For your lab report, create an initial writeup of your data and what you found. Think of this as a book report, where you describe ***how the data was taken*** and what you have **found** in your initial exploration. The goal is that another student should be able to read your report and **understand** both **the data** and any interesting features you have found. This will need to be several pages long.

INFO: red text will be removed before final submission. Any "#" symbol with a reference is a placeholder for assigning each reference an ordered number once all references are included and final submission is next.

Lab 5

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Physics 434
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Introduction

This lab report focuses on a preliminary overview of simulated data from the Large Hadron Collider (LHC) that will be further explored in future labs for Physics 434. Though the data is simulated, this particular report generally reviews the data and its origins as if it were genuine. The purpose of doing this is to explore the context of the LHC data and how it was taken, as well as what an initial examination of the data may reveal about QCD and Higgs Boson instances of appearance* in particle collisions.

Background Research on Particle Collisions, the LHC, and QCD and Higgs Particles

1. The LHC

The LHC is a particle accelerator that has seven total detectors, which are used to observe particles and particle collisions. The LHC is mainly a proton-proton collider; protons are hadrons and their collisions allow observations of high-energy phenomena. The main detector concerning the data and research for this report is the ATLAS detector, which is one of the two general purpose detectors of the LHC, and the CMS detector is also relevant to the data.

2. Particle Collisions

Gluons bind quarks together, with quarks being the building blocks of Hadrons such as protons.

3. Jet Analysis

The study of Jet substructures is a recent endeavor, having evolved from the study of jets. The concept of Jets depends on algorithms that are used to develop data into jets, but generally a jet can be defined as "a collimated spray of energetic hadrons" resulting from the hadronization of quark or gluon fragments. (Salem, #)

4. Outcomes of Particle Collisions: QCD
QCD jets are jets that came from light quarks or gluons (Thaler, Tilgburg, #)

5. Outcomes of Particle Collisions: Higgs

According the the Standard Model, a Higgs boson decays 60 percent of the time into bottom quarks, or b quarks. (Gohd, #) In our simulated data, we expect a Higgs subject two display two subjects, which are the two b quarks the Higgs boson has decayed into.

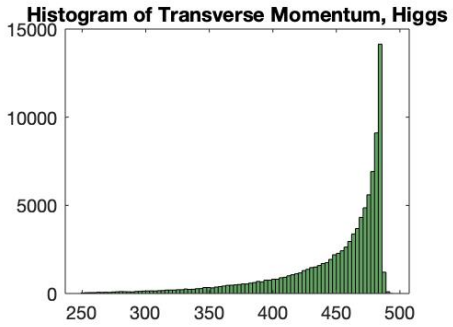
6. Differences Between QCD and Higgs Jets

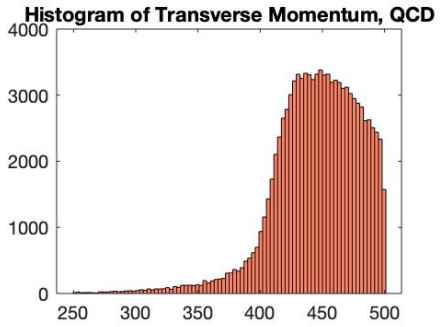
Data Review

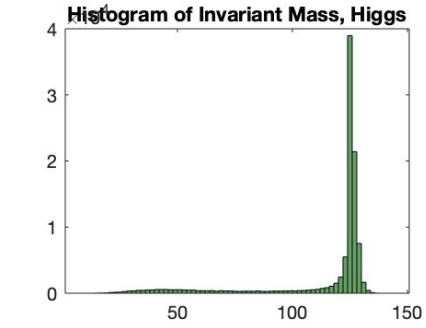
Variable	Symbol	Meaning	Equation
p_t	p_t	Transverse (xy plane) momentum	$\sqrt{p_x^2 + p_y^2}$
eta	η (also can be ξ?)	Pseudorapidty	$-\ln(\tan(\frac{\theta}{2})) = \frac{1}{2}\ln\frac{\lvert p\rvert + \lvert p_L\rvert}{\lvert p\rvert - \lvert p_L\rvert}$
phi	ϕ	Azimuthal angle	$\cos^{-1}\frac{x}{r}$
mass	m	invariant mass	$E^2 = p^2 + m^2$
ee2	e_2	2-point ECF ratio	$\sum_{i<j\in J} p_{T,i}p_{T,j}\Delta R_{i,j} \times \frac{1}{p_{T,J}^2}$
ee3	e_3	3-point ECF ratio	$\sum_{i<j<k\in J} p_{T,i}p_{T,j}p_{T,k}\Delta R_{ij}\Delta R_{ik}\Delta R_{jk} \times \frac{1}{p_{T,J}^3}$
d2	D_2	3 to 2 point ECF ratio	$e_3/(e_2)^3$
Angulraity	τ_{-2}		$\frac{1}{m_J}\sum_{i\in J} E_i \times \sin^{-2}\theta_i \times \cos^3\theta_i$
Other????			
girth	g		$\sum_{i\in J}\frac{p_{ti}}{p_{tJ}}\Delta R_{iJ}$
rapidity	r_i	rapidity	$\frac{1}{2}\ln\frac{\omega_i + p_{z,i}}{\omega_i - p_{z,i}}$
	ε	beam distances	p_{Ti}^2
N-sub jettiness	τ_N		$\frac{1}{d_0}\sum_i p_{T,i}\min\Delta R_{1,i}, \Delta R_{2,i}, \ldots, \Delta R_{N,i}$

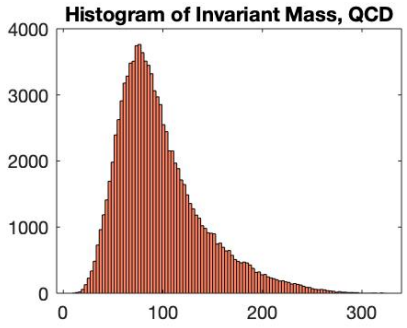
Here: what the data is, what each column of the data is. How is it meaningful that this data is from jets?

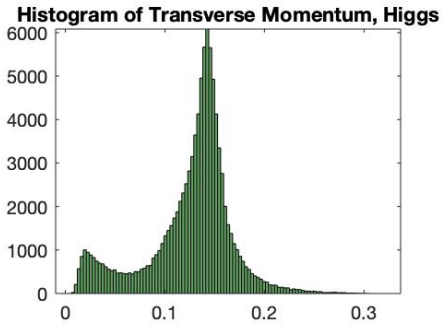
Initial Investigation of the Data

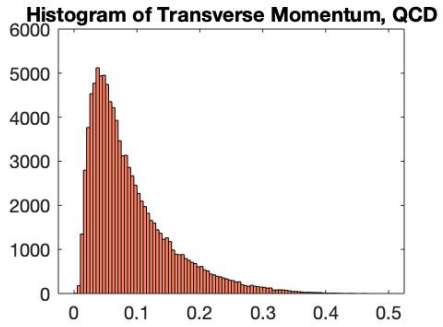


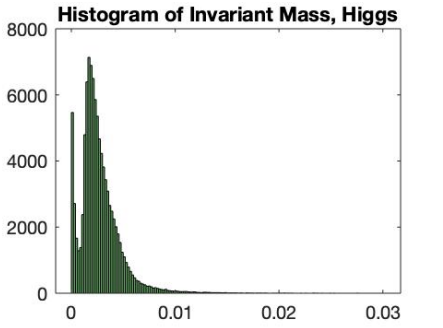


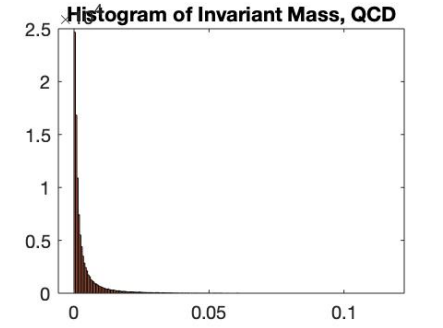












The shown histograms are of the Higgs and QCD data (green and orange face colors, respectively) in which the variance between the data appeared noticeably different.

References

Armando Fregoso, Alessandro, and Seymour, Michael. *Jet Substructure at the LHC With Analytical Methods*, 2014, pp. PQDT - UK & Ireland.

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Salam, Gavin. "Towards Jetography." *The European Physical Journal C*, vol. 67, no. 3, 2010, pp. 637–686.

Thaler, J., & Van Tilburg, K. (2010). Identifying Boosted Objects with N-subjettiness. JHEP 1103:015,2011.