



Search for tZq in 22 final states DPG - March 2021

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Introduction

CMS DESY.

 tZq process sensitive to both top-Z and WWZ couplings → interesting for EWK studies



- Direct precision measurements of the top-Z coupling became possible for the first time with Run-2 data
- Observed in the 3t channel from ATLAS and CMS

Purpose of the analysis:

 Study of tZq in the 2l channel (not observed), to bring complementary information and increase the sensitivity



Main backgrounds



- Drell-Yan and $t\bar{t} \rightarrow targe cross-sections compared to that of tZq$
- $t\bar{t}Z$ and $tZq \rightarrow comparable cross-sections, similar signatures <math>\otimes$

Cross-sections (2^ℓ) [pb]

DY 6077.22		
tĪ	88	
tīZ	0.11	
tZq	0.09	



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Event selection

Object identification:

- isolated leptons
- tight WP for b-jets (fake rate: ~0.1%)
- jets with $p_{\tau} > 25$ GeV and $|\eta| < 5$

Signal Region:

- \geq 4 jets, one of them b-tagged
- exactly 2 leptons (e[±], μ[±]), with:
 - opposite charge, same flavor
 |m_{ℓℓ} m_z| < 20 GeV





Control Regions and Signal Region



• 2 jets (CR):

• 3 jets (CR):





Event reconstruction: SR

• Recoil jet identification: choice based on a likelihood-ratio test which takes into account the $|\eta|$ and p_{τ} of the jets in the MC signal sample



• Hadronic top reconstruction: combination of jets with best χ^2



DNN for S/B discrimination

- Region with \geq 4 jets:
 - input variables from both pre-selection and event reconstruction
 - 4 output nodes: tZq, DY, $t\bar{t}$ and $t\bar{t}Z$



- Region with 3 jets:
 - input variables from pre-selection
 - 3 output nodes: tZq, DY and tt



DNN: input variables (1/2)



• Only variables with a good data/MC agreement have been used in the training:



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DNN: input variables (2/2)



• Variables with a strong disagreement have been excluded:



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Pre-fit plots: CRs



• 3 jet region: tZq output node

- 2 jet region: invariant mass of the leading jet
- 10^{6} events / bin events / bin Work in progress + data DY tt Work in progress + data DY tt 10⁶ others tīZ tZq others tīZ tZa 10⁵ 10⁵ 104 10⁴ ******** ~~~~~~ 10³ 10³ ~~~~~~ 10² 10² 10 10 10-1 10⁻¹ 20 30 50 60 70 80 90 100 0 10 40 0.9 0.1 0.2 0.3 0.5 0.6 0.7 0.8 Invariant mass of the leading jet DNN output

Pre-fit plots: SR



• tZq, DY and tt output: only events for which the value is the maximum among all nodes are included, in order to have orthogonal categories



Uncertainties and fit results



CMS

- Statistical uncertainties
- Systematic uncertainties:
 - luminosity
 - trigger efficiency
 - \circ normalization for ttZ and others (15%)
 - lepton and b-tag scale factors
 - o pile-up weights
 - Jet energy and resolution
 - \circ PS weights (tZq and ttZ)
 - PDF, α_s and matrix element
 - (tZq + main backgrounds)

Results (expected):

1.72 σ

Uncons	strained Gaussian	MS Internal	$\hat{r} = 1.0^{+0.6}_{-0.6}$
1	Pdf	·····	
2	jevLevelRelativeBal	•••• I	
3	prop_binsr_sr3_bin6		
4	jevLevelRelativeSample18	· · • · · · · · · · · · · · · · · · · ·	
5	rateTT	1.000+0.041	
6	jevLevelTimePtEta18	· · · · · · · · · · · · · · · · · · ·	
7	Pu	••••	
8	jevLevelJerEta3to5pT0to5018	••••••••••••••••••••••••••••••••••••••	
9	rateDY	1.000 ^{+0.042}	
10	jevLevelJerEta2p5to3pT0to5018		
11	jevLevelRelativeStatHF18		
12	jevLevelFlavorQCD	••••	
13	Prefire		
14	jevLevelTimePtEta17		
15	jevLeveUerEta3to5pT50toInf17		
16	prop_binsr_sr1_bin6		
17	EI	• ••• •	
18	jevLevelPileUpPtBB		
19	jevLeveUerEta2p5to3pT50toInf17		
20	prop_binsr_sr2_bin6		
21	jevLevelTimePtEta16		
22	jevLevelRelativeJERHF		
23	prop_binsr_sr2_bin3		
24	jevLevelRelativeSample16	•••••	
25	jevLevelRelativeStatFSR18	· · · · · · · · · · · · · · · · · · ·	
26	jevLevelJerEta3to5pT0to5017	•••••	
27	jevLevelRelativePtEC118		
28	jevLevelAbsoluteScale		
29	jevLevelRelativePtEC218	•••••	
30	jevLevelRelativePtHF	. i i • i i i i	
		-2 -1 0 1 2 -0.2 -0.2	.1 0 0.1 0.2
-←Pull [📕 + 1ơ Impact 📃 - 1ơ Impa	ct $(\widehat{\theta} - \theta_0) / \Delta \theta$	$\Delta \hat{r}$





- We set up an analysis for tZq in the 2ℓ final state:
 - two DNN have been trained in order to separate tZq from the main backgrounds
 - a statistical fit is performed simultaneously on 3 different regions, depending on jet multiplicity
 - $\circ\,$ an expected significance of 1.72 $\sigma\,$ is reached, data have not been included yet

Next steps:

- Partial unblinding of the analysis
- Ask for total unblindig and public result



Thank you!



Control Plots: CR (2 jets)





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Control Plots: CR (2 jets)





35.9 fb⁻¹ (13 TeV)



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Control Plots: CR (2 jets)



Control Plots: CR (3 jets)





Control Plots: CR (3 jets)





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Control Plots: CR (3 jets)



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41.5 fb⁻¹ (13 TeV)

-Work in progress

 10^{6}

Control Plots: SR

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Work in progress

35.9 fb⁻¹ (1<u>3 TeV)</u>

DY

Work in progress



59.7 fb⁻¹ (13 TeV)

tZa

Control Plots: SR





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Control Plots: SR



Pre-fit plots: CRs (2016)





0.0



Pre-fit plots: SR (2016)



Pre-fit plots: CRs (2017)





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0.0





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Pre-fit plots: CRs (2018)





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events / bin 1900 events / bin events / bin Work in progress + data tZq tīZ Work in progress + data DY tīZ + data Work in progress tīZ tī ■tZq tZq others tī DY others others DY tŦ 10⁵ 1400 6000 10 1200 5000 10³ 1000 4000 10² 800 3000 600 10 2000 400 200 1000 10 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 0 0.8 0.9 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 DNN output **DNN** output DNN output

Pre-fit plots: SR (2018)

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DESY