Light Charged Higgs Bosons at the Large Hadron Collider

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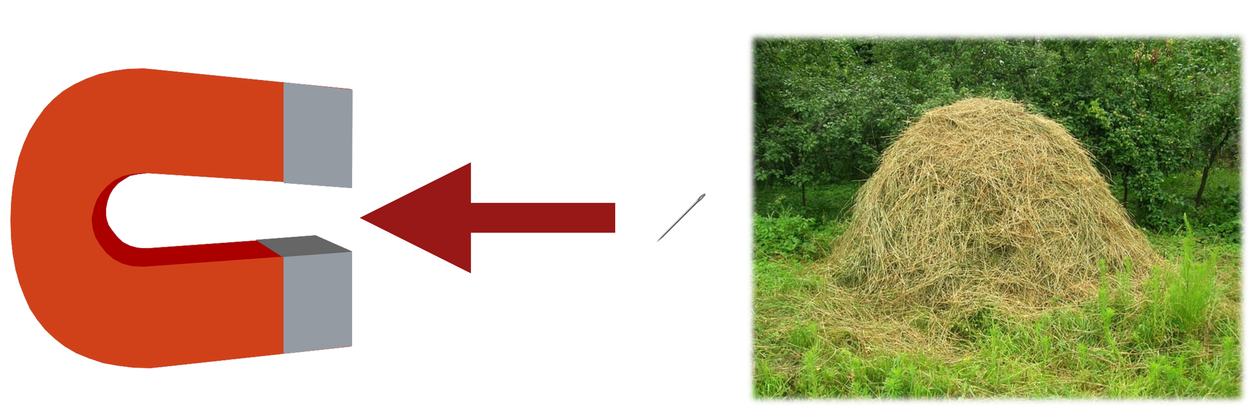
Introduction

In 2012, we found the last missing piece of the Standard Model of particle physics, the Higgs boson. Though this was a tremendous achievement, some questions still remain unanswered - Why is the mass of the Higgs boson so low? What is the nature of dark matter? To answer these questions, we need new theories that extend the Standard Model. Most of these new theories posit the existence of new, as yet undiscovered particles. To find these particles, we smash protons together at extremely high energies, creating new particles which live for a short time before decaying into more familiar particles that we can detect. By measuring the speed and direction of these familiar particles, we can 'play the movie backwards' and say whether a new particle was formed in the collision or not.

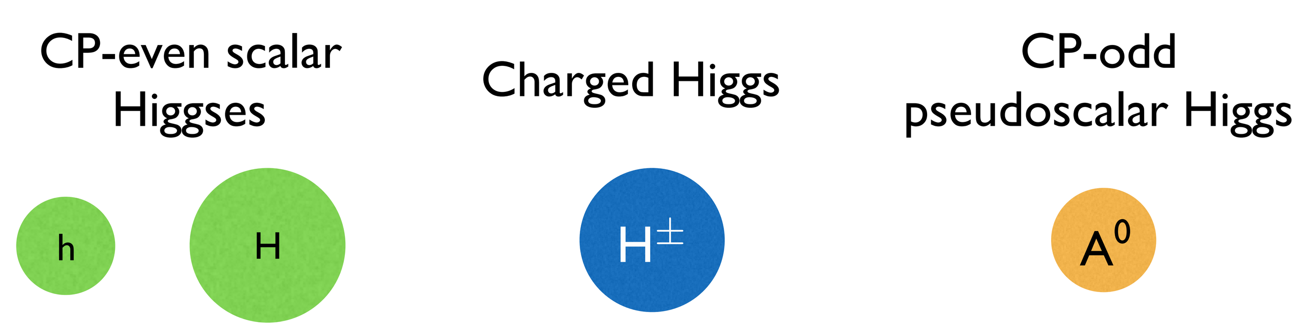
The trouble is, at a particle collider, there are hundreds of millions of collisions per second. Only a tiny fraction of these will create new particles. So it's like looking for a needle in a haystack, except way worse.

The good news is that we can devise clever ways to cut away background events and isolate the signal events, using our knowledge of physics. In fact, the right search strategy can act as a powerful magnet to yank that needle right out of the haystack!

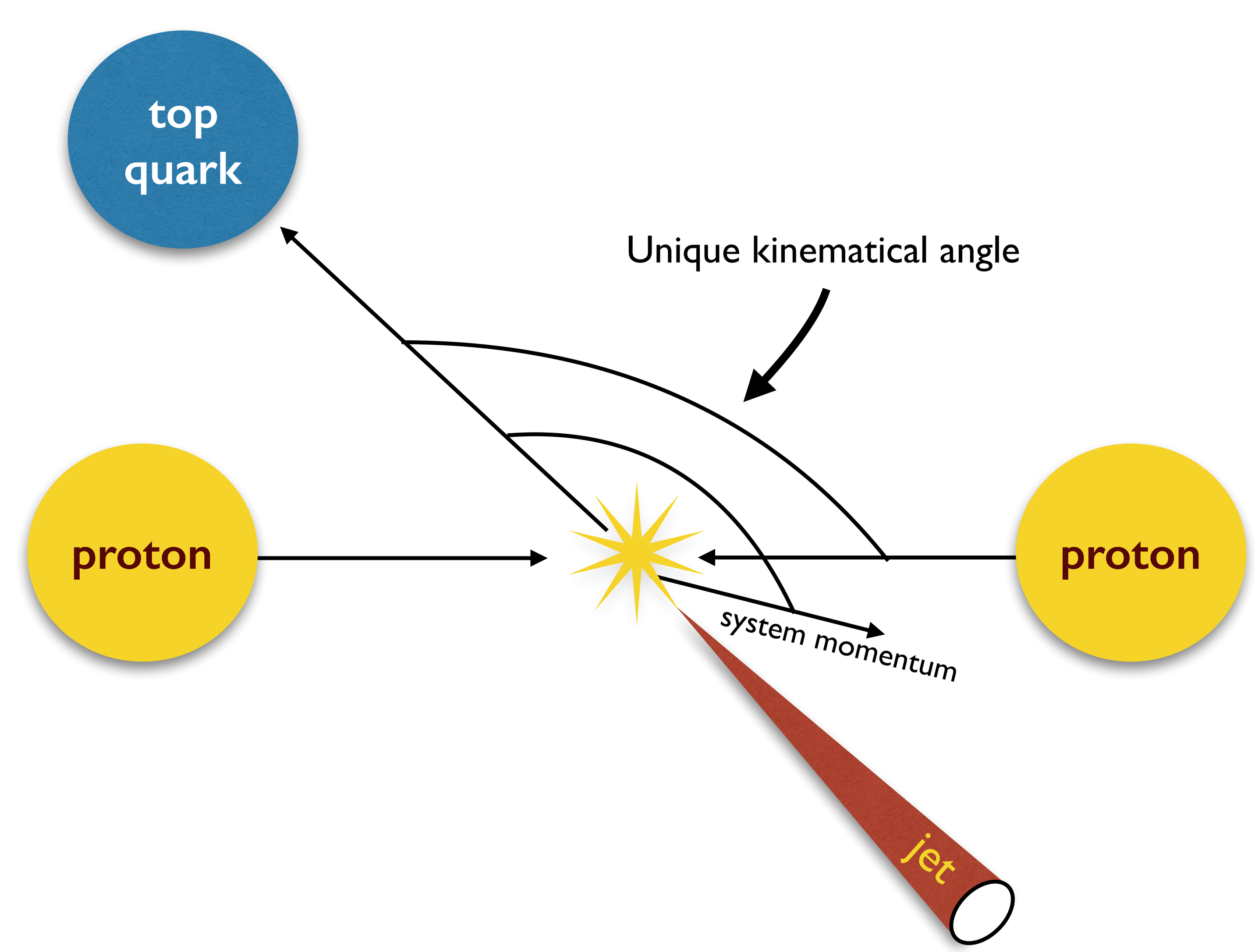


Model and Methods

We chose to study the Two-Higgs Doublet Model, a theoretically very well-motivated extension to the Standard Model, that predicts the existence of a number of new particles, shown below.

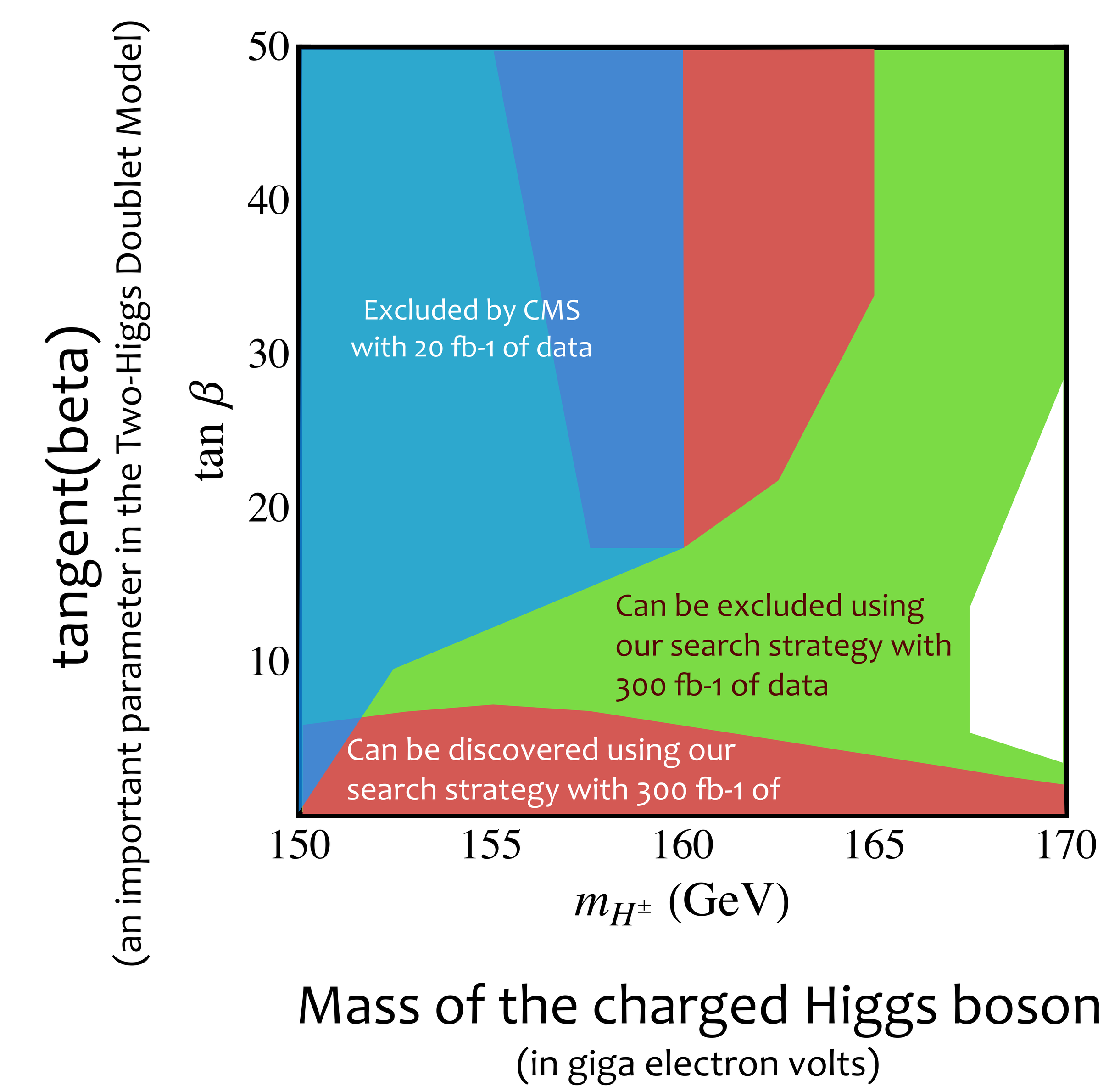


In our study, we focused on the prospects of finding the charged Higgs boson at the Large Hadron Collider. Current experimental searches have placed strict limits on what the mass of the charged Higgs boson can be, but they have neglected the very real possibility that the charged Higgs can decay into a lighter, pseudoscalar Higgs boson. If we consider this possibility, those limits are considerably weakened. We propose a way to examine this 'exotic' decay mode using a unique kinematical angle in the single-top channel.



Conclusion

The end product of our analysis is a plot showing the regions of the parameter space of the Two-Higgs Doublet Model that can be explored with our search strategy.



The blue region has already been excluded by the standard experimental searches. We expect that with additional data, they will be able to exclude most of the top half of the plot as well. However, they are weak for low values of tangent(beta), which is precisely where our analysis shines (the red region at the bottom). Thus, our search strategy is complementary to the traditional search strategy and is truly necessary for us to get the complete picture.

Charged Higgs bosons are challenging to find, but finding even one would be an unmistakeable and exciting sign of new physics beyond the Standard Model.