

Confronting COHERENT and LHC to test neutrino nonstandard interactions

Based on the work **Phys.Rev.D 112 (2025) 5, 055017 [arXiv: 2503.11766]**,
in collaboration with
G. Sánchez García (IFIC → UNAM) and V. Martín Lozano (IFIC)

Adrián Terrones Aragón

IFIC, CSIC-UV

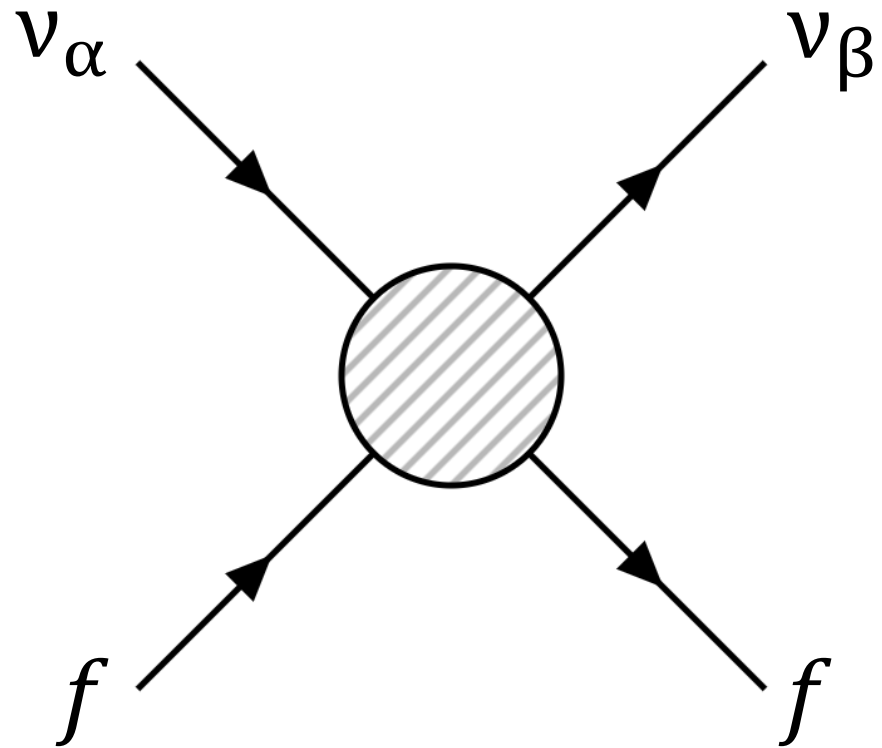
XVII CPAN days, Valencia, 19/11/2025



Non-standard interactions (NSIs)

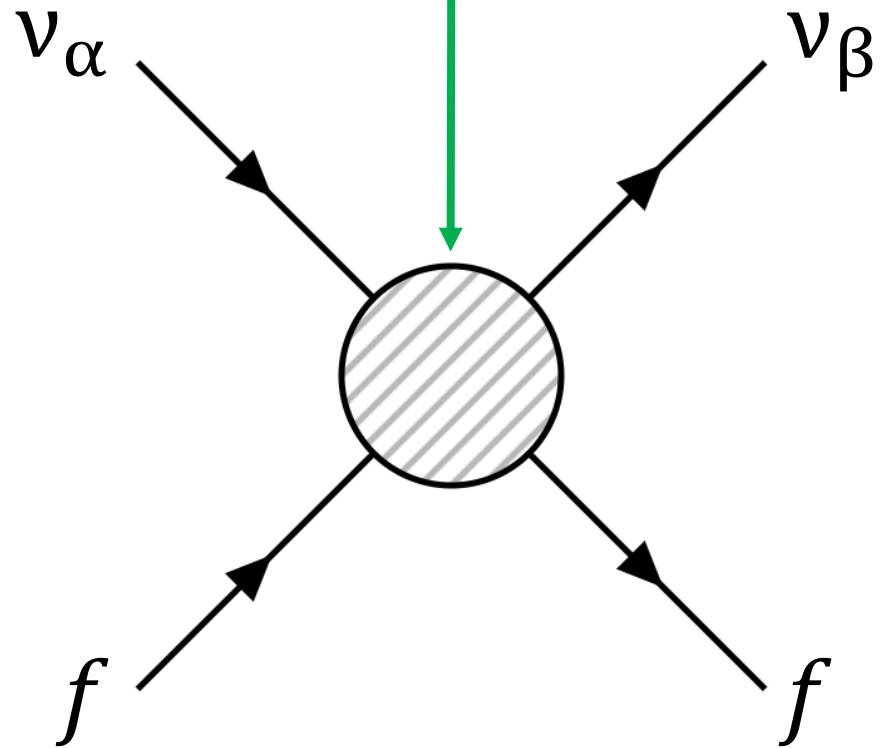
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$$\mathcal{L}_{\text{NSI}}^{\text{NC}} = -2\sqrt{2}G_F \varepsilon_{\alpha\beta}^{fC} (\bar{\nu}_\alpha \gamma^\mu P_L \nu_\beta) (\bar{f} \gamma_\mu P_C f)$$



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$$\varepsilon_{\alpha\beta}^{fV} \equiv \varepsilon_{\alpha\beta}^{fL} + \varepsilon_{\alpha\beta}^{fR}, \quad \varepsilon_{\alpha\beta}^{fA} \equiv \varepsilon_{\alpha\beta}^{fL} - \varepsilon_{\alpha\beta}^{fR} = 0$$

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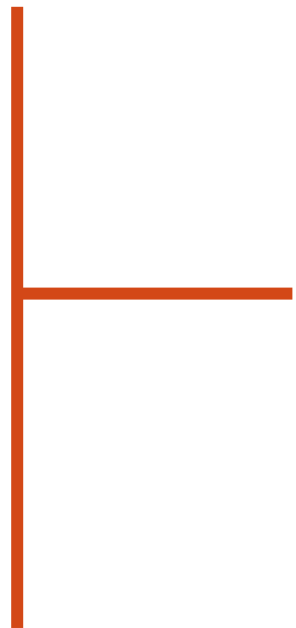


Underlying model: massive vector boson mediator

$$\mathcal{L}_{Z'} = (g_\nu^{\alpha\beta} \bar{\nu}_\alpha \gamma^\mu P_L \nu_\beta + g_{q_i}^V \bar{q}_i \gamma^\mu P_V q_i) Z'_\mu$$

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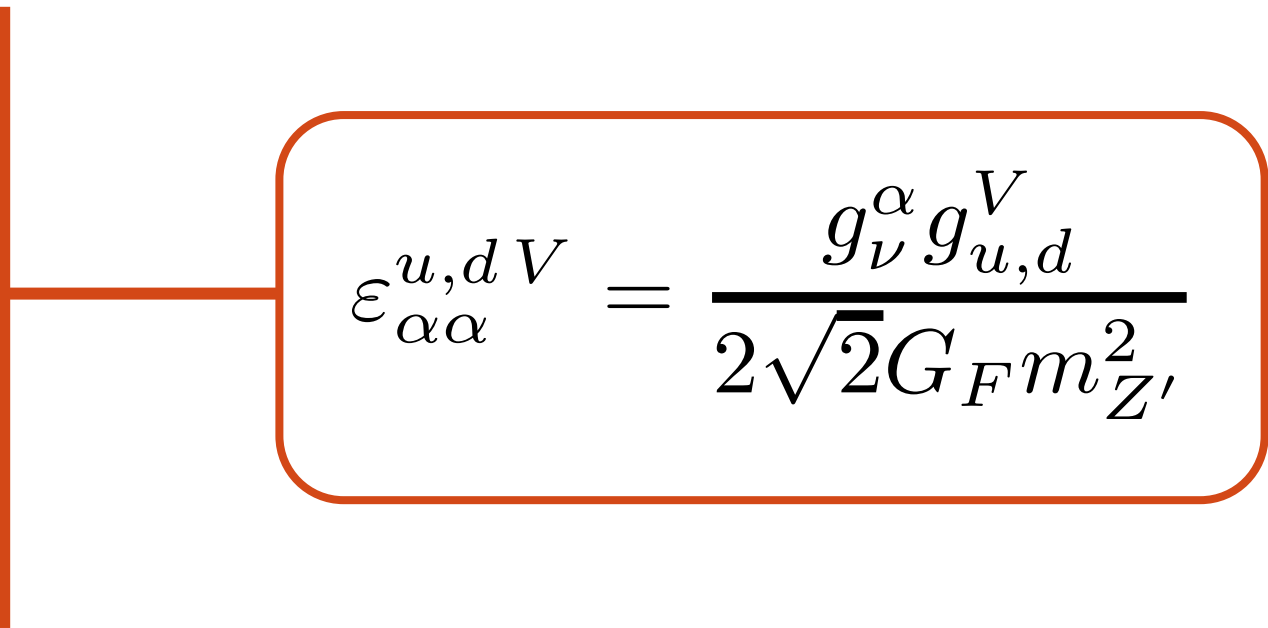
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Low energy: COHERENT (CE ν NS)

$E \sim \text{MeV}$

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Bounds from De Romeri, Miranda, Papoulias, Sánchez García,
Tórtola, Valle, JHEP04(2023)035 [2211.11905]

High energy: LHC

$E \sim \text{TeV}$

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$$\Gamma_{Z'}^i = \frac{N_C^i (g_i^V)^2 m_{Z'}}{12\pi} \sqrt{1 - \frac{4m_i^2}{m_{Z'}^2}} \left(1 + \frac{2m_i^2}{m_{Z'}^2} \right)$$

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Z' -explorer

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- Monojet + missing E ATLAS Collab. [2102.10874]
- Dijet ATLAS Collab. [1910.08447]
- Dilepton CMS Collab. [2103.02708], ATLAS Collab. [1709.07242]

Z'-explorer

Álvarez, Estévez, Sandá Seoane [2005.05194]

Martín Lozano, Sandá Seoane, Zurita [2109.13194]

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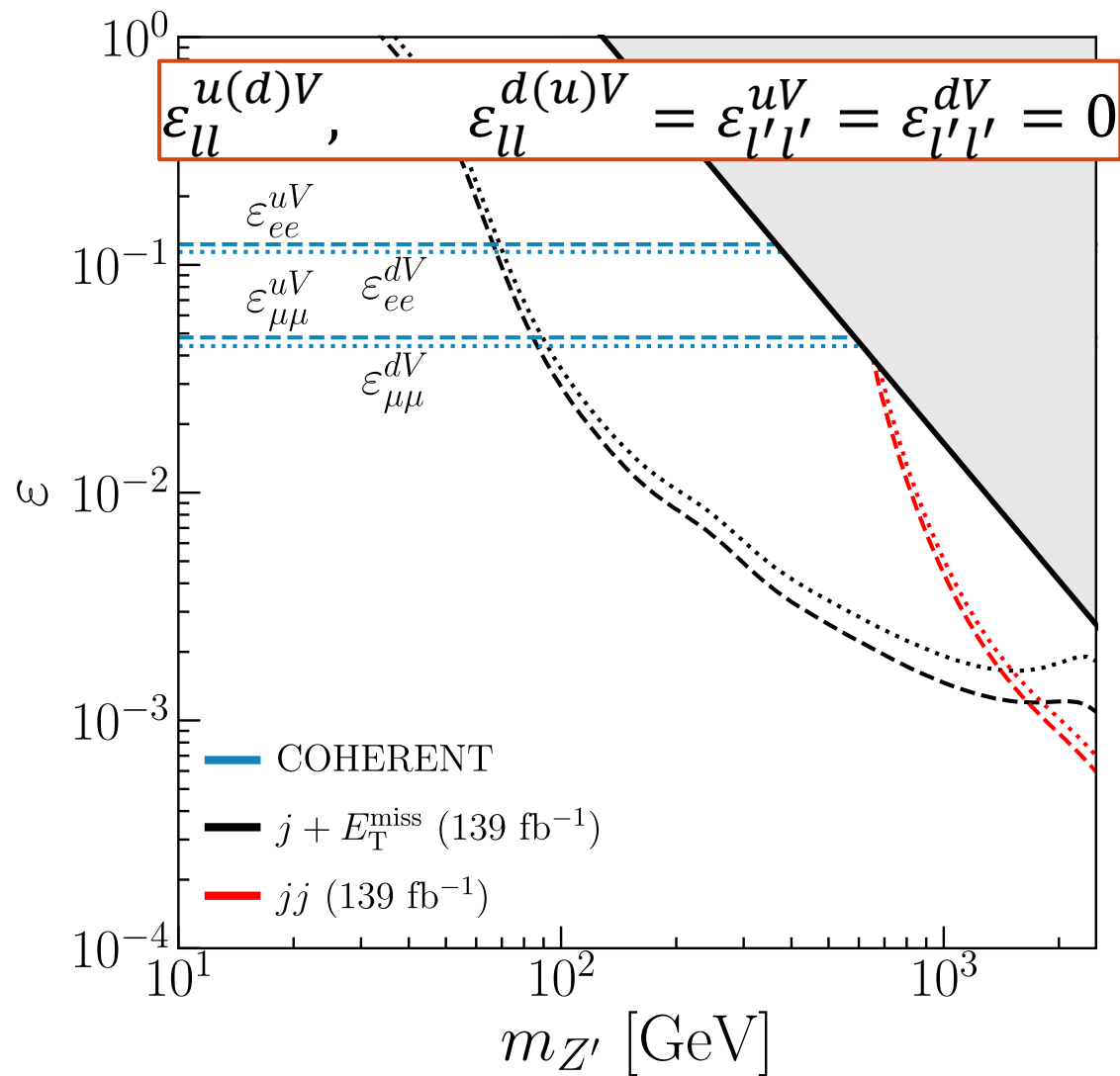
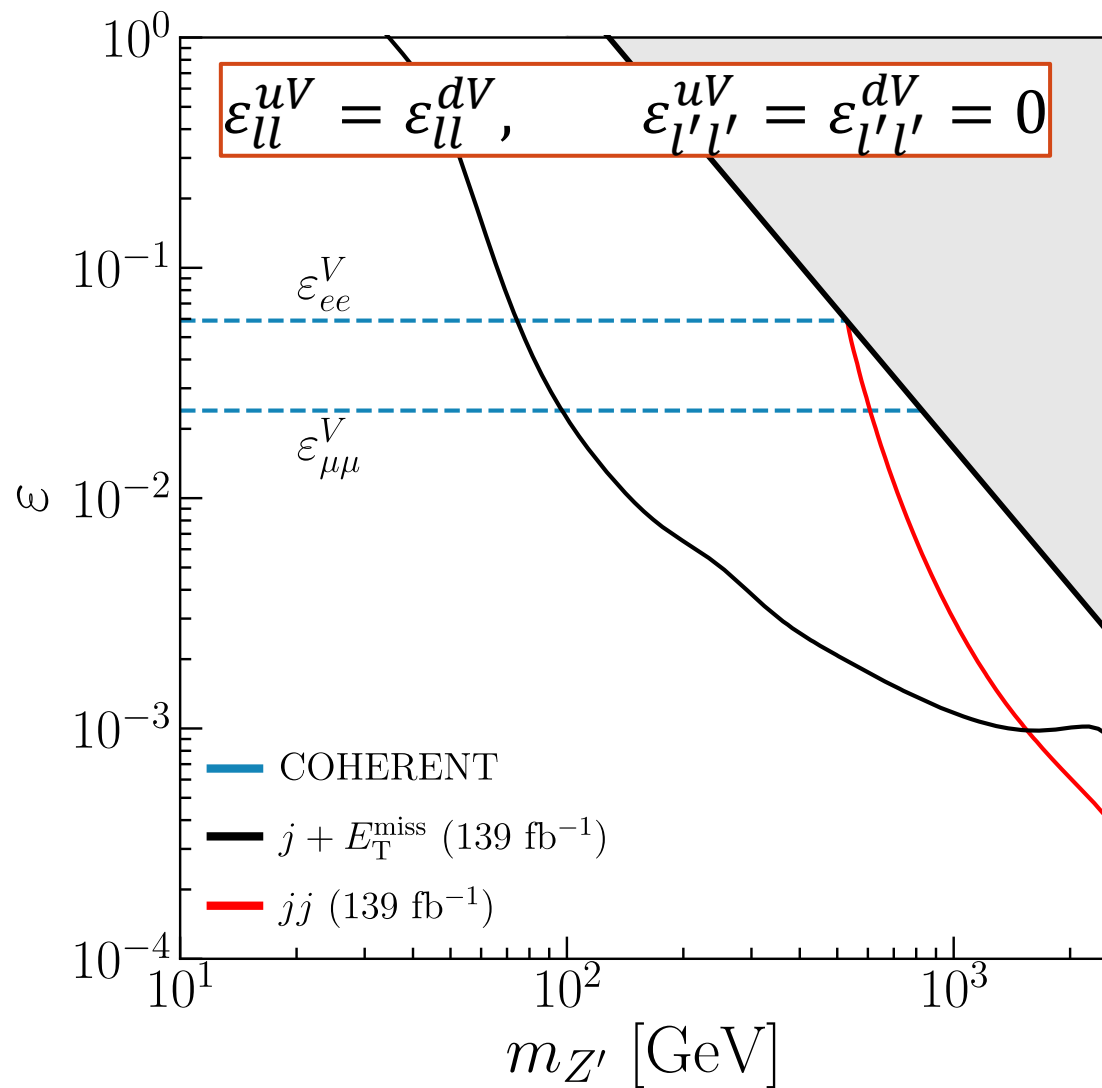
$$Z'\text{-explorer} \longrightarrow \mathcal{S} = \frac{\sigma_{\text{pred}}}{\sigma_{\text{lim}}^{95}}$$

Álvarez, Estévez, Sandá Seoane [2005.05194]

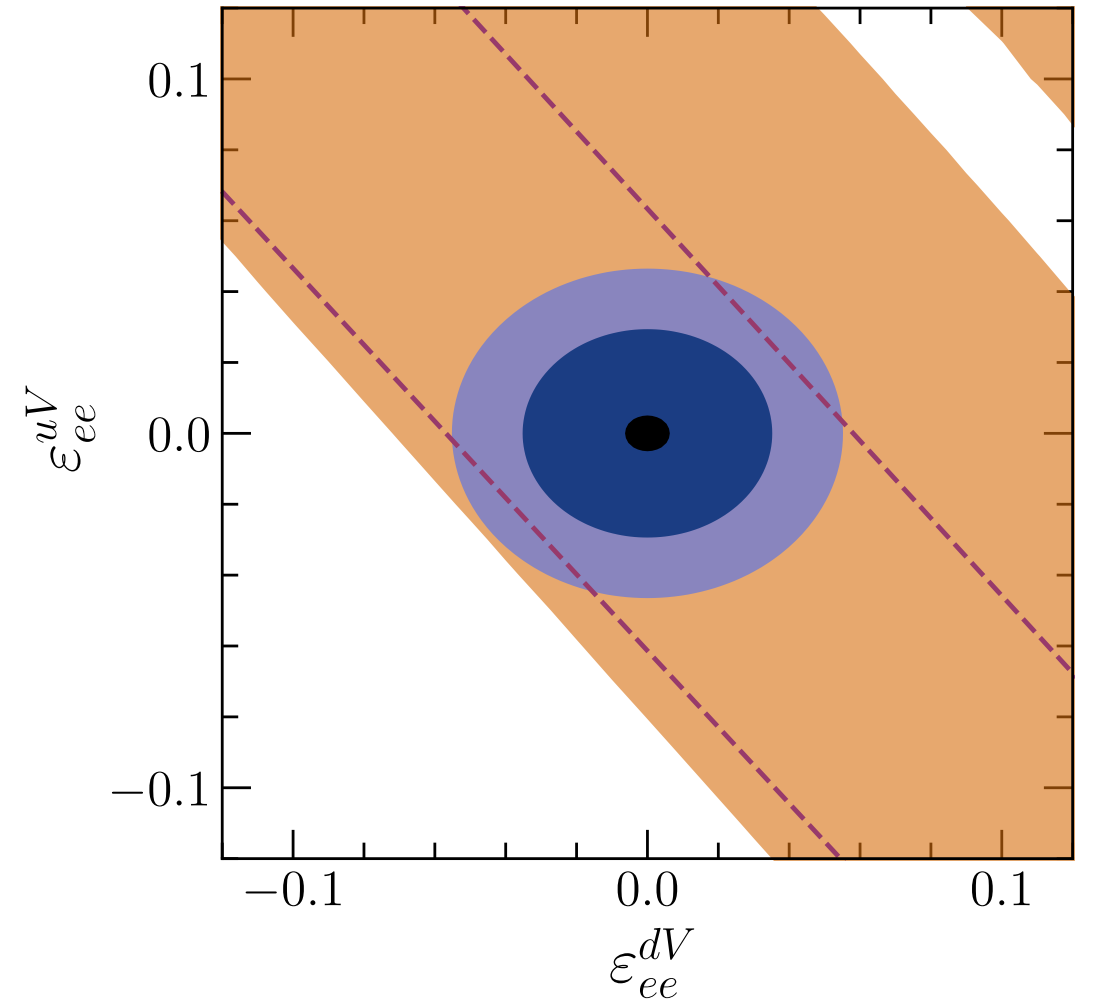
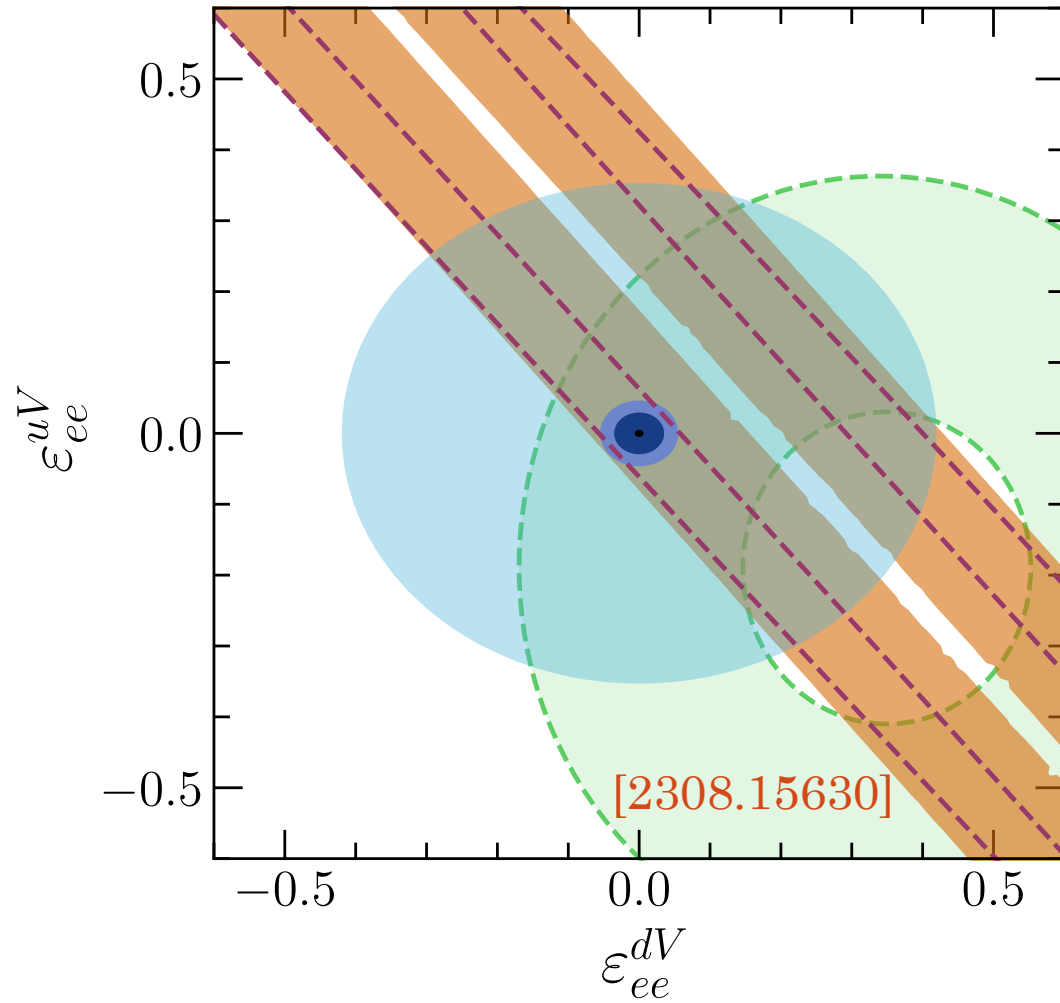
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Constraints

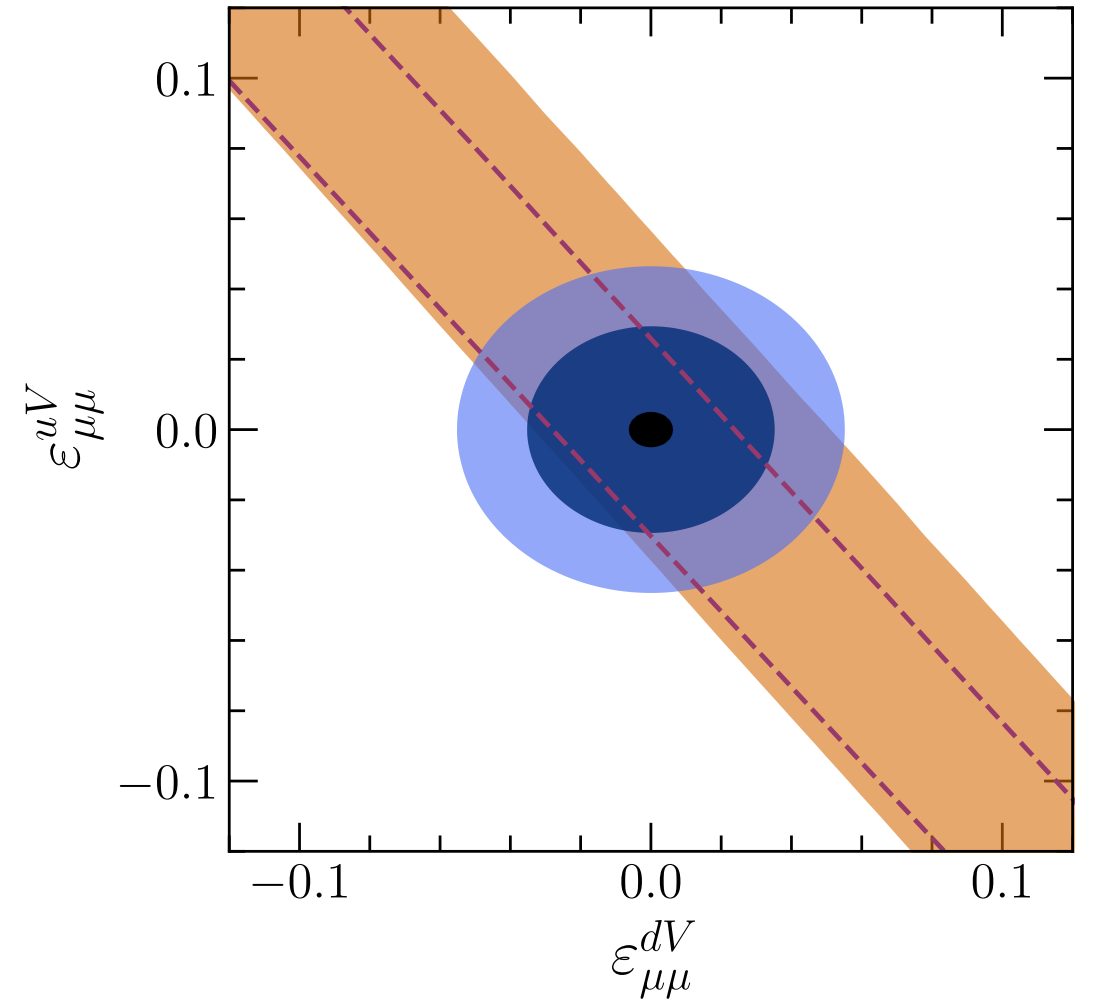
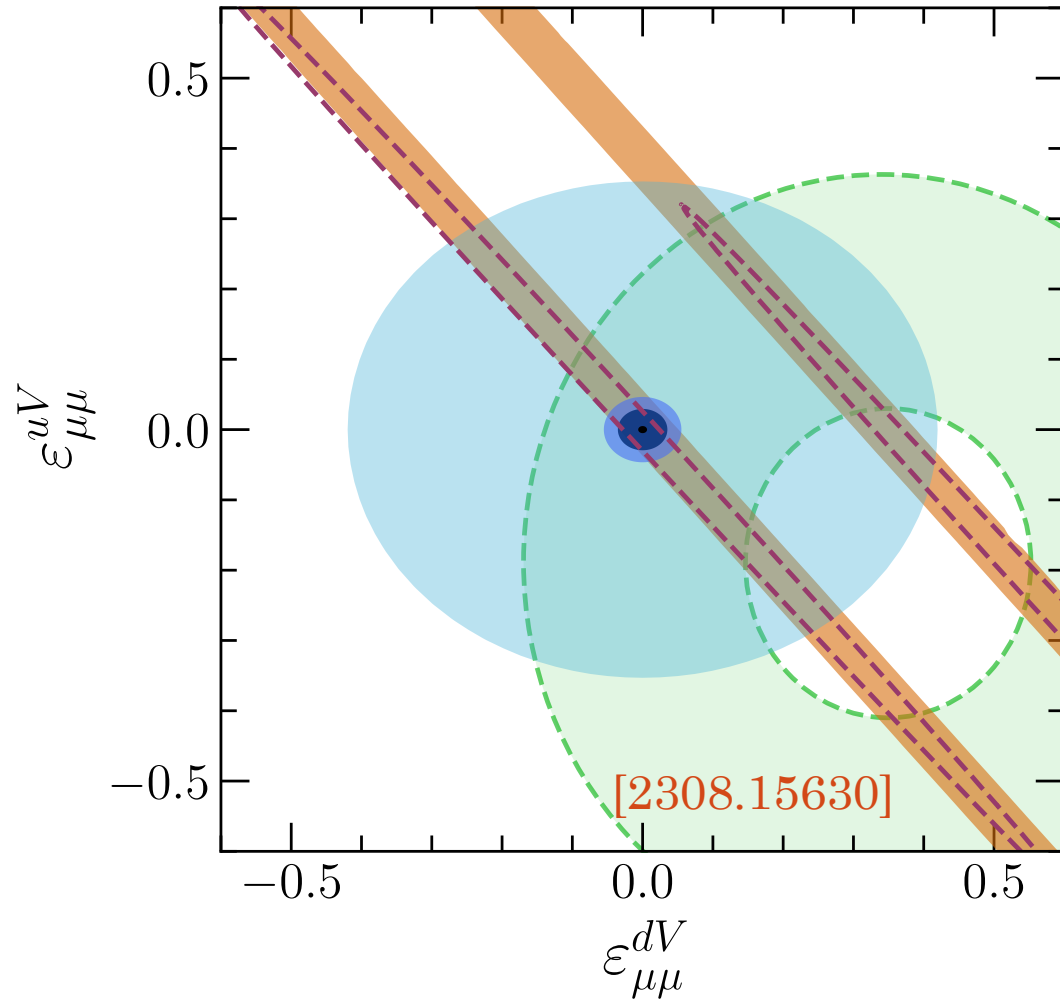
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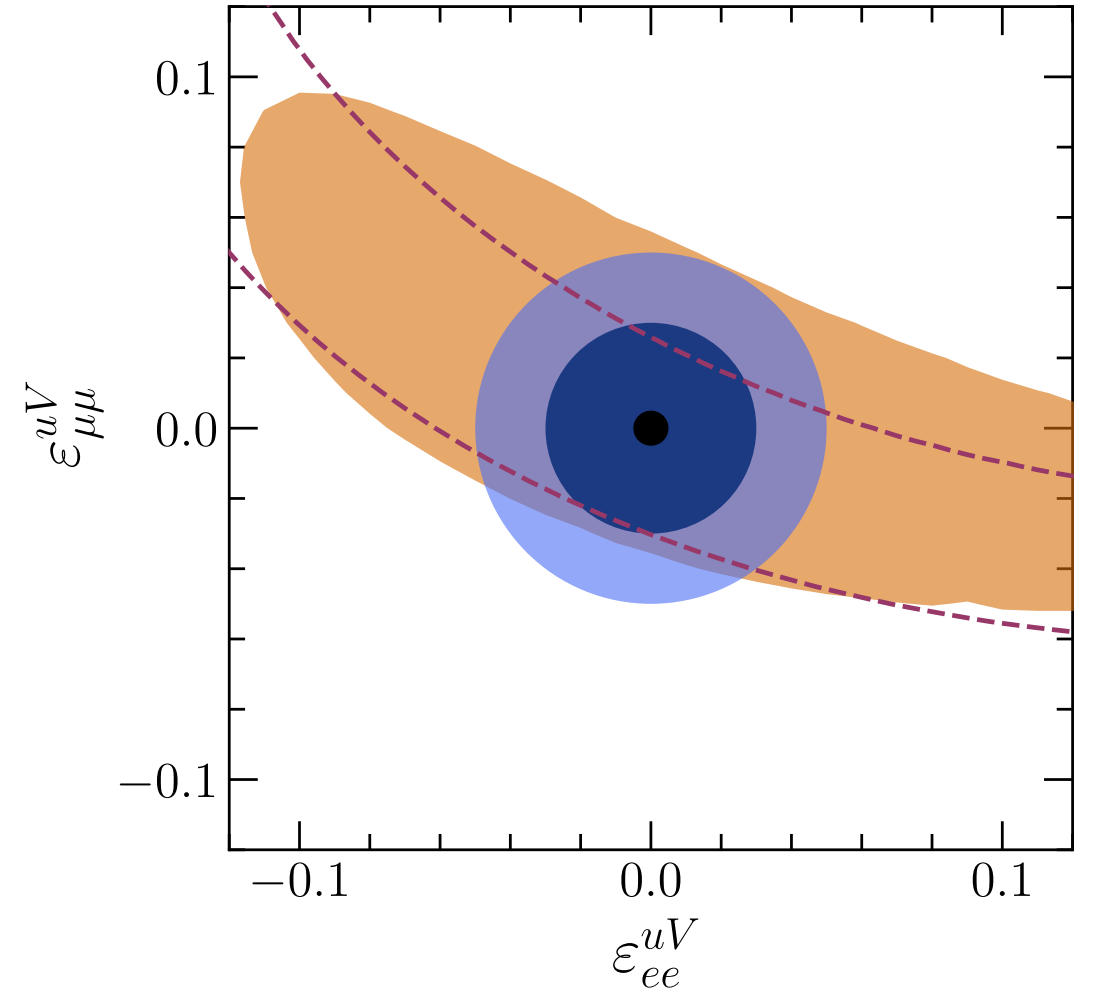
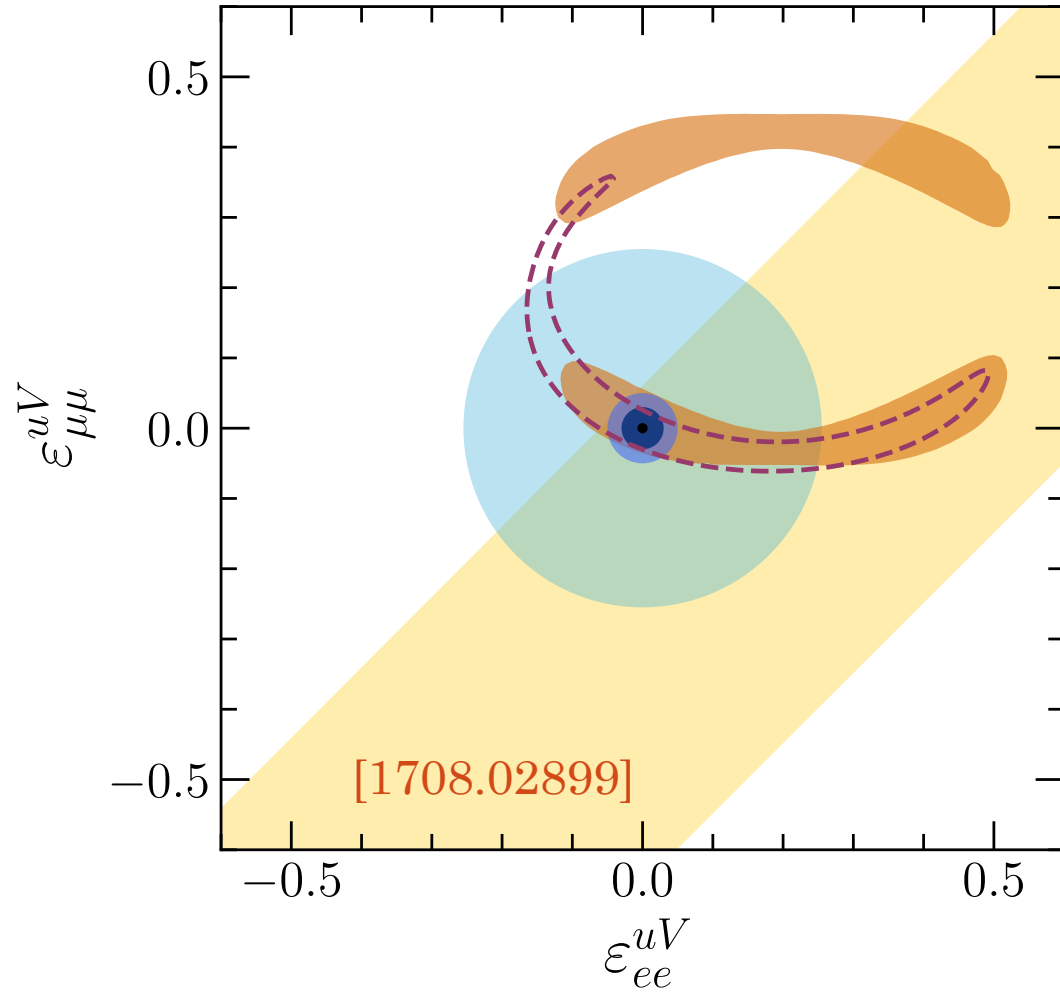
Constraints



CsI+LAr
 Cryo-CsI+NaI
 FASER
 Oscillations

$m_{Z'} = 70$ GeV
 $m_{Z'} = 80$ GeV
 $m_{Z'} = 100$ GeV
 $m_{Z'} = 300$ GeV

Constraints



Conclusions

- **Complementarity** between low- and high-energy experiments

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- **Complementarity** between low- and high-energy experiments
- COHERENT $\longrightarrow$ $m_{Z'}$ independent, flavor dependent
- LHC $\longrightarrow$ $m_{Z'}$ dependent, flavor independent
- LHC can **break** COHERENT degeneracies for $m_{Z'} \gtrsim 70$ GeV

Thank you!

Questions and comments appreciated :)

Backup slides

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- 6D EFT operator

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Non-standard interactions (NSIs): all-lepton

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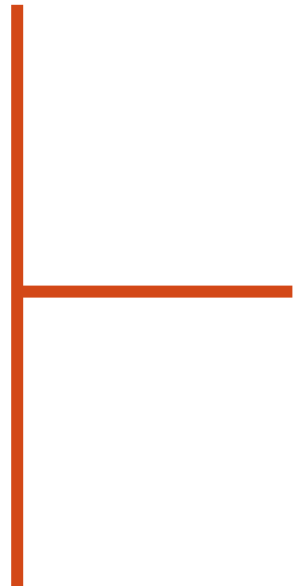
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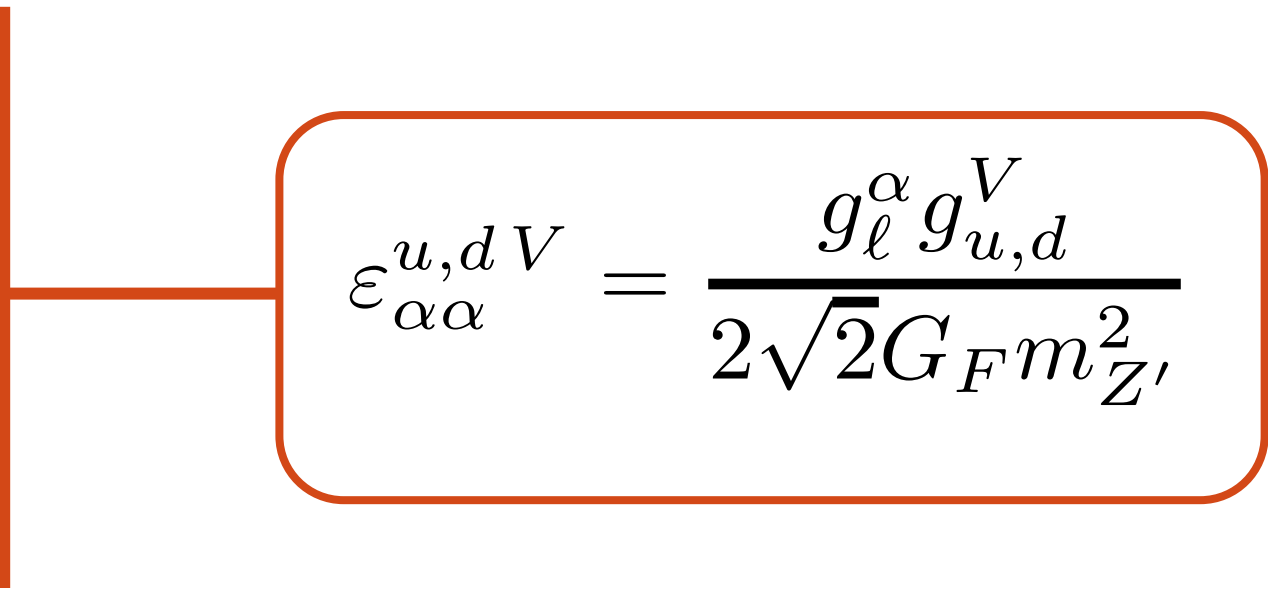
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If $\alpha \neq \beta$
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Lepton flavour violation

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Babu, Gonçalves, Jana, Machado [2003.03383]

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$$|\tilde{\epsilon}| \leq \frac{\sqrt{3}\pi}{\sqrt{n} G_F m_{Z'}^2} \frac{\Gamma_{Z'}}{m_{Z'}}$$

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$$|\tilde{\epsilon}|^2 = \sum_{\alpha\beta} |\epsilon_{\alpha\beta}|^2$$

Constraints: all-lepton interactions

