MC & Tools
Experimental Summary

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Les Houches - Physics at TeV Colliders - 2019

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

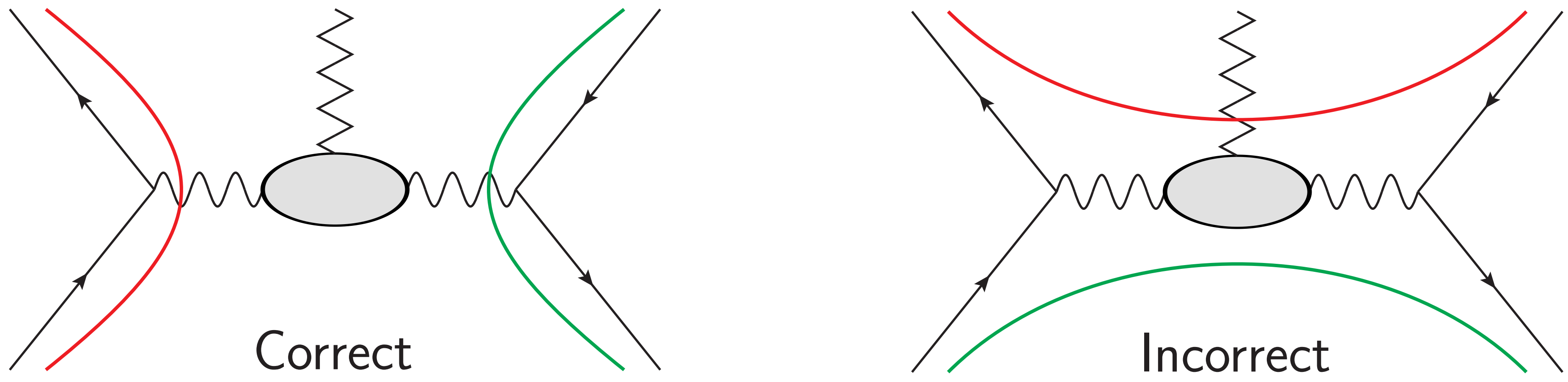
Outlook

- Jet activity in Vector Boson Fusion Z and W production

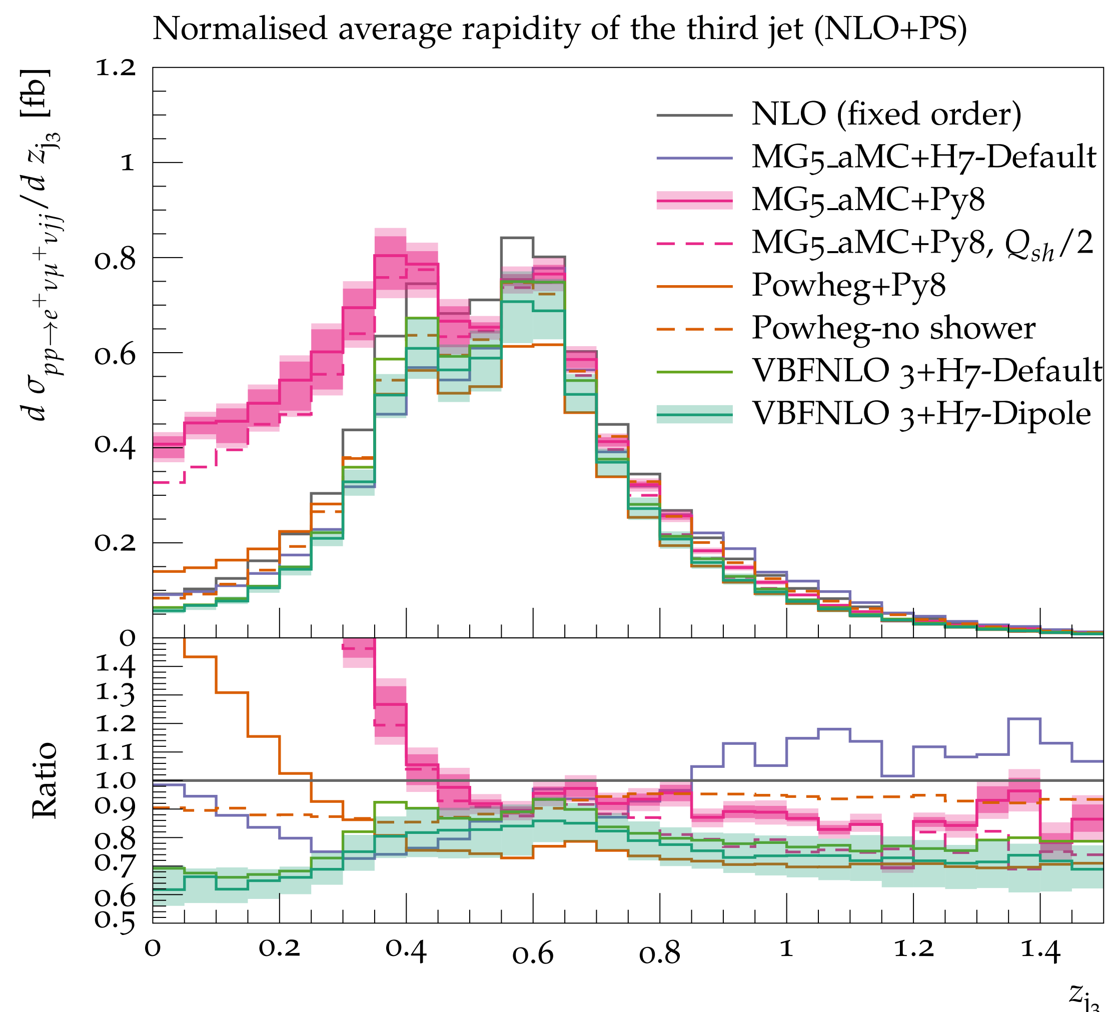
- MC variations: “case study”

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



arXiv:1803.07943

Third jet and Parton Shower

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

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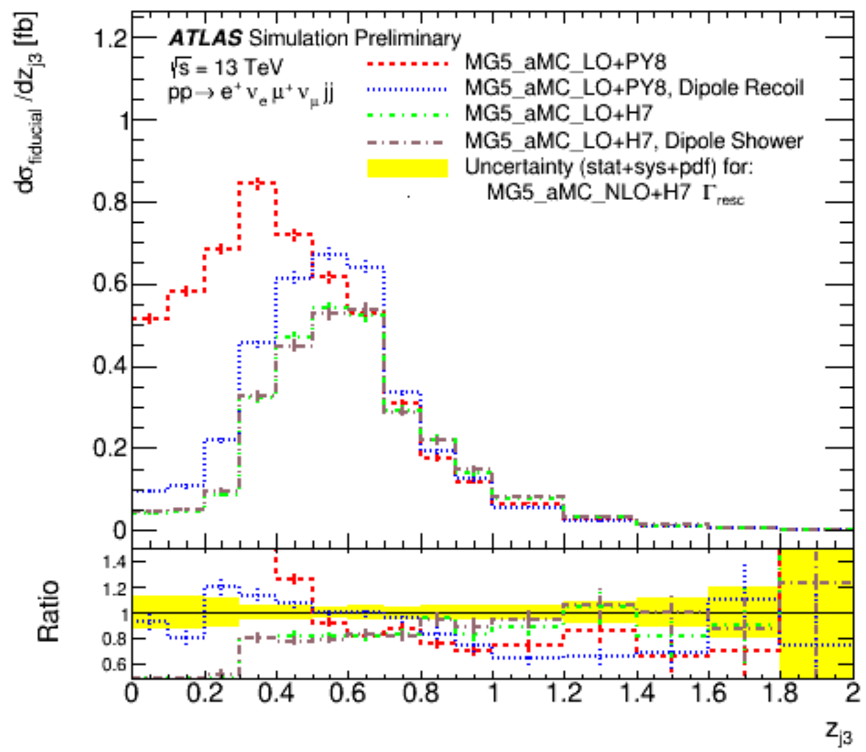
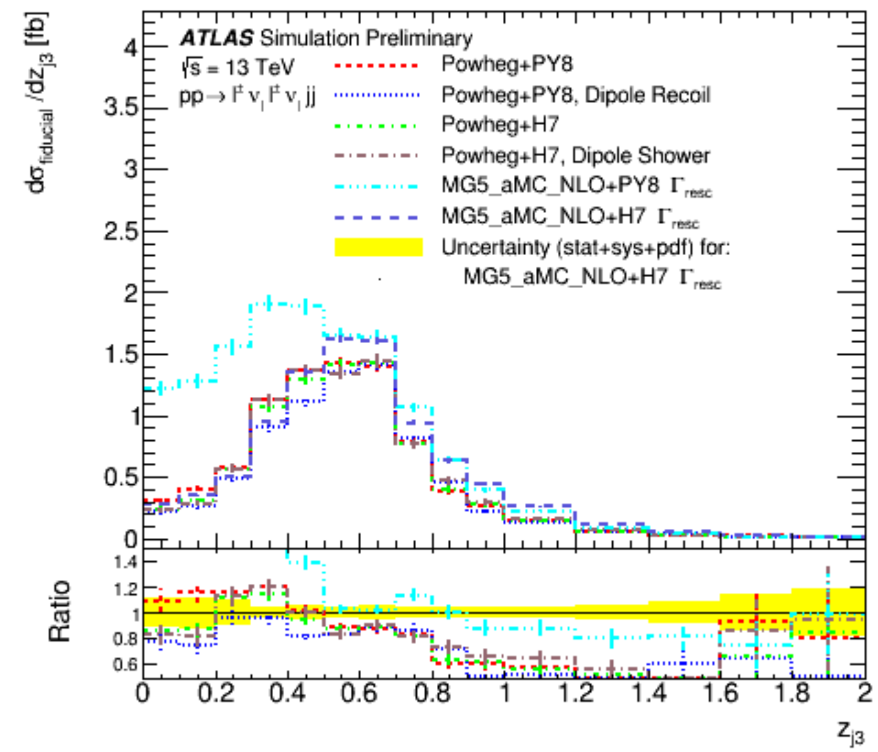
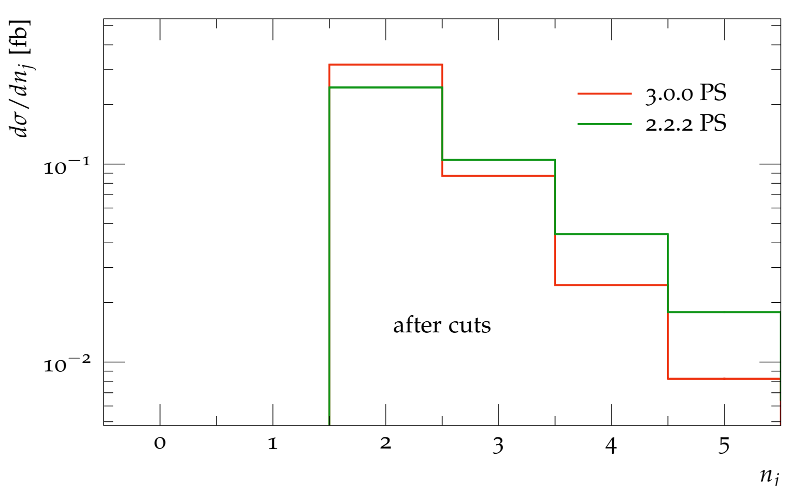
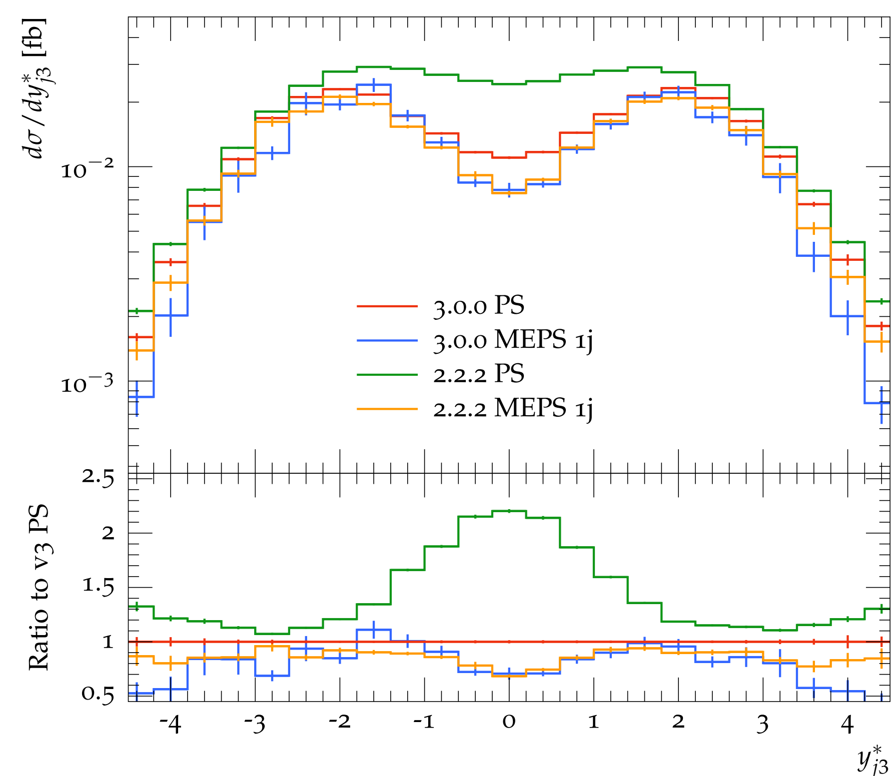






Sherpa 3.0.0 vs 2.2.2

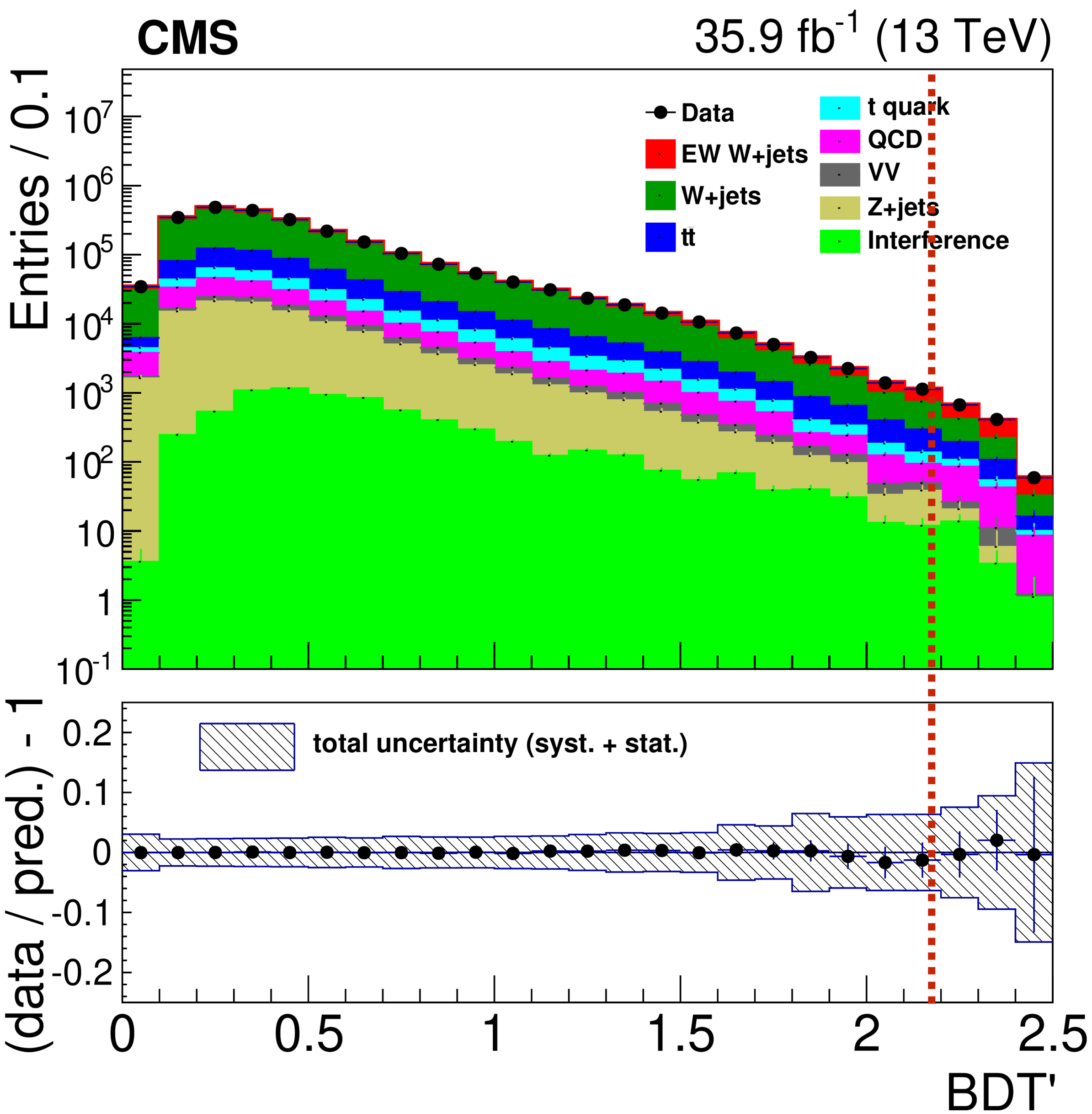
S. Höche, MBI Workshop, Ann Arbor, 2018

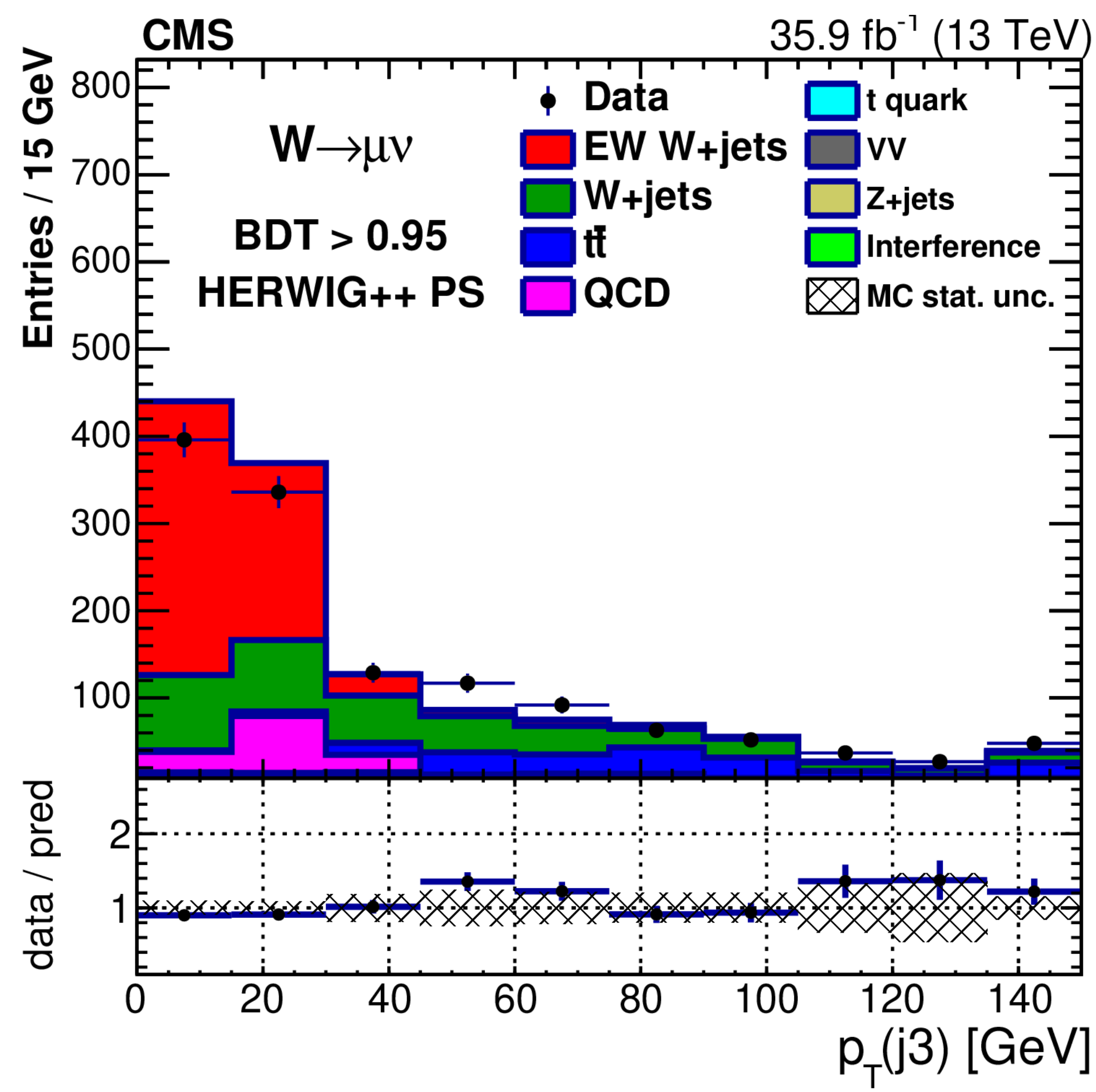


Jet activity in VBF W

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 mjj, Δηjj, z*, quark/gluon likelihood (QGL)



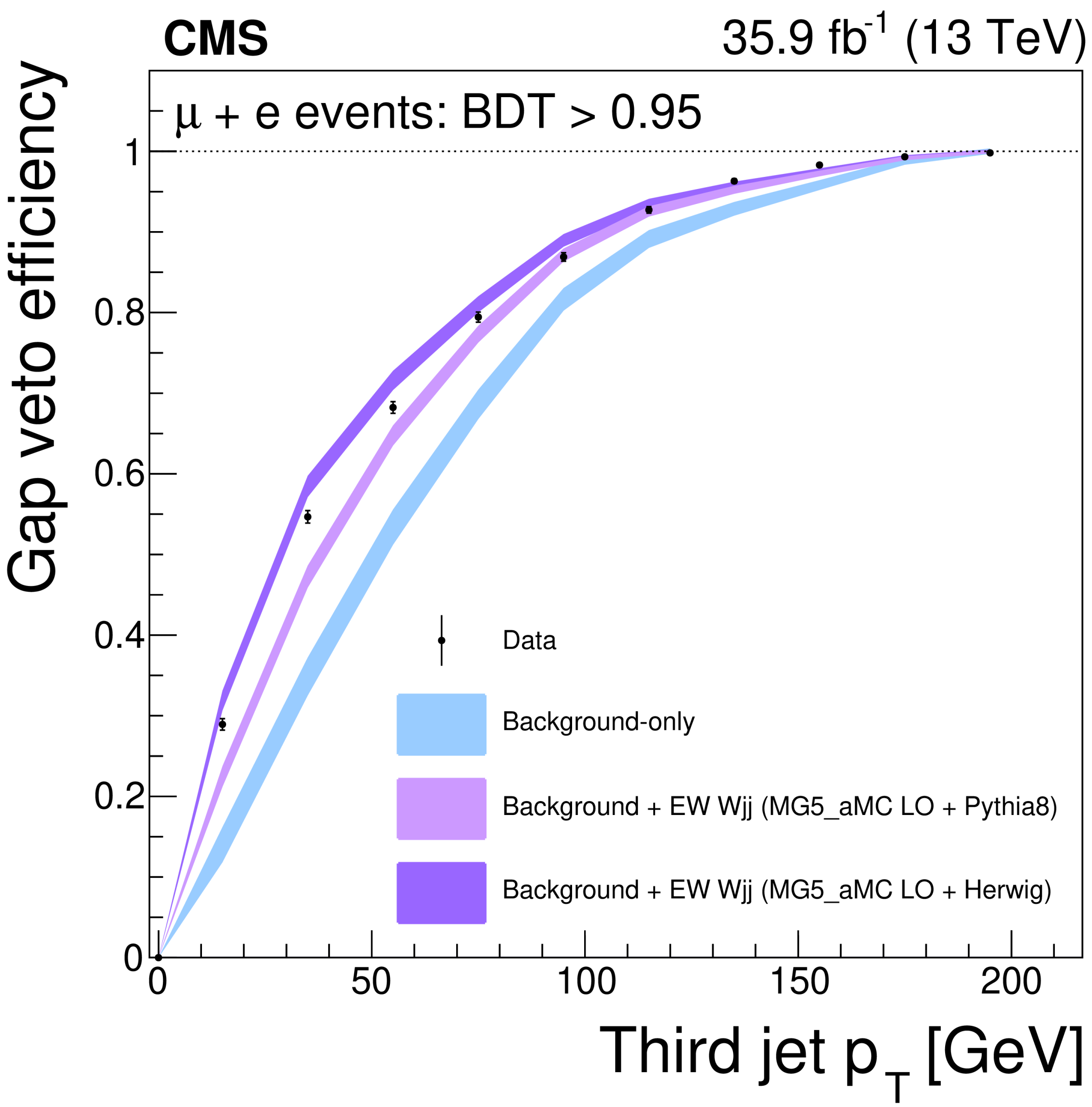


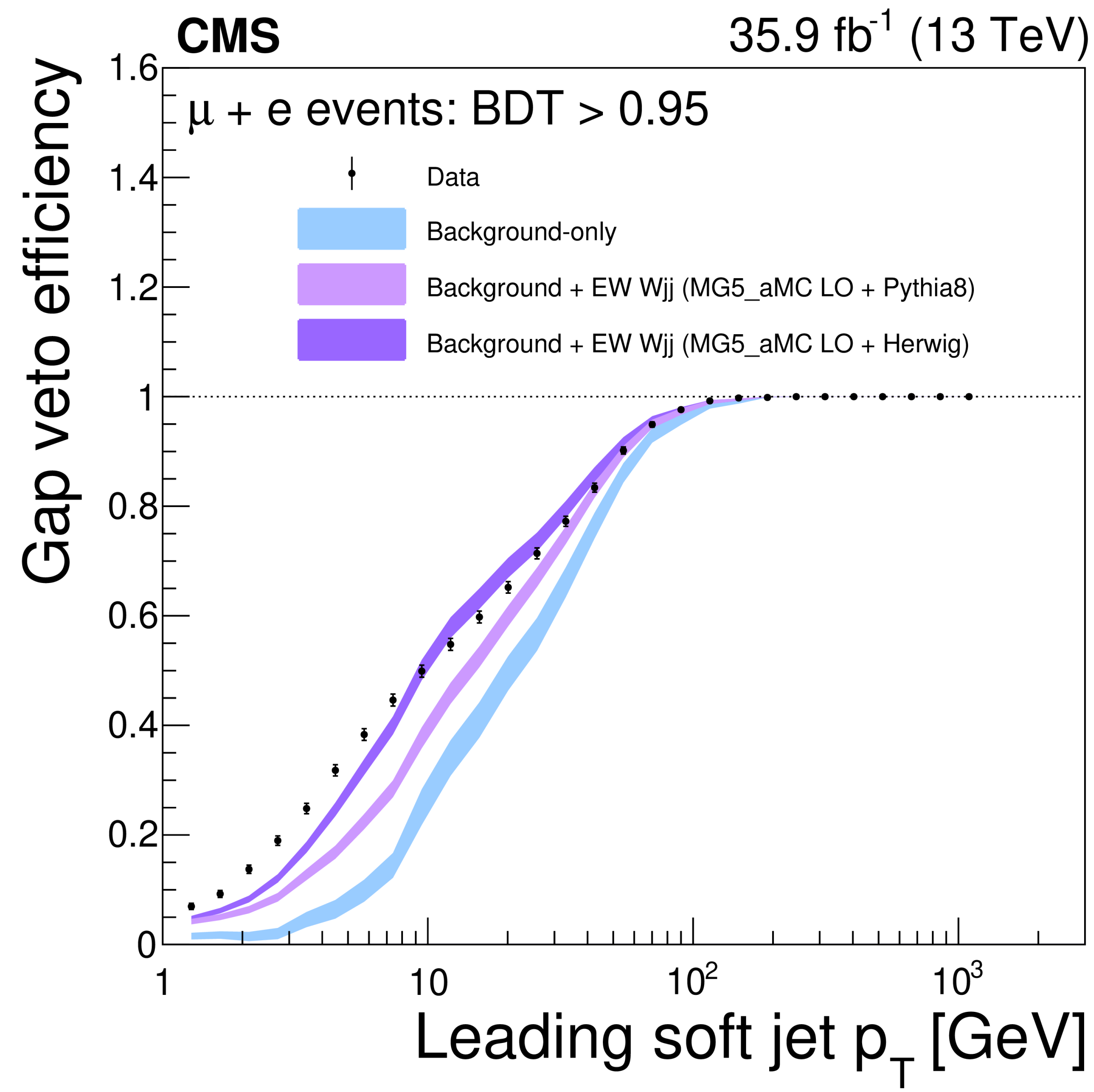
arXiv:1903.04040

Jet veto efficiency

Clear disagreement between MG+Pythia and data

MG+HW ok down to jet p_T ~ 10 GeV

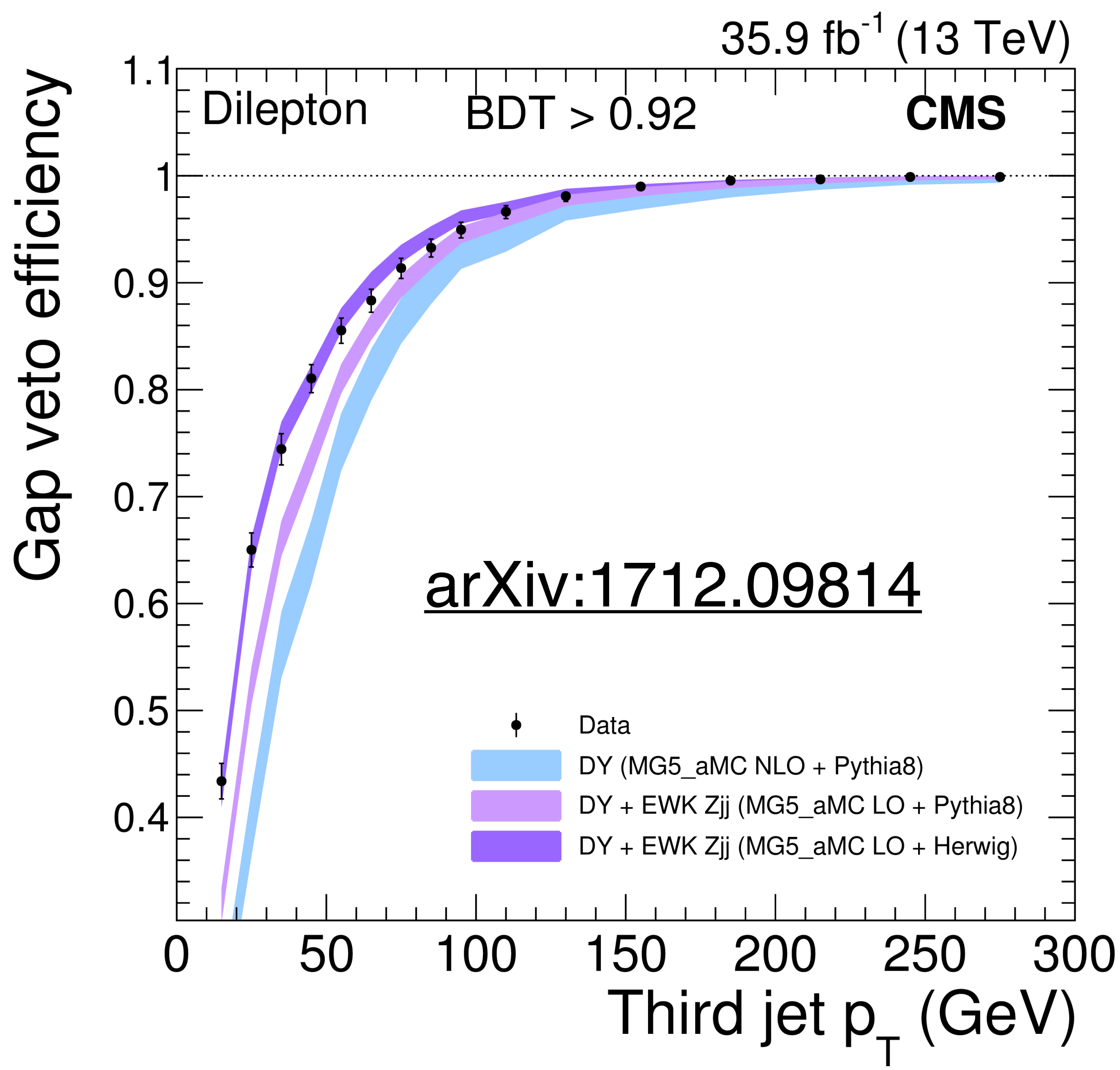


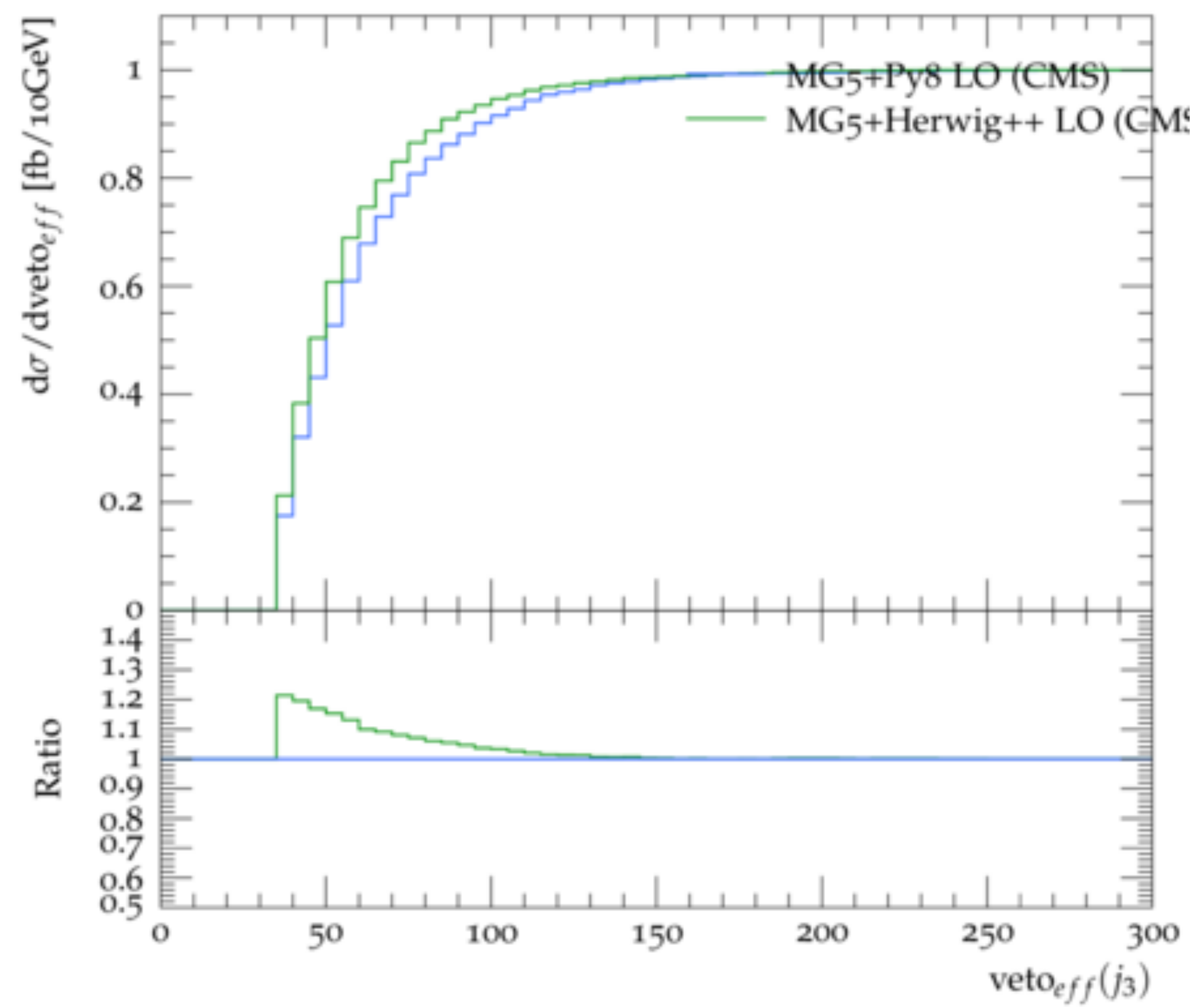


VBF Z measurement

Similar analysis for VBF Z, which also uses a BDT

Preliminary Rivet which selects signal events with mjj > 500 and Δηjj > 2.5





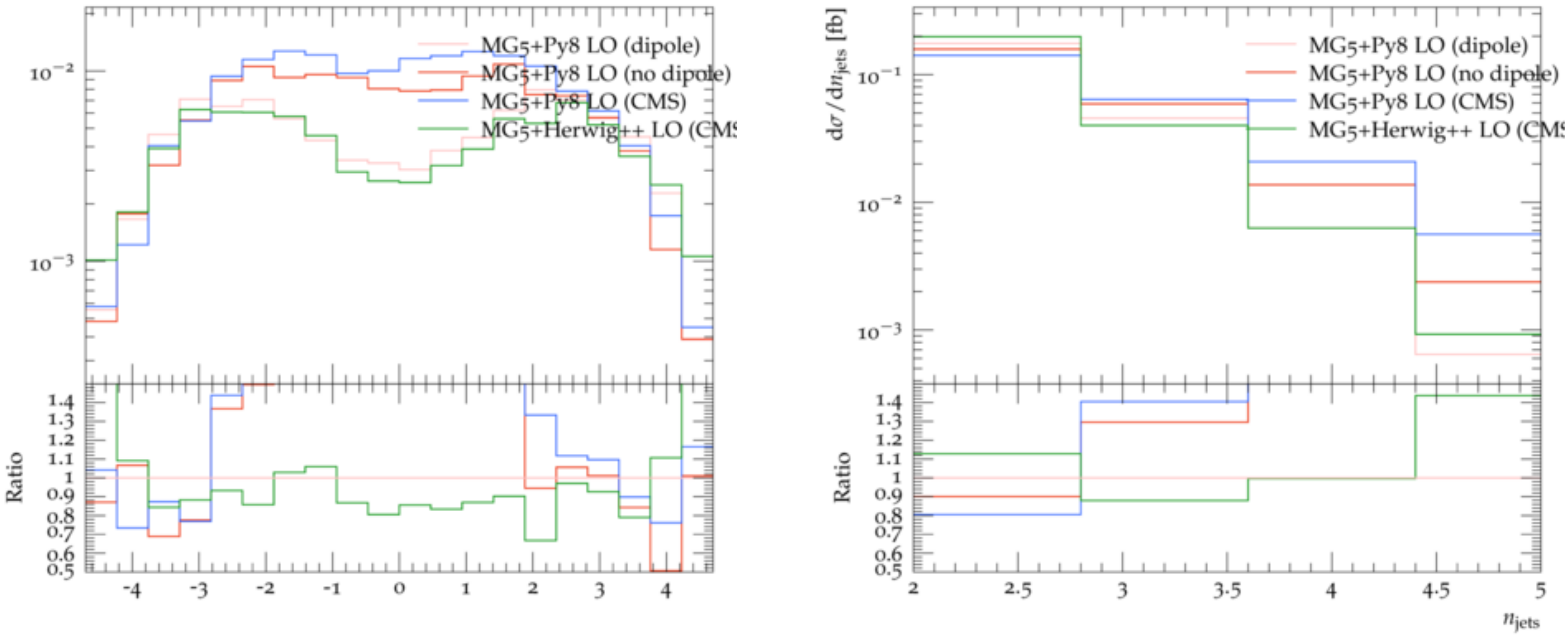
Same qualitative behaviour

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

VBF Z measurement

More plots from the preliminary Rivet routine

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



- 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: mjj, Δηjj, z*, quark/gluon likelihood

However we can train another BDT_{gen} on particle level inputs, (mjj_{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

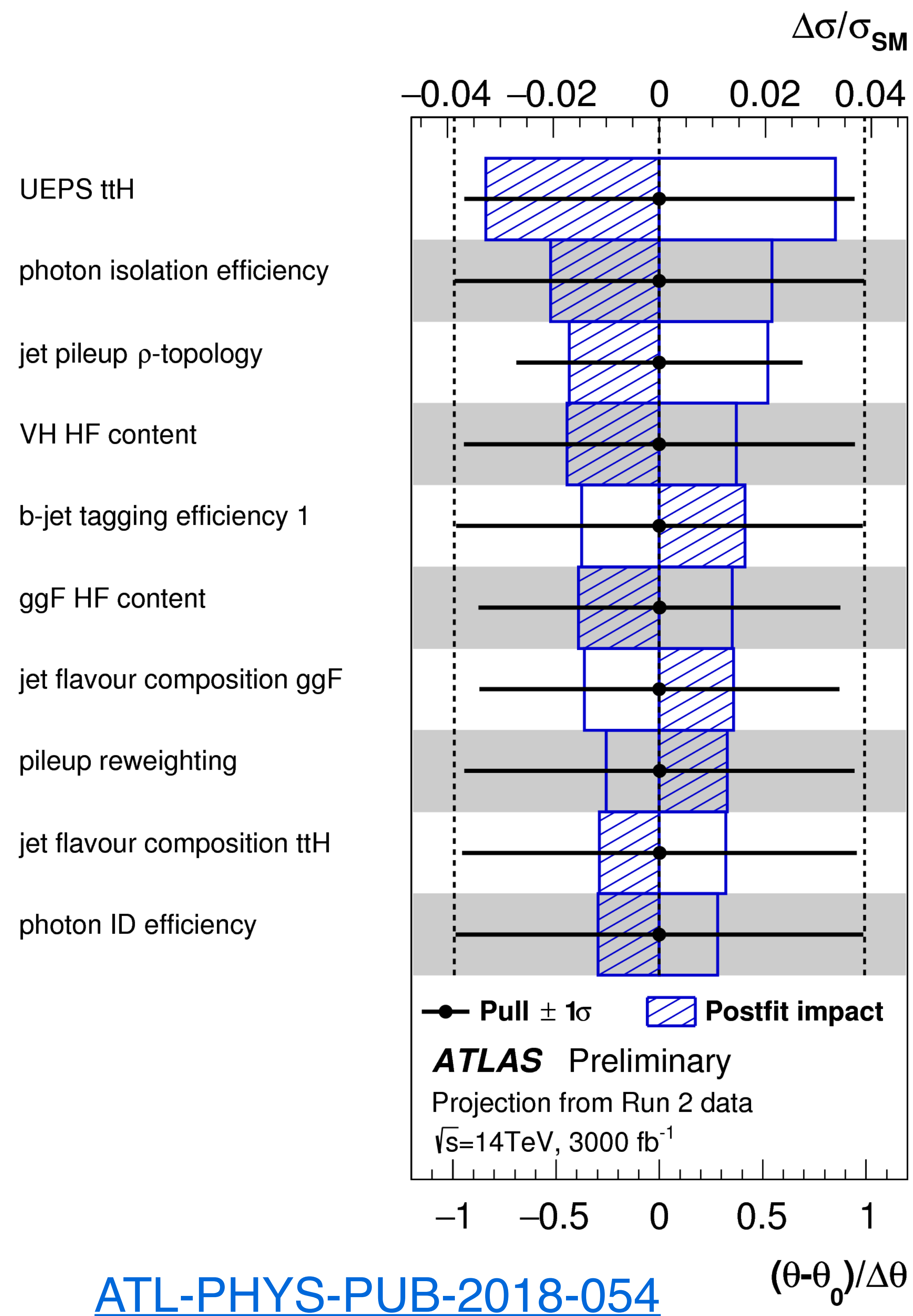
MC variations "case study"

Several possible "case studies" considered for an exercise on MC variations

- focus on something relevant (and controversial) for present measurements
- collected inputs: ttH, VBF H, p_T (H), DY,…

ttH most interesting:

- largest uncertainty at HL-LHC expected to come from UEPS
- (bad name!!!… actually just the difference between PYTHIA and HERWIG…)
- but **ttH** too difficult to start with
- **tt** is a good proxy to it



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MC variations for top—anti-top process

In addition **tt** 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 envelops 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
  - Idenitify all possible color flows in core interaction (after ME+PS clustering, e.g. $pp \to e^+e^-$ in $pp \to e^+e^-$+jets)
  - Compute corresonding 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