Summary

Despite the astonishing success of the Standard Model of particle physics (SM) in describing high energy physics results, culminated with the Higgs Boson discovery in 2012, it is widely accepted that it is not a complete theory. For example there are several cosmological and astrophysical observations indicating that SM can account for only ∼5% of the mass and energy in the universe. In particular ∼27% of the Universe mass-energy is of completely unknown nature: this is known as Dark Matter (DM).

One of the most interesting DM candidate is a weakly interacting massive particle (WIMP). If DM interacts with SM particles, WIMPs can be produced in proton-proton collisions at colliders like LHC and, as they don't interact with the detector, they can be measured only as missing transverse momentum (E_T^{miss}). To tag those events a detectable physics object, such as single photon or jet, as well as Z, W or Higgs boson, is required to be produced in association with DM particles. Such searches with the LHC detectors are known as Mono-X searches: first results on Run 1 measurements and preliminary analysis of Run 2 data, taken during 2015 and 2016, have shown no deviations from SM predictions. However, the increased amount of data collected by ATLAS detector in 2015-2018 will permit to enhance their discovery or exclusion potential, thus extending the reach of DM searches.

The *Mono-Photon* analysis fits in the Mono-X framework, searching for events where the final state carries a Mono-Photon signature. The $E_T^{miss} + \gamma$ final state is relatively clean, only few SM processes show such signature in their final state. The dominant backgrounds consist in processes with a Z or W boson produced in association with a photon (mainly Z($\rightarrow \nu\nu$) + γ) and are estimated by normalizing the Monte Carlo predictions for those backgrounds with a simultaneous fitting technique, which is based on control regions enriched by a specific process. Other backgrounds, like W/Z + jet, top and diboson, in which electrons or jets are reconstructed as photons, are estimated with data-driven techniques since MC simulations don't describe accurately fake photons. In particular the jets faking photons background estimation for the ATLAS Mono-Photon search is the subject of the work presented in this thesis.

Photons in ATLAS are reconstructed from clusters in the electromagnetic calorimeter and tracks in the inner detector. Photons candidates are then required to fulfill a set of identification criteria on shower shapes variables in the

calorimeter and finally an isolation selection is applied to define the photon sample. The estimation of the jets faking photons background is done using an ABCD method, in which the candidate photons are divided in four regions according to their isolation and identification (tightness), assuming that true photons are fully contained in the tight-isolated region, while the other regions contain only background photons (fake photons), and that the isolation and tightness variables are uncorrelated. The model has to be corrected to take into account signal leakage, from the signal region to each of the other three regions, and the correlation within all the four regions: this is done by means of MC simulations. To account for these effects three signal leakage coefficient (c_1, c_2, c_3) and one correlation factor (R) are computed using different MC samples: W + γ, Z + γ, Z($\nu\nu$) + γ for signal photons, and W + jets, Z + jets for background photons. Coefficients of W and Z bosons are pretty different, especially for c1 (signal leakage from the tight-isolated region to the tight-not isolated region): this difference is not fully understood and has been included as a systematic uncertainty. To evaluate the compatibility between simulations and real data an R' (R *prime*) coefficient has been computed, which is simply a correlation factor in a completely not-isolated region where the signal contamination is expected to be negligible: results for simulations and real data are compatible within one sigma, we can then assume that also MCs predictions in the signal region can be trusted.

With this method it has been possible to estimate purities for 2015-2016 data in each region of the analysis: a purity going from 83% to 100% in the various regions has been measured, with a statistical uncertainty going from 0.3% to 14% and a systematic error between 0.6% and 29%, mainly due to systematics on the tightness. Results are in good agreement with those of the publised analysis on the same dataset. The new analysis on Run 2 dataset is still ongoing with a factor of 4 more data that will produce much more precise evaluation of the number of signal Mono-Photon events. The methodologies developed in this work are ready to be applied to the entire Run 2 dataset as soon as the analysis will be unblinded. Results are expected to be published in January 2020.