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Giuliano Gustavino

Search for New Physics in Mono-jet Final States in pp Collisions

at $\sqrt{s}$ = 13 TeV with the ATLAS Experiment at the LHC

Doctoral Thesis accepted by
Sapienza University of Rome, Italy

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A zia Maria,
al suo sorriso
ed al suo esempio
di una vita vissuta sempre
con gioia ed allegria.

Supervisor's Foreword

Astronomical and cosmological observations support the existence of invisible matter that can only be detected through its gravitational effects, thus making it very difficult to study. This mysterious matter known as "Dark Matter" makes up about 27% of the known universe. As a matter of fact, one of the main goals of the physics programme of the experiments at the Large Hadron Collider (LHC) of the CERN laboratory, is the search of new particles that can explain the Dark Matter.

In this context, Giuliano Gustavino's thesis documents his original work performed in searching for Dark Matter effects in the data by collected the ATLAS experiment at LHC at the highest centre of mass energy, 13 TeV, ever reached at a particle collider. The results of Giuliano's work provide an outstanding picture of Dark Matter limits at low Dark Matter masses from new physics models. These limits are complementary to the ones obtained with direct detection experiments. Moreover, they expand our knowledge of one of the most important and challenging questions facing physicists today.

Rome, Italy
March 2017

Prof. Stefano Giagu

Abstract

Many cosmological observations indicate that the matter predicted and described by the Standard Model constitutes only a small fraction of the entire known universe. These astrophysics measurements infer the existence of Dark Matter which is constituted by beyond the Standard Model particles. Among the possible different approaches to search this kind of particles, in this thesis a detailed description of the mono-jet analysis is addressed in which final states with high transverse momentum and an energetic hadronic jet needed to tag the events are considered.

The results presented are based on the full dataset recorded in 2015 in the ATLAS experiment at the centre of mass energy of colliding protons of 13 TeV at LHC. The level of agreement observed between data and Standard Model predictions is interpreted as limits in different theoretical contexts, such as compressed supersymmetric models, theories which foresee extra-spatial dimensions, and in the Dark Matter scenario. In the latter, the limits are then compared with the ones obtained by other ATLAS analyses and by experiments based on completely different experimental techniques.

Finally, a set of possible analysis improvements is introduced in order to reduce the main uncertainties which affect the signal region and to increase the discovery potential by exploiting further the information of the final state.

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