Neutrinos: Overview of theory and phenomenology



A view from Toyama Castle Park. Credit: Tripadvisor

Eligio Lisi

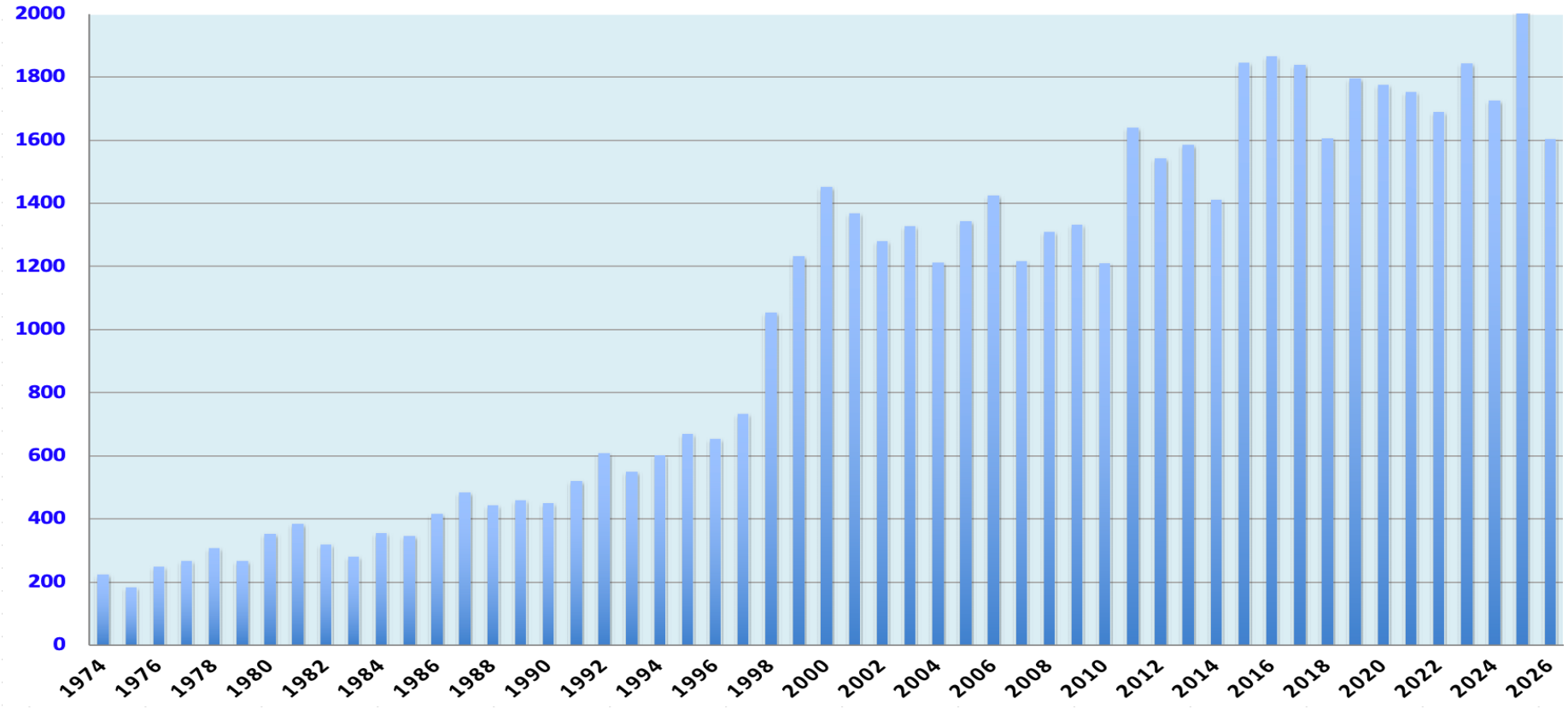
(INFN Bari, Italy)

ICFA Seminar 2026, Toyama International Conference Center, 3 November 2026, Toyama, Japan

Disclaimer

Rate of #neutrino# papers (1974-2026): currently ~2k/year. Source: INSPIRE

Large fraction involves ν theory + phenomenology. Only few topics covered in this talk.



Prologue

Neutrino masses are a bridge to new physics.

We have only just taken the first steps…



A view from Toyama Castle Park. Credit: Tripadvisor

We can't yet see what's at the other end, but…

It's already a pleasant walk, with nice views along the way!

Outline

Where we are: 3ν, circa 2026

The nearby theory landscape

A bridge to flavor physics

A bridge to higher scales

Epilogue

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The nearby theory landscape

A bridge to flavor physics

A bridge to higher scales

Epilogue

The current 3ν paradigm: (non)oscillation parameters

Mixing matrix: CKM→ PMNS (Pontecorvo-Maki-Nakagawa-Sakata)

$$U_{\alpha i} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{bmatrix} \begin{bmatrix} c_{13} & 0 & s_{13}e^{-i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta} & 0 & c_{13} \end{bmatrix} \begin{bmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & e^{i\alpha/2} & 0 \\ 0 & 0 & e^{i\beta/2} \end{bmatrix}$$

2-3 rotation

1-3 rotation
+ CPV "Dirac" phase
U(ν) → U*(ν̄)

1-2 rotation

Extra CPV phases
[if Majorana]
not tested in oscillat.

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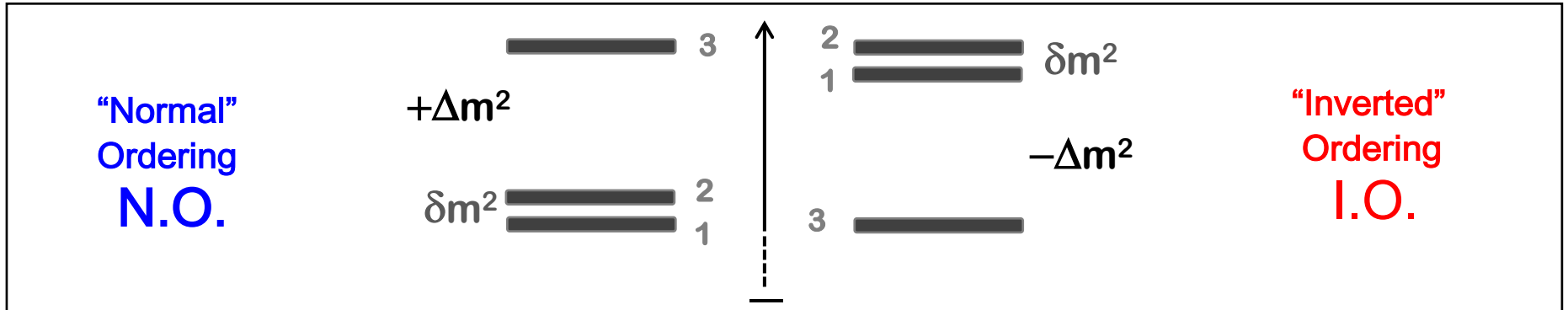
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Extra CPV phases
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Mass [squared] spectrum (E ~ p + m²/2E + "MSW interaction energy")



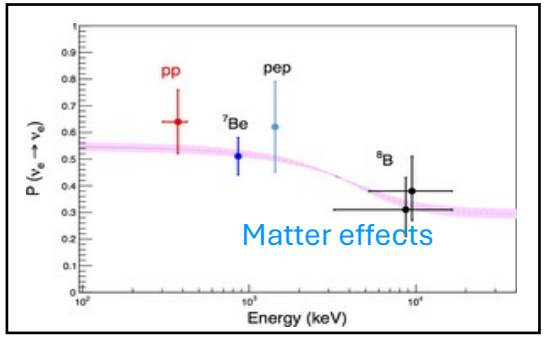
+ interaction energy in matter → ~ $G_F \cdot E \cdot$ density
(Mykheev-Smirnov-Wolfenstein – MSW effect)

5 knowns and 5 unknowns

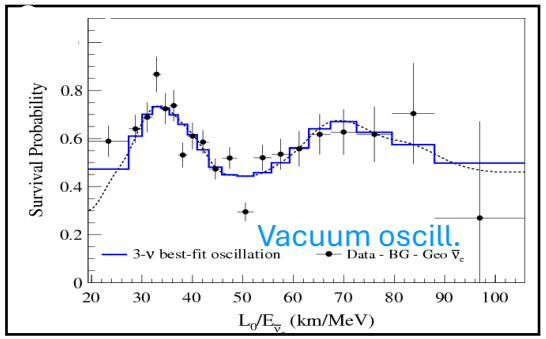
Oscillations: knowns	mass^2 splittings → oscillation frequencies	δm^2	$= \Delta m^2_{21} > 0$
		$\lvert\Delta m^2\rvert$	$= ½ \lvert\Delta m^2_{31} + \Delta m^2_{32}\rvert$
	mixing angles → oscillation amplitudes	θ_{13}	or: $\sin^2\theta_{ij}$
		θ_{12}	
		θ_{23}	
Oscillations: unknowns	Mass ordering	NO/IO	$\alpha = \text{sign}(\Delta m^2) = \pm 1$ (normal / inverted)
	CPV phase	δ	$\cos\delta = \pm 1$ → CP conservation
Nonoscill.: unknowns	Octant degen.	θ_{23} octant	disentangle, $< \pi/4$ or $> \pi/4$
	Lightest m_i	m_{lightest}	< few x 10^{-1} eV
	Neutrino nature	$\nu = \bar{\nu}$?	Dirac or Majorana?

3ν oscillations probed by different experiments in various flavor channels…

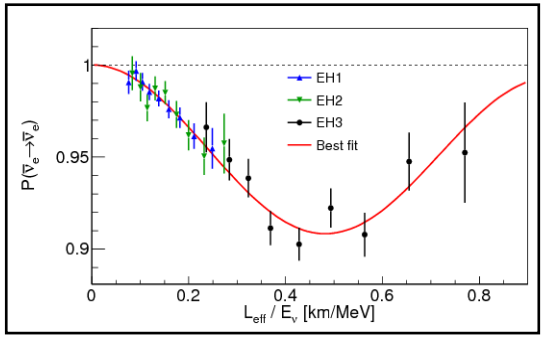
e→e (Solar)



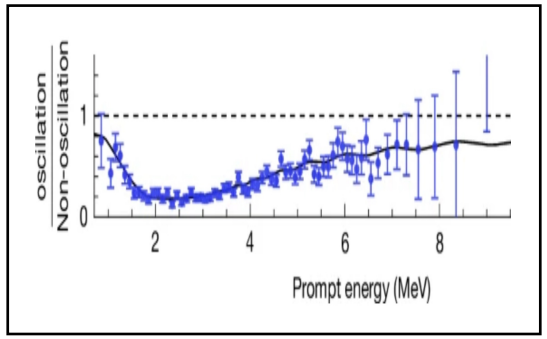
e→e (LB reactors)



e→e (SB reactors)



e→e (MB reac.= JUNO)



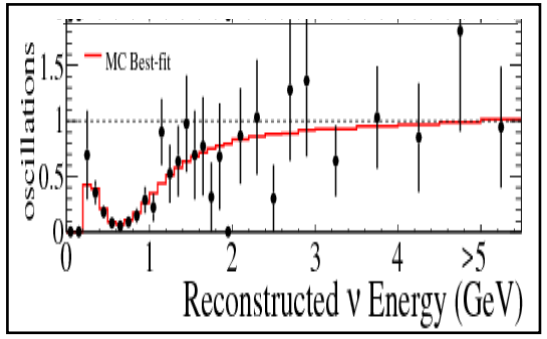
Solar

Long/Medium/ Short-Baseline reactors

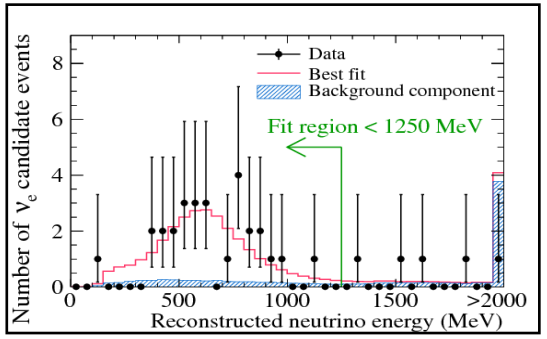
Atmospheric

Accelerator disappearance/ appearance

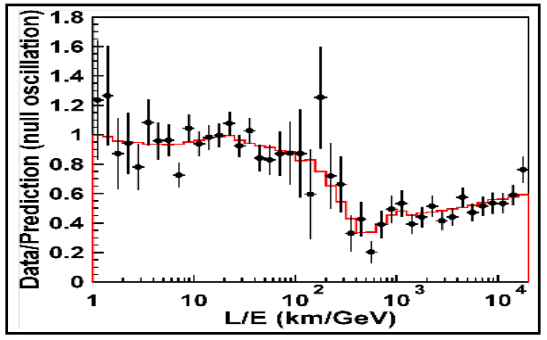
μ→μ (Accel. disapp.)



μ→e (Accel. appear.)

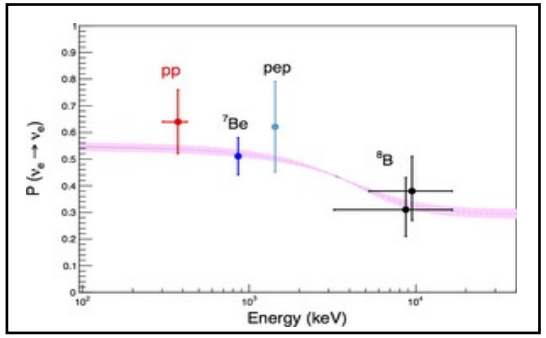


μ, e→μ, e (Atmos.)

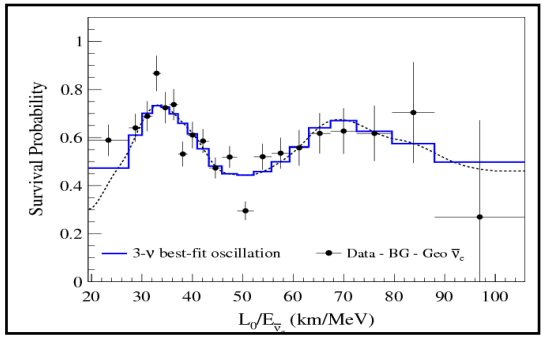


… each known oscillation parameter is overconstrained by ≥ 2 experiments

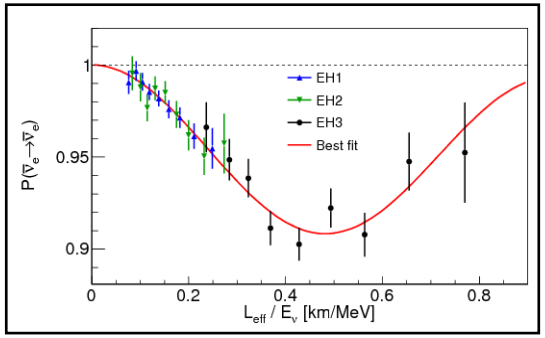
(δm^2 , θ_{12} , θ_{13})



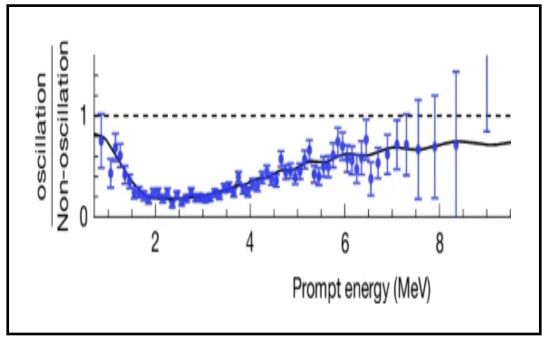
(δm^2 , θ_{12} , θ_{13})



(Δm^2 , θ_{13})



(δm^2 , θ_{12} , Δm^2 , θ_{13})



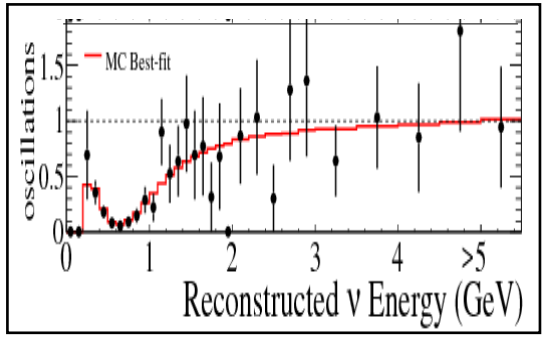
Redundance

Robustness

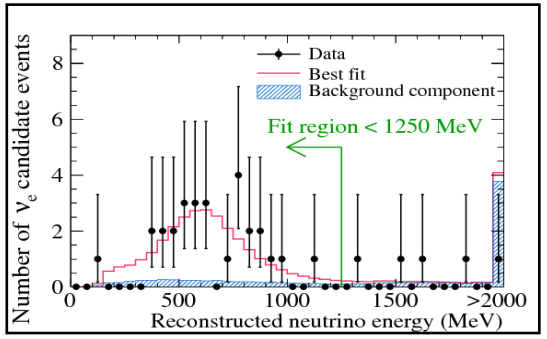
Complementarity

Synergy

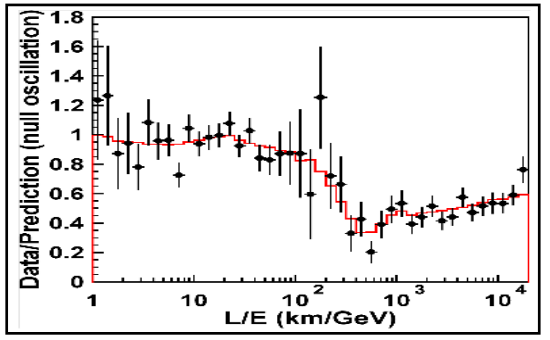
(Δm^2 , θ_{13} , θ_{23})



(Δm^2 , θ_{13} , θ_{23})

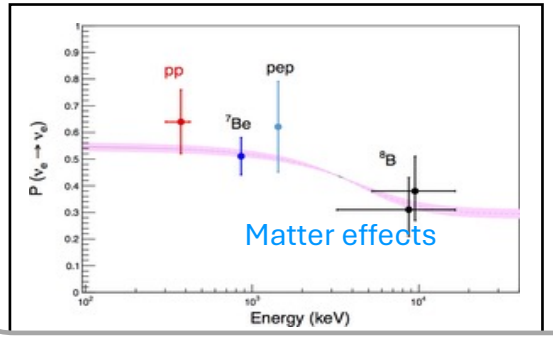


(Δm^2 , θ_{13} , θ_{23})

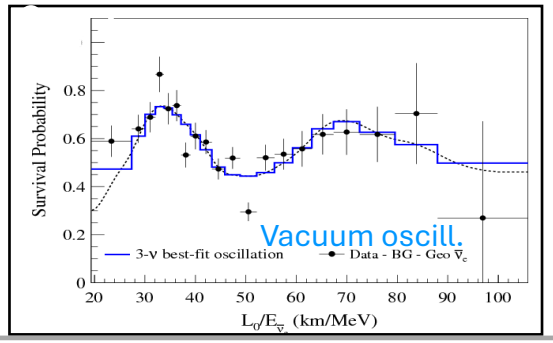


Sensitivity to unknown oscillation parameters: NO/IO, CP phase δ, θ_{23} octant

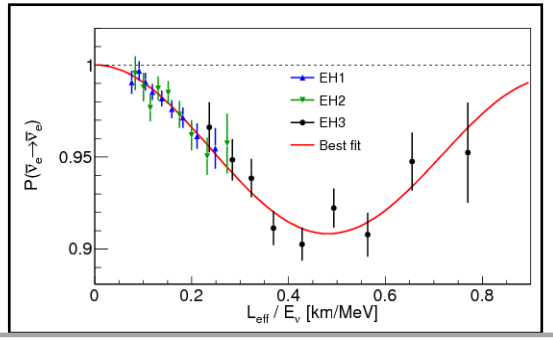
e→e (Solar)



e→e (LB reactors)

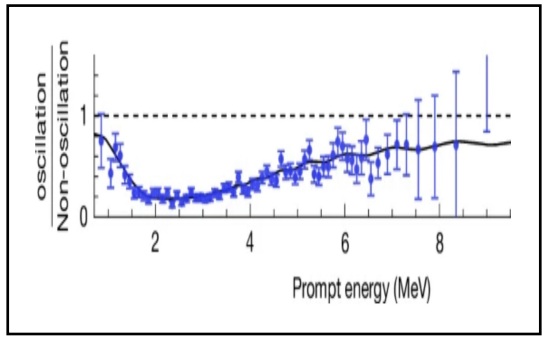


e→e (SB reactors)



None

e→e (MB reac.= JUNO)

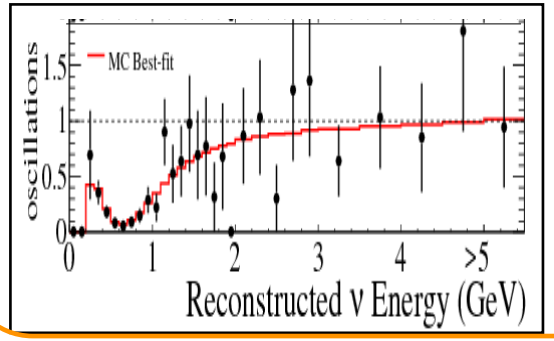


← Probes sign (Δm^2 / δm^2)

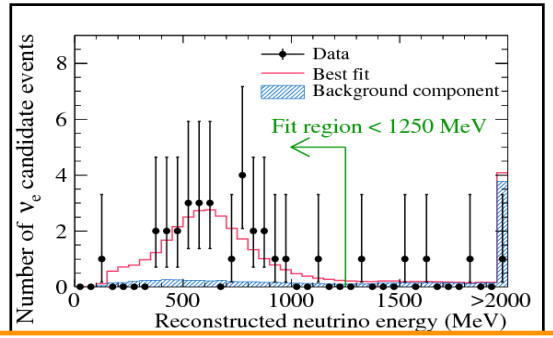
Probe sign (Δm^2 / E_{MSW})

NO/IO

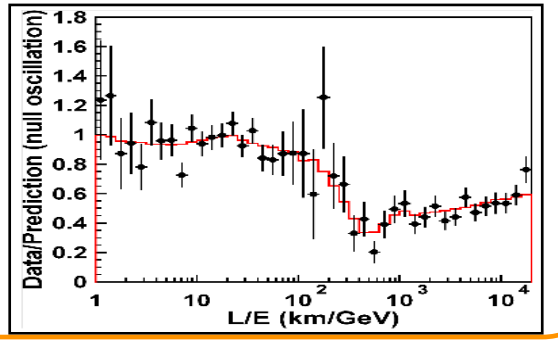
μ→μ (Accel. disapp.)



μ→e (Accel. appear.)

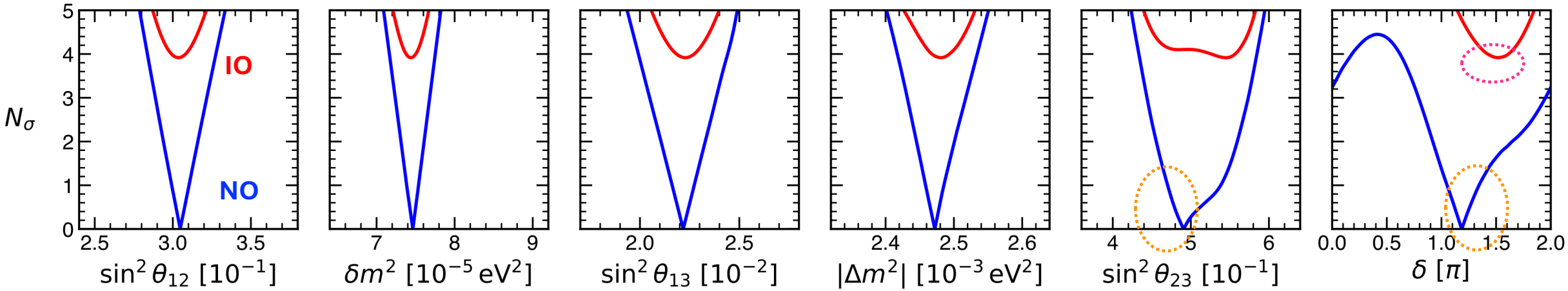


μ, e→μ, e (Atmos.)



δ, θ_{23}

Global analysis of 3ν oscillations* after Neutrino 2026

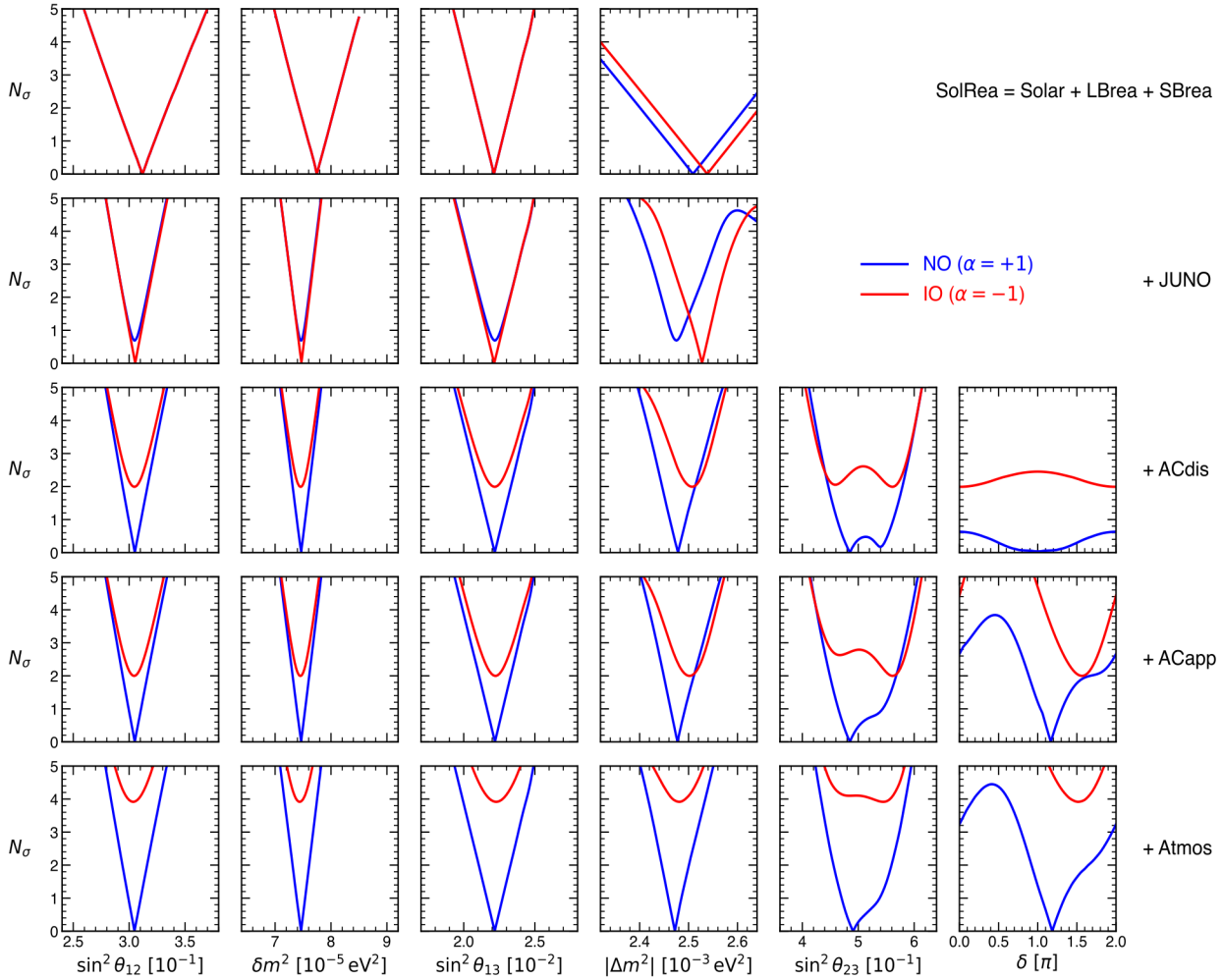


	NO					IO				
Parameter	best fit	1σ	2σ	3σ	"1σ"	best fit	1σ	2σ	3σ	"1σ"
$\delta m^2/10^{-5}\,\mathrm{eV}^2$	7.465	7.386–7.538	7.312–7.609	7.239–7.681	1.0%	7.439	7.364–7.516	7.292–7.589	7.218–7.662	1.0%
$\lvert\Delta m^2\rvert/10^{-3}\,\mathrm{eV}^2$	2.472	2.459–2.485	2.445–2.501	2.432–2.517	0.6%	2.481	2.465–2.497	2.449–2.513	2.429–2.529	0.7%
$\lvert\Delta m^2_{31}\rvert/10^{-3}\,\mathrm{eV}^2$	2.509	2.496–2.523	2.483–2.538	2.469–2.555	0.6%	2.444	2.428–2.459	2.412–2.476	2.392–2.492	0.7%
$\lvert\Delta m^2_{32}\rvert/10^{-3}\,\mathrm{eV}^2$	2.435	2.421–2.448	2.408–2.463	2.394–2.480	0.6%	2.518	2.502–2.534	2.486–2.551	2.466–2.567	0.7%
$\sin^2\theta_{12}/10^{-1}$	3.047	2.993–3.104	2.940–3.160	2.888–3.217	1.8%	3.036	2.981–3.092	2.928–3.150	2.876–3.208	1.8%
$\sin^2\theta_{13}/10^{-2}$	2.218	2.162–2.273	2.106–2.328	2.049–2.384	2.5%	2.228	2.173–2.283	2.118–2.338	2.063–2.393	2.5%
$\sin^2\theta_{23}/10^{-1}$	4.908	4.703–5.383	4.557–5.594	4.439–5.735	4.4%	5.446	5.188–5.592	4.546–5.716	4.408–5.819	4.3%
δ/π	1.186	1.052–1.343	0.920–1.647	0.790–1.951	16.3%	1.517	1.399–1.632	1.277–1.737	1.157–1.838	7.5%

- Precision of known parameters at (sub)percent level
- Slight preference for first octant (<0.4σ) and for CP violation (<1.4σ)
- Significant preference for normal ordering w.r.t. inverted ordering (3.9σ)
- Consistent with other (partial) analyses discussed recently

F. Capozzi, EL, F. Marcone, A. Marrone (Bari Group**) – **preliminary** results. See also the website **global-nu.org***

“Deconstructing” the 3.9σ preference for NO



⇐ **Adding** different data in sequence:

⇓

Data	$N_\sigma^{\mp}$	Data	$N_\sigma^{\mp}$	Data	$N_\sigma^{\mp}$	Data	$N_\sigma^{\mp}$
SolRea	0.0	SolRea	0.0	SolRea	0.0	SolRea	0.0
+ JUNO	−0.7	+ JUNO	−0.7	+ ACdis	+1.4	+ Atmos	+3.0
+ ACdis	+2.0	+ Atmos	+3.7	+ ACapp	+1.0	+ ACdis	+3.0
+ ACapp	+2.0	+ ACdis	+4.1	+ Atmos	+2.7	+ ACapp	+2.7
+ Atmos	+3.9	+ ACapp	+3.9	+ JUNO	+3.9	+ JUNO	+3.9

Subtracting data in the global fit:

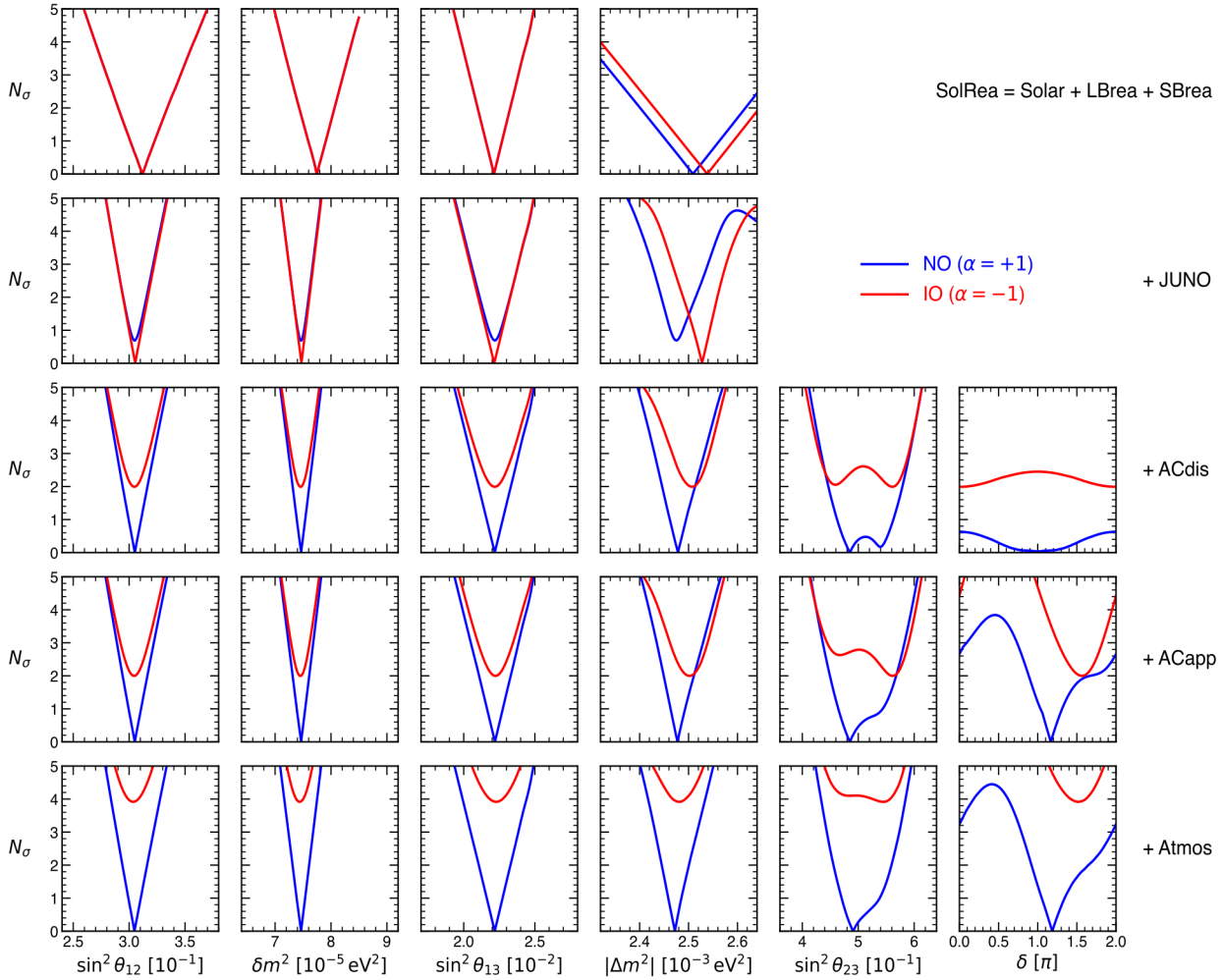
⇑

- ALL data – Accel.: 3.7σ
- ALL data - JUNO: 2.7σ
- ALL data – Atmos: 2.0σ

→ Atmos. + JUNO currently lead NO vs IO;
(Accel. data tensions limit their NO/IO impact)

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+ JUNO	−0.7	+ JUNO	−0.7	+ ACdis	+1.4	+ Atmos	+3.0
+ ACdis	+2.0	+ Atmos	+3.7	+ ACapp	+1.0	+ ACdis	+3.0
+ ACapp	+2.0	+ ACdis	+4.1	+ Atmos	+2.7	+ ACapp	+2.7
+ Atmos	+3.9	+ ACapp	+3.9	+ JUNO	+3.9	+ JUNO	+3.9

Subtracting data in the global fit:

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Crucial interplay of different oscill. expts on both frontiers: precision *(knowns)* and discovery *(unknowns)*

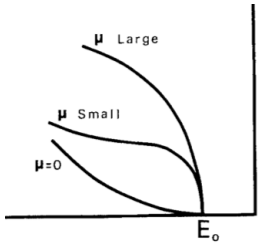
→ Maintain future complementarity: Reactors (JUNO), Atmospheric (HK, IC, KM3NeT), Acceler. (DUNE, HK)

Interplay with nonoscillation observables: (m_β , $m_{\beta\beta}$, Σ)

Probe absolute neutrino masses in different ways
May provide extra handles to distinguish NO vs IO

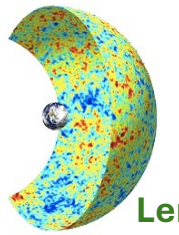
β decay (kinematics) - Sensitive to the "effective electron neutrino mass":

$$m_\beta = \left[c_{13}^2 c_{12}^2 m_1^2 + c_{13}^2 s_{12}^2 m_2^2 + s_{13}^2 m_3^2\right]^{\frac{1}{2}}$$



Cosmology (gravity) - Dominantly sensitive to sum of neutrino masses:

$$\Sigma = m_1 + m_2 + m_3$$



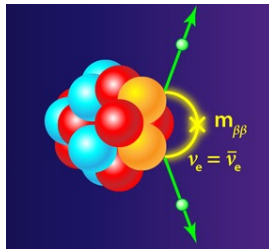
CMB

LSS

Lensing

0νββ decay: only if Majorana. "Effective Majorana mass" (+new CPV phases):

$$m_{\beta\beta} = \left|c_{13}^2 c_{12}^2 m_1 + c_{13}^2 s_{12}^2 m_2 e^{i\phi_2} + s_{13}^2 m_3 e^{i\phi_3}\right|$$



Current and prospective bounds →

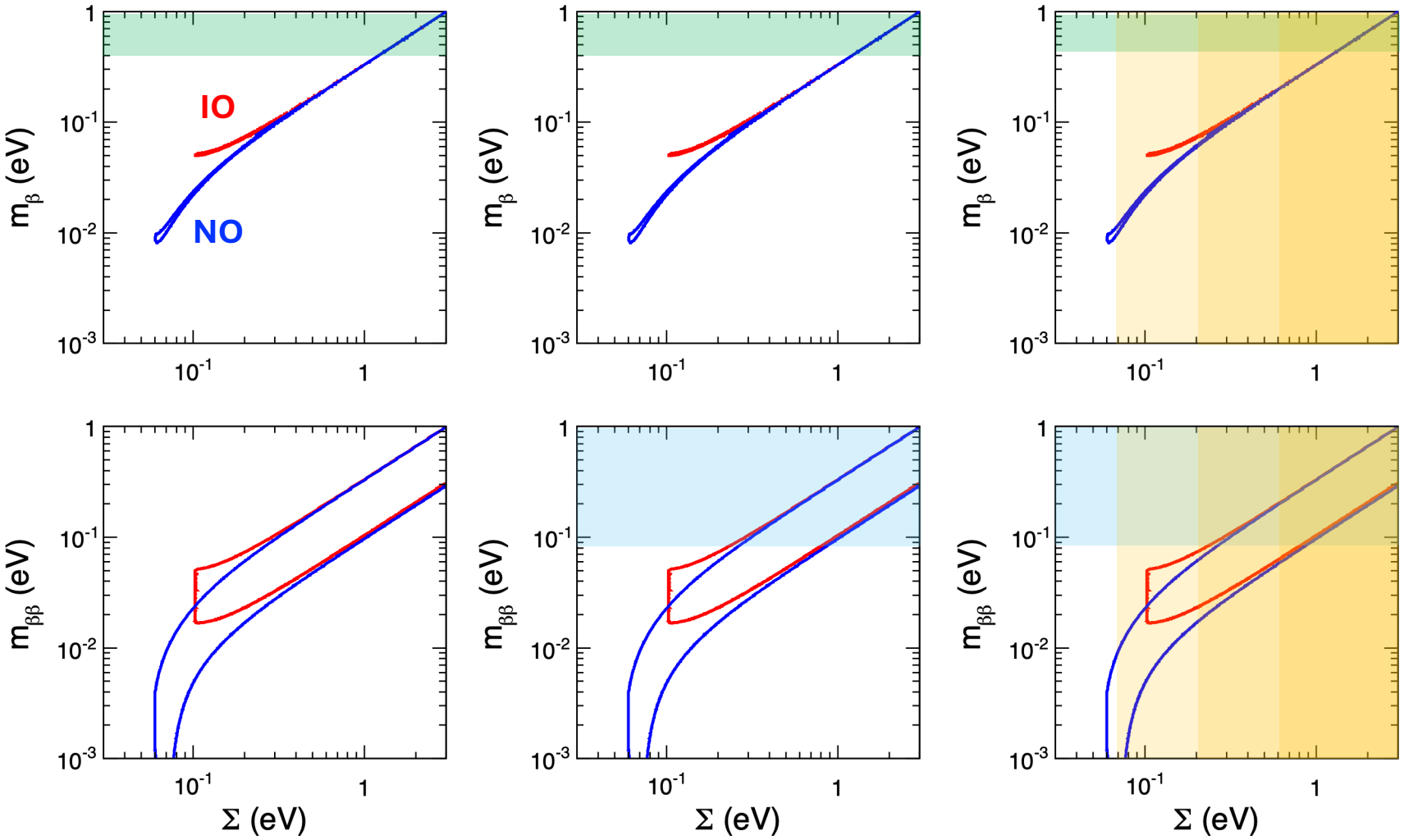
β: KATRIN

0νββ: KL-Zen, Exo, GERDA, Cuore...

[+ nuclear model uncert.]

Σ: Planck, BAO, lensing ...

[spread: model/data tension]



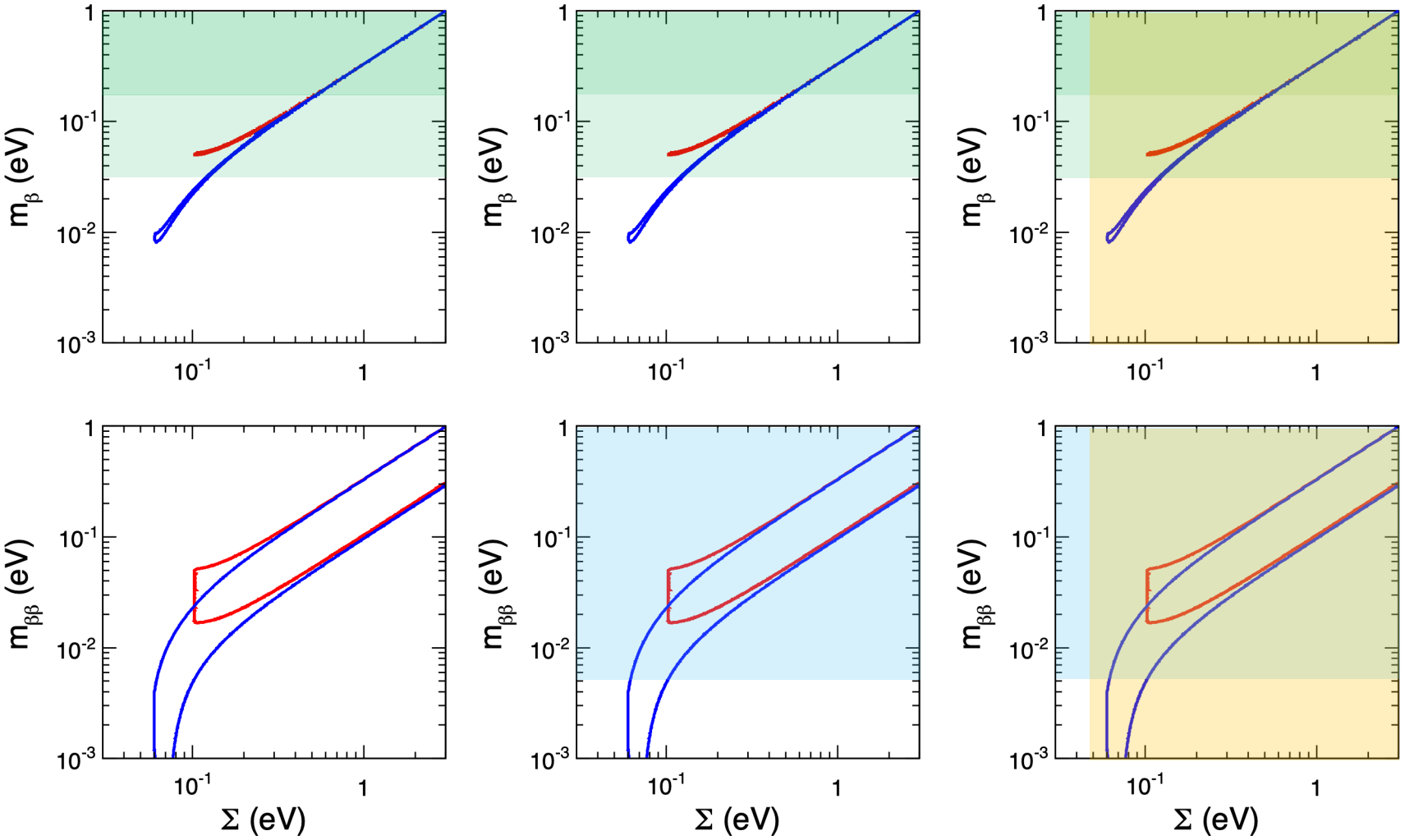
IO "under pressure" from cosmo data. But: lively debate after recent (too strong?) DESI constraints

... systematics? dynamical dark energy? ... Our conservative view: **Σ < 0.2 eV** "within a factor of three"

β: ~0.2 eV (KATRIN) and hopefully below in ← PROJECT-8 + Ho + …

0νββ: Well below IO limit @Ton scale **(LEGEND, NEXO, CUPID…)** w/ improved **NME**

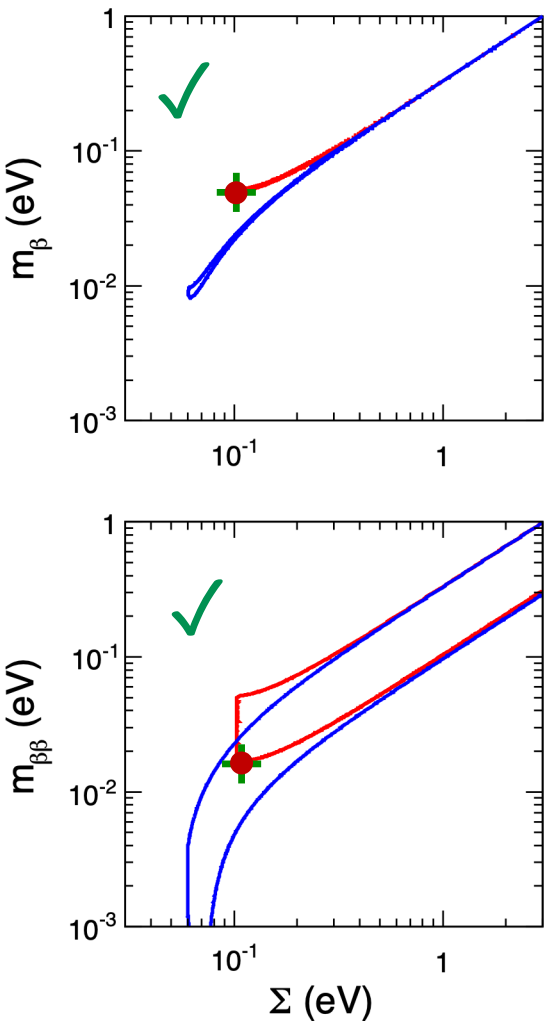
Σ: complete covering seems possible within a "robust" **cosmo model**



Large phase space for possible mass discoveries in sub-eV range. First claims on ν mass may come from cosmology, but laboratory detection via β (0νββ) decay is mandatory !

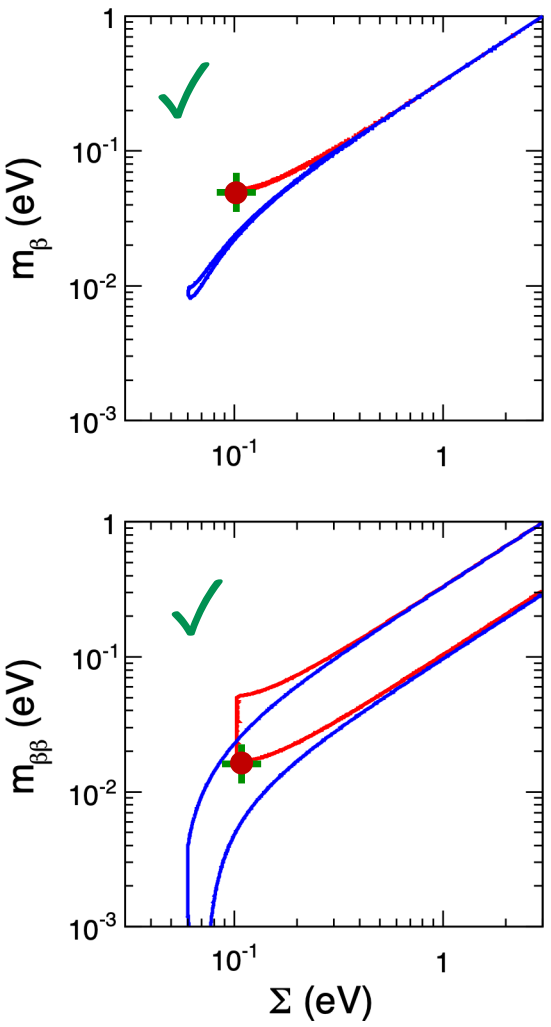
Future data ✚ dreams:

3ν convergence?

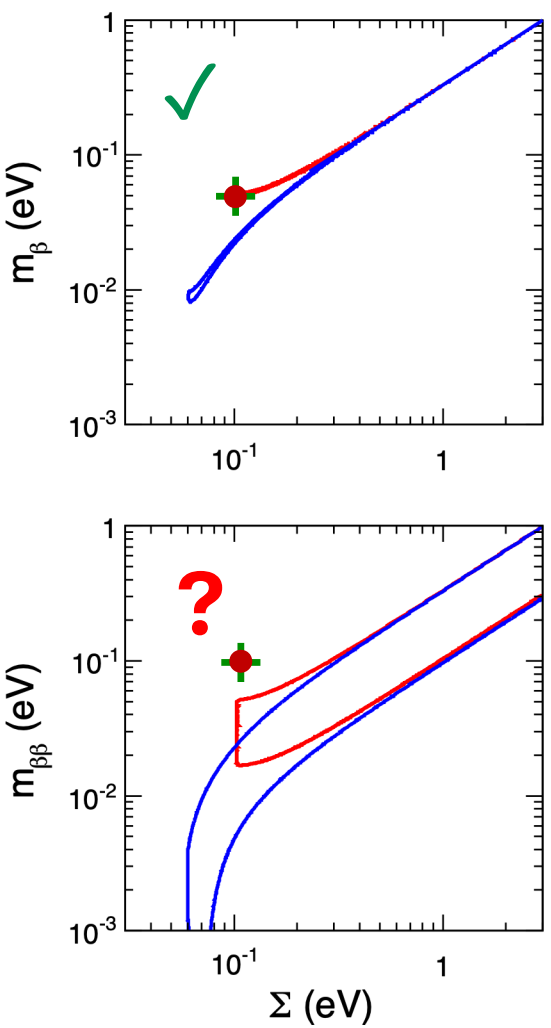


Future data ✚ dreams:

3ν convergence?



… or surprises?



Lack of convergence might suggest new physics: e.g., **new cosmo model**, **nonstandard 0νββ …**

Where we are: 3ν, circa 2026

The nearby theory landscape

A bridge to flavor physics

A bridge to higher scales

Epilogue

- *Stress-test the 3ν framework via BSM "perturbations"*
- *Apply SM theory to difficult calculations (e.g., ν in nuclei)*

Surprises beyond the 3ν paradigm?

Advancing the precision and discovery frontiers in JUNO, DUNE, HK, IC, KM3NeT,…
we might either confirm the paradigm, or find "anomalous" results beyond it, e.g.,

- **new (sterile) neutrino states?**
- **nonstandard 4-fermion interactions (NSI)?**
- **violations of fundamental symmetries?**
- **…**

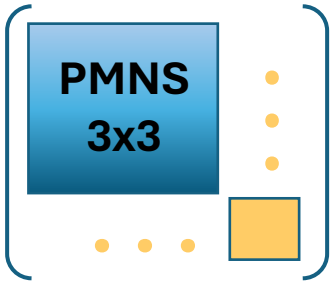
E.g., already in current data:

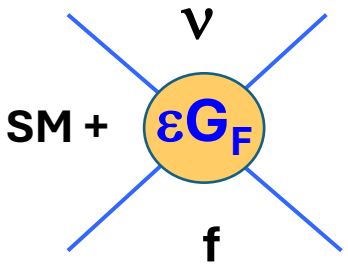
Saga of possible (fading) indications of sterile (~RH) neutrino state(s) at ~eV scale
NSI terms ~$\varepsilon_{\alpha\beta} G_F$ slightly preferred by SK solar data & by T2K vs NOvA tension

[not reviewed herein]

Even if you do not believe such hints… → Stress-tests of the 3ν paradigm

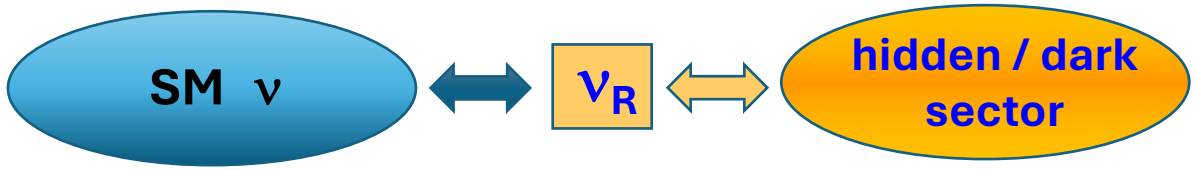
Testing the resilience of the 3ν paradigm to **extra ν states** or to **new interactions:**
Approach often involves PMNS unitarity violations or nonstandard FCNC, FDNC (NSI)





Extra parameters may dilute hints of PMNS unknowns: CPV, θ_{23} octant, ordering.
Rich phenomenology in (non)oscillation experiments + astrophysics & cosmology

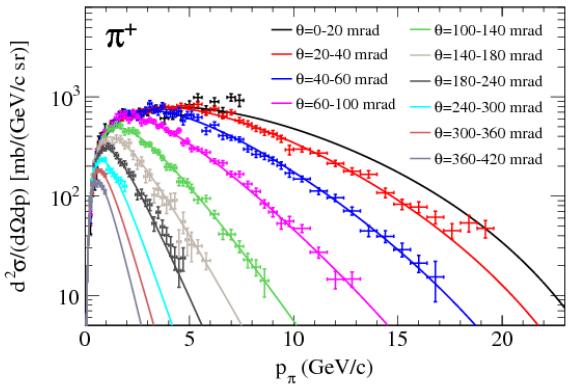
Going further: consider both extra states and interactions: RH neutrinos as a **bridge** ("portal") to weakly coupled **BSM physics** ("hidden" or "dark" sector), e.g. **DM**

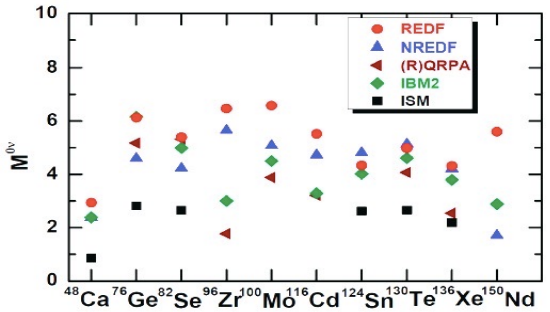


Low-scale BSM "portal" scenarios can provide new stress tests of the 3ν paradigm (as well as of $3\nu+1\nu_s$ models), e.g. via **modified neutrino dispersion relations.**

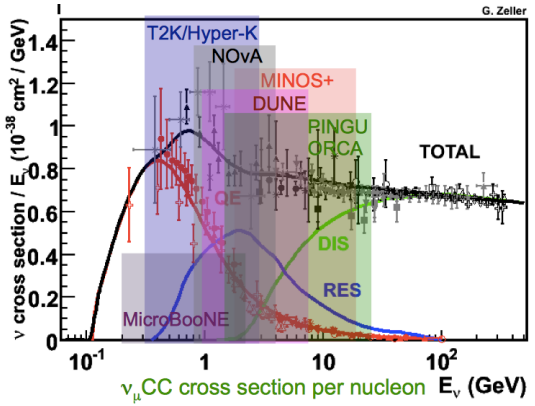
Within the SM: Ubiquitous “strong interaction” effects on “weak interactions”

Need hadron production data, e.g. pA → πX, +theory models to improve estimates of atm. and acceler. ν fluxes and errors



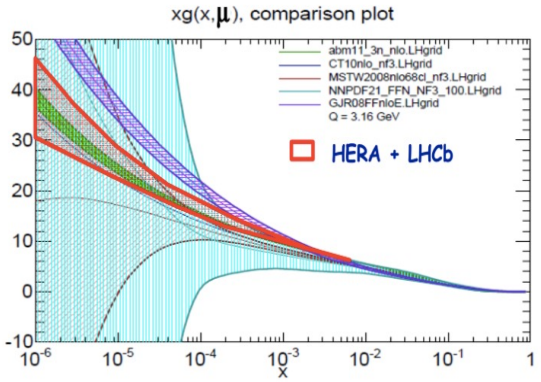


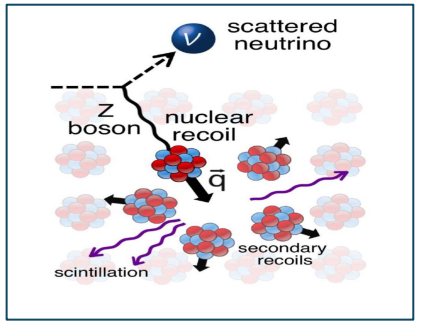
Current understanding of ν cross sections at O(GeV) does not match the needs of (next-generation) ν expts



Low-E: Better control of nuclear EW response to ν relevant to interpret 2β , CEvNS data and to connect them with other data in DM searches, reactor ν…

Improved PDFs at low-x via ~forward charm production at LHCb essential to constrain prompt component in UHE ν





Progress requires cooperation of different expt+theo communities:

→ emerging field might be named “Electroweak Nuclear Physics”

E.g., two recent EWNP highlights (among many)

Weak mixing angle from CEνNS & low-E ν

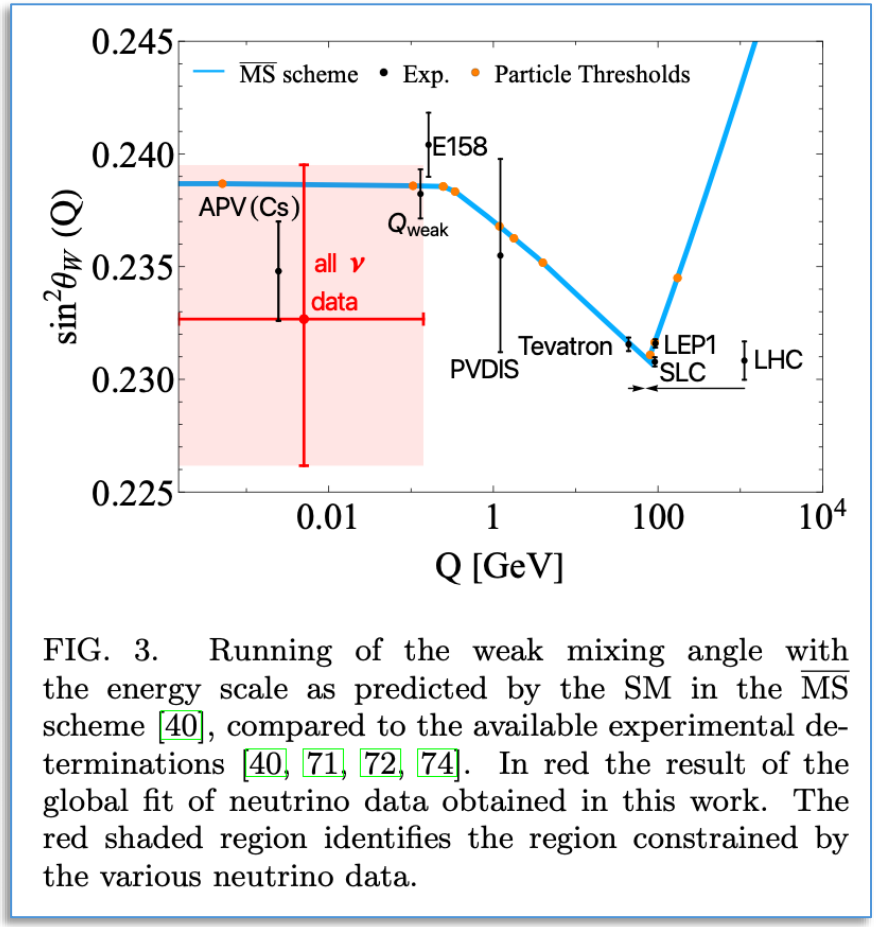


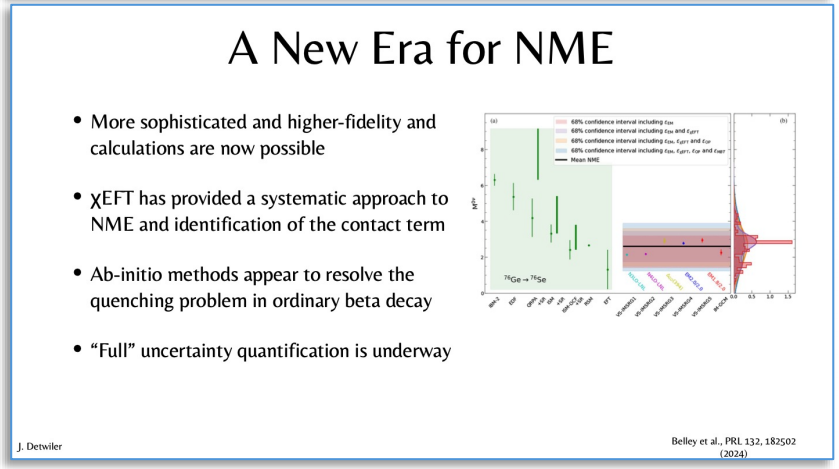
FIG. 3. Running of the weak mixing angle with the energy scale as predicted by the SM in the $\overline{\text{MS}}$ scheme [40], compared to the available experimental determinations [40, 71, 72, 74]. In red the result of the global fit of neutrino data obtained in this work. The red shaded region identifies the region constrained by the various neutrino data.

M. Atzori Corona et al., 2610.31254

CEvNS = coherent elastic neutrino-nucleus scattering

0νββ theo+expt effort to improve NME's



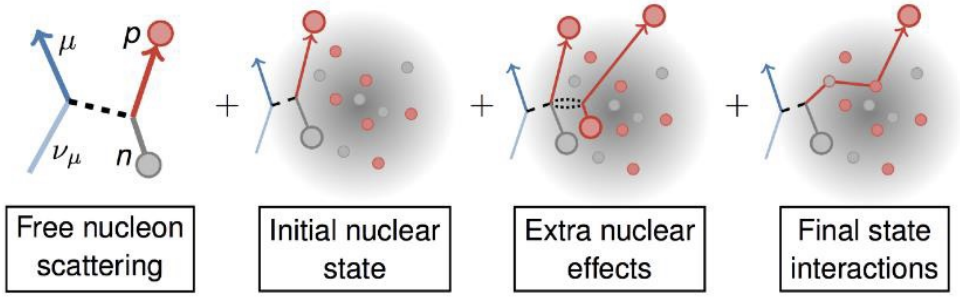


https://indico.global/event/18868

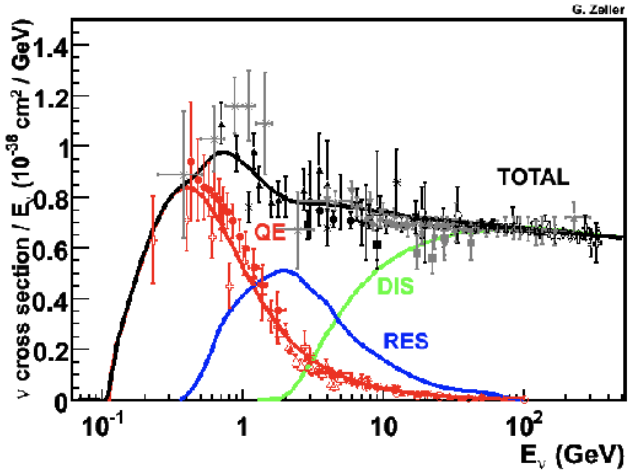
A long-standing general issue that affects several oscillation experiments:

Neutrino interactions in nuclei are not understood as accurately as desired!

Theory: complex nuclear effects



Experiment: relatively few data



Worldwide effort to improve the situation through **dedicated experiments** (including near detectors, ND) and **refined nuclear models** (including tuning to the above experiments), **but non-negligible uncertainties remain**

Where we are: 3ν, circa 2026

The nearby theory landscape

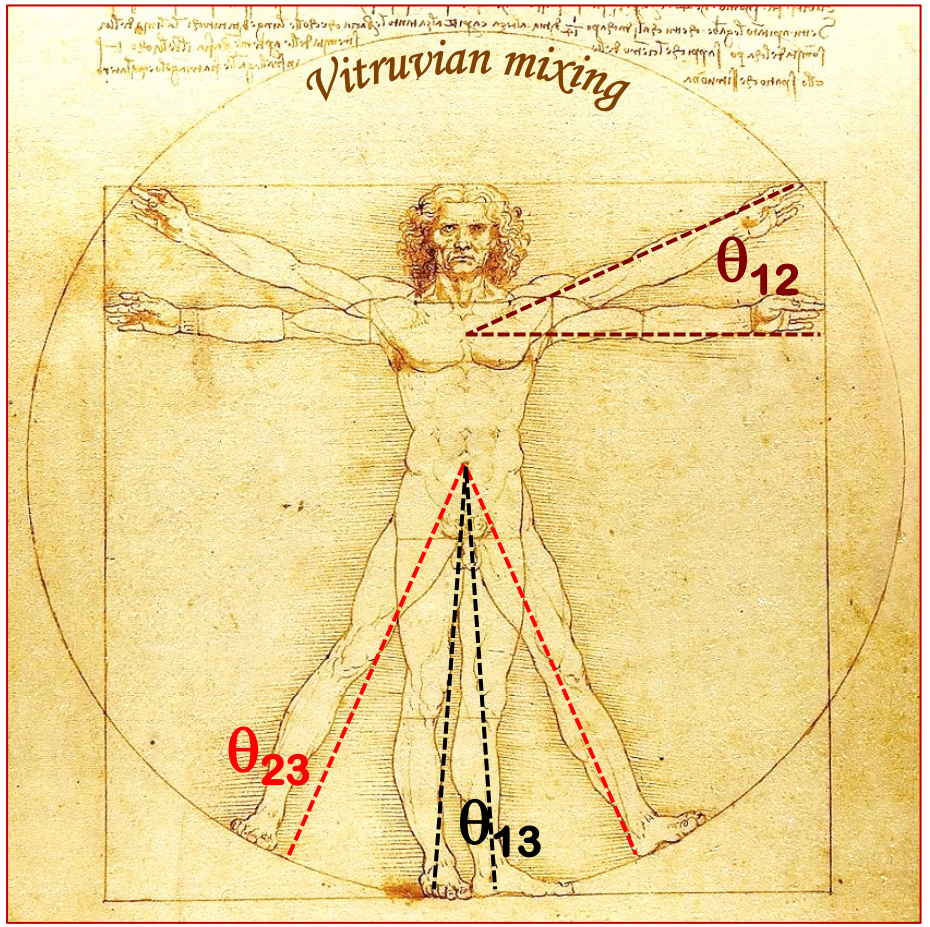
A bridge to flavor physics

A bridge to higher scales

Epilogue

The SM lacks an organizing principle for flavor (Yukawa's Y).

Are the PMNS parameters "accidental", or suggestive of a "pattern"?



"Anarchy" or elaborated "symmetries" of leptons (+quarks)?

Many interesting ideas, but no obvious answer/guidance so far.



Subnuclear Physics: Past, Present and Future
Pontifical Academy of Sciences, Scripta Varia 119, Vatican City 2014
www.pas.va/content/dam/accademia/pdf/sv119/sv119-altarelli.pdf

THE MYSTERY OF NEUTRINO MIXING

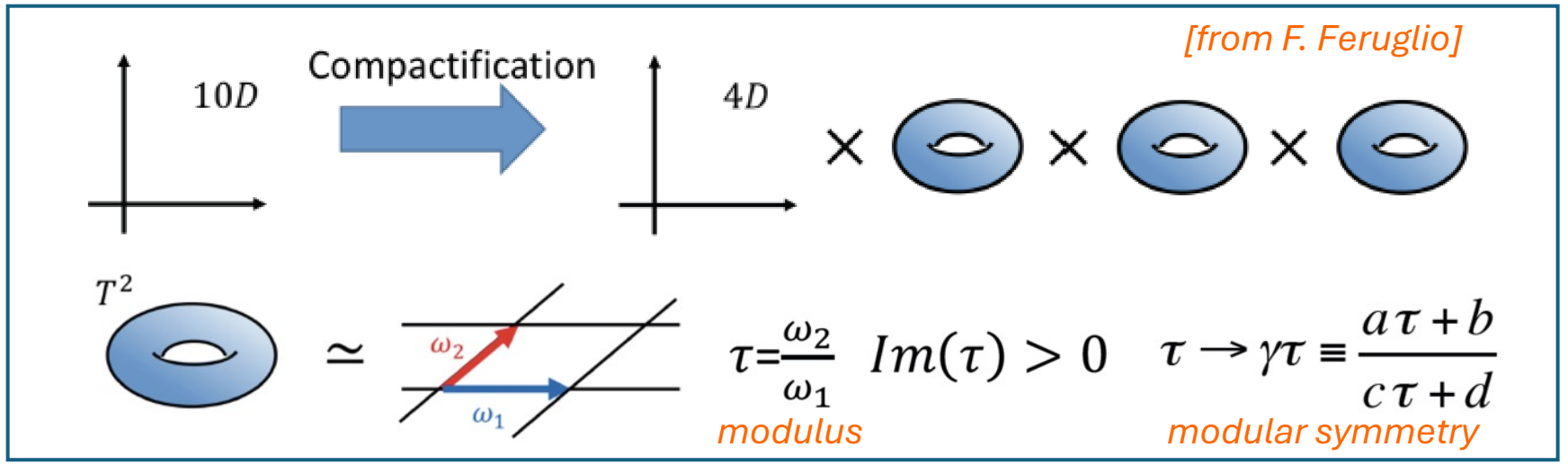
GUIDO ALTARELLI

> Finally, one could have imagined that neutrinos would bring a decisive boost towards the formulation of a comprehensive understanding of fermion masses and mixings. In reality it is frustrating that no real illumination was sparked on the problem of flavour. We can reproduce in many different ways the observations, in a wide range that goes from anarchy to discrete flavour symmetries) but we have not yet been able to single out a unique and convincing baseline for the understanding of fermion masses and mixings.

[But: the promising research line of modular symmetries just stemmed from Altarelli & Feruglio 2006 + Feruglio 2017…]

Various symmetry attempts "unified" under the concept of "modular symmetry" (MS)

[inspired by string theory & compactified extra-dim; requires SUSY; aims at quark+lepton flavor sectors]



Successful realizations of MS are rather constraining on neutrino flavor sector **(including $0\nu\beta\beta$ and Majorana phases)**

Dimensionless τ → no obvious scale, many options ... →

In a sense...

SM: tell EW scale, but not flavor structure

MS: may tell us flavor structure, but scale?

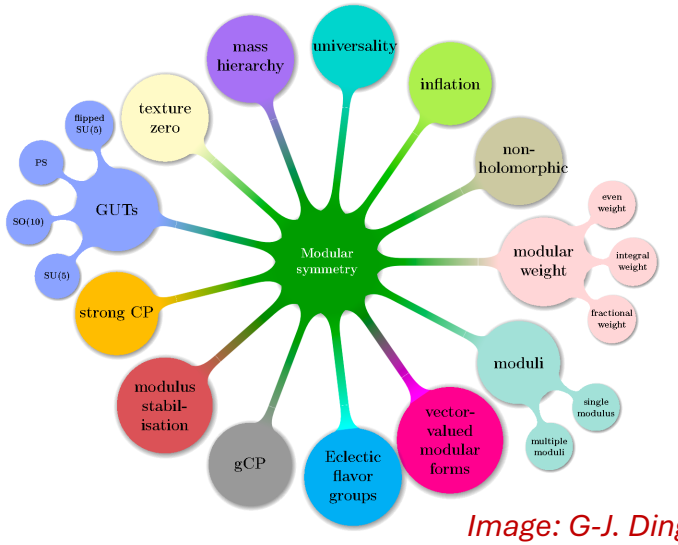
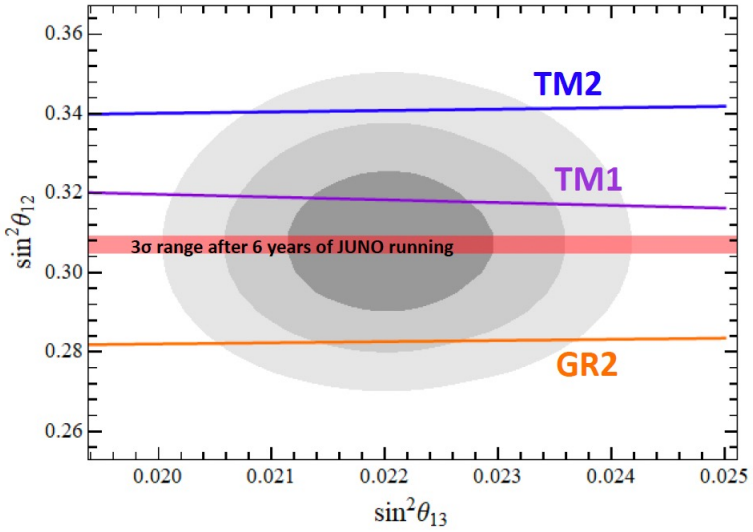


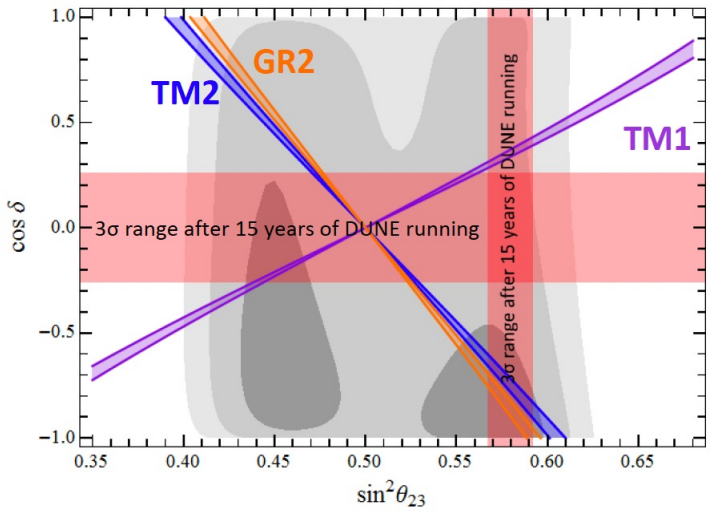
Image: G-J. Ding]

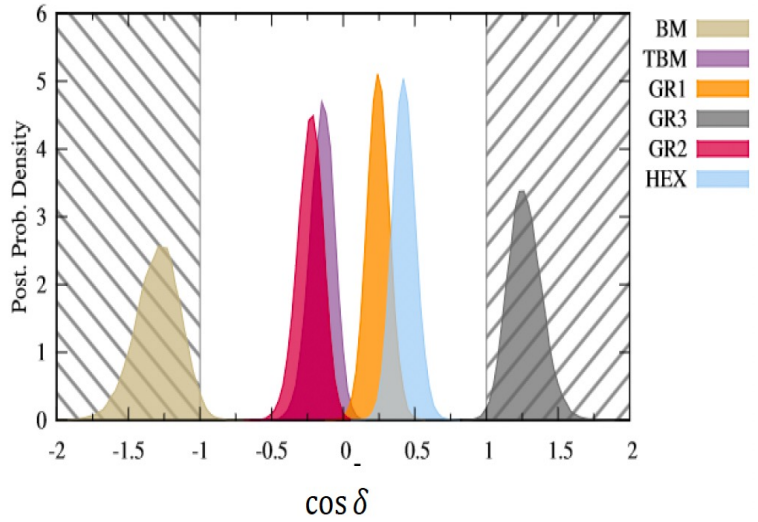
Testability and accuracy: two extreme viewpoints…

If there is no particular structure but **random entries** in the PMNS matrix (“anarchy”): higher precision data would bring **no further insights.**

If there is an underlying symmetry: PMNS known parameters become **correlated** and unknown ones are **predicted**. Future precise data could **select models:**







[Model compilation by G.-J. Ding]

Where we are: 3ν, circa 2026

The nearby theory landscape

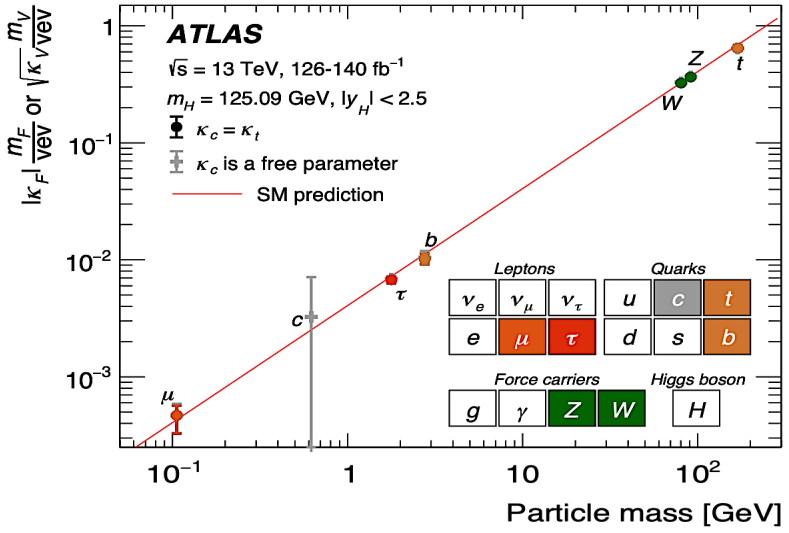
A bridge to flavor physics

A bridge to higher scales

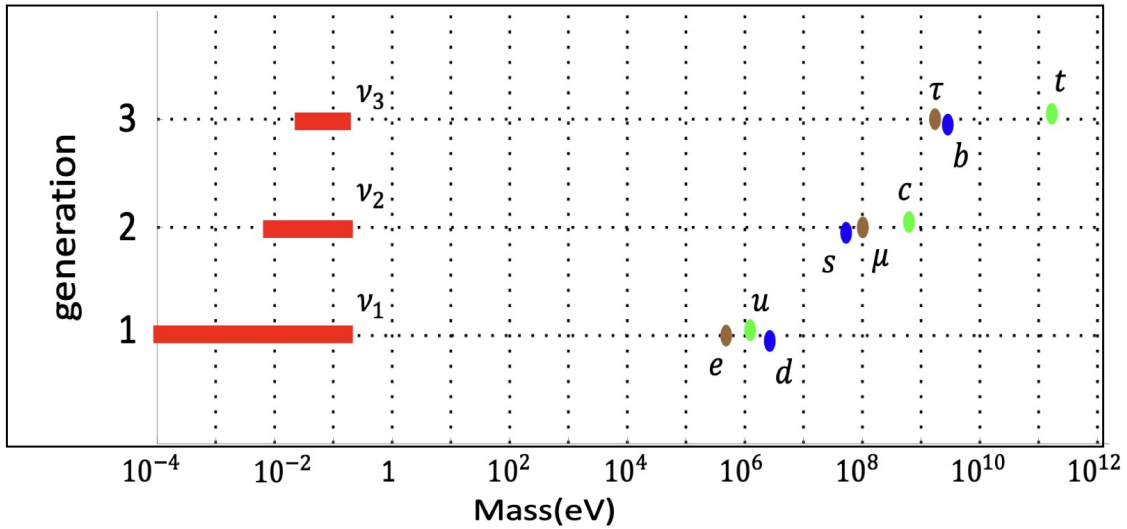
Epilogue

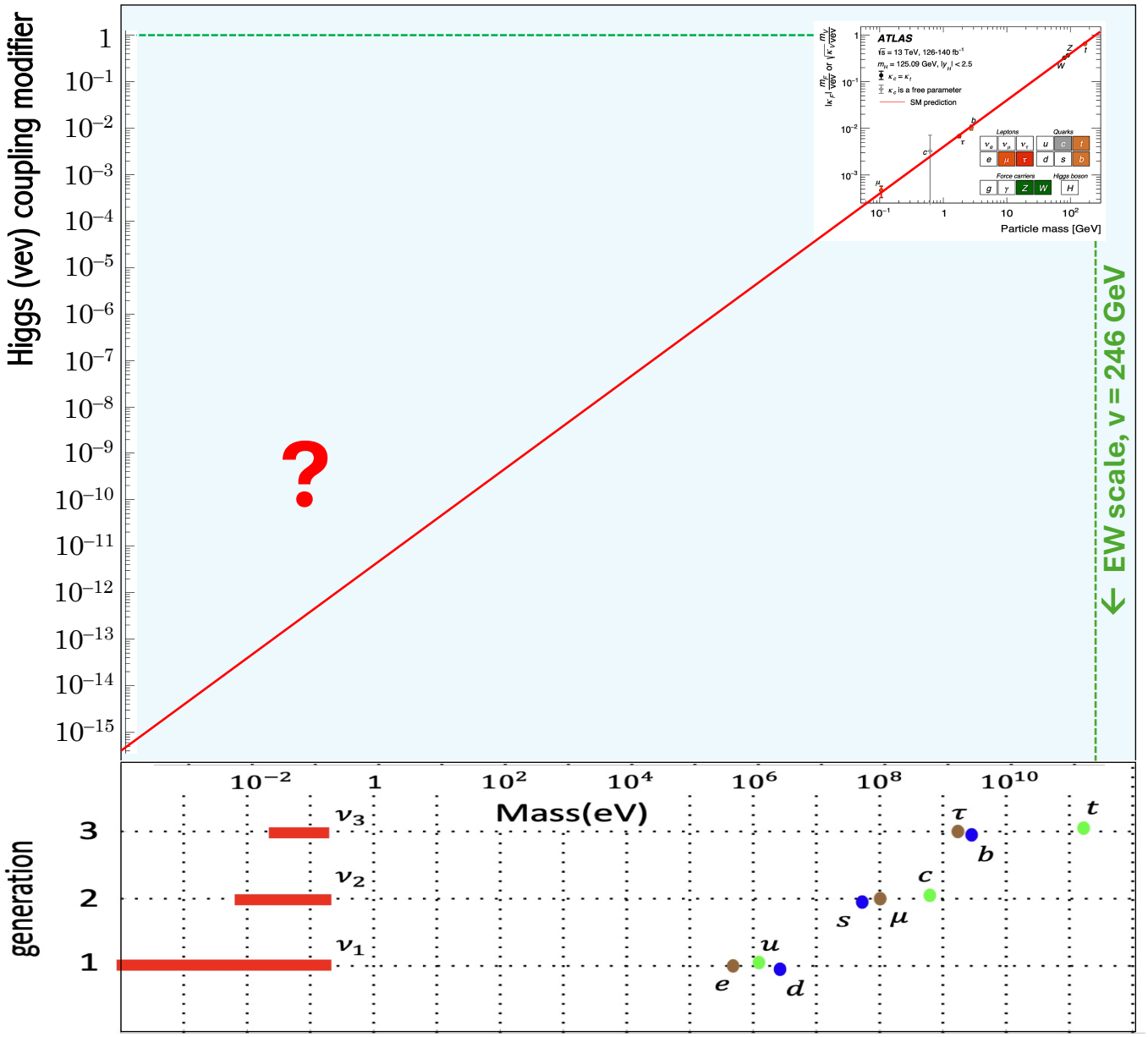
Linking two fundamental research fields:

[1] Testing the Higgs sector



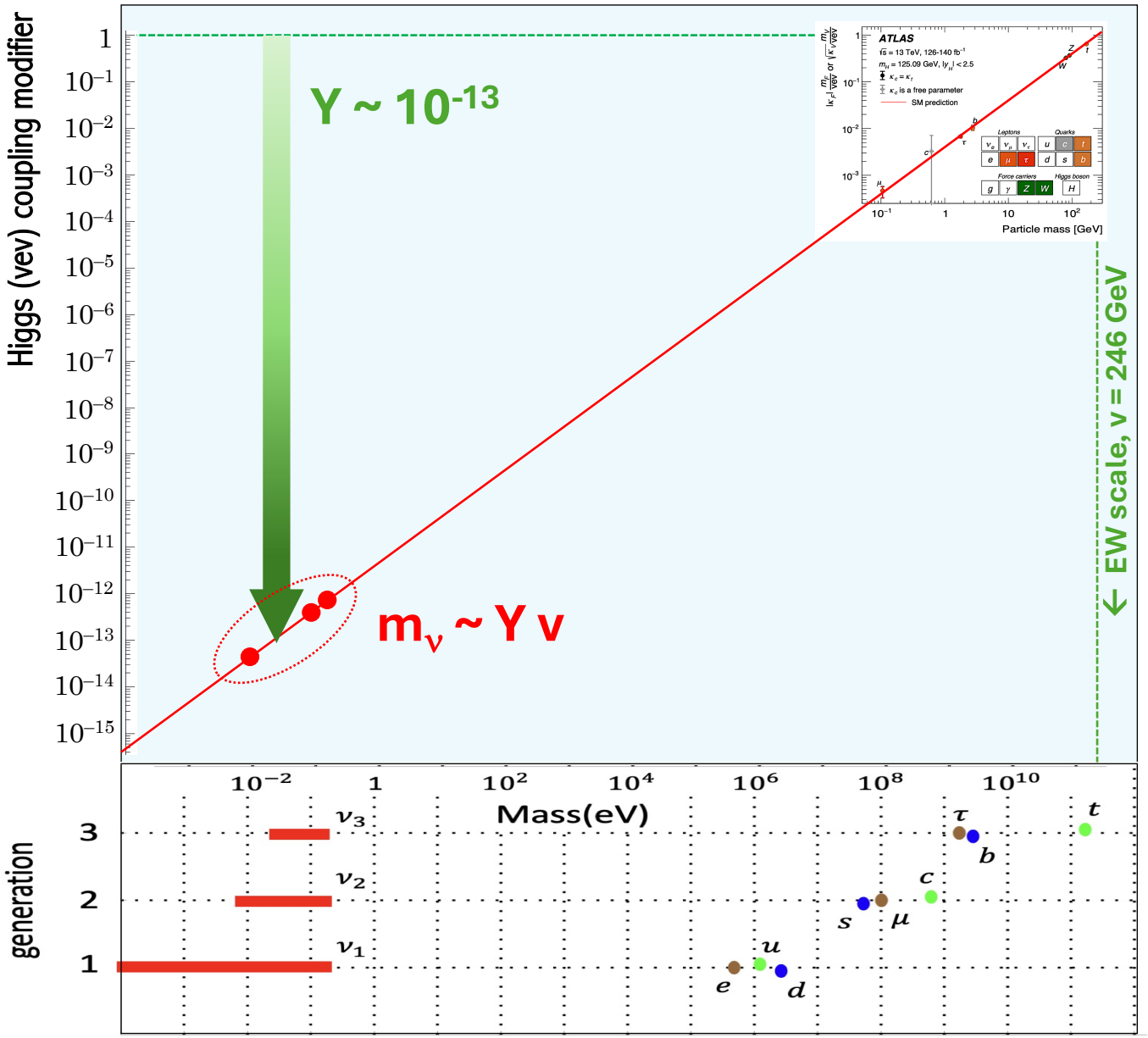
[2] Finding neutrino masses





1+2

Where are the ν's on this plot?
Why are they so light?



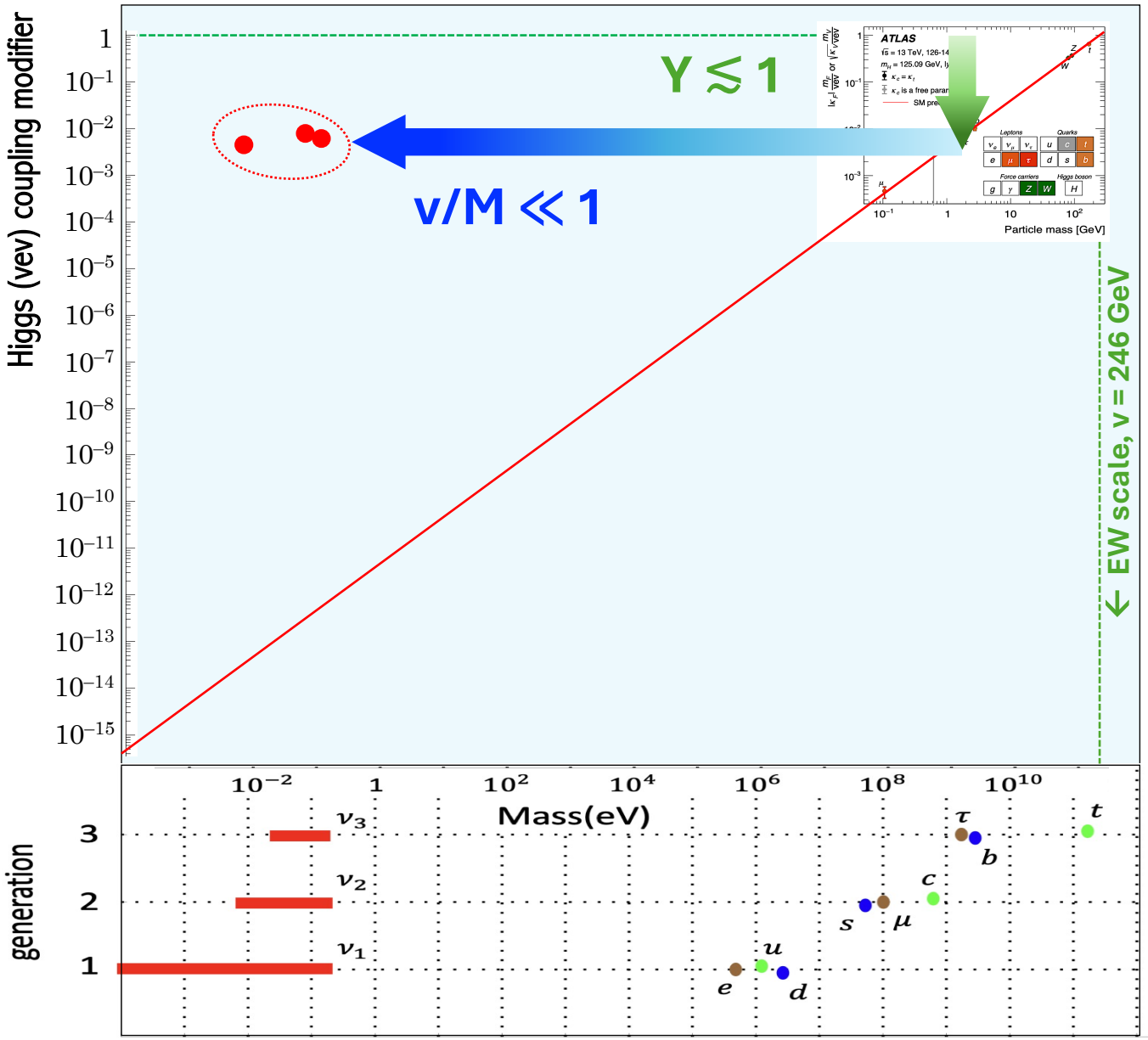
Dirac option

Neutrinos couple very weakly to the Higgs boson, **Y ~ 10^{-13}**, for some unknown reason

Dante, *Inferno*:

« ... Vuolsi così colà dove si puote
ciò che si vuole, e più non dimandare »

«... It is so willed there where is power to do that which is willed; and farther ask not »

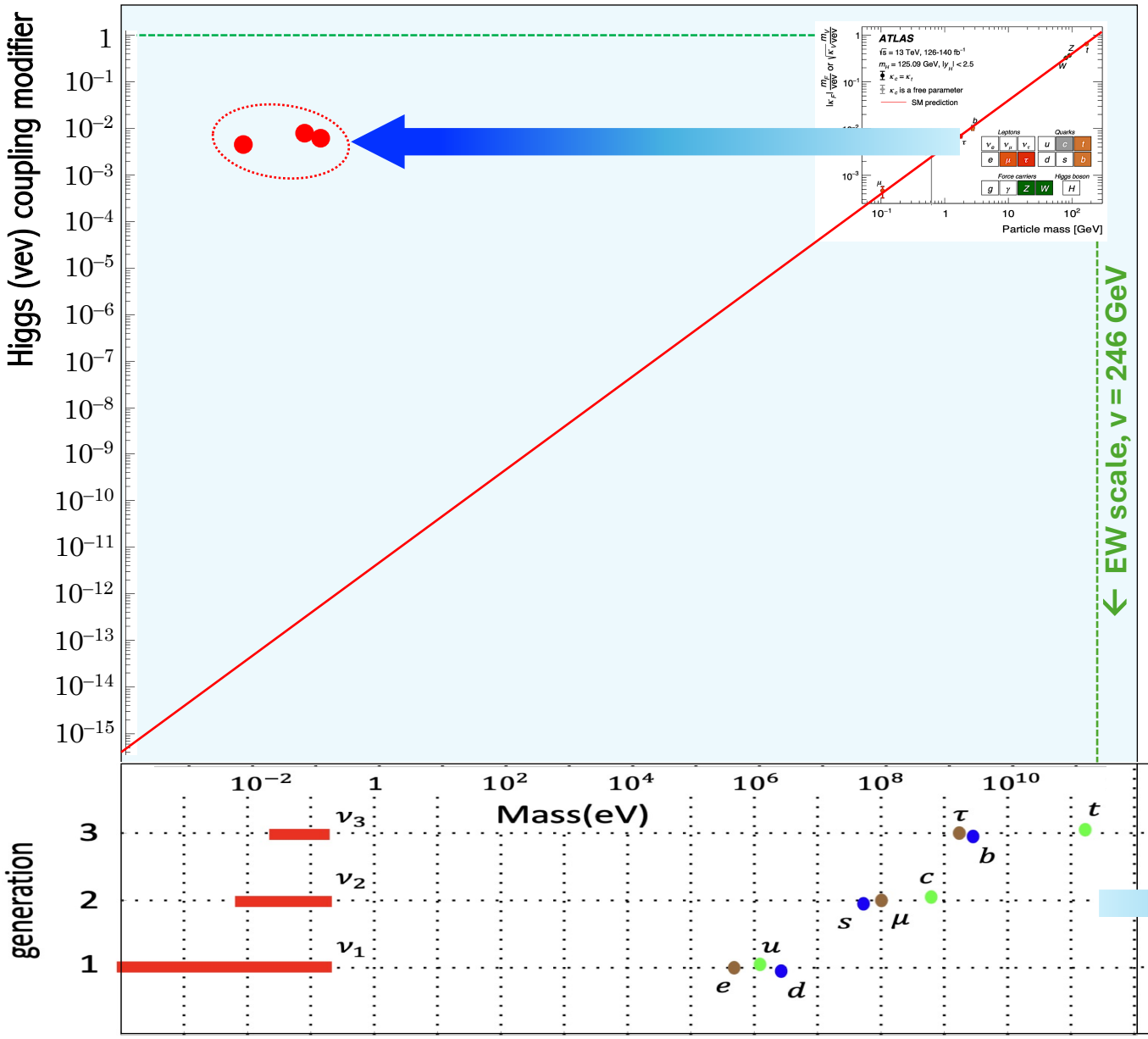


Majorana option

Neutrinos couple "normally" to the Higgs boson, **Y ≲ 1**, but also talk to (much) higher new physics scale(s) **M ≫ v**

→ ...get an extra "see-saw" suppression factor **v/M ≪ 1** ...

Majorana option



→ ...get an extra "see-saw" suppression factor **v/M ≪ 1** ...

... as well as a number of heavy **N** (SM singlets) at the **mass scale M,** mixed with light ones at O(v/M)

M/v ≫ 1

SM singlets may appear at any mass scale (s) → **Expt searches from low E to high E**

They may be linked to interesting phenomena → **Theory modeling, prospective signals**

… **0νββ decay**

light sterile ν oscill.

direct mass searches

dark matter

low-scale see-saw

beam-dump expts

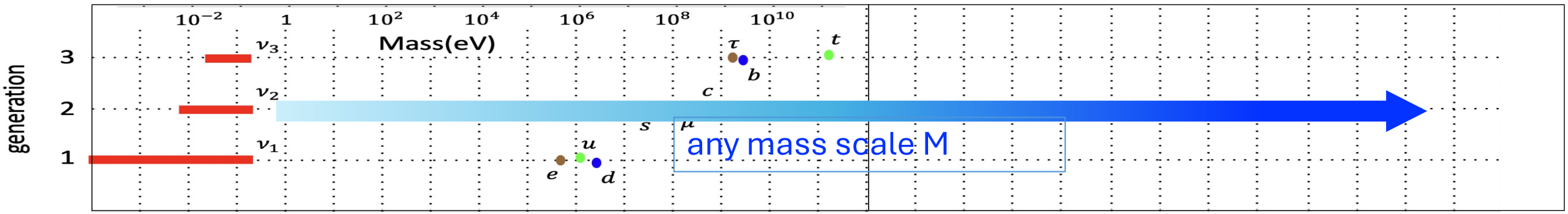
LHC searches of HNL

HNL in future expts

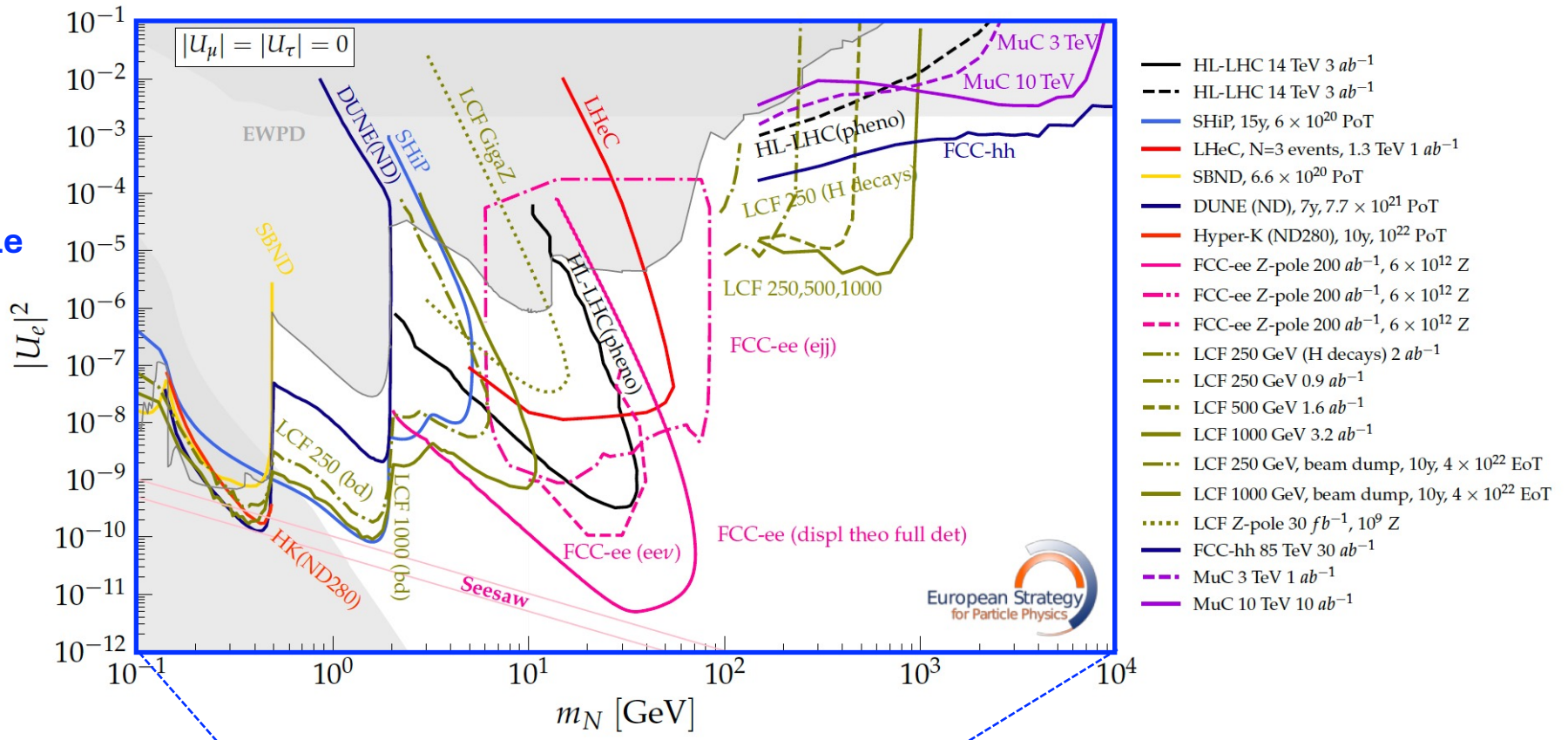
Leptogenesis

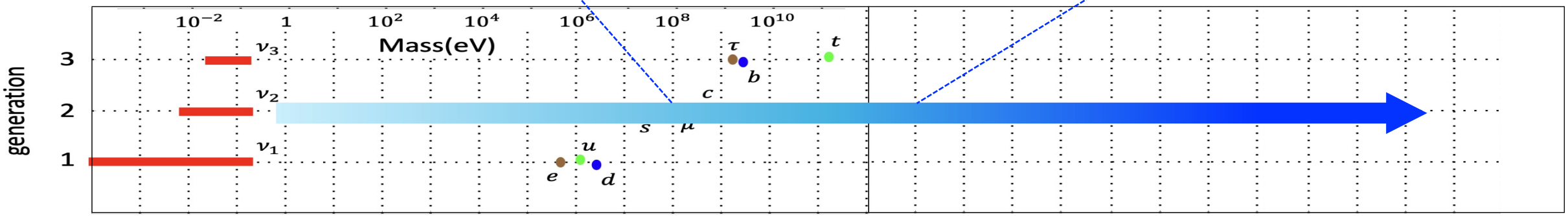
GUTs, proton decay

…



Expected sensitivities of **future** HEP expts to **HNL mass-mixing** parameters **across the EW scale**

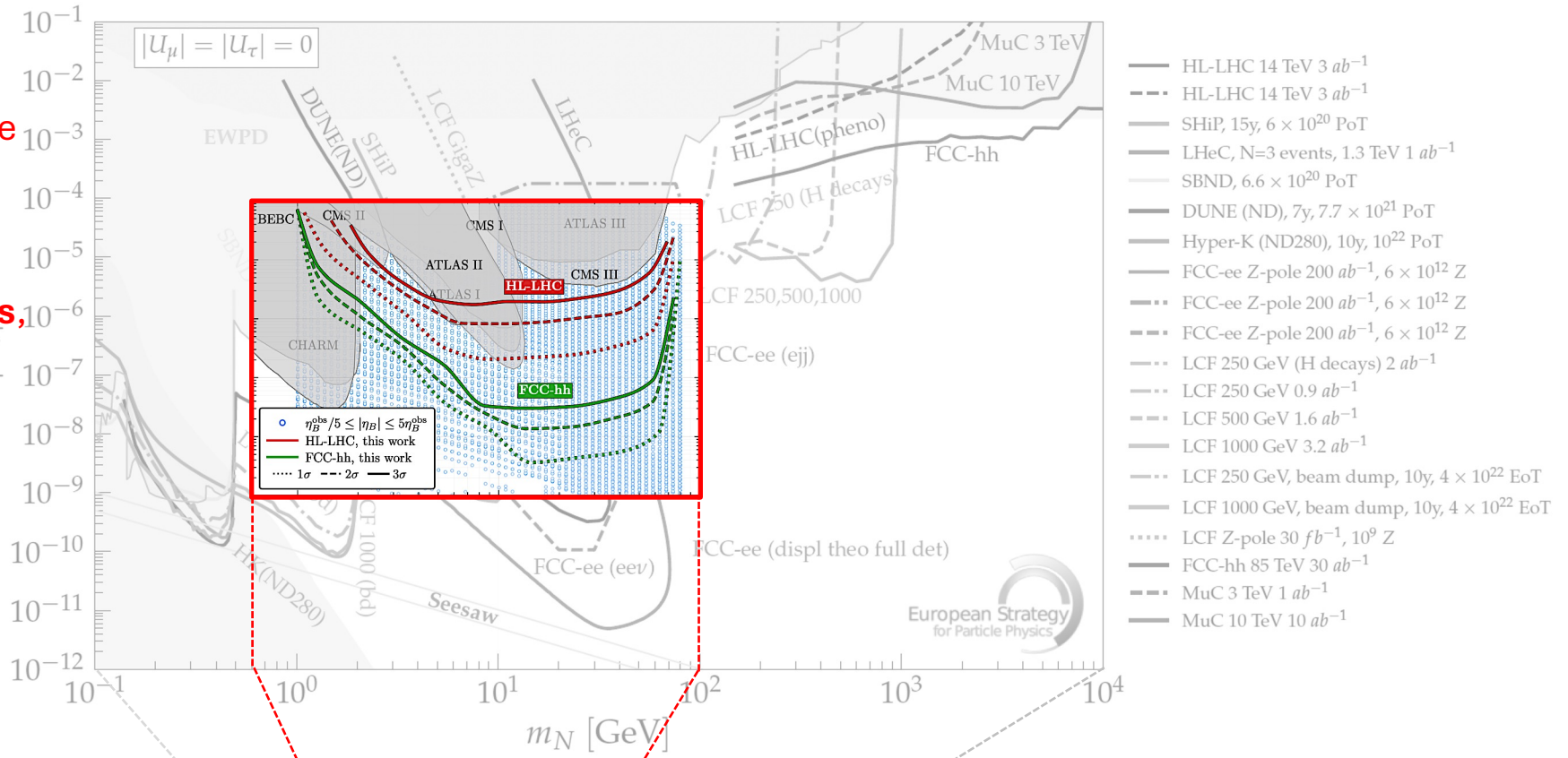


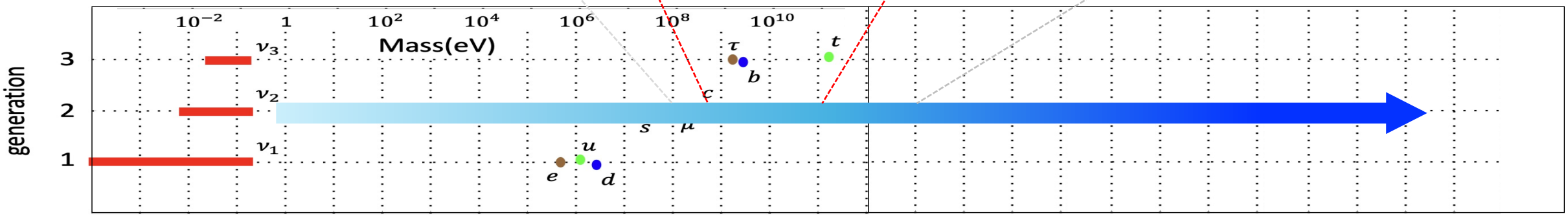


One very recent example of viable theoret. model providing both successfull **low-E leptogenesis** and observable CP-asym's in **LNV W± decays at future colliders,** over two decades in HNL mass

[Fortin et al., arXiv:2610.24063]

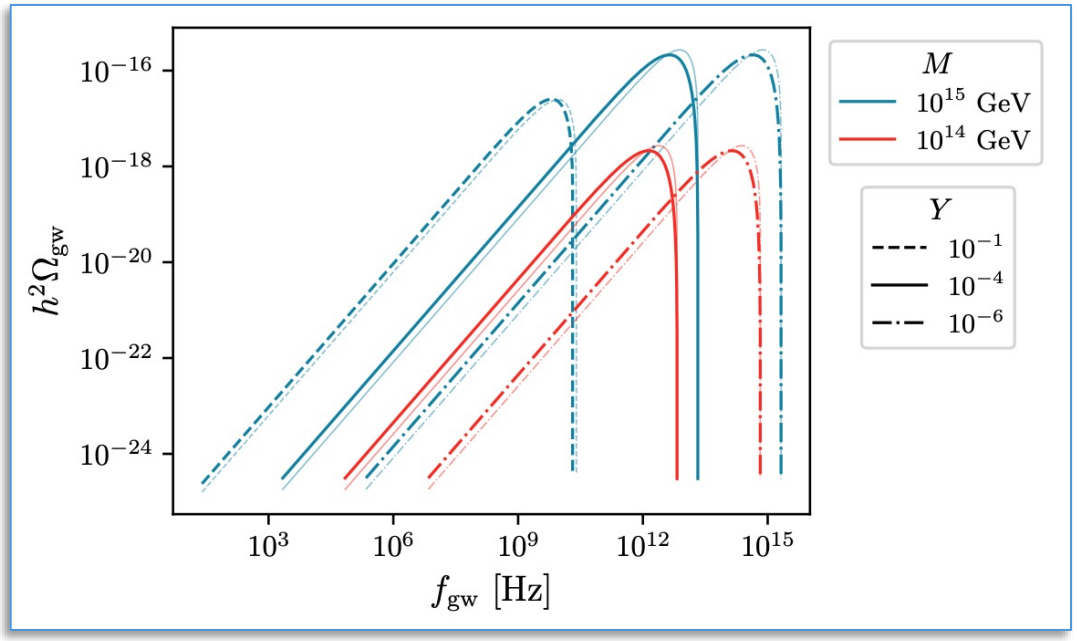
Model realizations

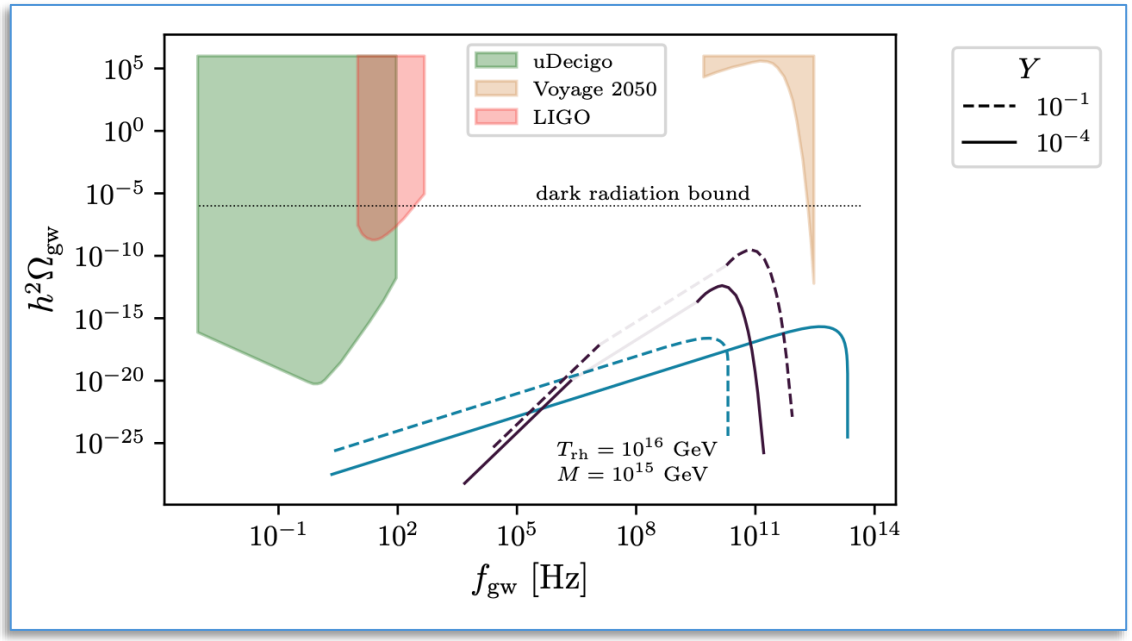




More ambitiously: Testing high-scale leptogenesis through its imprint on GW spectrum

A recent example from a growing literature:





[H. Murayama et al., 2506.15772]

Where we are: 3ν, circa 2026

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Epilogue

Epilogue

Neutrino masses are a bridge to new physics.

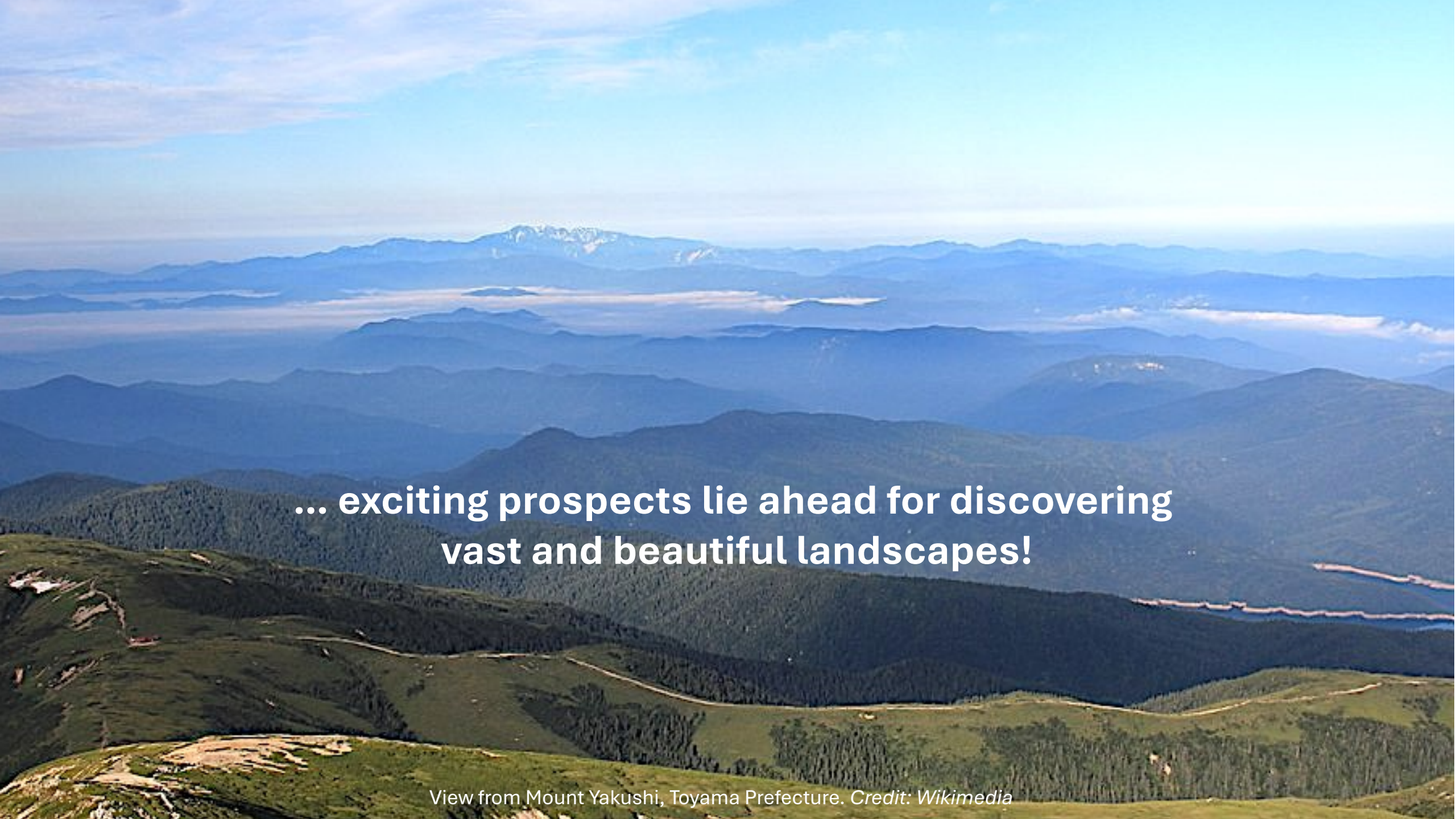
We have only just taken the first steps…



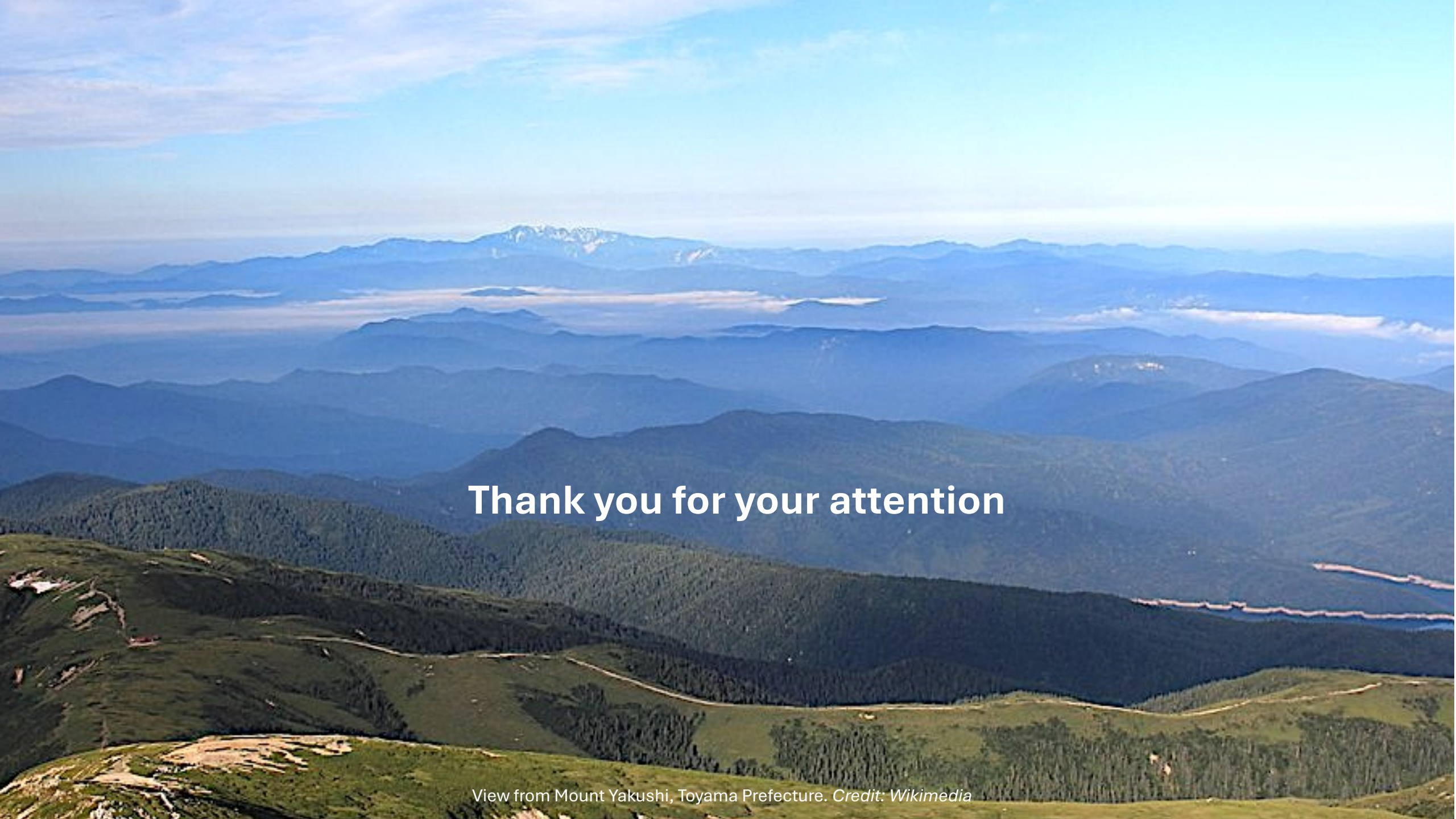
A view from Toyama Castle Park. Credit: Tripadvisor

We can't yet see what's at the other end,

and there may be a long walk after the bridge, but…



View from Mount Yakushi, Toyama Prefecture. *Credit: Wikimedia*



View from Mount Yakushi, Toyama Prefecture. *Credit: Wikimedia*

Extras

Broken “symmetries”? Time-honored ideas still illuminating the path forward…

perspective

NATURE PHYSICS | VOL 14 | FEBRUARY 2018

Symmetry and emergence

[**E. Witten**, arXiv:1710.01791]



In a modern understanding of particle physics, global symmetries are approximate and gauge symmetries may be emergent. This view, which has echoes in condensed-matter physics, is supported by a variety of arguments from experiment and theory.

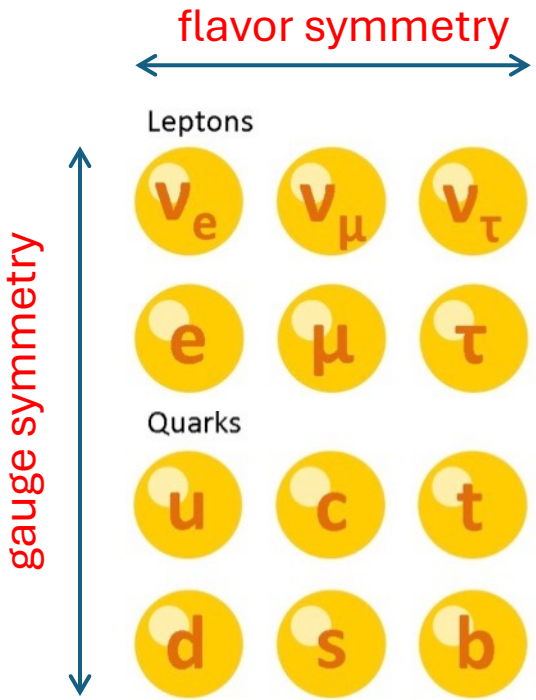
No reason for global symmetries to be exact, from different theoretical perspectives.

No global lepton number conservation	$\mathcal{L}_1 = \frac{1}{M} HHLL$	**Majorana neutrinos**
No global baryon number conservation	$\mathcal{L}_2 = \frac{1}{M^2} QQQL$	**Proton decay**
No a priori CP conservation in QCD	$\frac{\theta}{32\pi^2}\,\varepsilon^{\mu\nu\alpha\beta}\,\mathrm{tr}\,F_{\mu\nu}F_{\alpha\beta}$	**Axion**

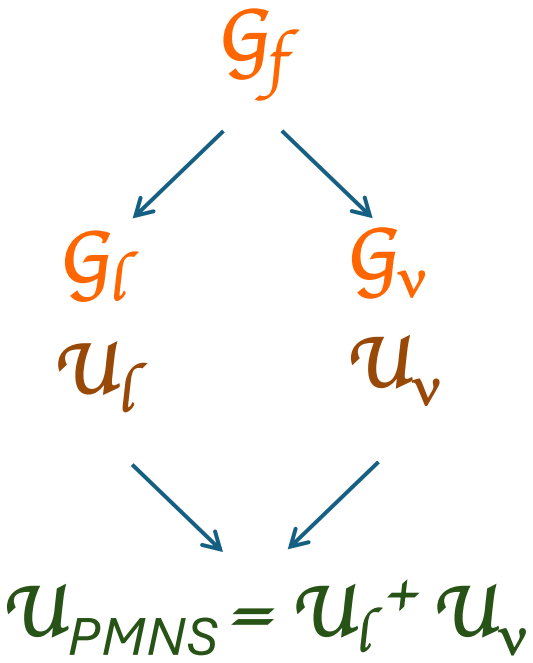
General arguments not weakened by lack of new physics signals at collider scale

Model building by assuming symmetries

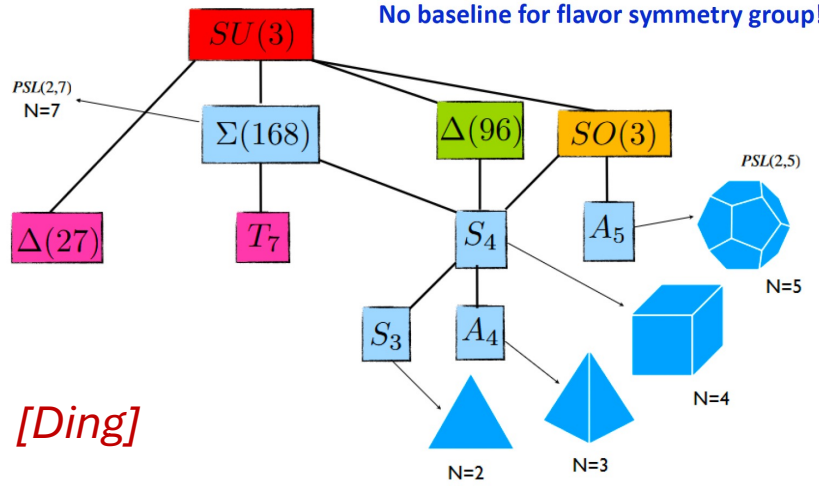
New scale(s) with higher symmetries



Flavor symmetries: group patterns



No baseline for flavor symmetry group!

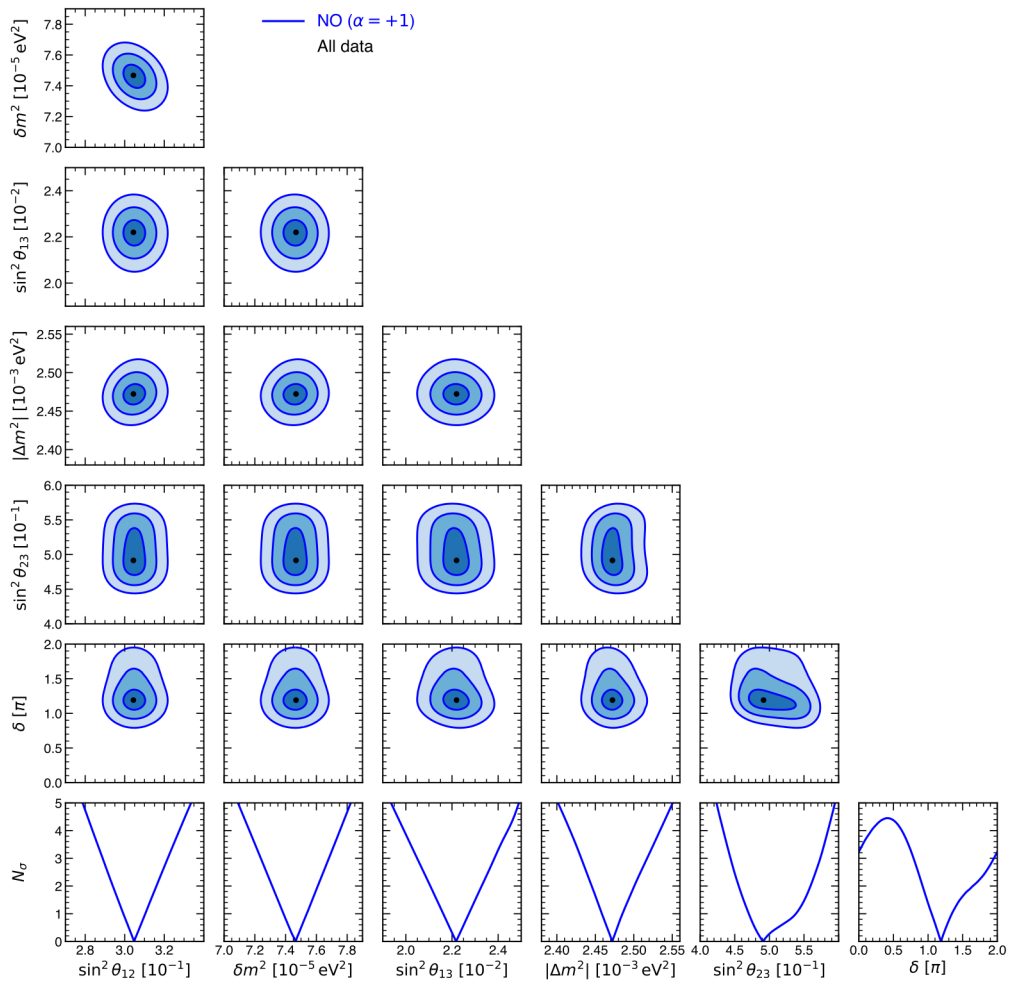


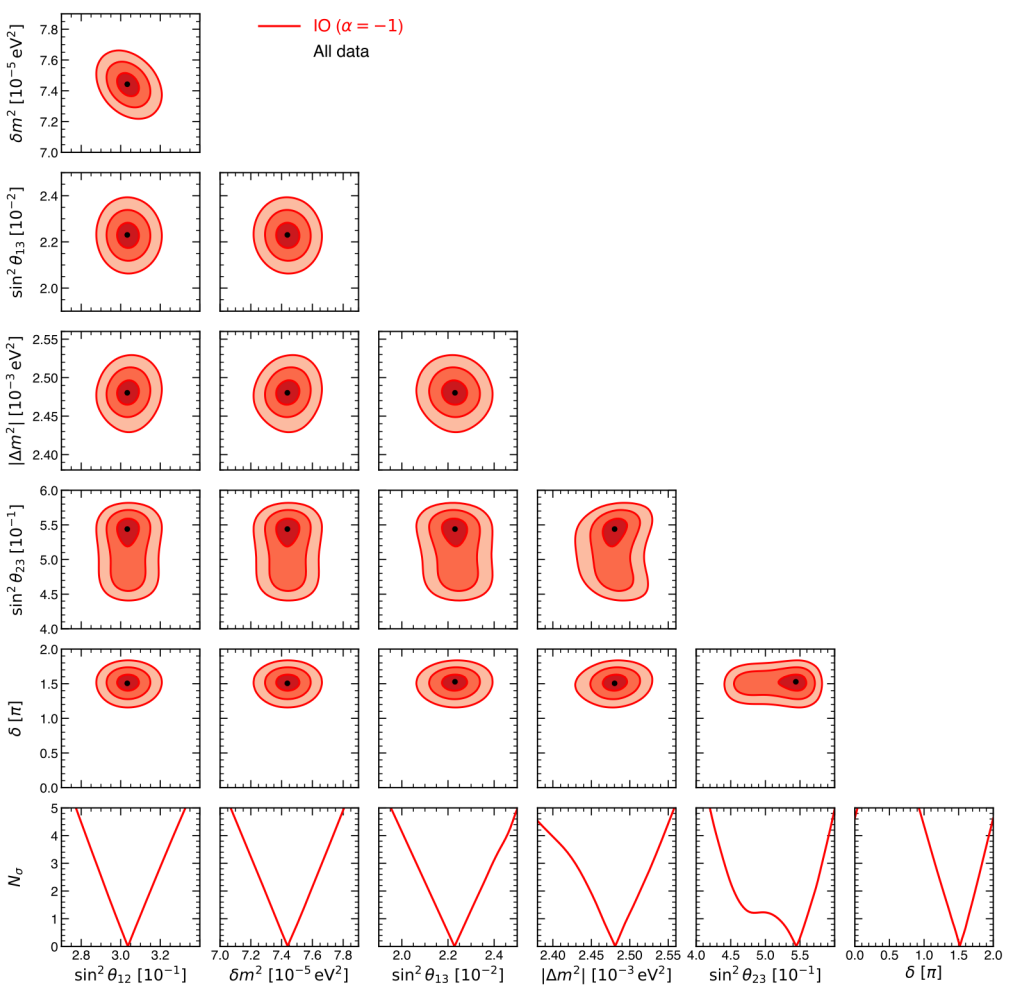
[Ding]

Hope to "explain" at least lepton,
+ possibly also quark flavor sector,
with relatively few new d.o.f.

$G_l \rtimes H_{CP}^l$	$G_\nu \rtimes H_{CP}^\nu$	U	# parameters
Z_n	$K_4 \times CP$	$Q_l^\dagger P_l^T \Sigma_l^\dagger \Sigma_\nu P_\nu Q_\nu$	0
Z_n	$Z_2 \times CP$	$Q_l^\dagger P_l^T \Sigma_l^\dagger \Sigma_\nu R_{23}(\theta) P_\nu Q_\nu$	1
$Z_2 \times CP$	$K_4 \times CP'$	$Q_l^\dagger P_l^T R_{23}^T(\theta_l) \Sigma_l^\dagger \Sigma_\nu P_\nu Q_\nu$	
$Z_2 \times CP$	$Z_2 \times CP'$	$Q_l^\dagger P_l^T R_{23}^T(\theta_l) \Sigma_l^\dagger \Sigma_\nu R_{23}(\theta_\nu) P_\nu Q_\nu$	2
Z_2	$K_4 \times CP$	$Q_l^\dagger P_l^T U_{23}^\dagger(\theta_l, \delta_l) \Sigma_l^\dagger \Sigma_\nu P_\nu Q_\nu$	
Z_n	CP	$Q_l^\dagger P_l^T \Sigma_l^\dagger \Sigma_\nu O_3(\theta_1, \theta_2, \theta_3) Q_\nu$	3
CP	$K_4 \times CP'$	$Q_l^\dagger O_3^T(\theta_1, \theta_2, \theta_3) \Sigma_l^\dagger \Sigma_\nu Q_\nu$	
Z_2	$Z_2 \times CP$	$Q_l^\dagger P_l^T U_{23}^\dagger(\theta_l, \delta_l) \Sigma_l^\dagger \Sigma_\nu R_{23}(\theta_\nu) P_\nu Q_\nu$	

Global fit covariances

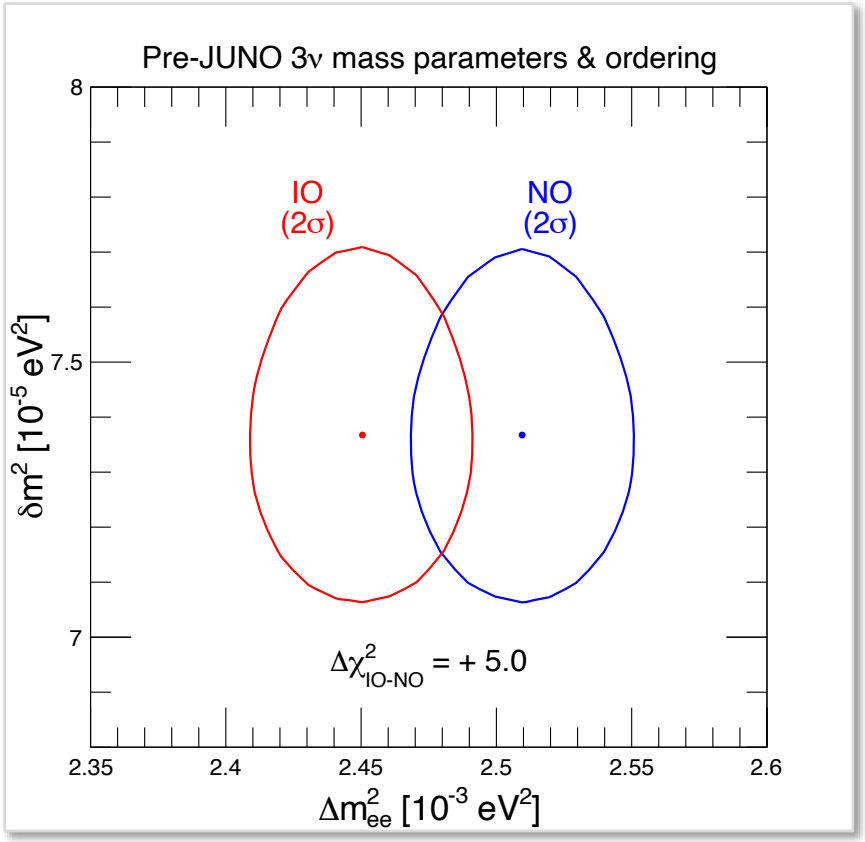




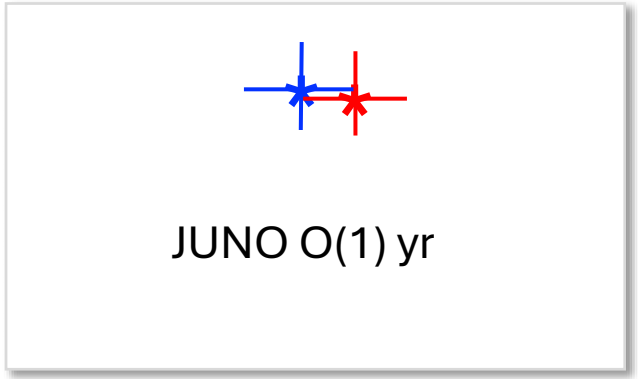
F. Capozzi, EL, F. Marcone, A. Marrone (Bari Group**) – **preliminary** results. See also the website **global-nu.org***

Before Neutrino 2026 Conference:

Pre-JUNO mass^2 parameters **(δm^2, Δm^2_{ee})** vs JUNO O(1) yr expectations



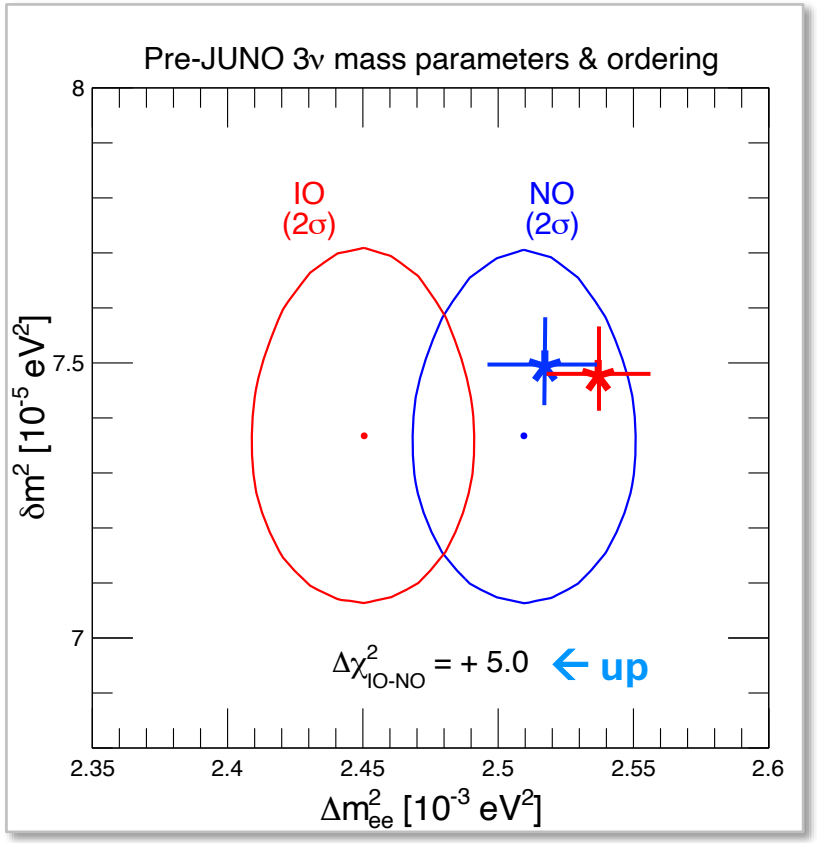
Where might JUNO data fall?



Relative position of best fit points in NO/IO is fairly well understood

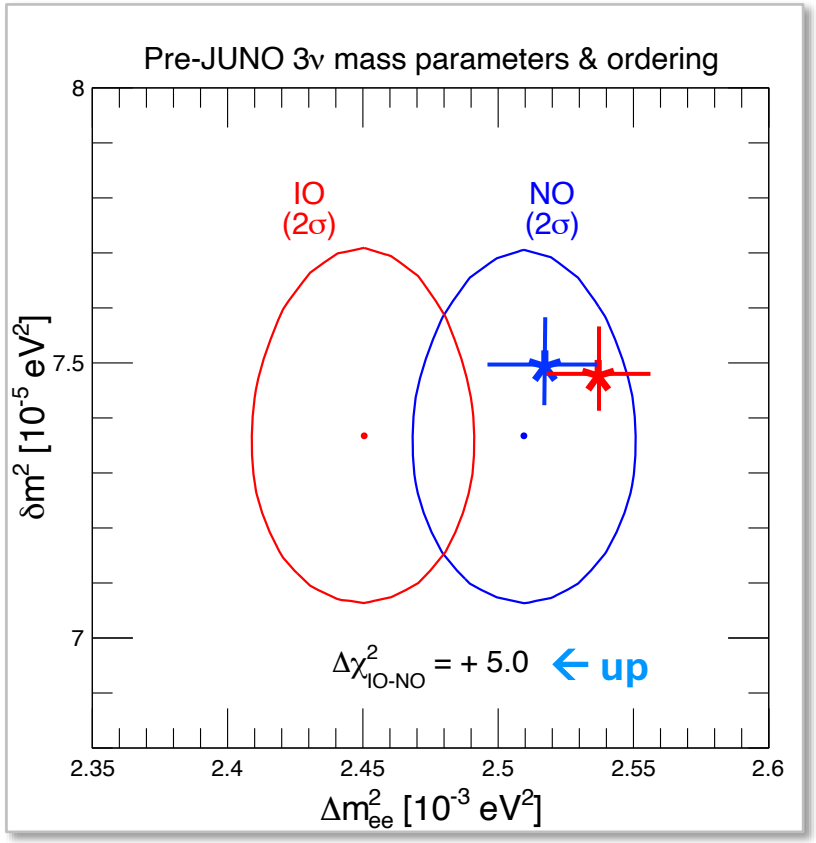
Examples of would-be JUNO outcomes after ~1 yr

A synergy favoring NO

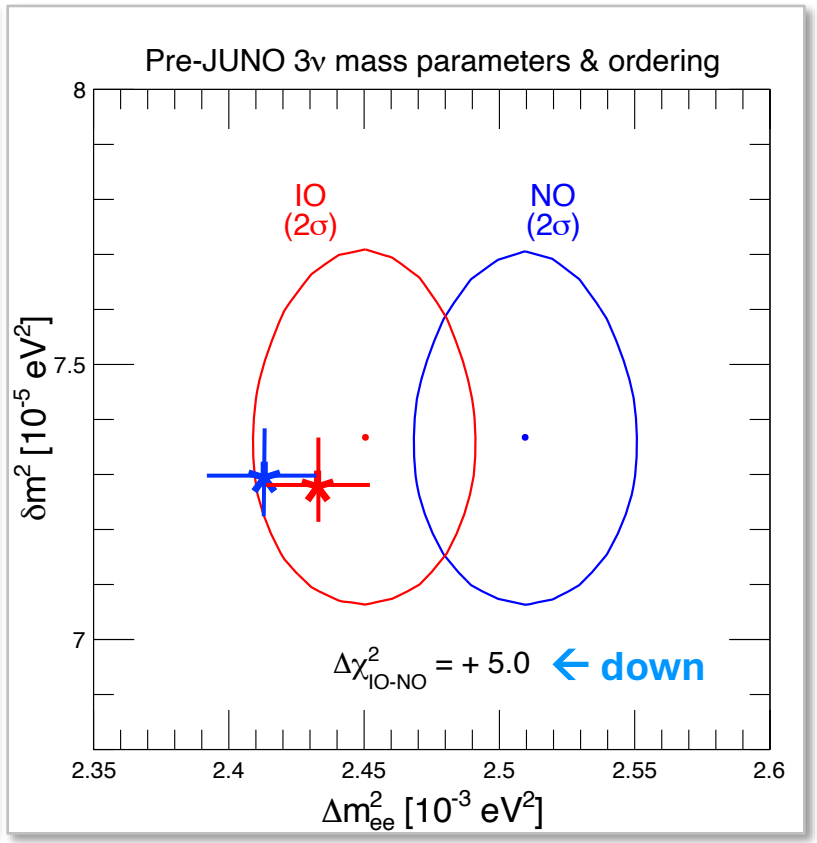


Examples of would-be JUNO outcomes after ~1 yr

A synergy favoring NO

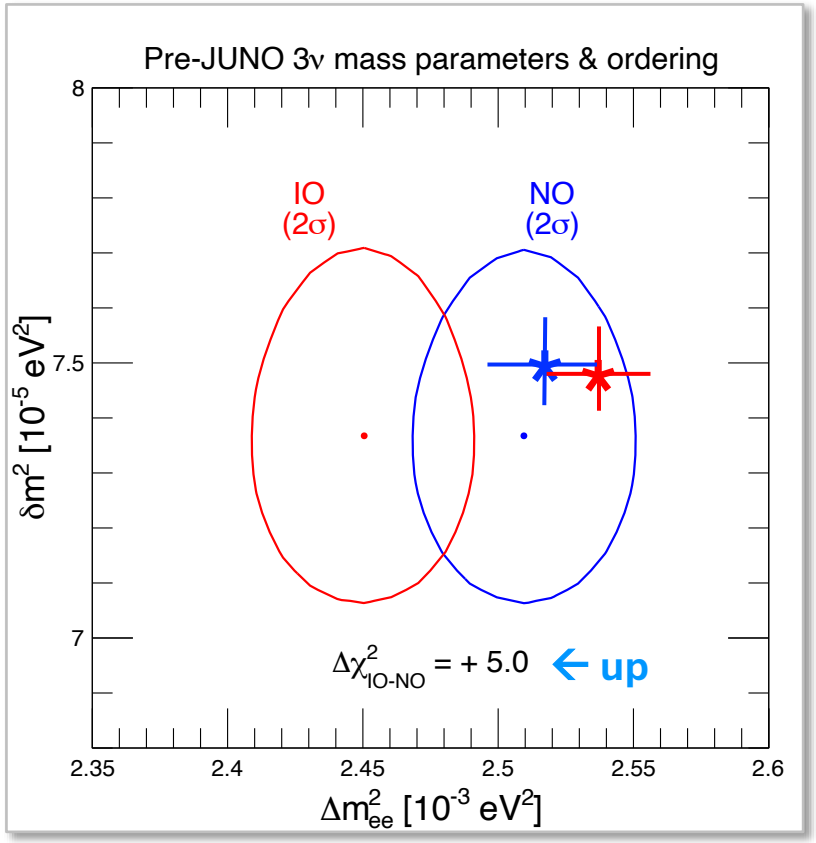


A synergy favoring IO

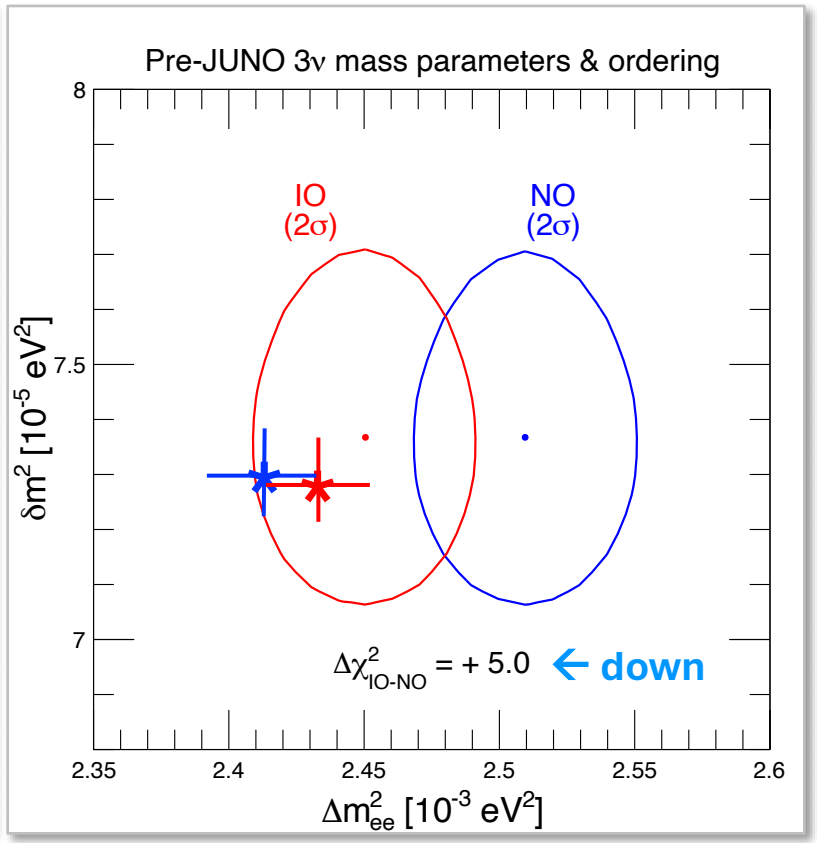


Examples of would-be JUNO outcomes after ~1 yr

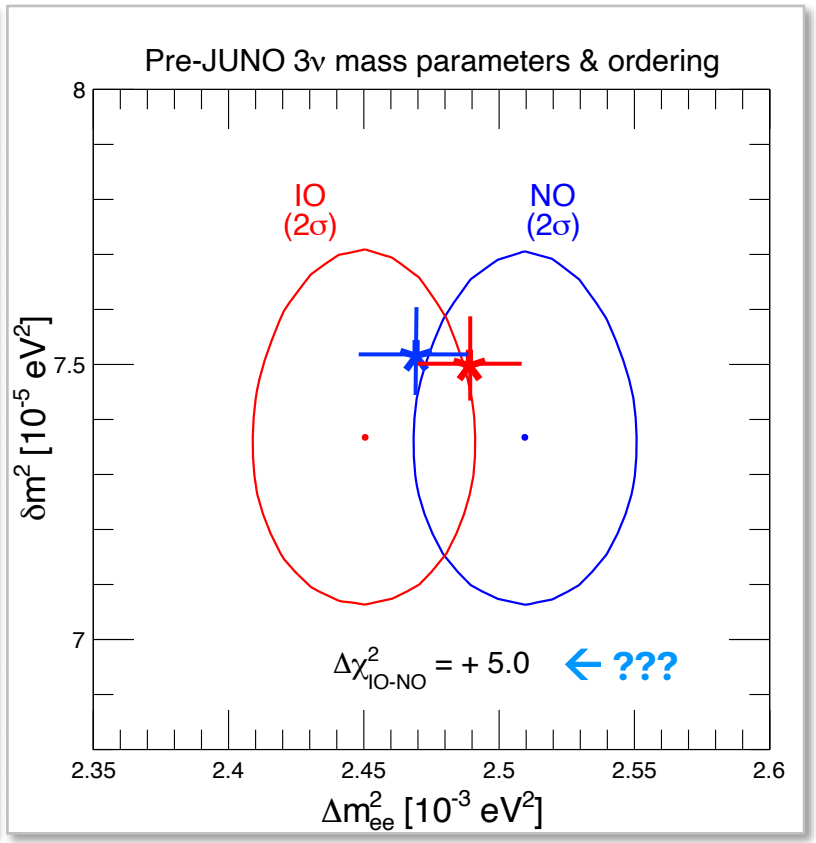
A synergy favoring NO



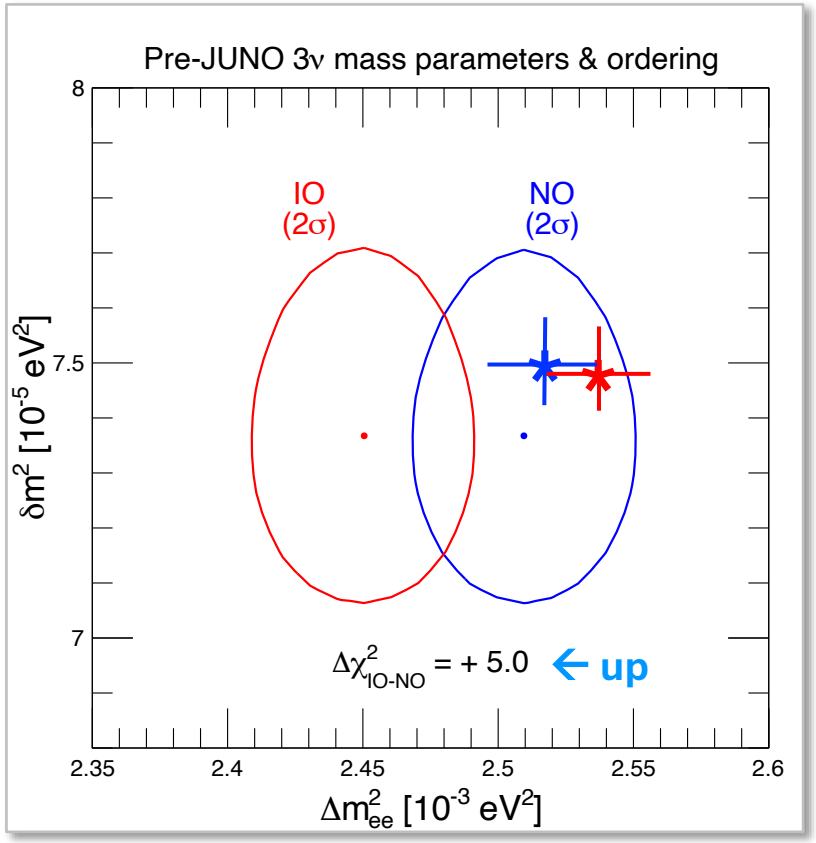
A synergy favoring IO



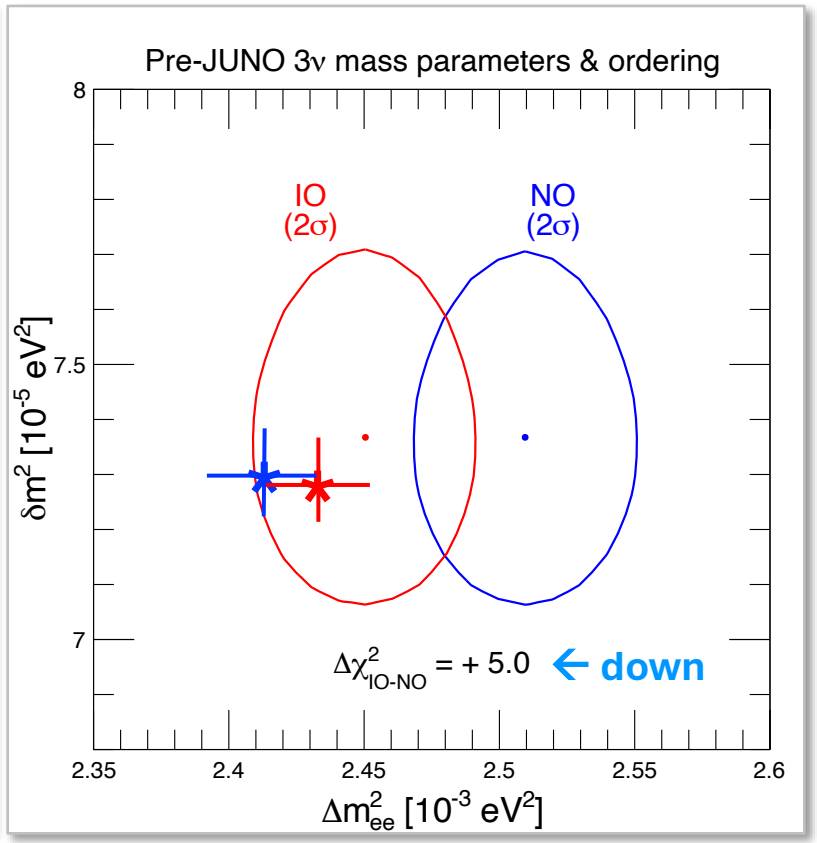
An undecided NO/IO…



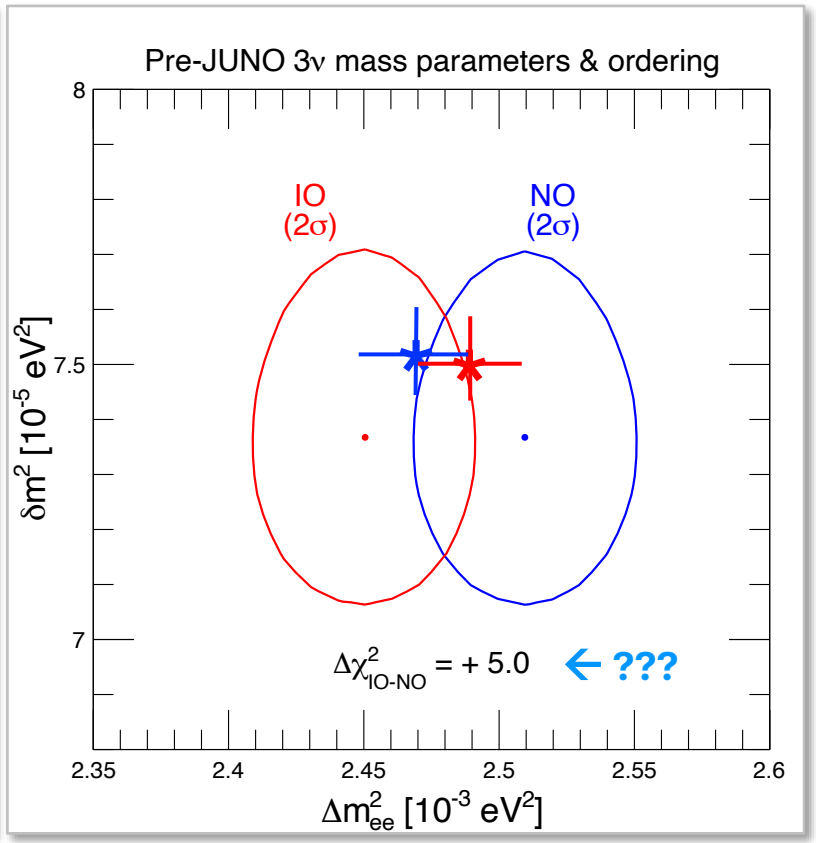
A synergy favoring NO



A synergy favoring IO

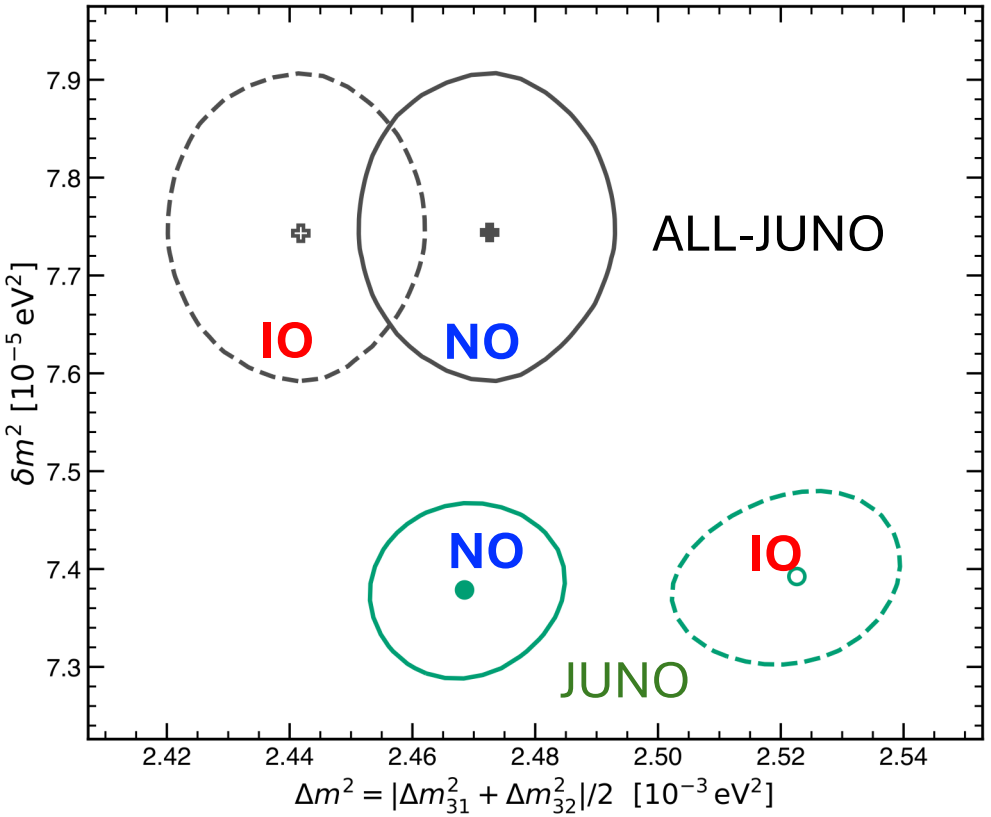


An undecided NO/IO…



… with further cascade (correlated) effects on the other oscillation unknowns

After Neutrino 2026 (1σ):



*F. Capozzi, EL, F. Marcone, A. Marrone (**Bari Group**) – **preliminary** results. See also the website **global-nu.org***