

# Triboson studies for HL/HE-LHC

Evelin Bakoš, Marija Vranješ Milosavljević, Nenad Vranješ

Institute of Physics Belgrade

Jay Lawhorn

Caltech

HL/HE-LHC WG1

14 May 2018



# Triboson production

## WWW

- Fully leptonic (lv)(lv)(lv)
- Semi hadronic (lv)(lv)(jj)

ATLAS CMS?  
ATLAS

## WWZ

- Fully leptonic (lv)(lv)(lv)
- Semi hadronic (lv)(jj)(ll)

ATLAS CMS  
ATLAS

## WZZ

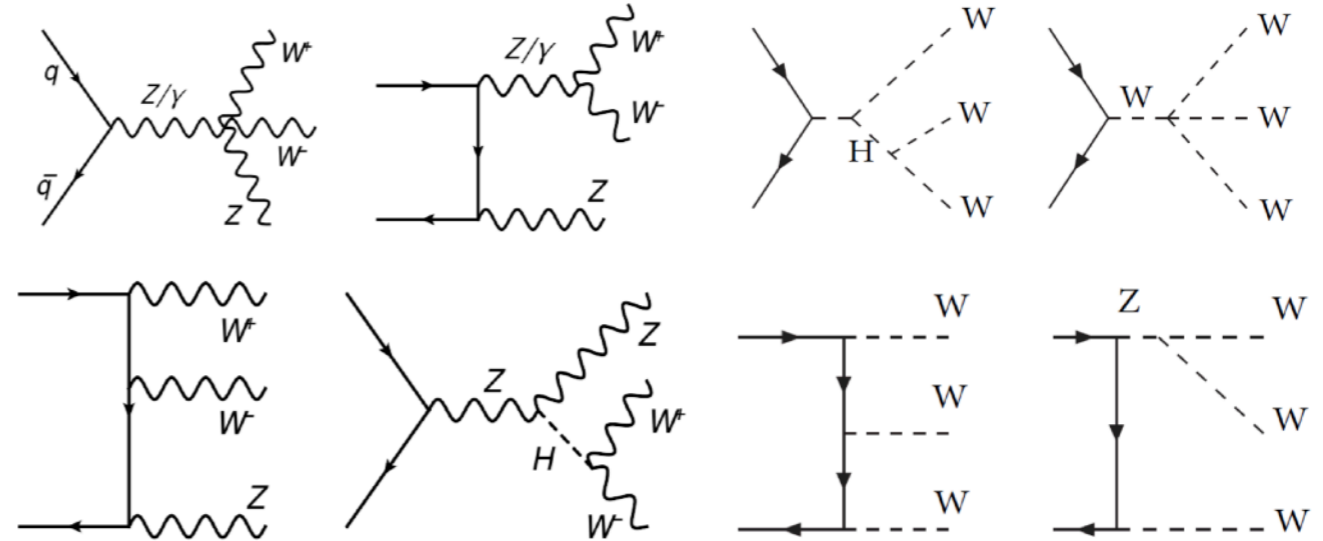
- Fully leptonic (lv)(ll)(ll)
- Semi hadronic (lv)(ll)(jj)

ATLAS CMS  
ATLAS

## ZZZ

- Fully leptonic (ll)(ll)(ll)
- Semi hadronic (ll)(ll)(jj)

CMS  
CMS?



- ZZZ is has low (cross-section\*branching ratio) to leptonic final state; challenging but potentially very interesting
- Optimise selection requirements to maximise sensitivity / significance
- Simple cut-and-count approach, significance calculation based on Cowan et al. ([arXiv:1007.1727](https://arxiv.org/abs/1007.1727)) with flat uncertainty on background
- Pure MC study using parameterized detector response
- If time & sufficient MC statistics, CMS will also consider shape-based signal extraction

# ATLAS theory input & questions

- ATLAS
  - Sherpa v(2.2.2)
    - Cross sections at NLO in QCD and  $0j@NLO + 1,2,3j@LO$
    - No on-shell Higgs-strahlung ( $m_H=125$  GeV) production due to the factorized decay setup
  - VBFNLO as alternative
    - Production LO ( $0j @ LO$ ), cross sections at NLO in QCD
    - VBFNLO cross sections  $\sim 50\%$  higher (includes on-shell Higgs)
- ATLAS fiducial phase space for WWW already posted
  - <https://twiki.cern.ch/twiki/bin/view/LHCPhysics/HLHEWG1>
  - Found higher  $p_T$  lepton cuts ( $p_T > 30$  GeV) significantly decrease contribution from on-shell Higgs
  - Sherpa has more realistic description of jet production (from available samples)
- VBFNLO vs Sherpa given fiducial phase spaces ?

# CMS theory input & questions

- Madgraph5 / aMC@NLO production at LO
  - Also includes weights for dim-8 aQGCs
- Fiducial cuts are WIP
  - Probably can match ATLAS WWW leptonic cuts
  - Hope to have other fully leptonic final states soon, likely with asymmetric lepton pT cuts
- **CMS and ATLAS:**
  - Would like theory input on inclusive and fiducial cross-sections, ideally to synchronize between two groups
  - Are NNLO QCD and NLO EWK cross sections recommended (or available) ?

# Contribution to Yellow Report (5 pages)

- Does page count include theory?
- Experimental side proposal:
  - Brief text description of setup and selection cuts
  - Tables with expected number of signal and background events per category + signal significance (one per channel)
  - ATLAS WWW:
    - Flagship distributions (probably ones most sensitive to aQGCs) after all selection cuts:  $m_T(3l3\nu)$ ,  $\sum p_T$
  - ATLAS/CMS WWZ & WZZ
  - CMS ZZZ:
    - Signal+background distribution(s) after all selection cuts
    - Projected sensitivity plot for varying aQGC values