CSIC
Consejo Superior de Investigaciones Científicas

MultiDark
Multimessenger Approach for Dark Matter Detection

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IFIC (CSIC-UV)

High-energy constraints from low-energy neutrino non-standard interactions

Based on: arXiv: 1912.09131 v2.0

In collaboration with Mariam Tórtola and Avelino Vicente

HEFT 2020

17-04-2020

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CC-NSI+EFT: [Falkowski et al, 1910.02971]

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    Necessary assumption to work with SMEFT

Standard Model Effective Field Theory (SMEFT)

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$$\mathcal{L}_{\mathrm{SMEFT}} = \mathcal{L}_{\mathrm{SM}} + \sum_{d\geq 5} \sum_{i=1}^{n_d} \frac{C_i^{(d)}}{\Lambda_{\mathrm{UV}}^{d-4}} Q_i^{(d)}$$

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Up to d=6

[B. Grzadkowski et al, 1008.4884]

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- Running of SMEFT Wilson Coefficients (WCs)

$$\mu \frac{dC_i}{d\mu} = \frac{1}{16\pi^2} \sum_j \gamma_{ij}^S C_j$$

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At one loop

[E. Jenkins et al, 1308.2627]

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[R. Alonso et al, 1312.2014]

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$$\mathcal{L}_{\mathrm{LEFT}} = \mathcal{L}_{\mathrm{QCD+QED}} + \mathcal{L}_{\not{L}}^{(3)} + \sum_{d\geq 5} \sum_{i=1}^{n_d} \frac{L_i^{(d)}}{v^{d-4}} \mathcal{O}_i^{(d)}$$

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Up to d=6 and matching with SMEFT

[E. Jenkins et al, 1709.04486]

Low-energy Effective Field Theory (LEFT)

- Running of LEFT WC

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↓ **At one loop**

[E. Jenkins et al, 1711.05270]

NSI + EFT: The Strategy

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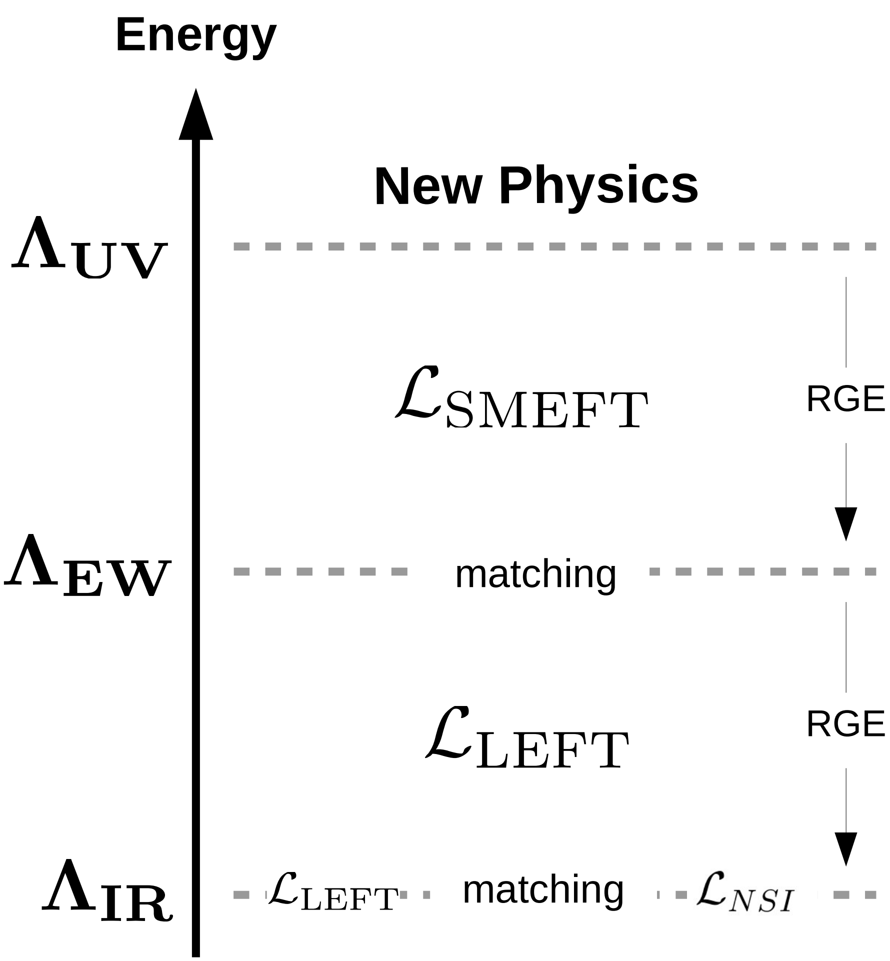
- We can now bring the bounds coming from low (high) energy experiments to high (low) energies

NSI + EFT: The Strategy



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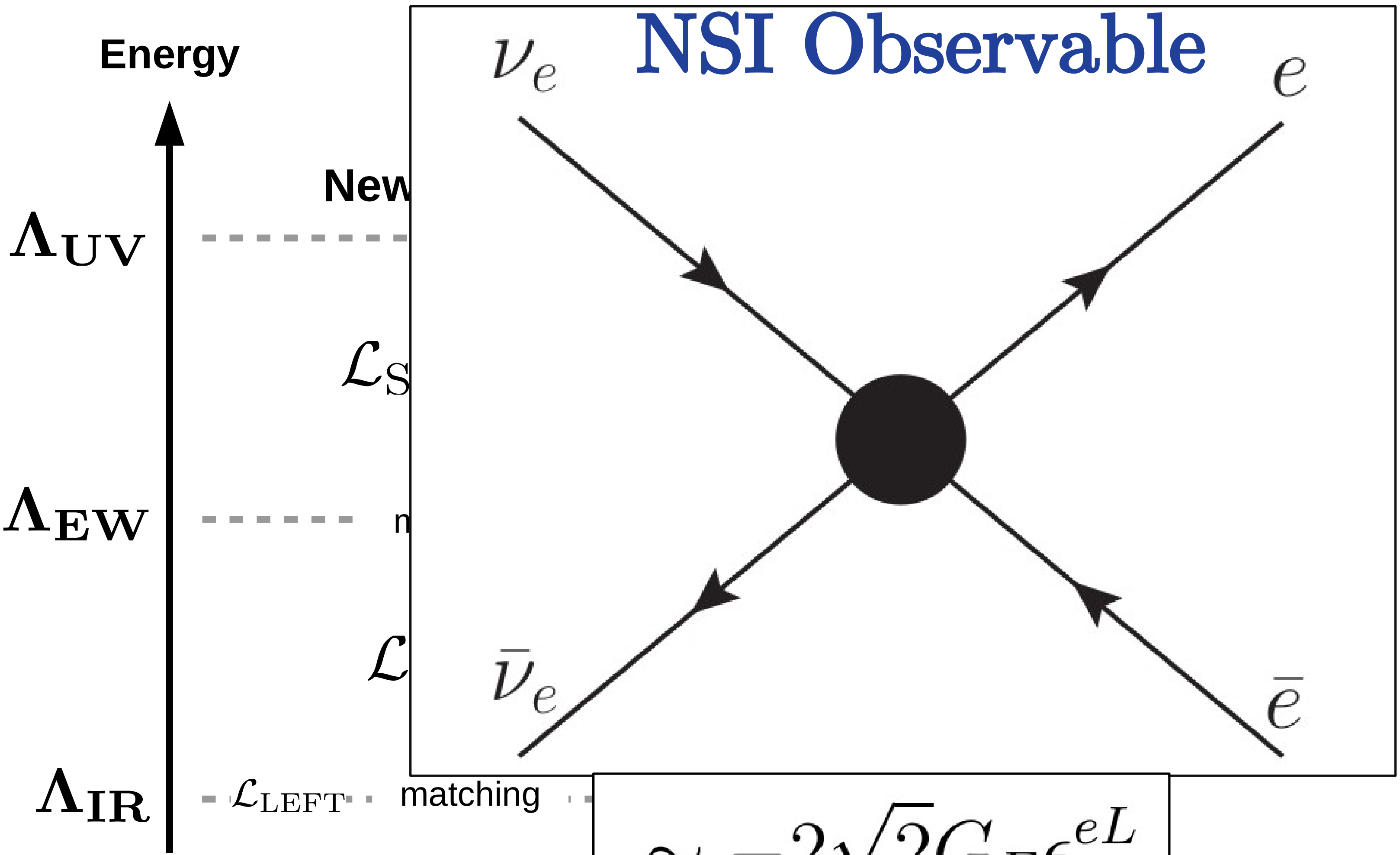

$$\sim -2\sqrt{2}G_F\epsilon_{ee}^{eL}$$

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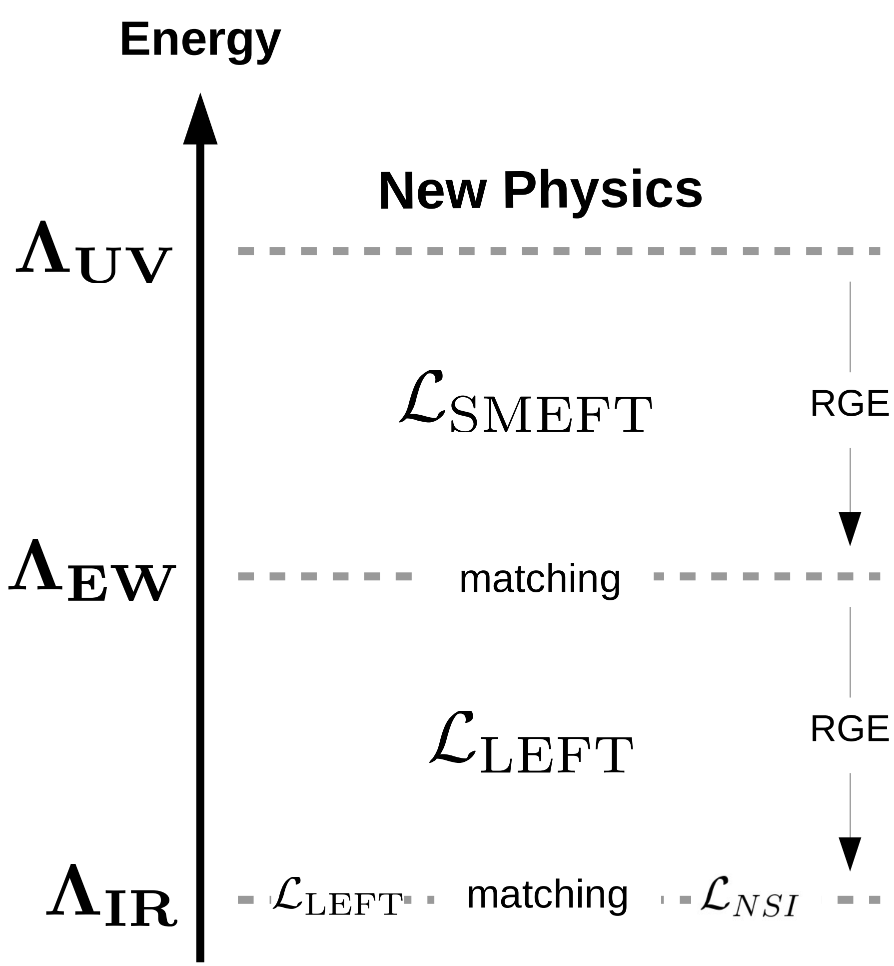

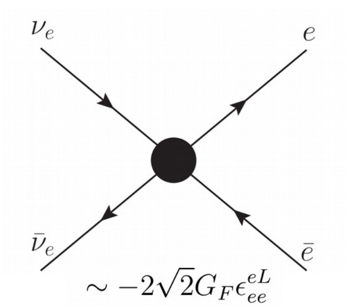

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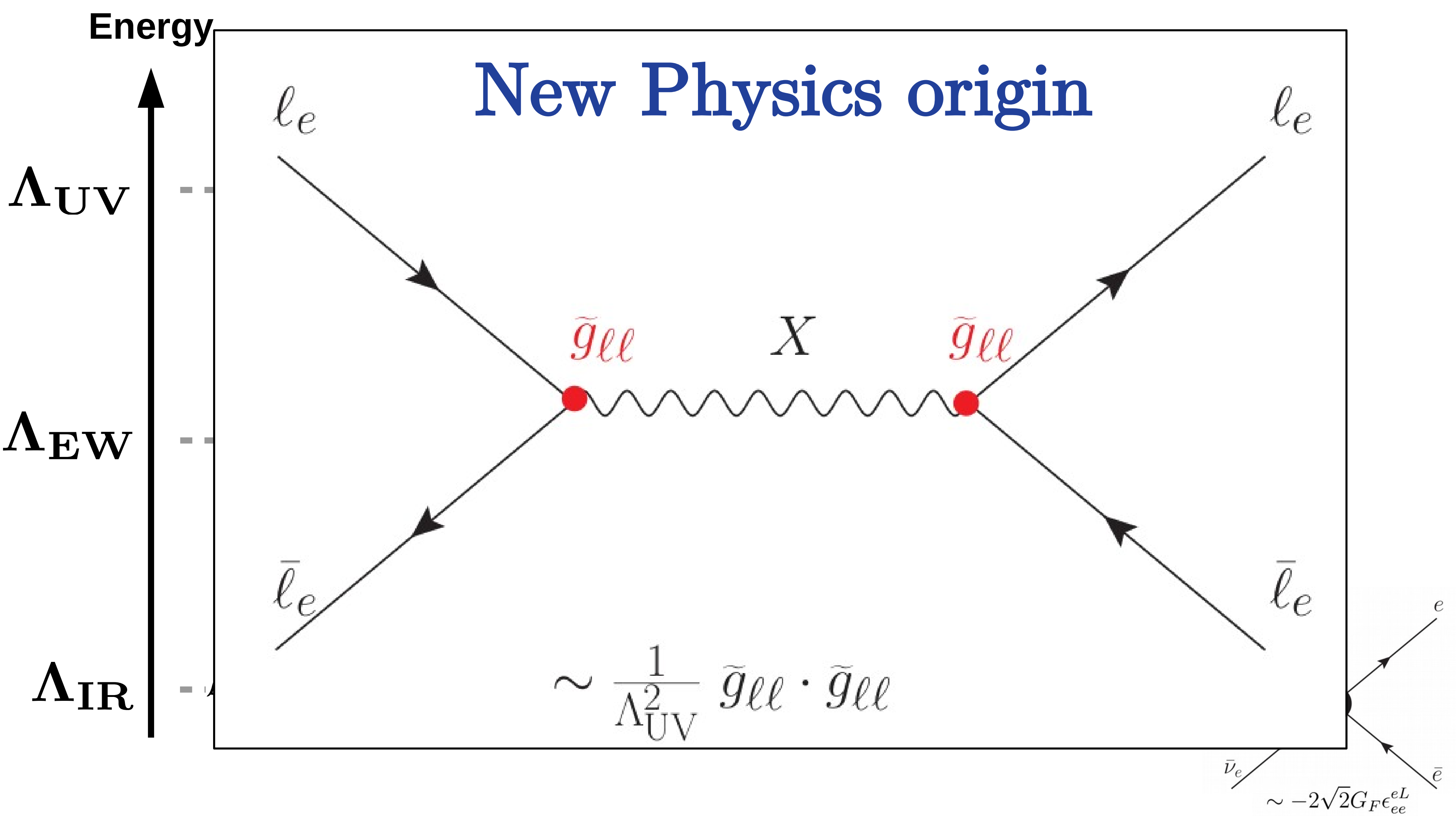

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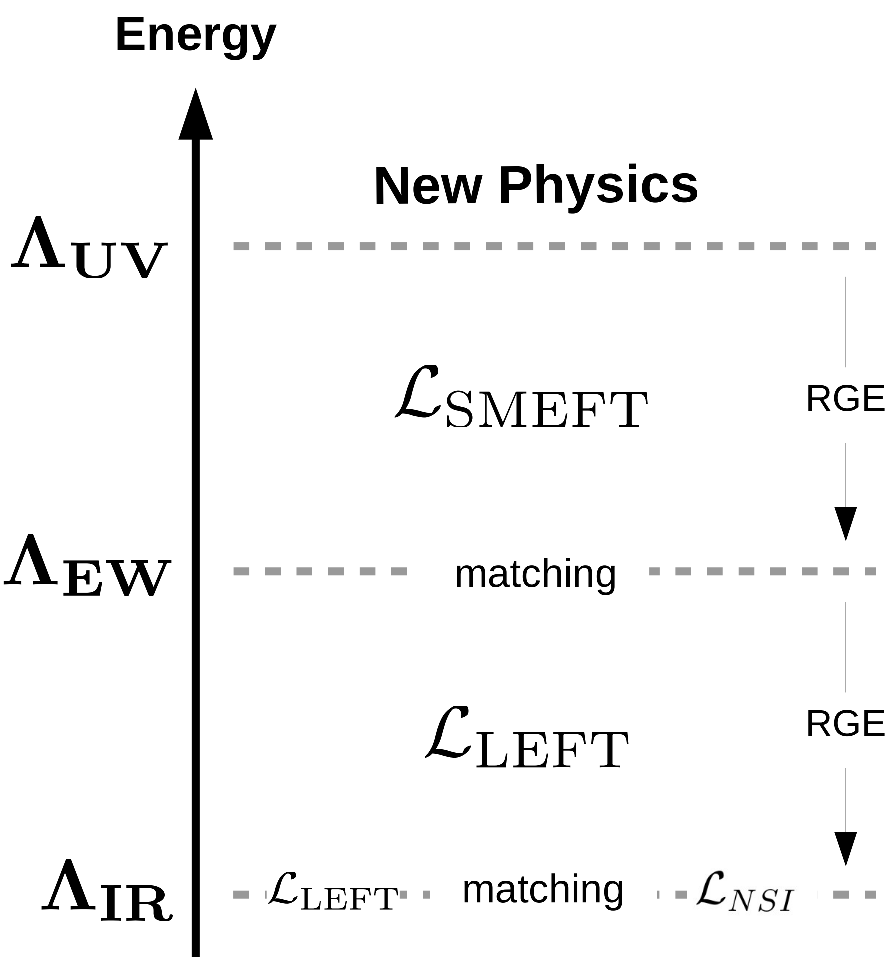

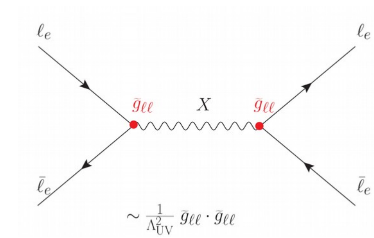

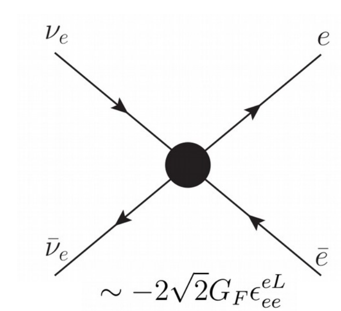

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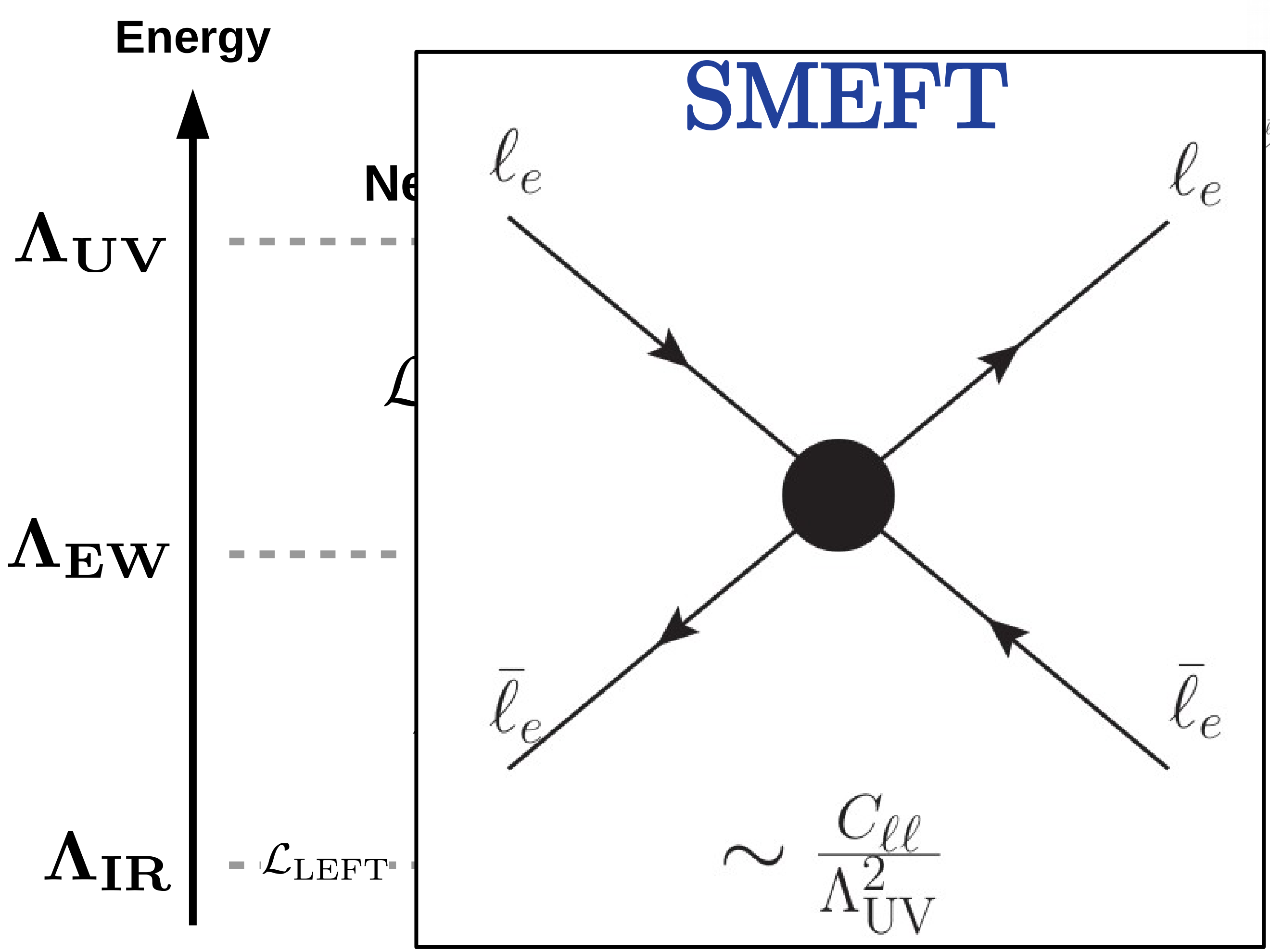

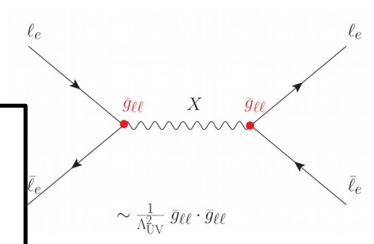

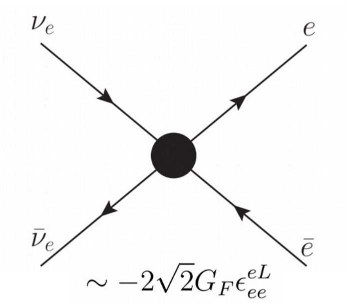

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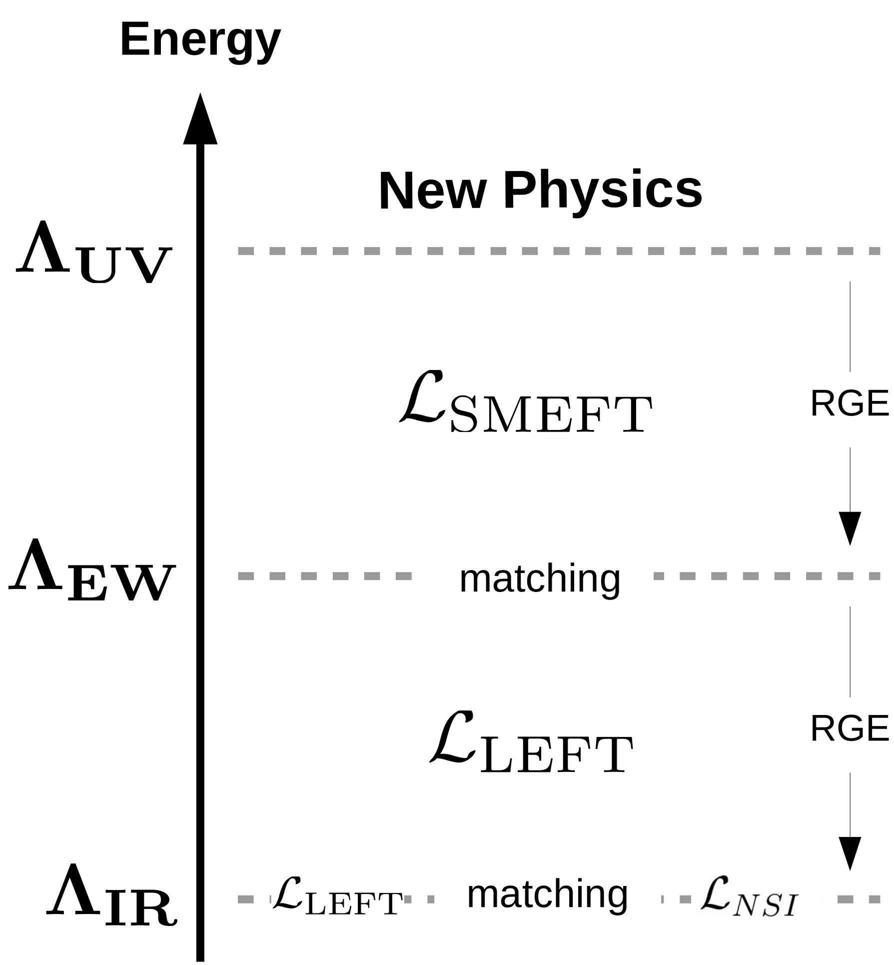

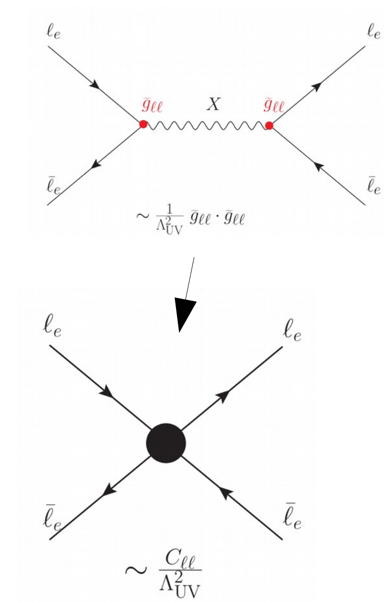

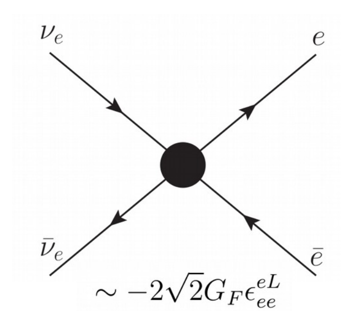

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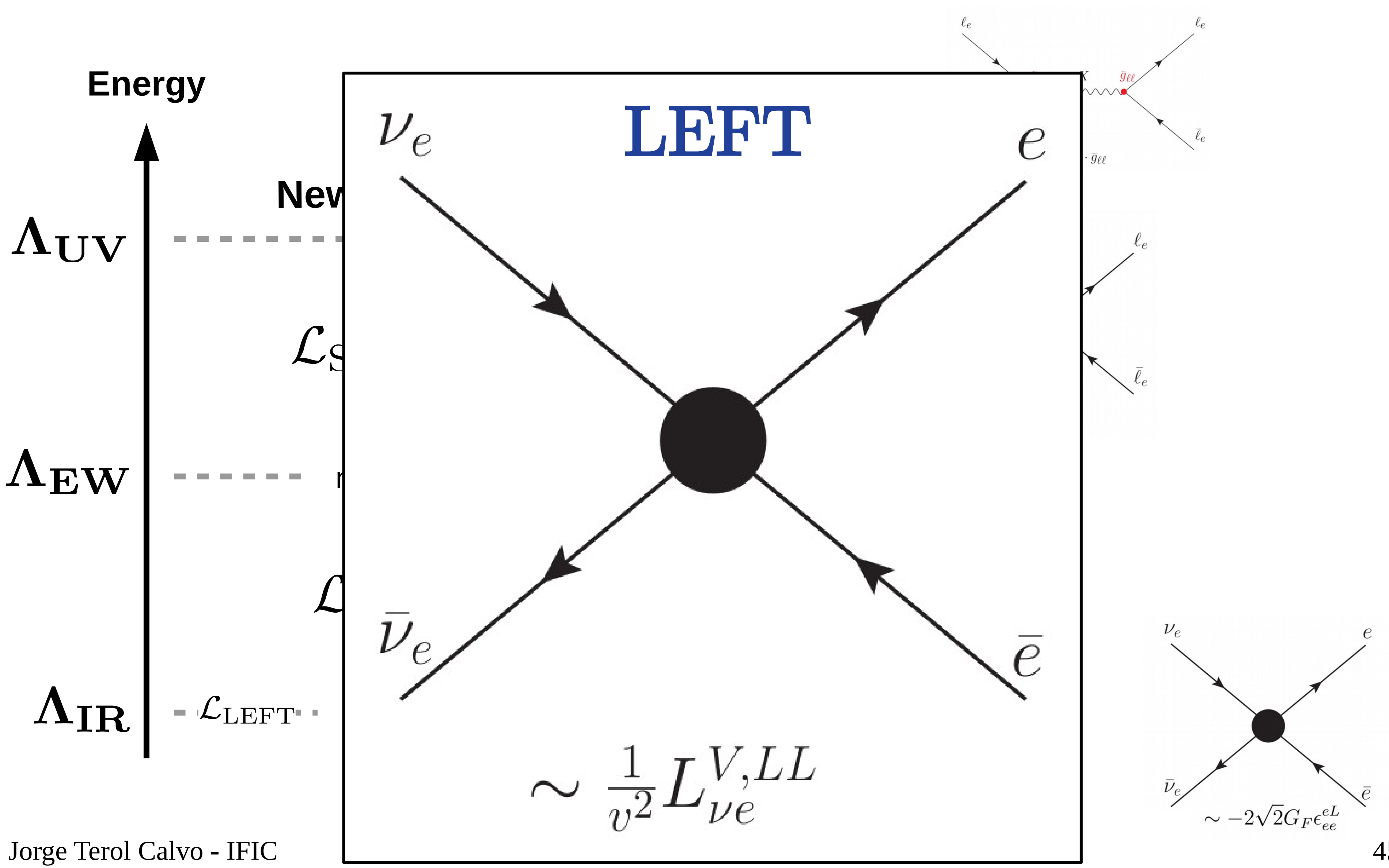

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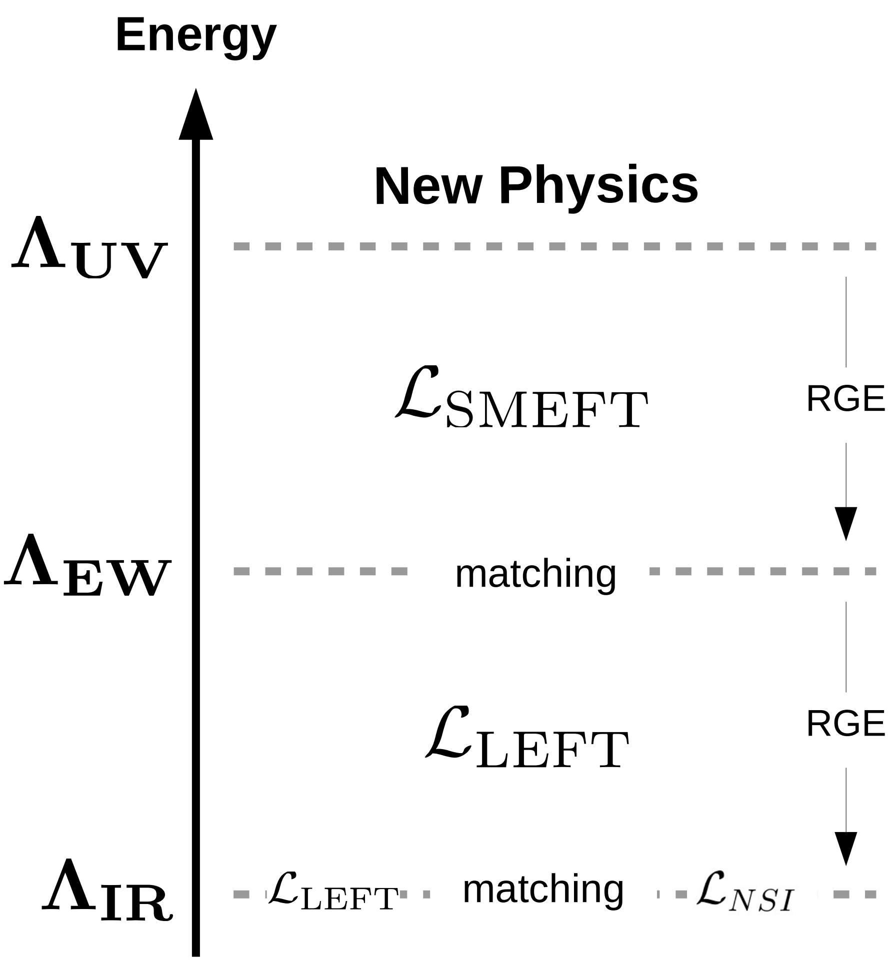

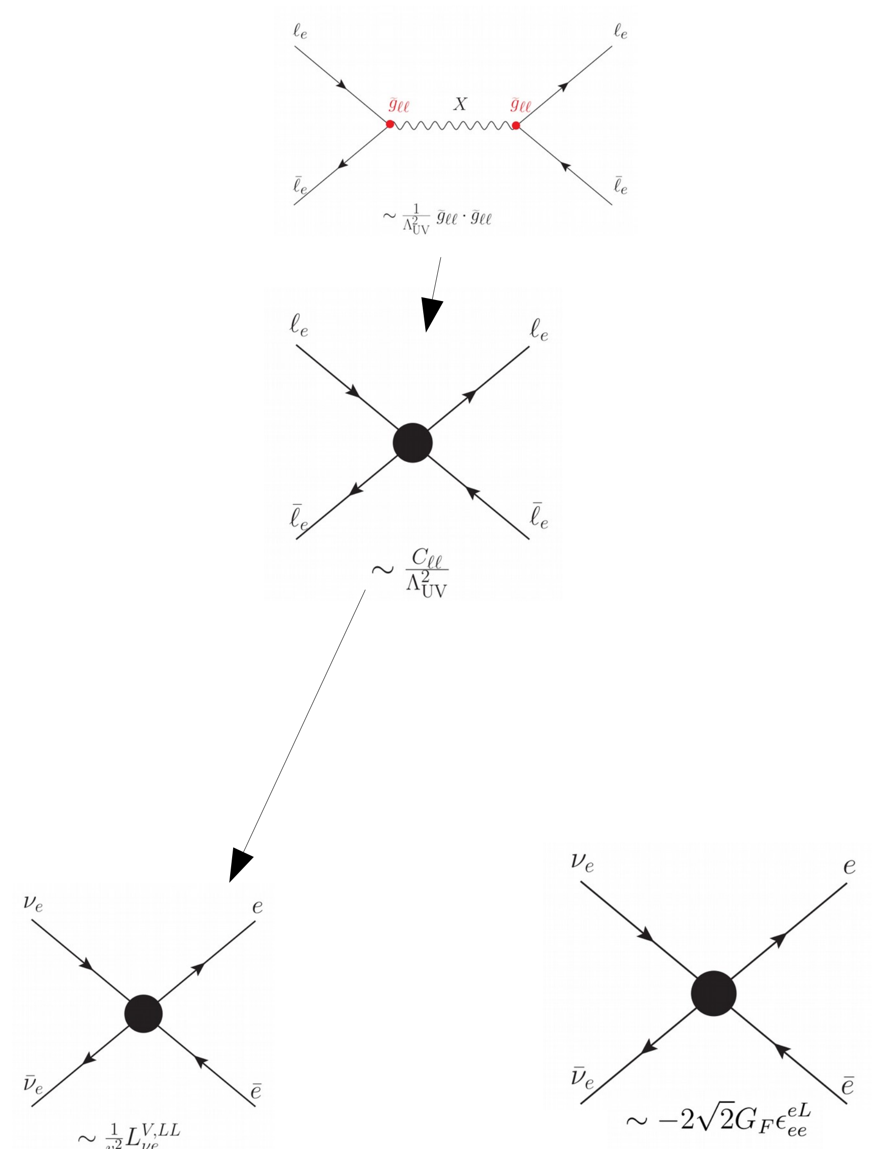

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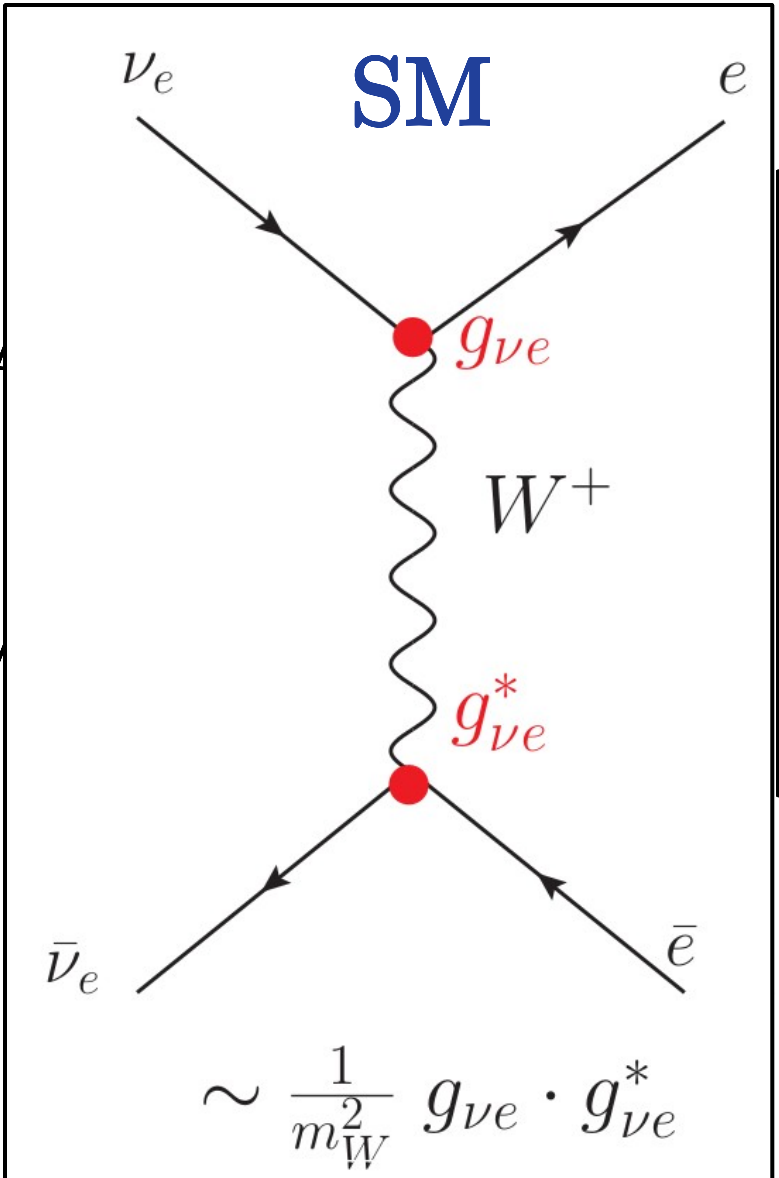

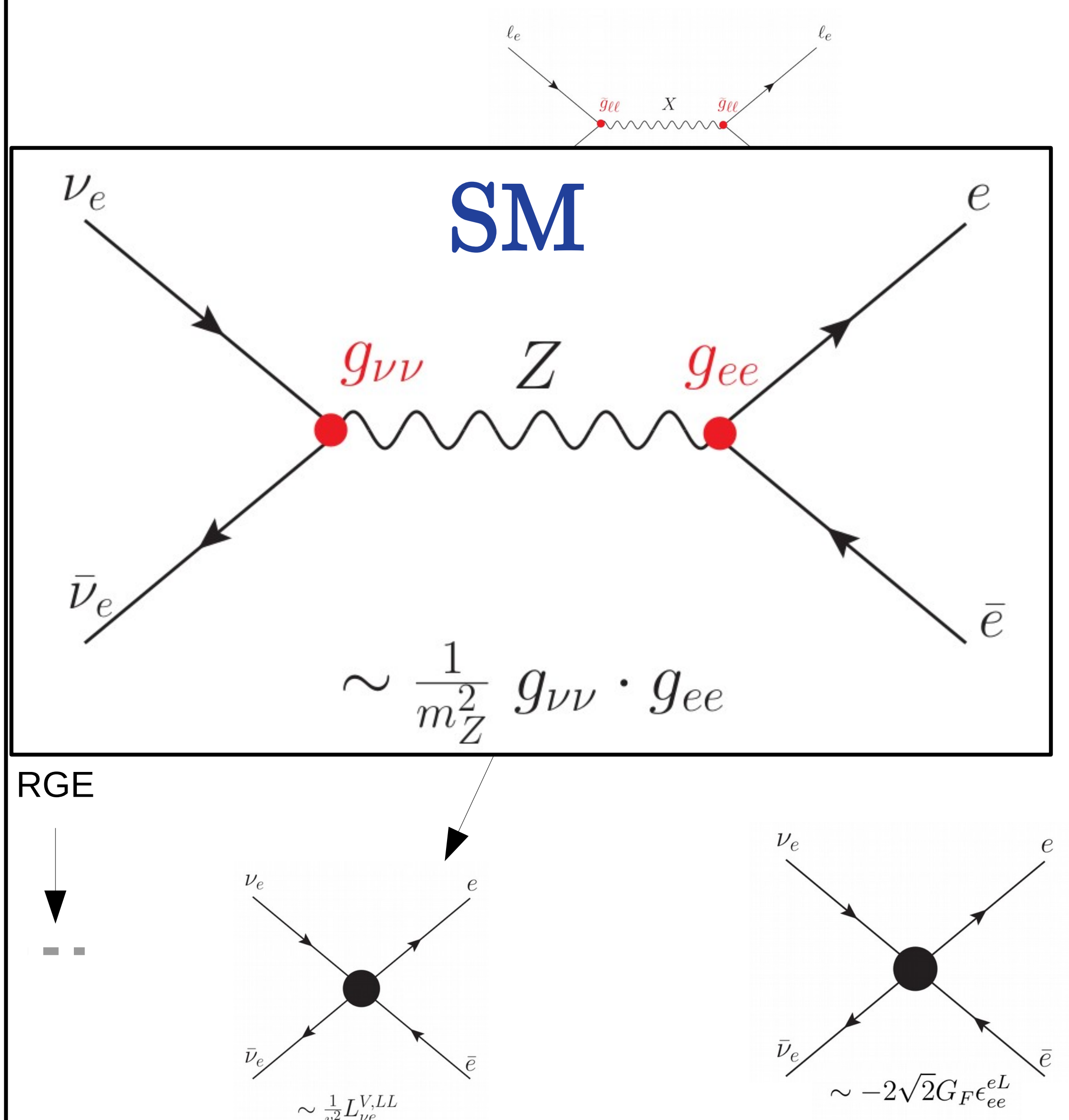

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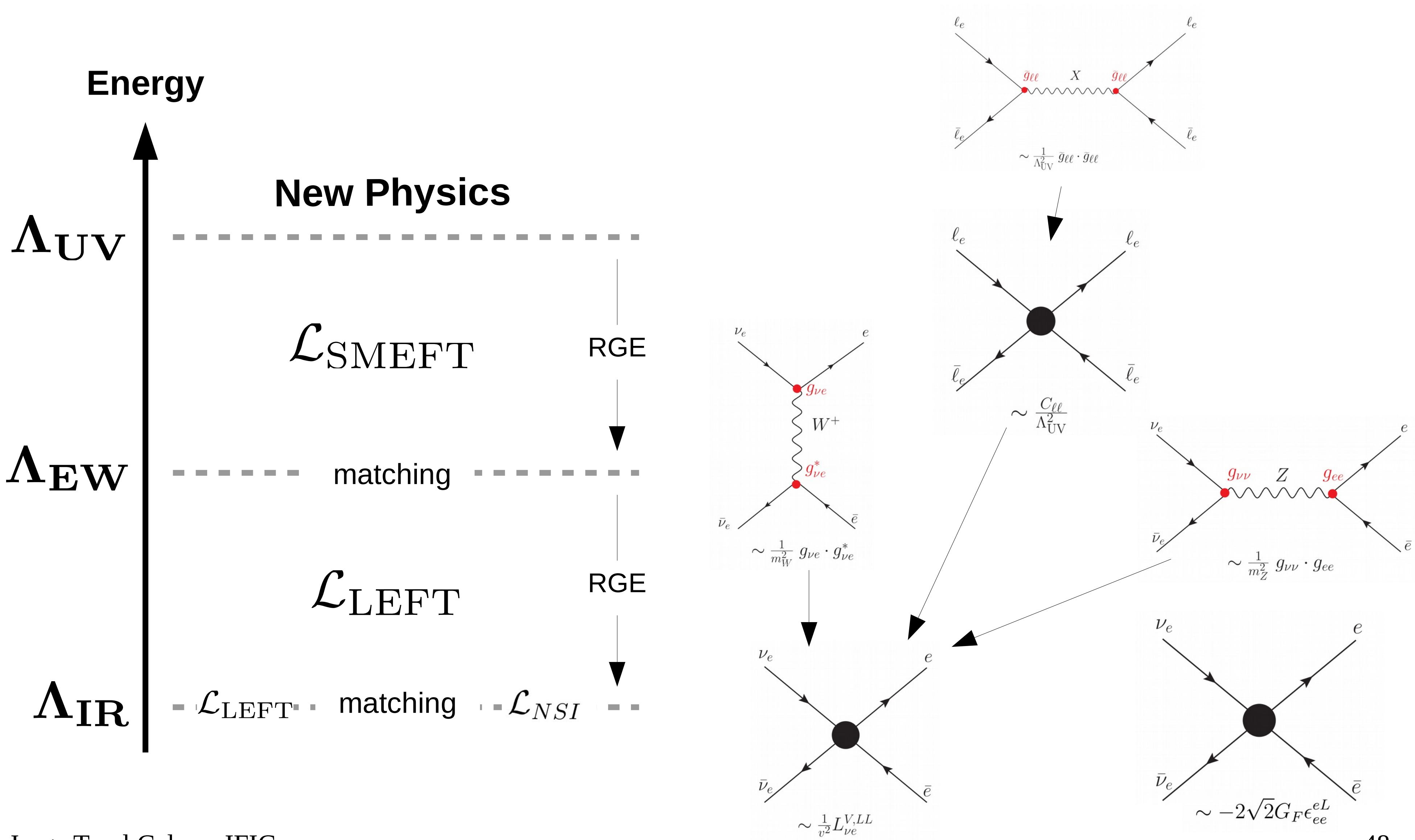

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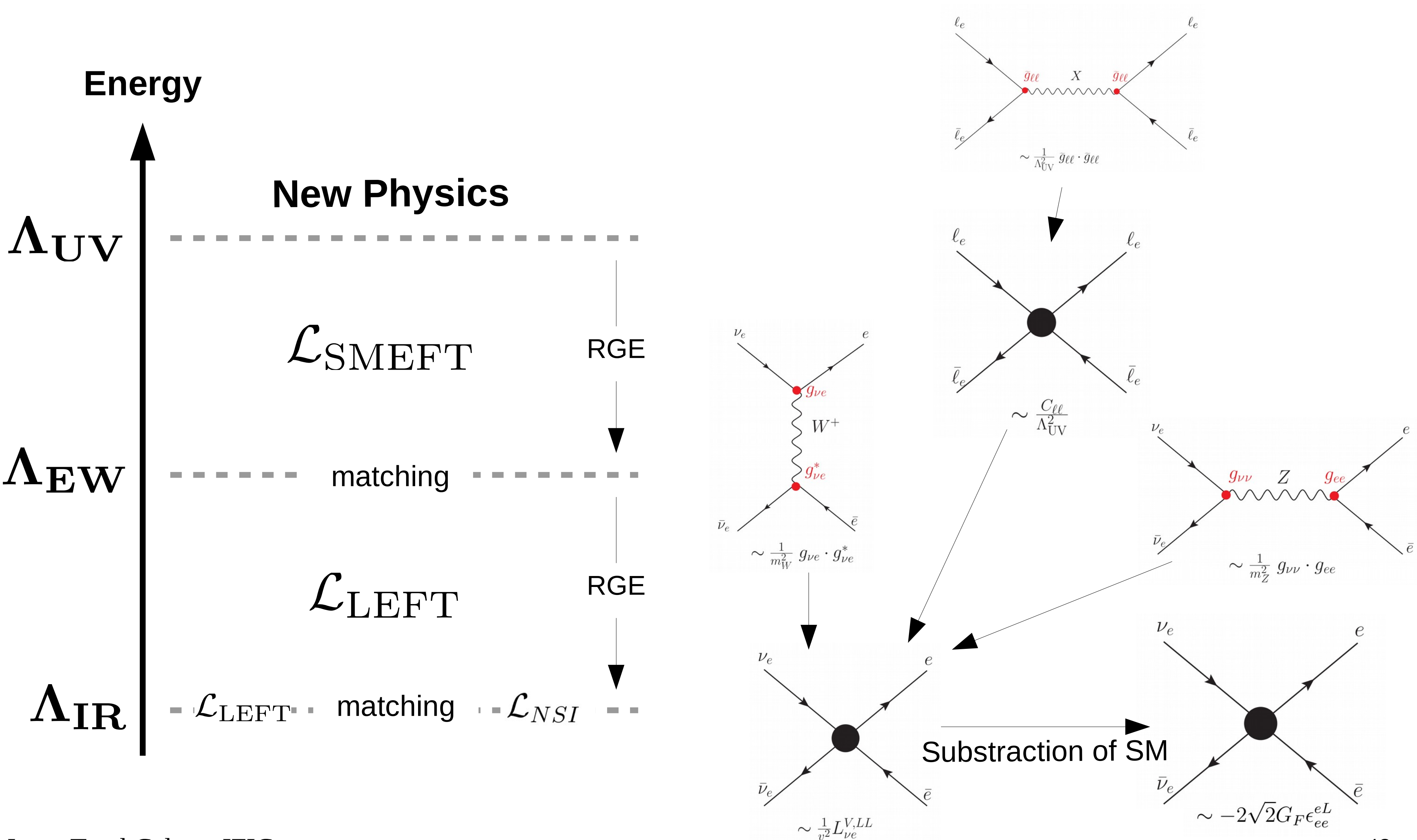

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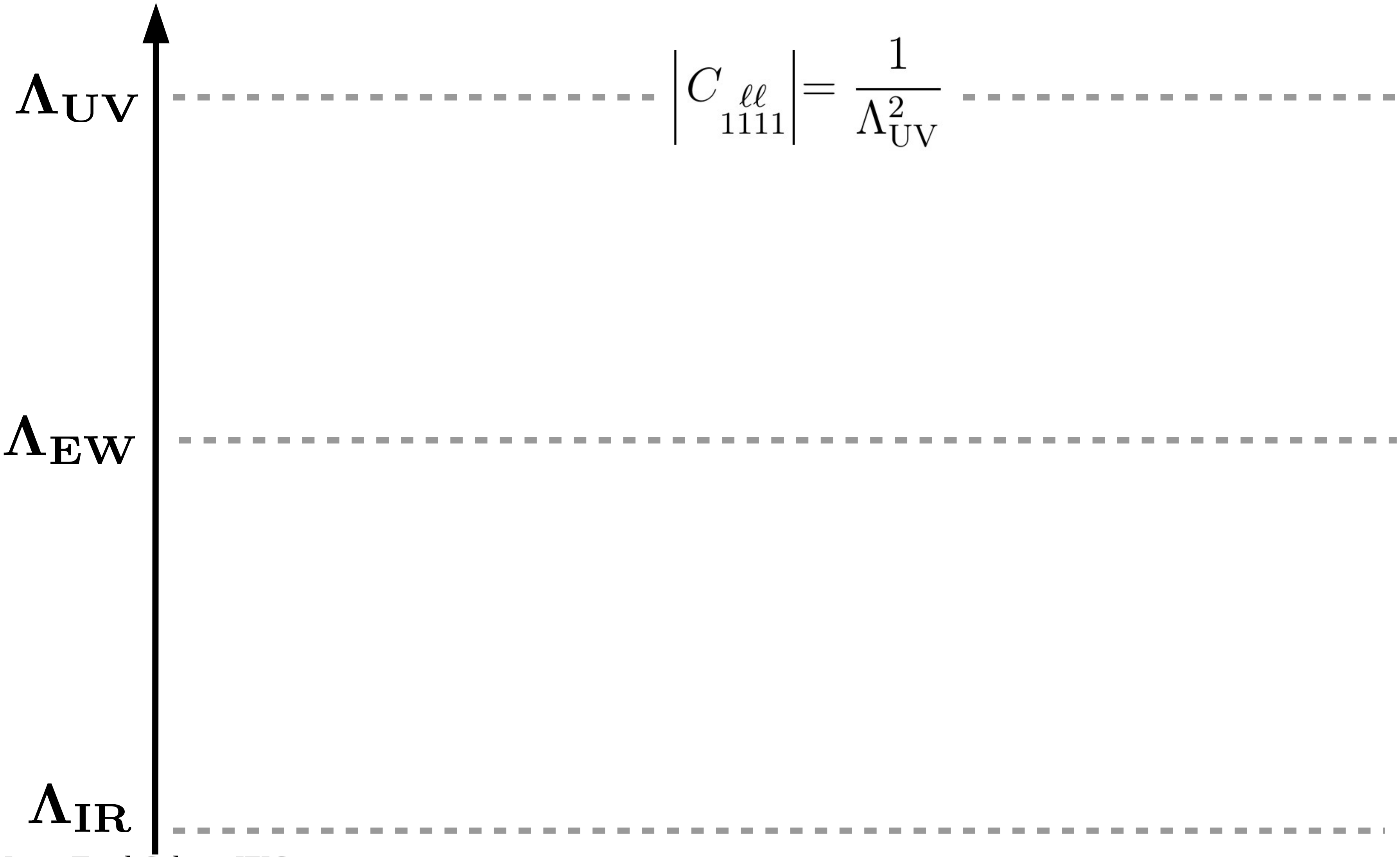

NSI + EFT: The Strategy

$\Lambda_{\mathbf{UV}}$

$$\left| C_{\substack{\ell\ell \\ 1111}} \right| = \frac{1}{\Lambda_{\rm UV}^2}$$

$$\dot{C}_{\substack{\ell\ell \\ 1111}} \sim 2 \left[Y_e^\dagger Y_e \right]_{11} C_{\substack{\ell\ell \\ 1111}}$$

+ all SMEFT RGE

$\Lambda_{\mathbf{EW}}$

$\Lambda_{\mathbf{IR}}$

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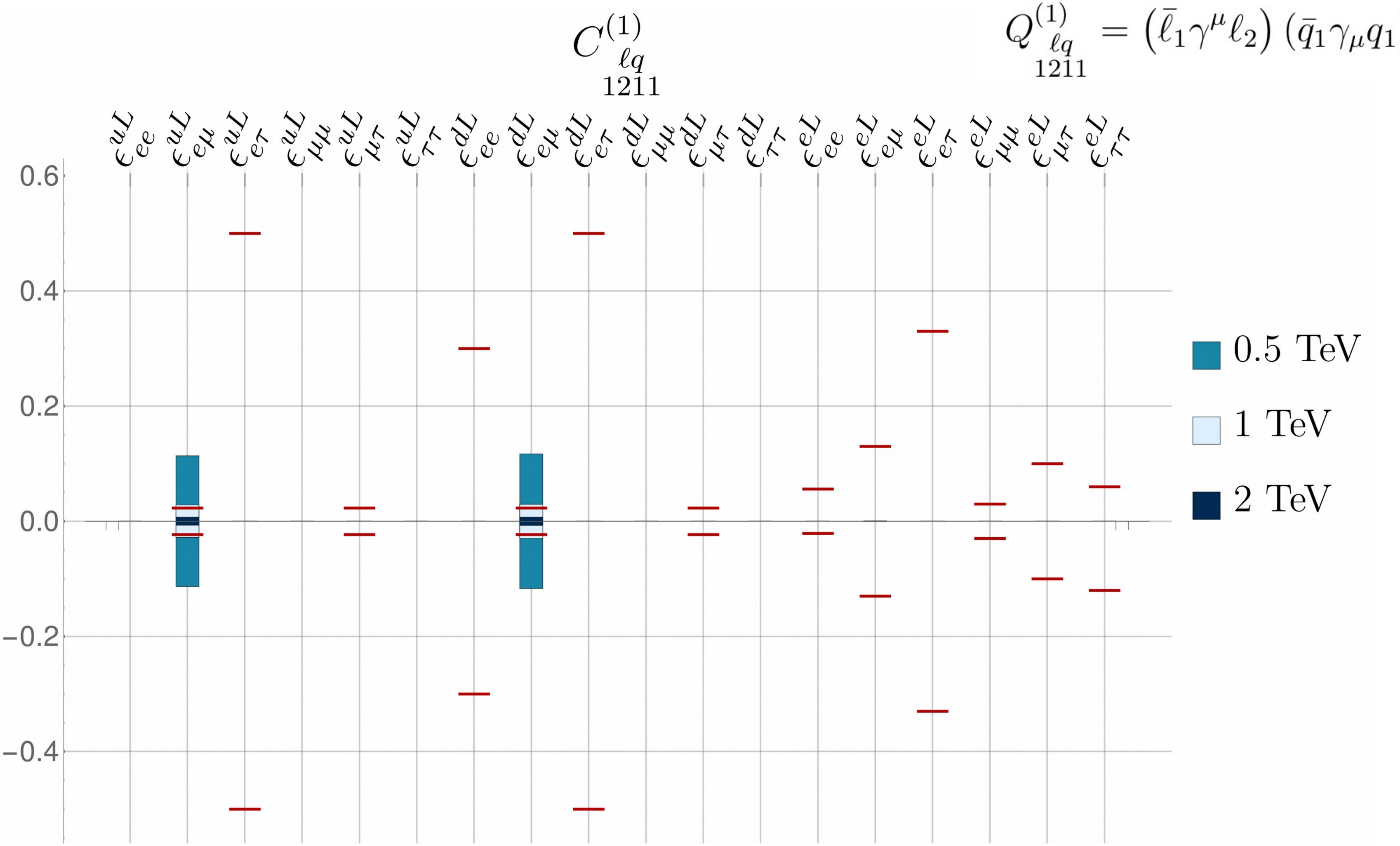
- Compared with experimental limits from

[Farzan and Tórtola, 1710.09360]

Numerical Results: What we get



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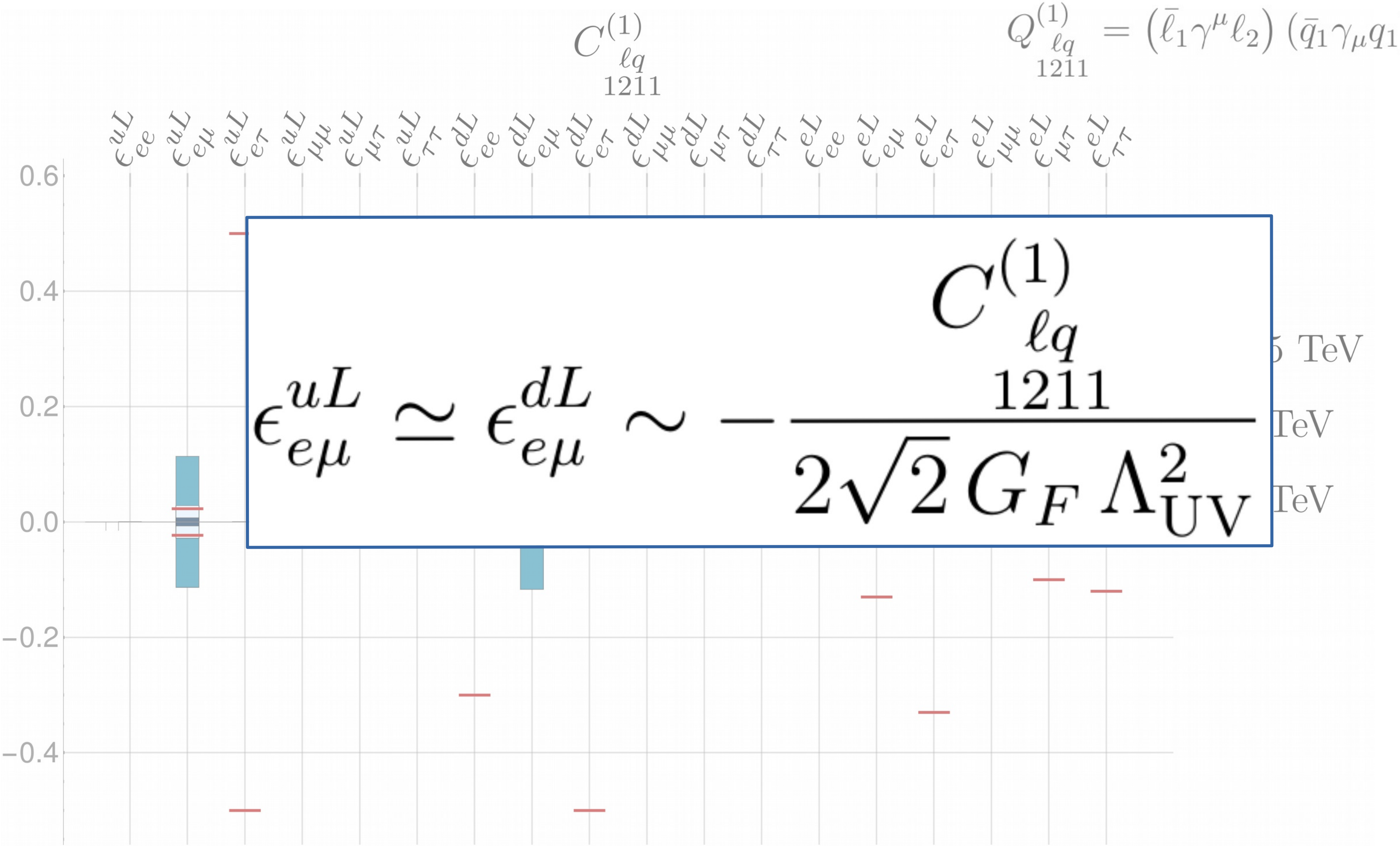

$$\epsilon^{uL}_{e\mu} \simeq \epsilon^{dL}_{e\mu} \sim -\frac{C^{(1)}_{\substack{\ell q\\1211}}}{2\sqrt{2}\,G_F\,\Lambda^2_{\mathrm{UV}}}$$

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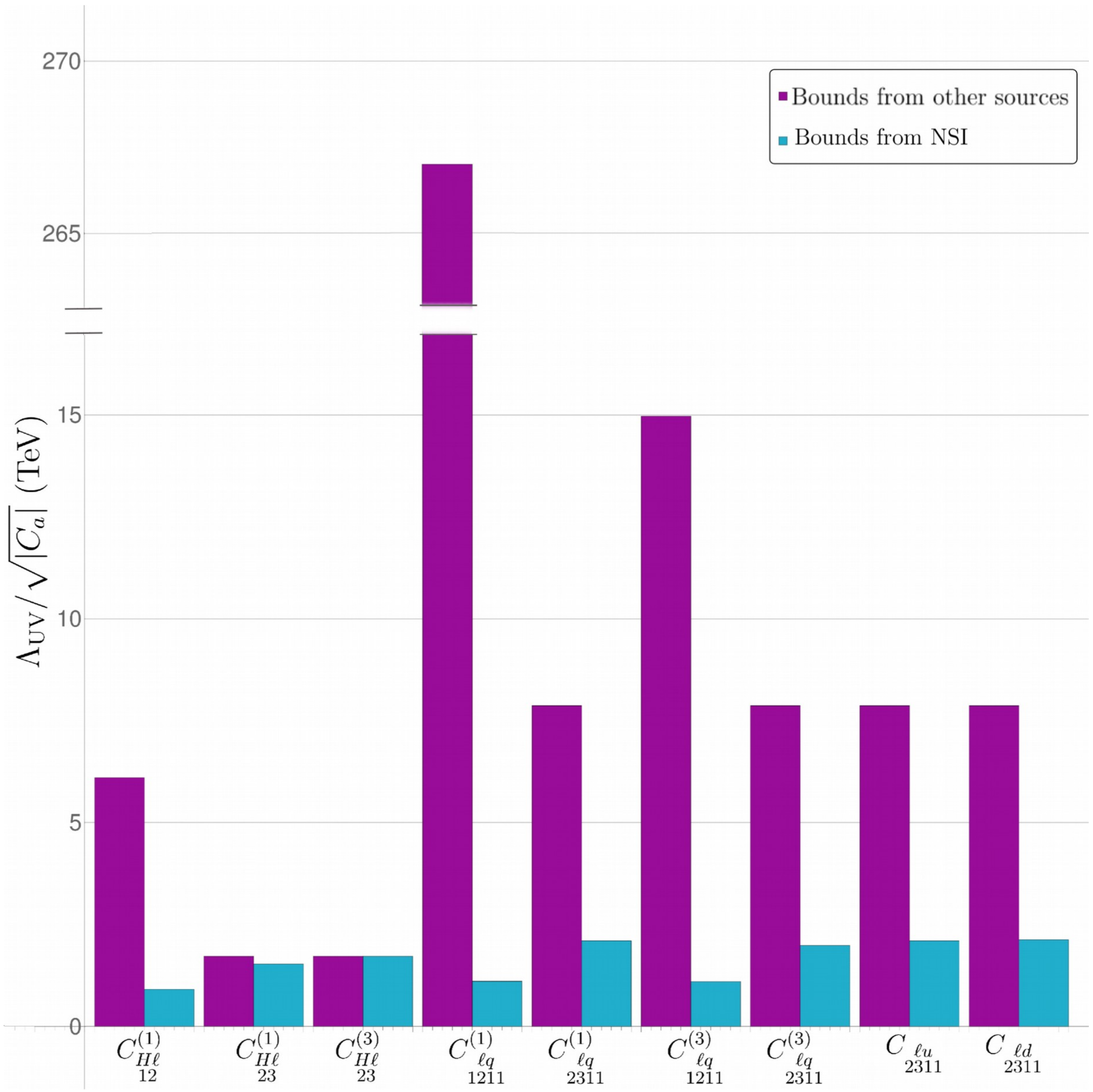
      [Cerri et al, 1812.07638]

Limits on SMEFT WCs from NSI: LFV



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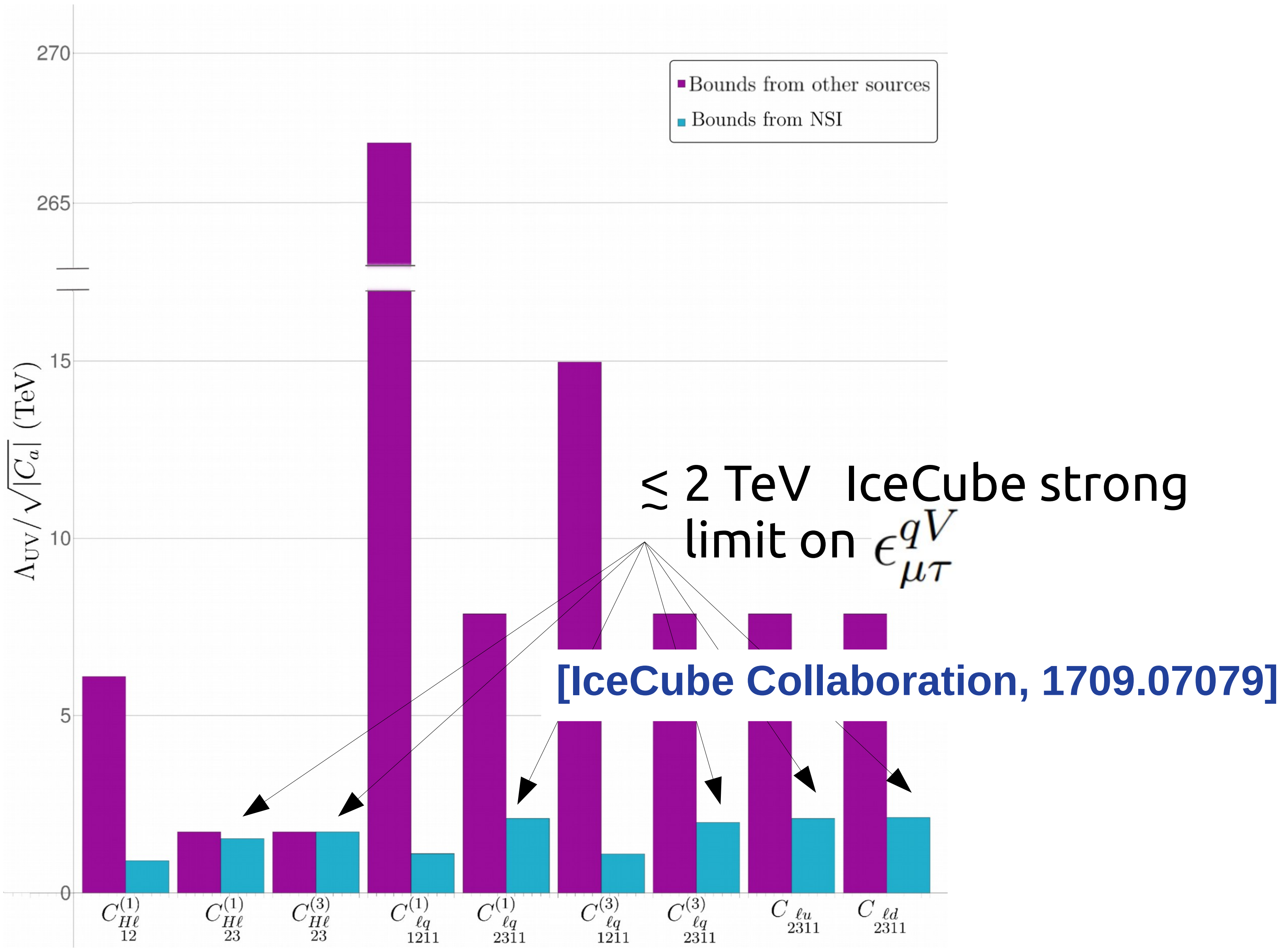
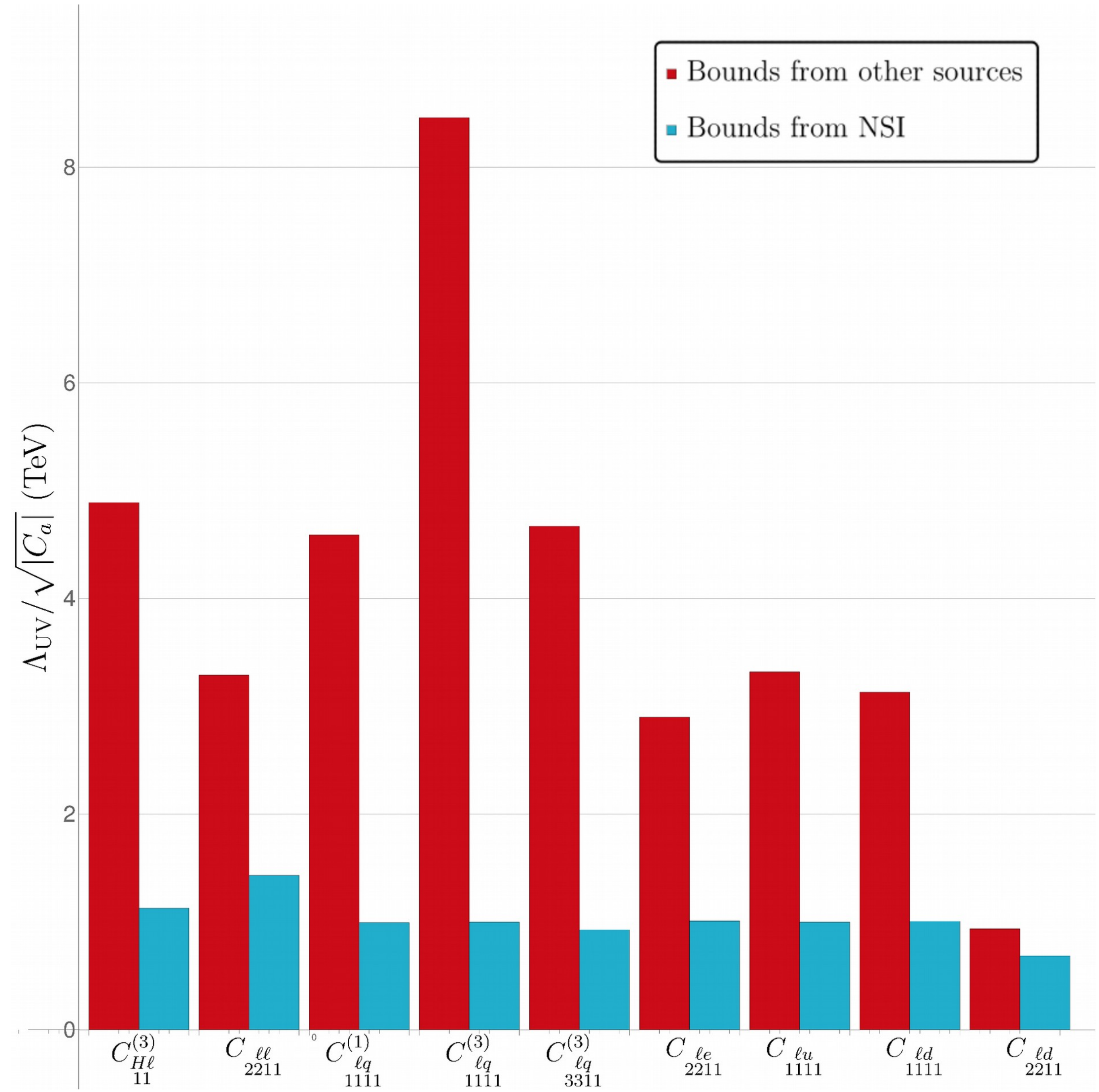


Limits on SMEFT WCs from NSI: LFC



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- Examples:

SMEFT WCs	RGE ✓	RGE ✗
$C^{(1)}_{\substack{H\ell \\ 23}}$	1.99 TeV	1.89 TeV
$C^{(3)}_{\substack{\ell q \\ 2311}}$	1.53 TeV	1.61 TeV

Conclusions

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- Systematic approach including full one-loop RGE running effects.

- The analysis has its limitations: One operator at a time, not includes CC-NSI...

Thank you!

Back Up Slides

NSI experiments

- Neutrino-Nucleon Scattering data $\epsilon_{e\mu}^{qL}$
- Combined analysis of atmospheric and neutrino-nucleon scattering data $\epsilon_{\mu\mu}^{dV}$
- Analysis of the atmospheric neutrino signal in IceCube DeepCore $\epsilon_{\mu\tau}^{qV}$
- Combined analysis of solar and KamLAND reactor data ϵ_{ee}^{eL}
- Combined analysis of reactor and accelerator data $\epsilon_{\mu\mu}^{eL}$
- Combination of oscillation and coherent neutrino-nucleus scattering data ϵ_{ee}^{uV}
- Analysis of atmospheric neutrino data $\epsilon_{\tau\tau}^{qV}$

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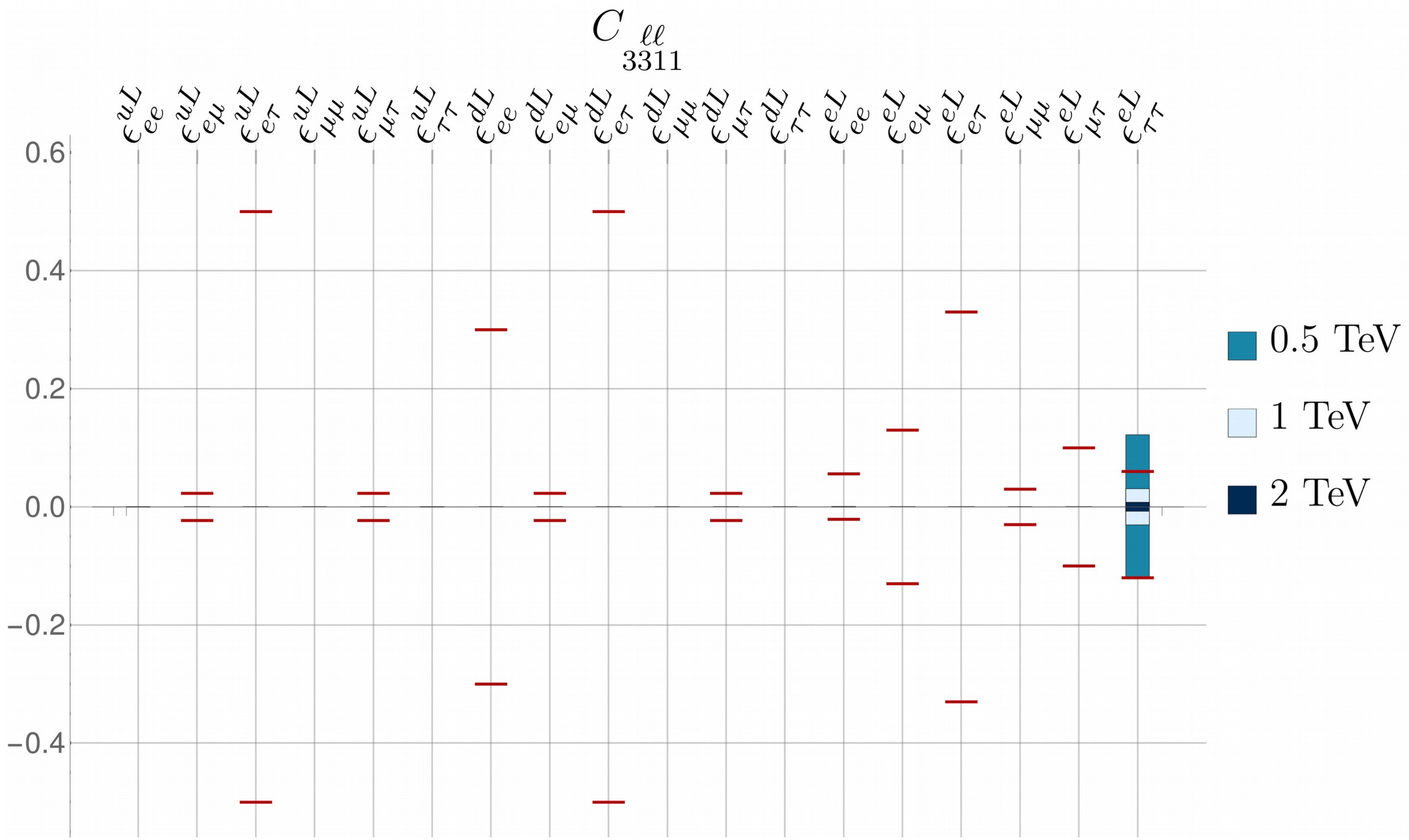

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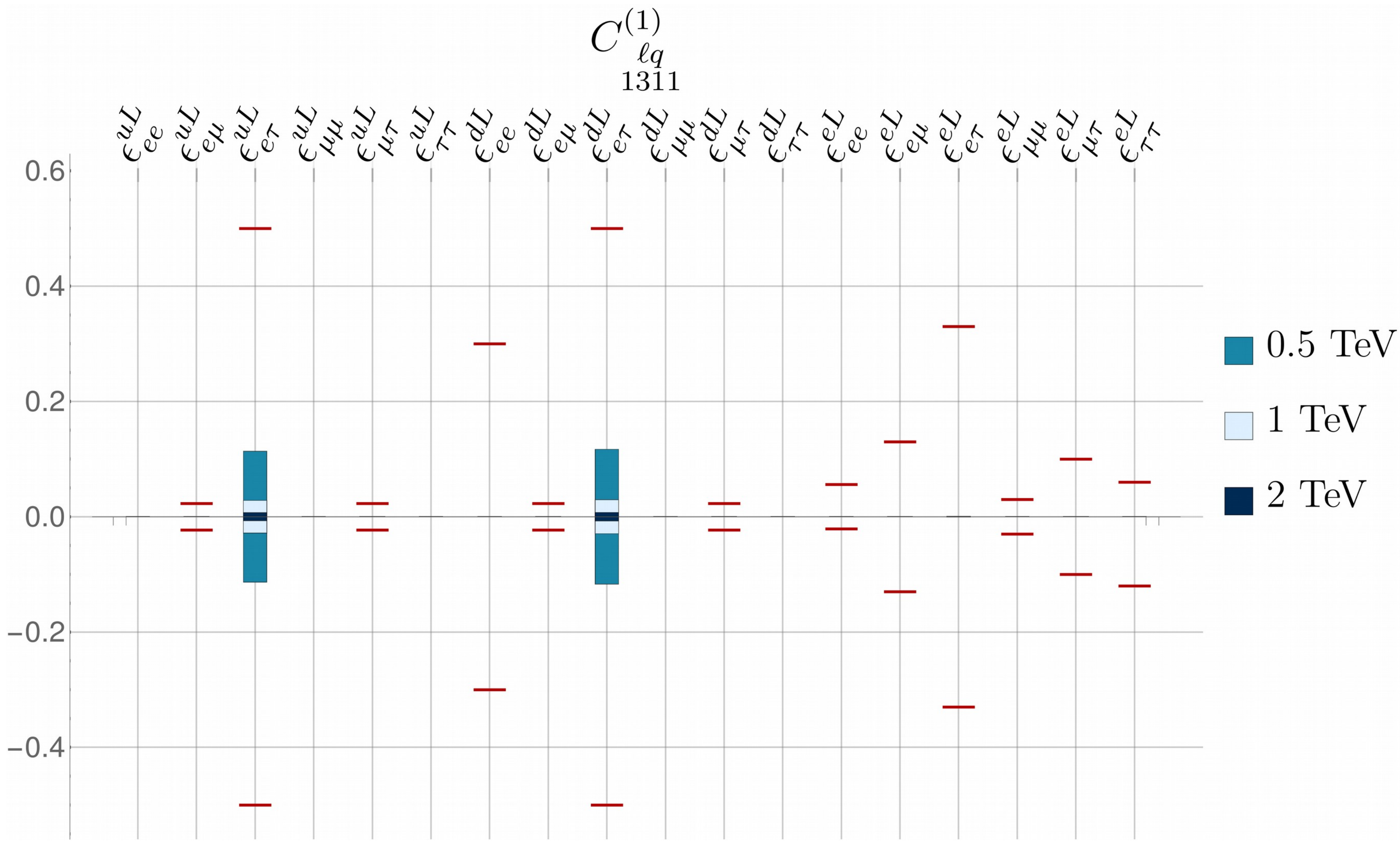

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