Search for exotics long-lived particles with ATLAS at the LHC

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Data taken in 2011 with the ATLAS detector at the Large Hadron Collider have been used to search for physics beyond the Standard Model. Results are presented based on a luminosity of 2 fb$^{-1}$ of $\sqrt{s} = 7$ TeV proton-proton collisions focusing on final states with exotic long-lived neutral particles. No evidence of new physics is found.

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1. Introduction

The Standard Model (SM) of particle physics has proven extremely successful, but despite its many successes still remains incomplete. New particles with decay path comparable to the LHC detector dimensions (Long-Lived Particles, LLP) are predicted in many models of physics beyond the SM, such as Hidden Sector scenarios or Supersymmetry (SUSY) models. These particles may be neutral and decay into SM and/or weakly interacting particles that escape the detection. This note presents the searches with ATLAS detector [1] for exotics LLP based on pp collision data collected during 2011 at $\sqrt{s} = 7$ TeV.

1.1 Hidden sector neutral particles

Decays far from the interaction point are signatures of long-lived neutral particles. ATLAS has performed a search based on $1.9$ fb$^{-1}$ for pairs of back-to-back particles decaying to heavy fermions in the muon system [2]. Such signatures may be due to Higgs decays to pairs of long-lived neutral particles $h \rightarrow \pi_\text{v} \pi_\text{v}$, where $\pi_\text{v}$ is a pseudoscalar from a Hidden Sector weakly coupled to the Standard Model sector. Limits have been set as a function of the proper decay length of the $\pi_\text{v}$, excluding the range $0.5$ - $23$ m depending on the Higgs mass ($120$ - $140$ GeV) and on the $\pi_\text{v}$ mass ($20$ - $40$ GeV). Exclusion limits are shown in Figure 1.

![Figure 1: Observed 95% upper limits on the production cross section for $h \rightarrow \pi_\text{v} \pi_\text{v}$ versus the $\pi_\text{v}$ proper decay length, expressed as a multiple of the SM cross section for Higgs production. Exclusion limits assume 100% branching ratio for the Higgs decaying to $\pi_\text{v}$’s.](image)

A specific model of a neutral long-lived, spinless, exotic particle which has a nonzero branching fraction to dileptons has been used in the search for displaced clusters of leptons (leptonjets). This scenario predicts up to two displaced dilepton vertices in the tracking volume per event. In the study, the model consists of a Higgs boson decaying to new hidden sector particles which finally produce two sets of collimated muon pairs: $h \rightarrow f_{d1} + f_{d1}, f_{d1} \rightarrow f_{d2} + \gamma_d, \gamma_d \rightarrow l^+l^-$ where $f_{d1}$ is a fermion from the hidden sector, $f_{d2}$ is a stable fermion from the hidden sector, and $\gamma_d$ is a dark photon decaying to pairs of leptons. In $1.9$ fb$^{-1}$ of data [3] no events consistent with this Higgs boson decay mode are observed. 95% CL upper limits on the cross section times branching ratio ($\sigma \times BR$) has been evaluated for the process $H \rightarrow \gamma_d \gamma_d + X$ ($X$ refers to the two stable $f_{d2}$ fermions) with the $\gamma_d$ mass set to $0.4$ GeV (the branching ratio to muons is maximum for this mass value).
The $(\sigma \times BR)$ is given as a function of the $\gamma_d$ mean lifetime, expressed as $c\tau$ for a Higgs mass of 100 and 140 GeV. These limits are shown on Figure 2. Table 1 shows the ranges in which the $\gamma_d c\tau$ is excluded at the 95% CL for $H \rightarrow \gamma_d \gamma_d + X$ branching ratios of 100% and 10%.

<table>
<thead>
<tr>
<th>Higgs boson mass [GeV]</th>
<th>excluded $c\tau$ [mm] BR(100%)</th>
<th>excluded $c\tau$ [mm] BR(10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>$1 \leq c\tau \leq 670$</td>
<td>$5 \leq c\tau \leq 159$</td>
</tr>
<tr>
<td>140</td>
<td>$1 \leq c\tau \leq 430$</td>
<td>$7 \leq c\tau \leq 82$</td>
</tr>
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Table 1: Ranges in which $\gamma_d c\tau$ is excluded at 95% CL for 100 and 140 GeV Higgs masses, assuming 100% and 10% branching ratio of $H \rightarrow \gamma_d \gamma_d + X$.

2. Conclusions

The search for new phenomena beyond the Standard Model is a very active field at the ATLAS experiment. Recent results for exotic Long-Lived Neutral Particle searches at ATLAS are presented in this note. No excess over the Standard Model expectation has been observed and limits are placed on the various models. The reader is invited to read the detailed papers on each of these analyses.

References

