Summary of 'D0 Collaboration, *'Simultaneous measurement of forward-backward asymmetry and top polarization in dilepton final states from $t\bar{t}$ production at the Tevatron'*

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The D0 collaboration presents a simultaneous measurement of the forward-backward asymmetry $A^{t\bar{t}}$ and the top polarization kP at the Tevatron in dilepton final states of $t\bar{t}$. The analyzed events orginate from $p\overline{p}$ collisions and correspond to an inverse luminosity of $\mathcal{L} = 9.7\,\mathrm{fb}^{-1}$. Due the center of mass energy of $\sqrt{s} = 1.96\,\mathrm{TeV}$ and the collision of protons with anti-protons, the production of $t\bar{t}$ is induced from quark anti-quark anhilation and not gluon fusion making this measurement possible.

The Standard Model (SM) of particle physics predicts values for the asymmetry and polarization. These values can also be extracted from Beyond Standard Model models like axigluon models[2]. Therefore, this analysis yields a test of those predictions with the experimental results. In this analysis the theory predictions are calculated for both SM and the axigluon models.

Using the dilepton final state of $t\bar{t}$ the signature of the events consist of two jets with high transverse momentum p_T originating from the hadronization of two b quarks, two high p_T leptons and missing transverse Energy $\not{E}_T^{\mathrm{miss}}$ from the undetected neutrinos. Due to this topology, processes with similar shapes lead to background contributions. The main processes for background are $Z \to ll$ with $l = e, \mu, \tau$, diboson production (WW, WZ, ZZ) but also W+jets and multijet events considering misreconstruction from jets as leptons. The last two background sources are considered "instrumental background" and their contribution is derived from data. Whereas, the firstly mentioned backgrounds are estimated using Monte Carlo (MC) samples. Furthermore, certain event selection criteria such as isolation criteria ,which suppresses misidentification of muons that originate from hadron decays as prompt ones, are applied in order to constrain the contribution of background events.

In order to yield a result for $A^{t\bar{t}}$ and kP, distributions that are related to these values are extracted from the data using a matrix element method[3]. The searched distributions are $\Delta y_{t\bar{t}}$, which represents the difference in rapidity of the top and anti-top, and $cos(\theta^{\pm})$ where θ is the angle between the (anti-)lepton and the (anti-)top. The matrix element method consists of a few steps. First, for every event a likelihood distribution is calculated. Second, the likelihood variables are constrained to a set of 4 to 6 variables depending on the lepton final states. Third, the likelihood distributions for $\Delta y_{t\bar{t}}$ and $cos(\theta^{\pm})$ are extracted by integration of the likelihood. Lastly, these likelihood distributions are accumulated and used in order to obtain a result for the asymmetry and polarization. It is noticeable, that $A^{t\bar{t}}$ and kP are not calculated using the maximum likelihood value of the $\Delta y_{t\bar{t}}$ and $cos(\theta^{\pm})$ but rather by using the entire likelihood distribution.

However, these extracted "raw" values called $A^{t\bar{t}}_{\mathrm{raw}}$ and kP_{raw} do not account for dilution effects of the detector, resolution effects of the reconstruction and the simplified constrains in the matrix element measurement, used in order to minimize the likelihood variables. Consequently, a calibration of the "raw" values has to be implemented. Using MC, a calibration matrix C, offset vector O and reweight factors for the $\Delta y_{t\bar{t}}$ and lepton angular distribution are calculated. So, the true values for $A^{t\bar{t}}$ and

kP can be calculated using

$$\begin{pmatrix} A^{t\bar{t}}_{\text{raw}} \\ kP_{\text{raw}} \end{pmatrix} = C \cdot \begin{pmatrix} A^{t\bar{t}} \\ kP \end{pmatrix} + O\,.$$

The main contributions to the systematic uncertainty arise from the variable variation of the model and from the hadronisation and showering from the signal modeling. However, the main uncertainty of this measurement is found within the statistical uncertainty caused by the lack of analyzed events. One specific detail about the uncertainties in this analysis is the statistical correlation between the measured quantities and the additional systematic uncertainty caused by the calibration of the raw values of $A^{t\bar{t}}$ and kP.
The results of the calibrated values for the asymmetry and the polarization are

$$\begin{aligned} A^{t\bar{t}} &= (15.0 \pm 6.4(\text{stat.}) \pm 4.9(\text{syst.}))\,\% \\ kP &= (7.2 \pm 10.5(\text{stat.}) \pm 4.2(\text{syst.}))\,\% \end{aligned}$$

with a correlation of $-56\,\%$ between them. These values are in agreement with the SM value of $A^{t\bar{t}} = (9.5 \pm 0.7)\,\%$ and $kP = (-0.19 \pm 0.05)\,\%$. This agreement can be seen in figure 1 due to the SM value being located in the 68 % confidence level interval of this measurement. However, all the considered BSM axigluon theories are also in agreement with the measurement regarding figure 1. By constraining one of the variables to its SM value, the other value can be recalculated. This leads to an result of

$$\begin{aligned} A^{t\bar{t}} &= (17.5 \pm 6.3)\,\% \\ kP &= (11.3 \pm 9.3)\,\% \end{aligned}$$

with fixed kP and $A^{t\bar{t}}$ values respectively. Finally, for $A^{t\bar{t}}$ a previous measurement in the lepton+jets channel [4] can be combined with the measurement value resulting in an value for the asymmetry of $A^{t\bar{t}} = (11.8 \pm 2.8)\,\%$.
This measurement yields no statement towards one of the BSM theories and is compatible with the SM prediction. However, this analysis shows how a measurement of the asymmetry and polarization can be extracted from a $p\bar{p}$ collider experiment. Unfortunately the LHC cannot contribute towards this, due to

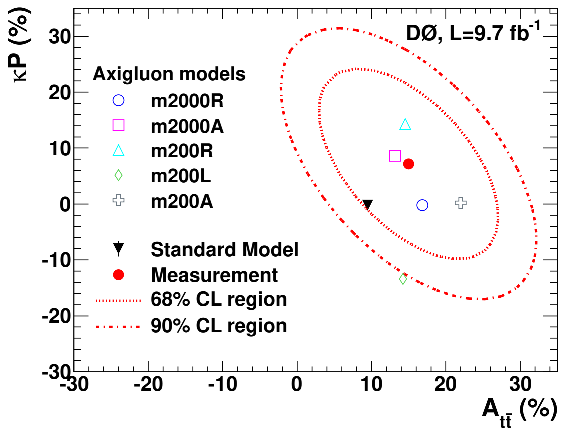

Figure 1: Asymmetry and polarization of the SM and other axigluon models compared to the measurement. The 68 % and 90 % confidence level regions of the measurement are shown as dotted lines.[1]

the main production channel of $t\bar{t}$ being gluon fusion where no asymmetry is present. Consequently, in order to obtain a more convincing result, this analysis should be repeated using more data from Tevatron. Therefore, lowering the high statistical uncertainty.

References

[1] D0 Collaboration, Simultaneous measurement of forward-backward asymmetry and top polarization in dilepton final states from $t\bar{t}$ production at the Tevatron, Phys. Rev. D 92 (2015) 052007.

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[4] D0 Collaboration, Measurement of the forward-backward asymmetry in top quark-antiquark production in $p\bar{p}$ collisions using the lepton+jets channel, Phys. Rev. D 90 072011 (2014).