

ISP220 Honors Project: Analyzing LHC Collisions in the ATLAS Detector

Fall 2021

Document 2, November 18, 2021

Due: December 16, 2021 (note this is an extension from the original date.)

The Data Analysis

By this point, you've been through Exercises 1 and 2, and so you're beginning to get a feel for what events of particular kinds would be like in the ATLAS detector. We do not scan these things by eye – there are billions of them every month. Rather we train computers to do “pattern recognition” analyses and only look at the displays when things go wrong, or when things go very right. Science is much more the former, than the latter.

We're doing the “Z-Path analysis” from <https://atlas.physicsmasterclasses.org/en/zpath.htm>

It involves calculations that the computer will do...just like for us...and identification of the kinds of events that you see. Note: these are real events,¹ there is no correct answer in the back of the book. You make your best evaluation!

I hope you've read all of the information gotten by clicking on each of the side tabs from Introducing the Z Boson through Search and Discover Through Mass.

We're about to do the last one, Get to Work!


You'll find everything you need in,

https://qstbb.pa.msu.edu/storage/ISP220_stuff/honors_project/

so ignore any instructions to get something else from their web page. Hanging from that directory is one called /data/ where you'll find many data sets of real ATLAS results and simulated potential discovery events that are new physics. Don't download anything yet. Keep reading.

- The “groupA-etc” directories are your data...see below.
- The tally directory contains 25 tally sheets that you'll fill out by hand as you analyze. One for each of you...see below.

¹ Not quite true. There are simulated events of “new physics”...signatures that we're looking for but have not yet found. There are Higgs Boson events in here also which you might be lucky enough to find. But remember, they don't come with a label. Just that a final state might look like a Higgs Boson final state, but it could also be less exciting. We need to collect a lot of such events and then look for a Higgs Boson as a grouping at the right mass. That, we've done.

In the tally sheets, count using whatever stick-marks you use to keep track of counting. To me, that means for “7” I’d have made the marks:  ||. Get what I mean?

What you’ll turn in is:

1. Your paper (see the first instructions)
2. Your tally sheets filled out
3. Your invariant mass plots (see below)

Here are your measurements:

1. **Count and categorize your events.** You’ll have a total of 100 to analyze into Z, Z’, Higgs (in gamma-gamma and/or eeee, eemumu, or mumumumu), or background. Follow the suggestions on the Analyzing Your Result page.
2. **Invariant mass calculations.** HEPATIA does this for you.

Your Data

Your data sets are found at:

https://qstbb.pa.msu.edu/storage/ISP220_stuff/honors_project/data/

Each of the group directories contain 50 real LHC events taken by our ATLAS detector. They’re randomized. You’re each assigned 100 events, from two of the directories according to the assignments in the table below. For example, Jack Dudek, you get the 50 events in group F and the 50 events in group F-2. The rest of you get them in that same way. Get it?

I’ve made a 25 minute movie that shows you exactly what to do. You can find it as

https://qstbb.pa.msu.edu/storage/ISP220_stuff/honors_project/Zpathintro.mp4

I think I’ve done everything you need. So you don’t have to follow the links on the Data samples and Tools page. Furthermore, the last line of the Do It! page in the Zpath.htm page?...we’ll not do that.

IMPORTANT: Computer files are often large and there are a variety of ways that computers “pack” them – compress them – into smaller, but unrecognizable formats. The most popular and widely used compression algorithm is “zip” or “gzip.” Files that are compressed have the extension “.zip” Hypatia wants to read zipped files, not individual files that have been unzipped. So when you go to download your two data files, you need to do it in a way that does not do the automatic unzipping.

- A MAC will automatically unzip a file that is a .zip file from the web unless you explicitly right-click, or control-click and “Download Linked File”...then it will download the file and preserve it in its zipped format. If you just click it, your MAC will enthusiastically unzip everything. Don’t do that.
- Windows will ask you do unzip, which of course you decline.

I've found yet another MAC issue. Hypatia will not recognize your downloaded data files unless the zip file is in the same directory as the app. **So you must move your data to the folder where Hypatia is located. I recommend that Windows users do the same.**

Your Workflow:

1. Fire up your HYPATIA tool.
2. Arrange your windows so you can see everything, as per the movie.
3. Download your two directories into local directories near your HYPATIA JAVA tool from the zipped files in the directory.
4. Choose the first directory and start analyzing.
5. You can save your work and go do something else and then come back. In File, you can save your HYPATIA project and then when you come back, open HYPATIA and load the saved file.
6. When you're done (or maybe before...just to play), save out the histograms that you made and include them in your writeup after you've done all 100 events. Remember some will be backgrounds (not interesting physics) and so your final results will probably be fewer than 100 events.
7. Export your histograms to the file that it does for you in File/Export Invariant Masses.

Do this by December 16, 2021.

What you should turn in is enumerated on the first document. Include your worksheets and the spreadsheet if you use it. If you print out any events, include them. Remember, keep a narrative like you're really doing an experiment...which you are!

Have fun! Here's the table with your assigned data:

Student_Name	Datasets	
Bhadange, Mihir R	A	A-2
Borneman, Tess Elizabeth	B	B-2
Davies, Cragen Pamela	C	C-2
Dillon, Steve James	D	D-2
Doyle, Leah Anne	E	E-2
Dudek, Jack	F	F-2
Fleming, Katie Julia	G	G-2
Garg, Akshaan	H	H-2
Gasperoni, Angelo	I	I-2
Green, Ella Rose	J	J-2
Hewagama, Irusha	K	K-2
Johnson-Hill, Aidan Thomas	L	L-2
Jones, Zachary Jordan	M	M-2
Kaczmar, Kristin Anna	N	N-2
Kevelighan, Brenden William	O	O-2
Kirkland, Kirsten Sophia	P	P-2
Korte, Kyle D	Q	Q-2
Lu, Chufei	R	R-2
McKay, George	S	S-2
McNeela, Danny James	T	T-2
Nurenberg, Brooklyn Paige	U	U-2
Rancilio, Mia Cristina	V	V-2
Robinson, Anel Imani	W	W-2
Roragen, Philip Harris	X	X-2
Tryan, Jenna Annette	Y	Y-2