

Constraints on generalized neutrino interactions

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Outline

1 Motivation

2 The general framework

3 The experimental observables

4 Conclusions

Motivation

Massive neutrinos and physics beyond the Standard Model.

$$\begin{bmatrix} M_L & D \\ D^T & M_R \end{bmatrix}$$

Minkowski; Gell-mann, Ramond, Slansky; Yanagida; Mohapatra, Senjanovic; Schechter, Valle

$$M_{\nu \text{ eff}} = M_L - DM_R^{-1}D^T$$

$$K = (K_L, K_H)$$

$$\mathcal{L} = \frac{ig'}{2 \sin \theta_W} Z_\mu \bar{\nu}_L \gamma_\mu \color{blue}{K^\dagger K} \nu_L .$$

Motivation

$SU(2)_L \otimes U(1)_Y \otimes SU(2)_R \otimes U(1)'_Y$ String inspired theories

$$\mathcal{L}_{\nu N}^{NC} = -\frac{G_F}{\sqrt{2}} \sum_{q=u,d} [\bar{\nu}_e \gamma^\mu (1 - \gamma^5) \nu_e] \{ \varepsilon^{qL} [\bar{q} \gamma_\mu (1 - \gamma^5) q] + \varepsilon^{qR} [\bar{q} \gamma_\mu (1 + \gamma^5) q] \},$$

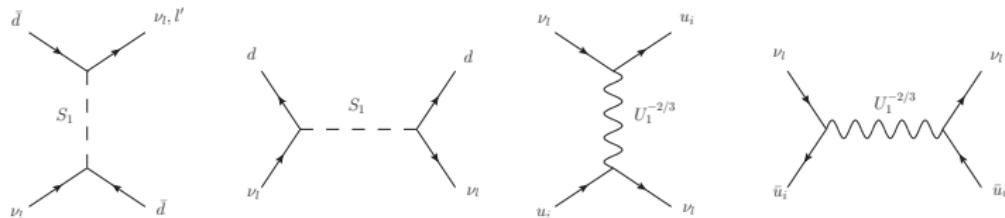
$$\begin{aligned}\varepsilon^{uL} &= -4 \frac{M_Z^2}{M_{Z'}^2} \sin^2 \theta_W \rho_{\nu N}^{NC} \left(\frac{\cos \beta}{\sqrt{24}} - \frac{\sin \beta}{3} \sqrt{\frac{5}{8}} \right) \left(\frac{3 \cos \beta}{2\sqrt{24}} + \frac{\sin \beta}{6} \sqrt{\frac{5}{8}} \right) \\ \varepsilon^{dR} &= -8 \frac{M_Z^2}{M_{Z'}^2} \sin^2 \theta_W \rho_{\nu N}^{NC} \left(\frac{3 \cos \beta}{2\sqrt{24}} + \frac{\sin \beta}{6} \sqrt{\frac{5}{8}} \right)^2, \\ \varepsilon^{dL} &= \varepsilon^{uL} = -\varepsilon^{uR},\end{aligned}$$

For the case of the Zee model see Zapata's talk

Motivation

$$\begin{aligned}\mathcal{L} \supset & + y_{3ij}^{LL} \bar{Q}_L^C i^a \epsilon^{ab} (\tau^k S_3^k)^{bc} L_L^{j,c} - y_{2ij}^{RL} \bar{u}_R^i R_2^a \epsilon^{ab} L_L^{j,b} - \\ & - \tilde{y}_{2ij}^{RL} \bar{d}_R^i \tilde{R}_2^a \epsilon^{ab} L_L^{j,b} + y_{1ij}^{LL} \bar{Q}_L^C i^a S_1 \epsilon^{ab} L_L^{j,b} + +\dots\end{aligned}$$

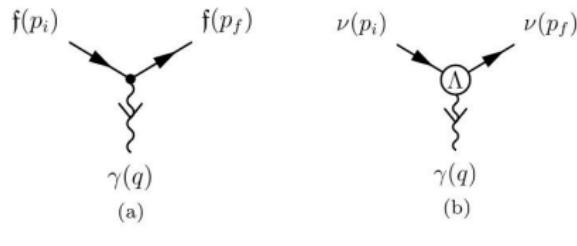
Scalar leptoquarks



See e.g. I. Dorsner et. al. Phys. Rept. 641 (2016) 1

Electromagnetic interactions

$$\mathcal{H}_{em}^f(x) = j_\mu^f(x) A^\mu(x) = q_f \bar{f}(x) \gamma_\mu f(x) A^\mu(x),$$

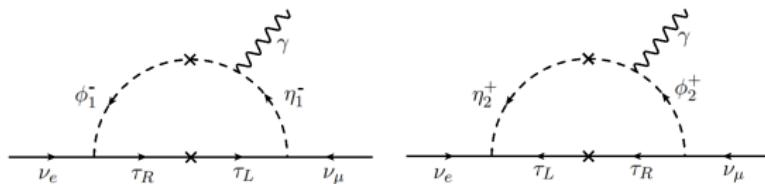


- * For neutrinos: $q_\nu = 0 \rightarrow$ there are no electromagnetic interactions at tree level.
- * However, such interactions can arise from loop diagrams at higher order in the perturbative expansion.

$$\begin{aligned}\mathcal{H}_{eff}(x) &= j_\mu^{eff}(x) A^\mu(x) = \\ &\sum_{k,j=1}^3 \overline{\nu_k}(x) \Lambda_\mu^{kj} \nu_j(x) A^\mu(x)\end{aligned}$$

C. Giunti, A. Studenikin RMP 87 (2015) 531

Electromagnetic interactions



$$\mu_{\nu_e \nu_\mu} = \frac{ff'}{8\pi^2} m_\tau \sin 2\alpha \left[\frac{1}{m_{h^+}^2} \left\{ \ln \frac{m_{h^+}^2}{m_\tau^2} - 1 \right\} - \frac{1}{m_{H^+}^2} \left\{ \ln \frac{m_{H^+}^2}{m_\tau^2} - 1 \right\} \right] .$$

Here (m_{h^+} , m_{H^+}) denote the common masses of the two charged scalars (h_i^+ , H_i^+).

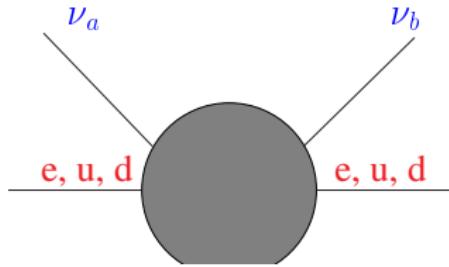
K.S. Babu, Sudip Jana, Manfred Lindner, JHEP 10 (2020) 040, arXiv:2007.04291

Non-standard interactions NSI

See Pleitez's and Chatterjee's talks

NSI effective Lagragian form:

$$\mathcal{L}_{\text{eff}}^{\text{NSI}} = - \sum_{\alpha\beta fP} \varepsilon_{\alpha\beta}^{fP} 2\sqrt{2} G_F (\bar{\nu}_\alpha \gamma_\rho L \nu_\beta) (\bar{f} \gamma^\rho P f)$$



Here $\alpha, \beta = e, \mu, \tau$; $f = e, u, d$; $P = L, R$; $L = (1 - \gamma_5)/2$; $R = (1 + \gamma_5)/2$

Generalized neutrino interactions

$$\mathcal{L}_{\text{eff}}^{NC} = -\frac{G_F}{\sqrt{2}} \sum_j \epsilon_{\alpha\beta}^{f,j} (\bar{\nu}_\alpha \mathcal{O}_j \nu_\beta) (\bar{f} \mathcal{O}'_j f),$$

ϵ	\mathcal{O}_j	\mathcal{O}'_j
$\epsilon^{f,L}$	$\gamma_\mu(1 - \gamma^5)$	$\gamma^\mu(1 - \gamma^5)$
$\epsilon^{f,R}$	$\gamma_\mu(1 - \gamma^5)$	$\gamma^\mu(1 + \gamma^5)$
$\epsilon^{f,S}$	$(1 - \gamma^5)$	1
$-\epsilon^{f,P}$	$(1 - \gamma^5)$	γ^5
$\epsilon^{f,T}$	$\sigma_{\mu\nu}(1 - \gamma^5)$	$\sigma^{\mu\nu}(1 - \gamma^5)$

Table: Effective operators and effective couplings.

Bischer and W. Rodejohann, Phys. Rev. D 99, 036006 (2019), arXiv:1810.02220

Han, J. Liao, H. Liu, and D. Marfatia, JHEP 07, 207 (2020), arXiv:2004.13869

D. Aristizabal Sierra, V. De Romeri, and N. Rojas, Phys. Rev. D 98, 075018 (2018), arXiv:1806.07424

NSI and degeneracies

The need for combined analysis

NSI degeneracies

$$H_{\text{NSI}} = \sqrt{2} G_F N_f \begin{pmatrix} 0 & \varepsilon \\ \varepsilon & \varepsilon' \end{pmatrix}.$$

Mixing angle in matter + NSI

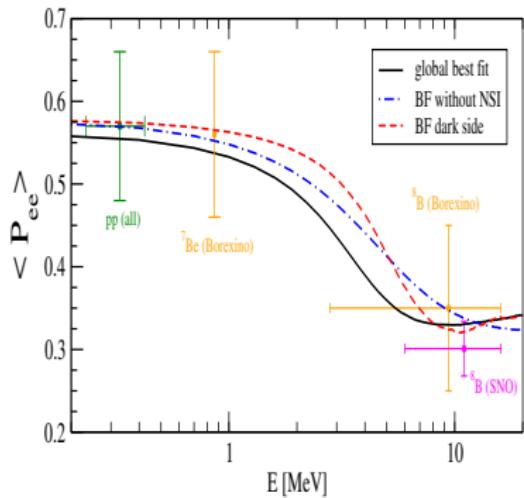
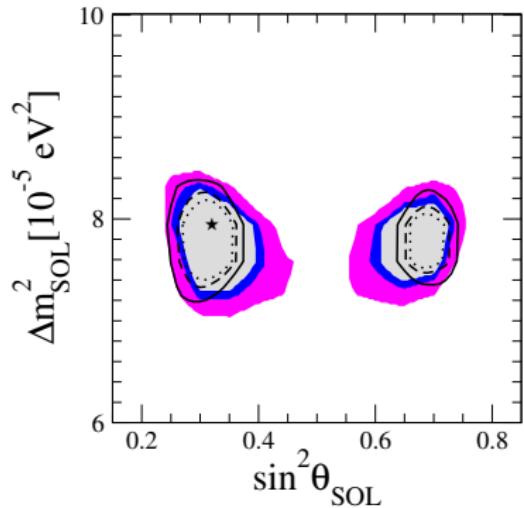
$$\tan 2\theta_m = \frac{\left(\frac{\Delta m^2}{2E}\right) \sin 2\theta + 2\sqrt{2} G_F \varepsilon N_d}{\frac{\Delta m^2}{2E} \cos 2\theta - \sqrt{2} G_F N_e + \sqrt{2} G_F \varepsilon' N_d}.$$

Resonance $\frac{\Delta m^2}{2E} \cos 2\theta - \sqrt{2} G_F N_e + \sqrt{2} G_F \varepsilon' N_d = 0.$

$$\varepsilon' > \frac{N_e}{N_d}$$

OGM, M. Tortola, J. W. F. Valle, JHEP 0610:008 (2006) hep-ph/0406280

NSI degeneracies



F. J. Escrivuela, OGM, M. Tortola, J. W. F. Valle, Phys. Rev. D **80** 105009 (2009)

M. C. Gonzalez-Garcia, M. Maltoni, JHEP **1309** 152 (2013)

M. C. Gonzalez-Garcia, M. Maltoni, T. Schwetz Nucl. Phys. B **908** 199 (2016)

NSI degeneracies

$$\begin{aligned}\varepsilon_{ee} &\rightarrow - \varepsilon_{ee} - 2 \\ \varepsilon_{\alpha\beta} &\rightarrow - \varepsilon_{\alpha\beta}^* \quad (\alpha\beta \neq ee)\end{aligned}$$

$$H_{mat} \rightarrow - H_{mat}^*$$

P. Coloma, T. Schwetz, Phys.Rev. D94 (2016) 055005

CE ν NS and NSI

See Giunti's, Aristizabal's, and Aguilar-Arevalo's talks

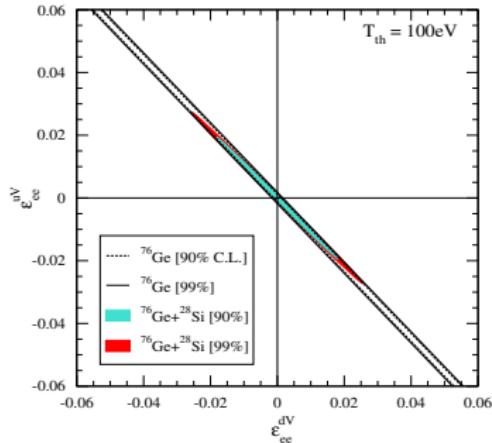
$$\begin{aligned}\frac{d\sigma}{dT}(E_\nu, T) &= \frac{G_F^2 M}{\pi} \left(1 - \frac{MT}{2E_\nu^2}\right) \times \\ &\times \left\{ \left[Z(g_V^p + 2\varepsilon_{ee}^{uV} + \varepsilon_{ee}^{dV}) + N(g_V^n + \varepsilon_{ee}^{uV} + 2\varepsilon_{ee}^{dV}) \right]^2 + \right. \\ &\left. + \sum_{\alpha=\mu,\tau} \left[Z(2\varepsilon_{\alpha e}^{uV} + \varepsilon_{\alpha e}^{dV}) + N(\varepsilon_{\alpha e}^{uV} + 2\varepsilon_{\alpha e}^{dV}) \right]^2 \right\}\end{aligned}$$

J. Barranco, OGM, T. I. Rashba JHEP 0512 (2005) 021

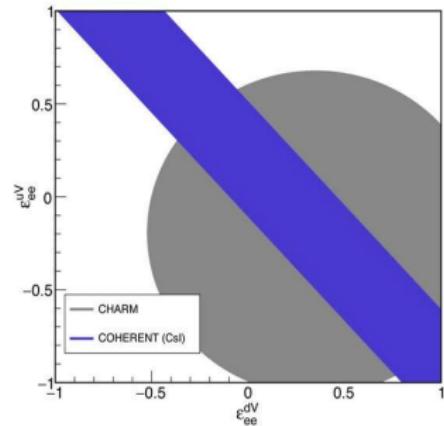
K. Scholberg PRD 73 (2007) 033005

J. Barranco, OGM, T. I. Rashba PRD 73 (2007) 033005

$\text{CE}\nu\text{NS}$ and NSI

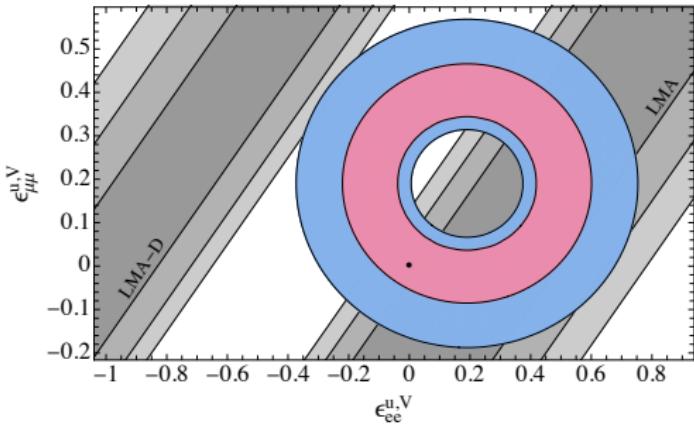


J. Barranco, OGM, T.I. Rashba
JHEP 0512:021 (2005)



COHERENT Coll.
Science 357 (2017) 1123

CE ν NS and NSI



P. Coloma et al Phys. Rev. D 96, 115007 (2017)

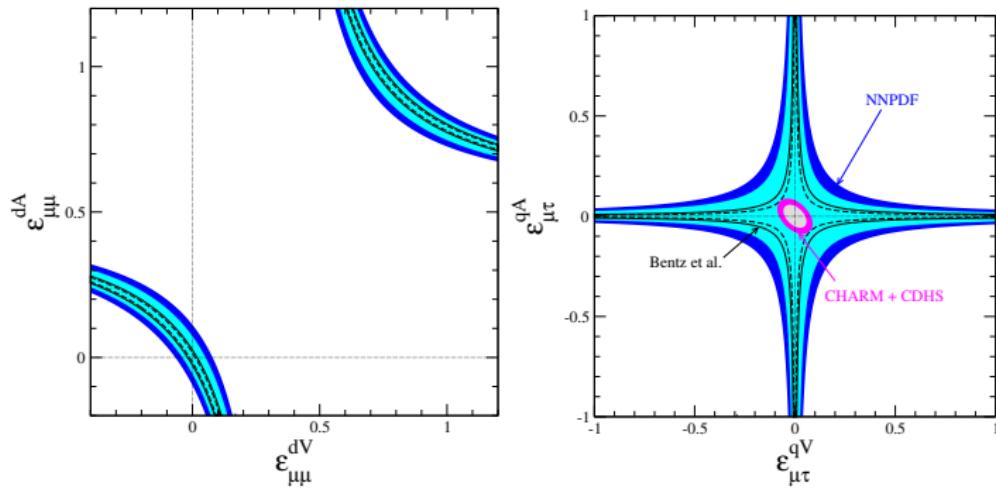
see also J. Liao and D. Marfatia Phys.Lett. B775 (2017) 54-57

D. K Papoulias and T. Kosmas Phys.Rev. D97 (2018) no.3, 033003

The experimental observables

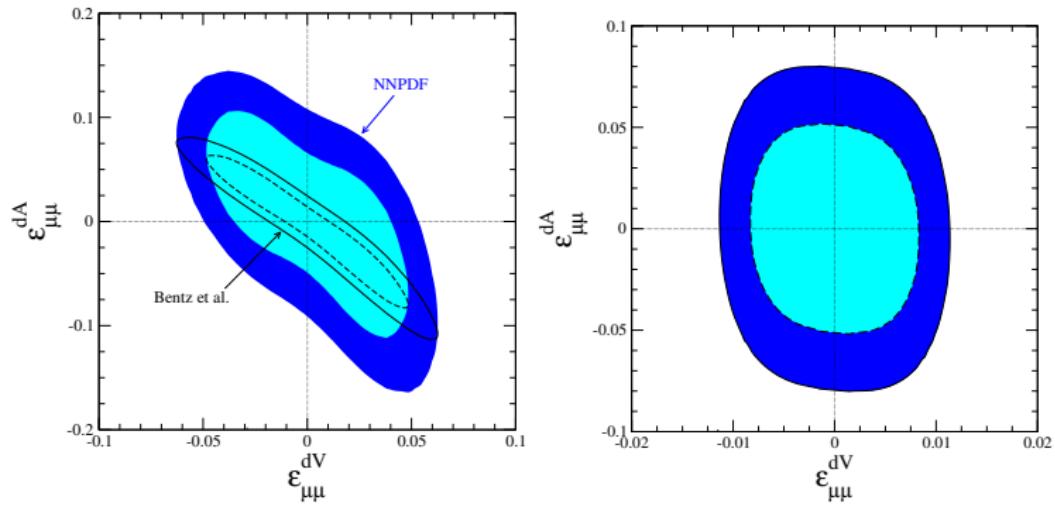
Neutrino-quark constraints for ν_μ

$$R^\mu = \frac{\sigma(\nu_\mu N \rightarrow \nu X) + \sigma(\bar{\nu}_\mu N \rightarrow \bar{\nu} X)}{\sigma(\nu_\mu N \rightarrow \mu X) + \sigma(\bar{\nu}_\mu N \rightarrow \bar{\mu} X)} = (\tilde{g}_{L\mu}) + (\tilde{g}_{R\mu})$$



Escrihuela, OGM, Tortola, Valle, PRD **83** 093002 (2011)

Neutrino-quark constraints for ν_μ

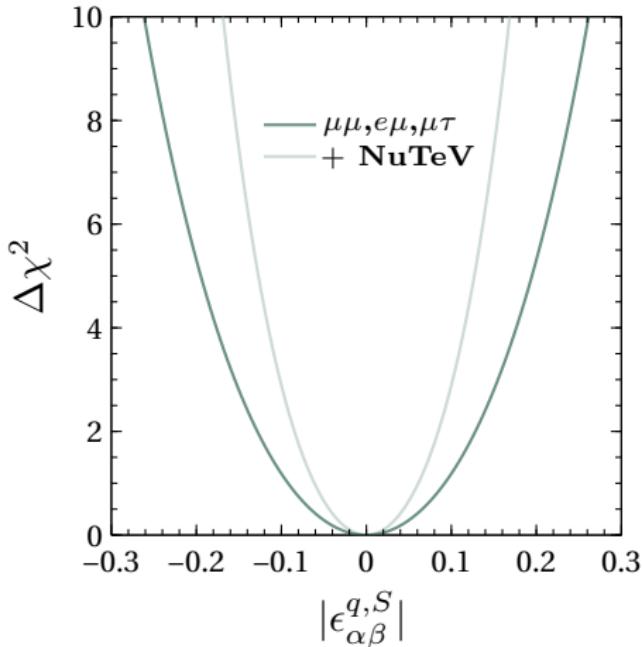
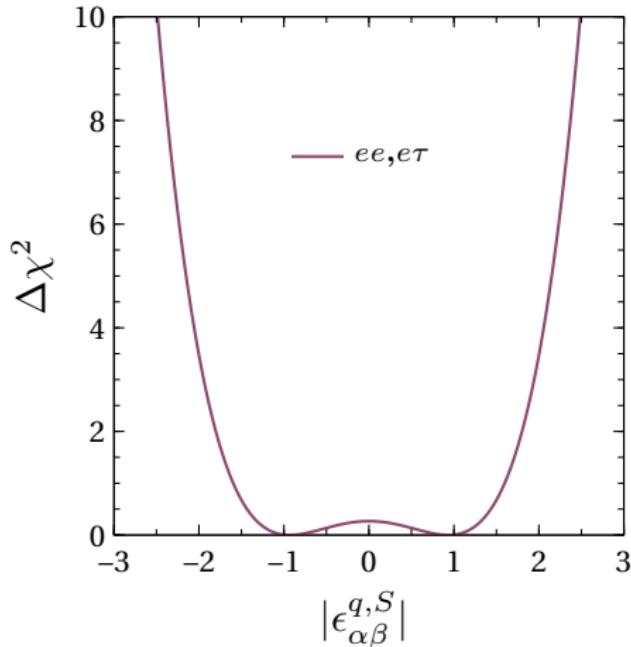


Neutrino-quark constraints for ν_μ

Global with NuTeV reanalysis	NSI with down	NSI with up
NNPDF	NU $-0.042 < \epsilon_{\mu\mu}^{dV} < 0.042$ $-0.091 < \epsilon_{\mu\mu}^{dA} < 0.091$	NU $-0.044 < \epsilon_{\mu\mu}^{uV} < -0.044$ $-0.15 < \epsilon_{\mu\mu}^{uA} < 0.18$
Bentz et al.	NU $-0.042 < \epsilon_{\mu\mu}^{dV} < 0.042$ $-0.072 < \epsilon_{\mu\mu}^{dA} < 0.057$	NU $-0.044 < \epsilon_{\mu\mu}^{uV} < -0.044$ $-0.094 < \epsilon_{\mu\mu}^{uA} < 0.14$
NNPDF/Bentz et al.	FC $-0.007 < \epsilon_{\mu\tau}^{dV} < 0.007$ $-0.039 < \epsilon_{\mu\tau}^{dA} < 0.039$	FC $-0.007 < \epsilon_{\mu\tau}^{uV} < 0.007$ $-0.039 < \epsilon_{\mu\tau}^{uA} < 0.039$

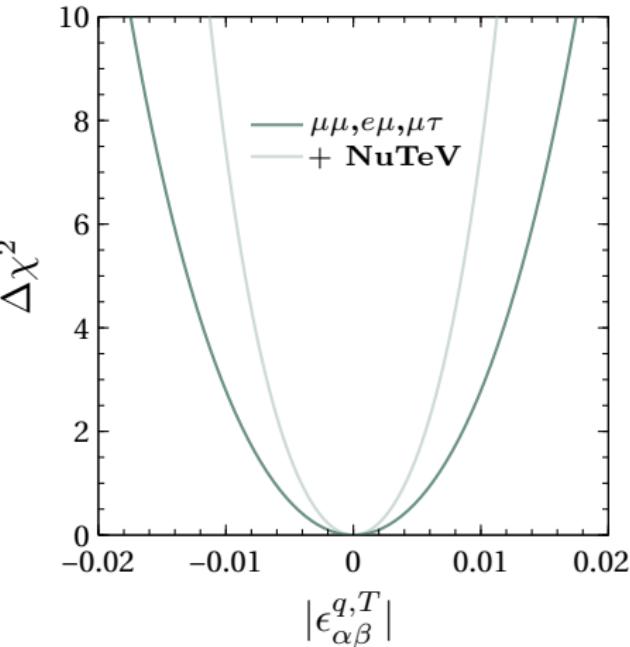
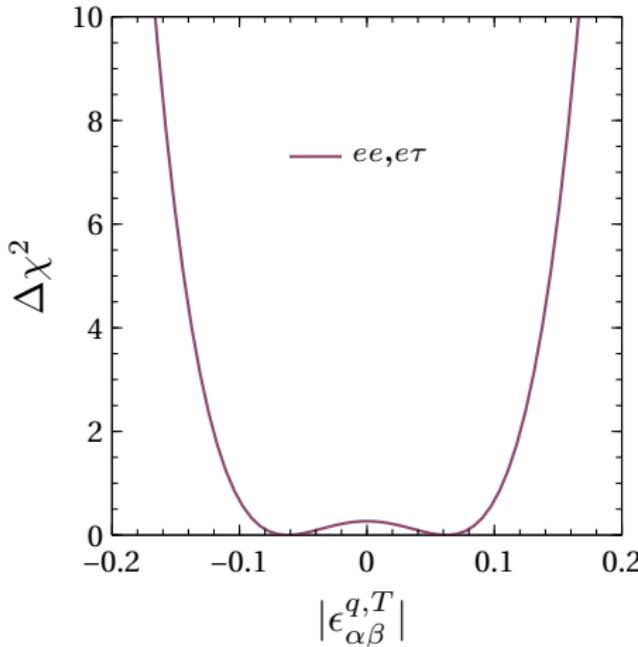
Escrihuela, OGM, Tortola, Valle, PRD **83** 093002 (2011)

Bounds on scalar GNI for neutrino-quark



F. J. Escrihuela, L. J. Flores, OGM, J. Rendon, JHEP 07 (2021) 061 arXiv:2105.06484

Bounds on tensor GNI for neutrino-quark



F. J. Escrihuela, L. J. Flores, OGM, J. Rendon, JHEP 07 (2021) 061 arXiv:2105.06484

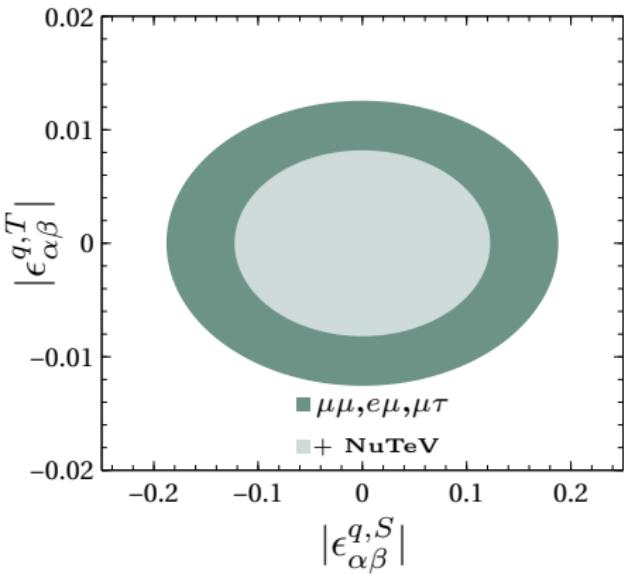
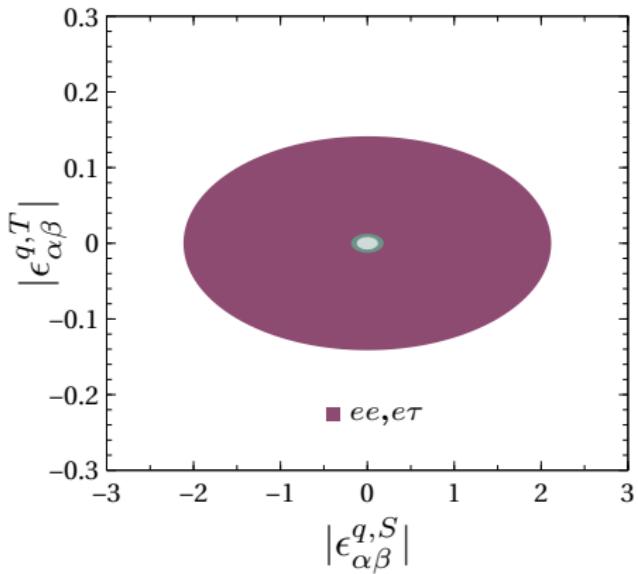
Bounds on GNI for neutrino-quark

Experiments	Scalar	Pseudoscalar	Tensor
CHARM- e	$ \epsilon_{ee}^{q,X} < 1.9$		$ \epsilon_{ee}^{q,T} < 0.13$
CHARM + CDHS (+ NuTeV)	$ \epsilon_{\mu\mu}^{q,X} < 0.15 \text{ (0.1)}$		$ \epsilon_{\mu\mu}^{q,T} < 0.01 \text{ (0.006)}$
All	$ \epsilon_{e\mu}^{q,X} < 0.15 \text{ (0.1)}$		$ \epsilon_{e\mu}^{q,T} < 0.01 \text{ (0.006)}$
CHARM- e	$ \epsilon_{e\tau}^{q,X} < 1.9$		$ \epsilon_{e\tau}^{q,T} < 0.13$
CHARM + CDHS (+ NuTeV)	$ \epsilon_{\mu\tau}^{q,X} < 0.15 \text{ (0.1)}$		$ \epsilon_{\mu\tau}^{q,T} < 0.01 \text{ (0.006)}$

Table: Combined 90% C.L. limits on the different scalar, pseudoscalar, and tensor neutrino interaction parameters, with $X = S, P$, for neutrino-quark interaction. For each suitable parameter, we also show in brackets the corresponding limits including the NuTeV measurements.

F. J. Escrihuela, L. J. Flores, OGM, J. Rendon, JHEP 07 (2021) 061 arXiv:2105.06484

Combined constraints on GNI for neutrino-quark



F. J. Escrihuela, L. J. Flores, OGM, J. Rendon, JHEP 07 (2021) 061 arXiv:2105.06484

Neutrino-electron NSI constraints

- Experiments:
 - ➊ Reactor neutrinos ($\bar{\nu}_e e^- \rightarrow \bar{\nu}_e e^-$)
 - ➋ LEP data ($e^+ e^- \rightarrow \nu \bar{\nu} \gamma$)
 - ➌ CHARM-II ($\nu_\mu e^- \rightarrow \nu_\mu e^-$)

The νe^- interaction

$$\frac{d\sigma}{dE_r} = \frac{G_F^2 m_e}{\pi} \left[A + 2B \left(1 - \frac{E_r}{E_\nu} \right) + C \left(1 - \frac{E_r}{E_\nu} \right)^2 + D \frac{m_e E_r}{E_\nu^2} \right], \quad (1)$$

where E_r is the kinetic energy of the recoiling electron and

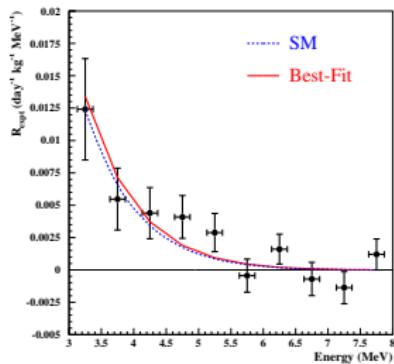
$$\begin{aligned} A &= 2|\epsilon_{\alpha\beta}^{e,L}|^2 + \frac{1}{4}(|\epsilon_{\alpha\beta}^{e,S}|^2 + |\epsilon_{\alpha\beta}^{e,P}|^2) + 8|\epsilon_{\alpha\beta}^{e,T}|^2 - 2\Re((\epsilon^{e,S} + \epsilon^{e,P})_{\alpha\beta}\epsilon_{\alpha\beta}^{e,T*}), \\ B &= -\frac{1}{4}(|\epsilon_{\alpha\beta}^{e,S}|^2 + |\epsilon_{\alpha\beta}^{e,P}|^2) + 8|\epsilon_{\alpha\beta}^{e,T}|^2, \\ C &= 2|\epsilon_{\alpha\beta}^{e,R}|^2 + \frac{1}{4}(|\epsilon_{\alpha\beta}^{e,S}|^2 + |\epsilon_{\alpha\beta}^{e,P}|^2) + 8|\epsilon_{\alpha\beta}^{e,T}|^2 + 2\Re((\epsilon^{e,S} + \epsilon^{e,P})_{\alpha\beta}\epsilon_{\alpha\beta}^{e,T*}), \\ D &= -2\Re(\epsilon_{\alpha\beta}^{e,L}\epsilon_{\alpha\beta}^{e,R*}) + \frac{1}{2}|\epsilon_{\alpha\beta}^{e,S}|^2 - 8|\epsilon_{\alpha\beta}^{e,T}|^2. \end{aligned} \quad (2)$$

For $\bar{\nu}$ $A \leftrightarrow C$

I. Bischer, W. Rodejohann Phys.Rev.D 99 (2019) 3, 036006 1810.02220

The $\nu_e e$ interaction

Experiment	Energy (MeV)	events	measurement
LSND $\nu_e e$	10-50	191	$\sigma = [10.1 \pm 1.5] \times E_{\nu_e} (\text{MeV}) \times 10^{-45} \text{cm}^2$
Irvine $\bar{\nu}_e - e$	1.5 - 3.0	381	$\sigma = [0.86 \pm 0.25] \times \sigma_{V-A}$
Irvine $\bar{\nu}_e - e$	3.0 - 4.5	77	$\sigma = [1.7 \pm 0.44] \times \sigma_{V-A}$
Rovno $\bar{\nu}_e - e$	0.6 - 2.0	41	$\sigma = (1.26 \pm 0.62) \times 10^{-44} \text{cm}^2/\text{fission}$
MUNU $\bar{\nu}_e - e$	0.7 - 2.0	68	$1.07 \pm 0.34 \text{ events day}^{-1}$



TEXONO Coll. Phys.Rev. D81 (2010) 072001 arXiv:0911.1597

The $\nu_\mu e \rightarrow \nu_\mu e$ interaction

$$\frac{d\sigma_{\text{CHARM}}^{\text{theo}}}{dy} = \frac{2G_F^2 m_e}{\pi} E_\nu \left[\left(\tilde{g}_L^2 + \sum_{\alpha \neq \mu} |\varepsilon_{\alpha\mu}^L|^2 \right) + \left(\tilde{g}_R^2 + \sum_{\alpha \neq \mu} |\varepsilon_{\alpha\mu}^R|^2 \right) (1-y)^2 \right]$$

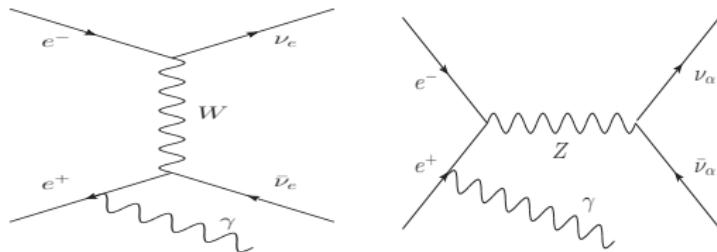
$$\sigma_{\nu N, S(P)}^{NC} = \sigma_{\bar{\nu} N, S(P)}^{NC} = \frac{G_F^2 s}{24\pi} \left[(\epsilon_\alpha^{u, S(P)})^2 \left(\frac{f_q + f_{\bar{q}}}{2} \right) + (\epsilon_\alpha^{d, S(P)})^2 \left(\frac{f_q + f_{\bar{q}}}{2} \right) \right], \quad (3)$$

$$\sigma_{\nu N, T}^{NC} = \sigma_{\bar{\nu} N, T}^{NC} = \frac{28G_F^2 s}{3\pi} \left[(\epsilon_\alpha^{u, T})^2 \left(\frac{f_q + f_{\bar{q}}}{2} \right) + (\epsilon_\alpha^{d, T})^2 \left(\frac{f_q + f_{\bar{q}}}{2} \right) \right], \quad (4)$$

$$|\epsilon_\alpha^{q, Y}|^2 \equiv \sum_\beta |\epsilon_{\alpha\beta}^{q, X}|^2. \quad (5)$$

T. Han, J. Liao, H. Liu, and D. Marfatia, JHEP 07, 207 (2020), arXiv:2004.13869

The $e^+e^- \rightarrow \nu\bar{\nu}\gamma$ interaction



$$\sigma_{\text{LEP}}^{\text{theo}}(s) = \int dx \int dc_\gamma H(x, s_\gamma; s) \sigma_0^{\text{theo}}(\hat{s}),$$

$$H(x, s_\gamma; s) = \frac{2\alpha}{\pi x s_\gamma} \left[\left(1 - \frac{x}{2}\right)^2 + \frac{x^2 c_\gamma^2}{4} \right],$$

O. Nicrosini and L. Trentadue, Nucl. Phys. B318, 1 (1989)

Z. Berezhiani and A. Rossi, Phys. Lett. B535, 207 (2002), arXiv:hep-ph/0111137

M. Hirsch, E. Nardi, and D. Restrepo, Phys. Rev. D67, 033005 (2003), arXiv:hep-ph/0210137

J. Barranco, OGM, C. A. Moura, JWF Valle, Phys. Rev. D77, 093014 (2008), 0711.0698

D. V. Forero and M. M. Guzzo, Phys. Rev. D 84, 013002 (2011)

The $e^+e^- \rightarrow \nu\bar{\nu}\gamma$ interaction

$$\sigma_0(s) = \sigma_W(s) + \sigma_Z(s) + \sigma_{W-Z}(s),$$

$$\sigma_0(s) = \frac{G_F^2 s}{12\pi} \left[2 + \frac{N_\nu(g_V^2 + g_A^2)}{(1 - s/M_Z^2)^2 + \Gamma_Z^2/M_Z^2} + \frac{2(g_V + g_A)(1 - s/M_Z^2)}{(1 - s/M_Z^2)^2 + \Gamma_Z^2/M_Z^2} \right],$$

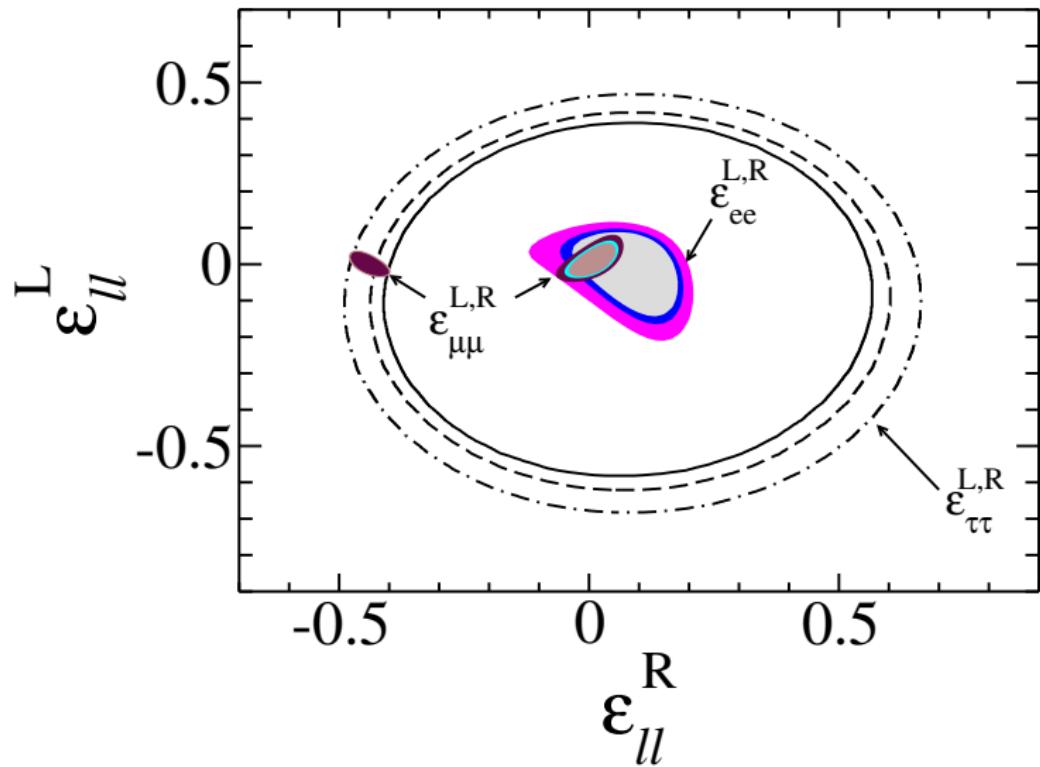
$$\sigma_0^{\text{NU}}(s) = \sum_{\alpha=e,\mu,\tau} \frac{G_F^2}{6\pi} s \left[(\varepsilon_{\alpha\alpha}^L)^2 + (\varepsilon_{\alpha\alpha}^R)^2 - 2(g_L \varepsilon_{\alpha\alpha}^L + g_R \varepsilon_{\alpha\alpha}^R) \frac{M_Z^2(s - M_Z^2)}{(s - M_Z^2)^2 + (M_Z \Gamma_Z)^2} \right]$$

$$+ \frac{G_F^2}{\pi} \varepsilon_{ee}^L M_W^2 \left[\frac{(s + M_W^2)^2}{s^2} \log \left(\frac{s + M_W^2}{M_W^2} \right) - \frac{M_W^2}{s} - \frac{3}{2} \right],$$

$$\sigma_0^{\text{FC}}(s) = \sum_{\alpha \neq \beta = e, \mu, \tau} \frac{G_F^2}{6\pi} s \left[(\varepsilon_{\alpha\beta}^L)^2 + (\varepsilon_{\alpha\beta}^R)^2 \right].$$

$$\sigma_0 = \frac{G_F^2 s}{48\pi} \sum_{\alpha, \beta} \left(8|\epsilon_{\alpha\beta}^{e,L}|^2 + 8|\epsilon_{\alpha\beta}^{e,R}|^2 + 3|\epsilon_{\alpha\beta}^{e,S}|^2 + 3|\epsilon_{\alpha\beta}^{e,P}|^2 + 32|\epsilon_{\alpha\beta}^{e,T}|^2 \right).$$

Neutrino-electron NSI constraints

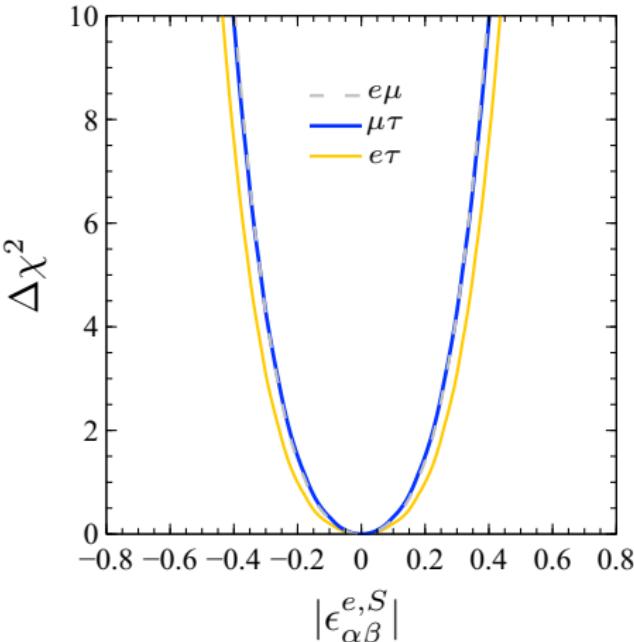
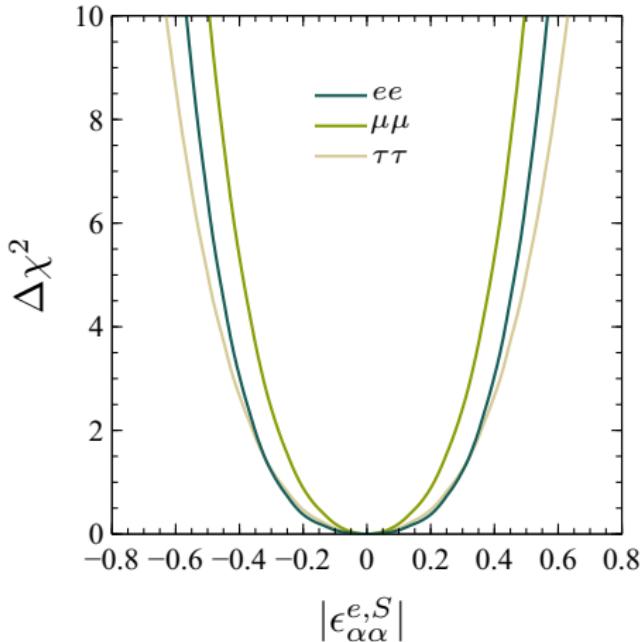


Neutrino-electron NSI constraints

	Region at 90% C. L.	one parameter
ε_{ee}^L	$-0.14 < \varepsilon_{ee}^L < 0.09$	$-0.03 < \varepsilon_{ee}^L < 0.08$
ε_{ee}^R	$-0.03 < \varepsilon_{ee}^R < 0.18$	$0.004 < \varepsilon_{ee}^R < 0.15$
$\varepsilon_{\mu\mu}^L$	$-0.033 < \varepsilon_{\mu\mu}^L < 0.055$	$ \varepsilon_{\mu\mu}^L < 0.03$
$\varepsilon_{\mu\mu}^R$	$-0.040 < \varepsilon_{\mu\mu}^R < 0.053$	$ \varepsilon_{\mu\mu}^R < 0.03$
$\varepsilon_{\tau\tau}^L$	$-0.6 < \varepsilon_{\tau\tau}^L < 0.4$	$-0.5 < \varepsilon_{\tau\tau}^L < 0.2$
$\varepsilon_{\tau\tau}^R$	$-0.4 < \varepsilon_{\tau\tau}^R < 0.6$	$-0.3 < \varepsilon_{\tau\tau}^R < 0.4$

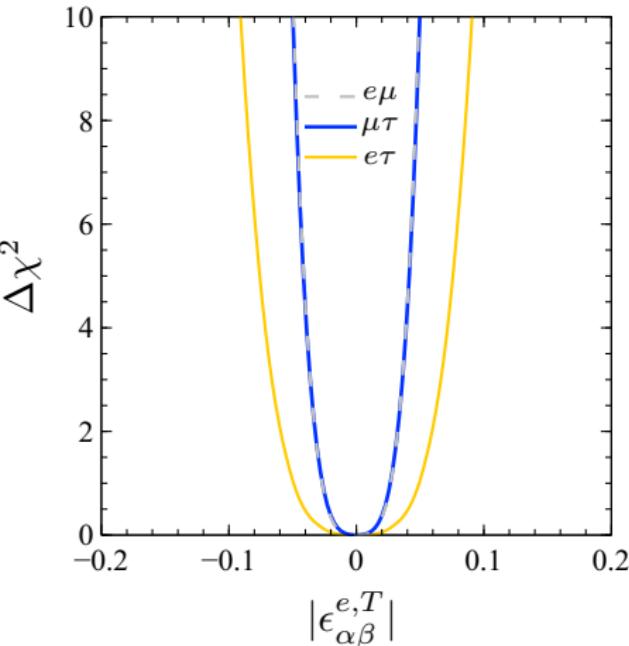
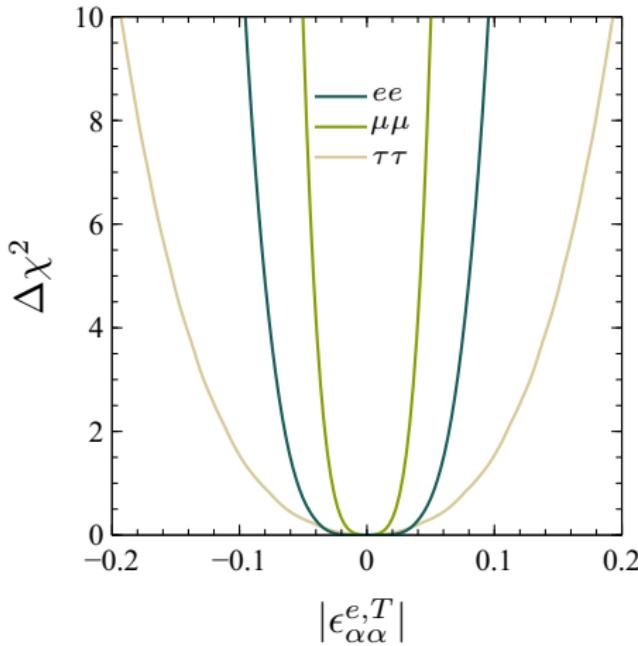
Barranco, OGM, Moura, Valle PRD **77** 093014 '08

Bounds on scalar GNI for neutrino-electron



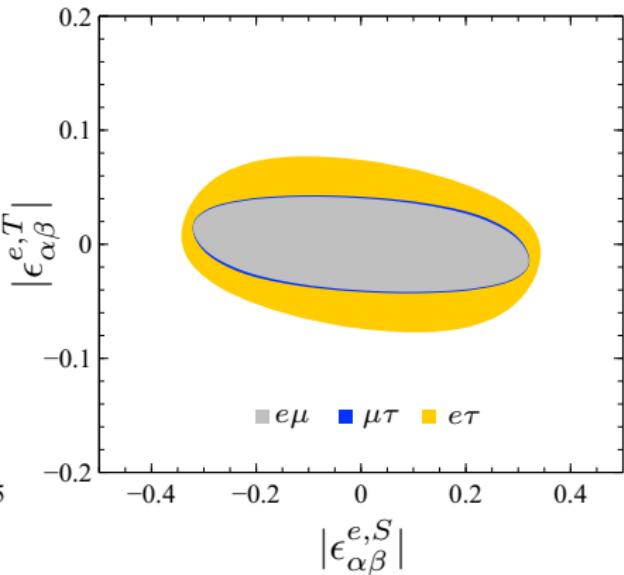
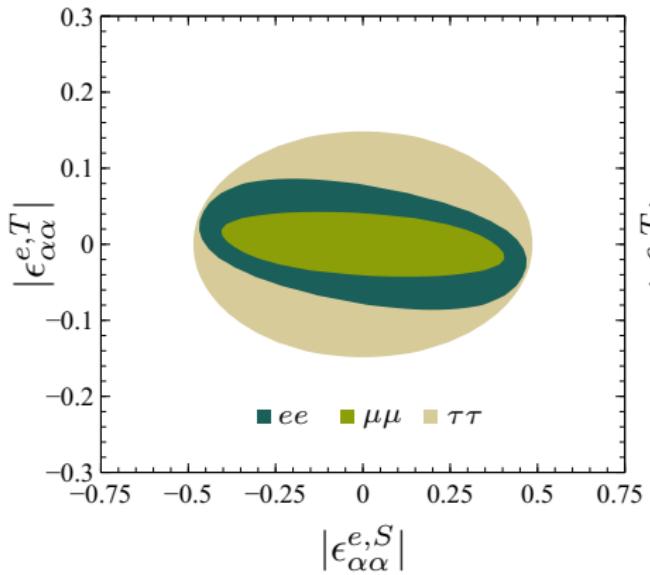
F. J. Escrihuela, L. J. Flores, OGM, J. Rendon, JHEP 07 (2021) 061 arXiv:2105.06484

Bounds on tensor GNI for neutrino-electron



F. J. Escrihuela, L. J. Flores, OGM, J. Rendon, JHEP 07 (2021) 061 arXiv:2105.06484

Global constraints on GNI for neutrino-electron



F. J. Escrihuela, L. J. Flores, OGM, J. Rendon, JHEP 07 (2021) 061 arXiv:2105.06484

Bounds on GNI for neutrino-quark

Experiments	Scalar	Pseudoscalar	Tensor
$e^-e^+ + \text{TEXONO}$	$ \epsilon_{ee}^{e,S} < 0.38$	$ \epsilon_{ee}^{e,P} < 0.40$	$ \epsilon_{ee}^{e,T} < 0.07$
$e^-e^+ + \text{CHARM-II}$	$ \epsilon_{\mu\mu}^{e,X} < 0.31$		$ \epsilon_{\mu\mu}^{e,T} < 0.03$
e^-e^+	$ \epsilon_{\tau\tau}^{e,X} < 0.40$		$ \epsilon_{\tau\tau}^{e,T} < 0.12$
$e^-e^+ + \text{TEXONO} + \text{CHARM-II}$	$ \epsilon_{e\mu}^{e,S} < 0.25$	$ \epsilon_{e\mu}^{e,P} < 0.25$	$ \epsilon_{e\mu}^{e,T} < 0.03$
$e^-e^+ + \text{TEXONO}$	$ \epsilon_{e\tau}^{e,S} < 0.28$	$ \epsilon_{e\tau}^{e,P} < 0.29$	$ \epsilon_{e\tau}^{e,T} < 0.07$
$e^-e^+ + \text{CHARM-II}$	$ \epsilon_{\mu\tau}^{e,X} < 0.25$		$ \epsilon_{\mu\tau}^{e,T} < 0.03$

Table: Combined 90% C.L. limits on the different scalar, pseudoscalar, and tensor neutrino interaction parameters, with $X = S, P$, for neutrino-quark interaction.

F. J. Escrihuela, L. J. Flores, OGM, J. Rendon, JHEP 07 (2021) 061 arXiv:2105.06484

Conclusions

- ✓ Neutrino physics suggest that physics beyond the Standard Model should be detectable in near future.
- ✓ The formalism of GNI is a useful tool to perform phenomenological test of a wide class of theoretically motivated BSM models.
- ✓ Global analysis provide constraints that, besides being restrictive, are robust and helps to avoid degeneracies.

Thanks