Search for heavy neutral di-lepton resonances with the ATLAS detector at the LHC

Abstract

Searches for a heavy neutral particle decaying into di-lepton pairs are presented, including electrons, muons, taus and lepton-flavor-violating decays. The analyses are based on 8 TeV data collected with the ATLAS detector at the Large Hadron Collider. These signatures constitute some of the most promising channels in searches for new physics. Many Beyond Standard Model (BSM) scenarios, such as grand-unification models (GUT), predict the existence of an additional neutral, spin-1 vector gauge boson, customarily referred to as $Z'$, decaying into a pair of leptons. Moreover, some of those models, such as the R-parity violating (RPV) supersymmetry (SUSY) or the Sequential Standard Model (SSM), can be extended to include lepton-flavor-violating (LFV) couplings for the $Z'$. Observations are consistent with the Standard Model predictions, and limits are set on the masses of these resonances.

Same-flavor di-lepton searches

The search for a $Z'$ resonance decaying in a pair of leptons ($e$, $μ$ or $τ$) is presented [1][2]. GUT and hierarchy problem solving models are considered. SSM is used as benchmark.

**Exactly two opposite-sign same-flavor leptons selected ($\Delta m_{ll} > 2.7$)**

- $μ$: $p_T > 25$ GeV, $|p_T| < 2.4$, $\sum p_T/p_T < 0.05$
- $e$: $p_T > 40$ (30) GeV for leading (subleading) $e$, $|p_T| < 2.47$
- $τ_{had}$: $p_T > 30$ GeV, $|p_T| < 2.47$, 1 or 3 charged tracks (prongs) associated
- $\tau_{μ}$ ($τ_{e}$): $p_T > 10$ (15) GeV, $|p_T| < 2.47$, $\sum p_T/p_T < 0.05$

Exclusion limits are determined by using pseudo-experiments with only SM processes. A Bayesian approach has been used.

<table>
<thead>
<tr>
<th>$Z'$ mass (GeV)</th>
<th>$\mu\mu$, $ee$</th>
<th>$ττ$, $ee$</th>
<th>$μ\mu$, $ττ$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected limit</td>
<td>2.87 TeV</td>
<td>1.95 TeV</td>
<td>2.60 TeV</td>
</tr>
<tr>
<td>Observed limit</td>
<td>2.90 TeV</td>
<td>2.02 TeV</td>
<td>2.62 TeV</td>
</tr>
</tbody>
</table>

**Searches for Lepton Flavor Violating modes**

A search for a heavy neutral particle, $Z'$, or $Z''$, decaying into a different-flavor lepton pair - $e\tau$ (or $\mu\tau$) - is presented [1][2].

**Exactly two opposite-sign different-flavor leptons with $\Delta m_{ll} > 2.7$ selected ($\mu$: $p_T > 25$ GeV, $|p_T| < 2.4$, $\sum E_T/E_T < 0.06$, $\sum p_T/p_T < 0.06$

A frequentist technique is used to set the expected and observed upper limits as a function of $m_{Z'}$ and $m_{Z''}$. Exclusion limits are determined using simulated pseudo-experiments containing only background processes.

**$Z'$ prospects: RunII and Phase-II Upgrades**

The LHC RunII and Phase-II upgrades will increase the sensitivity to $Z'$ resonances. The expected gain in sensitivity has been studied for 300, 1000 and 3000 $fb^{-1}$ at $\sqrt{s} = 14$ TeV [4]. The Sequential Standard Model has been considered for this study.

**Exactly two opposite-sign same-flavor leptons selected**

- $μ$: $p_T > 25$ GeV, $|p_T| < 2.4$ (2.47)

<table>
<thead>
<tr>
<th>$Z'$ mass (GeV)</th>
<th>$\mu\mu$, $ee$</th>
<th>$ττ$, $ee$</th>
<th>$μ\mu$, $ττ$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected limit</td>
<td>6.4 TeV</td>
<td>6.5 TeV</td>
<td>7.1 TeV</td>
</tr>
<tr>
<td>Observed limit</td>
<td>6.5 TeV</td>
<td>7.2 TeV</td>
<td>7.6 TeV</td>
</tr>
</tbody>
</table>

**Di-muon (left) and di-electron (right) mass spectra for $Z'$ SSM search.**

**References**


Antonio Salvucci and Luis R Flores Castillo, for the ATLAS Collaboration