Higgs Signal Optimisation

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Summary

1. General background on Higgs
2. How Higgs signals are simulated
3. How the signals are interpreted
4. How the Higgs signal is optimised
5. Problems in optimisation and improvements
6. Possible expansions of the project

Background

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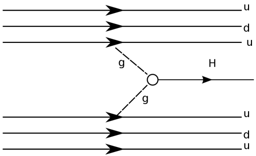

Figure: Gluons fusing into a Higgs at a proton-proton interaction

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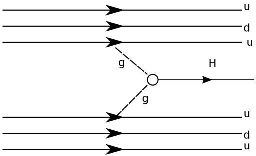

Figure: Gluons fusing into a Higgs at a proton-proton interaction

The Higgs decays in a very short period of time in many channels, the most common is 2 bottom quarks, but we investigate the decay into 2 photons (the diphoton channel.)

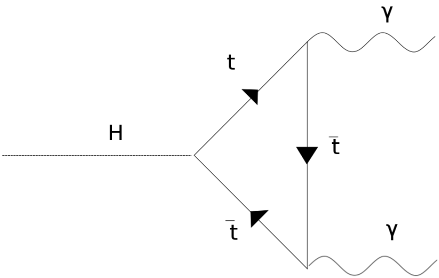

Figure: Decay of Higgs into 2 photons

This has a branching fraction of order of 10^{-3} but is much easier to detect experimentally.

Simulation

The Higgs events and background events are simulated using PYTHIA. The simulation consists of a text file of the Energy and momentum (4 momentum) of each photon in each event (read collision.) We will use 1 simulation of Higgs events (which still have background in them) and 1 simulation of background events.

Parsing

- We use a script written in Python 3 to parse the event data from the four momenta
- It calculates the invariant mass of each decay event and outputs this to a plaintext file for plotting
- It can also apply a range of filtering on the events to filter out events that are not Higgs
- The script is written as a library so that we can use its features from other scripts, like our filter optimisation scripts

Terms

Transverse momentum is the component of momentum perpendicular to the beam axis.
etc.. (explain so the audience aren't too confused about particle physics terms)

Weighting

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$$\frac{\text{num. Higgs events}}{\text{num. background events}} = \frac{\sigma(\text{Higgs produced}) \times B_f\,(H \to \gamma\gamma)}{\sigma(\text{background})}$$

By knowing the branching factor of the Higgs to two photons decay, as well as the cross sections of the background and of the Higgs production, we can use the above equation to calculate how much weighting we need to apply to the Higgs or background events in our histogram.

Filtering

- There are $\sim$ 100 Higgs events to $\sim$ 100,000,000 background events
- If we do not have good filtering then there is no chance of seeing the Higgs events amongst the background events
- We need an effective way to distinguish Higgs events from background events

Filter Methods

1. Transverse momentum filtering
2. Pseudorapidity filtering
3. Azimuthal angle filtering

Optimising our Filters

To optimise our filters so that we have the best ratio of Higgs events to background events, we need to optimise our filter methods for the highest statistical significance Σ,

$$\Sigma \equiv \frac{S}{\sqrt{S+B}} \tag{1}$$

where S is the number of filtered signal events and B is the number of filtered background events.

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We apply the filtering and calculate the significance for a series of different parameters, for example for different transverse momenta cuts, to see what gives us the best statistical significance.

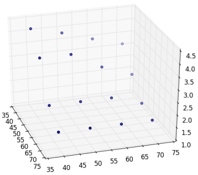

Figure: Statistical significance (height of points) for a series of different transverse momenta

This is a 3D plot generated from a script that calculates the statistical signifiance for various transverse momenta cuts. From graphs like these we can narrow down the ranges of transverse momenta that we filter until we get the highest statistical significance. We use PyPlot to generate our plots.

Seeing the Higgs

Actually observing it explanation

Issues

Further Explorations

Conclusion/Questions