Differential cross-section measurement of $t\bar{t}\gamma$ production and interpretation in the context of effective field theory using ATLAS data at $\sqrt{s} = 13$ TeV and 139 fb^{-1}

Binish Batool

Universität Siegen
binish.maadii@gmail.com

24.11.2025

Quantum Universe Attract.Workshop

Physics is about “why” and “how”

$t\bar{t}\gamma$ studies probe t-γ vertex, coupling is electromagnetic

$m_t \approx 173$ GeV close to $v_{\text{EWSB}} = 246$ GeV, $\frac{\sqrt{2}m_t}{v_{EWSB}}$ is ≈ 1. Any new physics motivated from EWSB may affect t-γ.

The dipole moment of the top quark can receive anomalous couplings. The presence of anomalous couplings can affect the cross-section of $t\bar{t}\gamma$.

Physics is about "why" and "how"

$t\bar{t}\gamma$ studies probe t-γ vertex, coupling is electromagnetic

- $m_t \approx 173$ GeV close to $v_{\text{EWSB}} = 246$ GeV, $\frac{\sqrt{2}m_t}{v_{EWSB}}$ is ≈ 1. Any new physics motivated from EWSB may affect t-γ.
- The dipole moment of the top quark can receive anomalous couplings. The presence of anomalous couplings can affect the cross-section of $t\bar{t}\gamma$.

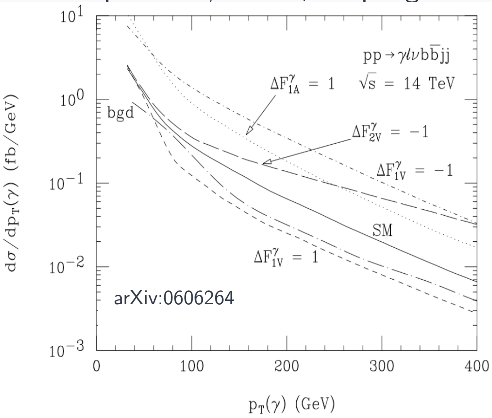
Physics is about “why” and “how”

$t\bar{t}\gamma$ studies probe t-γ vertex, coupling is electromagnetic

- $m_t \approx 173$ GeV close to $\mathrm{v_{EWSB}} = 246$ GeV, $\frac{\sqrt{2}m_t}{v_{EWSB}}$ is ≈ 1. Any new physics motivated from EWSB may affect t-γ.
- The dipole moment of the top quark can receive anomalous couplings. The presence of anomalous couplings can affect the cross-section of $t\bar{t}\gamma$.

Physics is about "why" and "how"

$t\bar{t}\gamma$ studies probe t-γ vertex, coupling is electromagnetic



GeV, $\frac{\sqrt{2}m_t}{v_{EWSB}}$ is ≈ 1. Any new physics

an receive anomalous couplings. The presence cross-section of $t\bar{t}\gamma$.

Physics is about "why" and "how"

$t\bar{t}\gamma$ studies probe t-γ vertex, coupling is electromagnetic

- $m_t \approx 173$ GeV close to $v_{\text{EWSB}} = 246$ GeV, $\frac{\sqrt{2}m_t}{v_{EWSB}}$ is ≈ 1. Any new physics motivated from EWSB may affect t-γ.
- The dipole moment of the top quark can receive anomalous couplings. The presence of anomalous couplings can affect the cross-section of $t\bar{t}\gamma$.

Part-1: Cross-section measurement of $t\bar{t}\gamma$ production process using ATLAS data and its comparison to the Standard Model prediction.

Physics is about "why" and "how"

$t\bar{t}\gamma$ studies probe t-γ vertex, coupling is electromagnetic

- $m_t \approx 173$ GeV close to $\mathrm{v_{EWSB}} = 246$ GeV, $\frac{\sqrt{2}m_t}{v_{EWSB}}$ is ≈ 1. Any new physics motivated from EWSB may affect t-γ.
- The dipole moment of the top quark can receive anomalous couplings. The presence of anomalous couplings can affect the cross-section of $t\bar{t}\gamma$.

Part-1: Cross-section measurement of $t\bar{t}\gamma$ production process using ATLAS data and its comparison to the Standard Model prediction.

Part-2: Interpretation of results in the context of Effective Field Theory.

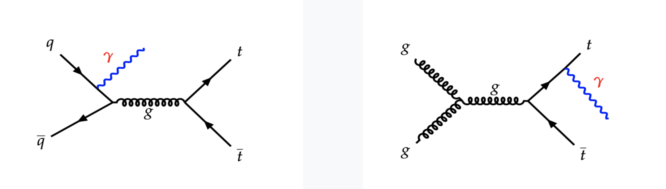
Part I:
$t\bar{t}\gamma$ production cross-section measurement

$t\bar{t}\gamma$ process

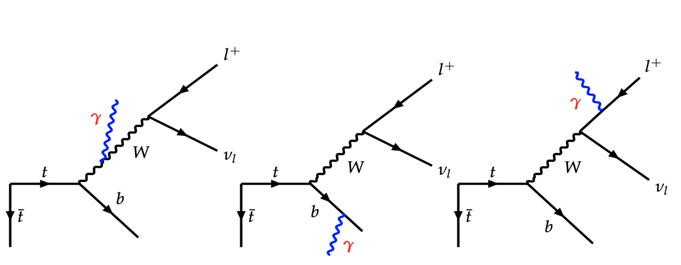
FSP ATLAS
Erforschung von
Universum und Materie

UNIVERSITÄT
SIEGEN

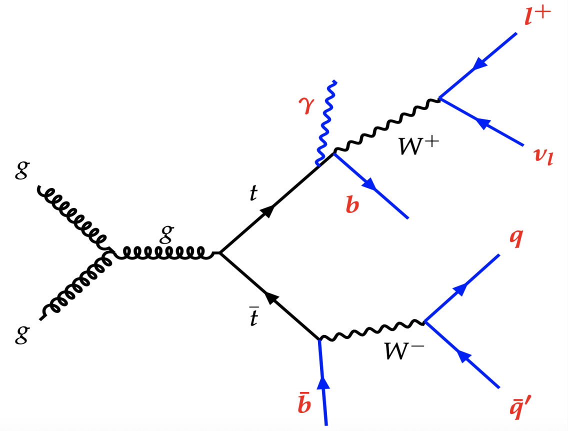
Production Mode



Decay Mode



$t\bar{t}\gamma$ production process



leptonic decay

hadronic decay

$$t\bar{t}\gamma \rightarrow l^+\nu_l q\bar{q}' b\bar{b}\gamma \quad \text{(signal)}$$

Analysis Strategy: Samples

Data: ATLAS between 2015-2018 (Run-2) at 13 TeV and 139 fb^{-1}

Monte Carlo (MC) Samples:

- Signal: $2 \rightarrow 3$ ($t\bar{t}\gamma$) at NLO QCD (MadGraph5_aMC@NLO and Pythia8)
- Background: $t\bar{t}\gamma$-decay, $t\bar{t}$, $tW\gamma$, $Z\gamma$, $W\gamma$, Zjets, Wjets, single top quark, dibosons

Groups: lep-fakes, h-fake, e-fake, Wtγ, Prompt-γ (W, Z, t, wt, $t\bar{t}$, $t\bar{t}\gamma$-decay, others) arXiv:2403.09452

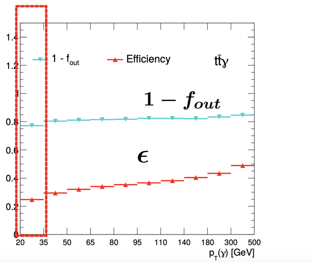
Analysis Strategy: Fiducial region

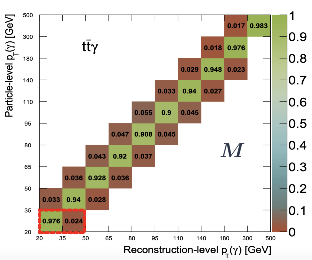
Fiducial region is defined by kinematics requirements for particles in MC and data.

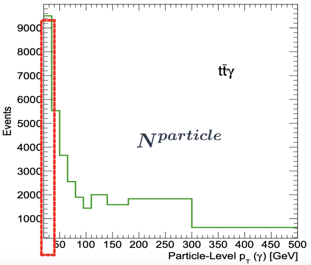
<table>
<tr><th>Particles</th><th colspan="2">Conditions</th></tr>
<tr><td>1 photon</td><td colspan="2">$p_T > 20$ GeV, $|\eta| < 1.37$ or $1.52 < |\eta| < 2.37$</td></tr>
<tr><td rowspan="5">1 lepton</td><td>muon</td><td>electron</td></tr>
<tr><td colspan="2">$p_T > 25$ GeV
Trigger $p_T > 25, 27, 28$ GeV in (2015 and 2016), (2017), and (2018) data resp.</td></tr>
<tr><td>$|\eta| < 2.5$</td><td>$|\eta| < 1.37$ or $1.52 < |\eta| < 2.47$</td></tr>
<tr><td>-</td><td>$|m(e, \gamma) - 91.19$ GeV$| > 5$ GeV</td></tr>
<tr><td rowspan="2">at-least 4 jets</td><td colspan="2">$p_T > 25$ GeV, $|\eta| < 2.5$</td></tr>
<tr><td colspan="2">at least one b quark</td></tr>
<tr><td>ΔR(γ, lepton)</td><td colspan="2">≥ 1.0</td></tr>
</table>

Analysis Strategy: Profile Likelihood Unfolding

Folding: $\sum_j N^{\text{pred}}_{\text{sig}_j} = \sum_i \frac{1}{1-fout_i} \cdot \epsilon_i M_{ji} N_i^{particle}$





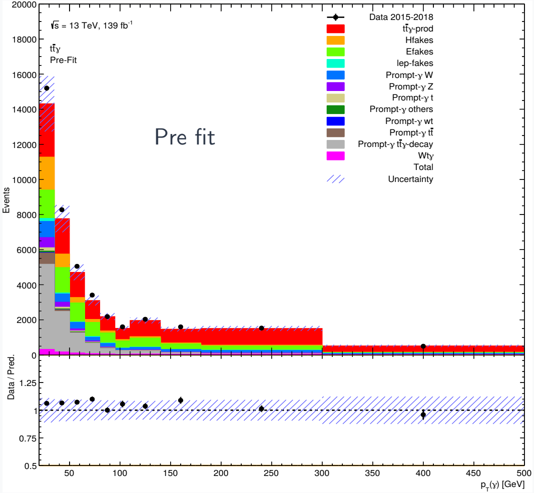


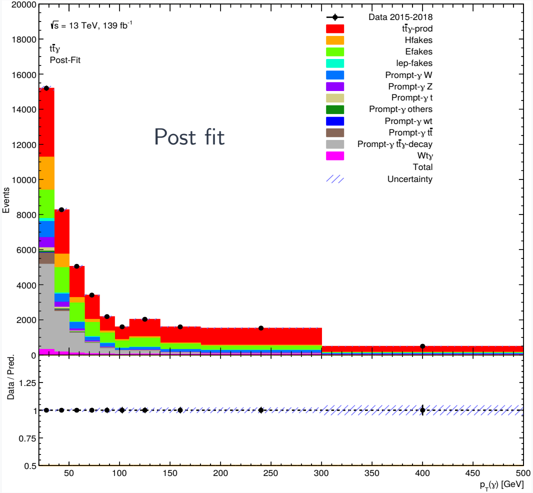
$$\mathcal{L} = \prod_j \mathrm{P}(N^{\text{obs}}_{sig,j} | \mu_j \cdot N^{\text{pred}}_{\text{sig}_j}(\boldsymbol{\theta}) + N^{\text{pred}}_{\text{bkg}_j}(\boldsymbol{\theta}, \mathbf{k})) \times \prod_s G(0 \mid \boldsymbol{\theta}_s, 1)$$

$$\sigma_j = \mu_j \cdot \frac{N^{\text{pred}}_{\text{sig}_j}}{L}$$

Absolute differential cross-section measurement is done as a function of $p_T(\gamma)$ and $|\eta(\gamma)|$

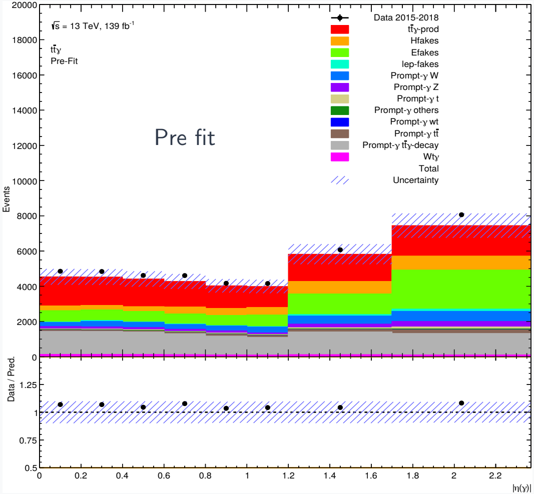
Results: $\frac{d\sigma}{dp_T(\gamma)} \times L$

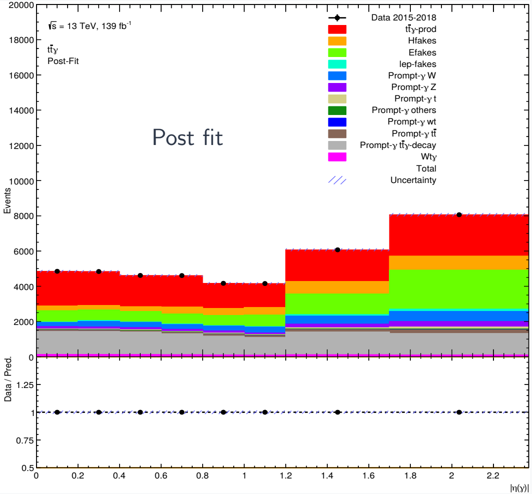




Data and SM prediction agree within uncertainties

Results: $\frac{d\sigma}{d|\eta(\gamma)|} \times L$

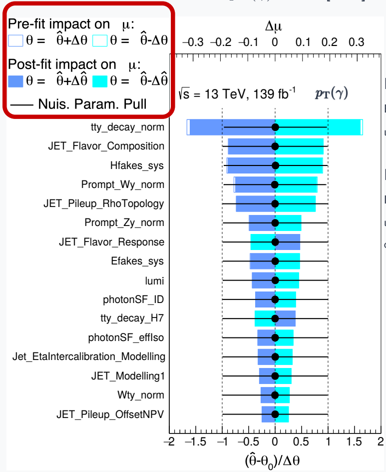




Data and SM prediction agree within uncertainties

Results: Systematics-impact ranking

Bin 1: $p_{\mathrm{T}}(\gamma)$ 20-35 [GeV]



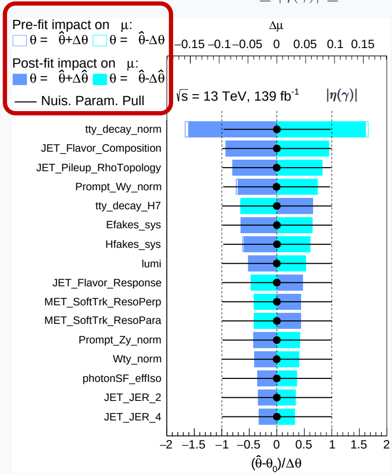
Pre-fit impact on μ:

Expected impact when each uncertainty is varied by $\pm 1\sigma$

Post-fit impact on μ:

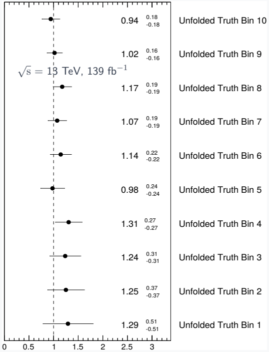
Impact on μ in data when each uncertainty is varied by data-driven constraints (post-fit covariance)

Bin 1: $0 \leq |\eta(\gamma)| \leq 0.2$

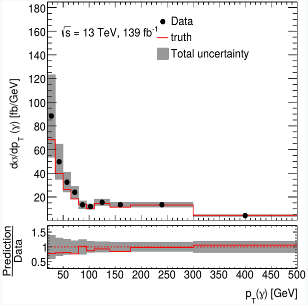


$t\bar{t}\gamma$_decay norm and jets related uncertainties dominate

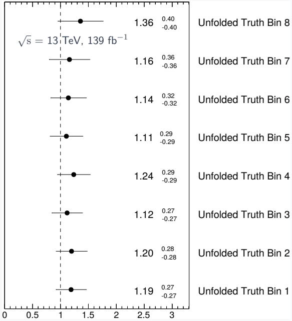
Results: $\frac{d\sigma}{dp_T(\gamma)}$ and $\frac{d\sigma}{d|\eta(\gamma)|}$



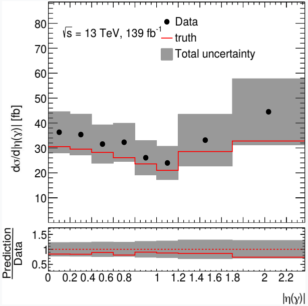
$\mu_{p_T(\gamma)}$



unfold $\frac{d\sigma}{dp_T(\gamma)}$



$\mu_{|\eta(\gamma)|}$



unfold $\frac{d\sigma}{d|\eta(\gamma)|}$

Part II:
Interpretation in the context of EFT

Interpretation: Background

$$\mathcal{L}_{eff} = \mathcal{L}_{SM} + \sum_{r=1}^{n_d} \frac{C_r^d}{\Lambda^{d-4}} \cdot O_r^d$$

(TEFT_EW UFO d = 6)
Λ = 1 TeV

O_{tB} O_{tG} O_{tW}

Interpretation strategy: Extract the EFT operators coefficients using $\frac{\mathrm{d}\sigma}{\mathrm{d}p_{\mathrm{T}}}$

Interpretation: Background

FSP ATLAS
Erforschung von Universum und Materie
UNIVERSITÄT SIEGEN

$$\mathcal{L}_{eff} = \mathcal{L}_{SM} + \sum_{r=1}^{n_d} \frac{C_r^d}{\Lambda^{d-4}} \cdot O_r^d$$

(TEFT_EW UFO d $=$ 6)
$\Lambda = 1$ TeV

O_{tB} $\quad$ O_{tG} $\quad$ O_{tW}

Interpretation strategy: Extract the EFT operators coefficients using $\frac{\mathrm{d}\sigma}{\mathrm{d}p_{\mathrm{T}}}$

Samples: 2$\rightarrow$3 ($t\bar{t}\gamma$) NLO QCD using MadGraph5 and Pythia8

SM_EFT $=$ (0, 0, 0)

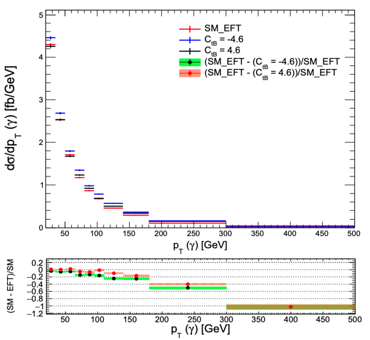
$(C_{tB}$, 0, 0), (0, C_{tG}, 0), (0, 0, $C_{tW})$, where $C_{tB} = \pm 4.6, C_{tG} = \pm 0.4, C_{tW} = \pm 1.8$ (arXiv:1901.05965)

$(\frac{1}{2}C_{tB}$, 0, 0), (0, $\frac{1}{2}C_{tG}$, 0), (0, 0, $\frac{1}{2}C_{tW})$

$(C_{tB}, C_{tG}$, 0), (0, $C_{tB}, C_{tW})$, $(C_{tG}$, 0, $C_{tW})$

Quantitative effect in $\frac{d\sigma}{dp_T}$

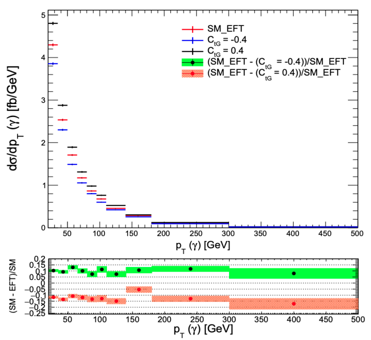
C_{tB}



Max relative effect:

103% with -4.6, 102% with +4.6

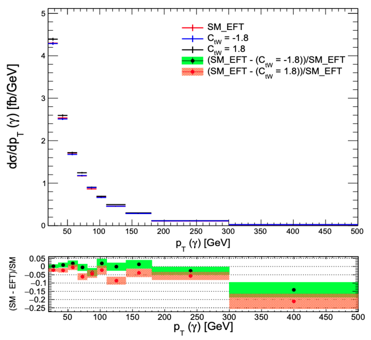
C_{tG}



Max relative effect:

12% with -0.4, 13% with +0.4

C_{tW}



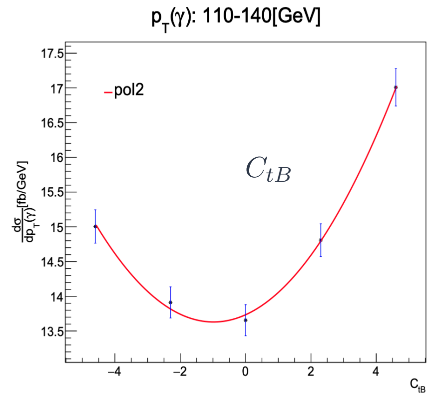
Max relative effect:

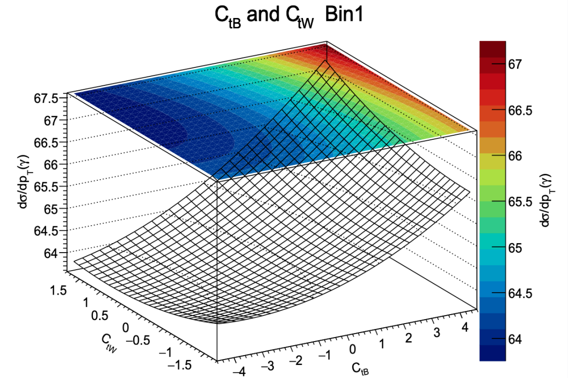
2% with -1.8, 5% with +1.8

Step 1: Parameterization 1D and 2D

$$\left(-C_i, -\tfrac{1}{2}C_i, C_0, +\tfrac{1}{2}C_i, +C_i\right) \text{ for 1D}$$

$$C_0 \cdot \sigma_{SM} + C_i \cdot \sigma_i + C_j \cdot \sigma_j + C_i^2 \cdot \sigma_{ii} + C_j^2 \cdot \sigma_{jj} + C_iC_j \cdot \sigma_{ij} \text{ for 2D}$$

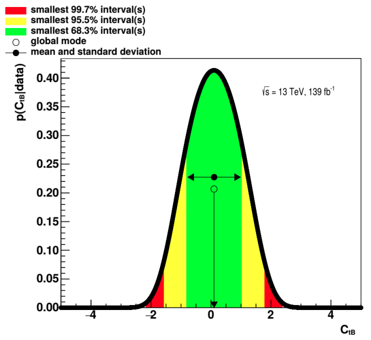


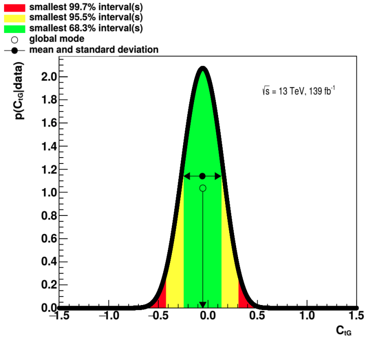


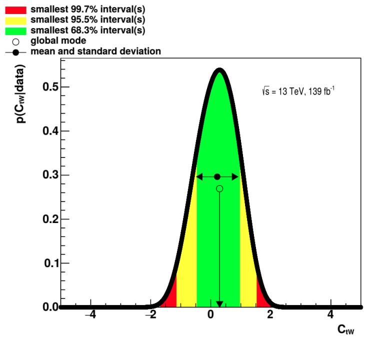
Fit results are used in posterior probability calculation to extract EFT operator coefficients limit

Results: 1D

C_{tB} | C_{tG} | C_{tW}



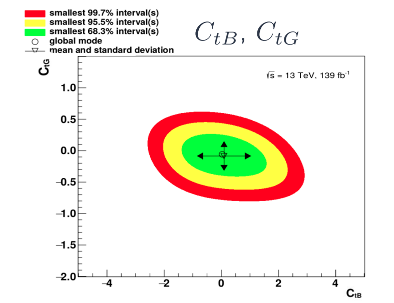


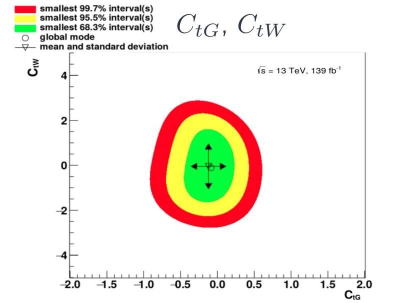


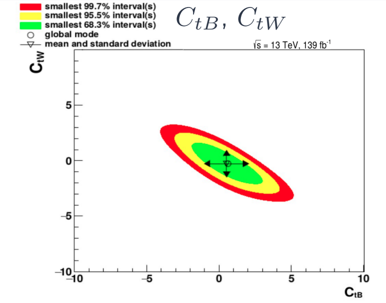
[-0.82, 1.02], best fit = 0.1 | [-0.24, 0.14], best fit = -0.05 | [-0.46, 0.97], best fit = 0.29

Best fit values agree with 0 within 1σ, hint at no observation of new physics

Results: 2D







$\mathcal{O}(\Lambda^{-2})(marg.)$ $\mathcal{O}(\Lambda^{-2})(marg.)$ $\mathcal{O}(\Lambda^{-2})(marg.)$

C_{tB} = [-0.31, 0.15], best fit = -0.06
C_{tG} = [-0.92, 1.04], best fit = 0.03

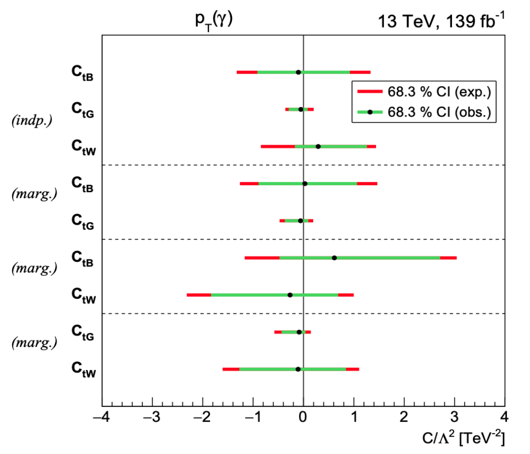
C_{tG} = [-1.17, 0.95], best fit = -0.11
C_{tW} = [-0.35, 0.13], best fit = -0.09

C_{tB} = [-1.57, 0.96], best fit = -0.27
C_{tW} = [-1.09, 2.10], best fit = 0.61

Best fit values agree with 0 within 1σ, hint at no observation of new physics

Results: Overview

Wilson coefficient	68.3% CI (exp.)	68.3% CI (obs.)	Best-fit
$\mathcal{O}(\Lambda^{-2})$ (indep.)	–	–	–
$[C_{tB}]$	$[-1.23, 1.43]$	$[-0.82, 1.02]$	0.10
$[C_{tG}]$	$[-0.31, 0.26]$	$[-0.24, 0.14]$	-0.05
$[C_{tW}]$	$[-1.14, 1.15]$	$[-0.46, 0.97]$	0.29
$\mathcal{O}(\Lambda^{-2})$ (marg.)	–	–	–
$[C_{tB}]$	$[-1.29, 1.44]$	$[-0.92, 1.04]$	0.03
$[C_{tG}]$	$[-0.42, 0.25]$	$[-0.31, 0.15]$	-0.06
$\mathcal{O}(\Lambda^{-2})$ (marg.)	–	–	–
$[C_{tB}]$	$[-1.78, 2.43]$	$[-1.09, 2.10]$	0.61
$[C_{tW}]$	$[-2.05, 1.27]$	$[-1.57, 0.96]$	-0.27
$\mathcal{O}(\Lambda^{-2})$ (marg.)	–	–	–
$[C_{tG}]$	$[-0.49, 0.23]$	$[-0.35, 0.13]$	-0.09
$[C_{tW}]$	$[-1.50, 1.21]$	$[-1.17, 0.95]$	-0.11



EFT operator coefficients limits are constrained in data

Summary

- Presented differential cross-section as a function of $p_{\mathrm{T}}(\gamma)$ and $|\eta(\gamma)|$
  - Systematic uncertainty related to $t\bar{t}\gamma_$decay normalization and jets flavour are dominating.
  - Results are in agreement with the SM prediction within uncertainties.
- Presented interpretation in the context of EFT using measurement in $p_{\mathrm{T}}(\gamma)$
  - Quantitative variation effect on $t\bar{t}\gamma$ cross-section
    - Variations in C_{tB} show larger impact
    - Variations in C_{tG} show normalisation effect
  - Coefficients limits are extracted:
    - No hint of new physics, limits are constrained in data
    - Extracted limits in 1D fit are constrained than 2D fit

Thank you

Backup

Analysis Strategy: Unfolding

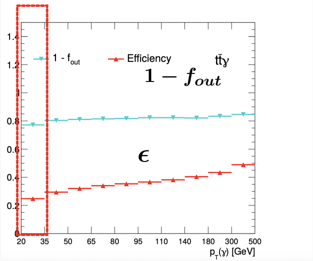
Measurement in data $\neq$ Standard Model Prediction
directly

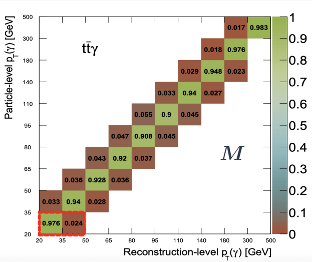
1) Reconstruction inefficiency: Fraction of events are not reconstructed **correction**: $(\epsilon) = \frac{N^{fid}_{reco}}{N^{fid}_{total}}$

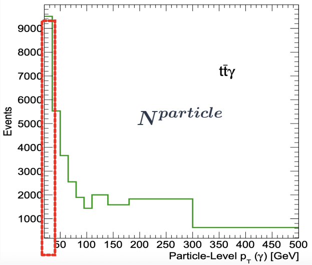
2) Migration effect: Events misreconstructed in wrong reconstruction level bins **correction**: (M)

3) Out-of-fiducial contamination: Events outside of the fiducial region get reconstructed **correction**: $(1\text{-}\ f_{out}) = 1\text{-}\ \frac{N^{reco}_{!fid}}{N_{reco}}$

Folding: $\sum_j N^{\text{pred}}_{\text{sig}_j} = \sum_i \frac{1}{1-f_{out_i}} \cdot \epsilon_i M_{ji} N^{particle}_i$







Analysis Strategy: Profile Likelihood Unfolding

$$\mathcal{L} = \prod_j \mathrm{P}\left(N^{\mathrm{obs}}_{sig,j} \,\middle|\, N^{\mathrm{pred}}_j(\boldsymbol{\theta})\right), \qquad N^{\mathrm{pred}}_j = N^{\mathrm{pred}}_{\mathrm{sig},j} + N^{\mathrm{pred}}_{\mathrm{bkg},j},$$

$\boldsymbol{\theta}$ = Nuisance parameters
(Experimental conditions and theoretical model assumptions)

Analysis Strategy: Profile Likelihood Unfolding

$$\mathcal{L} = \prod_j \mathrm{P}\left(N^{\text{obs}}_{sig,j} \,\middle|\, N^{\text{pred}}_j(\boldsymbol{\theta})\right), \qquad N^{\text{pred}}_j = N^{\text{pred}}_{\text{sig},j} + N^{\text{pred}}_{\text{bkg},j}, \qquad \boldsymbol{\theta} = \text{Nuisance parameters}$$

$$\mathcal{L} = \prod_j \mathrm{P}\left(N^{\text{obs}}_{sig,j} \mid \mu_j \cdot N^{\text{pred}}_{\text{sig},j}(\boldsymbol{\theta}) + N^{\text{pred}}_{\text{bkg},j}(\boldsymbol{\theta}, \mathbf{k})\right), \qquad \mu_j = \frac{N^{\text{obs}}_{sig,j}}{N^{\text{pred}}_{\text{sig},j}}, \qquad \mathbf{k} = \text{scaling factors}$$

Analysis Strategy: Profile Likelihood Unfolding

$$\mathcal{L} = \prod_j \mathrm{P}\left(N^{\mathrm{obs}}_{sig,j} \,\middle|\, N^{\mathrm{pred}}_j(\boldsymbol{\theta})\right), \qquad N^{\mathrm{pred}}_j = N^{\mathrm{pred}}_{\mathrm{sig},j} + N^{\mathrm{pred}}_{\mathrm{bkg},j}, \qquad \boldsymbol{\theta} = \text{Nuisance parameters}$$

$$\mathcal{L} = \prod_j \mathrm{P}\left(N^{\mathrm{obs}}_{sig,j} \mid \mu_j \cdot N^{\mathrm{pred}}_{\mathrm{sig},j}(\boldsymbol{\theta}) + N^{\mathrm{pred}}_{\mathrm{bkg},j}(\boldsymbol{\theta}, \mathbf{k})\right), \qquad \mu_j = \frac{N^{\mathrm{obs}}_{sig,j}}{N^{\mathrm{pred}}_{\mathrm{sig},j}}, \qquad \mathbf{k} = \text{scaling factors}$$

$$\mathcal{L} = \prod_j \mathrm{P}(N^{\mathrm{obs}}_{sig,j} | \mu_j \cdot N^{\mathsf{pred}}_{\mathsf{sig}_j}(\boldsymbol{\theta}) + N^{\mathsf{pred}}_{\mathsf{bkg}_j}(\boldsymbol{\theta}, \mathbf{k})) \times \prod_s G(0 \mid \boldsymbol{\theta}_s, 1)$$

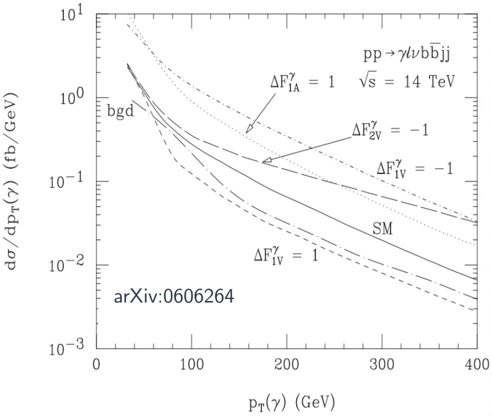
$$\sigma_j = \mu_j \cdot \frac{N^{\mathsf{pred}}_{\mathsf{sig}_j}}{L}$$

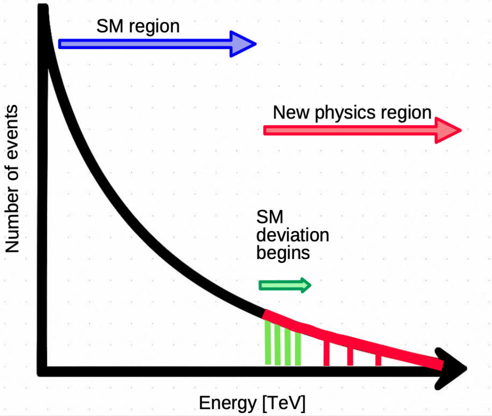
Absolute differential cross-section measurement is done as a function of $p_T(\gamma)$ and $|\eta(\gamma)|$

Interpretation: Motivation

$$\Gamma_\mu^{t\bar{t}\gamma} = -ie\left[\gamma_\mu\left(F_{1V}^\gamma(k^2)+\gamma_5 F_{1A}^\gamma(k^2)\right)+\frac{\sigma^{\mu\nu}}{2m_t}(q+\bar{q})^\nu\left(iF_{2V}^\gamma(k^2)+\gamma_5 F_{2A}^\gamma(k^2)\right)\right]$$

$= Q_t\,\frac{g_t\text{-}2}{2}$ $\qquad = d_t^\gamma\,\frac{2m_t}{e}$





Step 1: Parameterization-1D

FSP ATLAS Erforschung von Universum und Materie
UNIVERSITÄT SIEGEN

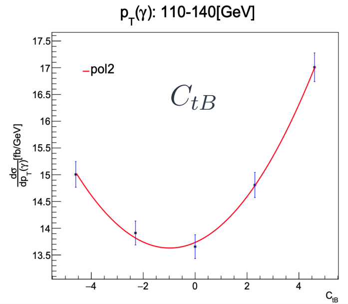
$$\sigma_{eff} \propto \left|\mathcal{M}_0 + \sum_i \frac{C_i}{(\Lambda/1\text{TeV})^2}\mathcal{M}_i\right|^2$$

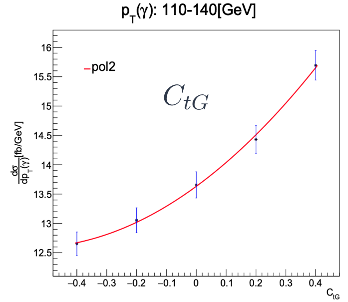
$$(-C_i, \quad C_0, \quad +C_i)$$

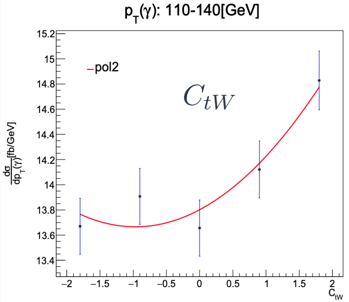
$$\sigma_{eff} = C_0 \cdot \sigma_{SM} + \sum_i \frac{C_i}{(\Lambda/1\text{TeV})^2} \cdot \sigma_i^{(1)} + \sum_{i\leq j} \frac{C_i C_j}{(\Lambda/1\text{TeV})^4} \cdot \sigma_{ij}^{(2)}$$

$$(-C_i, -\tfrac{1}{2}C_i, C_0, +\tfrac{1}{2}C_i, +C_i)$$

$$\sigma_{eff} = C_0 \cdot \sigma_{SM} + C_i \cdot \sigma_i + C_i^2 \cdot \sigma_{ii} \text{ (i=j)}$$







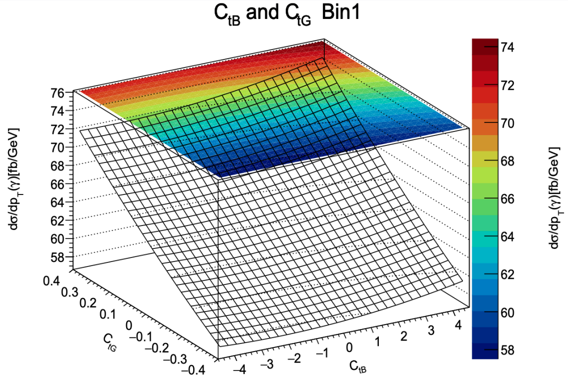
Fit results are used in posterior probability calculation to extract EFT operator coefficients limit

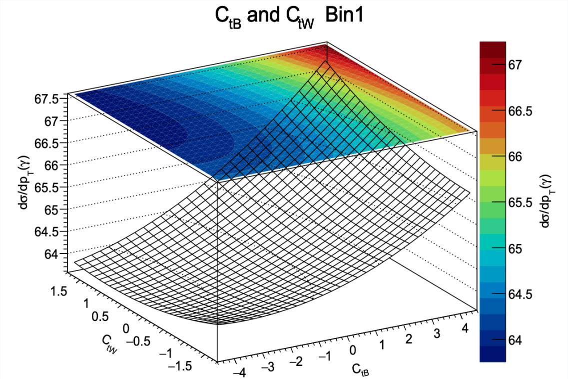
Step 1: Parameterization-2D

FSP ATLAS Erforschung von Universum und Materie

UNIVERSITÄT SIEGEN

$$\sigma_{eff} = C_0 \cdot \sigma_{SM} + C_i \cdot \sigma_i + C_j \cdot \sigma_j + C_i^2 \cdot \sigma_{ii} + C_j^2 \cdot \sigma_{jj} + C_i C_j \cdot \sigma_{ij}$$



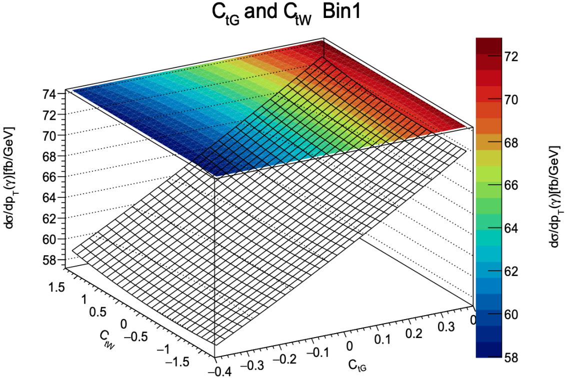


$(\pm)$ variations in C_{tB} and $(-)$ variations in C_{tG} increases $\frac{d\sigma}{dp_T}$

$(+)$ variations in both C_{tB} and C_{tW} increases $\frac{d\sigma}{dp_T}$

Step 1: Parameterization-2D

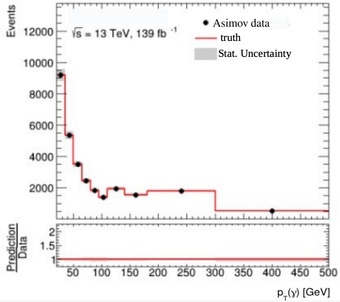
$$\sigma_{eff} = C_0 \cdot \sigma_{SM} + C_i \cdot \sigma_i + C_j \cdot \sigma_j + C_i^2 \cdot \sigma_{ii} + C_j^2 \cdot \sigma_{jj} + C_i C_j \cdot \sigma_{ij}$$



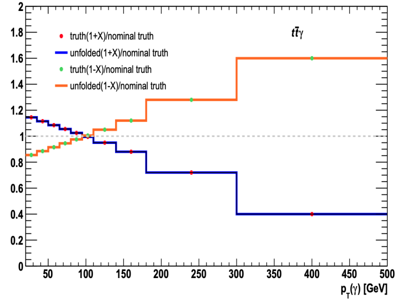
$(+)$ variations in C_{tG} and $(\pm)$ variations in C_{tW} increases $\frac{d\sigma}{dp_T}$

Profile Likelihood Unfolding: Validation

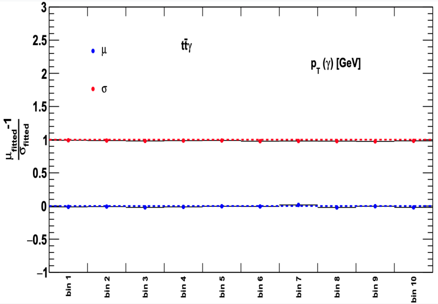
Closure Test



Stress Test



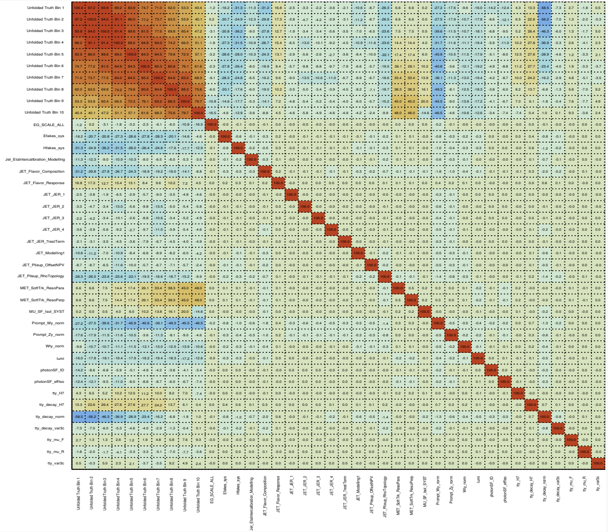
Pull test



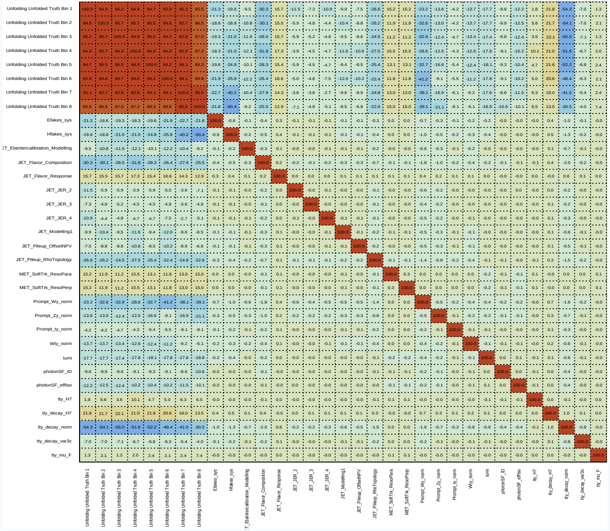
$$Weight = 1 \pm y \cdot \frac{100-i}{500} = 1 \pm X$$

$$Pull = \sum_i \frac{\hat{\theta}-\theta_{0_i}}{\Delta\theta_i} = 1 \pm X$$

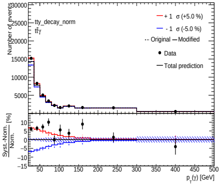
Correlarion: $p_{\mathrm{T}}(\gamma)$

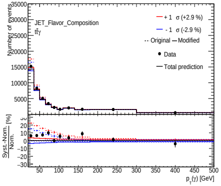


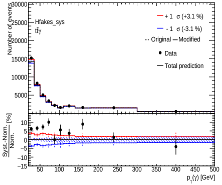
Correlarion: $|\eta(\gamma)|$

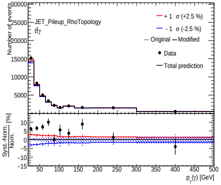


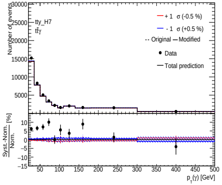
Systematics templates: $p_{\mathrm{T}}(\gamma)$

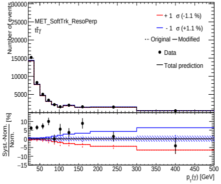


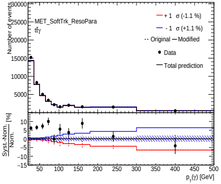


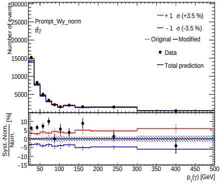


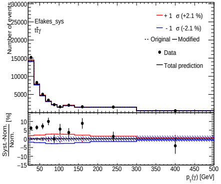


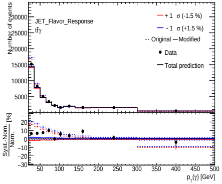




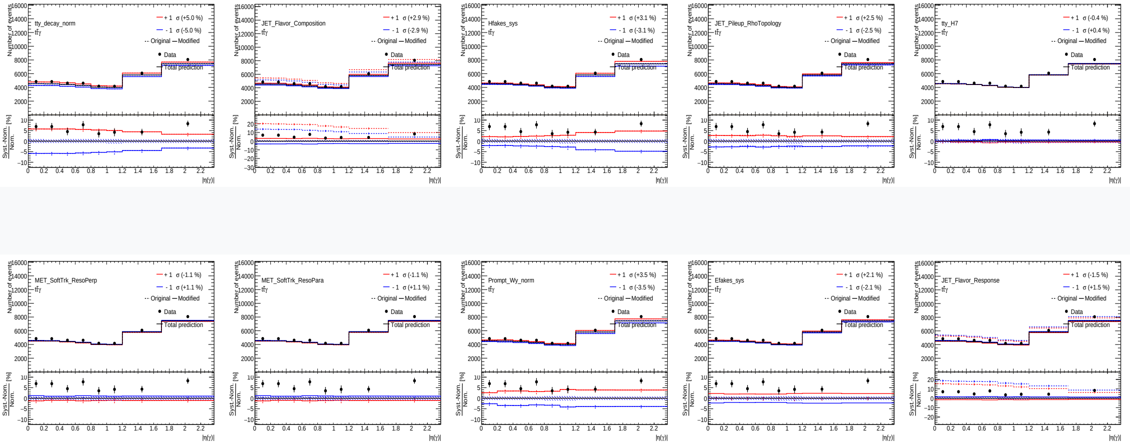




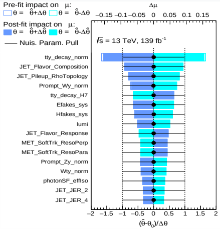


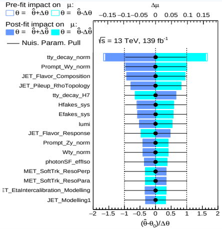


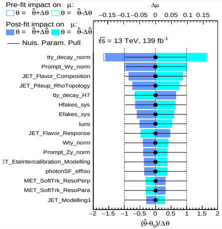
Systematics templates: $|\eta(\gamma)|$

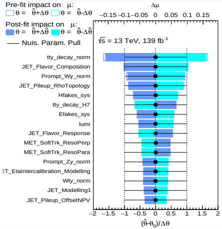


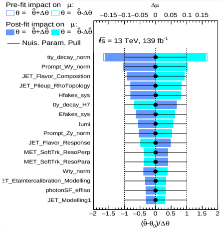
Systematics-impact ranking: $|\eta(\gamma)|$

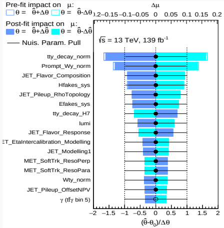


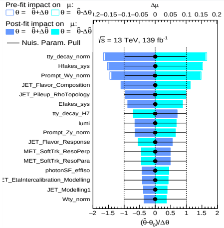


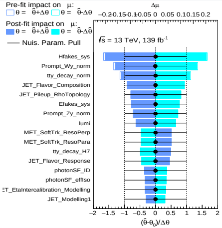


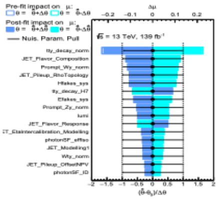




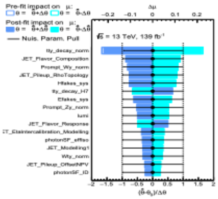






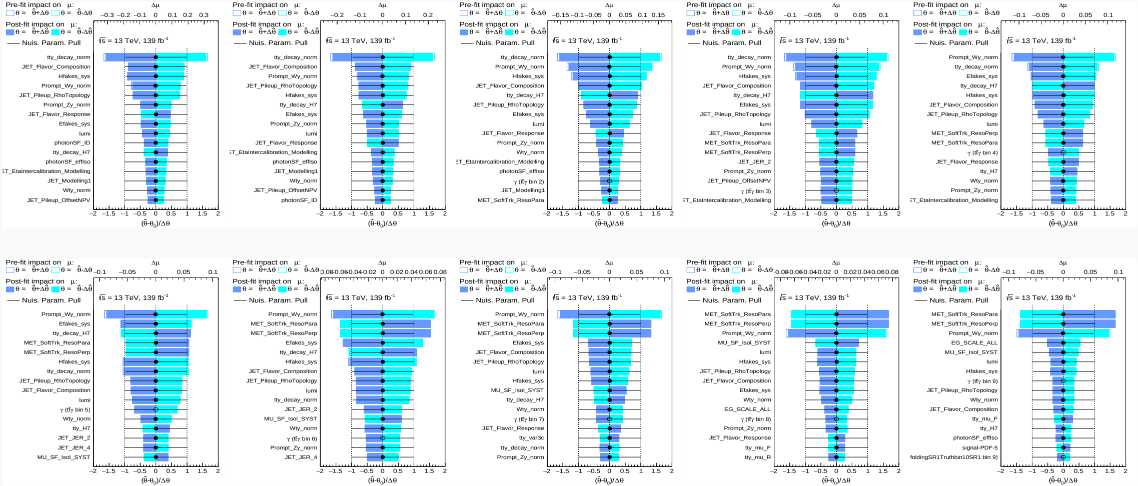


(b) $p_T(\gamma)$ bin 2: 35-50 [GeV]



(b) $p_T(\gamma)$ bin 2: 35-50 [GeV]

Systematics-impact ranking: $p_{\mathrm{T}}(\gamma)$



Constraint and pulls: $p_{\mathrm{T}}(\gamma)$ and $|\eta(\gamma)|$

$p_{\mathrm{T}}(\gamma)$

Nuisance Parameter (NP)	Pull $\pm$ Uncertainty
$t\bar{t}\gamma$-decay norm	0.003 ± 0.967
Prompt $W\gamma$-norm	-0.007 ± 0.965
h-fake	0.007 ± 0.976
e-fake	0.001 ± 0.987
$Wt\gamma$-norm	-0.003 ± 0.987

$|\eta(\gamma)|$

Nuisance Parameter (NP)	Pull $\pm$ Uncertainty
$t\bar{t}\gamma$-decay norm	0.002 ± 0.968
Prompt $W\gamma$-norm	-0.005 ± 0.968
h-fake	0.003 ± 0.975
e-fake	0.002 ± 0.988
$Wt\gamma$-norm	0.002 ± 0.987

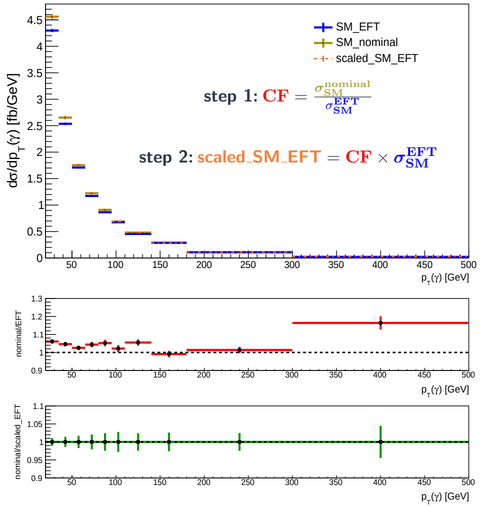
Correction factors (CF)

MadGraph Level Selection

$p_T\ (\gamma) > 15$ GeV,
$p_T\ (e/\mu) > 15$ GeV,

$p_T(\gamma) > 17$ GeV,
$p_T(e/\mu) > 23$ GeV,
p_T(jets) > 23 GeV,
$\Delta R\ (l,\gamma) > 0.8$.

p_T (jets) > 15 GeV,
$\Delta R\ (l,\gamma) > 0.4$.



Posterior Probability:

$$P(\vec{\lambda}|M,\vec{D}) = \frac{P(\vec{D}|\vec{\lambda},M)P_0(\vec{\lambda}|M)}{P(\vec{D}|M)}$$

$\vec{D}$: measured $\frac{d\sigma}{dp_T}$ (unfold data)

$\vec{\lambda}$: EFT coefficients, C_{tB}, C_{tG}, C_{tW}

M: polynomial fit $\times$ CF