

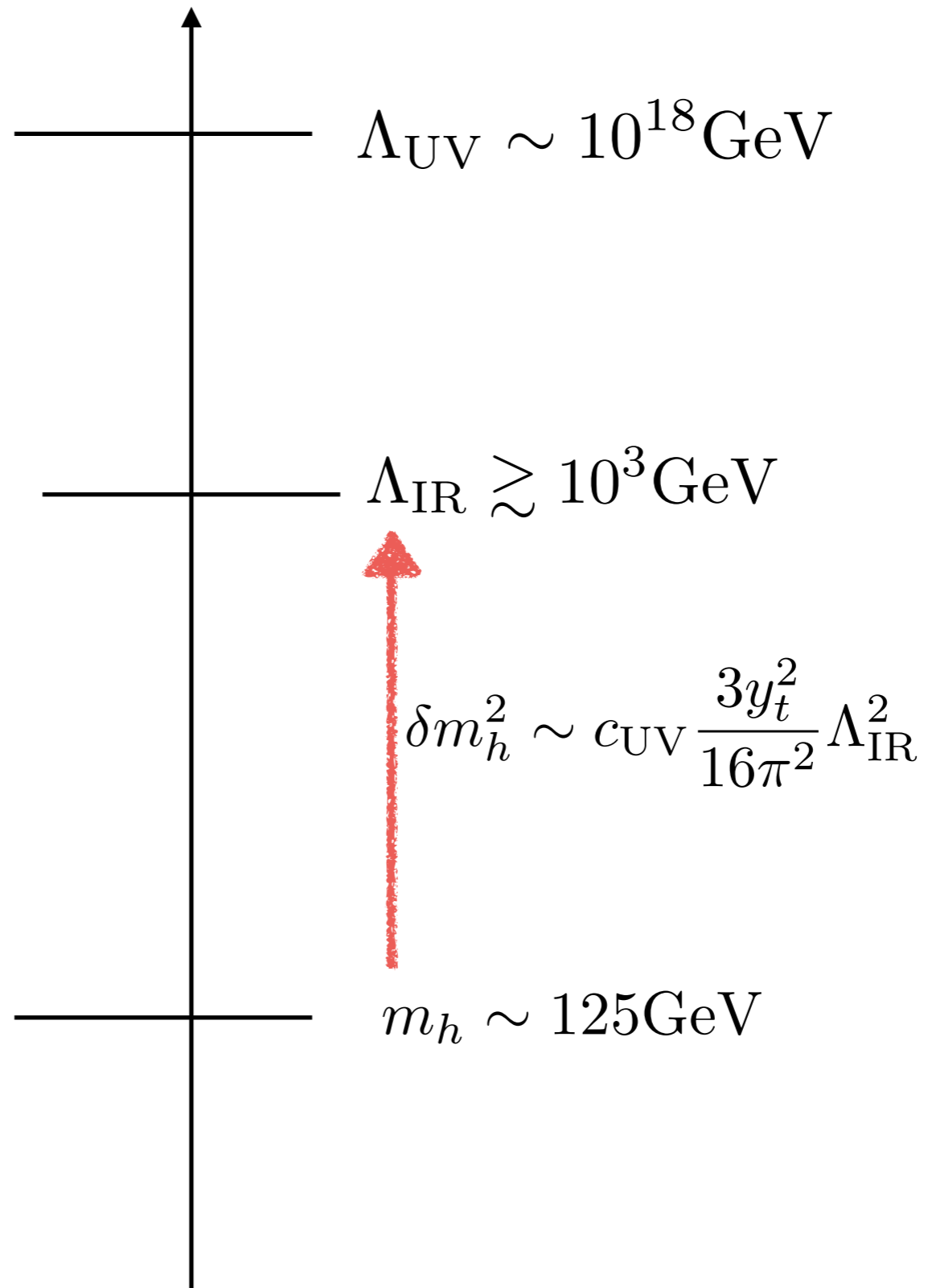
Composite Higgs models at the High Energy Muon Collider

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UC, Davis

Hierarchy problem

Need engineering the UV parameter



Naturalness as Guideline

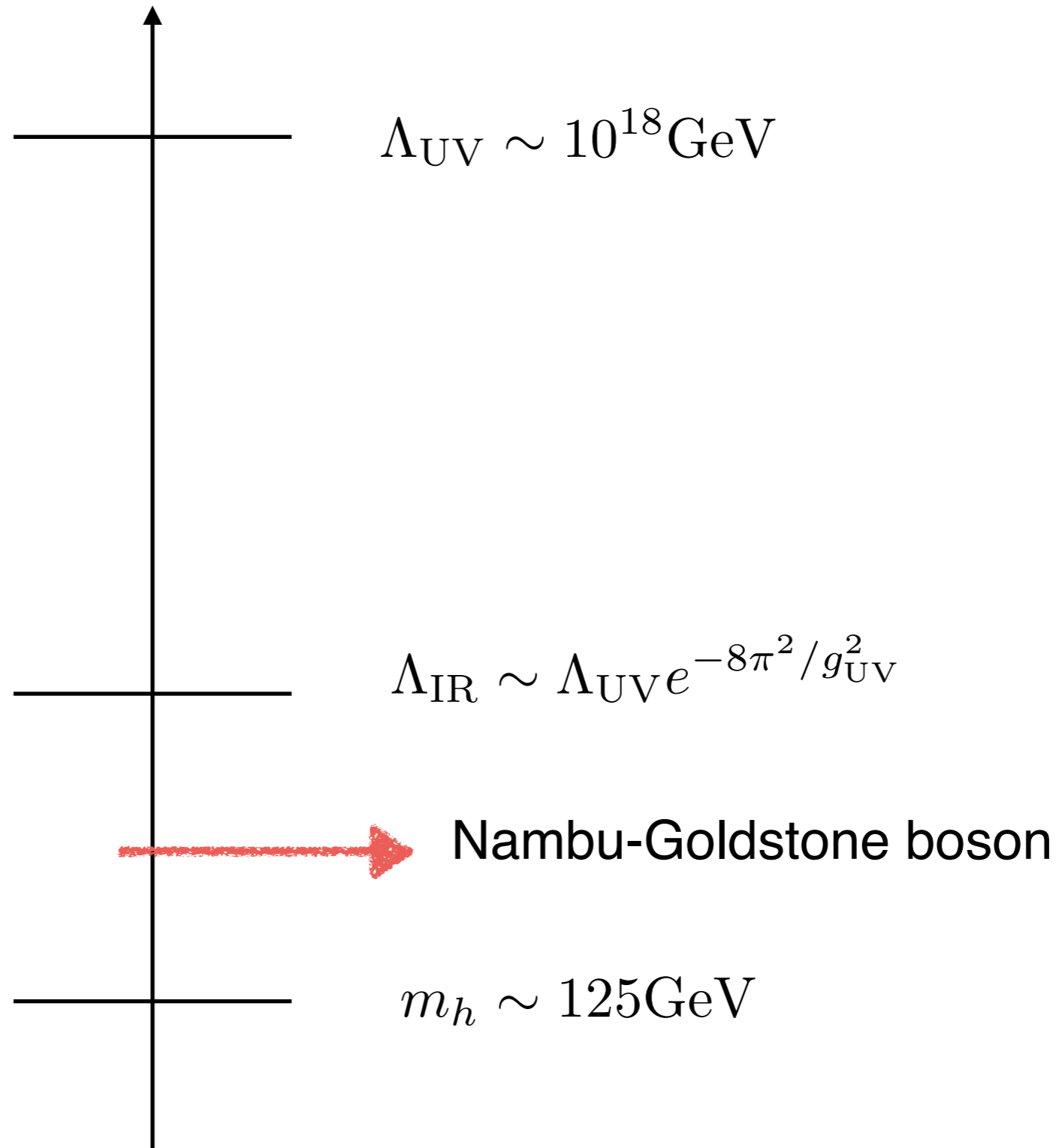
- Compositeness

$$\Lambda_{\text{IR}} \sim \Lambda_{\text{UV}} e^{-8\pi^2/g_{\text{UV}}^2} \longrightarrow \text{Dimensional Transmutation}$$

- Supersymmetry

$$Q|\phi\rangle = |\psi\rangle \longrightarrow \text{Enhanced chiral symmetry}$$

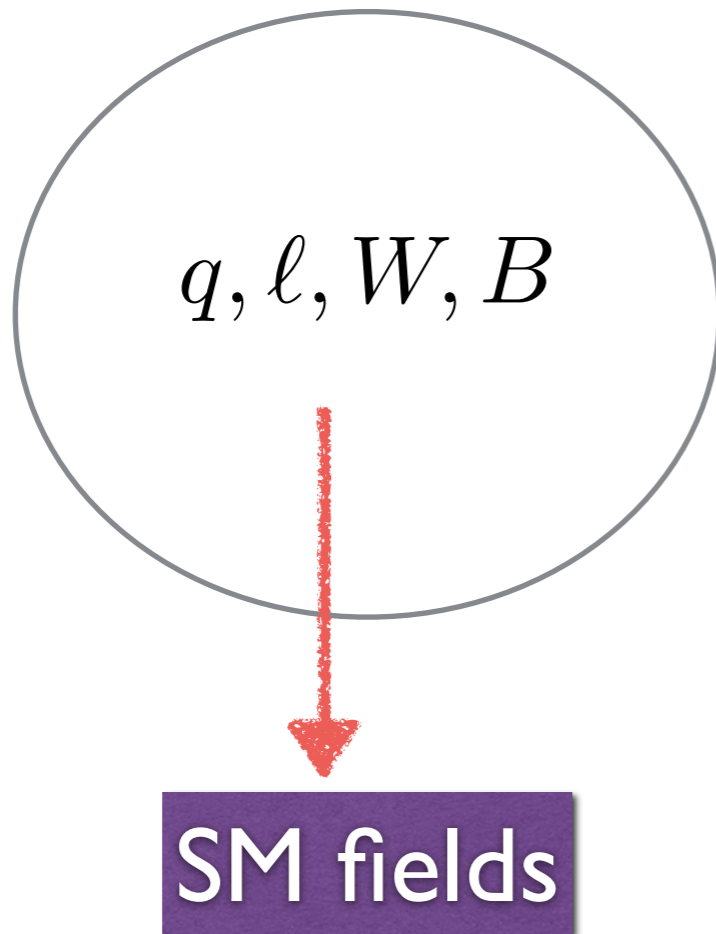
Compositeness



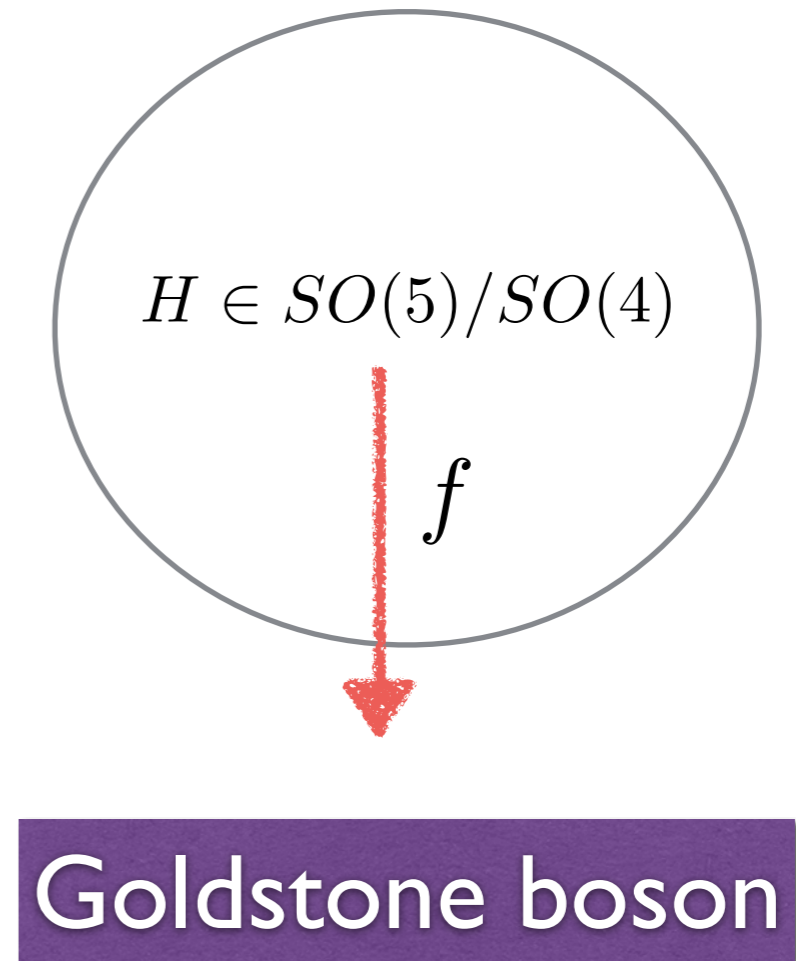
Enhanced shift symmetry!

Composite Higgs models: Assumption I

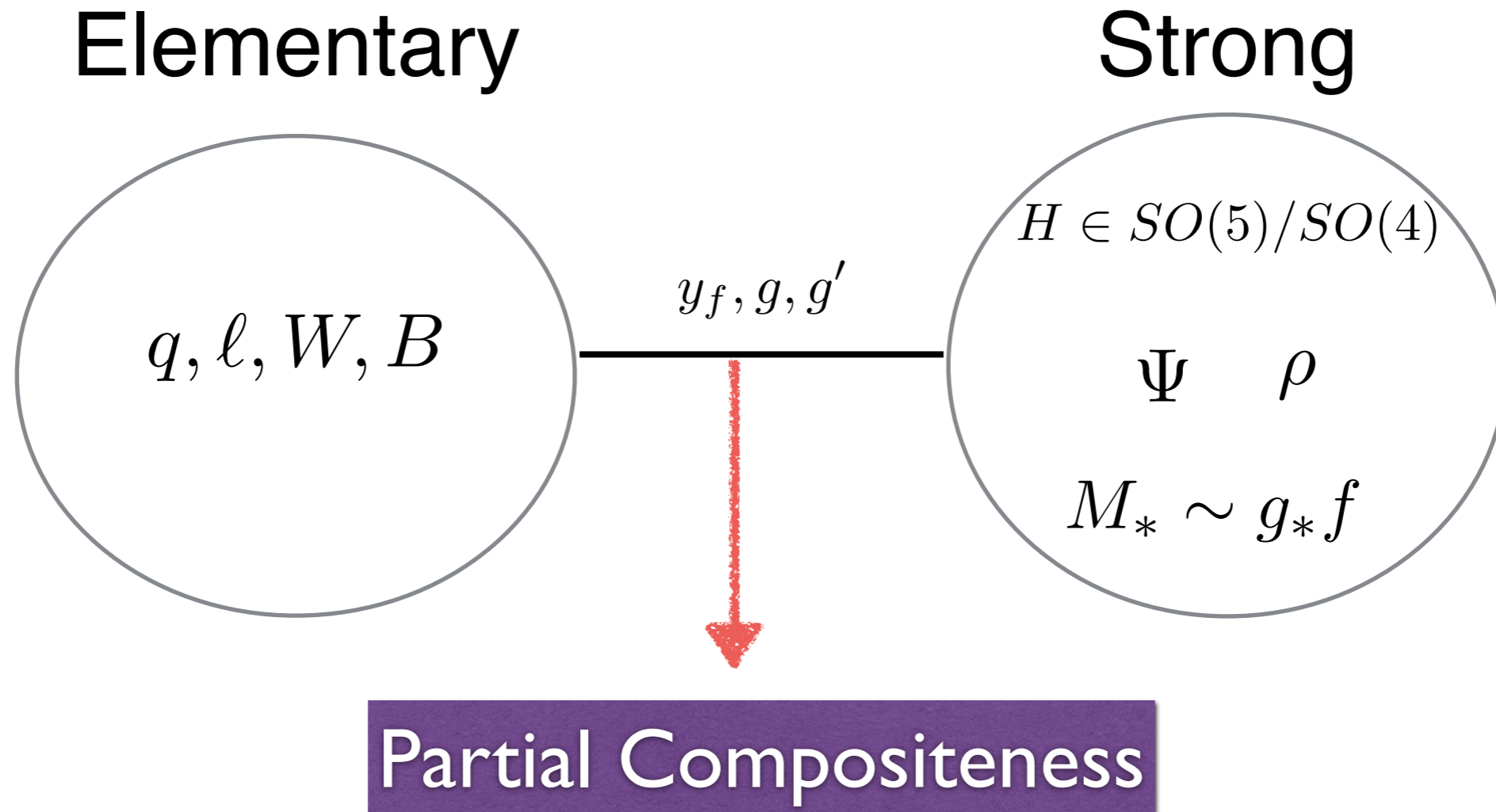
Elementary



Strong



Composite Higgs models: Assumption II



Partial compositeness: CFT

$$y_L \bar{q}_L^{I_L} \mathcal{O}_{I_L} + y_R \bar{q}_R^{I_R} \mathcal{O}_{I_R}$$

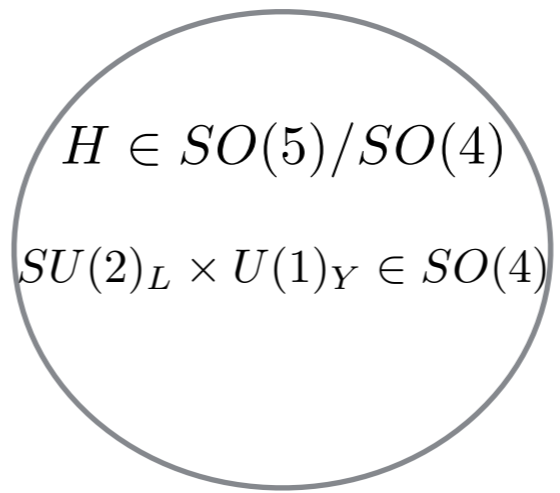
$$d_{\mathcal{O}} = \frac{3}{2} + |c + \frac{1}{2}|$$

$$y_{L,R}^{\text{IR}} \sim y_{L,R}^{\text{UV}} \left(\frac{\Lambda_{\text{IR}}}{\Lambda_{\text{UV}}} \right)^{d_{\mathcal{O}_{L,R}} - \frac{5}{2}}$$

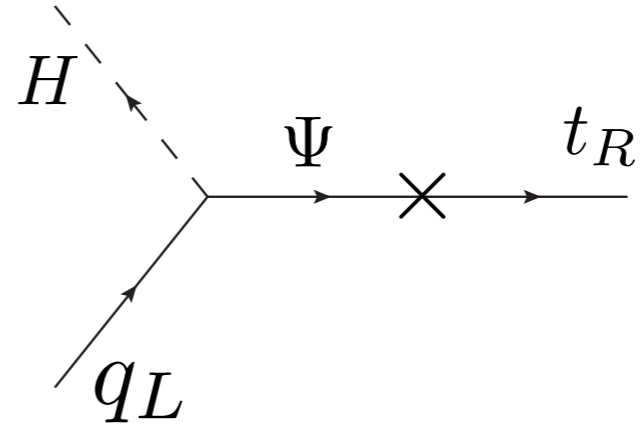
Scale Hierarchy turn to coupling hierarch

Partial compositeness: top quark mass

$$y_L \bar{q}_L^{I_L} \mathcal{O}_{I_L} + y_R \bar{t}_R^{I_R} \mathcal{O}_{I_R}$$



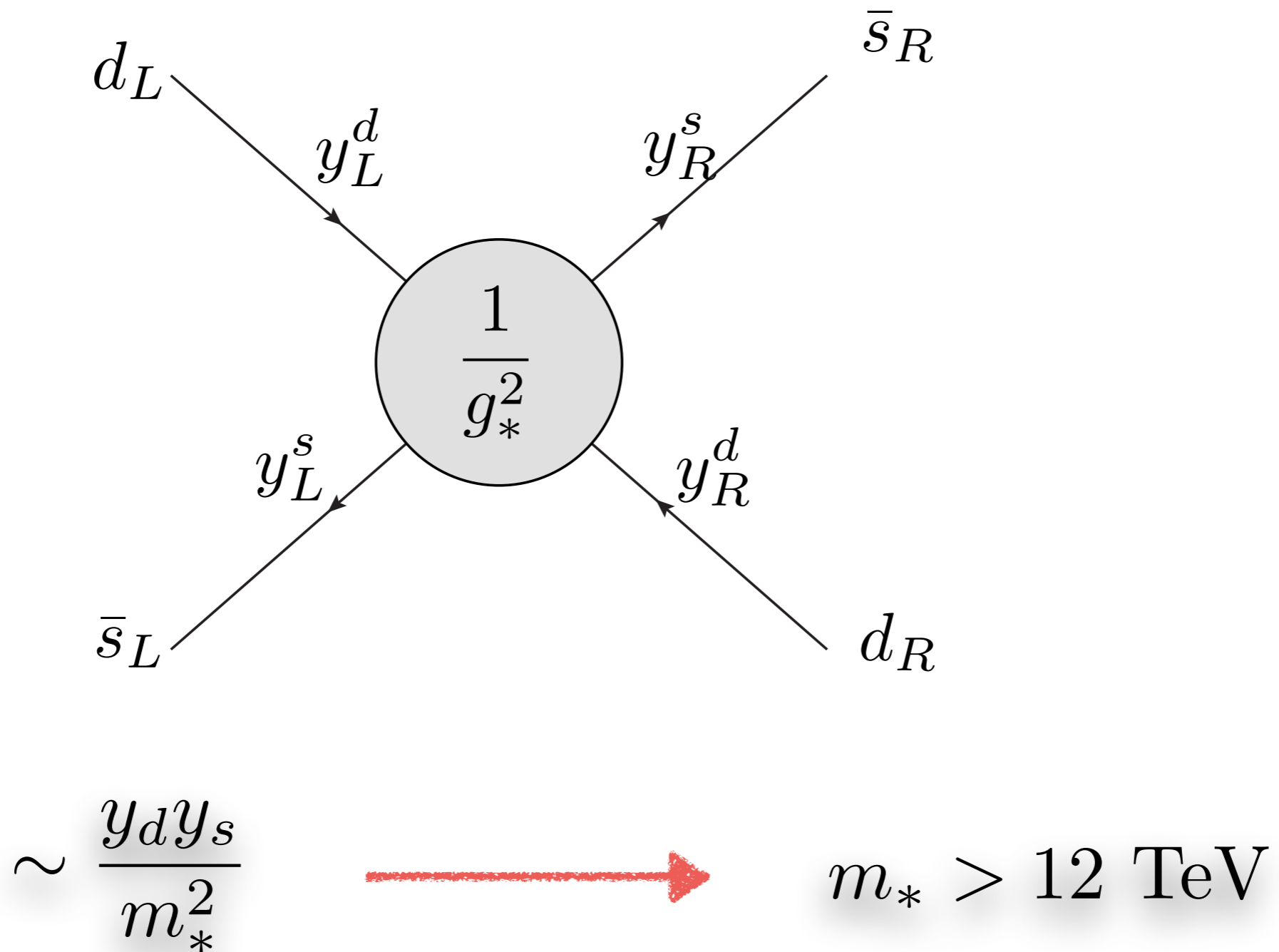
$$y_L \bar{q}_L H \Psi_R + y_R f \bar{t}_R \Psi_L$$



$$\frac{y_L y_R f}{M_\Psi} \bar{q}_L \tilde{H} t_R$$

$$y_t \sim \frac{y_L y_R}{g_*}$$

Partial compositeness: Flavor



Targets at the Muon Collider

- Probe the on-shell resonances up to kinematical limits
- Measure the couplings as precise as possible

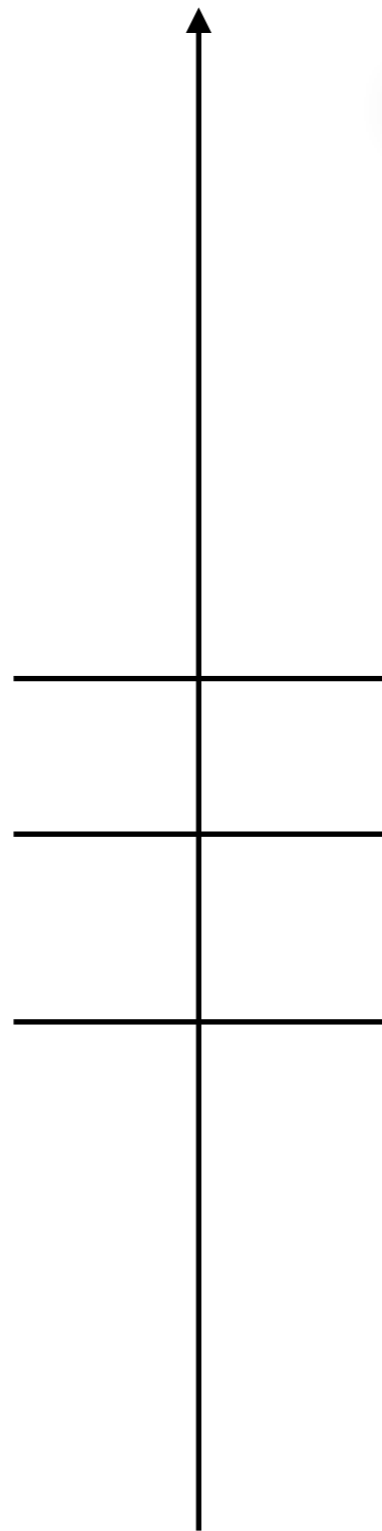
Direct Resonance searches

$$\rho_L = (3, 1)$$

$$Q_X = \left(\begin{array}{c} X_{5/3} \\ X_{2/3} \end{array} \right)_{\frac{7}{6}}$$

$$Q = \left(\begin{array}{c} T \\ B \end{array} \right)_{\frac{1}{6}}$$

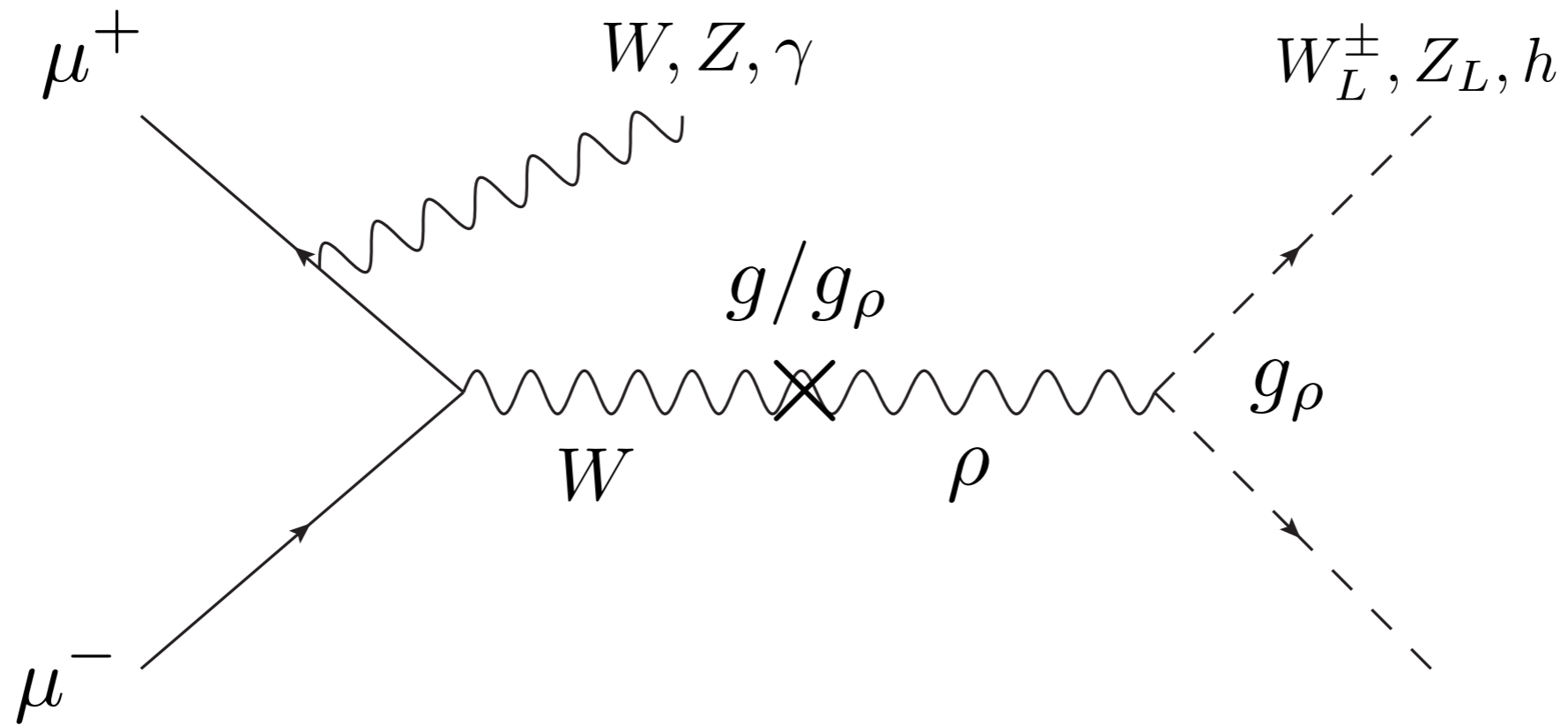
$$m_\rho = a_\rho g_\rho f$$



$$M_T = \sqrt{M_\Psi^2 + y_L^2 f^2}$$

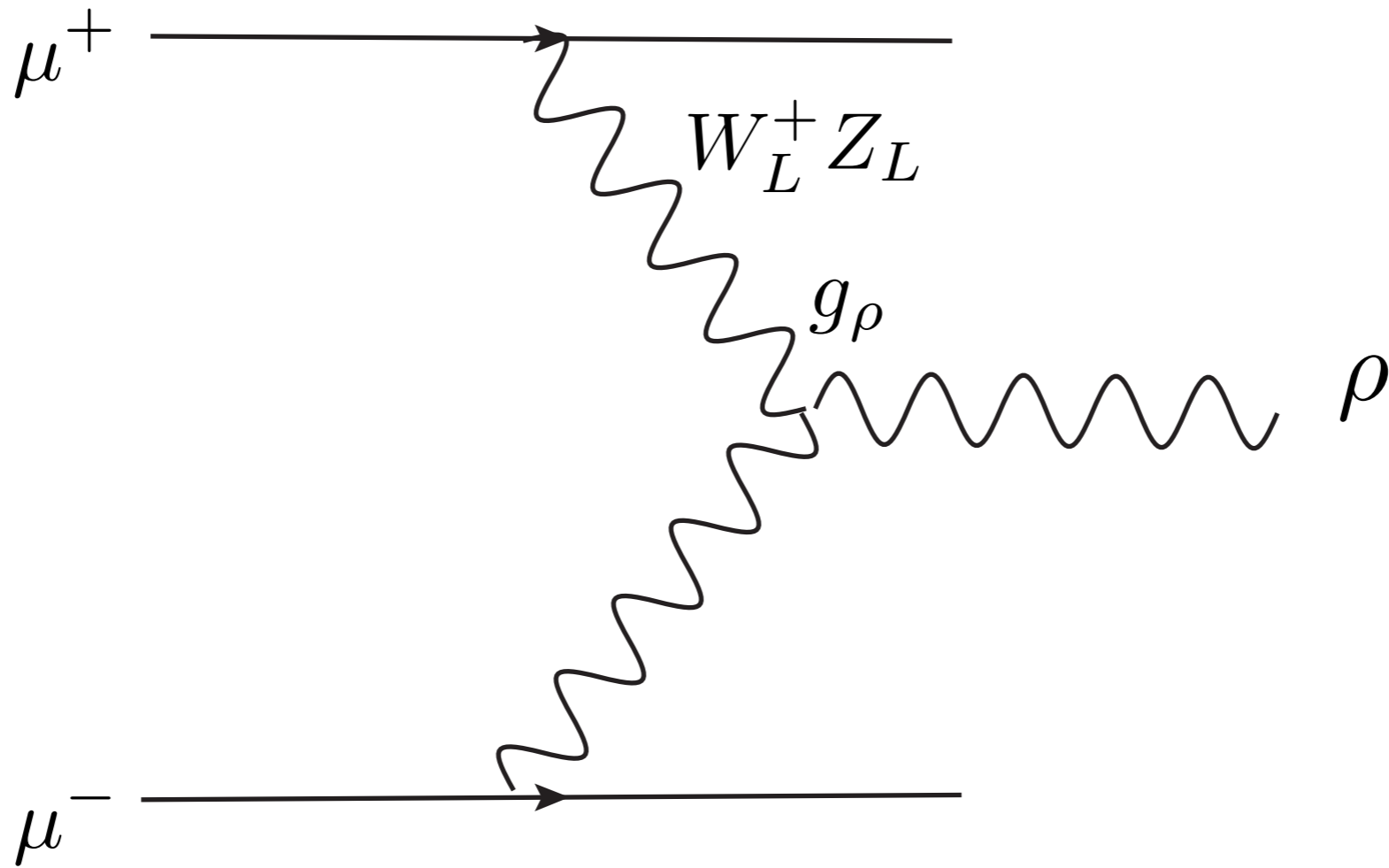
$$M_{X_{5/3}} = M_\Psi$$

Spin-1 resonances: DY-like

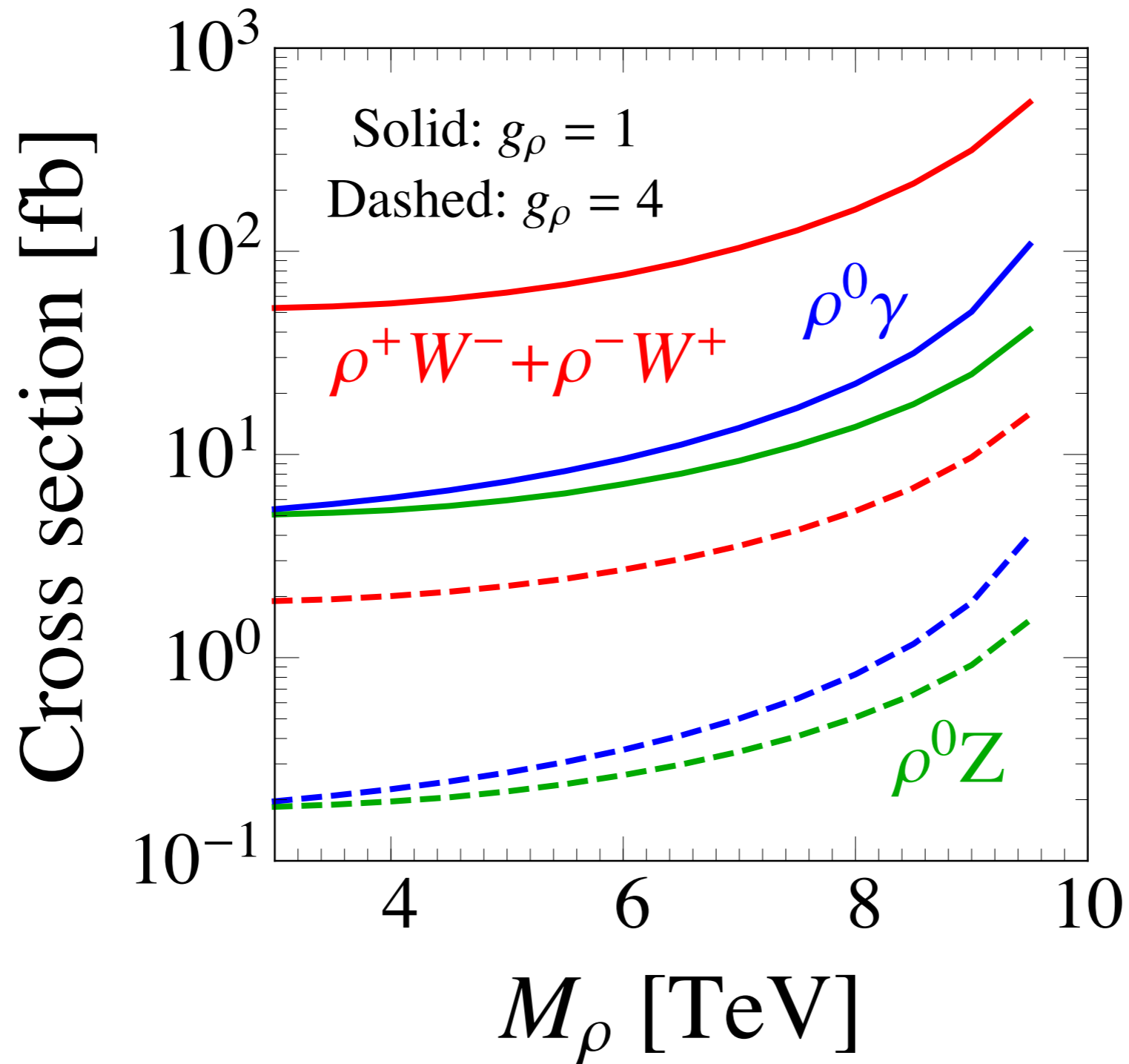


DL, L.T.Wang and K. P. Xie
Working in progress

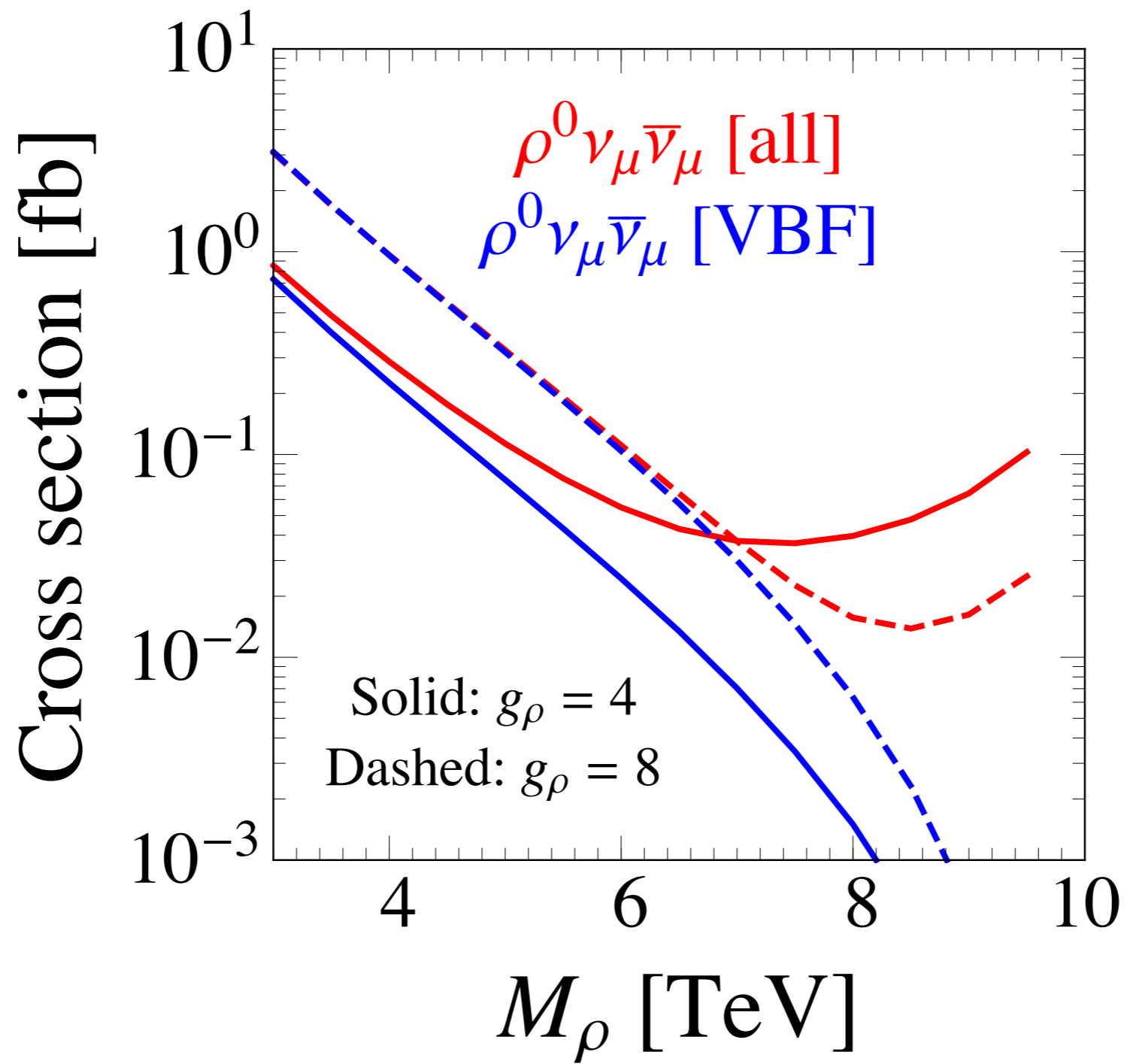
Spin-1 resonances: VBF



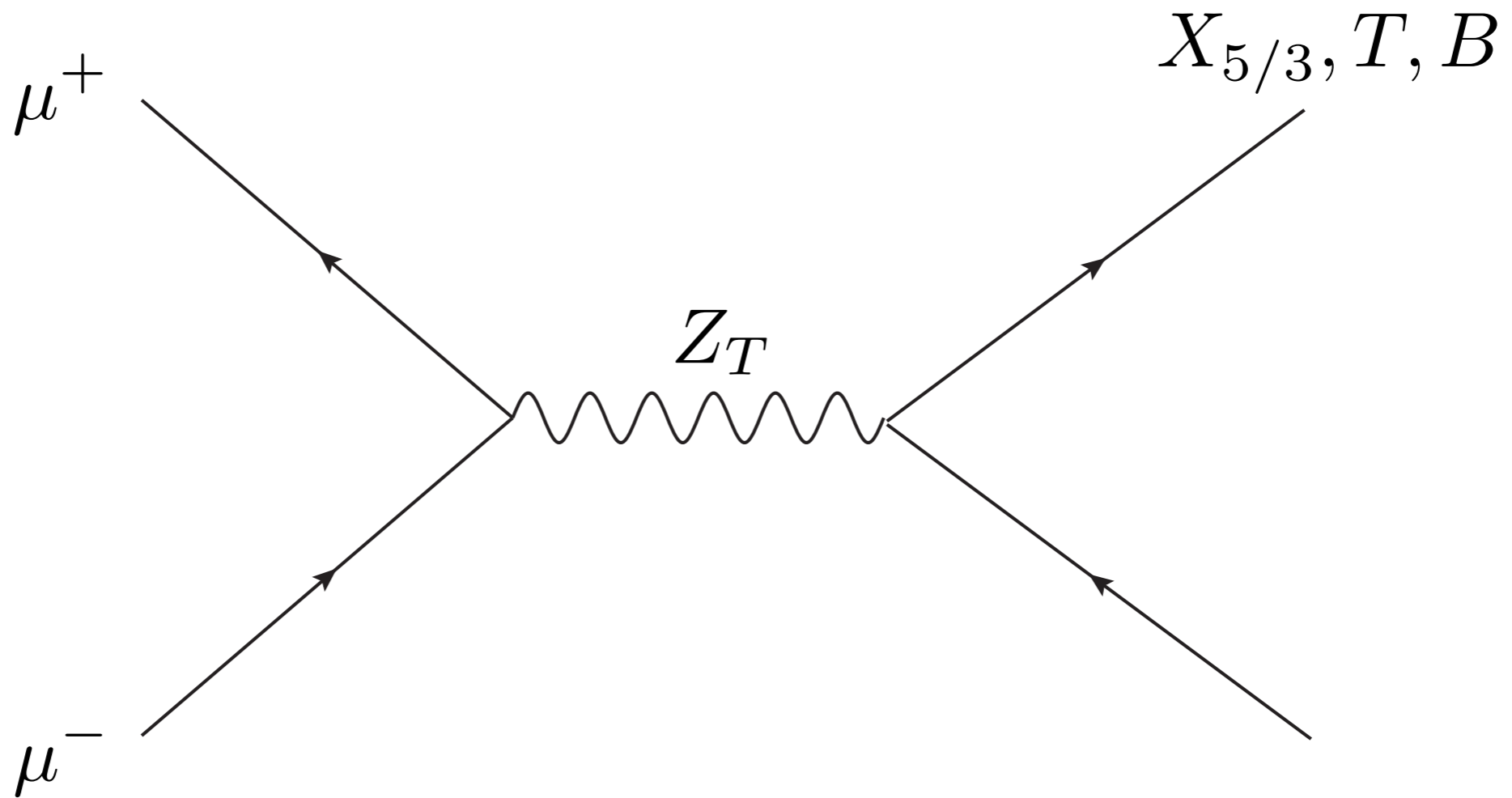
Spin-1 resonances: XS



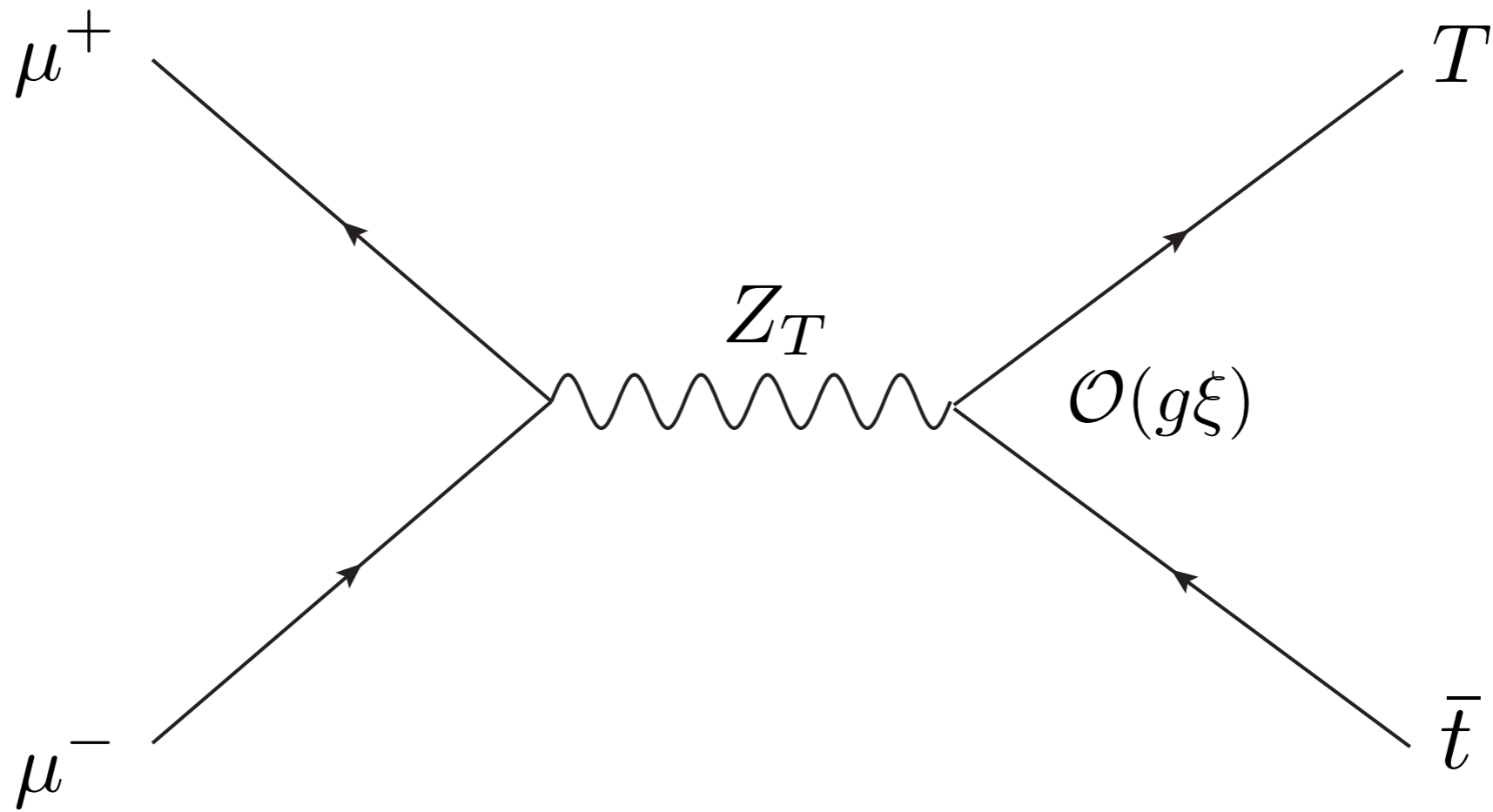
Spin-1 resonances: VBF



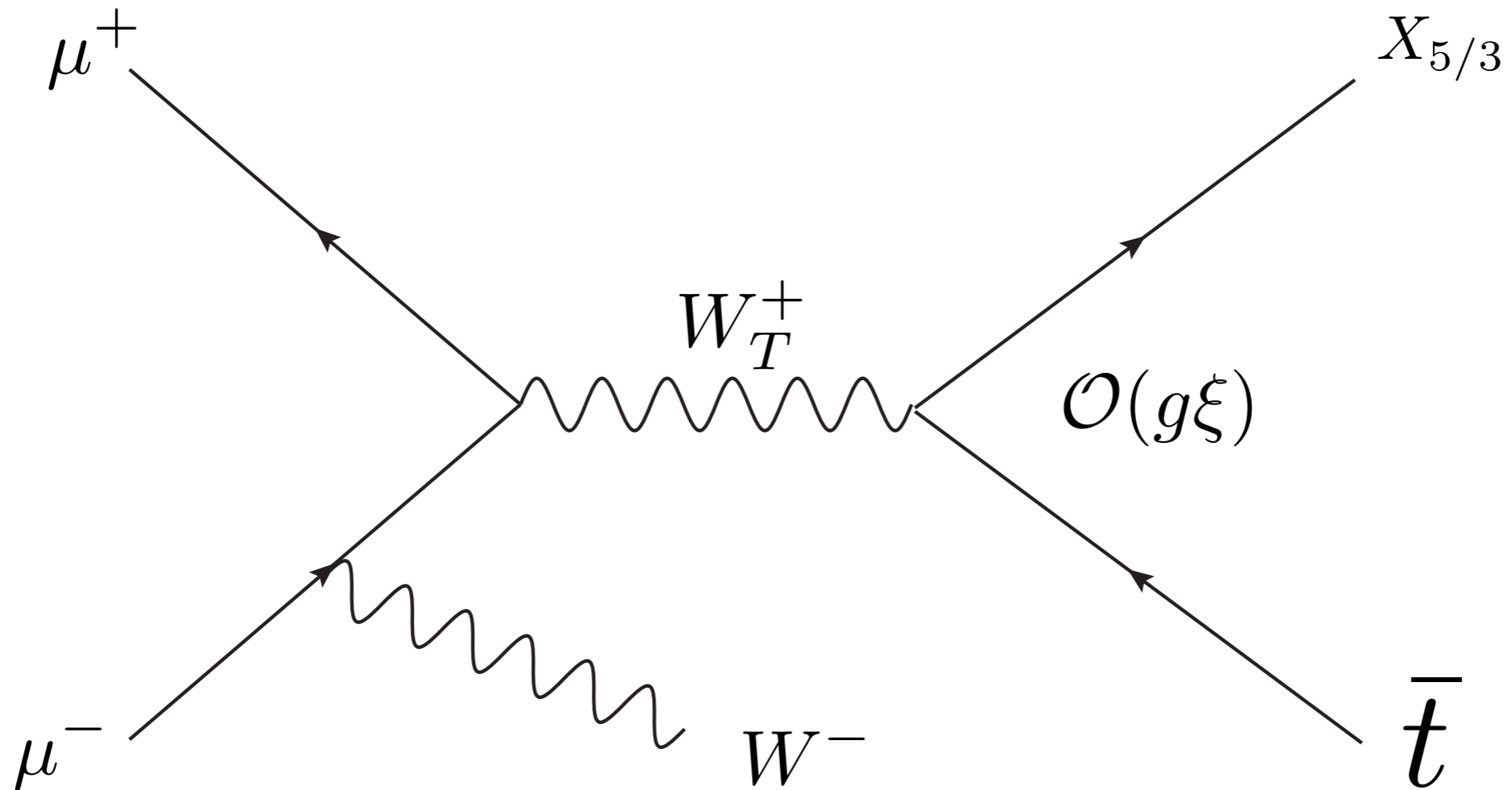
Top partners: DY Pair



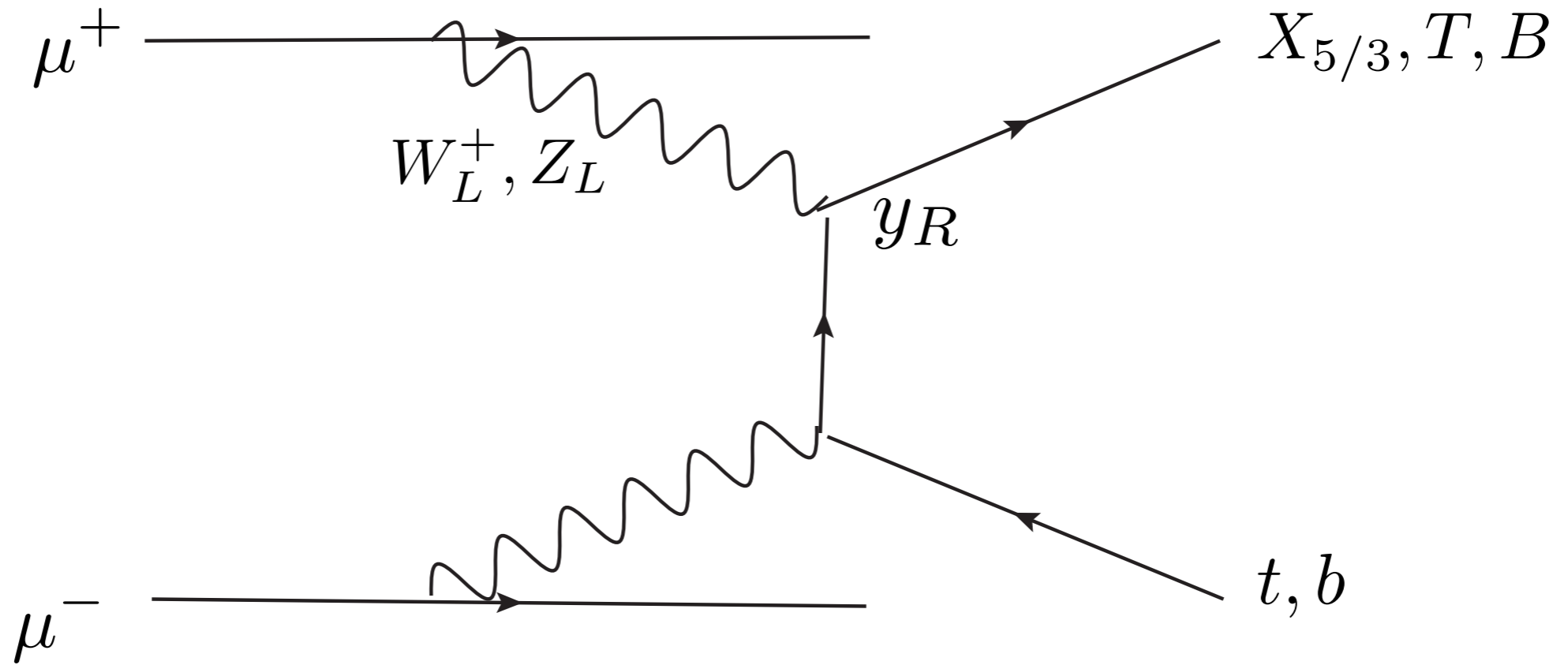
Top partners: DY Single



Top partners: DY-like Single

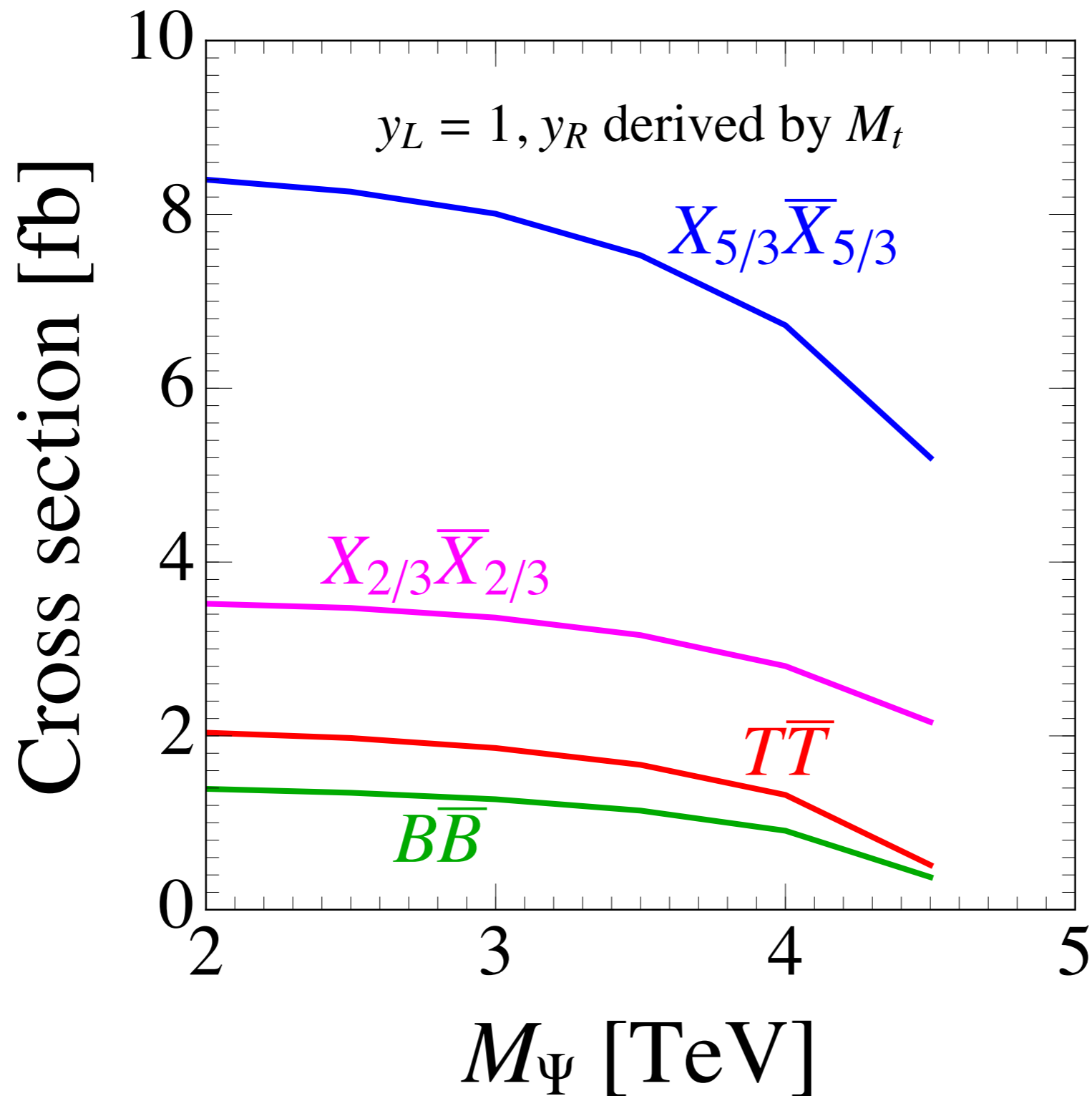


Top partners: VBF



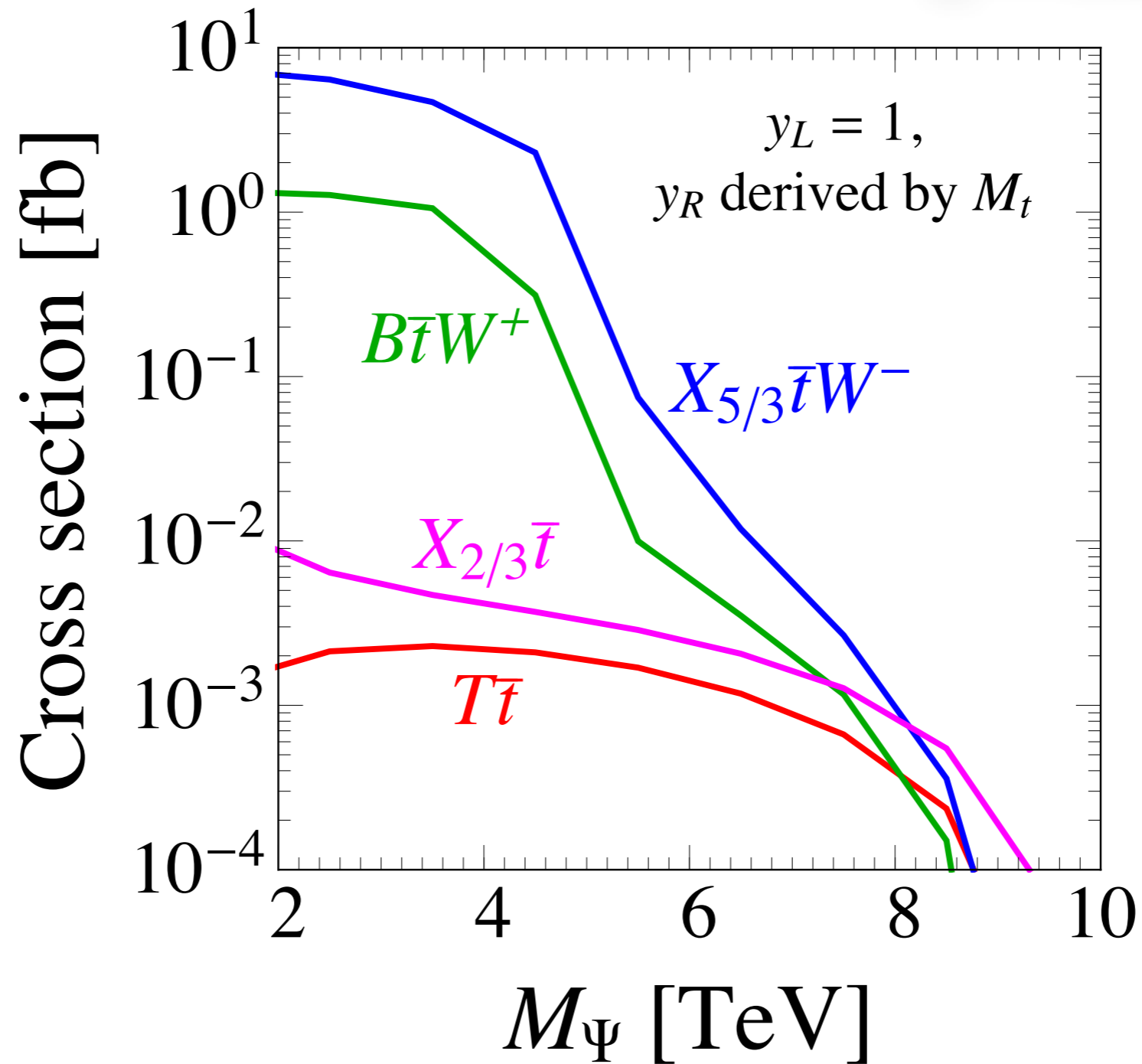
Relevant for large y_R

Top partners: Pair production XS



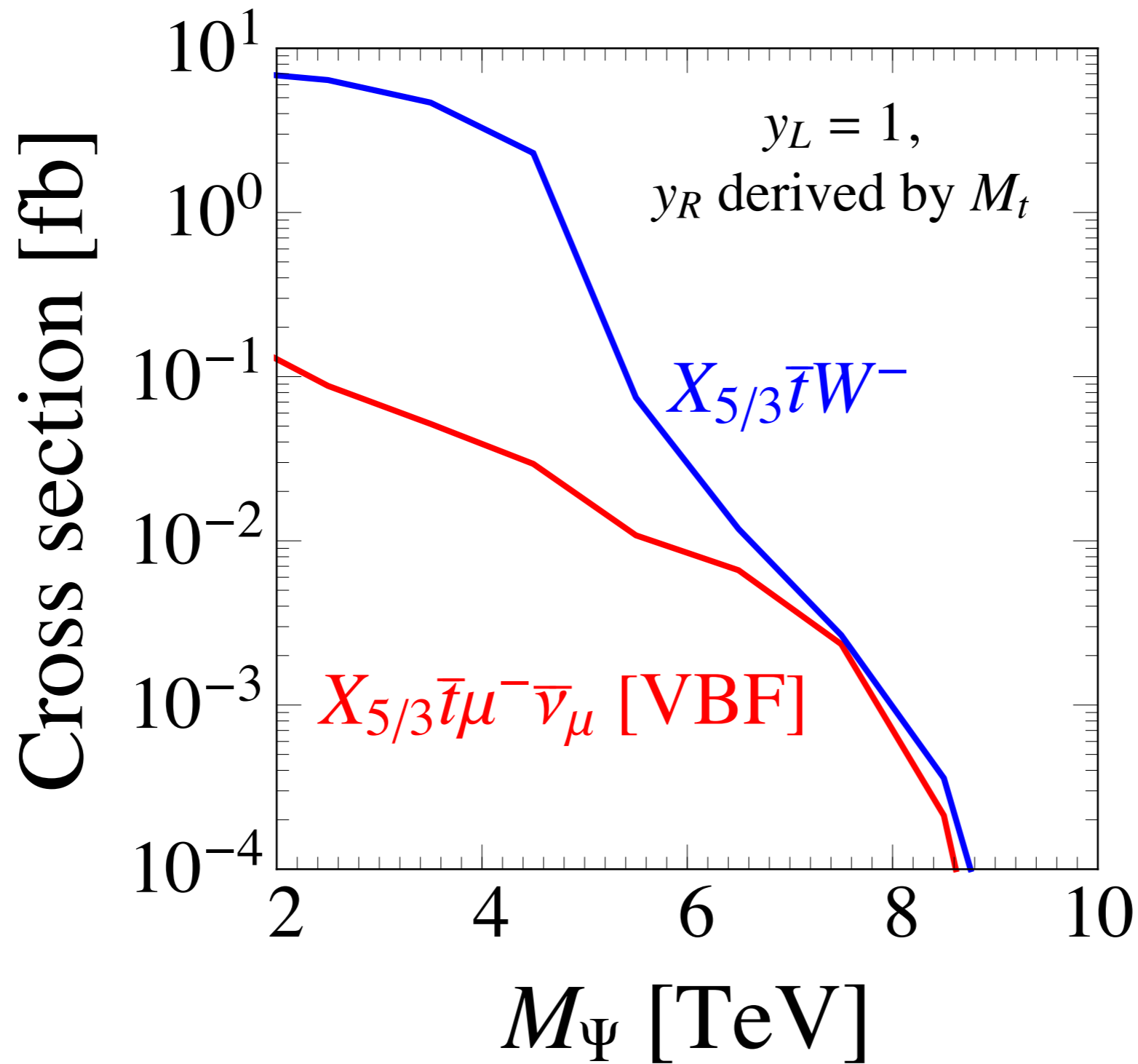
Top partners: XS

$$\xi = 0.015, f = 2 \text{ TeV}$$



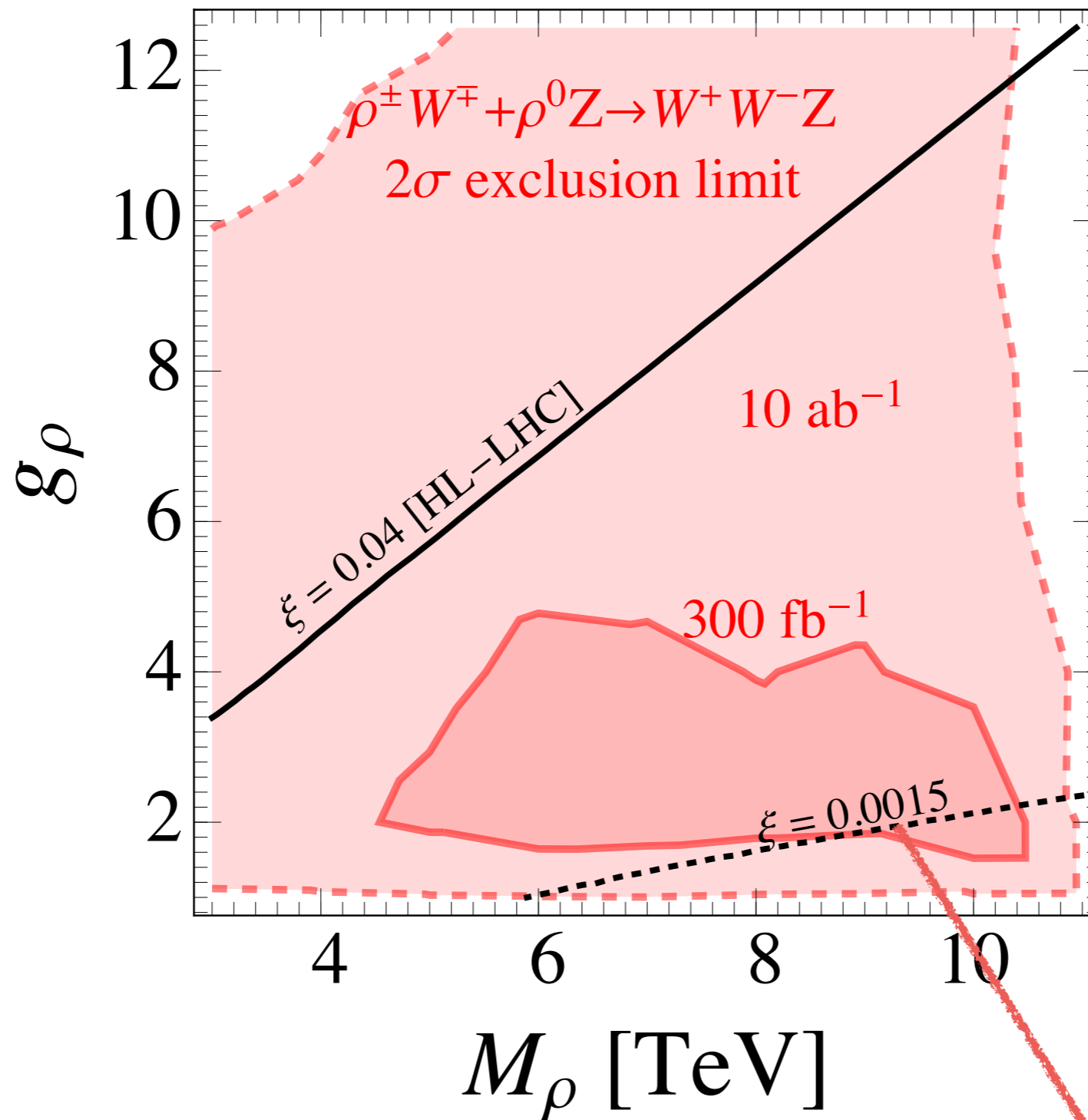
Pair production is included when possible

Top partners: VBF Production XS



$\xi = 0.015, f = 2 \text{ TeV}$

Projection: Spin-1

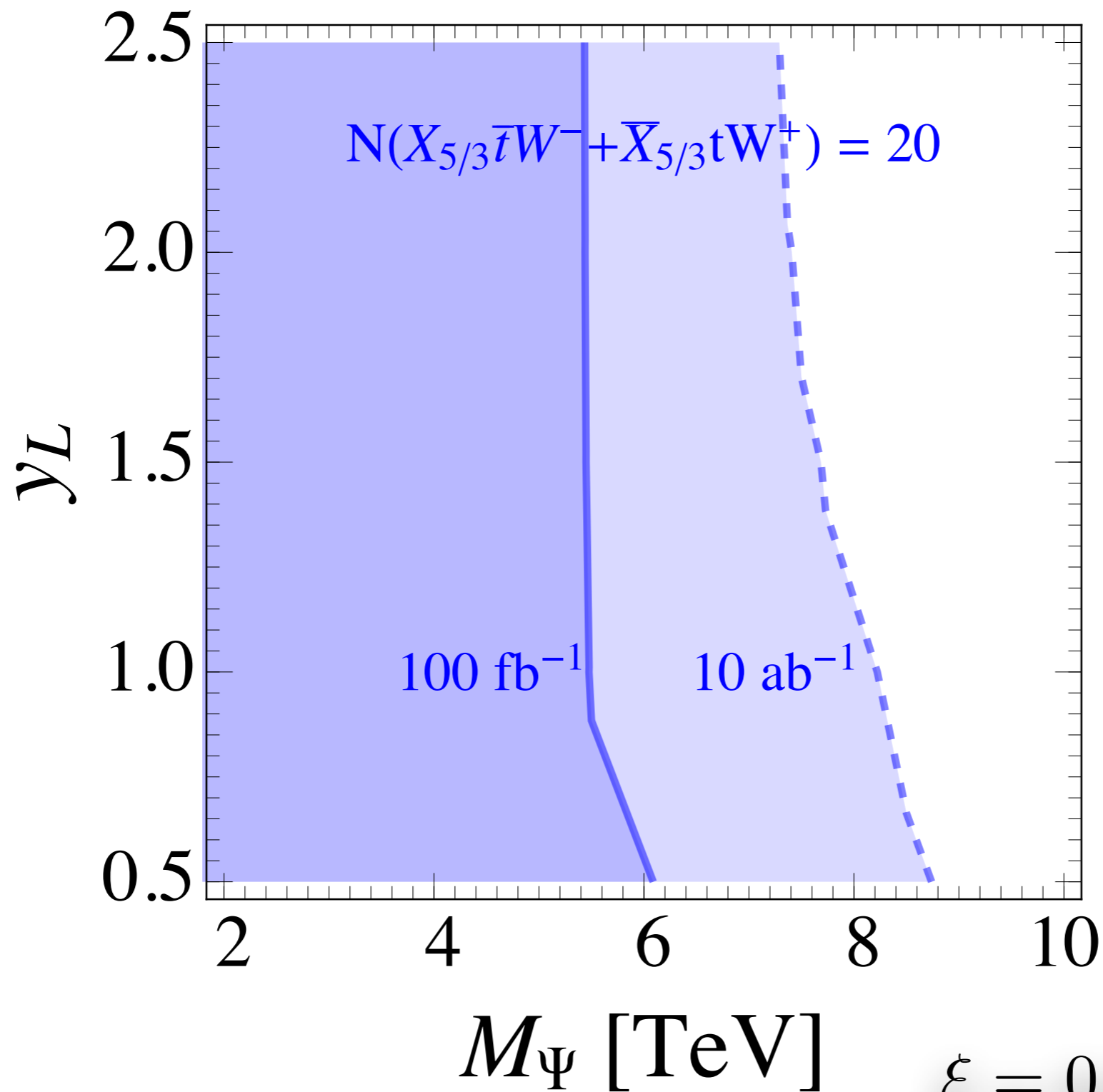


$$M_\rho = \frac{1}{\sqrt{2}} g_\rho f$$

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Working in progress

10 TeV Muon Collider
see T. Han, DL, I. Low and X. Wang

Projection: top partner



Conclusion

- Compositeness is an elegant way to address the hierarchy problem.
- Prospects at high energy muon collider are under careful scrutiny