Lepton Number Violation and Muon-to-Positron Conversion

KEVIN KELLY

NORTHWESTERN UNIVERSITY

BASED ON [1611.00032] WITH J. BERRYMAN, A. DE GOUVÊA, A. KOBACH

Neutrinos have Mass!

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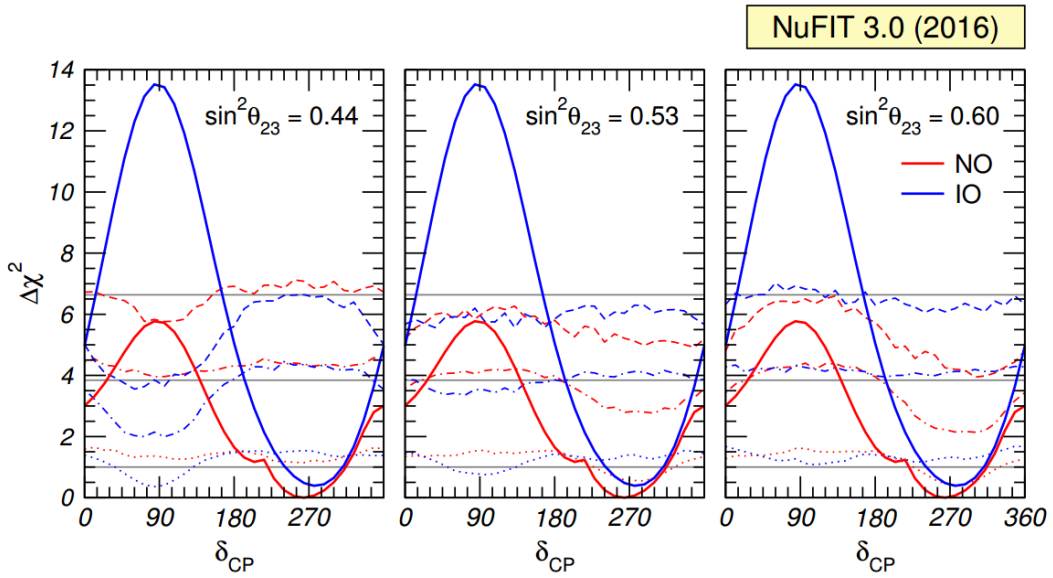
- There's still *plenty* to determine about Neutrinos:
  - CP-violation



[1611.01514]

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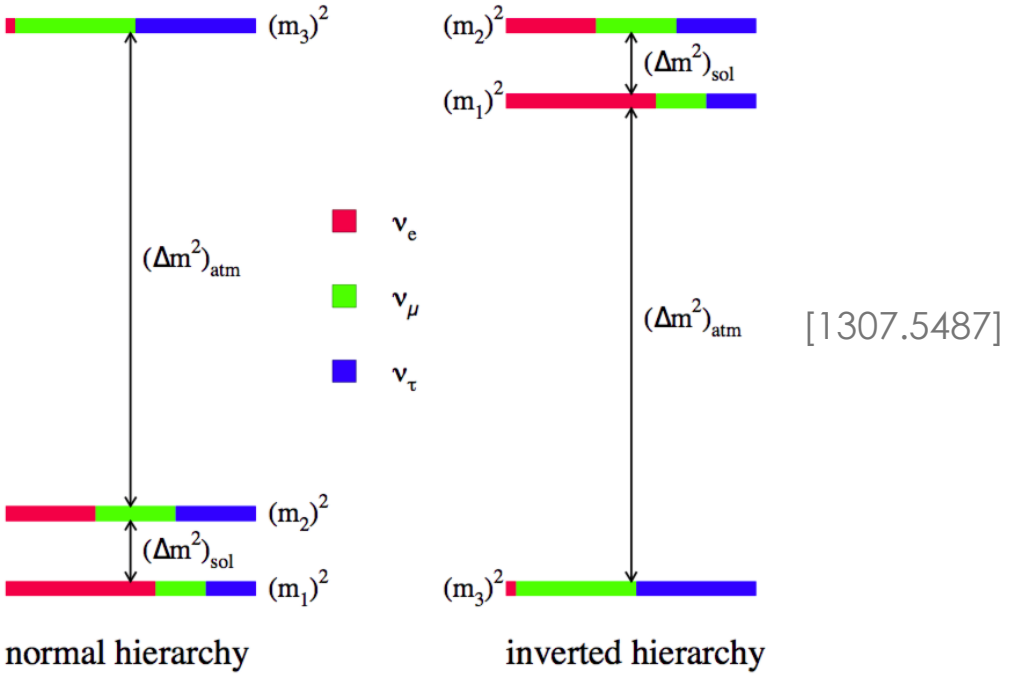
  - Mass Hierarchy



[1307.5487]

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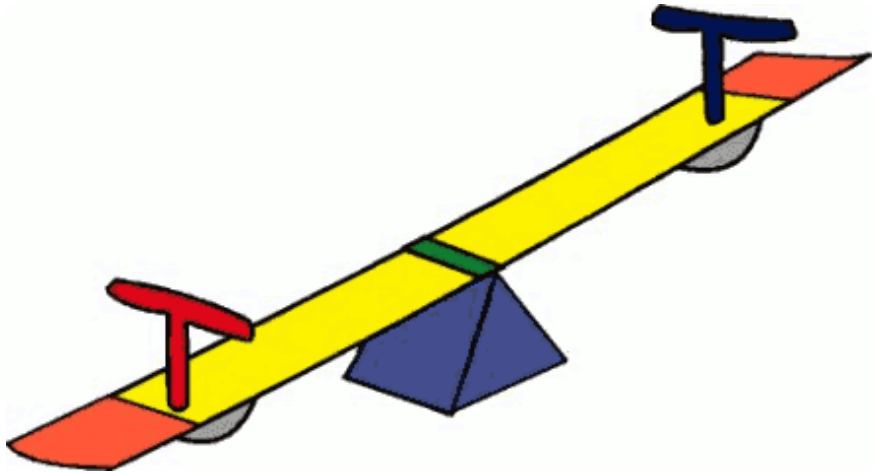
  - **Mass Mechanism**



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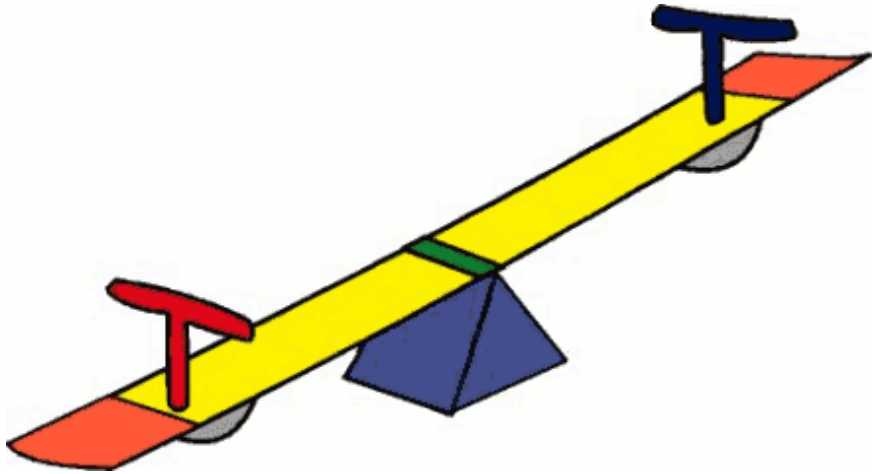

- Goal: study lepton-number-violating processes to probe the nature of neutrino masses

LNV Operators and Neutrino Mass

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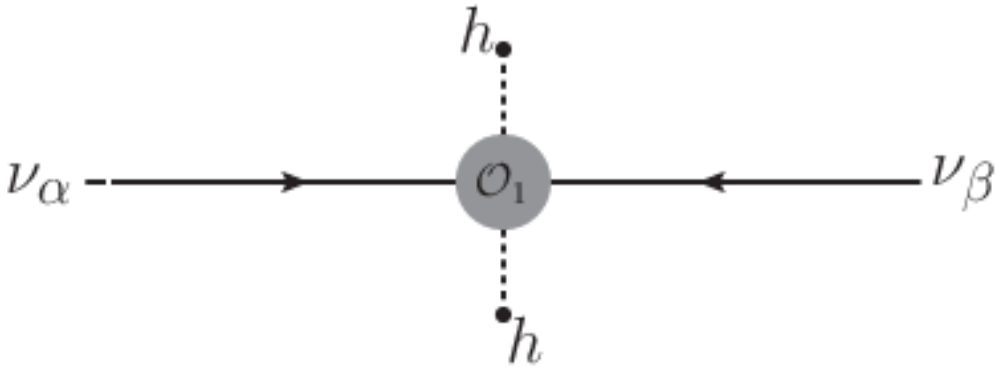

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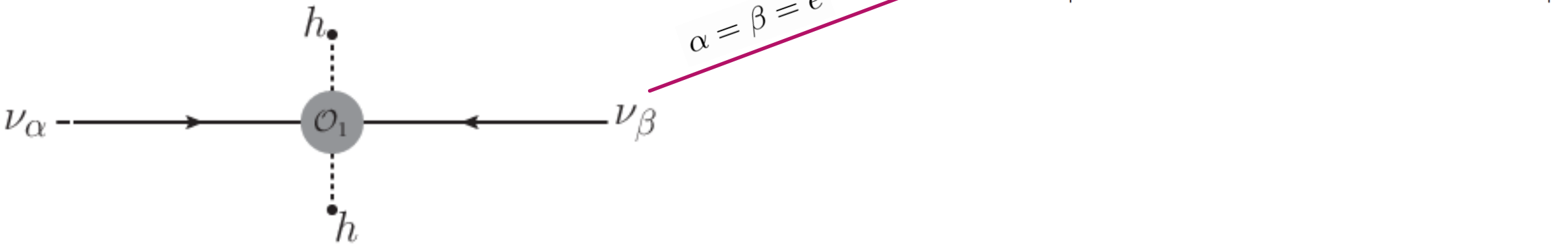

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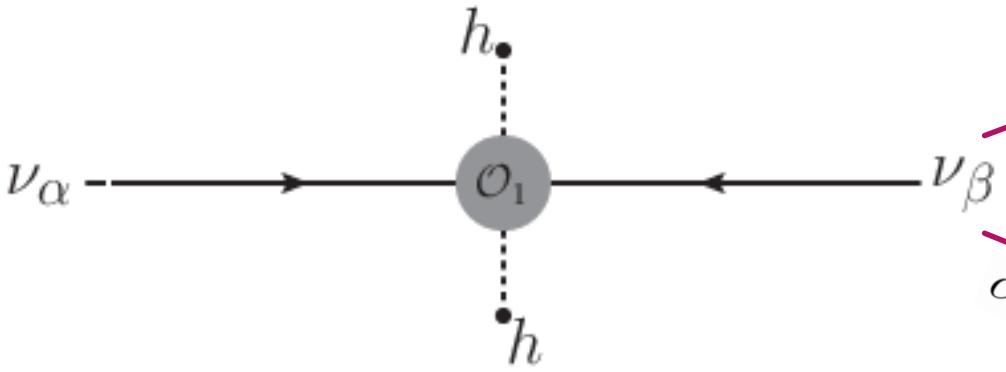

$\alpha = \beta = e$

$$|m_{ee}|^2 \equiv \left|U_{e1}^2 m_1 + U_{e2}^2 m_2 e^{i\alpha_1} + U_{e3}^2 m_3 e^{i\alpha_2}\right|^2$$

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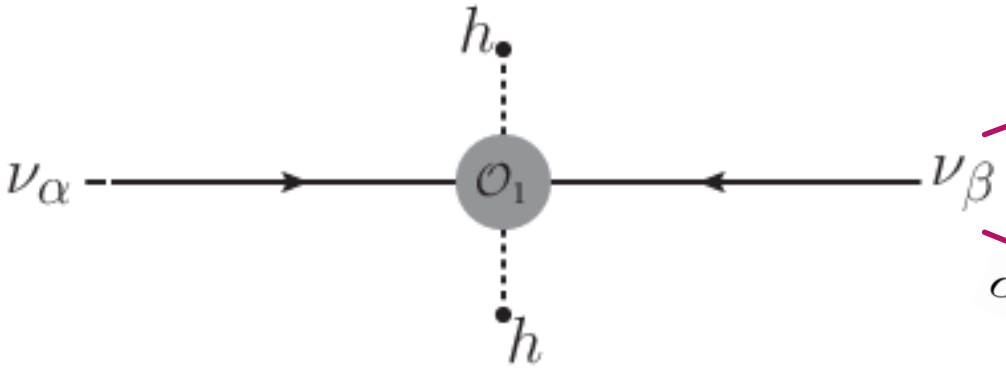
$$\mathcal{O}_1 = \frac{g_{\alpha\beta}}{\Lambda} (L_\alpha H)(L_\beta H)$$



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High-dimension example: Operator 14b

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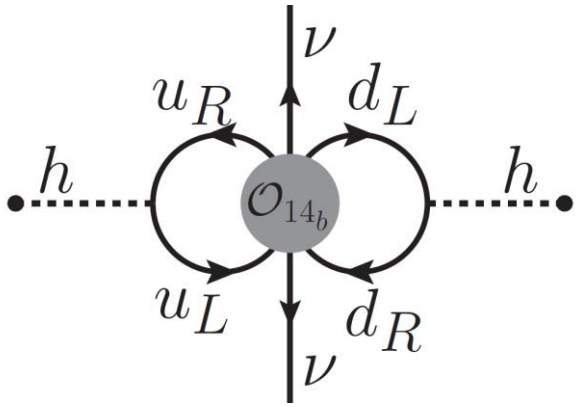

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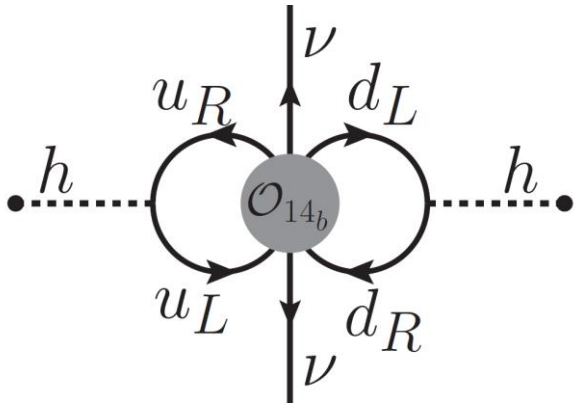

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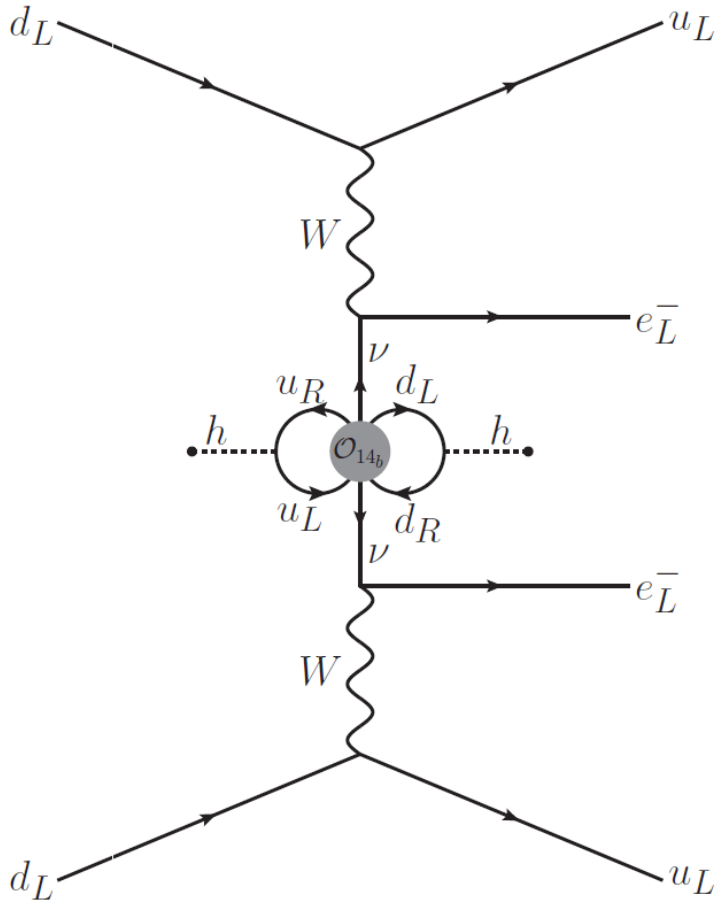
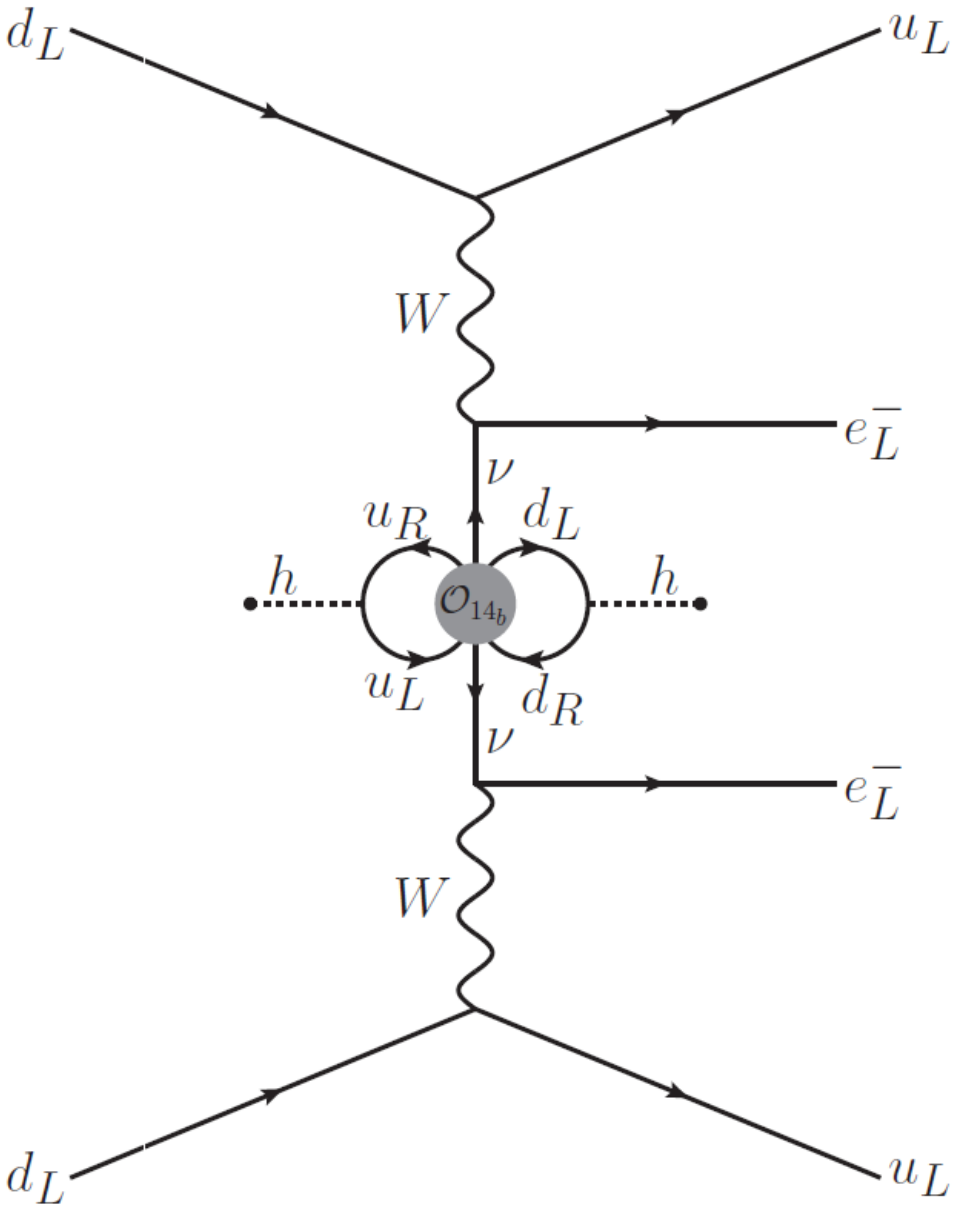
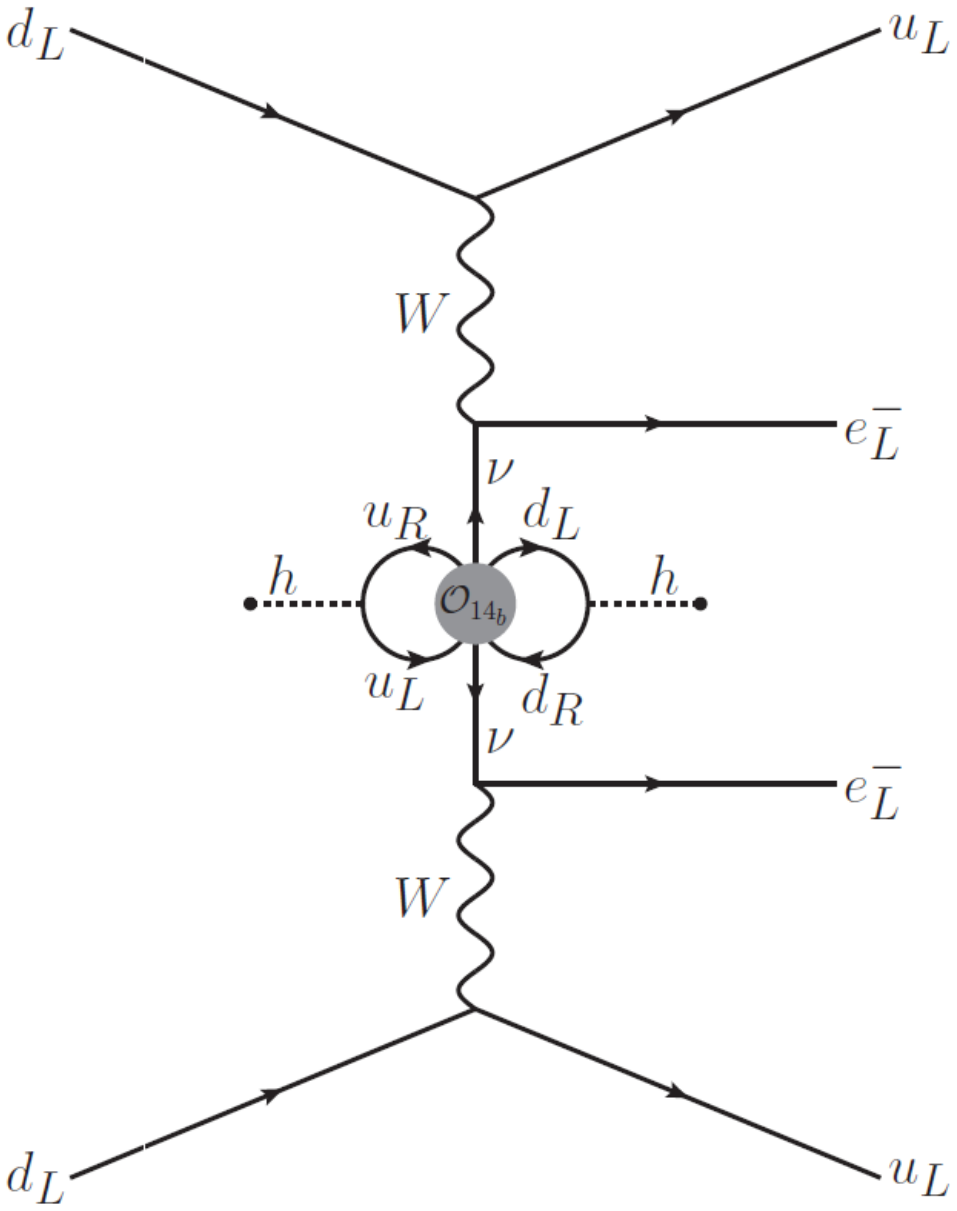


Contribution of this diagram to double-beta decay rate:



Contribution of this diagram to double-beta decay rate:

- **Dimension-9 Operator:** $\left(\frac{1}{\Lambda^5}\right)^2$



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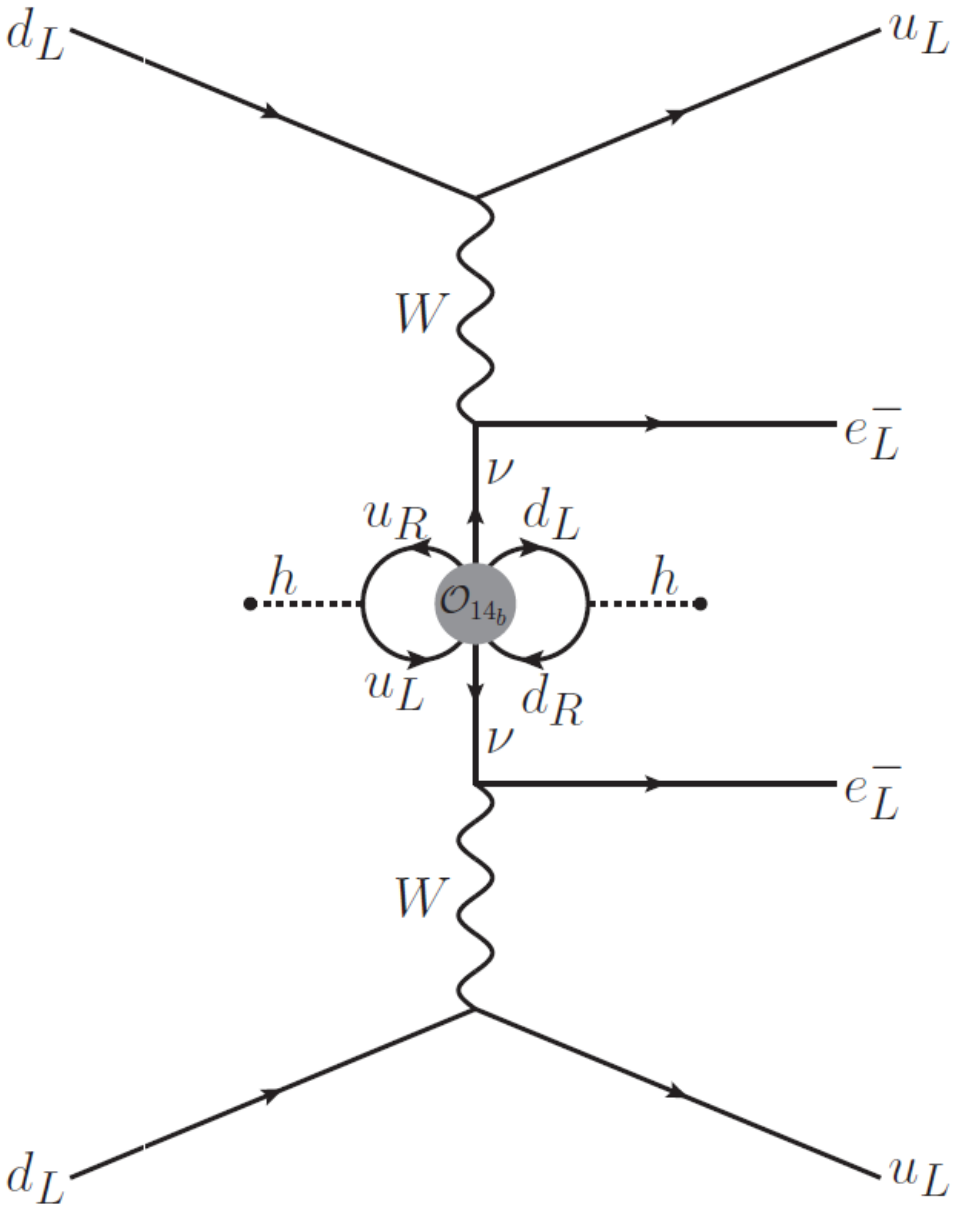

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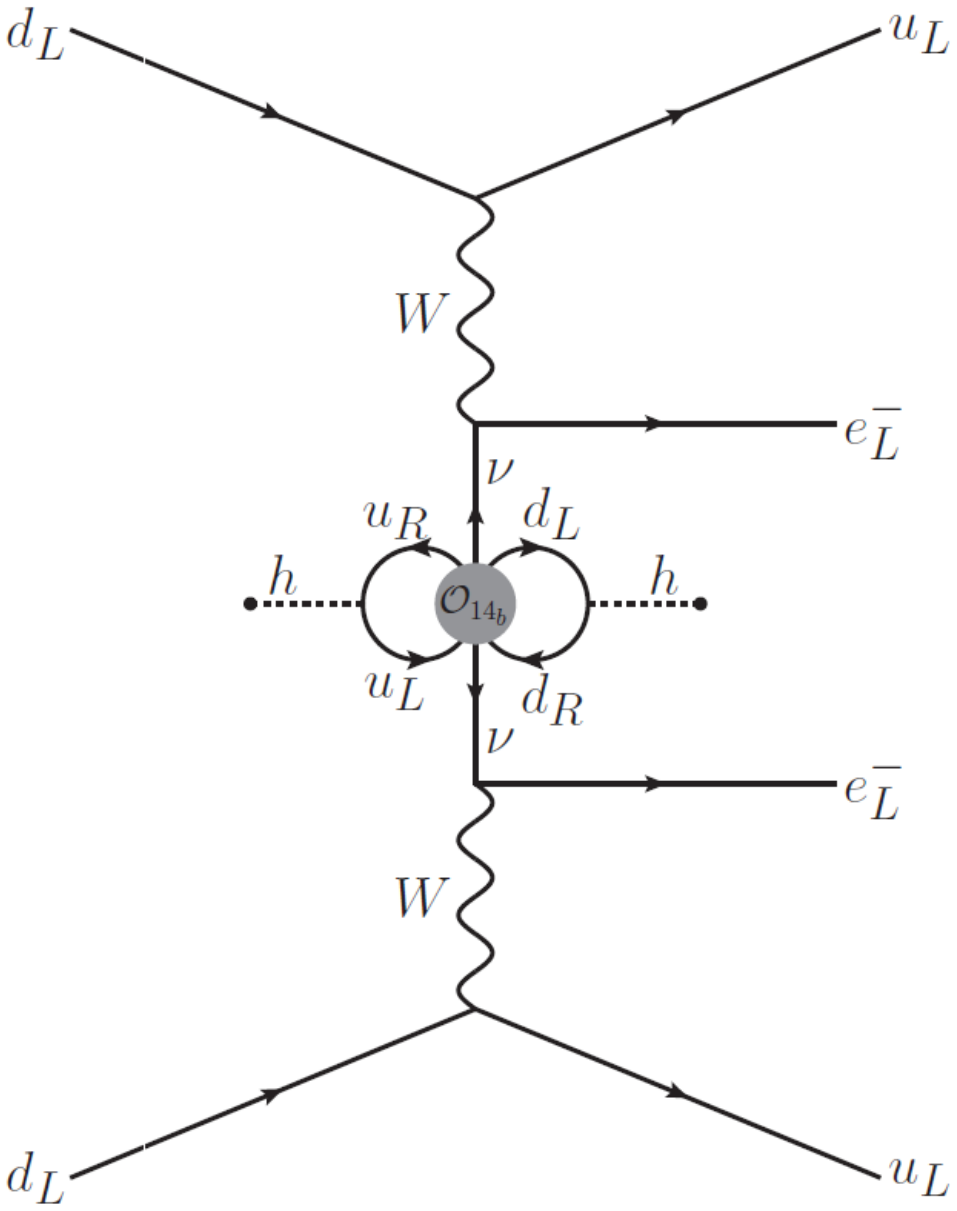

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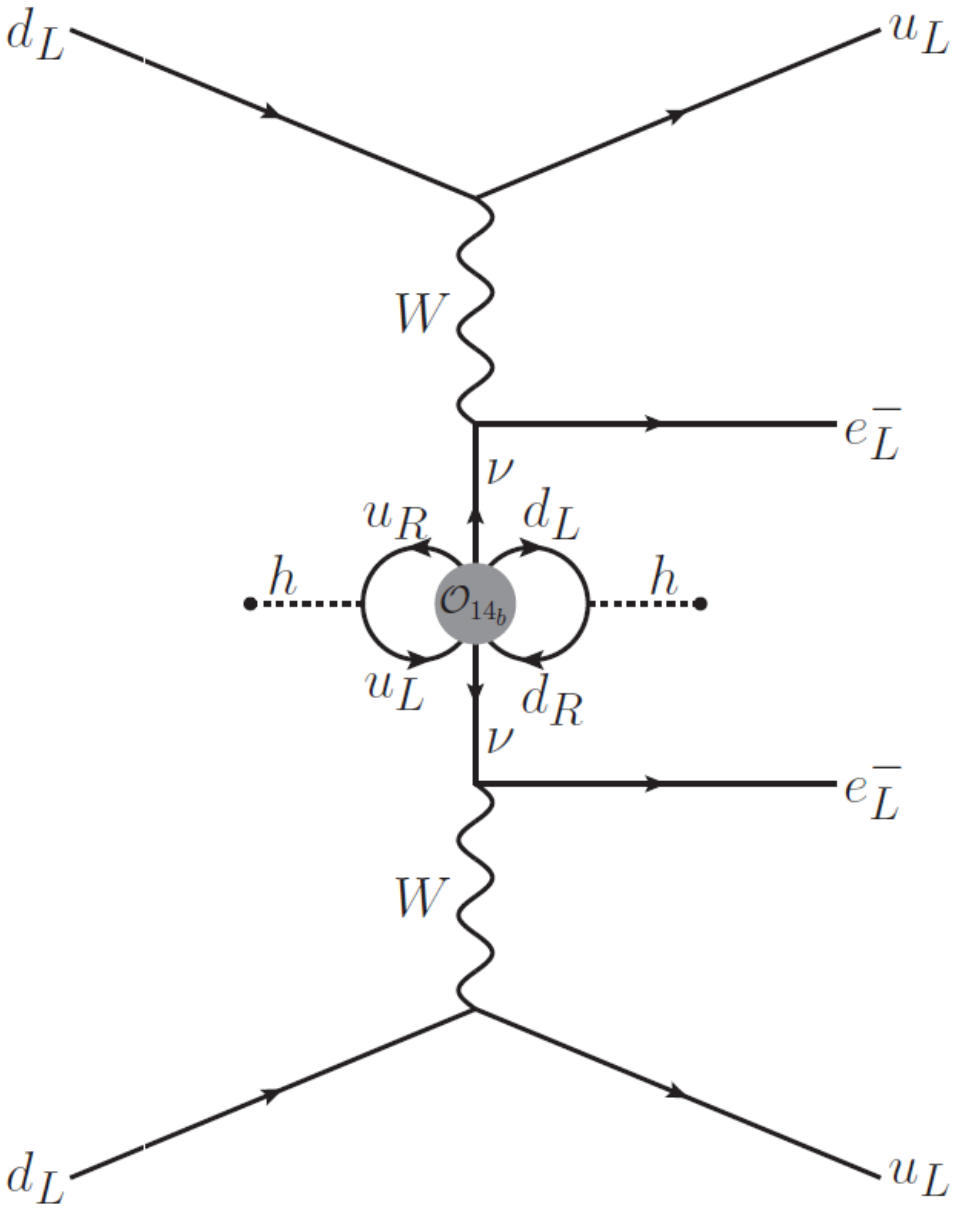

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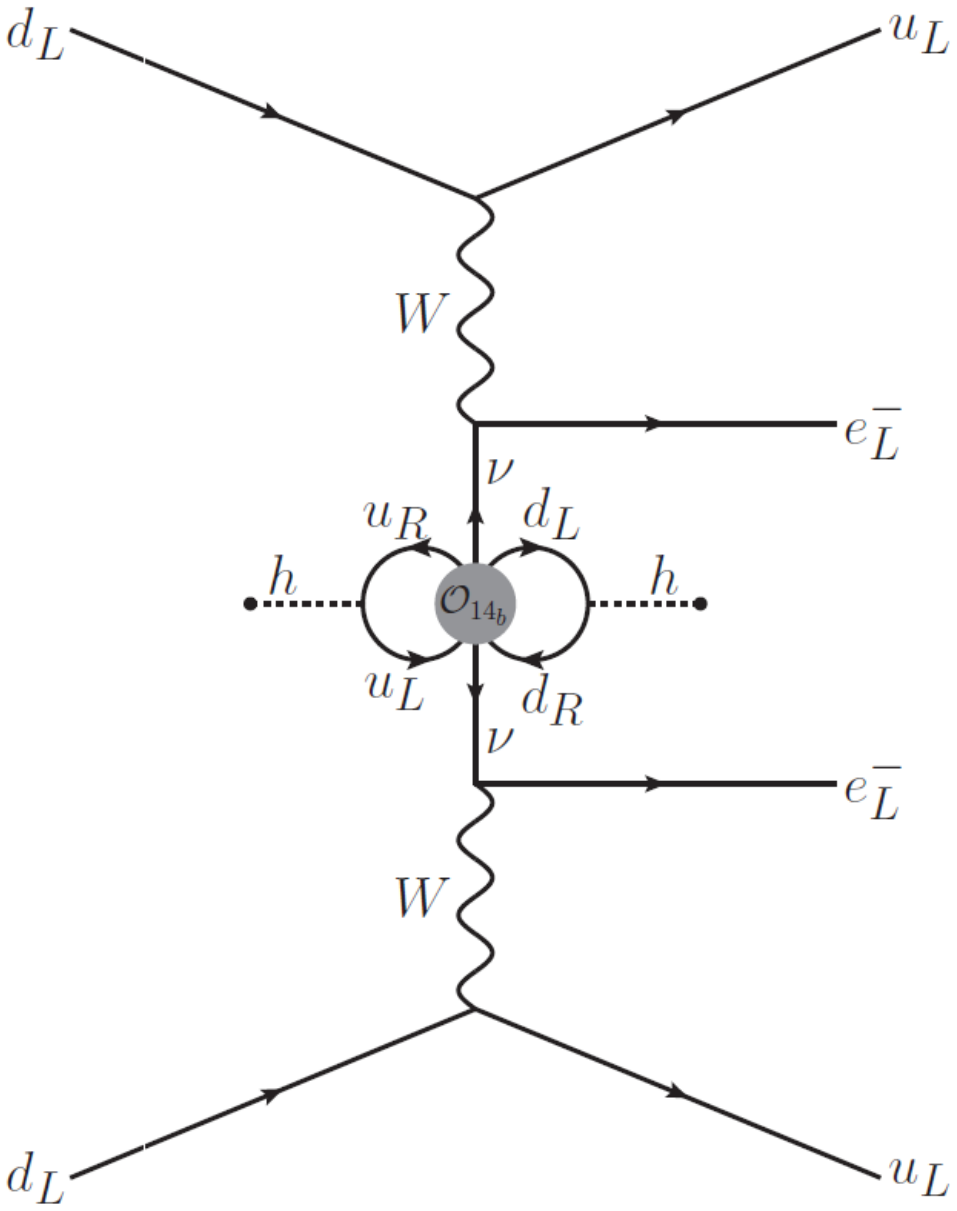

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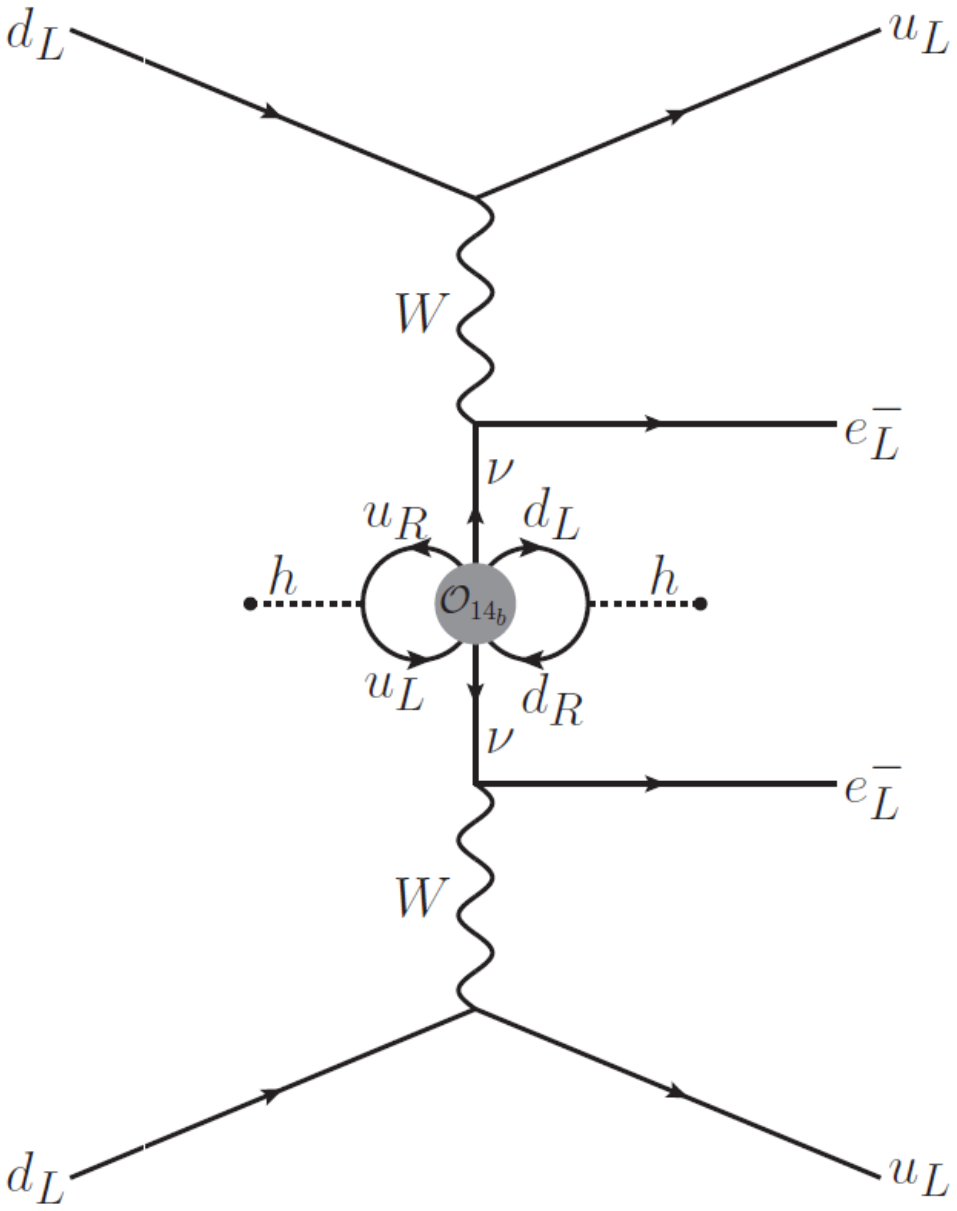

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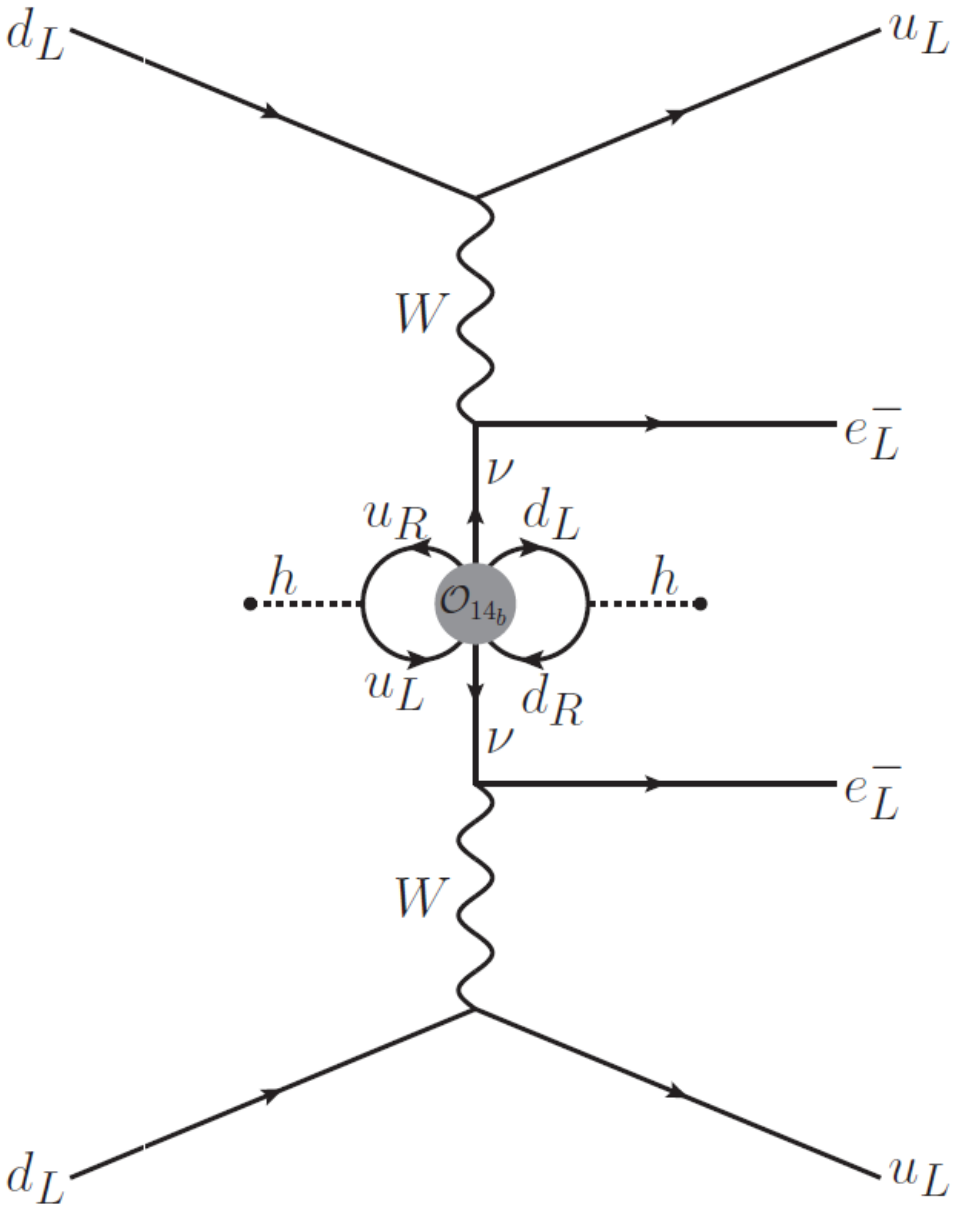
$$\Gamma^{(2)}_{0\nu\beta\beta} \simeq \left(\frac{G_F}{\sqrt{2}}\right)^4 \frac{1}{q^4} \left(\frac{y_t y_b v^2}{(16\pi^2)^2}\right)^2 \frac{?}{\Lambda^2}$$



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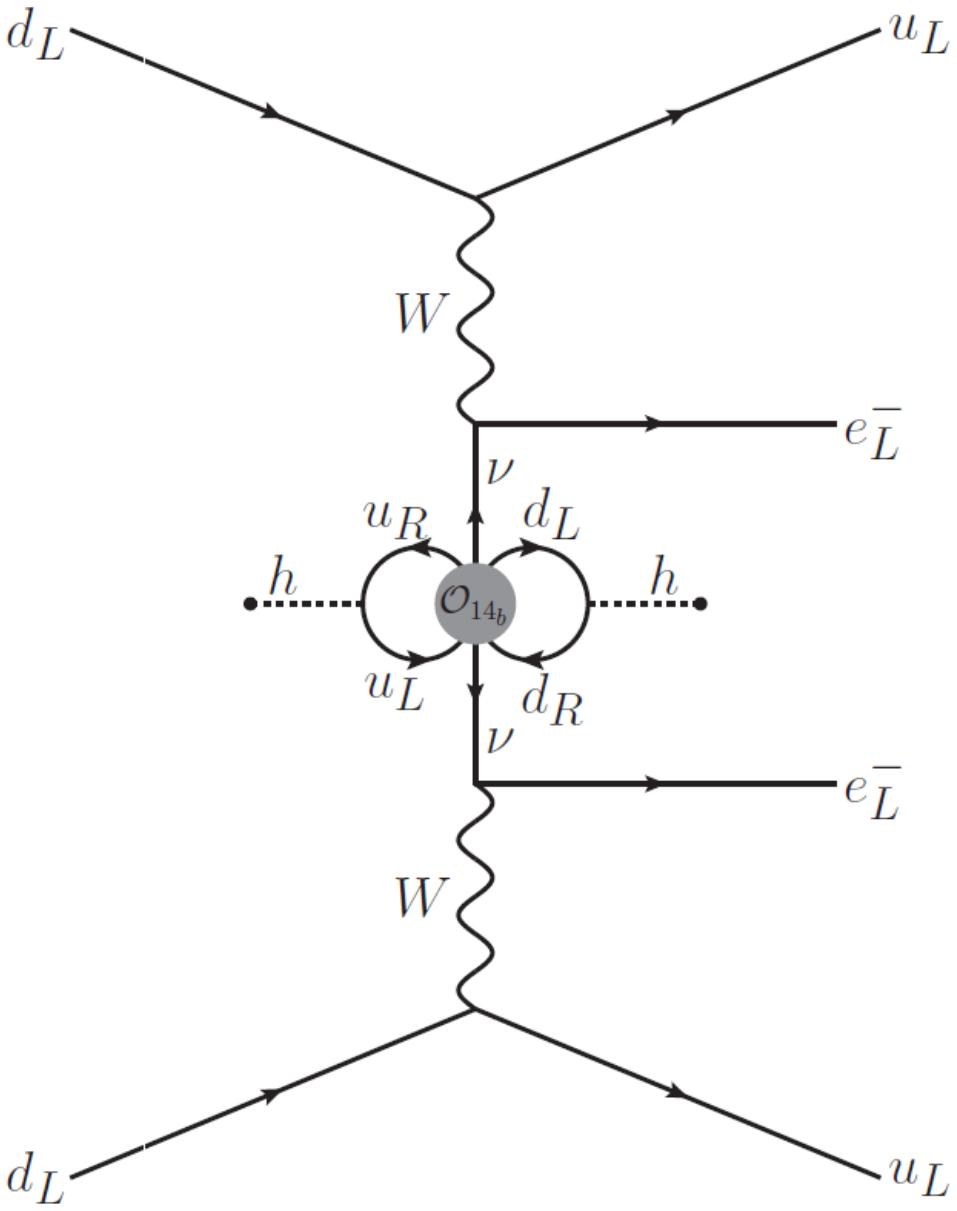
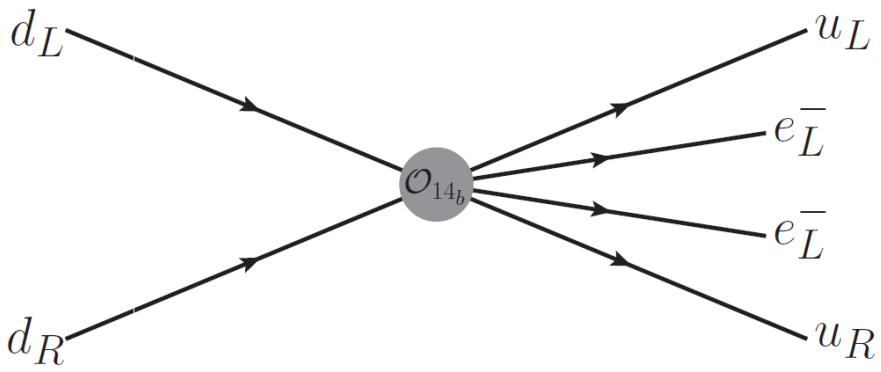
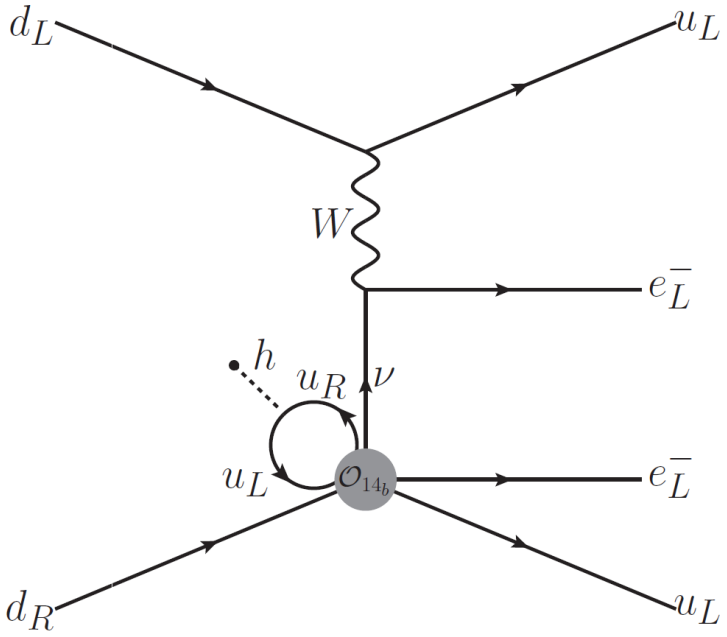


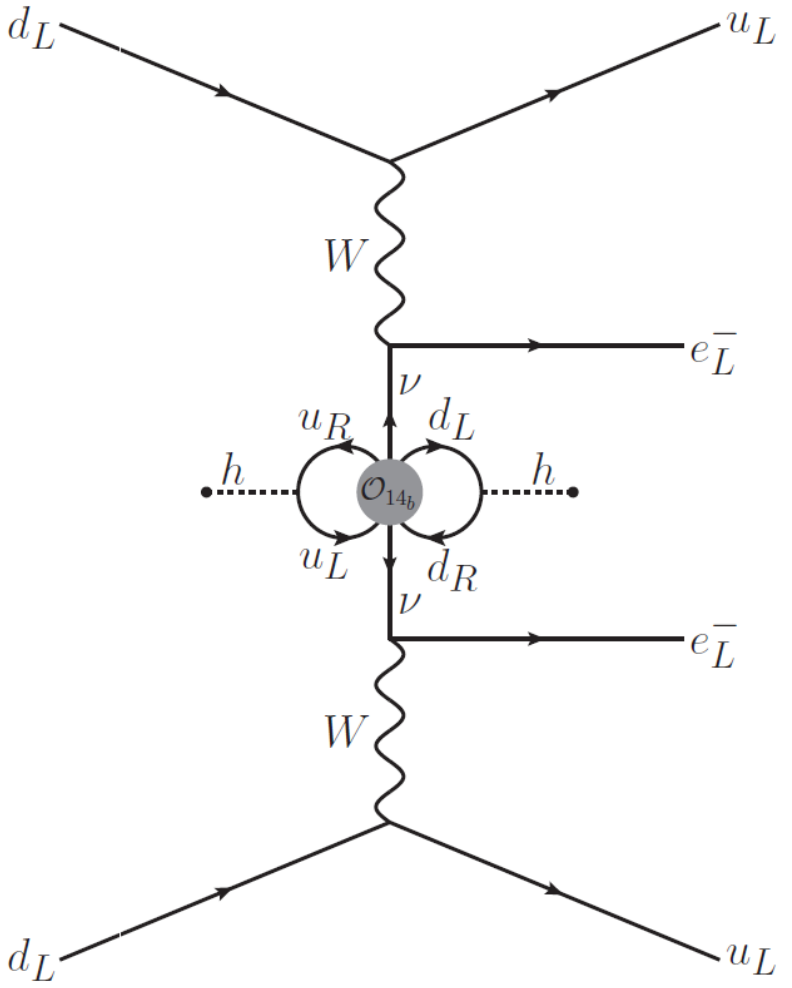
Including contributions at dimension 7 and 9:



$$\Gamma^{(0)}_{0\nu\beta\beta} \simeq \frac{Q^{11}}{\Lambda^{10}}$$



$$\Gamma^{(1)}_{0\nu\beta\beta} \simeq \left(\frac{G_F}{\sqrt{2}}\right)^2 \frac{1}{q^2} \left(\frac{y_t v}{16\pi^2}\right)^2 \frac{Q^{11}}{\Lambda^6}$$



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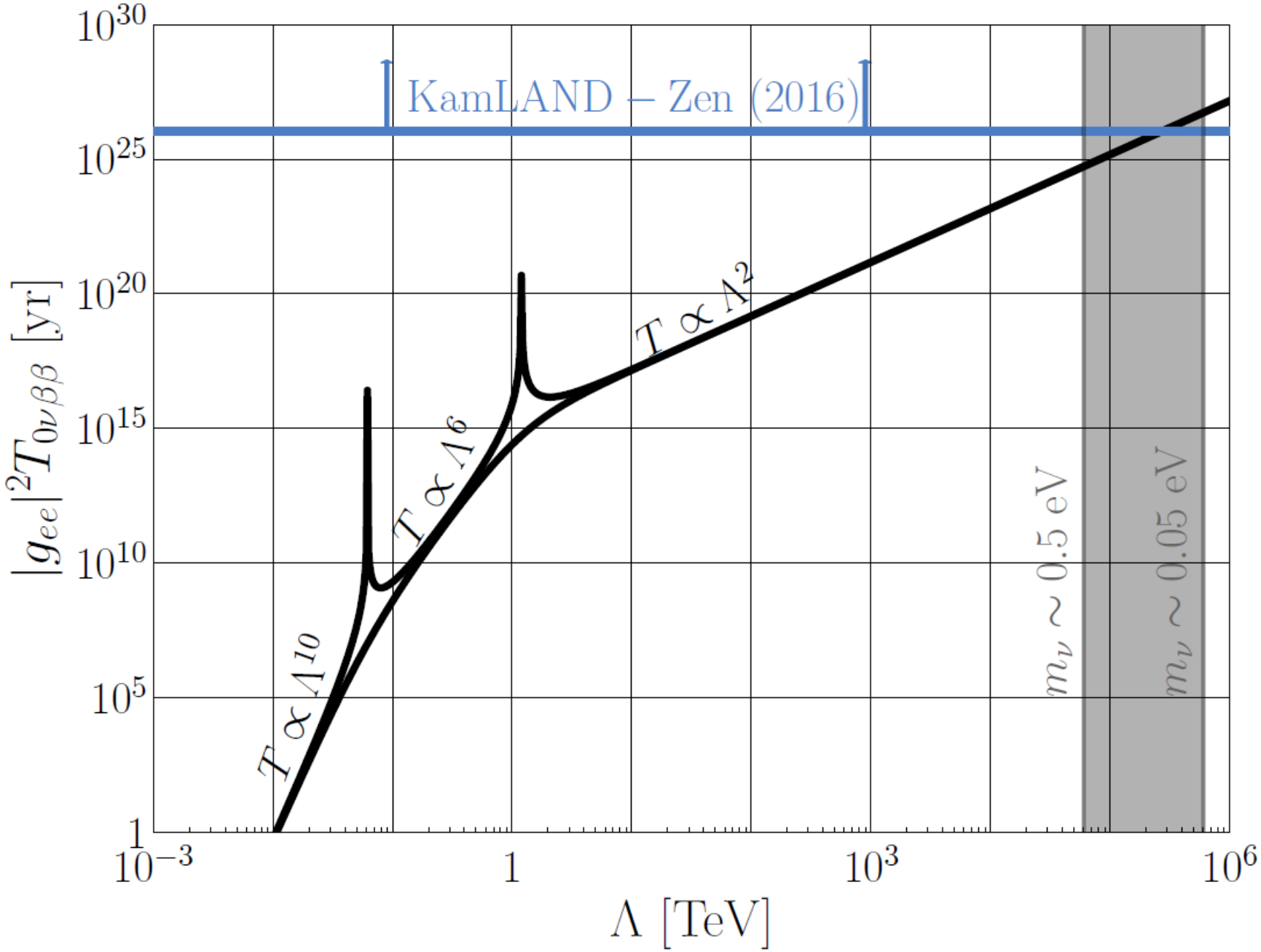
KamLAND – Zen (2016)
$T \propto \Lambda^{10}$
$T \propto \Lambda^{6}$
$T \propto \Lambda^{2}$
$m_\nu \sim 0.5$ eV
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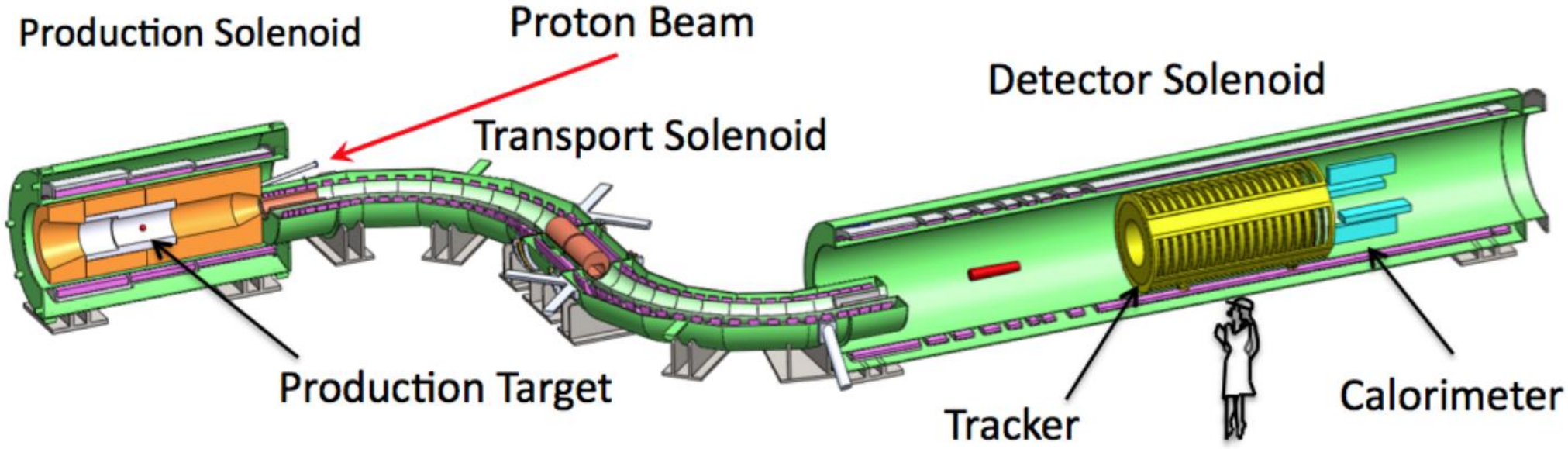
$|g_{ee}|^2 T_{0\nu\beta\beta}$ [yr]
Λ [TeV]
10^{30}
10^{25}
10^{20}
10^{15}
10^{10}
10^{5}
1
10^{-3}
1
10^{3}
10^{6}

What about muon-to-positron conversion?



The Mu2e Experiment: [1211.7019]

$$\text{Mu2e:} \quad R^{\text{Al}}_{\mu^- e^+} \gtrsim 10^{-16}$$

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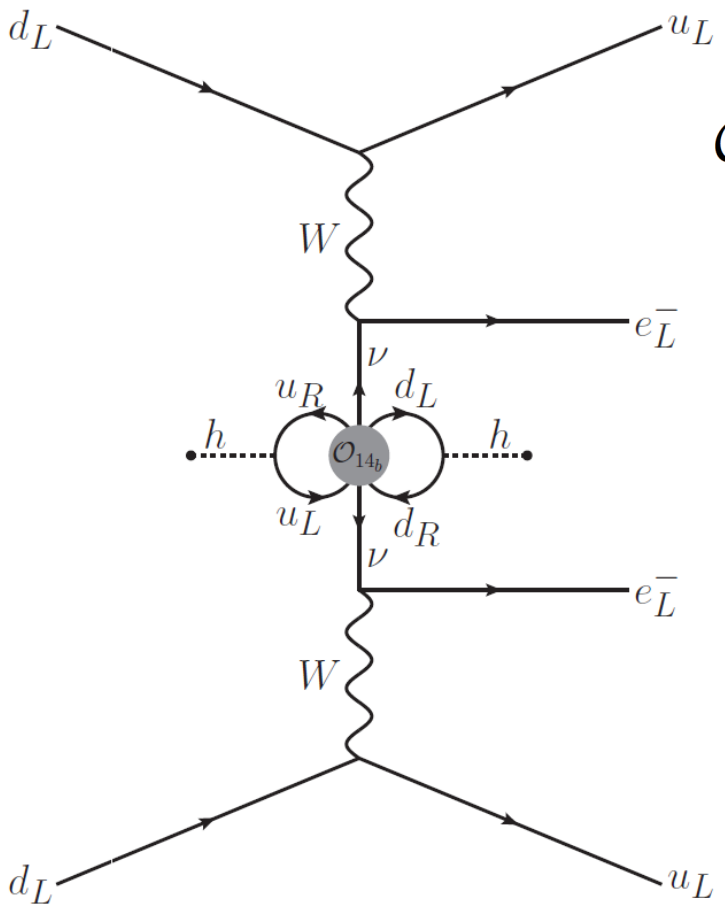

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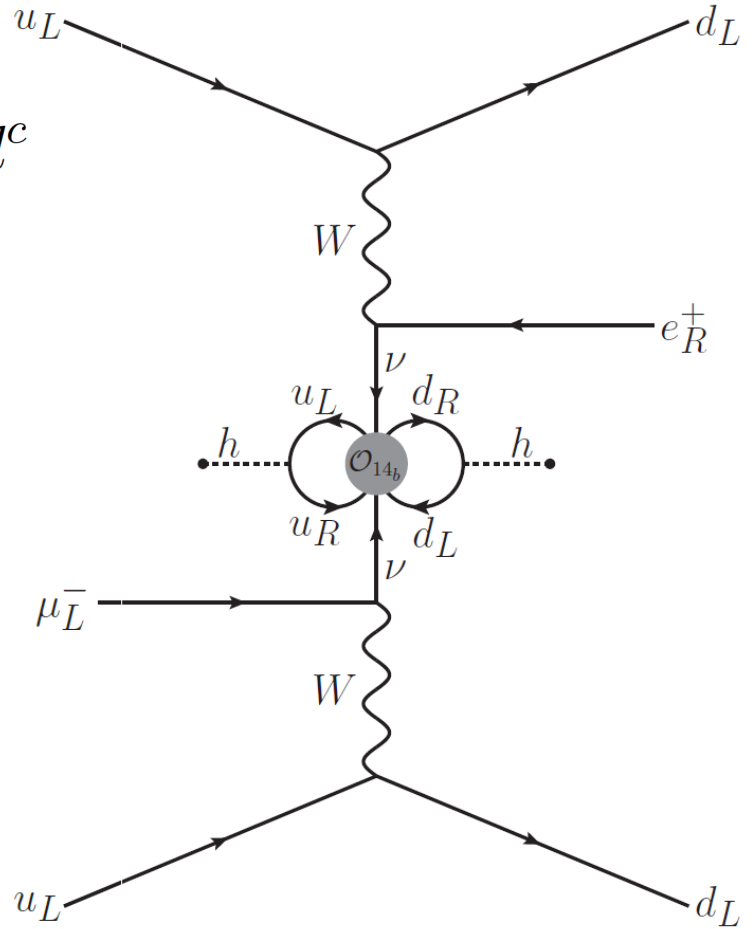
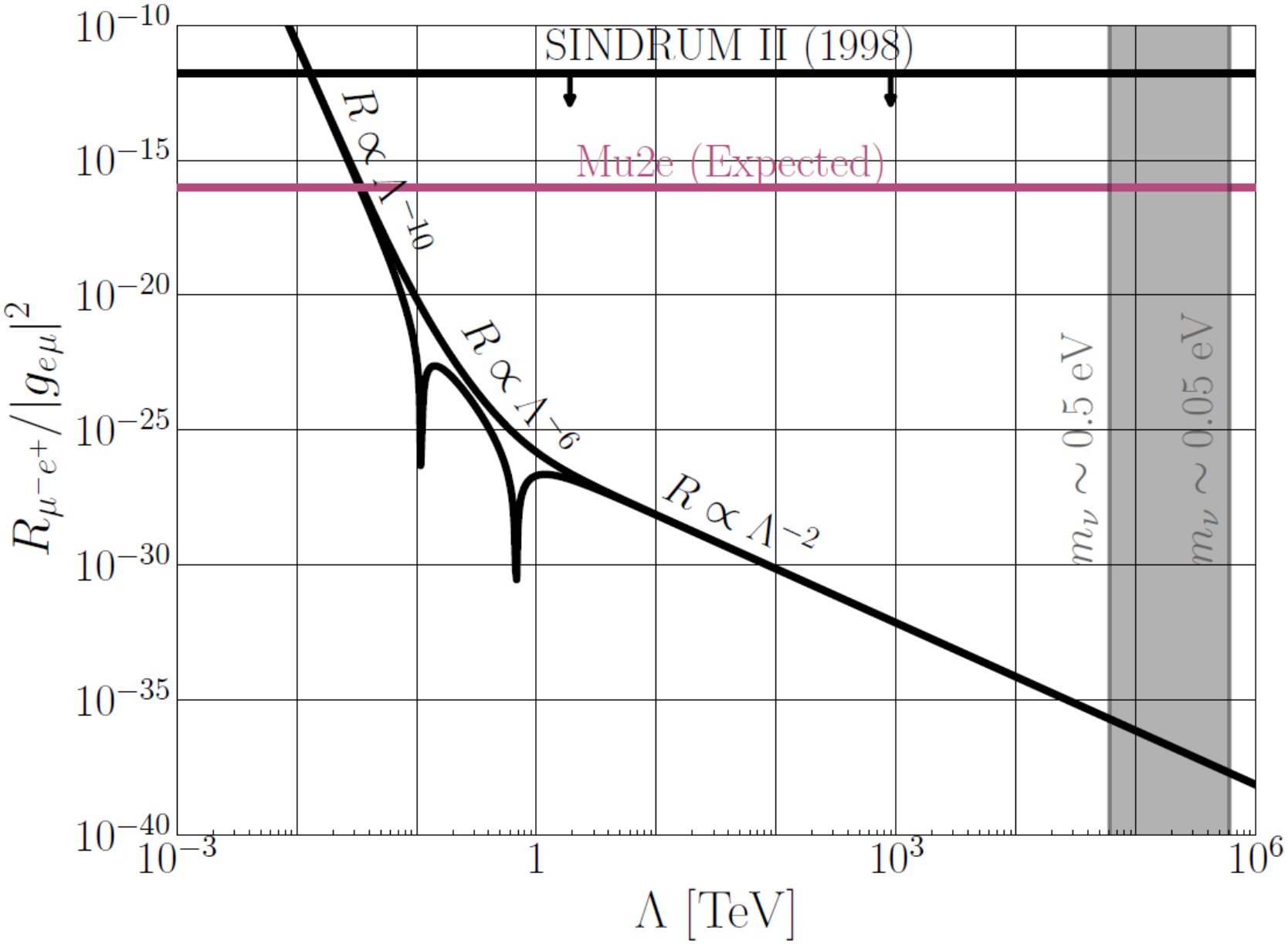
$$g_{ee} \longrightarrow g_{e\mu}$$




SINDRUM II (1998)
Mu2e (Expected)
$R \propto \Lambda^{-10}$
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$m_\nu \sim 0.5$ eV
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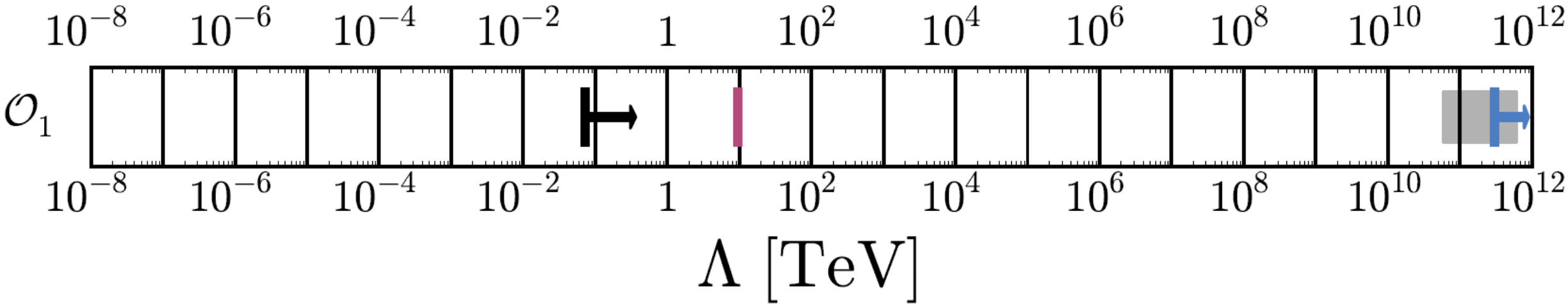
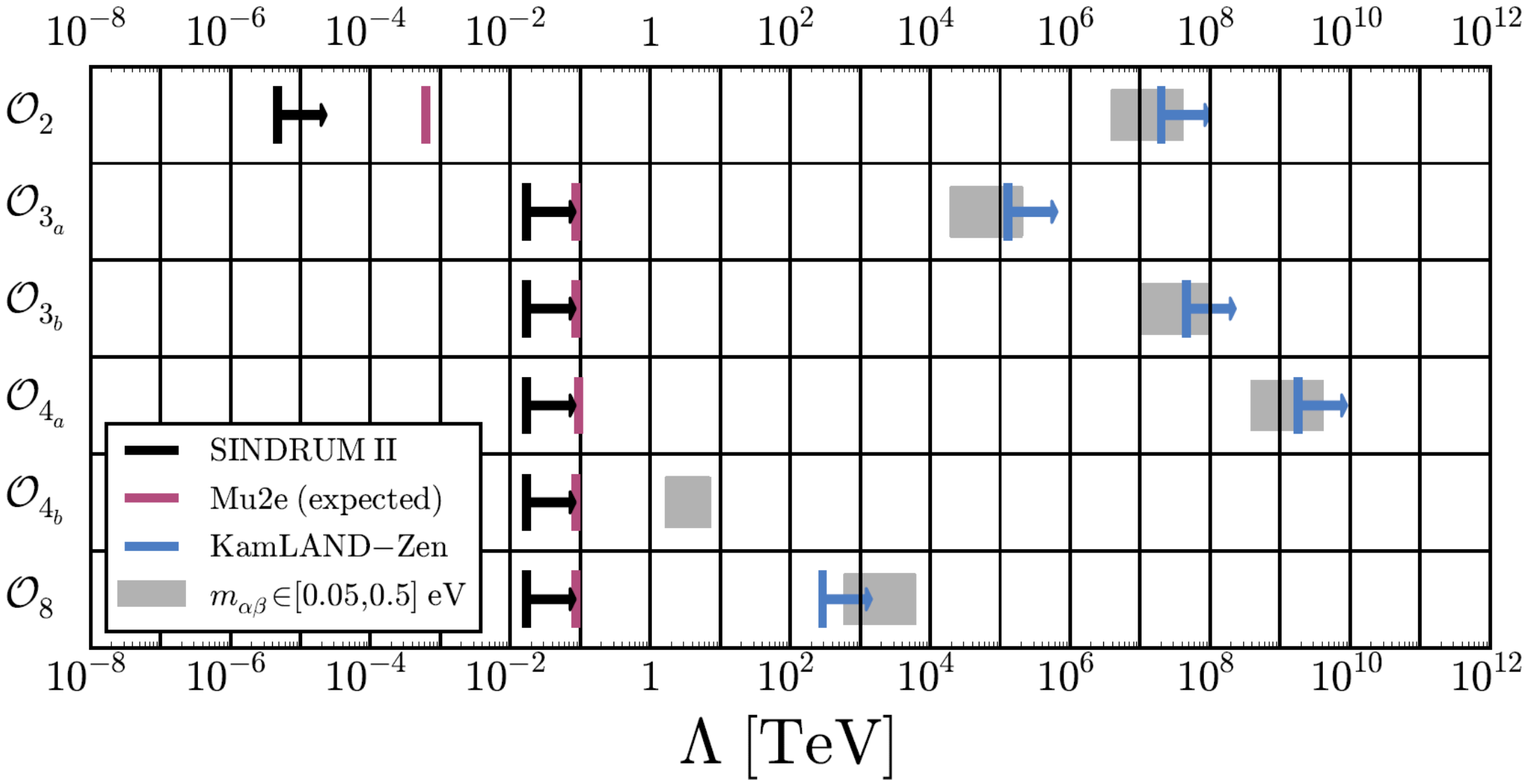
$R_{\mu^- e^+} / |g_{e\mu}|^2$
Λ [TeV]
10^{-10}
10^{-15}
10^{-20}
10^{-25}
10^{-30}
10^{-35}
10^{-40}
10^{-3}
1
10^{3}
10^{6}

Results: Dimension-5



Results: Dimension-7



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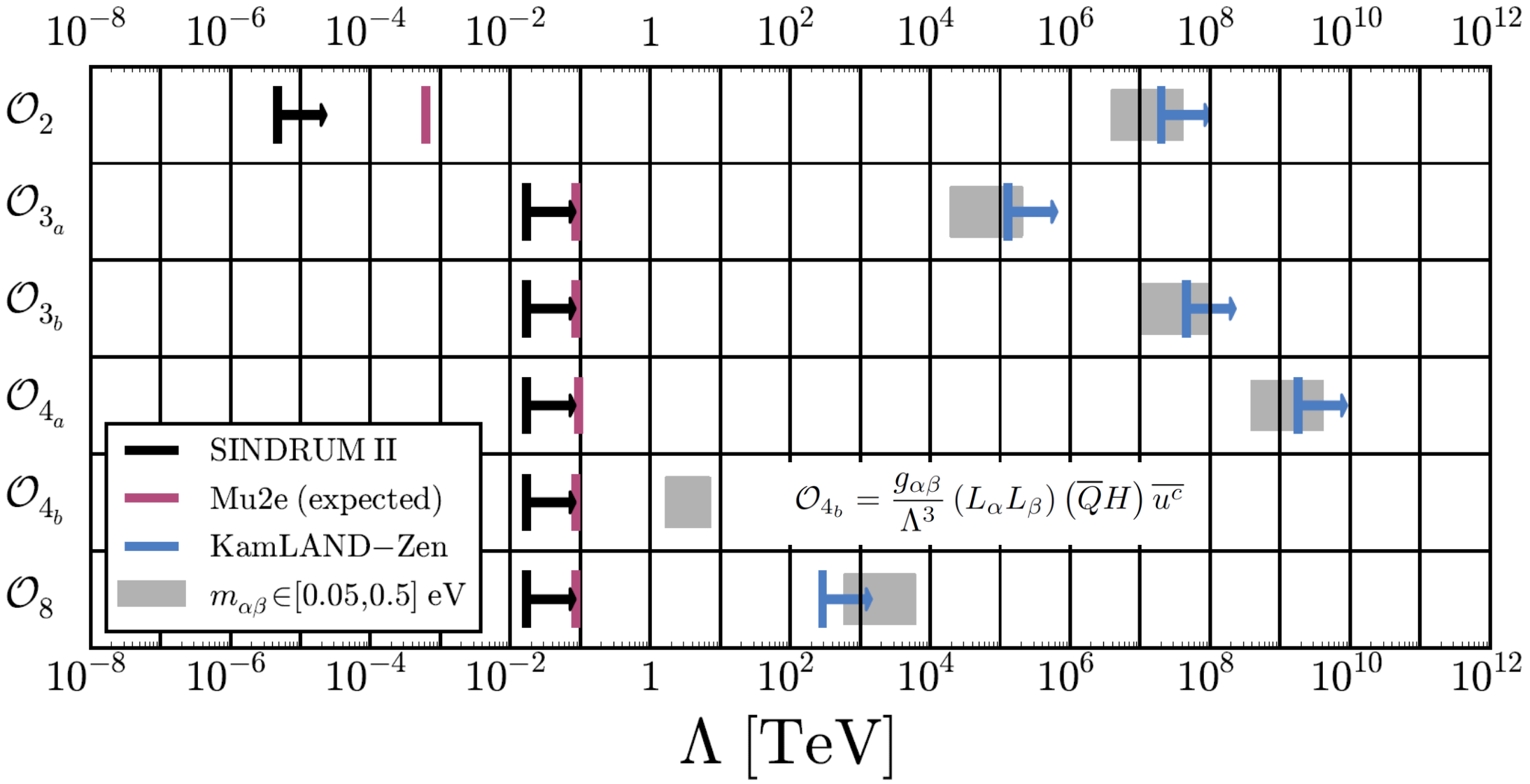
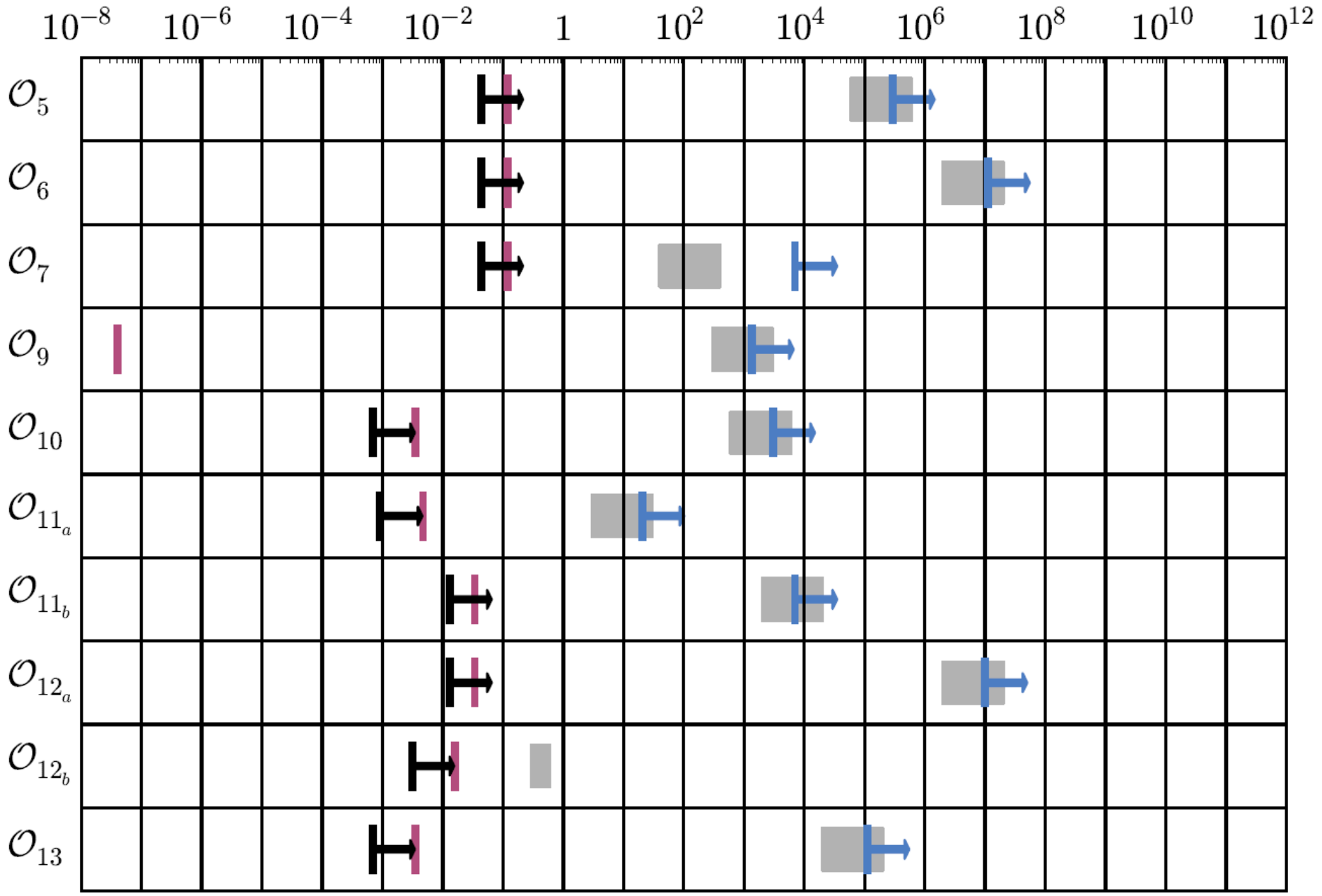
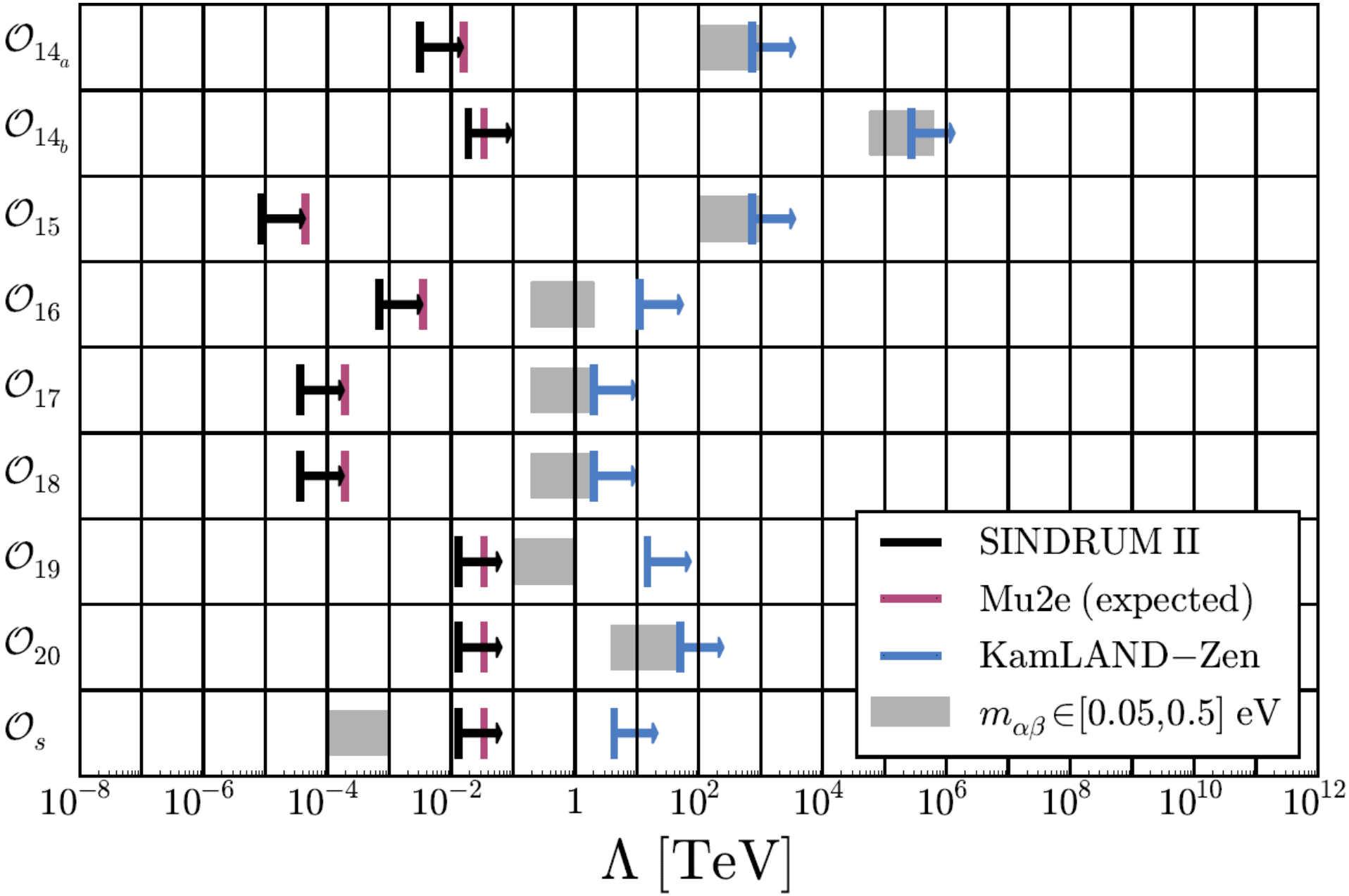


Results: Dimension-9



Results: Dimension-9



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- Thank you! Questions?