HEP-PIC 09

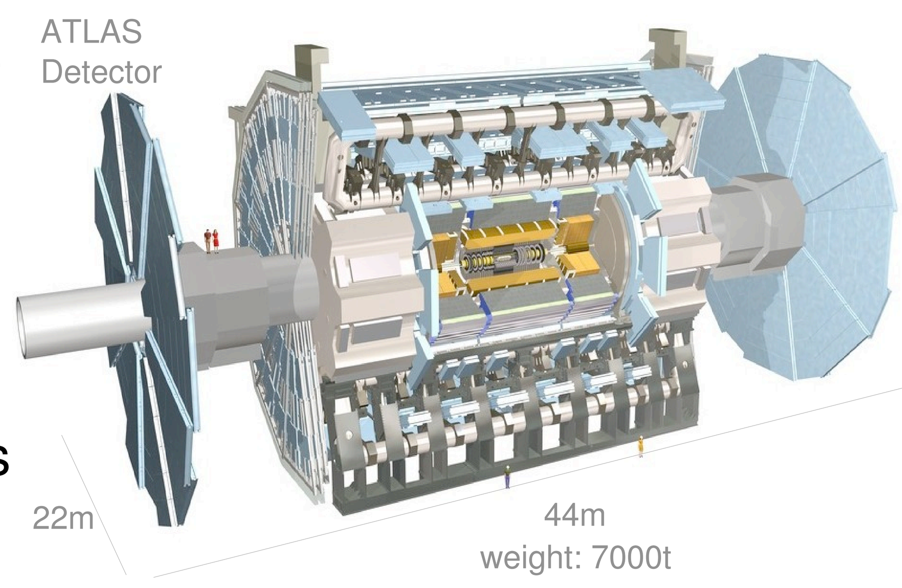
Analysis of the NMSSM Higgs Decay h1→a1a1 with ATLAS Experiment

C. Laflamme, H.K Lou, Dr. C. Potter, Prof. S. Robertson

1. The ATLAS Experiment

•As one of the two general detectors on the LHC, ATLAS is posed to investigate the fundamental constituents of matter, at the highest energies possible.

•Of particular interest, ATLAS will search for the elusive “Higgs Boson”, responsible for a particles mass.



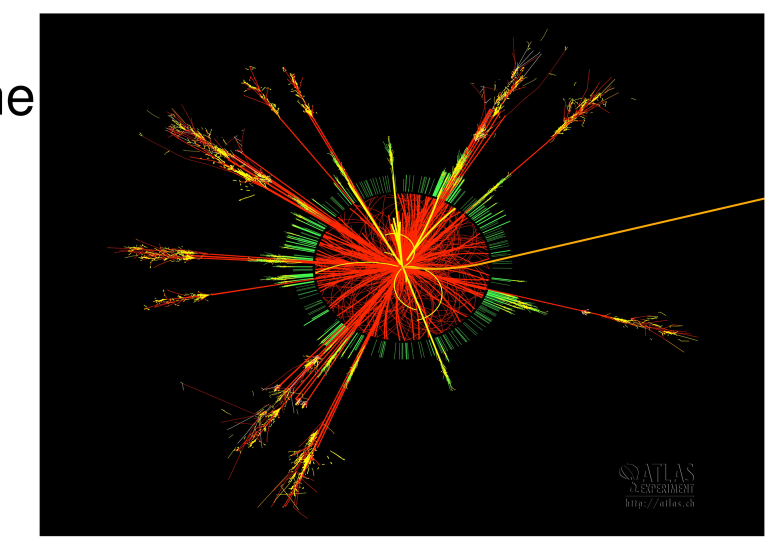
2.The Next to Minimal Super Symmetric Model (NMSSM)

▶Despite incredible experimental success, there exists several conspicuous problems to the Standard Model, a model was constructed to describe the fundamental particles and forces of nature.

▶Moving beyond the standard model, the NMSSM provides a solution to these problems, while remaining consistent with experimental results [1].

▶There are 7 Higgs Bosons required in the NMSSM
- ▷CP even higgs: h1, h2, h3
- ▷CP odd higgs: a1, a2
- ▷Charged Higgs h+, h-

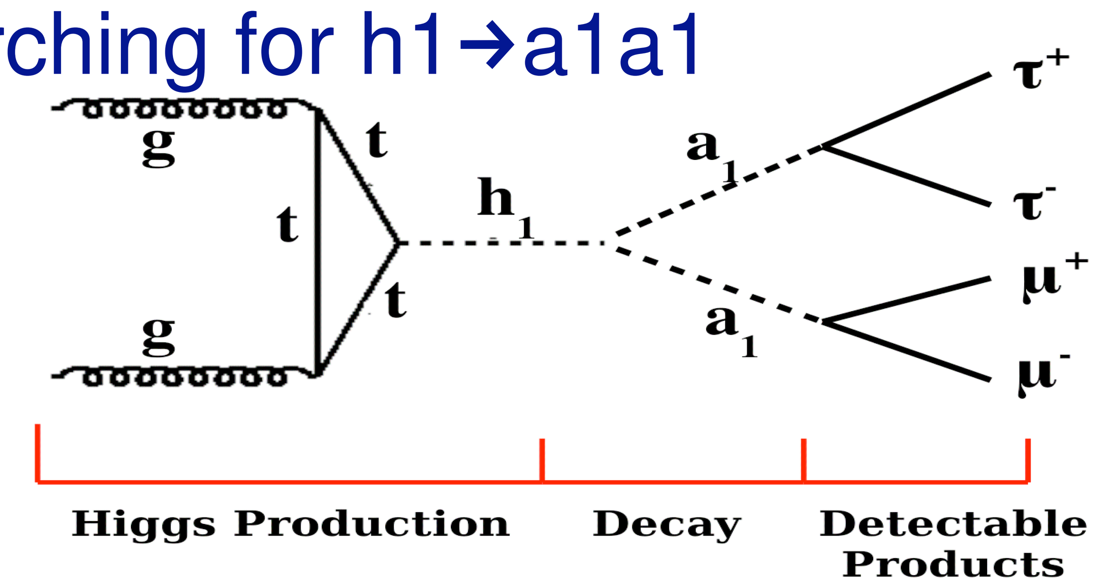
▶h1 is the lightest of the Higgs, and possess properties which are most similar to the standard model Higgs.



Computer Simulation of a Higgs Decay in the ATLAS detector

▶ In the theoretical framework of the NMSSM there exists possibility of the decay h1 → a1a1, which may dominate all other channels.
This possibility has not been ruled out experimentally and, if true, would mean that all of the standard Higgs boson search strategies at the LHC will be unsuccessful

3. Searching for h1→a1a1



▶We will search for the h1 in the decay scheme illustrated in the figure:
- ▷h1 produced by top-quark loop processes
- ▷h1 directly decays into 2 a1- each a1 subsequently decays into 2 heavy leptons (muons or taus)
- ▷The muons can be directly detected in the ATLAS detector
- ▷The taus will further decay into detectable muons, electrons or pions.

▶This analysis restricts to the case where one a1 decays into two muons, while the other a1 decays to two taus. Furthermore, it is focused oon the case where one tau will decay into a lepton (muon or electron) and the other decays into one or more pions, and the case where both taus decay into leptons.

4. Simulation Details

▶Although proton-proton collisions occur on the nano-second scale in the LHC, only 1 collision per billion will result in the creation of the h1 boson. Hence we must find a way to distinguish this “signal” collision from the rest of the “background”.

▶MonteCarlo techniques were used to create a signal sample.

▶Background data was taken to be the TopMix Sample*, a collection of processes which may look similar to our signal in the detector.

▶Some parameters used in our model of the NMSSM:
- ▷Br(a1→$\tau^-\tau^+$) = 0.8
- ▷Br(a1→$\mu^-\mu^+$) = 0.005
- ▷Cross Section 51.3 pb
- ▷ Mass a1 = 5GeV ; Mass h1 = 100GeV

* For more information on TopMix see: https://twiki.cern.ch/twiki/bin/view/AtlasProtected/TopMixingExercise

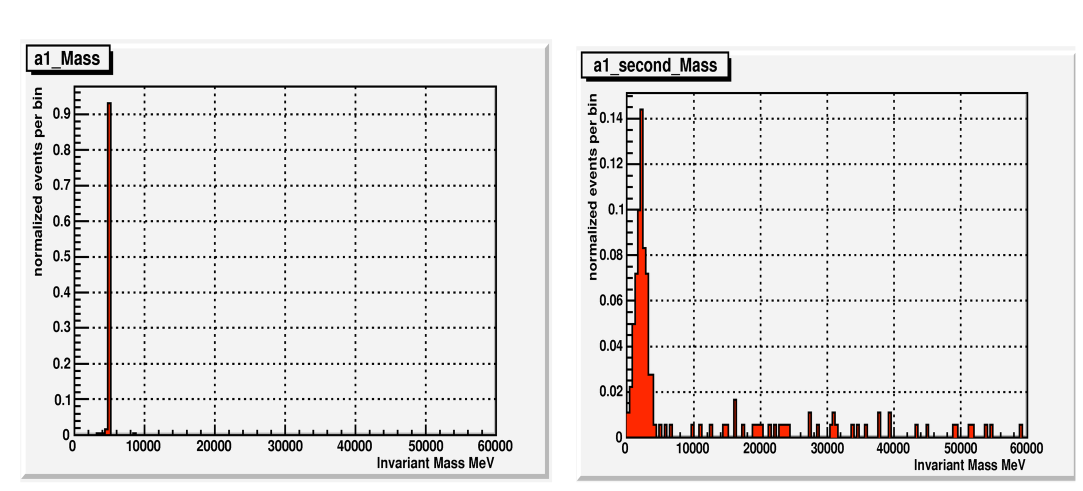
5.Reconstruction of the h1 transverse mass

▶Our goal is to find a way to reduce the background while keeping signal information. Unfortunately each time we try to remove some background (or each time we make a “cut”) we remove some of the signal as well.

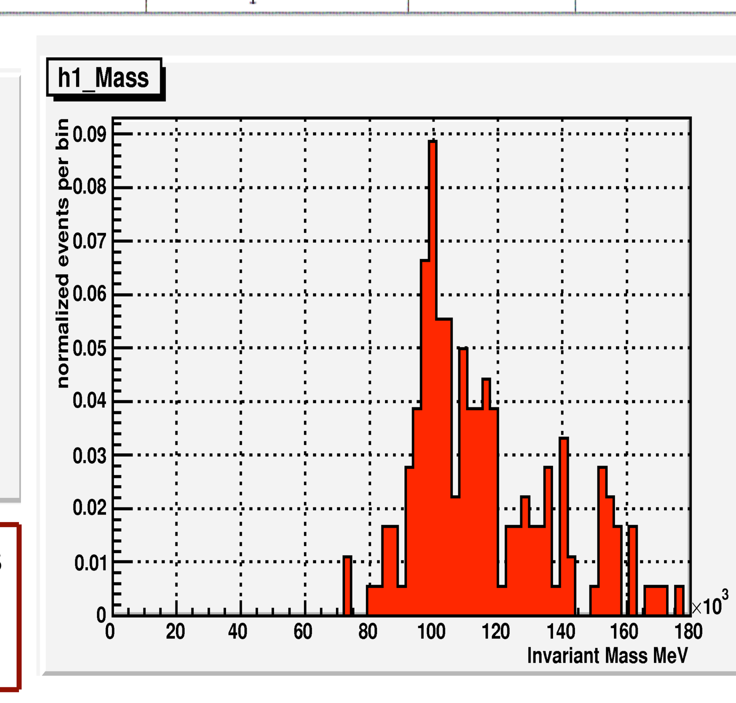
▶Limitations in the amount of signal we can obtain motivate the most efficient cuts possible. The cuts we made are:
- ▷Cut on Muon Multiplicity (number of muons in one collision)
- ▷Cut on Lepton Multiplicity (number of other leptons we find in one collision)
- ▷Cut on a1 reconstructed mass (theory tells us: 3.4 GeV < a1 < 10GeV)

Table 1: Cut Efficiencies

	Cut Made	Events Left	Efficiency (%)
Signal	No Cut	14824	100
	Muon Multiplicity	9108	61.44
	Lepton Multiplicity	199	1.34
	A_1 Mass	115	0.76
	Cut Made	Events Left	Efficiency (%)
Background	No Cut	1315954	100
	Muon Multiplicity	148720	11.30
	Lepton Multiplicity	77	0.006
	A_1 Mass	0	0



These plots show the reconstructed mass of the particles in question, taken by adding the mass of all the detectable particles created in any given collision.



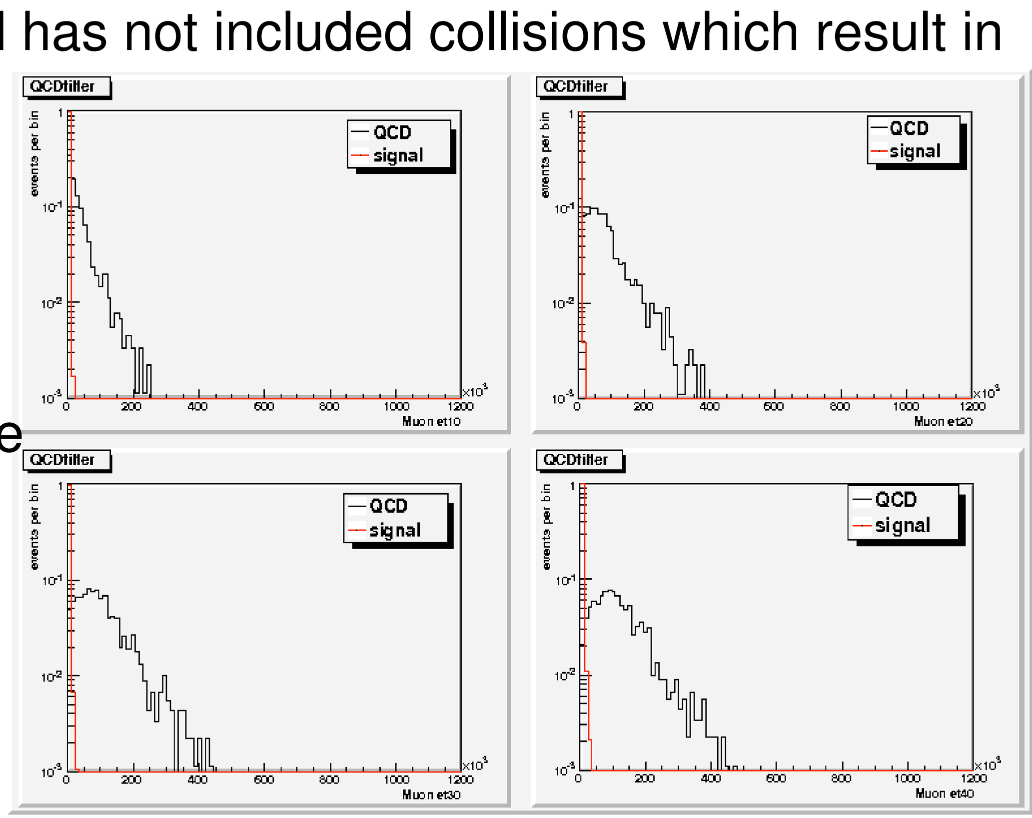
6. Quantum Chromodynamic (QCD) background

▶Up to this point, our background has not included collisions which result in interactions involving QCD.

▶QCD events are characterized by Jets– each lepton produced will have a lot of other energy very close to it.

▶However, our signal should have very isolated leptons.

▶These plots show the energy distribution in close proximity to the muon under consideration



7. Summary and conclusions

▶ We have found that straightforward cuts can be used to isolate the signal from the background.

▶Although it is difficult to know the QCD that we will see in real data, we have developed a methodology in reducing these events.

▶ With real data from the LHC imminent, this analysis provides a base from which we can test the theories of the NMSSM!

References : [1] arXiv:0808.2509v1