Introduction

The top quark has been discovered in 1995 by the CDF and D0 experiments at the Tevatron proton-antiproton ($p\bar{p}$) collider. Since its discovery, the study of the top quark has represented one of the most interesting and investigated fields in particle physics because of its very peculiar properties, like the high mass and the short decay time. The top quark mass value $m_t = 173.2 \pm 0.9\ GeV$ [7] constitutes one of the Standard Model (SM) fundamental free parameters and makes the top quark the heaviest known fundamental particle. For this reason, in many beyond SM theories, the top quark is the preferred coupling partner for most of the predicted new particles, as the Z' boson.

The top quark decays via the $t \rightarrow Wq$ process where the produced quark has bottom flavor in almost every cases; this implies that the $|V_{tb}|$ element of the Cabibbo-

Kobayashi-Maskawa (CKM) matrix is close to one. This establish an important experimental results for the SM. The top quark has also the peculiarity to decay before its hadronization. This implies the unique possibility to observe the properties of a *bare quark*, as for example spin effects on the decaying products.

Top quark studies play an important role in the physics program of the Large Hadron Collider (LHC) and in particularly for the ATLAS experiment. Thanks to the very high luminosity and collision energy at LHC, the number of produced top quarks is considerably larger with respect to Tevatron, allowing to perform high statistic precision measurements.

In proton-proton *(pp)* collisions, top quarks are produced in pairs or individually through the strong or the weak interaction respectively, allowing important tests on the features of these two fundamental forces present in the SM. The large amount of top quark pairs ($t\bar{t}$) allows measurements of the differential cross section as a function of different kinematic variables (rapidity, momentum, mass, etc.). These studies are used to verify the SM predictions and validate Monte Carlo models. They also have a great importance in the characterization of the top quark production mechanism: it is a key ingredient for the investigation of physical channels where the top quark is a dominant background (as for in some Higgs boson analysis) and permits to search for new physics by looking at new resonances decaying to $t\bar{t}$ pairs. Moreover, the measurements of $t\bar{t}$ production, having a multifarious signature involving jets, electrons, muons and missing transverse energy, needs a detailed understanding of the whole apparatus; it constitutes then a good opportunity to test the comprehension of the detector.

Two $t\bar{t}$ differential cross section measurements, performed applying different event selections on two different data samples, are presented in this thesis.

The first one is the measurement of the $t\bar{t}$ system differential production cross section performed on all the statistics collected in 2011 at a center of mass energy $\sqrt{s} = 7TeV$, with an integrated luminosity of $\mathcal{L} = 4.7fb^{-1}$. The analysis has been performed in the *lepton+jets* channel, where one of the W bosons coming from the top quark decays in a lepton and neutrino and the other one into two quarks. A cut-based selection is performed in order to reduce background, then events are unfolded to the *parton level* in order to allow comparison with theoretical predictions and results from other experiments. The differential cross section spectra as a function of the $t\bar{t}$ and top quark kinematic variables are measured and found to be in good agreement with the expectations; these results have been collected in an ATLAS public conference note [76]. During this measurement I followed all the analysis steps and in particular I has been involved in the implementation of unfolding techniques and in the estimation of the systematic uncertainties.

Thanks to the increased center of mass energy to $\sqrt{s} = 8TeV$ in pp collisions acquired during 2012, it is possible to study the cross section behavior at an unprecedented momentum scale. Many analyses, also in the top quark sector, have specifically concentrated efforts on the study of these frontier high-energy regions in order to search for hints of new physics or confirmation of the SM. Many specific algorithms have been developed in order to deal with such a high-momentum objects that possess peculiar signatures. In particular, in the hadronic decay of high transverse momentum top quarks, where the W boson decays to two quarks, the final state products can partially overlap and be reconstructed in a single, energetic and large radius jet, called *fat jet* or *large-R jet*. The identification of these boosted objects rely on tagging algorithms based on the *large-R* jets internal substructure. I'm involved in the application and tuning of some of these *tagging* techniques and in particular on a template based one called template overlap method (TOM). In this prospective, the second analysis described in this PhD thesis aims to study the behavior of $t\bar{t}$ pairs at high transverse momentum, measuring the differential production cross section as a function of the hadronic top p_T using a specific cut-based selection exploiting jet substructure properties. Studies for the application of more sophisticated selection algorithms are ongoing and only preliminary studies on the TOM technique will be presented here. The *lepton+jets* events used, have been extracted from the 2012 data samples at a center of mass energy $\sqrt{s} = 8TeV$ with an integrated luminosity of $\mathcal{L} = 20fb^{-1}$. Data have been unfolded at the *particle level* in order to obtain a more detector-independent comparison with theoretical predictions and other experiments results. This analysis is one of the first performed at such high momentum region and the results presented are still preliminary. I am the main code developer and analyzer for this measurements and I am currently performing all the analysis steps from the selection to the background estimates and the unfolding process. I also become one of the developers of an analysis package included in the ATLAS official analysis framework called Top Root Core (TRC). The package named TopD3PDBoosted, is designed to perform full top quark analyses in both boosted and resolved regimes; it is already used in more than one analysis. The package also includes the TOM algorithm ready to be used in boosted selections. I have been appointed as one of the editors of the internal note regarding this analysis [77].

The structure of the thesis is the following. In *Chapter 1* the theoretical aspects of the top quark and its cross section measurements are considered. The description of the ATLAS detector and its trigger system is done in *Chapter 2*. A detailed treatment of the Monte Carlo simulation for both $t\bar{t}$ signal and the different backgrounds considered are reported in *Chapter 3* together with the data-driven background estimation methods. In *Chapter 4* the reconstruction of physical objects used during the analysis is fully described beside the treatment of high transverse momentum objects topology and some of the main techniques adopted in ATLAS for their reconstruction. The events selection, the comparison between data and Monte Carlo events and the unfolding procedure are described in *Chapter 5* while the evaluation of the measure uncertainties and the presentation of the final differential cross section results are accomplished in *Chapter 6*. In the *Conclusion*, a summary of the results obtained is presented.