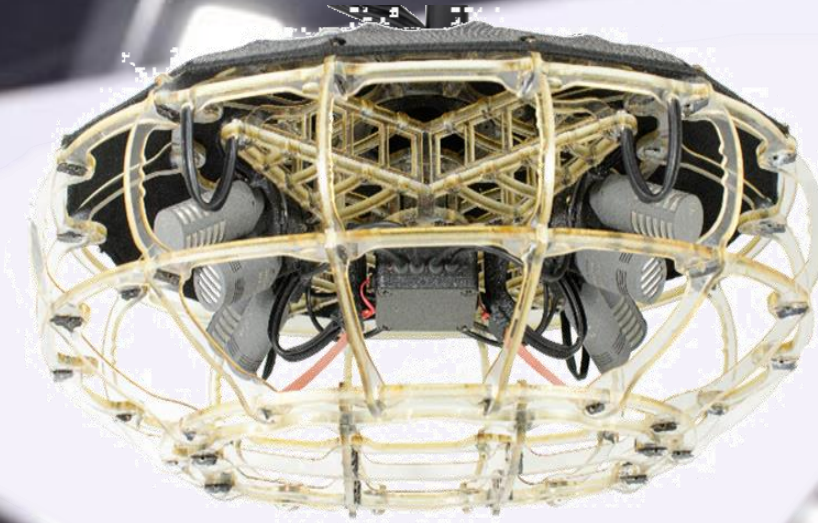


Development and application of a stereophonic multichannel recording technique for 3D Audio and VR



Helmut
Wittek
17.10.2017

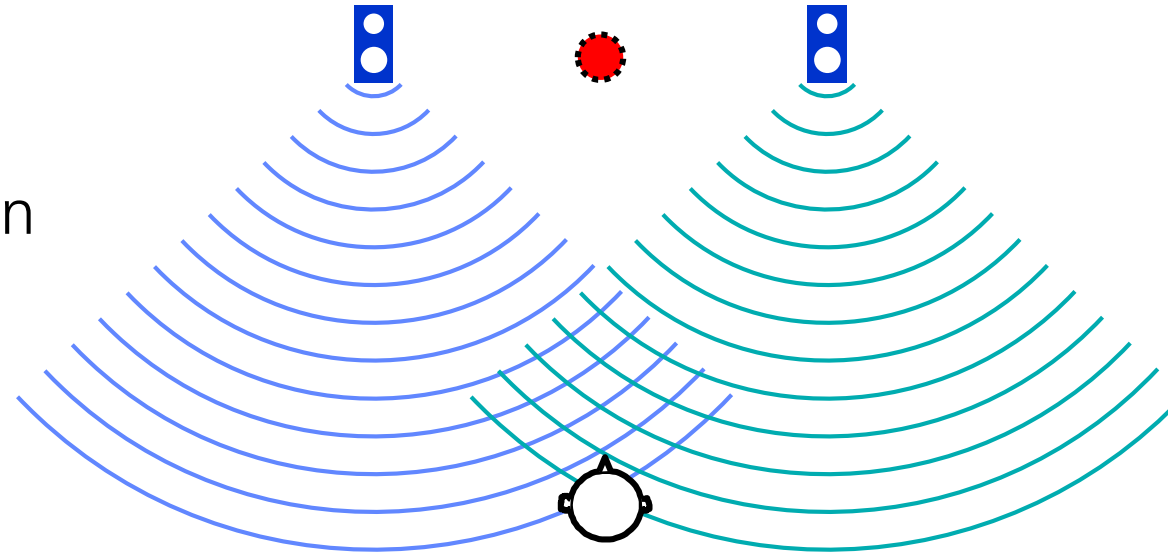
- Contents: Two main questions:
 - For a 3D-Audio reproduction, how **real** does the sound field have to be?
When do we want to **copy** the sound field?
How much **likeness/similarity** to the sound field in the recording room do we need?
 - Which **3D microphone recording techniques** are appropriate for recording a spatial sound field?

Microphone recording
for 3D-Audio

- 3D-Audio formats
- The Uncanny Valley
- 3D Stereo techniques
- ORTF-3D
- Stereo in VR/Binaural

Spatial sound reproduction techniques:

- Stereophony
- Sound field reconstruction
- Binaural

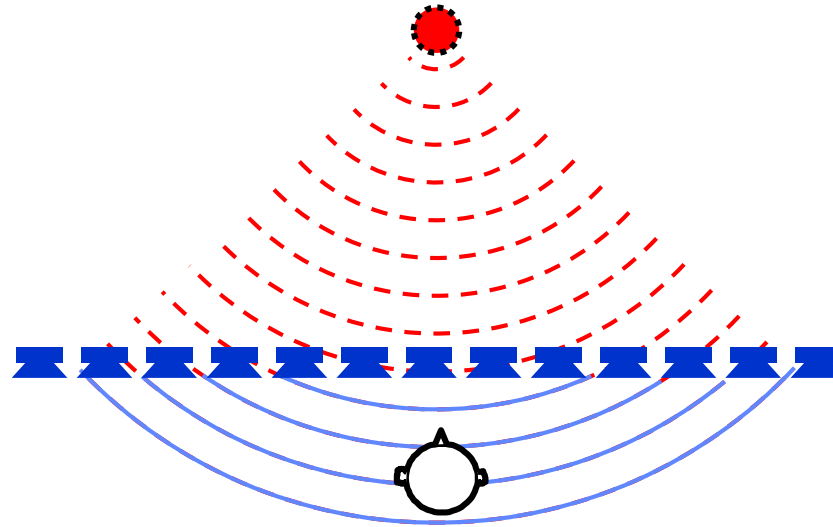


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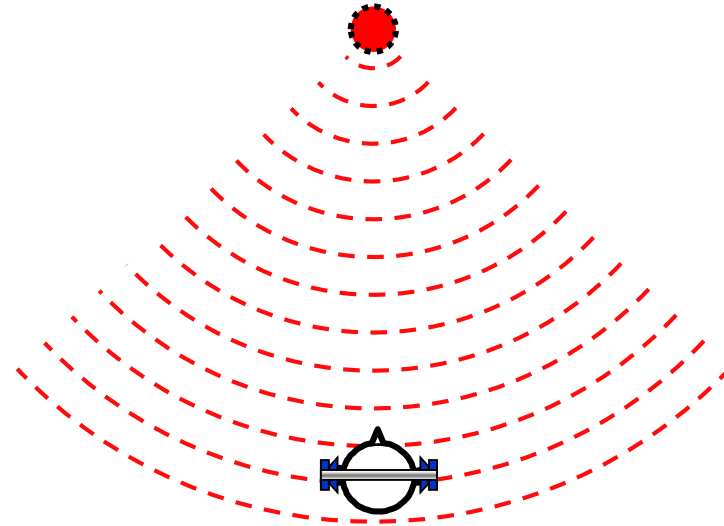
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* The term „Sound field reconstruction“ includes techniques like WFS or HOA

Spatial sound reproduction techniques:

- Stereophony
- Sound field reconstruction
- **Binaural**

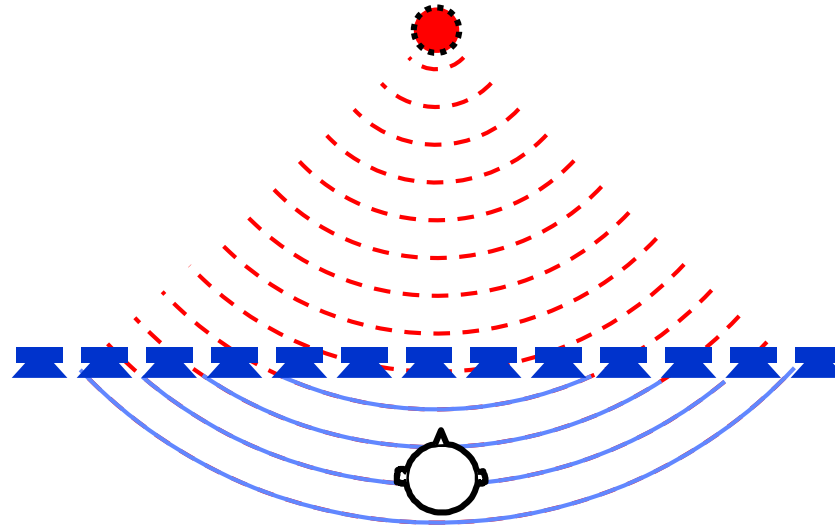


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Copying the sound field:

- Stereophony
- Sound field reconstruction*
- Binaural

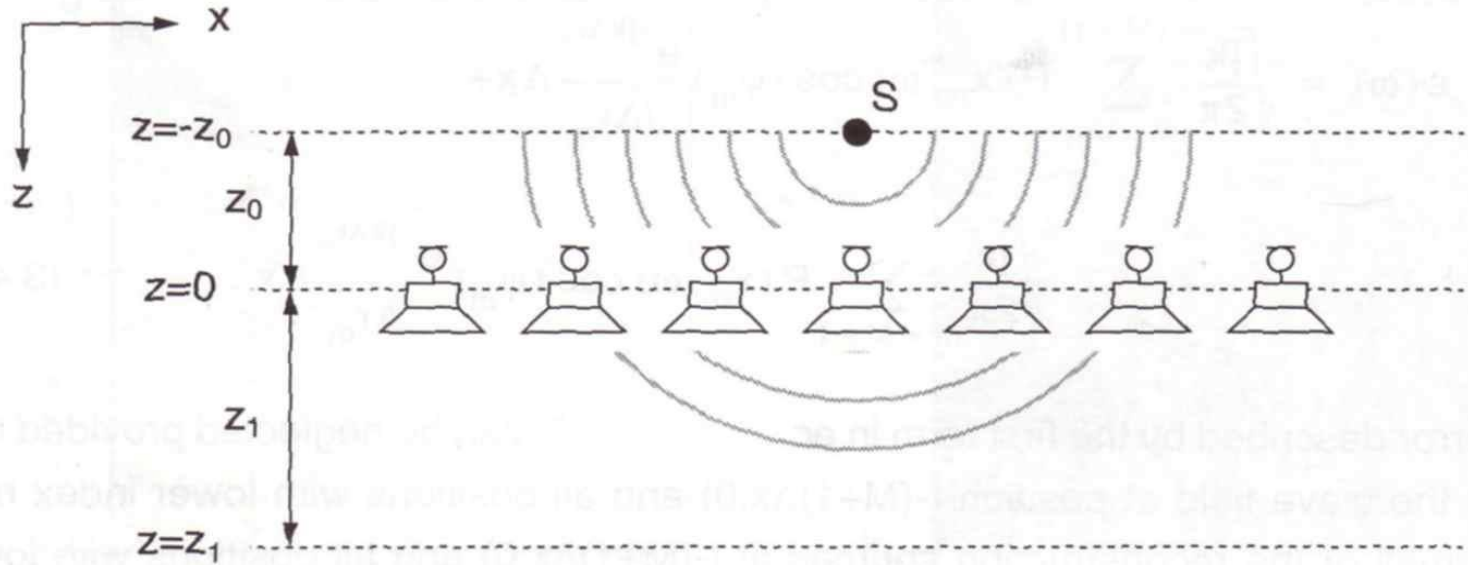


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* The term „Sound field reconstruction“ includes techniques like WFS or HOA

- Copying the sound field: Spatial Sampling → Spatial Reproduction
- WFS:



Verheijen, 1998

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- Copying the sound field: Spatial Sampling → Spatial Reproduction

- WFS:



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- Copying the sound field: Spatial Sampling → Spatial Reproduction
- Ambisonics:



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- Copying the sound field: Spatial Sampling → Spatial Reproduction
- Ambisonics:



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- Copying the sound field: Spatial Sampling → Spatial Reproduction
- Spatial Sampling works 100% only in theory
- Artefacts of „spatial sampling“ recording techniques:
 - Too low resolution
 - Small space: compromised hardware
 - Perceptually not sufficient
 - No aesthetic mix, no sound engineering involved



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- The „Uncanny Valley“
 - Formulated for Graphical Design in 1970 by Dr. M.Mori
 - Suggested for Spatial Audio by Francis Rumsey



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Microphone recording
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- 0% likeness, 0% familiarity



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- 10% likeness, 50% familiarity



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- 50% likeness, 80% familiarity



Microphone recording
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- 90% likeness, **-50** % familiarity

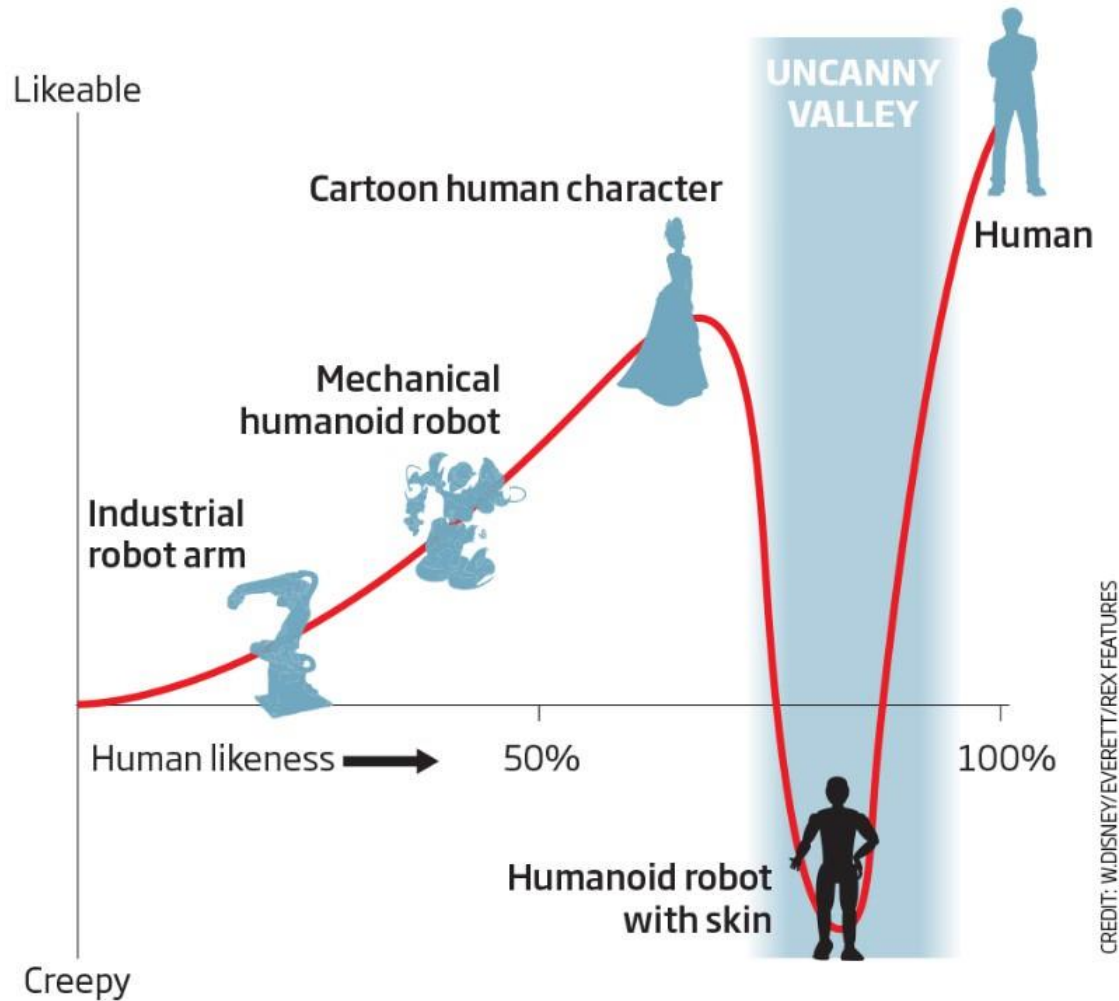


- 100% likeness, 100% familiarity

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- The „Uncanny Valley“
 - Formulated in 1970 by Dr. Masahiro Mori
 - Suggested for Spatial Audio by Francis Rumsey (ICSA, 2013)

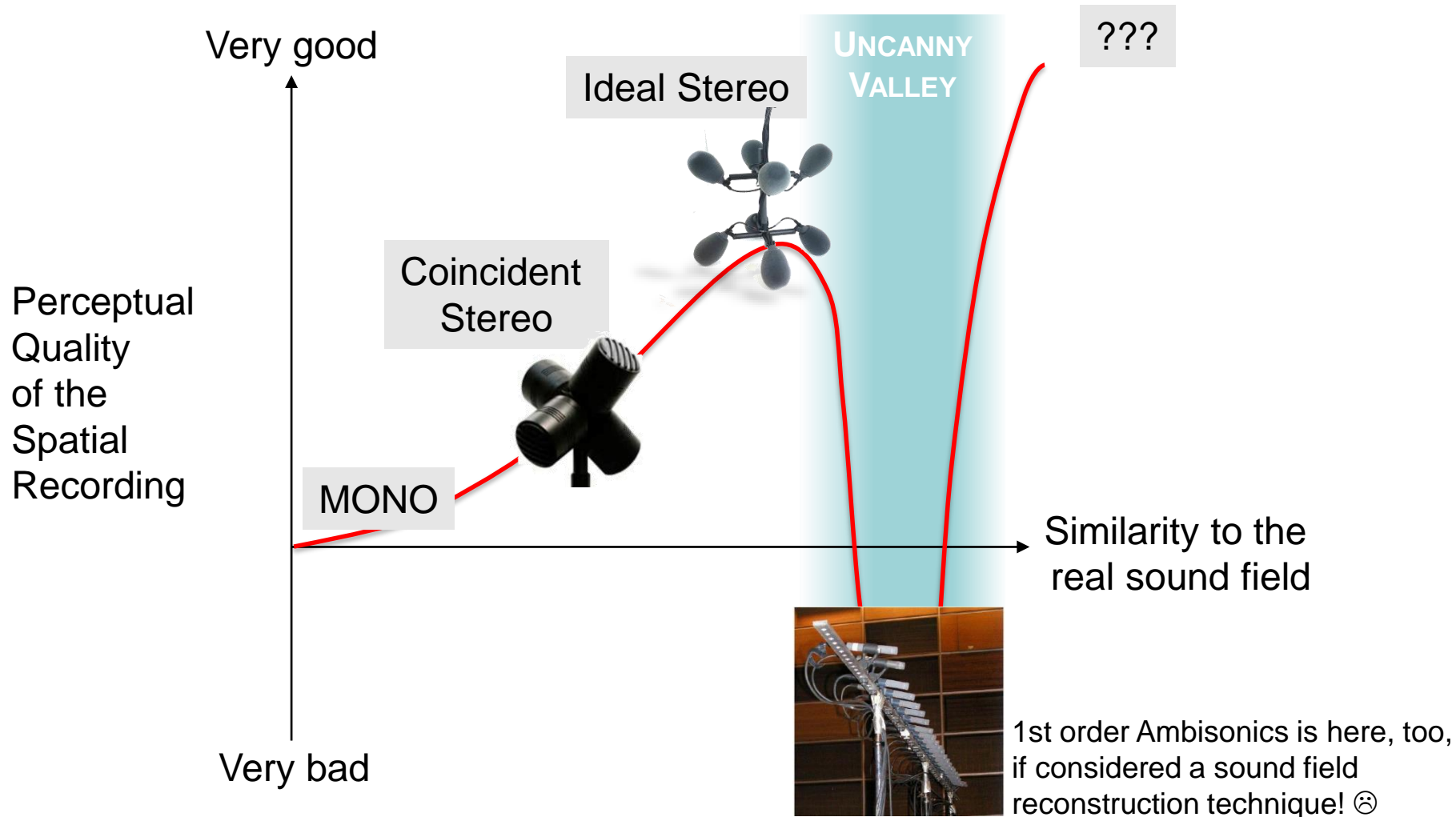


Microphone recording for 3D-Audio

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- The „**Uncanny Valley**“ of Spatial Audio Recording:
(unproven hypothesis!)



Microphone recording for 3D-Audio

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- Alternative:
 - Avoid **trying to copy** the sound field, instead use proper **stereophonic spatial imaging**
 - „Stereophonic techniques“ possible in all 3D-Audio formats
 - „Virtual loudspeakers“ in WFS, Ambisonics, VR/Binaural
 - Concept of „Virtual Panning Spots“ discussed in WFS research

Microphone recording
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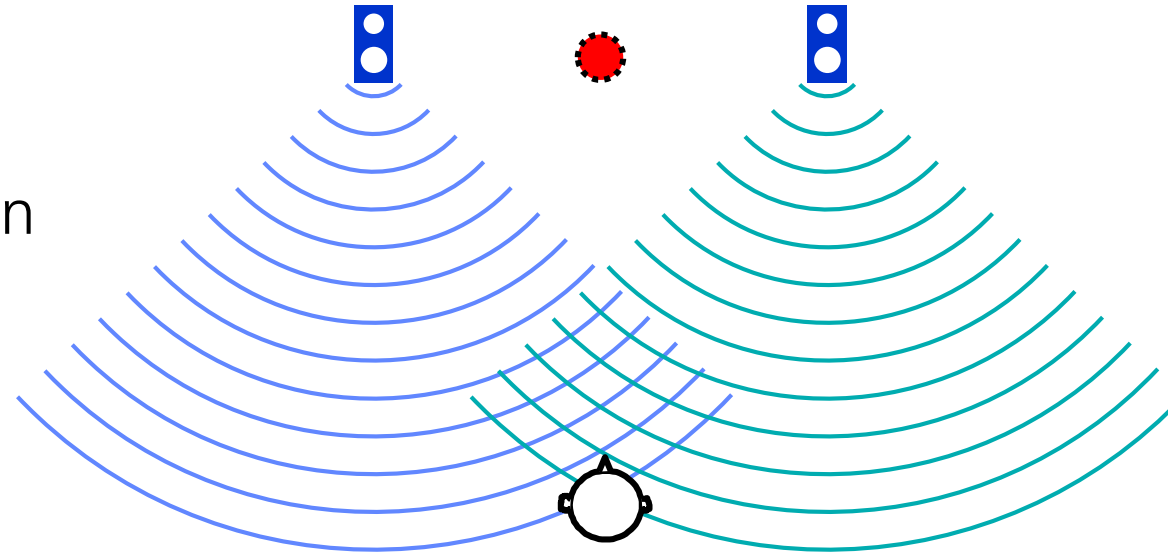
- Ambisonics, 1st order or HOA:
 - Inappropriate copying of the sound field leads to undesired artefacts:
 - **1st order** Ambisonics is physically inappropriate, but it also can be interpreted as coincident Stereo → the artefacts are: narrow spatial sound
 - Capturing HOA („Higher Order Ambisonics“) with a high enough order and a good enough transducer quality **in the whole frequency spectrum** would be appropriate → however there is no microphone capturing system of this kind available
 - HOA as a storage and mixing format is appropriate!

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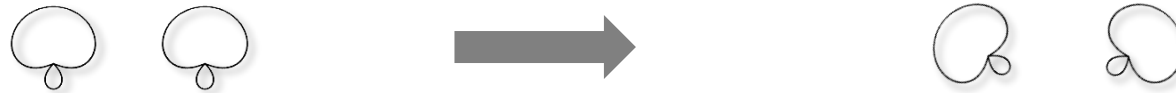
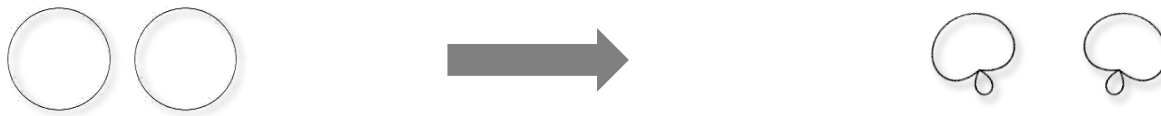
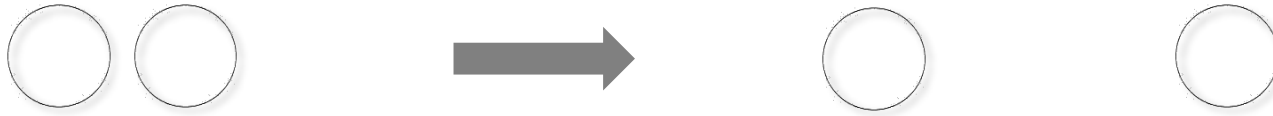


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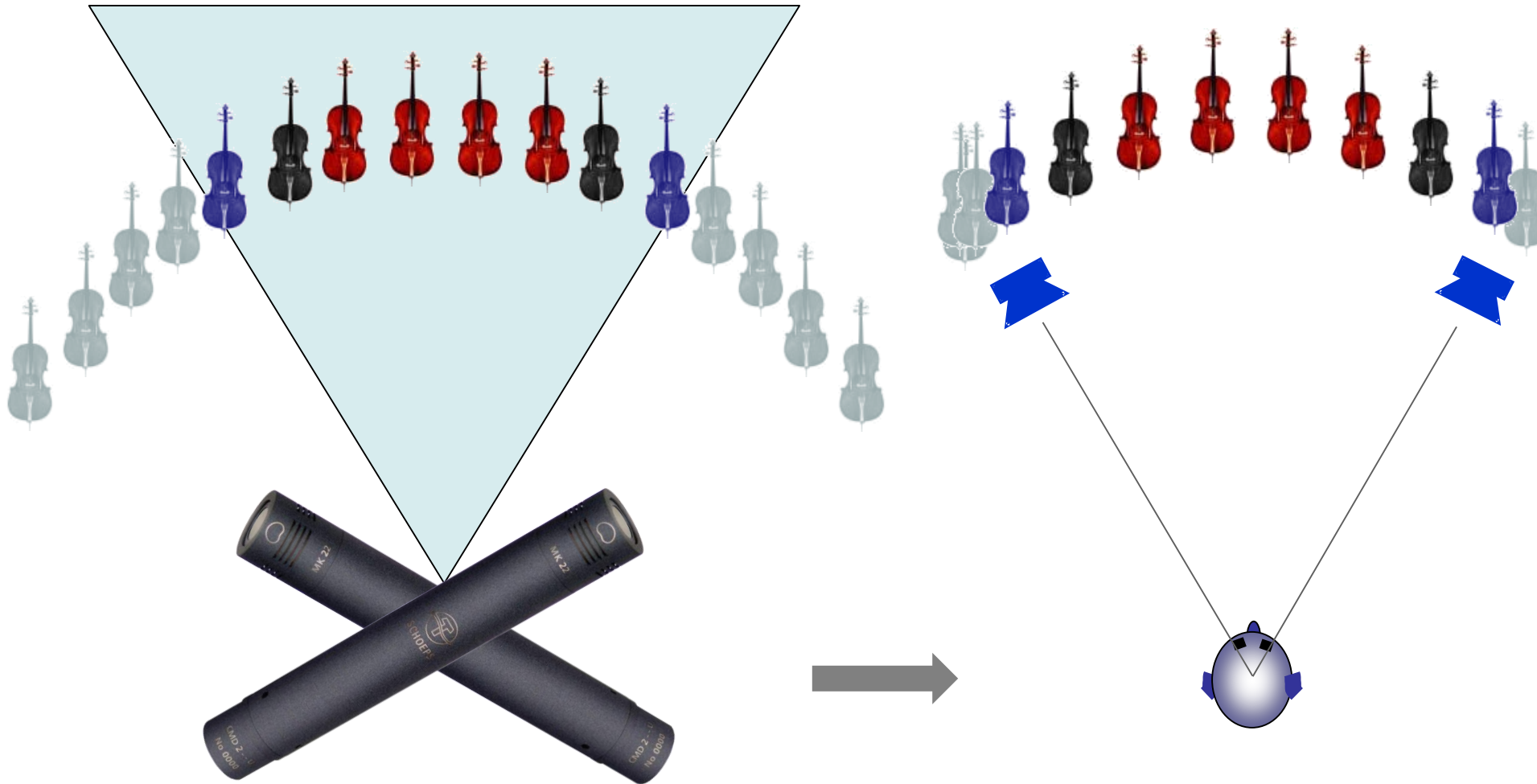
- Signal separation!



Microphone recording
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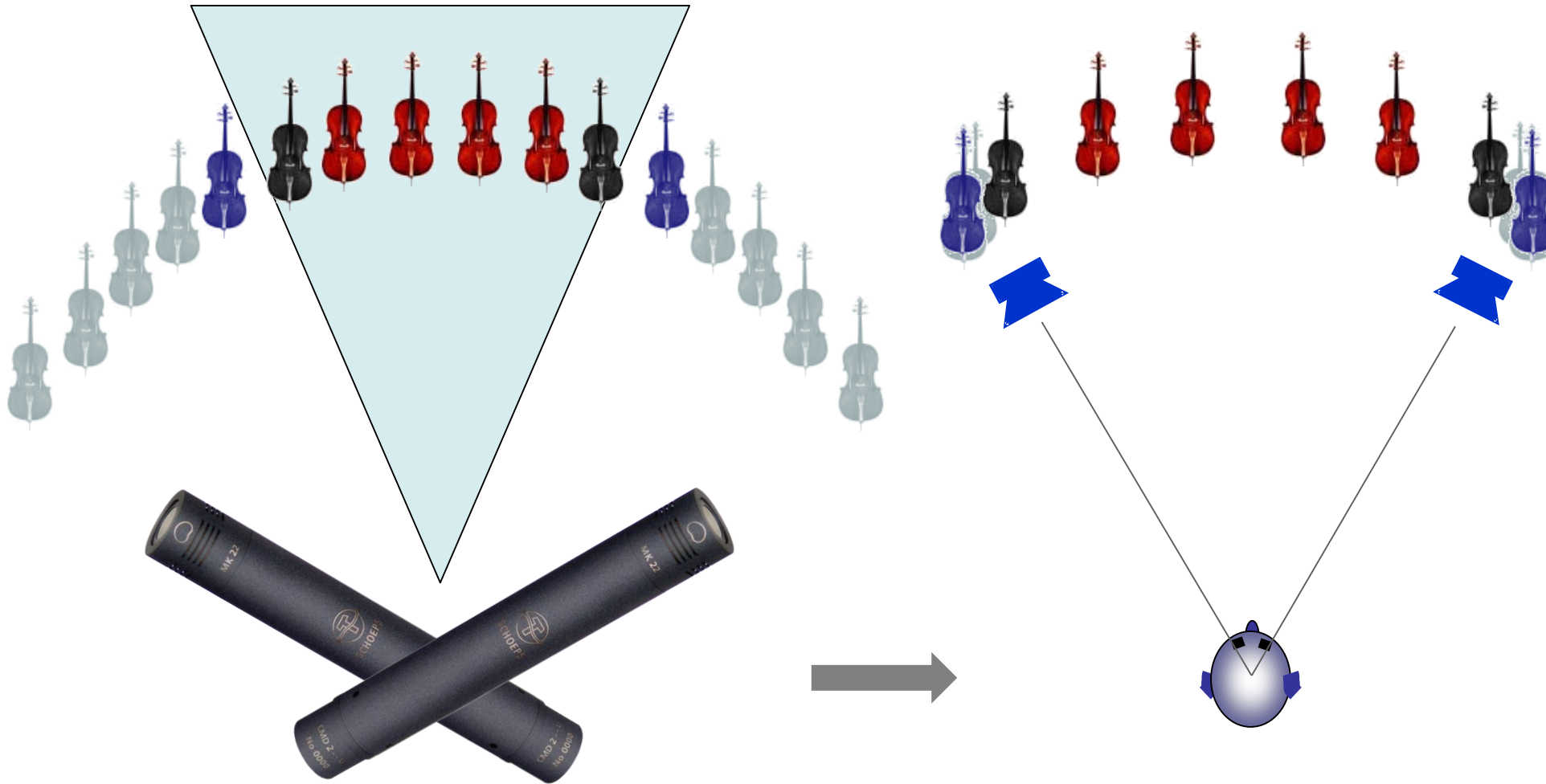
- Recording Angle



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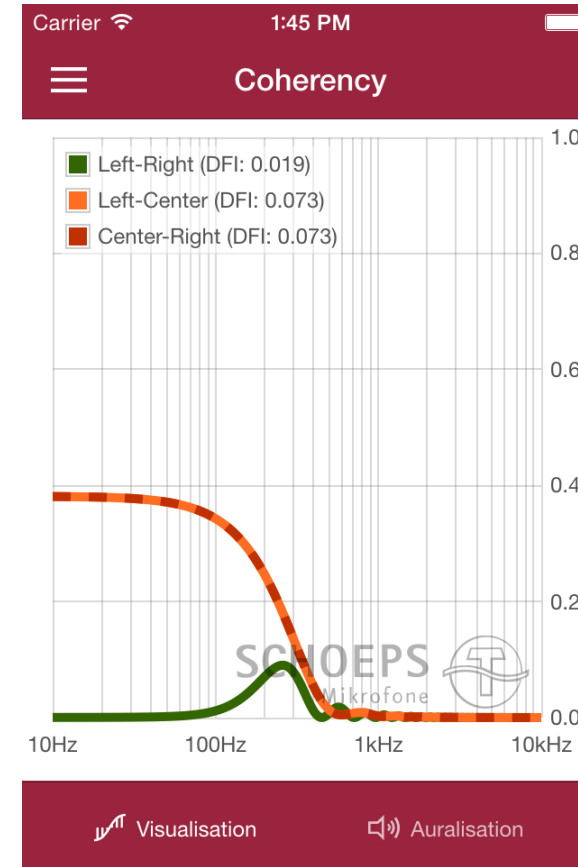
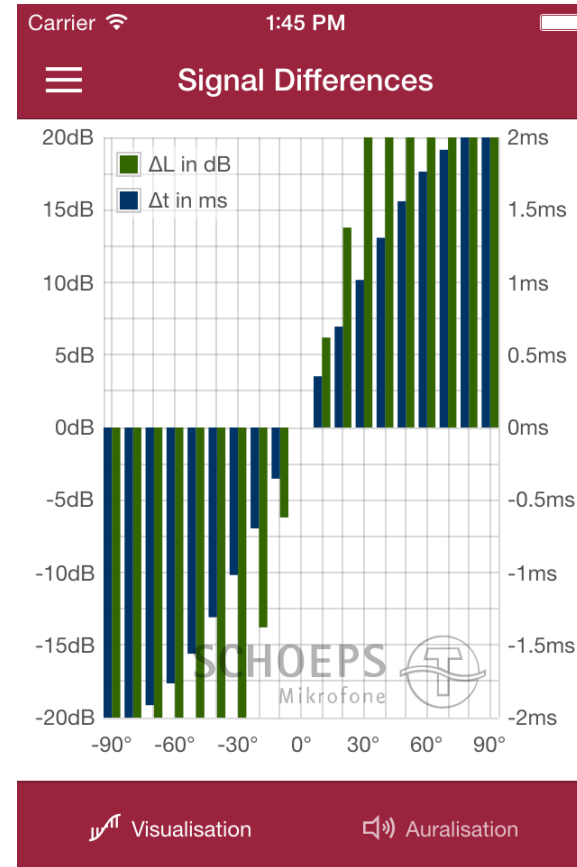
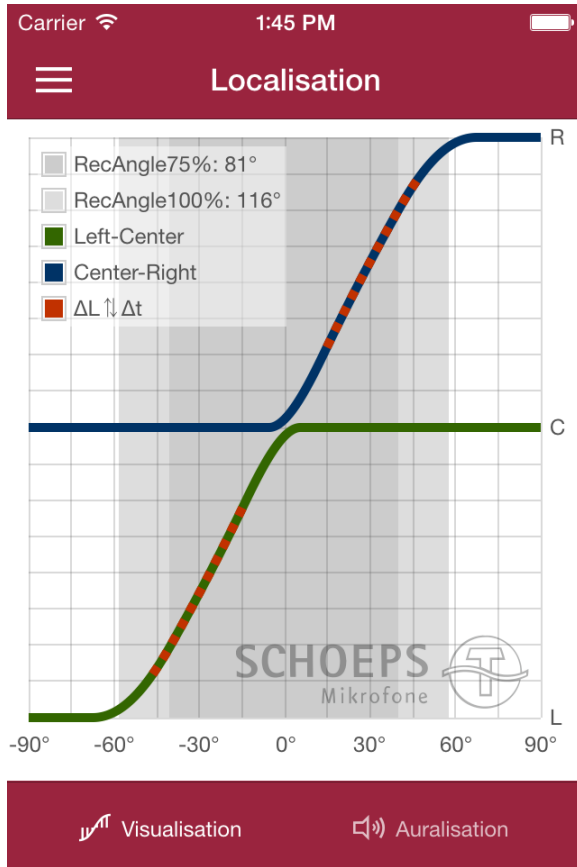
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Microphone recording
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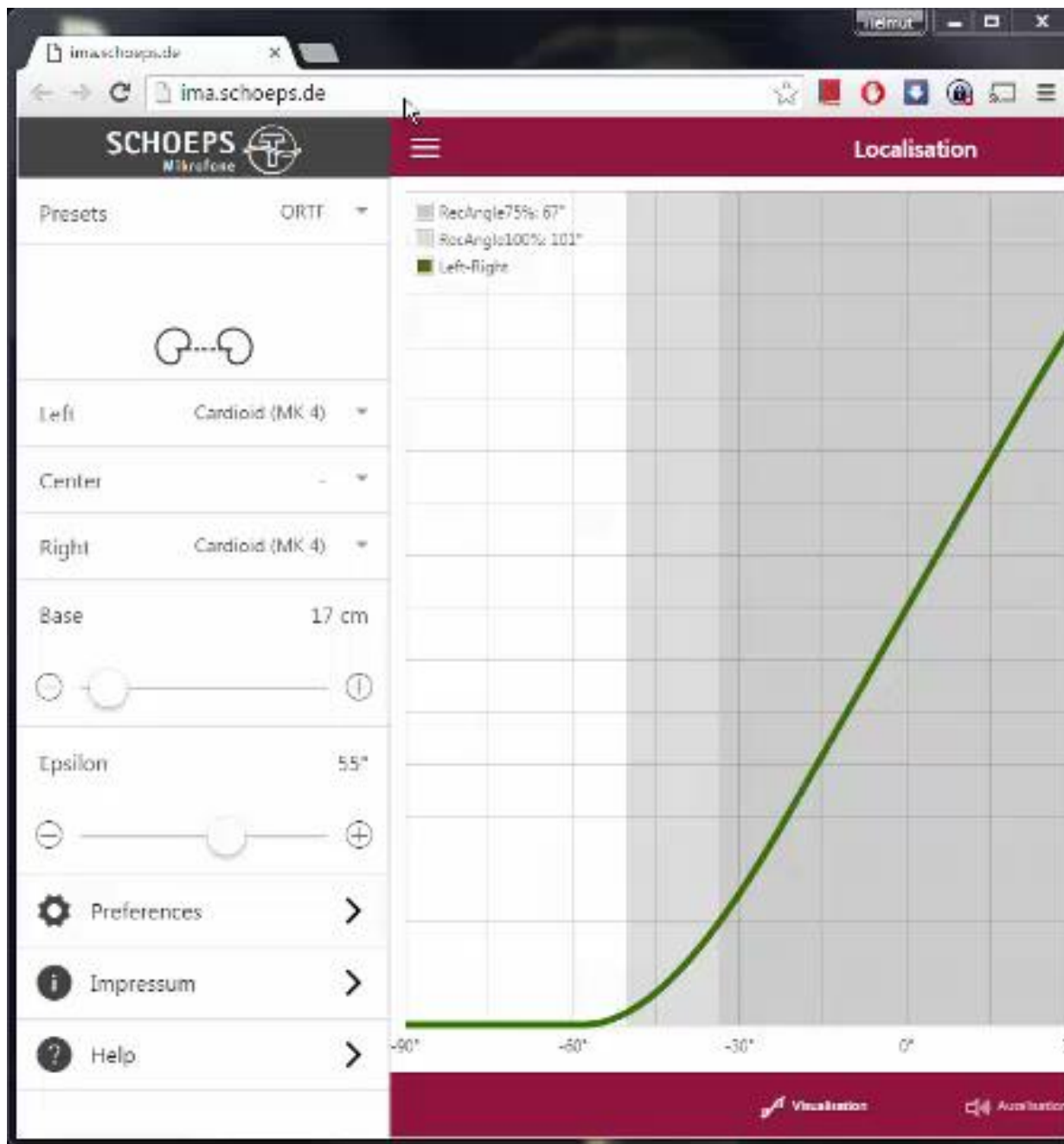
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- SCHOEPS-App "Image Assistant": App Store or ima.schoeps.de



Microphone recording for 3D-Audio

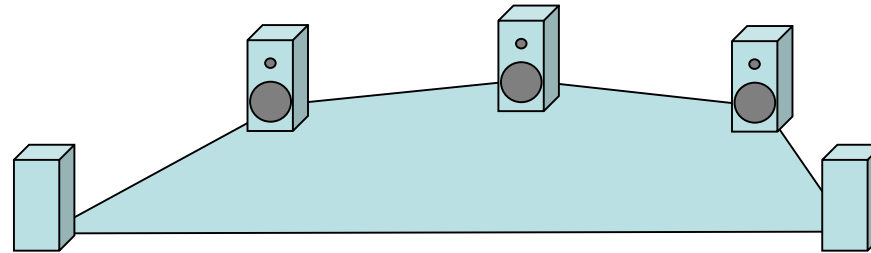
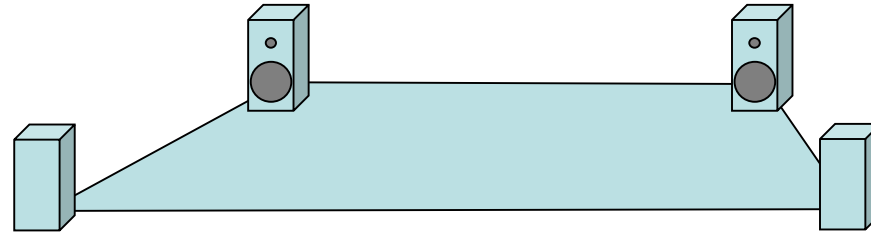
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Microphone recording for 3D-Audio

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- 3D-Audio: Stereo+Height
- Auro3D 9.1
- Dolby Atmos 5.1.4



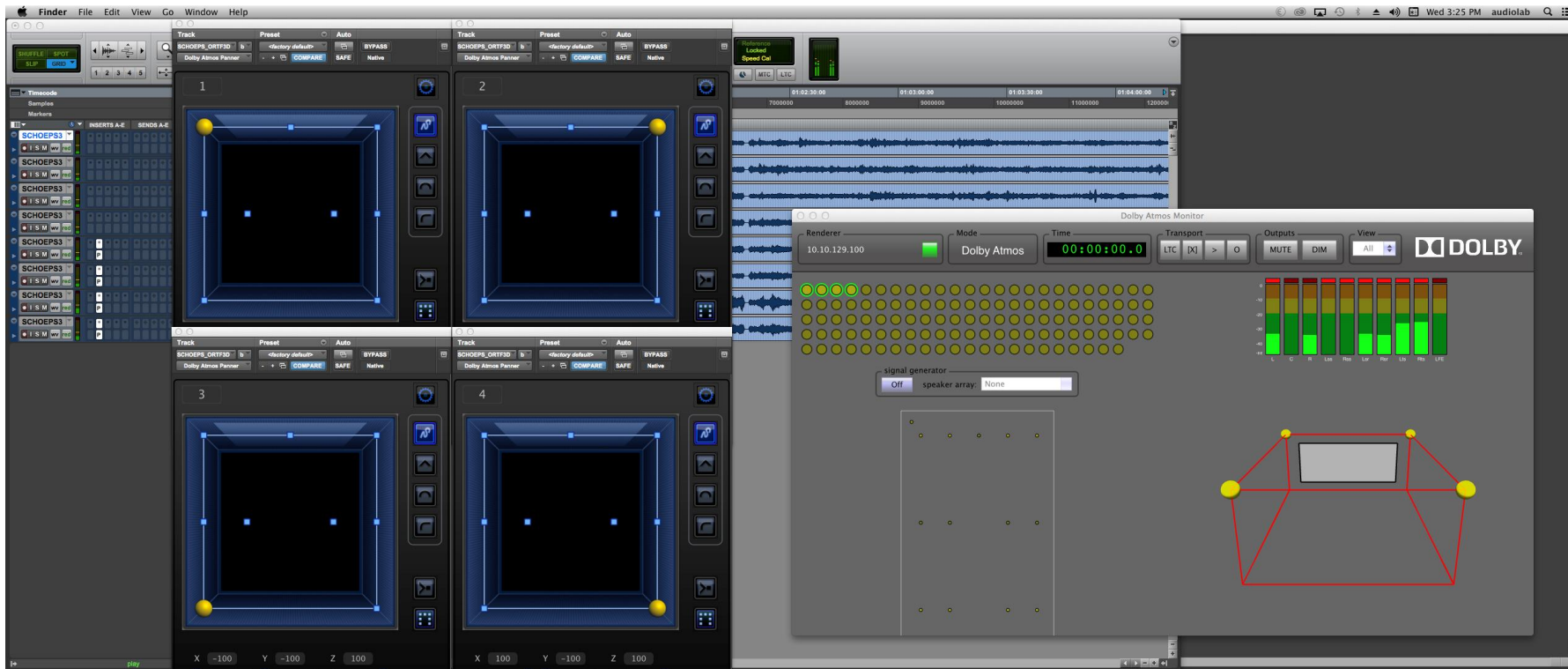
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- Dolby Atmos 5.1.4:

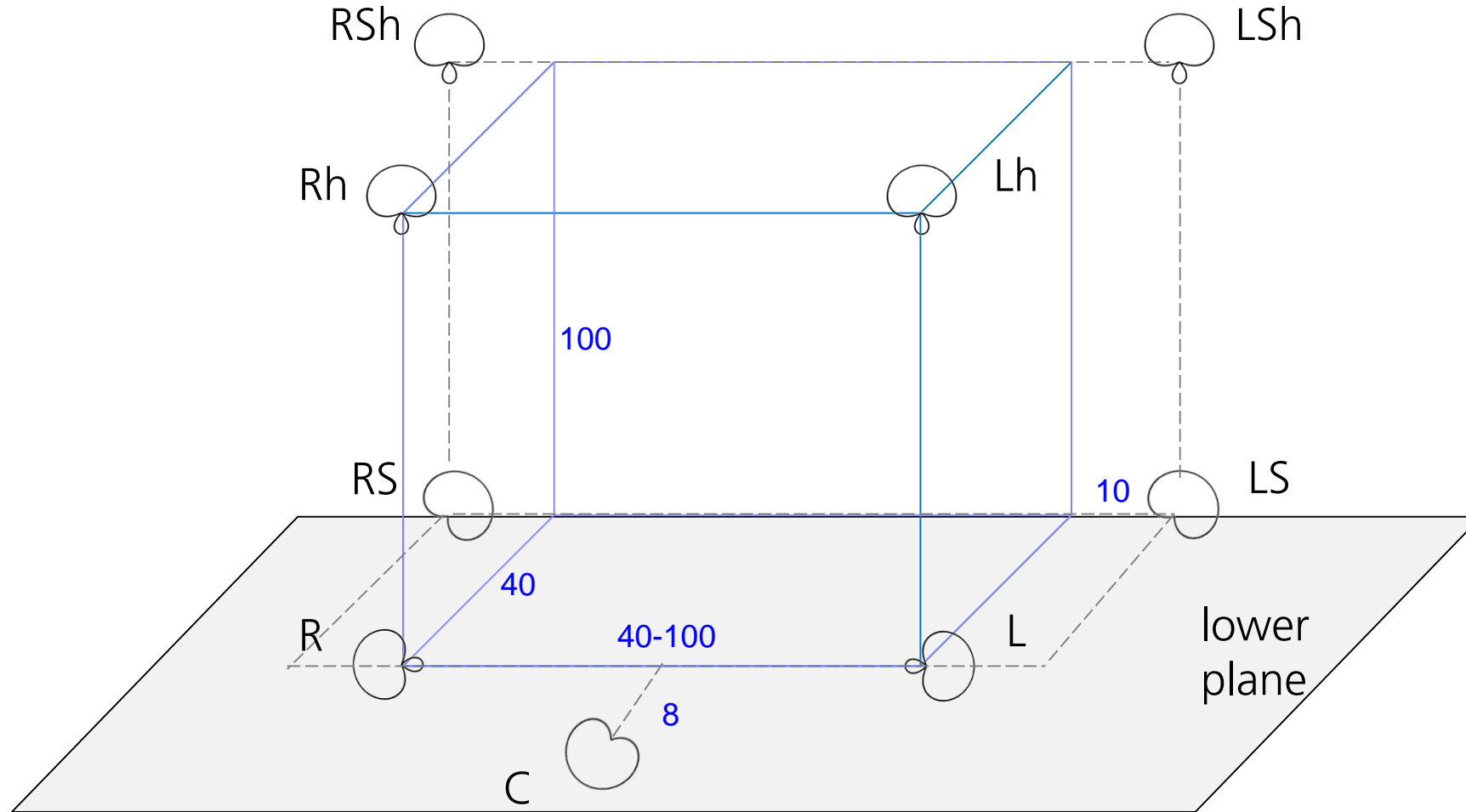
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„OCT 9“ for 9.1 Surround

- lower plane: OCT Surround
- upper plane: + 100cm, 4 supercardioids pointing upwards



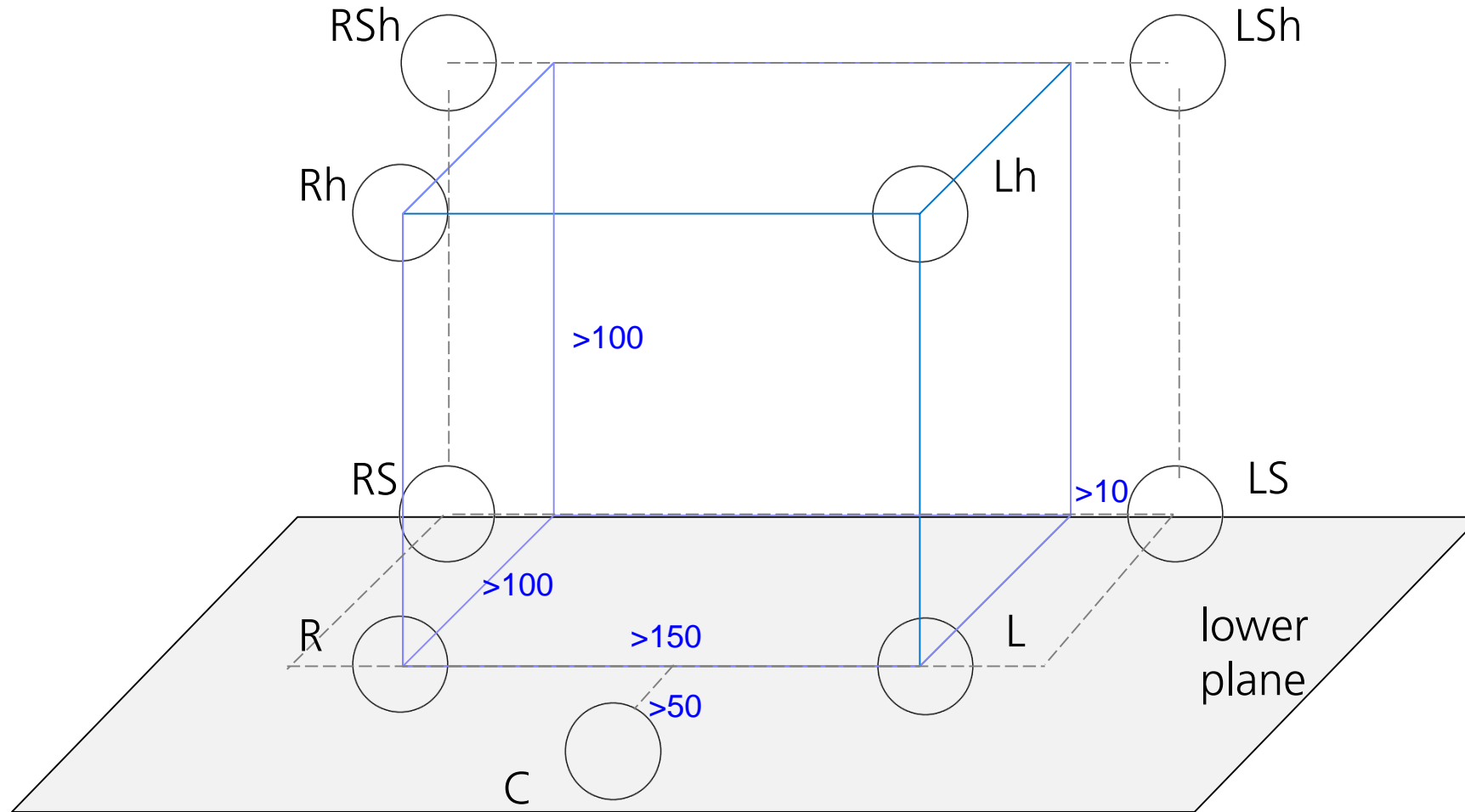
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„Omni Array“ for 9.1 Surround

- 9 Omnis



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- Test recordings in the Galaxy Studios, Belg

- OCT 9

- Omni array



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ORTF-3D regular

- 8 * Supercardioid on the edges of a cube with $d = 10\text{-}20\text{ cm}$



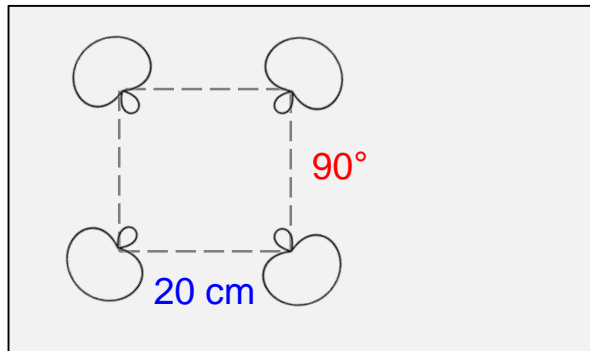
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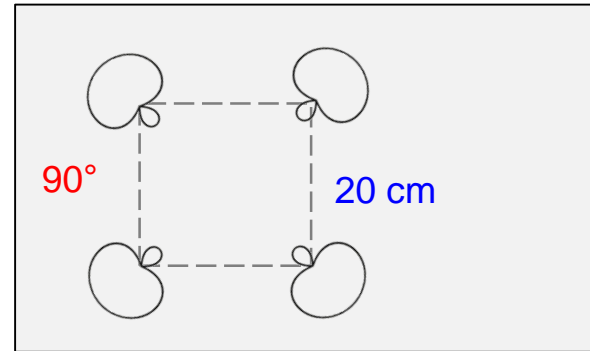
„ORTF-3D regular“ for 8.0 Surround

- lower + upper plane: IRT cross
- Vertical domain: ORTF-like

View from above



Side View

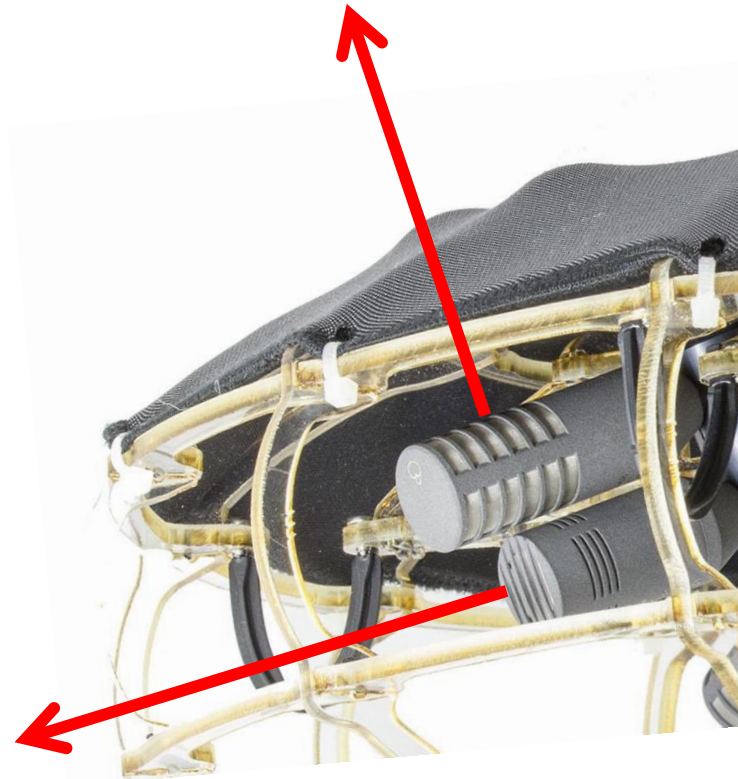
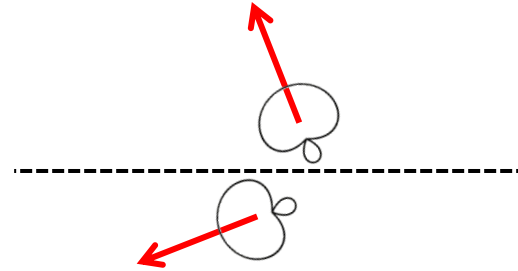


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ORTF-3D „FLAT“ (NEW)

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



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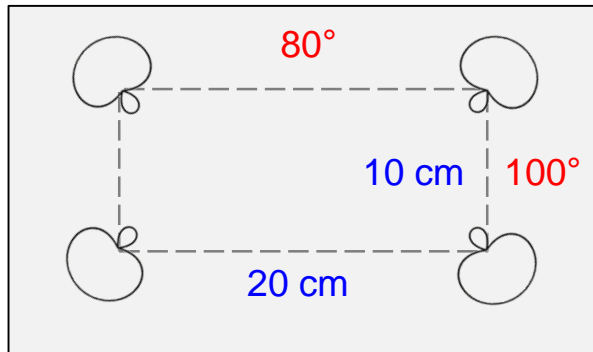
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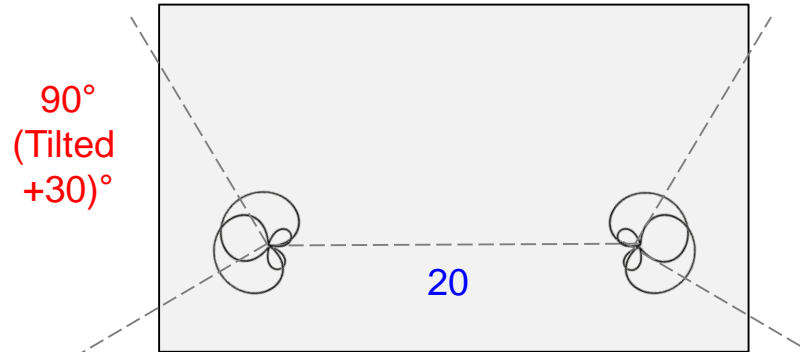
„ORTF-3D“ for 8.0 Surround

- lower + upper plane: ORTF Surround
- Vertical domain: Supercardioid X/Y

View from above

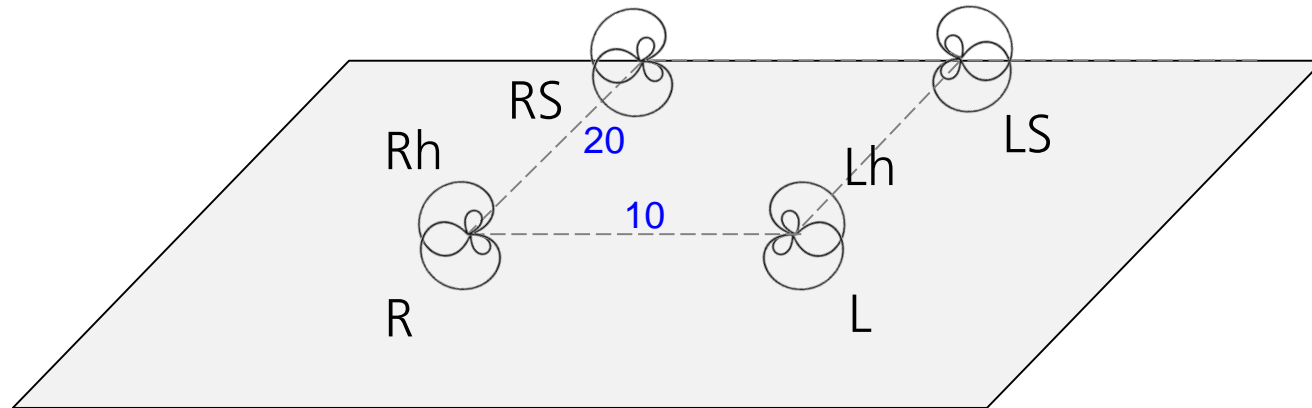


Side View



RSh

LSh



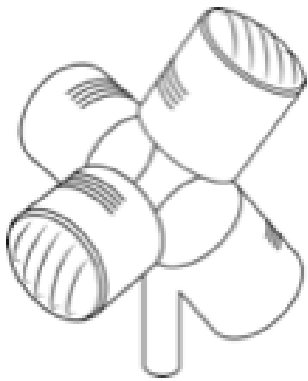
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VR/Sound for 360° video production using the ORTF-3D microphone:

Demo at SCHOEPS booth

first-order
Ambisonics



SCHOEPS
Mikrofone



ORTF-3D



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VR/Sound for 360° video production using the ORTF-3D microphone:

Demo app for Download:

<http://www.hauptmikrofon.de>



Stereo

Imaging

Microphone recording for 3D-Audio

Array design

for 3D-Audio

- 3D-Audio formats

- The Uncanny Valley

Stereophony

- 3D Stereo techniques

in Practice

- ORTF-3D

- Stereo in VR/Binaural

3D Stereo in

VR

- Demo App
- Theory



Stereo

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in Practice

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3D Stereo in

VR

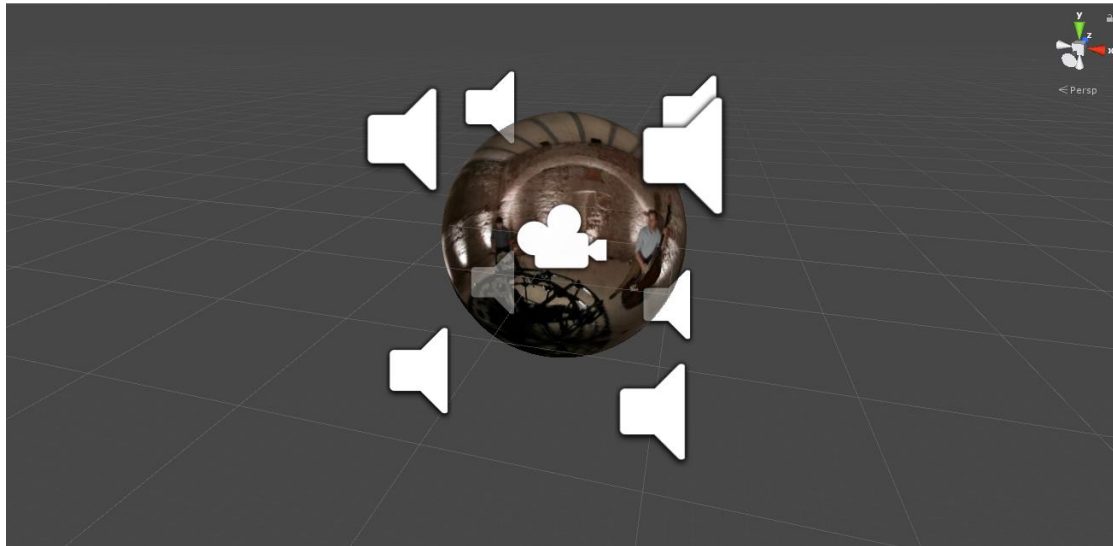
- Demo App

- Theory

VR/Sound for 360° video production using the ORTF-3D microphone:

Unity game engine:

- Route 8 channels discretely to 8 virtual speakers
- Binauralize, e.g. with *dearVR* – 3D audio reality engine



Stereo

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Array design

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Stereophony

- 3D Stereo techniques

in Practice

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3D Stereo in

VR

- Demo App

- Theory

VR/Sound for 360° video production using the ORTF-3D microphone: Cubical Virtual Loudspeaker array

Microphone recording
for 3D-Audio

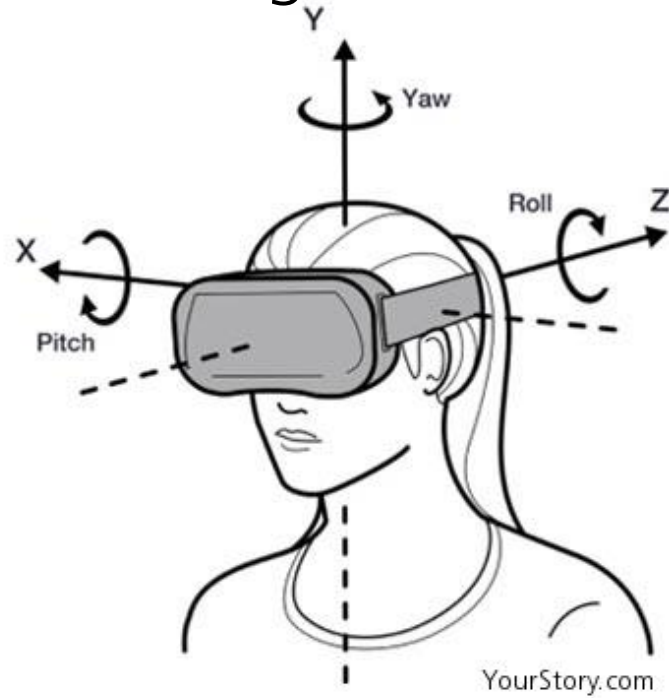
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Audio objects within the Game-Software „Unity“

3D Stereo in Virtual Reality - Theory

Requirement: Binaural sound field reproduction

- Rotational Head-Tracking



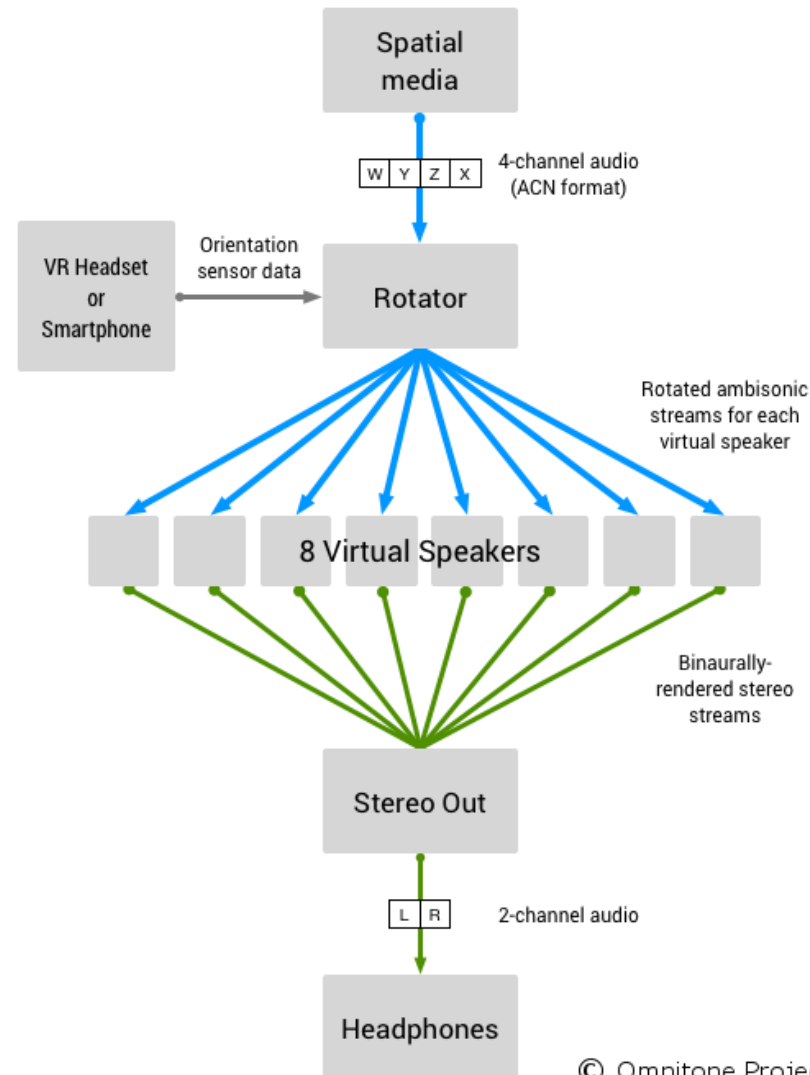
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3D Stereo in Virtual Reality - Theory

Two possibilities to rotate 3D sound field for binaural reproduction

1. Turn the whole sound field with non-diegetic speakers
2. Turn binaural spatializer HRTF angles with diegetic speakers



Microphone recording for 3D-Audio

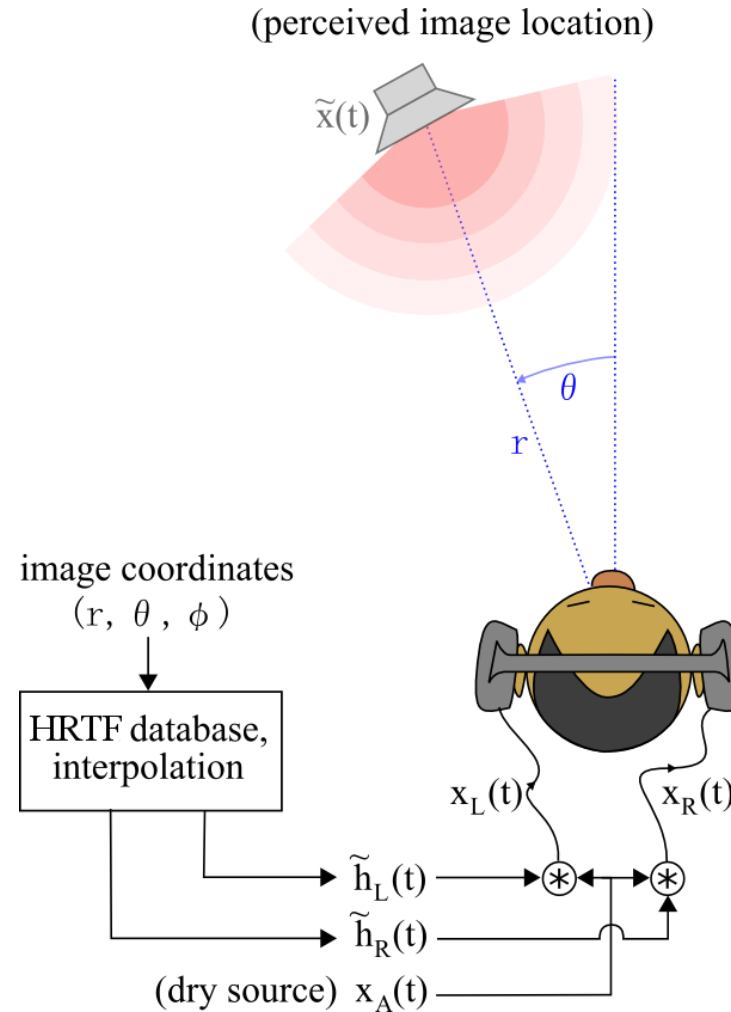
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3D Stereo in Virtual Reality - Theory

Two possibilities to rotate 3D sound field for binaural reproduction

1. Turn the whole sound field with non-diegetic speakers
2. Turn binaural spatializer HRTF angles with diegetic speakers
→ enables 3D Stereo

Binaural spatializer (1 sound source)



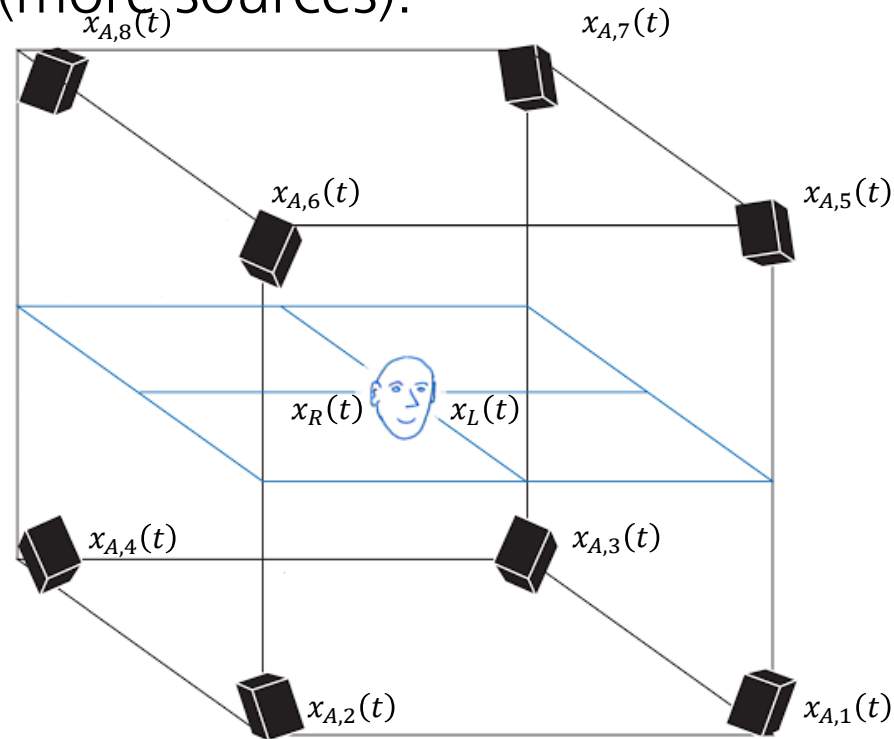
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3D Stereo in Virtual Reality - Theory

Binaural spatializer (more sources):



$$x_L(t) = \sum_i x_{L,i}(t) = \sum_i \left(x_{A,i}(t) * \tilde{h}_{L,i}(t) \right)$$

$$x_R(t) = \sum_i x_{R,i}(t) = \sum_i \left(x_{A,i}(t) * \tilde{h}_{R,i}(t) \right)$$

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Storage and distribution Format:

Either:

- Position and signals of the virtual loudspeakers (MPEG-H)

Or:

- (Higher Order) Ambisonics (Youtube, Facebook, etc.)
 - Through the definition of the virtual loudspeakers in e.g. Unity, their directions are stored in HOA.
 - Ambisonics plugins offer "9.1" preset

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Microphones for 360° VR recording:

- First Order Ambisonics (FOA) microphones:
small, cheap, limited spaciousness, comb filters
- Higher Order Ambisonics (HOA) microphones:
small, expensive, transducer quality
- Stereophonic microphone systems for 3D Audio:
less portable, expensive, optimal imaging & spaciousness



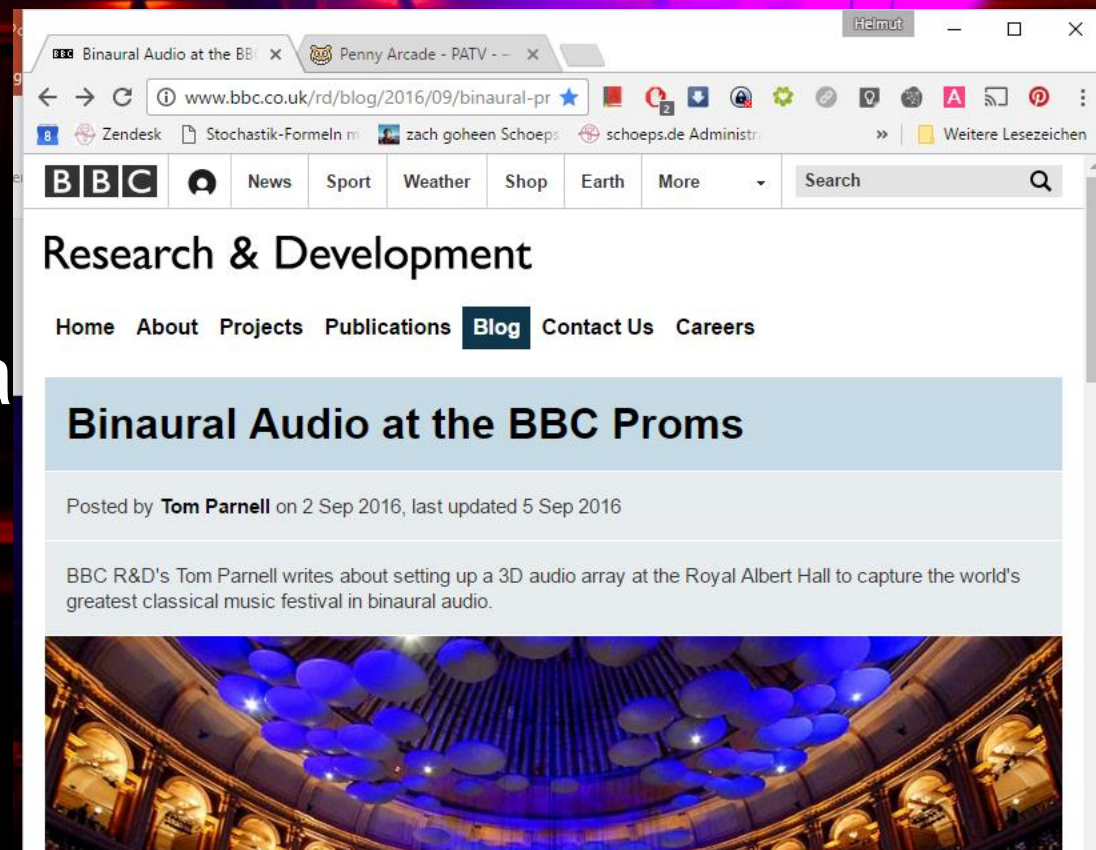
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Binauralized „ORTF-3D“ at the BBC Proms

Binauralized „ORTF-3D“ a



The image shows a screenshot of a web browser displaying a BBC Research & Development blog post. The browser's address bar shows the URL www.bbc.co.uk/rd/blog/2016/09/binaural-pr. The page features the BBC logo and navigation links for News, Sport, Weather, Shop, Earth, and More. The main heading is "Research & Development", and the sub-heading is "Binaural Audio at the BBC Proms". The post is attributed to Tom Parnell, dated 2 Sep 2016, and last updated on 5 Sep 2016. The text of the post describes the setup of a 3D audio array at the Royal Albert Hall. At the bottom of the screenshot, there is a photograph of the interior of the Royal Albert Hall, showing a large, ornate ceiling with numerous blue, spherical light fixtures.

BBC Binaural Audio at the BBC Proms


Research & Development

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Binaural Audio at the BBC Proms

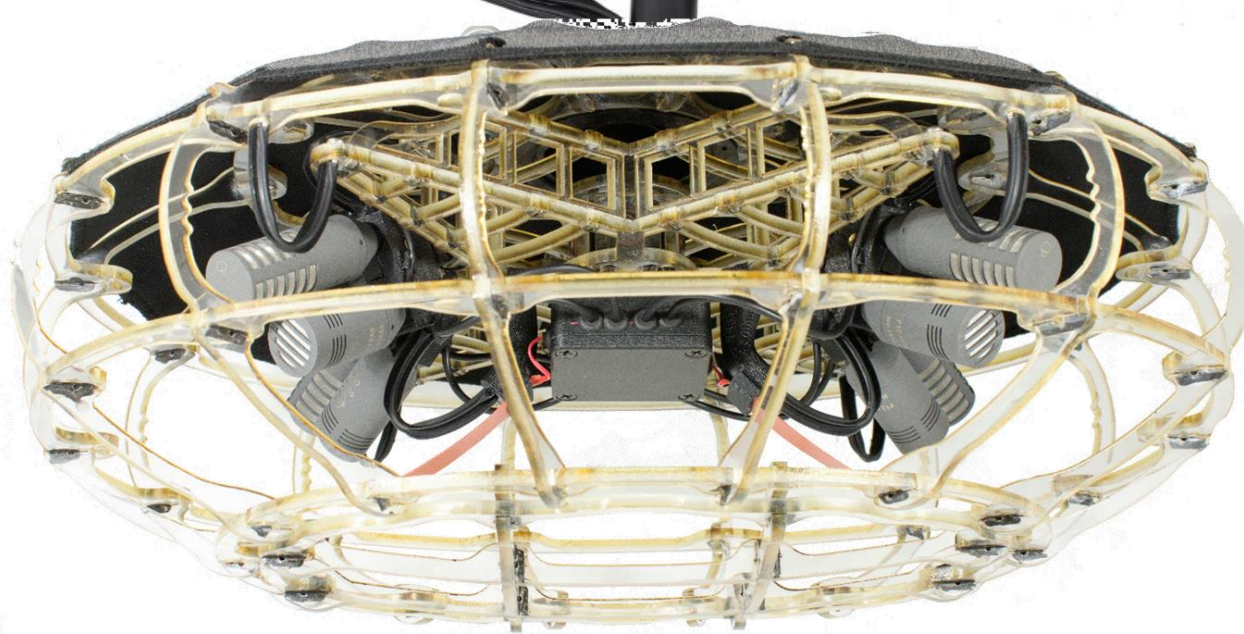
Posted by **Tom Parnell** on 2 Sep 2016, last updated 5 Sep 2016

BBC R&D's Tom Parnell writes about setting up a 3D audio array at the Royal Albert Hall to capture the world's greatest classical music festival in binaural audio.



- Conclusions
 - Sound engineers: **trust your ears**, don't believe in „scientific“ approaches without skepticism
 - Better make **good Stereo** than bad unperfect physical reproduction
 - An unperfect physical reproduction can sound much worse than a good Stereo recording (Example: First Order Ambisonics is worse than a good 9.1 Decca Tree)
 - Use **Stereo layers** for ambient sources and spatial recording in a WFS/Ambisonics/Binaural reproduction (Example: 9ch Decca-Tree recording on a Auro3D 9.1 preset put in a binaural renderer)
 - Use Stereo to be able to work in a sound engineering way, caring for **aesthetical** aspects
 - The **ORTF-3D** microphone is a good approach for recording a 3D ambience for all formats

- 3D-Audio formats
- The Uncanny Valley
- 3D Stereo techniques
- ORTF-3D
- Stereo in VR/Binaural



Thank you!

- wittek@schoeps.de
- www.hauptmikrofon.de
- SCHOEPS booth #834: See the 360° VR app and the **TEC-Award winning** ORTF-3D microphone

Microphone recording
for 3D-Audio

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