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Perspectives for $t\bar{t}$ cross-section measurement at ATLAS

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Summary. — The top-antitop pair production is one of the dominant processes in proton-proton collisions at multi-TeV energies. Here are presented the prospects for measuring the total top pair cross-section with the ATLAS detector using $200\,\mathrm{pb}^{-1}$ of data taken at 10 TeV. The cross-section is determined in the single-lepton channel, and in the dilepton channel. Data-driven methods are studied to estimate the main background in both channels.

PACS `29.85.Fj` – Data analysis.

1. – Introduction

Besides allowing a direct comparison with theoretical calculations, the measurement of the top-pair production cross-section at the LHC will likely be the first one implying the reconstruction of final states including jets, electrons (e), muons (μ) and missing transverse energy ($\not{E}_T$), and therefore it is an essential stepping stone toward the identification of new physics.

The analyses, in the single-lepton and dilepton $t\bar{t}$ decay channels, have been performed using Monte Carlo (MC) samples and full simulation of the ATLAS detector, assuming a center-of-mass energy of 10 TeV and considering an integrated luminosity of $200\,\mathrm{pb}^{-1}$. A more detailed description of the analyses can be found in [1].

2. – Event selection

For single-lepton events, the base selection consists in requiring: an e or μ trigger fired, exactly one isolated lepton (e or μ) with $p_T > 20\,\mathrm{GeV}$, $\not{E}_T > 20\,\mathrm{GeV}$, at least four jets with $p_T > 20\,\mathrm{GeV}$, of which at least three jets with $p_T > 40\,\mathrm{GeV}$, at least one dijet combination inside the hadronic top candidate with invariant mass within 10 GeV from the W peak mass. The hadronic top candidate is defined as the three-jet combination of all jets with the highest transverse vector sum momentum. In the $t\bar{t}$ hypothesis, two of these three jets come from the decay of a W-boson.

In the dilepton channel, the events are required to have: an e or μ trigger fired, exactly 2 opposite signed isolated leptons (e and/or μ) with $p_T > 20\,\mathrm{GeV}$, $\not{E}_T > 20\,\mathrm{GeV}$, at least 2 jets with $p_T > 20\,\mathrm{GeV}$ (for $e\mu$ channel) or with $p_T > 35\,\mathrm{GeV}$ (for ee and $\mu\mu$ channels),

TABLE I. – *Left: expected number of signal (S) events, total background (B) events and S/B ratio, for the different channels. QCD background is not included. Right: expected relative uncertainties (%) on the $t\bar{t}$ cross-section determination for different channels and methods. The errors coming from the statistics, from the systematic uncertainties and luminosity uncertainty are shown separately.*

	e+jets	μ+jets	ee	$\mu\mu$	$e\mu$
S	1286	1584	214	327	683
B	598	799	54	87	123
S/B	2.1	2.0	3.9	3.8	5.6

	Cut&Count / Fit		Cut&Count		
	e+jets	μ+jets	ee	$\mu\mu$	$e\mu$
stat.	3.0 / 14	3.0 / 15	8.5	6.6	4.3
syst.	14.5 / 10.5	13.5 / 10.5	13.3	9.8	9.1
lumi.	22 / 20	22 / 20	22	22	22
TOT	27 / 27	26 / 27	27	25	24

dilepton invariant mass ($m_{\ell\ell}$) outside a 5 GeV window around the Z mass (m_Z) peak (for ee and $\mu\mu$ channels only, to reject Z+jets background).

Table I (left) summarizes the expected number of signal and background events.

3. – Cross-section determination and systematic uncertainties

For both the single-lepton and dilepton channels, the $t\bar{t}$ cross-section can be obtained by performing a counting experiment, *i.e.* by subtracting the estimated number of background events from the number of observed events passing the selection, and dividing by the integrated luminosity and the selection efficiency. A second method, called likelihood fit, has been studied for the single-lepton channel. It consists in extracting both signal and background simultaneously by fitting the hadronic top candidate mass distribution.

Table I (right) shows the expected uncertainties for different channels and methods.

4. – Data-driven background evaluation

For the counting method in particular, it is essential to rely on data-driven methods to estimate the major backgrounds, while for the smaller ones, MC simulation is used.

The W+jets background, the main expected background for the single-lepton channel, can be extracted from data by assuming the ratio between Z+jets and W+jets cross-sections constant as a function of the number of jets. Counting the number of Z+4 jets allows to predict the number of W+4 jets.

The Z+jets residual background in the dilepton channel, after the m_Z veto (for the ee and $\mu\mu$ channels), can be extracted from data assuming that the $\not{E}_T$ and the $m_{\ell\ell}$ are uncorrelated, and counting the events in different regions of the $\not{E}_T$ *vs.* $m_{\ell\ell}$ plane.

To estimate the fake lepton background in both the single-lepton and dilepton channels, a method called "matrix method" can be used. The method consists in defining a *loose* and a *tight* isolation selections for leptons, counting the number of events passing each selection, and solving a system of equations by giving as input the probabilities of a *loose* lepton to pass the *tight* selection for *real* and *fake* leptons.

REFERENCES

[1] ATLAS COLLABORATION, *ATL-PHYS-PUB-2009-086, ATL-PHYS-PUB-2009-087* (2009).