



**HAL**  
open science

# Search for Sterile Neutrinos with KM3NeT/ORCA and ANTARES

A. Domi,, Joao A.B. Coelho

► **To cite this version:**

A. Domi,, Joao A.B. Coelho. Search for Sterile Neutrinos with KM3NeT/ORCA and ANTARES. 36th International Cosmic Ray Conference, Jul 2019, Madison, United States. 2019. in2p3-02282598

**HAL Id: in2p3-02282598**

**<https://hal.in2p3.fr/in2p3-02282598>**

Submitted on 3 Apr 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.





# Search for Sterile Neutrinos with KM3NeT/ORCA and ANTARES

A. Domi<sup>1,2,3</sup>, J. Coelho<sup>4</sup>

For the **ANTARES** and  
**KM3NeT** Collaborations

<sup>1</sup> Department of Physics, Università degli studi di Genova, Via Dodecaneso, 33, 16146 Genova.

<sup>2</sup> INFN, Genova, Via Dodecaneso, 33, 16146 Genova.

<sup>3</sup> Aix-Marseille Univ, CNRS/IN2P3, CPPM, Marseille, France.

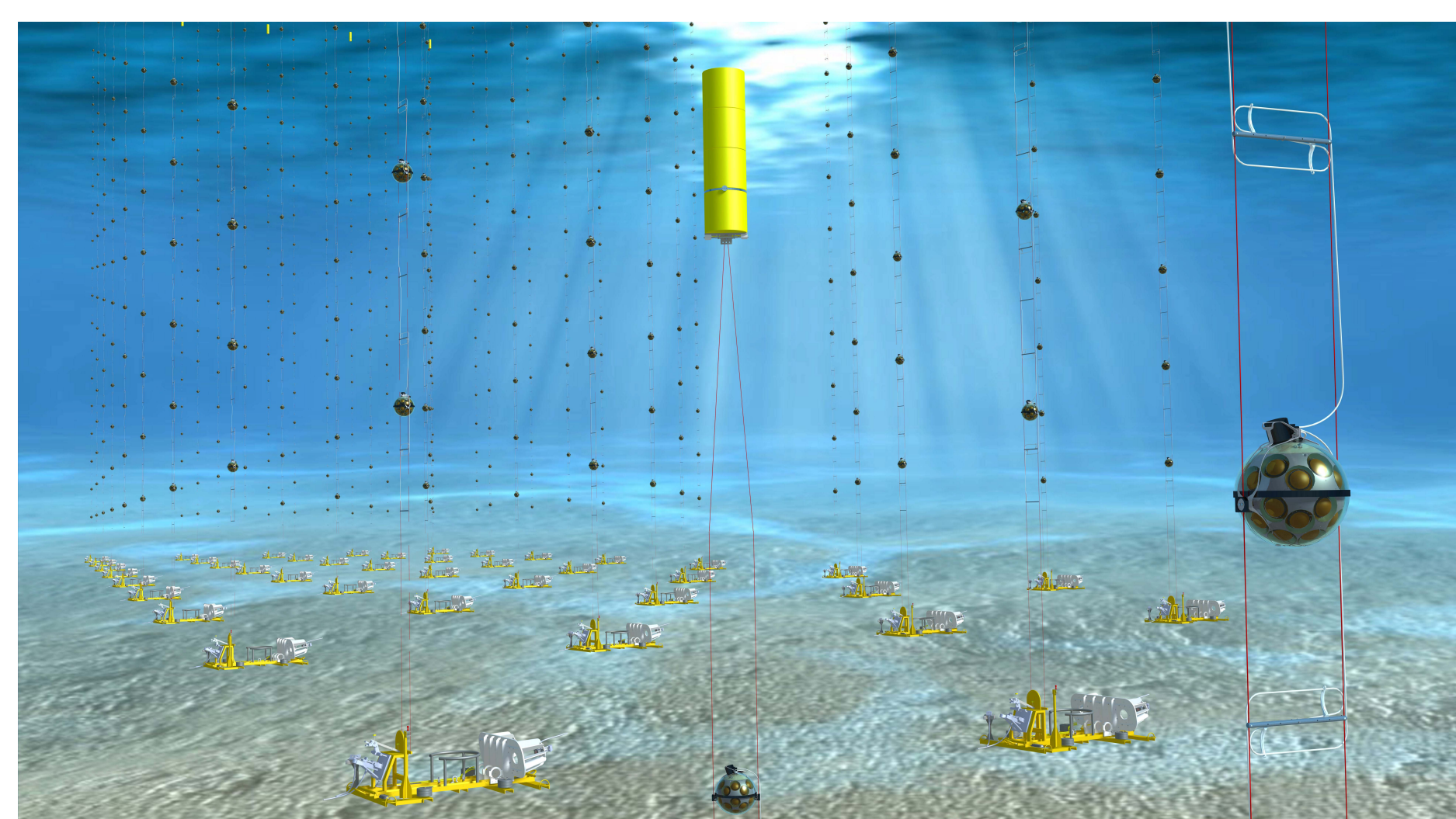
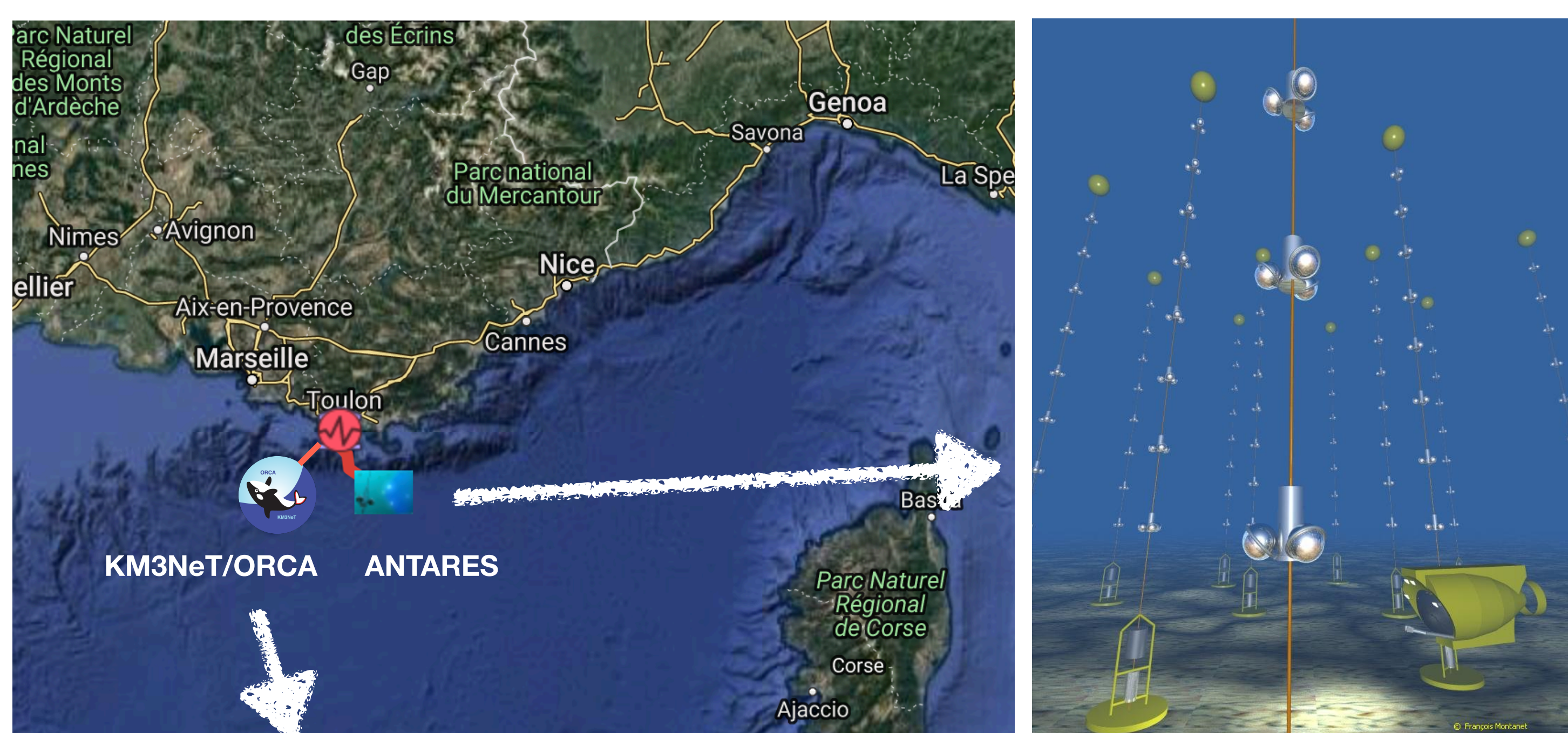
<sup>4</sup> LAL, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, France.

Anomalies in few reactors and short/long baseline experiments could be a hint of the presence of a light sterile neutrino (with mass  $\sim 1$  eV).

The investigation of these anomalies is a top priority in neutrino physics  $\rightarrow$  we can exploit the multi-potential of neutrino telescopes for this purpose!

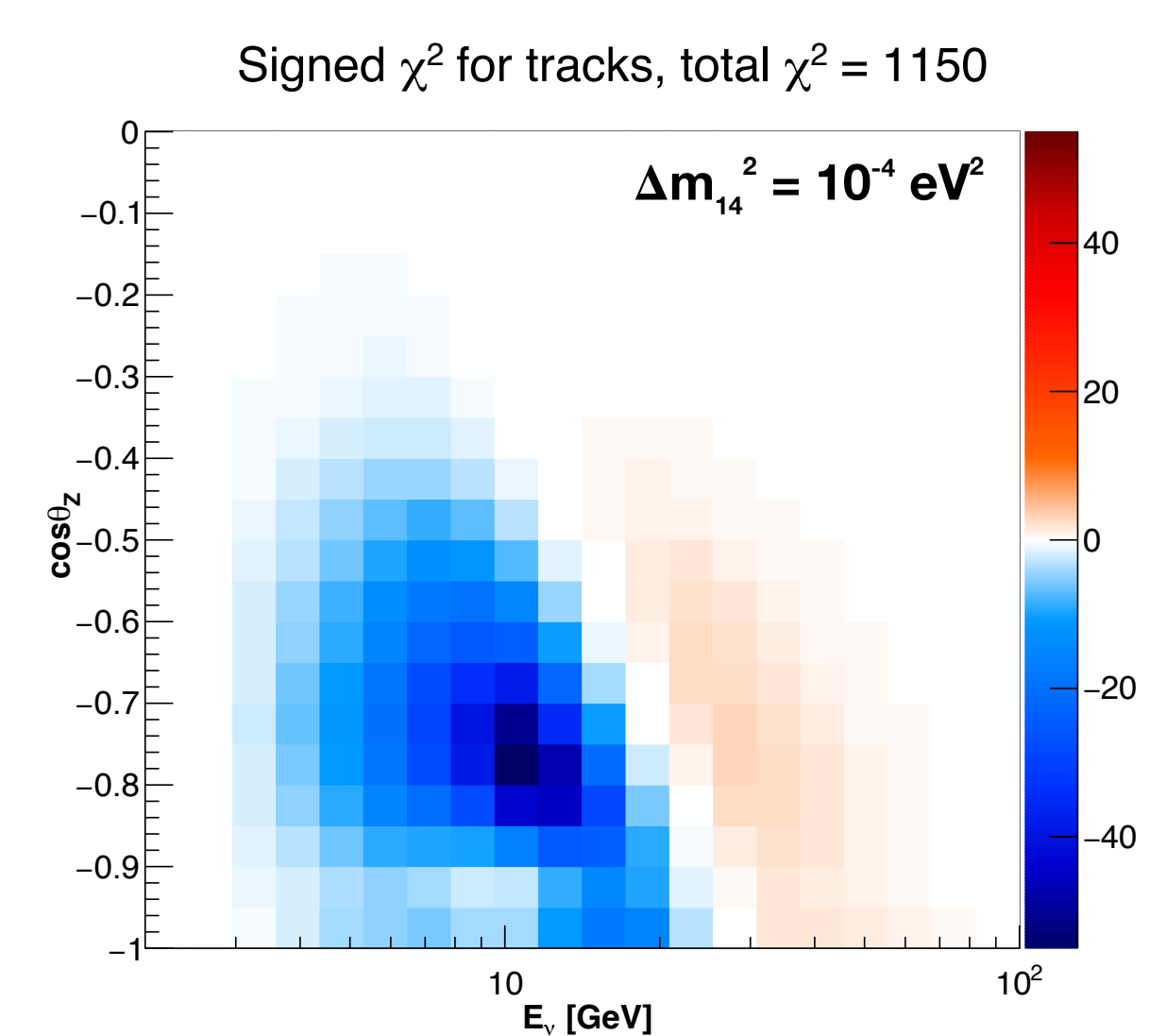
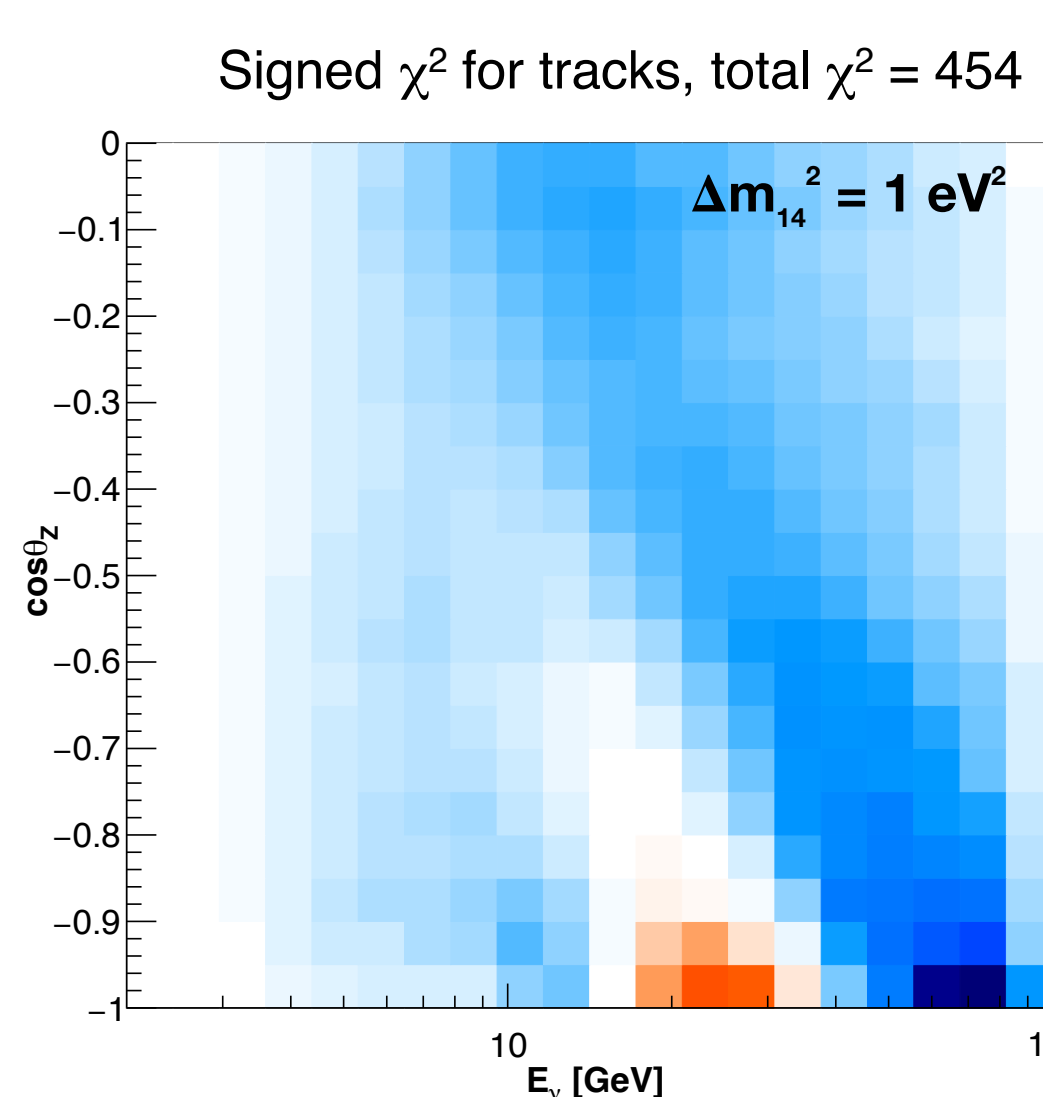
**ANTARES Data Sample:** from 2007 to 2016 (2830 days of livetime) [5].

**ORCA Detector Response:** a multi-dimensional response matrix is built from MC, taking into account triggering, reconstructions and particle identification and uncorrelated smearing of reconstructed energy and zenith angle..



ANTARES [1] and KM3NeT/ORCA [2]: deep sea neutrino telescopes in the abysses of the Mediterranean Sea. Neutrino detection possible by detecting the Cherenkov light emitted from the charged particles produced in neutrino interactions in the water. Use of PMTs (17" for ANTARES, 3" for ORCA).

$$\text{signed-}\chi^2 = \frac{(HP_{\text{Sterile}} - HP_{\text{Standard}})|HP_{\text{Sterile}} - HP_{\text{Standard}}|}{\sqrt{HP_{\text{Standard}}}}$$



## ANTARES Analysis

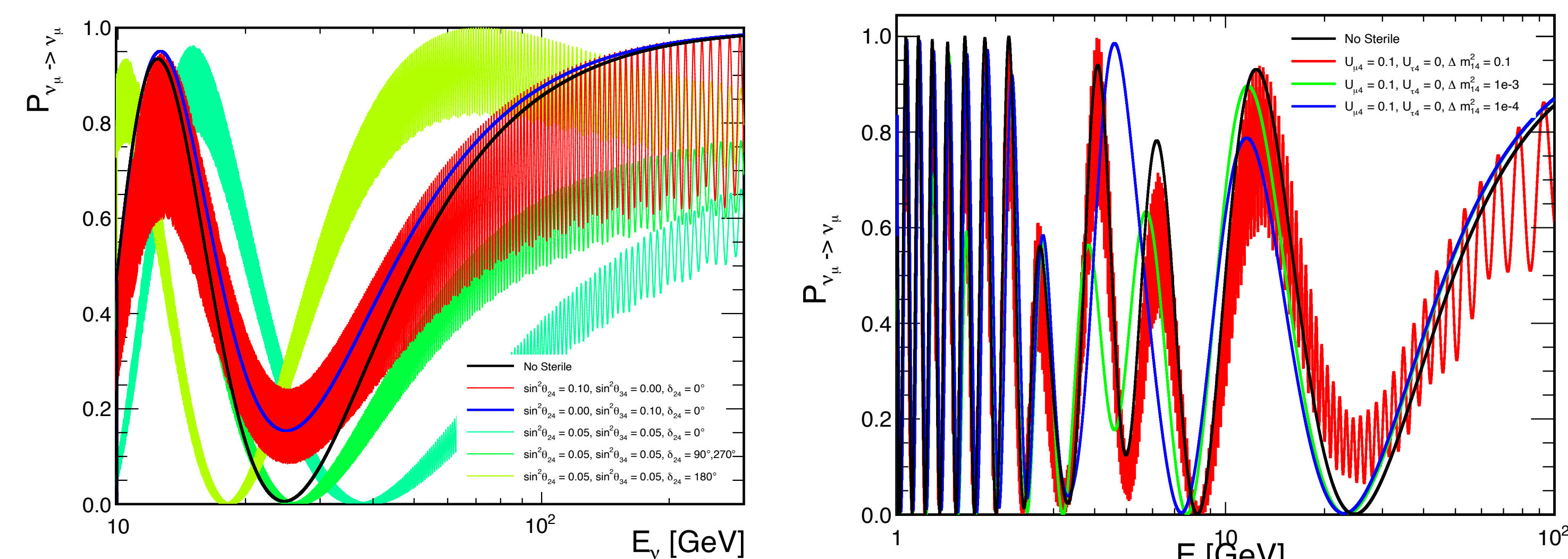
Parameter	Prior	Fit NH	Fit IH
$\theta_{24}$ [°]	none	$1.5^{+2.0}_{-5.0}$	$1.5^{+2.0}_{-5.0}$
$\theta_{34}$ [°]	none	$25.9^{+5.1}_{-4.2}$	$25.9^{+5.1}_{-4.2}$
$\delta_{24}$ [°]	none	$180 \pm 71$	$0 \pm 72$
$n_\nu$	none	$0.84^{+0.10}_{-0.09}$	$0.84^{+0.10}_{-0.09}$
$\nu/\bar{\nu}$ [σ]	$0.0 \pm 1.0$	$1.07^{+0.63}_{-0.55}$	$1.07^{+0.63}_{-0.55}$
$\Delta\gamma$	$0.00 \pm 0.05$	$-0.011 \pm 0.036$	$-0.011 \pm 0.036$
$\Delta m_{32}^2$ [ $10^{-3}$ eV <sup>2</sup> ]	none	$3.0^{+0.8}_{-0.6}$	$-3.0^{+0.6}_{-0.8}$
$\theta_{23}$ [°]	none	$52 \pm 8$	$52 \pm 8$
$\theta_{13}$ [°]	$8.41 \pm 0.28$	$8.41 \pm 0.28$	$8.41 \pm 0.28$
$M_A$ [σ]	$0.0 \pm 1.0$	$0.11^{+0.93}_{-0.97}$	$0.11^{+0.93}_{-0.97}$

## ORCA Analysis

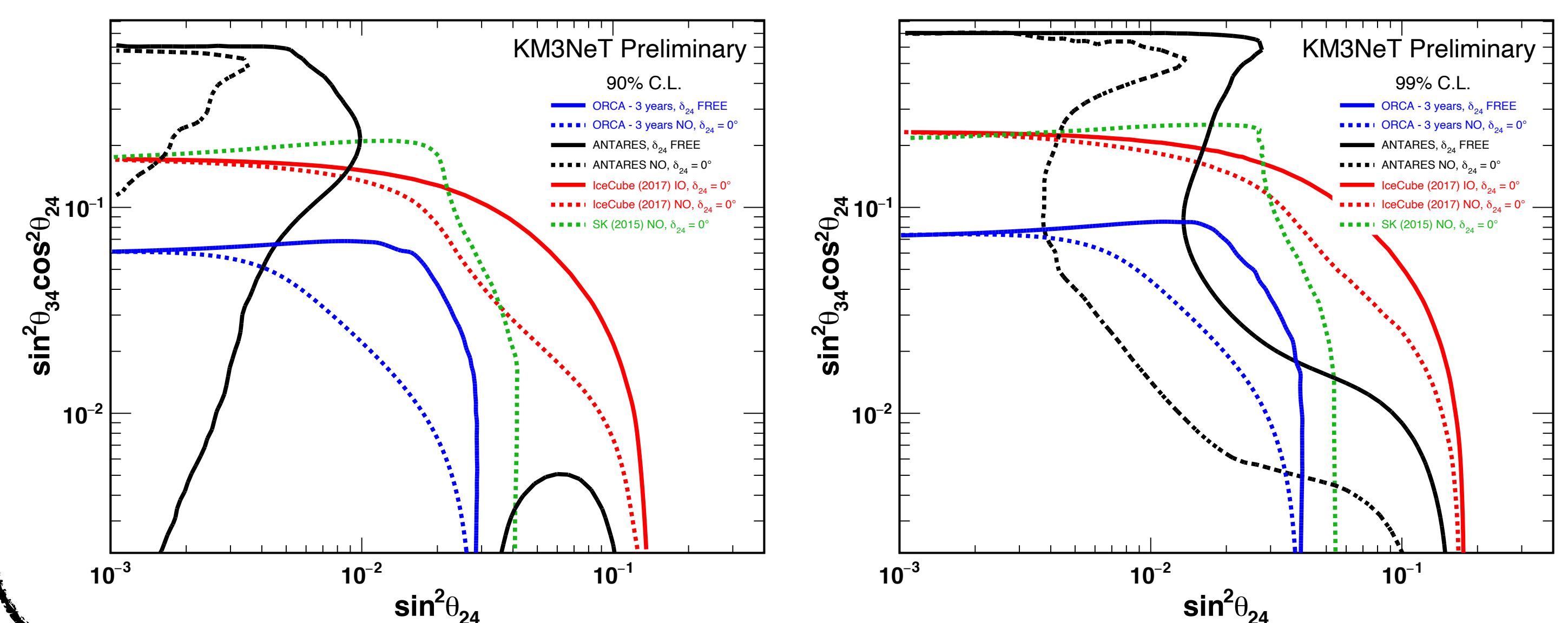
Parameter	Prior
$\theta_{13}$	$8.54^\circ \pm 0.15^\circ$
$\frac{\Delta m_{21}^2}{10^{-3} \text{eV}^2}$	$2.49 \pm 0.5$
Flux Norm	$1 \pm 0.10$
NC Scale	$1 \pm 0.05$
$\nu_\mu/\nu_e$ Skew	$0 \pm 0.05$
$\nu/\bar{\nu}$ Skew	$0 \pm 0.03$
Energy Slope	$0 \pm 0.05$
Energy Scale	$1 \pm 0.03$

## Atmospheric Neutrino Flux (HKKM 2014 - Gran Sasso site [3]) used as input for this analysis.

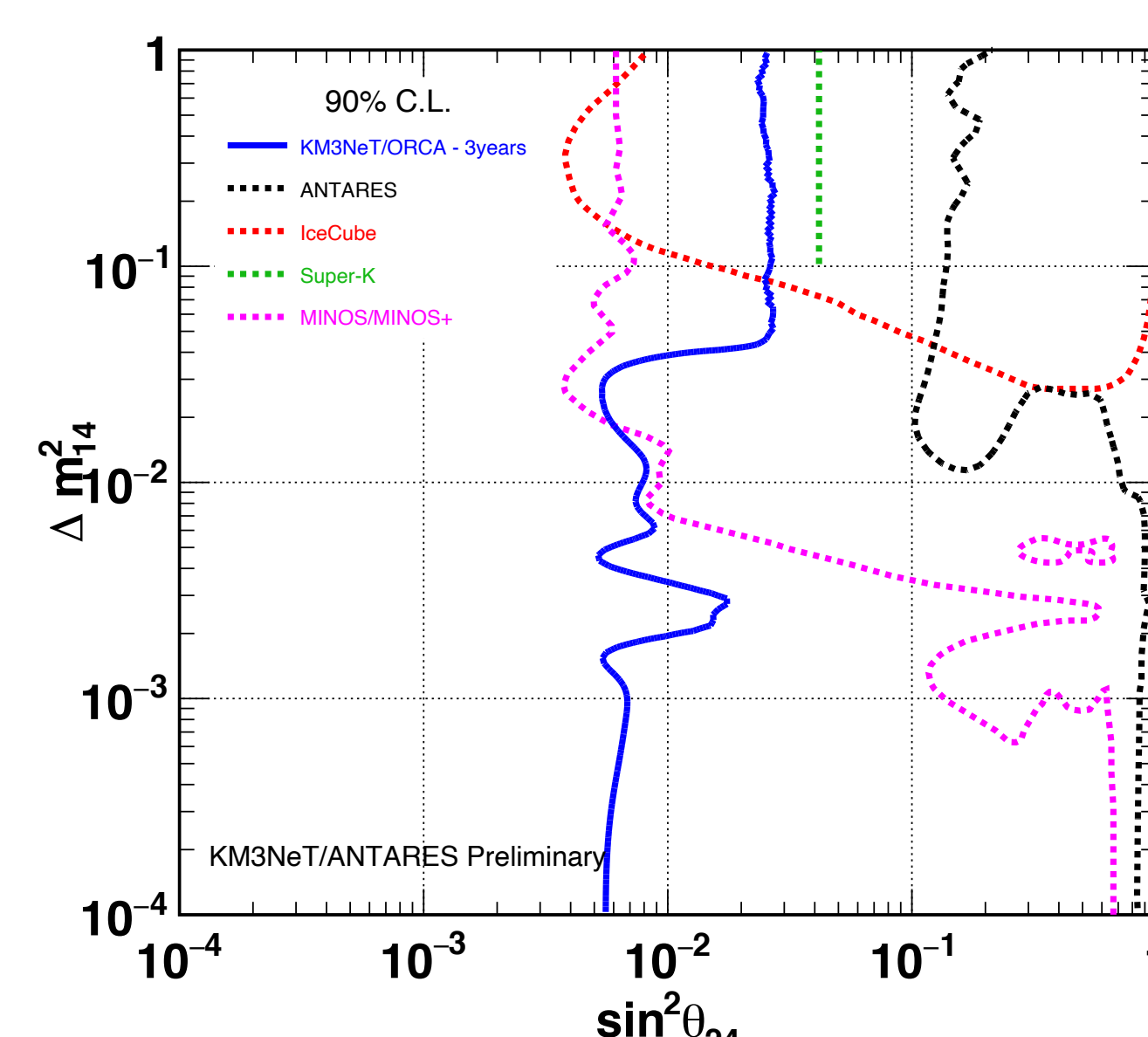
Oscillation pattern distorted by Earth's Matter effects, the **PREM Model** [4], with 42 layers and realistic Z/A values is used for this analysis.  $\rightarrow$  The possible presence of a light sterile neutrino changes the  $\nu$  oscillation probability.



## ORCA Sensitivity and ANTARES Upper Limits to Sterile Mixing Angles



## ORCA Sensitivity and ANTARES Upper Limits to Low Sterile Masses



[1] The ANTARES Collaboration, ANTARES: the first undersea neutrino telescope. Nucl. Instrum. Meth. A 656 (2011) 11.

[2] The KM3NeT Collaboration, Letter of Intent for KM3NeT 2.0, Journal of Physics G: Nuclear and Particle Physics, 43 (8), 084001, 2016.

[3] M. Honda et al., Atmospheric neutrino flux calculation using the NRLMSISE-00 atmospheric model. Phys. Rev., D92(2):023004, 2015.

[4] Adam M. Dziewonski and Don L. Anderson. Preliminary reference Earth model. Physics of the Earth and Planetary Interiors, 25(4):297–356, 1981.

[5] The ANTARES Collaboration, Measuring the atmospheric neutrino oscillation parameters and constraining the 3+1 neutrino model with ten years of ANTARES data. J. High Energy Phys. (2019) 2019: 113.