A few thoughts on some recent global/combined fit papers

V. V. Gligorov, LPNHE, 08.10.2025

Introduction

Was encouraged by Mathieu, Claudio, and Boris to start thinking about physics analysis with HyperK over the summer

I did some thinking, and while doing that I found (and was pointed to) a couple of interesting papers which I wanted to discuss

These papers are mainly about combining information from various collaborations, my question here is whether there is a useful exercise we can carry out with HyperK expected sensitivities in the period before HyperK sees data

Mass ordering sensitivity

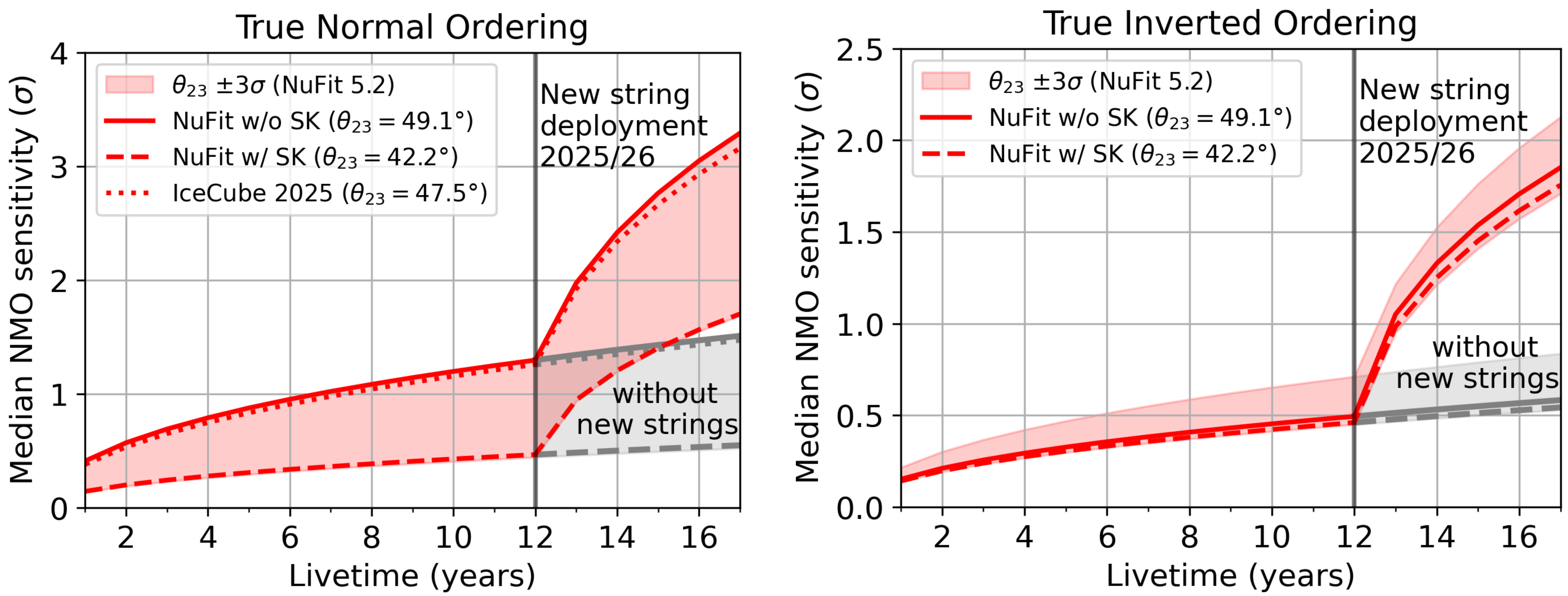

FIG. 13. Livetime evolution of the median NMO sensitivity for different true values of θ_{23}. The shaded region marks the possible range of sensitivities for the NuFit 5.2 3σ range of θ_{23}. The left plot is for a true normal ordering, and the right plot for a true inverted ordering.

Physics potential of the IceCube Upgrade for atmospheric neutrino oscillations

R. Abbasi,[16] M. Ackermann,[64] J. Adams,[17] S. K. Agarwalla,[40,*] J. A. Aguilar,[10] M. Ahlers,[21] J.M. Alameddine,[22] S. Ali,[35] N. M. Amin,[44] K. Andeen,[42] C. Argüelles,[13] Y. Ashida,[53] S. Athanasiadou,[64] S. N. Axani,[44] R. Babu,[23] X. Bai,[50] J. Baines-Holmes,[40] A. Balagopal V.,[40,44] S. W. Barwick,[29] S. Bash,[26] V. Basu,[53] R. Bay,[6] J. J. Beatty,[19,20] J. Becker Tjus,[9,†] P. Behrens,[1] J. Beise,[62] C. Bellenghi,[26] B. Benkel,[64] S. BenZvi,[52] D. Berley,[18] E. Bernardini,[48,‡] D. Z. Besson,[35] E. Blaufuss,[18] L. Bloom,[59] S. Blot,[64] I. Bodo,[40] F. Bontempo,[30] J. Y. Book Motzkin,[13] C. Boscolo Meneguolo,[48,‡] S. Böser,[41] O. Botner,[62] J. Böttcher,[1] J. Braun,[40] B. Brinson,[4] Z. Brisson-Tsavoussis,[32] R. T. Burley,[2] D. Butterfield,[40] M. A. Campana,[49] K. Carloni,[13] J. Carpio,[33,34] S. Chattopadhyay,[40,*] N. Chau,[10] Z. Chen,[56] D. Chirkin,[40] S. Choi,[53] B. A. Clark,[18] A. Coleman,[62] P. Coleman,[1] G. H. Collin,[14] D. A. Coloma Borja,[48] A. Connolly,[19,20] J. M. Conrad,[14] R. Corley,[53] D. F. Cowen,[60,61] C. De Clercq,[11] J. J. DeLaunay,[60] D. Delgado,[13] T. Delmeulle,[10] S. Deng,[1] P. Desiati,[40] K. D. de Vries,[11] G. de Wasseige,[37] T. DeYoung,[23] J. C. Díaz-Vélez,[40] S. DiKerby,[23] M. Dittmer,[43] A. Domi,[25] L. Draper,[53] L. Dueser,[1] D. Durnford,[24] K. Dutta,[41] M. A. DuVernois,[40] T. Ehrhardt,[41] L. Eidenschink,[26] A. Eimer,[25] P. Eller,[26] E. Ellinger,[63] D. Elsässer,[22] R. Engel,[30,31] H. Erpenbeck,[40] W. Esmail,[43] S. Eulig,[13] J. Evans,[18] P. A. Evenson,[44] K. L. Fan,[18] K. Fang,[40] K. Farrag,[15] A. R. Fazely,[5] A. Fedynitch,[58] N. Feigl,[8] C. Finley,[55] L. Fischer,[64] D. Fox,[60] A. Franckowiak,[9] S. Fukami,[64] P. Fürst,[1] J. Gallagher,[39] E. Ganster,[1] A. Garcia,[13] M. Garcia,[44] G. Garg,[40,*] E. Genton,[13,37] L. Gerhardt,[7] A. Ghadimi,[59] C. Glaser,[62] T. Glüsenkamp,[62] J. G. Gonzalez,[44] S. Goswami,[33,34] A. 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Mass ordering sensitivity

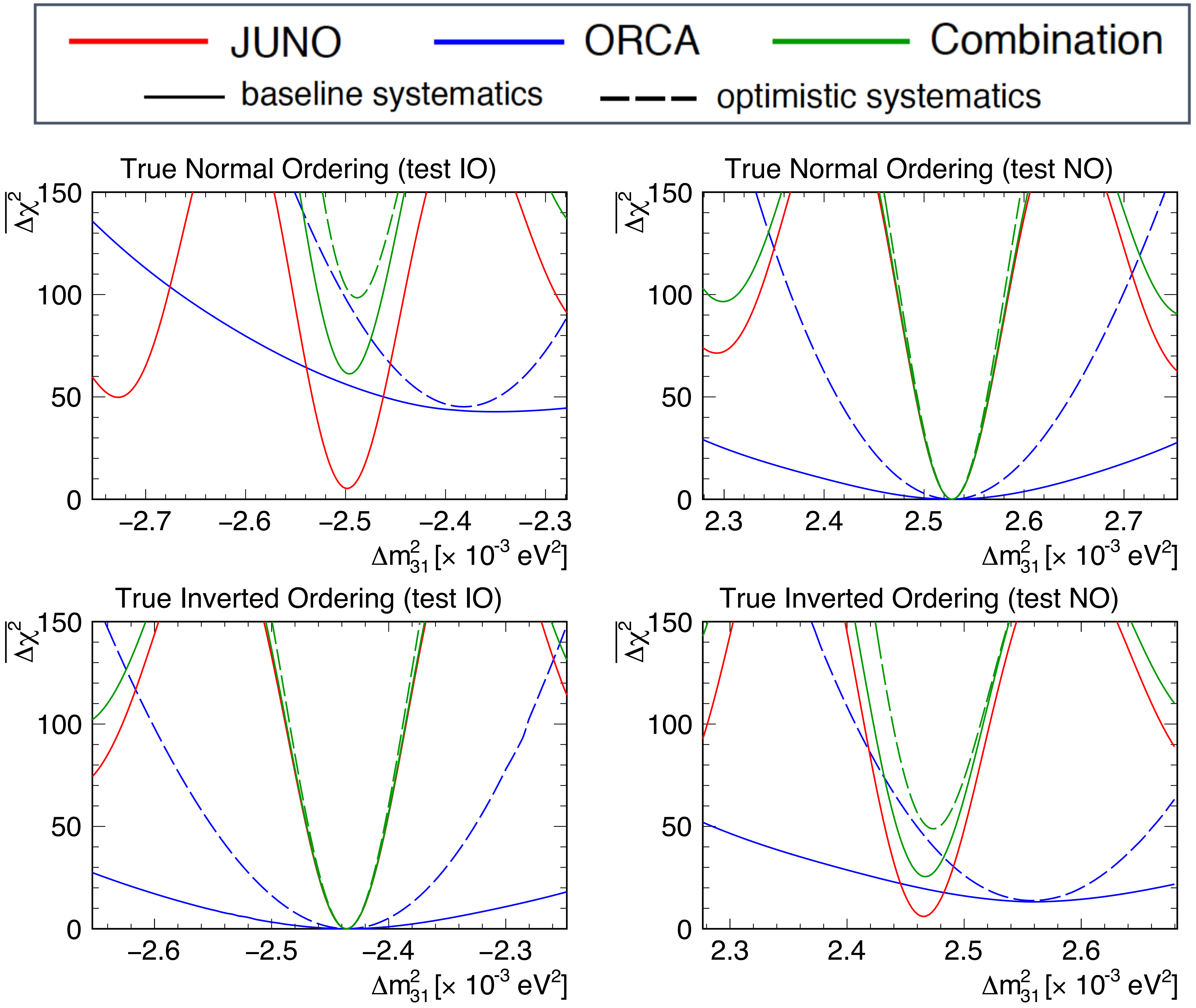


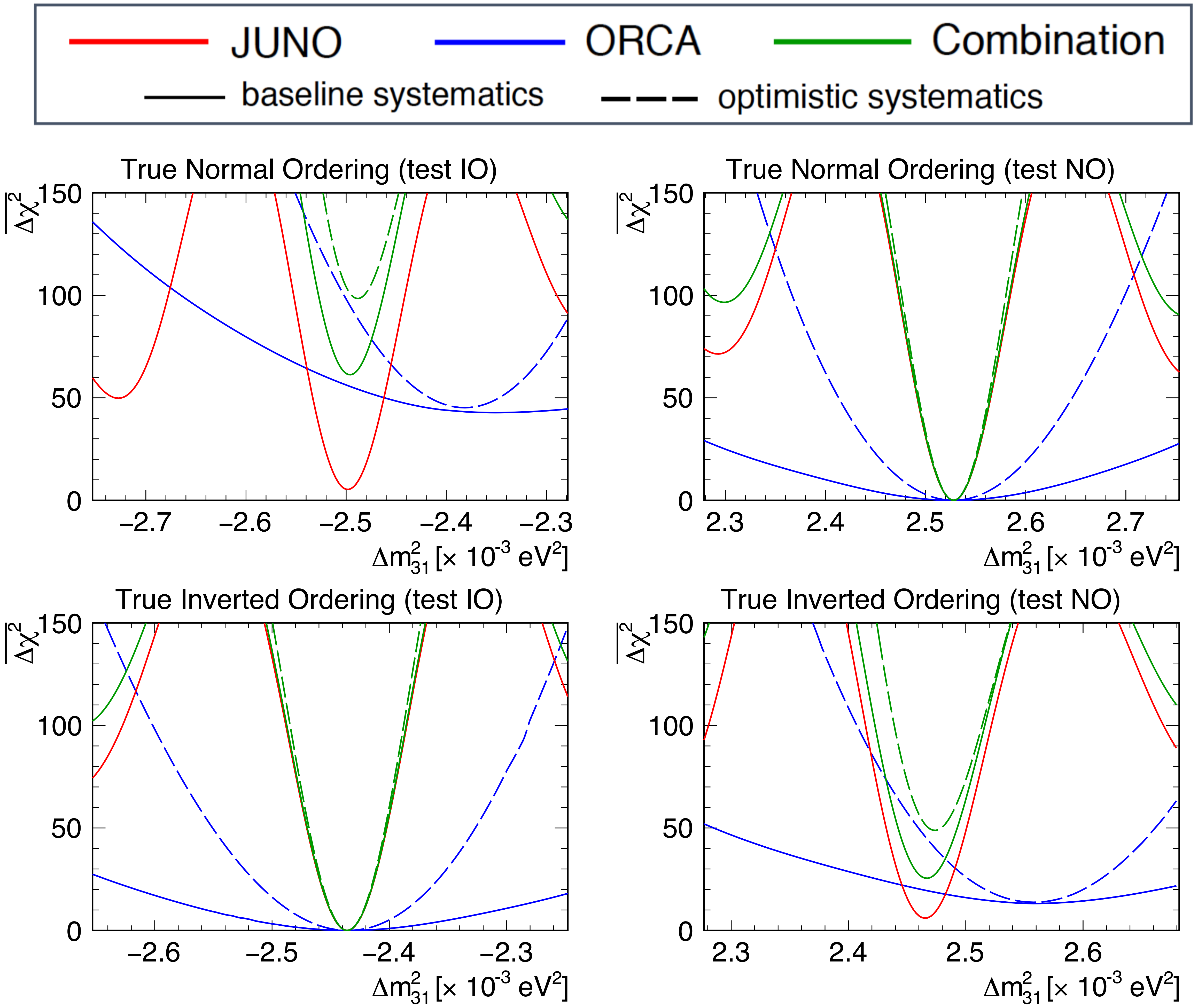
Figure 4: $\overline{\Delta\chi^2}$ profile for only JUNO (red), only ORCA (blue), and the combination of JUNO and ORCA (green) as a function of test values of Δm^2_{31} for 6 years of data taking assuming baseline (solid) or optimistic (dashed) systematics.

Combined sensitivity of JUNO and KM3NeT/ORCA to the neutrino mass ordering

S. Aiello[a] A. Albert[ba,b] M. Alshamsi[c] S. Alves Garre[d] Z. Aly[e] A. Ambrosone[f,g] F. Ameli[h] M. Andre[i] G. Androulakis[j,†] M. Anghinolfi[k] M. Anguita[l] M. Ardid[m] S. Ardid[m] J. Aublin[c] C. Bagatelas[j] B. Baret[c] S. Basegmez du Pree[n] M. Bendahman[c,o] F. Benfenati[p,q] E. Berbee[n] A. M. van den Berg[r] V. Bertin[e] S. Biagi[s] M. Boettcher[t] M. Bou Cabo[u] J. Boumaaza[o] M. Bouta[v] M. Bouwhuis[n] C. Bozza[w] H.Brânzaş[x] R. Bruijn[n,y] J. Brunner[e] R. Bruno[a] E. Buis[z] R. Buompane[f,aa] J. Busto[e] B. Caiffi[k] D. Calvo[d] S. Campion[ab,h] A. Capone[ab,h] V. Carretero[d] P. Castaldi[p,ac] S. Celli[ab,h] M. Chabab[ad] N. Chau[c,*] A. Chen[ae] S. Cherubini[s,af] V. Chiarella[ag] T. Chiarusi[p] M. Circella[ah] R. Cocimano[s] J. A. B. Coelho[c] A. Coleiro[c] M. Colomer-Molla[c,d] R. Coniglione[s] P. Coyle[e] A. Creusot[c] A. Cruz[ai] G. Cuttone[s] R. Dallier[aj] B. De Martino[e] I. Di Palma[ab,h] A. F. Díaz[l] D. Diego-Tortosa[m] C. Distefano[s] A. Domi[n,y] C. Donzaud[c] D. Dornic[e] M. Dörr[ak] D. Drouhin[ba,b] T. Eberl[al] A. Eddyamoui[o] T. van Eeden[n] D. van Eijk[n] I. El Bojaddaini[v] A. Enzenhöfer[e] V. Espinosa[m] P. Fermani[ab,h] G. Ferrara[s,af] M. D. Filipović[am] F. Filippini[p,q] L. A. Fusco[e] T. Gal[al] J. García Méndez[m] A. Garcia Soto[d] F. Garufi[f,g] Y. Gatelet[c] C. Gatius[n] N. Geißelbrecht[al] L. Gialanella[f,aa] E. Giorgio[s] S. R. Gozzini[d] R. Gracia[n] K. Graf[al] G. Grella[an] D. Guderian[bb] C. Guidi[k,ao] B. Guillon[ap] M. Gutiérrez[aq] J. Haefner[al] S. Hallmann[al] H. Hamdaoui[o] H. van Haren[ar] A. Heijboer[n] A. Hekalo[ak] L. Hennig[al] J. J. Hernández-Rey[d] J. Hofestädt[al] F. Huang[e] W. Idrissi Ibnsalih[f,aa] G. Illuminati[p,c] C. W. James[ai] D. Janezashvili[as] M. de Jong[n,at] P. de Jong[n,y] B. J. Jung[n] P. Kalaczyński[au] O. Kalekin[al] U. F. Katz[al] N. R. Khan Chowdhury[d] G. Kistauri[as] F. van der Knaap[z] P. Kooijman[y,bc] A. Kouchner[c,av] V. Kulikovskiy[k] M. Labalme[ap] R. Lahmann[al] M. Lamoureux[c,‡] G. Larosa[s] C. Lastoria[e] A. Lazo[d] R. Le Breton[c] S. Le Stum[e] G. Lehaut[ap] O. Leonardi[s] F. Leone[s,af] E. Leonora[a] N. Lessing[al] G. Levi[p,q] M. Lincetto[e] M. Lindsey Clark[c] T. Lipreau[aj] C. LLorens Alvarez[m] F. Longhitano[a] D. Lopez-Coto[aq] A. Lygda[j] L. Maderer[c] J. Majumdar[n] J. Mańczak[d] A. Margiotta[p,q] A. Marinelli[f] C. Markou[j] L. Martin[aj] J. A. Martínez-Mora[m] A. Martini[ag] F. Marzaioli[f,aa] S. Mastroianni[f] K. W. Melis[n] G. Miele[f,g] P. Migliozzi[f] E. Migneco[s] P. Mijakowski[au] L. S. Miranda[aw] C. M. Mollo[f] M. Moser[al] A. Moussa[v] R. Muller[n] M. Musumeci[s] L. Nauta[n] S. Navas[aq] C. A. Nicolau[h] B. Nkosi[ae] B. Ó Fearraigh[n,y] M. O'Sullivan[ai] M. Organokov[b] A. Orlando[s] J. Palacios González[d] G. Papalashvili[as] R. Papaleo[s] A. M. Păun[x] G. E. Păvălaş[x] C. Pellegrino[q,bd] M. Perrin-Terrin[e] V. Pestel[n] P. Piattelli[s] C. Pieterse[d] O. Pisanti[f,g] C. Poirè[m] V. Popa[x] T. Pradier[b] I. Probst[al] S. Pulvirenti[s] G. Quéméner[ap] N. Randazzo[a] S. Razzaque[aw] D. Real[d] S. Reck[al] G. Riccobene[s] A. Romanov[k,ao] A. Rovelli[s] F. Salesa Greus[d] D. F. E. Samtleben[n,at] A. Sánchez Losa[ah,d] M. Sanguineti[k,ao] D. Santonocito[s] P. Sapienza[s] J. Schnabel[al] M. F. Schneider[al] J. Schumann[al] H. M. Schutte[t] J. Seneca[n] I. Sgura[ah] R. Shanidze[as] A. Sharma[ax] A. Sinopoulou[j] B. Spisso[an,f] M. Spurio[p,q] D. Stavropoulos[j] S. M. Stellacci[an,f] M. Taiuti[k,ao] Y. Tayalati[o] H. Thiersen[t] S. Tingay[ai] S. Tsagkli[j] V. Tsourapis[j] E. Tzamariudaki[j] D. Tzanetatos[j] V. Van Elewyck[c,av,*] G. Vasileiadis[ay] F. Versari[p,q] D. Vivolo[f,aa] G. de Wasseige[c] J. Wilms[az] R. Wojaczyński[au] E. de Wolf[n,y] T. Yousfi[v] S. Zavatarelli[k] A. Zegarelli[ab,h] D. Zito[s] J. D. Zornoza[d] J. Zúñiga[d] N. Zywucka[t]
(KM3NeT Collaboration)

Note that here θ_{23} was taken at the 2021 value including atmospheric data which matches the current "no atmospheric data" results in the IceCube paper

Compare to T2K constraint



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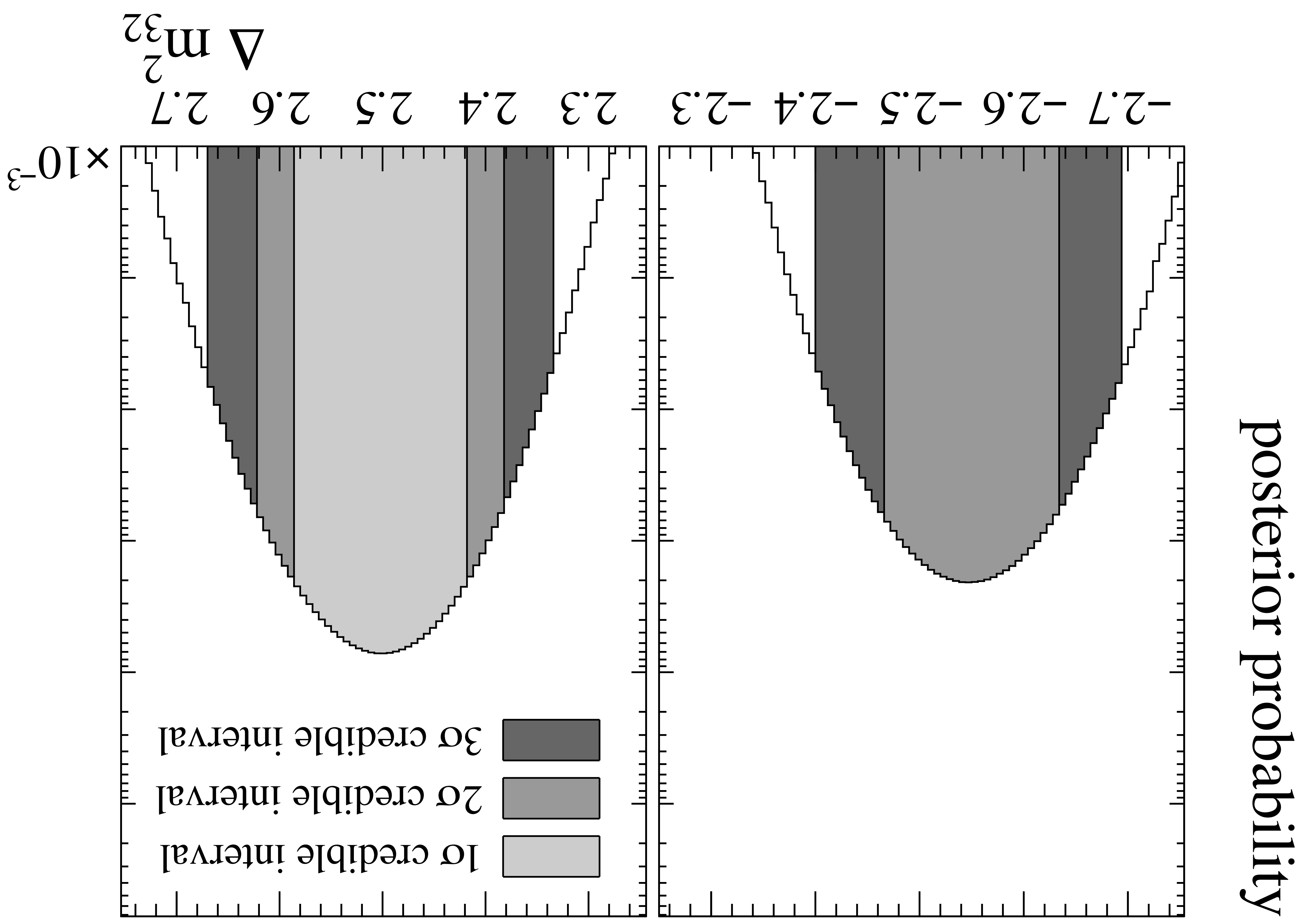


Mass ordering sensitivity

Table 3: Asimov median sensitivity to NMO after 6 years of data taking for each experiment alone, the "simple sum", and the combination of the two experiments, assuming the baseline scenario for systematics.

True NMO	JUNO, 8 cores	ORCA	Simple Sum	Combination
NO	2.3σ	6.5σ	6.9σ	7.8σ
IO	2.4σ	3.6σ	4.3σ	5.1σ

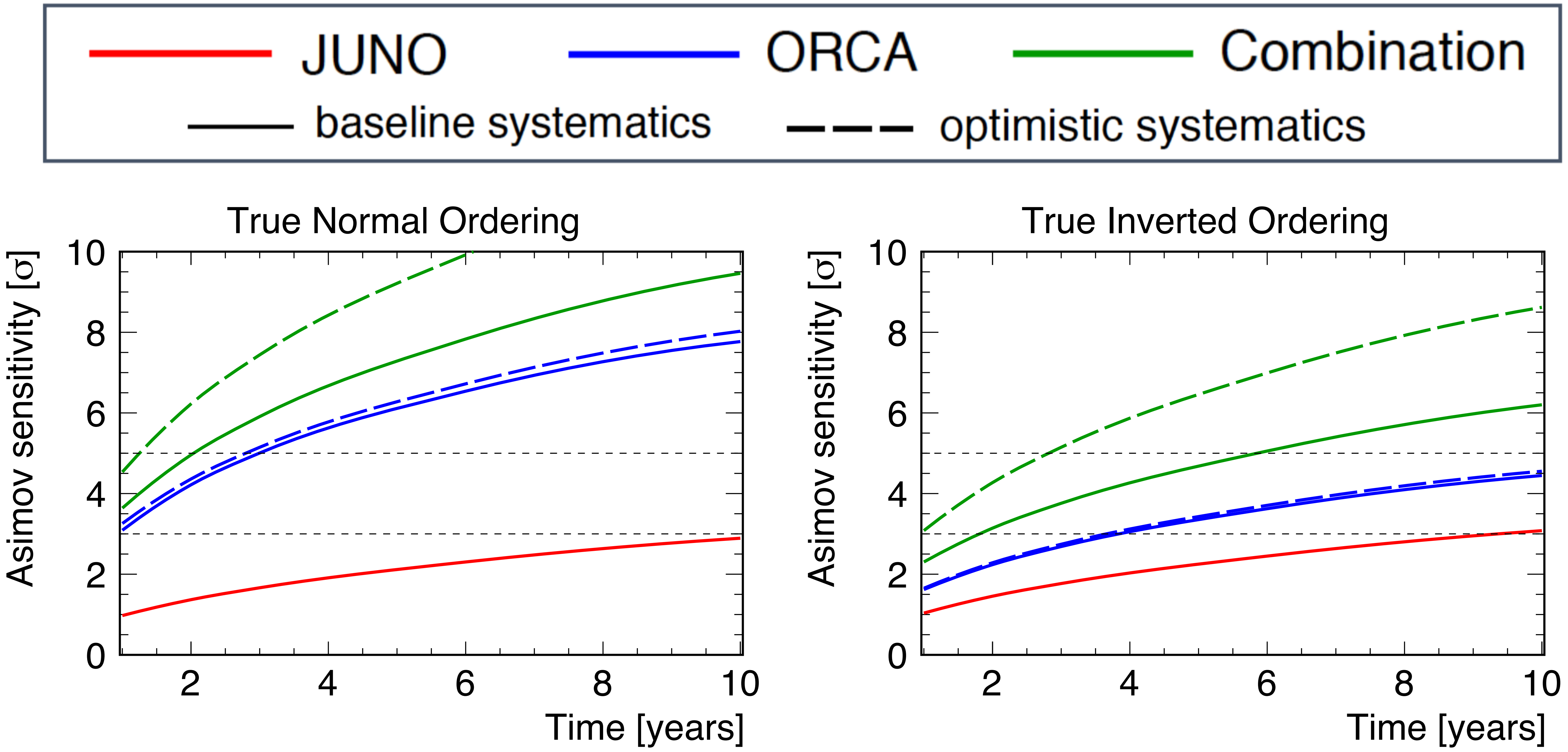


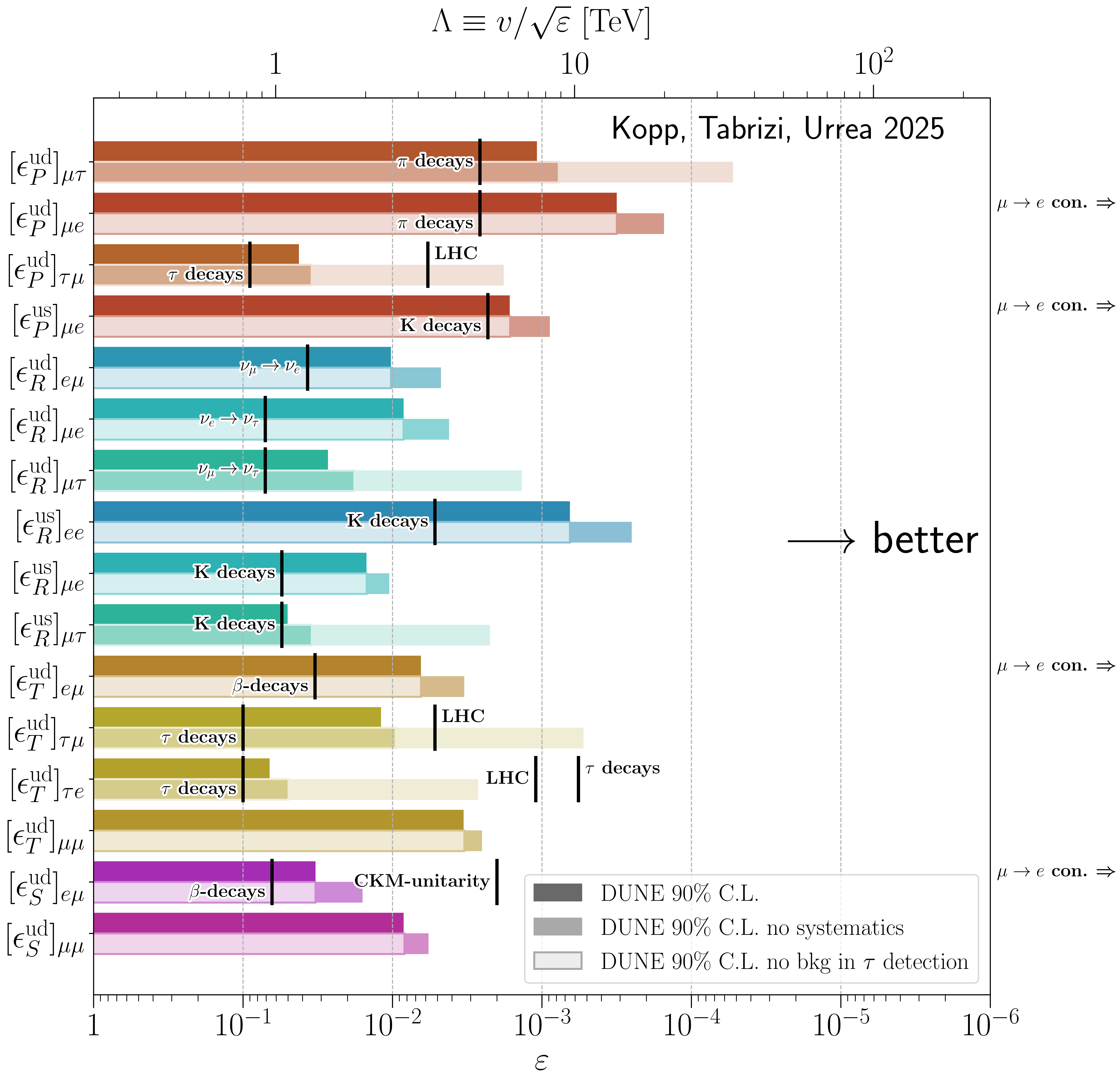
Figure 5: NMO sensitivity as a function of time for only JUNO (red), only ORCA (blue), and the combination of JUNO and ORCA (green), assuming baseline (solid) or optimistic (dashed) systematics.

Question on mass ordering

Assuming normal ordering, it doesn't seem impossible that ORCA+JUNO+IceCube can make a more relevant contribution to our overall understanding of mass ordering before DUNE does

Could it be relevant to repeat this study with SK/HyperK inputs as well? Perhaps even SK/HK + JUNO only

EFT fits to neutrino data



Effective Field Theory in Long-Baseline Neutrino Oscillation Experiments

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Abstract: We study the phenomenology of physics beyond the Standard Model in long-baseline neutrino oscillation experiments using the most general parametrisation of heavy new physics in the framework of Standard Model Effective Theory (SMEFT), as well as its counterpart below the electroweak scale, Weak Effective Field Theory (WEFT). We compute neutrino production, oscillation, and detection rates in these frameworks, consistently accounting for renormalisation group running as well as SMEFT/WEFT matching. We moreover use appropriately modified neutrino–nucleus cross sections, focusing specifically on the regime of quasi-elastic scattering. Compared to the traditional formalism of non-standard neutrino interactions (NSI), our approach is theoretically more consistent, and it allows for straightforward joint analyses of data taken at different energy scales and by different experiments including not only neutrino oscillation experiments, but also searches for charged lepton flavour violation, low-energy precision measurements, and the LHC. As a specific example, we carry out a sensitivity study for the DUNE experiment and compute projected limits on the WEFT and SMEFT Wilson coefficients. Together with this paper, we also release a public simulation package called "GLoBES-EFT" for consistently simulating long-baseline neutrino oscillation experiments in the presence of new physics parameterized either in WEFT or in SMEFT. GLoBES-EFT is available from GitHub.

Basic idea is to be able to fit not only oscillation data but also cross-sections/ND data in a global analysis of charged-current Wilson coefficients

Why only DUNE data?

[1]Here, we take the point of view that massive neutrinos are part of the Standard Model. This is motivated by the fact that the Glashow–Salam–Weinberg model with massless neutrinos could be considered "standard" for 15 years between 1983 (discovery of the W and Z bosons) and 1998 (discovery of neutrino oscillations), while the model with massive neutrinos has been the state of the art for 27 years already, thereby making it more standard than its predecessor without neutrino masses.

[2]The DUNE experiment is particularly well suited for new physics searches thanks to the large energy range covered by its wide-band beam, its long baseline, and the superb event reconstruction capabilities offered by its liquid argon detectors. Moreover, beam fluxes and detector response functions for DUNE are public, allowing us to model the experiment reliably. On the downside, DUNE is smaller than HyperKamiokande, limiting its reach in searches that are purely statistics dominated.

DUNE covers a richer set of WCs because it has both kaon and pion neutrino production (plus some tau neutrinos from charm), but at least the point about the simulation of the detector response should be resolvable (even only internally in ND280/HK).

BACKUPS