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Ambisonics & the ATK @ DXARTS



Joseph Anderson

*Research Scientist
Center for Digital Arts & Experimental Media
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Pacific Northwest Section of the AES

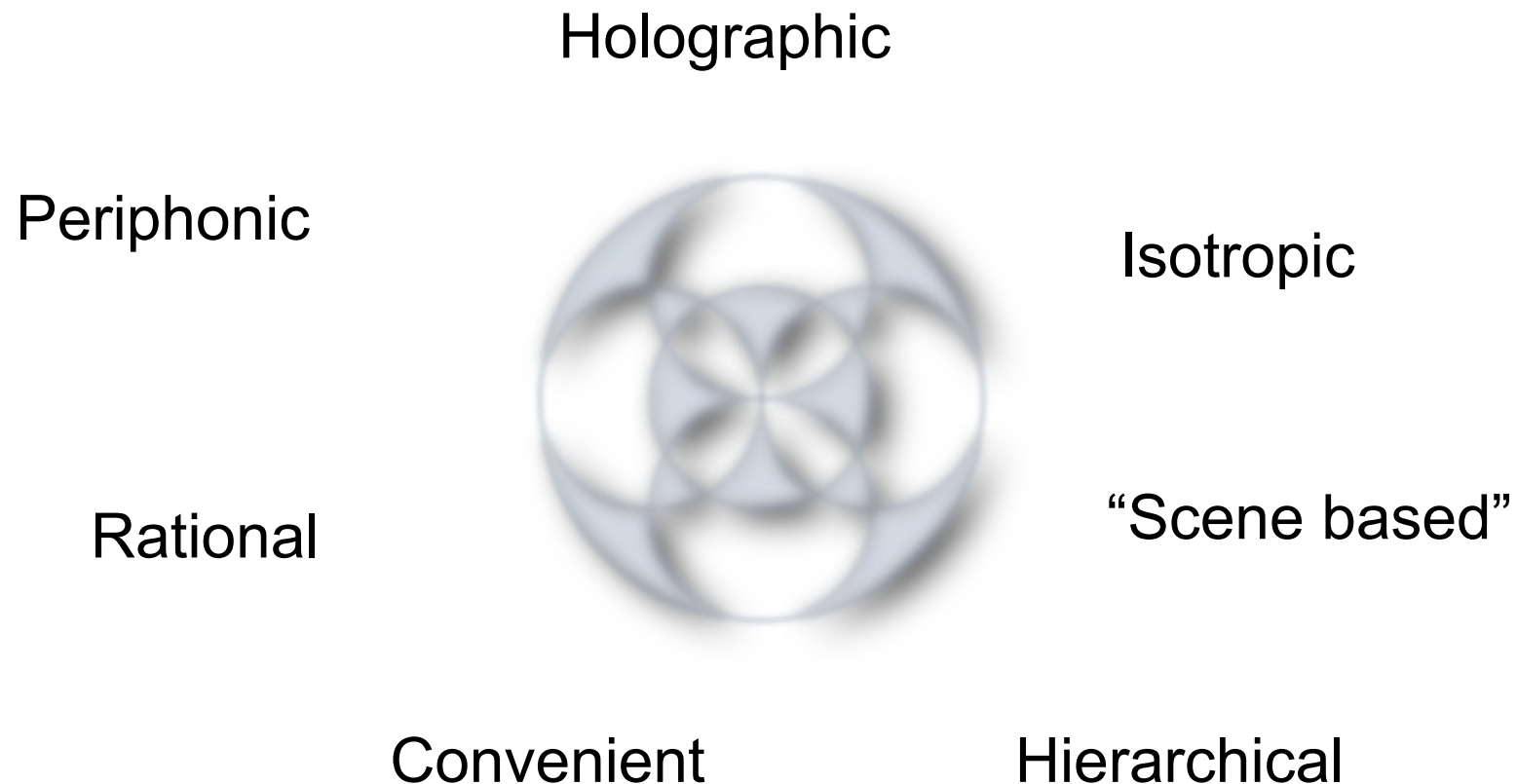
Wednesday, November 15, 2017

*University of Washington, Raitt Hall 121
Seattle, WA, USA*

Assigned Reading

- ♦ D. Arteaga, “Introduction to Ambisonics,” Universitat Pompeu Fabra, Barcelona, Spain, Lecture notes, Jun. 2017.
- ♦ J. Daniel, “Représentation de champs acoustiques, application à la transmission et à la reproduction de scènes sonores complexes dans un contexte multimédia,” PhD Thesis, Université Paris 6, Paris, 2001.
- ♦ M. Kronlachner, “Spatial Transformations for the Alteration of Ambisonic Recordings,” Master’s Thesis, Graz University of Technology, Graz, Austria, 2014.
- ♦ A. Politis, “Microphone array processing for parametric spatial audio techniques,” PhD Thesis, Aalto University, Helsinki, Finland, 2016.
- ♦ E. G. Williams, *Fourier Acoustics: Sound Radiation and Nearfield Acoustical Holography*. London: Academic Press, 1999.

Ambisonics is...



Ambisonic Vocabulary

order

encoding



decoding

B-format

NFC

A-format

HOA

Ambisonic Flavors

“Classic” B-format, aka Gerzonic

- ♦ FOA



Furse-Malham, aka FuMa

- ♦ HOA ($\leq 3^{\text{rd}}$)

AmbiX

- ♦ HOA

ACN-N3D (with NFC)

- ♦ HOA

Some other software solutions...

Production

- ♦ Blue Ripple Sound — Pro Audio
- ♦ ambiX — Ambisonic plug-in suite

Research

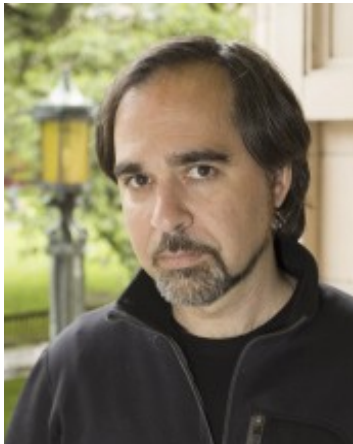
- ♦ Higher Order Ambisonics Library
- ♦ Ambisonic Decoder Toolbox
- ♦ Sound Field Synthesis Toolbox
- ♦ SOFiA



ATK People



Joseph Anderson*



Juan Pampin*



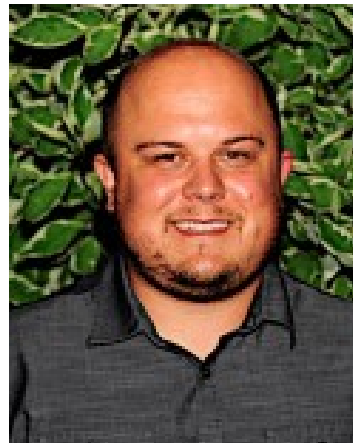
Joshua Parmenter*



Michael McCrea*

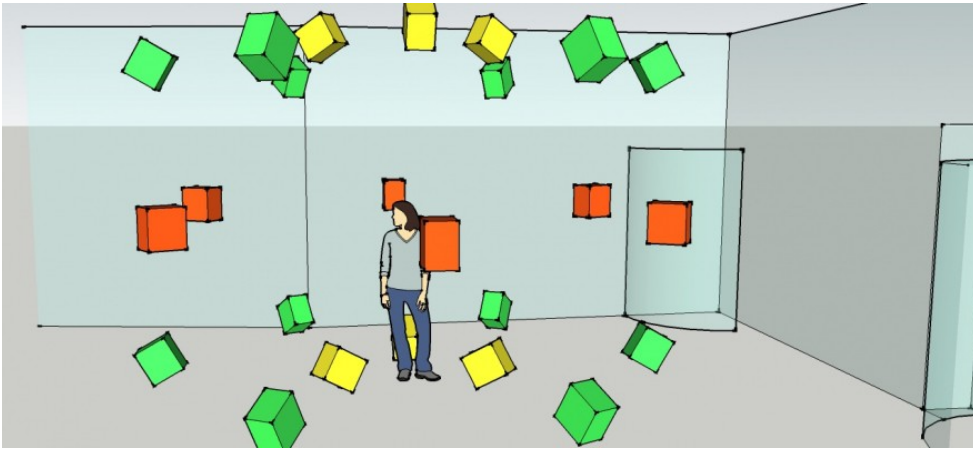


Trond Lossius†‡



Daniel Peterson*

ATK @ DXARTS



DXARTS Sound Lab – Mid-field Spherical Array



DXARTS Sound Lab – Near-field Hemi-spherical Array

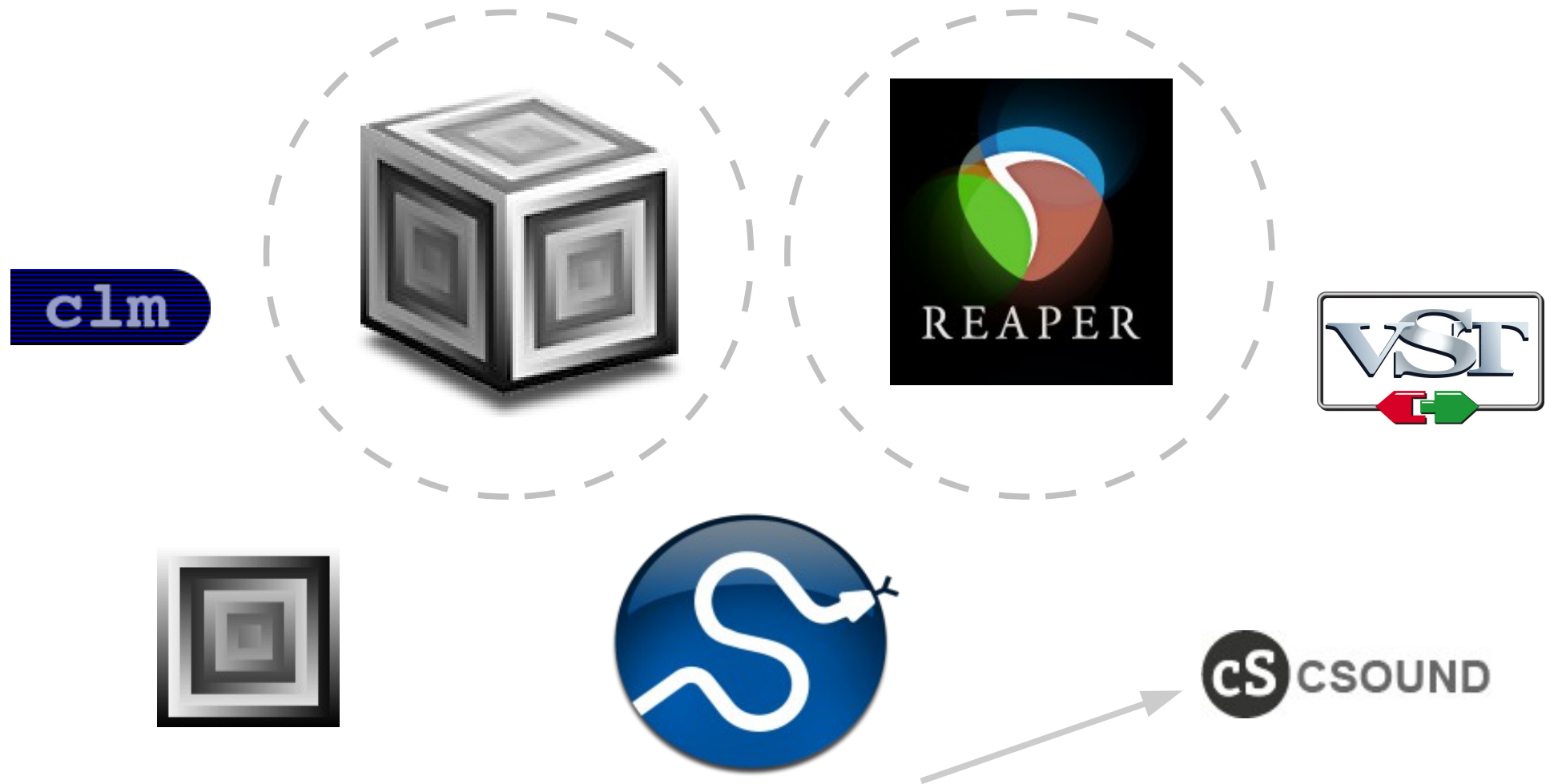


DXARTS Media Lab – Mid-field Hemi-spherical Array

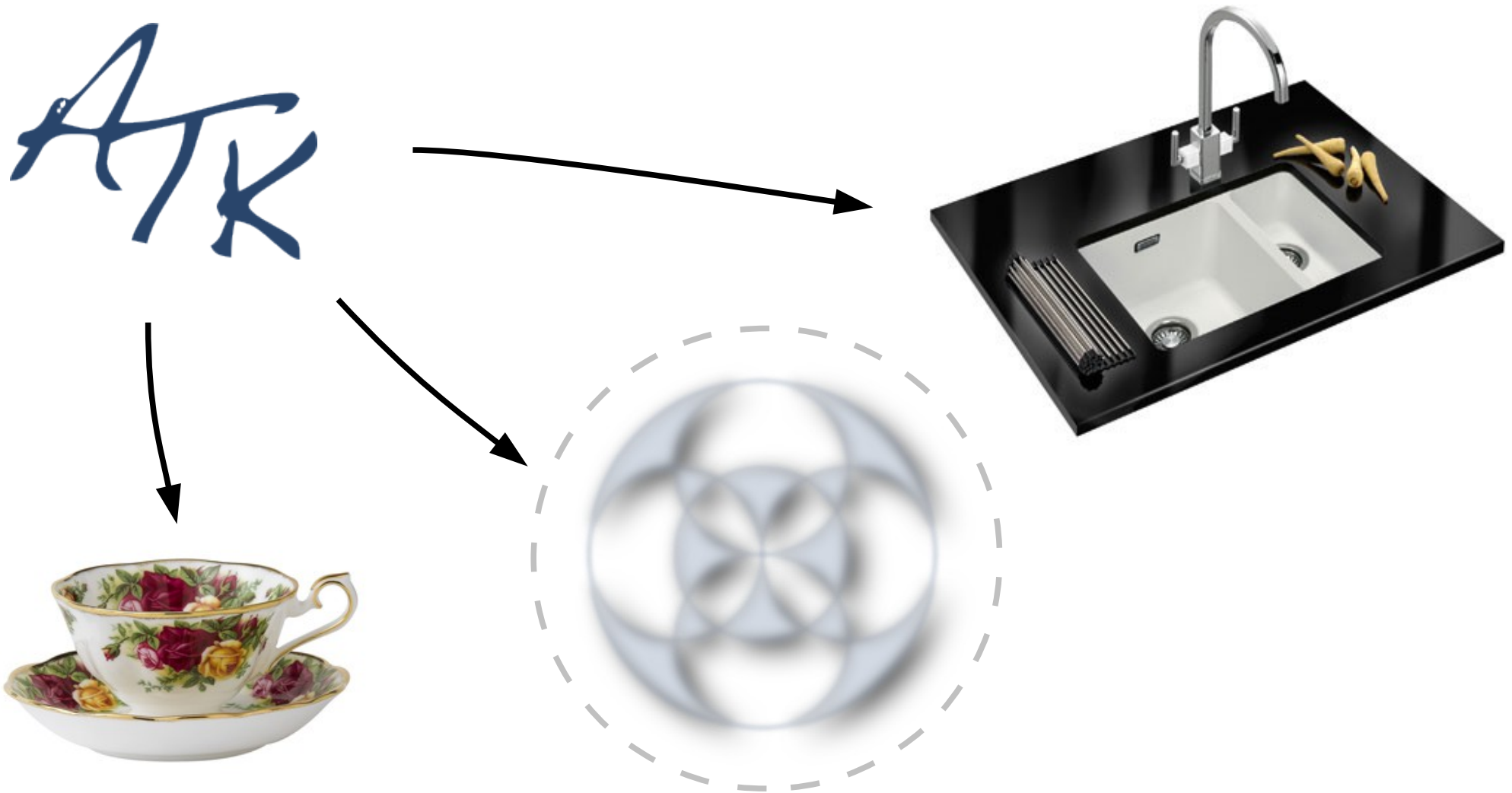


DXARTS Sound Lab – Loudspeaker Measurement & Correction

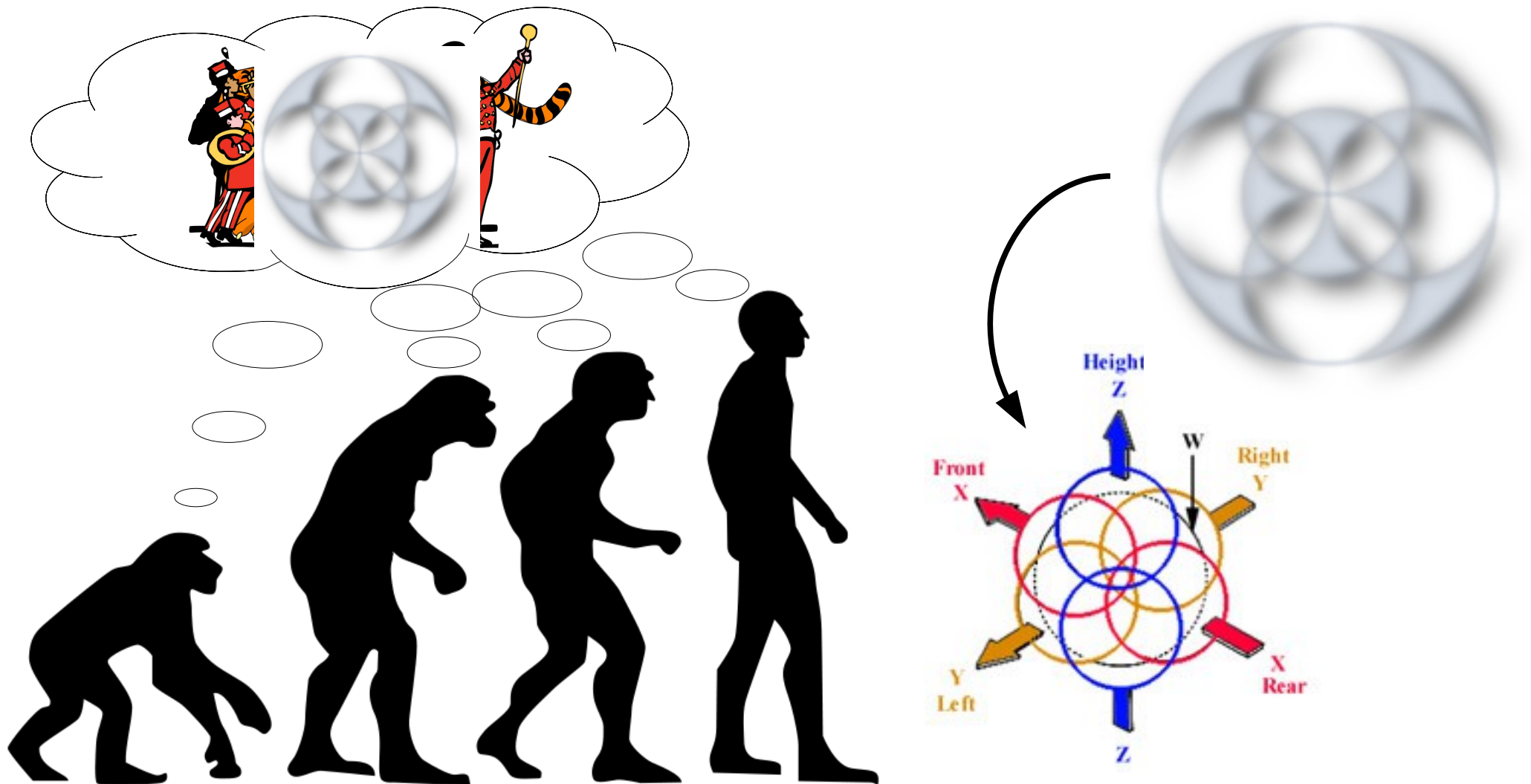
ATK Platforms



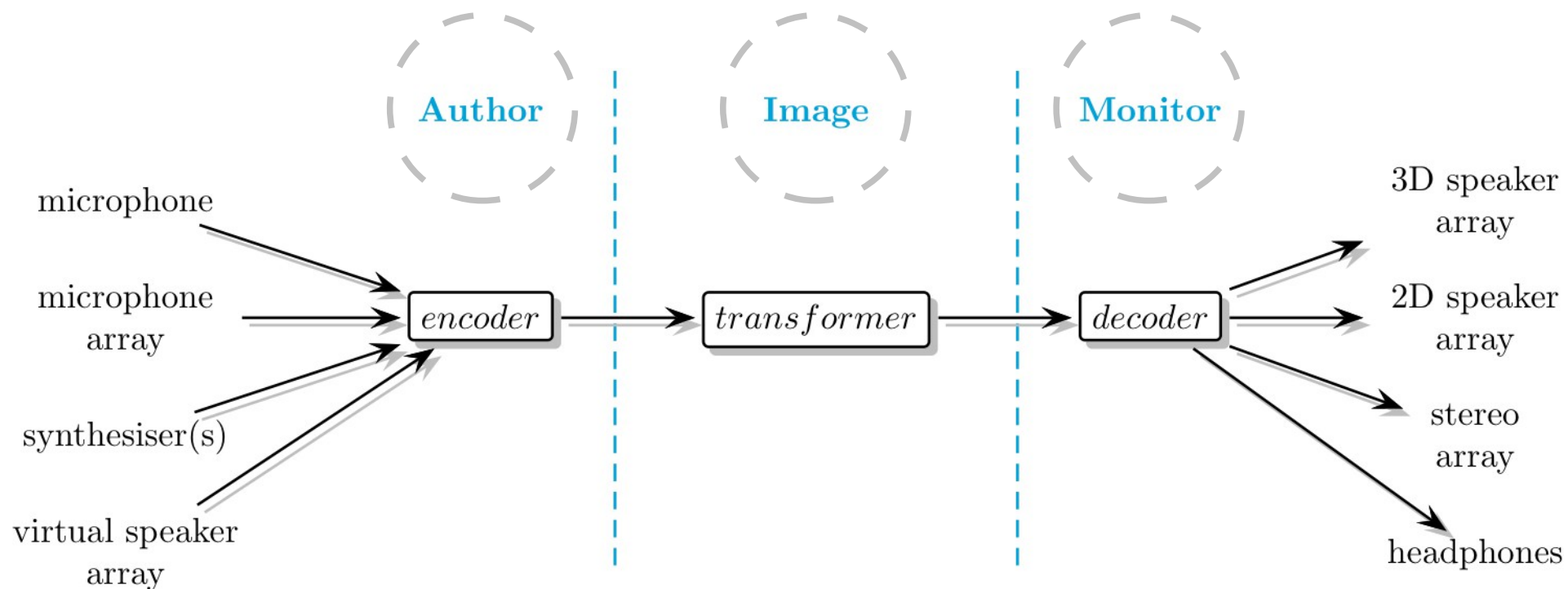
ATK Objectives



ATK: 'Think Ambisonic!'



ATK Paradigm

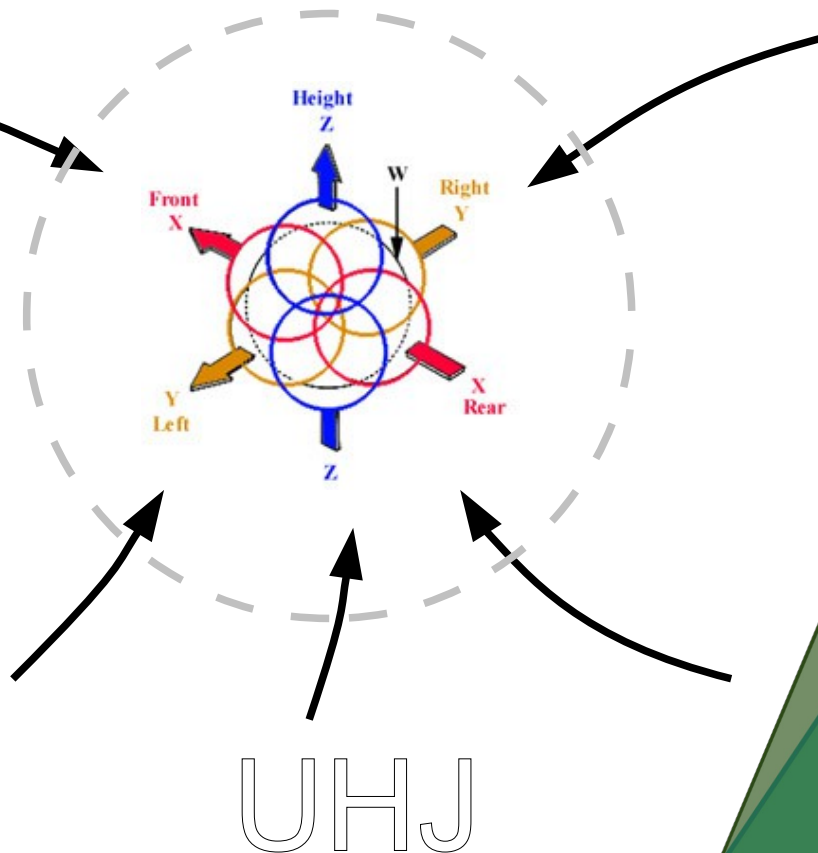


Encoding: Soundfield Authoring

$$\begin{pmatrix} \frac{1}{\sqrt{2}} \\ \cos \phi \cos \theta \\ \cos \phi \sin \theta \\ \sin \phi \end{pmatrix}$$



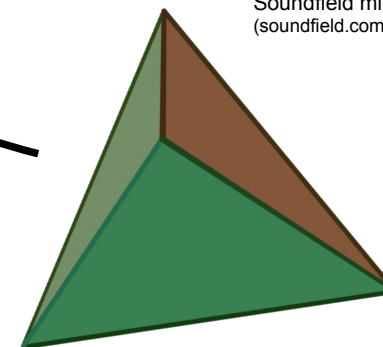
OUTRS tetrahedral microphone array, courtesy Stephen Thornton
(www.michaelgerzonphotos.org.uk)



UHJ

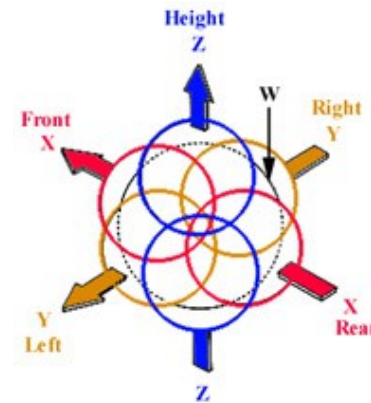


Soundfield microphone, Soundfield Ltd.
(soundfield.com)

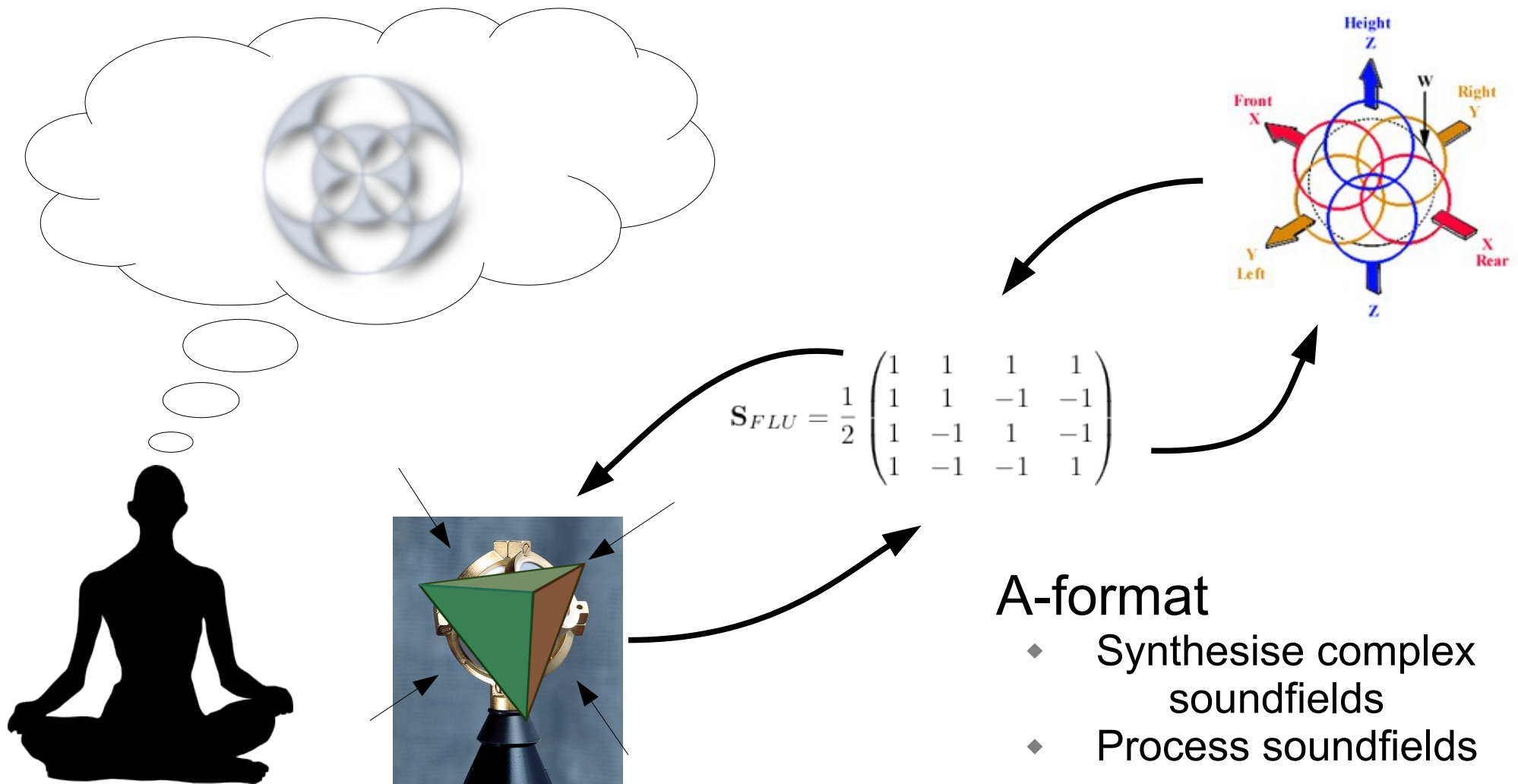


Encoding: Soundfield Authoring

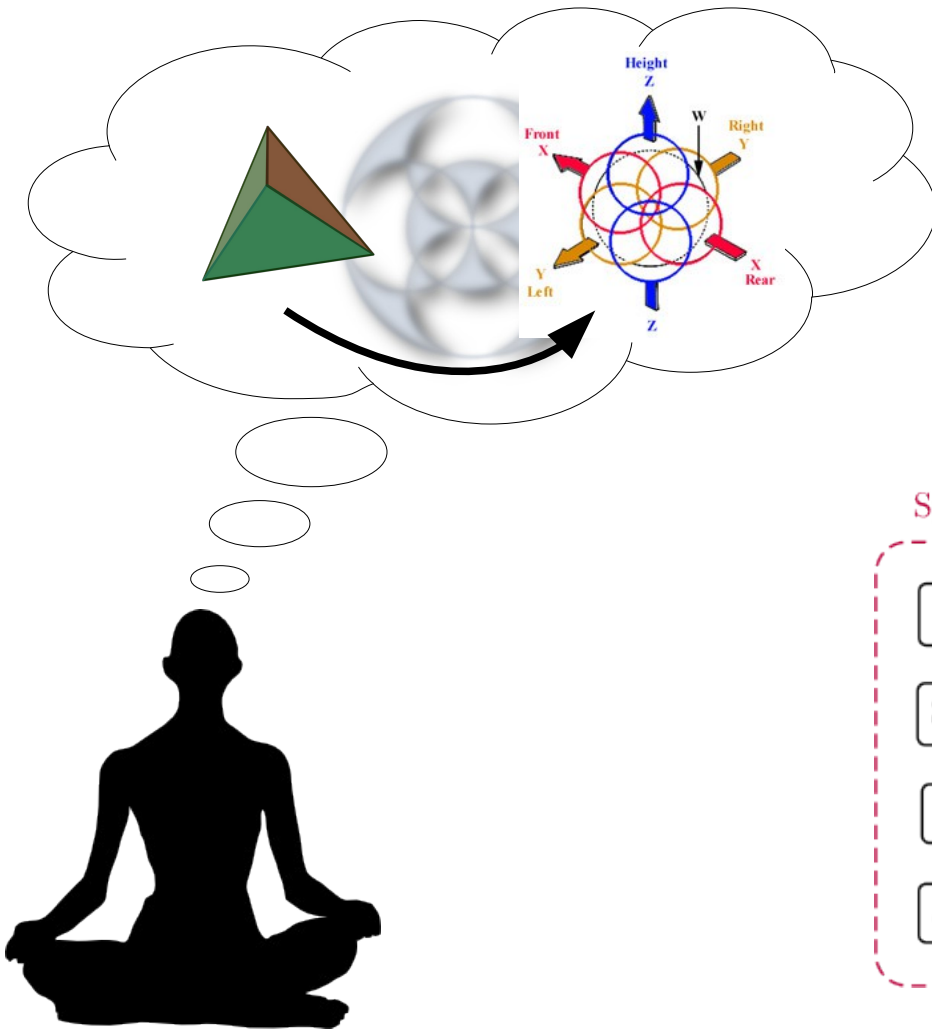
Encoding Mono using
ATK for Reaper



A-format & B-format: 'Think Ambisonic'

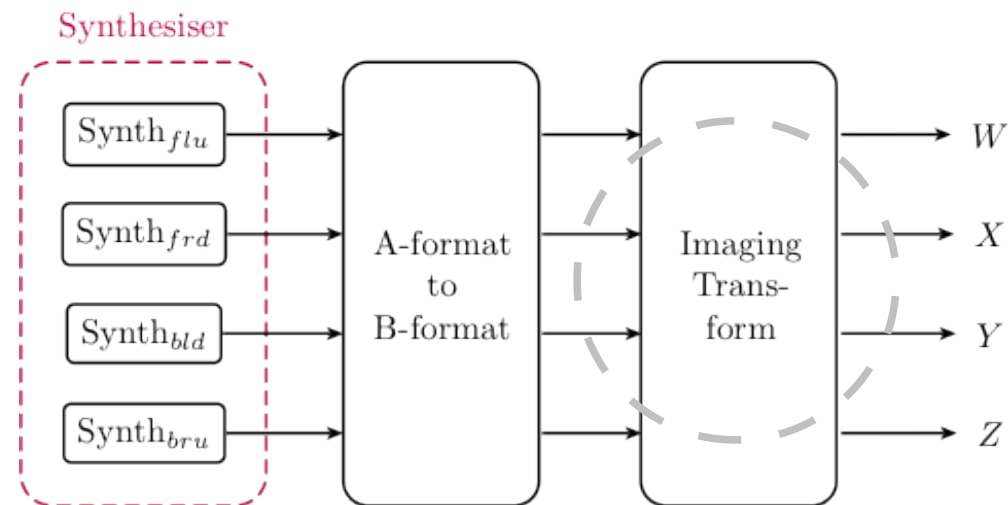


Soundfield Authoring: 'Think Ambisonic'

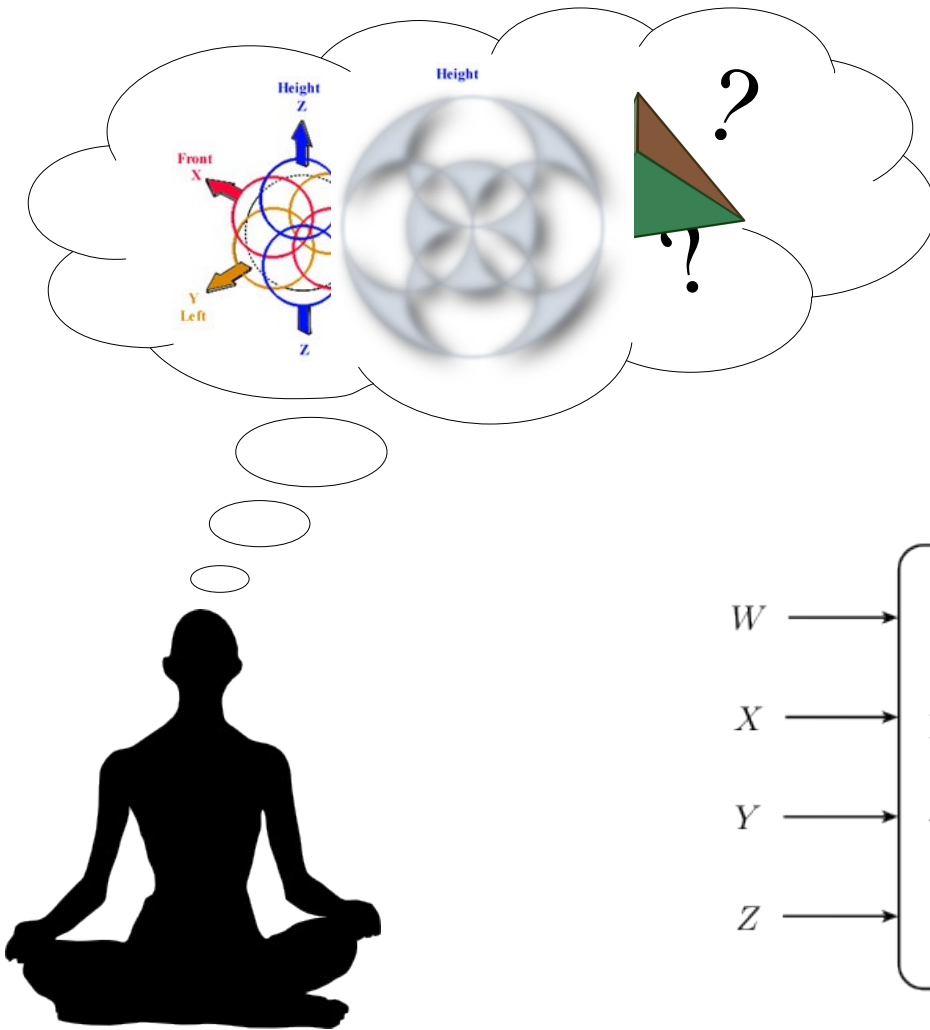


Synthesis

- ◆ In A-format
- ◆ Diffuse / active soundfield
- ◆ Followed by imaging

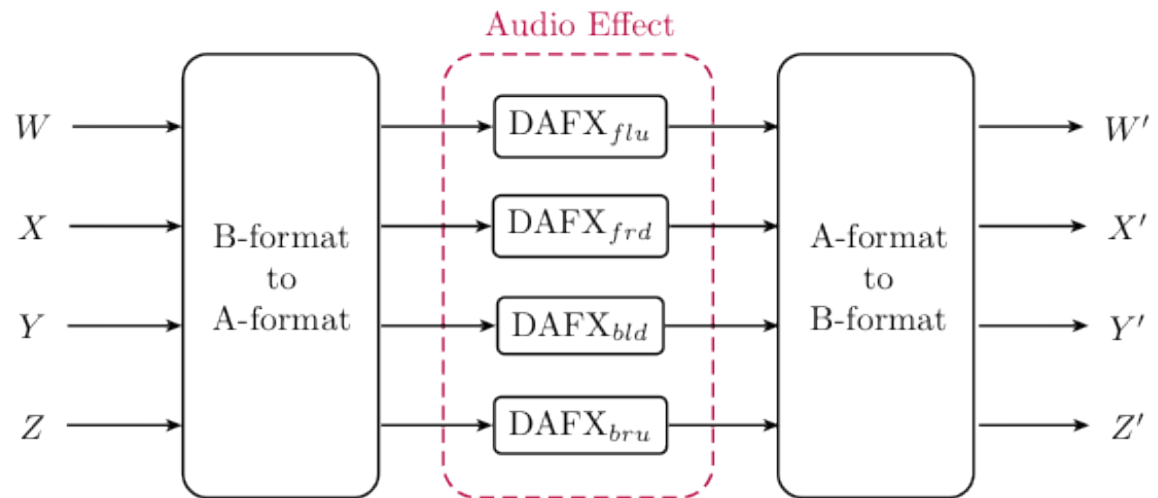


Soundfield DAFX: 'Think Ambisonic'



Audio Effects

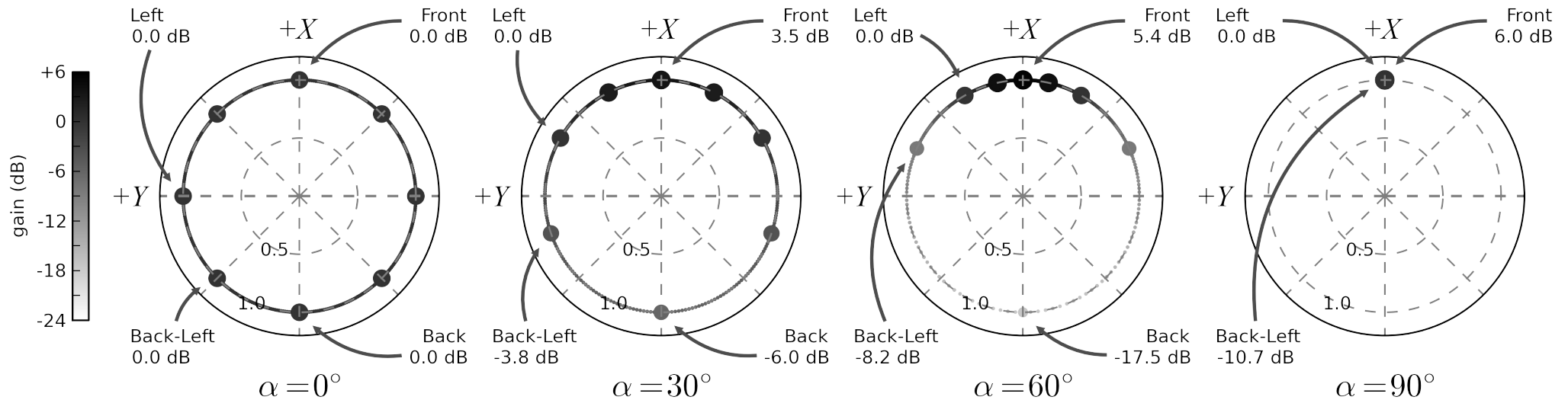
- ◆ Process in A-format
- ◆ Preserve imaging
- ◆ Effect complete soundfield
→ Ambisonic DAFX!



ATK Imaging: Zoom

- ◆ Zoom Transform
- ◆ Dominance
- ◆ Reshape Soundfield

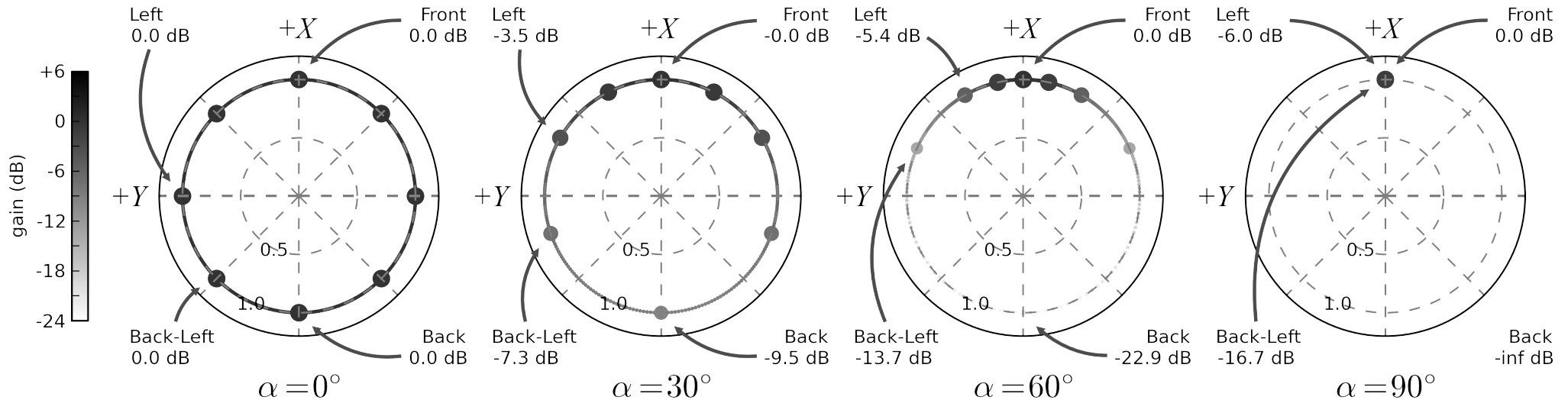
$$\mathbf{Z}_{X,\alpha} = \begin{pmatrix} 1 & \frac{1}{\sqrt{2}} \sin \alpha & 0 & 0 \\ \sqrt{2} \sin \alpha & 1 & 0 & 0 \\ 0 & 0 & \cos \alpha & 0 \\ 0 & 0 & 0 & \cos \alpha \end{pmatrix}$$



ATK Imaging: Focus

- ◆ Focus Transform
- ◆ Dominance Related
- ◆ Reshape Soundfield

$$\mathbf{F}_{X,\alpha} = \begin{pmatrix} \frac{1}{1+\sin|\alpha|} & \frac{1}{\sqrt{2}}\left(\frac{\sin\alpha}{1+\sin|\alpha|}\right) & 0 & 0 \\ \sqrt{2}\left(\frac{\sin\alpha}{1+\sin|\alpha|}\right) & \frac{1}{1+\sin|\alpha|} & 0 & 0 \\ 0 & 0 & \frac{\cos\alpha}{1+\sin|\alpha|} & 0 \\ 0 & 0 & 0 & \frac{\cos\alpha}{1+\sin|\alpha|} \end{pmatrix}$$

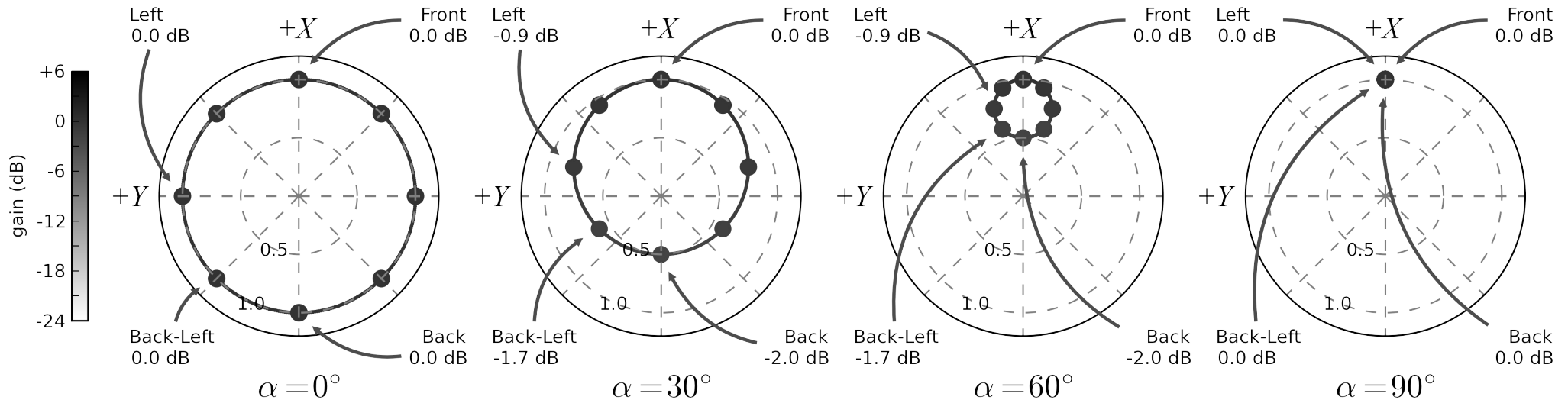


ATK Imaging: Push

◆ Push Transform

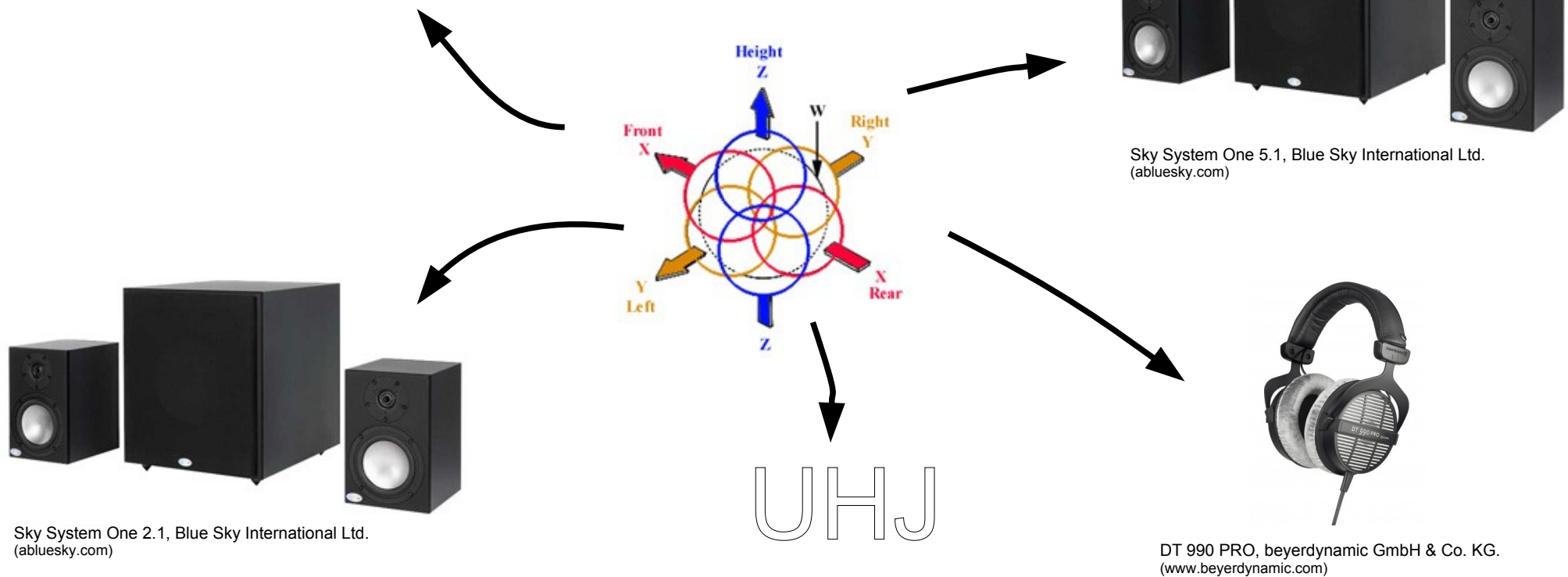
- ◆ Two metaphors:
 - ◆ Spatial Shelving-Filter
 - ◆ Re-align Tetrahedron
- ◆ Reshape Soundfield

$$\mathbf{U}_{X,\alpha} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ \sqrt{2} \sin |\alpha| \sin \alpha & \cos^2 \alpha & 0 & 0 \\ 0 & 0 & \cos^2 \alpha & 0 \\ 0 & 0 & 0 & \cos^2 \alpha \end{pmatrix}$$



Decoding: Soundfield Monitoring

$$\begin{pmatrix} \alpha_i \\ \beta_i \\ \gamma_i \end{pmatrix} = \frac{1}{\sqrt{2}} nk \left[\sum_{j=1}^n \begin{pmatrix} x_j^2 & x_j y_j & x_j z_j \\ x_j y_j & y_j^2 & y_j z_j \\ x_j z_j & y_j z_j & z_j^2 \end{pmatrix} \right]^{-1} \begin{pmatrix} x_i \\ y_i \\ z_i \end{pmatrix}$$



ATK Produced Works...

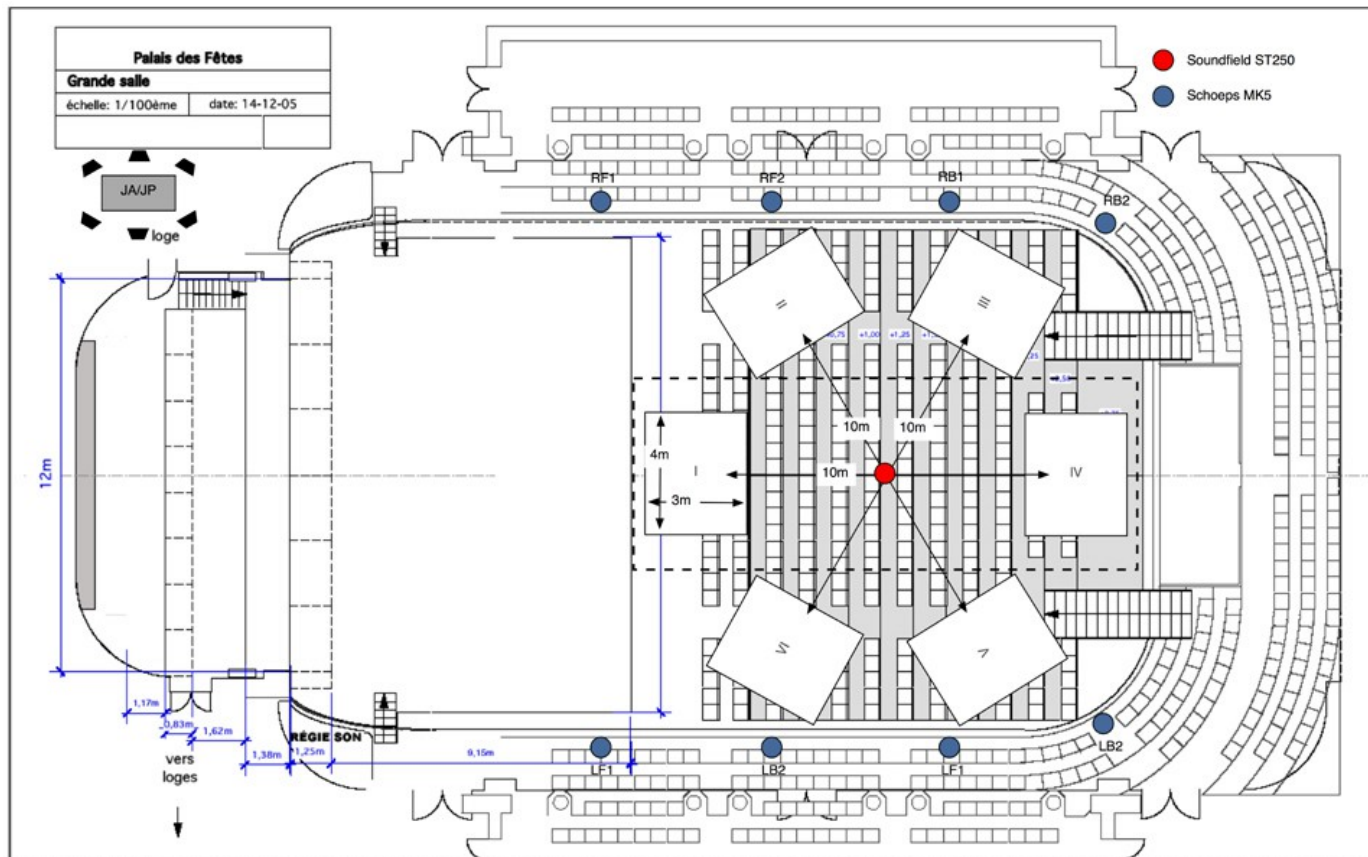


ATK Produced Works...



ATK Produced Works...

On Space recording plot

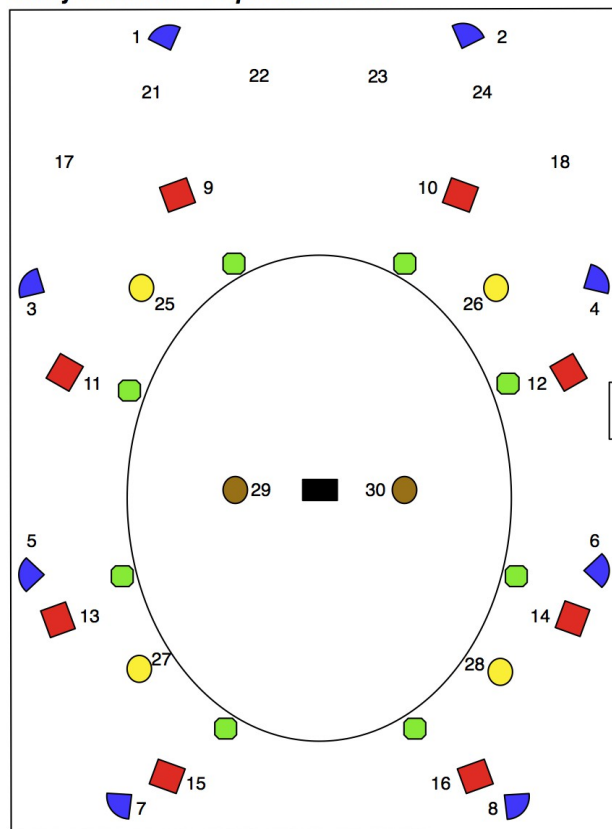


Palais des Fêtes



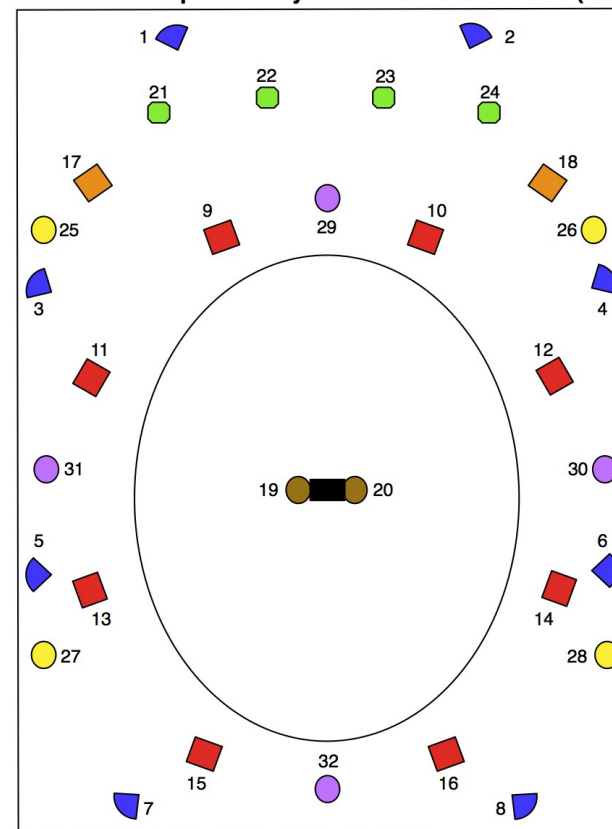
ATK Produced Works...

Jonty Harrison – *Espaces cachés*



- 1-8 8 High & Distant
 - 9-16 8 Main
 - 17-24 8 Close
 - 25-28 4 High Quad
 - 29-30 Subs & Tweeters
- TOTAL channel count = 30**

Possible set-up for Jonty Harrison – hcmf// 2015 (tbc)



- 1-8 8 Diffuse (4 wedge & 4 Mackie)
 - 9-16 8 Main (Meyer + sub)
 - 17-18 2 Reference/Solo (Meyer + sub)
 - 19-20 2 Desk (2 x 2 Moca Audio)
 - 21-24 4 Solo/Effects (Bose)
 - 25-28 4 High Quad (Mackie)
 - 29-32 4 Low Quad (Bellecour)
- TOTAL channel count = 32**

ATK in Action...

JONTY HARRISON
Voyages

The Center for Digital Art and Experimental Media and the School of Music co-host this presentation of Jonty Harrison's *Voyages*, presented in Holographic Higher Order Ambisonic surround-sound.

MUSIC OF TODAY

Tuesday, November 28, 2017
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Meany Theater

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\$10 STUDENTS/SENIORS

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W SCHOOL OF MUSIC
UNIVERSITY of WASHINGTON

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DXARTS
Center for Digital Arts and Experimental Media
University of Washington

TRAV

End of month!

ATK in Practice

Ambisonic Toolkit **(SuperCollider Library)** **Quick Look**

ATK in Practice

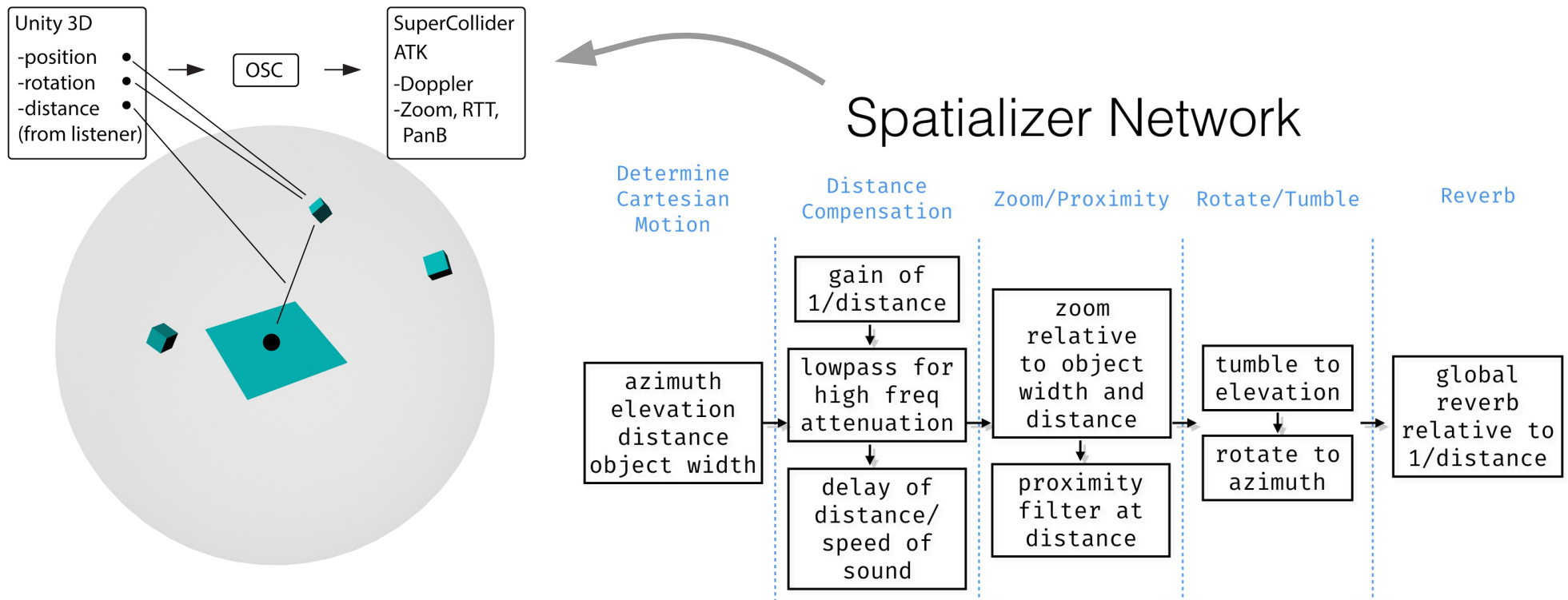


Seattle P-I



Ambisonic RIR from the Fort Worden Cistern Ewa Trebacz & Josiah Boothby

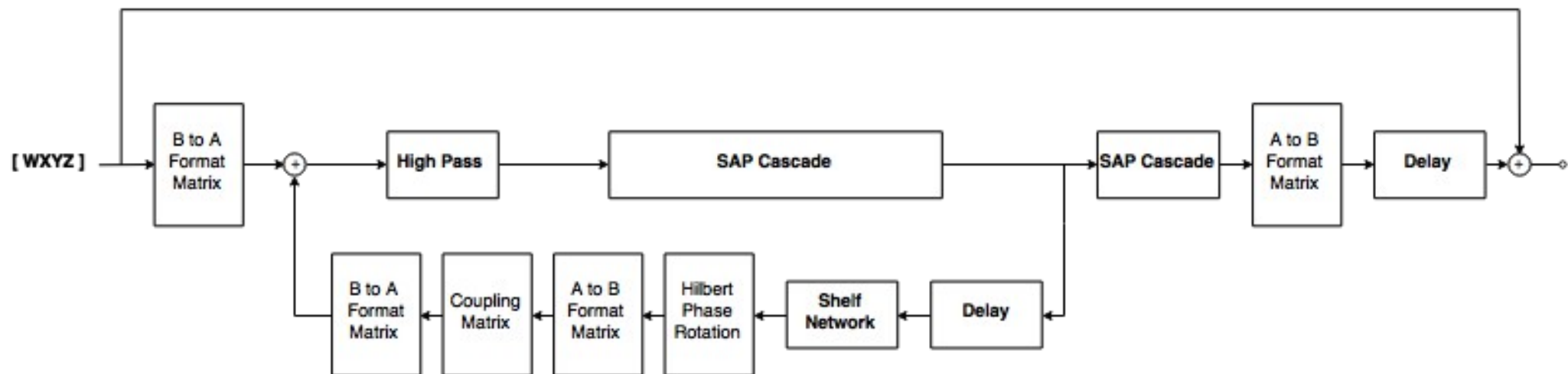
ATK in Practice



VR & Holographic Sound Synthesis with the ATK

Daniel Peterson & Martin Jarmick

ATK in Practice



AmbiVerbSC: An Ambisonic tank reverb model for SC3

James Wenlock

ATK, Future Development...



Coming Soon (SC3)...

- ◆ Soundfield Analysis
- ◆ Soundfield (matrix) transform display

On the Horizon...

- ◆ T-design A-format
- ◆ ADT integration
- ◆ Revised beam-forming model
- ◆ HOA-NFC! (SC3 & Csound)

ATK, WTF?



Questions...?

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Thanks!!

A handwritten signature in blue ink, consisting of the letters 'ATK' in a stylized, cursive-like font.

joanders@uw.edu

dxarts.washington.edu

www.ambisonictoolkit.net

Guides/Intro-to-the-ATK

github.com/ambisonictoolkit