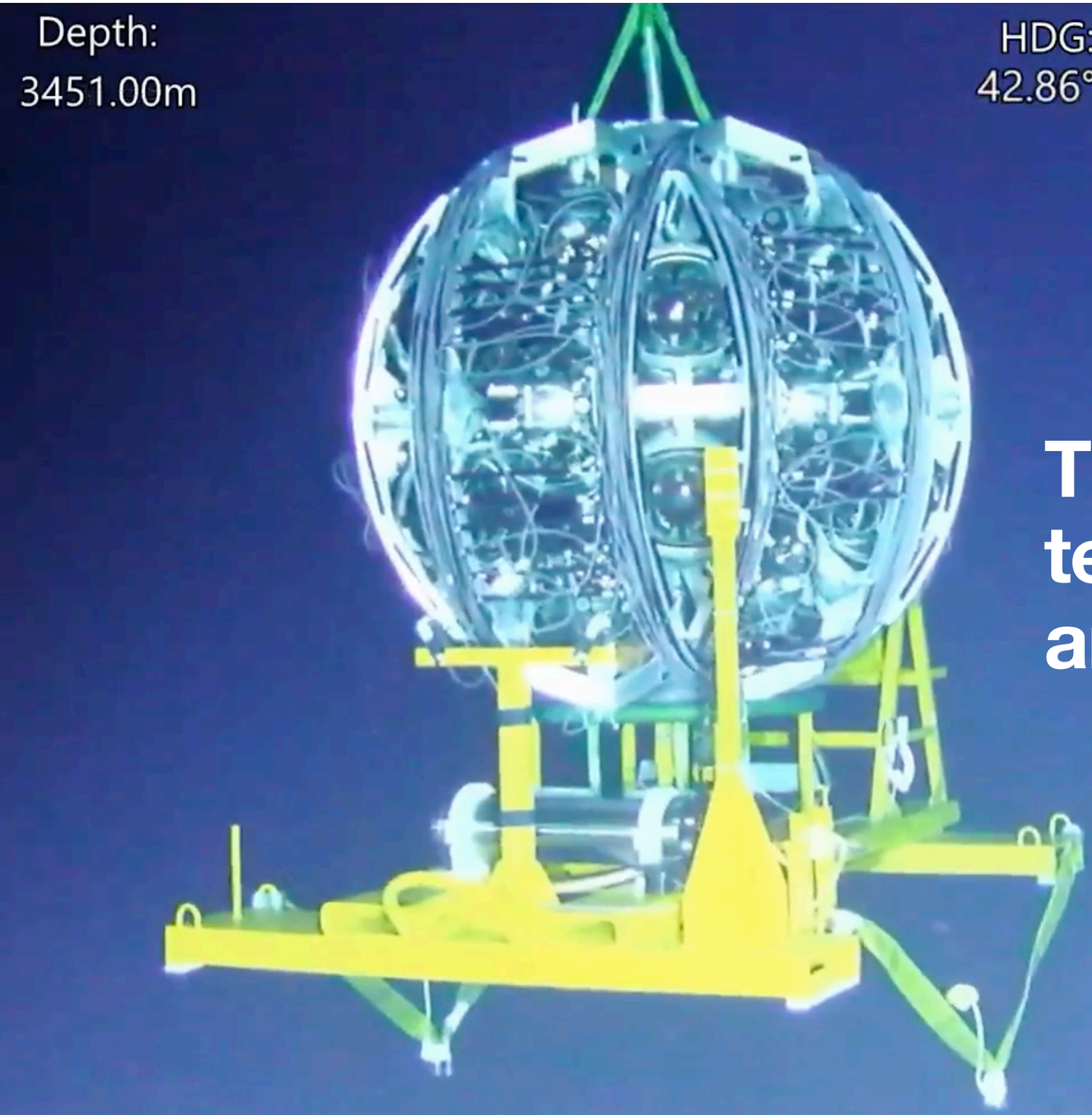
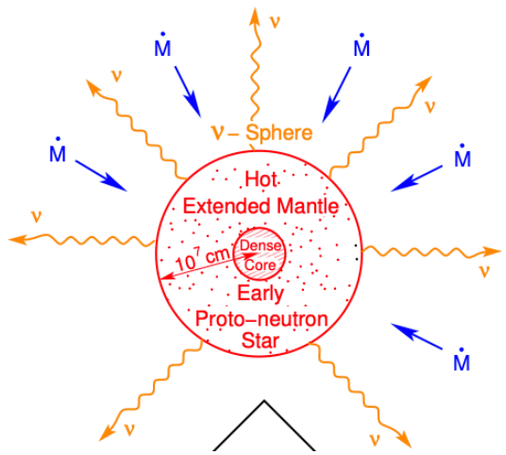
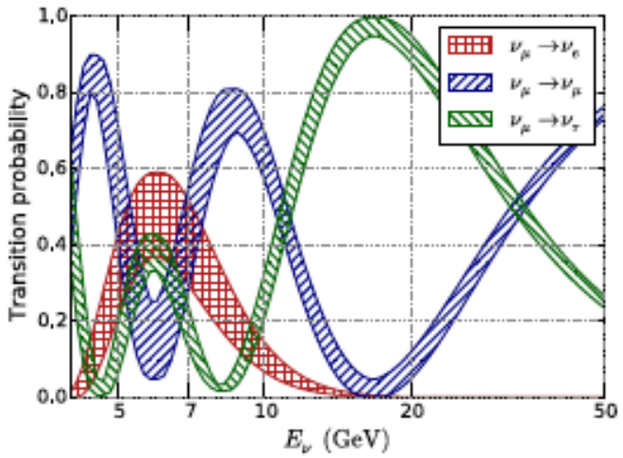


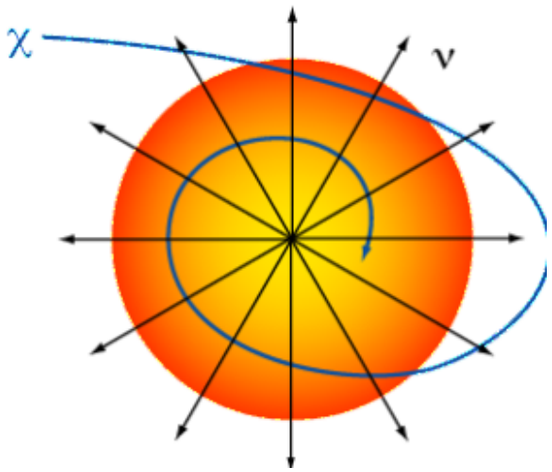
The KM3NeT neutrino telescopes: status and perspectives

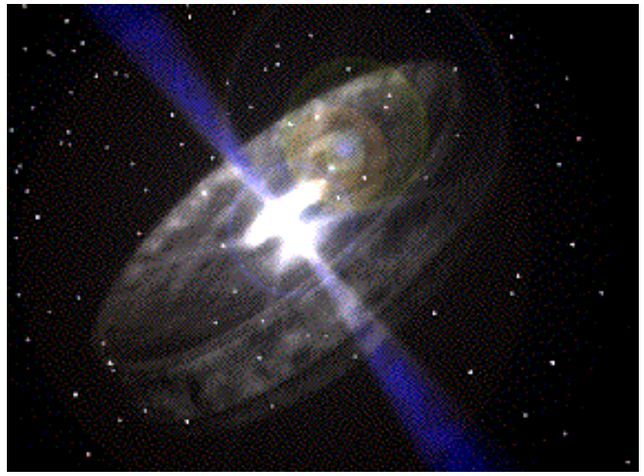
Simone Biagi
on behalf of the KM3NeT Collaboration

The physics case





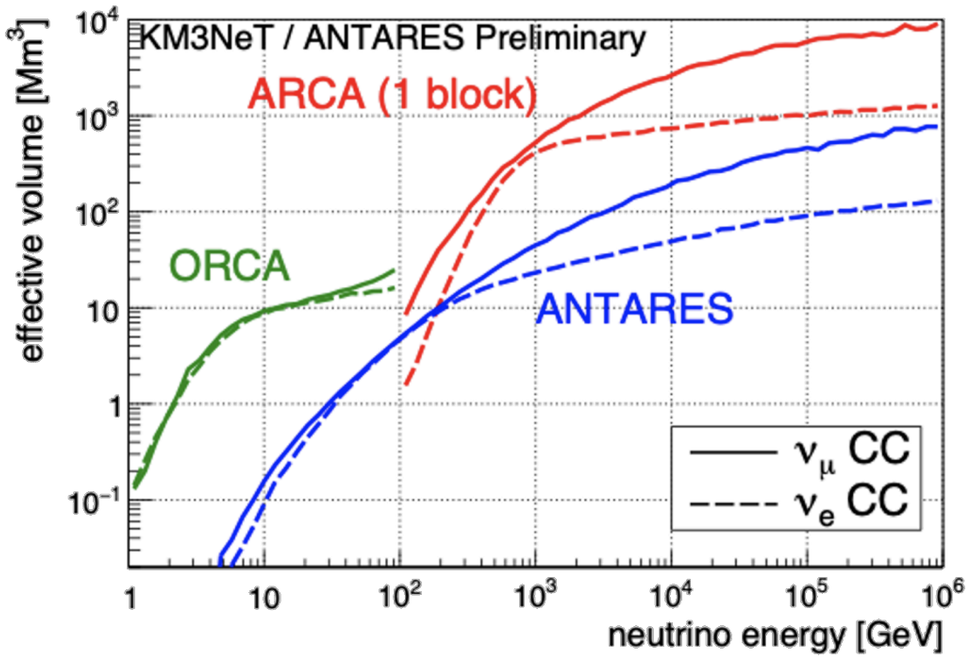




Super Novae explosion MeV	Neutrino oscillation GeV	Dark Matter (*) TeV	HE neutrinos Multi-messenger program PeV

ORCA

ARCA



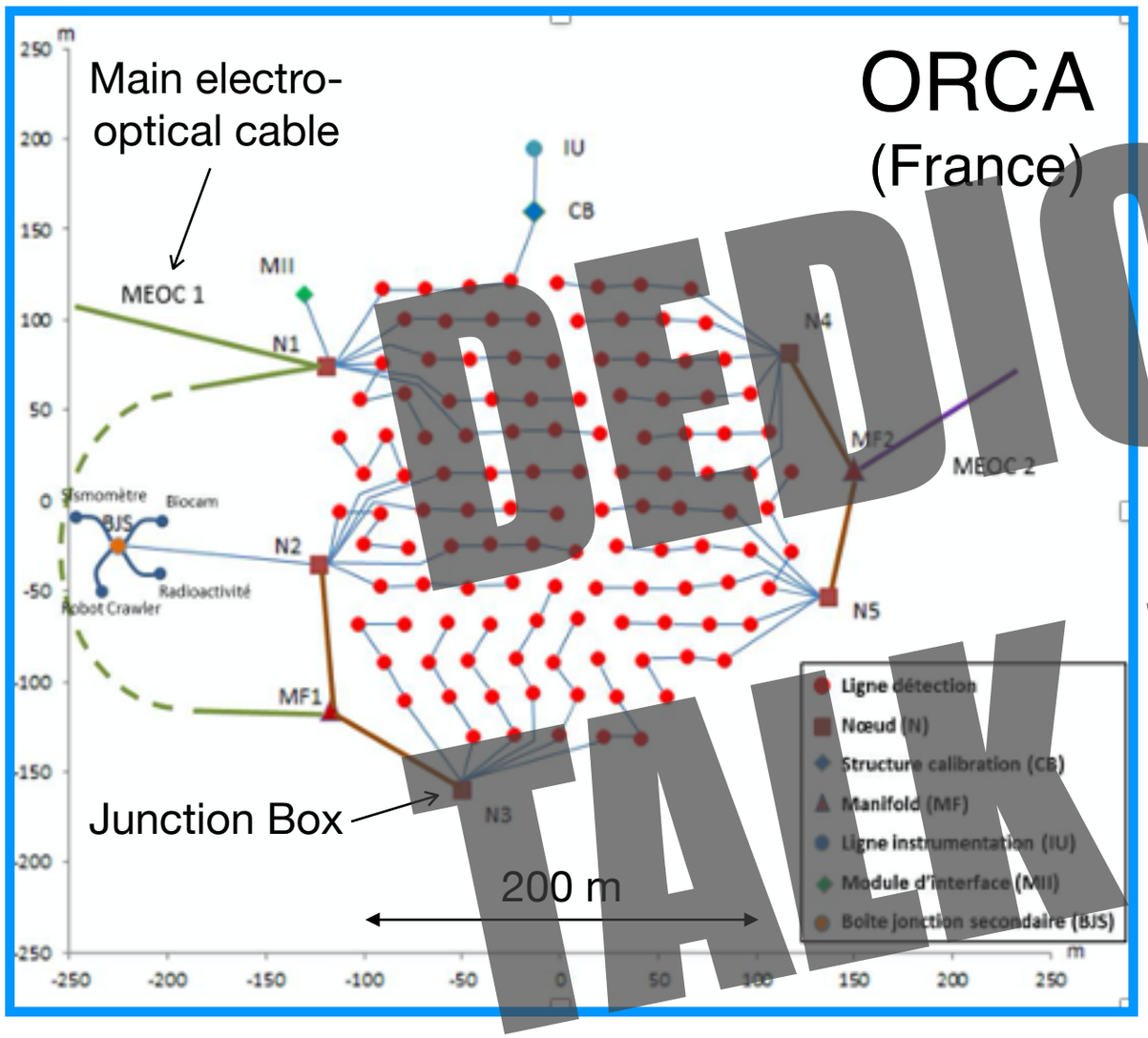
ARCA

➡ T03 - July 28th, h 10:50: D. Lopez-Coto, Indirect Dark Matter Searches with the ANTARES and KM3NeT Neutrino Telescopes

Neutrino Energy from **MeV** to **PeV**

The neutrino telescopes of KM3NeT

ORCA: Oscillation Research with Cosmics in the Abyss



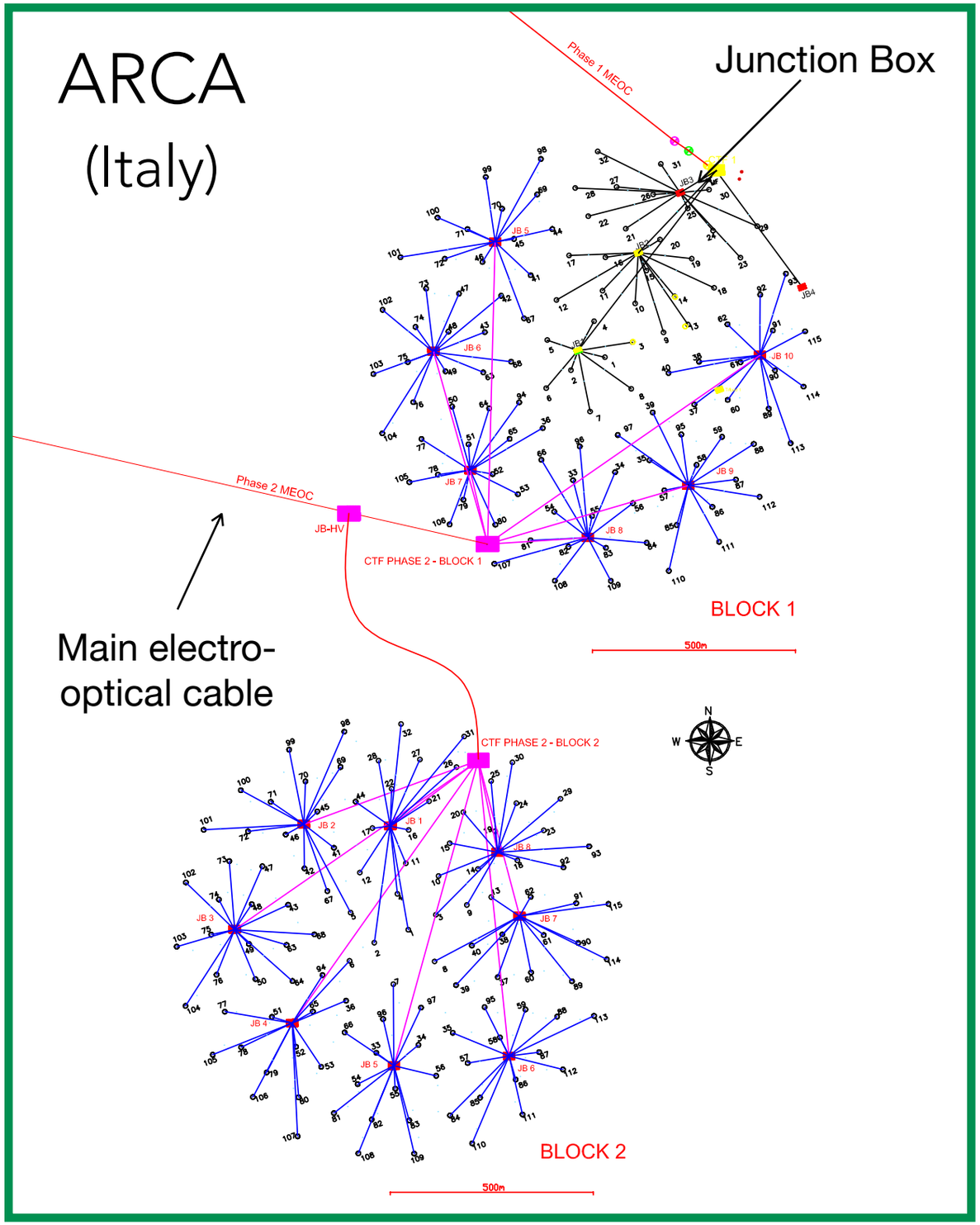
- 1 Building Block
- 115 Detection Units (DU), interspacing ~20 m
- 18 Digital Optical Modules (DOM) per DU, inter-DOM spacing 9 m
- Active volume ≈ 7 Mton
- 2500 m depth, close to Toulon
- Not discussed here!

➡ T04 - July 29th, h 09:50: R. Shanidze, KM3NeT/ORCA Overview

The neutrino telescopes of KM3NeT

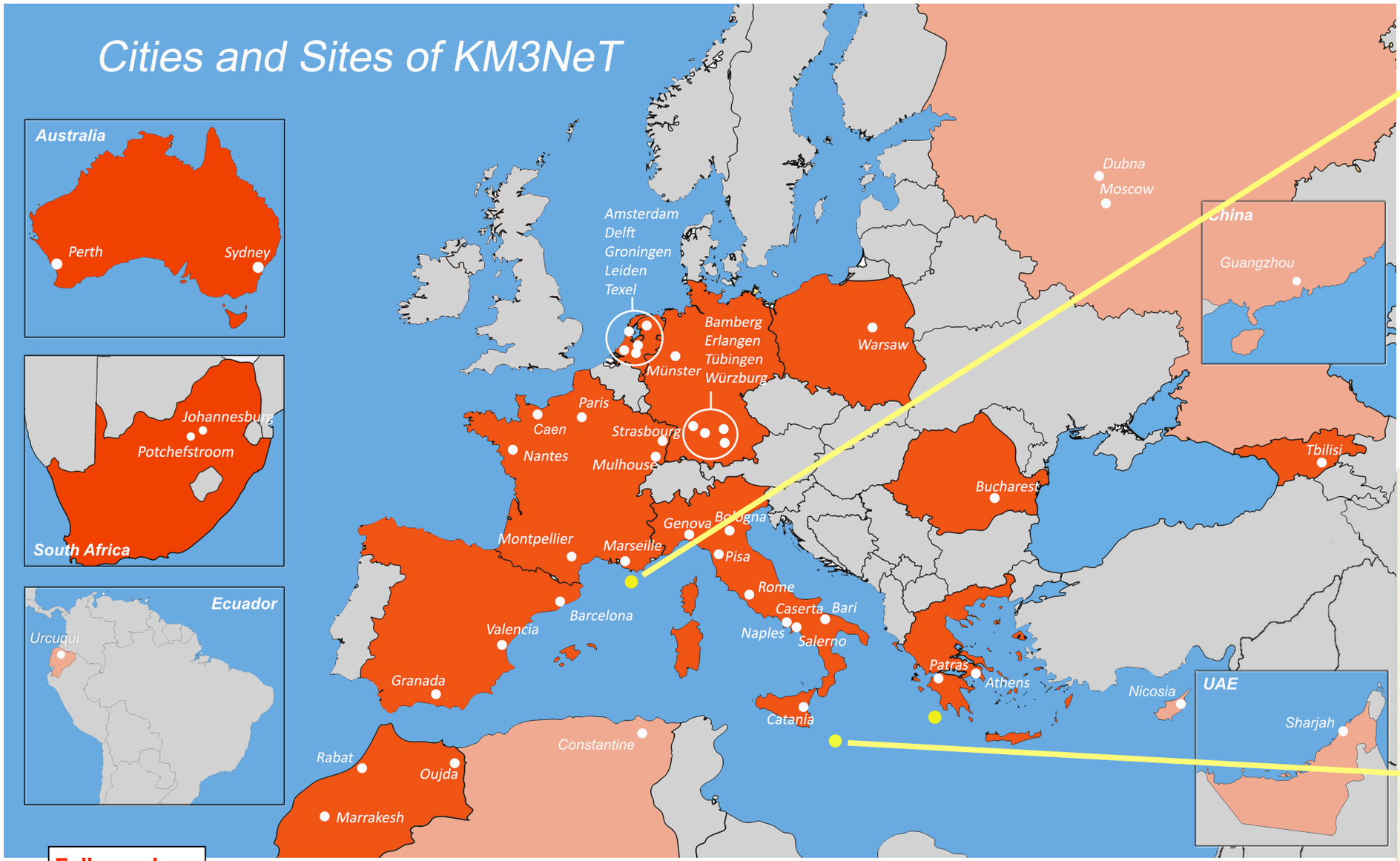
ARCA: Astroparticle Research with Cosmics in the Abyss

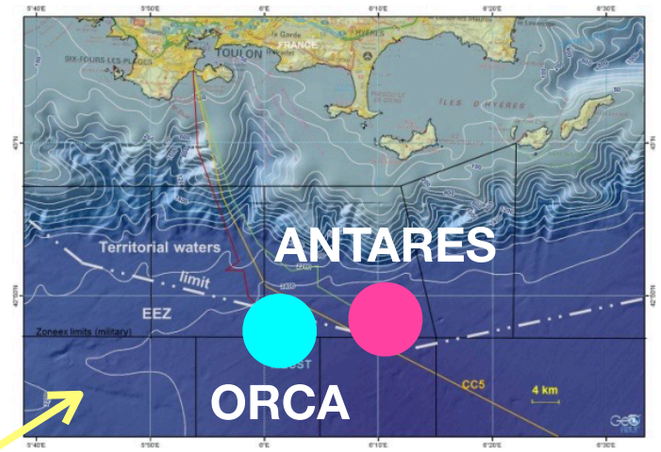
- 2 Building Blocks
- 115 Detection Units each, interspacing ~90 m
- 18 Digital Optical Modules (DOM) per DU, inter-DOM spacing 36 m
- Total active volume 1 km^3, ≈ 500 Mton/block
- 3500 m depth, SE the Sicilian coasts
- 2 Main Electro-Optical Cables (MEOC) for connection to shore of a network of 9+8 junction boxes and inter-link cables
- This talk focuses on ARCA!



The KM3NeT collaboration

56 institutes in 17 countries





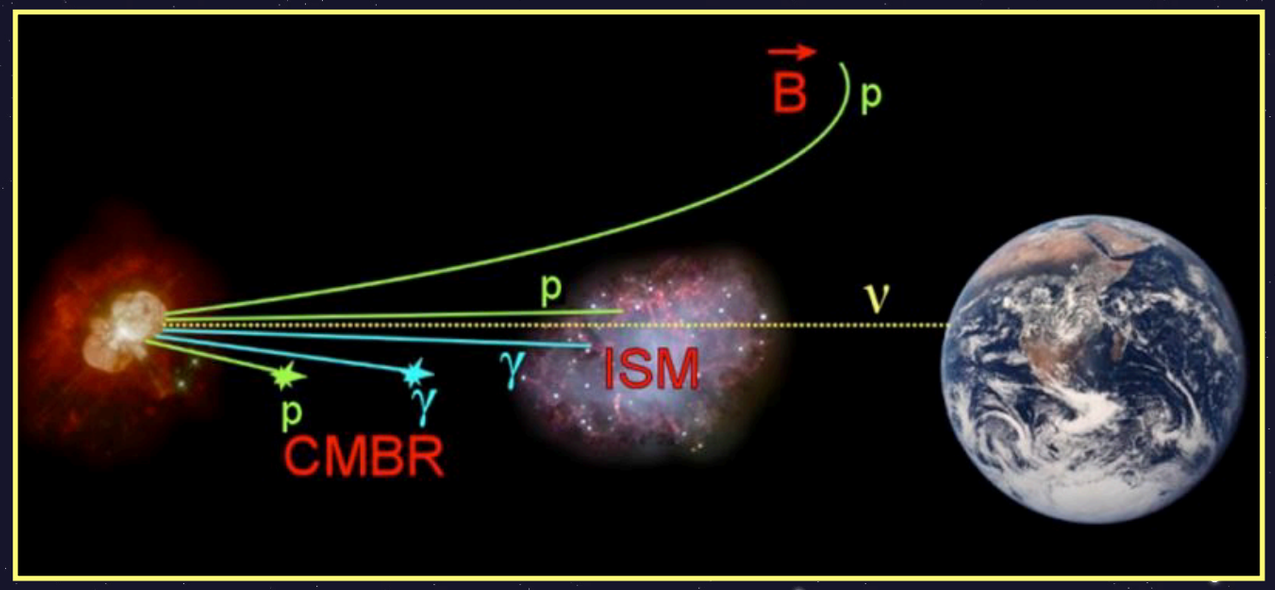
ANTARES in operation since 2008

First-generation neutrino telescope

Instrumented volume ~10 Mton

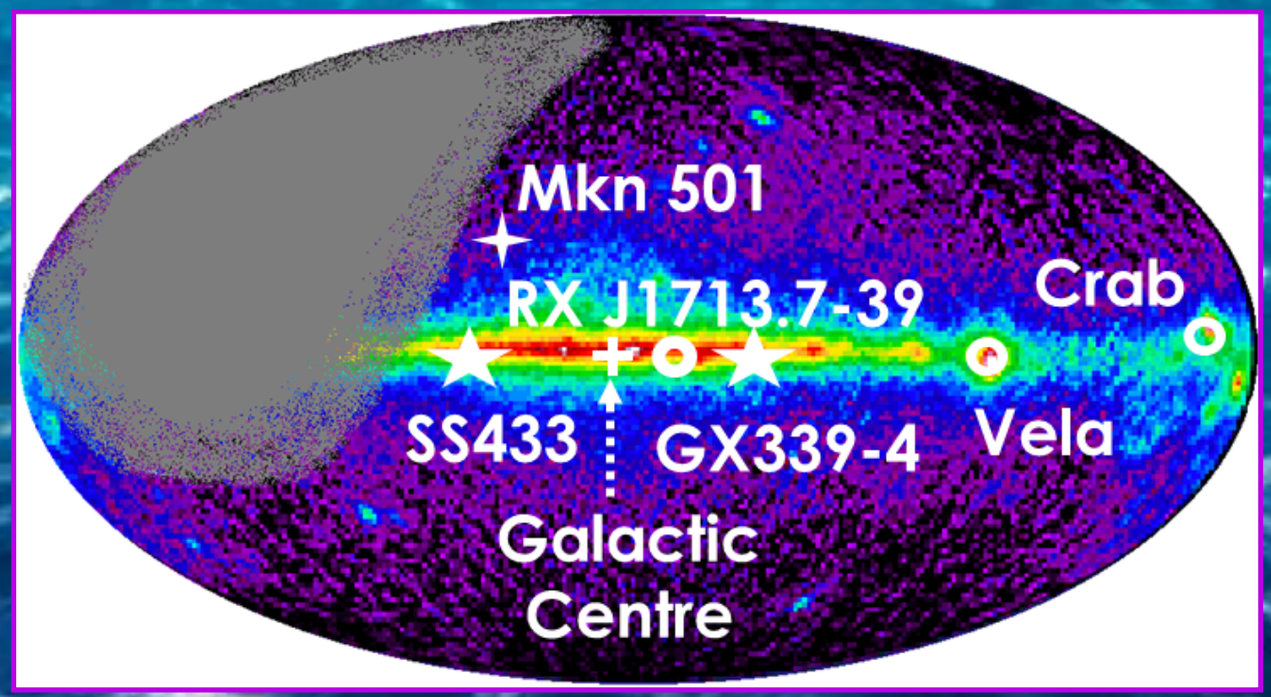
➡ T01 - July 27th, h 11:15: A. Margiotta, The ANTARES Neutrino Telescope

Neutrino Astrophysics in the Mediterranean Sea



- Origin of Cosmic Rays
- Neutral messengers point back to their sources
  - Neutrons are short-lived, photons are likely to interact ⇒ Neutrinos as cosmic probe
- Neutrinos are produced at sources via hadronic interactions
  - Cosmic diffuse flux
  - Point-like sources
  - Multi-messenger approach

- Detection principle: large volume of transparent medium instrumented with PMTs
- Located in the Northern Hemisphere
  - Complementary to IceCube
  - Southern sky sources, “Milky-Way optimised”
- Medium: Deep Sea Water
  - Very small light scattering = good angular resolution
  - Natural background (^{40}K and bioluminescence) taken into account.

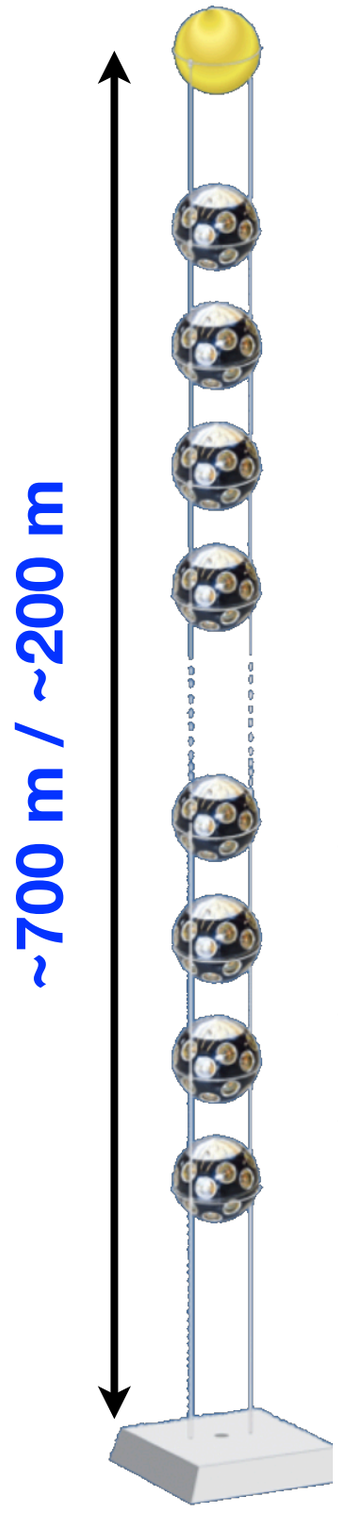


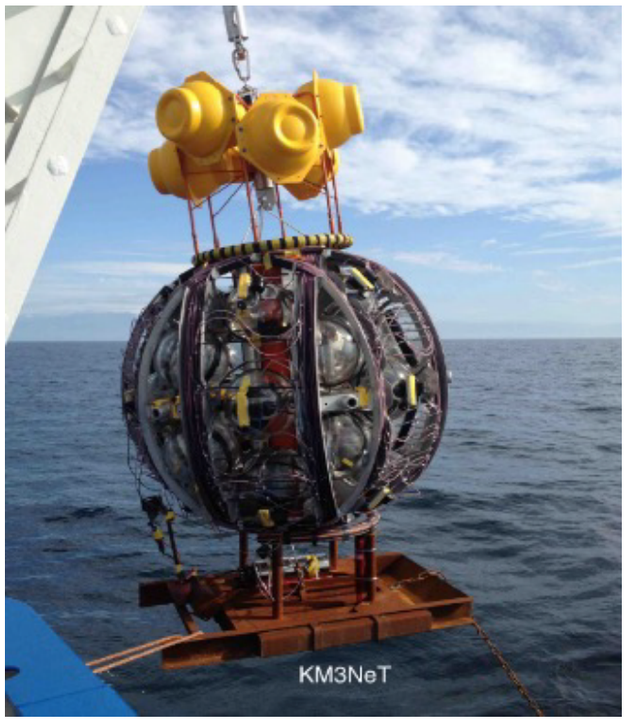
KM3NeT Technology in a nutshell

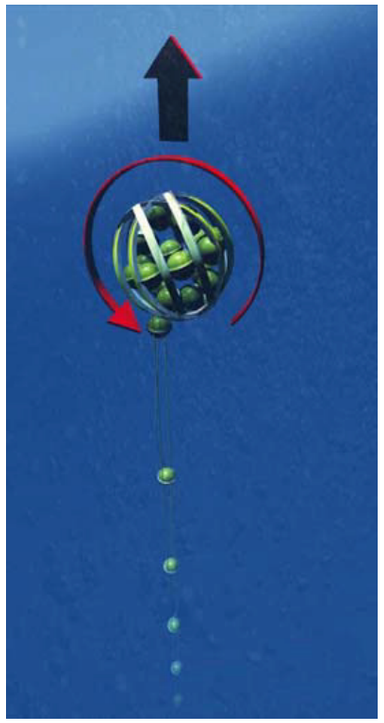
Digital Optical Module

- DOM: 31 x 3” PMTs
- Digital photon counting
- Directional information
- Wide acceptance angle
- All data to shore
- Gbit/s on optical fiber
- Custom White Rabbit
- 18 DOMs / String

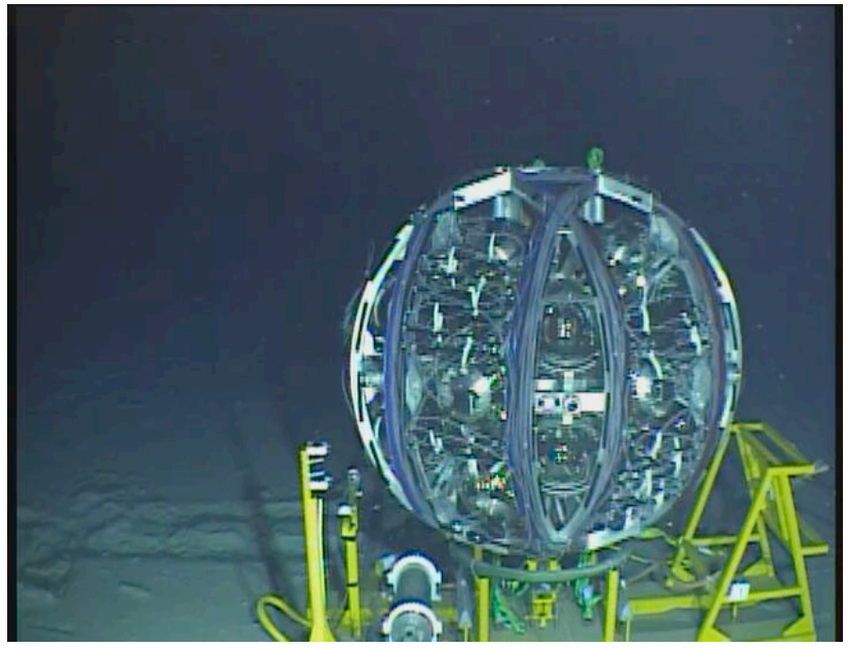
Detection Unit (string)



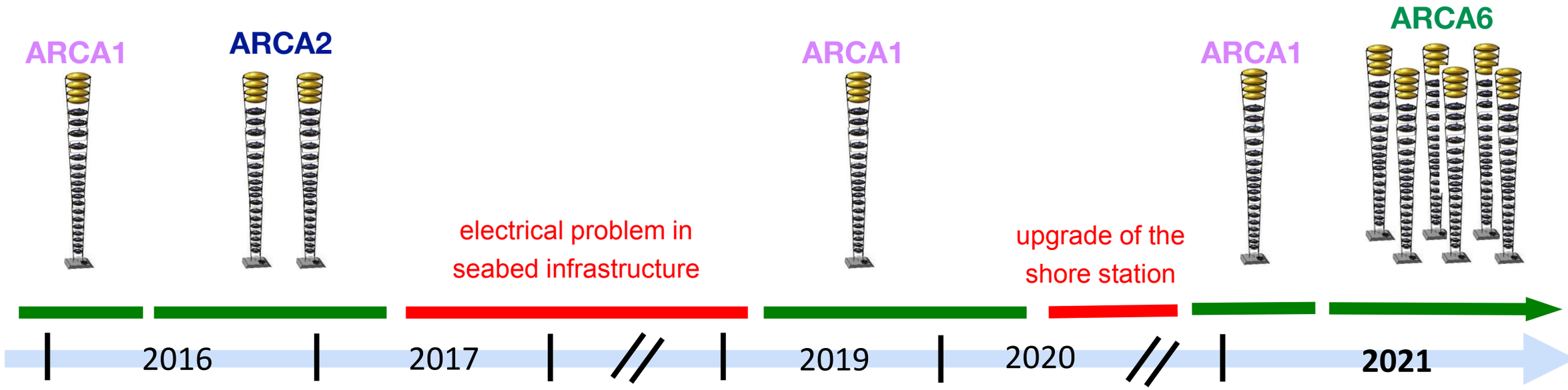


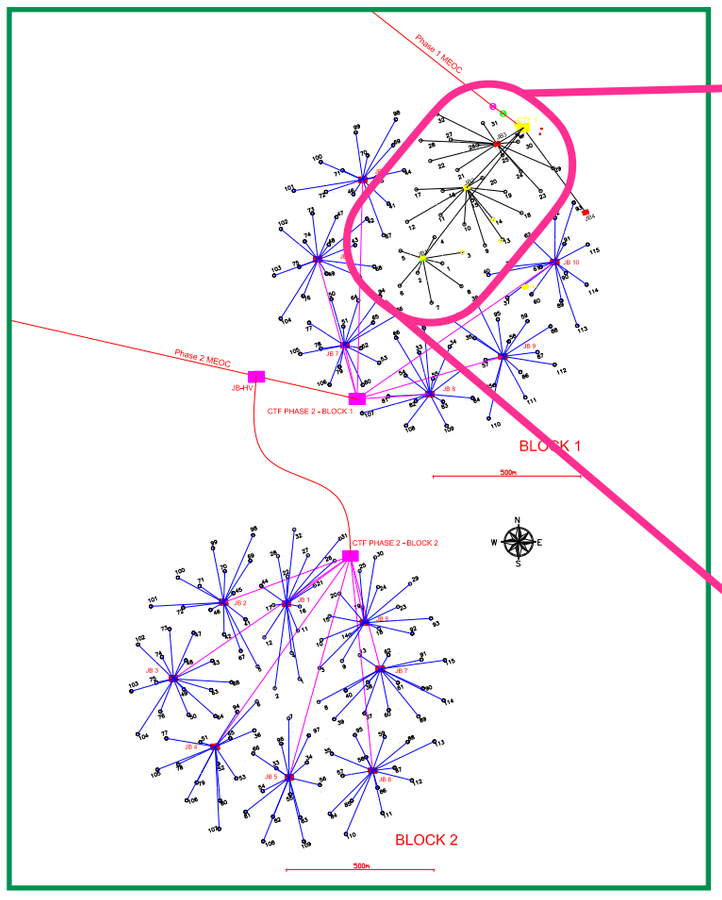


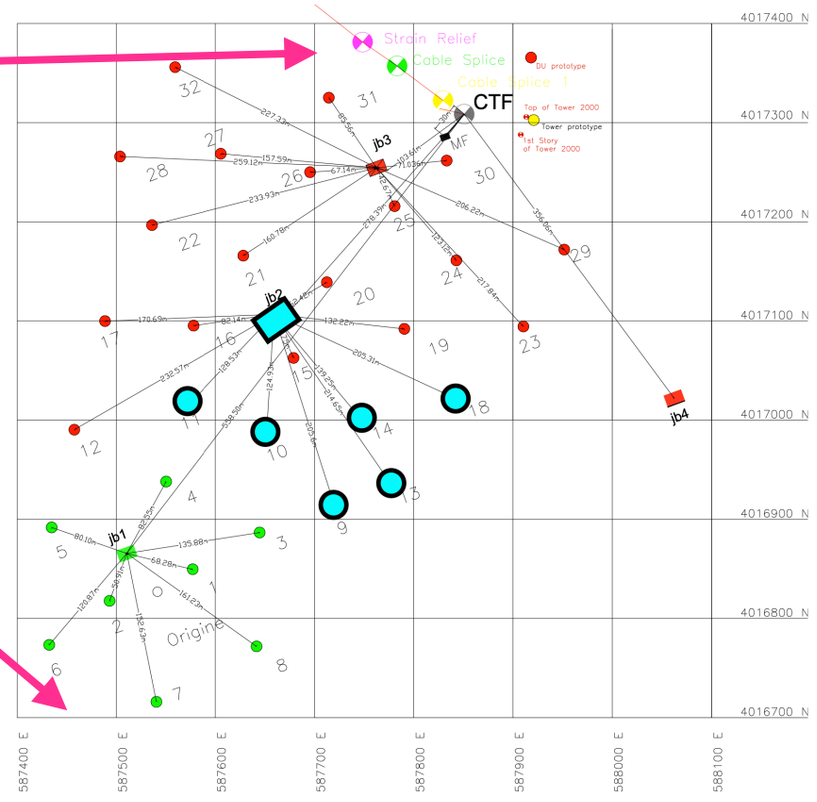
- Unfurling by autonomous ROV
- Rapid deployment
- Multiple strings in one sea campaign

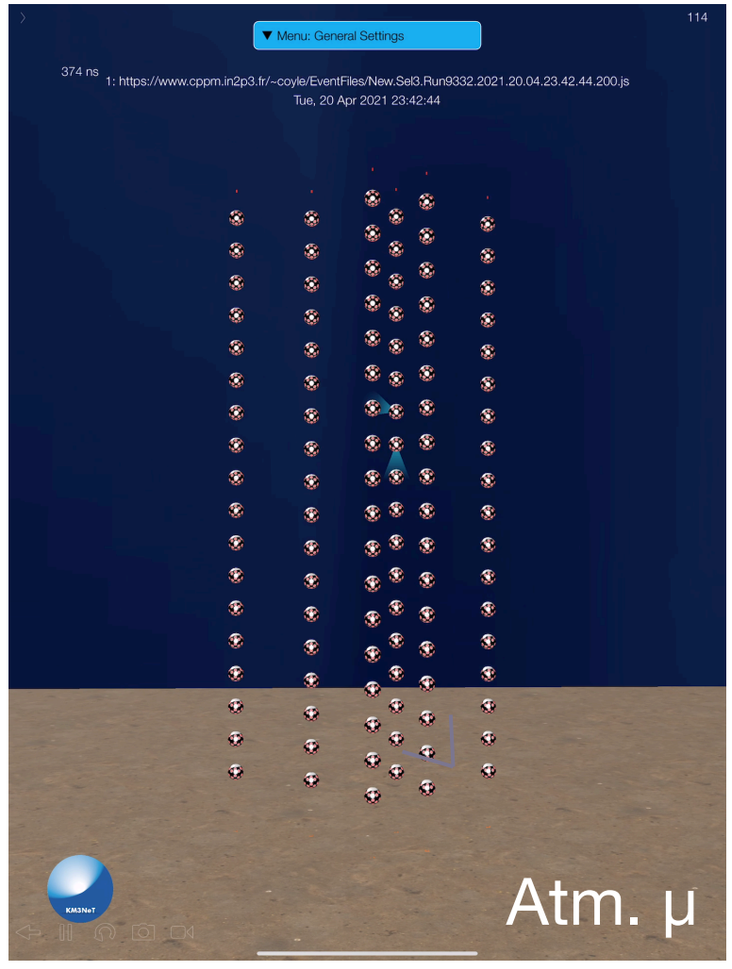


ARCA: Construction Phase



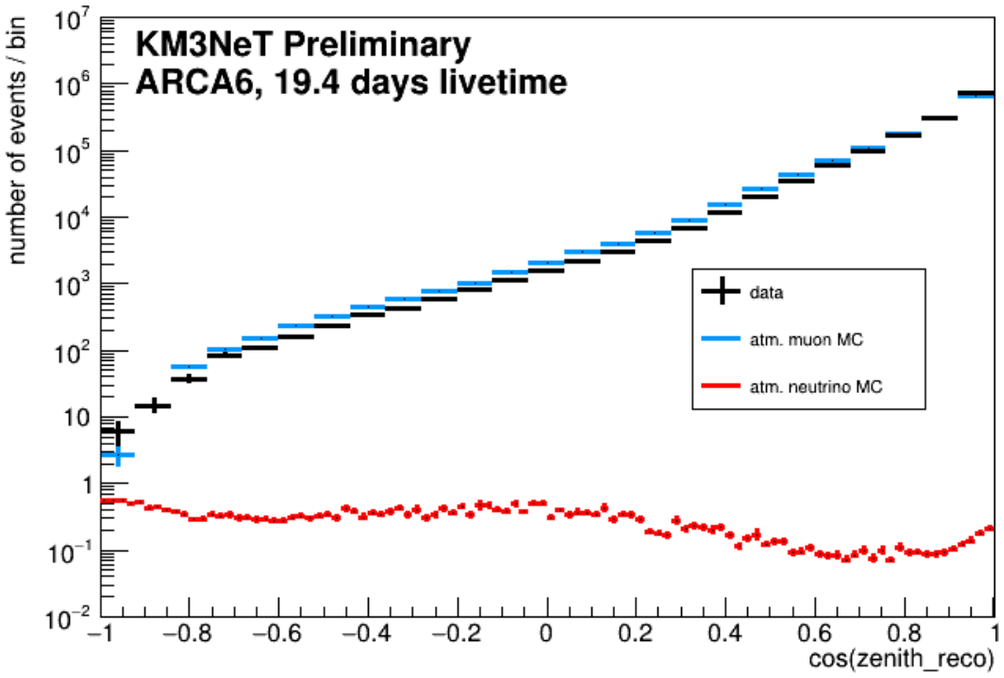






Phase-1 completion = 32 Detection Units

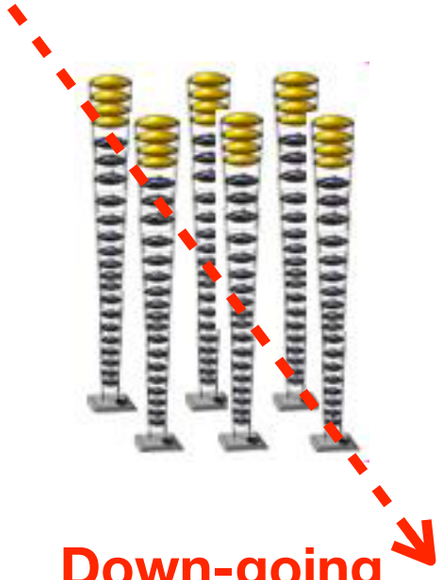
Selection of atmospheric neutrinos



- Selection criteria applied to remove atmospheric muon background
- 15 events observed as up-going
- MC: 4 events from atmospheric ν
- MC: 7 events form atmospheric μ

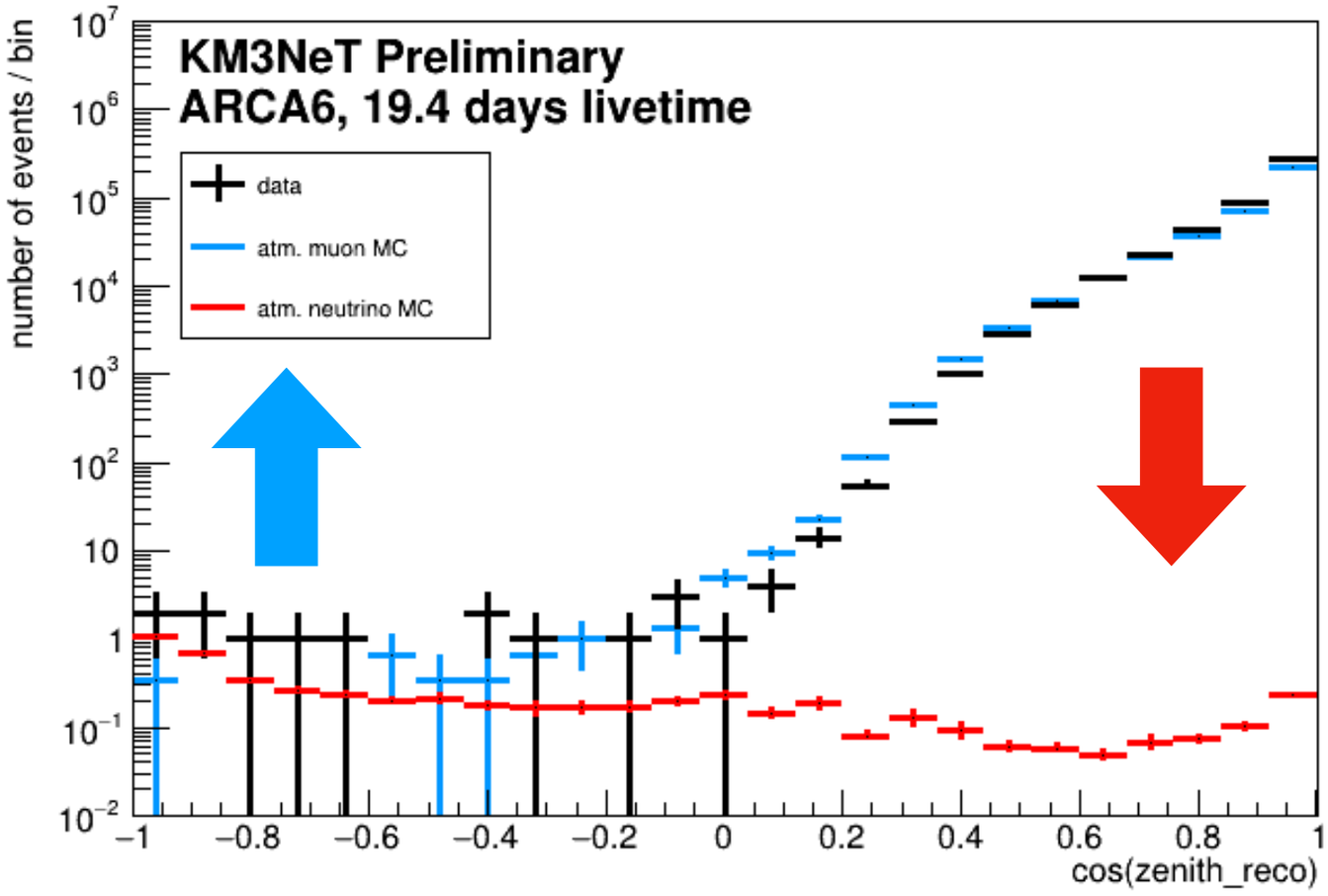
Up-going

(only ν can travel through the Earth)



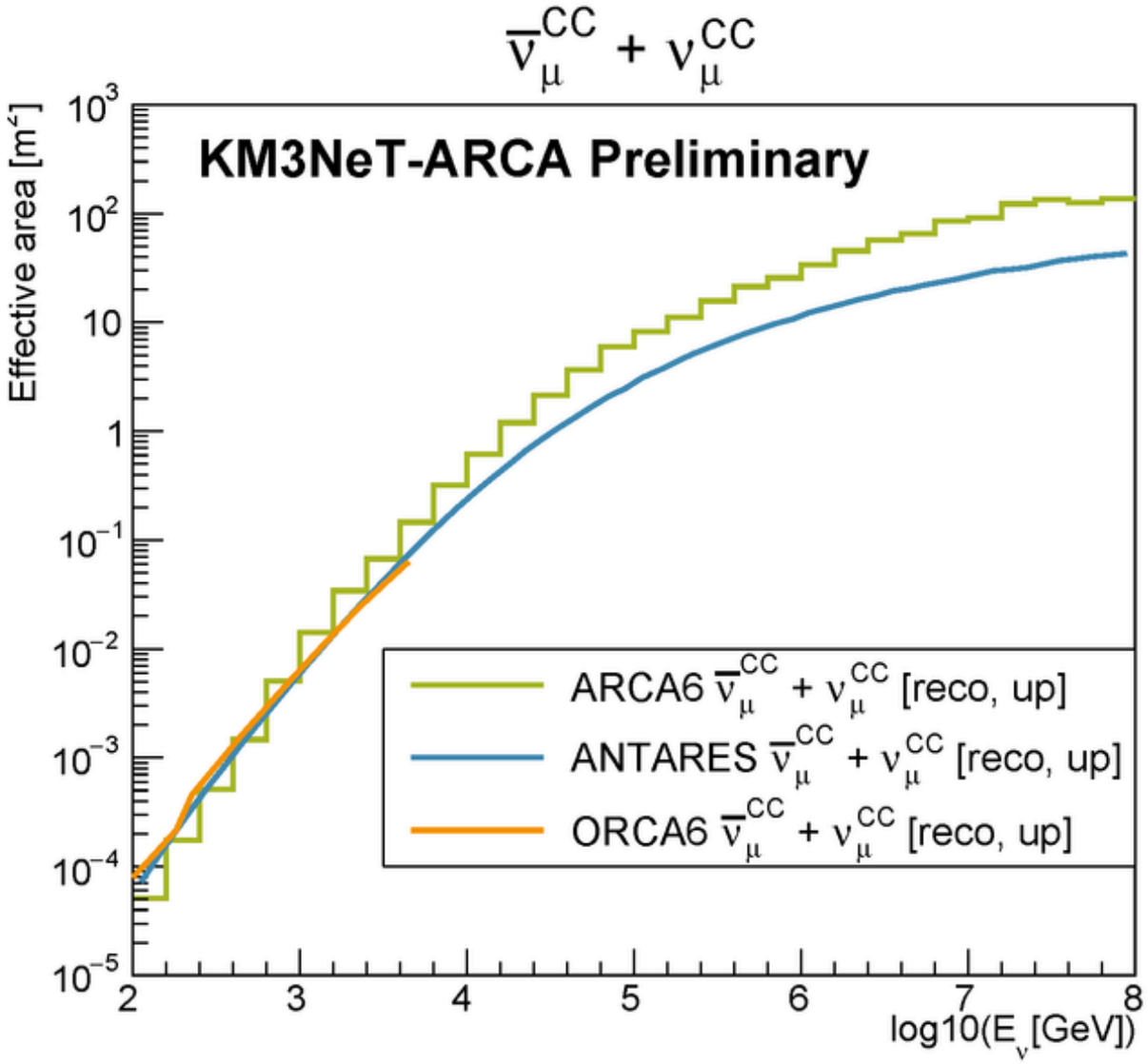
Down-going

(dominated by atmospheric μ)



KM3NeT Effective Areas

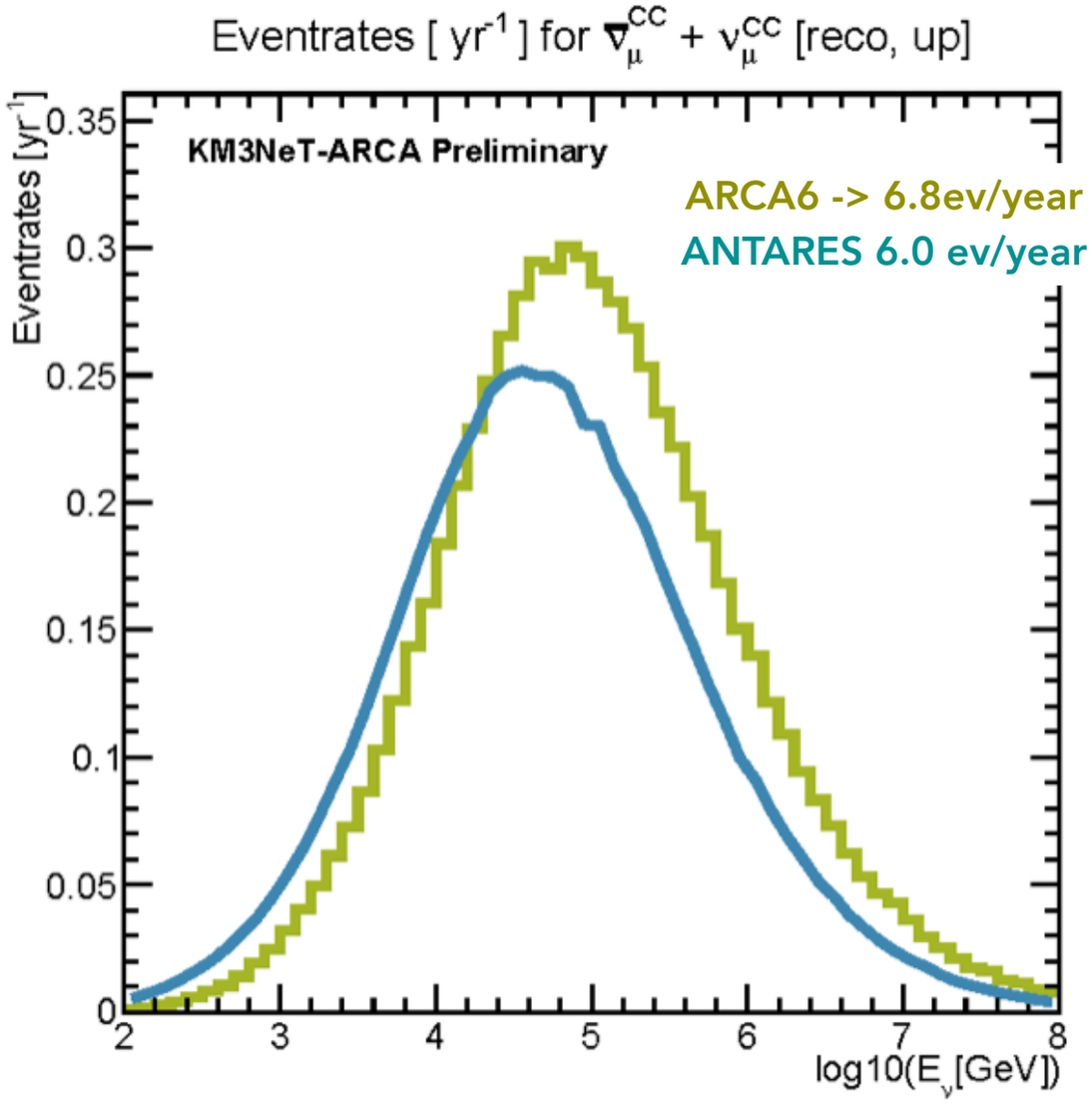
ARCA6 + ORCA6 compared to ANTARES



Effective areas ≳ of ANTARES

Number of events per year for a cosmic diffuse flux

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



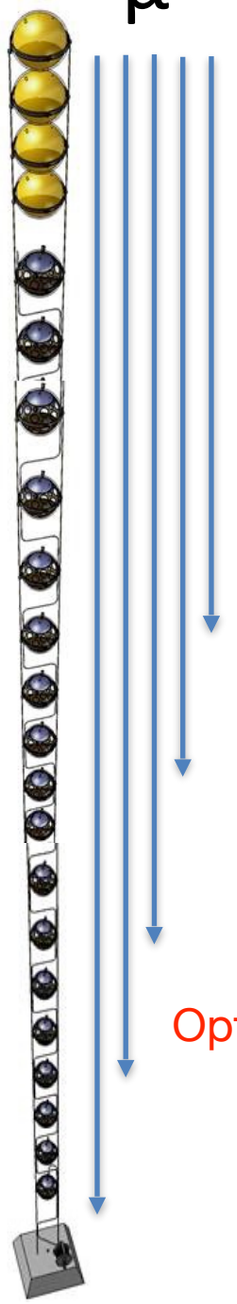
Selection —> up going tracks

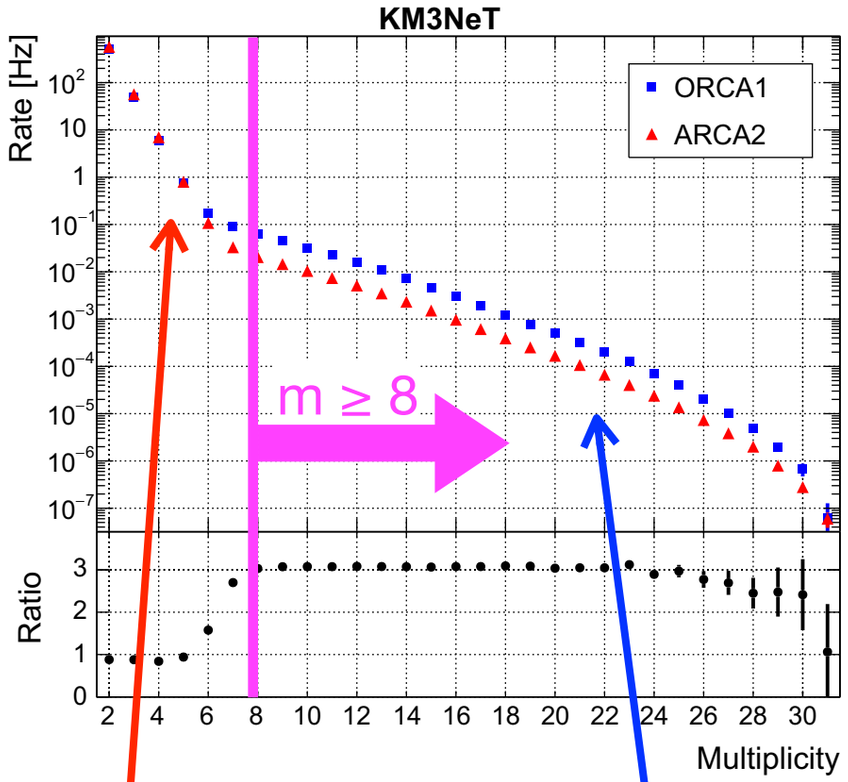
Atmospheric muon flux

Eur. Phys. J. C 80 (2020) 99

ARCA2 + ORCA1

μ

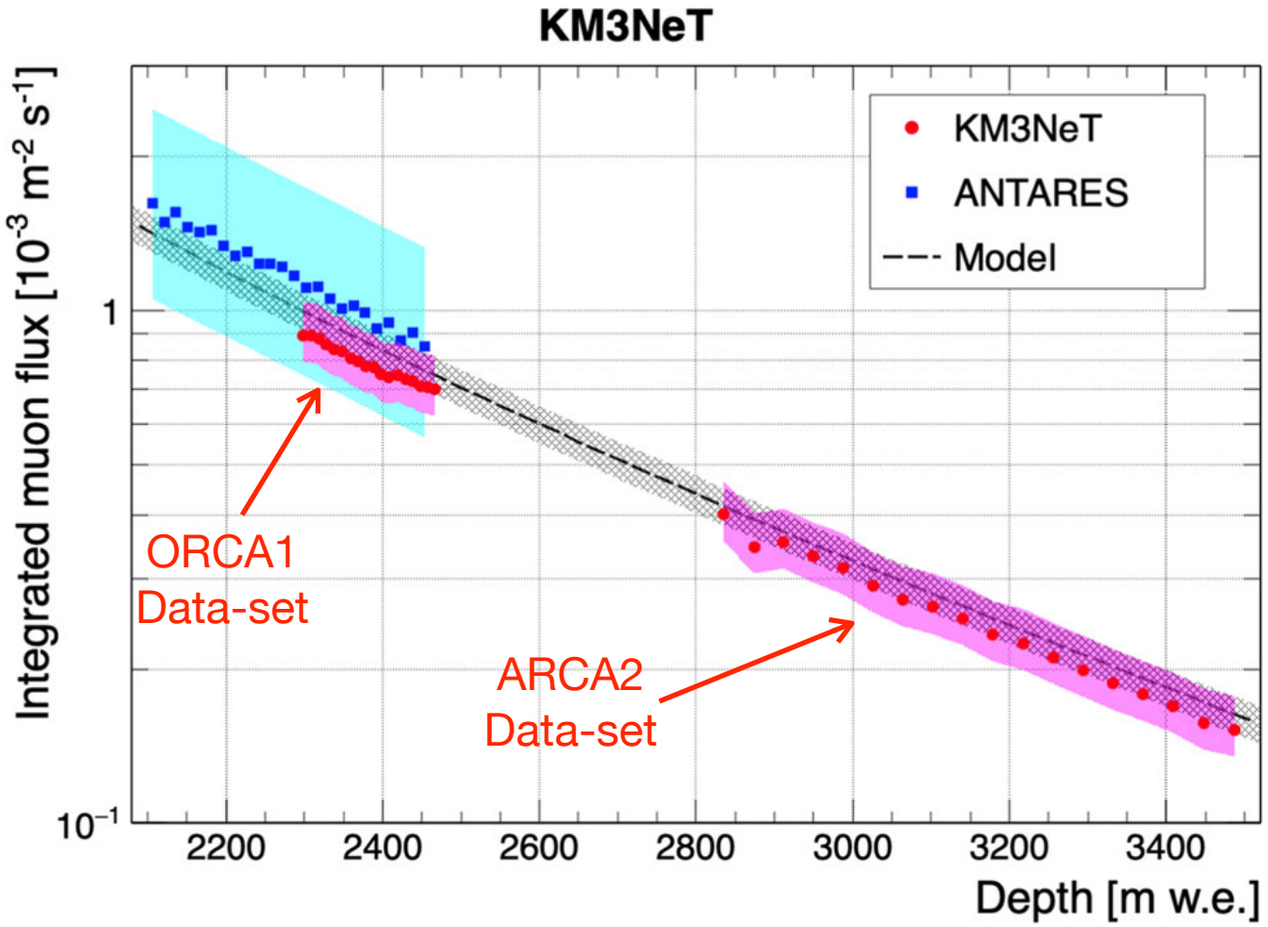




Optical background
(^{40}K decay)

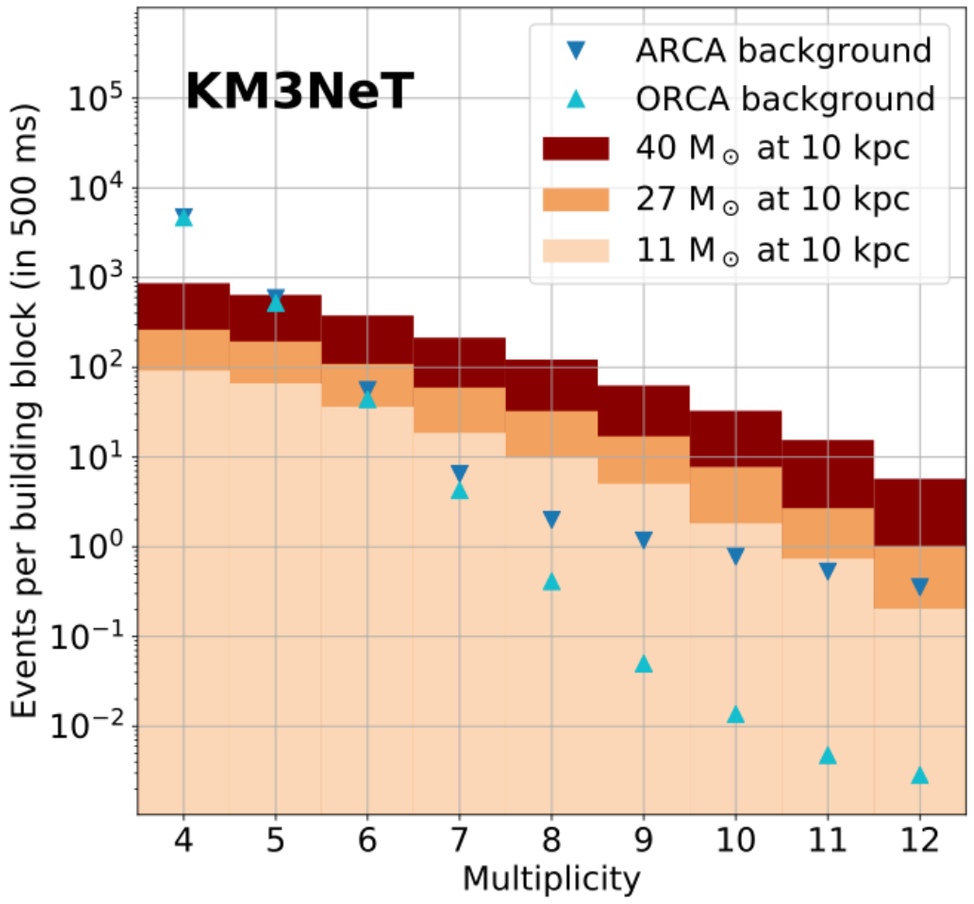
Atmospheric muons

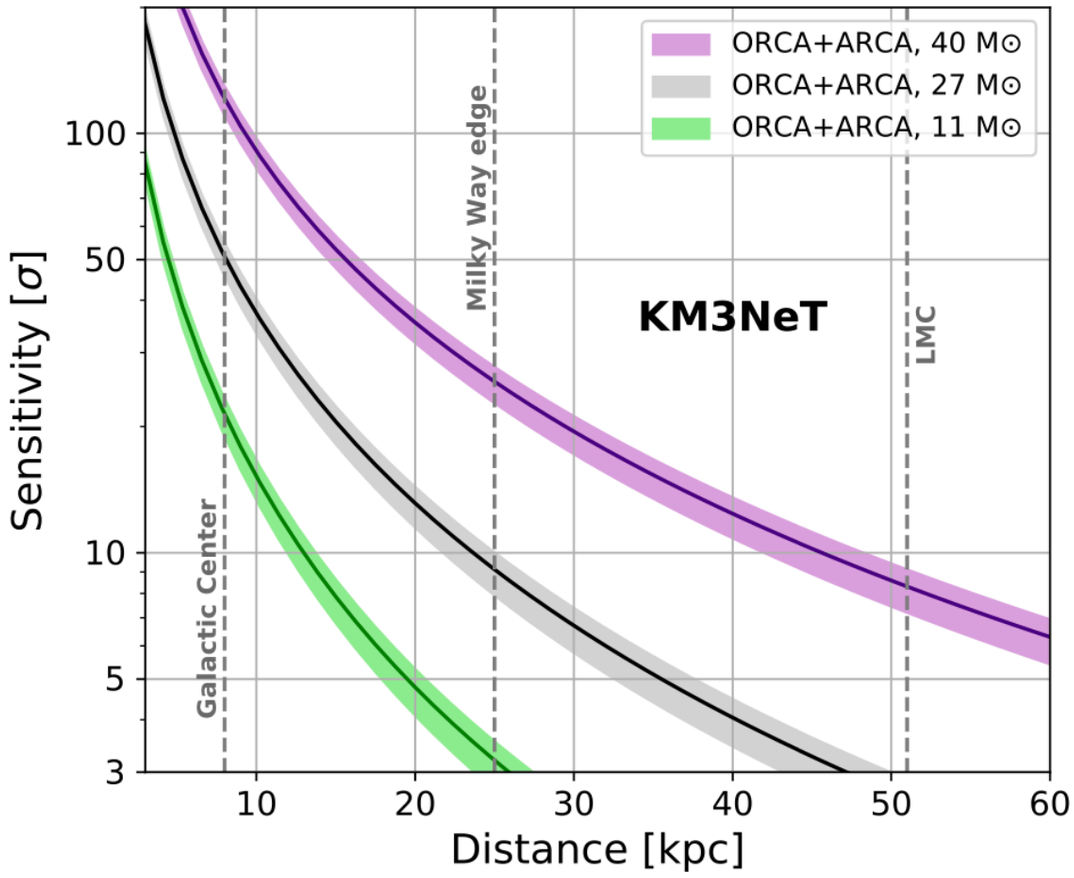
- Single-DOM measurement
- Useful to validate the calibration process
- Results compared with ANTARES and Bugaev model



Core Collapse Supernovae

Eur. Phys. J. C81 (2021) 445





ORCA 1 BB + ARCA 1BB

> 5σ for ARCA+ORCA for 27M⊙
at a distance < 25 kpc

ARCA6+ORCA6 already sensitive to 60% of Galactic CCSNe (<11 kpc)
Joint real time trigger operational for SNEWS since early 2019

ARCA Reconstruction Performances

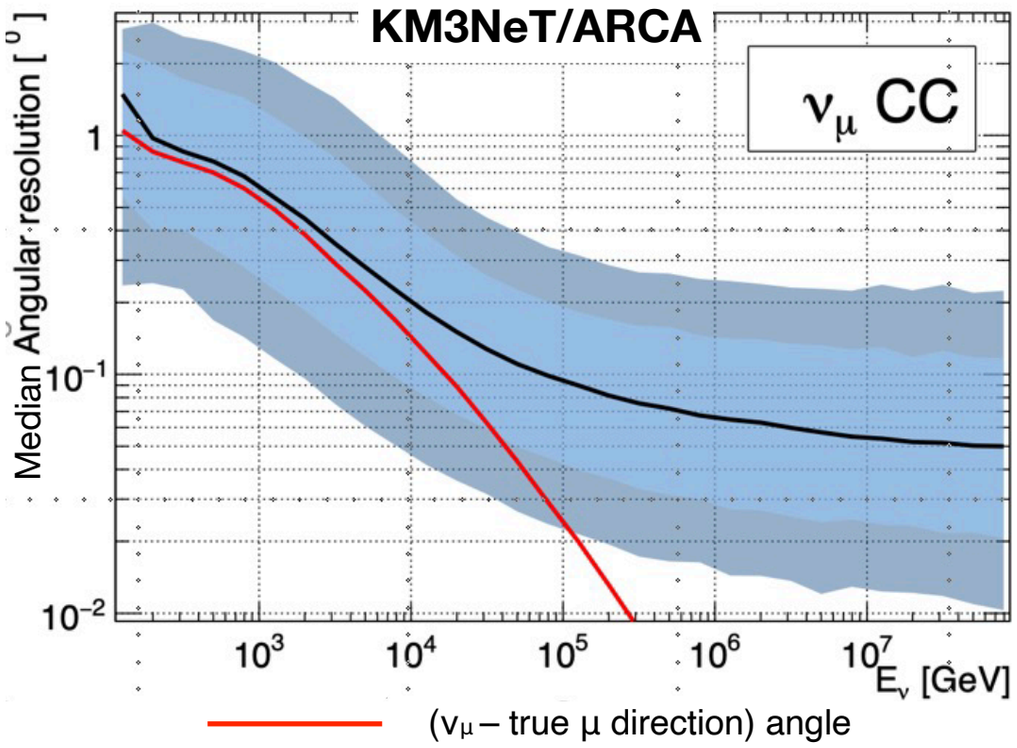
Track-like and shower-like events

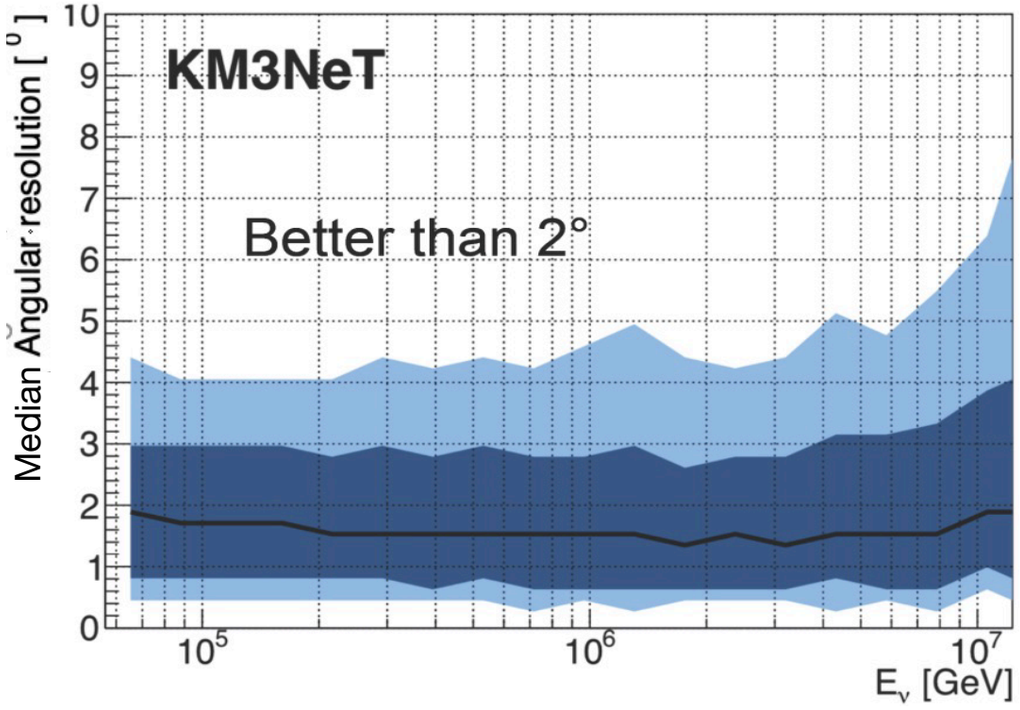
Tracks (ν_μ CC) **ideal tool for astronomy**

- **Ang. Resol. < 0.2°** above 10 TeV
- **Energy Resol. ~ 0.27** in $\log_{10}(E_{reco}/E_\mu)$ (10 TeV < E_μ < 10 PeV)

Shower (ν_x NC + ν_e CC) **contained events**

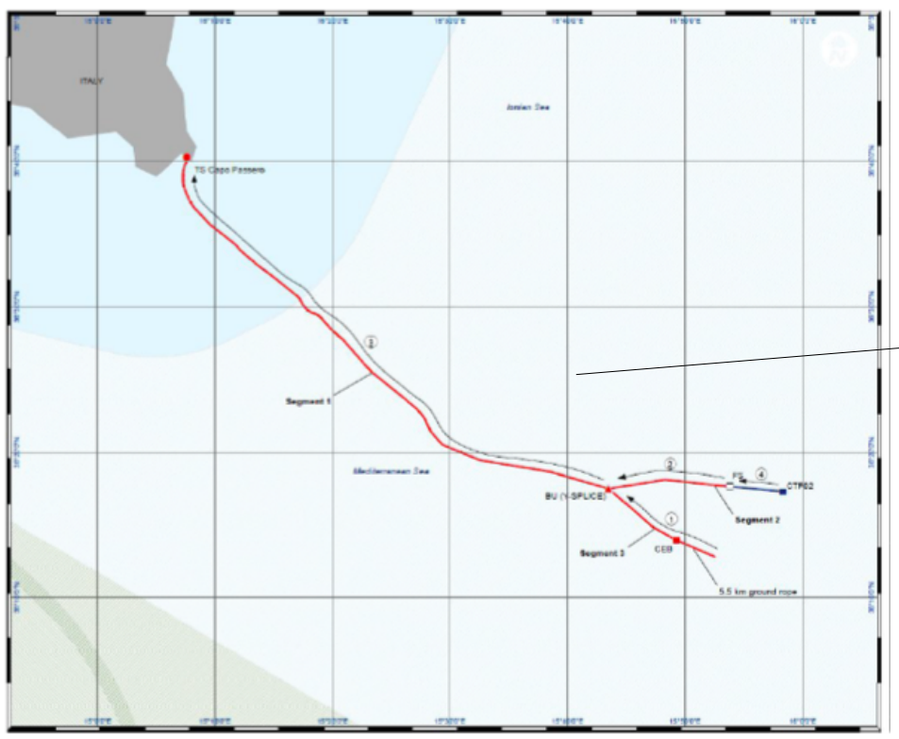
- **Ang. Resol. < 2°** above 50 TeV
- **Energy Resol. < 5%**

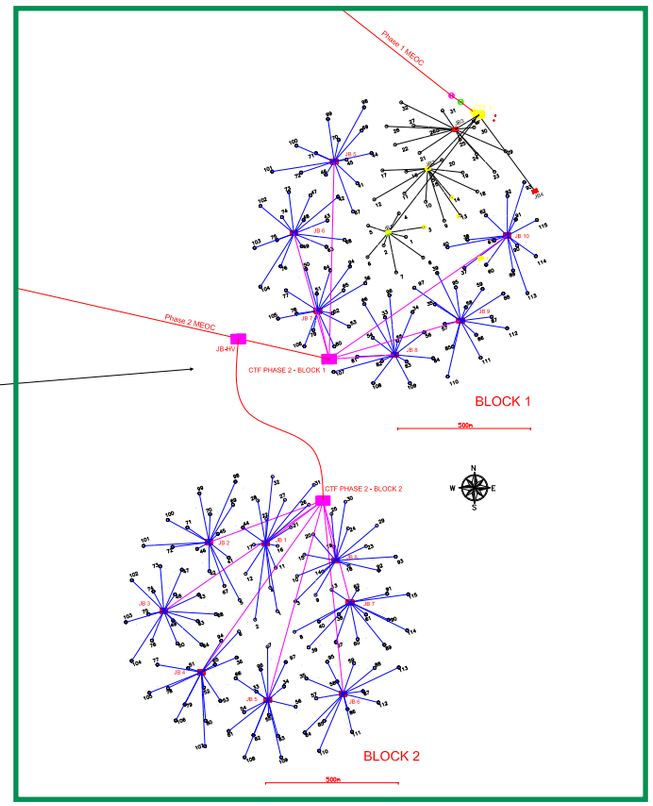




ARCA Status

Nov 2020: Successful laying of the second MEOC

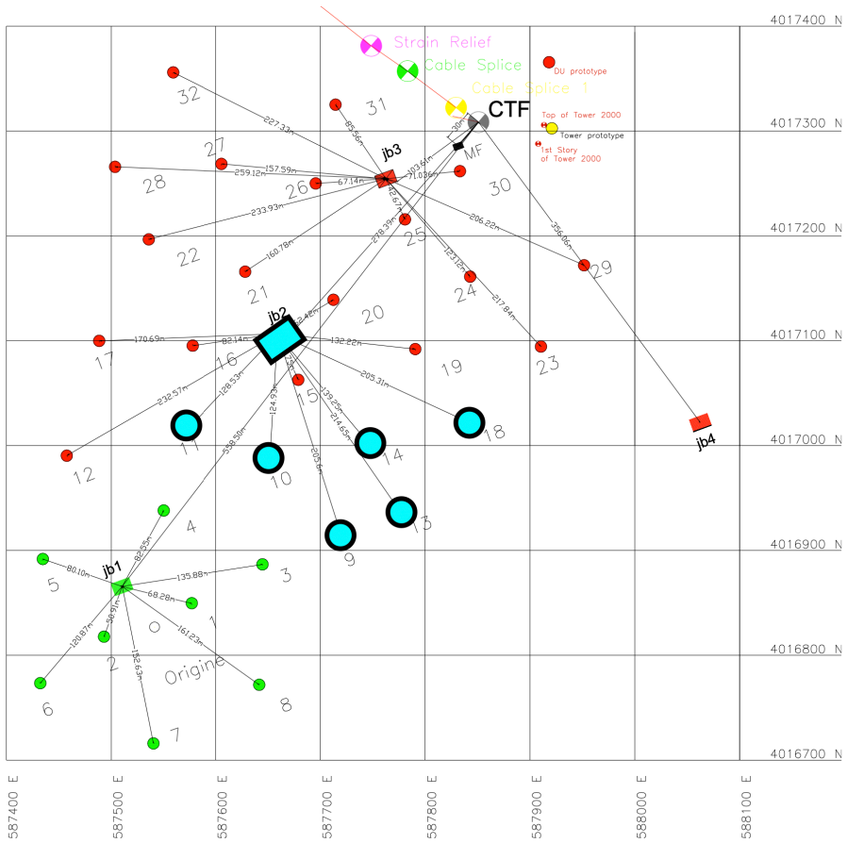




With two main cables
it is possible to connect
the full ARCA detector
(2 building blocks)

Next steps

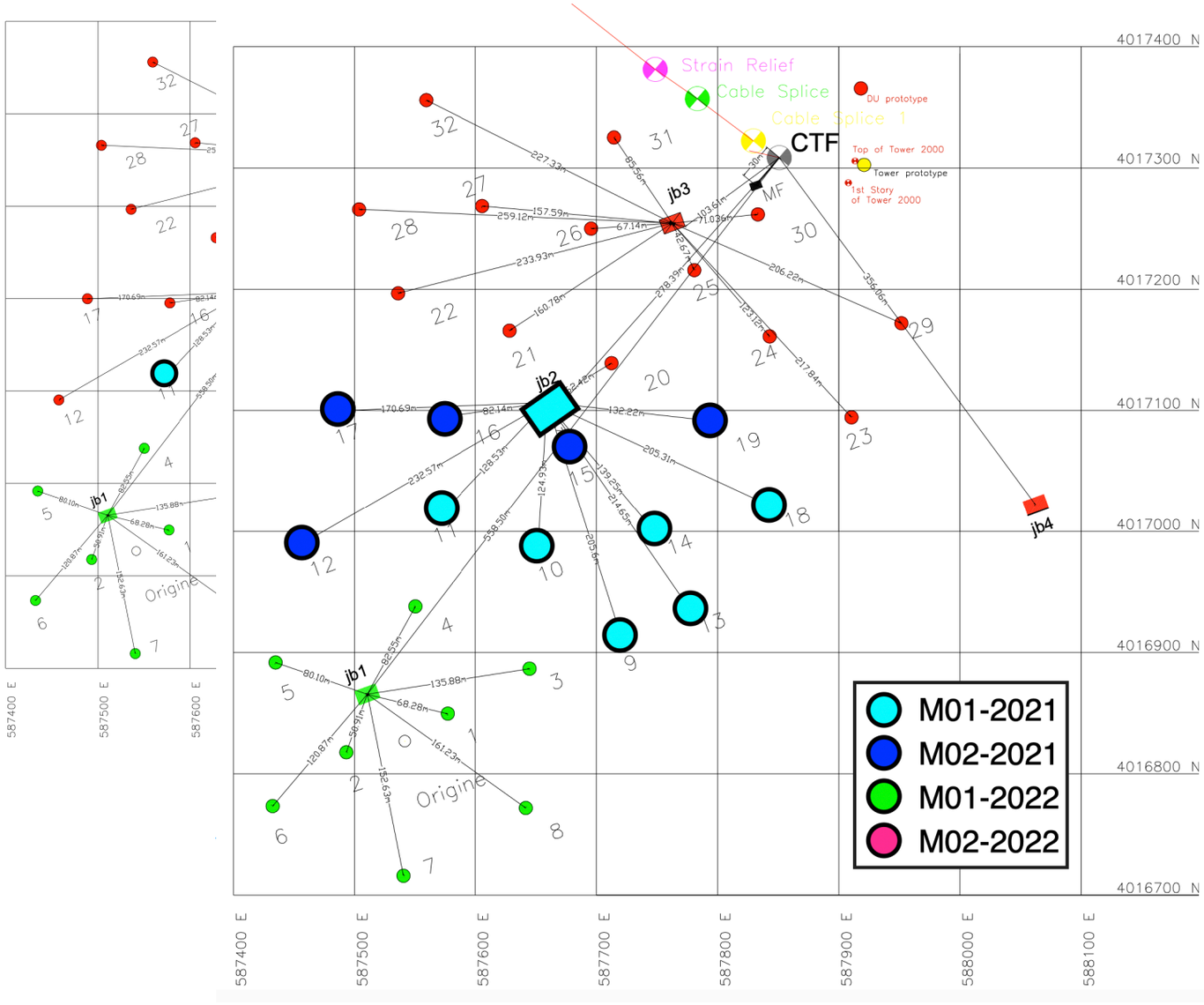
Planned ARCA sea campaigns



April 2021

Next steps

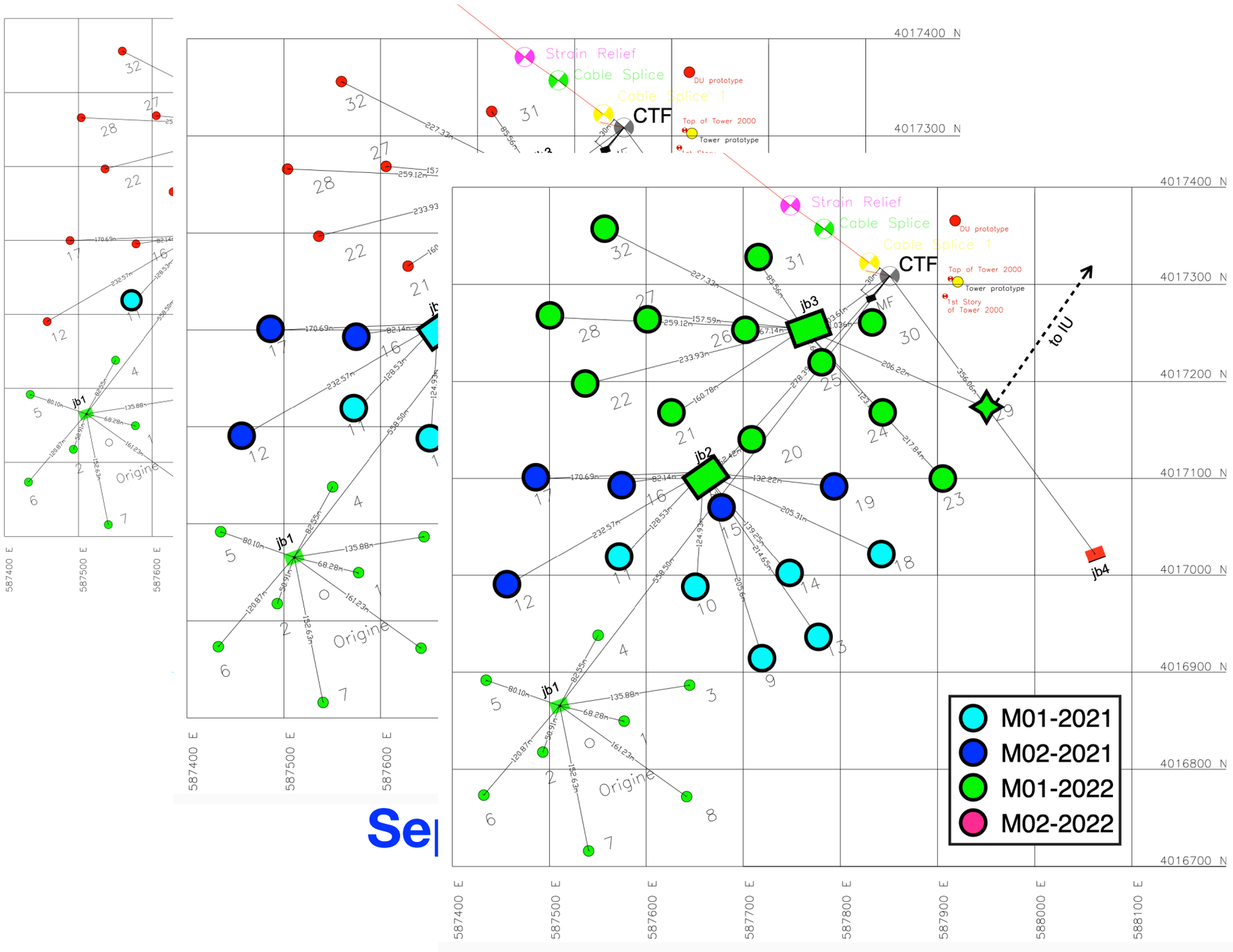
Planned ARCA sea campaigns



September 2021

Next steps

Planned ARCA sea campaigns

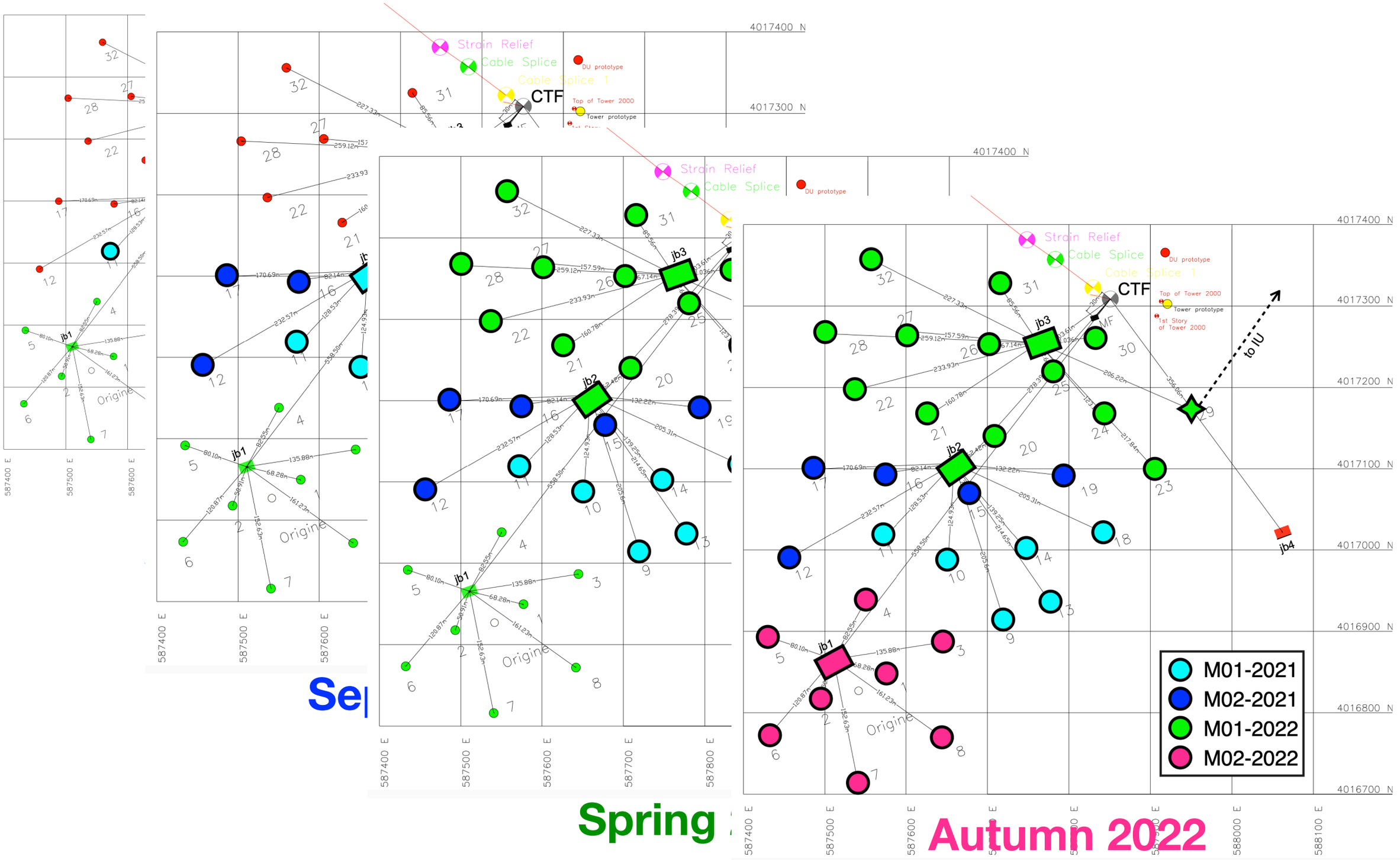


Sep

Spring 2022

Next steps

Planned ARCA sea campaigns



Sep

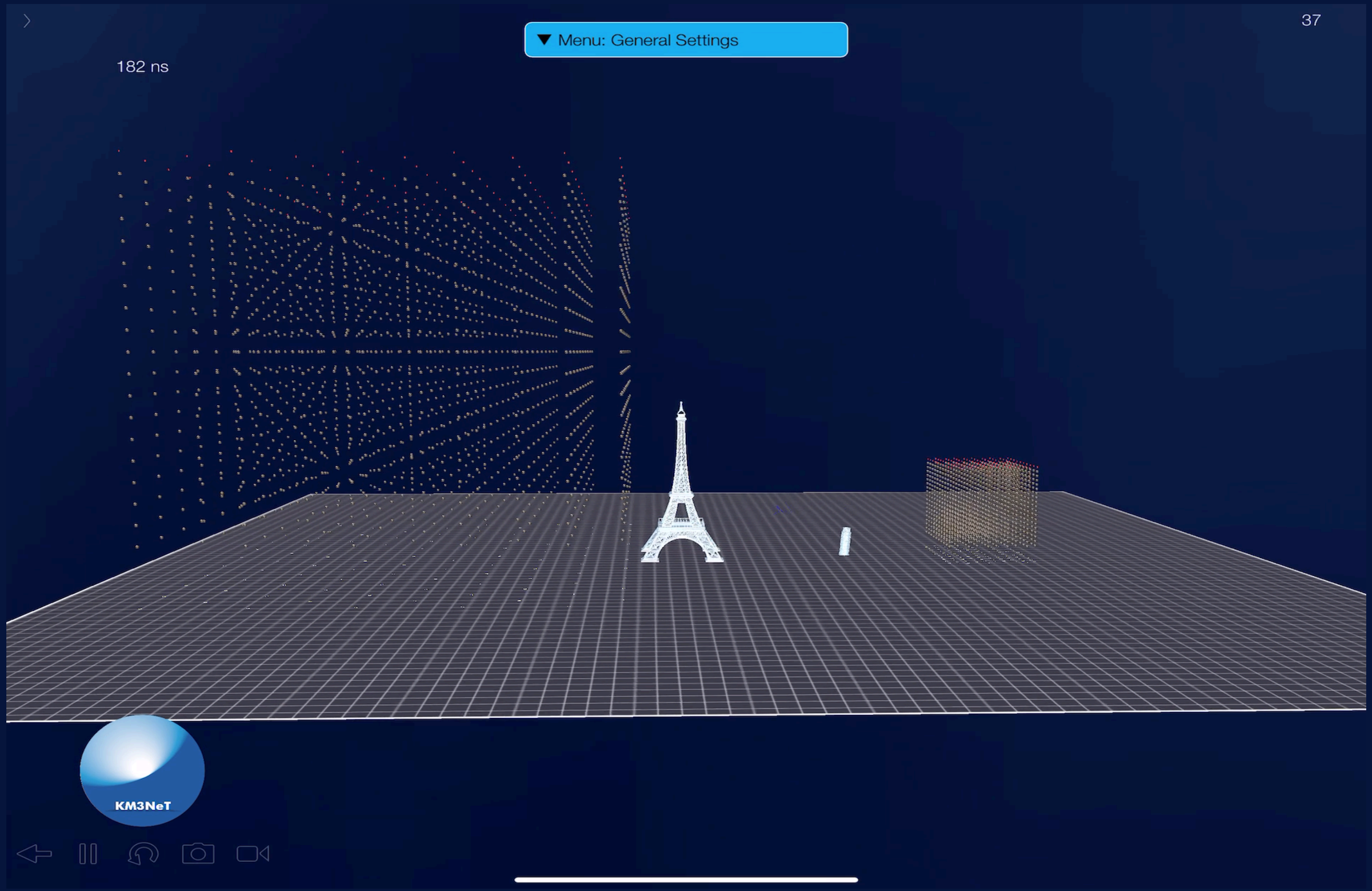
Spring

Autumn 2022

Summary

- Promising results from ARCA6 data, lifetime >98%
- Good data/MC agreement, calibration procedure well defined
- Phase-1 completion (32 DUs) foreseen within 2022
- Effective area already better than ANTARES
- Detector mass production in regime stage. Production rate will increase in the next years

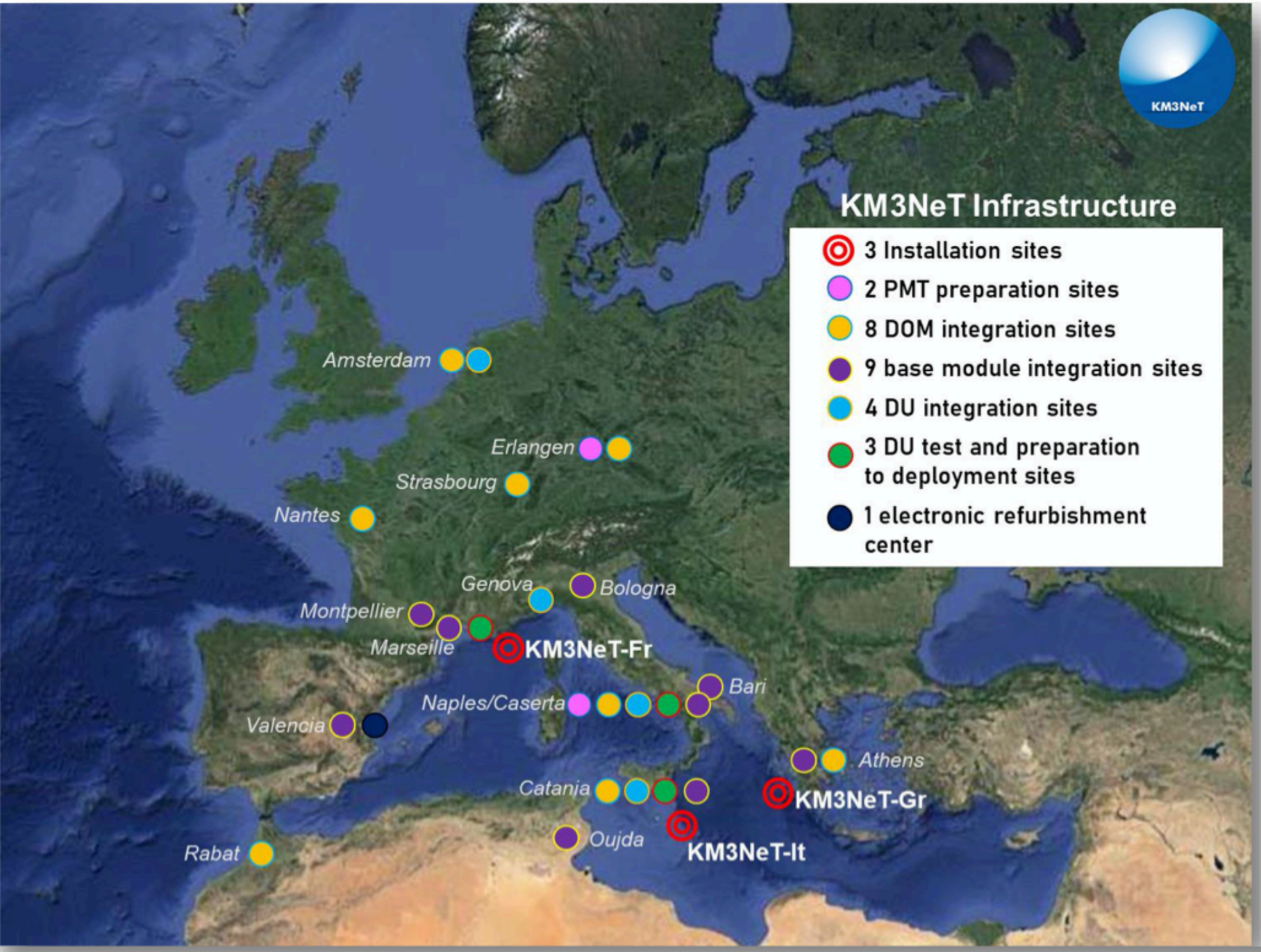
Thank you!



ARCA and ORCA Building Blocks

Spares

Detector construction



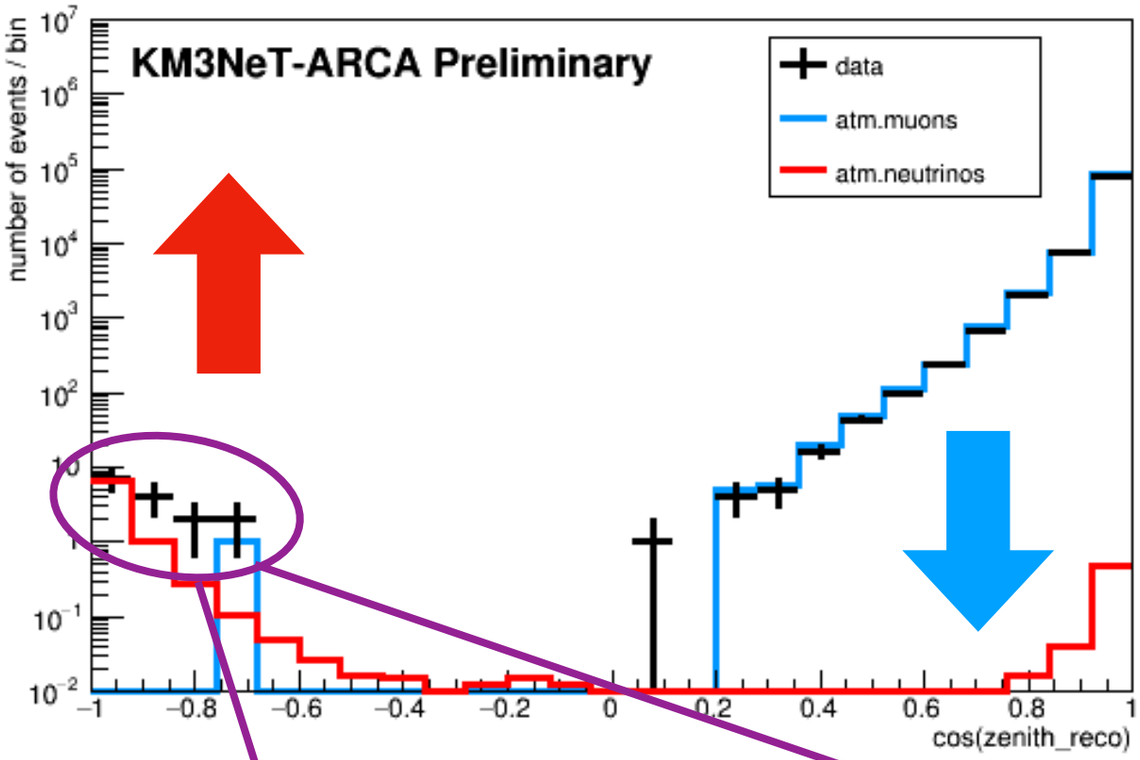
DOMs:
- 8 integration sites
- 640 DOM produced (400 ARCA,240 ORCA)
- 100 currently in progress

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)

Selection of atmospheric neutrinos



- A set of reconstruction quality requirements was applied in order to reject mis-reconstructed atmospheric muon events.
- 15 events observed as neutrino candidates
- MC: 8 events from atmospheric ν
- MC: 1 events form atmospheric μ