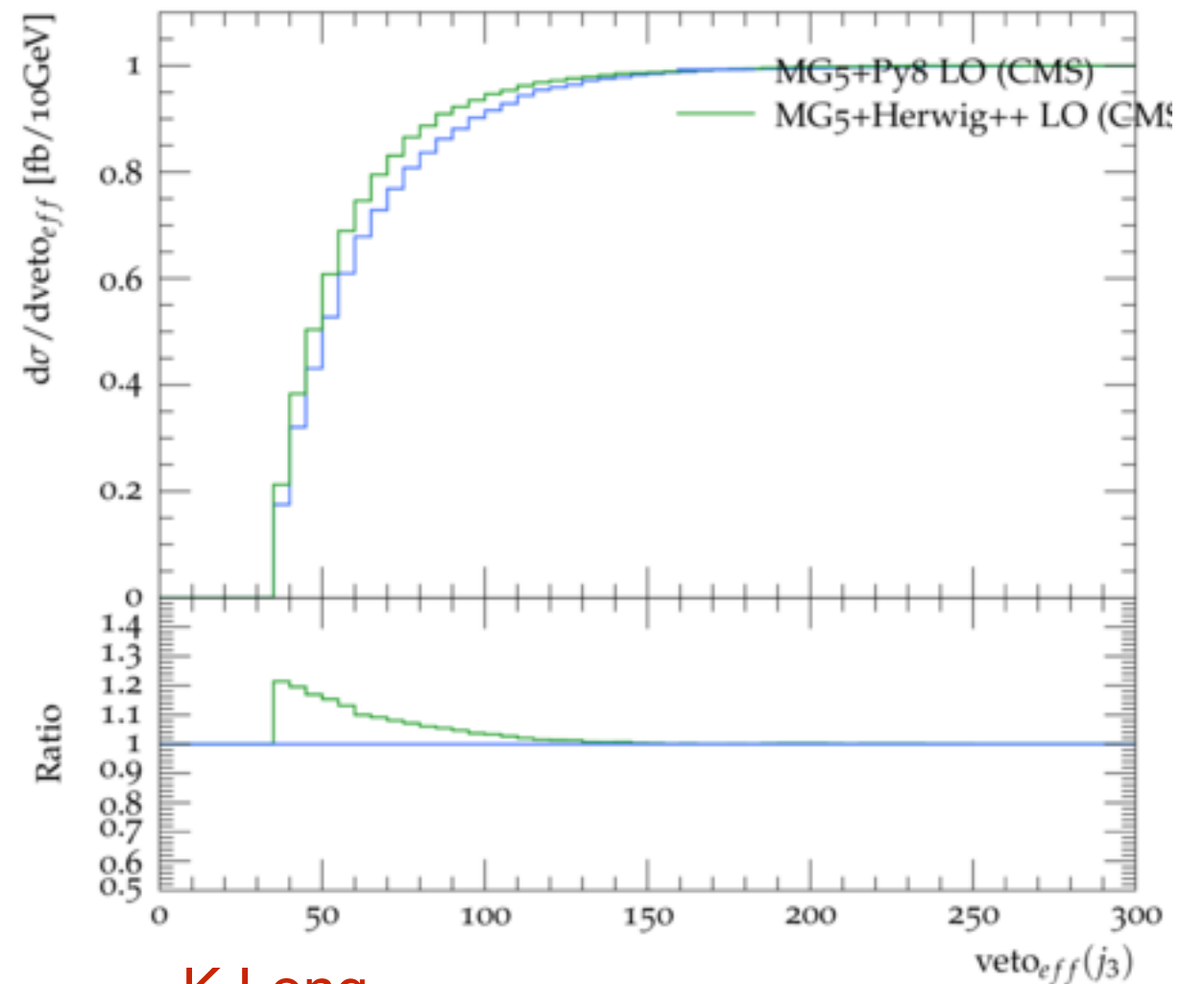
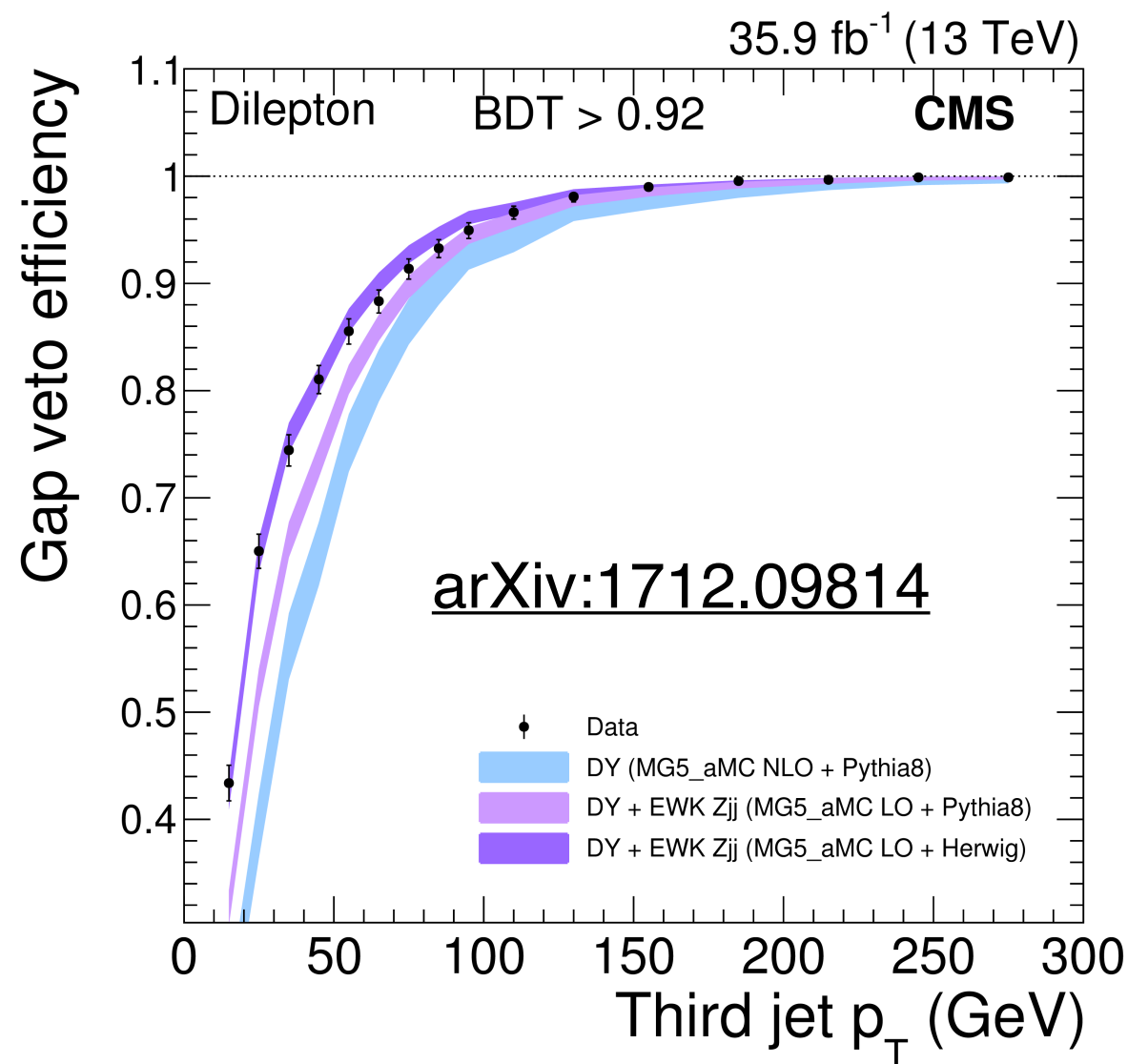
MG+HW ok down to jet $p_T \sim 10$ GeV



VBF Z measurement

Similar analysis for VBF Z, which also uses a BDT

Preliminary Rivet which selects signal events with $m_{jj} > 500$ and $\Delta\eta_{jj} > 2.5$



K.Long

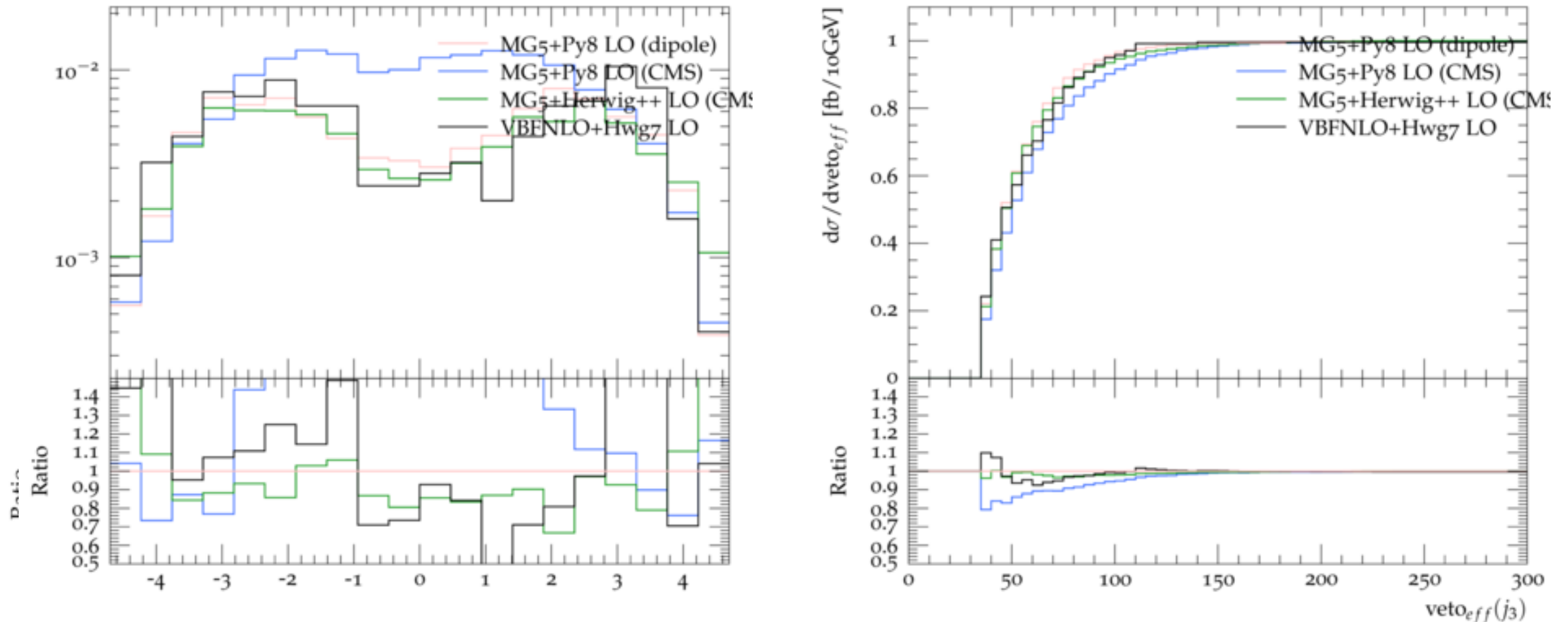
Same qualitative behaviour

Even without a fully unfolded measurement, MG+HW can be used as a “proxy” to the data

VBF Z measurement

More plots/predictions from the preliminary Rivet plugin

- ▶ the effect of “dipole recoil” in Pythia can be clearly seen



K.Long, L. Gellersen, C. Reuschle

- ▶ We plan to run a full set of comparisons: LO (fixed order), LO+PS, NLO (fixed order), NLO+PS

Unfolding BDT selection

An (ambitious) experimental project is to provide a “fast folding” for the Rivet analysis

The problem with BDT is that it uses measured observables as input: m_{jj} , $\Delta\eta_{jj}$, z^* , quark/gluon likelihood

However we can train another BDT_{gen} on particle level inputs, (m_{jj}^{true} , z^{*}_{true} , quark/gluon jet) to the output of the selection BDT:

- events with a $BDT > 0.95$ are tagged as signal
- events with a $BDT < 0.95$ are tagged as background

If able to tag them with good efficiency, we can obtain a sample as that in the data!

Not sure it will work, but worth trying...

For practical reason this is easier for VBF W analysis, so we agreed to focus on that for the proceedings instead of VBF Z

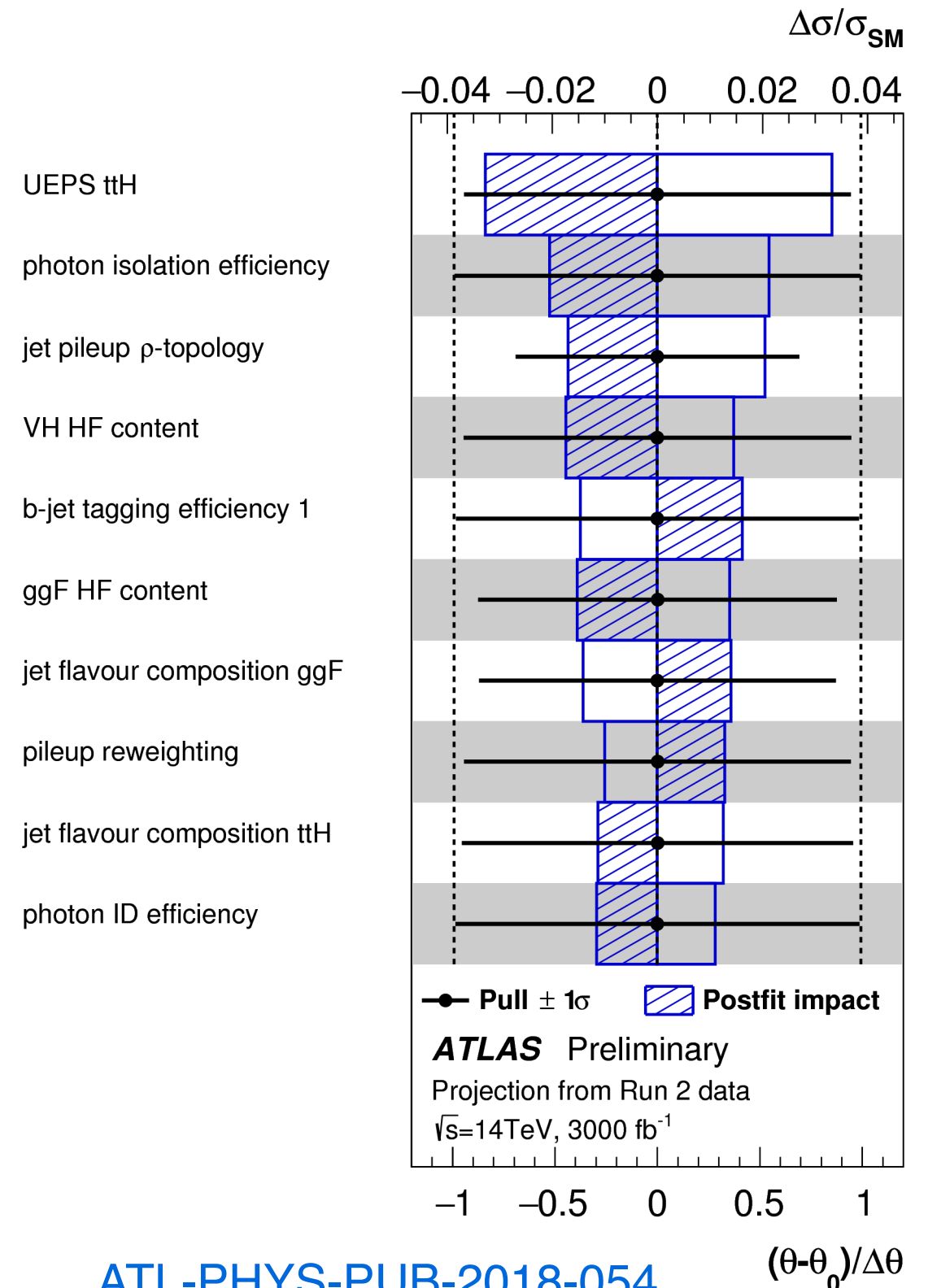
MC variations “case study”

Several possible “case studies” considered for an exercise on MC variations

- ▶ focus on something relevant (and controversial) for present measurements
- ▶ collected inputs: $t\bar{t}H$, VBF H , $p_T(H)$, DY ,...

$t\bar{t}H$ most interesting:

- ▶ largest uncertainty at HL-LHC expected to come from UEPS
- ▶ (bad name!!!... actually just the difference between PYTHIA and HERWIG...)
- ▶ but **$t\bar{t}H$** too difficult to start with
- ▶ **$t\bar{t}$** is a good proxy to it



MC variations for top—anti-top process

In addition $t\bar{t}$ is important by itself

- ▶ it is a standard candle
- ▶ there are many available measurements
- ▶ it is a background to many measurements

Plan:

- ▶ runs NLO+PS (at least to start with)
- ▶ select 2-3 observables
- ▶ produce envelope varying matching, PS model, NP model
- ▶ check that it behaves as expected
- ▶ check that envelopes for different setups overlaps

Conclusions(?)

...thanks for the fun!



Backup slides

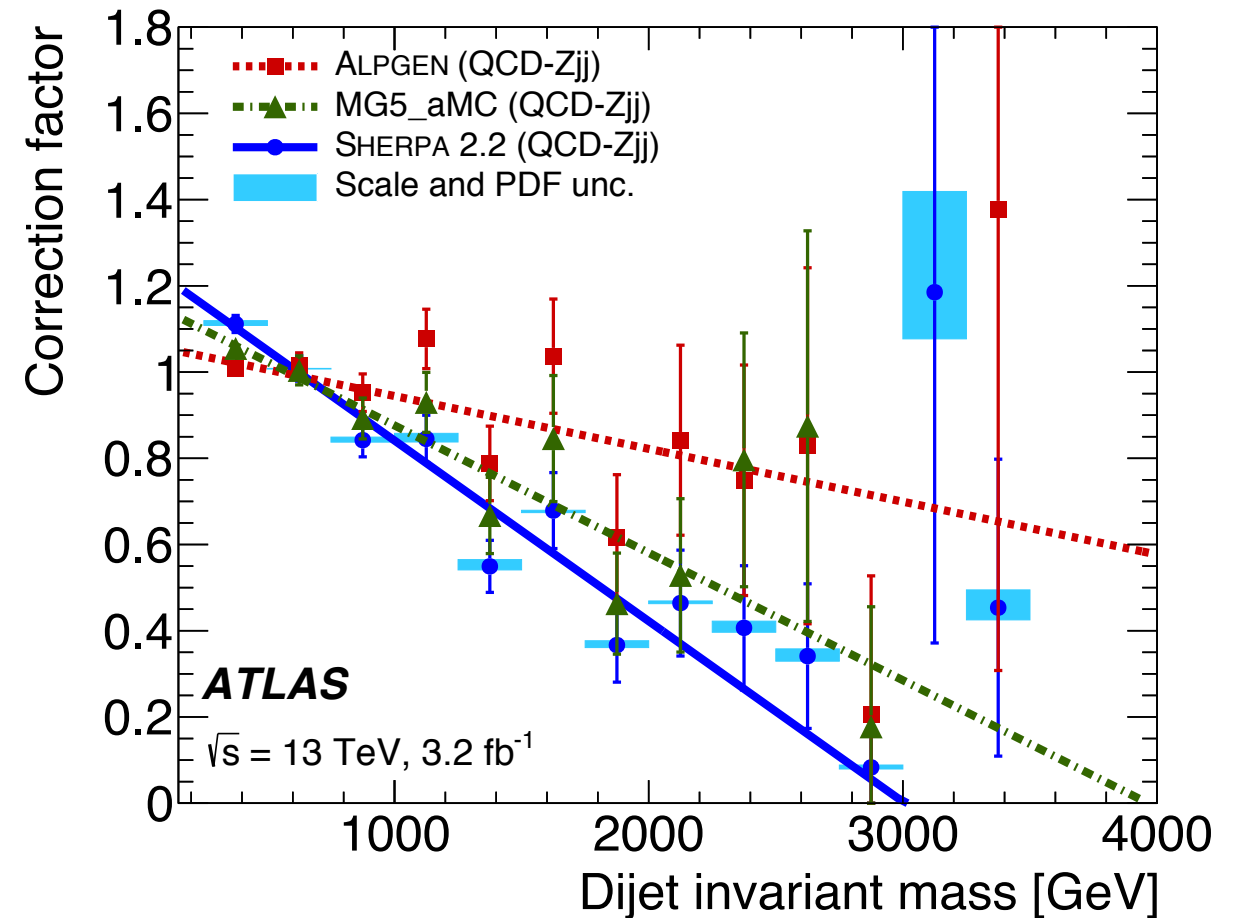
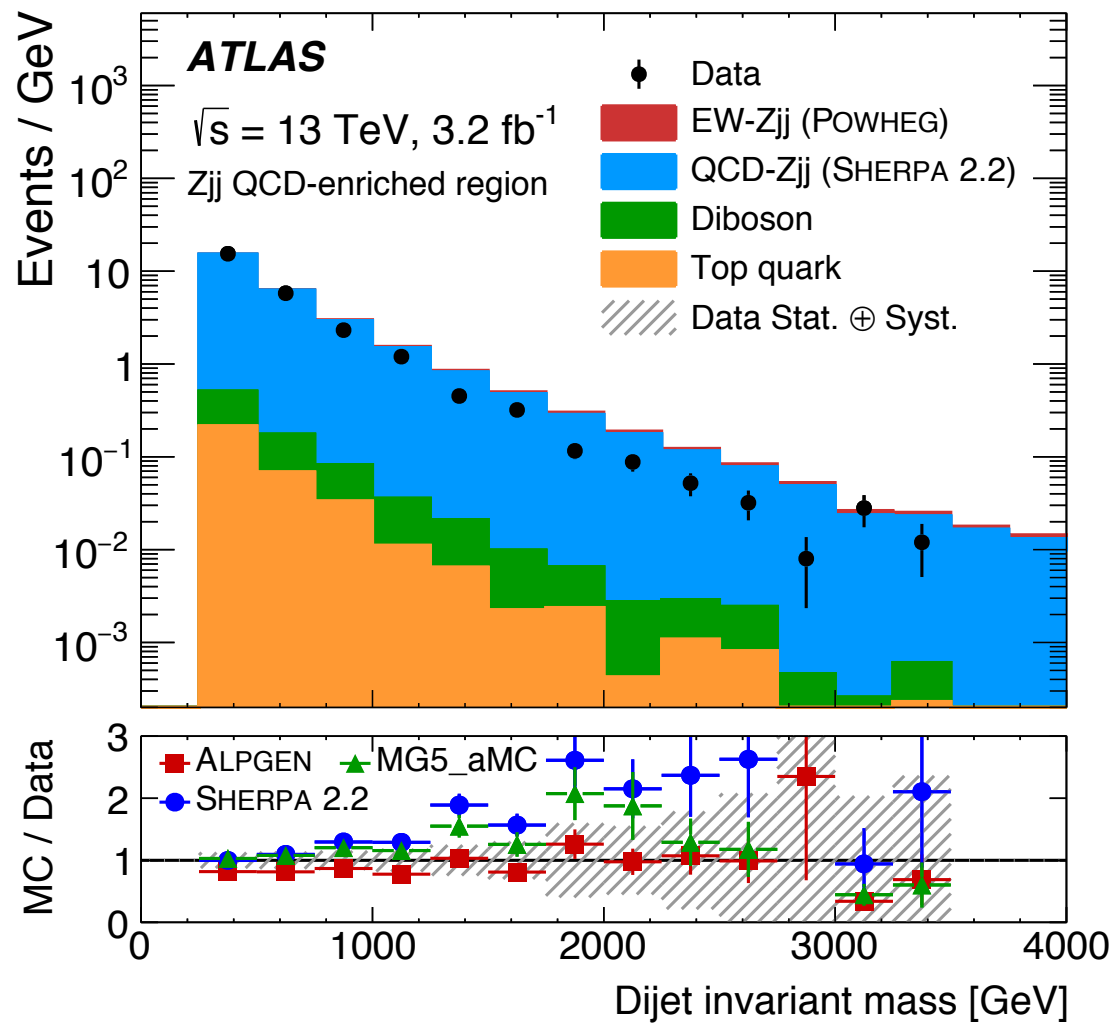
Sherpa 3.0.0 vs 2.2.2

- ▶ Current color selection in Sherpa based on hardcoded probabilities for the most relevant processes, VBF topologies are *not* included
- ▶ Alternative, generic option in future version 3.0.0
 - ▶ Identify all possible color flows in core interaction (after ME+PS clustering, e.g. $pp \rightarrow e^+e^-$ in $pp \rightarrow e^+e^- + \text{jets}$)
 - ▶ Compute corresponding partial amplitudes [Gleisberg,SH] arXiv:0808.3674
 - ▶ Select winner topology probabilistically
- ▶ Sherpa 3.0.0 also allows to specify different starting scales for parton-shower evolution of disconnected dipoles

from S. Höche, MBI Workshop, Ann Arbor, 2018

Zjj QCD background to VBF

Agreement on m_{jj} not always ok

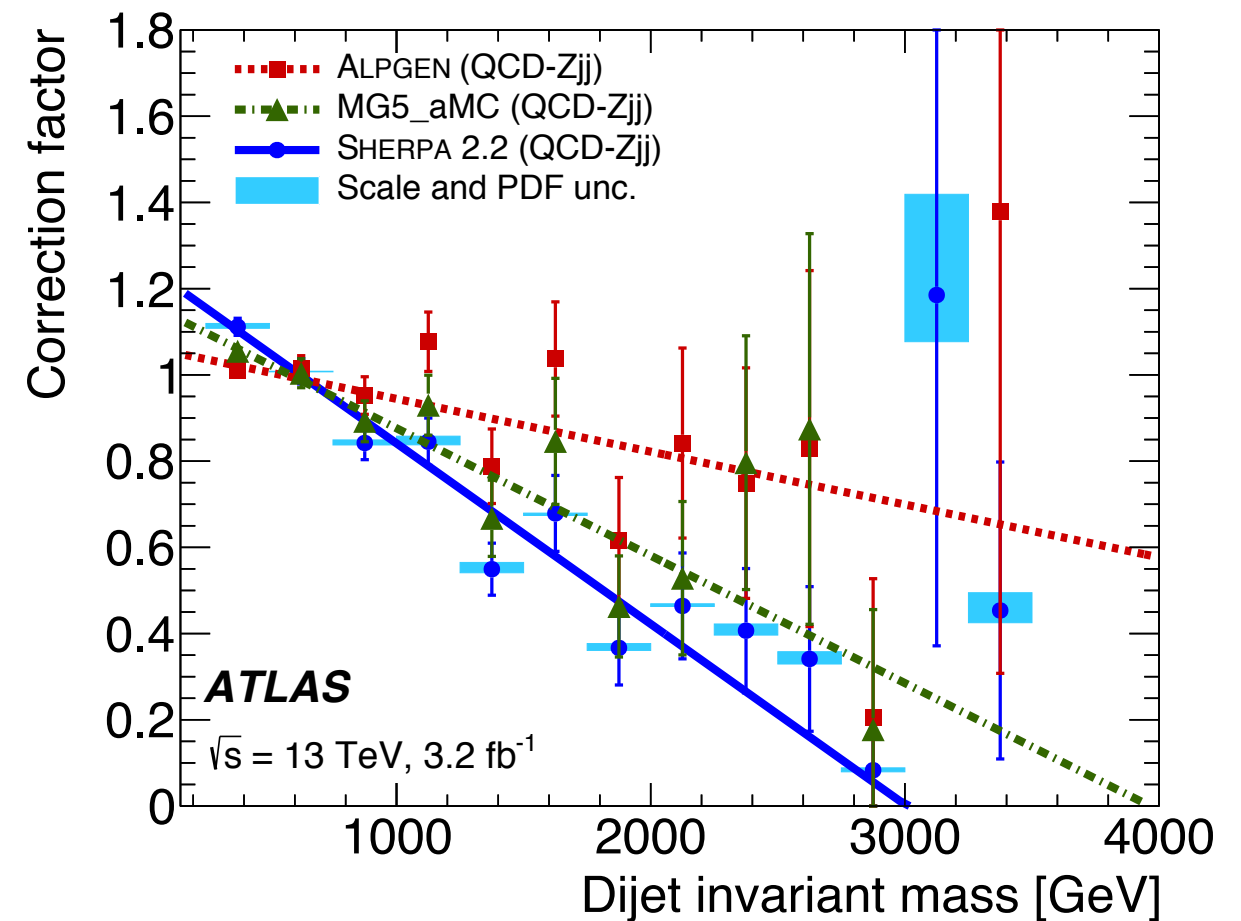
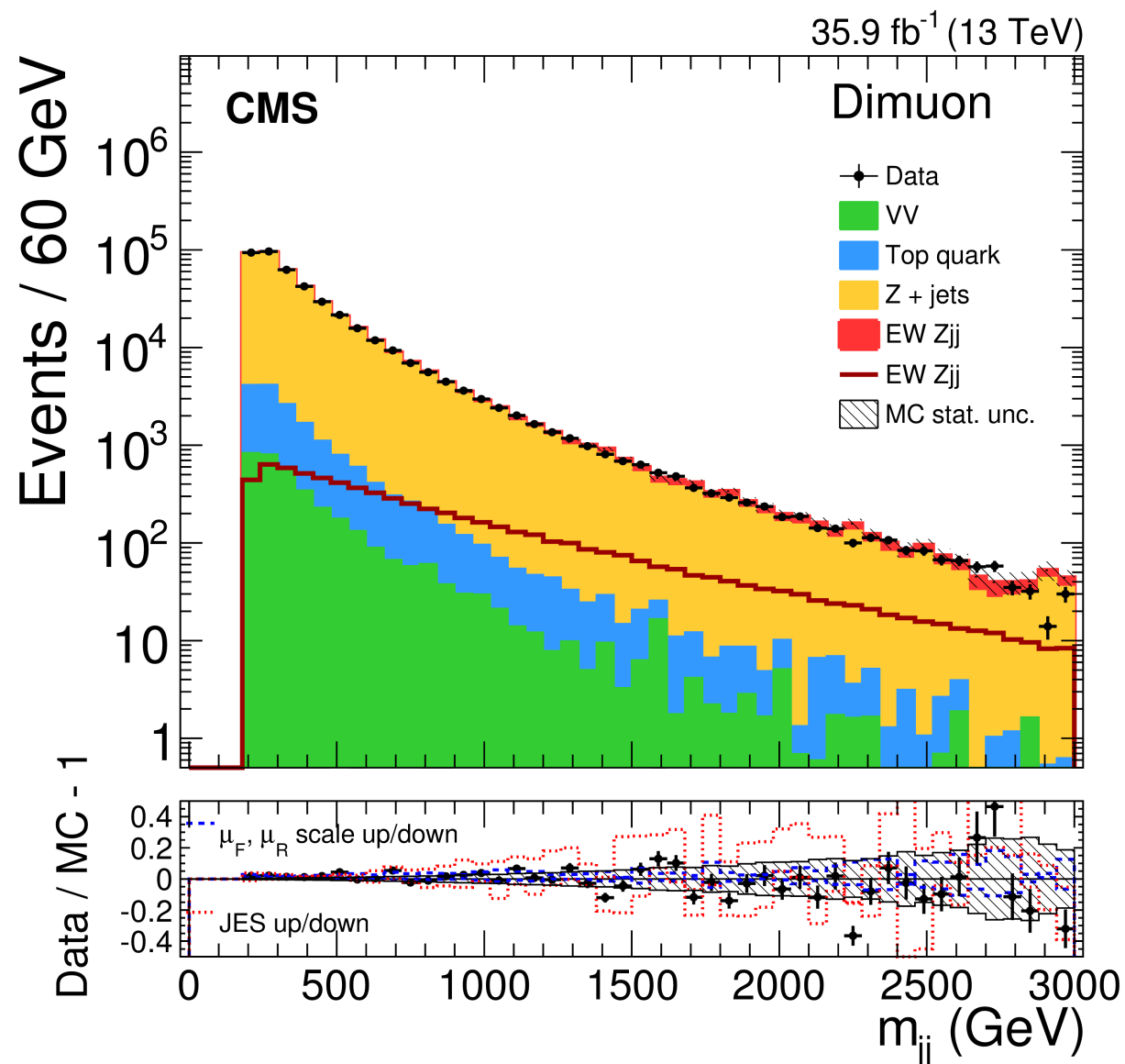


<https://arxiv.org/abs/1709.10264>

Zjj QCD background to VBF

Agreement on m_{jj} depends on additional jet(s)

e.g. look at MG5 NLO vs LO



<http://arxiv.org/abs/1712.09814>