



KM3NeT/ORCA Overview

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on behalf of the KM3NeT Collaboration

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FR 18-1268

- ✓ KM3NeT – research infrastructure in the Mediterranean Sea
- ✓ KM3NeT/ORCA: Physics goals
- ✓ Current Status (ORCA6) and first results
- ✓ P2O Proposal
- ✓ Summary and Outlook



S. Biagi, The KM3NeT neutrino telescopes: status and perspectives, T01, 26/07, 10:45

D. Lopez-Coto, Dark Matter Searches with the ANTARES and KM3NeT Neutrino Telescopes, T03, 28/07, 10:50

KM3NeT: Distributed Deep Sea Research Infrastructure

Cities and Sites of KM3NeT



KM3NeT sites:

KM3NeT-Fr (ORCA)

KM3NeT-It (ARCA)

KM3NeT-Gr

Collaboration
(Summer 2021):

57 Groups

47 Cities

17 Countries

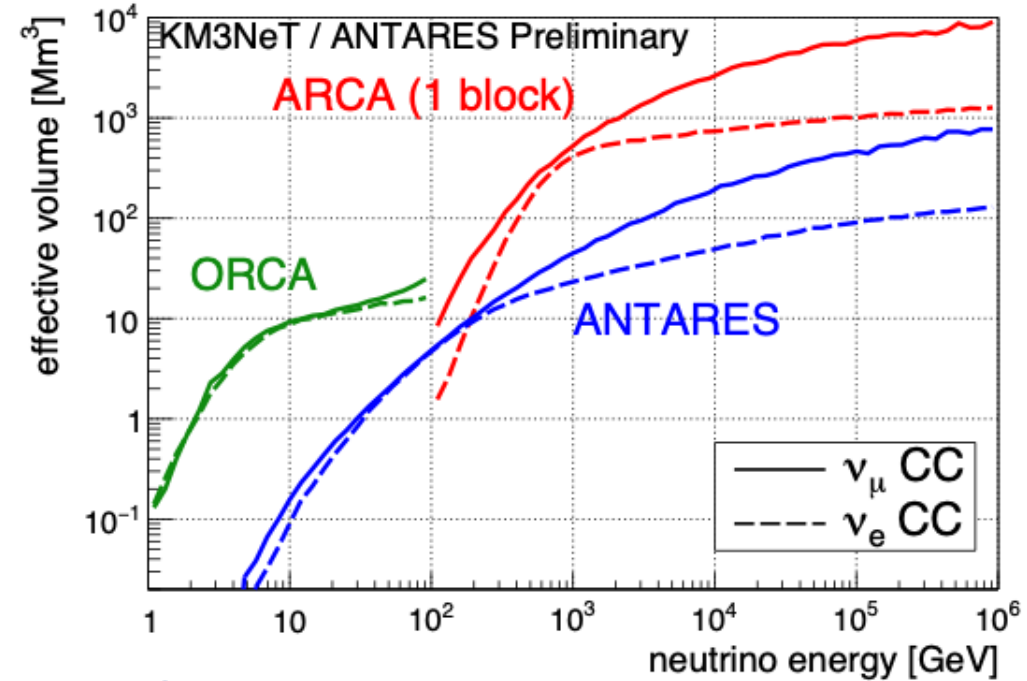
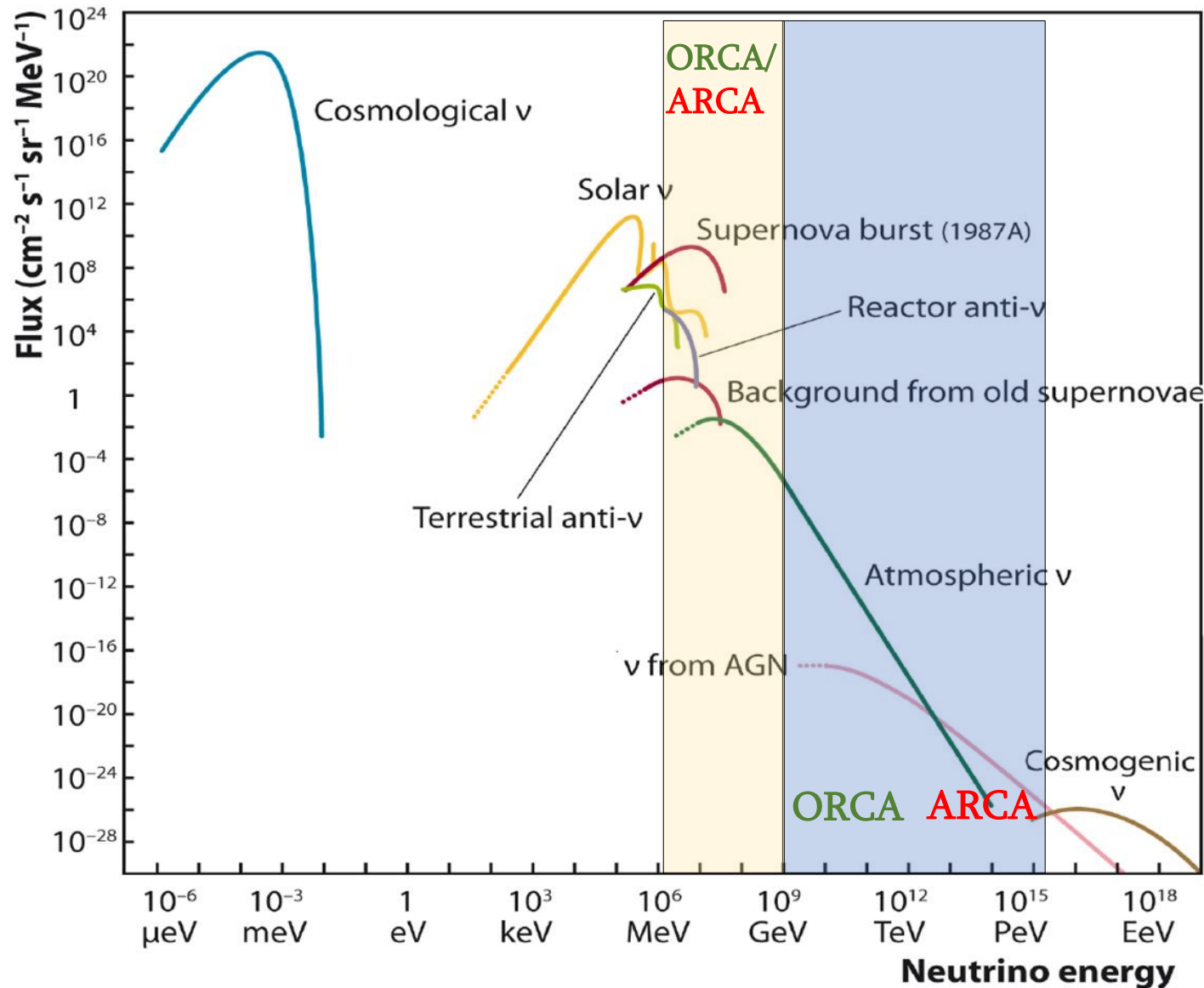
2 Large Cherenkov

detectors:

ARCA and ORCA

1 Technology

KM3NeT: Neutrino Energy Range



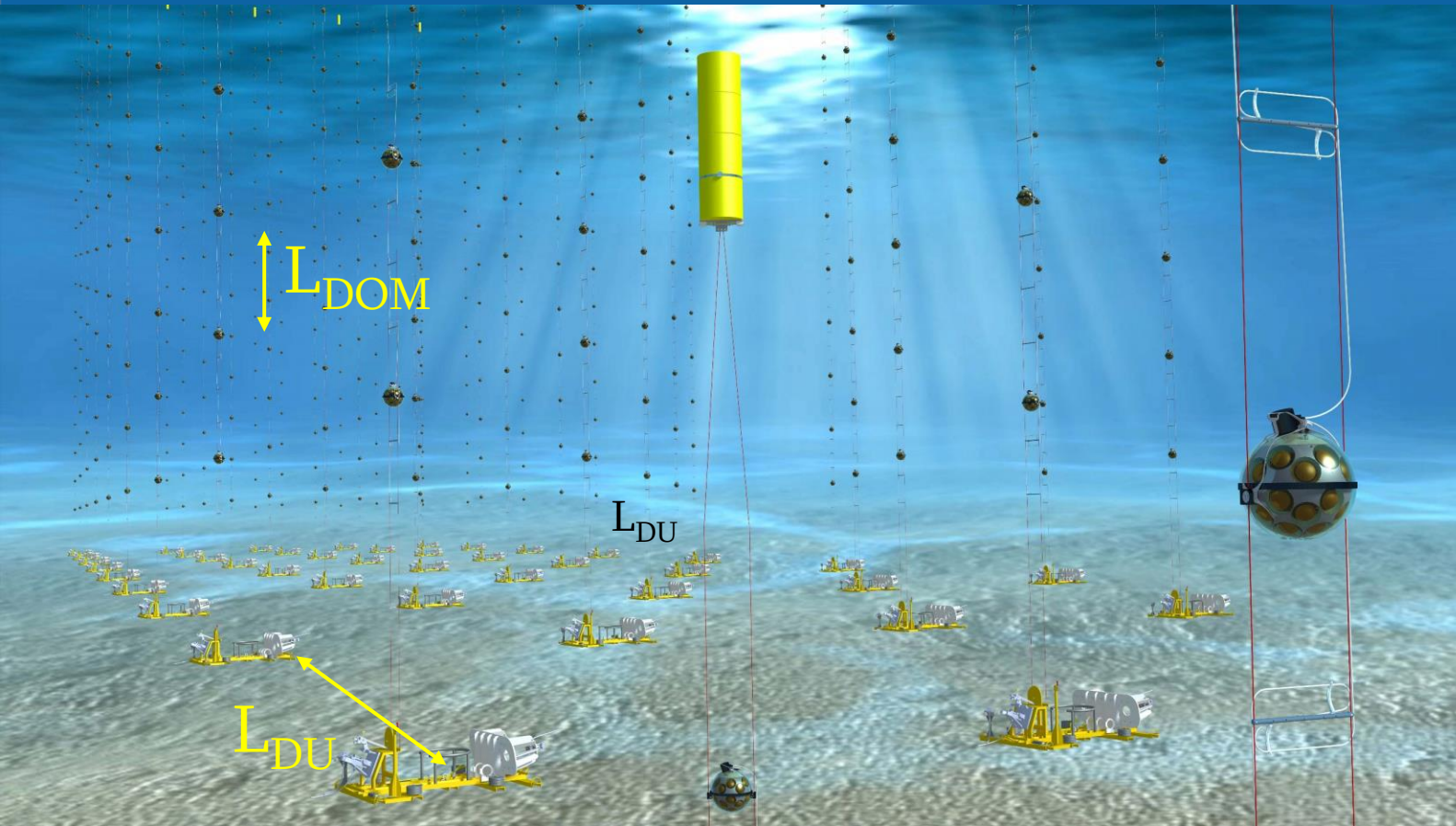
KM3NeT:

- neutrino energy range: MeV - PeV
- reconstruction of neutrinos:
above few GeV

ORCA:

Oscillation Research with Cosmics in Abyss

KM3NeT: Cherenkov Detector(s) in the Deep-Sea



KM3NeT Detector(s):

3D grid of photo-sensors for detecting Cherenkov Photons.

PMT: 3" Hamamatsu, R12199-02

Digital Optical Module(DOM)
31 PMT, sensors for calibration (time, position and orientation)

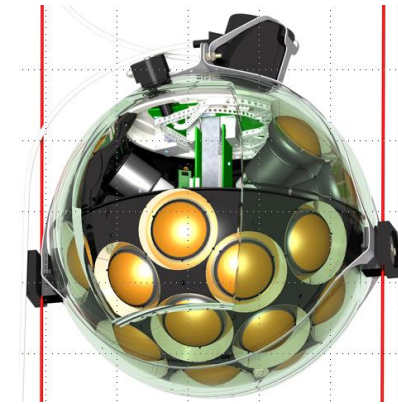
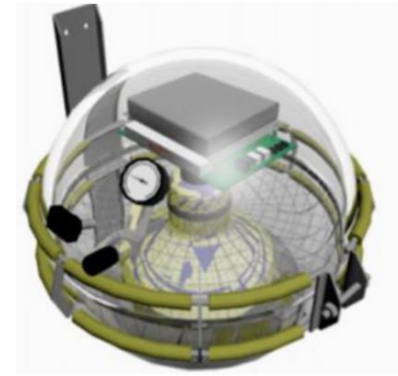
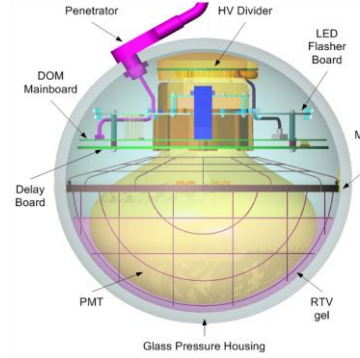
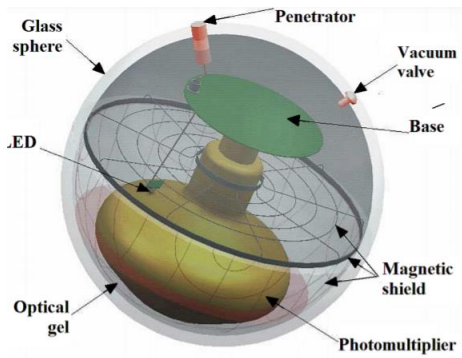
Detection Unit (DU): 18 DOMs

Building Block (BB): 115 DU

ORCA: 1 BB, $L_{DOM} = 9\text{m}$, $L_{DU} = 20\text{m}$, $M_{ORCA} = 7 \text{ Mton}$

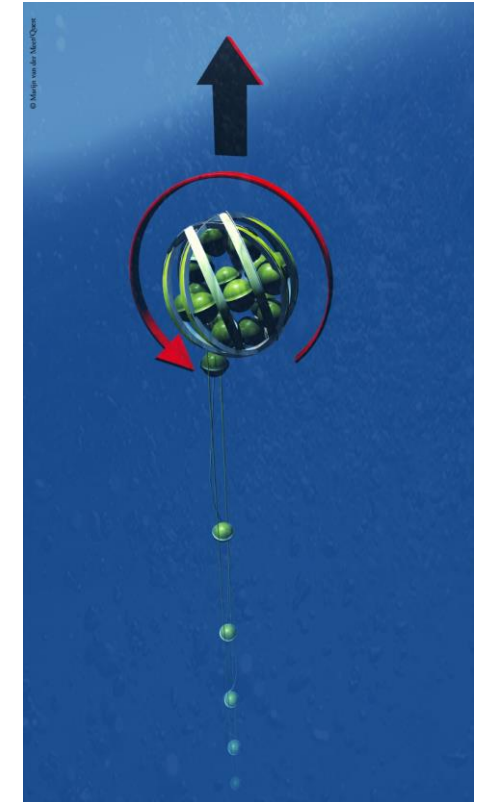
ARCA: 2 BB, $L_{DOM} = 36\text{m}$, $L_{DU} = 90\text{m}$, $M_{ARCA} = 2 \times 0.5 \text{ Gton}$

KM3NeT Innovations: MultiPMT DOM and LOM



KM3NeT Multi-PMT DOM: large sensitive (photo-cathode) area; improved photon counting; reduced noise; time coincidence for the deep-sea optical background (^{40}K , bioluminescence) rejection; direction sensitivity.

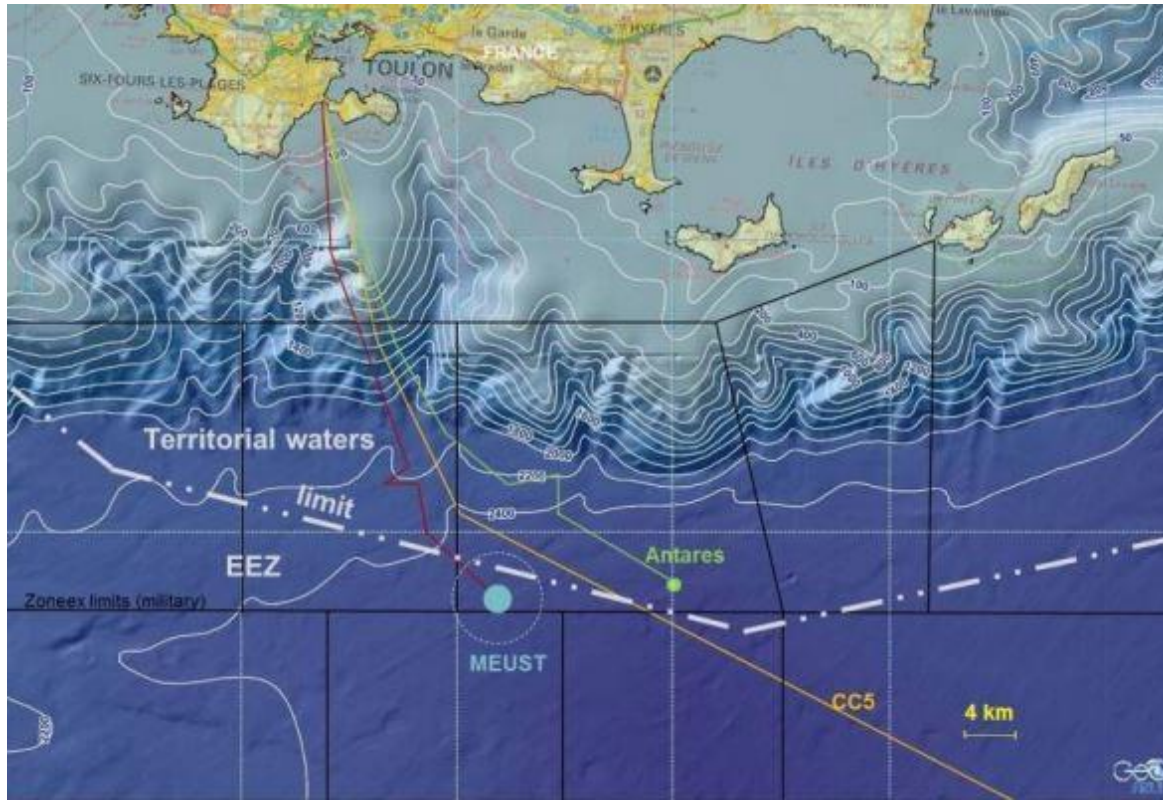
KM3NeT Launcher of Optical Modules (LOM)*



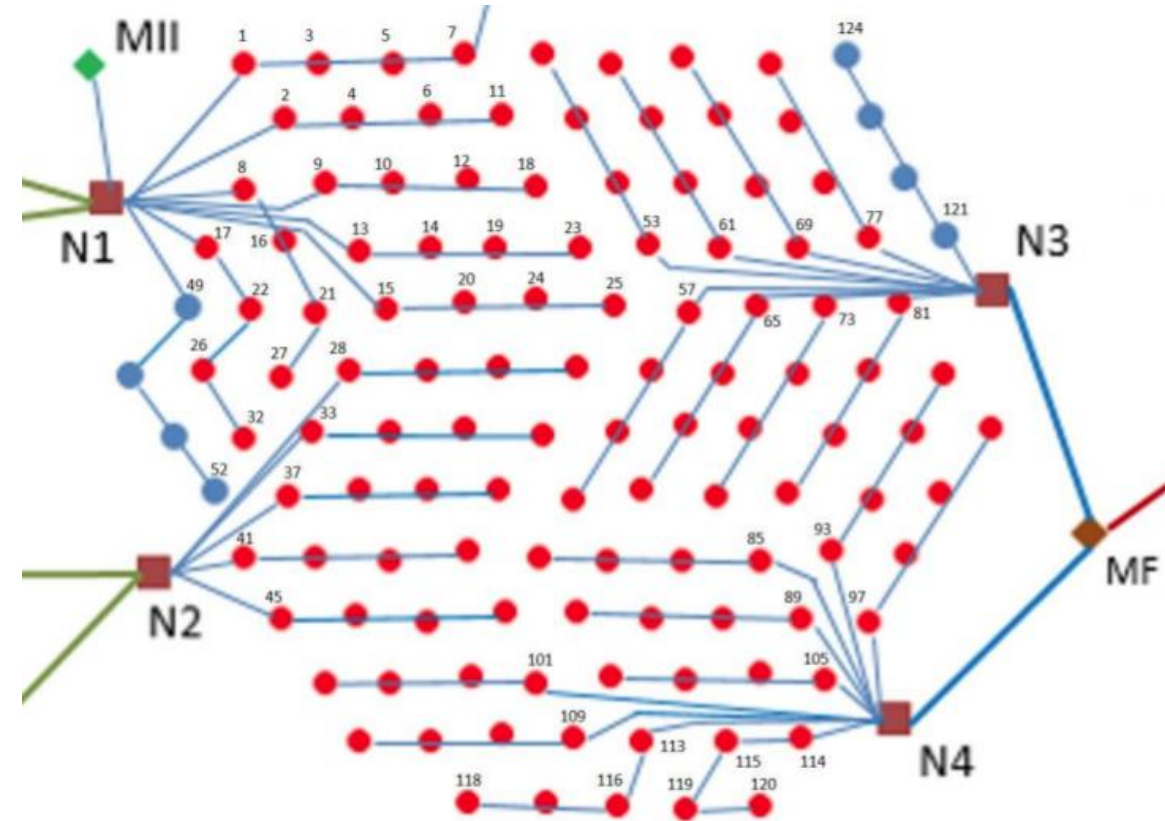
ANTARES	43.2	R7081-20	10	1
IceCube	36.5	R7081-02	10	1
Baikal-GVD	42.0	R7081-100	10	1
KM3NeT	43.2	R12199-02	3	31
Detector	OM(cm)	PMT	d(“)	PMT/OM

• *JINST* 15 (2020) 11, P11027

ORCA at KM3NeT-Fr

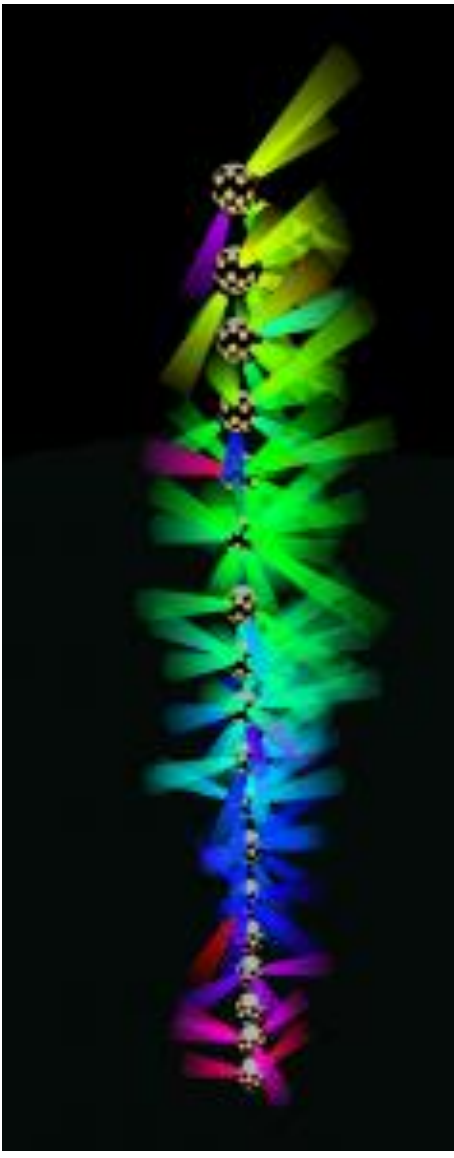
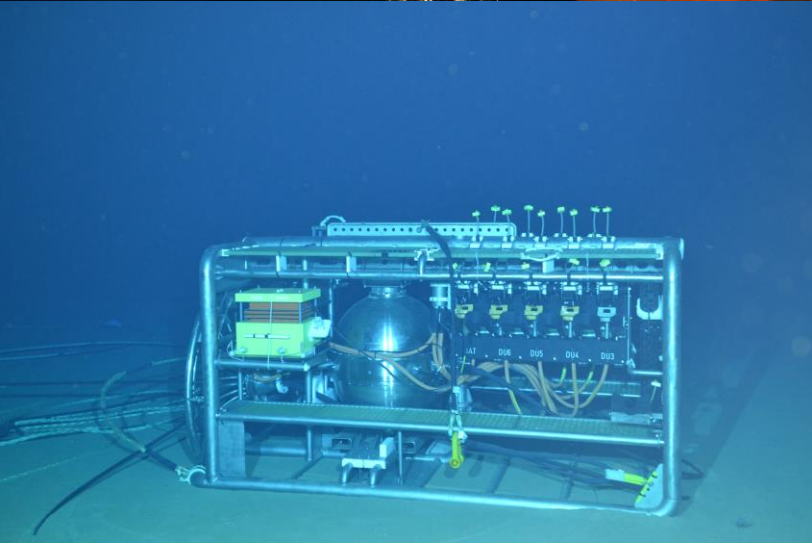
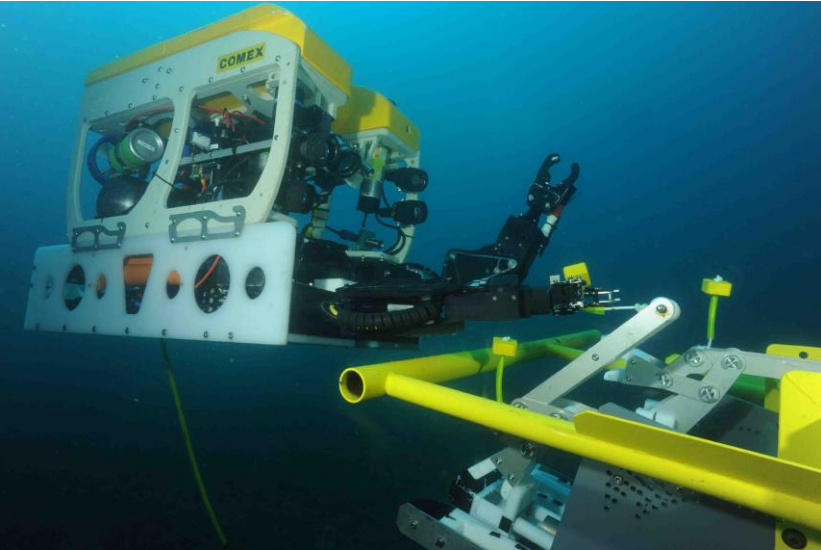
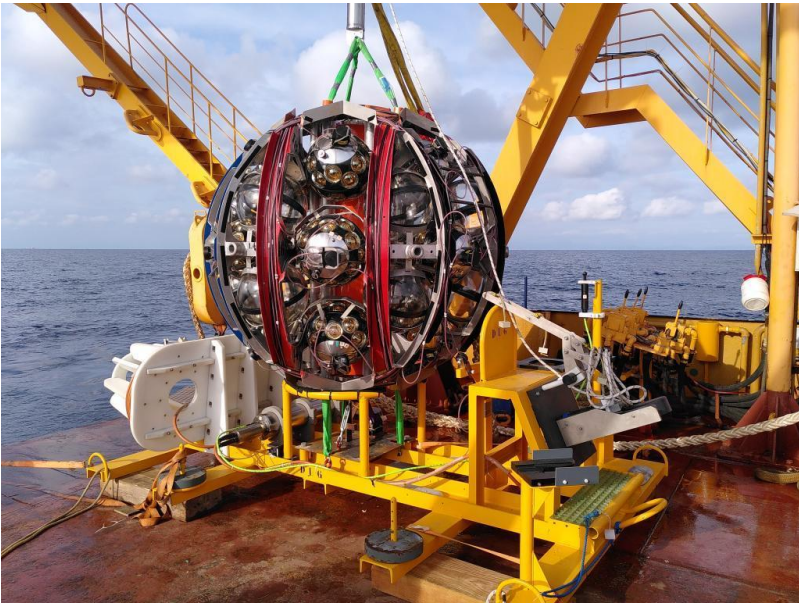


The KM3NeT-Fr deep sea installation ($42^{\circ}48'N$ $06^{\circ}02'E$) about 40 km off-shore Toulon, at a depth of about 2450 m. About 10 km west of the ANTARES (predecessor of KM3NeT) at Mediterranean Eurocentre for Underwater Sciences and Technologies (MEUST).



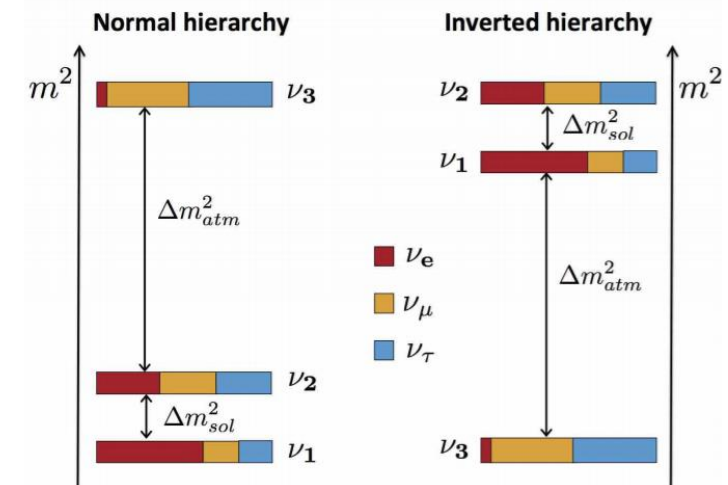
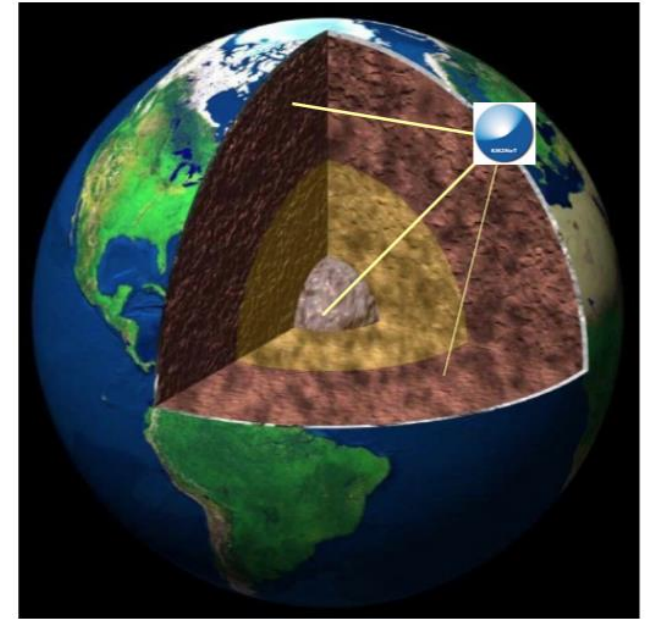
The KM3NeT/ORCA DU seabed positions.

KM3NeT/ORCA DU Deployment

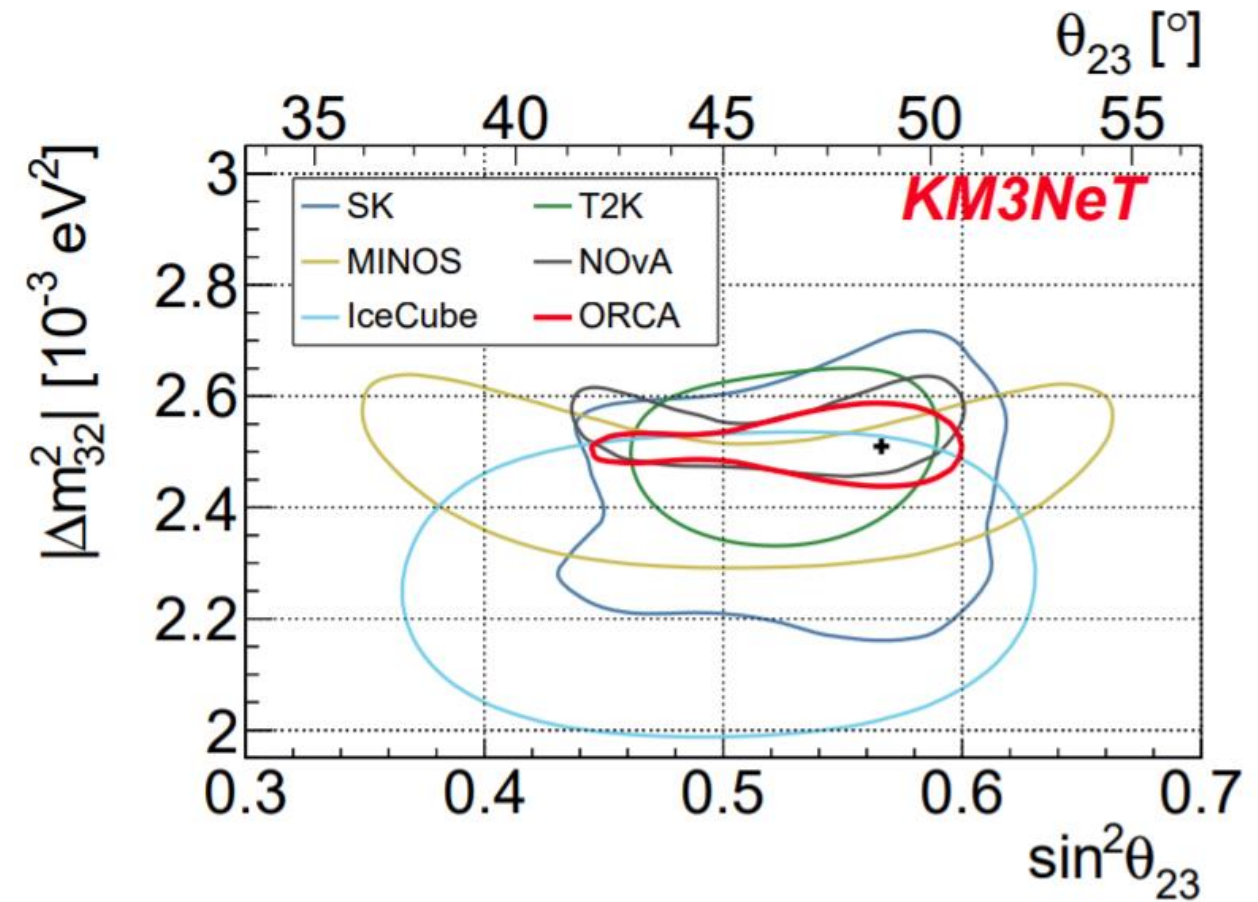
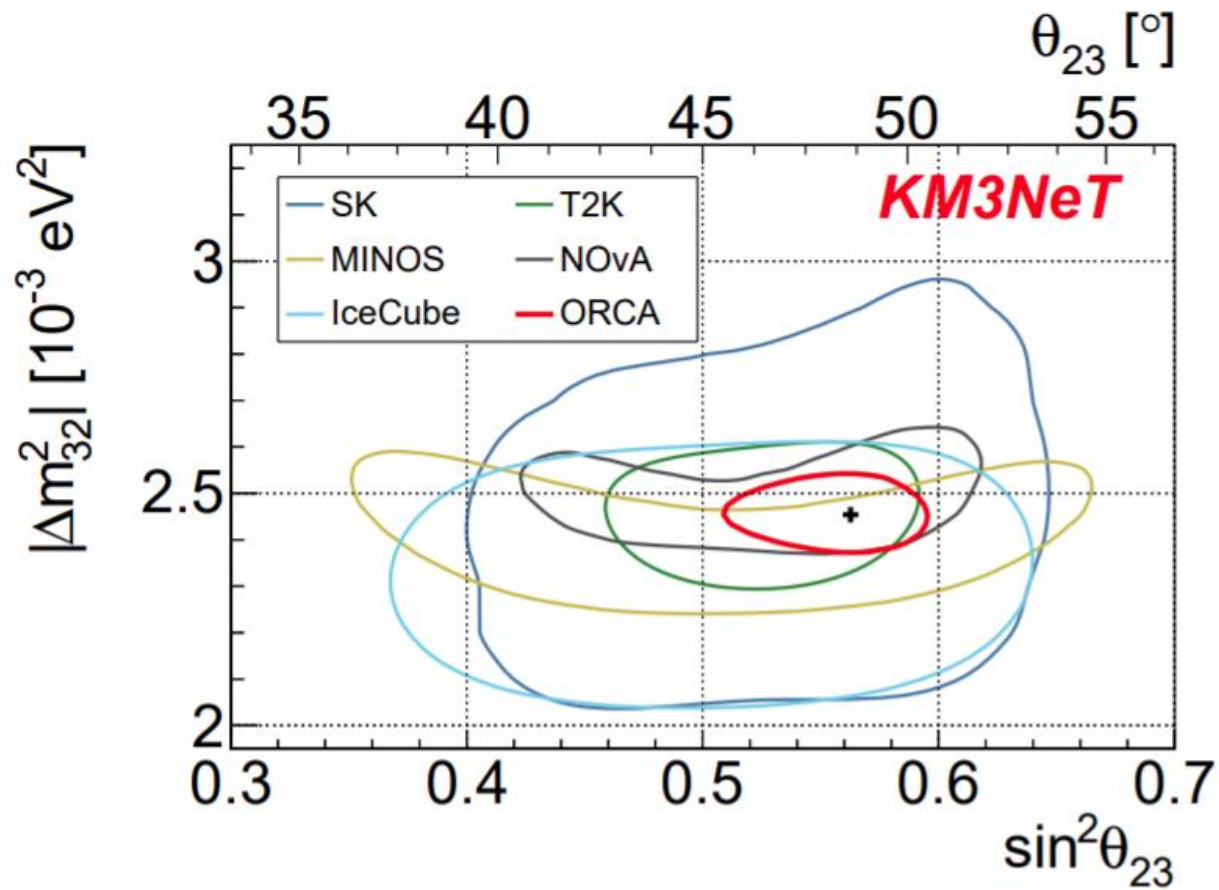


KM3NeT/ORCA: Physics Goals

- Neutrino oscillations and neutrino mass ordering (NMO)
- Search for the sterile neutrinos and NSI
- Neutrino oscillation tomography of the Earth
- Observation of next core collapse supernova burst
- Multi-messenger observations with neutrinos



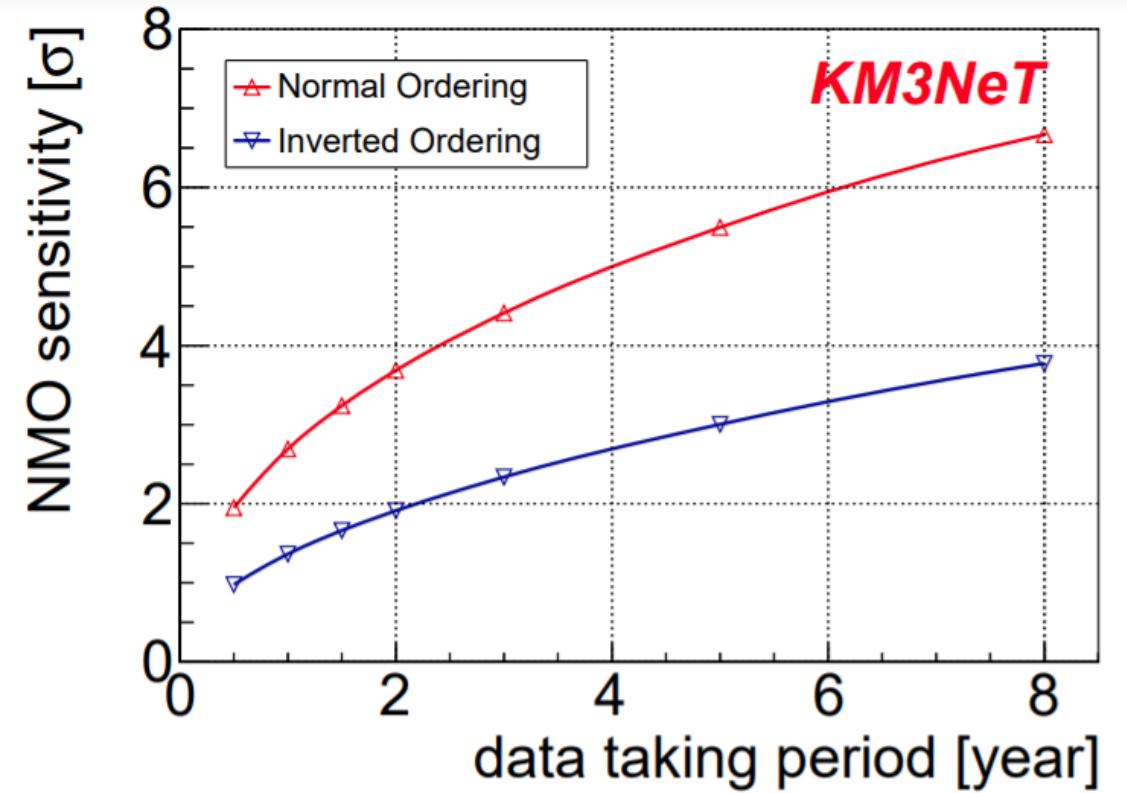
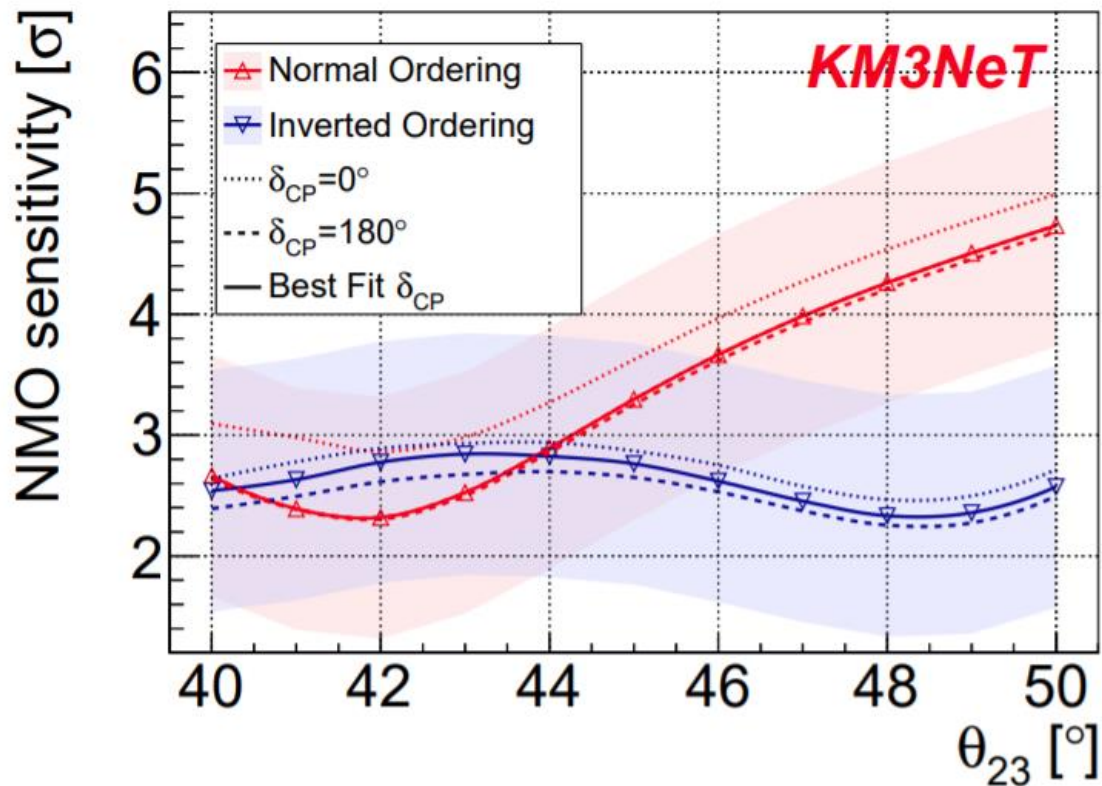
KM3NeT/ORCA: Oscillations



Expected measurement precision of Δm_{32}^2 and θ_{23} for both NO (left) and IO (right) after 3 years of data taking at 90% confidence level (red) overlaid with results from other experiments.

arXiv: 2103.09885, submitted to EPJ

KM3NeT/ORCA: Neutrino Mass Ordering (NMO)

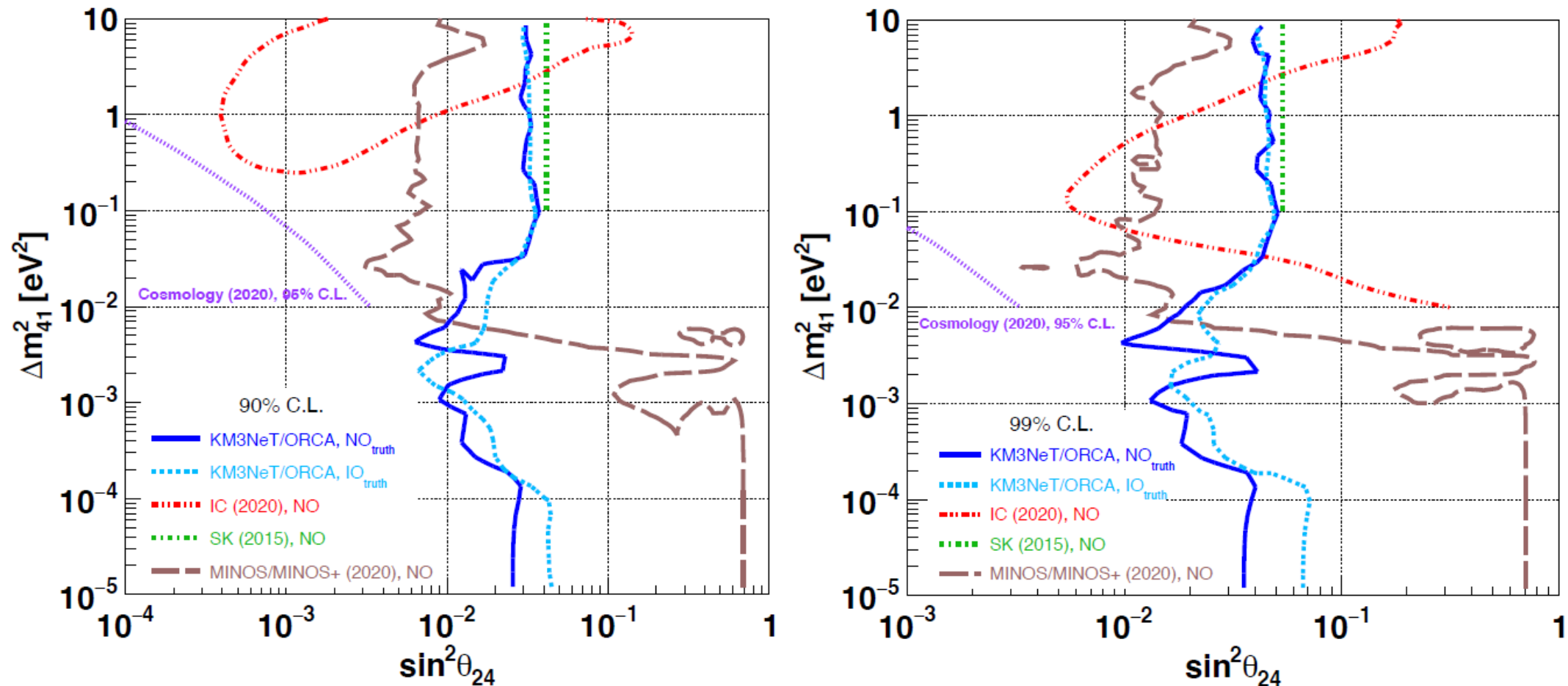


Sensitivity to NMO after 3 years of data taking, as a function of the true θ_{23} value, for NO and IO (right)

Sensitivity to NMO as a function of data taking time for both NO and IO (right).

arXiv: 2103.09885, submitted to EPJ

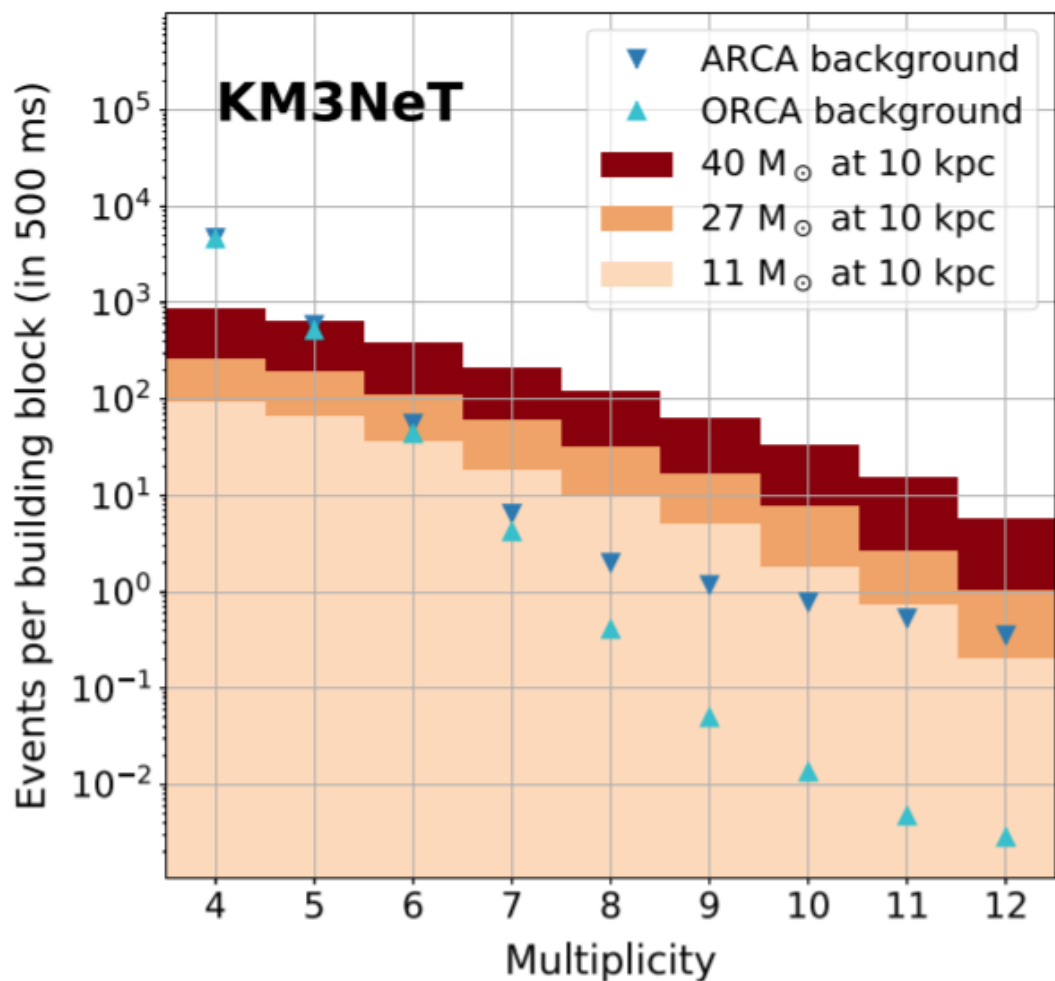
ORCA: Search for Sterile Neutrinos



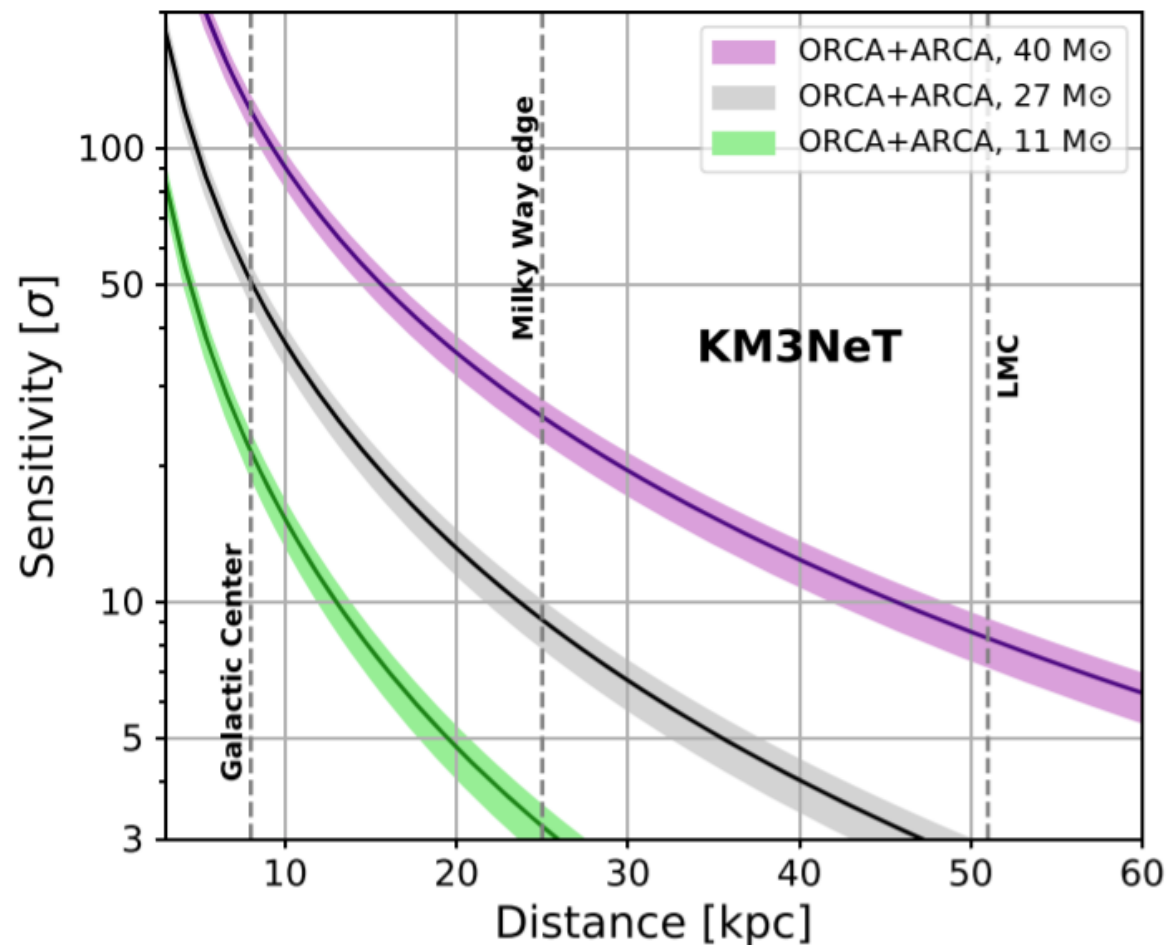
The 90% (left) and 99% C.L. (right) KM3NeT/ORCA sensitivity to the mixing parameter Θ_{24} , assuming 3 years of data taking. The excluded region is the one on the right of the lines.

arXiv: 2107.00344

Potential for the Next CCSN Observation with Neutrinos



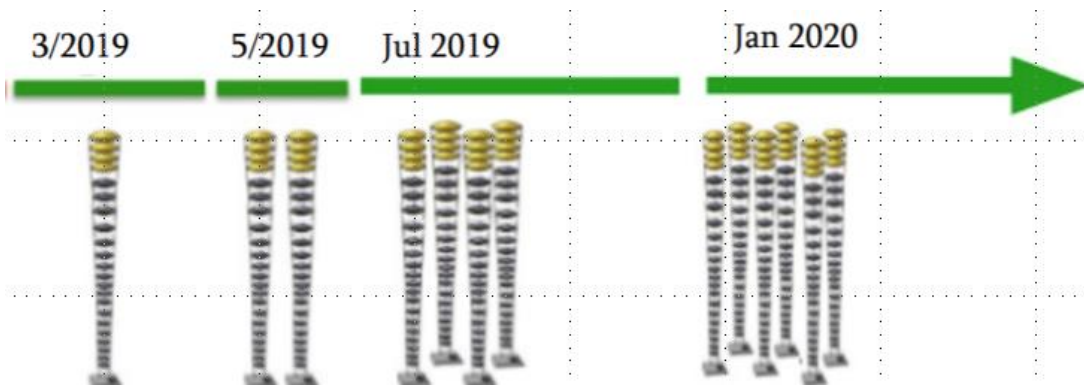
Expected events in a KM3NeT BB as a function of the multiplicity in KM3NeT/DOM.



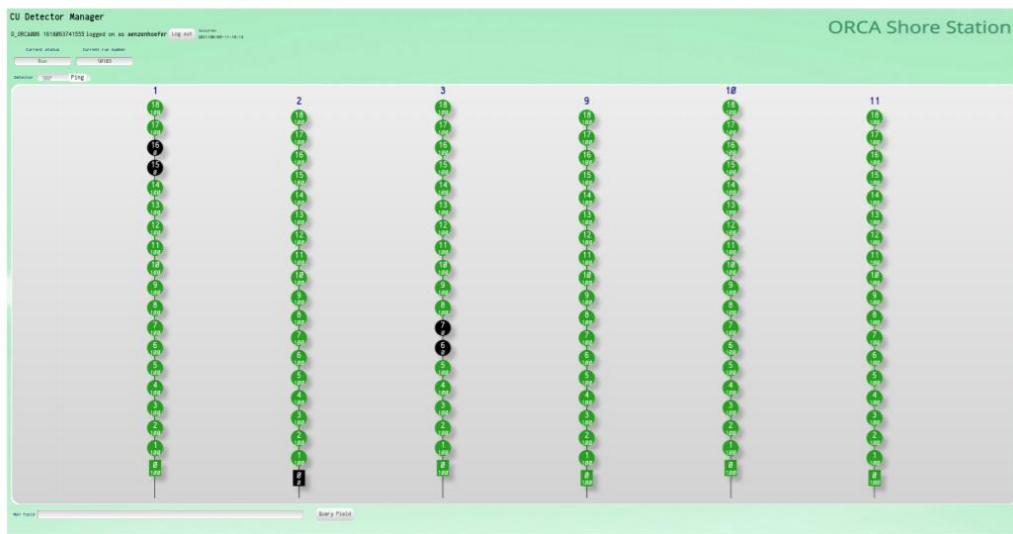
KM3NeT detection sensitivity as a function of the distance to the CCSN.

EPJ C81(2021), 445

Current Configuration: ORCA6

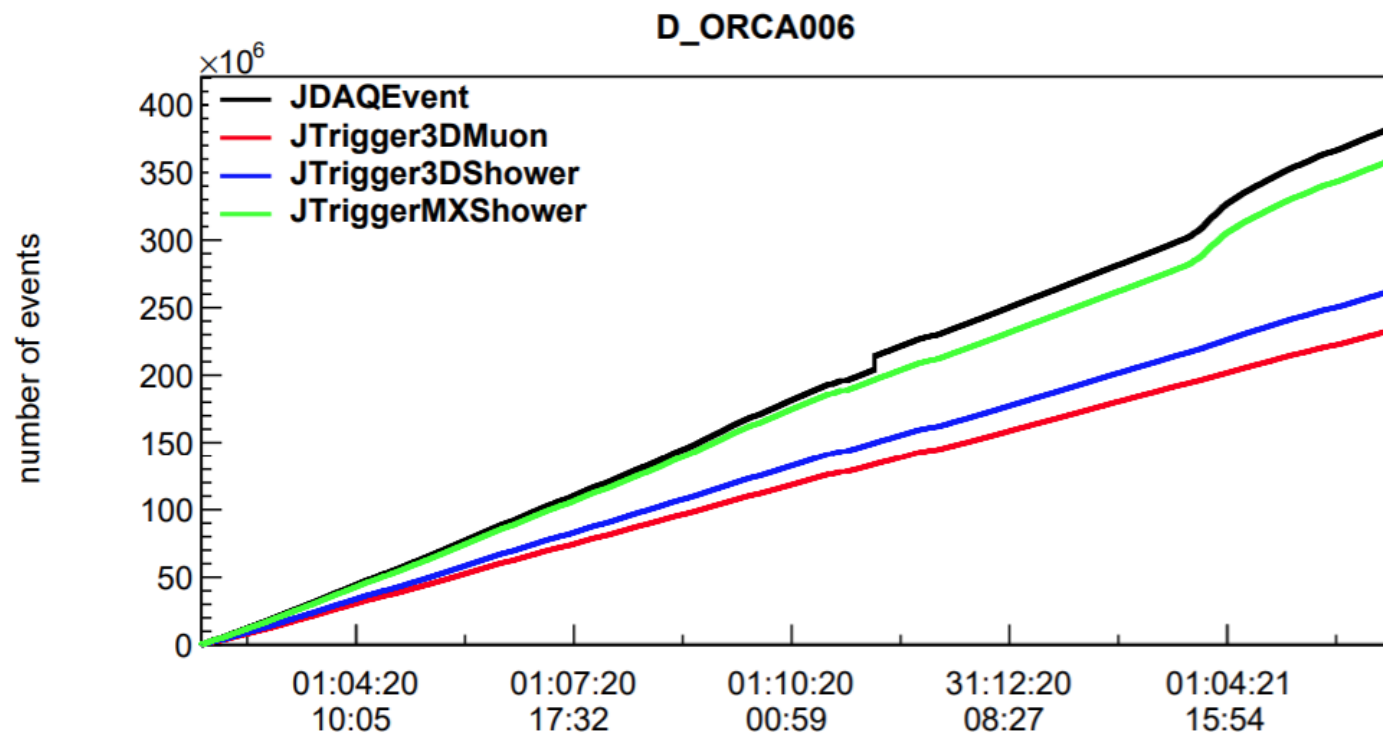


ORCA Status



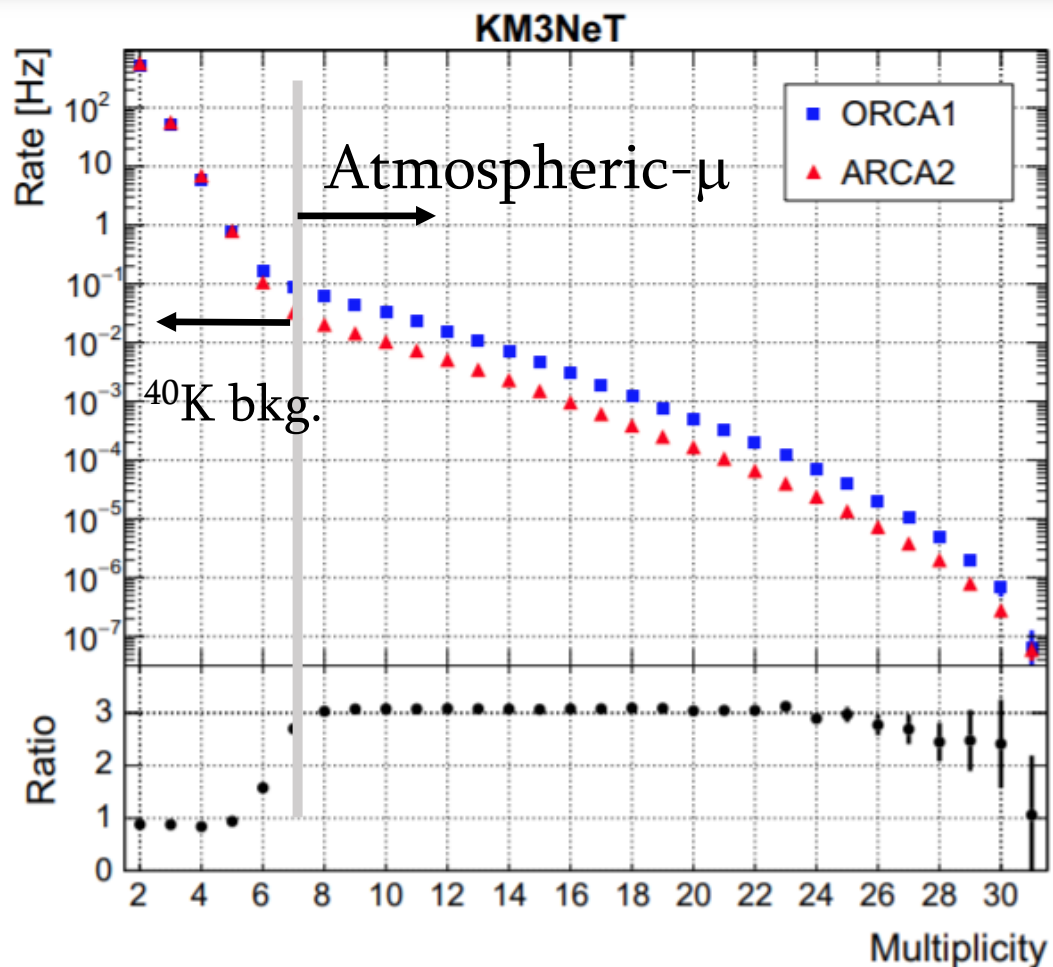
Since 27 January 2020, the ORCA detector is taking data with 6 DUs.

(First phase KM3NeT/ORCA is completed)

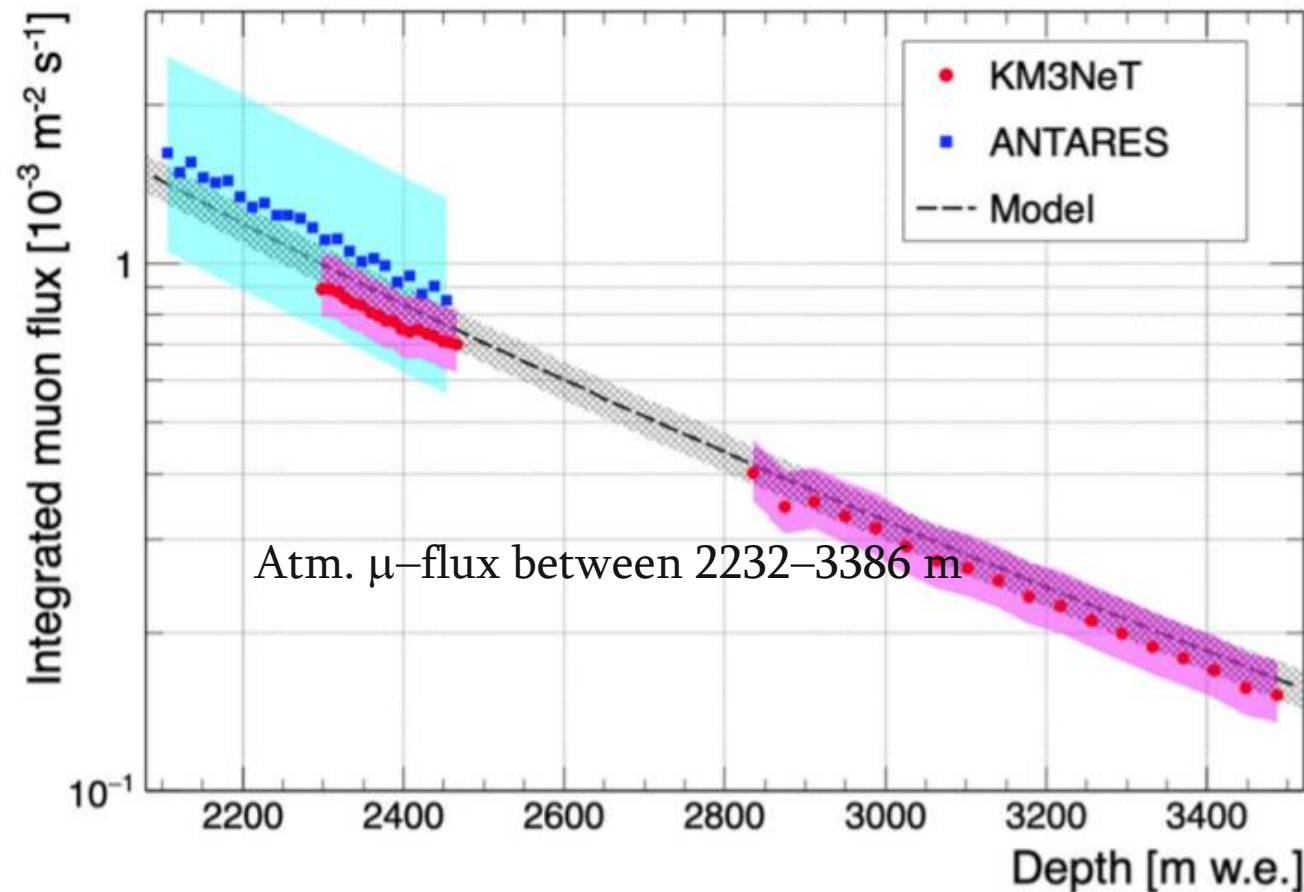


Data events (triggers) collected with ORCA6 detector

Muon Flux in the Deep-Sea



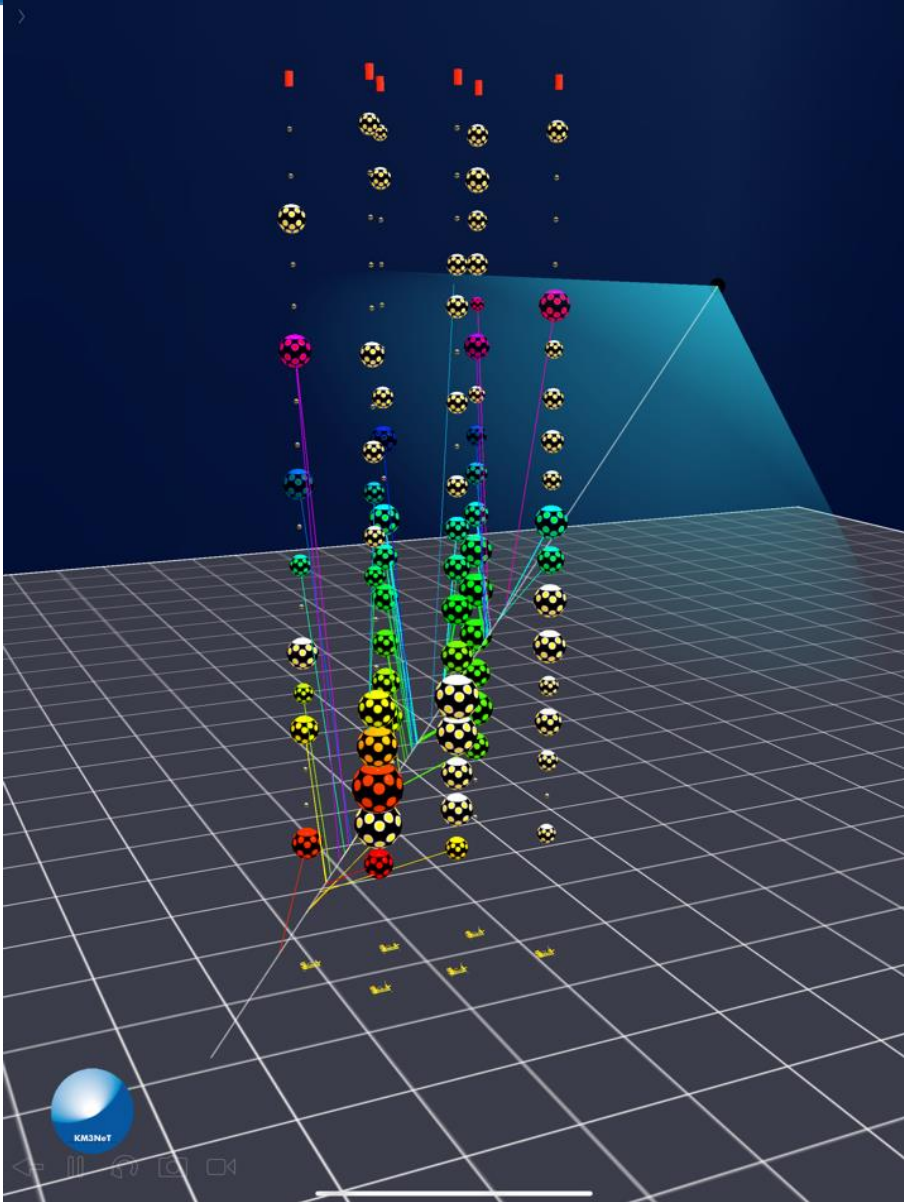
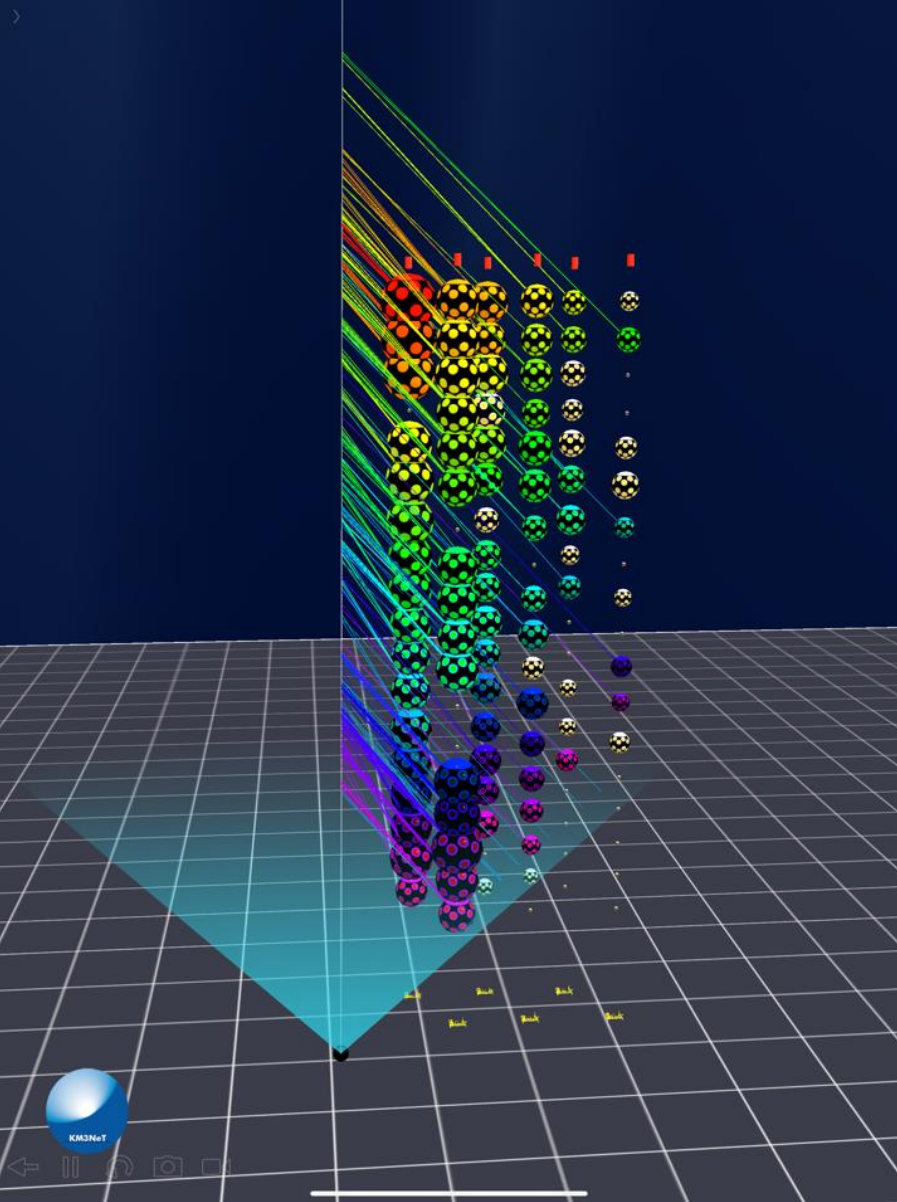
DOM coincidence rates as a function of the multiplicity for the ORCA1 and ARCA2 detectors averaged over all the DOMs .



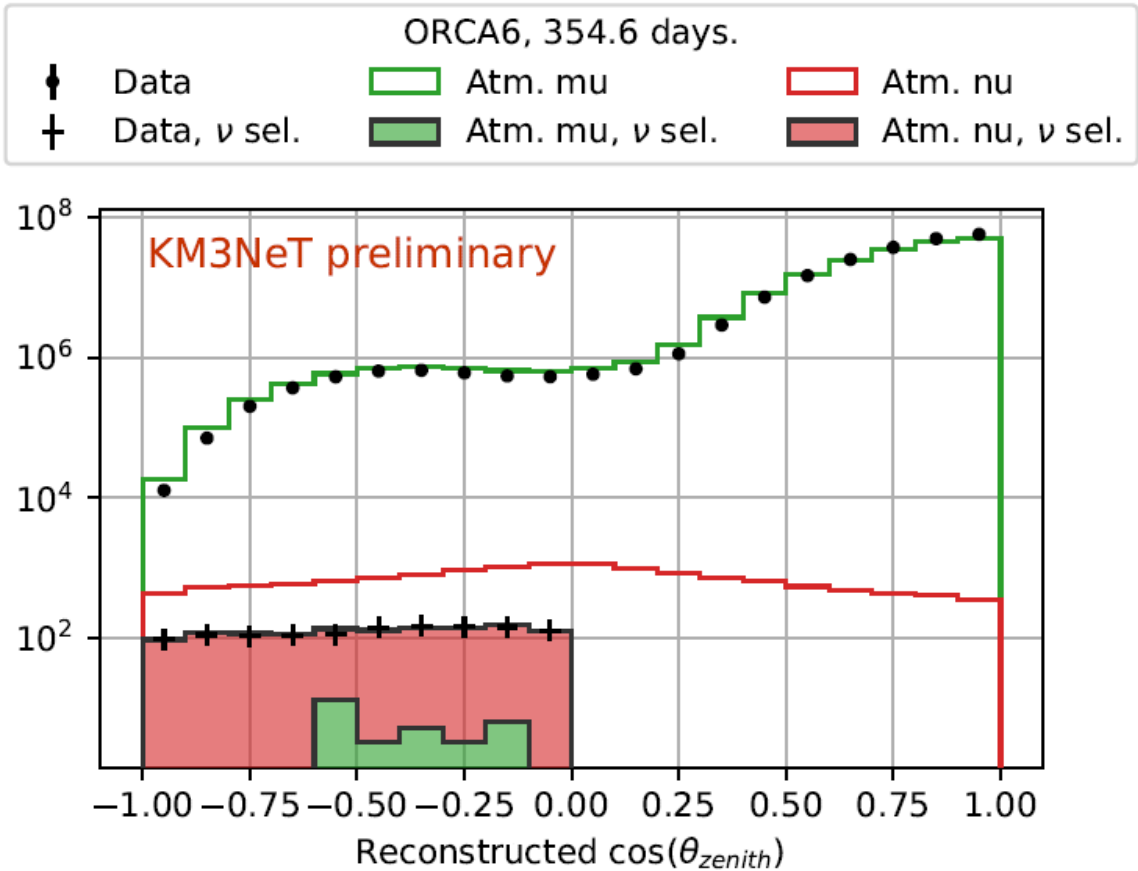
Integrated μ -flux measured with the ORCA1 and ARCA2 as a function of depth between 2232-3386m.
Dashed line – the model by Bugaev.

Eur. Phys. J. C (2020) 80:99

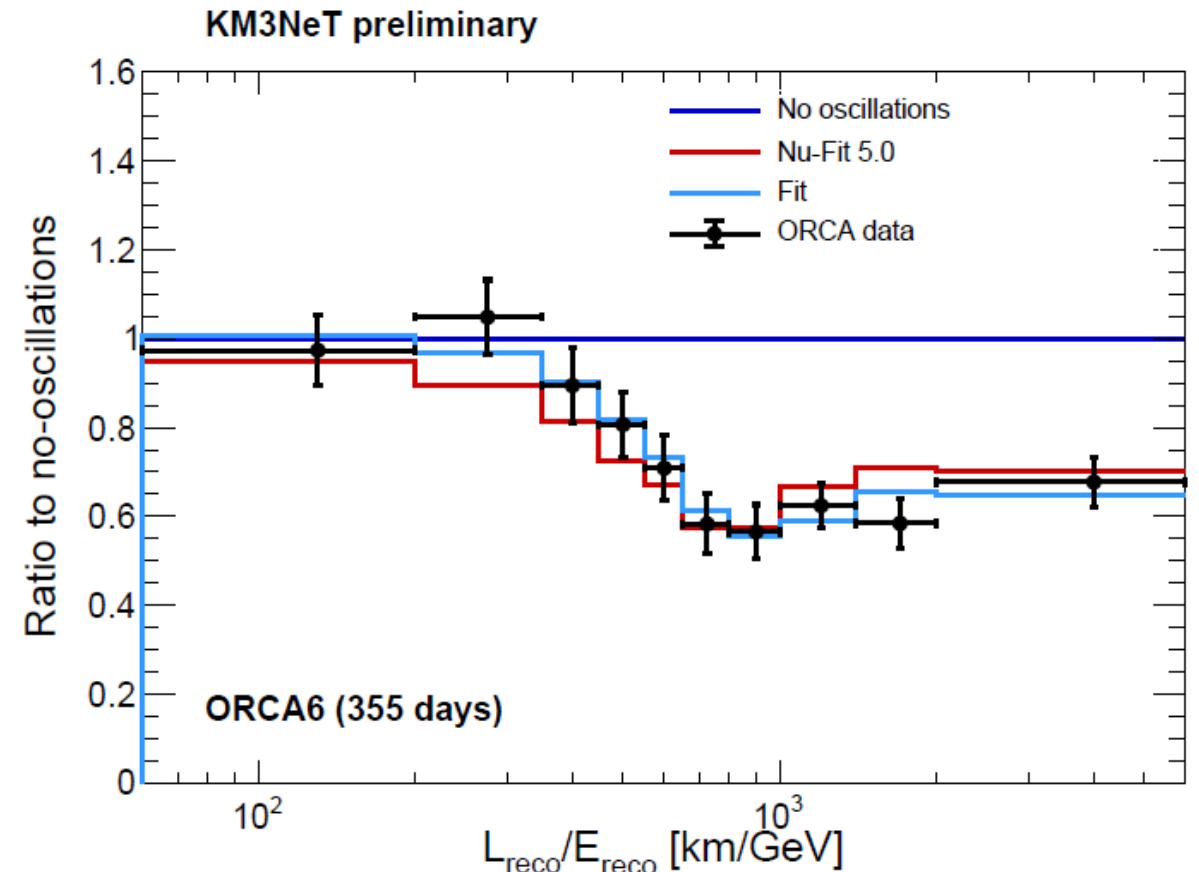
ORCA6: Muon and Neutrino Events



ORCA6: Neutrino Data and Observation of Oscillations

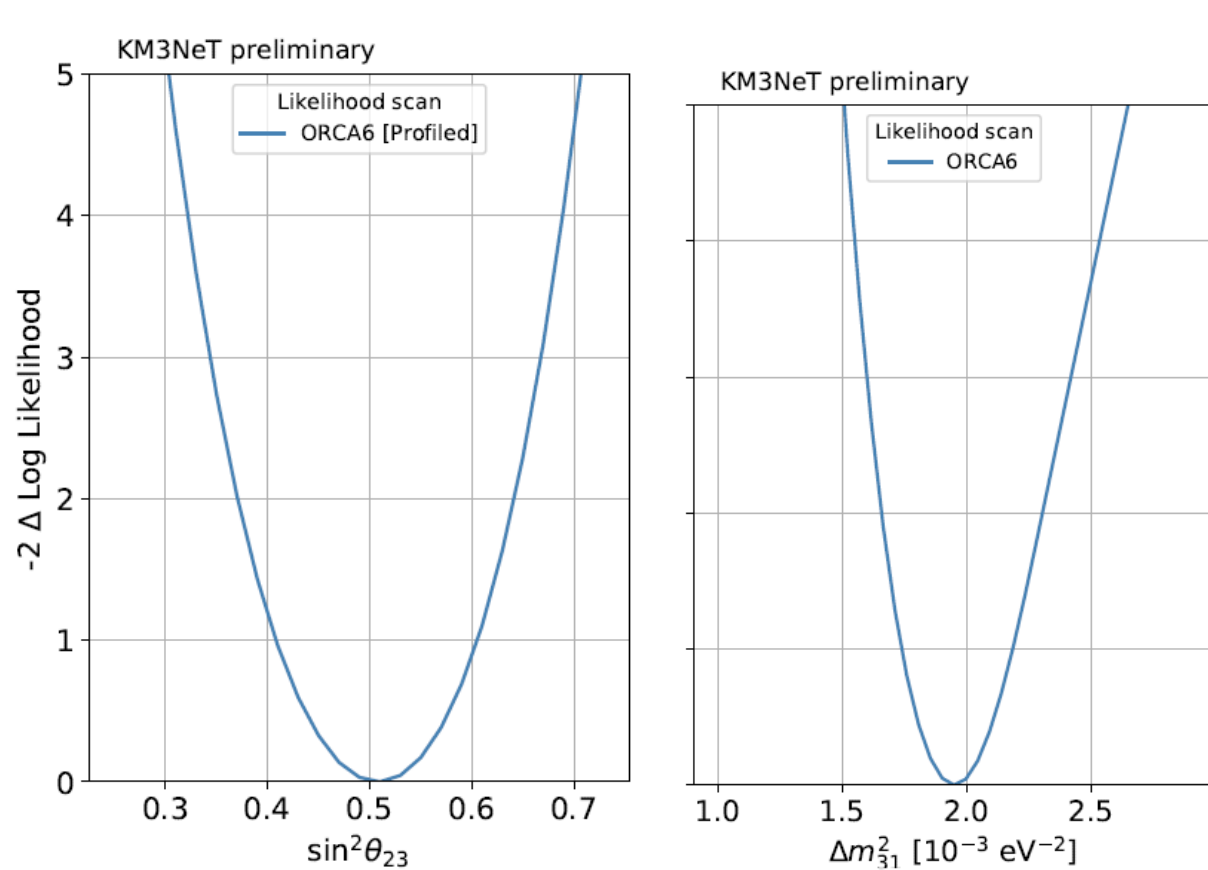


Distribution of the selected data and MC sets. The transparent and the opaque distributions are before and after applying the cuts.

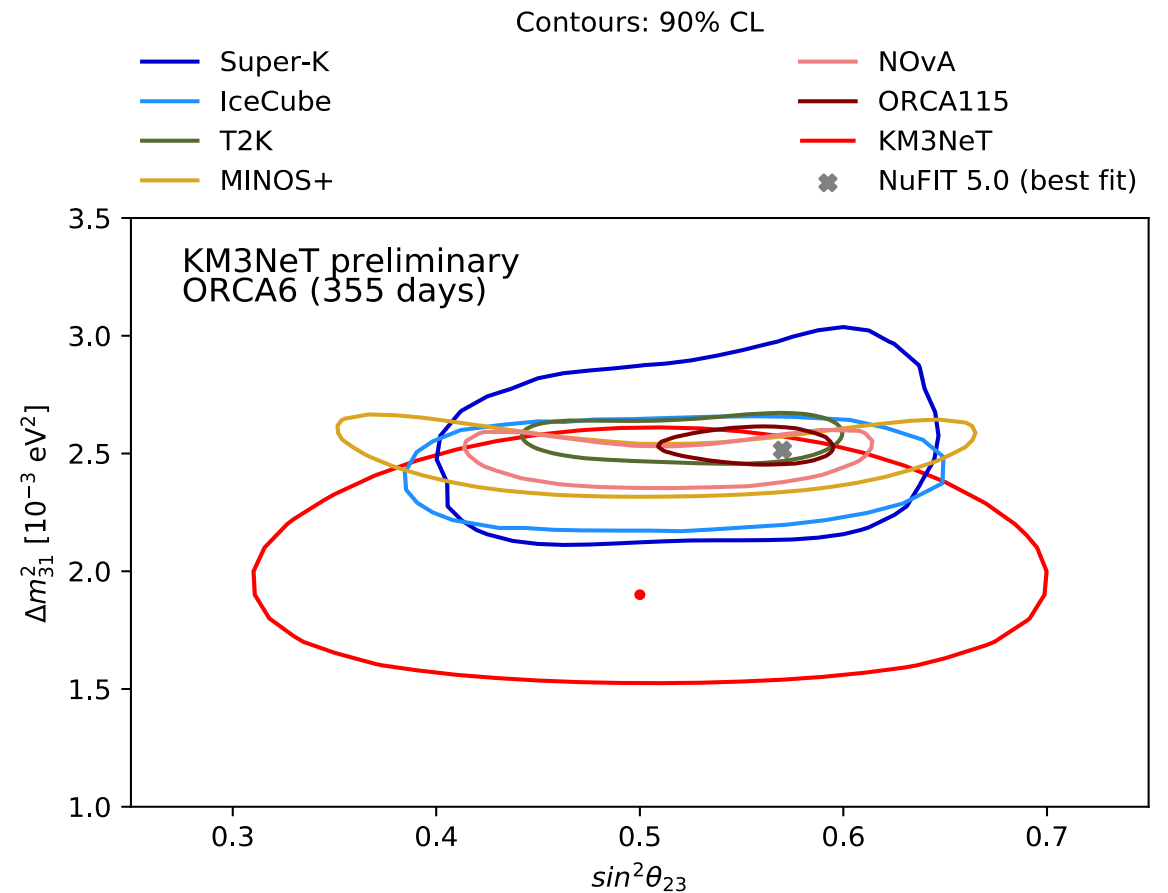


L/E distribution for the ORCA6 and expected number of events relative to the “no oscillation” hypothesis.

ORCA6 Oscillations: Preliminary Results



The profiled likelihood scan of $\sin^2\Theta_{23}$ (left) and m_{31}^2 (right).

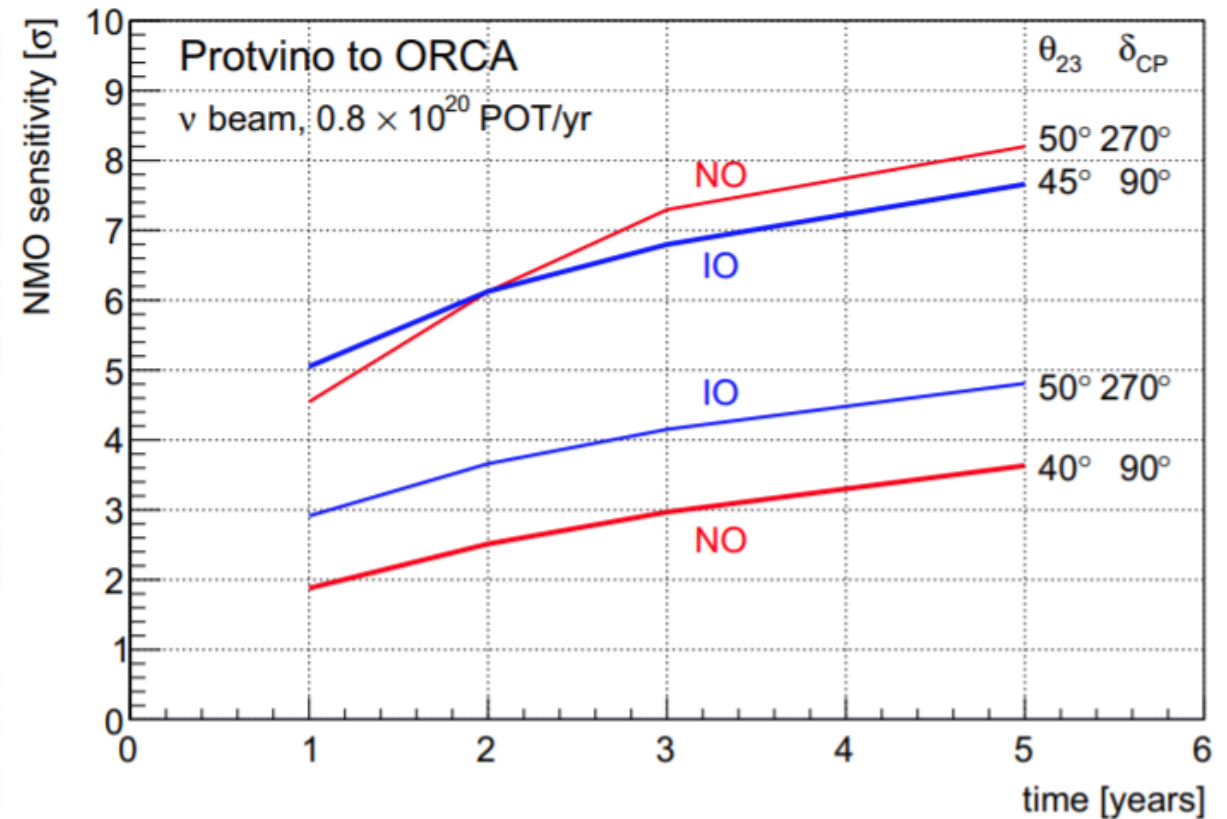


90% CL contour on the oscillation parameters $\sin^2\Theta_{23}$ and m_{31}^2 obtained from the ORCA6 data.

P2O: Protvino to ORCA



Neutrino beam from Protvino to ORCA. The path length is ≈ 2595 km and the deepest point is 135 km below sea level, in the upper mantle



Sensitivity of P2O as a function of the accumulated exposure time with the 90 kW beam. For NO and IO the most and the least favorable scenarios are shown.

*Eur.Phys.J.C*79 (2019) 9, 758

Summary and Outlook

- ✓ KM3NeT – a distributed research infrastructure with the neutrino detectors ARCA and ORCA is under construction in the Mediterranean sea.
- ✓ KM3NeT/ORCA (Oscillation Research with Cosmics in Abyss) is a detector to measure neutrino oscillations and neutrino mass ordering (NMO) with the atmospheric neutrinos.
- ✓ KM3NeT/ORCA is currently taking data with 6 DUs. Preliminary results on oscillation parameters are obtained with the ORCA6 data.
- ✓ Final KM3NeT/ORCA configuration with 115 DUs is expected for 2025.