



# 40<sup>th</sup> AES Conference Tokyo, 8-10 October 2010



## History and current state of the war between the two main approaches to surround sound: discrete speaker feeds versus hierarchical matrix

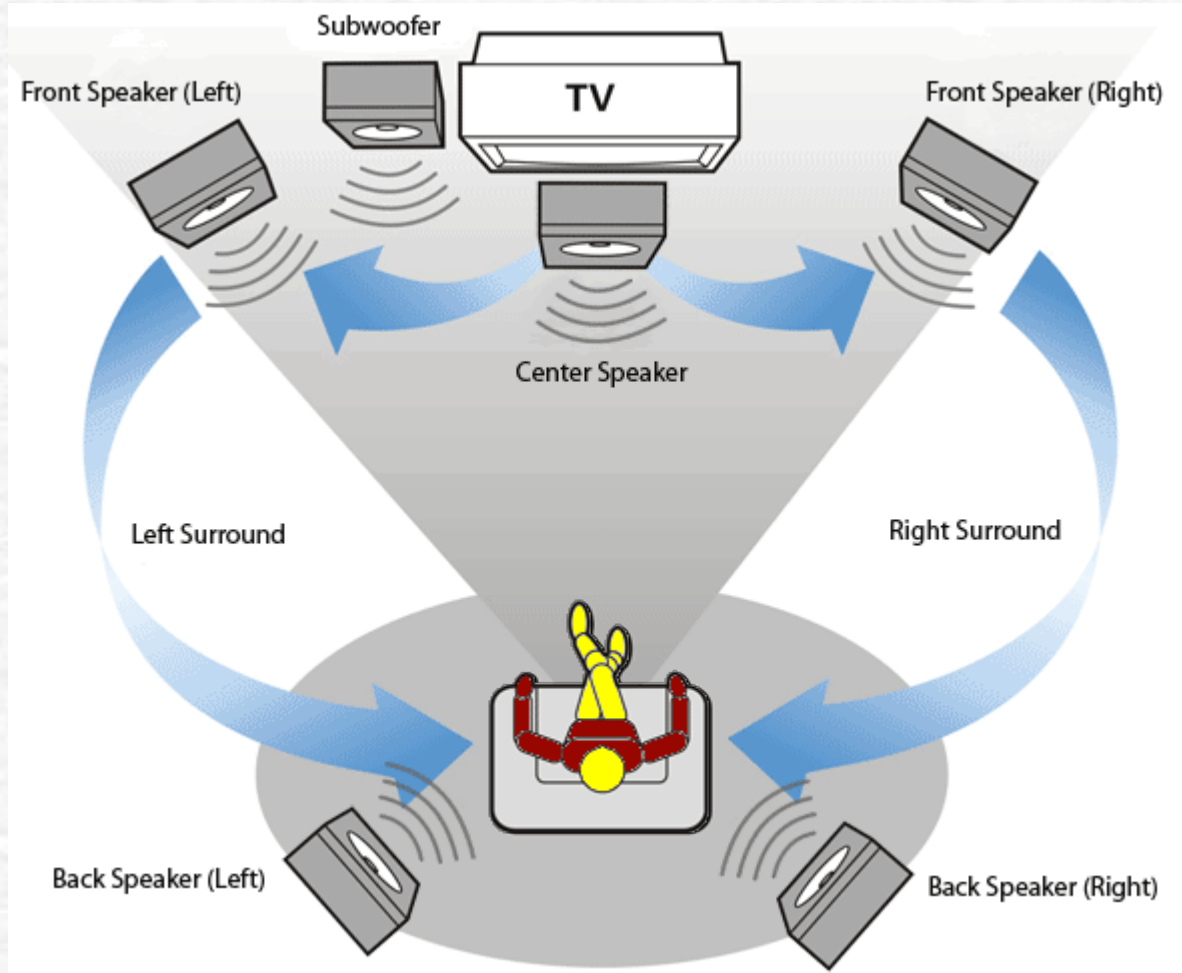
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[HTTP://pcfarina.eng.unipr.it](http://pcfarina.eng.unipr.it) - mail: [angelo.farina@unipr.it](mailto:angelo.farina@unipr.it)

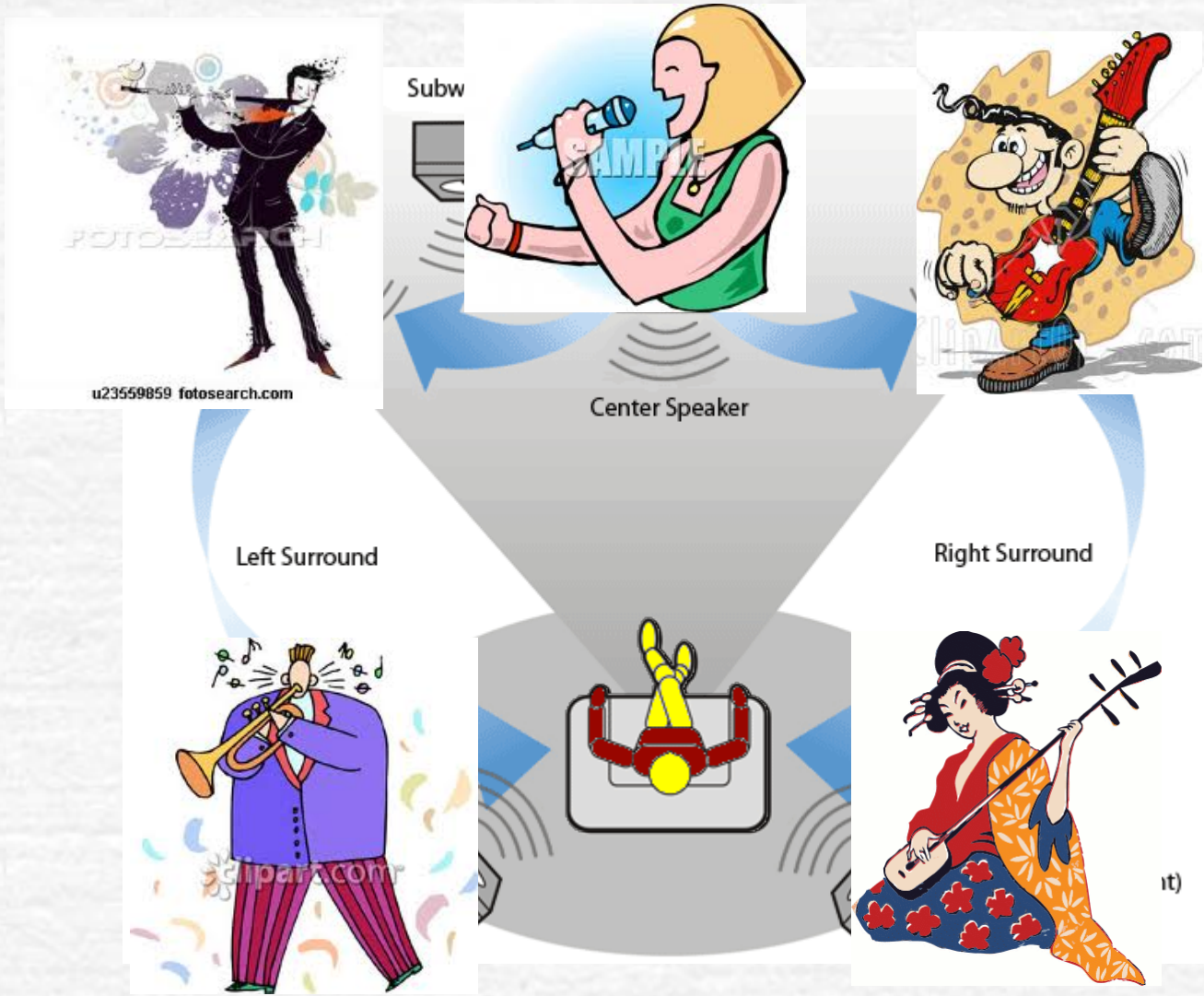


# Who is where ?

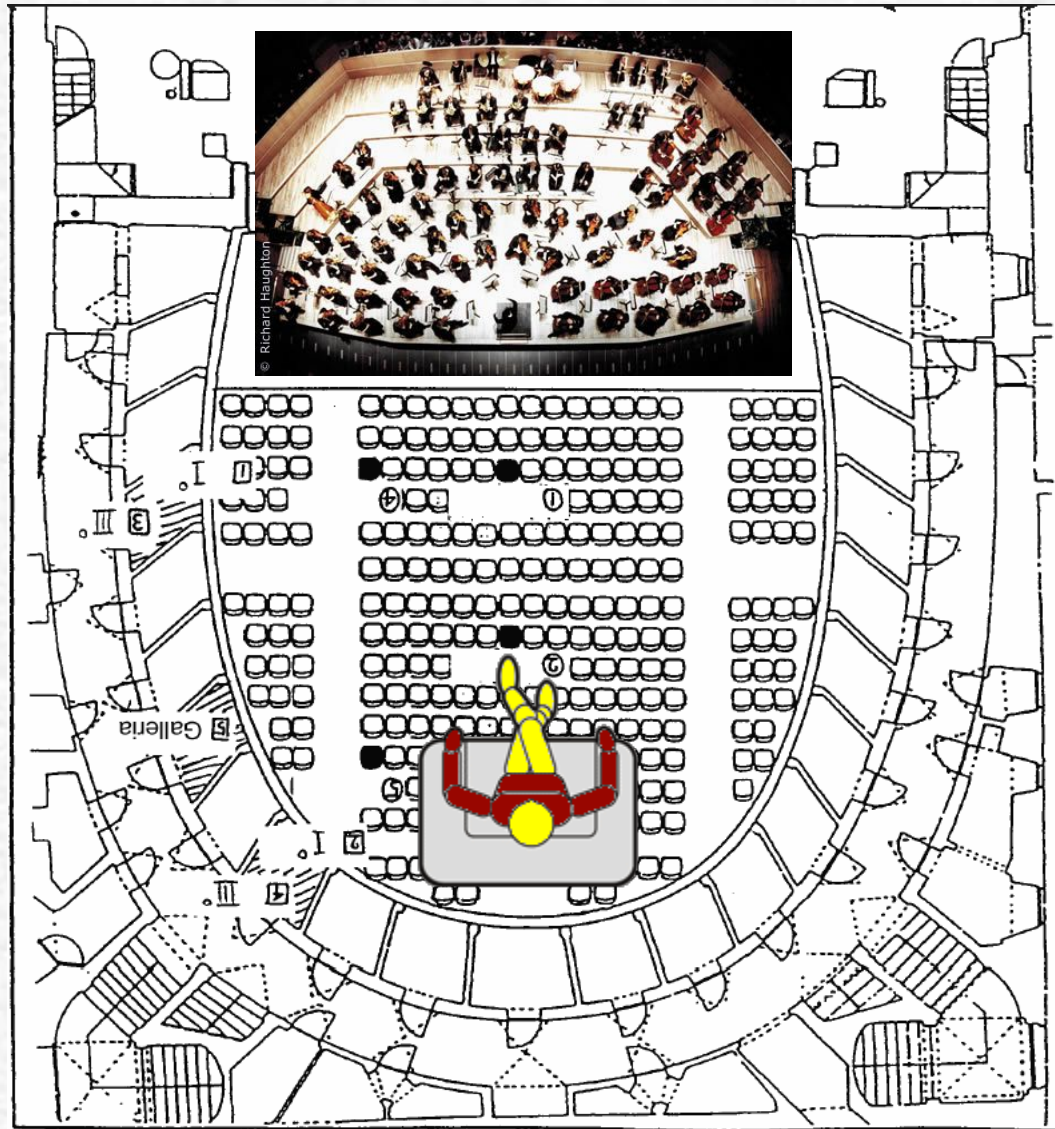


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# "They are here"



# "You are there"



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# “They are here”



**Gmebaphone (1973)**

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# Discrete vs. Matrix

## Discrete speaker feeds

- Quad-8

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- OCT-Surround
- Williams MMA
- Fukada-Tree
- Hamasaki-Square
- INA-5
- Decca Tree

**5 ch.**

- **Spot mikes + panning**

## Hierarchical Matrix

- Quad SQ/QS/EV/DY
- Ambisonics UHJ
- Dolby Surround
- Dolby Pro Logic
- Logic 7
- SRS Circle Surround

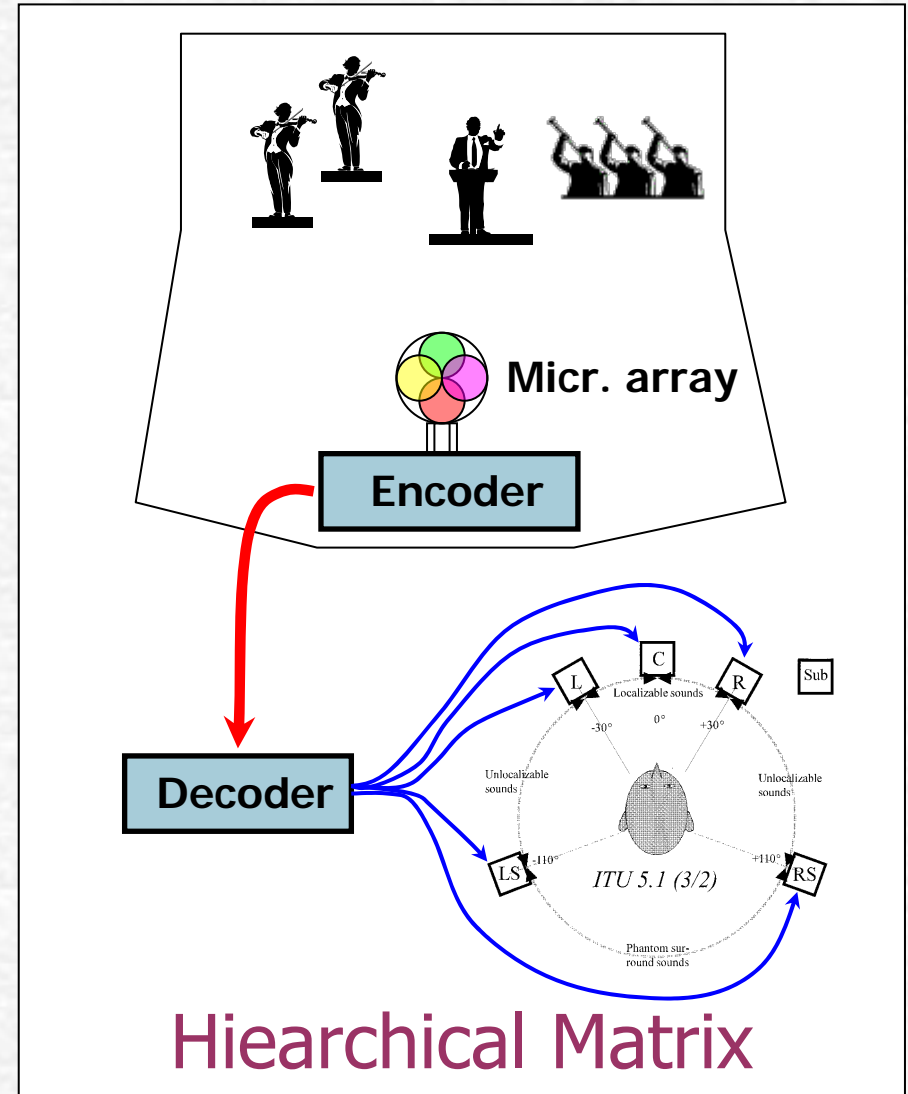
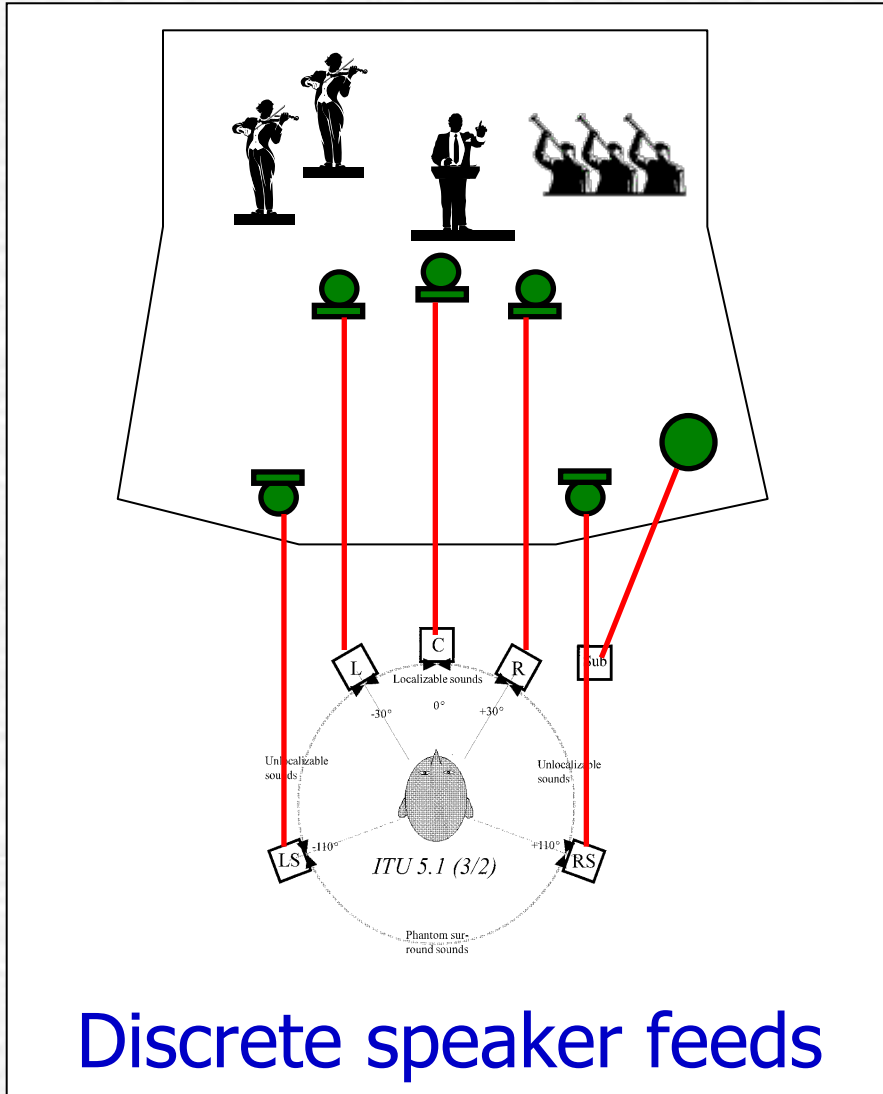
**2 ch.**

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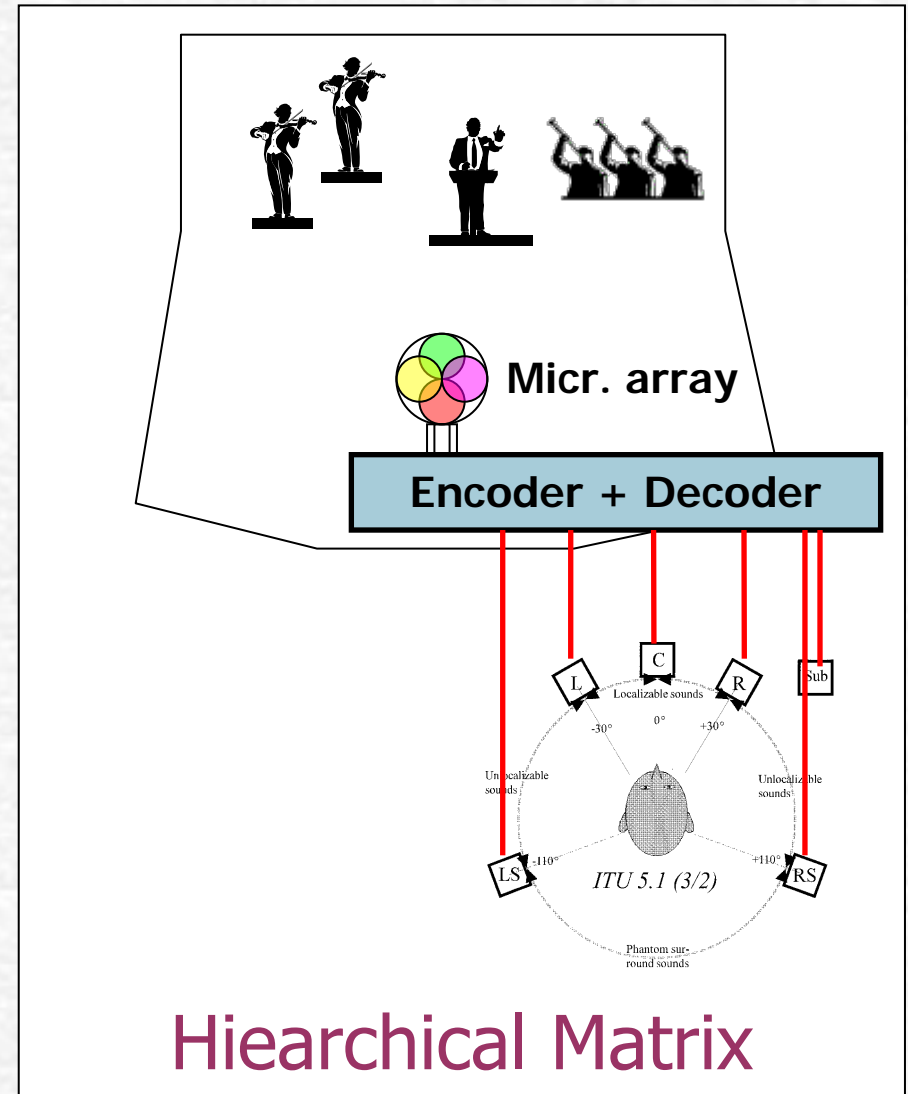
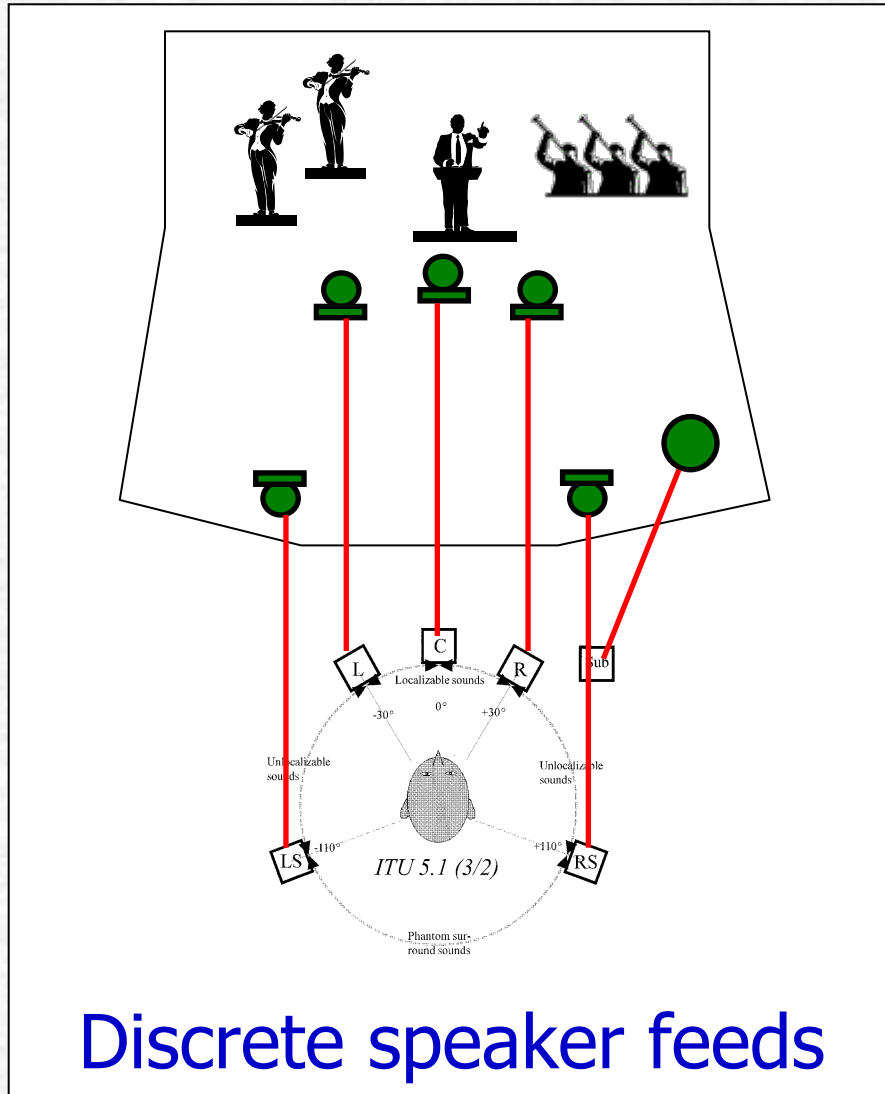
- 1<sup>st</sup> ord. Ambisonics
- SIRR / DirAC
- High Order Ambisonics



# Discrete vs. Matrix

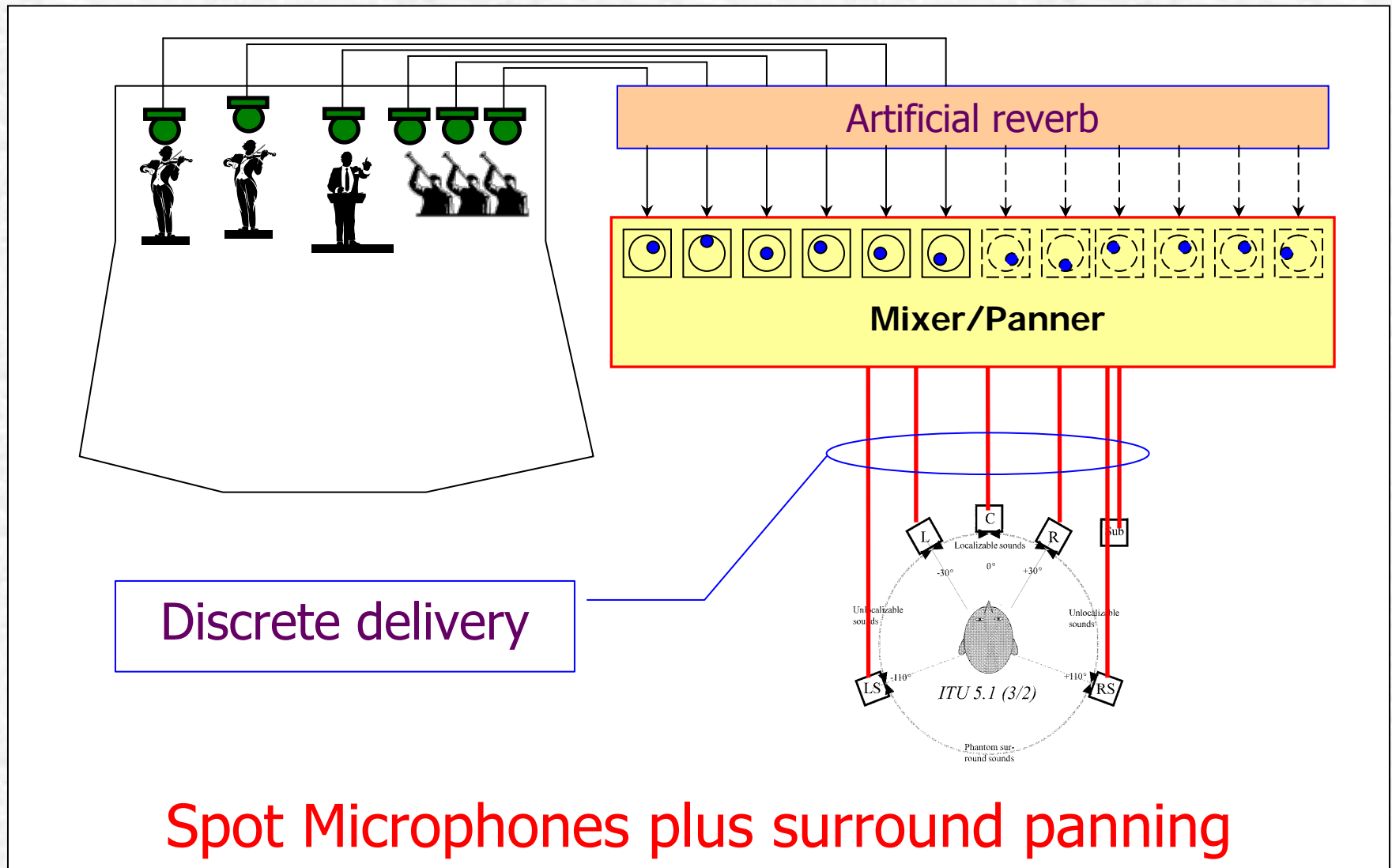


# Discrete vs. Matrix

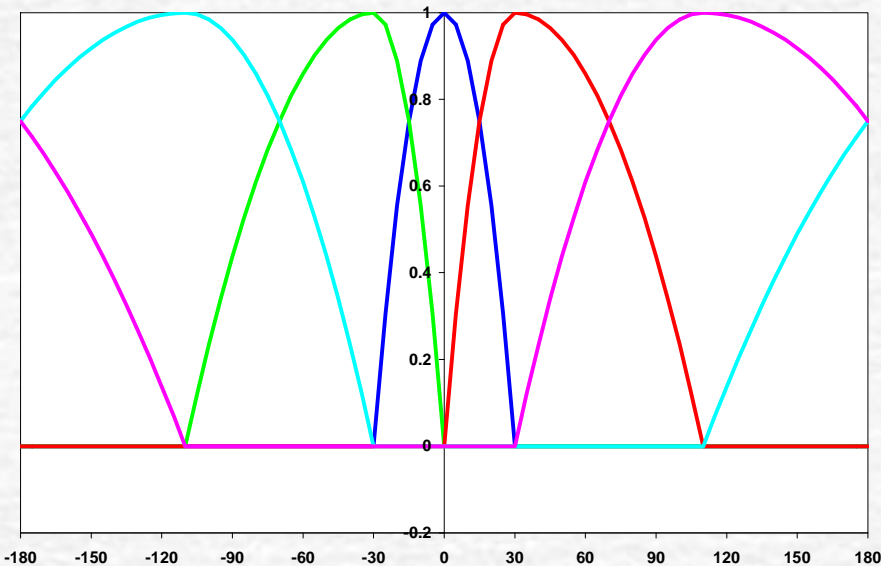




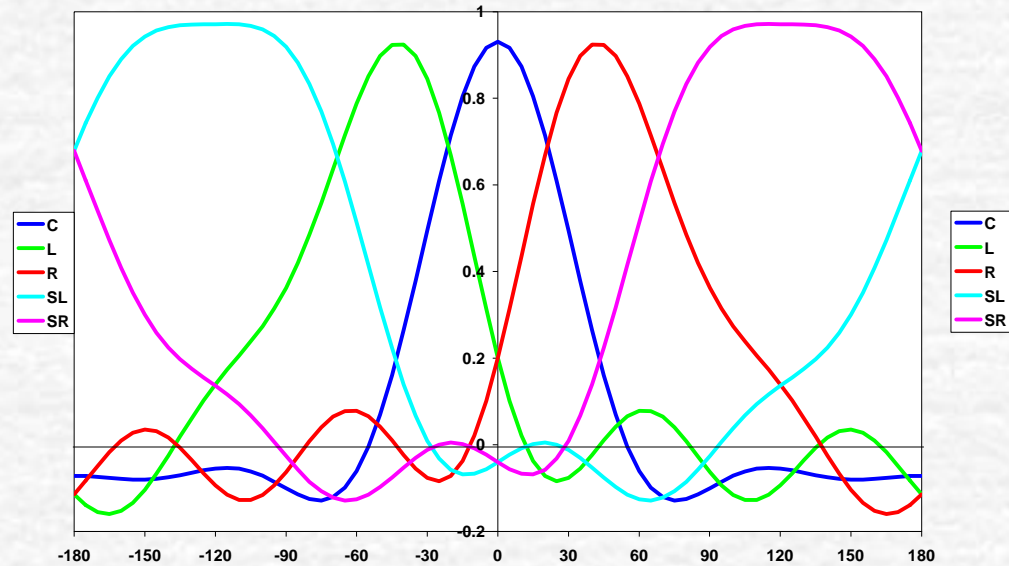
# But more often the approach is this:



# Surround Panning Laws



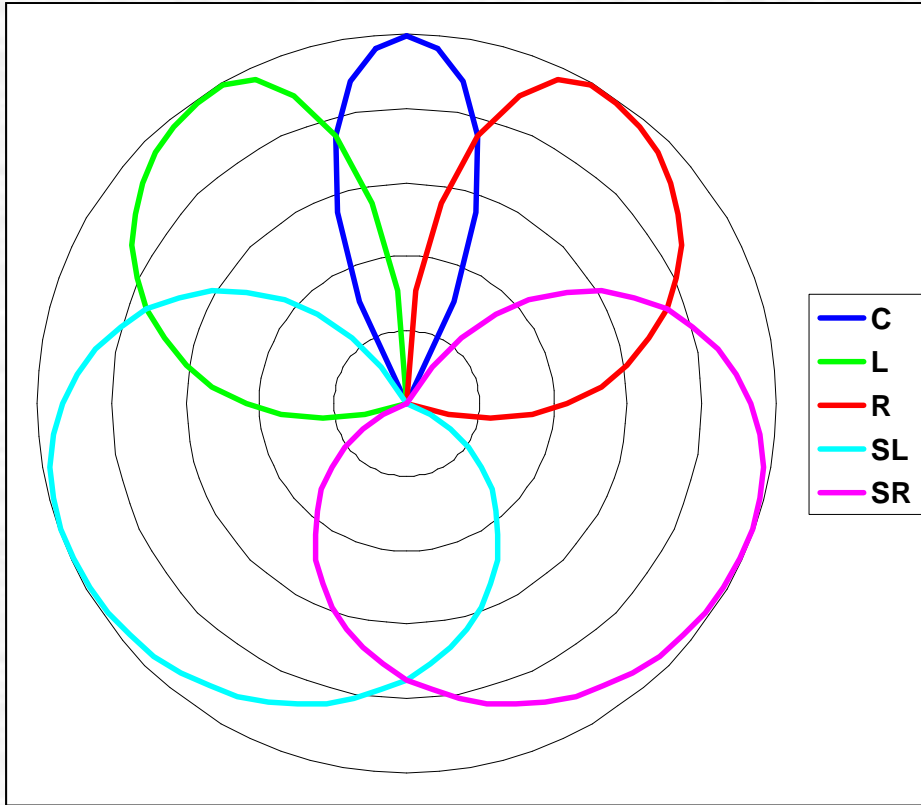
“Pairwise Panning” with constant power – signal is sent to just 2 loudspeakers simultaneously



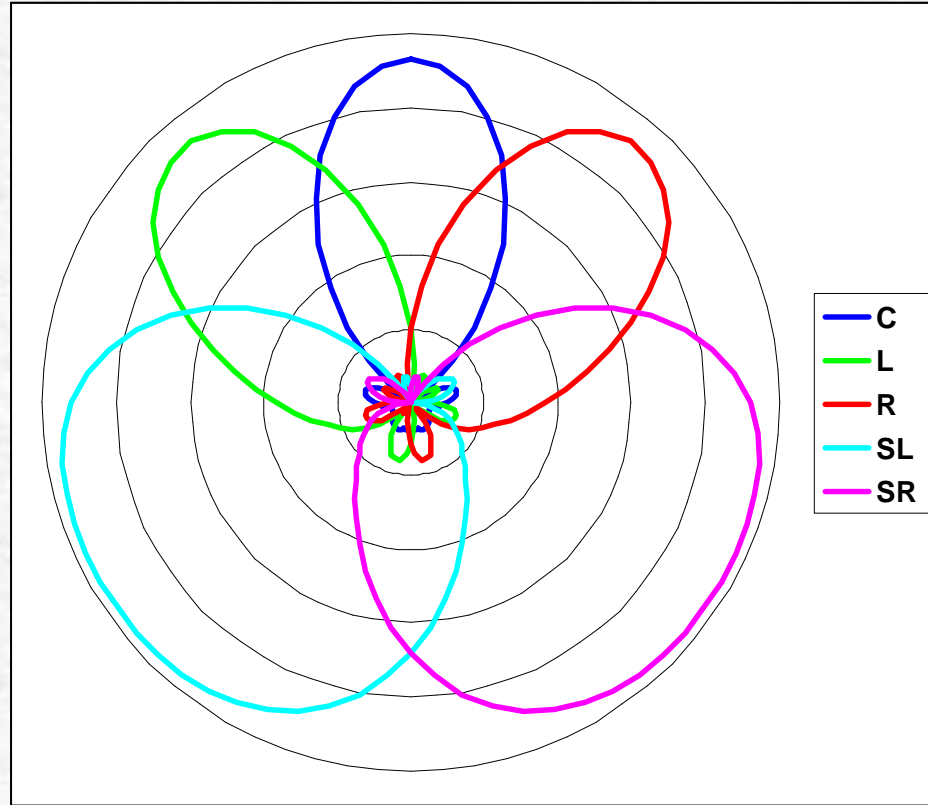
Peter Cravens' panning laws based on high-order Ambisonics decoding; all 5 speakers are always fed

Many different amplitude-panning laws are available

# Surround Panning Laws



“Pairwise Panning”



Peter Craven's panning

Polar patterns of the panning laws

# Which type of surround is being emulated by the spot mikes + panning method?

- At a first glance, it is **discrete**, as the signals are usually delivered ready for the loudspeakers
- But, as the panner usually adjusts amplitude only, the signals are in reality much more similar to those created by a **hierarchical matrix**



# So, what is the real difference between discrete and matrix?

- Whatever the method employed for recording or synthesizing the surround material, every loudspeaker can always be thought to be fed with a signal coming from one or more microphones (virtual or real)



# So, what is the real difference between the two systems?

- In a **Hierarchical Matrix** system, the virtual microphones are always **COINCIDENT**, albeit some types of “Logic” decoders can add delays, which emulates virtual microphones more far from the source
- In a **Discrete** system, the microphones can be either real or virtual, and they can be **SPACED** providing some potential perceptual advantages (and consequent risks)



# Historical review

- Here we show some milestones in the development of surround sound production
- Both **discrete** systems and **hierarchically matrixed** methods are described, as they interleaved during the years



# Timeline

Discrete

Matrix

Solid Music

1934

Fantasia – Fantasound (4 ch.)

1940

Cinerama (6 ch.)

1952

Cinemascope (4 ch.)

1953

Quadraphonic Q8 (4-4-4)

1970

1972

Quad over 2ch: SQ, QS (4-2-4)

1973

Ambisonics

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# Timeline

Discrete

Matrix

1975

Dolby Stereo (4-2-4, optical)

1984

Dolby Surround (VHS tape)

1987

Dolby Pro Logic (VHS tape)

1992

Dolby Digital (lossy, 5.1)  
DTS (5.1), SDDS (7.1), lossy

1993

1998: The DVD !!!!

1999

Dolby Digital Ex, DTS Es (6.1)

2000

Dolby Pro Logic II (5.1)

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# Timeline

## Discrete

Lucas film THX 10.1

NHK 22.2 surround

2+2+2 system

## Matrix

2001  
Ambiophonics

2002  
Dolby Pro Logic II x (6.1)

2003  
Waves IR1, IR360

2004  
Dolby Digital Plus, Dolby TrueHD

2005  
2006: HD-DVD and  
Blue Ray Disc

2007  
Schoeps Double MS

2009  
Dolby Pro Logic II z

2010  
High Order Ambisonics

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# Solid Music (1934)

EVERYDAY SCIENCE AND MECHANICS for APRIL, 1934

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THE INVISIBLE PARADE SEEMS TO MARCH AS THE DIRECTION AND VOLUME OF SOUNDS CHANGE

NUMEROUS SPEAKERS GIVE FORTH LOCALIZED PORTIONS OF TOTAL SOUND EFFECT

With discriminating projection of sounds from speakers properly spaced, the sources of sound seem to move invisibly about the auditorium.

## "Three-Dimensional" Sounds Created

● LIKE pictures on a screen, the best of public-address amplification and loud-speaker reproduction hitherto available has lacked reality. It is not that the instruments are defective in their repre-

tion high, but each of the multiple speakers used is giving out a different interpretation of the sounds picked up. The result is that the ear, receiving varied sounds from different directions, finds in



# Fantasia - Fantasound (1940)



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# Fantasia - Fantasound (1940)

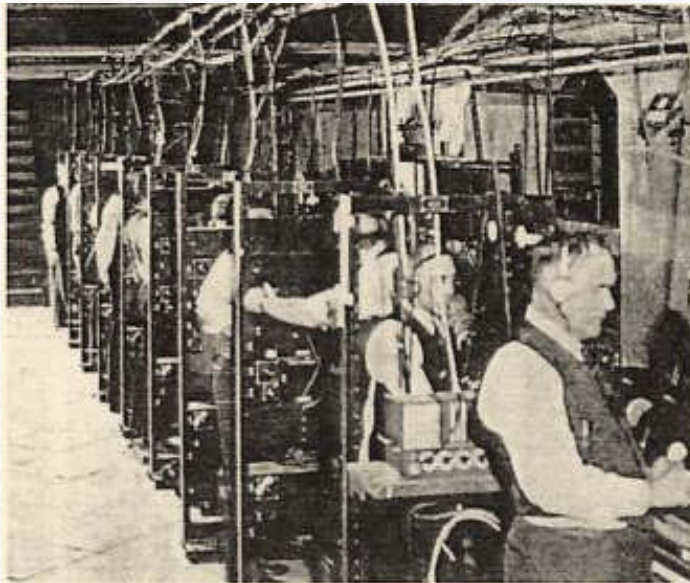


FIG. 11. View of eight recording channels at the Philadelphia Academy of Music.



FIG. 12. View of some of the mixer positions at the Philadelphia Academy of Music.



FIG. 13. View of the 3-channel mixing position used in scoring the *Fantasia* vocal numbers at Burbank. (Messrs. Hawkins, Hissrich, and Marr.)

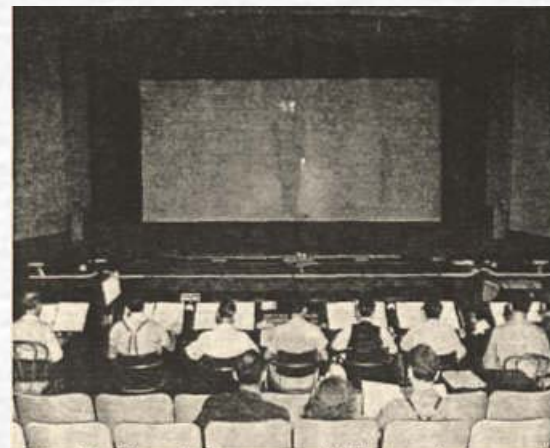


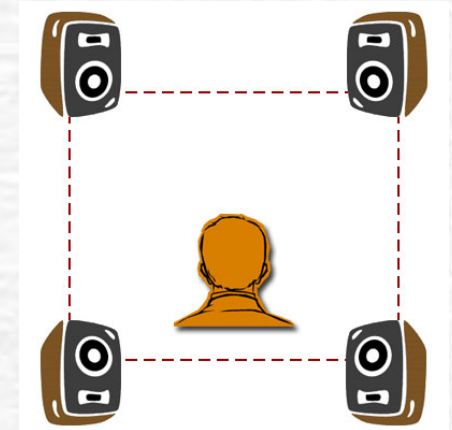
FIG. 14. View of the program dubbing console in operation. (Tone console not shown.) (Left to right, at console, Messrs. Blinn, Steck, Marr, Perry, Moss, Hawkins, Slyfield, and Hissrich. At rear, Ed Plumb, *Musical Director*; Luisa Fiels, *Asst. Music Cutter*, and Stephen Csillag, *Music Cutter*.)

# Cinerama (1953) – Cinemascope (1954)



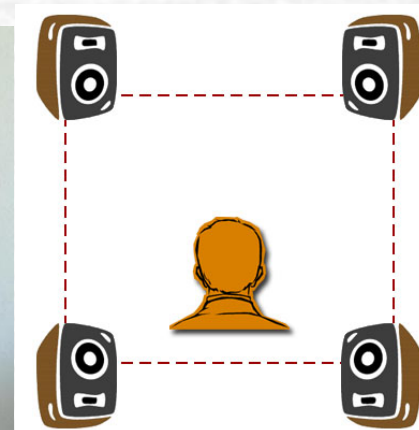
Cinemascope was also a discrete magnetic 4-channels, but one of them was used for surround

# Quadraphony (1970)



4-tracks tape, reel-to-reel deck, 4 loudspeakers

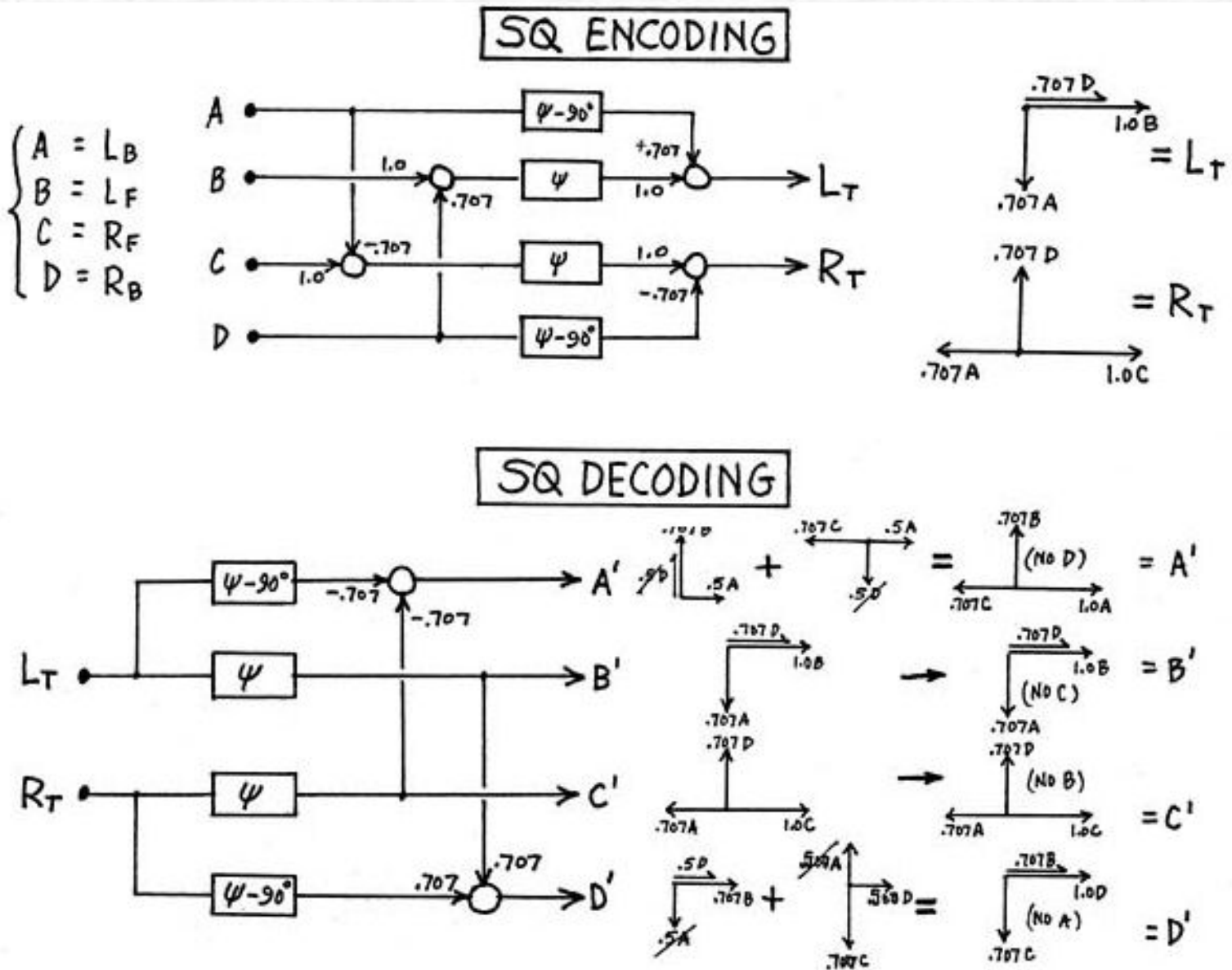
# Quad matrixed QS, SQ etc. (1972)



Matrix-encoded vinyl,  
analog decoder, 4 loudspeakers



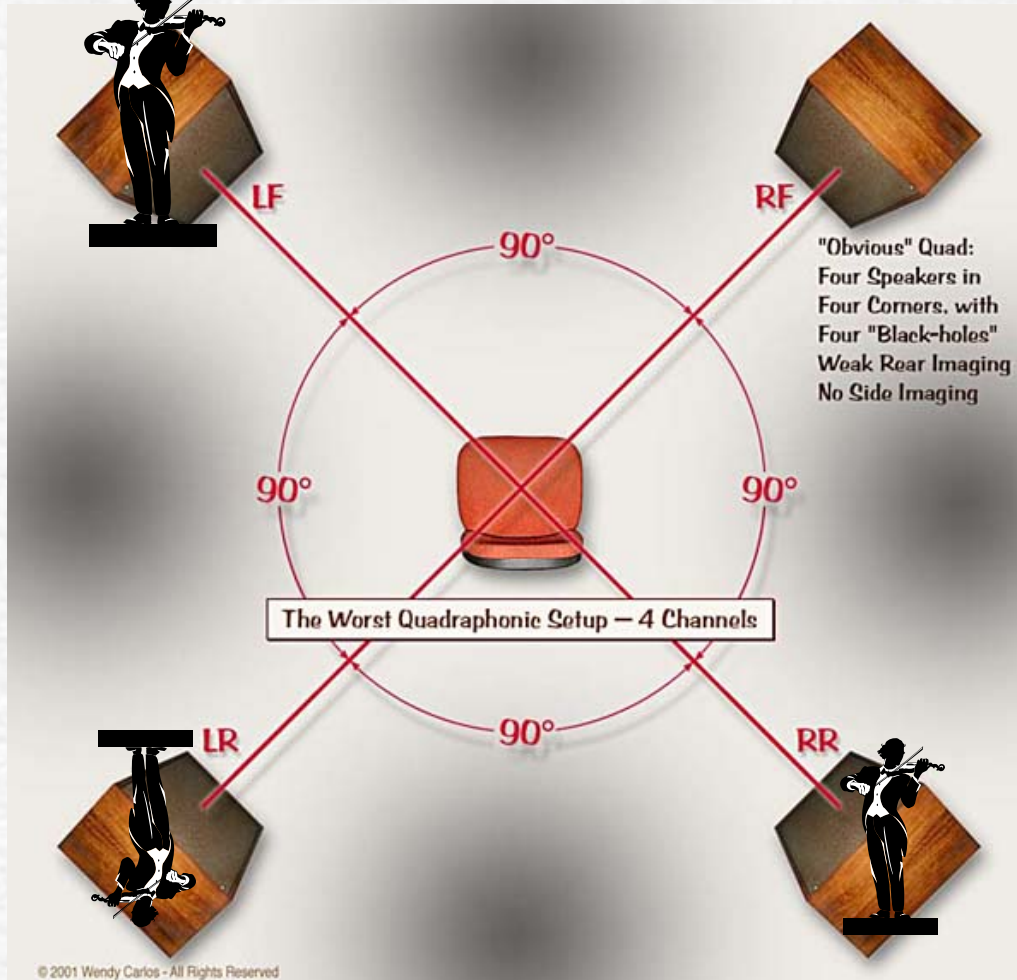
# Quad matrixed SQ (1972)



# Quad matrixed SQ (1972)

0 dB

$-\infty$  dB



-3 dB

-3 dB

A signal Hard-panned Front Left

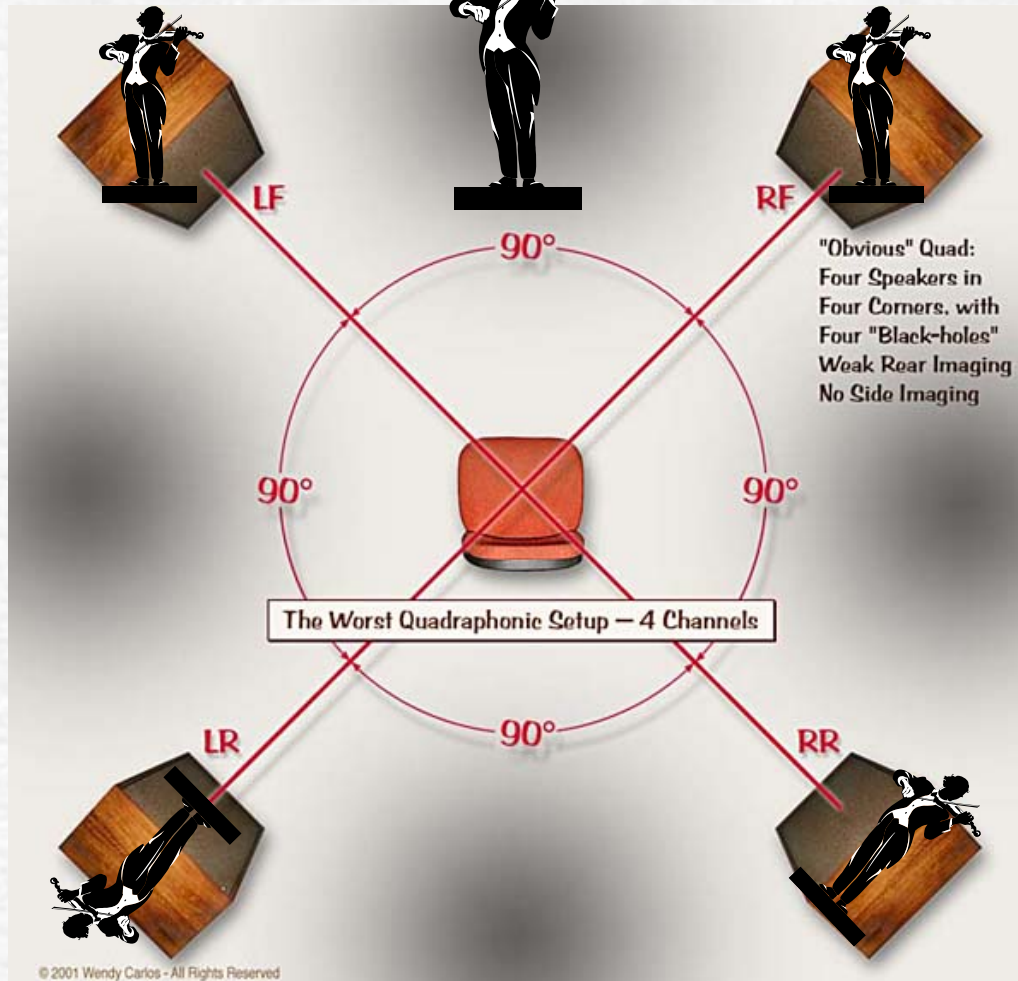
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# Quad matrixed SQ (1972)

-3 dB

-3 dB



-3 dB

-3 dB

A signal Hard-panned Center

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# Ambisonics (1973)



Michael Gerzon and Peter Fellgett

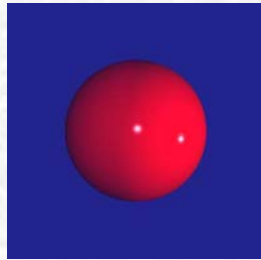
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# Ambisonics theory

It was the first method based on both mathematical/physical analysis and psychoacoustics

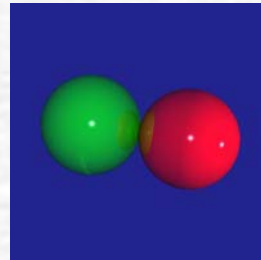
The spatial properties of the sound field in a point are described by 4 physical signals, the sound pressure and the three Cartesian components of particle velocity



W



X



Y

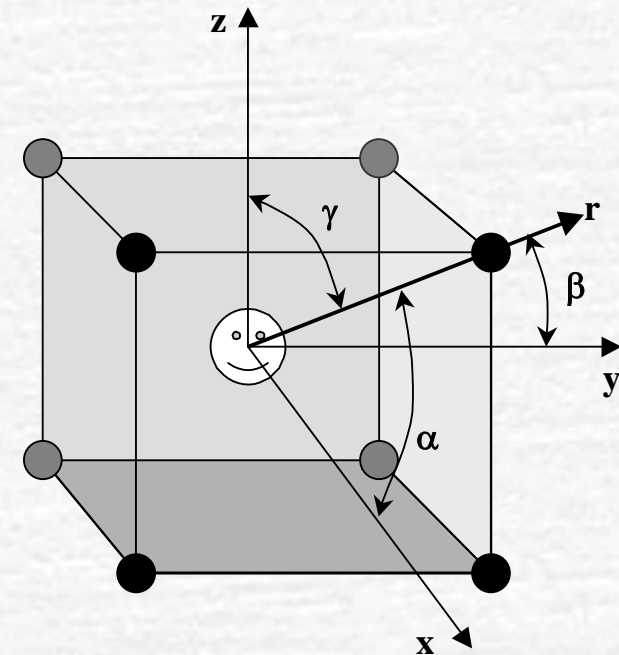
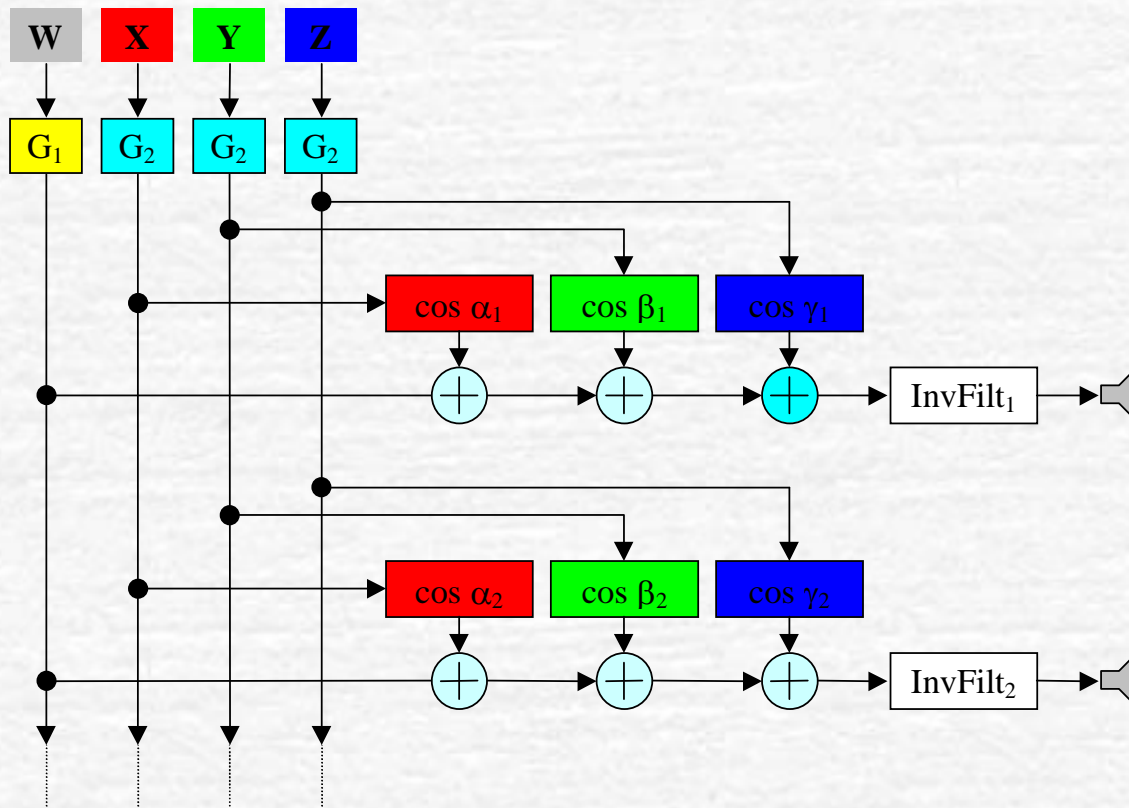


Z



# Ambisonics theory

Each loudspeaker is fed with a proper mix of these 4 signals, with gains carefully computed for satisfying a psychoacoustic criterion



# Psychoacoustic criteria

- At low frequency ( $<500$  Hz), the gains are adjusted so that the pressure and particle velocity signals are carefully reconstructed at the center of the array, making use of “push-pull” effects obtained generating out-of-phase signals
- At higher frequencies, the gains are adjusted so that the Sound Intensity vector recreated at the center of the array is as close as possible to the original one
- Shelf filters are employed for making the gains frequency-dependent



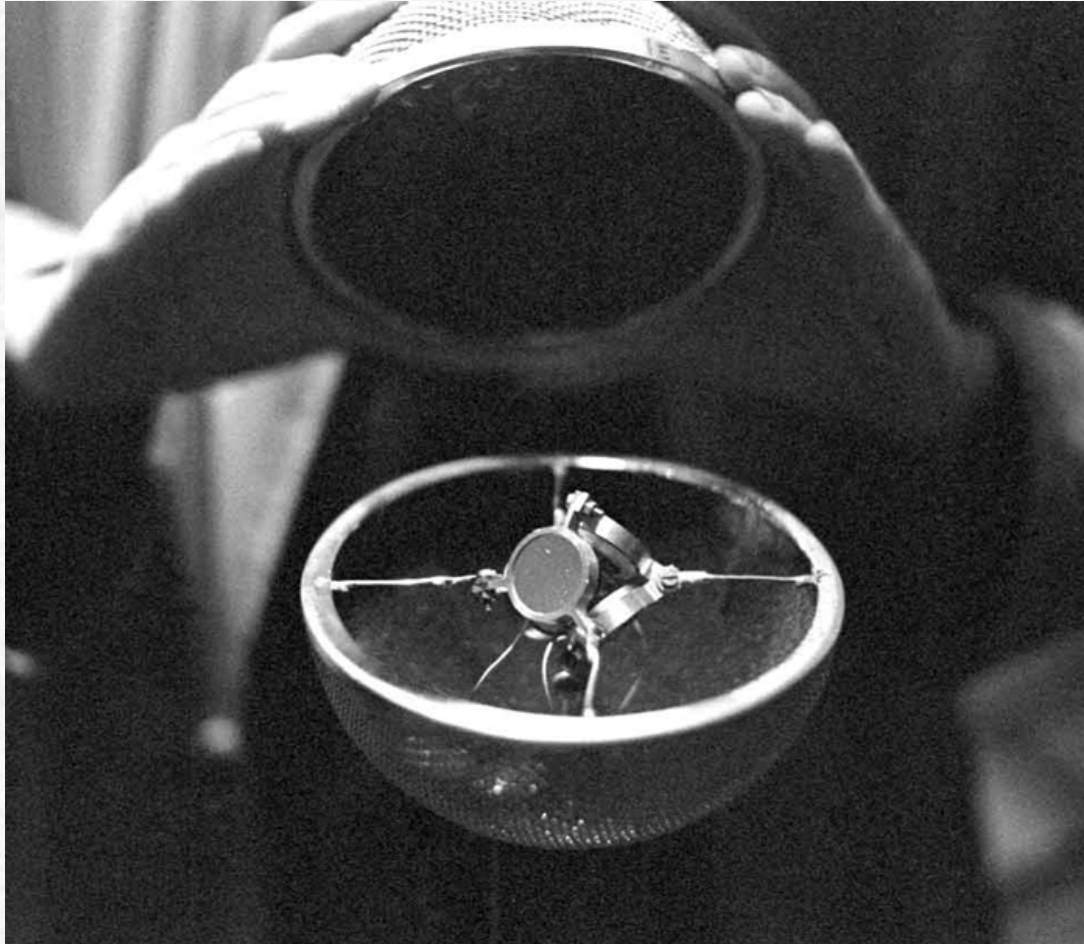
# Capturing the Ambisonics signals

- A tetrahedral microphone probe was developed by Gerzon and Craven, originating the Soundfield microphone





# Soundfield microphones

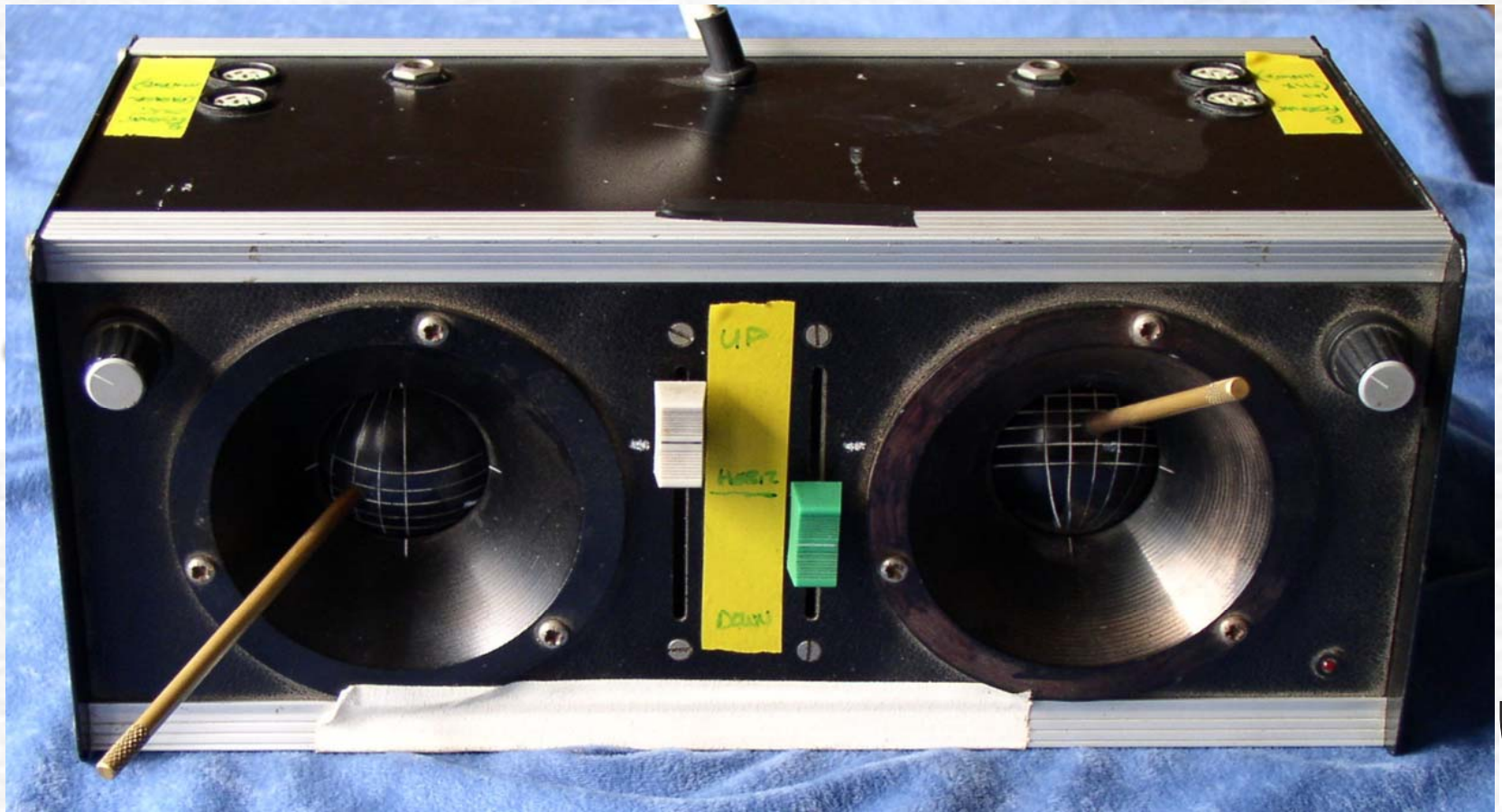


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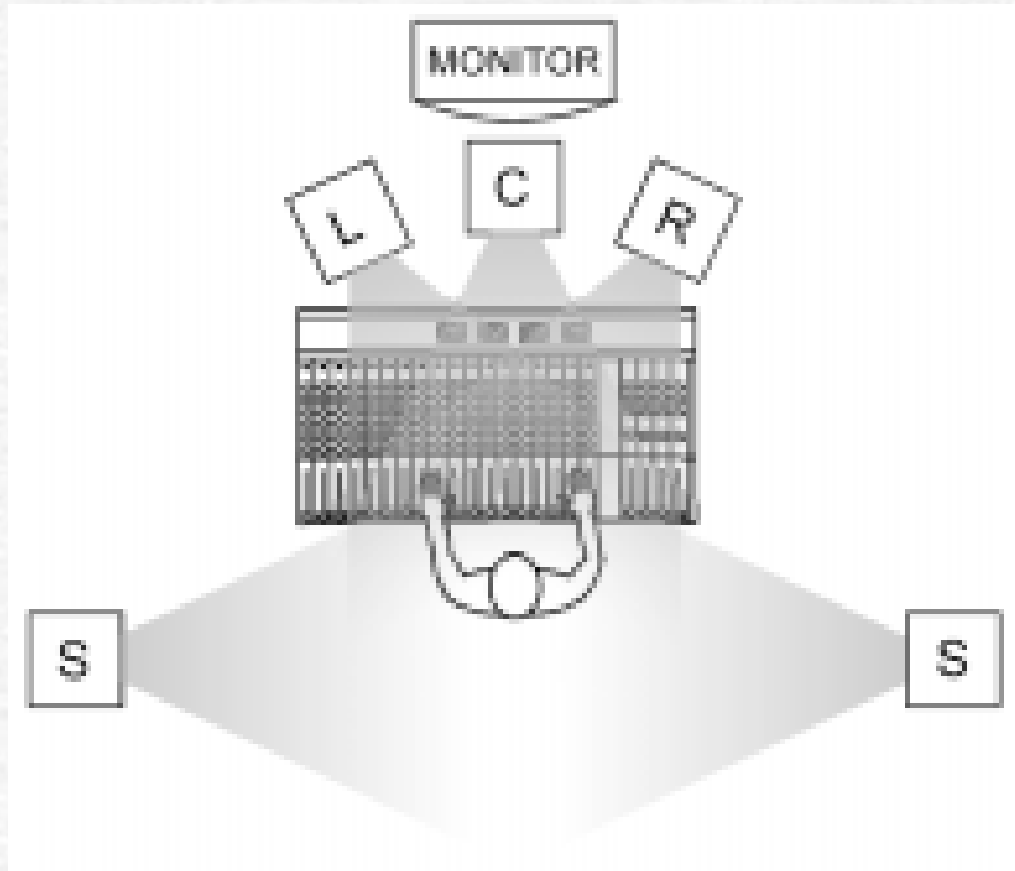


# Synthetic Ambisonics signals

One of the most appealing advantages of Ambisonics is the capability of creating synthetic signals with simple encoding formulas, and to change dynamically the source position

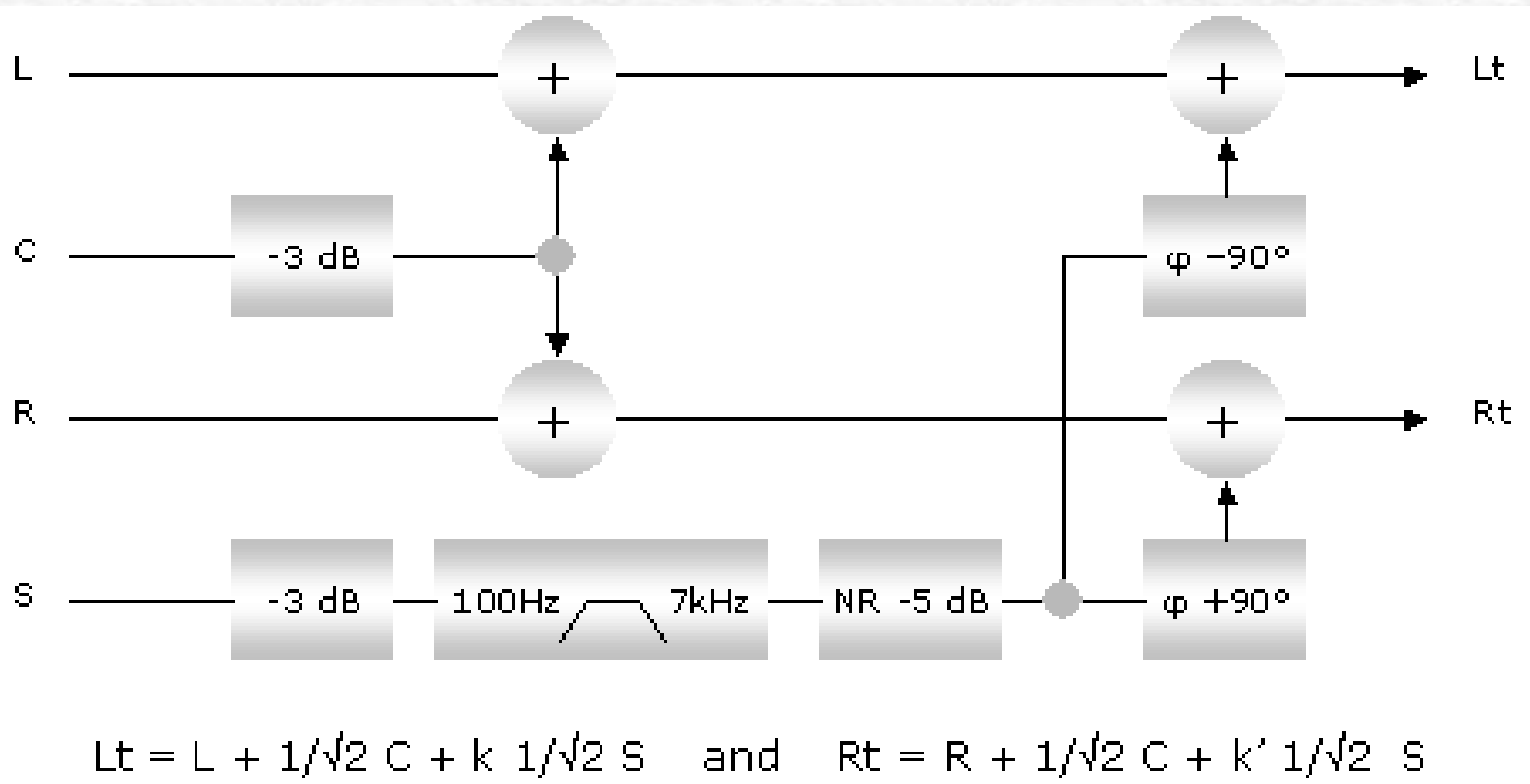


# Dolby Stereo / Surround (1975)



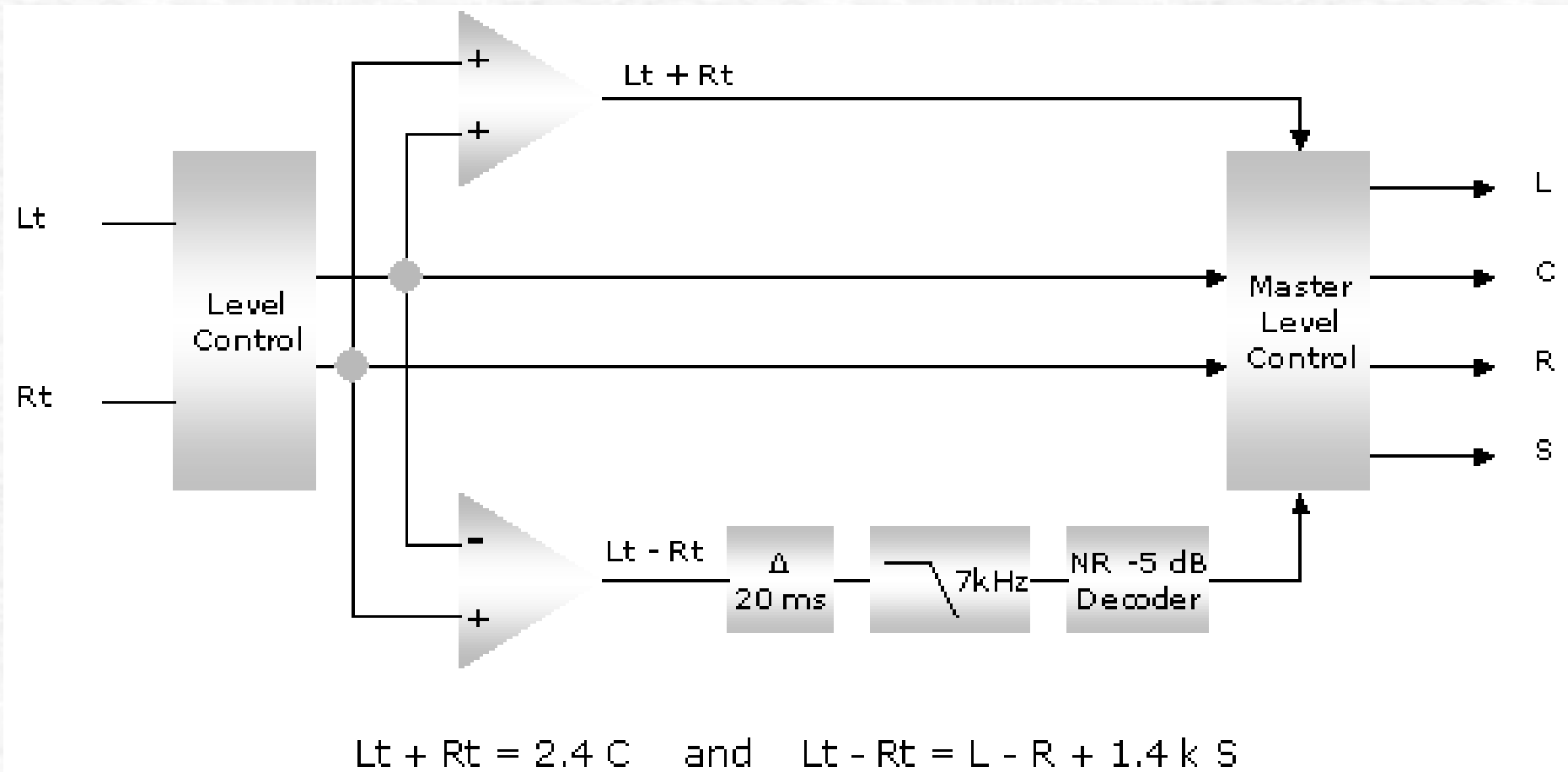
Layout

# Dolby Surround



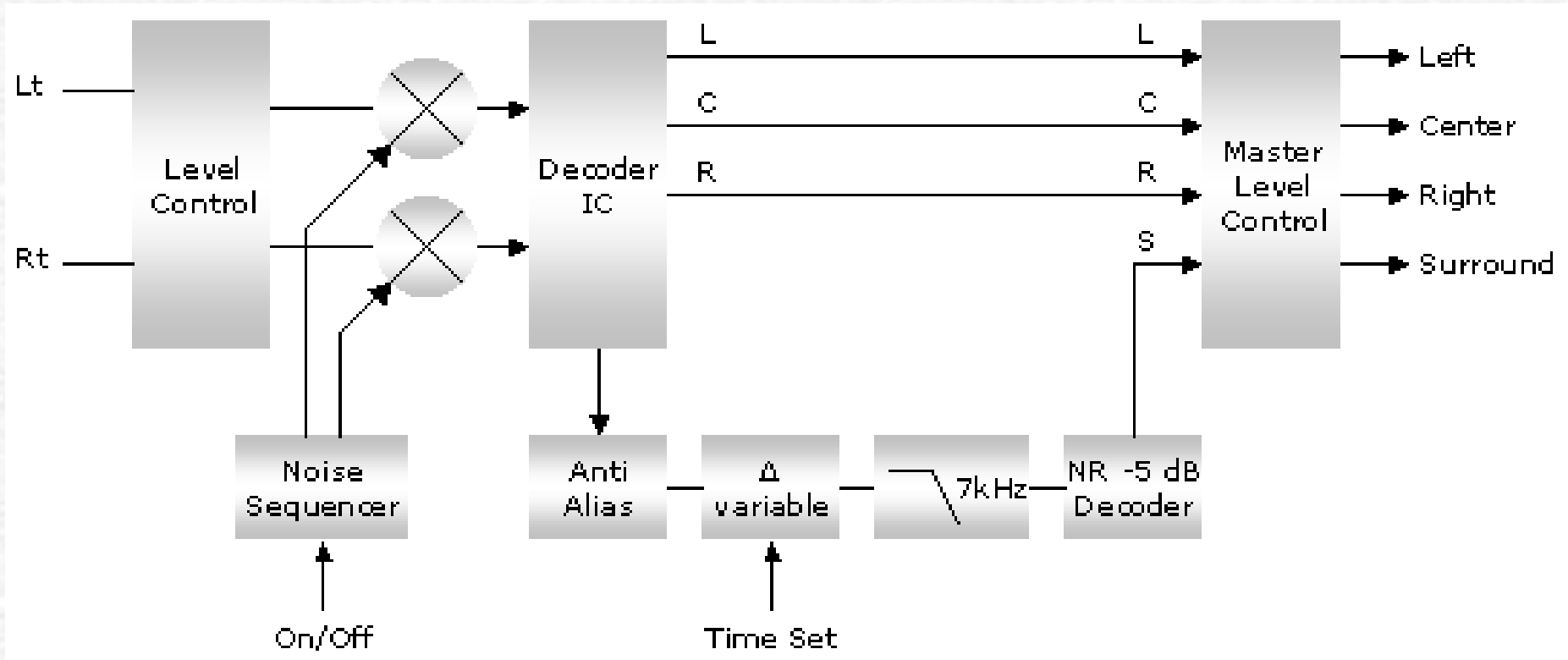
## Encoder

# Dolby Surround



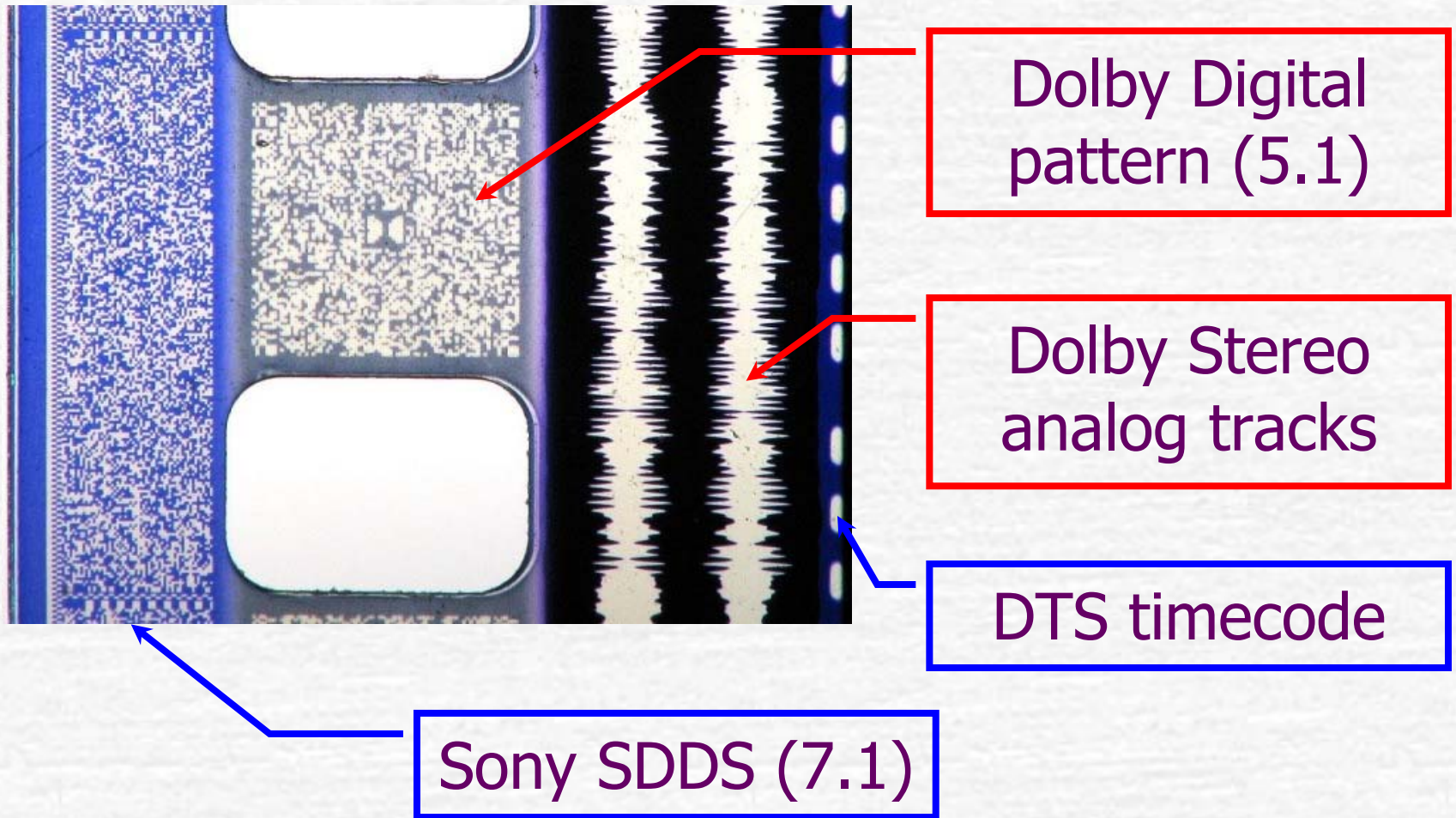
## Decoder

# Dolby Pro Logic (1987)



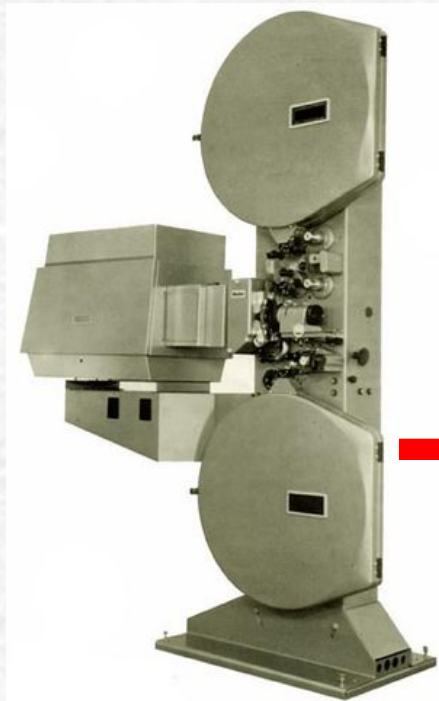
## Decoder

# Dolby Digital – AC3 (1992)

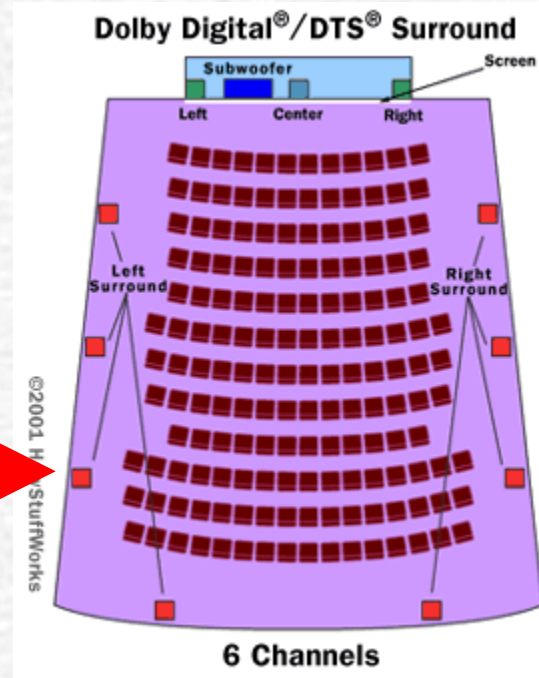


Optical digital patterns on the film

# DTS (1993)



DTS-6



An optical timecode on the film synchronizes a CD player loaded with a DTS-encoded audio CD





# Discrete microphone arrays

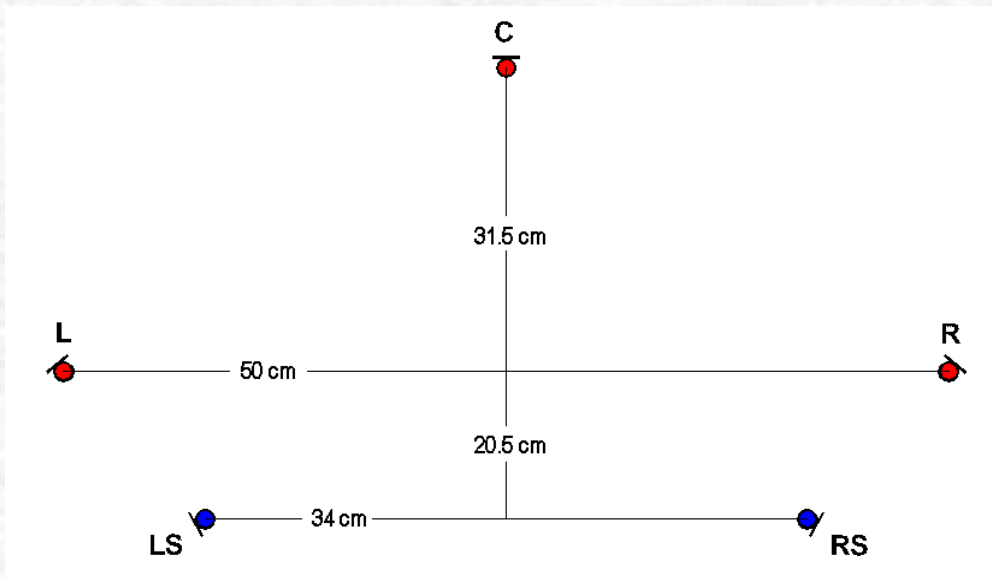


The new discrete digital formats allowed for true discrete microphone systems

# Discrete microphone arrays

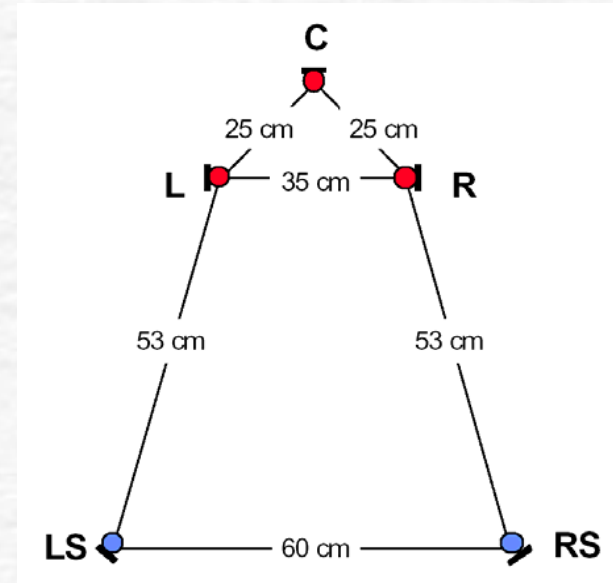
## Williams MMA

C : Cardioid,  $0^\circ$   
L, R : Cardioid,  $\pm 40^\circ$   
LS, RS : Cardioid,  $\pm 120^\circ$



## INA-5

C : Cardioid,  $0^\circ$   
L, R : Cardioid,  $\pm 90^\circ$   
LS, RS : Cardioid,  $\pm 150^\circ$

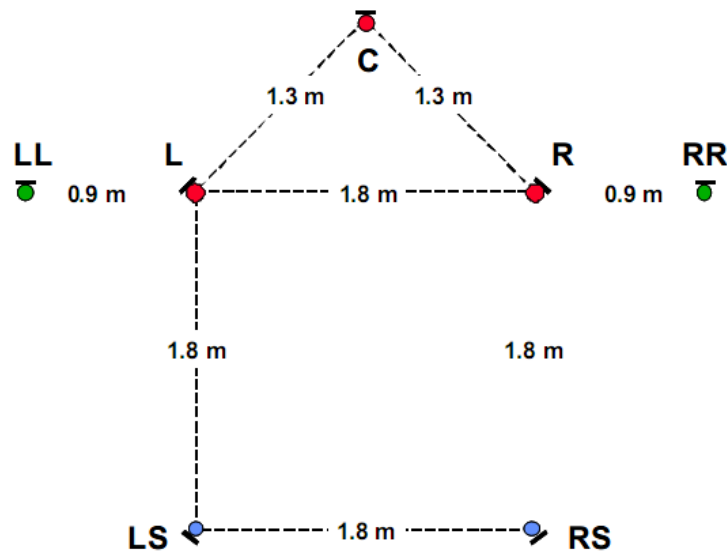


Several "standard" setups were developed

# Discrete microphone arrays

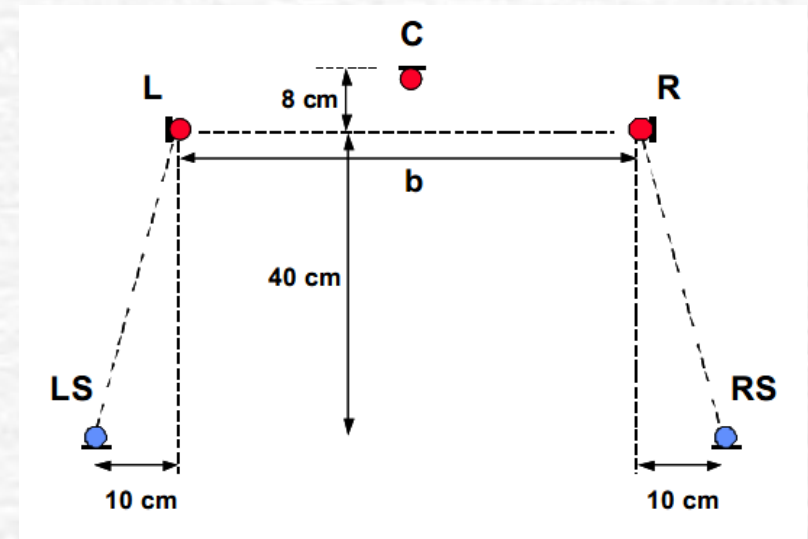
- Fukuda tree

C : Cardioid,  $0^\circ$   
L, R : Cardioid,  $\pm 45^\circ$   
LS, RS : Cardioid,  $\pm 135^\circ$   
LL, RR: Omni



- OCT-surround

C : Cardioid,  $0^\circ$   
L, R : Cardioid,  $\pm 90^\circ$   
LS, RS : Cardioid,  $\pm 180^\circ$



Several "standard" setups were developed

# Software for array design

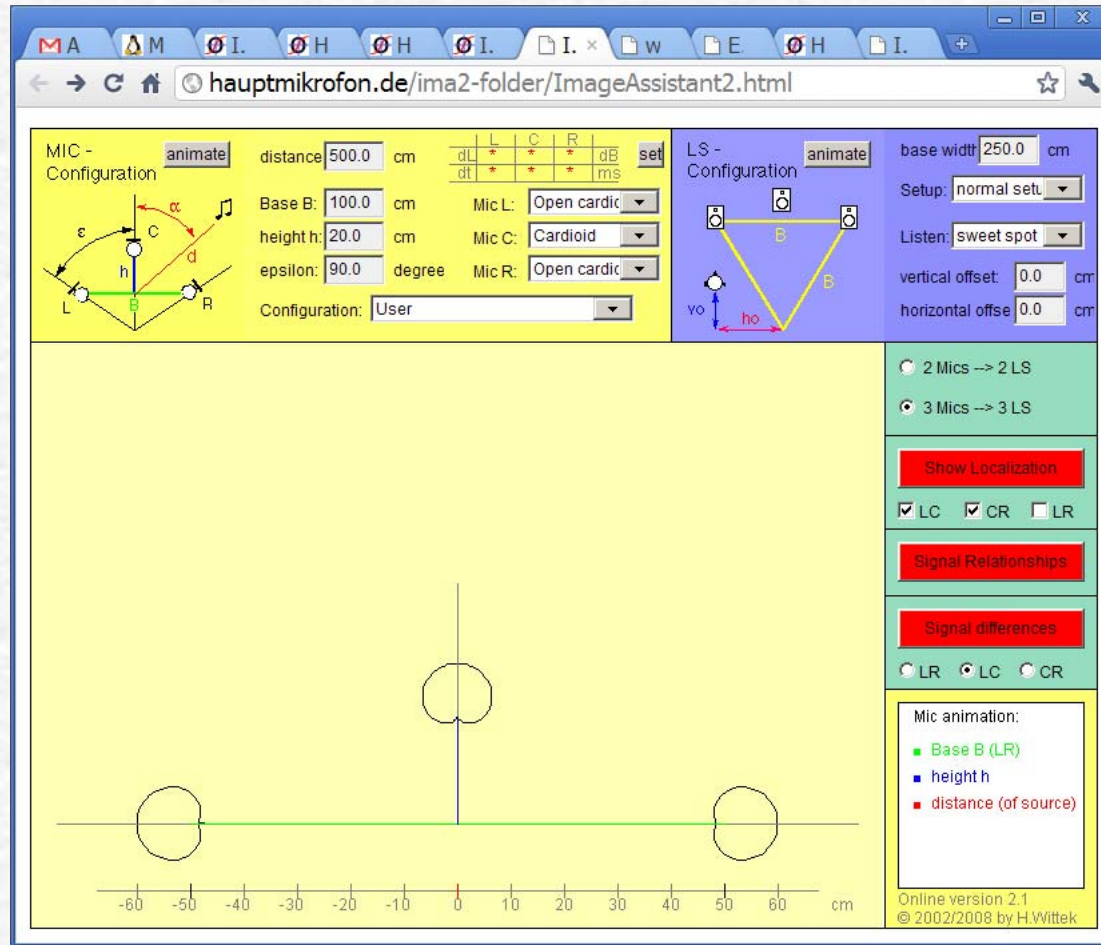


Image Assistant by H. Wittek

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# Software for array design

The screenshot shows the ImageAssistant2 web application interface. The browser address bar indicates the URL: `hauptmikrofon.de/ima2-folder/ImageAssistant2.html`. The interface is divided into several sections:

- MIC - Configuration (Yellow Panel):** Includes an "animate" button, a "distance" input set to 500.0 cm, and a table for microphone characteristics:

|    | L | C | R |    |
|----|---|---|---|----|
| dL | * | * | * | dB |
| dt | * | * | * | ms |

Other parameters include Base B: 100.0 cm, height h: 20.0 cm, epsilon: 90.0 degree, and Configuration: User. A diagram shows a microphone array with points L, C, R and a listening position B.
- LS - Configuration (Blue Panel):** Includes an "animate" button, base width: 250.0 cm, Setup: normal setu, Listen: sweet spot, vertical offset: 0.0 cm, and horizontal offset: 0.0 cm. A diagram shows a listening position (LS) relative to the microphone array.
- Main Visualization (Light Blue Area):** Displays a 3-microphone array (L, C, R) and a listening position (LS) forming a triangle. The LS is positioned below the array.
- Control Panel (Right Side):** Features radio buttons for "2 Mics -> 2 LS" and "3 Mics -> 3 LS", buttons for "Show Localization", "Signal Relationships", and "Signal differences", and radio buttons for "LR", "LC", and "CR".
- Legend (Bottom Right):** Defines LS animation: green line for LS base width, blue square for vertical offset, red square for horizontal offset, and a circle for Listening Position.
- Footer (Bottom Right):** Online version 2.1, © 2002/2008 by H.Wittek.

Image Assistant by H. Wittek

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# Software for array design

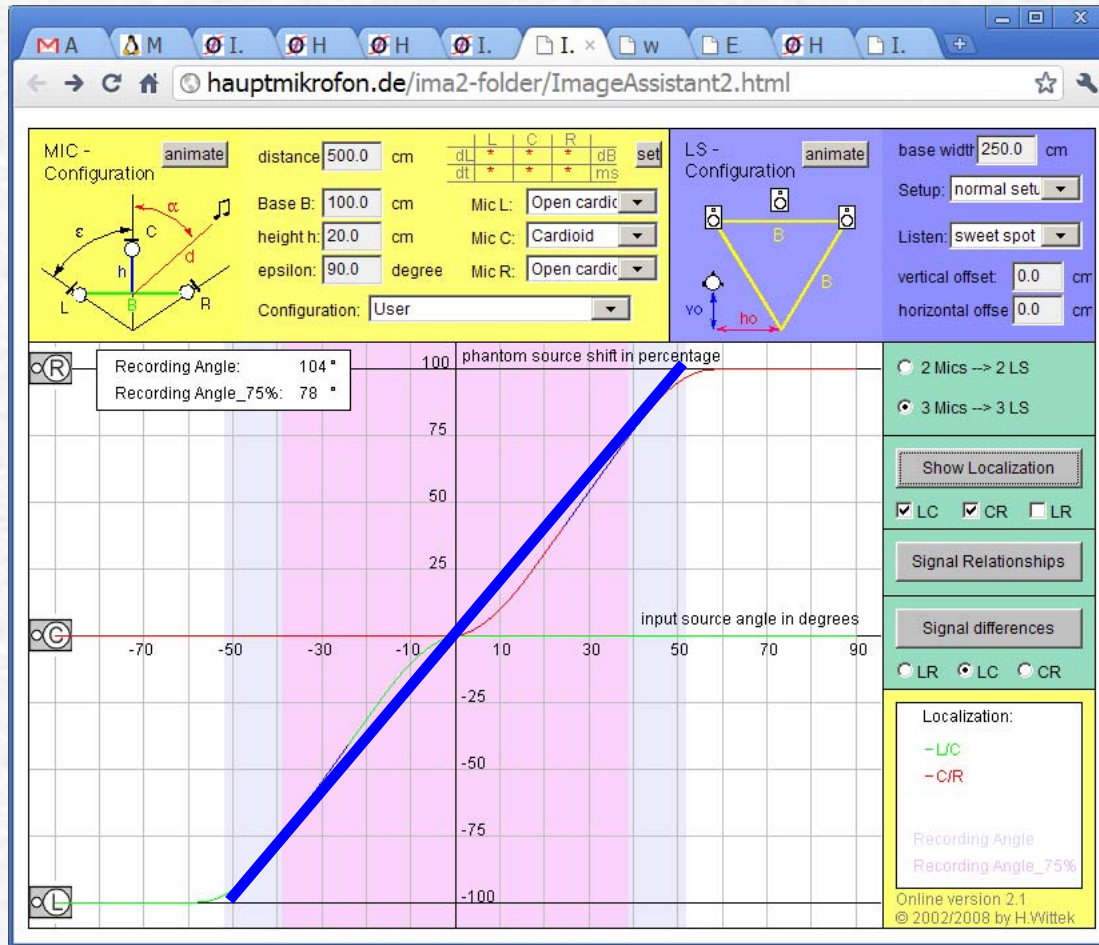


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- MIC - Configuration (Yellow Panel):** Includes an "animate" button, a diagram of a microphone array with parameters  $\epsilon$ ,  $h$ ,  $C$ ,  $L$ ,  $R$ , and  $d$ . Parameters include: distance: 500.0 cm, Base B: 100.0 cm, height h: 20.0 cm, epsilon: 90.0 degree, Configuration: User. A table shows microphone characteristics for L, C, and R channels.
- LS - Configuration (Blue Panel):** Includes an "animate" button and a diagram of a listening position (LS) with parameters  $vo$ ,  $ho$ , and  $B$ . Parameters include: base width: 250.0 cm, Setup: normal setu, Listen: one seat left, vertical offset: 0.0 cm, horizontal offset: -50.0 cm.
- Main Visualization (Light Blue Area):** Displays a 3D perspective view of the microphone array (three mics) and the listening position (LS) relative to the array.
- Control Panel (Right Side):** Includes radio buttons for "2 Mics -> 2 LS" and "3 Mics -> 3 LS", buttons for "Show Localization", "Signal Relationships", and "Signal differences", and radio buttons for "LR", "LC", and "CR".
- Legend (Bottom Right):** "LS animation:" with color-coded markers: green square for "LS base width", blue square for "vertical offset", red square for "horizontal offset", and a circle for "Listening Position".
- Footer (Bottom Right):** "Online version 2.1 © 2002/2008 by H.Wittek".

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# Software for array design

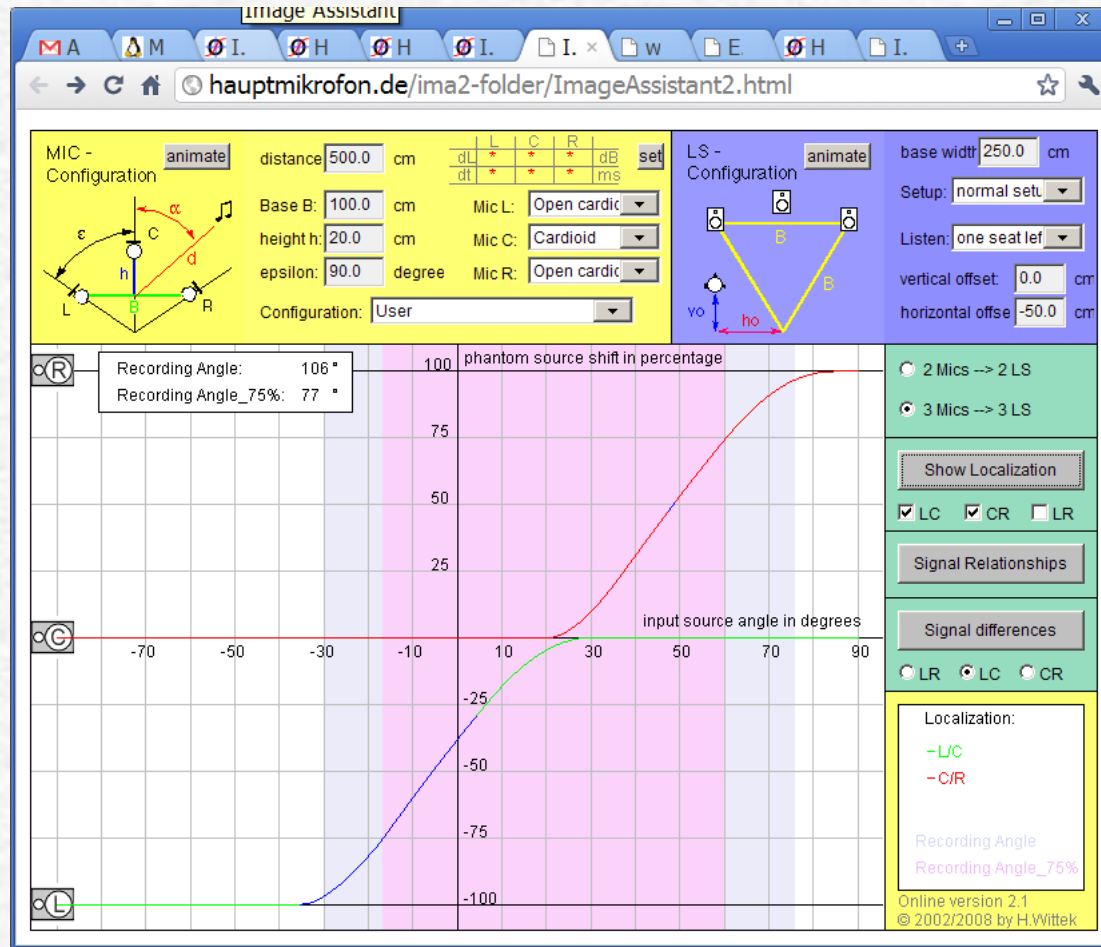


Image Assistant by H. Wittek

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# Software for array design

**SOS MMAD**

THE FIRST STAGE IN THE SELECTION OF A SPECIFIC MULTICHANNEL MICROPHONE ARRAY IS THE CHOICE OF THE FRONT TRIPLET COVERAGE

The Front Triplet Coverage determines the part of the original sound field that will be reproduced by the front set of loudspeakers. The left front segment (in red), as defined by the Front Triplet Coverage characteristics, will be reproduced between the left-hand front loudspeaker and the centre loudspeaker, whilst the right front segment (in green), will be reproduced between the centre and the right-hand loudspeakers, as shown below.

CLICK ON THE FRONT TRIPLET COVERAGE THAT IS REQUIRED

| FTC 100° + 100° | FTC 95° + 95° | FTC 90° + 90° | FTC 85° + 85°  |
|-----------------|---------------|---------------|--|
|                 |               |               |  |
|                 |               |               |  |
|                 |               |               | No solutions are available with satisfactory Critical Linking for this angle of Front Triplet Coverage |

[Click here for more information concerning Multichannel Microphone Array Design or the MMAD CD-ROM project](#)

SOS MMAD by Mike Williams

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# Software for array design

There are many microphone configurations that will produce a Front Triplet Coverage of  $75^\circ + 75^\circ$ . Here are a few possible combinations showing both the distance and the orientation of the microphones. Click on the required combination to go to the next stage in the MMAD process.

FTC  $75^\circ + 75^\circ$

| $100^\circ / 31 \text{ cm}$  | $90^\circ / 32.9 \text{ cm}$ | $80^\circ / 35.1 \text{ cm}$ | $70^\circ / 37.7 \text{ cm}$ |
|------------------------------|------------------------------|------------------------------|------------------------------|
|                              |                              |                              |                              |
| $60^\circ / 40.4 \text{ cm}$ | $50^\circ / 43.3 \text{ cm}$ | $40^\circ / 46.4 \text{ cm}$ | $30^\circ / 49 \text{ cm}$   |
|                              |                              |                              |                              |

Home Page  
Mic Array Design  
Mic Support Systems & Accessories  
Teaching Software  
Audio Bookshop

2 Channels ("Stereo")  
3 Channels ("Triphony")  
4 Channels ("Quadrphony")  
5 Channels ("Multichannel")  
6 Channels ("Hexaphony")  
7 Channels ("Septaphony")

FTC  $100^\circ + 100^\circ$   
FTC  $95^\circ + 95^\circ$   
FTC  $90^\circ + 90^\circ$   
FTC  $85^\circ + 85^\circ$   
FTC  $80^\circ + 80^\circ$   
FTC  $75^\circ + 75^\circ$   
FTC  $70^\circ + 70^\circ$   
FTC  $65^\circ + 65^\circ$   
FTC  $60^\circ + 60^\circ$   
FTC  $55^\circ + 55^\circ$

$100^\circ / 31 \text{ cm}$   
 $90^\circ / 32.9 \text{ cm}$   
 $80^\circ / 35.1 \text{ cm}$   
 $70^\circ / 37.7 \text{ cm}$   
 $60^\circ / 40.4 \text{ cm}$   
 $50^\circ / 43.3 \text{ cm}$   
 $40^\circ / 46.4 \text{ cm}$   
 $30^\circ / 49 \text{ cm}$

file:///E:/Users/Farina/Articoli/AES-40/KeyNote/MMAD/FTC/FTC\_75/FTC\_75\_Config/FTC\_75\_b40.htm

SOS MMAD by Mike Williams

40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



# Software for array design

The screenshot shows the SOS MMAD software interface. At the top, a browser window displays the URL: `file:///E:/Users/Farina/Articoli/AES-40/KeyNote/MMAD/FTC/FTC_75/FTC_75_Config/FTC_75_`. The main content area features a title "SOS MMAD" and a text block: "Using a Front Triplet Coverage of  $75^\circ + 75^\circ$  (with the microphones at  $90^\circ / 32.9$  cm), there are many different LSC / BPC configurations possible. Click on the required LSC / BPC configuration to go to the last stage in the MMAD process."

Below this, a section titled "The next stage is to choose the proportion of Back Pair Coverage to the left and right Lateral Segment Coverage" is followed by a diagram of a microphone array with six microphones and a color-coded coverage diagram. The diagram shows a circle divided into segments: red, green, cyan, black, magenta, and red. A larger diagram below shows the same array with a yellow circle highlighting the central area.

The main configuration grid is titled "FTC  $75^\circ + 75^\circ$  ( $90^\circ / 32.9$  cm)" and contains six circular diagrams representing different LSC / BPC configurations:

- LSC  $60^\circ$  &  $60^\circ$  / BPC  $90^\circ$
- LSC  $65^\circ$  &  $65^\circ$  / BPC  $80^\circ$  (highlighted with a blue circle)
- LSC  $70^\circ$  &  $70^\circ$  / BPC  $70^\circ$
- LSC  $75^\circ$  &  $75^\circ$  / BPC  $60^\circ$
- LSC  $80^\circ$  &  $80^\circ$  / BPC  $50^\circ$
- LSC  $85^\circ$  &  $85^\circ$  / BPC  $40^\circ$

At the bottom, there is a navigation menu with "Home Page" and "Mic Array Design". The "Mic Array Design" menu includes options for 2 Channels ("Stereo"), 3 Channels ("Triphony"), 4 Channels ("Quadraphony"), 5 Channels ("Multichannel"), 6 Channels ("Hexaphony"), and 7 Channels ("Septaphony"). A central panel shows "FTC  $75^\circ + 75^\circ$ " with a table of configurations:

|                             |                      |                                 |
|-----------------------------|----------------------|---------------------------------|
| FTC $100^\circ + 100^\circ$ | $100^\circ / 31$ cm  | LSC $60^\circ$ / BPC $90^\circ$ |
| FTC $95^\circ + 95^\circ$   | $90^\circ / 32.9$ cm | LSC $65^\circ$ / BPC $80^\circ$ |
| FTC $90^\circ + 90^\circ$   | $80^\circ / 35.1$ cm | LSC $70^\circ$ / BPC $70^\circ$ |
| FTC $85^\circ + 85^\circ$   | $70^\circ / 37.7$ cm | LSC $75^\circ$ / BPC $60^\circ$ |
| FTC $80^\circ + 80^\circ$   | $60^\circ / 40.4$ cm | LSC $80^\circ$ / BPC $50^\circ$ |
| FTC $75^\circ + 75^\circ$   | $50^\circ / 43.3$ cm | LSC $85^\circ$ / BPC $40^\circ$ |
| FTC $70^\circ + 70^\circ$   | $40^\circ / 46.4$ cm |                                 |

SOS MMAD by Mike Williams

40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



# Software for array design

The screenshot displays the SOS MMAD software interface. At the top, a browser window shows the file path: `file:///E:/Users/Farina/Articoli/AES-40/KeyNote/MMAD/FTC/FTC_75/FTC_75_Config/3071.htr`. Below the browser, a text box explains: "There are many microphone configurations that will produce a left and right Lateral Segment Coverage of 65° and Back Pair Coverage of 80°. Here are a few possible combinations showing both the distance and the orientation of the Back Pair of microphones. Click on the required combination to see the detailed full screen plan of the Multichannel Microphone Array and the value of Electronic Offset required to achieve Critical Linking."

The main area shows a grid of microphone array diagrams. The title for this grid is "FTC 75° + 75° (90° / 32.9 cms), LSC 65° & 65°, BPC 80°". Each diagram shows a circular array of microphones with various parameters labeled. The diagrams are arranged in a grid with the following labels below them:

|                |                |                |                |
|----------------|----------------|----------------|----------------|
| 100° / 27 cms  | 90° / 29.5 cms | 80° / 32 cms   | 70° / 34.5 cms |
| 60° / 37.1 cms | 50° / 39.8 cms | 40° / 42.7 cms | 30° / 45.8 cms |

At the bottom, there is a "Crosstrack shortcuts" section with two rows of buttons:

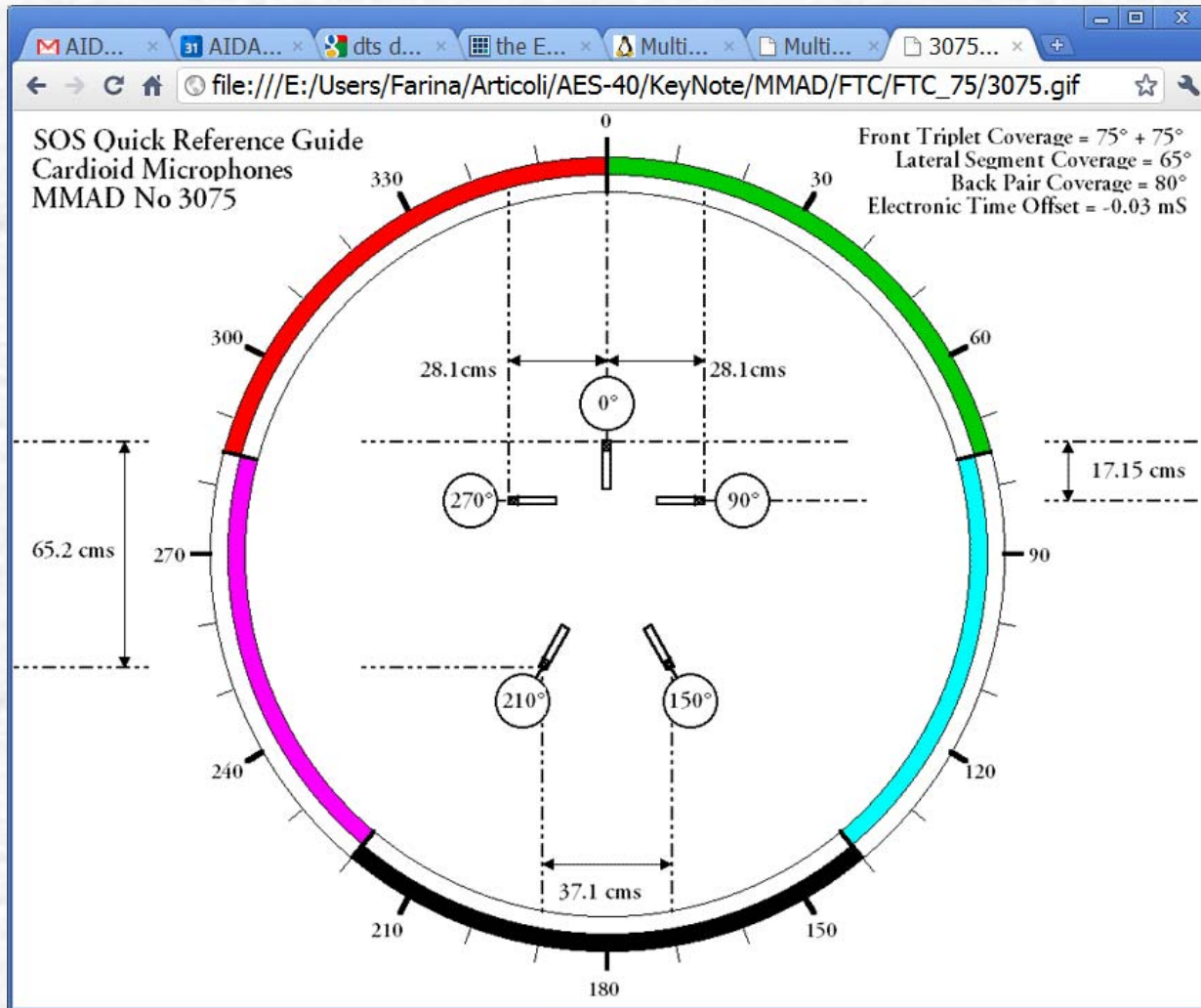
|            |          |     |     |     |     |     |     |     |     |     |     |
|------------|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| MMAD Start | FTC 100° | 95° | 90° | 85° | 80° | 75° | 70° | 65° | 60° | 55° | 50° |
|            | BPC 90°  | 80° | 70° | 60° | 50° | 40° |     |     |     |     |     |

SOS MMAD by Mike Williams

40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



# Software for array design



SOS MMAD by Mike Williams

40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



# A compact self-contained array



Holophone "pear-shaped" arrays

40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



# Characterization of the Holophone

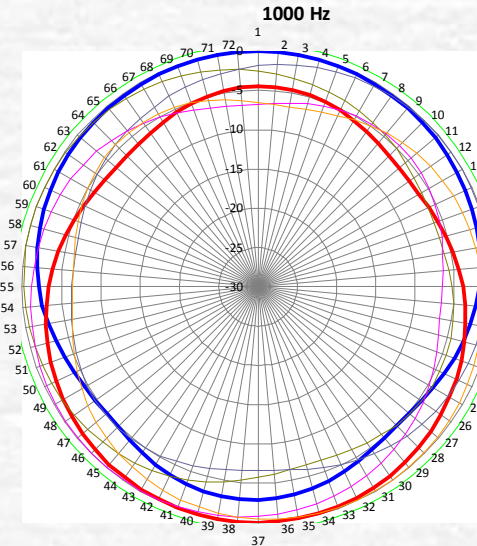
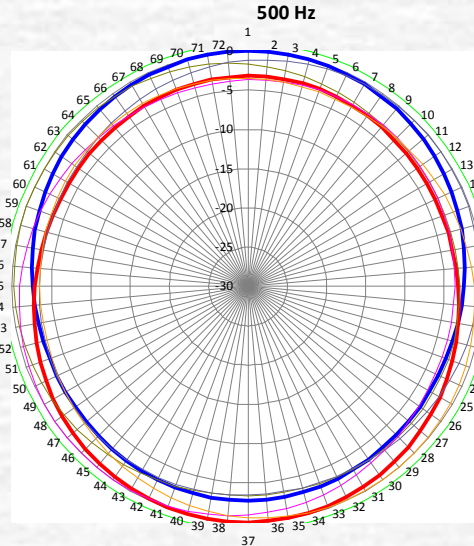
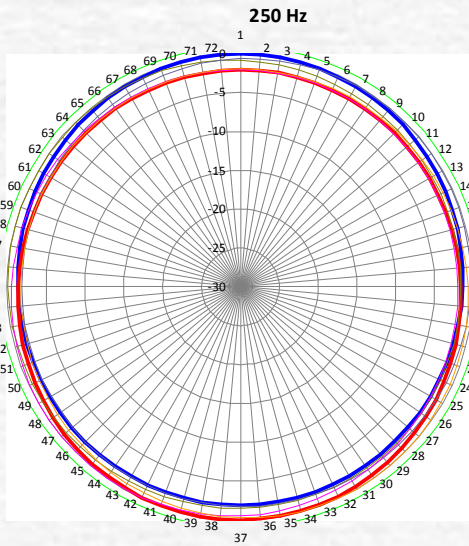


- The Holophone H2 Pro is a microphone system equipped with 8 capsules placed on an egg-shaped framework. The audio signals are delivered directly in G-format or using an audio mixer.

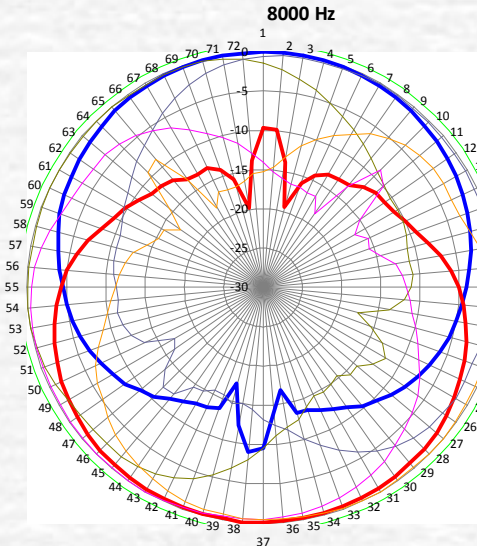
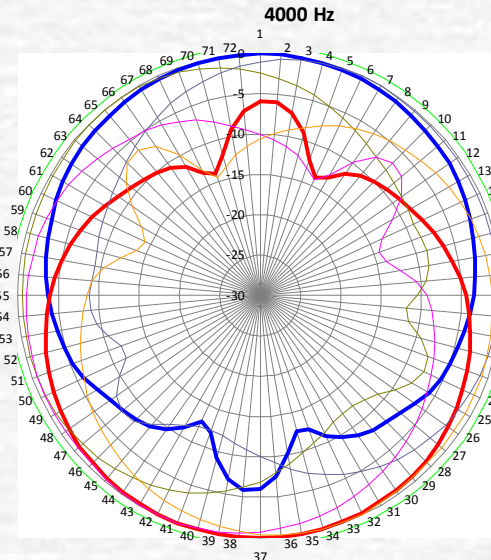
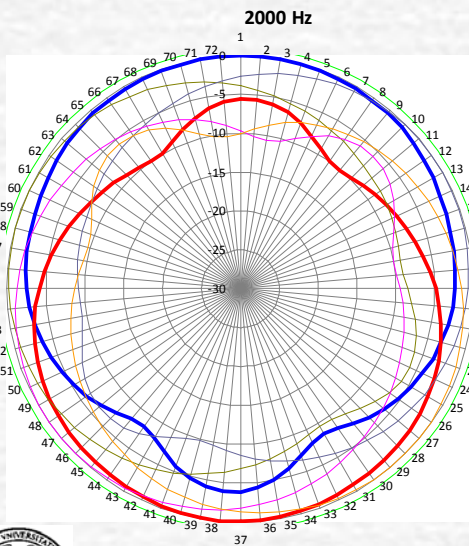


- The directivity of each Holophone capsule was measured in the Anechoic Room of “Università’ di Ferrara” (Italy)

# Holophone polar patterns



- C
- CS
- L
- R
- LS
- RS
- Top



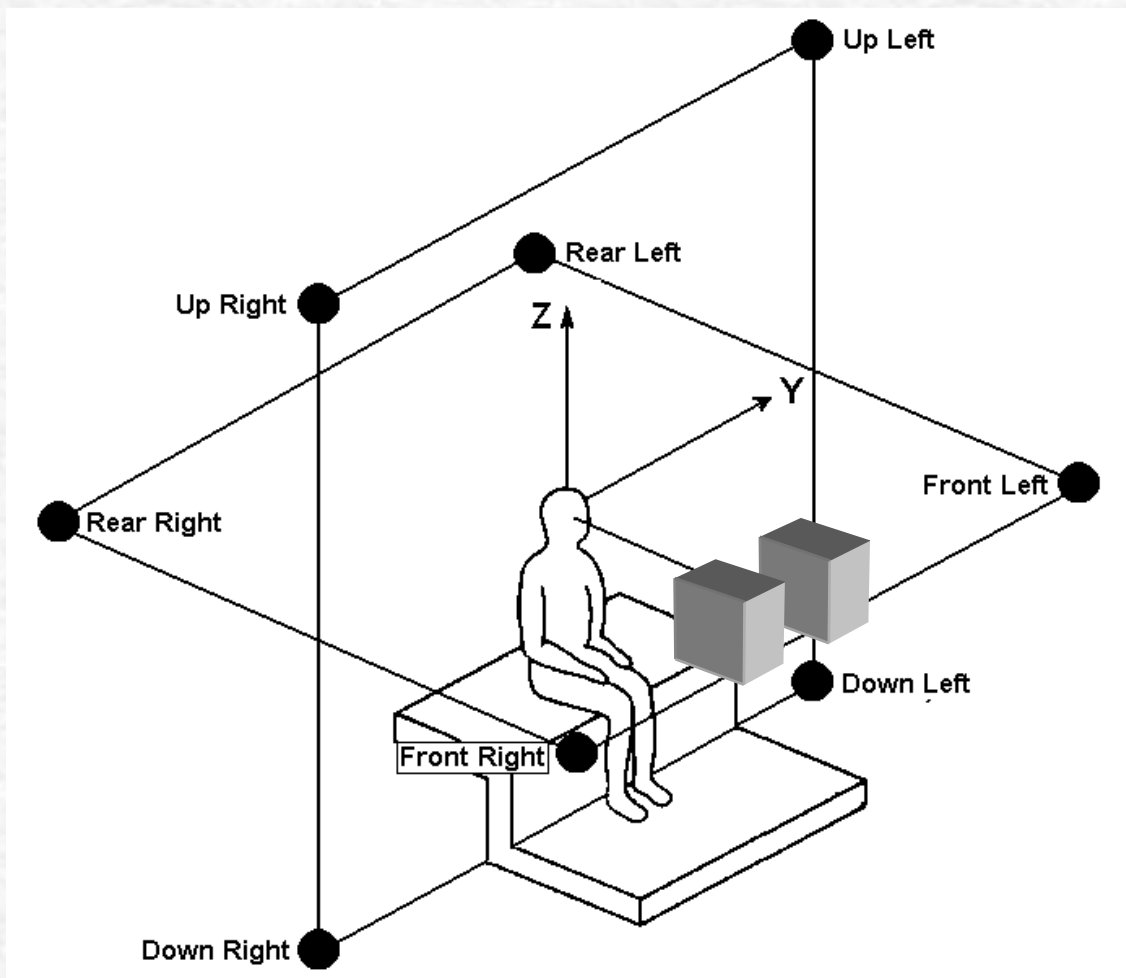
- C
- CS
- L
- R
- LS
- RS
- Top

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# Ambiophonics 3D (2001)

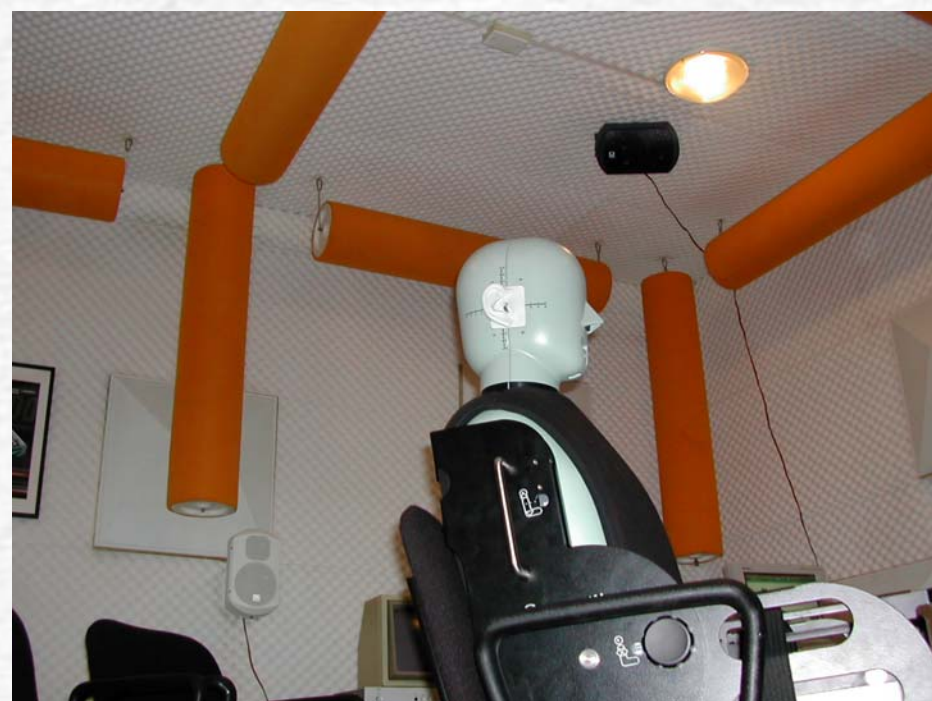


Layout

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# Ambiophonics (2001)



40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



# The Ambiophonics Institute



Photos taken on  
16 december 2002

40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



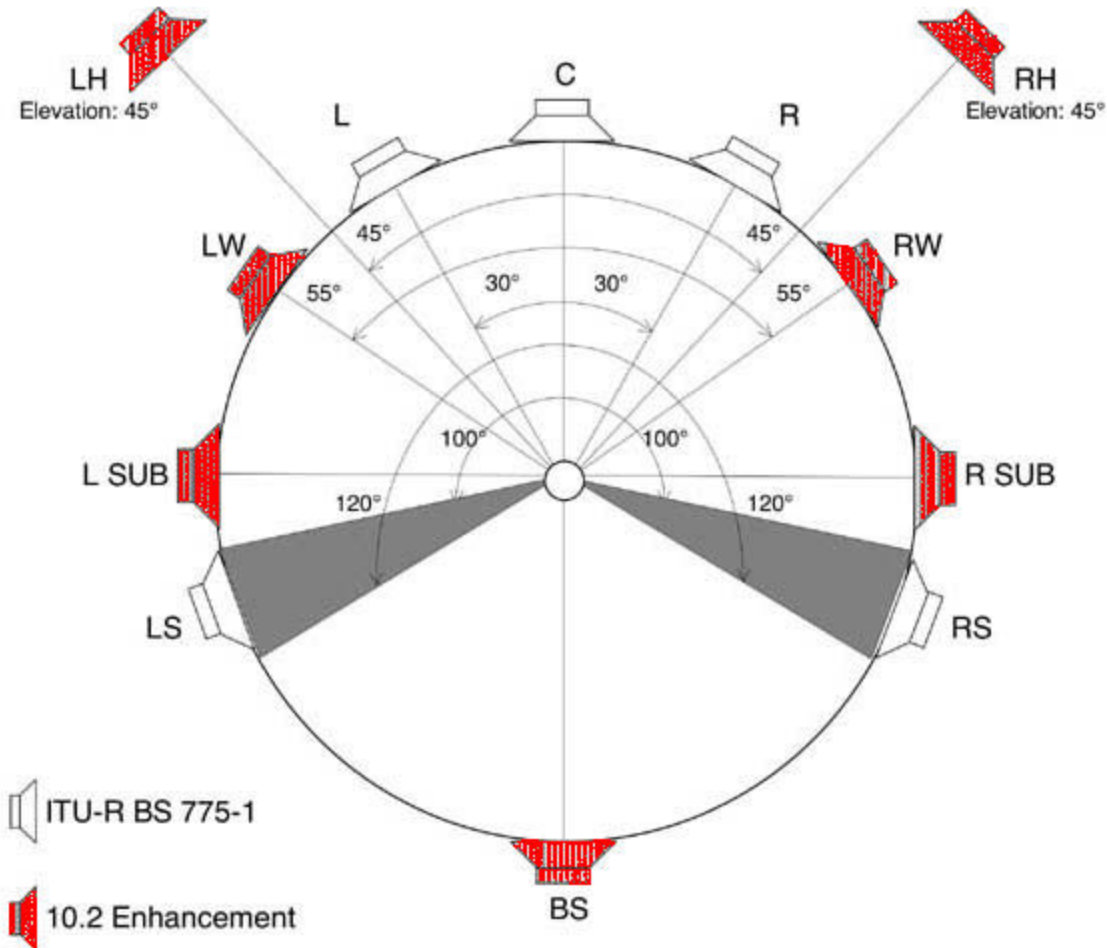
# The Ambiophonic Institute



40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



# THX 10.2 Surround (2001)



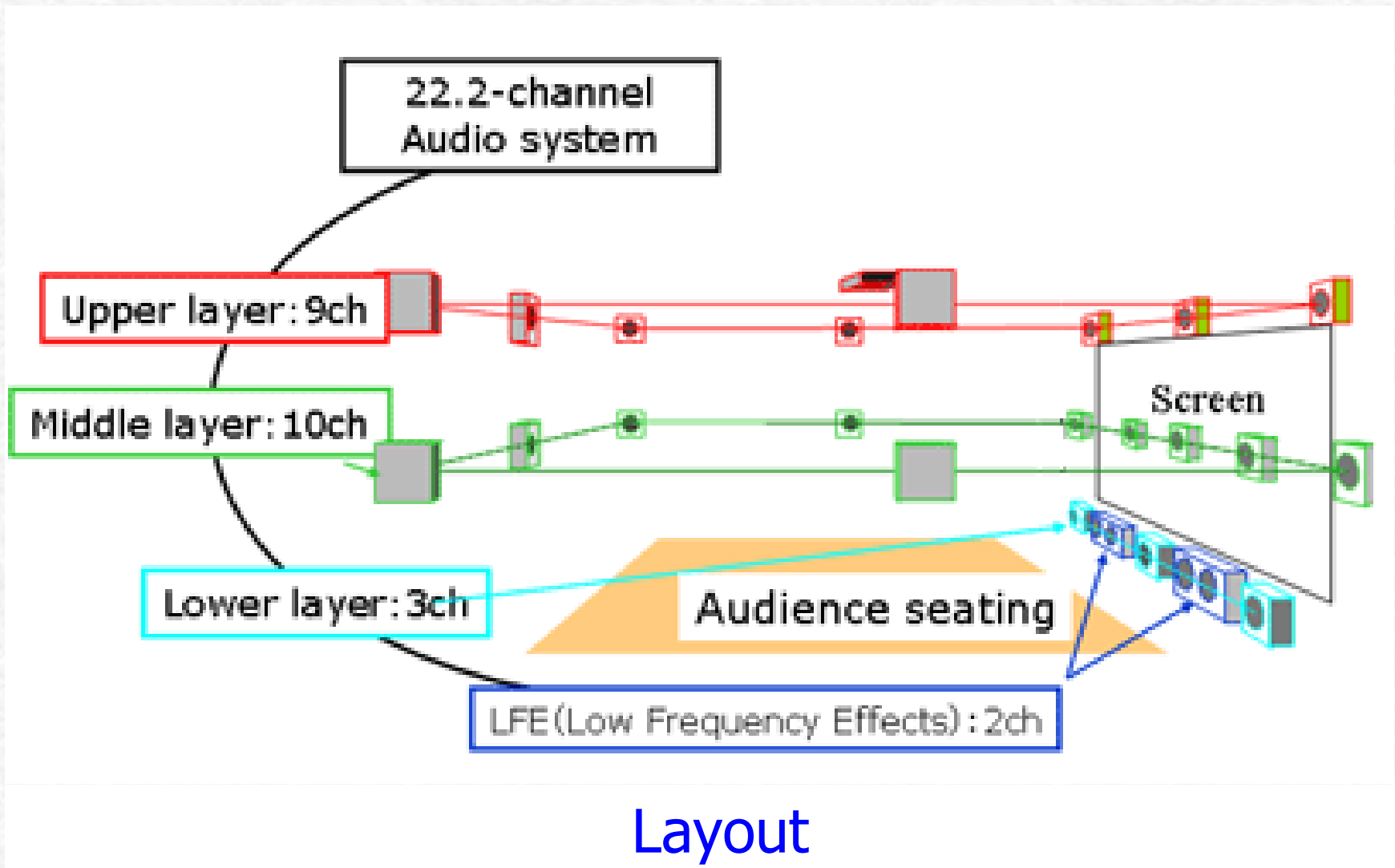
Layout



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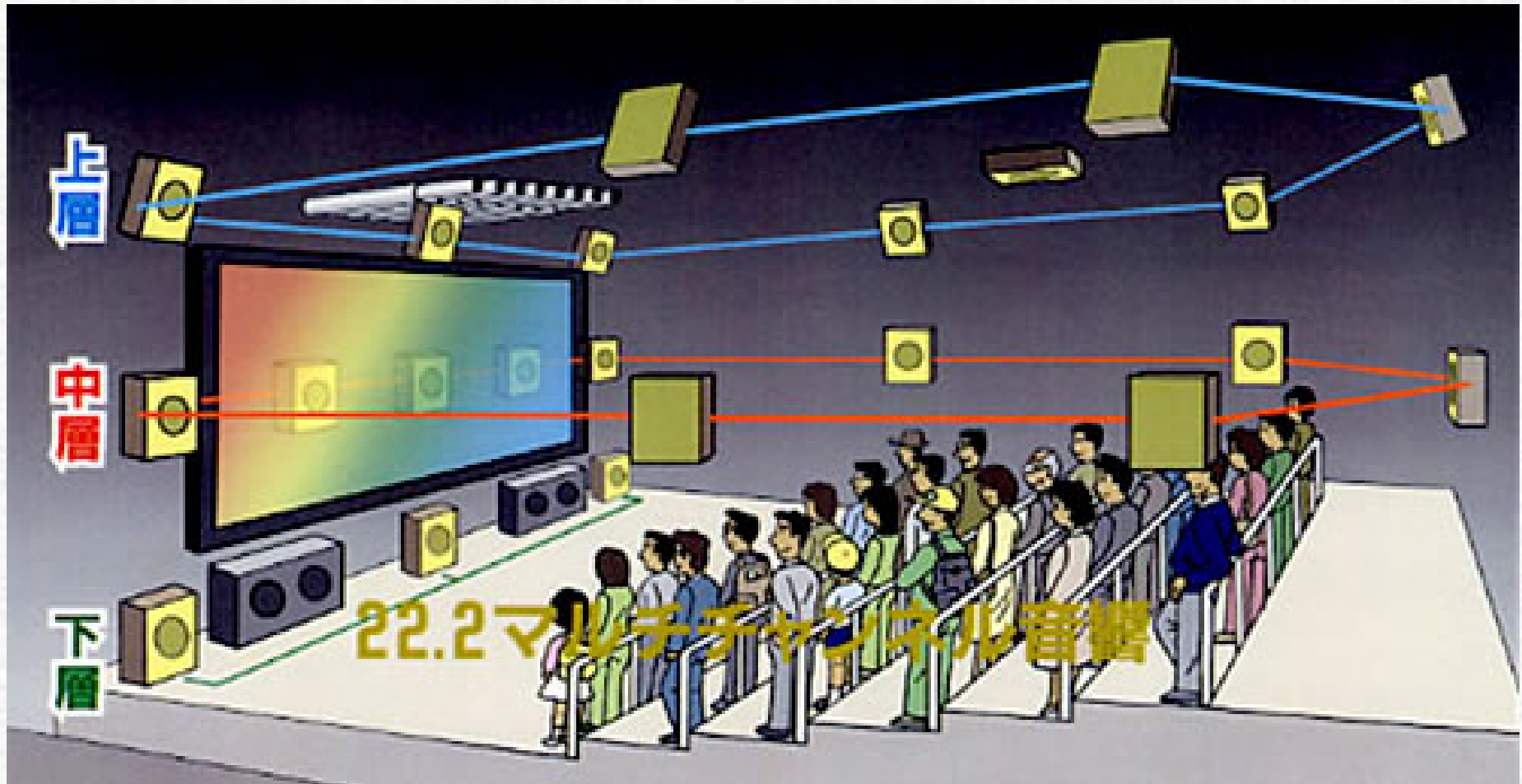


# NHK 22.2 Surround (2005)



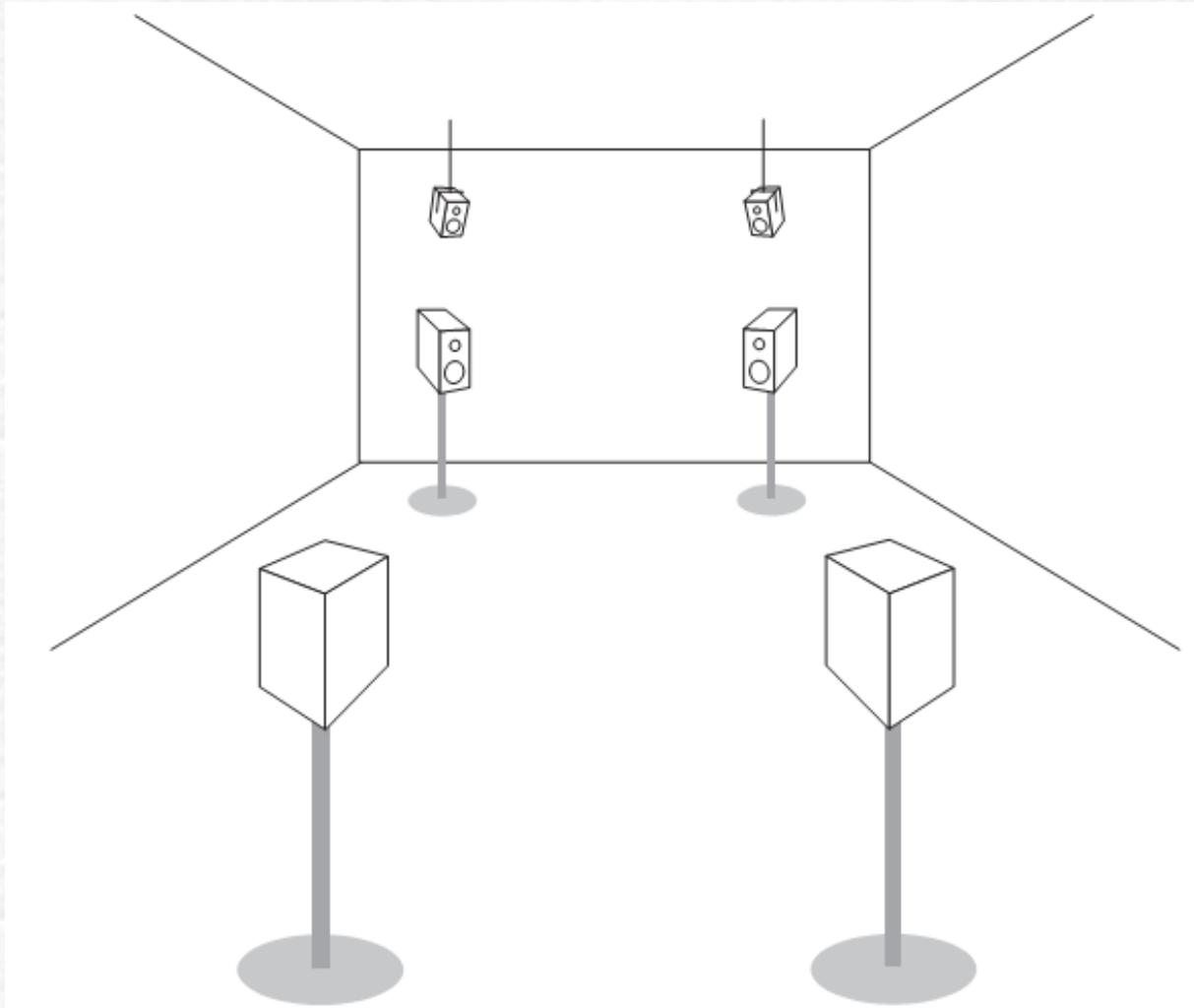
Layout

# NHK 22.2 Surround (2005)



Layout

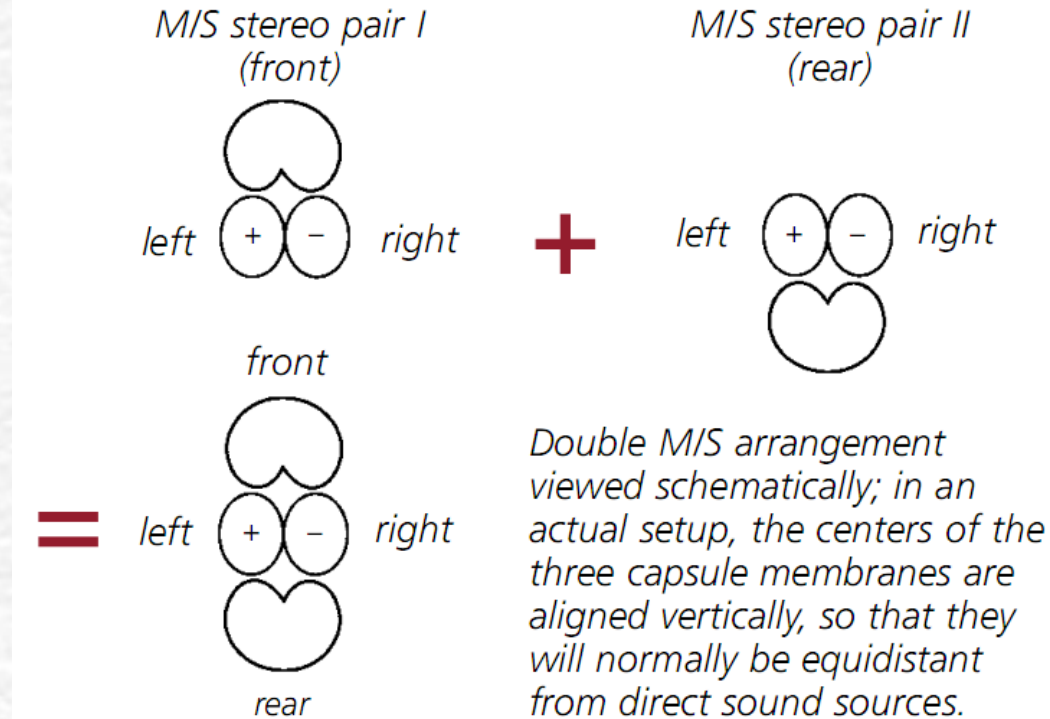
# The 2+2+2 system (2007)



Layout

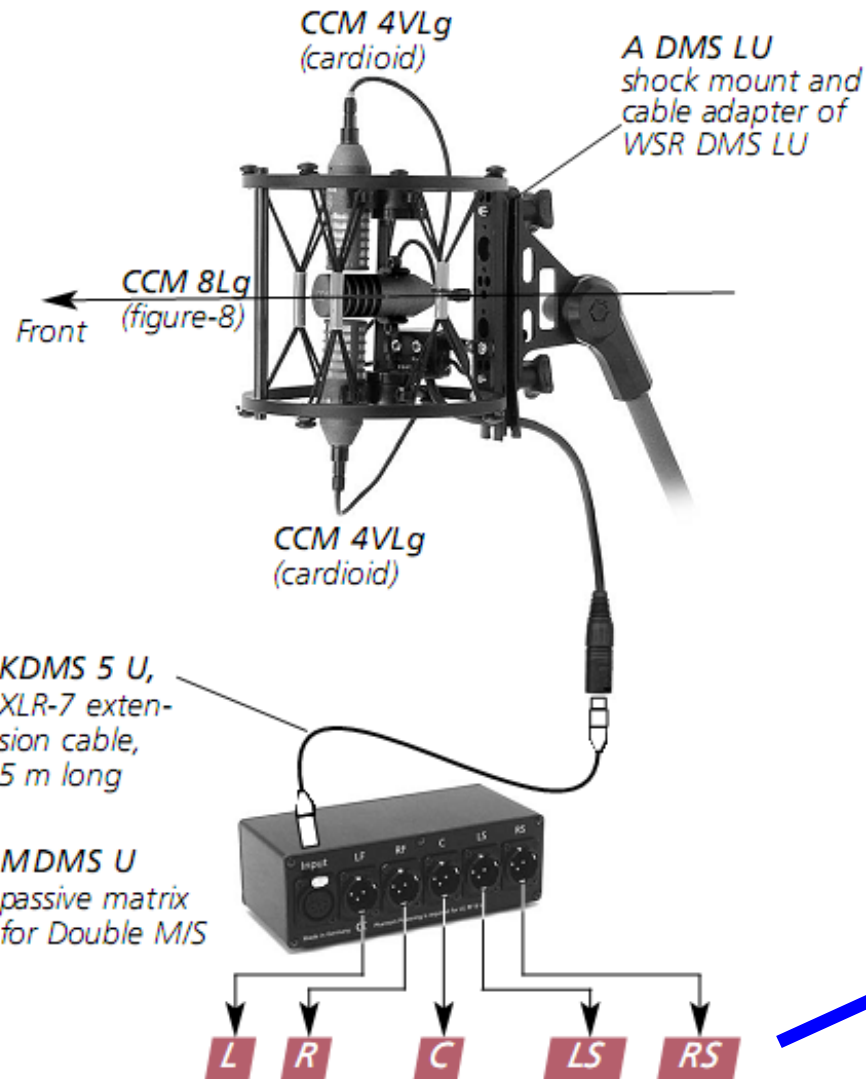


# Schoeps Double MS (2007)



## Layout

# Schoeps Double MS (2007)



Standard 5.1 surround signals can be derived employing an hardware processor with pre-optimized decoding coefficients

# Schoeps Double MS (2007)

The screenshot shows the 'DoubleMSTool' VST/RTAS plugin interface. At the top, it displays 'Audio 1', 'b', 'DoubleMSTool', and 'RTAS'. Below this are controls for '<factory default>', '- +', 'compare', 'auto', and 'safe'. The main interface is divided into several sections:

- Virtual Microphones POLAR PATTERN:** Includes sliders for 'Center' (0.36), 'L, R' (0.36), and 'LS, RS' (0.36).
- MICROPHONE ANGLE:** Includes sliders for 'L, R' (72 deg) and 'LS, RS' (144 deg).
- REAR DELAY:** A slider set to 0.0 ms.
- REAR LOWPASS:** A slider set to 'off'.
- Level VOLUME:** Includes sliders for 'Center', 'L, R', and 'LS, RS', all set to 0.0 dB, with 'Mute' buttons for each.
- Level Meter:** A polar plot showing the combined polar patterns of the virtual microphones, with a scale from 0 to -15 dB and angles from 0 to 180 degrees.
- SCHOEPS Mikrofone Double MS Tool:** Includes 'IN-LEVEL' and 'OUT-LEVEL' sections with sliders for 'Cardioid Front', 'Figure of Eight', 'Cardioid Rear', 'Front Left', 'Front Right', 'Center', 'Rear Left', and 'Rear Right'.

Greater control is obtained employing the free VST/RTAS plugin

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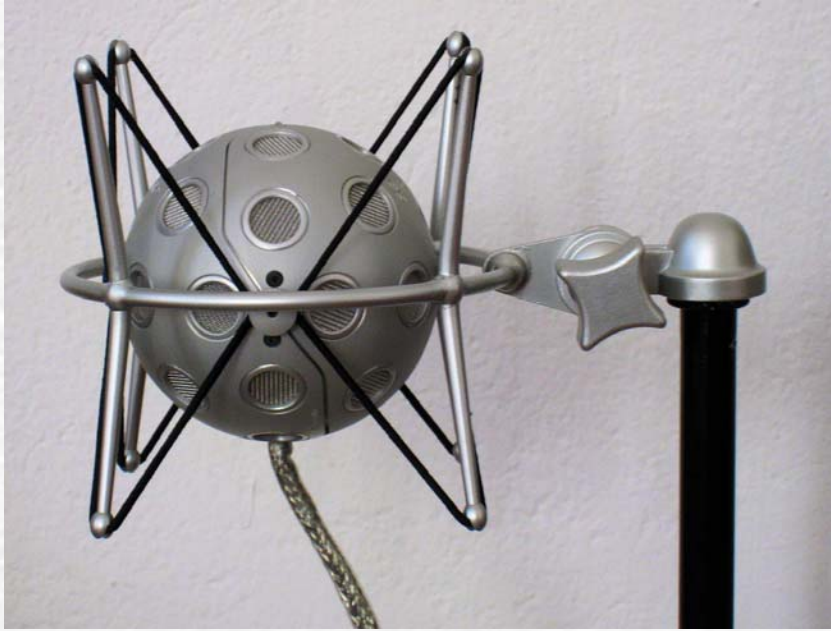


# Schoeps Double MS (2007)

- In practice, the double-MS system is another way of recording the horizontal components of the Ambisonics signals WXY (B-format), and decoding them with the “virtual microphone” approach
- Schoeps does not advertise this method as Ambisonics based, and relies on the superior quality of their capsules for beating the concurrent Soundfield microphone system



# High Order Ambisonics (2010)



Eigenmike®



Rig at ISVR

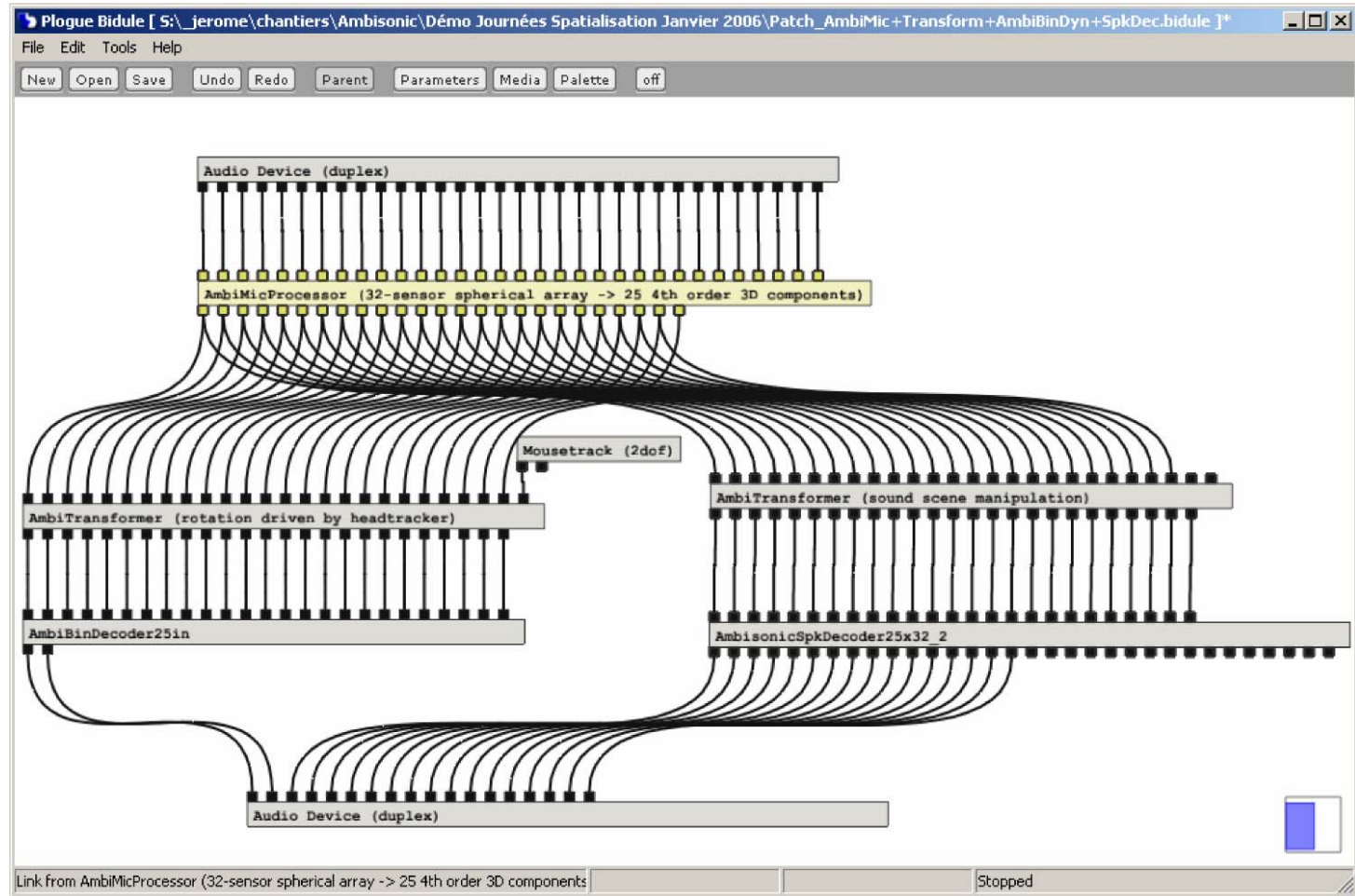
4<sup>th</sup> order mike, 40 loudspeakers rig

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# Software for 4th-order Ambisonics

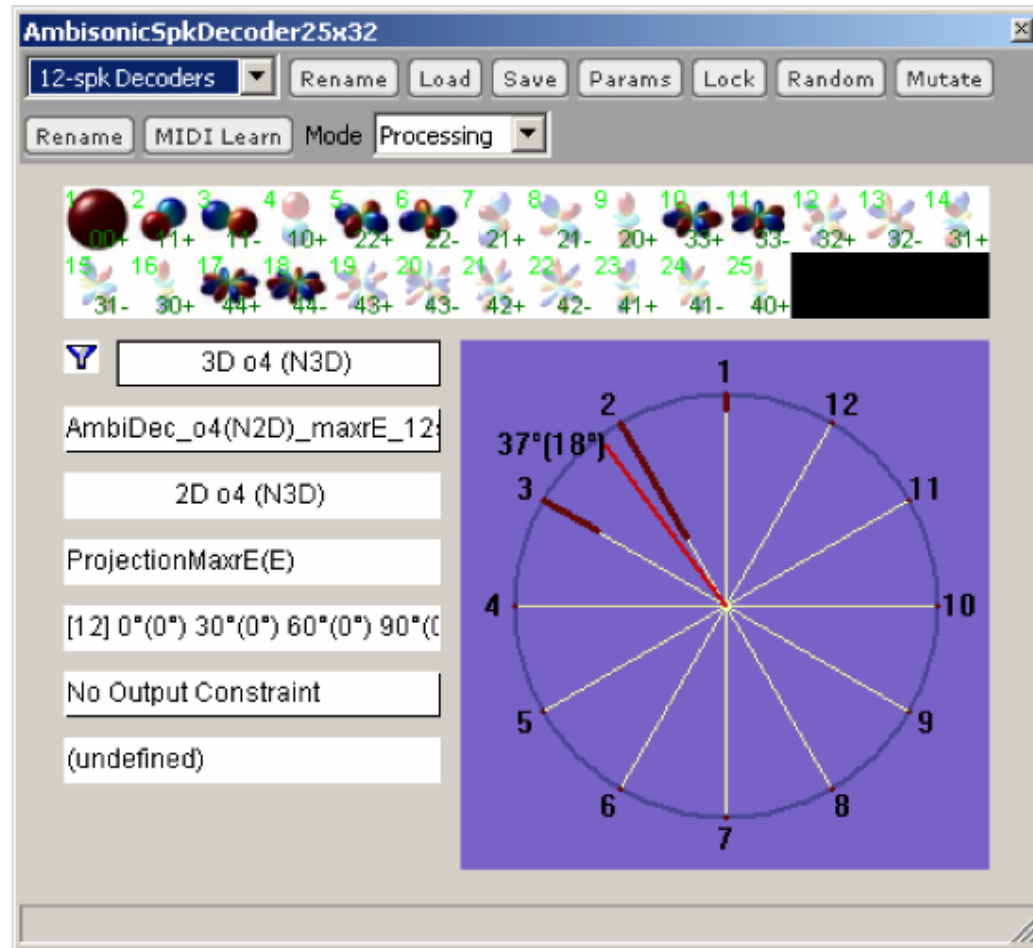
32 ch. VST plugins developed by France Telecom



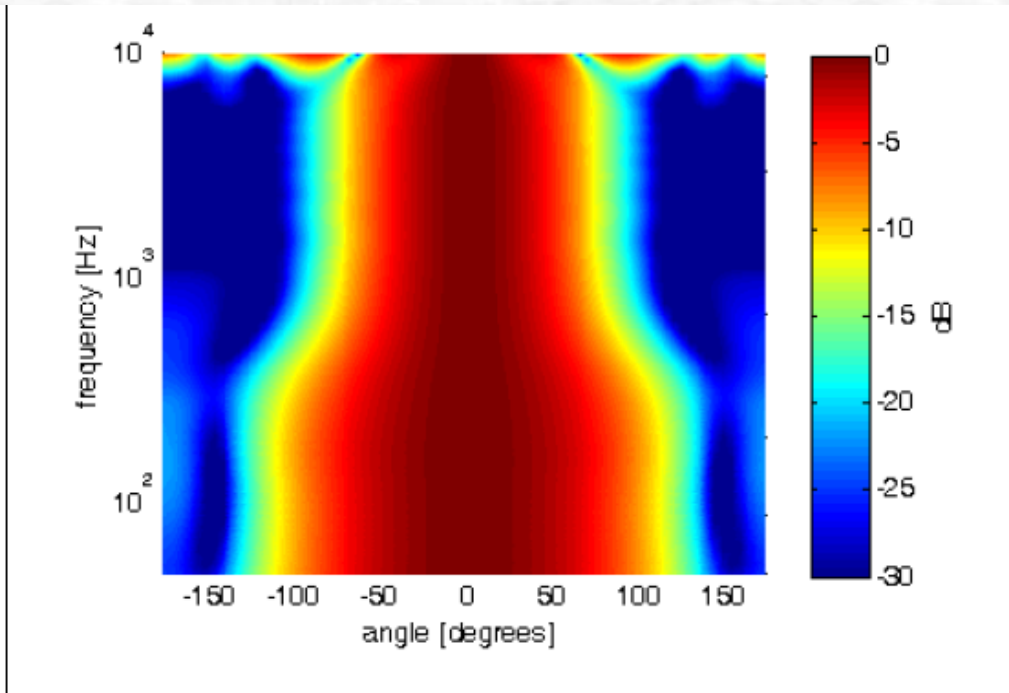
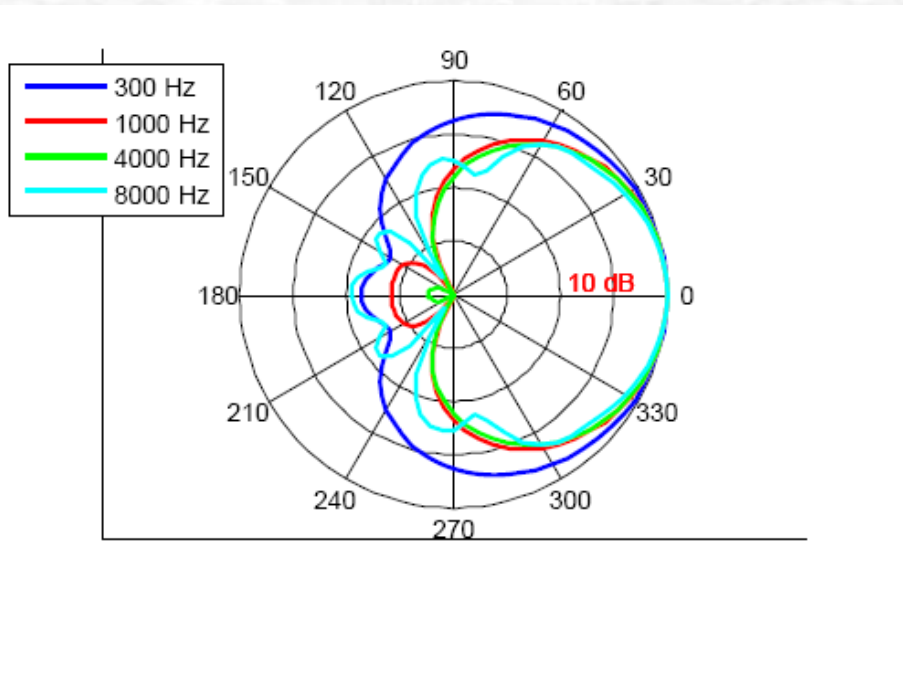
40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010

# Software for 4th-order Ambisonics

32 ch. VST plugins developed by France Telecom



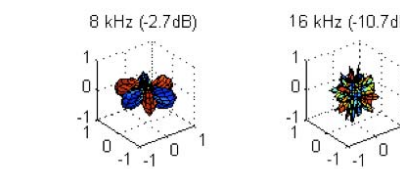
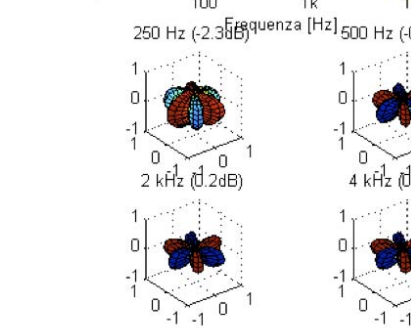
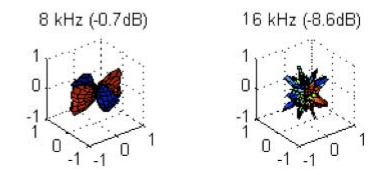
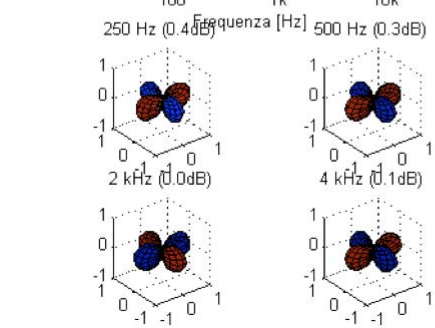
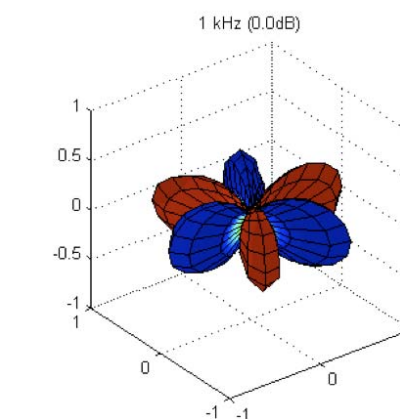
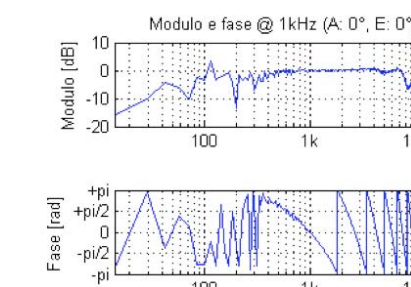
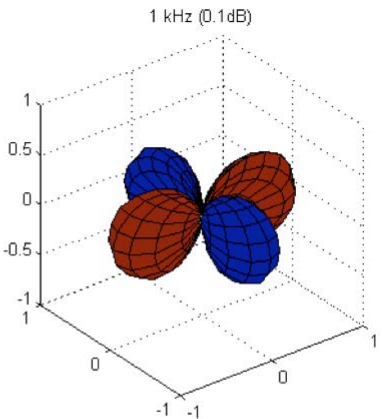
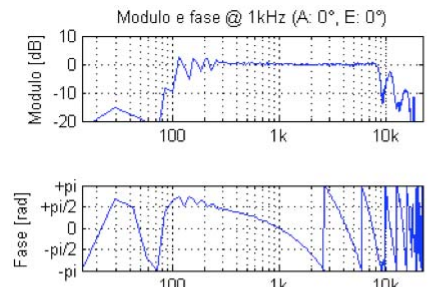
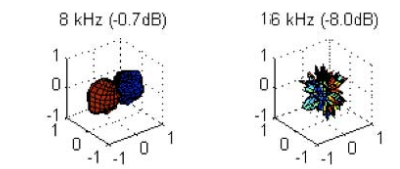
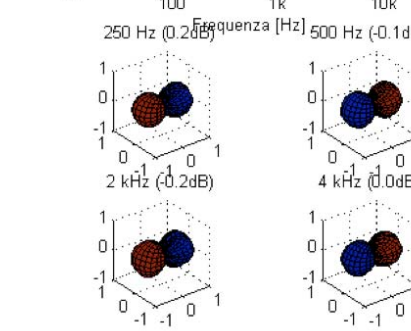
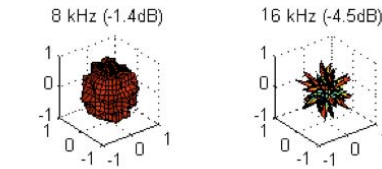
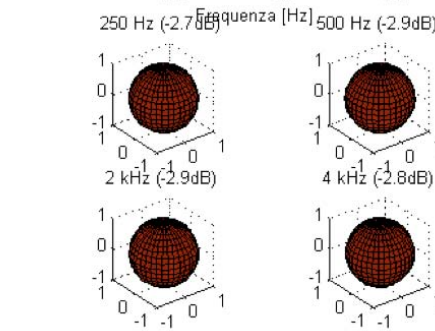
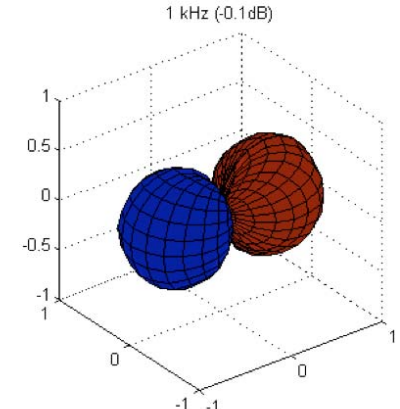
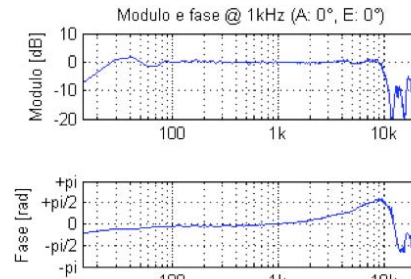
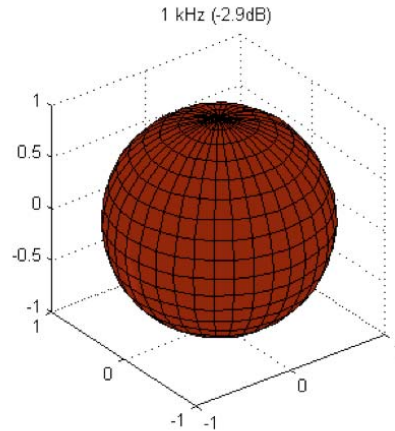
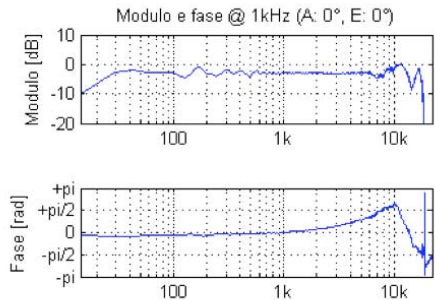
# Eigenmike – virtual 3<sup>rd</sup> order cardioid



Directivity patterns



# Spherical Harmonics



# Comparative experiments

- We present here some sound samples coming from three experiments
- The first was the ORF Seminar, Wien 2001
- The 2<sup>nd</sup> was Verdi Projekt at TU Ilmenau in 2002
- The third is currently undergoing at RAI Research Center in Turin, Italy



# The ORF seminar (Vienna)

The screenshot shows a web browser window with the URL [www.hauptmikrofon.de/index.php?option=com\\_content&view=article&id=61&Itemid=58](http://www.hauptmikrofon.de/index.php?option=com_content&view=article&id=61&Itemid=58). The page header features the logo for **hauptmikrofon.de** with the tagline "forum on sound engineering".

On the right side of the header, there is a link for **AES42 White Paper**, with sub-links for "White Paper 'Digital Microphones and AES42'/'Digitale Mikrofone und AES42'", "German version v2.1, 11.05.2010", and "English version v2.1, 11.05.2010". Below this, it says "The authors of the White Paper 'Digital microphones and..."

The main content area is titled **ORF Surround techniques**, written by Administrator on Tuesday, 22 December 2009 11:48. The article text reads: "The surround seminar at ORF (Vienna) performed a comparison of seven surround main microphones by a simultaneous recording with consecutive blindfolded listening test. *The recorded tracks are available for download now as a DVD image* in order to repeat the blindfolded listening test."

The article includes an **Introduction** section: "The rehearsal of the Radio Symphony Orchestra Vienna was recorded using seven different 5.1 Surround main microphone setups (see below). They played two different music samples which were pieces from Mozart and Berio, representing contrasting dynamic characteristics. The recorded samples can be compared in order to learn about the differences between the applied recording techniques. A DVD enables to compare intuitively by switching between the streams using the 'audio'-button of the DVD player remote. This DVD can be produced using the *DVD image available for download*. During the ORF Surround seminar and at an another later occasion the samples were compared in listening tests. The 18+14 participants had to assess different characteristics of these sound samples in a blind test. The results of these assessments are reproduced as mean values in 9 tables: **Results of the Vienna and Düsseldorf Listening Tests**. The Vienna test was performed by Florian Camerer and Christian Sodl, ORF. The DVD was produced by John Oag, formerly IRT. The diagrams were made by Helmut Wittek."

On the right side of the article, there is a photograph of a recording studio setup with multiple microphones on stands. Below the photo is the caption: "Picture of the recording session - the simultaneous recording of all configurations".

The left sidebar contains a navigation menu with sections: **Image Assistant** (Image Assistant 2.1), **Main** (News, about us), **Topics** (AES-42 White Paper), **Stereo** (ORF Surround techniques, Download DVD image, Listening test results), and **Ressources** (The Binaural Sky, WFS (IRT literature), Wittek publications).

# The ORF seminar



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# The ORF Seminar



*Recording hall:* Grosser Sendesaal (big transmission hall) of the Austrian Radio;  
*Orchestra:* Radio Symphony Orchestra of the ORF (RSO Vienna);  
*Musical program:* 1. W.A.Mozart: „Maurerische Trauermusik“ c-minor, KV 477  
2. L.Berio: Concert for Trombone & Orchestra (the soloist was not present at the rehearsals);  
Recording console AMS/Neve Capricorn;  
Monitors: 2x Genelec 1034 for L + R; 3x Genelec 1037 for C, LS + RS;  
No subwoofer (we did not record an LFE)  
Recording machines 2x SONY PCM 3324 DASH Multitrack recorders;

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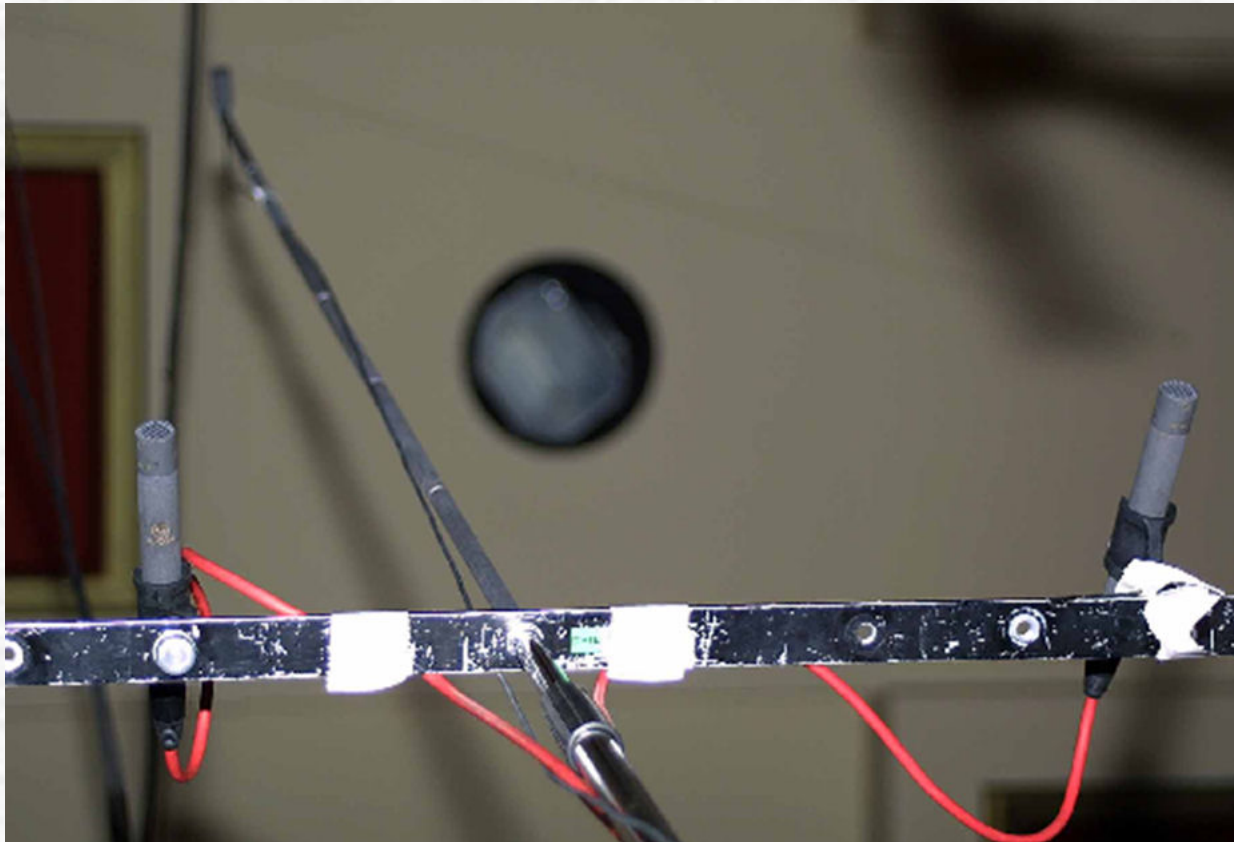


# The ORF seminar

## 8 Recording techniques:

- A: Stereo + C + Hamasaki square
- B: Decca-Tree + Hamasaki square
- C: OCT + Hamasaki-Square
- INA 5
- Schoeps KFM 360
- OCT Surround
- Soundfield MKV + Processor SP451

# The ORF seminar



**System A: Stereo + C + Hamasaki Square** (after A.Gernemann);  
This system is based on a „regular“ main microphone for 2-channel stereophony like AB or MS with an additional omnidirectional microphone for the Center high above the main pair (>2m)

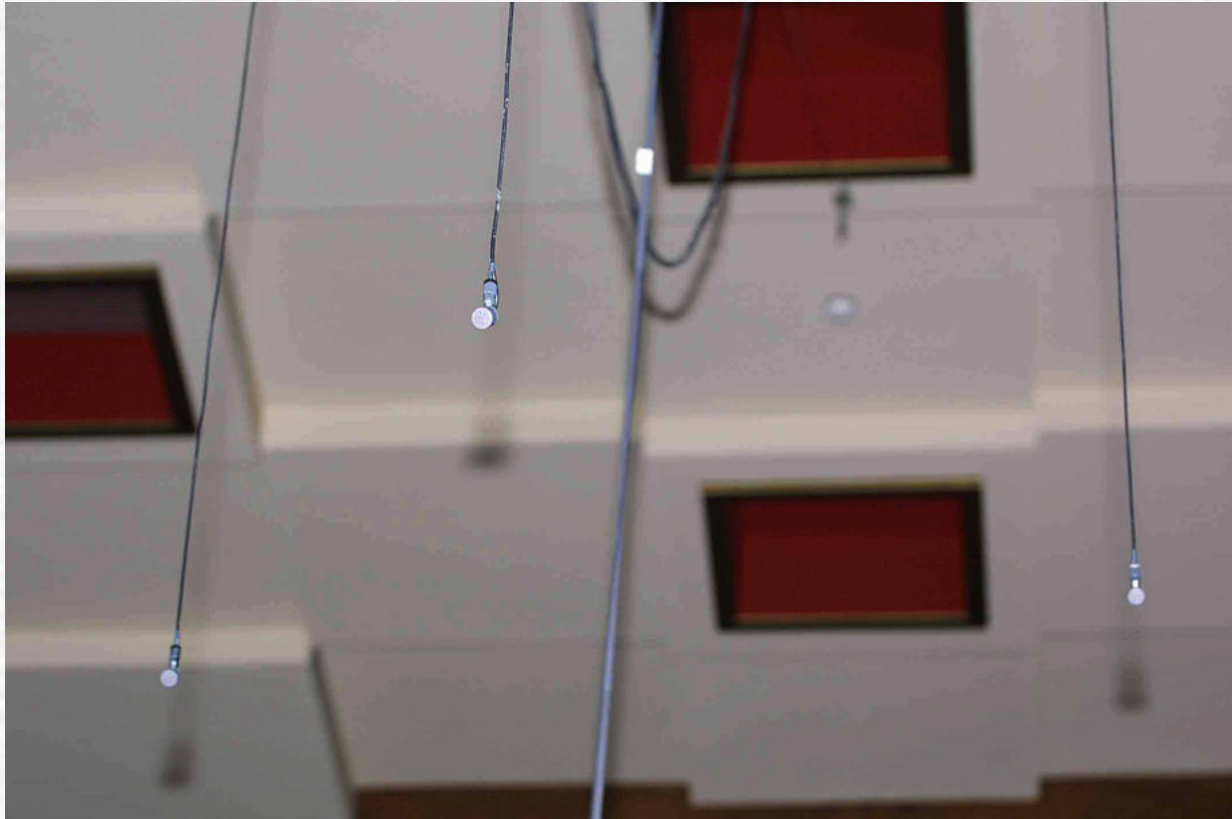
# The ORF seminar



**Hamasaki-Square:** invented by Kimio Hamasaki of the NHK Science and Research Laboratory. This consists of 4 fig-of-eight microphones pointed to the sides (Schoeps CMC8) arranged in a square of about 2m sidelength, placed not too far behind the main microphone (about 5m).

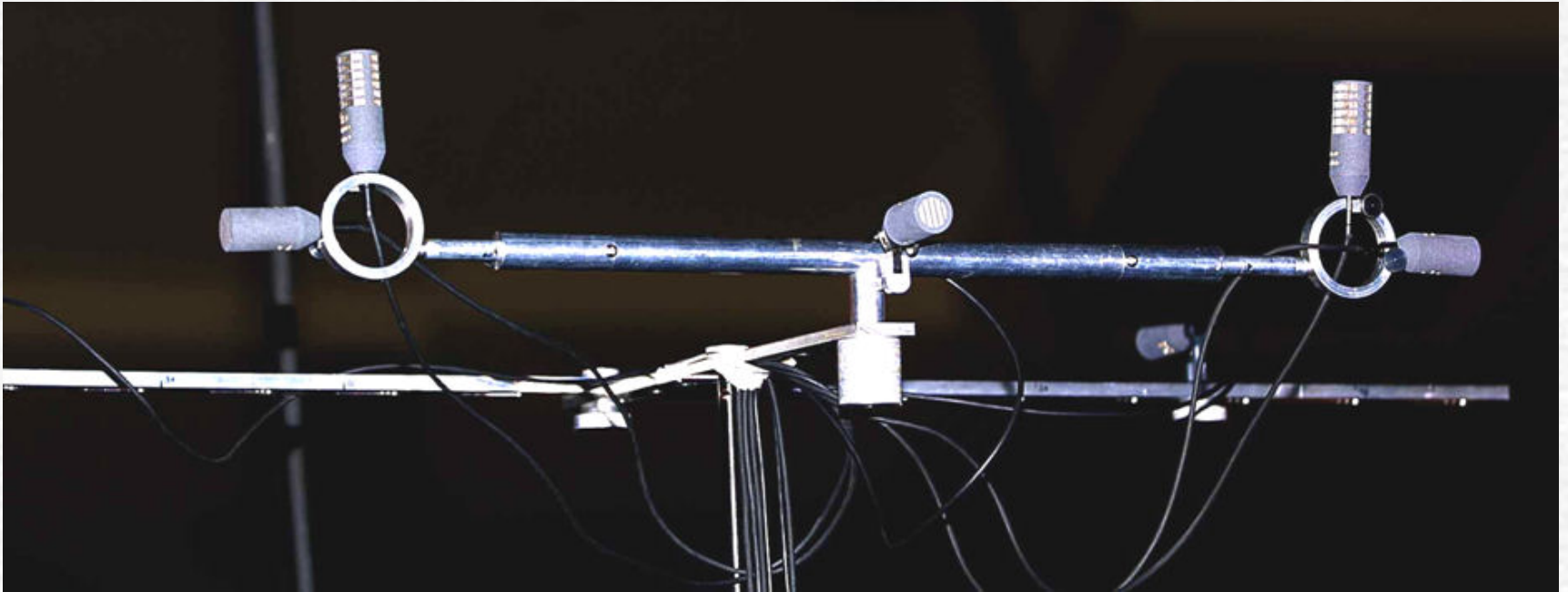


# The ORF seminar



**System B:**        **Decca-Tree + Hamasaki-Square;** This well-known setup with three omnis (here Schoeps CMC2S, see *fig.3*) is used as the standard configuration for the numerous recording sessions taking place in the „Grosser Sendesaal“ of the ORF (base-length: 1,5m). The system was reinforced with two additional Schoeps CMC2S omnis on the sides (3,5m), the so-called „out-riggers“. The 4 fig-of-eight microphones of the Hamasaki-Square were panned as before for Stereo+C.

# The ORF seminar



**System C: OCT (Optimised Cardioid Triangle) + Hamasaki-Square;**  
This system was devised by Guenther Theile. OCT chooses hypercardioids facing  $90^\circ$  away from the orchestra for L and R (base distance  $b=80\text{cm}$ ) and a cardioid facing forward for C closer to the orchestra ( $h=8\text{cm}$ ).  
The somewhat poorer bass response due to construction principles is compensated with the addition of two omnis adjacent to the hypercardioids which are lowpass-filtered at  $100\text{Hz}$  to provide low-end down to  $20\text{Hz}$  (The hypercardioids and the cardioid are highpass-filtered at  $100\text{Hz}$  accordingly.)

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# The ORF seminar



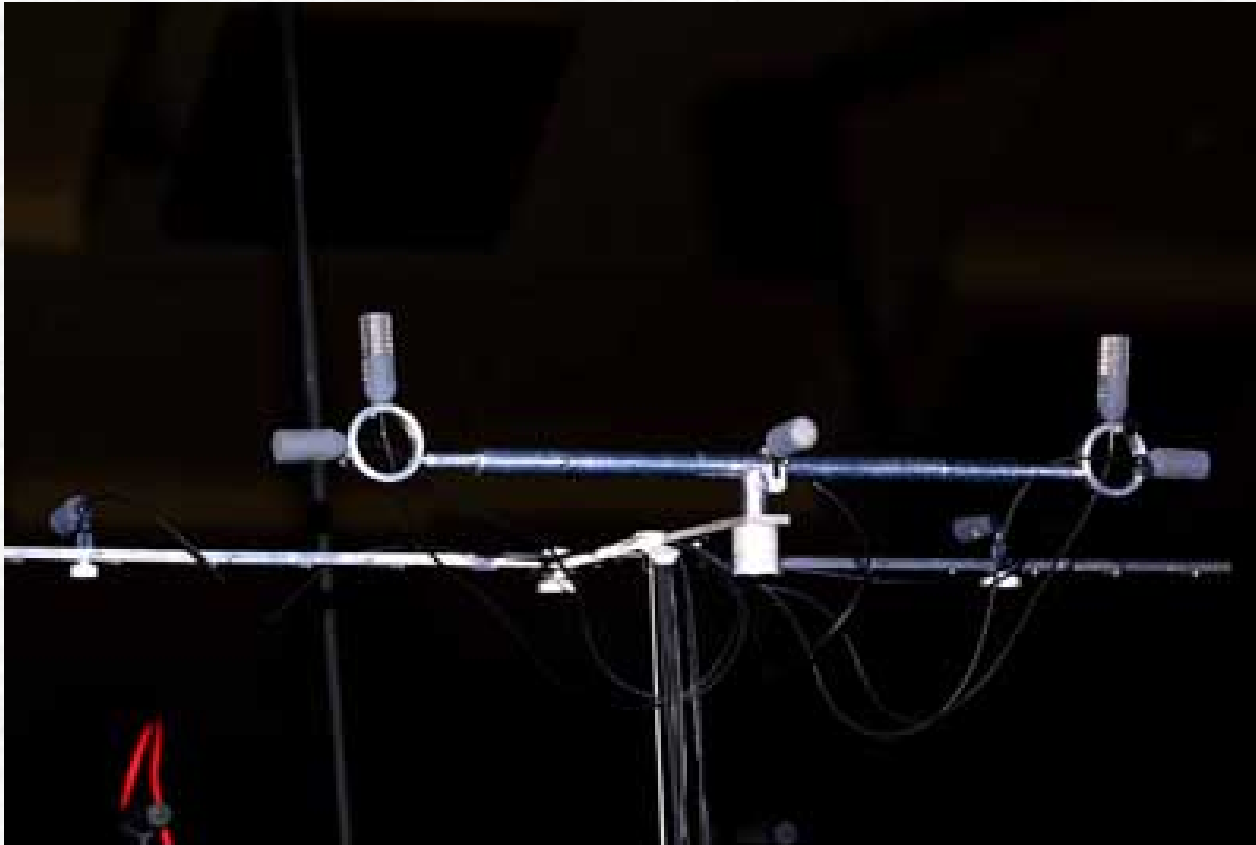
**System D:**      **INA5 (Ideale Nieren-Anordnung (Ideal Cardioid Arrangement))** (after Herrmann/Henkels); This system is also based on the Williams localization curves, so that the recording angles of adjacent microphone pairs just touch each other (representing the „sweet-spot“-group)

# The ORF seminar



**System E:** Schoeps KFM 360 (after J.Bruck);  
A sphere microphone (after G.Theile) is accompanied by two fig-of-eight microphones on the sides adjacent to the pressure transducers. Each omni/fig-of-eight-combination forms an MS-stereo-pair that after decoding delivers one front- and one surround-signal respectively. An optional center-signal is derived through a special 2-3-matrix (after Gerzon).

# The ORF seminar



**System F: OCT Surround;** Instead of the Hamasaki-Square for the surround signals two cardioids (Schoeps CCM4) are used right behind (50cm) the frontal OCT array and with a slightly extended base (100cm). The cardioids are oriented straight away from the orchestra ( $180^\circ$ ), so that their direct-signal-pickup is minimal.

# The ORF seminar



**System G:**            **Soundfield MKV + Processor SP451**; The Soundfield-microphone forms the practical basis of the **Ambisonics**-system (after M.A.Gerzon) that can provide complete periphonic sound-reproduction. For 5.1-loudspeaker-setups the special decoder (B-Format to 5.1) required is called „Vienna“-decoder.

The Soundfield-company produces their own B-Format-to-5.1-converter, the SP451 (not a Vienna-Decoder). It shall be noted that for horizontal reproduction the Z-channel is omitted.

# The ORF seminar

## Questionnaire

### ***Spatial presentation of the orchestra:***

- |            |                          |                               |
|------------|--------------------------|-------------------------------|
| <i>Q 1</i> | <i>wide – narrow</i>     | <i>(1 – wide, 5 – narrow)</i> |
| <i>Q 2</i> | <i>close – distant</i>   | <i>(1 – 5)</i>                |
| <i>Q 3</i> | <i>deep – flat</i>       | <i>(1 – 5)</i>                |
| <i>Q 4</i> | <i>stable – unstable</i> | <i>(1 – 5)</i>                |
| <i>Q 5</i> | <i>precise – blurred</i> | <i>(1 – 5)</i>                |

### ***Timbre (sound-colour) of the orchestra:***

- |            |                                      |                |
|------------|--------------------------------------|----------------|
| <i>Q 6</i> | <i>satisfactory – unsatisfactory</i> | <i>(1 – 5)</i> |
|------------|--------------------------------------|----------------|

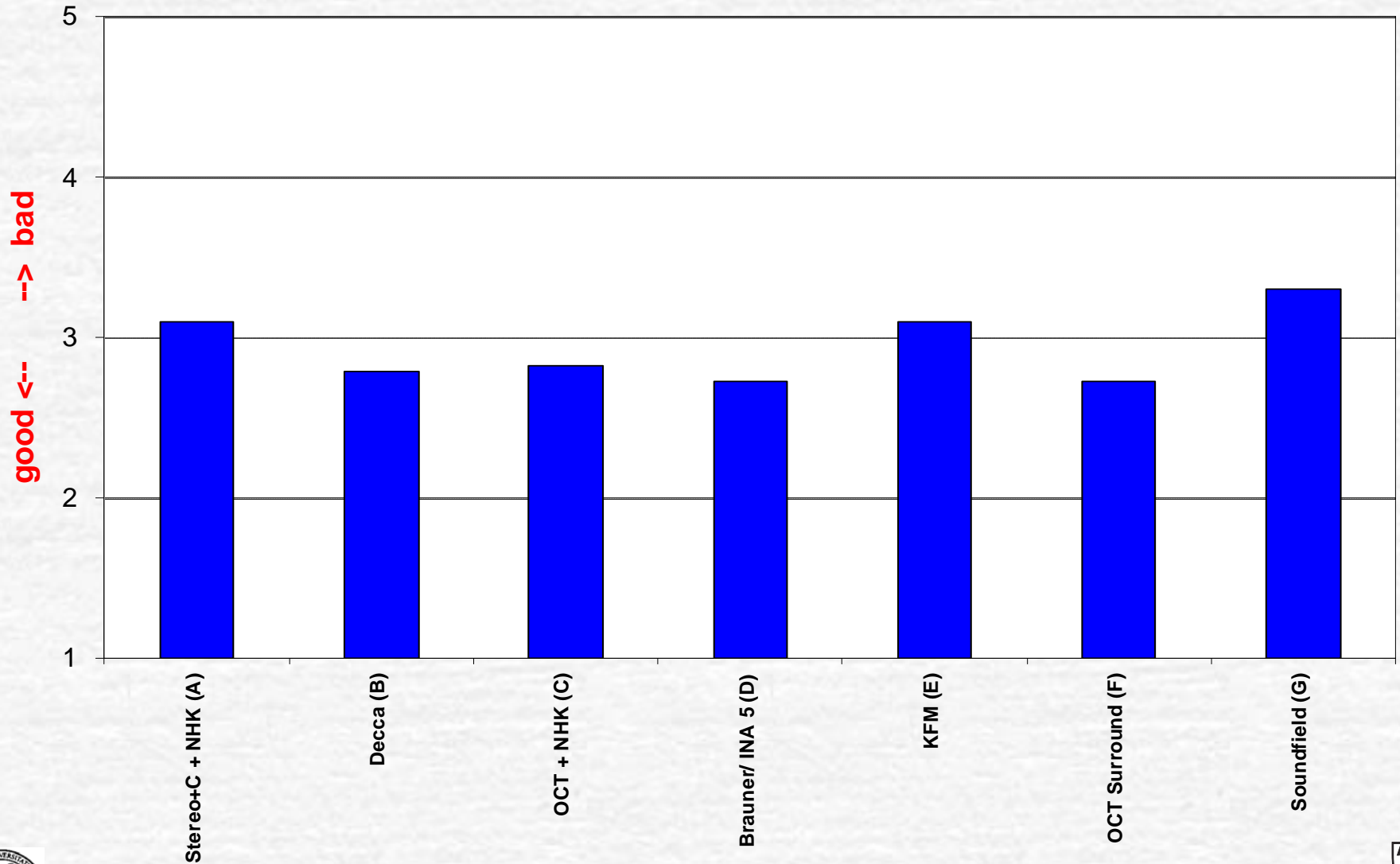
### ***Spatial imaging:***

- |            |  |                |
|------------|--|----------------|
| <i>Q 7</i> | <i>perfect spatial impression – imperfect sp.imp.</i>    | <i>(1 – 5)</i> |
| <i>Q 8</i> | <i>too much indirect sound – too little ind.sound</i>    | <i>(1 – 5)</i> |
| <i>Q 9</i> | <i>surround channels identifiable – surr.ch. not id.</i> | <i>(1 – 5)</i> |



# The ORF seminar

## Total Scores



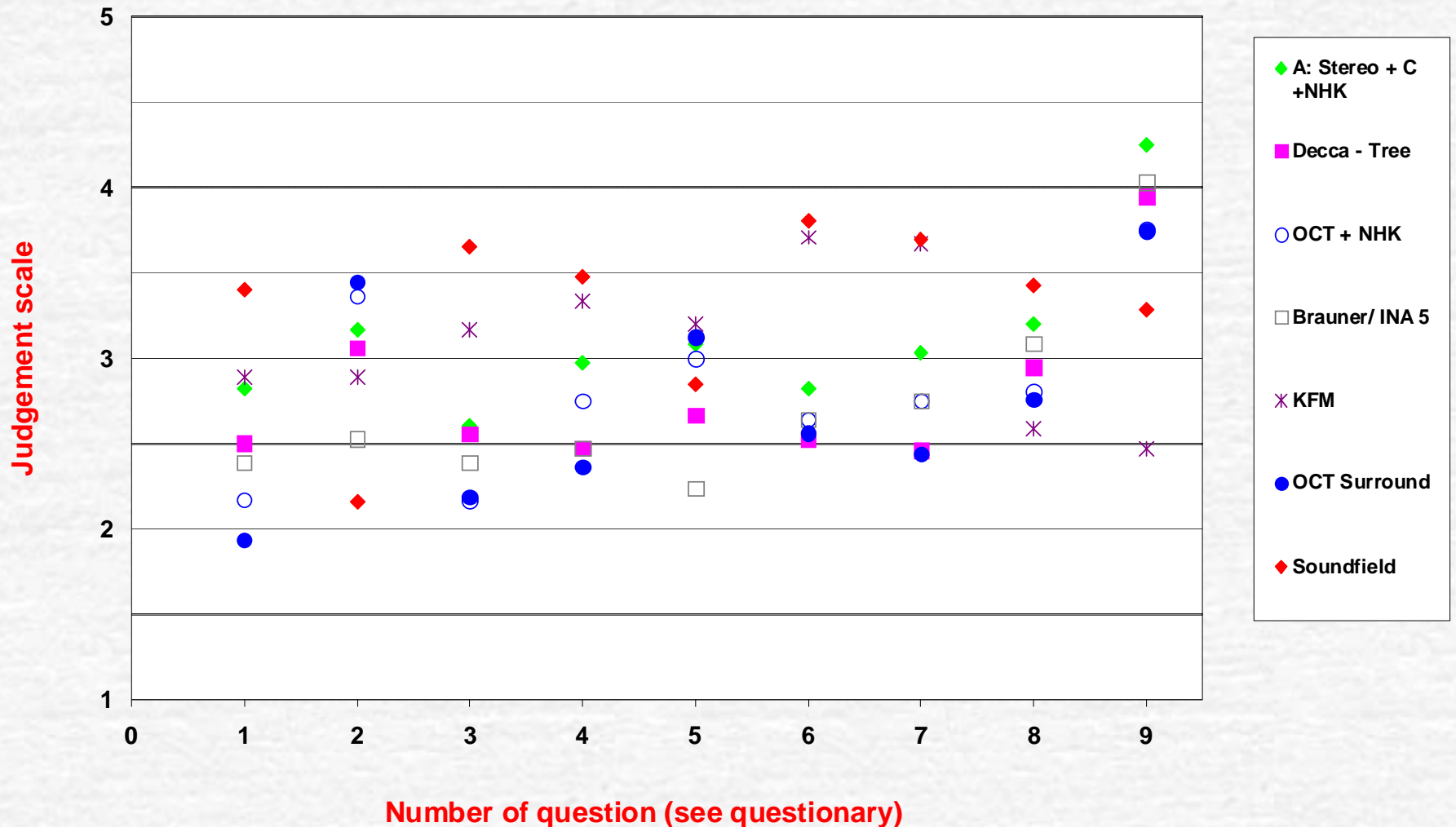
40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



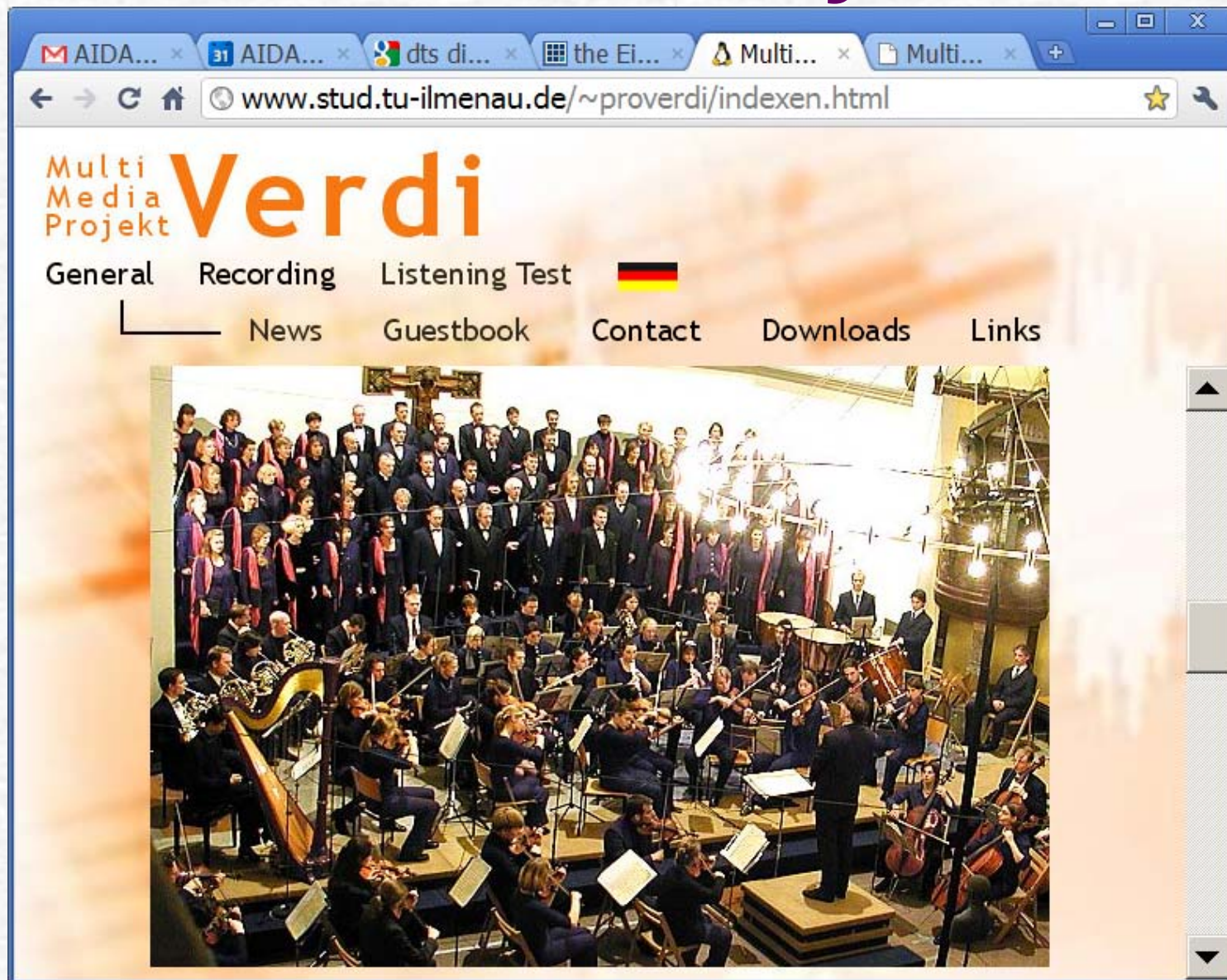


# The ORF seminar


Mean Values - both musical examples




# The Verdi Projekt



Multi Media Projekt **Verdi**

General Recording Listening Test 

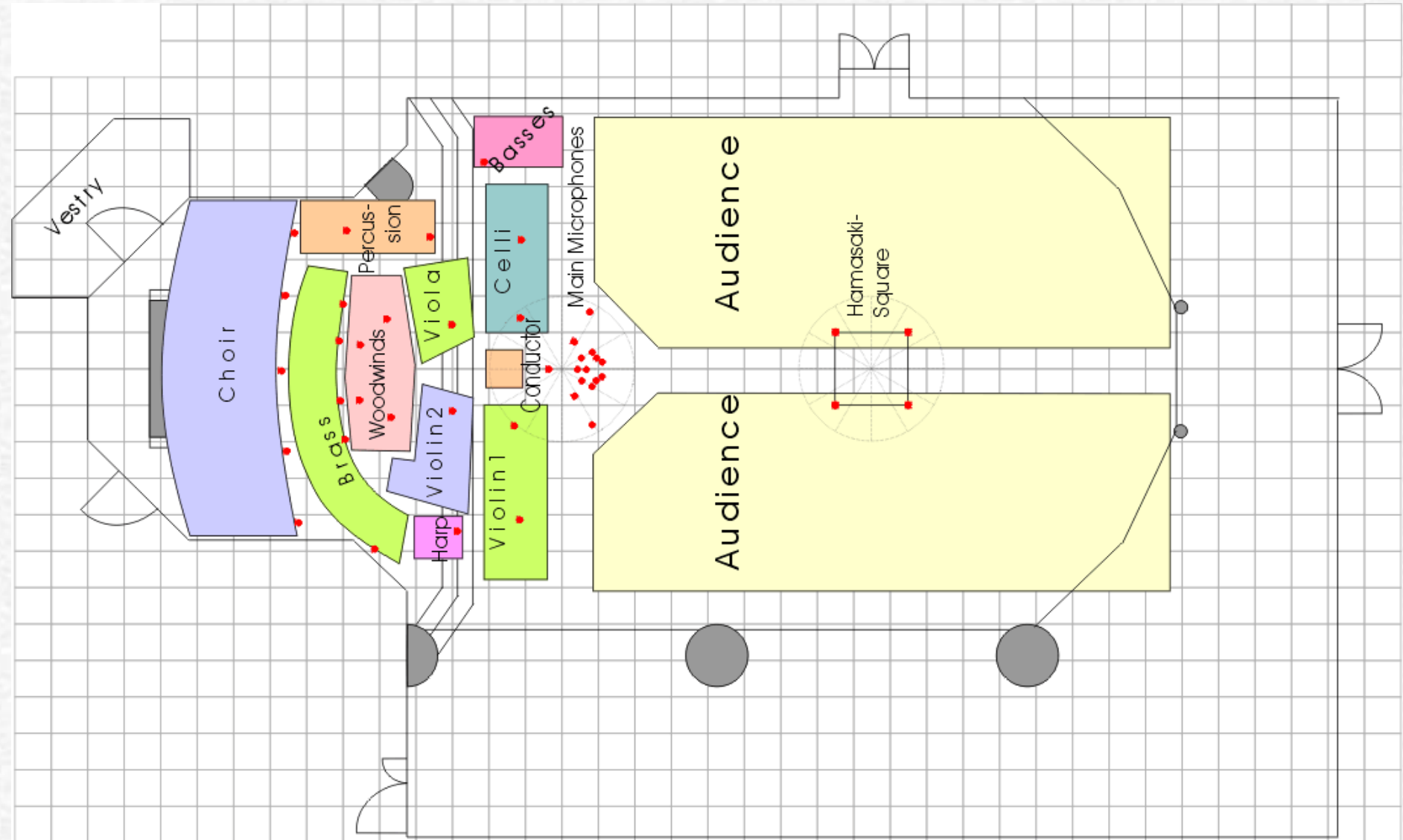
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40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



# The Verdi Projekt



# The Verdi Projekt



Some data:

- Recording made in a church in Hannover, on 25 November 2001
- 54-tracks simultaneous recording
- 18 technicians
- 9 microphone systems
- 6 resulting 5.1 productions
- 40 listeners for evaluating the 6 different mixes
- Additional test for 7 Soundfield-derived decodings (with few listeners and different rating scale)

# The Verdi Projekt

## The 6 main mixes:

## Overall SCORE

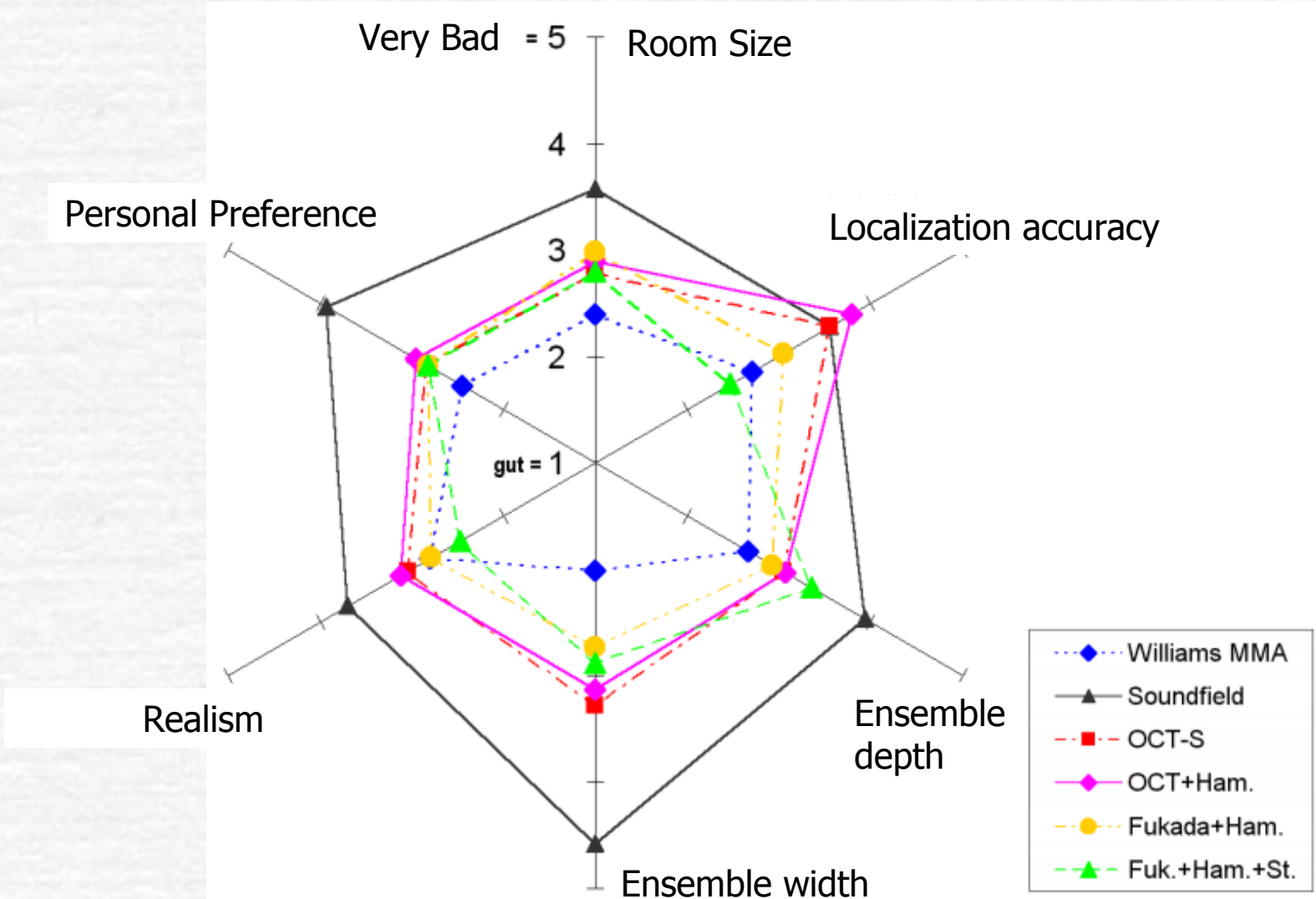
|  |                               |
|--|-------------------------------|
| • Williams MMA                                   | 2.0 <b>The best!</b>          |
| • Soundfield (NOT Ambi)                          | 4.0                           |
| • OCT Surround                                   | 3.2                           |
| • OCT + Hamasaki Square                          | 3.2                           |
| • Fukada-Tree + Hamasaki Square                  | 3.0                           |
| • Mix with spot microphones<br>& Hamasaki Square | 2.8 <b>The 2<sup>nd</sup></b> |

**Note: 1 means optimum, 5 means very bad**



# The Verdi Projekt

## Individual scores:



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# The Verdi Projekt: Soundfield

As the Soundfield decode did perform poorly, an additional session was organized, asking to skilled Ambisonics users to provide their decodes:

| <b>Decoding method</b>   | <b>Score</b>    |
|--------------------------|-----------------|
| A1 - Wiggins-HRTF        | 3 sufficient    |
| A2 - Wiggins-VIEN        | 3 sufficient    |
| A3 - Farina-Ambiophonics | 3.5 poor        |
| A4 - mac Caba            | 2.5 almost good |
| A6 – Dalenback           | 2.5 almost good |
| A7 - Rhonda Wilson       | 2.0 good        |
| A8 - Williams MMA        | 1.0 very good   |



# The RAI – CRIT project

Comparing the Holophone H2 Pro with the Eigenmike®



40<sup>th</sup> AES Conference - Tokyo, 8-10 October 2010



# The RAI – CRIT project



Recording of "La Boheme"  
at Teatro Regio in Turin



Recording of Sostakovic  
symphony n. 10  
at RAI Auditorium in Turin

# The RAI – CRIT project



“La Bohème” was recorded with 1 Holophone and 2 Eigenmikes  
Sostakovic was recorded with 1 Holophone and 1 Eigenmike



# The RAI – CRIT project

Listening tests are being currently performed at Centro Ricerche Rai in Turin

A new method of processing the Eigenmike® signals is currently being developed at the University of Parma, and will be presented at AES 40 on Sunday, 10 October, at 13.30 in PAPER SESSION 8: MICROPHONE AND MIXING TECHNIQUES

And do not miss the demo, TOMORROW at lunchtime



# DEMO sound samples

The presentation now includes some demos  
(if everything works....):

- Mozart sample from the ORF Seminar  
(there is also Berio, but I hate it....)
- Excerpt 2 from the main session of the Verdi Projekt
- Excerpt 2 from the Soundfield session
- La Boheme from the RAI-CRIT project
- Sostakovic Symphony 10 from the RAI-CRIT project

