Measurement of $pp \to Z \to \mu\mu + X$ cross section with the ATLAS detector at LHC

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Summary. — This work describes the measurement of the inclusive cross-section of the channel $Z \to \mu\mu$ that will represent one of the first physics measurement in ATLAS [1] [2]. A description of the analysis model used together with a discussion on the overall selection efficiency and acceptance calculation will be given.A discussion on the main source of uncertainty on the cross-section measurement will be given as well.

1. – Introduction

The LHC operations started successfully in November 2009 at the center of mass energy of $\sqrt{s} = 900$ GeV and restarted after the winter shutdown in March 2010 at $\sqrt{s} = 7$ TeV. A new long data taking period is foreseen in 2010-2011 with the goal to reach 1 fb^{-1} of integrated luminosity. The measurement of $Z \to \mu\mu$ production cross section will represent a stringent test of QCD and also the measurement of the Z boson properties, like reconstructed mass and width, can be used to assess the performance of the detector (i.e. trigger and reconstruction efficiencies, muon muomentum resolution). The measured total cross-section can be expressed as $\sigma = \frac{N-B}{LA\varepsilon}$ where N is the number of events passing a given set of cuts, L is the integrated luminosity, A is the geometrical acceptance of the signal, ε is the reconstruction efficiency of the signal in within the fiducial acceptance and B is the number of background events. The $Z \to \mu\mu$ cross section, calculated with FEWZ program at NNLO, is 989 pb at $\sqrt{s} = 7$ TeV. The overall measurement uncertainty gets contributions from the different terms as $\frac{\delta\sigma}{\sigma} = \frac{\delta N \oplus \delta B}{N-B} \oplus \frac{\delta L}{L} \oplus \frac{\delta A}{A} \oplus \frac{\delta\varepsilon}{\varepsilon}$. In this expression, $\delta N \sim 1/\sqrt{N}$ is of purely statistical origin, and the relative uncertainty decreases with increasing luminosity. The terms δB, δA and $\delta\varepsilon$ are of both theoretical and experimental origin. They are considered as systematic uncertainties in the cross-section measurements, but can be constrained via auxiliary measurements that will improve over time. The uncertainty on this parameter, δL, is expected to be at the beginning at the order of 20% and to decrease with the improved understanding of the LHC beam parameters and of the luminosity detector.

2. – Event selection and background rejection

A single lepton trigger requiring a muon (p_T >10 GeV) is used in the analysis. Events with two muons with p_T >20GeV and $|\eta|$ <2.5 and opposite charge are selected. The main backgrounds in the analysis are: $t\bar{t}$ events where muons come from the $t\bar{t}$ quarks decay in $t \rightarrow Wb$ and $W \rightarrow \mu\nu$, $W \rightarrow \mu\nu$ where one muon come from W decay and the other one is a fake muon, $Z \rightarrow \tau\tau$ due to possibility to have muons from τ decay, jet background due in particular to muons coming from b-hadron decay. In order to minimize the impact of this backgrounds, Inner Detector track isolation cuts are also applied (Σp_T <5 GeV and N^{ID}_{tracks} <6 within a cone around the candidate muon with a size ΔR =0.5). The invariant mass of the muon pair should fulfill $|91.2GeV - M_{\mu\mu}|$ <20 GeV. With this cuts $\sim$ 70% of the $Z \rightarrow \mu\mu$ events with muons in the acceptance are selected. The residual background fraction is 0.004 ± 0.001 and the dominant component comes from $t\bar{t}$ background.

3. – Acceptance calculation

Already in the first stage of data taking ($\sim$50 pb^{-1}), the uncertainties on the acceptance is relevant for the Z cross section measurement. The acceptance is calculated through Monte Carlo simulation (MC@NLO) imposing kinematical cuts (p_T and η) on outgoing muons from Z boson. The contributions to the systematic errors on the acceptance are: the errors on the PDF used, the Initial State Radiation (ISR), the intrinsic p_T of incoming partons, the QED corrections and the spin correlation between incoming partons and final leptons. The dominant contribution comes from the PDF and it has been estimated to be of the order of $\sim$ 4% [3]. Figure 1 shows the acceptance as function of $\sqrt{s}$ for three different p_T cuts on the muons coming from the Z boson decay.

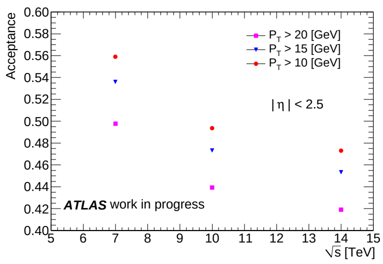

Fig. 1. – *Acceptance as function of c.m.e. for three different* p_T *cuts on the muons coming from the* Z *boson decay and* $|\eta| < 2.5$*(only statistical errors are shown).*

REFERENCES

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