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Search for EFT in top quark production with additional leptons

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CMS-PAS-TOP-22-006

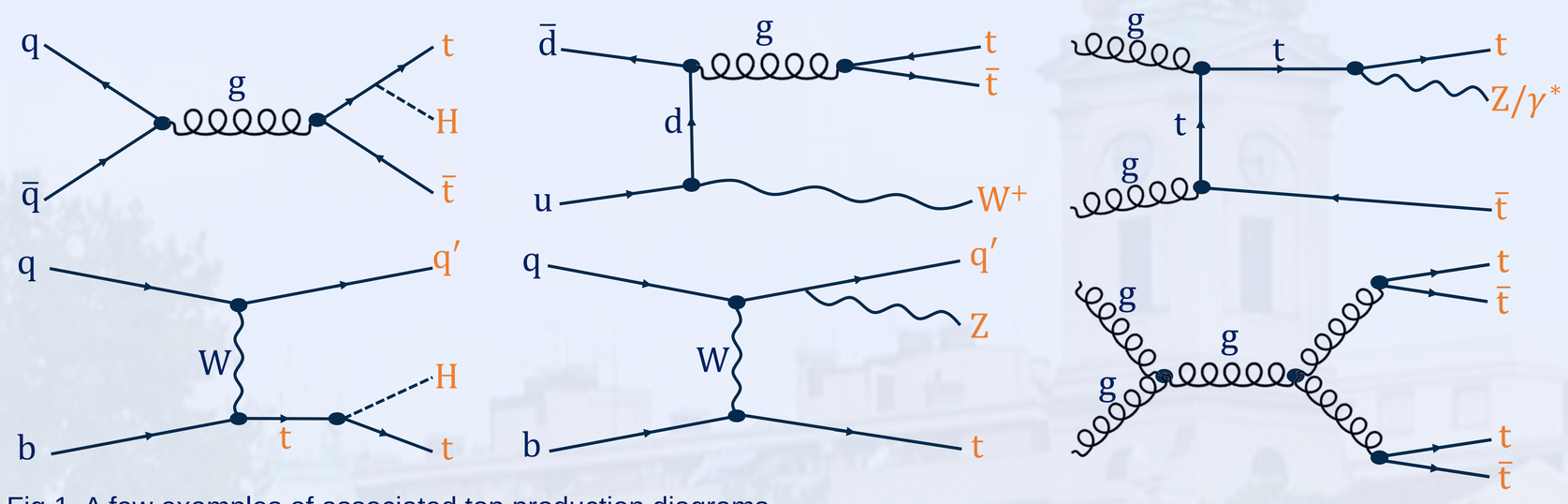
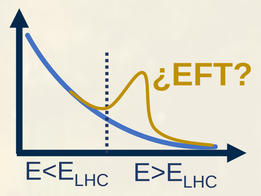


Fig 1. A few examples of associated top production diagrams.

Motivation

- New particles may not be light enough to be produced on-shell at the LHC. **Indirect methods** of probing higher energy scales are thus an important part of **searches for new physics at the energy frontier**.
- One example of this type of approach is **effective field theory (EFT),** a flexible framework that comprehensively describes the off-shell effects of new physics at a mass scale Λ.
- EFT extends the SM Lagrangian with higher-dimensional **operators**, that describe physics at a scale Λ, interacting with a strength determined by a dimensionless parameter called Wilson coefficient (WC), **c**.



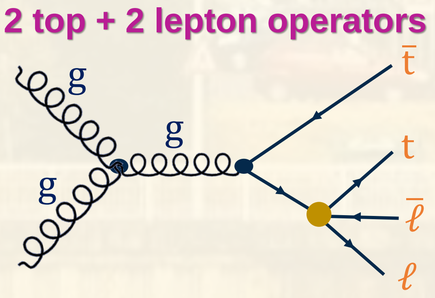
$$\mathcal{L}_{EFT} = \mathcal{L}_{SM} + \sum_{d,i} \frac{c_i^d}{\Lambda^{d-4}} \mathcal{O}_i^d$$

We focus on the d **6 terms**, as they are the lowest order terms that contribute.

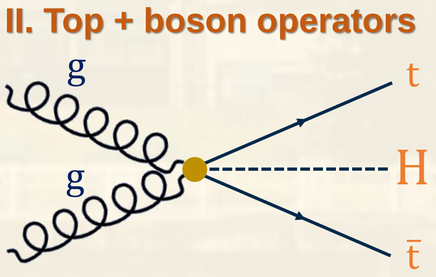
EFT IN TOP PHYSICS

- EFT operators can contribute to many top quark production modes.
- We focus on **multilepton final states**.
- **Signal processes**: $t\bar{t}H$, $t\bar{t}\ell\nu$, $t\bar{t}\ell\bar{\ell}$, tHq, $t\ell\bar{\ell}q$, $t\bar{t}t\bar{t}$ (Fig.1).
- We consider **26 WCs** that significantly impact associated top processes:

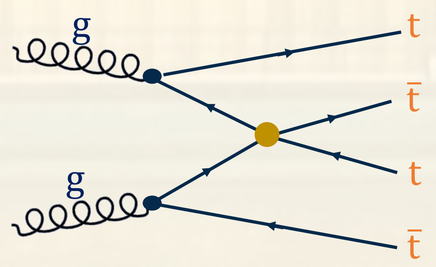
I. 2 top + 2 lepton operators



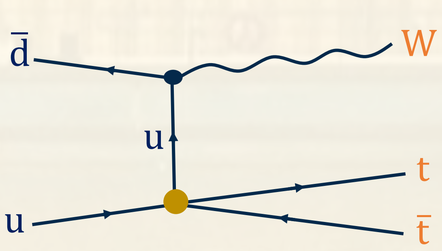
II. Top + boson operators



III. 4 heavy quarks operators



IV. 2 light + 2 heavy quarks operators



Summary

- A search for **new physics** in the production of top quarks with additional leptons, jets, and b jets in the context of EFT has been performed.
- The WCs corresponding to **26 EFT operators** were simultaneously fit to the data and their CIs were extracted.
- In all cases, data are found to be **consistent with SM** expectations.

References

CMS Collaboration, "Search for new physics in top quark production with additional leptons in the context of effective field theory using 138 fb^{-1} of proton-proton collisions at $\sqrt{s}$= 13 TeV", CMS-PAS-TOP-22-006.

Methodology

Event selection and strategy

- **Run 2** dataset is used, corresponding to an integrated luminosity of 138 fb^{-1}.
- **43 categories**: events with 2 same-sign leptons, 3 or 4 leptons, additionally requiring jets and b-tagged jets, and splitting in on/off-Z region and charge sum.
- Use different variables ($p_T(\ell j_0)$, $p_T(Z)$) in each region depending on the targeted operators → **178 bins**.

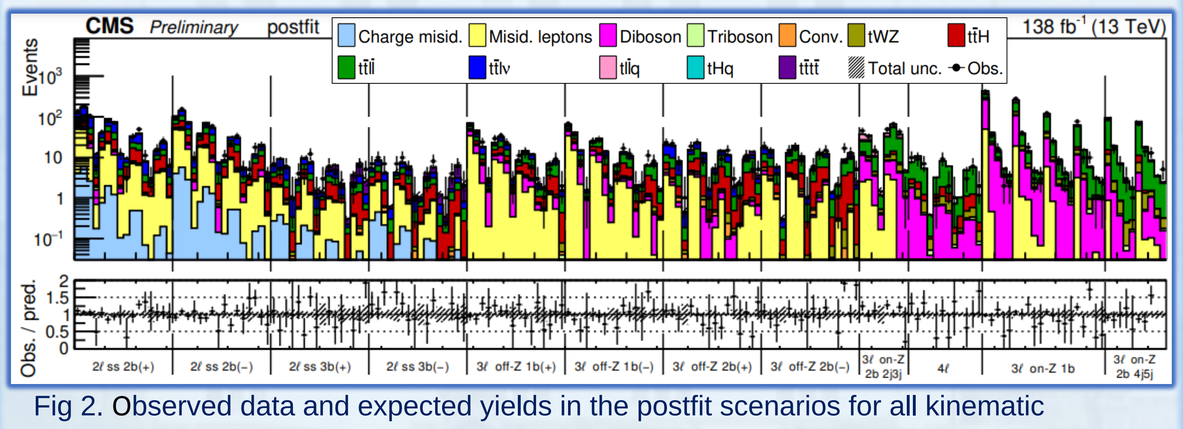


Fig 2. Observed data and expected yields in the postfit scenarios for all kinematic variables in each categories.

Backgrounds

- **Dominated by WZ production**: estimated with simulations and validated in control regions.
- **Nonprompt leptons**: estimated using **data driven** methods.

Results

Results are consistent with the SM.

Results are presented in terms of 95% confident intervals (CIs) for each WCs extracted for a **single WC** at a time:

- With the other **WCs profiled**.
- With the other **WCs fixed to their SM** values of zero.

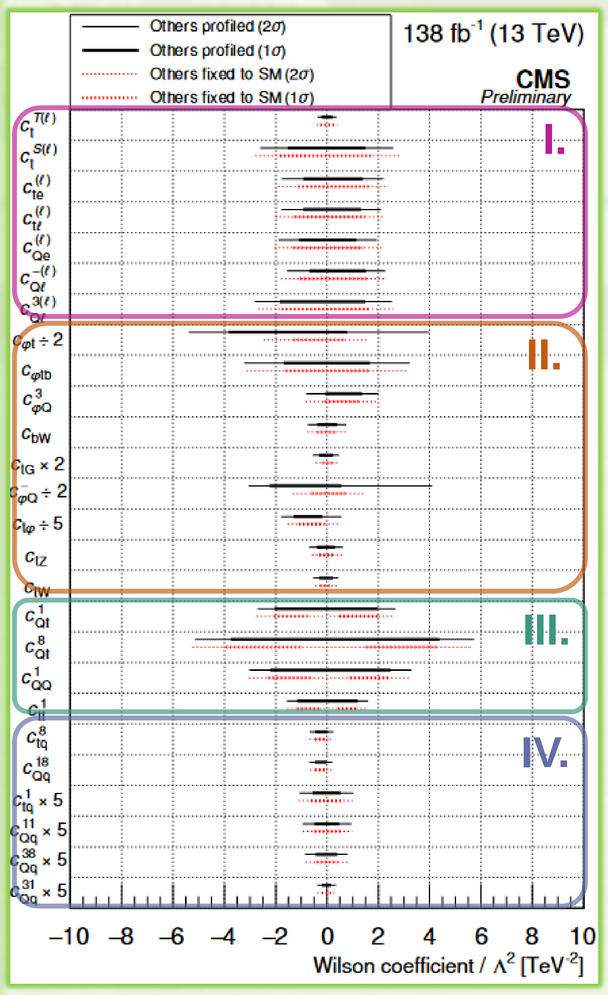


Fig 3. CIs extracted from the likelihood fits.

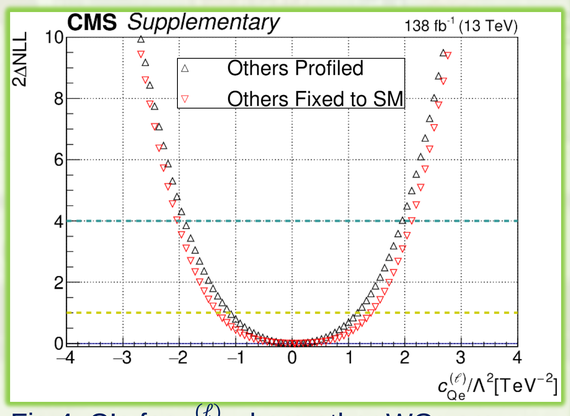


Fig 4. CIs for $c_{Qe}^{(\ell)}$ where other WCs are frozen or profiled.

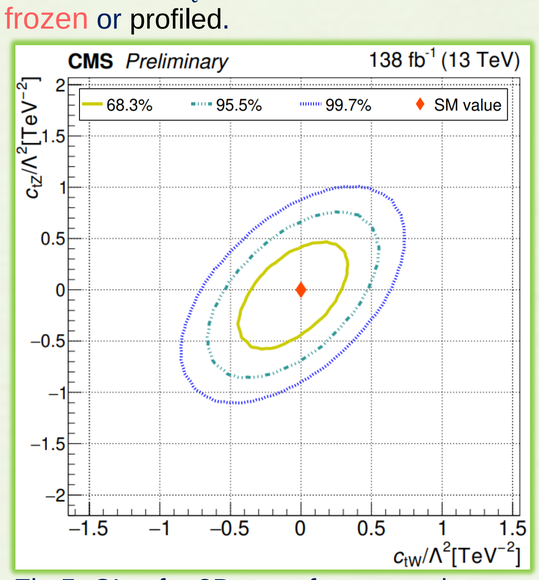


Fig 5. CIs of a 2D scan for c_{tW} and c_{tZ}.