

Measurement of differential $t\bar{t}\gamma$ cross sections at \sqrt{s} = 13 TeV with the ATLAS detector and EFT interpretation

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23.11.2021





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Aim : Measure differential $tt\gamma$ cross section in lepton+jets channel with full run 2 data set.

 $\sigma_{tt\gamma}$: Handle for the top quark and photon coupling $(t\gamma)$.

EFT is a model independent approach to probe the possible deviations from Standard Model.

$$\mathcal{L}_{eff} = \mathcal{L}_{SM} + \frac{1}{\Lambda^2} \sum_{i} C_i O_i + \mathcal{O}\left(\Lambda^{-4}\right)$$

 ttγ vertices are sensitive to three Dimension-6 operators

 $gt\bar{t}(O_{tG})$ and $t\bar{t}\gamma(O_{tB},O_{tW})$ arXiv: 1601.08193 Results are shown using pseudo data for $p_{T}(\gamma)$







- MadGraph5_aMC@NLO
 - tt γ NLO 2 \rightarrow 3 where γ comes from production

tt γ Sample

ttγ NLO Production 2 → 3 TEFT_EW UFO Model (EFT sample)

EFT Samples

- ► $O_{tG} = \pm 0.4$, $O_{tB} = \pm 4.6$, $O_{tW} = \pm 1.8$ Current limits from arXiv: 1901.05965
- SM nearly zero value of operators in EFT model i.e (~ 0, ~ 0, ~ 0).
- EFT samples are:
 - $O_{tG} = \pm 0.4, \pm 0.2, O_{tB} = \pm 4.6, \pm 2.3, O_{tW} = \pm 1.8, \pm 0.9$

$$(O_1, \sim 0, \sim 0)$$

- $(O_1, O_2, \sim 0)$
- (O_1, O_2, O_3)

Event Selection



Electron fakes: Electron mis-identified as photon

Hadron fakes: Photons from hadrons or mis-identified jets as photons

Prompt γ : Any background process with prompt photon e.g W γ , Z γ or $t\bar{t}$

 $tt\gamma$ LO decay: Events where photon originated from either of top quark decay



SM and EFT samples: $P_T(\gamma)$ distribution



- Photon kinematic variables are expected to be most sensitive to the EFT operator especially P_T(γ)
- ▶ O_{tG} affects $gt\bar{t}$ vertex: mostly impact production rate





Differential cross section obtained using PLU





Unfolding Tests



Closure Test:

Stress Test:

Pull Test:





Normalized Differential Cross Section



- Systematic Uncertainties
 - $t\bar{t}\gamma$ modeling
 - Experimental (signal and background)
 - ▶ tt modeling
 - Background normalization ±20% except data driven fakes









Effective Cross Section: $\sigma_{eff} = \sigma_{SM} + \frac{C_i}{\Lambda^2} \sigma_i^{(1)} + \frac{C_i^2}{\Lambda^4} \sigma_{ii}^{(2)}$

- Dependence of the normalized σ_{eff} is parameterized in each bin of $P_T(\gamma)$ and fit with polynomial of order 2.
- Example one $P_T(\gamma)$ bin for three operators.



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9







Tool used: EFTfitter (arXiv: 1605.05585)



 Using Asimov results to estimate the sensitivity to each operator individually





Summary

- Measurement of normalized differential cross section of $tt\gamma$ in lepton + jets channel is done as a function of $P_T(\gamma)$.
 - Showing only Asimov results
 - Unfolding results are robust
- Sensitivity due to two dimension six operator O_{tW} and O_{tB} is estimated from Asimov data as a function of $P_T(\gamma)$.

Outlook

 Extend the study to perform simultaneous limit extraction of operators.

Backup







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Nui. par. (0.1 % pruning) $P_T(\gamma)$

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Norm, dropped



Nui. par. (0.1 % pruning), Normalized Cross Section and Norm Factor

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Nui. par. (0.1 %), Normalized Cross Section and Norm Factor

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 $tt\gamma$

18