Monte Carlo modeling of Standard Model multi-boson production processes for √s = 13 TeV ATLAS analyses

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Abstract

Multi-boson production measurements provide an important test of the electroweak sector of the Standard Model (SM). The production of multiple gauge bosons V (= W±, Z, γ) opens up a multitude of potential decay channels categorized according to the number of charged leptons in the final state.

We present the Monte Carlo (MC) setup used by ATLAS to model multi-boson processes in √s = 13 TeV proton-proton collisions. The baseline Monte Carlo generators are compared with each other in key kinematic distributions of the processes under study. Sample normalization and systematic uncertainties are discussed.

Generators: Sherpa v2.1.1/2.2, PowhegBox v2, MadGraph5_aMC@NLO, MC@NLO
Parton Shower (PS): Pythia8, Herwig++

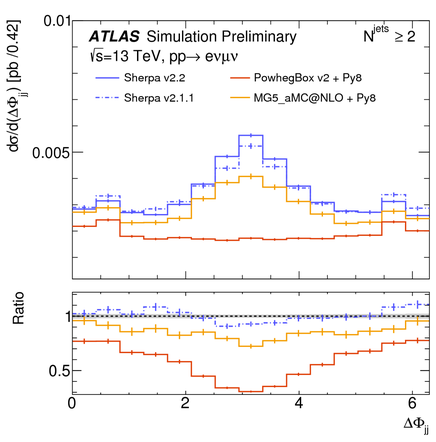
Modeled Process List

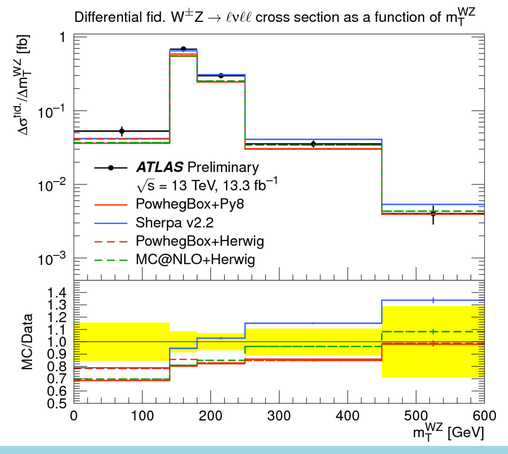
- ***Fully leptonic qq → VV***
- ***Electroweak qq→VVjj***
- ***Loop-induced gg → VV***
- ***Triboson qq → VVV***
- ***Leptonic/Hadronic qq → Vγ***
- ***Skipped: Semileptonic qq → VV(jj)***

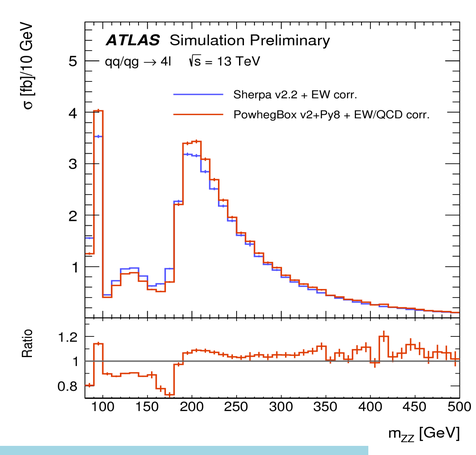
Fully Leptonic qq→VV

Modeled process accuracies

	$VV+0j$	$VV+1j$	$VV+2j$	$VV+3j$	$VV+\geq 4j$
Benchmark Generators: Sherpa v2.2	NLO	NLO	LO	LO	PS
Benchmark Generators: PowhegBox+PYTHIA8 /HERWIG++	NLO	LO	PS	PS	PS
MadGraph5_aMC@NLO +PYTHIA8	NLO	NLO	LO	PS	PS
MC@NLO +HERWIG	NLO	LO	PS	PS	PS

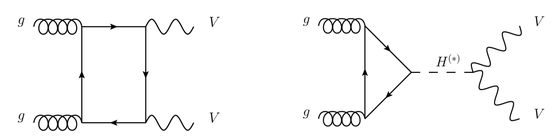


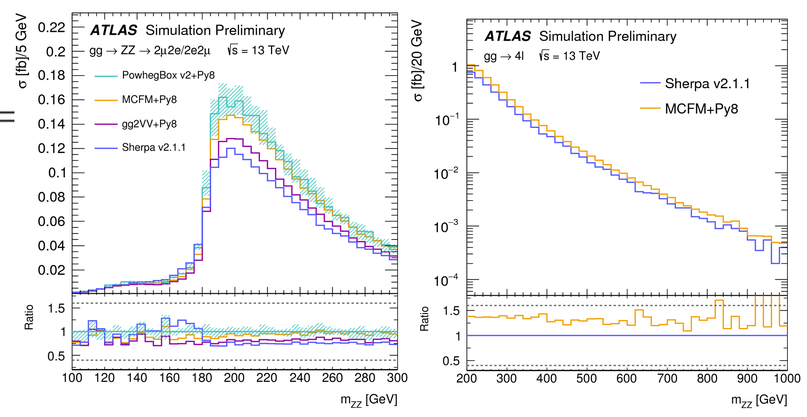




- ***PowhegBox 2nd jet from PS***
- ***MadGraph5_aMC@NLO predicts softer p_T^j and m_{jj} than Sherpa***
- ***Additional reweighting for PowhegBox to approximate NNLO QCD accuracy***

Loop-induced gg → VV





- ***QCD scale uncertainty of PowhegBox: 60% (the ONLY NLO Generator in gg → VV)***
- ***included continuum, resonant production and the IR interference in MCFM and Sherpa for high mass 4lep***

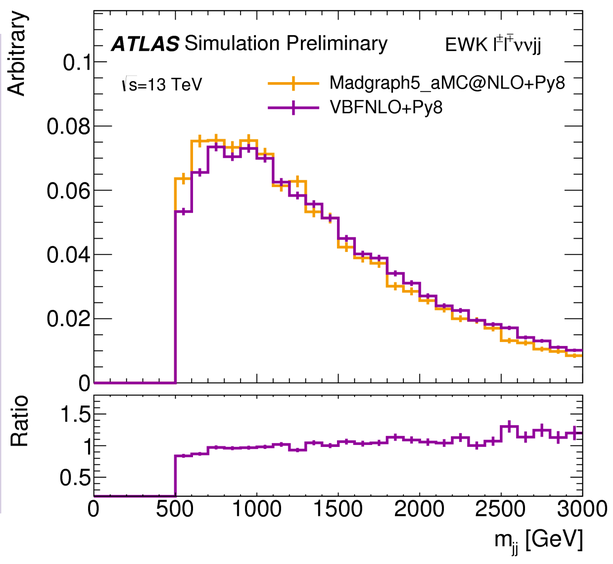
Electroweak qq→VVjj

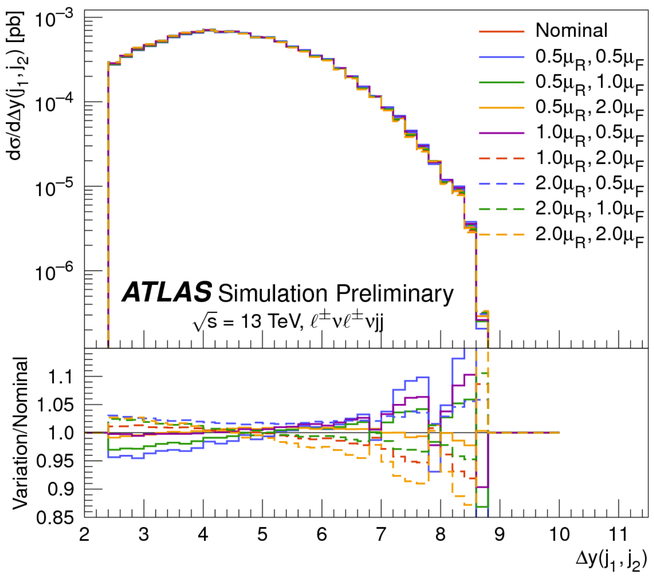
		$VV+2j$	$VV+3j$	$VV+\geq 4j$
$VVjj = \ell^\pm\ell^\mp 2\nu jj$	VBFNLO+PYTHIA8	LO	PS	PS
	MadGraph5_aMC@NLO+PYTHIA8	LO	PS	PS
$VVjj = \ell^\pm\ell^\pm 2\nu jj$	Sherpa	LO	PS	PS
	PowhegBox+PYTHIA8	NLO	LO	PS
$VVjj = \ell\ell/\ell\nu/\nu\nu jj\ jj$	Sherpa	LO	PS	PS
	MadGraph5_aMC@NLO+PYTHIA8	LO	PS	PS
$Z\gamma jj = 2\ell\gamma jj$	Sherpa	LO	PS	PS
	VBFNLO+PYTHIA8	LO	PS	PS
	MadGraph5_aMC@NLO+PYTHIA8	LO	PS	PS

Process classifications:

QCD VVjj
EWK=2
QCD=2

EWK VVjj
EWK=4
QCD=0

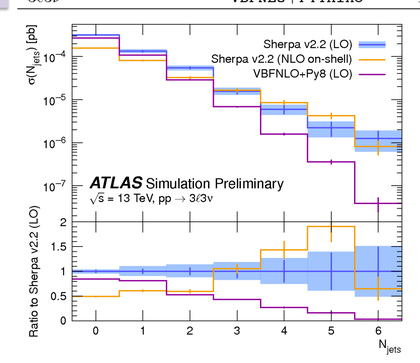


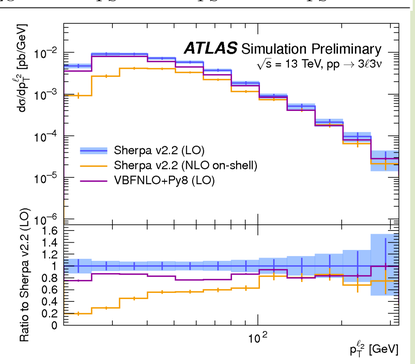


Triboson qq → VVV

Modeled Process accuracies

		$VVV+0j$	$VVV+1j$	$VVV+2j$	$VVV+\geq 3j$
VVV on-shell	Sherpa v2.2	NLO	LO	LO	PS
$6\ell, 5\ell 1\nu, 4\ell 2\nu, 3\ell 3\nu, 2\ell 4\nu$	Sherpa v2.2	LO	LO	PS	PS
$3\ell 3\nu$	VBFNLO+PYTHIA8	LO	PS	PS	PS

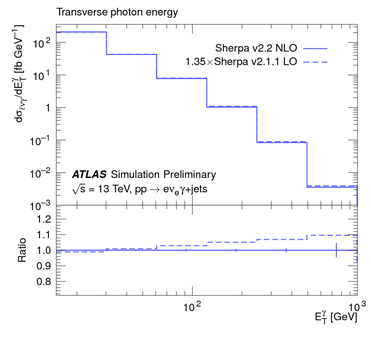




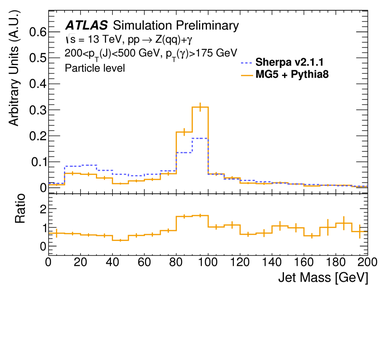
qq → Vγ

Modeled Process accuracies

		$V\gamma+0j$	$V\gamma+1j$	$V\gamma+2j$	$V\gamma+3j$	$V\gamma+\geq 4j$
$V = \ell\ell, \ell\nu, \nu\nu$	Sherpa v2.1.1	LO	LO	LO	LO	PS
	Sherpa v2.2	NLO	NLO	LO	LO	PS



Leptonic W±(lν)γ



Hadronic Z(qq)γ

Public references

Public Website:
http://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2017-005/

Full Text: https://cds.cern.ch/record/2261933/files/ATL-PHYS-PUB-2017-005.pdf