ACOUSTIC PARAMETRIC TECHNIQUES FOR NEUTRINO TELESCOPE

Dídac D.Tortosa
e-mail: didieit@upv.es
M. Ardid, M. Campo-Valera, C.D. Llorens,
J.A. Martínez-Mora, M. Saldaña

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8th International Conference on Acoustic and Radio EeV Neutrino Detection Activities
Catania 12th - 15th June 2018
1) REPRODUCE THE ACOUSTIC SIGNATURE OF NEUTRINO WITH A PARAMETRIC ARRAY  
1.1 ACOUSTIC SIGNATURE OF NEUTRINO  
1.2 PARAMETRIC EFFECT  
1.3 STATE OF THE ART  
1.4 DESIGN & DEVELOPMENT AN ARRAY  
1.5 FUTURE STEPS  

2) CALIBRATION OF THE ACOUSTIC SENSOR OF KM3NeT WITH PARAMETRIC TECHNIQUE  
2.1 CALIBRATION OF KM3NeT-DOM ACOUSTIC SENSOR  
2.2 EXPERIMENTAL SETUP  
2.3 RESULTS IN A TANK  
2.4 EXPECTATIVES IN A SMALL POOL  
2.5 FUTURE STEPS  
2.6 COMMUNICATION APPLICATION  

3) CONCLUSIONS  

1) REPRODUCE THE ACOUSTIC SIGNATURE OF NEUTRINO WITH A PARAMETRIC ARRAY

1.1 ACOUSTIC SIGNATURE OF NEUTRINO


Signal obtained by the propagation of the signal of the parametric array to 1 km distance.

\[ f \approx [2,50] \text{kHz} \]
1) REPRODUCE THE ACOUSTIC SIGNATURE OF NEUTRINO WITH A PARAMETRIC ARRAY

1.2 PARAMETRIC EFFECT

Therefore, the resulting wave \( p(x, t) \) will be proportional to the second derivative of the square envelope of the emitted signal.

1) REPRODUCE THE ACOUSTIC SIGNATURE OF NEUTRINO WITH A PARAMETRIC ARRAY

1.3 STATE OF THE ART

Previous works in acoustic calibration to detection of neutrino:

• **Linear array with 8 acoustic emissors (length: ~8 m)** to generate bipolar pulse at 23 kHz
  [Ooppakaev, W. Northumbria University].
  
    ☐ Tested *in situ* in ANTARES: Signal no detected (poor signal or bad pointing to the detector)

• **Compact parametric array with 3 acoustic emissors (length: ~40 cm)**
  [Adrián, S. Universitat Politècnica de València].
  
    ☐ Low efficiency of parametric generation
    ☐ Emitters misaligned
1) REPRODUCE THE ACOUSTIC SIGNATURE OF NEUTRINO WITH A PARAMETRIC ARRAY

1.4 DESIGN & DEVELOPMENT AN ARRAY

- **Aim:** Development a new compact calibrator to study the viability of neutrino acoustic detection in underwater detectors.

  **Emitter:** UCE-534541 piezo-ceramic

  **Matching:** Polyurethane EL241F

  **Backing:** Aluminum

  \( f_r = 496 \text{ kHz} \)

1) REPRODUCE THE ACOUSTIC SIGNATURE OF NEUTRINO WITH A PARAMETRIC ARRAY

1.4 DESIGN & DEVELOPMENT AN ARRAY

1 element of array: Characterization to parametric emission

ATENUATION

VOLTAGE VARIATION

DIRECTIVITY


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1) **REPRODUCE THE ACOUSTIC SIGNATURE OF NEUTRINO WITH A PARAMETRIC ARRAY**

1.4 DESIGN & DEVELOPMENT AN ARRAY


The studies reveal that the optimum separation between elements is among 10 and 15 cm to obtain the best acoustic neutrino signature (~1° opening).
1) **REPRODUCE THE ACOUSTIC SIGNATURE OF NEUTRINO WITH A PARAMETRIC ARRAY**

1.4 DESIGN & DEVELOPMENT AN ARRAY

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**Directivity to parametric emission**

Array with 3 elements

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Simulation of Secondary Beam (Bipolar Pulse)

![Simulation Graph](image1)

Experimental results 4m (3 points mean)

![Experiment Graph](image2)

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1) REPRODUCE THE ACOUSTIC SIGNATURE OF NEUTRINO WITH A PARAMETRIC ARRAY

1.4 DESIGN & DEVELOPMENT AN ARRAY

**Directivity to parametric emission**

Array with 5 elements

Array with 3 elements
1) **REPRODUCE THE ACOUSTIC SIGNATURE OF NEUTRINO WITH A PARAMETRIC ARRAY**

1.5 FUTURE STEPS

- Study the optimum configuration to improve the array: number of elements, distance between elements, ...

- Design and development of the electronics to give the needed power to each element of the array.

- Tests the array for long distances and *in situ*.
2) CALIBRATION OF THE ACOUSTIC SENSOR OF KM3NeT WITH PARAMETRIC TECHNIQUE

2.1 CALIBRATION OF KM3NeT-DOM ACOUSTIC SENSOR

To calibrate the piezo-ceramic sensors in DOMs of KM3NeT

An anechoic tank

A directive emitter in low frequencies

Using parametric effect

See presentation:
E.J.Buis et al. 2018. “Characterization of the KM3NeT hydrophone”. In ARENA2018

The South Pole of DOM
Piezo-ceramic sensor
2) CALIBRATION OF THE ACOUSTIC SENSOR OF KM3NET WITH PARAMETRIC TECHNIQUE

2.2 EXPERIMENTAL SETUP

**Signal emitted:**

- $f_c = 1$ MHz
- **Sweep:**
  - $f \in [10,50] kHz$
- **2nd beam:**
  - $f_d \in [20,100] kHz$

![Image of RESON TC3027 sensor](image)

$\text{RESON TC3027} \quad f_r = 1$ MHz

**Real & Imaginary Adm.**

![Graph showing real and imaginary admittance](image)

**Admittance [mS]**

![Graph showing frequency response](image)

**TVR [dB re $uPa/V @ 1m$]**

![Graph showing time-voltage response](image)

**Frequency [kHz]**

![Graph showing normalized amplitude](image)

**Normalized Amplitude**

- $L_r = 14.96$ cm
- $L_R = 47.12$ cm

**Distance [cm]**

- ![Graph showing normalized frequency response](image)
2) CALIBRATION OF THE ACOUSTIC SENSOR OF KM3NET WITH PARAMETRIC TECHNIQUE

2.3 RESULTS IN A TANK

SMALL TANK

\[ V \approx 0.75 \text{ m}^3 \]

\[ E-R = 0.50 \text{ m} \]

\[ 0.80 \text{ m} \]

\[ 1.10 \text{ m} \]

\[ 0.85 \text{ m} \]

Detect 1st reflection

Signal emitted

Reflection

Signal Produced by parametric effect

0.5 m

Power/Frequency [dB/Hz]

Frequency [MHz]

Time [ms]


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2) CALIBRATION OF THE ACOUSTIC SENSOR OF KM3NET WITH PARAMETRIC TECHNIQUE

2.3 RESULTS IN A TANK

Characterization to parametric emission

DIRECTIVITY

ATENUATION

VOLTAGE VARIATION
2) Calibration of the Acoustic Sensor of KM3Net with Parametric Technique

2.4 Expectatives in a Small Pool

**Small Pool**

- Dimensions: 4 m x 3 m x 2 m
- Volume: \( V \approx 24 \text{ m}^3 \) (approx.)
- Distance: \( E-R = 2 \text{ m} \)

**Small Pool Reflections**

- Time vs. Amplitude
- \( \Delta t > 1.5 \text{ ms} \)
- 2.4m Expectatives in a Small Pool

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2) CALIBRATION OF THE ACOUSTIC SENSOR OF KM3NET WITH PARAMETRIC TECHNIQUE

2.6 COMMUNICATION APPLICATION


Message: A R E N A
Binary (RFC 4648): 01000001 01010010 01000101 01001110 01000001

1st Beam

2nd Beam

Directivity BIT 1

Directivity BIT 0
3) CONCLUSIONS

• The parametric emitted (signal bipolar) is validated using three elements in the array, and very similar signature to the one expected for the neutrino is obtained.

• The simulation of the array with 5 elements present a directivity in 3° Full Width Half Maximum (σ=1.3°).

• Alternative technique to calibrate the acoustic sensor of KM3NeT-DOM without anechoic environment is validated. The next step is to prove it.

• It is possible to apply the directive technique in underwater communication to specific receivers.
THANKS YOU FOR YOUR ATTENTION

e-mail: didieit@upv.es

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