Searches for long-lived, Exotic particles at ATLAS

Christopher Phillip Marino, On behalf of the ATLAS Collaboration
University of Victoria, 3800 Finnerty Road Victoria, BC V8N 1M5, Canada

1 Introduction

Three recent searches for massive, exotic, long-lived particles are presented for 2011 LHC data using the ATLAS detector [1]. No new physics has been found but limits have been set, and tools for future searches have been developed. Improvements are under way using timing, ionization, and displaced vertices in several ATLAS subdetectors for searches with full 2011 data and 2012 data.

2 Disappearing-track signature

In models of anomaly-mediated supersymmetry breaking (AMSB), the lightest chargino ($\widetilde{\chi}_1^{\pm}$) is predicted to have a long lifetime due to a small mass difference between the $\widetilde{\chi}_1^{\pm}$ and the neutralino $\widetilde{\chi}_1^0$ to which it decays. The $\widetilde{\chi}_1^0$ leaves the detector allowing a trigger on a high-p_T jet and missing E_T. Candidates are identified as high-p_T tracks with few hits in the outer part of tracker, as the low-p_T π from the $\widetilde{\chi}_1^{\pm} \rightarrow \widetilde{\chi}_1^0 \pi^{\pm}$ decay sequence is not reconstructed. Backgrounds come primarily from hadronic interactions and mismeasured tracks. They are studied using control samples of non-disappearing tracks and low missing E_T, respectively. The p_T distributions are modeled for the control samples as well as the AMSB signal samples. A maximum likelihood fit of p_T distributions to data shows no signal contribution in 4.7 fb^{-1} of pp collisions. Model-independent limits for a new physics process with an isolated, disappearing track and limits on the signal cross-section as a function of $\widetilde{\chi}_1^{\pm}$ lifetime are extracted [2].

3 Hidden Valley

One Standard Model (SM) extension is a hidden sector (v-sector) with a light Higgs communicator. The Higgs' high mass and weak couplings create a barrier which hides the v-sector and makes production of v-particles rare at low energies. Some v-particles may decay to SM particles, and their production may be observable through displaced vertices. A range of π_v lifetimes gives decay signatures in all parts of the ATLAS detector. Decays to two b-jets near the muon system (from 4.5-11 m) have been used by searching for two vertices of > 3 muon segments not pointing back to the interaction point. A special trigger has been designed to improve efficiency by an order of magnitude near the muon system. No events meeting the analysis selection are observed in 1.94 fb^{-1} of pp collisions [3]. Exclusion limits are shown in Fig. 1(a).

4 R-hadrons

R-hadrons are hadronic states containing a heavy exotic long-lived parton. They have $\beta < 1$, resulting in high ionization, but can become neutral through hadronic interactions inside ATLAS. The Pixel detector provides ionization information close to the interaction point using minimum bias events to calibrate a dE/dx measurement. This dE/dx is used to determine a β via Bethe-Bloch and then a mass using momentum. The conversion is calibrated using protons and extrapolating to R-hadrons. Candidates are isolated, high p_T tracks, and 333 are observed in 2.1 fb^{-1} of pp collisions as is consistent with data-driven background estimation [4]. The result can be interpreted as excluding gluino R-hadrons with $m < 810$ GeV as shown in Fig. 1(b).

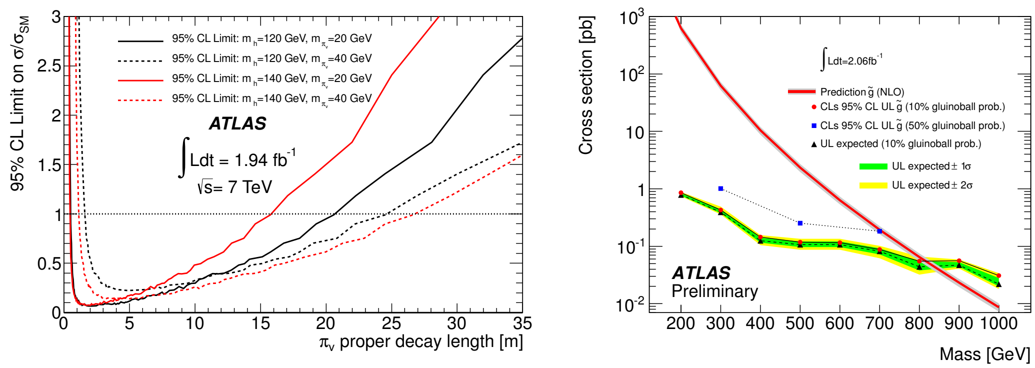

Figure 1: (a) Observed 95% CL (multiples of the SM cross-section for Higgs production with 100% branching ratio to π_v's) for $h^0 \to \pi_v \pi_v$ vs. the π_v proper decay length [3]. (b) Cross section as a function of mass for gluino R-hadrons [4].

References

[1] ATLAS Collaboration, JINST **3**, S08003 (2008).

[2] ATLAS Collaboration, Eur. Phys. J. C **72**, 1993 (2012).

[3] ATLAS Collaboration, Phys. Rev. Lett. **108**, 251801 (2012).

[4] ATLAS Collaboration, ATLAS-CONF-2012-022 (2012).