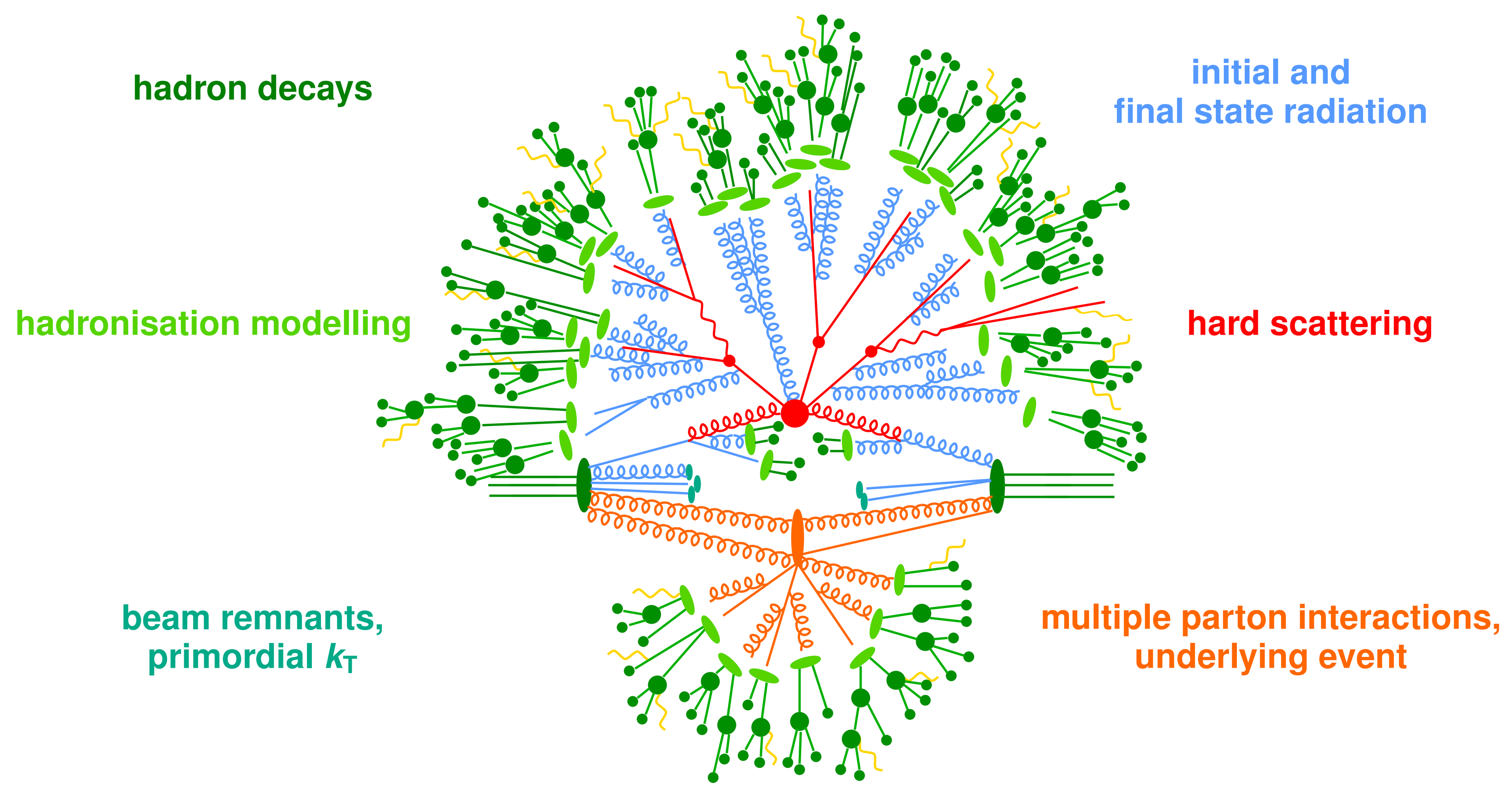
ICHEP2016 Poster Session – Chicago, 6 August 2016

Performance of Monte Carlo Event Generators for the Production of Boson and Multi-Boson States ATLAS Analyses

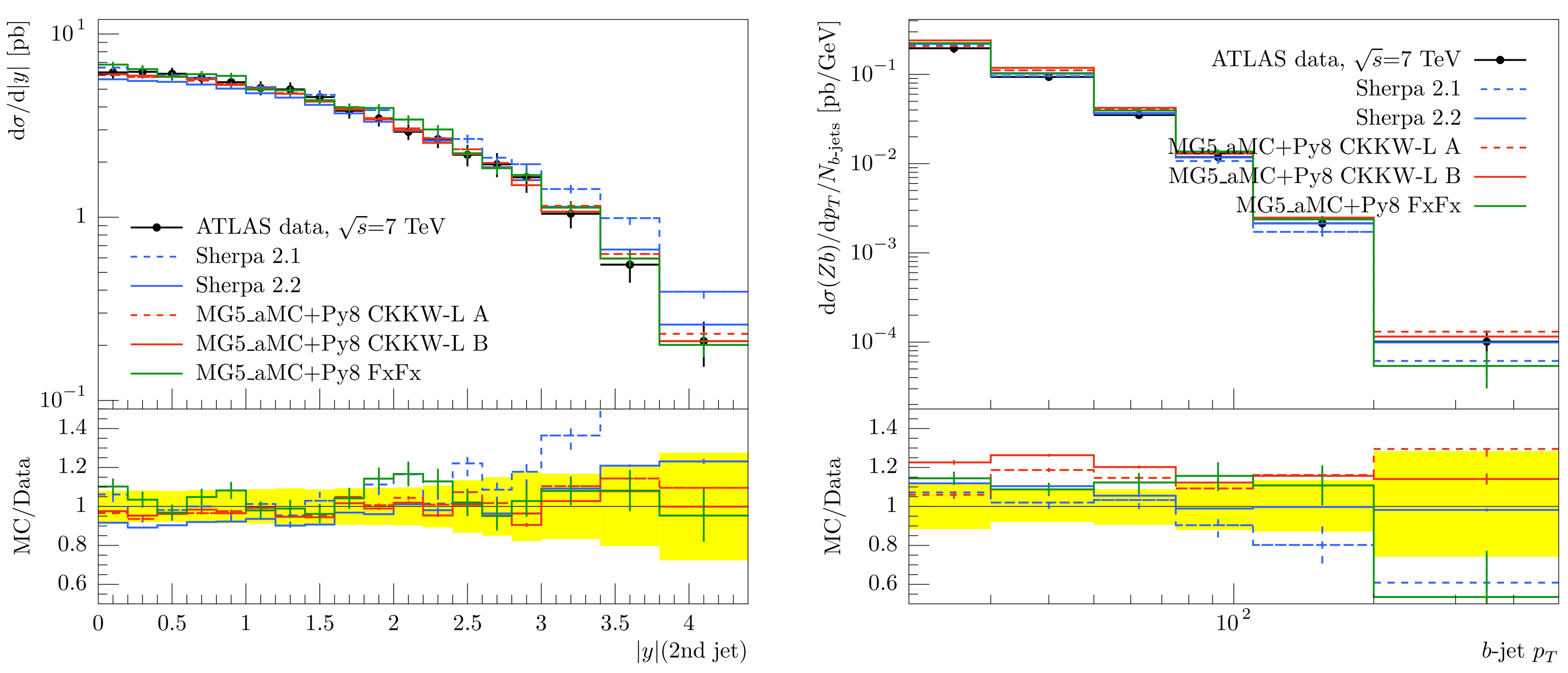
Simulating proton-proton collisions



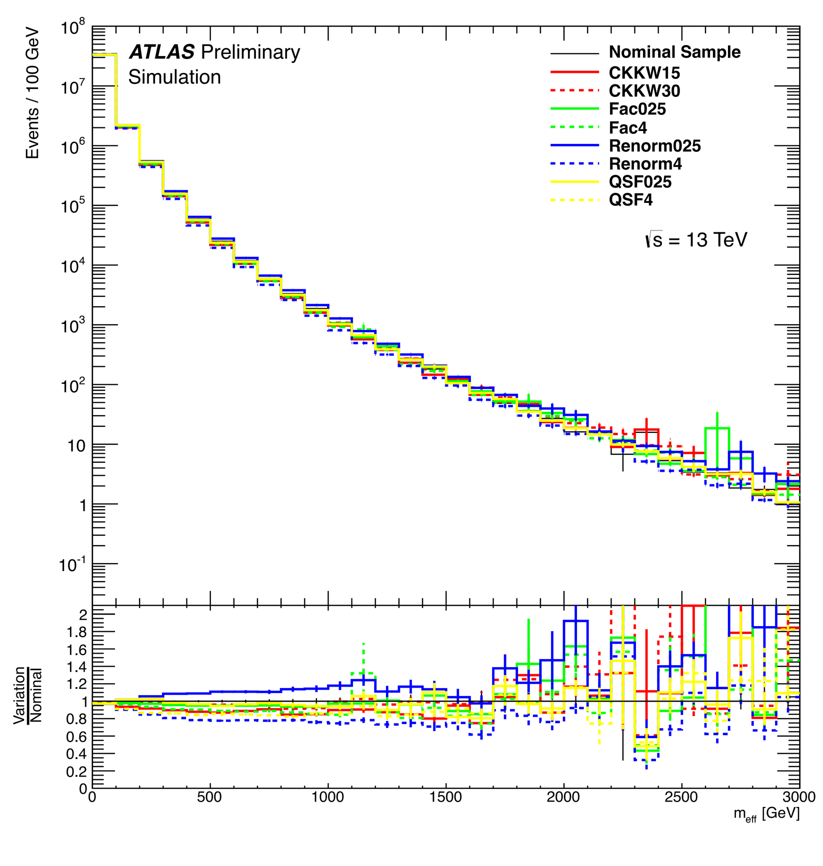
- calculate **matrix elements** at leading order (LO) or next-to-leading order (NLO)
- obtain additional multiplicities through **parton shower** (PS) or **multi-leg** formalisms
- avoid double counting using **matching schemes** (CKKW-L, MLM, FxFx, etc.)
- tune non-perturbative parameters for **parton shower**, **hadronisation** and the **underlying event**

$V+$ jets

- powerful testing ground to study QCD aspects and for comparison to state-of-the art calculations
- important background in Higgs precision measurements and for many new physics searches
- Baseline generators for Run 2:
  - SHERPA 2.1: multi-leg $V+0,1,2j$ @ NLO $+\,3,4j$ @ LO $+ \geq 5j$ @ PS using OPENLOOPS, CT10NLO and authors' default tune
  - SHERPA 2.2: multi-leg $V+0,1,2j$ @ NLO $+\,3,4j$ @ LO $+ \geq 5j$ @ PS using OPENLOOPS, NNPDF3.0NNLO and authors' (new) default tune
  - MADGRAPH+PYTHIA8: Multi-leg $V+\leq 4j$ @ LO, $\geq 5j$ @ PS with CKKW-L matching to PYTHIA8 using A14-based tune variations with NNPDF2.3LO ('A') or NNPDF3.0NLO ('B')
- investigate aMC@NLO matched to PYTHIA8 using the FxFx prescription and NNPDF2.3NLO to calculate $V+0,1,2j$ @ NLO
- also dedicated calculations for electroweak Vjj available

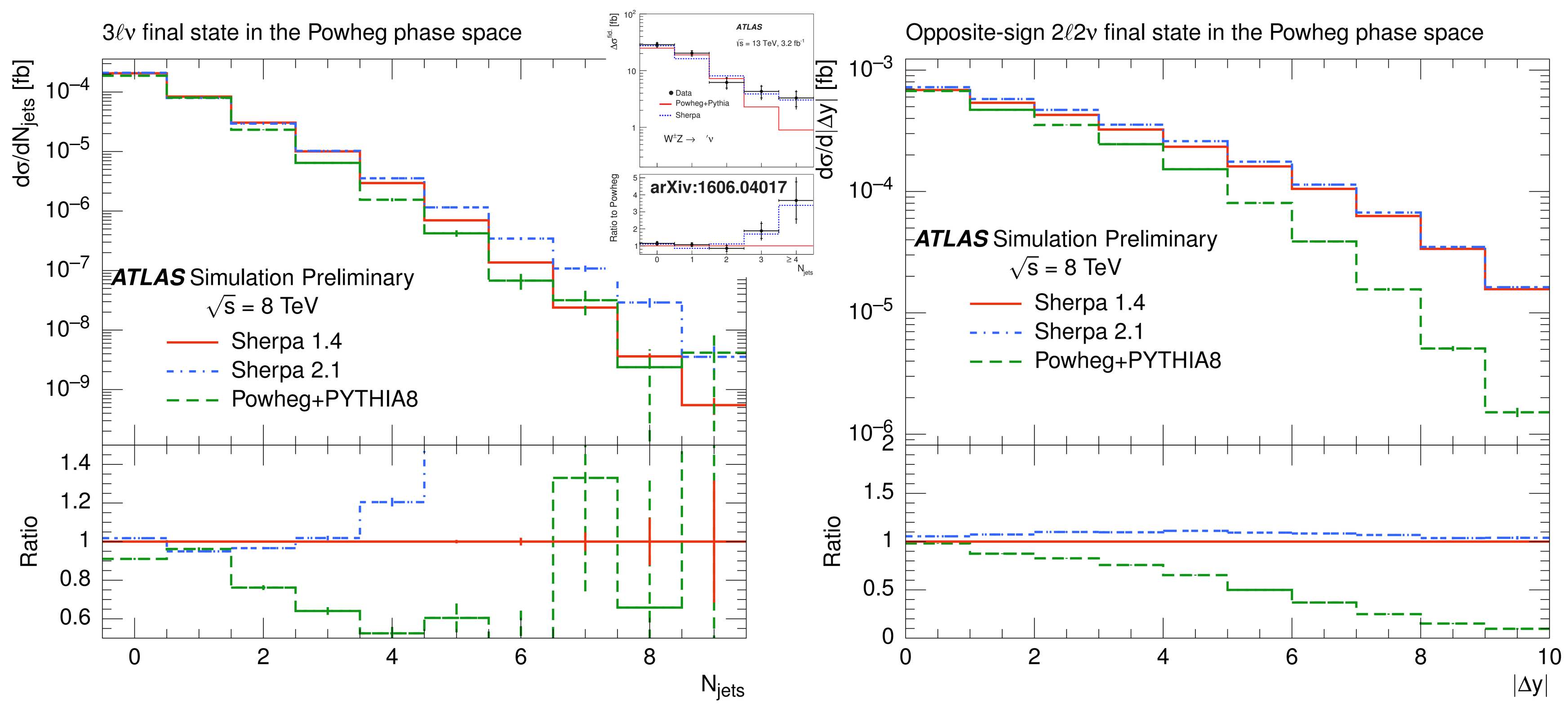


- forward activity excess in SHERPA 2.1; modelling improved in SHERPA 2.2
- SHERPA 2.1 slightly underpredicts rate of high-p_T b-jets; remedied in SHERPA 2.2
- b-jet p_T spectrum overestimated by MADGRAPH+PYTHIA8 predictions
- excellent description of jet multiplicities in early 13 TeV $Z+$jets data
- systematic uncertainties estimated using variations of the factorisation scale, the renormalisation scale, the resummation scale and the CKKW merging scale, each varied by factors of 2 and 0.5



Fully leptonic $VV+$ jets

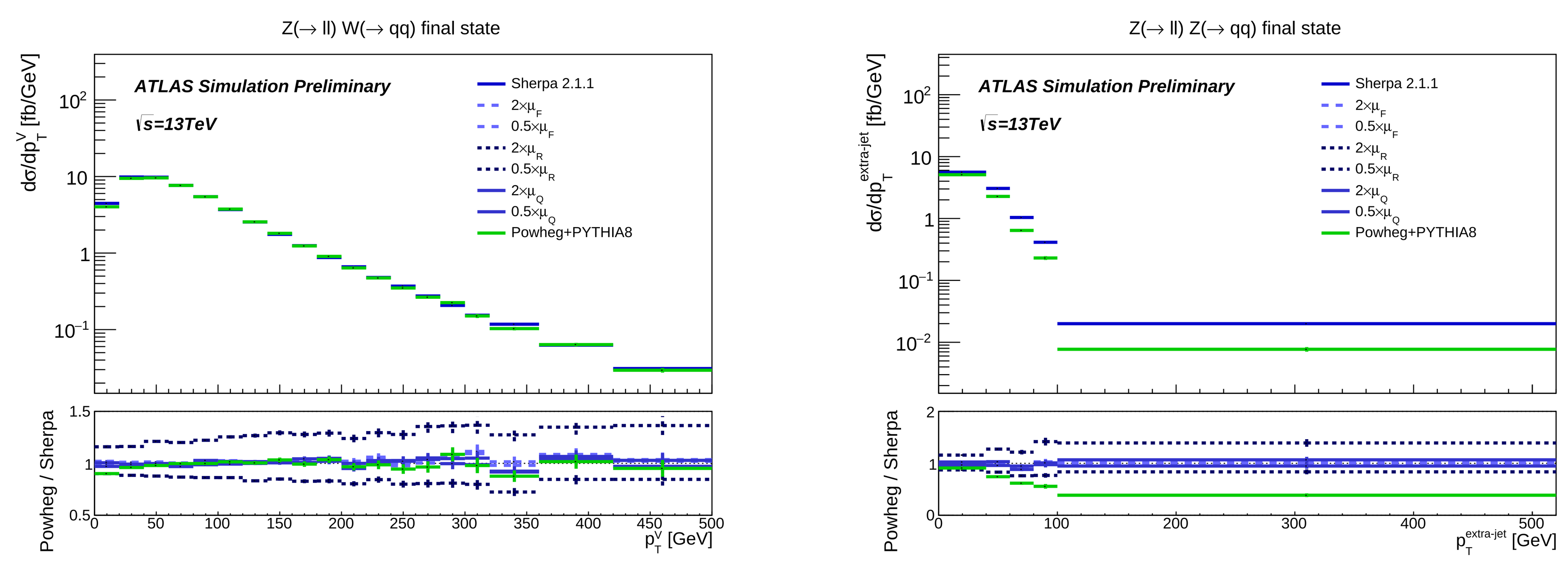
- Baseline generators for Run 2:
  - SHERPA 2.1: multi-leg $VV+0j$ @ NLO $+\,1,2,3j$ @ LO $+ \geq 4j$ @ PS using OPENLOOPS, CT10NLO and authors' default tune, ZZ also with $1j$ @ NLO
  - SHERPA 2.2: multi-leg $VV+0,1j$ @ NLO $+\,2,3j$ @ LO $+ \geq 4j$ @ PS using OPENLOOPS, NNPDF3.0NNLO and authors' (new) default tune
  - POWHEG+PYTHIA8: NLO POWHEGBOX v2 (CT10NLO) showered with PYTHIA8 (CTEQ6L1) using AZNLO and EVTGEN
- also dedicated calculations for electroweak $VVjj$ and loop-induced VV



- generally good agreement between generators
- forward activity excess in SHERPA 2.1 problematic for VBS-sensitive analyses
- NLO+PS approach clearly insufficient to describe multi-jet configurations adequately
- 4–5 % cross section uncertainty estimated using parton-level calculation (MCFM), explicit scale variations produced for SHERPA 2.1

Semileptonic $VV+$ jets

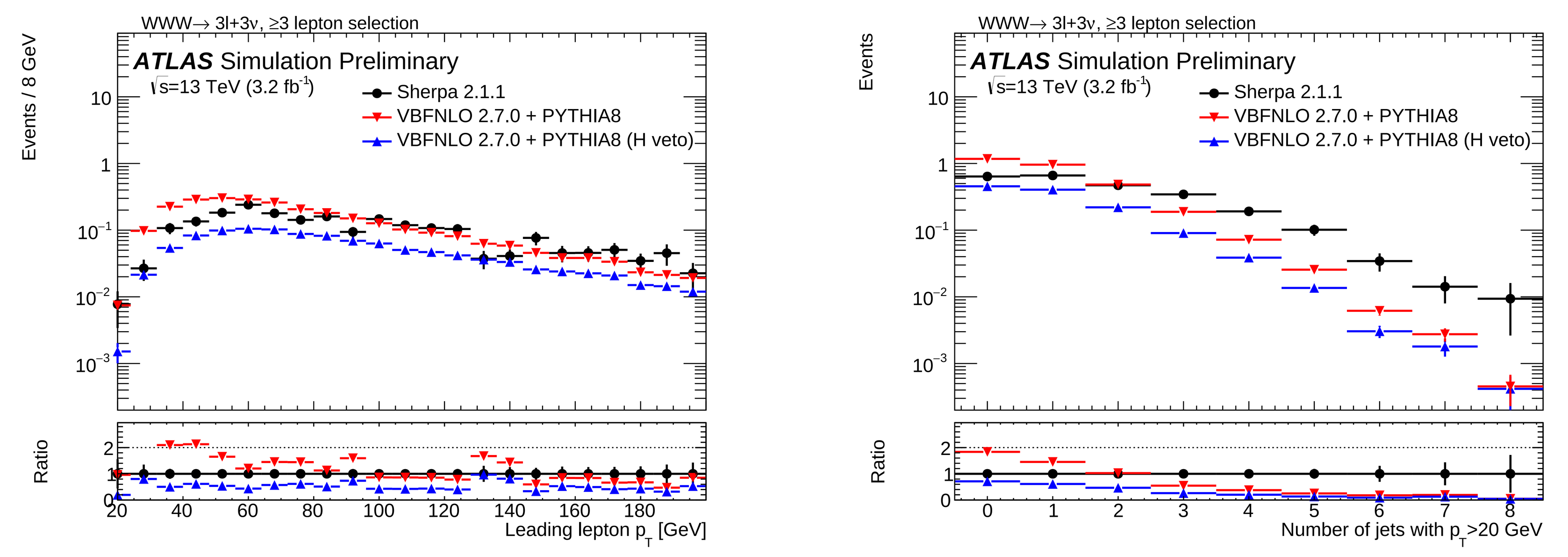
- Baseline generators for Run 2:
  - SHERPA 2.1: multi-leg $VV+0j$ @ NLO $+\,1,2,3j$ @ LO $+ \geq 4j$ @ PS using OPENLOOPS, CT10NLO and authors' default tune, ZZ also with $1j$ @ NLO, no matrix-element b-quark for WW to exclude top contributions
  - SHERPA 2.2: multi-leg $VV+0,1j$ @ NLO $+\,2,3j$ @ LO $+ \geq 4j$ @ PS using OPENLOOPS, NNPDF3.0NNLO and authors' (new) default tune, no matrix-element b-quark for WW to exclude top contributions
  - POWHEG+PYTHIA8: NLO POWHEGBOX v2 (CT10NLO) showered with PYTHIA8 (CTEQ6L1) using AZNLO and EVTGEN



- generally good agreement between generators
- POWHEG+PYTHIA8 predictions mostly within SHERPA 2.1 scale variations
- mismodelling of jet p_T spectra visible for POWHEG+PYTHIA8, in particular third-jet p_T spectrum insufficiently described (problematic for VBS analyses applying third-jet veto)
- 6 % cross section uncertainty estimated using MCFM; explicit scale variations for SHERPA 2.1

$VVV+$ jets

- Baseline generators for Run 2:
  - SHERPA 2.1: multi-leg on-shell $VVV+0j$ @ NLO $+\,1,2j$ @ LO $+ \geq 3j$ @ PS using OPENLOOPS, CT10NLO and authors' default tune, no matrix-element b-quarks to exclude top contributions
  - VBFNLO: LO VVV production using CTEQ6L1 including on-shell Higgs-strahlung production, showered with PYTHIA8 using A14 tune



- generally good agreement between generators once Higgs contribution is accounted for
- VBFNLO normalisation expected to be lower due to different accuracy
- jet multiplicity described better by multi-leg formalisam

Further documentation

- ATLAS Collaboration, *Monte Carlo Generators for the Production of a W or Z/γ^* Boson in Association with Jets at ATLAS in Run 2*, ATL-PHYS-PUB-2016-003, and references therein
- ATLAS Collaboration, *Multi-Boson Simulation for 13 TeV ATLAS Analyses*, ATL-PHYS-PUB-2016-002, and references therein

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