

News and Plans of the LHC EW WG Multiboson group

LHC EWWG Multiboson

Timeline in details

- (Topical)-Meetings every 1-2 weeks on Wednesday, 13.00 CERN time
- Sign up for mailing list: lhc-ewwg-multiboson@cern.ch
Using: <https://e-groups.cern.ch/e-groups/EgroupsSubscribeSearch.do>
- Currently we are planning the next meetings -- please let us know in case you want to present / contribute
 - Ideas / plans for studies summarized in the next slides
- General LHC-EW twiki (sign up to mailing list to access gitlab):
<https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCEW>
- **Plan: Yellow-Report end of the year**
→ **precision WG ready with a combination until then ($\sin^2\Theta$)**

Plans for the documentation / Yellow Report

- Based on the (topical) meetings and their minutes, plan to compile *LHC Yellow Report* to document definitions, agreements and plans
 - What are essential processes / phases spaces / distributions to be measured?
 - Recommendations for MCs and theory predictions
 - What information is needed to allow for common interpretations
- **1) Overview of current results of ATLAS/CMS results**
 - Description of future common volumes (only if converged, applicable)
 - Requirements: What measurements needed for common interpretation
- **2) Overview of LHCb results + prospects**
- **3) Overview of Generators / MC for diboson & multiboson (including new calculations)**
- **4) Overview of EFT Models**
- **5) Instructions / Studies recommendations on combinations**

1) Overview of current results *and recommendations*

- Overview of current results of ATLAS/CMS results
 - *Description of future common volumes (only if converged, applicable)*
 - *Requirements: What measurements needed for common interpretation*
- Channels included so far
 - Tribosons
 - **ZZ**
 - **ZZ VBS (-> ATLAS?)**
 - W/Z y VBS
 - WZ VBS
 - W/Z y VBS
 - WW
 - ssWW VBS
 - W/Z VBF
- Would like to collect within the next 1-2 weeks for a first round of (convenor) comments and collating into 1 document to be send around for comments.

2) LHCb prospects

- → Need to follow up!

3) Overview of Generators / MC

- Theory plans
 - Fixed-order tools:
 - NNLO QCD(+NLO EW): MATRIX
 - NLO EW: Sherpa(+OpenLoops/Recola), MoCaNLO+Recola, (-> recola people) Madgraph_aMCatNLO
 - ggVV
 - Particle-level tools:
 - Powheg
 - Sherpa
 - Matrix
 - MadGraph/aMCatNLO
 - Herwig7 (+VBFNLO)
 - Consider 13 TeV only (extend range of observables)
- ATLAS/CMS comparisons (of rivet routines) for the used MC samples
What assumptions used? Converge on recommendations for e.g. scales?
 - WZ VBS
 - ssWW
 - Others → contributors welcome!!!!

4) Fiducial BSM regions / Overview of EFT

Multiboson Production		
Final state	Object	Selection requirements
WW	leptons	$p_{T, \text{lead}} > 25 \text{ GeV}, \eta < 2.5$
	neutrinos	$(\sum \vec{p}_\nu) > 30 \text{ GeV}$
	jets	no jets with $p_T > 30 \text{ GeV}$ and within $ \eta < 5.0$
	final BSM region	$m_{\ell\ell}: 380\text{-}600 \text{ GeV}, > 600 \text{ GeV}$
WZ	leptons	$p_{T, \text{lead}} > 25 \text{ GeV}, p_T > 15 \text{ GeV}, \eta < 2.5$
	neutrinos	$(\sum \vec{p}_\nu) > 30 \text{ GeV}$
	jets	no b -jets with $p_T > 30 \text{ GeV}$ and within $ \eta < 5.0$
	bosons	$m_{T,W} > 30 \text{ GeV}$ (see Eq. ??), $\Delta(m_Z, m_{\ell\ell}) < 15 \text{ GeV}$
final BSM region	$m_{T,WZ}: 380\text{-}600 \text{ GeV}, > 600 \text{ GeV}$ (see Eq. ??)	
ZZ	leptons	$p_T > 25 / 15 / 10 \text{ GeV}$ (leading leptons), $ \eta < 2.5$
	bosons	$\Delta(m_Z, m_{\ell\ell}) < 25 \text{ GeV}$
	final BSM region	$m_{WZ}: 0.8\text{-}1.0 \text{ TeV}, > 1.0 \text{ TeV}$
	$W\gamma$	leptons
photons		$E_T > 25, \eta < 2.5, \Delta R(\ell, \gamma) > 0.7$
neutrinos		$(\sum \vec{p}_\nu) > 30 \text{ GeV}$
bosons		$m_{T,W} > 50 \text{ GeV}$
final BSM region		$p_{T,\gamma}: 25\text{-}60 \text{ GeV}, 60\text{-}90 \text{ GeV}, 90\text{-}150 \text{ GeV}, > 150 \text{ GeV}$
$Z(\rightarrow \ell\ell)\gamma$		leptons
	photons	$E_T > 25, \eta < 2.5, \Delta R(\ell, \gamma) > 0.4$
	bosons	$\Delta(m_Z, m_{\ell\ell}) < 10 \text{ GeV}$
	final BSM region	$p_{T,\gamma}: 100\text{-}250 \text{ GeV}, > 250 \text{ GeV}$
$Z(\rightarrow \nu\nu)\gamma$	photons	$E_T > 25, \eta < 2.5, \Delta R(\ell, \gamma) > 0.4$
	neutrinos	$(\sum \vec{p}_\nu) > 30 \text{ GeV}$
	final BSM region	$p_{T,\gamma}: 100\text{-}250 \text{ GeV}, > 250 \text{ GeV}$

Vectorboson Fusion		
Final state	Object	Selection requirements
$Z \text{ VBF} / Zjj$	leptons	$p_{T, \text{lead}} > 25 \text{ GeV}, \eta < 2.5$
	jets	$p_{T,j1} > 55 \text{ GeV}, p_{T,j1} > 40 \text{ GeV}, \eta < 4.5$
	bosons	$\Delta(m_Z, m_{\ell\ell}) < 10 \text{ GeV}$
	further jets	$p_T > 25 \text{ GeV}$, none in interval between leptons
	event	$p_T^{\text{balance}} < 0.15$ (see Eq. ??)
final BSM region	$m_{jj}: 0.8\text{-}1.2 \text{ TeV}, > 1.2 \text{ TeV}$	
Vectorboson Scattering		
Final state	Object	Selection requirements
$WW \text{ VBS} / WWjj$	leptons	$p_T > 20 \text{ GeV}, \eta < 2.5$, same-sign
	jets	$p_{T,j1} > 30 \text{ GeV}, p_{T,j1} > 30 \text{ GeV}, \eta < 4.5, \Delta\eta_{jj} > 2.5$
same-sign	final BSM region	$m_{jj}: 0.25\text{-}0.5 \text{ TeV}, > 0.5 \text{ TeV}$
$Z\gamma \text{ VBS} / Z\gamma jj$	leptons	$p_T > 35, \eta < 2.5$
	photons	$E_T > 75, \eta < 2.5, \Delta R(\ell/j, \gamma) > 0.4$
	bosons	$\Delta(m_Z, m_{\ell\ell}) < 10 \text{ GeV}$
	jets	$p_{T,j1} > 30 \text{ GeV}, p_{T,j1} > 30 \text{ GeV}, \eta < 4.5, \Delta\eta_{jj} > 3.0$
	final BSM region	$m_{jj} > 0.5 \text{ TeV}$
$WZ \text{ VBS} /$	leptons	$p_{T, \text{lead}} > 25 \text{ GeV}, p_T > 15 \text{ GeV}, \eta < 2.5$
	neutrinos	$(\sum \vec{p}_\nu) > 30 \text{ GeV}$
	jets	$p_{T,j1} > 55 \text{ GeV}, p_{T,j1} > 40 \text{ GeV}, \eta < 4.5$
	bosons	$\Delta(m_Z, m_{\ell\ell}) < 25 \text{ GeV}$
	further jets	$p_T > 25 \text{ GeV}$, none in interval between leptons
	event	$p_T^{\text{balance}} < 0.15$ (see Eq. ??)
final BSM region	$m_{WZ}: 0.8\text{-}1.0 \text{ TeV}, > 1.0 \text{ TeV}$	
$ZZ \text{ VBS} / ZZjj$	leptons	$p_T > 25 / 15 / 10 \text{ GeV}$ (leading leptons), $ \eta < 2.5$
	jets	$p_{T,j1} > 55 \text{ GeV}, p_{T,j1} > 40 \text{ GeV}, \eta < 4.5$
	bosons	$\Delta(m_Z, m_{\ell\ell}) < 25 \text{ GeV}$
	further jets	$p_T > 25 \text{ GeV}$, none in interval between leptons
	event	$p_T^{\text{balance}} < 0.15$ (see Eq. ??)
	final BSM region	$m_{WZ}: 0.8\text{-}1.0 \text{ TeV}, > 1.0 \text{ TeV}$

4) Fiducial BSM regions / Overview of EFT

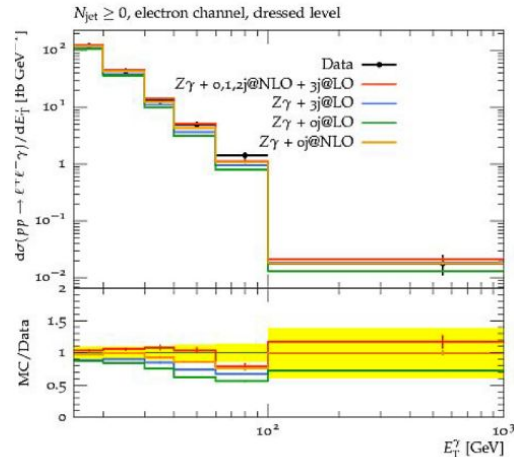
- Which are common EFT-sensitive phase spaces?
- \sim Similar to Higgs STXS (in the sense that unified phase space)
- \rightarrow **unfolded measurements in these pre-defined phase spaces would ease later combination!!**
- What can be expected?

5) Recommendations - a check list!

A check list

- Exact definition of fiducial PS
- Rivet Routine (highly recommended)
- Results presented in HepData or other common formats
- Detailed information concerning uncertainties
- Essential to have
 - separated statistical and systematic uncertainties
 - covariance matrices for both statistical and systematic components
- Ideal to also have (for cross-experiment combination and theory-experiment comparison)
 - separated uncertainties per source
 - covariance matrices per uncertainty source, or with correlation information

Cross section measurement	Fiducial requirements
Common requirements	$p_{T_1}^{\ell} > 20 \text{ GeV}, p_{T_2}^{\ell} > 10 \text{ GeV}, p_{T_1}^{\ell s_1} > 5 \text{ GeV},$ $ \eta^{\ell} < 2.5, m_{\ell\ell} > 4 \text{ GeV}$ (any opposite-sign same-flavor pair)
$Z \rightarrow 4\ell$	$m_{Z_1} > 40 \text{ GeV}$ $80 < m_{4\ell} < 100 \text{ GeV}$
$ZZ \rightarrow 4\ell$	$60 < (m_{Z_1}, m_{Z_2}) < 120 \text{ GeV}$



$ \Delta y_{jj} $	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - ∞
$\Delta\sigma_{W\pm Z}^{\text{fid.}}$ [fb]	2.27	1.29	0.95	0.29	0.09	0.07
Relative Uncertainties [%]						
Statistics	11	16	17	34	60	52
All systematics	12	15	13	20	33	30
Luminosity	2.6	2.7	2.4	3.1	3.0	2.5
Total	16	22	21	39	68	60

Further possible studies

- Review of current summary plots
 - What could be added ?
 - How could they be simplified?
- **Review of tools?**
- Open for ideas

- Next meeting: 17th October 2018

Backup

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Introduction: News and Plans

- Following from general LHCEWWG workshop 13./14. December 2017 (<https://indico.cern.ch/event/678694>)
→ **Push for common efforts between experiments to get more out of data**
- From Maarten Boonekamp's slides:
 - Work plan (for each sub-group)
 - Documentation
 - Meetings
 - Two group-wide meetings per year (2018: May/June; October/November)
- For multibosons: Follow this timeline
→ **ensure optimal results for measurements and EFT/BSM interpretations**