

Updated physics reach of the ESSnuSB project

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(On behalf of ESSnuSB Project)

Abstract

In this presentation, I will discuss the physics sensitivities of the proposed ESSnuSB experiment. In particular, I will discuss

- Measurement of δ_{CP} with the updated event selection
- Capability to measure neutrino mass hierarchy and octant of θ_{23}
- Capability of to probe two of the new physics scenarios: (i) light sterile neutrinos and (ii) invisible neutrino decay.

Introduction

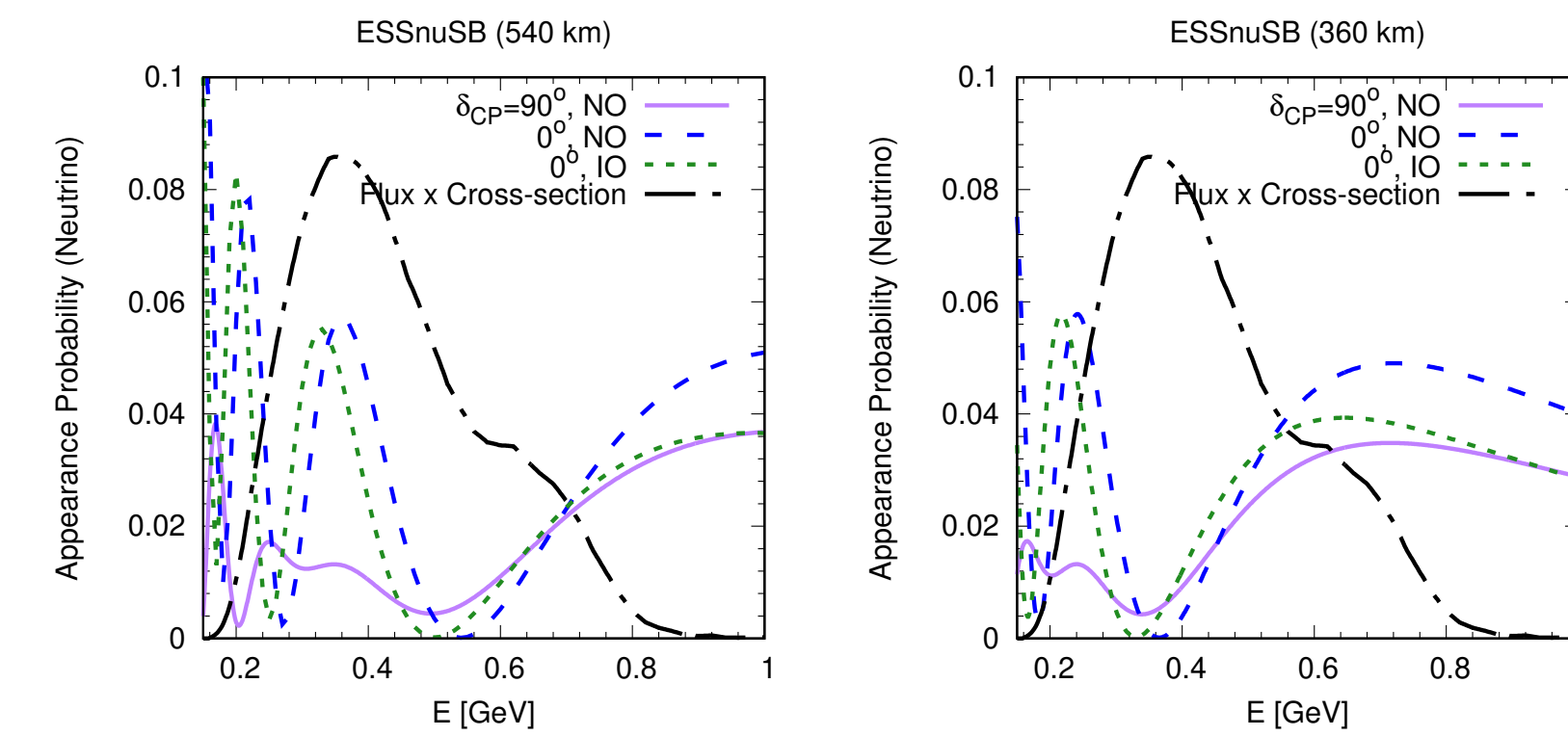
- Parameters of standard 3-flavor neutrino oscillation: θ_{12} , θ_{23} , θ_{13} , Δm_{31}^2 , Δm_{21}^2 , δ_{CP} .
- Unknowns:
 - The sign of Δm_{31}^2 ($\Delta m_{31}^2 > 0$: Normal Hierarchy (NH) or $\Delta m_{31}^2 < 0$: Inverted Hierarchy (IH))
 - The octant of θ_{23} ($\theta_{23} > 45^\circ$: Higher Octant (HO) or $\theta_{23} < 45^\circ$: Lower Octant (LO)).
 - The value of the CP violating phase δ_{CP}
- Several new physics scenarios can also be probed in neutrino oscillation experiments

The ESSnuSB Experiment



- 2.5 GeV proton beam
- 507 kt WC FD
- 10 years of running (5+5)
- 540/360 km baseline length
- Both FD and ND

Probability and Flux



- 540 km: 2nd Maximum
- 360 km: 1st and 2nd Maxima

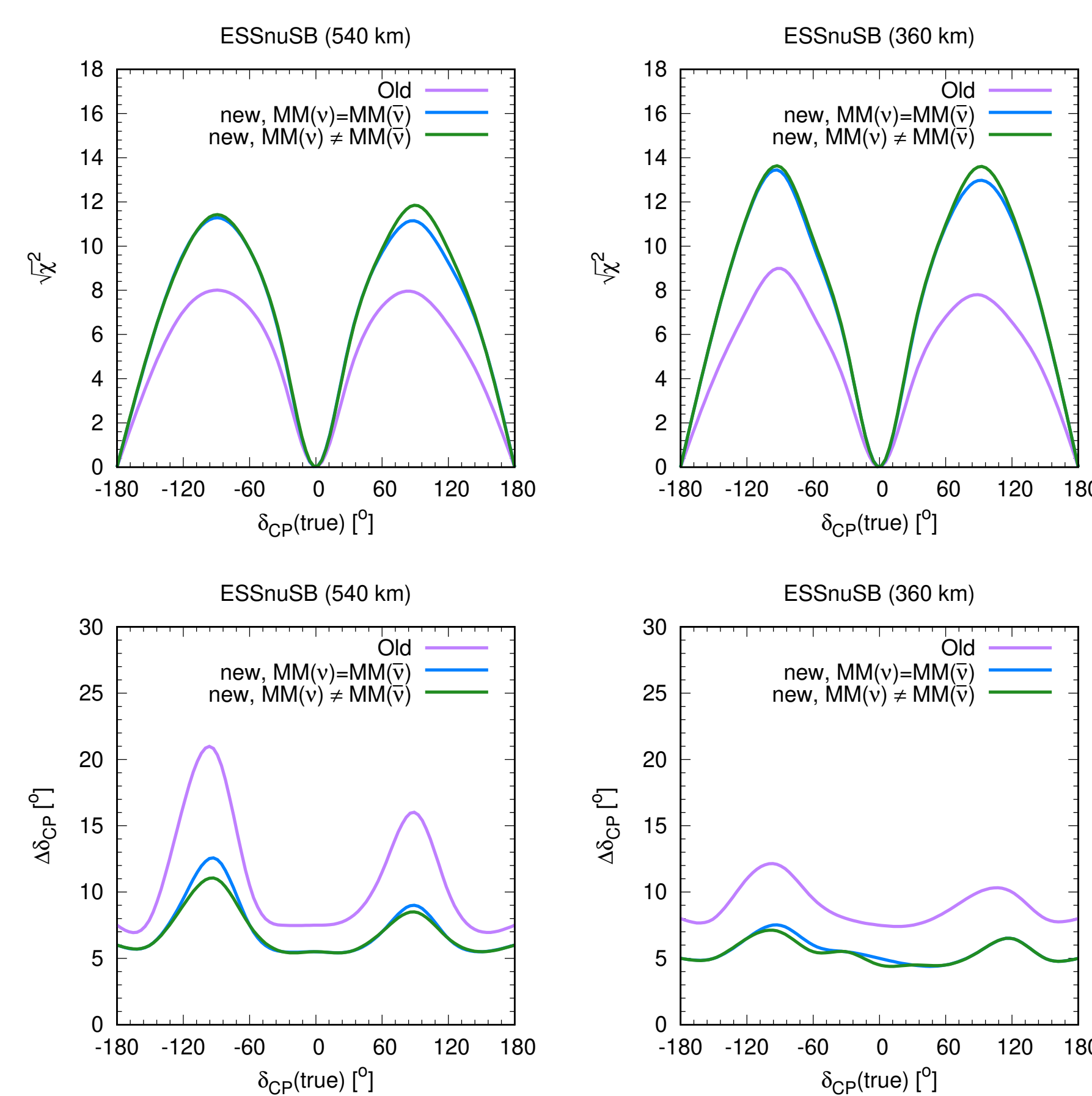
Events with Updated Event Selection

Appearance Channel: +ve (−ve) Polarity
Nufit, $\delta_{CP} = 0^\circ$

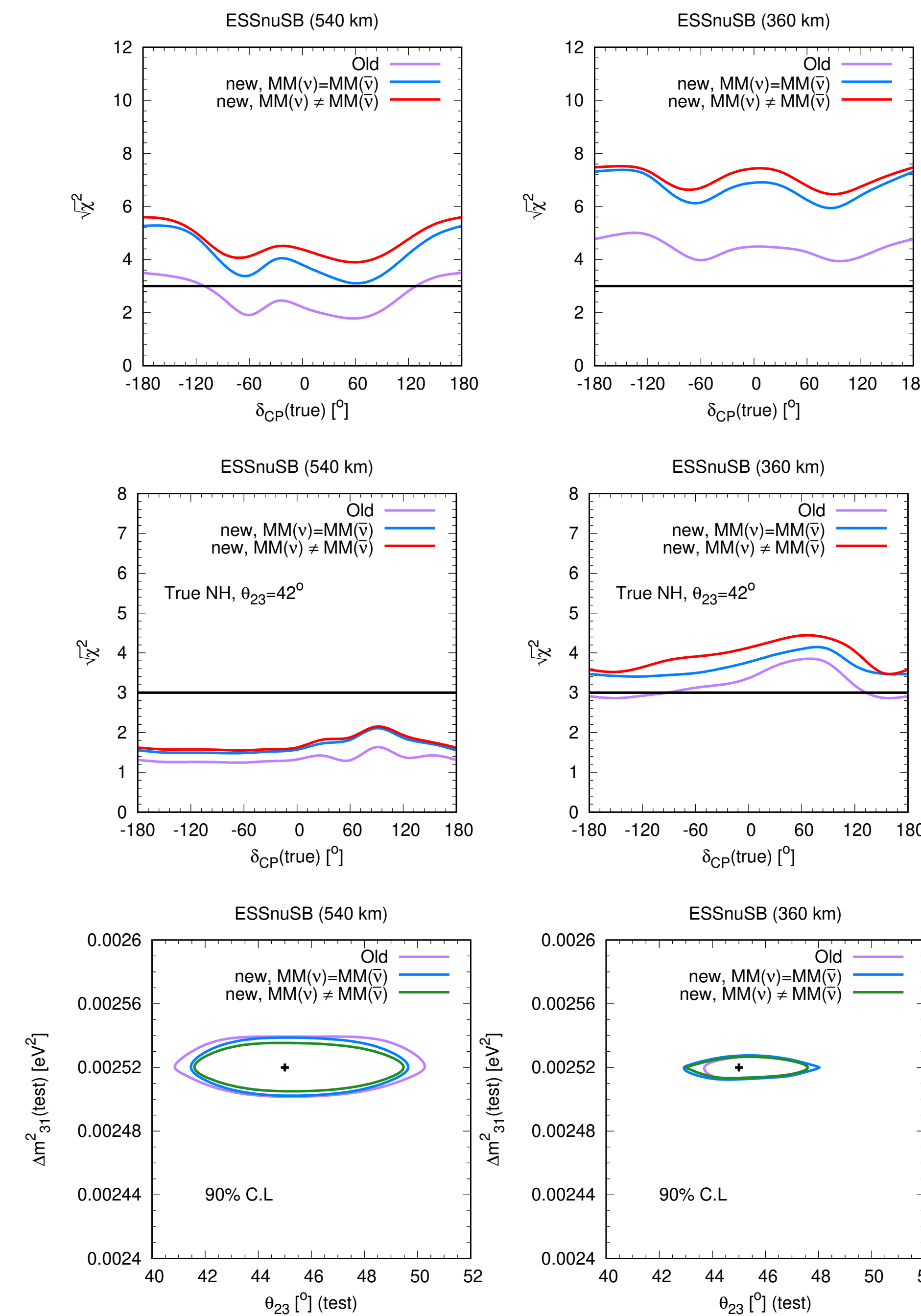
Channel	Old		New	
	540 km	360 km	540 km	360 km
$\nu_\mu \rightarrow \nu_e$	242.19	479.11	242.15	479.08
$(\bar{\nu}_\mu \rightarrow \bar{\nu}_e)$	(56.57)	(91.09)	(56.55)	(91.09)
Total Events				
$\nu_\mu \rightarrow \nu_e$	124.15	244.63	229.96	433.77
$(\bar{\nu}_\mu \rightarrow \bar{\nu}_e)$	(28.67)	(46.24)	(54.89)	(88.22)
Selected Events				

Two fold increase in the events with the new migration matrices (MM)

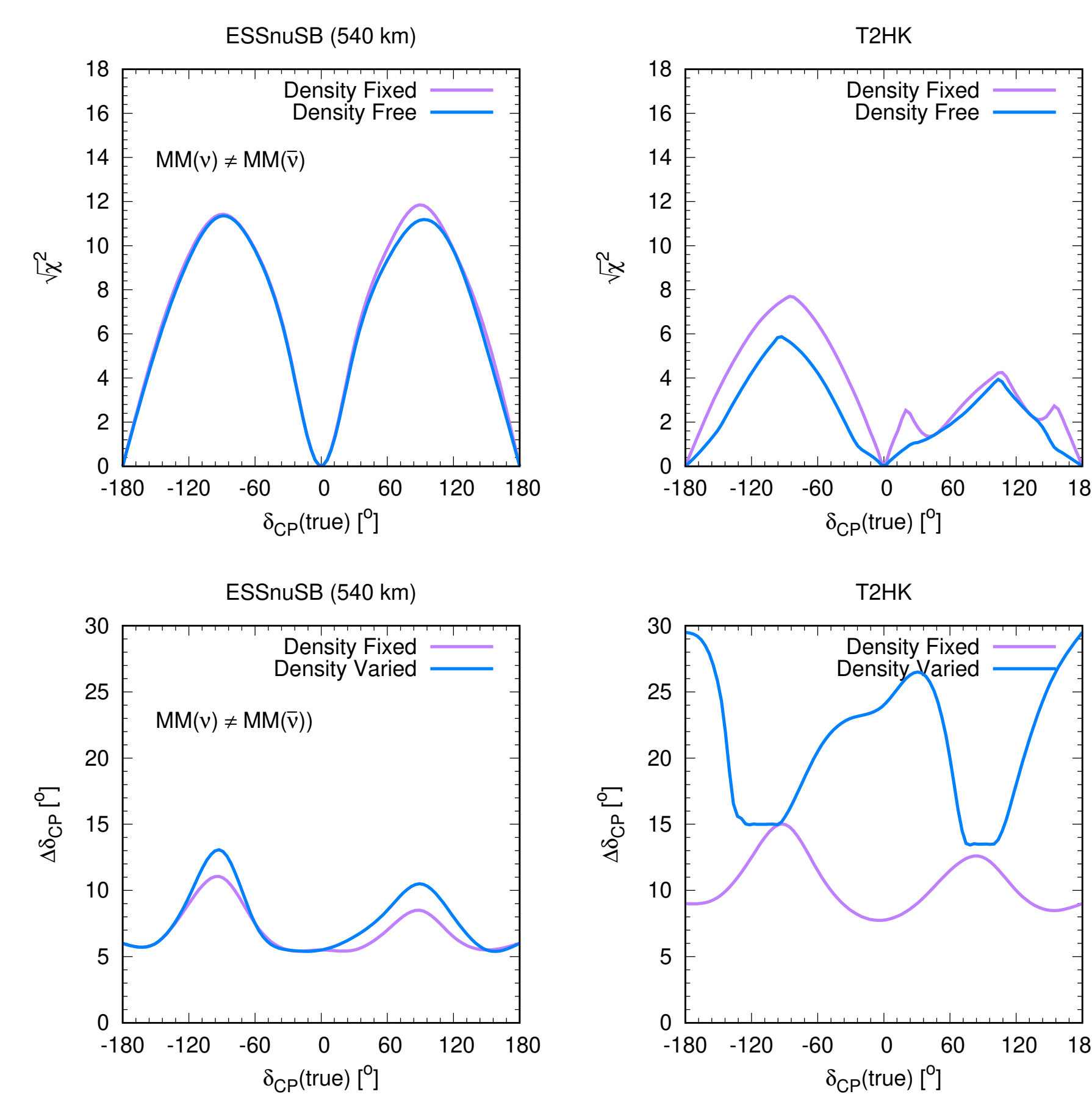
Results: δ_{CP}



Hierarchy, Octant and Precision



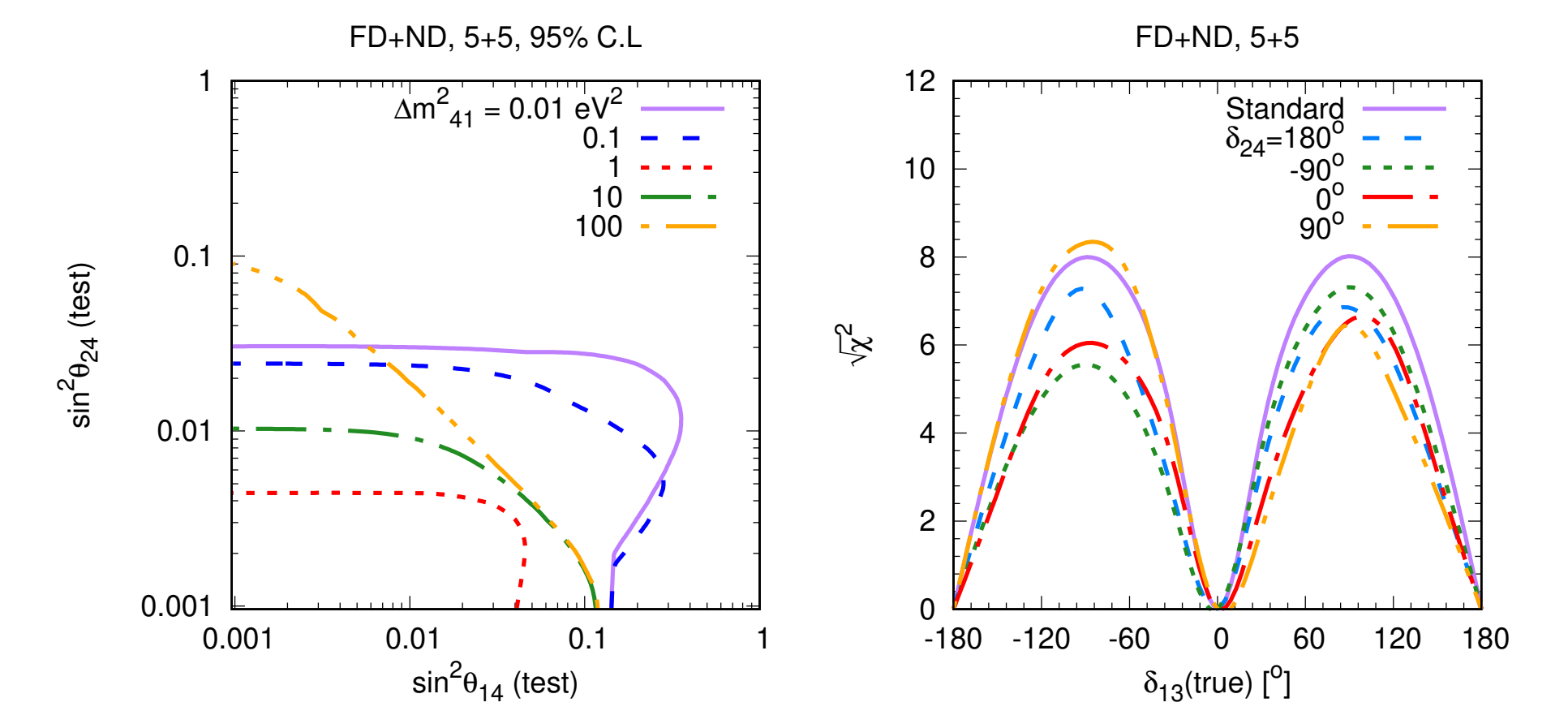
Effect of Matter density



Probing Light Sterile Neutrinos

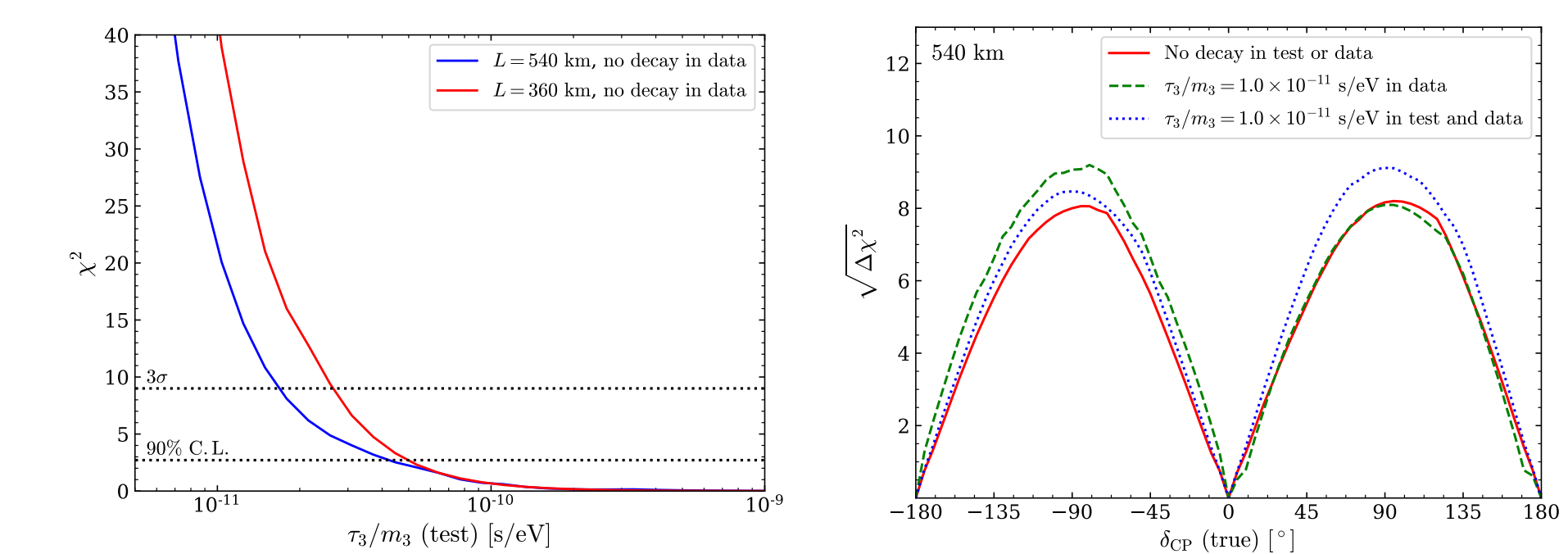
- Experiments suggests there can be 4th neutrino $\Delta m^2 \sim 1$ eV mass

$$U_{PMNS}^{4\nu} = U(\theta_{34}, \delta_{34})U(\theta_{24}, 0)U(\theta_{14}, \delta_{14})U_{PMNS}^{3\nu}$$



Probing Invisible Neutrino Decay

- Heavy neutrino decays into a light sterile neutrino
- Assuming ν_3 decays which implies $\Delta m_{31}^2 \rightarrow \Delta m_{31}^2 - i\alpha_3$ where $\alpha_3 = m_3/\tau_3$ with $\tau_3 =$ rest-frame lifetime of ν_3 having mass m_3 .



Conclusion

- ESSnuSB offers excellent capability to measure δ_{CP}
- Results are not sensitive to matter effects
- Several new physics scenarios can also be probed

References

- [1] Ghosh, Klicek et al. (In Progress)
- [2] Ghosh, Ohlsson, Mod.Phys.Lett.A 35 (2020) 05, 2050058
- [3] Ghosh, Ohlsson, Rosauró-Alcaraz, JHEP 03 (2020) 026
- [4] Choubey, Ghosh, Kempe, Ohlsson, JHEP 05 (2021) 133

Acknowledgements

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