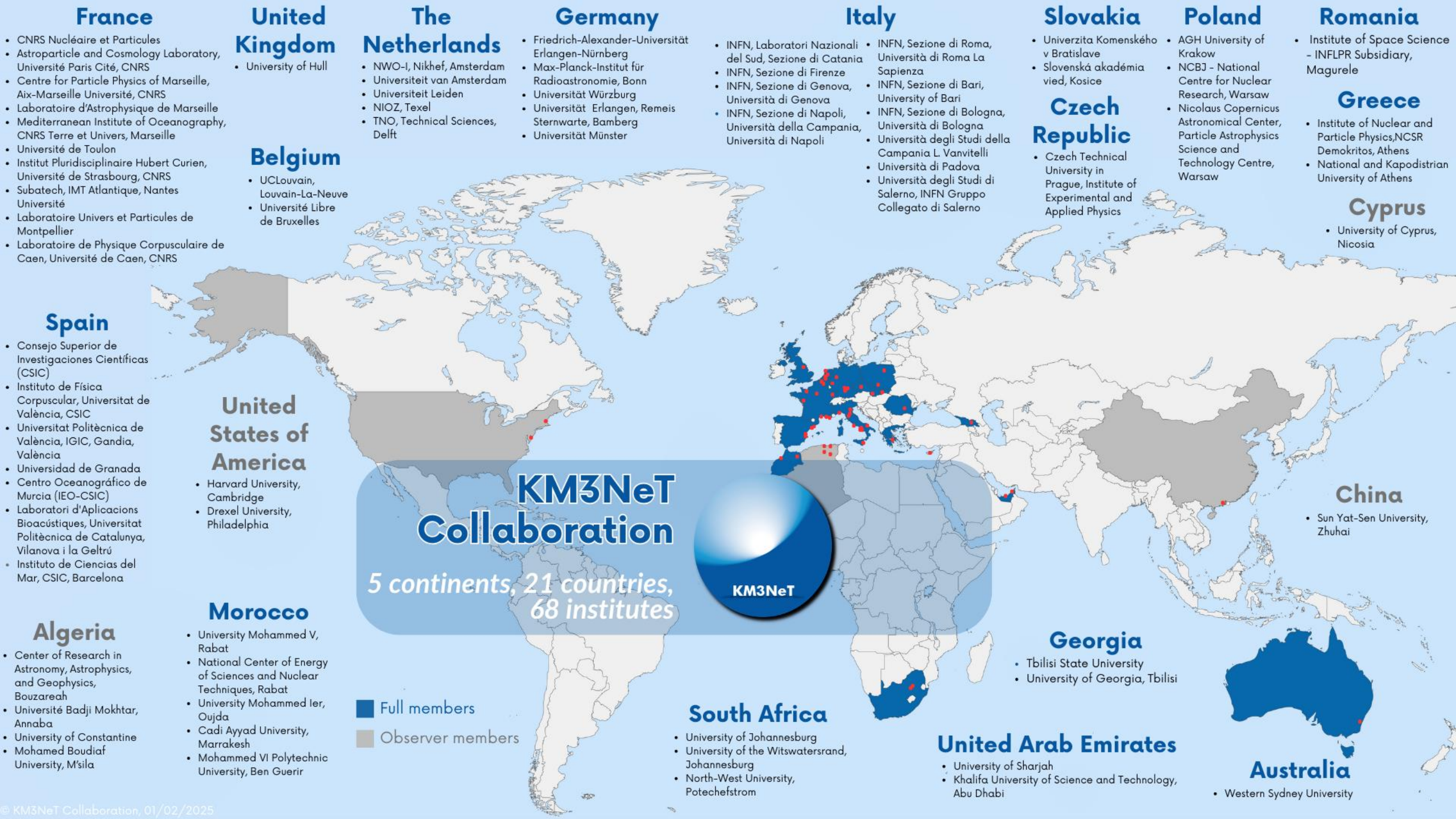
KM3NeT webinar



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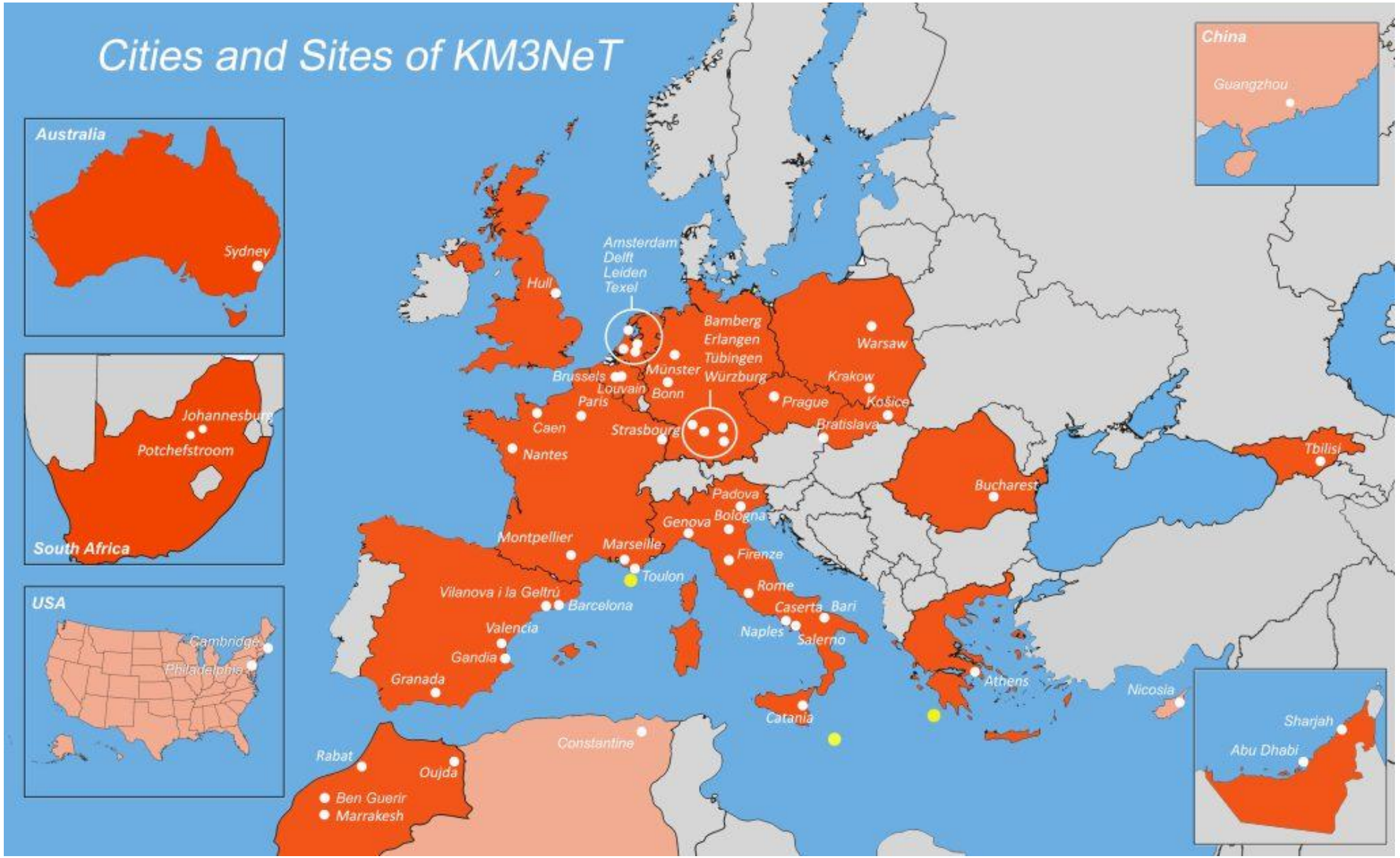
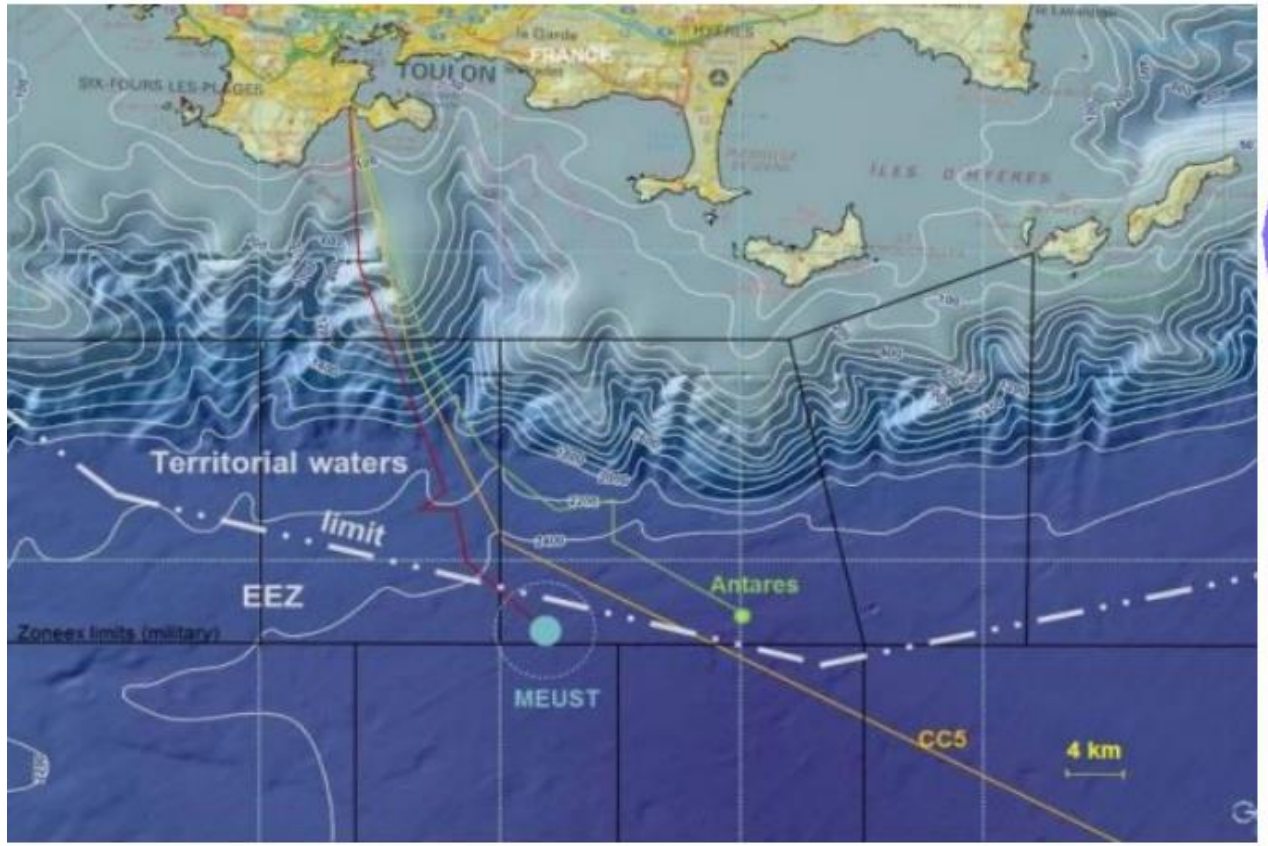
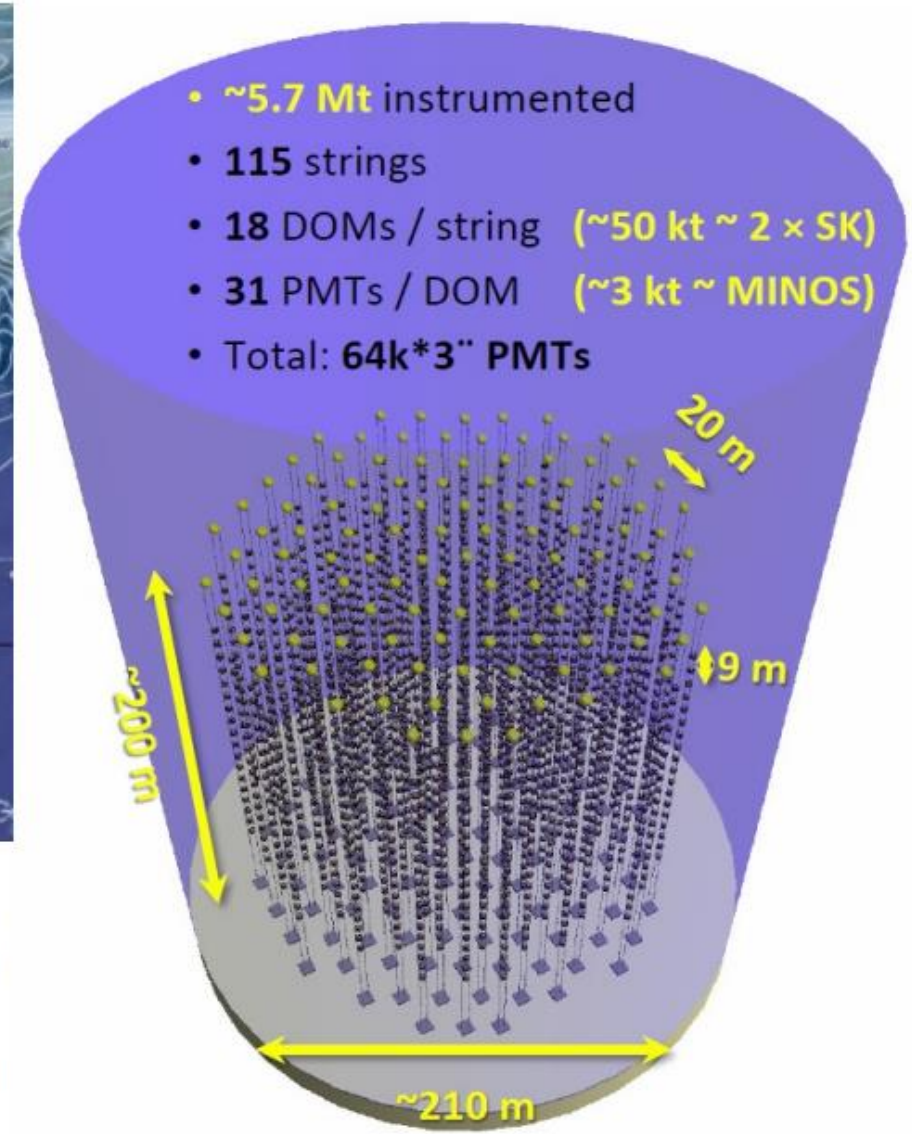

Cities and Sites of KM3NeT
Australia
Sydney
South Africa
Johannesburg
Potchefstroom
USA
Cambridge
Philadelphia
China
Guangzhou
Amsterdam
Delft
Leiden
Texel
Hull
Bamberg
Erlangen
Tübingen
Würzburg
Münster
Brussels
Louvain
Bonn
Paris
Caen
Nantes
Strasbourg
Warsaw
Krakow
Prague
Košice
Bratislava
Tbilisi
Bucharest
Padova
Bologna
Genova
Montpellier
Marseille
Toulon
Firenze
Rome
Caserta
Bari
Naples
Salerno
Vilanova i la Geltrú
Barcelona
Valencia
Gandia
Granada
Catania
Athens
Nicosia
Constantine
Rabat
Oujda
Ben Guerir
Marrakesh
Sharjah
Abu Dhabi



KM3NeT/ORCA დეტექტორი წყალქვეშა მეცნიერებების და ტექნოლოგიების ხმელთაშუა ზღვის ევროცენტრის ინფრასტრუქტურის ძირითადი ნაწილია (MEUST: Mediterranean Eurocentre for Underwater Sciences and Technologies). განლაგებულია 2500 მ სიღრმეზე, ქ. ტულონიდან (საფრანგეთი) დაახლოებით 40 კმ-ს დაშორებით.

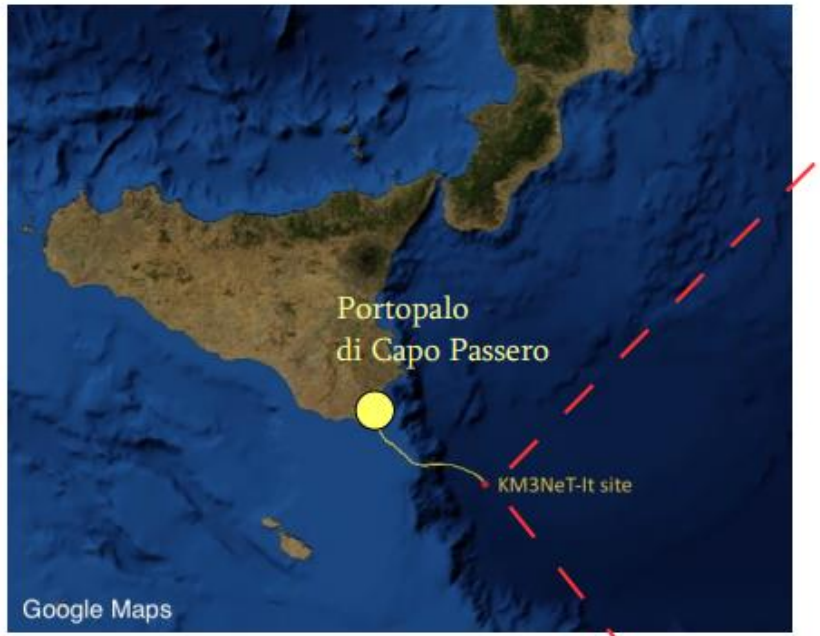


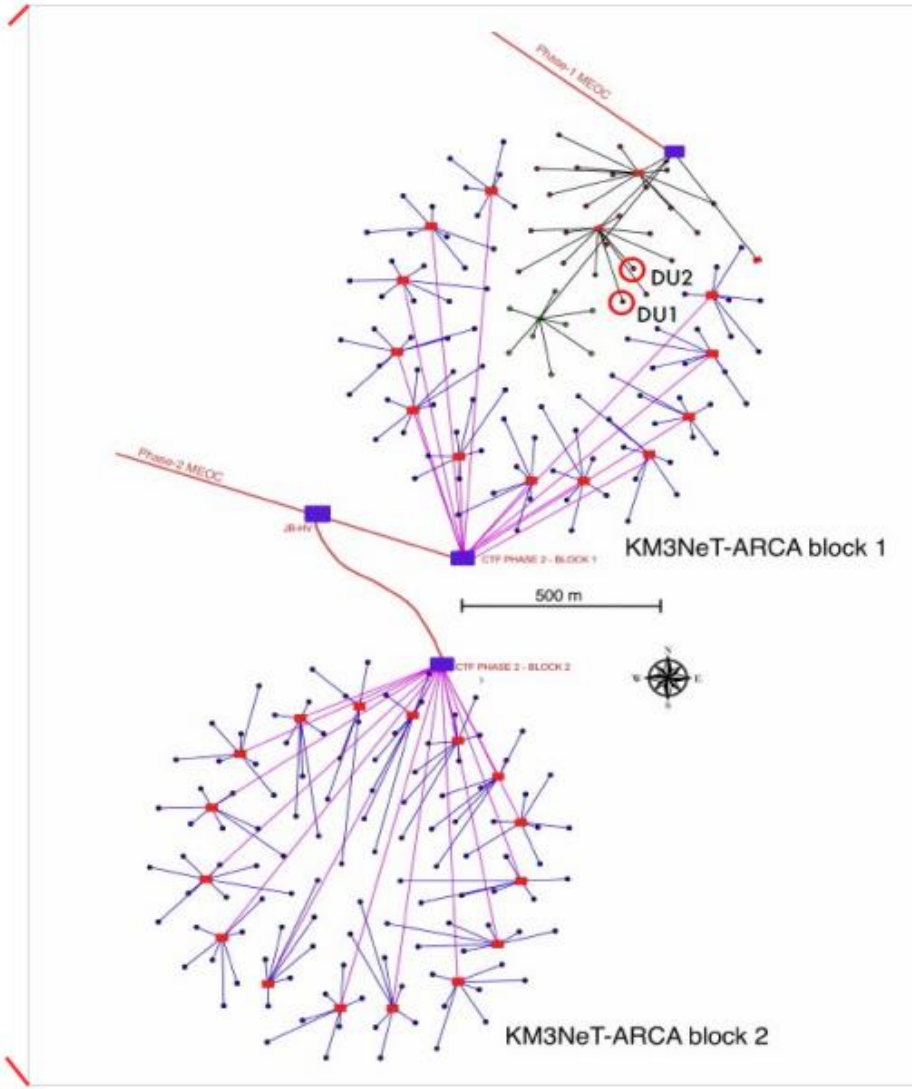
KM3NeT/ORCA დეტექტორის სქემა.

[ORCA: **O**scillation **R**esearch with **C**osmics in **A**byss]

KM3NeT/ARCA დეტექტორი განლაგებულია სიცილიის სანაპიროდან (ქ. პორტო პალო დი კაპო პასერო) დაახლოებით 100 კმ-ის დაშორებით, 3500 მ სიღრმეზე.

[ARCA: **A**stroparticle **R**esearch with **C**osmics in **A**byss]

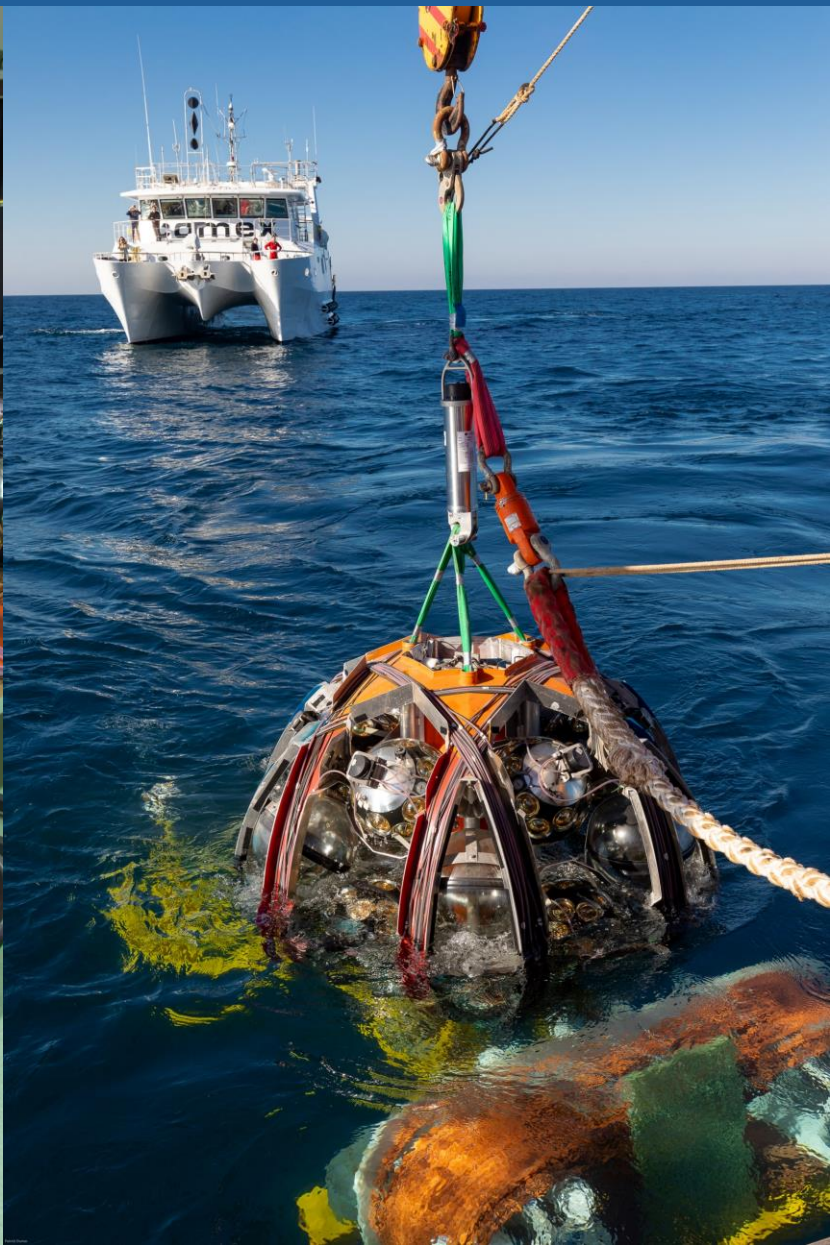




KM3NeT/ARCA: 2 ბლოკი, თვითოეული 115 ხაზით (detection unit, DU). ხაზზე მოთავსებულია 18 მოდული (DOM).
1 ბლოკი: 2070 მოდული, 64170 ფეგ.

დეტექტორის მოცულობა დაახ. 1 კმ^3.
მანძილი ხაზებს შორის - 90 მ, მოდულებს შორის: 36 მ


KM3NeT
Opens a new window on our universe



თბილისის სახელმწიფო უნივერსიტეტი KM3NeT კოლაბორაციაში

2017

თებერვალი თსუ გახდა KM3NeT კოლაბორაციის ასოცირებული წევრი
ANTARES/KM3NeT კონფერენციის მიტინგი ათენში (საბერძნეთი)

2018

მაისი თსუ ჯგუფის გახდა KM3NeT კოლაბორაციის სრული წევრი
ANTARES/KM3NeT კოლაბორაციის მიტინგი გრანადაში (ესპანეთი)

21 სექტემბერი ხელი მოეწერა მემორანდუმს, თბილისის სახელმწიფო უნიერსიტეტსა და KM3NeT კოლაბორაციას შორის.
დაიწყო გადახდა KM3NeT საერთო ფონდში.

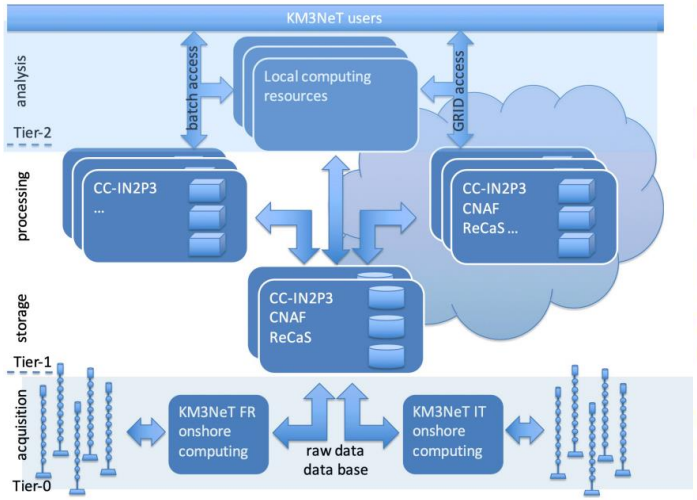
ANTARES და KM3NeT კოლაბორაციების ვორკშოპი

2019, 25 თებერვალი-1 მარტი, თბილისის სახელმწიფო უნივერსიტეტი

MG-ISE-18-804

KM3NeT-თსუ ჯგუფი (Tier-2 კომპუტინგი)

FR-18-1268



KM3NeT Web DB access system

Google drive
(KM3NeT documents)

Jupyter
(KM3NeT docker)

Git repository
(KM3NeT Software)

HEPI TSU

KM3NeT Computing
(KM3NeT Tier-2)

in2p3-cc (Lyon-cc)

HPSS

KM3NeT-თსუ ჯგუფი (Tier-2 კომპუტინგი)

FR-18-1268

KM3NeT	DU	Events (x10⁶)	Period	L-days
ORCA	6	280	27/01/2020-3/03/2021	367.5
ARCA	6	108	23/04/2021-18/06/2021	53.6

jupyterhub
Web based python environment

ROOT Data Analysis Framework
High level data analysis

Not secure | t2.km3net.tsu.ge:9999/user/papalashvili/lab?

File Edit View Run Kernel Tabs Settings Help

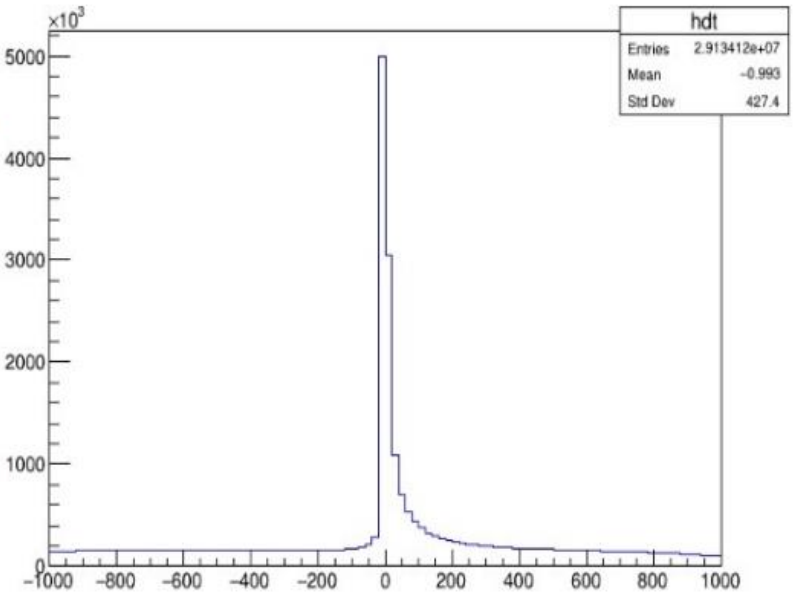
/ Examples /

Name

cher_t.ipynb

Code

```
[1]: import aa, ROOT
from ROOT import EventFile, TH1D, cherenkov_pars, Det, gPad, double
f=EventFile("/home/km3net/repo/data/KM3NeT_00000049/v6/datav6_ORCA_test.jchain.aar
det=Det("/home/papalashvili/bootcamp/KM3NeT_00000049_00008070.detx")
hist_dt=TH1D("hdt" , "time residuals", 100, -1000,1000 )
d_track=double(-999.9)
d_photon=double(-999.9)
d_closest=double(-999.9)
cos_angle=double(-999.9)
phot_dir=double(-999.9)
time=double(-999.9)
for evt in f:
    if len(evt.trks)>0:
        trk=evt.trks[0]
        det.apply(evt)
        for h in f.evt.hits:
            cherenkov_pars(trk, h.pos, h.dir, time, d_track, d_photon, d_closest,
            hist_dt.Fill(h.t-time)
hist_dt.Draw()
gPad.Draw()
```



KM3NeT-თსუ ჯგუფი (AI მეთოდები კვლევაში)

FR-22-13708

TBILISI STATE UNIVERSITY

11. FEB. 2025

Determination of Multi-muon event rates in KM3NeT with the Transformer-Based Deep Learning Models

NIKOLOZ BUJIASHVILI
TAMTA KHVICHIA

FR 22-13708

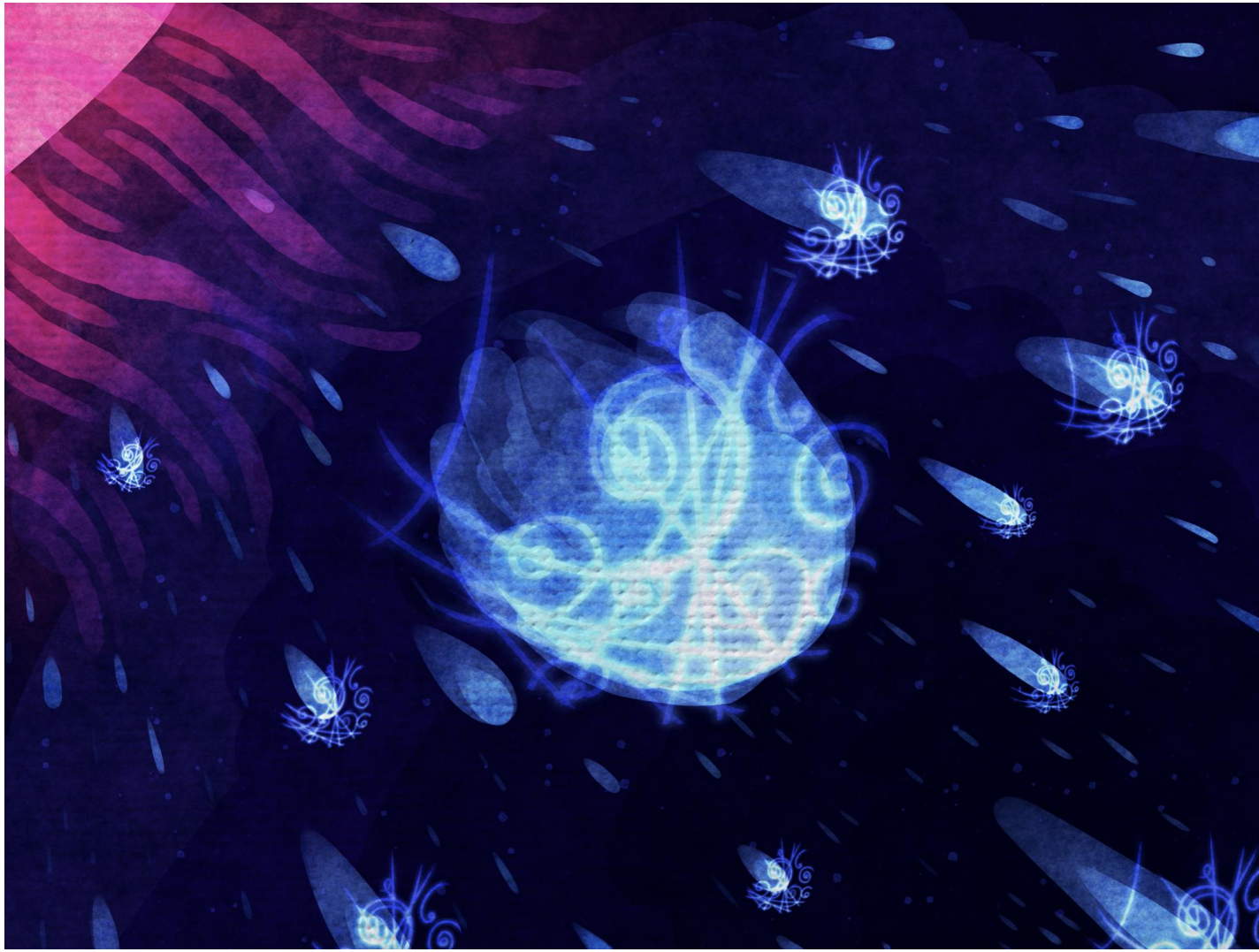
KM3NeT-თსუ ჯგუფი

სტუდენტური ნაშრომები:

სადოქტორო დისერტაცია	1
გოგიტა პაპალაშვილი	
სამაგისტრო ნაშრომი	3
გ. ქისტაური, თ. ხვიჩია, დ. ჯანეზაშვილი	
საბაკალავრო ნაშრომი	3
გ.ქაჩლიშვილი, დ. ბანდური, ნ. ხარაზიშვილი	

პუბლიკაციები (12/2/2025)

რ შანიძე	53
გ. პაპალაშვილი	43
გ. ქისტაური	36
დ. ჯანეზაშვილი	15
გ. თაყაძე	4
ვ. კიკვაძე	2
ხ. მოდებაძე	1
ლ. ხარხელაური	1



Thanks, grazie, merci, gracias, danke, شكرا على, ευχαριστώ, dank U, dziękuję, mersi, მადლობა!

Article

Observation of an ultra-high-energy cosmic neutrino with KM3NeT

https://doi.org/10.1038/s41586-024-08543-1

Received: 19 August 2024

Accepted: 18 December 2024

Published online: 12 February 2025

Open access

Check for updates

The KM3NeT Collaboration*

The detection of cosmic neutrinos with energies above a teraelectronvolt (TeV) offers a unique exploration into astrophysical phenomena[1–3]. Electrically neutral and interacting only by means of the weak interaction, neutrinos are not deflected by magnetic fields and are rarely absorbed by interstellar matter: their direction indicates that their cosmic origin might be from the farthest reaches of the Universe. High-energy neutrinos can be produced when ultra-relativistic cosmic-ray protons or nuclei interact with other matter or photons, and their observation could be a signature of these processes. Here we report an exceptionally high-energy event observed by KM3NeT, the deep-sea neutrino telescope in the Mediterranean Sea[4], which we associate with a cosmic neutrino detection. We detect a muon with an estimated energy of 120^{+110}_{-60} petaelectronvolts (PeV). In light of its enormous energy and near-horizontal direction, the muon most probably originated from the interaction of a neutrino of even higher energy in the vicinity of the detector. The cosmic neutrino energy spectrum measured up to now[5–7] falls steeply with energy. However, the energy of this event is much larger than that of any neutrino detected so far. This suggests that the neutrino may have originated in a different cosmic accelerator than the lower-energy neutrinos, or this may be the first detection of a cosmogenic neutrino[8], resulting from the interactions of ultra-high-energy cosmic rays with background photons in the Universe.

Cosmic neutrinos may be produced either in the vicinity of the cosmic-ray source or along the cosmic-ray propagation path, leading to the production of secondary unstable particles, which subsequently decay into neutrinos. Cosmic rays interacting in the Earth's atmosphere produce atmospheric neutrinos, which form an experimental background to cosmic neutrinos. To detect cosmic neutrinos, very-large-volume neutrino observatories monitor natural bodies of water or ice for the Cherenkov light induced by the passage of the charged particles that result from neutrino interactions in or near the detector. The KM3NeT research infrastructure comprises two detector arrays of optical sensors deep in the Mediterranean Sea[4]. The ARCA detector is located offshore Portopalo di Capo Passero, Sicily, Italy, at a depth of about 3,450 m and connected by means of an electro-optical cable to the shore station of the INFN, Laboratori Nazionali del Sud (LNS). The geometry of ARCA is optimized for the study of high-energy cosmic neutrinos. The ORCA detector is located at a depth of about 2,450 m, offshore Toulon, France, and is optimized for the study of neutrino oscillations. Both detectors are under construction but already operational. Once completed, they will comprise 345 (230 for ARCA and 115 for ORCA) vertical detection lines, each holding 18 optical modules. Each module hosts 31 3-inch photomultiplier tubes (PMTs) pointing in all directions and ensuring 4π coverage[9]. Both detectors can identify all flavours of neutrino interactions: those producing long-lived muons, denominated 'tracks', and those producing electromagnetic and hadronic cascades at the neutrino interaction vertex, denominated 'showers'.

Of interest in this article are neutrino interactions that produce high-energy muons, which can travel several kilometres in seawater before being absorbed. These muons lose energy as they propagate mainly because of stochastic radiative processes such as bremsstrahlung, pair production and photonuclear reactions. The average energy loss per unit path length is proportional to the muon energy. Electromagnetic cascades arise from these stochastic energy losses; the number of charged particles that produce Cherenkov radiation in the cascades is proportional to the amount of energy lost by the muon in the process. The recorded time of arrival and time-over-threshold of the signals on the PMTs (denoted as 'hits') are used to reconstruct the muon direction and energy.

Although atmospheric neutrinos are more abundant at lower energies (≈TeV), cosmic neutrinos should become dominant at energies above 100 TeV. The neutrino energy is thus a crucial parameter for establishing a cosmic origin. The IceCube Collaboration announced the discovery of PeV cosmic neutrinos in 2013 (ref. 10). The most energetic neutrinos reported so far are a 6.05 ± 0.72 PeV electron antineutrino observed at the energy of the Glashow resonance[11] and a muon neutrino above 10 PeV from the observation of a 4.4-PeV muon[5].

The neutrino event KM3-230213A

An extremely high-energy muon traversing the ARCA detector was observed on 13 February 2023 at 01:16:47 UTC. This event is referred to here as KM3-230213A. At that time, 21 detection lines were in operation.