Search for resonant VH production with a W or Z boson decaying leptonically

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CAP Congress
17 juin 2014
Motivations

• Higgs discovery : Strong constraint on BSM theories
  • is SM valid at the TeV scale?
• Dynamical electroweak symmetry breaking scenarios
  • new strong interactions
  • new resonances that couple to W, Z and Higgs
• Minimal Walking Technicolor, Little Higgs, Composite Higgs, ...

• Previous CONF note ATL-CONF-2013-074

Analysis is still blinded, no results available yet :(
Minimal Walking Technicolor

- Search for resonant dijet in associated production with a vector boson
  - final states: 0, 1 and 2 leptons
  - electron and muon channel
- 20.3 fb\(^{-1}\) of data collected by the ATLAS detector
- Test of Minimal Walking Technicolor (MWT) model
  - Composite Higgs model based on Walking Technicolor
  - Agrees with EW precision measurements (S-parameter \(\sim 0.3\))
- New resonances: \(R_1\) and \(R_2\)
- \(g/\tilde{g}\): coupling constant to SM particles
- \(\tilde{g}\): mesons-bosons, \(\sim g/\tilde{g}\): mesons-fermions
- \(M_A\): mass scale (sets mass for \(R_1\) and \(R_2\))
Heavy Vector Triplet

- Interpretation in Heavy Vector Triplet models
  - new heavy vector couples to SM particles
  - $g_{VcH}$ : Higgs and gauge bosons
  - $g^2c_F/g_V$ : SM fermions
- Two benchmark models
  - Model A : extension of the SM gauge group (weakly coupled)
  - Model B : Composite Higgs model (strongly coupled)
    - fermionic couplings suppressed

R. Torre et al. 1402.4431
Follow Higgs group working on associated production VH

<table>
<thead>
<tr>
<th>Cut</th>
<th>Loose electron</th>
<th>ZH signal electron</th>
<th>WH signal electron</th>
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<td>$</td>
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<td>VeryLoose Likelihood</td>
<td>VeryTight Likelihood</td>
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<td>track Isolation cone 0.2</td>
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<td>sum pT tracks/pT &lt; 0.1</td>
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<td>OQ cut</td>
<td>OQ cut</td>
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**Work in progress**

<table>
<thead>
<tr>
<th>Cut</th>
<th>Loose Muon</th>
<th>ZH muon selection</th>
<th>WH muon selection</th>
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<td>$d_0$</td>
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<td>Combined/ST passMCP</td>
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<td>$\eta &lt; 2.7$ 2.5 &lt; $\eta$ &lt; 2.7</td>
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<tr>
<td>$\eta$</td>
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<td>calo Iso cone 0.3</td>
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<tr>
<td>ID - MS cuts</td>
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</table>

Signal electron

mardi 17 juin 2014
Jets

- Anti-kt algorithm, $R = 0.4$
- $p_T > 30$ GeV
- $|\eta| < 2.5$
- b-tagging: MV1c at 70%
  - superior c-jet rejection than MV1 (smaller for light jet)
- Overlap removal
  - jets within $\Delta R < 0.4$ of loose electrons
  - low $p_T$ muons ($< 20$ GeV) within $\Delta R < 0.4$ of a jet
  - loose electrons within $\Delta R < 0.1$ of a loose muon
Event selection

- At least two jets in the event to form the Higgs mass
- Most selections following Higgs group

**W→lv selection**
- One electron or one muon with $E_T > 25$ GeV
- 2nd loose electron or muon veto
- Missing $E_T > 30$ GeV
- $M_T(W) > 40$ GeV

**Z→ll selection**
- Two electrons, one tight with $E_T > 25$ GeV and one VL with $E_T > 7$ GeV
- One tight muon ($E_T > 25$ GeV) and one VL ($E_T > 7$ GeV)
- Missing $E_T < 60$ GeV
- $83 < M(ll) < 99$ GeV
- Same flavor requirement

**Z→νν selection**
- Missing $E_T > 120$ GeV
- Missing $p_T > 30$ GeV
- $\Delta \phi(MET, MPT) < \pi/2$
- $\Delta \phi(MET, j) > 1.5$
## Backgrounds

<table>
<thead>
<tr>
<th>Process</th>
<th>Generator</th>
<th>$\sigma \times BR$</th>
<th>$N_{\text{events}}$</th>
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<td>Top-quark</td>
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<tr>
<td>$t\bar{t}$</td>
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<tr>
<td>$Wt$-channel</td>
<td>POWHEG</td>
<td>22.37 pb</td>
<td>20M</td>
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</tbody>
</table>

- $\text{V+jets} :$ shape from MC, rate from data
- $\text{ttbar} :$ shape + rate from MC
- $\text{diboson} :$ shape + rate from MC
- $\text{QCD multijet}$ is data driven
Signal region

- $105 < M_{bb} < 145$ GeV
- kinematic cuts on $lljj$ or $lvjj$ candidate
- $p_T(j) > 0.1 \times M_{lljj}$
- $p_T(V) > -77 + 0.48 \times M_{Vjj}$
- $\Delta\Phi(ll) > 9.7 \times 10^7/M_{lljj}^{3.28} + 1$ (2-lepton only)
- single BG shape as $M_{lljj}$ is varied
- optimized by Higgs group for this analysis

MC Only
Control regions

**V+jets CR**
- selection of W/Z candidate + 2 jets with $p_T > 30$ GeV
- 0, 1 and 2 b-tag regions
  - SR cuts in $M_{jj}$ sideband (1 and 2 tag)

**ttbar CR**
- 1-lepton : at least 4 jets in the event
- 2-lepton : $e\mu$ events

**QCD CR**
- missing $E_T < 30$ GeV
- no $\Delta\phi$ (jet, $MET$) cut
Control regions (2)  

Preliminary results

0 tag  

Blinded!  

1 tag
Systematics

**Objects**
- 14 independant components for JES
- JER
- Energy scale + smearing for leptons
- $p_T$ reconstruction + b-jet corrections
- b-tagging efficiencies:
  - Light jet b-tagging : 10 NP
  - c-jet b-tagging : 15 NP
  - b-jet b-tagging : 10 NP

**Shape**
- Diboson → Herwig vs Pythia
- QCD → invert lepton isolation (one lepton analysis)
- Signal → renormalization factor, eigenvectors with CTEQ66
Very Preliminary results

**1 tag**

\[ S/\sqrt{B} \sim 0.9 \]

**2 tag**

\[ S/\sqrt{B} \sim 1.6 \]

- expect to have a sensitivity for masses up to \(~1.2\) TeV
### Samples

<table>
<thead>
<tr>
<th>Dataset Number</th>
<th>$M_A$ [GeV]</th>
<th>S parameter</th>
<th>$\tilde{g}$</th>
<th>Higgs mass [GeV]</th>
<th>$\sigma \times BR$ [fb]</th>
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</table>

- Produced with MadGraph4
- Samples generated for only one value of $\tilde{g}$
  - cross sections are affected, not kinematics
- Limits in the $M_A$ vs $\tilde{g}$ plane
  - parton level for $\tilde{g} > 2$

*arXiv:1405.4123*
Conclusion

- Latest version of the paper to be circulated to the Editorial Board by the end of the week
  - hopefully a meeting next week
- We should get the green light for unblinding