Search for dijet resonances along with an isolated charged lepton at \( \sqrt{s} = 13 \, \text{TeV} \) pp collision with the ATLAS detector

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Motivation

Resonance search in the dijet invariant mass spectrum provides scopes to find BSM Physics.

The final state lepton provides many benefits:

- Sensitive to different physics and final states compared to inclusive searches.
- Overcome trigger limitations by using lepton as spectator object & cover a wide \( m_j \) range.
- Reduces QCD multijet background.

Along with model independent searches, following BSM models were probed:

- Sequential Standard Model (SSM)
- Technicolor Model
- Charged Higgs Model
- Simplified Dark Matter Model

Event and object selection

<table>
<thead>
<tr>
<th>Object</th>
<th>Type</th>
<th>pT</th>
<th>Eta (p)</th>
<th>Cleaning/Isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron Selection</td>
<td>pT &gt; 60 GeV</td>
<td>(</td>
<td>n</td>
<td>&lt; 1.37, 1.52 &lt;</td>
</tr>
<tr>
<td>Muon Selection</td>
<td>pT &gt; 60 GeV</td>
<td>(</td>
<td>n</td>
<td>&lt; 2.7</td>
</tr>
<tr>
<td>Jet Selection</td>
<td>Anti-EMTopo EMTopo jets</td>
<td>pT &gt; 20 GeV</td>
<td>(</td>
<td>n</td>
</tr>
</tbody>
</table>

- Overlap removal techniques applied between leptons & jets

Systematic uncertainties

Systematic uncertainties include those associated with the background fit, fit parameters, JES, JER, lepton systematics, PDF, scale, luminosity etc.

- The fit uncertainty extracted by fitting pseudo-experiments with an alternative 5p fit.
- Uncertainties on limits are not dominated by systematic uncertainties.
- Systematic uncertainties are also included as nuisance parameters.
- The combined effect from all systematic uncertainties leads to a 6% worsening of the limits.

Model specific limits

Limits set on BSM models:

- \( Z' \) in SSM excluded at 2 TeV.
- \( \tilde{t}_L \) in Technicolor excluded below 350 GeV.
- Charged Higgs excluded at 1.12 TeV (for \( \tan \beta = 0.5 \)).
- \( Z' \) in Simplified DM model excluded at 1.2 TeV (for leptophobic couplings \( g_\rho = 0.25, g_j = 0 \) and \( g_{\text{DM}} = 1 \)).

Background modeling studies

- Using full 139 fb\(^{-1} \) Run 2 dataset of ATLAS, search was conducted at the range: 0.22 TeV < \( m_{jj} \) < 6.3 TeV.
- Various single-electron/muon triggers with different \( p_T \) (muon), \( E_T \) (electron), quality, and isolation thresholds were used.
- Lowest unprescaled thresholds were \( p_T > 24 \) GeV for muon triggers, \( E_T > 26 \) GeV for electron triggers.
- Dominant sources of background modeled by MC are multijet (\( \geq 2 \) jets), \( tt \) and W+jets processes.

BumpHunter found no significant excess from null hypothesis.
- Largest deviation at \( m_j = 1.3 \) TeV, with global \( p\text{-value} = 0.305 \), corresponding to \( Z \)-value = 0.5a.
- Based on the studies of the control regions, background-only hypothesis for the signal region is constructed over the \( m_{jj} \) search range.

Conclusions

- Searched for resonance in \( m_j \) in events with at least two jets and one isolated lepton using full Run 2 dataset – Found no significant excess.
- Set limits on Gaussian-approximated signals – limits range from 50 fb to 0.1 fb in the 0.25 - 6 TeV mass range.
- 3 and 4 body invariant mass distributions constructed from jets and leptons on same strategy can also extend and complement the results of some of the shown BSM physics scenarios.

Reference: