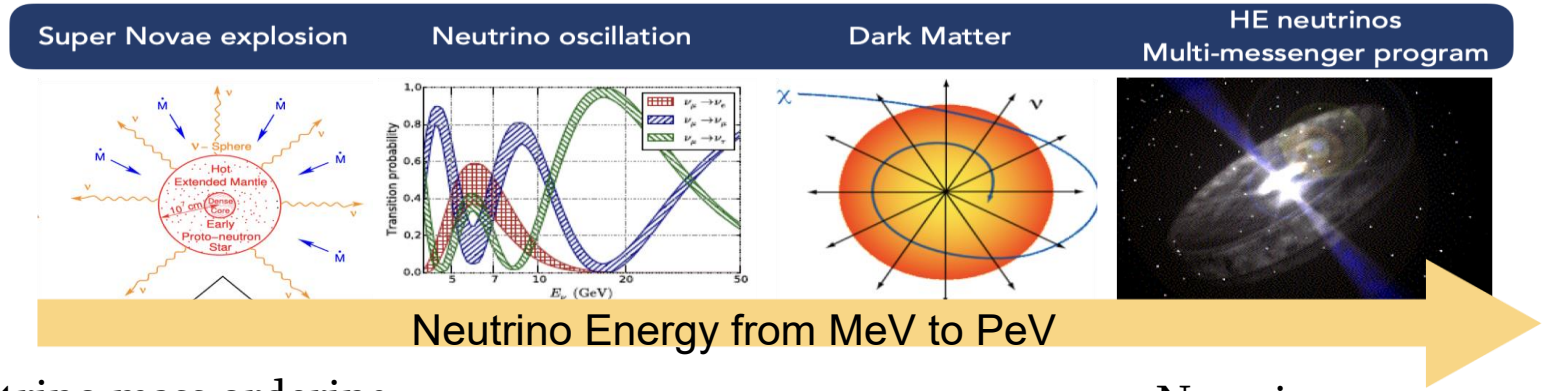
Status and Recent Results from the KM3NeT Neutrino Telescope

Gogita Papalashvili
INFN - Sezione di Bari, Italy

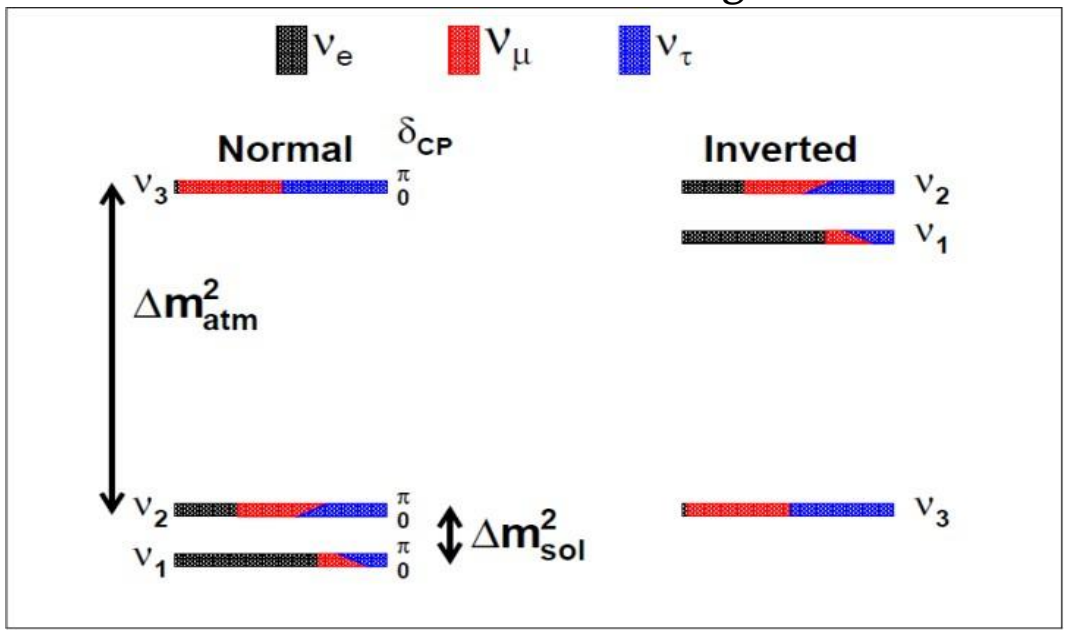
on behalf of the
KM3NeT Collaboration

Neutrino Physics and Astrophysics with KM3NeT

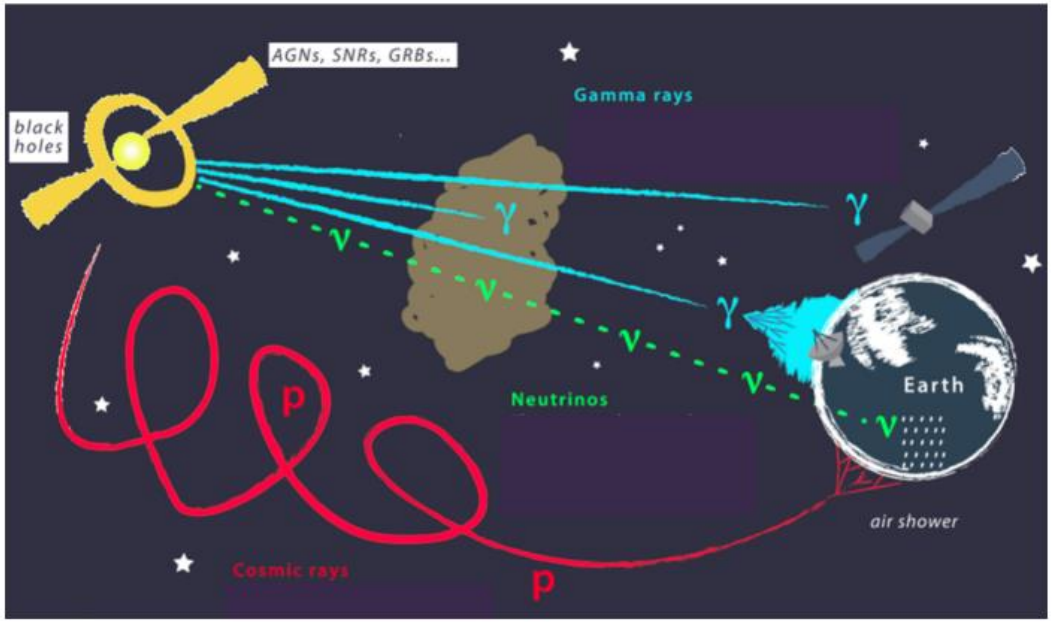
KM3NeT – **C**ubic **K**ilometre **N**eutrino **T**elescope;
Underwater Neutrino telescope located in the depths of Mediterranean Sea



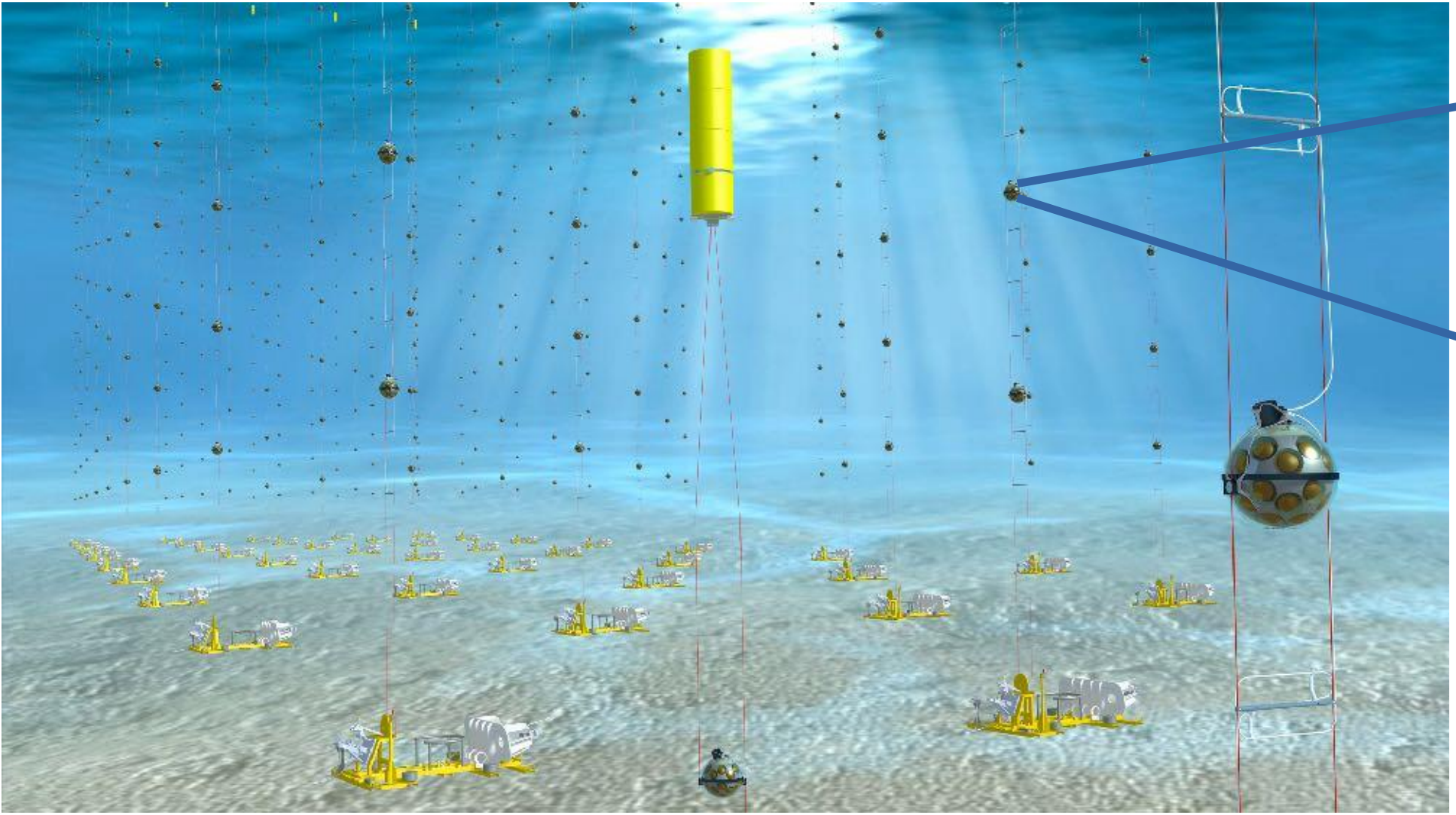
Neutrino mass ordering



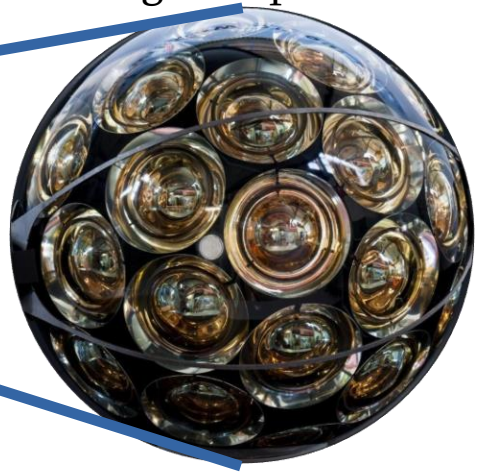
Neutrino astronomy



KM3NeT Telescope



DOM – Digital Optical Module



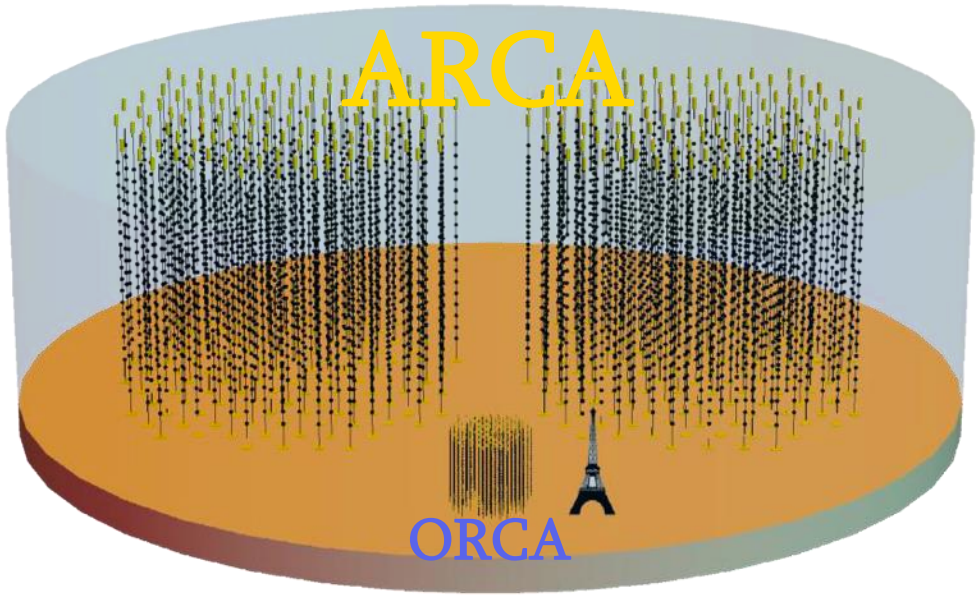
31 x 3-inch PMTs

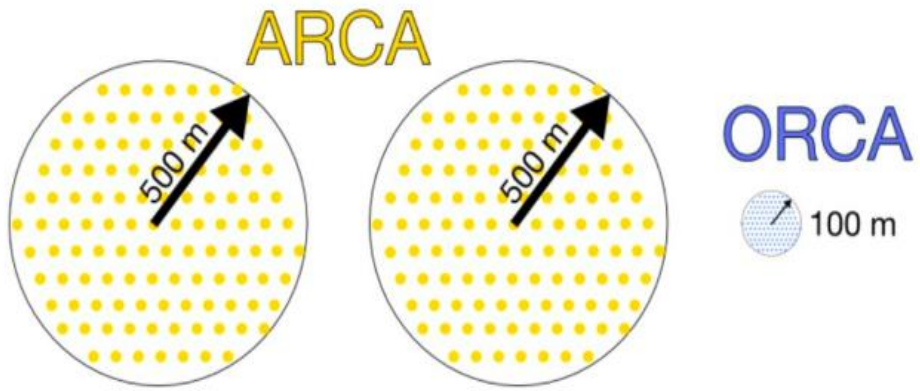
JINST 17 P07038

KM3NeT/ARCA and KM3NeT/ORCA Telescopes

ARCA – Astroparticle Research with Cosmics in the Abyss

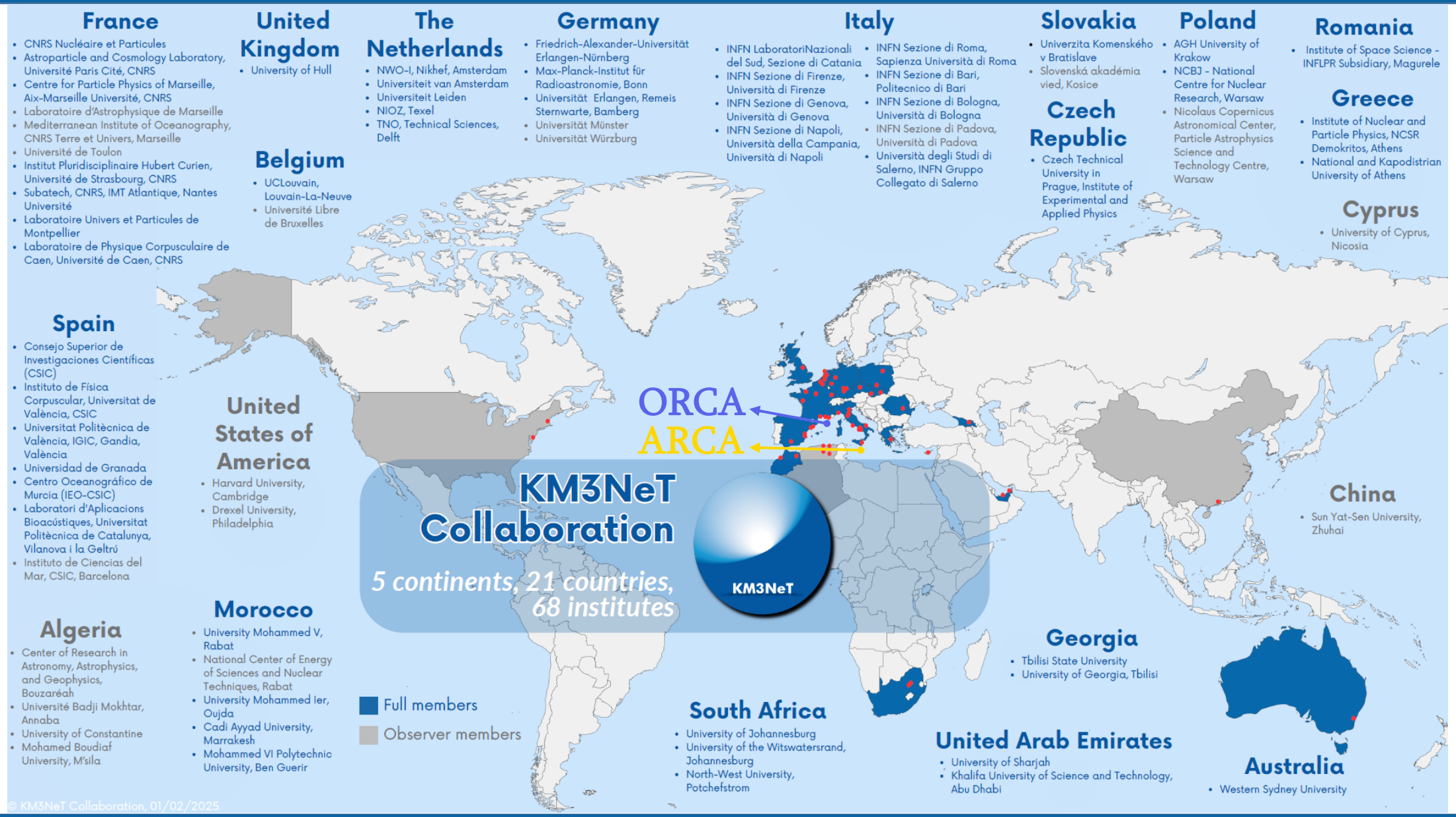
ORCA - Oscillation Research with Cosmics in the Abyss



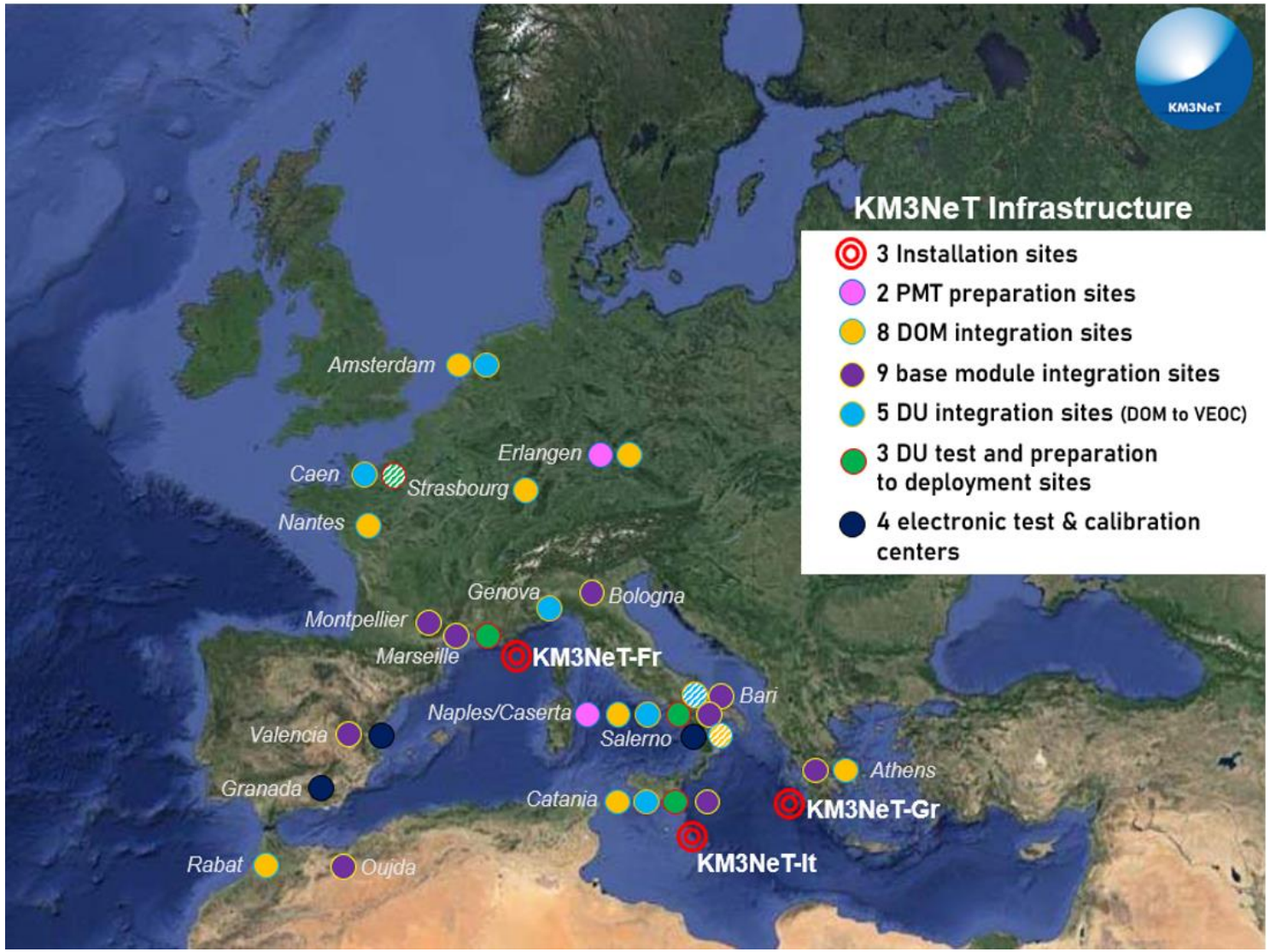


Detector	Depth	Horizontal Spacing	Vertical Spacing	Detection units	Volume	Designed energy range
ARCA	~3500 m	90 m	36 m	2 x 115	~1 Gton	TeV–PeV
ORCA	~2500 m	20 m	9 m	115	~7 Mton	GeV

KM3NeT Collaboration



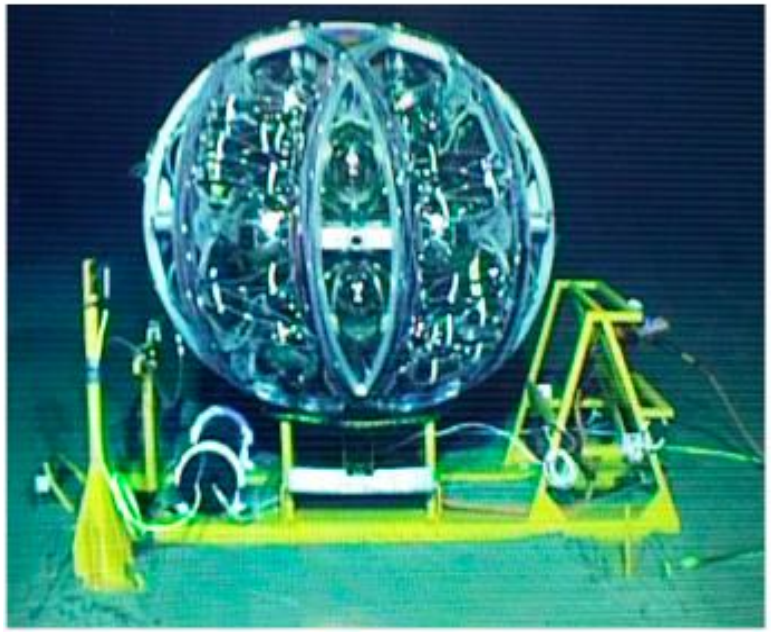
KM3NeT Sites



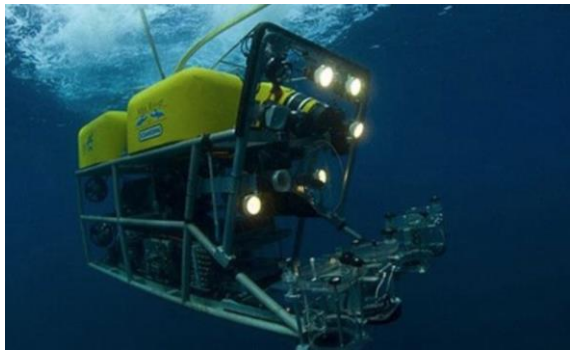
KM3NeT Detection Unit Deployment

LOM - Launcher of Optical Modules

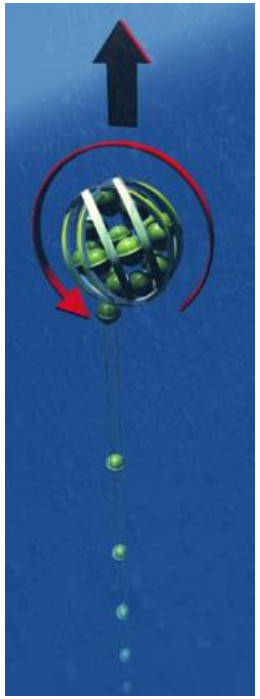
LOM on the Seabed



ROV - remotely operated vehicle is used for connecting DU to the junction box

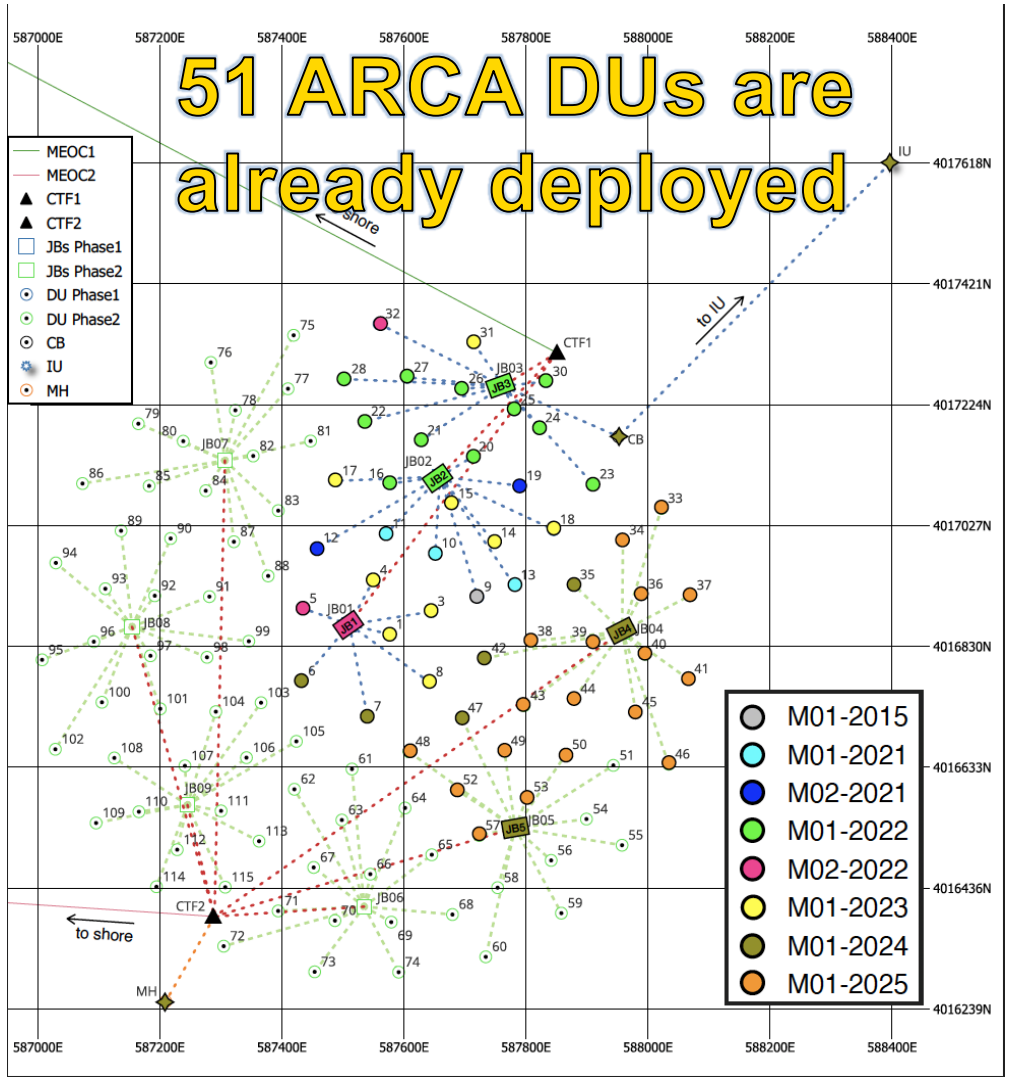


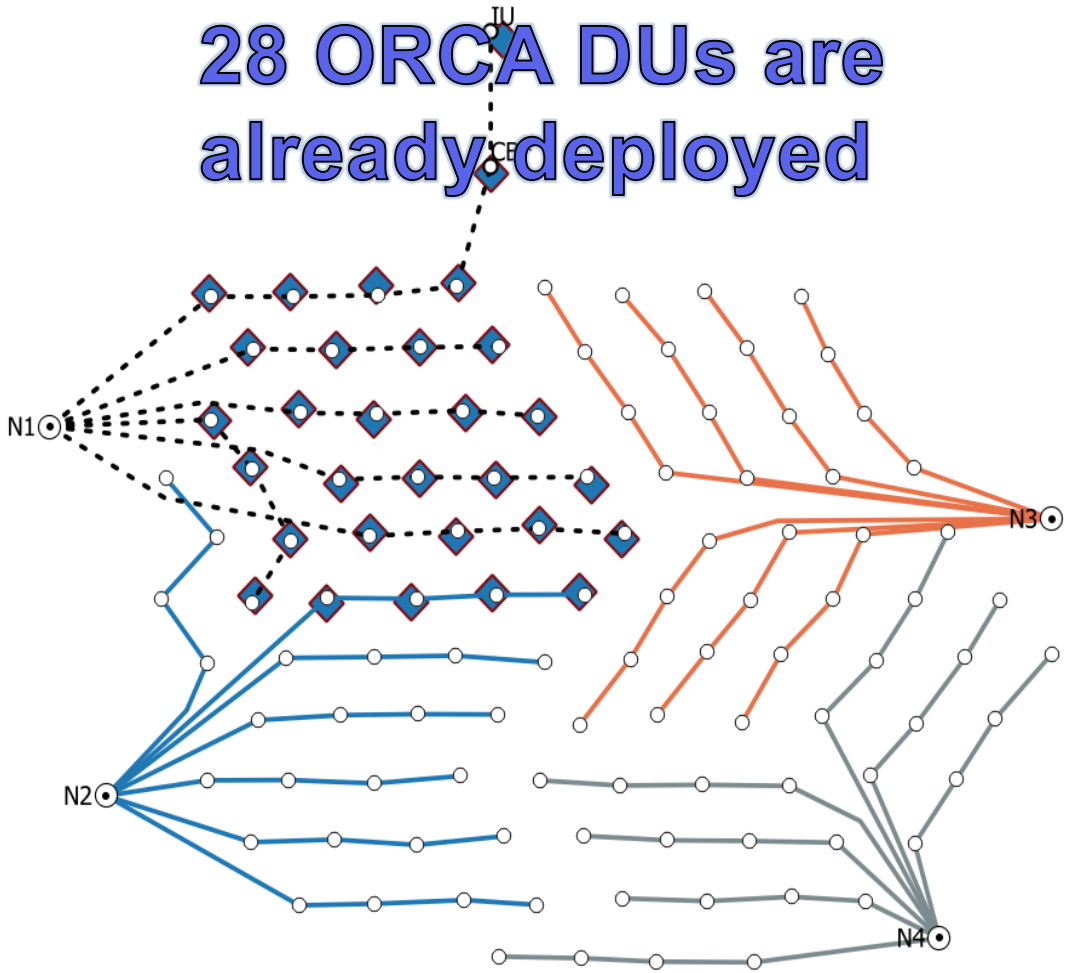
DU is unfurled; LOM is recover-ed and reused



JINST 15 P11027

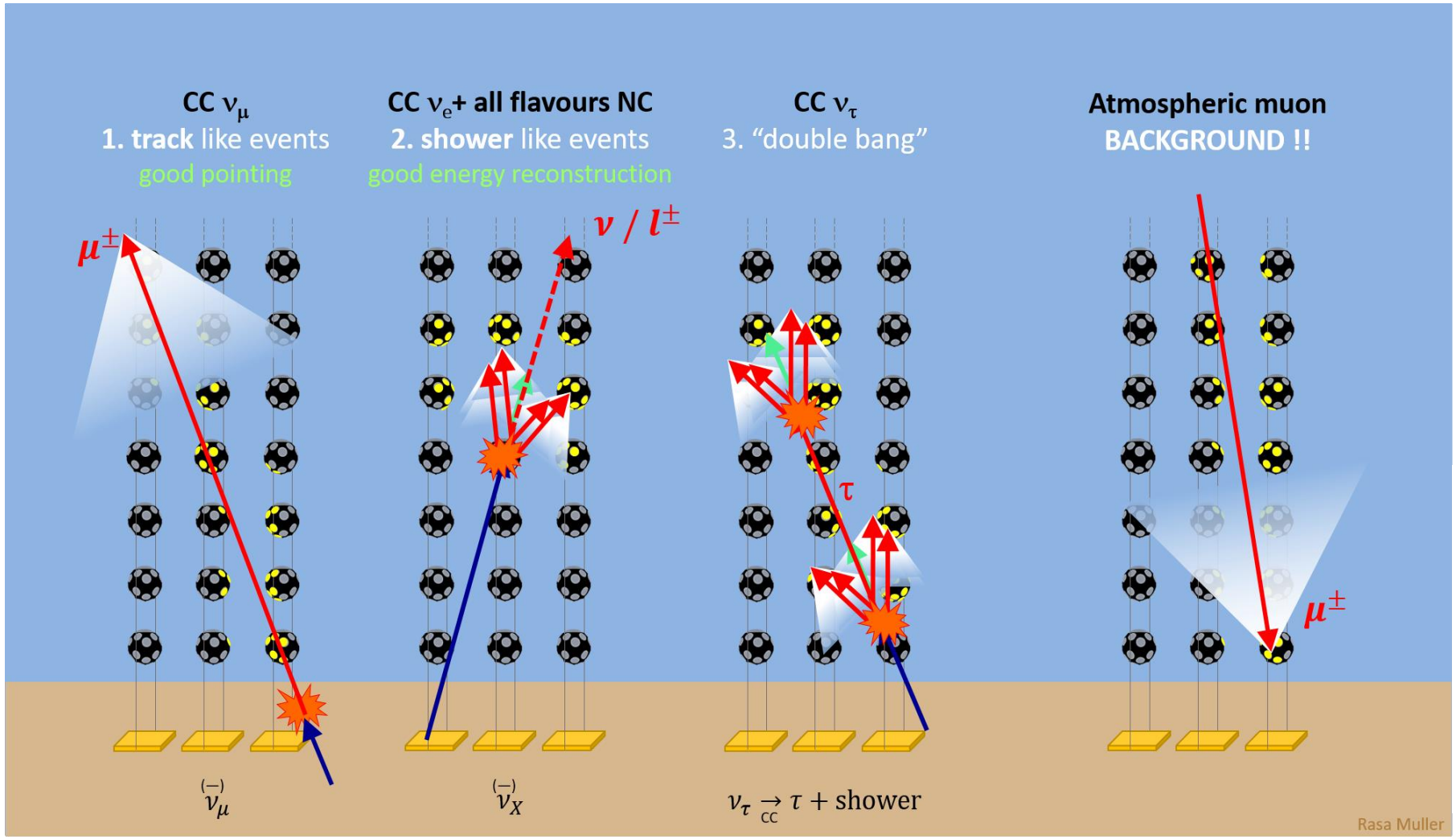
Construction Status

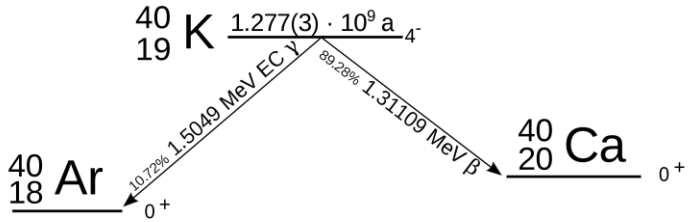




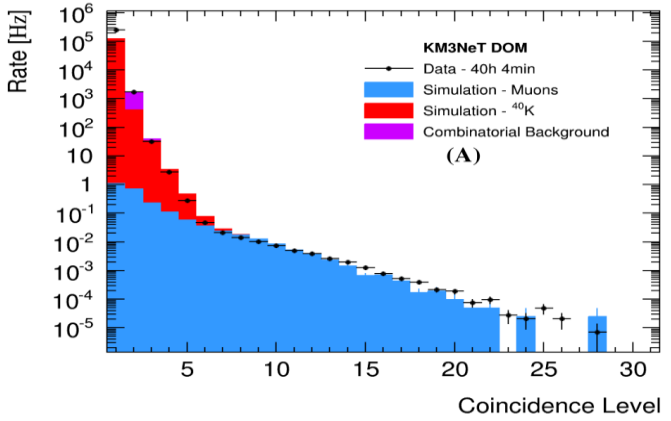
Construction of both ARCA and ORCA detectors is expected to be completed by 2030

KM3NeT Events



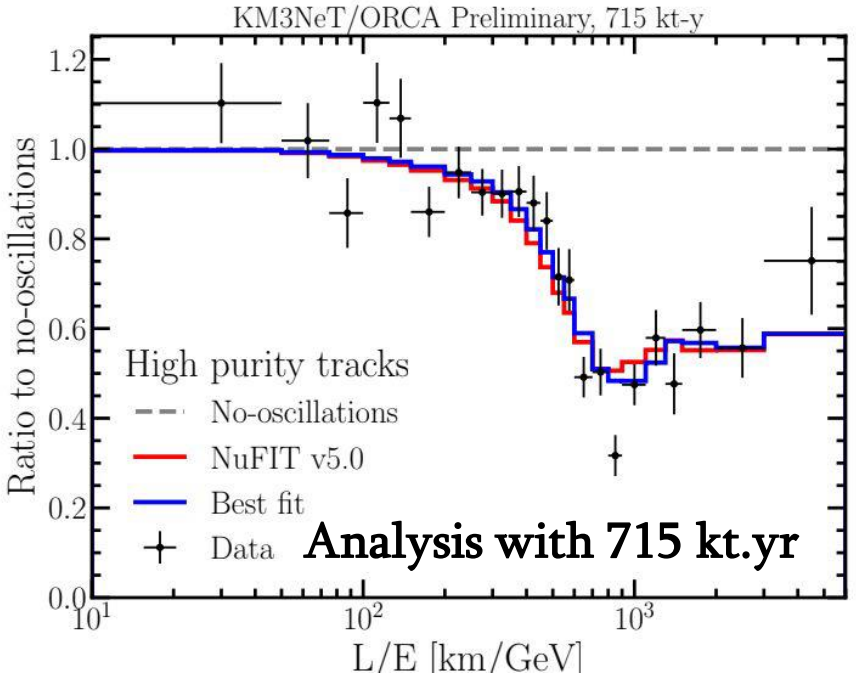


~7 kHz background hits per PMT induced by ^{40}K beta decays in seawater. Discarded thanks to the multi-PMT design of the DOMs.

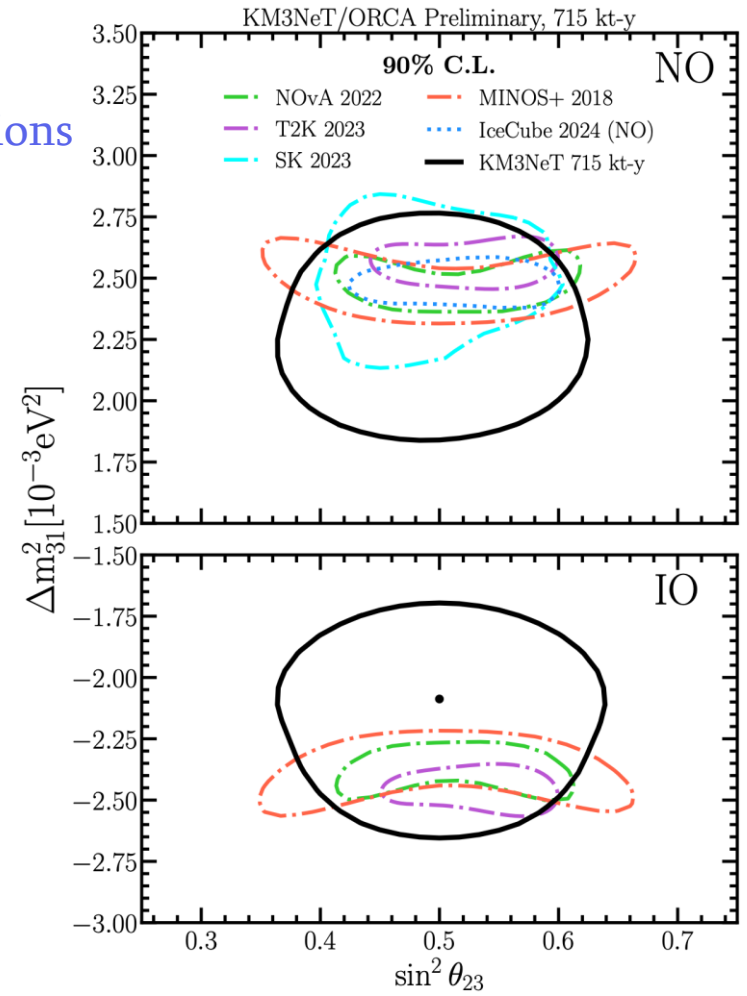


Neutrino Physics with KM3NeT/ORCA

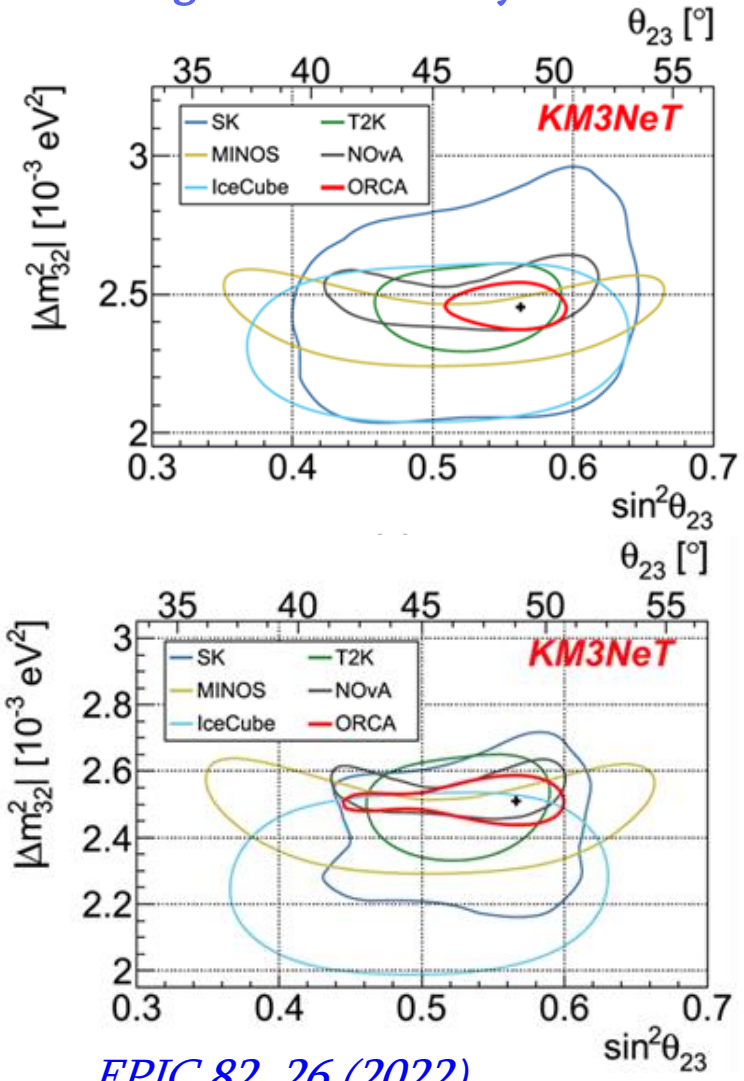
Oscillation vs no oscillation hypotheses with data from ORCA 6, 10 and 11 DU configurations



Analysis with 715 kt.yr



Expected sensitivity for ORCA full configuration with 3 years of data



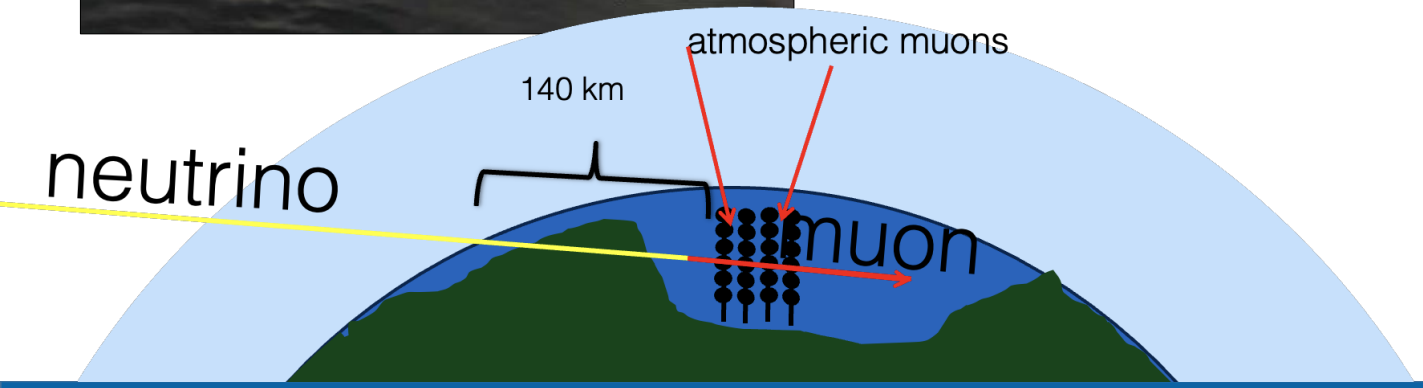
JHEP 10 (2024) 206

EPJC 82, 26 (2022)

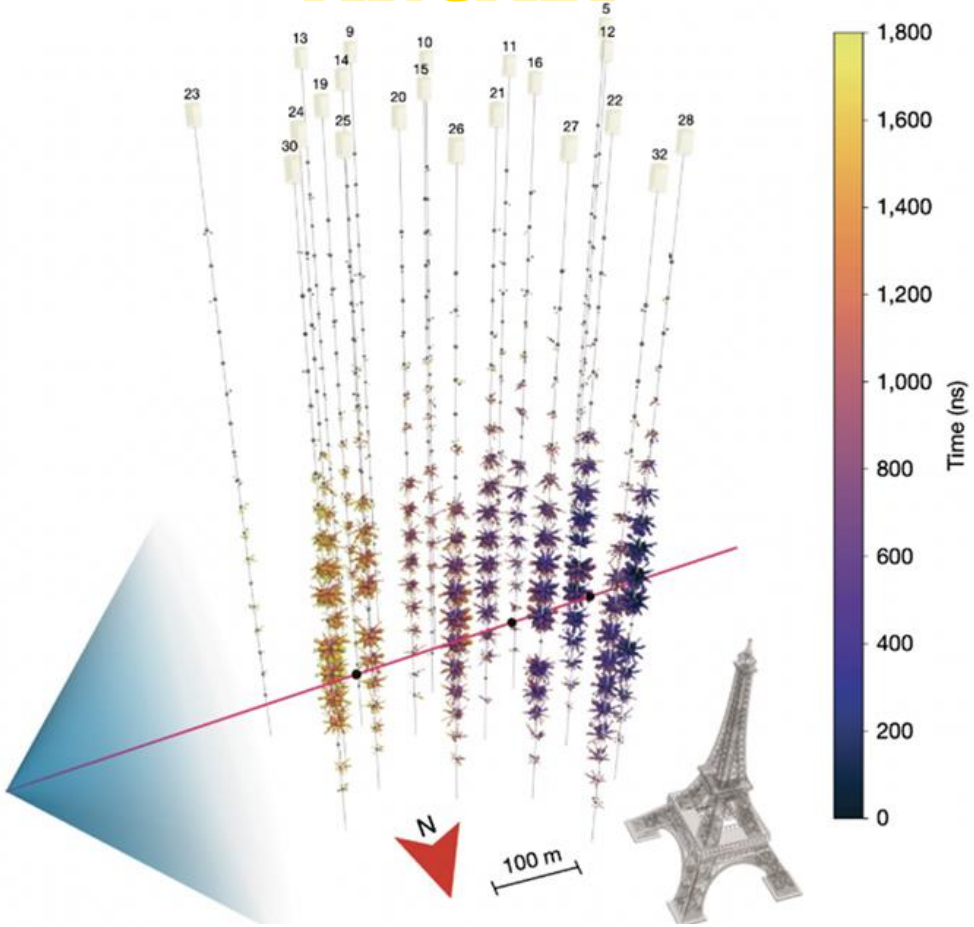
Highest ever energy neutrino detected with ARCA!

KM3-230213A

- Detected on February 13, 2023 at 01:16:47 UTC.
- 28086 hits, 3672 PMTs triggered - 1/3 of ARCA21
- **Highest energy neutrino ever recorded!**



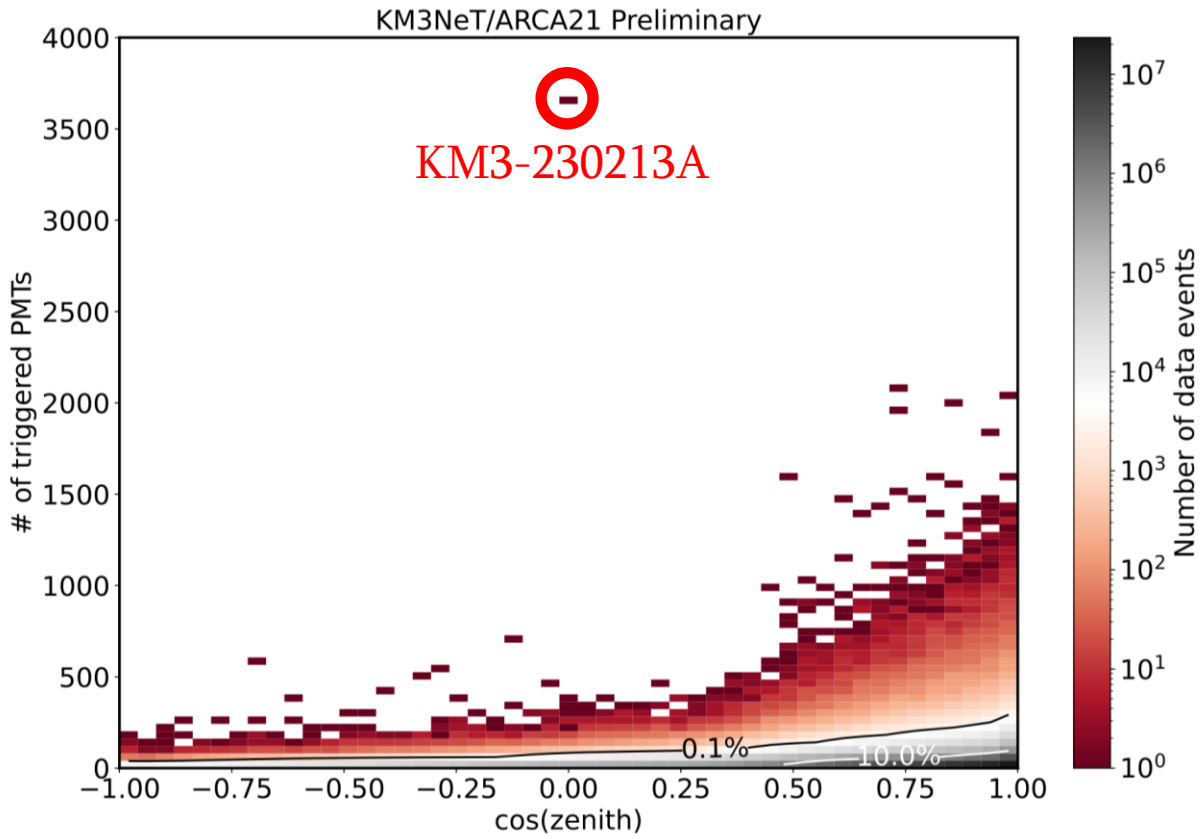
ARCA21



Nature 638, 376–382 (2025)

KM3-230213A Ultra-High-Energy Event

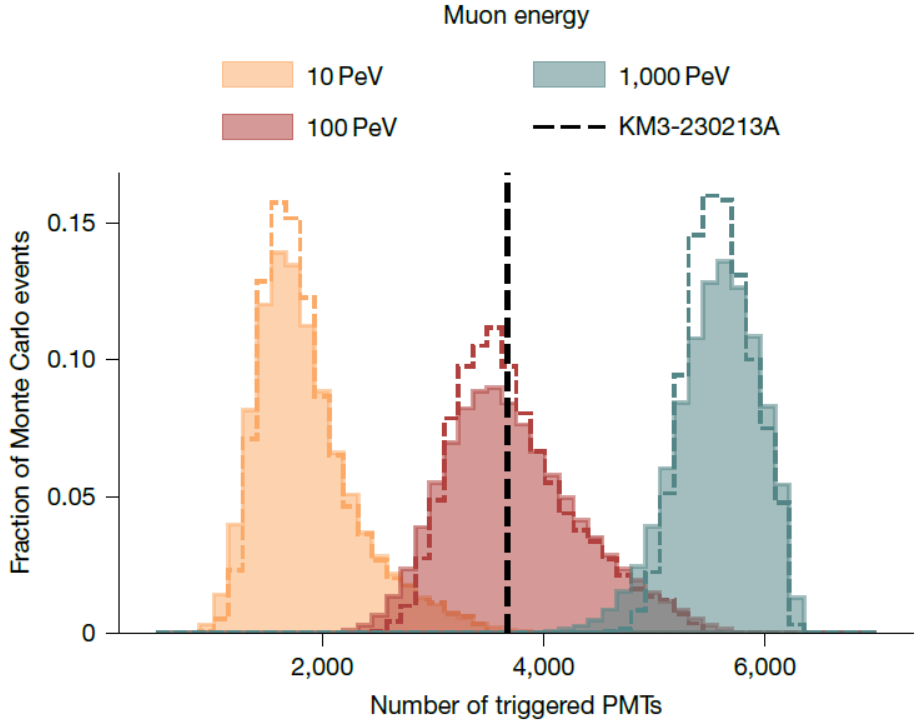
One in ~~a million~~ ~100 million of ARCA21 events!



Highest energy neutrino ever observed

$$E_\mu = 120^{+110}_{-60}\ \text{PeV} \qquad E_\nu = 220^{+570}_{-100}\ \text{PeV}$$

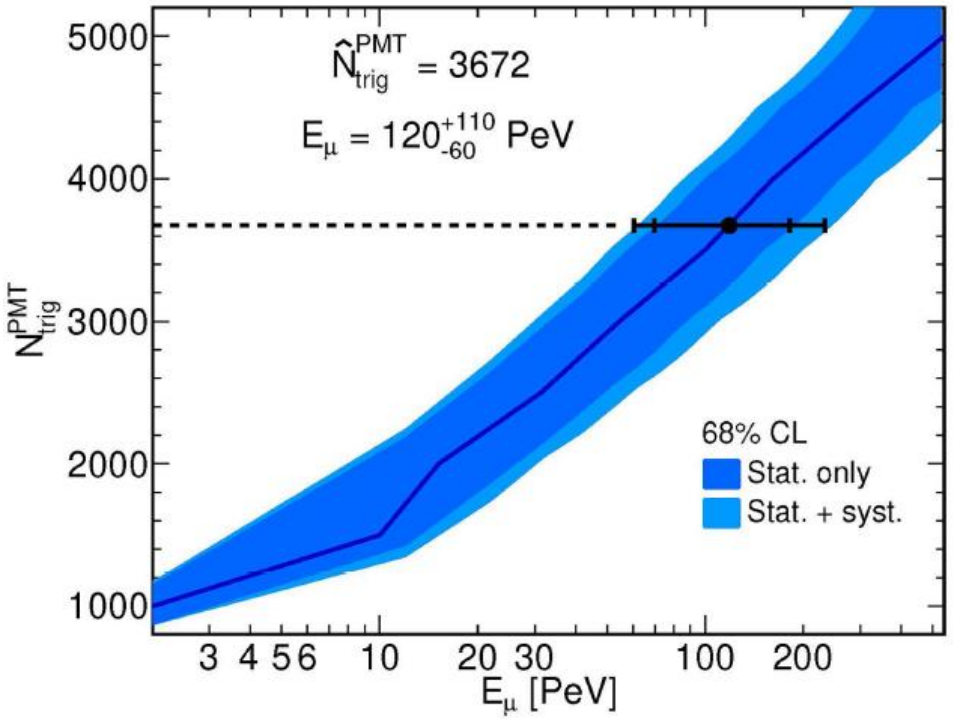
MC studies for energy estimations



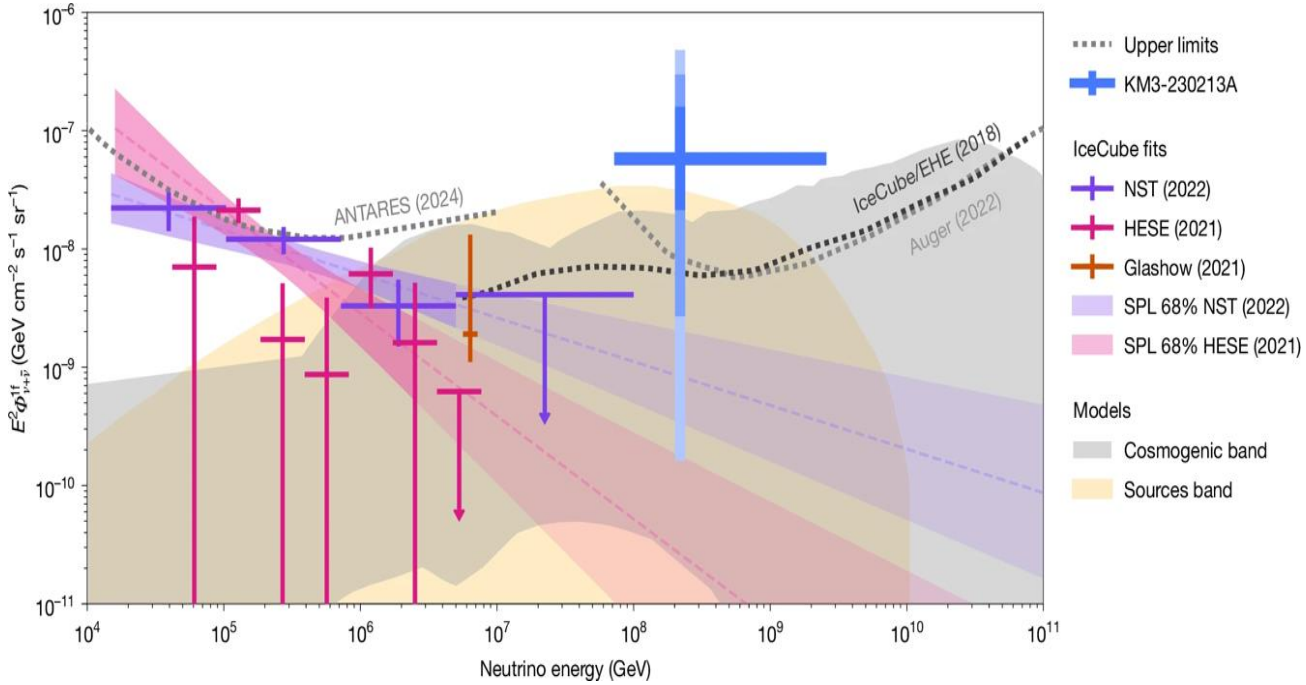
KM3-230213A Ultra-High-Energy Event

One in ~~a million~~ ~100 million of ARCA21 events!

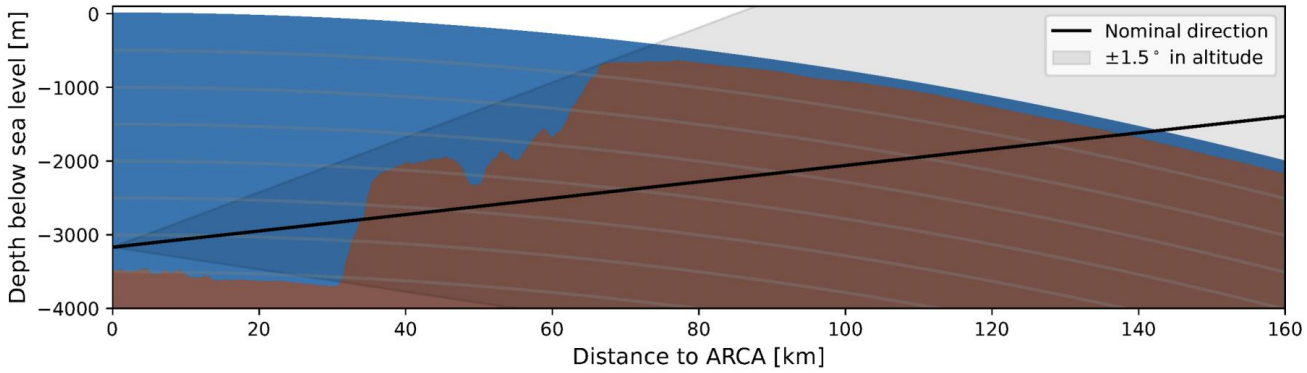
$E_\mu = 120^{+110}_{-60}$ PeV $E_\nu = 220^{+570}_{-100}$ PeV



Highest energy neutrino ever observed



KM3-230213A Direction

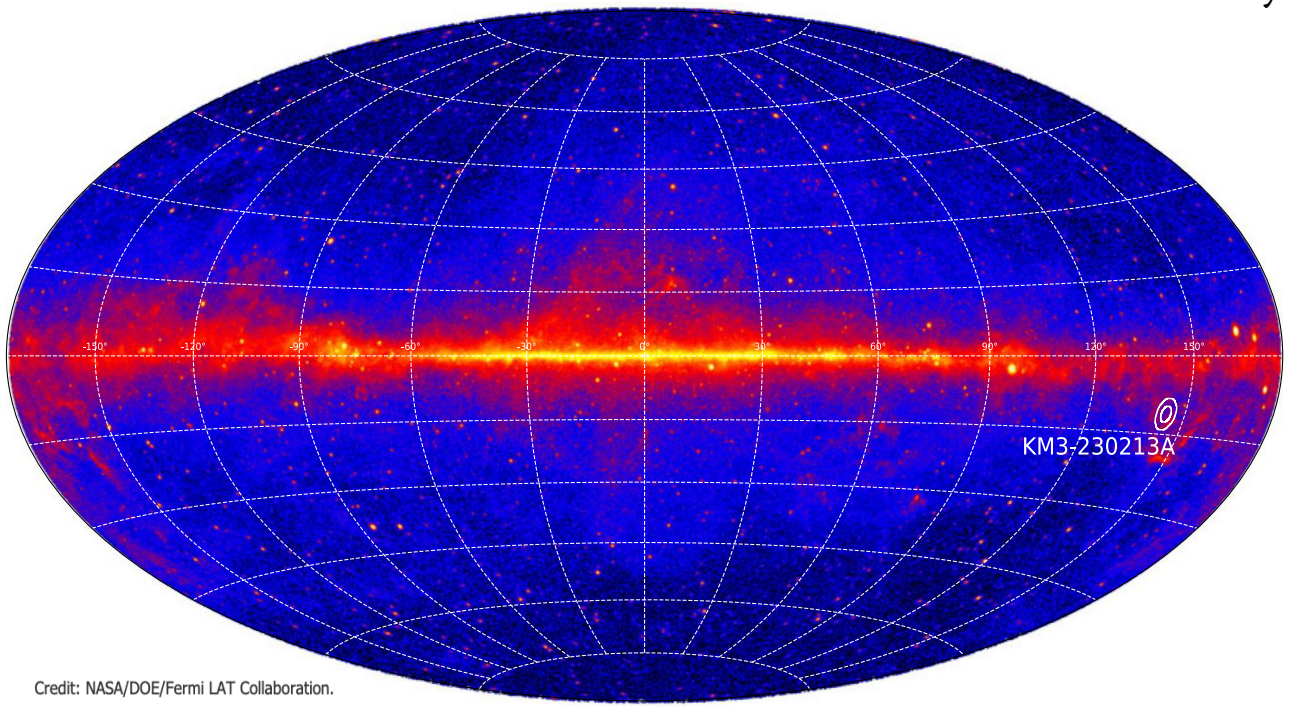


Local coordinates: (**zenith, azimuth**) = **89.4°**, **259.8°**;
Almost horizontal - **0.6°** above the horizon.

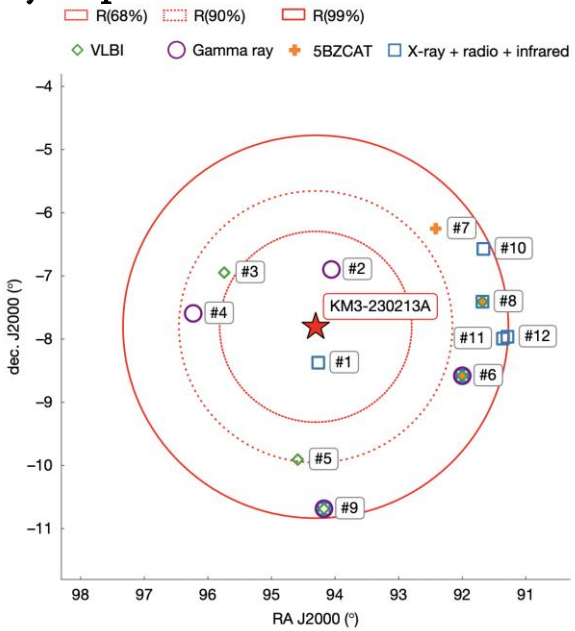
Equatorial coordinates : **RA 94.3°; Dec: –7.8°**

Containment radii: **R(68%)=1.5°, R(99%)=3.0°**

Recalibration with the recently installed new positioning system will allow us to improve the direction estimate.

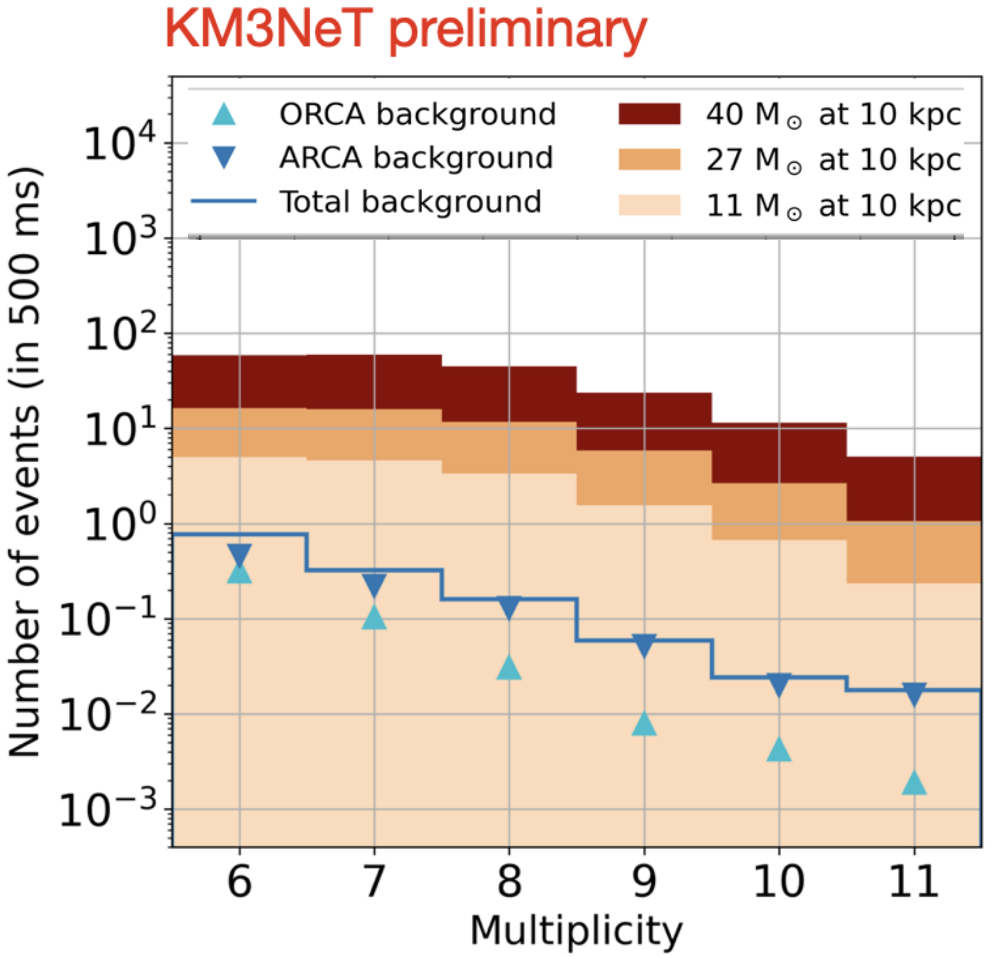


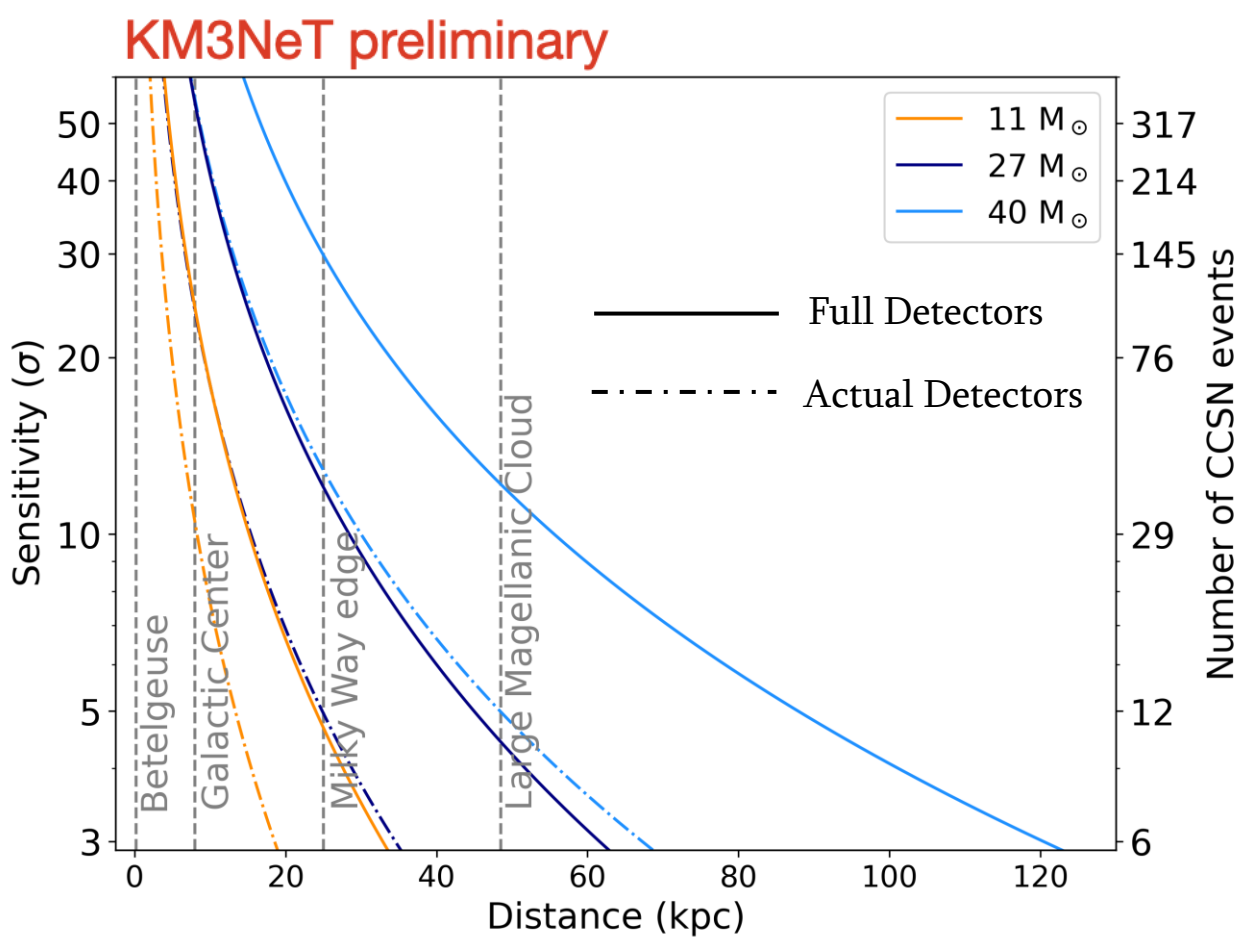
Sky map in the direction of KM3-230213A



Core Collapse Supernovae detection capabilities

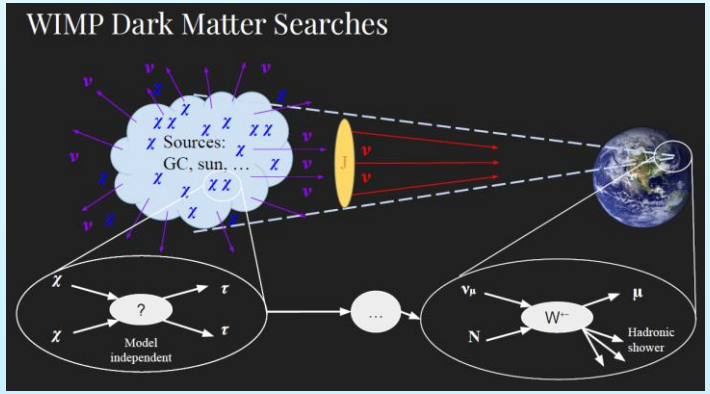
Core collapse supernovae (CCSN) emit a large flux of MeV-scale neutrinos. While KM3NeT is not optimized for such low energies, both ARCA and ORCA would detect the resulting excess of Cherenkov light.

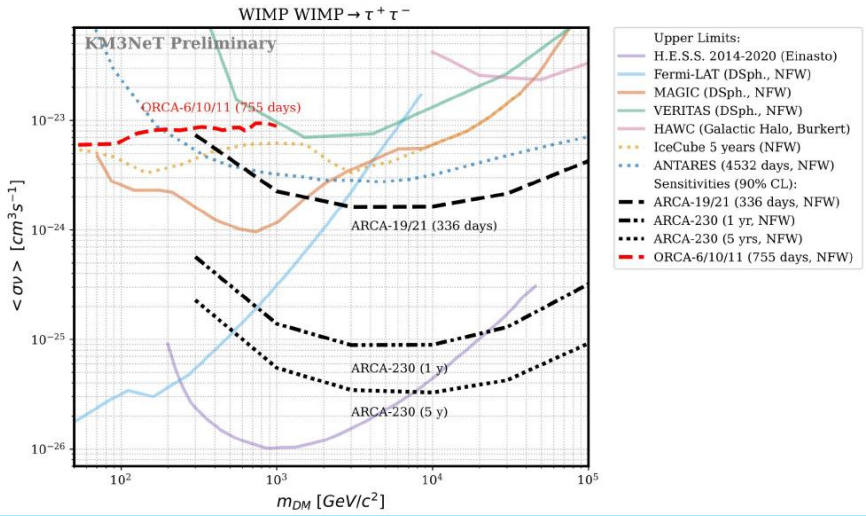




Other Scientific Studies and Topics Within KM3NeT

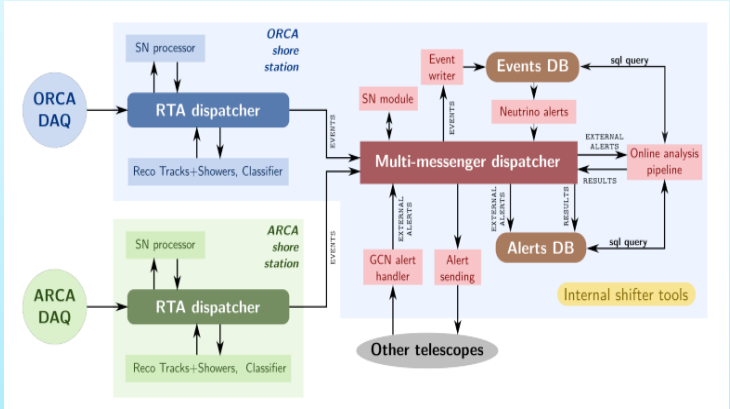
Dark Matter Searches





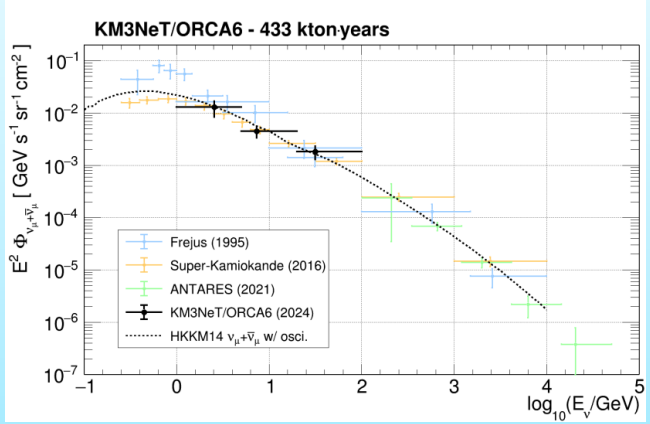
[JCAP03(2025)058]

Multi-messenger Astronomy



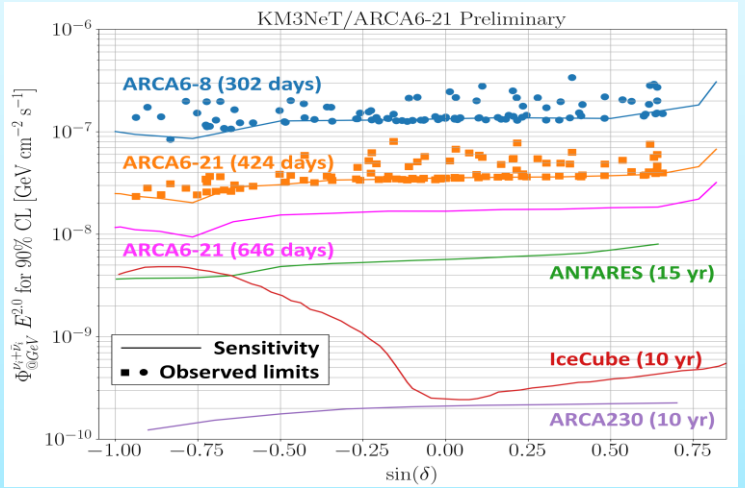
[EPJ Web of Conf. 319, 12010 (2025)]

Atmospheric neutrino flux



[arXiv: 2504.09119]

Point-like sources



[EPJC 84, 885 (2024)]

And many more, not discussed in this talk!

Summary

- The KM3NeT collaboration is constructing the deep-sea ARCA and ORCA neutrino telescopes for fundamental research in neutrino physics and astrophysics.
- As of now, 51 detection units of ARCA and 28 of ORCA have been deployed. Full construction is expected to be completed by 2030.
- Neutrino oscillation measurements with the first ORCA units demonstrate the detector's efficiency and sensitivity.
- The ultra-high-energy event KM3-230213A was observed by the ARCA21 detector, highlighting its potential for high-energy neutrino astronomy.
- Although KM3NeT is not optimized for MeV-scale neutrinos, it can detect core-collapse supernovae via the excess hit rate induced by the supernova neutrino flux.
- Many more topics and studies not discussed in this talk.

Thank you for your attention!