Probing 23% of the Universe at the Large Hadron Collider



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Introduction

With recent astronomical measurements, we know that 23% of the Universe is composed of dark matter, whose origin is unknown. Supersymmetry (SUSY), a leading

theory in particle physics, provides us with a cold dark matter candidate, the lightest supersymmetric particle (LSP). SUSY particles, including the LSP, can be created at the Large Hadron Collider (LHC) at CERN. We perform a systematic study to characterize the SUSY signals in the "focus point" region, one of a few cosmologically-allowed parameter regions in our SUSY



model. We also present a methodology for extracting the dark matter signals at the LHC, and show the accuracy to which we can

measure the dark matter relic density and the SUSY parameters.

The 'focus point' is one of the few regions in the mSUGRA parameter space that is consistent with both cosmological constraints and particle physics observations. This region got its name from another parameter, µ, being 'focused to a small value'. The LSP (dark matter candidate) of focus point is the neutralino-1, $\tilde{\chi}_{1}^{0}$, a combination of the photino, bino, and higgsino fermions. One particularly interesting trait of having a small μ in focus point is that the $\tilde{\chi}_{1}^{0}$ has a very large higgsino component. This causes $\tilde{\chi}_{1}^{0}$ to couple more strongly to heavier particles, favoring the top quark in hadronic decays to the χ_2^0 .



What is cosmologically significant about 'focus point'?

The $\widetilde{\chi}_{1}^{0}$ is allowed to annihilate with itself since it is its own antimatter particle. The $\tilde{\chi}_{1}^{0}$ - $\tilde{\chi}_{1}^{0}$ annihilation cross section is typically too small (predicting a relic

Z channel

dark matter density that is too large). The small µ of focus

 $\langle \sigma_{\rm ann} v \rangle = \frac{\pi \alpha^2}{8M^2}$

u point allows for a larger annihilation $\underbrace{\Omega_{\tilde{\mathbf{x}}_{0}^{*}}}_{0.23}h^{2} \sim \int_{0}^{x_{f}} \frac{1}{\langle \sigma_{ann} v \rangle} dx$ cross section for our dark matter candidate by opening up the 'Z channel' (pictured above).

Methodology

We first perform a monte-carlo event simulation using a program called ISAJET. This program calculates the outcomes of p-p collisions at LHC energies. We then put this data through a detector level simulation, PGS4, to account for observational errors such as track smearing. This data is then analyzed in ROOT in order to hunt for observational signatures that can allow us to predict our input parameters. Finally we determine a method of solving for our input parameters and use this information to predict the dark matter relic density of our SUSY



Analysis

We first decide which events we want to look for. Since $\tilde{\chi}_1^0$ is undetectable (otherwise it wouldn't be 'dark





We are working on how we can disect the gluino mass from observables. We will then use these values to calculate our mSUGRA parameters and the dark matter relic density! In the mean time, we are testing the efficiencies of our generation codes and analyzing our cuts for data analysis at the CMS. To be continued! Many thanks to the Cyclotron REU and TAMU HEP

