

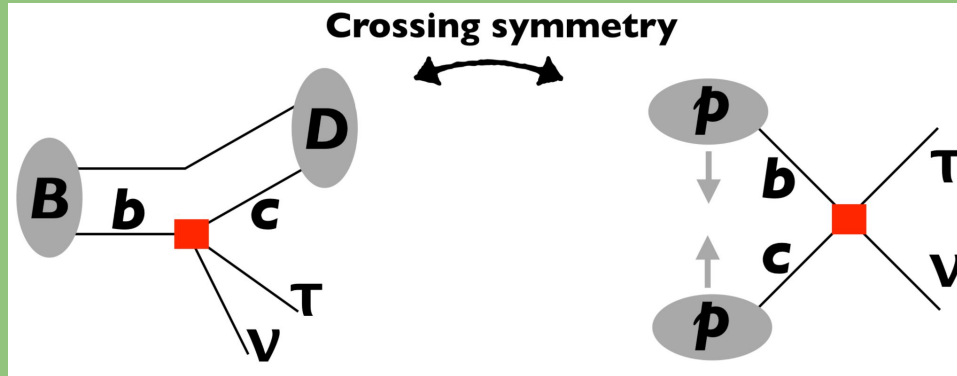
Quarkophobic W' for LHC searches

Alfredo Gurrola - José Ruiz
Villa de Leyva - Dec 1st 2022



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

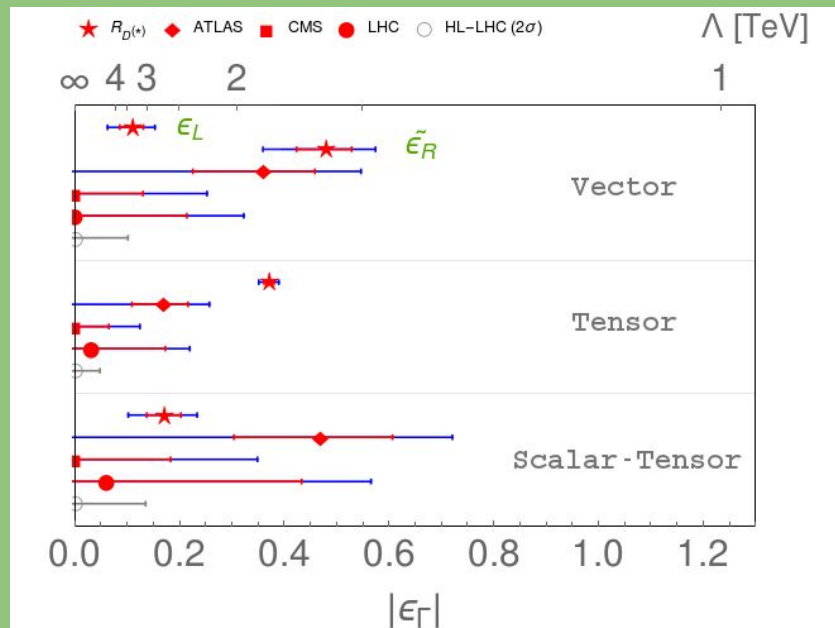
Low
energy



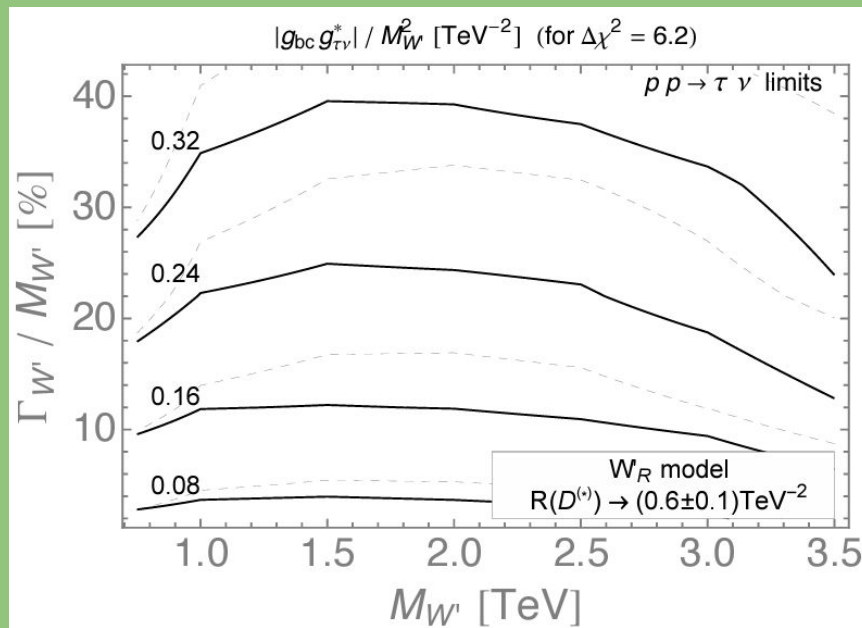
High
energy

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

Competitive and complimentary

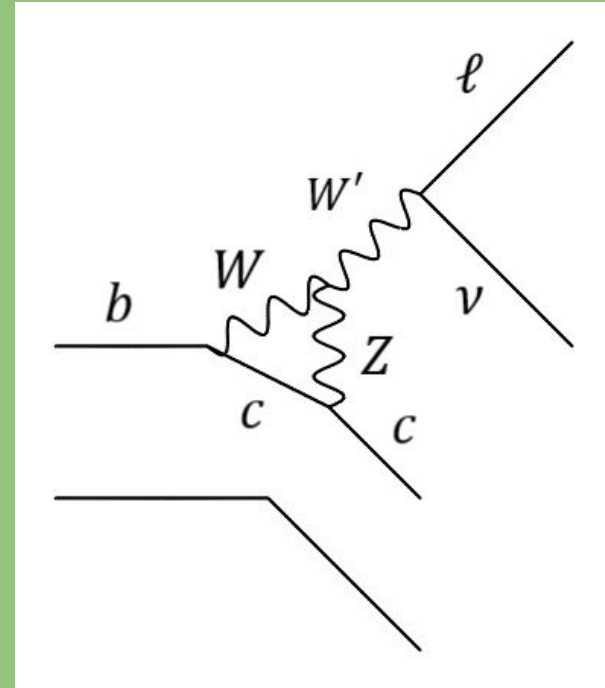
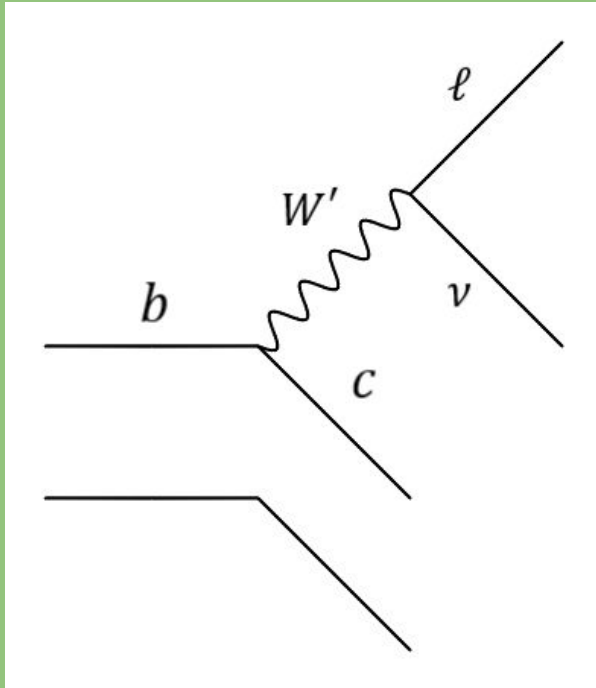


EFT

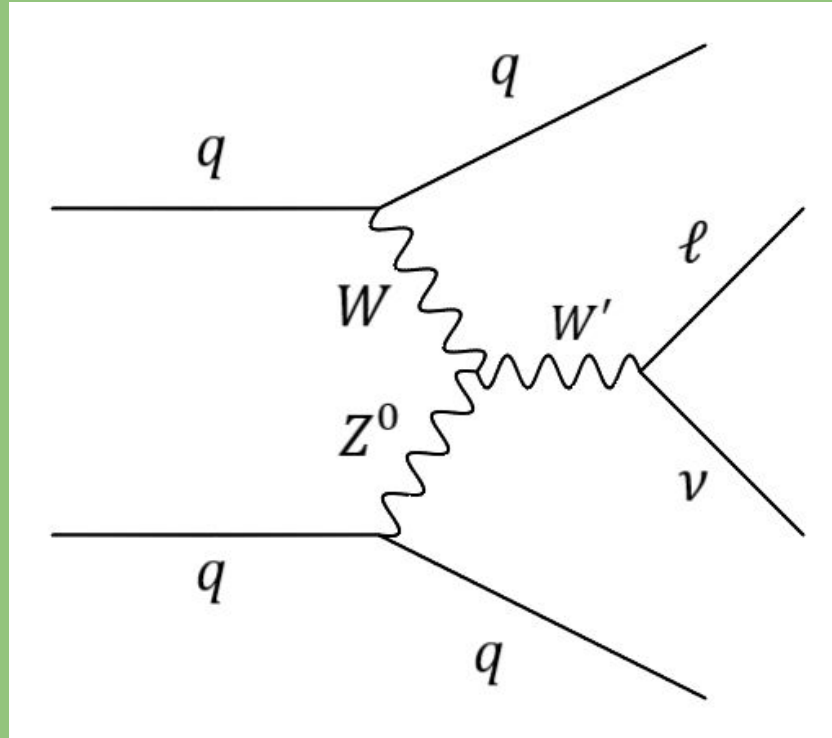


W'

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.

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

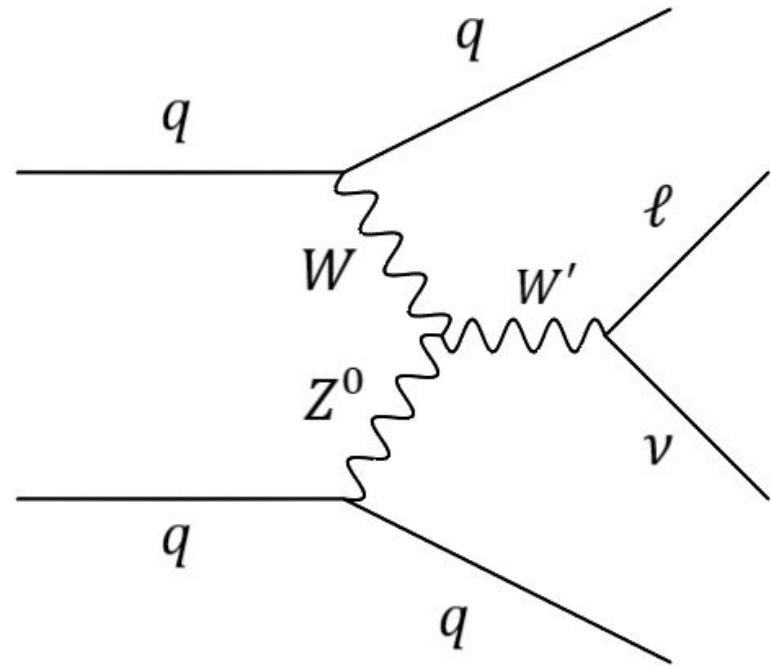
$$\mathcal{L}_{VWW'}^2 = g_2^V (W_\mu^+ W_\nu'^- V^{\mu\nu} + W_\mu'^+ W_\nu^- V^{\mu\nu})$$

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

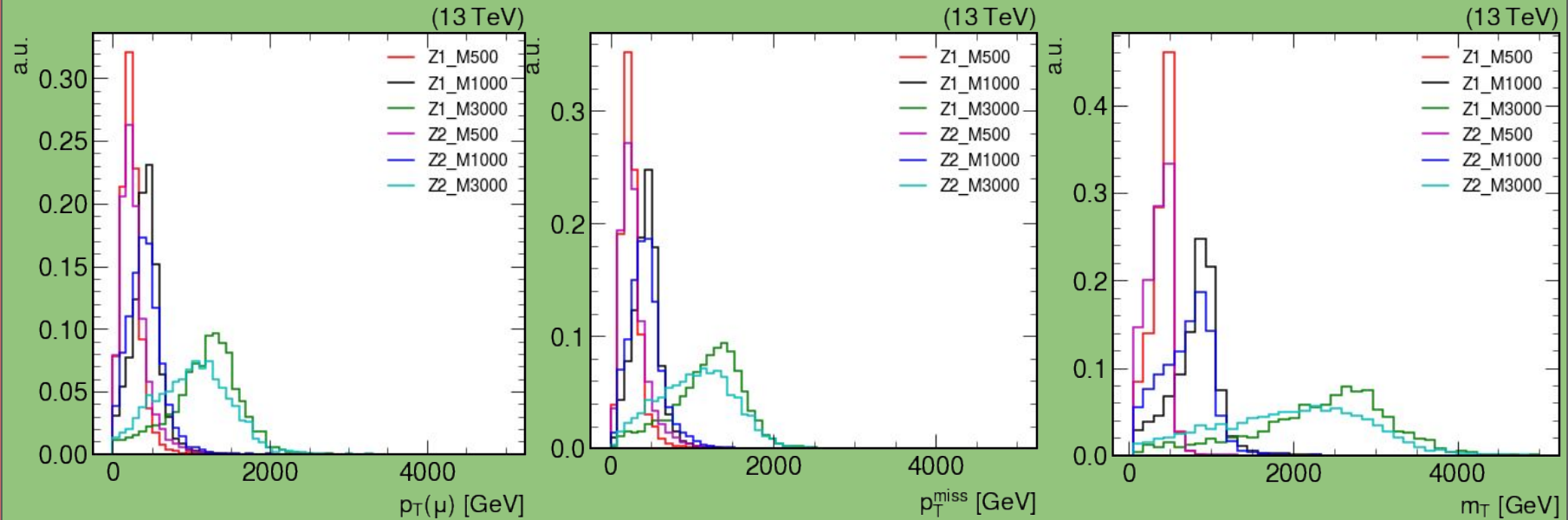
$$\mathcal{L}_l = \sum_l \bar{\nu}_l \gamma_\mu (g_l^R (1 + \gamma^5) + g_l^L (1 - \gamma^5)) W'^\mu l$$

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.



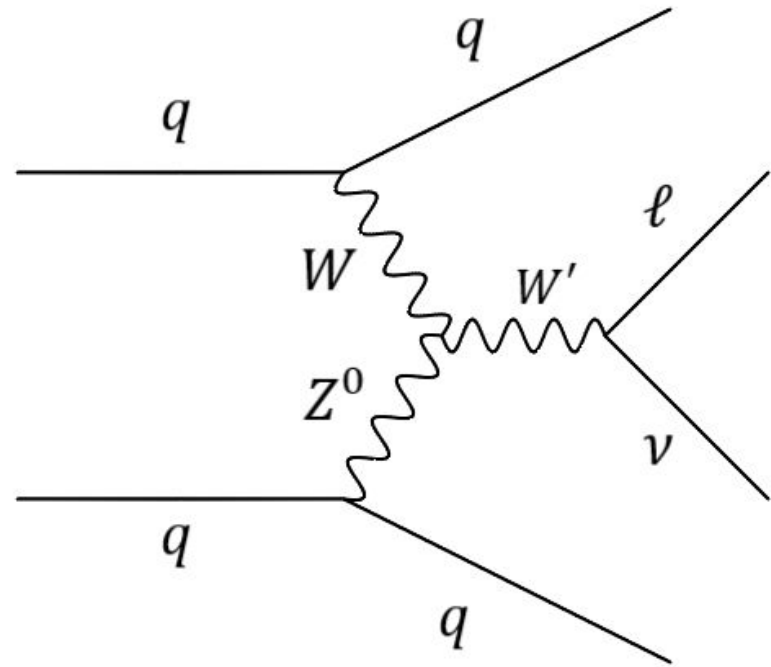
Differences among couplings



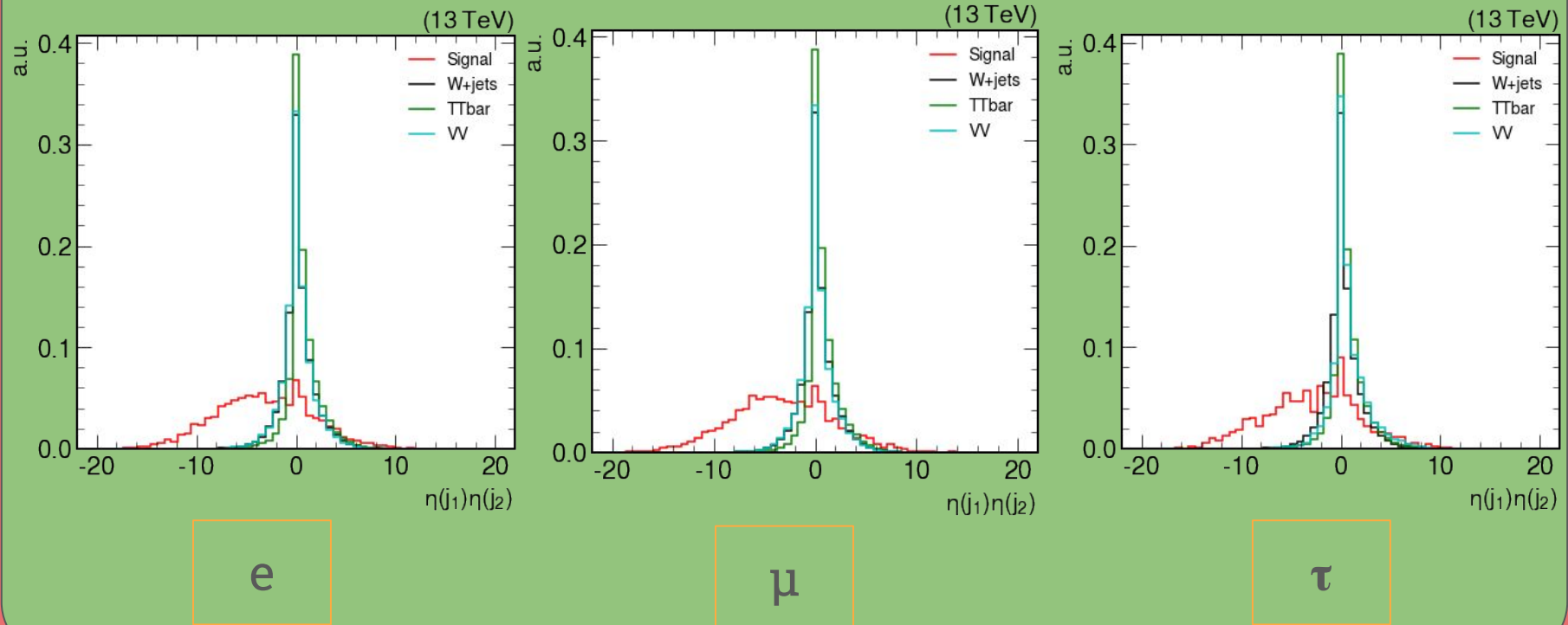
Vector Boson Fusion W' production at the LHC

Characteristics of the final state:

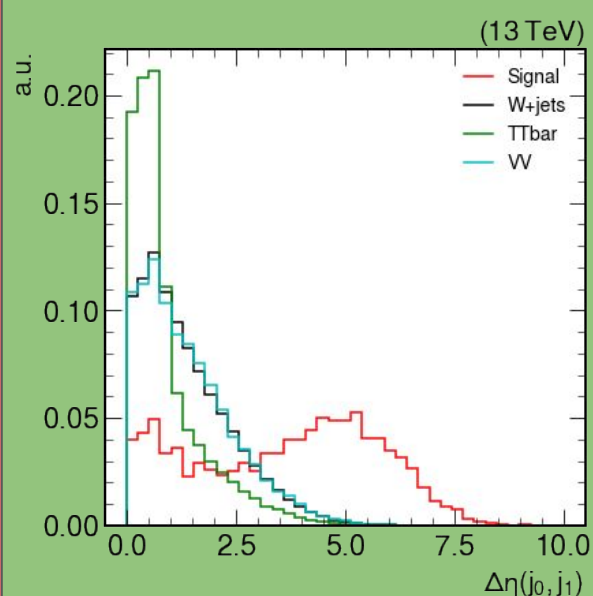
1. Two opposite hemispheres jets.
2. Large η separation among jets.
3. Large dijet invariant mass.
4. High p_T lepton.
5. High MET.



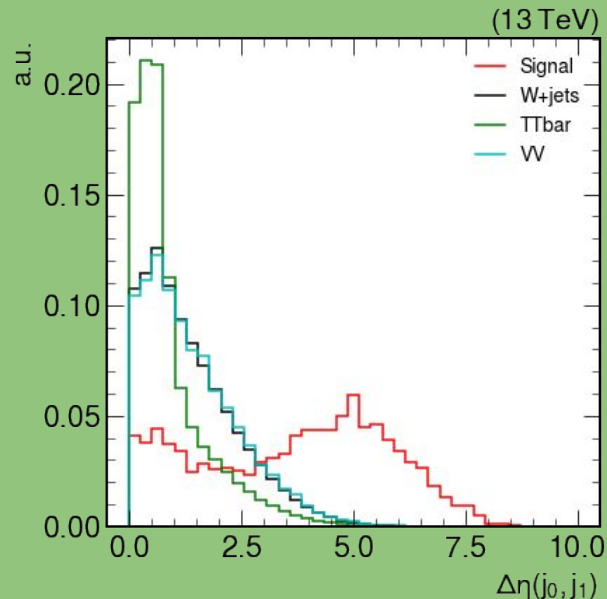
Search designed for 1 TeV W' (Z type 1 coupling)



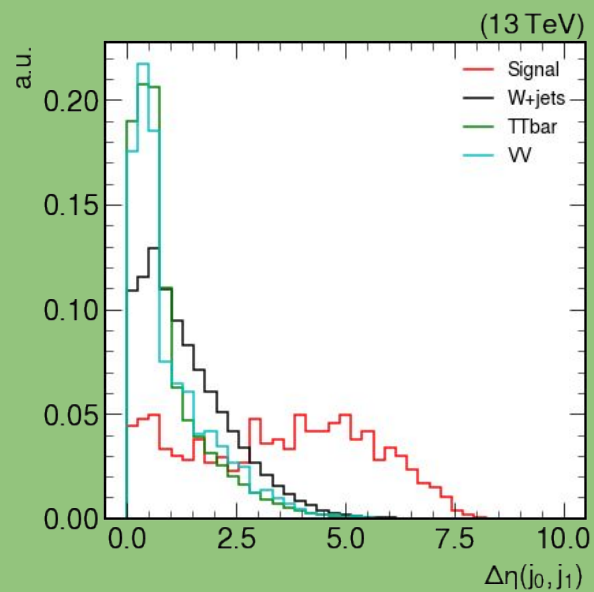
VBF variables



e

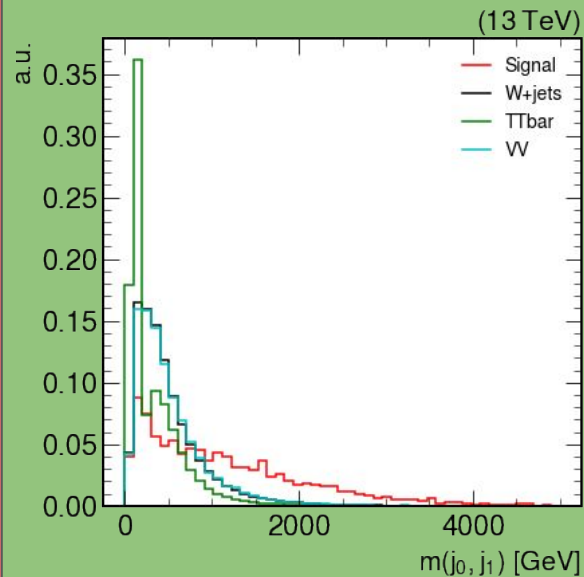


μ

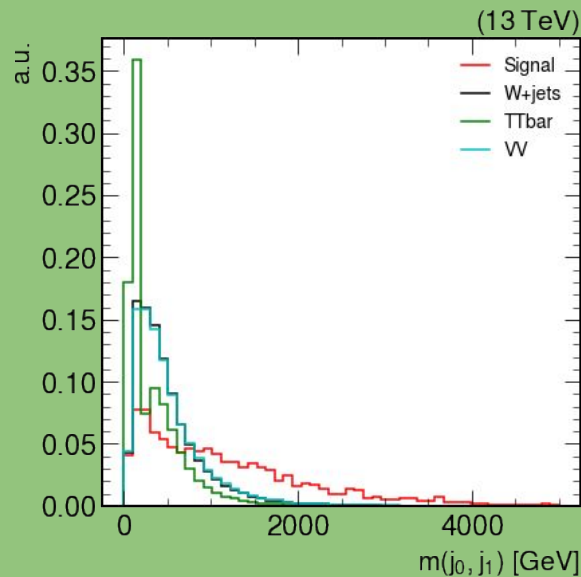


τ

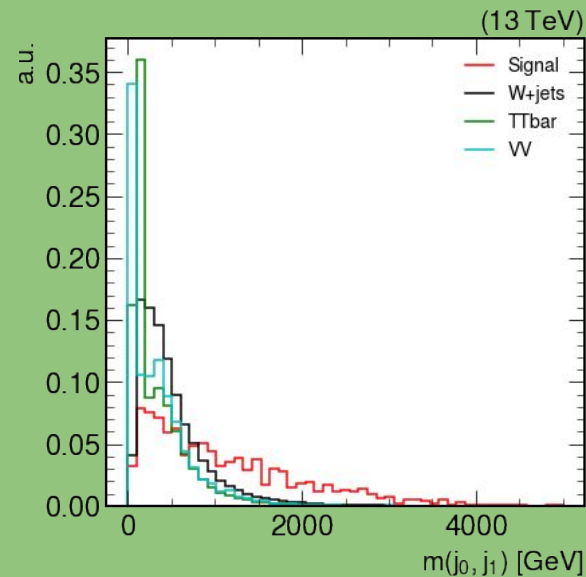
VBF variables



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

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

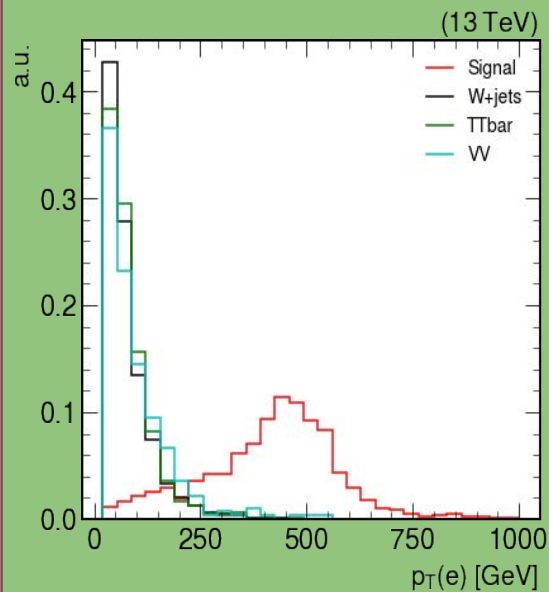
Cut 4: $p_T(l) > 150$ GeV

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

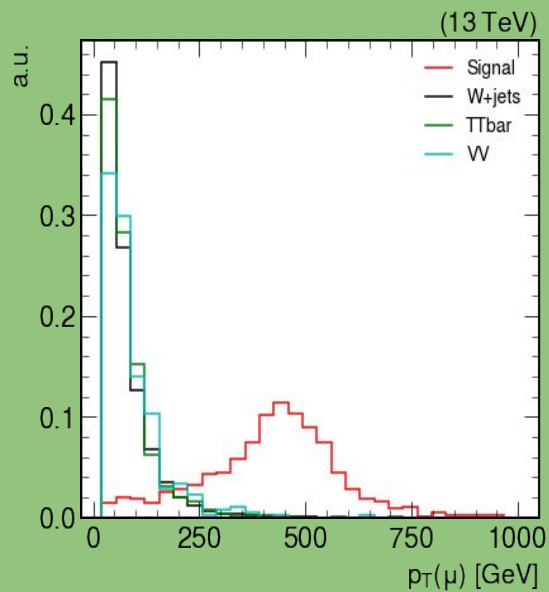
Cut 6: $|\Delta(\phi(l), p_T^{miss})| > 1.5$

τ

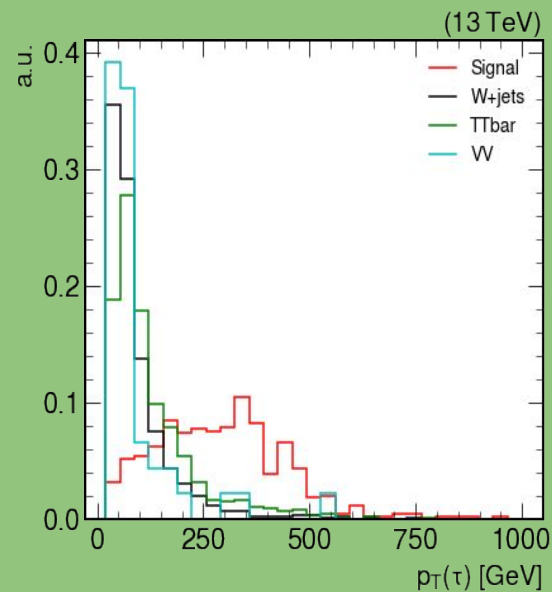
W' variables



e

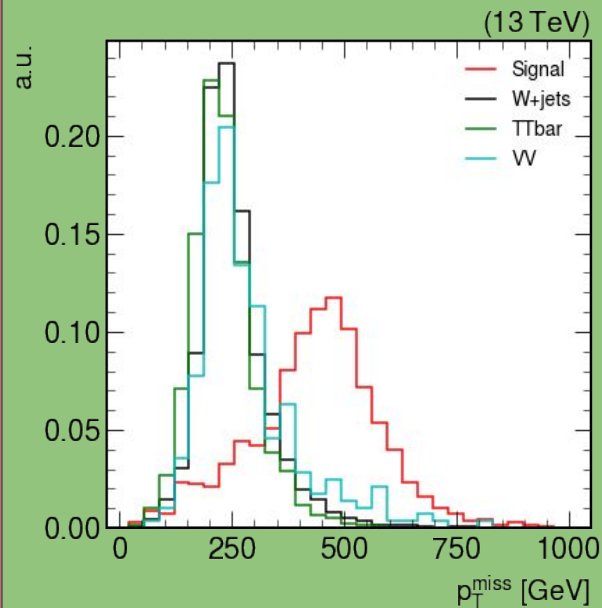


μ

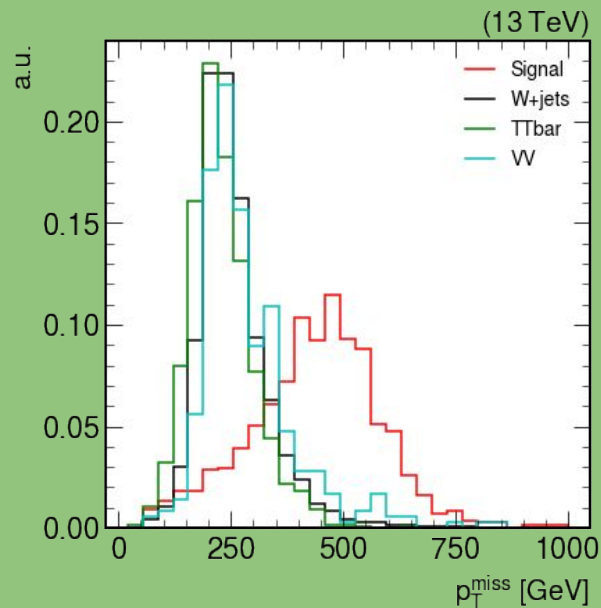


τ

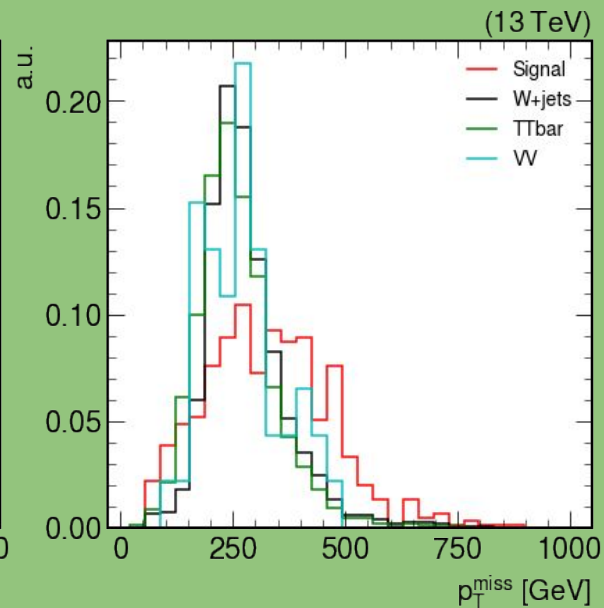
W' variables



e

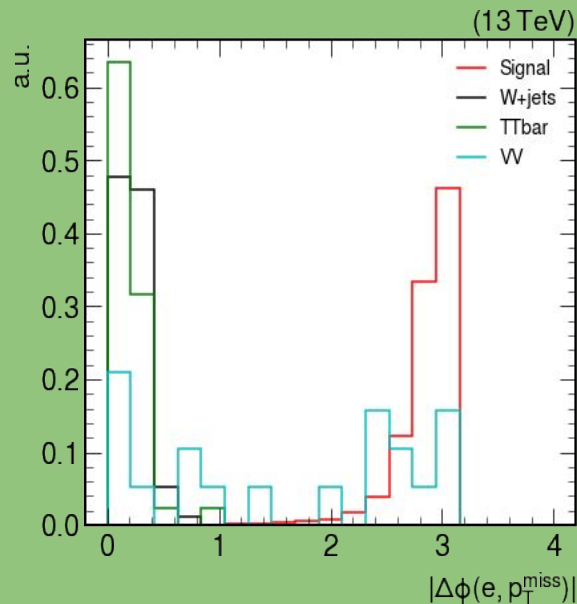


μ

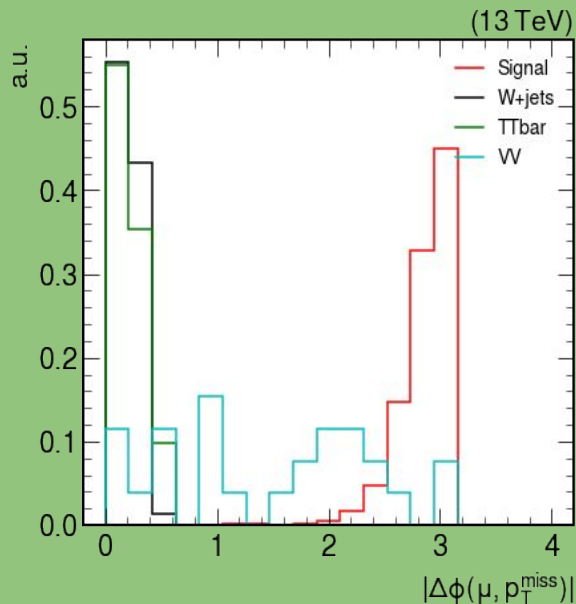


τ

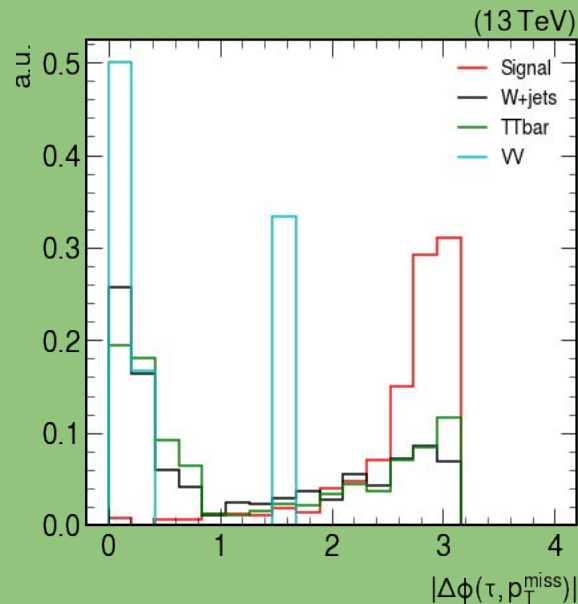
W' variables



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

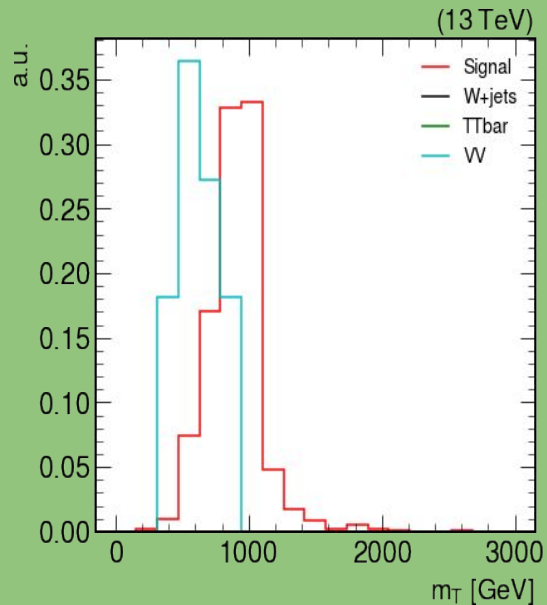
μ

Cut flow: Tau

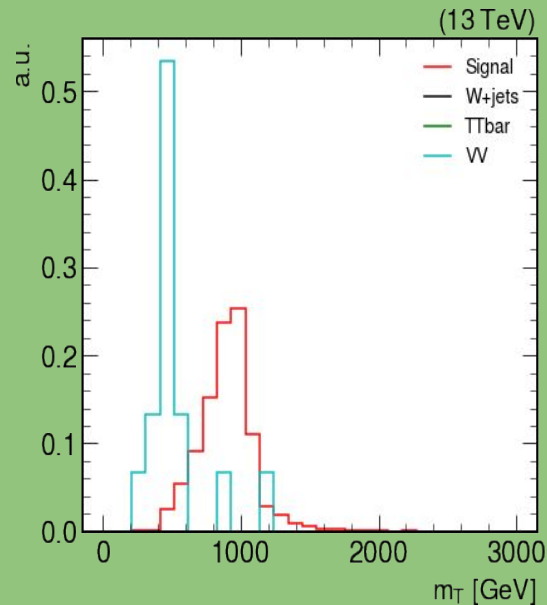
	Signal	W+jets	$t\bar{t}$	VV	$S/\sqrt{S+B}$
Initial	468.6	46671.3	17559.7	451.1	1.8
Cut 1	334.2	20778.8	5339.8	163.8	2.0
Cut 2	207.3	4085.0	703.3	26.5	2.9
Cut 3	178.5	860.5	137.0	5.0	5.2
Cut 4	145.5	129.5	36.6	0.8	8.2
Cut 5	145.5	129.5	36.6	0.8	8.2
Cut 6	136.8	53.6	15.7	0.3	9.5

τ

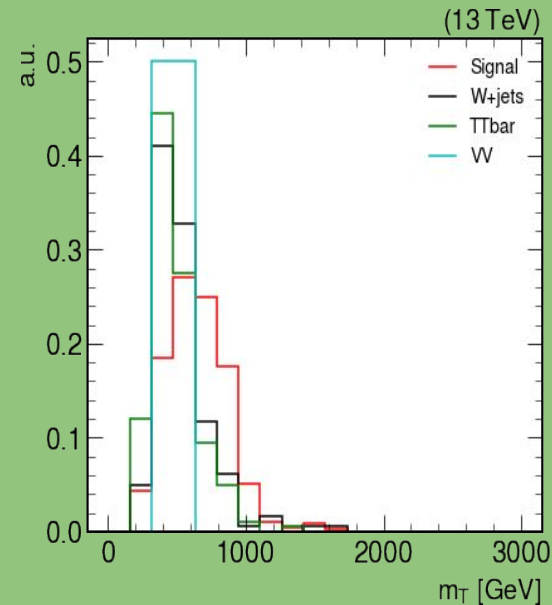
W' variables



e



μ



τ

Some further considerations

$g_{VWW'}$

$R(D^*)$

LHC

?

LHC

$M(W') \text{ [GeV]}$

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.

A nighttime photograph of a flooded cobblestone square. In the background, a long, two-story building with a central tower and arched windows is brightly lit, its lights reflecting on the water. The foreground shows the wet, reflective cobblestones and several large, rectangular concrete blocks partially submerged in the floodwater. The sky is dark, and the overall scene is illuminated by the warm yellow light of the building's windows and streetlights.

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