Jet veto cross-section measurements at ATLAS

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THE ROYAL SOCIETY

Jet vetos

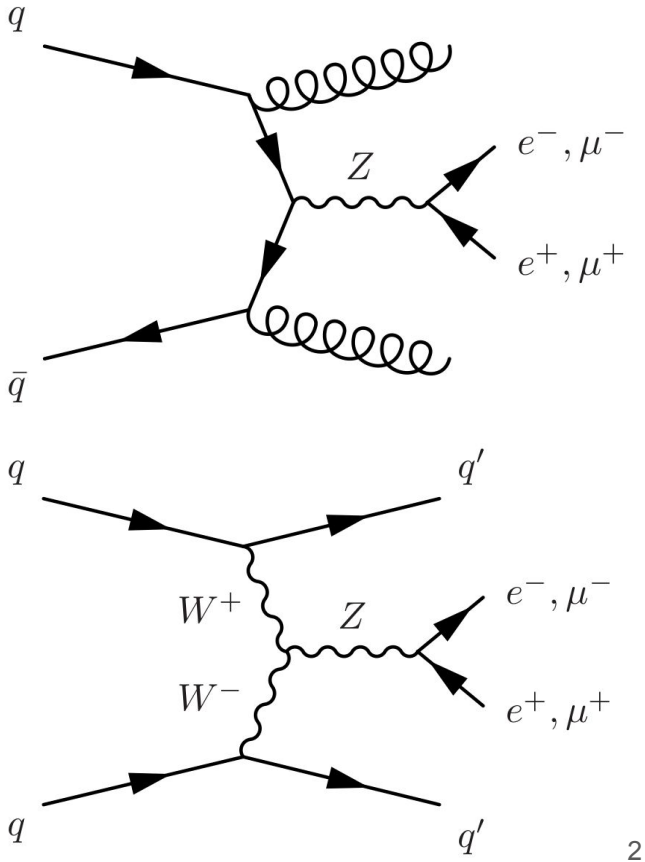
Most LHC processes break apart the colliding protons very disruptively:

many colour dipoles ⇒ QCD everywhere!

What about the strange events *without* extra jets?

- **Diffraction:** exchange of vacuum excitations
- **QCD fluctuations:** sometimes just no radiation!
- **VBF/S:** initiated by uncoloured EW bosons

Define observables with *vetoing* of extra jets



Recent ATLAS jet veto measurements

No recent diffractive gap measurements, sorry!

Instead, constraints on QCD dynamics in VBF and top-pair production events:

JHEP 09 (2016) 074 — Jet activity in eμ top quark events at 8 TeV

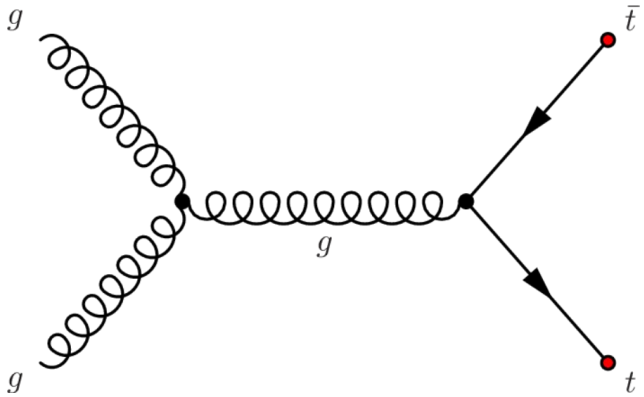
Eur. Phys. J. C77 (2017) 220 — Jet activity in eμ top quark events at 13 TeV

Phys. Lett. B. 775 (2017) 206 — EW production of Z + dijets at 13 TeV

Eur. Phys. J. C 77 (2017) 474 — EW production of W + dijets at 7 & 8 TeV

Top quark pair gap fractions at 8 and 13 TeV

Lowest-order top pair production → only top quarks.
But many coloured partons: extra
(mainly ISR) radiation likely. *How likely?*



Select dilepton tt events: eμ + bb requirement
e & μ pT > 25 GeV, |η| ≲ 2.5

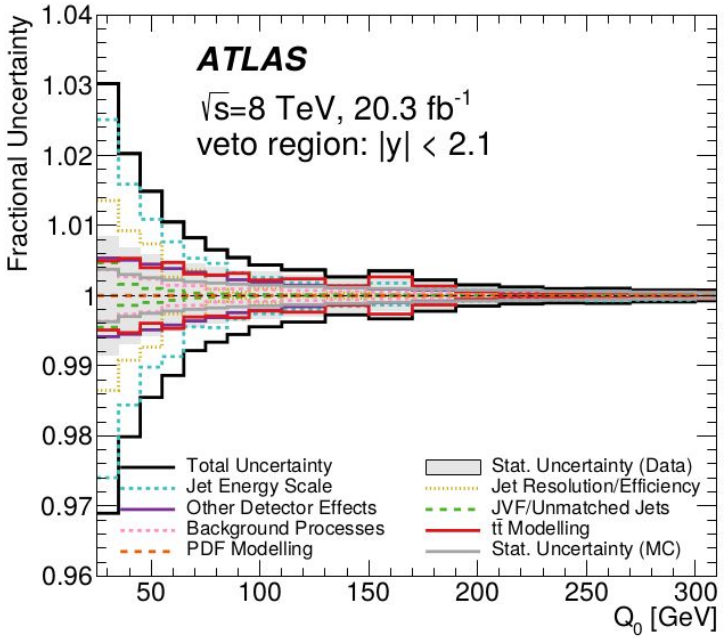
Define "veto region" rapidity ranges in which additional (i.e. not from top) jets are banned:
|y| in 0...0.8...1.5...2.1
NB. Top locations ignored! Also m_{tt} selection

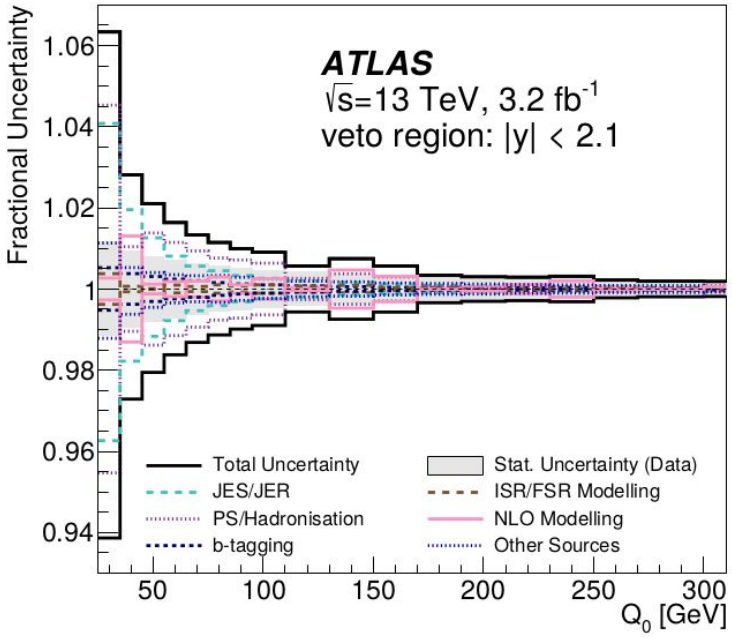
$$f_{\text{gap}}(Q_0) = \frac{n(Q_0)}{N_{t\bar{t}}}$$

$$f_{\text{gap}}(Q_{\text{sum}}) = \frac{n(Q_{\text{sum}})}{N_{t\bar{t}}}$$

Veto on lead extra jet ($p_{T1} < Q_0$) or scalar sum of all jets > 25 GeV ($\Sigma p_T < Q_{sum}$)

Top quark pair gap fractions: uncertainties





Both 8 and 13 TeV measurements systematics-limited for inclusive tt system mass

Major systematics: jet energy scale & resolution + top-pair hard & soft modelling

Top quark pair gap fractions: 8 TeV inclusive results

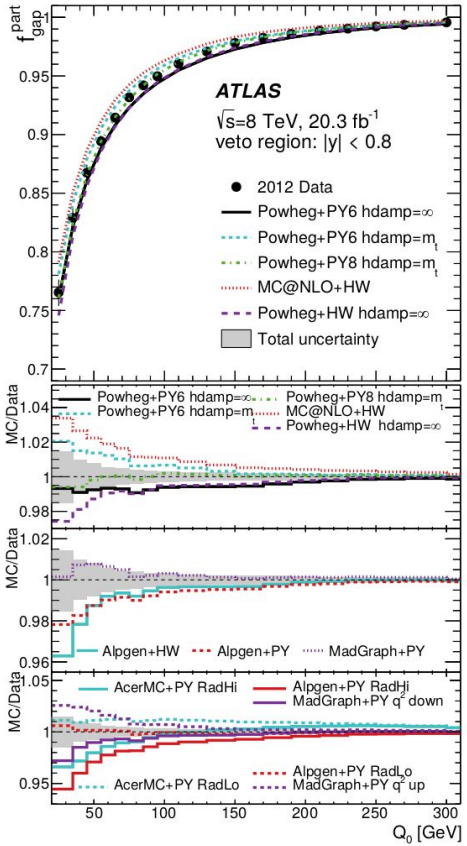
Data/MC comparisons accurate to within a few percent

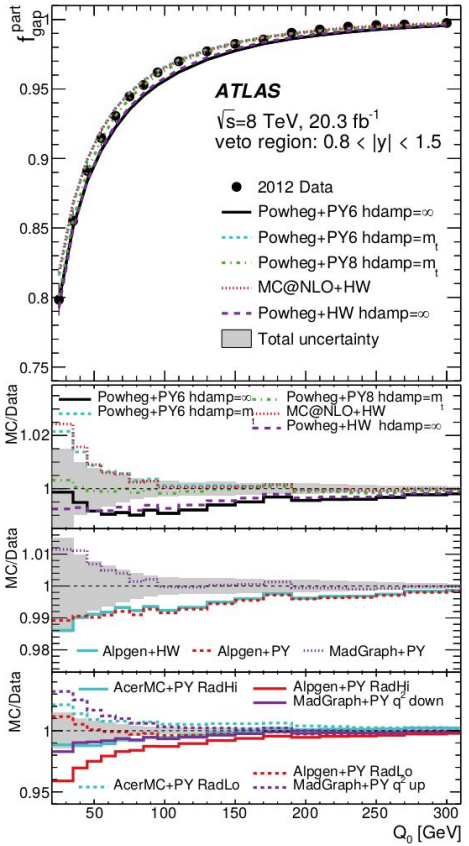
Consequence of Powheg NLO + extensive prior tuning. Py8 > PY6

Unsurprisingly, MC and uncertainties most troublesome at low Q_0, Q_{sum}

Worst uncertainties & descriptions at central rapidities (and full range)

Full correlations published for fits





Top quark pair gap fractions: 13 TeV inclusive results

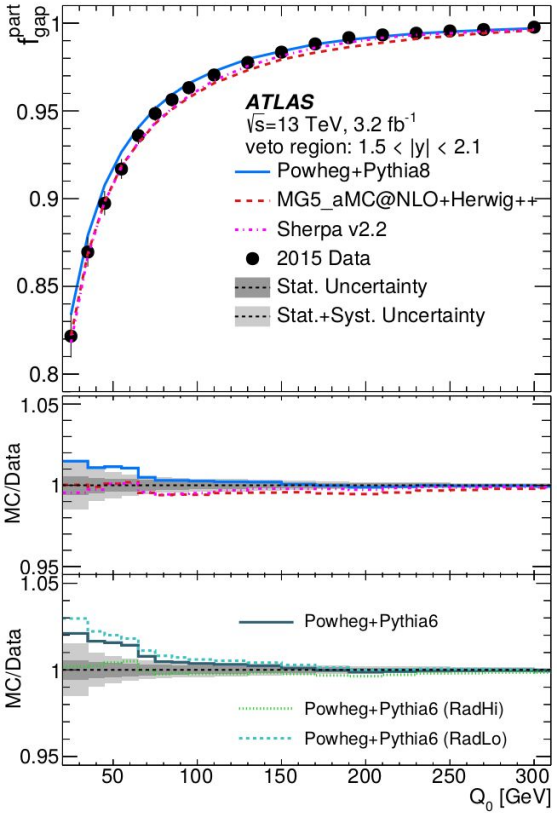
Complex MC story...

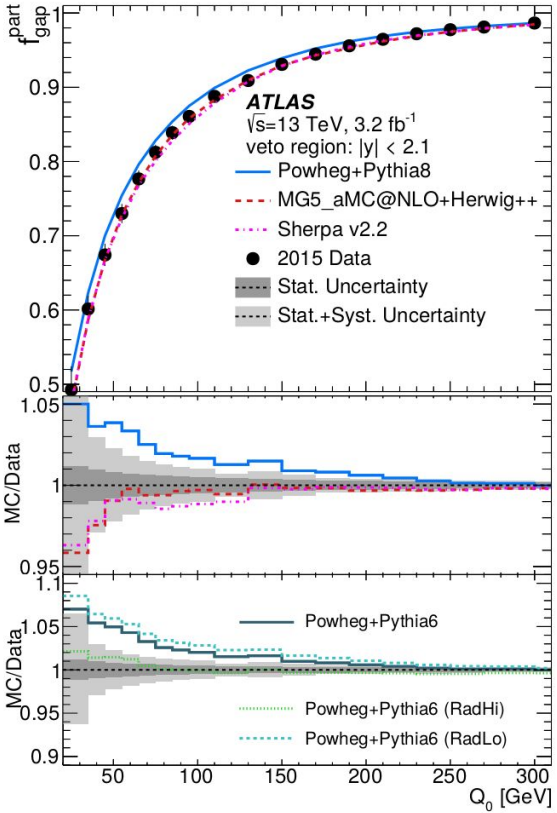
Again Powheg works better with Py8… but some over-survival/underactivity

Multileg aMC@NLO and Sherpa better/overactive

Herwig low-Q_0 disruption?

NB. MC-systs feedback





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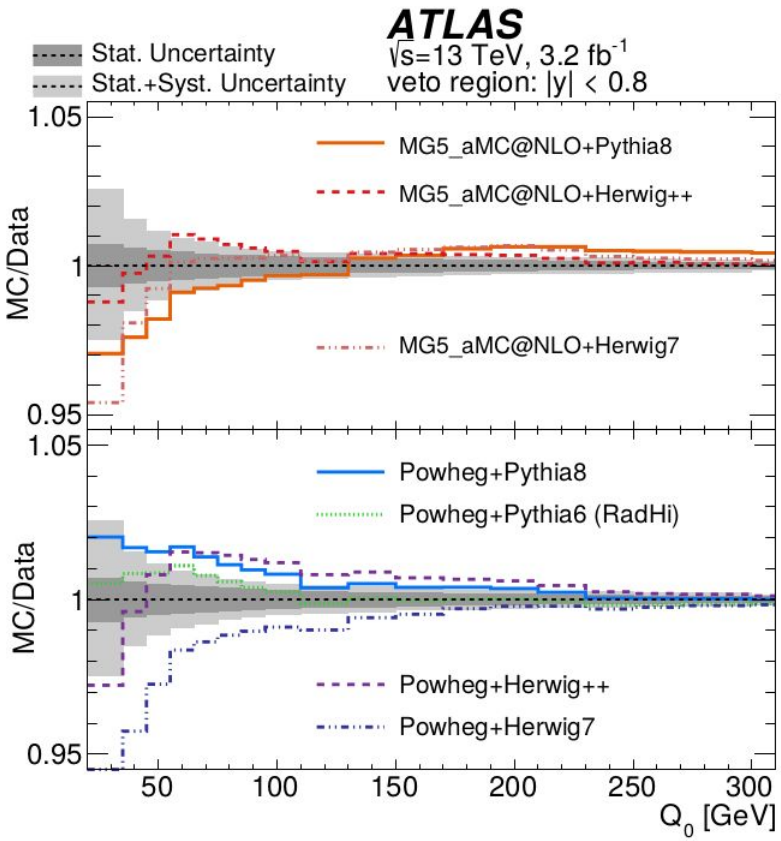
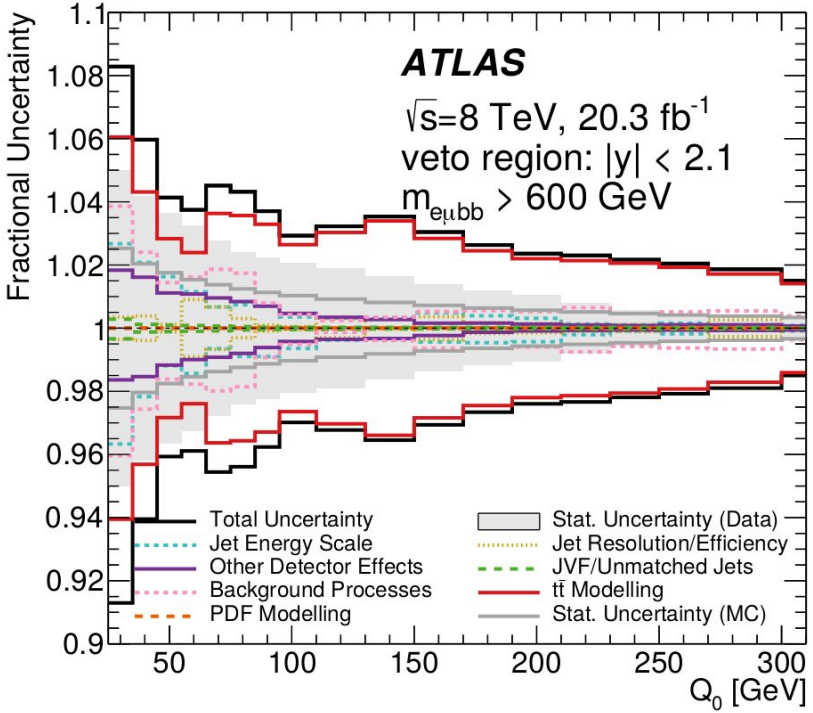
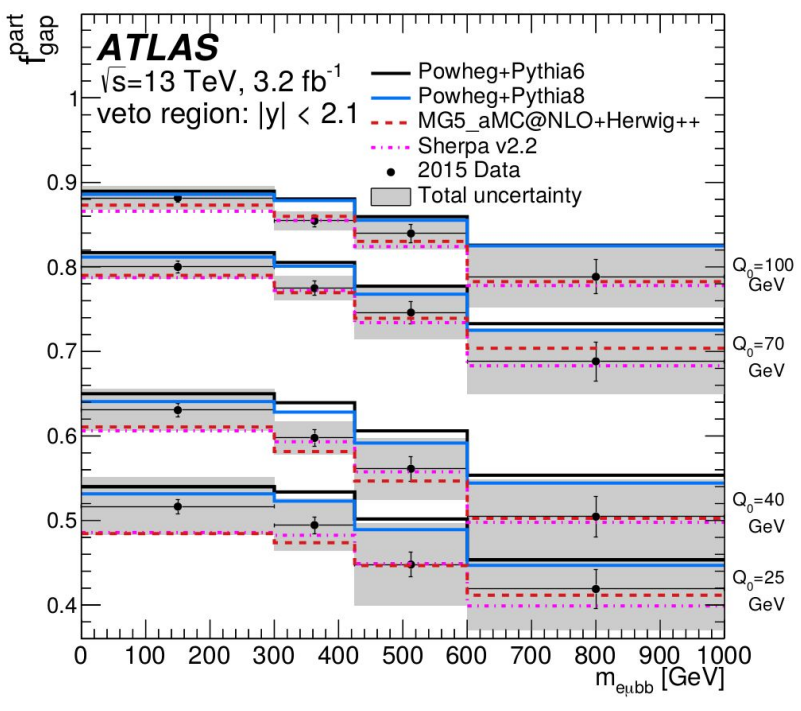


Top quark pair gap fractions: high-m_{tt} results





Dependence on m_{tt} also measured: (MC) uncertainties inflate, but multileg MCs ok

Vector boson fusion Z+jj at 13 TeV

Cross-sections for inclusive, QCD-enriched, and high-mass ⊗ EW-enriched

Fiducial definitions: no extrapolation, direct comparison with particle-level MC

Bkg subtraction & correction: $\sigma^f = \frac{N^f_{\text{obs}} - N^f_{\text{bkg}}}{L \cdot C^f}$ $\sigma^f_{\text{EW}} = \frac{N^f_{\text{obs}} - N^f_{\text{QCD}-Zjj} - N^f_{\text{bkg}}}{L \cdot C^f_{\text{EW}}}$

Base selection: isolated leptons in $|\eta| < 2.47$, $p_T > 25$ GeV, $m_{\ell\ell} \sim m_Z \pm 10$ GeV
isolated jets $|y| < 4.4$, $p_T > \{55,45\}$ GeV

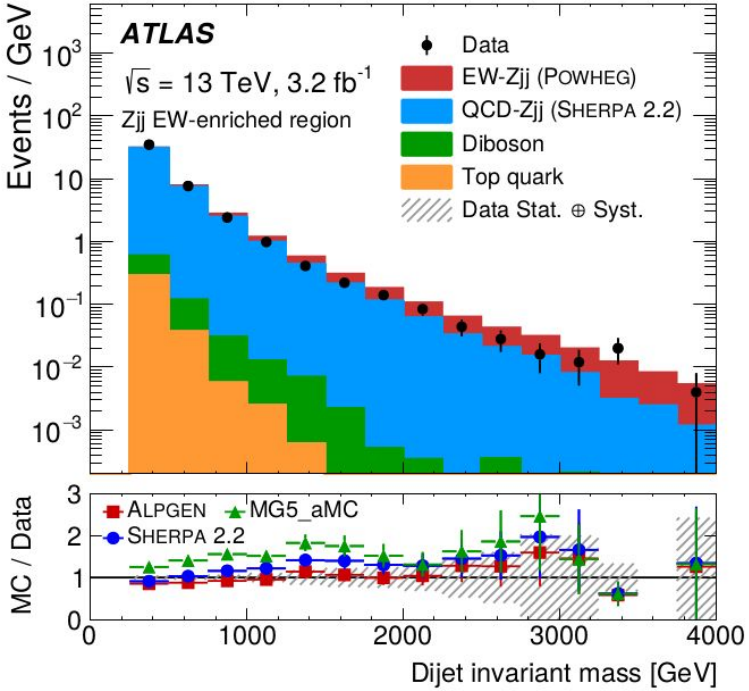
QCD/EW-enriched:

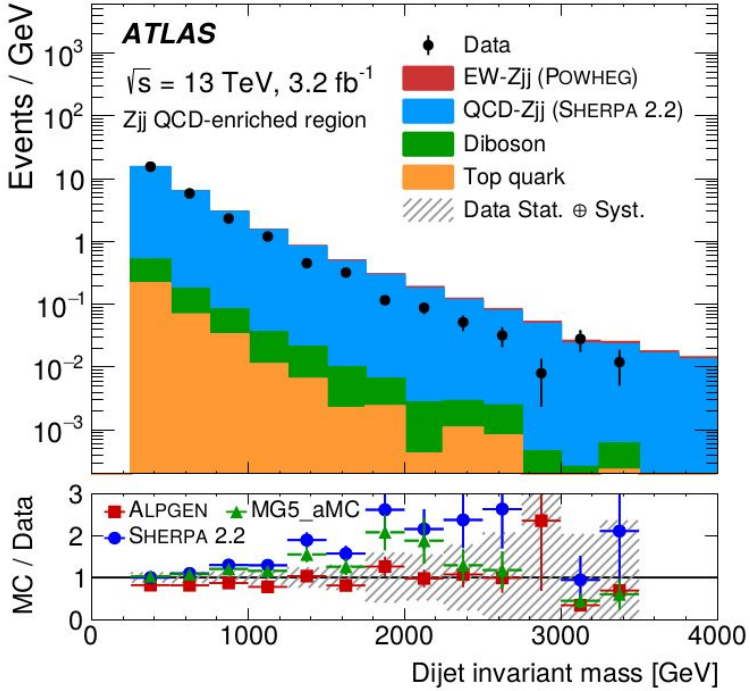
$m_{jj} > 250$ GeV, and high-mass versions with $m_{jj} > 1$ TeV

0/1 >25 GeV jets in jj interval + small 2/3j balance (= $|\Sigma \mathbf{p}_T|/\Sigma|p_T|$)

NB. no explicit rapidity gap! p_T-balance ~ equivalent

Vector boson fusion Z+jj: detector level m_{jj}

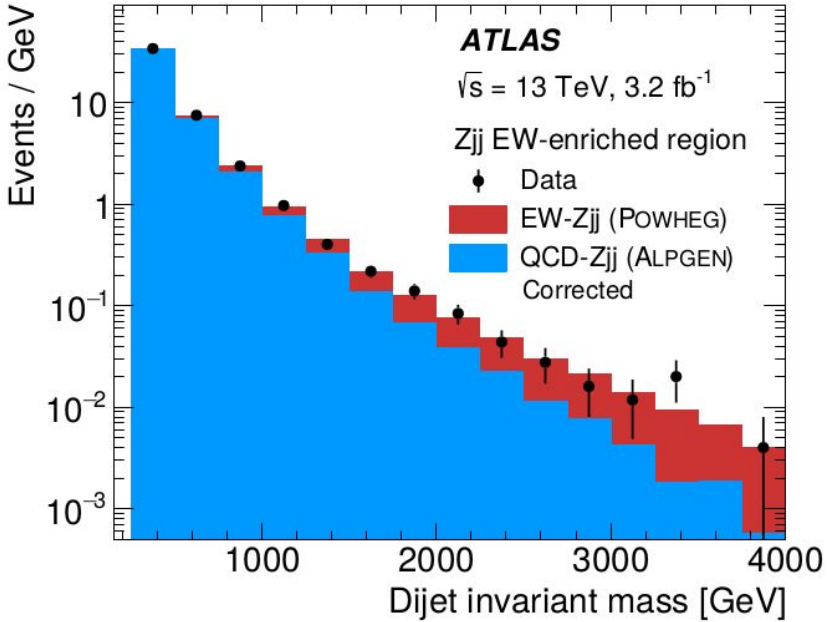


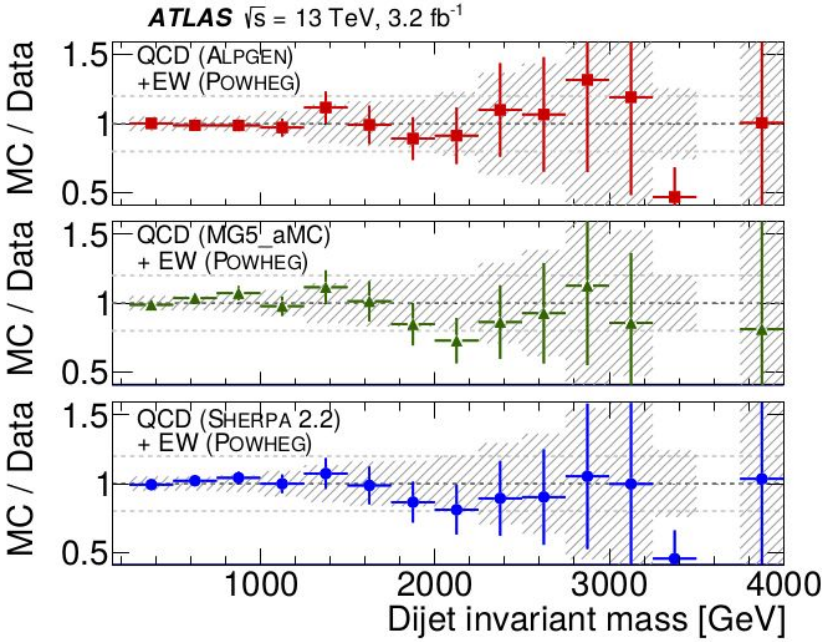


Det-level MC/data: Sherpa Zjj 2NLO+4LO, Sherpa diboson, Powheg+PY6 top

All QCD-Zjj normalised to FEWZ NNLO total cross-section

Vector boson fusion Z+jj: QCD & EW templates





Diboson & top subtracted: corrected QCD and EW Zjj MC templates

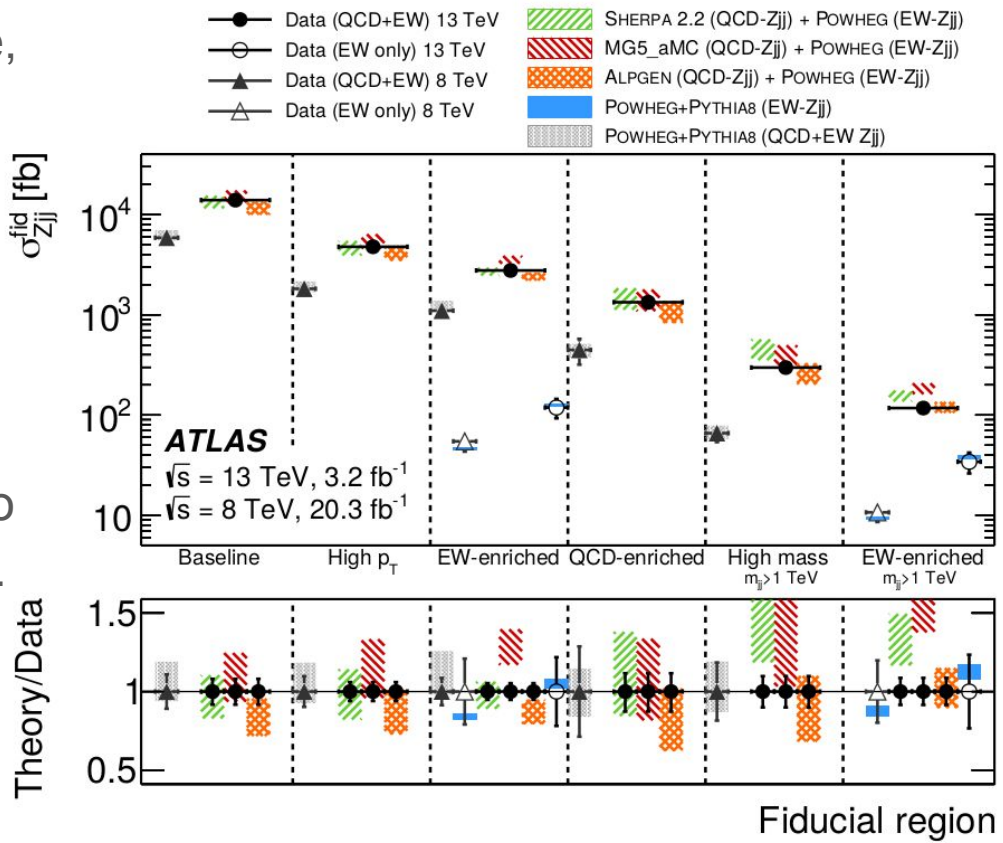
Vector boson fusion Z+jj: results

Fiducial cross-sections for inclusive, QCD-dominated, and EW VBF production of Zjj final-state

Total EW-enhanced xsec > QCD 3-jet region, for 25 GeV jet veto

Sherpa QCD modelling best (vs two LO MC models), cf. Powheg 8 TeV.

Powheg EW slightly too steep collider energy dependence

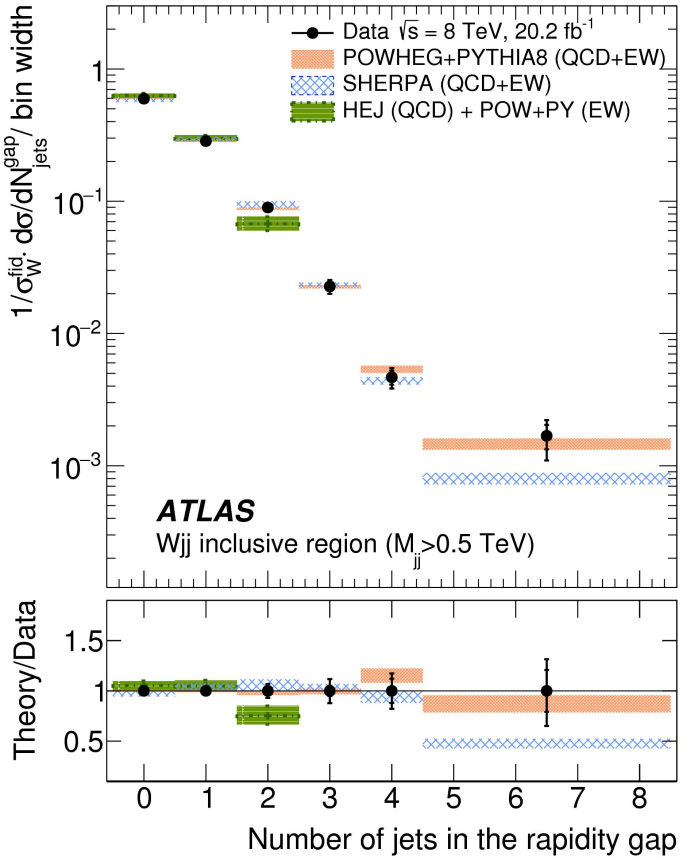


Electroweak W+jj at 7 and 8 TeV

Similar process to Zjj: VBF & other EW production modes (W brem and non-resonant) + QCD

Missing E_T > 20 GeV, 1 lepton with p_T > 25 GeV, m_T > 40 GeV, and 2j. VBF via M_{jj} > 500 GeV, Δy_{jj} > 2

Inclusive selection (bkg subtracted): Differential fiducial obs, e.g. (di)jet kinematics and jets in gap between leading jet pair



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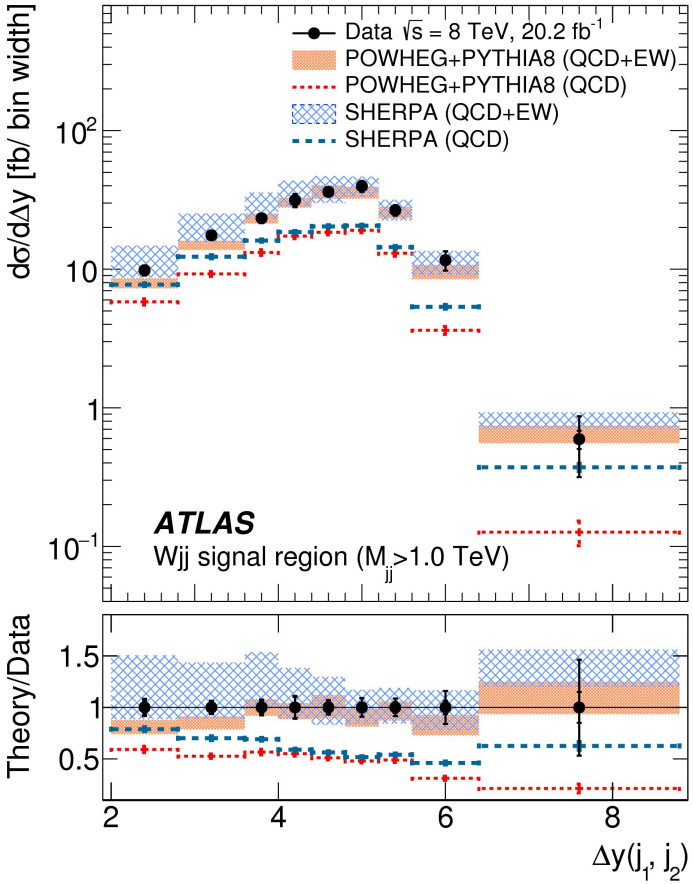
EW signal region: require central lepton and no jets between the leading jj.

More differential observables...



Conclusions

- **Jet vetos now measured several times in ATLAS Runs 1 and 2**
  Mainly for high-scale physics event selections
- Initial significant MC discrepancies now “solved” by MC tuning and QCD model development — looks like we *understand* the ISR physics(?)
- Performance of QCD MC models vs measurements out to high mass gives confidence for VBF background subtraction
- Jet vetos also important for Higgs physics cf. resummation
- The future...
  - More differential measurements of EW gaps/vetos in Run 3
  - Return to diffractive and pure-QCD gap measurements? Theory wishes?