Light scalars in the triplet seesaw model

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The two scalar triplet Model

The **SM does not explain** small neutrino masses

2STM

(Ferreira, et al., 2021)

$$\Delta_{1,2} = \begin{pmatrix} \delta^{+}_{1,2}/\sqrt{2} & \delta^{++}_{1,2} \\ \delta^{0}_{1,2} & -\delta^{+}_{1,2}/\sqrt{2} \end{pmatrix}$$

Scalar sector:

$$\theta_1 \neq \theta_2 \longrightarrow \textbf{Spontaneous CPV} \longrightarrow$$

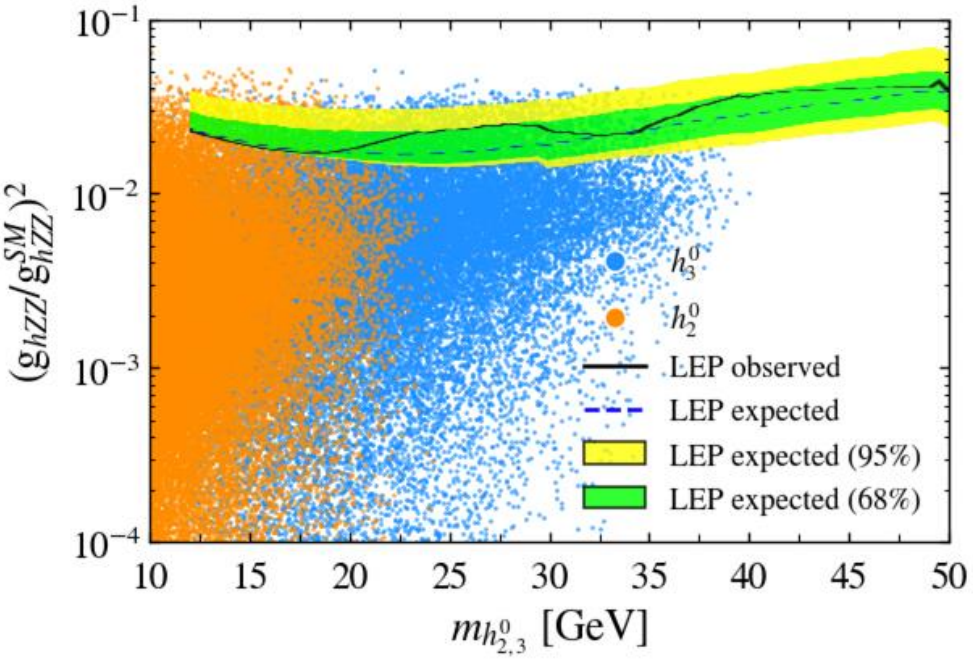
h^0_1	Goldstone
h^0_2	Light
h^0_3	Light
h^0_4	SM Higgs-like
h^0_5	Decoupled
h^0_6	Decoupled
H^+_1	Goldstone
H^+_2	Electroweak
H^+_3	Decoupled
H^{++}_1	Electroweak
H^{++}_2	Decoupled

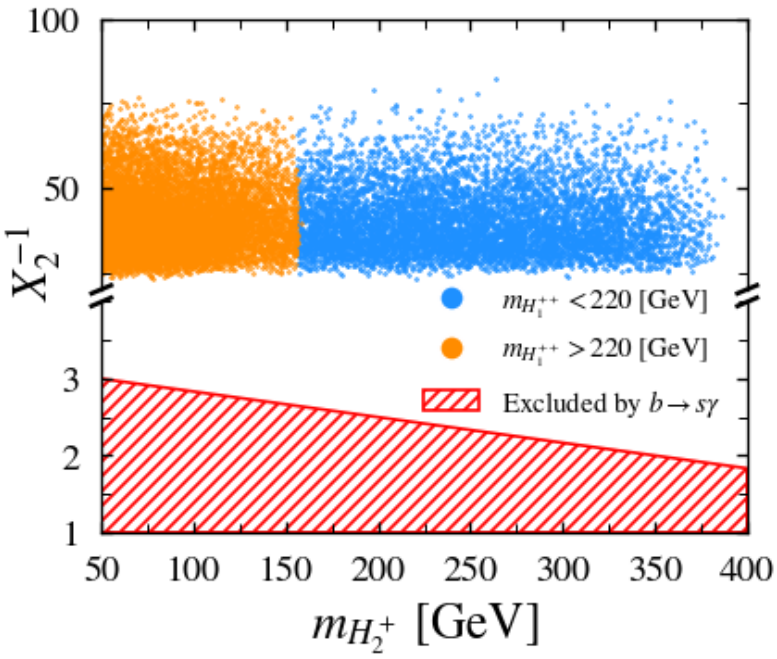
Lepton sector:

$$\mathbf{M}_\nu = \sqrt{2}\left(Y^{\Delta_1} u_1 e^{i\theta_1} + Y^{\Delta_2} u_2 e^{i\theta_2}\right)$$

LEPTONIC CPV

Compatibility with scalar searches





Neutral scalars (light):

- ✓ Significant portion of the parameter space **below the LEP upper bound**

Charged scalars (electroweak):

- ✓ **Not constrained** by B physics
- ✓ Significant portion of the parameter space **above the ATLAS lower bound**

Texture zeros in the neutrino mass matrix

$\mathbb{Z}_3$ symmetry:

$$\omega = \exp(2i\pi/3)$$

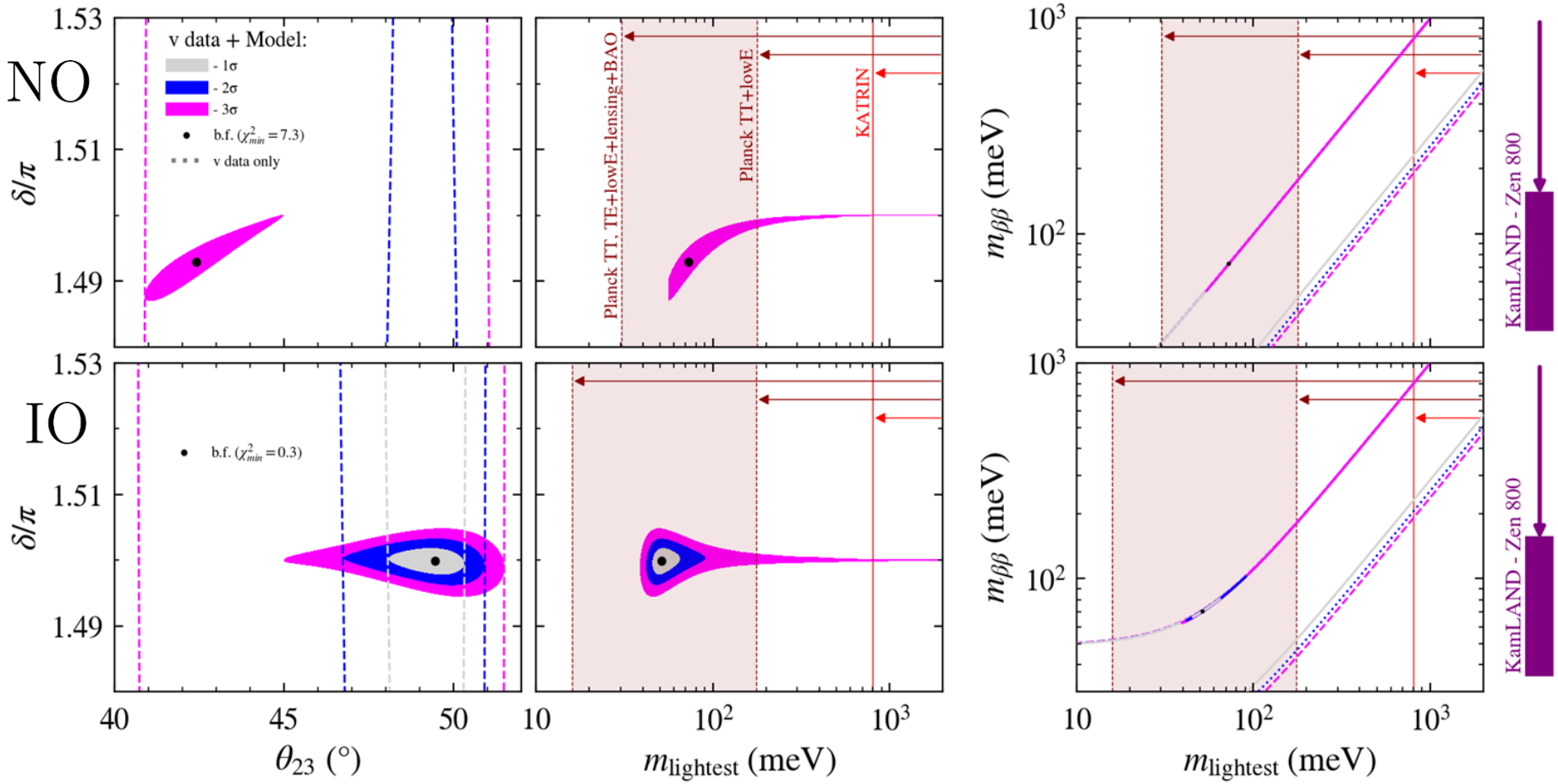
$$\begin{pmatrix} \ell_L^1 \\ \ell_L^2 \\ \ell_L^3 \end{pmatrix} \to \begin{pmatrix} 1 & 0 & 0 \\ 0 & \omega & 0 \\ 0 & 0 & \omega^2 \end{pmatrix} \begin{pmatrix} \ell_L^1 \\ \ell_L^2 \\ \ell_L^3 \end{pmatrix}, \quad \begin{aligned} \text{Case B}_1: &\quad \Delta_1 \to \Delta_1, \quad \Delta_2 \to \omega^2\, \Delta_2 \\ \text{Case B}_2: &\quad \Delta_1 \to \Delta_1, \quad \Delta_2 \to \omega\ \ \Delta_2 \end{aligned}$$

Neutrino mass matrix patterns with two 'texture' zeros:

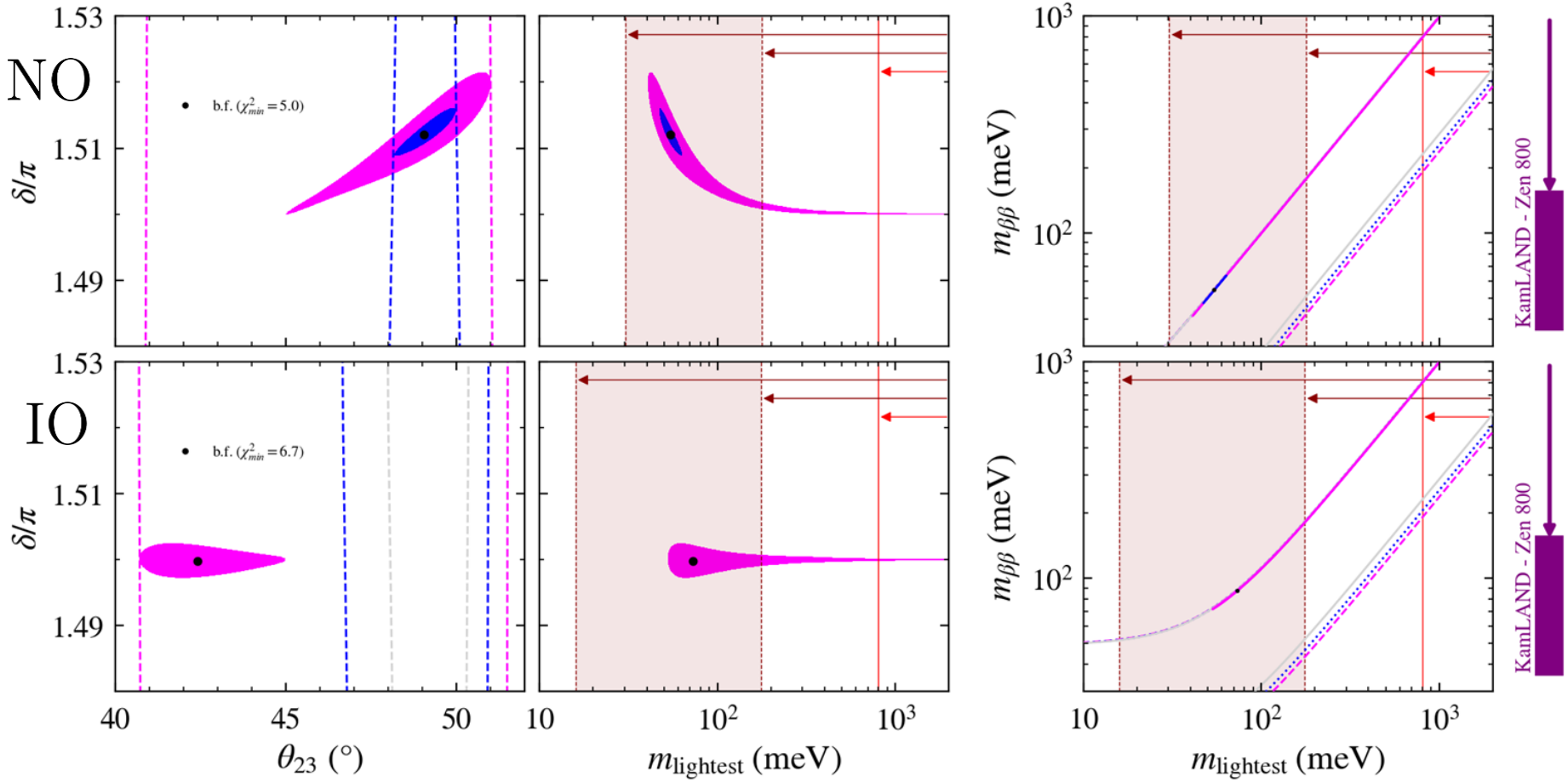
$$\text{Case B}_1 : \mathbf{M}_\nu \sim \begin{pmatrix} \times & \times & 0 \\ \cdot & 0 & \times \\ 0 & \cdot & \times \end{pmatrix}$$

$$\text{Case B}_2 : \mathbf{M}_\nu \sim \begin{pmatrix} \times & 0 & \times \\ 0 & \times & \times \\ \cdot & \cdot & 0 \end{pmatrix}$$

Compatibility with experimental data (B_1)



Compatibility with experimental data (B_2)



Summary and outlook

Work done:

- ✓ Study of the **2STM** theoretical framework;
- ✓ Study of the **neutrino mass matrix patterns** compatible with current experimental data;
- ✓ Preliminary **light scalar - fermion coupling study** (analytical and numerical).

Future work:

- ✓ 1-loop analysis and Astro / LFV constraints
- ✓ Update analysis with new experimental data including JUNO

Paper writing and publication

Thesis writing

Thesis presentation

Thank you !