Leptophobic Spin-2 Resonances at the LHC

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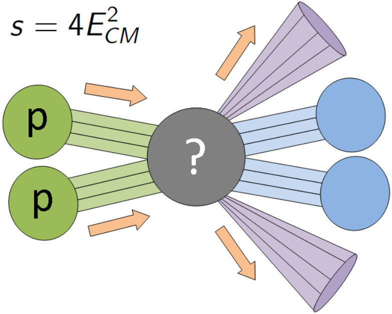
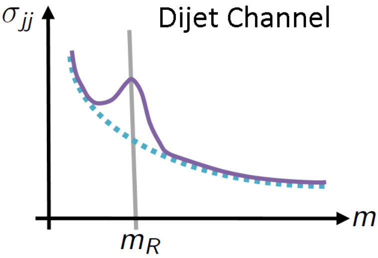
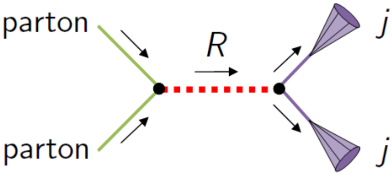
Resonant Production at LHC: First Impressions





- $\sigma_{jj,R}$ = peak **dijet cross section**
- m_R = **invariant mass** of resonance (several TeV)
- Γ_R = **total decay width** of the resonance
  (if wider than mass resolution of detector)

Model-Building Assumptions



- Model resonance as **new s-channel particle** R
- **Leptophobic**: else we'd detect via leptonic channels
- Focus on decays to **light jets**, where...

$$\mathbf{j} \equiv \text{light quarks } (\mathbf{u,d,s,c}) \text{ and gluons } (\mathbf{g})$$

- Assume **narrow width:**

$$\Gamma_R/m_R \lesssim 0.15$$

What Spin-2 Resonance Models are Consistent?

- Focus on **Spin-2 particle** and **Tree-Level calculations**

- **Not Excluded:** focus on parameter space not yet excluded to 95% CL (12.9 fb^{-1} of CMS LHC-13 data)

- **Within Reach:** only consider parameter space that the LHC is 5σ sensitive to at $\sqrt{s} = 14$ TeV with...

$$\mathcal{L}_{int} = 0.3\ \text{ab}^{-1} \qquad 1\ \text{ab}^{-1} \qquad 3\ \text{ab}^{-1}$$

- **PDF set:** CTEQ6L1 parton distribution functions

Leptophobic Graviton Model

Particle	Mass	Spin	$SU(3)_C \times U(1)_Q$
$X_2^{\mu\nu}$	m_{X_2}	2	neutral singlet

$$\mathcal{L}_{int} = -\frac{3.83}{m_{X_2}}\left[\kappa\frac{k}{\overline{M}_{Pl}}\right]\left\{r\,T^{g}_{\mu\nu} + T^{q}_{\mu\nu}\right\}X_2^{\mu\nu}$$

Assume **flavor universal, generation diagonal** couplings.

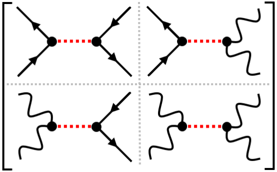
$$X_2 \longrightarrow \begin{cases} q\bar{q} \\ gg \end{cases} \gg \begin{cases} q\bar{q}g & q\bar{q}V \\ ggg & gggg \end{cases}$$

$q\bar{q}X_2$ and ggX_2 terms are mass dimension 5...

$$\textbf{[coupling]} = E^{-1} \implies \textbf{Unitarity Concerns}$$

Partial Wave Unitarity and Tree-Level Constraint

$i\mathcal{M}_{2_i \to X_2 \to 2_f} =$



$= 80\pi i \mathcal{A}_2 d^2_{\mu,\mu'}$

Only one nonzero eigenvalue of $\mathcal{A}_2$: called a_2, depends on $\hat{s}$

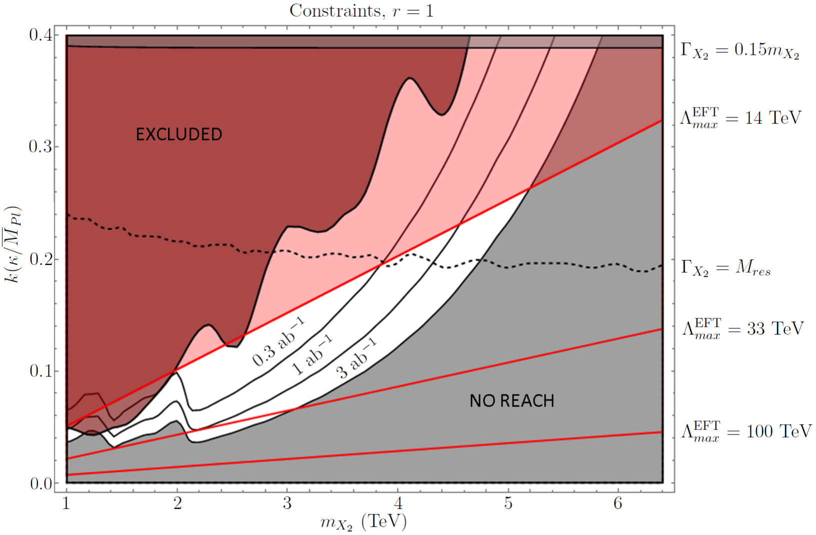
Unitarity demands

$$|\Re[a_2]| \leq \frac{1}{2}$$

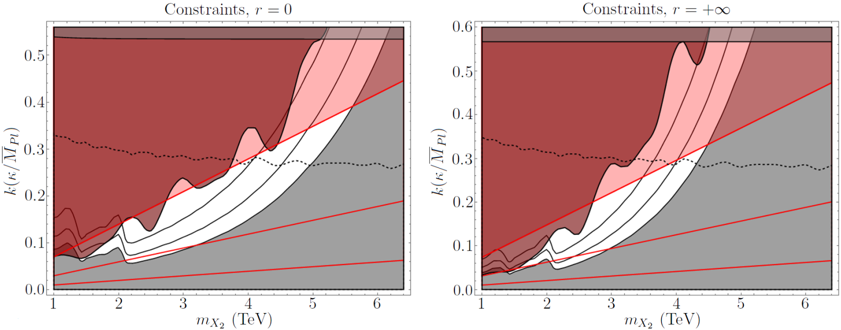
such that for consistency for $\sqrt{\hat{s}}$ up to Λ^{EFT}_{max}...

$$* \qquad \boxed{\kappa \frac{k}{\overline{M}_{Pl}} \leq \frac{1}{\Lambda^{EFT}_{max}} \frac{m_{X_2}}{3.83} \sqrt{\frac{40\pi}{(9+8r^2)}}} \qquad *$$

Leptophobic Graviton, Gluon = Quark Coupling



Leptophobic Graviton, $r \neq 1$

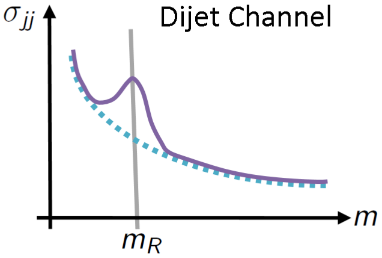


Quark-Exclusive & **Gluon-Exclusive**

$$r = \frac{ggX_2 \text{ coupling}}{q\bar{q}X_2 \text{ coupling}}$$

* **Conclusions Similar to $r = 1$ Case** *

Describing Dijet Resonances and D_{col} Analysis



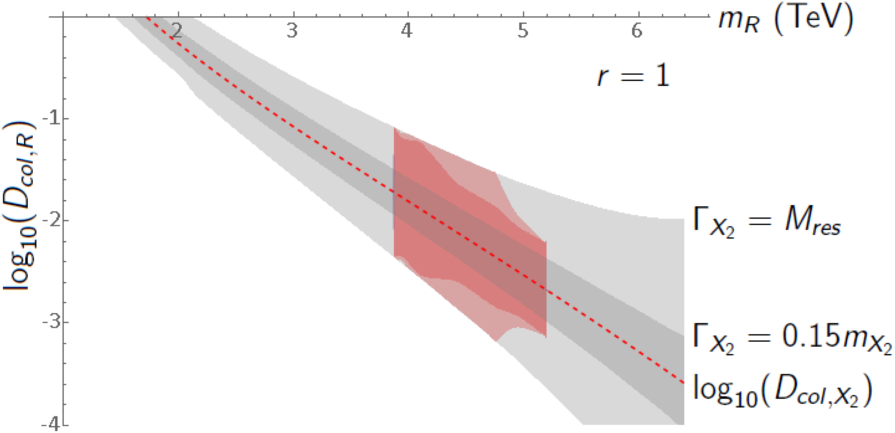
Color Discriminant Variable

$$D_{col,R} \equiv \frac{m_R^3 \sigma_{Rjj}}{\Gamma_R}$$

Resolve Width only if $\Gamma_R >$ detector mass resolution M_{res} (that is, *above* the dashed line in previous plot)

Models with D_{col} predicted outside of the uncertainty of a measured dijet resonance are unlikely to describe that dijet resonance.

$\log(D_{col})$ Plot for Leptophobic Graviton X_2, $r = 1$



Leptophobic Z'

Particle	Mass	Spin	$SU(3)_C \times U(1)_Q$
Z'_μ	$m_{Z'}$	1	neutral singlet

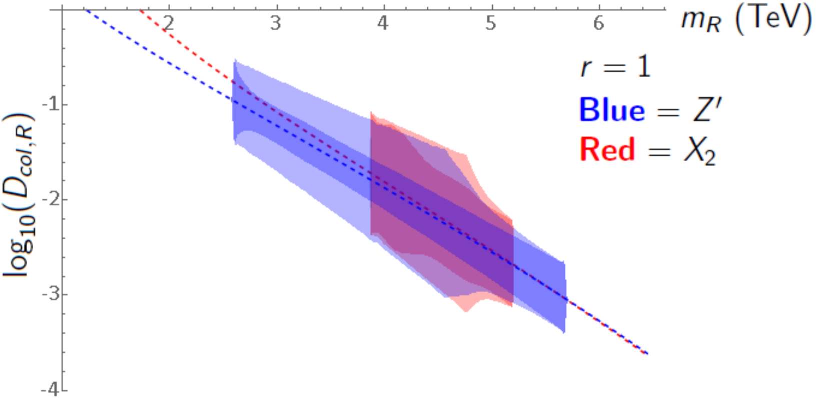
$$\mathcal{L}_{int} = ig \sum_i \overline{q}_i \gamma^\mu (g_L P_L + g_R P_R) q_i Z'_\mu$$

Assume **flavor universal & diagonal** couplings: $Z' \to q\overline{q}$

Previous D_{col} analyses demonstrate leptophobic Z' is distinguishable from...

- **Colorons**
- **Excited Quarks**
- **Diquarks**

$\log(D_{col})$, X_2 compared to Leptophobic Z'



Significant Overlap!

$\Downarrow$

X_2 inherits distinguishability of Z'

Conclusion & Summary

- The **Leptophobic Graviton** is distinguishable from...
  - Colorons
  - Excited Quarks
  - Diquarks

- Below ≈ 4 TeV, X_2 unlikely to describe a resolvable dijet resonances discovered at the LHC.

- Distinguishing X_2 from leptophobic Z' necessitates spin analysis.

Thank you for attending! Questions?