VBS WV semileptonic

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**WW/WZ->lvjj**

- Identify leptonically decaying W boson while other W or Z boson decays to jets
- Select dijet events and boosted events such that the decay jets merge into a single jet

Maximizes sensitivity to $a_{QGC}$

Limits already surpass LEP and will improve with Run2 Data

![Graphs and diagrams related to WW/WZ->lvjj analysis](image-url)
Goal

Estimate sensitivity for VBS and aQGC in 1 lepton channel at HL/HE-LHC.

HL-LHC
1. Request VBS specific sample. (VBS, aQGC, large amount of W+jets)
2. TRUTH DAOD + smearing function
3. Event selection, SR definition
4. Estimate sensitivity @ 3000 fb-1
5. Limits on aQGC
6. Can we isolate the longitudinal component?

HE-LHC
1. Produce events locally
2. Detector simulation with Delphes
4. Main Question:
   • Can we still do precision EWK physics?
   • How about pileup effects?
Workflow for HL-LHC

- Use ATLAS Smearing functions
- Working on a pub note with Early Sep Timescale

Caveat, Delphes does not include pileup and uses PFlow
Plans for aQGCs

- We want to generate VBS MC with aQGC EFT incorporated.
- In Eboli model there are 21 dim-4 operators which satisfy SU(2)L × U(1)Y symmetry:
  - 3 “Scalar” operators labeled FSn -
  - 10 “Tensor” operators labeled FTn (n=appropriate integer)
  - 8 “Mixed” operators labeled FMn
- Madgraph UFOs by authors available with all the operators ready —→ generation takes long time.
- Madgraph has a feature that can reweigh matrix element after generation to that of a different model or parameter choice.
- Tested to work well with aQGC samples as long as you stay within type (FS/FM/FT) and enough stats in phase space reweighing to (stats in tails).
Longitudinal Polarization

- Can we isolate the longitudinal component?
  
  - $V_L V_L$ scattering linked to the mechanism responsible for the EWSB

- Started generating samples:
  
  - The baseline is to use MadGraph without specifying $W/Z$ decay. Then a modified version of the DECAY package is used to keep track of the polarization information. (Instructions from Marc Andre Pleier)

- Alternative: use Whizard
HE-LHC

For HE-LHC 27 TeV analysis will use Delphes framework

- Started generating some samples at 27 TeV with Pythia 8 showering
  - Using Madgraph v2.6.1
  - Shower with Pythia8
- Run Delphes with the card provided by Delphes authors for HE-LHC
- Expanded one of the example c++ code to analyze events

<table>
<thead>
<tr>
<th></th>
<th>13 TeV</th>
<th>27 TeV</th>
<th>ratio</th>
</tr>
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<tbody>
<tr>
<td>WWlvqq</td>
<td>1.7</td>
<td>9.5</td>
<td>5.59</td>
</tr>
<tr>
<td>WZlvqq</td>
<td>0.25</td>
<td>1.2</td>
<td>4.8</td>
</tr>
<tr>
<td>ttbar</td>
<td>695</td>
<td>3123</td>
<td>4.49</td>
</tr>
<tr>
<td>W+jets</td>
<td>17881</td>
<td>45466</td>
<td>2.54</td>
</tr>
</tbody>
</table>
Selection

- Exactly one lepton with pt >30 GeV
- Met > 40 GeV (mostly to reduce the multijet contribution)
- TagJets: 2 jets with highest Mjj and Eta1*Eta2 >0
  - Tagjet1 >40 GeV
  - Tagjet1 >30 GeV
- 2 categories:
  - **Boosted**: Antikt 1.0 jet with 200 GeV
    - Mass compatible with W/Z and 2 prong structure
  - **Resolved**: 2 small R jets
    - Antikt 0.4
    - 2 jets with mass compatible with W/Z
Kinematic plots

Using non-trimmed jets

- Use the jet mass (or dijet mass) to define a Signal Region (SR) and a Sideband Region (SB).

- Loose D2 cut is also applied.

Graphs showing distributions of leading fat jet $P_T$, mass, $f_{\Delta \text{eta}}$, $\text{FatjetD2}$, and $M_{\text{jj}}$ for W+jets, WW2JET, and ttbar.
Sensitivity

- Estimating significance of WW+WZ EWK
- Fit to $M_{ll}$:
  - Signal (5% systematic)
  - $t\bar{t}$-bar (5% normalization systematic)
  - $W+$jets (10% normalization systematic)
- Shape systematic:
  - Applying difference between Sherpa and Madgraph at 13 TeV
  - Plan to include a mass and pt smearing of 20%

**Luminosity needed to reach 5 sigma**

<table>
<thead>
<tr>
<th></th>
<th>no syst</th>
<th>w syst</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal Region only</strong></td>
<td>300 fb$^{-1}$</td>
<td>400 fb$^{-1}$</td>
</tr>
<tr>
<td><strong>with Mass sideband regions</strong></td>
<td>300 fb$^{-1}$</td>
<td>350 fb$^{-1}$</td>
</tr>
</tbody>
</table>

Can we do better?
Use BDT? Especially helpful if we want to separate the longitudinal component!
BDT

Boson centrality
Very low stats left —> probably need some more MC

Fitting directly the BDT response

Luminosity needed to reach 5 sigma

no syst

Signal Region only

250 fb^{-1}
Pileup

• Not considering PU for now
• Tried adding PU to Delphes, following suggestions from Delphes authors
• Requires generating min bias events with Pythia
• Use (PileUpMerger) and change the input to the subsequent algorithms from Delphes/stableParticles to PileUpMerger/stableParticles.

Our aim is to demonstrate that with the current offline tools we can go back to the variable with no PU
• Studying higher PU points

Studies made by K. Terashi

Trimming seems to do good
Conclusion

- Studies planned for LHC Yellow-Report:
  - VBS semileptonic $VV$ (most likely only 1 lepton) and aQGC search
  - Investigating possibility of separating longitudinal component
  - Exotic $VV \rightarrow$ semileptonic resonance search
- HL-LHC at 300/3000fb–1 with ATLAS smearing functions
- HE-LHC at 27TeV with Delphes
- HL-LHC Studies:
  - Early Sep Pub note expected
- HE-LHC Studies:
  - Privately produced MC
  - Several studies investigating Delphes and pile-up effects
  - Write-up strategy still to be decided
1. Some kinematic plots with and without PU?
2. Discriminant variable (mlvJjj or BDT) for the discovery significance
3. Table of lumi needed to reach 5 sigma with and without systematics
4. aQGCs exclusion parameters plots
5. possible BDT for isolating the longitudinal component
Backup
Selection

![Graph showing Nbjets distribution for ttbar and WW2JET with htemp table showing entries, mean, and RMS values.](image-url)