Classifying Charged Particles from High Energy Collisions at the Large Hadron Collider

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Introduction

Overall project goal:

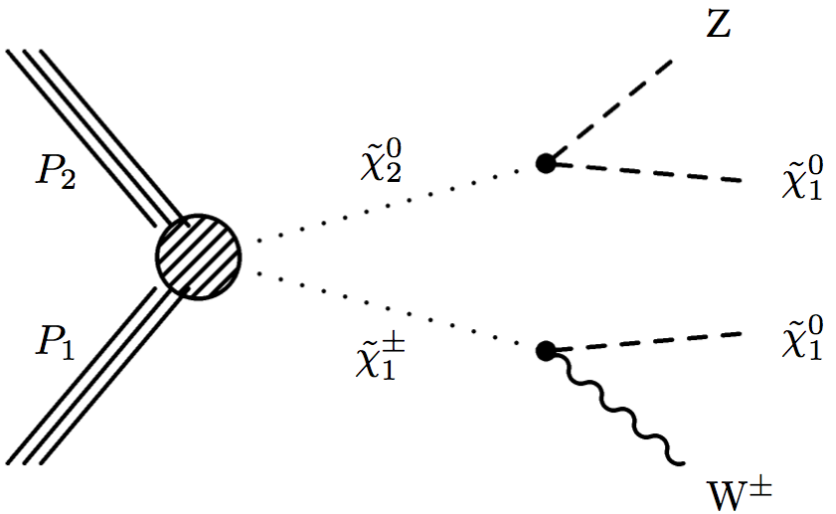
Classify particles better to assist with search for particle darkmatter

Specific focus:

- Discrminate low momentum true muons($\mu^{\pm}$) from particles imitating muons in reconstruction

Motivation

KU CMS analysis in progress – searching for particle dark matter via compressed SUSY models



- Protons P_1, P_2 collide producing SUSY $\tilde{\chi}_1^\pm$,$\tilde{\chi}_2$
- SUSY $\tilde{\chi}_1^\pm$,$\tilde{\chi}_2$ decays to D.M. $\tilde{\chi}_1^0$ and known particles $W^\pm$,Z
- $W^\pm$,Z immediately decay into charged particles($\mu^\pm$) that we see in the detector

A compressed scenario implies $\tilde{\chi}_1^\pm$,$\tilde{\chi}_2$ and $\tilde{\chi}_1^0$ are very close in rest mass

With compression the decay products of $\tilde{\chi}_1^\pm$,$\tilde{\chi}_2$ are soft (low momentum), including ending charged particles

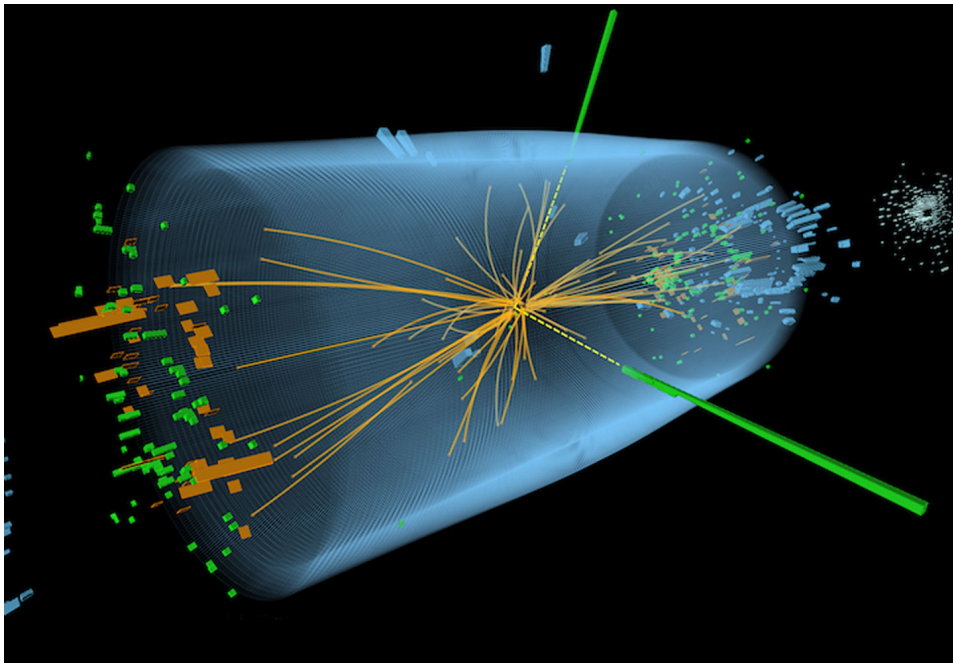
The current CMS detector is less optimized for correctly identifying soft $\mu^\pm$

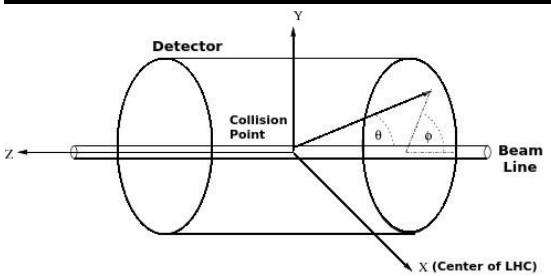
If we can optimize soft charged particle classification, we have a better chance of discovering compressed $\tilde{\chi}_1^\pm$,$\tilde{\chi}_2$, and $\tilde{\chi}_1^0$

Anatomy of an Event

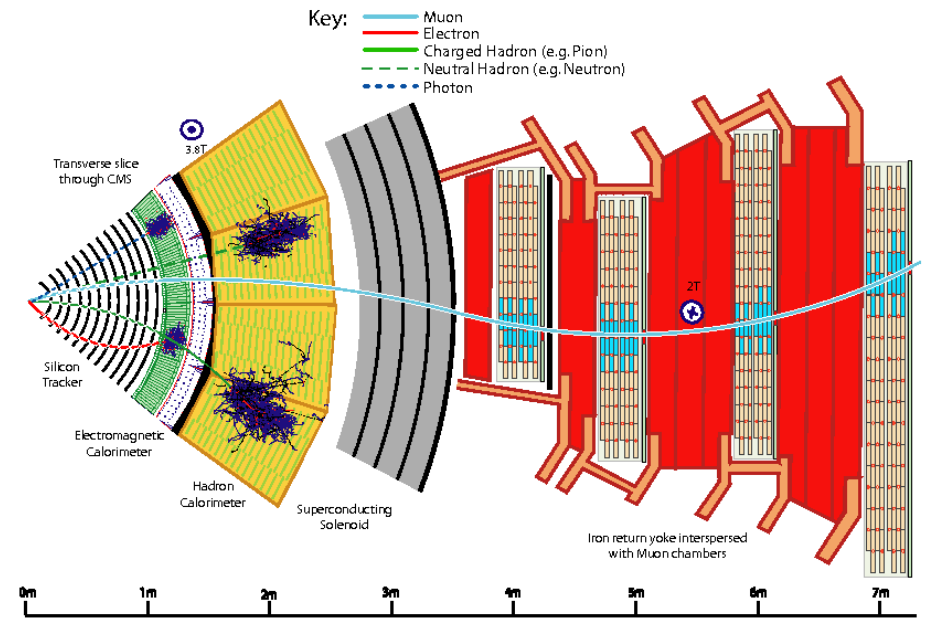
The "physics workflow"

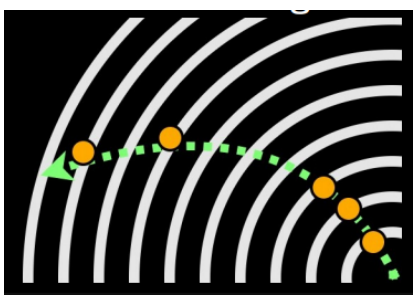
- An event consists of colliding protons which produces particles showering outward(transverse)
- We measure the energy and momentum of all the visible particles in the event
- There are 100s of charged particles per event
- Reconstruct intermediate or invisible particles through momentum and energy conservation





Charged Particle Reconstruction





Charged particles bend in Mag. field and create "tracks"

Tracks are connecting the dots: "hits" that are fit with a curve

Main particle of interest is the Muon($\mu^{\pm}$)
- at high energies μ is easily correctly identified
- low energies leaves room for ambiguity

Sometimes other particles can be reconstructed incorrectly as a muon
- Common fakes: Pion($\pi^{\pm}$), Electron($e^{\pm}$), Kaon($K^{\pm}$), Proton(p), or non physical junk particles
- created from punch through
- junk particles are a result of hit combinatorics

ML Model Introduction

- Use fully simulated processes to get collections of reconstructed muons
- Reconstructed muons contains both true(Gen.) muons and fakes.
- reconstructed to truth particle from the simulation's Gen.collection
  - > some particles cant be matched because they are junk – this is unmatched label
- Utilize two types of classification
  1. I.D. true muons against everything else [Unmatched,π,K,e,p] – binary classification
  2. I.D. every particle simultaneously – 6 classes logistic
     - Network inputs are measured quantites and track quality metrics

End of Pt. I

backup

Project Repository: `https://github.com/Jphsx/KUSoftMVA`