A simplified model of heavy vector singlets at the LHC and future colliders

Michael J. Baker[a], **Timothy Martonhelyi**[a], Andrea Thamm[a], Riccardo Torre[b]
[a] The University of Massachusetts Amherst, [b] INFN Genova

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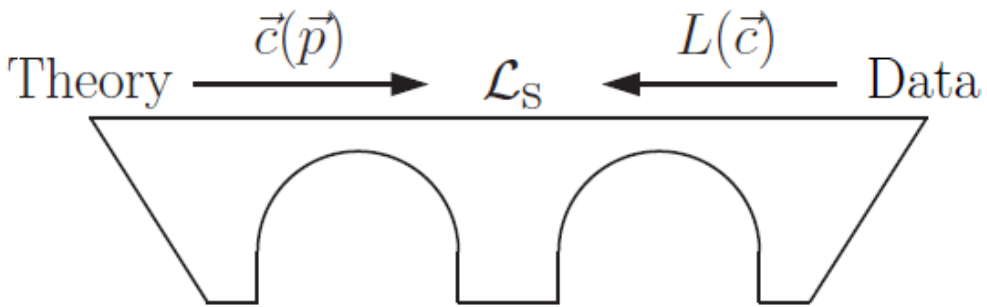
Simplified models

Simplified models provide a model-independent framework for doing collider physics phenomenology:

- Only consider one or two new particles/interactions
- Incredibly useful for direct searches of BSM physics



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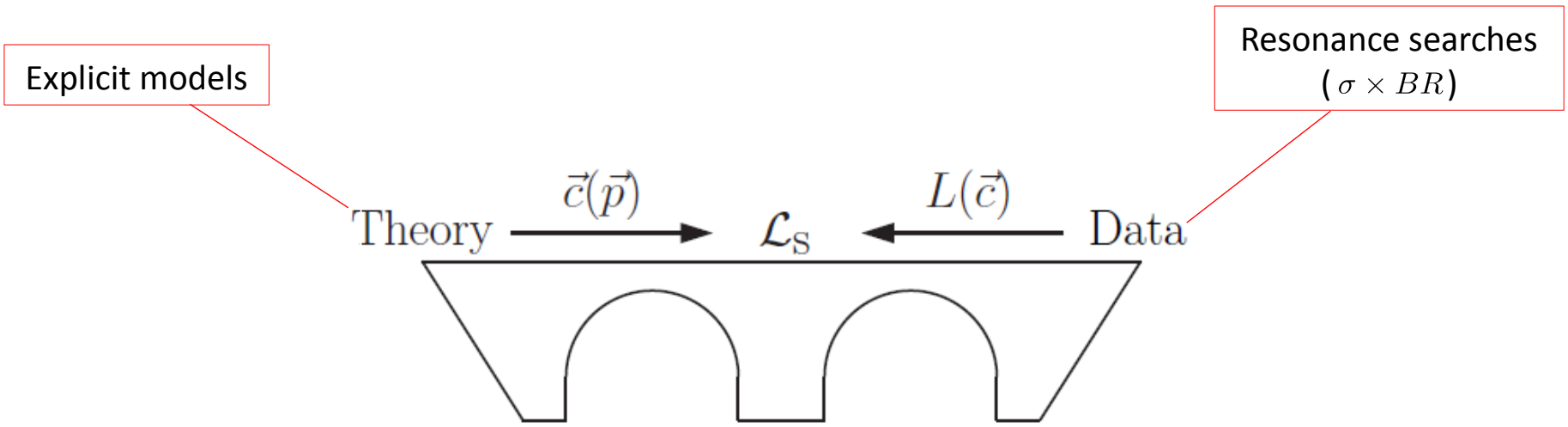

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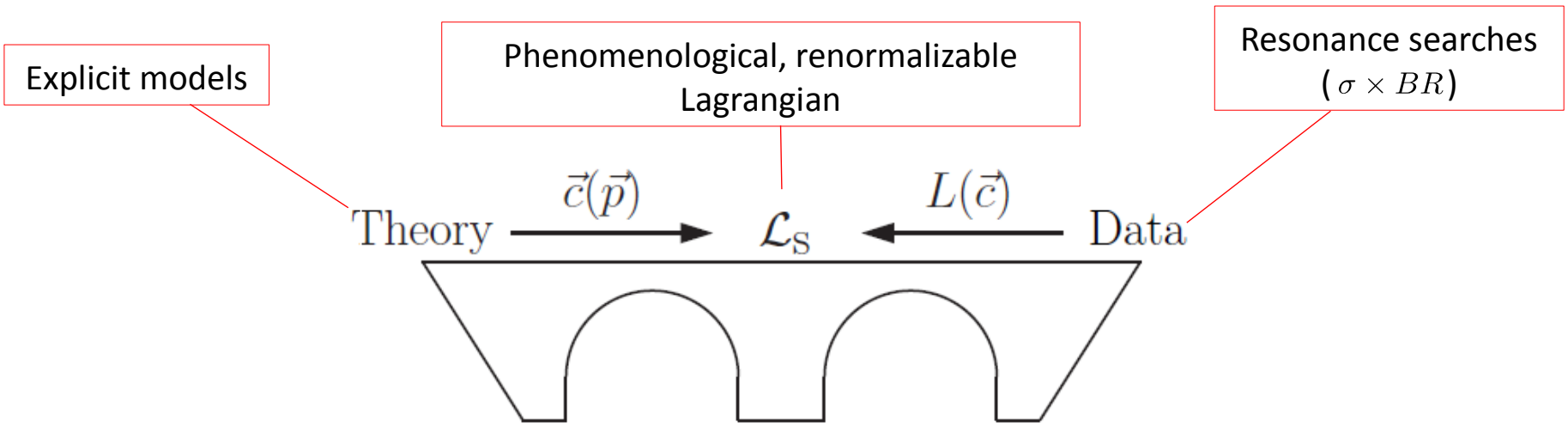

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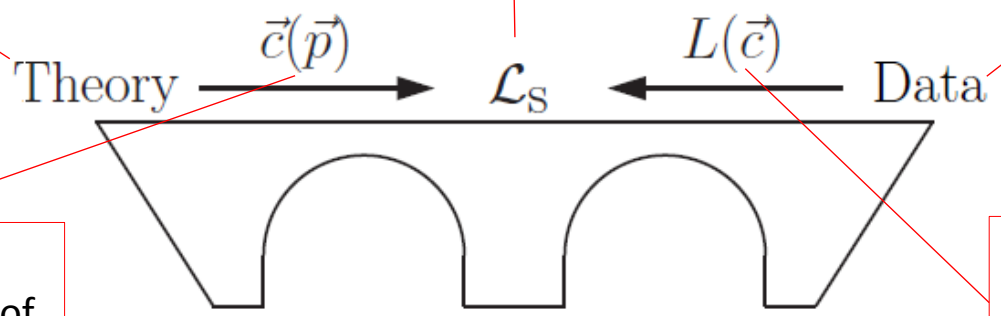
Explicit models

Phenomenological, renormalizable Lagrangian

Resonance searches ($\sigma \times BR$)



Simplified parameters expressible as functions of explicit model parameters

Experimental limits converted into limits on simplified parameters

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Heavy vector singlets

Introduce two new vectors that transform as

$$V^0 \sim (\mathbf{1}, \mathbf{1}, 0) \qquad \mathcal{L}_{V^0} \supset i\frac{g_V}{2} c_H^0 V_\mu^0 H^\dagger \overleftrightarrow{D}^\mu H + \frac{g_V}{2} c_\Psi^0 V_\mu^0 J_\Psi^\mu$$

$$V^\pm \sim (\mathbf{1}, \mathbf{1}, \pm 1) \qquad \mathcal{L}_{V^+} \supset i\frac{g_V}{\sqrt{2}} c_H^+ V_\mu^+ H^\dagger \overleftrightarrow{D}^\mu \tilde{H} + \frac{g_V}{\sqrt{2}} c_q^+ V_\mu^+ J_q^\mu$$

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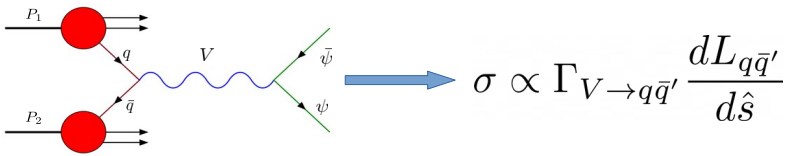
$$\sigma \times BR \propto (g_V c_X)^2 \times (g_V c_Y)^2$$

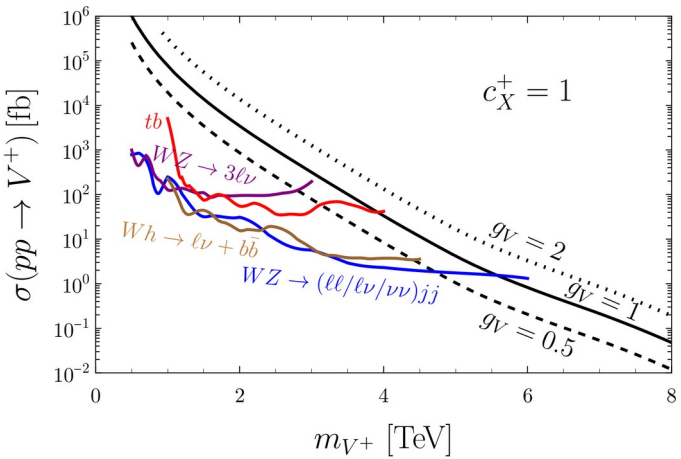
These “simplified” parameters provide a bridge between experiment and UV complete models, with very broad applicability to BSM theories

Current LHC limits vs. FCC-hh

Experimental limits obtained by ATLAS and CMS on the production cross-section, for a given parameter combination:



$$\sigma \propto \Gamma_{V \to q\bar{q}'} \frac{dL_{q\bar{q}'}}{d\hat{s}}$$



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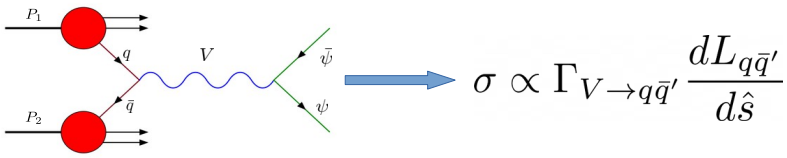

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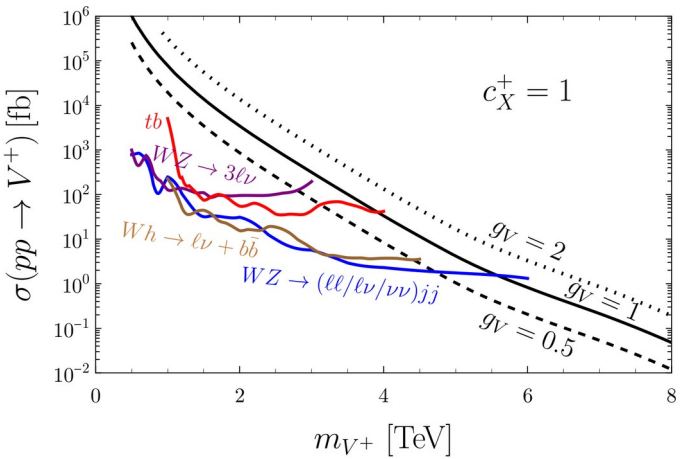

We can extrapolate to future colliders of energy S and luminosity L. Only need to know the parton luminosities at appropriate CoM energy.

A. Thamm, R. Torre, A. Wulzer: 1502.01701

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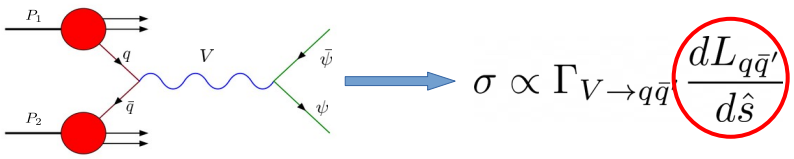

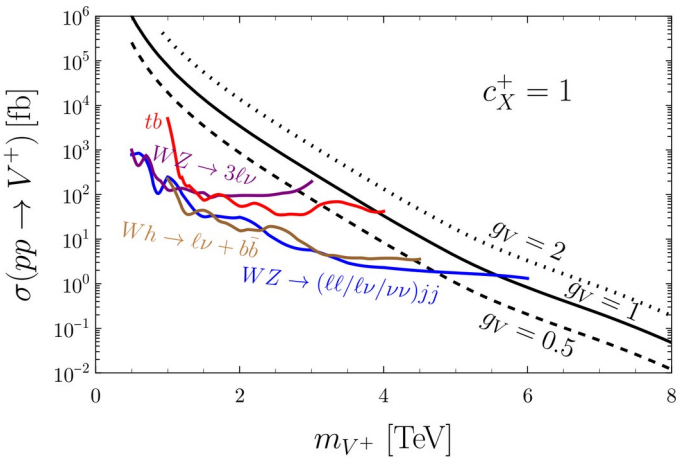

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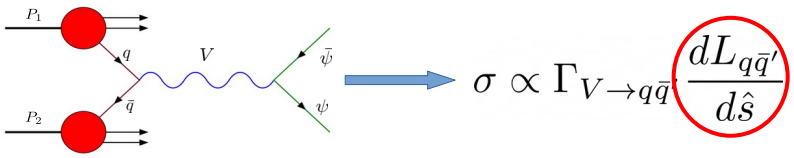

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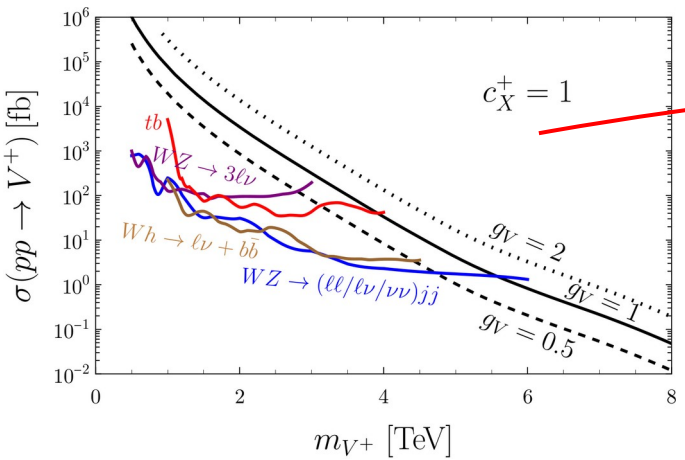

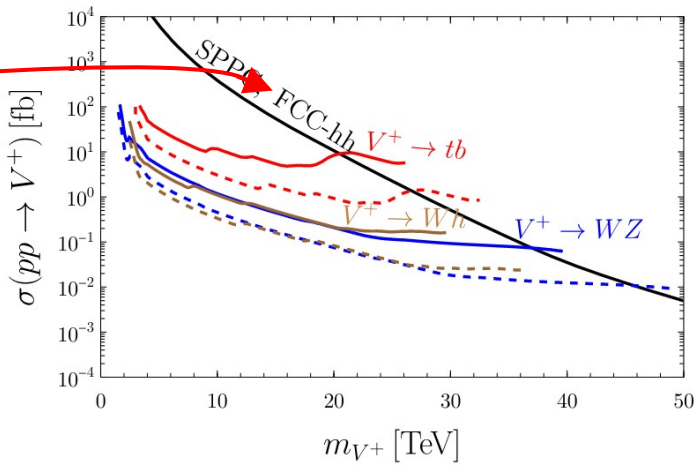

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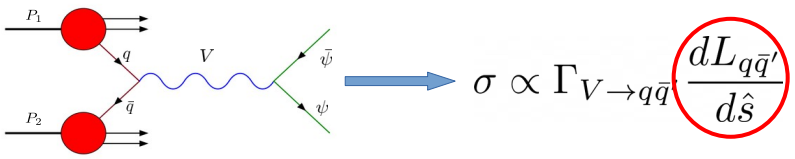

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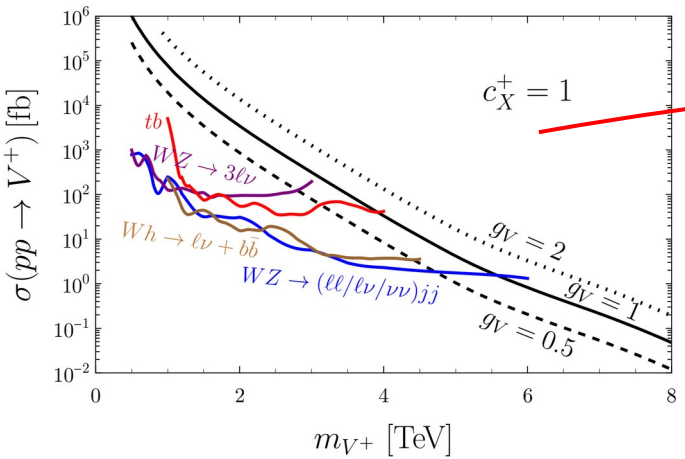
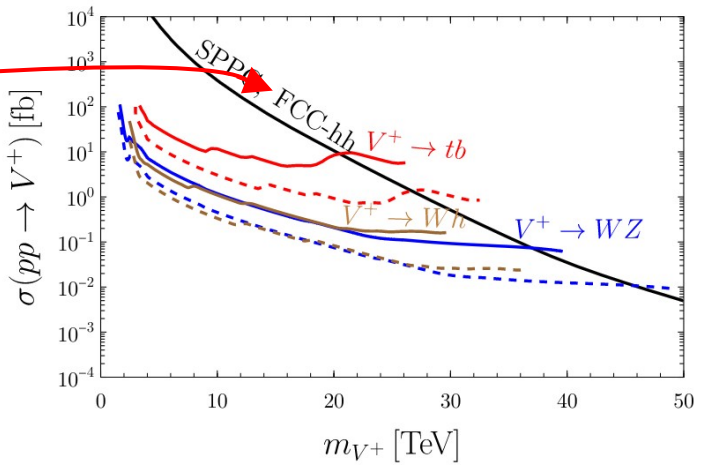


~Order of magnitude higher mass reach than the LHC!



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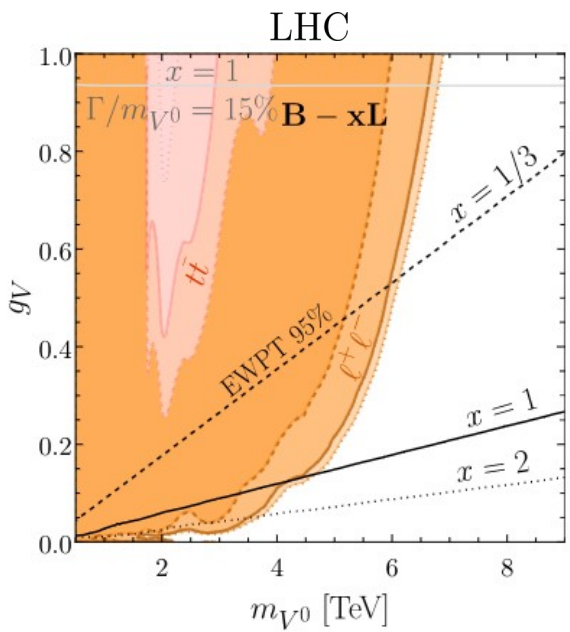

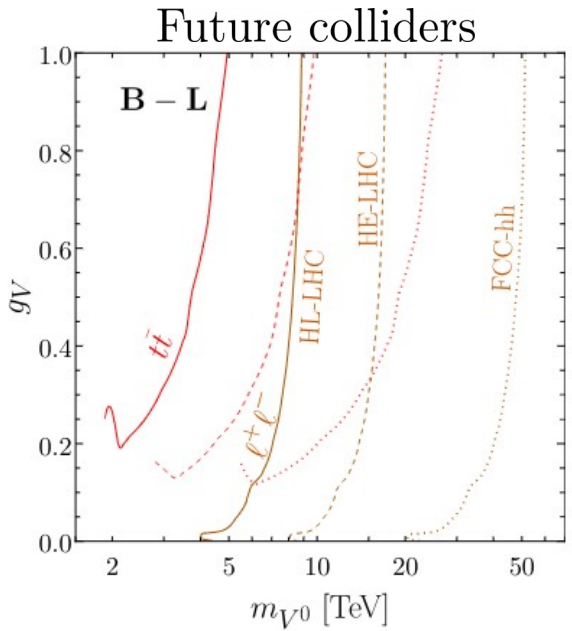

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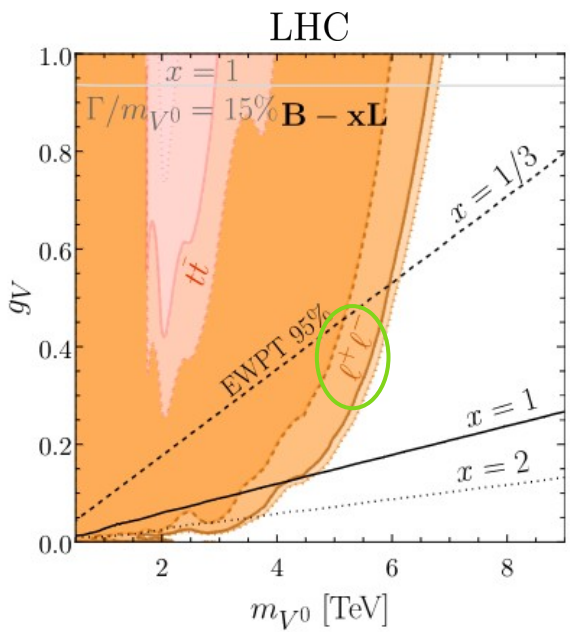

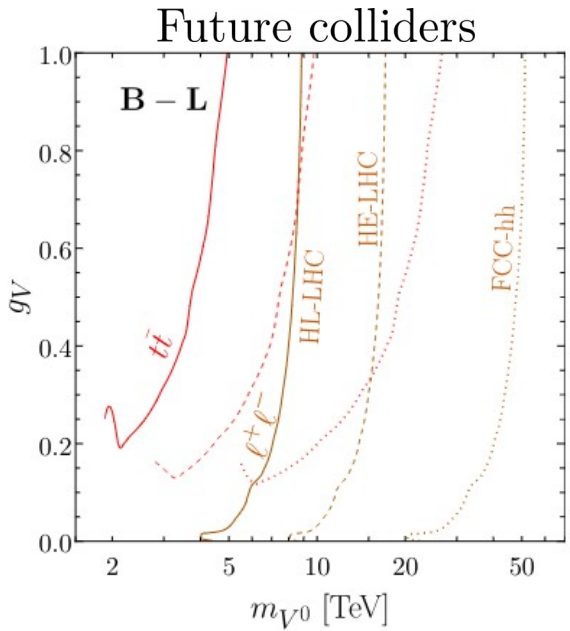

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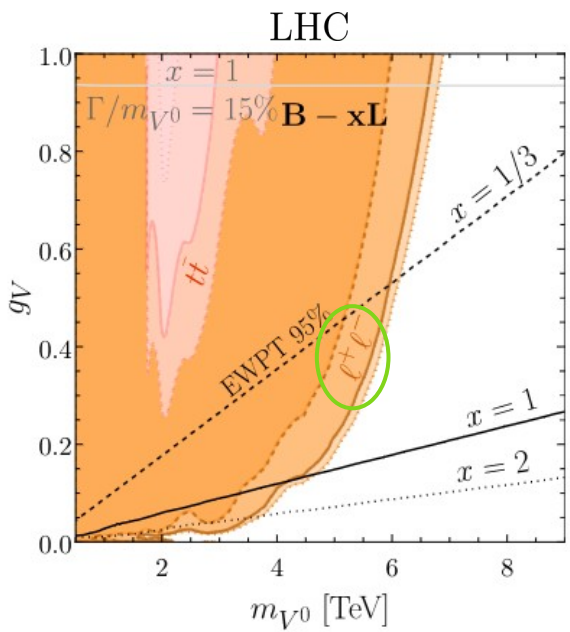

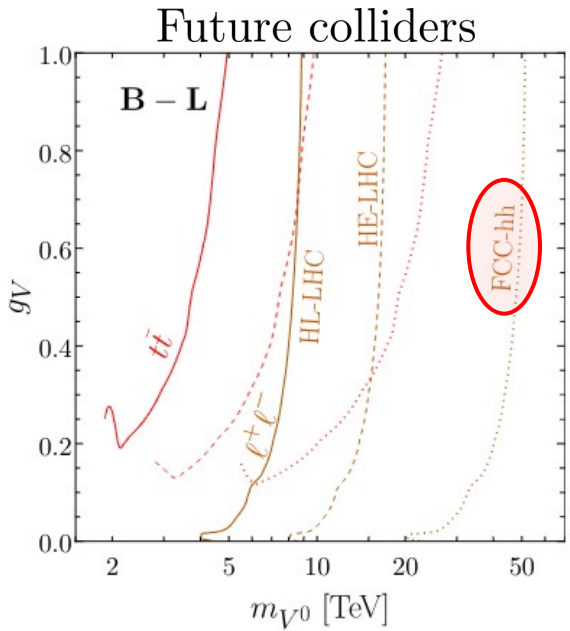

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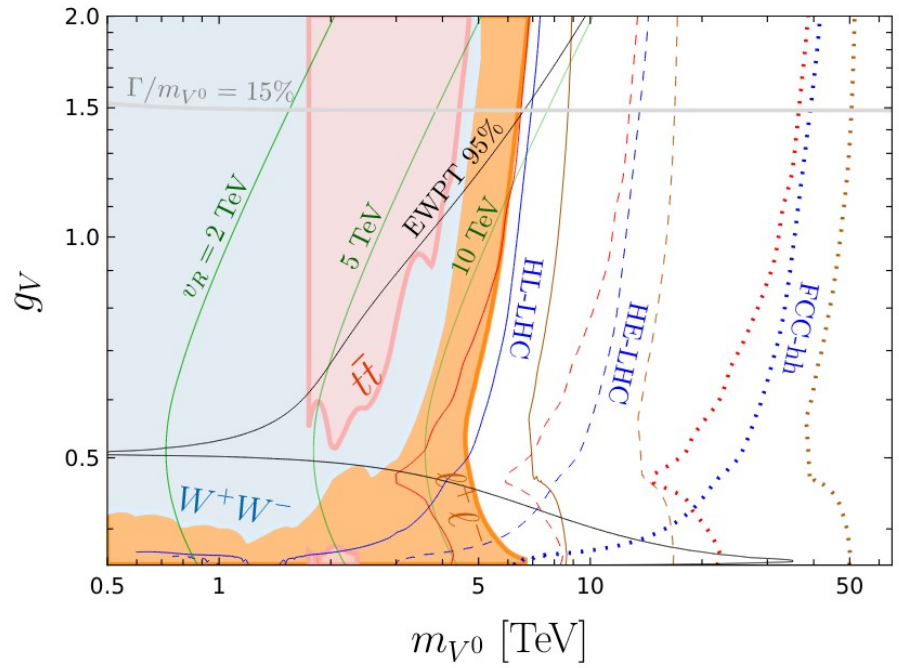

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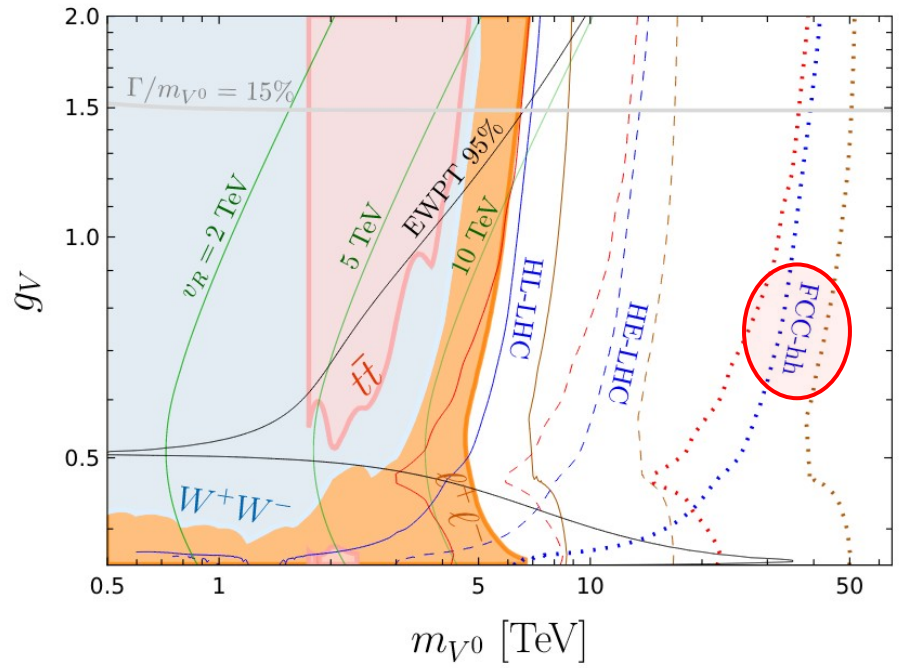

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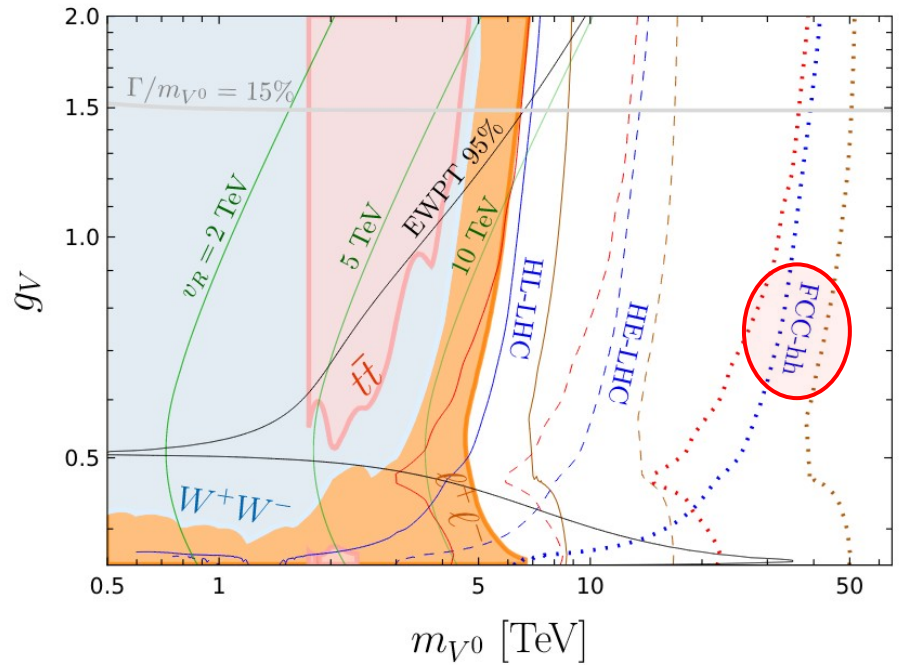

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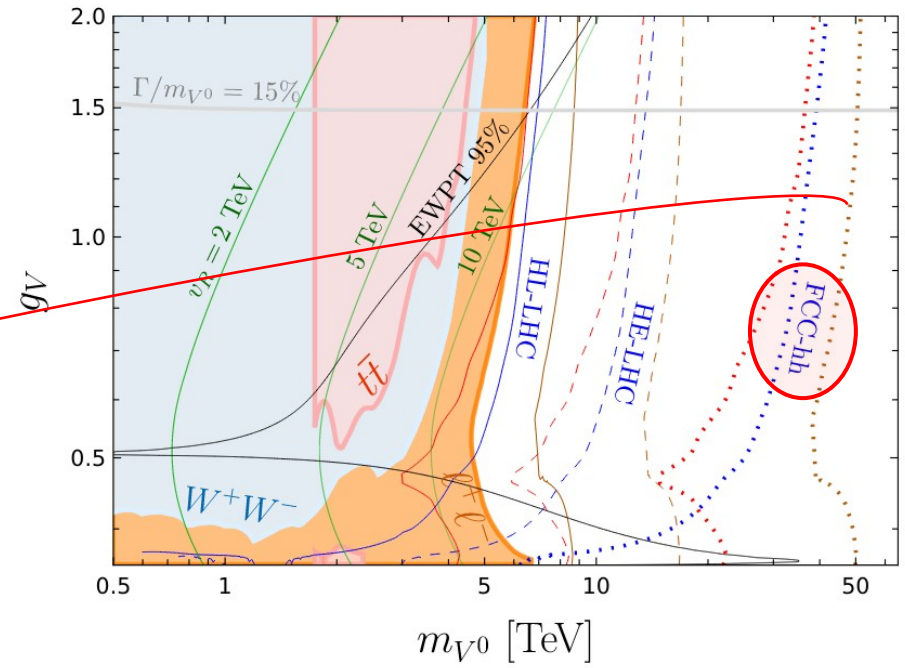

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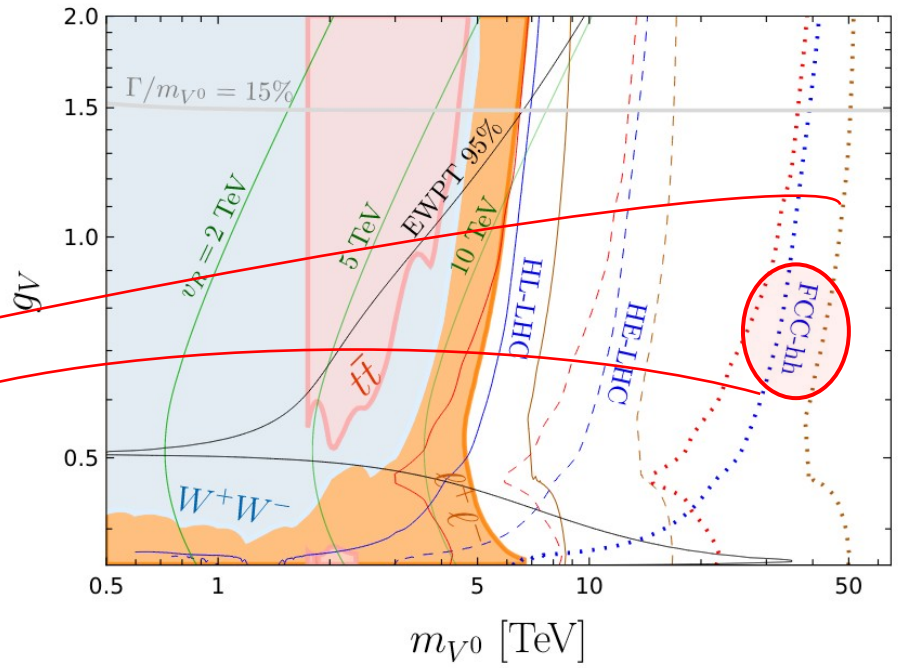

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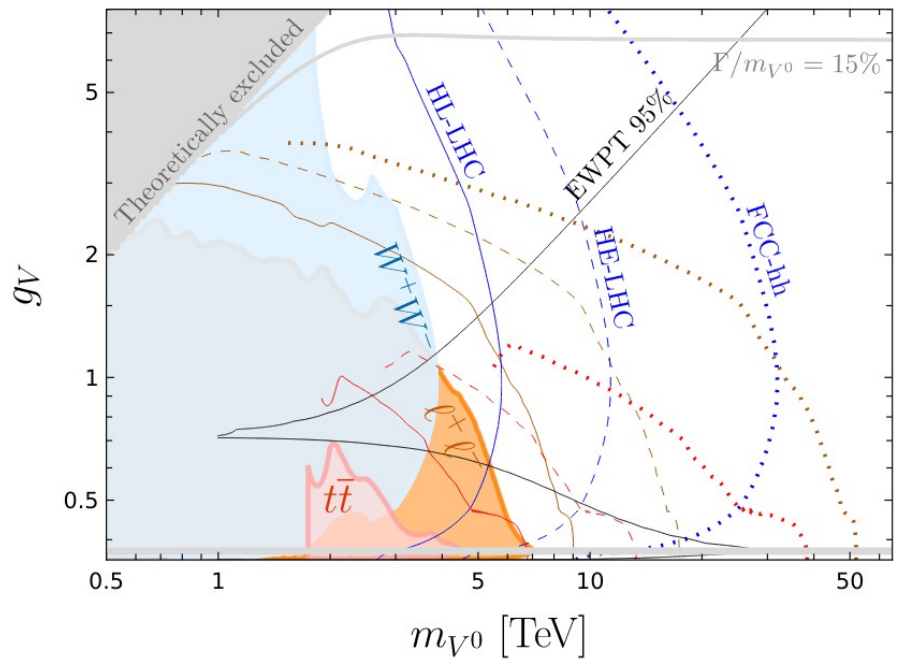

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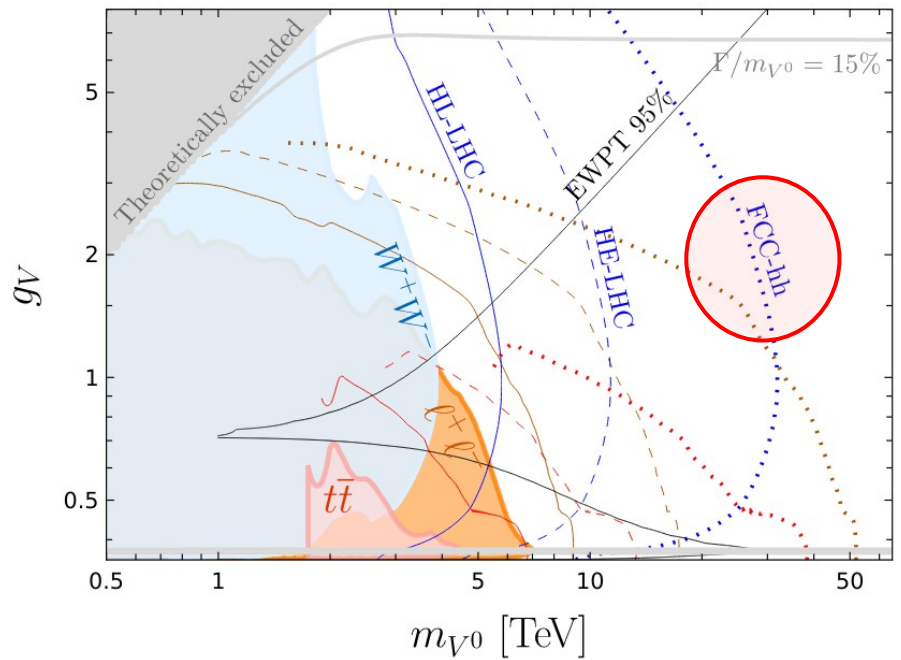
- **FCC-hh**:

  Up to 50 TeV (di-lepton) Up to 30 TeV (di-boson)



Summary

Using this simplified model of heavy vector singlets, we can motivate future efforts at colliders for direct BSM searches.

- Simplified models are an indispensable tool in collider phenomenology, allowing for a quick and easy comparison with many explicit models
- Vector singlets are a common prediction of BSM theories (weakly coupled gauge extensions, composite Higgs)
- We can easily project current limits to future colliders of higher energy/luminosity for a rough sense of their reach

A future 100 TeV proton collider such as the FCC-hh would be a tremendous help to searches for BSM physics