Astroparticle Physics at LNS

Simone Biagi

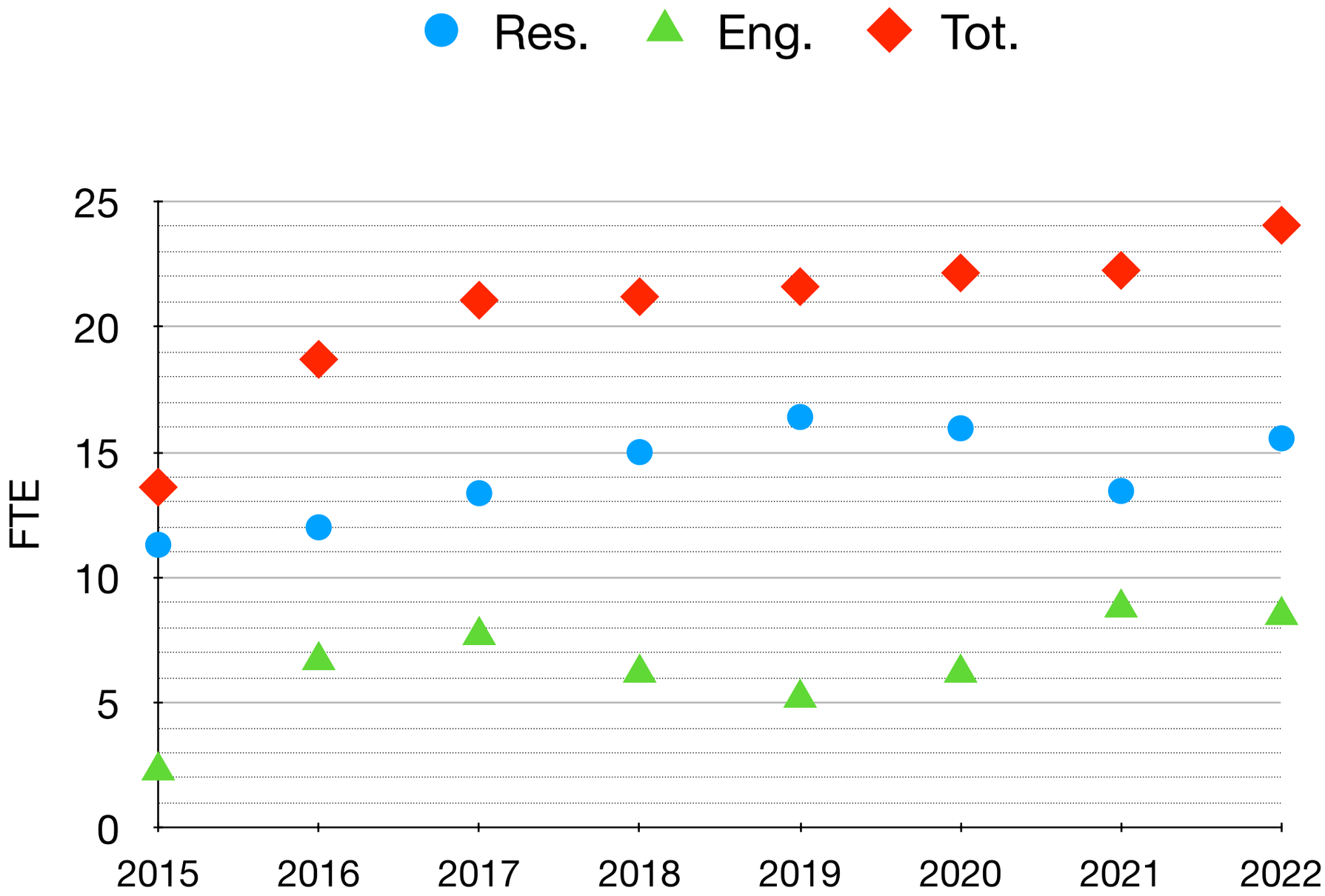
CSN2* @LNS

- 19 researchers (including associated professors from Uni-CT)
- 11 engineers
- 5 post-DOCs
- 3 retired (0 FTE)

- 5 experiments: large (>100 people) international collaborations
- Università di Sassari: associated group — linked to LNS

*CSN2 = INFN Astroparticle Committee

Interest in astroparticle growing!



KM3

Loc. coord. Rosa Coniglione
Nat’l coord. Giacomo Cuttone

KM3NeT
Opens a new window on our universe

ANTARES

KM3NET

KM3NeT is a research infrastructure hosting two neutrino detectors in the Mediterranean Sea

- KM3NeT/ARCA (Astroparticle Research with Cosmics in the Abyss)
  - observation of high energy (GeV ÷ PeV) neutrino sources ☛ a telescope offshore Capo Passero (Sicily-Italy) is in construction at a depth of 3500m
- KM3NeT/ORCA (Oscillation Research with Cosmics in the Abyss)
  - determination of the neutrino mass hierarchy ☛ a detector offshore Toulon (France) able to detect neutrinos of tens of GeV is in construction at a depth of 2500m

1 collaboration 1 technology 👉 2 detectors

ESFRI Roadmap Mid-term Evaluation

https://www.esfri.eu/latest-esfri-news-project-landmarks-news/esfri-monitoring-2016 <https://www.esfri.eu/latest-esfri-news-project-landmarks-news/esfri-monitoring-2016>

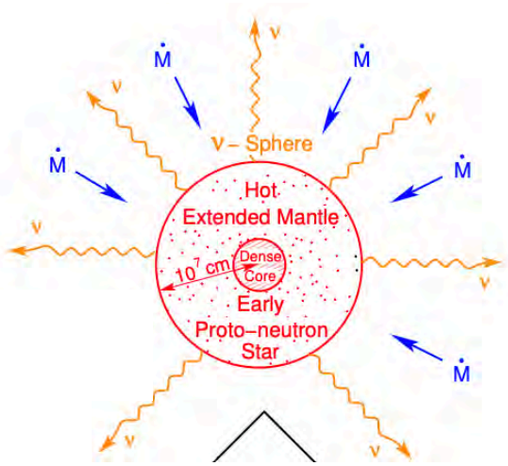
KM3 Neutrino Telescope 2.0 (KM3NeT)

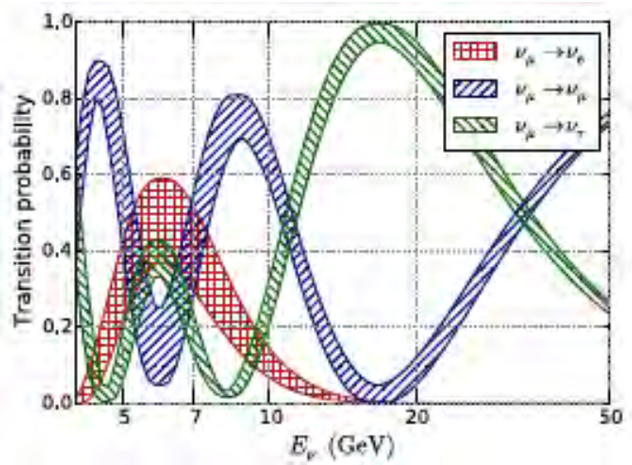
The ESFRI WGs consider that KM3NeT project has been developing very well toward implementation in the 10-year framework. The WGs do not identify any critical issues. A particular recommendation highlights the need to keep the timeline of the project, since the scientific impact is expected to be very significant if the project is implemented on time.

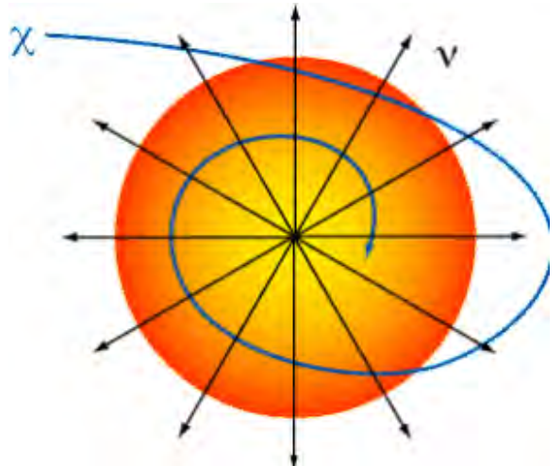
MONITORING OF ESFRI 2016 PROJECTS			
	cientific Case	*mplementation Case*	*Overall*
CTRIS	High	High	High
ANUBIUS	ledium/High	Medium	Medium
-RIHS	Medium	Medium	Medium
ST	High	Medium	Medium/High
MPHASIS	ledium/High	Medium/High	Medium/High
M3NeT	Very High	High	igh/Very High

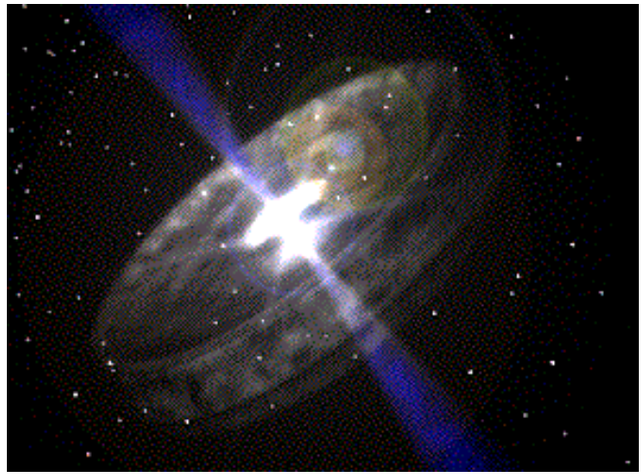
- ACTRIS – Aerosols, Clouds and Trace gases Research Infrastructure *(Main SWG: Environment)*
- DANUBIUS-RI – International Centre for Advanced Studies on River-Sea Systems *(Main SWG: Environment)*
- EMPHASIS – European Infrastructure for Multi-scale Plant Phenomics and Simulation *(Main SWG: Health & Food)*
- E-RIHS – European Research Infrastructure for Heritage Science *(Main SWG: Social and Cultural Innovation)*
- EST – European Solar Telescope *(Main SWG: Physical Sciences & Engineering)*
- KM3Net – KM3 Neutrino Telescope 2.0 *(Main SWG: Physical Sciences & Engineering)*

The physics case





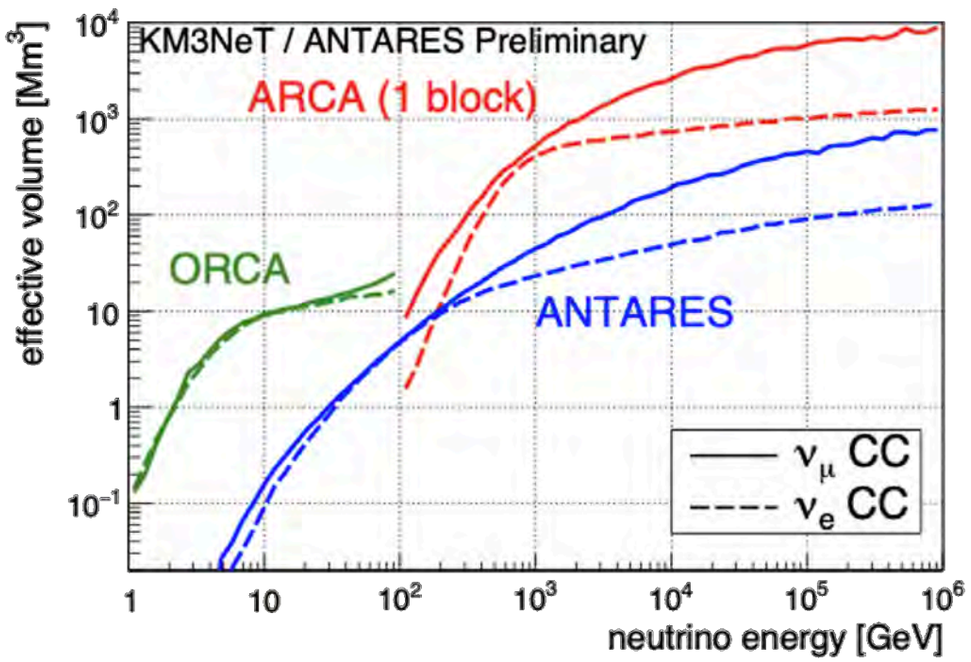




Super Novae explosion MeV	Neutrino oscillation GeV	Dark Matter (*) TeV	HE neutrinos Multi-messenger program PeV

ORCA

ARCA



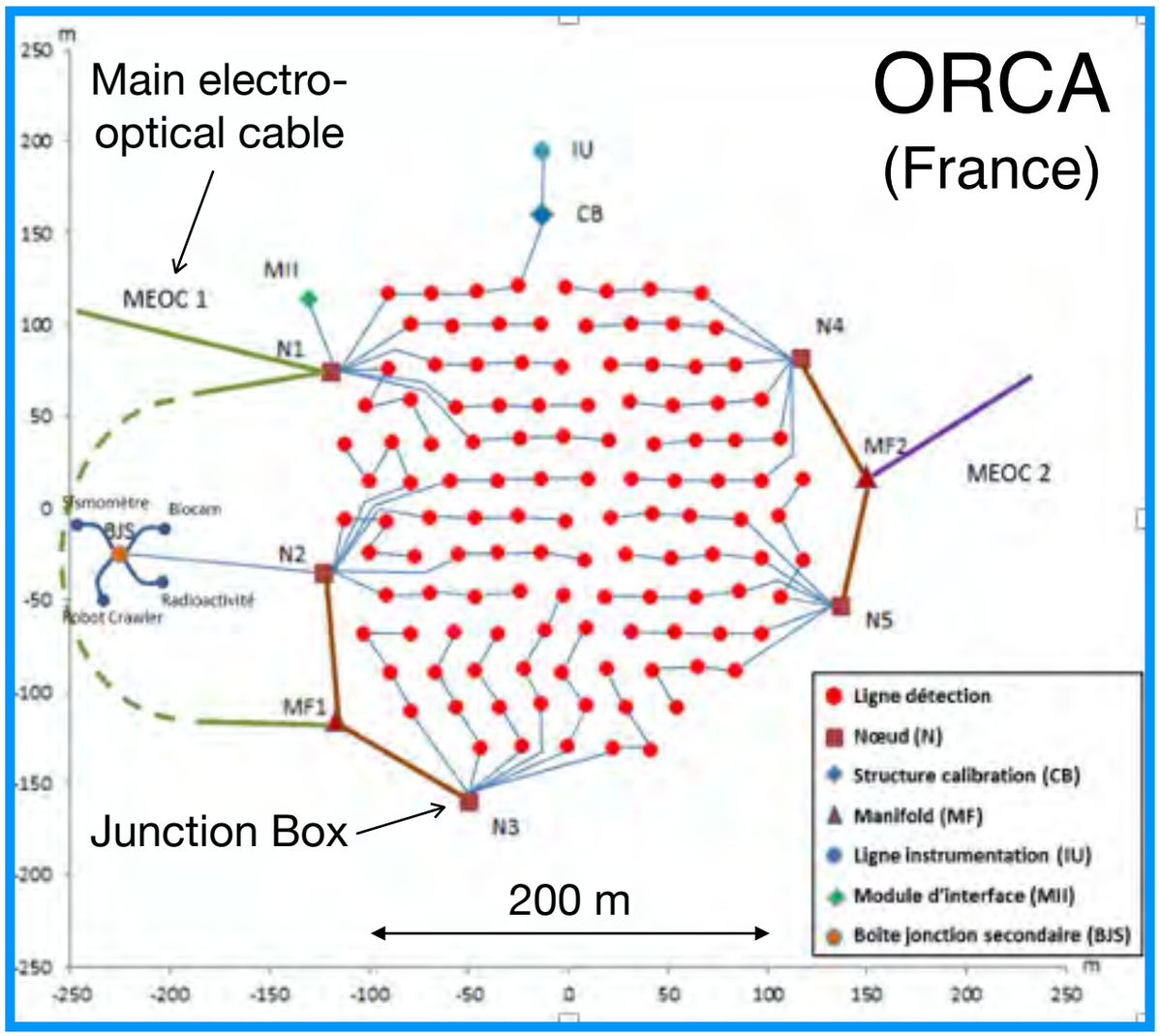
ARCA

ANTARES:
A small size detector (0.01 km³)
working from more than 10 years

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

The neutrino telescopes of KM3NeT

ORCA: Oscillation Research with Cosmics in the Abyss

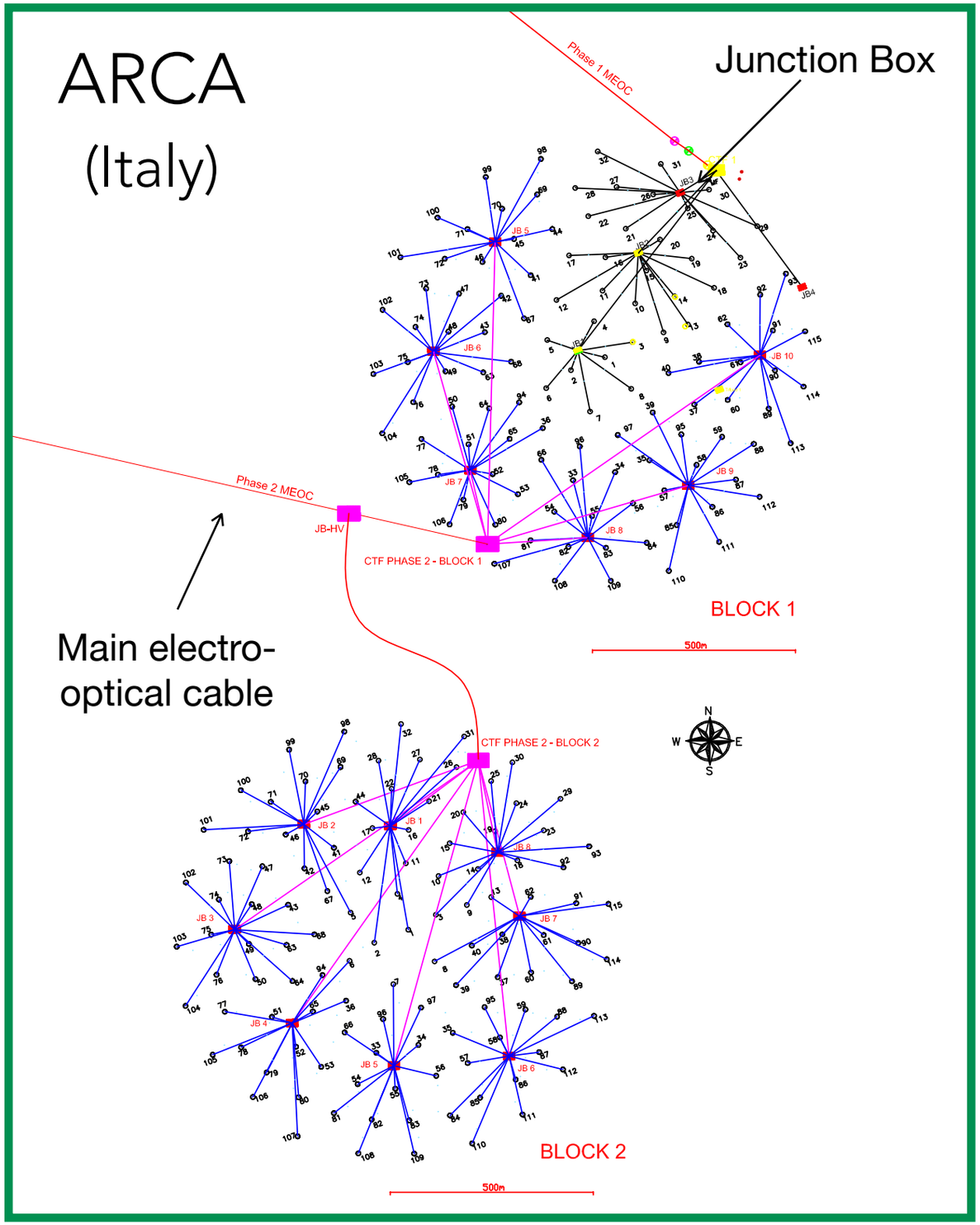


- 1 Building Block
- 115 Detection Units (DU), interspacing ~20 m
- 18 Digital Optical Modules (DOM) per DU, inter-DOM spacing 9 m
- Active volume ≈ 7 Mton
- 2500 m depth, close to Toulon

The neutrino telescopes of KM3NeT

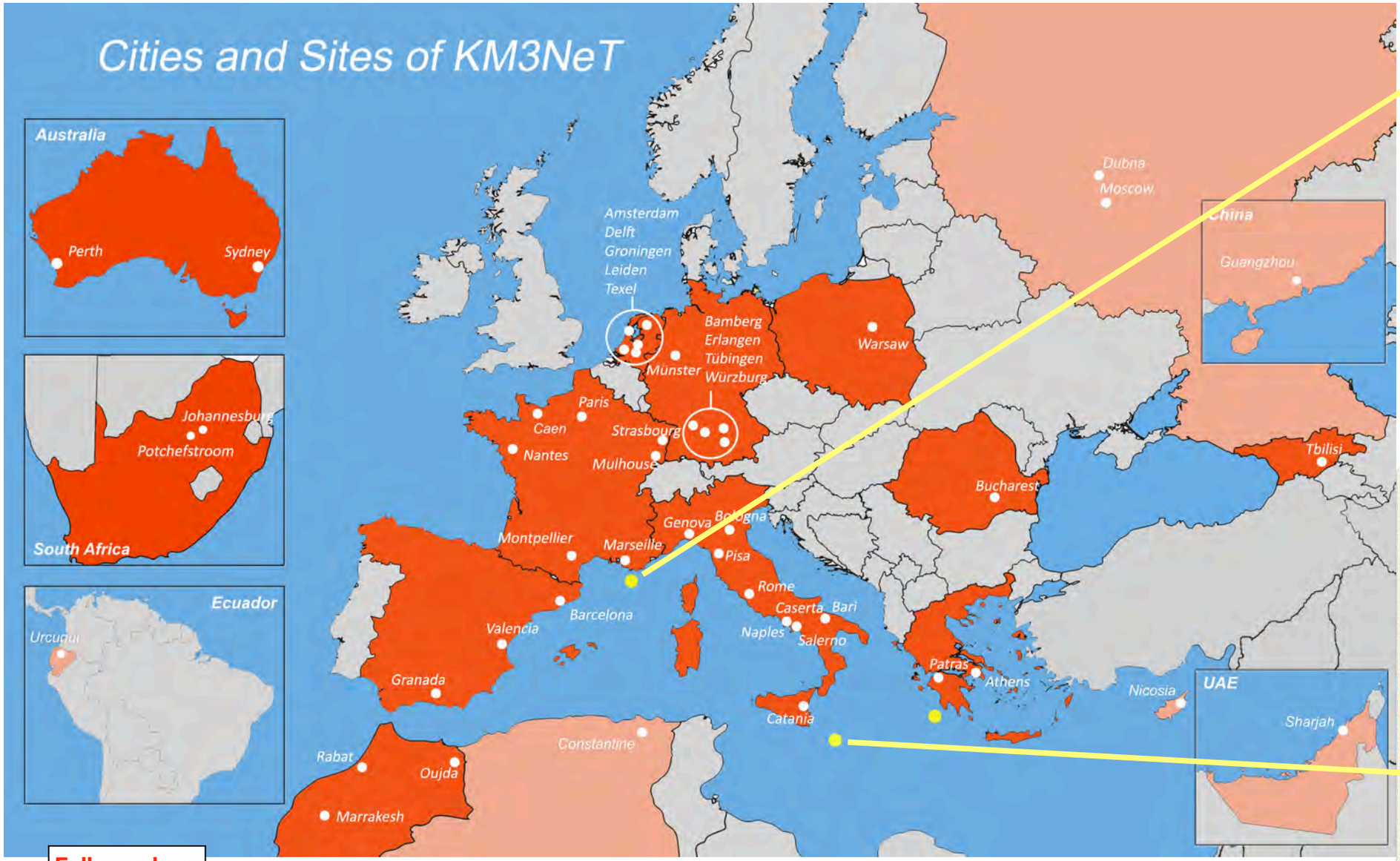
ARCA: Astroparticle Research with Cosmics in the Abyss

- 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

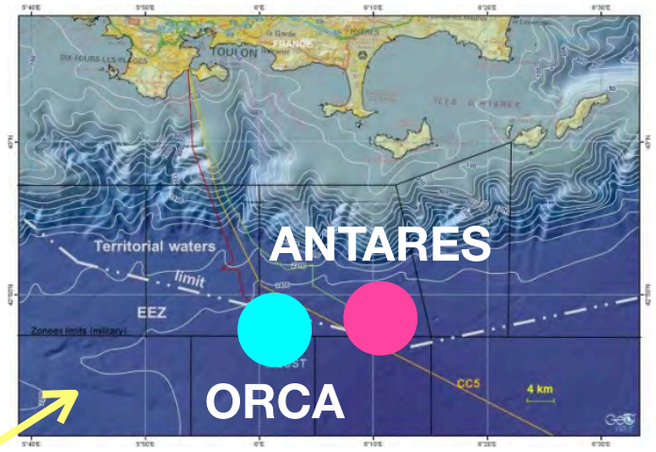


The KM3NeT collaboration

56 institutes in 17 countries



Full members
Observers

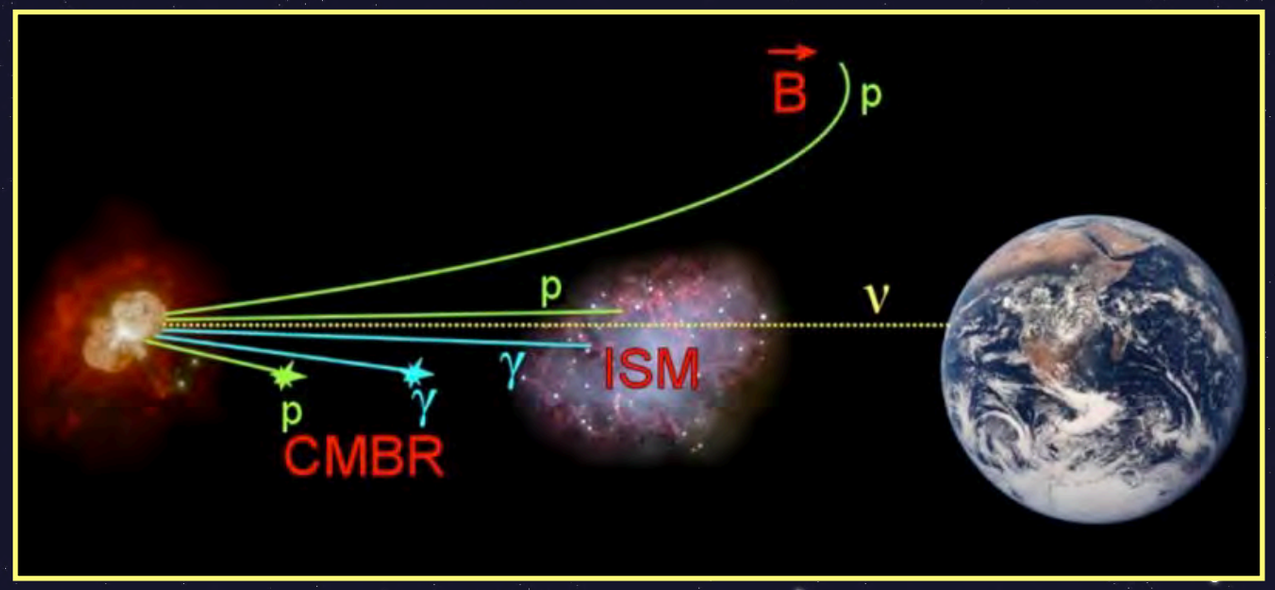


ANTARES in operation since 2008

First-generation neutrino telescope

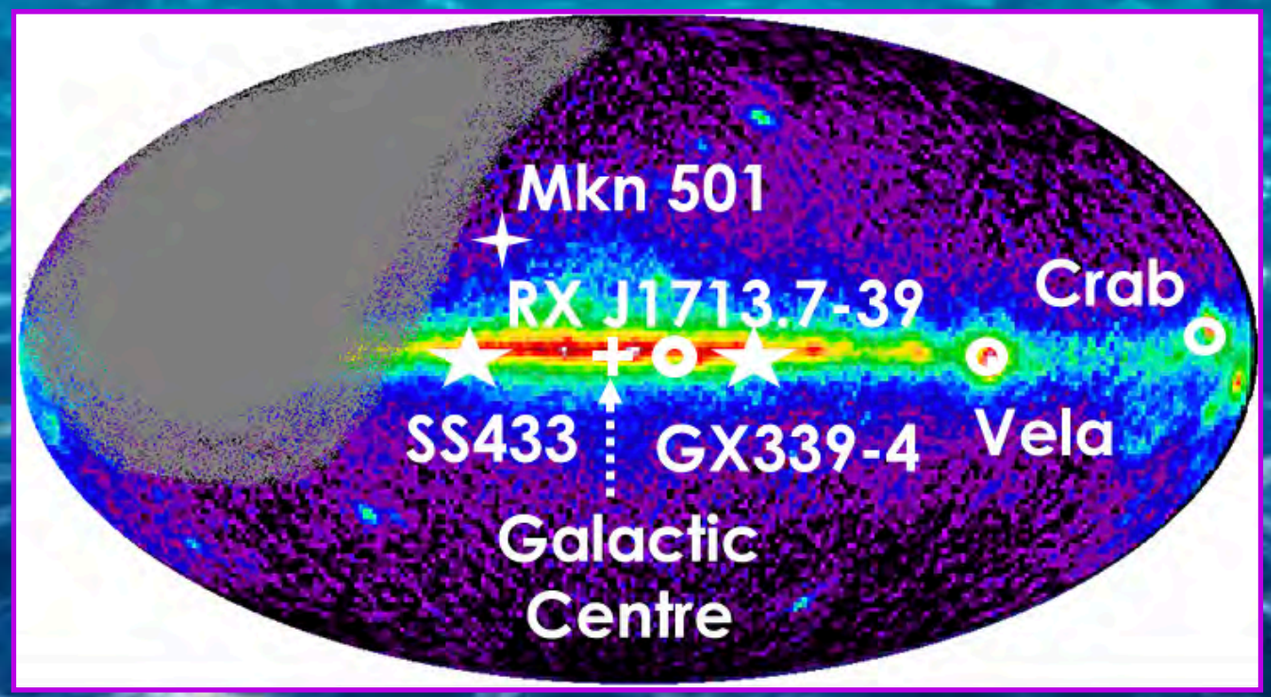
Instrumented volume ~10 Mton

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.

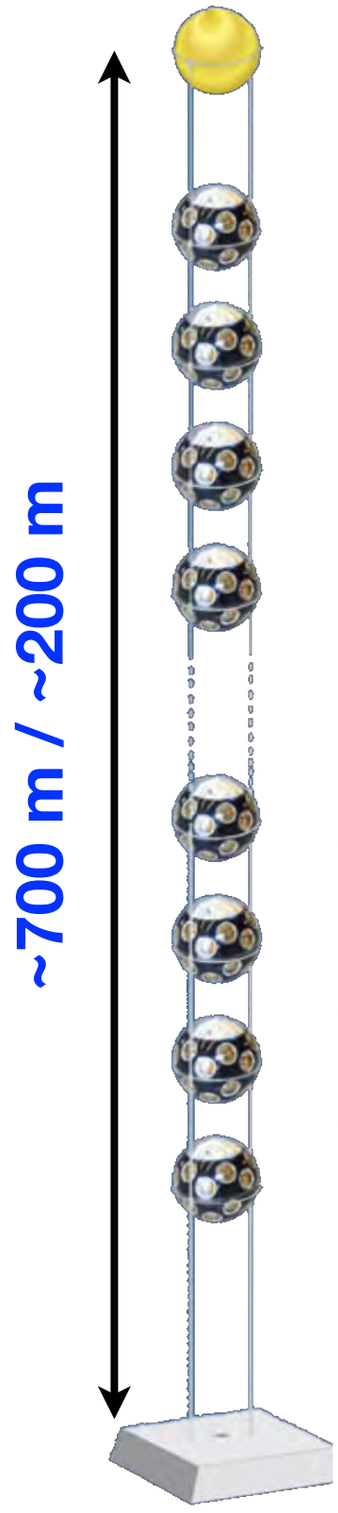


KM3NeT Technology in a nutshell

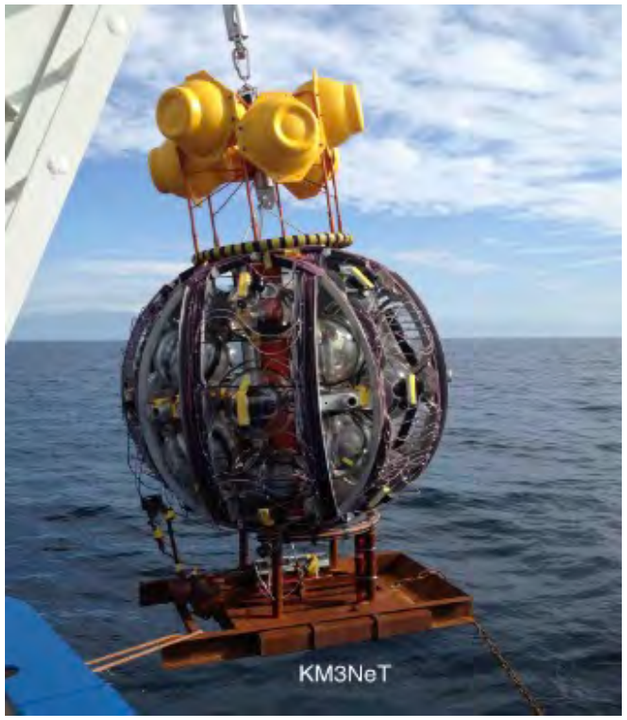
Digital Optical Module

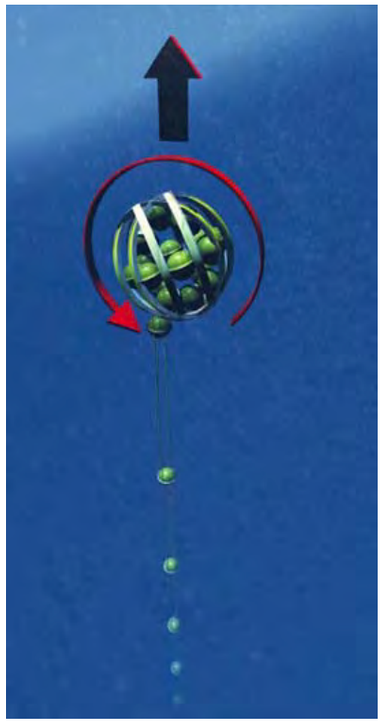
- DOM: 31 x 3” PMTs
- Digital photon counting
- Directional information
- Wide acceptance angle
- All data to shore
- Gbit/s on optical fiber
- Custom White Rabbit
- 18 DOMs / String

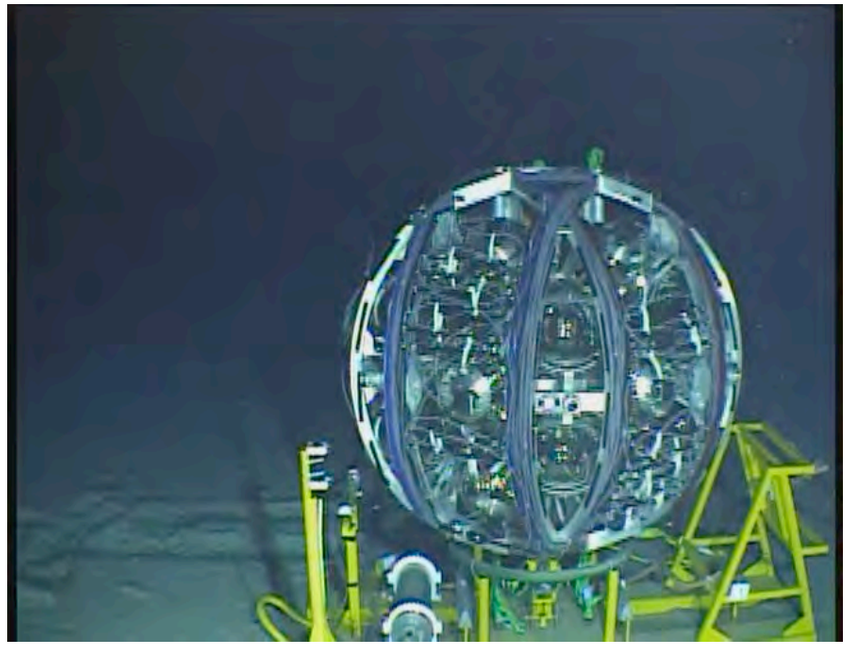
Detection Unit (string)



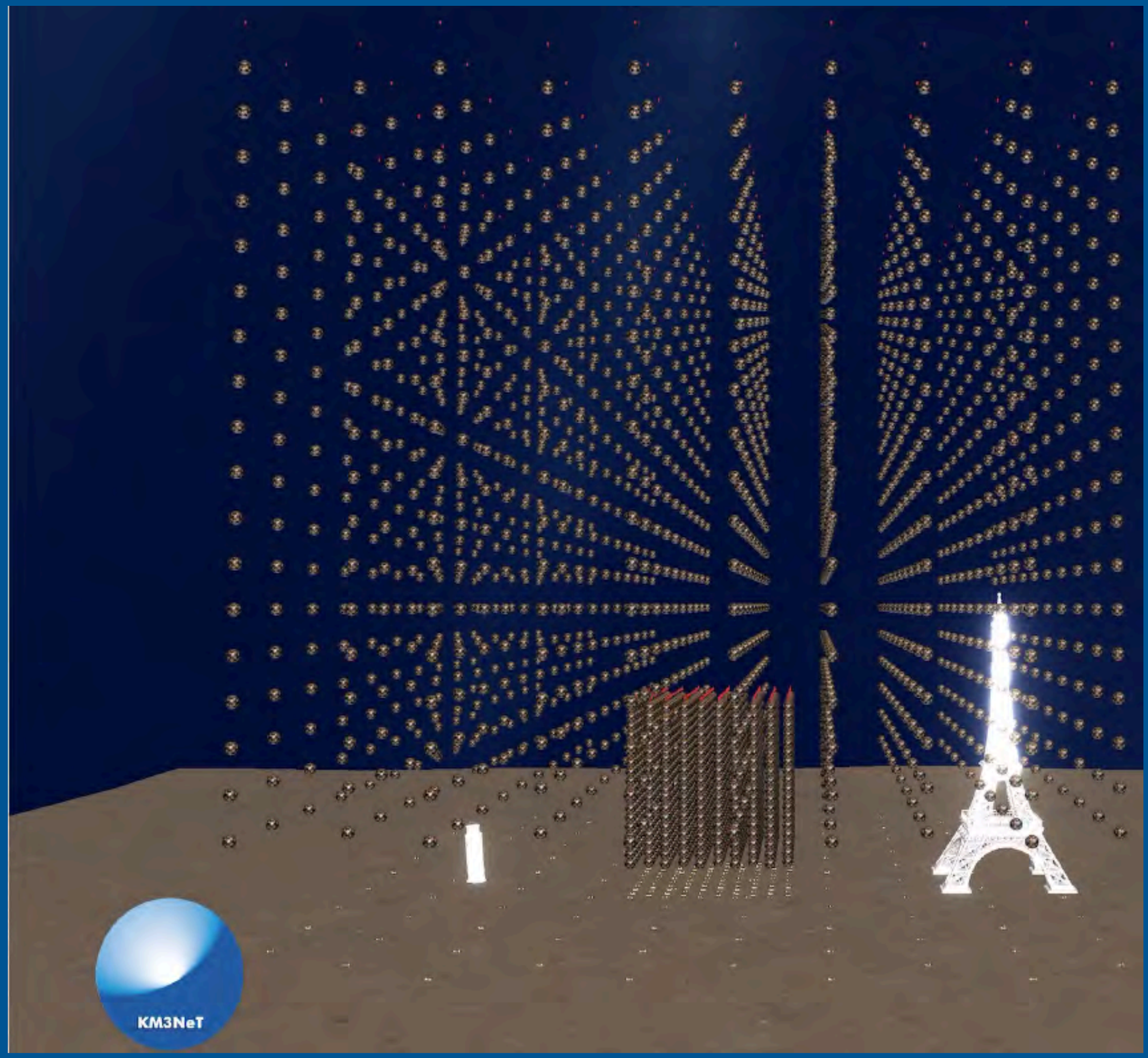
- Unfurling by autonomous ROV
- Rapid deployment
- Multiple strings in one sea campaign



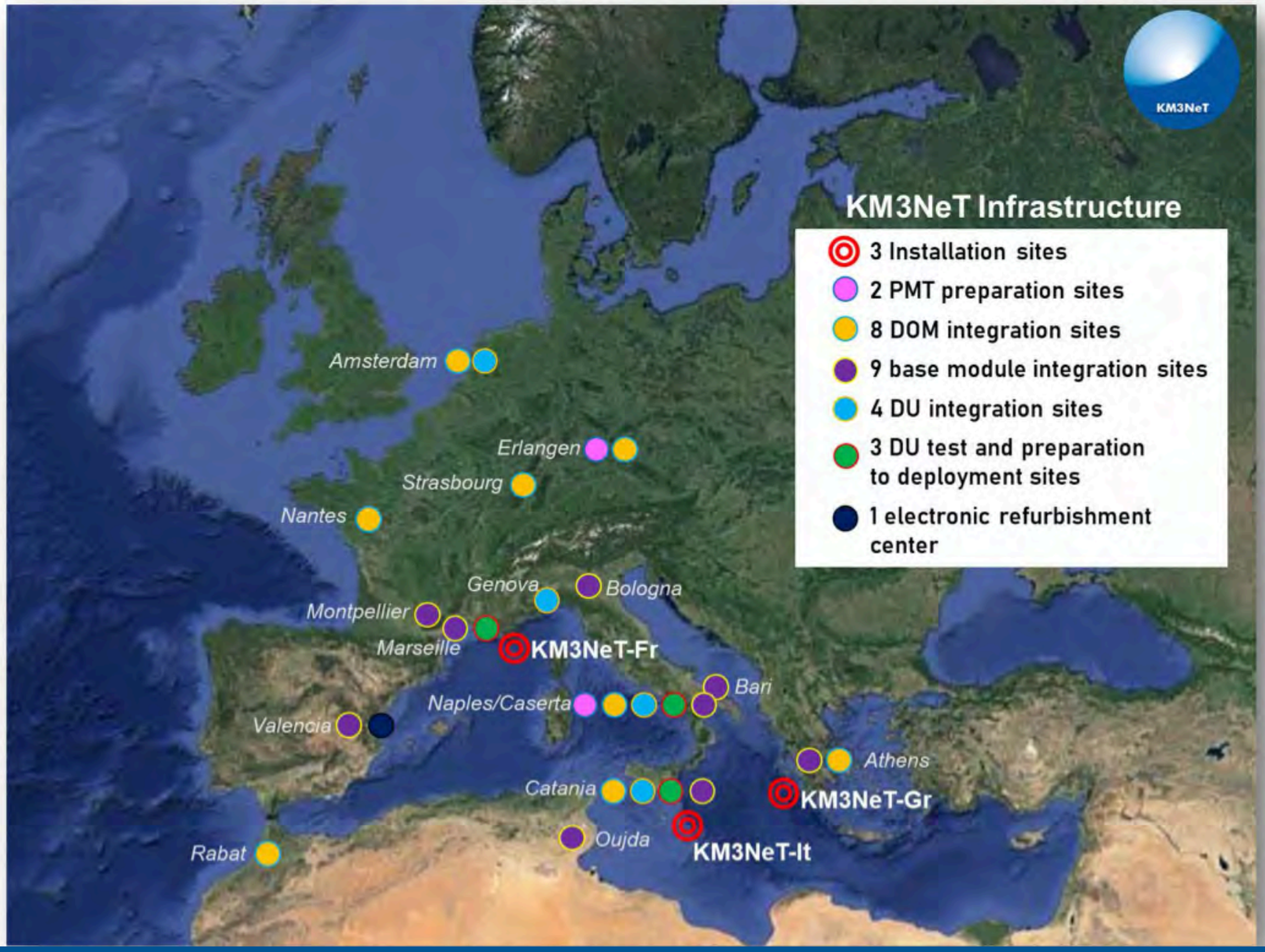




THE KM3NET DETECTORS



THE 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)

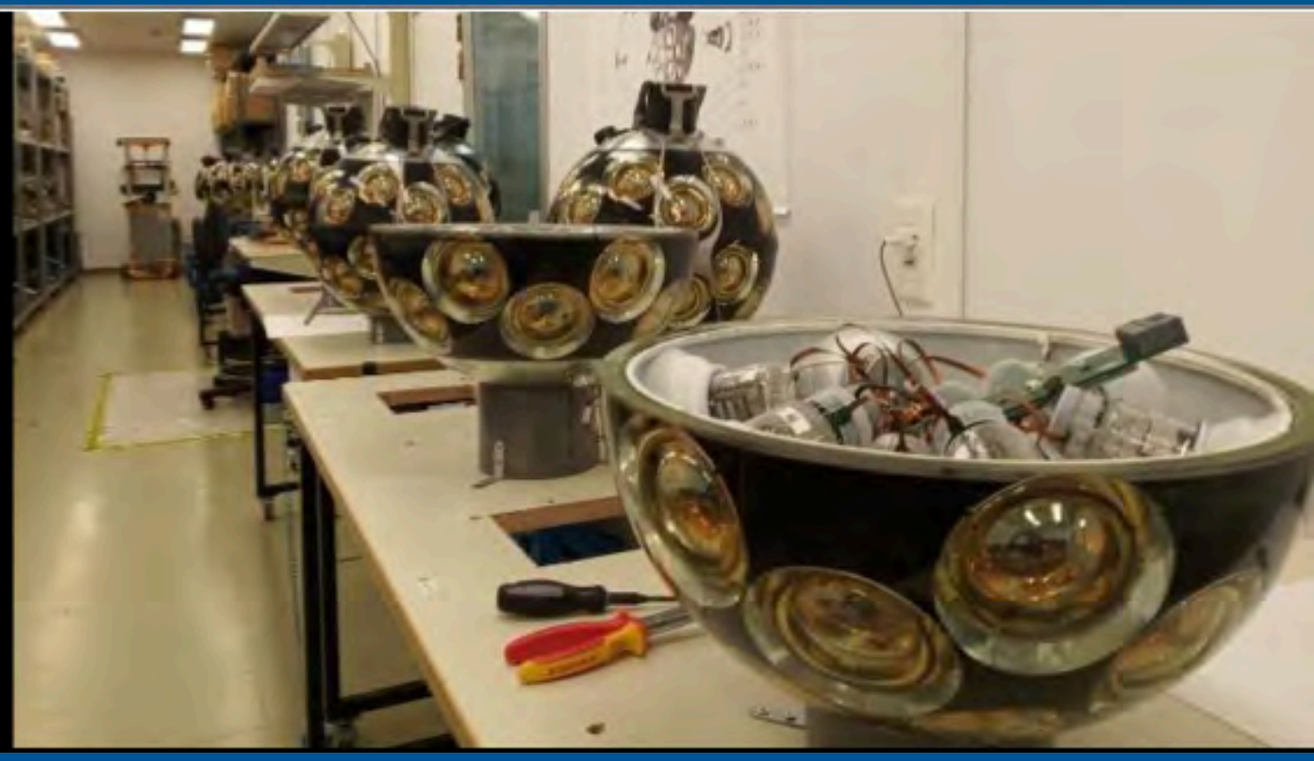
Ai LNS
- BM integration site (resp. G. Larosa)
- DU integration site (resp. P. Sapienza)

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

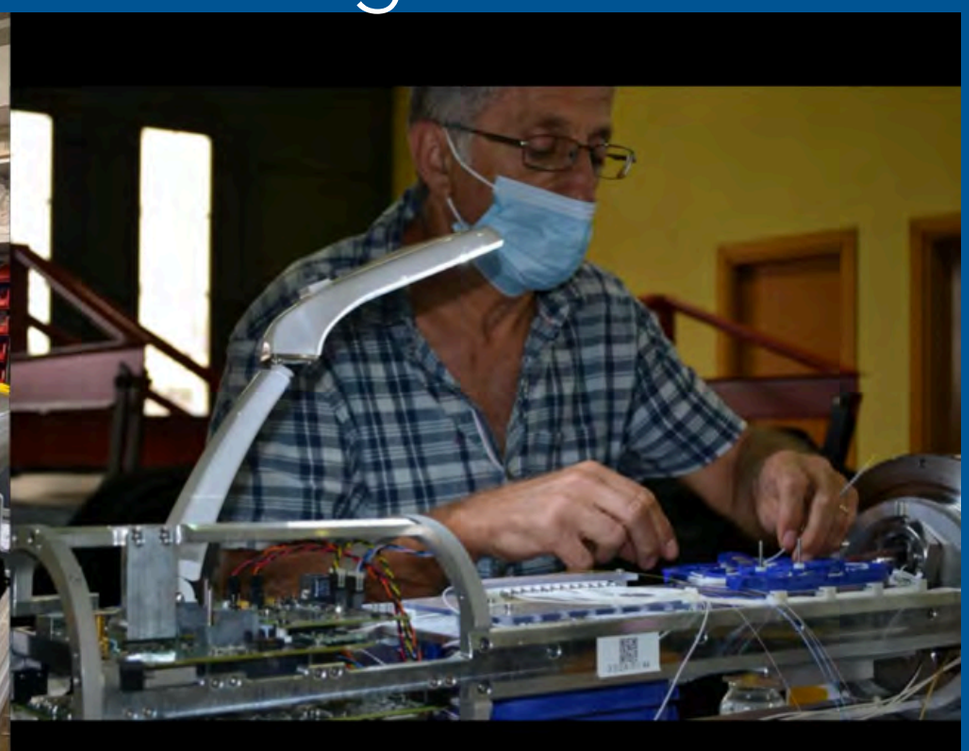
THE INTEGRATION

DOM integration





Base Module integration

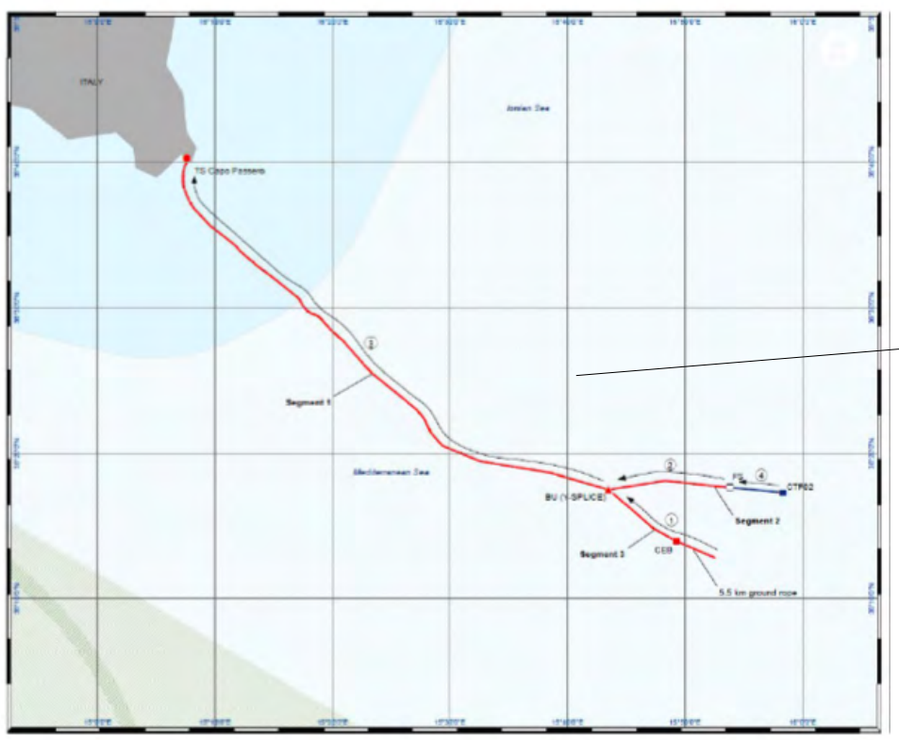



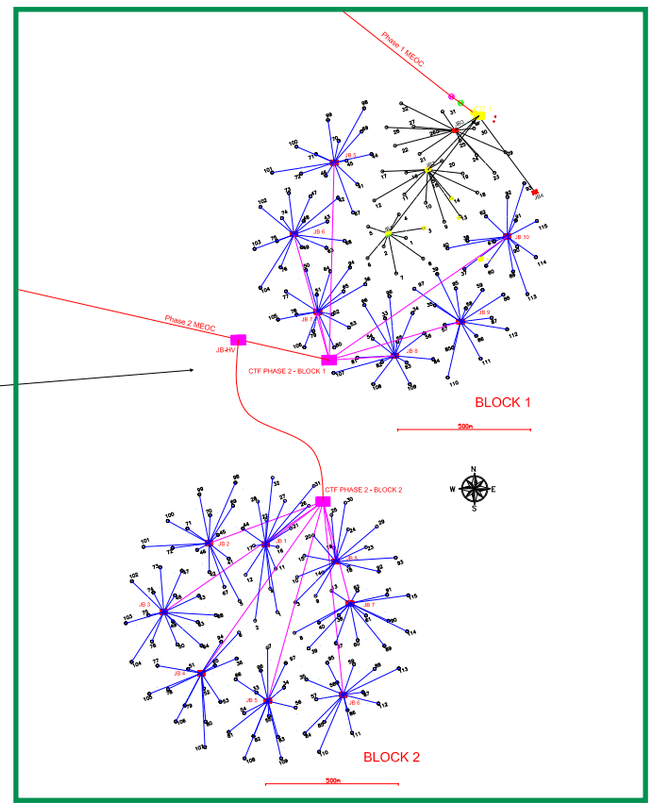
THE INTEGRATION

DU integration

ARCA Status

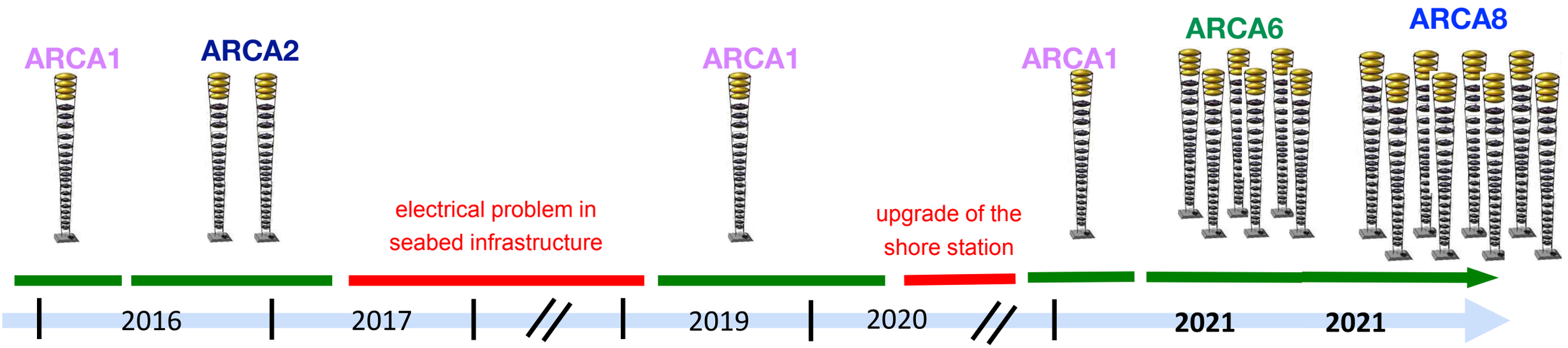
Nov 2020: Successful laying of the second MEOC

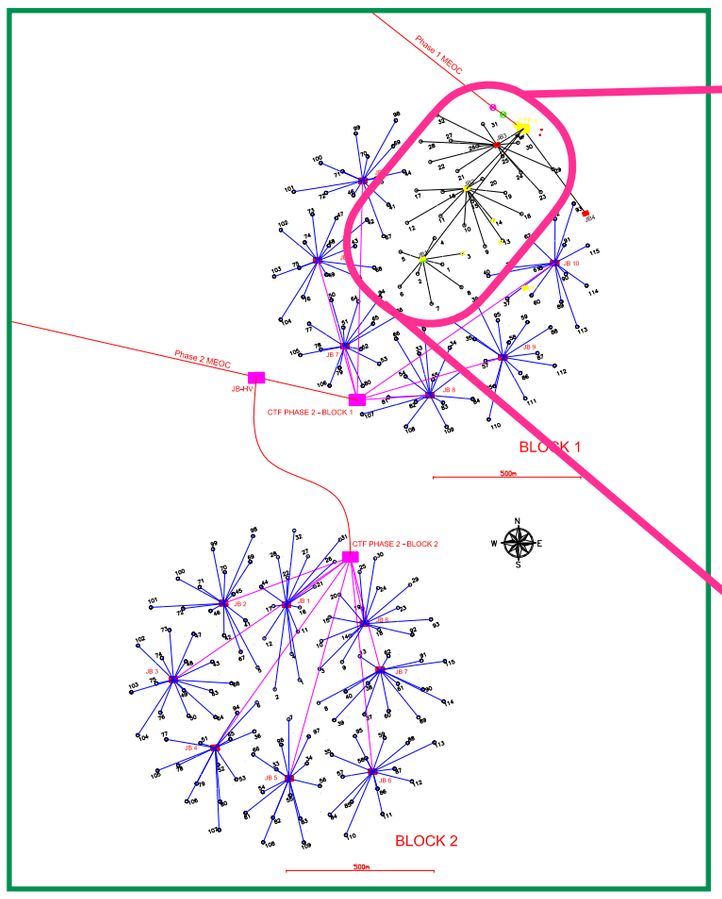


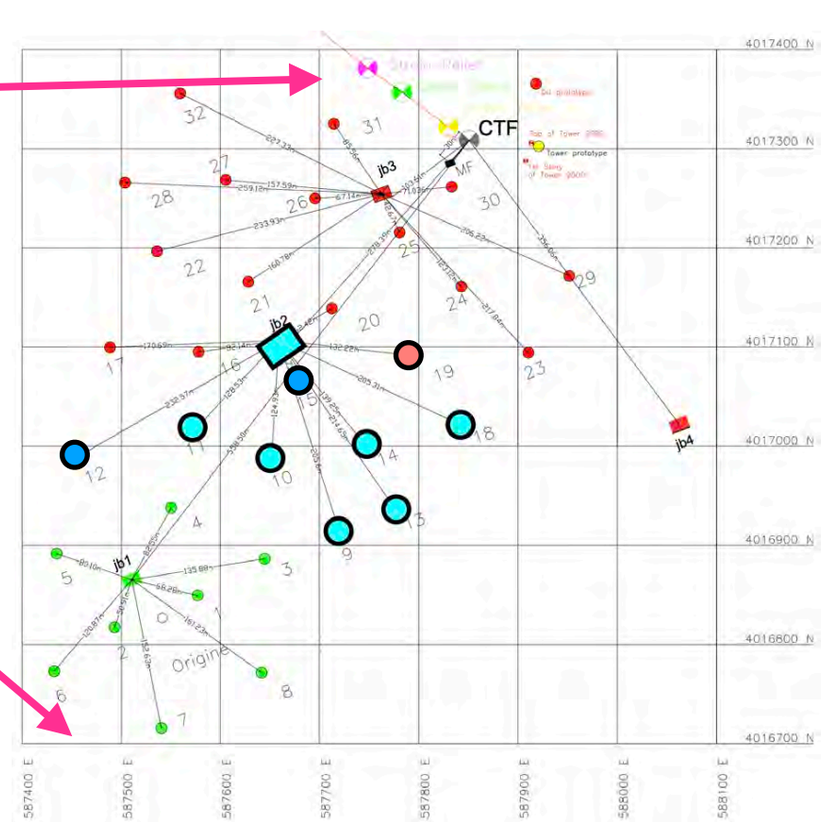


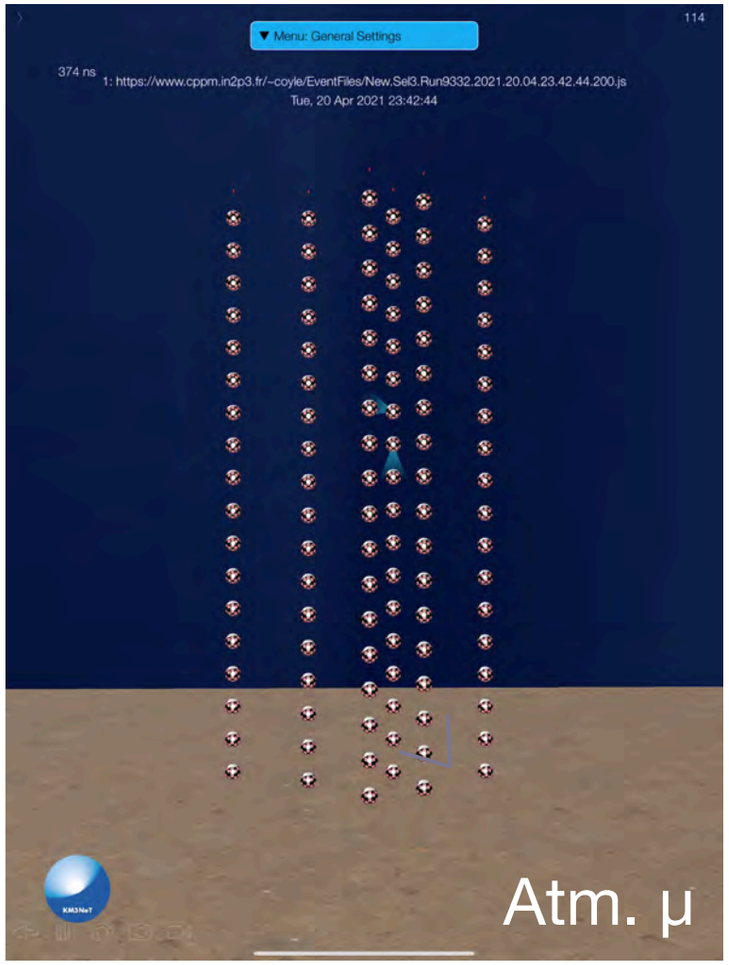
With two main cables
it is possible to connect
the full ARCA detector
(2 building blocks)

ARCA: Construction Phase







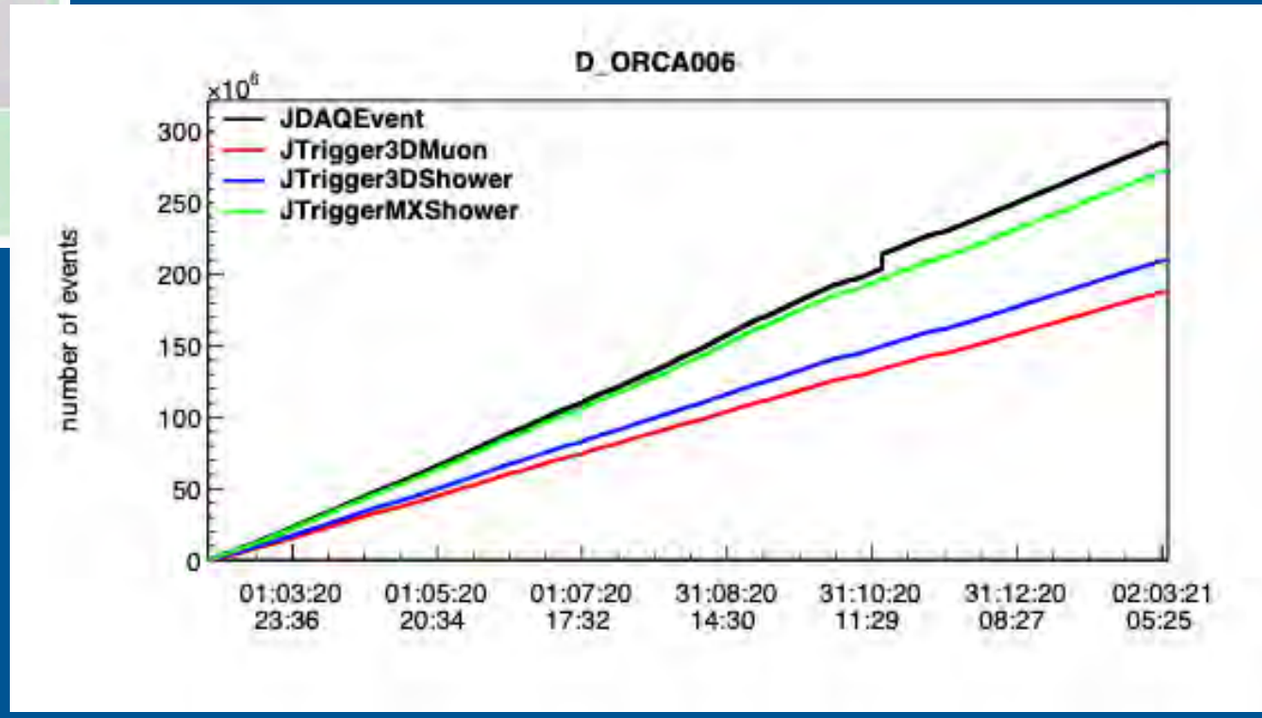


Phase-1 completion = 32 Detection Units

ORCA STATUS

From February 2020 six detection units in operation

More than one year of data available

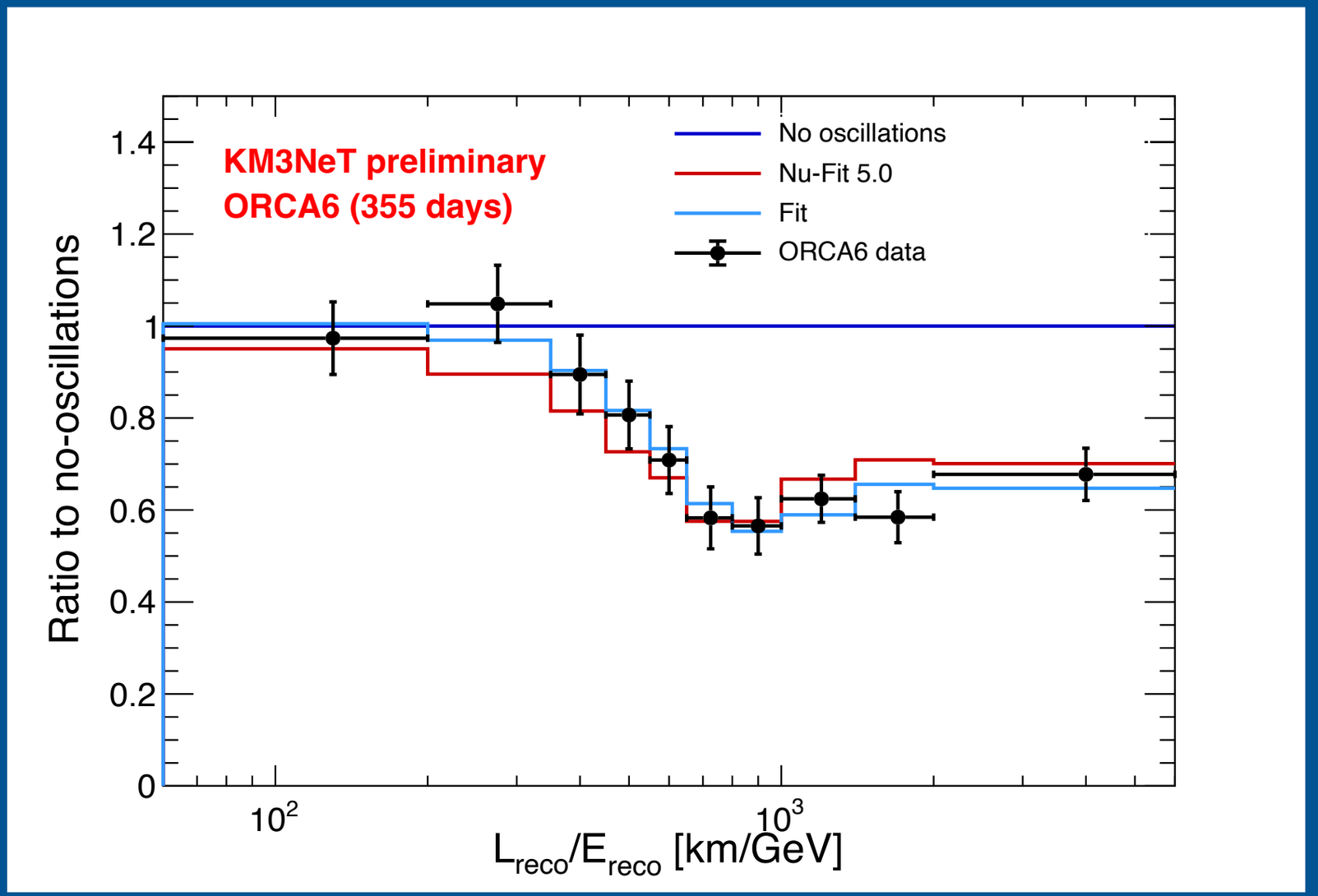


Data Taking efficiency of 98.8%

THIS WEEK:
A campaign for deployment of +7 Detection Units!

ORCA FIRST RESULTS

ORCA6



no-oscillation hypothesis disfavoured at ~ 6 sigma

Very good agreement Data /MC

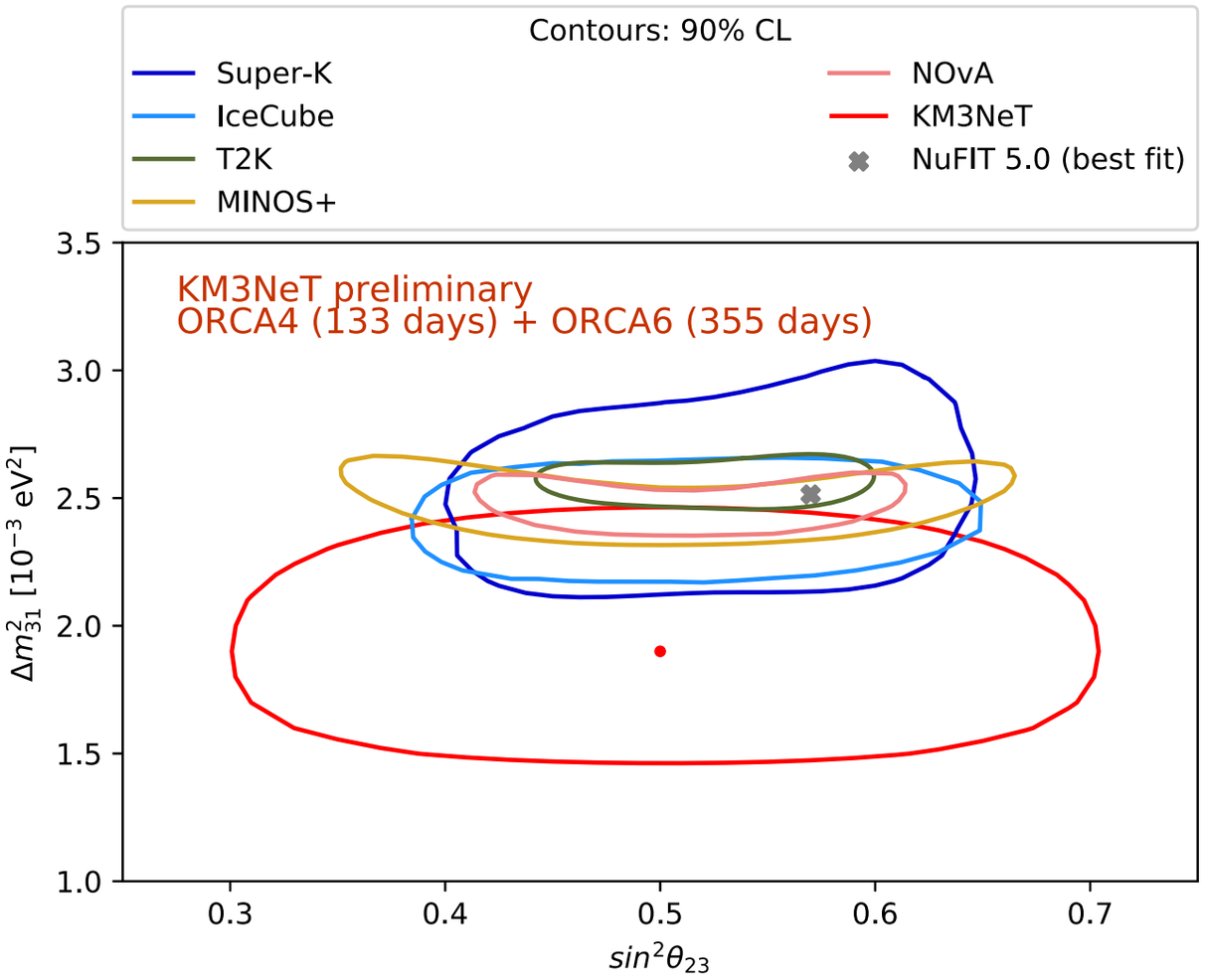
We see neutrino oscillation

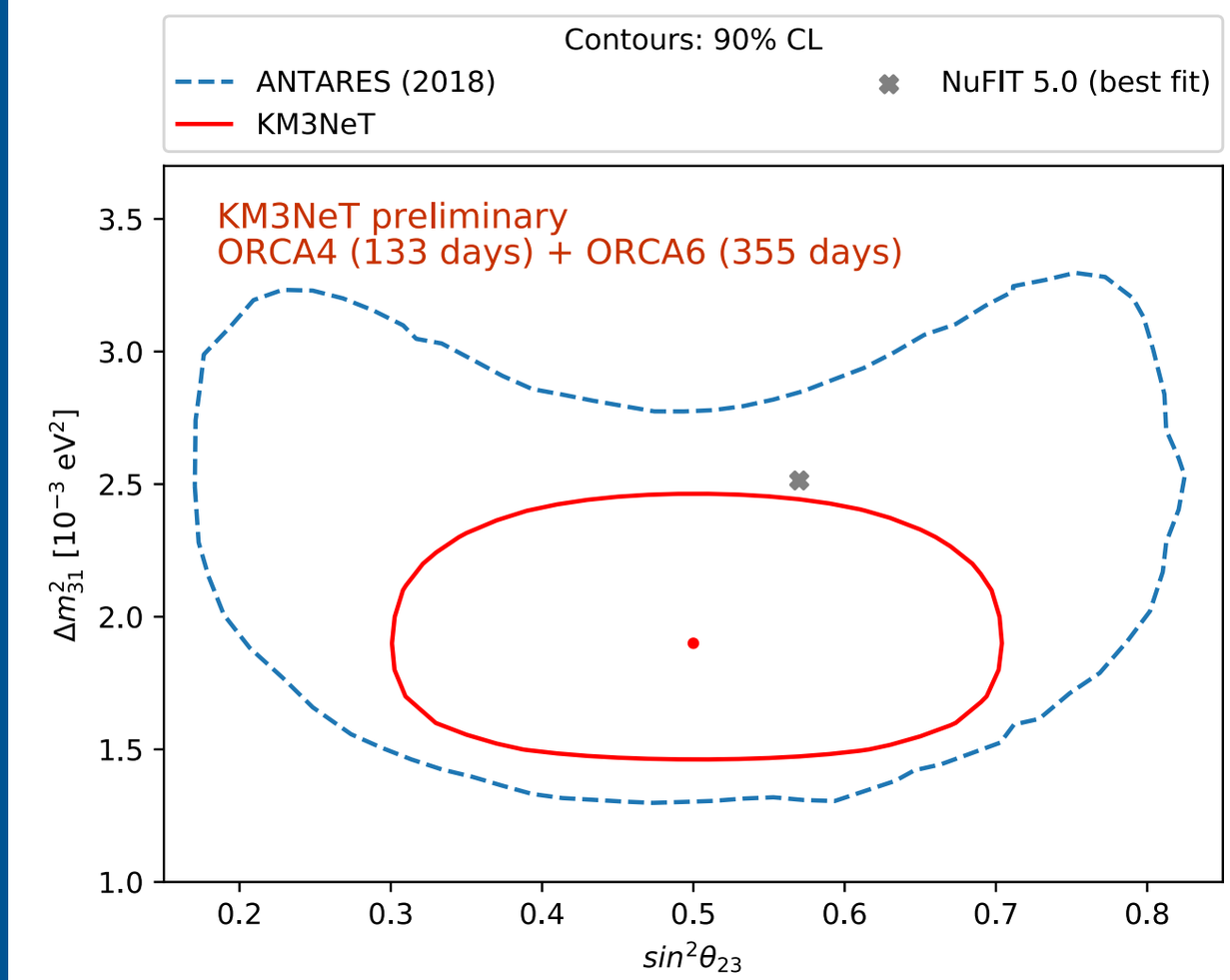
ORCA6 FIRST RESULTS

To be presented at ICRC2021

ORCA6

Antares 8 years of data



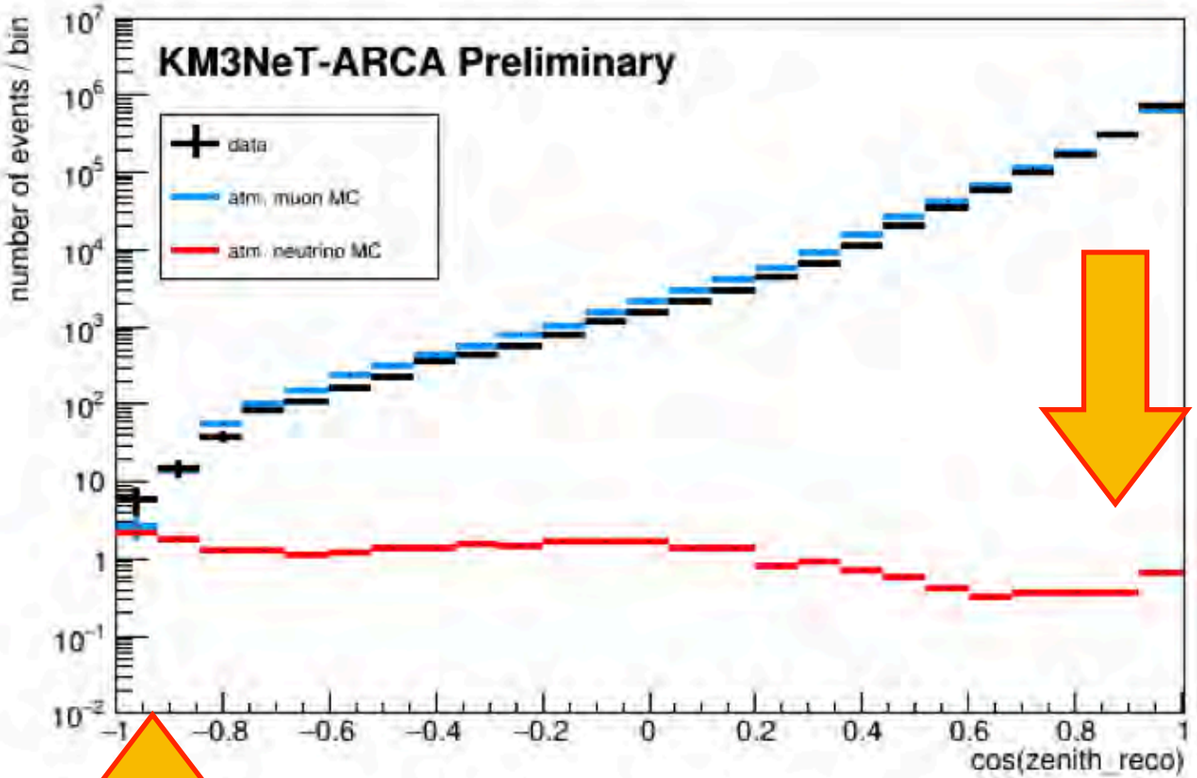


Results competitive with the other experiments even with a small size detector

Much better than Antares after about 1 year of data taking

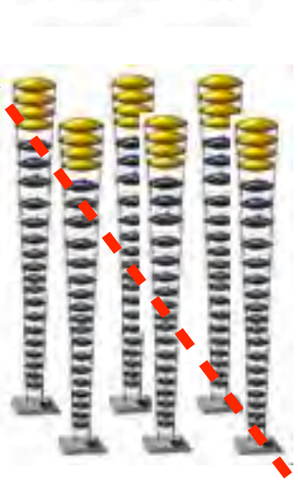
ARCA6: FIRST RESULTS

Data: 19 days ARCA 6 strings



Up-going

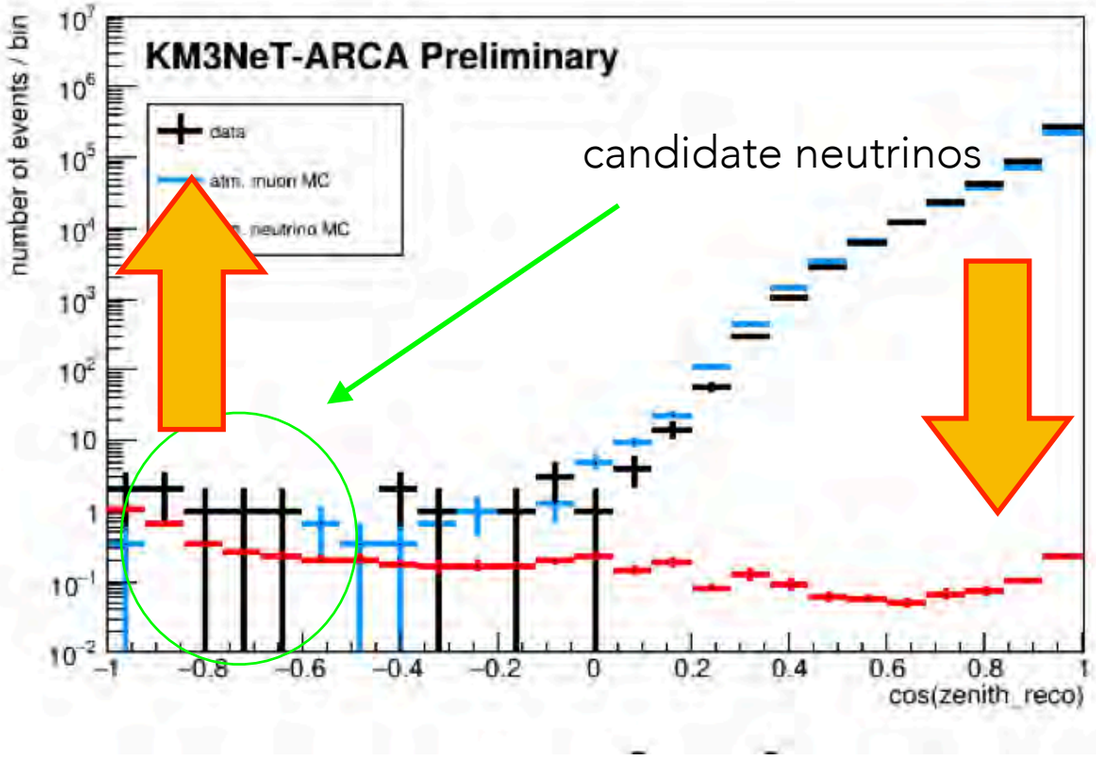
(only ν can travel through the Earth)



Down-going

(dominated by atmospheric μ)

Quality cuts applied to select upgpoing-neutrinos

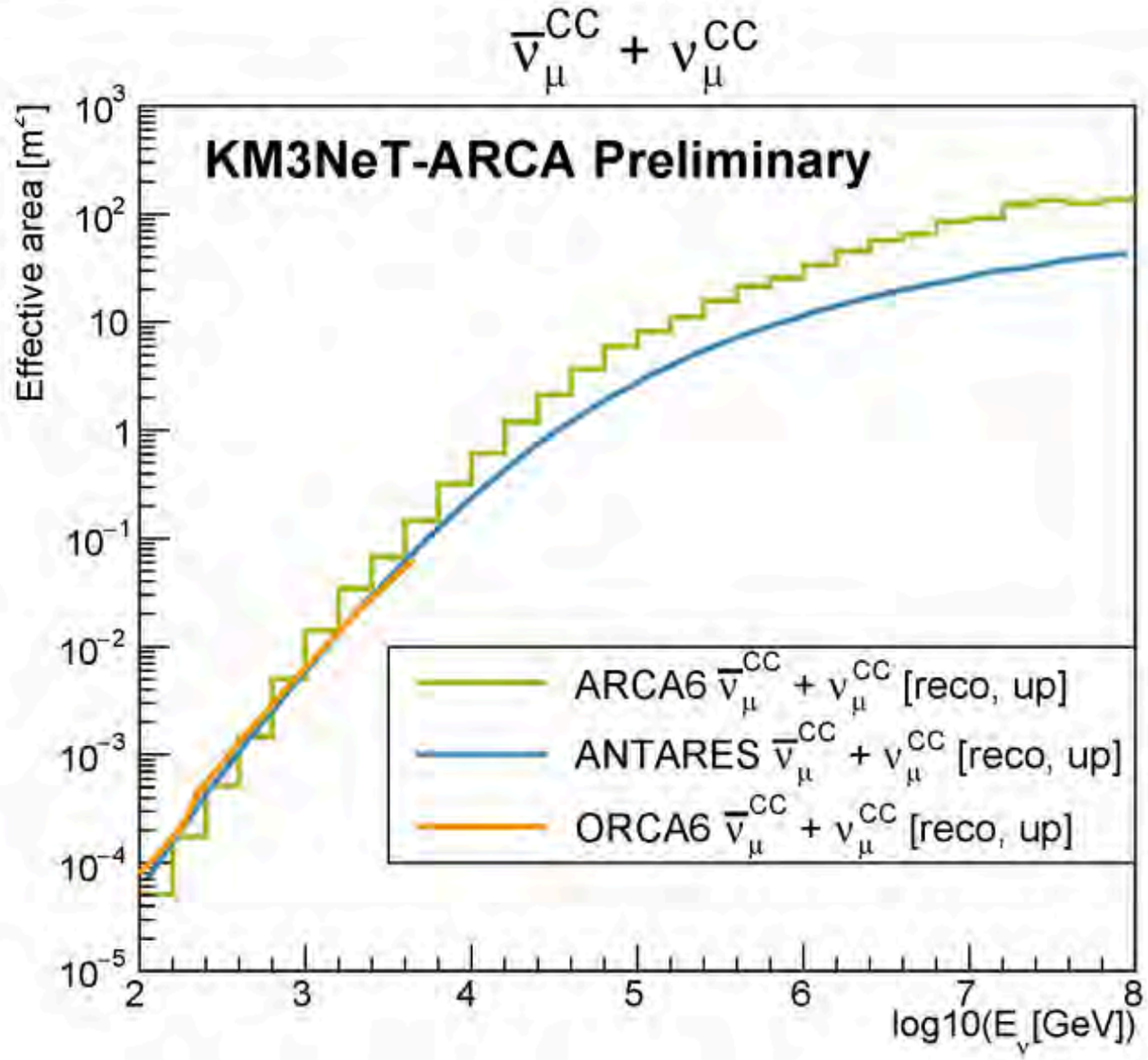


Coszen < - 0.8
Data : 5
(a)NumuCC: 2.0
Mupage : 0.7

Coszen < 0
Data : 15
(a)NumuCC: 4.0
Mupage : 7.0

KM3NeT Effective Areas

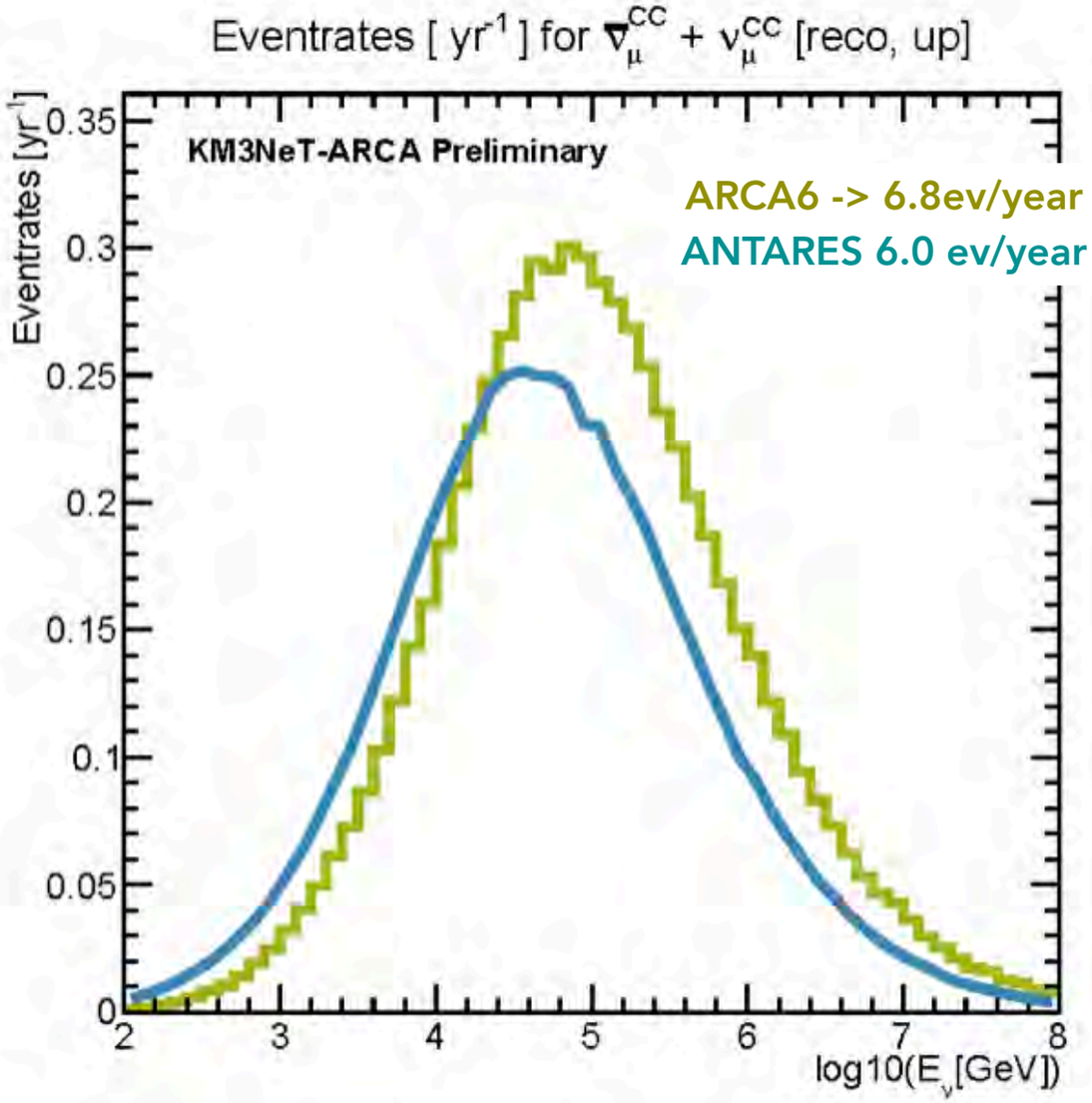
ARCA6 + ORCA6 compared to ANTARES



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

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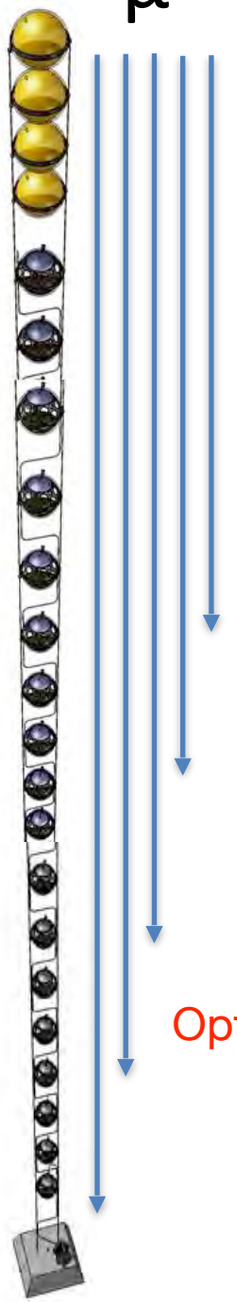
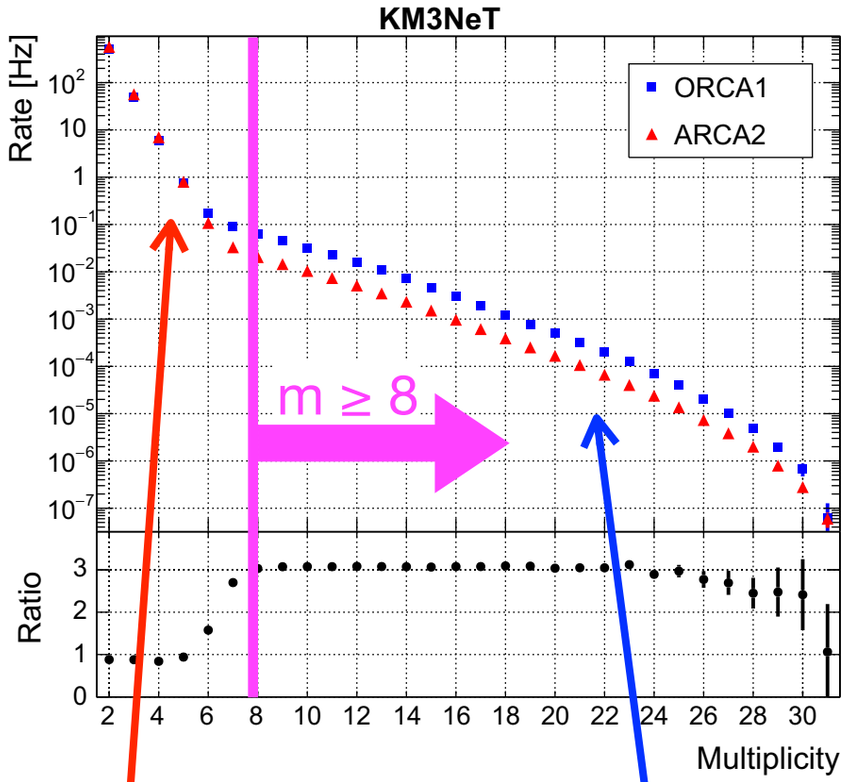
ARCA2 + ORCA1

μ

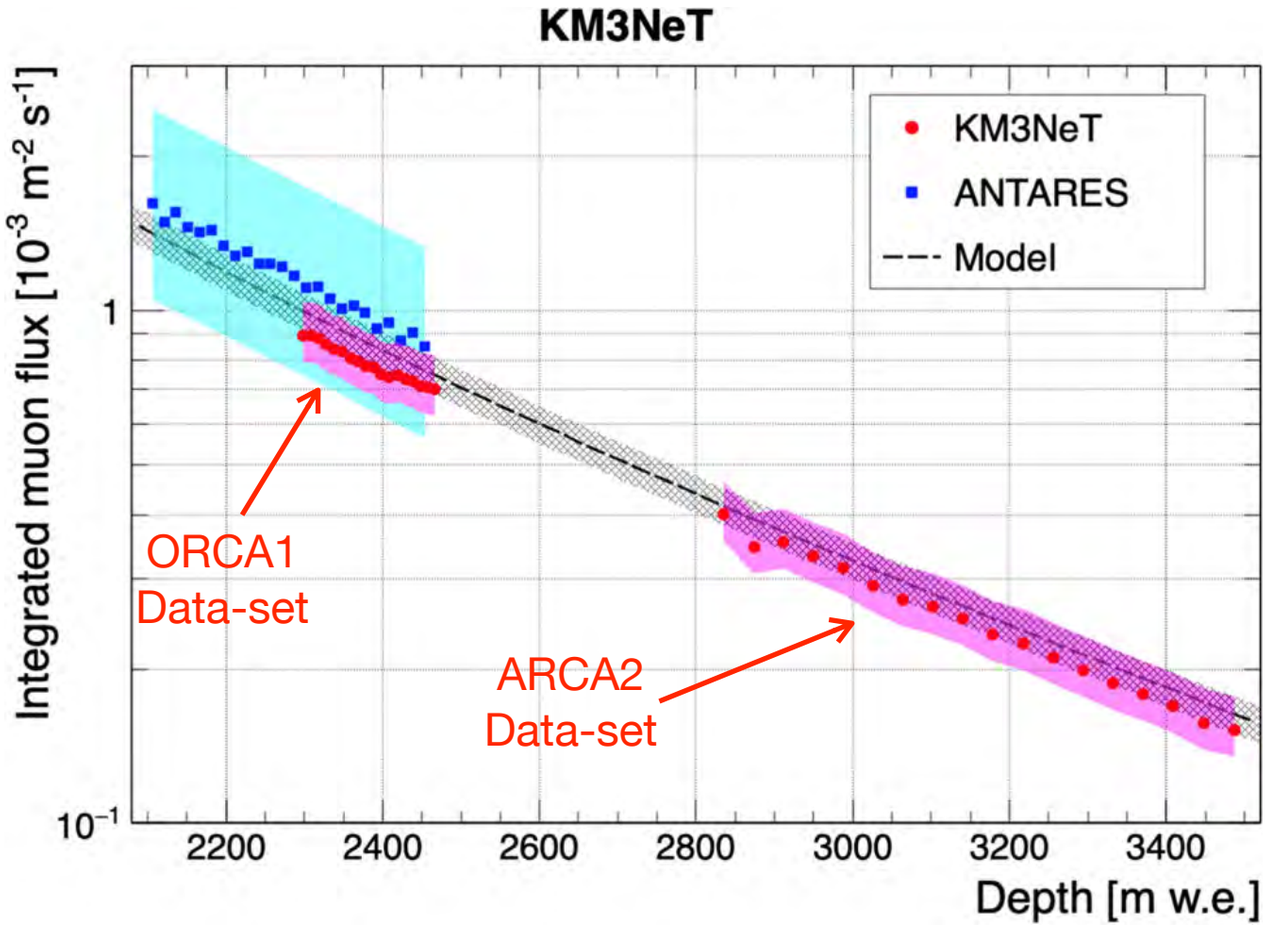




Optical background
(^{40}K decay)

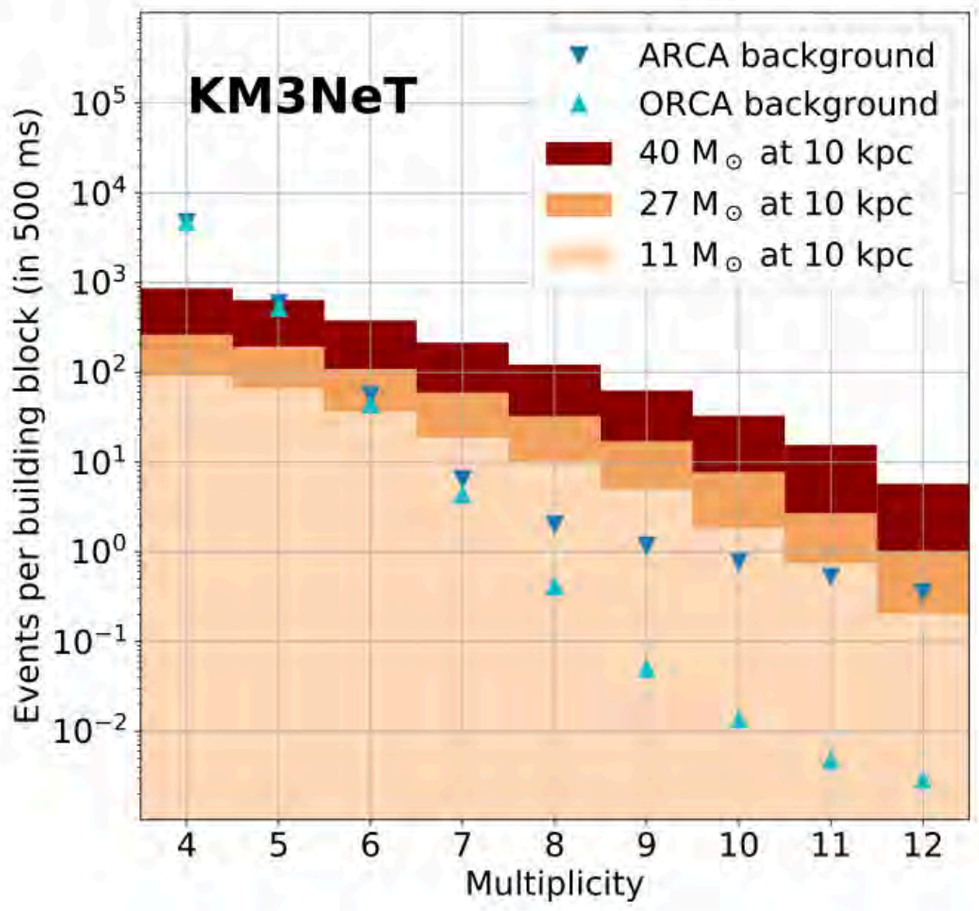
Atmospheric muons

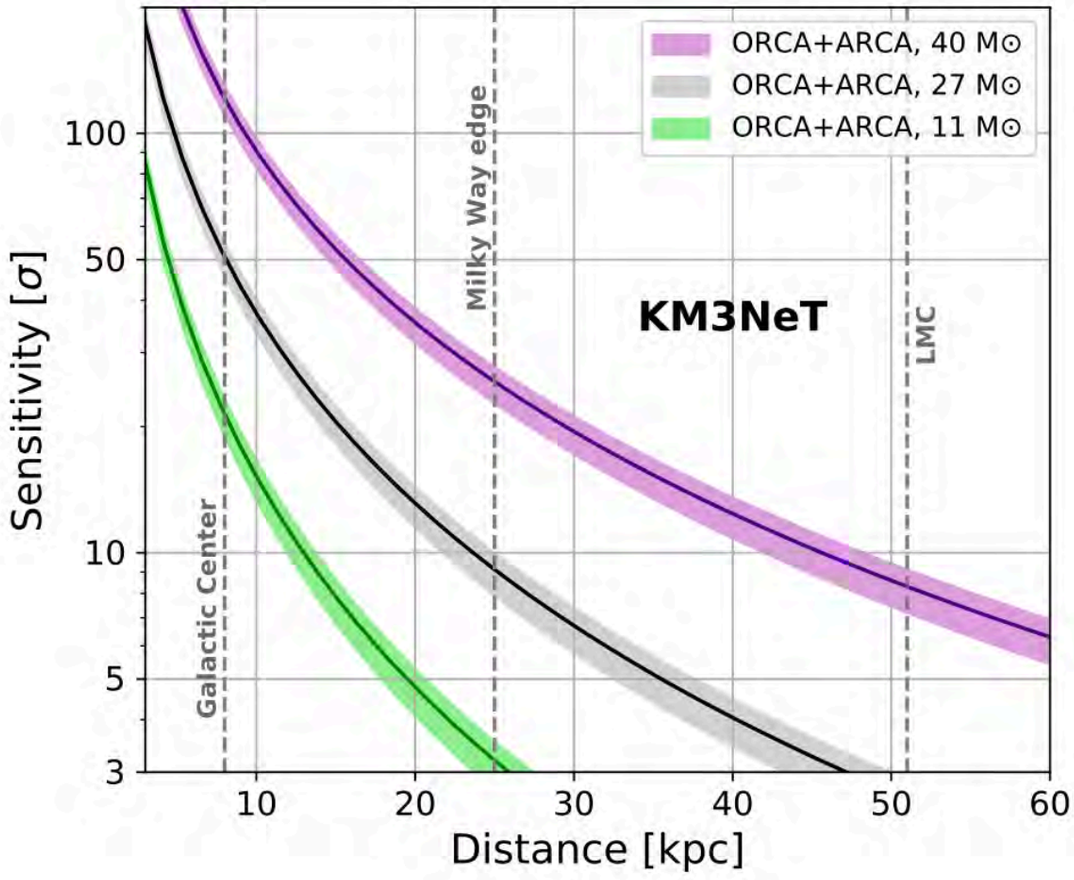
- Single-DOM measurement
- Useful to validate the calibration process
- Results compared with ANTARES and Bugaev model



Core Collapse Supernovae

Eur. Phys. J. C81 (2021) 445





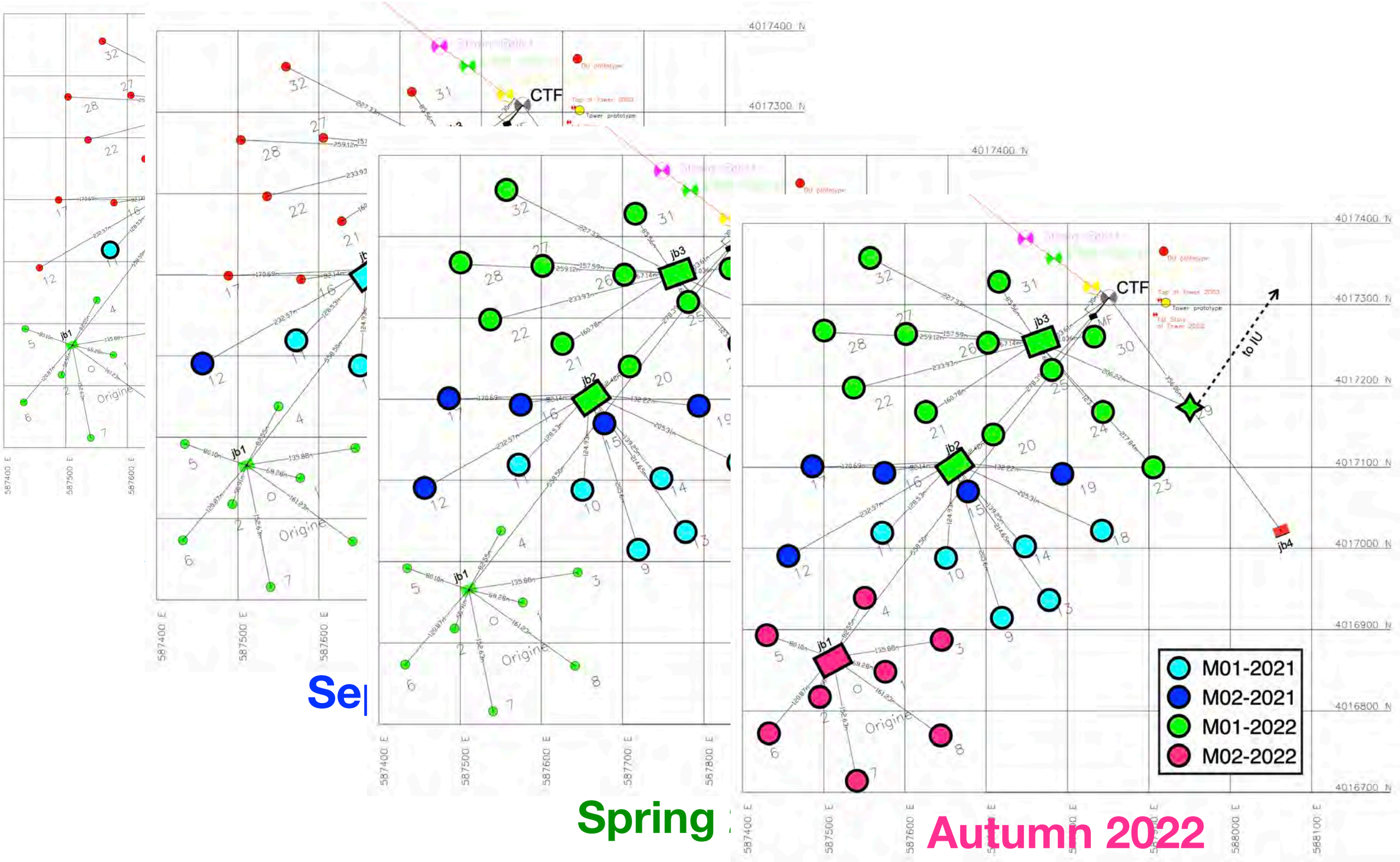
ORCA 1 BB + ARCA 1BB

> 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

Next steps

Planned ARCA sea campaigns



Se

Spring

Autumn 2022

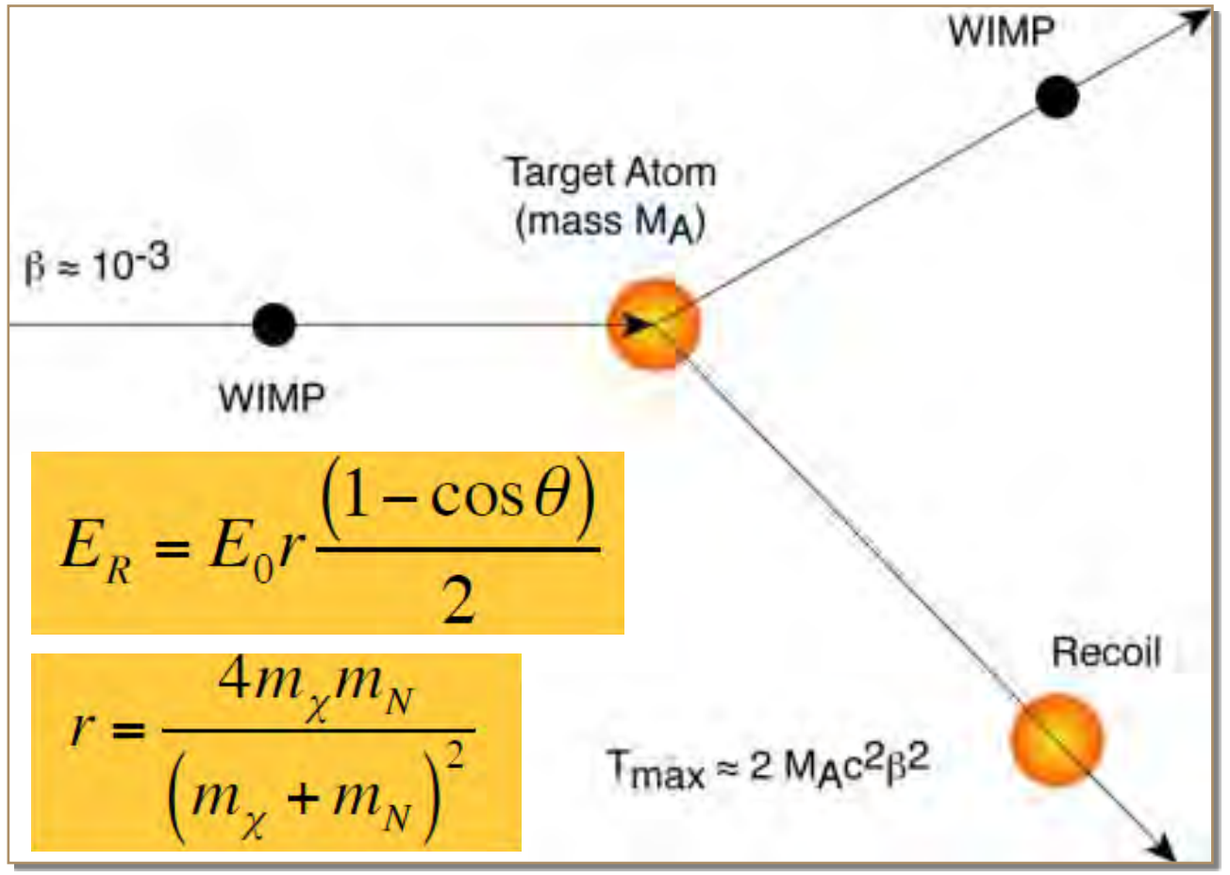
DarkSide

Loc. coord. Luciano Pandola

Physics background

- Search for **dark matter** in the form of Weakly Interacting Massive Particles (WIMPs), using a dual-phase TPC with low-radioactivity LAr
  - WIMP is a favourite candidate, but there are many others
- Signature: low energy (< 100 keV) nuclear recoil produced by WIMP elastic scattering
  - Backgrounds: e^- recoils, neutron-induced recoils

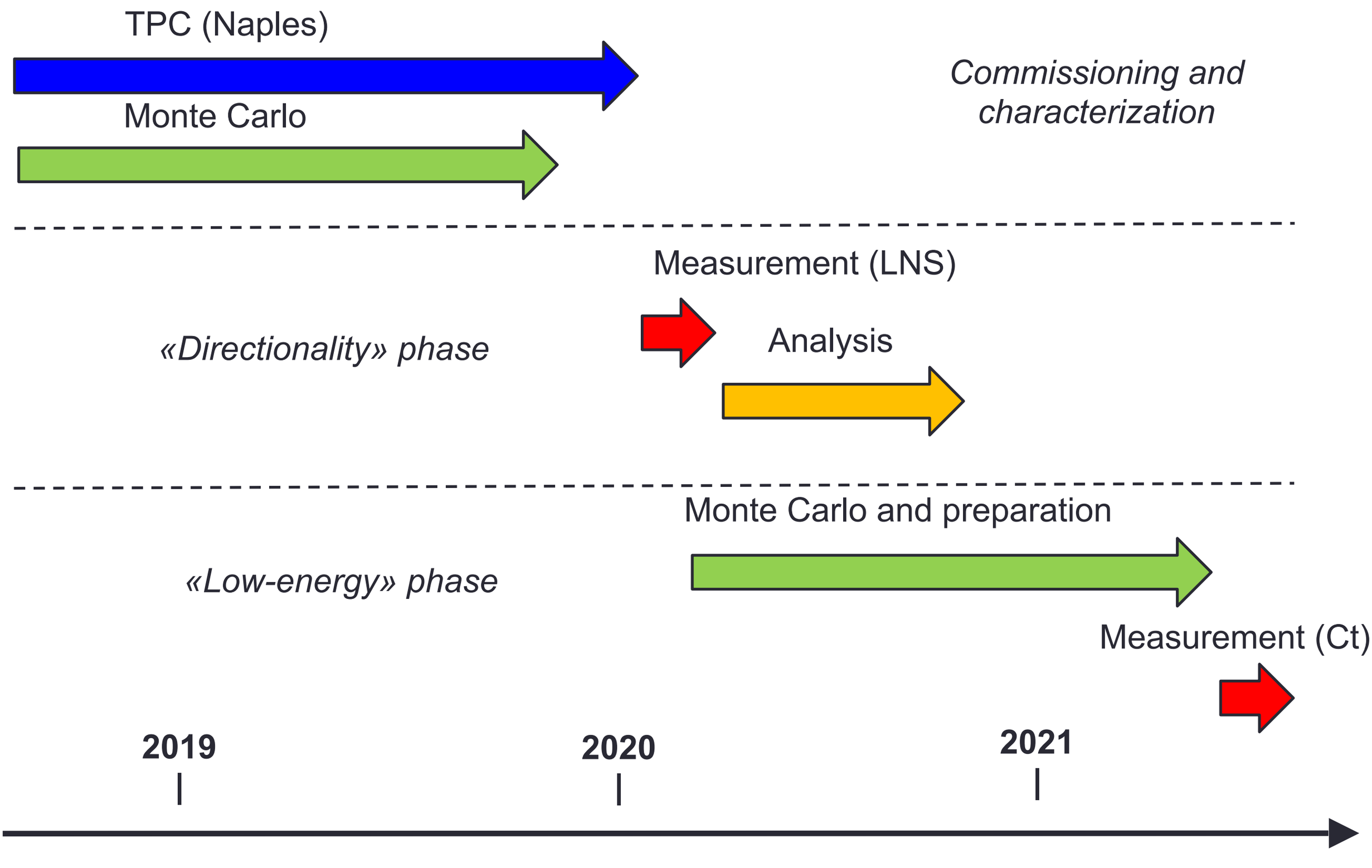
- Global effort worldwide:
  - Rates in the range from 10^{-1} to 10^{-6} events / (kg·day)
  - next generation experiments should eventually reach **exposures** in the range of **kton· day**
  - Need very low background level (and underground site)



DS activities@ LNS

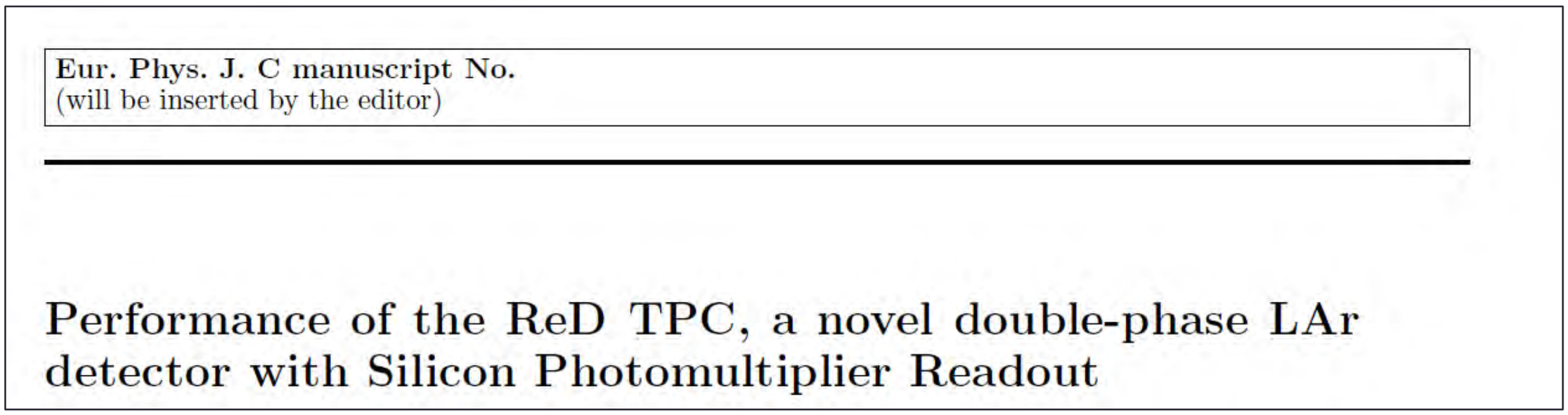
- Main involvement is in the **ReD project**, whose goals are:
  - demonstrate that a dual phase LAr TPC has a potential sensitivity to the direction of Ar recoil;
  - characterize the response of the LAr TPC to very low-energy recoils (< few keV) → recently became a **hot topic (S2-only)**
  - act as a test bench of the technical solutions for DarkSide-20k TPC
- Nuclear recoils of known directions can be produced by neutron elastic scattering
- **Beam at LNS**: we hosted the measurement by delivering a neutron beam via ^{7}Li+p reaction and by taking care of the logistics; provide the ΔE/E Si Telescope
  - Beam run (tailored to *directionality*): **done in February 2020** (^{7}Li beam)
- During the **beam stop**:
  - run a dedicated calibration with a **fission neutron source (^{252}Cf)** → focus on low-energy recoils
  - Cooperation with the DarkSide group @Sezione

Timeline of the ReD project – three phases



Phase 1 – Commissioning (Naples)

- TPC Commissioning (at INFN Naples)
- Key results:
  - System (w/ cold SiPM) **stable** for many months (< 1% rms in SER)
  - Light response good 9.80(21) PE/keV at ^{241}Am and stable (< 2%)
  - TPC performance (g1, g2, $\sigma_{S2/S1}$) appropriate for the directionality runs
  - g1 and g2, S1-S2 anti-correlation, fit of recombination model
- **Paper** available with the summary of results
  - arXiv 2106.13168 (June 24th)
  - submitted to Eur. Phys. J. C

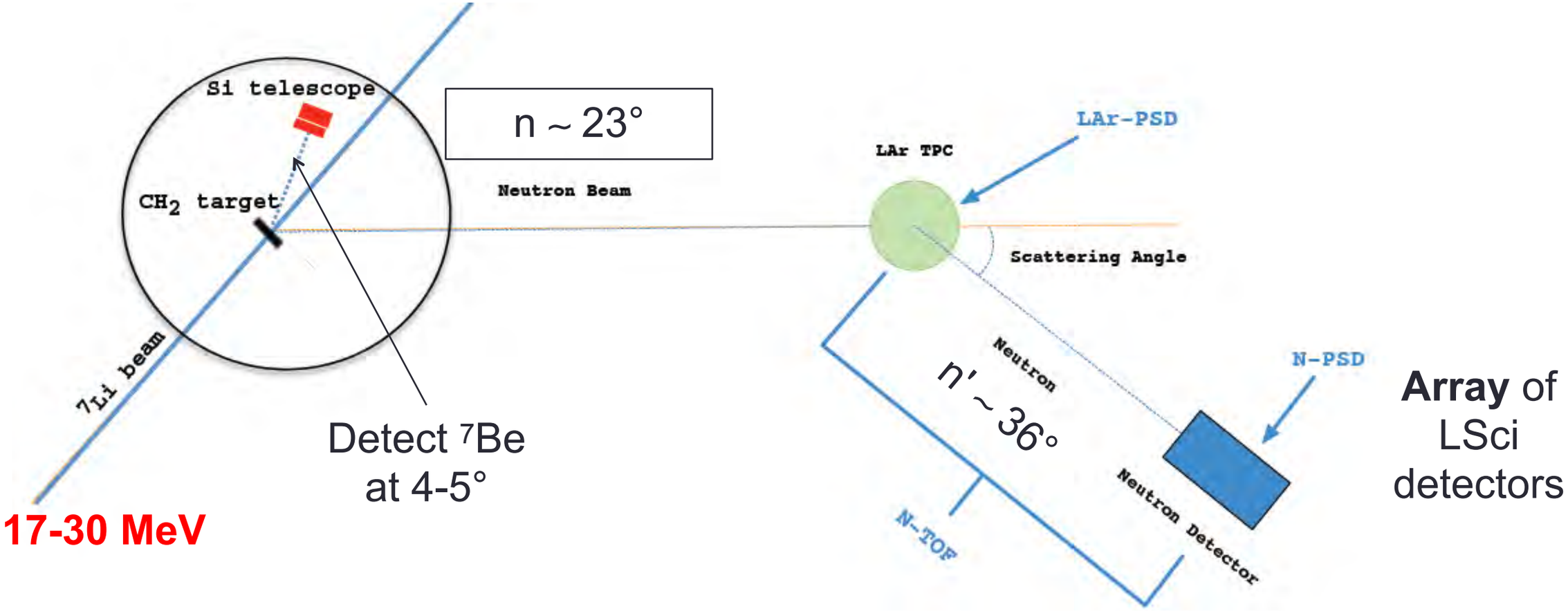


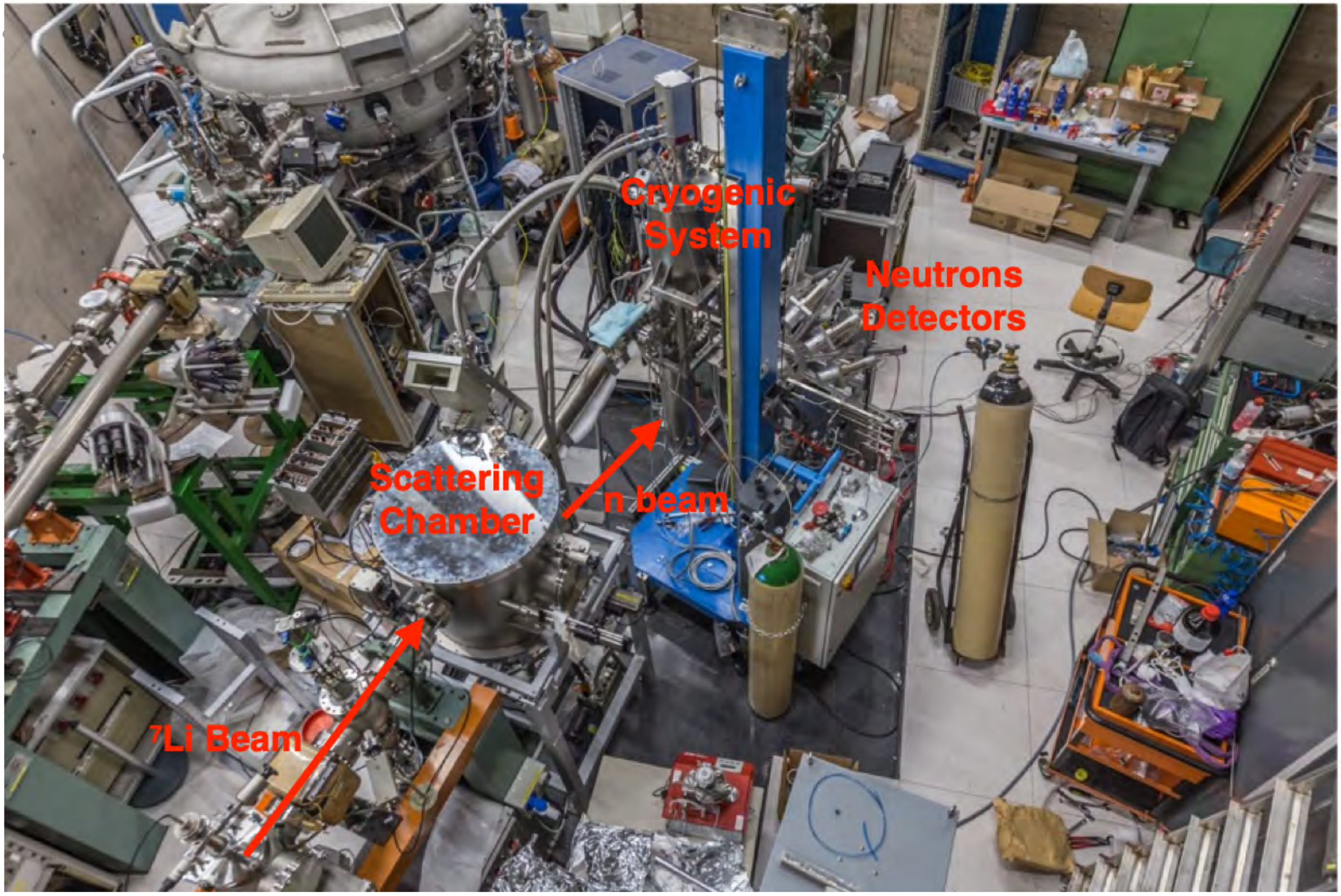
Eur. Phys. J. C manuscript No.
(will be inserted by the editor)

Performance of the ReD TPC, a novel double-phase LAr detector with Silicon Photomultiplier Readout

ReD measurement@LNS – recap

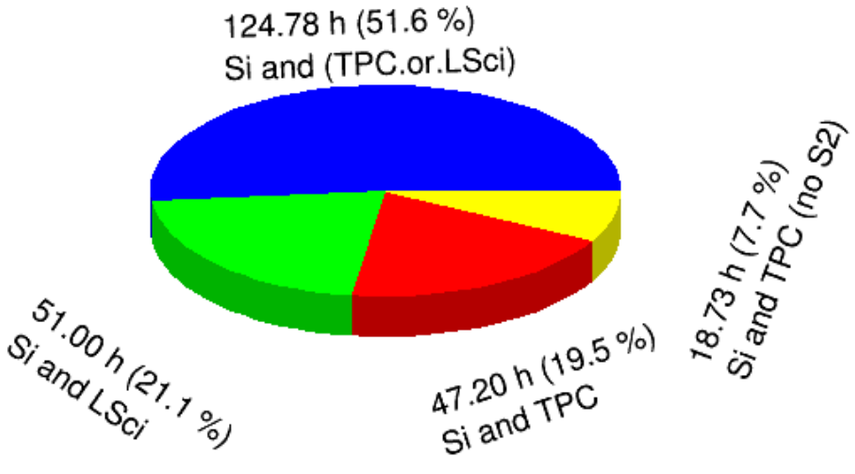
- Use a neutron beam produced via **p(^{7}Li,n)**
  - TANDEM accelerator at LNS, Catania
- Detect the associate particle (^{7}Be) and ToF to **tag neutron energy** event by event (fixed by kinematics)




Cryogenic System
Neutrons Detectors
Scattering Chamber
n beam
^{7}Li Beam

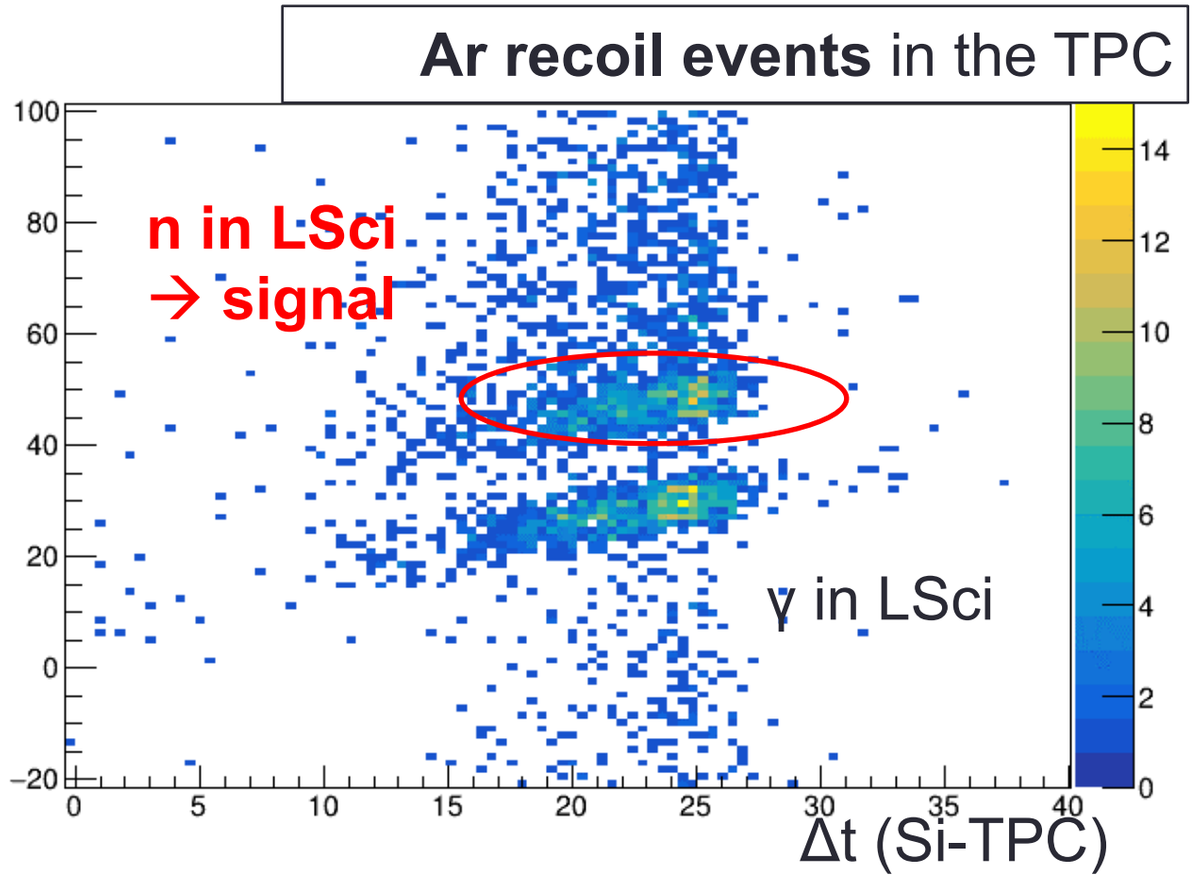
Phase 2– Directionality run (LNS)

- Neutron beam run at LNS, shortly before the lockdown (Feb 1st to Feb 14th)
- In total, 124 runs are selected for the final analysis
  - Total time: 241.7 h (= 10.07 days)
- Daily calibrations with laser and ^{241}Am
  - Special laser runs w/ source and beam on
- Data analysis **finalized**, under internal review
- Report results about directionality in a scientific paper
  - Submit abstracts and presents results (or at least *appetizers*) in the fall conferences

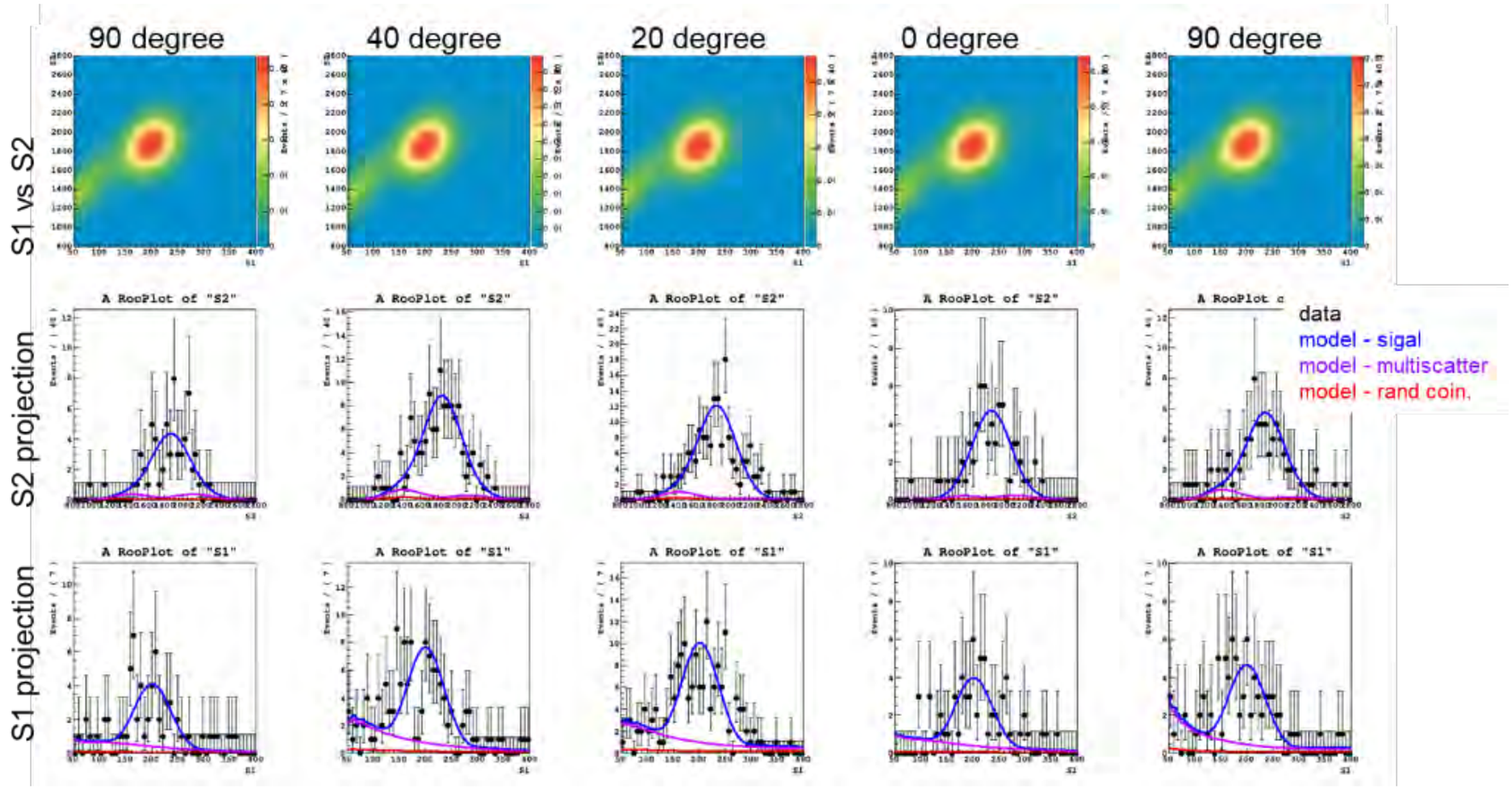


ReD run @ LNS

- Very clean identification of three-fold coincidences **(Si ∧ TPC ∧ n-Spectrometer)** events
  - based on: ^{7}Be tagging, timing and possibly PSD (TPC and LSci)

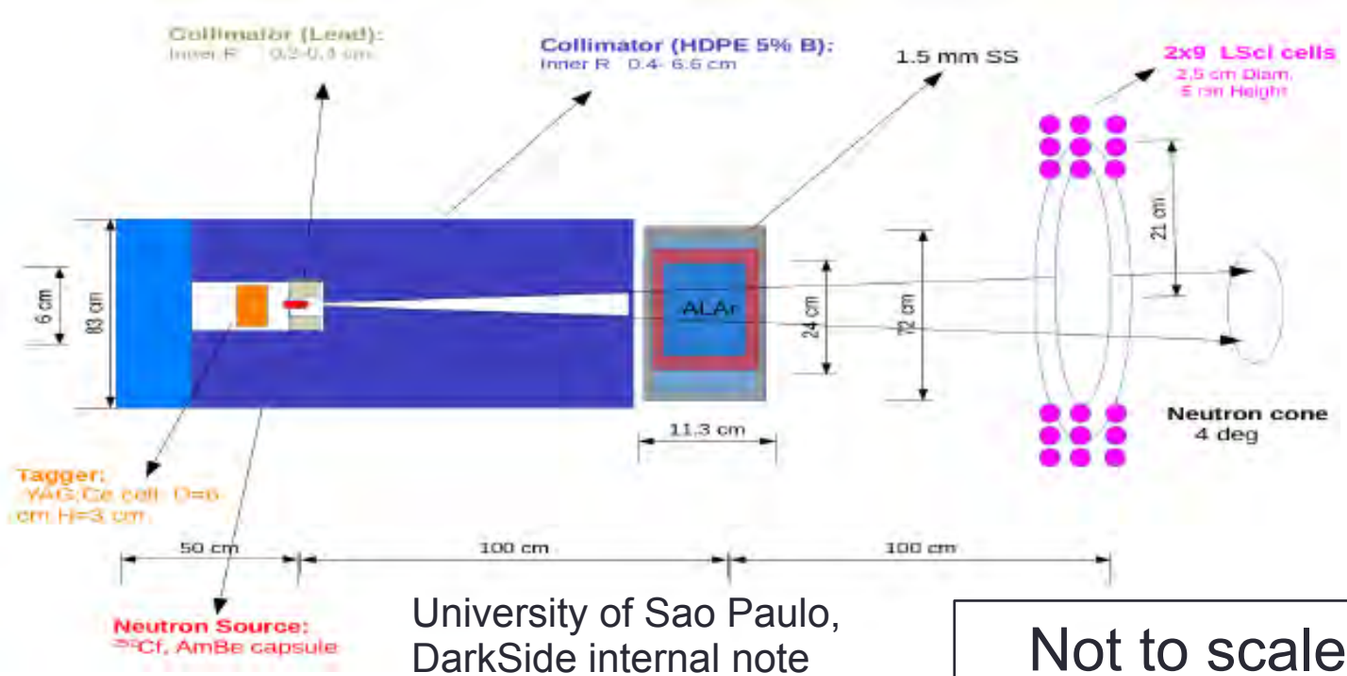


- Statistical analysis (unbinned likelihood)



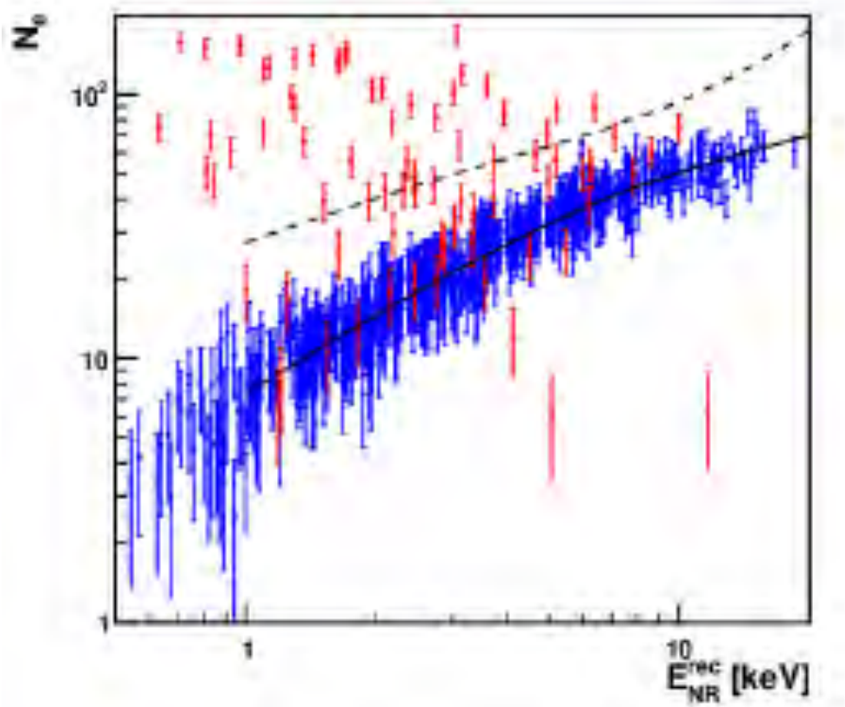
Phase 3 – Low-energy phase (INFN-Ct)

- Low-energy recoil measurements (< few keV) by using neutrons from a **^{252}Cf fission source**
  - Neutrons **O(2 MeV)**, more appropriate for **E_{rec} ~ few keV**
  - Directionality **not** possible
  - Use close fission tagger (BaF_2) and time of flight
- Implement conceptual design from Sao Paulo group
- Neutron spectrometer to detect neutrons scattered off-Ar re-designed
  - Use 1-inch plastic scintillators, instead of 3-inch liquid scintillators



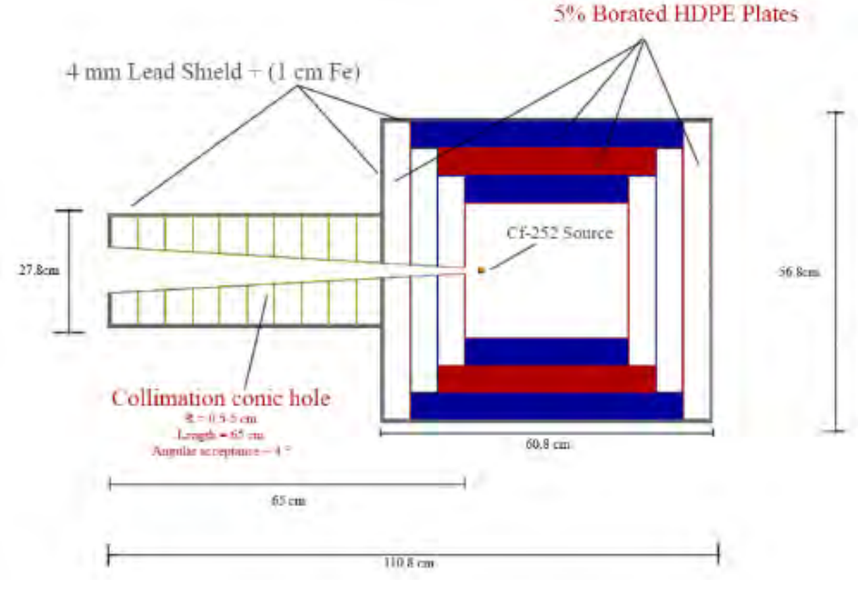
University of Sao Paulo, DarkSide internal note

Not to scale



Phase 3 – Low-energy phase

- ReD setup moved to INFN – Sezione di Catania to continue the programme
- Plan 2-3 weeks of data taking with ^{252}Cf and 4-6 weeks of background →fall of 2021
  - Expected O(1) cpm of triple-coincidences (1.5 MBq source)
- Sensitivity down to 2-5 keV_{NR}
  - Limited by accidental coincidences
  - Possible improvements but need bigger TPC and better layout
    - Application submitted for a PRIN
- Calibrate with **^{37}Ar** and **^{83m}Kr** before warm-up
  - Response to ER in the same energy range
  - Slipping to 2022



URANIA Facility

- The URANIA plant will extract and purify the underground Ar (low in ^{39}Ar) from the CO_2 wells at the Kinder Morgan Doe Canyon Facility, Colorado
  - Plant **built** at the Company site
  - 95% completed
- Expected production: 50 tons
  - To be purified and further depleted by distillation in the ARIA facility
- LNS actively involved in the design and construction of the plant (G. Schillaci)

Nu_at_FNAL

Loc. coord. Carla Distefano

DEEP UNDERGROUND
NEUTRINO EXPERIMENT

NU_AT_FNAL

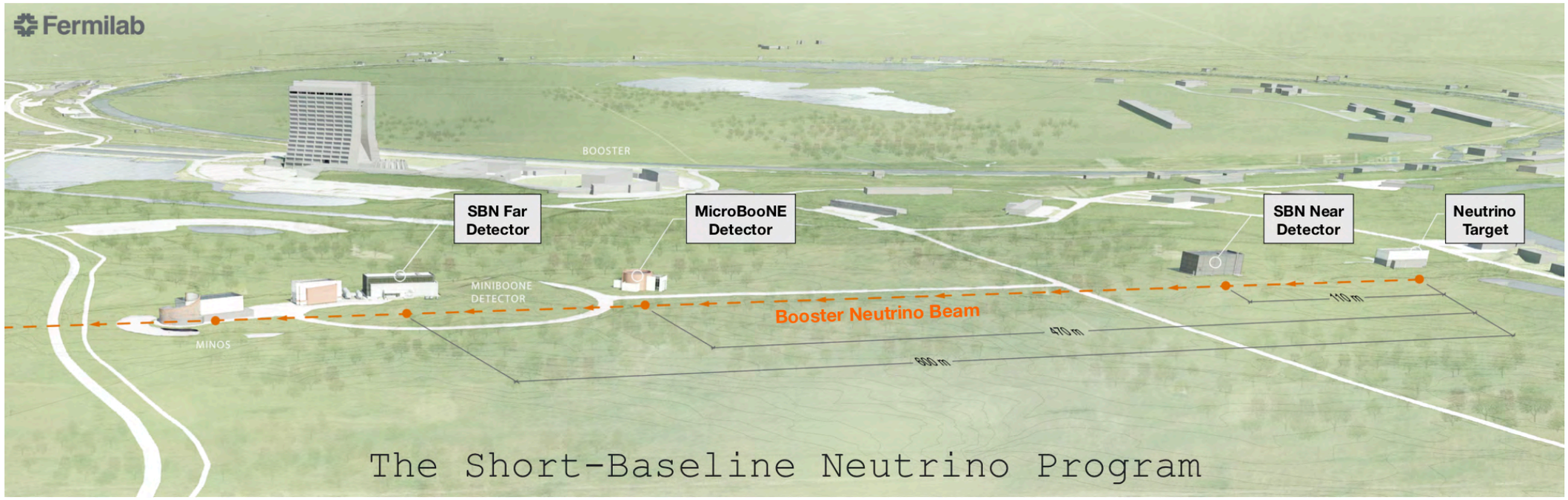
Research program funded by CSN2, including two experiments related to neutrino physics at Fermi National Accelerator Laboratory (FNAL):

SBN (Short Baseline Neutrino) Experiment → sterile neutrinos (eV-scale)

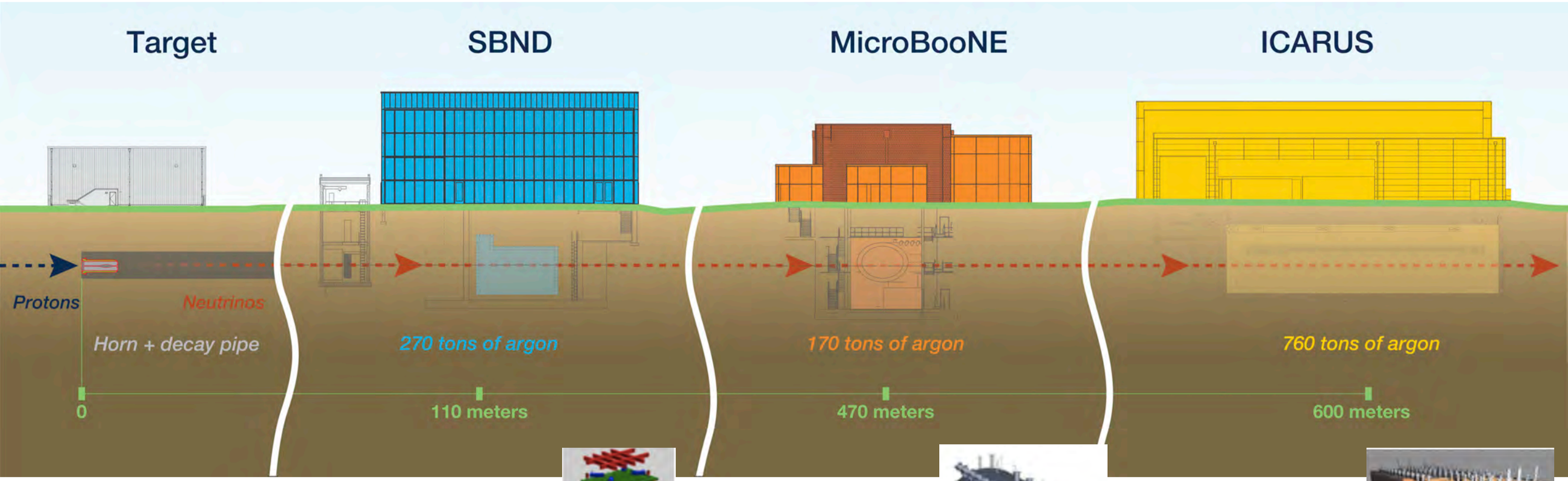
DUNE (Deep Underground Neutrino) Experiment → CP violation

SBN: lay-out

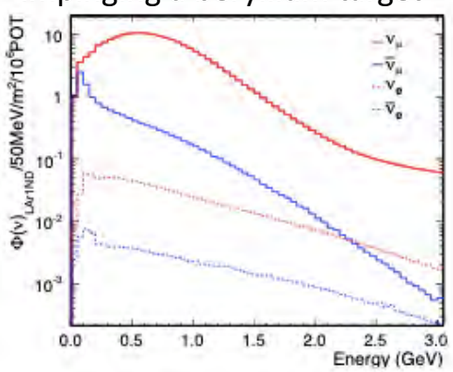
Three liquid argon time projection chamber (LArTPC) detectors in the Booster Neutrino Beam (BNB) at Fermilab.



- using the same target/technology for near, medium and far detector reduces systematic uncertainties
- make a high precision measurement on ν-Ar cross sections (1 yr: 1.5 million ν_μ and 12,000 ν_e)
- develop LArTPC technology for future large neutrino experiments like DUNE



8 GeV protons from the Booster accelerator impinging a beryllium target



arXiv:1503.01520

- LArTPC
- 110 m from ν production
- 112 ton active volume
- 2x2.0 m drift length
- 100 kV high voltage
- 1.28 ms drift time at 500V/cm
- 3 wire planes: 0, ∓60 deg, 3mm wire pitch, 11264 wires
- Cold analog and digital electronics
- 120 8" PMTs && scin. bars

- LArTPC
- 470 m from ν production
- 85 ton active volume
- 2.56 m drift length
- 128 kV high voltage
- 1.6 ms drift time at 500V/cm
- 3 wire planes: 0, ∓60 deg, 3mm wire pitch, 8256 wires
- Cold analog/warm digital electronics
- 32 8" PMTs

- LArTPC
- 600 m from ν production
- 476 ton active volume
- 4x1.5 m drift length
- 75kV high voltage
- 0.95 ms drift time at 500V/cm
- 3 wire planes: horizontal, ∓30 deg, 3mm wire pitch, 53246 wires
- Warm analog and digital electronics
- 360 8" PMTs

ICARUS

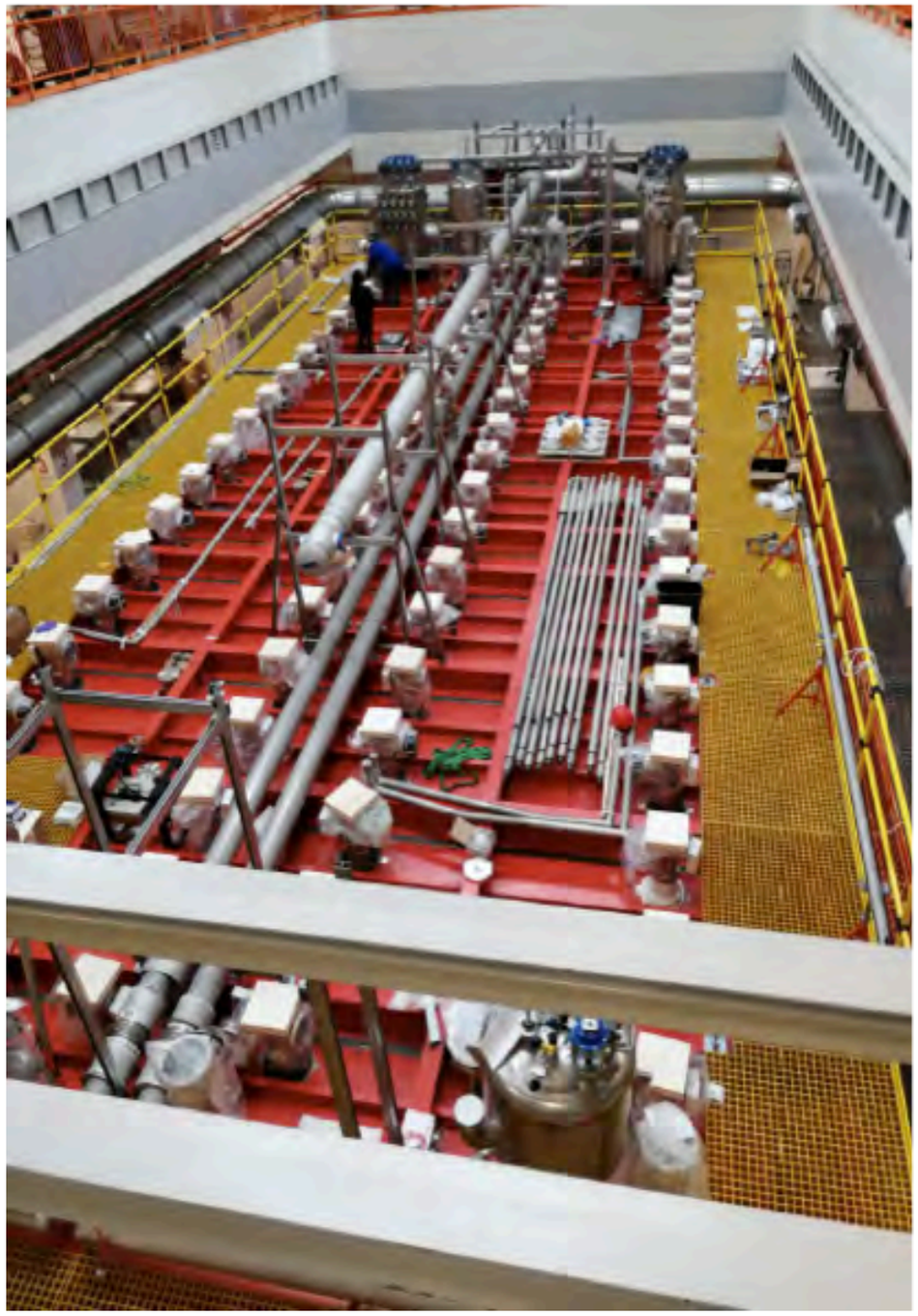
LNS group in ICARUS Collaboration

Commissioning is going on

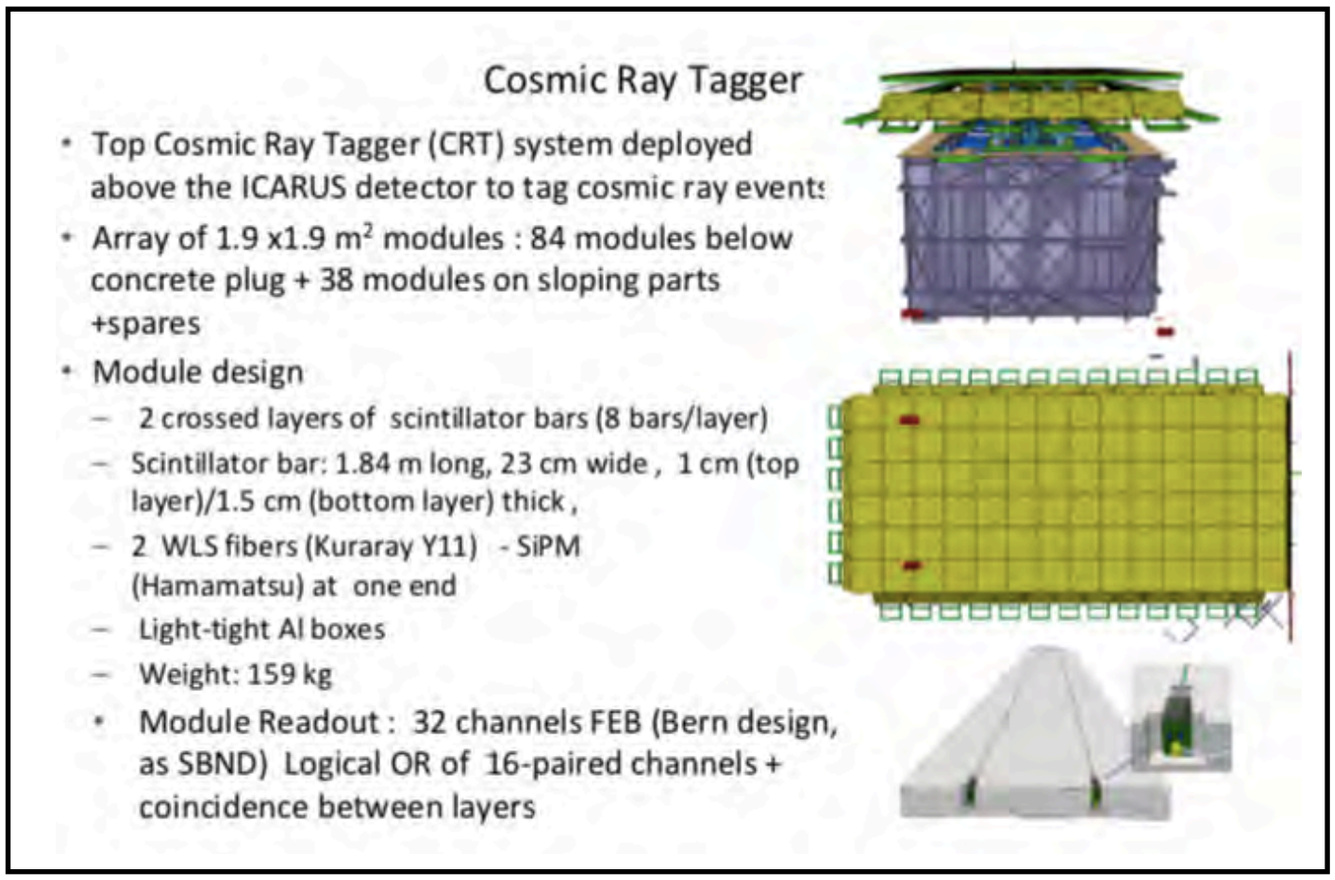
- started in mid 2020 with cosmic rays
- first runs with neutrino beam earlier this year

LNS group in shift since July 2020

CRT installation and commissioning to be completed



ICARUS Cosmic Ray Tagger



At the nominal BNB intensity of 5×10^{12} pot/spill:

- 1 neutrino CC interaction every 240 spills
- expected cosmic rays rate of 1 every 55 spills

LArTPC (slow technology): drift times in the msec range, detectors at the surface record significant cosmic activity with each readout (5-15 muons per readout in SBN detectors)

⬇

Cosmic Ray Tagger (CRT)

LNS participated at construction and test of the ICARUS CRT (2019-2020)

CRT modules are at FNAL ready for installation (delay to Covid-19)

Start of installation and testing in summer (completed by the end of the year) → participation of the LNS group limited by COVID-19

DUNE: science program

- Neutrino Oscillation Physics → Universe is made of matter
  - Search for leptonic (neutrino) CP Violation (matter-antimatter asymmetry)
  - Resolve the mass ordering ($m_3 > m_{1,2}$ or $m_{1,2} > m_3$)
  - Precision oscillation physics
    - Parameter measurements, θ_{23} octant
    - Testing the current 3-neutrino model, non-standard interactions, ...

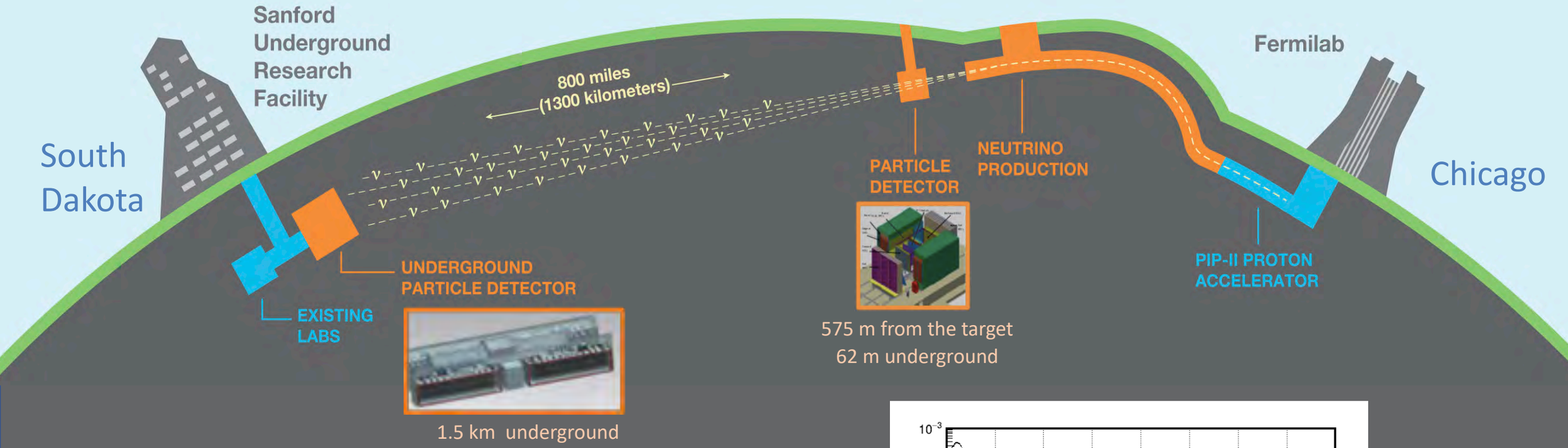
- Nucleon Decay → force unification

- Supernova burst physics (3000 ν_e events in 10 sec from SN at 10 kpc)
  → birth of a neutron star or a black hole

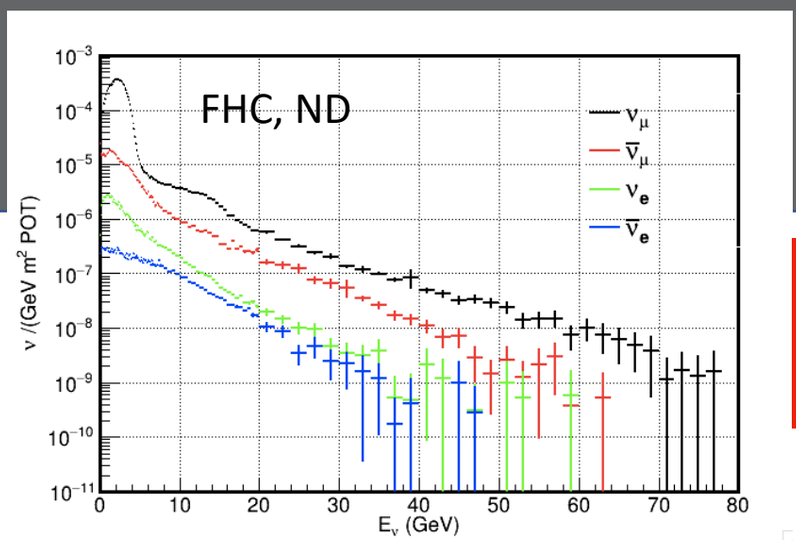
+ many other topics (ν interaction physics with near detector, atmospheric neutrinos, sterile neutrinos, WIMP searches, Lorentz invariance tests, etc.)

DUNE: overview

- Neutrinos from high-power proton beam: 1.2 MW from day one; upgradeable to 2.4 MW
- Massive underground Liquid Argon Time Projection Chambers: 4 x 17 kton fiducial mass of > 40 kton
- Near detector to characterize the beam (100s of millions of neutrino interactions)



On-axis detectors: broad neutrino energy range

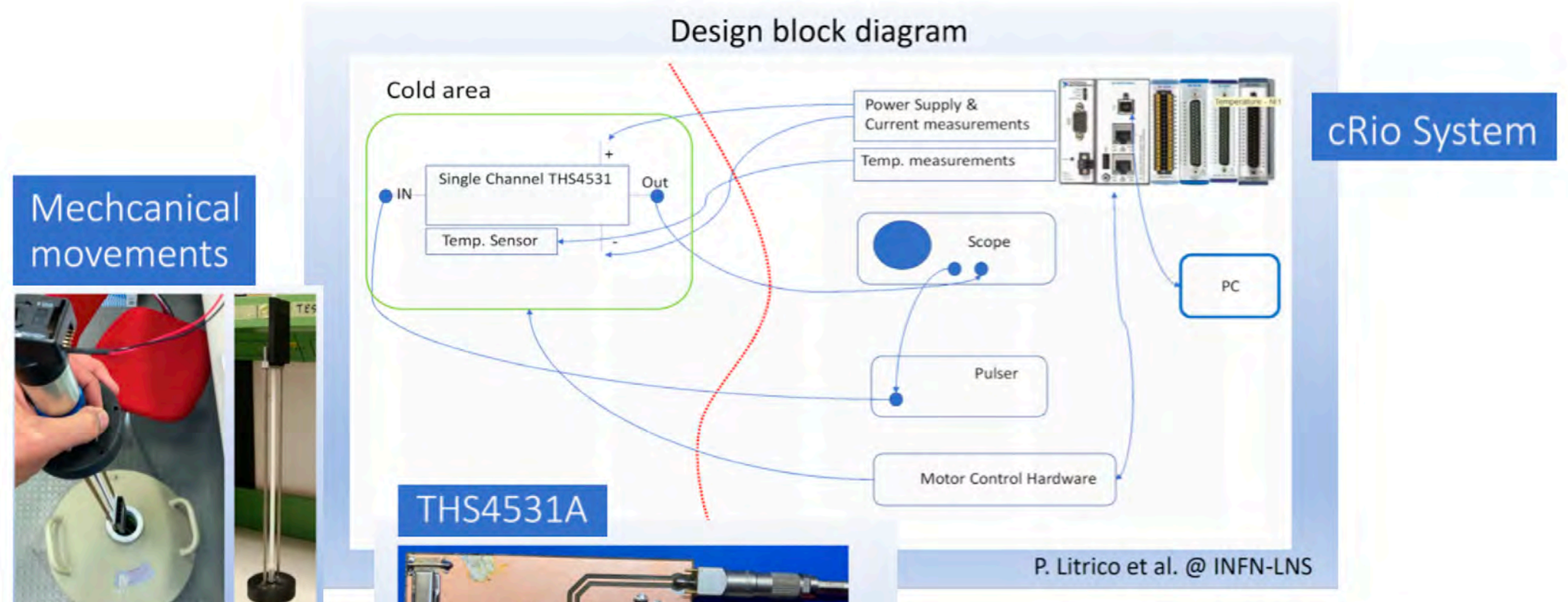


7.5×10^{13} protons every 1.2 seconds at 120 GeV

Photon Detection System

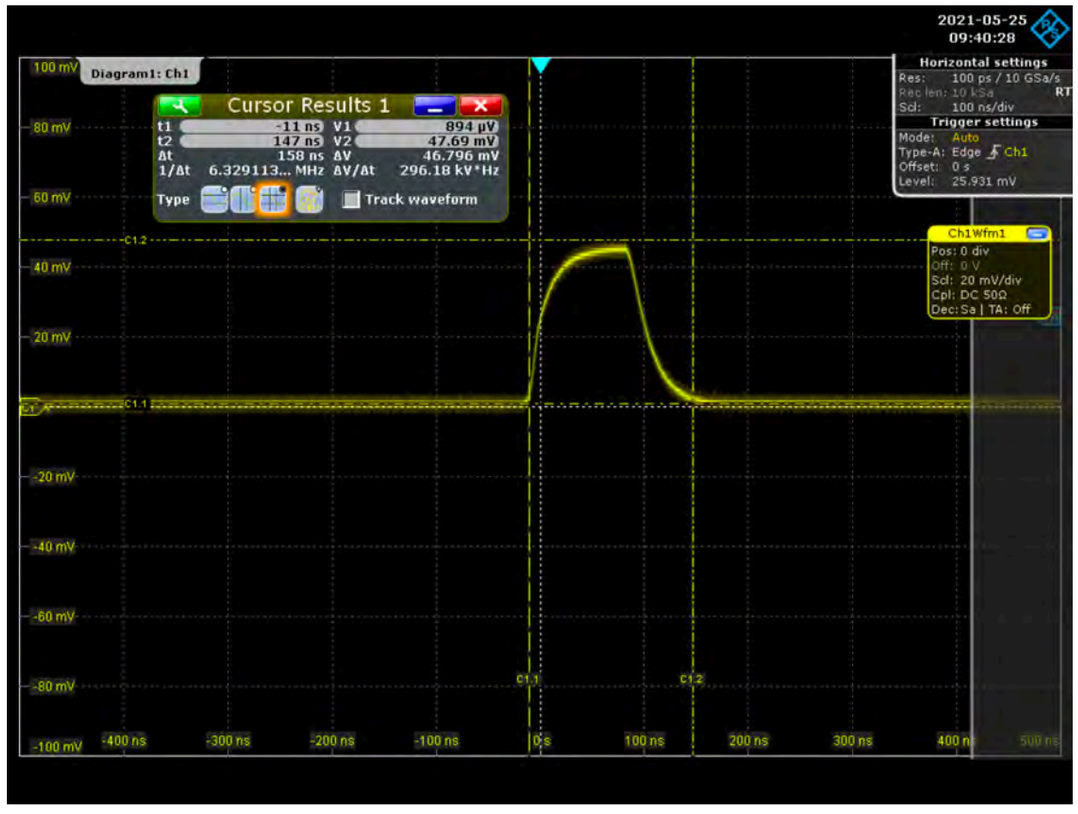
LNS responsible for Qualification of electronic components at cryogenic temperatures for the Far Detector

Prototype complete and working

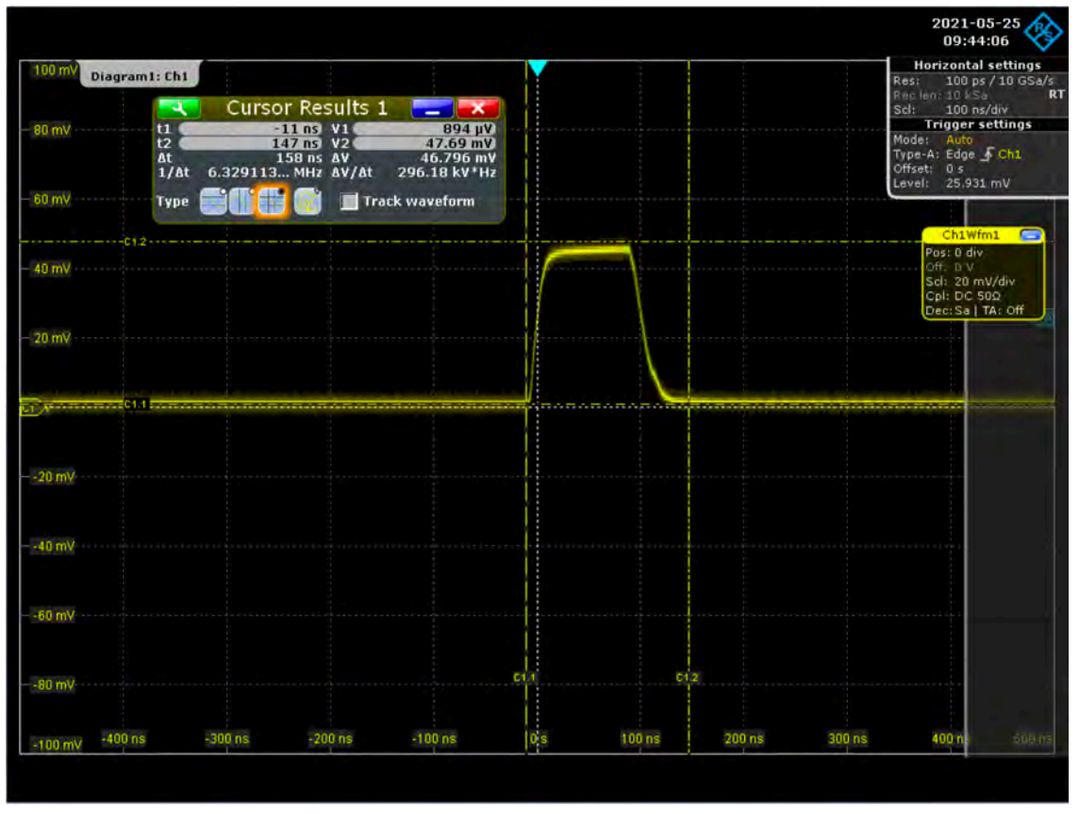


First results

THS4531 output @ ambient temperature



THS4531 output @ 77K



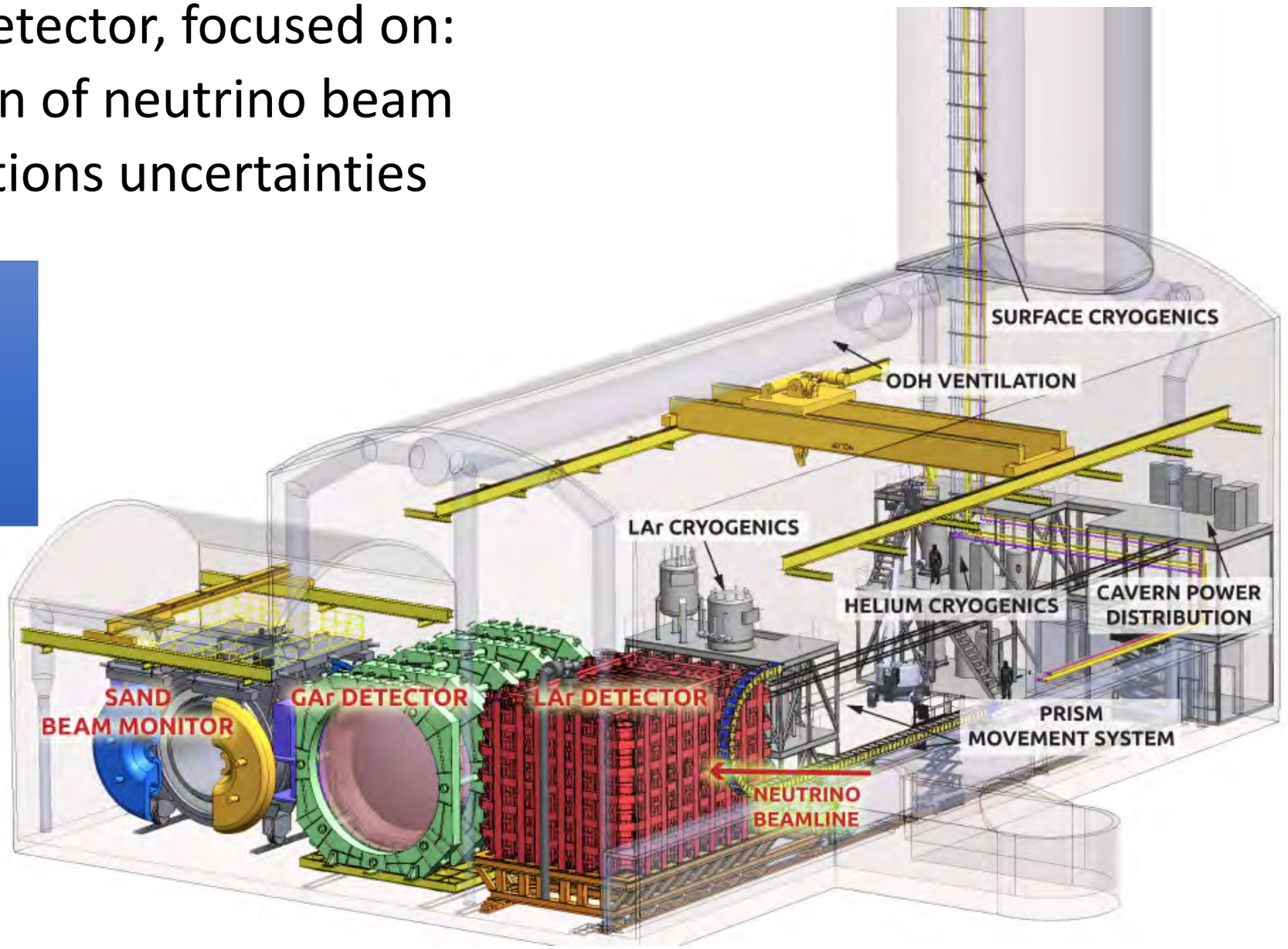
Next step: finalisation of full system for mass production

The Near Detector complex

Multi-technology Near Detector, focused on:

- Precise characterisation of neutrino beam
- Limitation of cross sections uncertainties

Italian group mainly involved in **SAND**



SAND will continuously monitor the rate, spectrum and profile of the neutrino beam → real time variations of the beam operating conditions

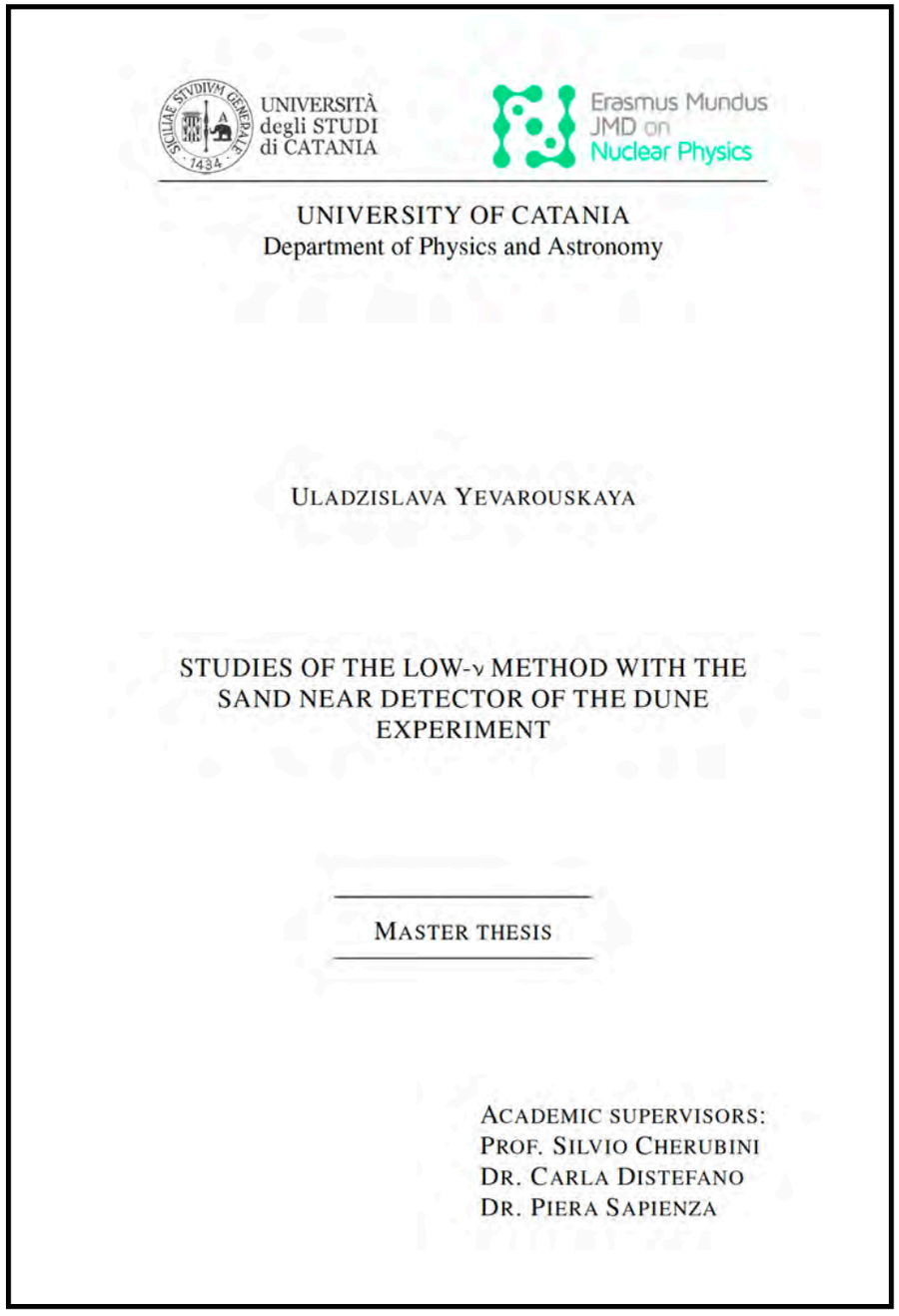
SAND is the only component that will be permanently located on-axis along the neutrino beam (the other systems will move off-axis for about 50% of the time).

LNS activities in SAND

Monte Carlo simulations: generation of neutrino events with GENIE, mass production

Possible application of low-nu method:

Inclusive CC neutrino cross section does not depend on the neutrino initial energy in the limit of low neutrino energy transfer to the hadronic system (ν → 0)


UNIVERSITÀ degli STUDI di CATANIA

Erasmus Mundus JMD on Nuclear Physics

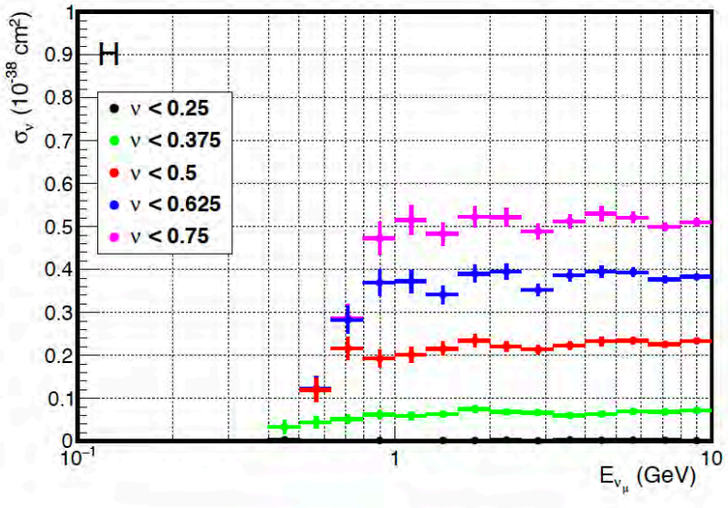
UNIVERSITY OF CATANIA
Department of Physics and Astronomy

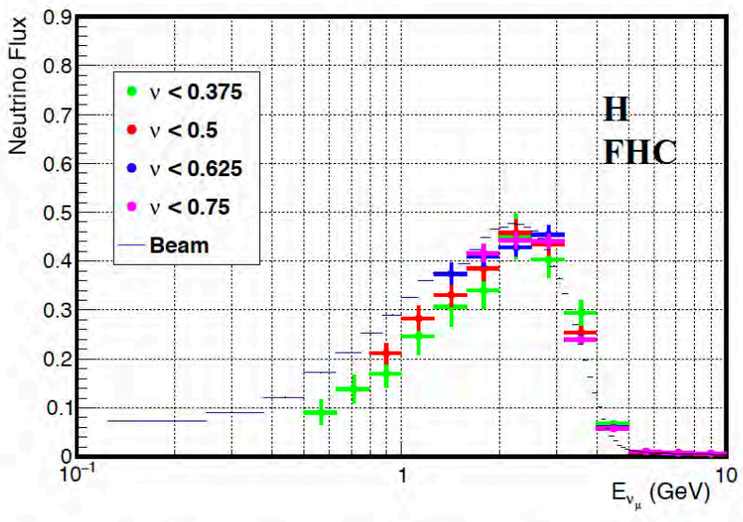
ULADZISLAVA YEVAROUSKAYA

STUDIES OF THE LOW-ν METHOD WITH THE SAND NEAR DETECTOR OF THE DUNE EXPERIMENT

MASTER THESIS

ACADEMIC SUPERVISORS:
PROF. SILVIO CHERUBINI
DR. CARLA DISTEFANO
DR. PIERA SAPIENZA





Virgo/ET

Loc. coord. Domenico D’Urso
Associated group University of Sassari

INFN UNISS Role

- VIRGO: Data analysis. Search for Burst Multi-messenger event candidates
- ET: Sos Enattos Characterization and Candidature

VIRGO: Status

- ➢ Detector upgrades on going (Ad Virgo+, Phase I)
  - ❑ Quantum noise reduction: implementation of a frequency-dependent squeezing system
  - ❑ Newtonian noise cancellation system installed
  - ❑ installation of the instrumented baffles around Input Mode Cleaner mirror, in order to reduce the diffused light
  - ❑ testing the new suspensions for heavier mirrors

- First observation of GW associated to the merge of a Neutron Star and a Black Hole:
  - GW200105 (8.9 and 1.9 solar masses)
  - GW200115 (5.7 and 1.5 solar masses)

VIRGO: UniSS/LNS Contribution

- Burst Multi-messenger events: Search for transient GWs signals associated with GRB and FRB during LIGO-Virgo third observational run

- Implementation of pre-filter trigger to distinguish event candidates by means of machine learning techniques
  - Hierarchical approach
  - Test on Monte Carlo data with very promising results.

VIRGO: Burst Multi-messenger events

GRB search

October 2019

1. Training X-pipeline
2. Analysis O3a
3. Opening boxes GRB O3a: Results
4. Run coordination team
5. GRB O3b network set
6. Testing newest version of X-pipeline
7. GRB O3b analysis
8. GRB O3b opening boxes
9. Results review
10. GRB O3b paper (ongoing work)

July 2021

FRB search

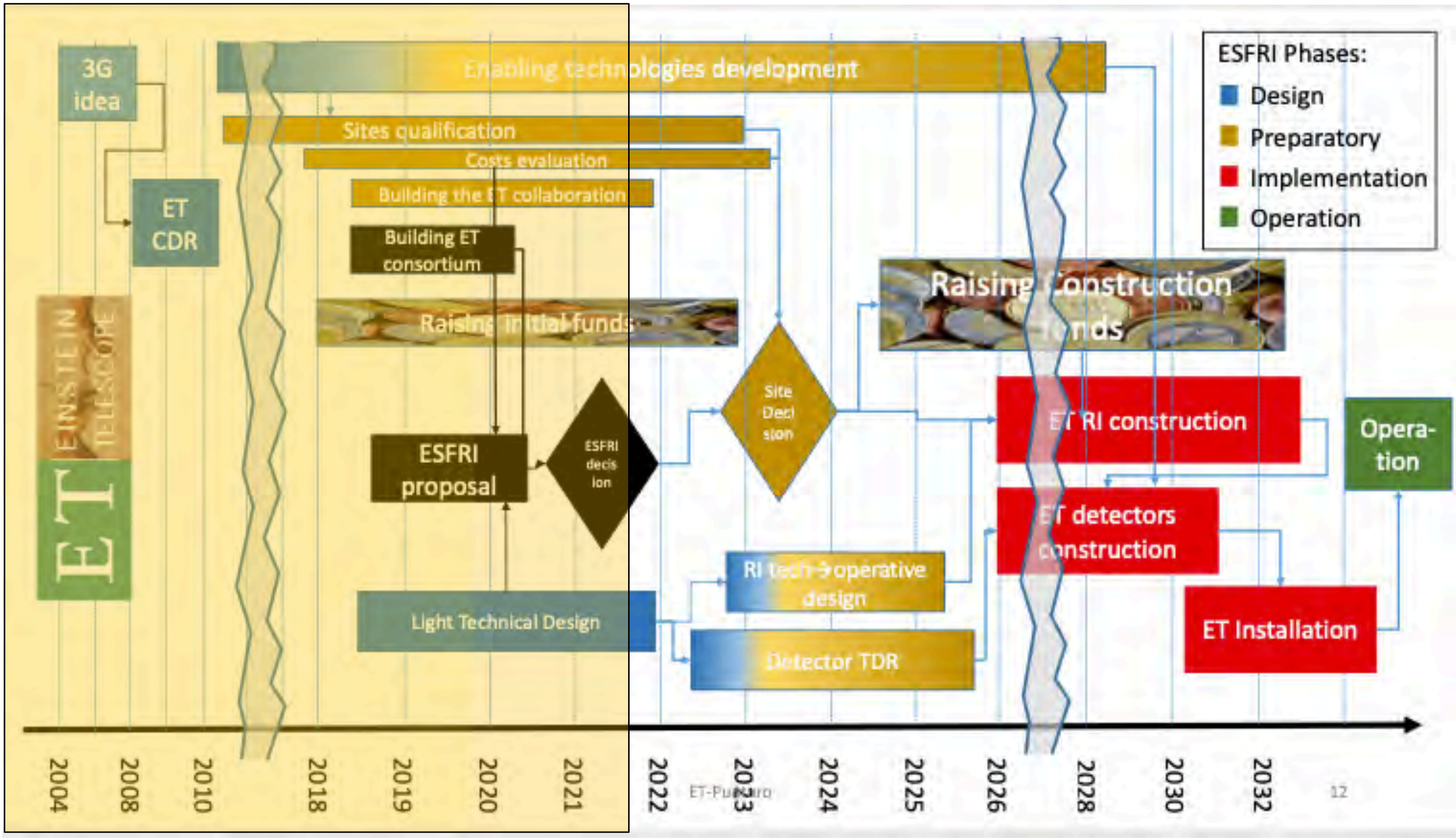
January 2020

1. Responsible for FRBs configuration analysis
2. FRBs to be analyzed
3. Setting the parameters of the search
4. Setting waveforms for FRB search
5. Minimum sky position uncertainty CHIME's localization sky uncertainty set
6. Latests modifications in the configuration file
7. .ini review
8. New set of FRBs (official FRB O3a analysis)
9. Analysis (ongoing work)
10. Review of the entire FRB analysis (ongoing work)
11. Paper (ongoing work)

July 2021

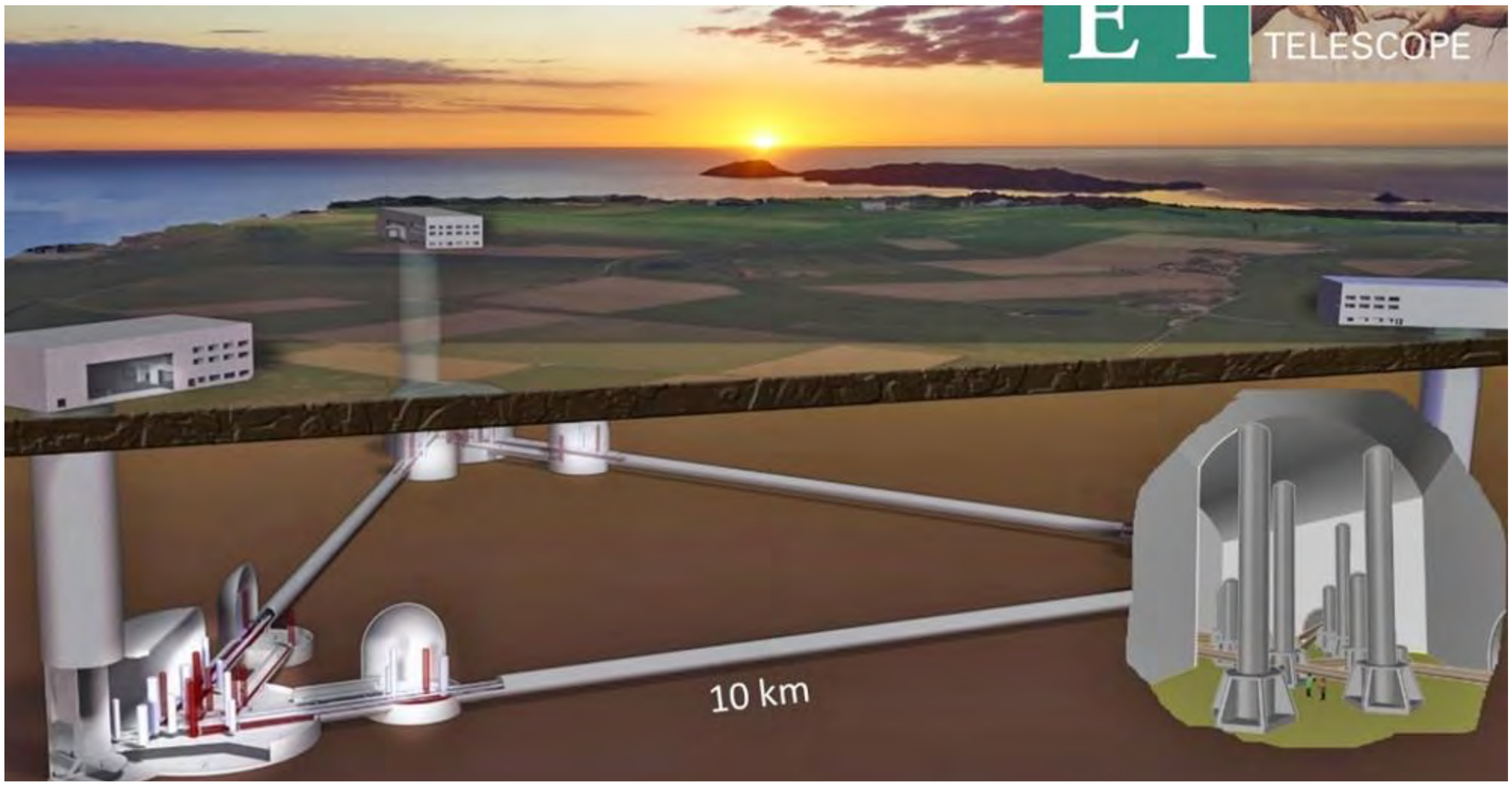
250 GRBs reported by Fermi and Swift, ~30 analyzed by LNS group

ET Roadmap


3G idea
ET CDR
EINSTEIN TELESCOPE
ET
Enabling technologies development
Sites qualification
Costs evaluation
Building the ET collaboration
Building ET consortium
Raising Initial funds
ESFRI proposal
ESFRI decision
Light Technical Design
Site Decision
RI tech→operative design
Detector TDR
Raising Construction Funds
ET RI construction
ET detectors construction
ET Installation
Opera-tion
ESFRI Phases:
Design
Preparatory
Implementation
Operation
2004
2008
2010
2018
2019
2020
2021
2022
2023
2024
2025
2026
2028
2030
2032
ET-Pathfinder
12

ET: ESFRI Proposal approved

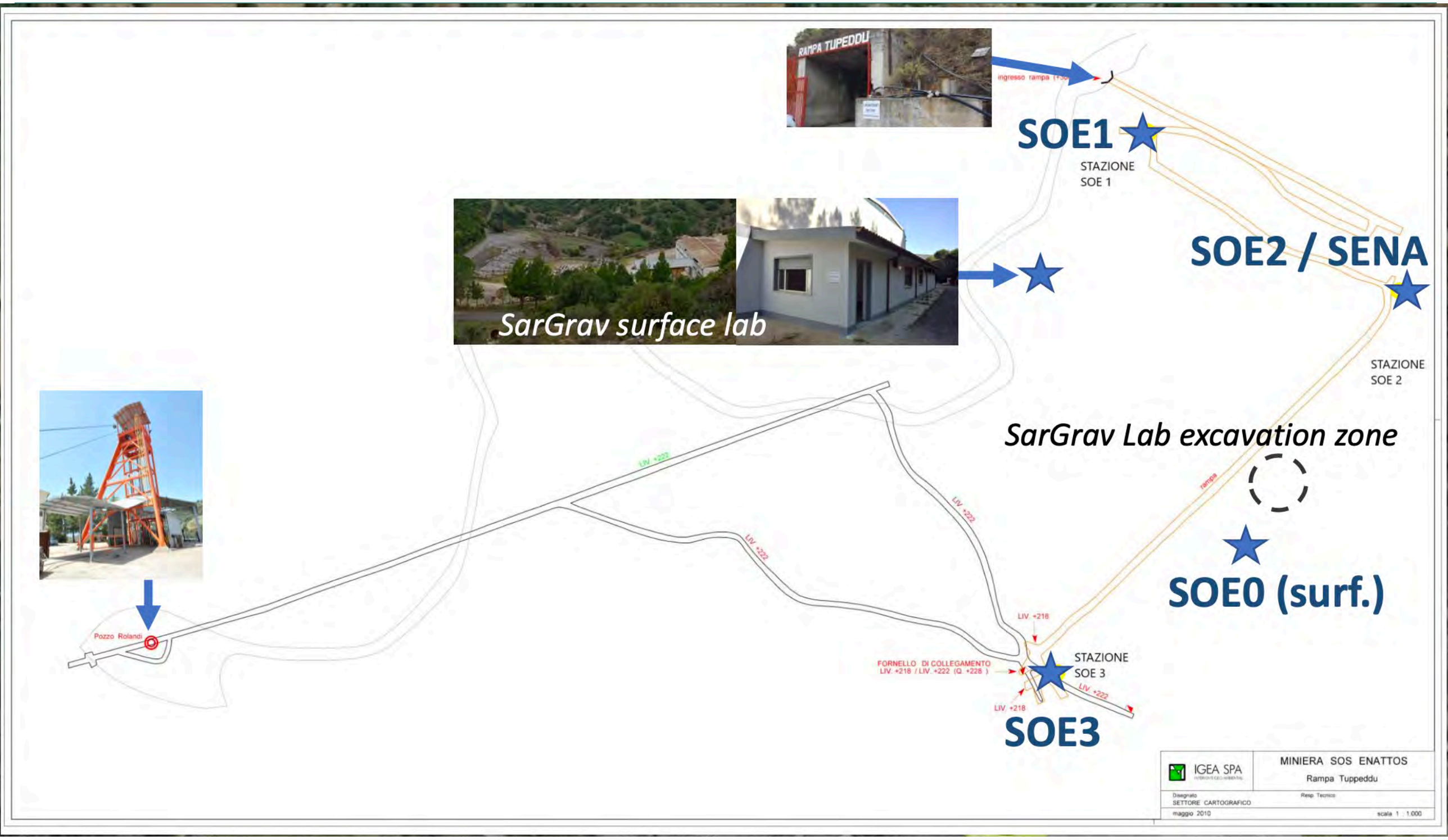
- On 30 June, the European Strategy Forum on Research Infrastructures (ESFRI) decided to include ET in the update of its roadmap for 2021.



ET: Sos Enattos Characterization

- Sensors on site
  - 4 broadband triaxial seismometers (1 surface vault installation + 3 underground)
  - 3 short-period triaxial seismometers (first *seed* of a new array)
  - 2 magnetometers (1 buried at surface, 1 underground)
  - High precision tiltmeter (Archimedes prototype)
  - Weather station
- Data acquired at the SarGrav control room, transmitted via UMTS link to remote server (INGV-PI server → ET repository) and through an INFN access point
- Underground station equipped with GPS signals for DAQ

Sos Enattos Measurement Stations

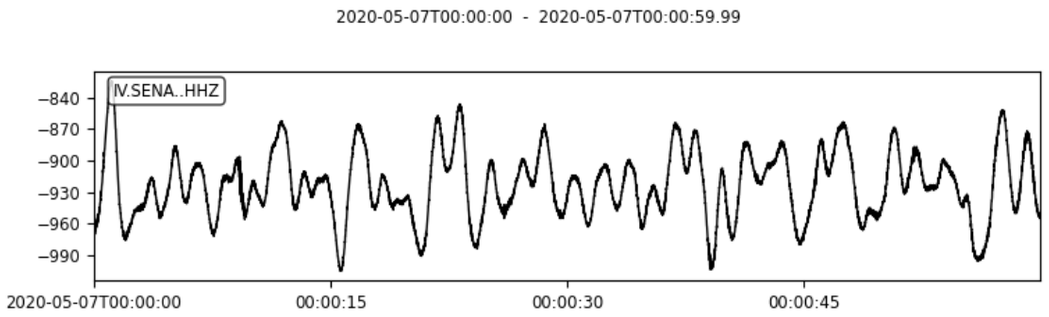


ET Sos Enattos Candidature: Next Steps

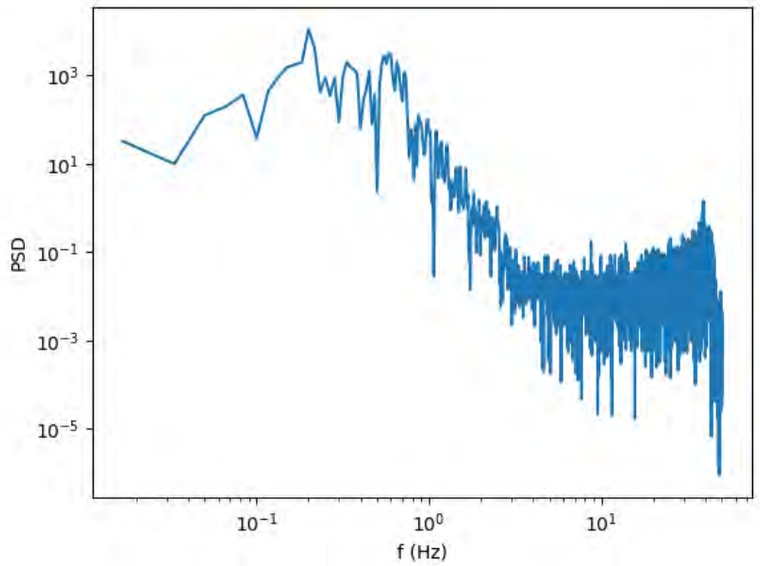
- Infrasound microphone arrays to be deployed in surface and underground;
- Geological survey along the ET “triangle” with georesistivimeter probe.
- Borehole excavation at the corner P2 and P3 completed
- Long-period borehole micro-seismic measurements at depth 250-300m with broadband borehole seismometers (*Nanometrics Trillium120 BH Slim*);
- Surface seismic measurements at the corners close to the boreholes with broadband seismometers (*Nanometrics Trillium120H*).

ET: LNS-UNISS Role

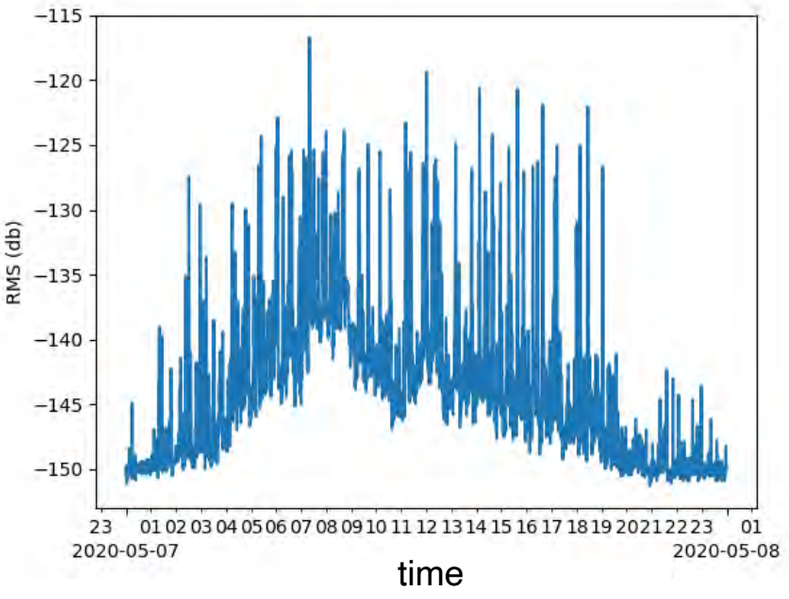
First analysis of seismic sensor data published



Waveform => PSD

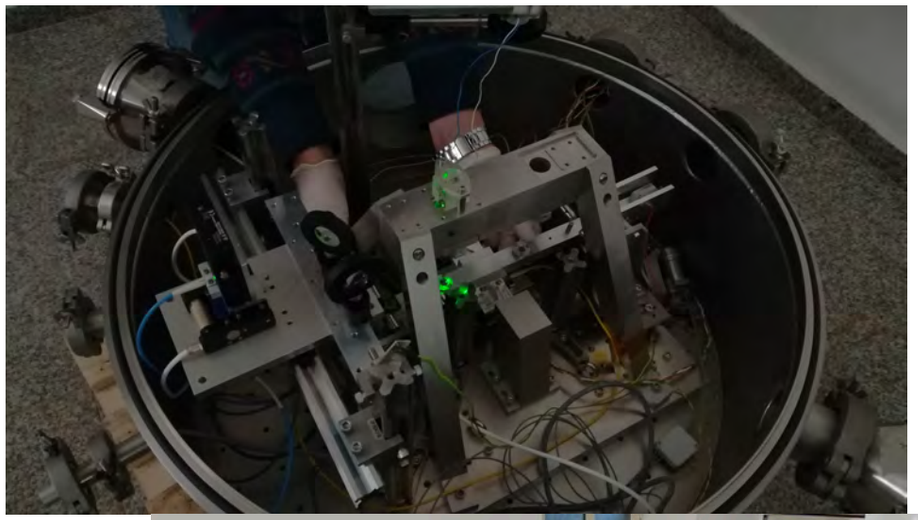


PSD => RMS



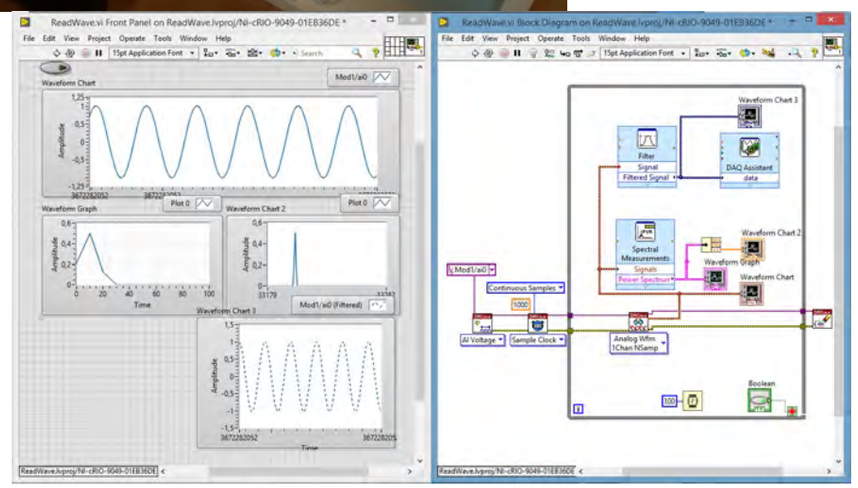
ET: LNS-UNISS Role

- **Control room preparation**
- **Optical components assembly for the Archimedes balance prototype**



@UNISS

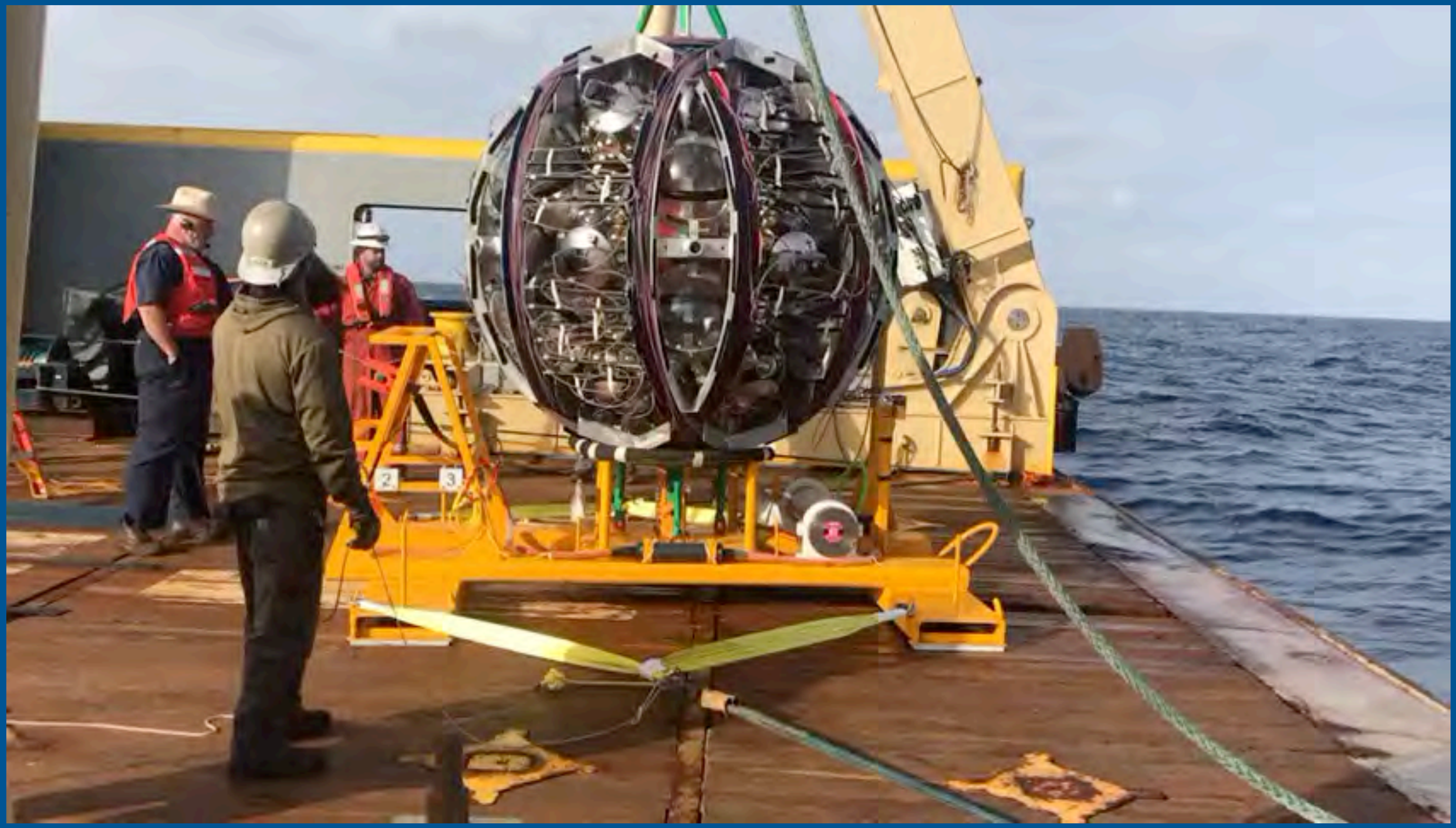
- **Configuration of NI-cRIO-9049 electronic system for Archimedes balance (founded by SarGrav project)**



SPARE

MOVIE: DU DEPLOYMENT

Deployment DU



MOVIE: THE UNROLLING