KM3NET

R. Coniglione
LNS-INFN

La sigla KM3NeT

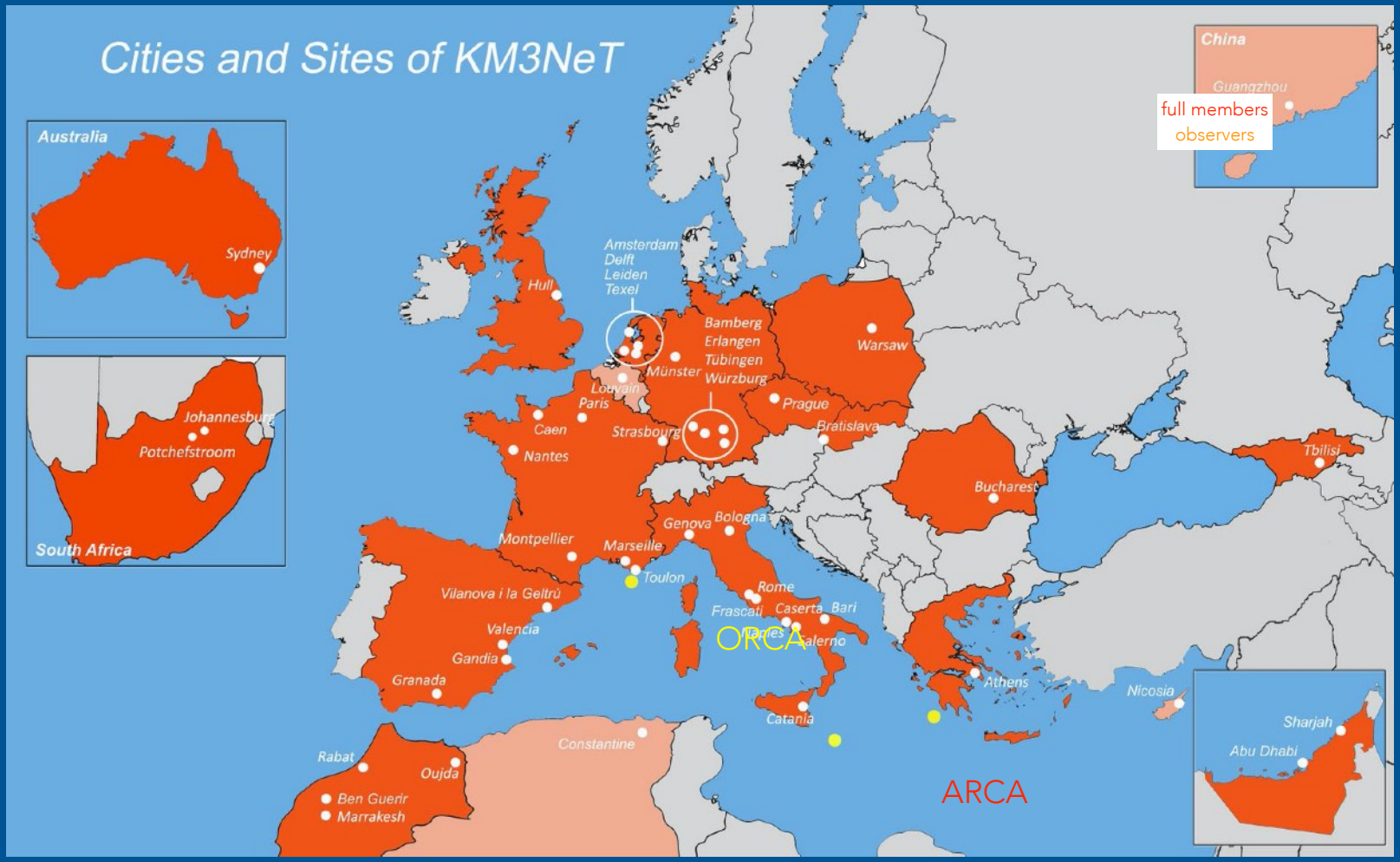
Resp. Nazionale G. Cuttone

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<100 GeV) - rivelatore al largo delle coste di Tolone in costruzione
- Attività ANTARES
  - Piccolo rivelatore per la neutrino astronomia che ha preso dati per più di 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

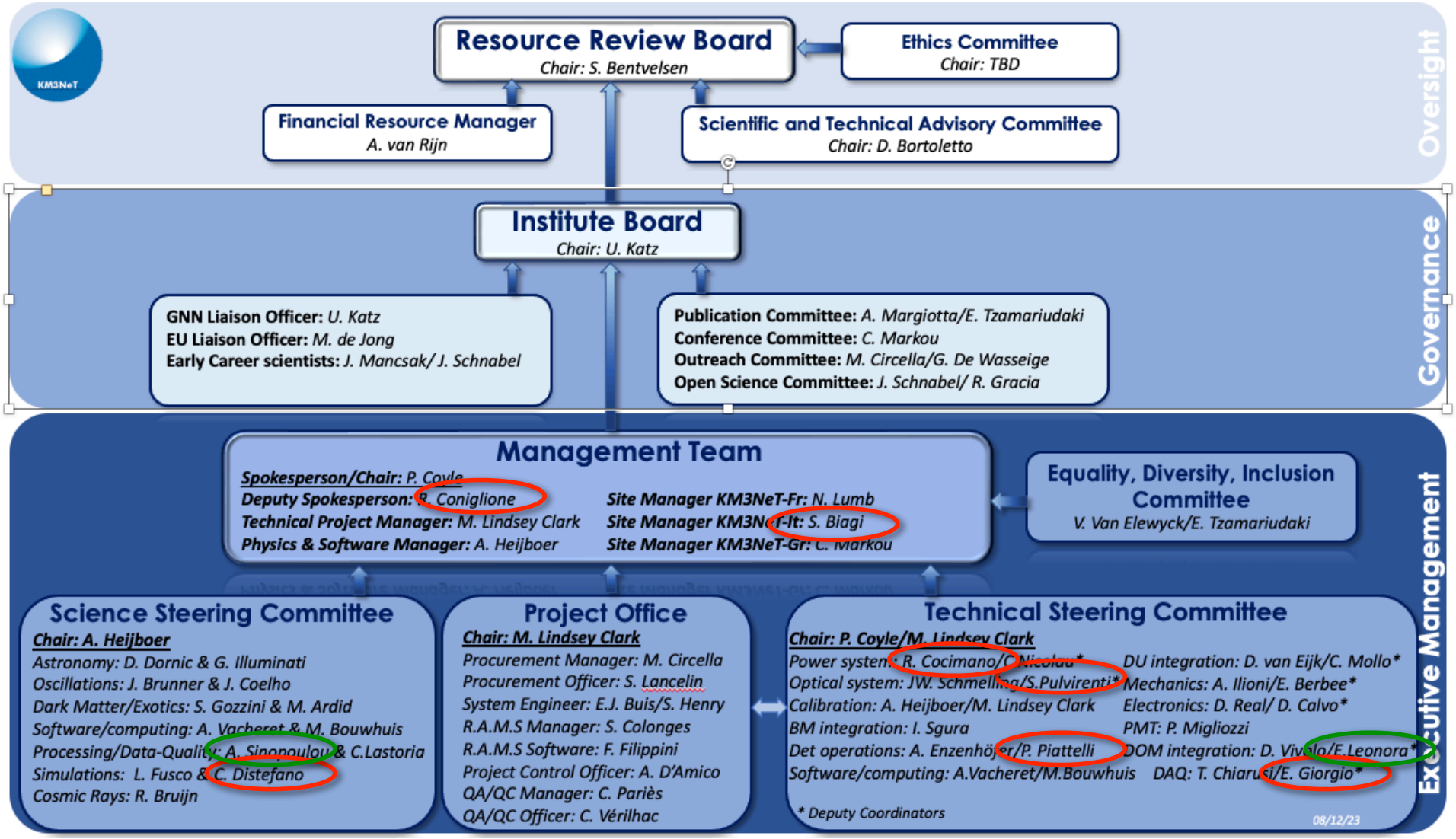
THE KM3NET COLLABORATION

63 institutes in 22 countries

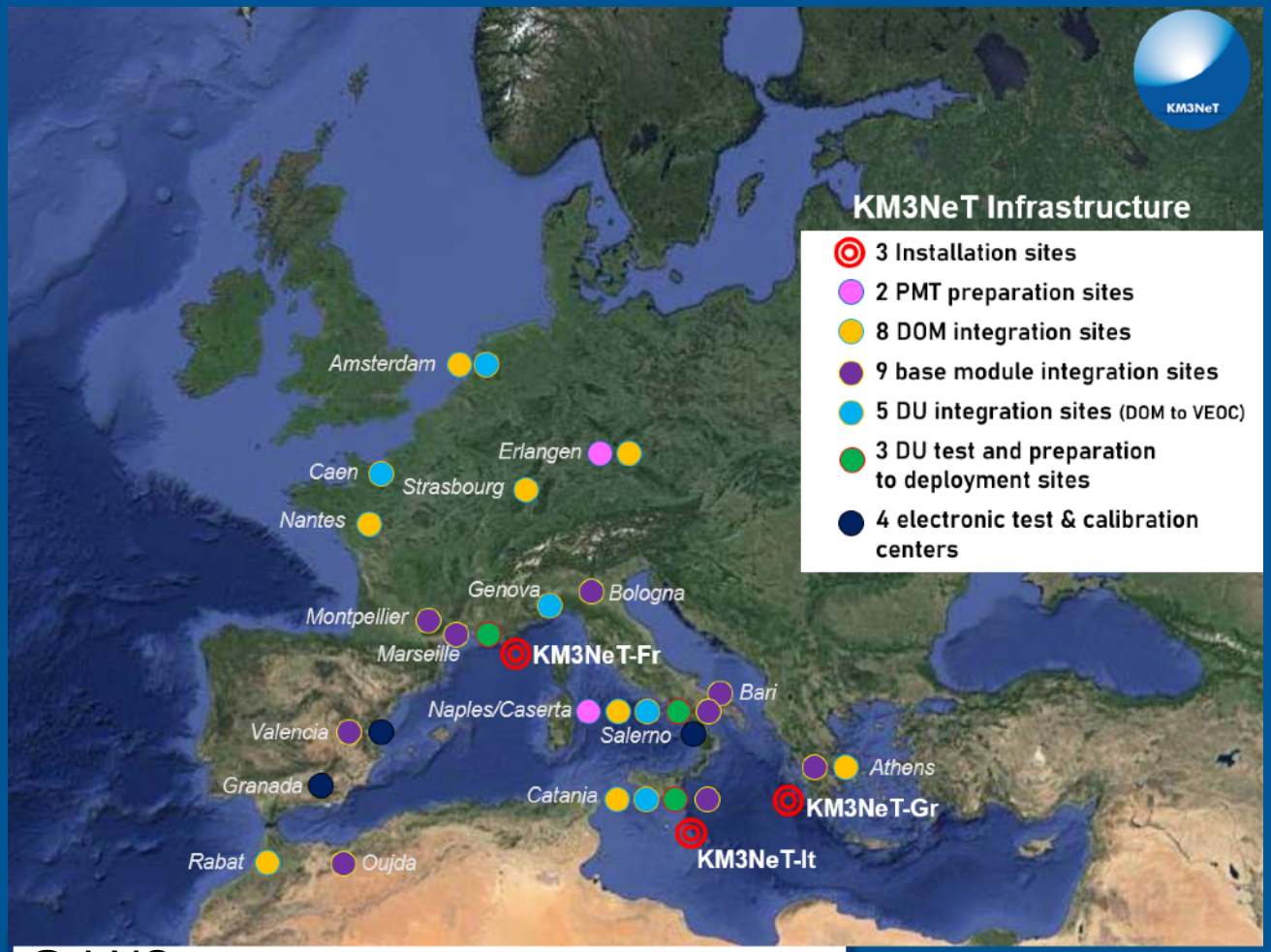


+ Harvard University (USA) + Drexel University (USA)

KM3NeT Organigramma



THE DETECTOR CONSTRUCTION



DOMs
- 8 integration sites
- 1508 DOMs integrated
- 80 currently on bench

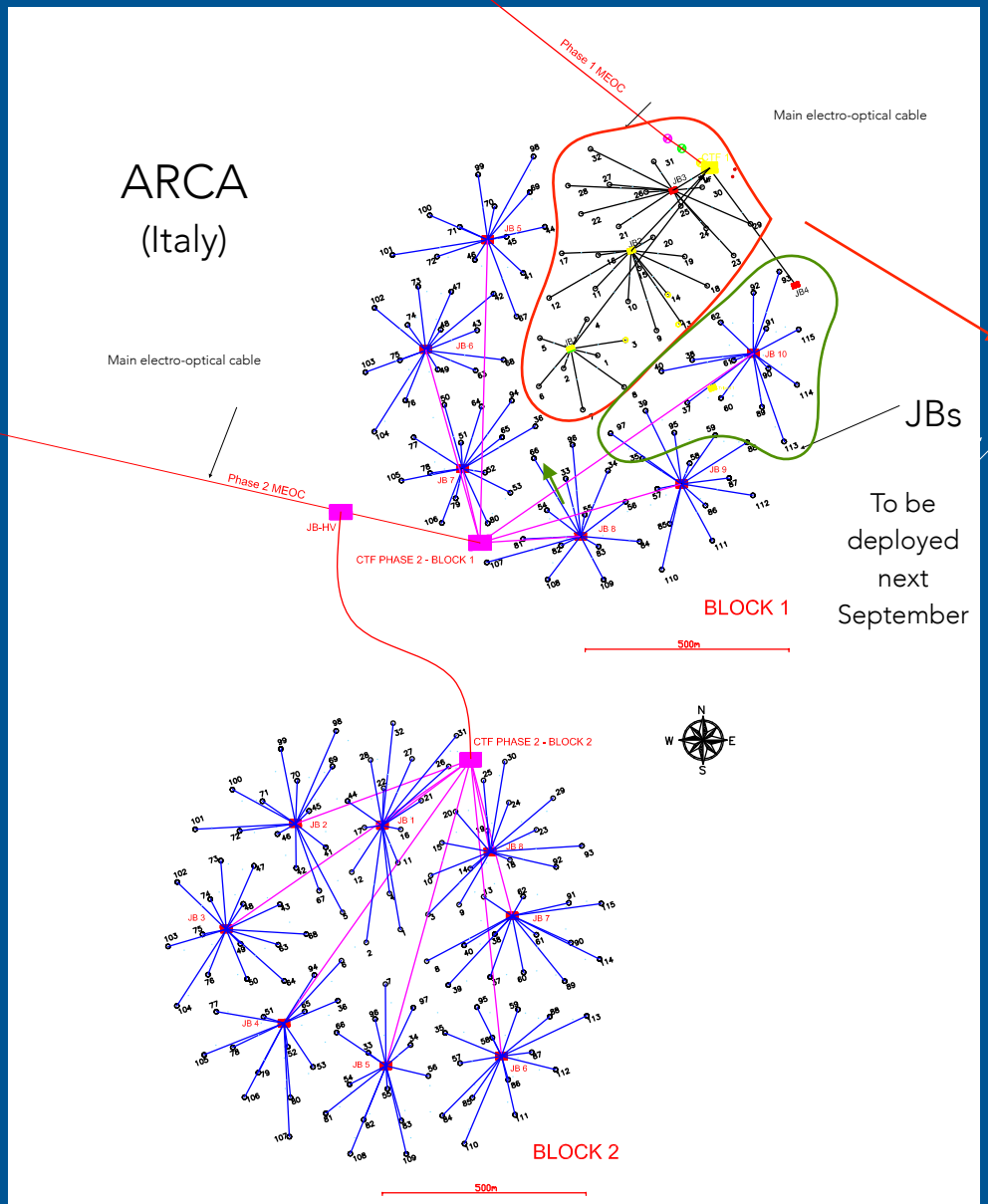
BMs
- 9 integration sites
- 88 BMs integrated
- 4 currently on bench

DUs
- 6 integration sites
- 71 DUs integrated
- 49 deployed

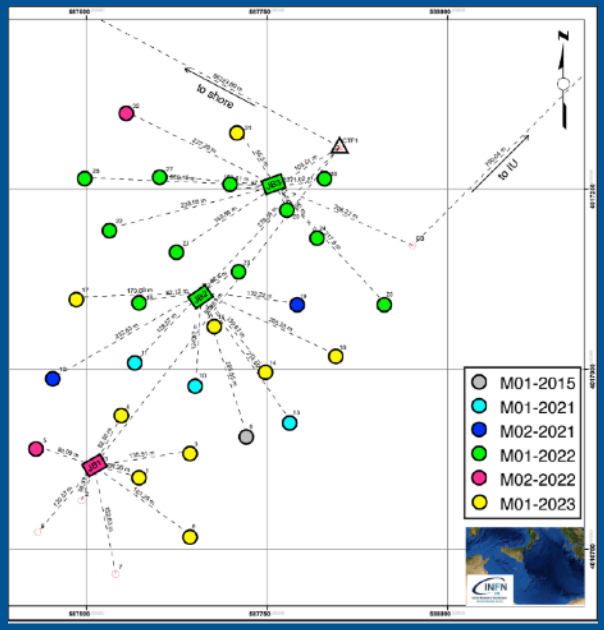
@ LNS
BM integration site (resp. G. Larosa)
DU integration site (resp. P. Sapienza)
@ Sezione Catania
DOM integration site (resp. E. Leonora)

Più di 1500 DOM integrati

THE KM3NET/ARCA STATUS

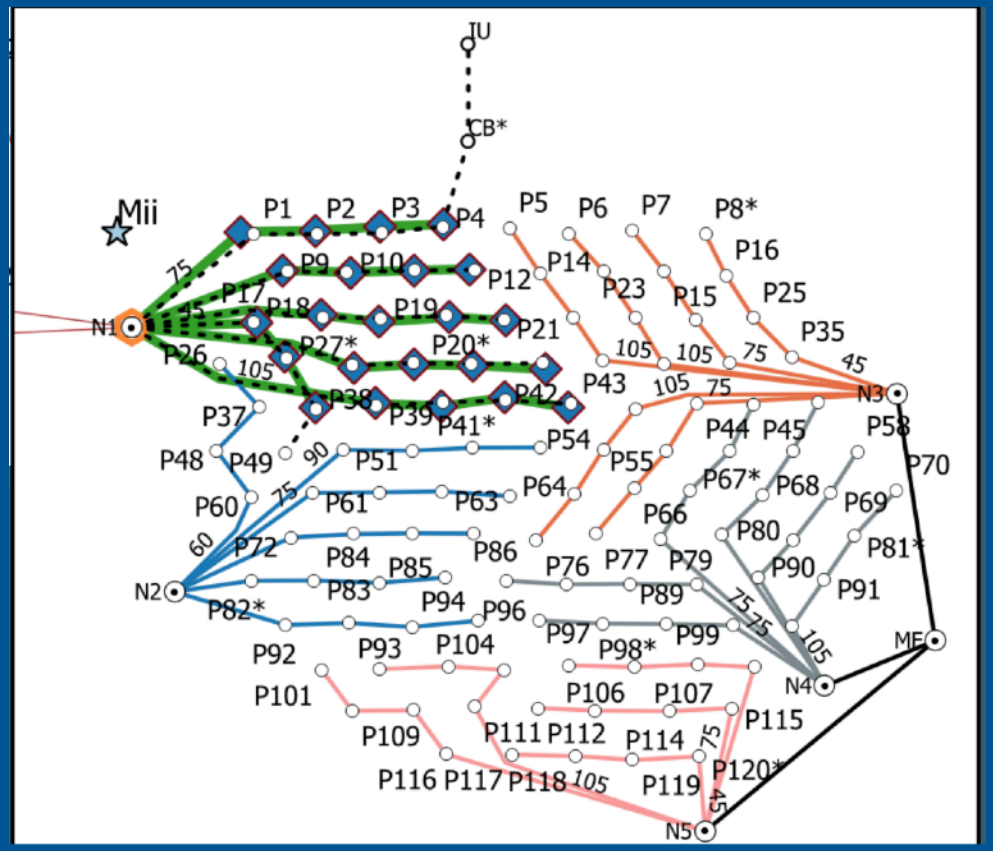


Current status 28 DUs deployed
+ 3 JB



THE KM3NET/ORCA STATUS

Current status 23 DUs deployed



Many sea campaigns/year

Next one foreseen before the end of the year 👉 complete the DUs of node1 and deploy the node2 & 4-5 DUs

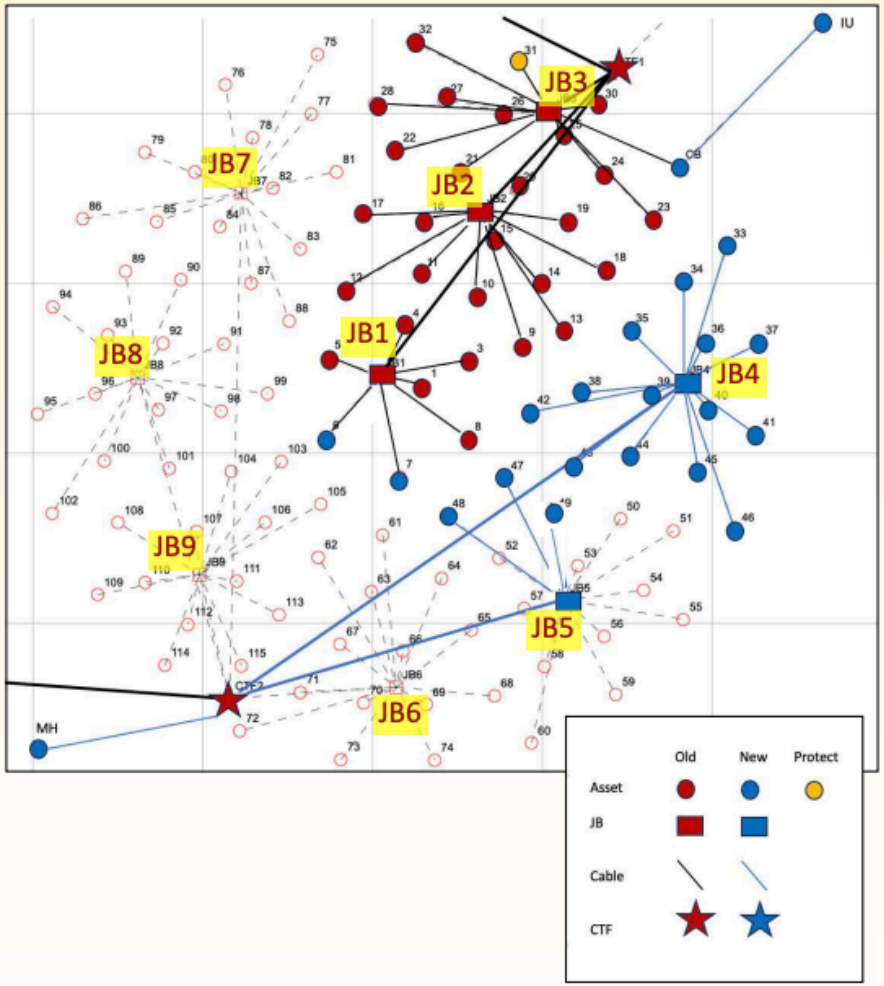
Almost completed the first node

👇

20% of the full detector in water

ARCA NEXT SEA CAMPAIGN

September-October 2024



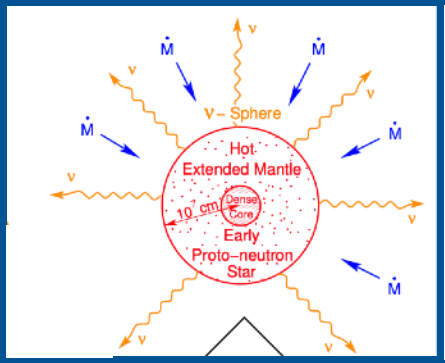
- Deploy
  - 2 x DU (Phase-1) to JB1
  - CB in position 29 with its IU
  - JB4 and JB5, with related interlinks
  - 14 x DU to JB4
  - 3 x DU to JB5
  - Marine Hazard (MH) to CTF2, interdiscipl. proj.
- Recovery
  - ARCA.0031 (low priority)
  - ARCA.0009 (very-very low priority)
  - Interlink.0002 (ARCA.0002 removed from map)
  - 1 non-working acoustic tripod
- Acoustic positioning (approx 3 full days)
  - Deploy 4 tripods with EXAIL transponders + KM3NeT beacons — final coordinates needed by CALIB WG after feedback from EXAIL¶
  - Box-in procedure for improved positioning

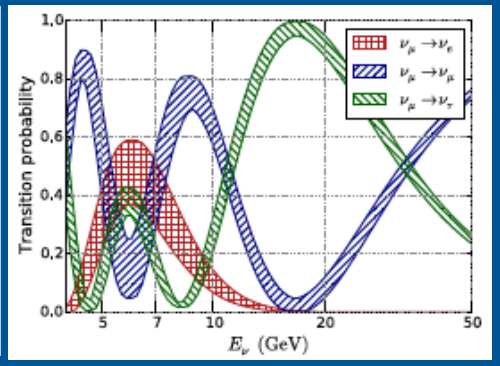
* Interlinks IL.0002, IL.0006, and IL.0007 are on the seafloor, connected to JB and protected on DU-side.

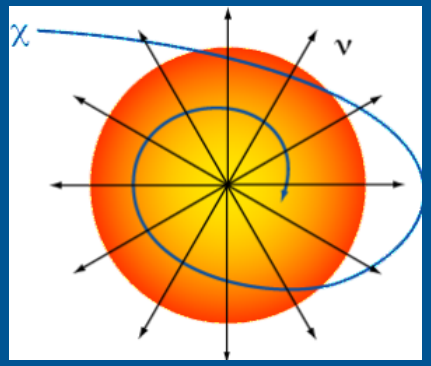
ARCA&ORCA: RESULTS

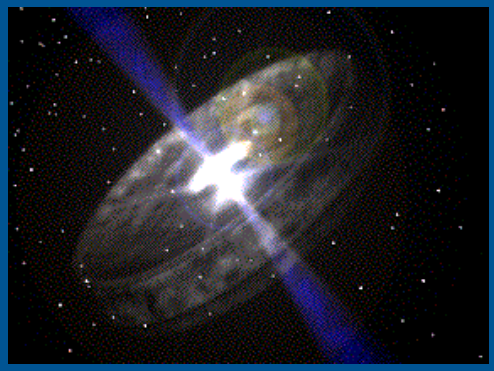
Presented the past week at ICRC2024 and CRIS-MAC conferences

THE PHYSICS









Supernova explosions
Single DOMs as detectors
ARCA&ORCA

Neutrino oscillation
Main topic of ORCA

Dark Matter
ORCA & ARCA

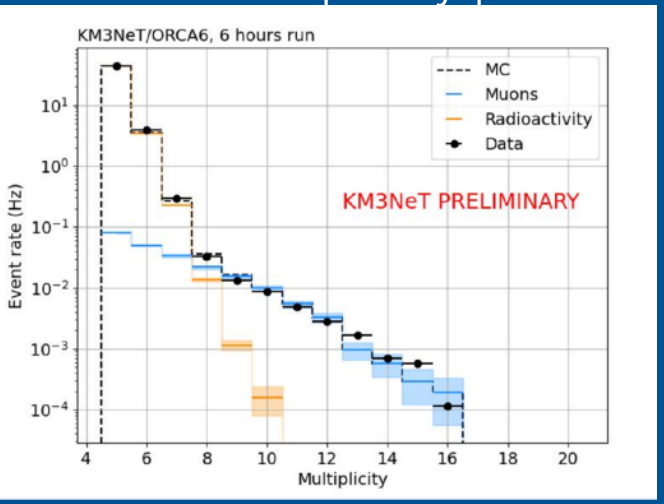
HE neutrinos
Multi-messenger program
Main topic of ARCA

From MeV … …. to PeV

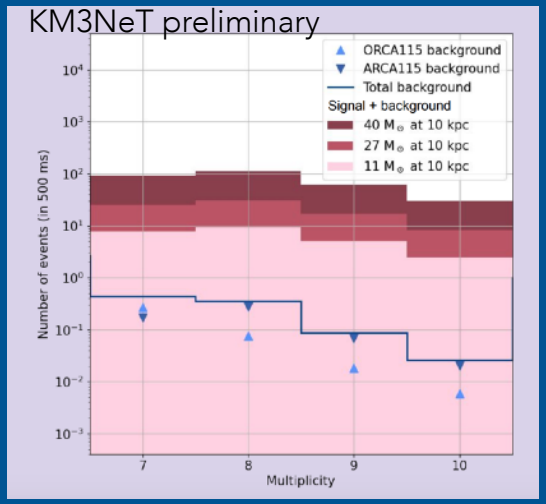
A DOM as a single detector

Muon background rejection improved

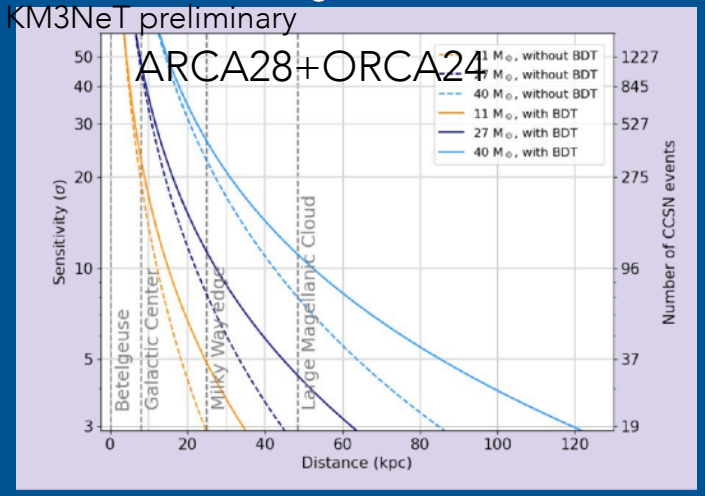
PMT multiplicity plot



Signal expected above background



Significance

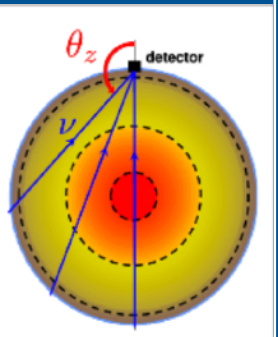


>5σ for ARCA+ORCA for 27$M_\odot$ at a distance <50kpc

An on-line alert system for CCSN already implemented

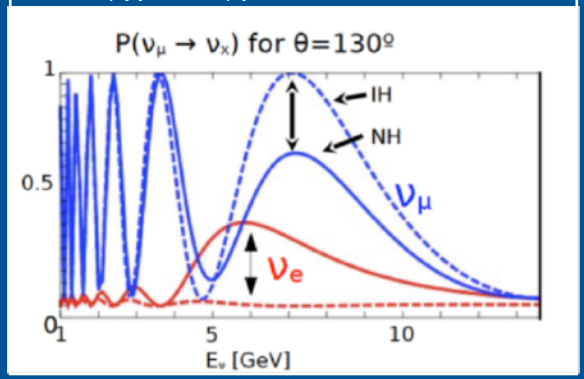
Integrated in SNEWS

Baseline from 50 to

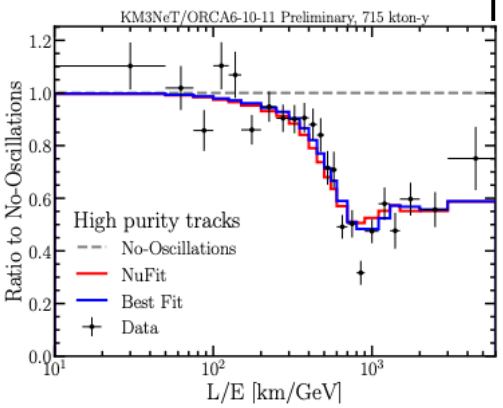


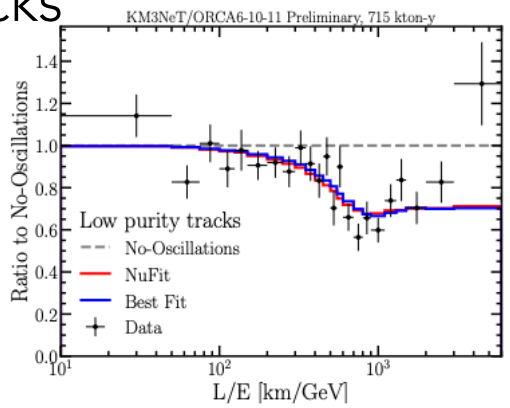
Neutrino Mass Ordering measuring atmospheric neutrinos crossing the Earth

Energy range of interest 5-15



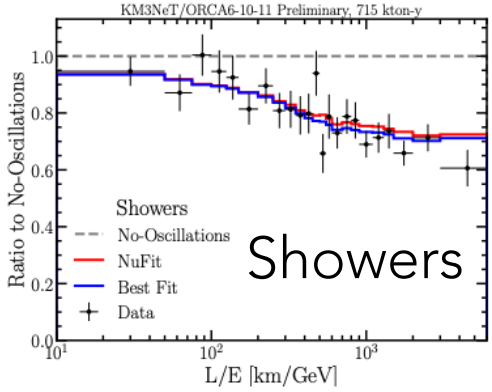
Tracks





ORCA6-7-11 data

Oscillations clearly seen both in track and shower events



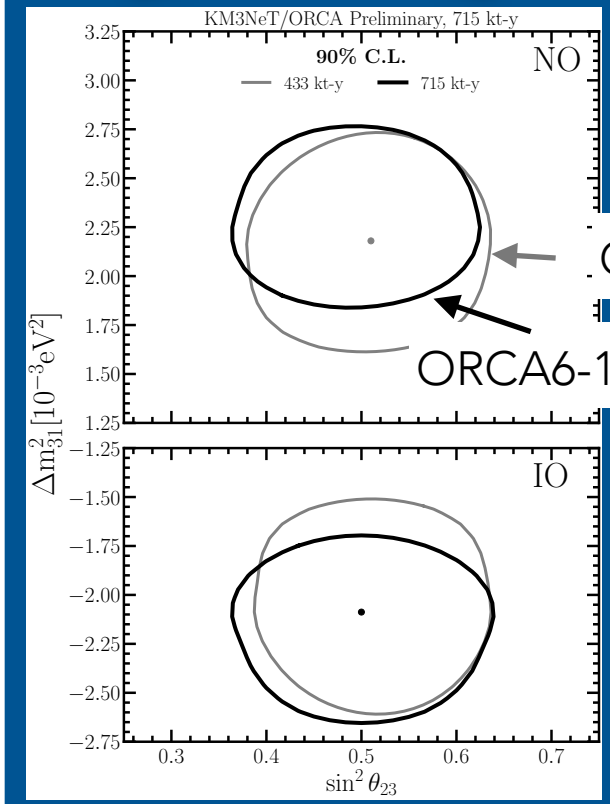
Showers

Same kind analysis of ICRC2023
increased the exposure

👇

From 433kt-yr to 715 kt-yr

Δm^2_{32} vs $\sin^2\theta_{23}$



ORCA6 👉 433 kton-yr

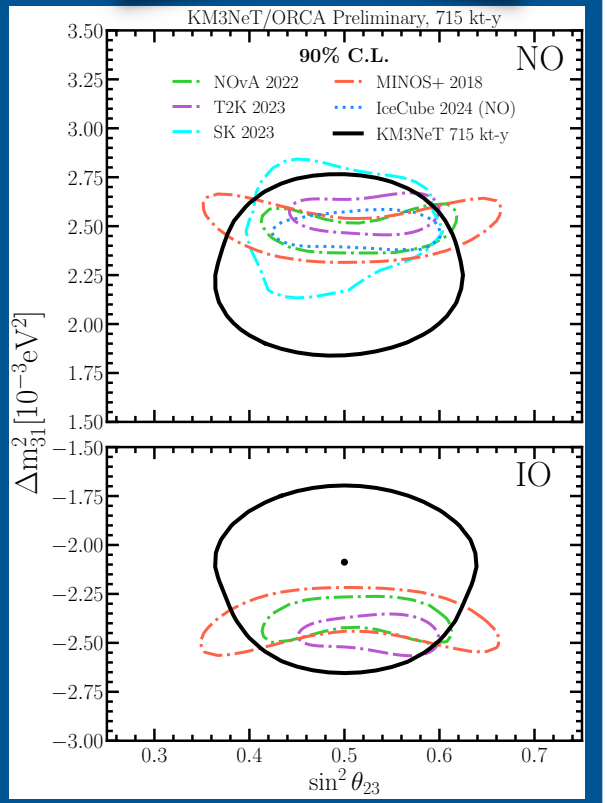
ORCA6-10-11 👉 715 kton-yr

$$\Delta m^2_{31} = \begin{cases} -2.09^{+0.17}_{-0.21} \times 10^{-3}\mathrm{eV}^2, & \mathrm{IO} \\ [2.10, 2.37] \times 10^{-3}\mathrm{eV}^2, & \mathrm{NO} \end{cases}$$

$$\sin^2\theta_{23} = 0.50 \pm 0.07$$

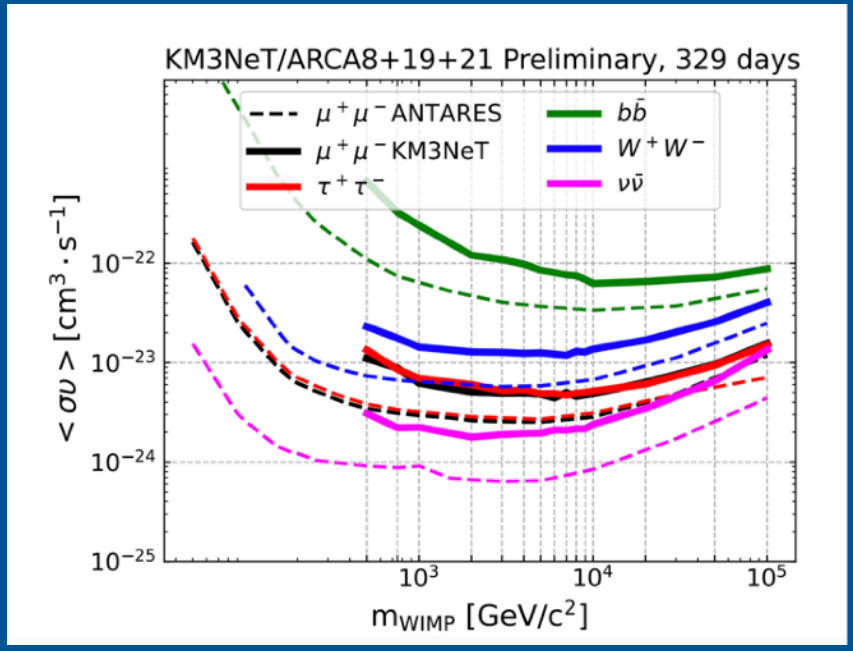
$$2\log(\mathcal{L}_{IO}/\mathcal{L}_{NO}) = 0.61$$

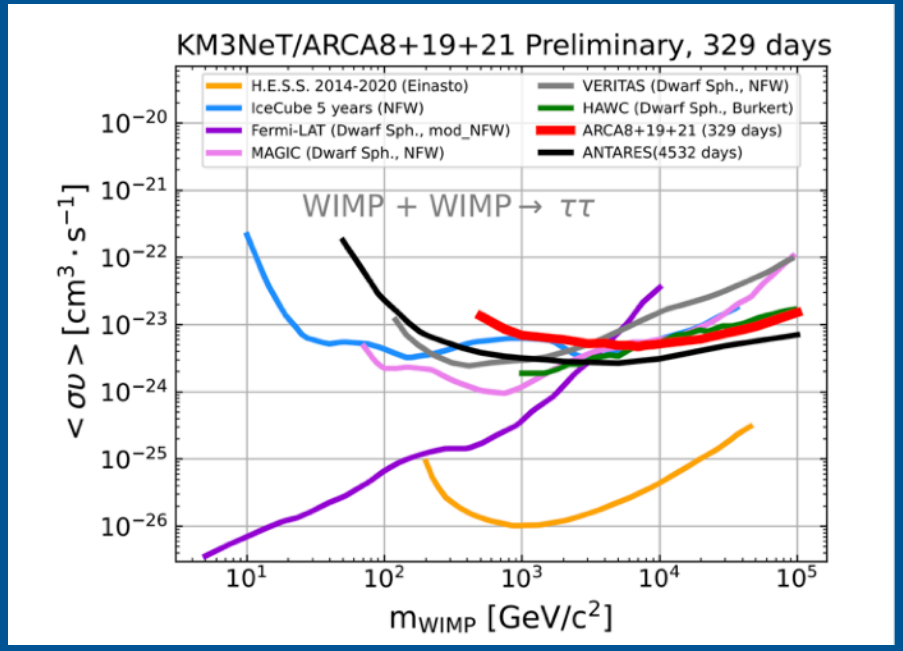
Δm^2_{32} vs $\sin^2\theta_{23}$



KM3NeT/ORCA competitive

From the Galactic Center



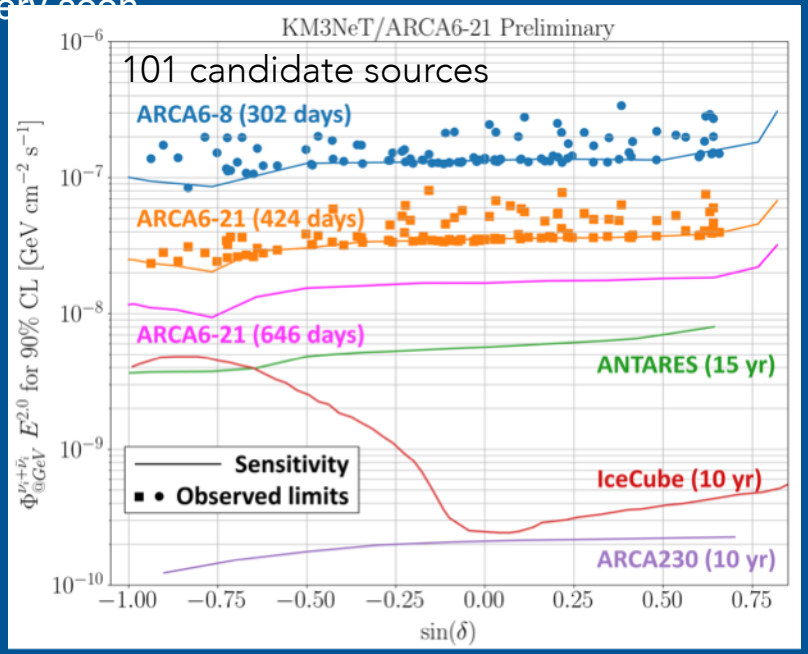


KM3NeT quickly reaching the ANTARES limits

SEARCH FOR POINT-LIKE SOURCES

ARCA21 unblinded until December 2022

Unblinding of ARCA21 data full period expected very soon

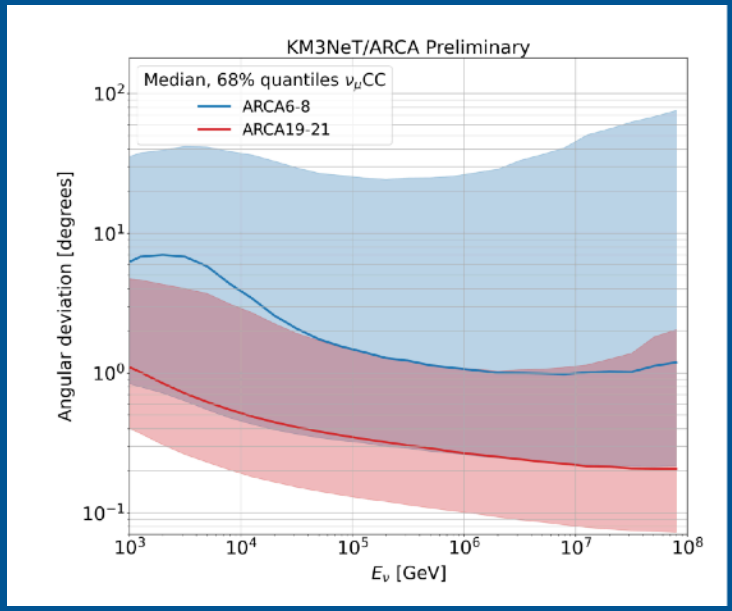


Large improvement in sensitivity is expected in the next year:
+ ARCA28 from sept 2023 + ARCA48 from sept 2024

KM3NeT upper limits are quickly reaching the ANTARES 15yr limits

Improvements also in angular resolution

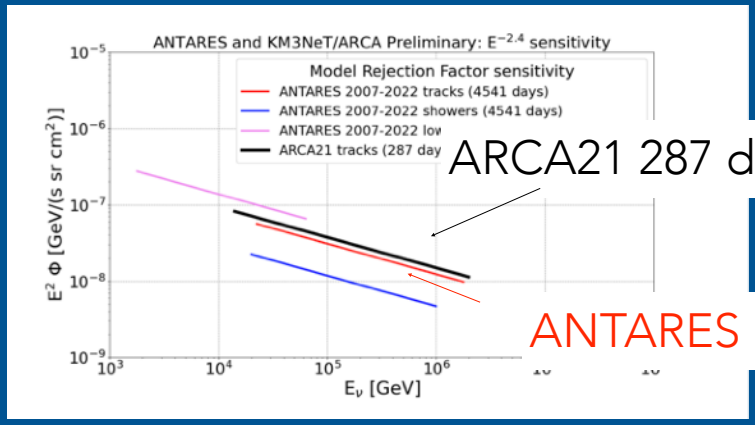
Angular resolution



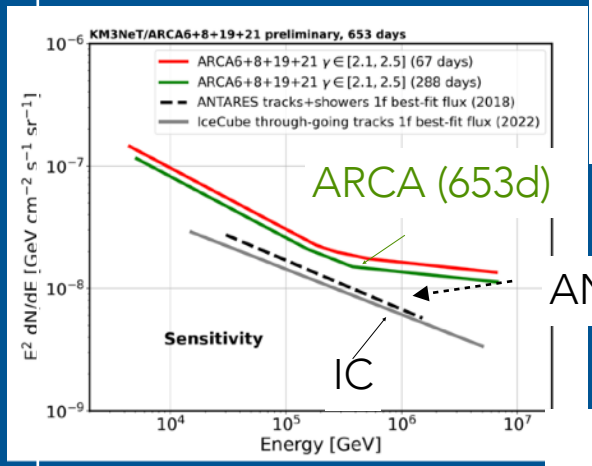
Joint ARCA-ANTARES point-like searches on going. ANTARES (15y) contributes most significantly, enhancement by 10% observed adding ARCA data (424d)

SEARCH FOR DIFFUSE FLUXES

From the full sky



With the data collected until Sept. 2023 same sensitivity of ANTARES 15yr for track events

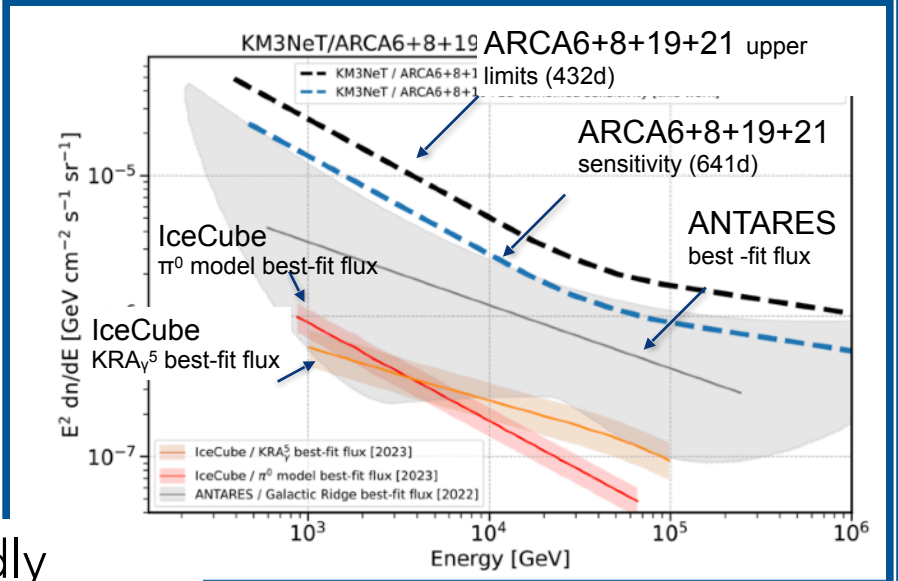


From the galactic plane

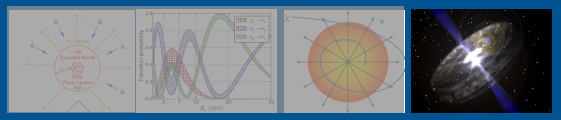
ARCA6 & ARCA8 & ARCA19 fully analyzed
ARCA21 partially analyzed (until December 2022)

KM3NeT On-Off zone analysis

|l| < 31° and |b| < 5° for KM3NeT/ARCA6-8 and
|l| < 31° and |b| < 4° for KM3NeT/ARCA19-21

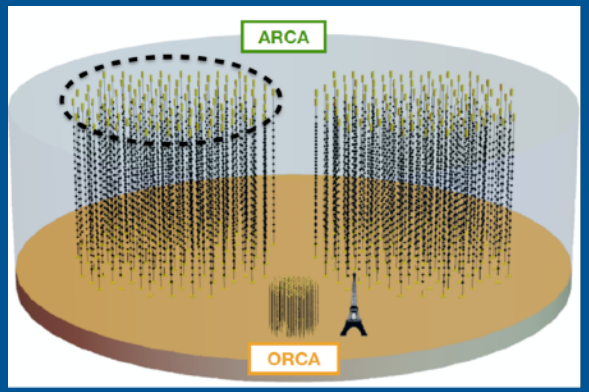


ARCA rapidly approaching ANTARES sensitivities



MULTI-MESSENGER PROGRAM

A dedicated software is installed at the shore stations for Real-Time Analysis (RTA)



Sending alerts

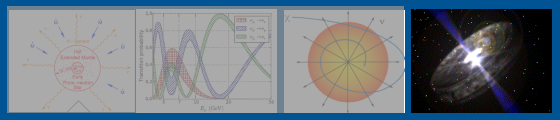
Send neutrino alert to external communities

Receiving alerts

Receive alert from external communities - on-line analysis and follows ups

Receiving alert system operative 👉 **RTA platform already** active from November 2022 in ARCA and in ORCA detectors

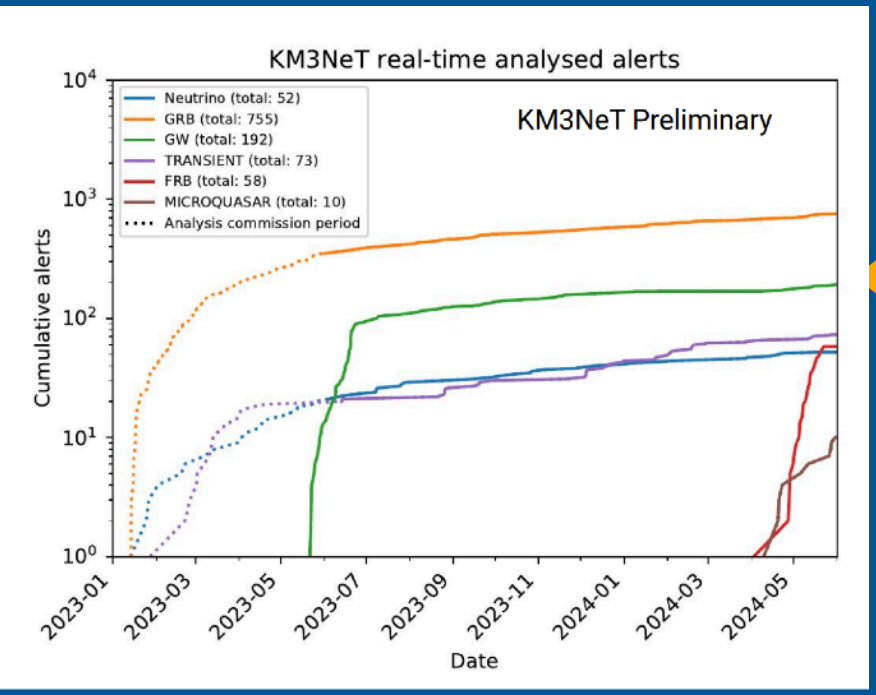
Sending alert system on going 👉 **High-energy neutrino alerts** will be sent in real-time by end of 2024.



MULTI-MESSENGER PROGRAM

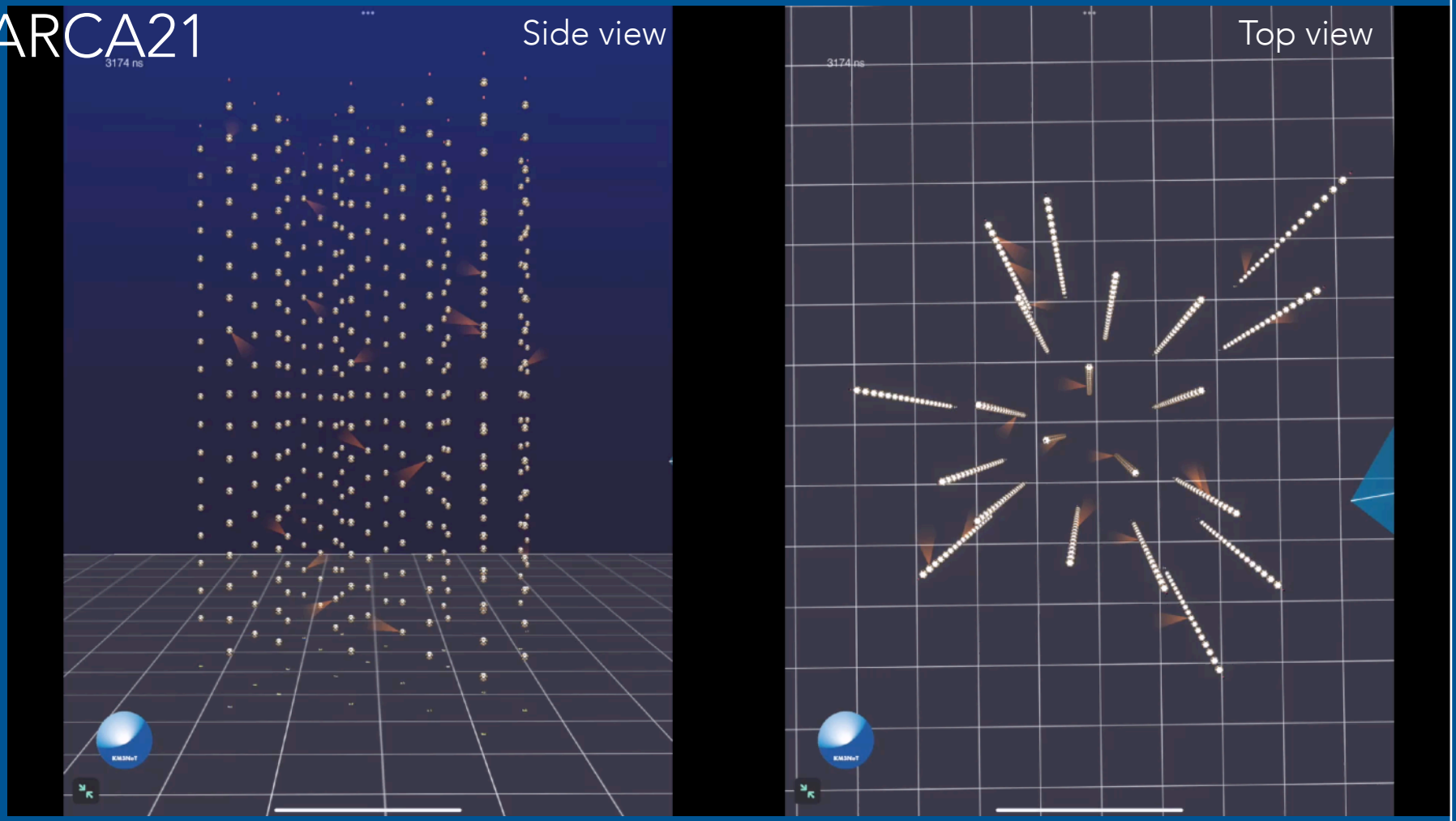
oS(ICRC2023)1125

A dedicated software is installed at the shore stations for Real-Time



Several thousands of alert received and analyzed in real time 👉 so far no significant excess found in any of the observed alerts

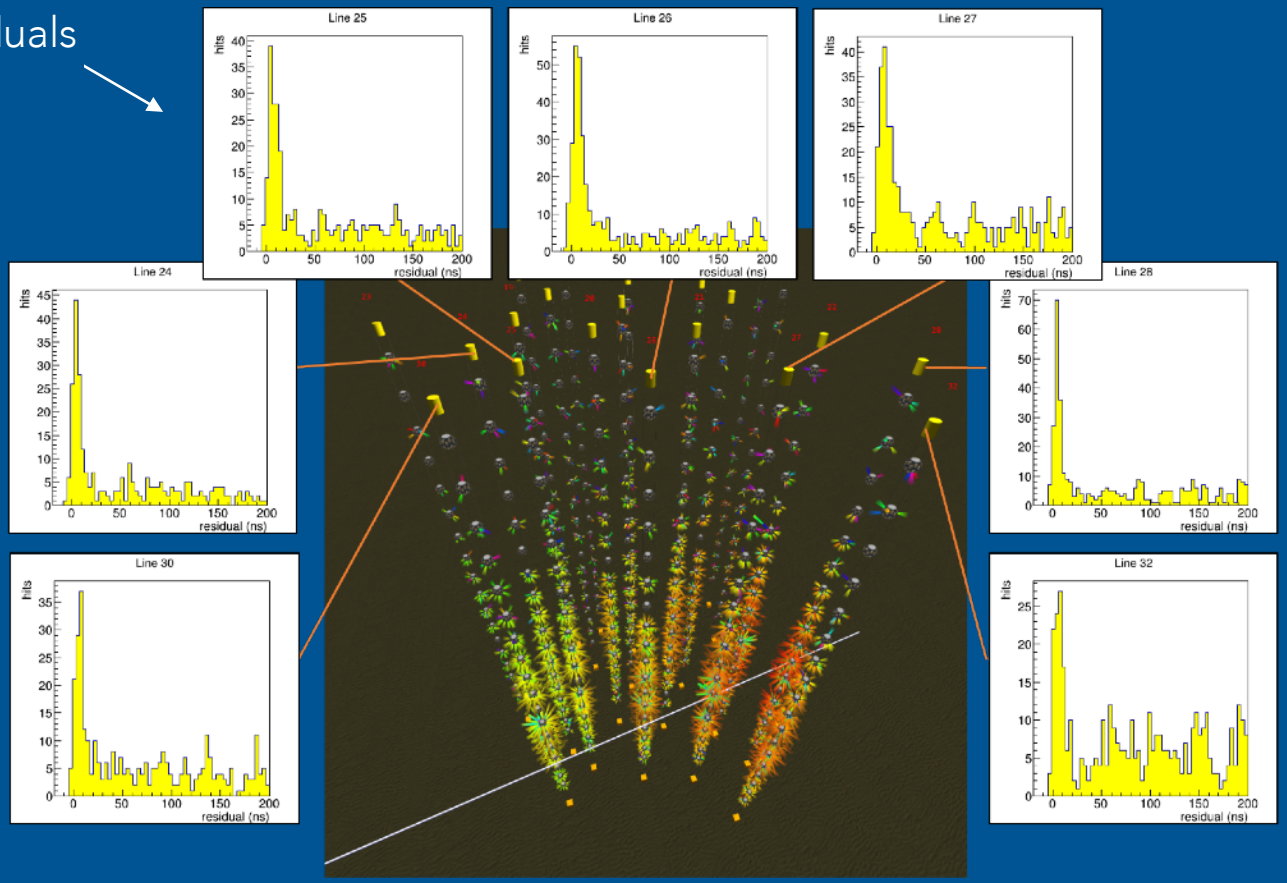
A very energetic cosmic event detected



A very energetic cosmic event detected

The event is well reconstructed as a track

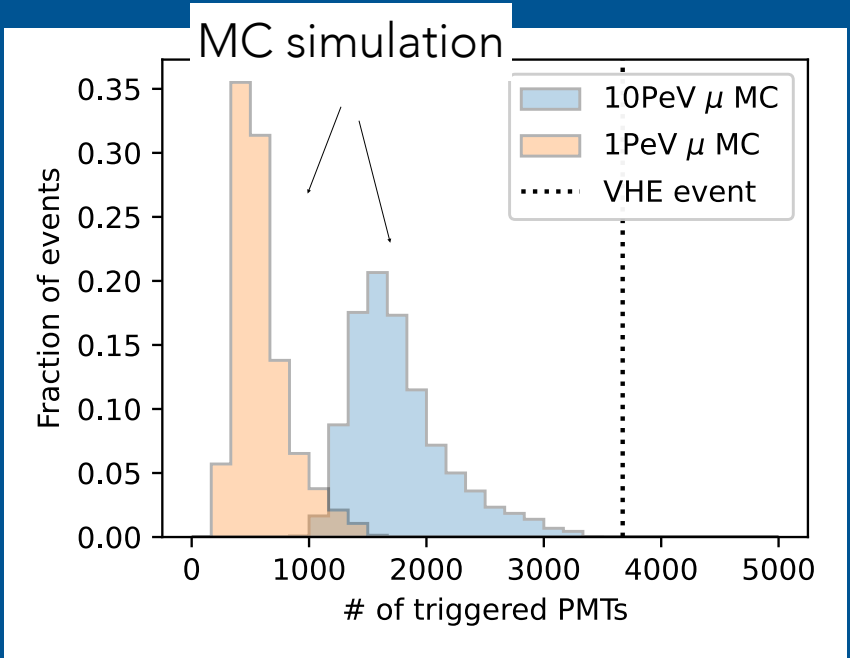
Time residuals

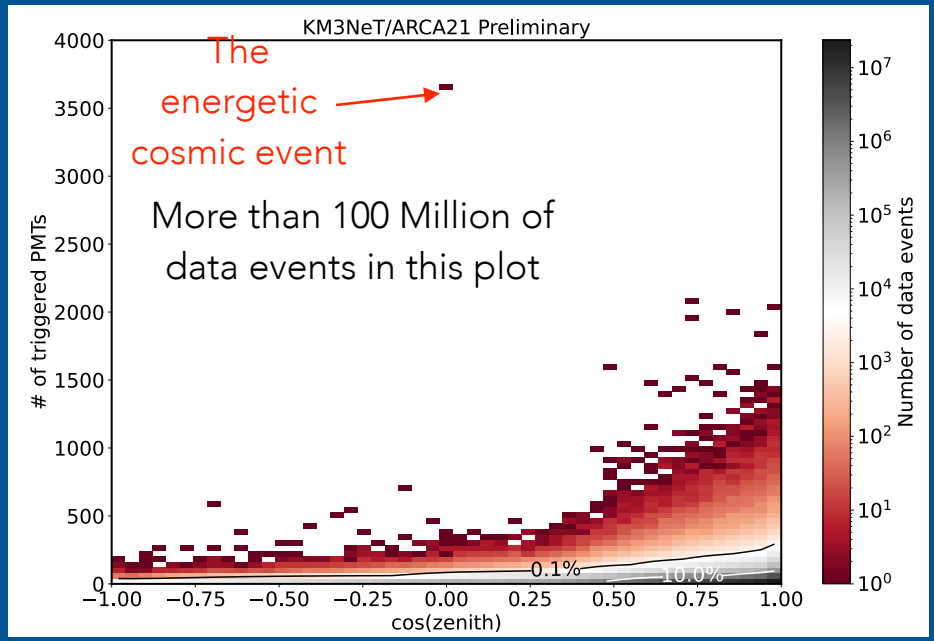


A very energetic cosmic event detected

The event is a horizontal event (1° above the horizon) with energy above 10 PeV

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

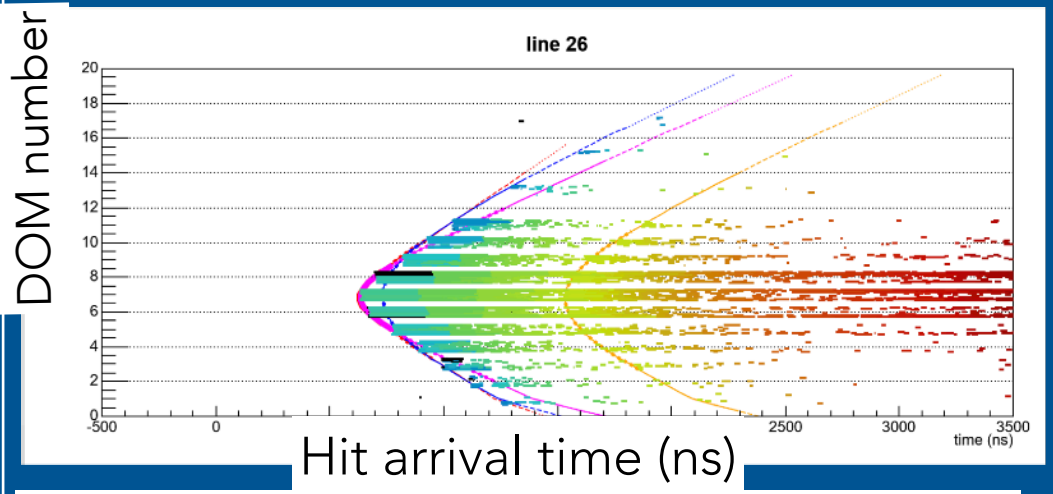




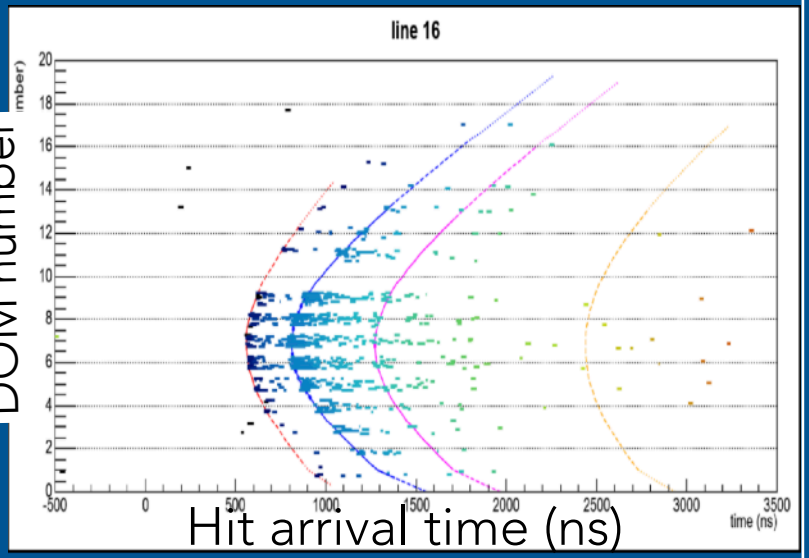
THE EVENT WITH THE HIGHEST ENERGY

From the track and shower reconstructions 👇

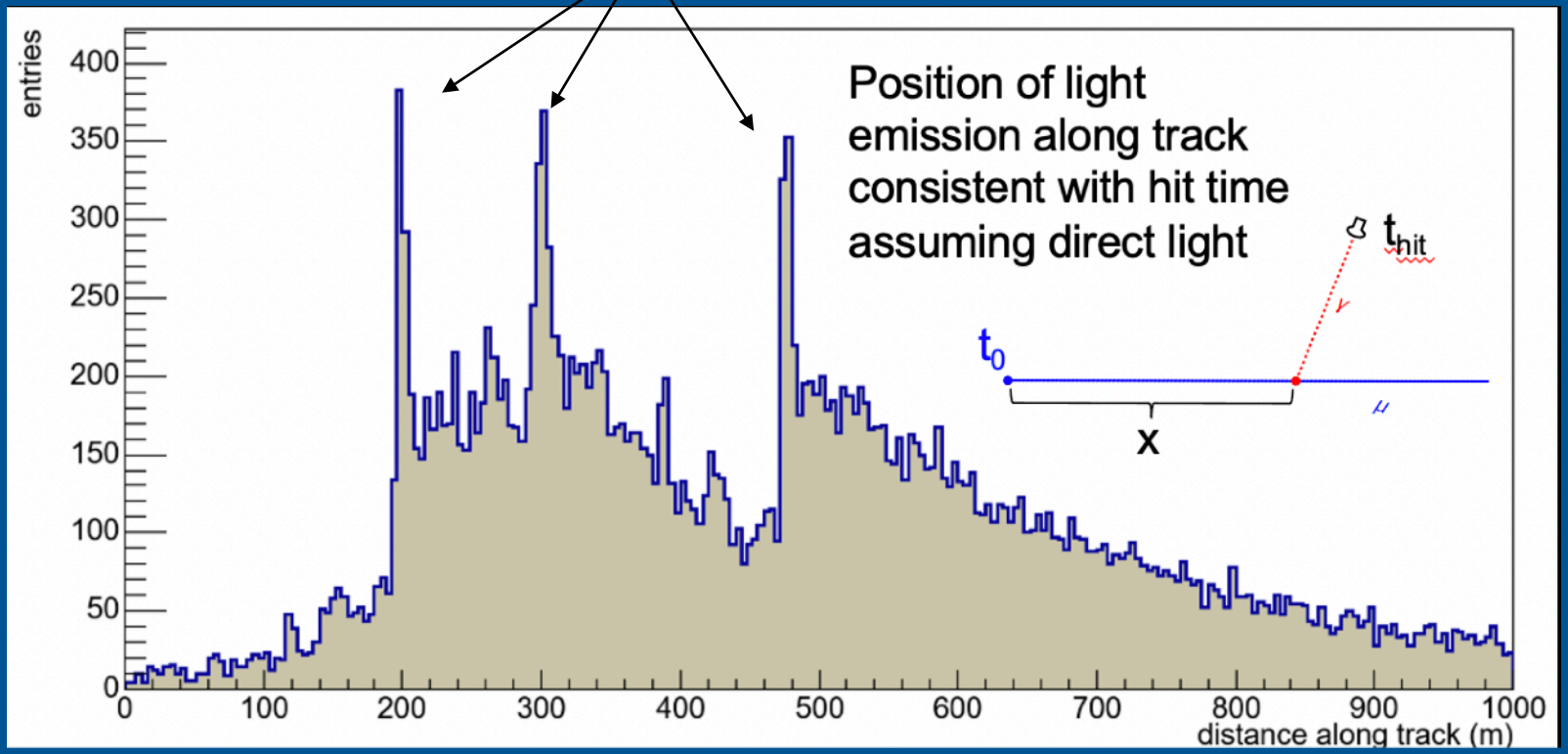
A muon track and three showers detected



Hit times are fully consistent with photons from Cherenkov emission



Hit times consistent with the emission from three points along the track 👉 stochastic light emission

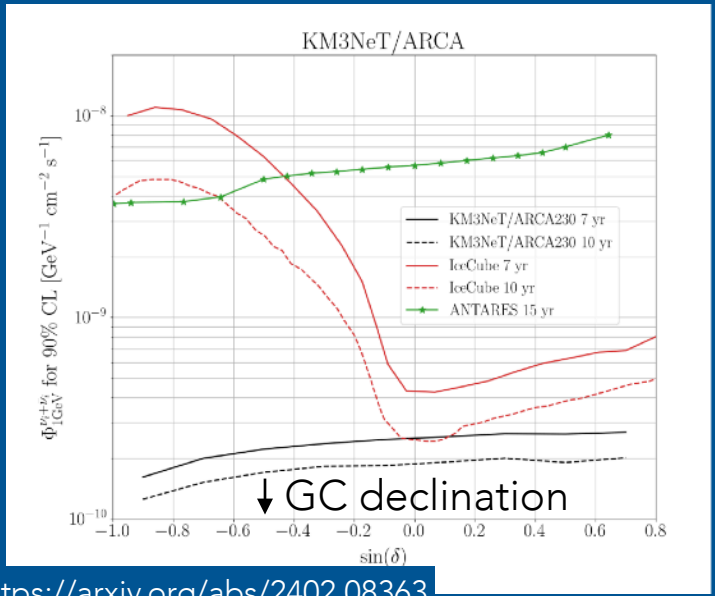


KM3NET PERSPECTIVES

eS(ICRC2023)1125

ARCA - Sensitivity for point-like searches

ARCA 230

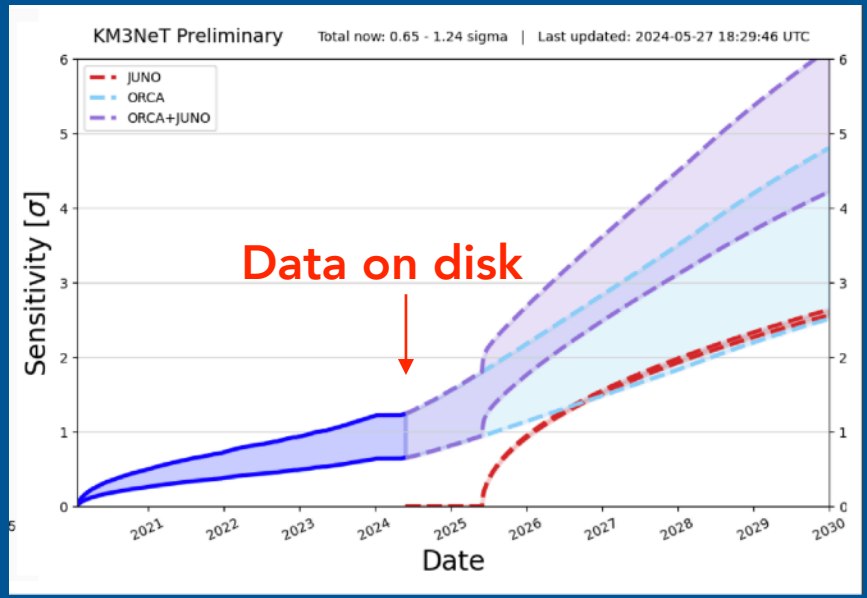


https://arxiv.org/abs/2402.08363

Big expectations for the southern sky

ORCA - Neutrino mass ordering

Predictions based on the current construction plan.



5σ can be reached in the next 5-6 years if combined with Juno

2020 2021 2022 2023 2024 2025 2026 2027 2028 2029

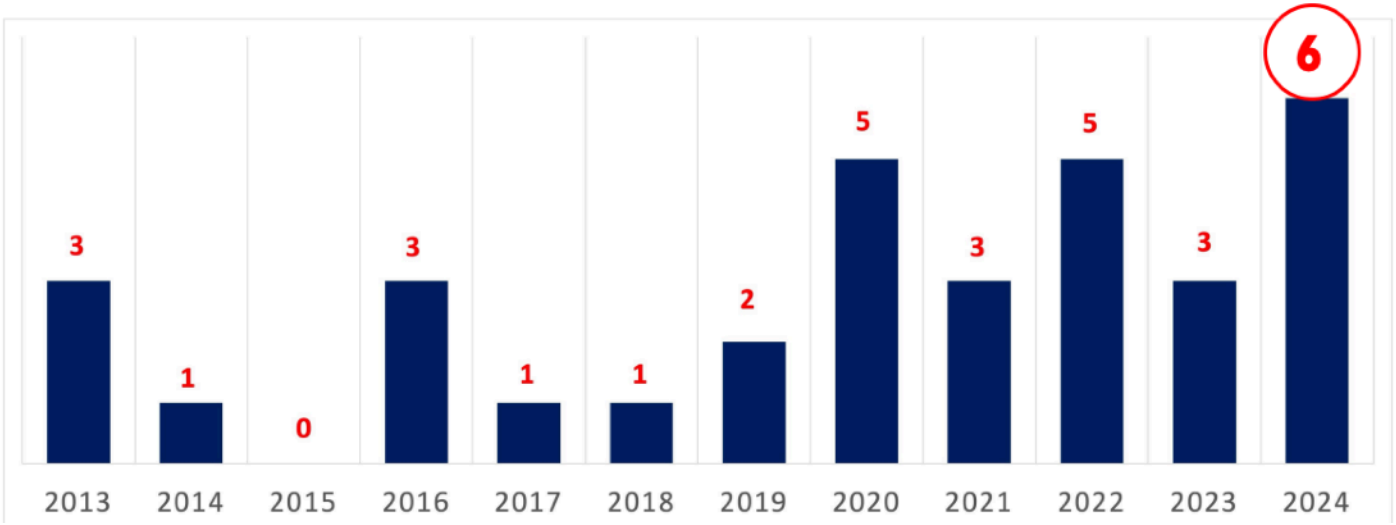
ANTARES decommissioning

ARCA 48DUs ORCA 24 DUs

ARCA & ORCA completion

KM3NET PUBLICATIONS

KM3NET IN PEER-REVIEWED JOURNALS – PAPERS/YEAR



- KM3NeT CLB Embedded software, **Computer Physics Communications 296 (2024) 109036** (arXiv:2308.01032) c.a.: V. van Beveren, D. Real
- Prospects for combined analyses of hadronic emission from γ-ray sources in the Milky Way with CTA and KM3NeT/ARCA, **European Physics Journal C 84 (2024) 112** (arXiv:2309.03007) – c. a.T. Unbehaun, L. Mohrmann (CTA consortium)
- Searches for neutrino counterparts of gravitational waves from the LIGO/Virgo third observing run with KM3NeT, **Journal of Cosmology and Astroparticle Physics 04 (2024)026** (arXiv:2311.03804) – c. a.: M. Lamoureux, S. Le Stum, G. Vannoye **NEW**
- The Power Board of the KM3NeT Digital Optical Module: design, upgrade, and production, **Electronics 13 (2024) 2044** (arxiv:2311.14872) – c.a.: D. Real, D. Calvo
- KM3NeT/ARCA Differential Sensitivity for Diffuse and Point-Like Emissions: Probing Starburst Galaxies Emissions, **Astrop. Phys. 162(2024) 102990** (arxiv:2406.11946) – c. a.: A. Ambrosone, W. Idrissi Ibnsalih, A. Marinelli
- Atmospheric muons measured with the KM3NeT detectors in comparison with updated numeric predictions (arXiv:2403.11946) – c.a.: V. Kulikovskiy, A. Romanov; **JUST ACCEPTED FOR PUBLICATION ON EPJ C**

KM3NET PUBLICATIONS

PAPERS IN PREPARATION – SUBMITTED TO JOURNAL

- **Astronomy potential of KM3NeT/ARCA** (arXiv:2402.08363) - main author: T. van Eeden;
  EPJC - resubmitted (May 18th) after the second round of comments

- **Search for Neutrino Emission from GRB 221009A using the KM3NeT ARCA and ORCA detectors** (arXiv: 2404.05354) - main authors: J. Palacios, S. Le Stum, G. Vannoye;
  JCAP - submitted on May 3rd - positive referee comments received (June 9th) - minor request of changes - preparing a new version + reply.

KM3NeT @ LNS

Attività in corso ai LNS

KM3NeT4RR 👉 WP a responsabilità LNS:

- WP1 - Management
- WP2 - On shore infrastructures (P. Piattelli) - tenders on going
- WP5 - Sea Floor Network (S. Biagi) - tenders on going
- WP7 - Implementation of multi messenger liasons (R. C.) - post docs at INAF and Universities almost all hired + 3 PhDs - first meeting in Bologna 24/5/2023

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

Tenders all assigned - People hired

INFRADEV2: EU project started 1st of January 2023

- WP2 - Legal Entity (P. Sapienza) - AISBL in definition
- WP3 - Accelerating implementation - a post doc for RAM software analysis hired (R = reliability, A = Availability, M = Maintainability) (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 - Call opened
  - Project started

Attività in corso ai LNS

- Definizione Campagne marine
- Upgrade stazione di terra Capo Passero
- Espansione rete di fondo (JB + interlink cables)
- Integrazione DU
- Integrazione BM
- Procurement
- Detector and infrastructure operation

LNS e KM3NeT

Tutti i LNS contribuiscono alla riuscita di KM3NeT ed in particolare

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

RICHIESTE 2025

Capitolo		Valori inseriti (multipli di 0.5k€
Missioni	meeting collaborazione 1/3 FTE x 1.5k€ x2	20,00
	meeting steering committee 3 persone x 1 meeting	4,00
	gruppi di lavoro e workshop tematici	19,00
	1campagna marina 3 persone in nave e 15 persone nella stazione di terra (20gg di durata totale)	86,00
	contatti ditte - estero (MacArtney DK)	45,00
	contatti ditte - Italia (Elmacom, MBE)	27,00
	coordinamento tecnico (Klaus Leismuller)	4,00
	viaggi tecnici PNRR estero	6,00
	Missioni Caserta per integrazione	12,00
	attività installazione, manutenzione a Capo Passero	10,00
	presentazioni km3net a conferenze Italia	
	presentazioni km3net a conferenze estero	
Missioni	**Totale**	**233,00**

Preliminary

Consumo	Materiale consumo integrazione stringhe e Base Module - Calcolato come 1k€ per il numero totale di DU da integrare -> 1 k€ *20	20
	Materiale consumo per Capo Passero - Cavetterie - etichette e placche	7
	Materiale consumo acustica - reburbishemnt beacon, pacchi batterie, gel	8
	Materiale consumo ottica e potenza - riparazione strumenti di misura	10
Consumo	**Totale**	**45,00**
Altro consumo	**Common Funds**	**600,00**
Trasporti		
	DU da LNS a Caserta 7.5kEuro/DU	**60**
	Trasporto strumentazione da LNS a Porto Catania	4
Trasporti	**Totale**	**64,00**

GRAN Totale		**942,00**
Totale senza CF e senza calcolo		**342,00**

Preliminary

Anno	MIssioni	Consumo	Trasporti	Calcolo	Totale	Common funds
2025	233	45	64	0	342	600
2024	242 (60SJ)	35	116	273	393 (calcolo non incluso)	520

FTE 2025 - Preliminari

NOME	FTE KM3 2025	FTE fondi esterni	FTE Totali	Fondi Esterni Note
Biagi Simone	80	0	80	
Calì Michele	100			
Cherubini Silvio	50		50	
Cocimano Rosanna	100	0	100	
Coniglione Rosa	65	35	100	KMINFRADEV2 (25%) & PRIN_2022A7ZC3K (10%)
Cuttone Giacomo	56	4	60	KMINFRADEV2
Di Mauro Letizia Stella		100	100	CIR01_00018 (IPANEMA)
Distefano Carla	70		70	
Ferrara Giovanna	10		10	KM3NeT4RR Università CT
Giorgio Emidio	70		70	
Larosa Giuseppina	100		100	
Musumeci Mario	50		50	
Orlando Angelo	100		100	
Piattelli Paolo	63	17	80	KMINFRADEV2
Pulvirenti Sara	92	8	100	PRIN_2022N2J9PX
Riccobene Giorgio	80	0	80	
Santonocito Domenico	20		20	
Sapienza Piera	53	17	70	KMINFRADEV2
Viola Salvo	55	5	60	PRIN_2022N2J9PX
Zito Daniele		100	100	PNRR-KM3NeT4RR
Valsecchi Veronica	50		50	
Didac Diego i Tortosa	100		100	
Dino Franciotti	50		50	
Bonanno Danilo		100	100	PNRR ITINERIS da confermare
Sanfilippo Simone		100	100	ITINERIS da confermare
Daniele Paesani		100	100	KM3NeT4RR
Ciancio Sebastiano			100	KM3NeT4RR
Totale	**14,14**	**5,86**	**20**	
Totale KM3+fondi esterni	**20**			

Numero FTE invariati rispetto al 2024