CONSTRAINING SCALAR LEPTOQUARKS USING COHERENT DATA

ROBERTA CALABRESE

IN COLLABORATION WITH:

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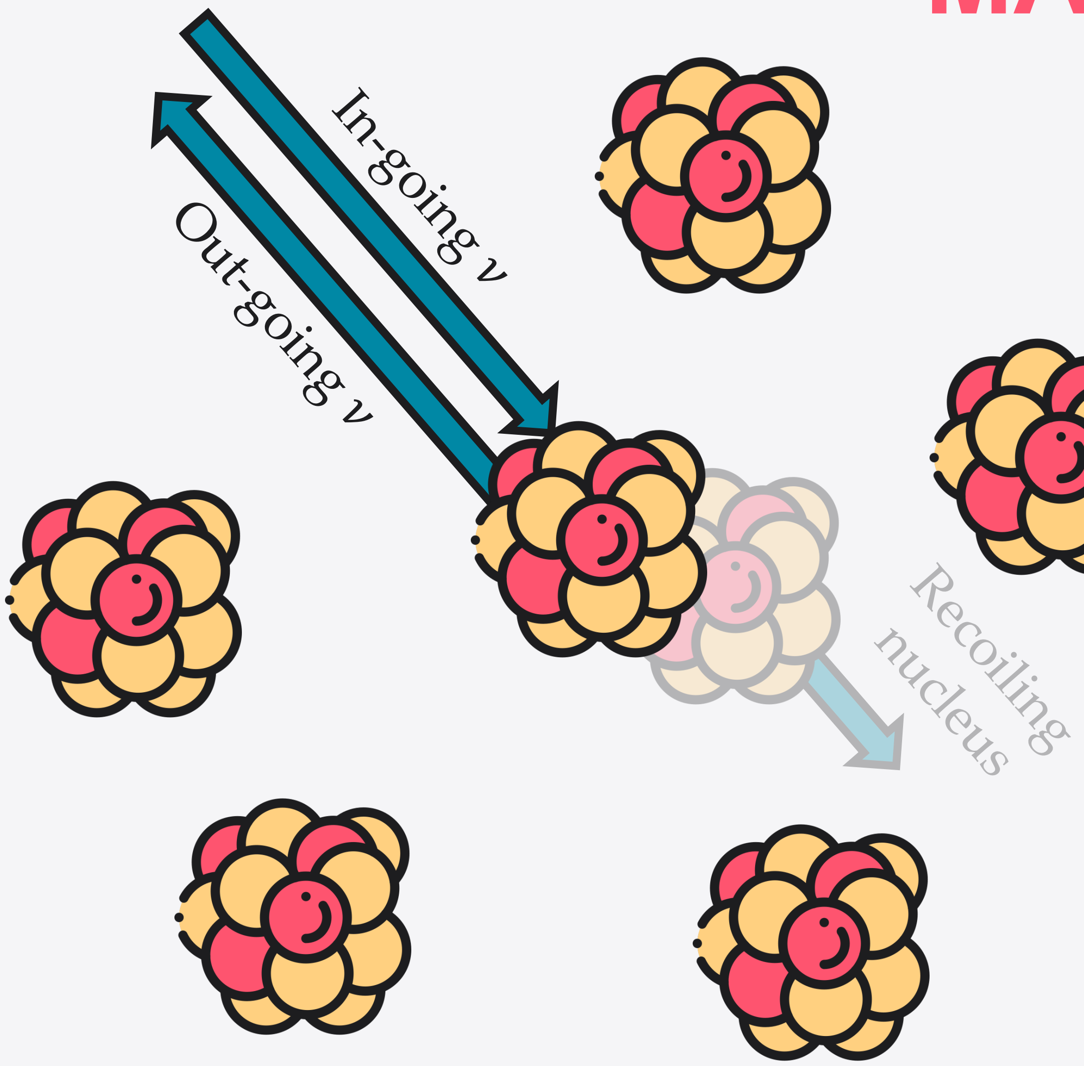
BASED ON:

PHYSICAL REVIEW D 107 (2023) 5, 055039

MAIN IDEA



CONSTRAIN LOW MASS SCALAR LEPTOQUARKS ($[10^2 - 10^4]$ GEV) USING COHERENT DATA!

PROTON DECAY

Leotoquark may cause the proton decay.

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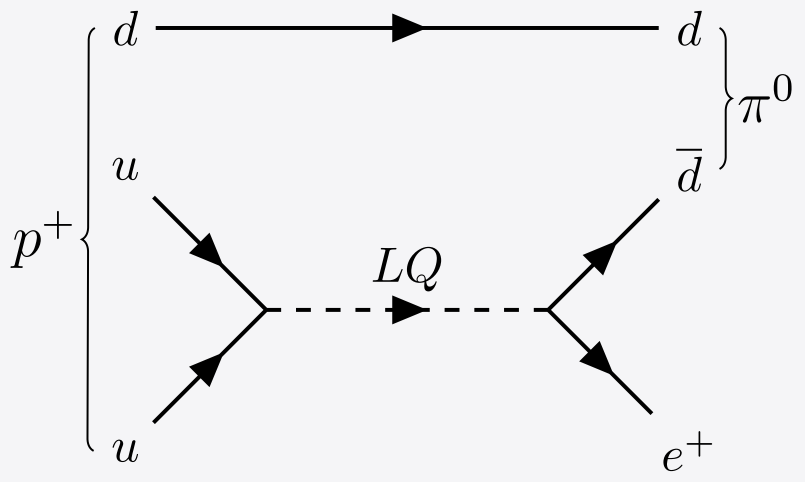

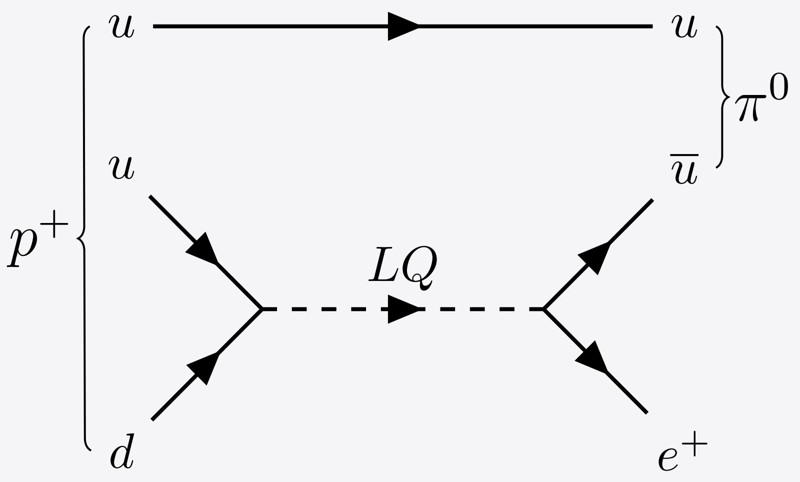

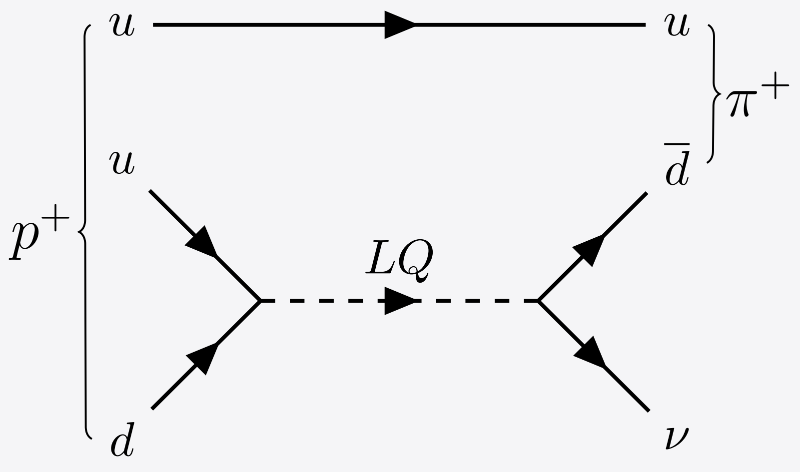

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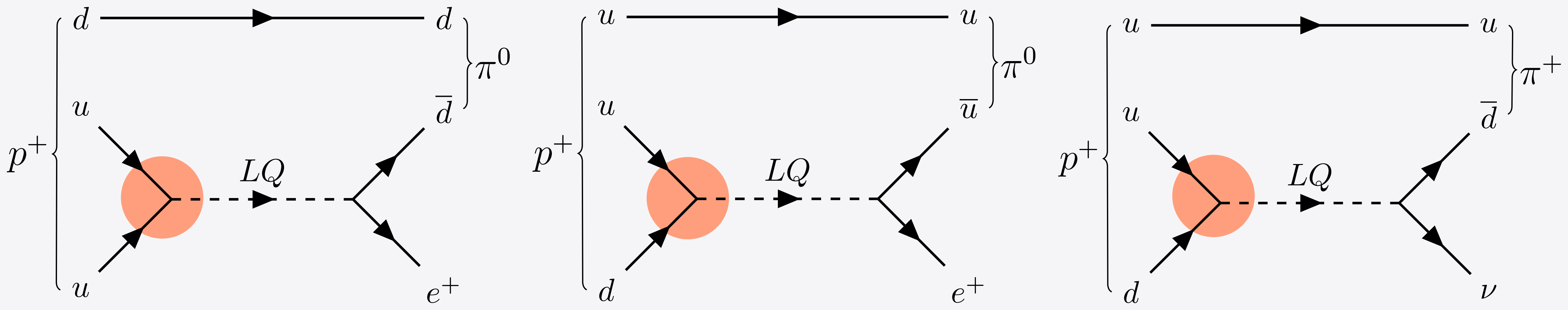
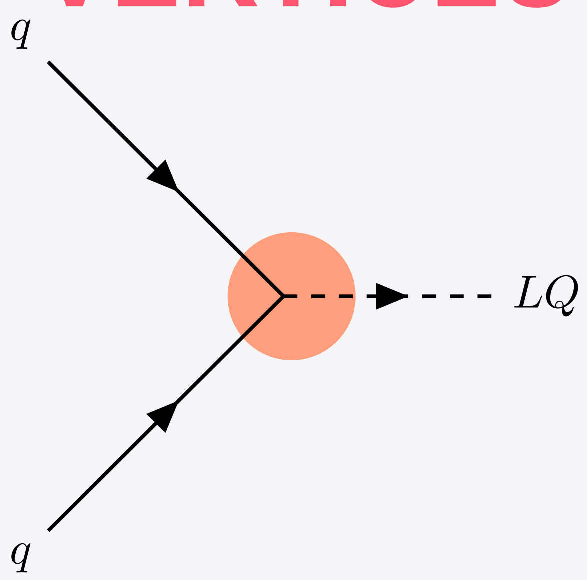


''diquarks'' vertices are the problem!

Are there Leptoquarks that do not exhibit these vertices?

SEARCHING FOR DIQUARK VERTICES



Phys.Rept. 641 (2016) 1-68

LQ	$SU(3)_c \times SU(2)_L \times U(1)_Y$	Vertices (a,b,c = 1,2)	
S_3	$\left(\overline{3}, 3, \frac{1}{3}\right)$	$\overline{Q}^a_L \epsilon^{ab} \left(\tau^k S^k_3\right)^{bc} L^c_L$	
		$\overline{Q}^a_L \epsilon^{ab} \left(\left(\tau^k S^k_3\right)^\dagger\right)^{bc} Q^c_L$	
S_1	$\left(\overline{3}, 1, \frac{1}{3}\right)$	$\overline{Q}^{Ca}_L S_1 \epsilon^{ab} L^b_L$	$\overline{u}^C_R S_1 e_R$
		$\overline{Q}^{Ca}_L S^*_1 \epsilon^{ab} Q^b_L$	$\overline{u}^C_R S^*_1 d_R$
R_2	$\left(3, 2, \frac{7}{6}\right)$	$\overline{u}_R R^a_2 \epsilon^{ab} L^b_L$	
		$\overline{e}_R R^{a*}_2 Q^a_L$	
$\widetilde{R}_2$	$\left(3, 2, \frac{1}{6}\right)$	$\overline{d}_R \widetilde{R}_2 \epsilon^{ab} L^b_L$	
$\tilde{S}_1$	$\left(\overline{3}, 1 \frac{4}{3}\right)$	$\overline{d}^C_R \tilde{S}^*_1 d_R$	

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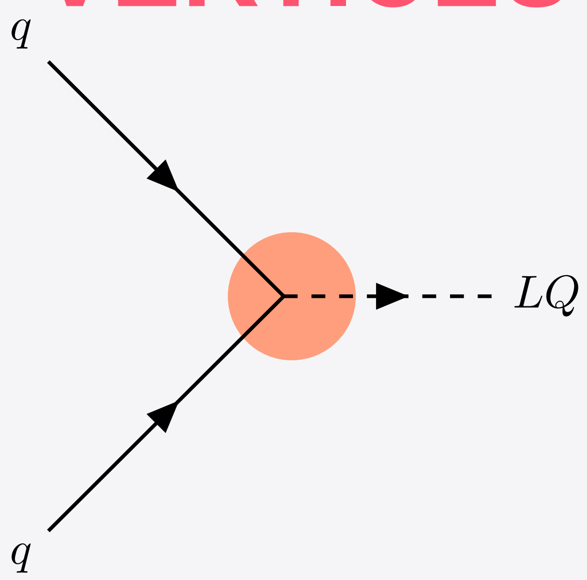

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R_2	$\left(3, 2, \frac{7}{6}\right)$	$\overline{u}_R R_2^a \epsilon^{ab} L^b_L$	
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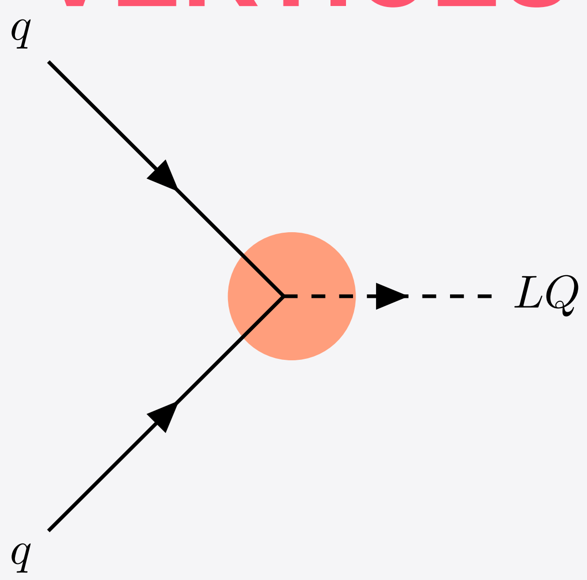

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OUR CHOICE

We minimally extend the Lagrangian to include the relevant interactions

CASE 1: $\widetilde{R_2}$

$$\mathcal{L} \supset -g_{ij}\overline{d}_R^i\, \widetilde{R_2} L_L^j + h.c =$$

$$= -y_{ij}\left(\overline{d}^i P_L \ell^j \Delta_1^{2/3} - \overline{d}^i P_L \nu^j \Delta_1^{-1/3}\right)$$

CASE 2: R_2

$$\mathcal{L} \supset -g_{ij}\overline{u}_R^i\, R_2 L_L^j + h.c =$$

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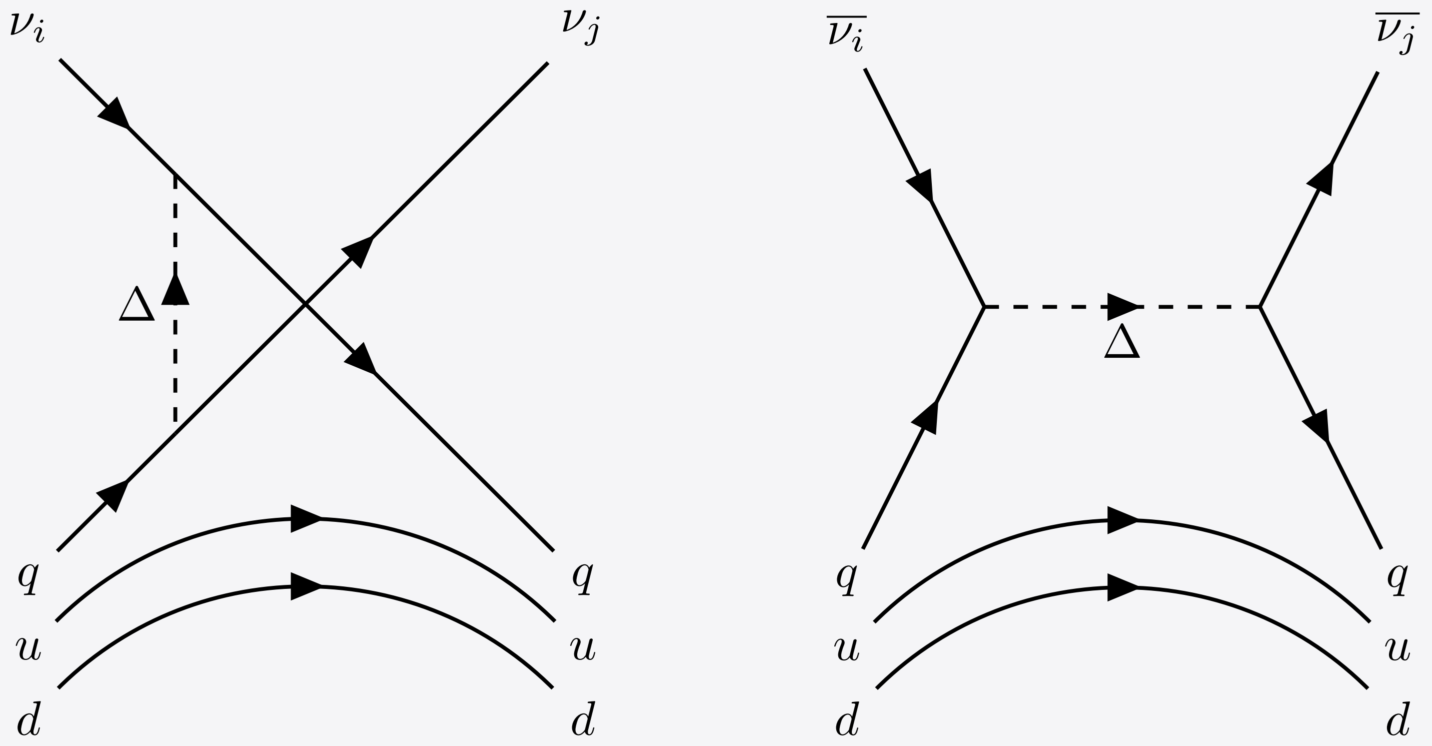
Additionally, we assume $\Delta_{1,2}$ to couple only with the first generation of quarks to avoid the constraints from Flavor Changing Neutral Currents

CEνNS & LEPTOQUARKS

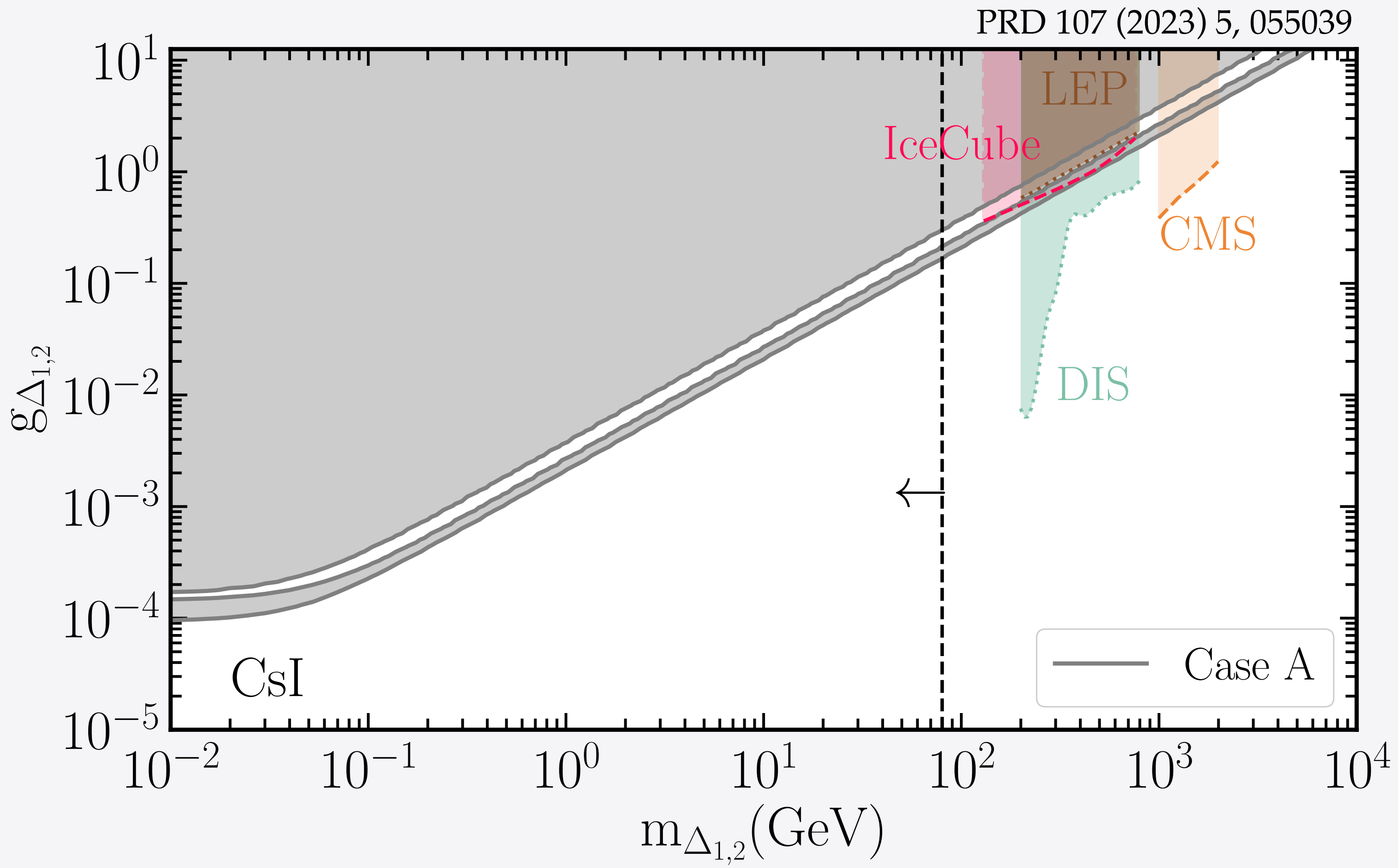
Through **FIERZ TRANSFORMATIONS** we obtain the following effective Lagrangian

$$\mathcal{L} \sim -\frac{g^2}{2m_\Delta^2}\left(\overline{\psi_N}\gamma^\mu P_R \psi_N\right)\left(\bar{\nu}\gamma_\mu P_L \nu\right)$$

It has a ***V − A*** **AXIAL STRUCTURE**!



CONSTRAINTS



In this case, we assume Δ to couple with ν_e and ν_μ with the same coupling.

Other scenarios were considered!

CONCLUSIONS

- ★ We use Coherent Elastic Neutrino-Nucleus Scattering data to constrain scalar Leptoquarks in wide mass range
- ★ We consider Scalar Leptoquarks that does not present ”diquarks” coupling
  → they do not contribute to proton decay
- ★ Our constraints are competitive with the ones coming from LHC, IceCube, LEP, and DIS.

CONSTRAINTS SHAPE

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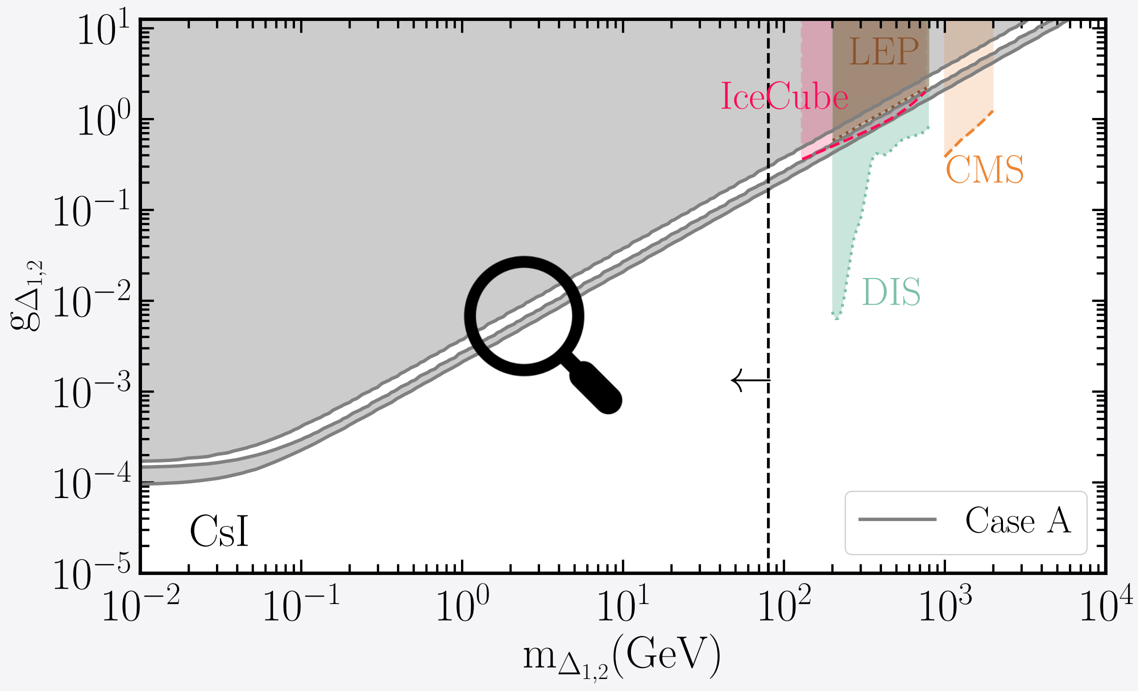

CEνNS cross section is

$$\frac{d\sigma_i}{dT_{nr}} = \frac{G_F M}{\pi}\left(1 - \frac{MT_{nr}}{2E_\nu^2}\right) Q^2_{i,\Delta_k}$$

$$Q^2_{i,\Delta_k} = \left(Q_{ii,SM} - Q_{ii,\Delta_k}\right)^2 + \sum_{i\neq j} Q^2_{ij,\Delta_k}$$

Where

$$Q_{ij,\Delta_1} = \frac{y_{1i}y_{1j}}{4\sqrt{2}G_F}\frac{ZF_z(|q|^2) + 2NF_N(|q|^2)}{|q|^2 + m_\Delta^2}$$

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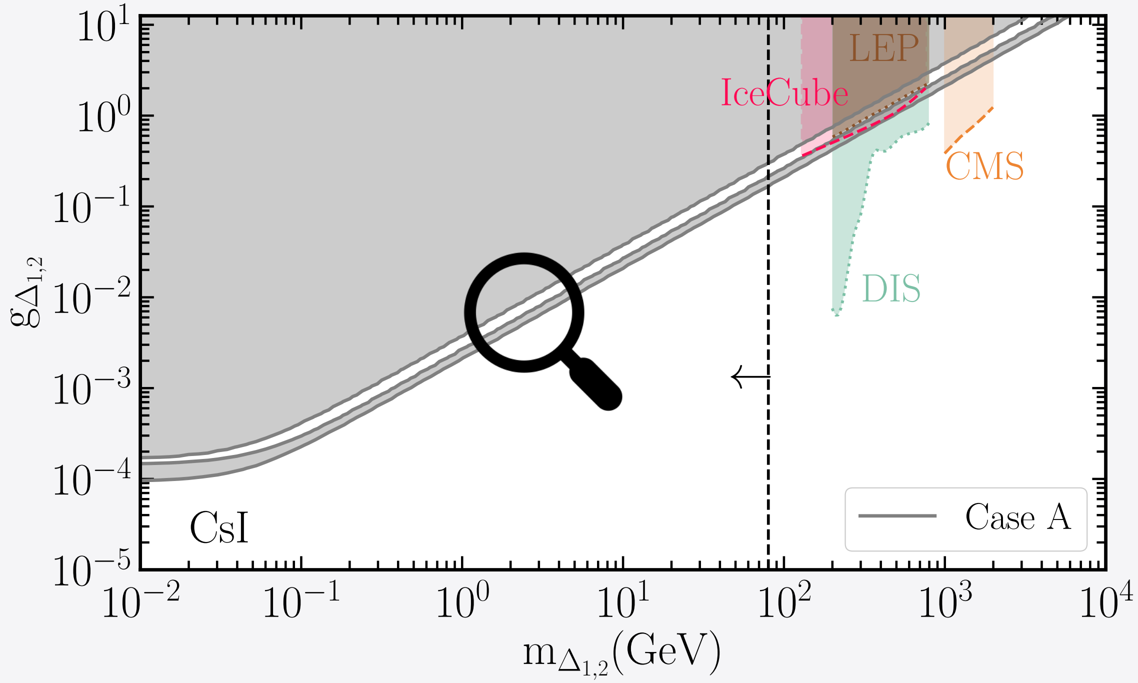

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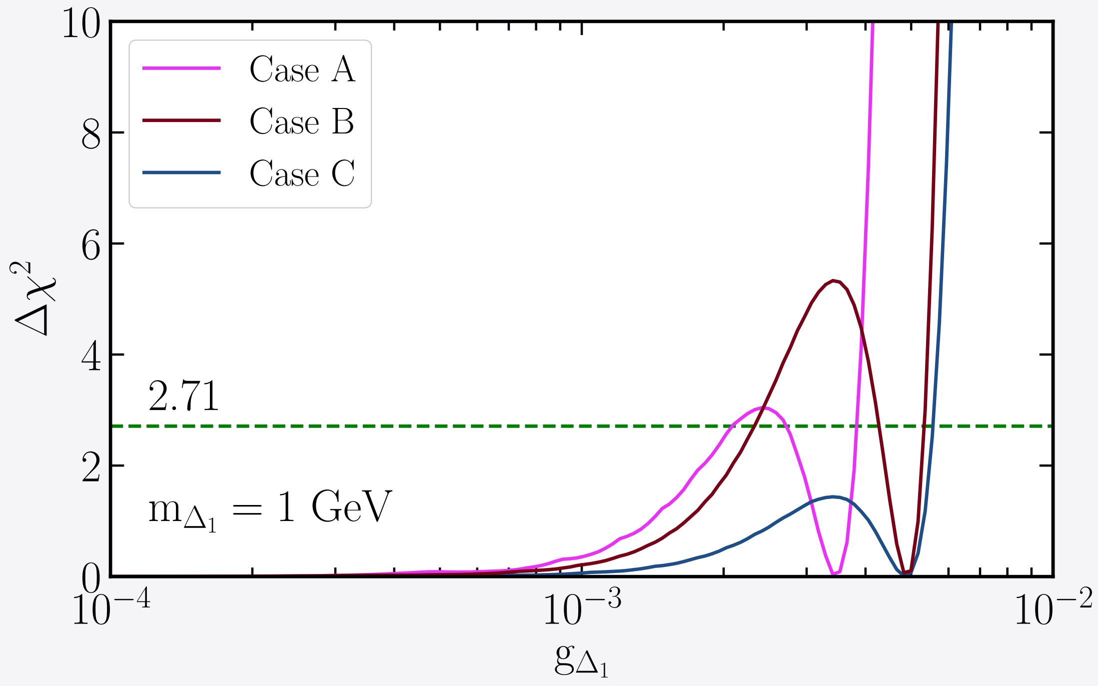

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