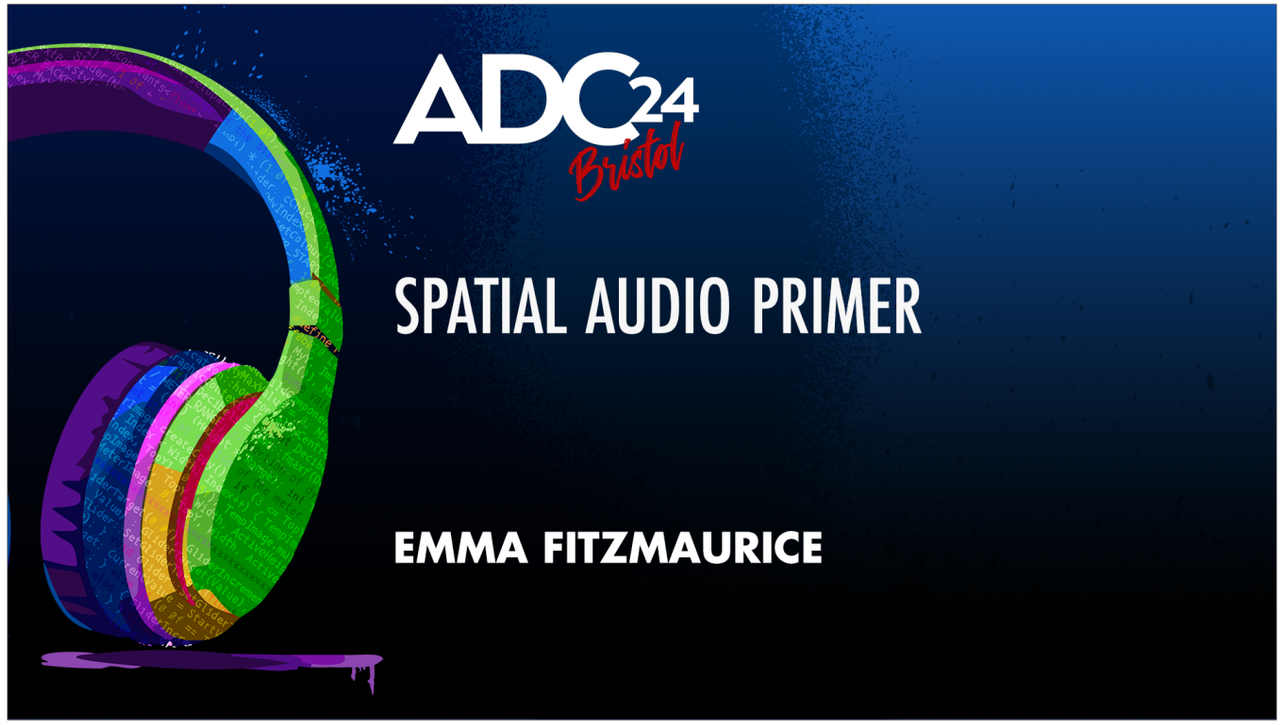
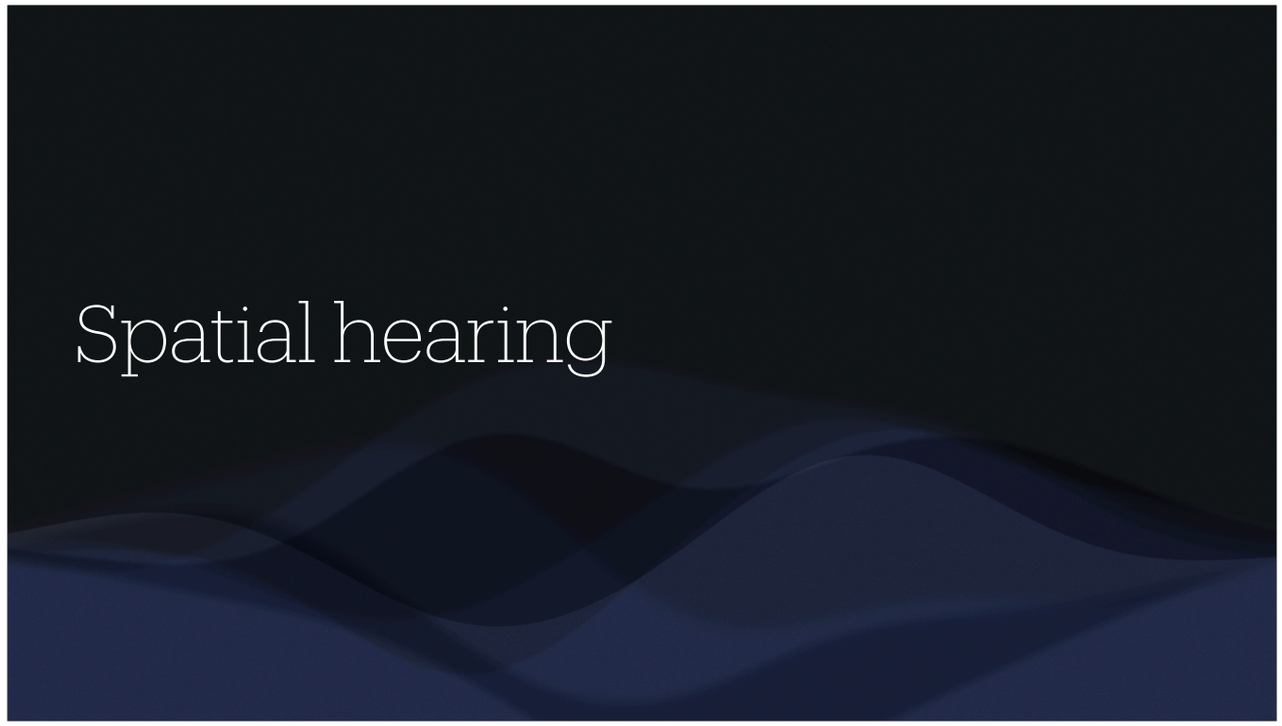
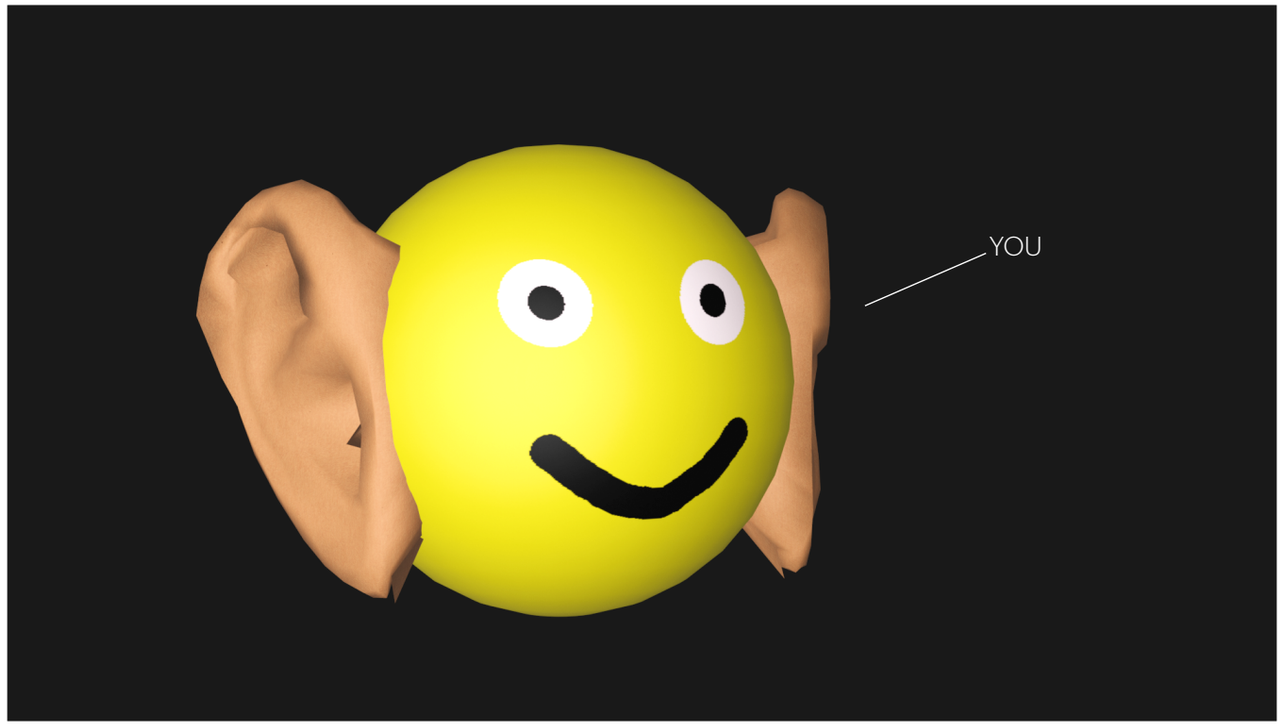

ADC24
Bristol
SPATIAL AUDIO PRIMER
EMMA FITZMAURICE



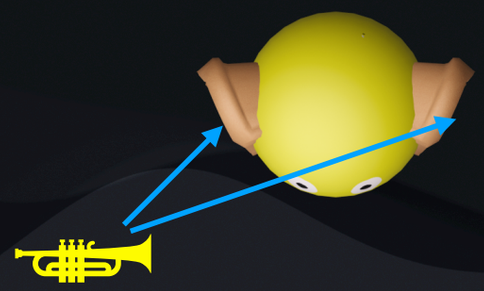
- To understand spatial audio first understand spatial hearing
- Two Ears + a brain
- Tissue conduction - loud low frequency - call all of that 'Nominal' and never mention it again.



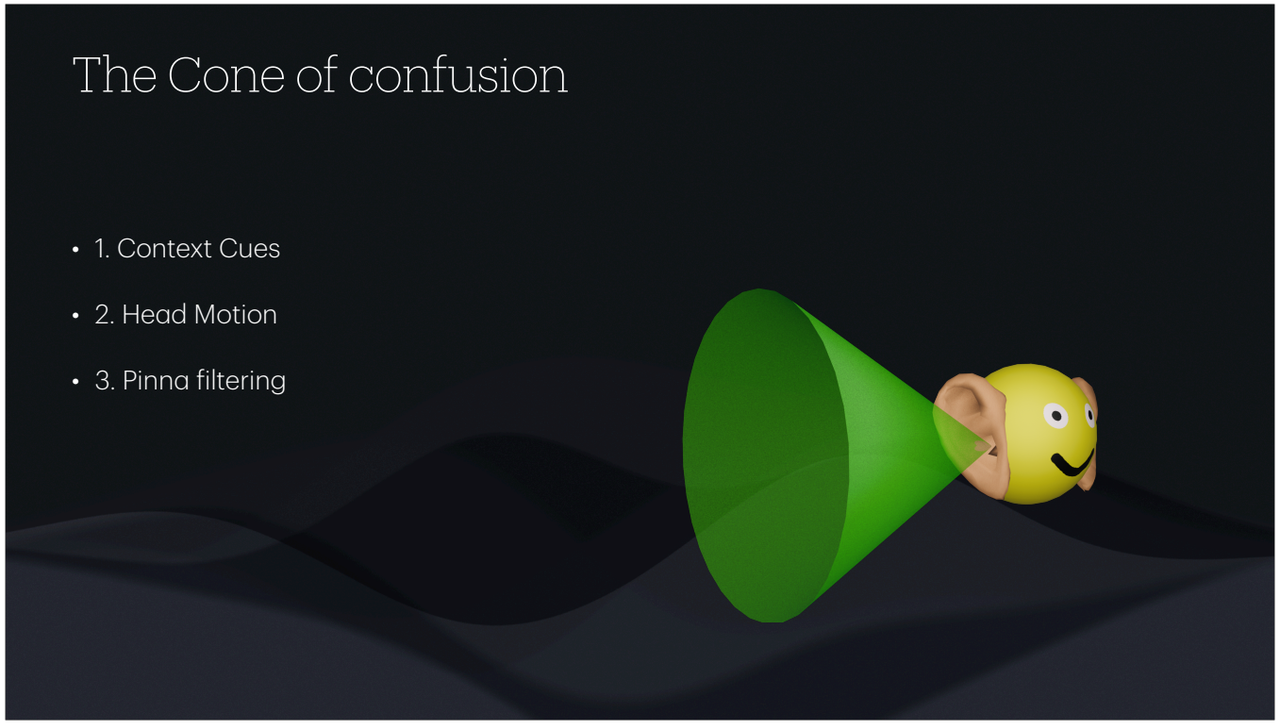
- This is you, you're looking good
- 2 ears and a pretty round head

Duplex Hearing Theory

- The Right Honourable, The Lord, John William Strutt, 3rd Baron Rayleigh 1907
- Time Difference
- Level Difference



- Lord Rayleigh
- Time difference nearer sooner
- Level difference head interference – a little inverse square but not much at ear spacing
- Priority shift
- Triangulation fail

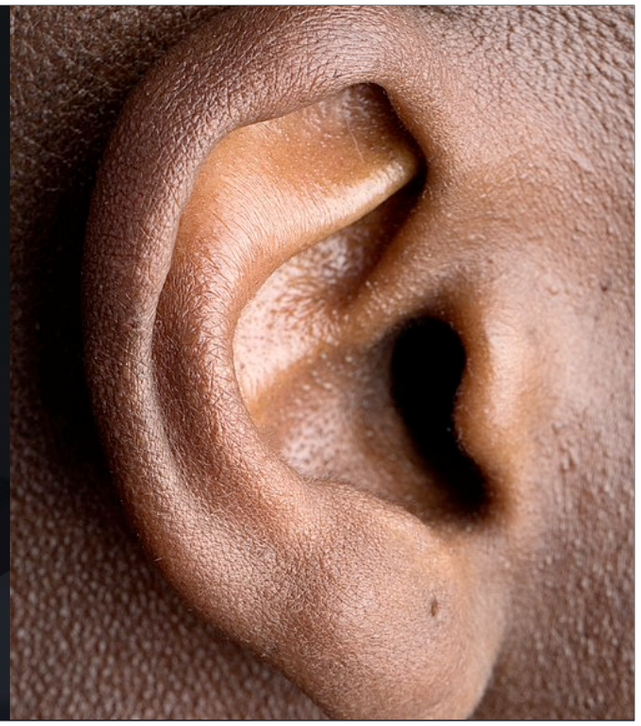


- Triangulation fail = cone of confusion
- Cannot differentiate where on cone

- Context cues, visual match, recognised sound

- Head motion, move your head slightly and you generate a couple more cones
- let your subconcious find where they intersect and you've found your source.

Pinna Filtering

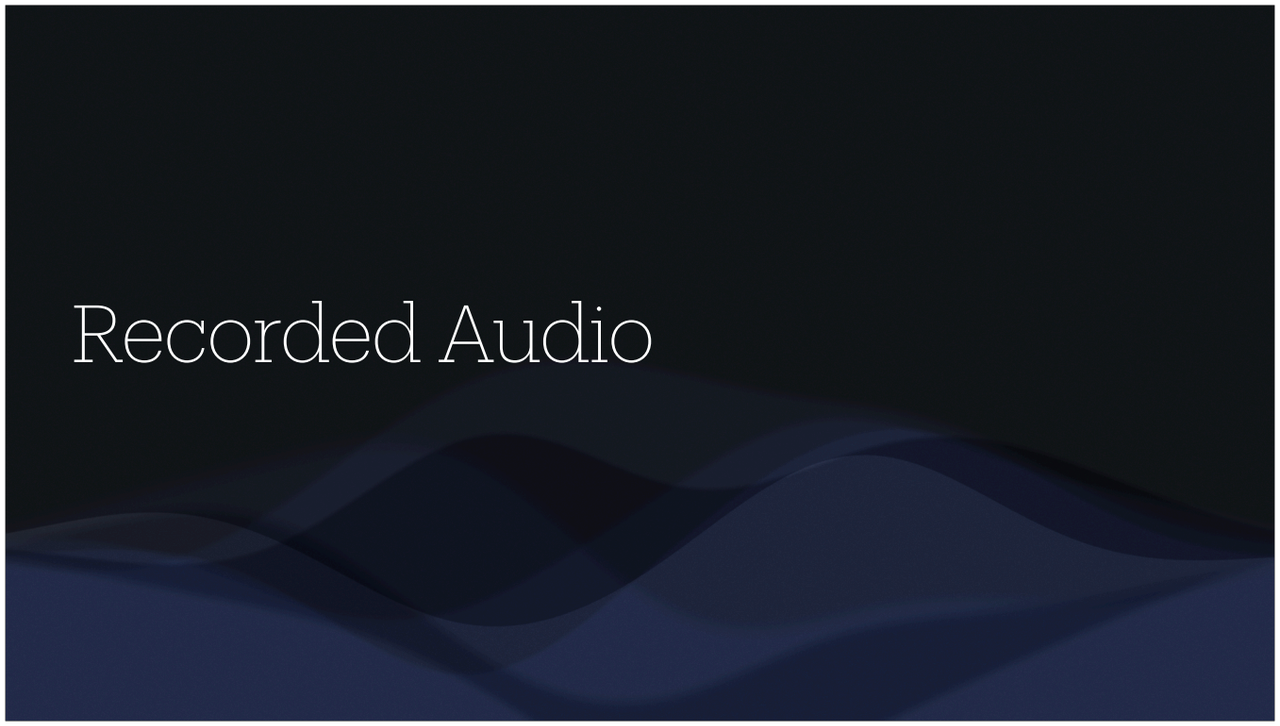


- The pinna is the big flappy bit of your ear that's on the outside of your head
- They’re not going to be significant at low frequencies
- all these flaps and folds make it a prime environment for some acoustic parkour.
- Reflections sum in your ear causing comb filtering
- Dependent on angle of entry
- Personal

Distance

- Similar to the secondary cues of the cone of confusion but worth calling out on it’s own
- Reflections

- Mechanics based on 2 ears can be spoofed with headphones
- Basic – direct recording with mics in ears
- Collapse duplex + Pinna into a HRTF
- Record IR – Anechoic chamber to remove distance
- Finite Impule Response filter apply to audio with convolution
- Intermediate format
- Data sets include MIT and York SADIE

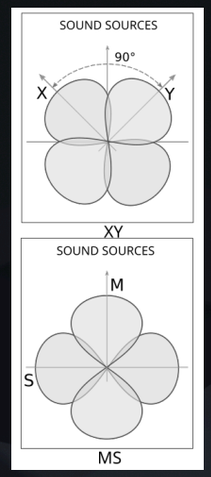

Recorded Audio

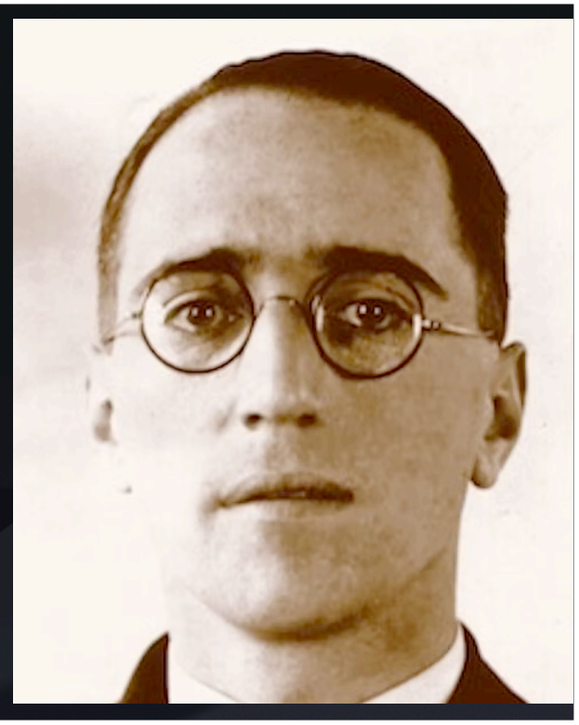
Mono

- Basic form of audio
- Late 1800s wax cylinder
- Compatibilty important

- Play 2 different signals at once out of different speakers
- Loudspeakers processed by hearing system as opposed to headphones

Blumlein





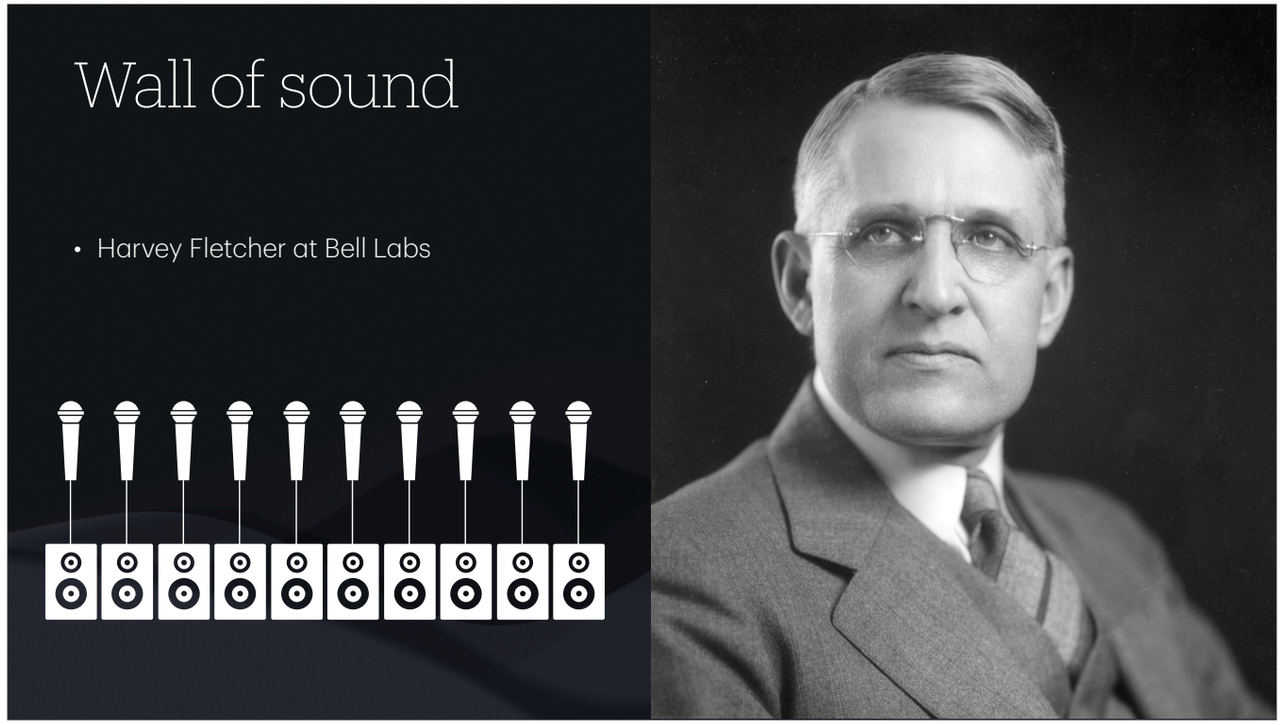
- Patent in 1931 (394325).

- Based on coincident signals
- 2 figure 8s (pressure gradient) at 90 degrees as close as possible
- Still commonly used
- L/R M/S inter-compatible
- Amplitude difference only

- Shuffler - take amplitude panned signals - Mid Side them - give the low end 90 degrees of phase shift - LR them and you've got phase panned low end
    - And vice versa

- 45 degree vinyl cutting

- Also invented the long tailed pair differential amp & many other wonderful things
- Big brain on this guy

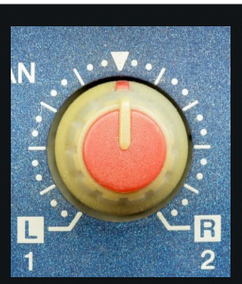


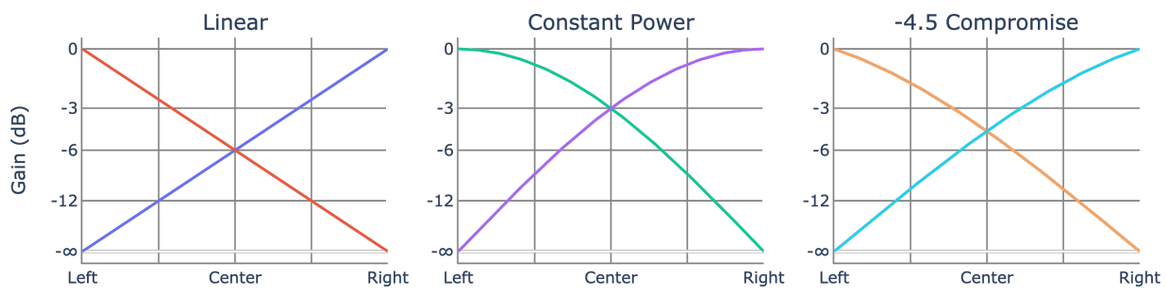
- Harvey Fletcher Bell Labs
- The Wall of Sound. Pre Phil Spector or the Grateful Dead.
- Setup an array of microphones along one wall, paired up to an array of loudspeakers along the wall of a separate listening room.
- It was a good system with the slight inconveniences of setting up 80 microphones and 80 loudspeakers every time you want to do it, and the fact they couldn’t record 80 tracks so it was only good for moving a live performance from one room to another.

- 2 channel recordings with Leopold Stokowski Philadelphia orchestra,
- 2 separate tracks on vinyl

- The Fletcher in the Fletcher-Munsen equal loudness curves,
- Invented the hearing aid
- don’t know if he ever met Blumlein but if they did they could have had quite the nerd off.

Panning





- Not recording into stereo but putting mono recording into stereo
- 1930s, delays mean tape, not very practical
- Amplitude panning
- Sometimes a switch
- Panning Laws

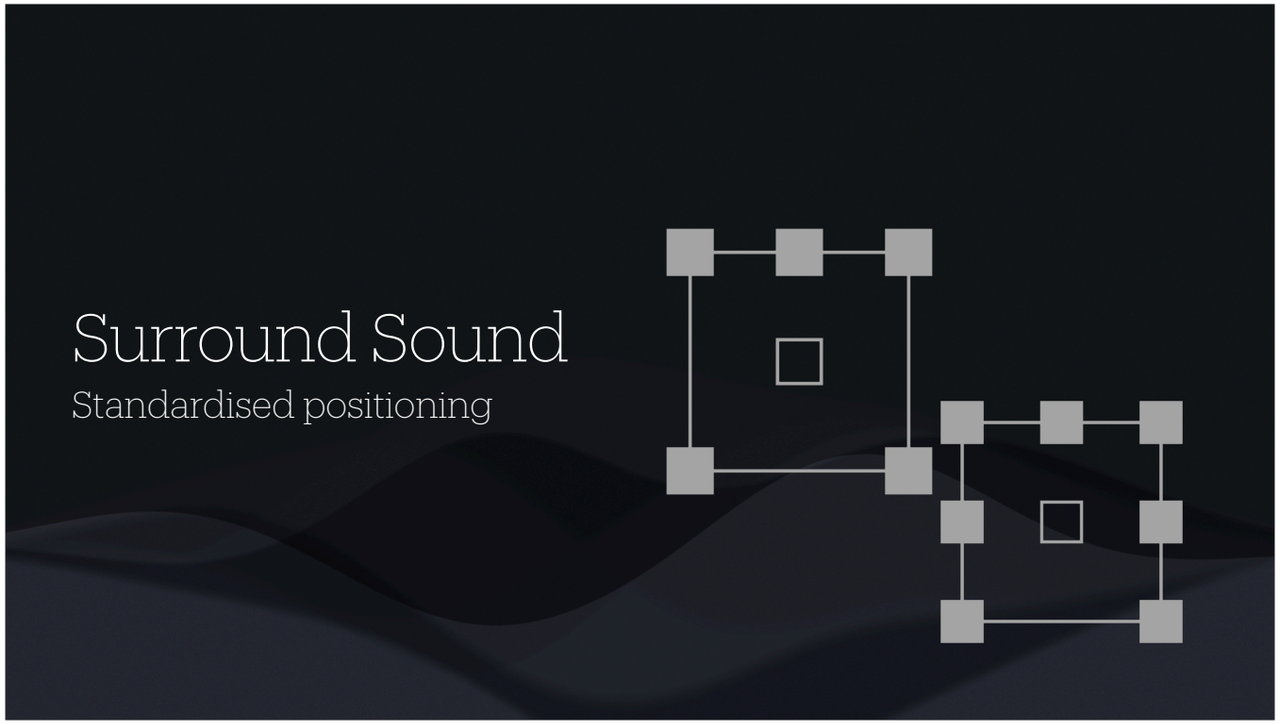
- First idea is linear panning
- Gives a center gain of 0.5 or -6db
- Leaves a hole as you pan across
- Very mono compatible

- 2nd constant power panning
- Made from the first quarter of Cos and Sine waves -3dB or 0.707
- Fixes level drop but give a center boost when monoed

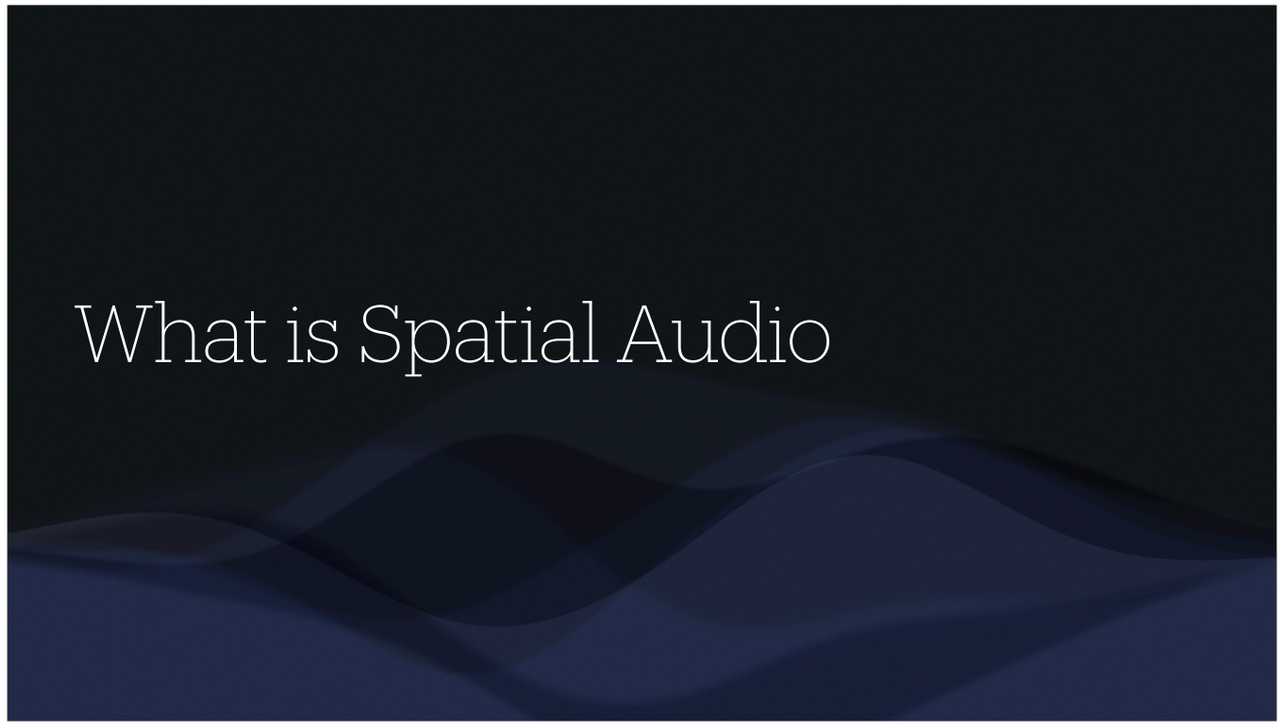
- Often compromise with-4.5db 0.596
- A bit of each issue

- In the digital age can be augmented with time delays
- <~35ms, Haas effect.

- Manipulate the psycho acoustic processing of how we process reverberant reflections
- Can cause mono compatibility issues with comb filtering



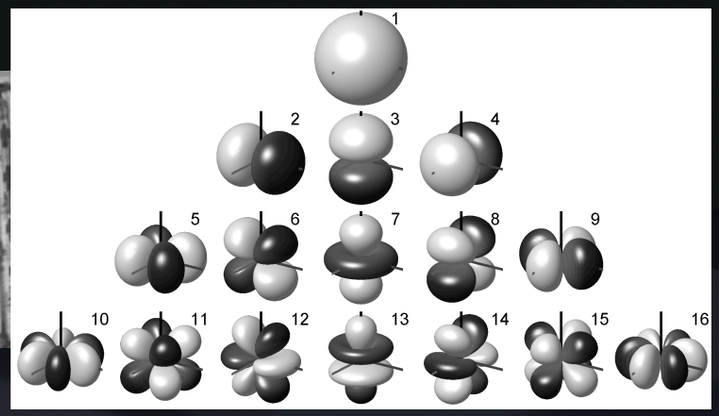
- Expand 2 channel panning to fixed arrays



- Not speaker feeds
- hold off on defining the speakers, or virtual speakers if we’re going for binaural.
- client side rendering
- deliver audio in an intermediate format, then playback system processes it down to whatever speakers in whatever position

- 3D readiness
- surround sound rigs with different height speakers didn’t take off, chicken and egg setups and mixes
- With spatial formats we can add height for systems that support it without requiring it.
- Portability
- One spatial mix -> cinemas with speakers all over the walls, home surround sound systems, laptop speakers, headphones

Ambisonics



- Pioneered by Michael Gerzon,
- Based on encoding an arbitrarily complex sound scape using real spherical harmonics.

- Spherical harmonics pop up all over physics - atomic orbitals, quantum mechanics, geology etc
- Based on Laplace equations
- They come in these orders
- Can choose order
- Channel counts of square numbers
- Up the orders they become these increasingly strange spikey things
- These weird skinny lobes serve to increase your effective spatial resolution

- Think about them in our context is as microphone polar patterns, 1 is omni 1st order are figure 8s
- Encode by looking at the angle of the source and calculating the gain of each harmonic
- Mixing patterns creates virtual mics to decode

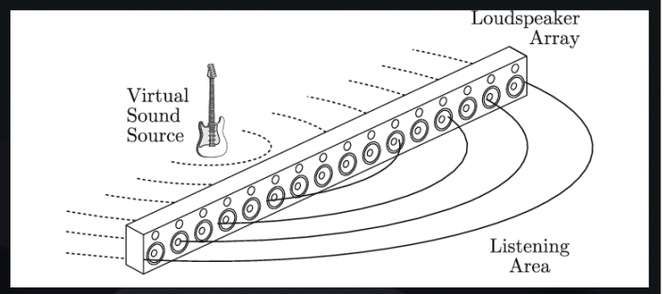
- Builds on Blumlein stereo
- Very transformable
    - Great for VR

- Mostly at home in Reaper because it lets you just set a channel to have up to 128 tracks

- Using external plugins like Sparta or Blue Ripple or WigWare

- Dominant format is Ambix, a convention on ordering and normilisation of the channels the spherical harmonics are on

Wave Field Synthesis



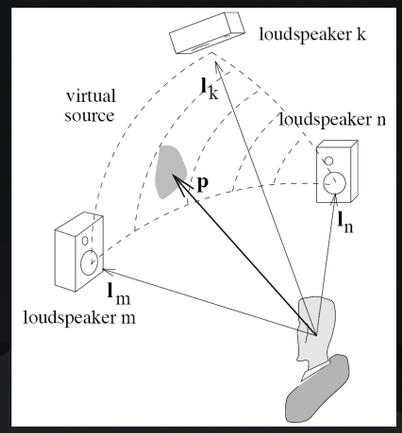
- Wave Field synthesis is built on the idea of a dense speaker array
- Building on wall of sound
- Recreates the wavefront of virtual sources.
- Huygens principle, you can recreate a wavefront with point sources

- Doesn't have a sweet spot,
- Ambisonics + Stereo we've just been through all this stuff about sphere's and the sweet spot to listen to it from is the centre of that sphere but
- Just get far enough away from the speakers for them to be a point source you're all good, the auditory illusion of the positions of each sound should hold wherever you go

- Complexities of setup means it’s all installations
- Vegas Sphere has Holoplot system

VBAP

Vector Base Amplitude Panning



- Vector base amplitude panning
- Development of the panning approach from our stereo section.
- It’s really a generalisation of the equal power pan law based on vector mathematics.
- Vectors have a magnitude and direction

- Take the vector from listening position to sound position
- Find a triangle of loudspeakers that surround the point you want the sound to appear, (or either side if 2d) and take the vectors from the listening position
- Then simultaneous equations them till the loudspeaker ones equal the sound position one.

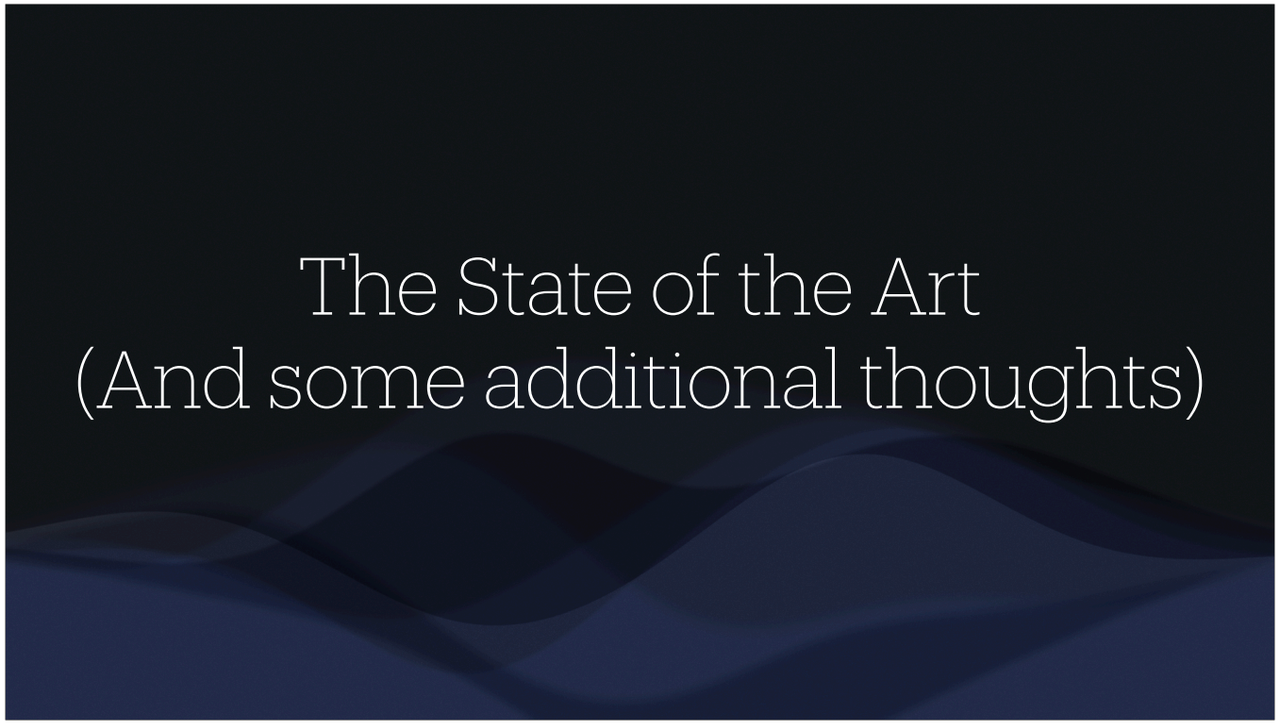
- With Ambisonics we have Ambix but object based needs a packaging format
- Don’t know how the renderer works I would guess VBAP
- Uses broadcast WAVs and ADM to define metadata, specs for that are available
- 128 tracks per file, Sorry data compression
- Bed tracks in standard surround formats up to 7.1.2
- Objects for selected tracks

- Just as AI gets stem separation we start shipping stems anyway

- Built into Logic, Pro Tools, Studio One, Nuendo, Davinci Resolve
- Plugin for other DAWs

- Atmos isn’t the only game in town there are other formats doing similar things
- THX - support both sound objects and ambisonic elements

- 360 reality audio thing is SONY - format of choice PeerTracks, the NFT, Blockchain, Crypto music streaming service.



- Atmos is looking likely to become dominant for object based
    - Big commercial backing and buy in
    - Certifying everything
- Ambisonics doesn’t have the same kind of commercial backing but is to cool to go away
    - Would hope people who go in for supporting spatial include it

- So long busses as we know them
- May keep hand crafting stereo mixes?

FIN