Efficiency of parametric ultrasound generation in relaxing media for very shallow-water echo sounders

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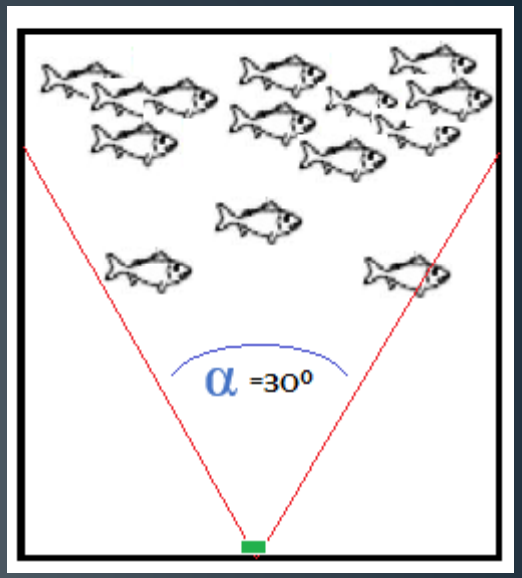
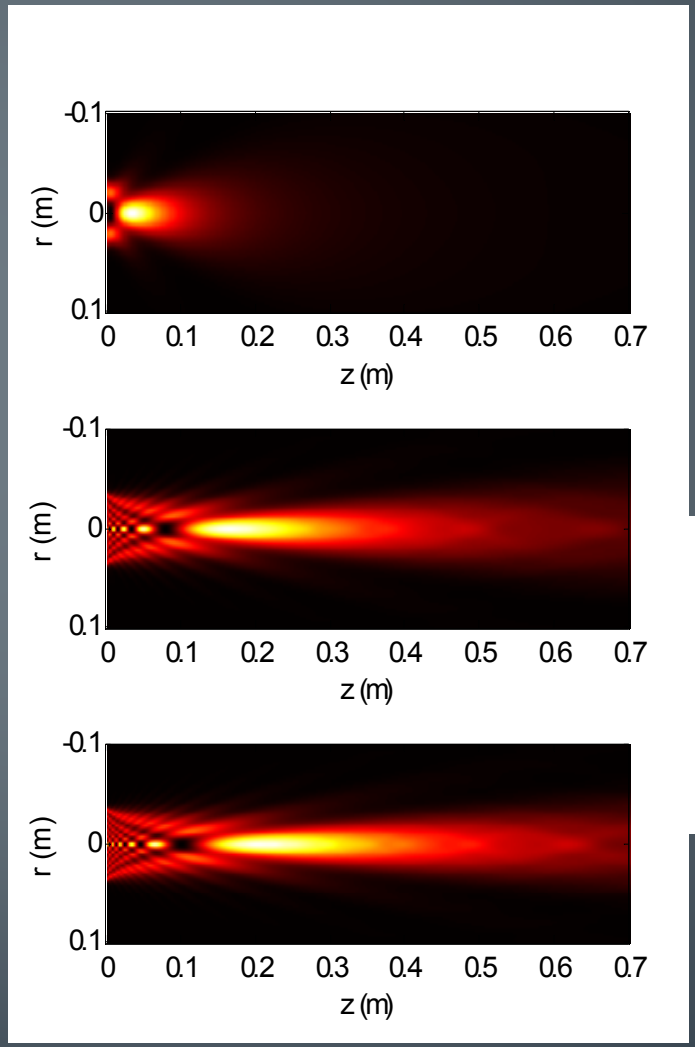
1. INTRODUCTION



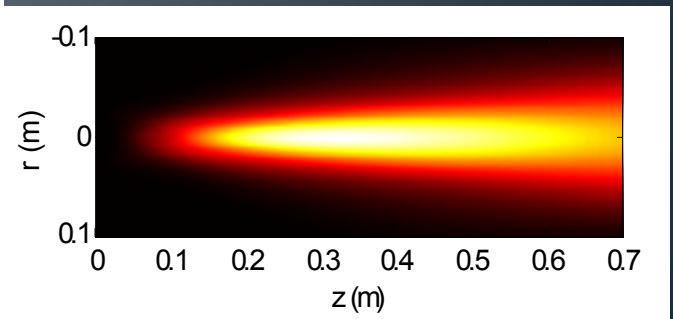
45kHz Primary source

222.5kHz Primary beam

177.5kHz Primary beam 2



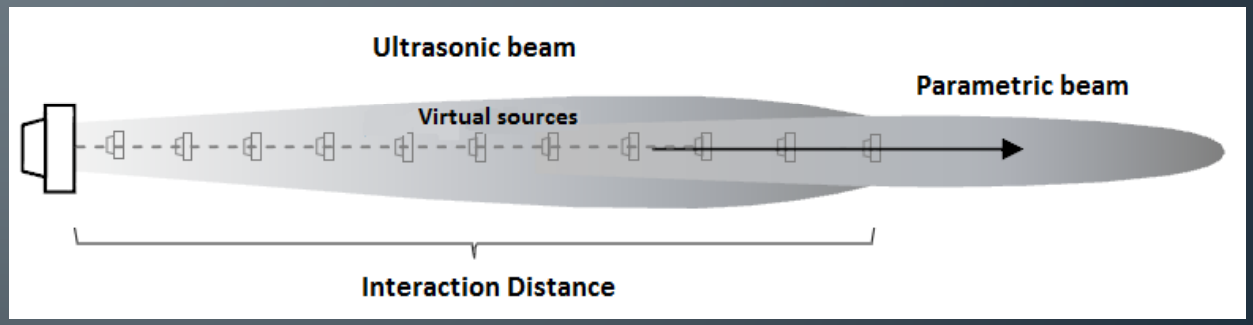
45kHz Parametric beam



1. INTRODUCTION

- Parametric acoustic generation is a non-linear effect introduced P.Westervelt in the 60's.

- Generation of spectral components: high frequency harmonics, difference-frequency harmonics and sum harmonics



1. INTRODUCTION

- Difference-frequency harmonic :
  - Low attenuation
  - Narrow and nearly side-lobe acoustic beams
- Applications:
  - Fish Biomass Estimation and behavior characterization in very shallow water (<20m)

1. IN

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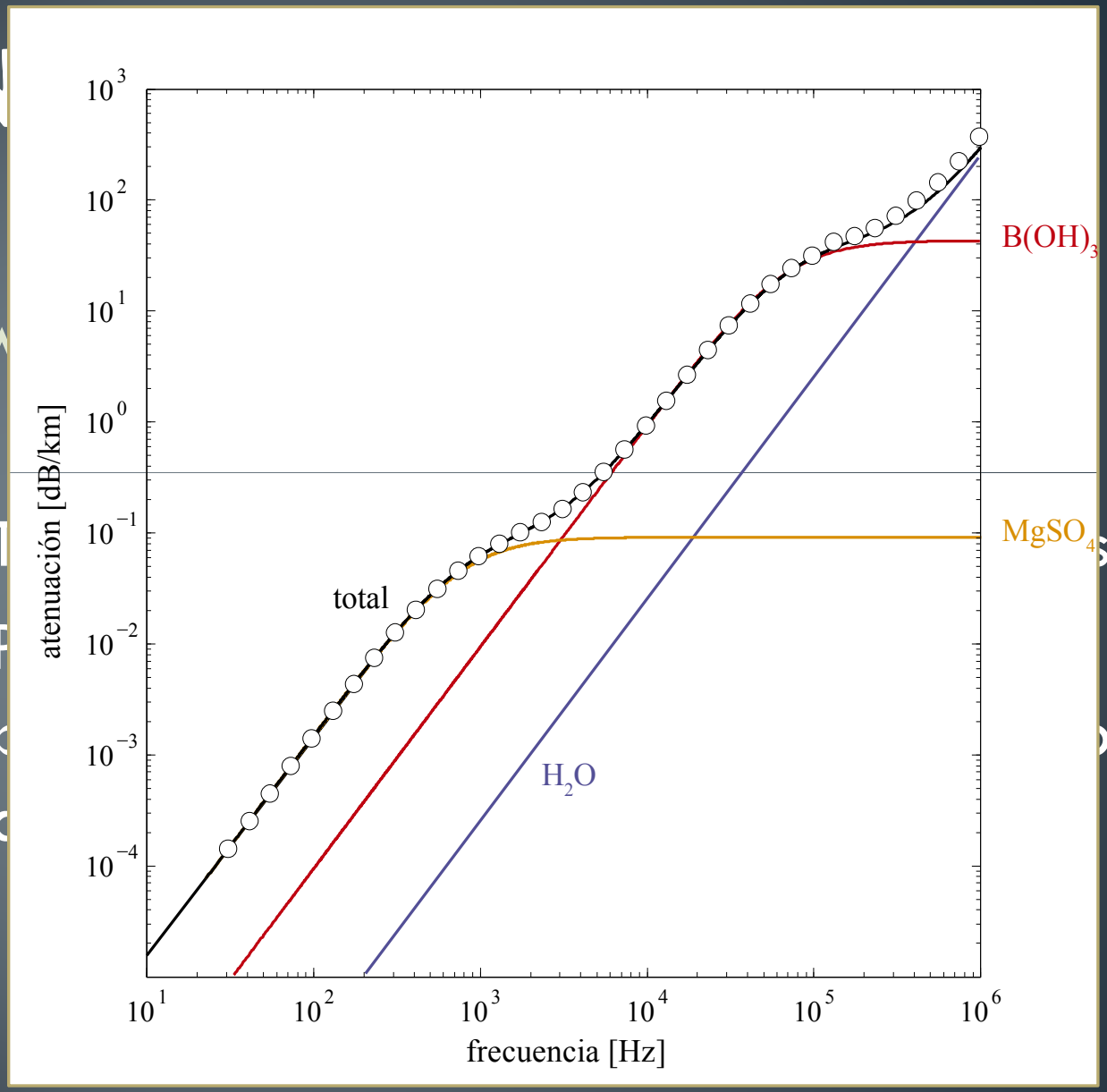


1. INTRODUCTION

OBJECTIVE:

1. Design of parametric echosounder for shallow water with 20°to 30° of aperture

2. Study the efficiency of the parametric sound generation

COMPUTATIONAL FINITE DIFFERENCES METHOD

EXPERIMENTAL RESULTS

INTRODUCTION OF RELAXATION LOSSES

MODEL FOR SEA WATER

2. METHODS

- Navier-Stockes equation (momentum conservation)

$$\frac{\partial \rho}{\partial t} = -\nabla \cdot (\rho \mathbf{v})$$

$$\rho\left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v} \cdot \nabla \mathbf{v}\right) = -\nabla p + \eta \nabla^2 \mathbf{v} + \left(\zeta + \frac{1}{3}\eta\right) \nabla (\nabla \cdot \mathbf{v})$$

$$\frac{\partial S_n}{\partial t} = -\frac{1}{\tau_n} S_n + \frac{\eta_n c_0^2}{\tau_n} \rho'$$

$$p = c_\infty^2 \rho' + \frac{c_0^2}{\rho_0} \frac{B}{2A} \rho'^2 - \sum_{n=1}^{N} S_n$$

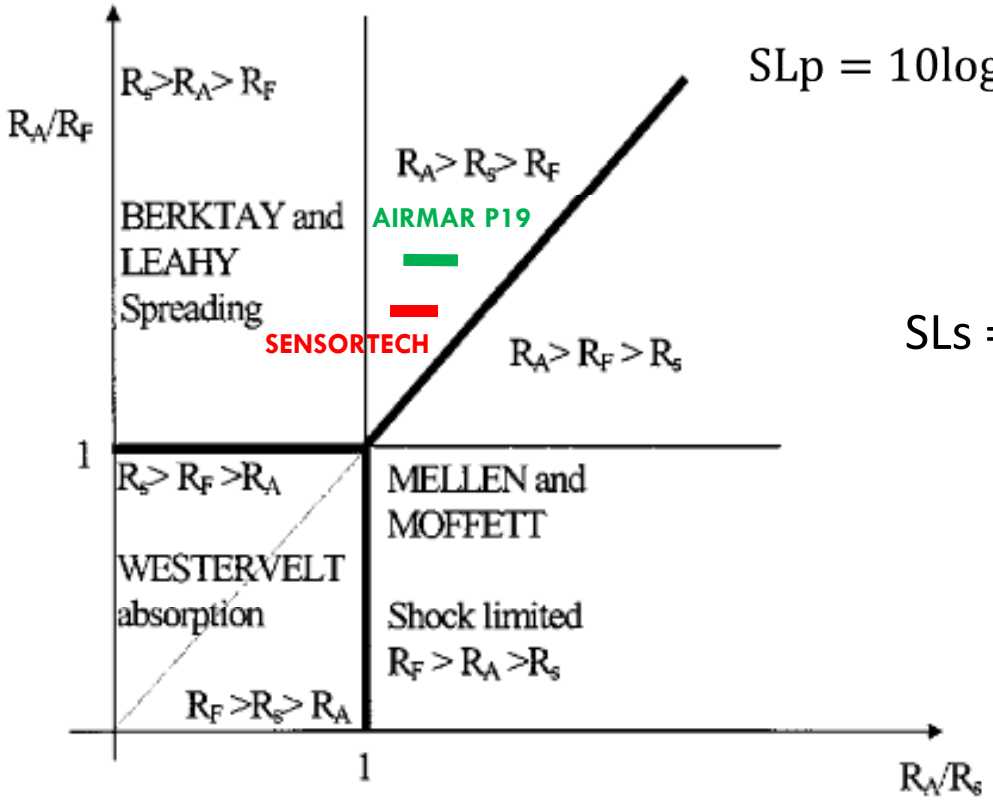
✓Divergence

✓Diffraction (Beams)

✓Model in 2 directions (Back Scattering)

✓Complex field (Multiple scattering)

2. METHODS

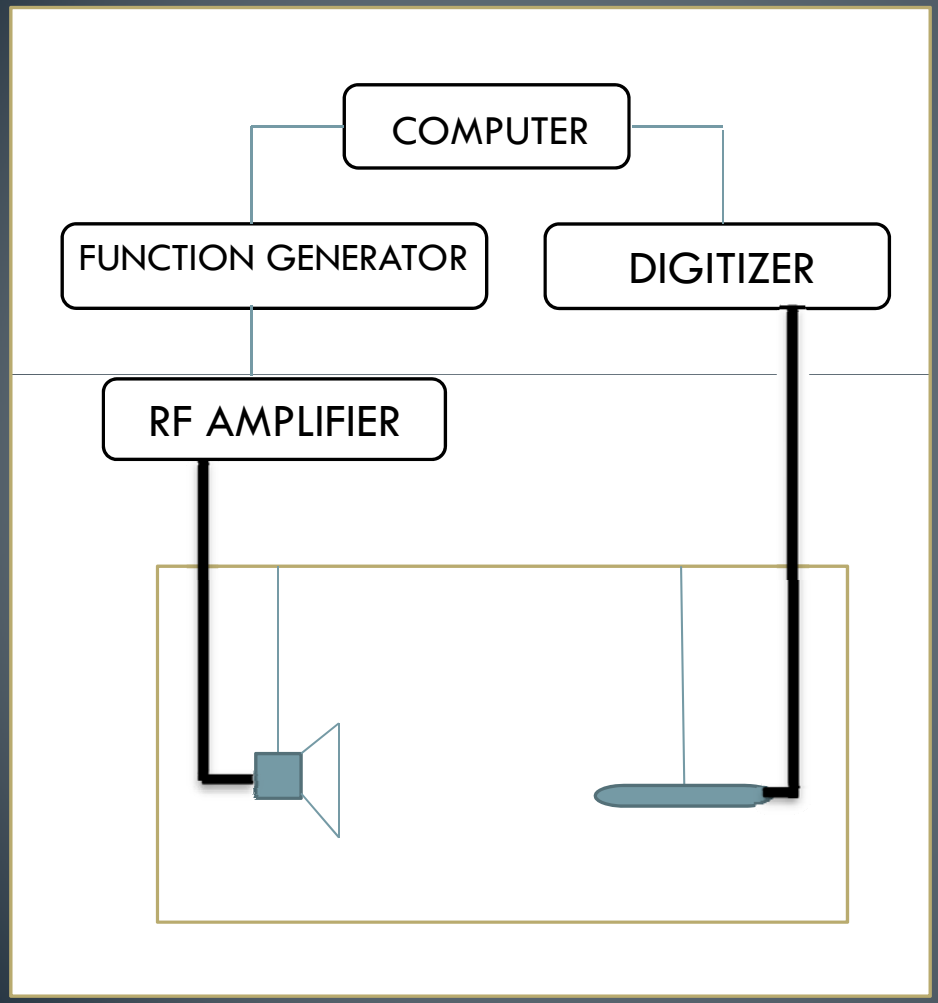


$$SLp = 10\log W_0 + 171 + 10\log\frac{4\pi S}{\lambda p^2}$$ (ref. dB/µPa @ 1m).

$$SLs = 2SL_p + 20\log(f_s)_{kHz} + 20\log\Delta - 287$$

$$2\theta_{3dB} = \max\left\{4\sqrt{\frac{\alpha_T\lambda_s}{4\pi}}, 1.03\frac{\lambda_p}{d}\right\}$$

3. EXPERIMENTAL SETTINGS



TRANSMISOR:

- AIRMAR P19, fr:195kHz,Φ=75mm
- SENSORTEC SX20 fr:210kHz, Φ=40mm

RECEPTOR:

- RESON TC4034 (Omnidirectional spherical hydrophone)

MEASURE PROCEDURE:

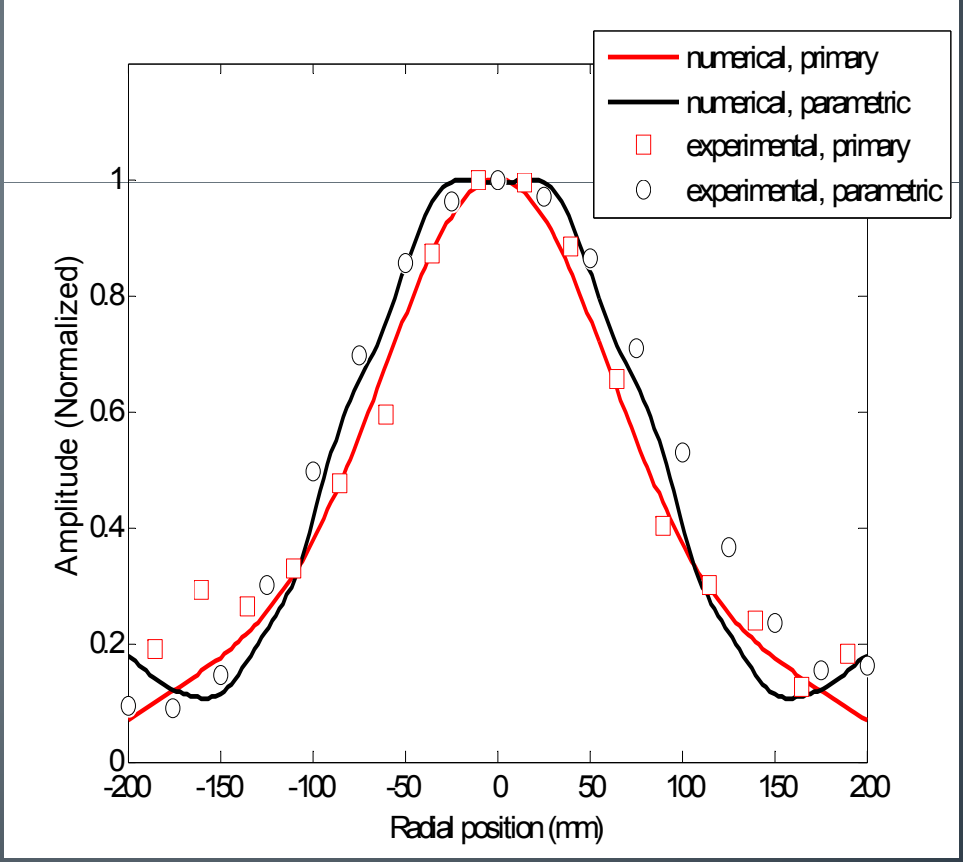
- **DIRECTIVITY**: Acoustics waves are evaluated along the axis transducer axis in three different axial lines (-200 to 200 mm) with a spatial resolution of 25 mm.

- **ATTENUATION**: Acoustics waves are evaluated along the transducer axis, from 100 to 500 mm with a resolution of 50mm

4. RESULTS

DIRECTIVITY:

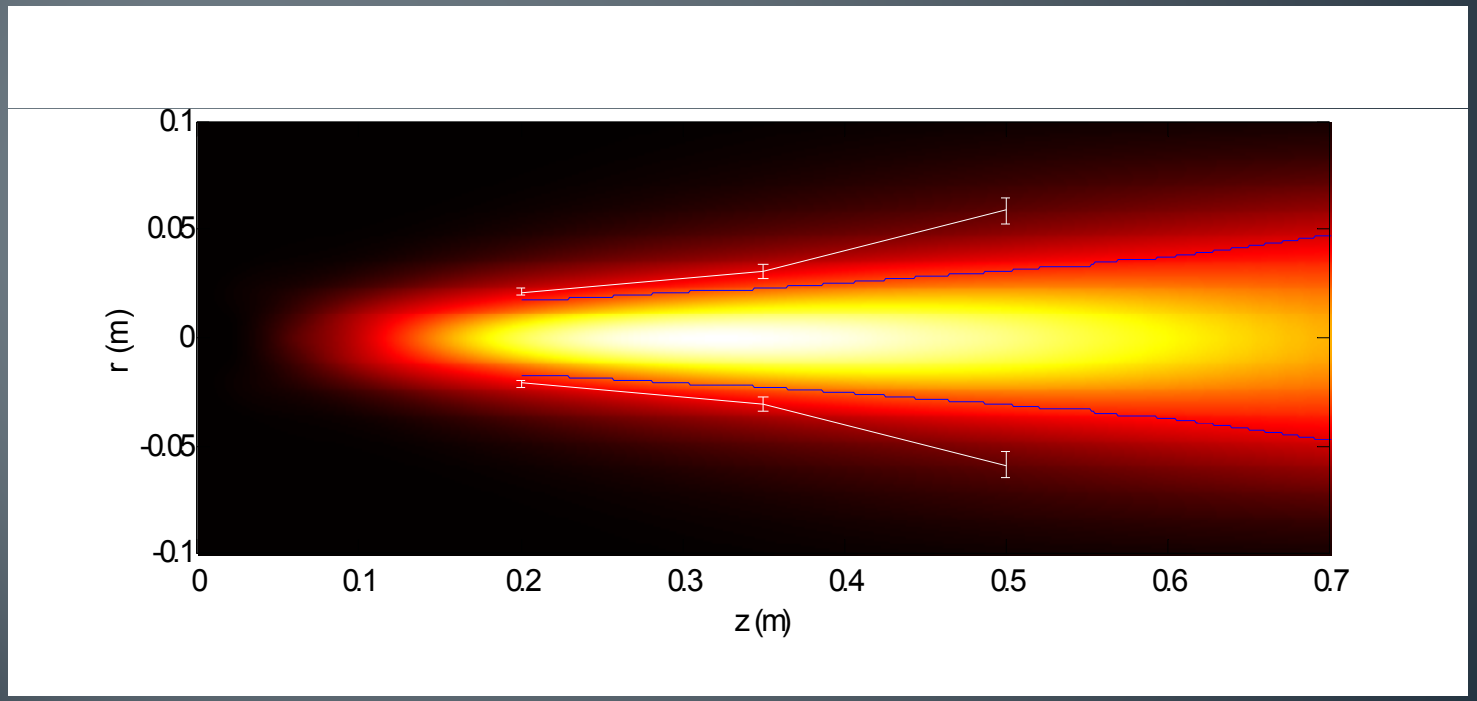
PRIMARY BEAM Vs SECUNDARY BEAM



4. RESULTS

DIRECTIVIDAD:

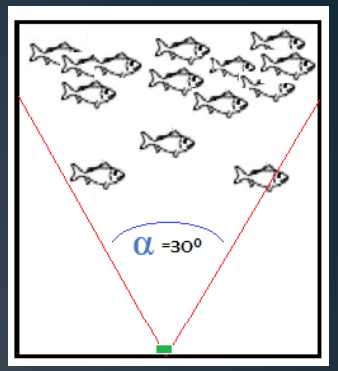
SECONDARY BEAM Vs E-R DISTANCE



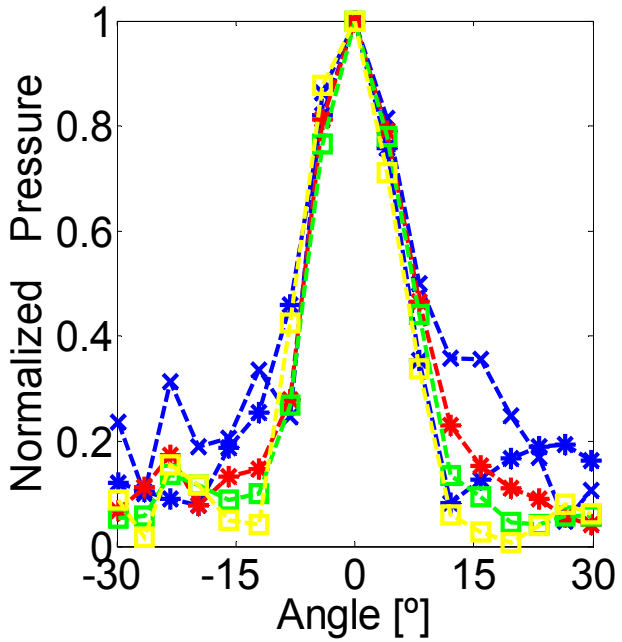
4. RESULTS

DIRECTIVITY:

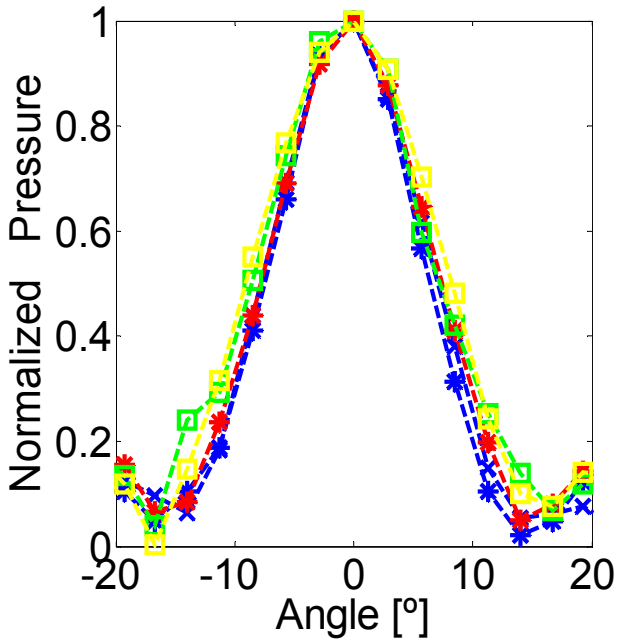
SECONDARY BEAM Vs FREQUENCY

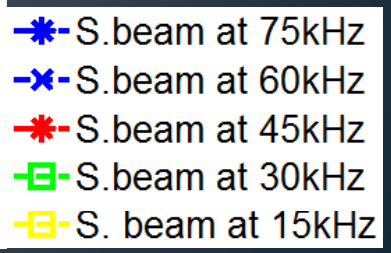


AIRMAR P19



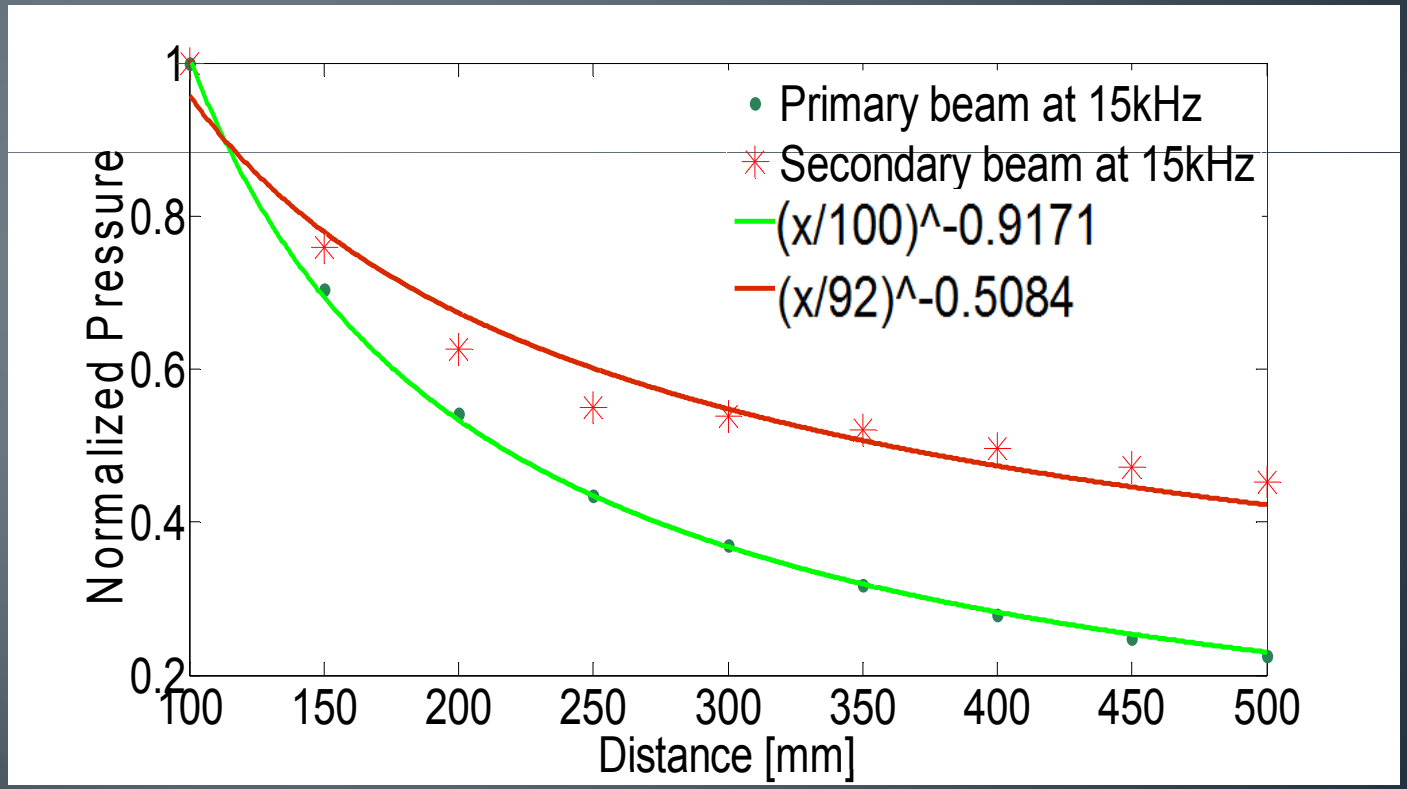
SENSORTECH SX20





4. RESULTS

SPREADING AND ATTENUATION:



4. RESULTS

ANALITICAL APROACH Vs EXPERIMENTAL RESULTS

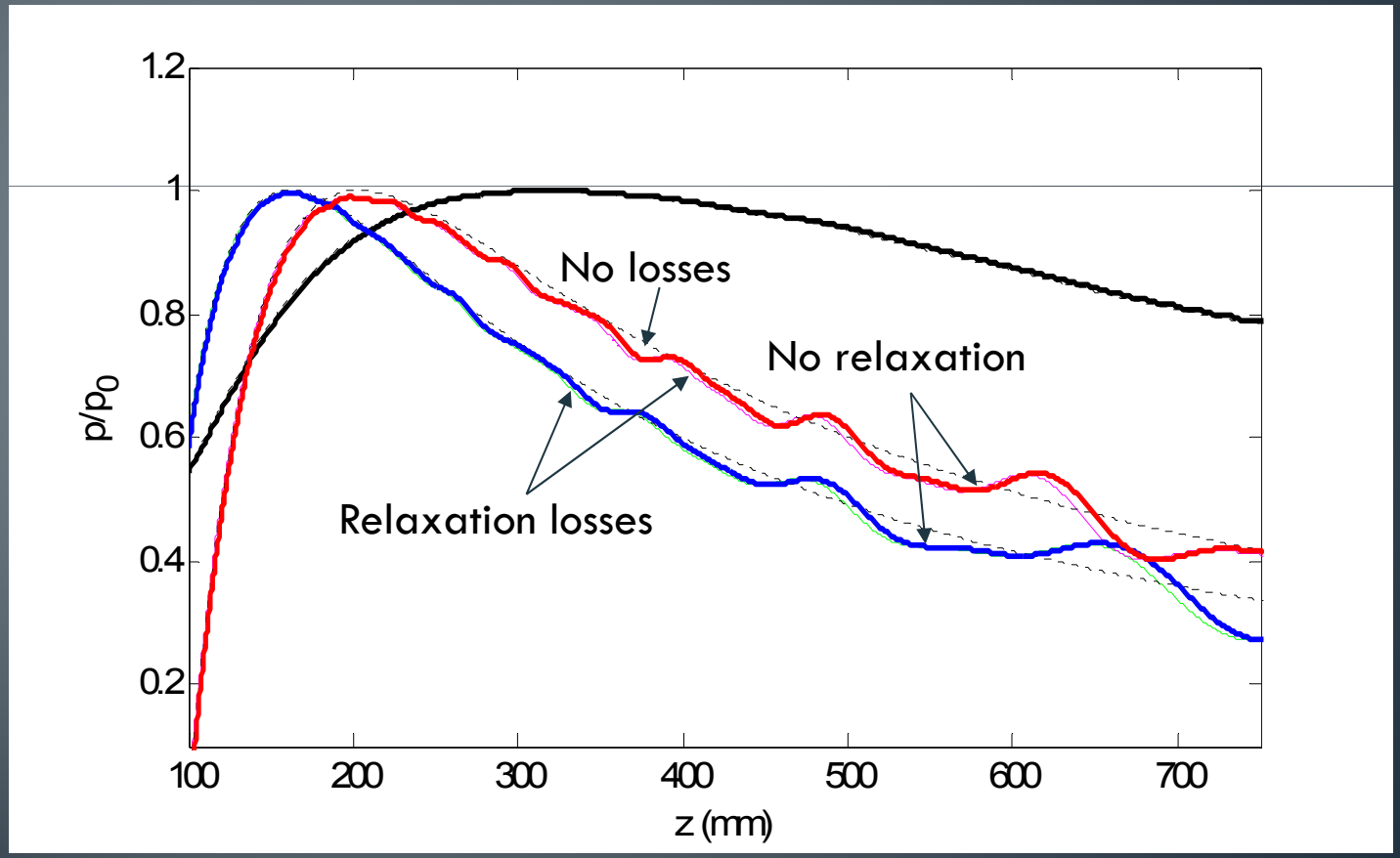
- TRANSDUCERS:
    1. Airmar P19 Φ: 75mm
    2. Sensortech Sx20 Φ: 40mm
- FREQUENCY: 45kHz
- DISTANCE T-R: 350mm

2θ3dB (measure)	2θ3dB (analitical solution)
6°	5.88°
10°	11°

4. RESULTS

SEA WATER:

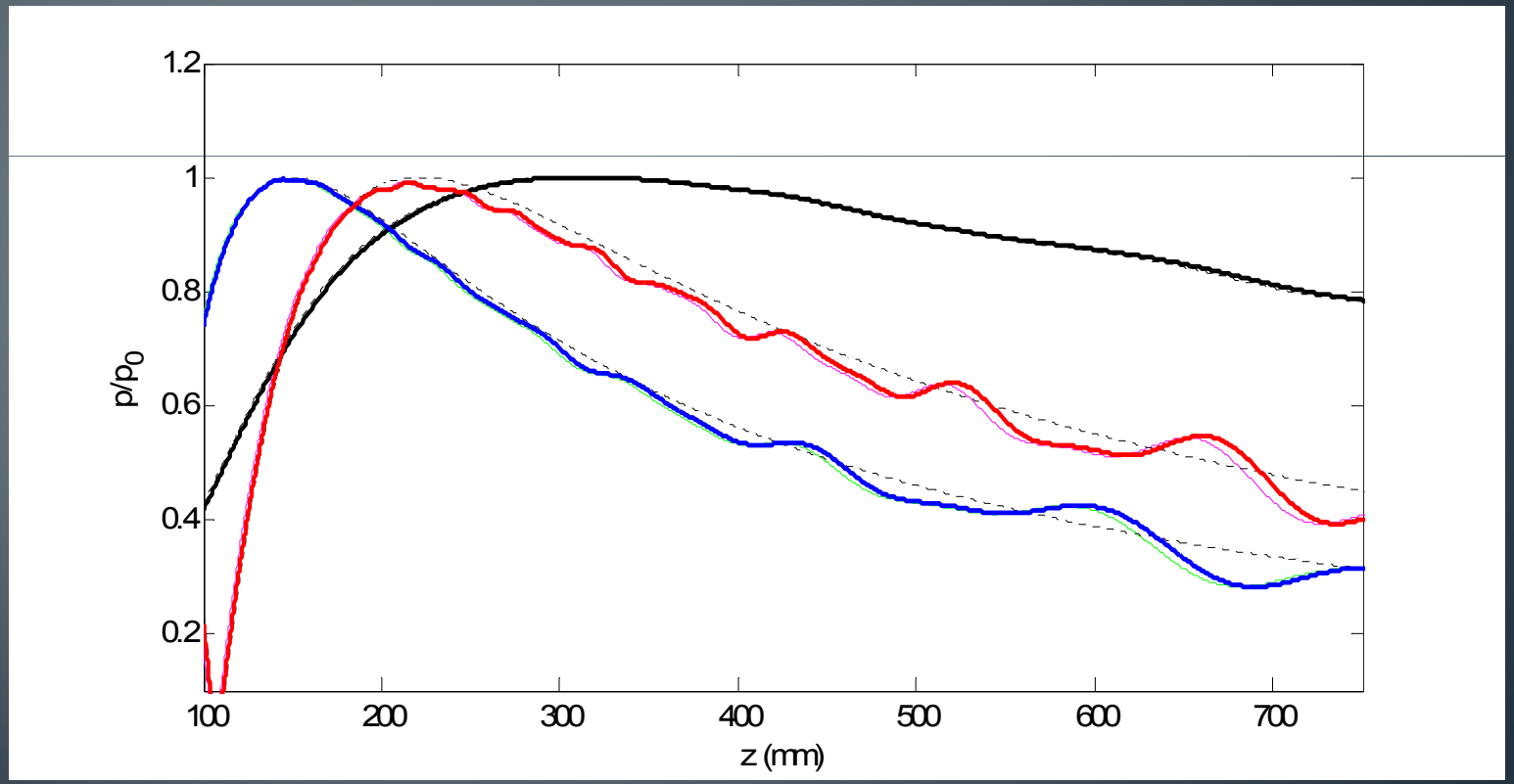
45kHz



4. RESULTS

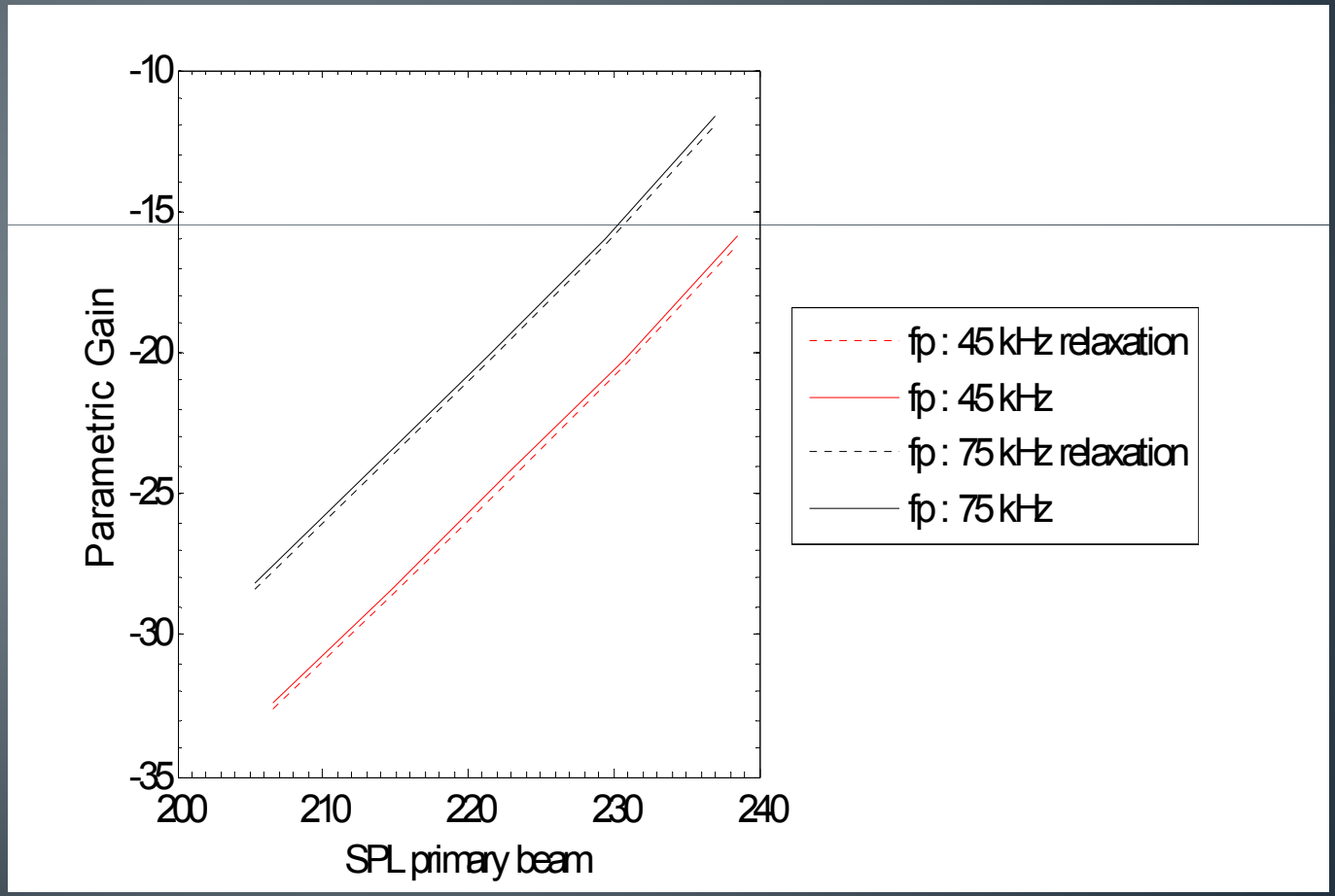
SEA WATER:

75kHz



4. RESULTS

SEA WATER:



4. RESULTS

BIG APERTURE SIMULATION:

5. CONCLUSION

- A preliminary design for shallow water echosounders has been setup

- Relaxation losses do not offer important changes in SHALLOW water.

6. FUTURE LINES

- Experimental measures with transducers with big apertures
- Multiple and back scattering calculation
- Design parametric array (Experimental and simulation)

7. BIBLIOGRAPHY

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