
UNIWERSYTET ŚLĄSKI
INSTYTUT FIZYKI
IM. AUGUSTA CHEŁKOWSKIEGO
Bartosz Dziewit
II DZIEŃ INSTYTUTU FIZYKI UŚ
PREZENTUJEMY NAUKĘ, BUDUJEMY WIĘZI

Theory and Phenomenology of Particle Physics, University of Silesia research group

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About Us

The research is carried out in several directions, with an emphasis on precise calculations of higher-order perturbation effects for electroweak observables at LHC and future lepton accelerators. We are particularly focused on the activities related to the FCC-ee project at CERN.

The research topics of the group include:
1. Precise calculation of parameters and observables of the Standard Model (SM)
2. Phenomenology of SM extensions (neutrinos, additional gauge bosons, Higgs scalars)
3. Development of methods and tools for the calculation of multi-loop Feynman integrals

Detailed research goals:
1. Use of new computational techniques and advanced algebra to define and constraint elements of the neutrino mixing matrix with non-standard neutrinos.
2. Phenomenology of non-standard particles at the LHC and future lepton accelerators (H++, W2, Z2, heavy neutrinos).
Precise calculation of electroweak of electroweak pseudoobservables for the LHC and

RECENT POSTS

- Miniatura NCN grants for Dr Biswajit Karmakar and Dr Nora Salone
- Dr Monojit Ghosh visit (December 2025)
- We started the Polish-Swiss-Croatian Collaboration (2025-2029)
- Future of Particle Physics: ESPPU in Venice
- Seminar by Artur M. Ankowski "Neutrino cross sections: importance and challenges"
- Scientific STAND-UP: "The Secret Life of a Scientist"
- Visitor : Jürgen Reuter (DESY)
- We organize: MTTD 2025
- Review article in PPNP
- Interview with J. Gluza about research (in Polish)

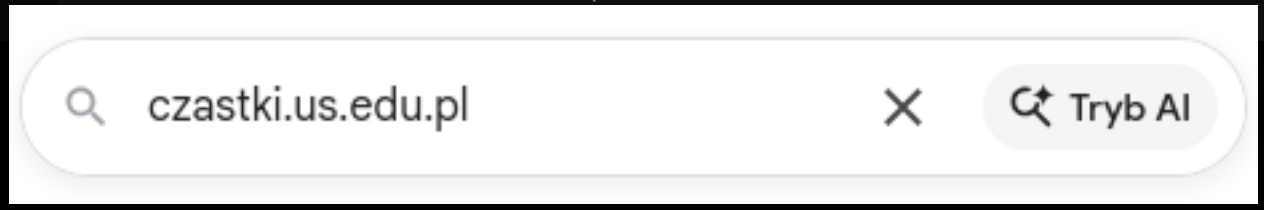
Janusz Gluza
Personal webpage
janusz.gluza@us.edu.pl
office number: 310A

Biswajit Karmakar
Personal webpage
biswajit.karmakar@us.edu.pl
office number: 318

Evgen Dubovyk
ievgen.dubovyk@us.edu.pl
office number: 312A

Stéphane Delorme
stephane.delorme@us.edu.pl
office number: 312A

Nora Salone
nora.salone@us.edu.pl
office number: 315



Trzy kierunki badań

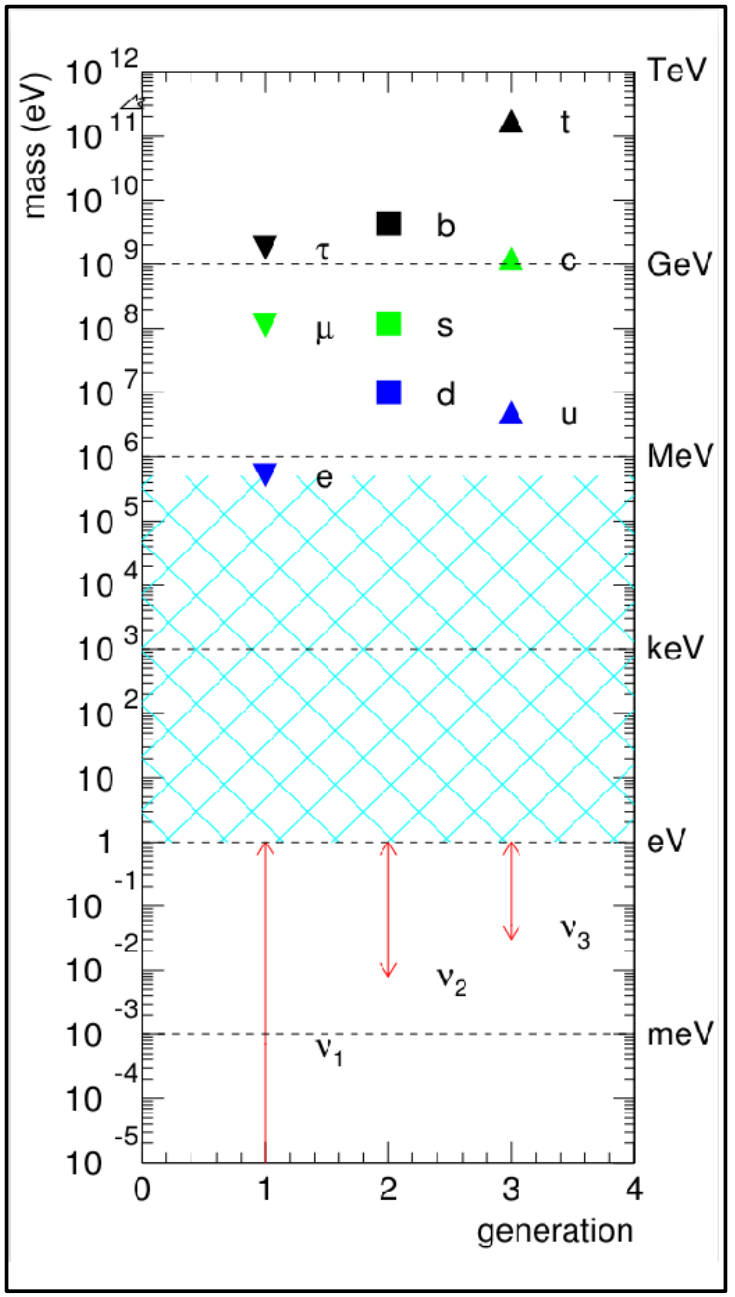
Tematy badawcze grupy obejmują:

1. Precyzyjne obliczenia parametrów i obserwabli Modelu Standardowego (SM).
2. Fenomenologię rozszerzeń SM (neutrina, dodatkowe bozony cechowania, skalary Higgsa)
3. Rozwój metod i narzędzi do obliczania wielopętlowych całek Feynmana.


submarine racing
so intense

Masy fermionów

- Nie znamy siły oddziaływania każdej cząstki z polem Higgsa,
- zatem nie znamy stałych Yukawy występujących w potencjale Yukawy,
- nie potrafimy obliczyć numerycznych wartości mas z zasad pierwszych,
- nie wiemy dlaczego istnieją trzy rodziny kwarków i leptonów,
- dlaczego masy wszystkich naładowanych fermionów mają strukturę hierarchiczną,
- nie potrafimy określić wartości mas neutrin,
- a także odpowiedzieć na pytanie dlaczego są one tak małe w porównaniu z innymi cząstkami.



Macierz mieszania leptonów:

$$(U_{PMNS})_{\alpha i} = \sum_{\beta=e,\mu,\tau} (U_L^l)^{\dagger}_{\alpha\beta} (U^{\nu})_{\beta i} \cdot$$

Macierz mieszania w prądzie naładowanym jest wyrażona w bazie masowych stanów własnych zarówno naładowanych leptonów (e, μ, τ) jak i neutrin (ν_1, ν_2, ν_3). Z tego powodu mamy dowolność w wyborze modeli teoretycznych. Możemy szukać symetrii: w bazie stanów własnych naładowanych leptonów, wtedy

$$U_L^l = \mathrm{I} \quad \mathrm{i} \quad U_{PMNS} = U^{\nu} \equiv U,$$

$$U^T M_\nu U = m_{diag}$$

$$U_{\mathrm{PMNS}} = R_x(\theta_{23}) R_y(\theta_{13}, \delta_{\mathrm{CP}}) R_z(\theta_{12}) U_M(\alpha_1, \alpha_2) = U U_M(\alpha_1, \alpha_2)$$

$$= \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & 0 & s_{13} e^{-i\delta_{\mathrm{CP}}} \\ 0 & 1 & 0 \\ -s_{13} e^{i\delta_{\mathrm{CP}}} & 0 & c_{13} \end{pmatrix} \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} U_M$$

$$= \begin{pmatrix} c_{12}c_{13} & s_{12}c_{13} & s_{13} e^{-i\delta_{\mathrm{CP}}} \\ -s_{12}c_{23} - c_{12}s_{23}s_{13} e^{i\delta_{\mathrm{CP}}} & c_{12}c_{23} - s_{12}s_{23}s_{13} e^{i\delta_{\mathrm{CP}}} & s_{23}c_{13} \\ s_{12}s_{23} - c_{12}c_{23}s_{13} e^{i\delta_{\mathrm{CP}}} & -c_{12}s_{23} - s_{12}c_{23}s_{13} e^{i\delta_{\mathrm{CP}}} & c_{23}c_{13} \end{pmatrix} U_M$$

Progress in Particle and Nuclear Physics
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Review

Phenomenology of lepton masses and mixing with discrete flavor symmetries

Garv Chauhan [a], P.S. Bhupal Dev [b], Ievgen Dubovyk [c], Bartosz Dziewit [c], Wojciech Flieger [d], Krzysztof Grzanka [c], Janusz Gluza [c], Biswajit Karmakar [c], Szymon Zięba [c]

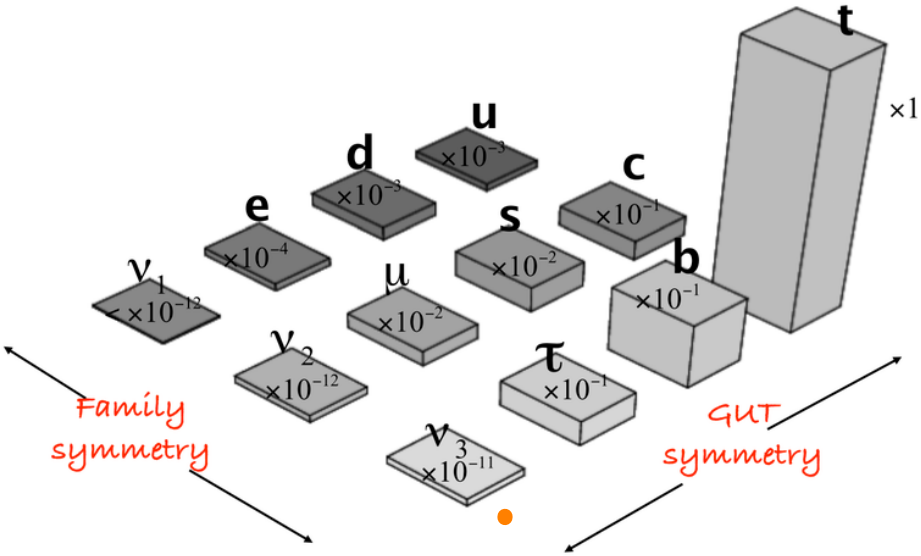
Parameter	Ordering	NuFIT 5.2 (2022) [19, 20]		de Salas et al. (2021) [21, 22]		Capozzi et al. (2021) [23]	
		bf$\pm 1\sigma$	3σ range	bf$\pm 1\sigma$	3σ range	bf$\pm 1\sigma$	3σ range
$\sin^2\theta_{12}/10^{-1}$	NO, IO	$3.03^{+0.12}_{-0.12}$	$2.70 - 3.41$	$3.18^{+0.16}_{-0.16}$	$2.71 - 3.69$	$3.03^{+0.13}_{-0.13}$	$2.63 - 3.45$
$\sin^2\theta_{23}/10^{-1}$	NO	$4.51^{+0.19}_{-0.16}$	$4.08 - 6.03$	$5.74^{+0.14}_{-0.14}$	$4.34 - 6.10$	$4.55^{+0.18}_{-0.15}$	$4.16 - 5.99$
	IO	$5.69^{+0.16}_{-0.21}$	$4.12 - 6.13$	$5.78^{+0.10}_{-0.17}$	$4.33 - 6.08$	$5.69^{+0.12}_{-0.21}$	$4.17 - 6.06$
$\sin^2\theta_{13}/10^{-2}$	NO	$2.225^{+0.056}_{-0.059}$	$2.052 - 2.398$	$2.200^{+0.069}_{-0.062}$	$2.000 - 2.405$	$2.23^{+0.07}_{-0.06}$	$2.04 - 2.44$
	IO	$2.223^{+0.058}_{-0.058}$	$2.048 - 2.416$	$2.225^{+0.064}_{-0.070}$	$2.018 - 2.424$	$2.23^{+0.06}_{-0.06}$	$2.03 - 2.45$
$\delta_{\rm CP}/\pi$	NO	$1.29^{+0.20}_{-0.14}$	$0.80 - 1.94$	$1.08^{+0.13}_{-0.12}$	$0.71 - 1.99$	$1.24^{+0.18}_{-0.13}$	$0.77 - 1.97$
	IO	$1.53^{+0.12}_{-0.16}$	$1.08 - 1.91$	$1.58^{+0.15}_{-0.16}$	$1.11 - 1.96$	$1.52^{+0.15}_{-0.11}$	$1.07 - 1.90$
$\Delta m^2_{21}/10^{-5}\text{eV}^2$	NO, IO	$7.41^{+0.21}_{-0.20}$	$6.82 - 8.03$	$7.50^{+0.22}_{-0.20}$	$6.94 - 8.14$	$7.36^{+0.16}_{-0.15}$	$6.93 - 7.93$
$\lvert\Delta m^2_{\rm atm}\rvert/10^{-3}\text{eV}^2$	NO	$2.507^{+0.026}_{-0.027}$	$2.427 - 2.590$	$2.55^{+0.02}_{-0.03}$	$2.47 - 2.63$	$2.485^{+0.023}_{-0.031}$	$2.401 - 2.565$
	IO	$2.486^{+0.028}_{-0.025}$	$2.406 - 2.570$	$2.45^{+0.02}_{-0.03}$	$2.37 - 2.53$	$2.455^{+0.030}_{-0.025}$	$2.376 - 2.541$
$\Delta\chi^2$	IO - NO	6.4		6.4		6.5	

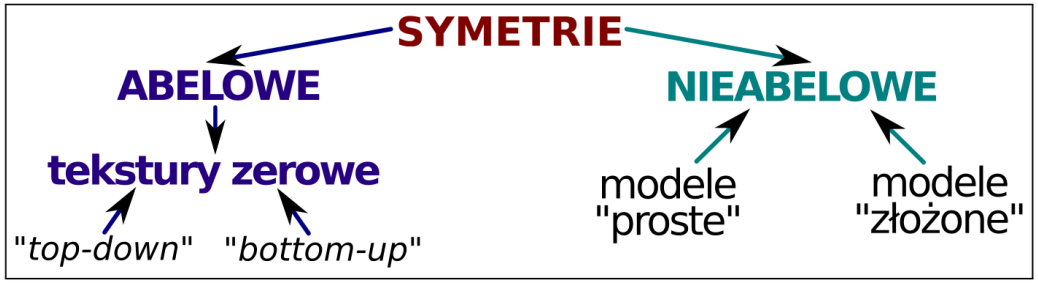
Symetrie rodzinne

Można rozważać modele zakładające, że zarówno w sektorze leptonowym jak i kwarkowym, istnieją fundamentalne symetrie, wiążące między sobą fermiony różnych generacji, dające relacje pomiędzy masami oraz elementami macierzy mieszania w ramach rodziny.

$$G_{SM} \times \mathcal{G}$$

$$G_{SM} = SU(3)_C \times SU(2)_L \times U(1)_Y$$





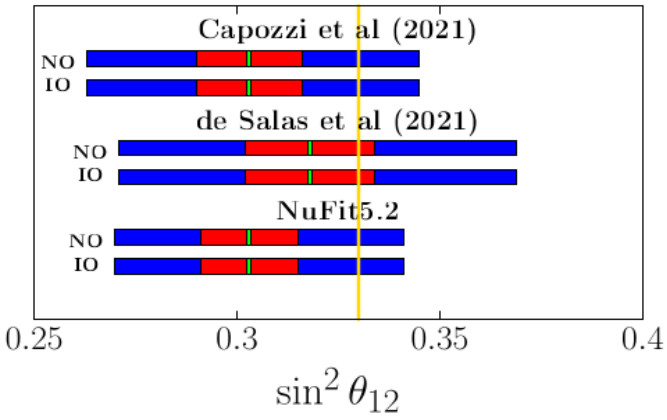
Rys historyczny:

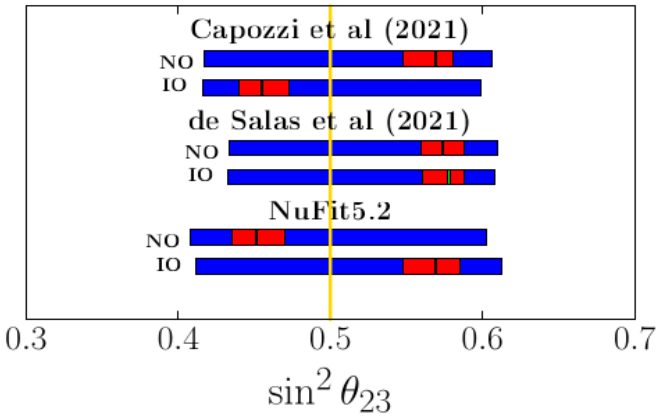
$$U_{TBM} = \begin{pmatrix} \frac{2}{\sqrt{6}} & \frac{1}{\sqrt{3}} & 0 \\ -\frac{1}{\sqrt{6}} & \frac{1}{\sqrt{3}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{6}} & -\frac{1}{\sqrt{3}} & \frac{1}{\sqrt{2}} \end{pmatrix}$$

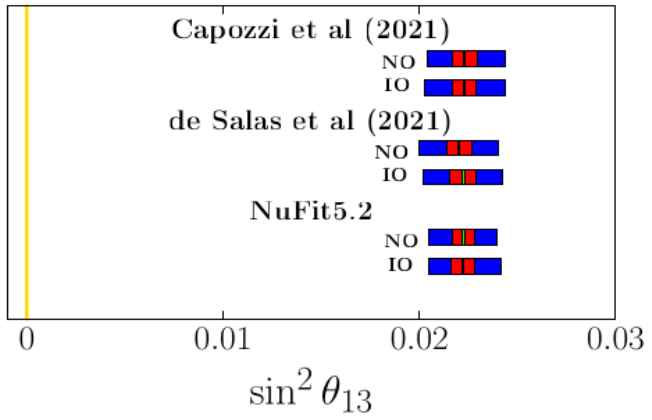
$$|U_{\mu 3}| = |U_{\tau 3}| = 1/\sqrt{2} \quad \Rightarrow \theta_{23} \approx \frac{\pi}{4}$$

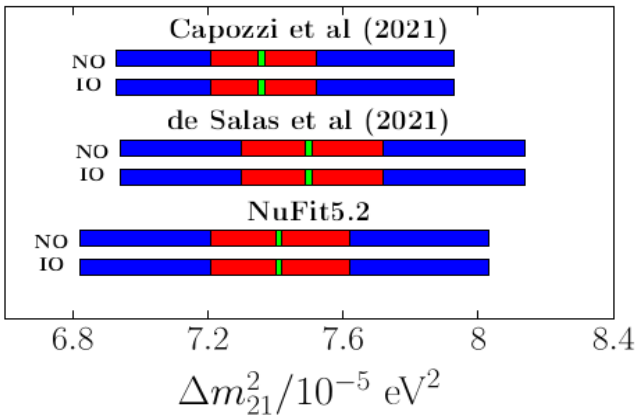
$$|U_{e2}| = |U_{\mu 2}| = |U_{\tau 2}| = 1/\sqrt{3} \quad \Rightarrow \theta_{12} \simeq 35^\circ$$

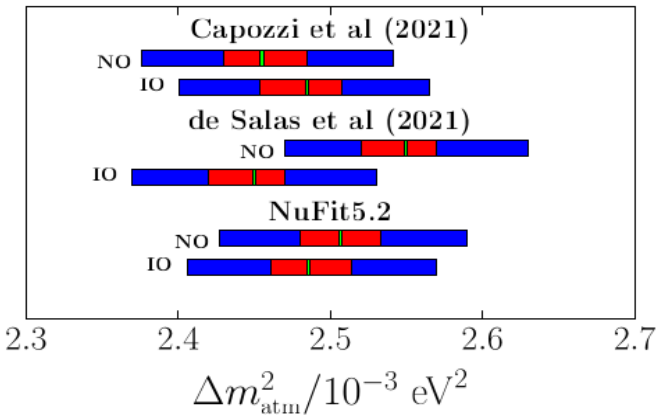
$$U_{e3} = 0$$

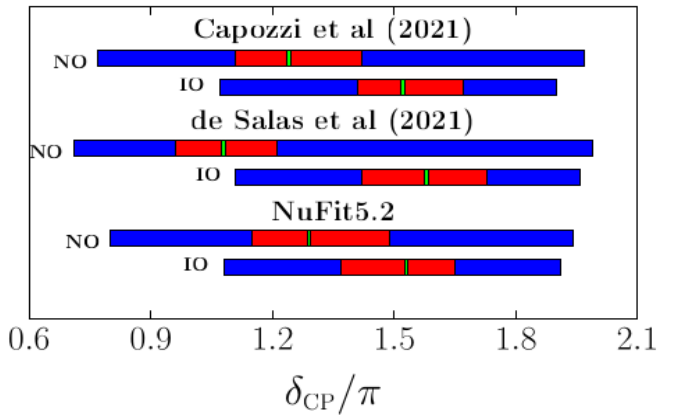












SM with one Higgs doublet

$$A_L^{i\dagger}(M_l M_l^\dagger)A_L^i = (M_l M_l^\dagger)$$

$$A_L^{i\dagger}(M_\nu M_\nu^\dagger)A_L^i = (M_\nu M_\nu^\dagger)$$

where $A_L^i = A_L(g_i), i = 1, 2, \ldots, N$ are 3-dim representations matrices for the left handed lepton doublets for some N-order flavour symmetry group $\mathcal{G}$.
The Schur's lemma implies that $M_l M_l^\dagger$ and $M_\nu M_\nu^\dagger$ are proportional to identity matrices, so one gets a trivial lepton mixing matrix.

Beyond SM

- Break family symmetry group by scalar singlet so called "flavon"
- add more Higgs multiplets

Symetrie nieabelowe

- Badanie tradycyjnego MS z jednym dubletem Higgsa, z uwzględnieniem bieżących informacji o masach i macierzach mieszania kwarków i leptonów.
- Analiza MS przy założeniu, że złamanie symetrii przy wyższych energiach prowadzi do różnych symetrii rodzinnych dla fermionów górnych i dolnych.
- Przebadanie teorii z bogatszym sektorem bozonów Higgsa - teorie z dwoma dubletami, z tripletem Higgsa oraz z singletem.
- Rozważenie sytuacji, w której oprócz trzech aktywnych neutrin pojawiają się neutrina sterylne (jedno lub więcej), a sektor Higgsa ma strukturę standardową lub rozbudowaną.
- Analiza sytuacji ze złamaną symetrią CP w sektorze leptonowym.

Przykład: 2HDM - neutrina Diraca

$$
\begin{aligned}
L_{\alpha L} \to L'_{\alpha L} &= (A_L)_{\alpha,\chi}\, L_{\chi L} \\
l_{\beta R} \to l'_{\beta R} &= \left(A_l^R\right)_{\beta,\delta} l_{\delta R} \\
\nu_{\beta R} \to \nu'_{\beta R} &= \left(A_\nu^R\right)_{\beta,\delta} \nu_{\delta R} \\
\Phi_i \to \Phi'_i &= (A_\Phi)_{ik}\, \Phi_k,
\end{aligned}
$$

$$(A_L,\quad A_l^R,\quad A_\nu^R)$$

3 wymiarowe reprezentacje

$$(A_\Phi)$$

2 wymiarowe reprezentacje

$$\mathcal{G}$$

$$\mathcal{L}\left(L_{\alpha L}, l_{\beta R}, \nu_{\gamma R}, \Phi_i\right) = \mathcal{L}\left(L'_{\alpha L}, l'_{\beta R}, \nu'_{\gamma R}, \Phi'_i\right)$$

$$
\begin{aligned}
\left((A_\Phi)^\dagger \otimes (A_L)^\dagger \otimes (A_l^R)^T\right)(h^l) &= (h^l) \\
\left((A_\Phi)^T \otimes (A_L)^\dagger \otimes (A_\nu^R)^T\right)(h^\nu) &= (h^\nu)
\end{aligned}
$$

$$
\begin{aligned}
M^l &= -\frac{1}{\sqrt{2}}\left(v_1^* h_1^{(l)} + v_2^* h_2^{(l)}\right) \\
M^\nu &= \frac{1}{\sqrt{2}}\left(v_1 h_1^{(\nu)} + v_2 h_2^{(\nu)}\right)
\end{aligned}
$$

NARODOWE CENTRUM NAUKI

Niestandardowe neutrina i efekty łamania symetrii CP w sektorze leptonowym
2020/37/B/ST2/02371
Konkurs: OPUS 19

Partial A_4 flavor symmetry of the leptonic 3HDM *

BARTOSZ DZIEWIT, MAREK ZRAŁEK, JORIS VERGEEST
Silesian University, Katowice, Poland

Received December 6, 2025

Flavor invariance of leptonic Yukawa terms in the 3HDM

Bartosz Dziewit (Silesia U.), Joris Vergeest (Silesia U.), Marek Zrałek (Unlisted, PL) (Dec 3, 2023)

Published in: *Phys.Lett.B* 853 (2024) 138667 • e-Print: 2312.01380 [hep-ph]

Phenomenology of lepton masses and mixing with discrete flavor symmetries

Garv Chauhan (Virginia Tech.), P.S. Bhupal Dev (Washington U., St. Louis and McDonnell Ctr. Space Sci.), Ievgen Dubovyk (Silesia U.), Bartosz Dziewit (Silesia U.), Wojciech Flieger (Munich, Max Planck Inst.) et al. (Oct 31, 2023)

Published in: *Prog.Part.Nucl.Phys.* 138 (2024) 104126 • e-Print: 2310.20681 [hep-ph]

Lepton masses and mixing in a two-Higgs-doublet model

Piotr Chaber (Silesia U.), Bartosz Dziewit (Silesia U.), Jacek Holeczek (Silesia U.), Monika Richter (Silesia U.), Marek Zrałek (Silesia U.) et al. (Aug 25, 2018)

Published in: *Phys.Rev.D* 98 (2018) 5, 055007 • e-Print: 1808.08384 [hep-ph]

Matter To The Deepest

15–19 września 2025
spinPLACE
Europe/Warsaw strefa czasowa

Wpisz wyszukiwane hasło

Contact
mttd2025@us.edu.pl

Matter To The Deepest Recent Developments In Physics Of Fundamental Interactions XLVI International Conference of Theoretical Physics

Matter To The Deepest is one of the oldest conferences in Poland, organized every two years by theoretical particle and astrophysics physicists from the University of Silesia in Katowice.

This will be 50 years after the first event started in 1975. Thus, apart from the traditional subjects which include

1. Precision tests of the Standard Model at low and high energies
2. Methods in multi-loop calculations,
3. Extensions of the Standard Model,
4. Neutrinos, astrophysics and cosmology,

we enjoy the retrospective session: Half of the century's progress in high energy physics with talks by Fred Jegerlehner, Bennie Ward and Wiesław Płaczek (Tuesday).

and

Public talk "The future of particle physics" by Prof. Dr. Sven-Olaf Moch (Thursday).

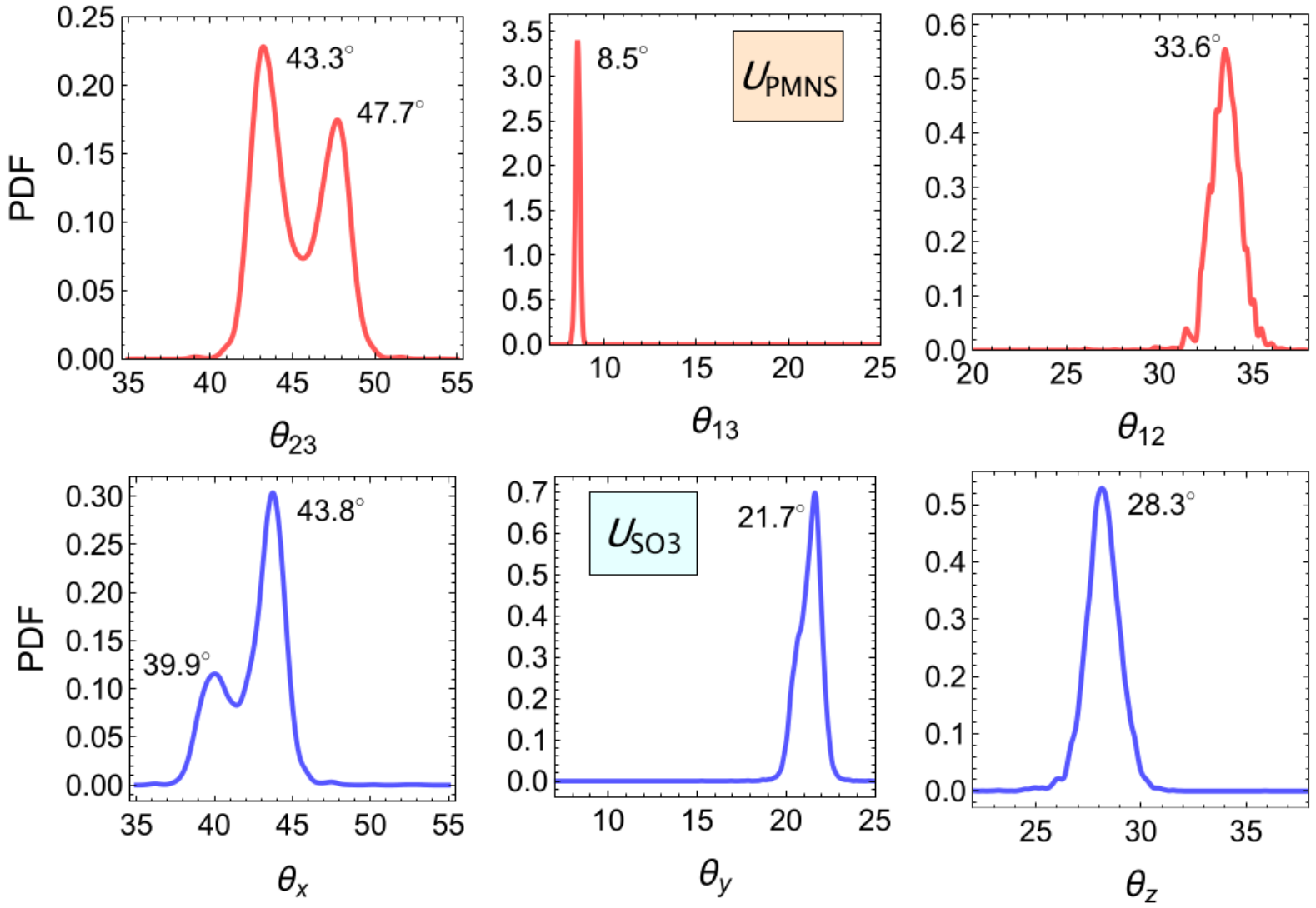
https://indico.if.us.edu.pl/e/mttd2025

Bartek Dziewit - II Dzień Instytutu Fizyki im. Augusta Chełkowskiego 12.06.2025

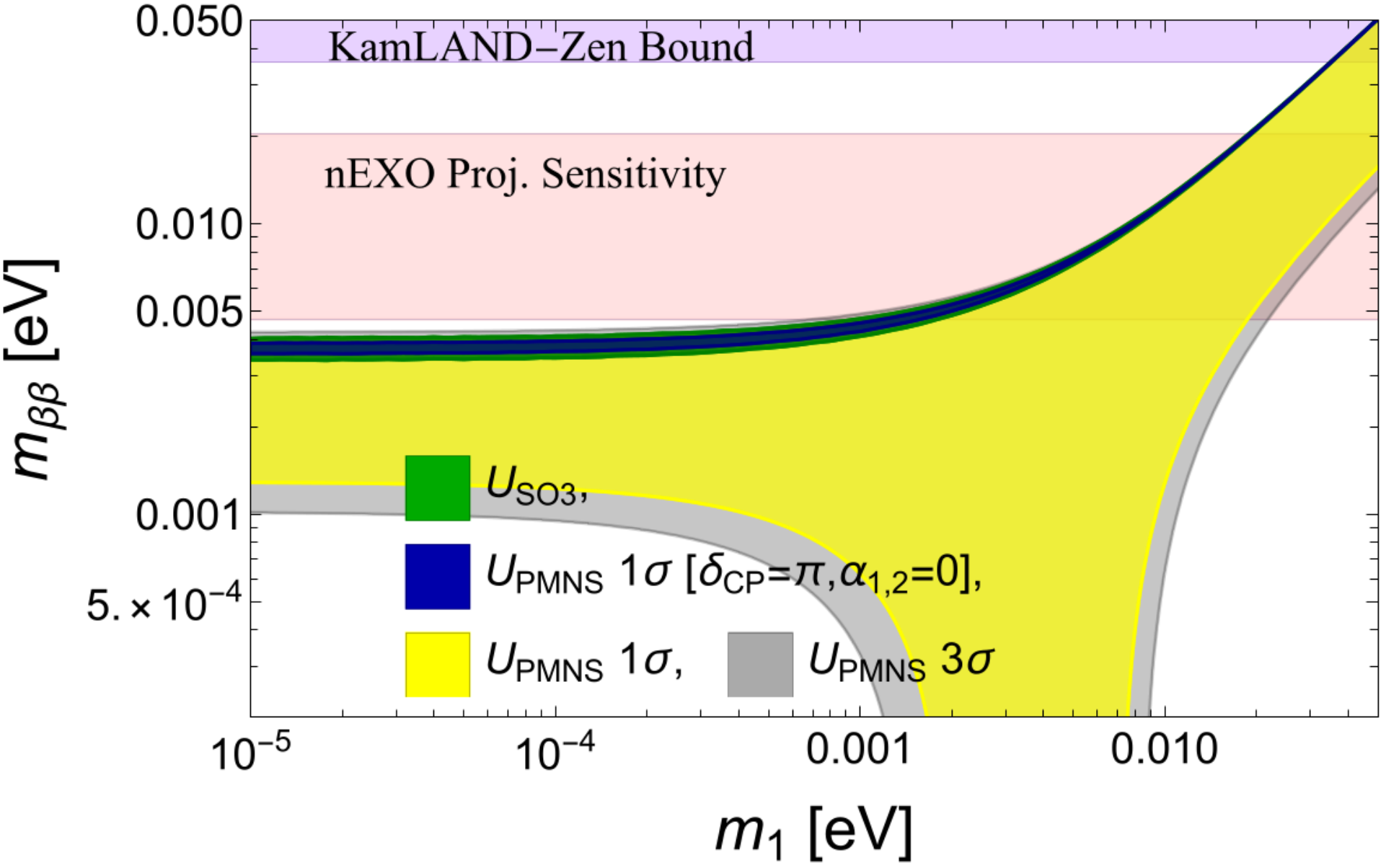
CP-conserving SO(3) parameterization of the neutrino mixing matrix

Jarosław Duda (Jagiellonian U. (main)), Janusz Gluza (Silesia U.), Biswajit Karmakar (Silesia U.)

Sep 29, 2025



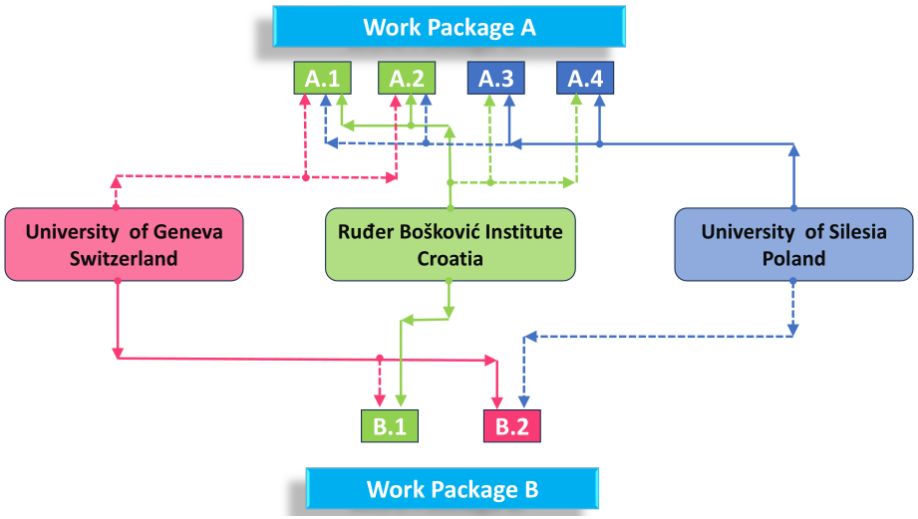
arXiv:2509.25328v2 [hep-ph] 20 Oct 2025



arXiv:2509.25328v2 [hep-ph] 20 Oct 2025

MAPS – Multilateral Academic Projects

Swiss National Science Foundation



MAPS is a multilateral initiative that supports collaborative research projects between researchers in Switzerland and their colleagues in Bulgaria, Croatia, Hungary, Poland and Romania.

Bringing theory and experiments together for precision neutrino physics

Federico Sanchez, Manojit Ghosh, Janusz Gluza

01.07.2025 – 30.06.2029

Summary

Scientific abstract

This project joins experimentalists and phenomenologists with complementary expertise from Switzerland (CH), Poland (PL) and Croatia (HR) covering critical research areas: neutrino interaction cross--sections and their impact on neutrino oscillations and model building for neutrino masses and mixings. The main tasks to be undertaken are:A. Study of neutrino oscillation phenomenology with T2K, ESSnuSB and other experiments We will analyse experimental and simulated data to understand new physics effects as well as some of the tensions among present neutrino experiments. In particular, attention will be given to understand the effects of systematic uncertainties on the sensitivity to three flavour neutrino oscillations and new physics phenomena. We will try to explore if T2K data prefers any new physics beyond the standard three flavour scenario and try to propose a solution to the current tension between T2K and NO$/nu$A data. We will also work on phenomenological effects for existing and proposed neutrino mass and mixing models, testing them for various neutrino experimental oscillation baselines. We will also try to understand if a new physics

Overview

Grant number
230193

Funding scheme
MAPS

Call
MAPS

Approved amount
717,446 CHF

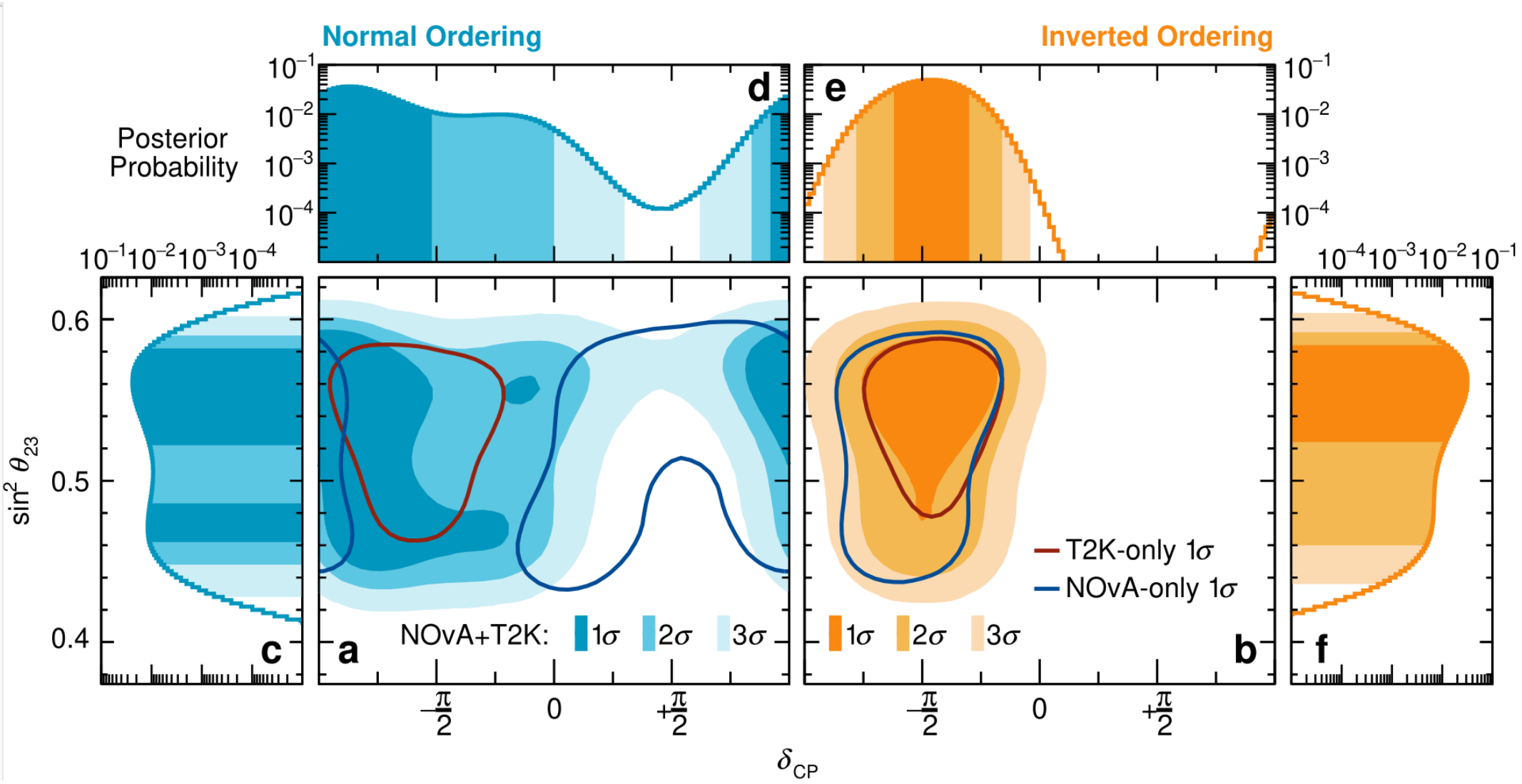
Status
Ongoing

"From the theoretical point of view, we will determine and discuss neutrino mixingmatrices including CP–violating phases and additional neutrino states consistent with, (i) unitary neutrino mixing constraints; (ii) low-energy neutrino experiments; (iii) neutrinosmass and mixing experimental data and (iv) family symmetry constraints."

https://data.snf.ch/grants/grant/230193

Joint neutrino oscillation analysis from the T2K and NOvA experiments

(The T2K and NOvA Collaborations)



https://arxiv.org/abs/2510.19888