Capture of 3D sound with a spherical microphone array

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DELTATEC
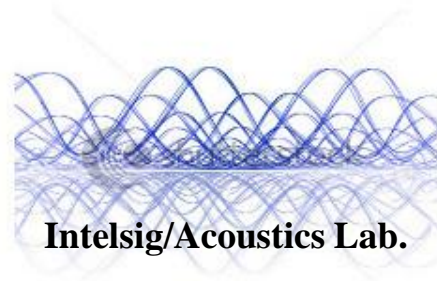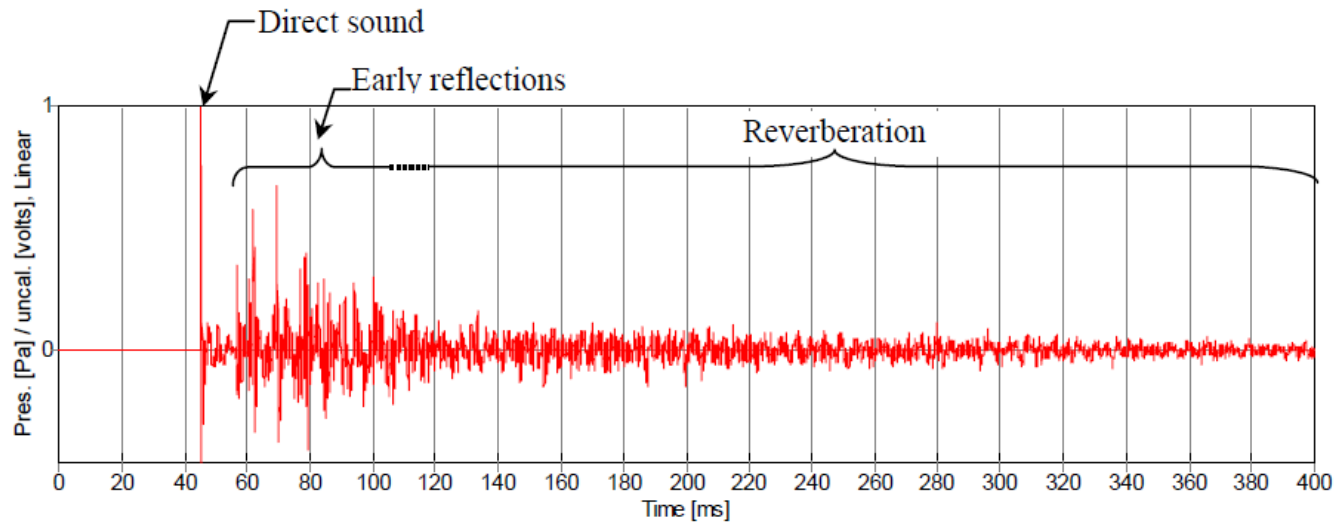LET'S DESIGN THE FUTURE

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- Microphone arrays
  - Applications
  - Geometry
  - Beamforming
- Designed array
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CONTEXT

- Master's thesis in the field of architectural acoustics at the University of Liege

- Objective : Extract 3D Room Impulse Responses with a spherical microphone array
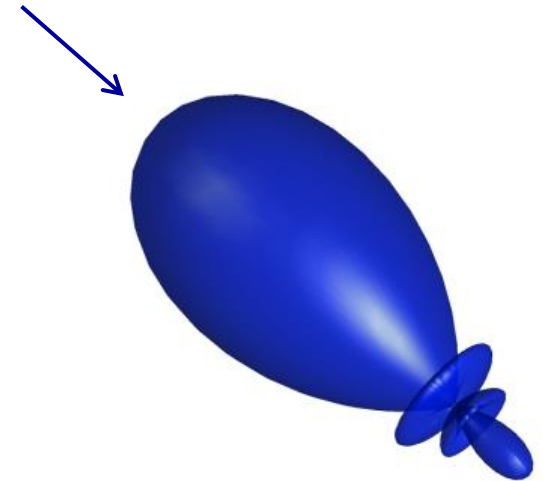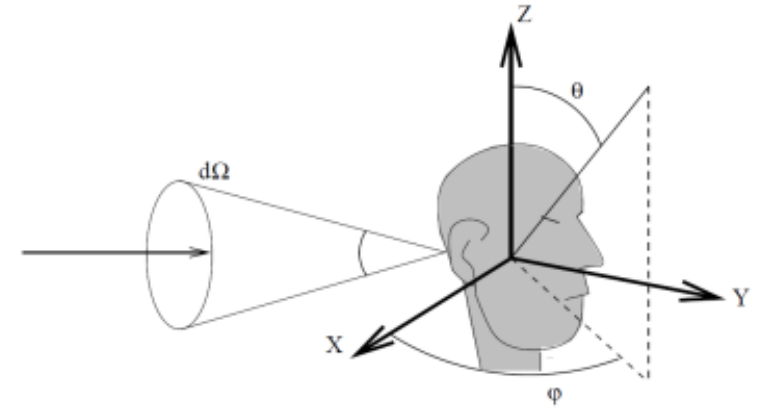
MICROPHONE ARRAYS

- They consist of

  - An arrangement of two or several microphones: *geometry*

  - A linear combination of the signals measured by the microphones: *beamforming*
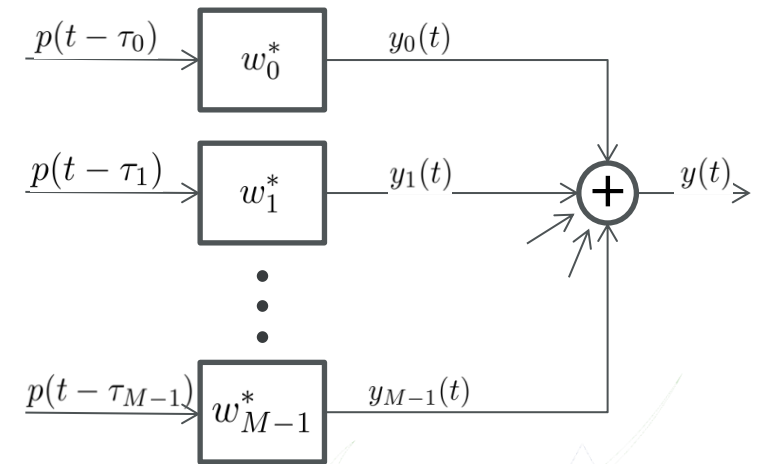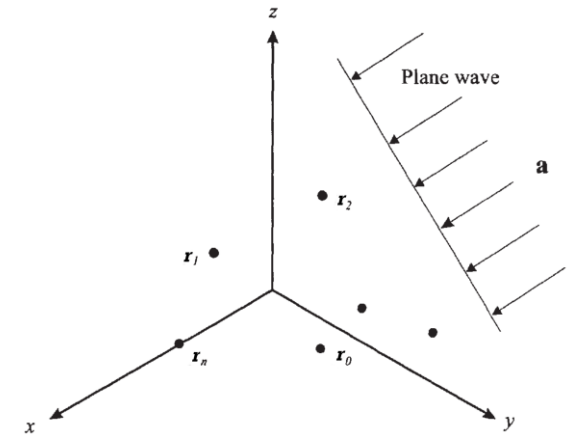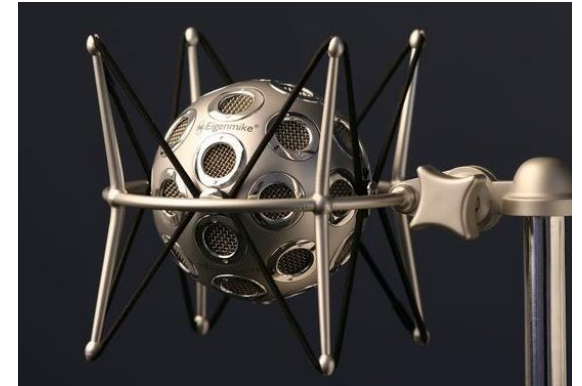
MICROPHONE ARRAYS

- Microphone Array = Geometry + Beamforming

- A microphone array can act like a highly directional microphone by combining the measured signals.

- The main response axis of the beam can be steered in the space thanks to post treatment (electronic steering)


Beam pattern of array output

MICROPHONE ARRAYS : Applications

- Three main uses:
  - Extract a particular signal from ambient noise (ex : telephone, conference)

  - Multichannel reproduction based on 3D sound field recording

  - Extract acoustic source localisation: the beam is steered in every direction to examine the room and to localize the sound.
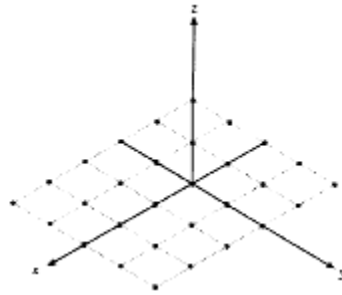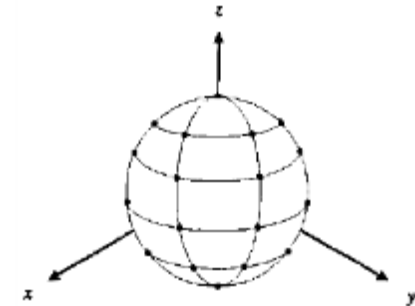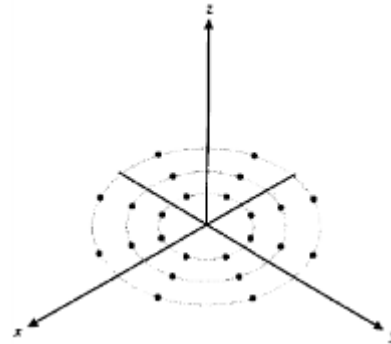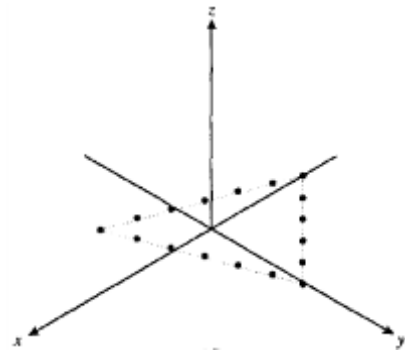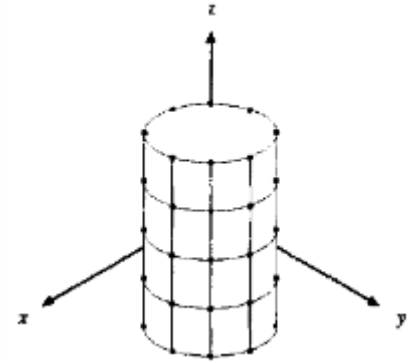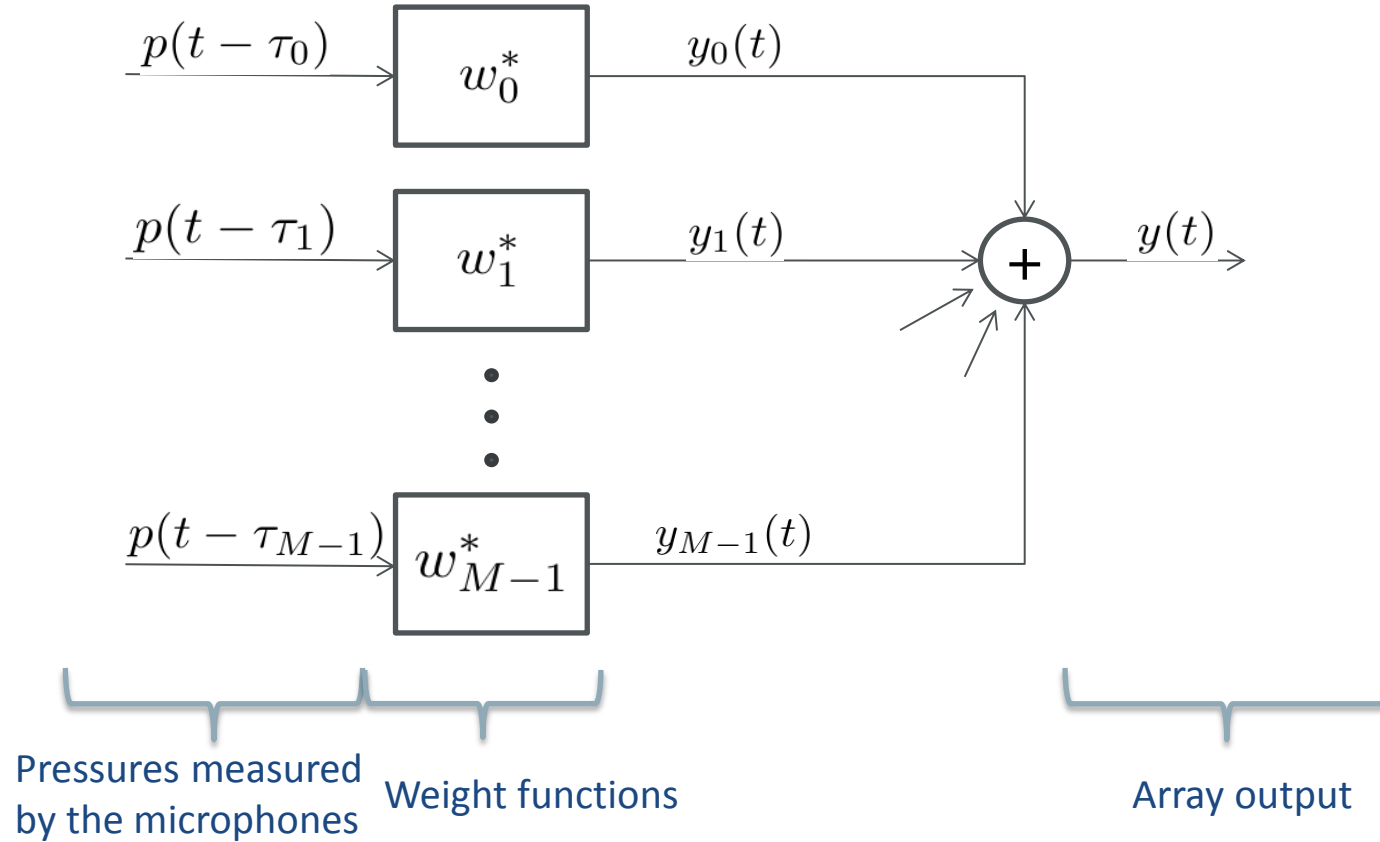
MULTIPLE GEOMETRIES

Linear
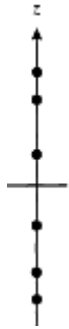
Planar

Volumetric

BEAMFORMING

$$Y(\omega) = \sum_{j=0}^{M-1} W^*(\omega, \Omega_j) P(\omega, \Omega_j)$$

Frequency domain

$$= \sum_{n=0}^{N} \sum_{m=-n}^{n} W_{nm}^*(\omega) P_{nm}(\omega)$$
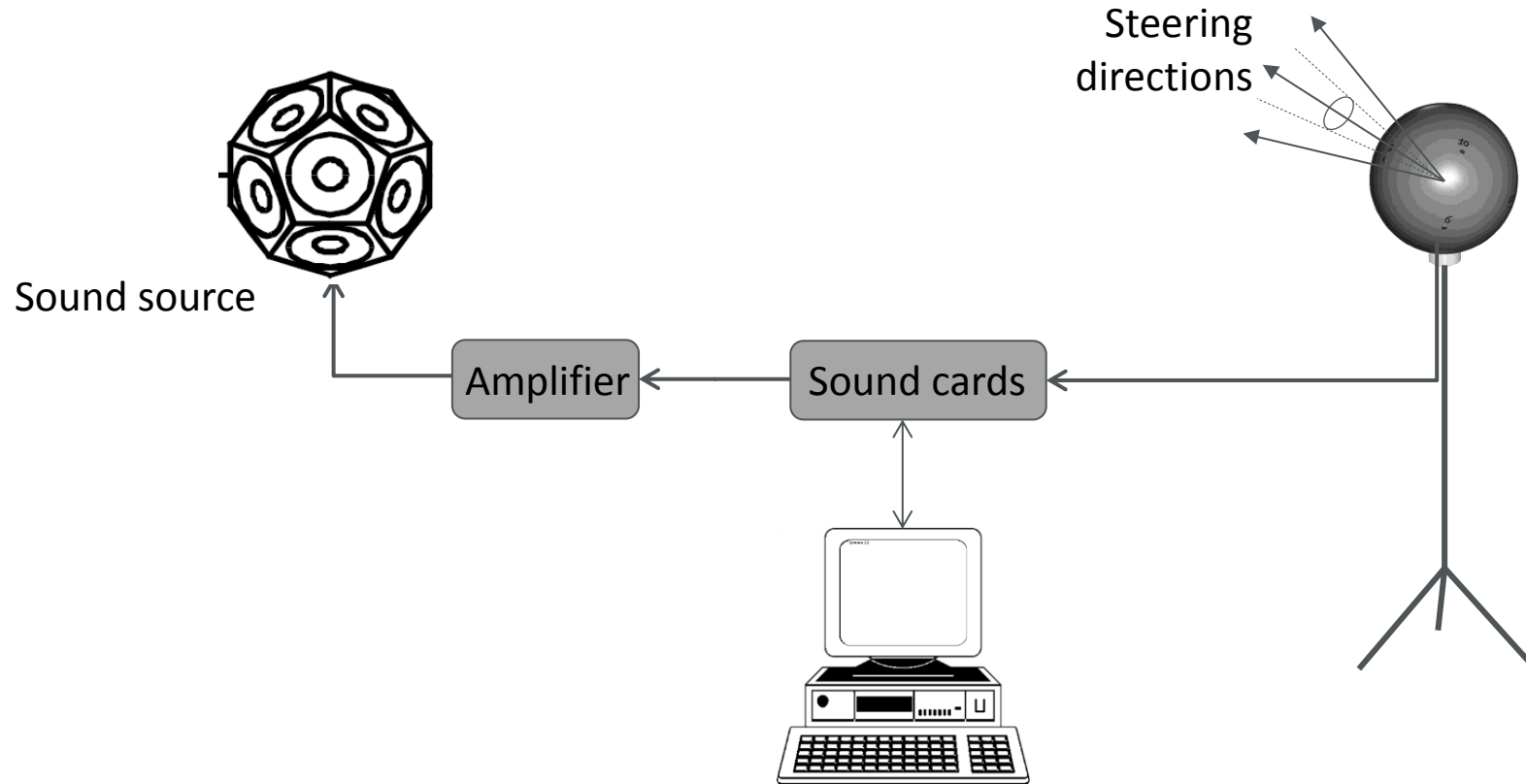
Spherical harmonics domain

MICROPHONE ARRAY DESIGNED

- Spherical microphone array with a 10 cm radius ("rigid" sphere).

- 16 omnidirectional microphones are distributed nearly uniformly on the surface of the sphere.

- 2 sound cards, each with 8 inputs.

- Multichannel recordings in .wav format.
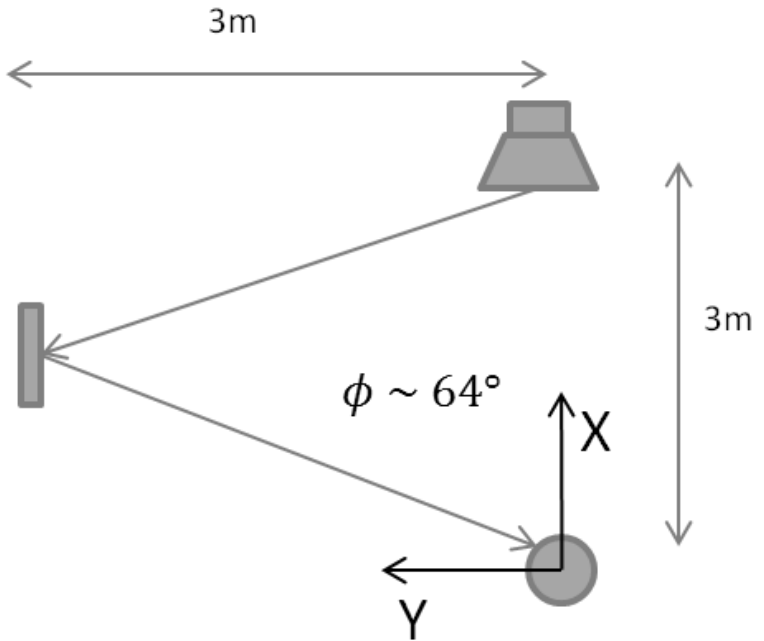
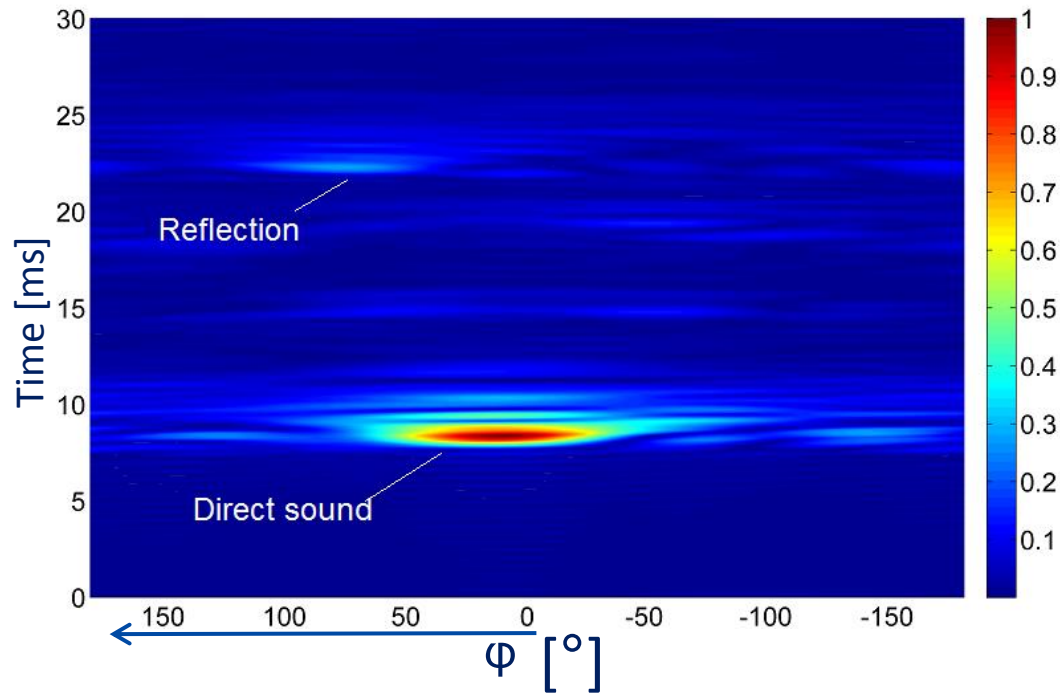- Post-signal processing with Matlab ®.

TEST 1 : Equipment

Different steering directions are defined during post-processing.

TEST 1 : Measurement Setup
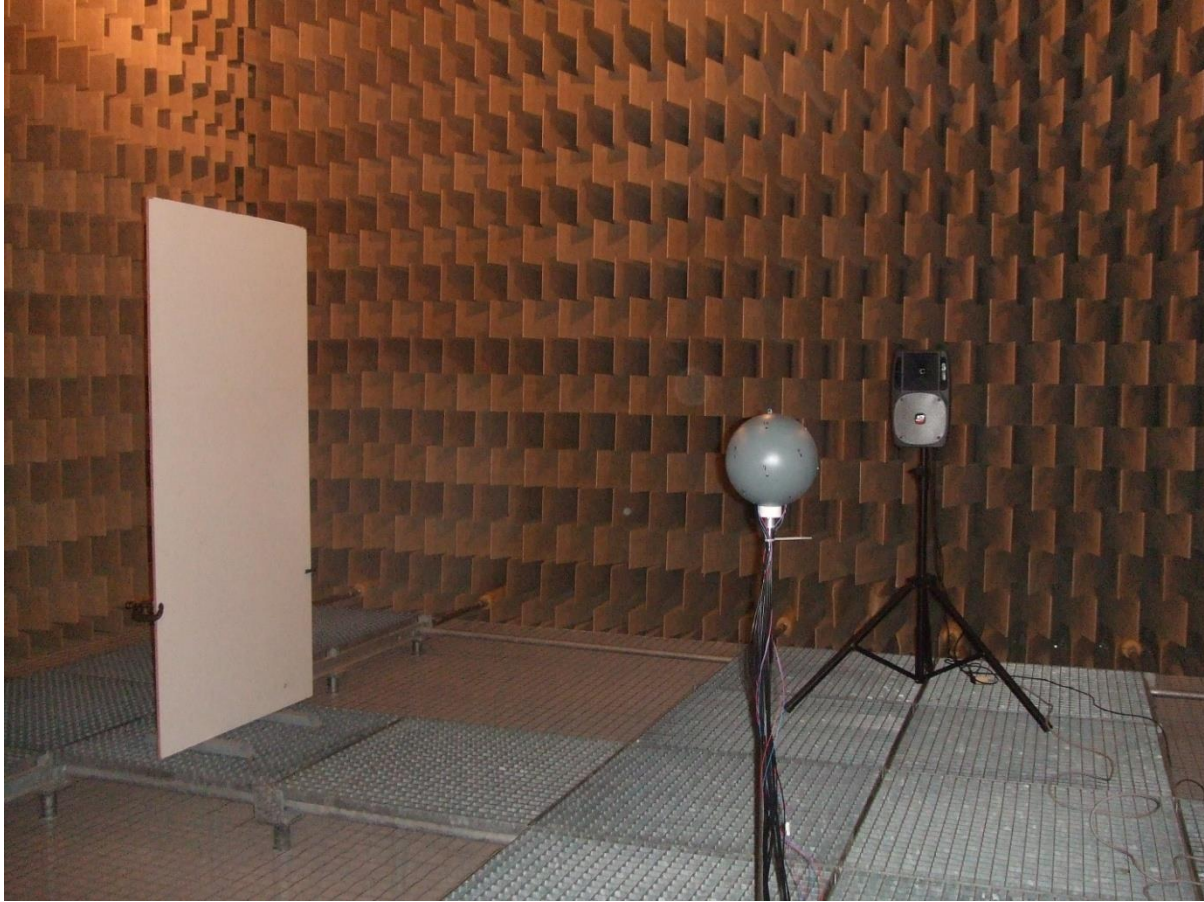
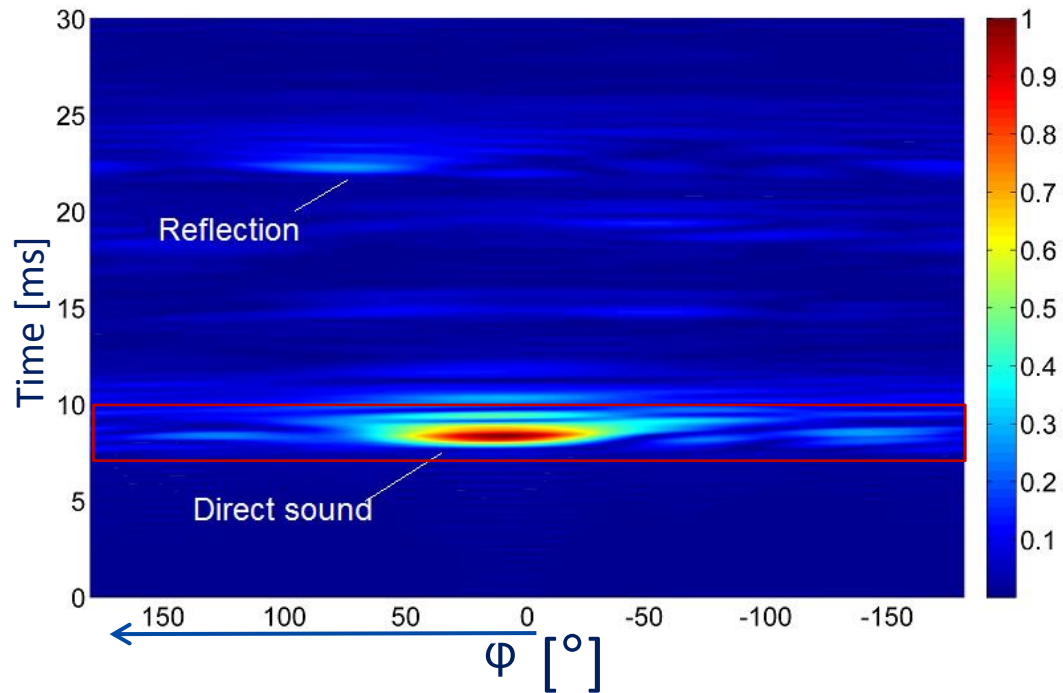# TEST 1 : Analysis of results
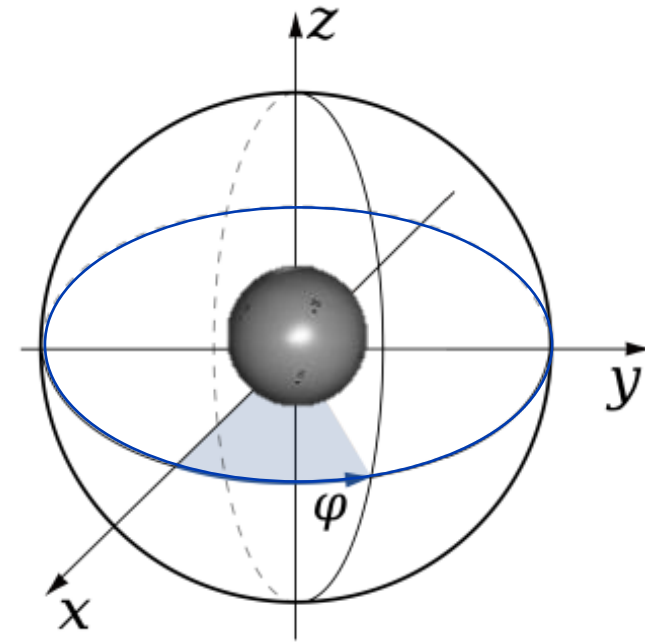
Time evolution of array output
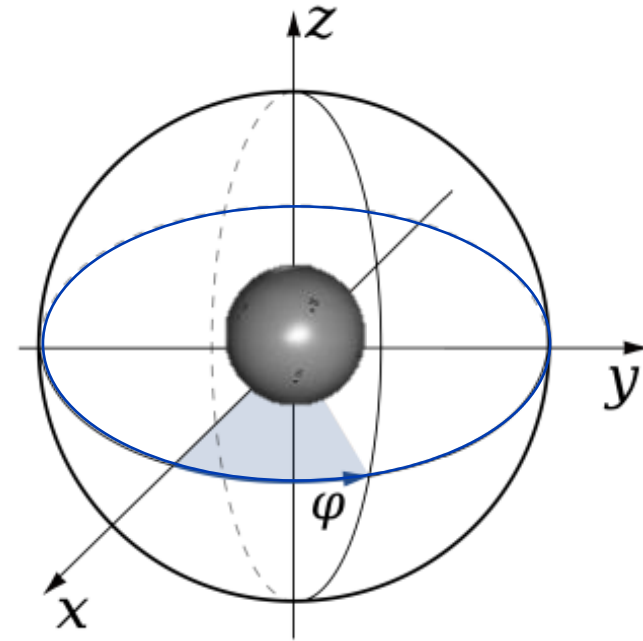in horizontal plane

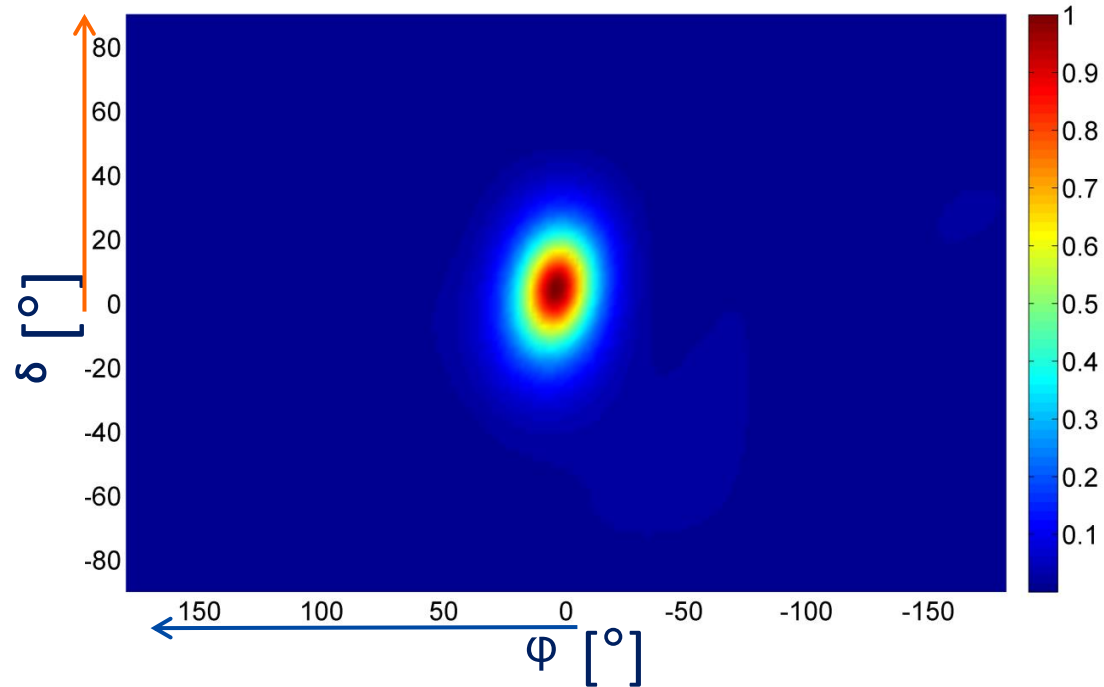Spherical coordinates

TEST 1 : Analysis of results

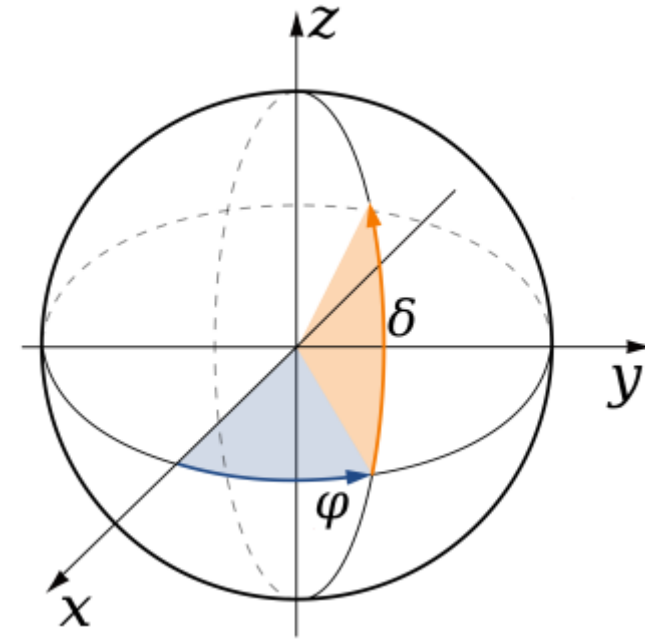Time evolution of array output
in horizontal plane

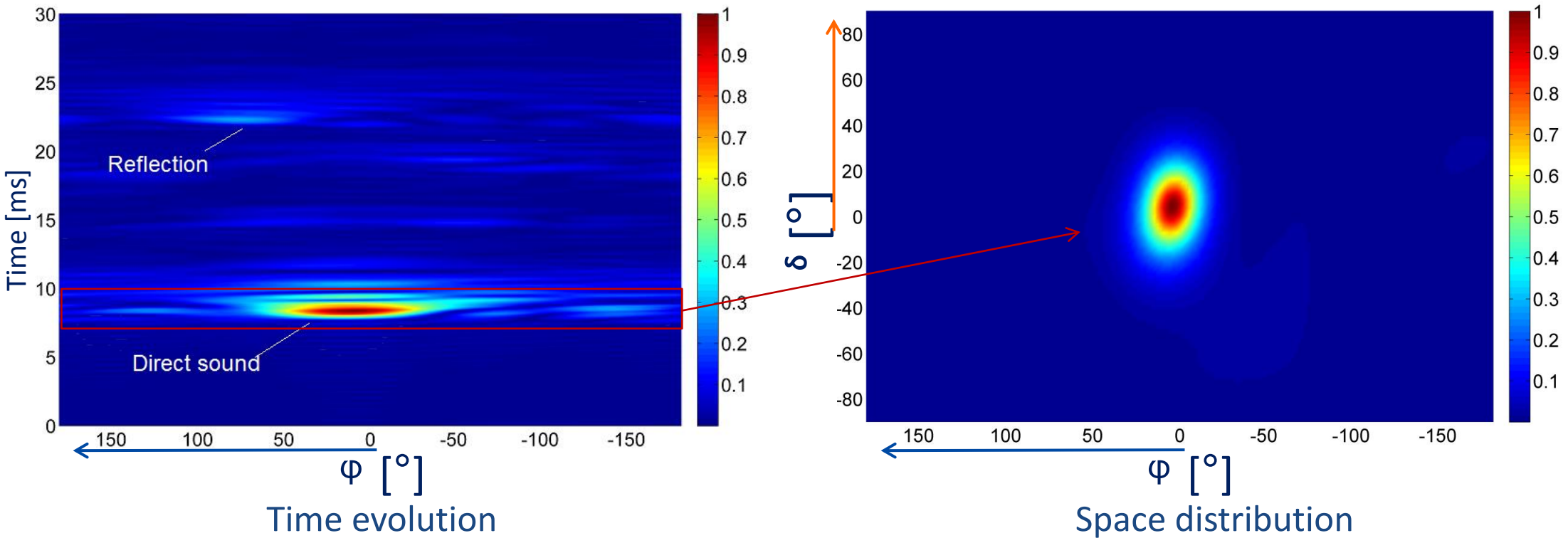Spherical coordinates

TEST 1 : Analysis of results

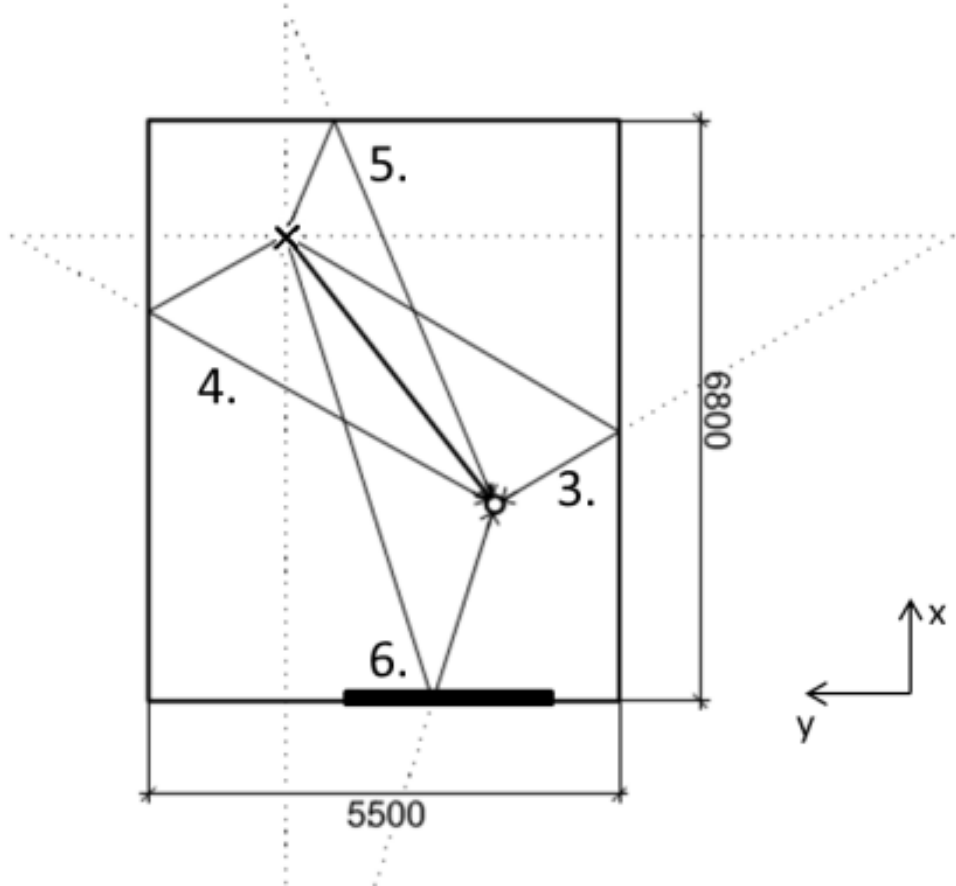Space distribution of array output at a certain time

Spherical coordinates
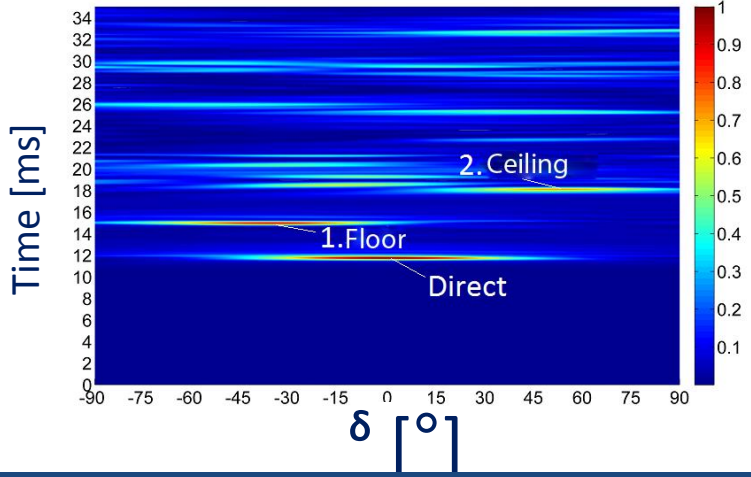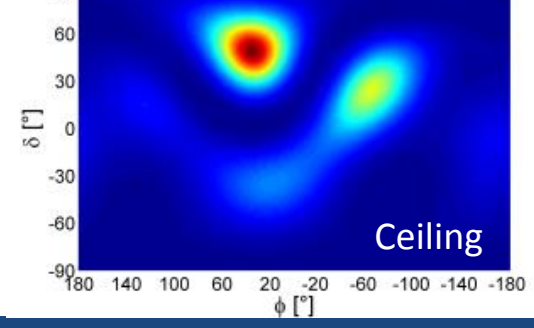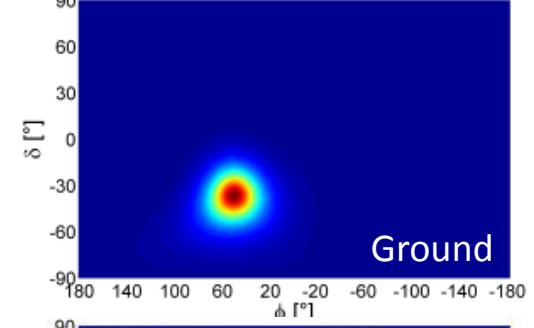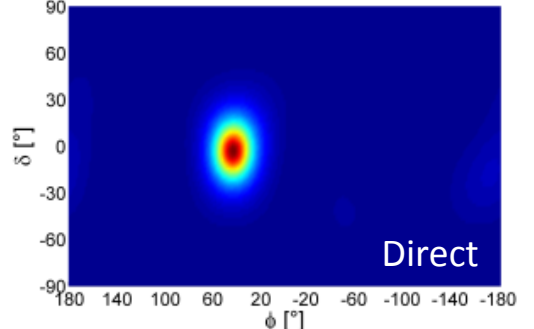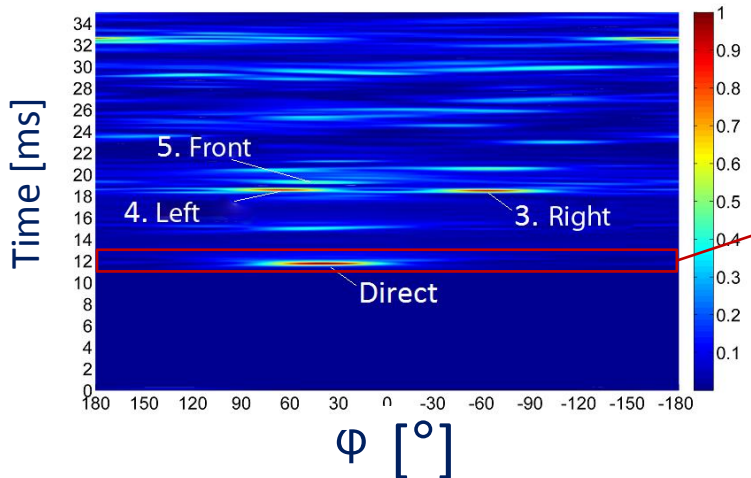
TEST 1 : Analysis of results

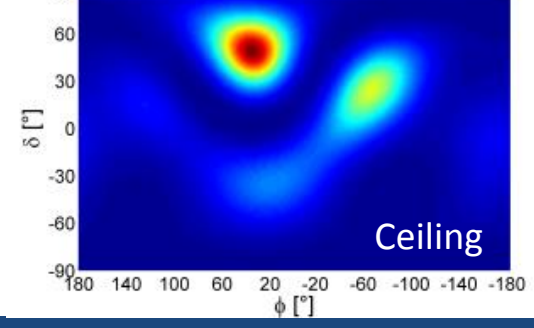
Time evolution

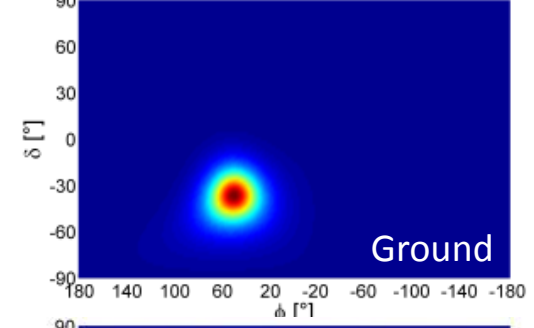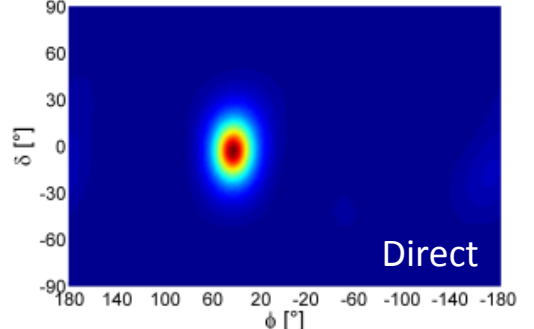Space distribution

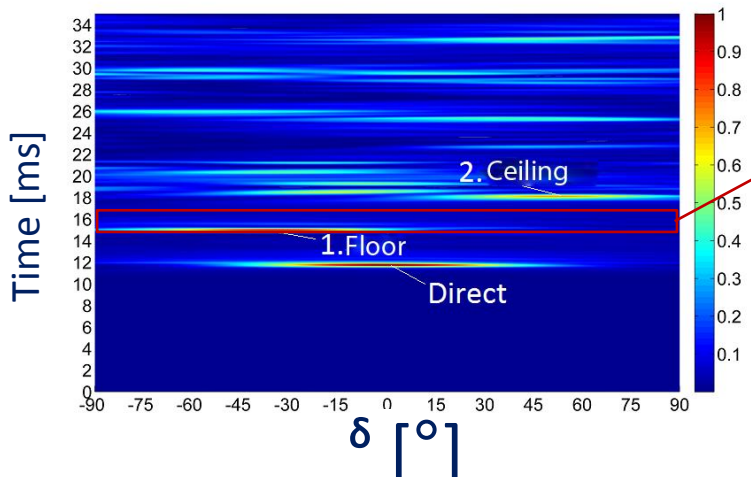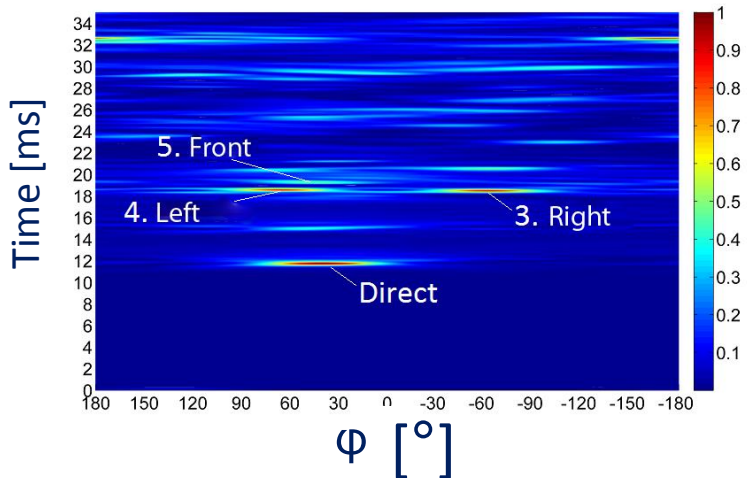➡ Localization of sound source in time and space

TEST 2 : Directional impulse responses in a cubic room

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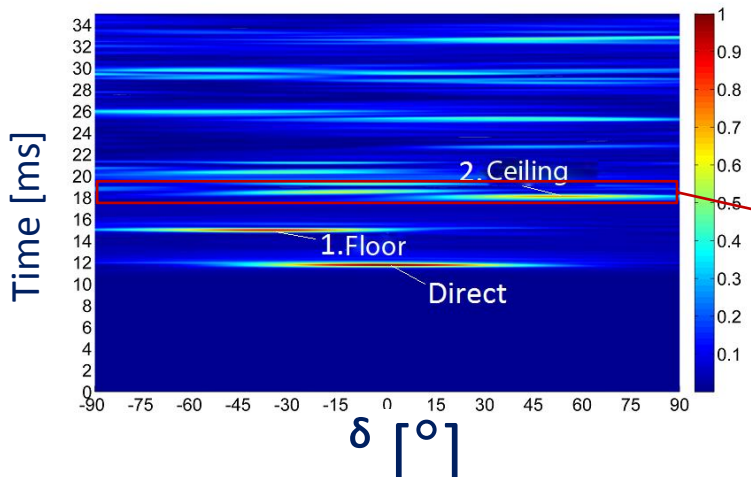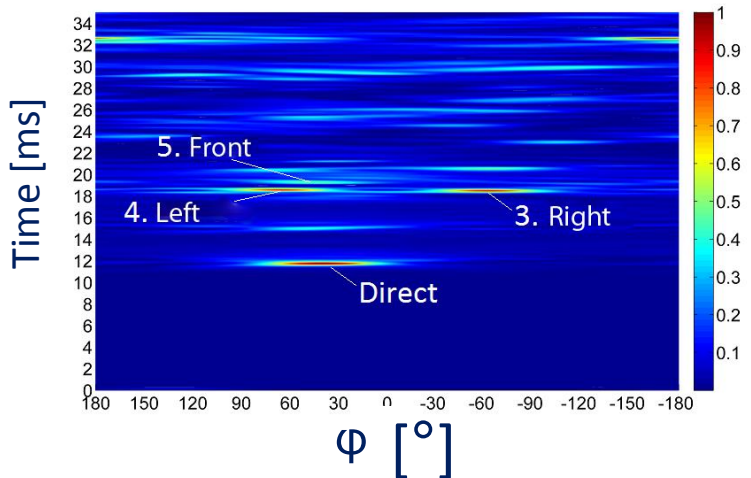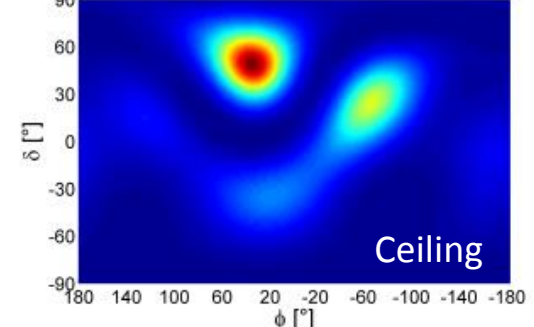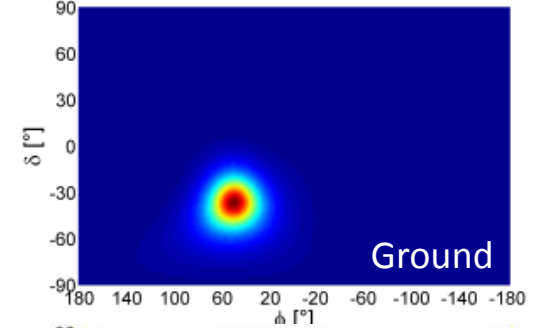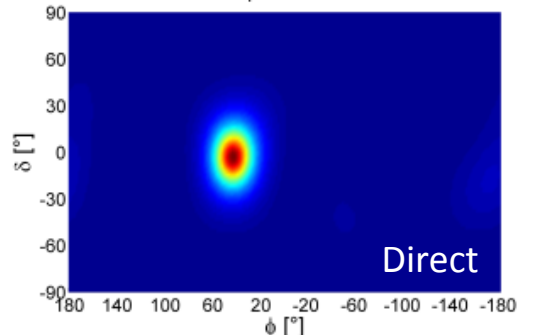# TEST 2 : Directional impulse responses in a cubic room

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CONCLUSION AND PROSPECTS

- This tools allows
  - to get directional informations about rooms
  - to localize individual sound waves in the temporal and spatial domain
- The final outcome of this project: to create a practical tool for acousticians
- The array can be used for others applications
  - 3D recording and multichannel reproduction (Master project 2014)

ACKNOWLEDGEMENTS