KM3NET

R. Coniglione
LNS-INFN

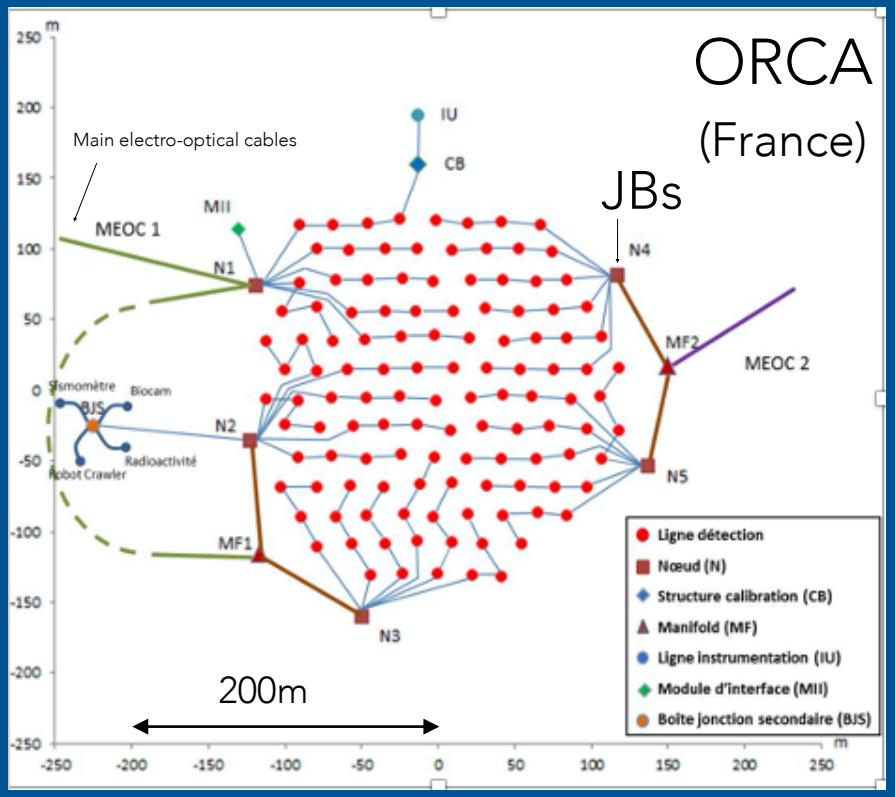
La sigla KM3NeT

Resp. Nazionale G. Cuttone

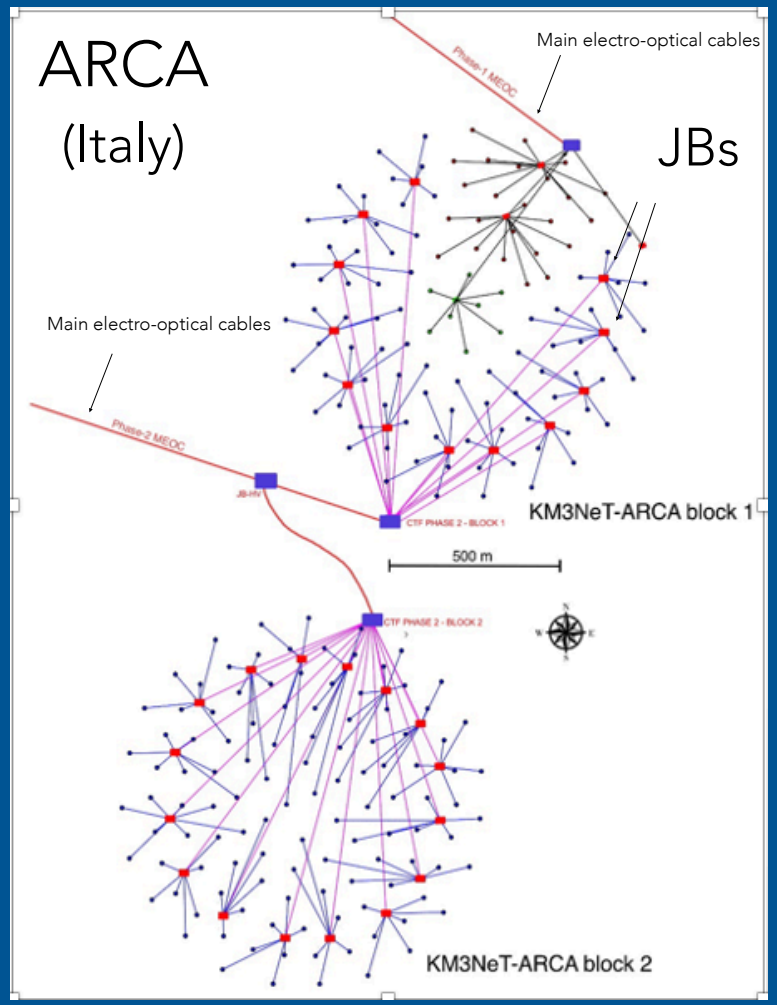
La sigla KM3NeT comprende:

- 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 recentemente smantellato

THE DETECTORS



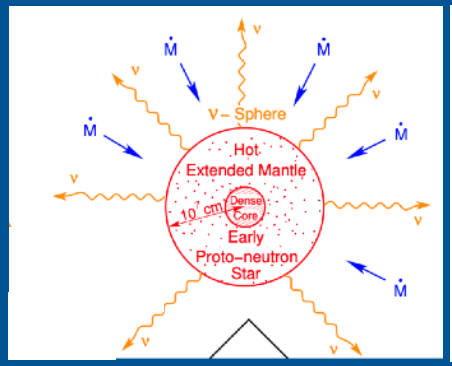
ORCA is composed of 1 building block of 115 DUs with 20 m DU interspacing and 9m inter DOM spacing (7 Mton)

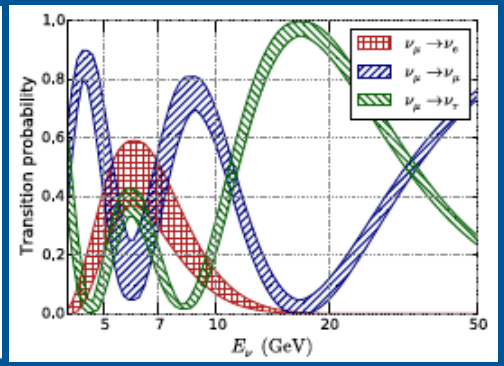


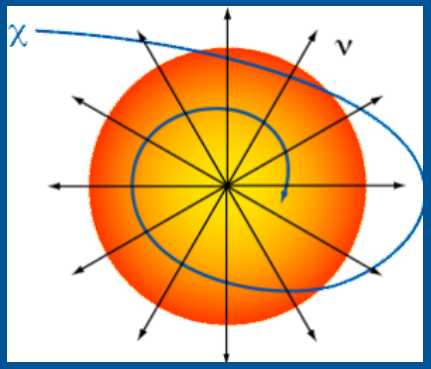
ARCA is composed of 2 building blocks of 115 DUs each with 90 m DU interspacing and 36m inter DOM spacing (0.5 km3=500Mton/block)

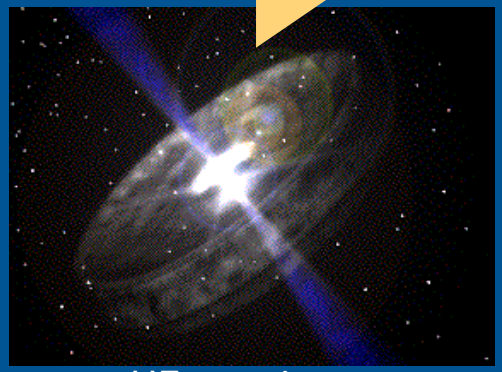
THE PHYSICS

Neutrino Energy from MeV to PeV









Super Novae explosion
MeV

Neutrino oscillation
GeV

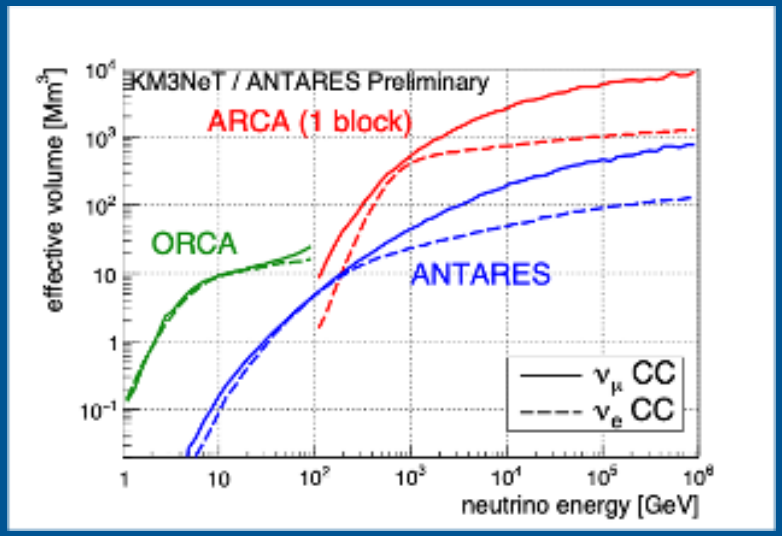
Dark Matter
TeV

HE neutrinos
Multi-messenger program
PeV

ARCA + ORCA

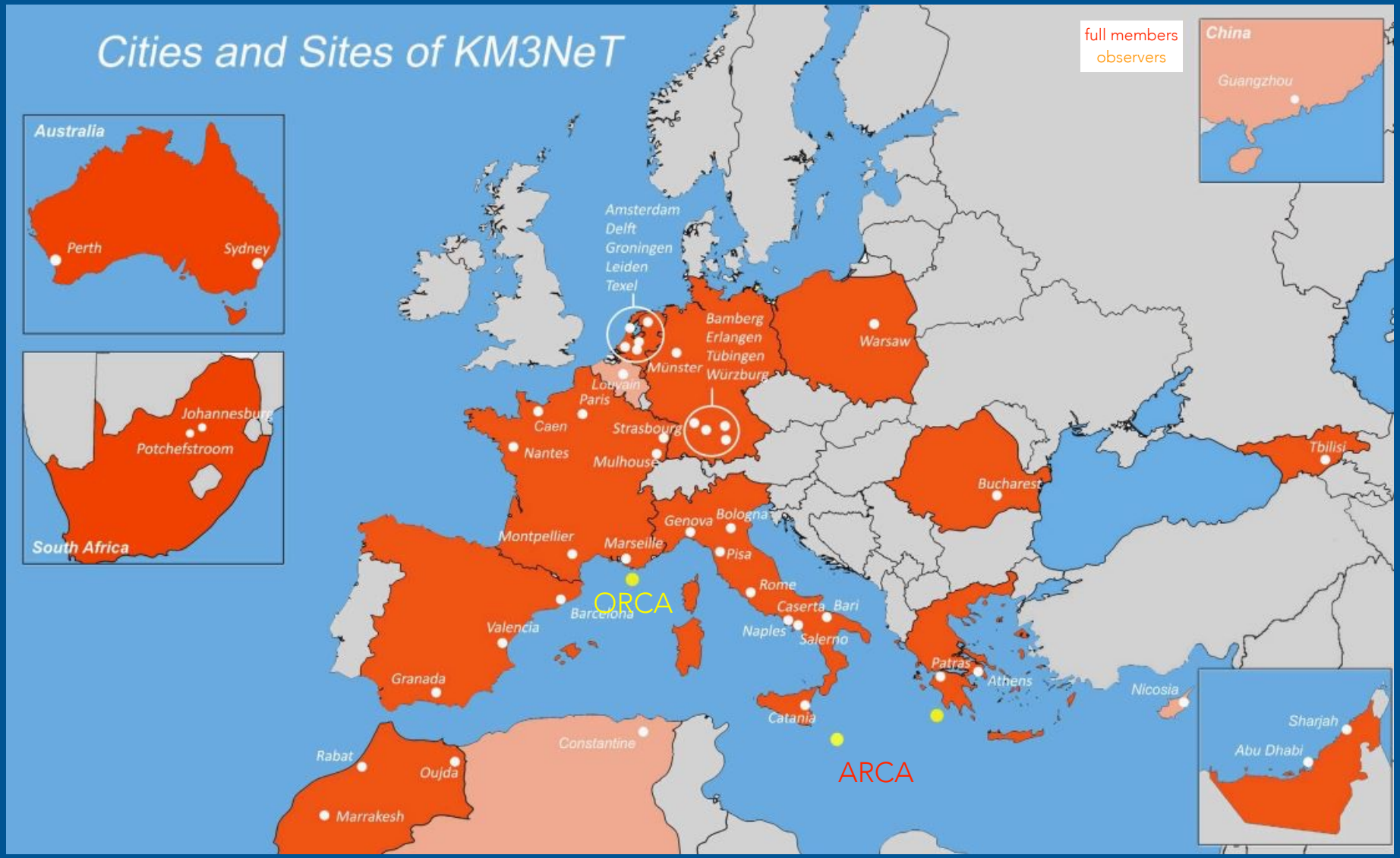
ORCA

ARCA

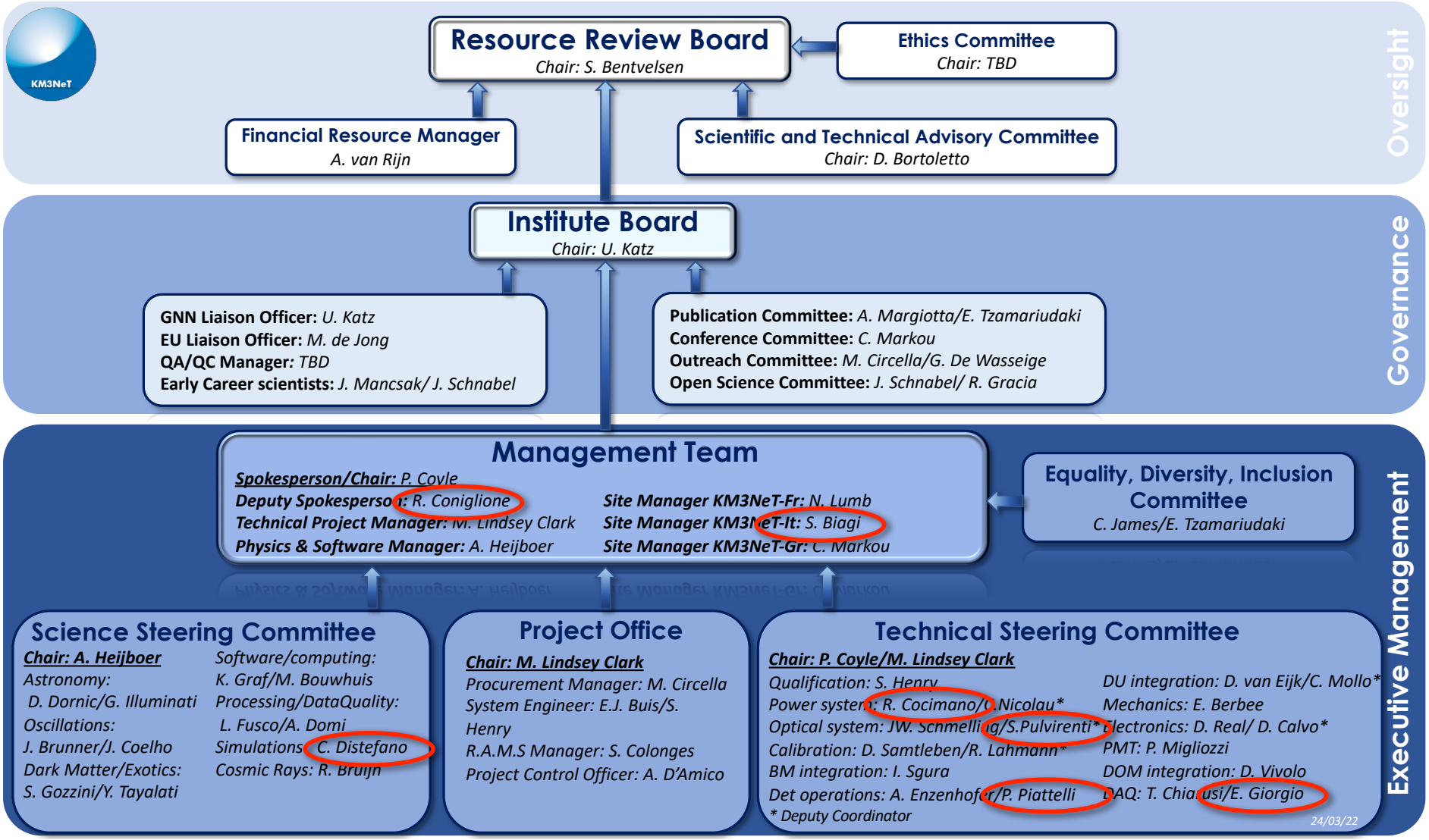


THE KM3NET COLLABORATION

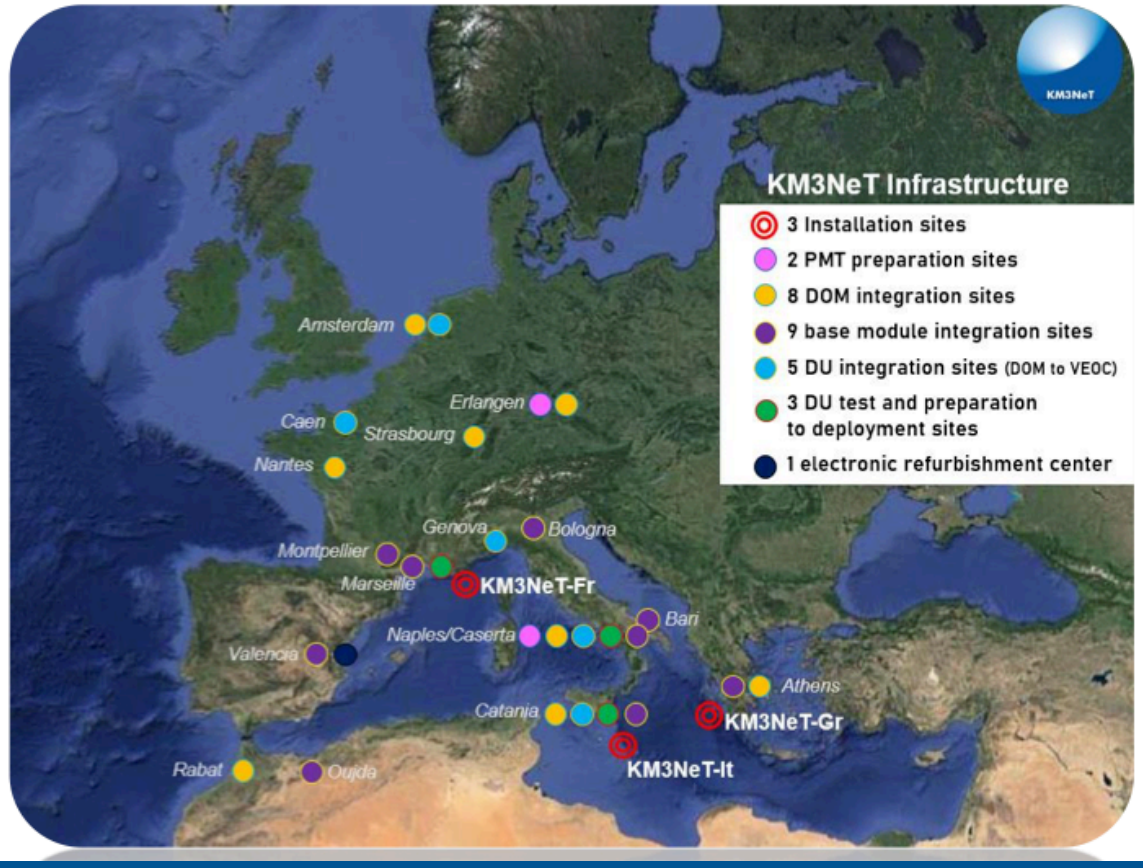
56 institutes in 17 countries



KM3NeT Organigramma



THE DETECTOR CONSTRUCTION



DOMs
- 8 integration sites
- 946 DOMs integrated (52 DUs worth)
- 36 currently on bench

BMs
- 8 integration sites (Welcome to Oujda!)
- 53 BMs integrated
- 4 currently on bench

DUs
- 6 integration sites (Welcome to Caen!)
- 37 DUs integrated
- 7 currently on bench
- 19 deployed

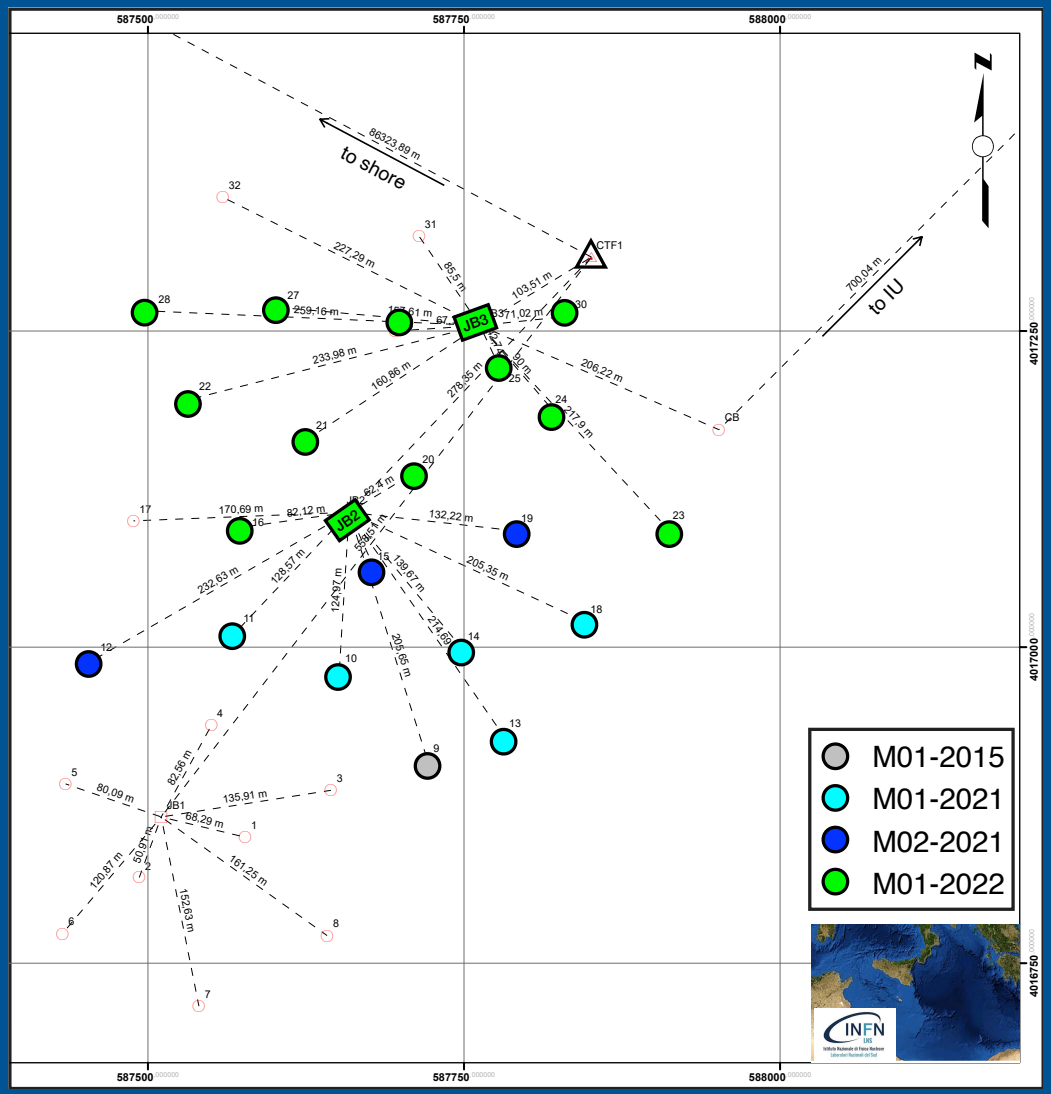
Ai LNS
- BM integration site (resp. G. Larosa)
- DU integration site (resp. P. Sapienza)

Alla Sezione Catania
- DOM integration site (resp. E. Leonora)

ARCA STATUS

1-14 June 2022 👉 Successful deployment of 11 DUs and 2 JBs + recovery of TJB

19 DUs now in operation



The biggest sea campaign from ever: great work of off shore and on shore people

👇

Commissioning phase on going

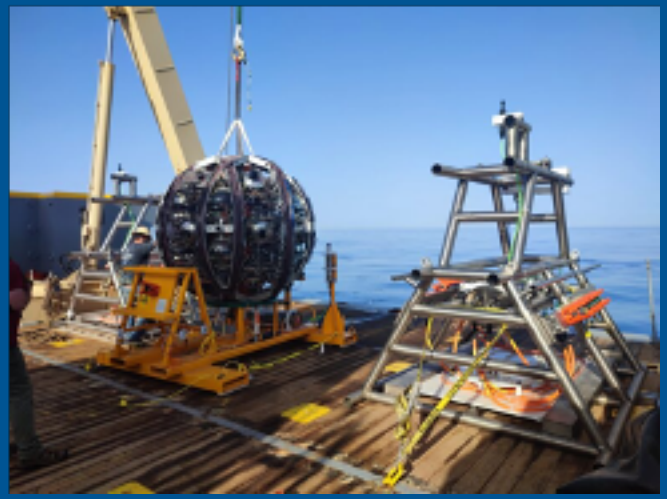
👇

First data on disk

ARCA STATUS

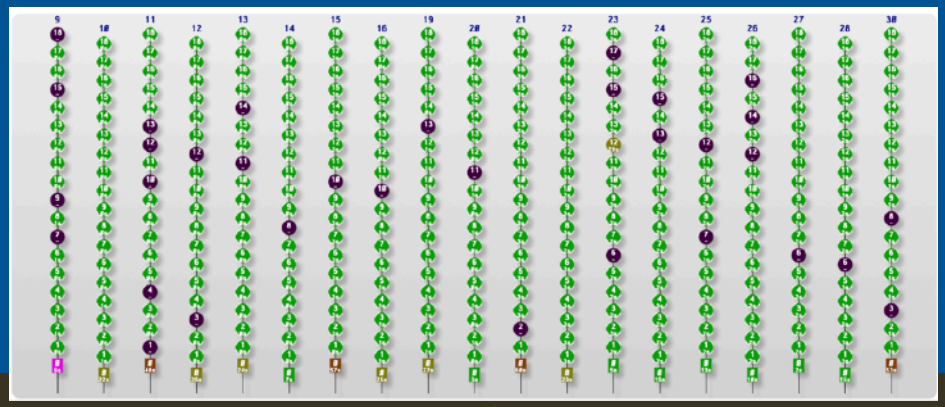
11 DUs and 2 JBs + recovery of TJB

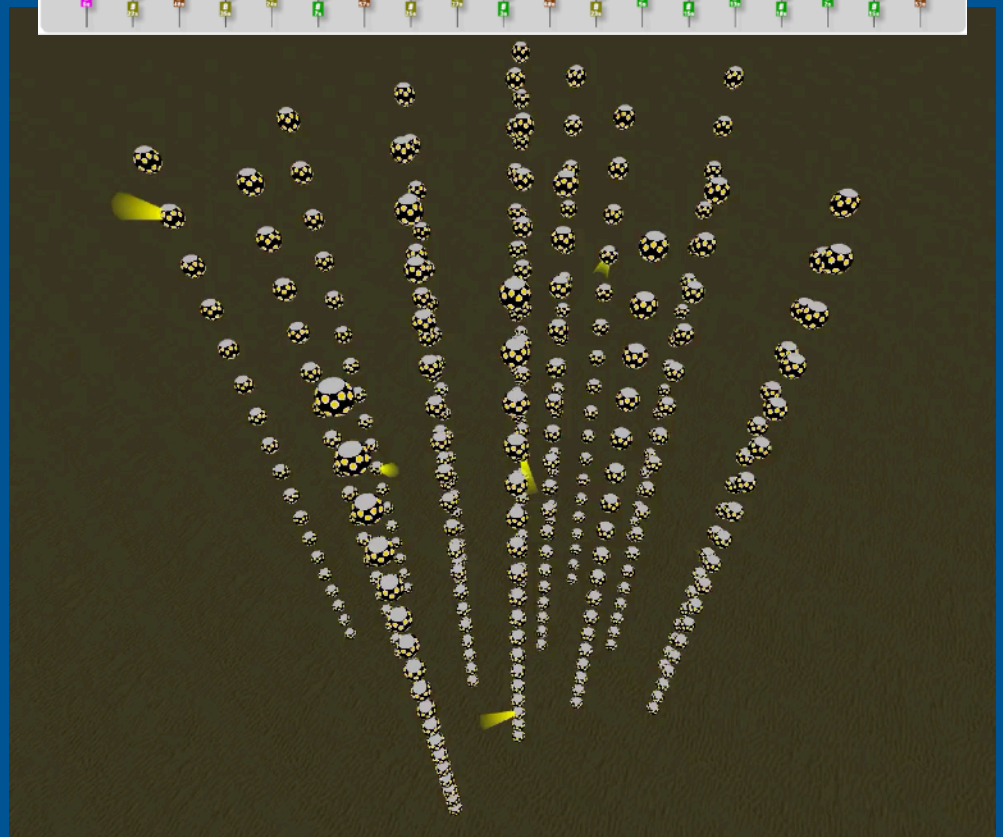
19 DUs now in operation

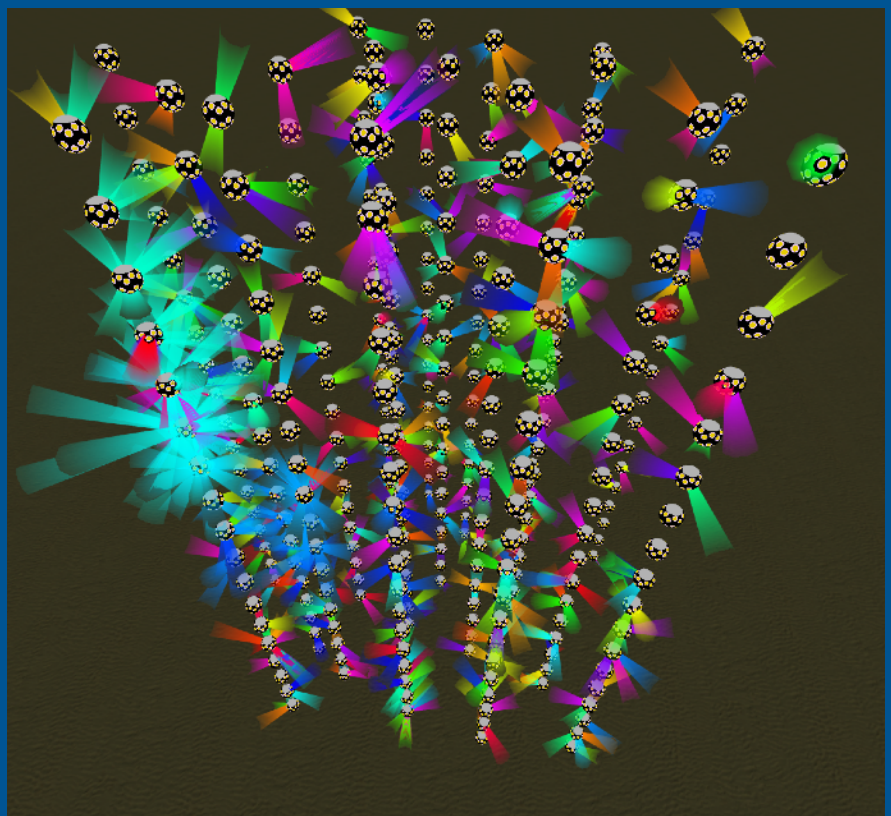


ARCA STATUS

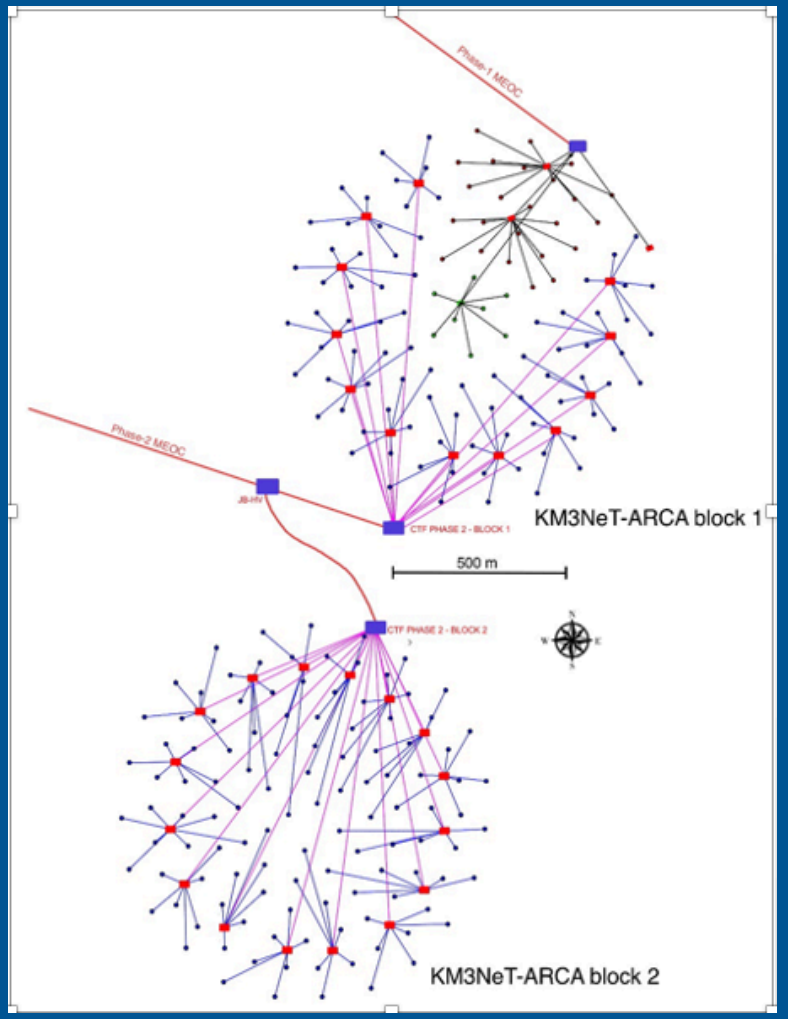
19 DUs now in operation







ARCA SECOND BRANCH STATUS

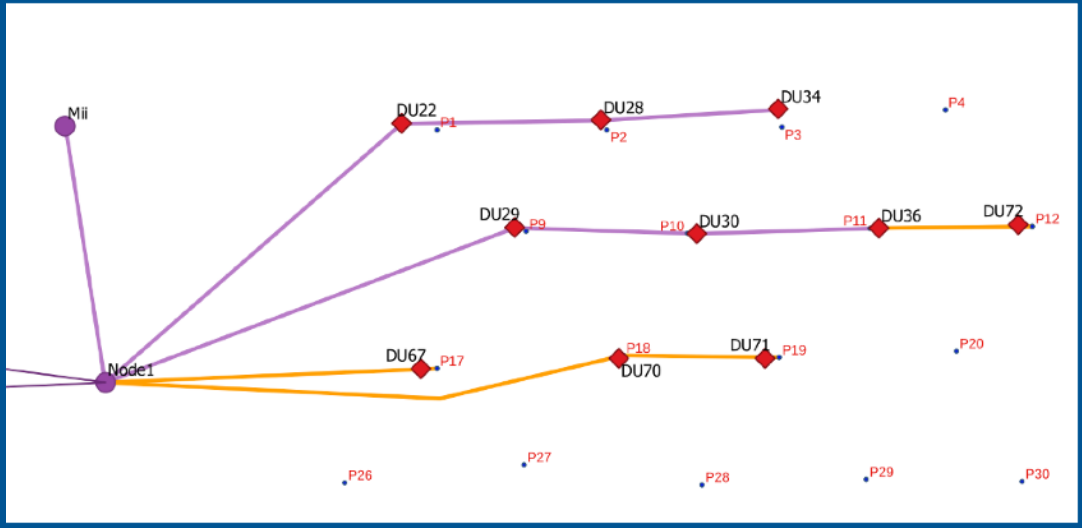


Next months:

- Test of CTF (Calais)
- Deploy of CTF and connection with the cable (sea campaign in September)

ORCA STATUS

10 DUs now in operation



KM3NET PUBBLICATIONS

The KM3NeT potential for the next core-collapse supernova observation with neutrinos
EPJ C81 (2021) 445 : 2102.05977 — Published

Determining the Neutrino Mass Ordering and Oscillation Parameters with KM3NeT/ORCA
EPJ C82 (2022) 26 : 2103.09885 — Published

Combined sensitivity of JUNO and KM3NeT/ORCA to the neutrino mass ordering
JHEP 03 (2022) 55: 2108.06293 — Published

Implementation and first results of the KM3NeT real-time core-collapse supernova neutrino search
EPJ C82 (2022) 317 : 2109.05890 — Published

Nanobeacon: A time calibration device for the KM3NeT neutrino telescope
https://arxiv.org/abs/2111.00223 — Accepted NIMA

The KM3NeT multi-PMT Optical Module
https://arxiv.org/abs/2203.10048 — Accepted JINST

Several other papers in preparation

KM3NeT4RR italian project

Inside the PNRR (Piano Nazionale di Ripresa e Resilienza) a call dedicated to the reinforcement of existing research infrastructures has been published at the end of 2021. Project submitted end of February. Duration of the project 30 months

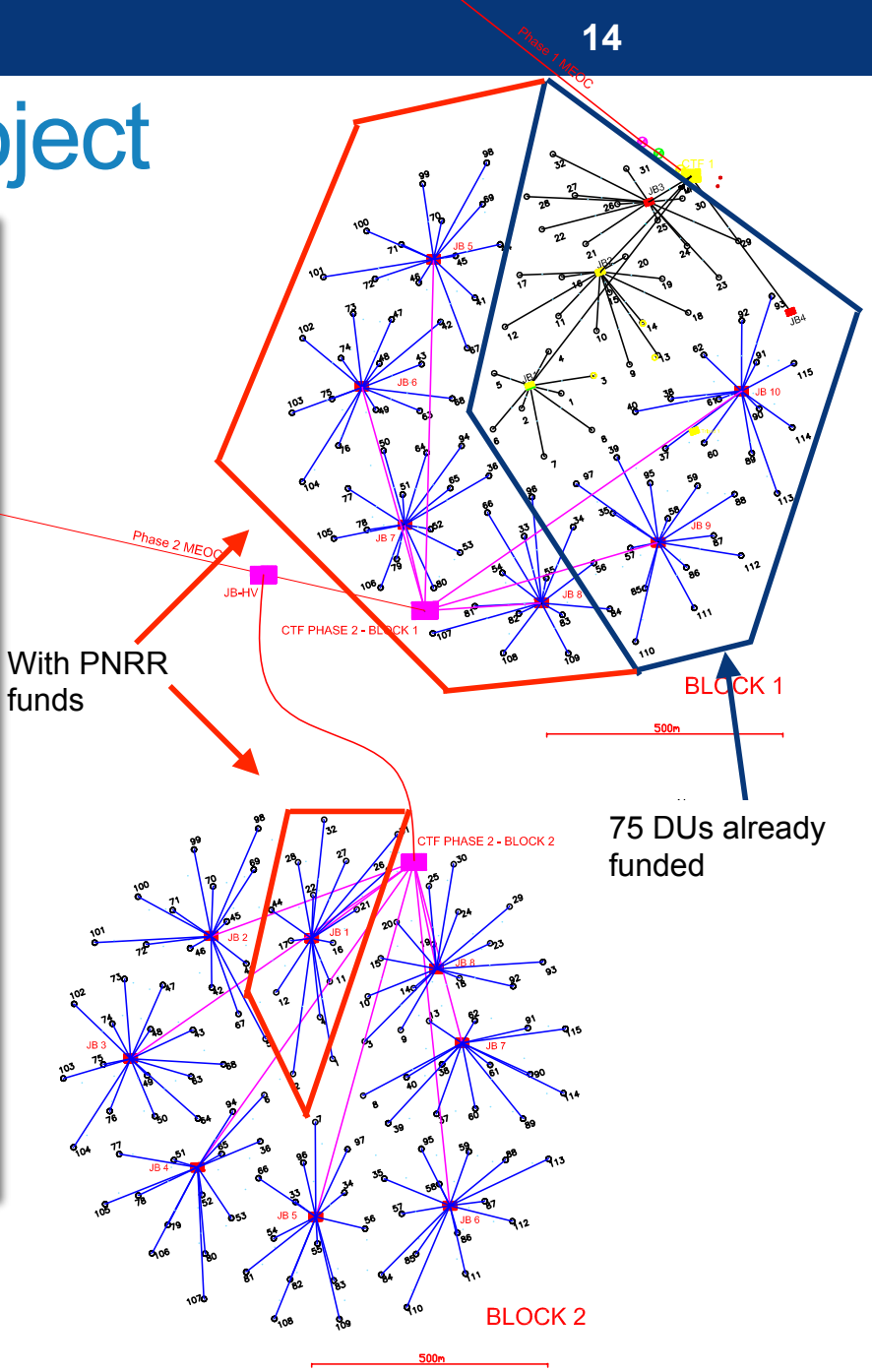
Approved funds 67M€

- ~ 55 DUs
- The related sea floor infrastructure (5 JBs + 1CTF + IL cables)
- The reinforcement of INFN KM3NeT laboratories
- Human resources

This funds will allow the completion of the first block and the construction of about 15 DUs of the second block of the ARCA detector.

8 Working packages

130 DU funded so far



New call within HORIZON-INFRADEV: KM3NeT-INFRADEV2

1.5 ME/3 years
Submitted: Jan 20, 2022

WP1: Management (CNRS)
WP2: Legal Entity (INFN)
WP3: Accelerating implementation (CNRS)
Procurement officer (CNRS)
RAMS officer (Italy)

WP4: Data management/open science (FAU)
3 postdocs (IFIC, Nikhef, Erlangen)

WP5: Sustainability & socio-economic impact (NCSR)
1 postdoc (Greece)

Project accepted
Kick Off: 1st Nov 2022

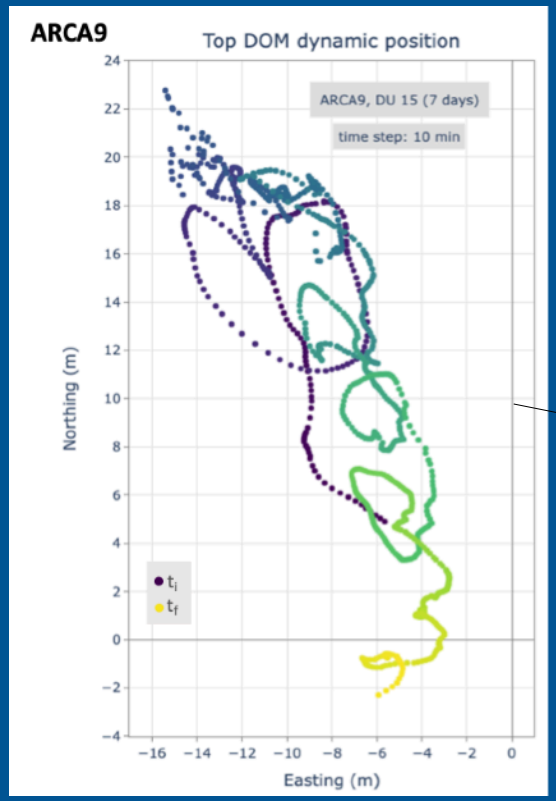
Physics results

11	Combined Analysis of KM3NeT + CTA with Gammapy	T. Unbehaun (tim.unbehaun@fau.de)	KM3NeT/ARCA	Astronomy	G. Ferrara
14	First search for neutrino counterparts from gravitational wave sources with KM3NeT	Sébastien Lestum (lestum@cppm.in2p3.fr), Godefroy Vannoye (vannoye@cppm.in2p3.fr), Mathieu Lamoureux (mathieu.lamoureux@uclouvain.be), Feifei Huang (feifei.huang@cppm.in2p3.fr), Damien Dornic (ddornic@cppm.in2p3.fr), Gwenhael de Wasseige (gwenhael.dewasseige@uclouvain.be)	KM3NeT	Astronomy	M. Boettcher
15	PKS* neutrino follow-up with ORCA/ARCA	Francesco Filippini (francesco.filippini9@unibo.it), Juan Palacios Gonzalez (juanpala@ific.uv.es), Rasa Muller (rasm@nikhef.nl), Feifei Huang (feifei.huang@cppm.in2p3.fr), Sebastien le Stum (lestum@cppm.in2p3.fr), Giulia Illuminati (giulia.illuminati3@unibo.it), Damien Dornic (ddornic@cppm.in2p3.fr), Angela Zegarelli (angela.zegarelli@roma1.infn.it), Silvia Celli (silvia.celli@roma1.infn.it)	KM3NeT ORCA+ARCA	Astronomy	G. Pavalas
16	Search for cosmic neutrino point sources and extended sources with 6-8 lines of KM3NeT/ARCA (and ANTARES)	Rasa Muller (rasm@nikhef.nl), Barbara (barbara.caiffi@ge.infn.it), Vladimir Kulikovskiy (Vladimir.Kulikovskiy@ge.infn.it), Matteo Sanguineti (Matteo.Sanguineti@ge.infn.it), Aart Heijboer (aart.heijboer@nikhef.nl), Thijs van Eeden (t.j.uan.van.eeden@nikhef.nl)	KM3NeT/ARCA	Astronomy	T. Chiarusi
17	Study of the diffuse astrophysical neutrino flux with KM3NeT/ARCA data	A. Sinopoulou (sinopoulou@inp.demokritos.gr), E. Drakopoulou, F. Filippini(francesco.filippini9@unibo.it), E.Tzamariudaki	KM3NeT/ARCA	Astronomy	S. Navas
24	Online Multi-Messenger Program of KM3NeT	William Assal, Silvia Celli, Jerome de Favereau de Jeneret, Pavel Demin, Damien Dornic, Feifei Huang (feifei.huang@cppm.in2p3.fr), Vladimir Kulikovskiy, Emmanuel Le Guirriec, Sebastien Le Stum, Andres Jorge Tanasijczuk, Hichem Tedidit, Godefroy Vannoye.	KM3NeT	Astronomy	T. Chiarusi
26	Monitoring the neutrino sky for the next Galactic Core-Collapse Supernova with KM3NeT	Godefroy Vannoye (vannoye@cppm.in2p3.fr)	KM3NeT	Astronomy	S. Navas
28	KM3NeT/ARCA expectations for starburst galaxies observation	Walid Idrissi Ibnsalih, Antonio Ambrosone, Maria Rosaria Musone, Antonio Marinelli, Pasquale Migliozzi,Ofelia Pisanti, Gennaro Miele	KM3NeT	Astronomy	S. Navas
25	Cosmic ray muon rates measured with KM3NeT ARCA and ORCA detectors and their sensitivities towards detecting the prompt muons	P. Kalaczyński	KM3NeT	Cosmics	O. Kalekin
27	Sensitivity of the KM3NeT detector to a flux of nucleartites	Alice Paun (alice.paun@spacescience.ro), Gabriela Pavalas (gpavalas@spacescience.ro), Vlad Popa	KM3NeT	DM/Exotics	G. Ferrara
10	Probing neutrino invisible decay with KM3NeT/ORCA6	V. Carretero (victor.carretero@ific.uv.es)	KM3NeT/ORCA	Oscillations	C. Markou
12	Sensitivity to quantum decoherence in neutrino oscillations	N. Lessing (nadja.n.lessing@fau.de)	KM3NeT	Oscillations	M. Bouwhuis
13	First limits on neutrino non-standard interactions with KM3NeT/ORCA6	J. Manczak (jmanczak@ific.uv.es)	KM3NeT/ORCA	Oscillations	T. Pradier
18	Measurement of neutrino oscillations with KM3NeT/ORCA	Zineb Aly (aly@cppm.in2p3.fr)	KM3NeT/ORCA	Oscillations	O. Kalekin
19	Neutrino reconstruction with Graph Neural Networks in KM3NeT/ORCA6	João Coelho (jcoelho@apc.in2p3.fr) Shen Liang (shen.liang@u-paris.fr)	KM3NeT/ORCA	Oscillations	P. Mijakowski
20	Parameter-based particle identification using machine learning techniques in KM3NeT/ORCA	Alfonso Lazo (Alfonso.Lazo@ific.uv.es) Lukas Maderer	KM3NeT/ORCA	Oscillations	A. Moussa
22	Searches for sterile neutrinos with KM3NeT	Alba Domi (Alba.Domi@ge.infn.it) João Coelho	KM3NeT	Oscillations	G. Ferrara
29	Different optical modules for different cosmic neutrino detectors	Emanuele Leonora	KM3NeT	Technical	G. Ferrara
30	Full ARCA performances (update PS/diffuse) with tracks+sho	Thijs van Eeden (t.j.uan.van.eeden@nikhef.nl)	KM3NeT	Astronomy	C. Markou

18 contributions + 1 plenary to Neutrino 2022

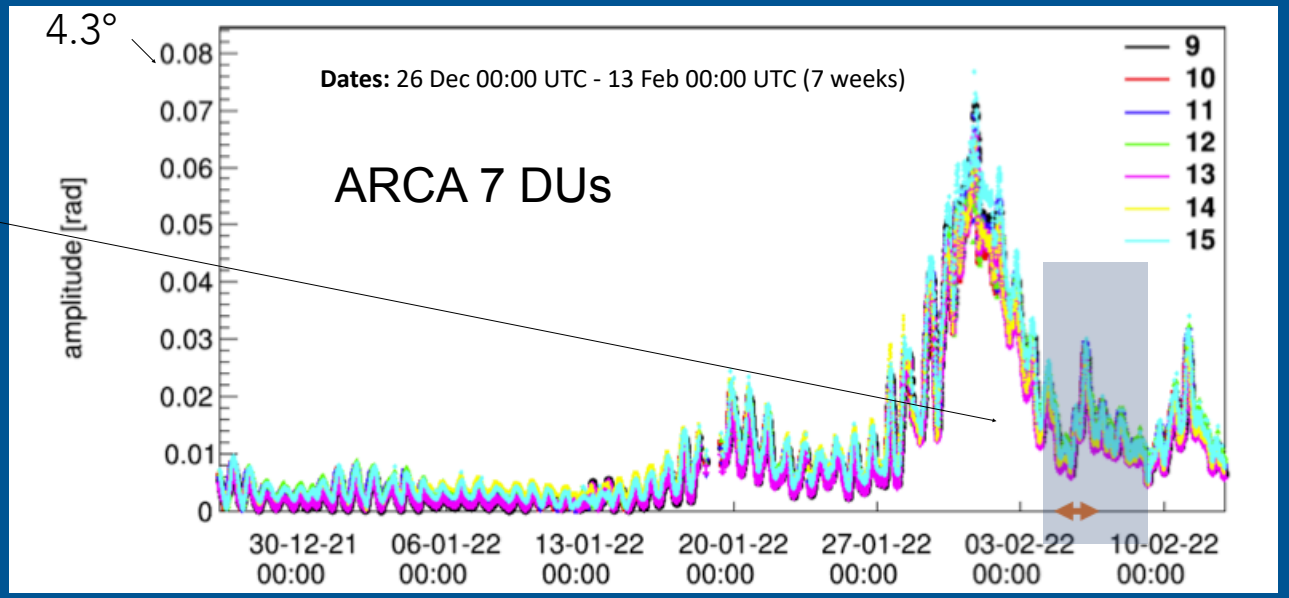
Position

Based on acoustic beacon and piezo



~28 m max displacement of the topmost DOM

Tilt amplitude

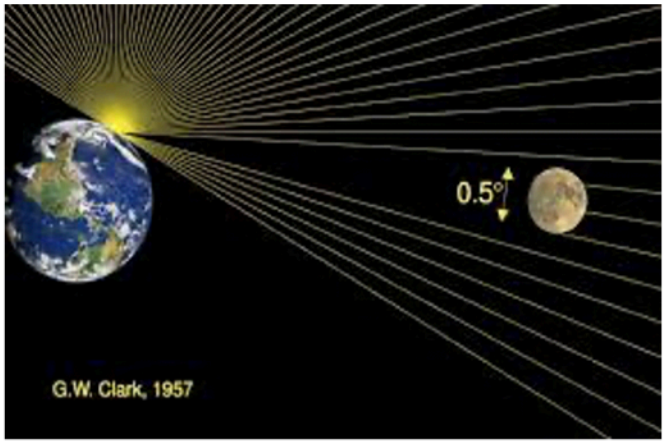


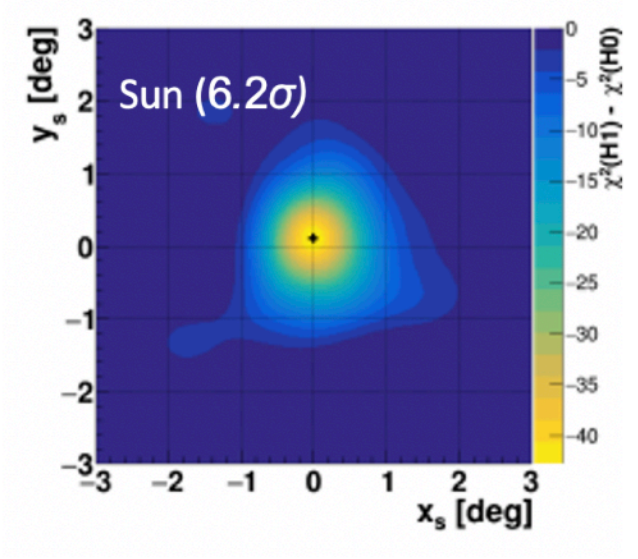
Dynamic positioning applied to the data

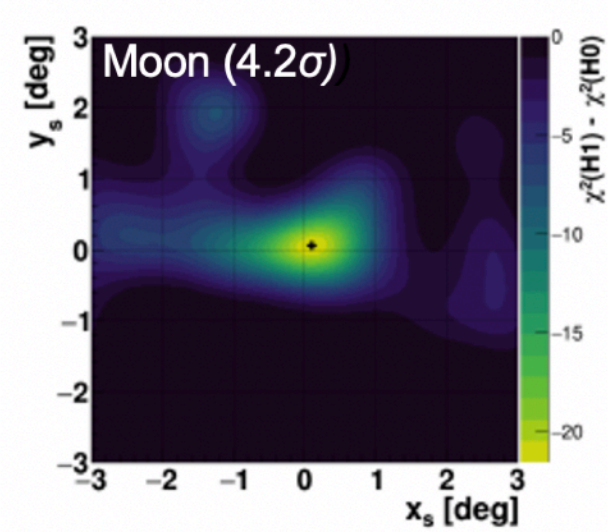
ORCA FIRST RESULTS

Checking resolution: Sun/Moon shadows with ORCA

- No standard candle source
- Cosmic rays to the rescue

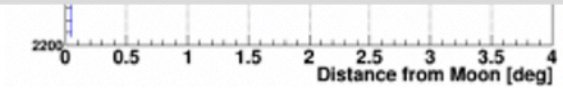






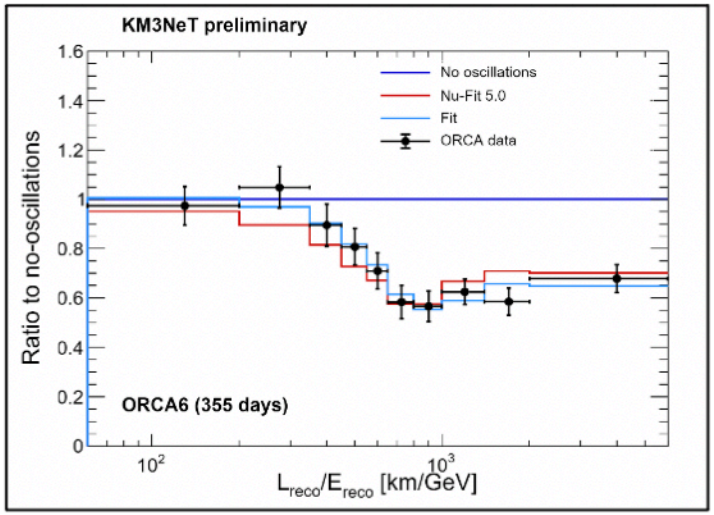
Events

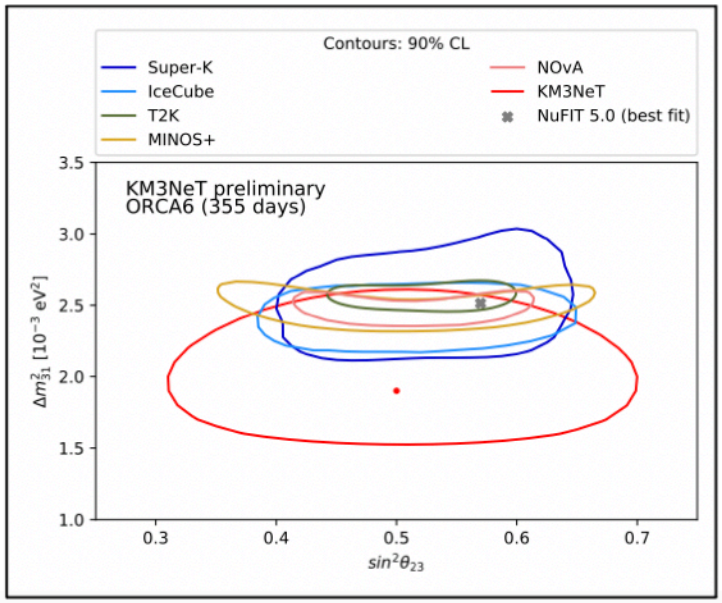
	Sun	Moon
Significance	6.0 σ	2.4 σ
Amplitude	1.42 ± 0.38	0.70 ± 0.29
Resolution	0.68° ± 0.12°	0.54° ± 0.16°



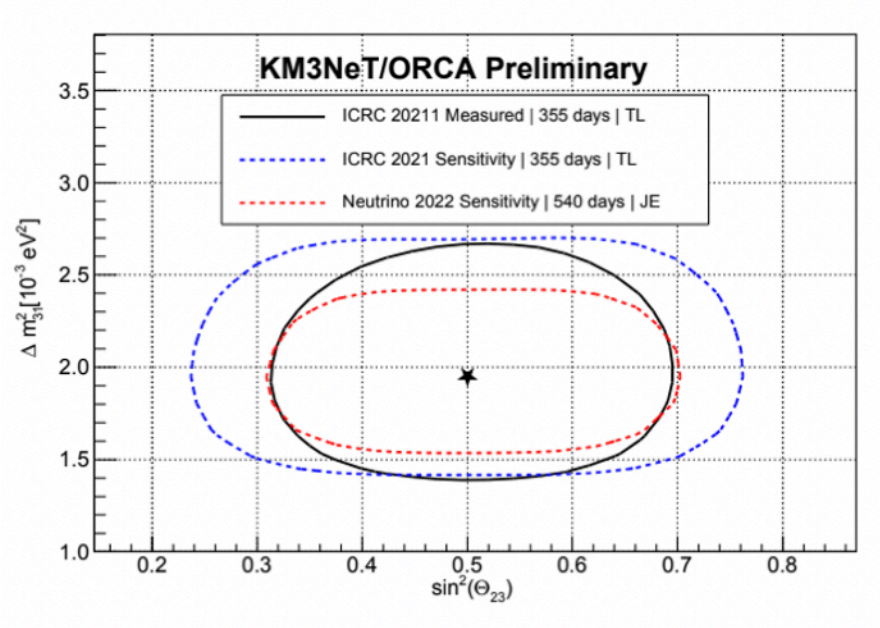
ORCA6 OSCILLATIONS: FIRST RESULTS

1 year of data with 6 lines of ORCA





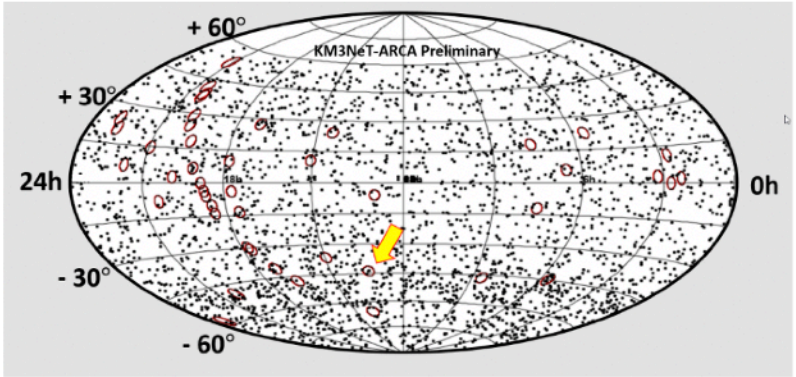
Update coming soon

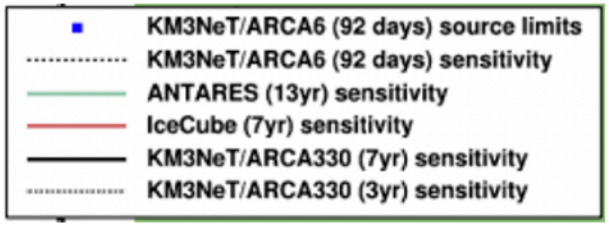


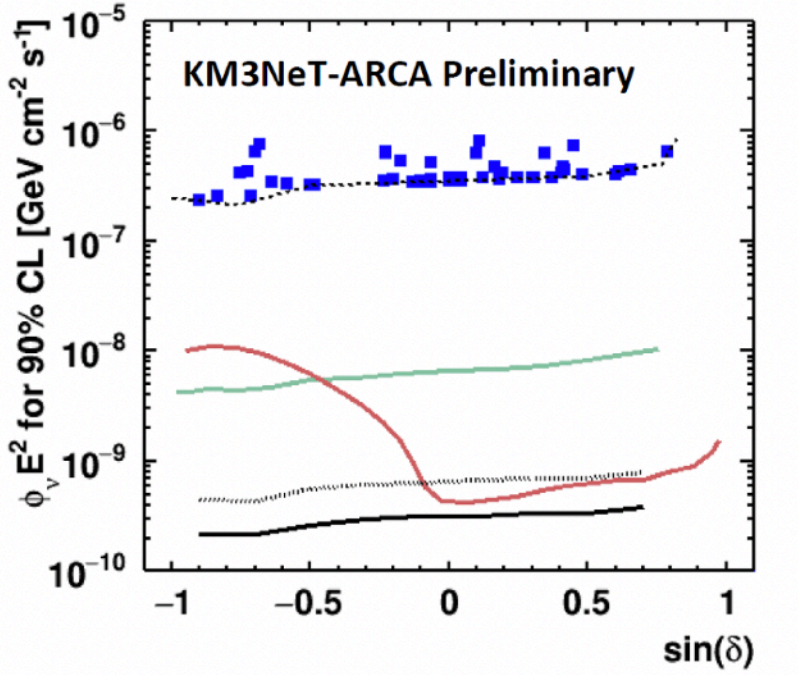
- More data 355 -> 540 days
- Better selection & particle identification
- Neutrino Sample increased by a factor 4
- Unblind in next months

ARCA6: FIRST UPPER LIMITS

Astronomy: ARCA 6, 100 days







- **Time integrated point source search May-Sept 2021, dynamic calibration**
- **Background dominated by muons**
- **Resolution ~1.3 degree for E^{-2}**
- **No significant excess observed**
- **Limits not yet competitive, as expected**

ARCA6: FOLLOW UPS

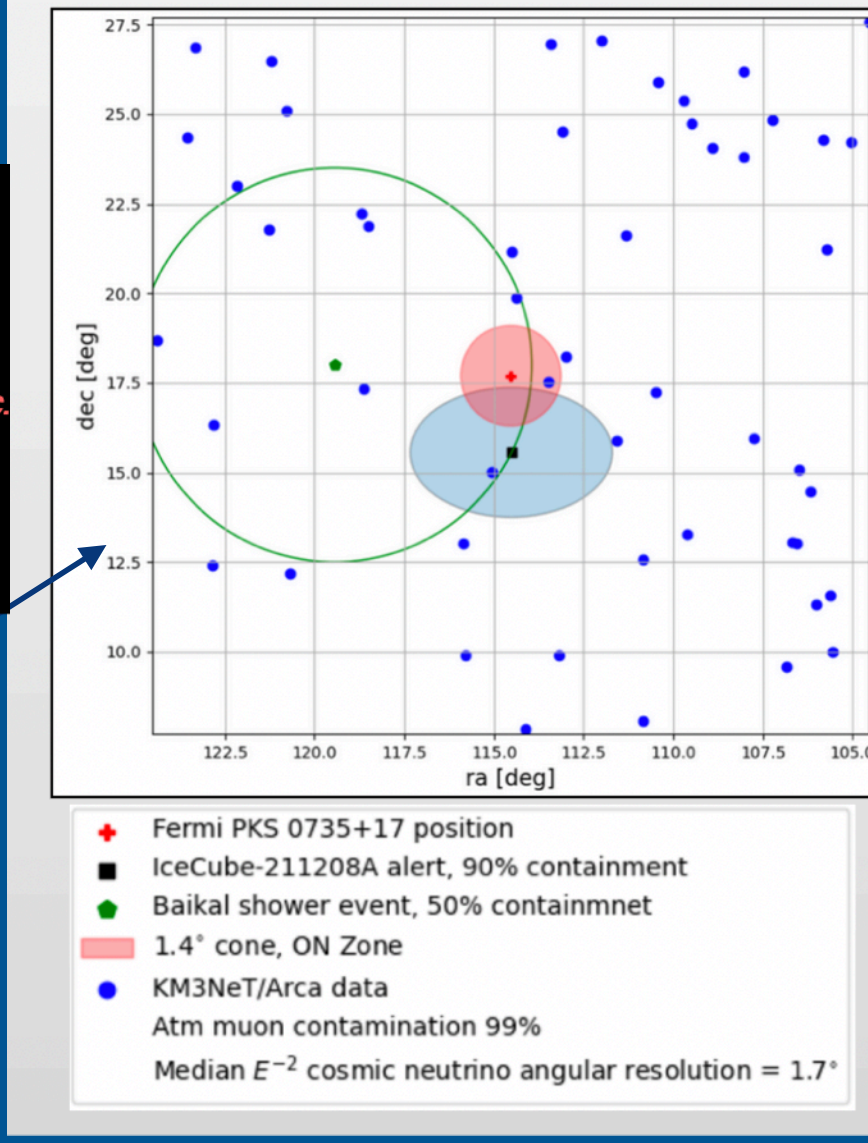
First KM3NeT ATEL published

https://www.astronomerstelegram.org/?read=15290

Search for neutrino counterpart to the blazar PKS0735+178 potentially associated with IceCube-211208A and Baikal-GVD-211208A with the KM3NeT neutrino detectors.

ATel #15290; *F. Filippini, G. Illuminati (Univ. Bologna, INFN Bologna), A. Heijboer, C. Gatius, R. Muller (Nikhef), D. Dornic, F. Huang, S. Le Stum (CPPM, Aix-Marseille Univ.), J. Palacios GonzÃ¡lez (IFIC), S. Celli, A. Zegarelli (Univ. La Sapienza, INFN Roma), R. Coniglione (INFN LNS), D. Samtleben (Nikhef, Leiden Univ.), Y. Y. Kovalev, A. Plavin (ASC Lebedev) on behalf of the KM3NeT Collaboration*
*on **21 Mar 2022; 10:54 UT***

IC alert	Potential blazar
IC211208A	PKS 0735+17
IC220205B	PKS 1741-03
IC220225A	PKS 0215+15
IC220304A	TXS 0310+022



KM3NeT @ LNS

Attività in corso ai LNS

- PNRR 👉 WP a responsabilità LNS:
  - WP2 - On shore infrastructures (P. Piattelli)
  - WP5 - Sea Floor Network (S. Biagi)
  - WP7 - Implementation of multi messenger liasons (R. C.)

- INFRADEV2
  - WP2 - Legal Entity (P. Sapienza)

- Definizione Campagne marine
- Upgrade stazione di terra Capo Passero
- Posa CTF Alcatel
- Espansione rete di fondo (JB + interlink cables)
- Integrazione DU
- Integrazione BM
- Procurement
- Operatività rivelatore

LNS e KM3NeT

Tutti i LNS contribuiscono alla riuscita di KM3NeT ed in particolare

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

RICHIESTE 2023

Richieste straordinarie 2022

Preliminari

Quasi esaurito il budget di missioni 2022

Attività	Dettaglio	Richiesta (k€)	Note
Conferenze (invited talks)	3 persone per 4 gg	3,00	circa 1 k€ a persona
Missione a Malta per finalizzazione processo 6 per campagna marina Settembre	4 persone per 4 gg	4,00	circa 1 k€ a persona
Missione sulla nave per campagna marina di Settembre deployment 5 DU + JB1	2 persone per 7-8 gg	3,00	0,2k€ al giorno incluso di viaggio
Attivity on shore per campagna marina Settembre-Capo Passero	5-6 persone per 8-10 gg (2 viaggi)	7,86	diaria 50euro/giorno+albergo 100 euro a notte + viaggio
Campagna Marina Alcatel	2 persone per 8 gg sulla nave	3,00	0,2k€ al giorno incluso di viaggio
Test CTF FAT @Calais	5 persone per 8 giorni + trasporto strumentazione	13,00	1,2 K€ a persona
Commissioning CTF @Capo Passero	3 persone per 8 gg	4,08	diaria 50euro/giorno+albergo 100 euro a notte + viaggio
Training CTF @ Capo Passero	4 persone per 4 gg	3,04	diaria 50euro/giorno+albergo 100 euro a notte + viaggio
Collaboration Meeting	5 persone per 5 giorni (Roma)	5,00	1K€ a persona
Missioni Mac Artney (danimarca)	2 persone per 5 gg	3,40	viaggio 0,8k€ giari giornaliera 0,180k€
Missioni Capo Passero preparazione	15 persone *1gg	2,40	1 giorno di missiona a Capo Passero 0,160k€
Training BM integration (Caserta o Bari)	3 persone per 3 gg	2,40	circa 0,8 k€ a persona
Finalizzazione integrazione Calibration base	4 persone per 3 giorni	3,00	circa 0,8 k€ a persona
Totale		57,18	

Si richiedono circa 54k€

Richieste 2023

Capitolo		Keuro	Richieste 2022
Missioni	Totale	177,23	184,85
Consumo	Totale	80,00	60
Altro consumo	Common Funds	370,00	200
Trasporti	Totale	43,00	41
GRAN Totale		670,23	
Totale senza CF		300,23	

Capitolo		Formula	Keuro
Missioni	meeting collaborazione 1/3 FTE x 1.5€ x2	1/3 * FTE * 1.5K * 2 coll. meeting	15,20
	meeting steering committee 3 persone x 3 meeting	3 persone*3gg*3meeting	16,92
	gruppi di lavoro e workshop tematici	3 persone*4gg*3meeting	13,68
	2 campagne marine 2 persone in nave e 12 persone nella stazione di terra	(2 persone sulla nave*8 gg*2campagne)+(15 persone a terra *8gg*2campagne)	41,20
	contatti ditte - estero (MacArtney DK)	3viaggi*4persone*4giorni	30,00
	contatti ditte - Italia (Elmacom, MBE)	4viaggi*4persone*4giorni	18,24
	coordinamento tecnico (Klaus Leismuller)	2viaggi*1persone*6giorni	3,76
	viaggi gestione PNRR	3viaggi*3 persone*3giorni	5,82
	Missioni Caserta per integrazione instrumentation unit	10giorni*3persone	6,30
	attività installazione, manutenzione a Capo Passero	50 missioni per 1 giorno	10,00
	presentazioni km3net a conferenze	10% del totale delle richieste	16,11
Missioni	**Totale**		**177,23**

Preliminari

Comsumo	Materiale consumo integrazione stringhe e Base Module - Calcolato come 1% del costo totale di una DU per il numero totale di DU da integrare -> 0.01* 250 k€ *20*		50,00
	Materiale consumo per Capo Passero - Cavetterie - etichette e placche		7,00
	Materiale consumo acustica - reburbishemnt beacon, pacchi batterie,		8,00
	Materiale consumo Calibration Unit		5,00
	Materiale consumo ottica e potenza - riparazione strumenti di misura		10,00
Consumo	**Totale**		**80,00**
Altro consumo	**Common Funds**		**370,00**
Trasporti	Trasporto materiale per la Calibration Unit a Caserta		5,00
	Trasporto elettronica dai LNS a McArtney (Danimarca)		20,00
	Trasporto strumentazione da LNS a Porto		4,00
	Movimentazione al porto di Catania		14,00
Trasporti	**Totale**		**43,00**

FTE - Preliminari

Comsumo	Materiale consumo integrazione stringhe e Base Module - Calcolato come 1% del costo totale di una DU per il numero totale di DU da integrare -> 0.01* 250 k€ *20*		50,00
	Materiale consumo per Capo Passero - Cavetterie - etichette e placche		7,00
	Materiale consumo acustica - reburbishemnt beacon, pacchi batterie, gel		8,00
	Materiale consumo Calibration Unit		5,00
	Materiale consumo ottica e potenza - riparazione strumenti di misura		10,00
Consumo	**Totale**		**80,00**
Altro consumo	**Common Funds**		**370,00**
Trasporti	Trasporto materiale per la calibration unit a Caserta (base, ancora, boe...)		5,00
	Trasporto JB da Danimarca a Malta		15,00
	Trasporto strumentazione da LNS a Porto Catania		4,00
	Movimentazione al porto di Catania		14,00
Trasporti	**Totale**		**38,00**
GRAN Totale			**662,06**
Totale senza CF			**292,06**

Percentuali

NOME	FTE KM3 2023	FTE fondi esterni	FTE Totali	Fondi Esterni Note
Bellia Giorgio	0		0	
Biagi Simone	50	30	80	MarineHazard30
Cherubini Silvio	50		50	
Cocimano Rosanna	100	0	100	
Coniglione Rosa	70	30	100	Escape30
Cuttone Giacomo	20	45	65	MarineHazard45
Distefano Carla	25	35	60	MarineHazard35
Ferrara Giovanna	0		0	
Giorgio Emidio	80		80	FE altri 20 ??
Larosa Giuseppina	100		100	
Migneco Emilio	0		0	
Musumeci Mario	50		50	
Orlando Angelo	70	30	100	MarineHazard30
Piattelli Paolo	80	0	80	
Pulvirenti Sara	95	5	100	MarineHazard5
Riccobene Giorgio	80	0	80	
Santonocito Domenico	20		20	
Sapienza Piera	70	0	70	
Viola Salvo	100	0	100	
Zito Daniele	80	20	100	Escape20
			0	
Totale	**11,4**	**1,95**	**13,35**	
Totale KM3+fondi esterni	**13,35**			

Preliminari