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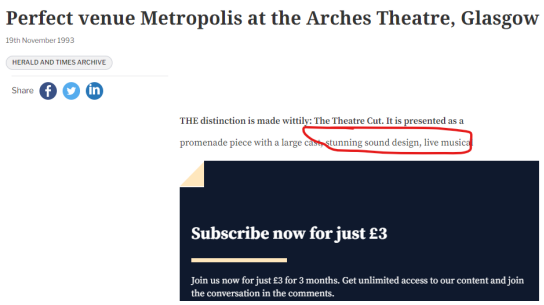
Ronan Breslin – Hello!!

Theatre Credentials? A few highlights.

Arches Theatre Company
Metropolis: The Theatre Cut (music and sound design)



Music and Sound Director for Mischief La Bas
1993 to 2014 – a few examples

Painful Creatures (2003/2004)
Various outdoor venues

Peeping at Bosch (2009)
Tramway

The Zoo (2015)
Glasgow Science Centre

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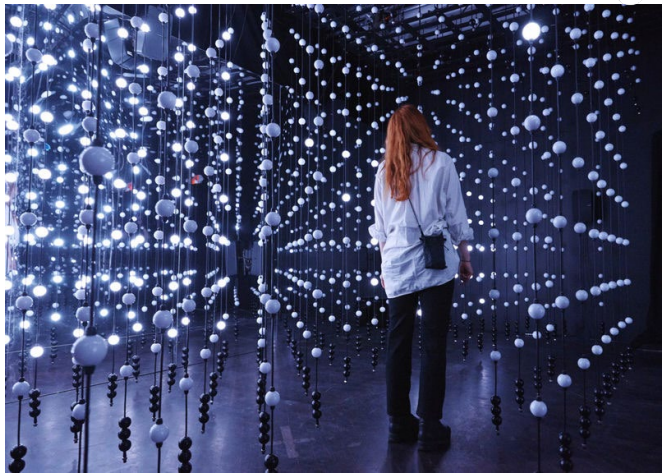
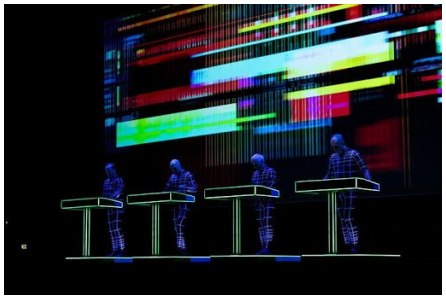
What is Spatial Audio?





- Ambisonics
- Wave Field Synthesis
- Binaural Audio

- Object and Scene-Based Audio
- Channel-Based Surround Sound: 5.1, 7.1, 10.2, 22.2
- Object and Bed-Based Audio: Dolby Atmos (basic Atmos is 7.1.4)

- Historical systems: eg. Fantasound, Cinerama.

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What is Spatial Audio?

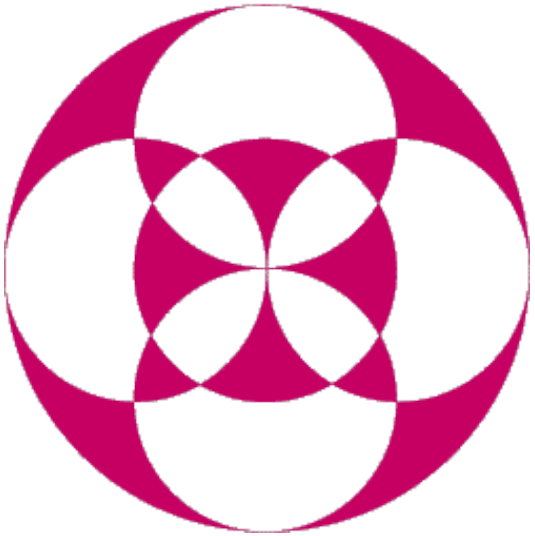
- According to immersive sound expert Francis Rumsey there is a "…dichotomy between those systems based on an underlying mathematical model of an acoustical soundfield and those [systems] that simply kept adding loudspeakers and attempting to apply basic stereophonic principles…"
- Rumsey goes on to state that the former method is the scientists' interpretation of the "way to do surround sound" including sound field reconstruction and wave field synthesis while a channel based stereophonic system is the "… recording engineers' idea of the way to so surround sound", based on tried and tested cinematic techniques.

So, it's a huge subject!

And is there a middle way between the scientists and the practitioners?

We don't have long so I think we will focus on ambisonics.

What is it?



Ambisonics commercial logo from 1970s.

Ambisonics

- Spatial Audio System developed by mathematician Michael Gerzon of Oxford University and Professor of Cybernetics P B Felgett of Reading University.
- Mature technology – developed in 1970's.
- Based on the capture and replay of a soundfield at a single point in space. Hence the development of the Soundfield Microphone (more shortly). Direction of sound source is encoded not speaker channels.
- Flexible system in that encoding is separate from decoding.
- As long as speaker positions are known, ambisonic signal can be decoded over any (sensible) speaker array OR binaurally encoded to headphones.
- All speakers in array contribute to localisation and directional cues of audio signal – unlike 5.1 or other channel-based configurations.

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Ambisonics

- Capable of full periphonic and isotropic surround – height and depth
- Minimum four channels required for periphonic reproduction
- L ≥ N where L is the number of speakers and N is the number of channels (as always though – the more speakers the better)
- Hierarchical system - can be expanded – higher orders
- "Theoretically any arbitrary geometry of the loudspeaker array can be chosen, which is a remarkable advantage … in contrast with channel based formats such as 5.1 or 22.2" [1]

[1] Roginska, A., Geluso, P. Eds. 2018. Immersive Sound: The Art and Science of Binaural and Multi-Channel Audio. Routledge (AES).

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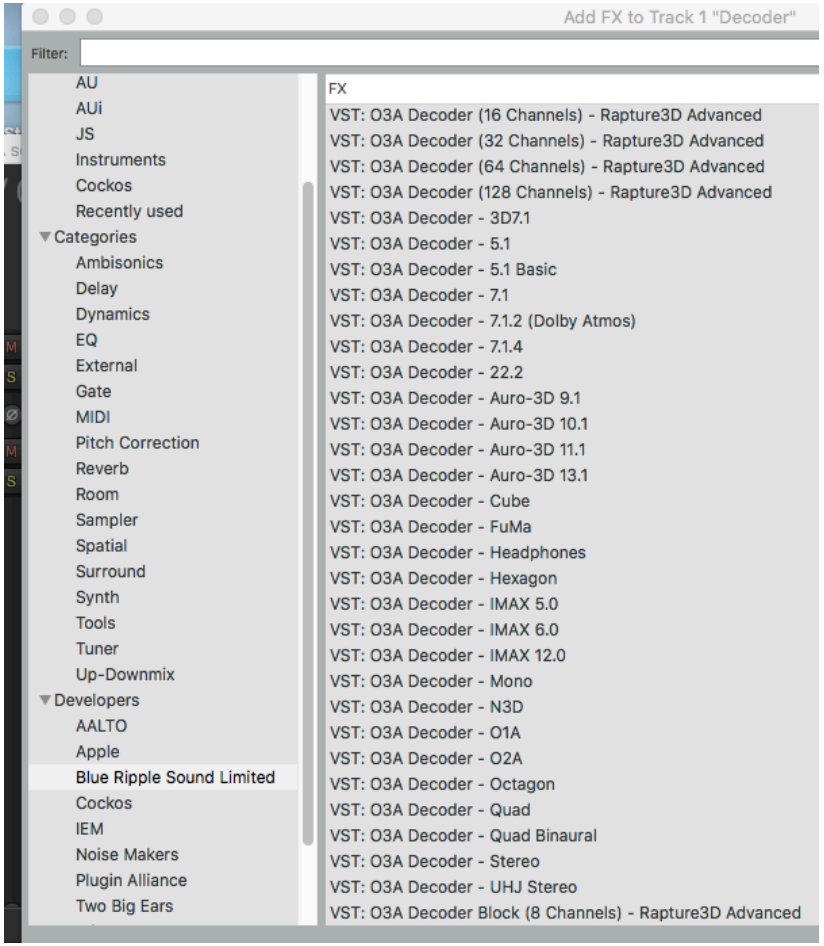
Ambisonics Decoders



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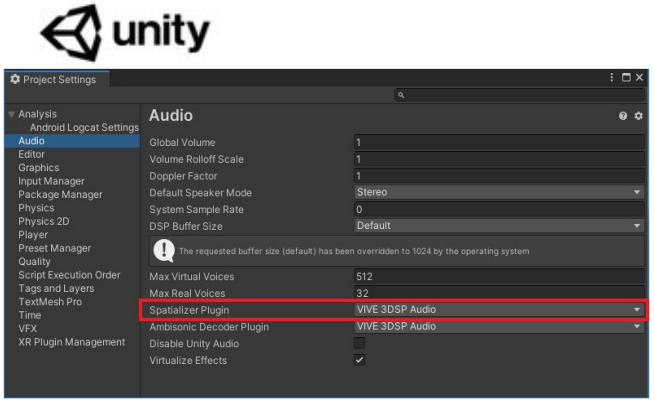
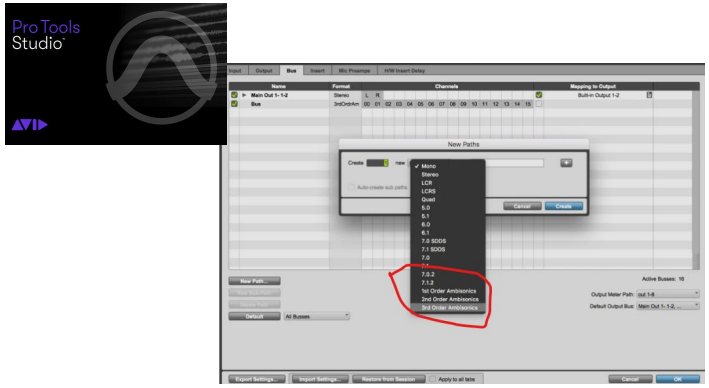
Ambisonics

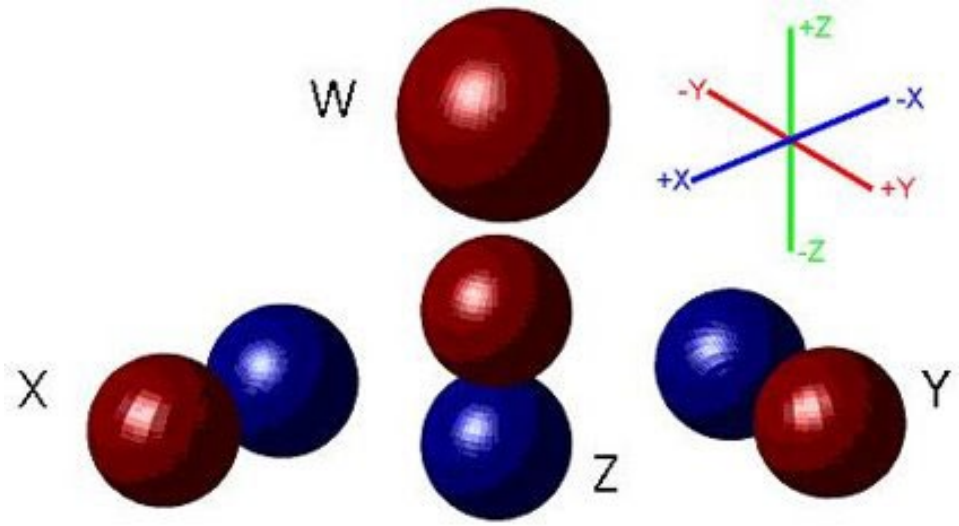
- Now implemented in all major DAWS including Pro Tools.
- A key element of game audio engines and VR audio authoring.
- Many first order ambisonic microphones on the market and some higher order microphones.
- IMHO – a very efficient and flexible method for delivering spatial audio to an audience - either live or as a pre-record.





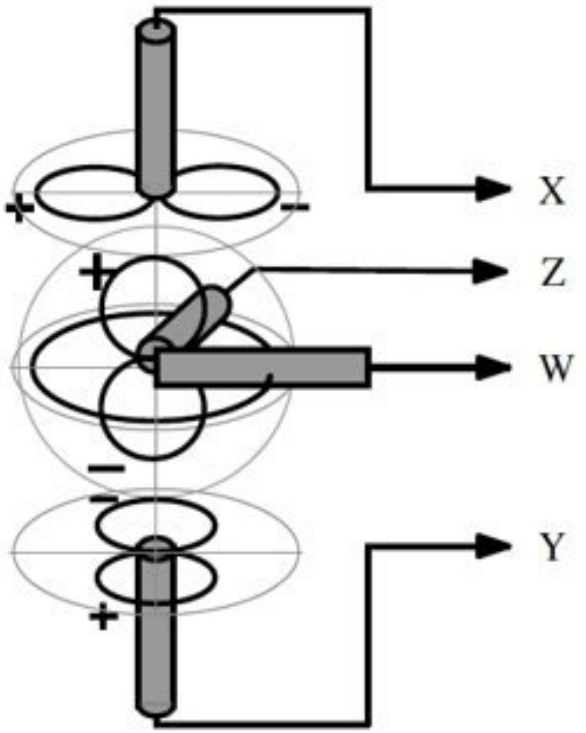
Ambisonics – The concept via soundfield microphone array

- First Order Ambisonics (WXYZ) - captures a 3D soundfield albeit at low spatial resolution



- Consists of W, X, Y, Z channels - corresponding to omni W pick-up pattern, and three fig-8 X, Y, Z pick-up patterns
- B-Format

3D FOA ambisonic recordings could be described as Triple-MS

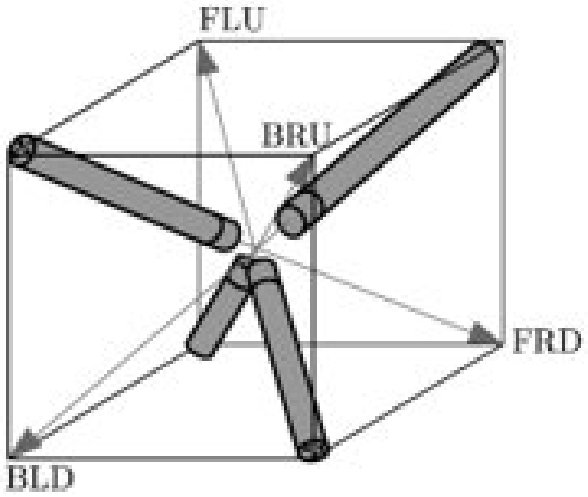


(a) Native 3D FOA recording

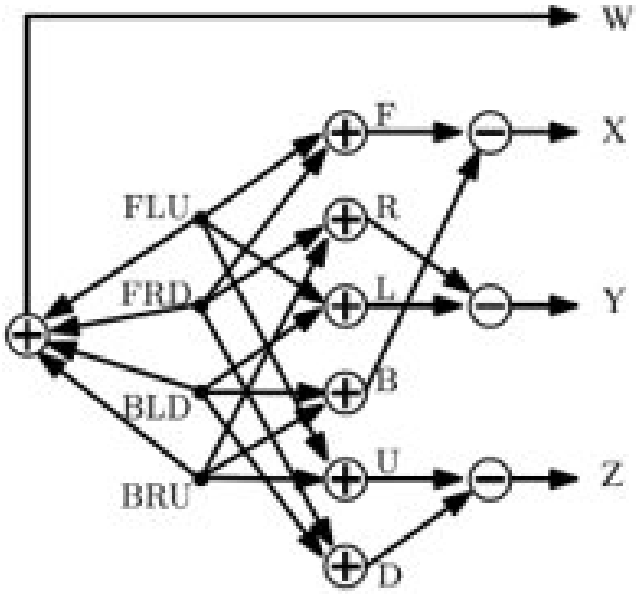
(b) Picture of the recording setup

However it is too difficult to build a phase-coherent microhone array with a pressure component and three pressure-gradient components.

Solution – Tetrahedral array of cardioid microphones



(a) Tetrahedral array with four cardioids



(b) Encoder of microphone signals

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FOA Ambisonic Microphones

(a) Tetrahedral array of 4 cardioids

(b) SPS200

(c) MK4012

(d) ST450

- A-Format to B-Format
- W = LF + LB + RF + RB
- X = LF – RB + RF – RB
- Y = LF + LB – RF – RB
- Z = LF – RB – RF + RB

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Sennheiser Ambeo (£1200)

Zoom H3 VR Mic and recorder (£250)

So I have made a recording with my fancy microphone?

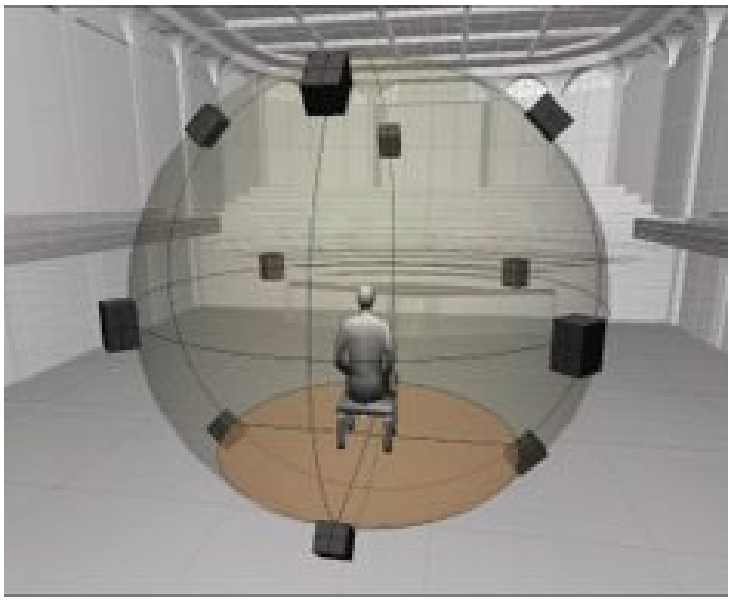
How do I hear it?

You need a decoder!

An Ambisonic decoder converts Ambisonic B-Format recordings to play back the recording on a speaker array (or headphones) defined by the encoder.

Each speaker receives a weighted sum of W, X, Y, Z according to the approximate relationship …

$$L_n = W/\sqrt{2} + X \cos\phi \cos\theta + Y \sin\phi \cos\theta + Z \sin\theta$$



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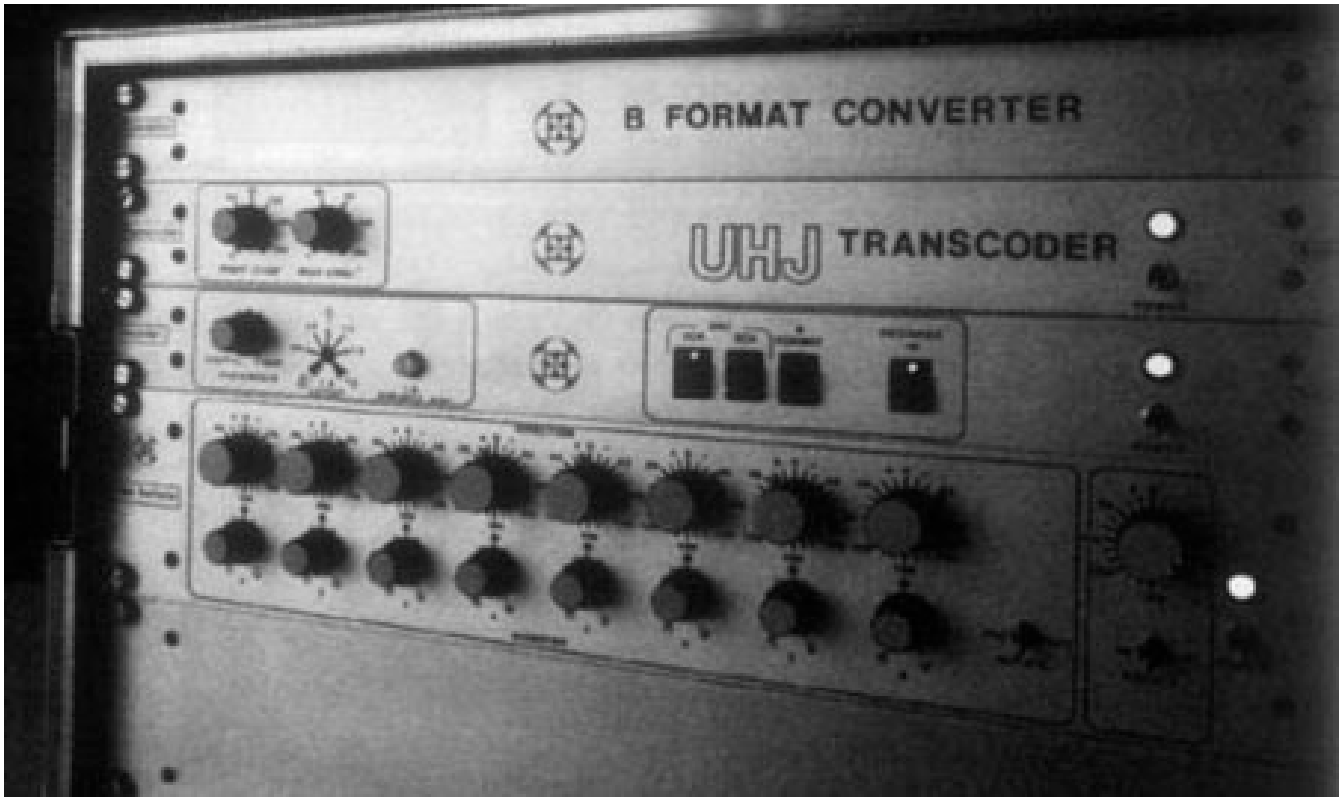
What do ambisonic decoders look like?

Here is an old one from the late 70's.



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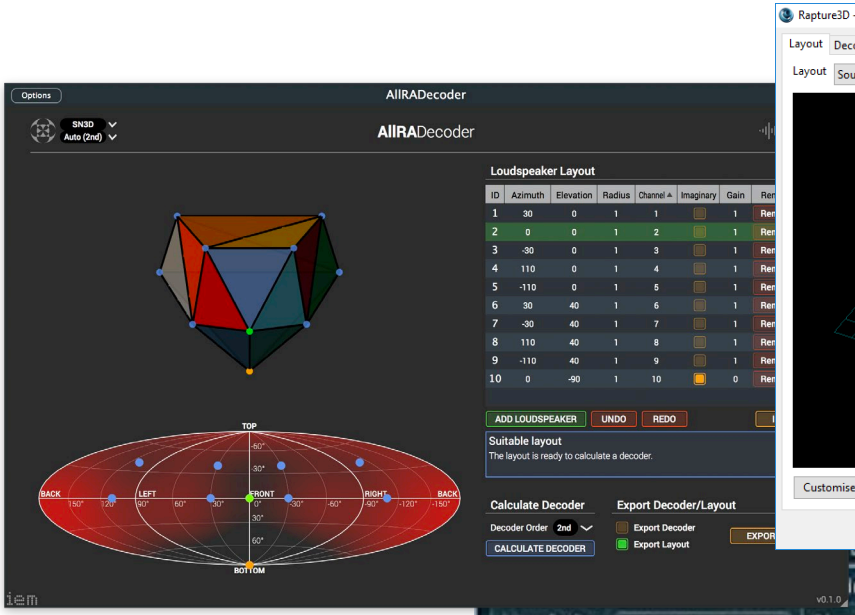
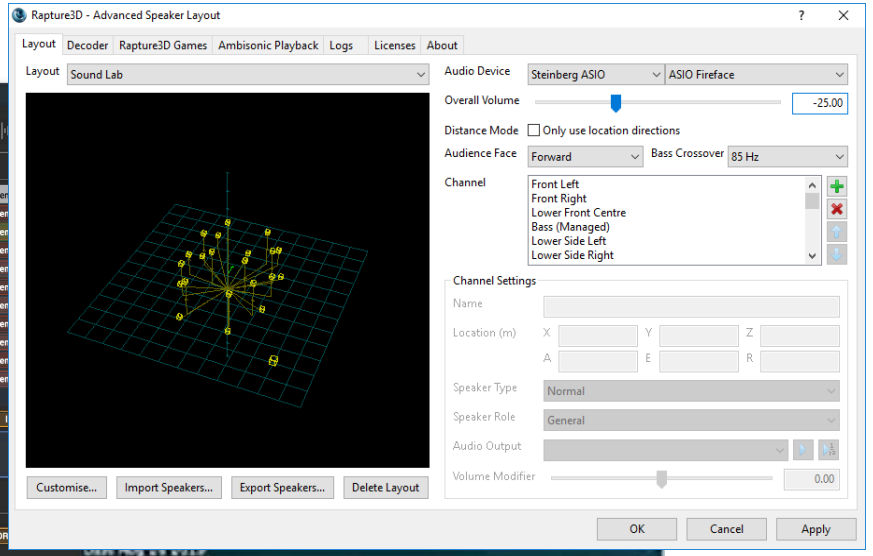
As you can guess current decoders are all software based.





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The GSA/Arup SoundLab @ The Hub

You are all welcome to visit and have a play!

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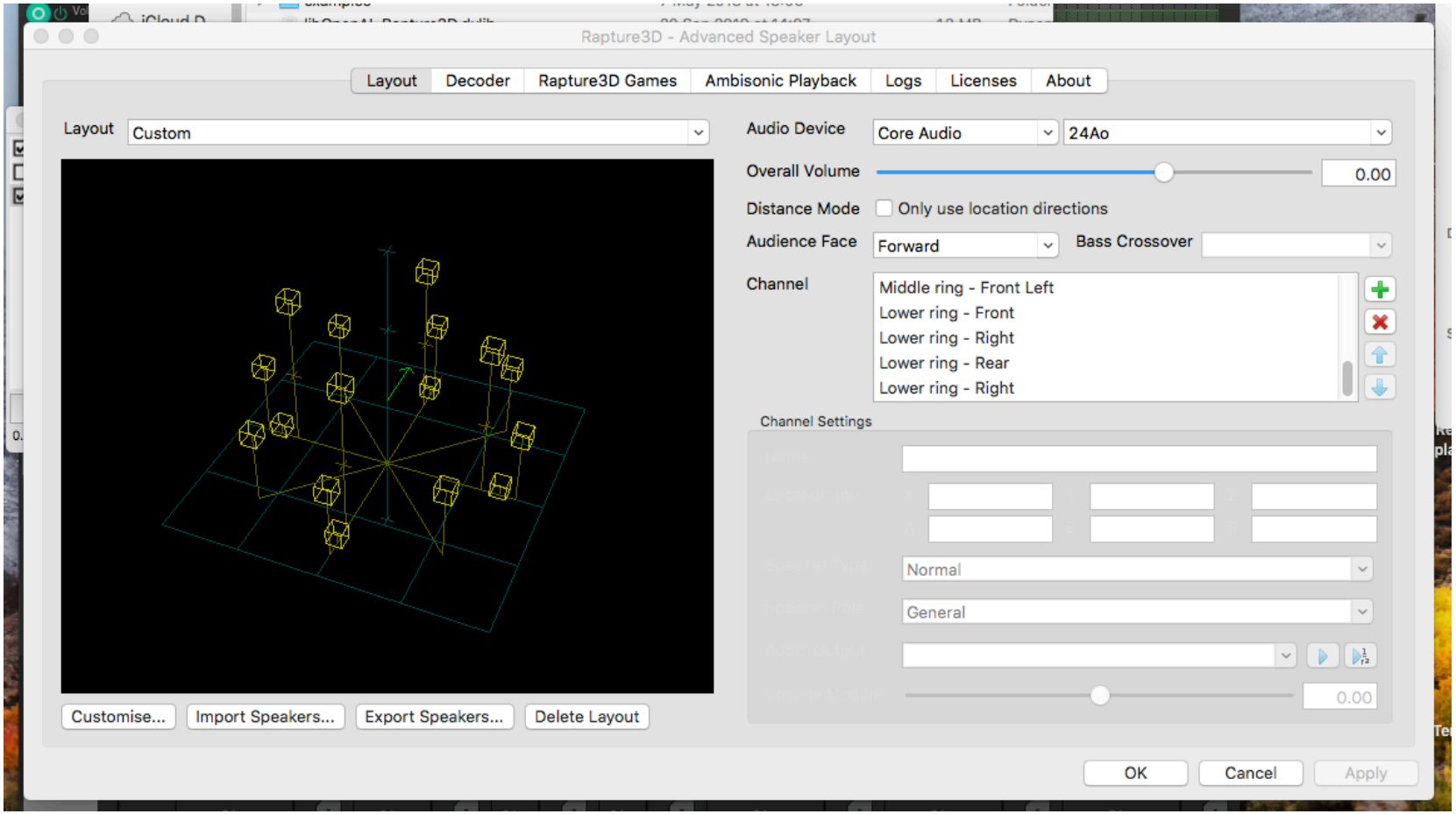
Here is the decoder from the SoundLab



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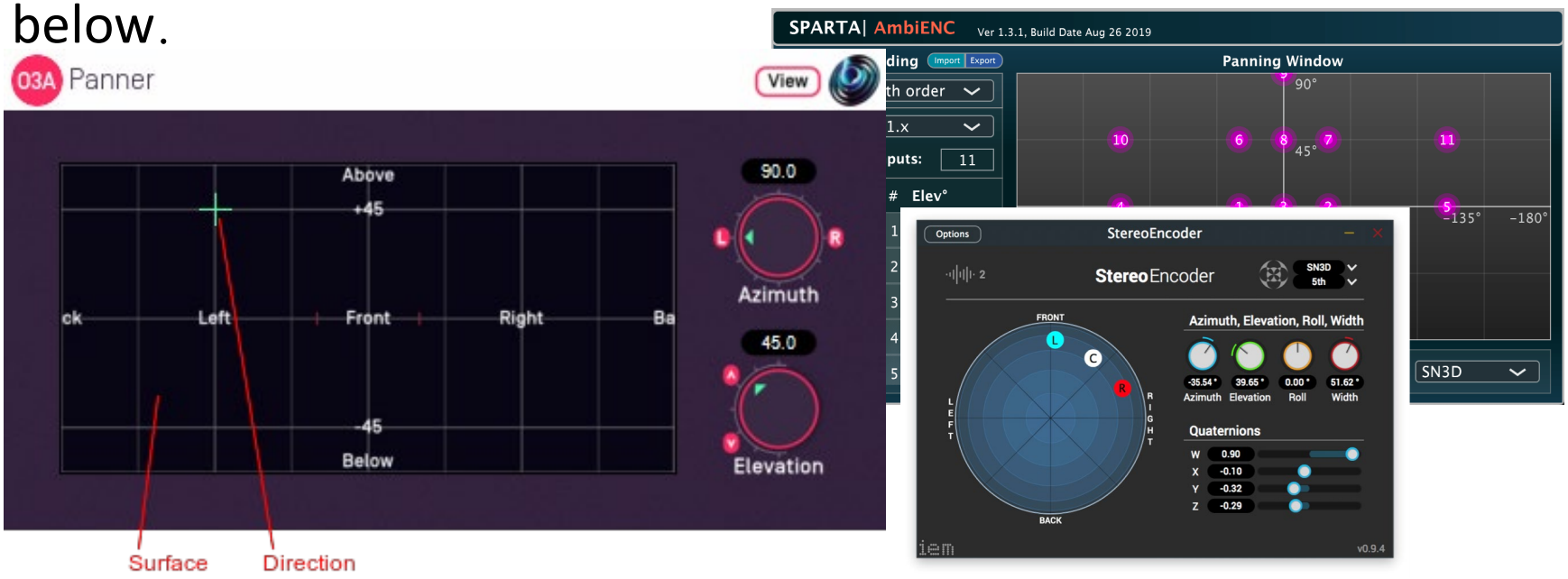
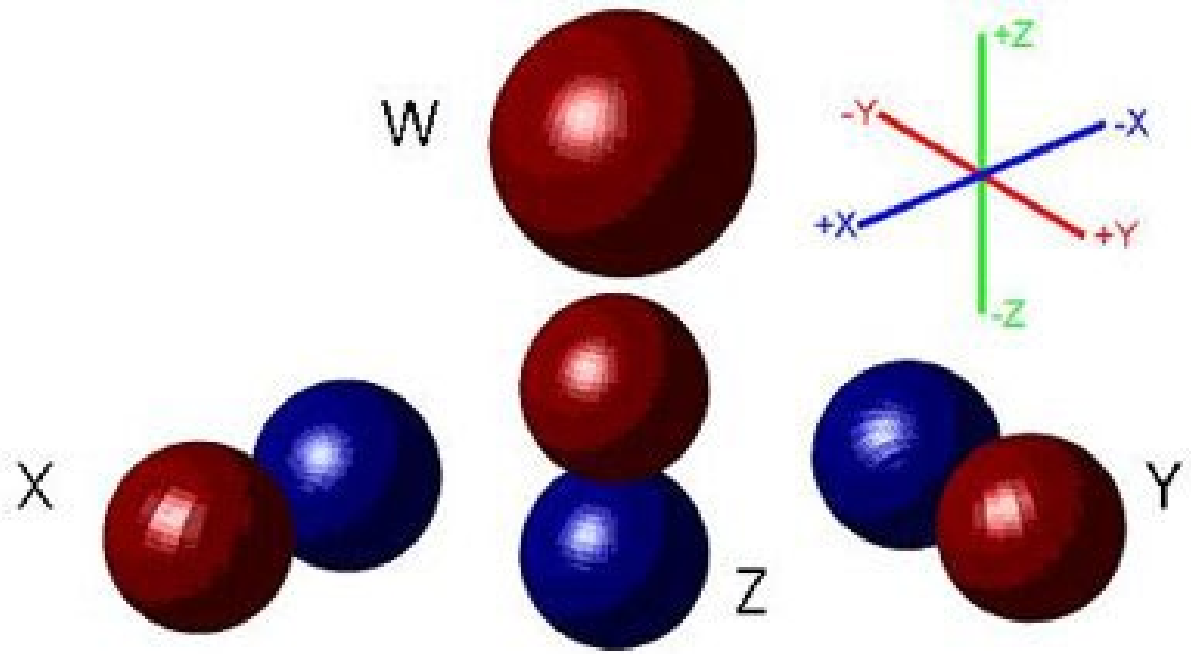
I don't have an ambisonic microphone but I have a load of mono and stereo audio files that I would like to use to make an ambisonic soundfield for my theatre production. What now?

Ambisonic soundfields can be constructed using various encoders. An encoder converts any audio signal to a B-Format signal. The most common encoder is an ambisonic panner. See below.

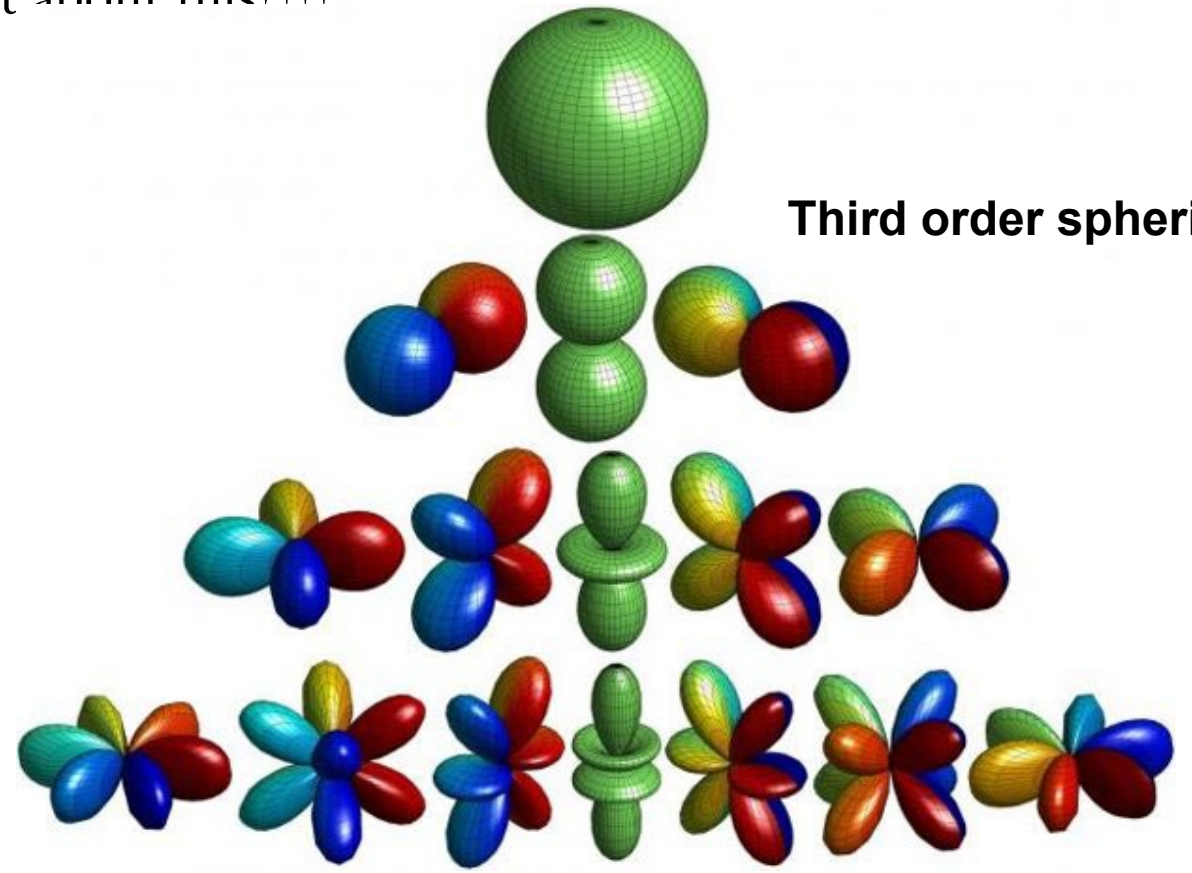


Synthesising an ambisonic sound field also allows you to use higher order ambisonics -

Remember this!!



Now what about this?!!!



Third order spherical harmonics

These spherical harmonics can be directly related to the concept of virtual microphone patterns.

- Encoding at higher order ambisonics adds further spherical harmonics to the representation of a sound field thus improving

1. Spatial Resolution and directivity of sound sources.
2. Increased HF cut-off of the time/frequency spectrum.
3. Increased listening area .. aka sweet spot.

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Wow great!! What's the catch?

Channel count!

$$N = (M+1)^2$$

Each sound source (mono or stereo) will require

- Four audio channels for first order..
- Nine channels for second order
- Sixteen channels for third order
- And 64 channels for seventh order

That means if you were working at 7th order and had just ten mono audio sources you would require 640 audio channels to properly describe each source's directivity

From personal experience first order is great for ambiences and third order is totally sufficient for good directivity.

Ambisonics is hierarchical so we can mix orders but the final mix will consist of as many channels as is required by the highest order.

Practically I use the DAW Reaper for spatial audio work as it has a highly flexible routing structure – let's have a quick look!

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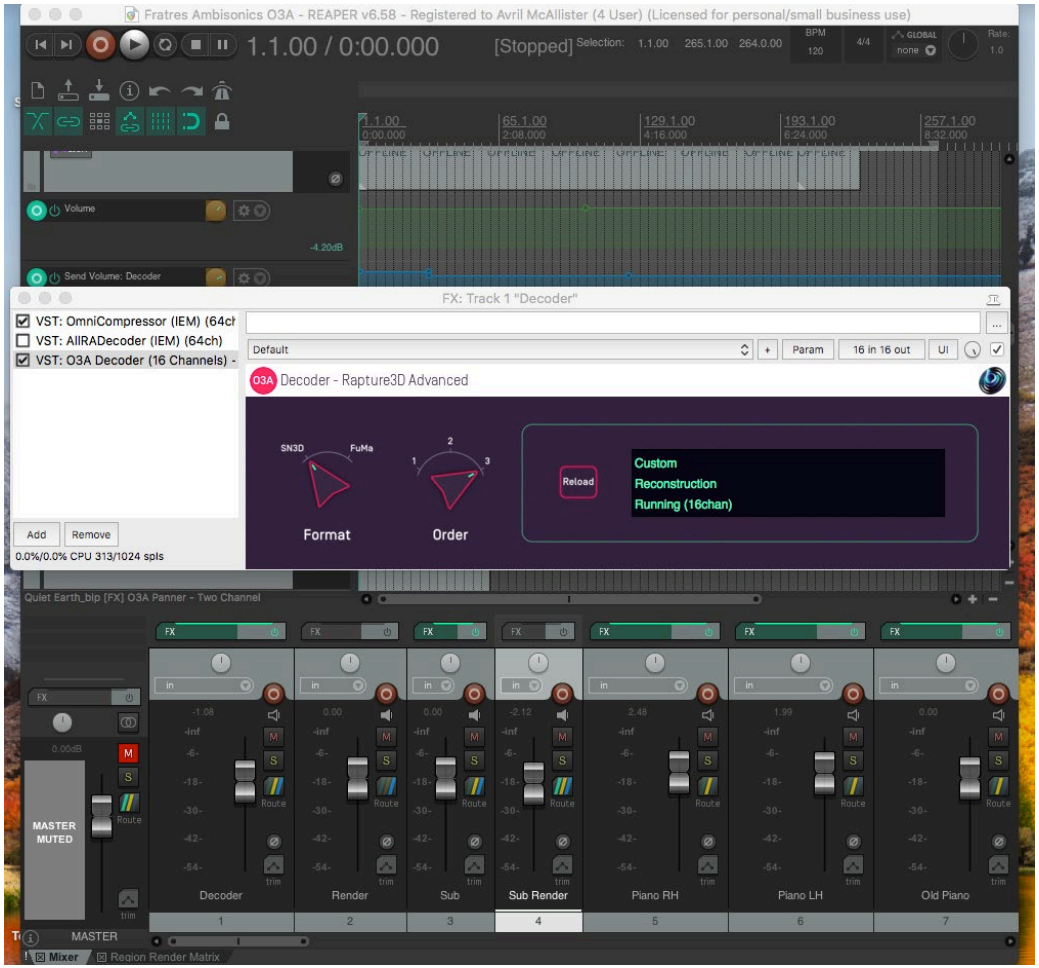
Reaper with Decoder



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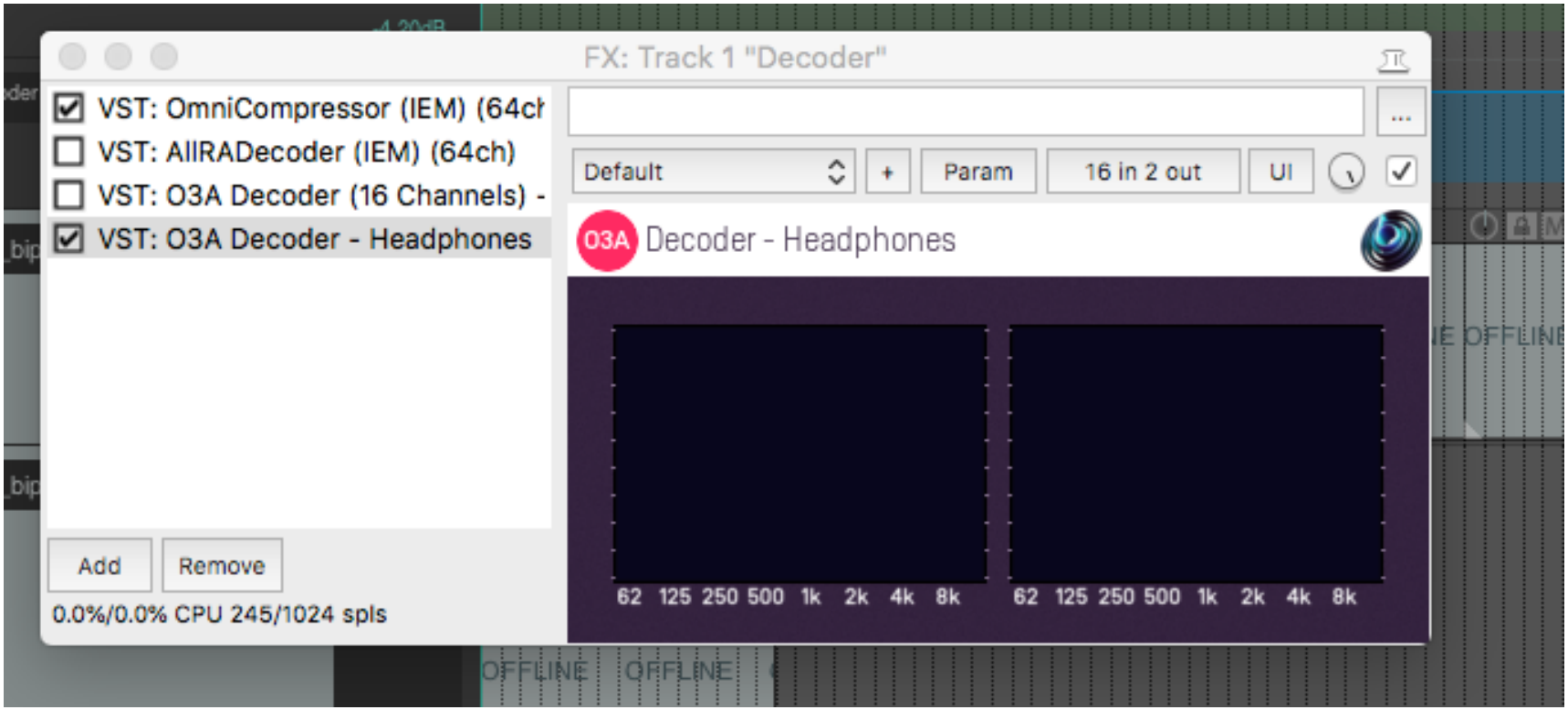
And...of course an Ambisonic mix can be decoded to a binaural mix.



Yes – higher order ambisonic microphones do exist but.

At the (relatively) cheaper end we have the Zylia microphones. TOA (£1200)

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Or at the FBI/CIA/MI5 end we have the Eigenmike (at least £20k)

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Case Studies

Piano Drop

Raydale Dower, 2011

Supported with a Creative Scotland Vital Spark Award and realised in partnership between Tramway, GSA Digital Design Studio and Arup Acoustics.

TRAMWAY

DIGITAL DESIGN STUDIO THE GLASGOW SCHOOL OF ART

ARUP

CREATIVE SCOTLAND
ALBA | CHRUTHACHAIL

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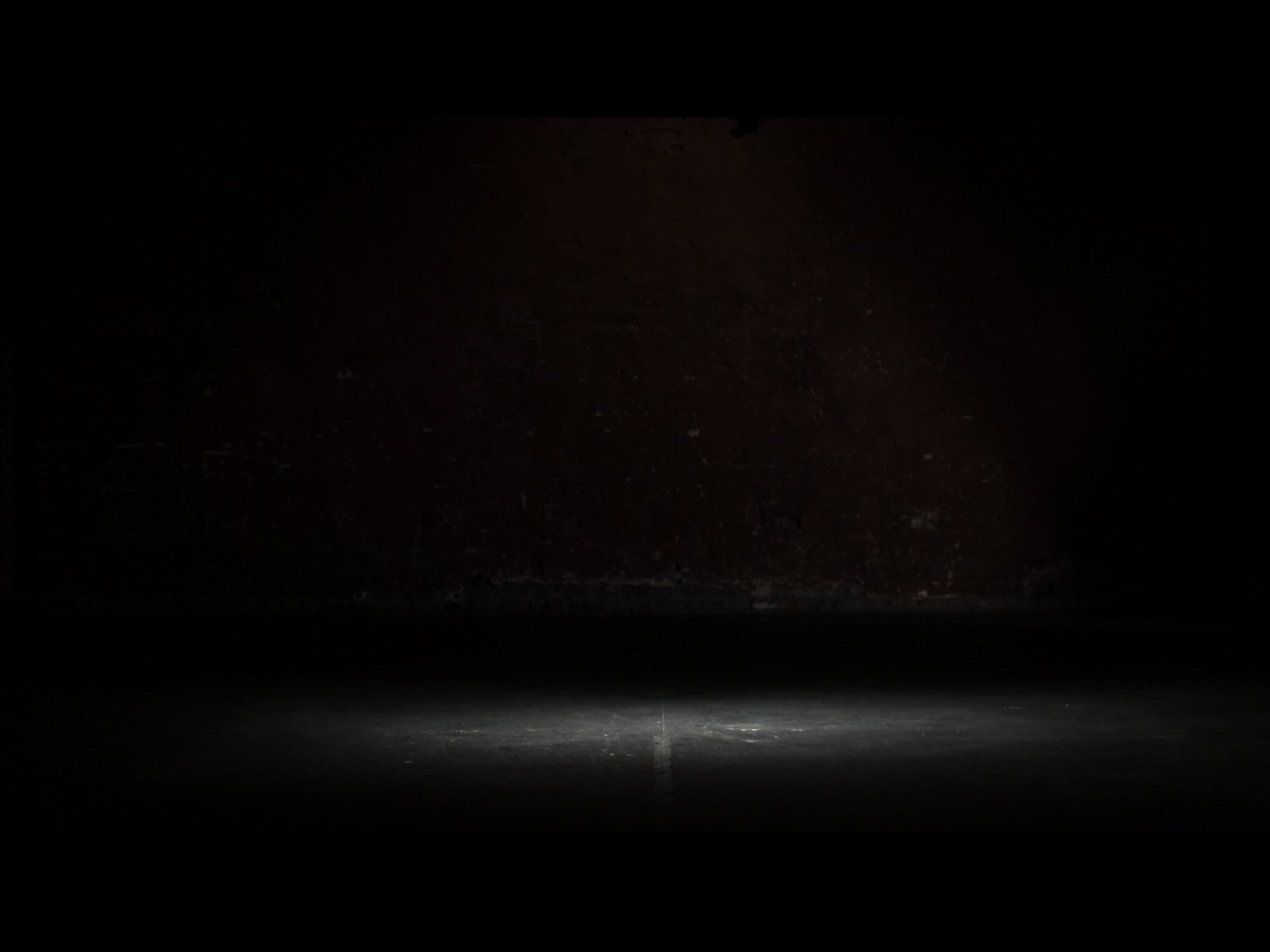
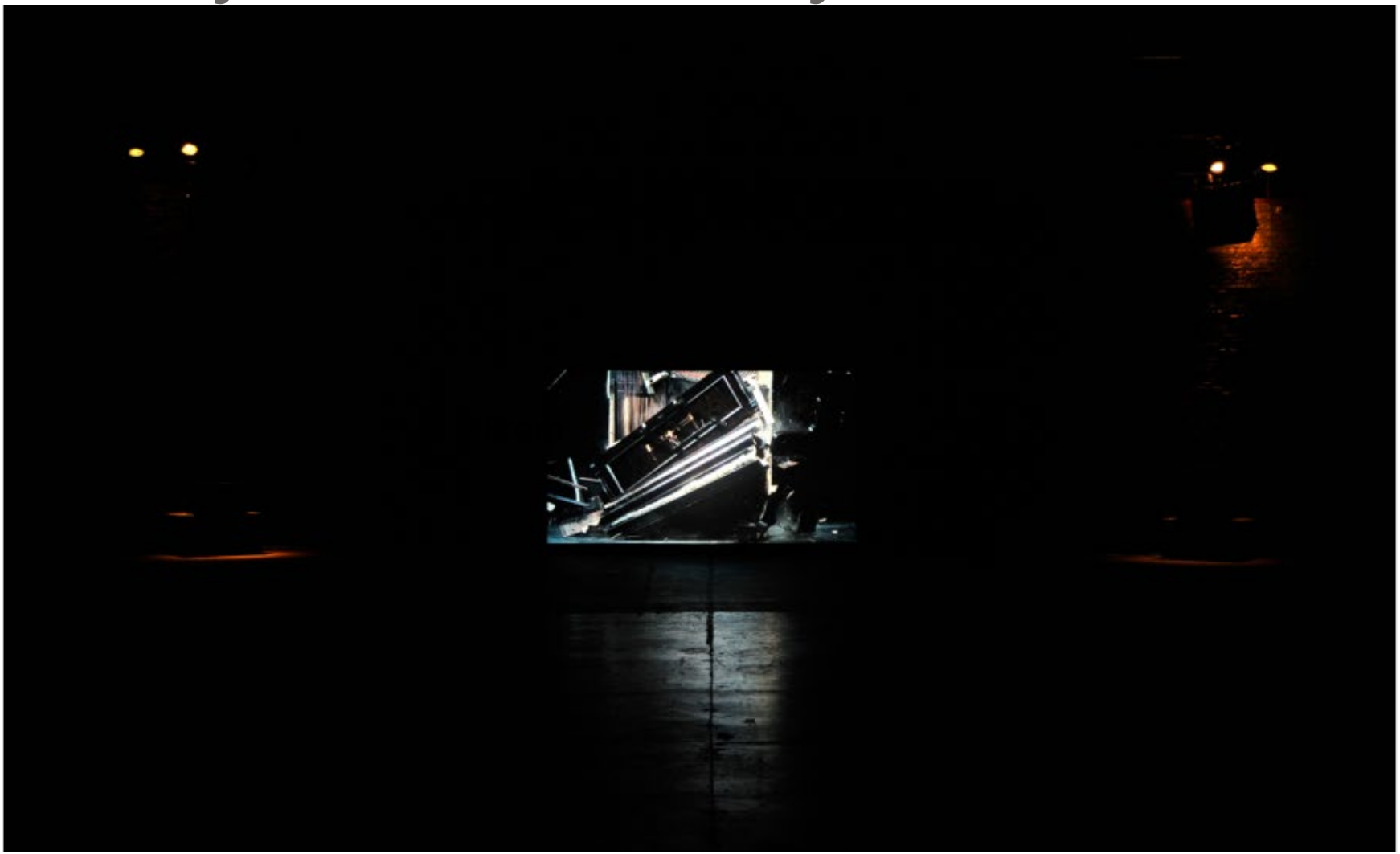


Playback in Tramway 1



From the artist From memory and looking at slides I think the final speaker array was 16m square and about 8m tall (cube). Speakers used were an Alcon ribbon array as used for classical concerts!

- Tech Deets
- Sound stretch
- https://sonosaurus.com/paulxstretch/ (but the original python version)

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Fraser Macbeath Tiugainn Dachaidh

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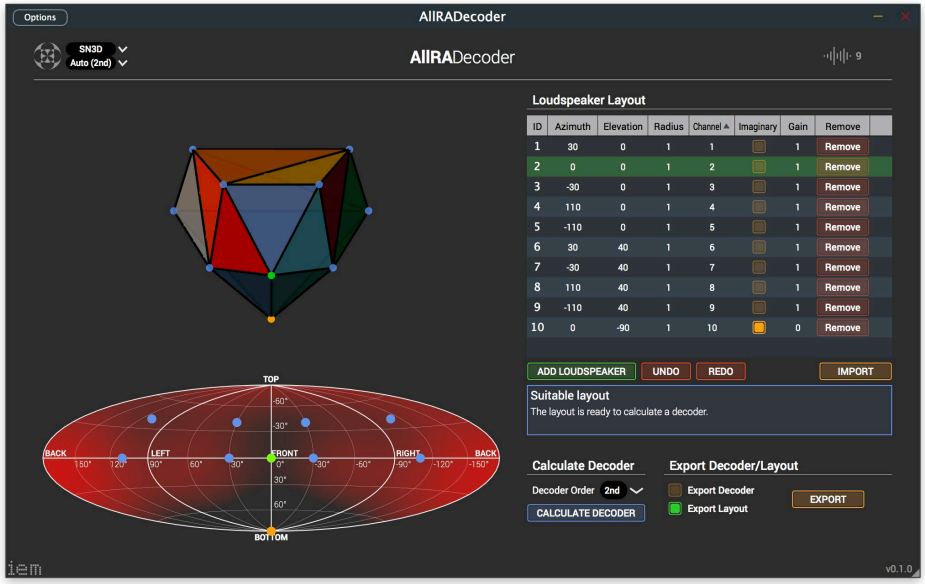
This installation built on the concept showcased in my video of the same name. It aims to bring attention to population decline in the Hebrides. This instance of the work used props from abandoned Hebridean houses and ambisonic sound to place the viewer inside a crumbling home inhabited by a form of decaying sonic memory.

RSA Benno Schotz Prize

IEM ALLRAD decoder used for exhibition audio playback



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Laura Campbell "The Uninvited Guest"

The Uninvited Guest explores themes of escape, loneliness and transformation within a 360 degrees miniature static mountainous scene where a character exists transforming unseen.

Utilising sound field recordings, voice, music, SFX, acoustic and synthesised instruments a remote landscape is created for one audience member inspired by living in ólafsfjörður North Iceland for 3 months.

Playback of ambisonic sound and object based audio is via 10 speakers housed within a nonagon structure made of wood, foam, felt, polystyrene and sand.

The audio is mixed in Ableton Live 10 played back using Reaper Digital Audio Workstation, Blue Ripple panners, AllRA Decoder triggered via a makey makey kit.

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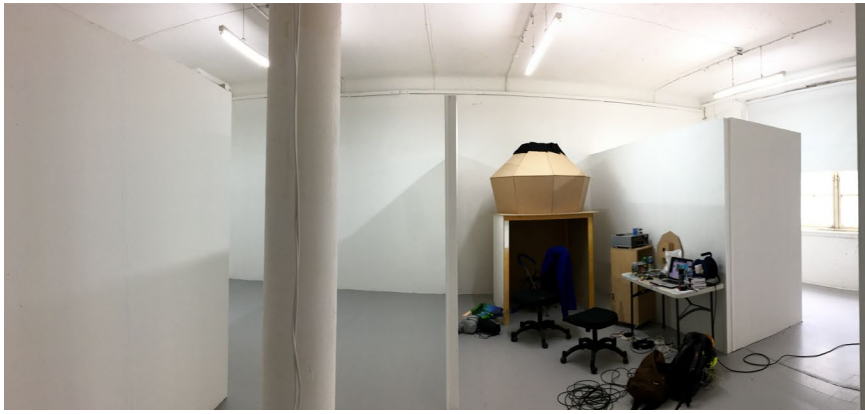

https://www.friend-or-foe.info/laura-installation

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Questions?