

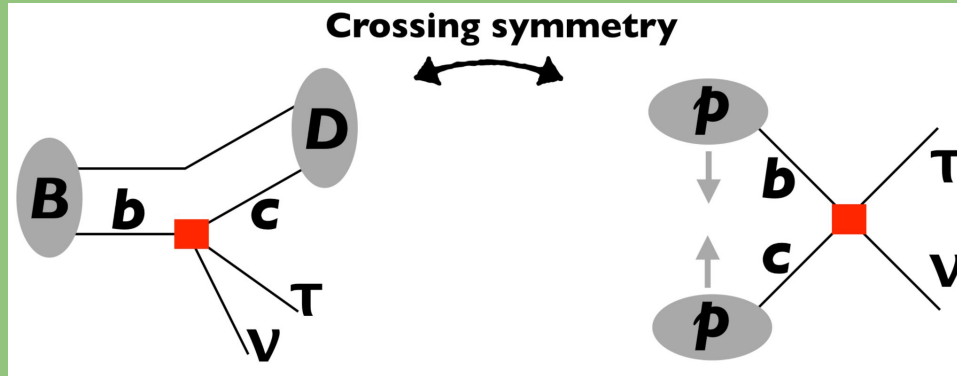
Quarkophobic W' for LHC searches

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Universidad San Francisco de Quito - Nov 17 2022



An initial motivation coming from $R(D^*)$

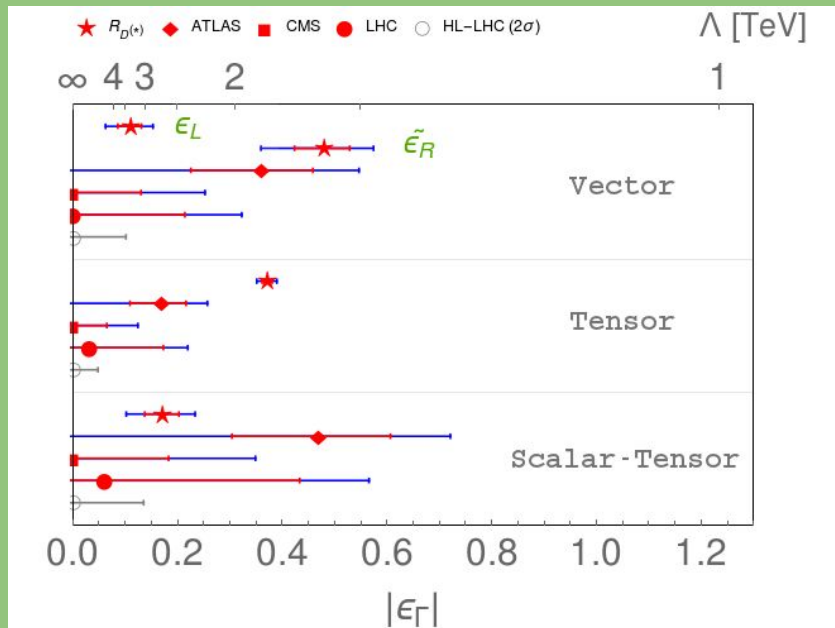
Low
energy



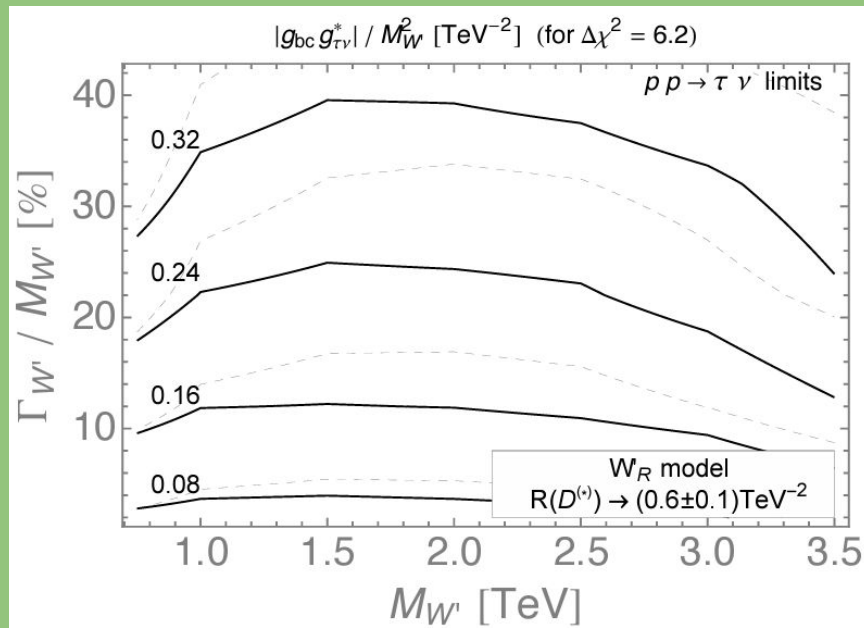
High
energy

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

Competitive and complimentary

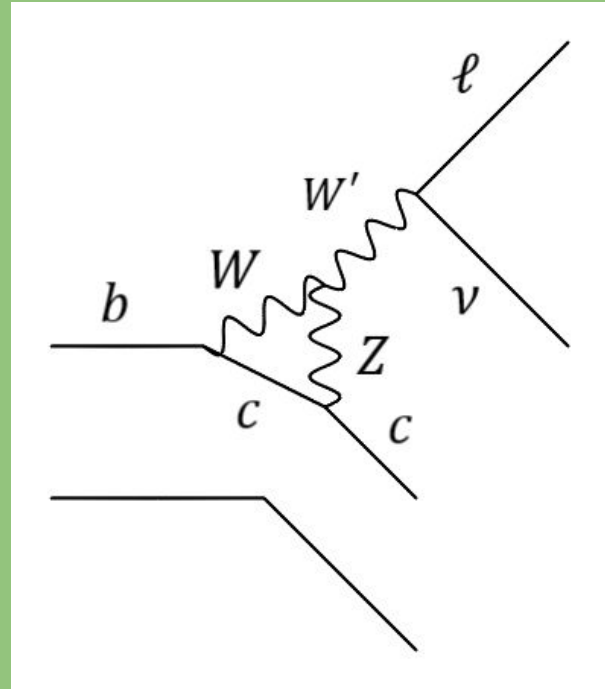
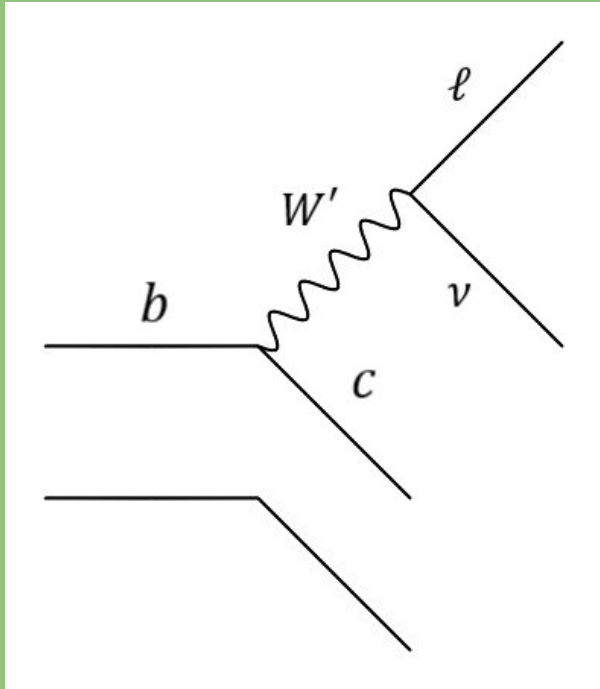


EFT

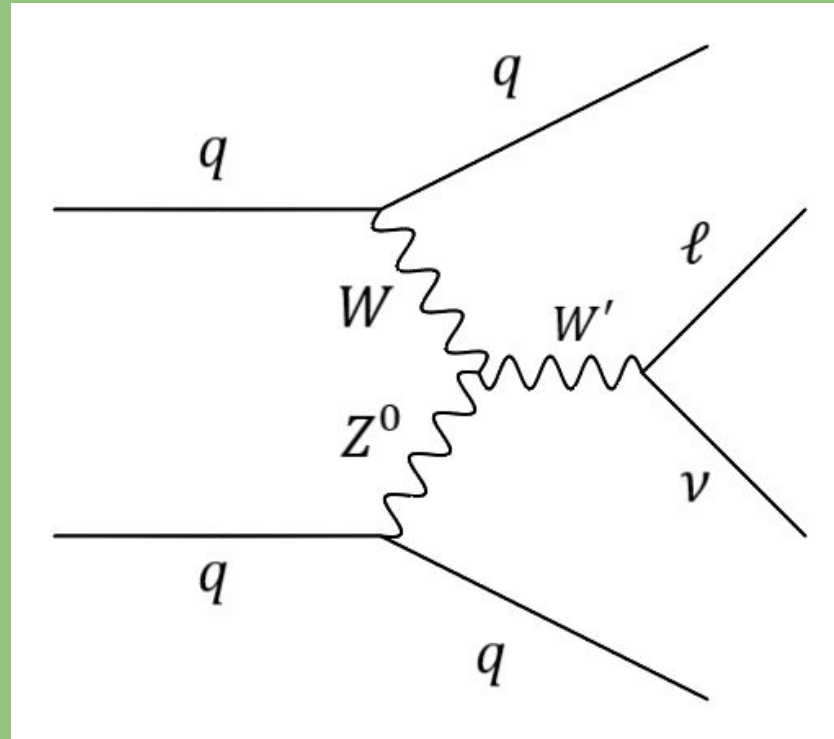


W'

Quarkophobic W'



Vector Boson Fusion W' production at the LHC



A simplified model implementation

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

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

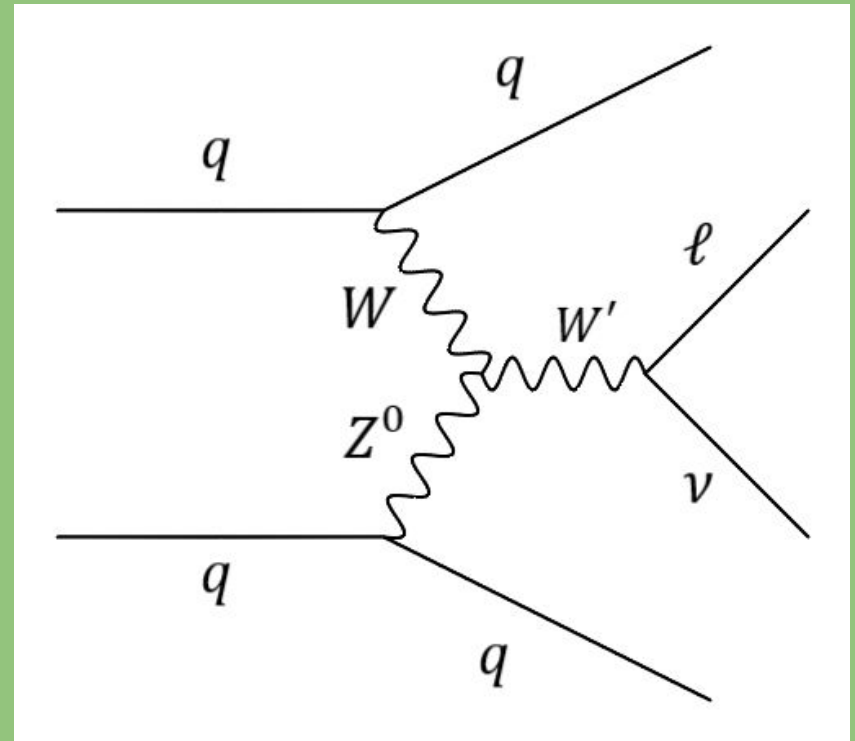
$$\mathcal{L}_{VWW'}^2 = g_2^V (W_\mu^+ W_\nu'^- V^{\mu\nu} + W_\mu'^+ W_\nu^- V^{\mu\nu})$$

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

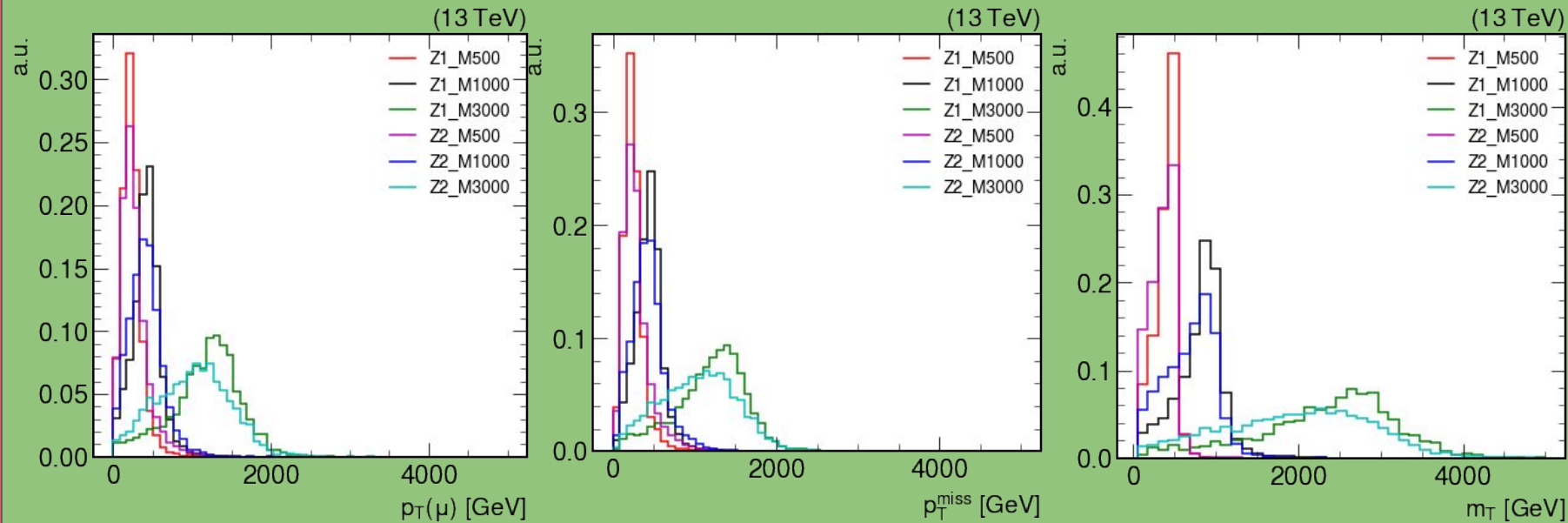
$$\mathcal{L}_l = \sum_l \bar{\nu}_l \gamma_\mu (g_l^R (1 + \gamma^5) + g_l^L (1 - \gamma^5)) W'^{\mu l}$$

With the model implemented ([link](#))

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.



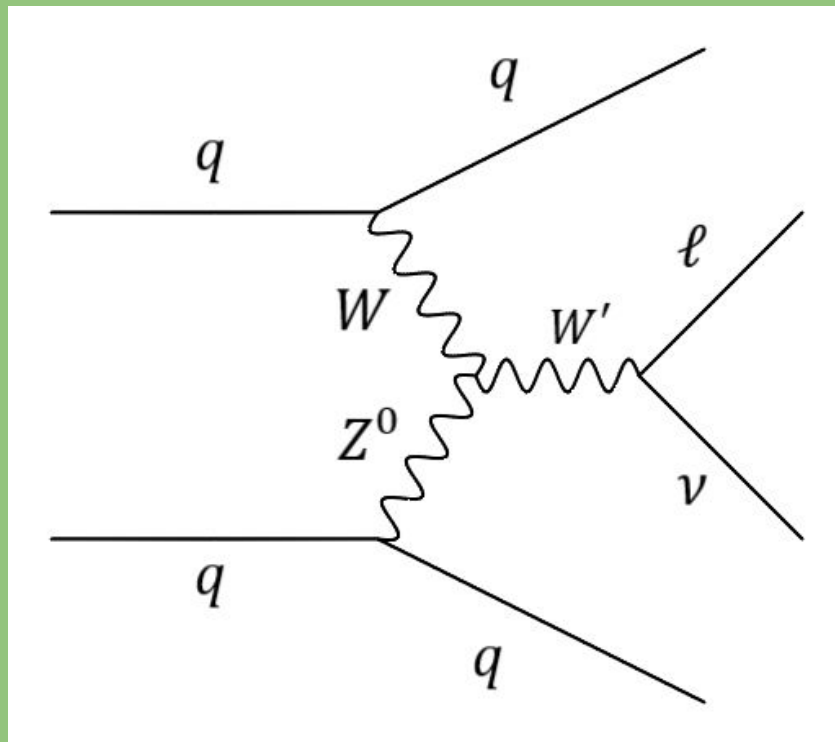
Differences among couplings



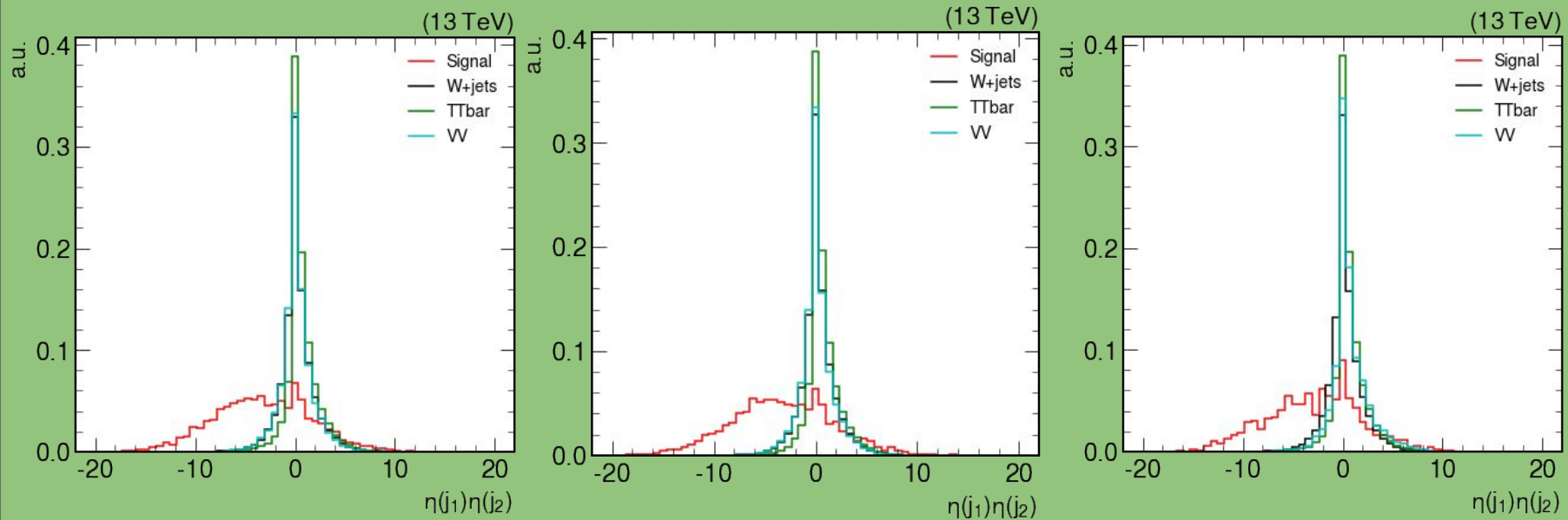
Vector Boson Fusion W' production at the LHC

Characteristics of the final state:

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



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

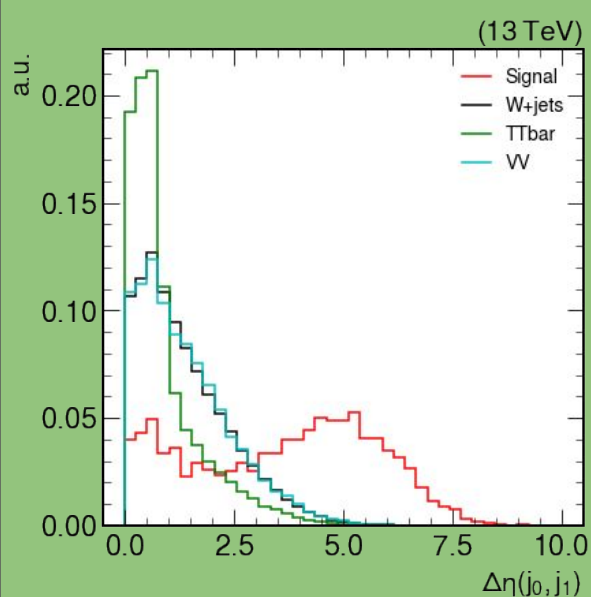


e

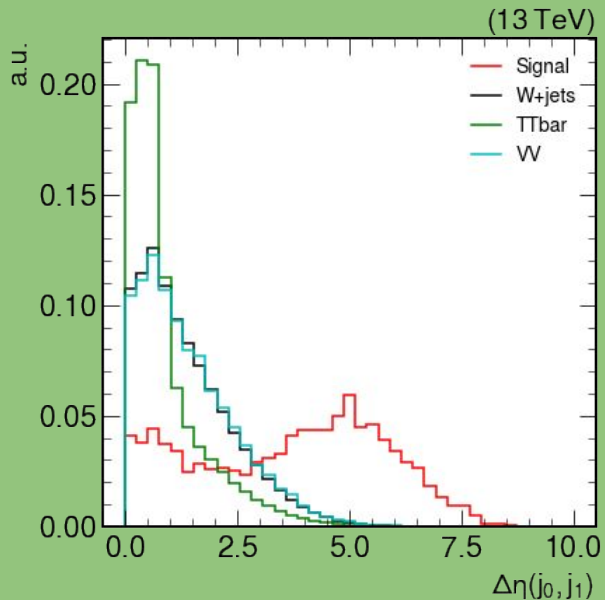
μ

τ

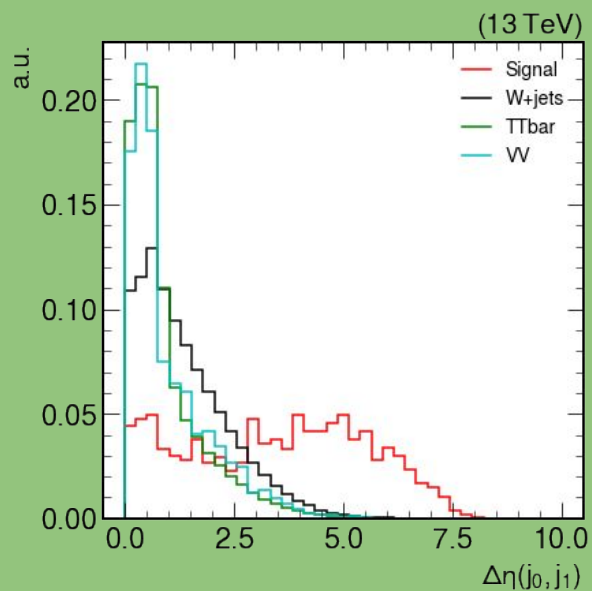
VBF variables



e

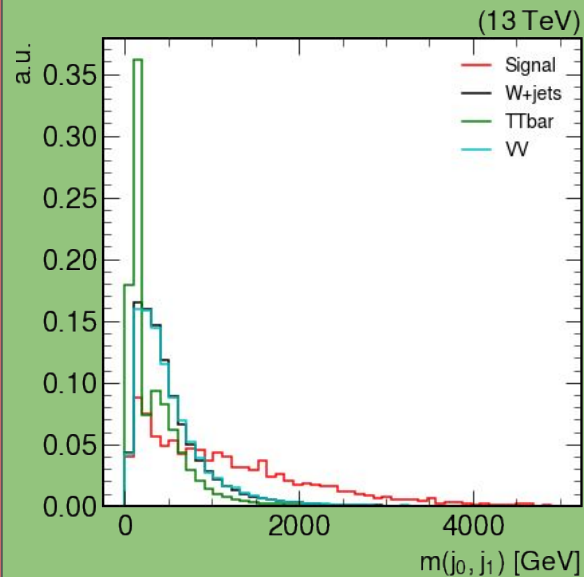


μ

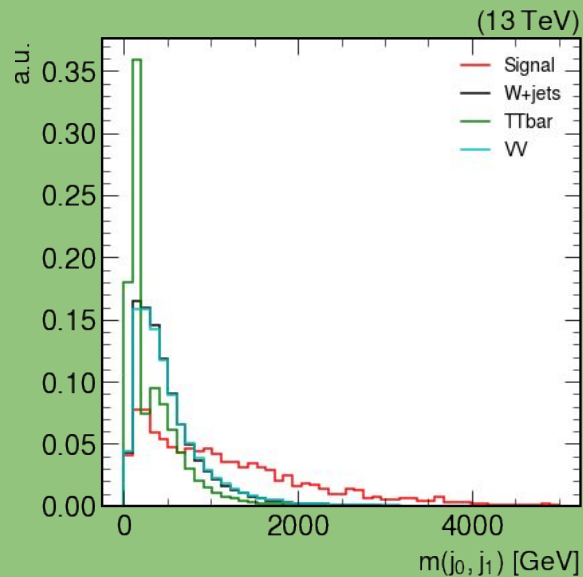


τ

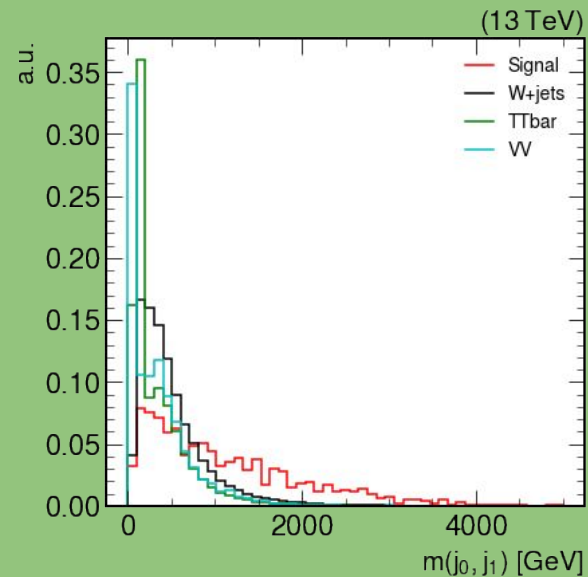
VBF variables



e



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

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

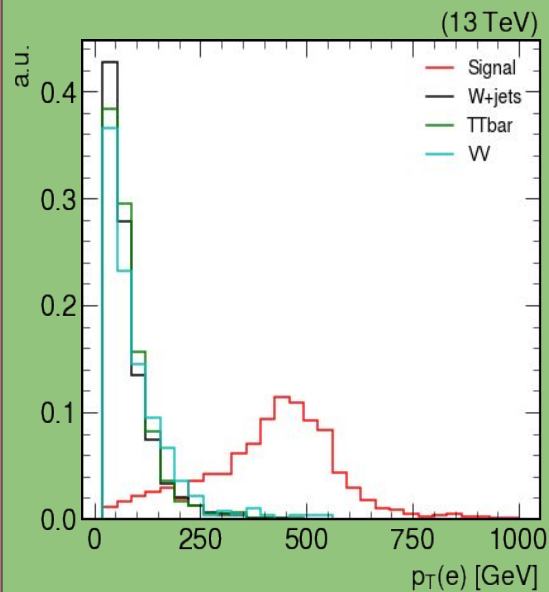
Cut 6: $|\Delta(\phi(l), p_T^{miss})| > 1.5$

e

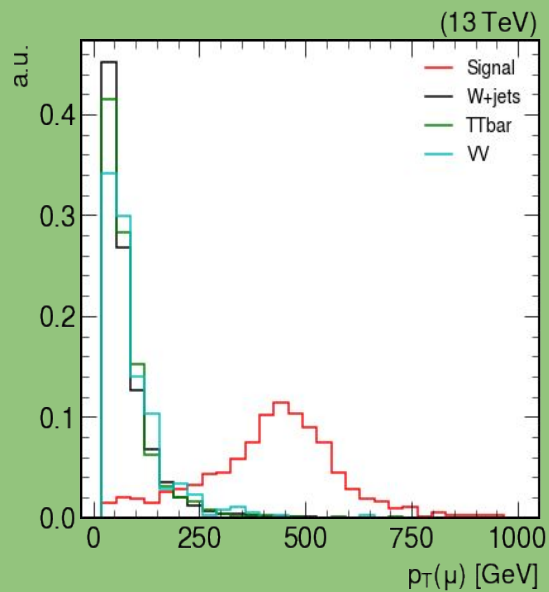
μ

τ

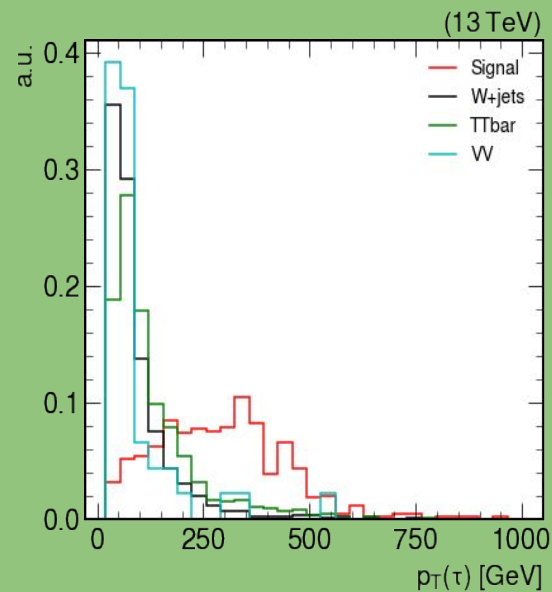
W' variables



e

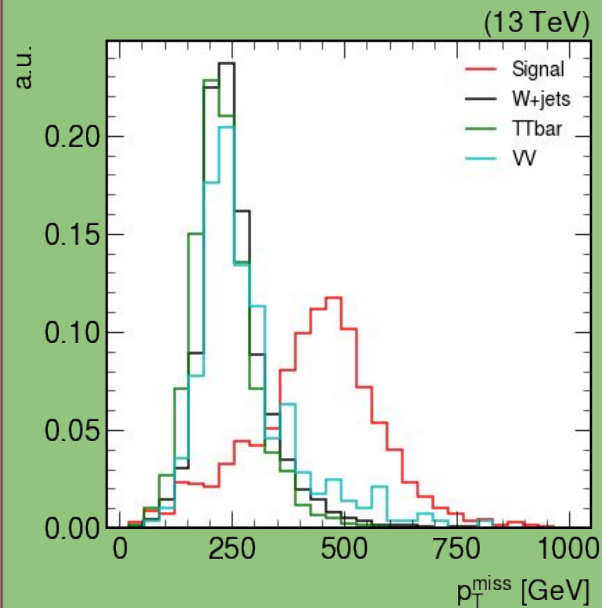


μ

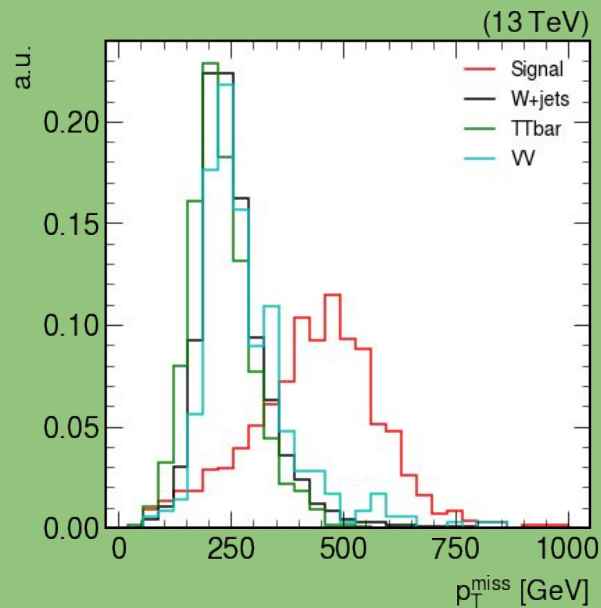


τ

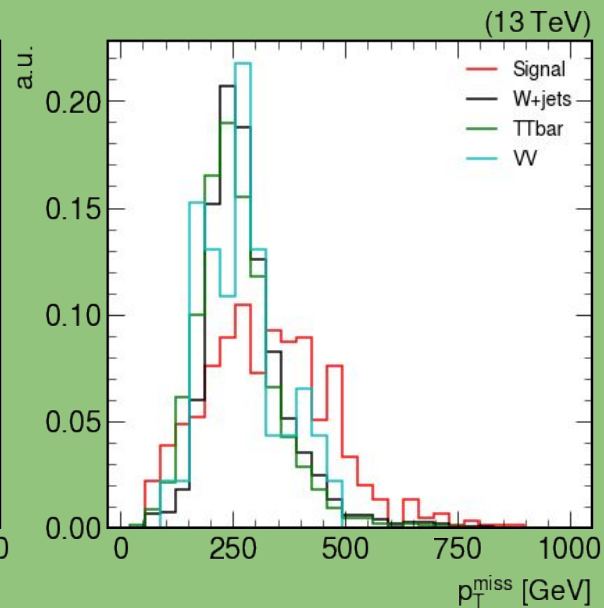
W' variables



e

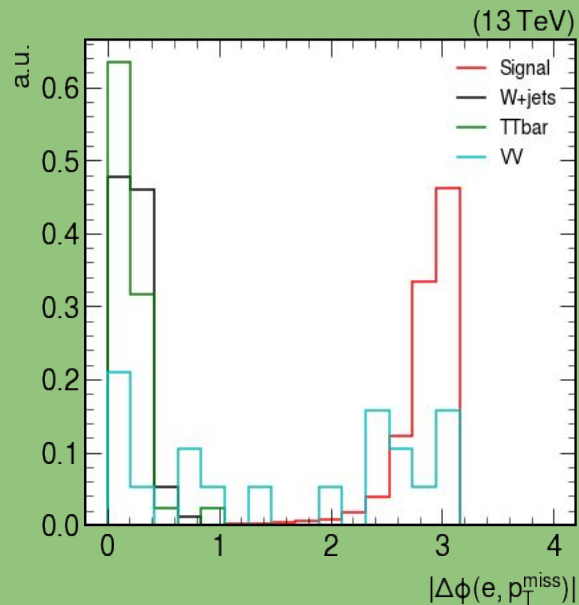


μ

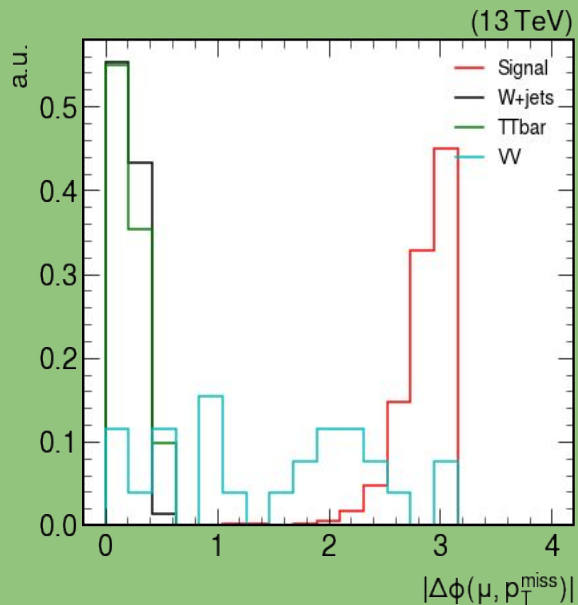


τ

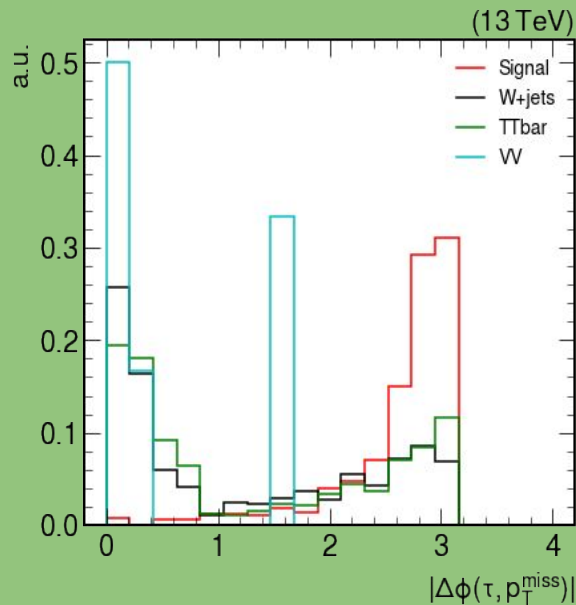
W' variables



e



μ



τ

Cut flow: Electron and Muon

	Signal	W+jets	$t\bar{t}$	VV	$S/\sqrt{S+B}$		Signal	W+jets	$t\bar{t}$	VV	$S/\sqrt{S+B}$
Initial	1026.0	119107.0	36528.8	1453.0	2.6	Initial	1259.4	152156.8	48246.6	1870.3	2.8
Cut 1	751.8	53656.2	10932.3	609.1	2.9	Cut 1	930.3	68480.3	14364.6	788.2	3.2
Cut 2	487.5	10633.7	1353.6	112.2	4.3	Cut 2	593.7	13461.8	1796.9	147.8	4.7
Cut 3	427.5	2152.9	283.0	22.4	8.0	Cut 3	527.1	2771.8	365.0	27.9	8.7
Cut 4	380.7	93.9	11.2	1.8	17.2	Cut 4	474.0	118.4	17.6	2.1	19.2
Cut 5	371.1	75.1	9.4	1.4	17.4	Cut 5	459.9	91.7	11.6	1.9	19.3
Cut 6	370.2	0.0	0.0	0.7	19.2	Cut 6	459.6	0.0	0.0	0.9	21.4

e

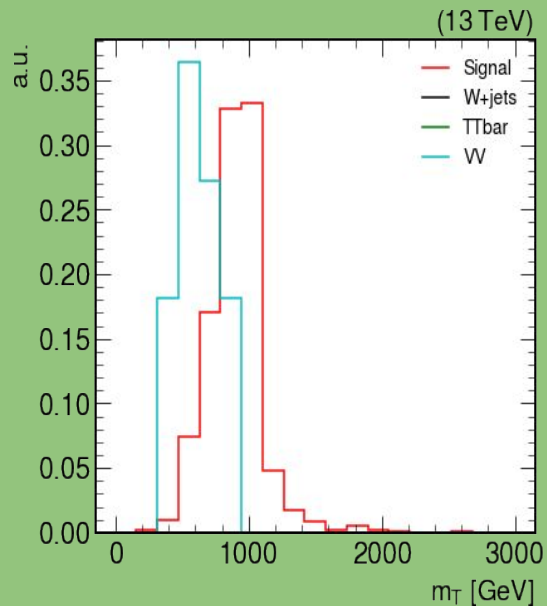
μ

Cut flow: Tau

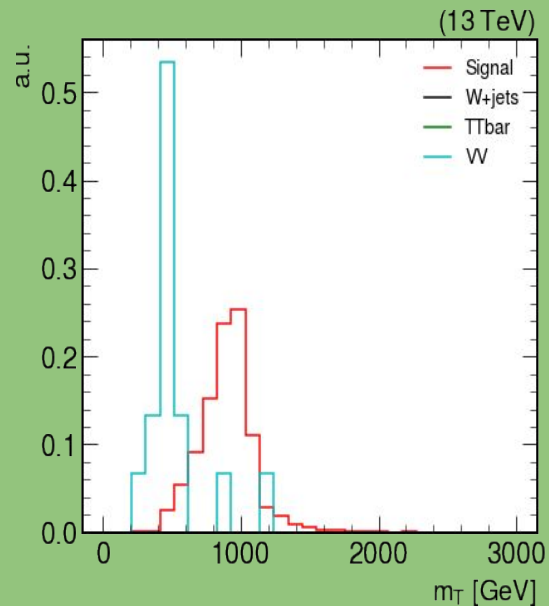
	Signal	W+jets	$t\bar{t}$	VV	$S/\sqrt{S+B}$
Initial	468.6	46671.3	17559.7	451.1	1.8
Cut 1	334.2	20778.8	5339.8	163.8	2.0
Cut 2	207.3	4085.0	703.3	26.5	2.9
Cut 3	178.5	860.5	137.0	5.0	5.2
Cut 4	145.5	129.5	36.6	0.8	8.2
Cut 5	145.5	129.5	36.6	0.8	8.2
Cut 6	136.8	53.6	15.7	0.3	9.5

τ

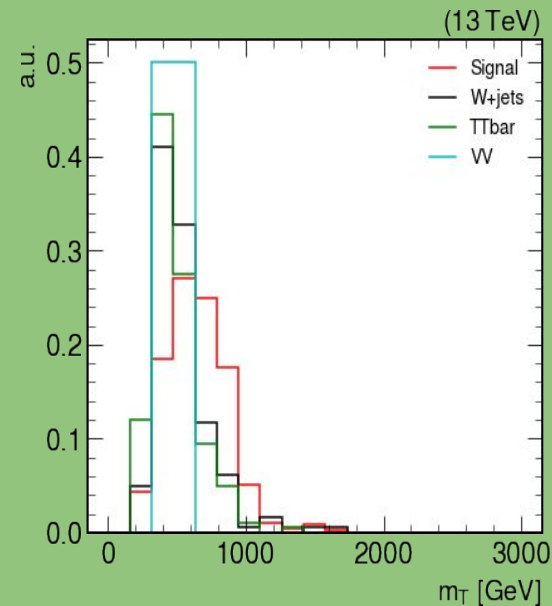
W' variables



e



μ



τ

Some further considerations

$g_{VWW'}$

R(D*)

LHC

?

LHC

M(W') [GeV]

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. Designed 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 [%]		Signal [%]	W-jets [%]	$t\bar{t}$ [%]	VV [%]
Cut 1	73.27	45.05	29.93	41.92	Cut 1	73.87	45.01	29.77	42.14
Cut 2	47.51	8.93	3.71	7.72	Cut 2	47.14	8.85	3.72	7.9
Cut 3	41.67	1.81	0.77	1.54	Cut 3	41.85	1.82	0.76	1.49
Cut 4	37.11	0.08	0.03	0.12	Cut 4	37.64	0.08	0.04	0.11
Cut 5	36.17	0.06	0.03	0.10	Cut 5	36.52	0.06	0.02	0.1
Cut 6	36.08	<0.06	<0.03	0.05	Cut 6	36.49	<0.06	<0.02	0.05

e

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