Search for leptophobic bosons decaying into $\mu\mu$, b jets, and MET with the CMS experiment

Livia Kong, Cornell University

Introduction

- The standard model (SM) lacks a description for dark matter, which is implied by astrophysical observations to exist but has not yet been detected directly.
- An extension of the SM to include a leptophobic $Z'$ boson allows for the production of stable weakly interacting particles that offer dark matter candidates.
- The $Z'$ decays via new fermions (anomalons) into neutral SM bosons and stable anomalons (the dark matter candidate), creating signatures that can be detected by the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider:
  - Muon pair production from a $Z$ boson
  - Two b quark jets from a Higgs boson
  - Missing transverse energy (MET) from two stable anomalons

Goal: Estimate CMS sensitivity to this interaction over backgrounds such as top pair production (ttbar) and Drell-Yan (DY) processes with jets.

Methods

1. Simulate $Z'$ signals at various mass points and backgrounds (ttbar, DY + jets)
   - MadGraph: Monte Carlo event generation
   - Pythia: Hadronization
   - Delphes: Detector simulation
2. Study kinematics using ROOT
   - Reconstruct $H$ and $Z$ from jets and muons
   - Plot $p_T$, $\eta$, $\phi$, and mass of jets, muons, and boson candidates, as well as MET distributions
3. Define event selections
   - Define cuts on kinematic variables (ex. MET) to keep signal while rejecting background

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Results

Higgs reconstruction using the two leading (highest $p_T$) jets (top left) and jet combination with mass closest to the Higgs mass (top right). Both methods, which have extremely similar matching efficiencies for $\Delta R < 0.15$, are relatively ineffective and only reach efficiencies of < 50% (top right overlay).

Leading jet $Z'$ candidates matched to the generated Higgs (bottom right) have a cleaner mass peak at 125 GeV. This reveals that the two leading jets are generally not the two daughter b jets. Requiring both jets to be btagged removes the poorly reconstructed candidates (bottom right overlay).

False Higgs candidates formed from ttbar (bottom left) peak closer to the signal than DY (top left), suggesting ttbar as a leading background.

Conclusions and future objectives

- First study of the leptophobic $Z'$ boson in the low $Z'$ mass range
- Notable kinematic features include high MET and strong response to changes in $Z'$ mass
- Higgs reconstruction methods using leading jets and jet system with mass closest to 125 GeV have similarly low efficiencies
- Improve Higgs reconstruction method and reconstruct $Z$ in the future

High signal MET with low background MET is promising for making cuts

Acknowledgements

Thank you to Grace Cummings for your insightful discussions and generous guidance.

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics. This work was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Science Undergraduate Laboratory Internships Program (SULI).