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Monte Carlo modelling of SM processes in ATLAS at 13 TeV

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Monte Carlo generators used by the ATLAS collaboration at the start of Run 2 for processes where single or multiple W or Z/γ* bosons are produced in association with jets or top pairs are presented. The model predictions are then compared to each other and/or with unfolded data at 7, 8 and 13 TeV.

Generators Overview

1 **Fixed LO Matrix Element generators**
- ✓ Calculates 2 → N matrix element (ME)
- ✓ Better description of subleading jets and of high-p_T behaviour

2 **NLO inclusive generators**
- ✓ Calculates ME at NLO

3 **NLO Multileg Generators**
- ✓ 2 → [1,2,3] at NLO

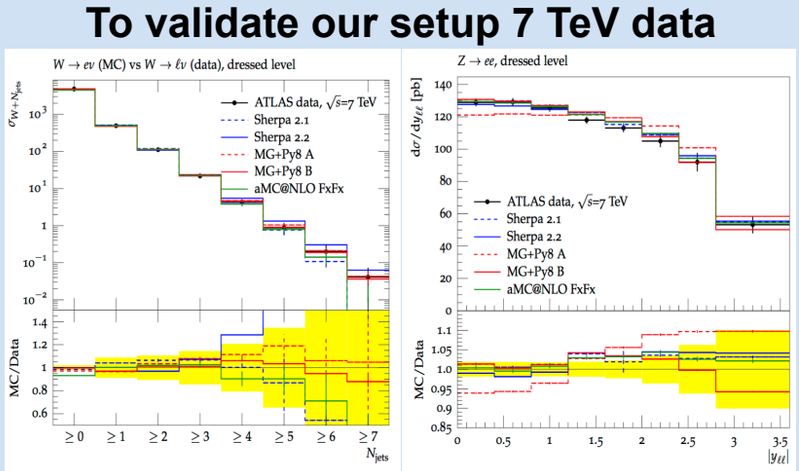
4 **General purpose showering MCs:**
- ✓ Usually leading order (LO) ME plus resummation
- ✓ Leading-log (LL) approximation showering for additional radiation
- ✓ Includes multi parton interactions (MPI) and underlying events (UE) models

NLO merging: prescriptions which allows for consistent merging of event files of various jet multiplicities at NLO accuracy, avoiding double counting (**better description of the event achieved by including higher multiplicity ME)**

Single boson production + jets (ATL-PHYS-PUB-2016-003)

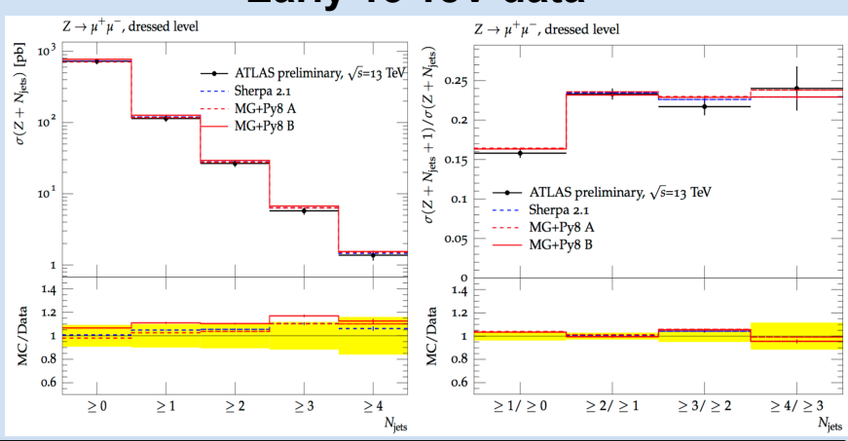
- ✓ **Sherpa2.1:** NLO accuracy for V+0,1,2 jets, LO for 3,4 jets and higher multiplicities via Sherpa model of Parton Shower (PS); CKWW-L merging with μ_Q = 20 GeV, CT10 NLO PDF (α_s = 0.118)
- ✓ **Sherpa2.2:** Same setup as above; NNPDF NNLO PDF (α_s = 0.118)
- ✓ **Madgraph+PY8 A:** CKWW-L merging with μ_Q = 30 GeV; LO ME for 0-4 jets with additional jets produced by PS. NNPDF2.3 LO (α_s = 0.13) and A14 Pythia8 tune
- ✓ **Madgraph+PY8 B:** Madgraph_2.2.3 and Pythia8.210. Same setup as above but NLO PDF (NNPDF3.0 NLO, α_s = 0.118)

To validate our setup 7 TeV data



- ✓ **Madgraph+PY8 FxFx:** *V* + 0,1,2 jets to NLO accuracy and LO for higher multiplicities. FxFx merging with μ_Q = 15 GeV; Monash tune with NNPDF2.3 LO (α_s = 0.13)

Early 13 TeV data



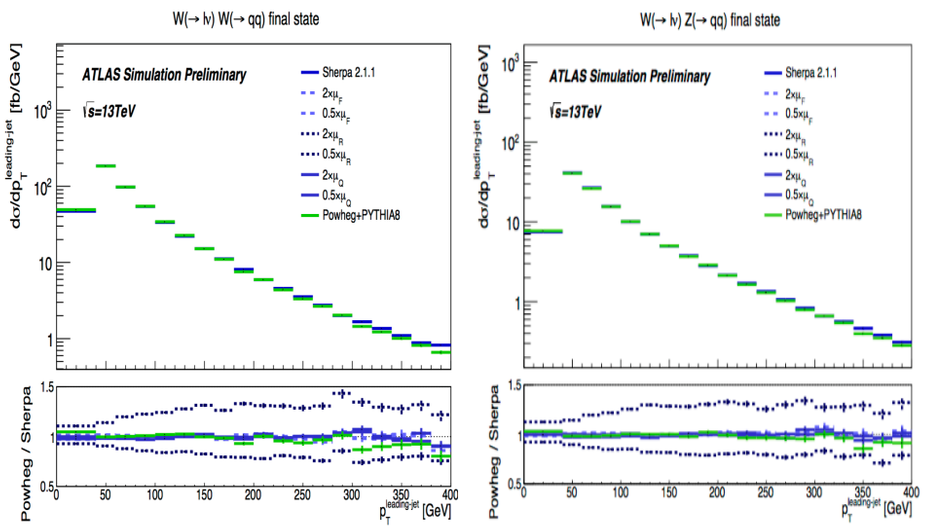
Multi bosons processes (ATL-PHYS-PUB-2016-002)

- ✓ **Sherpa2.1.1:**
  - ✓ *ZZ*: NLO ME up to 1 additional parton
  - ✓ *WZ, WW*: NLO ME (inclusive process)
  - ✓ *WW*: final states without b-quarks
  - ✓ Showering is done within the Sherpa framework
- ✓ **Powheg v2:**
  - ✓ *WW,WZ* and *ZZ* to NLO QCD
  - ✓ Events generated using CT10 NLO PDF
  - ✓ Pythia8 for the shower, using AZNLO tune and CTEQ6L1

Systematic uncertainties: Two methods

MCFM uncertainties: NLO cross sections for 13 TeV *WW*, *WZ* and *ZZ* production with semi-leptonic decay modes evaluated using MCFMv7.0.1 with CT10 NLO PDF. Scale uncertainties derived using the max and min values obtained by varying renormalization and factorization scales independently by factors of two;

Explicit variation: Sherpa 2.1 additional samples generated with μ_R and μ_F varied (1/2 and 2 of nominal scale), different merging and resummation scales. For Powheg+Pythia8 samples, scale variations and PDF uncertainties are also estimated. Below, and example of the systematic uncertainties for **semi-leptonic Sherpa 2.1 samples**:



tt production in association with W/Z (ATL-PHYS-PUB-2016-005)

- ✓ **MG5_aMC+PY8 LO:** LO with 2 additional partons for ttW and ttZ(vv), 1 for ttZ(ll); CKLW-L merging with μ_Q = 30 GeV. NNPDF2.3LO PDF is used in both the ME and PS; Pythia8 tune is A14
- ✓ **Sherpa LO:** same setup as above; NNPDF3.0NLO PDF used with a dedicated PS (Sherpa authors)
- ✓ **MG5_aMC+PY8 NLO:** samples inclusive at NLO in the ME calculation (with NNPDF3.0NLO PDF); showered with Pythia8 (A14 tune in use)

tt + W → lν | tt + Z → 2ν | tt+ Z → 2l