Measurement of the W-helicity in top quark decays with the ATLAS detector using a template method

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1 Introduction

In the Standard Model of Particle Physics (SM), the *Wtb* vertex has a pure *V*-*A*-structure. The helicity of the W-boson in top quark decays can be therefore longitudinal, left-handed or right-handed. The right-handed contribution is strongly suppressed in the SM. Any deviation from the predicted values could be a hint to new physics processes as eg. new particles or non SM couplings.

A data set of 35 pb^{-1}, taken with the ATLAS experiment in 2010, has been used to study the helicity fractions in $t\bar{t} \rightarrow$ l+jets decay. The helicity fractions have been extracted via different methods, using the angular distribution of the charged lepton. One of them is a template method that will be presented in the following. All results obtained so far are in good agreement with the SM.

2 The Template Method

For the reconstruction of the event one high-p_T lepton, missing transverse energy and at least four jets (at least one of them b-tagged) are required. For the μ+jets channel 246 events and for the e+jets channel 156 events have been selected which is in good agreement with the Monte Carlo (MC) prediction. The events are fully reconstructed using a kinematic fitter based on a Likelihood approach. The kinematic fit is performed using the four highest p_T jets. All possible jet-parton assignments (permutations) are calculated. Non-gaussian transfer functions (obtained from MC) are applied in the fit. *B*-tagging information is used in the fit. Furthermore the top quark mass is fixed to 172.5 GeV which is the mass used in the generated MC samples. The permutation with the highest Likelihood value is chosen to reconstruct the angular distribution of the lepton.
The signal templates are created using the PROTOS generator [2]. Samples with pure left-handed, pure right-handed and pure longitudinal W-bosons are created.

Therefore every possible final state can be created by reweighting the signal templates. A likelihood fit is performed while fixing F_{R} to zero. One background template is used in the fit. The background contribution is constrained by a Gaussian distribution.

3 Results

Systematic uncertainties have been estimated using pseudo data. Ensemble tests have been performed with 2000 ensembles each. The ensembles have been created assuming Poissonian fluctuations in each bin. The difference of the mean values between the standard pseudo-experiment and the systematic varied distribution has been used as uncertainty. Each channel has been studied separately. Afterwards, a combined likelihood fit has been performed. The uncertainties are dominated by the statistical uncertainty, ISR/FSR and jet modeling.
For the combination, the fractions obtained are $F_0 = 0.59$ and $F_{\mathrm{L}} = 0.41$ with a statistical uncertainty of 0.10 and a systematic uncertainty of 0.07. The result of the combined fit is compared to the Standard Model expectation in Fig. 1. No deviation

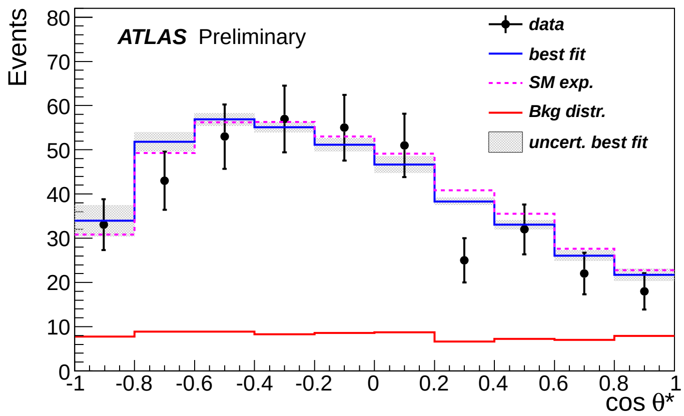

Figure 1: Comparison of the data distribution with the best fit result (solid line) and the SM expectation (dashed line). The results are in good agreement with the SM expectation [1].

from SM expectations has been found.

4 Interpretation in the effective field theory

The measurement presented above can be used to make statements about new physics processes. If an effective Lagrangian is considered as discussed in [3], new operators are introduced, denoted here as O_x (dimension-six operators). One of these new operators (C_{uW}^{33}) can alter the helicity fractions [4, 5].
The results presented in the previous section are used to set a limit on the corresponding coefficient C_{uW}^{33}:

$$\frac{\mathrm{Re}\,(C_{uW}^{33})}{\Lambda^2} \in [-2.14, 5.77]\ \mathrm{TeV}^{-2} \quad (\text{at } 95\ \%\ \text{C.L.}) \quad . \tag{1}$$

This result is still in agreement with the Standard Model prediction. More data and a better understanding of the systematic uncertainties is neccesary to reduce the uncertainties and to therefore set a more precise limit on the coefficient.
The helicity fractions have been calculated with a second method studying angular asymmetries. Those results are in good agreement with the ones presented above and can be found in [1].

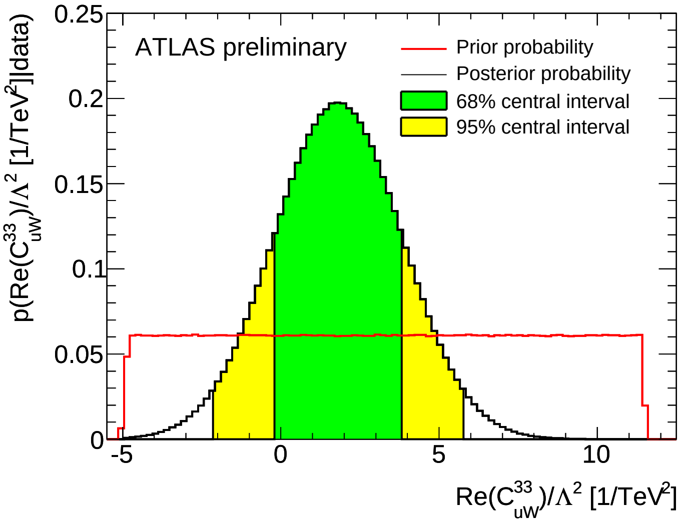

Figure 2: Limit on the dimension six operator using the results from the template fit. The flat a-priori distribution is shown along with the posterior distributio n including the 68 % and the 95 % regions [1] .

References

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