Strength and correlations of slepton flavour violation in SUSY seesaw models

Simon Albino [a]

albino@physik.uni-wuerzburg.de

Institute for Theoretical Physics and Astrophysics
University of Würzburg, Germany

[a] in collaboration with Frank Deppisch (DESY) and Reinhold Rückl (Würzburg)

LFV in SUSY Framework

- Source of LFV: Off-diagonal terms in

$$M_{\tilde{l}}^2 = \begin{pmatrix} m_L^2 & m_{LR}^2 \\ (m_{LR}^2)^\dagger & m_R^2 \end{pmatrix}$$

- Reparameterization:

$$m_L^2 = \overline{m}_L^2(\delta_{ij} + \delta_{ij}^{LL})$$

$$m_R^2 = \overline{m}_R^2(\delta_{ij} + \delta_{ij}^{RR})$$

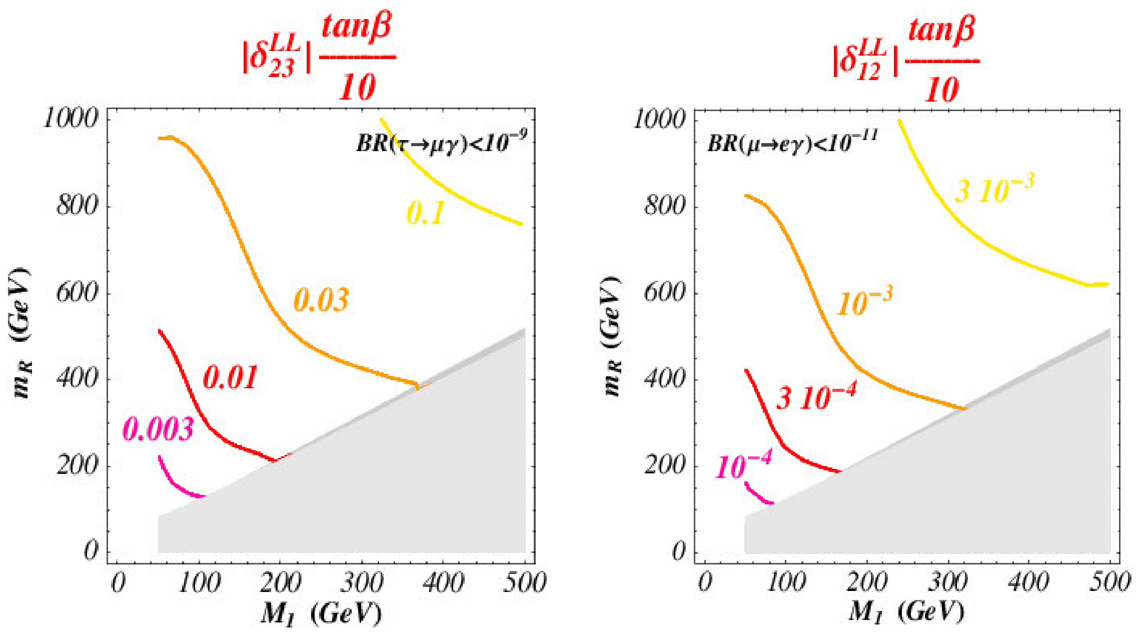
$$m_{LR}^2 = (A_e)_{ii}^* \delta_{ij} v \cos\beta - \delta_{ij} m_{l_i} \mu \tan\beta + \overline{m}_L \overline{m}_R \delta_{ij}^{LR}$$

$$\overline{m}_{L(R)} = \frac{1}{3} \sum_{i=1}^{3} (m_{L(R)})_{ii} \qquad (*)$$

Hall, Kostelecky, Raby, Nucl. Phys. B 267 (1986) 415

Model Independent δ_{ij}^{AB} Bounds

- Bounds in general mSUGRA considered by *Masina, Savoy, Nucl. Phys. B 661 (2003) 365*
- Similar studies in e.g. *Paradisi, JHEP 0510 (2005) 006*



"m_R"$=\overline{m}_R$ as defined in (*)

M_1: U(1)-gaugino mass

- However, definite models predict 12↔23 correlations

δ_{ij}^{AB} in Type I Seesaw (mSUGRA)

- Renormalization group results ($i \neq j$)

$$\delta_{ij}^{LL} \propto -\frac{1}{8\pi^2}(3m_0^2 + A_0^2)(Y_\nu^\dagger L Y_\nu)_{ij}$$

$$\delta_{ij}^{RR} \propto 0_{ij}$$

$$\delta_{ij}^{LR} \propto -\frac{3}{16\pi^2} A_0 v \cos\beta Y_e \cdot (Y_\nu^\dagger L Y_\nu)_{ij}$$

- Master formula for $Y_\nu^\dagger L Y_\nu$:

$$Y_\nu^\dagger L Y_\nu = \frac{1}{v^2 \sin^2\beta} U \cdot \text{diag}\sqrt{m_i} \cdot R^\dagger \cdot \text{diag}\left(M_i \ln \frac{M_{\text{GUT}}}{M_i}\right) \cdot R \cdot \text{diag}\sqrt{m_i} \cdot U^\dagger$$

  - ν, ν_R eigenmasses: m_i, M_i
  - ν mixing: $U = V(\theta_{ij}, \delta) \cdot \text{diag}(e^{I\phi_1}, e^{I\phi_2}, 1)$
  - R: complex matrix, $R^T R = \mathbf{1}$

Assumption I: $M_i = M_R, i = 1, 2, 3$

- Take R real $\implies$ no R dependence since $R^\dagger R \to \mathbf{1}$
- Scatter all other seesaw parameters over allowed ranges

$$Y_\nu^\dagger L Y_\nu \approx \frac{M_R \ln(M_{\rm GUT}/M_R)}{v^2 \sin^2\beta} V \cdot \mathrm{diag}(m_i) \cdot V^\dagger$$

a. "Degenerate" ν ($m_1 \approx 0.3$ eV $\gg \Delta m^2_{12}, |\Delta m^2_{23}|$)

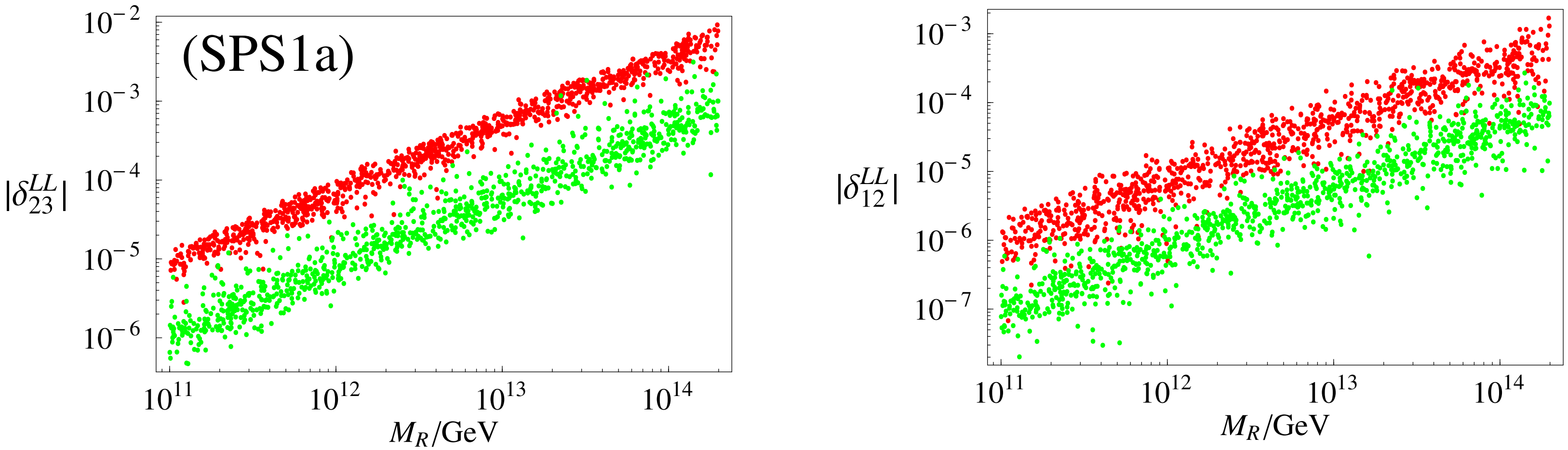
$$V \cdot \mathrm{diag}(m_i) \cdot V^\dagger \approx m_1 \delta_{ij} + \frac{1}{2m_1} \left(\Delta m^2_{12} V_{i2} V^*_{j2} + \Delta m^2_{23} V_{i3} V^*_{j3}\right)$$

b. Hierarchical ν ($m_1 = 0 - 0.03$ eV)

$$V \cdot \mathrm{diag}(m_i) \cdot V^\dagger \approx \sqrt{\Delta m^2_{12}} V_{i2} V^*_{j2} + \sqrt{\Delta m^2_{23}} V_{i3} V^*_{j3}$$

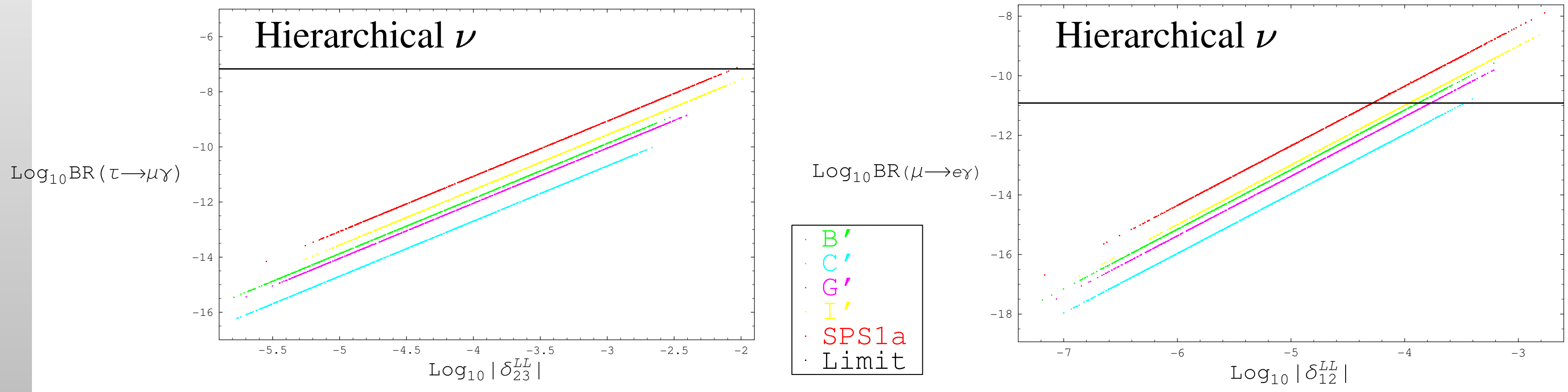
Dependence of δ_{ij}^{AB} on M_R – Deg. ν_R

- Focus on $ij = 12, 23$ mixing (13 exp. more difficult)
- Consider degenerate and hierarchical ν



- $|\delta_{ij}^{LL}|$ roughly linearly dependent on M_R
- $|\delta_{ij}^{LL}|_{\text{hier.}} \approx 10\times\, |\delta_{ij}^{LL}|_{\text{deg.}}$

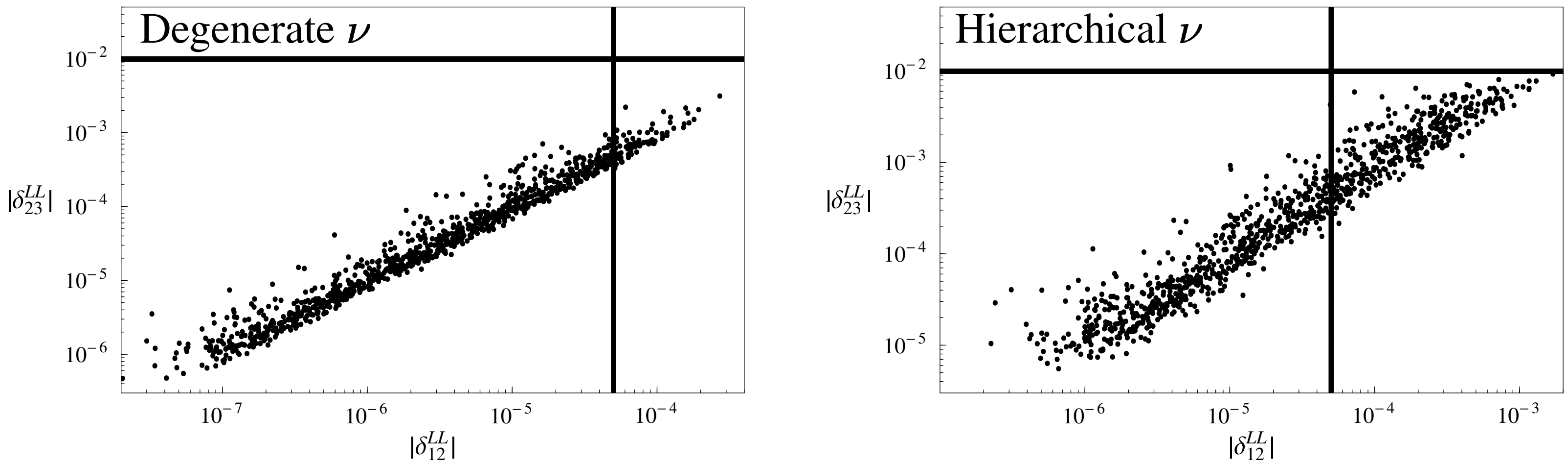
Constraints on δ_{ij}^{AB} – Deg. ν_R



- BR$\propto|\delta^{LL}|^2$ in range considered $\rightarrow$ mass insertion justified
- Direct exp. bounds (BaBar 2005, PDG), SPS1a:

$$\text{BR}(\tau\rightarrow\mu\gamma)<6.8\times10^{-8}\implies|\delta_{23}^{LL}|\lesssim10^{-2}$$
$$\text{BR}(\mu\rightarrow e\gamma)<1.2\times10^{-11}\implies|\delta_{12}^{LL}|\lesssim10^{-4.3}$$

Correlations Between δ_{ij}^{AB} – Deg. ν_R



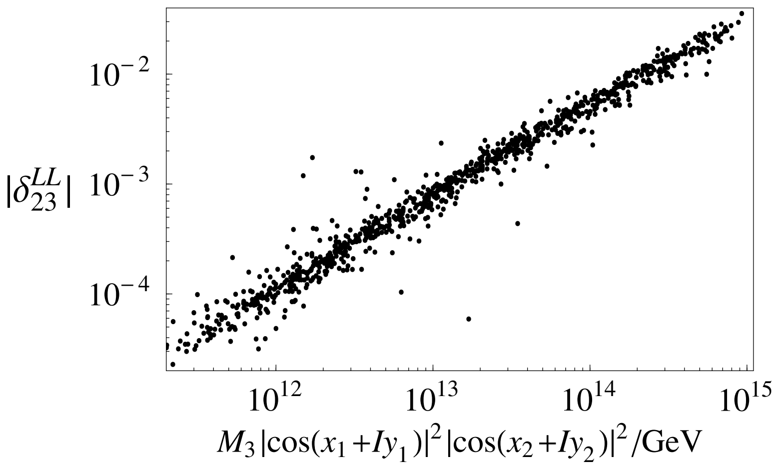
Exp. bound on $|\delta_{12}^{LL}| < 10^{-4.3}$ from $\mathrm{BR}(\mu \to e\gamma) \implies$ stronger bound on $\mathrm{BR}(\tau \to \mu\gamma)$ than direct exp. search:

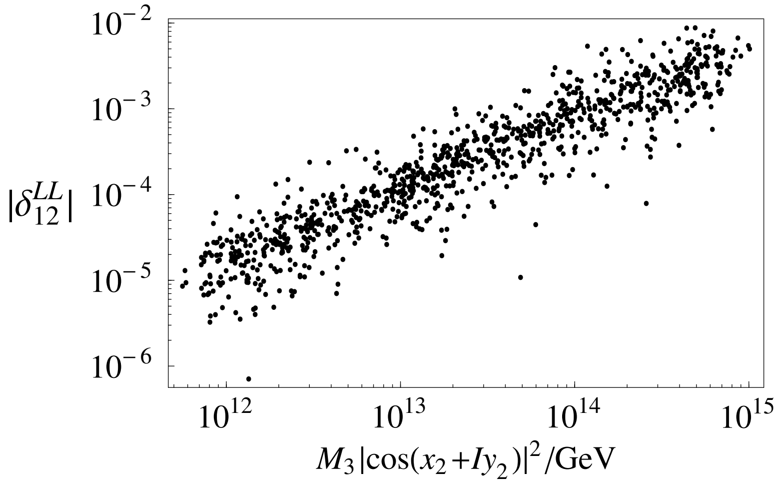
$$|\delta_{23}^{LL}| \lesssim 10^{-3}$$

Assumption II: $M_1 \ll M_2 \ll M_3$

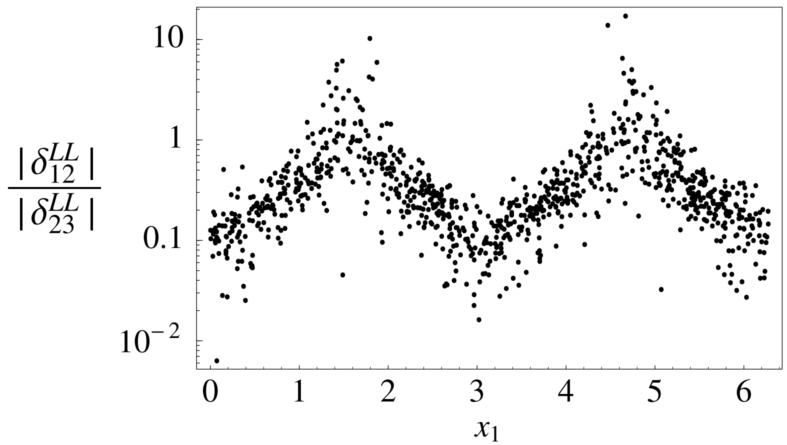
Scatter parameters as before, but also:

- $R(x_i + Iy_i)$: $0 < x_{1,2,3} < 2\pi$, $|y_{1,2,3}| < 1$ (pert. Y_ν)
- Leptogenesis: $|y_{1,2,3}| > 10^{-3}$, $M_1(m_i, R) \gtrsim 10^{9-10}$ GeV
- Gravitino bound: $M_1 < 10^{11}$ GeV
- Hierarchy: $10M_1 < M_3 < 10^4 M_1$, $M_1 < M_2 < 0.1M_3$

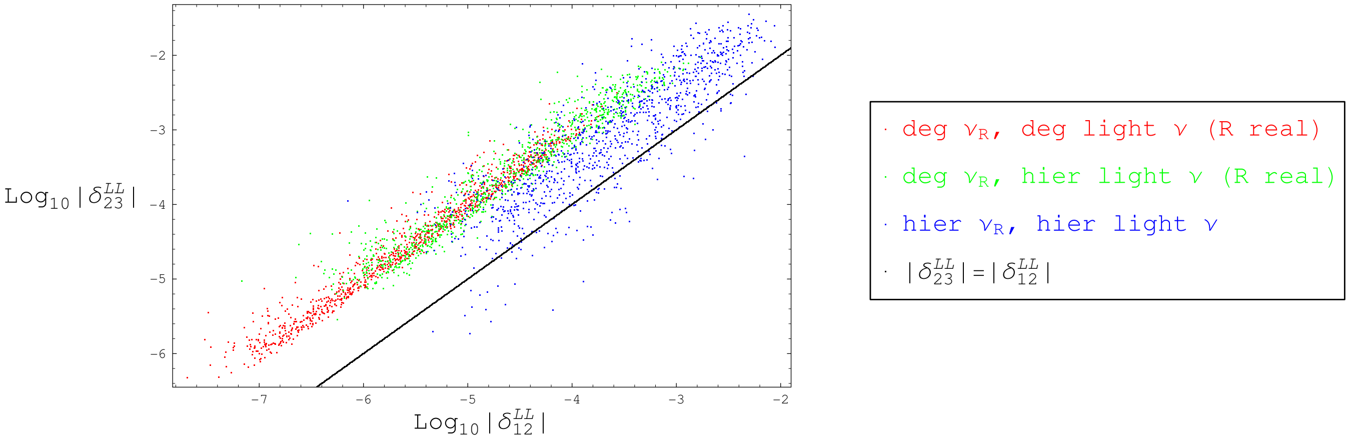




Correlations Between δ_{ij}^{AB} – Hier. ν_R, ν



- $x_1 = \frac{\pi}{2}, \frac{3\pi}{2} \to |\delta_{12}^{LL}| \approx |\delta_{23}^{LL}|$
- (Degenerate ν_R (and R real): $|\delta_{12}^{LL}| \lesssim 0.1 |\delta_{23}^{LL}|$)



Maximal $|\delta_{23}^{LL}|$ at given $|\delta_{12}^{LL}|$ is model independent

Summary and Outlook

General implications in type I seesaw:

Presently: $\mathrm{BR}(\mu \to e\gamma) < 10^{-11} \implies |\delta_{12}^{LL}| < 10^{-4.3}$

$\implies |\delta_{23}^{LL}| < 10^{-3} \implies \mathrm{BR}(\tau \to \mu\gamma) < 10^{-9}$

* Stronger than direct exp. $\tau \to \mu$ bound 6.8×10^{-8}

In future: $\mathrm{BR}(\mu \to e\gamma) < 10^{-14} \implies |\delta_{12}^{LL}| < 10^{-6}$

$\implies |\delta_{23}^{LL}| < 10^{-4.5} \implies \mathrm{BR}(\tau \to \mu\gamma) < 10^{-12}$

* beyond sensitivity of B factories and LHC

Outlook:

Scan correlations over mSUGRA spectrum

Study absolute maxima of $|\delta_{12,23}^{LL}|$ in parameter space

Consider complex R for degenerate ν_R

Outlook: Complex R – Deg. ν_R

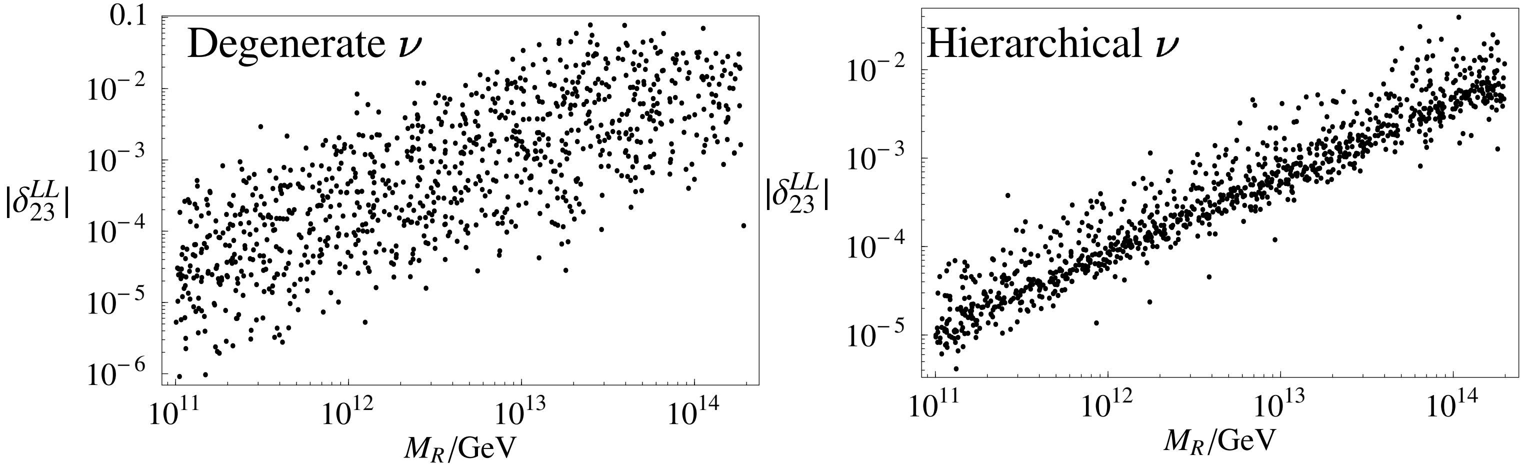
- Complex R changes $Y_\nu^\dagger L Y_\nu$ by

$$\Delta_R(Y_\nu^\dagger L Y_\nu) \approx U \text{diag}(\sqrt{m_i})(R^\dagger R - \mathbf{1})\text{diag}(\sqrt{m_i})U^\dagger$$

- Small y_i: $(R^\dagger R - \mathbf{1})_{kk} \approx 0$

  $\implies$ Hierarchical ν: $\Delta_R(Y_\nu^\dagger L Y_\nu) \approx 0$

- Include x_i, y_i in the scatter:

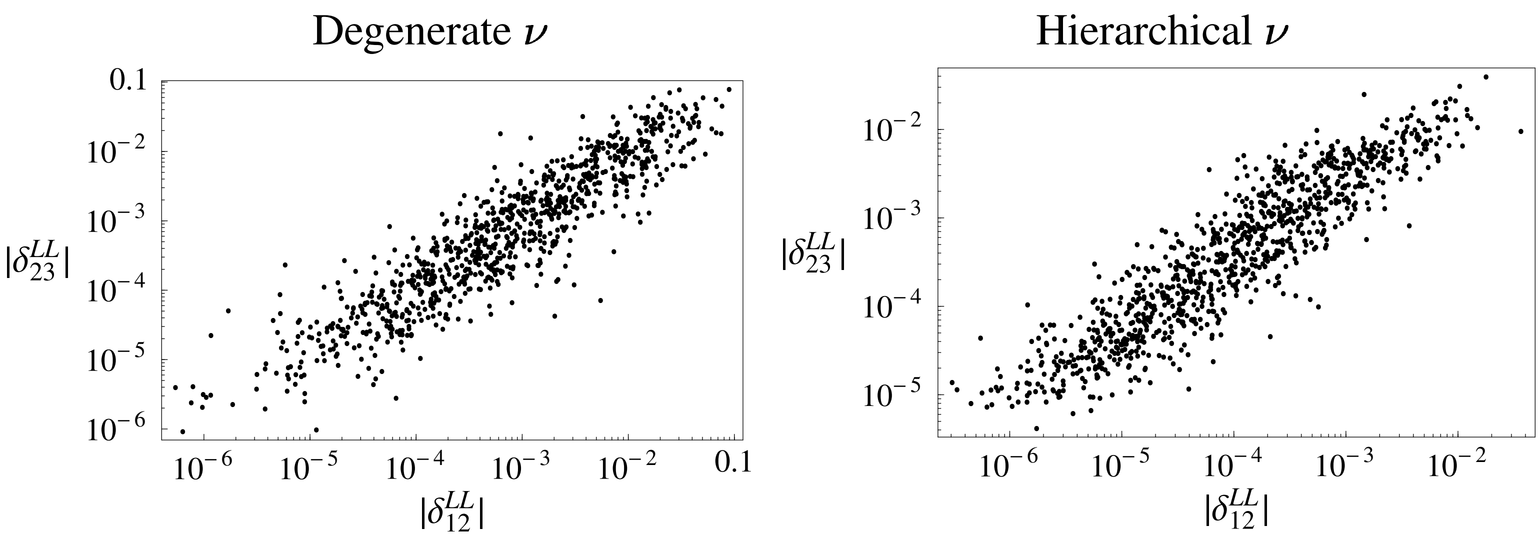


- Degenerate ν: Max$(|\delta_{23}^{LL}|) \uparrow$, Hierarchical ν: No change

- Can have deg. $|\delta_{23}^{LL}| >$ hier. $|\delta_{23}^{LL}|$

Outlook: Complex R – Deg. ν_R

- Real R: $|\delta_{12}^{LL}| \lesssim 0.1|\delta_{23}^{LL}|$
- Complex R:



- New solutions with complex R allow for $|\delta_{12}^{LL}| \approx |\delta_{23}^{LL}|$