



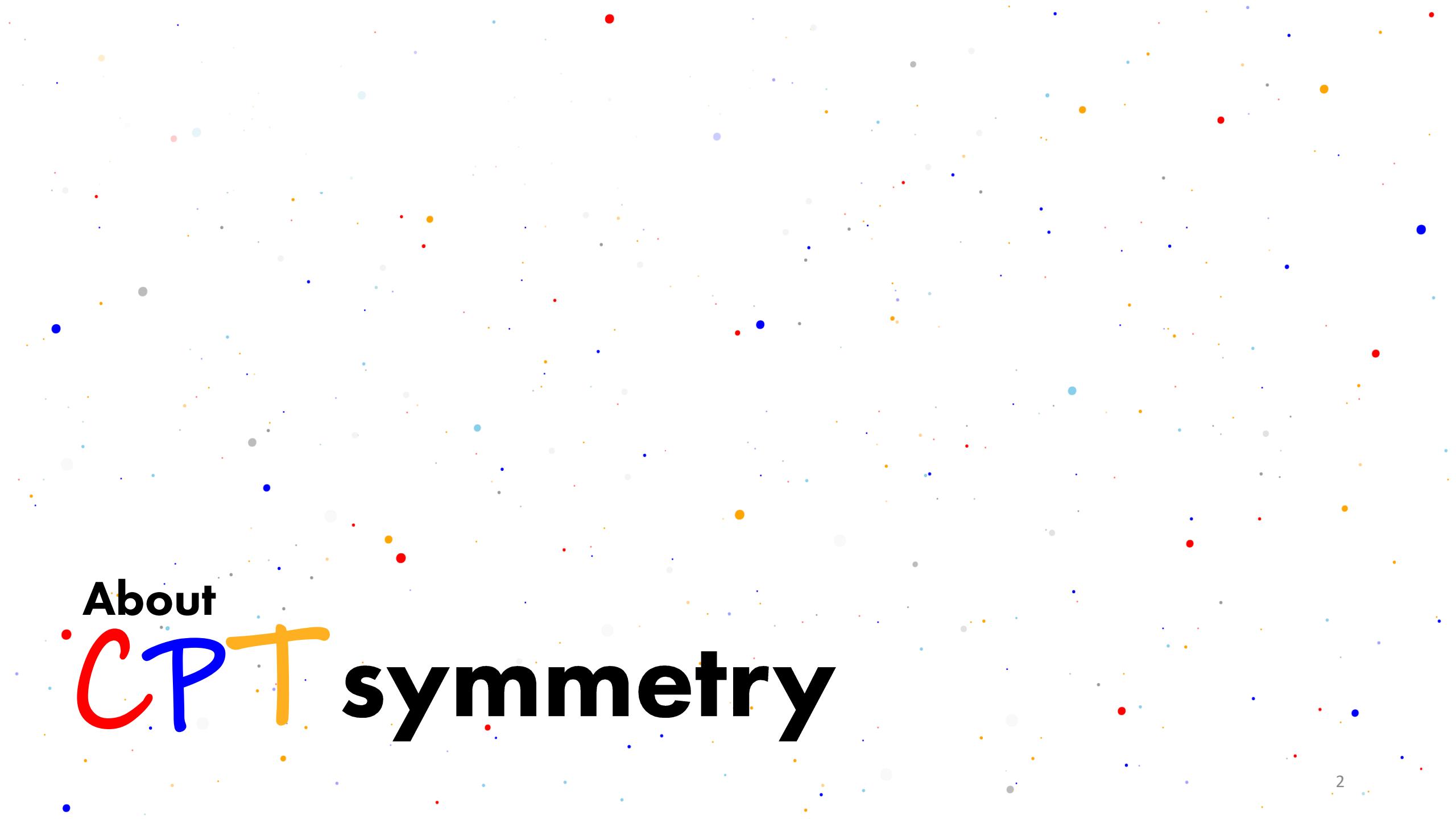
ConSELLERIA DE INNOVACIÓN,
UNIVERSIDADES, CIENCIA
Y SOCIEDAD DIGITAL



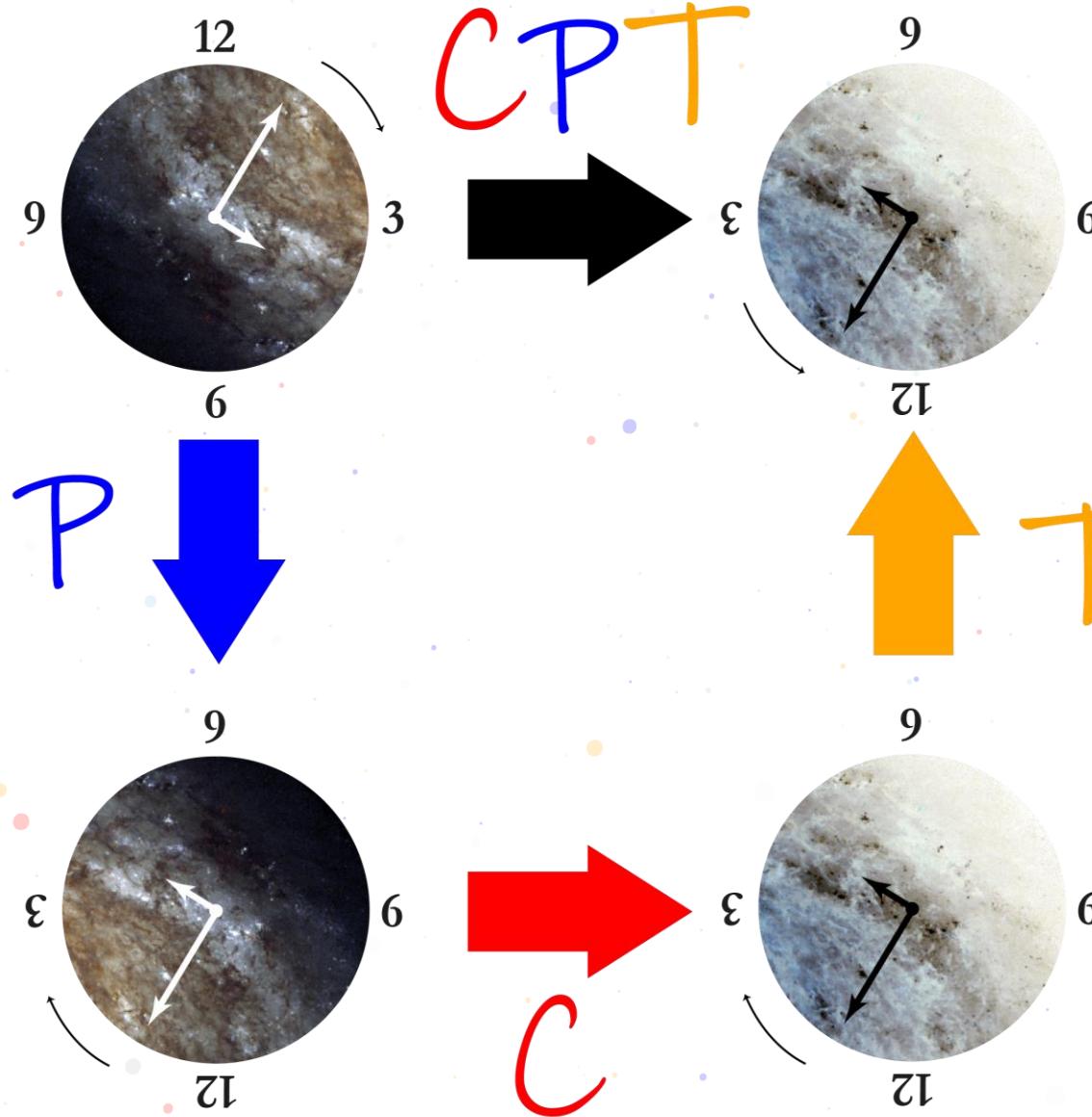
TESTING CPT INVARIANCE WITH THE NEUTRINO SOLAR SECTOR

Pablo Martínez-Miravé (IFIC, CSIC – Univ. Valencia)

TAUP 2023, Wien - Based on Phys. Rev. D 108, 035039



About **CPT** symmetry



About **CPT** symmetry

CPT is a keystone of high energy physics which stems from requiring **Lorentz invariance, unitarity and locality**.

CPT violation could result from

- Lorentz violation
- Non-local Lorentz-invariant field theories

R. Jost, Helv.Phys.Acta
30 (1957) 409-416

Addazi et al,
Prog.Part.Nucl.Phys.
125 (2022) 103948

About **CPT** symmetry

From CPT Theorem, particles and antiparticles have the same mass and lifetime.

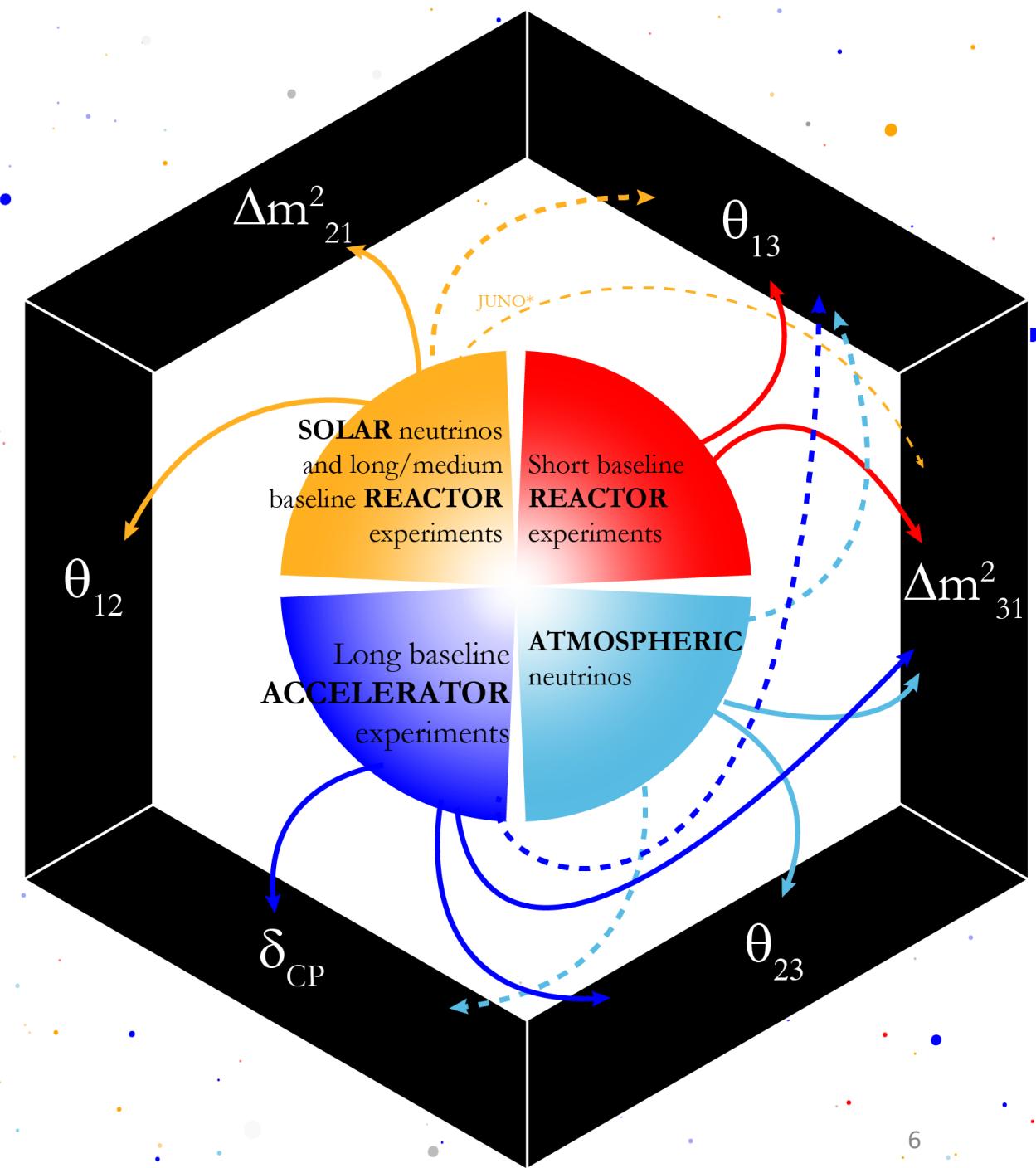
In some CPT breaking models, a mass splitting between particles and antiparticles is realised.

- Chaichian et al,
Phys.Lett.B 699 (2011)

- Chaichian et al,
Eur.Phys.J.C 73 (2013)
3, 2349

- About

CPT symmetry and neutrino oscillations

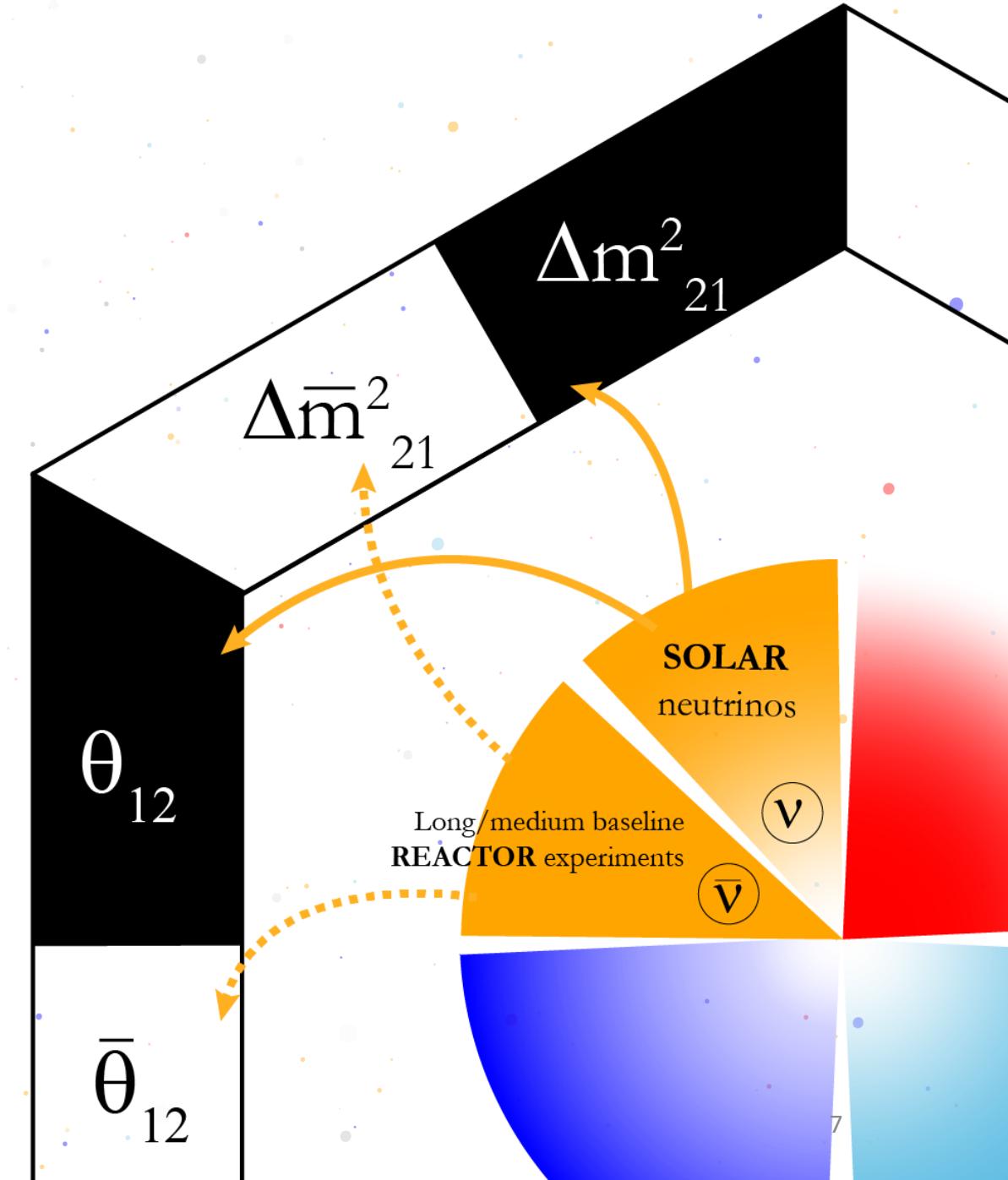


• About

CPT symmetry

and neutrino oscillations

CPT violation could manifest as different mixing and mass splittings for neutrinos and antineutrinos.



CURRENT STATUS

Limits based on data from 2020

G. Barenboim et al.
JHEP 07 (2020) 155

$$|\Delta(\Delta m_{21}^2)| = |\Delta m_{21}^2 - \Delta \bar{m}_{21}^2| < 4.7 \times 10^{-5} \text{ eV}^2$$

$$|\Delta(\Delta m_{31}^2)| = |\Delta m_{31}^2 - \Delta \bar{m}_{31}^2| < 2.5 \times 10^{-4} \text{ eV}^2$$

$$|\Delta(\sin^2 \theta_{12})| = |\sin^2 \theta_{12} - \sin^2 \bar{\theta}_{12}| < 0.14$$

$$|\Delta(\sin^2 \theta_{13})| = |\sin^2 \theta_{13} - \sin^2 \bar{\theta}_{13}| < 0.029$$

$$|\Delta(\sin^2 \theta_{23})| = |\sin^2 \theta_{23} - \sin^2 \bar{\theta}_{23}| < 0.19$$

CURRENT STATUS

- Updated limits

$$|\Delta(\Delta m_{21}^2)| = |\Delta m_{21}^2 - \Delta \bar{m}_{21}^2| < 3.7 \times 10^{-5} \text{ eV}^2$$

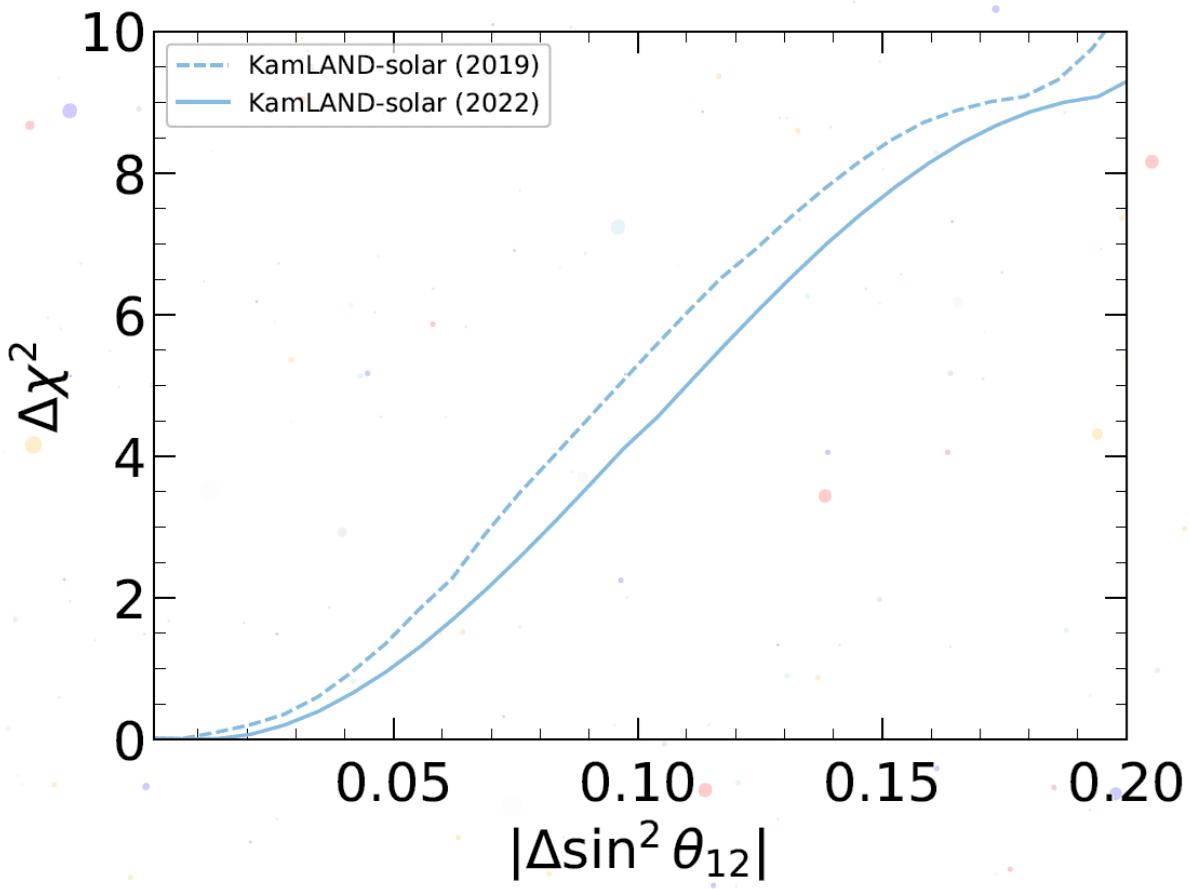
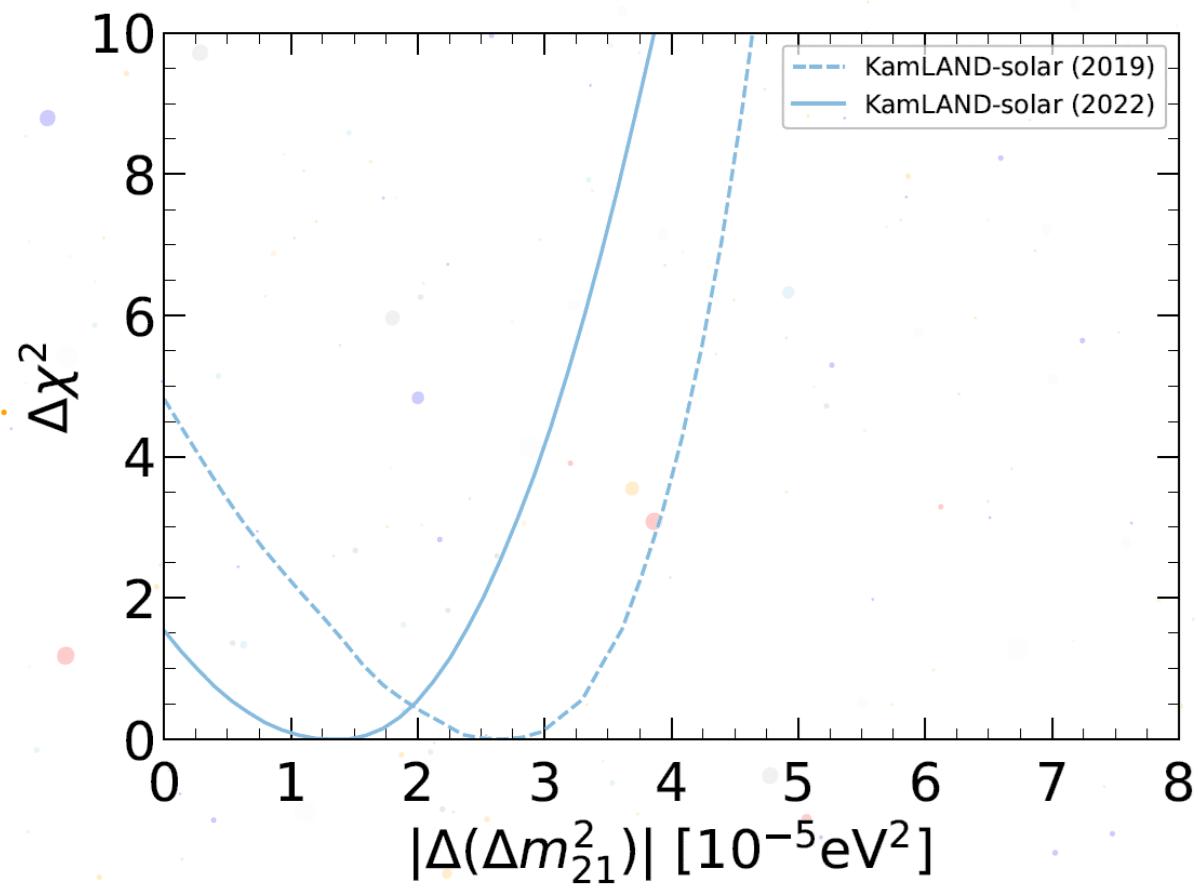
$$|\Delta(\Delta m_{31}^2)| = |\Delta m_{31}^2 - \Delta \bar{m}_{31}^2| < 2.5 \times 10^{-4} \text{ eV}^2$$

$$|\Delta(\sin^2 \theta_{12})| = |\sin^2 \theta_{12} - \sin^2 \bar{\theta}_{12}| < 0.187$$

$$|\Delta(\sin^2 \theta_{13})| = |\sin^2 \theta_{13} - \sin^2 \bar{\theta}_{13}| < 0.029$$

$$|\Delta(\sin^2 \theta_{23})| = |\sin^2 \theta_{23} - \sin^2 \bar{\theta}_{23}| < 0.19$$

CURRENT STATUS





FUTURE PROSPECTS

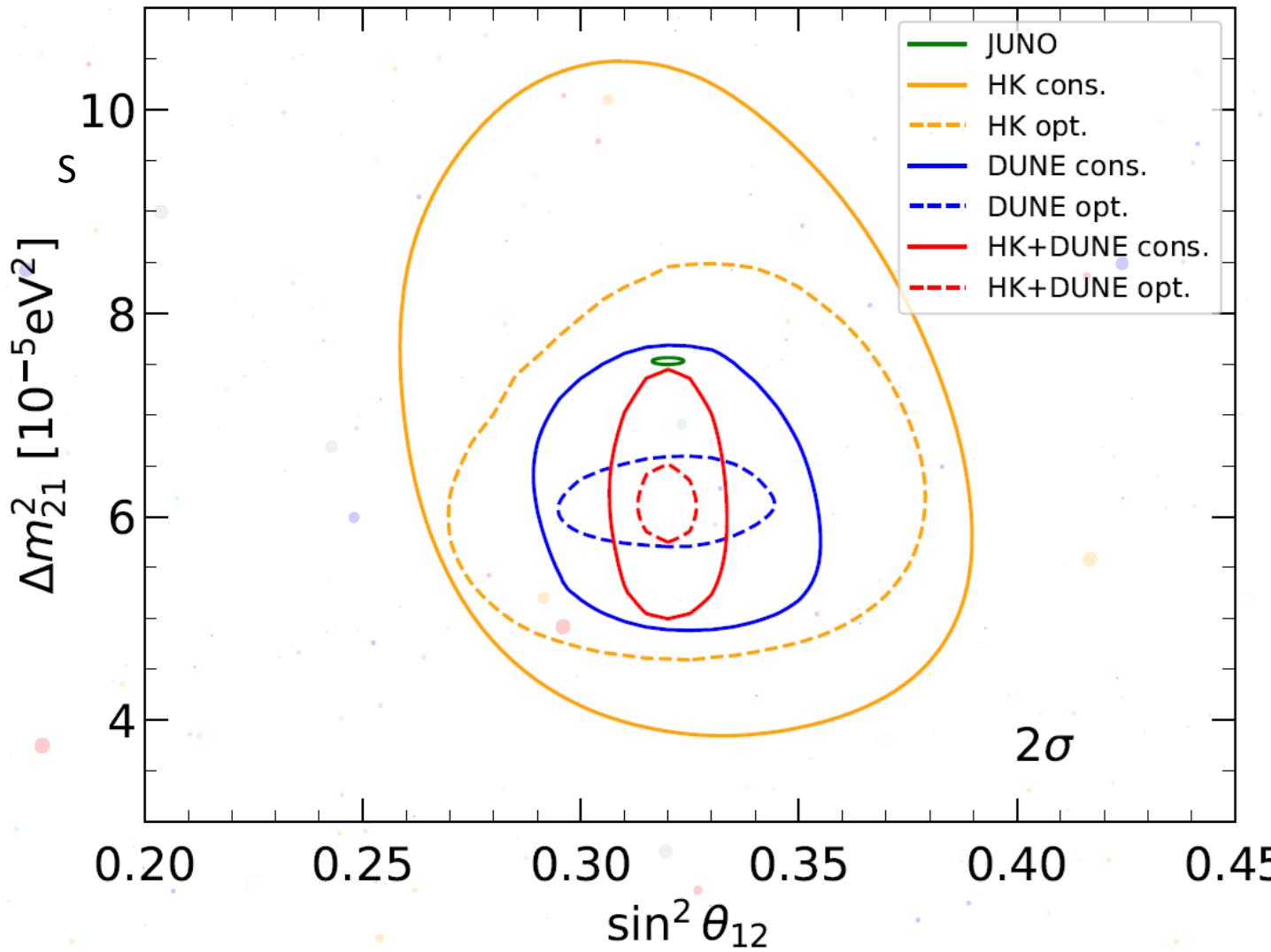
JUNO

Extremely sensitive to the parameters of the
solar sector using **reactor antineutrinos**.

DUNE and Hyper-Kamiokande

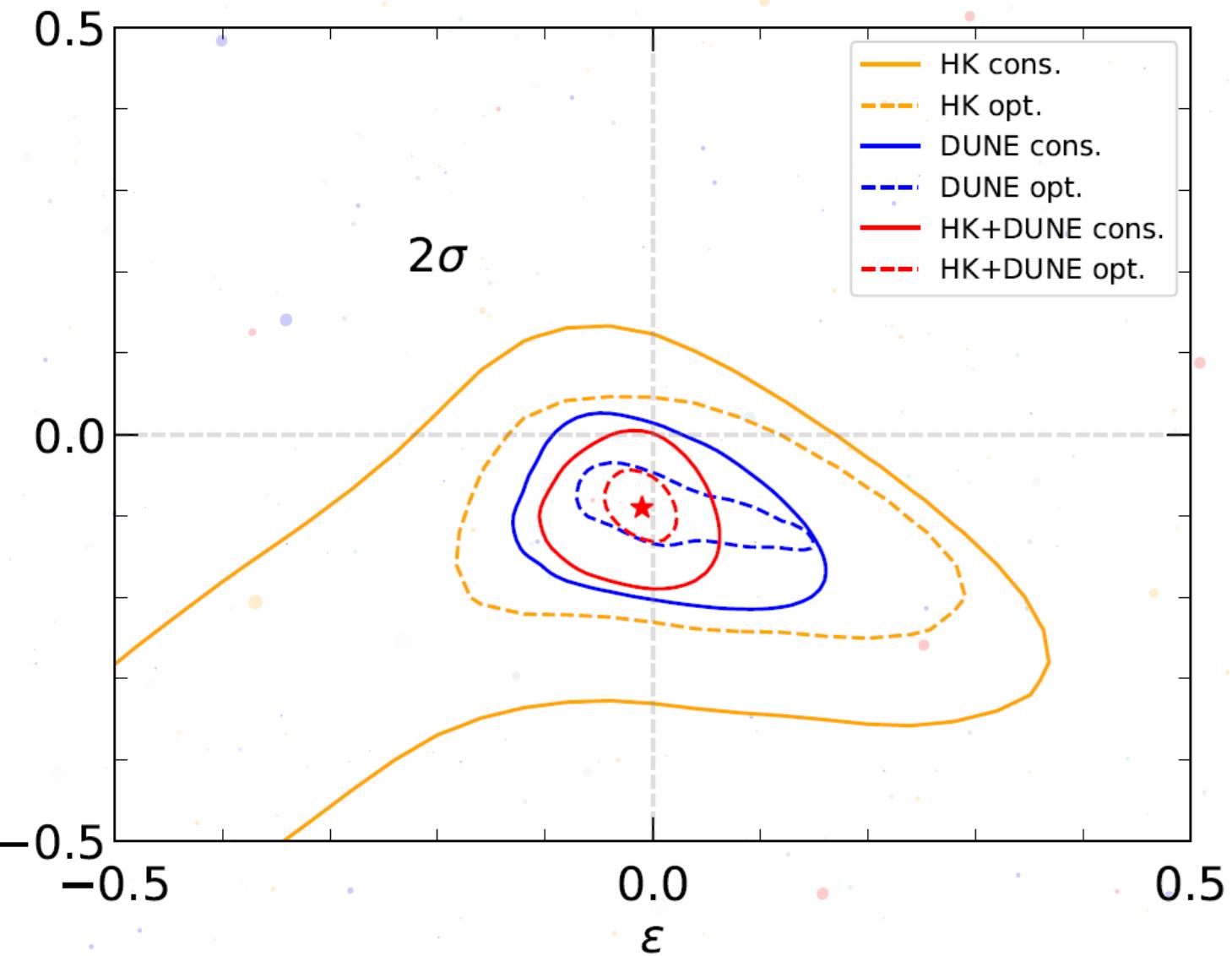
Measurement of **solar neutrinos** using different detection channels.
We consider different experimental set-ups (**conservative and optimal**).

An example of a CPT violating scenario

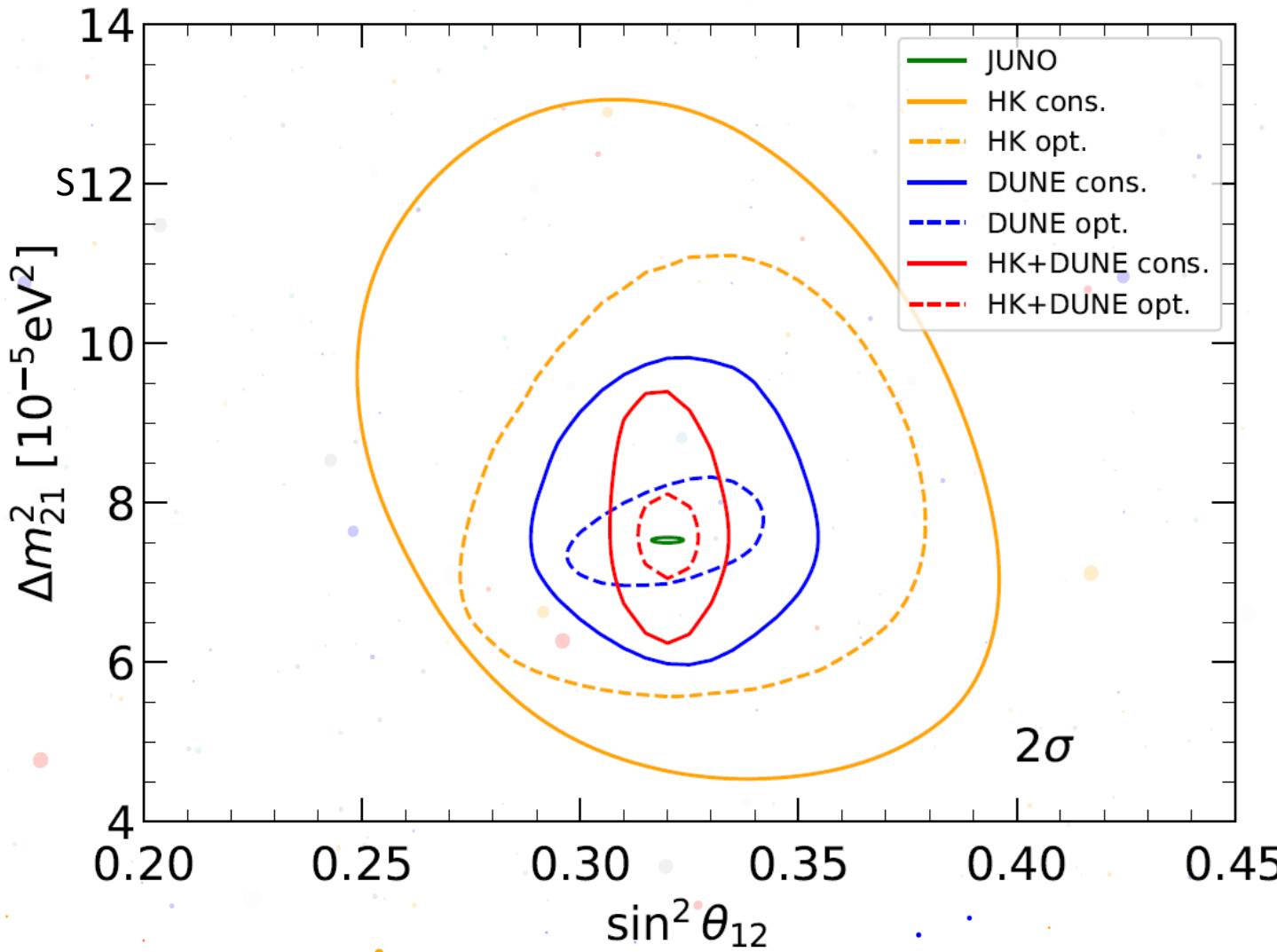


JUNO, Hyper-Kamiokande and DUNE (and a combined analysis of both) will improve existing limits significantly or provide evidence of CPT violation in the neutrino sector.

If the mismatch persisted, one could also invoke the existence of **non-standard interactions (NSI)** to explain it.



An example of a CPT conserving scenario



JUNO, Hyper-Kamiokande and DUNE (and a combined analysis of both) will improve existing limits significantly or provide evidence of CPT violation in the neutrino sector.

- From **neutrinos**:

	$ \Delta \sin^2 \theta_{12} $	$ \Delta(\Delta m_{21}^2) [10^{-5} \text{eV}^2]$
current bound	0.187	3.7
JUNO + HK + DUNE conservative	0.018	2.4
JUNO + HK + DUNE optimal	0.011	0.8

- Current limit from the **kaon system**:

$$|m^2(K^0) - m^2(\bar{K}^0)| < 0.25 \text{ eV}^2$$

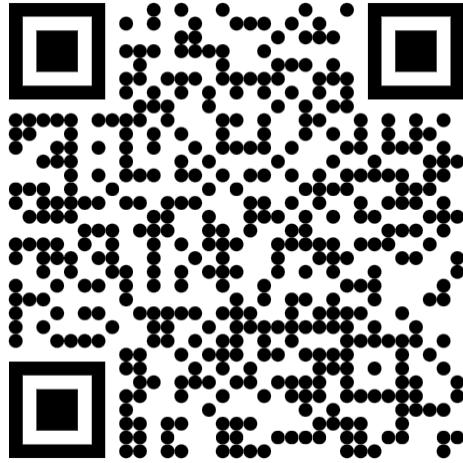
TAKE-HOME MESSAGE

**TESTING CPT
INVARIANCE WITH THE NEUTRINO SOLAR SECTOR**

CPT violation could manifest as **particles and antiparticles having different masses** and lifetimes.

Future neutrino observatories, including JUNO, DUNE, and Hyper-Kamiokande, will **improve existing limits**.

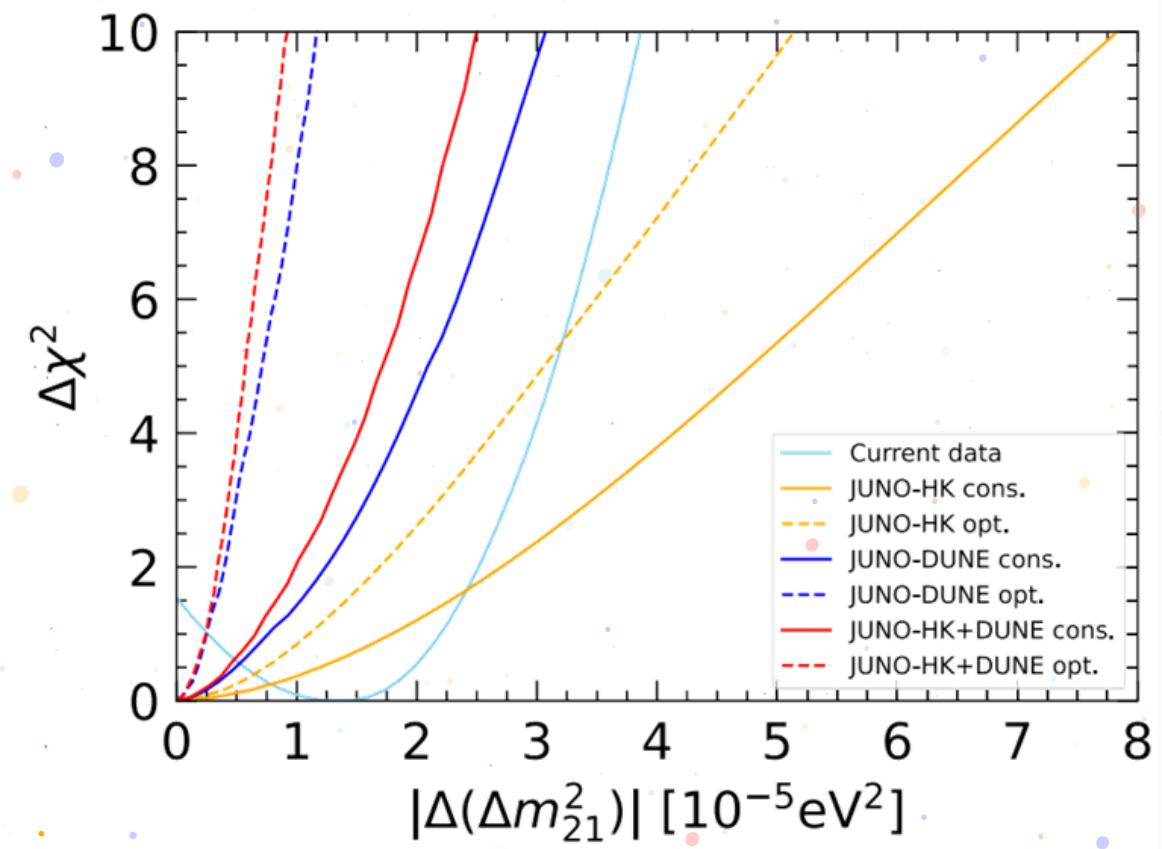
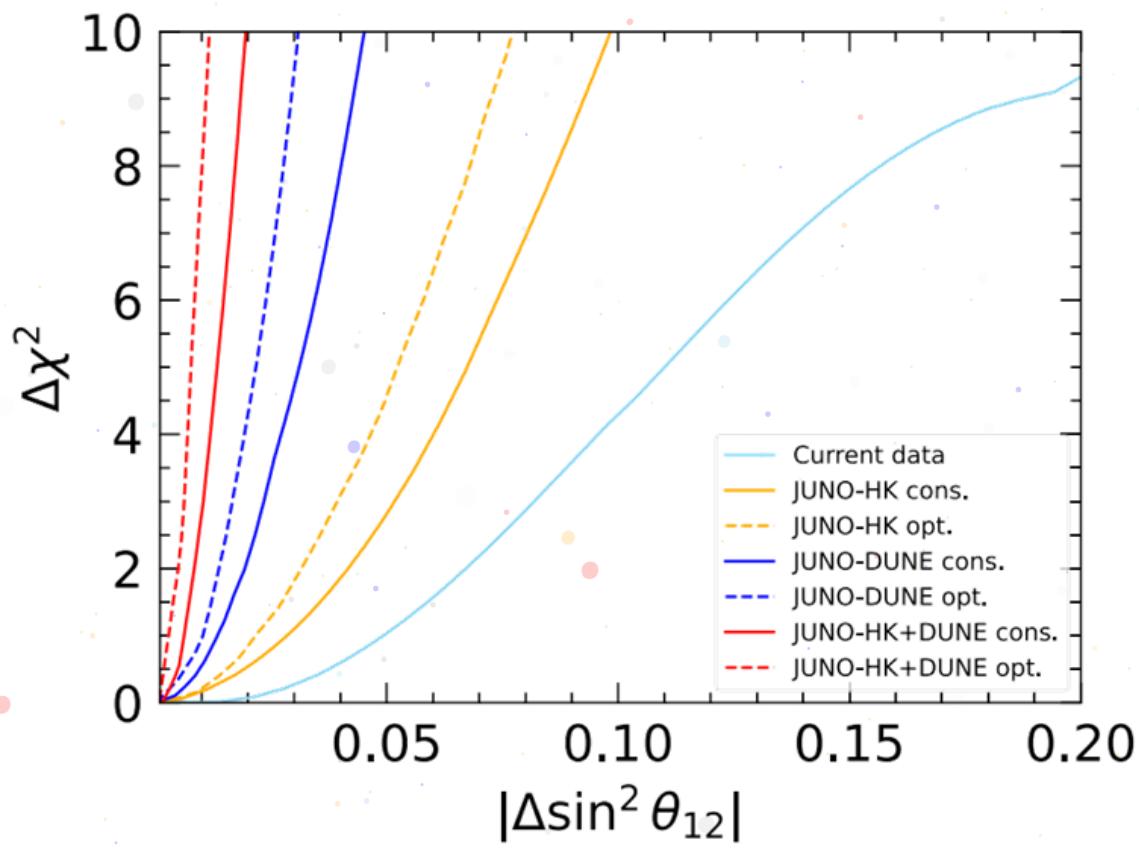
Phys. Rev. D 108, 035039





**SPARE
SLIDES**

An example of a CPT conserving scenario (II)



A CPT violating scenario (II)

