UNIVERSITY OF ILLINOIS CHICAGO

Measurement of the charge asymmetry in highly boosted events in the single-lepton channel at 13TeV & Global EFT Interpretation

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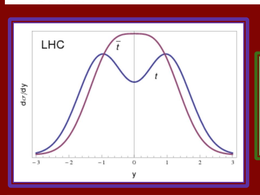
Motivation

- $t\bar{t}$ production from gg fusion is symmetric under charge conjugation at all orders
  - However, in quark-antiquark annihilation processes, higher-order Standard Model effects introduce a charge asymmetry. This results in the **top quarks being produced preferentially** in the direction of the incoming quark
- At the high momentum transfer, the relative contribution of valence quarks becomes more significant. By measuring A_C in highly Lorentz-boosted $t\bar{t}$ events, we can more rigorously test QCD predictions and enhance sensitivity to BSM processes affecting charge asymmetry.

- In boosted scenarios, there is a higher proportion of qq-initiated events compared to gg than in non-boosted situations. This is making A_C more evident in boosted scenarios than in resolved ones.



$$A_C = \frac{N(\Delta|y| > 0) - N(\Delta|y| < 0)}{N(\Delta|y| > 0) + N(\Delta|y| < 0)}$$

$\Delta|y| = |y_t| - |y_{\bar{t}}|$

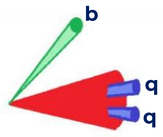
Ac in boosted topologies [1]

- Using dedicated techniques for **Top** and **W tagging**
- Using **non-isolated, high pT leptons**
- kinematic cuts for boosted topology (2D cut, etc.)

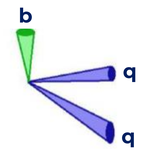
Event Categorization

1.Merged
- Top-tagged jets assigned to t_{had} AND jets with $\Delta R > 0.8$ from t_{had} assigned to t_{lep}.
- 1 Top-tagged jets AND 0 W Tagged jets

2.SemiResolved:
- W-tagged jets assigned to t_{had} AND jets with $\Delta R > 0.8$ from W-tag assigned to t_{lep} or neither.
- 0 Top-tagged jets AND 1 W-tagged



3.Resolved
- All AK4 jets are taken into account separately.
- 0 Top-tagged jets AND 0 W-tagged



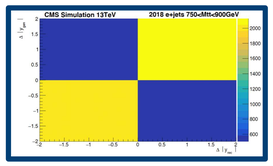
Improvements to reconstruction in each topology are in progress for the new analyses.

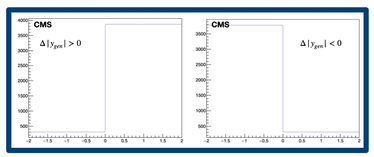
Unfolding using Higgs Combine

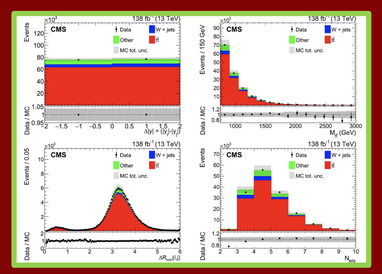
•We want to **correct the reconstructed data by removing the smearing** which is a result of poor detector resolution and acceptance

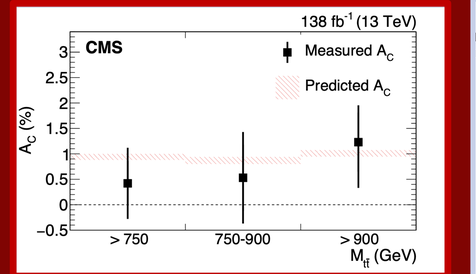
$$\mathscr{L}_k = \prod_{j=1}^{N_{reco}} P(n_j; \sum_{i=1}^{N_{gen}} A_{ij}(\vec{\delta_u})\mu_i + b_j) N(\vec{\delta_u})$$

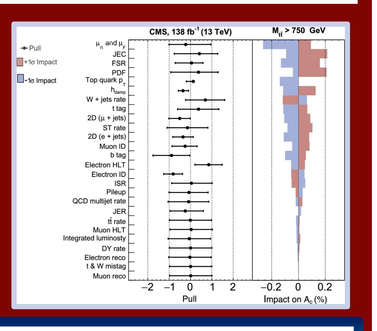
•Ac directly extracted from a **maximum likelihood fit** taking effects and correlation of systematic and statistical uncertainties into account











Results

•A_C **corrected to full phase space** 0.0056 ± 0.0070

•Theory prediction NNLO in perturbation theory with NLO EWK corrections 0.0089±0.002

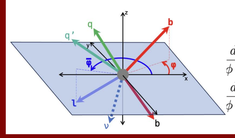
•Leading systematics come from simulation

Spin Correlation

•Looking at the top's rest frame, we measure the angular variables $\Delta\varphi$ and $\Sigma\varphi$. Below is a diagram of the variables involved and an expression for the resulting differential distribution:

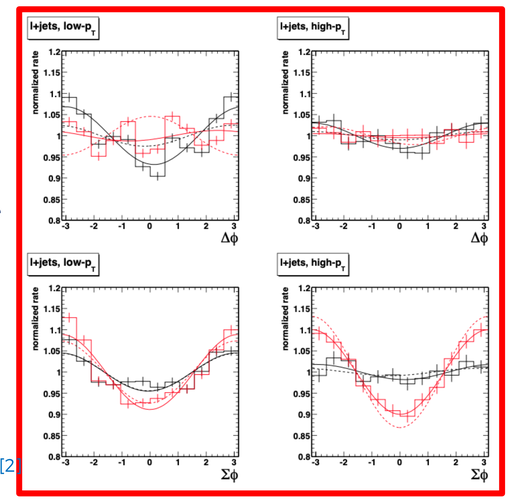
•In contrast to the charge asymmetry measurement, the main production mechanisms responsible for the spin correlations are the gluon-gluon fusion diagrams thus making them more sensitive to any modification of the gluon-gluon coupling.

•A set of precision measurements containing these angular variables, the charge asymmetry, and others can compile a powerful set of distributions that characterize this well-known process



$$\frac{d\sigma}{d(\phi-\bar{\phi})} \propto 1 + \left(\frac{\pi}{4}\right)^2 \kappa\bar{\kappa}\left[\left(\frac{C^{11}+C^{22}}{2}\right)\cos(\phi-\bar{\phi}) + \left(\frac{C^{21}-C^{12}}{2}\right)\sin(\phi-\bar{\phi})\right]$$

$$\frac{d\sigma}{d(\phi+\bar{\phi})} \propto 1 + \left(\frac{\pi}{4}\right)^2 \kappa\bar{\kappa}\left[\left(\frac{C^{11}-C^{22}}{2}\right)\cos(\phi+\bar{\phi}) + \left(\frac{C^{21}+C^{12}}{2}\right)\sin(\phi+\bar{\phi})\right]$$ [2]



Methods of Extracting Limits on EFT Coefficients

Global Fits:
- Global fits include combining multiple measurements to extract limits on EFT coefficients.

Limit Extraction Techniques:
- **Single-Operator Fits**: Fix all other operators to the Standard Model (SM) value and allow a single operator to float during the fit. Repeat this for all relevant operators. This method has set strict (~order 0.01) limits, and the fit is relatively simple.

- **Simultaneous (Marginalized) Fits:** Allow all operators to float during the fit, though the fit procedure becomes more complicated. These have set significantly weaker limits (~order 0.1).

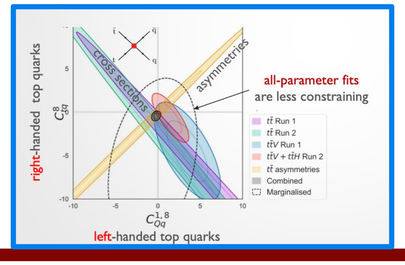
Improving Limits through Complementary Measurements

Single vs. Marginalized Fits:

•Single-operator fits involving A_c measurements and cross-section measurements constrain the coefficients in a complementary way, allowing for extracting good limits when combined.

•Marginalized fit of the same measurements and operators, the limits get significantly worse.

[3]



Incorporating Spin Correlation Measurements

•The goal is to determine if including spin correlation measurements would improve the marginalized fit in such a way that it would enhance the limits extracted.

•It's known that spin correlation and polarization measurements in $t\bar{t}$ events are significantly affected by 4-fermion operators. This motivates the inclusion of these measurements to improve the limits extracted from a marginalized fit.

References

[1] https://doi.org/10.1016/j.physletb.2023.137703 published in PLB
[2] https://doi.org/10.1007/JHEP03(2013)117
[3] Ellis, Sanz, et.al. FitMaker JHEP04(2021)279]