

Yellow report precision EWK, status and plans

The LHC-EWWG Multiboson subgroup conveners

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LHC EWWG summer meeting - 18rd December 2019

First public result!

- Comparison of ATLAS and CMS VBS Monte Carlo (ssWW)
- Using official results
- Results presented in July already: [\(link to slides\)](#)

Comparison of ATLAS and CMS VBS Monte Carlo simulation

The ATLAS and CMS Collaborations

Work within the LHC EWK physics working group (LHC-EWK-WG), More information at <https://twiki.cern.ch/twiki/bin/view/LHCPhysics/EWWG3>

Abstract

This is a collection of comparison plots, giving an overview over the different samples and settings employed at the ATLAS and CMS experiment to model VBS processes. This document contains a set of plots showing preliminary results of the comparison.

Keywords

Multiboson, MC modelling

Few updates: Added fiducial cross-sections

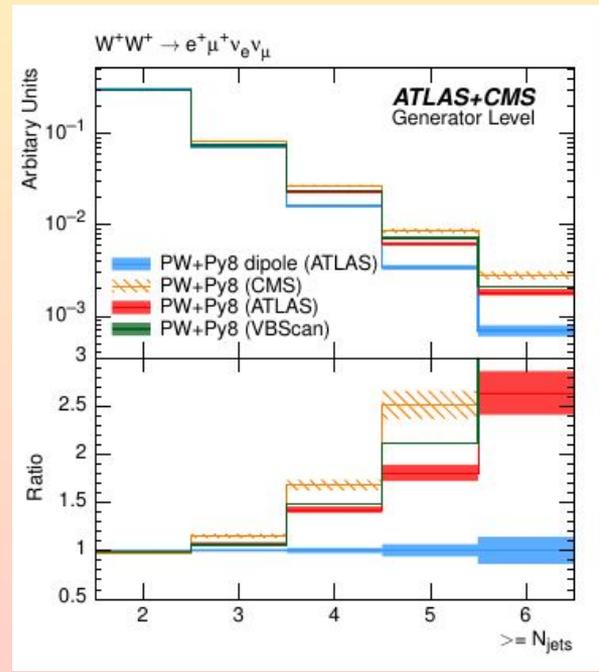
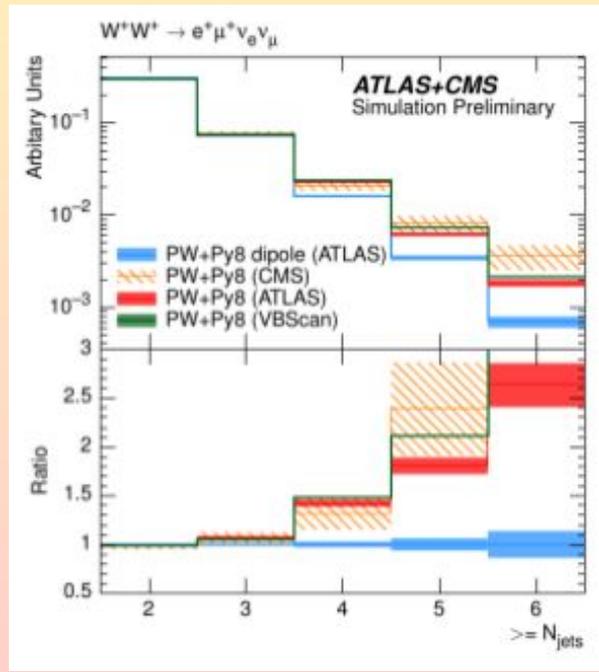
- After cross-checking over the summer, found reason for low CMS cross-section:
 - Un-intentional ‘skimming’ compromised scaling of events

| Sample name | Generator | μ -scale | Shower | Tune | PDF | further settings |
|---------------------------------|------------------------|---|--------------|----------|---------------|---|
| ATLAS | | | | | | |
| Sherpa (ATLAS) | SHERPA v2.2.2 | dynamic scale, m_{WW} | internal | internal | NNPDF3.0-NNLO | multileg-LO, exactly six EW vertices with one additional parton at LO accuracy in QCD |
| PW+Py8 (ATLAS) | POWHEG v2, VBS approx. | fixed scale, m_W | PYTHIA 8.212 | AZNLO | NNPDF3.0-NLO | |
| PW+Py8 dipole-recoil (ATLAS) | POWHEG v2 | fixed scale, m_W | PYTHIA 8.235 | AZNLO | NNPDF3.0-NLO | Dipole Recoil [5] |
| MG5+Py8 dipole-recoil (ATLAS) | MG5_AMCNLO v2.6.2 | dynamic scale, $\sqrt{p_T^{jet1} p_T^{jet1}}$ | PYTHIA 8.235 | A14 | NNPDF3.0-NLO | LO, Dipole Recoil [5] |
| CMS | | | | | | |
| MG5+Py8 (CMS) | MG5_AMCNLO v2.3.3 | dynamic scale, using a 2→2 topology from the clustered external state | PYTHIA 8.212 | CUETP8M1 | NNPDF3.0-NLO | LO, exactly six EW vertices |
| PW+Py8 (CMS) | POWHEG v2 | fixed scale, m_W | PYTHIA 8.212 | CUETP8M1 | NNPDF3.1-NNLO | NLO |
| generic samples (VBScan) | | | | | | |
| PW+Py8 (VBScan) | POWHEG v2 | dynamic scale, $\sqrt{p_T^{jet1} p_T^{jet2}}$ | PYTHIA 8.230 | Monash | NNPDF3.0-NLO | NLO |

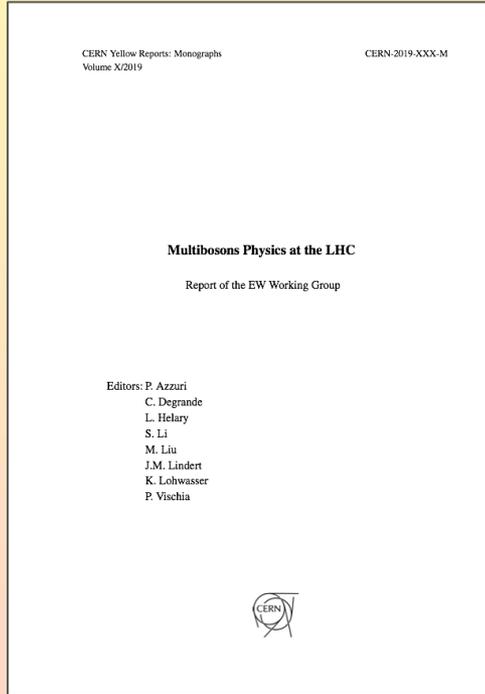
| ATLAS | | |
|---------------------------------|--|---|
| Sample name | Fiducial cross-section [fb] $W^+W^+ \rightarrow e^+\mu^+\nu_e\nu_\mu$ | Fiducial cross-section [fb] $W^\pm W^\pm \rightarrow e^\pm\mu^\pm\nu_e\nu_\mu$ |
| Sherpa (ATLAS) | 0.968 ± 0.005 | 1.136 ± 0.005 |
| PW+Py8 (ATLAS) | 1.320 ± 0.009 | 1.768 ± 0.009 |
| PW+Py8 dipole-recoil (ATLAS) | 1.322 ± 0.009 | 1.769 ± 0.009 |
| MG5+Py8 dipole-recoil (ATLAS) | 1.313 ± 0.028 | 1.734 ± 0.028 |
| CMS | | |
| MG5+Py8 (CMS) | 1.281 ± 0.018 | 1.707 ± 0.021 |
| PW+Py8 (CMS) | 1.438 ± 0.014 | 1.907 ± 0.015 |
| generic samples (VBScan) | | |
| PW+Py8 (VBScan) | 1.364 ± 0.0004 | n/a |

Update increased statistics → nicer distributions

- central conclusions do not change:
 - Smaller jet multiplicity and more central third jets for dipole-recoil spectrum
 - CMS samples with more jets, but harder m_{jj}



YR status: Still slowly ongoing/dragging



gitlab: <https://gitlab.cern.ch/lhcewkwg/lhcewkwg-multiboson/Report2018>

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1. Measurements of Multibosons: current results and outlook
2. Predictions for Multibosons: state-of-the-art and best-practise
3. Predictions for Multibosons: MC/phenomenological studies
4. Fiducial cross-section and BSM

1. Measurements of Multibosons: current results and outlook

What's there

- WW (ATLAS, CMS, comparisons)
- WZ (CMS). Corinne Goy kindly picked up ATLAS side
- VBS ssWW (ATLAS, CMS)
- ZZ (ATLAS CMS) and ZZ VBS
- Tribosons ($W\gamma\gamma$ $WW\gamma$, $WZ\gamma$)

How can I contribute?

- Text describing your analysis of a missing final state
- Common RIVET routine for your favourite process which lacks it

We will do a last call for contributors. In the worst case, we will pick up / write the pieces to finish the reports early next year (April?), including recommendations for Full-Run-2 / Run-3 and studies on the way there

What's in the making

- A few final states ($Z\gamma$, $W\gamma$, VBS WZ)
- Phase space agreements
- Brief review of procedures and possible agreements
 - Use similar generators where possible? (but differences reported even with the same ones, see later slides)
 - Systematics: particularly the ones connected with generators (some are treated differently across experiments)
 - Unfolding: publish useful material (response+correlation matrices, etc), describe well the procedures

3. Predictions for Multibosons: MC/phenomenological studies

- NLO EW corrections are becoming ubiquitous (VV, VVV, VBS) and partly publically available (MATRIX)
- Although largely automated these are highly complex computations.
- Although “NLO EW” unambiguously defined there can be subtle differences in the implementations, e.g. in the context of CMS (complex mass scheme).
- More validation needed?** E.g. for
 - VVV? ([1912.04117](#) vs. [1806.00307](#) revealed important differences)
 - VBS? (should be in collaboration with VBScost)
- For VV in-detail validation within LH17:

$$u\bar{u} \rightarrow e^+e^-\mu^+\mu^-$$

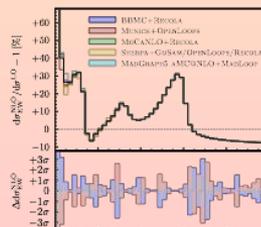
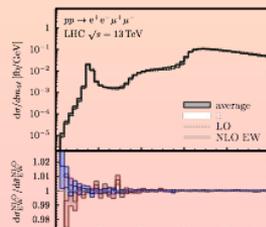
individual phase-space points:

| a) PSP 1 | $B/10^{-15}$ | $V_{\text{finite}}/10^{-16}$ | $V_1/10^{-17}$ | $V_2/10^{-17}$ |
|-----------|------------------|------------------------------|------------------|-------------------|
| MADLOOP | 5.26592465401088 | 6.60297993618509 | 2.63915540074976 | -3.09566543908773 |
| RECOLA | 5.26592465401090 | 6.60088670209820 | 2.63915540075328 | -3.09566543908732 |
| OPENLOOPS | 5.26592465401100 | 6.60088670210145 | 2.63915540078563 | -3.09566543905505 |
| GoSAM | 5.26592465401086 | 6.60088670209788 | 2.63915540076095 | -3.09566543909091 |
| NLOX | 5.26592465401084 | 6.60088670211436 | 2.63915540076702 | -3.09566543908783 |

$$\gamma\gamma \rightarrow e^+e^-\mu^+\mu^-$$

| c) PSP 1 | $B/10^{-13}$ | $V_{\text{finite}}/10^{-14}$ | $V_1/10^{-15}$ | $V_2/10^{-15}$ |
|-----------|------------------|------------------------------|------------------|-------------------|
| MADLOOP | 4.63762790127829 | 6.79330655006349 | 4.07216839247769 | -2.23061748556626 |
| RECOLA | 4.63762790127830 | 6.79163662486900 | 4.07216839245629 | -2.23061748556050 |
| OPENLOOPS | 4.63762790127838 | 6.79163662486753 | 4.07216839246097 | -2.23061748560388 |
| GoSAM | 4.63762790127830 | 6.79163662486761 | 4.07216839247955 | -2.23061748556541 |

cross sections:
(in qq channels)



→ very convincing agreement
between automated tools

Some general news from VBScan

- VBSCost network
<https://vbscanaction.web.cern.ch/>
- Organisation of schools and meetings 2019/20:

PREFIT - Spring School (full)

BSM models in Vector Boson Scattering Processes

(Lisbon meeting: <https://indico.cern.ch/event/846927/>)

Second In-person Meeting in the Third Grant Period

Helsinki meeting: <https://indico.cern.ch/event/864506/>



PREFIT School

Precision Effective Field Theory School

2-13 March 2020 at DESY, Hamburg

ORGANIZING COMMITTEE
Senka Durić, Pietro Govoni,
Andreas Meyer, Jürgen Reuter,
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Borut Korševan, Predrag Milenović,
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Daniela Reuzzi, German Rodrigo,
Heidi Rzehak, Wouter Waalewijn
Marco Zaro, George Zoupanos

TOPICS
Experimental Techniques
Monte Carlo Generators
Machine Learning
Global fits
Effective Field Theory
Precision Physics at the LHC

LECTURERS
Ilaria Brivio, Kyle Cranmer,
Admir Greljo, Gudrun Heinrich,
Fabio Maltoni, Andrea Marini,
Antonio Pich, Gavin Salam,
Veronica Sanz, Michele Selvaggi,
Steven Schramm, Nicholas Wardle,
and others

Lectures, hands-on sessions and group projects for theorists and experimentalists

Registration:
<https://indico.cern.ch/event/prefit20>



| | | | |
|------|------------------|---|--|
| 2019 | VBSCAN-PUB-01-19 | Sleptons without Hadrons https://arxiv.org/abs/1901.09937 | |
| | VBSCAN-PUB-02-19 | QCD and electroweak corrections to WZ scattering at the LHC By Ansgar Denner, Stefan Dittmaier, Philipp Maierhöfer, Mathieu Pellen, Christopher Schwan. arXiv:1904.00882 [hep-ph]. | |
| | VBSCAN-PUB-03-19 | Same-sign WW Scattering in the HEFT: Discoverability vs. EFT Validity By P. Kozow, L. Merlo, S. Pokorski, M. Szeleper arXiv:1905.03354 [hep-ph] | |
| | VBSCAN-PUB-04-19 | An event generator for same-sign W-boson scattering at the LHC including electroweak corrections By Mauro Chiesa, Ansgar Denner, Jean-Nicolas Lang, Mathieu Pellen arXiv:1906.01863 [hep-ph] | |
| | VBSCAN-PUB-07-19 | Dynamical vector resonances from the EChL in VBS at the LHC: the WW case By R.L. Delgado, C.Garcia-Garcia , M.J. Herrero To be submitted soon. | |
| | VBSCAN-PUB-08-19 | Exploring the scattering of vector bosons at LHCb By Mathieu Pellen arXiv:1908.06805 [hep-ph] | |
| | VBSCAN-PUB-09-19 | Automated Predictions for Polarized Parton Scattering By Diogo Buarque Franzosi, Olivier Mattelaer, Richard Ruiz and Sujay Shil arXiv:1912.01725 [hep-ph] | |

Summary

- Yellow Report: things are marching slower than expected.
- Combinations: discussions should start/continue
- Simulators show differences, sometimes even when the setup should be equivalent
 - VBS comparisons using RIVET show striking differences in ssWW
 - **Call for volunteers to check other processes in CMS/ATLAS/Theory comparison**
 - **VBF processes could be equally interesting (mjj modelling) -> esp. b/c of BDT usage ZZ -> 4l lineshape (difficult to get the contributions right, and similar issues as WW)**
 - **The more people can provide comparison studies, the better we can understand what is going on!**