SOUND CANOPY

Immersive Sound Feel

From idea to reality in the field: dedicated sound systems that keep the music on the dance floor

Stas Rogozin

Magna-Tech Electronics

Second generation in the design and construction of halls and cinemas worldwide



STAS ROGOZIN

TECHNOLOGY EXPERT

20+ years in professional AV

400+ projects worldwide



AREAS OF EXPERTISE

- Professional sound reinforcement and acoustic system design
- Video projection and immersive technologies
- Museums, planetariums, hotels, cinemas and event venues
- Intelligent sound management and noise mitigation
- AV system integration, automation and control

THE CHALLENGE

Loud on the dance floor, quiet next door

Event gardens, beach venues and parties often sit a few dozen metres from homes and hotel rooms.

On the dance floor

The dancers expect a high level, a full sound and a physical bass.

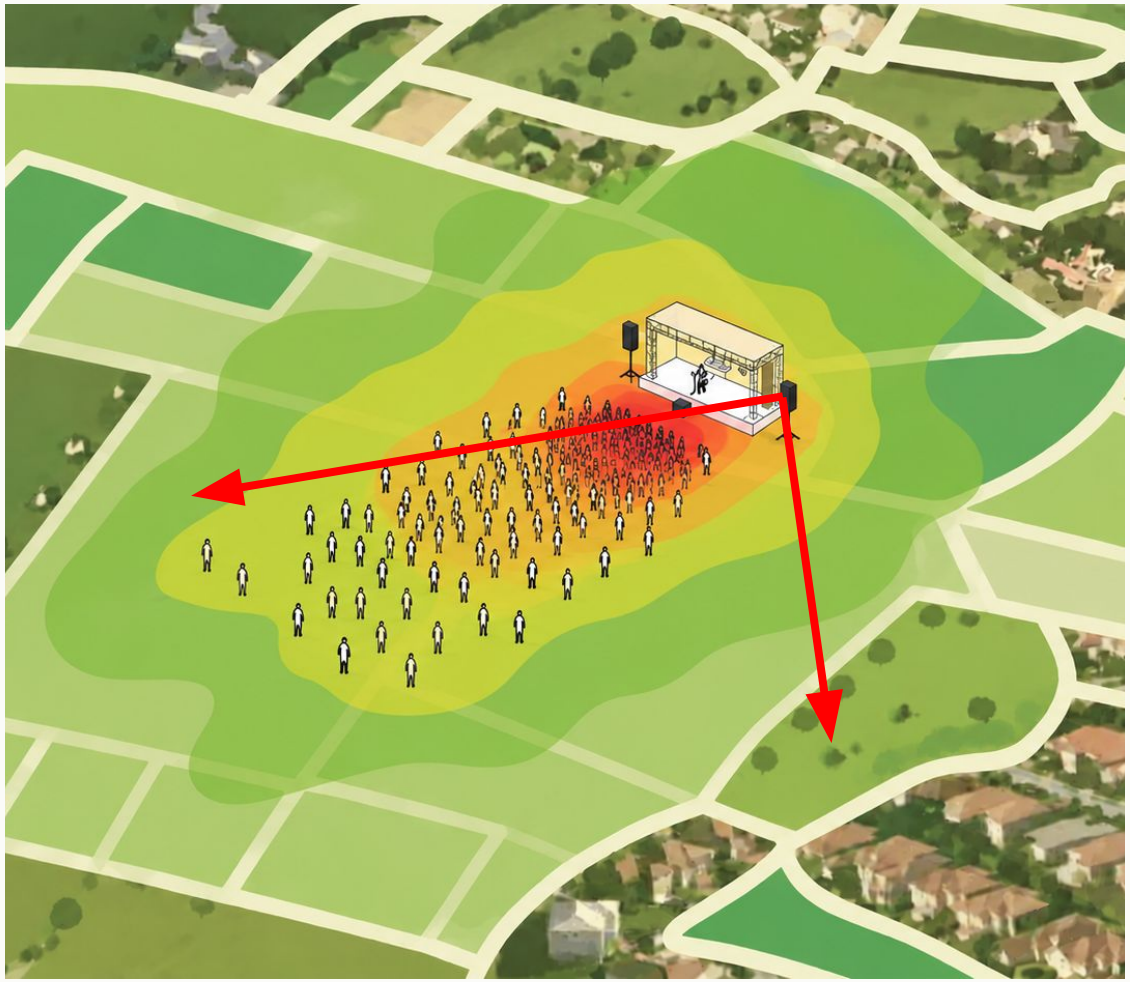
At the neighbours

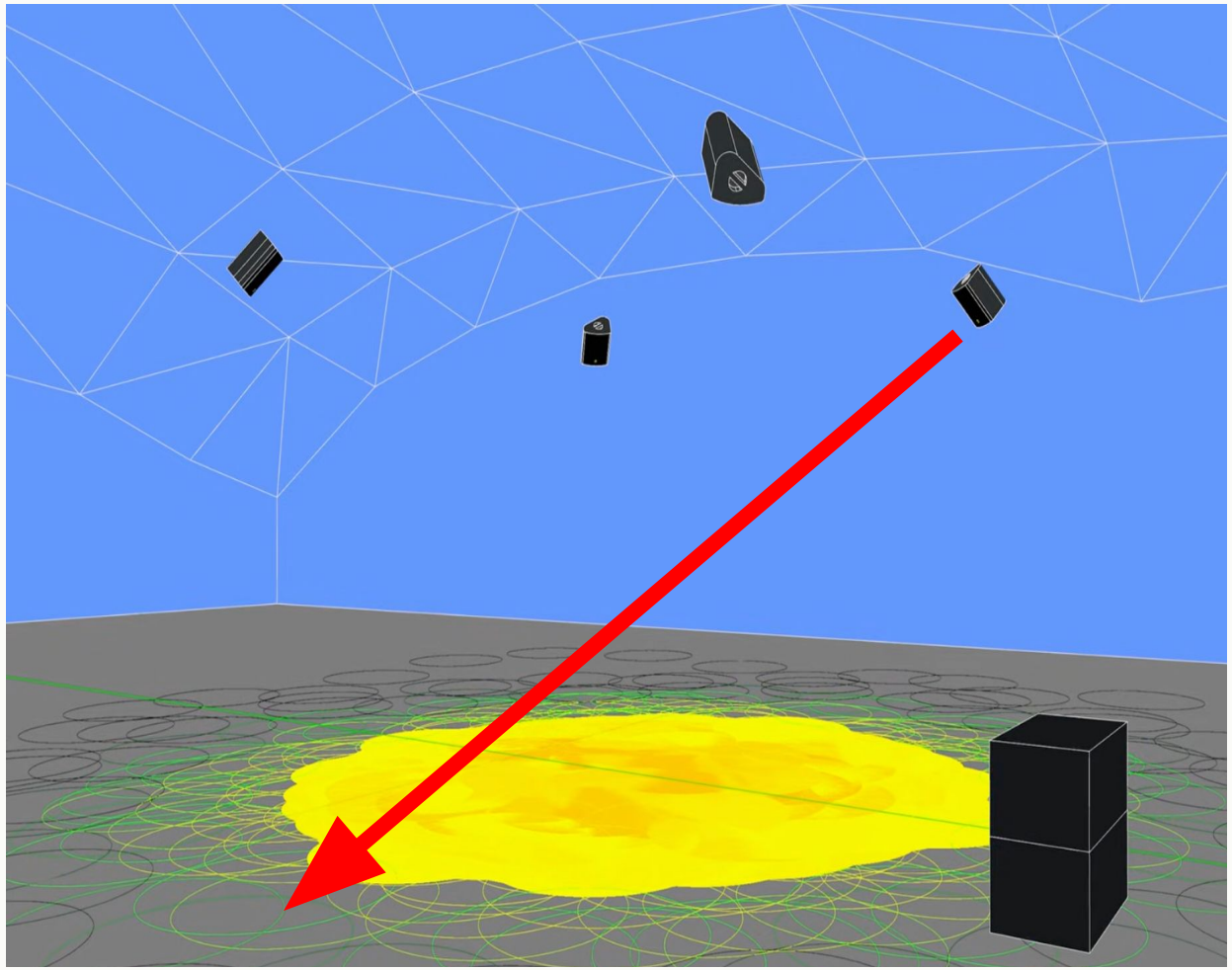
The noise limit applies at their windows, all evening, whatever the DJ does.

The task: keep the sound on the dance floor.



Problem - conventional approach





THE CONVENTIONAL APPROACH

A few loudspeakers at the corners

Long throw
Dancers stand up to 9 m from the nearest loudspeaker; each doubling of distance costs 6dB.

High power per loudspeaker
Each one covers a large area from far away, so each is driven hard.

Through the crowd
Sound crosses the floor almost horizontally; bodies absorb it, and the system is turned up.

Aimed outward
A loudspeaker aimed across the floor is also aimed beyond the opposite edge.

None of this is a fault of a product. It is the geometry of serving a large area from a few distant points.

Much better solution



THE IDEA

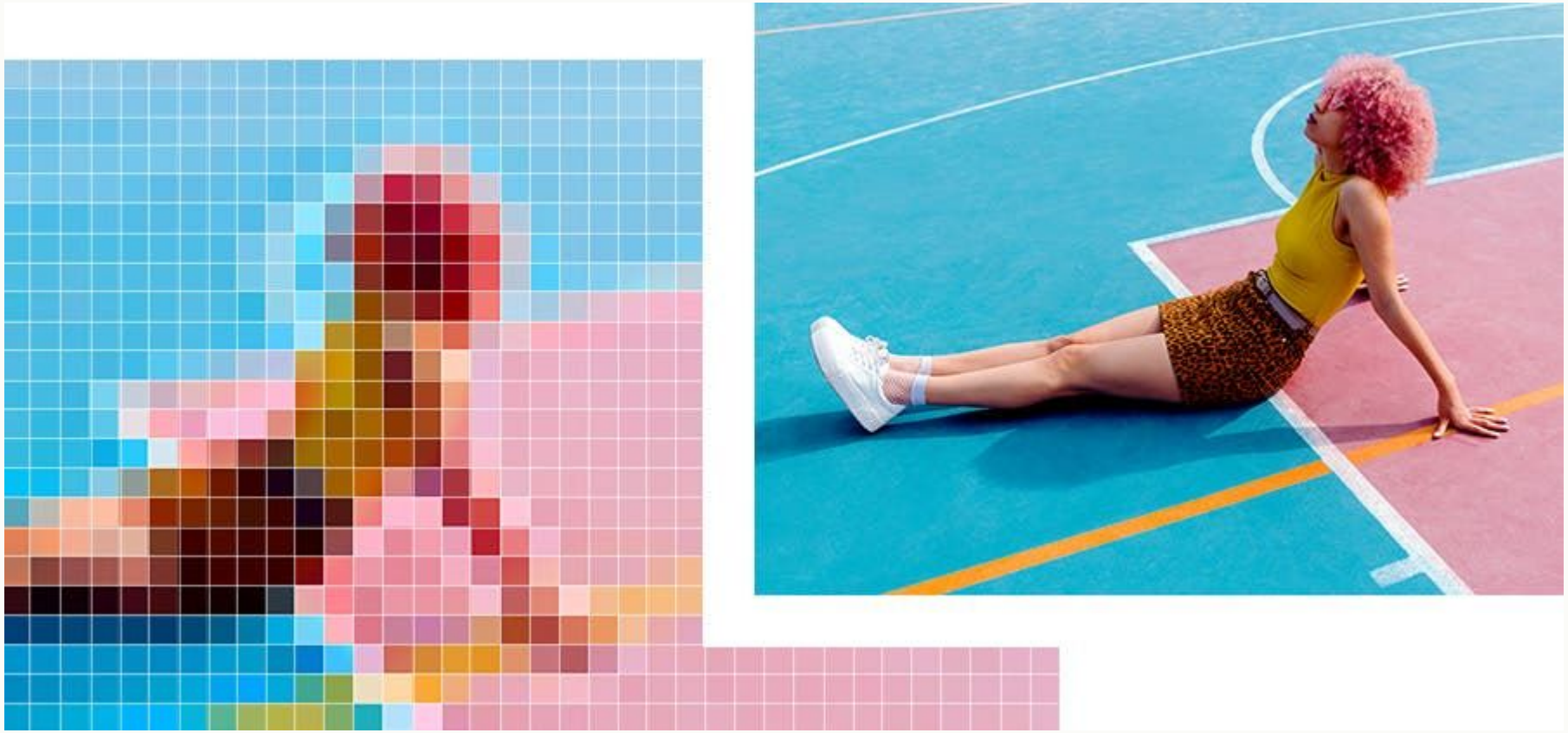
Headphones without headphones

What headphones give	Why it matters
A source very close to the ear	Direct sound dominates: detail, clarity and impact at low power
The same sound wherever you go	Every listener is always in the sweet spot
Sound that surrounds you	The listener feels inside the music, not in front of it

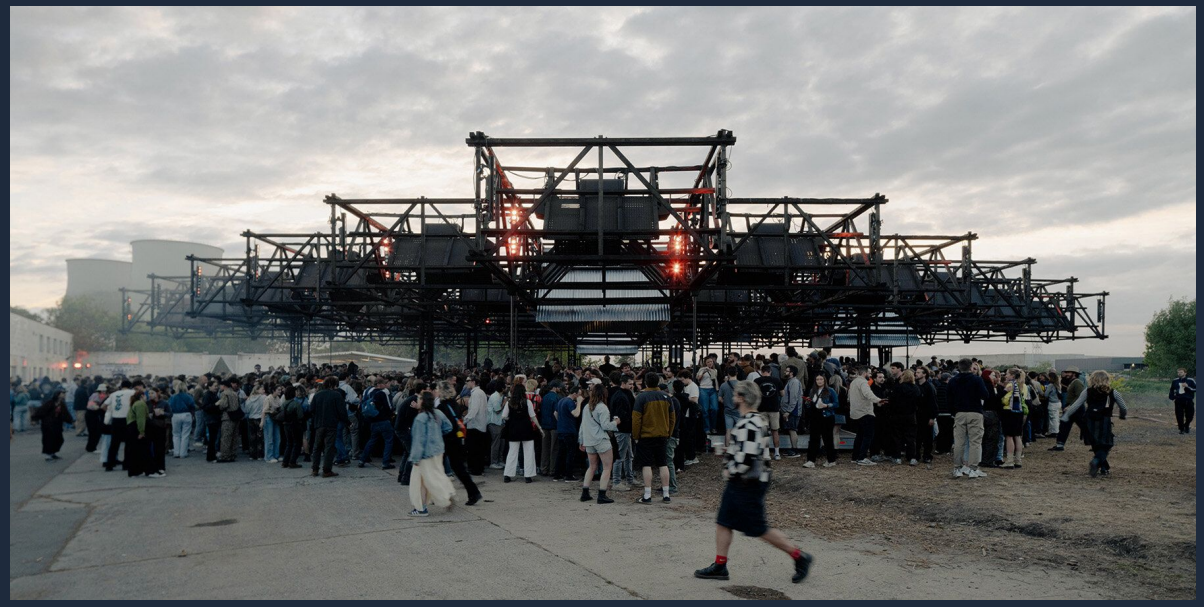
SOUND CANOPY brings this to the whole dance floor: every guest close to a source, at a similar distance, within the coverage of several.

Personal like headphones, yet shared: everyone dances to the same sound, at the same moment.

Think of a sound as pixels on a screen



Distributed Overhead Sound Reinforcement System (Sound Canopy)





Immersive Sound Feel: every dancer inside the sound, less noise at the receivers.

Dark Skies sound installation at Horst Arts & Music Festival (Belgium)

The installation is composed of 116 top speakers and 58 subwoofers, system spans over 1,000 sqm

THE METHOD

Distributed Overhead Sound Reinforcement System (Sound Canopy)

OUR APROACH

A calculated canopy

Loudspeakers above the floor, aimed down; within about ±2dB across the floor.

Cardioid subwoofers

Low frequencies steered away from the receivers.

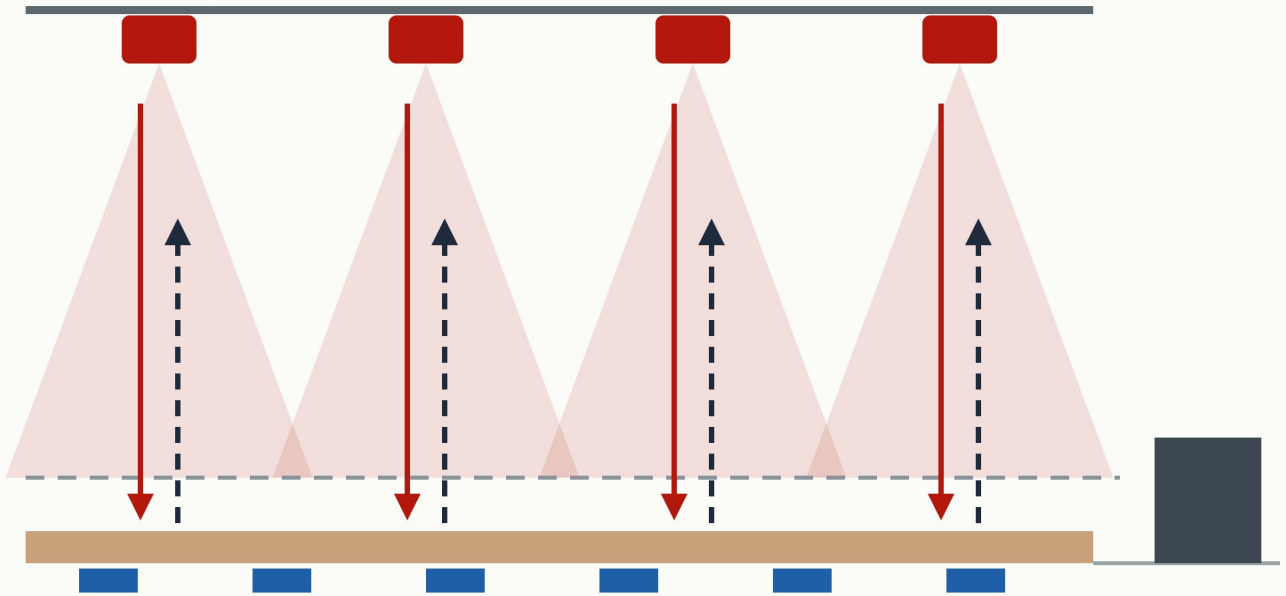
Tactile transducers

The bass is felt through the floor, not radiated into the air.

Proximity replaces power. Direction keeps the sound on the floor.

ELEMENT 1 · SOUND CANOPY

A calculated canopy above the floor



Section, not to scale. Red: loudspeakers, coverage and the sound projected down. Dark dashed arrows: reflection from the floor. Grey dashed line: listening height, 1.7 m. Blue: tactile transducers. Dark grey: subwoofer.

Calculated for each venue

The loudspeaker, its spacing and its height follow from the coverage needed at listening height.

Projected down, no corners

The sound is aimed at the floor and reflected back up from it: most of the energy stays on the dance floor, little escapes outward.

Frequency control

The canopy is high-passed: it plays the mid and high frequencies, and the bass is separated.

ELEMENT 1 · HEIGHT

How high: a design trade-off

$$L_{1\,\mathrm{m}} = L_{ear} + 20\,\lg\left(\frac{d}{1\,\mathrm{m}}\right)\ \mathrm{dB}$$

$$N \propto \frac{A}{(d\tan(\theta/2))^2}$$

$L_{1\,\mathrm{m}}$	Level of each loudspeaker at 1 m on axis, dB
L_{ear}	Level needed at the ear, dB: the design target
d	Distance from the loudspeaker to the ear, m
N	Number of loudspeakers
A	Area of the dance floor, m²
θ	Coverage angle of the loudspeaker

Lower

Less level from each loudspeaker, but more loudspeakers for even coverage.

Higher

Fewer loudspeakers, but each must play louder.

Halve the distance: 6dB less from each loudspeaker, four times as many loudspeakers.

The height also follows from the reduction needed at the receivers and the site.

ELEMENT 1 · HEIGHT IN PRACTICE

16 low or 9 high: similar coverage, different cost

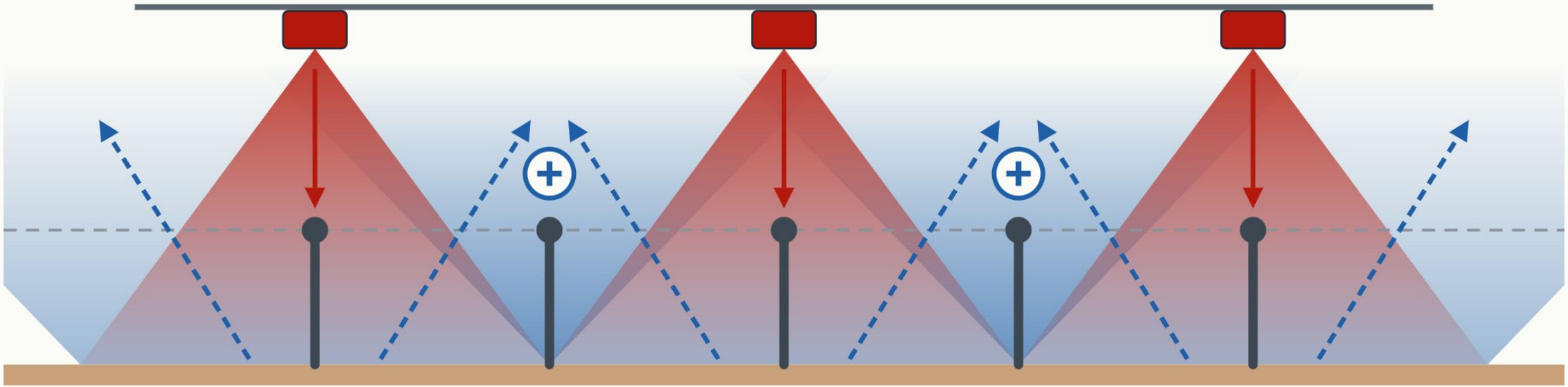
	16 loudspeakers, low	9 loudspeakers, high
Height above the floor	3.25 m	5.7 m
Spacing	2.75 × 2.25 m	3.4 × 3.0 m
Distance to the ear beneath a loudspeaker	1.55 m	4.0 m
Floor reflection at the dancers	+1.0dB	+1.1dB
Level per loudspeaker for 95dB on the floor	98.3dB	102.4dB
At the receivers, 50 to 100 m away	Reference	+2.1 to +2.6dB

Fewer, higher loudspeakers: each one 4.1dB louder, and more sound at the receivers.

Same loudspeaker for both, 110° coverage; ears at 1.7 m; floor with dancers, absorption 0.5; free field.

ELEMENT 1 · THE FLOOR

The floor works as an extra loudspeaker



Sound from the loudspeaker, fading down

Sound reflected by the floor, spreading up

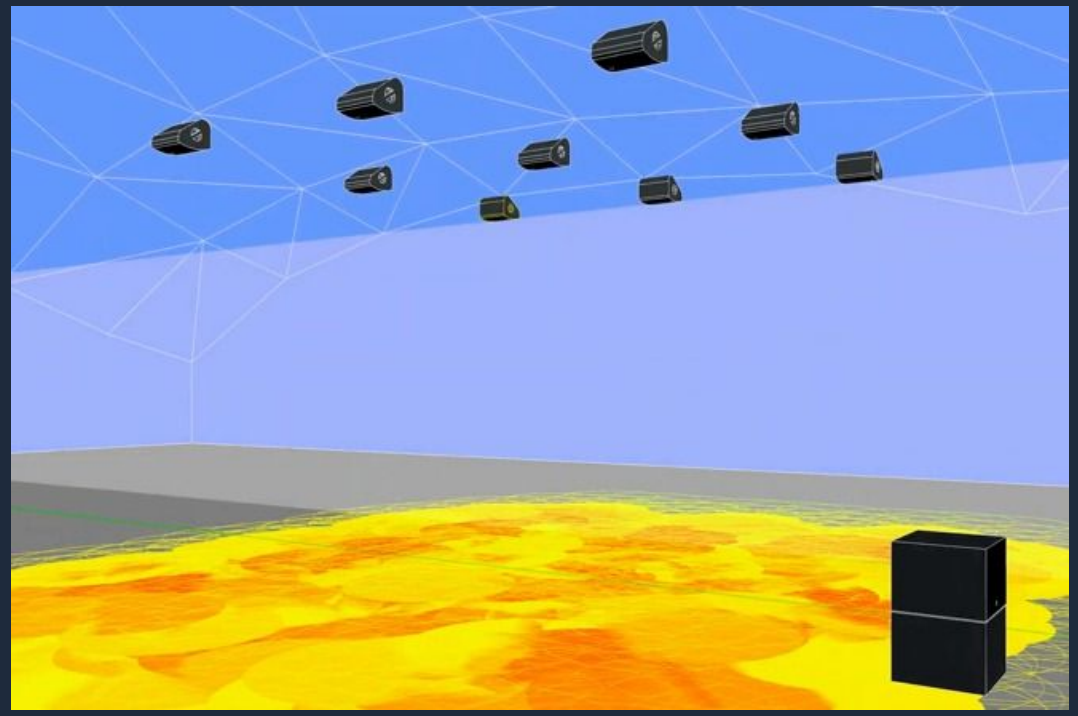
Reflections meet and reinforce

The floor sends the sound back up. Between neighbouring loudspeakers the reflections meet and reinforce each other, so a dancer between them hears almost as much as one beneath.

OUR TECHNOLOGY

Calculated for every height

For any loudspeaker height, our technology calculates exactly:



How many loudspeakers
The SPL the dance floor needs.

How far apart
The spacing that keeps every point of the floor even.

The most SPL on the floor
The highest level for the dancers from the least sound power.

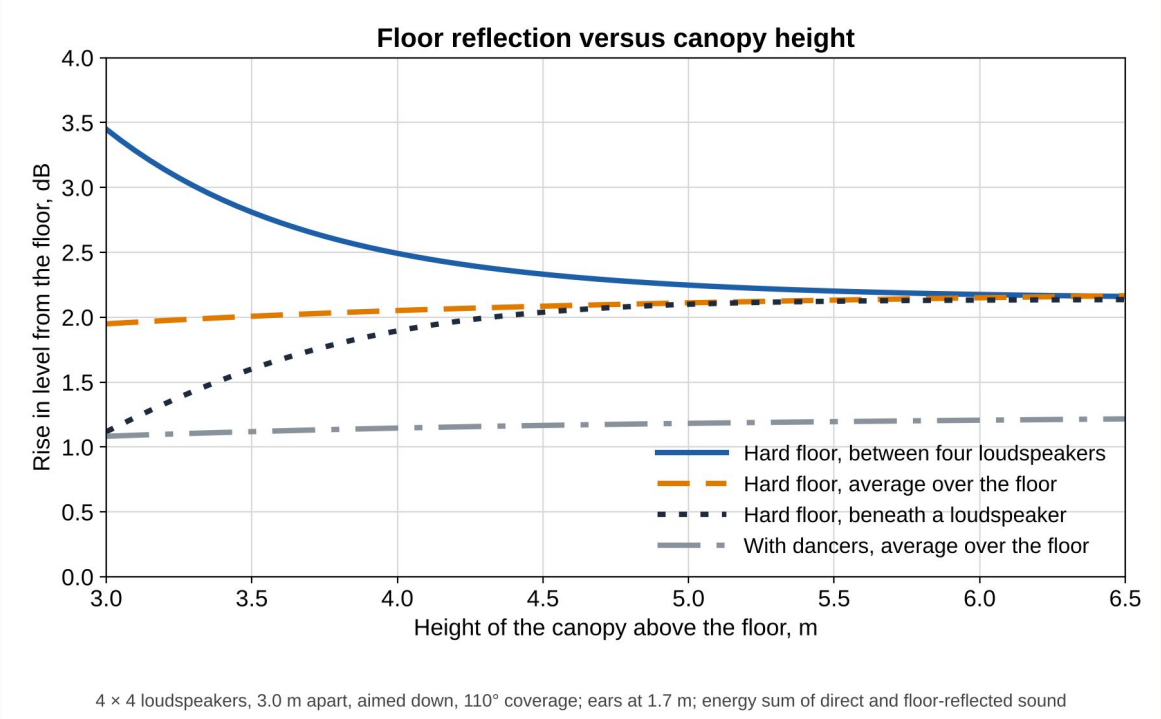
People at the event venue
A musical atmosphere they can enjoy, not a noisy one.

Neighbours living nearby
A lower level at their homes.

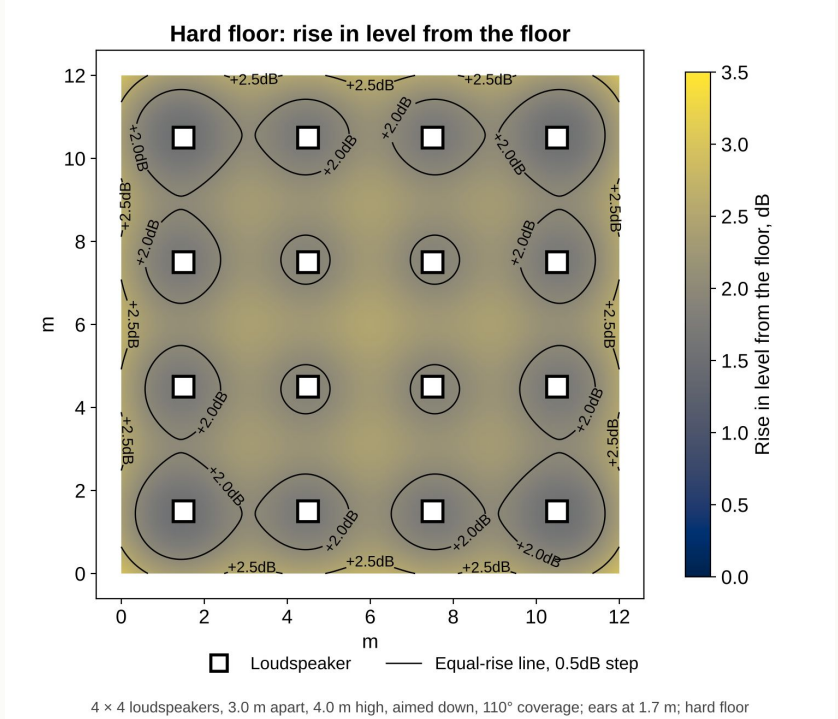
Hard Floor



Hard floor: what the reflection adds



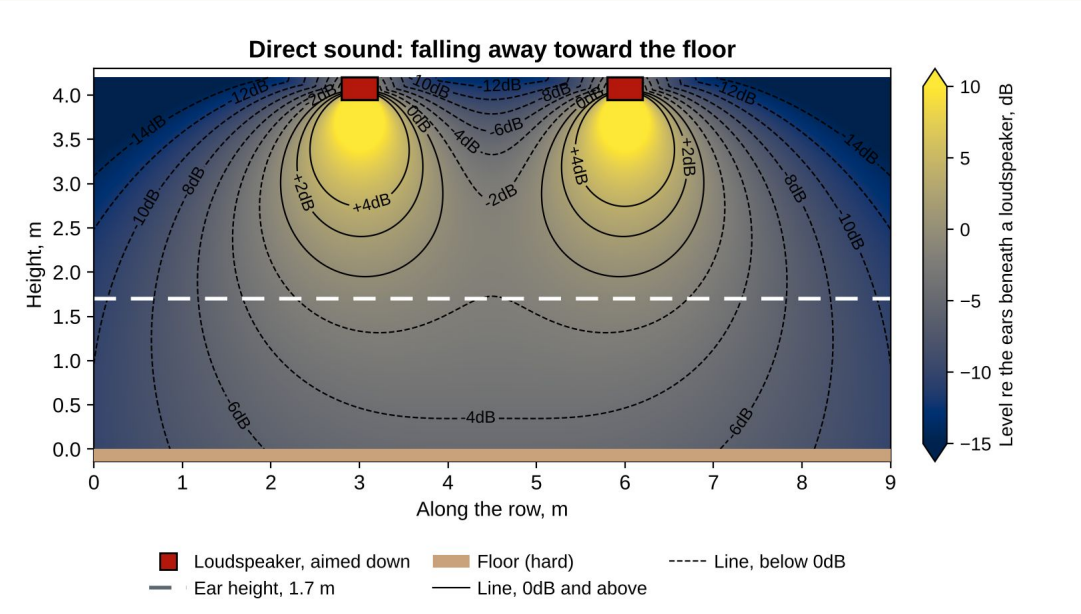
Hard floor: about +2dB on average, for every canopy height from 3.0 to 6.5 m, ears at 1.7 m.

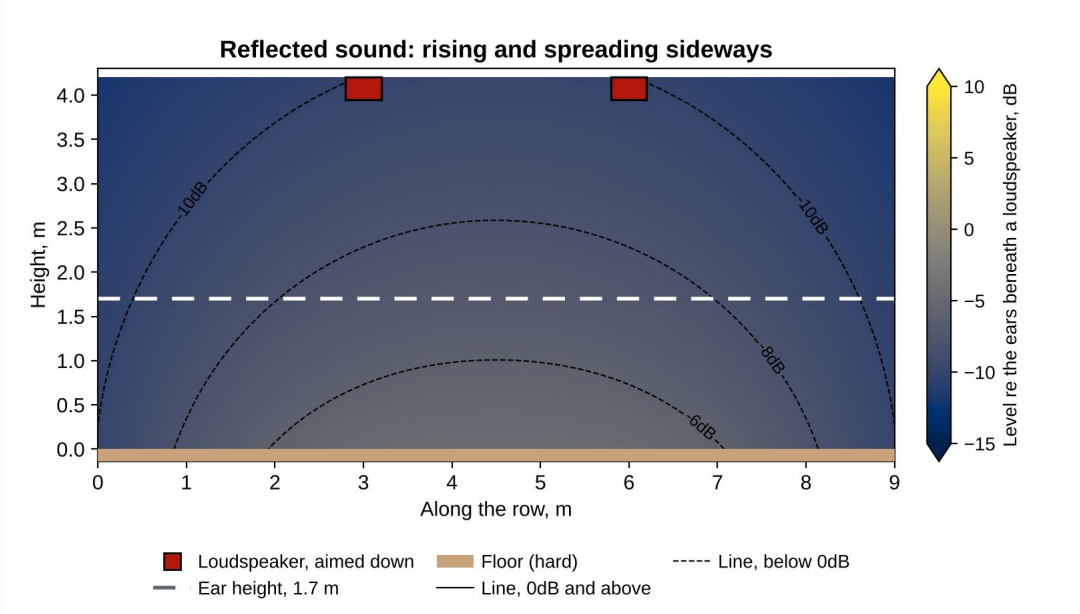


At 4.0 m: +1.9dB beneath an inner loudspeaker, +2.5dB between four.

ELEMENT 1 · THE FLOOR, SIDE VIEW

How the floor fills the gaps



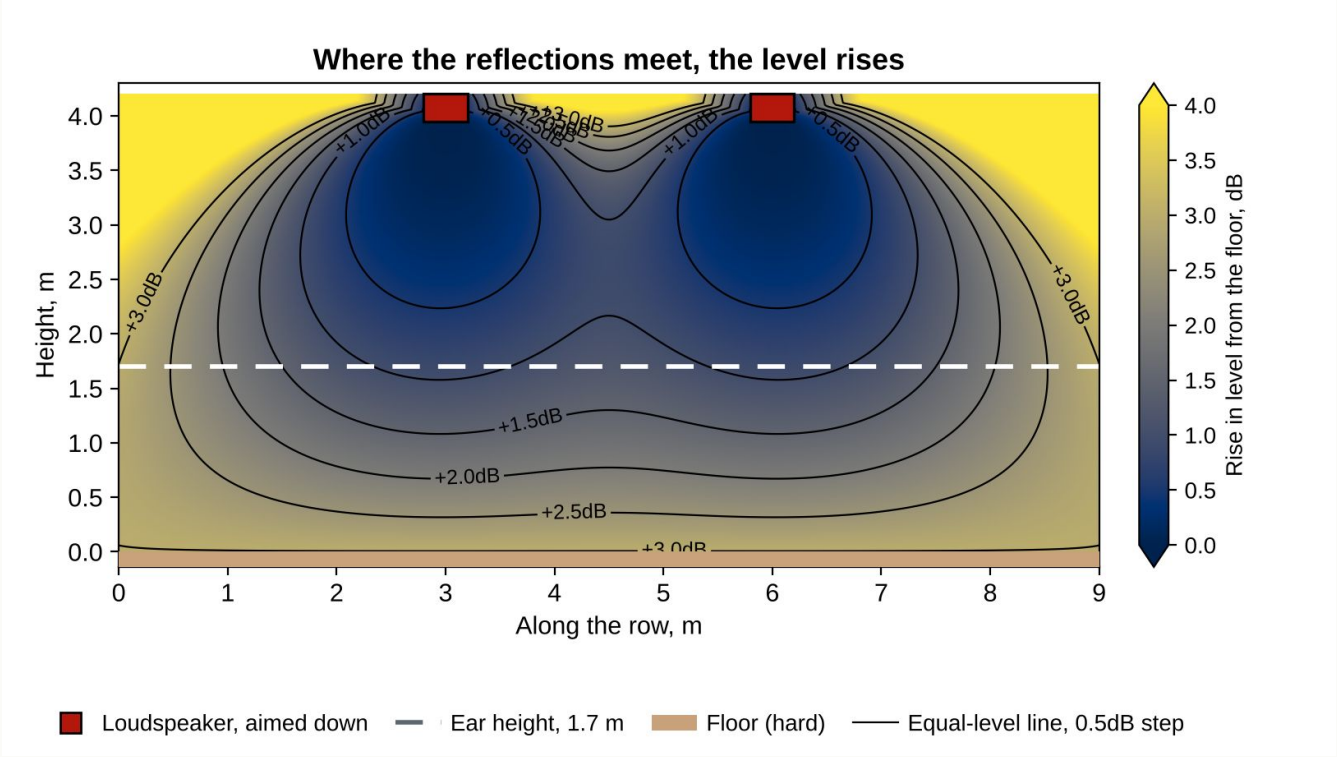


Midway between two neighbours the direct sound leaves each loudspeaker 33° off its axis, the reflected sound only 15°: the floor returns the most where the direct sound is weakest.

Side view through two neighbouring canopy loudspeakers, 4.0 m high, 3.0 m apart, 110° coverage, hard floor; levels relative to the ears beneath a loudspeaker. In the full canopy more neighbours add, across the row too.

ELEMENT 1 · THE FLOOR, SIDE VIEW

Where the reflections meet, the level rises



The floor makes up for not standing directly beneath a loudspeaker.

TWO REFLECTIONS MEET

+3dB

more reflected sound midway between the two than from one loudspeaker alone

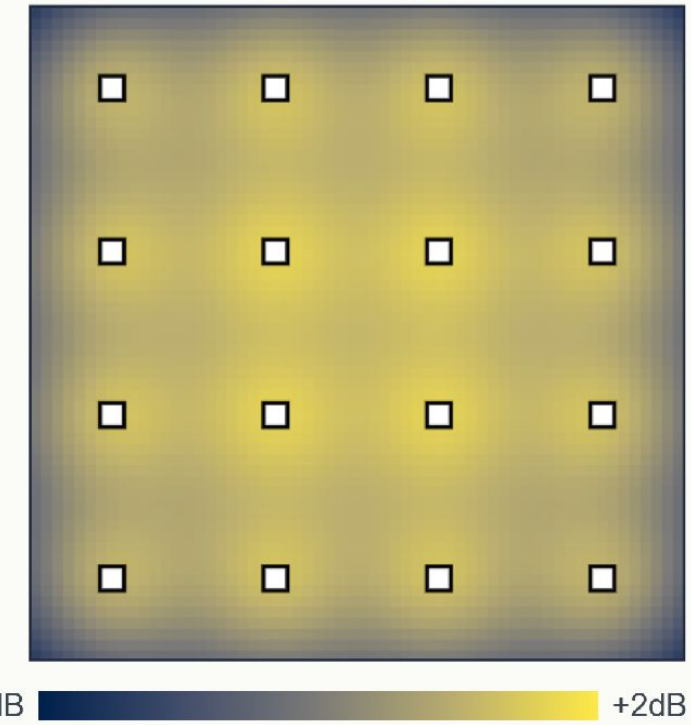
At the ears: +0.9dB beneath a loudspeaker, +1.2dB midway between two.

Full canopy, hard floor: +1.9dB beneath, +2.5dB between four.

CALCULATOR · FLOOR REFLECTION AND HEIGHT

What the floor gives, at every height

Interactive version: SOUND CANOPY Calculator



CANOPY HEIGHT ABOVE THE FLOOR

4.0 m

3.0 | 3.5 | **4.0** | 4.5 | 5.0 | 5.5 | 6.0

Distance to the ear beneath a loudspeaker	**2.30 m**
Floor reflection, with dancers	**+1.1dB**
Floor reflection, hard floor	**+2.1dB**
Level per loudspeaker for 95dB, without the floor	**101.4dB**
Level per loudspeaker for 95dB, with the floor	**100.2dB**
Uniformity across the floor	**±2.1dB**

4 × 4 loudspeakers, 3.0 m apart, aimed down, 110° coverage; ears at 1.7 m; floor with dancers, absorption 0.5. Map: level relative to the floor average.

FREQUENCY CONTROL

Which loudspeaker plays what, and how

The high-pass filter separates the bass from the mid and high frequencies.

Band	Source	Control toward the receivers
Mid and high	The canopy, high-passed	Aimed down: the floor on axis, the receivers far off axis
Low	Cardioid subwoofers	Spacing, delay and polarity cancel the output toward the receivers
Lowest	Tactile transducers	Felt through the floor by contact, hardly radiated into the air

Each band has its own source and its own control.

AT THE RECEIVERS

Less sound leaves the venue

Proximity

Each loudspeaker serves dancers close to it, so it needs less power.

Direction

Aimed down, the canopy has the floor on axis and the receivers far off it.

No beams across the floor

Nothing is aimed past the far edge toward the receivers.

SOUND CANOPY GEOMETRY ALONE

3 to 7dB

less at the receivers than with corner loudspeakers

Before screening by buildings and fences, and before the limiter.

Every country sets noise limits at the receivers. SOUND CANOPY helps the venue meet them.

Distance is expensive, direction is free

$$L_p = L_W - 20 \lg r - 11 + DI(\theta) \quad \text{dB}$$

L_p	Sound pressure level at the listener, dB
L_W	Sound power level of the loudspeaker, dB re 1pW
r	Distance from the loudspeaker to the listener, m
θ	Angle from the loudspeaker axis to the listener
$DI(\theta)$	Directivity index in that direction, dB
11	10 lg 4π: spherical spreading in free field

Distance is expensive

Every doubling of distance costs 6dB.

Direction is free

Off the loudspeaker axis, the level falls at no cost in power.

we dont waste energy but we use directivity

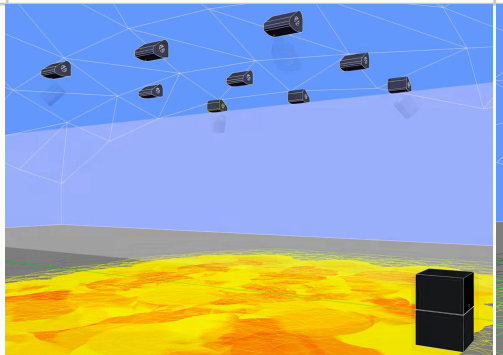
Proximity replaces power

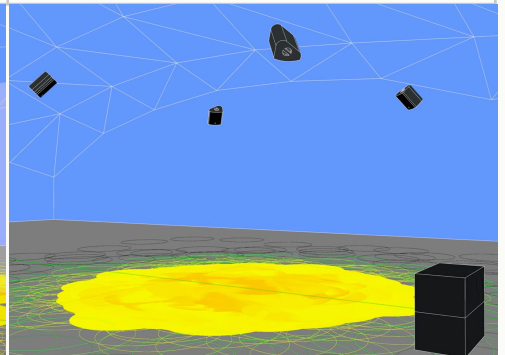
$$\Delta L_W = 20 \lg \frac{r_2}{r_1} \text{ dB}$$

ΔL_W	Extra sound power level needed for the same level at the dancer, dB
r_1	Shorter distance to the dancer, m
r_2	Longer distance to the dancer, m

A dancer 9 m from the loudspeaker instead of 3 m: about 9.5dB more power.

12 m × 12 m floor, same floor average	SOUND CANOPY	Corner loudspeakers
Greatest distance from a dancer to the nearest loudspeaker	3.2 m	9.0 m
Average distance to the nearest loudspeaker	2.7 m	5.5 m
Drive level per loudspeaker	Reference	About 7dB higher





Sound leaving the venue: two levers

$$L_{p,\,far} \approx 10\lg \sum_{i=1}^{N} 10^{(L_{w,\,i} + DI_i(\theta_i))/10} - 20\lg d - 11 \quad \text{dB}$$

$L_{p,\,far}$	Level at a distant receiver, dB
$L_{w,\,i}$	Sound power level of loudspeaker i, dB
$DI_i(\theta_i)$	Directivity index of loudspeaker i toward the receiver, at the angle θi from its axis, dB
d	Distance from the dance floor to the receiver, m
N	Number of loudspeakers

Lever 1: lower power

Each loudspeaker serves dancers close to it.

Lever 2: direction

Aimed down, the receivers lie far off axis.

Both are built into the geometry: before any screening, and before the limiter.

A REPRESENTATIVE CALCULATION

Same floor, same average level

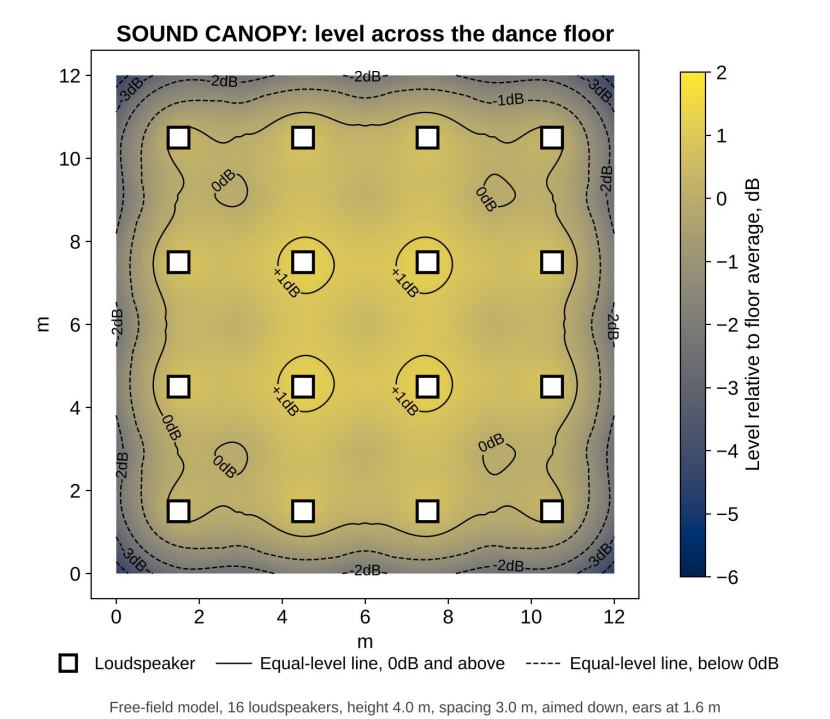
	SOUND CANOPY	Corner loudspeakers
Loudspeakers	16, in a 4 × 4 grid, 3.0 m apart	4, at the corners of the floor
Height	4.0 m	4.5 m
Aiming	Straight down	At the centre of the floor

Common to both: a 12 m × 12 m floor, ears at 1.6 m, the same generic loudspeaker with about 120° coverage, the same average level on the floor, receivers 4 m above ground, free field.

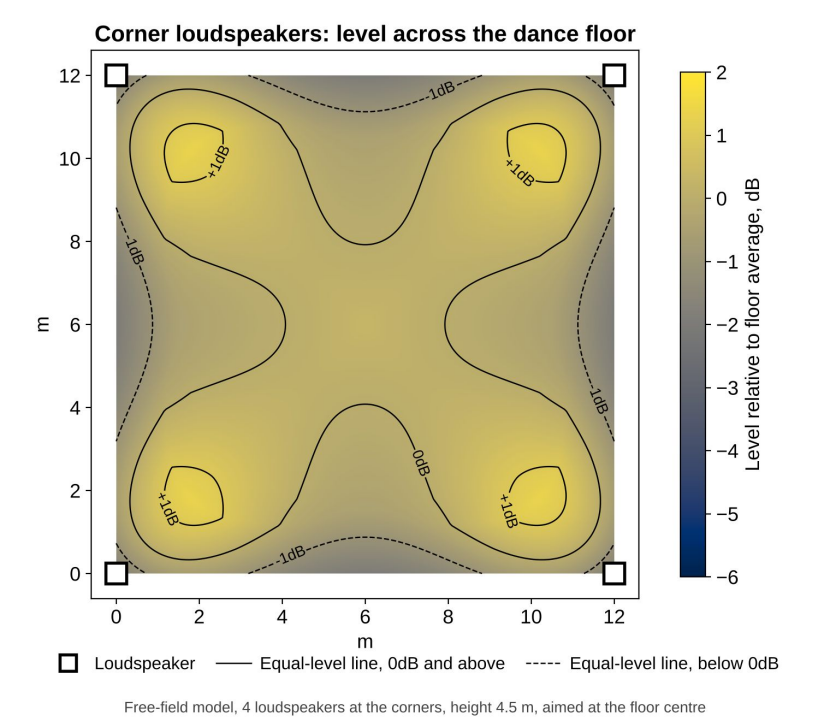
All levels are relative to the floor average, so the results hold at any operating level.

CALCULATION · LEVEL ACROSS THE DANCE FLOOR

Two systems, the same floor average



95% of the floor within ±2dB; every dancer within 3.2 m of a loudspeaker.



Even in free field too, but dancers up to 9 m from the sound, and each loudspeaker 7dB harder.

CALCULATION · WHERE THE SOUND POWER GOES

Twice the share of sound power on the floor

SOUND CANOPY

50%

of each loudspeaker's sound power lands on the dance floor; its reflection returns up through the dancers.

CORNER LOUDSPEAKERS

26%

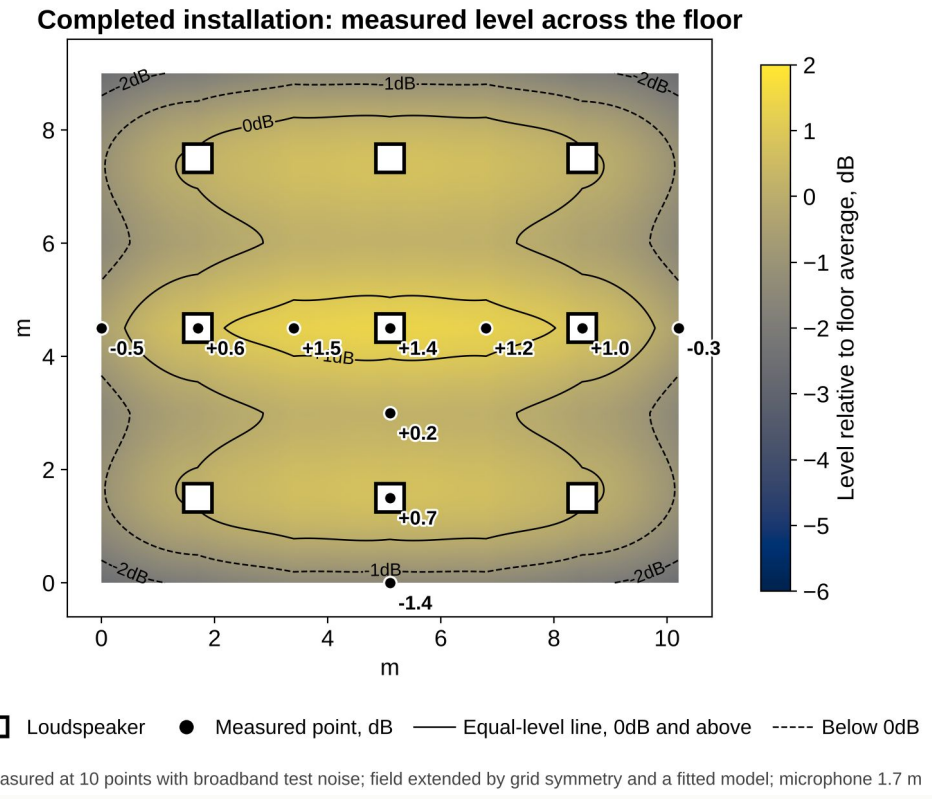
lands on the floor; the rest passes over it, and the grazing reflection continues outward.

Same floor, same average level	SOUND CANOPY	Corner loudspeakers
Level per loudspeaker for 95dB, floor reflection included	100.1dB	107.4dB

About 7dB less from each canopy loudspeaker for the same 95dB on the floor.

MEASURED · COMPLETED INSTALLATION

The calculation, confirmed in the field



Measured at 10 points with broadband test noise; field extended by grid symmetry and a fitted model; microphone 1.7 m

Between loudspeakers
About 1dB lower than beneath the loudest one.

At the edge of the floor
About 2dB lower: 1.7 and 1.9dB measured.

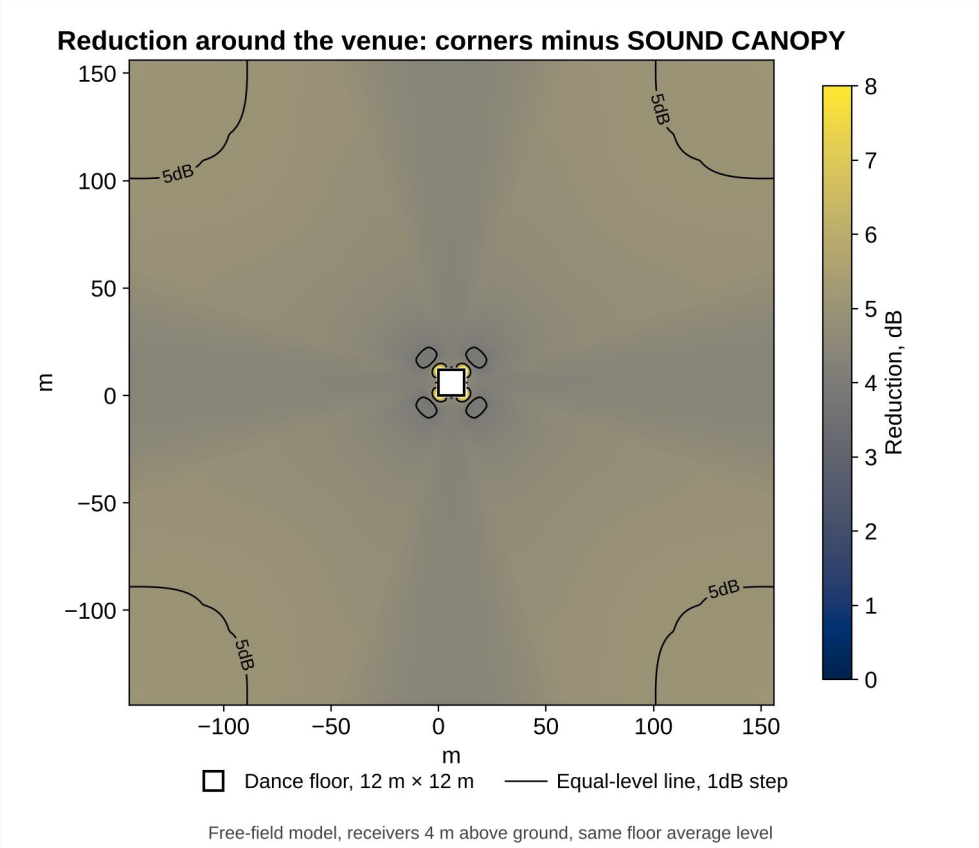
Whole floor
Within about ±2dB.

As calculated.



CALCULATION · REDUCTION

Less sound all around the venue



BEYOND 20 M FROM THE FLOOR

4 to 5dB

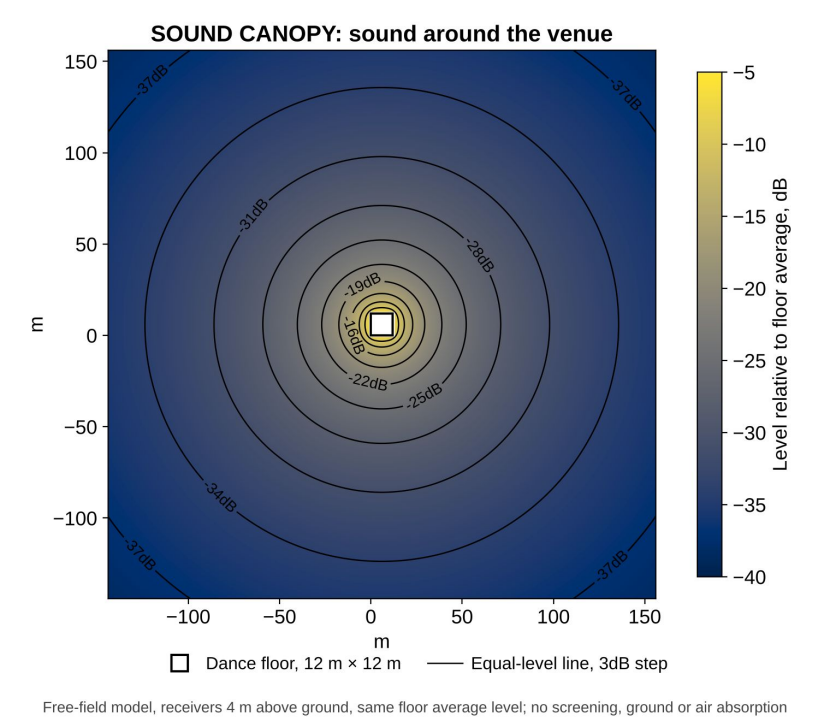
less with SOUND CANOPY, in every direction; about 5dB toward the diagonals.

3dB is half the sound energy reaching the neighbours.

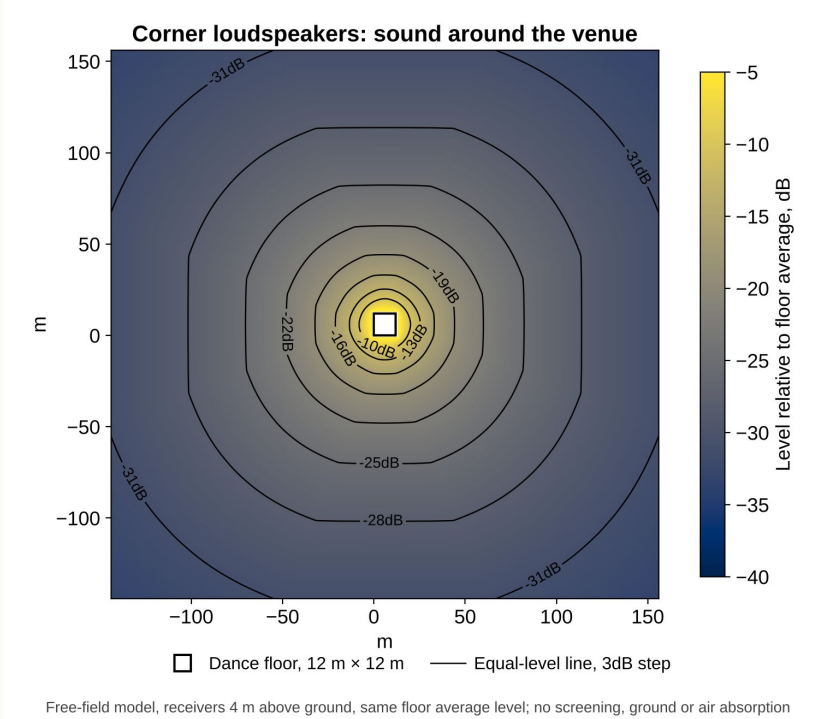
Geometry alone: before screening and before the limiter.

CALCULATION · AROUND THE VENUE

The same floor average, less sound outside



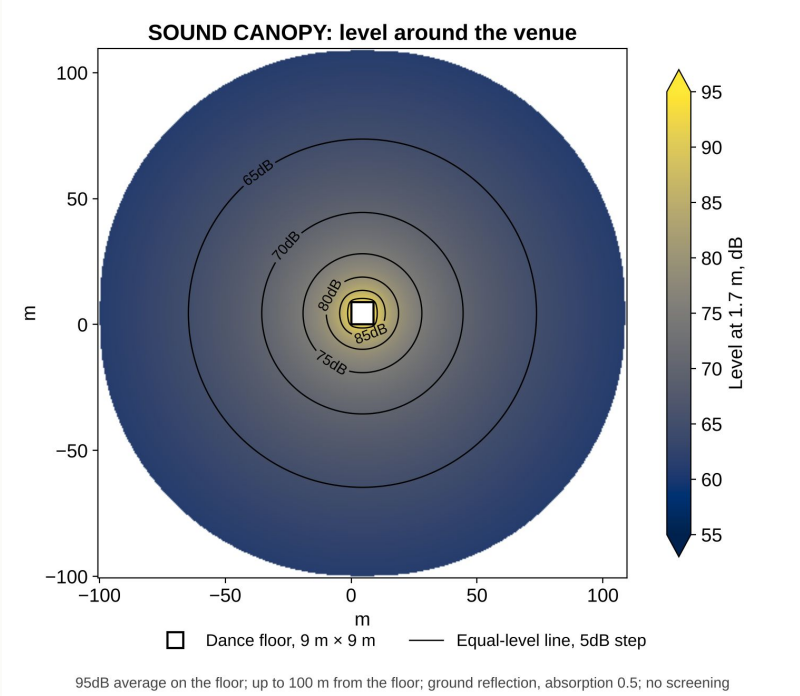
50 m from the floor edge: 26.7dB below the floor average.



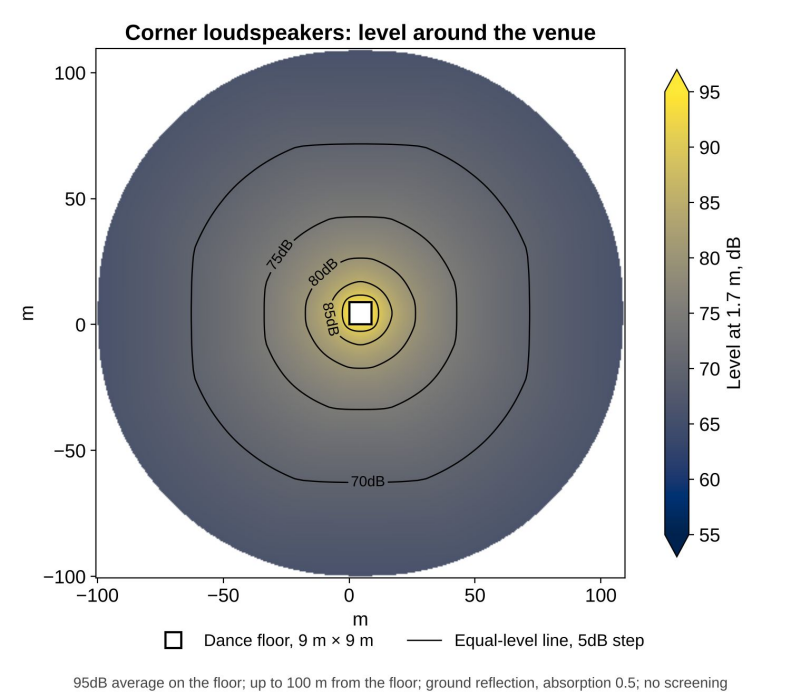
50 m from the floor edge: 22.3dB below the floor average.

SIMULATION · UP TO 100 M FROM THE DANCE FLOOR

Same 95dB on the floor, less sound around it



95dB average on the floor; up to 100 m from the floor; ground reflection, absorption 0.5; no screening



95dB average on the floor; up to 100 m from the floor; ground reflection, absorption 0.5; no screening

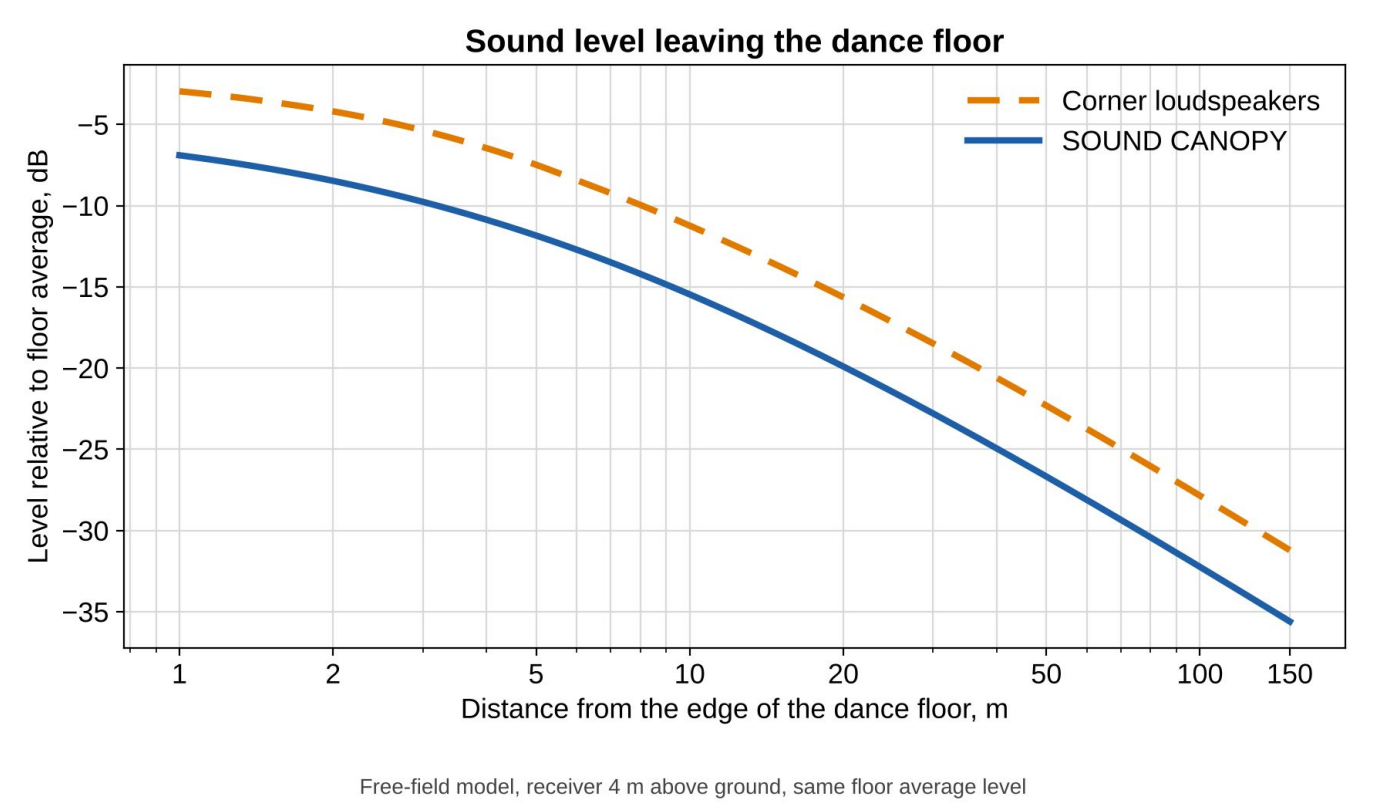
The simulation

Dance floor 9 m × 9 m, 95dB average on it.
SOUND CANOPY: 16 loudspeakers at 3.5 m, aimed down.
Corners: 4 loudspeakers at 4.5 m, aimed at the centre.

100 m from the floor: 61dB with SOUND CANOPY, 66dB with four corner loudspeakers.

CALCULATION · LEVEL VERSUS DISTANCE

The reduction holds at every distance



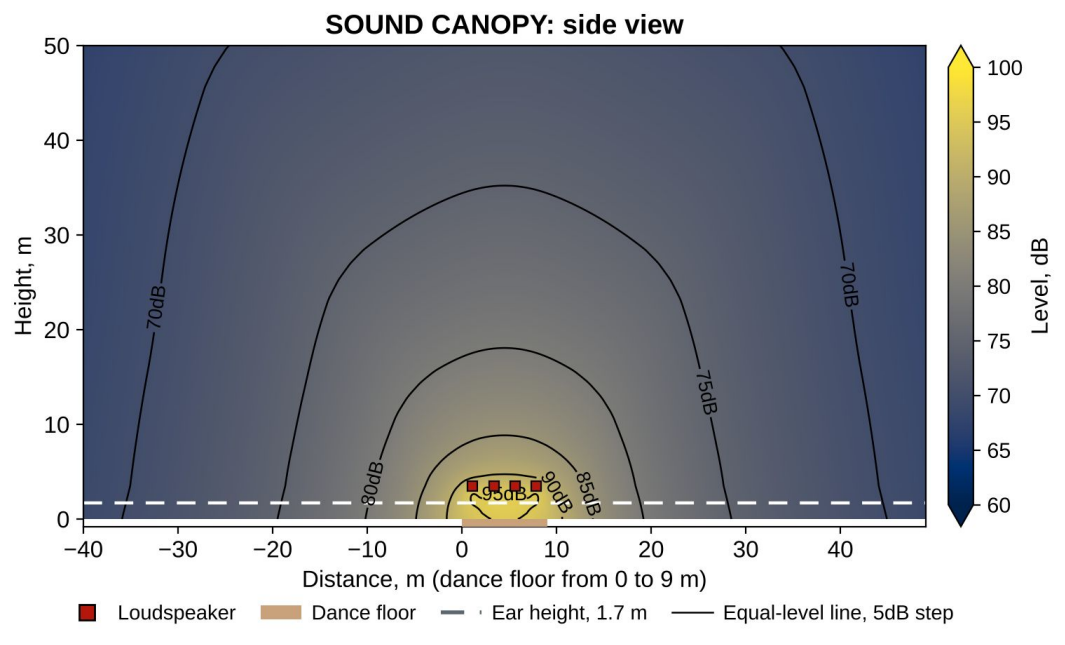
Free-field model, receiver 4 m above ground, same floor average level

From the floor edge	Reduction
25 m	4.3dB
50 m	4.4dB
100 m	4.4dB
150 m	4.4dB

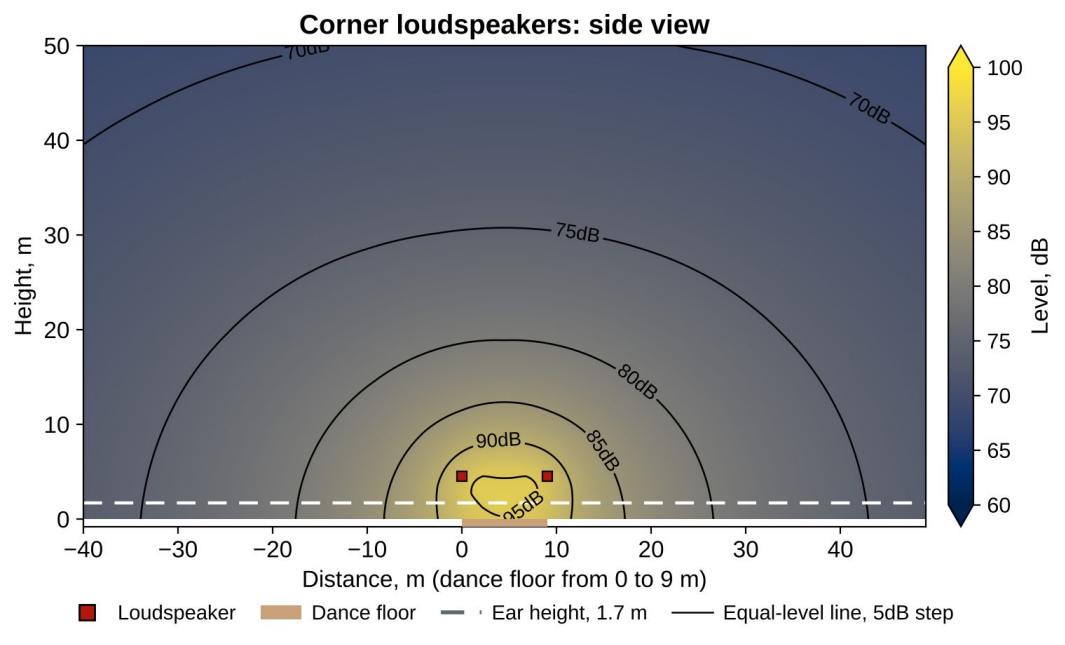
The curves run parallel: the canopy stays about 4.4dB lower all the way out.

SIMULATION · SIDE VIEW

A mushroom of sound over the dance floor



Ear height: 85dB at 4.5 m from the floor edge

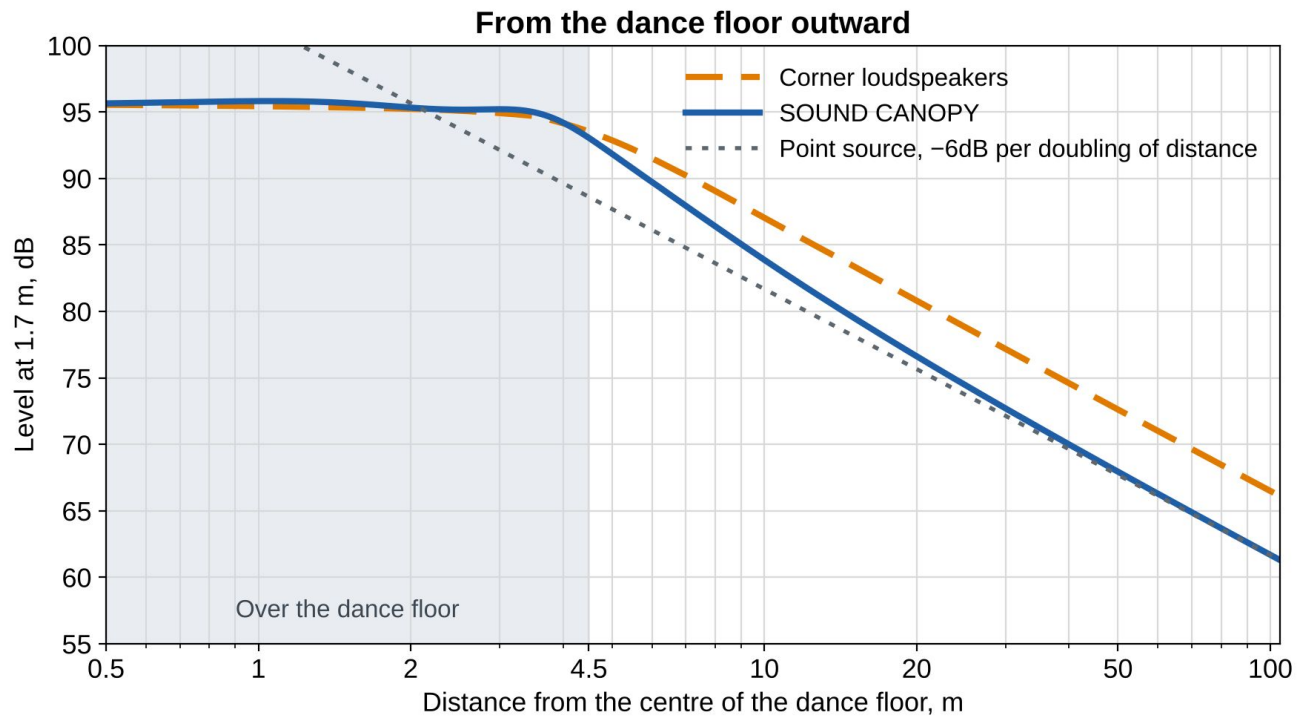


Ear height: 85dB at 8.0 m from the floor edge

SOUND CANOPY sends the sound down to the floor and up to the sky, not sideways to the neighbours.

SIMULATION · FROM THE FLOOR OUTWARD

Three zones: surface, mushroom, weaker source



9 m × 9 m floor, 95dB average; canopy of 16 at 3.5 m, corners 4 at 4.5 m; same generic loudspeaker; ground reflection, absorption 0.5

1 · Over the floor: a surface

Nearly flat: 95.5dB at the centre, 93.1dB at the edge.

2 · Just beyond: the mushroom

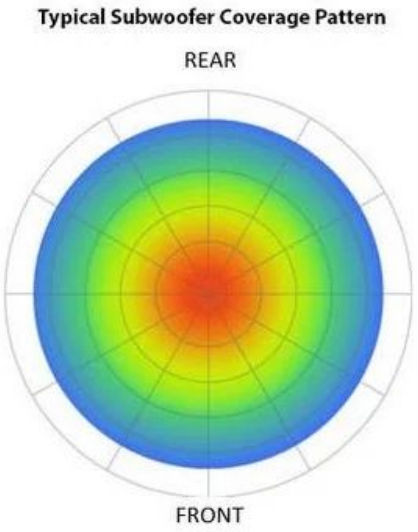
Falls faster than a point source, and faster than the corners.

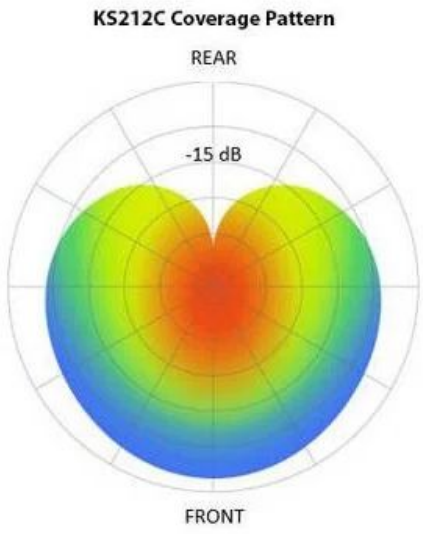
3 · Far away: a weaker source

Parallel, about 4.8dB lower: less sound power, aimed down.

ELEMENT 2 · LOW FREQUENCIES

Cardioid subwoofers







Dance floor: In the front

Quiet zone at rear

Why subwoofers spill

The wavelength is far longer than the cabinet, so a single subwoofer radiates in all directions.

How cardioid works

Front- and rear-firing units combine; spacing, delay and polarity cancel the output behind the array.

In practice

At least two units, placed and turned so that the null points at the receivers.

ELEMENT 3 · THE LOWEST FREQUENCIES

Bass you feel through the floor

Felt, not radiated

Transducers under the floor turn the bass into vibration of the floor. The dancers feel it; almost nothing goes into the air.

Where

Under the dance floor, and where needed under the DJ booth and the stage.

Per venue

The number and layout follow the floor structure; not every venue needs them.





DESIGN

Every venue is designed, not copied

1 Survey

The site, the receivers, the background noise and the limits that apply.

2 Targets

About 97dB(A) on the floor, ±2dB across it, and the limit at every receiver.

3 Site limits

The structure and the other technical limits of the venue.

4 The canopy

Loudspeaker, height, spacing and number; the heat map of the floor.

5 Low frequencies

The direction of the cardioid null and the layout of the transducers.

6 Prediction

The level at every receiver, from a propagation model, before installation.

Then verified by measurement after commissioning.

OPERATION

A closed, controlled system

System limiter

The total output is set from the design and the commissioning measurements.

Continuous monitoring

Microphones track the levels on the floor and at the receivers.

No external loudspeakers

An added loudspeaker bypasses both the geometry and the limiter.



The level on the floor, shown to the operator at the DJ booth, with 5- and 15-minute averages.

VENUES

SOUND CANOPY in different venues



Event hall

Canopy on a truss under a timber roof



Event garden

Canopy on trusses under a shade sail



Event garden, during an event

Canopy under a pergola

SUMMARY

Six design rules

1 Calculate the canopy

Loudspeaker, height, spacing and number, from the targets and the site.

2 Aim down, no corners

Every dancer close to a loudspeaker; nothing aimed across the floor.

3 Split the spectrum

The canopy high-passed; each band to its own source.

4 Aim the null

Cardioid subwoofers, with the null toward the receivers.

5 System loudspeakers only

An added loudspeaker breaks the geometry and bypasses the limiter.

6 Prove it

Measure the floor map and the levels at the receivers.

Proximity replaces power. Direction replaces brute force. Felt bass replaces travelling bass.

Thank you

Everyone inside the music. The neighbours outside the noise.

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