Acoustic Antenna for KM3NeT Neutrino Telescope

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overwiew, motivation, and KM3NeT collaboration details.

2 **Technical Aspects**

Detection principles and conceptual design of the Acoustic antenna.

3 **Broader Impact**

Applications beyond neutrino detection and conclusions.

KM3NeT Collaboration

Global Effort

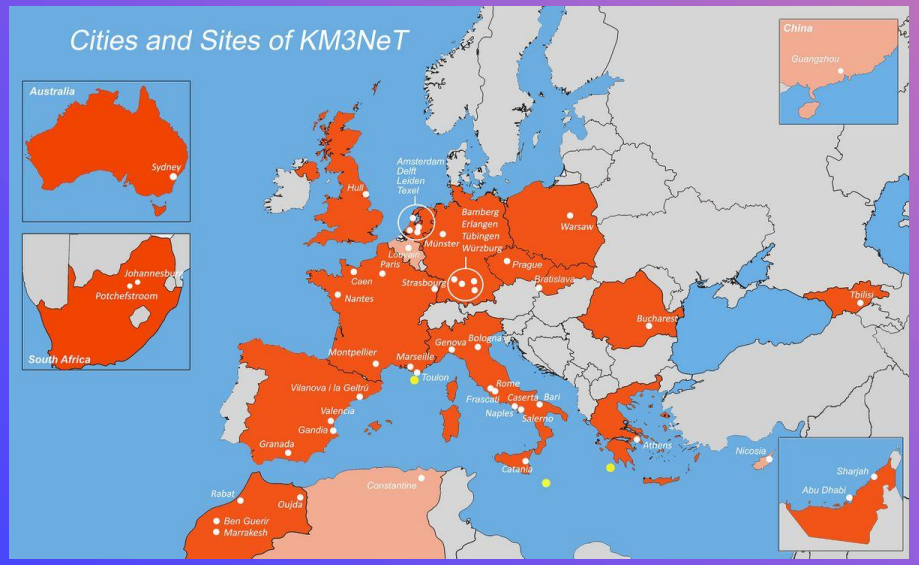
250 members from 63 institutes across 22 countries.

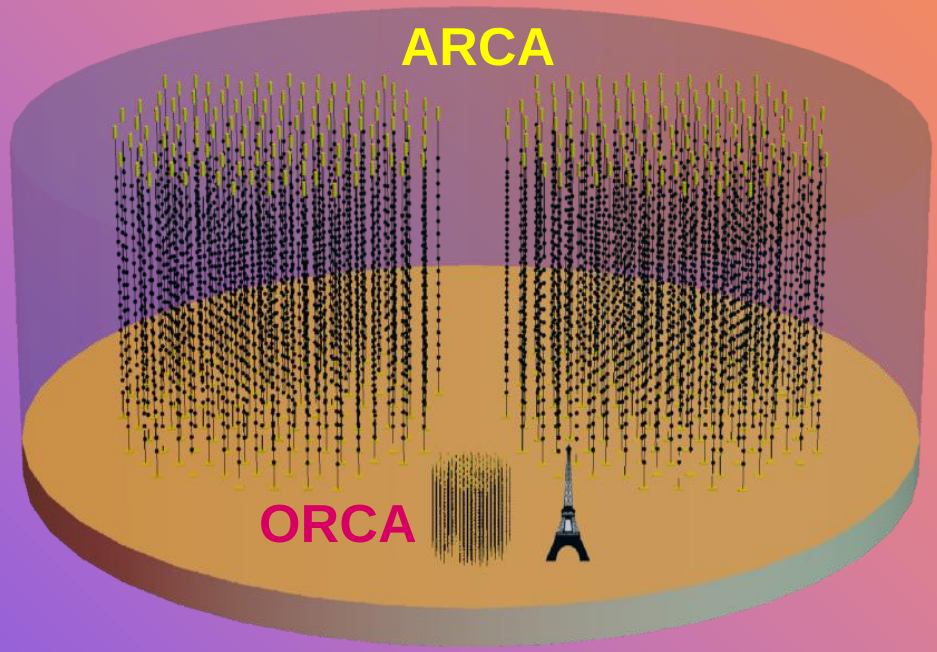
Dual Detectors

ORCA and ARCA with shared same technology and data processing.

Research Focus

Neutrino oscillations and astronomy in deep sea.





Neutrino Properties

Almost no mass.

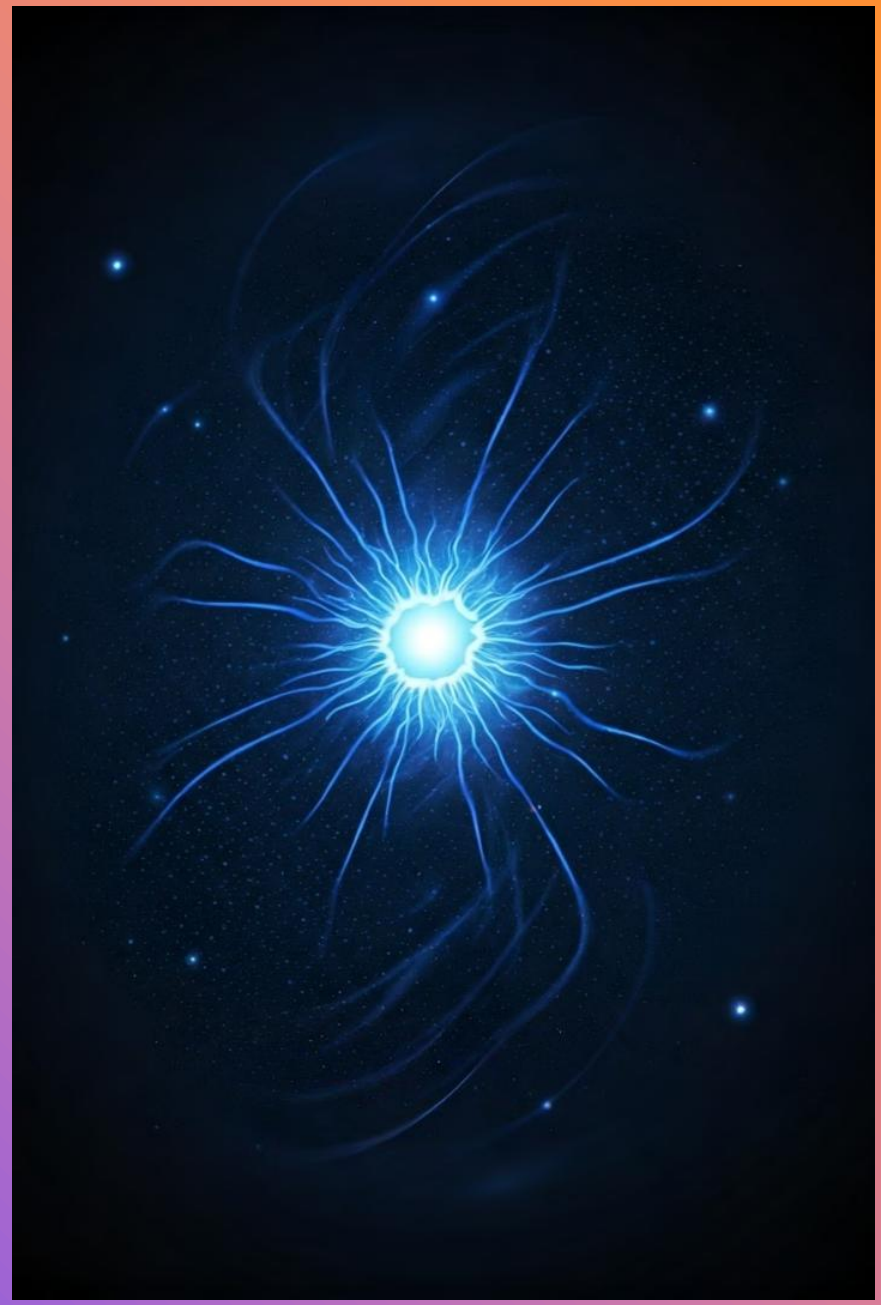
Extremely light particles, barely interacting with matter.

No electric charge.

Not deviated by magnetic fields in space.

Cosmic Messengers.

Travel cosmological distances, providing insights into distant phenomena.



KM3NeT Detection Units

Top Buoy

Provides buoyancy and supports vertical structure.

Digital Optical Modules (DOMs)

18 DOMs per unit, housing 31 photomultiplier (PMT) each.

Detection Unit Base

Anchors structure to seafloor.

Optic Detection Principle

1

Neutrino Interaction

Neutrino ν collides with matter in detector volumen.

2

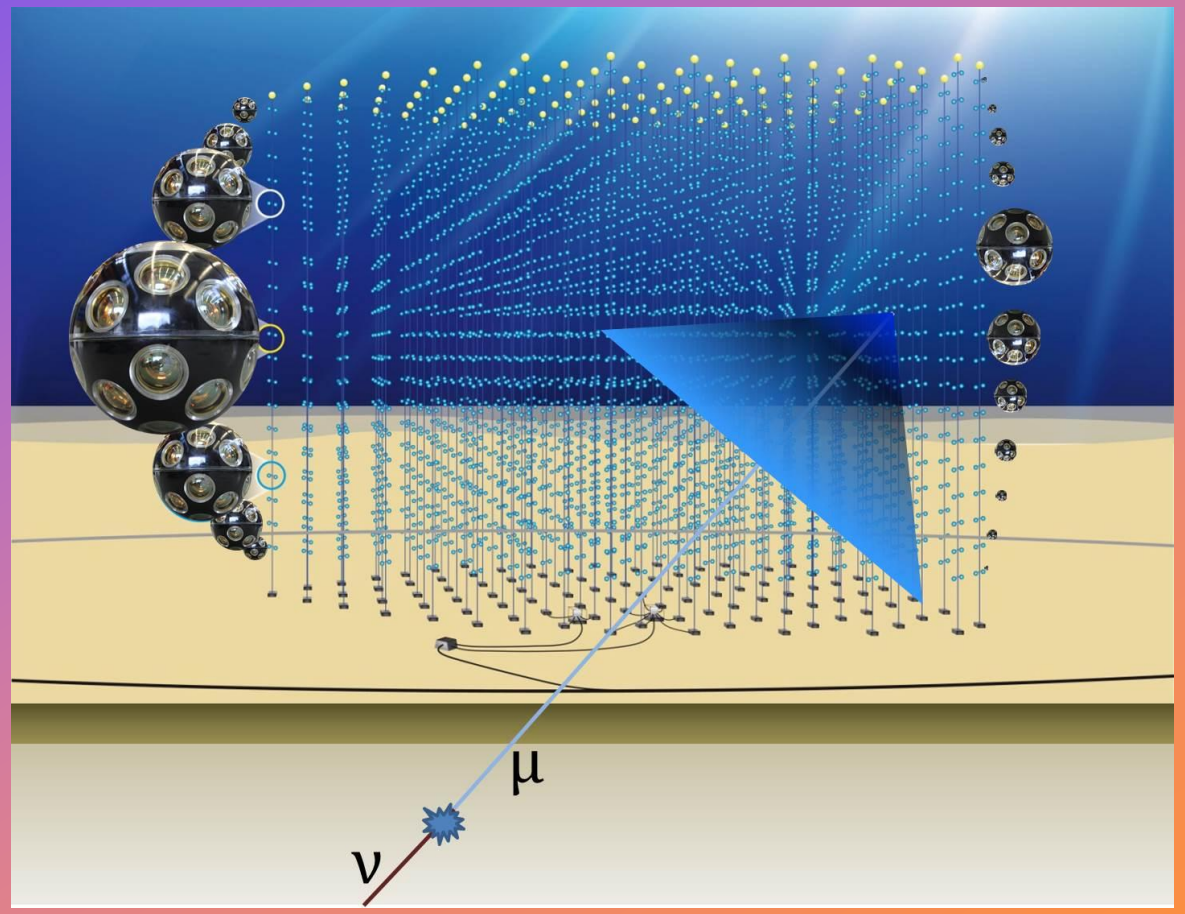
Charged Particle Production

Interaction produces charged particles, i.e. primarily muon μ.

3

Cherenkov Radiation

Particles emit Cherenkov light, detected by PMTs.

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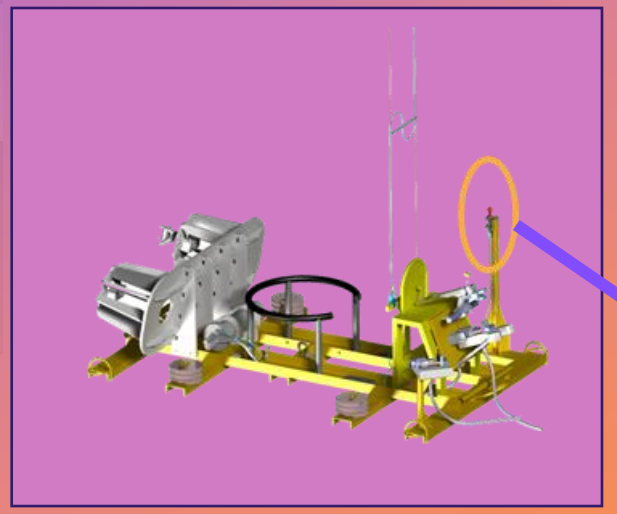
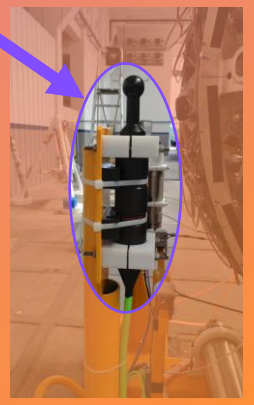
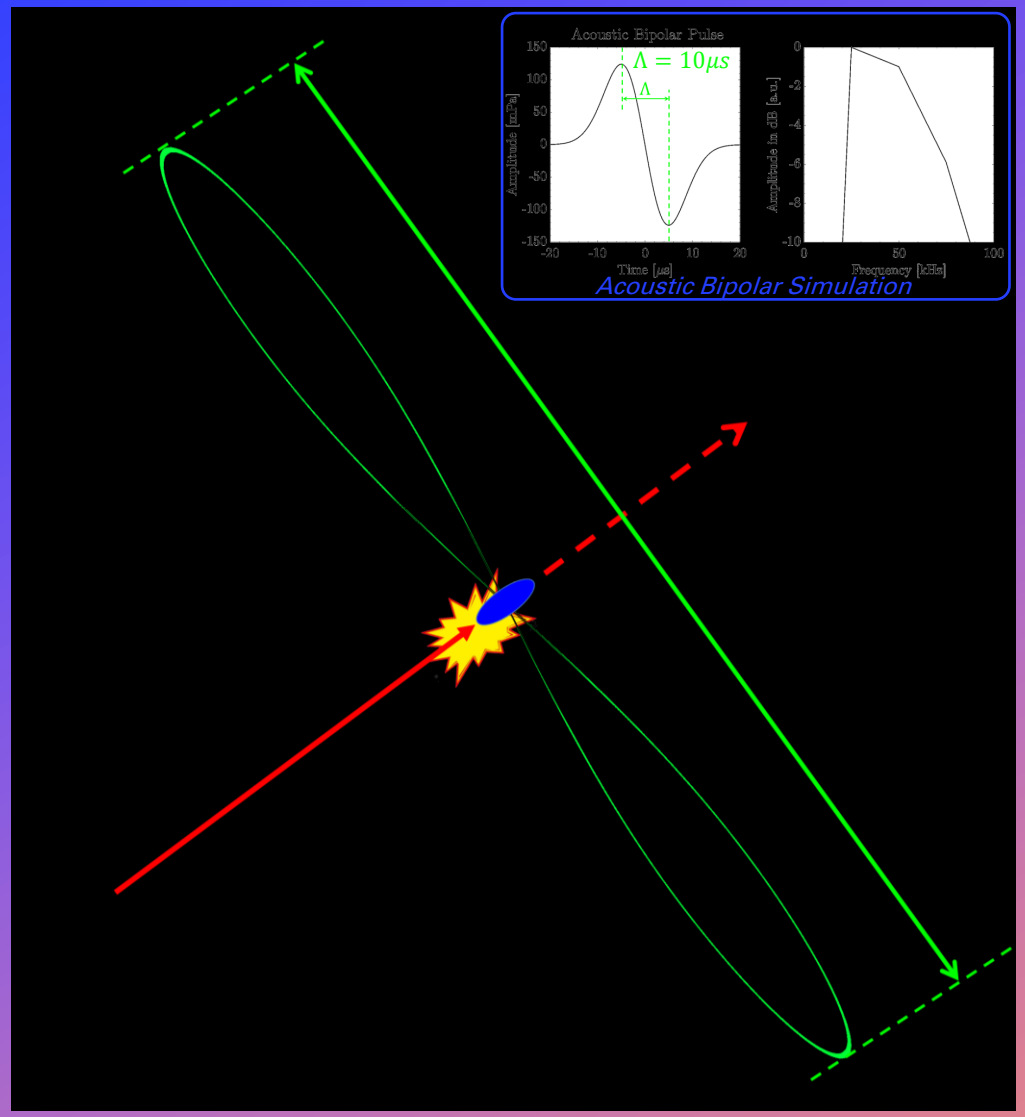
Acoustic Detection Principle

Mechanism	Thermo-acoustic effect from particle particle interaction.
Signal	Bipolar acoustic pulse.
Frequency	1 Hz - 50 kHz range.
Directionality	Narrow beam, typically < 5° opening opening angle.







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Acoustic Antenna Design

Hydrophones Spacing

~1 meter intervals for optimal spatial resolution of triggering events.

Frequency Range

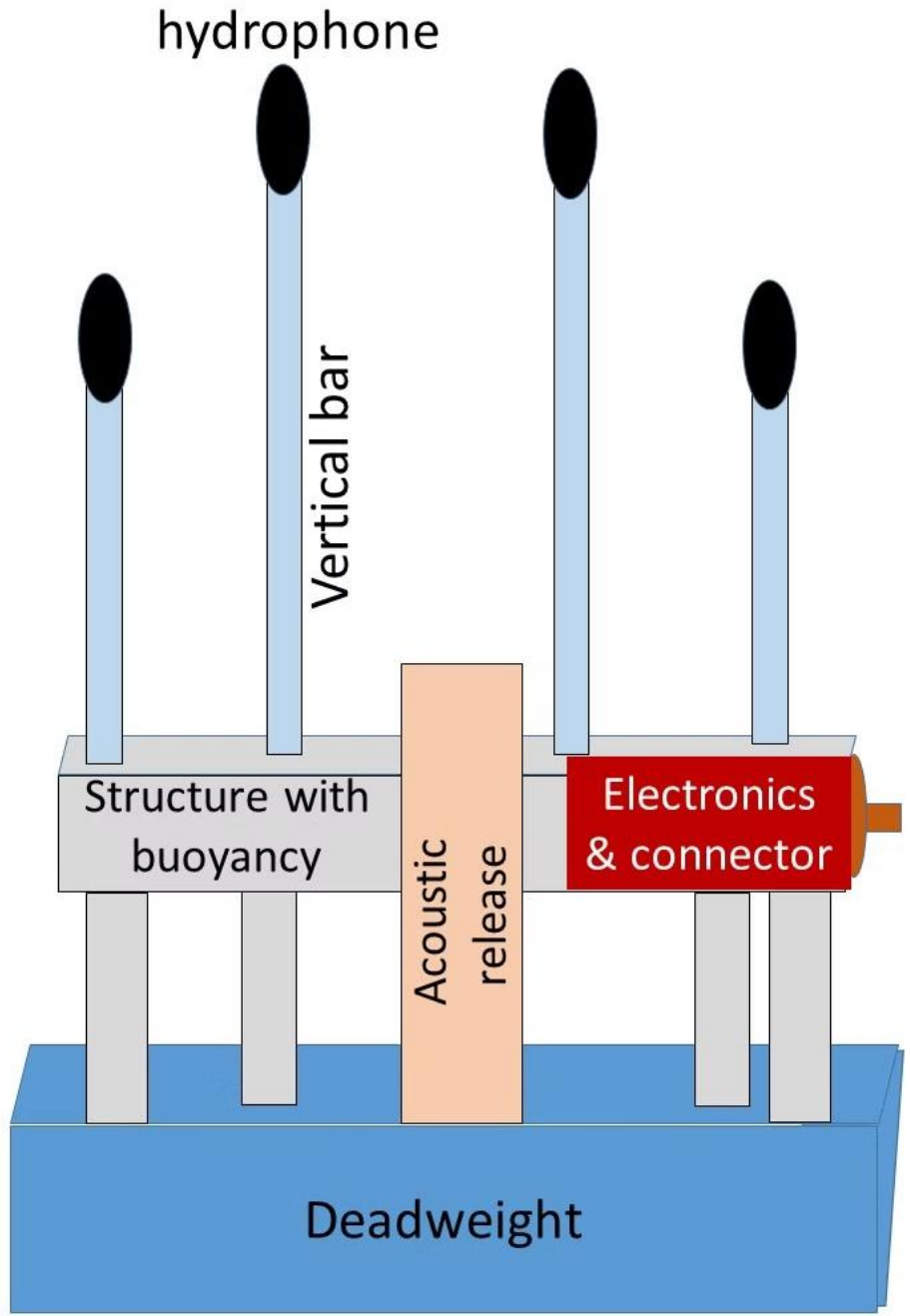
1Hz-50 kHz to capture neutrino-induced acoustic signals and other underwater acoustic phenomena within this range.

Synchronization

Integrated with the KM3NeT timing system for precise measurements.

Signal Processing

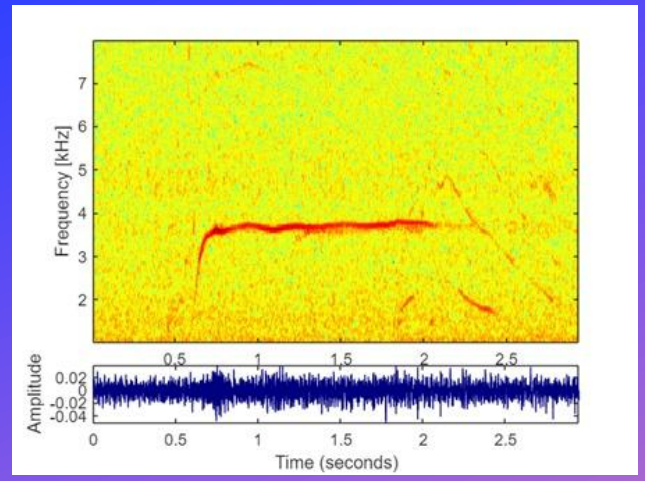
Advance correlation techniques for event triggering designed to identify sharp, broadband acoustic pulses.

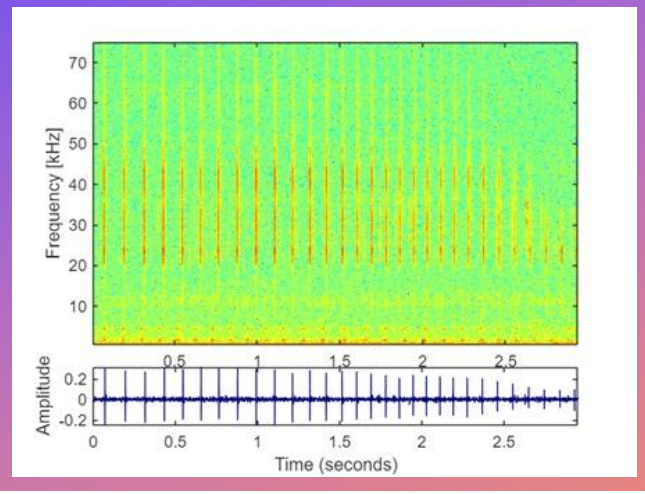


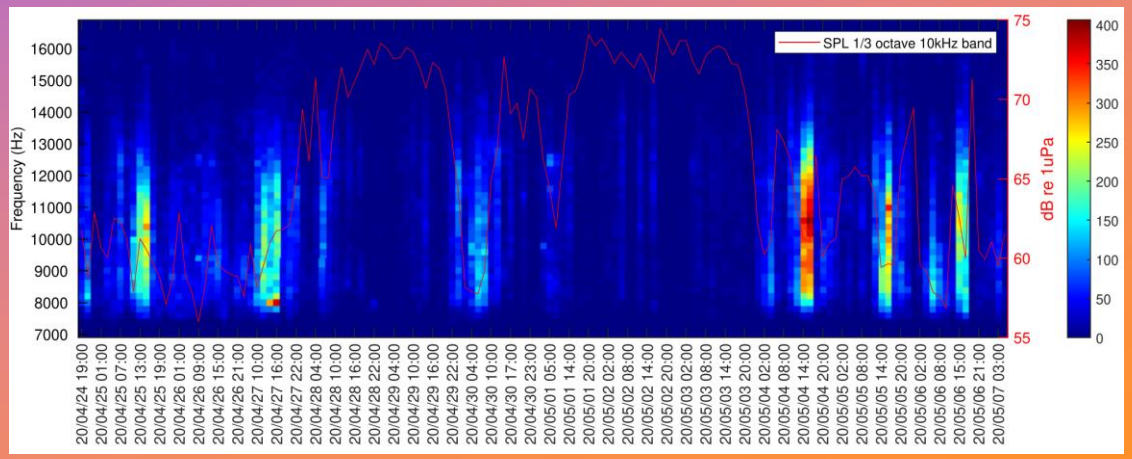
APPLICATIONS BEYOND NEUTRINO DETECTION

Marine Biology

Monitoring cetacean populations, determine presence/absence, migration patterns, etc.

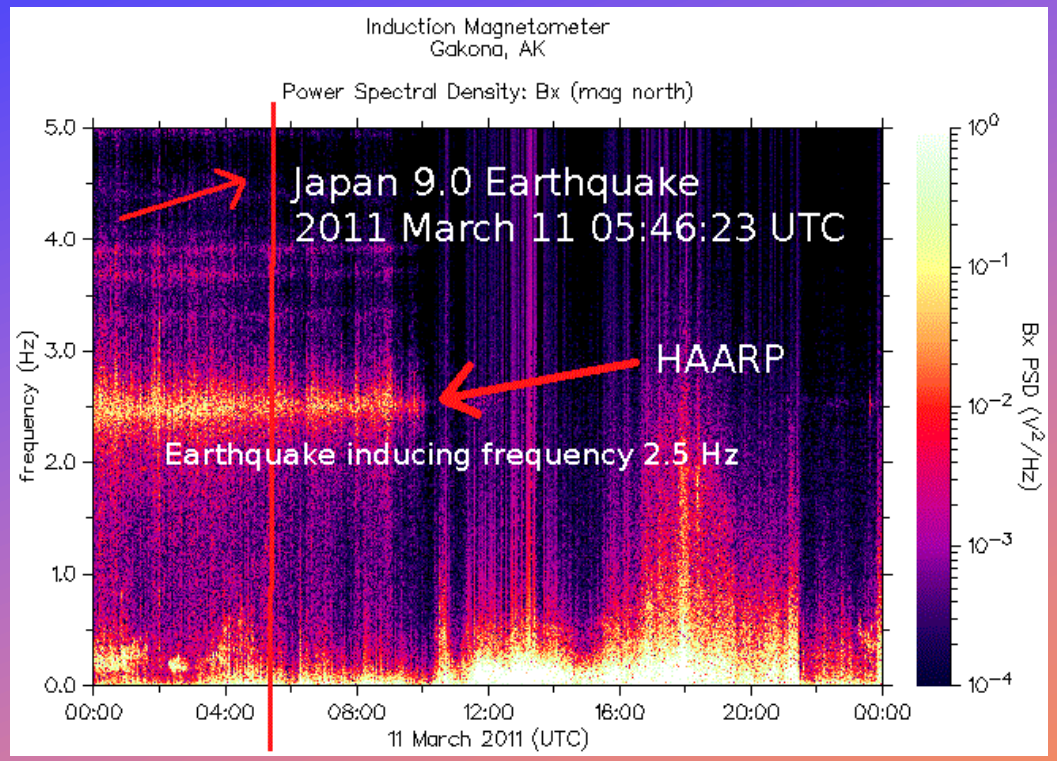






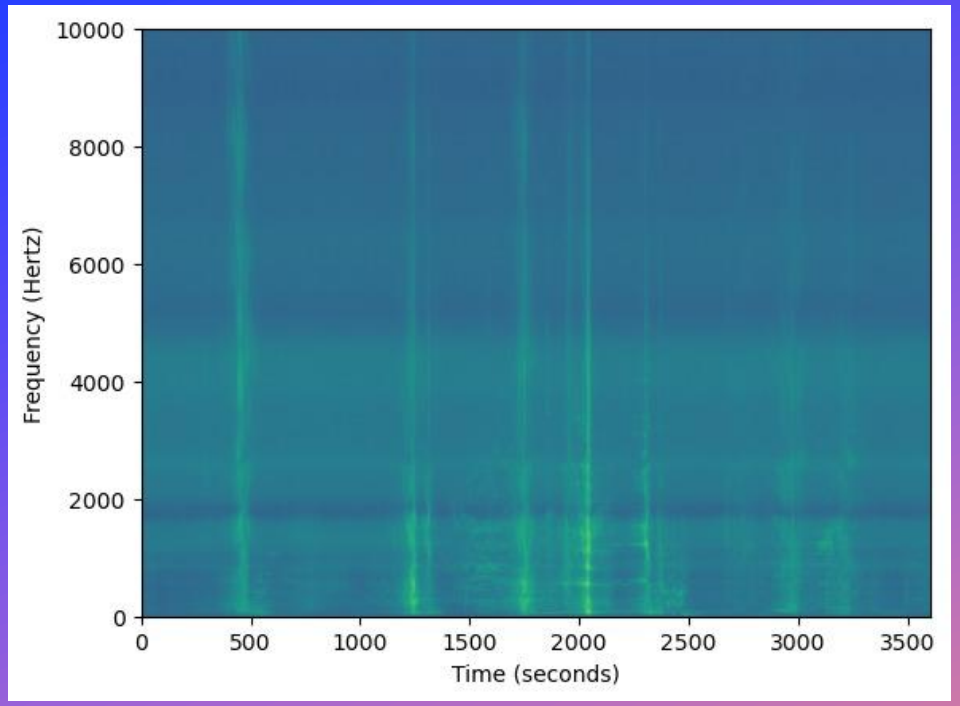
Seismic Monitoring

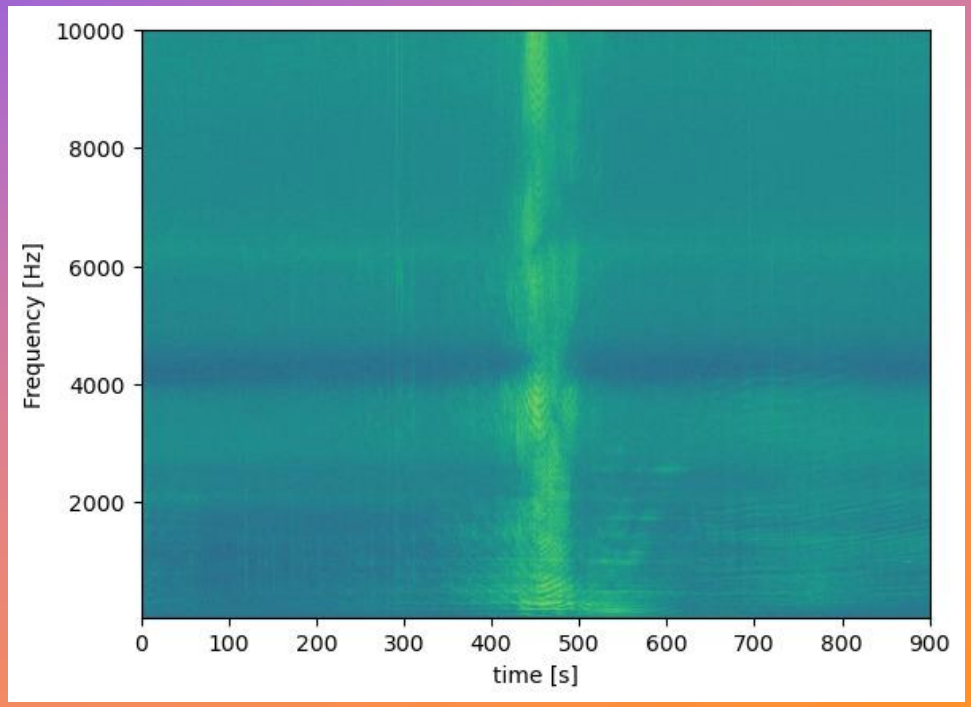
Detecting underwater seismic activity and tectonic movements.



Anthropogenic Noise

Studying human-induced acoustic pollution in deep marine enviroments.





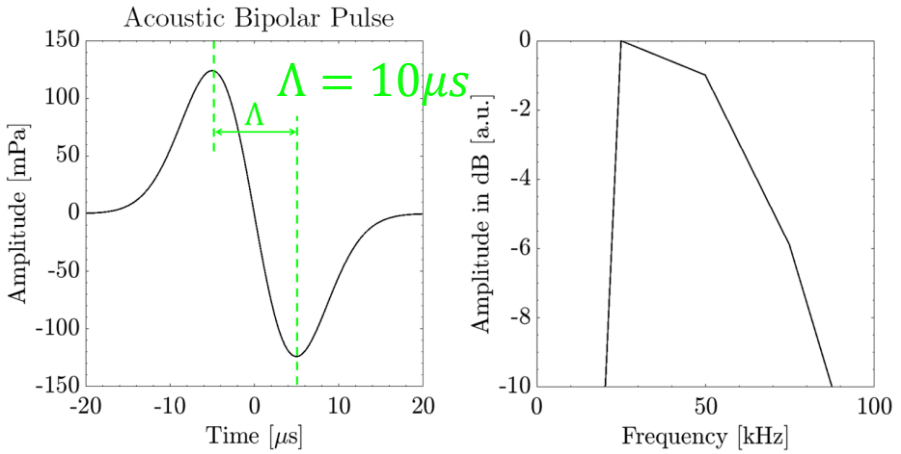
CONCLUSIONS AND FUTURE WORK

- A four-hydrophone acoustic antenna is being developed as an innovative component for the KM3NeT neutrino telescope, enabling the detection of acoustic signals generated by neutrino interactions.
- Its compact design, advanced signal processing capabilities, and seamless integration with the KM3NeT infrastructure make it an excellent addition for enhancing physics and environmental studies.
- The antenna will also supply valuable data for oceanographic and environmental monitoring.
- Looking ahead, once the design phase is complete and the antenna prototype is built, it will undergo laboratory testing and shallow-sea trials before full integration into KM3NeT.

THANKS FOR YOUR ATTENTION

BACKUP

Bipolar Pulse simulation



[**Waters, D**. Study of the acoustic signature of UHE neutrino interactions in water and ice. *Nucl. Instrum. Methods Phys. Res., Sect. A* **2009**, 607, 398–411. DOI: 10.1016/j.nima.2009.05.009]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HTI-96-Min Hydrophone Series

HTI-96-Min Hydrophones are widely used in the seismic industry for ocean bottom cables and nodal systems.

Specifications:

Sensitivity	Without Pre-Amp:	-201 dB re: 1V/µPa (8.9 V/bar)
	With Pre-Amp:	Max -165 dB re: 1V/µPa (562 V/bar) Min -240 dB re: 1V/µPa (0.1V/bar)
Frequency Response		2 Hz to 30 kHz
Equivalent Input Self Noise	RMS: 1 Hz - 1000 Hz	78 dB re: 1 µPa (0.08 1 µbar)
	Spectral	54 dB re: 1 µPa/√Hz @ 10 Hz 42 dB re: 1 µPa/√Hz @ 100 Hz 42 dB re: 1 µPa/√Hz @ 1000 Hz
Preamplifier Type		Voltage Mode Current Mode
Maximum Operating Depth		10,000 feet 3,048 meters
Size		2.50" length x 0.75" diameter

DG1330 Hydrophone

The DG1330 is a digital omnidirectional hydrophone, a professional tool specifically designed and produced for the Km3Net project, where our hydrophone was selected by INFN to record acoustic signals at depths of up to 3500m.

- Two channels with different gain
- Very low self noise on both channels
- Wide frequency range
- High sensitivity, high dynamic range
- 24Bit, up to 216 kHz sample rate
- External 25MHz digital clock input or internal clock
- AES/EBU interface
- Customizable

Working band:	5-90.000 Hz
High pass filter on preamplifier :	700 Hz (on demand)
CH1 output sensitivity:	-156dB re 1V / uPa @ 5kHz
CH2 output sensitivity:	-176 dB re 1V / uPa @ 5kHz
Directivity :	Spherical - Omnidirectional
Max working depth :	3500 m
Gain @5kHz:	46 dB (CH1), 26dB (CH2
Equivalent input acoustic noise @5kHz:	34 dB re 1uPa / sqrtHz
Input impedance:	10 MOhm
Supply voltage range:	9 -18 Vdc
Current consumption:	100mA @ 12 Vdc
Output:	AES3 protocol
Weight in air:	1600 gr with 4m cable
Body construction:	POMC (stainless steel inner core)
Dimensions:	330 x 52 mm