Estimating $ZZ \to llνν$ background in the $ll + E_T^{miss}$ final state using $Zγ \to llγ$ data

A Thesis

submitted to
Indian Institue of Science Education and Research, Pune
in partial fulfillment of the requirements for the
BS-MS Dual Degree Programme

by

Mangesh Sonawane
Registration Number: 20121083

Indian Institute of Science Education and Research, Pune
Dr. Homi Bhabha Road,
Pashan, Pune 411008, INDIA

June 2017 - April 2018

Conducted at : DESY
Notkestraße 85,
22607, Hamburg
Germany

Supervisor: Dr. Beate Heinemann

Certificate

This is to certify that this dissertation, entitled "Estimating $ZZ \to ll\nu\nu$ background in the $ll + E_T^{miss}$ final status using $Z\gamma \to ll\gamma$ data", submitted towards the partial fulfilment of the BS-MS dual degree programme at the Indian Institute of Science Education and Research (IISER), Pune, represents the work carried out by Mangesh Sonawane at the Deutsches Elektronen-Synchrotron (DESY), Hamburg, under the supervision of Dr. Beate Heinemann, Professor of Experimental Particle Physics at the Institute of Physics, University of Freiburg, during the academic year 2017-2018.

Mangesh Sonawane

Dr. Beate Heinemann

Committee:
Dr. Beate Heinemann
Dr. Seema Sharma

I dedicate this thesis to my parents, Avinash and Ranjana Sonawane, my mentors, Dr. Sourabh Dube and Dr. Seema Sharma, and to my friends and colleagues and IISER, without whose timely advice and support this thesis would not have been made possible.

Declaration

I hereby declare that the matter containined within the thesis entitled "Estimating $ZZ \to ll\nu\nu$ background in the $ll + E_T^{miss}$ final status using $Z\gamma \to ll\gamma$ data", contains the results of the work carried out by me at the Deutsches Elektronen-Synchrotron (DESY) Hamburg, under the supervision of Dr. Beate Heinemann, and the same has not been submitted elsewhere for any other degree.

Mangesh Sonawane

Dr. Beate Heinemann

Committee:
Dr. Beate Heinemann
Dr. Seema Sharma

Acknowledgements

I would like to express my deepest gratitude for Dr. Beate Heinemann for her guidance and patient mentoring. It's not just technical skills that I have acquired under her supervision, but also an understanding of how a physicist approaches the subject and tackles the inevitable problems that surface.

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Abstract

In the search for Dark Matter (DM) at the LHC, SM particles are produced in association with DM particles, which are invisible as they don't interact with the detector. Thus events with large imbalance in transverse momentum are of interest. One such signature is $ll + E_T^{miss}$. The dominant background contributing to the search for DM in the $ll + E_T^{miss}$ is $ZZ \rightarrow ll\nu\nu$. Currently, this background is determined using Monte Carlo simulation, with an uncertainty of $\approx 10\%$ [1]. The goal of this study is to establish a data driven method to estimate this background, and reduce the uncertainty. Using $Z\gamma \rightarrow ll\gamma$, which is a process with low backgrounds and has a high $BR*\sigma$, it is possible to estimate the $ZZ \rightarrow ll\nu\nu$ contribution. In regions where $p_T(\gamma) \gg M_Z$, the two processes are kinematically similar. They have the same production mechanisms, but differ due to the photon and Z boson couplings to the quarks being different, as well as the difference in mass (photons are massless, while Z bosons are massive). Introducing a transfer factor R as the ratio $\sigma(ZZ)/\sigma(Z\gamma)$ which is determined from simulation, the contribution of $ZZ \rightarrow ll\nu\nu$ to the background can be estimated from $Z\gamma \rightarrow ll\gamma$ data. The uncertainty on the prediction of R due to theoretical aspects is estimated in this work.

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