Vector Boson Scattering at the LHC: A Combined Measurement with CMS Run 2 Data

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on the behalf of the CMS Collaboration

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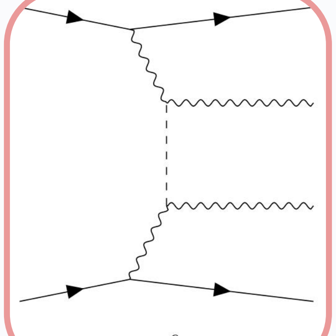
Vector Boson Scattering

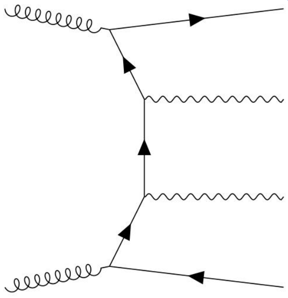
Vector boson scattering (VBS) happens at the LHC when the two incoming partons radiate electroweak vector bosons that interact with each other

- At LO, the pure EWK signal is ~α^6, while the mixed QCD induced ~$\alpha_s{}^2\alpha^4$ and the interference is ~$\alpha_s\alpha^5$
- Without photons, VBS presents a 6-fermions final state: 2 jets coming from the initial state partons, 4 coming from the scattered bosons
- 2 highly energetic jets ("tagging" jets) :
  - large gap in **η (|Δη$_{jj}$|)**
  - high jet invariant mass (**m$_{jj}$**)
- leptons (lν or 2l) from the boson are emitted centrally with respect to the tagging jets (**Z$_X$**)

$$Z_X = \eta_X - \frac{1}{2}(\eta_{j_1} + \eta_{j_2})$$



α^6

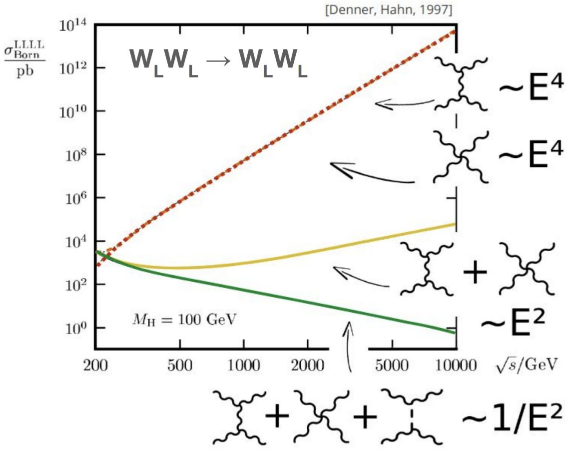


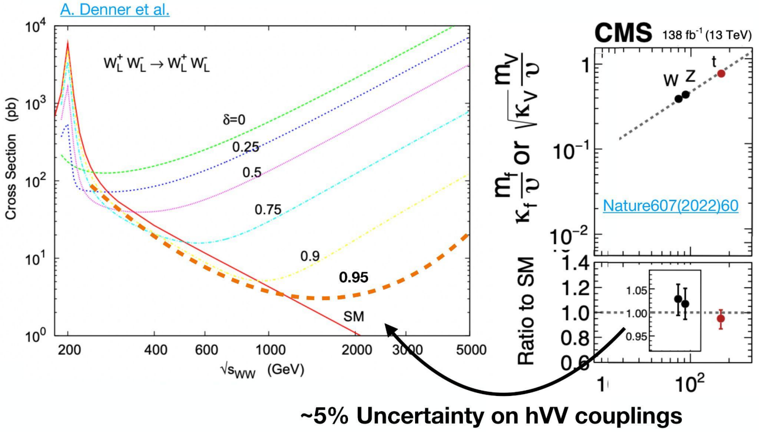
$\alpha_S^2\alpha^4$

Vector Boson Scattering

VBS is a fundamental probe to understand the electroweak symmetry breaking (Brout–Englert–Higgs) mechanism

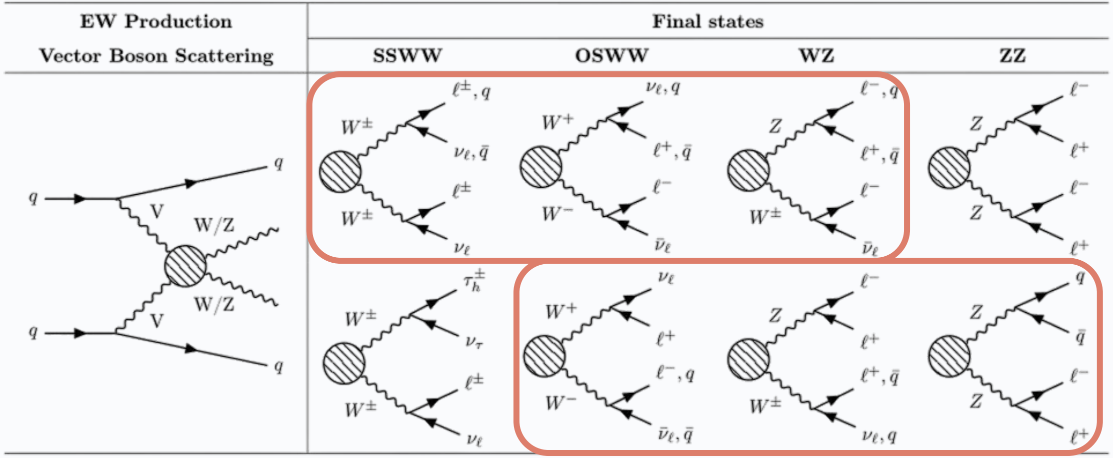
The presence of the Higgs field regularizes the VBS cross-section cancelling exactly the ~E^2 divergence of bosonic-only processes





This is a very delicate equilibrium: if H boson is **not** the SM one (**δ**), cancellation is only partial, expected divergence of $V_L V_L \to V_L V_L$ cross section @ high energies → New physics

Input Analyses



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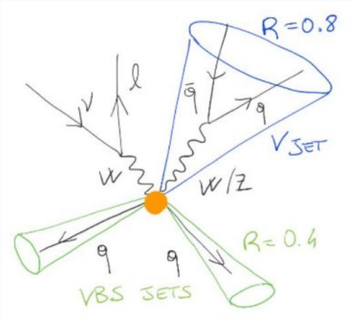
WZ	$pp \rightarrow W^\pm Zjj$	$3\ell\nu jj$	3	[2]
ZZ(4ℓ)	$pp \rightarrow ZZjj$	$4\ell jj$	4	[6]

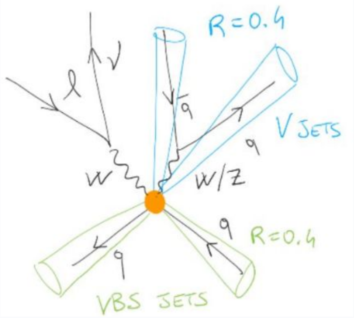
1 lepton

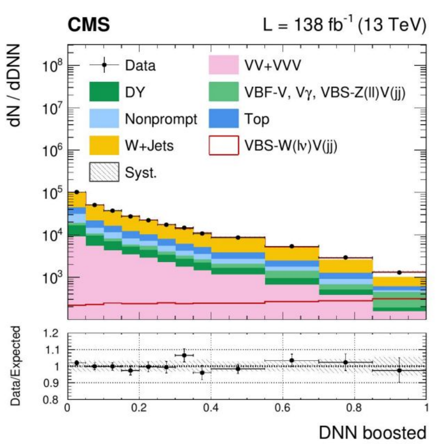
Phys. Lett B 834 (2022) 137438

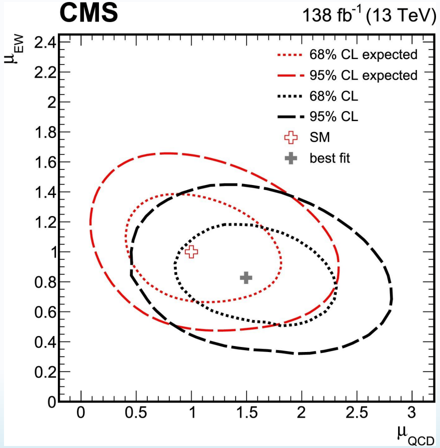
First evidence for WW/WZ semileptonic VBS. Final state requires 1 charged lepton + MET and 4(3) jets.

- Resolved regime: 4 AK4 jets
- Boosted regime: 2 AK4 + 1 AK8 (boosted decay of the V boson)
- DNN trained in each regime to improve performance









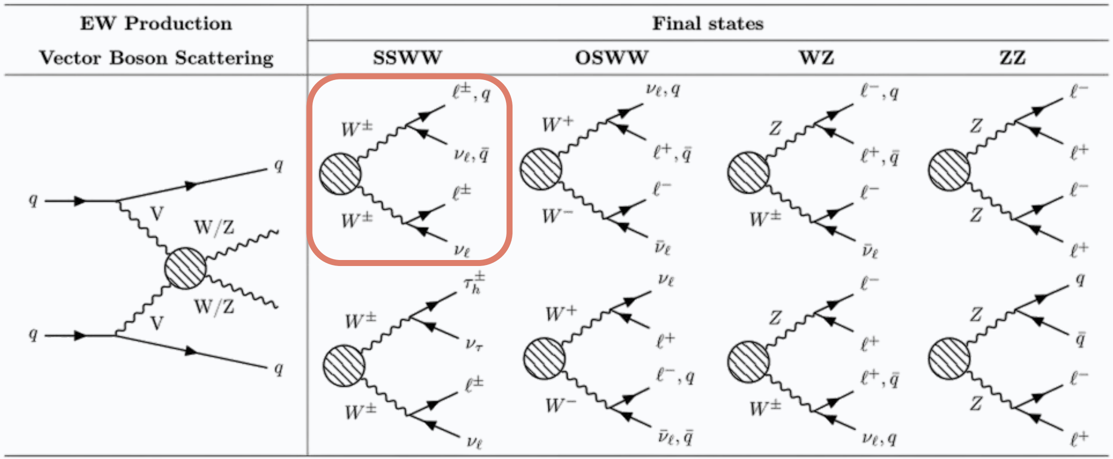
Results include a 2D fit for the pure EWK and mixed-QCD production of a W + jets

$$\mu_{EW} = 0.85 \pm 0.12(stat)^{+0.19}_{-0.17}(syst) = 0.85^{+0.23}_{-0.21}$$

$$\mu_{EW+QCD} = 0.97 \pm 0.06(stat)^{+0.19}_{-0.21}(syst) = 0.97^{+0.20}_{-0.22}$$

in agreement with the SM expectations

Input Analyses



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2 leptons (I)

Phys. Lett B 809 (2020) 135710

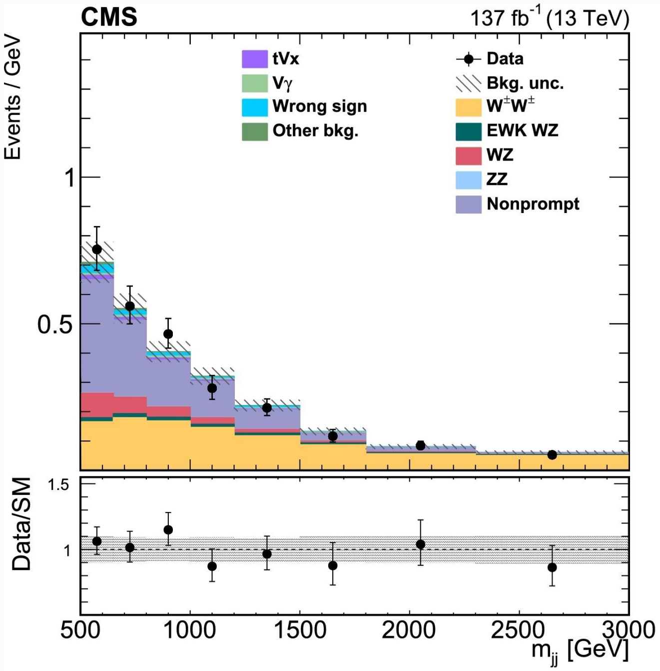
SSWW VBS final state: 2 (VBS) jets and 2 isolated lepton + MET.
Significant contribution from VBS-WZ (with 1 lepton lost) → $W^{\pm}W^{\pm}$ and WZ cross-section measurement is simultaneous

Other backgrounds:

- Non-prompt: tight-to-loose ratio relaxing one lepton requirements
- Wrong-sign: efficiency correction factors estimated in Z events
- QCD-induced $W^{\pm}W^{\pm}$ + 2 jets, $W^{\pm}Z$ + 2 jets
- QCD and EW ZZ + 2 jets

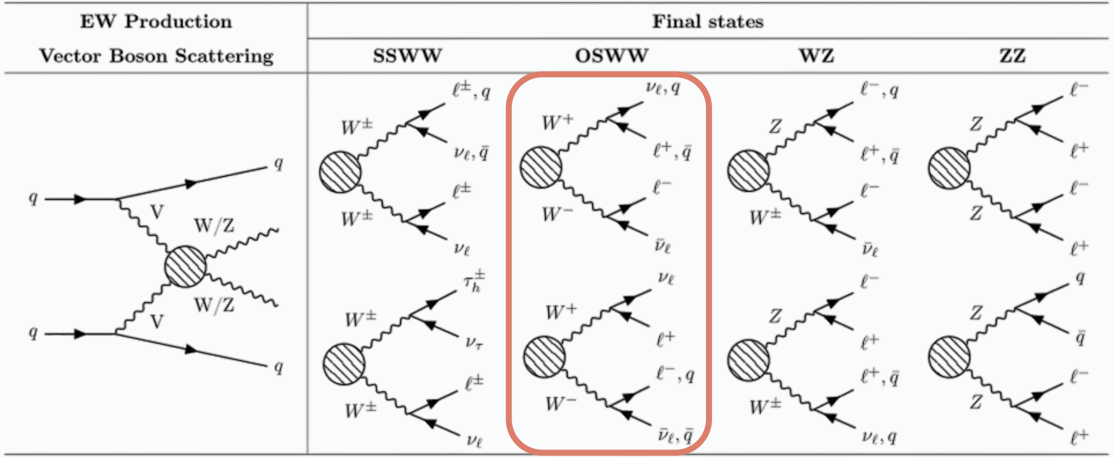
Observables:

- EW $W^{\pm}W^{\pm}$ signal is extracted with a 2D fit m_{jj} x m_{ll} (8x4 bins)
- m_{jj} used to constrain QCD-WZ and ZZ normalizations



VBS EW production of $W^{\pm}W^{\pm}$ is observed with a significance >> 5σ

Input Analyses



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2 leptons (II)

First observation of the EW production of a leptonically decaying W^+W^- pair + jets. Final state requires 2 leptons + MET + 2 (VBS) jets. Different background composition depending on SF / DF channels:

- (SF) ee, $\mu\mu$: major contribution from DY
- (DF) eμ: reduced DY contribution, leading sensitivity

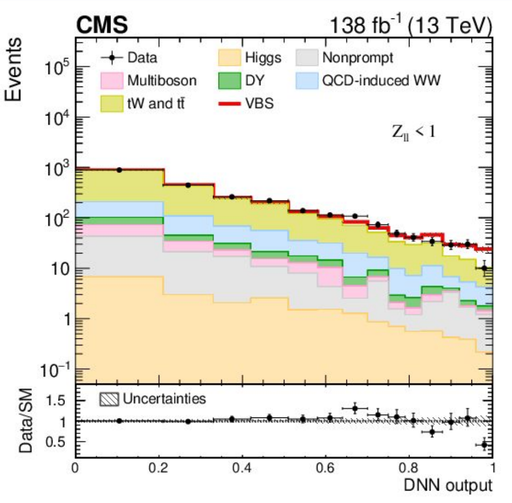
Lepton-flavor dependent signal extraction:

- (SF): 5 m_{jj} bins for m_{jj} ≥ 500 and $|\Delta\eta_{jj}|$ ≥ 3.5, 3 bins in $|\Delta\eta_{jj}|$ and m_{jj} with low sensitivity
- (DF): DNN trained against main backgrounds. Different model trained depending on Z_{ll} value

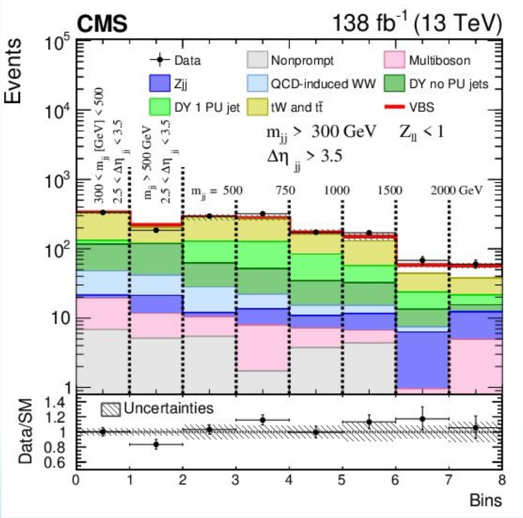
The leptonic VBS W^+W^- cross section is observed with a significance of 5.6σ (5.2 expected)

$$\sigma_{EW} = 10.2 \pm 2.0\text{fb}$$

in agreement with the SM expectations (9.1 ± 0.6 fb)



Phys. Lett B 841 (2023) 137495



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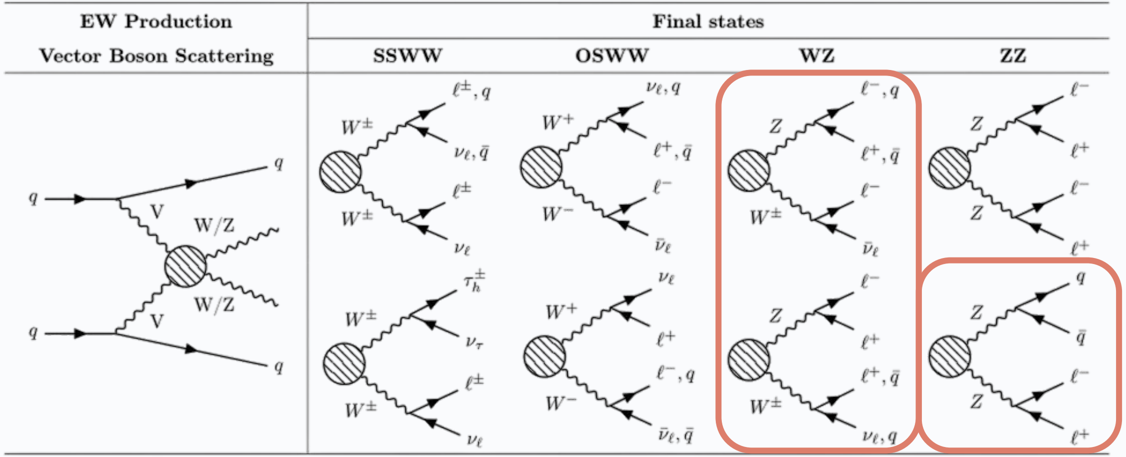

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2 leptons (III)

CMS-PAS-SMP-22-011

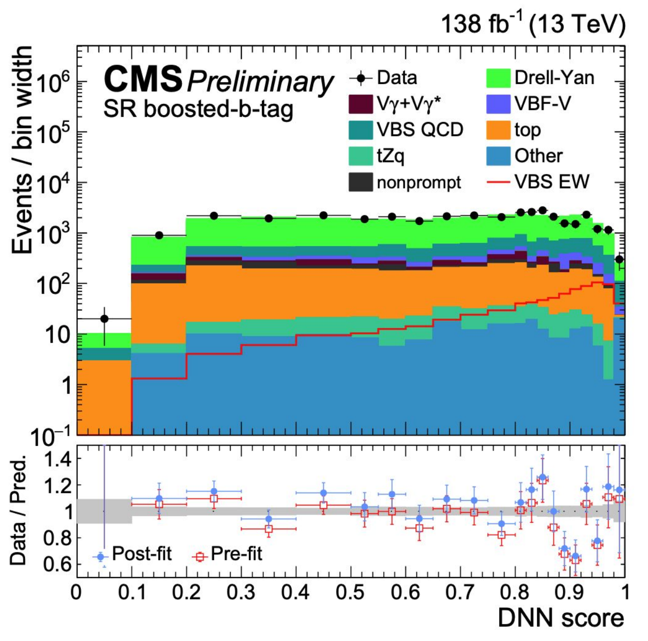
Measurement for ZW/ZZ semileptonic VBS. Final state requires 2 OS charged leptons and 4(3) jets.

- Resolved regime: 4 AK4 jets
- Boosted regime: 2 AK4 + 1 AK8 (boosted decay of the V boson)
- SR splitted in btag/bveto to account for different mismodeling in the DY events
- Multiple DNNs trained in each regime and used to extract the signal cross-section
- $p_T(Z)$ x VBS trialing jet p_T is used in the DY CRs to constrain and correct the main background

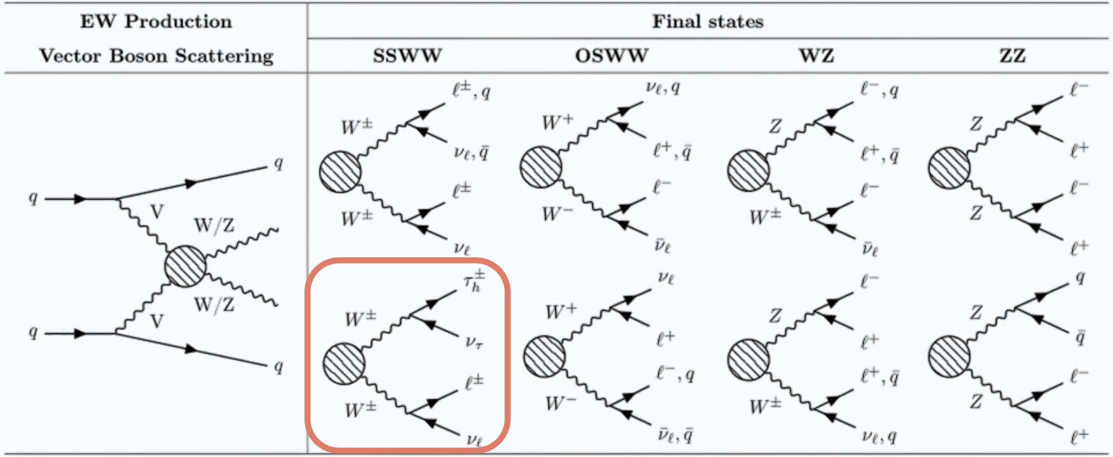
The semileptonic VBS ZV cross section is measured with a significance of 1.3σ (1.8 expected)

$$\mu_{EW} = 0.63^{+0.53}_{-0.51}$$

in agreement with the SM expectations



Input Analyses



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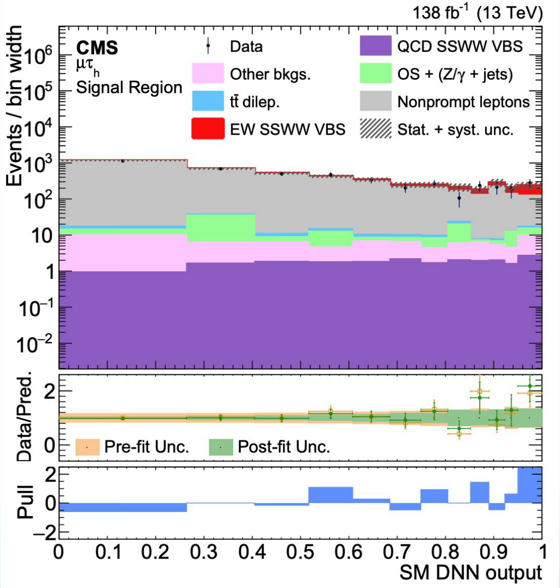
2 leptons (IV)

arXiv:2410.04210

- SSWW VBS with 1 tau: τ_h exploited for the first time in VBS. Final state requires 2 (VBS) jets, 1 lepton and 1 τ_h + MET
- τ_h: reconstructed using hadron-plus-strips (HPS) algorithm [7]. DeepTau [8] is also used to distinguish them from quarks, gluons or charged leptons.
- DNN trained for enhance signal significance in SR, also used in CRs to boost separation in the fit

Region	EW-VBS	Fake	$t\bar{t}$	OS+Z/γ	QCD-VBS
SR $e\tau_h$	3.0%	92.2%	0.9%	2.0%	0.3%
SR $\mu\tau_h$	3.1%	93.3%	0.5%	1.7%	0.3%
$t\bar{t}$ CR	-	37.1%	61.6%	8.2%	-
OS CR	-	56.4%	7.9%	35.1%	-



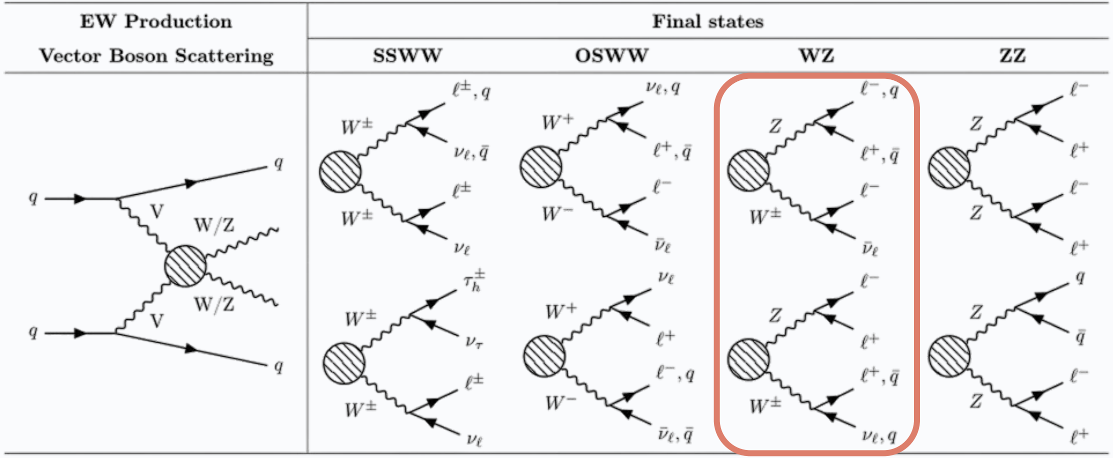
Results include a 2D fit for the pure EWK and mixed-QCD VBS production

EW $W^{\pm}W^{\pm}$ jj $\rightarrow \ell\tau_h 2\nu$ jj significance of 2.7σ (2.9 EW + QCD)

$$\mu_{EW} = 1.44^{+0.63}_{-0.53} \qquad \mu_{EW+QCD} = 1.43^{+0.60}_{-0.54}$$

in agreement with the SM expectations

Input Analyses



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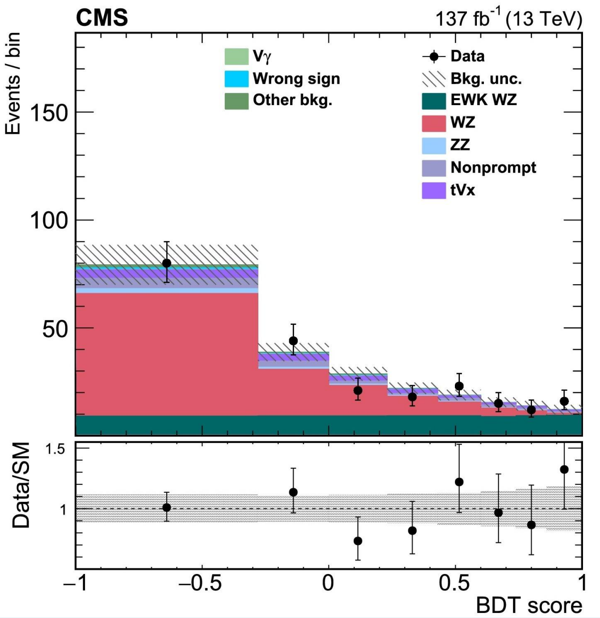
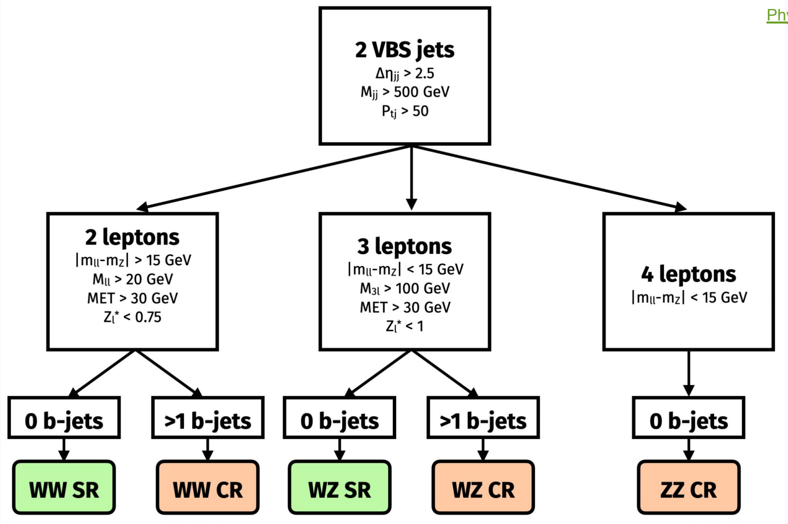
3 leptons

Phys. Lett B 809 (2020) 135710

The VBS WZ production is treated as a background for the $W^{\pm}W^{\pm}$ analysis, but since is an interesting process itself, it's measured together with the VBS $W^{\pm}W^{\pm}$

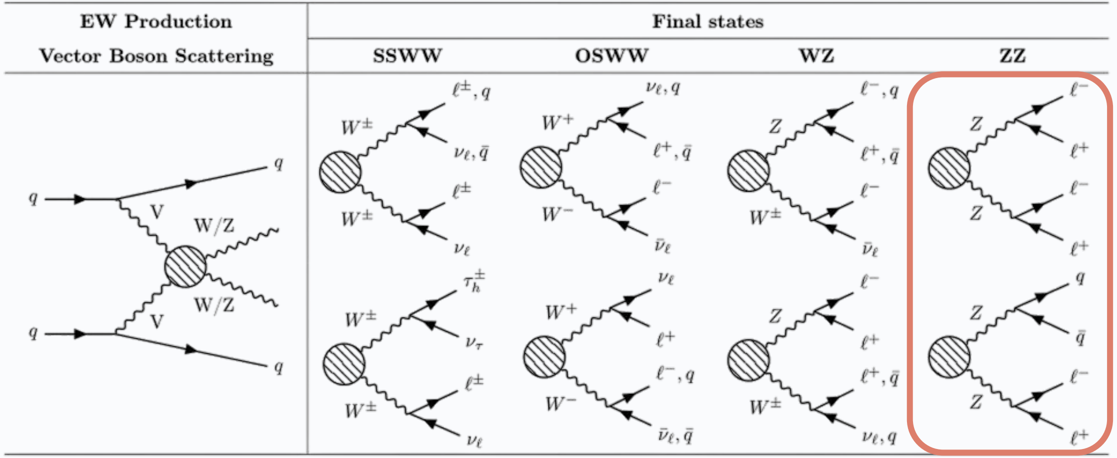




QCD-WZ induced events are the main background: BTD is trained in the WZ SR and used to extract the signal

> VBS EW production of $W^{\pm}Z$ is observed with a significance of 6.8σ (5.3 expected)

Input Analyses



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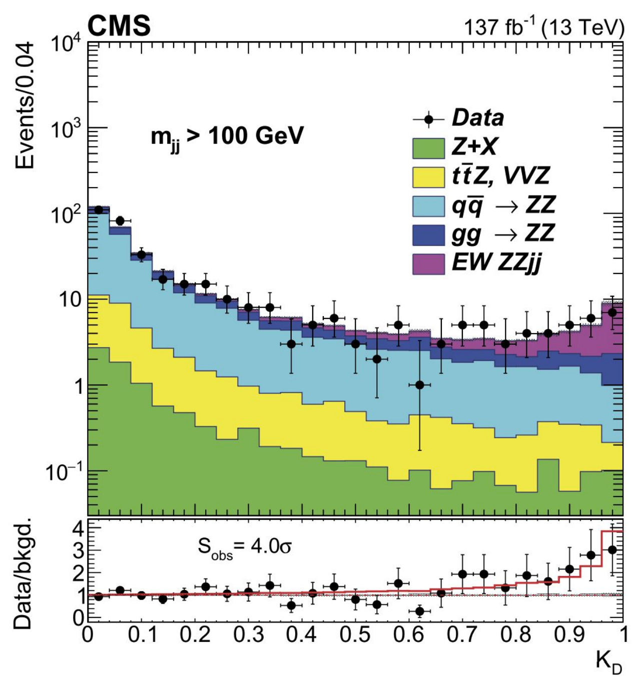
4 leptons

Phys. Lett B 812 (2021) 135992

Evidence for EW production of four charged leptons. Final state with 2 (VBS) jets and two OS same-flavor lepton pairs consistent with Z decays

- ZZ-inclusive region: $m_{jj} > 100$
- loose VBS-enriched: $|\Delta\eta_{jj}| > 2.4$, $m_{jj} > 400$
- tight VBS-enriched: $|\Delta\eta_{jj}| > 2.4$, $m_{jj} > 1$TeV
- CR defined inverting one of the loose VBS conditions

Signal is extracted with a Matrix Element Discriminant (K_D) after having check the performances against a BDT.



Evidence for VBS EW production of ZZ with 4.0σ (3.5 expected)

Inclusive region: $\sigma_{EW} = 0.33^{+0.11}_{-0.10}(stat)^{+0.04}_{-0.03}(syst)\text{fb}$

loose VBS-enriched: $\sigma_{EW} = 0.180^{+0.070}_{-0.060}(stat)^{+0.021}_{-0.012}(syst)\text{fb}$

tight VBS-enriched: $\sigma_{EW} = 0.09^{+0.04}_{-0.03}(stat) \pm 0.02(syst)\text{fb}$

in agreement with the SM expectations

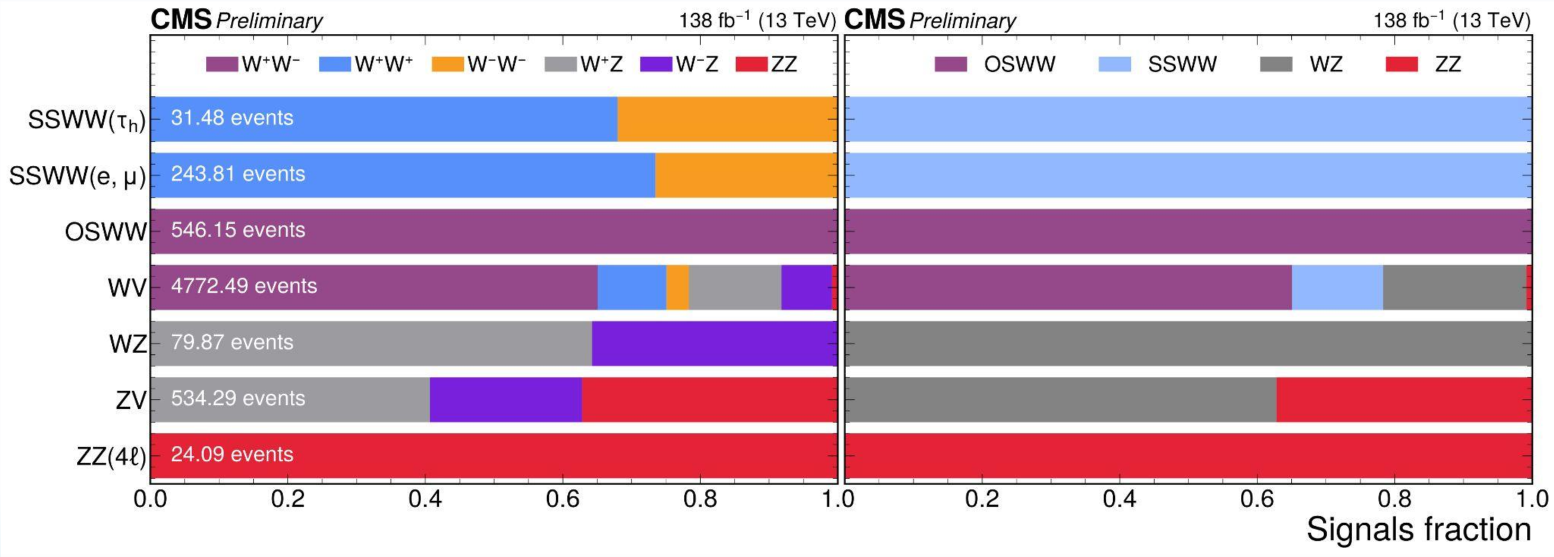
Statistical Model

CMS-PAS-SMP-24-013

Two combination models are considered: one with four parameters of interest (4-POIs), providing a global probe of VBS processes, and another with six parameters of interest (6-POIs), which extends the analysis to test the expected charge asymmetry in production.

6-POIs: $W^{\pm}W^{\pm}$, $W^{+}W^{+}$, $W^{-}W^{-}$, $W^{+}Z$, $W^{-}Z$, ZZ

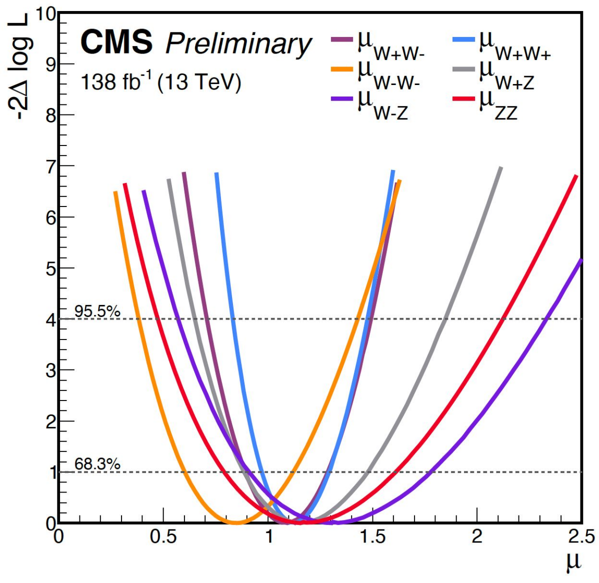
4-POIs: $W^{\pm}W^{\pm}$, $W^{\pm}W^{\mp}$, $W^{\pm}Z$, ZZ

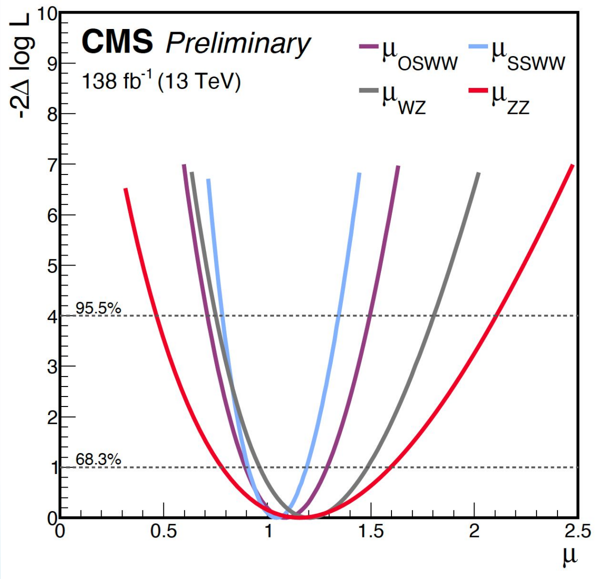


Results

CMS-PAS-SMP-24-013

		OSWW	SSWW		WZ		ZZ
4-POI	μ	$1.09^{+0.21}_{-0.18}$ $\left(^{+0.20}_{-0.19}\right)$	$1.04^{-0.14}_{-0.14}$ $\left(^{+0.14}_{-0.14}\right)$		$1.19^{+0.28}_{-0.23}$ $\left(^{+0.29}_{-0.24}\right)$		$1.15^{+0.44}_{-0.37}$ $\left(^{+0.44}_{-0.37}\right)$
	σ	6.2 (6.1)	$\gg 5$ ($\gg 5$)		7.0 (5.5)		4.0 (3.6)
6-POI		W^+W^-	W^+W^+	W^-W^-	W^+Z	W^-Z	ZZ
	μ	$1.08^{+0.20}_{-0.19}$ $\left(^{+0.18}_{-0.18}\right)$	$1.11^{+0.17}_{-0.15}$ $\left(^{+0.14}_{-0.16}\right)$	$0.84^{+0.27}_{-0.24}$ $\left(^{+0.28}_{-0.25}\right)$	$1.15^{+0.32}_{-0.27}$ $\left(^{+0.32}_{-0.27}\right)$	$1.30^{+0.47}_{-0.40}$ $\left(^{+0.44}_{-0.37}\right)$	$1.16^{+0.44}_{-0.38}$ $\left(^{+0.42}_{-0.35}\right)$
	σ	6.1 (6.1)	$\gg 5$ ($\gg 5$)	4.0 (4.6)	5.7 (4.7)	4.2 (3.2)	4.0 (3.6)

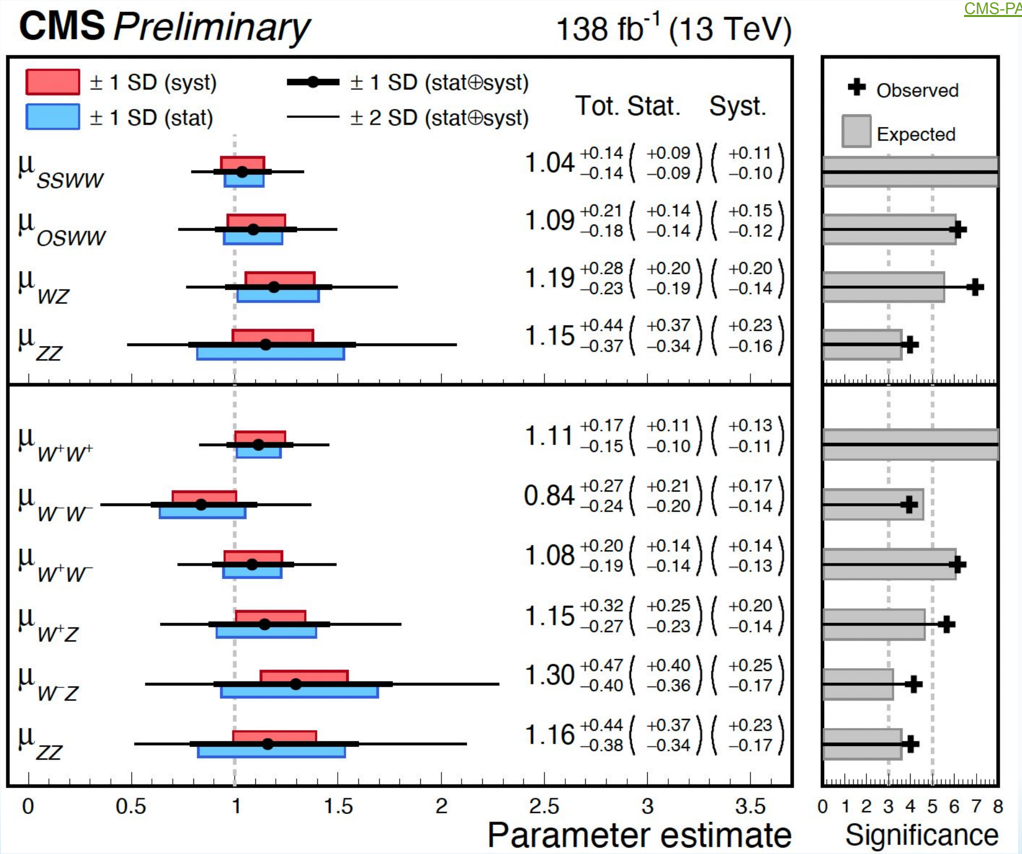




Results

CMS-PAS-SMP-24-013

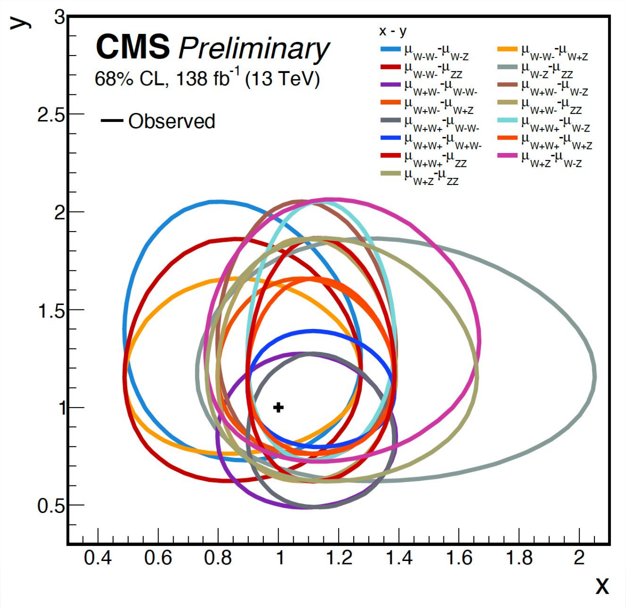
- Most channels show an excess. Signal modeling is currently only at LO; NLO corrections can reduce yields by up to 40% in the high-energy tails → even larger excesses are expected
- Several analyses are now equally affected by systematic and statistical uncertainties, opening the door to **polarized** VBS studies
- All charged coupling coefficients have been fitted simultaneously, providing individual evidence for each and achieving a 5–10% improvement

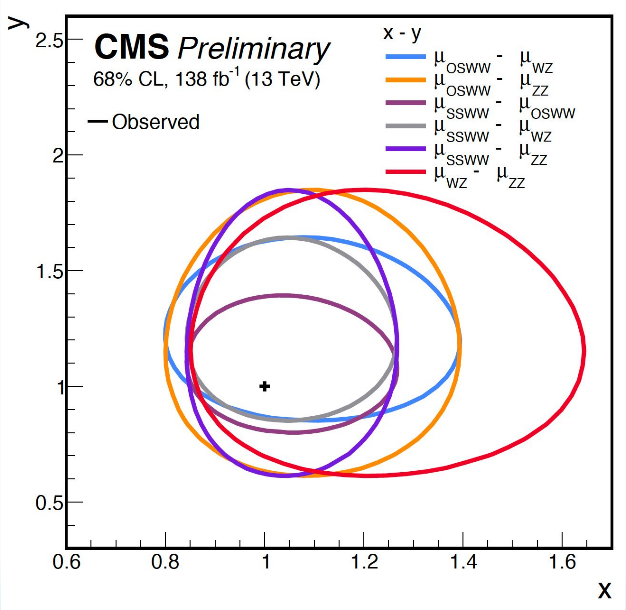


Results

CMS-PAS-SMP-24-013

A simultaneous scan is performed over pairs of signal strengths, with the remaining μ parameters profiled alongside the nuisance parameters. The results show only mild correlations and are in good agreement with SM expectations.



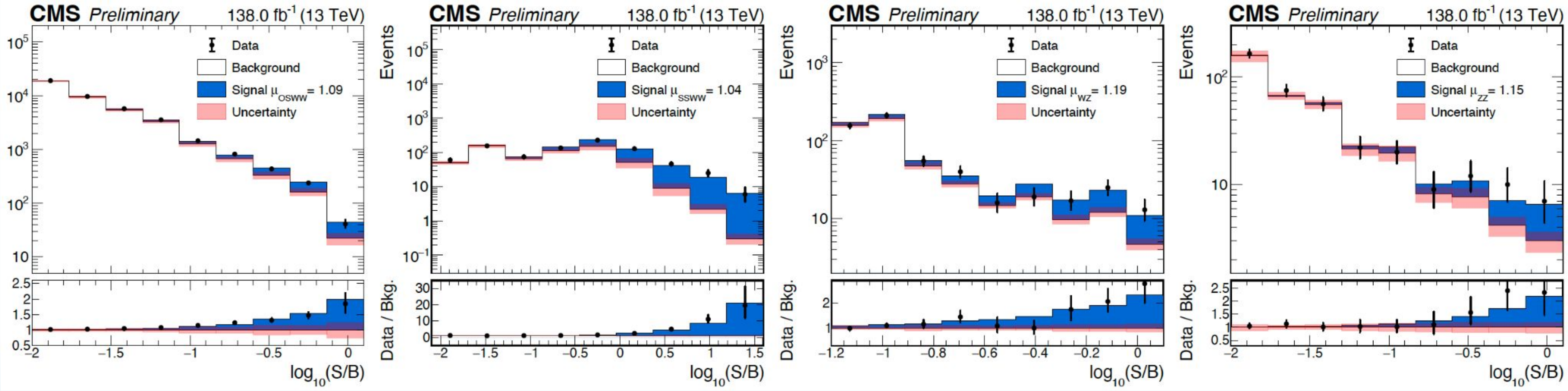


S/B plots

CMS-PAS-SMP-24-013

Prefit log(S/B) plots show good agreement with the SM prediction at LO, differentially

- For all the input templates bins, log[S(μ=1)/B] is computed
- Postfit yields of signal, backgrounds and data is assigned to the leading S distribution: plots are mutually exclusive (data is not shown twice)
- Uncertainty on the background prediction is computed with 500 toys



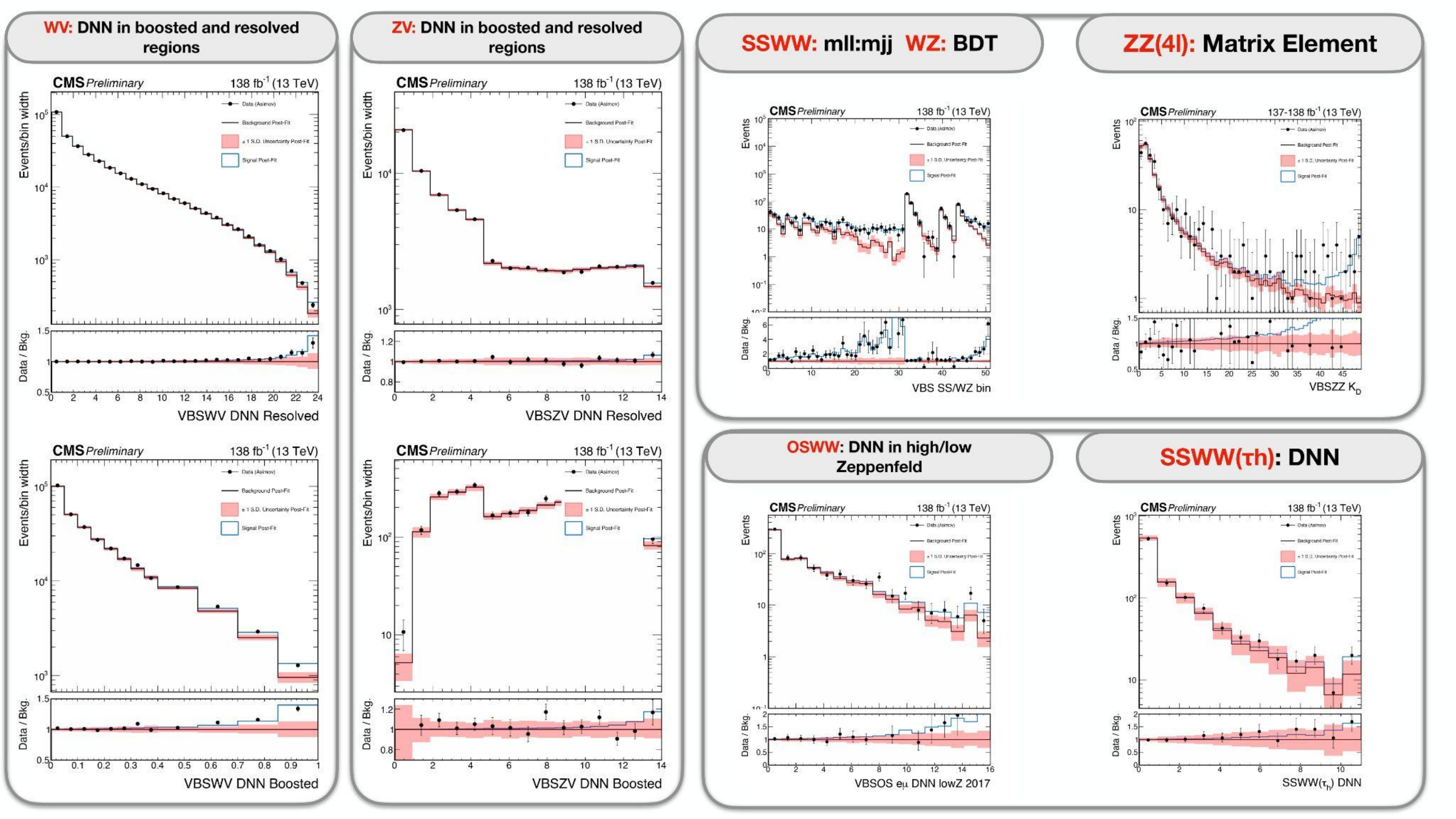
Conclusions

- First VBS combination including five fully leptonic and two semileptonic channels
- Two statistical models used: one with 4 and one with 6 parameters of interest
- Results based on 1D and 2D profile likelihood scans show good agreement with the SM, even in log(S/B) bins
- Combined fit improves signal strength (μ) precision by 5–10% over individual analyses
- A mild excess of data observed compared to predictions
- First simultaneous evidence for all six charged VBS parameters

This VBS combination marks a first step toward a global interpretation of VBS processes.
Future developments will explore EFT interpretations and polarization-sensitive measurements.

Backup

Input analyses



Overlap (I)

Table 14: Summary table of the signal regions defined in the analyses entering the combination along with some of the selections that make them orthogonal to each other

Region	n. ℓ	ℓ veto	SF	$\lvert\sum$ charge$\rvert$	b-veto	m_{ll}	MET	n. AK4
WV-SR	1	yes	-	1	yes	-	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
SS-SR	2	yes	-	2	yes	> 20 GeV	> 30 GeV	≥ 2
OS-SR(SF)	2	yes	Yes	0	yes	> 120 GeV	> 60 GeV	≥ 2
OS-SR(DF)	2	yes	No	0	yes	> 50 GeV	> 20 GeV	≥ 2
ZV-SR(btag)	2	yes	Yes	0	no	$\in [76, 106]$ GeV	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
ZV-SR(bveto)	2	yes	Yes	0	yes	$\in [76, 106]$ GeV	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
WZ-SR	3	yes	Yes (Z)	1	yes	$\in [76, 106]$ GeV	> 30 GeV	≥ 2
ZZ-SR	4	yes	Yes	0	-	$\in [60, 120]$ GeV	-	≥ 2

Table 15: Summary table of the signal regions defined in the analyses entering the combination along with some of the selections that make them orthogonal to each other

Region	n. ℓ	ℓ veto	SF	$\lvert\sum$ charge$\rvert$	b-veto	m_{ll}	MET	n. AK4
SS-SR	2	yes	-	2	yes	> 20 GeV	> 30 GeV	≥ 2
OS-SR(SF)	2	yes	Yes	0	yes	> 120 GeV	> 60 GeV	≥ 2
OS-SR(DF)	2	yes	no	0	yes	> 50 GeV	> 20 GeV	≥ 2
ZV-Top	2	yes	no	0	-	$\in [76, 106]$ GeV	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
OS-DY(DF)	2	yes	no	0	yes	$\in [50, 80]$ GeV	> 20 GeV	≥ 2
OS-DY(SF)	2	yes	yes	0	yes	$\in [76, 106]$ GeV	> 60 GeV	≥ 2
ZV-DY(bveto)	2	yes	yes	0	yes	$\in [76, 106]$ GeV	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
ZV-SR(bveto)	2	yes	yes	0	yes	$\in [76, 106]$ GeV	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)

2 leptons - bveto

2 charged leptons regions (b-vetoed): Negligible overlap

- SSWW SRs orthogonal to all other b-vetoed regions thanks to |Σ charge| = 2
- SSWW(τ_h) OS CR only region requiring a τ_h
- ZV Top CR partially overlap with OS-SR(DF), OS-DY(DF) → Removed ZV Top CR
- OSWW DY CR, ZV-DY and ZV-SR different MET requirements and target different kinematic regimes in number of jets: ZV SR $m_V \in [65, 105]$ inverted for ZV DY CR

Region	n. ℓ	ℓ/τ veto	SF	$\lvert\sum \text{charge}\rvert$	b-veto	m_{ll}	MET	n. AK4
SS-SR	2	yes/yes	-	2	yes	> 20 GeV	> 30 GeV	≥ 2
SS(τ)-SR	2	yes/no	-	2	yes	-	> 50 GeV	≥ 2
SS(τ)-OS	2	yes/no	-	0	yes	-	-	≥ 2
OS-SR(SF)	2	yes/-	Yes	0	yes	> 120 GeV	> 60 GeV	≥ 2
OS-SR(DF)	2	yes/-	no	0	yes	> 50 GeV	> 20 GeV	≥ 2
OS-DY(DF)	2	yes/-	no	0	yes	$\in [50, 80]$ GeV	> 20 GeV	≥ 2
OS-DY(SF)	2	yes/-	yes	0	yes	$\in [76, 106]$ GeV	> 60 GeV	≥ 2
ZV-DY(bveto)	2	yes/-	yes	0	yes	$\in [76, 106]$ GeV	-	(≥ 4) or (≥ 2 + ≥ 1 AK8)
ZV-SR(bveto)	2	yes/-	yes	0	yes	$\in [76, 106]$ GeV	-	(≥ 4) or (≥ 2 + ≥ 1 AK8)

2 leptons - btag

Potential overlaps from 2 charged leptons regions (b-tag): Negligible overlap

- SSWW-btag orthogonal to all other b-tag regions thanks to |Σ charge| = 2
- SSWW(τ_h) Top CR only region requiring a τ_h
- OSWW(ee, μμ) Top CR orthogonal by SF requirements and m_{ll} > 120 GeV
- ZV Top CR partially overlap with OS-SR(DF), OS-DY(DF) → Removed ZV Top CR
- ZV Top CR partially overlap with OS-Top CR (eμ) → Removed ZV Top CR

Region	n. ℓ	ℓ/τ veto	SF	$\lvert\sum$ charge$\rvert$	b-veto	m_{ll}	MET	n. AK4
SS-b	2	yes/yes	-	2	no	$>$ 20 GeV	$>$ 30 GeV	$\geq$ 2
SS(τ)-Top	2	yes/no	-	0	no	-	$>$ 50 GeV	$\geq$ 2
OS-Top(SF)	2	yes/-	yes	0	no	$>$ 120 GeV	$>$ 60 GeV	$\geq$ 2
ZV-DY(btag)	2	yes/-	yes	0	no	$\in$ [76, 106] GeV	-	($\geq$ 4) or ($\geq$ 2 + $\geq$ 1 AK8)
ZV-SR(btag)	2	yes/-	yes	0	no	$\in$ [76, 106] GeV	-	($\geq$ 4) or ($\geq$ 2 + $\geq$ 1 AK8)
OS-Top(DF)	2	yes/-	no	0	no	$>$ 50 GeV	$>$ 20 GeV	$\geq$ 2

Other regions

Other regions do not show significant overlaps

- WV CR only regions with 1 charged lepton and veto on additional ones
- SSWW/WZ ZZ CR not sensitive to EW ZZ → 4ℓ but used to measure normalization of QCD-induced part → Removed ZZ CR

Region	n. ℓ	ℓ/τ veto	SF	$\lvert\sum$ charge$\rvert$	b-veto	m_{ll}	MET	n. AK4
WV-Top	1	yes/-	-	1	no	-	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
WV-Wjets	1	yes/-	-	1	yes	-	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
ZZ-SR	4	yes/-	yes	0	-	$\in [60, 120]$ GeV	-	≥ 2

Overlap (II)

Table 16: Summary table of the signal regions defined in the analyses entering the combination along with some of the selections that make them orthogonal to each other

Region	n. ℓ	ℓ veto	SF	$\lvert\sum \text{charge}\rvert$	b-veto	m_{ll}	MET	n. AK4
WV-Top	1	yes	-	1	no	-	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
SS-b	2	yes	-	2	no	> 20 GeV	> 30 GeV	≥ 2
WZ-b	3	yes	yes (Z)	1	no	$\in [76, 106]$ GeV	> 30 GeV	≥ 2
OS-Top(SF)	2	yes	yes	0	no	> 120 GeV	> 60 GeV	≥ 2
ZV-DY(btag)	2	yes	yes	0	no	$\in [76, 106]$ GeV	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
ZV-SR(btag)	2	yes	yes	0	no	$\in [76, 106]$ GeV	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
ZV-Top	2	yes	no	0	-	$\in [76, 106]$ GeV	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
OS-Top(DF)	2	yes	no	0	no	> 50 GeV	> 20 GeV	≥ 2

Table 17: Summary table of the signal regions defined in the analyses entering the combination along with some of the selections that make them orthogonal to each other

Region	n. ℓ	ℓ veto	SF	$\lvert\sum \text{charge}\rvert$	b-veto	m_{ll}	MET	n. AK4
WV-Wjets	1	yes	-	1	yes	-	-	(≥ 4) or $(\geq 2 + \geq 1$ AK8)
ZZ-SR	4	yes	yes	0	-	$\in [60, 120]$ GeV	-	≥ 2
SS-ZZ	4	yes	yes	0	-	$\in [76, 106]$ GeV	-	≥ 2

Correlation table (I)

Nuisance	type	SS(e,μ)/WZ	SS(τ_h)	OSWW	WV	ZV	ZZ	Nuisance	type	SS(e,μ)/WZ	SS(τ_h)	OSWW	WV	ZV	ZZ
CMS_2e2mu_Zjets_2016	lnN	-	-	-	-	-	✓	CMS_2e2mu_Zjets_2017	lnN	-	-	-	-	-	✓
CMS_2e2mu_Zjets_2018	lnN	-	-	-	-	-	✓	CMS_4e_Zjets_2016	lnN	-	-	-	-	-	✓
CMS_4e_Zjets_2017	lnN	-	-	-	-	-	✓	CMS_4e_Zjets_2018	lnN	-	-	-	-	-	✓
CMS-4mu-Zjets-2016	lnN	-	-	-	-	-	✓	CMS-4mu_Zjets_2017	lnN	-	-	-	-	-	✓
CMS_4mu_Zjets_2018	lnN	-	-	-	-	-	✓	CMS_PS_FSR_DY	shape	-	-	-	✓	-	-
CMS_PS_FSR_QCD_WV	shape	-	-	-	✓	-	-	CMS_PS_FSR_QCD_ZV	shape	-	-	-	✓	-	-
CMS-PS-FSR-VBF-V-dipole	shape	-	-	-	✓	-	-	CMS-PS-FSR-VBS-WV	shape	-	-	-	✓	-	-
CMS_PS_FSR_VBS_ZV	shape	-	-	-	✓	-	-	CMS_PS_FSR_VVV	shape	-	-	-	✓	-	-
CMS_PS_FSR_Vg	shape	-	-	-	✓	-	-	CMS_PS_FSR_VgS	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_boost_1	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_boost_2	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_boost_3	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_boost_4	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_boost_5	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_boost_6	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_boost_7	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_res_1	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_res_10	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_res_11	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_res_12	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_res_13	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_res_14	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_res_15	shape	-	-	-	✓	-	-
CMS-PS-FSR-Wjets-res-16	shape	-	-	-	✓	-	-	CMS-PS-FSR-Wjets-res-17	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_res_18	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_res_19	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_res_2	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_res_20	shape	-	-	-	✓	-	-
CMS-PS-FSR-Wjets-res-21	shape	-	-	-	✓	-	-	CMS-PS-FSR-Wjets-res-3	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_res_4	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_res_5	shape	-	-	-	✓	-	-
CMS_PS_FSR_Wjets_res_6	shape	-	-	-	✓	-	-	CMS_PS_FSR_Wjets_res_7	shape	-	-	-	✓	-	-
CMS-PS-FSR-Wjets-res-8	shape	-	-	-	✓	-	-	CMS-PS-FSR-Wjets-res-9	shape	-	-	-	✓	-	-
CMS_PS_FSR_ggWW	shape	-	-	-	✓	-	-	CMS_PS_FSR_top	shape	-	-	-	✓	-	-
CMS_PS_ISR_DY	shape	-	-	-	✓	-	-	CMS_PS_ISR_QCD_WV	shape	-	-	-	✓	-	-
CMS-PS-ISR-QCD-ZV	shape	-	-	-	✓	-	-	CMS-PS-ISR-VBF-V-dipole	shape	-	-	-	✓	-	-
CMS_PS_ISR_VBS_WV	shape	-	-	-	✓	-	-	CMS_PS_ISR_VBS_ZV	shape	-	-	-	✓	-	-
CMS_PS_ISR_VVV	shape	-	-	-	✓	-	-	CMS_PS_ISR_Vg	shape	-	-	-	✓	-	-
CMS-PS-ISR-VgS	shape	-	-	-	✓	-	-	CMS-PS-ISR-Wjets-boost-1	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_boost_2	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_boost_3	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_boost_4	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_boost_5	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_boost_6	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_boost_7	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_res_1	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_res_10	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_res_11	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_res_12	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_res_13	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_res_14	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_res_15	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_res_16	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_res_17	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_res_18	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_res_19	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_res_2	shape	-	-	-	✓	-	-
CMS-PS-ISR-Wjets-res-20	shape	-	-	-	✓	-	-	CMS-PS-ISR-Wjets-res-21	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_res_3	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_res_4	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_res_5	shape	-	-	-	✓	-	-	CMS_PS_ISR_Wjets_res_6	shape	-	-	-	✓	-	-
CMS-PS-ISR-Wjets-res-7	shape	-	-	-	✓	-	-	CMS-PS-ISR-Wjets-res-8	shape	-	-	-	✓	-	-
CMS_PS_ISR_Wjets_res_9	shape	-	-	-	✓	-	-	CMS_PS_ISR_ggWW	shape	-	-	-	✓	-	-
CMS_PS_ISR_top	shape	-	-	-	✓	-	-	CMS_PU_2016	shape?	-	-	✓	✓	✓	-
CMS-PU-2017	shape	-	-	✓	✓	✓	-	CMS-PU-2018	shape?	-	-	✓	✓	✓	-
CMS_btag_cferr1	shape	-	-	✓	✓	✓	-	CMS_btag_cferr2	shape	-	-	✓	✓	✓	-
CMS_btag_heavy_2016	shape	✓	-	-	-	-	-	CMS_btag_heavy_2017	shape	✓	-	-	-	-	-
CMS-btag-heavy-2018	shape	✓	-	-	-	-	-	CMS-btag-hf	shape	-	-	✓	✓	✓	-
CMS_btag_hfstats1_2016	shape	-	-	✓	✓	✓	-	CMS_btag_hfstats1_2017	shape	-	-	✓	✓	✓	-
CMS_btag_hfstats1_2018	shape	-	-	✓	✓	✓	-	CMS_btag_hfstats2_2016	shape	-	-	✓	✓	✓	-
CMS-btag-hfstats2-2017	shape	-	-	✓	✓	✓	-	CMS-btag-hfstats2-2018	shape	-	-	✓	✓	✓	-
CMS_btag_jes	shape	-	-	✓	✓	✓	-	CMS_btag_lf	shape	-	-	✓	✓	✓	-
CMS_btag_lfstats1_2016	shape	-	-	✓	✓	✓	-	CMS_btag_lfstats1_2017	shape	-	-	✓	✓	✓	-
CMS_btag_lfstats1_2018	shape	-	-	✓	✓	✓	-	CMS_btag_lfstats2_2016	shape	-	-	✓	✓	✓	-
CMS_btag_lfstats2_2017	shape	-	-	✓	✓	✓	-	CMS_btag_lfstats2_2018	shape	-	-	✓	✓	✓	-
CMS_btag_light_2016	shape	✓	-	-	-	-	-	CMS_btag_light_2017	shape	✓	-	-	-	-	-
CMS_btag_light_2018	shape	✓	-	-	-	-	-	CMS_eff_e	shape	✓	-	-	-	-	-
CMS-eff-e-2016	shape	-	-	✓	✓	✓	✓	CMS-eff-e-2017	shape?	-	-	✓	✓	✓	✓
CMS_eff_e_2018	shape	-	-	✓	✓	✓	✓	CMS_eff_m	shape	✓	-	-	-	-	-
CMS_eff_m_2016	shape	-	-	✓	✓	✓	✓	CMS_eff_m_2017	shape?	-	-	✓	✓	✓	✓
CMS-eff-m-2018	shape	-	-	✓	✓	✓	✓	CMS-eff-prefiring-2016	shape?	✓	-	✓	✓	✓	✓
CMS_eff_prefiring_2016_ewk_ZZ	shape	-	-	-	-	-	✓	CMS_eff_prefiring_2017	shape?	✓	-	✓	✓	✓	✓
CMS_eff_prefiring_2017_ewk_ZZ	shape	-	-	-	-	-	✓	CMS_eff_prefiring_2018	shape	✓	-	-	-	-	-
CMS-eff-trigger-2016	shape	-	-	✓	✓	✓	-	CMS-eff-trigger-2017	shape	-	-	✓	✓	✓	-
CMS_eff_trigger_2018	shape	-	-	✓	✓	✓	-	CMS_embed_veto_2016	lnN	-	-	✓	-	-	-
CMS_embed_veto_2017	lnN	-	-	✓	-	-	-	CMS_embed_veto_2018	lnN	-	-	✓	-	-	-
CMS-fakeE3L-2016	shape	✓	-	-	-	-	-	CMS-fakeE3L-2017	shape	✓	-	-	-	-	-
CMS_fakeE3L_2018	shape	✓	-	-	-	-	-	CMS_fakeE_2016	shape	✓	-	-	-	-	-
CMS_fakeE_2017	shape	✓	-	-	-	-	-	CMS_fakeE_2018	shape	✓	-	-	-	-	-
CMS_fakeM3L_2016	shape	✓	-	-	-	-	-	CMS_fakeM3L_2017	shape	✓	-	-	-	-	-
CMS_fakeM3L_2018	shape	✓	-	-	-	-	-	CMS_fakeM_2016	shape	✓	-	-	-	-	-
CMS_fakeM_2017	shape	✓	-	-	-	-	-	CMS_fakeM_2018	shape	✓	-	-	-	-	-
CMS_fake_e_2016	shape	-	-	✓	✓	✓	-	CMS_fake_e_2017	shape	-	-	✓	✓	✓	-
CMS_fake_e_2018	shape	-	-	✓	✓	✓	-	CMS_fake_m_2016	shape	-	-	✓	✓	✓	-
CMS_fake_m_2017	shape	-	-	✓	✓	✓	-	CMS_fake_m_2018	shape	-	-	✓	✓	✓	-
CMS_fake_stat_e_2016	shape	-	-	✓	✓	✓	-	CMS_fake_stat_e_2017	shape	-	-	✓	✓	✓	-
CMS-fake-stat-e-2018	shape	-	-	✓	✓	✓	-	CMS-fake-stat-m-2016	shape	-	-	✓	✓	✓	-
CMS_fake_stat_m_2017	shape	-	-	✓	✓	✓	-	CMS_fake_stat_m_2018	shape	-	-	✓	✓	✓	-
CMS_fake_syst	lnN	-	-	-	-	✓	-	CMS_fake_syst_e	lnN	-	-	✓	-	-	-
CMS-fake-syst-e-WV	lnN	-	-	-	✓	-	-	CMS-fake-syst-em	lnN	-	-	-	-	✓	-
CMS_fake_syst_m	lnN	-	-	✓	-	-	-	CMS_fake_syst_m_WV	lnN	-	-	-	✓	-	-
CMS_fatjet_jmr_2016	shape	-	-	-	✓	✓	-	CMS_fatjet_jmr_2017	shape?	-	-	-	✓	✓	-
CMS-fatjet-jmr-2018	shape	-	-	-	✓	✓	-	CMS-fatjet-jms-2016	shape?	-	-	-	✓	✓	-
CMS_fatjet_jms_2017	shape	-	-	-	✓	✓	-	CMS_fatjet_jms_2018	shape?	-	-	-	✓	✓	-
CMS_fatjet_res_2017	lnN	-	-	-	✓	-	-	CMS_fatjet_res_2018	shape?	-	-	-	✓	✓	-
CMS-fatjet-tau21eff-2016	shape	-	-	-	✓	-	-	CMS-fatjet-tau21eff-2017	shape	-	-	-	✓	-	-
CMS_fatjet_tau21eff_2018	shape	-	-	-	✓	-	-	CMS_fj_scale_JESAbsolute	lnN	-	-	-	✓	-	-
CMS_fj_scale_JESAbsolute_2016	lnN	-	-	-	✓	-	-	CMS_fj_scale_JESAbsolute_2017	lnN	-	-	-	✓	-	-
CMS_fj_scale_JESAbsolute_2018	lnN	-	-	-	✓	-	-	CMS_fj_scale_JESBBEC1	lnN	-	-	-	✓	-	-
CMS_fj_scale_JESBBEC1_2016	lnN	-	-	-	✓	-	-	CMS_fj_scale_JESBBEC1_2017	lnN	-	-	-	✓	-	-
CMS_fj_scale_JESBBEC1_2018	lnN	-	-	-	✓	-	-	CMS_fj_scale_JESEC2	lnN	-	-	-	✓	-	-
CMS_fj_scale_JESEC2_2016	lnN	-	-	-	✓	-	-	CMS_fj_scale_JESEC2_2017	lnN	-	-	-	✓	-	-
CMS_fj_scale_JESEC2_2018	lnN	-	-	-	✓	-	-	CMS_fj_scale_JESFlavorQCD	lnN	-	-	-	✓	-	-
CMS_fj_scale_JESHF	lnN	-	-	-	✓	-	-	CMS_fj_scale_JESHF_2016	lnN	-	-	-	✓	-	-
CMS_fj_scale_JESHF_2017	lnN	-	-	-	✓	-	-	CMS_fj_scale_JESHF_2018	lnN	-	-	-	✓	-	-
CMS-fj-scale-JESRelativeBal	lnN	-	-	-	✓	-	-	CMS-fj-scale-JESRelativeSample-2016	lnN	-	-	-	✓	-	-
CMS_fj_scale_JESRelativeSample_2017	lnN	-	-	-	✓	-	-	CMS_fj_scale_JESRelativeSample_2018	lnN	-	-	-	✓	-	-
CMS_fj_tau21ptextr_2016	shape	-	-	-	✓	-	-	CMS_fj_tau21ptextr_2017	shape	-	-	-	✓	-	-
CMS-fj-tau21ptextr-2018	shape	-	-	-	✓	-	-	CMS-hww-CRSR-accept-DY	lnN	-	-	✓	-	-	-
CMS_hww_CRSR_accept_top	lnN	-	-	✓	-	-	-	CMS_hww_VZScale	lnN	-	-	✓	-	-	-
CMS_hww_VgStarScale	lnN	-	-	✓	-	-	-	CMS_jetpuid_2016	shape	-	-	✓	✓	✓	-
CMS-jetpuid-2017	shape	-	-	✓	✓	✓	-	CMS-jetpuid-2018	shape	-	-	✓	✓	✓	-
CMS_pu	shape	✓	-	-	-	-	-	CMS_res_j_2016	shape?	✓	-	-	-	-	✓
CMS_res_j_2017	shape	✓	-	✓	✓	✓	✓	CMS_res_j_2018	shape?	✓	-	✓	✓	✓	✓
CMS-scale-JESAbsolute	shape	-	-	✓	✓	✓	-	CMS-scale-JESAbsolute-2016	shape?	-	-	✓	✓	✓	-
CMS_scale_JESAbsolute_2017	shape	-	-	✓	✓	✓	-	CMS_scale_JESAbsolute_2018	shape?	-	-	✓	✓	✓	-
CMS_scale_JESBBEC1	shape	-	-	✓	✓	✓	-	CMS_scale_JESBBEC1_2016	shape?	-	-	✓	✓	✓	-
CMS-scale-JESBBEC1-2017	shape	-	-	✓	✓	✓	-	CMS-scale-JESBBEC1-2018	shape?	-	-	✓	✓	✓	-
CMS_scale_JESEC2	shape	-	-	✓	✓	✓	-	CMS_scale_JESEC2_2016	shape?	-	-	✓	✓	✓	-
CMS_scale_JESEC2_2017	shape	-	-	✓	✓	✓	-	CMS_scale_JESEC2_2018	shape?	-	-	✓	✓	✓	-

Correlation table (II)

Nuisance	type	SS(e,μ)/WZ	SS(τ_h)	OSWW	WV	ZV	ZZ	Nuisance	type	SS(e,μ)/WZ	SS(τ_h)	OSWW	WV	ZV	ZZ
CMS_scale_JESFlavorQCD	shape	-	-	✓	✓	✓	-	CMS_scale_JESHF	shape?	-	-	✓	✓	✓	-
CMS_scale_JESHF_2016	shape	-	-	✓	✓	✓	-	CMS_scale_JESHF_2017	shape?	-	-	✓	✓	✓	-
CMS_scale_JESHF_2018	shape	-	-	✓	✓	✓	-	CMS_scale_JESRelativeBal	shape?	-	-	✓	✓	✓	-
CMS_scale_JESRelativeSample_2016	shape	-	-	✓	✓	✓	-	CMS_scale_JESRelativeSample_2017	shape?	-	-	✓	✓	✓	-
CMS_scale_JESRelativeSample_2018	shape	-	-	✓	✓	✓	-	CMS_scale_cleanfatJER_2016	shape	-	-	-	-	✓	-
CMS_scale_cleanfatJER_2017	shape	-	-	-	-	✓	-	CMS_scale_cleanfatJER_2018	shape	-	-	-	-	✓	-
CMS_scale_cleanfatJES_2016	shape	-	-	-	-	✓	-	CMS_scale_cleanfatJES_2017	shape	-	-	-	-	✓	-
CMS_scale_cleanfatJES_2018	shape	-	-	-	-	✓	-	CMS_scale_e	lnN	✓	-	-	-	-	-
CMS_scale_e_2016	shape	-	-	✓	✓	✓	-	CMS_scale_e_2017	shape?	-	-	✓	✓	✓	-
CMS_scale_e_2018	shape	-	-	✓	✓	✓	-	CMS_scale_j_2016	shape	✓	-	-	-	-	✓
CMS_scale_j_2017	shape	✓	-	-	-	-	✓	CMS_scale_j_2018	shape	✓	-	-	-	-	✓
CMS_scale_m	lnN	✓	-	-	-	-	-	CMS_scale_mVjer_2016	shape	-	-	-	-	✓	-
CMS_scale_mVjer_2017	shape	-	-	-	-	✓	-	CMS_scale_mVjesTotal_2016	shape	-	-	-	-	✓	-
CMS_scale_mVjesTotal_2017	shape	-	-	-	-	✓	-	CMS_scale_mVjesTotal_2018	shape	-	-	-	-	✓	-
CMS_scale_m_2016	shape	-	-	✓	✓	✓	-	CMS_scale_m_2017	shape?	-	-	✓	✓	✓	-
CMS_scale_m_2018	shape	-	-	✓	✓	✓	-	CMS_scale_met_2016	lnN	-	-	✓	✓	-	-
CMS_scale_met_2017	lnN	-	-	✓	✓	-	-	CMS_scale_met_2018	lnN	-	-	✓	✓	-	-
CMS_topPtRew	shape	-	-	-	✓	✓	-	CMS_trigger_2016	shape	✓	-	-	-	-	-
CMS_trigger_2017	shape	✓	-	-	-	-	-	CMS_trigger_2018	shape	✓	-	-	-	-	-
CMS_wseff	shape	✓	-	-	-	-	-	EWKCorrVVWZ	shape	✓	-	-	-	-	-
EWKqqZZCorr	shape	✓	-	-	-	-	-	FES	shape	-	✓	-	-	-	-
FR_sys_electron_2016M	lnN	-	✓	-	-	-	-	FR_sys_electron_2017	lnN	-	✓	-	-	-	-
FR_sys_electron_2018	lnN	-	✓	-	-	-	-	FR_sys_muon_2016M	lnN	-	✓	-	-	-	-
FR_sys_muon_2017	lnN	-	✓	-	-	-	-	FR_sys_muon_2018	lnN	-	✓	-	-	-	-
FSR	shape	-	✓	-	-	-	-	ISR	shape	-	✓	-	-	-	-
PF	shape	-	✓	-	-	-	-	PS_FSR	shape?	-	-	✓	-	✓	-
PS_ISR	shape	-	-	✓	-	✓	✓	QCDScale_TTTo2L2Nu	shape	-	✓	-	-	-	-
QCDScale_TVX	shape	-	✓	-	-	-	-	QCDScale_Triboson	shape	-	✓	-	-	-	-
QCDScale_VG	shape	-	✓	-	-	-	-	QCDScale_WZ	shape	-	✓	-	-	-	-
QCDScale_WpWpJJ_QCD	shape	-	✓	-	-	-	-	QCDScale_WrongSign	shape	-	✓	-	-	-	-
QCDScale_ZZtoLep	shape	-	✓	-	-	-	-	QCDScale_qcdloop_ZZ	lnN	-	-	-	-	-	✓
QCDScale_sig	shape	-	✓	-	-	-	-	QCDscale_AsLnN	lnN	-	-	✓	-	-	-
QCDscale_DY	shape	-	-	✓	✓	✓	-	QCDscale_IntfWW_ACCEPT	shape	✓	-	-	-	-	-
QCDscale_IntfWZ_ACCEPT	shape	✓	-	-	-	-	-	QCDscale_Other_ACCEPT	shape	✓	-	-	-	-	-
QCDscale_QCD_OSWW	shape	-	-	✓	✓	-	-	QCDscale_QCD_SSWW	shape	✓	-	-	✓	-	-
QCDscale_QCD_WZ	shape	-	-	-	✓	-	-	QCDscale_QCD_ZZ	shape	-	-	-	✓	-	-
QCDscale_TVX	shape	✓	-	-	-	✓	-	QCDscale_VBF-V	shape	-	-	-	✓	✓	-
QCDscale_VBS_VV_QCD	shape	-	-	-	-	✓	-	QCDscale_VG_ACCEPT	shape	✓	-	-	-	-	-
QCDscale_VH	lnN	-	-	✓	-	-	-	QCDscale_VV	shape	-	-	✓	-	-	-
QCDscale_VVV	shape	-	-	-	✓	✓	-	QCDscale_VZ	shape	-	-	-	-	✓	-
QCDscale_Vg	shape	-	-	-	✓	✓	-	QCDscale_VgS	shape	-	-	-	✓	✓	-
QCDscale_WJets	shape	-	-	-	✓	✓	-	QCDscale_WS_ACCEPT	shape	✓	-	-	-	-	-
QCDscale_WWewk_AsLnN	lnN	-	-	✓	-	-	-	QCDscale_WZ_ACCEPT	shape	✓	-	-	-	-	-
QCDscale_ZZ_ACCEPT	shape	✓	-	-	-	-	-	QCDscale_ewk_OSWW	shape	-	-	✓	✓	-	-
QCDscale_ewk_SSWW	shape	✓	-	-	✓	-	-	QCDscale_ewk_WZ	shape	✓	-	-	✓	-	-
QCDscale_ewk_ZZ	shape	-	-	-	✓	-	✓	QCDscale_ggVV	lnN	-	-	✓	-	-	-
QCDscale_ggZH	lnN	-	-	✓	-	-	-	QCDscale_gg_ACCEPT	lnN	-	-	✓	-	-	-
QCDscale_qcd_ZZ	shape	-	-	-	-	-	✓	QCDscale_qqH	lnN	-	-	✓	-	-	-
QCDscale_qqbar_ACCEPT	lnN	-	-	✓	-	-	-	QCDscale_top	shape	-	-	✓	✓	✓	-
QCDscale_ttH	lnN	-	-	✓	-	-	-	QCDscale_ttZ_tribos	lnN	-	-	-	-	-	✓
QGLmorph_gluon_higheta_16	shape	-	-	-	✓	-	-	QGLmorph_gluon_higheta_1718	shape	-	-	-	✓	-	-
QGLmorph_gluon_loweta_16	shape	-	-	-	✓	-	-	QGLmorph_gluon_loweta_1718	shape	-	-	-	✓	-	-
QGLmorph_quark_higheta_16	shape	-	-	-	✓	-	-	QGLmorph_quark_higheta_1718	shape	-	-	-	✓	-	-
QGLmorph_quark_loweta_16	shape	-	-	-	✓	-	-	QGLmorph_quark_loweta_1718	shape	-	-	-	✓	-	-
TES	shape	-	✓	-	-	-	-	THU_ggH_Mig01	shape	-	-	✓	-	-	-
THU_ggH_Mig12	shape	-	-	✓	-	-	-	THU_ggH_Mu	shape	-	-	✓	-	-	-
THU_ggH_PT120	shape	-	-	✓	-	-	-	THU_ggH_PT60	shape	-	-	✓	-	-	-
THU_ggH_Res	shape	-	-	✓	-	-	-	THU_ggH_VBF2j	shape	-	-	✓	-	-	-
THU_ggH_VBF3j	shape	-	-	✓	-	-	-	THU_ggH_qmtop	shape	-	-	✓	-	-	-
THU_qqH_EWK	shape	-	-	✓	-	-	-	THU_qqH_JET01	shape	-	-	✓	-	-	-
THU_qqH_Mjj1000	shape	-	-	✓	-	-	-	THU_qqH_Mjj120	shape	-	-	✓	-	-	-
THU_qqH_Mjj1500	shape	-	-	✓	-	-	-	THU_qqH_Mjj350	shape	-	-	✓	-	-	-
THU_qqH_Mjj60	shape	-	-	✓	-	-	-	THU_qqH_Mjj700	shape	-	-	✓	-	-	-
THU_qqH_PTH200	shape	-	-	✓	-	-	-	THU_qqH_PTH25	shape	-	-	✓	-	-	-
THU_qqH_YIELD	shape	-	-	✓	-	-	-	UE_CP5	lnN	-	-	✓	✓	✓	-
UE_CUET	lnN	-	-	✓	✓	✓	-	VBS_2016M	shape	-	✓	-	-	-	-
VBS_2017	shape	-	✓	-	-	-	-	VBS_2018	shape	-	✓	-	-	-	-
WZTauH	shape	✓	-	-	-	-	-	WZTauL	shape	✓	-	-	-	-	-
btag	shape	-	✓	-	-	-	-	ggZZCorr	shape	✓	-	-	-	-	-
jer_2016M	shape	-	✓	-	-	-	-	jer_2017	shape	-	✓	-	-	-	-
jer_2018	shape	-	✓	-	-	-	-	jes_TTTo2L2Nu_2016M	lnN	-	✓	-	-	-	-
jes_TTTo2L2Nu_2017	lnN	-	✓	-	-	-	-	jes_TTTo2L2Nu_2018	lnN	-	✓	-	-	-	-
jes_TVX_2016M	lnN	-	✓	-	-	-	-	jes_TVX_2017	lnN	-	✓	-	-	-	-
jes_TVX_2018	lnN	-	✓	-	-	-	-	jes_Triboson_2016M	lnN	-	✓	-	-	-	-
jes_Triboson_2017	lnN	-	✓	-	-	-	-	jes_Triboson_2018	lnN	-	✓	-	-	-	-
jes_VG_2016M	lnN	-	✓	-	-	-	-	jes_VG_2017	lnN	-	✓	-	-	-	-
jes_VG_2018	lnN	-	✓	-	-	-	-	jes_WZ_2016M	lnN	-	✓	-	-	-	-
jes_WZ_2017	lnN	-	✓	-	-	-	-	jes_WZ_2018	lnN	-	✓	-	-	-	-
jes_WpWpJJ_QCD_2016M	lnN	-	✓	-	-	-	-	jes_WpWpJJ_QCD_2017	lnN	-	✓	-	-	-	-
jes_WpWpJJ_QCD_2018	lnN	-	✓	-	-	-	-	jes_WrongSign_2016M	lnN	-	✓	-	-	-	-
jes_WrongSign_2017	lnN	-	✓	-	-	-	-	jes_WrongSign_2018	lnN	-	✓	-	-	-	-
jes_ZZtoLep_2016M	lnN	-	✓	-	-	-	-	jes_ZZtoLep_2017	lnN	-	✓	-	-	-	-
jes_ZZtoLep_2018	lnN	-	✓	-	-	-	-	jes_sig_2016M	lnN	-	✓	-	-	-	-
jes_sig_2017	lnN	-	✓	-	-	-	-	jes_sig_2018	lnN	-	✓	-	-	-	-
lep_2016M	shape	-	✓	-	-	-	-	lep_2017	shape	-	✓	-	-	-	-
lep_2018	shape	-	✓	-	-	-	-	lumi_13TeV_2016	lnN	✓	-	✓	✓	✓	✓
lumi_13TeV_2017	lnN	✓	-	✓	✓	✓	✓	lumi_13TeV_2018	lnN	✓	-	✓	✓	✓	✓
lumi_13TeV_BBDefl	lnN	✓	-	✓	✓	✓	✓	lumi_13TeV_CurrCalib	lnN	✓	-	✓	✓	✓	✓
lumi_13TeV_DynBeta	lnN	-	-	-	✓	✓	-	lumi_13TeV_Ghosts	lnN	✓	-	✓	✓	✓	✓
lumi_13TeV_LSCale	lnN	✓	-	✓	✓	✓	✓	lumi_13TeV_XYFact	lnN	✓	-	✓	✓	✓	✓
lumi_161718	lnN	-	✓	-	-	-	-	lumi_1718	lnN	-	✓	-	-	-	-
lumi_2016M	lnN	-	✓	-	-	-	-	lumi_2017	lnN	-	✓	-	-	-	-
lumi_2018	lnN	-	✓	-	-	-	-	metUnclust	shape	-	✓	-	-	-	-
mischarge_electron_2016M	lnN	-	✓	-	-	-	-	mischarge_electron_2017	lnN	-	✓	-	-	-	-
mischarge_electron_2018	lnN	-	✓	-	-	-	-	mischarge_muon_2016M	lnN	-	✓	-	-	-	-
mischarge_muon_2017	lnN	-	✓	-	-	-	-	mischarge_muon_2018	lnN	-	✓	-	-	-	-
mistag	shape	-	✓	-	-	-	-	pdf_1718	shape?	-	-	-	✓	✓	-
pdf_Higgs_gg	lnN	-	-	✓	-	-	-	pdf_Higgs_gg_ACCEPT	lnN	-	-	✓	-	-	-
pdf_Higgs_qqbar	lnN	-	-	✓	-	-	-	pdf_Higgs_qqbar_ACCEPT	lnN	-	-	✓	-	-	-
pdf_Higgs_ttH	lnN	-	-	✓	-	-	-	pdf_Tot	shape	-	✓	-	-	-	-
pdf_ewk_ZZ_16	lnN	-	-	-	-	-	✓	pdf_ewk_ZZ_1718	lnN	-	-	-	-	-	✓
pdf_ewk_ZZ_1718bar	lnN	-	-	-	-	-	✓	pdf_gg_ACCEPT	lnN	-	-	✓	-	-	-
pdf_qcd_16	lnN	-	-	-	-	-	✓	pdf_qcdloop_16	lnN	-	-	-	-	-	✓
pdf_qcdloop_1718	lnN	-	-	-	-	-	✓	pdf_qqbar	shape?	✓	-	✓	-	-	-
pdf_qqbar_ACCEPT	lnN	-	-	✓	-	-	-	pu	shape	-	✓	-	-	-	-
puID	shape	-	✓	-	-	-	-	singleTopToTTbar	shape	-	-	✓	✓	-	-
tau_vsele_2016M	shape	-	✓	-	-	-	-	tau_vsele_2017	shape	-	✓	-	-	-	-
tau_vsele_2018	shape	-	✓	-	-	-	-	tau_vsjet_2016M	shape	-	✓	-	-	-	-
tau_vsjet_2017	shape	-	✓	-	-	-	-	tau_vsjet_2018	shape	-	✓	-	-	-	-
tau_vsmu_2016M	shape	-	✓	-	-	-	-	tau_vsmu_2017	shape	-	✓	-	-	-	-