משרד החינוך
המינהל הפדגוגי
האגף למחוננים ולמצטיינים

מכון הנרייטה סאלד
המכון הארצי למחקר במדעי ההתנהגות

Searching for undiscovered resonances at ATLAS

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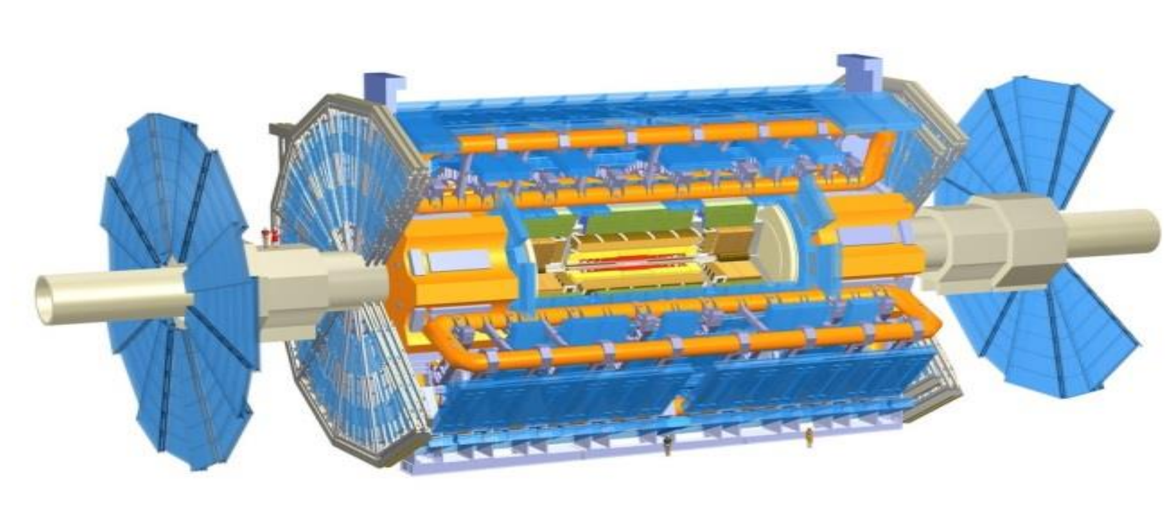
The LHC and ATLAS

The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator. It collides two highly energetic beams of protons, and ultra-sophisticated detectors record these powerful collisions.

One of these detectors is ATLAS, a general purpose detector whose job it is to collect as much data as possible about the particles emitted from a collision.



ATLAS Experiment © 2013 CERN

What is a jet?

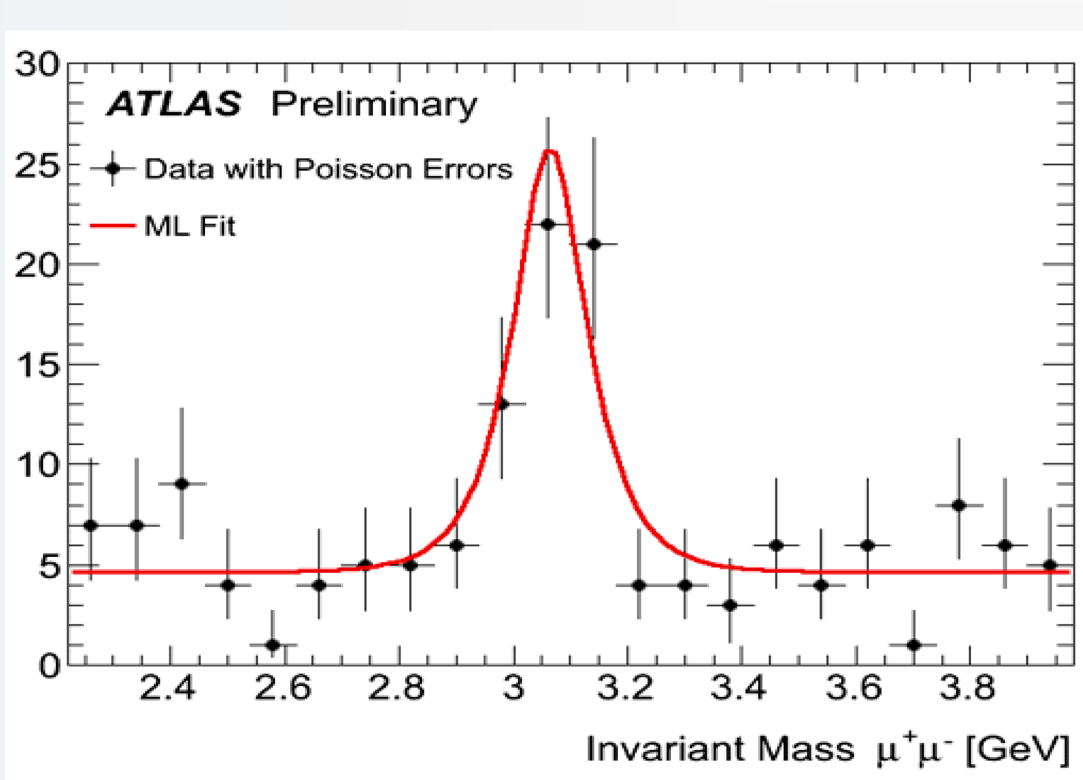
A jet is a collimated beam of particles created whenever a parton is emitted through a process called hadronization.

Because we cannot detect the original parton, we must infer its existence and properties through the jet that it creates.

What is a Resonance?

A resonance is a very short lived particle with well-defined mass decaying at the collision point. When one looks at a graph of the probability of a collision occurring as a function of the energy released in the collision, one sees that the probability peaks at a certain energy.

Normally this peak is hard to see because the "signal" (collisions in which the resonance appears) is only a small part of all events. In order to distinguish the signal from the background events, we must increase the ratio of signal events to background events, called the signal to noise ratio.



Goal

Multi-jet events (events with at least 3 jets) have scarcely been studied. Some models predict hypothetical resonances that decay into a large number of partons (jets). In this research project we aim at developing a cut procedure (filter) that will facilitate the discovery of such resonances. In particular, we have developed a simple algorithm that successfully discovers a simulated resonance. This algorithm can then be applied to real data.

Methodology

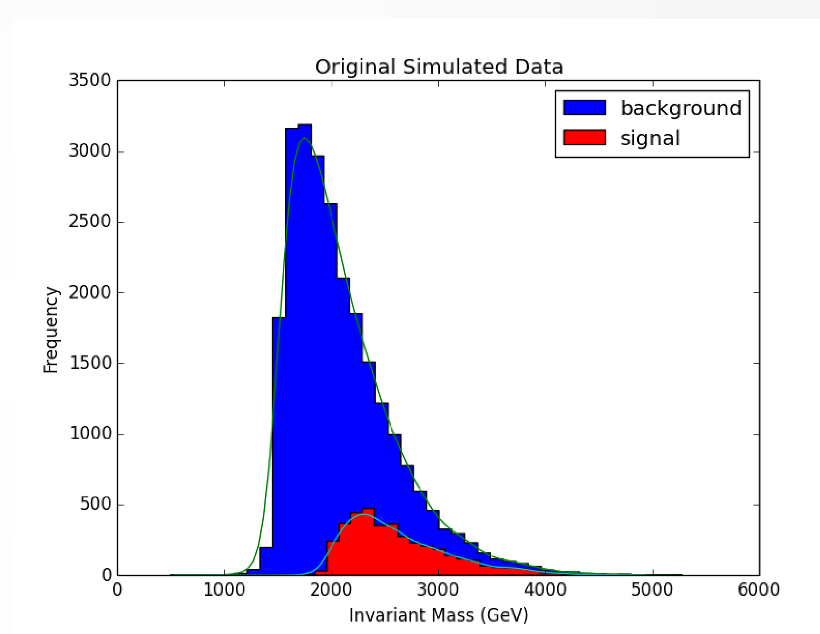
In order to filter out background events we simulated signal as well as background events. The produced particles were then grouped into jets using a standard "jet finder" tool. Next we constructed several characteristics of these events searching for quantities with different distributions in signal than in background samples. We wish to study high-energy, multijet events, so we apply the following cuts:

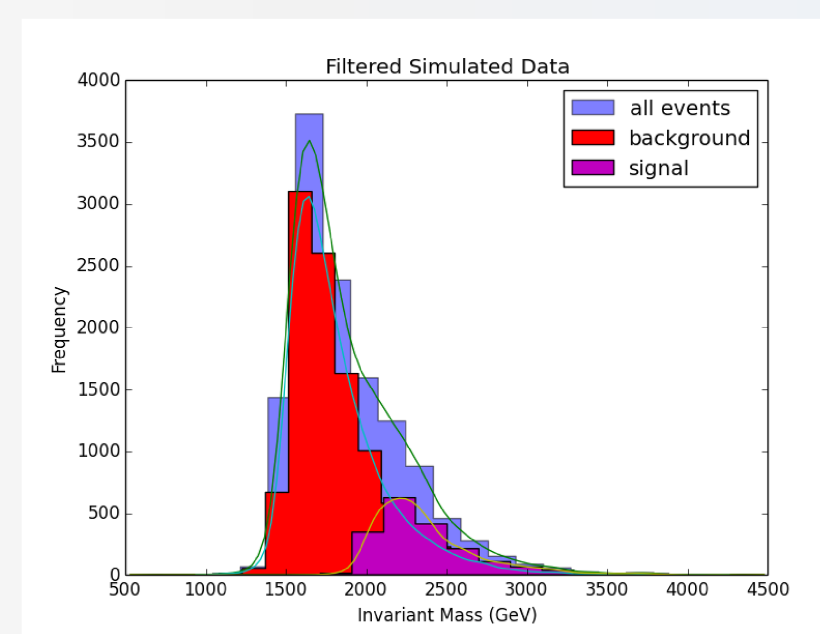
-Sum of transverse momentum (h_T) > 2.5 TeV

-Number of jets ≥ 3.

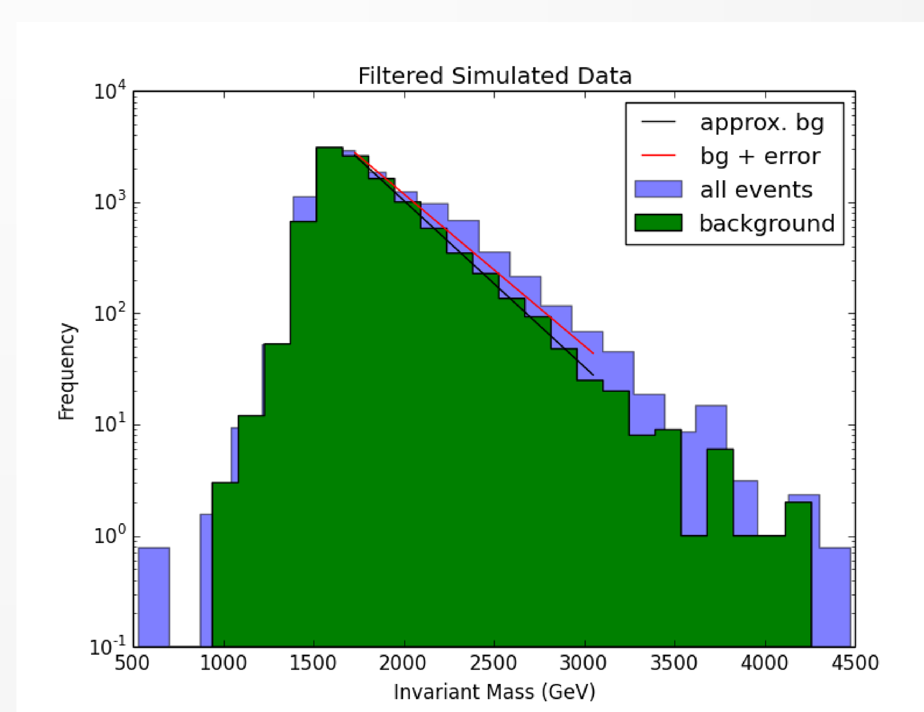
Background events are expected to consist of two oppositely directed systems of jets. Signal, on the other hand, should consist of many jets distributed isotropically. Hence, we require that $\frac{h_T}{m} > 0.9$.

Results

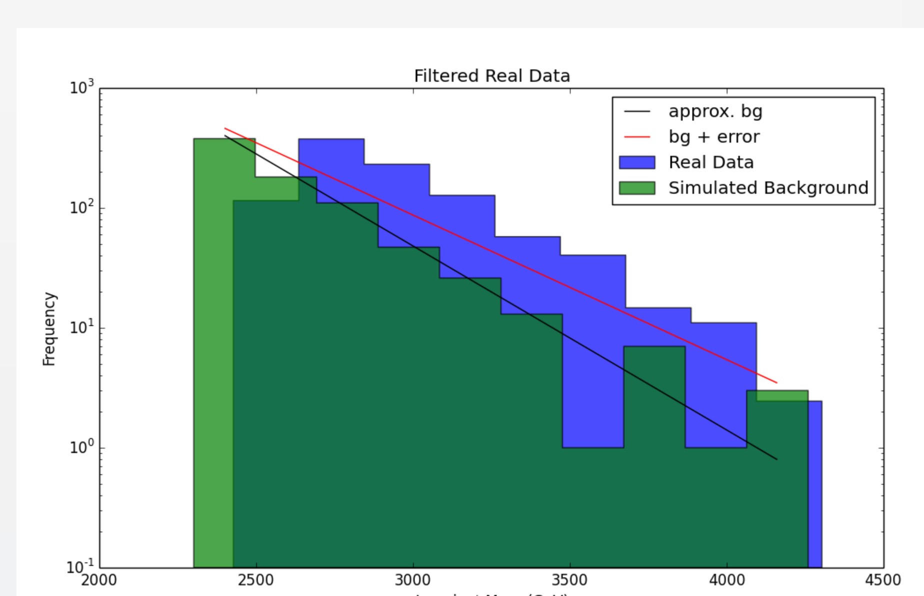




The cuts have significantly increased the signal to noise ratio – from 0.28 to 1.06.



The black line is fit to the filtered background, and the red line represents the upper bound for an error of $\pm 3\sigma$.



This graph may hint at the existence of a resonance with properties similar to our simulated resonance.

The data from ATLAS resembles the result we would expect should a resonance exist. This suggests further research may be in order that will allow us to draw more concrete conclusions. One step towards this increasing the statistical significance is increasing our sample size – both of the simulated and real data. Another way to increase our confidence in the results is to perform a rigorous comparison of the properties of the simulation and its theorized properties ensuring the simulation is accurate.