Top-antitop charge asymmetry measurements in the lepton+jets channel with the ATLAS detector

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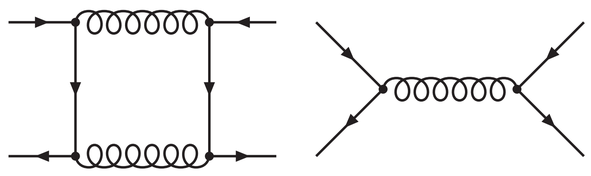
Top 2018, Bad Neunahr

Introduction I.

Definition of $t\bar{t}$ charge asymmetry

$$A_{\mathrm{C}}^{t\bar{t}} = \frac{N(\Delta|y| > 0) - N(\Delta|y| < 0)}{N(\Delta|y| > 0) + N(\Delta|y| < 0)},$$

where $\Delta|y| = |y_t| - |y_{\bar{t}}|$ and y_t ($y_{\bar{t}}$) is the rapidity of the top (antitop) quark.



- In the Standard Model (SM), non-zero asymmetry is predicted due to interference of higher order quark-antiquark annihilation diagrams (main contribution from Box-Born diagram interference)
- Many theories beyond the Standard Model (BSM) predict an enhancement of the asymmetry
- Two measurements were performed by the ATLAS experiment at $\sqrt{s} = 8$ TeV using 20.3 fb^{-1} data in the lepton+jets channel: in the so-called resolved topology [1] and with highly boosted $t\bar{t}$ events [2]

Event Selection and Reconstruction II.

Both Lepton+Jets Topologies

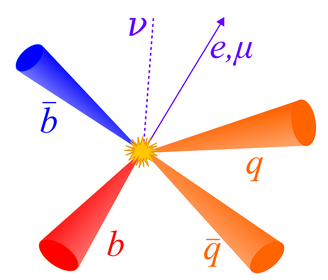
- Single lepton trigger requirements, 1 good lepton with $p_{\mathrm{T}} > 25$ GeV
- $E_{\mathrm{T}}^{\mathrm{miss}}$ requirements, $E_{\mathrm{T}}^{\mathrm{miss}} + m_{\mathrm{T}}^{\mathrm{W}} > 60$ GeV

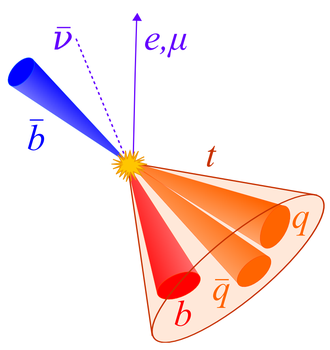
Resolved

- At least 4 jets with $p_{\mathrm{T}} > 25$ GeV
- Events are separated into six signal regions based on the lepton charge $(+1, -1)$ and b-tag multiplicity (70% eff. working point)
- Kinematic Likelihood Fitter [3] is used to reconstruct $t\bar{t}$ kinematics

Boosted

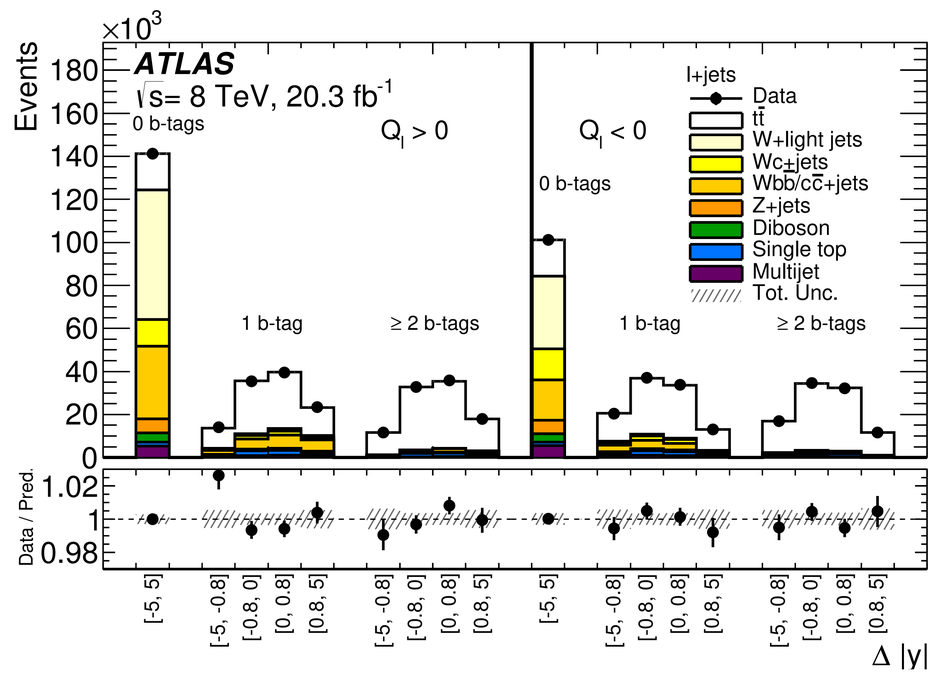
- At least one jet with $p_{\mathrm{T}} > 25$ GeV, close to lepton ($\Delta R < 1.5$)
- At least one top-tagged large jet ($R = 1.0$) with $p_{\mathrm{T}} > 300$ GeV, well separated from the lepton ($\Delta\phi(\ell, \mathrm{jet}_{R=1.0}) > 2.3$)
- Either the jet close to lepton or a jet matched to the large jet ($\Delta R < 1.5$) must be b-tagged (70% eff. working point)





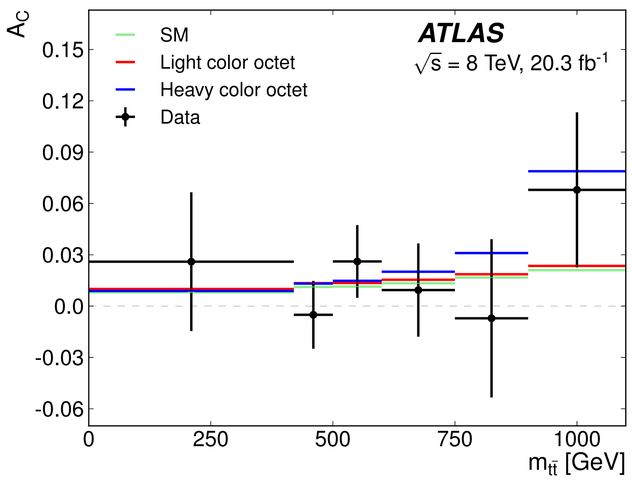
Unfolding III.

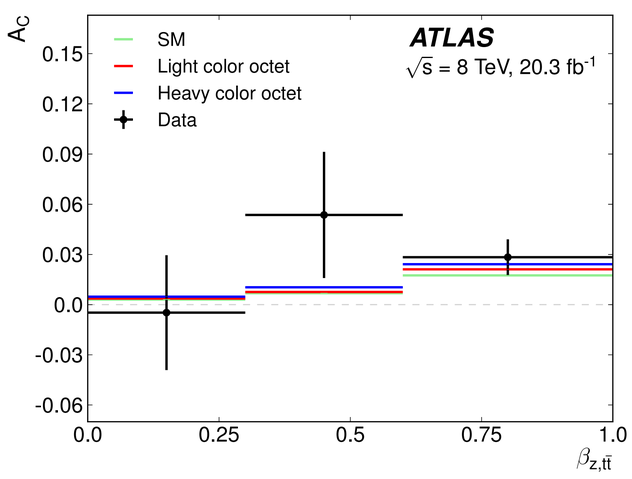
- Fully Bayesian Unfolding (FBU) [4] is used in both measurements to unfold the reconstructed distributions to the parton level
- In the case of the boosted topology, measurement is performed in a fiducial phase space ($m_{t\bar{t}} > 0.75$ TeV and $-2 < \Delta|y| < 2$) due to small sensitivity outside this region
- For all systematic uncertainties corresponding nuisance parameters are assigned. FBU enables to marginalize systematic uncertainties and thus to reduce the total uncertainty
- In the resolved topology 0-b tag region is used for in-situ calibration of the W+jets background:

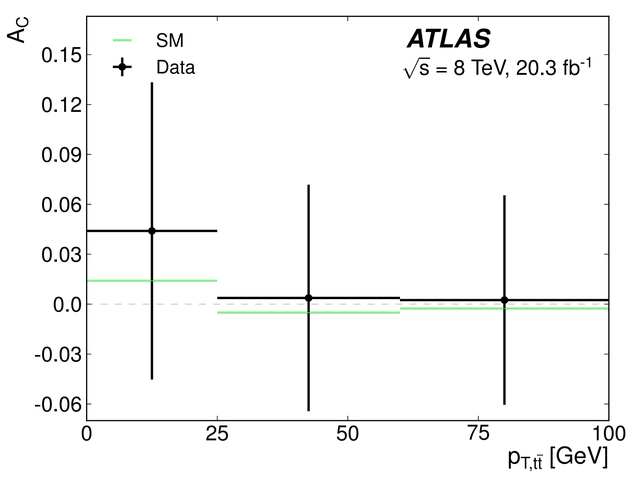


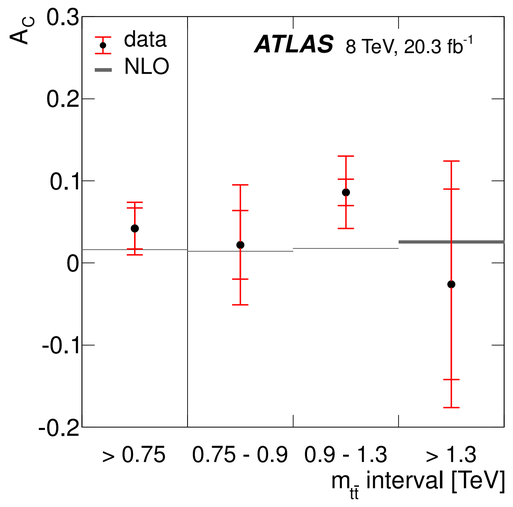
Results IV.

- Inclusive asymmetry is measured to be $A_{\mathrm{C}} = 0.009 \pm 0.005$ (stat.+syst.), compatible with the Standard Model prediction $A_{\mathrm{C}}^{\mathrm{SM}} = 0.0111 \pm 0.0004$ [5]
- Fiducial asymmetry ($m_{t\bar{t}} > 0.75$ TeV and $-2 < \Delta|y| < 2$) is measured to be $A_{\mathrm{C}} = 0.042 \pm 0.032$, compatible with $A_{\mathrm{C}}^{\mathrm{SM}} = 0.0160 \pm 0.0004$ [6]
- Three measurements as a function of mass, β_z and p_{T} of the $t\bar{t}$ system are shown for the resolved topology, mass dependency was estimated also in the boosted topology (right)
- Inclusive and differential measurements as a function of $t\bar{t}$ mass are mostly limited by stat. uncertainties; measurements as a function of $t\bar{t}$ β_z and p_{T} are mostly limited by modelling uncertainties
- No significant deviations from the SM predictions are observed

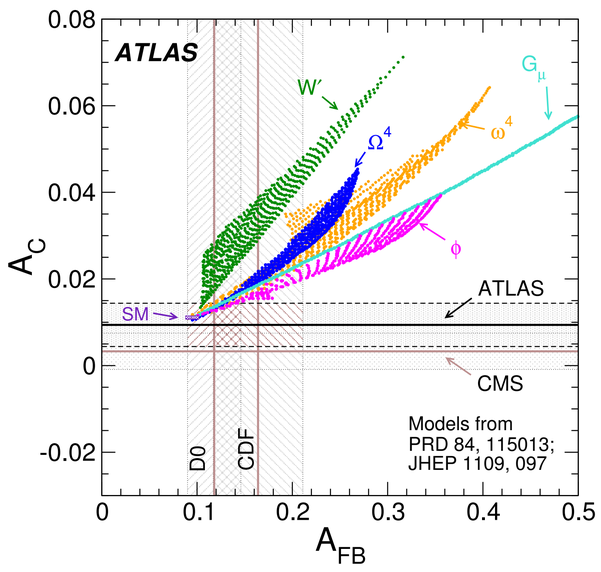


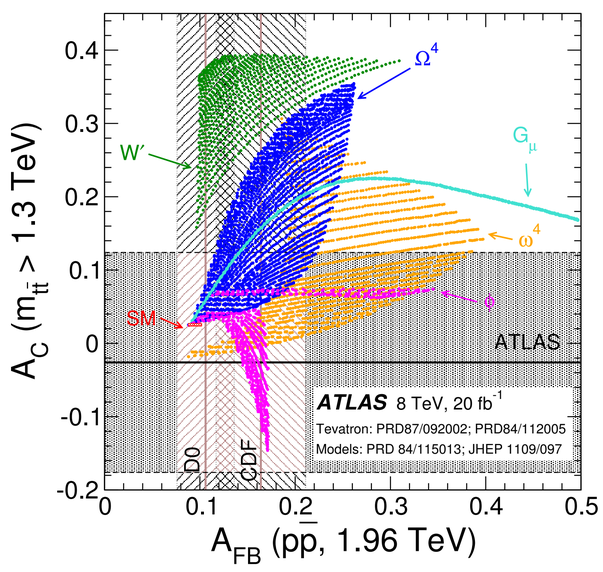






Impact on BSM Scenarios V.





- Measured A_{C} and A_{FB} (forward-backward asymmetry measured at Tevatron) values compared with the SM predictions, as well as various BSM predictions; inclusive (left) and for $m_{t\bar{t}} > 1.3$ TeV (right)
- ATLAS 8 TeV A_{C} measurements allow for exclusion of a large phase-space of the parameters describing various BSM models

Lepton+jets A_{C} Measurement at 13 TeV VI.

- A_{C} measurement in the lepton+jets channel at 13 TeV is ongoing
- Challenging due to larger fraction of symmetric gluon fusion in $t\bar{t}$ production but allowing to study higher $t\bar{t}$ mass region with where a higher charge asymmetry is expected
- Resolved and boosted topologies are selected to be orthogonal and are combined at the level of FBU - combination helps to reduce the total uncertainties in all regions

References

[1] ATLAS Collaboration, Eur. Phys. J. C **76** (2016) 87

[2] ATLAS Collaboration, Phys. Lett. B **756** (2016) 52

[3] J. Erdmann et al., Nucl. Instrum. Meth. A **748** (2014) 18-25

[4] G. Choudalakis, (2012) arXiv:1201.4612

[5] W. Bernreuther and Z. G. Si, Phys. Rev. D **86** (2012) 034026

[6] J. H. Kuhn and G. Rodrigo, JHEP **1201** (2012) 063