2.0, 5.1 and 3D-Audio
Main Microphone Techniques

Demo: Paralympics Eröffnung

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SCHOEPS GmbH

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Contents:

- Stereophony Basics
  - 4 Spatial Sound reproduction principles
  - Psychoacoustics of Stereo
- Stereophonic Imaging
  - Direct/Diffuse Field
  - Directional Image
  - Room Image
- Array design methods and practical solutions for
  - Two-channel stereo
  - Multichannel stereo
  - 3D-Audio

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Spatial sound reproduction techniques:

- Real source
- Stereophony
- Sound field reconstruction
- Binaural

Basics

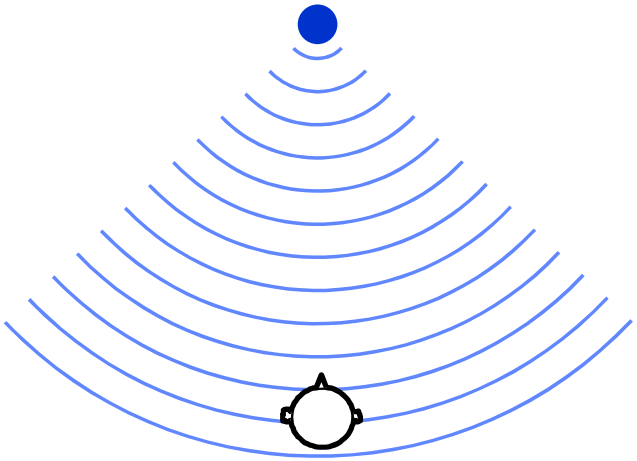
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

Array design

Spatial sound reproduction techniques:

- **Real source**
- Stereophony
- Sound field reconstruction
- Binaural



Basics

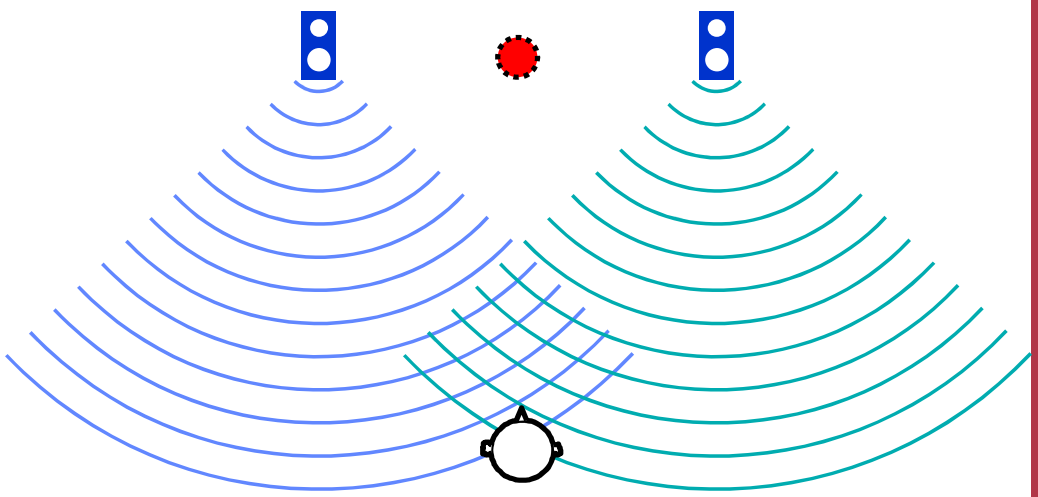
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

Array design

Spatial sound reproduction techniques:

- Real source
- **Stereophony**
- Sound field reconstruction
- Binaural



Basics

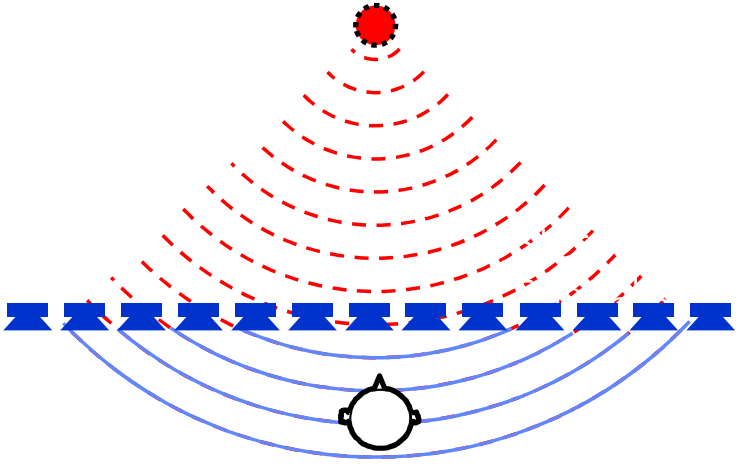
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

Array design

Spatial sound reproduction techniques:

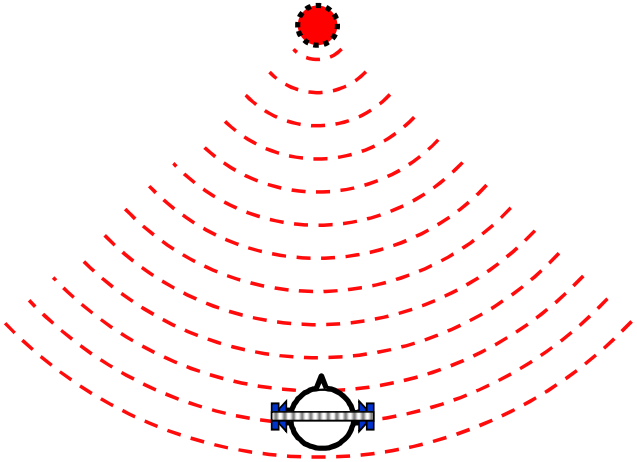
- Real source
- Stereophony
- **Sound field reconstruction***
- Binaural



* The term „Sound field reconstruction“ includes techniques like WFS or HOA

Spatial sound reproduction techniques:

- Real source
- Stereophony
- Sound field reconstruction
- **Binaural**



Basics

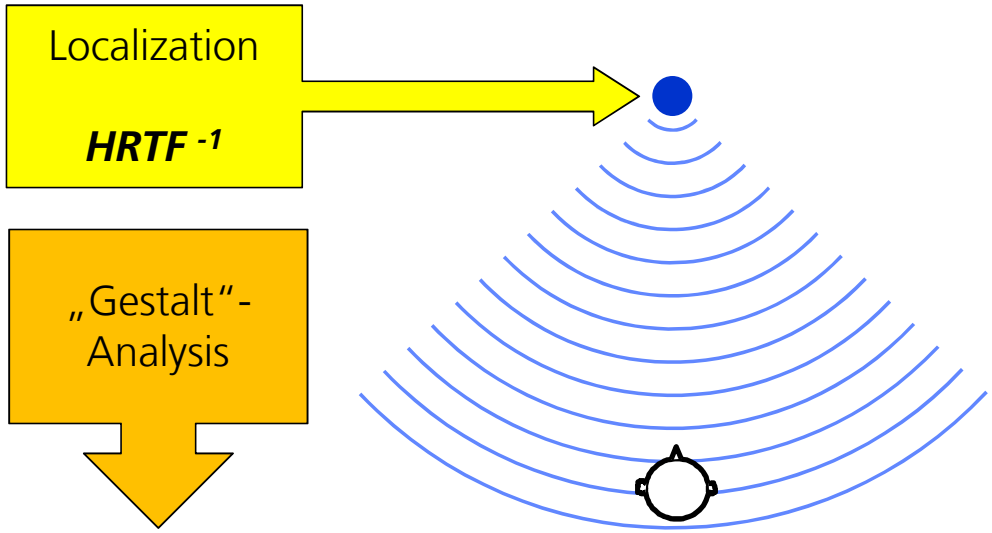
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

Array design

Localization and perception model:

- **Real source = Sound field reconstruction = Binaural**



Basics
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

Array design

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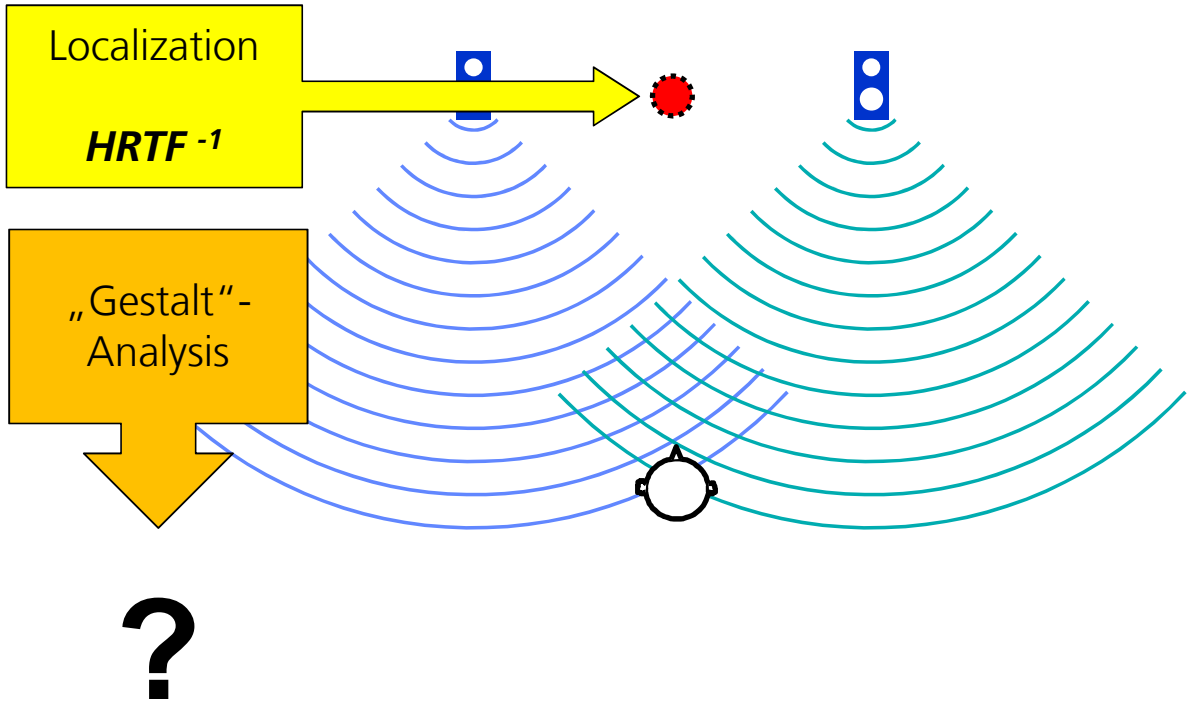
Localization and perception model:

- **Stereophony unexplained!** Summing localization with strong comb filtering

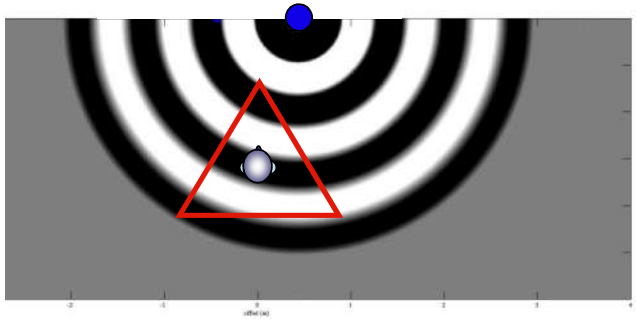


Basics
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

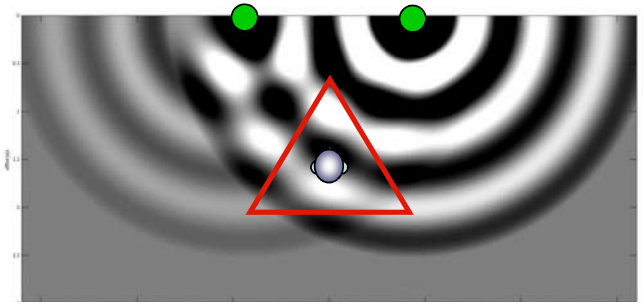
Array design

Stereophony unexplained!

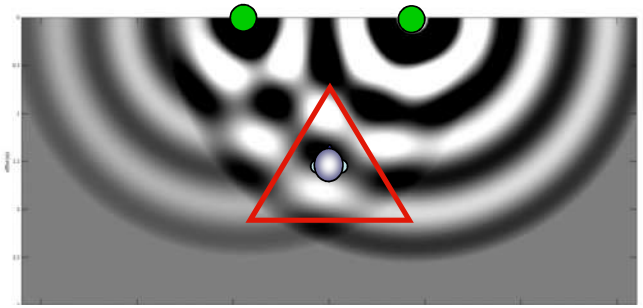


Real source, +15°

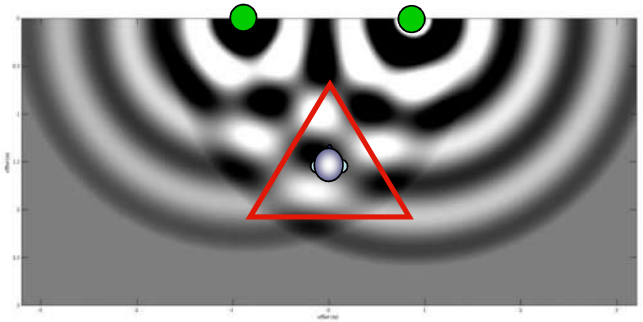
ΔL = 7dB
Δt = 0 ms



ΔL = 3.5dB
Δt = 0.2ms



ΔL = 0dB
Δt = 0.4 ms



Phantom Source, perceived +15°

Basics

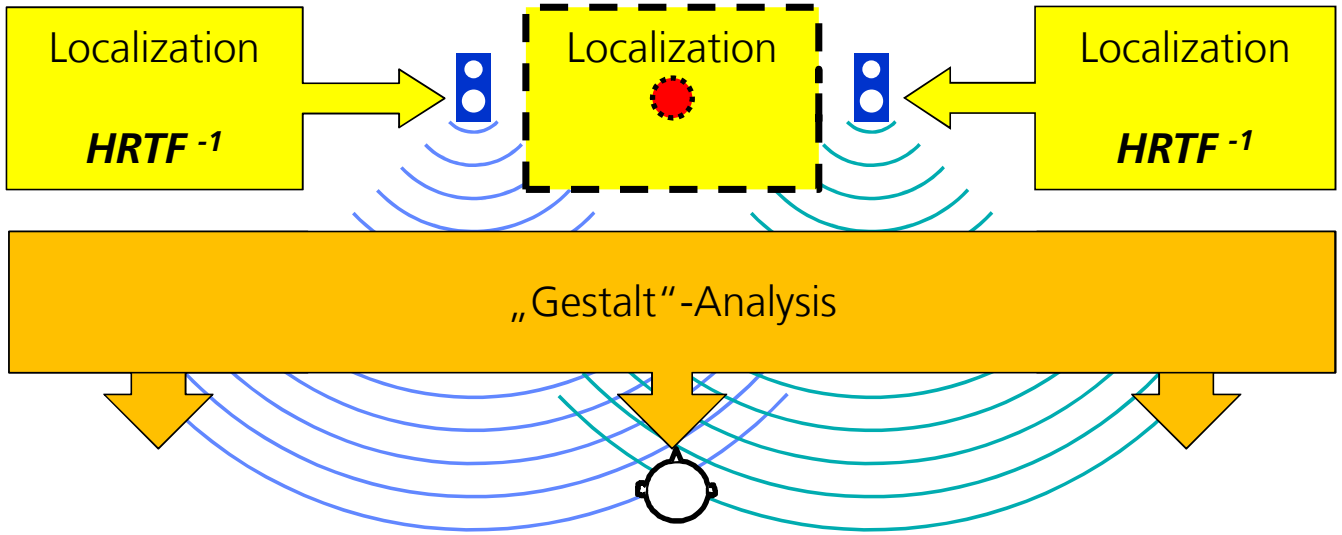
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

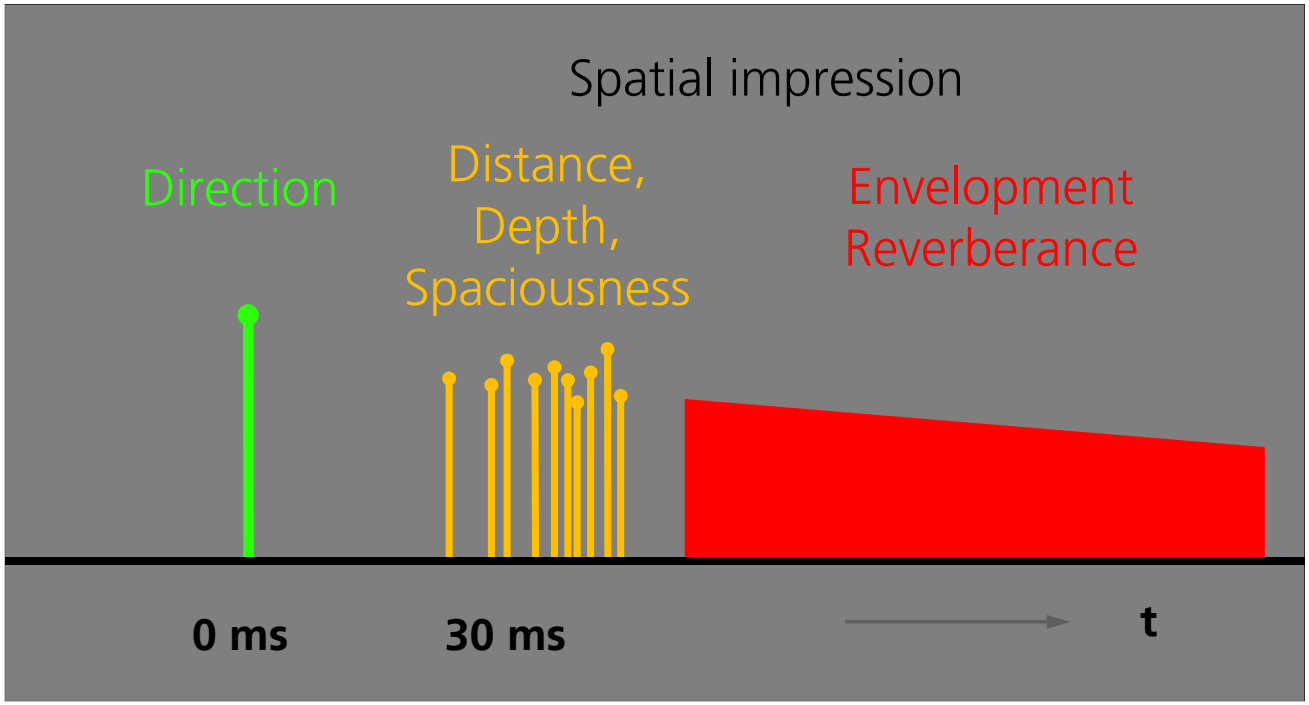
Array design

Localization and perception model:

- **Stereophony** after the „Association model“ of Theile



REF G.Theile: “On the Naturalness of Two-Channel Stereo Sound”, JAES, Vol.39, 1991



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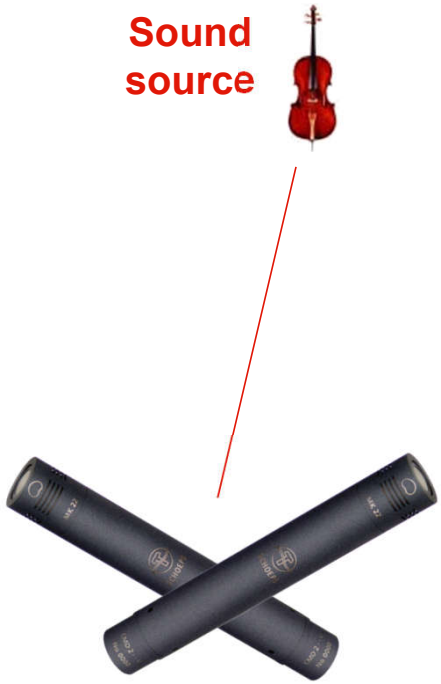
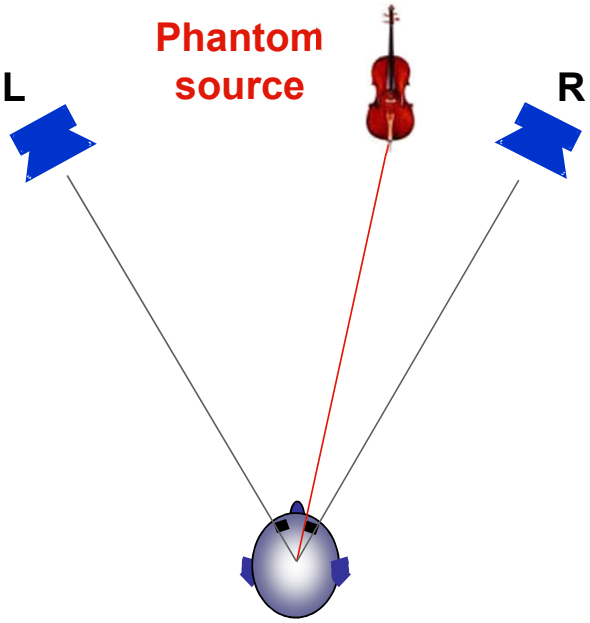
Basics
Stereo Imaging
- Direct/Diffuse
- Directional Image
- Room Image

Array design

- The Recording angle



Δt, ΔL
between microphones

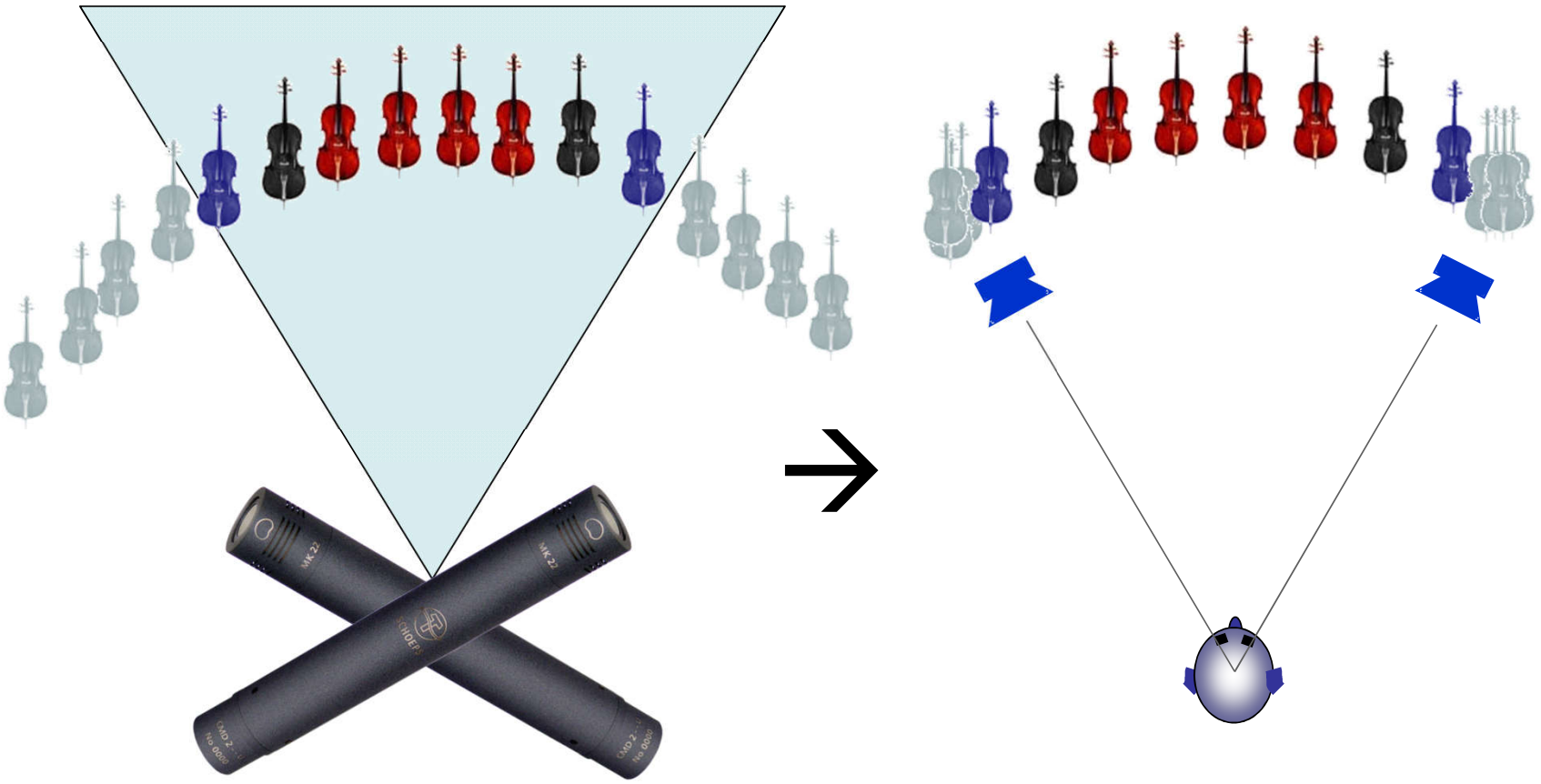


Δt, ΔL
between loudspeakers

Basics
Stereo Imaging
- Direct/Diffuse
- Directional Image
- Room Image

Array design

- The Recording angle



Basics
Stereo Imaging
- Direct/Diffuse
- Directional Image
- Room Image

Array design

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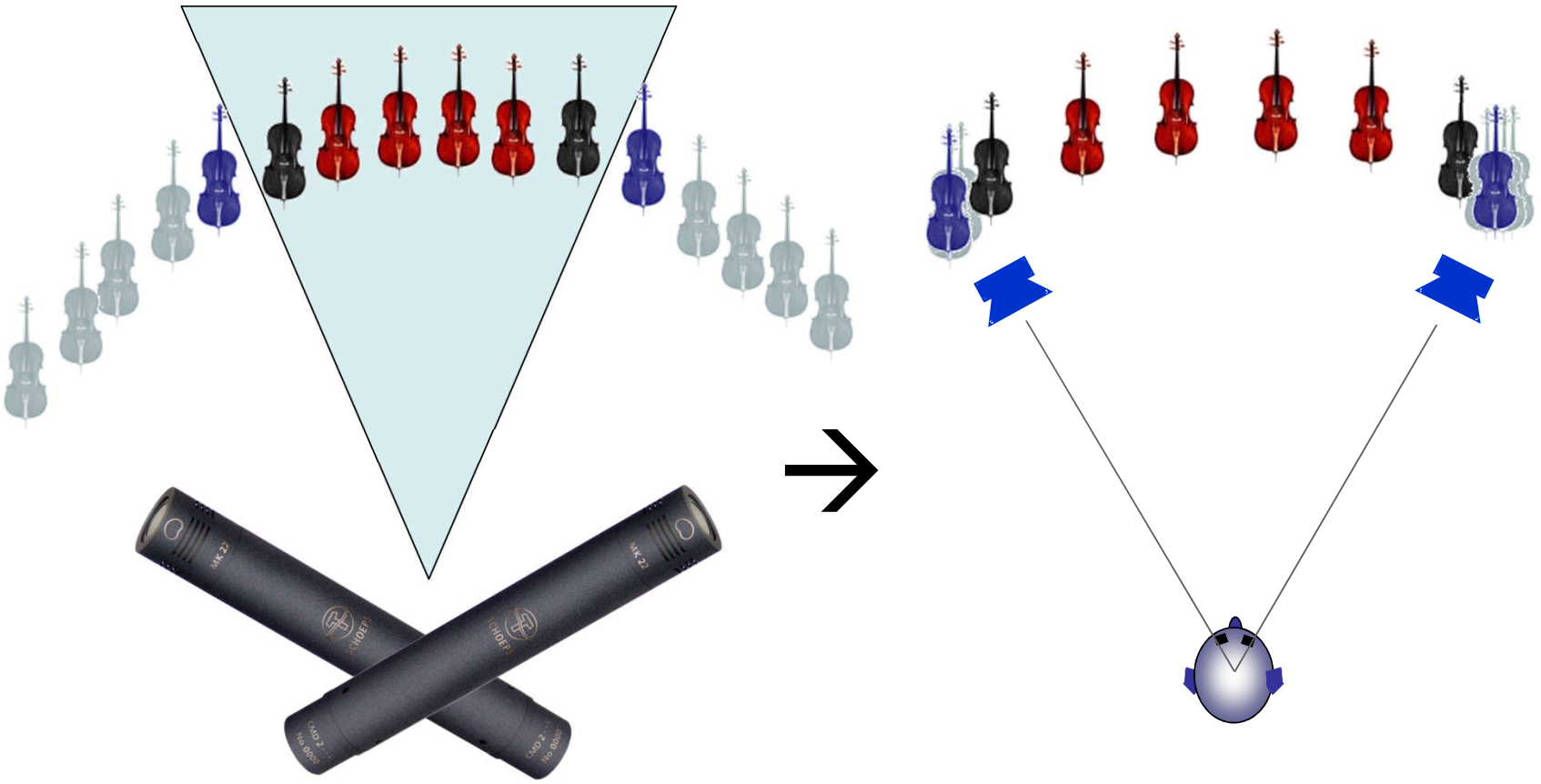
- The Recording angle



Demo Recording Angle:
Cedric 4 Stereofoniepaare “Schulhof” oder “Enten”

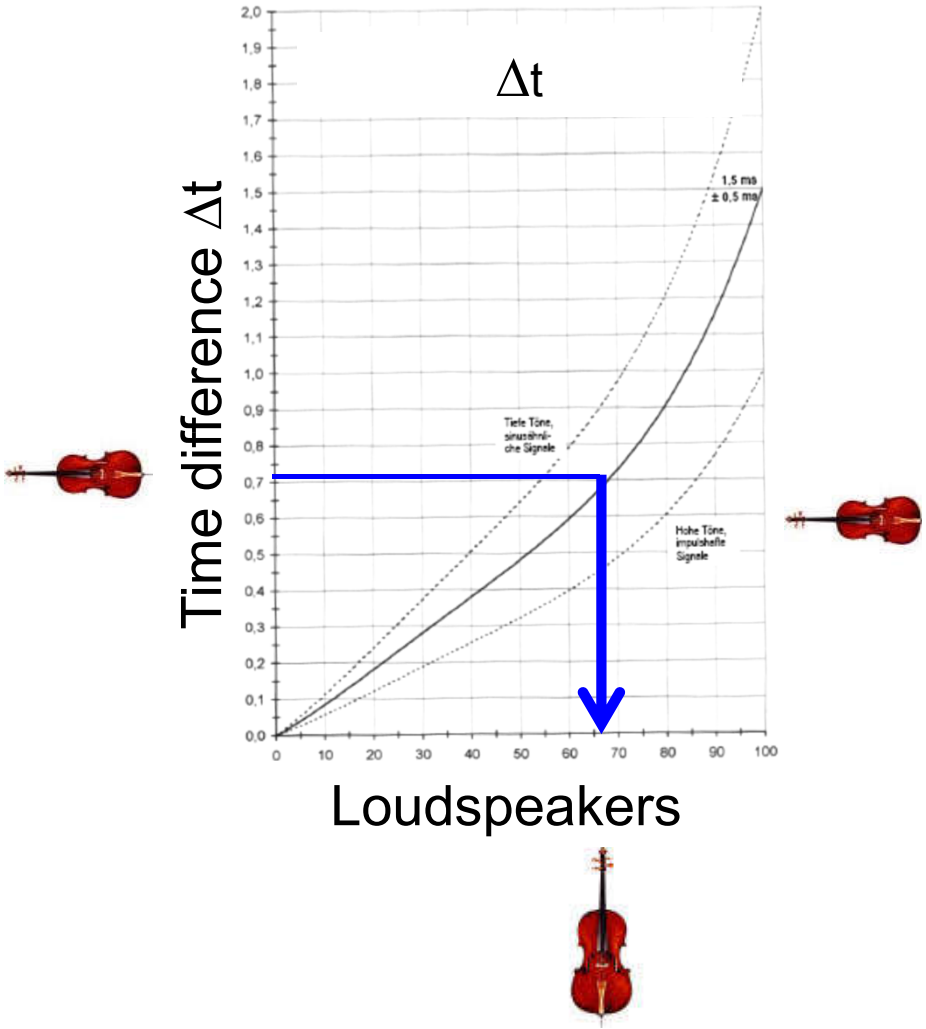
Basics

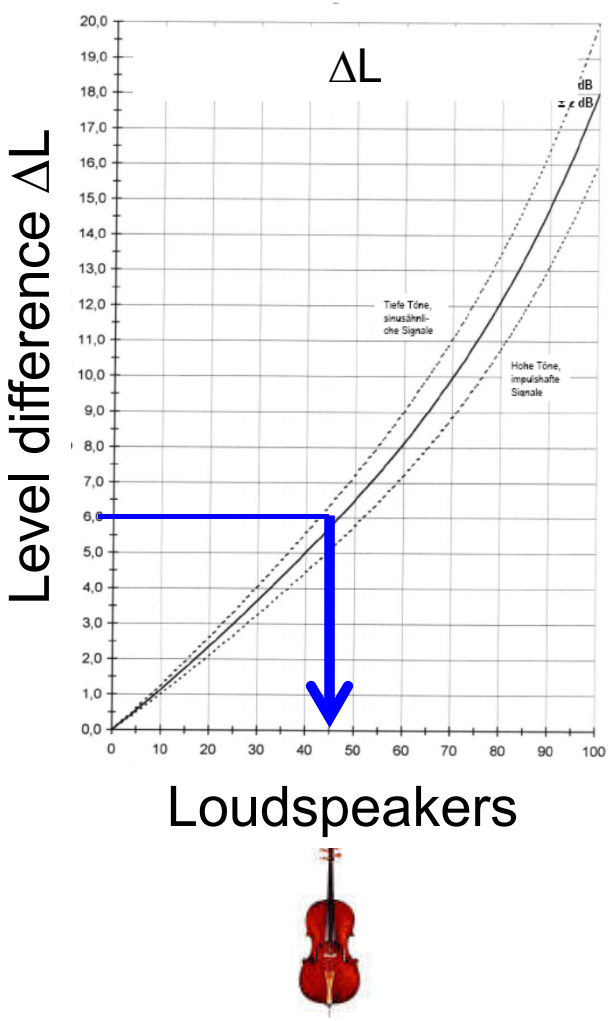
Stereo Imaging

- Direct/Diffuse
- Directional Image
- Room Image

Array design

- The Recording angle





REF *E.Sengpiel:* www.sengpielaudio.com

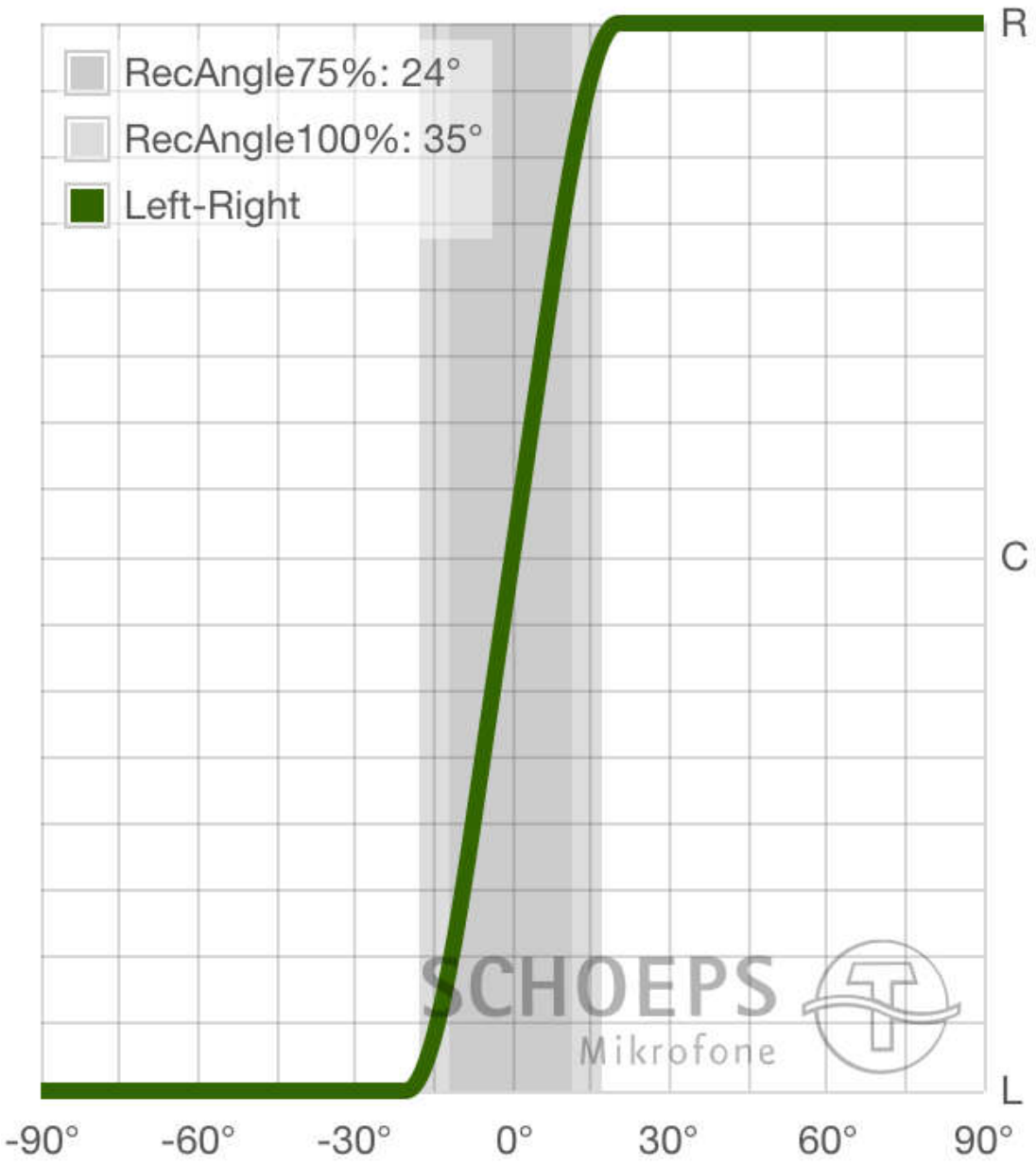
Basics

Stereo Imaging

- Direct/Diffuse
- Directional Image
- Room Image

Array design

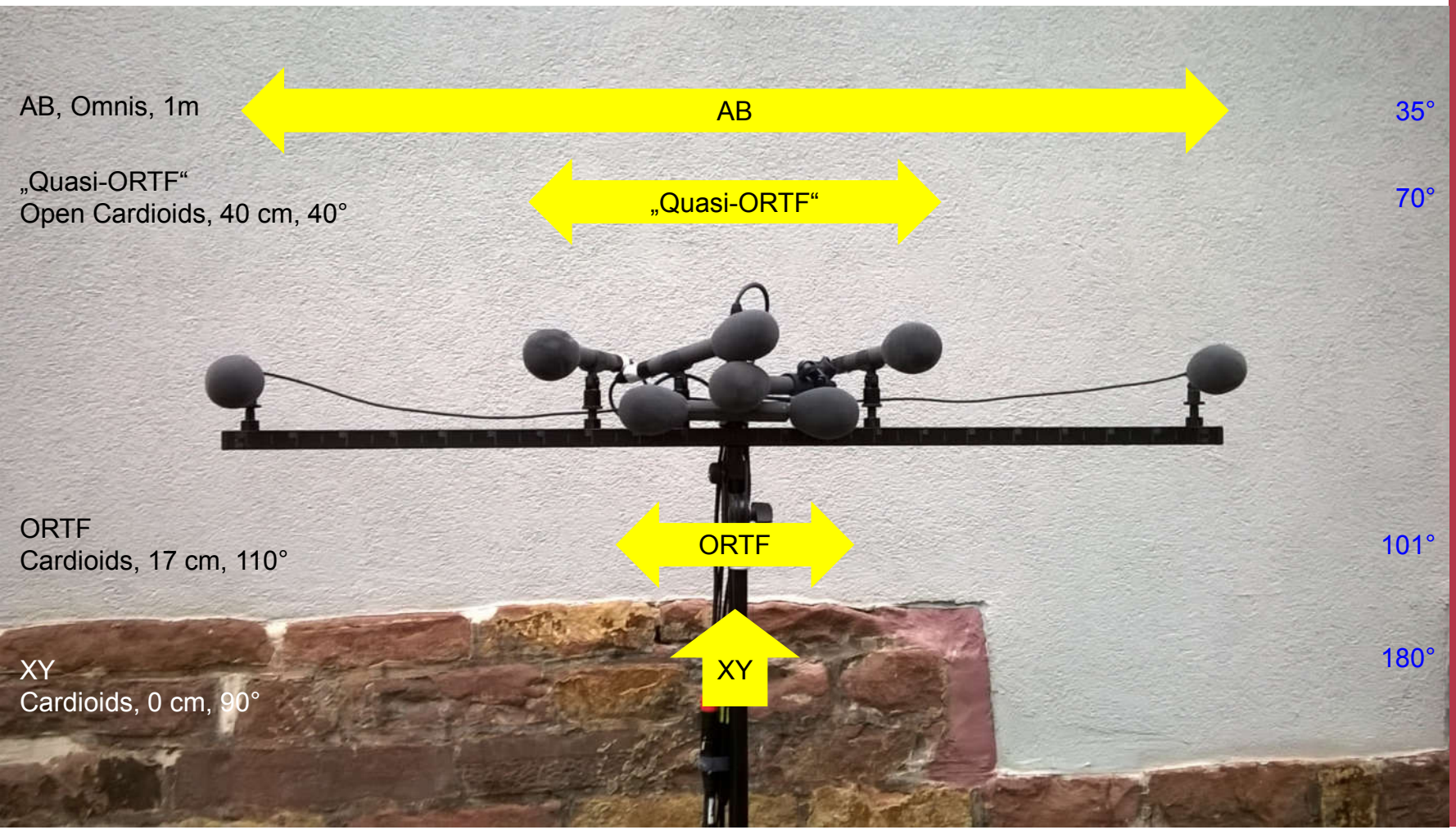
- Localisation Curve



Basics
Stereo Imaging
- Direct/Diffuse
- Directional Image
- Room Image

Array design

2ch Ambience Recording: the effect of microphone spacing



*outdoor recordings on a 1 m Stereo bar MAB1000 with windshields B 5 D

Basics

Stereo Imaging

- Direct/Diffuse
- Directional Image
- Room Image

Array design

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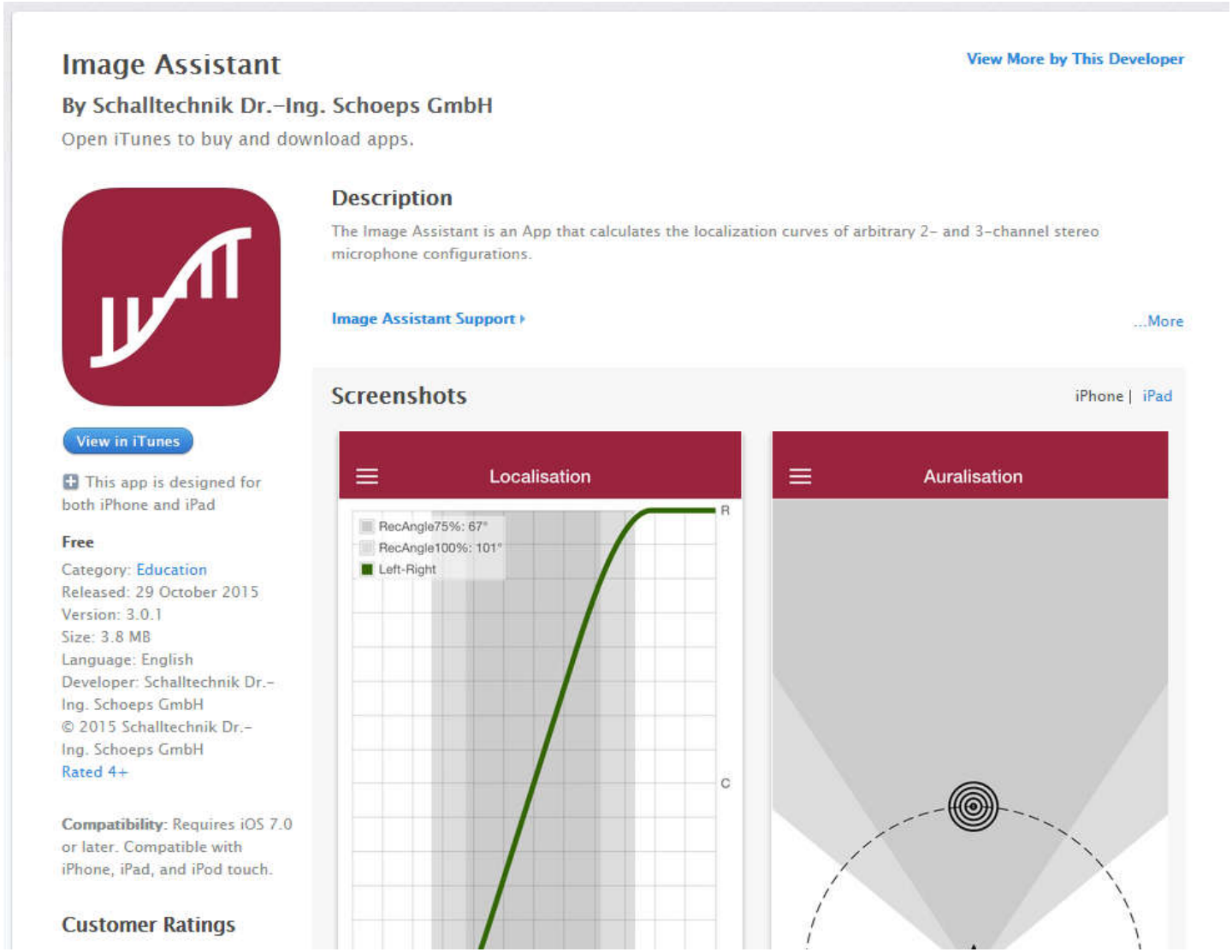
2ch Ambience Recording: the effect of microphone spacing

Basics
Stereo Imaging
- Direct/Diffuse
- Directional Image
- Room Image

Array design

- SCHOEPS-App “Image Assistant” **ima.schoeps.de**



Demo

Basics

Stereo Imaging

- Direct/Diffuse
- Directional Image
- Room Image

Array design

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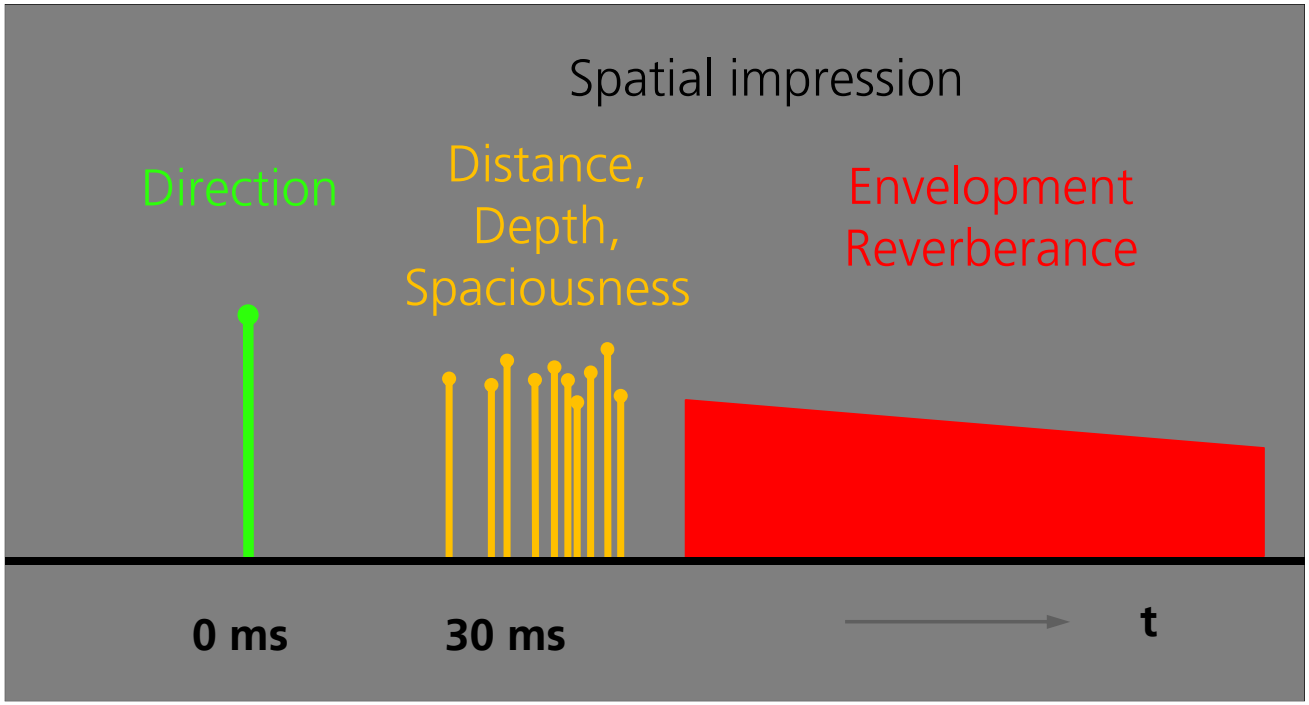

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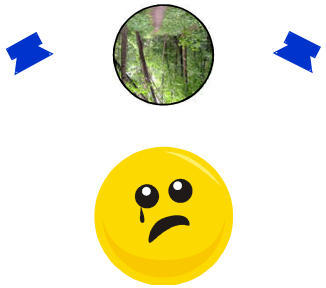
Basics
Stereo Imaging
- Direct/Diffuse
- Directional Image
- Room Image

Array design

Diffuse sound in the recording room → diffuse sound in the reproduction room



Basics

Stereo Imaging

- Direct/Diffuse
- Directional Image
- Room Image

Array design

Diffuse sound in the recording room → diffuse sound in the reproduction room

→ different diffuse signals
= decorrelated in the diffuse field

Basics

Stereo Imaging

- Direct/Diffuse
- Directional Image
- Room Image

Array design

- The larger the distance, the more independent the signals

- The larger the directivity, the more independent the signals

- The larger the opening angle, the more independent the signals

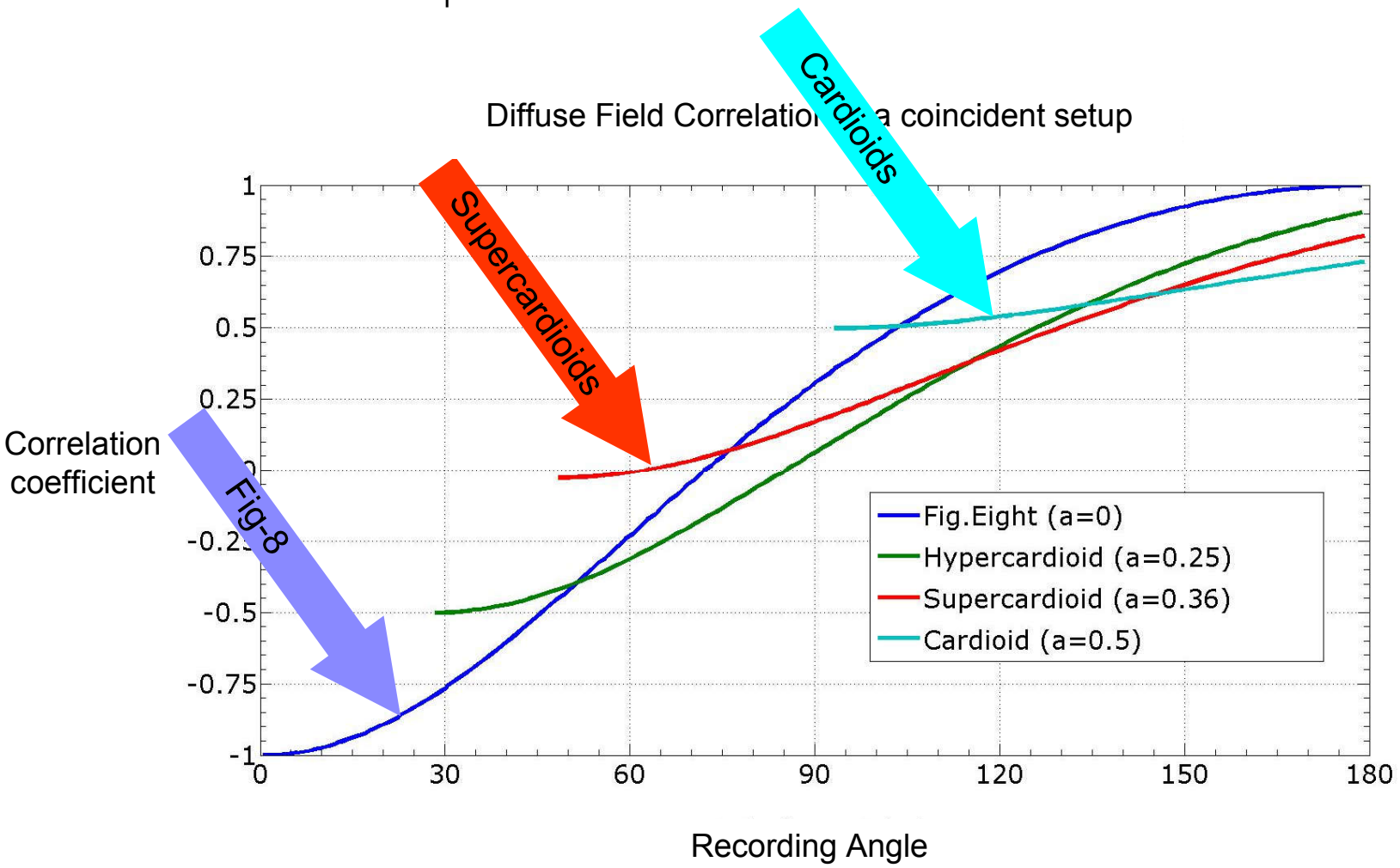
Basics
Stereo Imaging
- Direct/Diffuse
- Directional Image
- Room Image

Array design

- ΔL - Coincident microphones

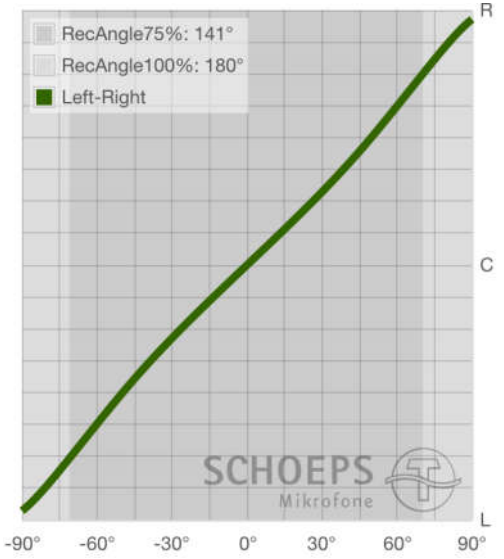
Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

- ΔL - Coincident microphones



XY Cardioids, 90°

- compact
- small stereo width and a large DFC
  → it can sound boring



Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

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XY Supercardioids, 60°

- compact
- good signal separation
- good stereo width
- low DFC

Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

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M/S

- compact
- flexible
- good room and imaging properties if decoded properly
- DFC can be 0
- Can be used on the boom with M = supercardioid or shotgun
- Good musical qualities with M = Omni or wide cardioid

Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

- $\Delta t + \Delta L$ – Stereo based on level and arrival time differences

Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

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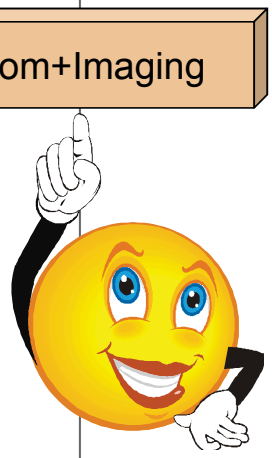
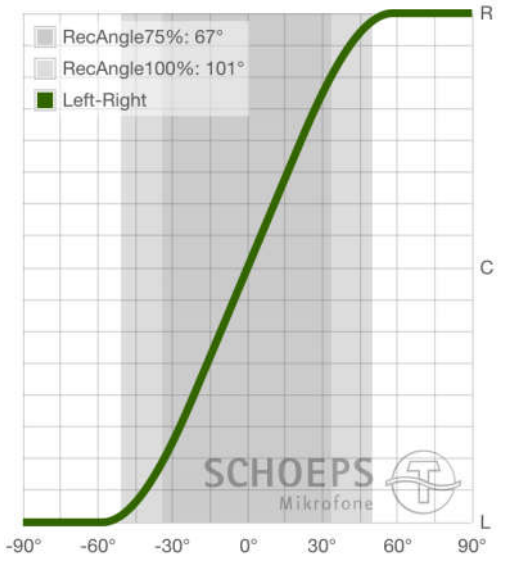
ORTF

- relatively compact
- very good imaging
- open and nice room sound





Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

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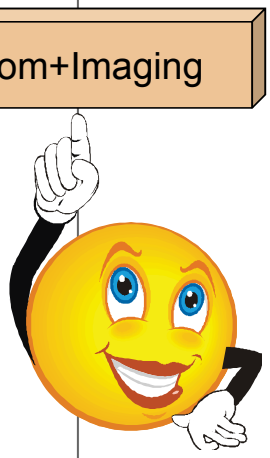
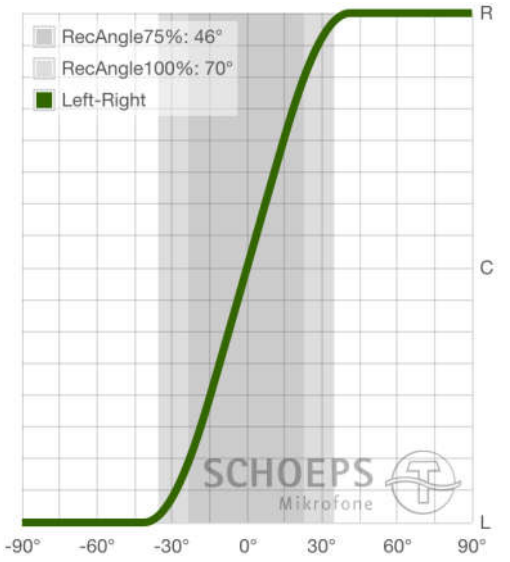
Quasi-ORTF

- Flexible recording angle
- good imaging
- open room sound





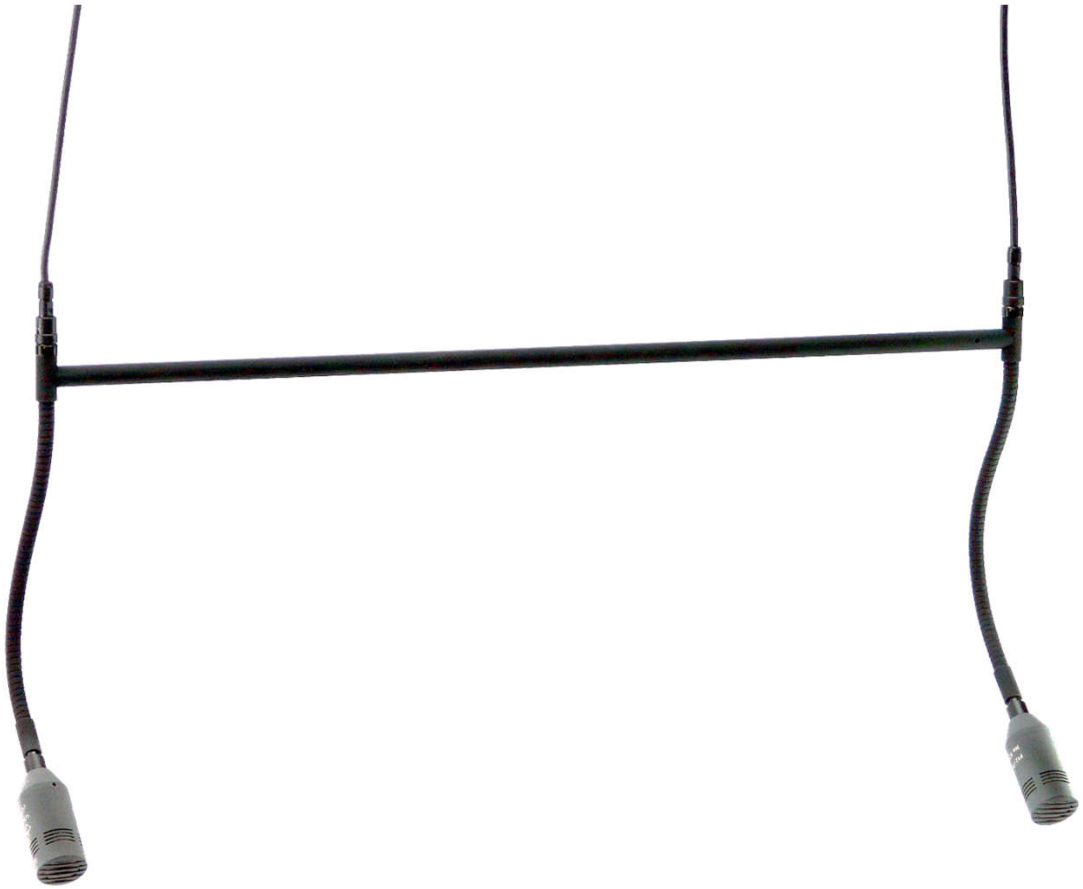
Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

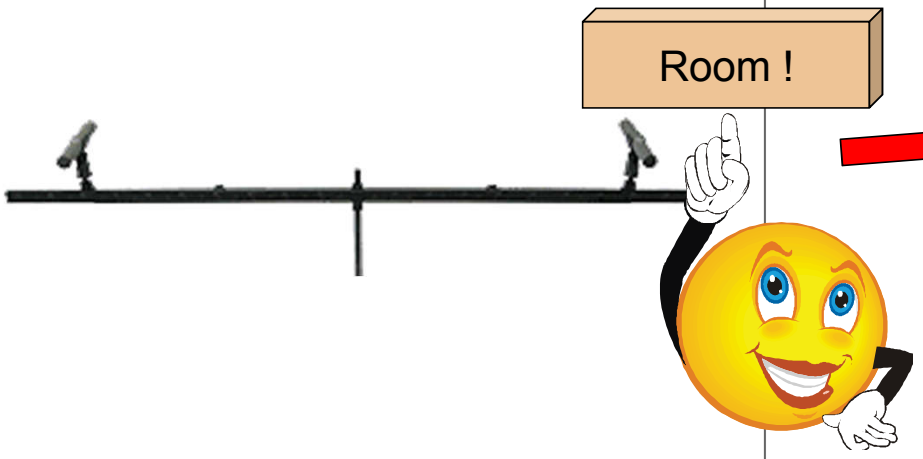
- Δt – Stereo based on arrival time differences

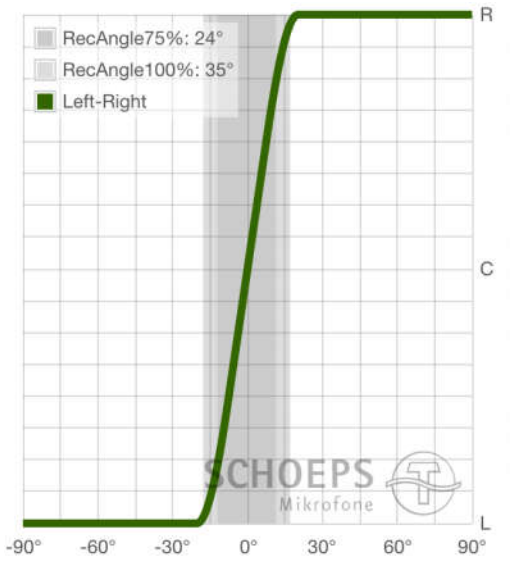


Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

A/B

- Not compact, d ≥ 40 cm
- Often prefered sound colour
- Open room sound
- Average imaging quality





Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

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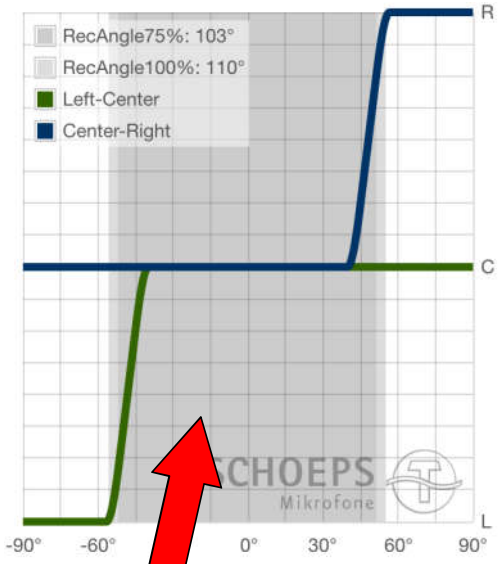
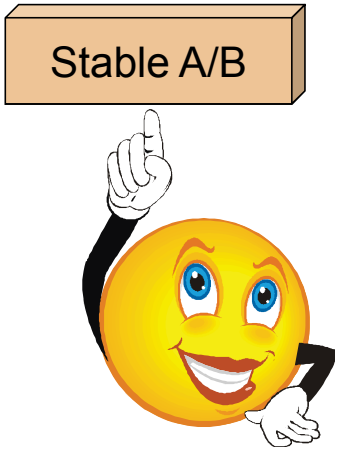
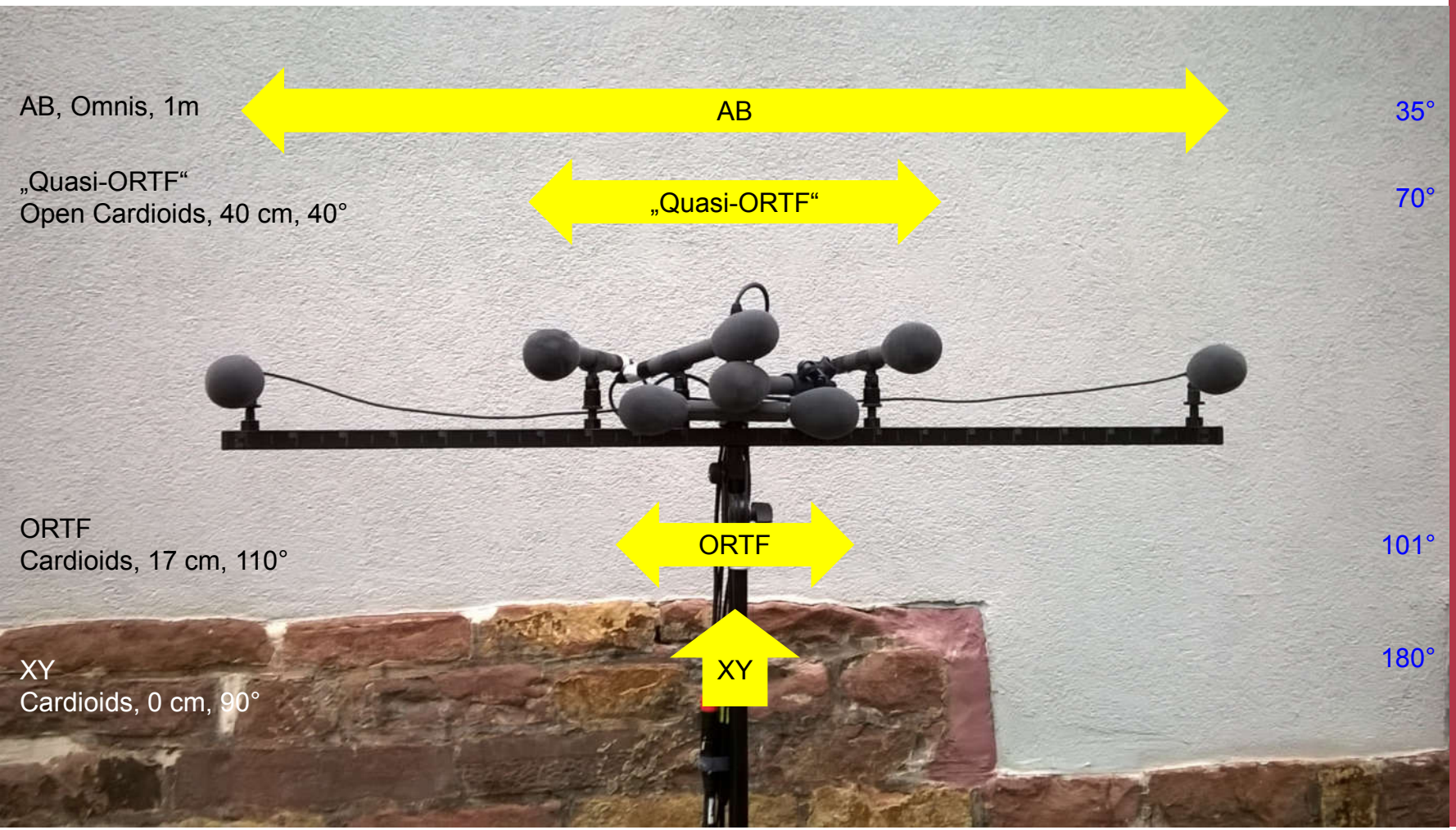
Decca-Tree

- Three stable phantom source locations (-30°, 0°, 30°)
- Robust image through large Δt
- Robust image through ΔL (1/r – law)
- Often prefered sound colour
- Open room sound





- Comparison of four 2ch stereo setups (ambience)* (Demo: Cedric, Bahnfahrt, Bahn+Motorroller)

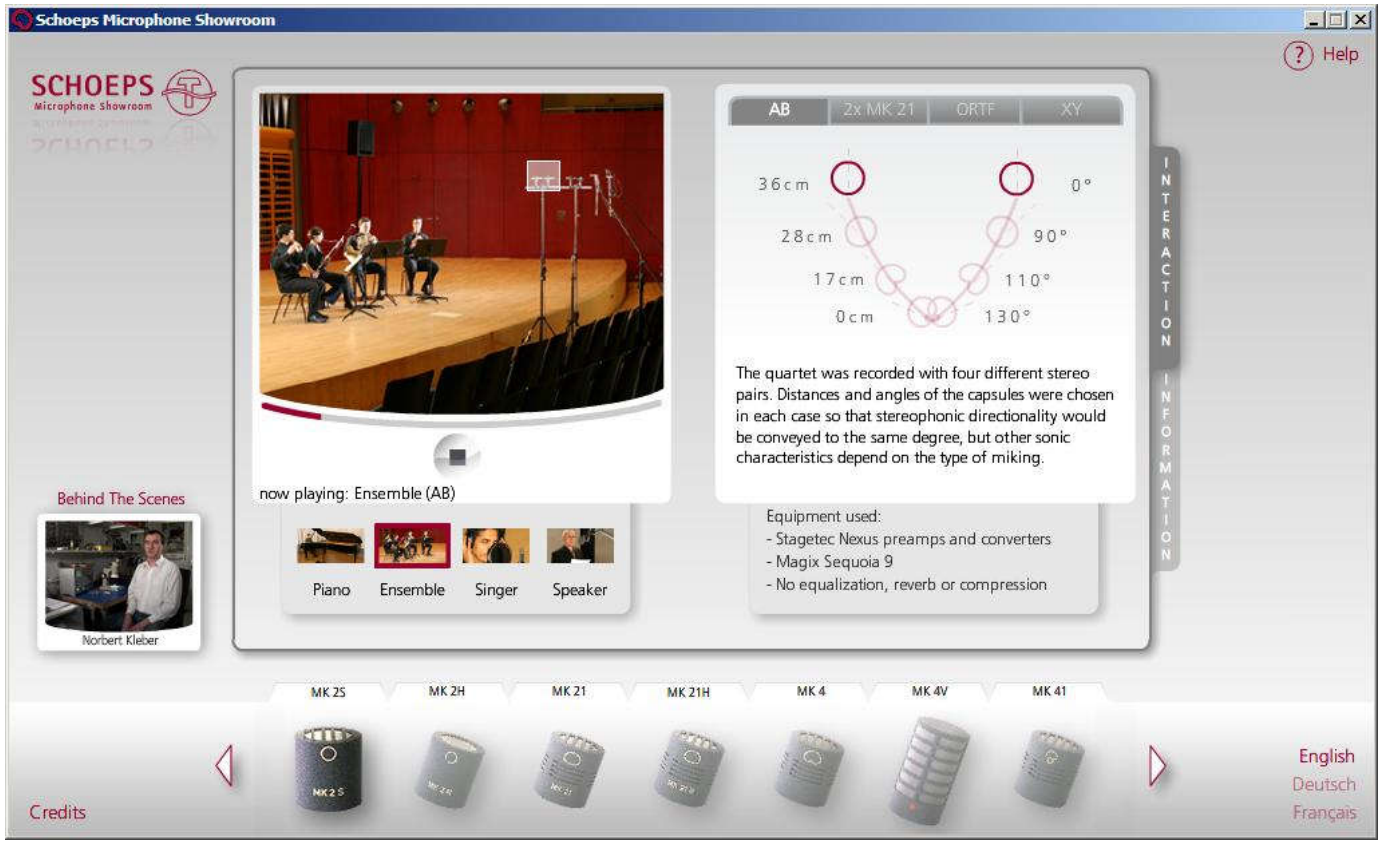


*outdoor recordings on a 1 m Stereo bar MAB1000 with windshields B 5 D

2ch Ambience Recording: the effect of microphone spacing

Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

- Microphone Showroom: www.schoeps.de/showroom



Basics

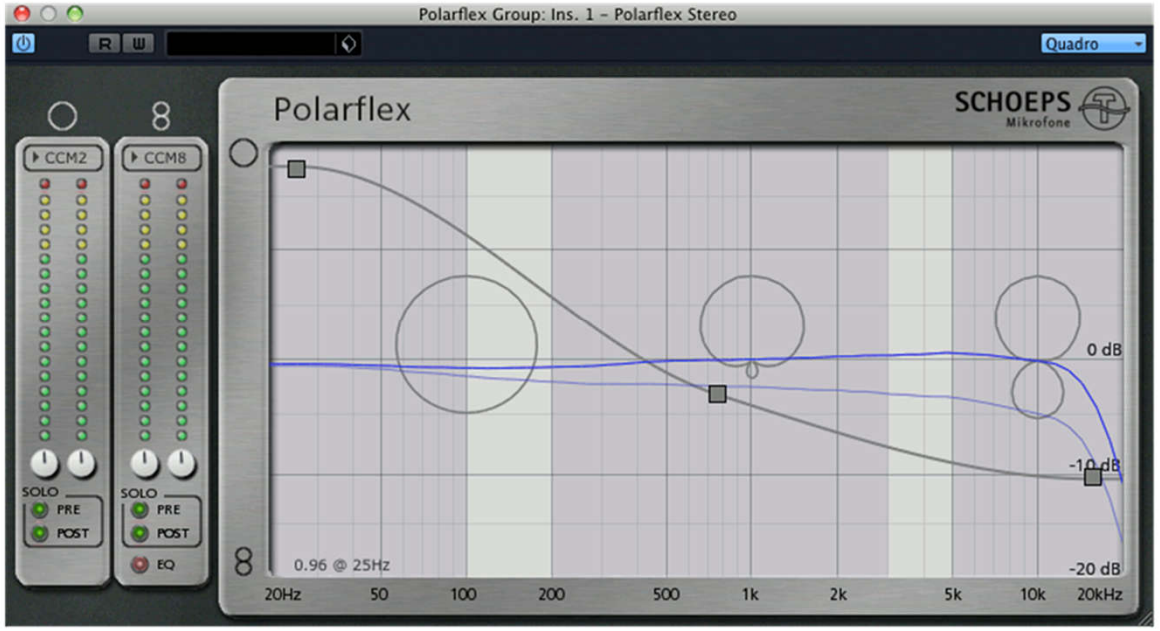
Stereo Imaging

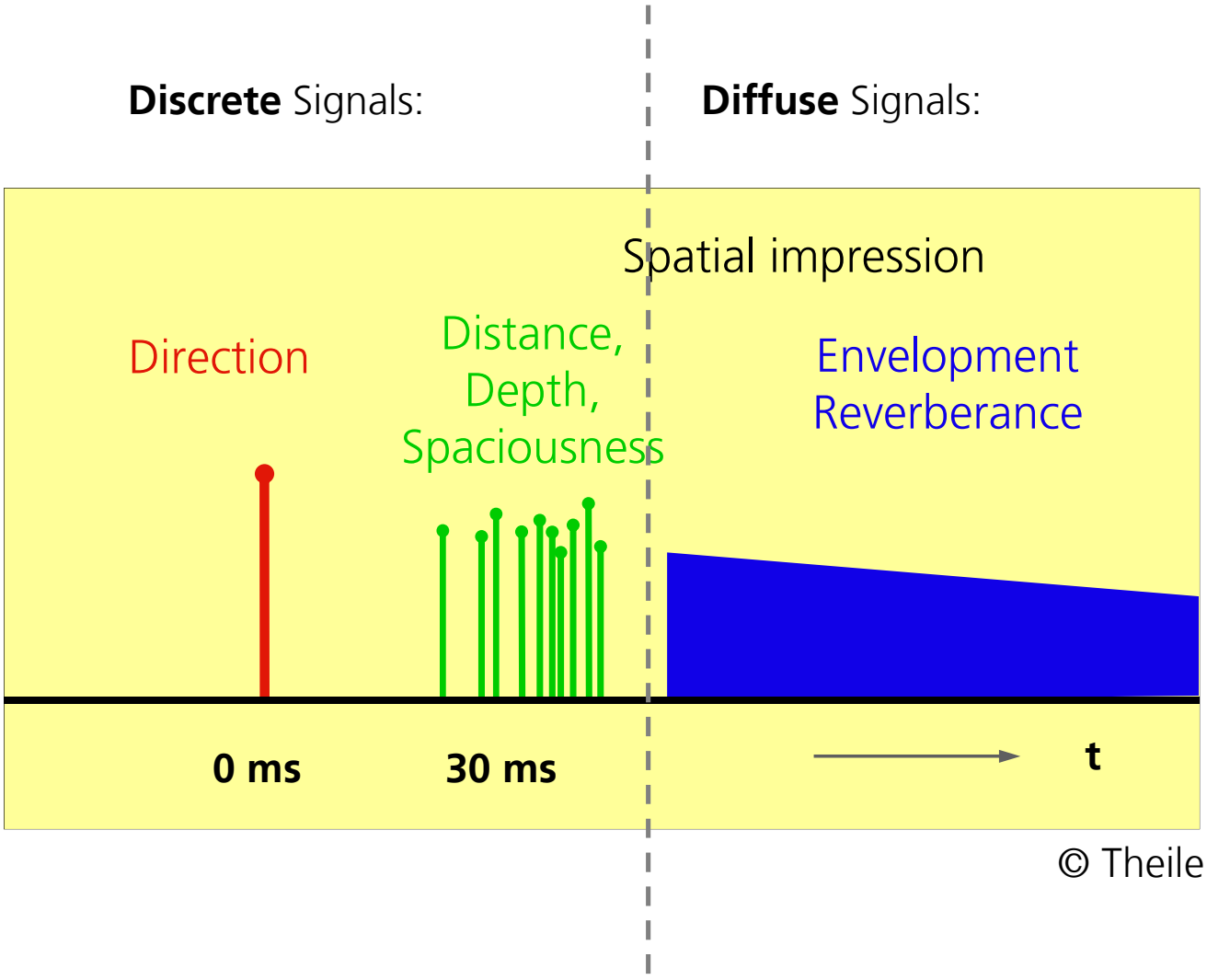
Array design

- Two-channel
- Multichannel
- 3D-Audio

- Polarflex technique

- Mix Omni and Fig-8 in three frequency bands
- Variation of the diffuse field response





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Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

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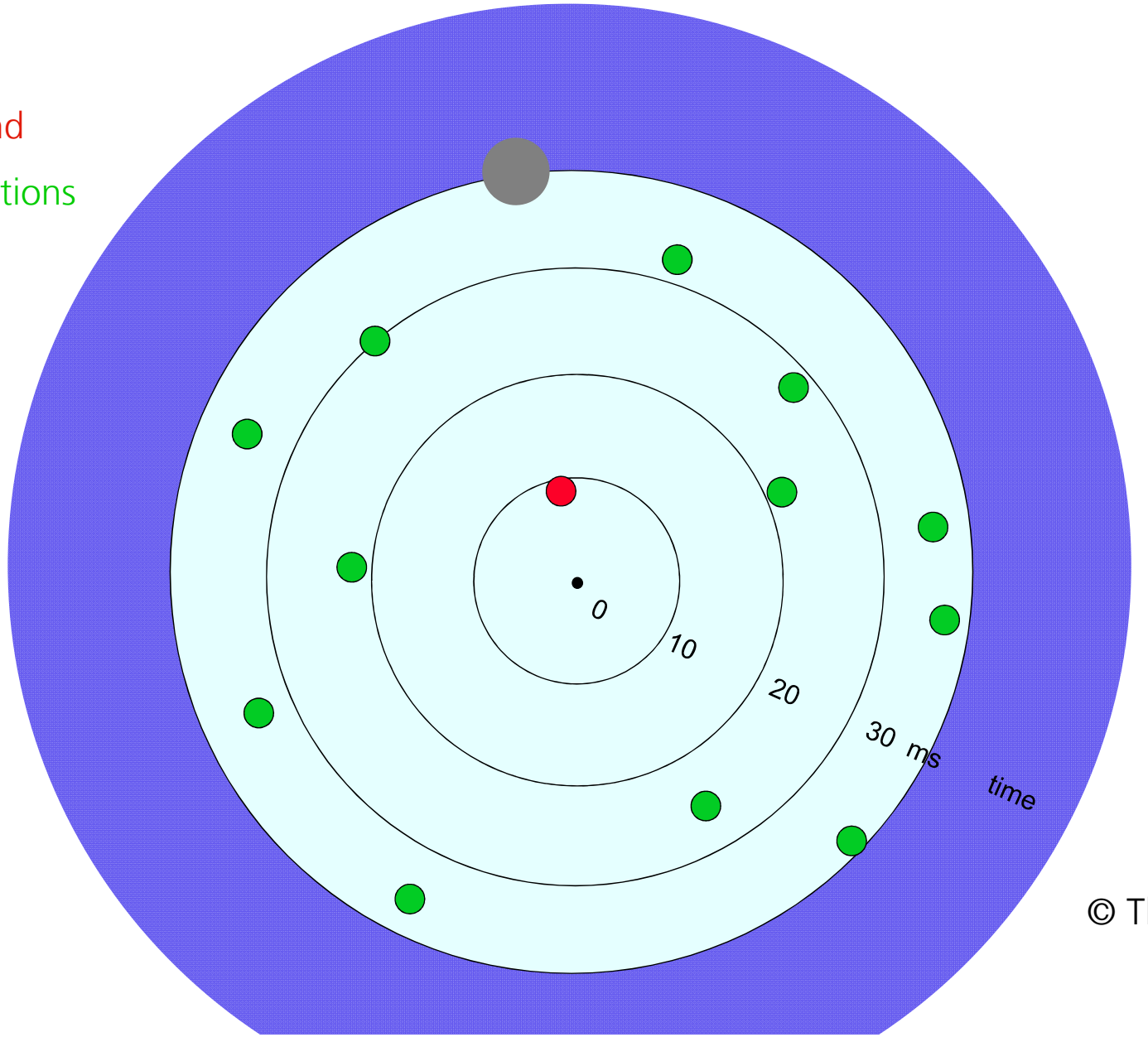
Direct Sound

Early Reflections

Reverb



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Basics

Stereo Imaging

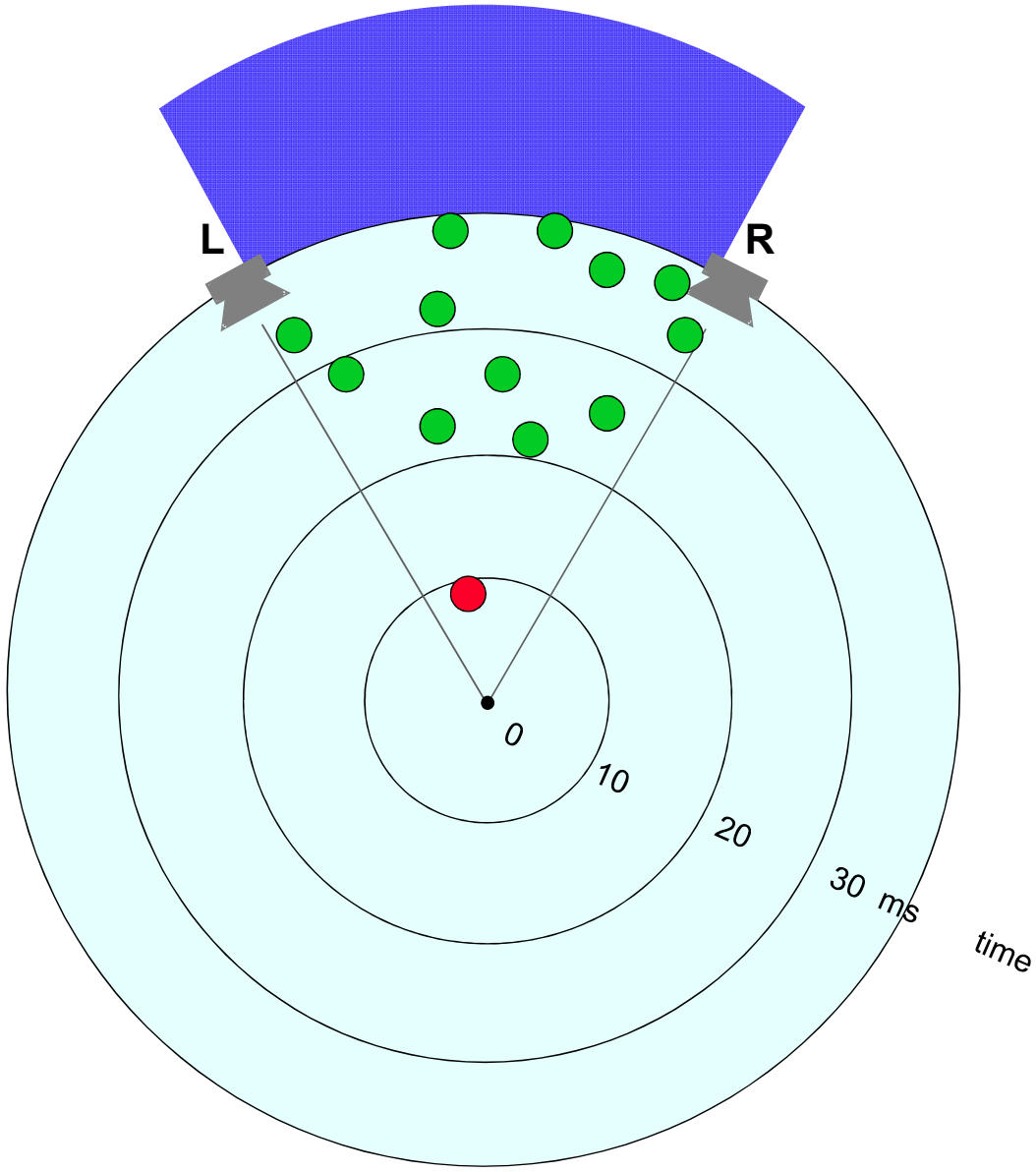
Array design

- Two-channel
- Multichannel
- 3D-Audio

Direct Sound

Early Reflections

Reverb



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Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

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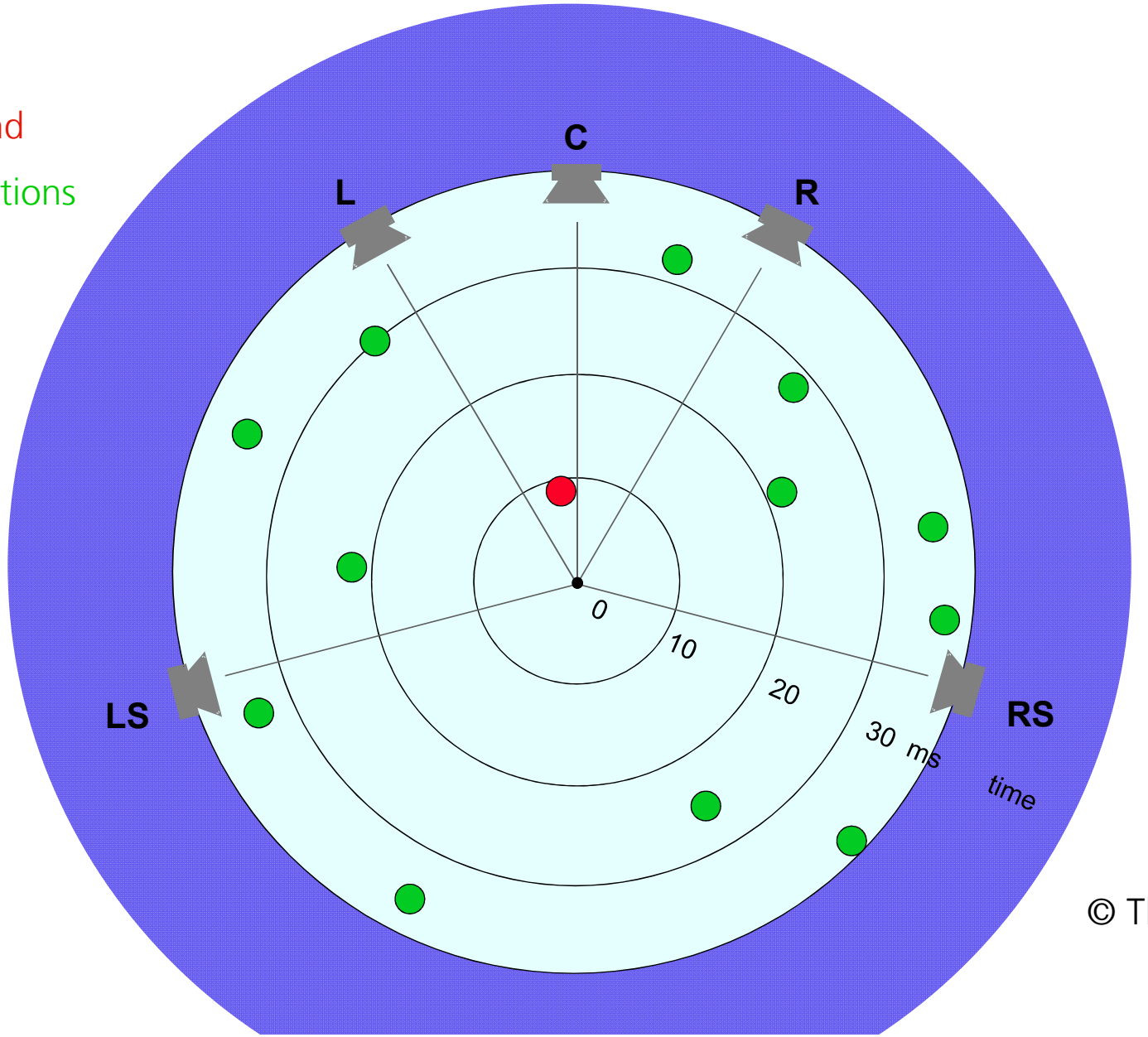
Direct Sound

Early Reflections

Reverb



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Basics

Stereo Imaging

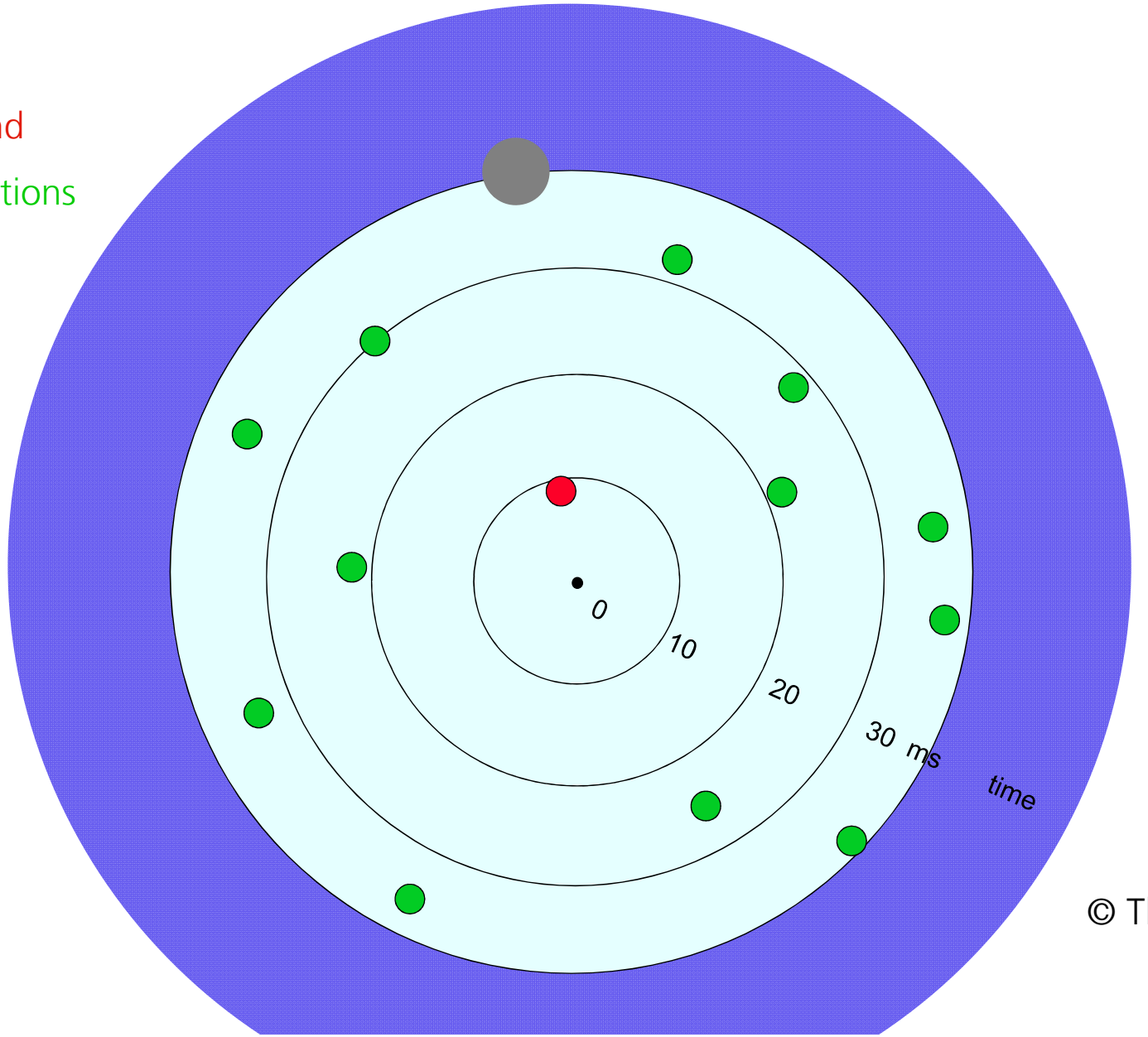
Array design

- Two-channel
- Multichannel
- 3D-Audio

Direct Sound

Early Reflections

Reverb



© Theile

Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

- Demo Direktschall, Reflektionen/Tiefe, Diffusfeld zwischen Stereo und 5.1 (Auro3D-OCT9 Galaxy)

Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

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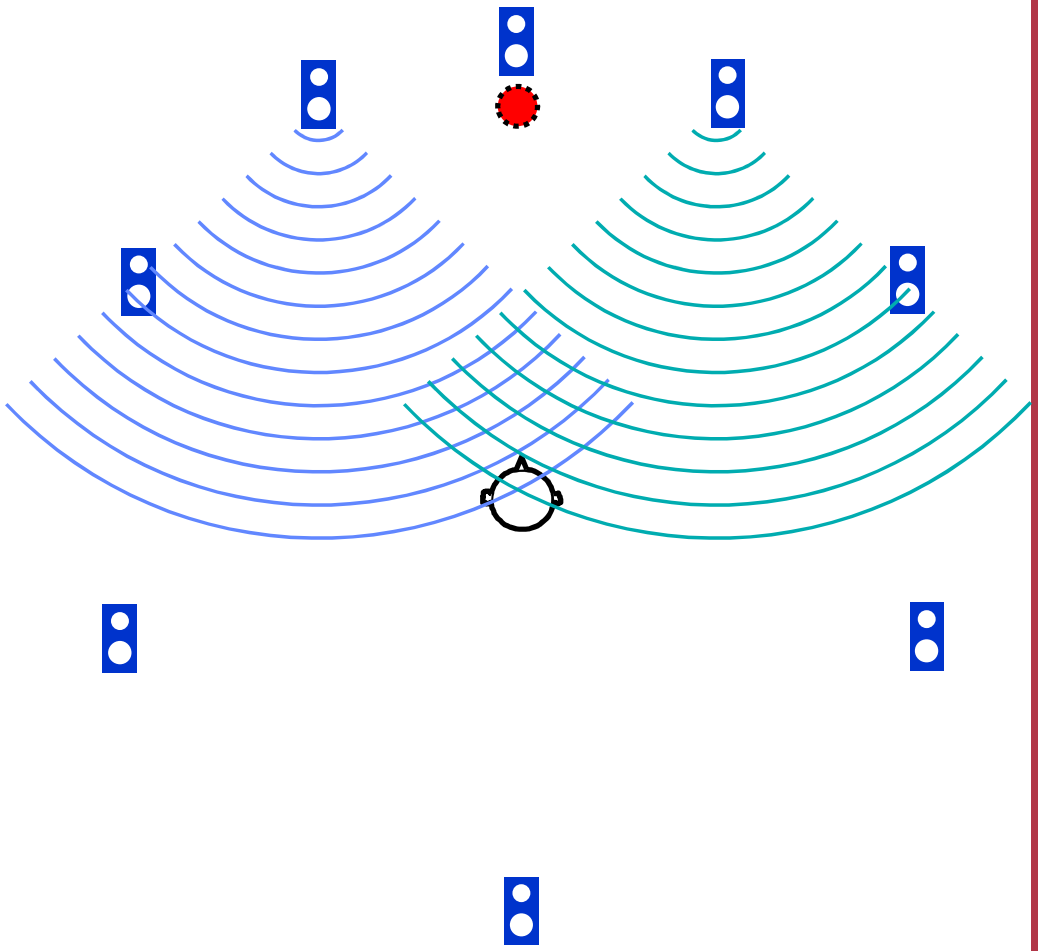
Spatial sound reproduction techniques:

- ***Multichannel*** Stereophony??



Basics

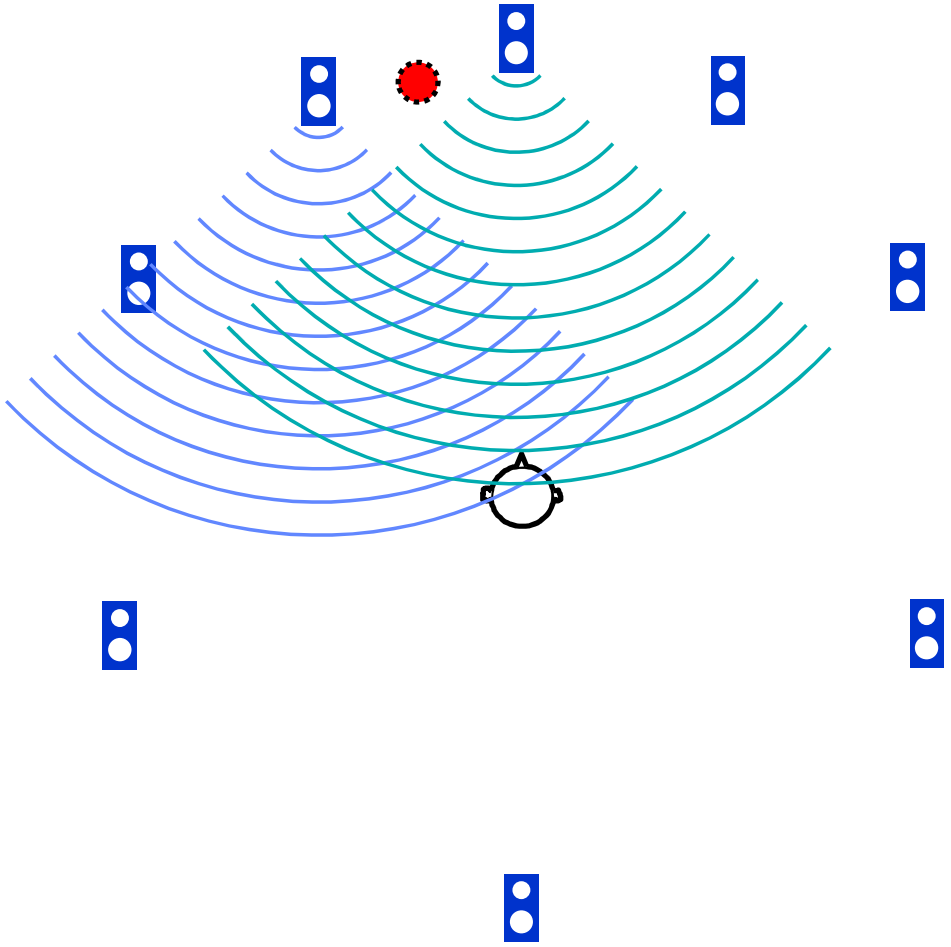
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

Array design for 3D-Audio

Spatial sound reproduction techniques:

- ***Multichannel*** Stereophony??



Basics

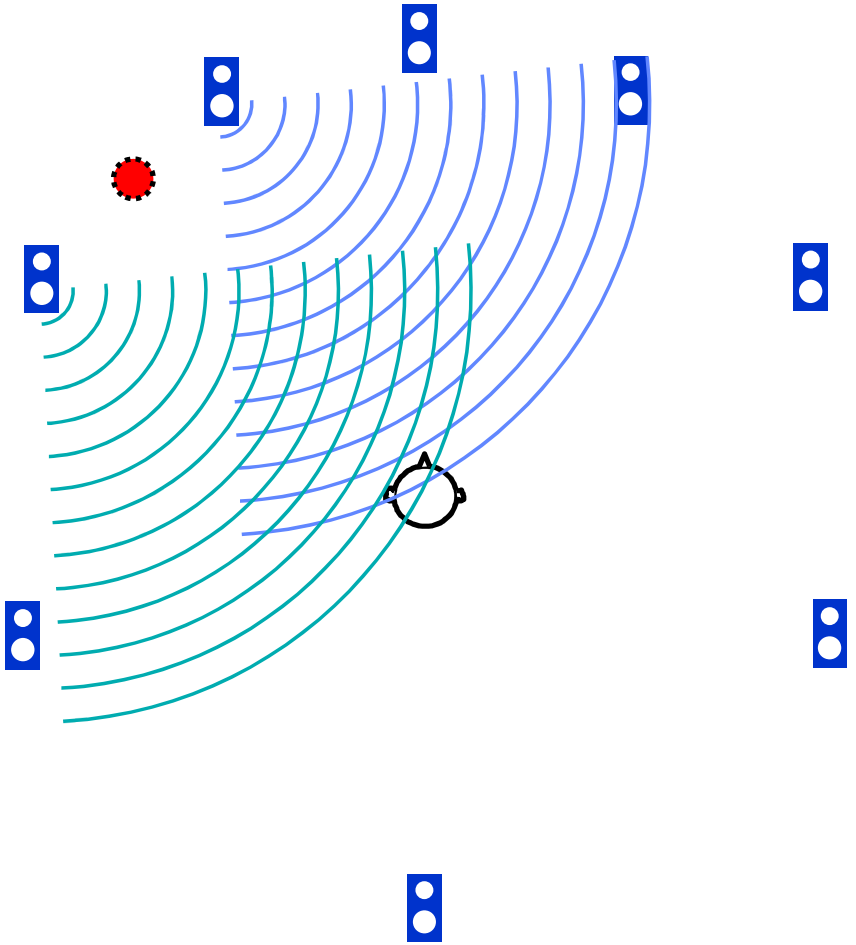
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

Array design for 3D-Audio

Spatial sound reproduction techniques:

- ***Multichannel*** Stereophony??



Basics

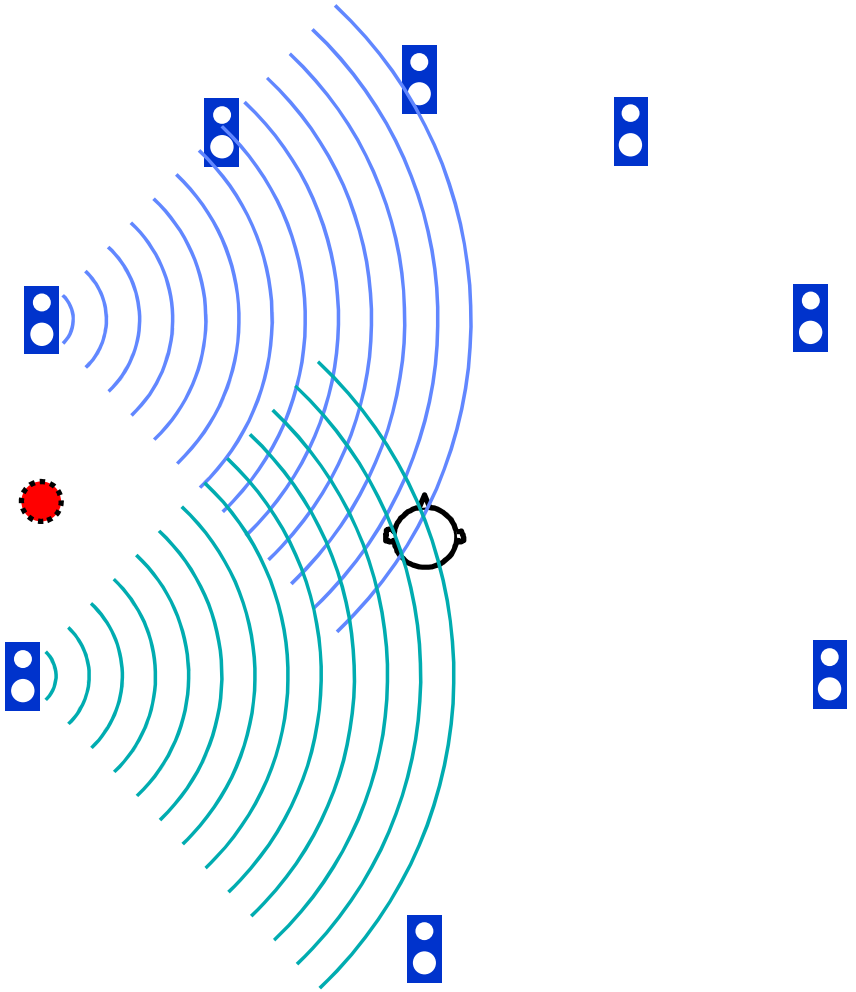
- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

Array design for 3D-Audio

Spatial sound reproduction techniques:

- ***Multichannel*** Stereophony??



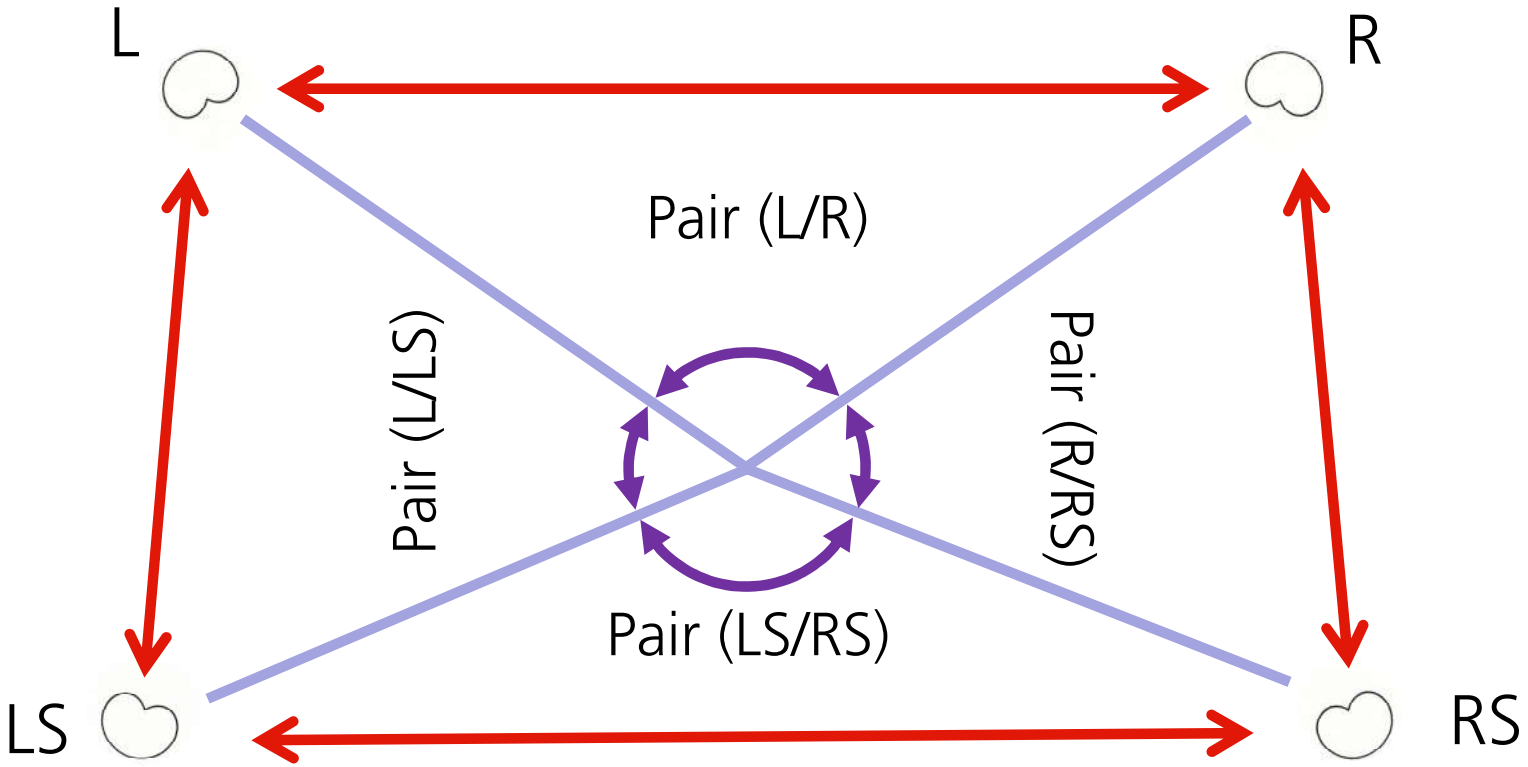
Basics

- 4 Spatial Sound reproduction principles
- Psychoacoustics of Stereo

Stereo Imaging

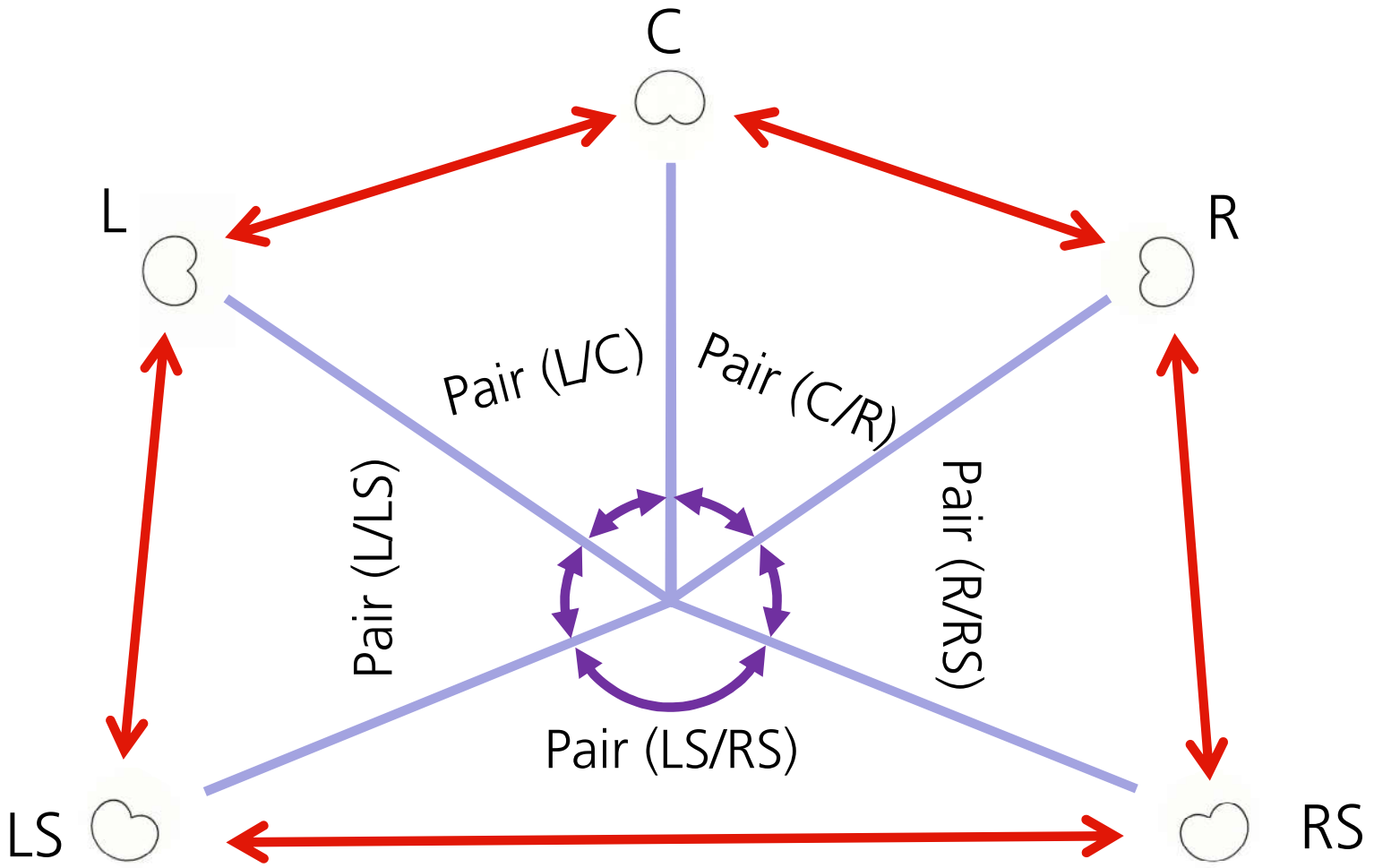
Array design for 3D-Audio

- 5.1 Array design for D/D scenes



Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

- 5.1 Array design for D/D scenes



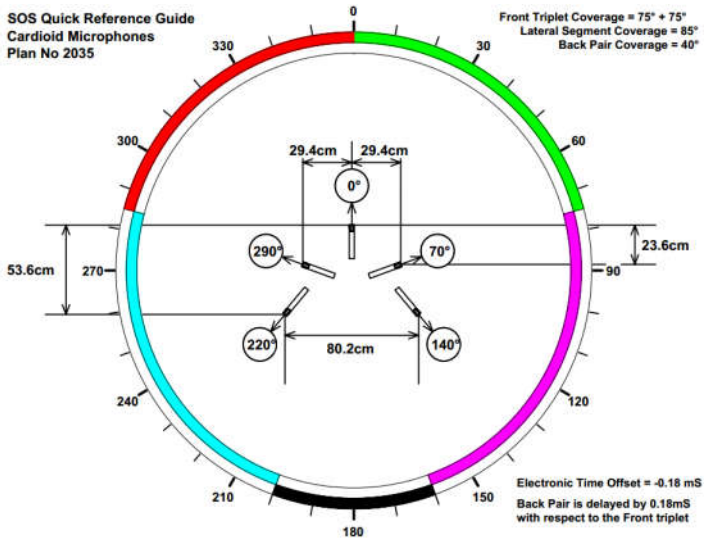
Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

Williams: MMAD

- Critical Linking of sectors
- http://www.mmad.info

Similar techniques based on this principle:

- INA 3/5 by Herrmann/Henkels
- Fukada-Tree
- etc.



REF M. Williams

Demo: Williams

Basics

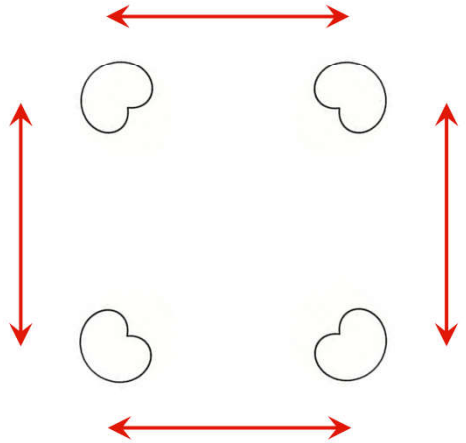
Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

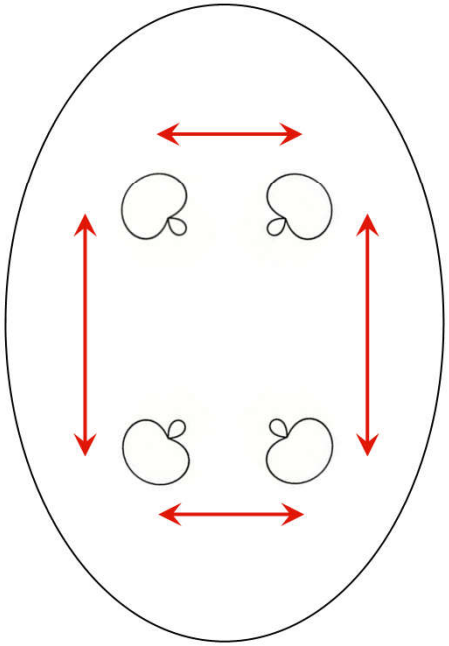
IRT cross

- 4 Cardioids at 20 cm - 90°
- 4 Supercardioids at 14 cm - 90°



“ORTF Surround”:

- 4 Supercardioids at 10cm/100°/80°



Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

IRT cross

- 4 Cardioids at 20 cm - 90°
- 4 Supercardioids at 14 cm - 90°

“ORTF Surround”:

- 4 Supercardioids at 10cm/100°/80°

Basics

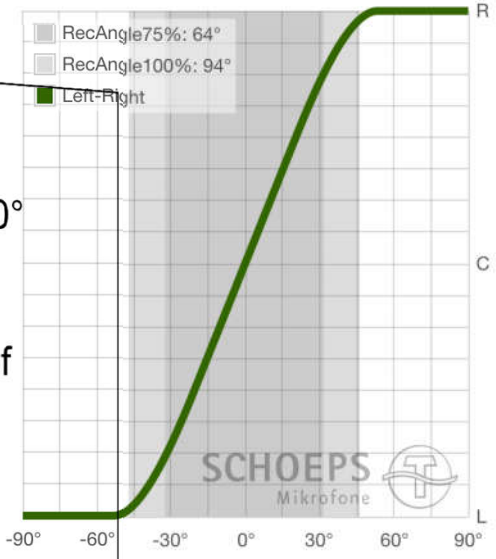
Stereo Imaging

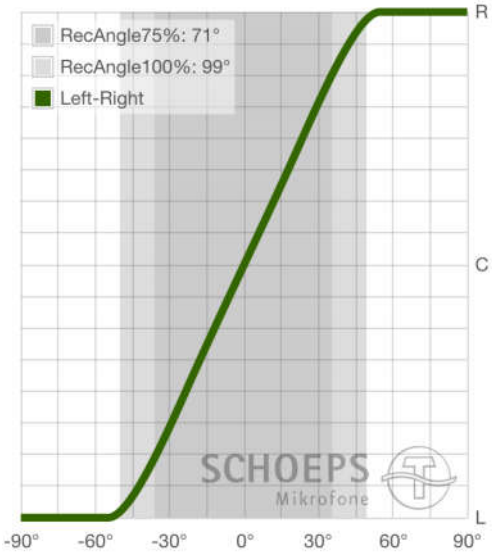
Array design

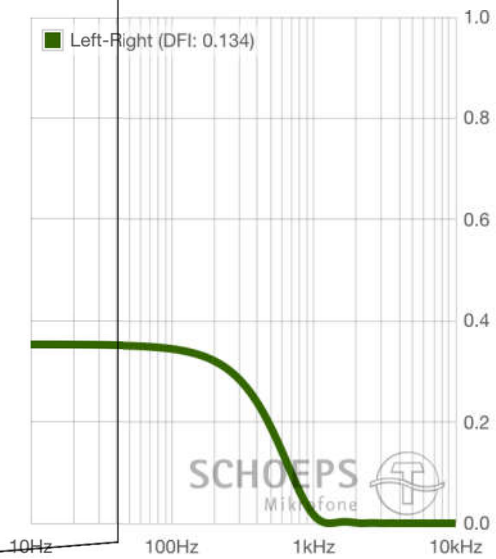
- Two-channel
- Multichannel
- 3D-Audio

“ORTF Surround”:

- 4 Supercardioids at 10cm/100°/80°
- Minimum Crosstalk
- Optimal Directional Image
- Very good decorrelation in spite of the small dimensions







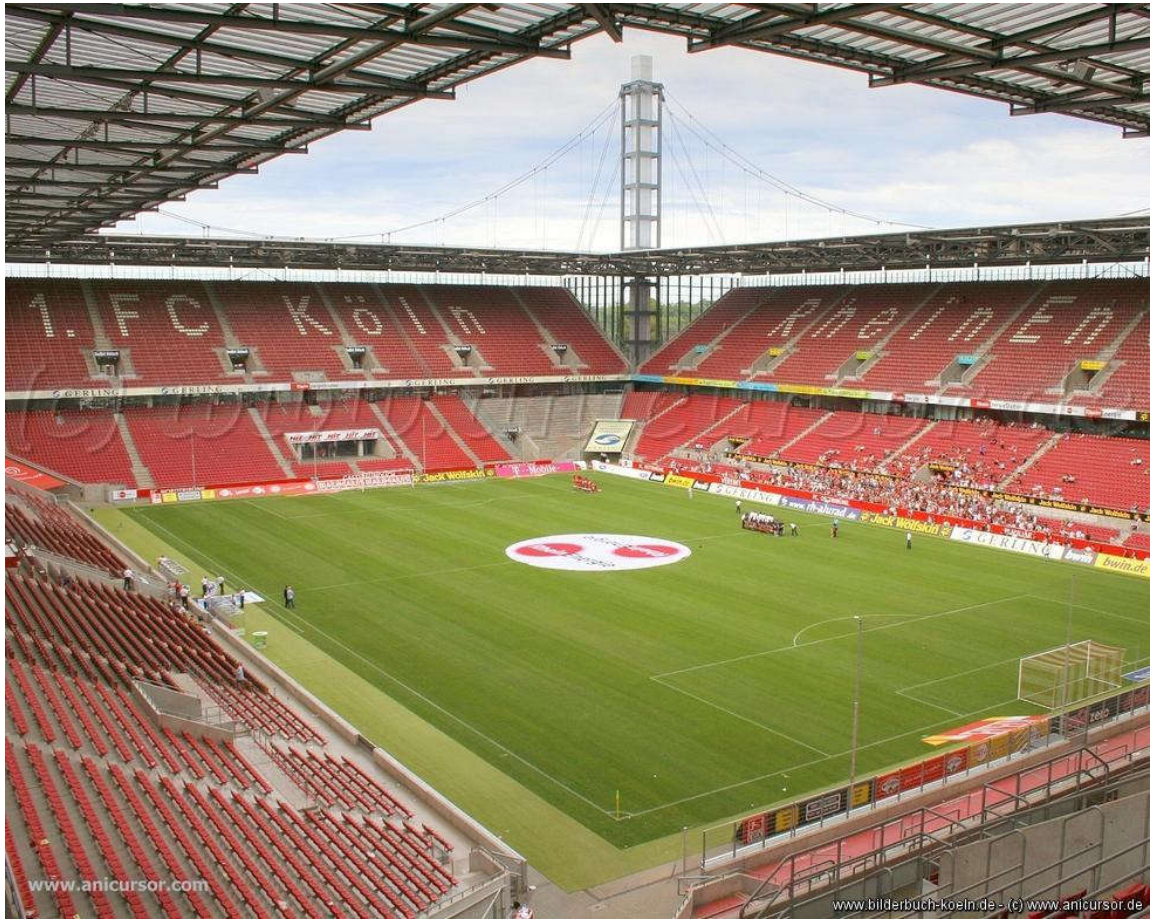
Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

- Demo: ORTF Surround (Barbeau, Paralympics, WorldCup)



Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

- Additional Criteria for the Array design in 5.1

- Scene type: Which content is in the Front/Back? **D**irect or **A**mbience?
  - e.g. D/D: Direct sound in the Front and Back
- Use of Center channel

Example	Scene type	Special properties	Center channel	Suitable setup
Documentary ambience with discrete sources	D/D	Outdoor capability	X	5 wide cardioids
Dry radio drama recording in the studio	D/D	Post production, little diffuse sound	X/-	Double M/S
Stadium ambience for Sports	D/D	Small size, easy-to-use	-	ORTF Surround
Ensemble in the concert hall	D/A	Front Directional image	X	OCT Surround, OCT + Hamasaki
Large Orchestra in the concert hall	D/A	Uses spot microphones	X	5 omnis
Concert hall ambience	A/A	Direct sound suppression	-	Hamasaki Square

Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

- 5.1 Array design for D/A scenes

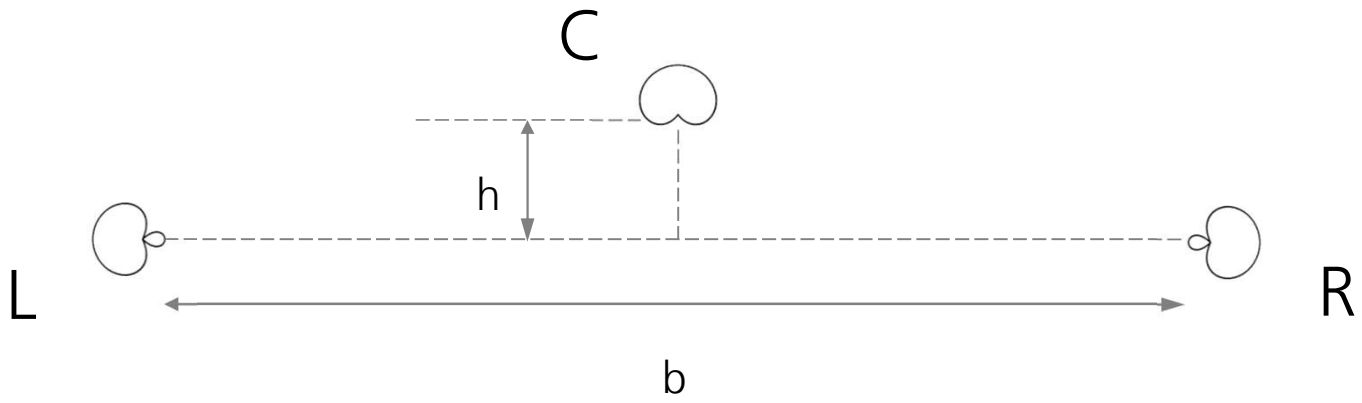
Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

- 5.1 Array design for D/A scenes
- OCT: h = 8cm; b = 40..100cm



Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

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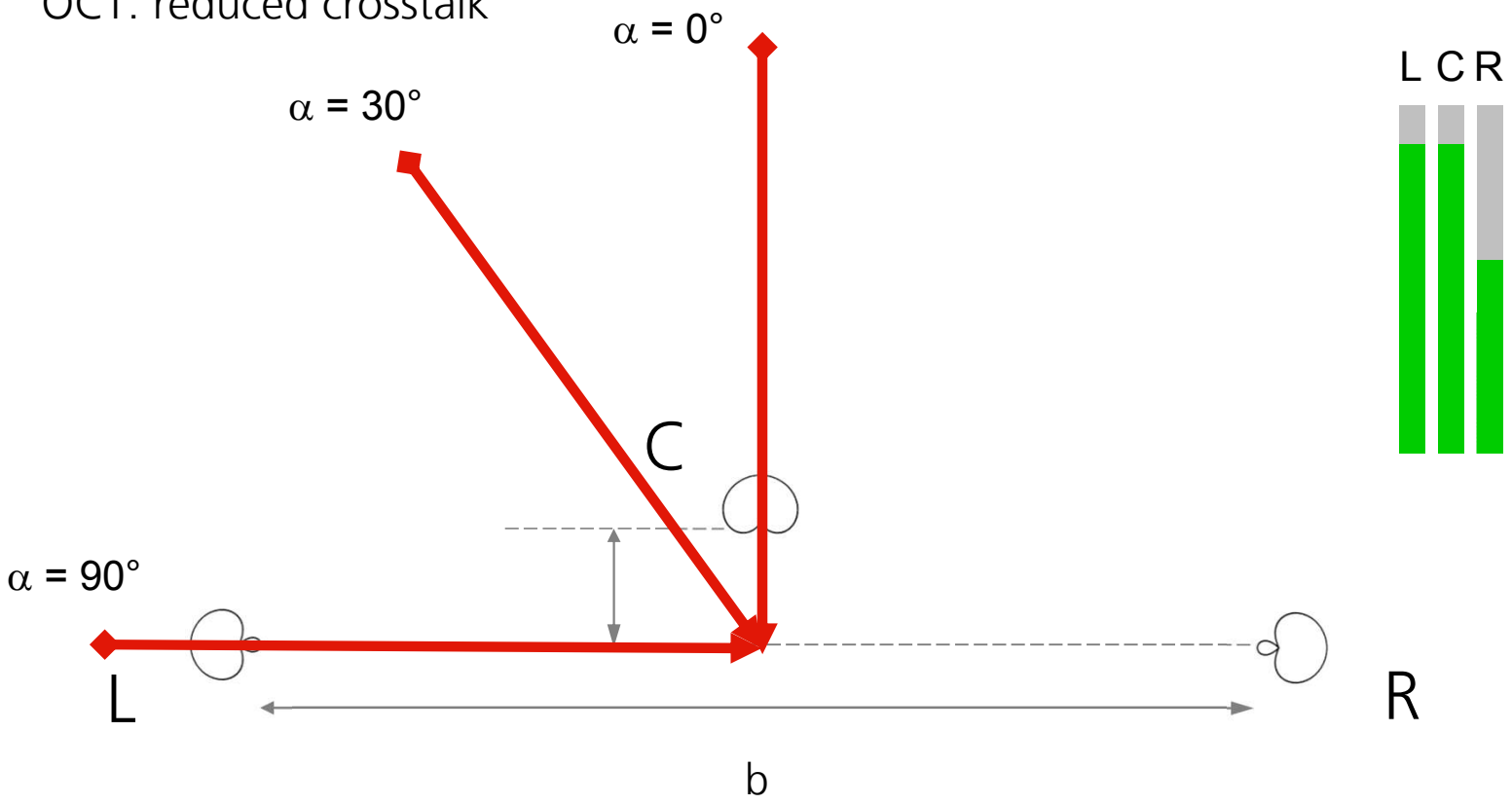
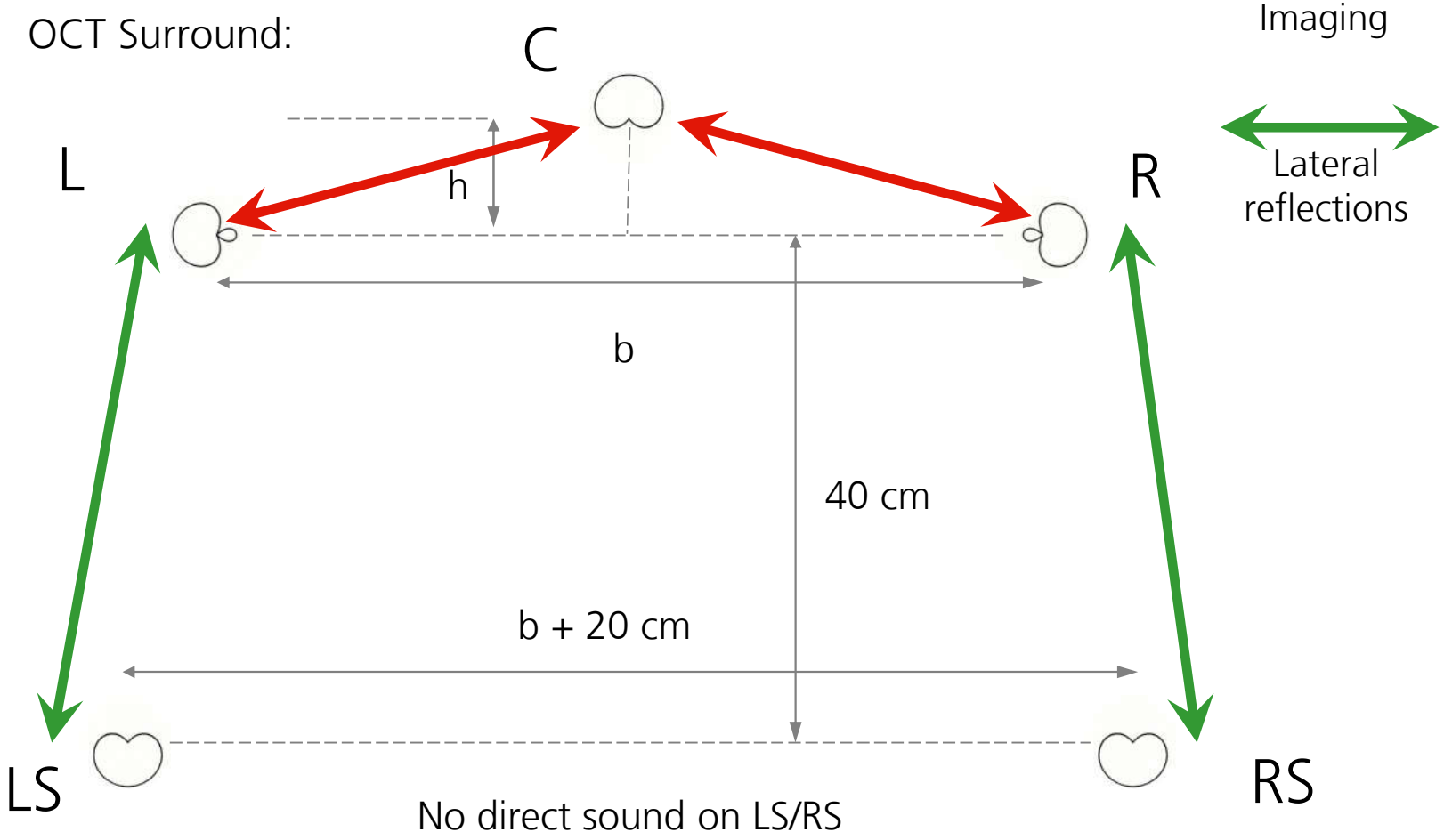
- 5.1 Array design for D/A scenes
- OCT: reduced crosstalk



Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

- 5.1 Array design for D/A scenes
- OCT Surround:



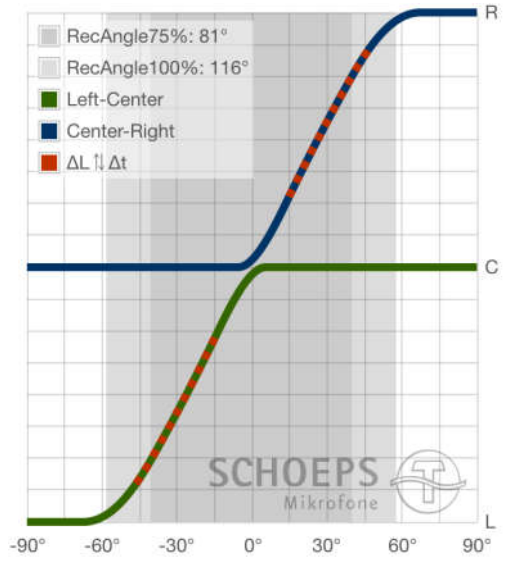
Directional Imaging

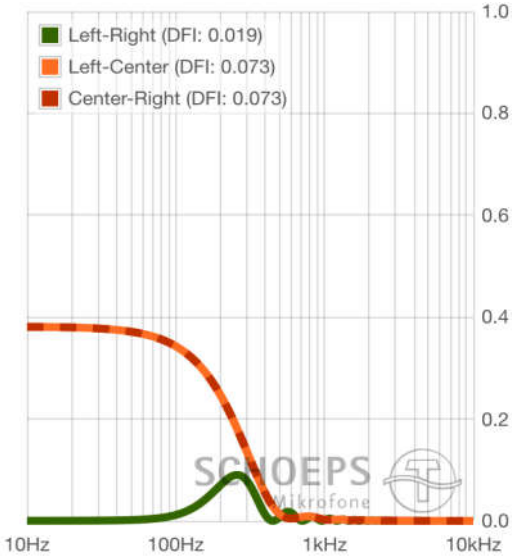
Lateral reflections

Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

OCT

- ORTF-like Surround Array
- Minimum Crosstalk
- Optimal Directional Image
- Natural Depth





Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

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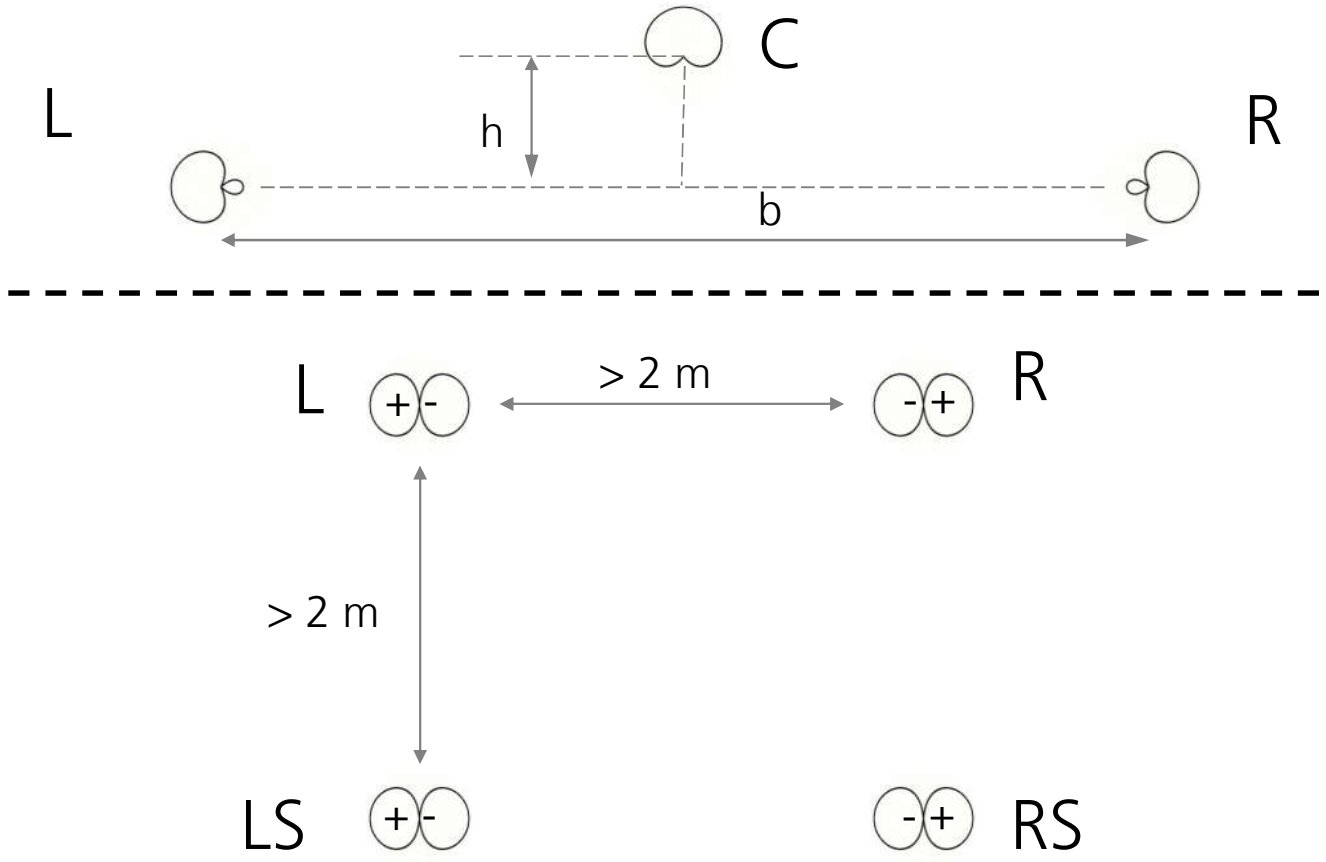
- 5.1 Array design for D/A scenes
- OCT + Hamasaki square



No direct sound on LS/RS

Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

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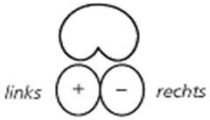
Double M/S

- Front M/S pair + Rear M/S pair =
- Combined Double M/S triplet
- Decoding like 2 * M/S

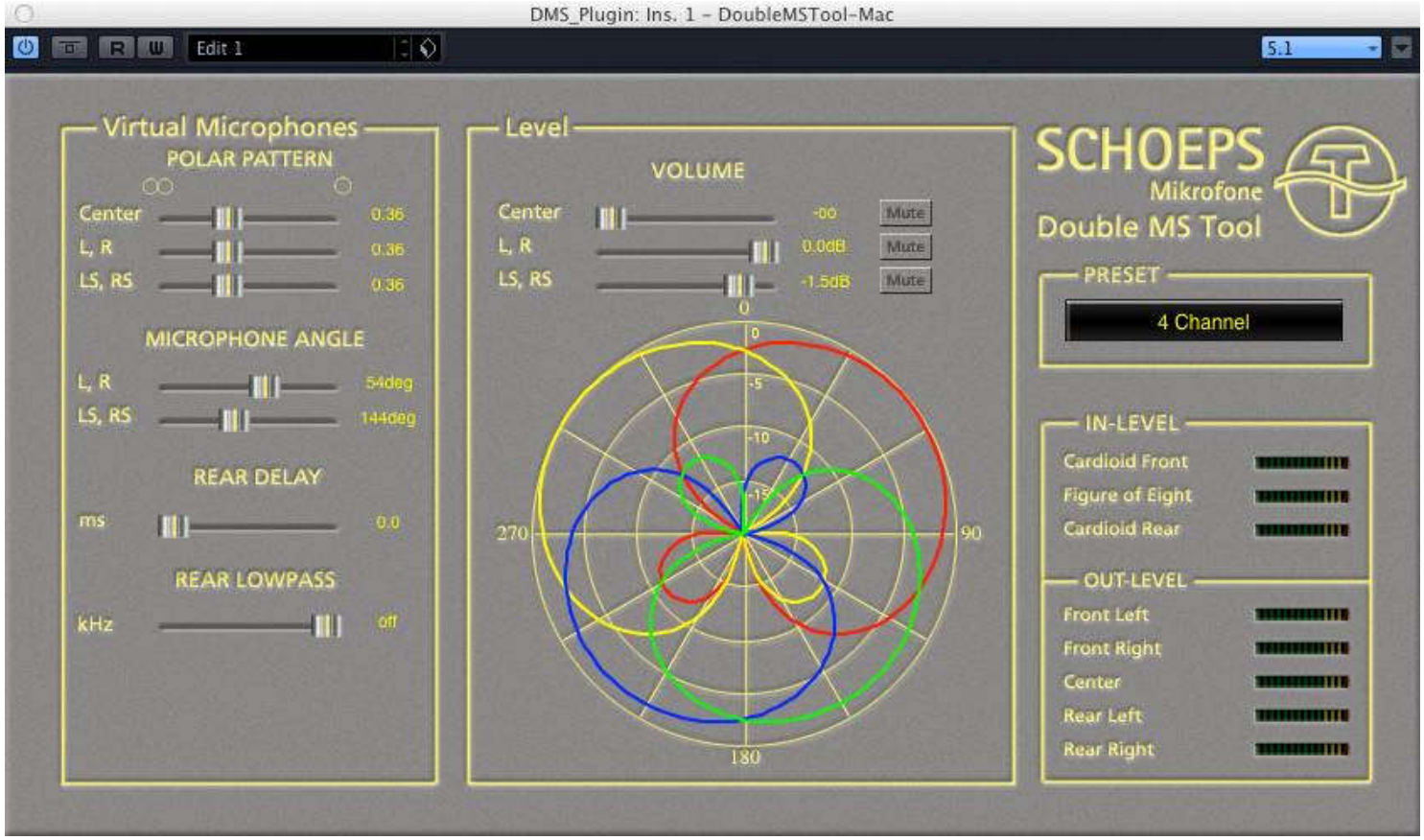


Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

- Double M/S

Demo DMS (Rossini, etc.)

Decoding with Plug-in



Double M/S Plug-in

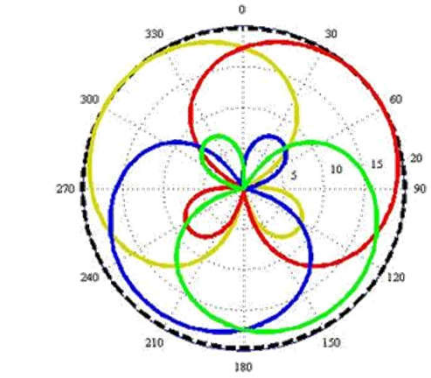
Basics

Stereo Imaging

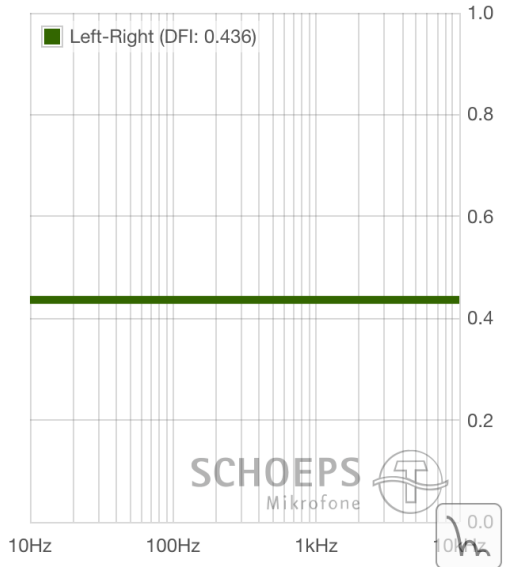
Array design

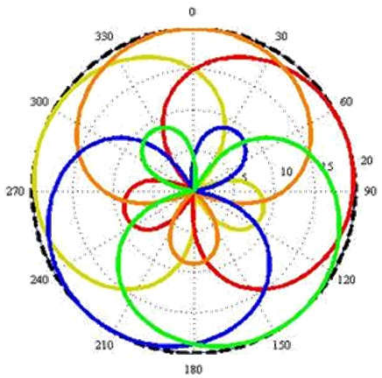
- Two-channel
- Multichannel
- 3D-Audio

- Double M/S



4ch decoding





5ch decoding

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- Various Double M/S setups

Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

- 5.1 Array design for D/A scenes

- Two recording principles with different priorities:

ORTF-like recording techniques

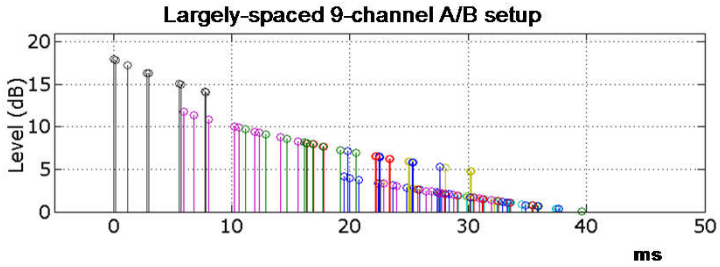
- Closely spaced, directive microphones
- Typical properties:
  - proportional and clear directional imaging
  - natural spatial impression
- Application: chamber music, drama, sports, ambience

Wide a/b-like recording techniques

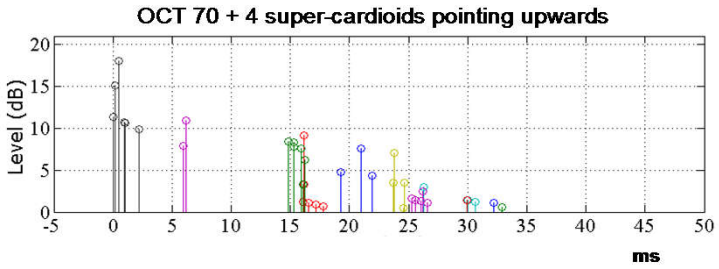
- Widely spaced, omni-directional microphones
- Typical properties:
  - stable, but not proportional directional imaging
  - enhanced spatial impression
- Application: music, film music

- 5.1 Array design for D/A scenes
- Two recording principles with different priorities:

Wide a/b-like recording techniques



ORTF-like recording techniques

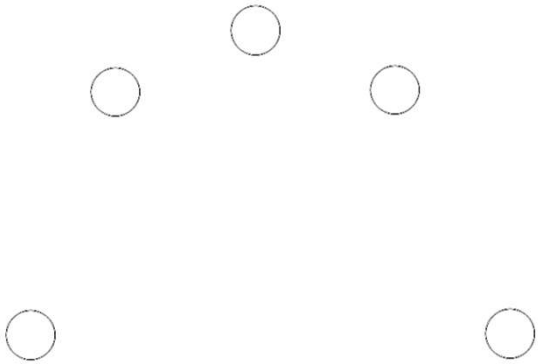


OCT by Theile

- ORTF-like Surround Array
- Minimum Crosstalk
- Optimal Directional Image
- Natural Depth

Omni Array

- 5 Omnis at large distances
- Good in reverberant rooms
- Open room sound



Demo Vergleich OCT-Decca (Galaxy)

Basics

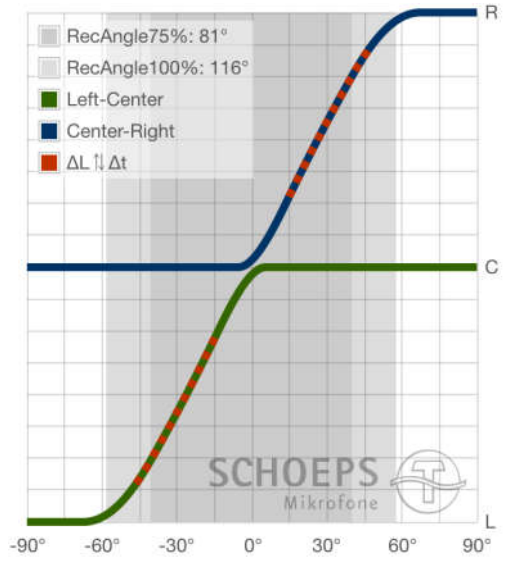
Stereo Imaging

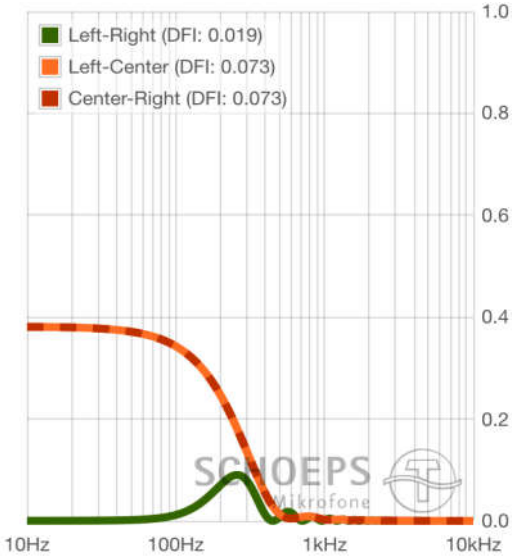
Array design

- Two-channel
- Multichannel
- 3D-Audio

OCT

- ORTF-like Surround Array
- Minimum Crosstalk
- Optimal Directional Image
- Natural Depth





Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

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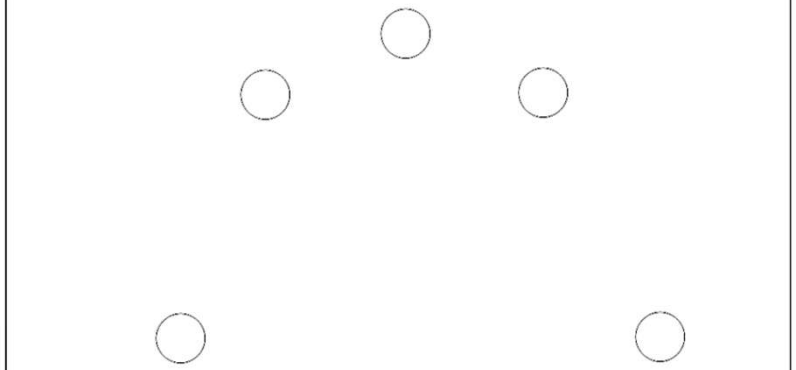
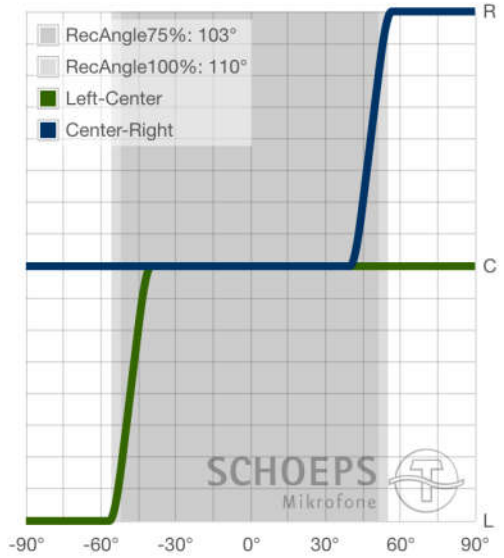
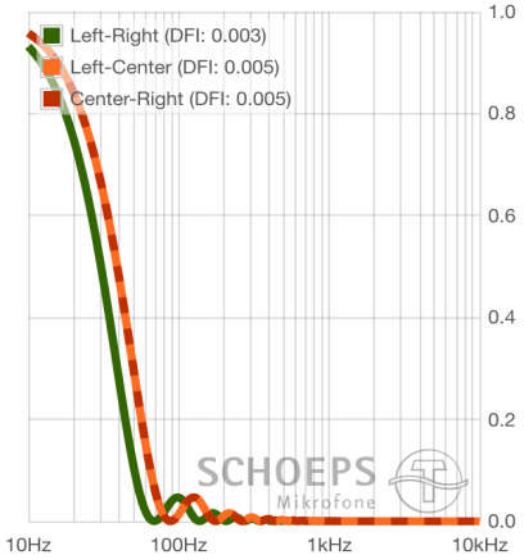
Omni Array

- 5 Omnis at large distances
- Good in reverberant rooms
- Open room sound







Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

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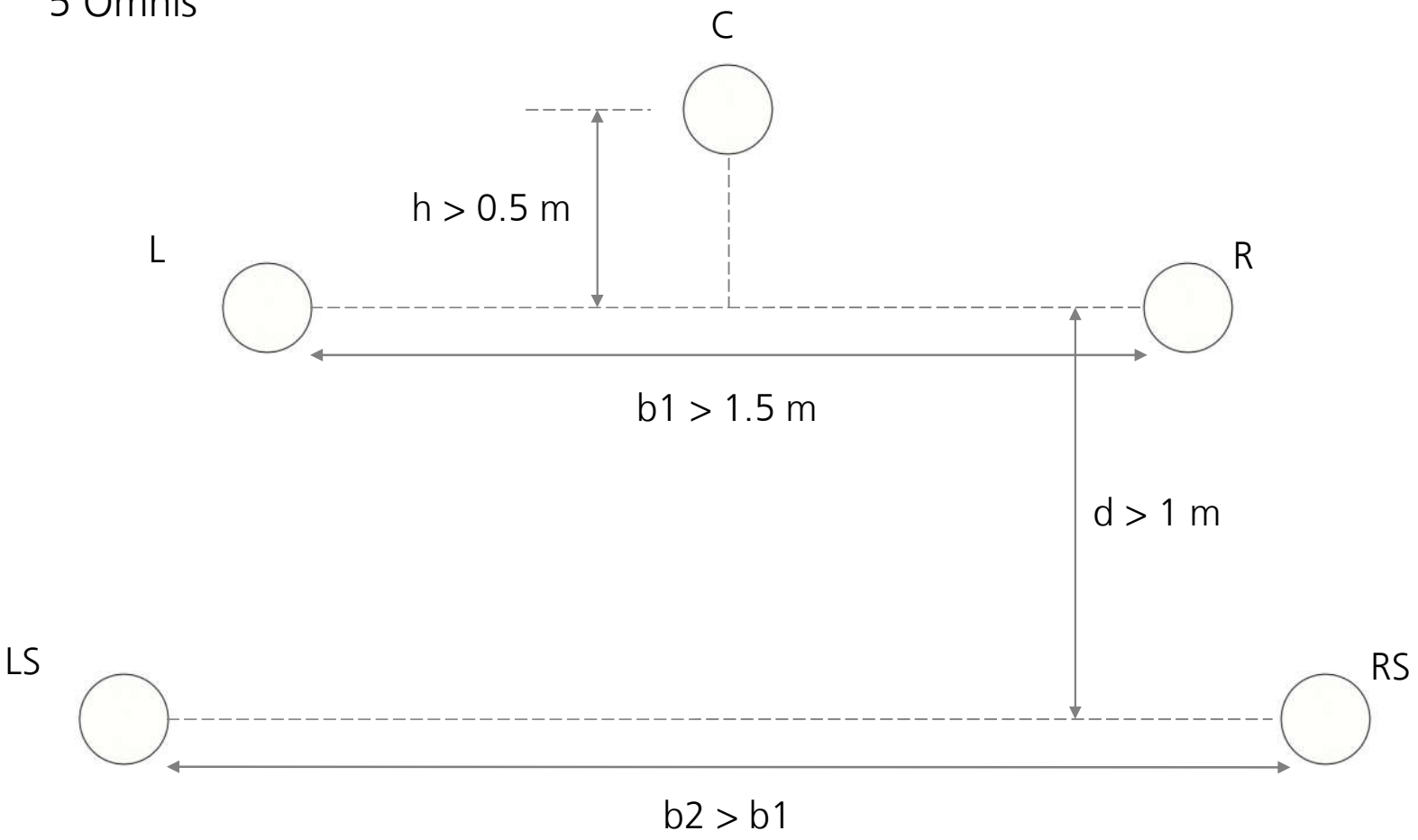
- 5.1 Array design for D/A scenes
- 5 Omnis



Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

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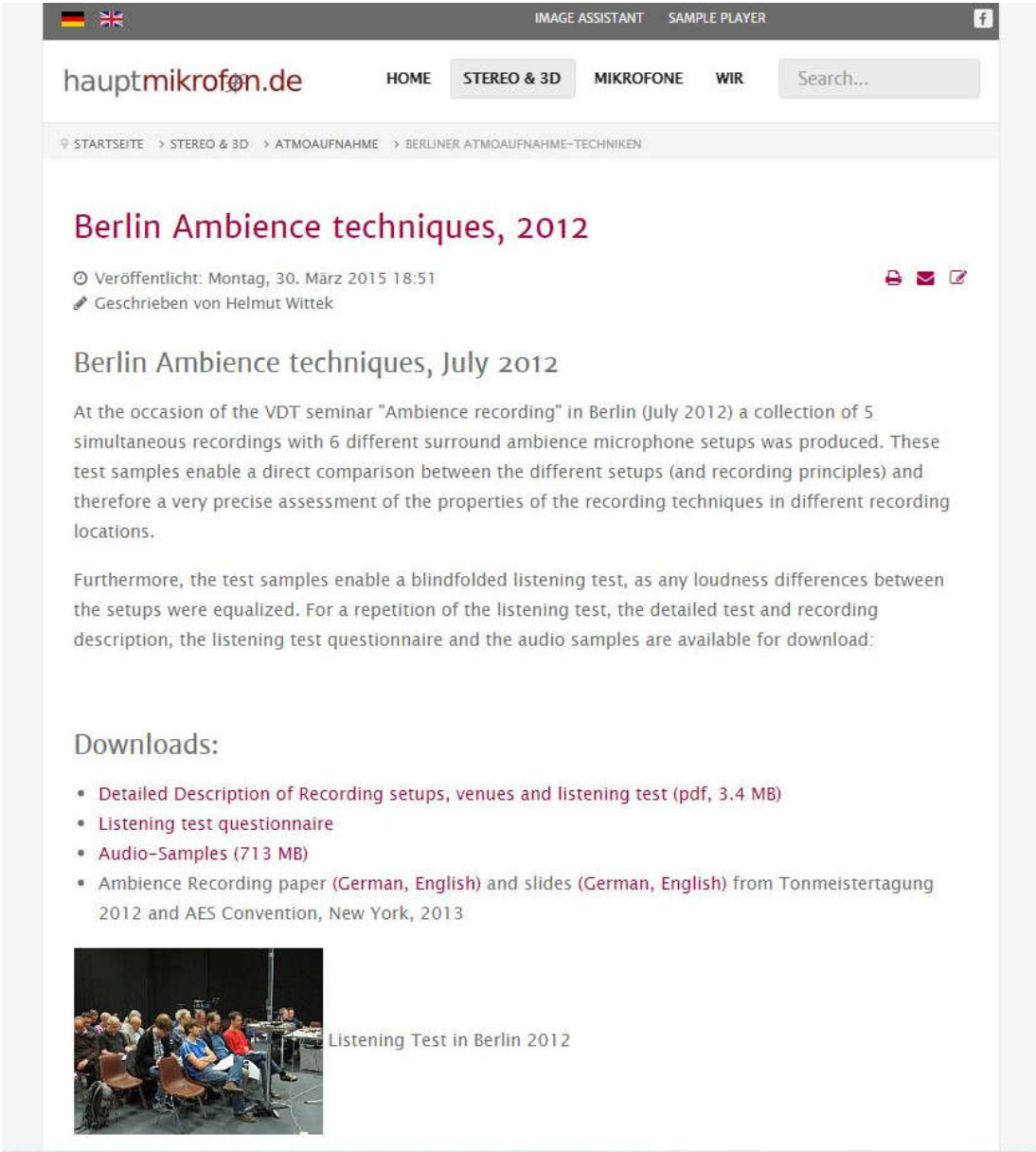
ambience.hauptmikrofon.de

- 5 * 6 Audio samples for Download
- Listening test can be performed
- Descriptions of the setups



Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

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- Recordings with 6 different setups:
  - Omni-Setup
  - Setup with wide cardioids
  - IRT Cross
  - ORTF Surround
  - Double-M/S
  - Double-M/S with shotgun

- Ambience recordings at 5 different locations:
  - Nr.1: Street square with tramway
  - Nr.2: Supermarket
  - Nr.3: Workshop with machines
  - Nr.4: Applause in a room
  - Nr.5: People speaking in a room

Nr.1: Street square with tramway

Nr.2: Supermarket

Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

Nr.3: Workshop with machines

Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

All microphone setups at one place

Nr.4: Applause and people speaking in a room

Basics

Stereo Imaging

Array design

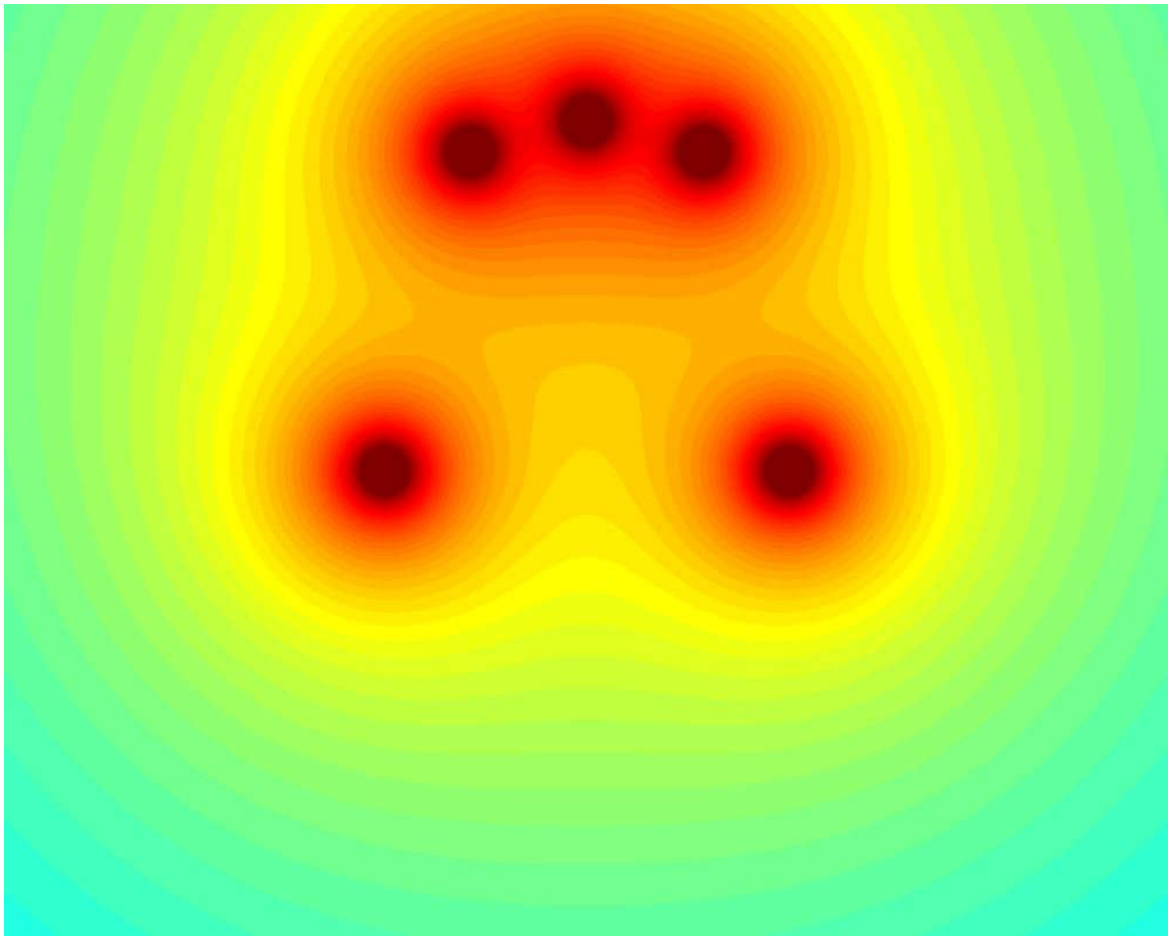
- Two-channel
- Multichannel
- 3D-Audio

- Array design for 3D-Audio
  (= Stereo + height)

Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

- „Diffuse Field Listening Area“

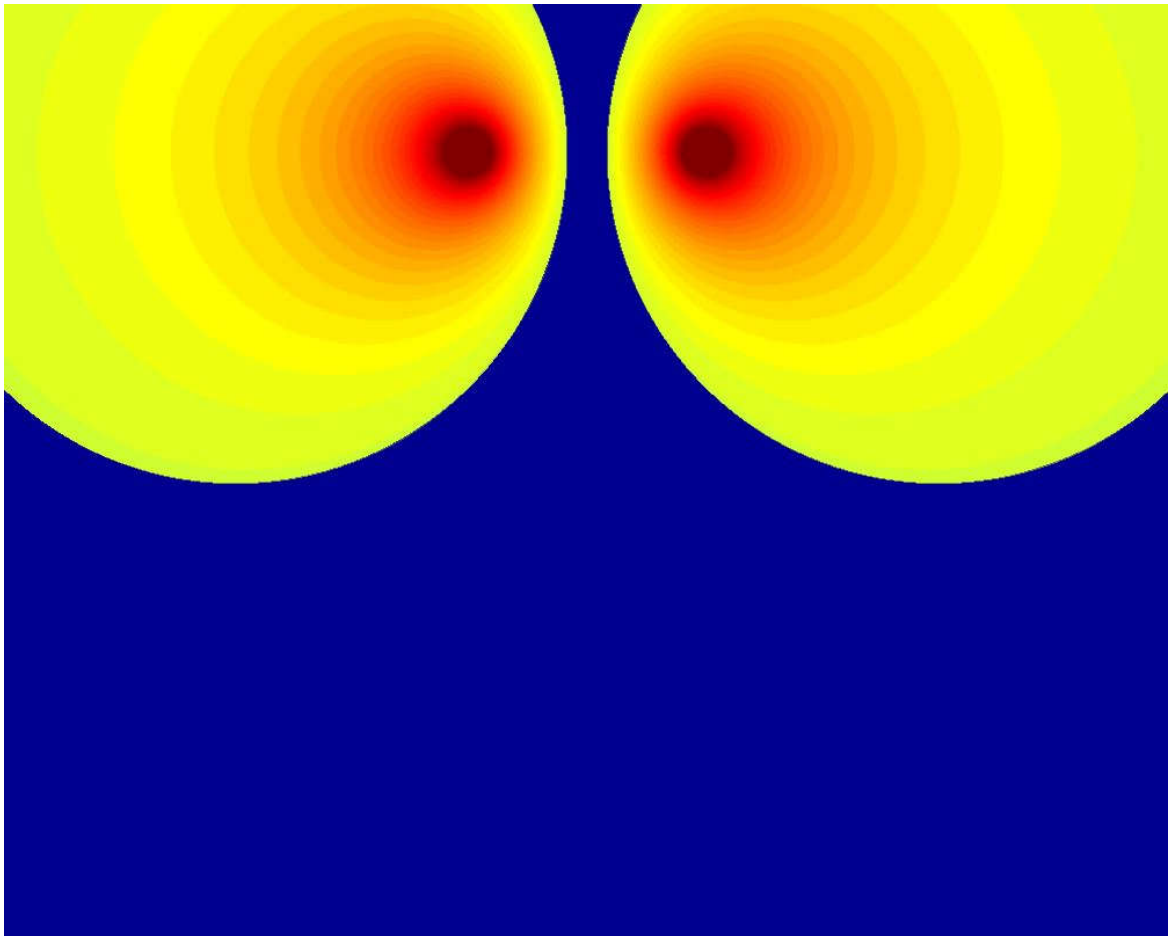
5ch Total power sum



Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

- „Diffuse Field Listening Area“

2 ch Diffuse Field Listening Area



Blue Zone:

No individual loudspeaker is more than 3 dB louder than the sum of all other loudspeakers

Basics

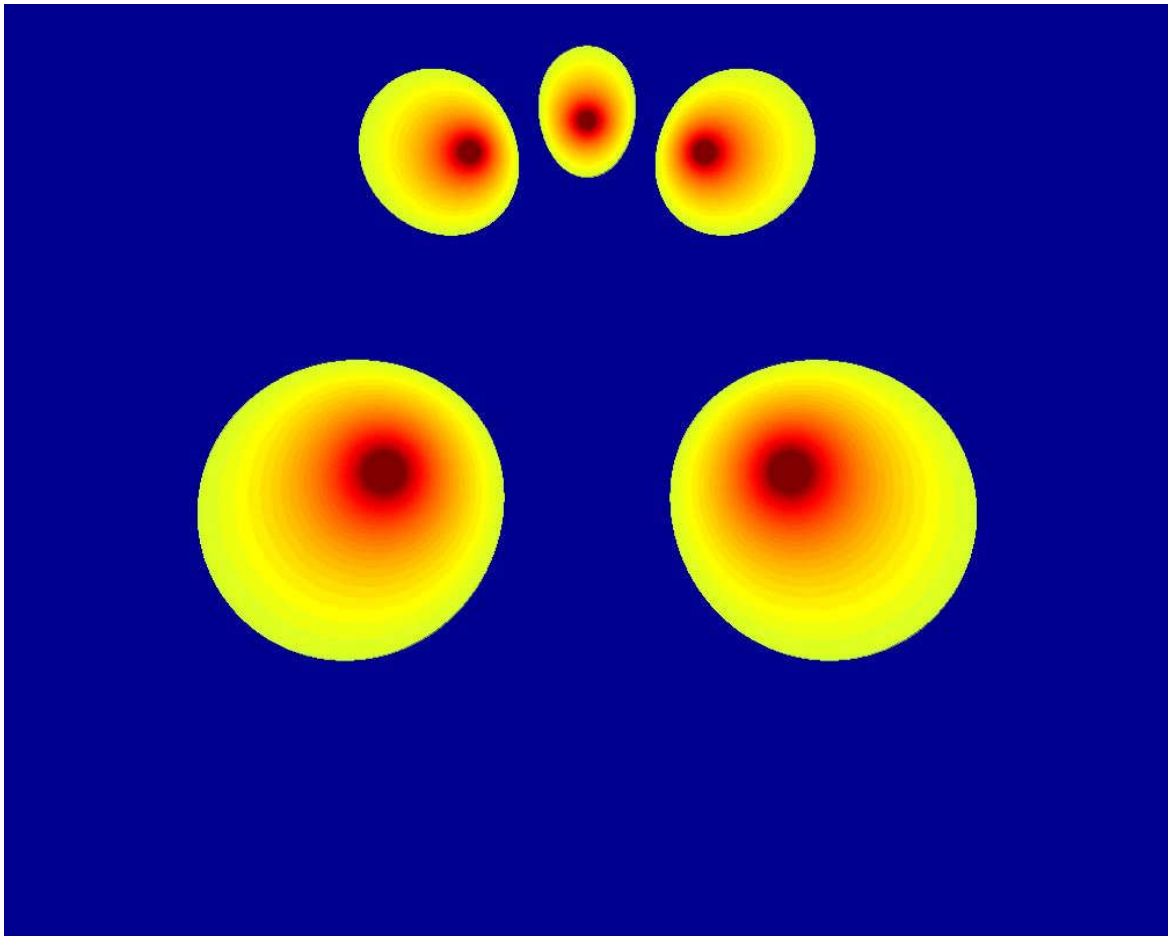
Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

- „Diffuse Field Listening Area“

5 ch Diffuse Field Listening Area



Blue Zone:

No individual loudspeaker is more than 3 dB louder than the sum of all other loudspeakers

Basics

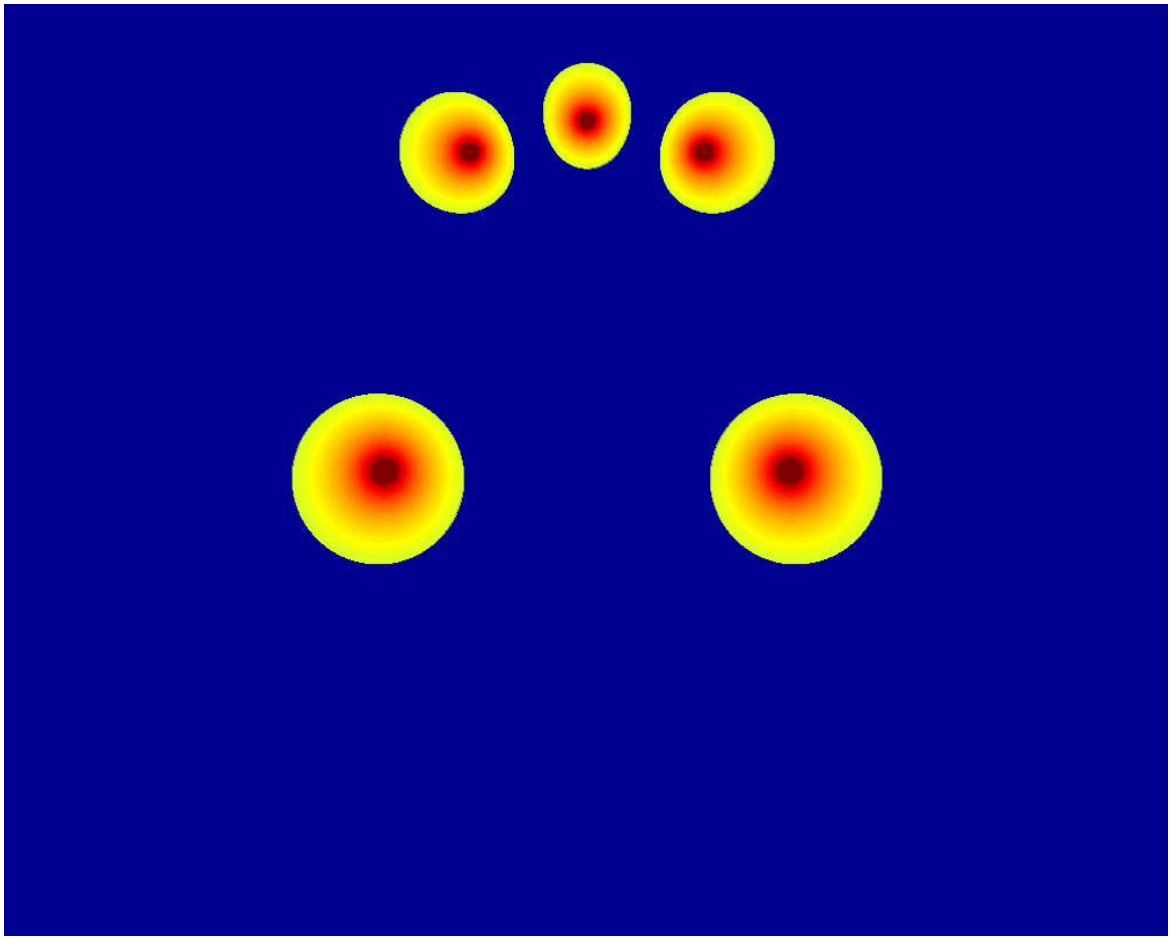
Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

- „Diffuse Field Listening Area“

9 ch Diffuse Field Listening Area



Blue Zone:

No individual loudspeaker is more than 3 dB louder than the sum of all other loudspeakers

Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

- Array design for 3D-Audio (= Stereo + height)
- Hypothesis: Less coloration and better perception of depth/distance through better source separation

Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

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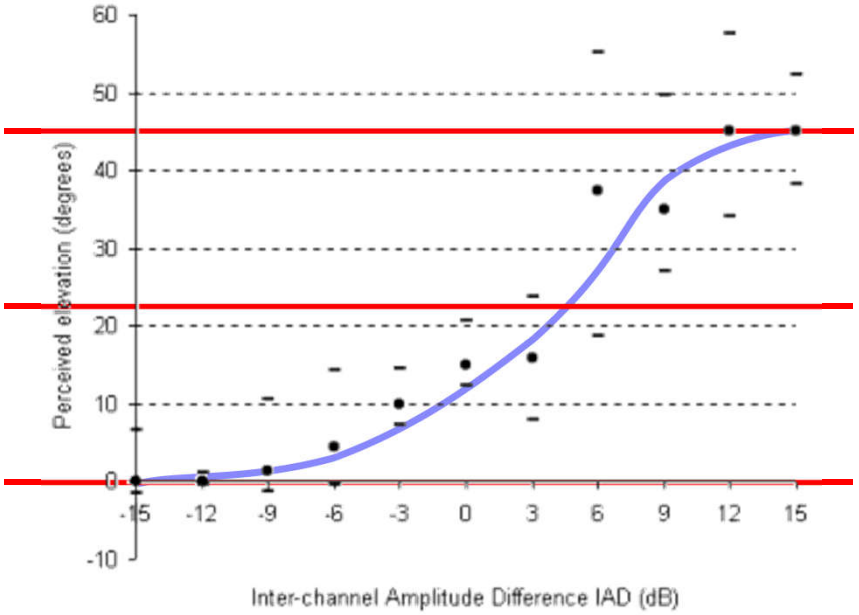
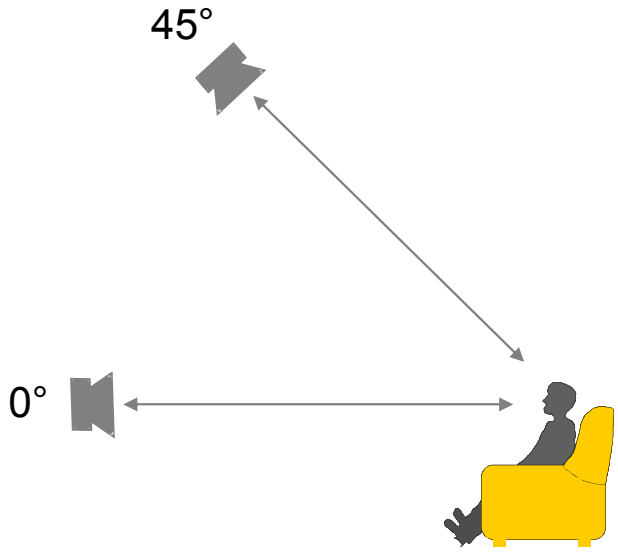
- Panning/Stereophonic Imaging between vertical loudspeaker pairs (Demo Vertical Shaker)



high

middle

low



REF Jim Barbour, AES

Demo Vertical Panning (3D Grundlagen)

Basics

Stereo Imaging

- Directional Image
- Room Image

Array design for 3D-Audio

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- Array design for 3D-Audio (= Stereo + height)

- Typification of scenes: What is the content in Front/Back/Up?
  - D/D/D
  - D/D/A
  - D/A/A

- Array design for 3D-Audio (= Stereo + height)
- Two recording principles with different priorities:

ORTF-like recording techniques

- Closely spaced, directive microphones
- Typical properties:
  - proportional and clear directional imaging
  - natural spatial impression
- Application: chamber music, drama, sports, ambience

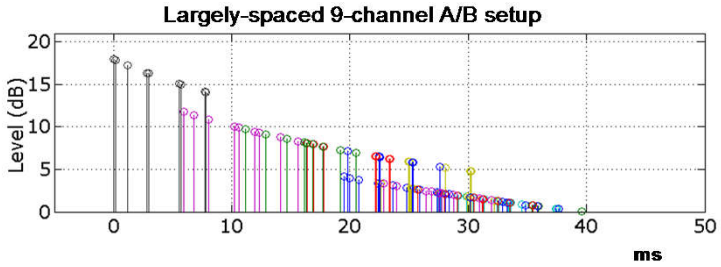
Wide a/b-like recording techniques

- Widely spaced, omni-directional microphones
- Typical properties:
  - stable, but not proportional directional imaging
  - enhanced spatial impression
- Application: music, film music

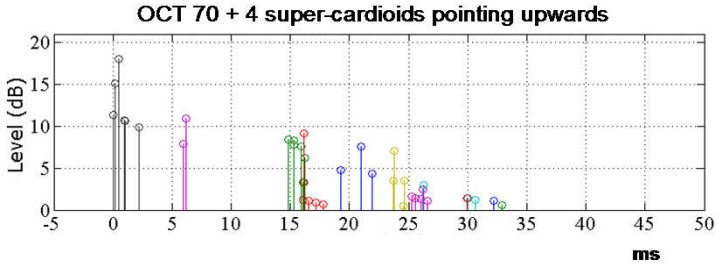
Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

- Array design for 3D-Audio (= Stereo + height)
- Two recording principles with different priorities:

Wide a/b-like recording techniques



ORTF-like recording techniques



Basics

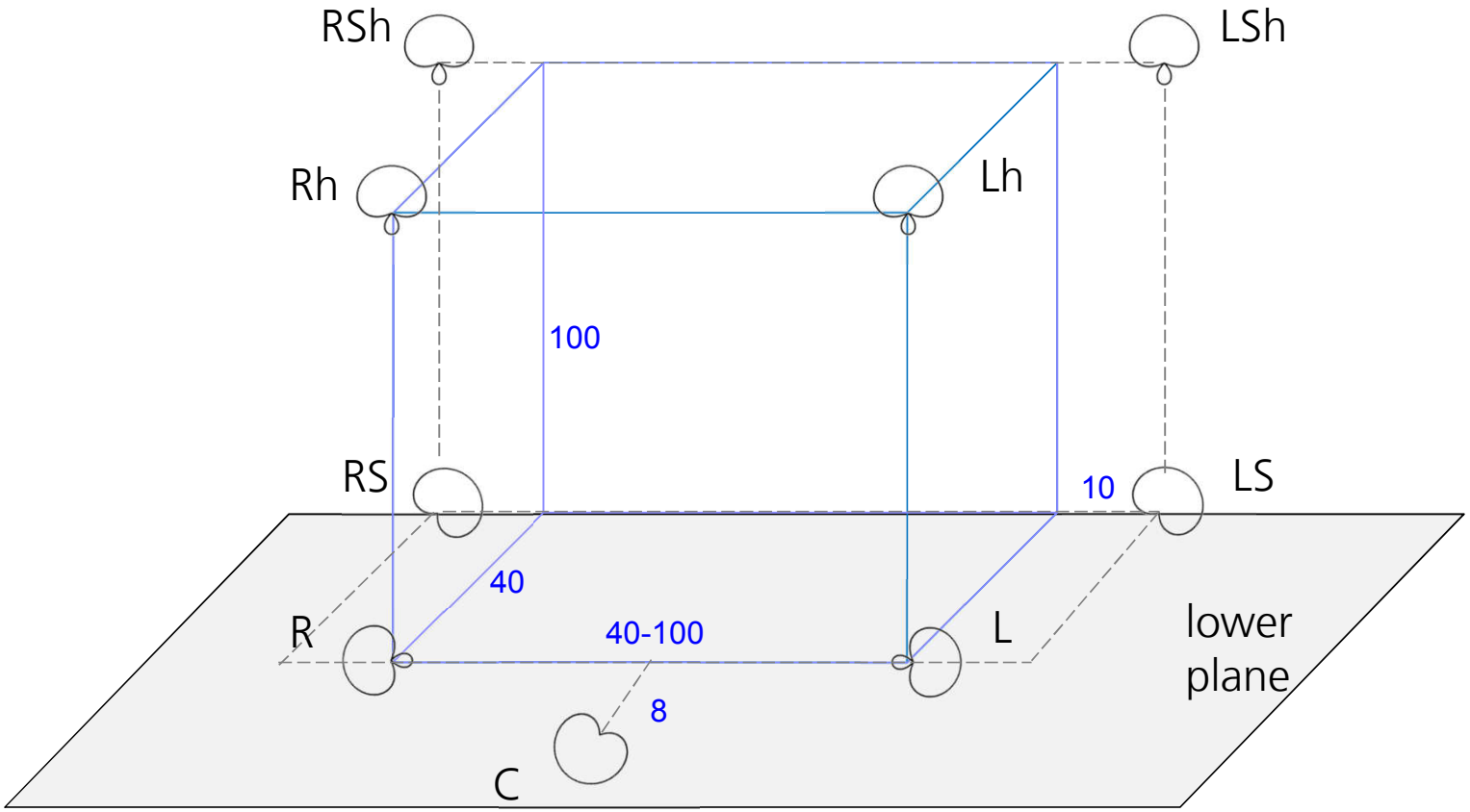
Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

„OCT 9“ for 9.1 Surround

- lower plane: OCT Surround
- upper plane: **+ 100cm (?)**, 4 supercardioids pointing upwards



Basics

Stereo Imaging

Array design

- Two-channel
- Multichannel
- 3D-Audio

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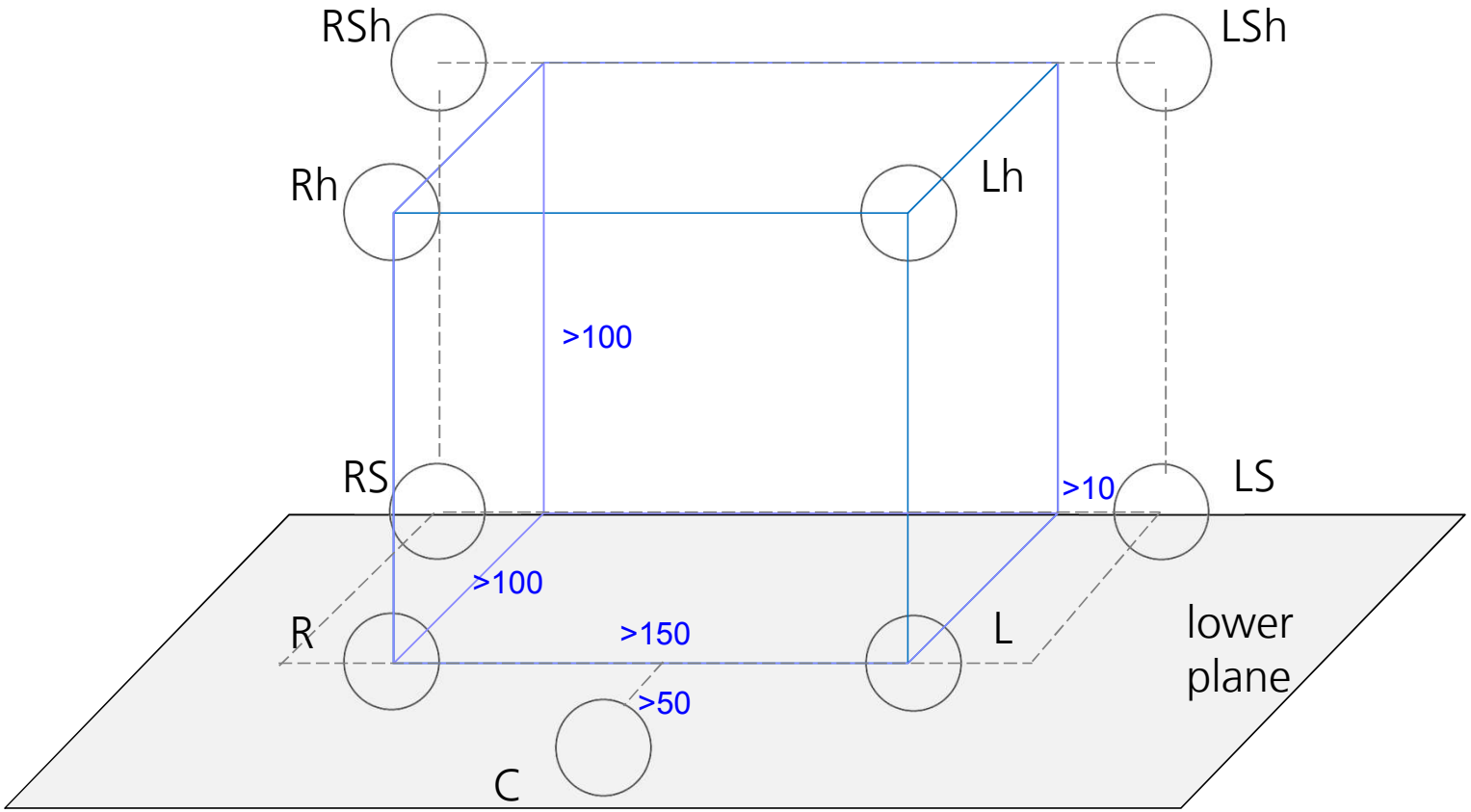
„Omni Array“ for 9.1 Surround

- 9 Omnis



Basics
Stereo Imaging
Array design
- Two-channel
- Multichannel
- 3D-Audio

- Test recordings in the Galaxy Studios, Belgium
- OCT 9
- Omni array

Basics

Stereo Imaging

Array design

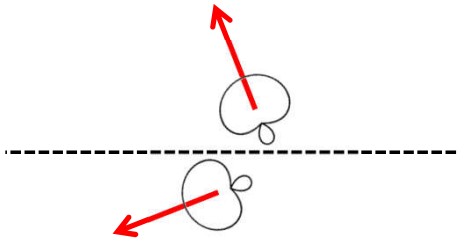
- Two-channel
- Multichannel
- 3D-Audio

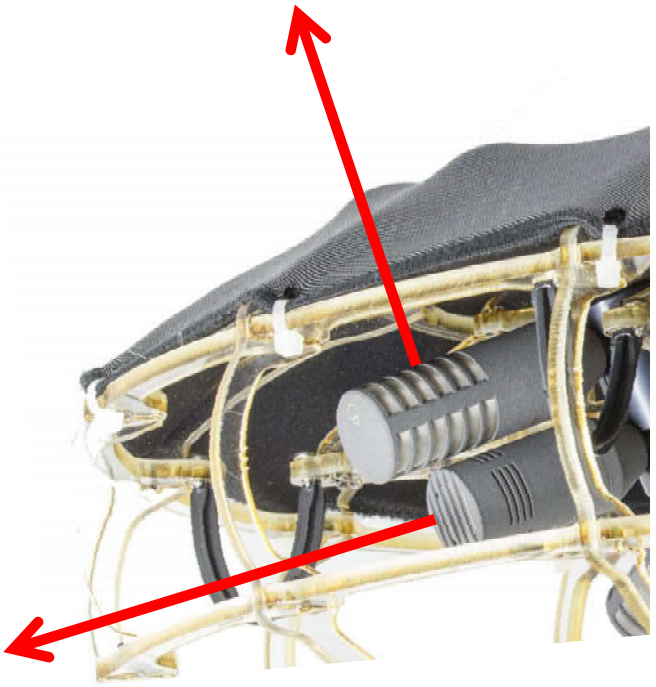
ORTF-3D regular

- 8 * Supercardioid on the edges of a cube with d = 10-20 cm

ORTF-3D „FLAT“ **(NEW)**

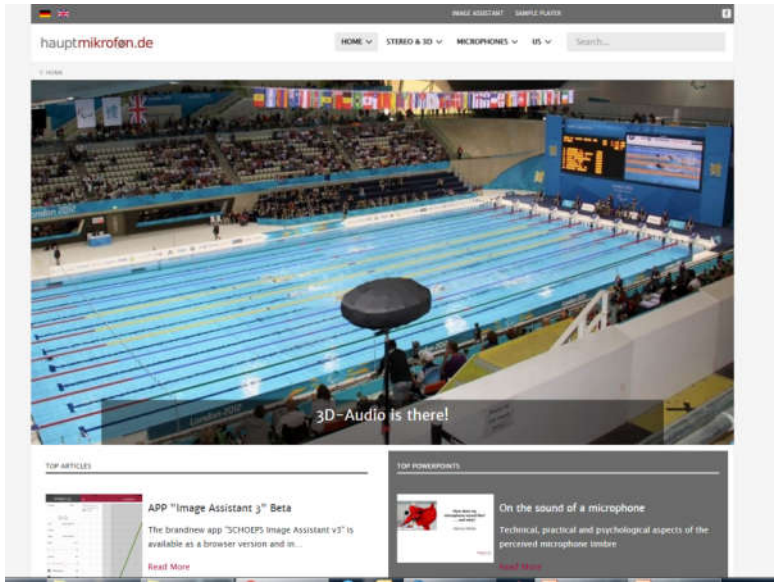
- 8 * Supercardioid on the edges of a rectangle/square with d = 10-20 cm
- Coincident X/Y microphone pairs for each vertical loudspeaker pair
- Orientation of the XY pair: +60° (height layer) / -30° (ground layer)





Demo Worldcup
Demos ORFT-3D Ambience

- www.hauptmikrofon.de (new launch today!)



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