Studies of particle-level measurements and SM monte carlo in constraining new physics

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18th MCnet Meeting

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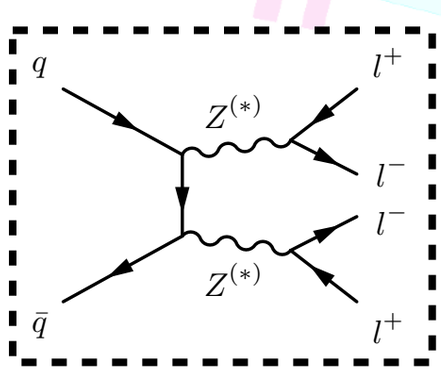
Supervised by Prof.Jon Butterworth

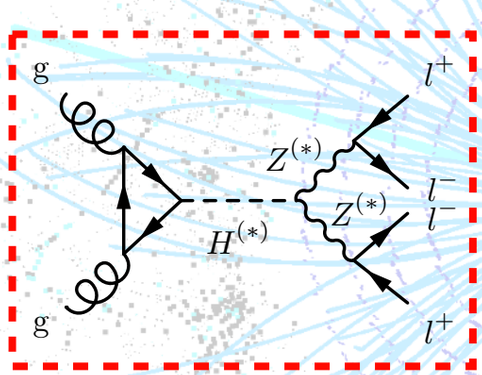
Outline

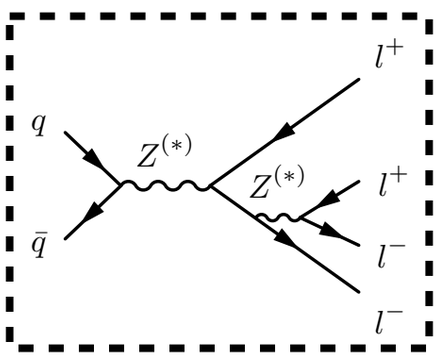
1. Unfolding an ATLAS measurement
2. SM predictions with Herwig 7
3. Towards (re-)interpretation
4. Summary

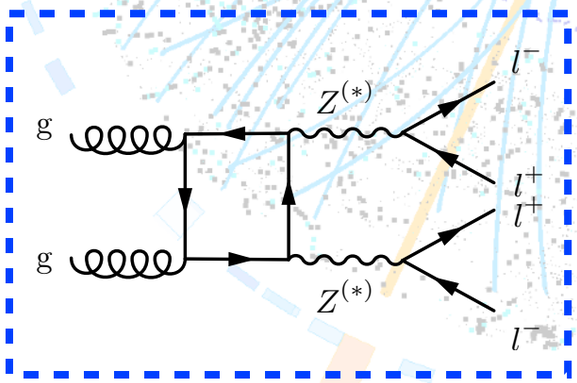
The 4 lepton analysis

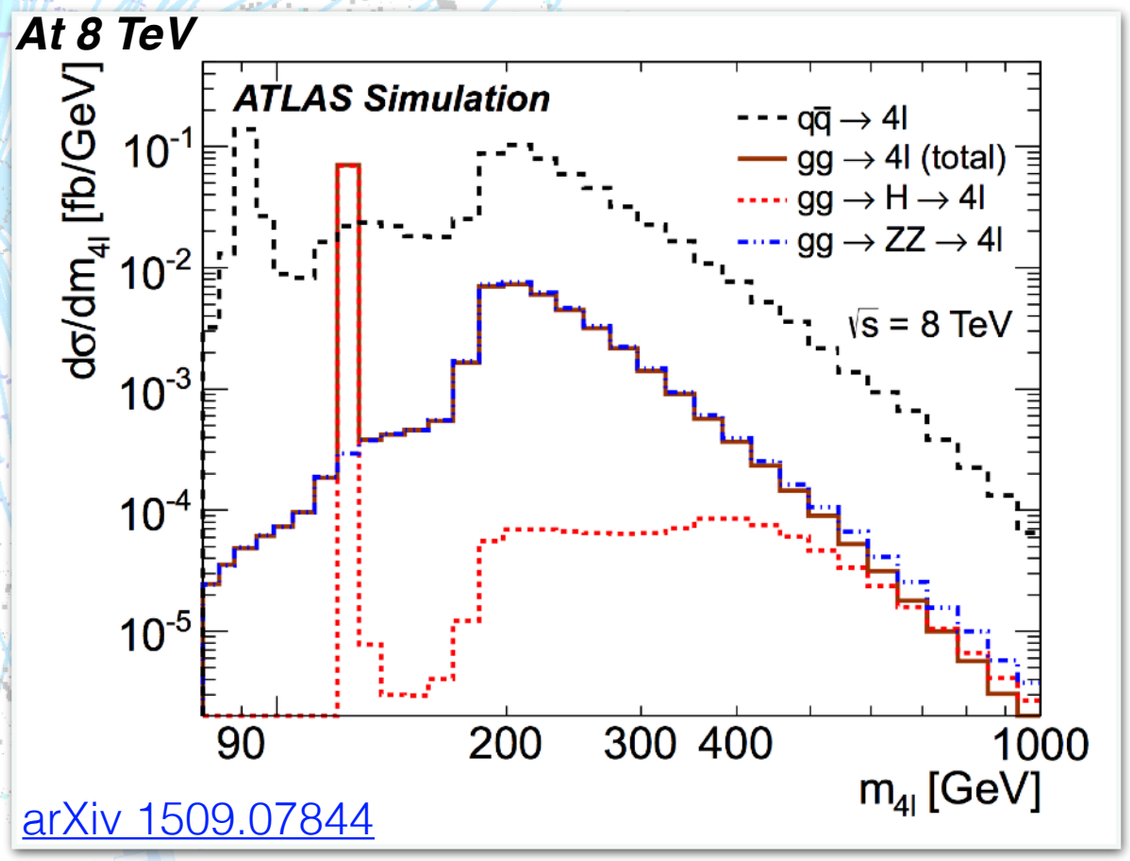
- Measure the differential distribution of the 4-lepton mass spectrum
  - Signal are from ZZ to 4-lepton final states
- Present measurements at particle level (i.e. unfold)









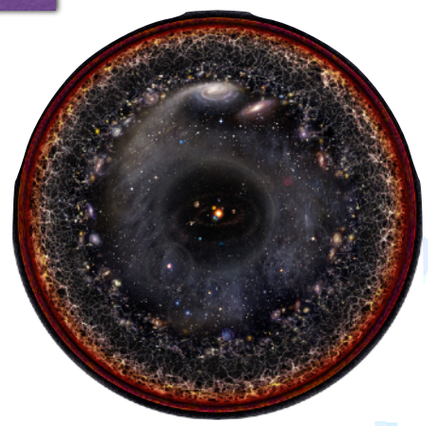


arXiv 1509.07844

Unfolding, what's that?

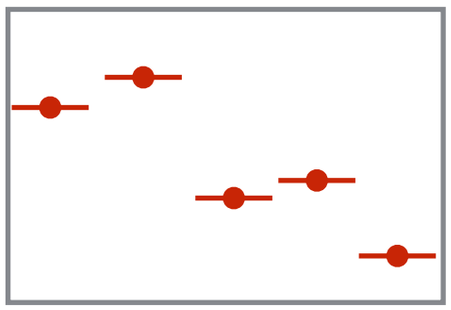
Particle level ***Detector level***

Laws of nature



Particle collisions

Particle detector

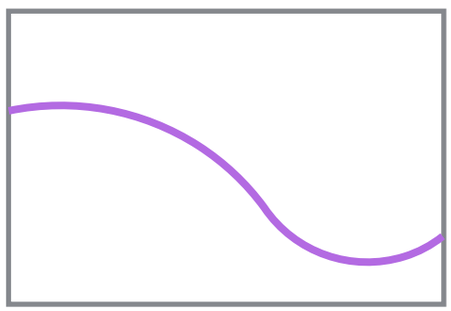


Detector effects

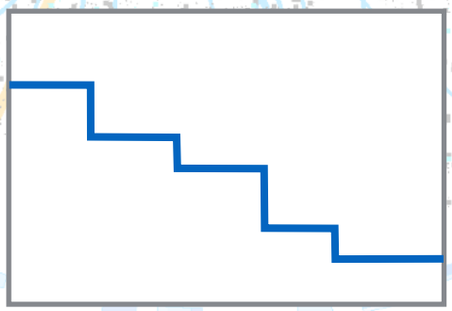
Unfolding

"truth" *"reco"*

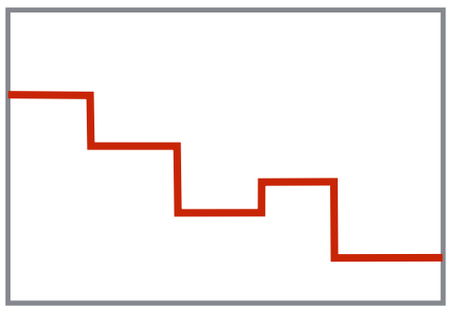
Theory



MC event generator



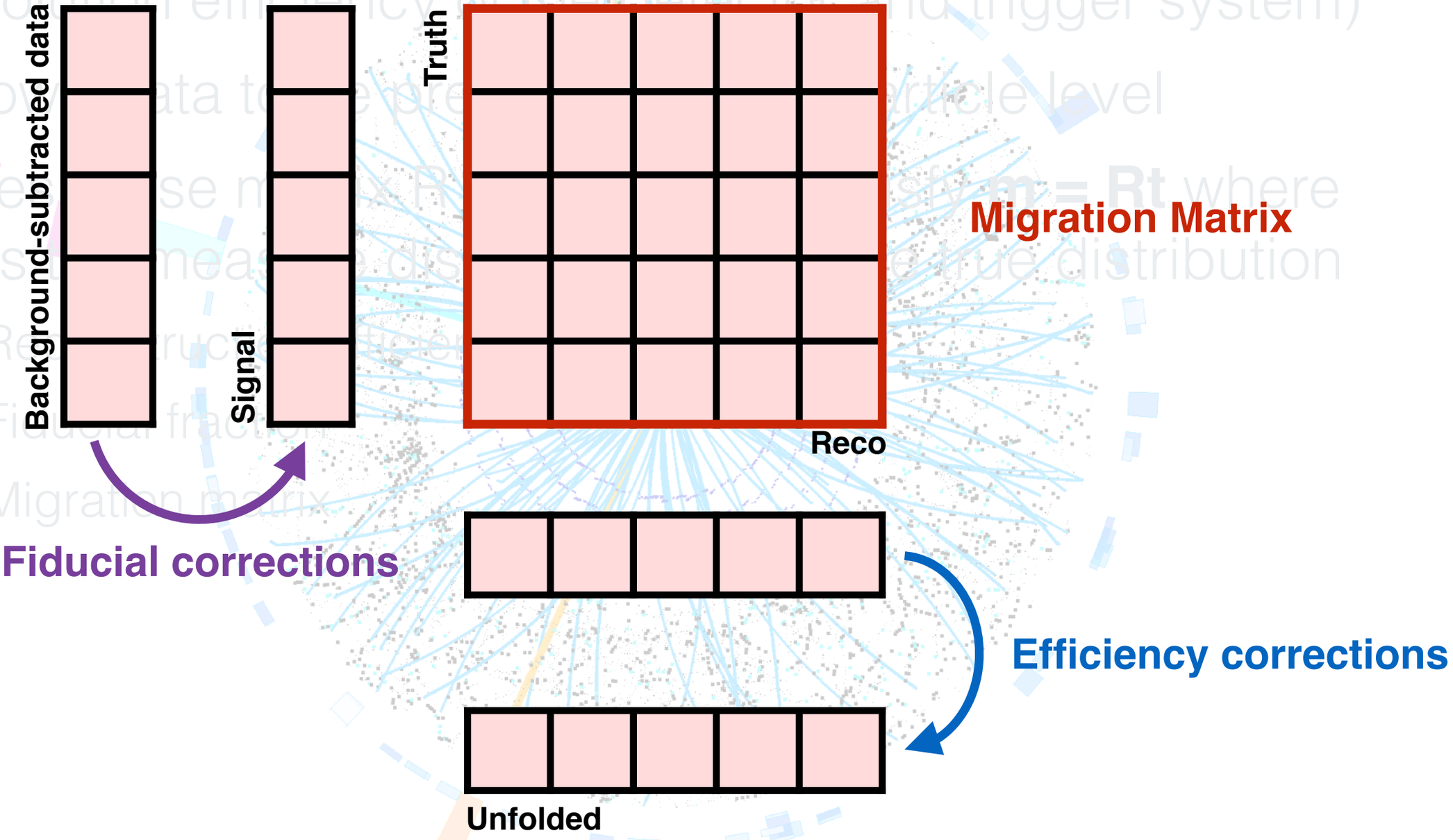
Detector simulation



Unfolding: Methodology

- Unfold: correct for experimental effects using the simulation
- Procedure uses response matrix R to describe the relationship between the number of events in bin *x* of a reco distribution and the yield in bin *y* of the corresponding truth distribution
  - **Reconstruction efficiency**
  - **Fiducial fraction**
  - **Migration matrix**

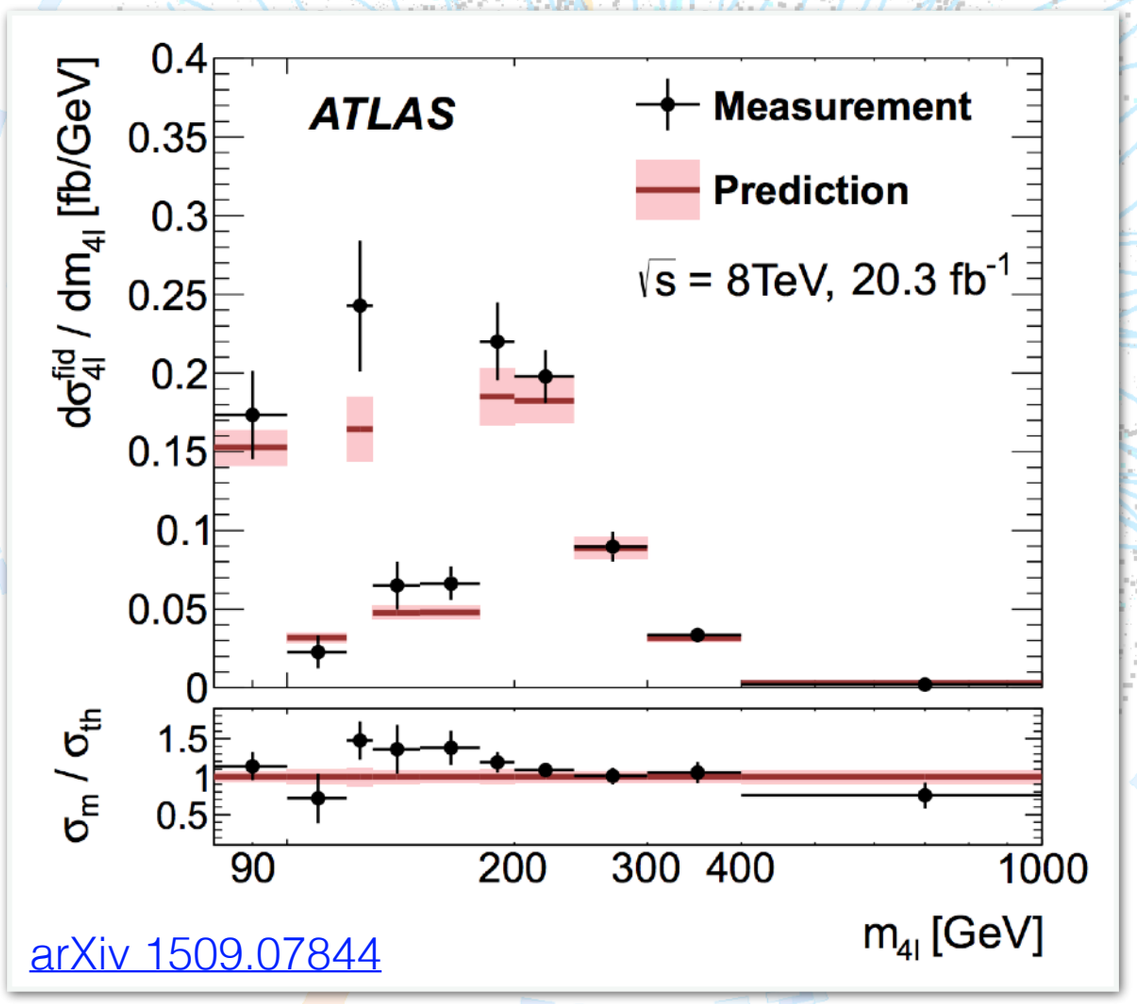
Unfolding: Methodology



The 4 lepton analysis

- Measured differential cross section distribution as a function of the four-lepton invariant mass, at 8 TeV

At 8 TeV



arXiv 1509.07844

The 4 lepton analysis

- L as

➡ ***Preserved in Rivet***

- ATLAS_2015_CONF_2015_041_EL – Z+jets at 13 TeV
- ATLAS_2015_CONF_2015_041_MU – Z+jets at 13 TeV
- ATLAS_2015_I1345452 – Pseudo-top-antitop cross sections
- 5_I1351916 – Z forward-backward asymmetry
- 5_I1351916_EL – Z forward-backward asymmetry
- ATLAS_2015_I1351916_MU – Z forward-backward asymmetry
- ATLAS_2015_I1364361 – Total and differential Higgs cross sections at 8 TeV with
- ATLAS_2015_I1376945 – Colour flow in hadronic top decay at 8 TeV
- ATLAS_2015_I1387176 – Energy-energy correlation
- ATLAS_2015_I1390114 – $tt + b(b)$ at 8 TeV
- ATLAS_2015_I1393758 – Jet charge
- ATLAS_2015_I1394679 – Multijets at 8 TeV
- ATLAS_2015_I1394865 – Inclusive 4-lepton lineshape
- ATLAS_2015_I1397635 – Wt at 8 TeV
- ATLAS_2015_I1397637 – Boosted ttbar differential cross-section
- ATLAS_2015_I1404878 – ttbar (to l+jets) differential cross sections at 8 TeV
- ATLAS_2015_I1408516 – Z p_T and Z ϕ^*
- ATLAS_2015_I1408516_EL – Z p_T and Z ϕ^* in electron channel
- ATLAS_2015_I1408516_MU – Z p_T and Z ϕ^* in muon channel
- ATLAS_2016_CONF_2016_037 – Search for SUSY in 13 \text{TeV} events with 2
- ATLAS_2016_CONF_2016_054 – ATLAS 2016 1-lepton SUSY search at 13 \text{
- ATLAS_2016_CONF_2016_078 – ATLAS ICHEP16 0-lepton SUSY search at 13 \
- ATLAS_2016_CONF_2016_092 – Inclusive jet cross sections using early 13 TeV
- ATLAS_2016_CONF_2016_094 – ATLAS 2016 1-lepton + many jets SUSY search
- ATLAS_2016_I1419070 – Number of tracks in jets

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Herwig 7.1: Multi-jet Merging

arXiv:1705.06919

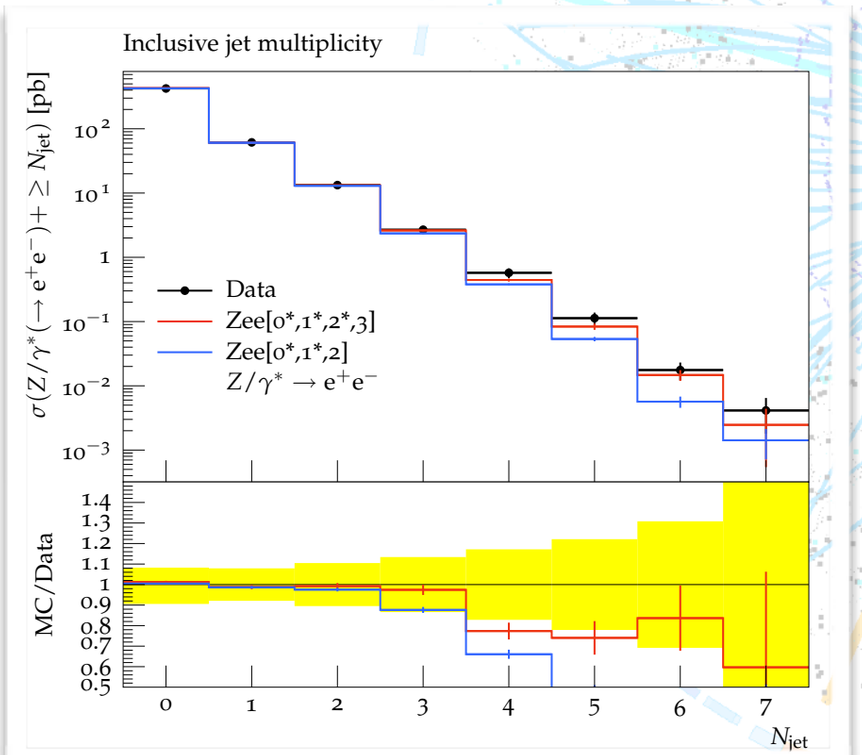
- Herwig 7: automated NLO matching to parton showers
- 7.1 release added multi-jet merging: want to describe observables that receive contributions from many final state multiplicities at high precision
- Multi-jet merging already implemented in various other generators currently used by ATLAS
- This work: focus on the VB + jets process

Herwig 7.1: Multijet Merging

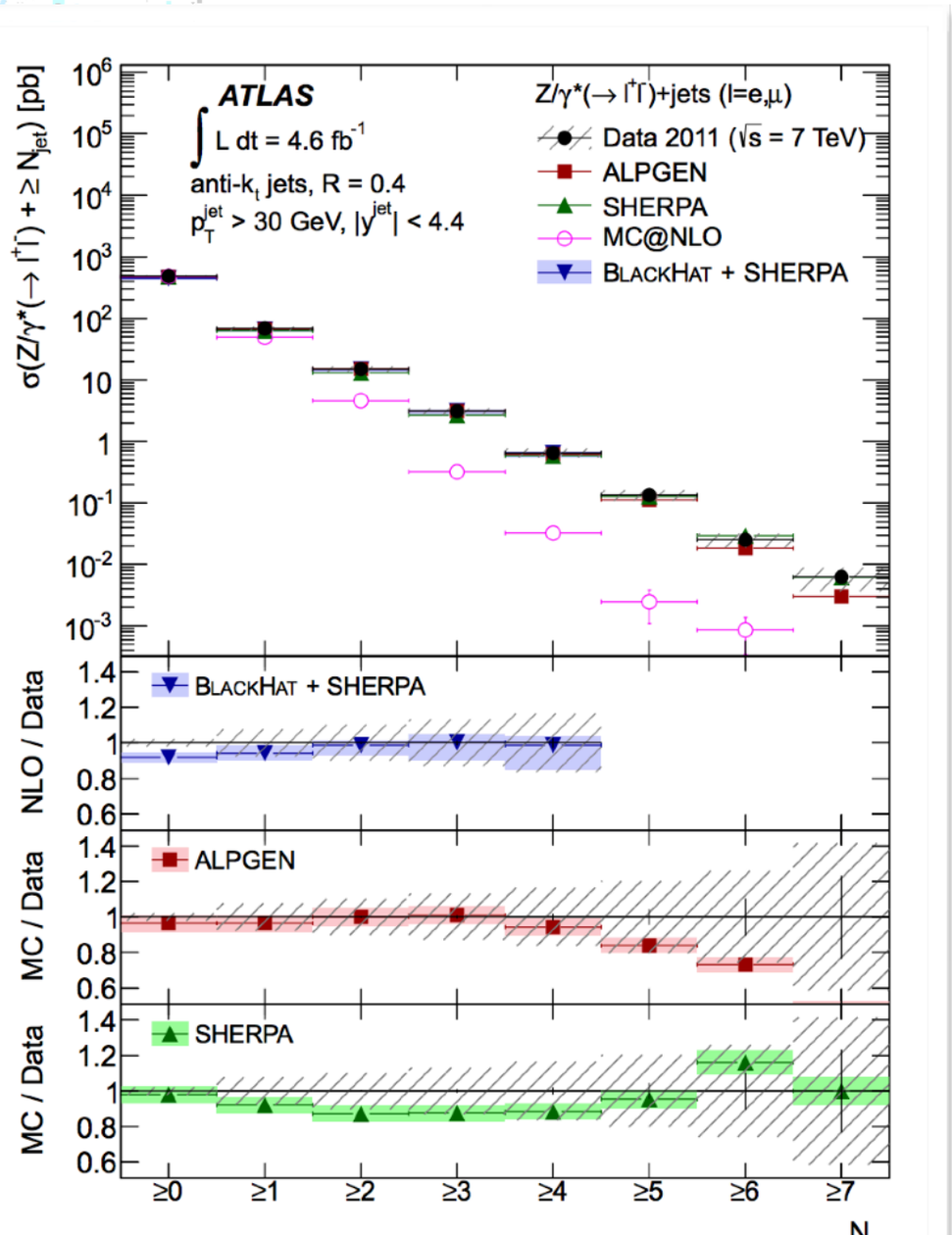
Z + jets production at 7 TeV

- ATLAS_2013_I1219109_MU – W + b production at 7 TeV
- ATLAS_2013_I1230812 – Z + jets in pp at 7 TeV
- ATLAS_2013_I1230812_EL – Z+ jets in pp at 7 TeV (electron channel)
- ATLAS_2013_I1230812_MU – Z+ jets in pp at 7 TeV (muon channel)
- ATLAS_2013_I1234228 – High-mass Drell-Yan at 7 TeV

Herwig7



ATLAS 7 TeV Measurement

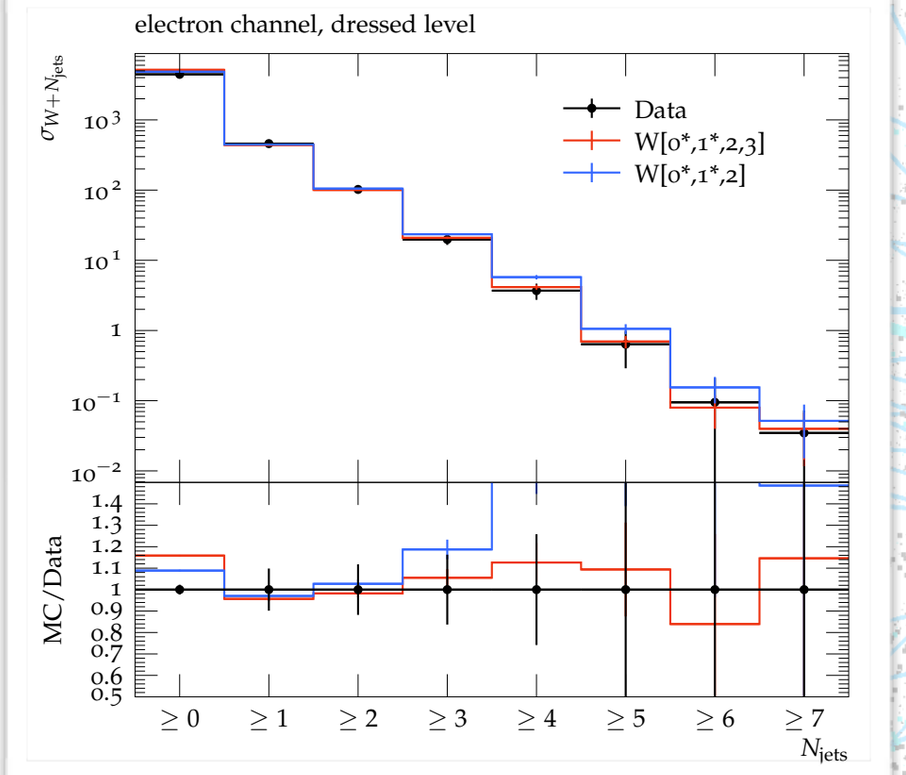


arXiv 1304.7098

Herwig 7.1: Multijet Merging

W + jets production at 7 TeV

Herwig7



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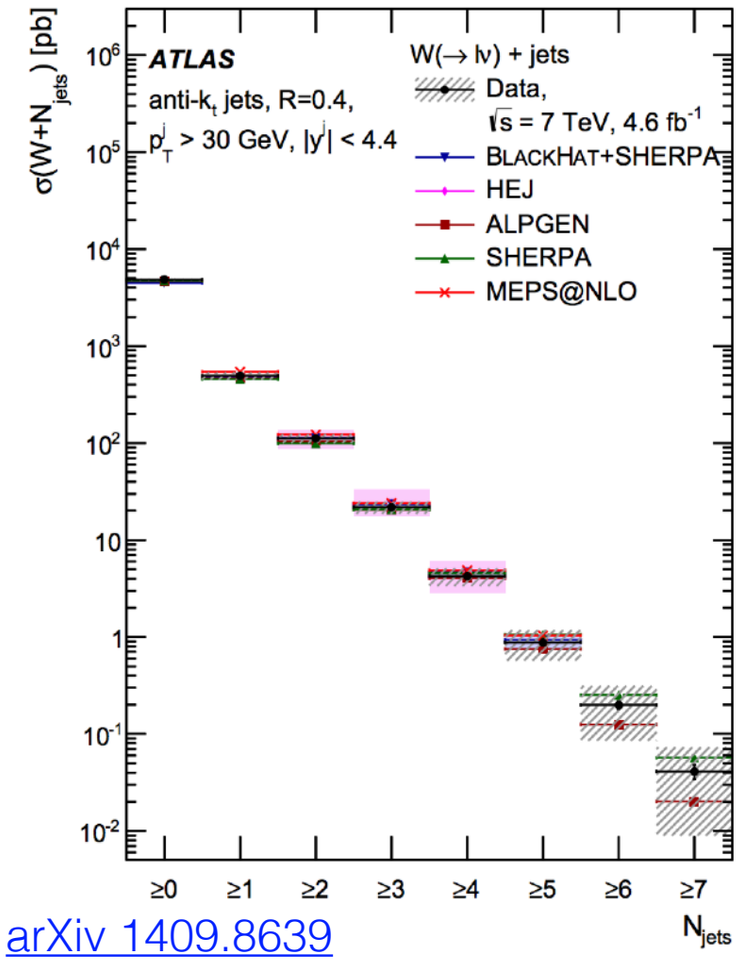
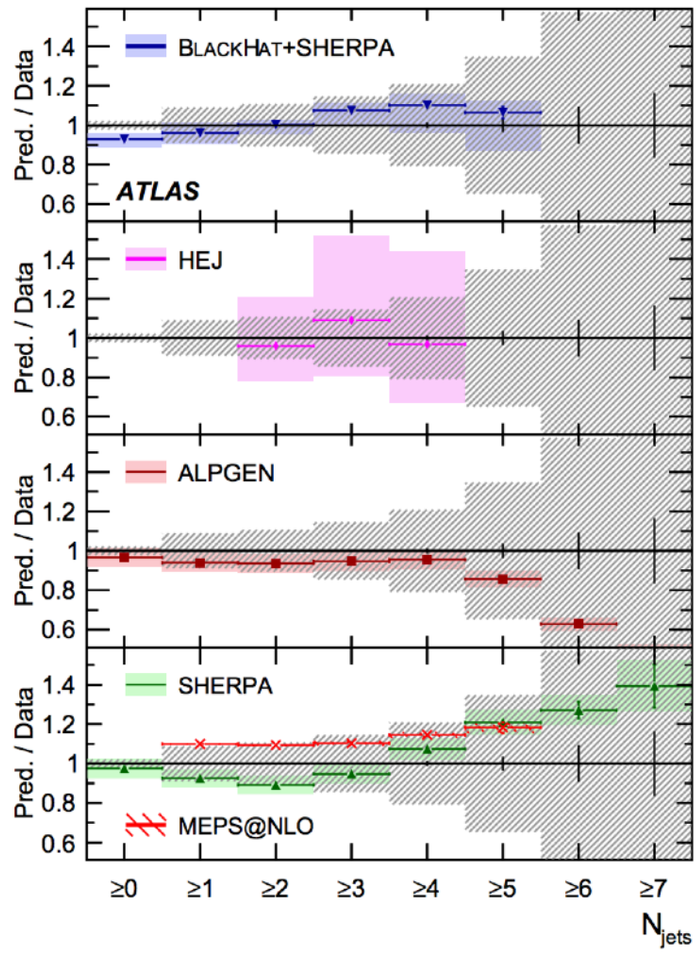


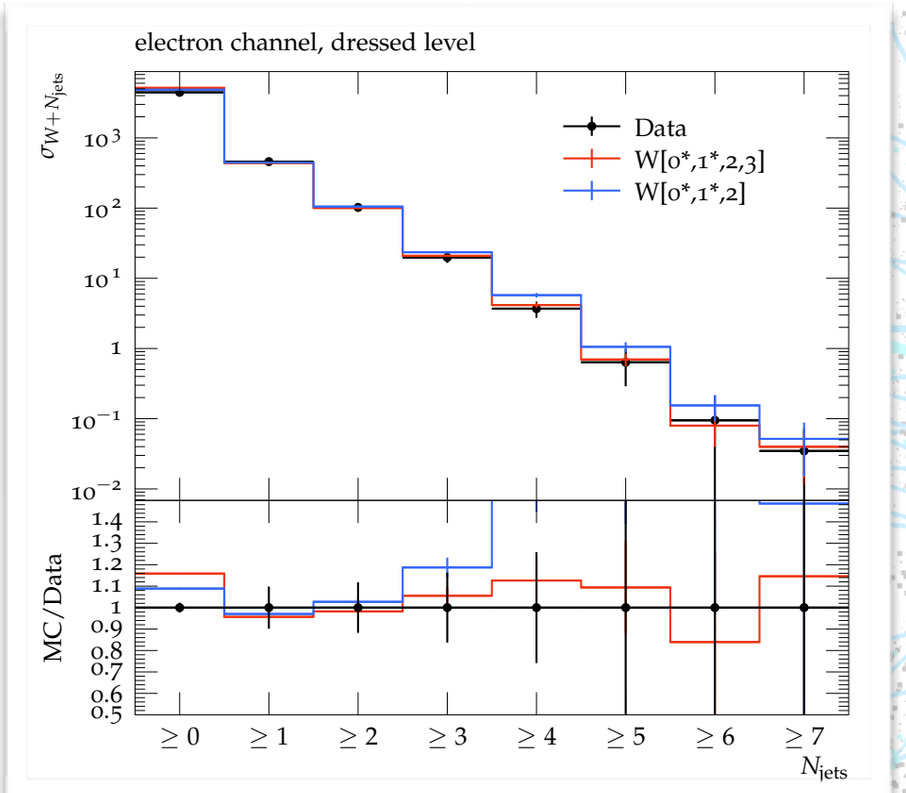


arXiv 1409.8639

Herwig 7.1: Multijet Merging

W + jets production at 7 TeV

Herwig7



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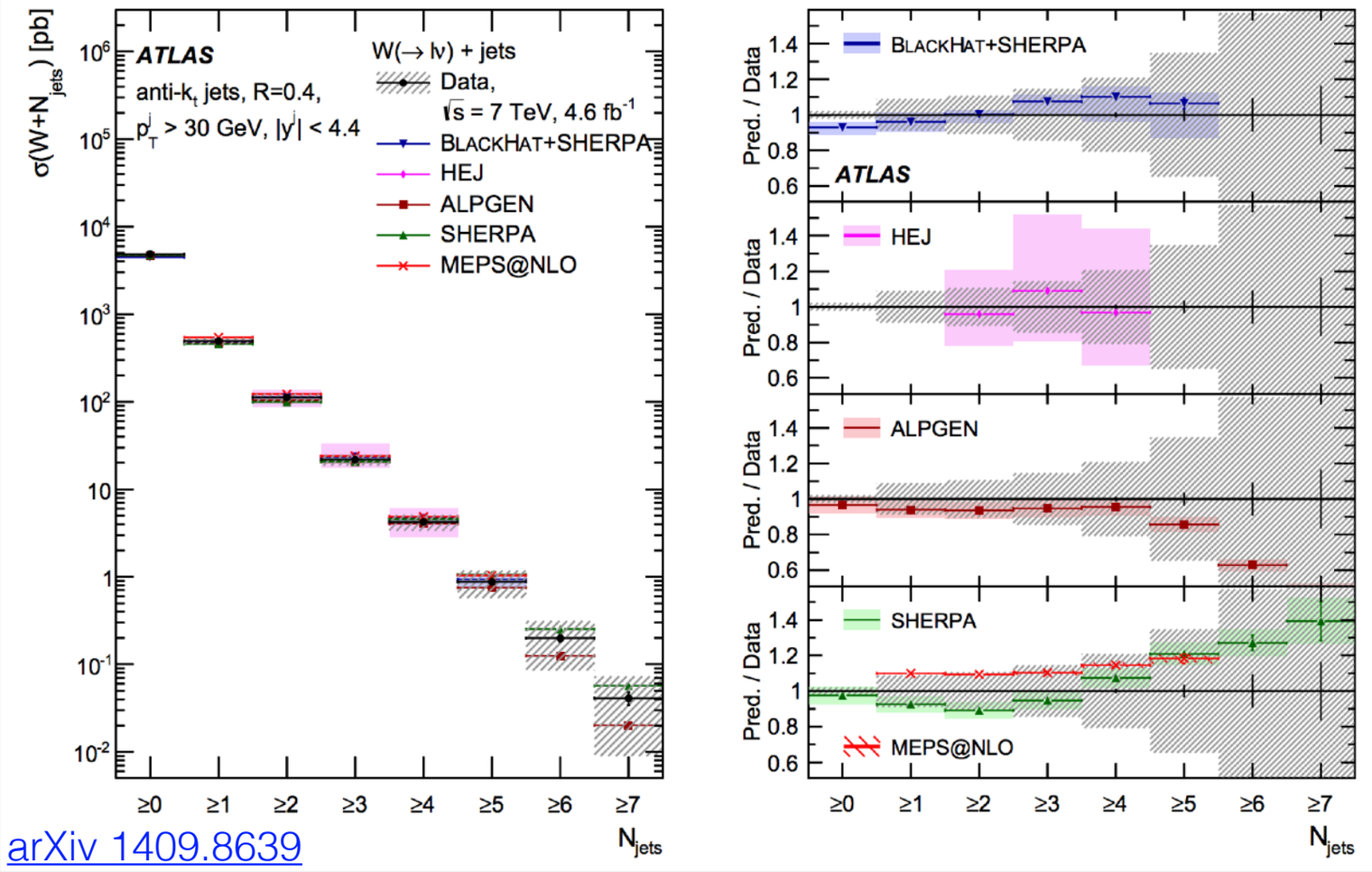

arXiv 1409.8639

➡ Many generators available, all run differently!

➡ Compare between generators for consistencies/differences

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Towards (Re-)interpretation

- Unfolded, model-independent measurements can be used for future re-interpretation
- Identify BSM model to test, get MC simulation and produce an output file
  - E.g. Lagrangian → FeynRules → Herwig7
- Perform statistical test of BSM against data and compute limits

→ ***Philosophy of CONTUR*** arXiv:1606.05296

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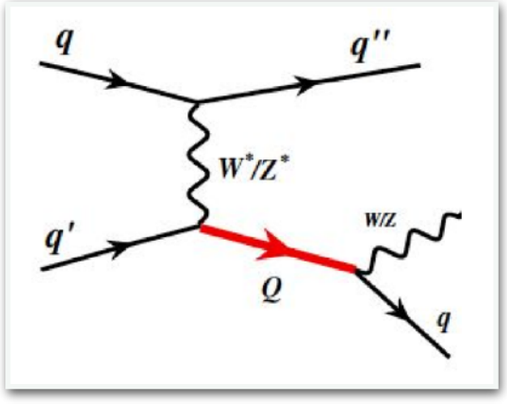
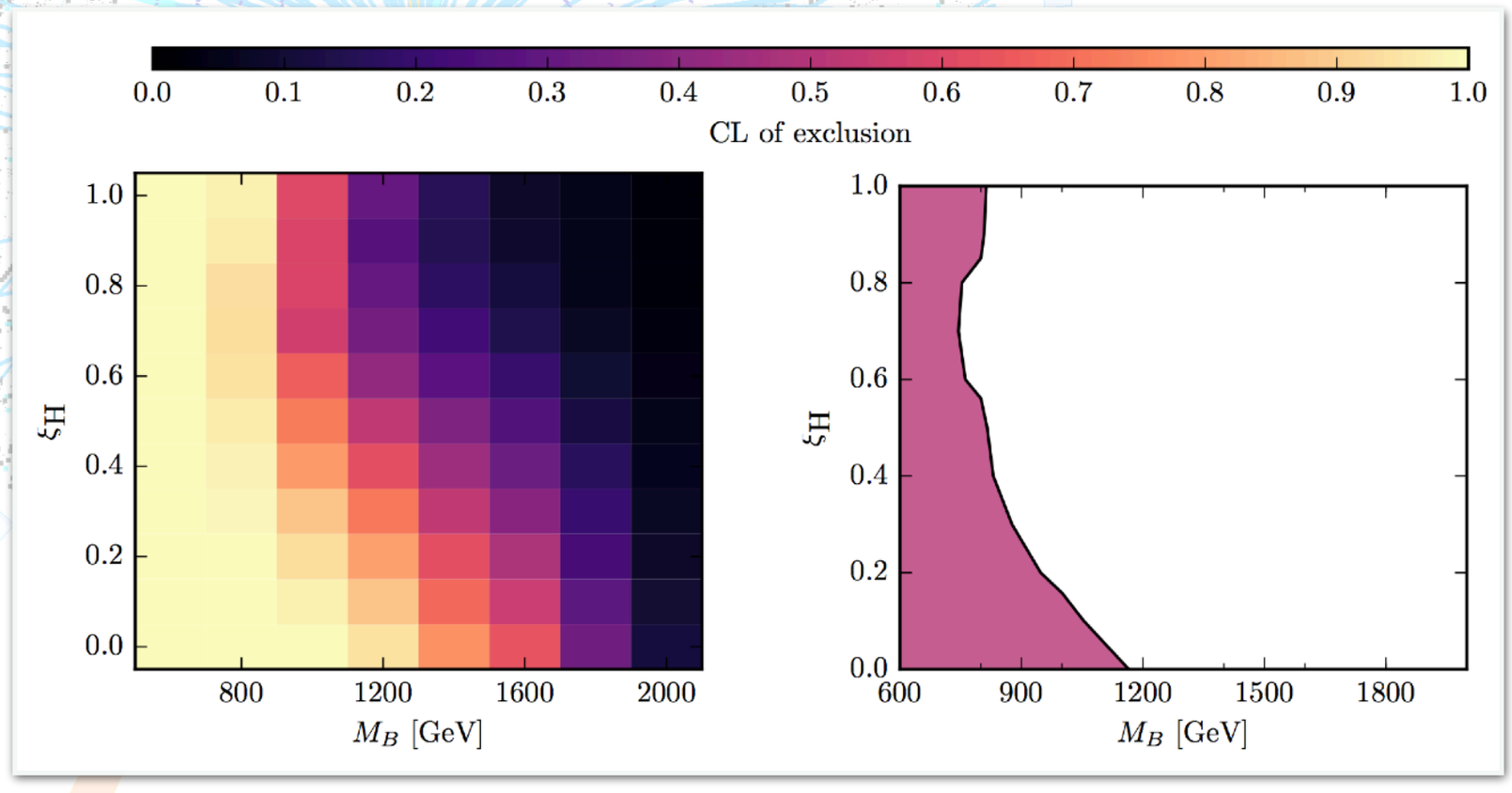
VLQ Model

- Decays to qZ, qW, qH where q is {t,b}
- BR(qH)+BR(qW)+BR(qZ)=1





Summary

- Unfolded measurements (e.g. those stored in Rivet) are very resourceful
  - Can be used for generator validations/tuning
  - Can be exploited by tools like contur to probe new physics
- Ongoing stuff:
  - 4 lepton measurement with more data
  - Including SM predictions in contur
  - Exploration of new physics models using contur

THANK YOU!