Search for Long-Lived Massive Particles at CMS

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Long-lived massive particles are predicted by several theories of beyond the Standard Model physics, such as the minimal supersymmetric standard model, split supersymmetry, and gauge-mediated supersymmetry breaking. The first two models predict hadron-like particles, stops and gluinos, respectively, and the last predicts a lepton-like particle, the stau. The particles considered here carry electric charge in the case of the lepton-like particles, and the hadron-like particles will hadronize to form a color-singlet "R-hadron" state. In both cases, due to their large masses, these particles travel at low values of β, resulting in increased dE/dx over a minimum ionizing particle and prolonged time of flight. Here we consider the case in which their lifetimes are long enough to traverse the entire CMS detector (7.4 m) before decaying. A search for these particles was conducted with the CMS detector using data from the Large Hadron Collider collected in pp collisions at $\sqrt{s} = 7$ TeV in 2011 [1].

A complete description of the CMS detector can be found elsewhere [2]. Here we note the silicon inner tracking system, used to measure the dE/dx, and the muon system consisting of drift tubes and resistive plate chambers in the barrel region, used to measure the time of flight. Combining either of these measurements with the particle's momentum, measured in the tracker, yields a mass measurement.

Two different triggers are used: a single muon trigger, and a missing transverse energy trigger to add efficiency for R-hadrons becoming neutral due to nuclear interactions in the detector. Selection variables used include the transverse momentum P_T, the dE/dx compatibility with minimum ionizing particles I_{as}, and $1/\beta$ calculated from the time of flight. The distributions of these variables for background and several models is shown in Figure 1. Two different analyses were conducted: one using the tracker only and the other adding the time-of-flight information from the muon system.

The analysis was conducted as follows. To predict the background, an ABCD or sideband method was used, taking advantage of the uncorrelated P_T, I_{as}, and $1/\beta$ measurements. This estimates the amount of background in the signal region D. A mass cut is applied to the data at the nominal model reconstructed mass minus twice the expected mass resolution, and its affect on the background estimate in the D

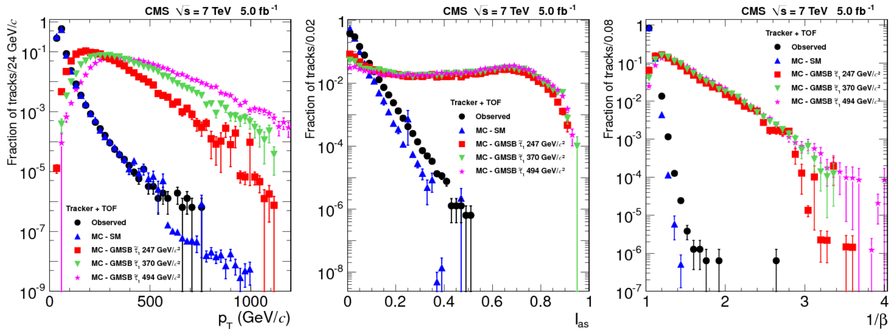

Figure 1: Selection variables for several signal models, data, and Monte Carlo background.

region is accounted for. Then the statistical analysis is performed using the estimated background and the observed number of events.

As there is no evidence of signal, 95% confidence level upper limits are set using CLs. The results are shown in Figure 2. Using theoretical calculations of HSCP cross sections, the calculated mass lower limits are: 314 GeV and 223 GeV for the GMSB stau and pair produced stau; 1098 GeV and 928 GeV for the gluino, using the cloud and charge suppression nuclear interaction models; 737 GeV and 626 GeV for the stop, using the cloud and charge suppression nuclear interaction models.

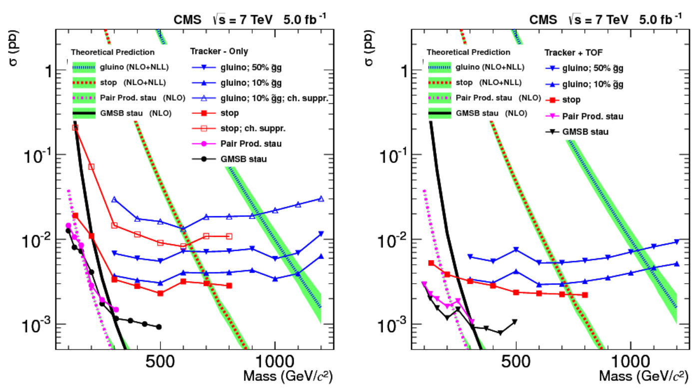

Figure 2: Upper limits on the cross section for various models. Left: Tracker-only analysis. Right: Tracker+time-of-flight analysis.

References

[1] S. Chatrchyan *et al.* [CMS Collaboration], Phys. Lett. B **713**, 408 (2012) [arXiv:1205.0272 [hep-ex]].

[2] S. Chatrchyan *et al.* [CMS Collaboration], JINST **3**, S08004 (2008).