Design and application of linear microphone arrays

Dr.-Ing. Matthias Domke

Microtech Gefell GmbH

MICROTECH GEFELL

microphones & acoustic systems - founded 1928 by Georg Neumann

Structure

1. Introducing Microtech Gefell GmbH
2. Design problems regarding to the audio frequency range
3. Distribution of the microphone capsules
4. Signal processing for the microphone capsules
5. Application example: orchestra stage
6. Application example: theatre stage
7. Summary

Microtech Gefell GmbH

founded in 1928 by Georg Neumann in Berlin

moved to Gefell during the world war II
Georg Neumann & Co

under the communist regime the name changed to
VEB Mikrofontechnik Gefell

the new name after German Reunion is
Microtech Gefell GmbH

with a long tradition in development

and manufacturing of studio and

measurement microphones

General Manager: Dr.-Ing. M. Domke
Owner: Georg Neumann KG

Product range

studio microphones

measurement microphones

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Problem: wide range of the wavelength

frequency	wavelength	array length
100 Hz	3,400 m	1,700 m
1000 Hz	0,340 m	0,170 m
10000 Hz	0,034 m	0,017 m

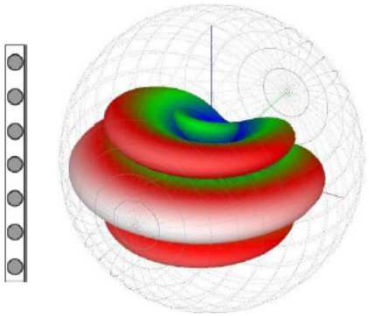
- a long linearray is necessary for the low frequency directivity

- a small transducer distance is necessary for reduced grating lobes at high frequencies ➔ at low frequencies the transducer density is to high and the sample distance is unnecessarily low
- the directivity increases when the frequency increases ➔ the directivity at high frequencies is much to high

- constant relationship between the array length and the wavelength (the array length must decrease if the frequency increases)
- constant relationship between the sample distance and the wavelength (reduced transducer density in the low frequency part of the array)

Distribution of the microphone capsules

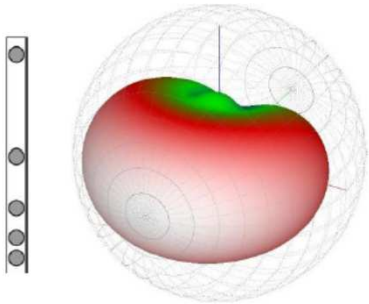
equidistant



Disadvantage:

- very high number of microphone capsules and processing channels

logarithmic, asymmetric



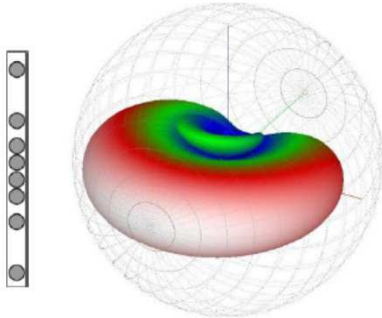
Advantage

- very low number of microphone capsules and processing channels

Disadvantage

- wide vertical coverage angle

logarithmic, symmetric



Advantages

- low number of microphone capsules and processing channels
- narrow vertical coverage angle

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Constructions

KEM 975

8 microphone capsules

4 equidistantly spaced microphone capsules (25 mm)

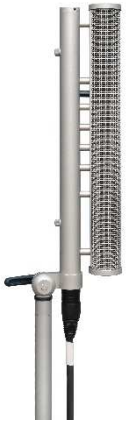
array length = 300 mm

f_{gu} = 570 Hz

analog signal processing

no latency

beamsteering not possible



R-ZeMiS 12

12 microphone capsules

4 equidistantly spaced microphone capsules (25 mm)

array length = 1200 mm

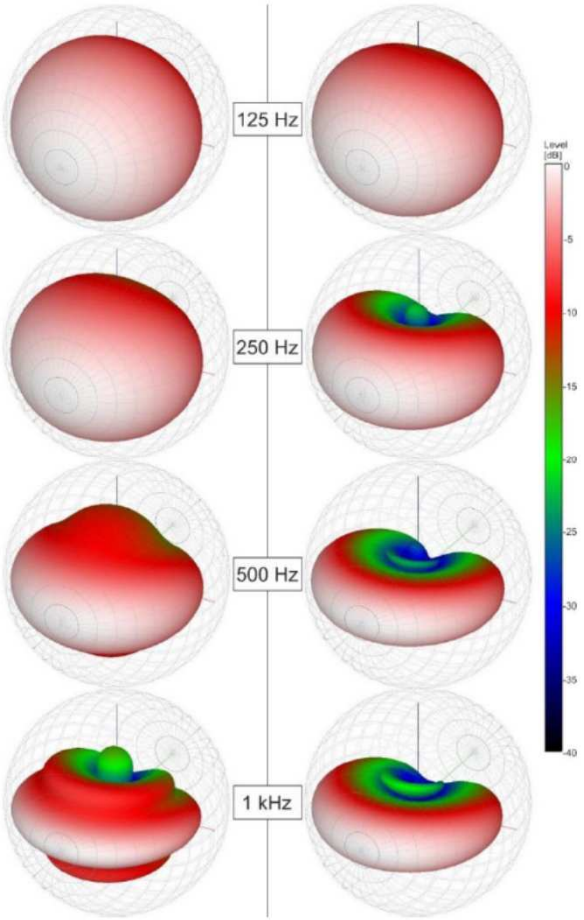
f_{gu} = 145 Hz

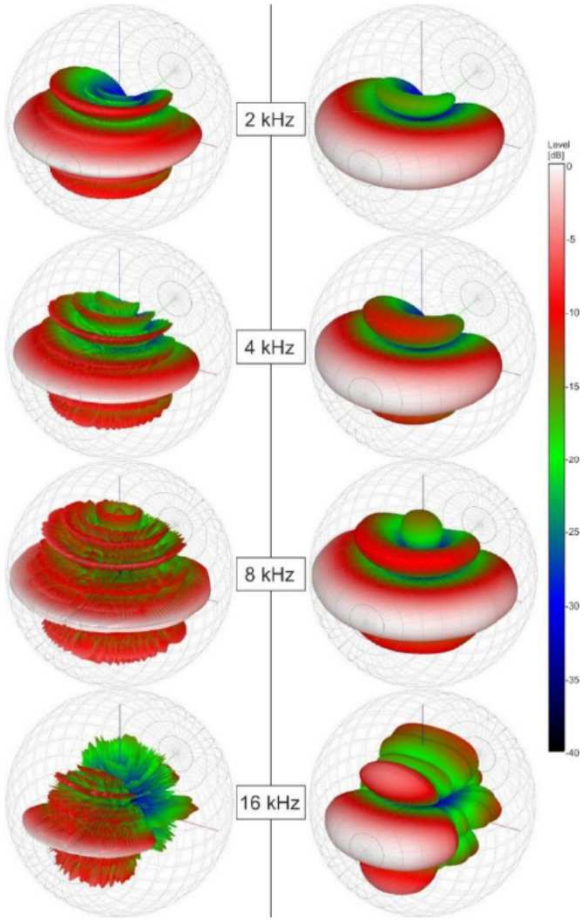
digital signal processing

4,2 ms latency

beamsteering possible

Summation of the capsules - Beamforming





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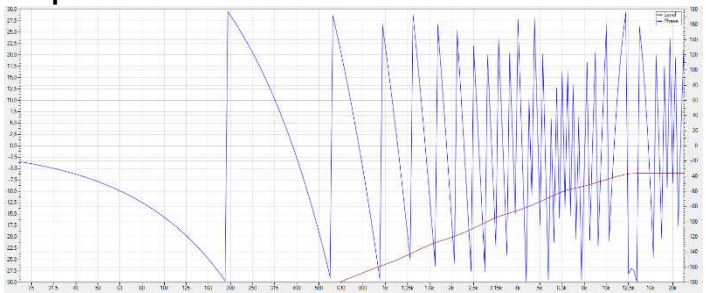
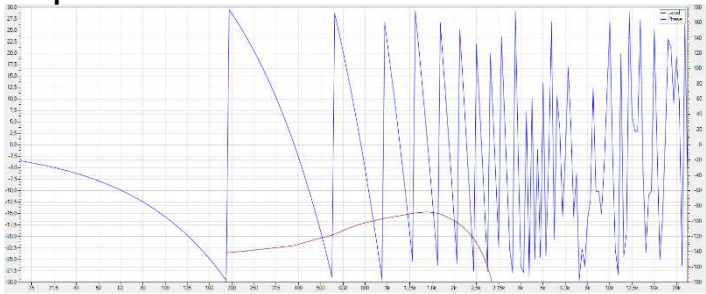
Transfer functions of the FIR-filters

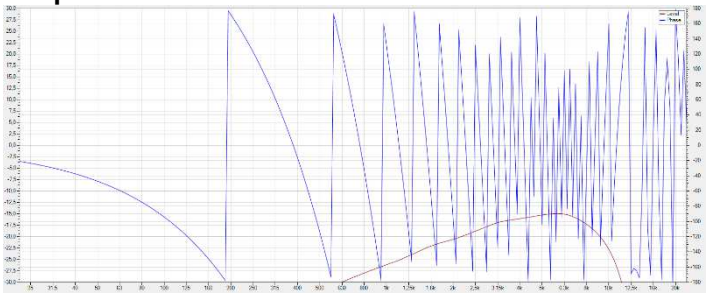
capsule 1/-1



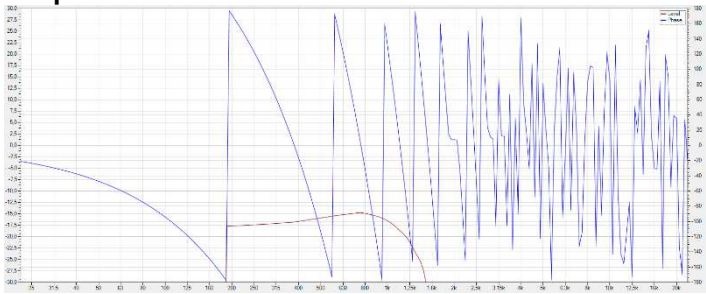
capsule 4/-4



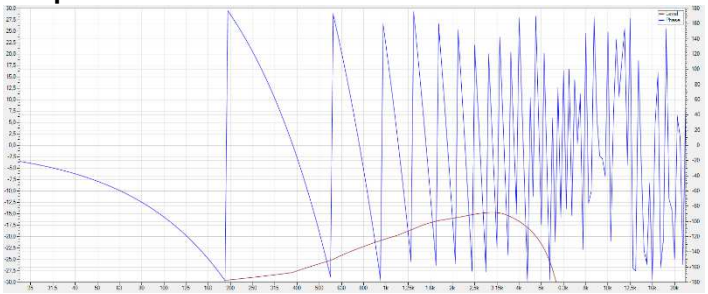
capsule 2/-2



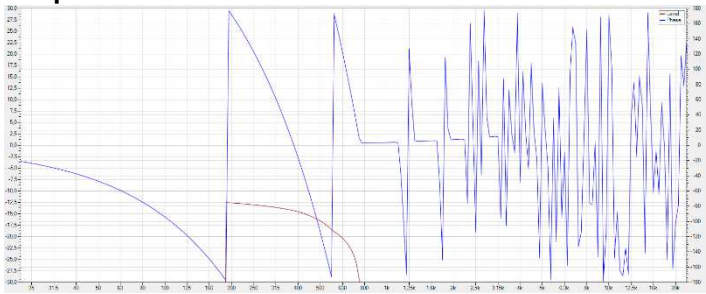
capsule 5/-5



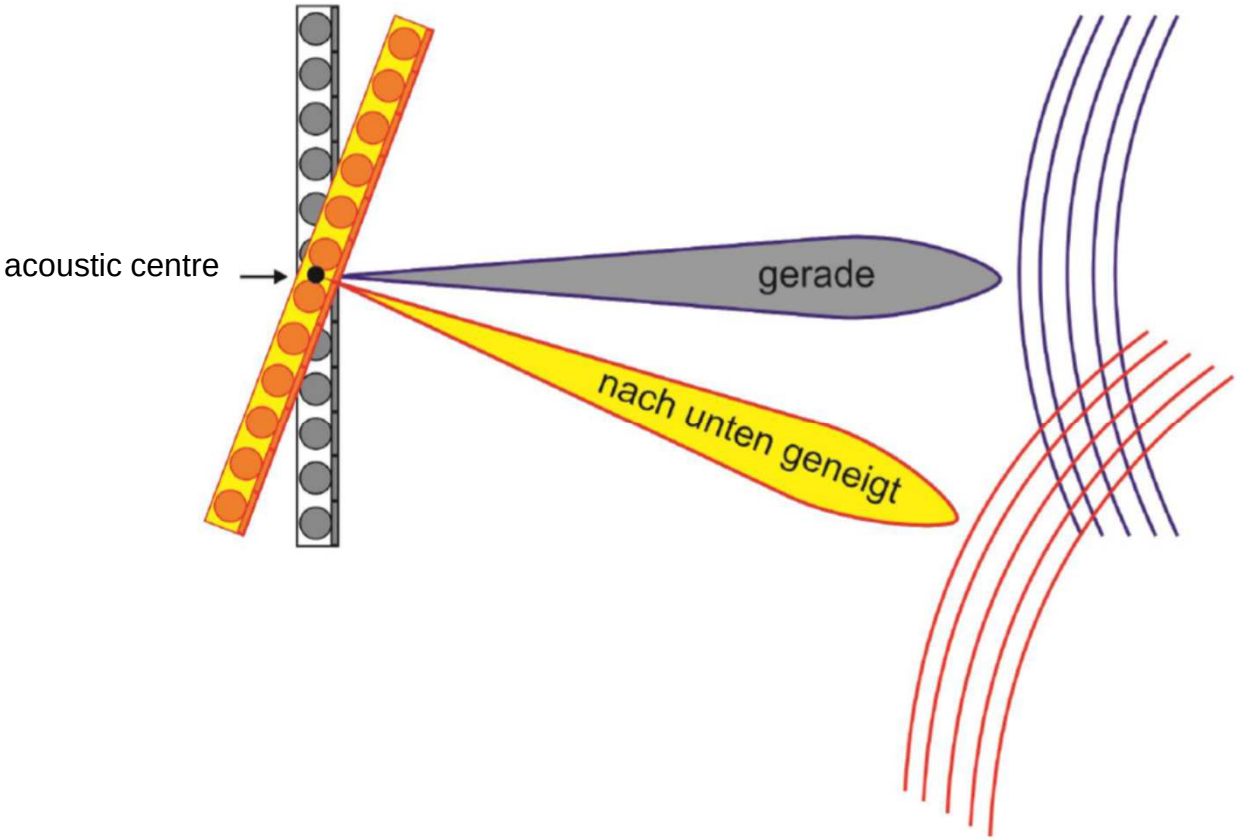
capsule 3/-3



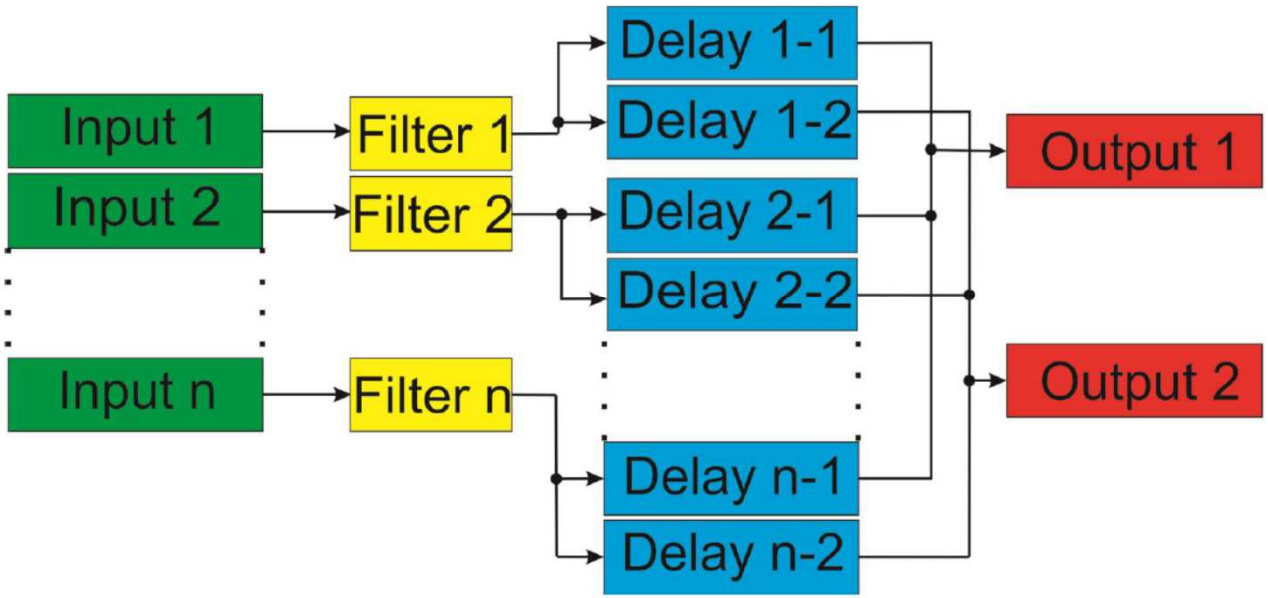
capsule 6/-6



Beam steering with delays



Signal processing – filter , delay and sum



Application of the KEM 975: orchestra stage

Problems when recording an orchestra stage

- unequal distribution of the recording level with an increasing distance between the microphone and the sound source (instrument)
- soundfield at the microphone position is influenced by reflexions from the walls and the ceiling of the stage

Problems with additional microphones very close to an instrument

- a compensation of level and delay is necessary
- such microphones are not invisible
- some instruments have a multi directional and frequency dependend radiation of sound

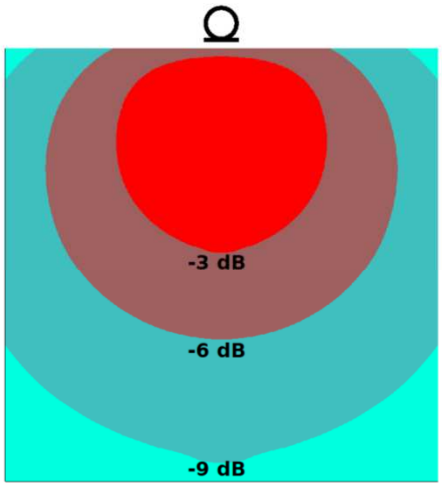
The microphone for the recording of an orchestra should

- be in the far field of the orchestra
- have an equal distribution of the recording level from the nearest to the farest instrument position
- have enough directivity to reduce the reflexions from the walls and the ceiling of the orchestra stage

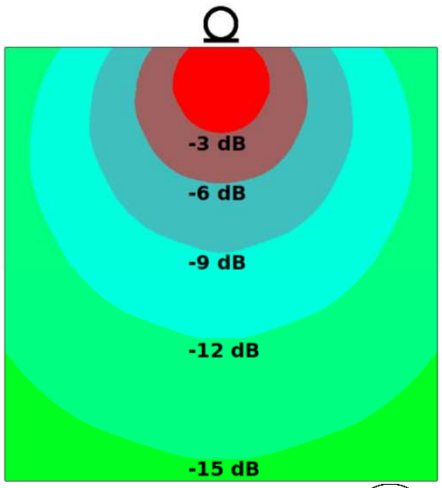
Level distribution on the stage

Stage dimensions: (10 x 10) m

Microphone heigth: 3 m



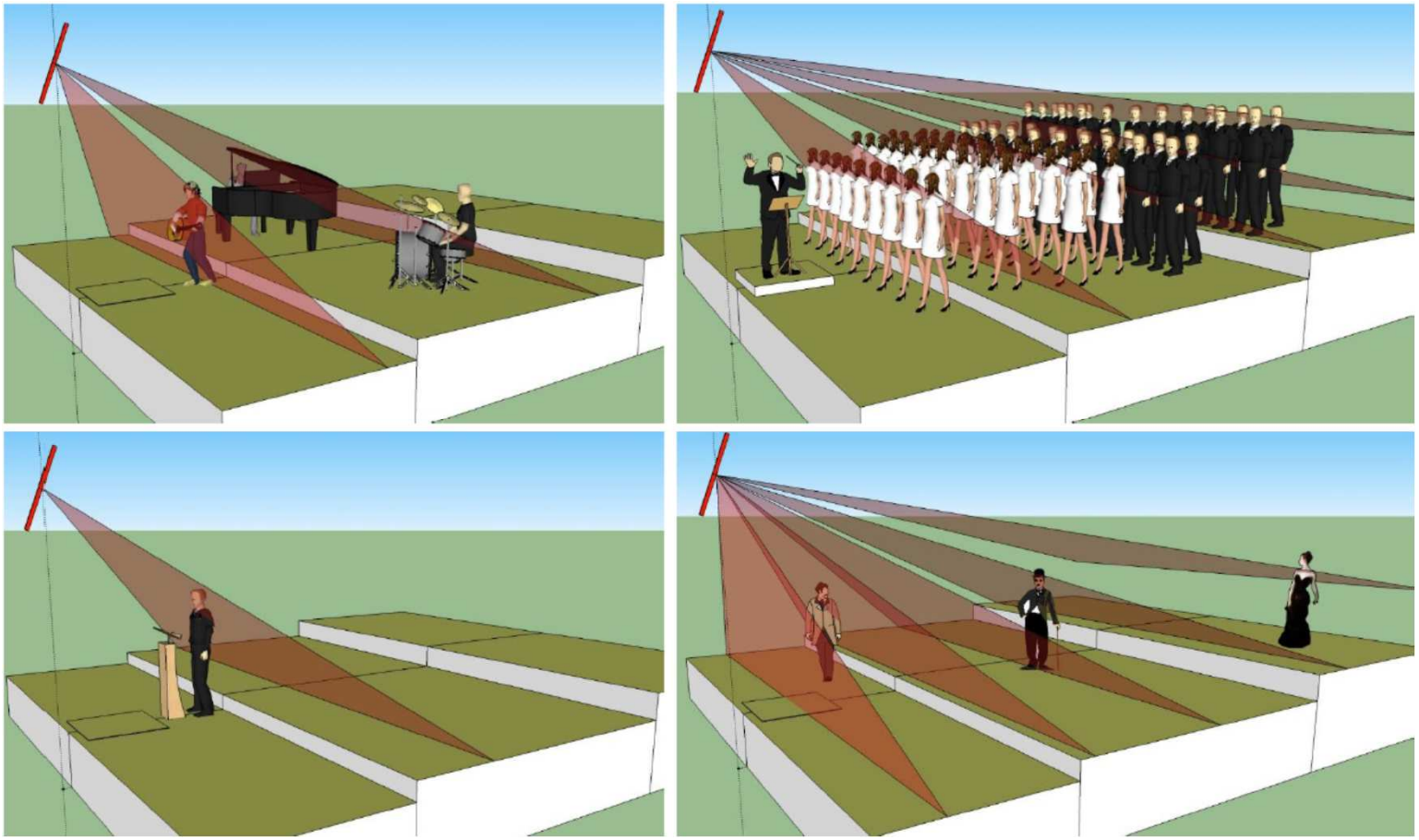
KEM 975 (analog)



cardioid

The distribution of the recording level on the orchestra stage is more equal with the microphone array KEM 975 in comparison with an conventional microphone with cardioid polar pattern.

Applications with single and multiple beams



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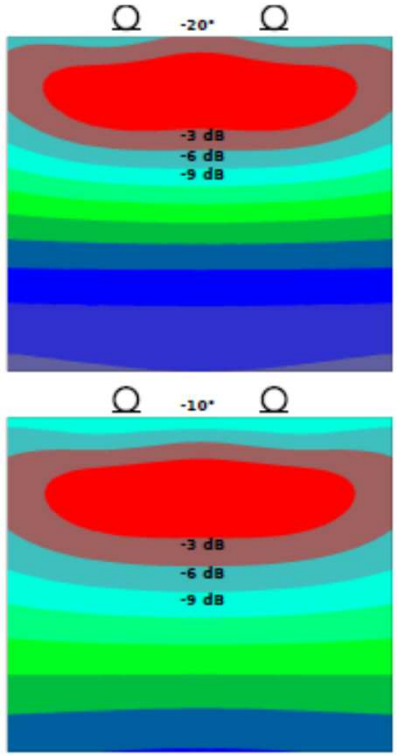
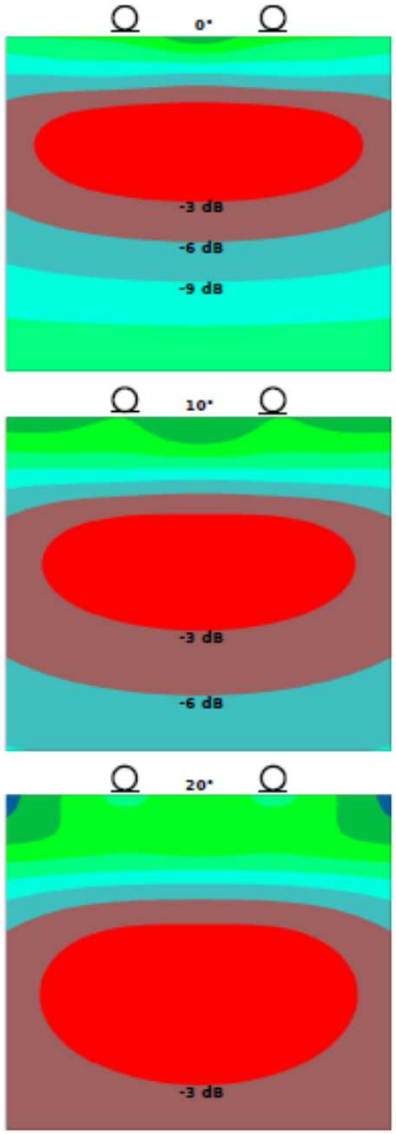
Orchestra stage

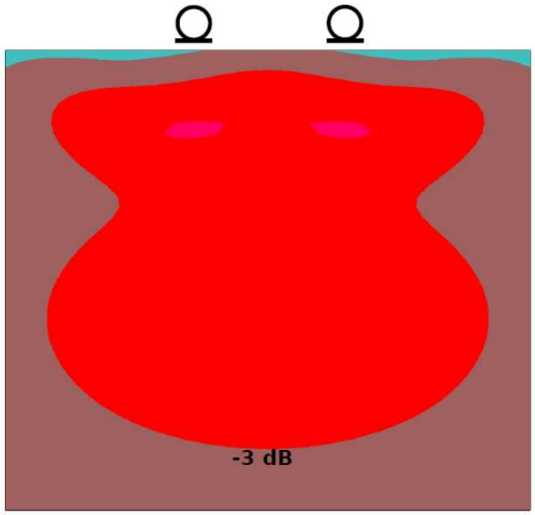
Beamsteering on the Orchestra stage

Stage dimensions:	(12 x 11) m
Microphone placement:	4 m / -35°
Recording angle:	30°



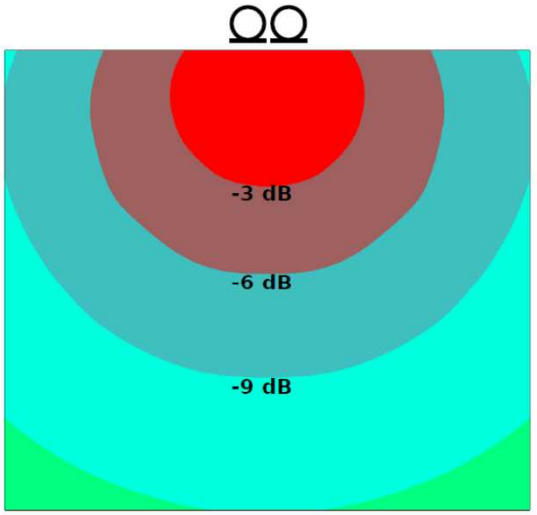


Beam combination on the orchestra stage



R-ZeMiS 12 (digital)

$Beam_{-20°} \times 0{,}5 + Beam_{20°}$



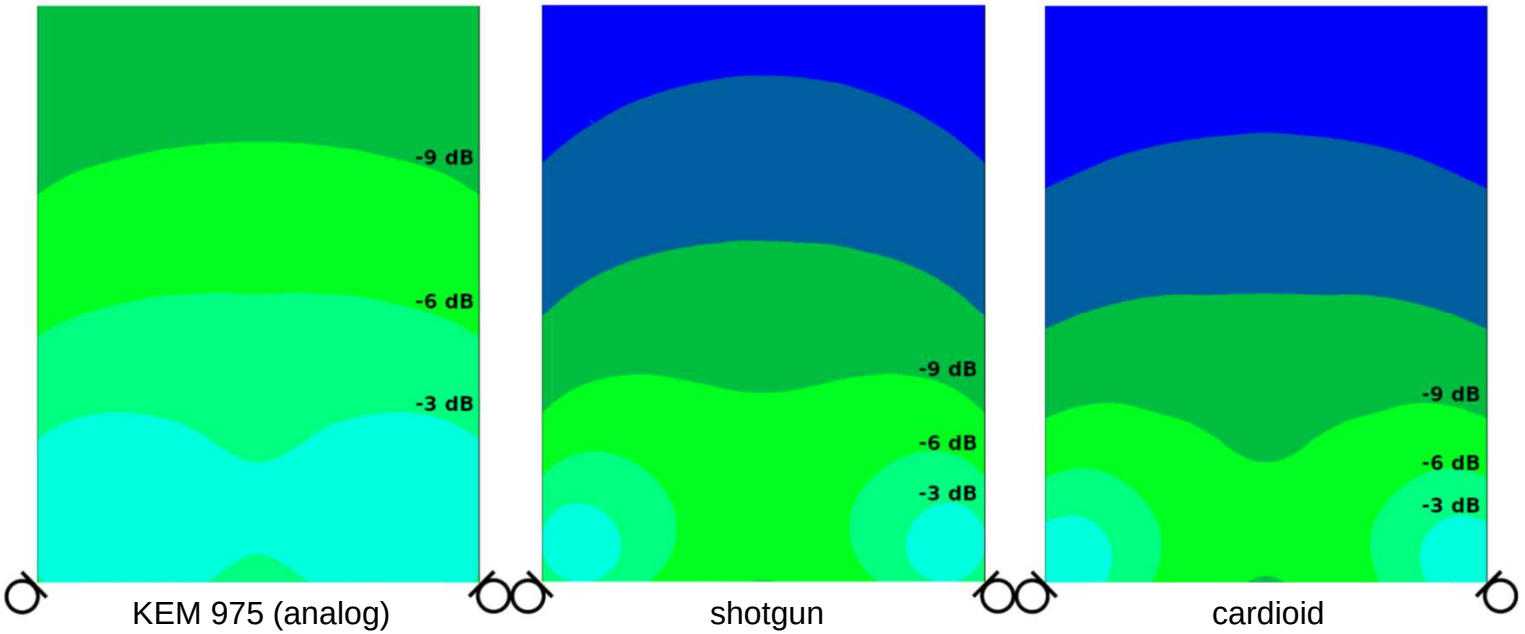
ORTF stereo microphone

with cardioid capsules

very equal distribution of the recording level on the orchestra stage from the nearest to the farest instrument position with the linear microphone array

Theatre stage

Comparison between different microphone solutions for sound reinforcement and a reverberant enhancement system



KEM 975 (analog) shotgun cardioid

Stage dimensions:	(10 x 15) m
Recording distance:	10 m
Microphone placement:	3 m / -10°

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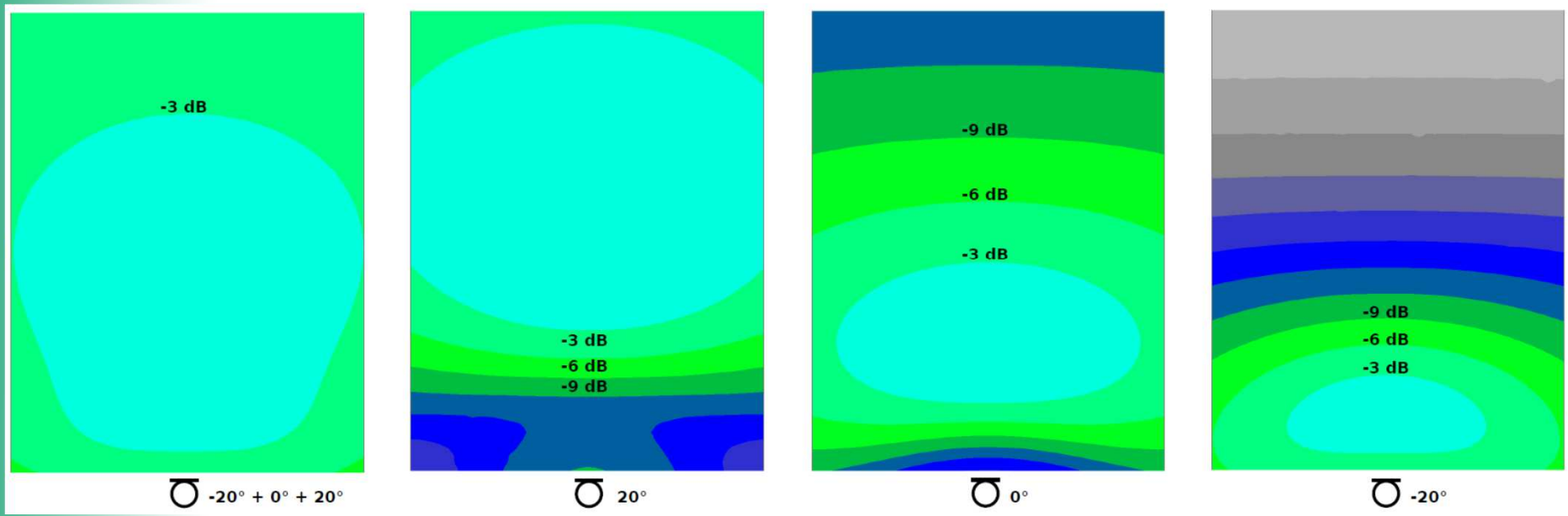
Beamsteering on the theatre stage

Microphone model:	R-ZeMiS 12 (digital)
Microphone placement:	6 m / -35°
Recording angle:	30°



very equal distribution of the recording level on the theatre stage from the nearest to the farest actor position with the linear microphone array

Summary

1. a constant relationship between the sample distance and the wavelength reduces the number of necessary capsules

2. a constant relationship between the array length and the wavelength leads to a frequency independend directivity

3. with beamsteering by delays certain parts of a stage can be covered

4. by combining single beams with adjusted levels a main beam can be created with a sensitivity adapted to the distance

5. this results in a controlable and very equal distribution of the recording level on the stage

Thank you for your attention

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