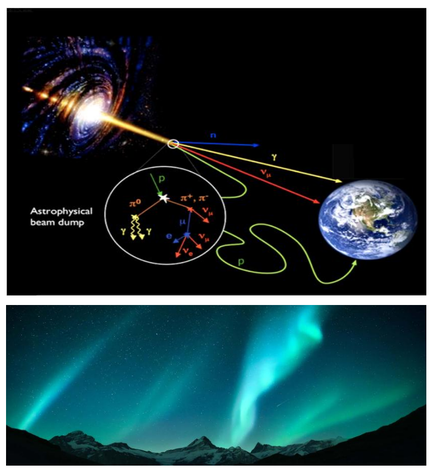
Ultra-high energy cosmic neutrino discovered with KM3NeT neutrino telescope

Origin of cosmic rays

The aim of *high-energy* neutrino astronomy is to reveal the astrophysical sources of the most energetic particles in the Universe which remain unknown yet. The record energies of incoming particles exceed 10^8 TeV, millions times larger than the energies available in terrestrial accelerators like LHC at CERN.

Neutrinos, unlike cosmic rays and gamma-rays, are not influenced by either the intergalactic magnetic fields or the cosmic microwave background radiation, which makes them perfect for *identification* of distant high-energy particle *sources* in our Universe.

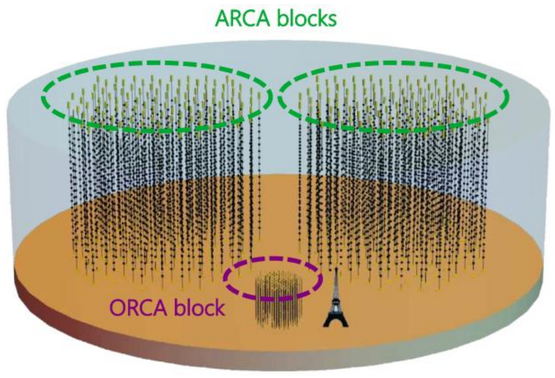
Illustration of cosmic rays reaching the Earth



KM3NeT detectors: ARCA and ORCA

The KM3NeT experiment (KiloMeter Cubic Neutrino Telescope) is hosting two neutrino detectors in the Mediterranean Sea:

- ARCA (Astroparticle Research with Cosmics in the Abyss) is designed for observation of high energy) neutrino sources.
- ORCA (Oscillation Research with Cosmics in the Abyss) aims at the neutrino mass hierarchy.



Cherenkov light that is emitted by secondary charged particles originating in neutrino interactions is detected by 31 photo-multiplier tubes inside the Digital Optical Module (DOM) that is the elementary detection unit of the telescope.

Vertical string of 18 DOMs forms a Detection Unit (DU) of KM3NeT.

	ARCA	ORCA
Location	Italy (Sicily)	France (Toulon)
Anchor depth	3450 m	2450 m
Distance from shore	100 km	40 km
DUs	115 x 2 blocks	115
DU horizontal spacing	90 m	20 m
DOM vertical spacing	36 m	9 m
DOMs per DU	18	18
Instrumented water volume	1 Gton	7 Mton
DUs deployed (**2025**)	**51**	**33**

Ultra-high energy event

- Neutrino event KM3-230213A - significantly high amount of 28086 (35% of the detector = 21 DUs – lines at that time) registered Cherenkov light signals
- Horizontal event (0.6° above horizon) – traversing muon with estimated energy of 120^{+110}_{-60} PeV
- Median neutrino energy is 220 PeV - world record up to date
- The estimated galactic coordinates of the incoming neutrino $l = 216{,}1^\circ$, $b = -11.1^\circ$ do not reveal firmly potential source object

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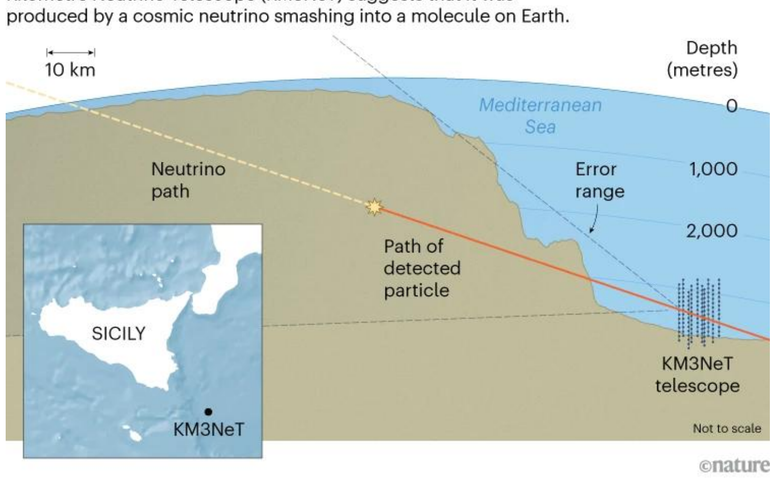
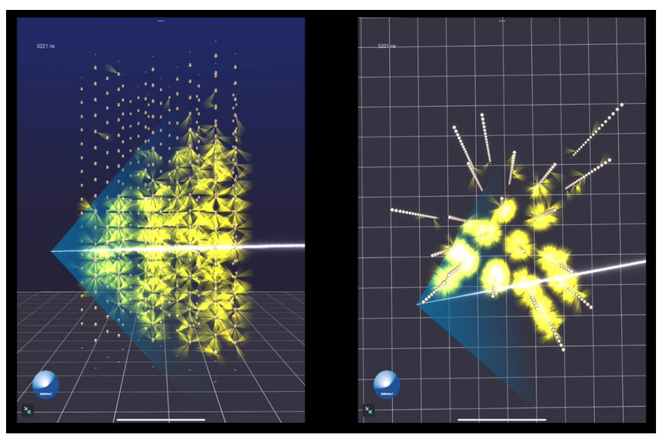


- Evidence suggests that the neutrino is most likely of the cosmic origin due to its large energy and low Galactic fluxes at high energies
- Milestone in neutrino and multi-messenger astronomy
- This single neutrino is not sufficient to draw firm conclusions. More observations are expected to come in the next years.



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