

The global picture of neutrino oscillation phenomenology after NU2020

@ GdR Neutrino Meeting 2020

Albert Zhou (KIT)

November 23, 2020



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DAAD

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The fate of hints: updated global analysis of three-flavor neutrino oscillations

I. Esteban, M. C. Gonzalez-Garcia, M. Maltoni, T. Schwetz, A. Zhou

JHEP 09 (2020) 178 [arXiv:2007.14792]

Historical overview of neutrino oscillations (1)

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- (Super-K was originally trying to observe proton decay from GUT: neutrinos were just a background! Maybe Xenon1T suffers the same fate??).

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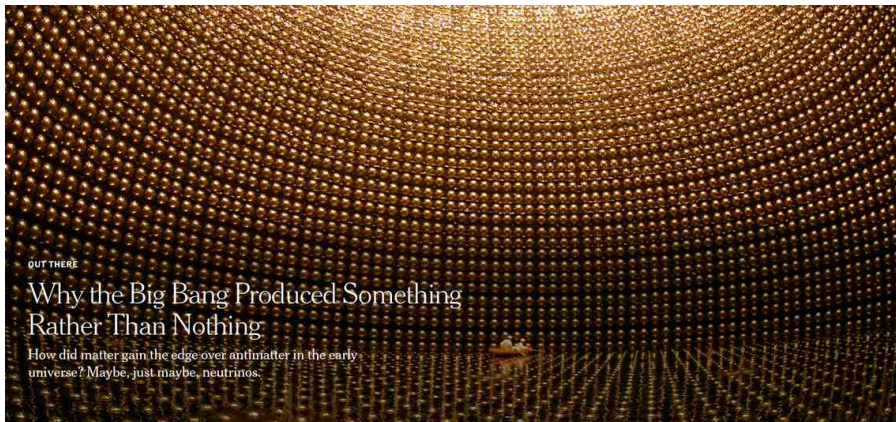
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- We've come a long way!

CP-violation in neutrino sector? (Press coverage)



The Super-Kamiokande Neutrino Observatory, located more than 3,000 feet below Mount Ikeno near the city of Hida, Japan. Kamioka Observatory, Institute for Cosmic Ray Research, University of Tokyo

Figure: NY Times Article on T2K Nature paper

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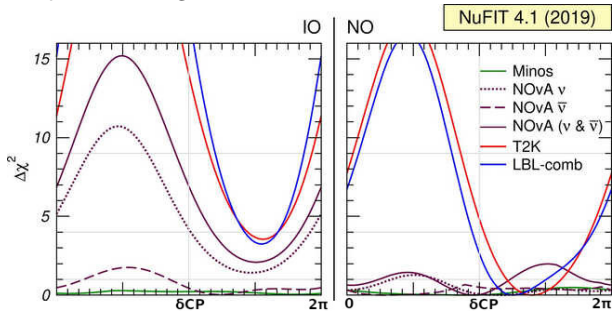
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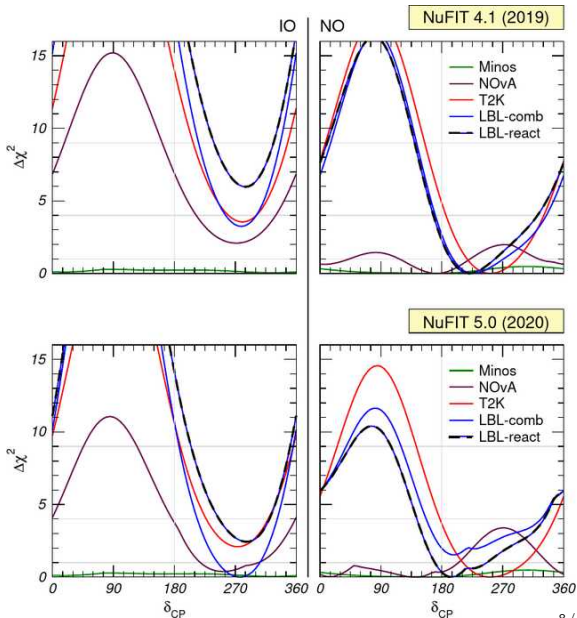
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- However even from NuFit 4.0, “The combination of those effects . . . leads to a disfavouring of $\sin \delta_{CP} \sim -1$ from NOvA, somewhat in contradiction with the T2K preferred region.”



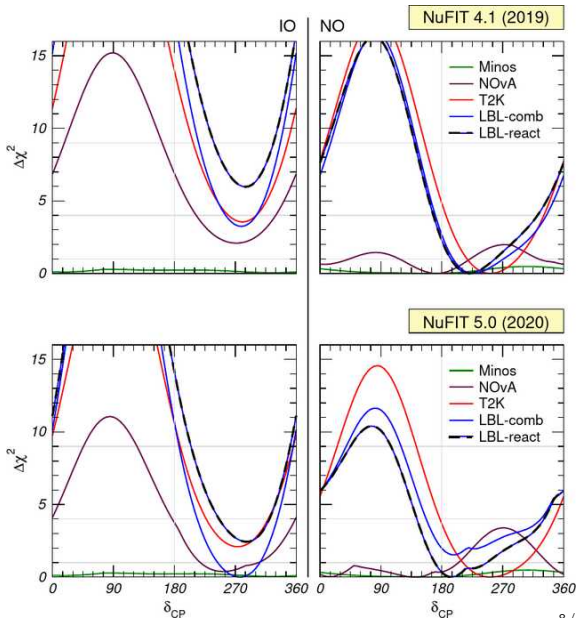
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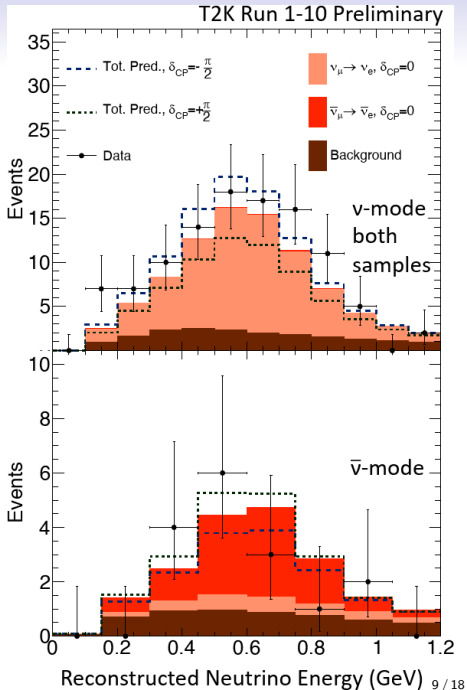
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- **NuFit 5.0:** We report best-fit $\delta_{CP} = 1.08\pi$ with CP-conservation $\delta_{CP} = \pi$ within 0.6σ .
- Essentially T2K and NOvA continue opposite trajectory.



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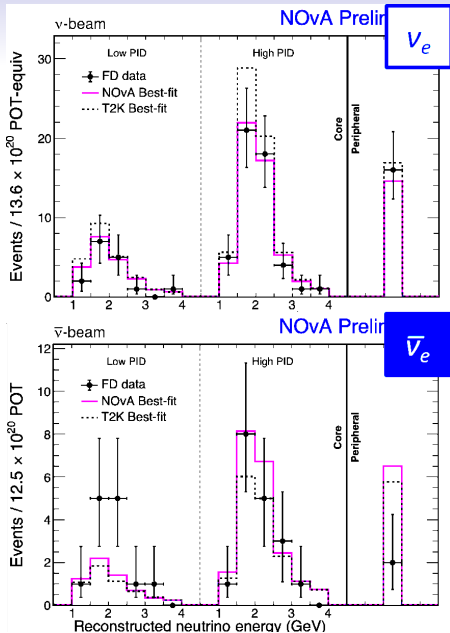


Figure: Courtesy NOvA NU2020

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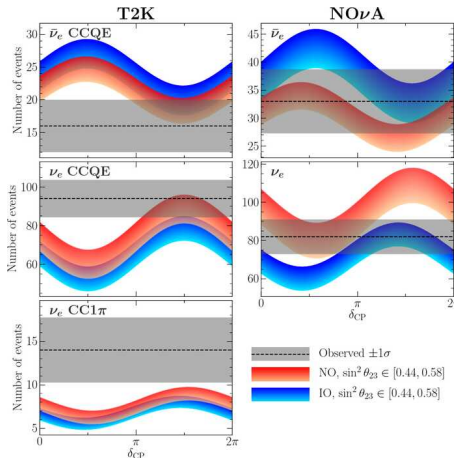


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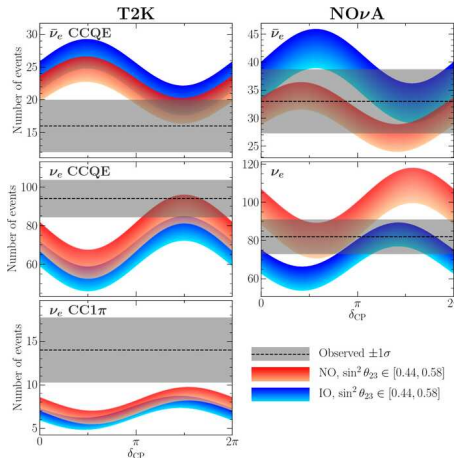


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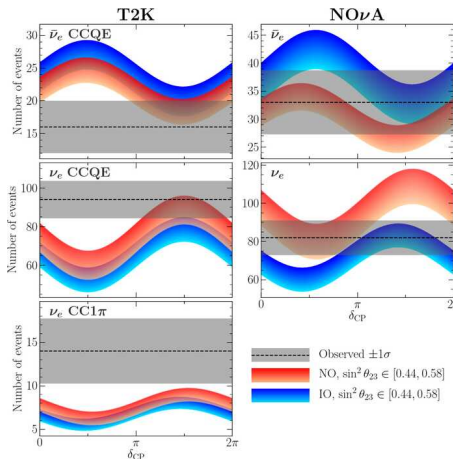


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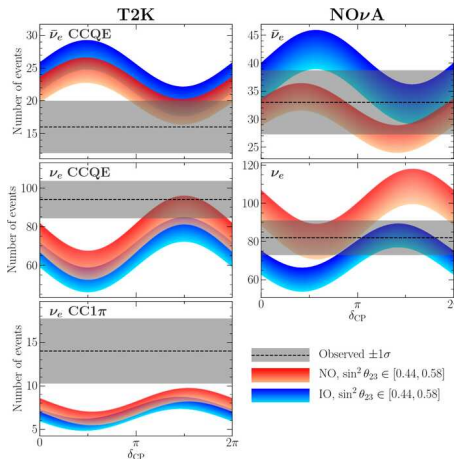


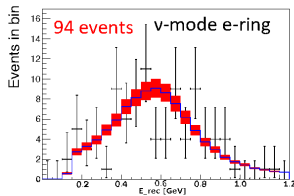
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Note CC1 π very low.

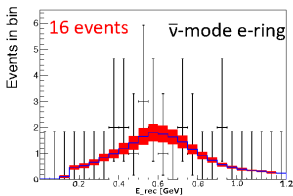
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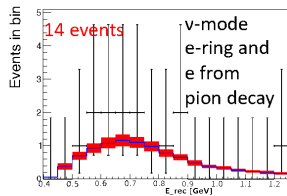
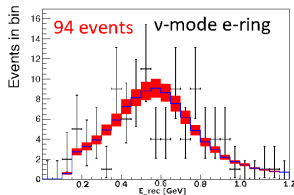


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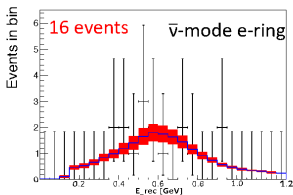
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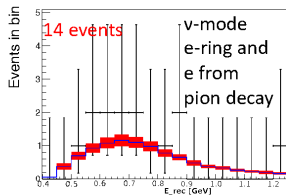
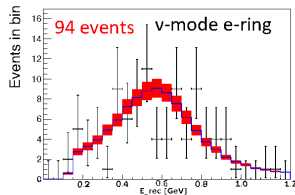


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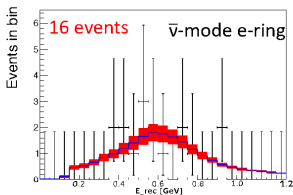
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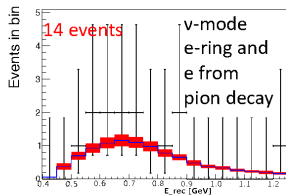
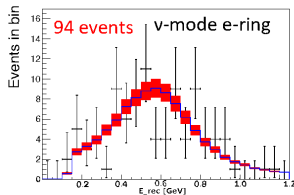


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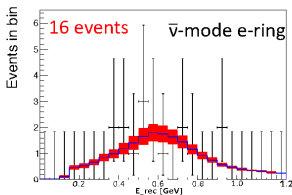
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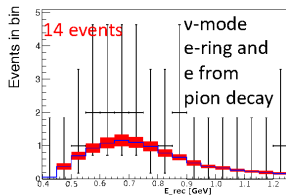
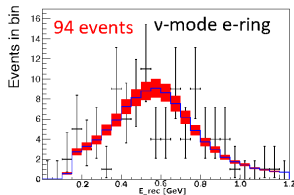


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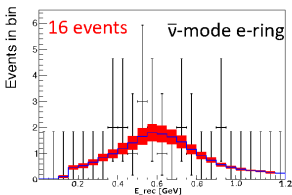
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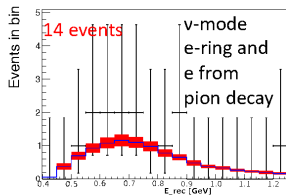


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- Possible due to large number of events directly from source. (Idea of appearance experiment is to have intense flavour-pure source and measure contamination from oscillation.)

Disappearance channel

- Medium baseline reactor experiments $L \sim 1000$ m (Daya Bay, Double CHOOZ, RENO) sensitive to $\Delta m_{ee}^2 \approx \Delta m_{\text{atm}}^2$.

$$P(\bar{\nu}_e \rightarrow \bar{\nu}_e) \approx 1 - \sin^2 2\theta_{13} \sin^2 \left(1.27 \cdot \Delta m_{ee}^2 \frac{L}{E_\nu} \right) \quad (2)$$
$$\Delta m_{ee}^2 = \Delta m_{31}^2 - s_{21}^2 \Delta m_{21}^2.$$

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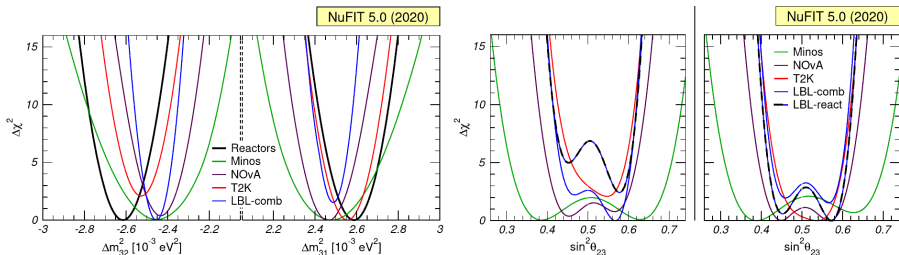
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- Conclusion: reactors can be important for determining mass ordering.

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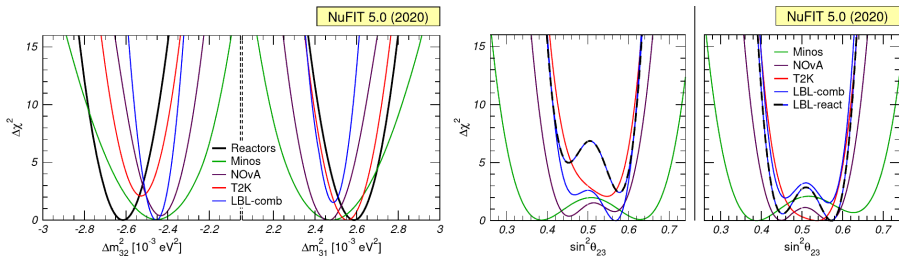
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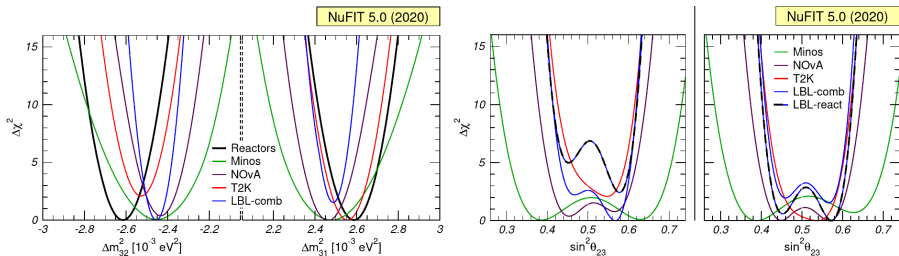
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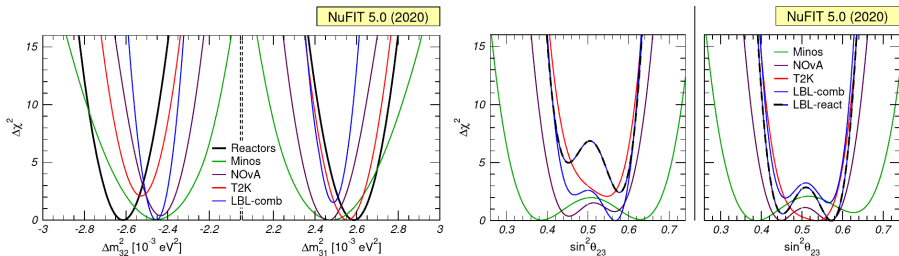
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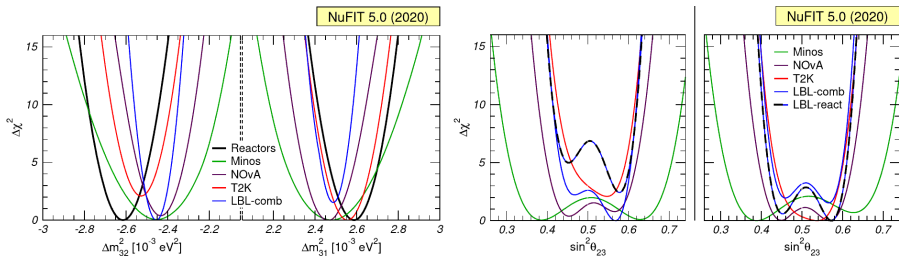
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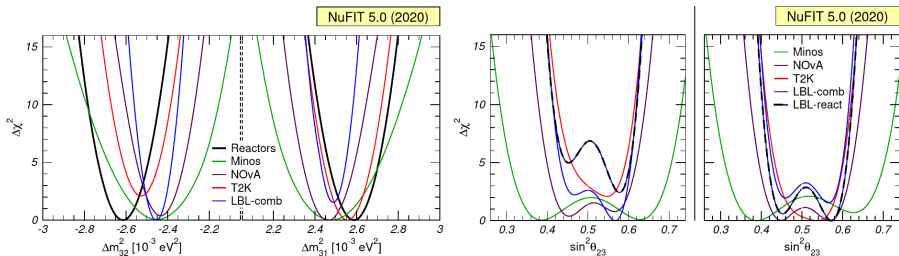
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T2K vs. NOvA (θ_{13} free)	6.7/4	0.15	1.4	3.6/4	0.46	0.7
T2K vs. React.	0.3/2	0.87	0.2	2.5/2	0.29	1.1
NOvA vs. React.	3.0/2	0.23	1.2	6.2/2	0.045	2.0
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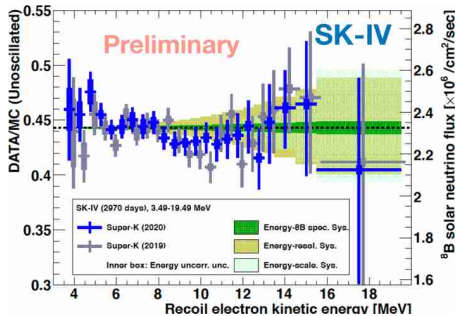
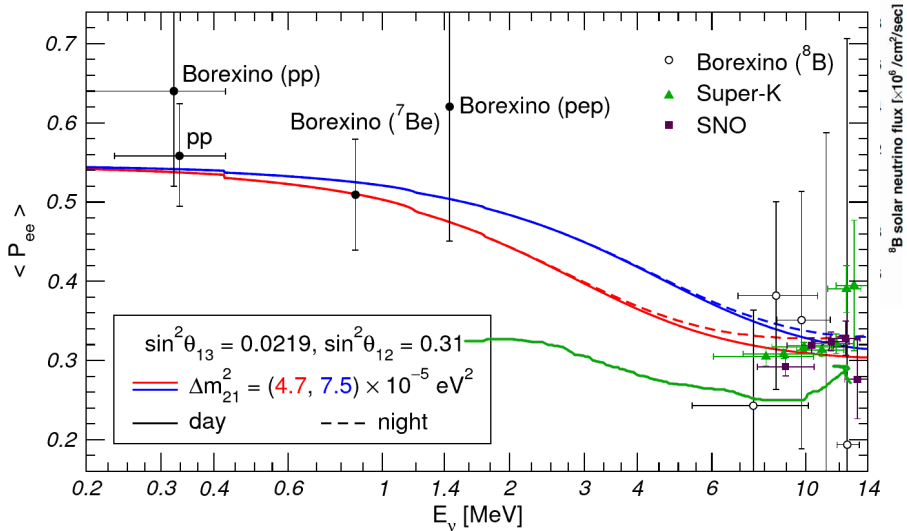


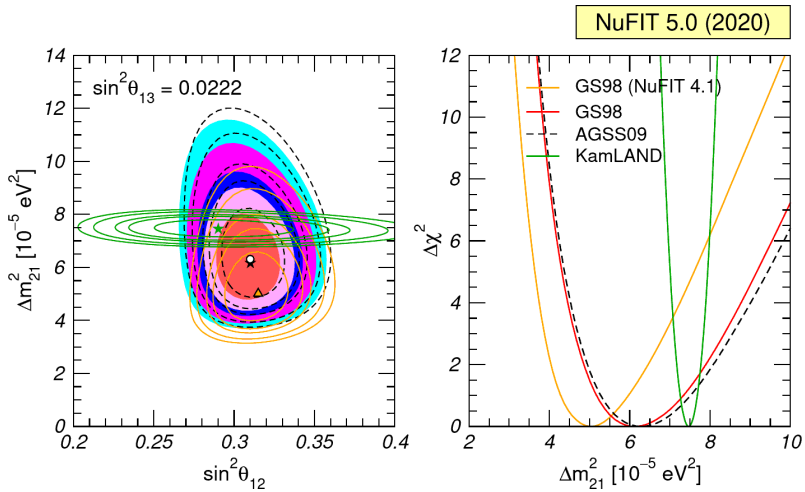
Figure: Courtesy SK collab. NU2020

Solar sector (1)

NuFIT 2.0 (2014)



Solar sector (2)



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