Considerations on Stereo and Surround recording, reproduction and perception

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Contents

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Contents:

- An overview of psychoacoustics and applied microphone techniques
- Both theory and practical demonstration, by calculating and listening

Topics

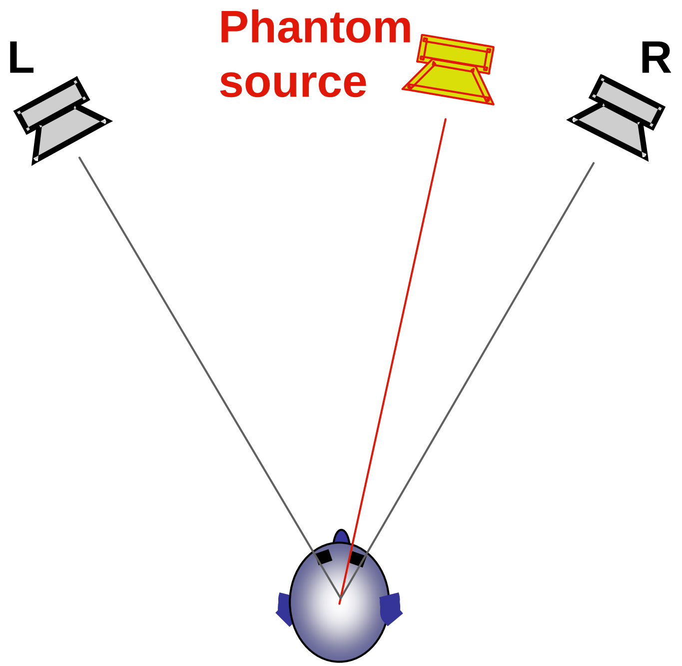
- Source localisation / stereophonic localisation
- Theories of microphone design
- Microphone setups and their properties
- The microphone and its properties

Source localisation

- Where is the source?
- At which distance?
- In which room, what is the room like?
- What does the source radiate?

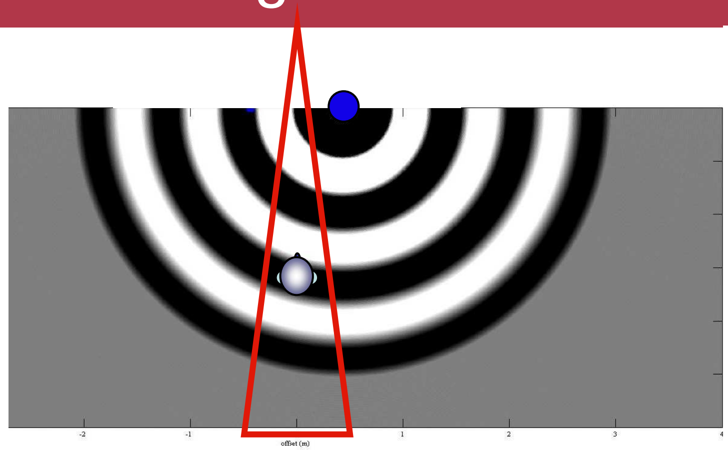
Stereophonic localisation

- $\geq$ 2 radiating sources
- Only one perceived “phantom” source

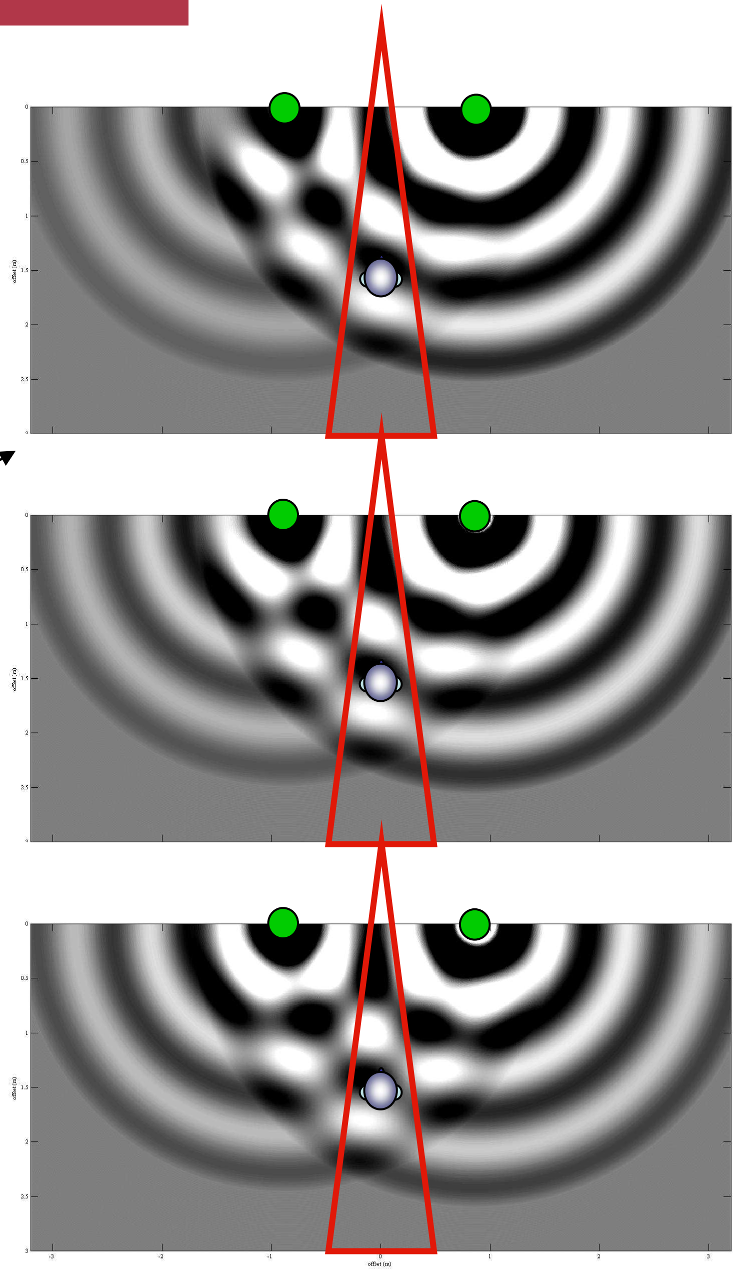


- Existing theory:
  Summing localisation = synthesis of the loudspeaker signals that leads to the original source signal (Blumlein)

Summing localisation



Real source, 15° on the right



Phantom Source,
perceived ca. 15° on the right,
ΔL=7dB, Δt=0 ms

Phantom Source,
perceived ca. 15° on the right,
ΔL=3.5dB, Δt=0.2ms

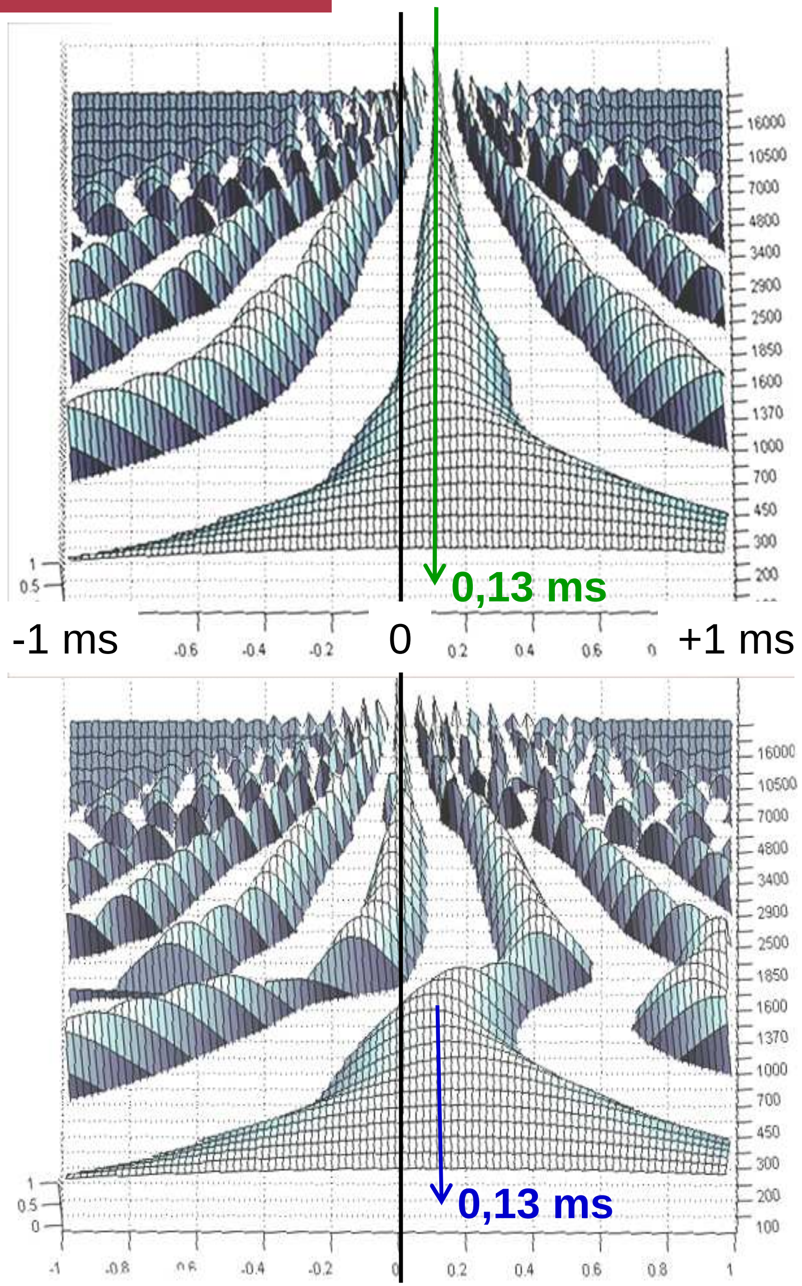
Phantom Source,
perceived ca. 15° on the right,
ΔL=0dB, Δt=0.4 ms

Summing localisation

Interaural Cross Correlation
(= Interaural Time Delay ITD
vs. frequency)

Real source
Perceived Direction **+ 15°**

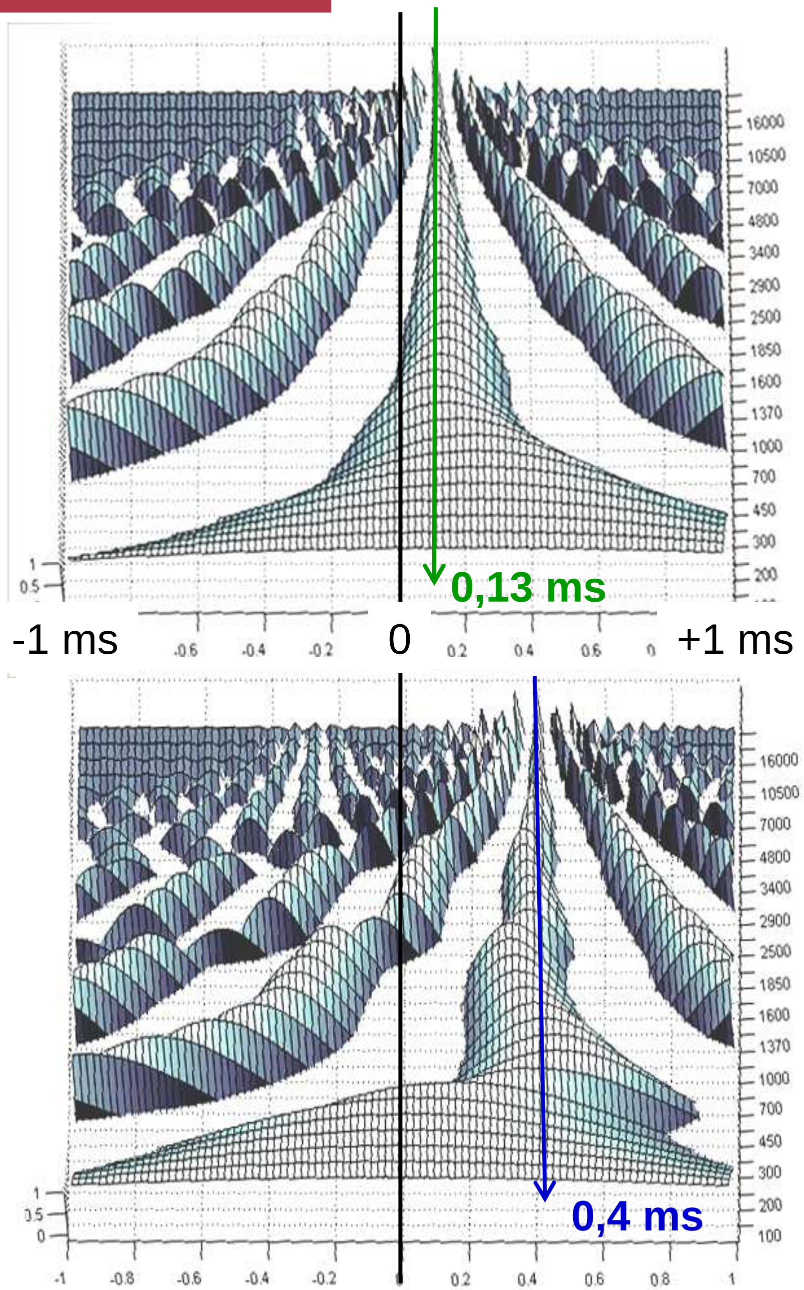
Phantom source
Perceived Direction **+ 15°**
Interchannel Level Difference
ΔL = 7 dB



Summing localisation

Interaural Cross Correlation
(= Interaural Time Delay ITD
vs. frequency)

Virtual source
Perceived Direction **+ 15°**



Phantom source
Perceived Direction **+ 15°**
Interchannel Time Delay
Δt = 0,4 ms

Other hypothesis

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- *Problems of the summing localisation theory:*
  - *Works only below ca. 1500 Hz*
  - *Works only for level panning*
  - *Works only in the sweet spot*
  - *It cannot explain the perceived sound colour*
- Other hypothesis for stereophonic localisation/perception:
  Stereo signals can be perceived *separately*
  - „Binaural decolouration" (Salomons, Brüggen)
  - „Association model" (Theile, 1980)
    - After the separate localisation, the fusion of the coherent signals takes place → no physical superposition, no comb filtering

Consequences for the sound engineer

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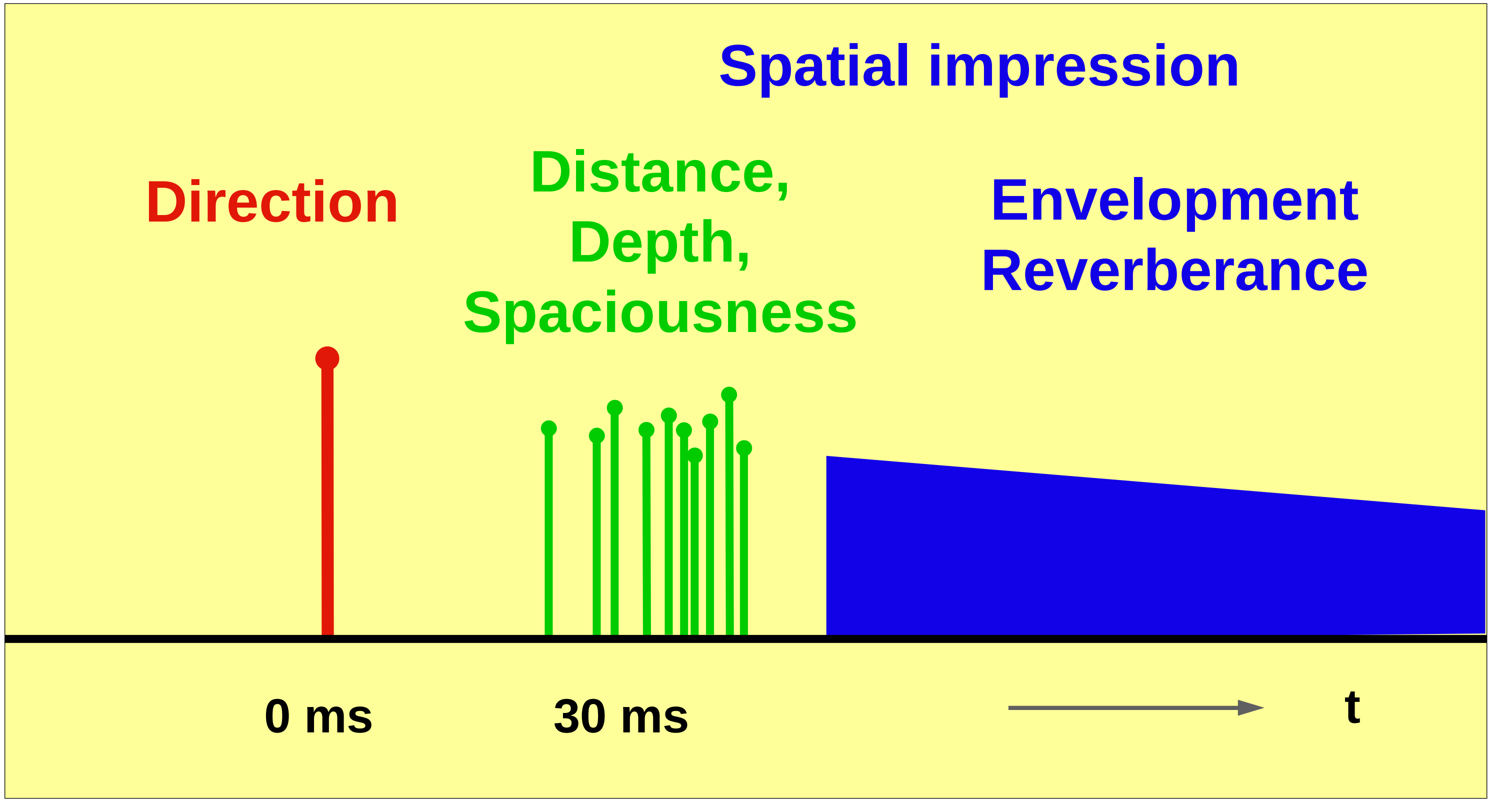
1. Do we aim at a „physical" synthesis in stereo? (as do *Ambisonics*, *Blumlein*)
2. Can only *coincident microphones* create spatial sound?
3. Are time differences allowed?
   (see e.g. Lipshitz: „Are the purists wrong?", JAES)
4. Can we use microphones at ear spacing? (like ORTF, SCHOEPS sphere microphone)
5. Is it wise to al crosstalk in surround microphones? (see Lee/Rumsey, AES)

Source localisation

- Where is the source?
- At which distance?
- In which room, what is the room like?



© Theile

Source localisation

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Discrete Signals:

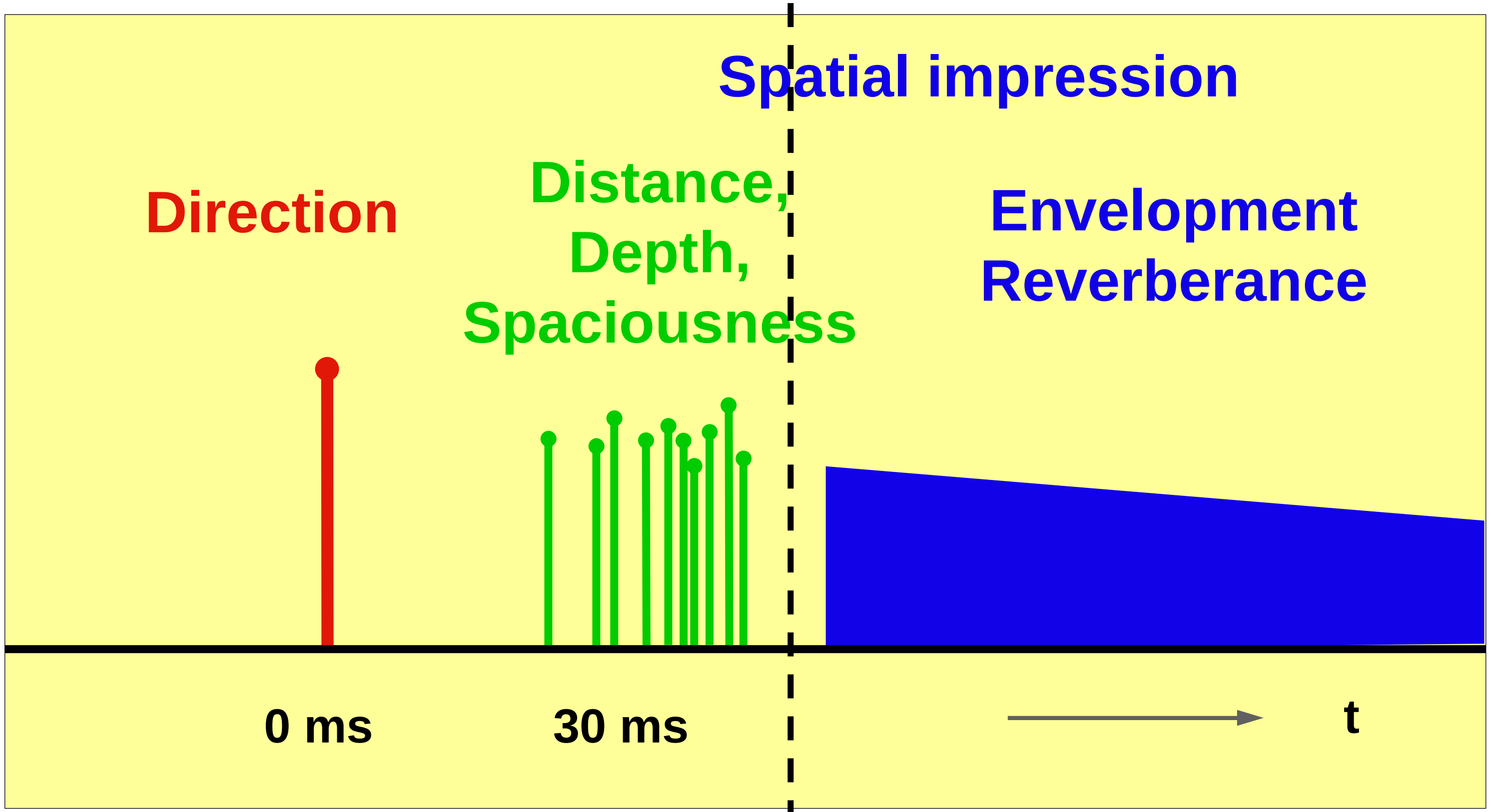
Correlated at both ears

From discrete directions

Diffuse Signals:

Decorrelated at both ears

From all directions

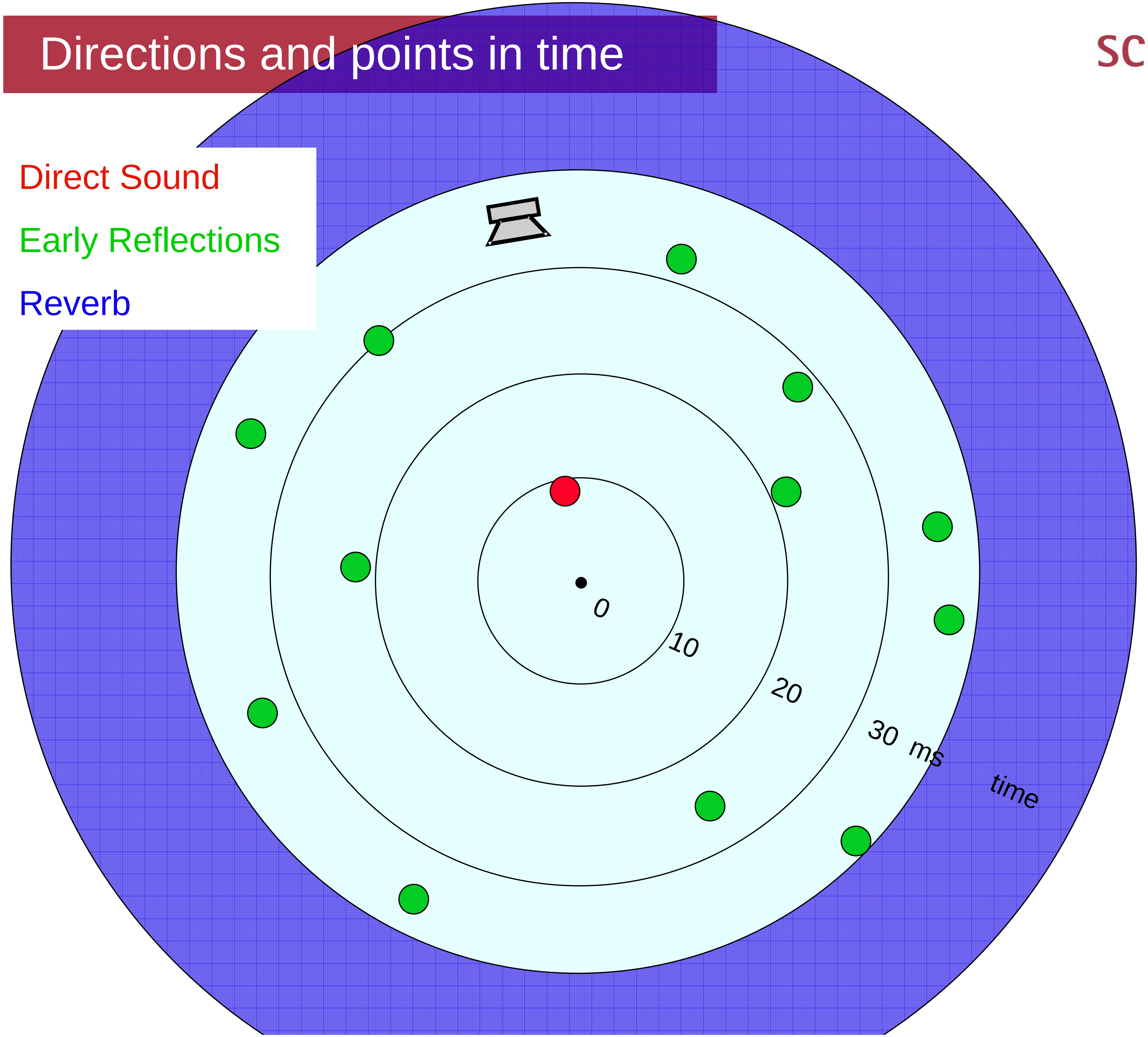


Directions and points in time

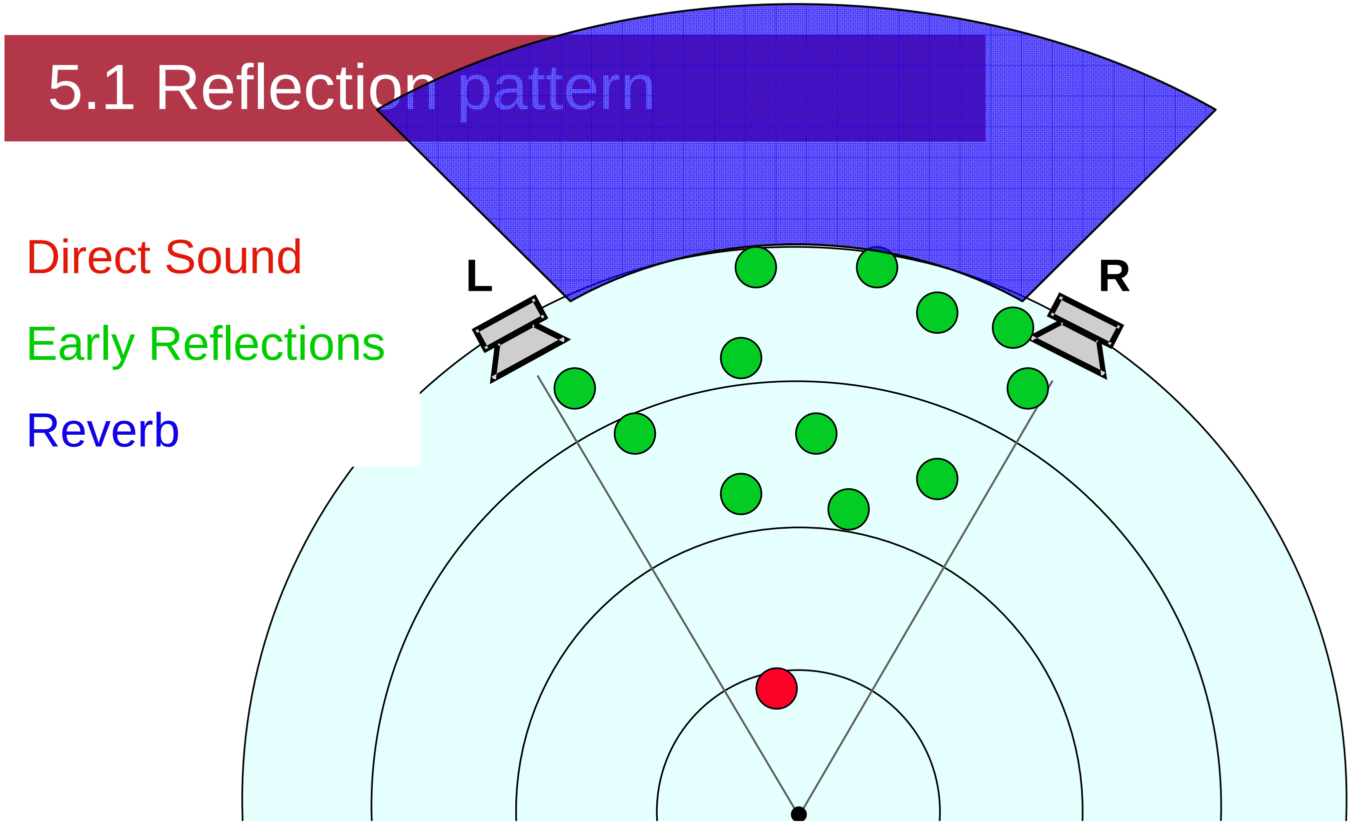
Direct Sound

Early Reflections

Reverb



5.1 Reflection pattern



1. Envelopment is hardly possible in 2-ch stereo
2. No real depth is possible in 2-ch stereo
3. Reflection density too high! → has to be reduced
4. Reverb should be reproduced as diffuse as possible → decorrelated!

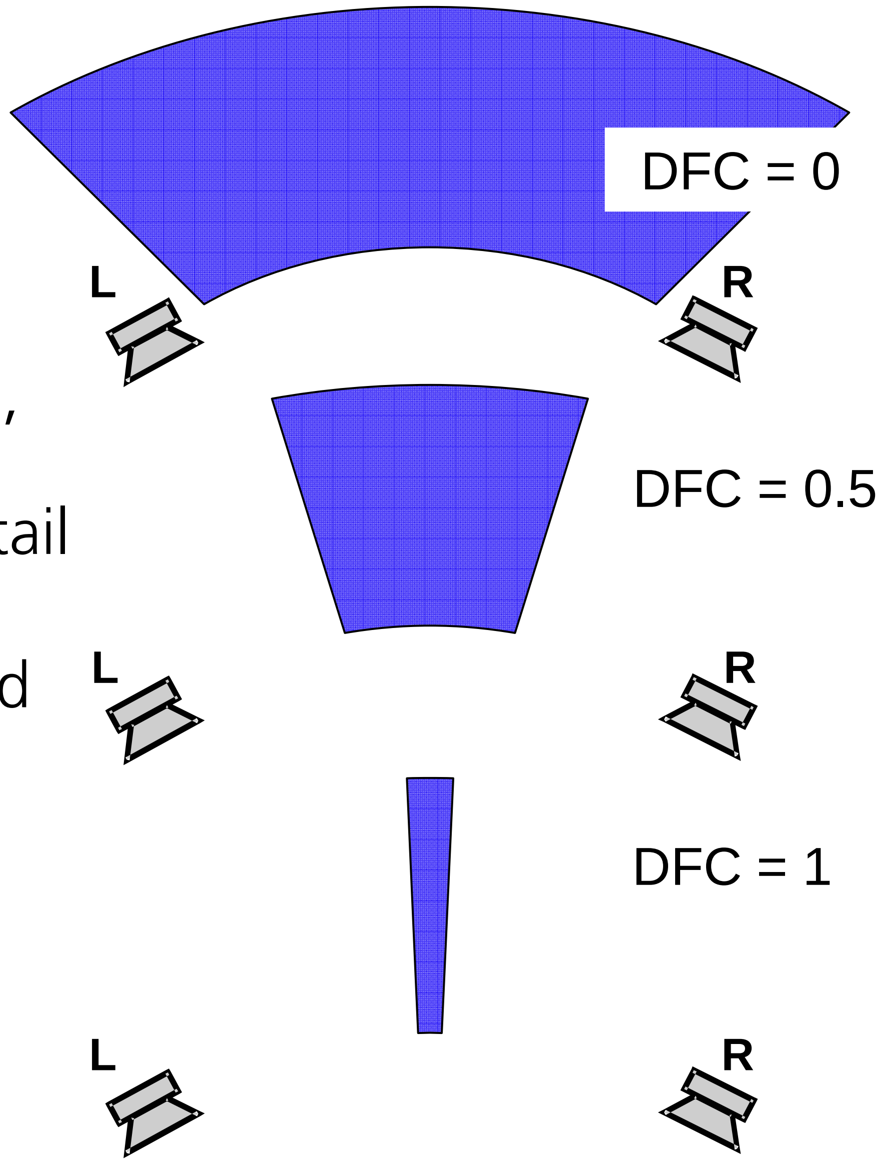
Diffuse field correlation

Reproduction of the reverb tail:

- Should be diffuse, should be perceived from everywhere
- The more correlation, the narrower the image of the reverb tail

→ The diffuse sound should be reproduced decorrelated. The decisive measure is called:

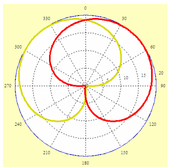
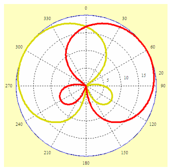
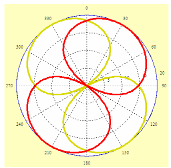
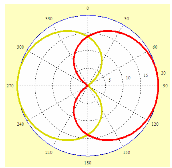
Diffuse field correlation (DFC)



Diffuse field correlation

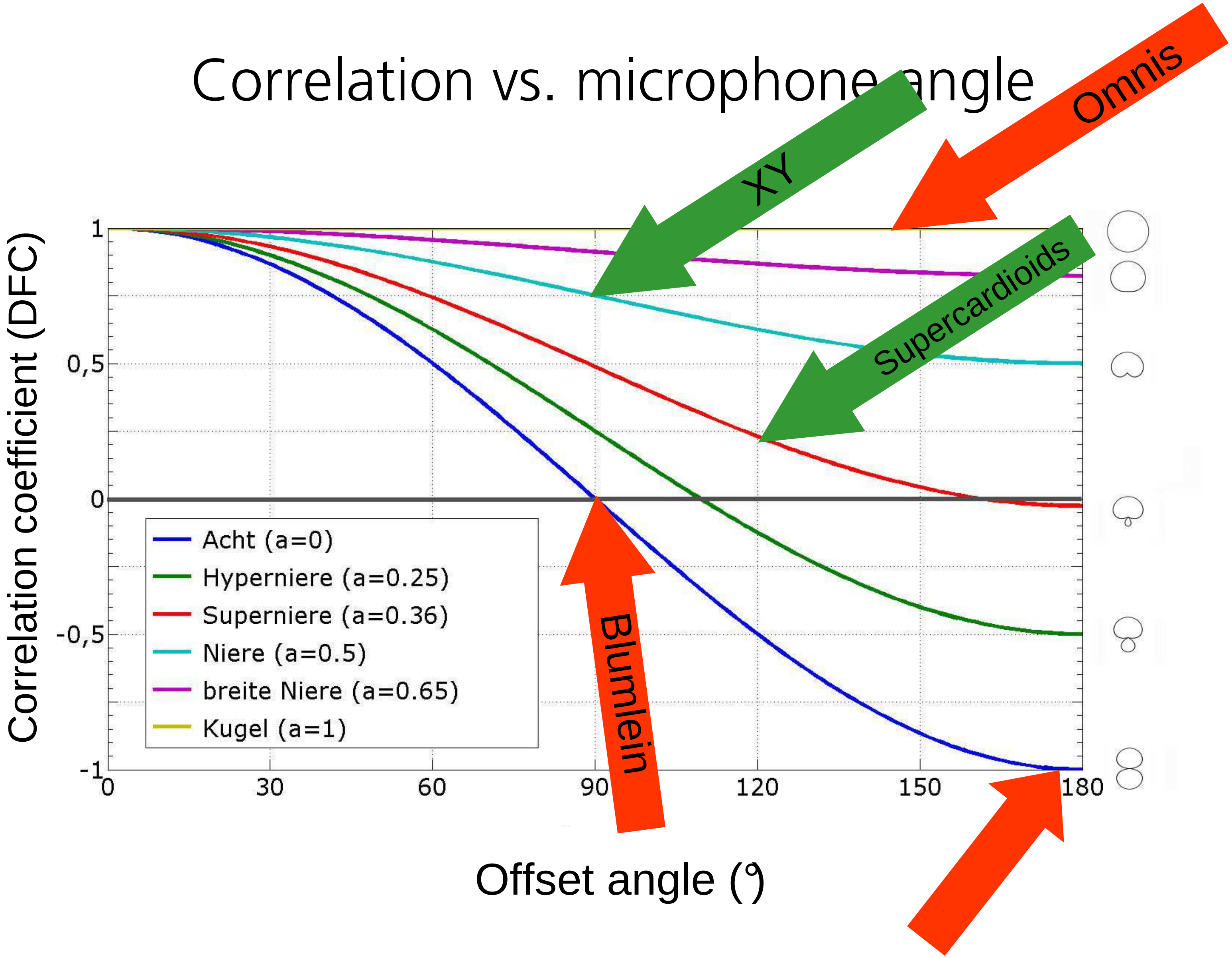
- Perceptual consequence of correlated diffuse field reproduction → Demo

- DFC of coincident microphone setups:

Setup	XY, 90°, Cardioids	XY, 120°, Super-cardioids	Blumlein, 90°, Figure-8	XY, 180°, Cardioids
DFC	**0.75**	**0.23**	**0**	**0.5**
				

Correlation

Correlation vs. microphone angle

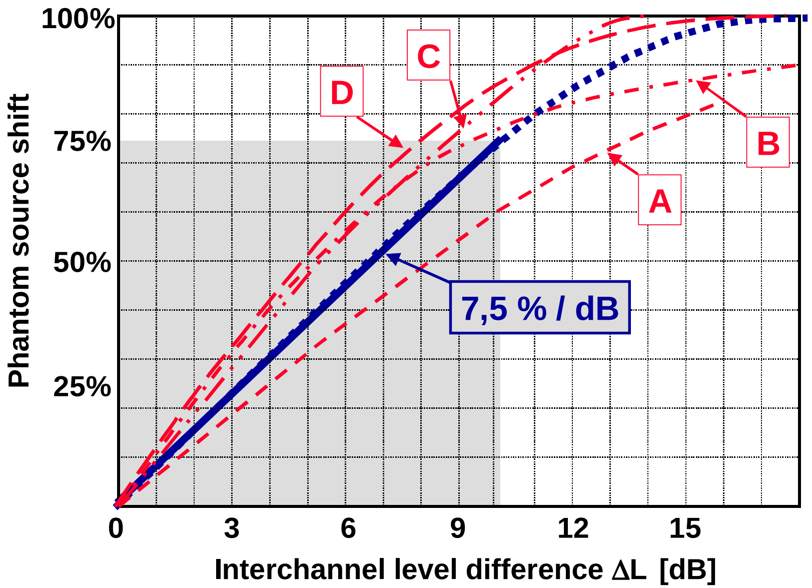


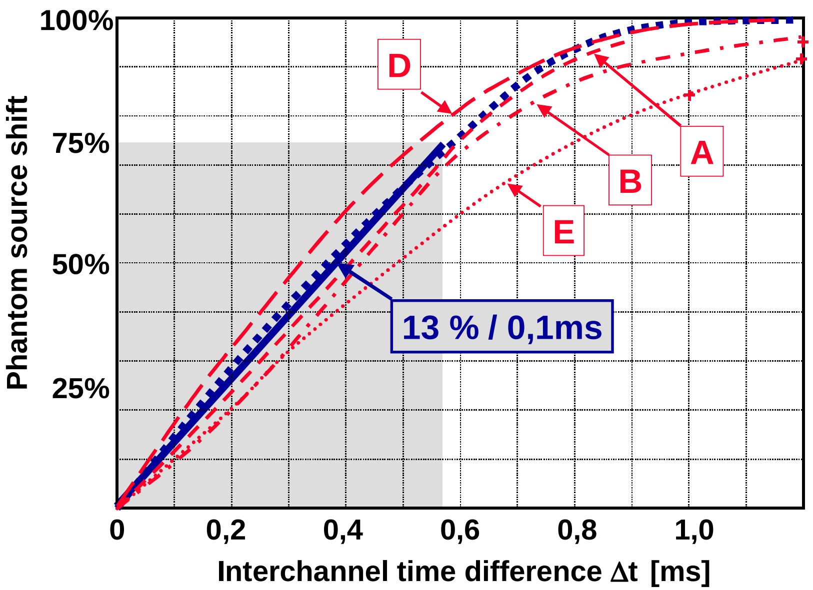
a/b and ORTF correlation

- DFC of spaced microphones → Calculation
- Shuffling techniques could correct for that…

Directional Imaging

- Level and time differences govern the perceived phantom source direction
- $\phi_L = f(\Delta L)$;
- $\phi_t = f(\Delta t)$;
- $\phi = \phi_L + \phi_t$;
- The necessary interchannel differences are rather similar to those known from natural hearing

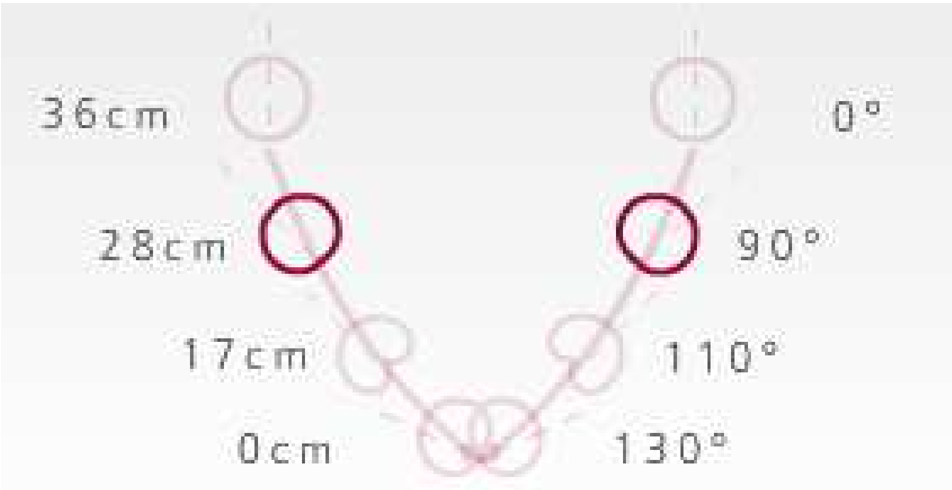




Comparison of stereo setups

- Recording angle
- Recording angle 75%
- Image Assistant on www.hauptmikrofon.de
- Comparison of different stereo setups sharing the same recording angle → Demo *Showroom*

www.schoeps.de/showroom/



2-ch Microphone Design

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- *Directional Image*:
  can be calculated, differences between stereo techniques regarding the image
- *Diffuse Field Correlation DFC*:
  should be minimal: not possible with small a/b or normal cardioid XY
- *Further points of interest*:
  - Reality is not always ideal!
  - Type and properties of single capsules (pressure/pressure gradient transducer)
  - Direct/Reverb ratio → controls reflection level
  - Loudness balance
  - Size of the setup
  - Sensitivity to wind noise

XY

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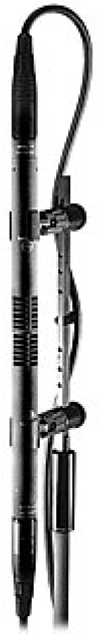
UMS 20

UMS 20



M100C

CMXY

MS

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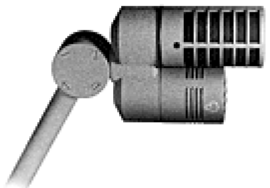
UMS 20

CMIT MS

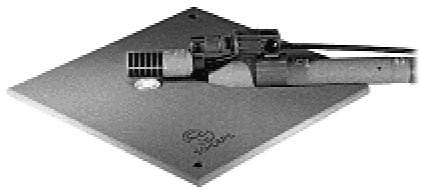
CMC 64 + CCM 8



RCY

WSR MS

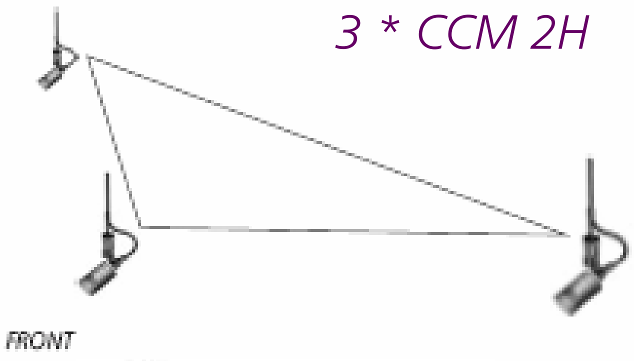
MS-BLM



SGMSC
(CCM4 + CCM8)

ORTF and AB Stereo

Decca
3 * CCM 2H



MSTC 64 U, STC

UMS 20

M100C

KFM 6

MAB1000

ORTF
Outdoor Set

5.1 Reflection pattern

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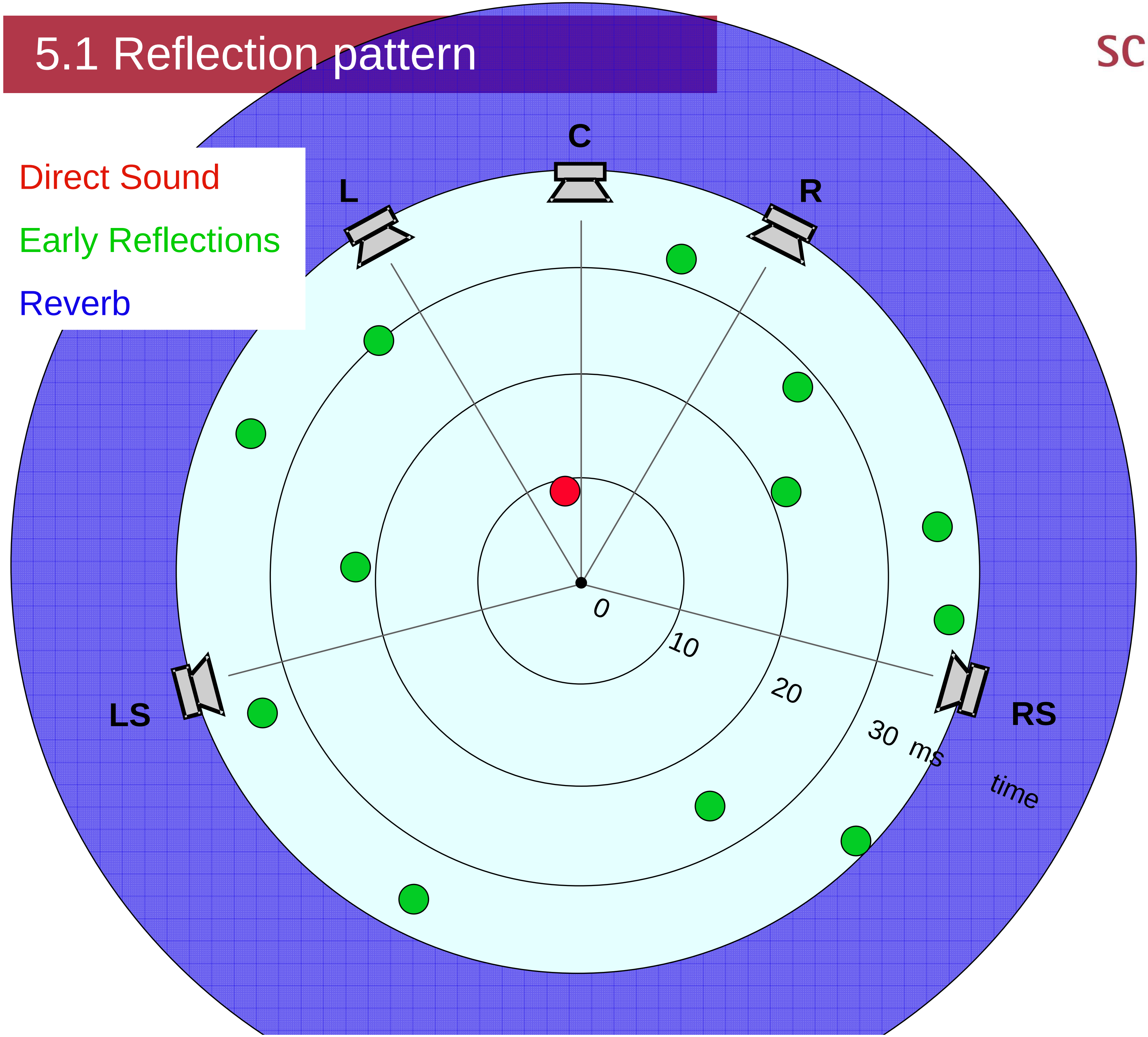
Direct Sound

Early Reflections

Reverb



5.1 Spatial reproduction

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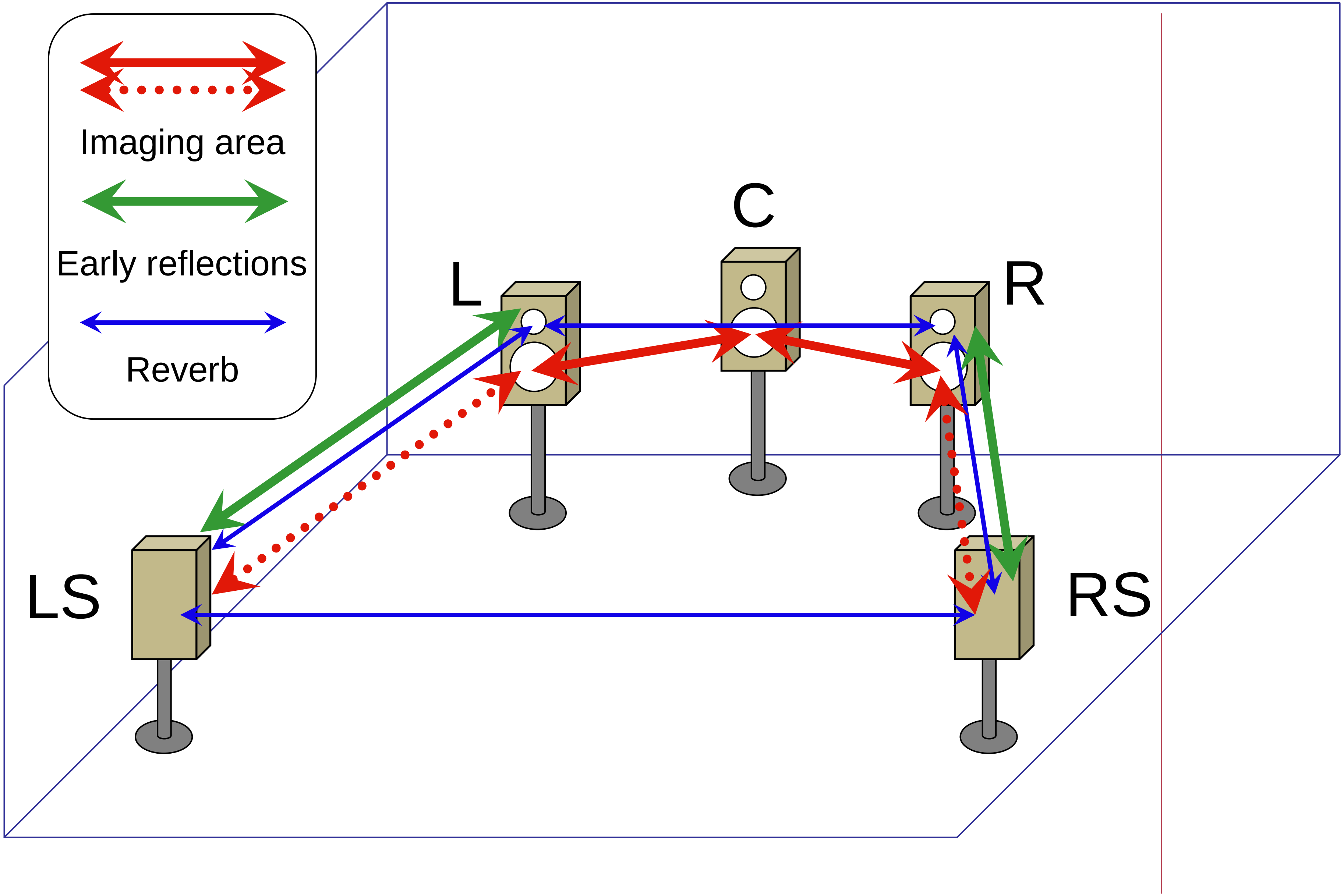

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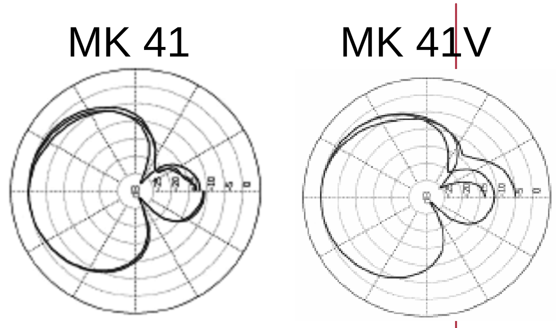
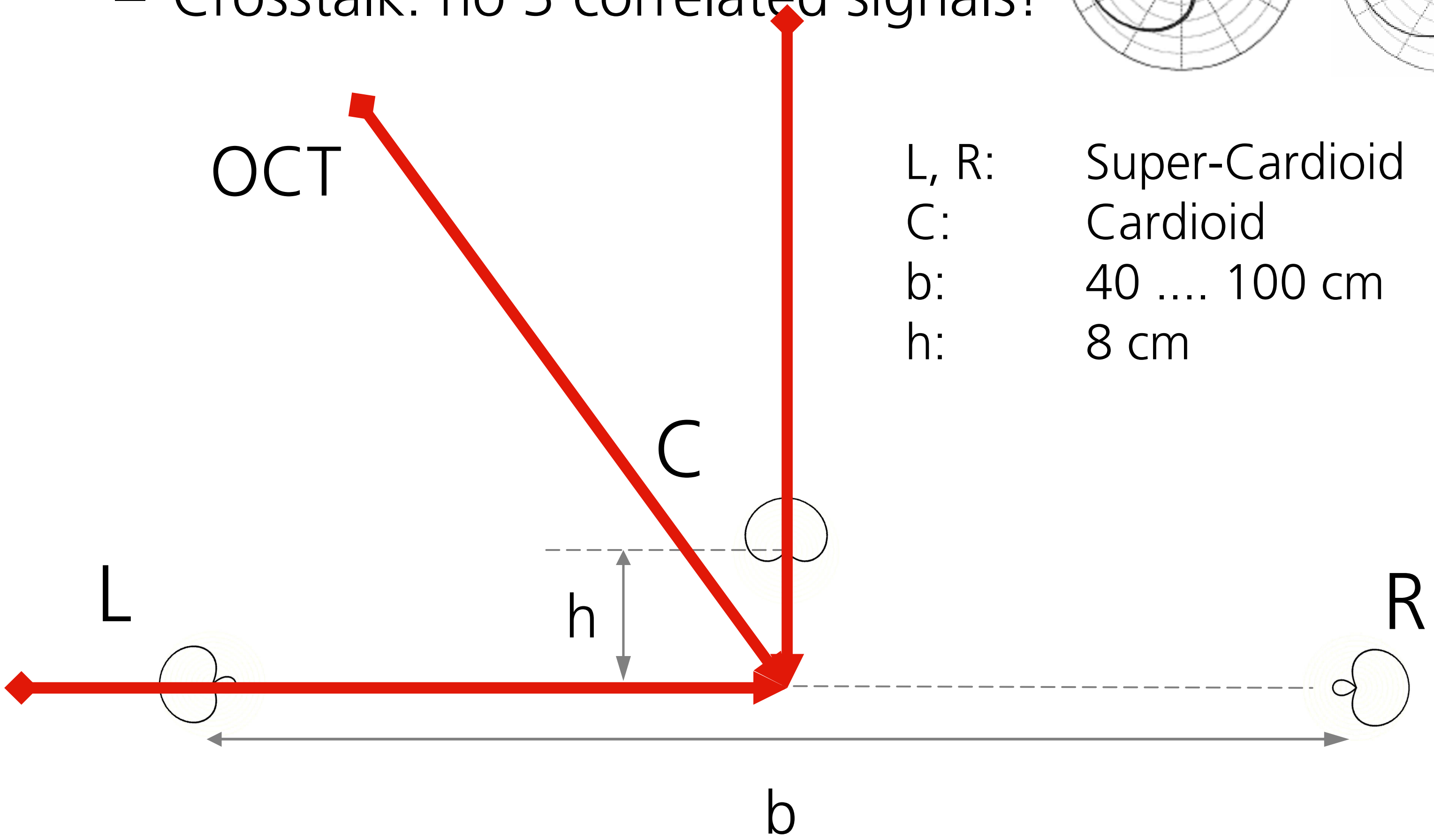
- Directional Image:
  - [Image Assistant]
  - Crosstalk: no 3 correlated signals!

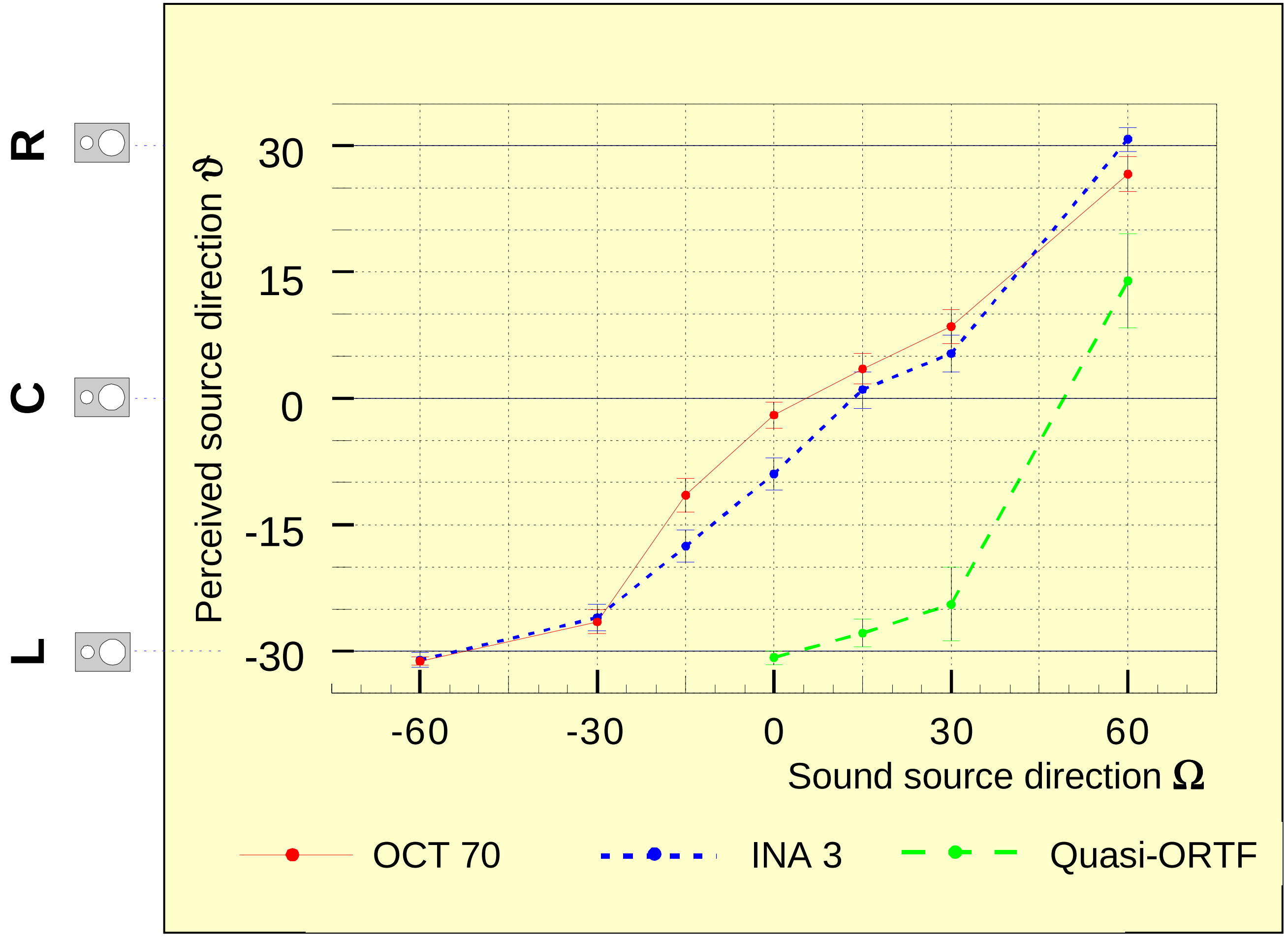




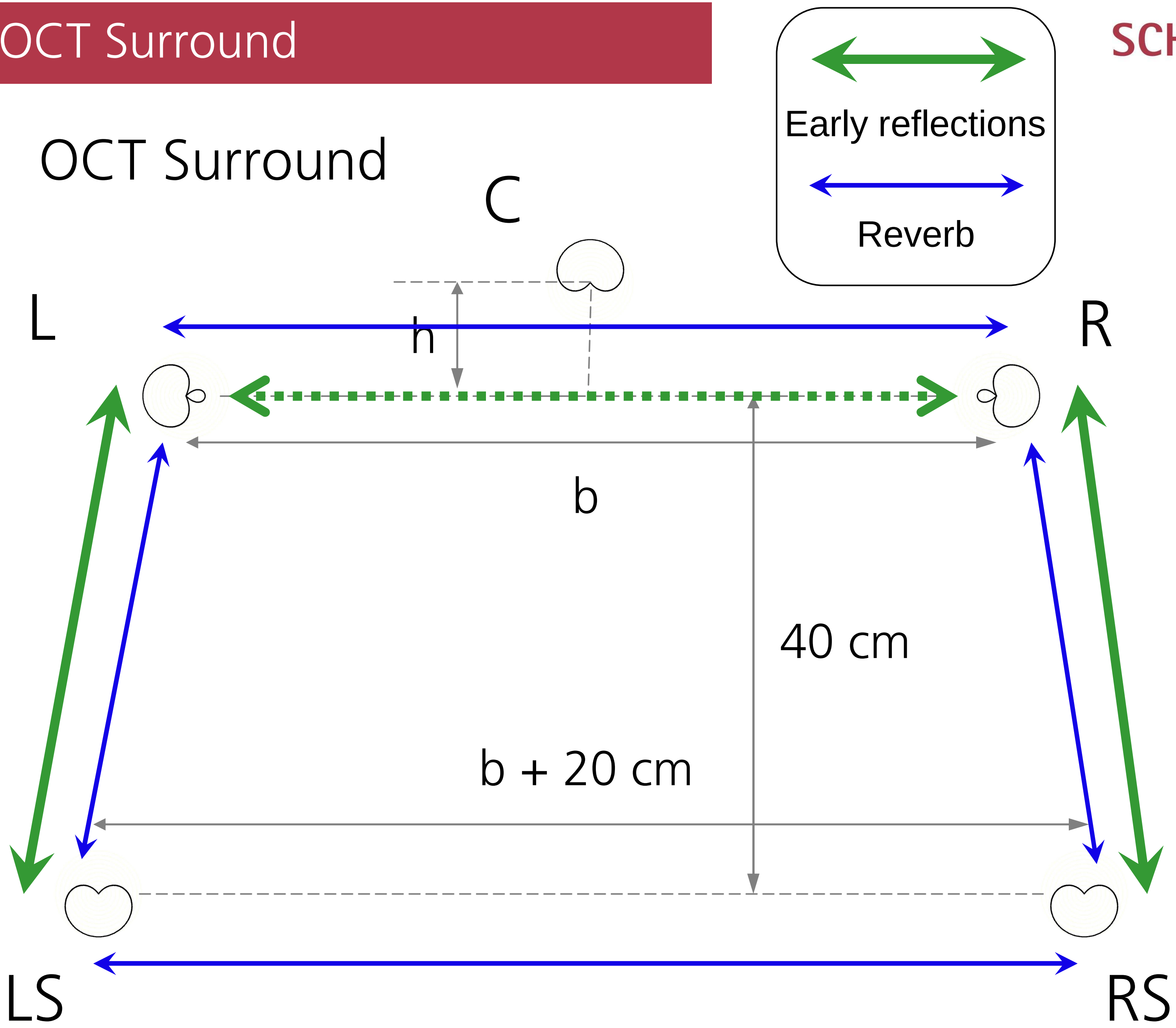
L, R:	Super-Cardioid
C:	Cardioid
b:	40 .... 100 cm
h:	8 cm

Stability in 5.1

- Localisation curve on off-centre position

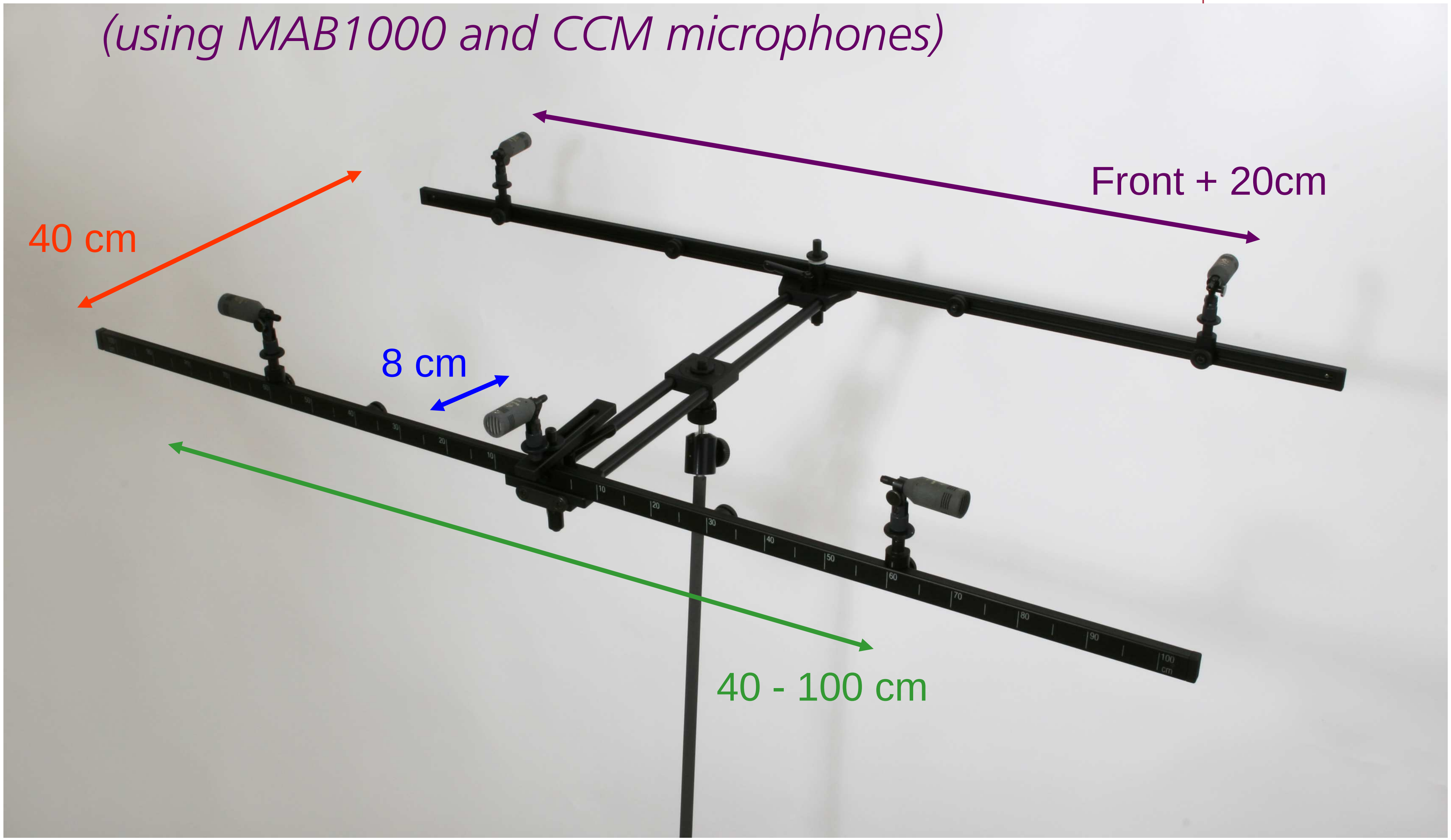


OCT Surround



OCT Surround Setup

OCT Surround
(using MAB1000 and CCM microphones)



OCT + Hamasaki

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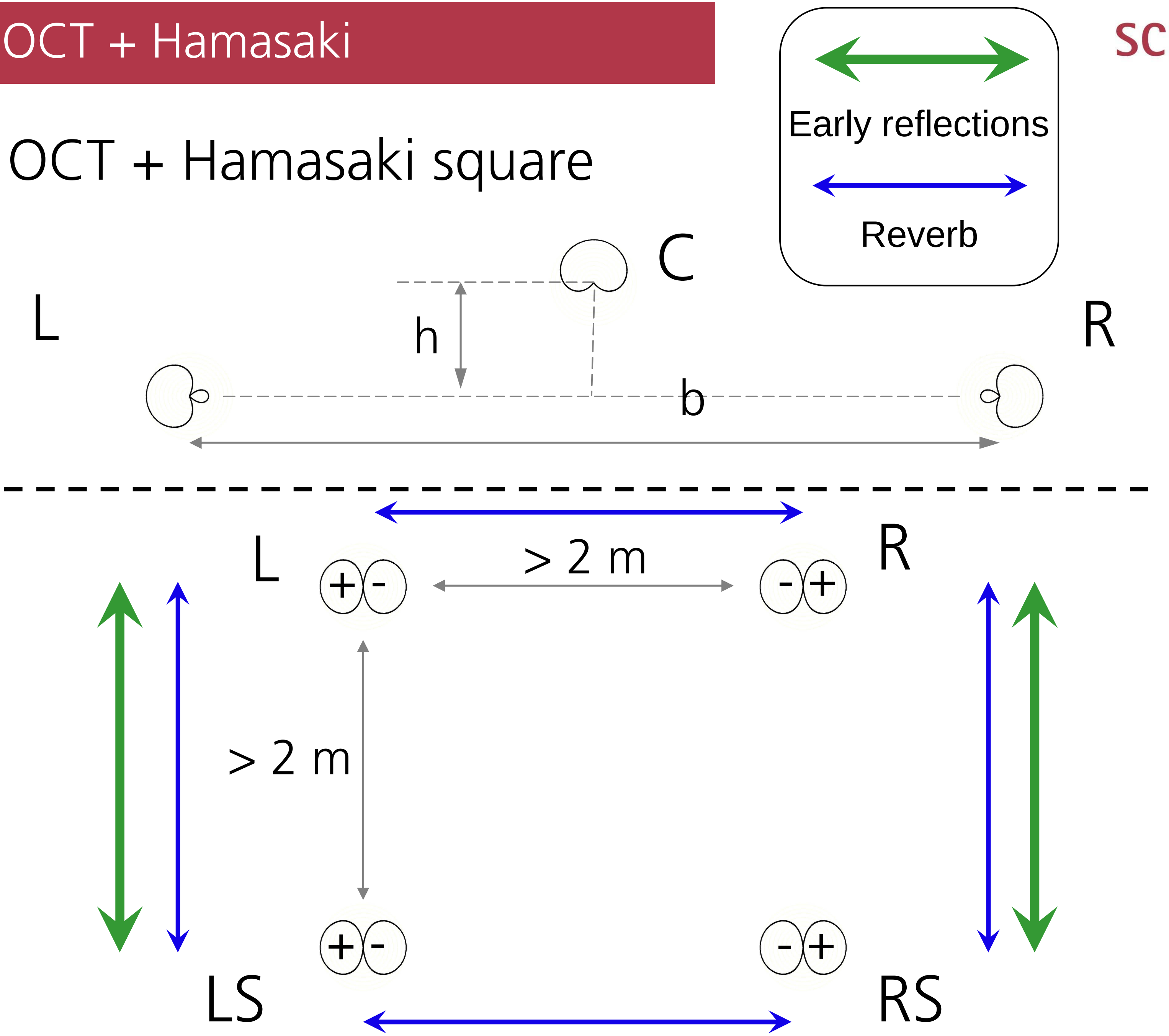
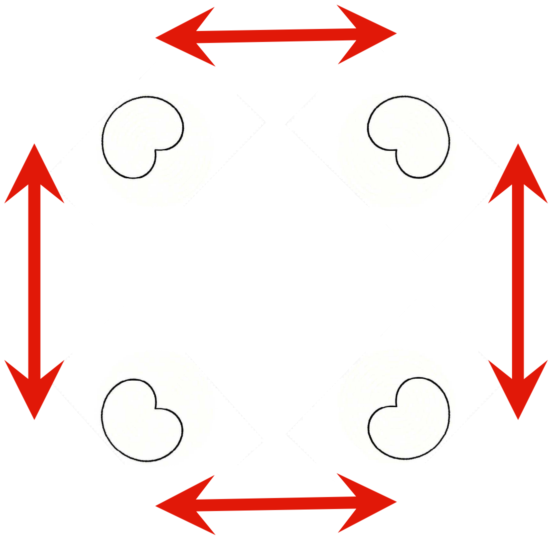
OCT + Hamasaki square



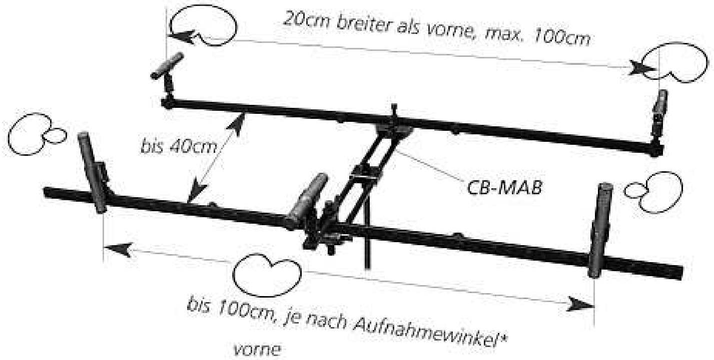
IRT cross

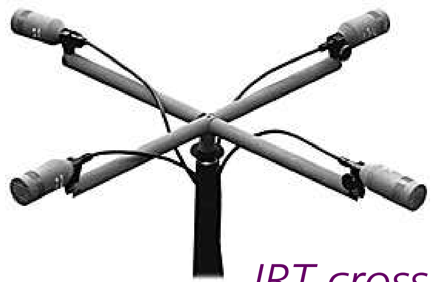
- IRT cross for Surround atmos: 20-25cm



Surround – non-coincident

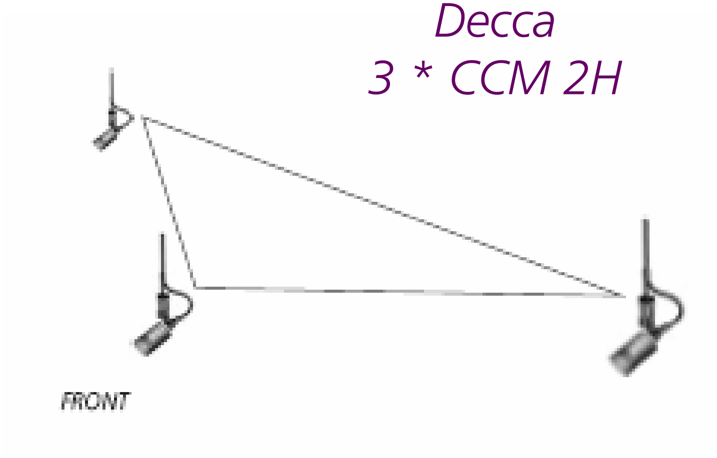
OCT Surround





IRT cross

Decca
*3 * CCM 2H*



KFM 360
mit 2 KompaktMikrofonen CCM 8Lg (Acht)

+

DSP-4 KFM 360
Steuereinheit mit integrierten A/D- und D/A-Wandlern

KFM 360

Double MS: The M/S principle

$$M = L + R$$

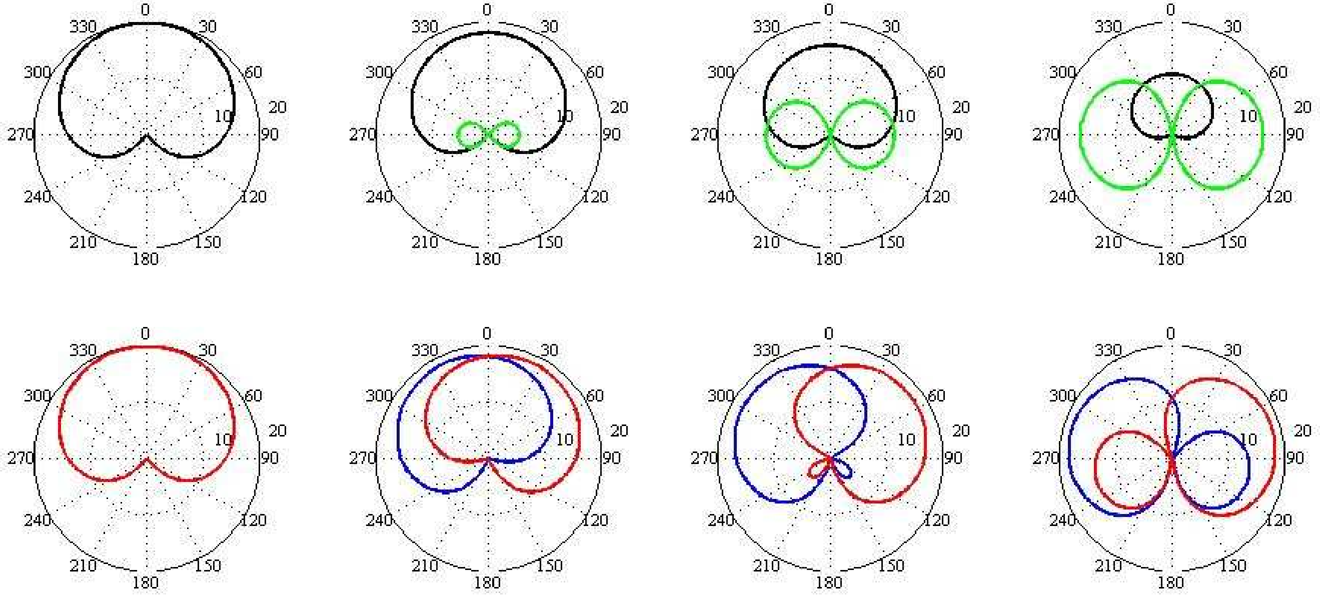
$$S = L - R$$

$$L = \frac{1}{2} * (M + S)$$

$$R = \frac{1}{2} * (M - S)$$

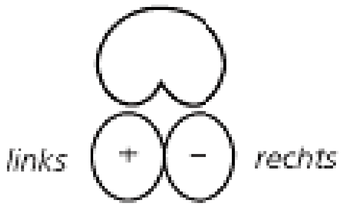
M
S

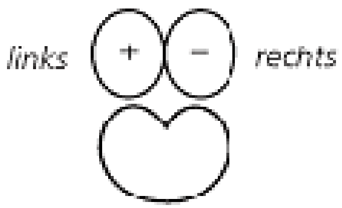
L
R



The Double M/S idea

- Front M/S pair
- Rear M/S pair
- Combined
  Double M/S triplet





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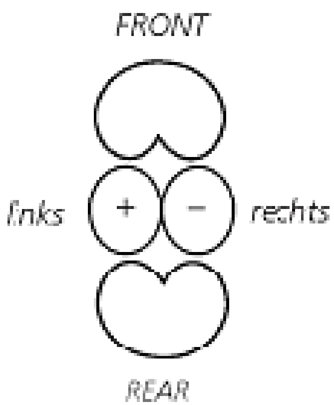


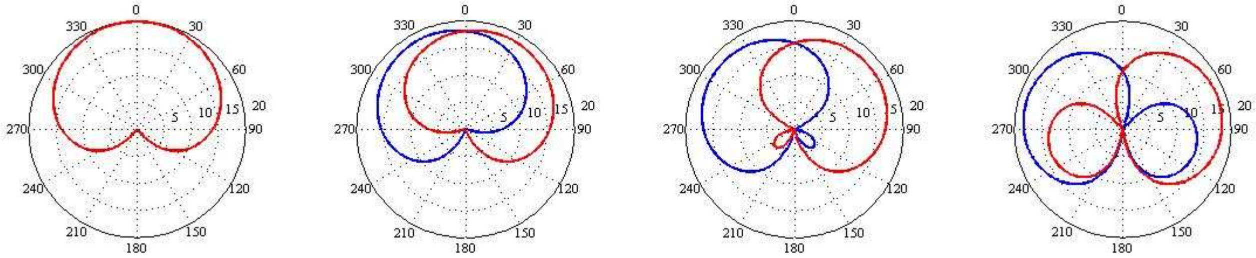
Double M/S enables 2 different decoding methods:

a) each pair is decoded separately

b) decoding utilizes the third microphone as well

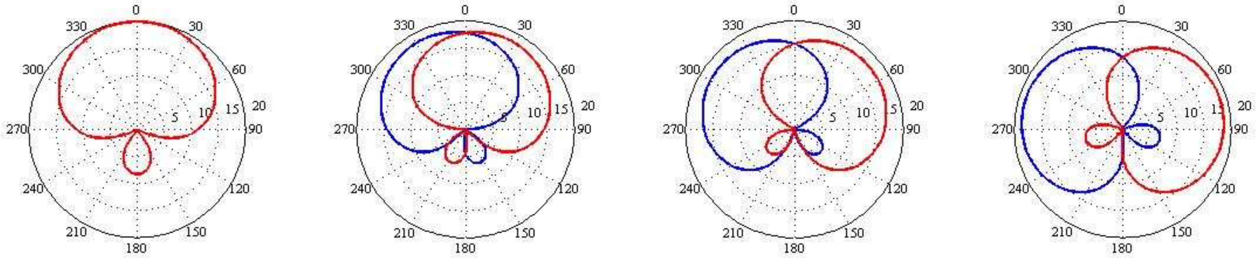
L R

a)



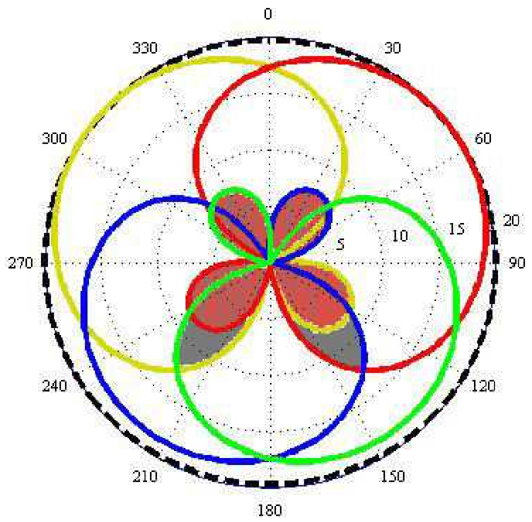
L R

b)

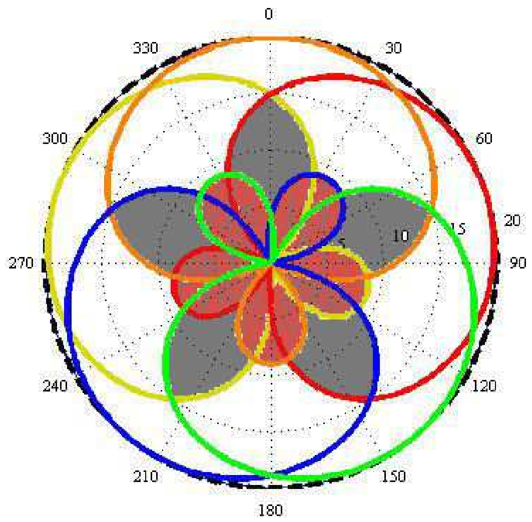


Crosstalk

- Crosstalk in Double M/S



4ch



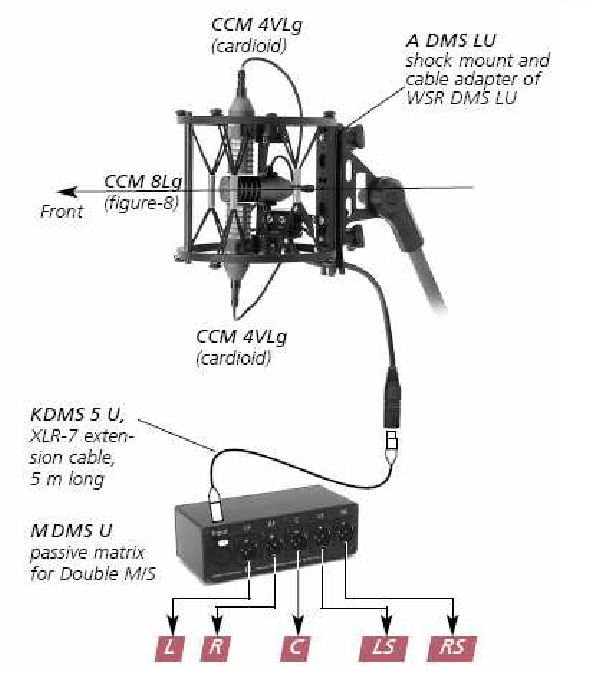
5ch

→ Avoid crosstalk by optimal decoding

Tools for Decoding

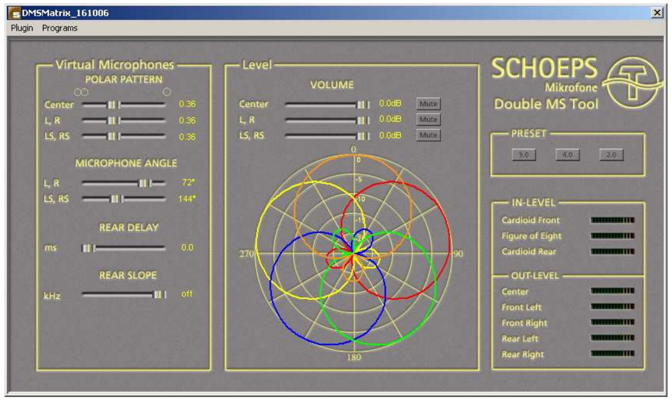
Decoding variants:

- 2 M/S Matrices
- Hardware (MDMS U)



Double M/S set

- Software (VST PlugIn)

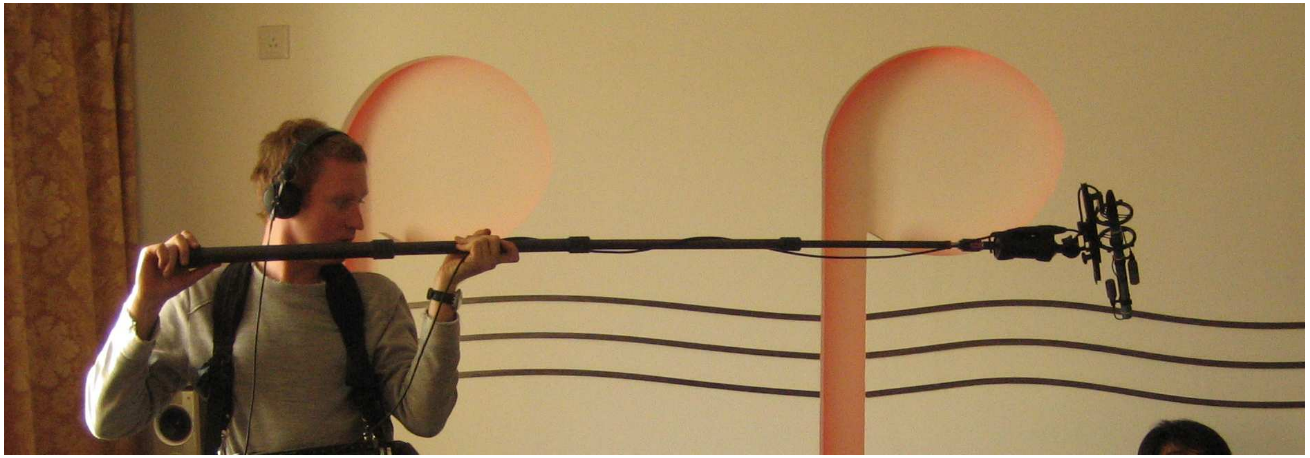


- Try by yourself, it's free!

  www.schoeps.de/dmsplugin.htm

Film recording

- Double M/S with shotgun



Surround - coincident

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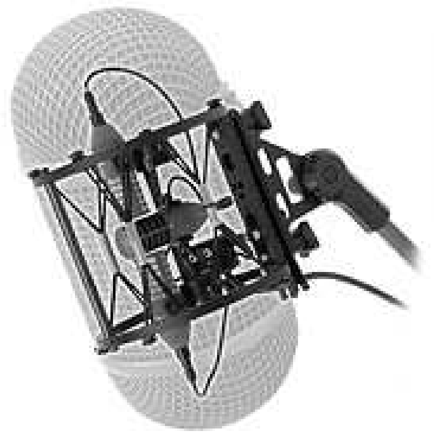

Double M/S

CMIT-Double M/S

Higher Order Techniques

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- Which higher order technique can be used in practice?

for reproduction:

- Wavefield synthesis (WFS) and Higher Order Ambisonics (HOA) can recreate sound fields
- Stereo can (only) generate the same perception in the sweet spot

for recording:

- Higher order microphone techniques are either noisy and/or can not yet deliver a fully satisfying and stable timbral quality, but proposals will come for special applications

WFS or Stereo?

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Wittek, Rumsey, Theile, Journal of the AES, Vol.55/9, 2007:

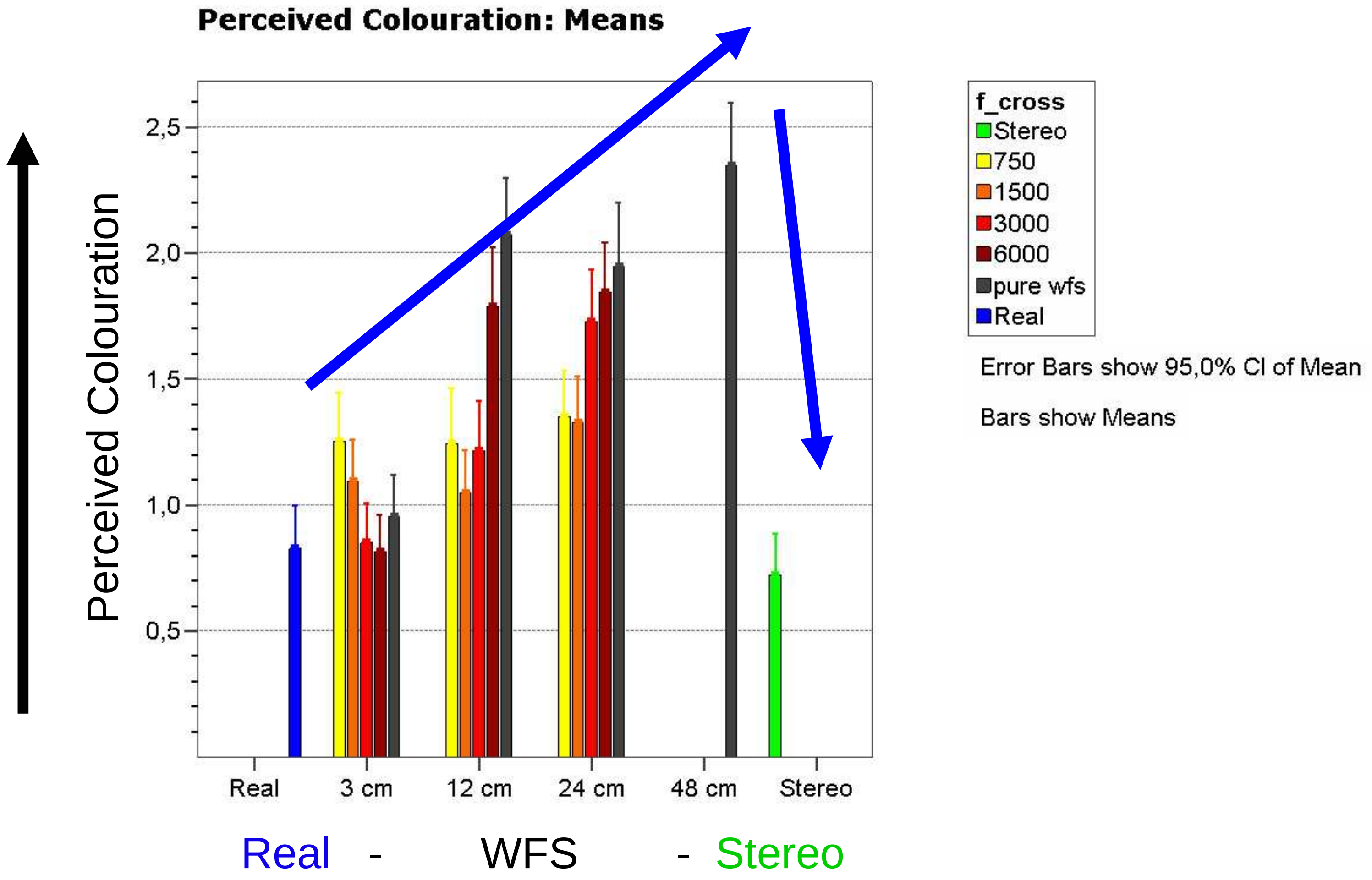
Colouration of WFS and Stereo:

Is stereo just a poor 2-ch wavefield synthesis?

WFS or Stereo?

Wittek, Rumsey, Theile, Journal of the AES, Vol.55/9, 2007:

Colouration of WFS and Stereo



What does the microphone need?

- The microphone is the basis for all.
- Well-known parameters govern the quality:
  - Good frequency response
  - Smooth polar pattern
  - Low noise floor
  - Good reliability
  - And the sound…

Thank you.

wittek@schoeps.de