KM3NET

S. Biagi con l'aiuto di R. Coniglione
INFN-LNS

Riunione Gruppo 2 @LNS 30/06/2025

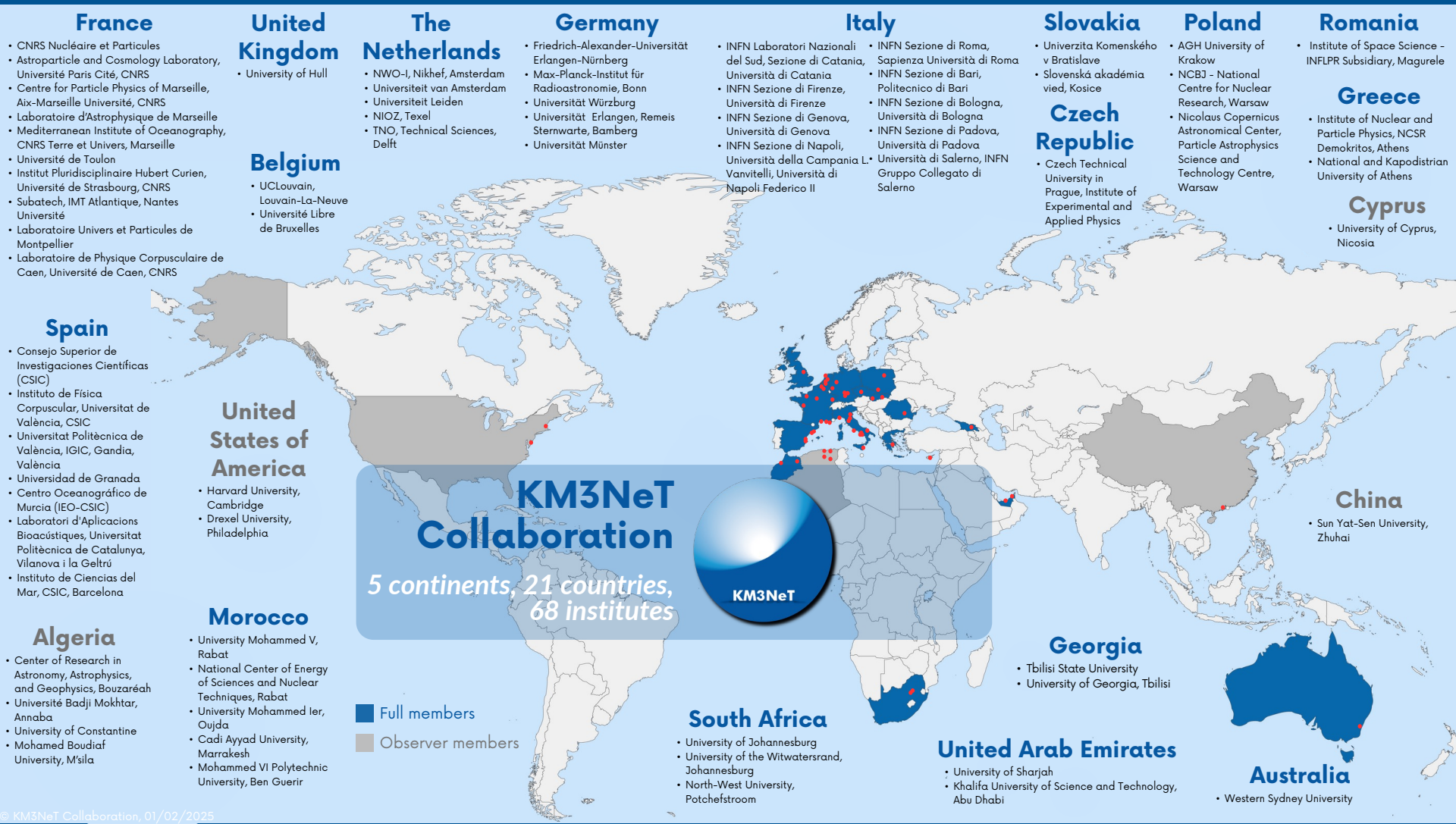
La sigla KM3 in CSN2

Resp. Nazionale P. Migliozzi (NA) dal 01/06/2025

La sigla KM3NeT comprende:

- Attività KM3NeT
  - ARCA
    - Rivelazione di neutrini di alta energia (>1 TeV) da sorgenti cosmiche - rivelatore in costruzione a Capo Passero
  - ORCA
    - Rivelazione di neutrini atmosferici per lo studio delle proprietà fondamentali del neutrino (E<1 TeV) - rivelatore in costruzione al largo di Tolone
- Attività ANTARES
  - Rivelatore di prima generazione per la neutrino astronomia che ha preso dati per 13 anni ed è stato smantellato nel 2022 👉 articoli con i risultati di tutto il periodo di presa dati in corso (legacy papers). Dopo la pubblicazione di questi articoli la collaborazione verrà definitivamente chiusa.

THE KM3NET COLLABORATION



France
- CNRS Nucléaire et Particules
- Astroparticle and Cosmology Laboratory, Université Paris Cité, CNRS
- Centre for Particle Physics of Marseille, Aix-Marseille Université, CNRS
- Laboratoire d'Astrophysique de Marseille
- Mediterranean Institute of Oceanography, CNRS Terre et Univers, Marseille
- Université de Toulon
- Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg, CNRS
- Subatech, IMT Atlantique, Nantes Université
- Laboratoire Univers et Particules de Montpellier
- Laboratoire de Physique Corpusculaire de Caen, Université de Caen, CNRS

United Kingdom
- University of Hull

Belgium
- UCLouvain, Louvain-La-Neuve
- Université Libre de Bruxelles

The Netherlands
- NWO-I, Nikhef, Amsterdam
- Universiteit van Amsterdam
- Universiteit Leiden
- NIOZ, Texel
- TNO, Technical Sciences, Delft

Germany
- Friedrich-Alexander-Universität Erlangen-Nürnberg
- Max-Planck-Institut für Radioastronomie, Bonn
- Universität Würzburg
- Universität Erlangen, Remeis Sternwarte, Bamberg
- Universität Münster

Italy
- INFN Laboratori Nazionali del Sud, Sezione di Catania, Università di Catania
- INFN Sezione di Firenze, Università di Firenze
- INFN Sezione di Genova, Università di Genova
- INFN Sezione di Napoli, Università della Campania L. Vanvitelli, Università di Napoli Federico II
- INFN Sezione di Roma, Sapienza Università di Roma
- INFN Sezione di Bari, Politecnico di Bari
- INFN Sezione di Bologna, Università di Bologna
- INFN Sezione di Padova, Università di Padova
- Università di Salerno, INFN Gruppo Collegato di Salerno

Slovakia
- Univerzita Komenského v Bratislave
- Slovenská akadémia vied, Kosice

Czech Republic
- Czech Technical University in Prague, Institute of Experimental and Applied Physics

Poland
- AGH University of Krakow
- NCBJ - National Centre for Nuclear Research, Warsaw
- Nicolaus Copernicus Astronomical Center, Particle Astrophysics Science and Technology Centre, Warsaw

Romania
- Institute of Space Science - INFLPR Subsidiary, Magurele

Greece
- Institute of Nuclear and Particle Physics, NCSR Demokritos, Athens
- National and Kapodistrian University of Athens

Cyprus
- University of Cyprus, Nicosia

Spain
- Consejo Superior de Investigaciones Científicas (CSIC)
- Instituto de Física Corpuscular, Universitat de València, CSIC
- Universitat Politècnica de València, IGIC, Gandia, València
- Universidad de Granada
- Centro Oceanográfico de Murcia (IEO-CSIC)
- Laboratori d'Aplicacions Bioacústiques, Universitat Politècnica de Catalunya, Vilanova i la Geltrú
- Instituto de Ciencias del Mar, CSIC, Barcelona

United States of America
- Harvard University, Cambridge
- Drexel University, Philadelphia

Algeria
- Center of Research in Astronomy, Astrophysics, and Geophysics, Bouzaréah
- Université Badji Mokhtar, Annaba
- University of Constantine
- Mohamed Boudiaf University, M'sila

Morocco
- University Mohammed V, Rabat
- National Center of Energy of Sciences and Nuclear Techniques, Rabat
- University Mohammed Ier, Oujda
- Cadi Ayyad University, Marrakesh
- Mohammed VI Polytechnic University, Ben Guerir

China
- Sun Yat-Sen University, Zhuhai

Georgia
- Tbilisi State University
- University of Georgia, Tbilisi

South Africa
- University of Johannesburg
- University of the Witwatersrand, Johannesburg
- North-West University, Potchefstroom

United Arab Emirates
- University of Sharjah
- Khalifa University of Science and Technology, Abu Dhabi

Australia
- Western Sydney University

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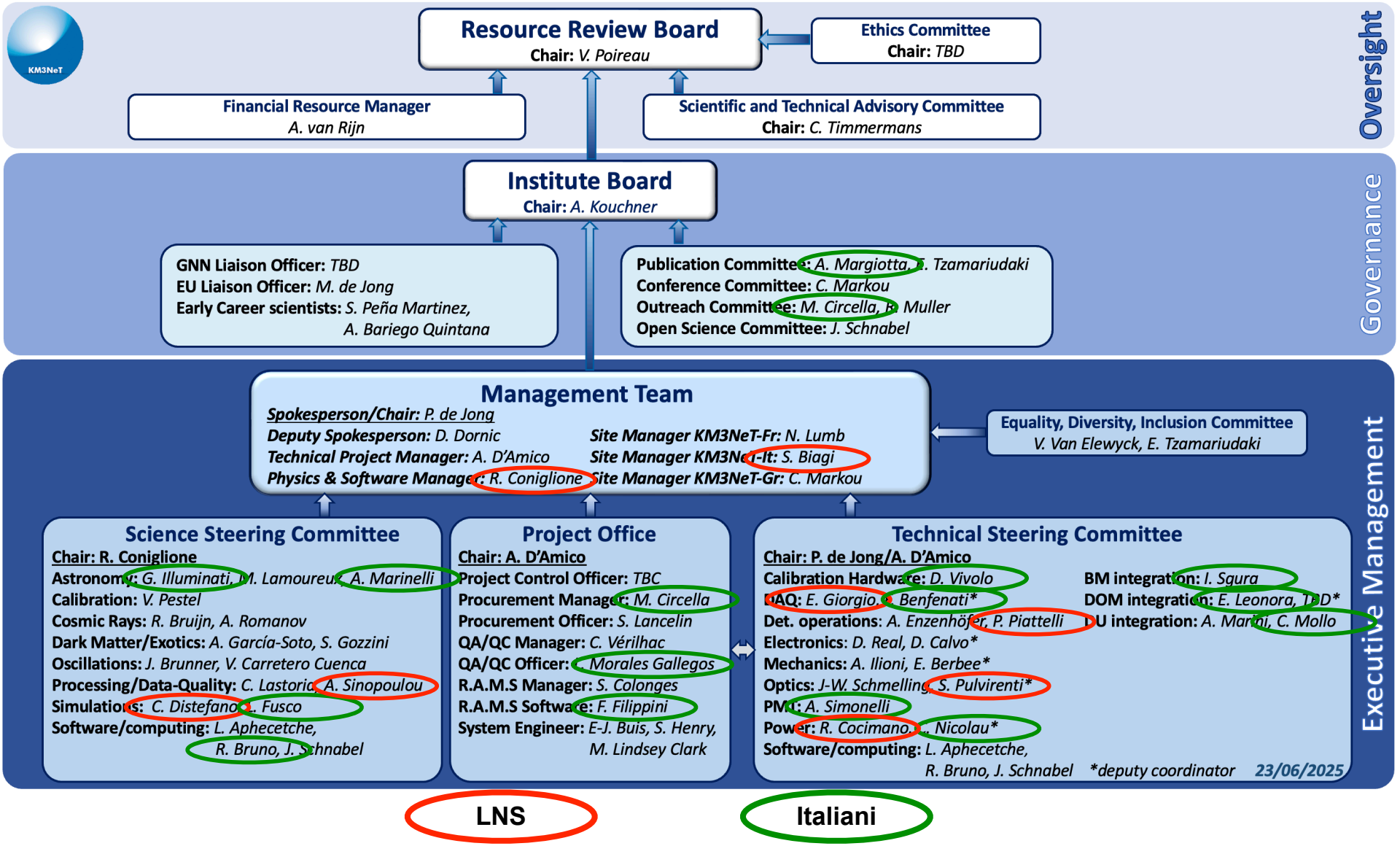
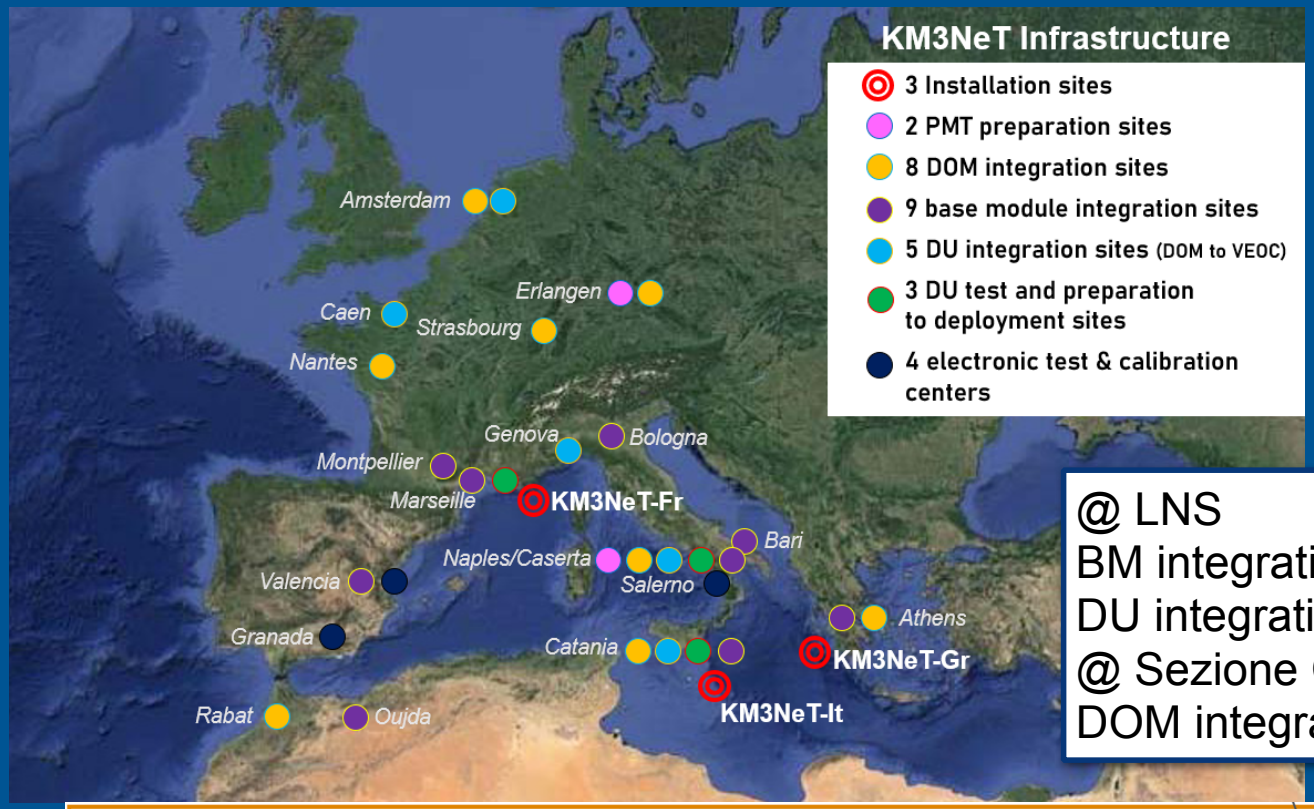
KM3NeT Organigramma



THE DETECTOR CONSTRUCTION



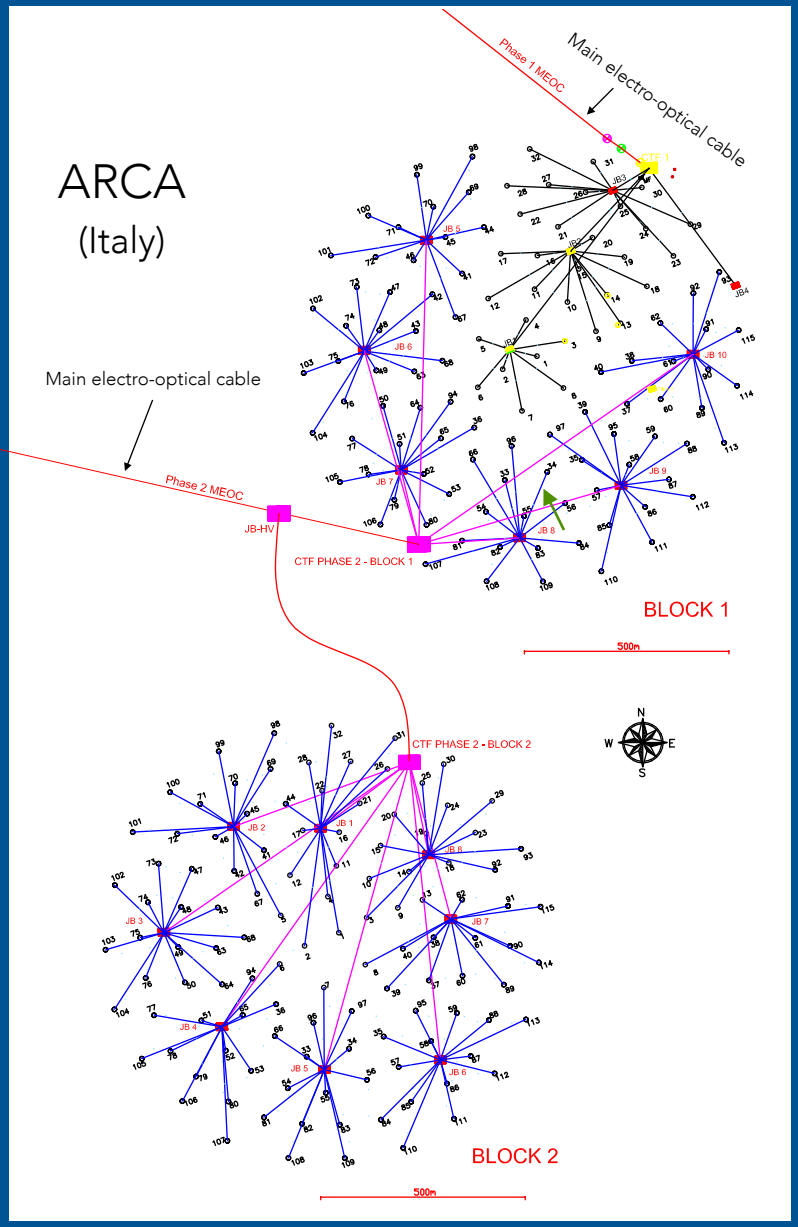
~2000 DOM integrati
~100 BM integrati
~90 DU integrate

@ LNS
BM integration site (resp. **G. Larosa**)
DU integration site (resp. **P. Sapienza**)
@ Sezione Catania
DOM integration site (resp. E. Leonora)

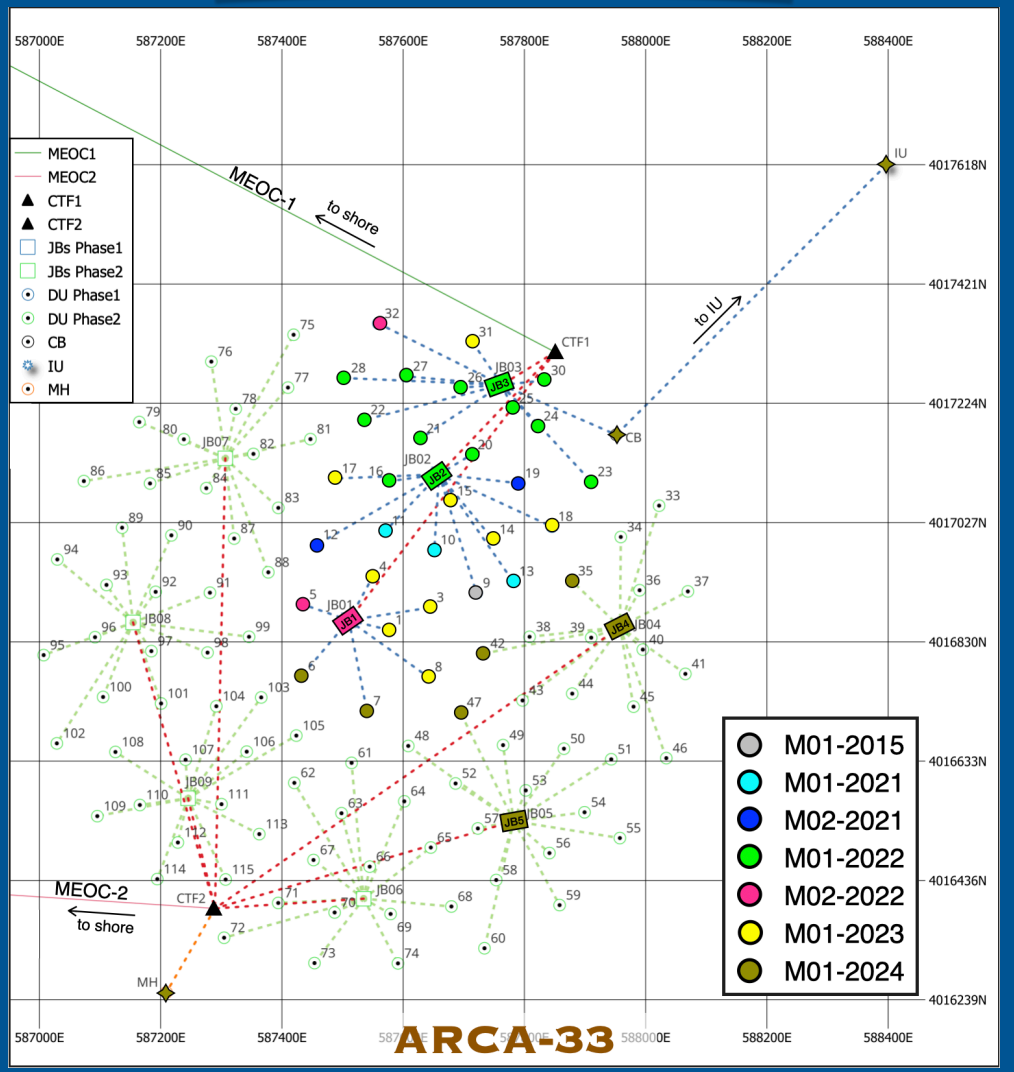
	ARCA		ORCA		
	quantity	% completed out of total	quantity	% completed out of total	Total
Optical Modules	1116	28%	828	40%	1944
Base Modules	59	26%	44	38%	103
Detection Units	58	26%	33	29%	91

	ARCA	ORCA
Optical Modules production sites	4	4
Base Modules production sites	4	3(+1 2026 - Nantes)
Detection Unit sites (partial production)	1(+1 2026 - Bari)	2 (Caen site upgraded by 2026)
Detection Unit sites (complete production)	2	1 (CPPM upgrade in 2026)

THE KM3NET/ARCA STATUS

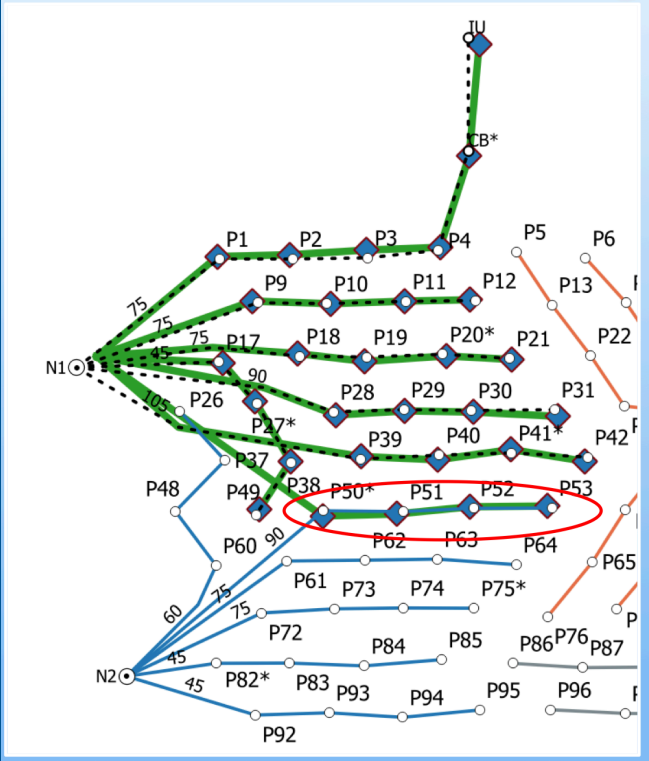


33 DUs deployed
+ 5 Junction Boxes

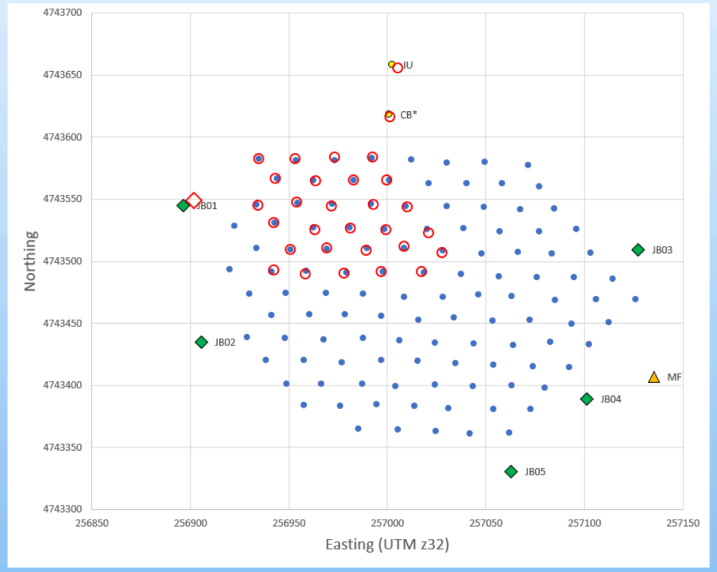


THE KM3NET/ORCA STATUS

Attualmente 28 DUs deposte e funzionanti
Installazione nodo-2 prevista a metà agosto



Node 1 after Sea op#17



Full site (116 DUs)

- Row of 4 DUs destined for node 2 deployed and connected to node 1 for testing
- 18/18 working DOMs on 3 of these DUs, 16/18 on DU86 (old VEOC, c.f. fiber feedthrough issue)
- → Total of 28 DUs now deployed (all functional): 24% full detector
- 485/504 working DOMs (96%)

- Only 24 DUs currently read out, because of attenuation issue on spare output of node 1
- Some hope that this issue can be overcome → being studied by Alex in collaboration with Jan-Willem

Accordo per “prestito”di 180 DOM da ARCA a ORCA

Completing ORCA

With funding requests in France, the Netherlands and Spain under review (and partially granted), we are nearing funding for ~100 DUs on 4 nodes.

A possible 5th node is unfunded, and also needs a new manifold to be designed and funded.

A look at the schedule teaches us that we could have 96 DUs on 4 nodes 6 months earlier without the design activities and procurement for a manifold and 5th node.
Even 104 DUs on 4 nodes would be 1 month earlier.

The physics groups have been asked to make an assessment of the impact of declaring ORCA final with 4 nodes and 104 DUs (as opposed to 5 nodes and 115 DUs).

Completing ARCA

ARCA is designed to have two building blocks

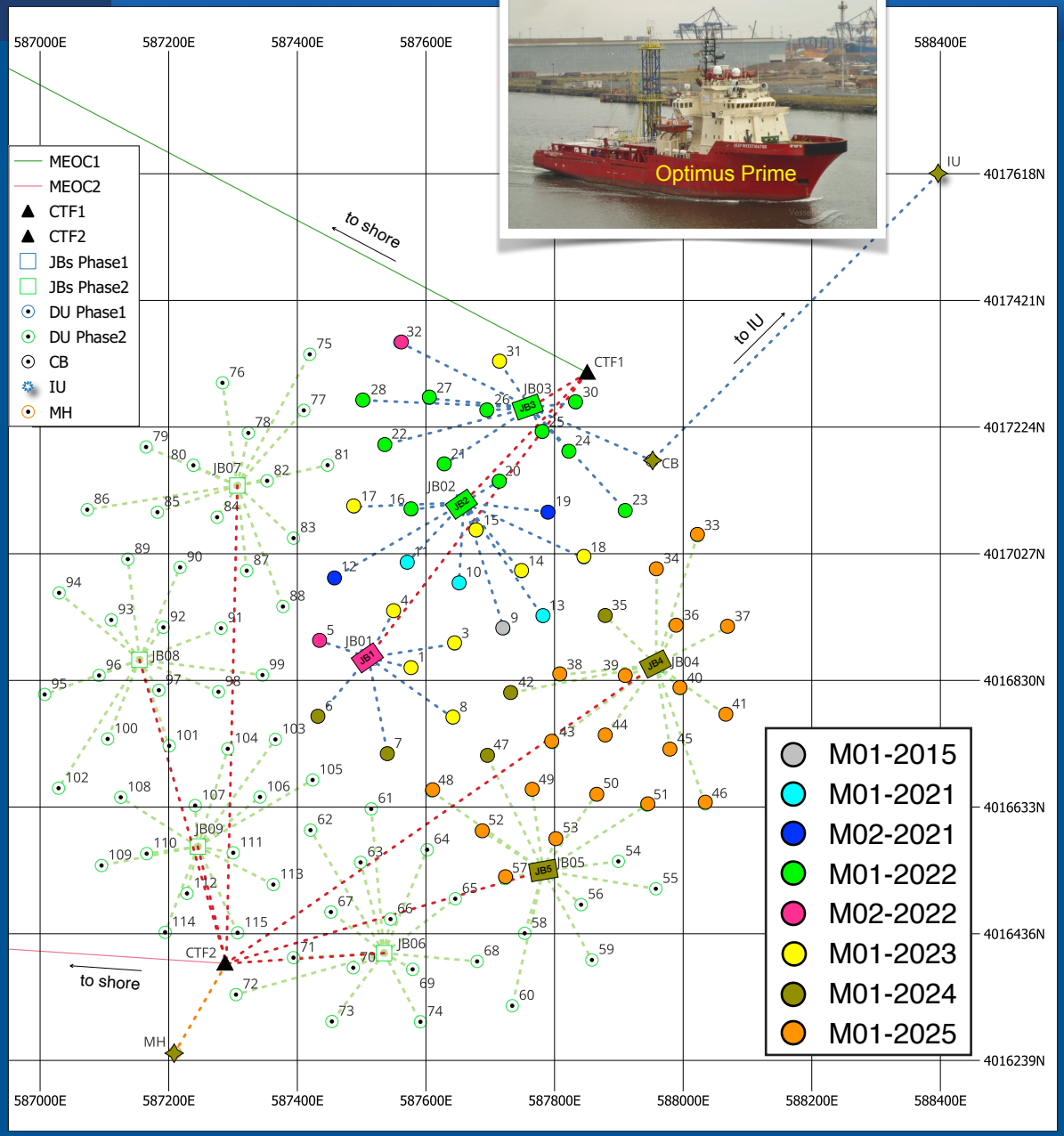
Funding for junction boxes and cabling: ~65% secured
Funding for DUs: ~55% secured

New funding proposals are submitted/being written to increase these numbers to ~70%

Two concerns and how we try to mitigate them:

- KM3NeT4RR project finishes in the fall; potential loss of personpower in integration sites.
  New funding sought to maintain personpower.
- High costs of sea-operations. (Boat rental, mobilization/demobilization of boats).
  New funding sought for sea-operations;
  Looking at new marine partner.

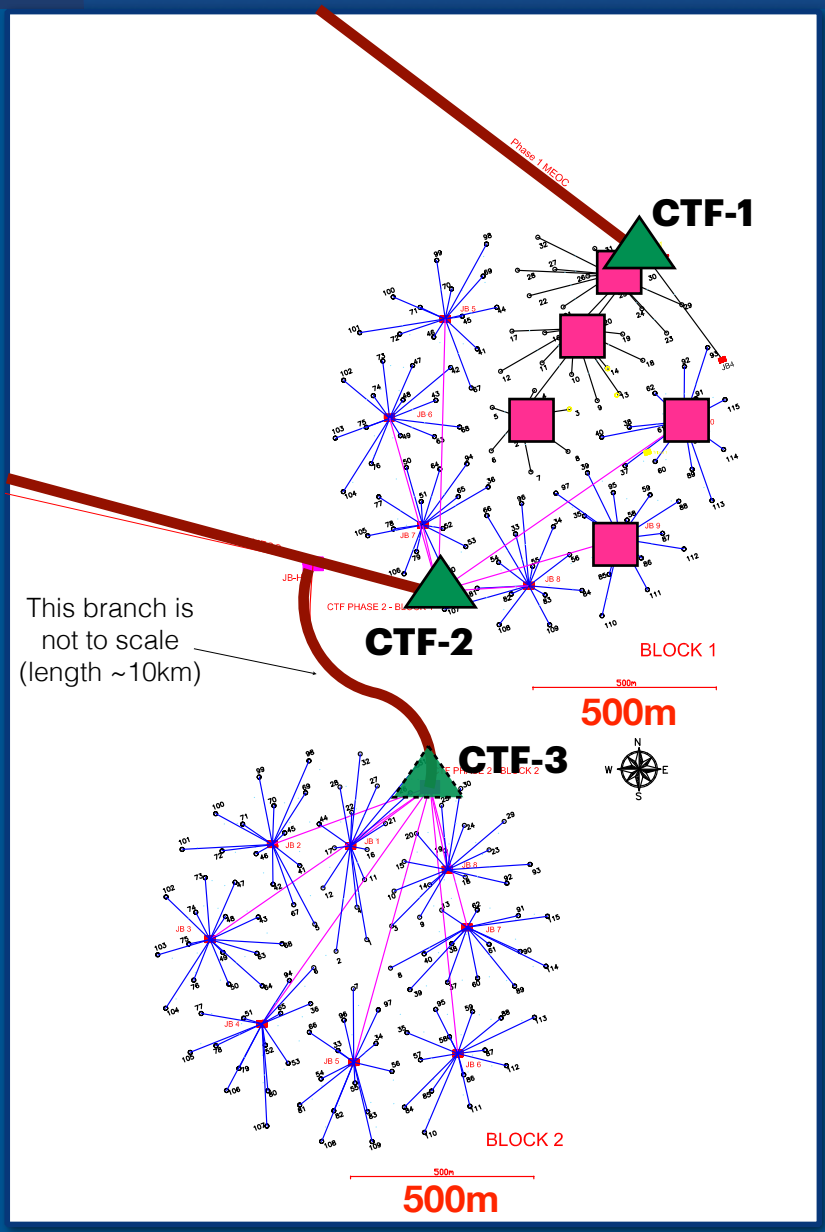
ARCA SEA OP. M01-2025



1-31 JULY 2025

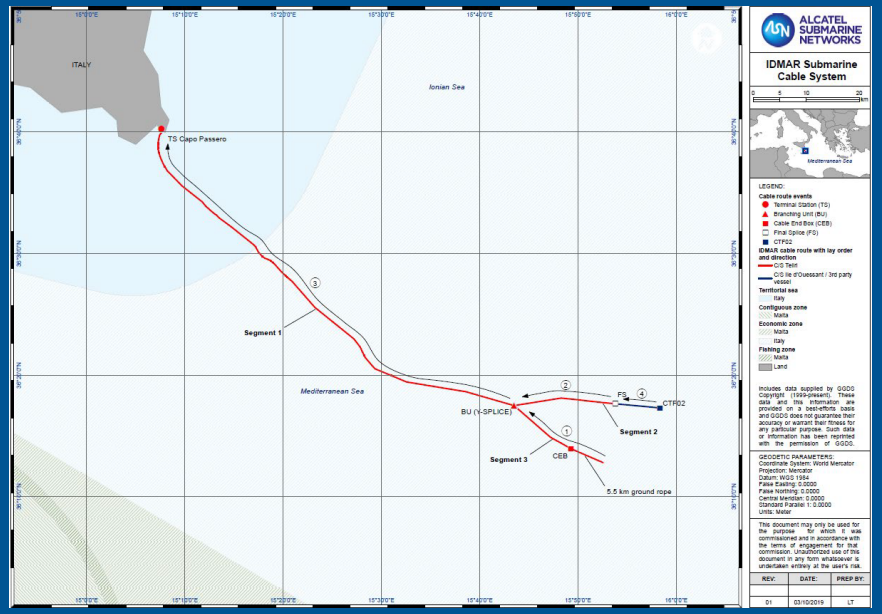
- Sailing from Malta: **July 8th**
- Return to Malta: **July 23rd**
- Campaign split in two hitches:
  - test CTF-1 + 11 DUs in the 1st
  - 3 TABs + 8 DUs in the 2nd
- MAX priority: Test CTF-1 and (hopefully!) recovery of Phase-1
- Deploy 12 DUs to JB4 + 7 DUs to JB5 (2 “spare” DUs transported to Malta)
- Deploy 3 TABs + ROV box-in (improved absolute positioning)
- The offshore Crew is set
  - Hitch I: Klaus L, Nunzio R, Daniele V
  - Hitch II: Klaus L, Antonio D’A, Andrea S
- Recovery ARCA.0031/IU-base/CB and deploy JB6 postponed to 2026

ARCA SEA OP. M02-2025



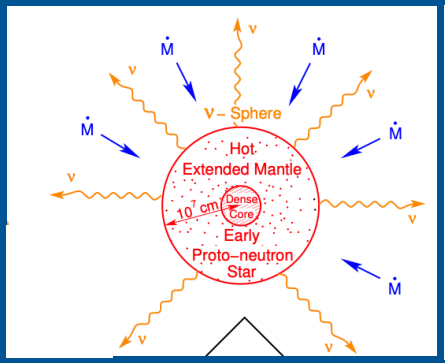
SEPTEMBER 2025

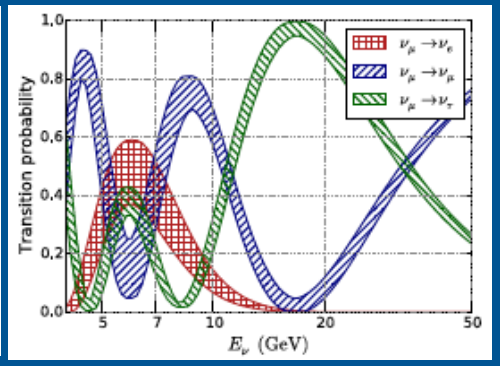
- Installation of CTF-3 scheduled for mid-September 2025 (TBC)
- CTF-3 is the “twin” of CTF-2. It is an Alcatel product; construction, deployment, and splicing will be carried out by Alcatel
- Funded under the PNRR program, it will enable the connection of ARCA BB2

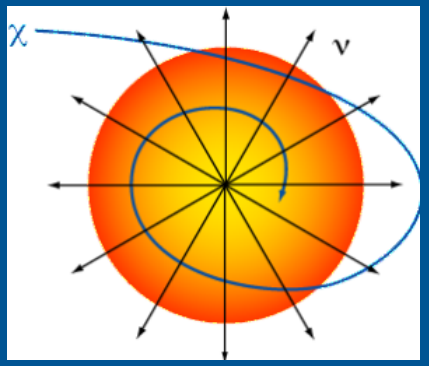


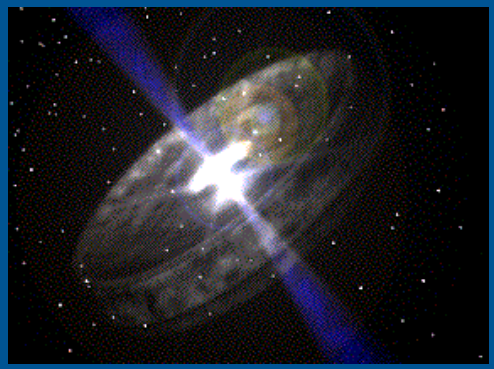
ARCA&ORCA: RESULTS

THE PHYSICS









Supernova explosions
Single DOMs as detectors
ARCA&ORCA

Neutrino oscillation
Main topic of ORCA

Dark Matter
ORCA & ARCA

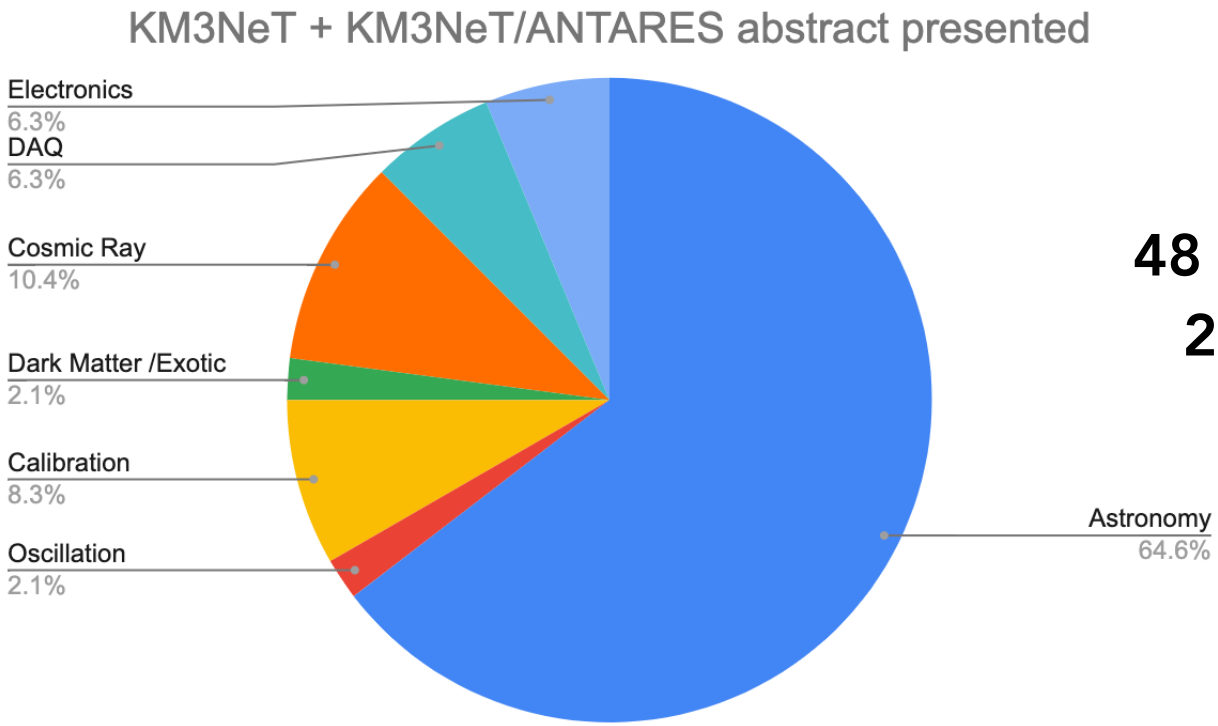
HE neutrinos
Multi-messenger program
Main topic of ARCA

From MeV … …. to PeV

ICRC2025

Many analysis ongoing
we are in the stage of internal reviews, unblinding and approval of public plots

New results are expected at ICRC 2025 and other summer conferences



48 abstracts presented
24 accepted as talk

Oscillation

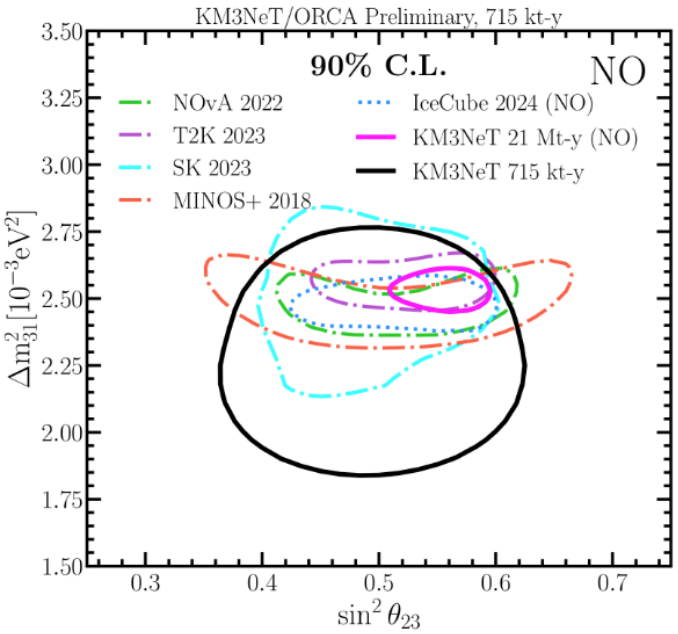
Main analyses ongoing:

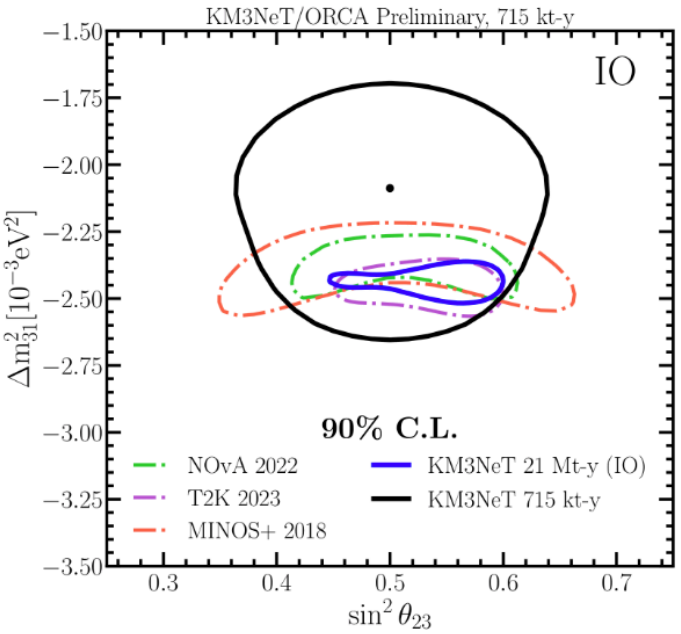
- Neutrino mass ordering
-
- Lorenz invariance violation (KM3NeT/ ANTARES/IC joint analysis)
- Sterile neutrinos (ARCA&ORCA)
- Non Standard Interaction
- Quantum decoherence (ARCA&ORCA)
- ....

$\Delta m^2_{31} - sin^2\theta_{23}$

Δm^2_{32} vs $\sin^2\theta_{23}$

ORCA 715 kton-years (ORCA6-11)
ORCA full detector 1year for comparison



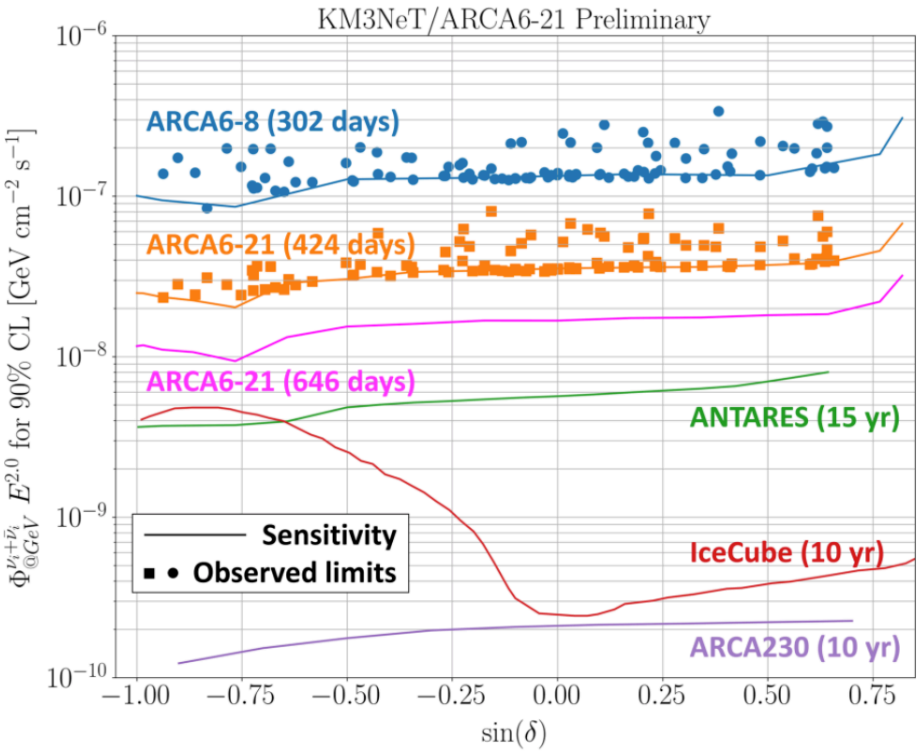


Astronomy

Result presented at Neutrino2024
ARCA6-21

Main analyses ongoing:

- **Point-like searches ARCA&ORCA**
- **Diffuse full sky and diffuse from the Galactic Plane**
- **Stacking analyses** (Extreme blazars, HBL blazars, Low/high-z AGN, Seyfert galaxies, Spectral analysis on Galactic with HAWC, ULIRG/Starburst galaxies)
- **Transient sources ARCA&ORCA** (FRB,GWHEN sub threshold, Microquasars, Stacking GRB, TDE, untriggered flaring analysis)
- **Online analyses (ARCA&ORCA)**
- **…..**



Unblinding of data with the full ARCA21 period soon.
Result to be presented at ICRC2025

The Ultra-High-Energy: KM3-230213A

The February 13 2023 an event with the highest energy ever seen has been detected with ARCA when it consisted of 21 Lines

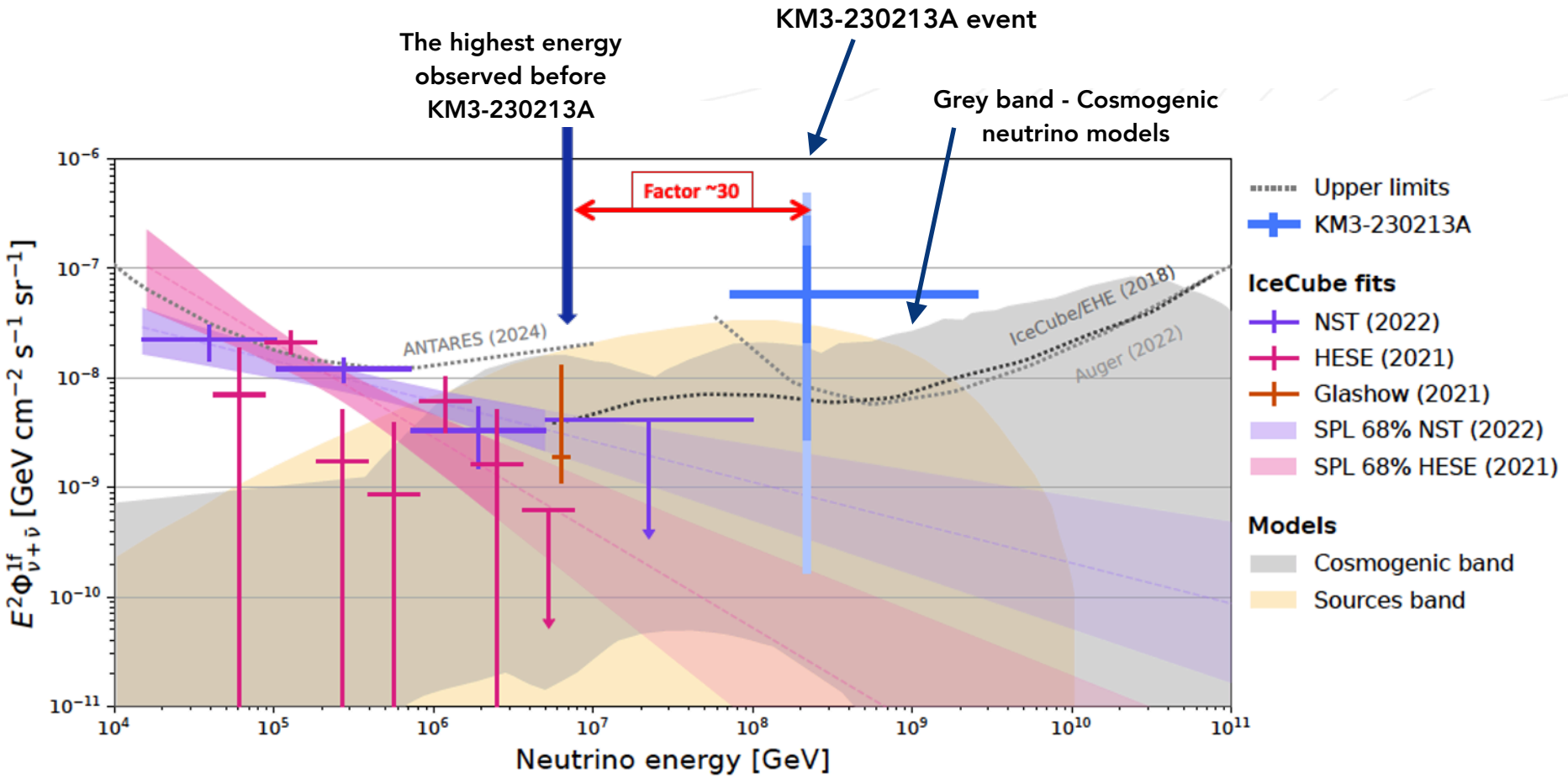
The KM3NeT detector has observed a cosmic neutrino with energy well above 100 PeV (petaelectronvolt)

30 times higher the most energetic neutrino detected so far

- **Paper submitted to Nature 19 August**
- **Paper accepted 18 December**
- **Publication on Nature the 12 of February 2025 - Nature 638, 376–382 (2025) and public announcement on**

Big impact on public media.

The Ultra-High-Energy: KM3-230213A



Companion papers

At the date of the official announcement 4 KM3NeT companion papers were published on arXiv

- **On the potential cosmogenic origin of the ultra-high-energy event, arXiv:2502.08508**
  Published on Astrophysical Journal Letters

- **The ultra-high-energy event KM3-230213A within the global neutrino landscape, arXiv:2502.08173**
  Submitted to Physical Review X. Positive referee answers

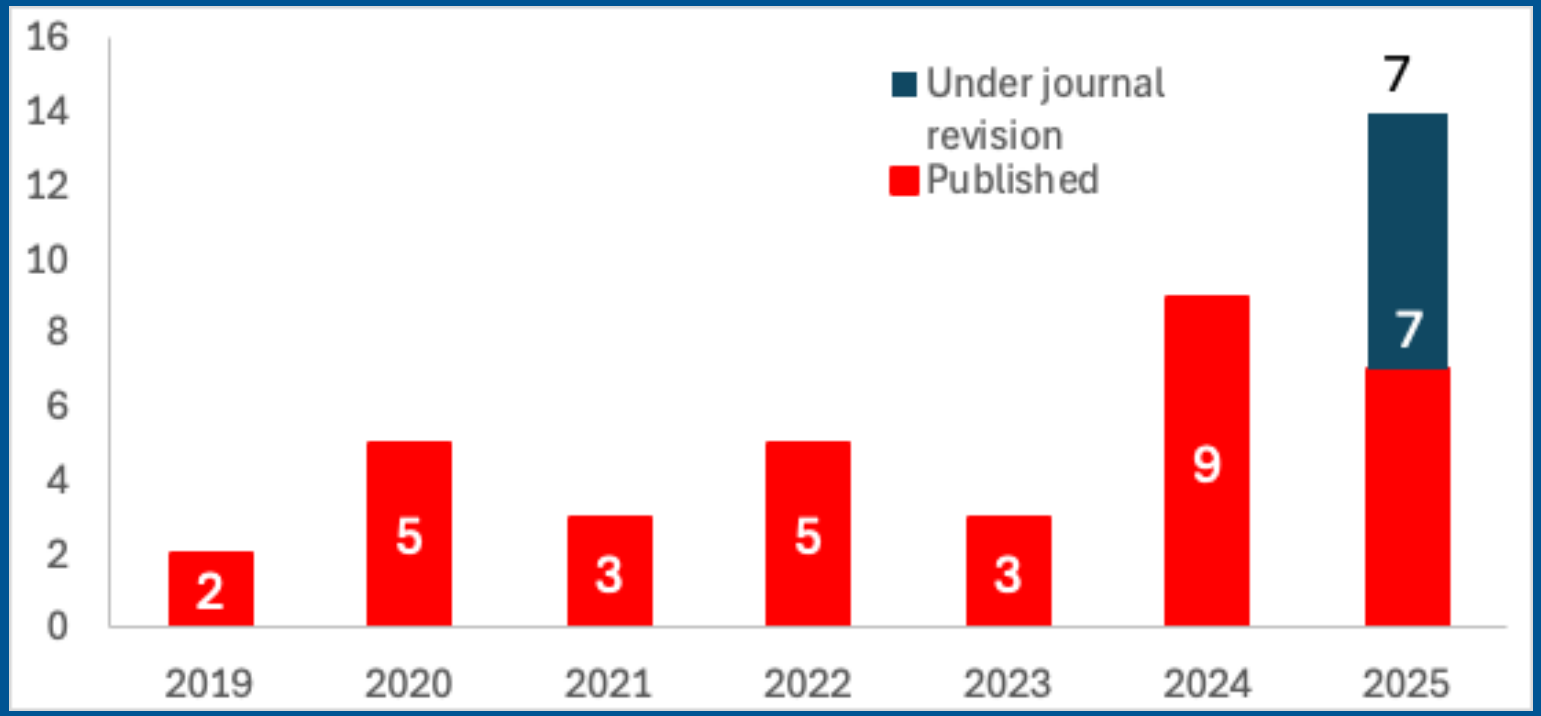
- **On the Potential Galactic Origin of the Ultra-High-Energy Event KM3-230213A, arXiv:2502.08387**
  Submitted to Astrophysical Journal Letters

- **Characterising Candidate Blazar Counterparts of the Ultra-High-Energy Event KM3-230213A, arXiv:2502.08484**
  Submitted to Astrophysical Journal Letters

Published just after on arXiv

- **KM3NeT Constraint on Lorentz-Violating Superluminal Neutrino Velocity arXiv:2502.12070**

KM3NET PUBLICATIONS



2024 & 2025 papers

83% physics results & interpretation

4% software

13% technical

KM3NeT @ LNS

Attività in corso ai LNS - Fondi esterni

KM3NeT4RR 👉 WP a responsabilità LNS:

- WP1 - Management
- WP2 - Onshore infrastructures (P. Piattelli)
- WP5 - Sea Floor Network (SB)
- WP7 - Implementation of multi messenger liasons (R. Coniglione)

- At LNS 👉 1 Infrastructure manager + 2 tecnologi (+2 su ITINERIS) + 8 tecnici

Gare completate entro novembre 2025

Contratti personale TD in scadenza!

INFRADEV2: EU project started 1st of January 2023

- WP2 - Legal Entity (P. Sapienza) - AISBL signed!
- WP3 - Accelerating implementation - a post doc for RAM software analysis (Bologna)
- WP5 - Sustainability and socio-economic impact - a post doc for socio-economic impact study hired (LNS)

- PRIN 👉 ALICA - Atmospheric Leptons In Cherenkov Arrays
  - PI Matteo Sanguineti Genova
  - At LNS 👉 66k€ - 1 year post-doc: Anna Sinopoulou
  - Project ends this year

Nuove richieste di fondi esterni

KM3NeXT (P.I. Alessia Tricomi)

- Bando regione Sicilia per 20 ME, LNS e Sez. CT
- Acquisizione di 22 DU complete + componenti per completare altre 6-8 DU
- Acquisizione di 1 JB con i suoi interlink
- Progetto sottomesso, in attesa di risposta da regione

NAUTILUS (P.I. Pasquale Migliozzi)

- Bando PN IR per 15 ME, LNS e Sezz. BA-BO-CT-NA
- Acquisizione di 5 DU complete
- Richiesti contratti per tutti i tecnici PNRR delle varie strutture coinvolte (18 mesi)
- Costi campagne marine per 2 anni
- Fondi per un nuovo nodo (CTF o JB)

Attività in corso ai LNS

- Definizione Campagne marine
- Upgrade stazione di terra Capo Passero
- Espansione rete di fondo (JB + interlink cables)
- Integrazione - test - calibrazione DU
- Integrazione BM
- Procurement
- Operatività telescopio e infrastr. sottomarina
- Simulazioni Monte Carlo
- Analisi dati
- Posizionamento acustico (assoluto e relativo)
- Divulgazione @Portopalo

LNS e KM3NeT

Tutti i LNS contribuiscono alla riuscita di KM3NeT ed in particolare

- Amministrazione
- Servizio fondi esterni
- Servizio di elettronica e rivelatori
- Reparto infrastrutture marine
- Divisione tecnica
- Divisione acceleratori

RICHIESTE 2026

FTE 2026

							Sigla Affine 1	Sigla Affine 2
1	Simone	Biagi	Dipendente	Primo Ricercatore	CNS II	80		
2	Danilo	Bonanno	Dipendente	Tecnologo TD	CNS II	100	PNRR_ITINERIS (100%)	
3	Michele	Calì	Associato	Prof. Univ. Catania	CNS II	80		
4	Silvio	Cherubini	Associato	Prof. Univ. Catania	CNS II	50		
5	Sebastiano	Ciancio	Dipendente	Dirigente Tecnologo TD	CNS II	100	PNRR_KM3NeT4RR (100%)	
6	Rosanna	Cocimano	Dipendente	Primo Tecnologo	CNS II	100		
7	Rosa	Coniglione	Dipendente	Primo Ricercatore	CSN II	100	KMINFRADEV2 (10%)	PRIN_2022A7ZC3K (10%)
8	Giacomo	Cuttone	Dipendente	Dirigente di Ricerca	CSN V	60	KMINFRADEV2 (4%)	
9	Didac	Diego Tortosa	Dipendente	Assegnista di Ricerca INFN	CNS II	100	FOCUS (100%)	
10	Carla	Distefano	Dipendente	Primo Ricercatore	CSN II	70		
11	Giovanna	Ferrara	Associato	RTDA Univ. Catania	CNS II	10	PNRR_KM3NeT4RR (10%)	
12	Dino	Franciotti	Dipendente	Dirigente Tecnologo	CNS II	50		
13	Emidio	Giorgio	Dipendente	Primo Tecnologo	CSN II	70		
14	Abdelghani	Idrissi	Dipendente	Assegnista di Ricerca INFN	CSN II	100	CIR01_00018 (IPANEMA) (100%)	
15	Giuseppina	Larosa	Dipendente	Tecnologo	CNS II	80		
16	Giuseppe	Laudani	Dipendente	Assegnista di Ricerca INFN	CNS II	100	LOW_NOISER (100%)	
17	Emilio	Migneco	Pensionato		CSN II	0		
18	Mario Salvatore	Musumeci	Dipendente	Primo Tecnologo	CNS II	50		
19	Angelo	Orlando	Dipendente	Primo Tecnologo	CNS II	100		
20	Daniele	Paesani	Dipendente	Tecnologo TD	CNS II	100	PNRR_KM3NeT4RR (100%)	
21	Paolo	Piattelli	Dipendente	Dirigente di Ricerca	CNS II	80		
22	Sara Rita	Pulvirenti	Dipendente	Primo Tecnologo	CNS II	100	PRIN_2022N2J9PX (DIVES) (17%)	MELITE_NATO (5%)
23	Giorgio Maria	Riccobene	Dipendente	Primo Ricercatore	CNS II	100	LOW_NOISER (?%)	INGV_PORTO (?%)
24	Simone	Sanfilippo	Dipendente	Tecnologo TD	CNS II	100	PNRR_ITINERIS (100%)	
25	Domenico	Santonocito	Dipendente	Primo Ricercatore	CNS III	20		
26	Piera	Sapienza	Dipendente	Dirigente di Ricerca	CSN II	70	KMINFRADEV2 (20%)	
27	Anna	Sinopoulou	Dipendente	Assegnista di Ricerca INFN	CNS II	100	PRIN_2022A7ZC3K (100%)	
28	Veronica	Valsecchi	Dipendente	Primo Tecnologo	CSN II	50		
29	Salvatore	Viola	Dipendente	Ricercatore	CNS II	80	PRIN_2022N2J9PX (DIVES) (14%)	MELITE_NATO (8%)
30	Daniele	Zito	Dipendente	Tecnologo TD	CSN II	100	PNRR_KM3NeT4RR (100%)	

FTE totali = 23

Contratti in scadenza entro 2025

Fondi esterni

Richieste economiche 2026 — missioni

Descrizione	Richiesta
Meeting management Italia (tutti i coordinatori sempre presenti)	11 520.00 €
Meeting di collaborazione KM3_INT (tutti i coordinatori sempre presenti)	76 050.00 €
Meeting Steering Scientific KM3NeT (solo coordinatori scientifici)	3 900.00 €
Meeting Project Steering Committee KM3NeT	5 880.00 €
Preparazione campagna marina (Site Man. + Mar. Op. Man.)	8 800.00 €
Visite DAQ manager presso altri siti integrazione	3 660.00 €
Visite Optics manager presso altri siti integrazione	2 440.00 €
Visite presso aziende coordinatori attività	5 760.00 €
Visite presso aziende USA (Teledyne/ODI) coordinatori attività	8 800.00 €
Attività di coordinamento Membri Management (STAC, RRB)	7 840.00 €
Attività presso il sito di Malta per il P6	26 250.00 €
Attività sulla nave campagna marina	8 100.00 €
Turni a Portopaolo durante campagna marina (alberto=albergo+macchina)	48 600.00 €
Attività integrazione shore station a Portopalo	20 100.00 €
Workshop tecnici per BM integration	3 720.00 €
Workshop tecnici per DU integration	5 580.00 €
Meeting di analisi F2F	11 505.00 €
	258 505.00 €

Richieste economiche 2026 — non missioni

Colonna1	Richiesta
Materiale consumo per integrazione DOMs	- €
Materiale consumo per integrazione BMs	5 000.00 €
Materiale consumo per integrazione stringhe: P1&P2&P3	3 600.00 €
Materiale consumo per integrazione stringhe: P4&P5	5 400.00 €
Materiale consumo per integrazione stringhe: P6 a Malta	1 800.00 €
Manutenzione processo 3	1 500.00 €
Manutenzione Fiber splicer	5 000.00 €
Batterie e schede per "pacco batteria" di tripodi per posizionamento	14 000.00 €
Strutture meccaniche tripodi per posizionamento acustico	40 000.00 €
Trasporto al porto di Catania	10 000.00 €
Software Autodesk (AutoCAD+Inventor) licenze individuali per progettazioni meccaniche	14 000.00 €
Attenuatore per laser beacon	1 500.00 €
Consumo per spese funzionamento laboratorio JB	2 000.00 €
	103 800.00 €

Common funds 7.3 kE per author, numero di firme INFN = 87 Richiesta = 635k

Spazi

Proposta attività per il 2026: integrazione 10 Base Module + 9 Detection Unit

Supporto LNS per:

- laboratorio integrazione DU (porto)
- laboratorio integrazione BM (LNS)
- laboratorio test e integrazione Junction Box (LNS)
- gestione infrastruttura di Portopalo di Capo Passero (condizionamento, impianti di alimentazione, logistica, spazi, ecc…)

Servizi e Personale

Supporto dei LNS fondamentale per la riuscita di KM3NeT:

- Divisione tecnica
- Divisione acceleratori
- Servizi di Amministrazione
- Servizio fondi esterni
- Servizio di elettronica e rivelatori
- Reparto infrastrutture marine

Tale supporto sarà ovviamente importante anche per tutto il 2026.

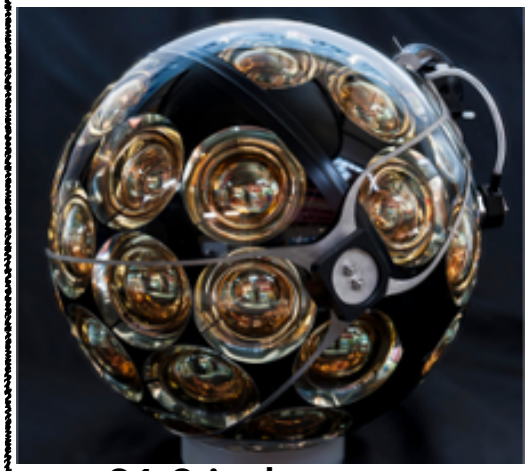
A fine novembre 2025 in scadenza 8 contratti tecnici PNRR (4 elettronici, 2 meccanici, 2 informatici).

In attesa di nuovi fondi esterni, se approvati, si richiede ai LNS il supporto di risorse umane per proseguire le diverse attività di integrazione cercando di non accumulare eccessivi ritardi, e risorse umane a supporto alla gestione e presa dati dell'apparato a Portopalo.

Spares

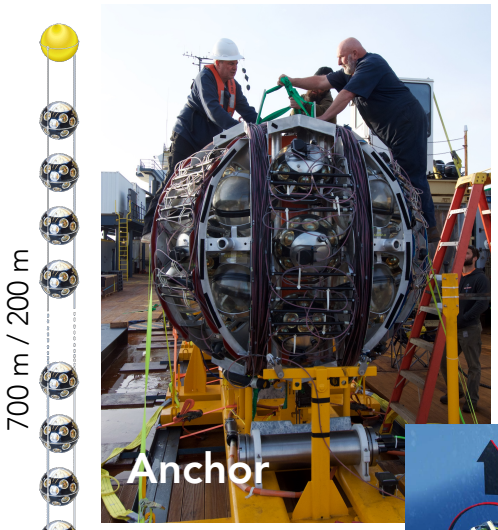
Detector basic elements

The optical sensor



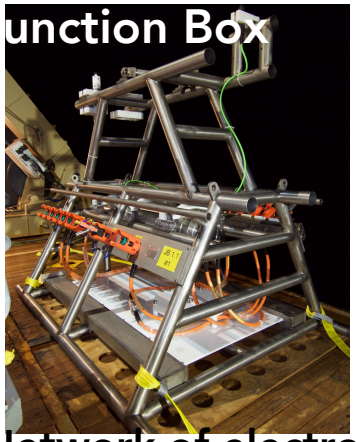
31 3 inches photomultipliers + electronics inside a glass sphere

The String



18 optical sensors in a string

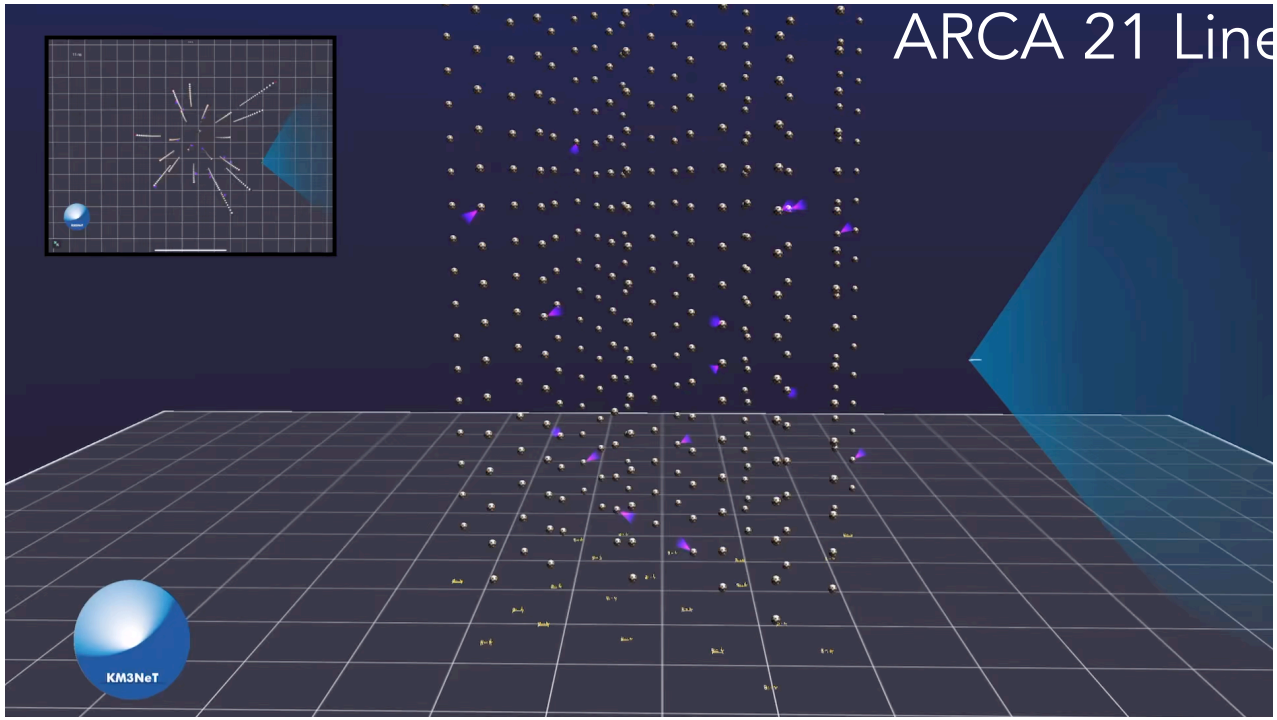
The sea floor network



Network of electro-optical cables and Junction-Boxes to distribute power and collect signals from deep sea to shore

The KM3NeT ultra-high-energy event

Huge amount of light detected 👉 35% of the total number of photomultipliers were triggered



- **Energy is measured from the amount of light:**

$$E_\mu = 120^{+110}_{-60}\ \text{PeV}$$

(10 000 times the energy of the LHC)

- **The neutrino Energy is higher:**

$$E_\nu = 220^{+570}_{-100}\ \text{PeV}$$