

# Background Info on Microphones > Directivity Patterns <

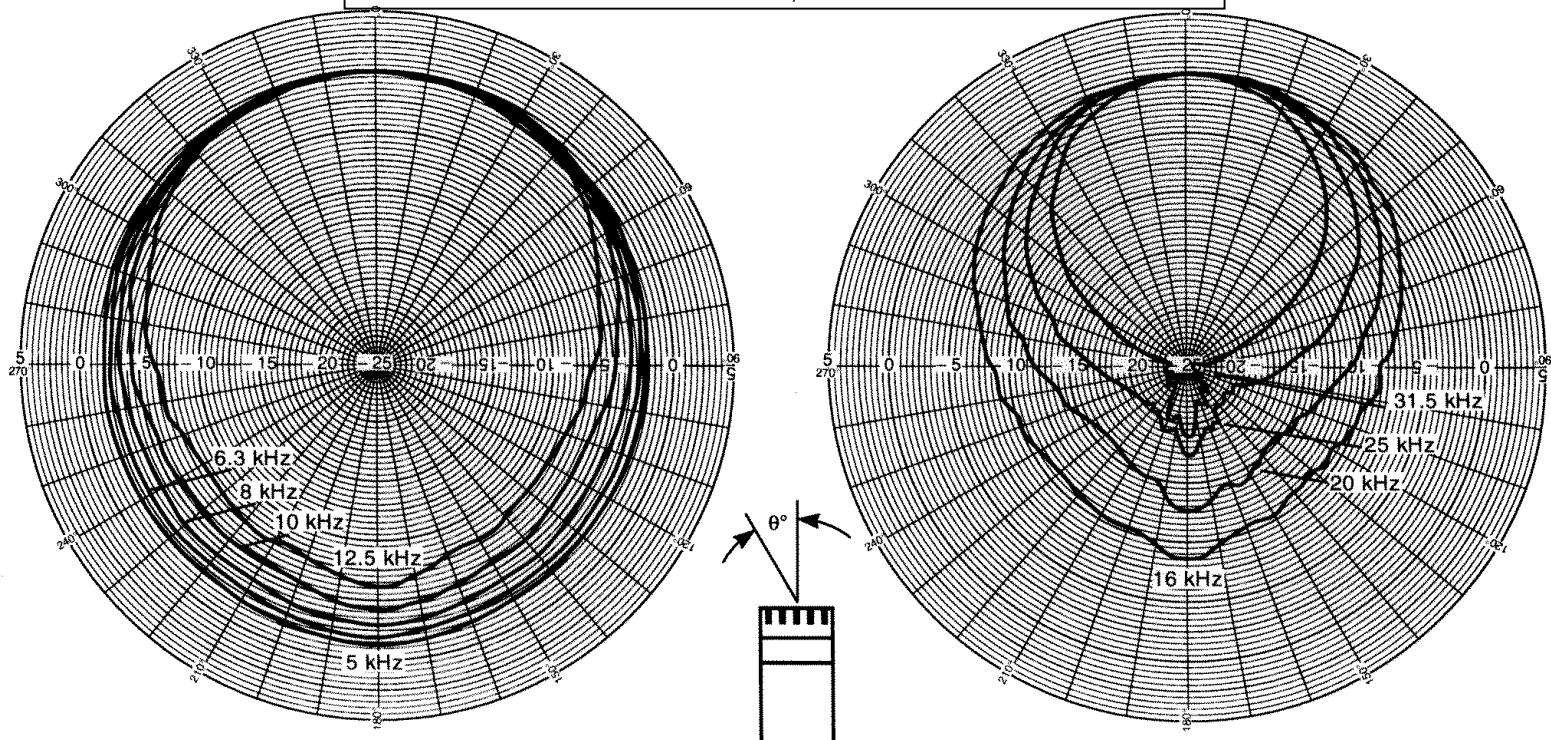
Measuring Mics, Studio / PA Mics  
and the Human Head (Binaural)

# Purpose

- To provide potential users with background information on the directivity characteristics of transducers often used in sound recordings and measurements
- To identify for potential users how the intended usage can affect the selection of the transducer.

# Directivity of a Measuring Mic

Omni-directional pattern defines the operating range



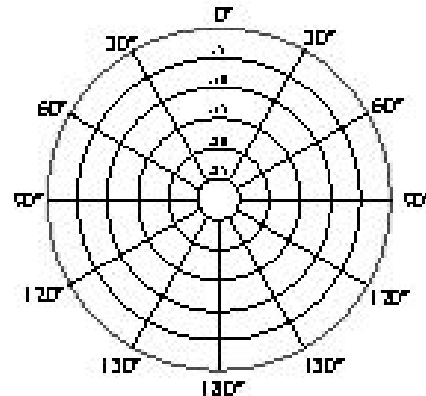
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Fig. 3.14 Typical directional characteristics of the microphone with Protection Grid DB 3420

# Directivity of a Measuring Mic

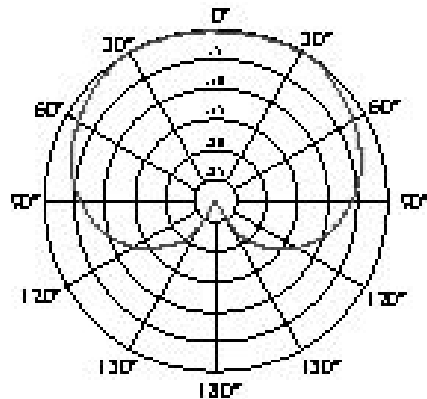
- The simple directivity patterns of measuring mics allow the sound pressure to be measured to within a well defined tolerance (small numeric value) without requiring precise data on the relative angles between the mic and the sound source.
- The principle task of the measuring mic is to produce numeric data concerning the sound.

# Directivity of Studio / PA Mics

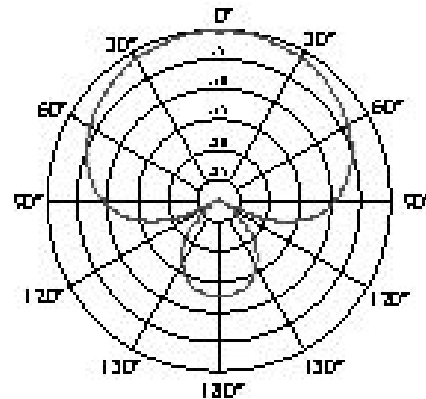


Omni-Directional

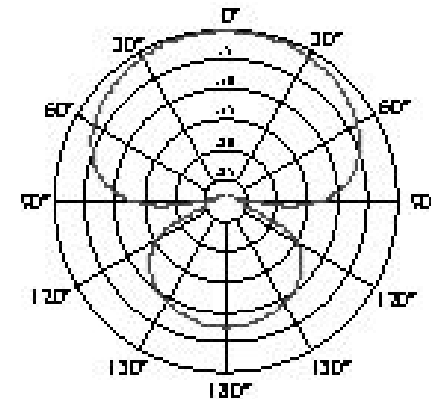
Directivity used to accept the desired sound and reject the unwanted sound.



Cardioid



Super-Cardioid



Hyper-Cardioid

# Directivity of Studio / PA Mics

- The principle task of studio or PA mics is to record the sound with sufficient fidelity to satisfy the needs of human listening during playback.

# Measuring vs. Studio / PA Mics

- All mics exhibit directivity patterns that are non-symmetrical at “high” frequencies (i.e. where the mic size approaches the wavelength of the sound being measured)
- All Measuring Mics are omni-directional in their operating range. (i.e. the omni-directional pattern defines the operating range)

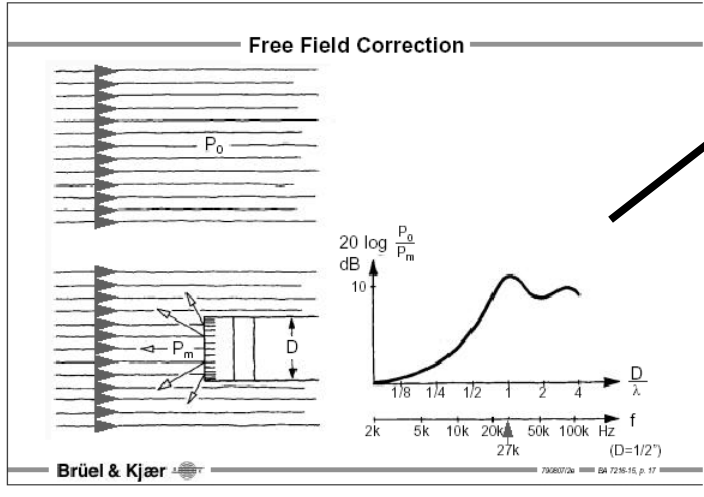
# Directivity Pattern Measurements

- Performed in full Anechoic Rooms
- Performed using a sound source calibrated using a measuring microphone
- Measuring mics form the basis for modern measurement of sound

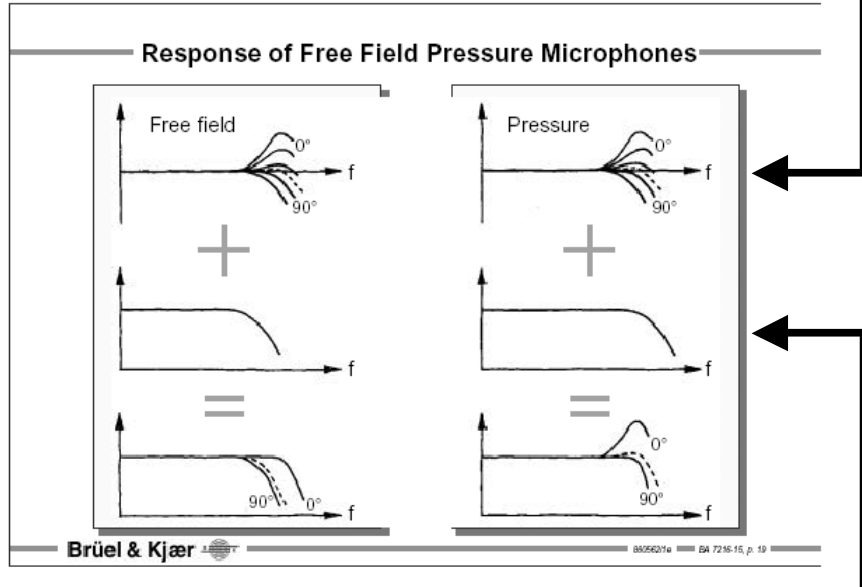
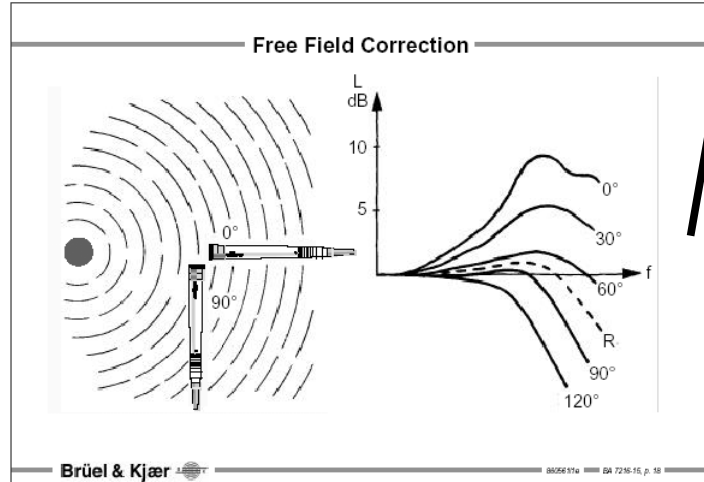


# Types of Measuring Mics

Effects of Mic Physical Geometry



Free field mics and Pressure mics have the same directivity.



Free field mics and Pressure mics have different equalizations.

# Directivity of Human Head

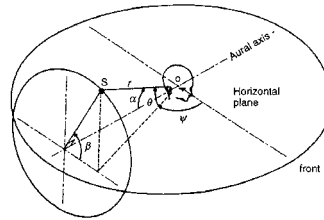


FIG. 1. Definition of an intraural-pole-axis coordinate system. S: sound source; O: center of the head; r: distance between a sound source and the center of head;  $\alpha$ : azimuth angle;  $\theta$ : elevation angle;  $\alpha$ : the angle between the aural axis and a straight line connecting the sound source with the center of a subject's head;  $\beta$ : the angle between the horizontal plane and the perpendicular from the sound source to the aural axis, that is, the vertical angle in a plane parallel to the median plane, called the sagittal plane.

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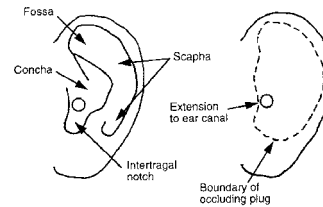


FIG. 3. The occluded part of a pinna.

## C. Pinna conditions

The localization tests were done under four pinna conditions: (a) both ears open, i.e., the pinna cavities of both ears were not occluded; (b) right ear open, i.e., the pinna cavities of the right ear were entirely open while those of the left ear were occluded except for a passageway to the ear canal; (c) left ear open, i.e., the pinna cavities of the left ear were entirely open while those of the right ear were occluded except for a passageway to the ear canal; and (d) both ears occluded, as described above. The occluded part of cavities is shown in Fig. 3. In this experiment, the pinna cavities were occluded using a material normally used for dental impressions (Algix), and the passageway to the ear canal was made of a drinking straw. The surface of the occlusion was flattened to be level with the end of the straw and the helix. The length of the straw was almost equal to the distance from the surface to the entrance of the auditory canal.

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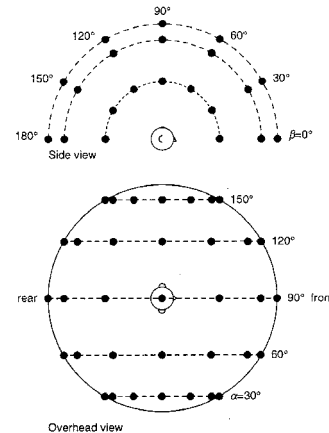


FIG. 2. Arrangement of loudspeakers used for the localization test. In the side view, loudspeakers in sagittal planes defined by angles  $\alpha=120^\circ$  and  $150^\circ$  are hidden by those in sagittal plane defined by angles  $\alpha=60^\circ$  and  $30^\circ$ , respectively.

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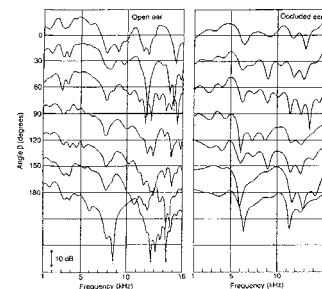


FIG. 4. Measured amplitudes of head-related transfer functions of an open ear (left) and an occluded ear (right). Left ear of one of three subjects. Source angle  $\alpha=90^\circ$ .

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Directivity of the Human Head is complicated and probably unique for each individual

Head-related Transfer Functions (HRTF)

# Directivity of Human Head

Example HRTF Summaries

HRTF  
in  
Horiz.  
Plane

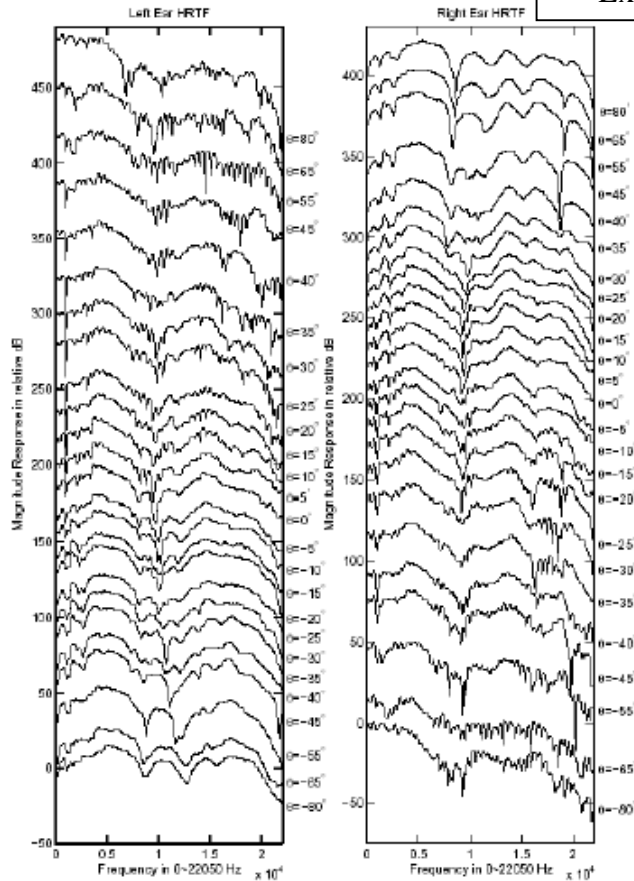


Figure 3.1: Frequency domain comparison of HRTFs as a function of azimuth in the horizontal plane (elevation=0°).

HRTF  
in  
Median  
Plane

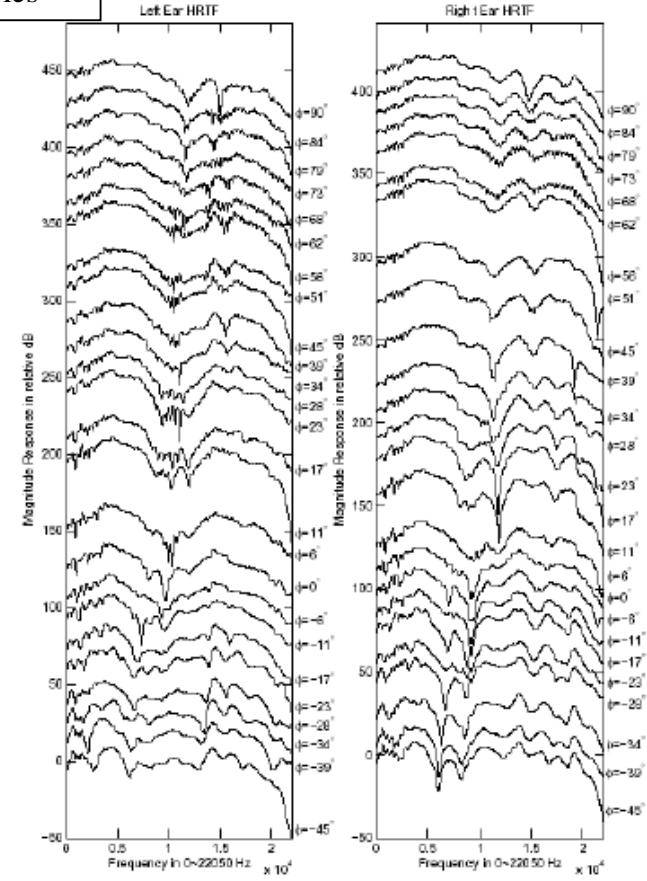


Figure 3.2: Frequency domain comparison of HRTFs as a function of elevation in the median plane (azimuth=0°).

MS Degree Thesis: Ming Li, University of Kaiserslautern, 2003

# Human Hearing and Localization

- The localization capabilities of human hearing are partially due to the complicated 3-D directivity (HRTF) of the human head.
- Localization capabilities are also related to differences in time-of-arrival of sound at the two ears (which can be simulated by spacing two measuring mics some distance apart).
- Other factors are topics of research.

# Human Hearing and Localization

- Binaural heads are generally used in sound recordings when there is a need to preserve (to a greater degree than studio mics) the localization capabilities of human hearing during playback.
- Binaural heads are typically constructed using 2 measuring mics mounted in a specially designed baffle (head shape) that alters the directivity of the measuring mics to simulate HRTF's.

# Summary

- Measuring mics form the basis for modern measurement of sound
- All measuring mics are omni-directional in their operating range
- Measuring mics are equalized for use in specific sound fields
- Directional mics and binaural heads have specific uses for sound recording and reinforcement (PA)
- Directional mics are not typically used for noise measurements

# End of Presentation