Measurement of the cross section of ttW in proton-proton collision at $\sqrt{s} = 13$ TeV

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$t\bar{t}W$ production at the LHC

- W boson only radiated from initial-state quarks
- Via $q\bar{q}'$ at LO, gq at NLO and gg at NNLO
- Sizeable difference between $t\bar{t}W^+$ and $t\bar{t}W^-$ production cross sections
- Large charge asymmetry due to spin correlation between the decay products [1]

Trilepton signal region









Motivation

- Highly sensitive to some EFT operators
- Dominant background to several LHC searches
- Previous measurements were higher than predictions (CMS [2] and ATLAS [3])
- Foundation for charge asymmetry and differential measurements



$m(\ell\ell)$	> 30 GeV m(ee) - m(Z) > 15 GeV	> 12 GeV $ m(\ell^{\pm}\ell^{\mp}) - m(Z) > 10$ GeV	1 2 3 >3 2 3 4 >4 2 3 4 >4 ≥0j 0j 1b >1b Number of jets
Jets	≥ 2 jets	≥ 2 jets	$t\bar{t}W$ cross section measurements
B-tagged jets	≥ 2 loose bJets or ≥ 1 medium bJets	≥ 1 medium bJets	• Perform binned profile likelihood fit to dilepton, trilepton signal regions and control regions to measure the $t\bar{t}W$. $t\bar{t}W^+$ and $t\bar{t}W^-$ cross sections
p_T^{miss}	> 30 GeV	_	• Additionally ratio of $t\bar{t}W^+$ cross section to that of $t\bar{t}W^-$ is also
Categories	Flavour and charge of leptons	Jet, b-tagged jet multiplicities and lepton charge	measured $138 \text{ fb}^{-1}(13 \text{ TeV}) = \frac{\text{CMS}}{550} = \frac{138 \text{ fb}^{-1}(13 \text{ TeV})}{550}$
			- CMS ■ Measurement // EPJC 80 (2020) 428 [4] - + Best fit
Dilepton signal region			
• Multiclass neutral network (INN) with 4 hodes (<i>ILW</i> , <i>ILHTZ</i> , <i>ILΥ</i> and nonprompt)			Image: Nominal ± stat ± syst Image: Nominal ± stat ± syst 400 Image: ee 845 ± 117 ± 111 Image: Nominal ± stat ± syst 1mage: Nominal ± stat ± syst
 Fit to NN discriminant 			$= e \mu$ $= 996 \pm 61 \pm 68$ $= 350 \begin{bmatrix} -2 \\ -2 \end{bmatrix}$
$138 \text{ fb}^{-1} (13 \text{ TeV}) = 138 \text{ fb}^{-1} (13 \text{ TeV})$			$\begin{bmatrix} \mu \mu \\ - & 005 \pm 03 \pm 04 \\ - & 905 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & - & - & - & - & - & - & - \\ - & 005 \pm 42 \pm 51 \end{bmatrix} = 300 \begin{bmatrix} - & $
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References:



[1] F. Maltoni, M. Mangano, I. Tsinikos, and M. Zaro, Phys. Lett. B 736 (2014) 252 [2] CMS collaboration, JHEP 08 (2018) 011 [3] ATLAS Collaboration, Phys. Rev. D 99, 072009 [4] EPJC 80 (2020) 428, A. Kuleszaa et al. [5] JHEP 11 (2021) 029, R. Frederix, I. Tsinikos

