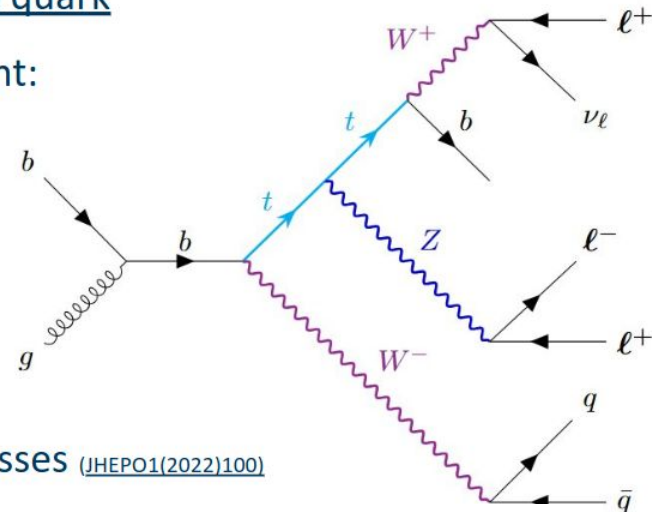

Search for the tWZ process using proton-proton collision data at $\sqrt{s} = 13.6$ TeV

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Input for RA3 discussion on rare processes,
material from C. Costa's talk at the ATLAS-D

tWZ process

- tWZ: rare process sensitive to the electroweak coupling of the top quark
- The tWZ process has never been observed at the ATLAS experiment:
 - ↳ $\sigma = 148^{+10}_{-9}$ fb at $\sqrt{s} = 13.6$ TeV (NLO MC)
 - ↳ Large background contributions (e.g. ttZ and WZ) and events with non-prompt leptons
- Sensitive to 13 Standard Model Effective Field Theory (SMEFT) operators with different dependence than other top+boson processes ([JHEPO1\(2022\)100](#))
- Using Run 3 data collected between 2022-2024 with the ATLAS detector corresponding to 159 fb^{-1} .
- The three and four lepton channels are the most sensitive.
- Defined regions based on the number of leptons (prompt or fake), b-tagged jets and $m_{\ell\ell}$ requirements



3 Lepton

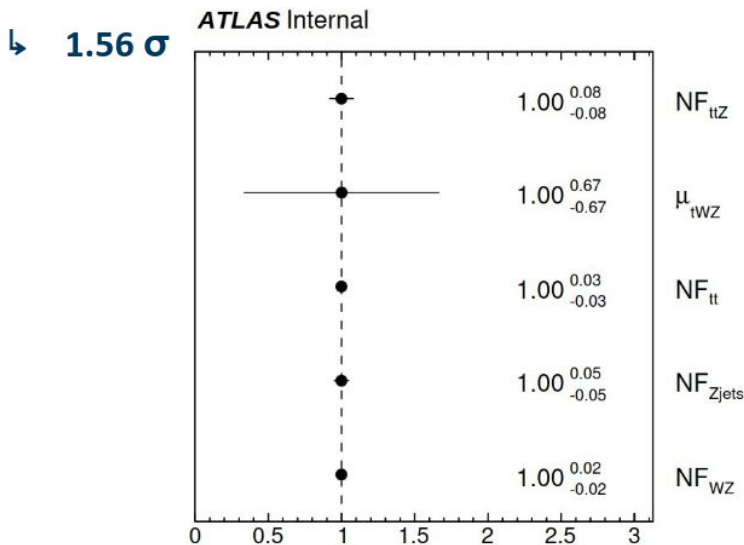
Variable	Regions used for training				
	tWZ-3L Region	ttZ CR	WZ CR	Zjets CR	tt CR
$N_{\ell} (\ell = e, \mu)$	3 tight ID leptons			2 tight, 1 medium ID leptons	
$p_T(\ell_1, \ell_2, \ell_3)$	$> 28, 18, 10$ GeV			$> 28, 18, 10$ GeV	
N_{jets}	≤ 3			≥ 2	
$p_{T\text{jets}}$	> 25 GeV (A) $> 35, 30, 25$ GeV (B)			> 25 GeV	
$N_{b\text{-jets}}$	1			1	
E_T^{miss}	> 30 GeV			< 30 GeV	
$N_{Z\text{candidate}}, m_{l-l^+} - m_Z < 10$ GeV	1			1	

4 Lepton

Variable	All regions used for training				
	tWZ OF Region	tWZ SF Region	tWZ Loose Region	ttZ CR	ZZ CR
$N_{\ell}^{\text{tight}} (\ell = e, \mu)$	4	4	3	4	4
N_{ℓ} (loose & not tight)	-	-	1	-	-
$p_T(\ell_1, \ell_2, \ell_3, \ell_4)$	$> 28, 18, 10, 10$ GeV				
N_{jets}	1	1	1	≥ 2	≥ 1
$p_{T\text{jets}}$	> 25 GeV	> 25 GeV	> 25 GeV	> 20 GeV	
$N_{b\text{-jet}}$	1	1	1	2	1
$N_{Z\text{candidate}}, m_{l-l^+} - m_Z < 10$ GeV	1	1	1	1	2
Lepton flavour	Opp. flavour non-Z leptons	Same flavour non-Z leptons	-	-	-

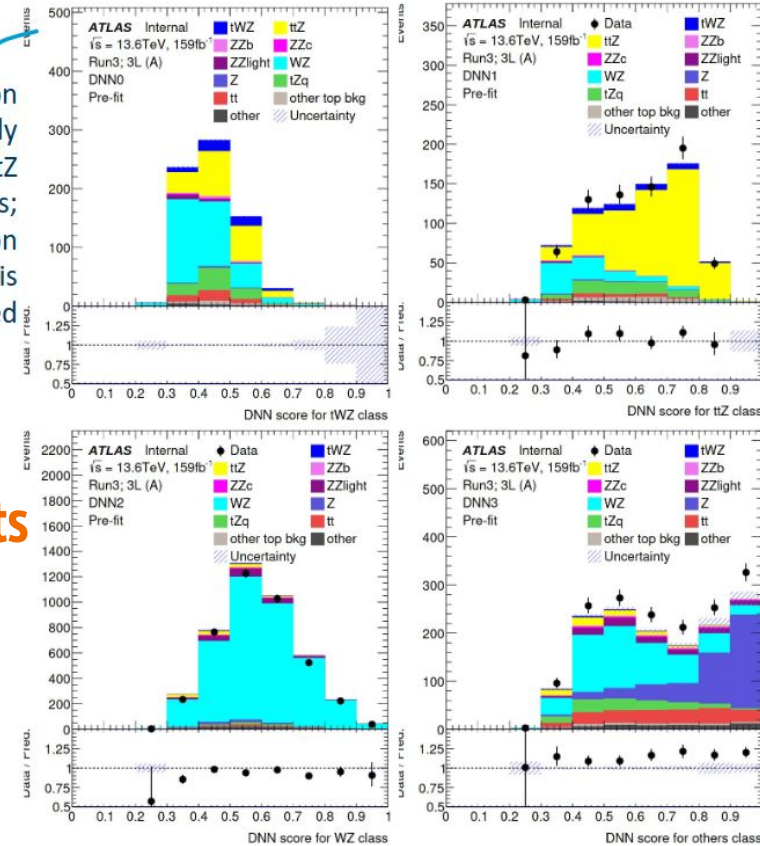
Analysis strategy - Multiclass DNN for Signal-background

- **4 classes** for the 3L Channel:
 - ↳ **signal: tWZ**
 - ↳ **3 background classes: ttZ, WZ and others**
- **4 regions** defined based on the largest classifier score
- **3 classes** for the 4L Channel:
 - ↳ **signal: tWZ**
 - ↳ **2 background classes: ttZ and ZZ**
- Extracting the signal strength ($\mu = \frac{\sigma}{\sigma_{SM}}$) for tWZ, ZZ, ttZ, tt and WZ simultaneously
- **Expected significance:**



The tWZ region is still strongly affected by ttZ and WZ events; further optimization of the classifier is needed

Example results 3L channel



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Summary

- First tWZ production measurement at ATLAS is ongoing, shown results for the 3-lepton channel
 - Final goal: combined measurement of Run 2 and Run 3 data for the three and four lepton channels
- Multi-class analysis using DNN for signal and background separation
 - New optimization strategies being discussed: further feature studies, introduction of new physics-motivated features, focus on tWZ and ttZ discrimination
- Ongoing: Include systematic uncertainties
- Next: combination with Run 2

(Also progress on others RA3 topics, focusing here on the rare process...)