

KM3NET

R. Coniglione
LNS-INFN

La sigla KM3NeT

Resp. Nazionale G. Cuttone

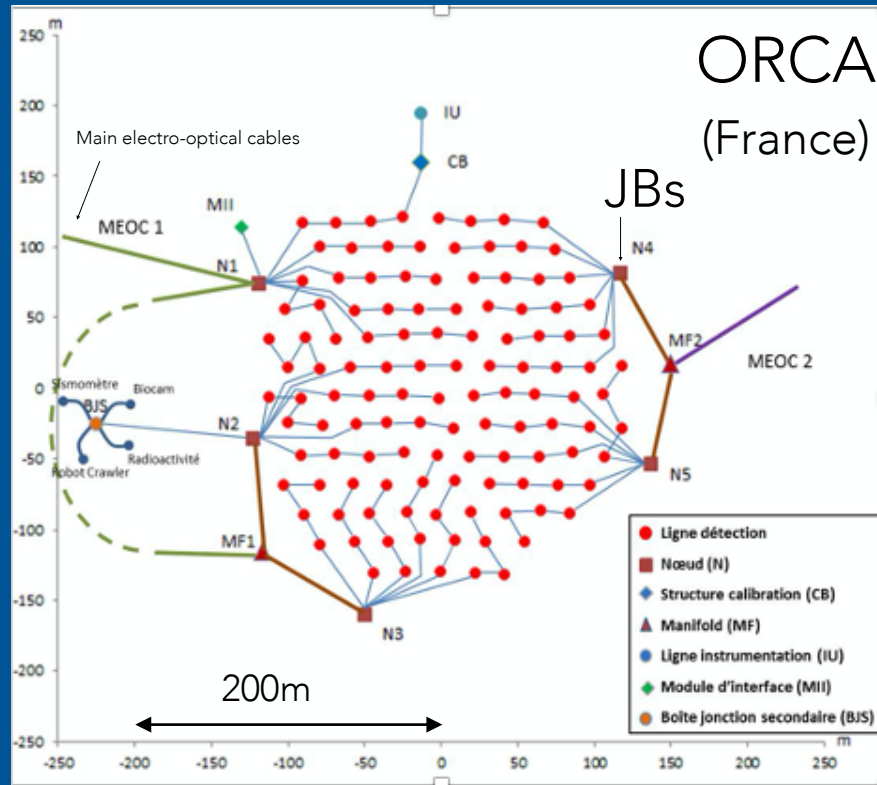
La sigla KM3NeT comprende:

- 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 prende dati da più di 12 anni e prossimo alla chiusura - rivelatore al largo delle coste di Tolone

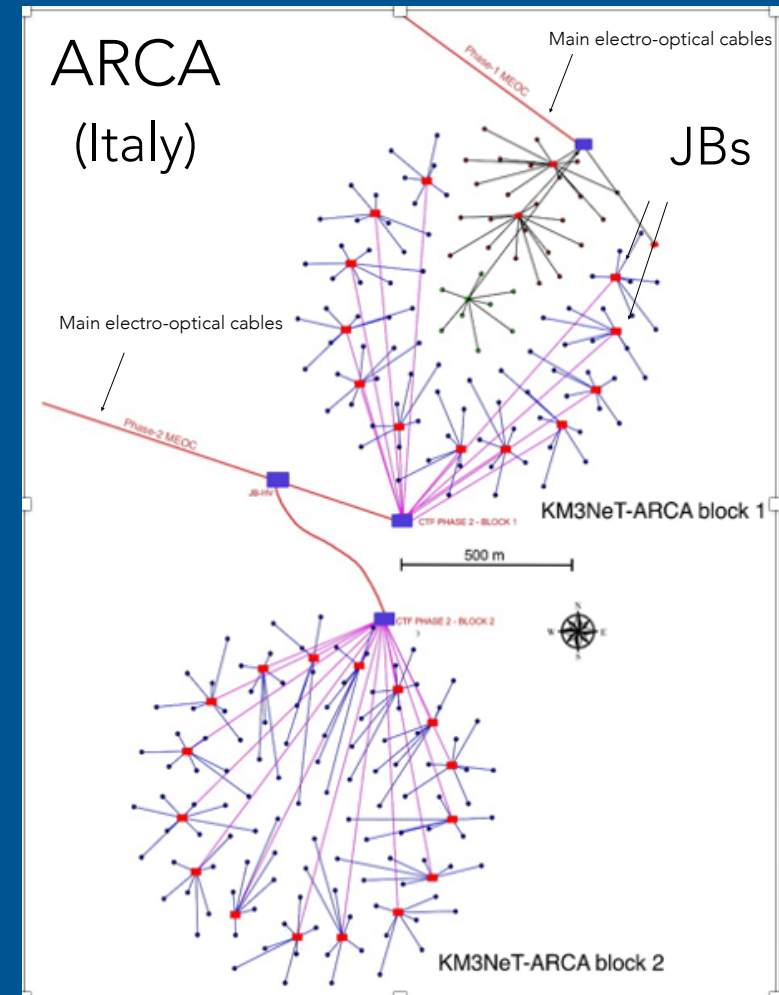


THE DETECTORS

3



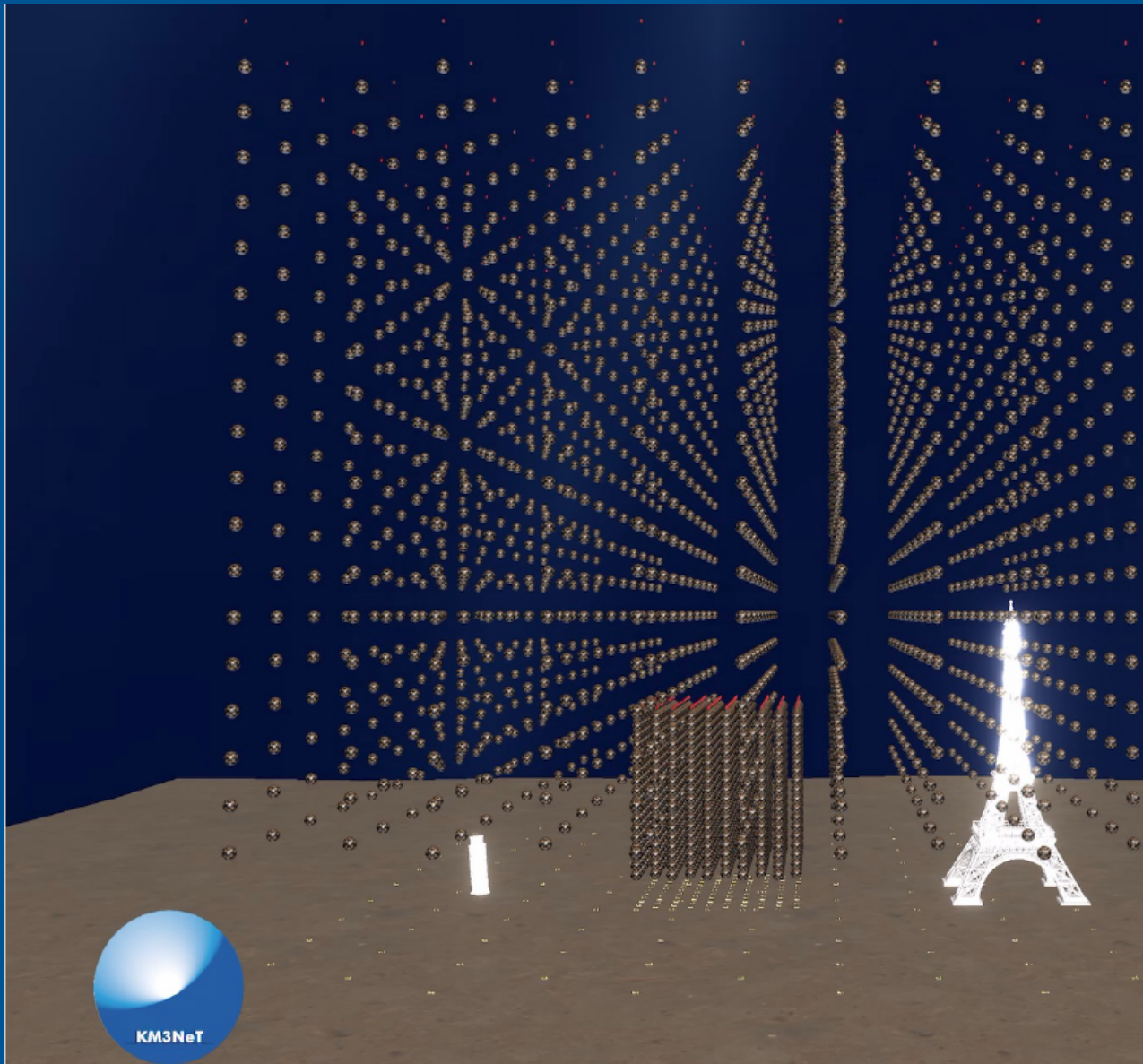
ORCA is composed of 1 building block of 115 DUs with 20 m DU interspacing and 9m inter DOM spacing (7 Mton)



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 KM3NET DETECTORS

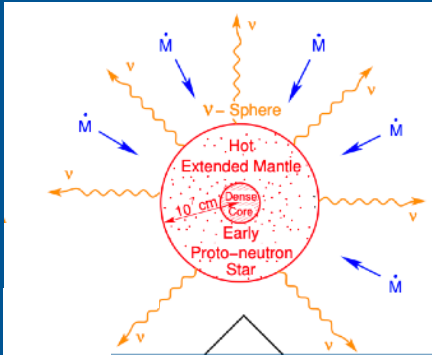
4



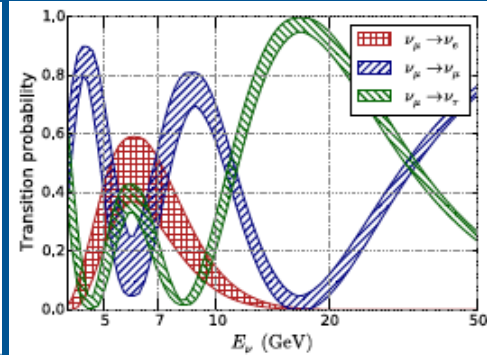
THE PHYSICS

5

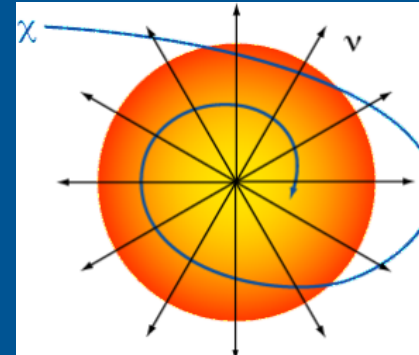
Neutrino Energy from MeV to PeV



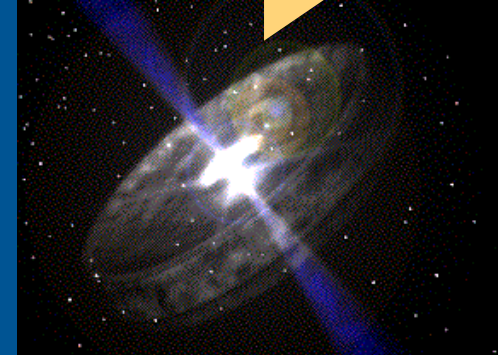
Super Novae explosion
MeV



Neutrino oscillation
GeV



Dark Matter
TeV

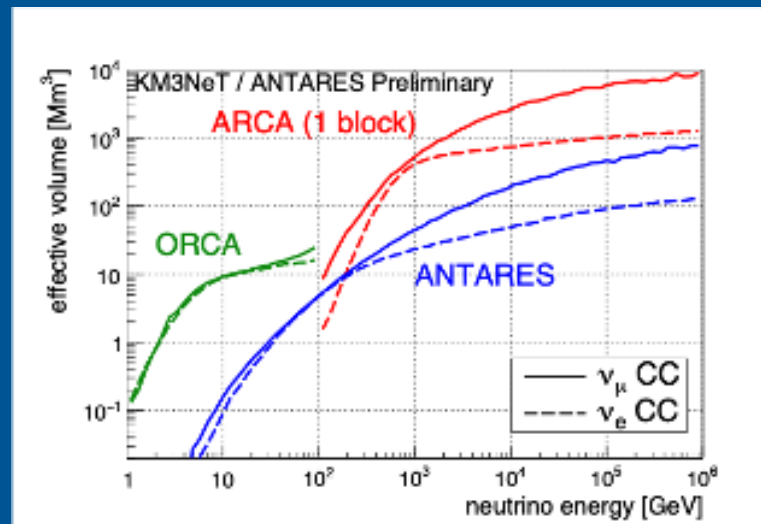


HE neutrinos
Multi-messenger program
PeV

ARCA + ORCA

ORCA

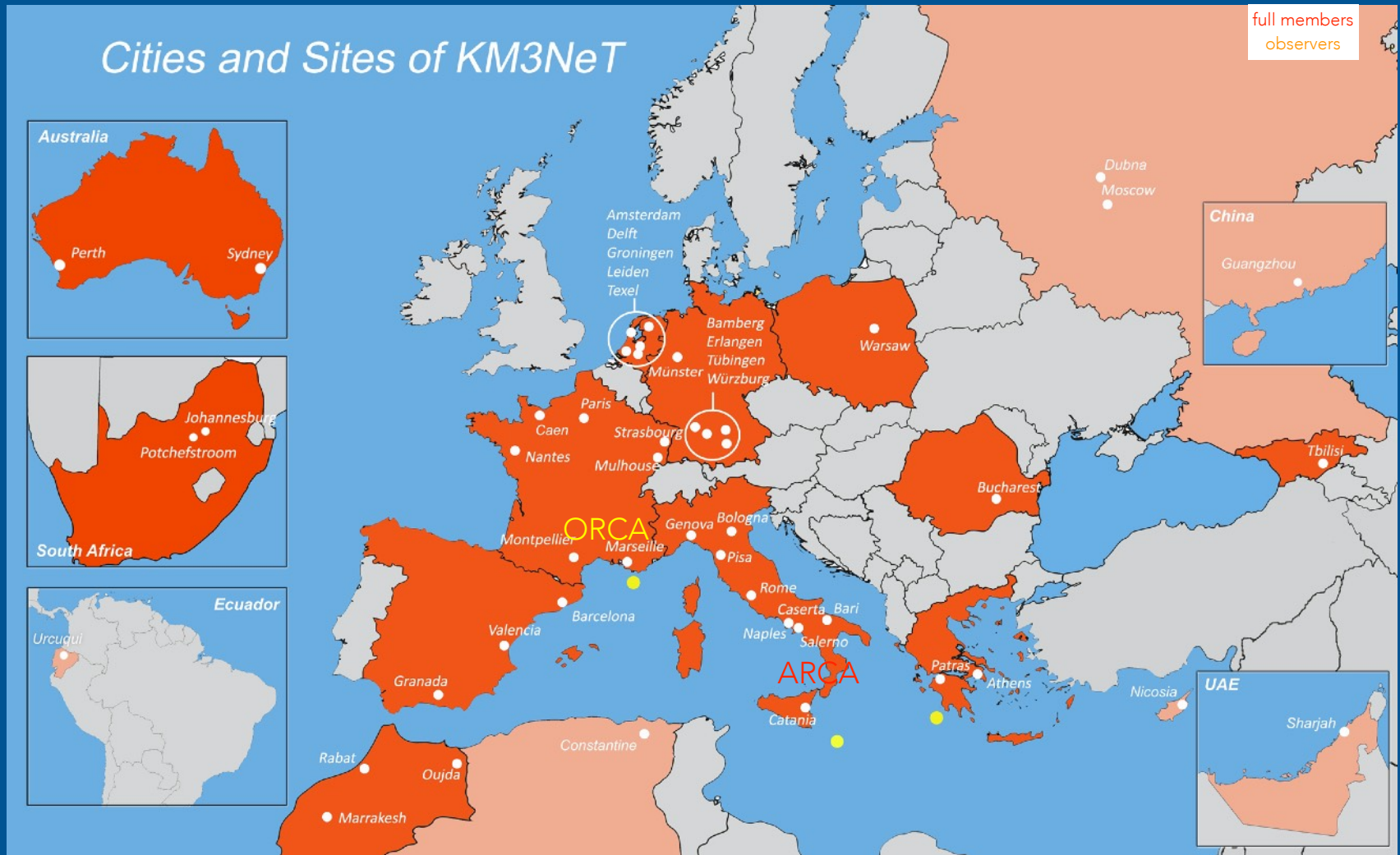
ARCA



THE KM3NET COLLABORATION

6

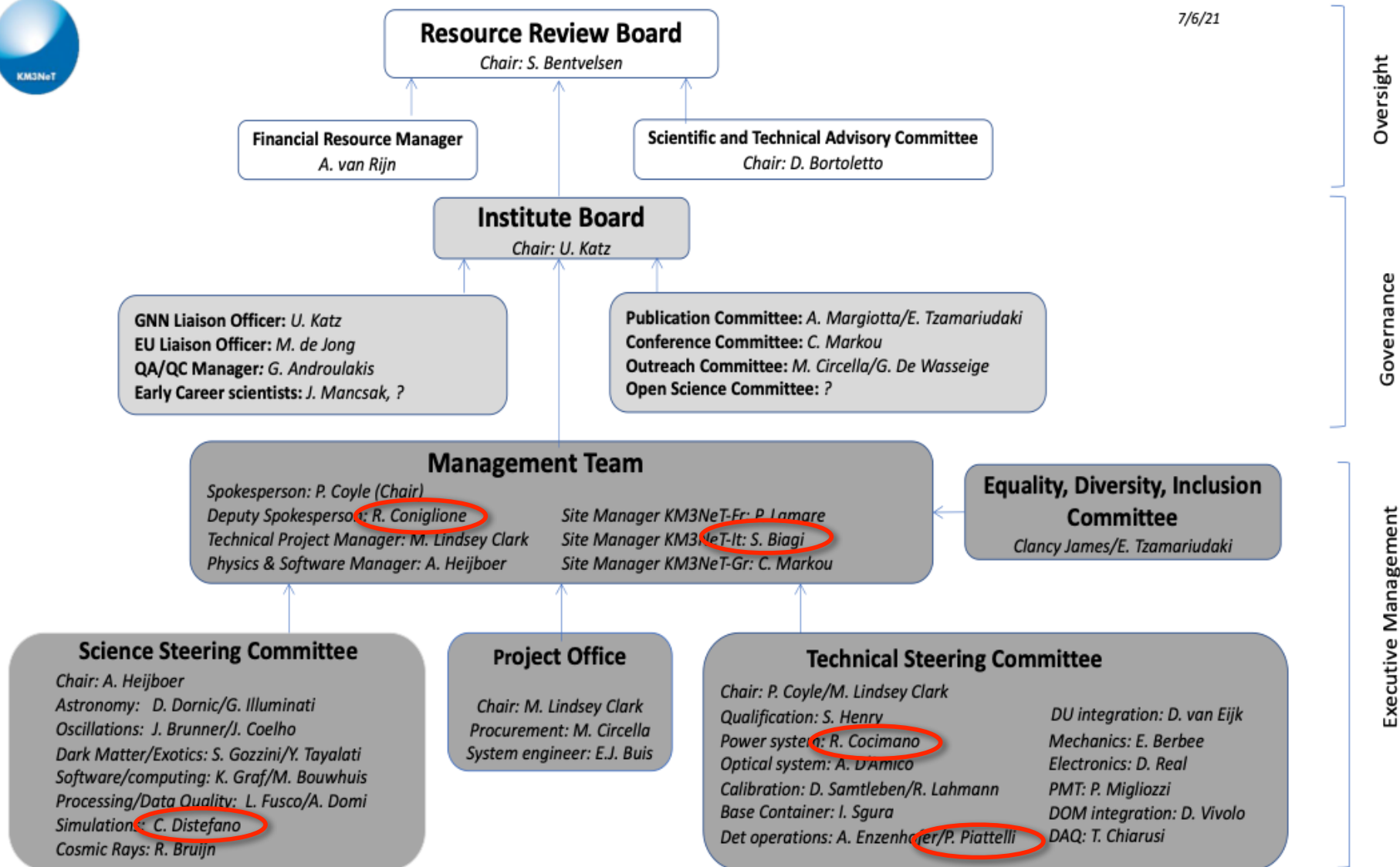
56 institutes in 17 countries



KM3NeT Organigramma

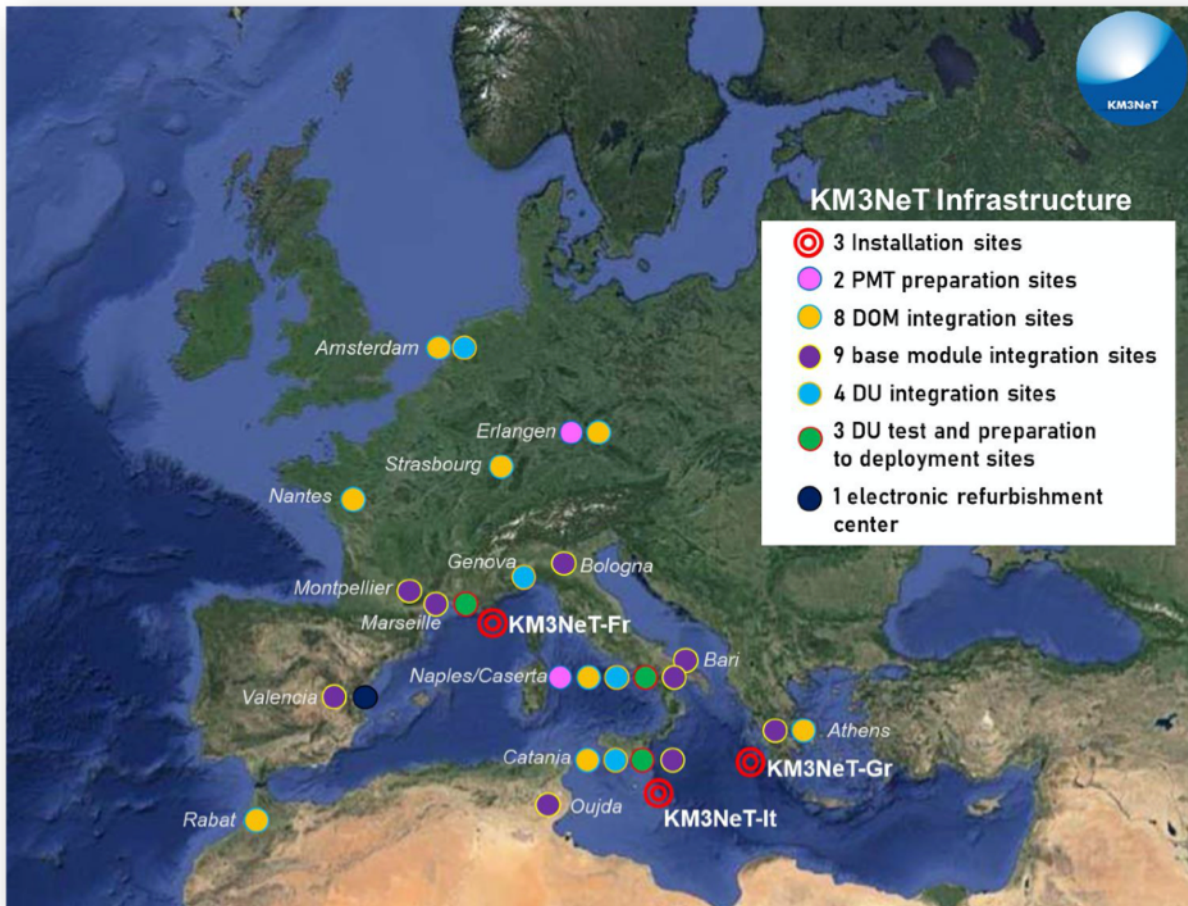


7/6/21



THE DETECTOR CONSTRUCTION

8



DOMs:

- 8 integration sites
- 640 DOM produced (400 ARCA, 240 ORCA)
- 100 currently in progress

BMs:

- 9 integration sites
- 27 BMs produced
- 6 currently in progress

DUs:

- 5 integration sites
- 13 DUs produced
- 8 currently in progress

Total: 22 integration sites!
(last year: 15)



Ai LNS

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

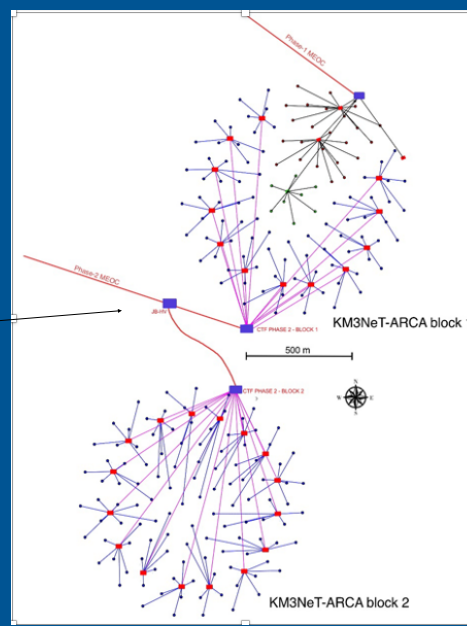
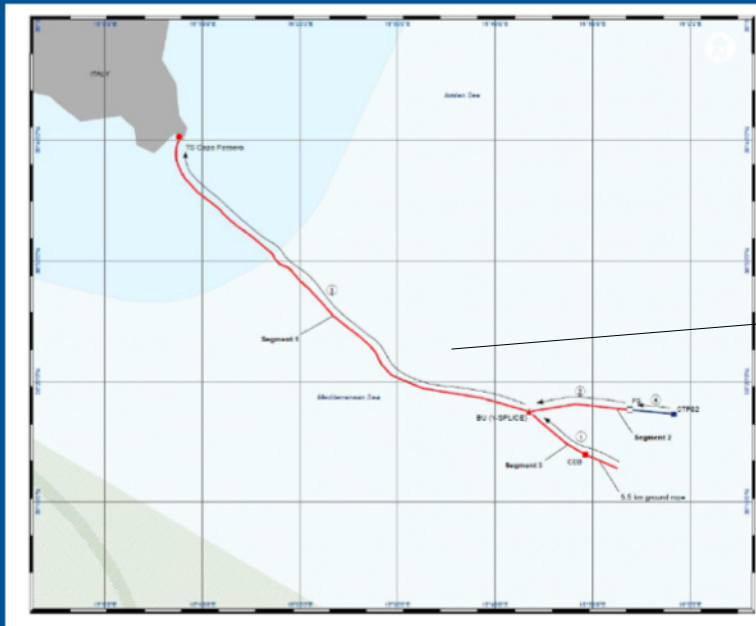
Alla Sezione Catania

- DOM integration site (resp. E. Leonora)

ARCA STATUS

9

Nov 2020 📍 Successful laying of a second MEOC cable (Alcatel)



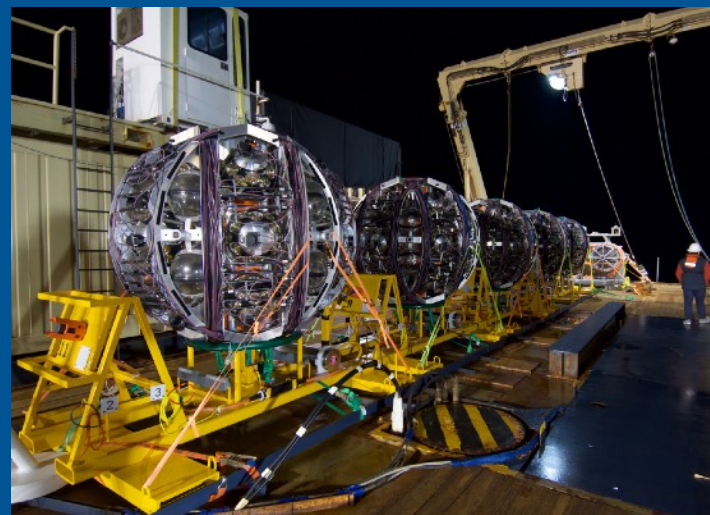
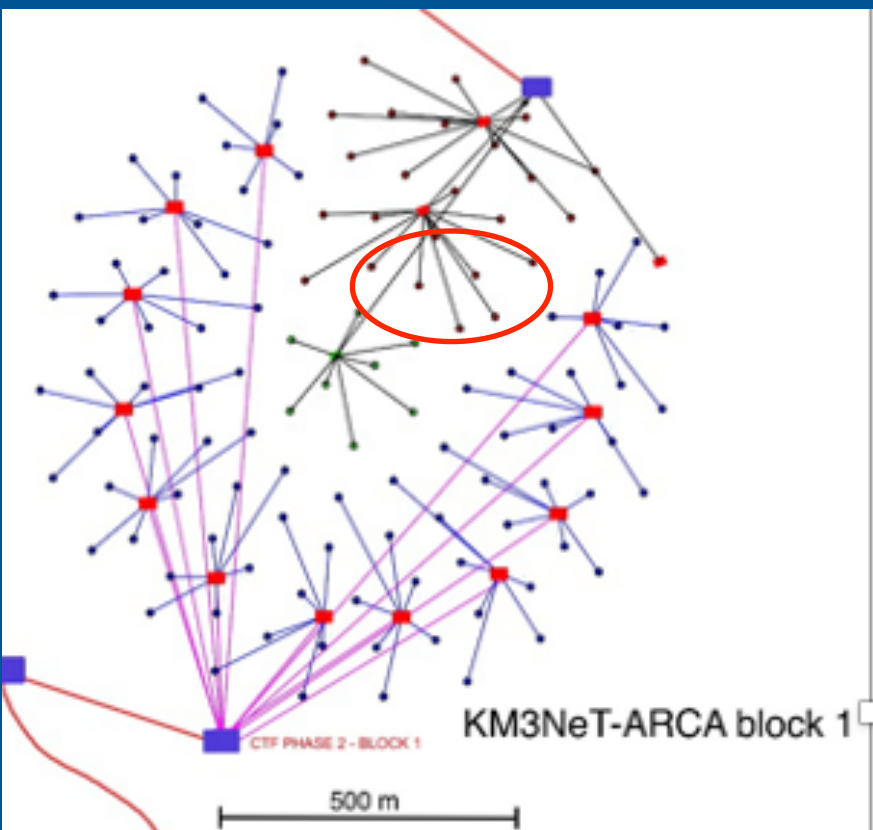
With this second main cable is possible to connect the full detector (2 blocks)

ARCA STATUS

10

8-15 April 2021 📌 Successful deployment of 5 DUs and 1 JB
6 DUs now in operation (1 DU deployed in Dec 2015 and still in operation)

5 DUs on deck before deployment



Commissioning phase over
Stable data taking from 13-May

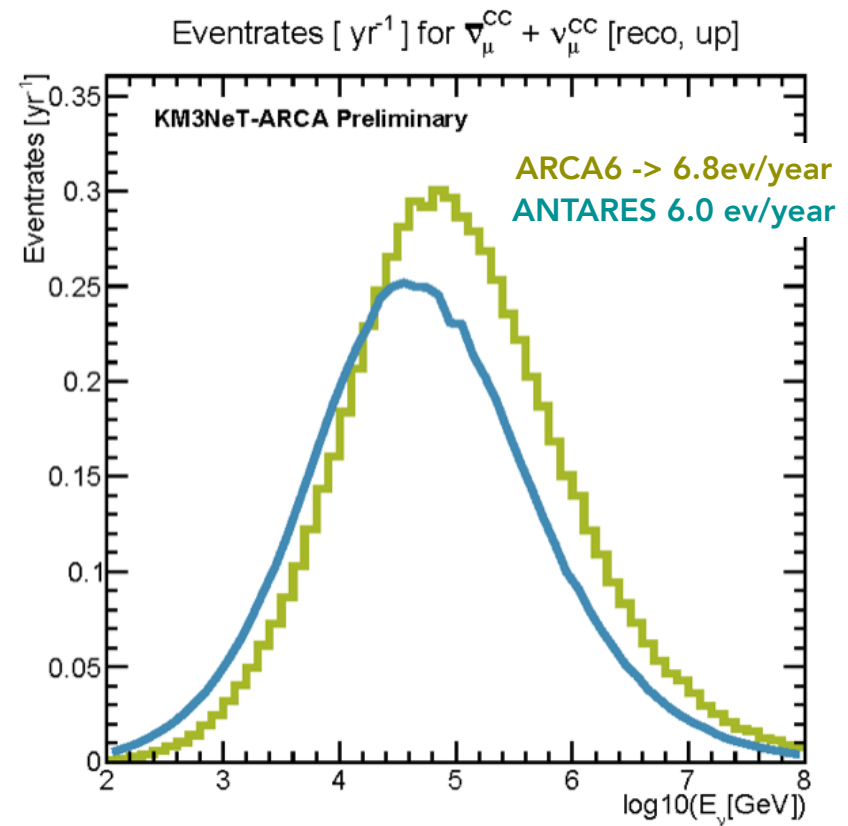
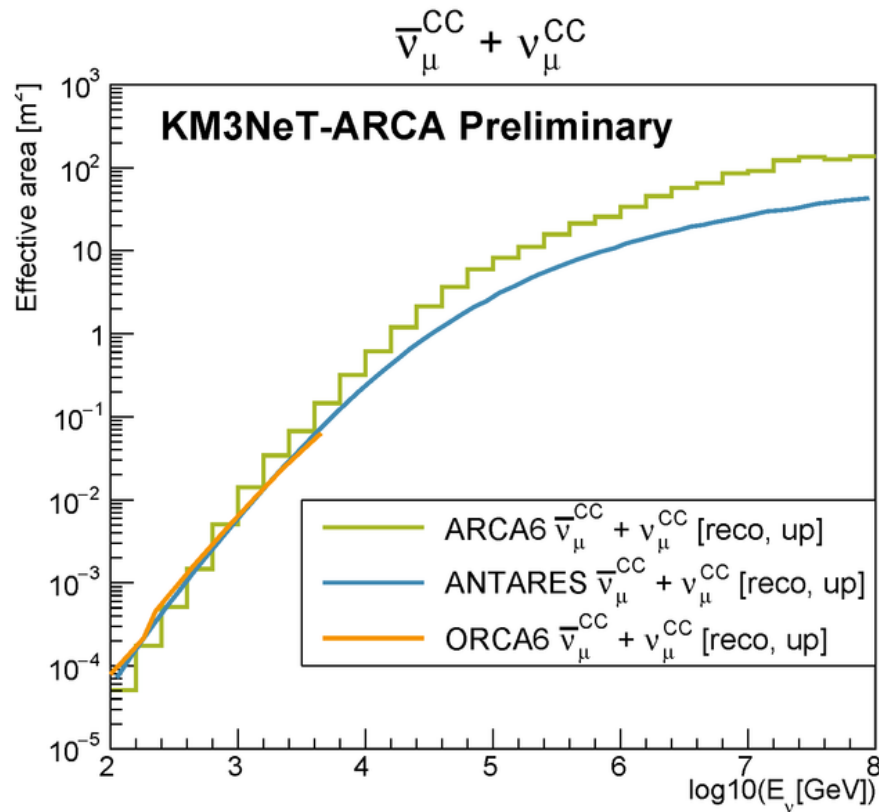
THE EFFECTIVE AREAS

11

Selection 🙌 up going tracks

Number of events per year for a cosmic diffuse flux

$$\Phi = 10^{-8} E^{-2} \text{GeV}^{-1} \text{cm}^{-2} \text{s}^{-1} \text{sr}^{-1}$$



Effective areas $\geq$ of ANTARES

12

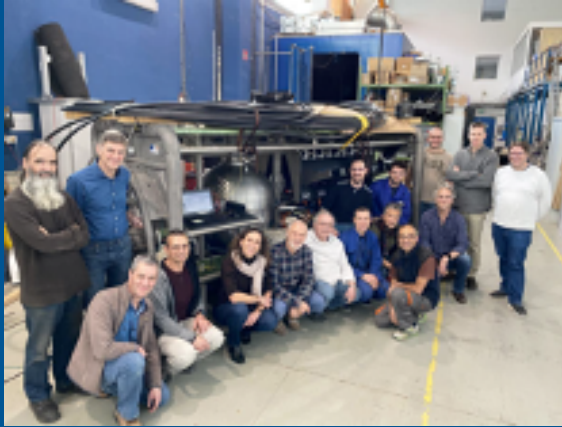
More than one year of
data available



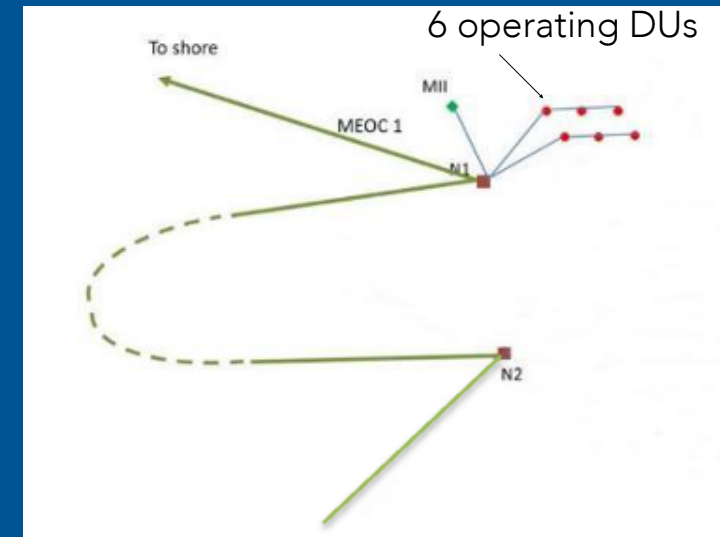
ORCA STATUS

13

October 2020 👉 Successful connection of a second JB



We can now connect up to 52 DUs

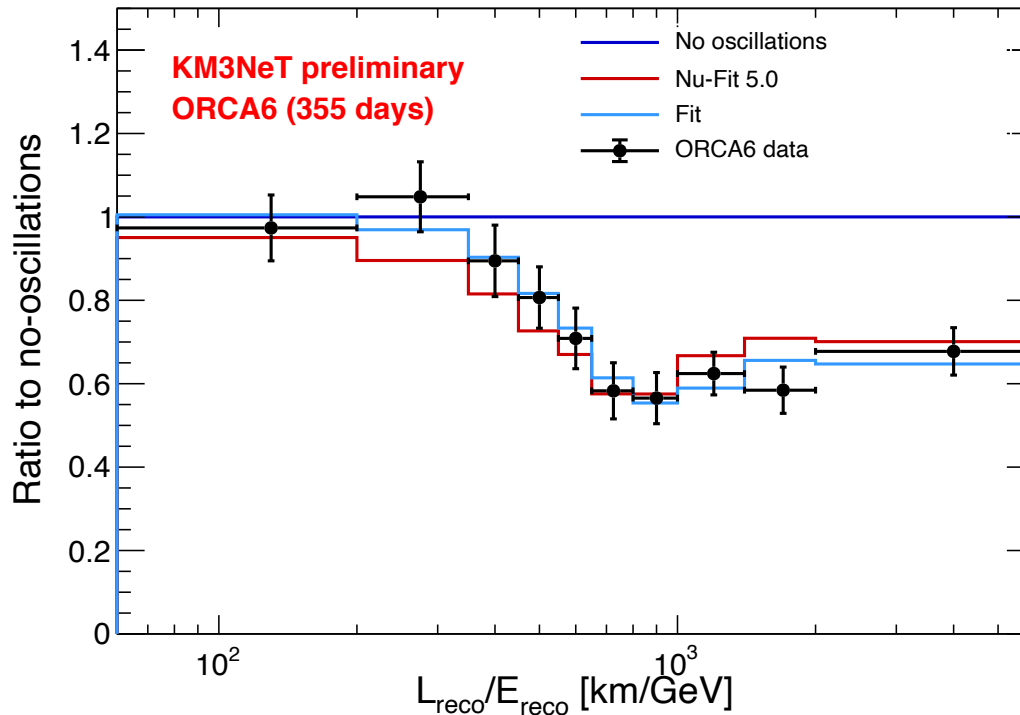


First results

ORCA FIRST RESULTS

15

ORCA6



no-oscillation hypothesis
disfavoured at ~ 6 sigma

Very good agreement Data /MC

We see neutrino oscillation

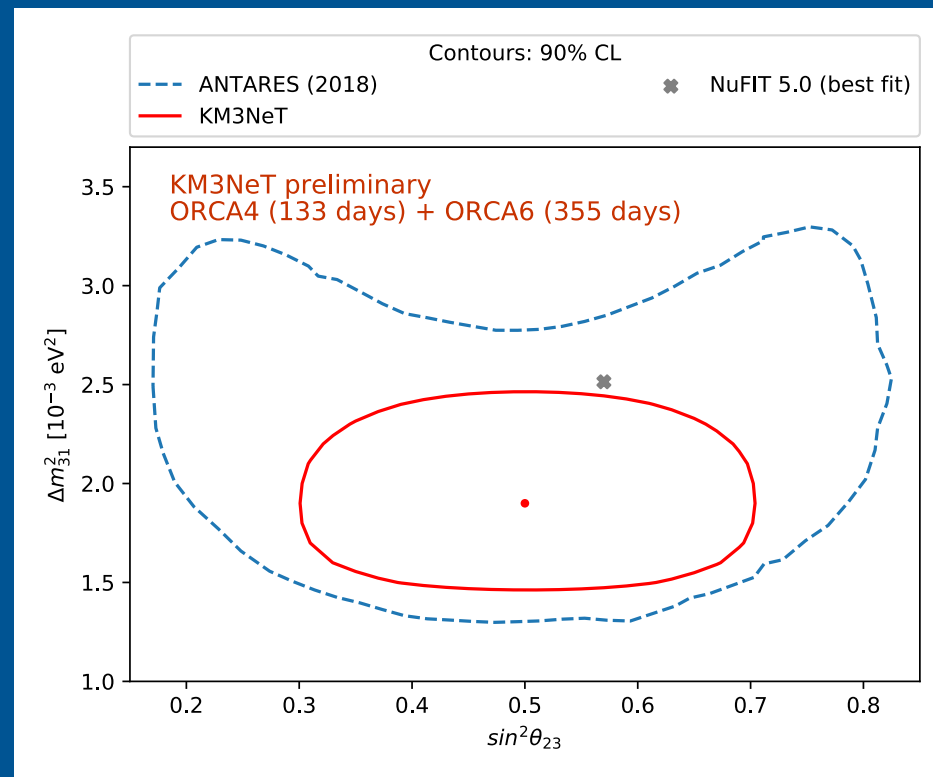
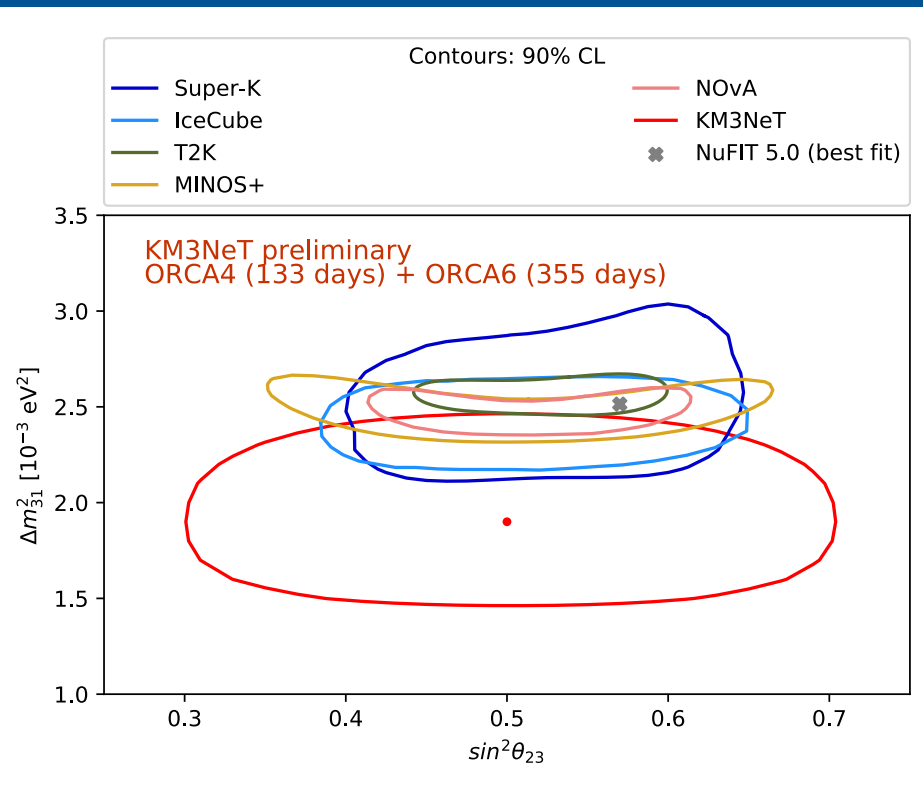
ORCA6 FIRST RESULTS

16

To be presented at ICRC2021

ORCA6

Antares 8 years of data



Results competitive with the other experiments even with a small size detector

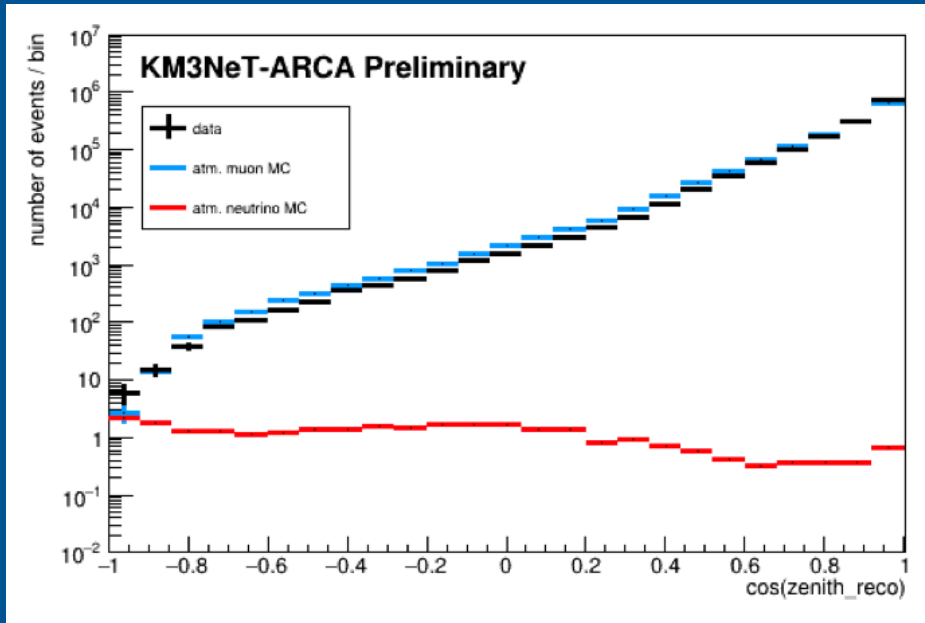
Much better than Antares after about 1 year of data taking

ARCA6: FIRST RESULTS

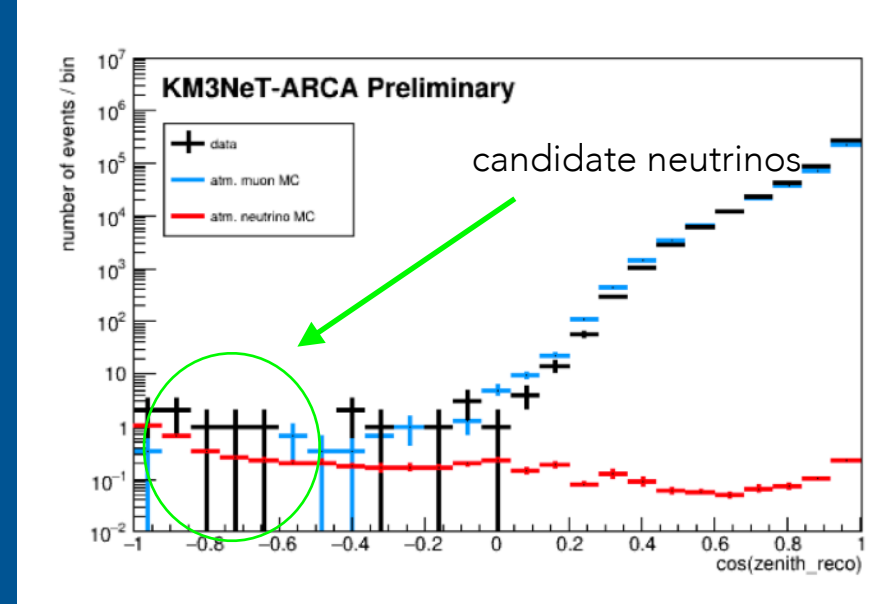
17

Data: 19 days ARCA 6 strings

No Quality cuts applied



Quality cuts applied to select upgoing-neutrinos



Coszen < - 0.8

Data : 5

(a)NumuCC: 2.0

Mupage : 0.7

Coszen < 0

Data : 15

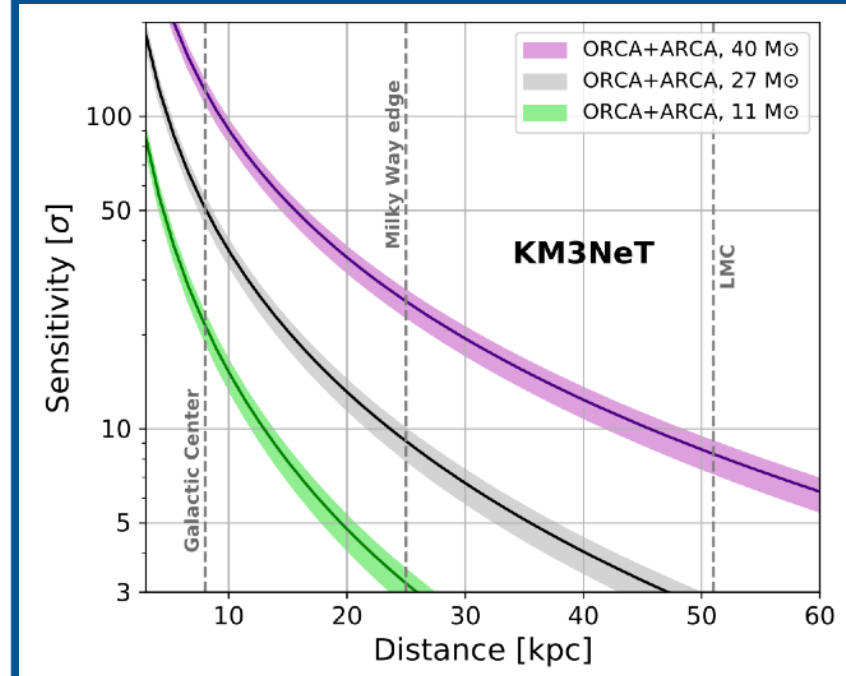
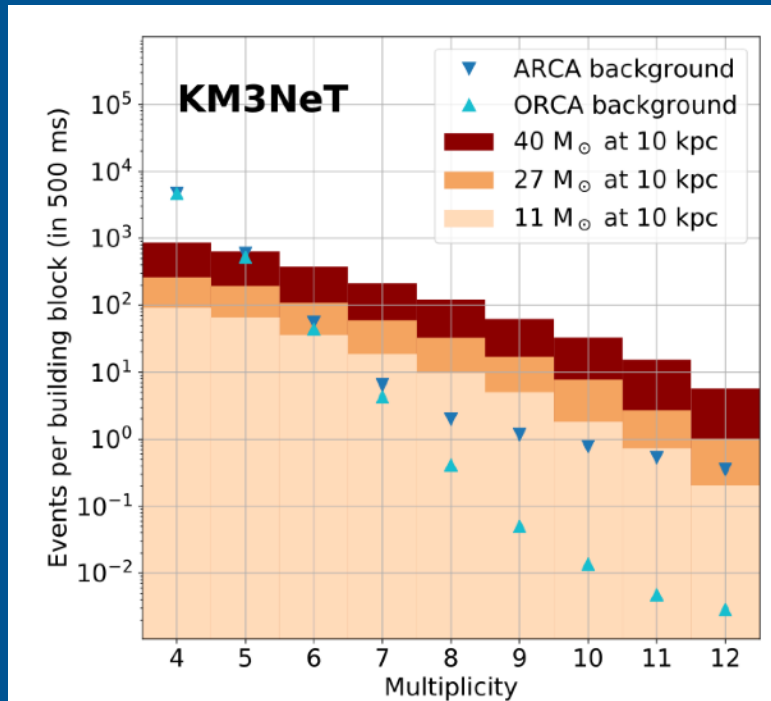
(a)NumuCC: 4.0

Mupage : 7.0

CORE COLLAPSE SUPERNOVAE

18

Accepted on APJ C <https://arxiv.org/abs/2102.05977>



$>5\sigma$ for ARCA+ORCA for $27M_{\odot}$ at a distance $<25\text{kpc}$

A trigger for CCSN already implemented
Integrated in SNEWS

Pubblicazioni KM3NeT

2020

- Deep-sea deployment of the KM3NeT neutrino telescope detection units by self-unrolling
Journal of Instrumentation 15 (2020) P11027
- Event reconstruction for KM3NeT/ORCA using convolutional neural networks
Journal of Instrumentation 15 (2020) P10005
- gSeaGen: the KM3NeT GENIE-based code for neutrino telescope -> LNS (C. Distefano)
Computer Physics Communications 256 (2020) 107477
- The Control Unit of the KM3NeT Data Acquisition System
Computer Physics Communications 256 (2020) 107433
- Dependence of atmospheric muon flux on seawater depth measured with the first KM3NeT detection units
Eur. Phys. J. C (2020) 80:99 --> LNS (S. Biagi, R.C.)

2021

- Architecture and performance of the KM3NeT front-end firmware
J. of Astron. Telesc. Instrum. and Syst. 7(1), 016001 (2021)
- The KM3NeT potential for the next core-collapse supernova observation with neutrinos
Eur. Phys. J. C81 (2021) 445

KM3NeT @ LNS

Finanziamenti italiani

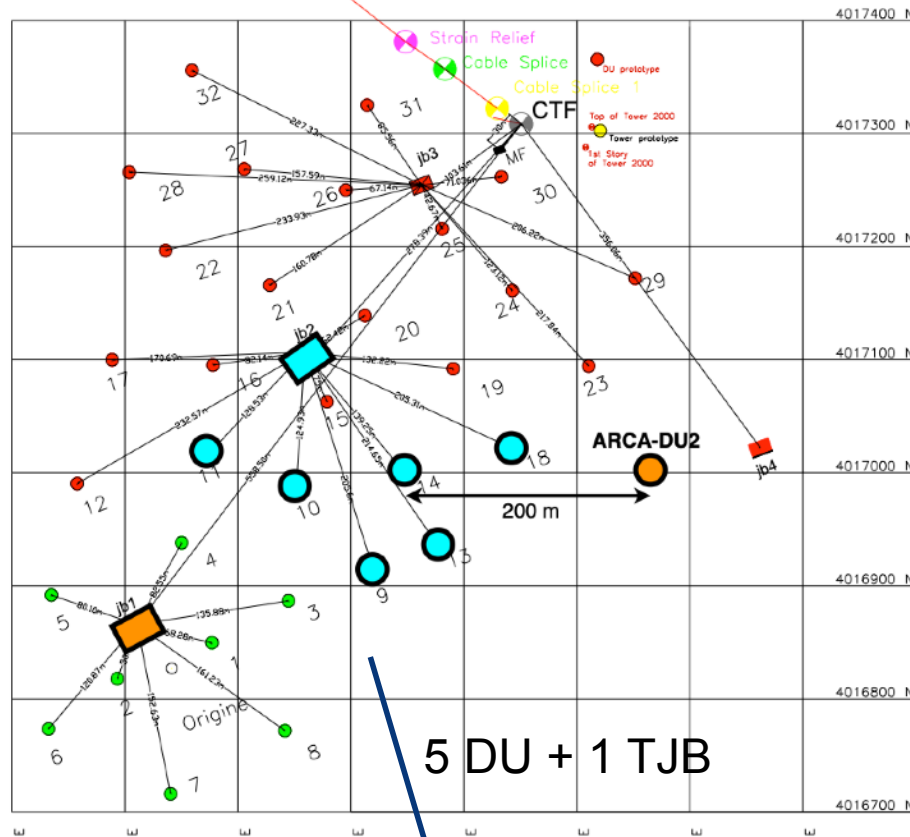
- Principali fonti di finanziamento Italiani INFN, PON, POR, FOE (per rete di fondo e rivelatore) + Progetti europei (INFRADEV+ESCAPE)
- Budget disponibile sufficiente per costruzione e installazione di rete di fondo e stringhe di circa un terzo del rivelatore di progetto (76/230 ARCA)

Attività in corso ai LNS

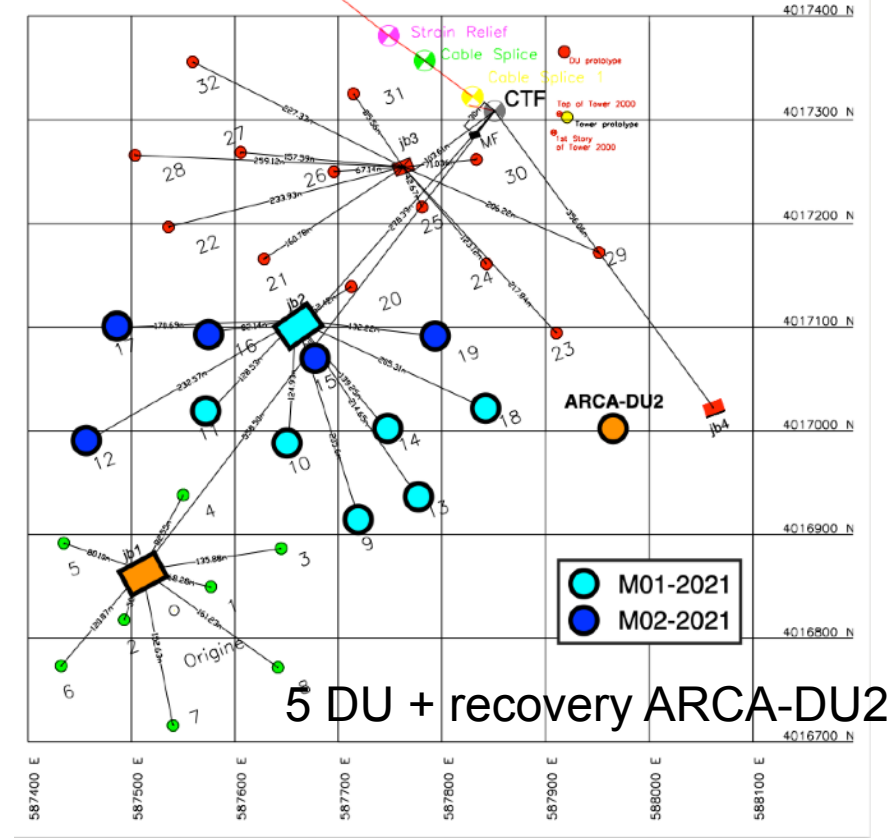
- Definizione Campagne marine
- Upgrade stazione di terra Capo Passero
- Posa cavo Alcatel
- Espansione rete di fondo (JB + interlink cables)
- Integrazione DU
- Integrazione BM
- Procurement
- Operatività rivelatore

Campagne marine

Aprile 2021



Settembre 2021

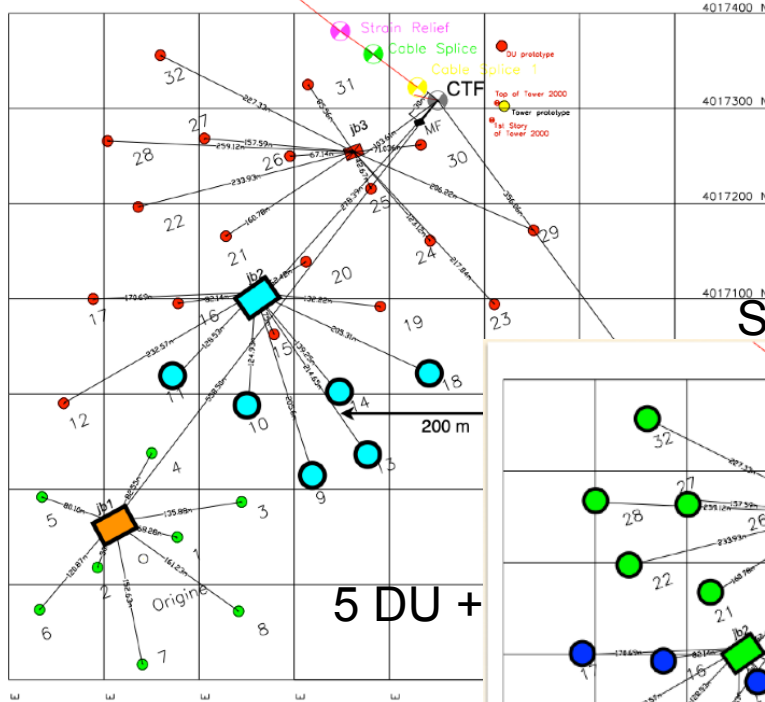


Grande successo !!! Ma grande sforzo per integrazione, logistica (trasporto + attività doganali), turni, operatività stazione di terra, personale sulla nave -> In tempo di COVID

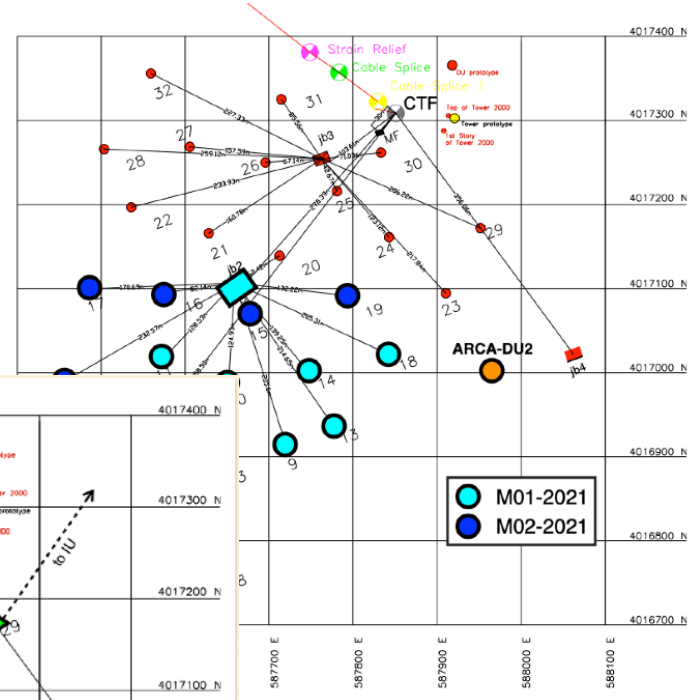
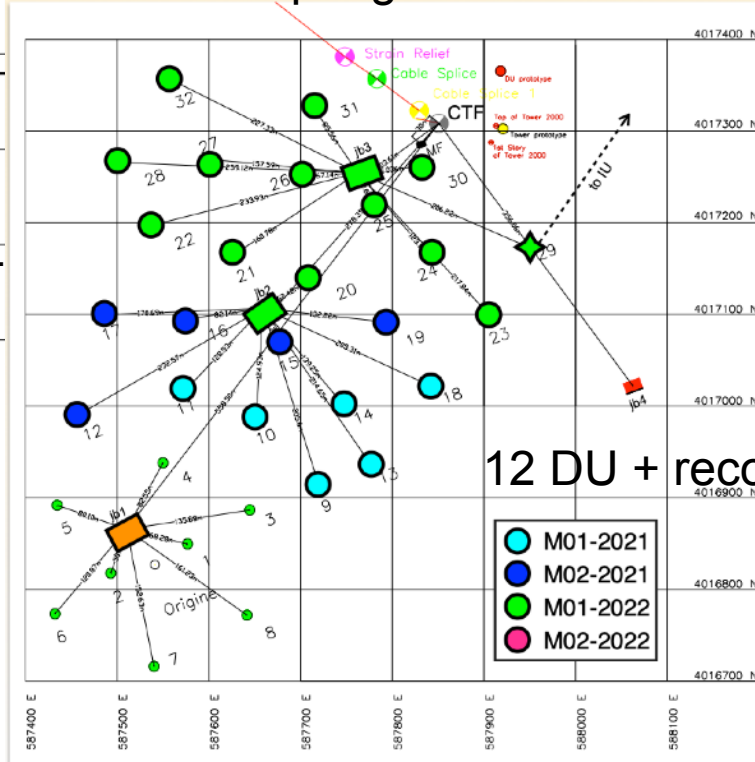
Campagne marine

Settembre 2021

Aprile 2021



Spring 2022



12 DU + recovery TJB + 2 JB + CU

THE NEXT IMPORTANT SEA CAMPAIGNS

25

September - October 2021

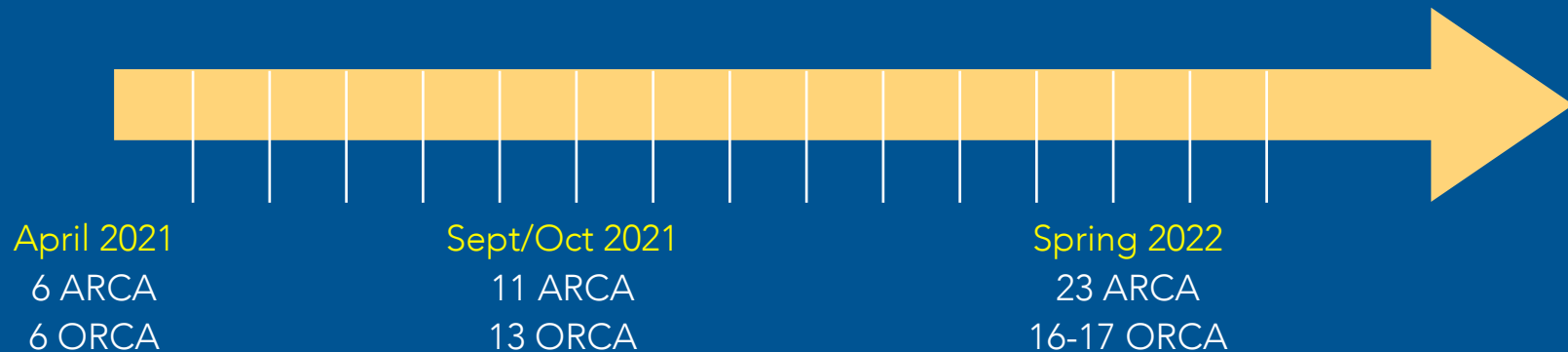
5 DUs at ARCA site

7 DUs + CU (Calibration Unit) at ORCA site

Spring 2022

12 DUs + 1JB +1 CB (Calibration Base) + 1 IU (Instrumentation Unit) at ARCA site

3-4 DUs at ORCA site



Upgrade stazione di terra

Riccobene, Cocimano, Giorgio,
Orlando, Pulvirenti, Piattelli, Zito,
Ferrara.. + servizio Calcolo e reti

Completamente restaurata -> consegnata fine 2020
Già pronta per la campagna marina di Settembre

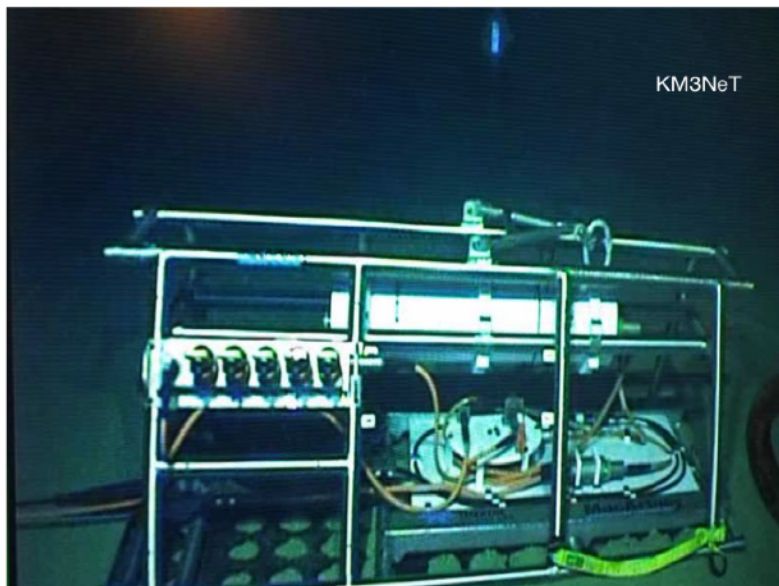


April sea Campaign -> Onshore & offshore teams

Posa Cavo alcatel

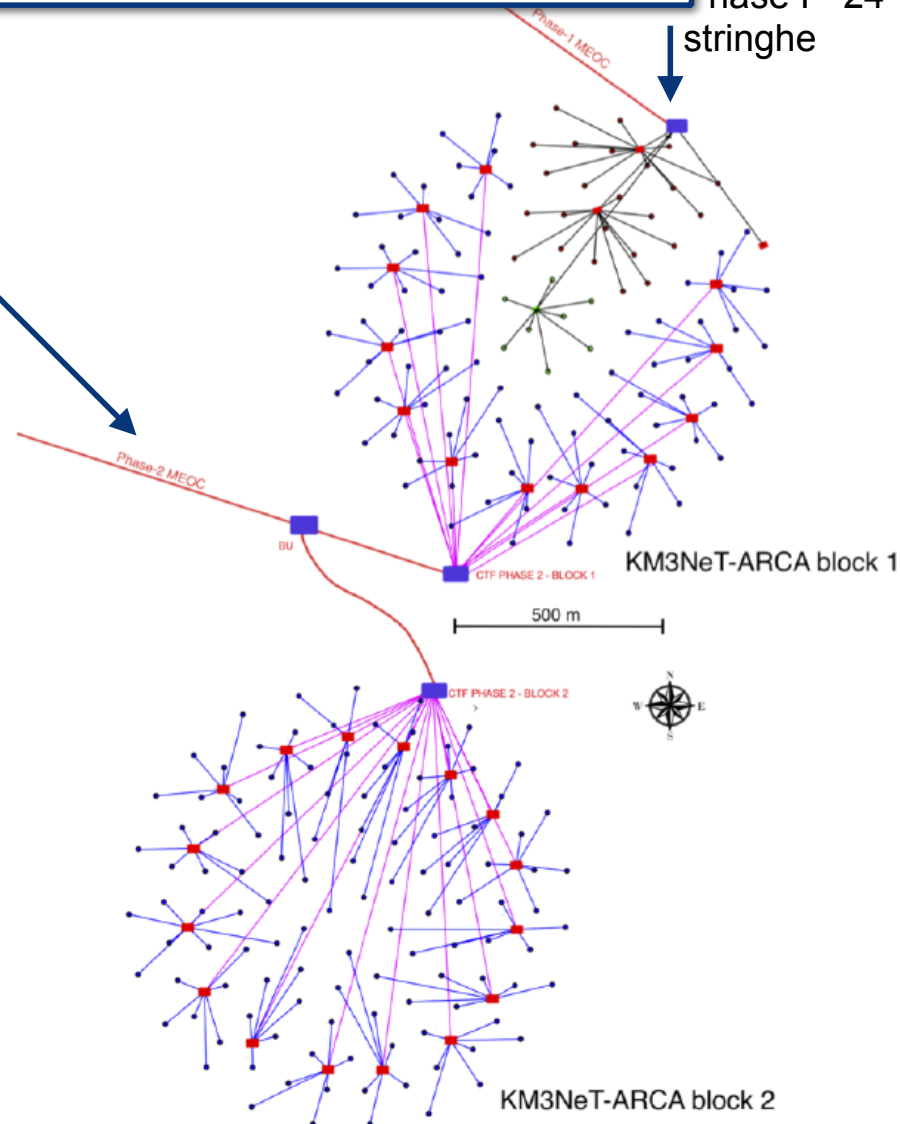
- Main cable ALCATEL
 - Completamento rete di fondo con
 - Posa del secondo main cable (Nov2020)
 - Alimentatori di terra (PFE)
 - Posa Beach joint (Luglio 2021)
 - Posa CTF (Cable Termination Frame) (Settembre 2021)
 - Posa MVC (Settembre 2021)

CTF del primo cavo già in acqua



Riccobene, Cocimano, Cuttone, Orlando, Pulvirenti, Sedita, Biagi...

Phase I - 24 stringhe



Attività in corso ai LNS

Biagi, Cocimano, Cuttone, Giorgio, Leonardi,
Orlando, Pulvirenti
+ Serv. Elettronica

- Rete di fondo e JB
- 1 TJB già installata in Aprile 2021
- 2 JB (Junction Box) per Primavera 2022
- Attività di test dell'OPA (Optical and Power Assembling) ai LNS. Schede di elettronica con componenti HiRel)
- Integrazione OPA con il fare meccanico presso MacArtney (Danimarca)

OPA @ LNS

JB mechanical frames @MacArtney



Attività in corso ai LNS

Sapienza, Cacopardo, Riccobene, Piattelli, E. Giorgio, G. Ferrara, Pulvirenti, Cocimano, Larosa
+ Serv. Elettronica + Serv. Infr. Marine +
Meccanici

- **Integrazione delle Detection Units (DU)**

- Attività di integrazione delle DU al Porto di Catania in tutte le sue parti: dalla connessione dei DOM con il VEOC (Vertical Electro-Optical Cable) alla calibrazione e caricamento sul LOM (Launcher of Optical Modules) e test a Malta
- **3 DU assemblate per la campagna marina di Aprile 2021**
- **3 DU quasi completamente assemblate per la campagna marina di Settembre 2021**
- 2-3 DU in corso

- **Integrazione Base Module**

- Già assemblati 3 BM



ANTARES

Optical sensor
1 PMT of 10 inches

Depth 2475m

12 lines of 75 PMTs

1 line for Earth and Marine sciences

25 storeys / line

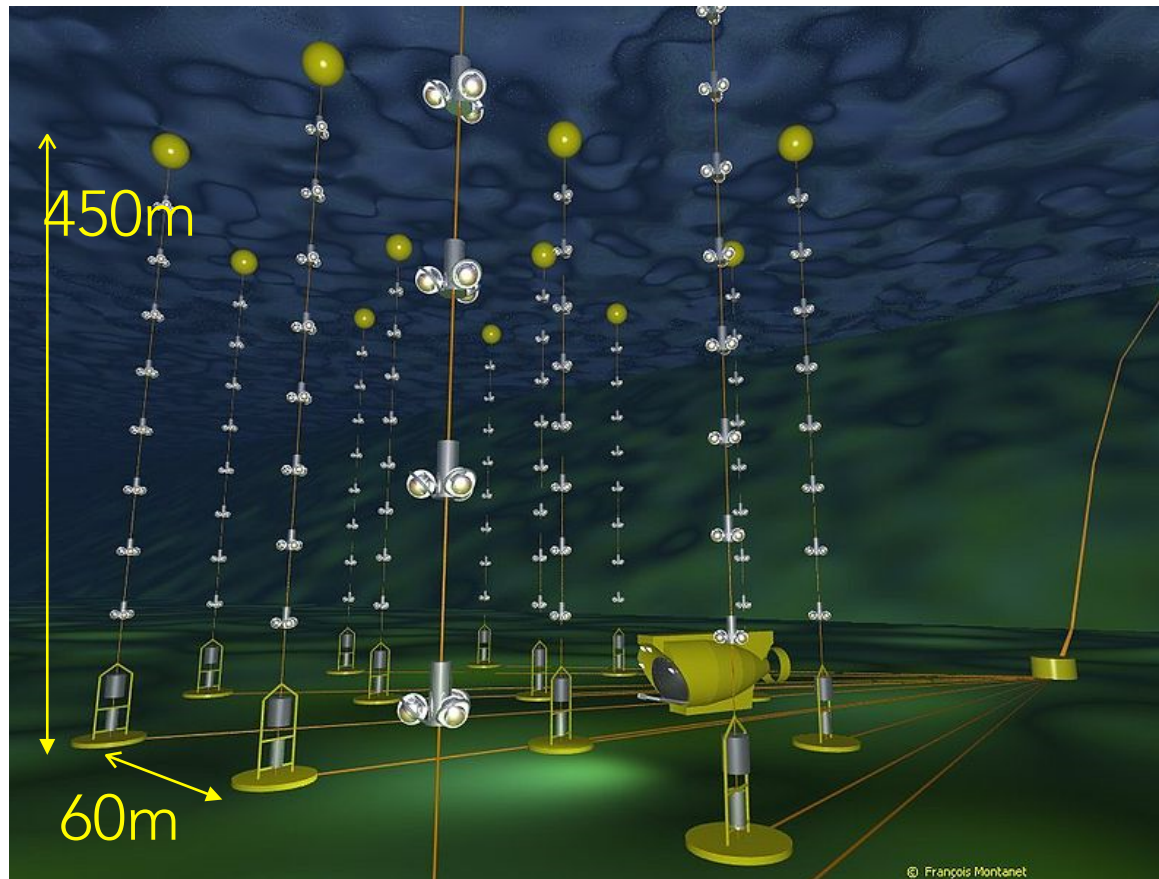
3 PMTs / storey

885 PMTs

Volume 0.01 km³

Detector completed
in 2008

Taking data since 11
years with a duty
cycle of ~95%



ANTARES

Molto attivo nel programma multimessanger con analisi

- Analisi in tempo reale e “alert”
- Analisi in coincidenza con segnali da altri detectors (IceCube- Ligo - Auger - GVD (Baikal)...)

Last update 06-April-2021

92) ANTARES search for point sources of neutrinos with 11 yr of data: a likelihood stacking analysis

A. Albert et al., ApJ 911 (2021) 48 (11 pp.), [PDF file](#), [online version](#)

91) ANTARES upper limits on the multi-TeV neutrino emission from the GRBs detected by IACTs

A. Albert et al., JCAP 03 (2021) 092 (16 pp.), [PDF file](#), [online version](#)

90) Measurement of the atmospheric ν_e and ν_μ energy spectra with the ANTARES neutrino telescope

A. Albert et al., Phys. Lett. B 816 (2021) 136228 (7 pp.), [PDF file](#), [online version](#)

89) Monte Carlo simulations in the ANTARES underwater neutrino telescope

A. Albert et al., JCAP01 (2021) 064 (19 pp.), [PDF file](#), [online version](#)

88) Constraining the contribution of Gamma-Ray Bursts to the high-energy diffuse neutrino flux with 10 years of ANTARES data

A. Albert et al., Monthly Notices of the Royal Astronomical Society, Volume 500, Issue 4 (2021) 5614–5628, [PDF file](#), [online version](#)

87) Observation of the cosmic ray shadow of the Sun with the ANTARES neutrino telescope

A. Albert et al., Physical Review D 102, 122007 (2020) (Vol. 102, No. 12) (7 pp.), [PDF file](#), [online version](#)

86) Combined search for neutrinos from dark matter self-annihilation in the Galactic Center with ANTARES and IceCube

A. Albert et al., Physical Review D 102, 082002 (2020) (Vol. 102, No. 8) (13 pp.), [PDF file](#), [online version](#)

85) Search for neutrino counterparts of catalogued gravitational-wave events detected by Advanced-LIGO and Virgo during run O2 with ANTARES

A. Albert et al., Eur. Phys. J. C 80, 487 (2020) (9 pp.), [PDF file](#), [online version](#)

84) Search for dark matter towards the Galactic Centre with 11 years of ANTARES data

A. Albert et al., Phys. Lett. B, 805 135439 (2020) (6 pp.), [PDF file](#), [online version](#)

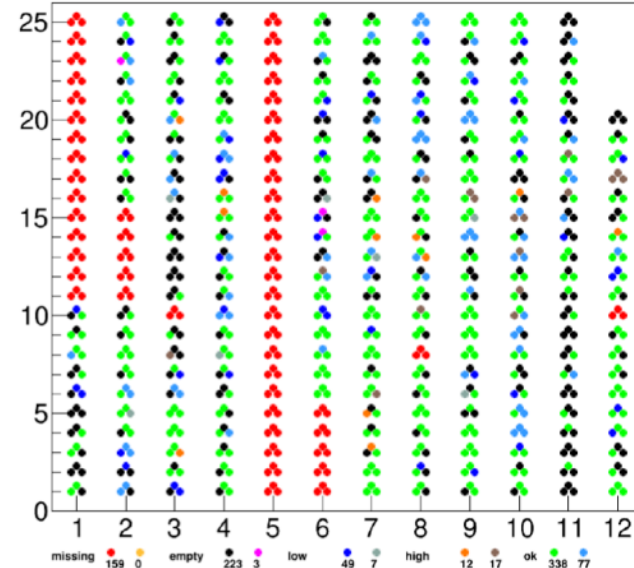
83) ANTARES and IceCube Combined Search for Neutrino Point-like and Extended Sources in the Southern Sky

A. Albert et al., The Astrophysical Journal, 892:92 (2020) (12 pp.), [PDF file](#), [online version](#)

82) Model-independent search for neutrino sources with the ANTARES neutrino telescope

A. Albert et al., Astropart. Phys. Vol. 114 (2020) 35-47, [PDF file](#), [online version](#)

Run 89391 Sat Jun 12 21:44:55 2021
Line 1-12 Physics Trigger 3N+2T3+K40+GC+TQ+TS0 SNbuffer May2020



In discussione lo
smantellamento del
rivelatore

In pubblicazione:

- Correlations neutrinos-gammas with HAWC

Luigi Fusco and Giovanna Ferrara

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 2022

FTE

Preliminari

NOME	FTE KM3 2022	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	50	30	80	Escape30
Cuttone Giacomo	10	45	55	MarineHazard45
Distefano Carla	35	35	70	MarineHazard35
Ferrara Giovanna	80		80	
Giorgio Emidio	50	20	70	Escape20
Larosa Giuseppina	100		100	
Leonardi Ornella	30		30	
Leone Francesco	50		50	
Migneco Emilio	0		0	
Musumeci Mario	50		50	
Orlando Angelo	70	30	100	MarineHazard30
Papaleo Riccardo	80		80	
Piattelli Paolo	80	0	80	
Pulvirenti Sara	65	35	100	MarineHazard35
Riccobene Giorgio	80	0	80	
Rovelli Alberto	100	0	100	
Santonocito Domenico	20		20	
Sapienza Piera	70	0	70	
Viola Salvo				
Zito Daniele	80	20	100	Escape20
			0	
Totale	13	2,45	15,45	
Totale KM3+fondi esterni	15,45			

FTE calcolati come sigla
KM3NeT + fondi esterni

Richieste 2022

Capitolo		Formula	Keuro
Missioni	meeting collaborazione 1/3 FTE x 1.5€ x3	1/3 * FTE * 1.5K * 3 coll. meeting	22,94
	meeting steering committee 3 persone x 6 meeting	3 persone*3gg*6meeting	24,12
	gruppi di lavoro e workshop tematici	3 persone*4gg*3meeting	13,68
	2 campagne marine 3 persone in nave e 10 persone nella stazione di terra	(3 persone sulla nave*8 gg*2campagne)+(10 persone a terra *8gg*2campagne)	33,40
	contatti ditte fase 2 - estero (MacArtney DK)	3viaggi*4persone*4giorni	30,00
	contatti ditte fase 2 - Italia (Elmacom, MBE)	4viaggi*4persone*4giorni	18,24
	coordinamento tecnico	5viaggi*1persone*6giorni (Klaus)	9,40
	viaggi comitato di gestione PON PACK	2viaggi*1 persone*3giorni (Paolo)	1,96
	Missioni Caserta per integrazione instrumentation unit	10giorni*3persone	6,30
	attività installazione, manutenzione a Capo Passero	40 missioni per 1 giorno	8,00
	presentazioni antares e km3net a conferenze	10% del totale delle richieste	16,80
Missioni	Totale		184,85
Consumo	Totale		60,00
Altro consumo	Common Funds		200,00
Trasporti	Totale		41,00
GRAN Totale			485,85

Richieste 2021

169,5

40

200

20

Richieste 2022			
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	attività installazione, manutenzione a Capo Passero	40 missioni per 1 giorno	8,00
	presentazioni antares e km3net a conferenze	10% del totale delle richieste	16,80
Missioni	Totale		184,85
Consumo	Materiale consumo integrazione stringhe e Base Module -		15,00
	Materiale consumo per Capo Passero - Cavetterie - etichette e placche		7,00
	Materiale consumo acustica - reburishemnt beacon, pacchi batterie, gel		8,00
	Materiale consumo Calibration Unit		20,00
	Materiale consumo ottica e potenza - riparazione strumenti di misura		10,00
Consumo	Totale		60,00
Altro consumo	Common Funds		200,00
Trasporti	Trasporto materiale per la calibration unit a Caserta (base, ancora, boe...)		5,00
	Trasporto TJB da Malta a Caserta		15,00
	Trasporto LOM et al. da LNS a Porto Catania		4,00
	Movimentazione al porto di Catania		7,00
	Trasporto 2 OPA da LNS a MacArteny		10,00
Trasporti	Totale		41,00
GRAN Totale			485,85

Richieste straordinarie 2021

Preliminari

Quasi esaurito il budget di missioni 2021

- **Main cable ALCATEL**
 - Completamento rete di fondo con
 - Posa Beach joint (Luglio 2021)
 - Posa CTF (Cable Termination Frame) (Settembre 2021)
 - Posa MVC (Settembre 2021)
- **Missione Marina Settembre 2021 per DU deployment**

Per trasporto cavi da Malta a ODI/teledin U.S.A.



A) Trasporti -> Richiesta aggiuntiva $20 \text{ k€} * 2 = 40 \text{ k€}$

B) Missioni -> Sblocco sub-judice di 2.5 k€ + richiesta aggiuntiva $(39,65 - 10) \text{ k€} = 27 \text{ k€}$

MOVIE: DU DEPLOYMENT

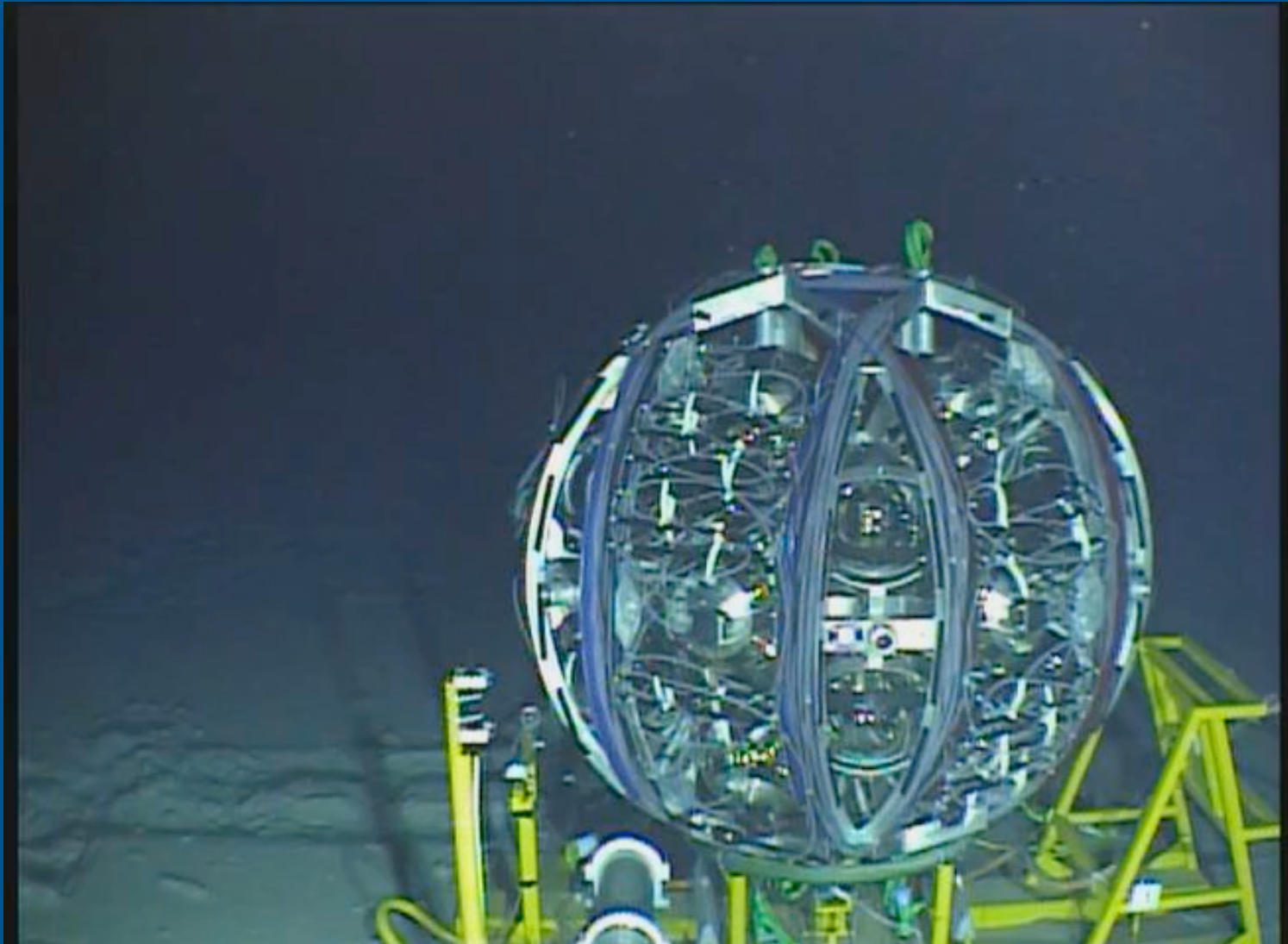
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Deployment DU



MOVIE: THE UNROLLING

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MOVIE: LOM AT SEA SURFACE

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