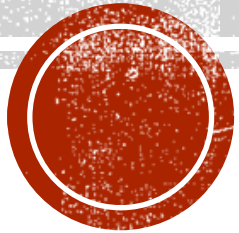
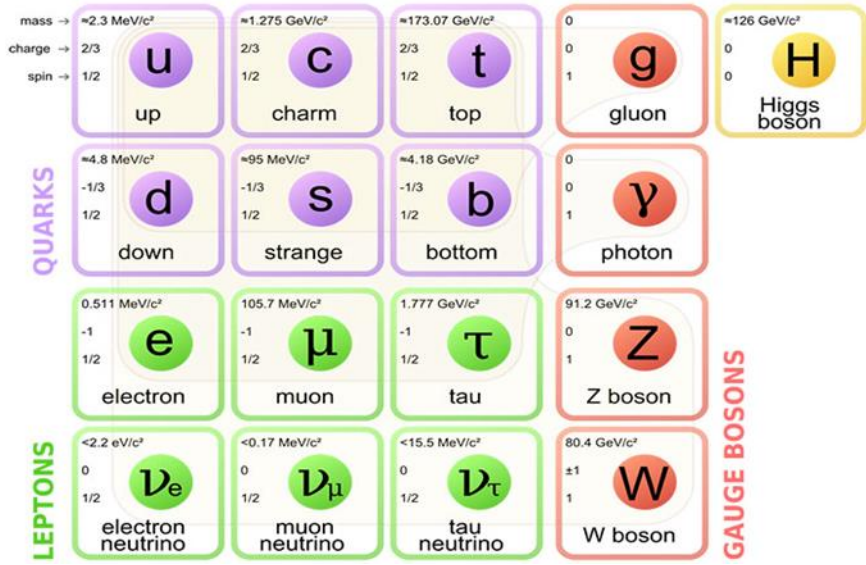
Optimization of the Cut-Based analysis in the H to WW* channel of the Gluon-Gluon Fusion (OPTIMIZED)

By Noel Marichalar



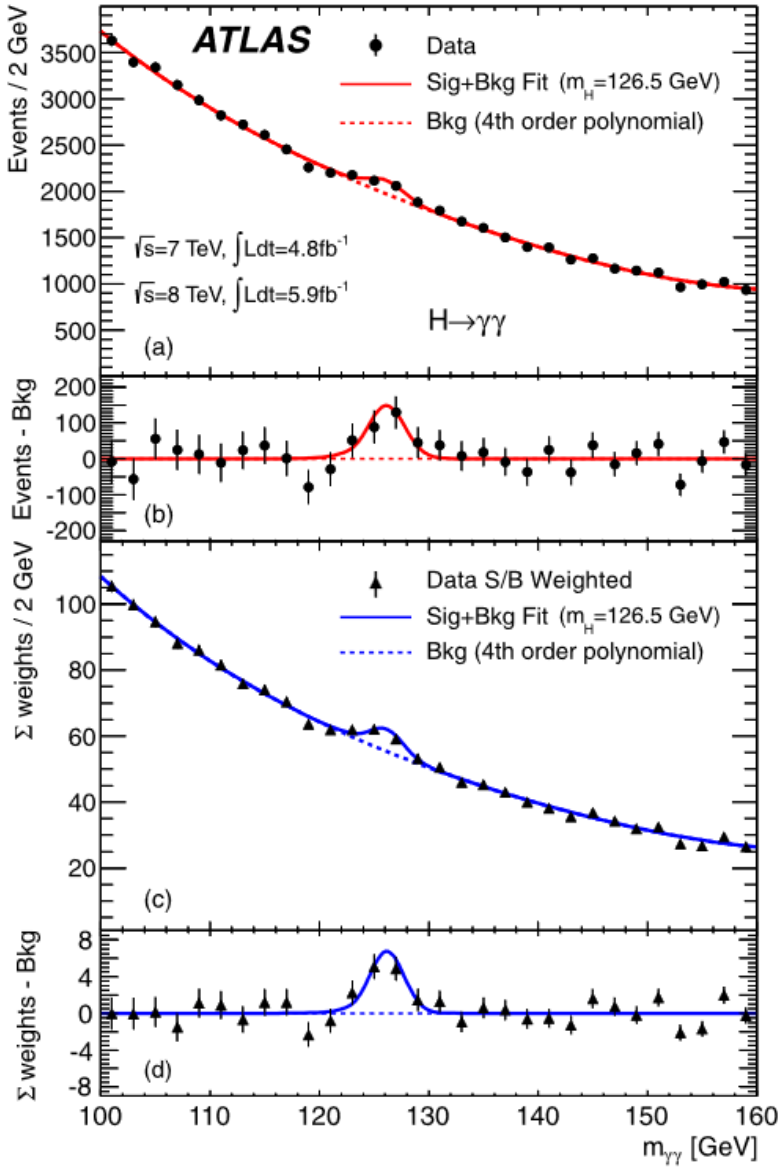
QUICK REFRESHER: STANDARD MODEL

- Fundamental units of the Universe
- Three of the four fundamental forces
- All but first generations decay to lighter particles
- Fundamental particles can decay using "virtual" interaction particles.
- A big unanswered question: Where do particles get their Mass?



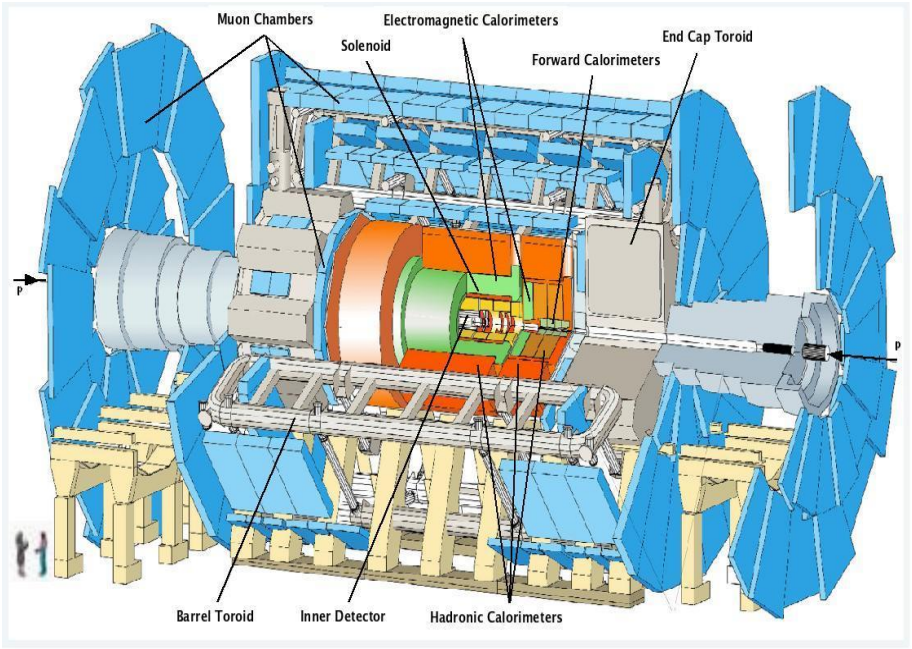
2012- FAMOUS DISCOVERY

- Theorized in 1964
- Interactions with its field explain the mass of fundamental particles
- Existence proved in 2012 by the CMS and ATLAS detectors of the LHC



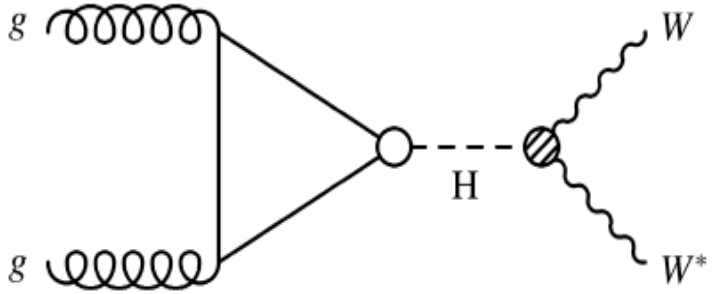
QUICK REFRESHER: ATLAS DETECTOR

- One of the two detectors used to discover the Higgs Boson
- Inner detector – measures charged particle trajectories and momenta
- Calorimeters – measure the energy of specific particles (photon/electron-positron pairs or hadron showers)
- Muon chambers – measure momenta and trajectories of muons

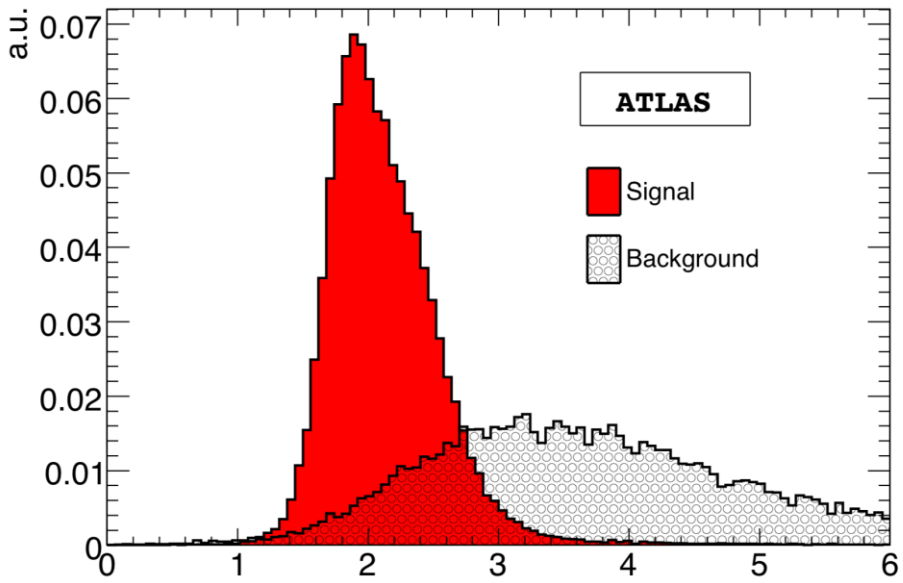


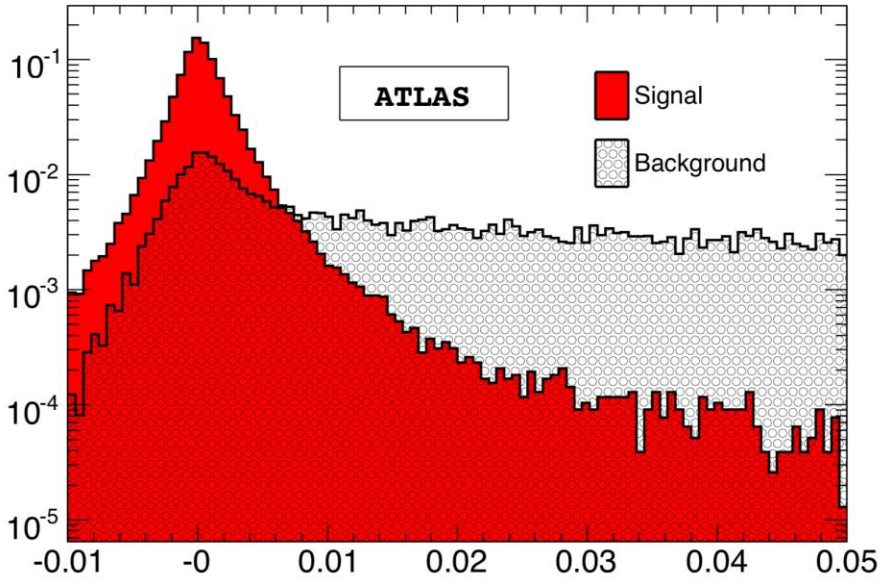
GOAL OF MY SUMMER'S RESEARCH

- Perform cut-based analysis on a channel of the Higgs Boson known as Gluon-Gluon fusion.
- Compare my results to the previously used cuts
- Optimize cuts if able



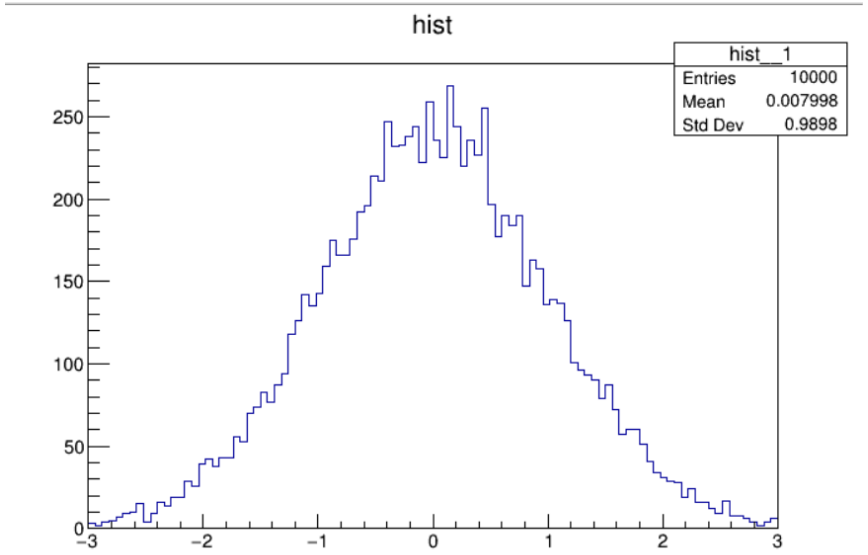
CUT BASED ANALYSIS





ROUGH BEGINNINGS

- Learn about Particle Physics: The Particle Adventure | Unsolved Mysteries | The Standard Model as a theory
- Learn about Root/Linux
- Learn about the Analysis
- Learn to Graph
- Learn/Teach myself basic C++ Code



1.5*(ROUGH BEGINNINGS)

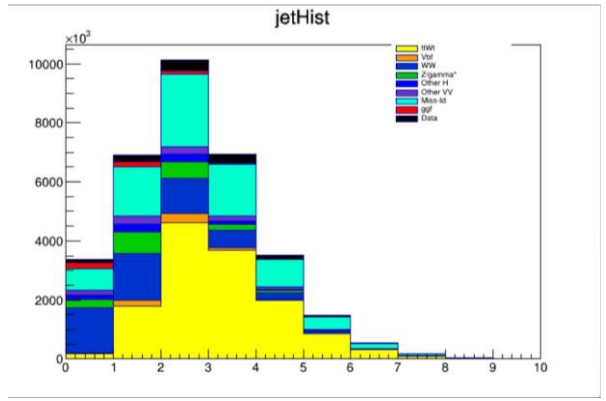
Category	$N_{\text{jet},(p_T>30\text{ GeV})} = 0$ ggF	$N_{\text{jet},(p_T>30\text{ GeV})} = 1$ ggF	$N_{\text{jet},(p_T>30\text{ GeV})} \geq 2$ ggF	$N_{\text{jet},(p_T>30\text{ GeV})} \geq 2$ VBF
Preselection	Two isolated, different-flavor leptons ($\ell = e, \mu$) with opposite charge $p_T^{\text{lead}} > 22$ GeV , $p_T^{\text{sublead}} > 15$ GeV $m_{\ell\ell} > 10$ GeV			
	$p_T^{\text{miss}} > 20$ GeV			
Background rejection	$N_{b\text{-jet},(p_T>20\text{ GeV})} = 0$			
	$\Delta\phi_{\ell\ell,E_T^{\text{miss}}} > \pi/2$ $p_T^{\ell\ell} > 30$ GeV	$m_{\tau\tau} < m_Z - 25$ GeV		
		max $(m_T^{\ell}) > 50$ GeV		
$H \to WW^* \to e\nu\mu\nu$ topology	$m_{\ell\ell} < 55$ GeV $\Delta\phi_{\ell\ell} < 1.8$			
			fail central jet veto or fail outside lepton veto	central jet veto outside lepton veto $m_{jj} > 120$ GeV
			$\lvert m_{jj} - 85\rvert > 15$ GeV or $\Delta y_{jj} > 1.2$	
Discriminating fit variable	m_T			DNN

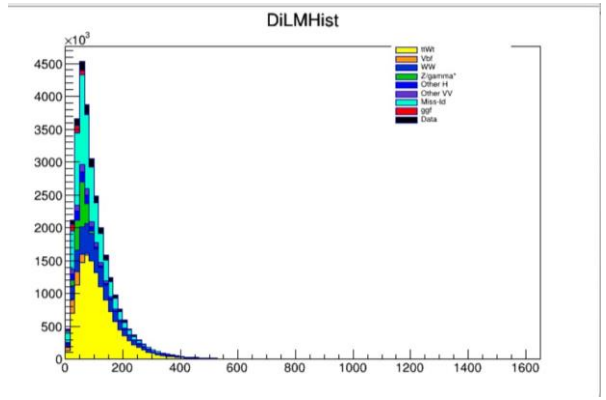
ROUGH MIDDLES TOO

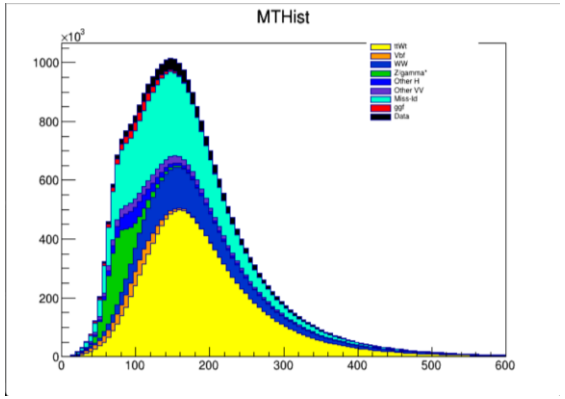
- Learn how to create Cuts with C++ code
- Obtain all the files needed for me to start
- Compress signal/backgrounds into useable files
- Create code for each file

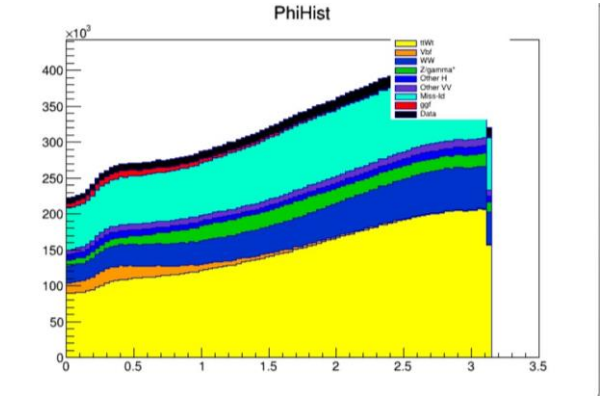
ROUGH MIDDLES PART TOO

- Graph with Preselection Cuts
- Realize my Histograms were wrong
- Try different methods of combining files (a few)
- Run into more issues and restart twice



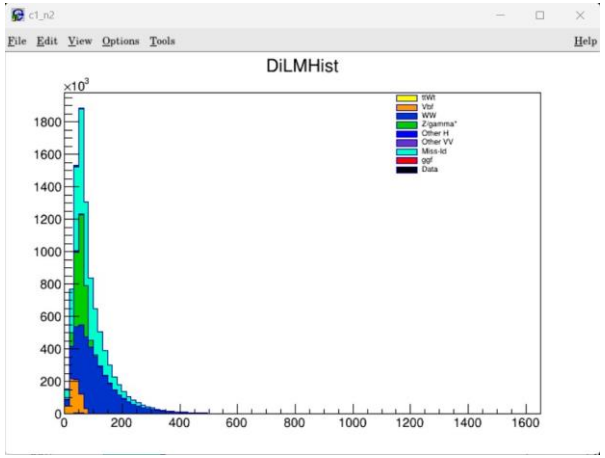


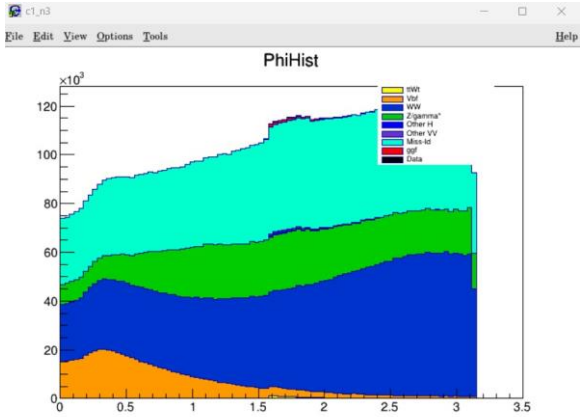


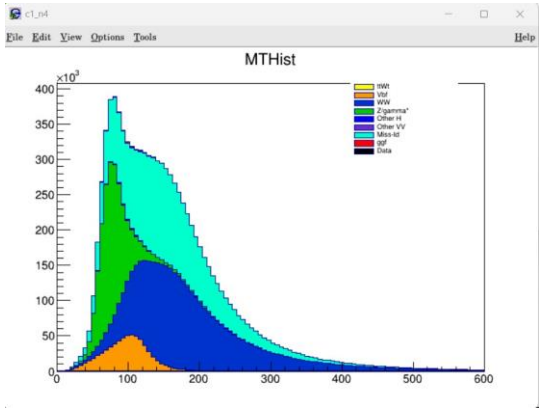


...ROUGH ENDS (THREE?)

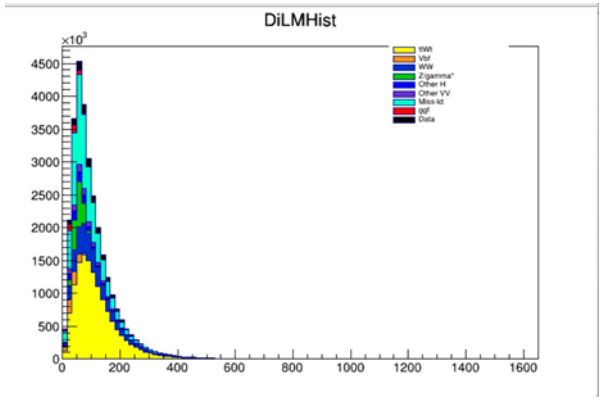
- Apply selection cuts
- Create Final Histograms (A few times)
- Compare to the papers







MY RESULTS!


DiLMHist
×10³
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Other H
Other VV
Miss-Id
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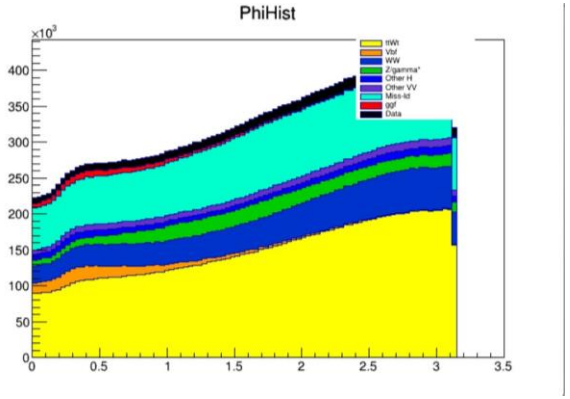
Data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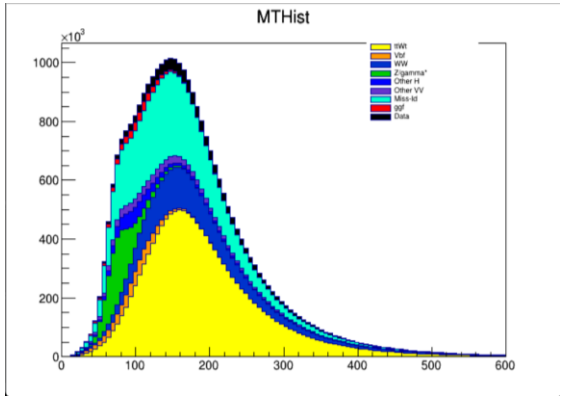
Data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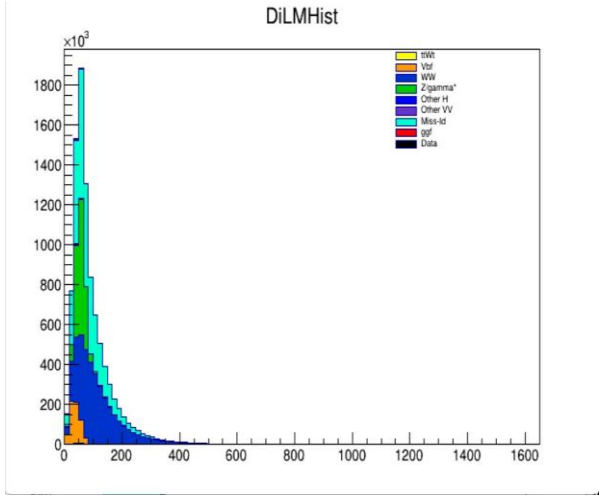
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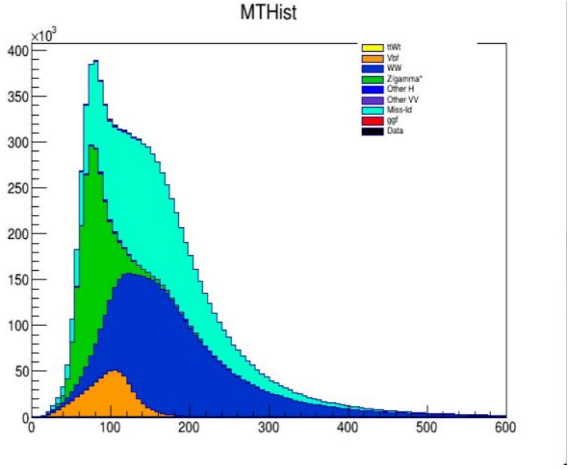
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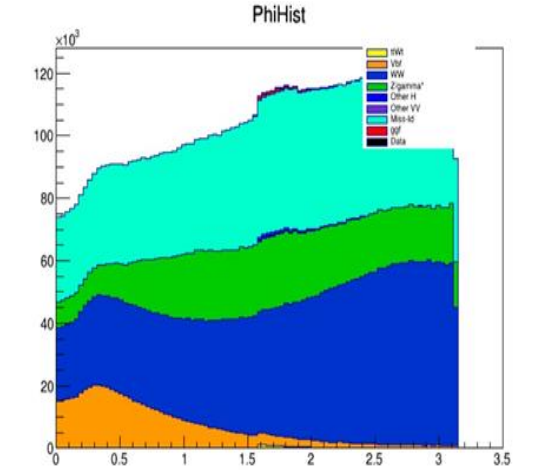
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Other H
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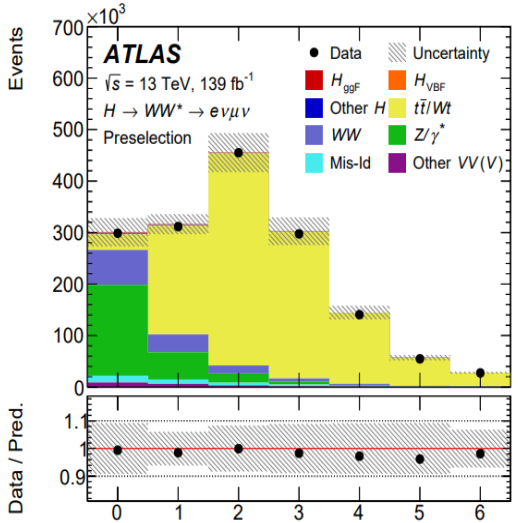
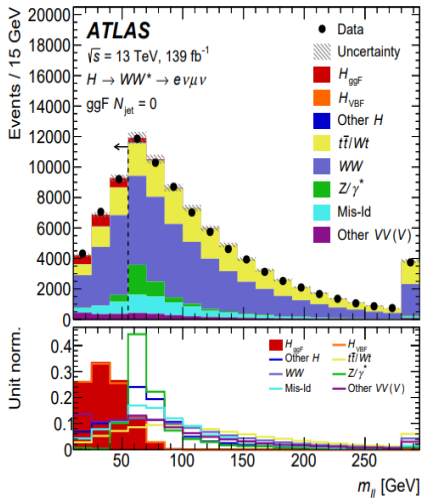
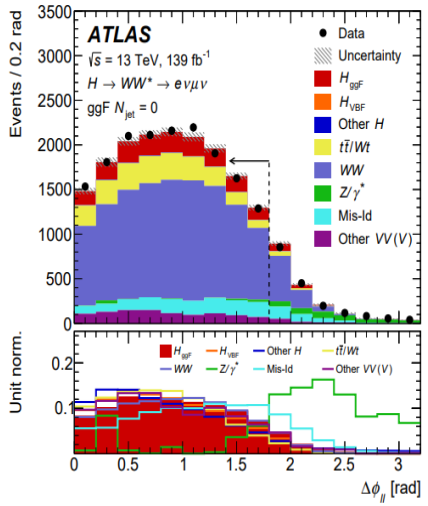
Data

COMPARISON TO PREVIOUSLY USED CUTS

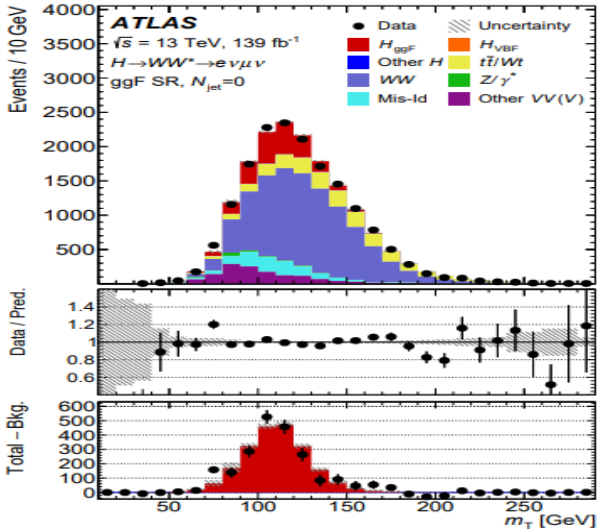




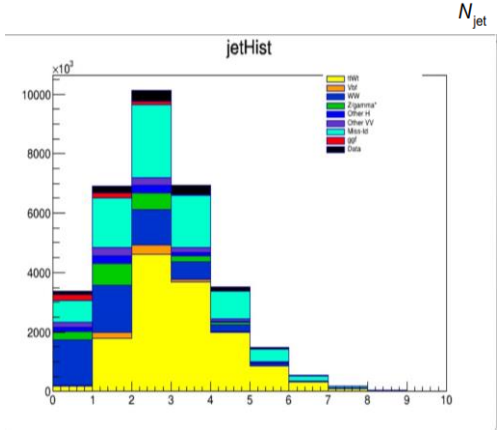
(a)

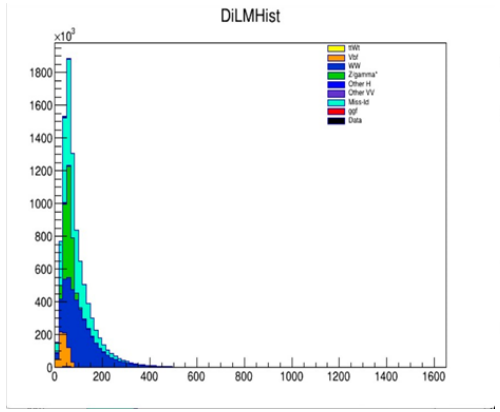


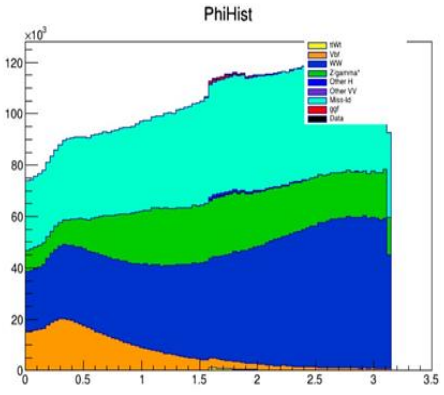
(b)

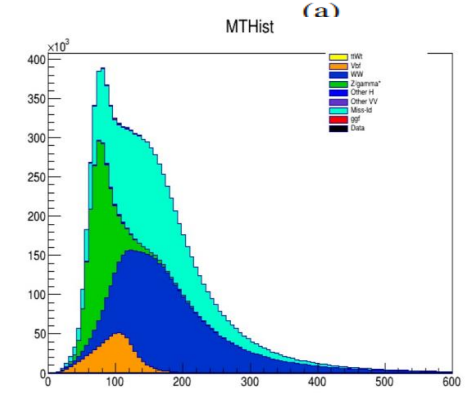


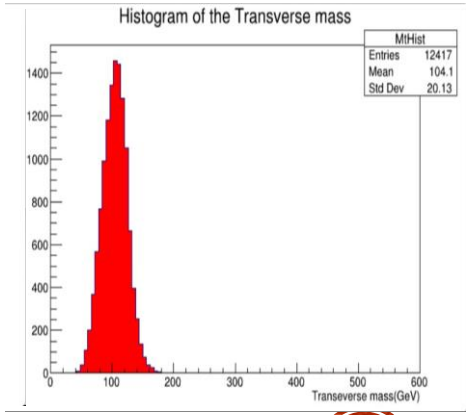
(a)





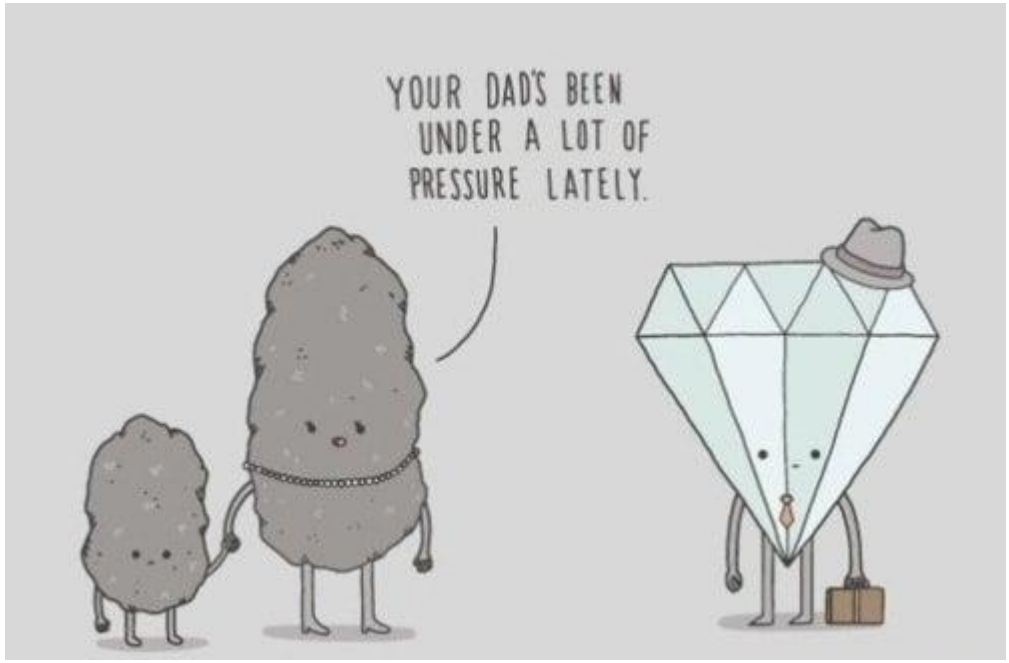






CONCLUSION

- I did not re-observe the Higgs in the WW Channel
- My ability to code was insufficient in applying the selection criteria
- Though, I had lots of fun
- I plan on continuing to play around with this data and these plots to at least get the results displayed by the ATLAS group.



SPECIAL THANKS!

- First to myself for making the correct decision coming here
- Dr. Strauss
- Dr. Abbott
- My great friends made here at OU
- Naps! Much needed
- https://arxiv.org/abs/2207.00338
- https://www.nevis.columbia.edu/~seligman/root-class/RootClass2023.pdf
- The Particle Adventure | Unsolved Mysteries | The Standard Model as a theory