Quarkofobic W' for LHC searches

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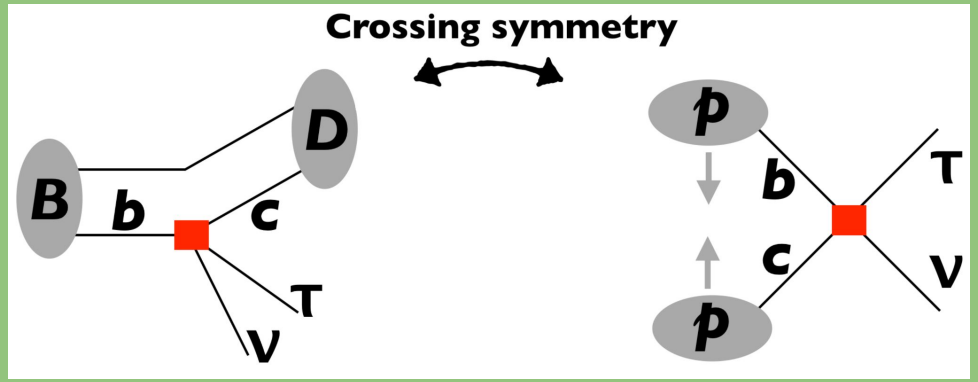
An initial motivation coming from R(D*)

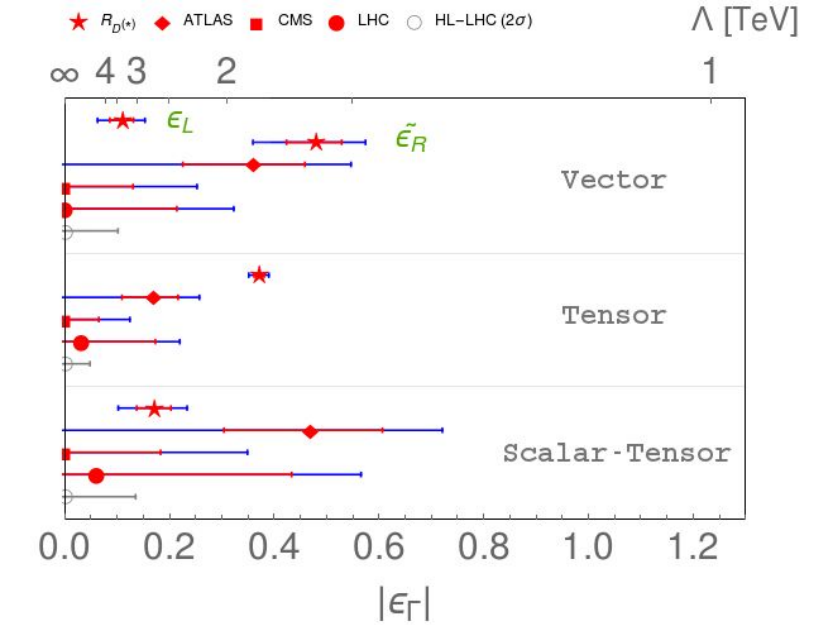
Low energy

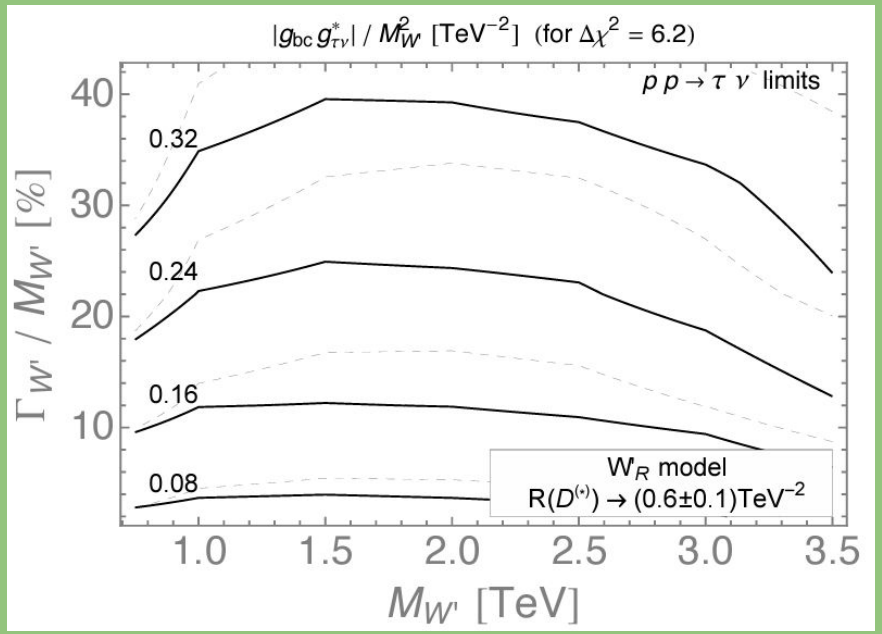


High energy

A. Greljo, J. Camalich, J. Ruiz-Álvarez: Phys.Rev.Lett. 122 (2019) 13, 131803

Competitive and complimentary

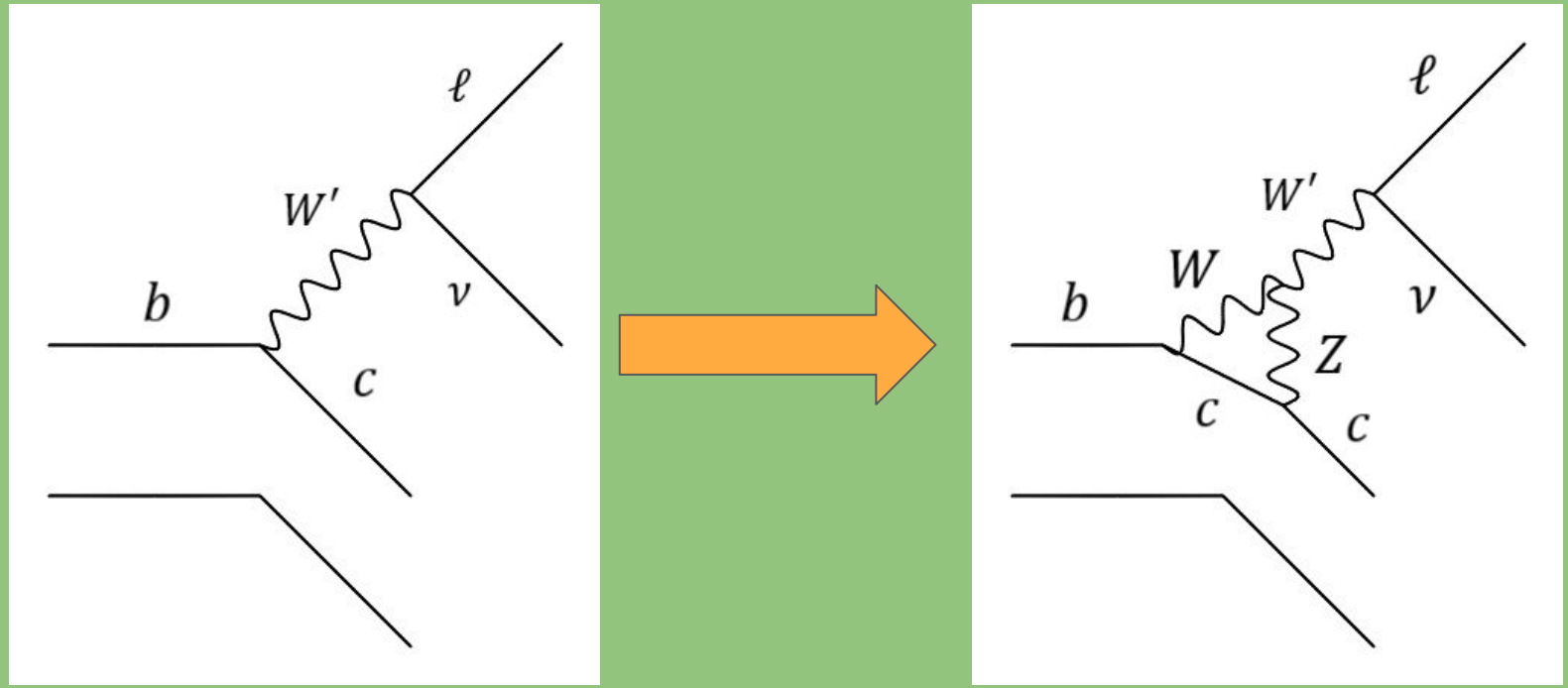




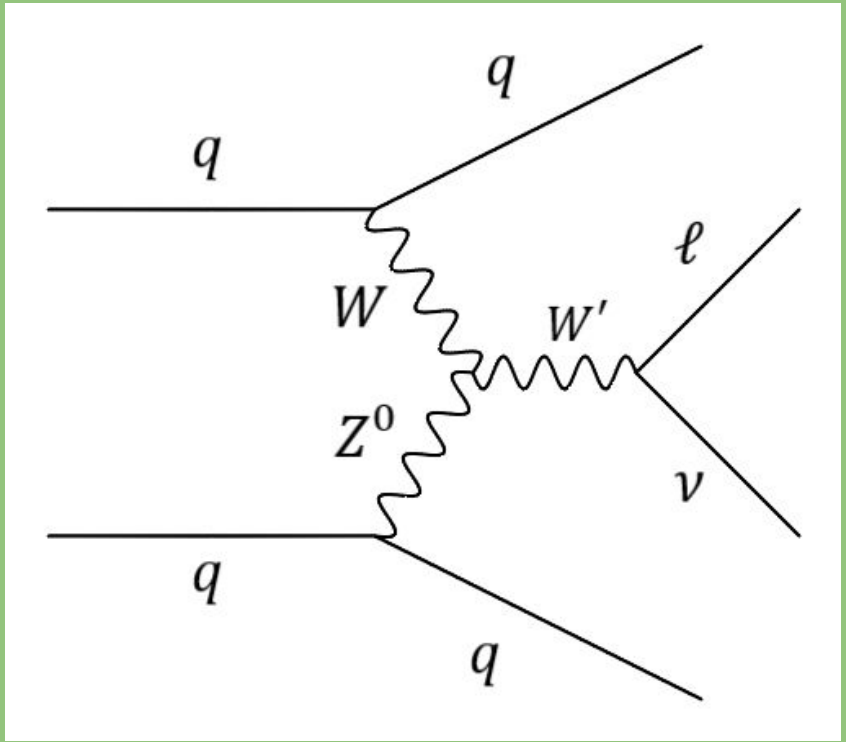
EFT

W'

Quarkofobic W’



Vector Boson Fusion W’ production at the LHC



A simplified model implementation

1. Simplified: No complete model, only inclusion of vertices of interest.
2. Mimicking of SM TGC.
3. Minimal couplings: Only including what necessary to get processes.

$$\mathcal{L}^1_{VWW'} = g_1^V V^\mu (W^-_{\mu\nu} W'^{+\nu} - W^+_{\mu\nu} W'^{-\nu} + W'^-_{\mu\nu} W^{+\nu} - W'^+_{\mu\nu} W^{-\nu})$$

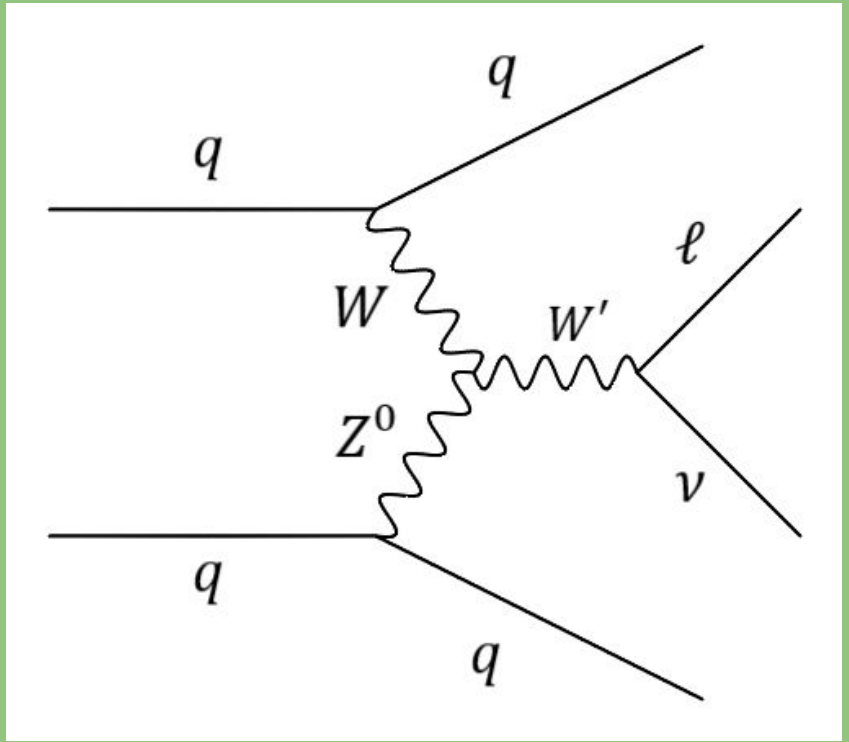
$$\mathcal{L}^2_{VWW'} = g_2^V (W^+_\mu W'^-_\nu V^{\mu\nu} + W'^+_\mu W^-_\nu V^{\mu\nu})$$

$$V_{\mu\nu} = \partial_\mu V_\nu - \partial_\nu V_\mu \text{ and } V = Z \text{ or } \gamma$$

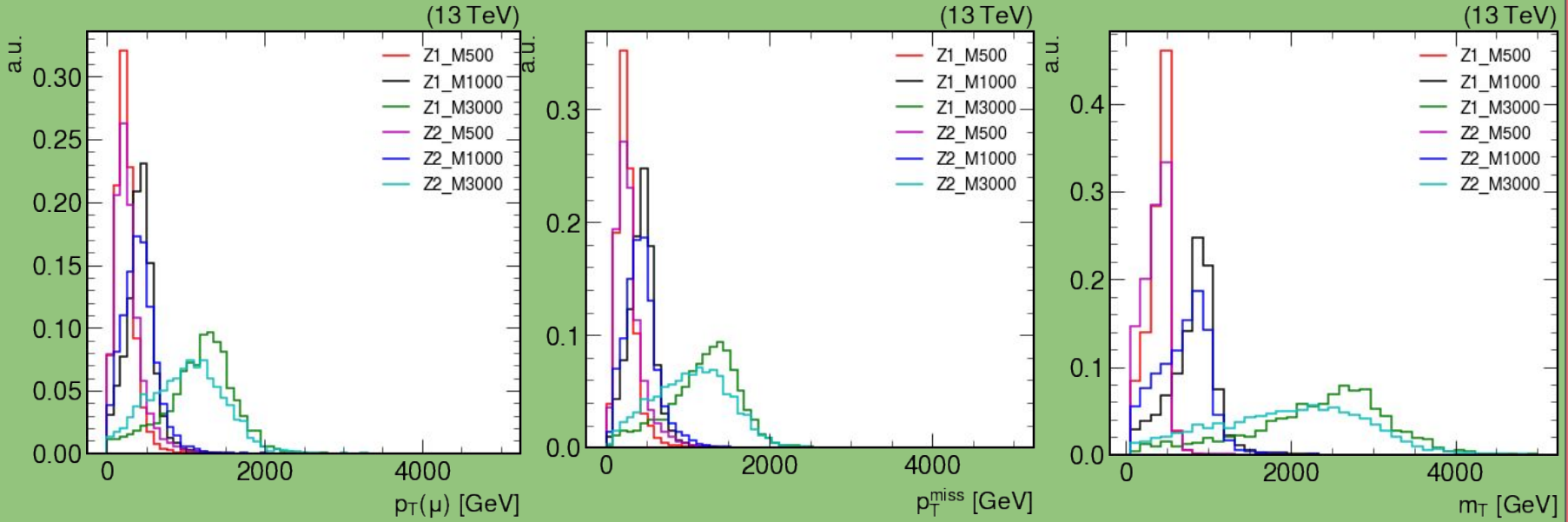
$$\mathcal{L}_l = \sum_l \bar{\nu}_l \gamma_\mu (g_l^R (1+\gamma^5) + g_l^L (1-\gamma^5)) W'^\mu l$$

With the model implmented

1. Production of MC events:
    a. MadGraph
    b. Pythia 8
    c. Delphes
2. Design a selection of events
3. Find exclusion limits
4. Possible caveats



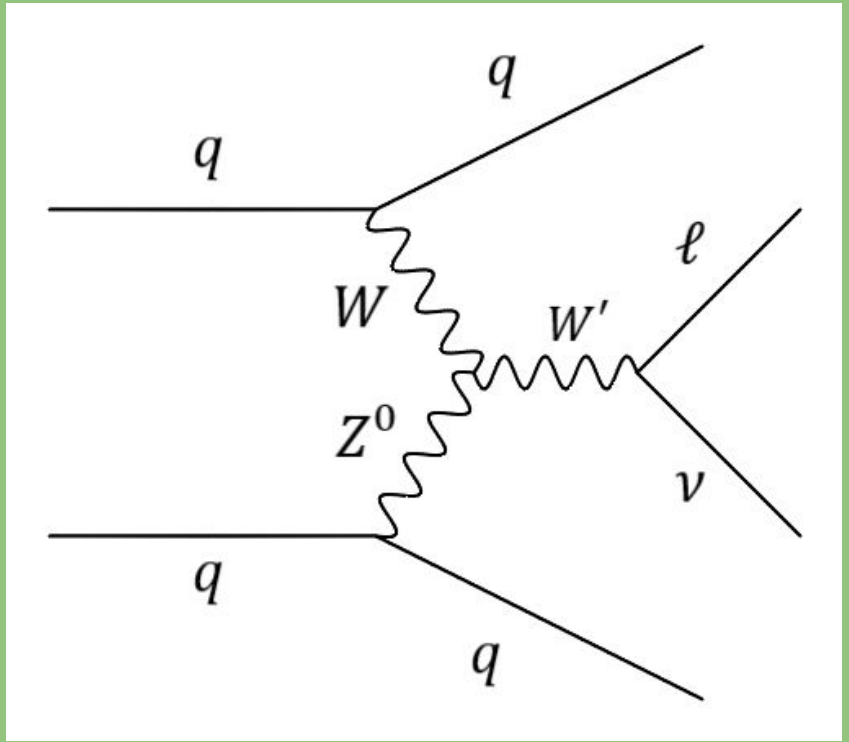
Differences among couplings



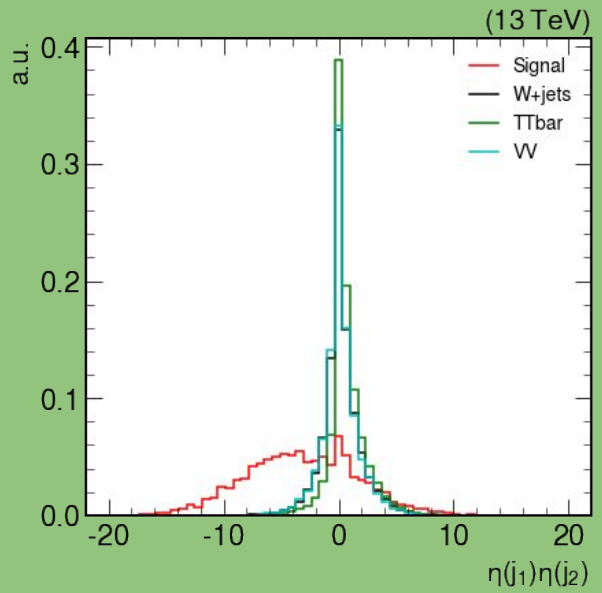
Vector Boson Fusion W' production at the LHC

Characteristics of the final state:

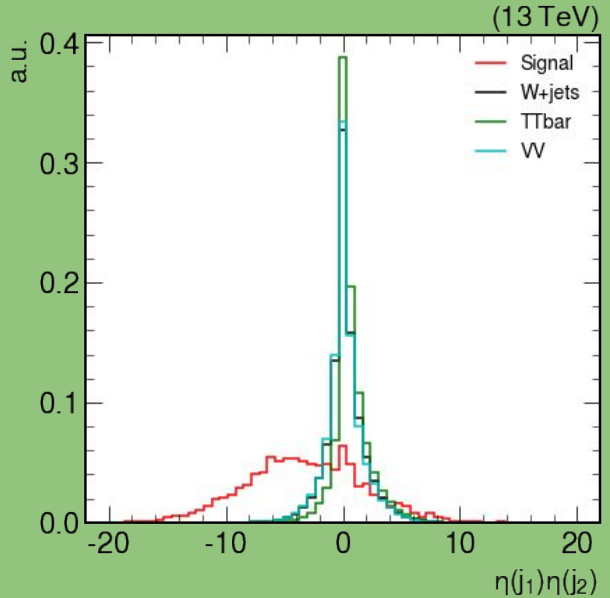
1. Two opposite hemispheres jets.
2. Large η separation among jets.
3. Large dijet invariant mass.
4. Hight p_T lepton.
5. Hight MET.



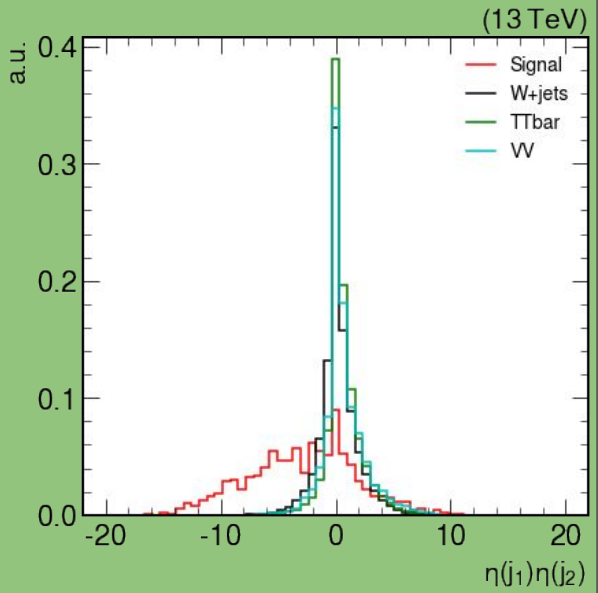
Search designed for 1 TeV W' (Z type 1 coupling)



e

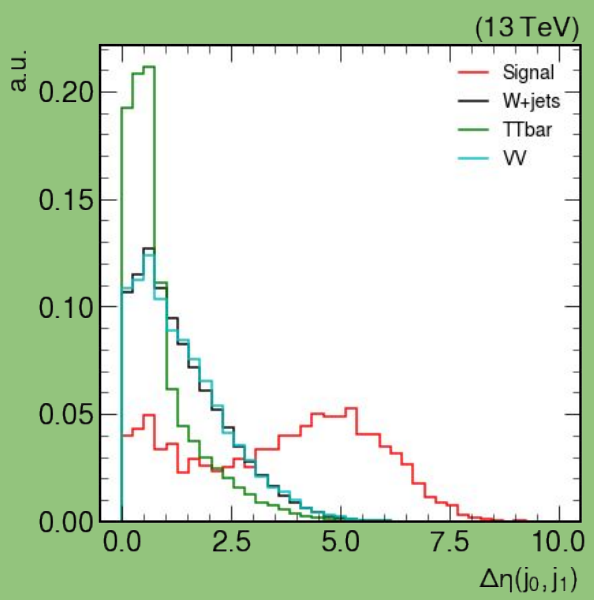


μ



τ

VBF variables



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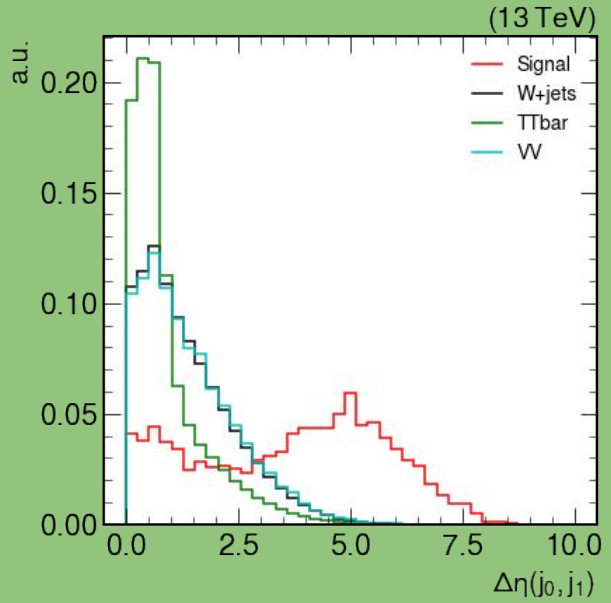
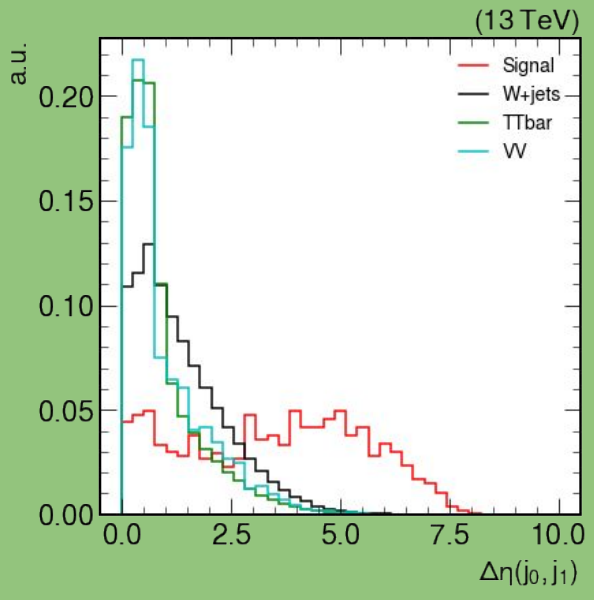
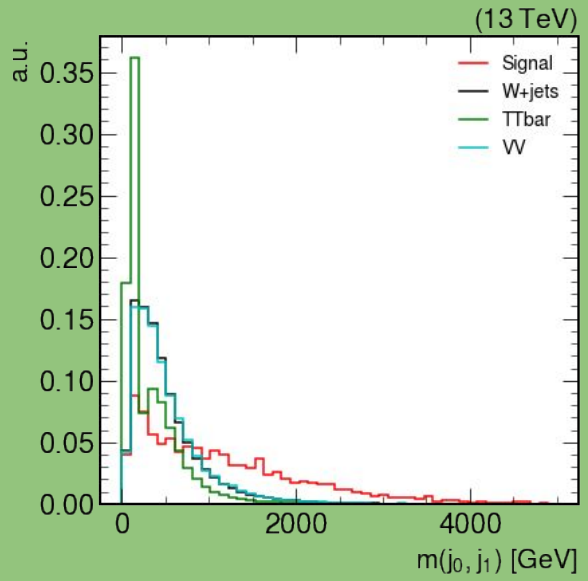


μ



τ

VBF variables



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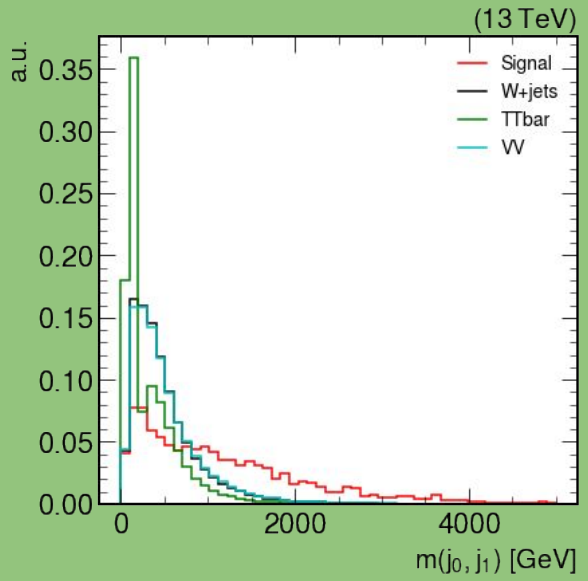
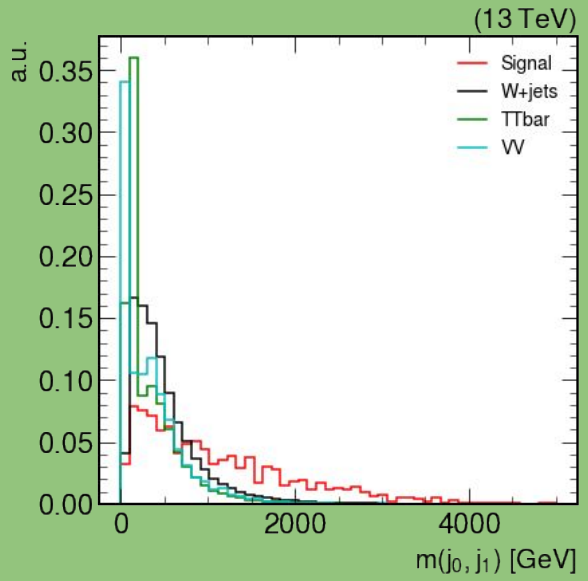


μ



τ

Selections

At least two jets with p_T>60 GeV, N(b)=0, N(l)=1, other leptons veto p_T>30 GeV

e
μ

Cut 1: $\eta(j_1) \times \eta(j_2) < 0$

Cut 2: $m_{jj} > 1000$ GeV

Cut 3: $|\Delta(\eta(j_1), \eta(j_2))| > 4.0$

Cut 4: $p_T(l) > 200$ GeV

Cut 5: $p_T^{miss} > 200$ GeV

Cut 6: $|\Delta(\phi(l), p_T^{miss})| > 1.0$

Cut 1: $\eta(j_1) \times \eta(j_2) < 0$

Cut 2: $m_{jj} > 1000$ GeV

Cut 3: $|\Delta(\eta(j_1), \eta(j_2))| > 4.0$

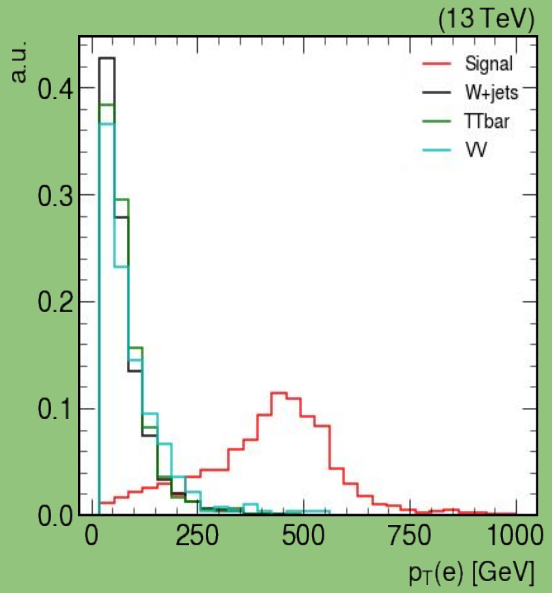
Cut 4: $p_T(l) > 150$ GeV

Cut 5: $p_T^{miss} > 50$ GeV

Cut 6: $|\Delta(\phi(l), p_T^{miss})| > 1.5$

τ

W' variables



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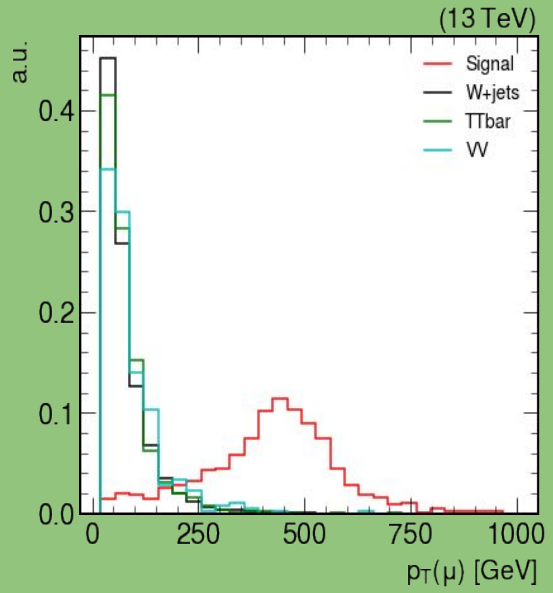

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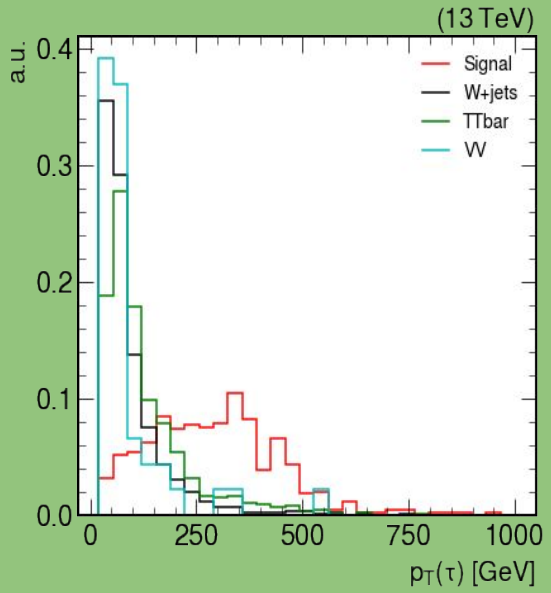
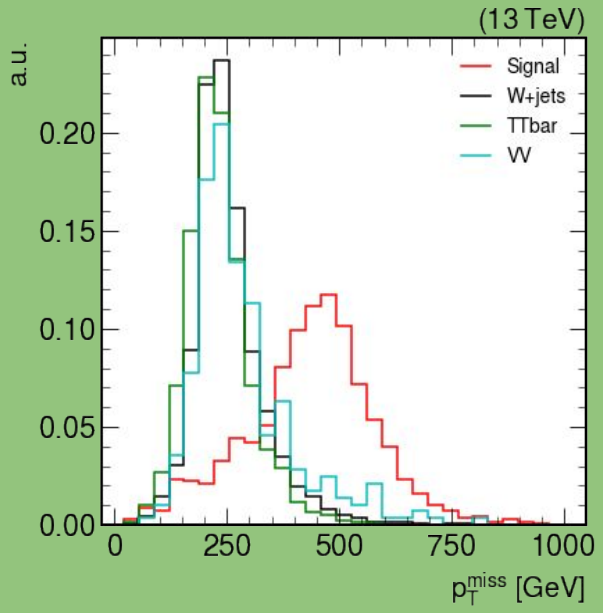


τ

W’ variables



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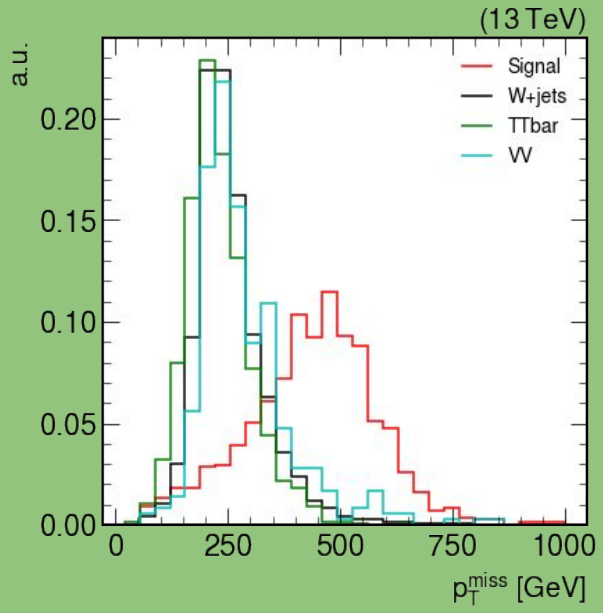

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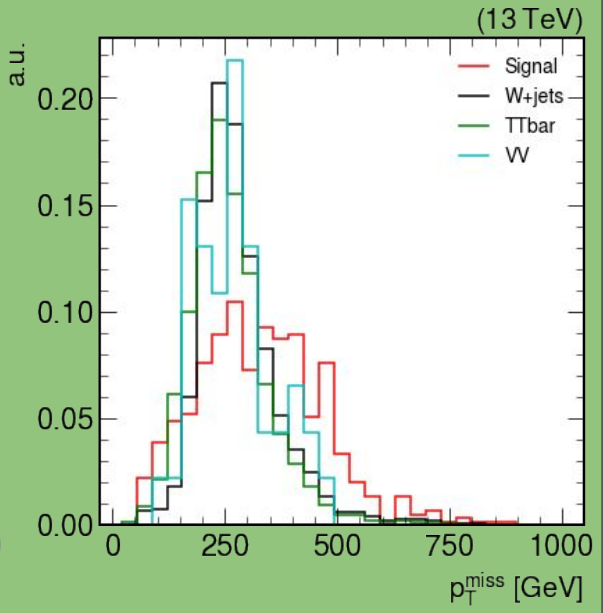
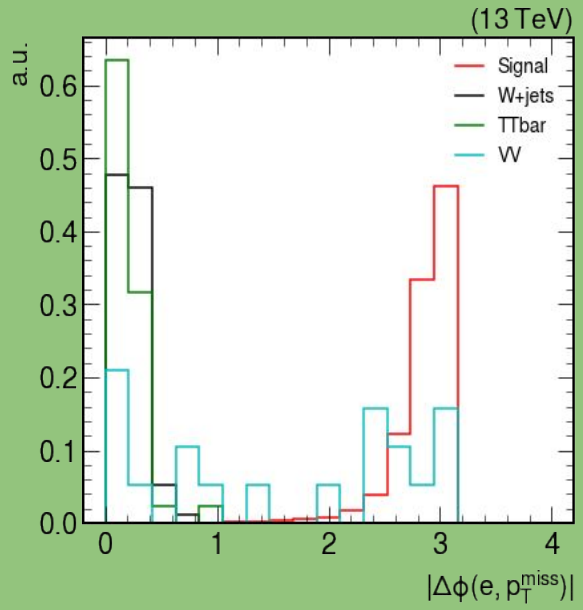
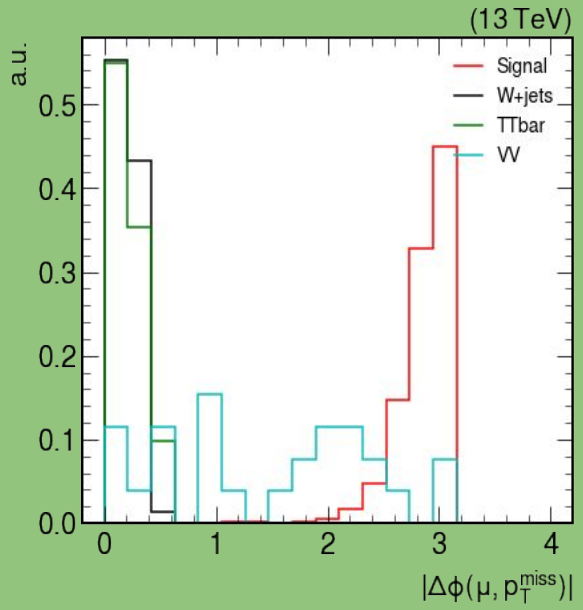
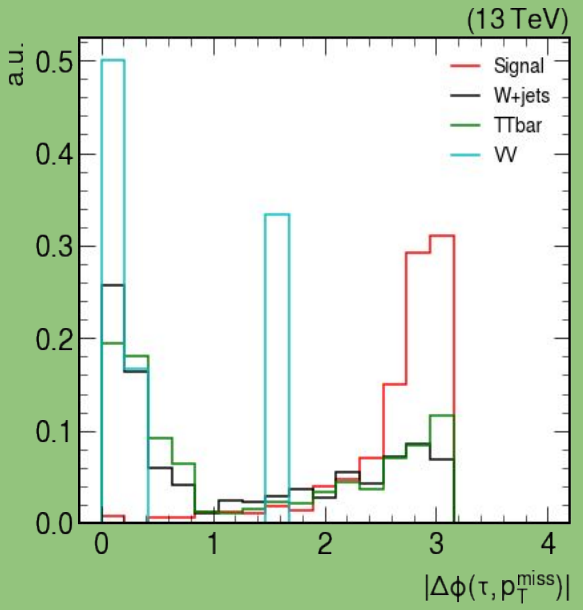


τ

W’ variables







e

μ

τ

Cut flow: Electron and Muon

	Signal	W+jets	$t\bar{t}$	VV	$S/\sqrt{S+B}$
Initial	1026.0	119107.0	36528.8	1453.0	2.6
Cut 1	751.8	53656.2	10932.3	609.1	2.9
Cut 2	487.5	10633.7	1353.6	112.2	4.3
Cut 3	427.5	2152.9	283.0	22.4	8.0
Cut 4	380.7	93.9	11.2	1.8	17.2
Cut 5	371.1	75.1	9.4	1.4	17.4
Cut 6	370.2	0.0	0.0	0.7	19.2

e

	Signal	W+jets	$t\bar{t}$	VV	$S/\sqrt{S+B}$
Initial	1259.4	152156.8	48246.6	1870.3	2.8
Cut 1	930.3	68480.3	14364.6	788.2	3.2
Cut 2	593.7	13461.8	1796.9	147.8	4.7
Cut 3	527.1	2771.8	365.0	27.9	8.7
Cut 4	474.0	118.4	17.6	2.1	19.2
Cut 5	459.9	91.7	11.6	1.9	19.3
Cut 6	459.6	0.0	0.0	0.9	21.4

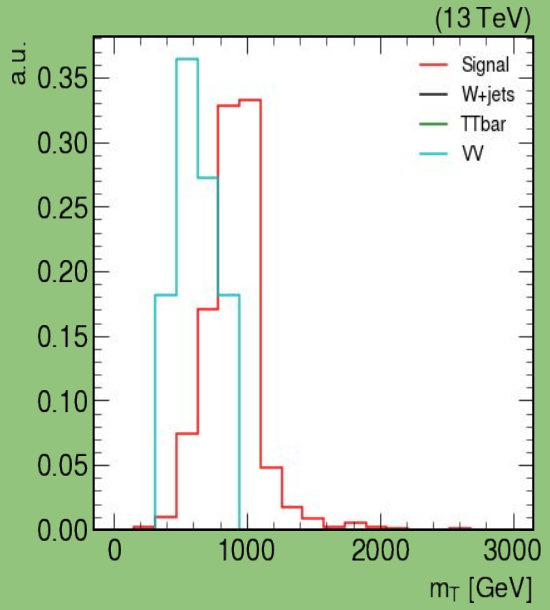
μ

Cut flow: Tau

	Signal	W+jets	$t\bar{t}$	VV	$S/\sqrt{S+B}$
Initial	468.6	46671.3	17559.7	451.1	1.8
Cut 1	334.2	20778.8	5339.8	163.8	2.0
Cut 2	207.3	4085.0	703.3	26.5	2.9
Cut 3	178.5	860.5	137.0	5.0	5.2
Cut 4	145.5	129.5	36.6	0.8	8.2
Cut 5	145.5	129.5	36.6	0.8	8.2
Cut 6	136.8	53.6	15.7	0.3	9.5

τ

W’ variables



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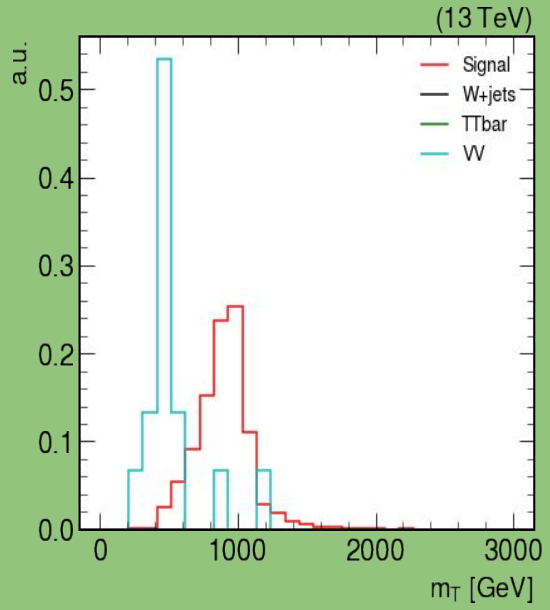

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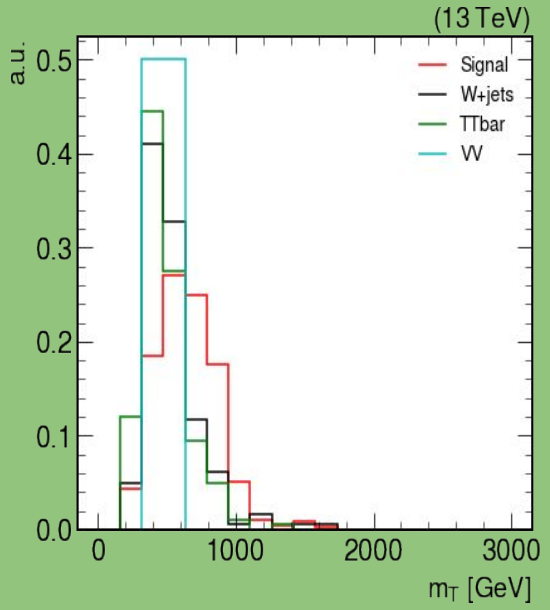
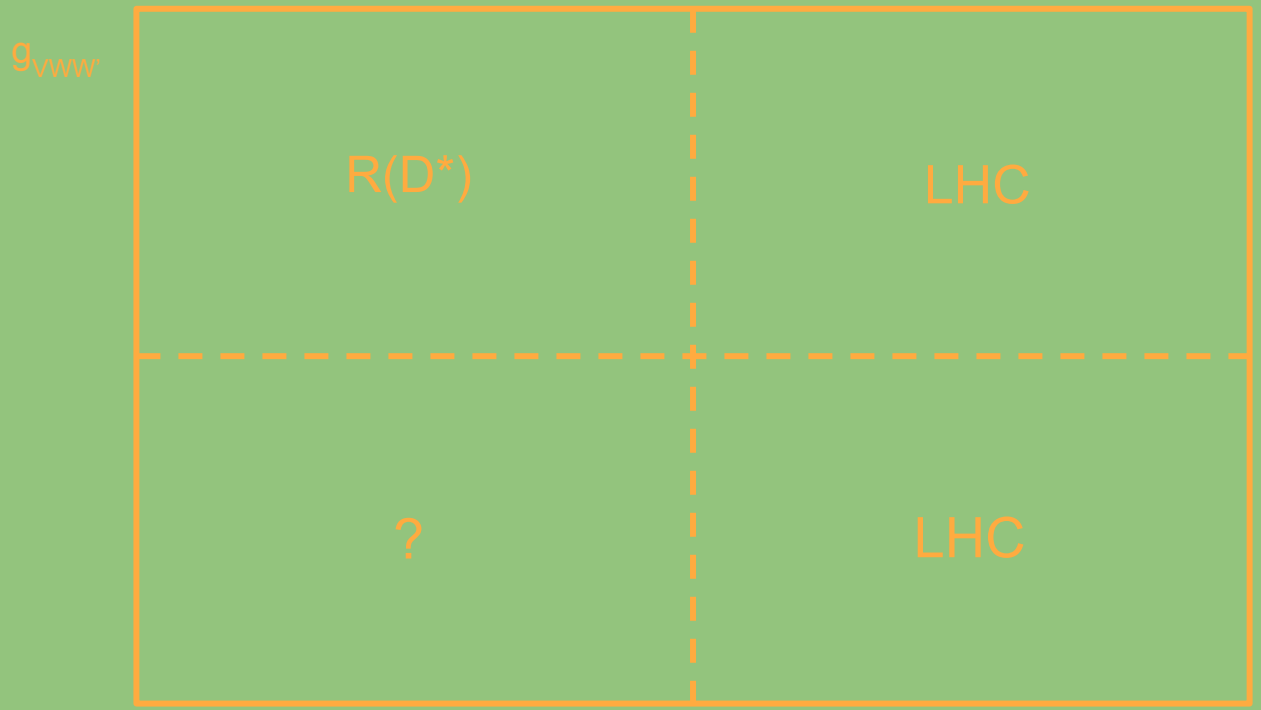


τ

Some further considerations



Conclusions

1. TGC with a W’ give a new unexplored signature at the LHC.
2. TGC with a W’ might be interesting for R(D*) anomalies.
3. Implemented a simplified W’ model with TGC for LHC searches.
4. Desgined a search at the LHC for VBF produced high mass W’.
5. Proven sensitivity in this search.
6. Tau channel certainly more challenging than other leptons.
7. Low mass W’ will be, at least, very challenging at the LHC.

Thanks

Efficiencies: Electron and Muon

	Signal [%]	W−jets [%]	$t\bar{t}$ [%]	VV [%]
Cut 1	73.27	45.05	29.93	41.92
Cut 2	47.51	8.93	3.71	7.72
Cut 3	41.67	1.81	0.77	1.54
Cut 4	37.11	0.08	0.03	0.12
Cut 5	36.17	0.06	0.03	0.10
Cut 6	36.08	<0.06	<0.03	0.05

e

	Signal [%]	W−jets [%]	$t\bar{t}$ [%]	VV [%]
Cut 1	73.87	45.01	29.77	42.14
Cut 2	47.14	8.85	3.72	7.9
Cut 3	41.85	1.82	0.76	1.49
Cut 4	37.64	0.08	0.04	0.11
Cut 5	36.52	0.06	0.02	0.1
Cut 6	36.49	<0.06	<0.02	0.05

μ

Efficiencies: Tau

	Signal [%]	W+jets [%]	$t\bar{t}$ [%]	VV [%]
Cut 1	71.32	44.52	30.41	36.3
Cut 2	44.24	8.75	4.0	5.87
Cut 3	38.09	1.84	0.78	1.12
Cut 4	31.05	0.28	0.21	0.17
Cut 5	31.05	0.28	0.21	0.17
Cut 6	29.19	0.11	0.09	0.07

τ