Search for leptophobic bosons decaying into μμ, b jets, and MET with the CMS experiment

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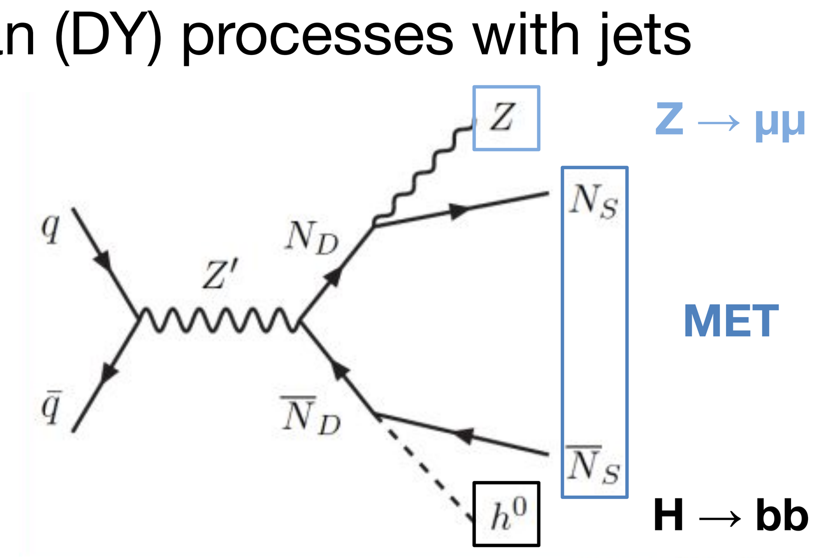
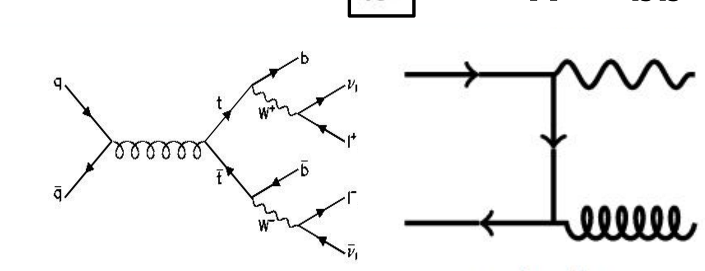
FERMILAB-POSTER-23-247-STUDENT

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



Cascade decay of a leptophobic Z' boson. Forbidding the Z' from decaying into leptons can invoke decays to anomalons, which couple to SM bosons and stable N_S anomalons—a potential dark matter candidate. The final states considered are on the right.



Top pair production *(left)* and Drell-Yan *(right)*. Both processes can generate μμ, b jets, and MET, mimicking the signatures of the Z' boson to create background.

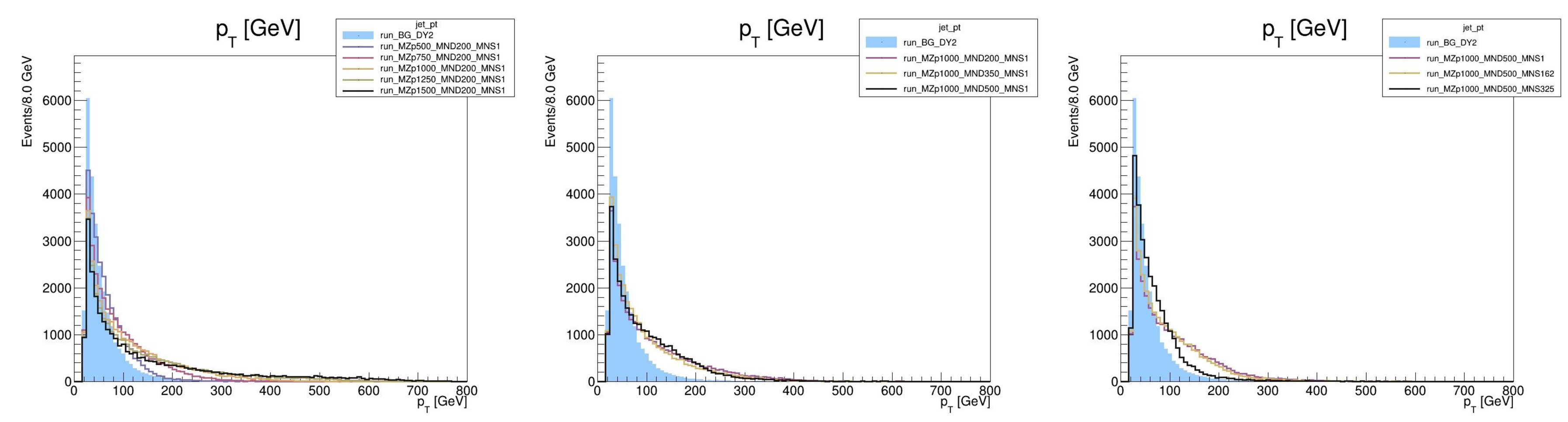
Methods

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, η, ϕ, 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

Table of generated mass points for a low mass Z'. Each row investigates the effect of changing the mass of one particle while holding the others constant.

MZp [GeV]	MND [GeV]	MNS [GeV]
500, 750, 1000, 1250, 1500	200	1
1000	200, 350, 500	1
1000	500	1, 162, 325

Results

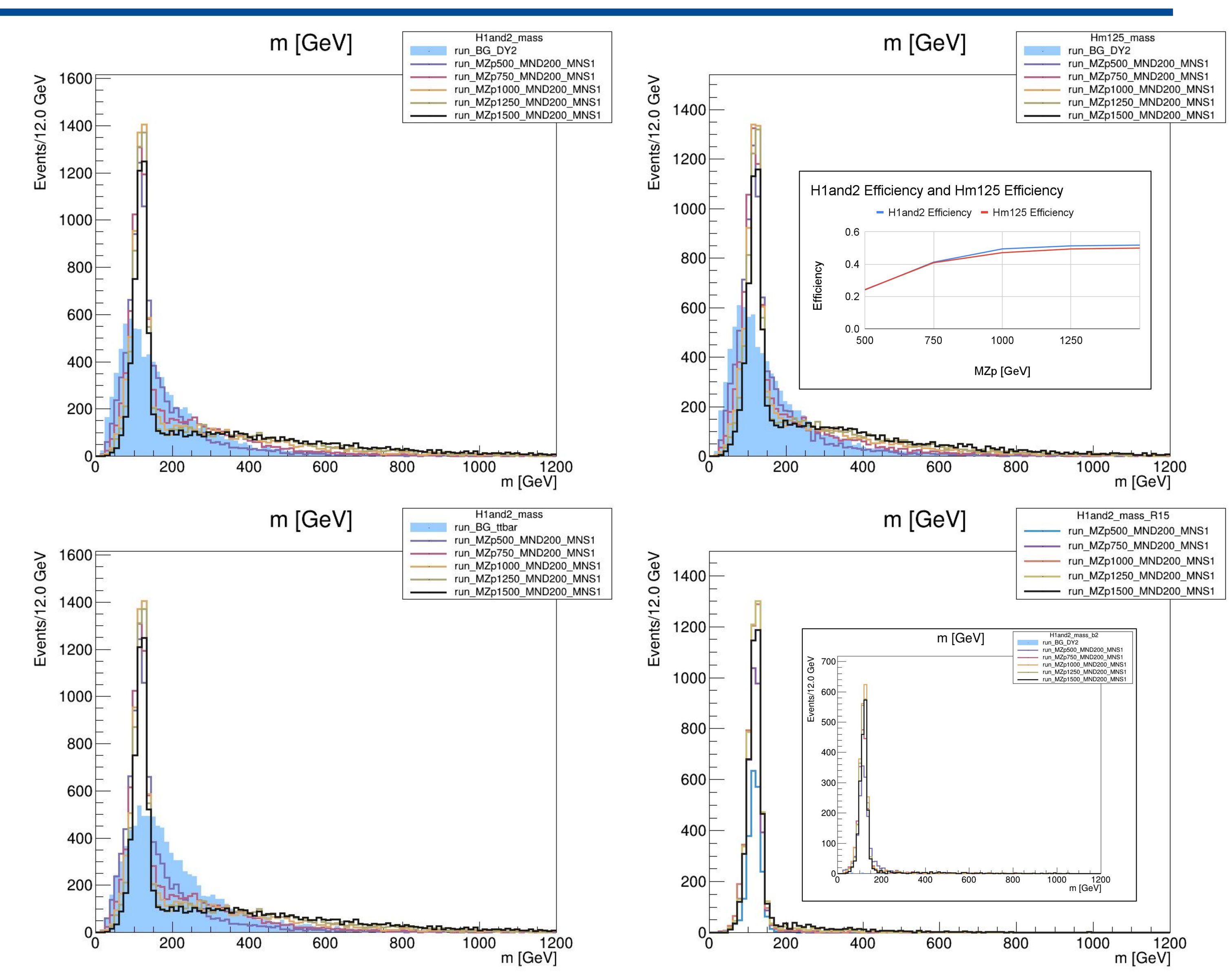


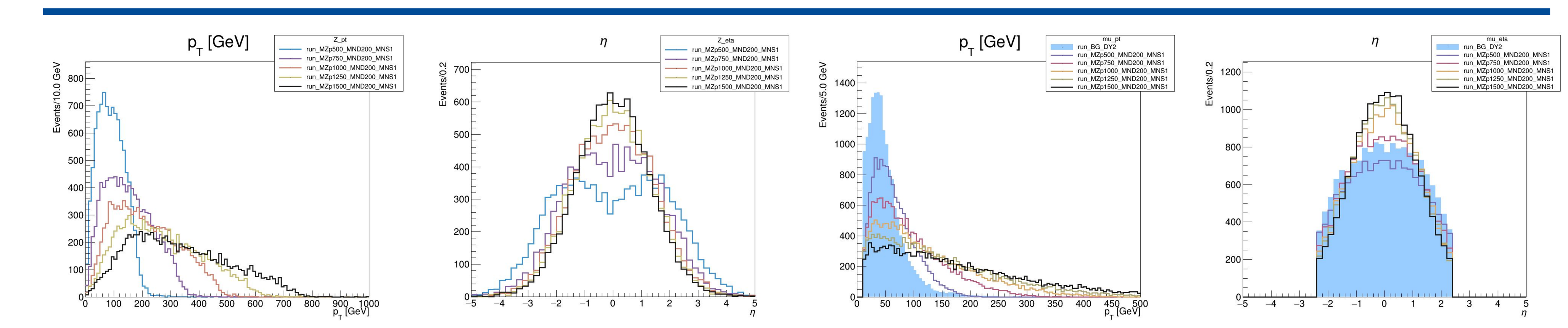
Jet p_T histograms at various Z' *(left)*, N_D *(center)*, and N_S *(right)* masses. Increasing Z' mass and decreasing N_S mass are correlated with higher jet p_T. Variations in N_D mass have little effect on jet p_T. In general, the kinematic variables across all objects are mainly dependent on the Z' and N_S masses, while changes to N_D have limited influence. Jet p_T for the DY + 2 jet background is also shown for comparison. Note that the background signal has not been normalized to luminosity.

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 ΔR < 0.15, are relatively ineffective and only reach efficiencies of < 50% *(top right overlay)*.

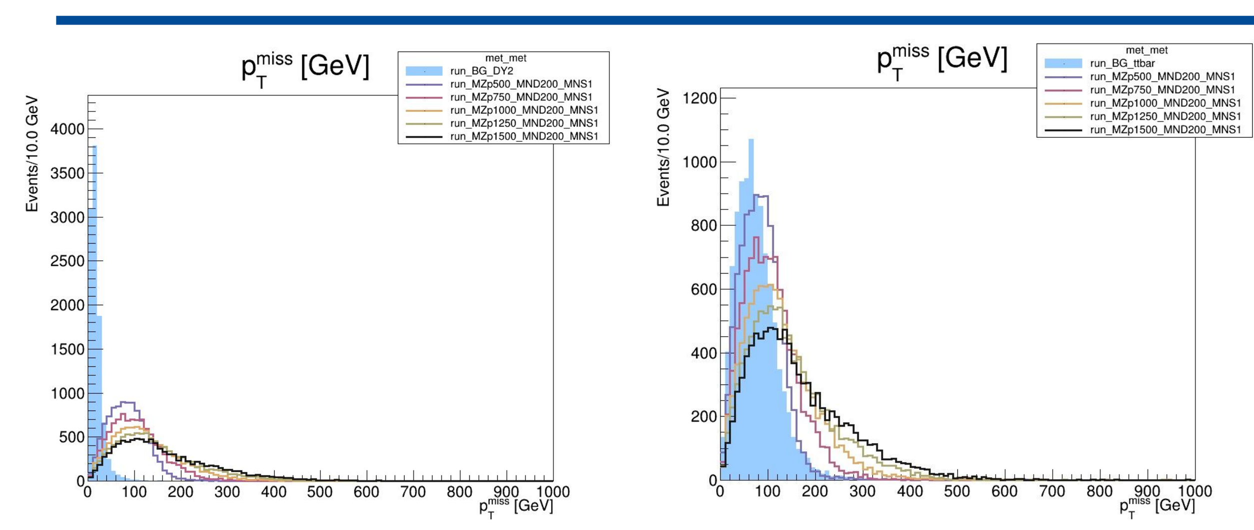
Leading jet Higgs candidates matched to the generated Higgs *(bottom right)* have a cleaner mass peak at 125 GeV. This reveals that the two leading jets are generally not the two daughter b jets. Requiring both jets to be btagged removes the poorly reconstructed candidates *(bottom right overlay)*.

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





p_T and η for generated Z bosons *(left)* and detector muons *(right)*. The muon signals will be used to reconstruct the generator level Z bosons.



MET for various Z' masses plotted over DY *(left)* and ttbar *(right)* backgrounds. The signals have high MET in comparison to the backgrounds; an appropriate selection is to accept signals with high MET.

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).