Search for pair production of Higgs bosons in the $b\bar{b}b\bar{b}$ final state using proton–proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector

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Abstract

We present a search for Higgs boson pair production, with two $b\bar{b}$ pairs in the final state. This analysis uses the full 2015 and 2016 data collected collected by the ATLAS Collaboration at $\sqrt{s} =$ 13 TeV, corresponding to $X \pm y$ fb^{-1} of 2015 and $A \pm B$ fb^{-1} of 2016 pp collision data. The data are interpreted in the context of the bulk Randall-Sundrum warped extra dimension model with a Kaluza-Klein graviton decaying to hh.Relative to the 2015 analysis, this analysis focuses on improvements in the boosted analysis in the highest resonance mass range (between 2000 GeV and 3000 GeV). The data is found to be compatible with the Standard model, and no signs of new physics have been observed.

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This is the dedication.

Acknowledgments

Thank you Melissa Franklin, the best adivsor ever. It was five years ago when I made the decision, that of all the schools I visited, Melissa is the only one that will make my life ”suffer” the most for the next five years. And I think it is safe to say that I was still right. This is probably one of the hardest paths I could foresee, yet at every corner, Melissa is there to guide me and show me the lights at the end of the tunnel. She is always pushing me to understand the details I ignore, and think about every action I make in analysis or operations. Her encouragements, or complains about my progress, have always been insparational and keep me moving ahead. There have been multiple nights when I was worried about work, and after talking to her, I always felt much more confident. Thank you, Melissa. Thank you, Melissa. Thank you, Melissa.

Thanks to my friend, Stephen–I don't know how to pronaunce his middle name–Chan, for his great acompany and help. Dr. Chan has been extermely awesome-o.

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Thank you my mother Liping Sun, who has always been the greatest understanding for me. She has always been the wisest person I know, and she will always be.

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Introduction

Why do we look for $hh \to 4b$?

There are two types of analysis in particle physics. The first one is measurement, which yeilds a observable with an uncertainty. This could either imrpove our knowledge of the Standard Model, or show some inconsistency with the Standard Model. The other type is search, which generally assumes some new physics model and try to justfy in data wether the new model is justified in some observables. A successful search turns the subject into a measurement, yet a null result will set a new limit for a given physics model.

Knowledge knows no bounds.

Random People

1

Motivation for searches beyond the Standard Model

There's something out there that we don't know.

Run.

Random Person

2

Machine of discovery–The Large Hadron Collider

2.1 Design

2.2 Performance

DAMN.

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Eyes of giant–The ATLAS Detector

We love ATLAS.

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Game of Jigsaw–Reconstruction

4.1 Introduction to objects

Leptons are rare in proton-proton collisions. Less than 1% of the total tracks are made from leptons, and these are often related to very interesting physics processes, especially invovling the electroweak forces.

Electrons are maximal inoizing in the tracking system. They get absorbed completely in ECAL nd leaves no signature in the HCAL.

Muons are special for leaving minimally ionizing signatures in the detector. They usually penetrate the calorimeter and form tracks in the Muon Spetrometer. This is useful for reducing the generate rate of events, hence for triggering. They are also very clean in reconstruction and have exceelnt resolutions up to 1 TeV.

Jet mass, see .

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Censor of work–Data Quality

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Event Selection

6.1 Optimization Strategy

To improve the analysis, a quantity which defines the sensitivity of analysis is maximized. This is usually described as $\frac{S}{\sqrt{B}}$, when no knowledge of the model cross section is available, or $\frac{S}{\sqrt{S+B}}$, if the signal cross section is known. These parametrizations have limitations, particularly when the signal yield and the number of estiamted background are both small. A better parametrization for low signal strengh is $\frac{S}{\sqrt{1+B}}$, where the extra $\sqrt{1+B}$ accounts for poisson fluctuations.

For this analysis, two methods are used: one is calculate the number of signal and backgrounds within 68% of the signal m_{hh}mass window, the other is to implement the full signal and background predicions after smoothing and compare the asymptotic expected exclusion limits. Both methods yield comparable results.

To avoid bias during the optimzation process, data's signal regions are blinded.

6.2 b TAGGING

b-tagging, which is the identification of the $b$hadron, [1] is the core and main limiting factor of this analysis. Because of the relatively long lifetime, it is possible to tag the $b$hadron using the inner detector informations. A higher b-tagging efficiency will increase the signal selection efficiency, while a lower b-tagging fake rate will reduce the background like $gg \to c\bar{c}$ in the signal regions.

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Background Estimation

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8 Systematics

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Result

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Intepretation

In order to avoid the Oops-Leon cases, commonly accepted standard for announcing the discovery of a particle is that the number of observed events is 5 standard deviations (σ) above the expected level of the background.

With no excess observed, a limit needs to be set on the cross section of the signal [2].

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Conclusion

We will find something new one day, because there is always soemthing new.

A

Some extra stuff

Some appendix.

References

[1] Georges Aad et al. Performance of *b*-Jet Identification in the ATLAS Experiment. *JINST*, 11 (04):P04008, 2016. doi: 10.1088/1748-0221/11/04/P04008.

[2] Glen Cowan, Kyle Cranmer, Eilam Gross, and Ofer Vitells. Asymptotic formulae for likelihood-based tests of new physics. *Eur. Phys. J.*, C71:1554, 2011. doi: 10.1140/epjc/s10052-011-1554-0,10.1140/epjc/s10052-013-2501-z. [Erratum: Eur. Phys. J.C73,2501(2013)].