

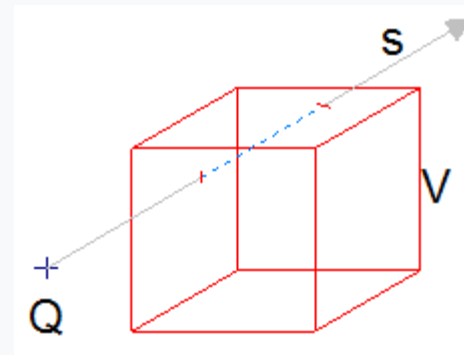
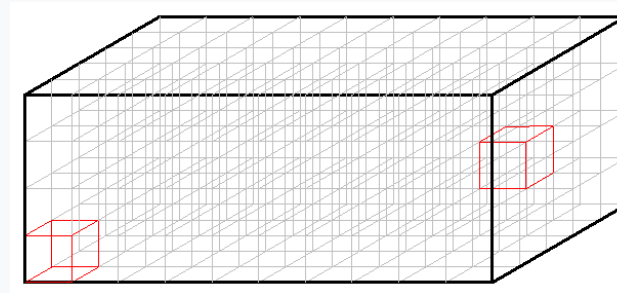
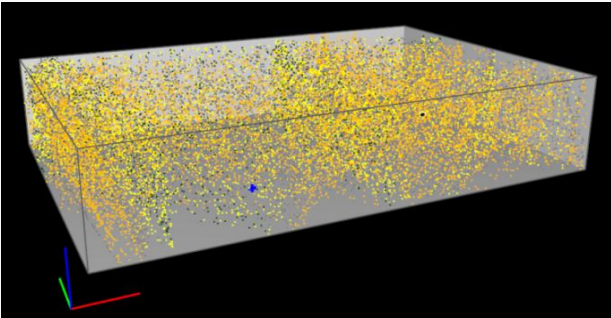
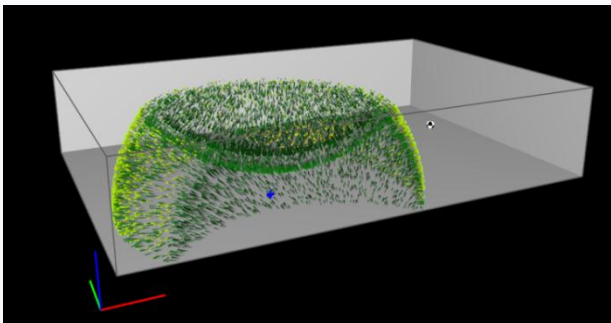
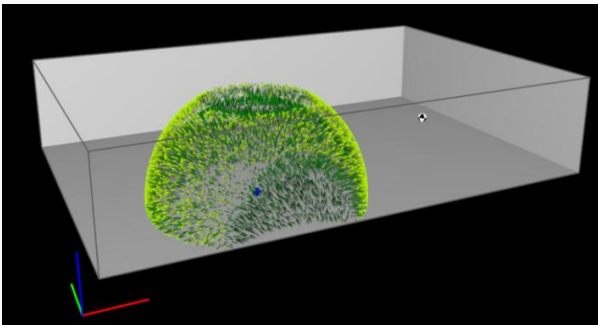
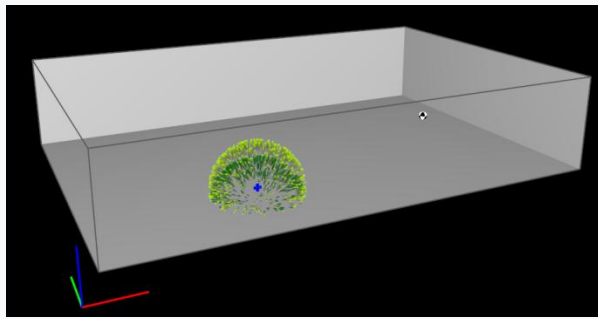
# Noise exposure forecast at workplaces

BUY QUIET 2016

Wolfgang Probst

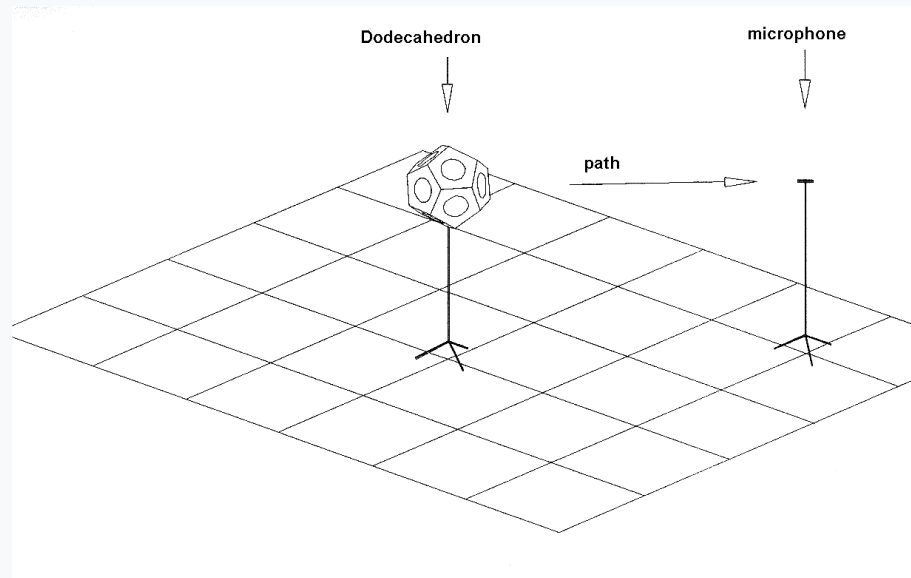


## SERT (Sound Energy Ray Tracing)

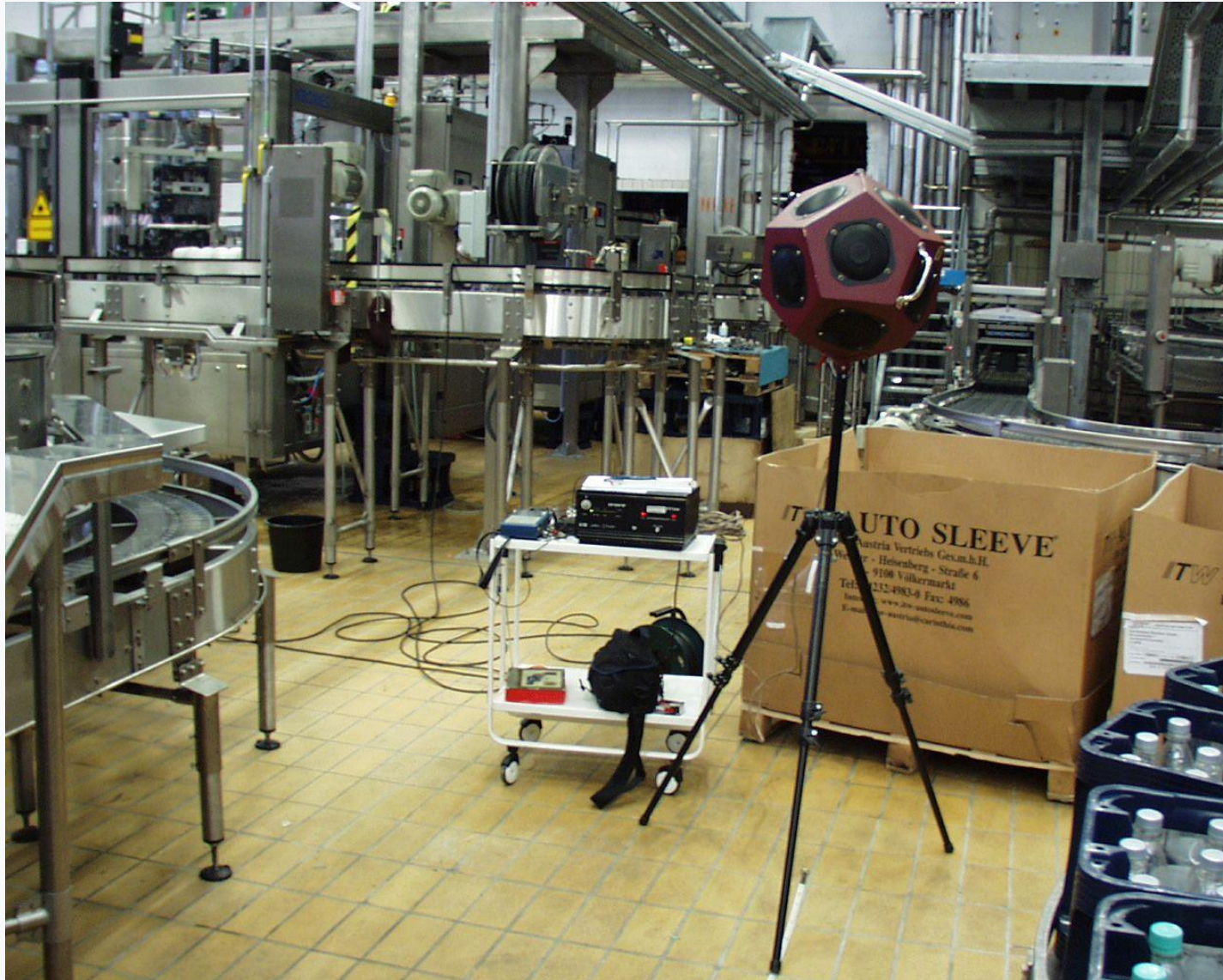


German guideline to calculate sound propagation:

VDI-RICHTLINIEN		Februar 1996
VEREIN DEUTSCHER INGENIEURE	Berechnung und Messung der Schallausbreitung in Arbeitsräumen	VDI 3760

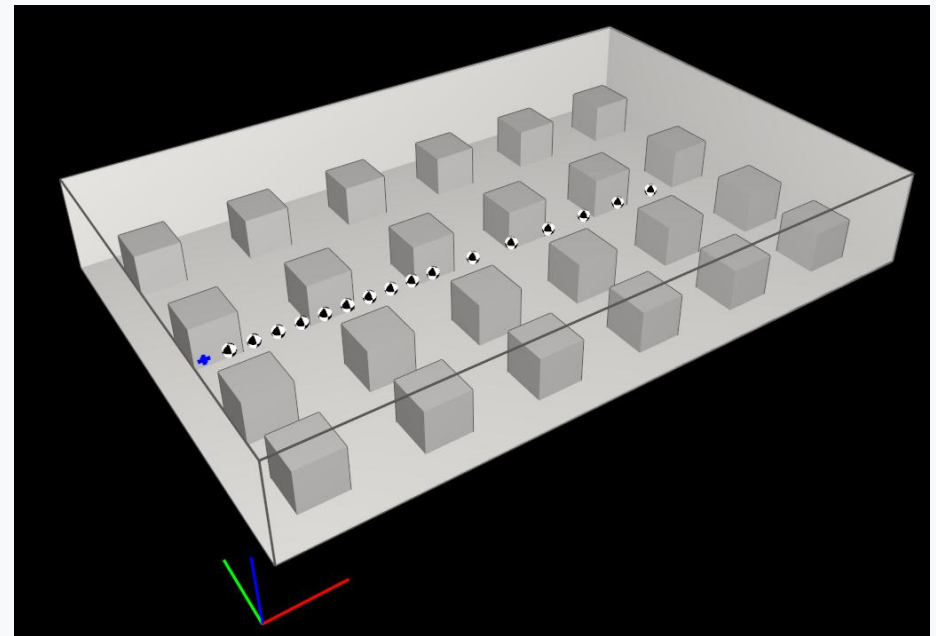


Measurements in 122 industrial halls have been performed during development of guideline VDI 3760 with financial support of BAuA



Measurements along straight paths with dodecahedron as calibrated source

1	3					Objektnr., Zustandsnr.
Industriebetrieb XYZ						Name
mit RA-Massnahmen / mit Maschinen						Zustand
30	20	4.5				Länge / Breite / Höhe
0.045						Streukörperdichte
0.034	0.042	0.043	0.045	0.05	0.06	Streukörperabsorption
0.06	0.073	0.075	0.078	0.085	0.105	Absorptionsgrad Wand 1
0.06	0.073	0.075	0.078	0.085	0.105	Absorptionsgrad Wand 2
0.06	0.073	0.075	0.078	0.085	0.105	Absorptionsgrad Wand 3
0.06	0.073	0.075	0.078	0.085	0.105	Absorptionsgrad Wand 4
0.3	0.55	0.69	0.83	0.87	0.88	Absorptionsgrad Decke
0.06	0.073	0.075	0.078	0.085	0.105	Absorptionsgrad Boden
1.05	0.88	0.72	0.65	0.64	0.58	Nachhallzeiten
107.9	112.8	108.6	104.4	104.6	97.7	Schalleistungspegel Quelle
1.5	9	1.5	30	9	1.5	Pfadanfang und -ende X/Y/Z
1/2/3/4/5/6/7/8/9/10/12/14/16/18/20/22						Abstände Quelle-IP
100	101.7	97.9	95.5	94.8	89.7	IP 1
94.1	98.9	94.5	91.5	92.3	85	IP 2
92.3	94.3	89.9	87.2	86.7	80.8	IP 3
91.3	92.1	88.9	87.4	85.5	78.9	IP 4
:	:	:	:	:	:	:
:	:	:	:	:	:	:
84.6	85.2	76.5	73.8	76.2	68.9	IP 16

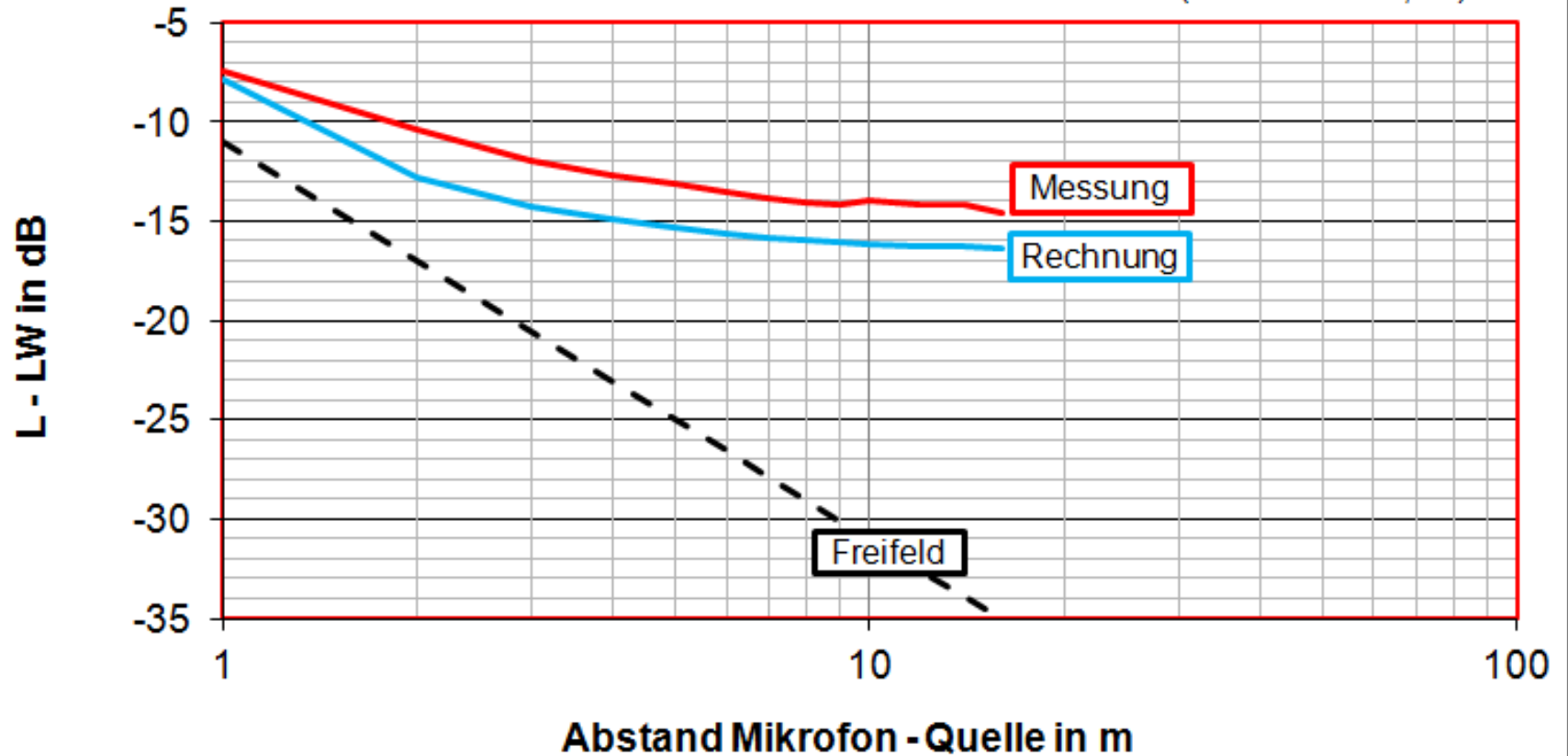


Data to describe room, source, path and measured sound pressure levels



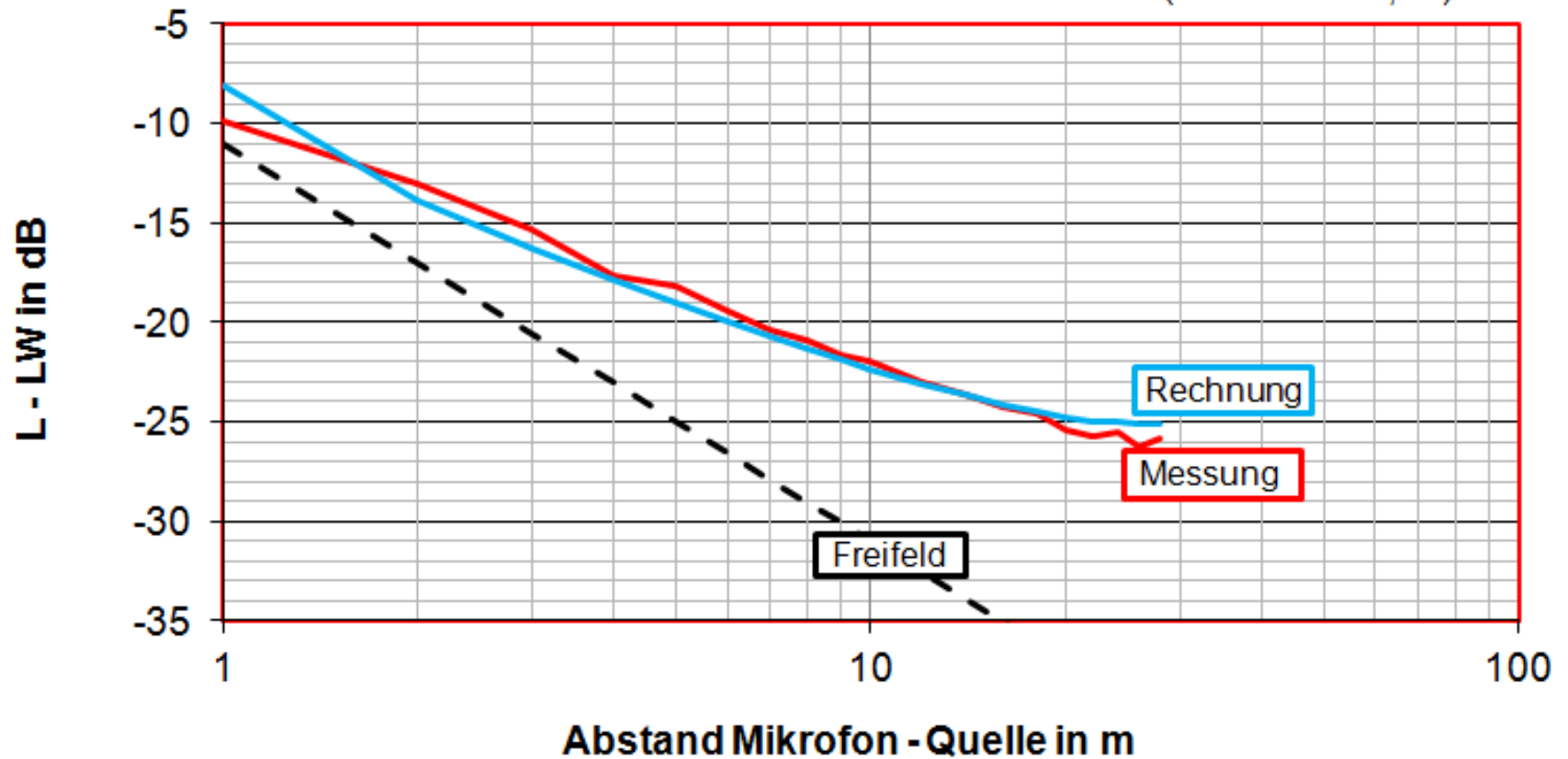
Model of the room with machinery and path

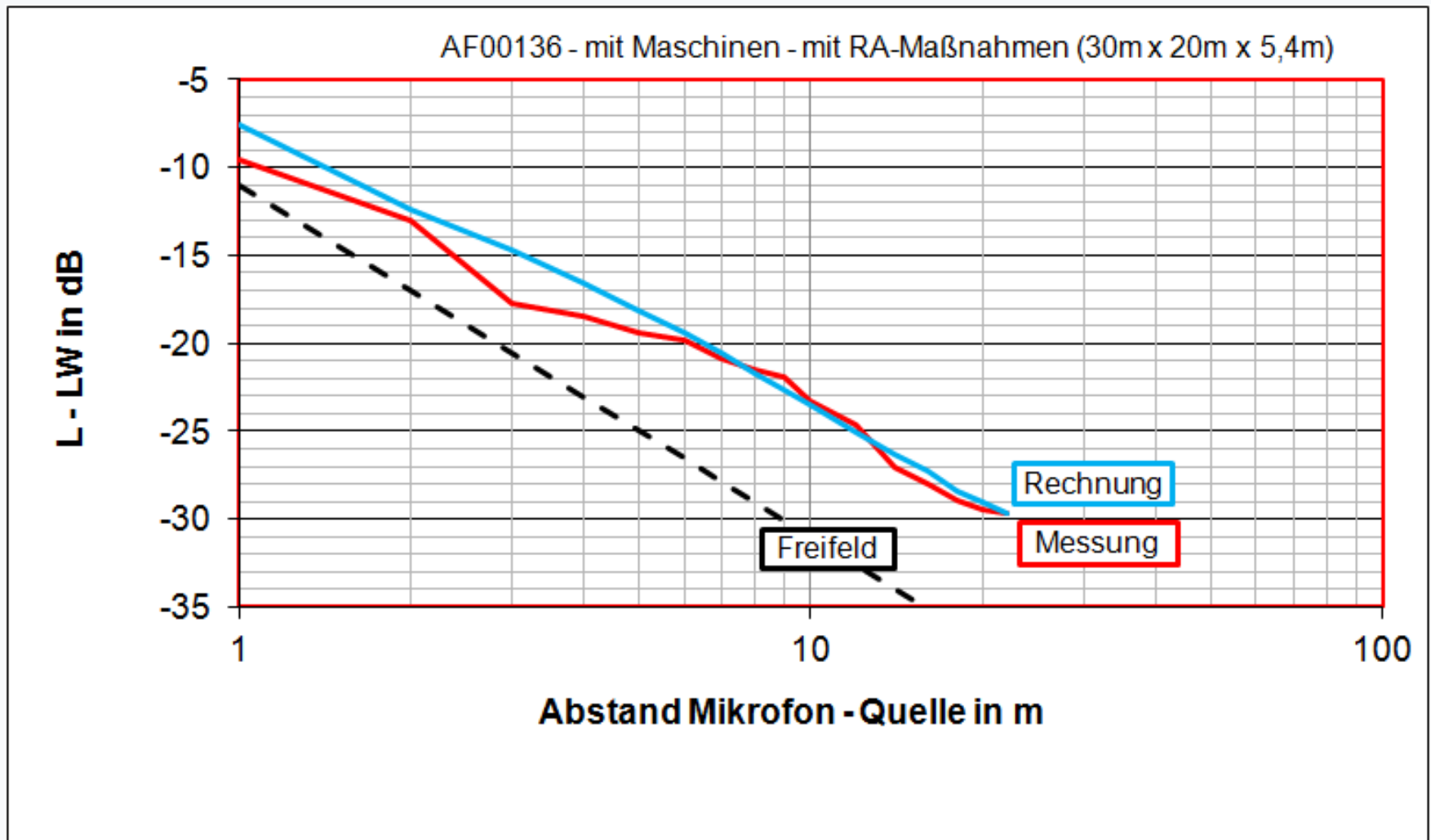
AF00116 - leer - keine RA-Maßnahmen (30m x 20m x 5,4m)



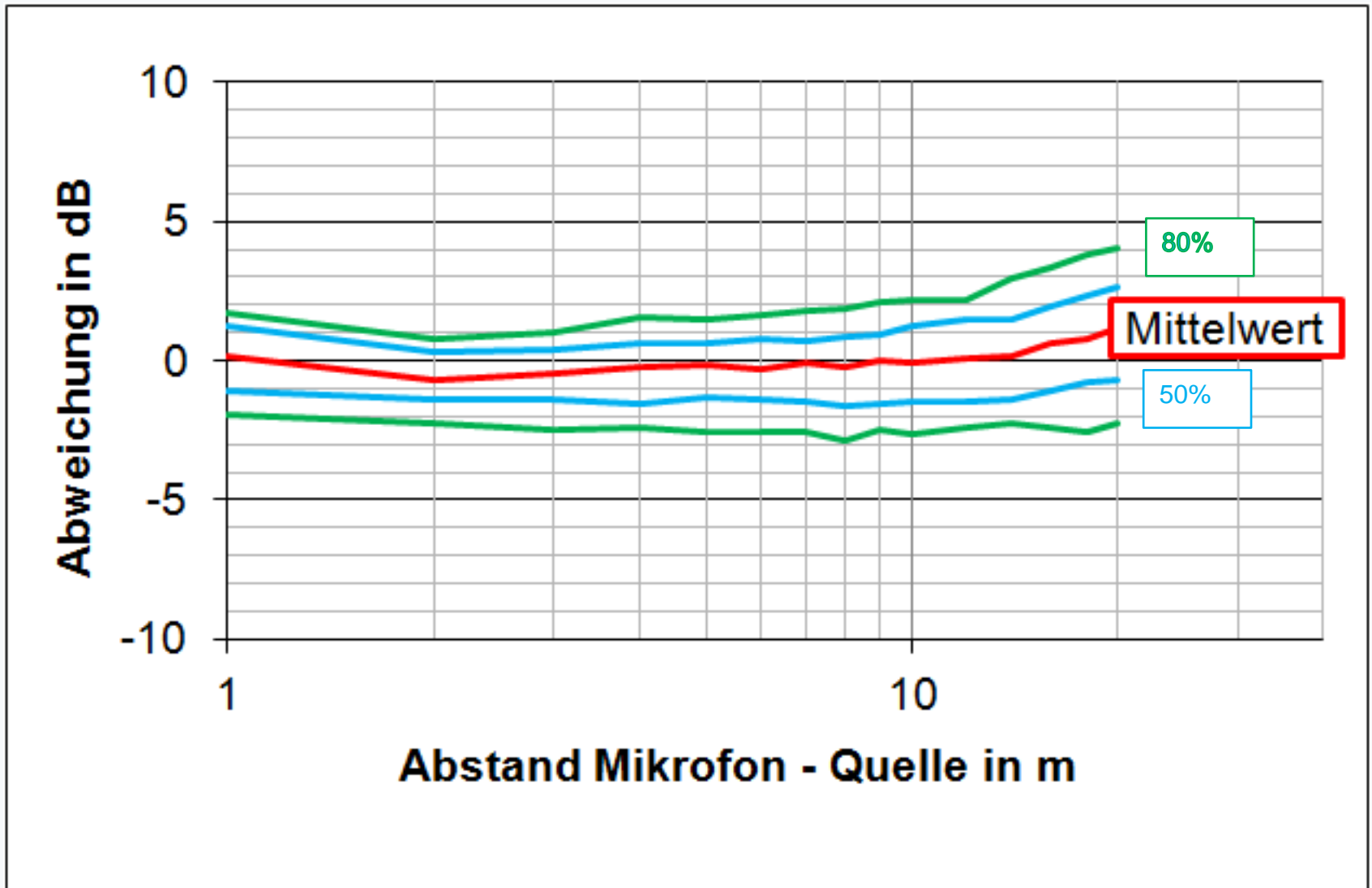
Comparison of measured levels with those calculated with SERT-method : Room AF00116 empty

AF00126 - leer - mit RA-Maßnahmen (30m x 20m x 5,4m)









Statistical analysis of the deviations for 122 halls: mean value  $< \pm 1$  dB, 50%  $< \pm 2$  dB

**Noise prediction**

Emission of sources

Technical Layout and architectural design

Immission at workplaces

Emission sound pressure level  $L_{pA}$  if  $> 70$  dB(A)  
 +  
 Sound power level  $L_{WA}$  if  $L_{pA} > 80$  dB(A)

Lower exp. action value  $L_{ex,8h} = 80$  dB(A)  
 Upper exp. action value  $L_{ex,8h} = 85$  dB(A)  
 ⋮

Machine directive 2006/42/EC

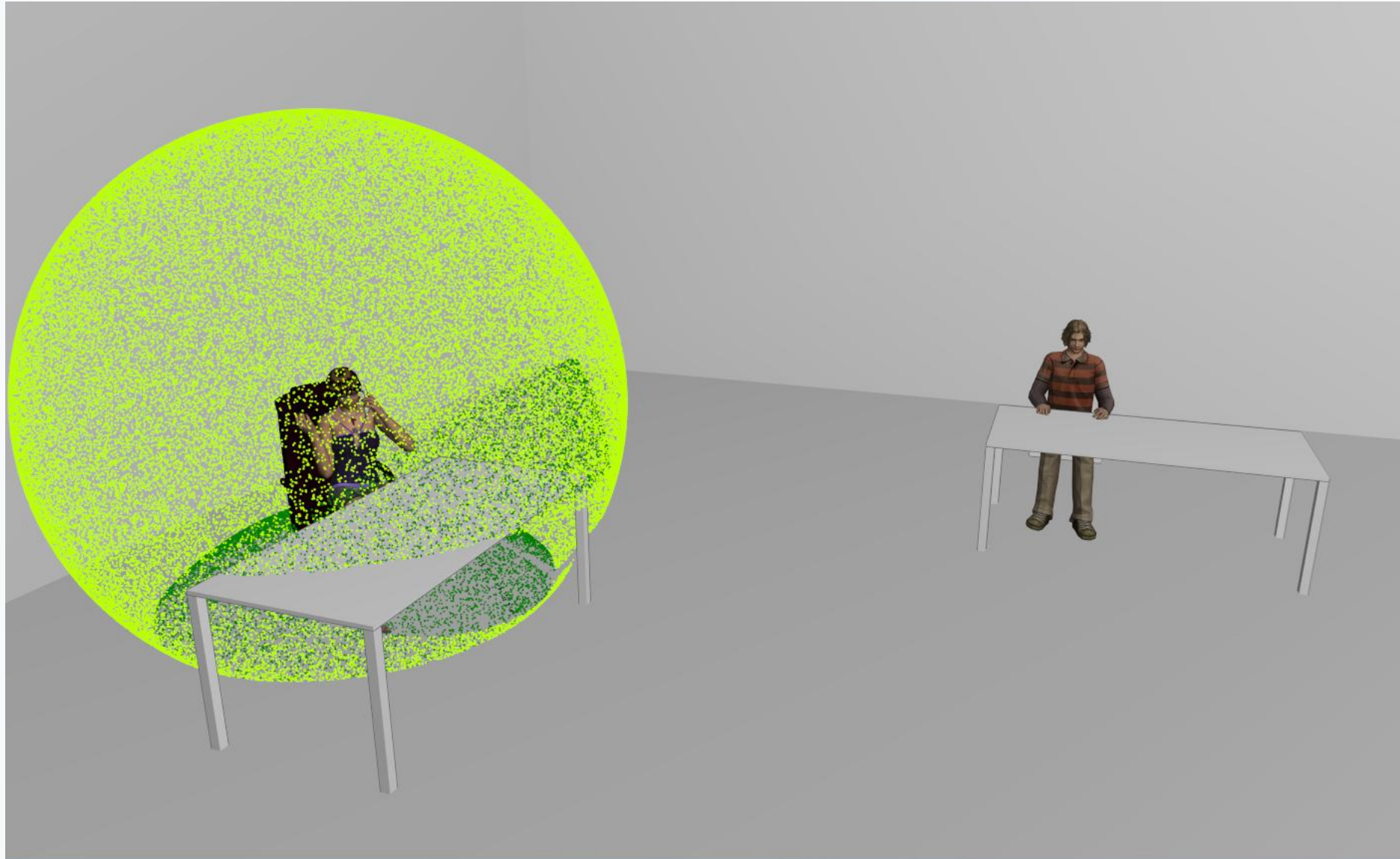
Physical Agents  
 Noise Directive 2003/10/EC

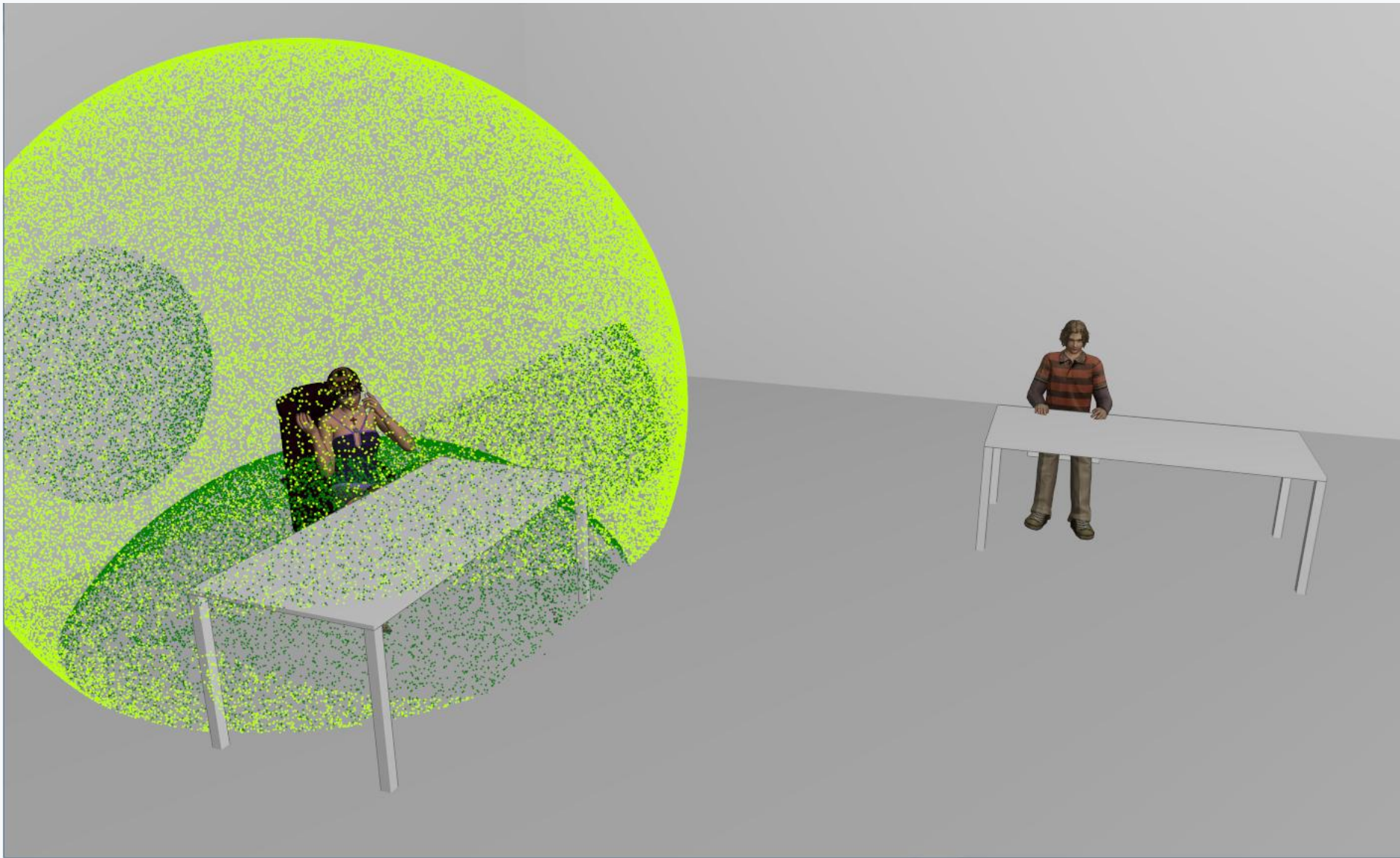


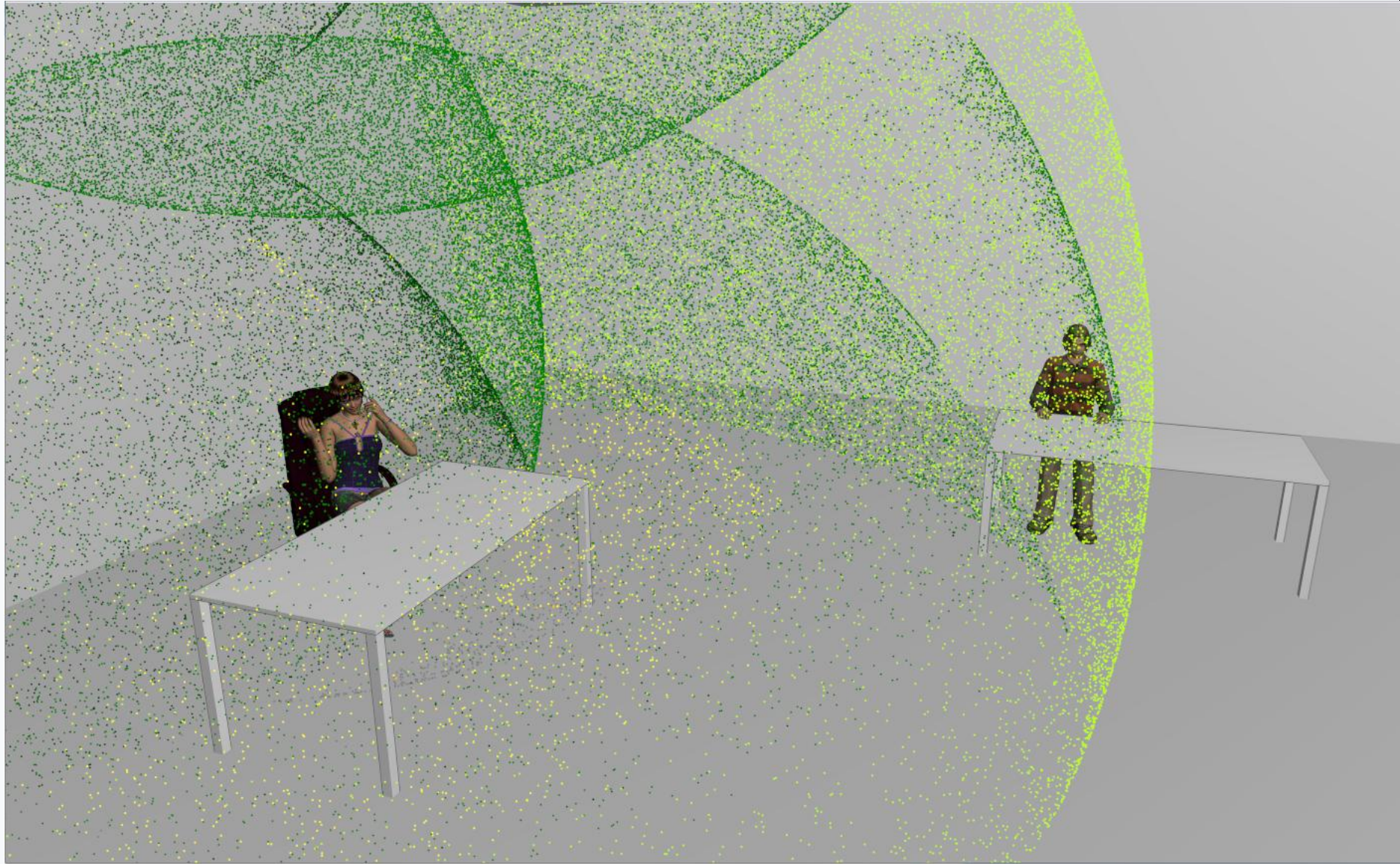


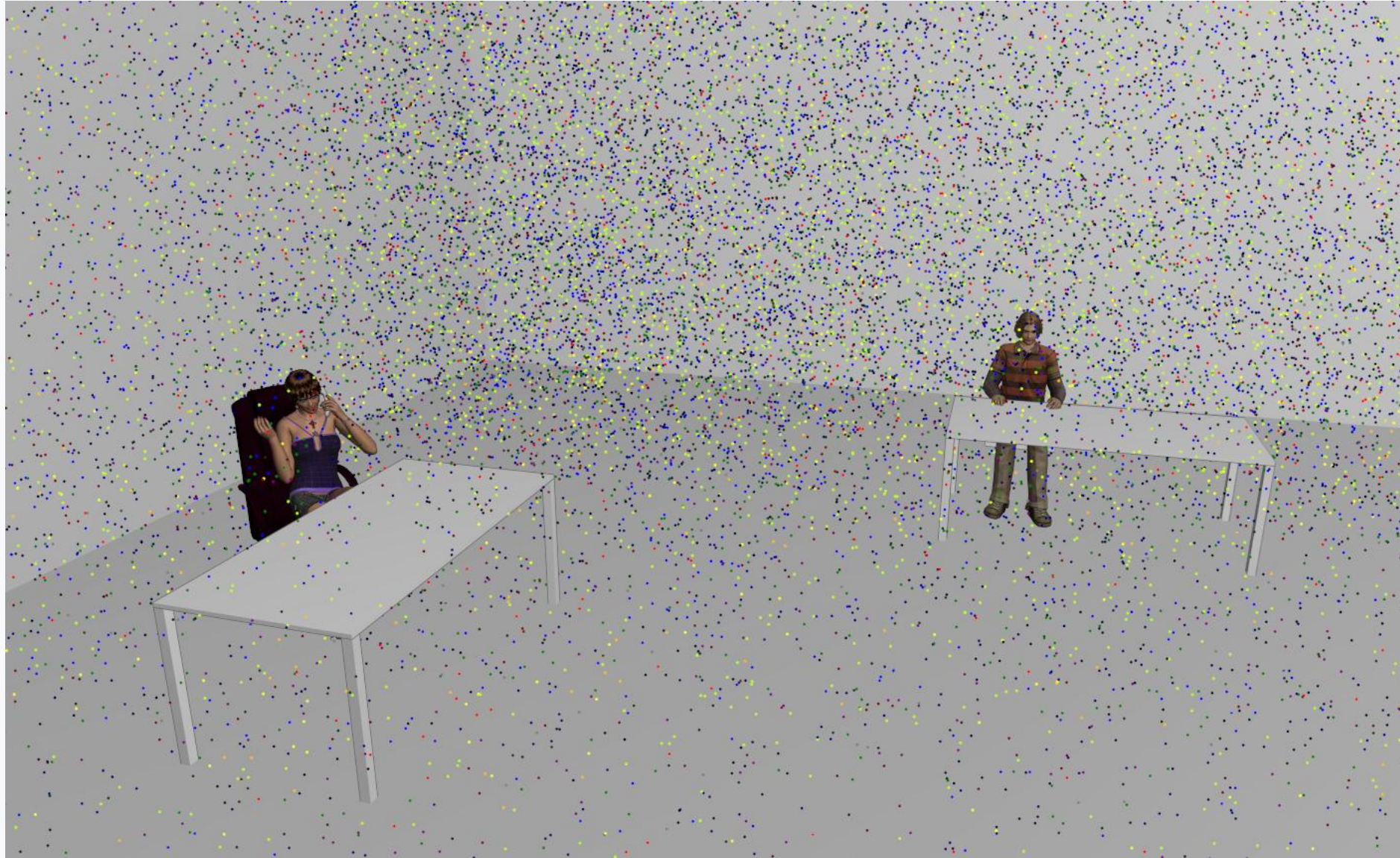
Speaking person → Simulation as point source



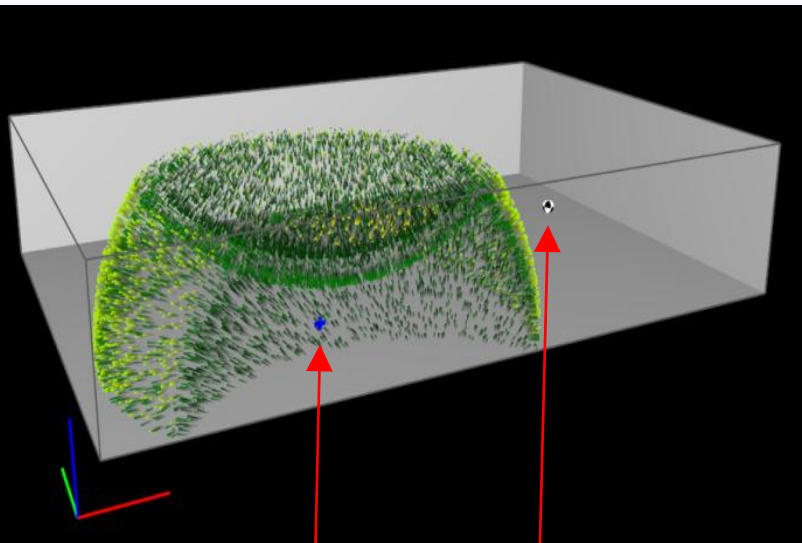






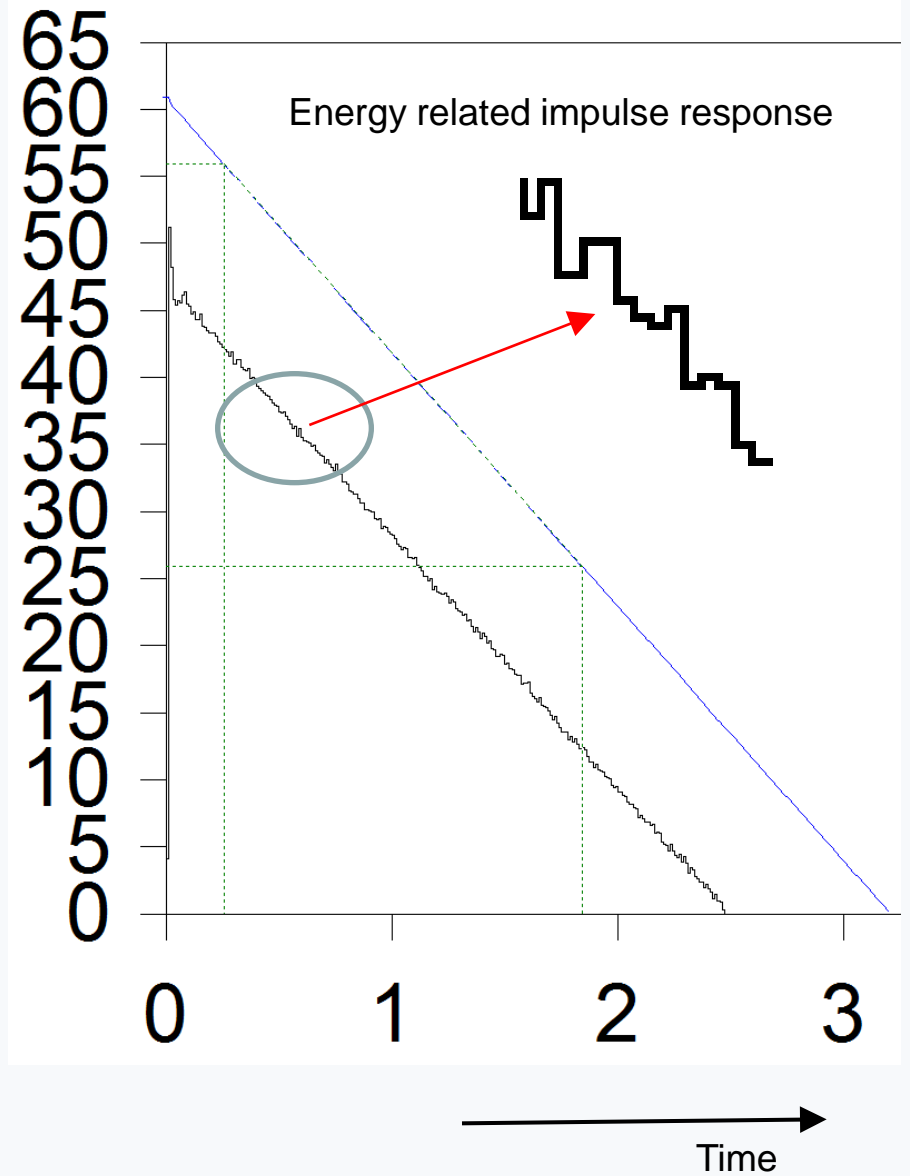


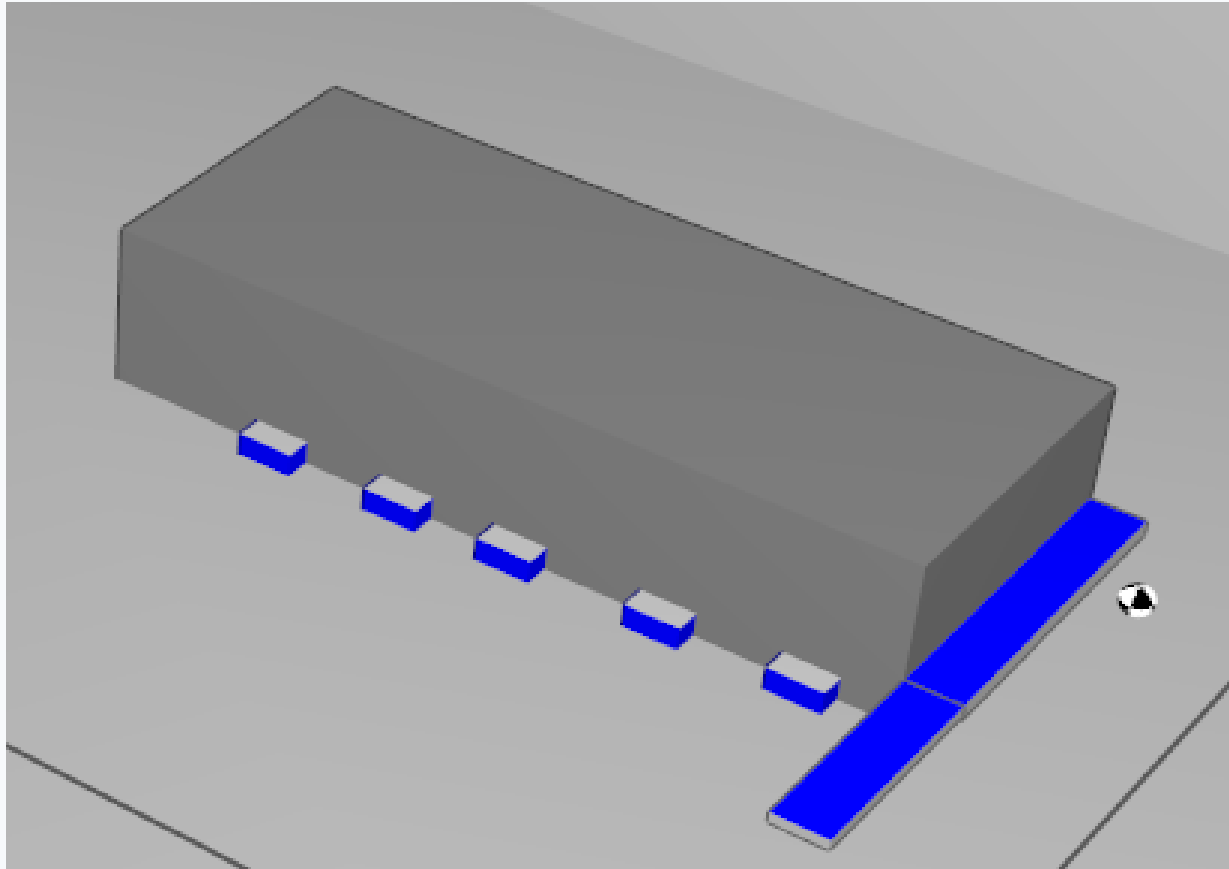




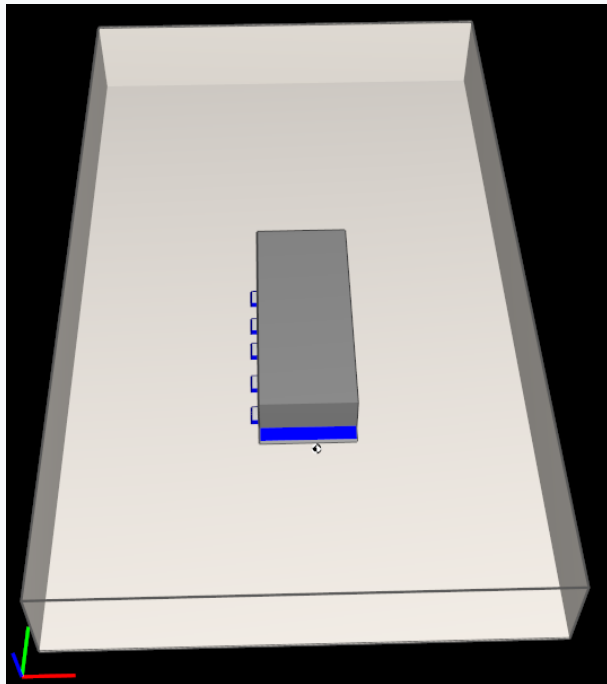
source

receiver

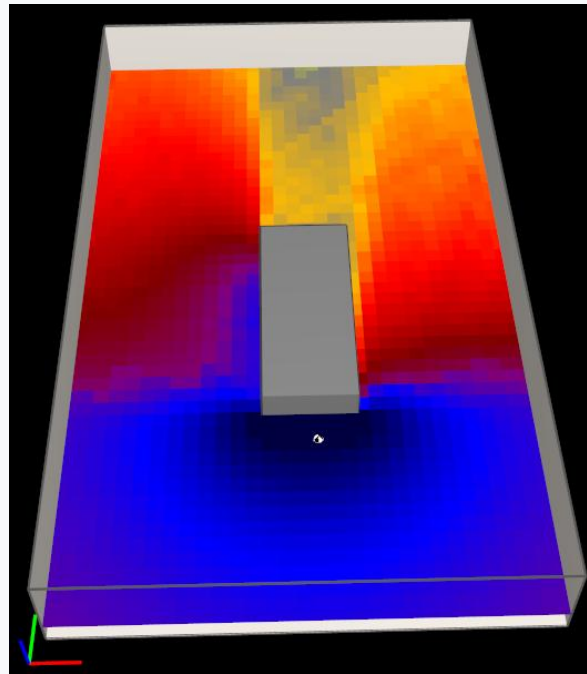




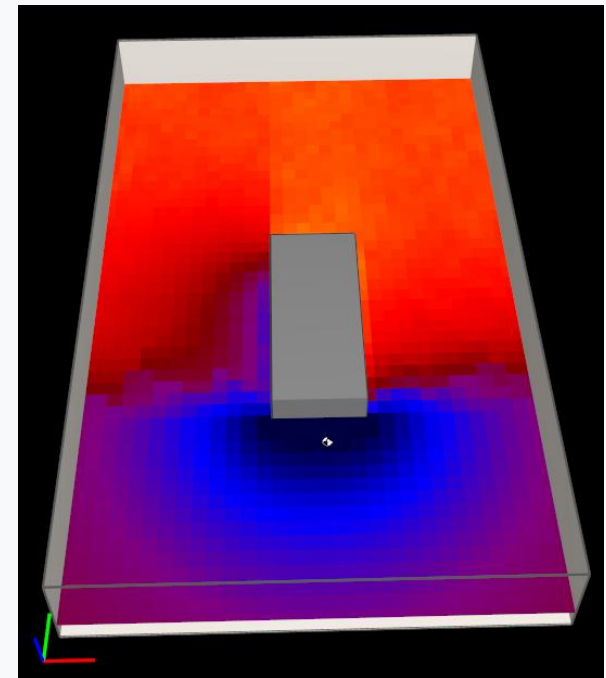
Detailed modeling of a washing machine



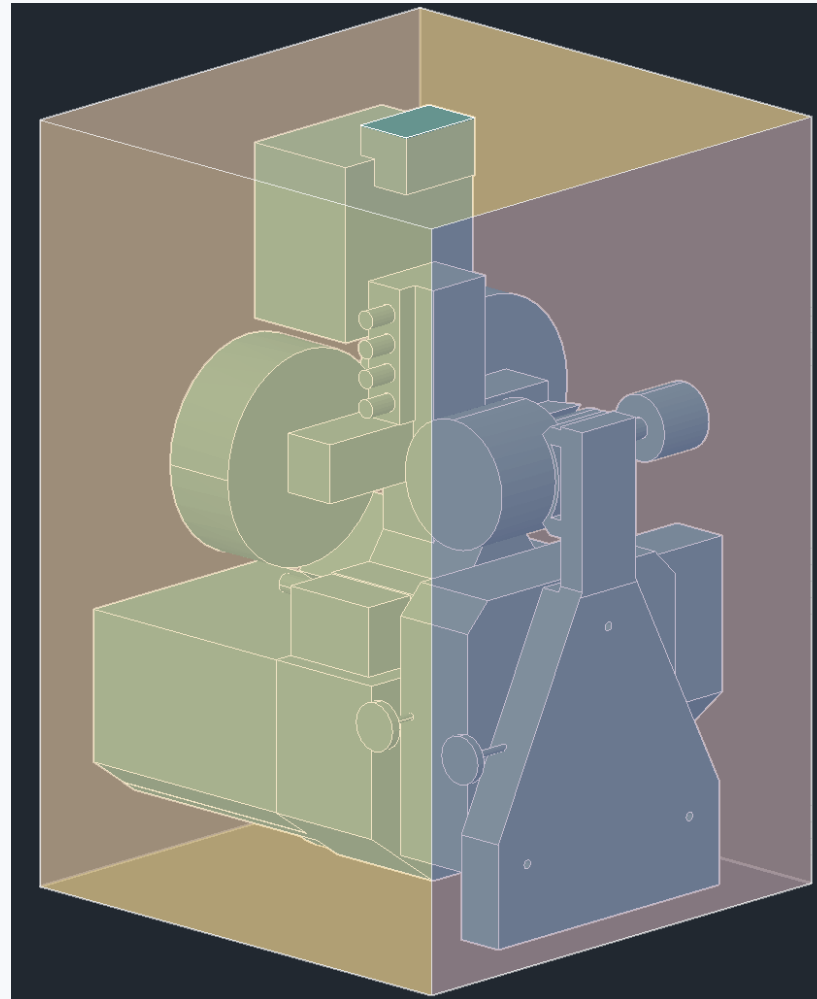
Washing machine in a room



Free field calculated noise map  
(only ground reflection included)



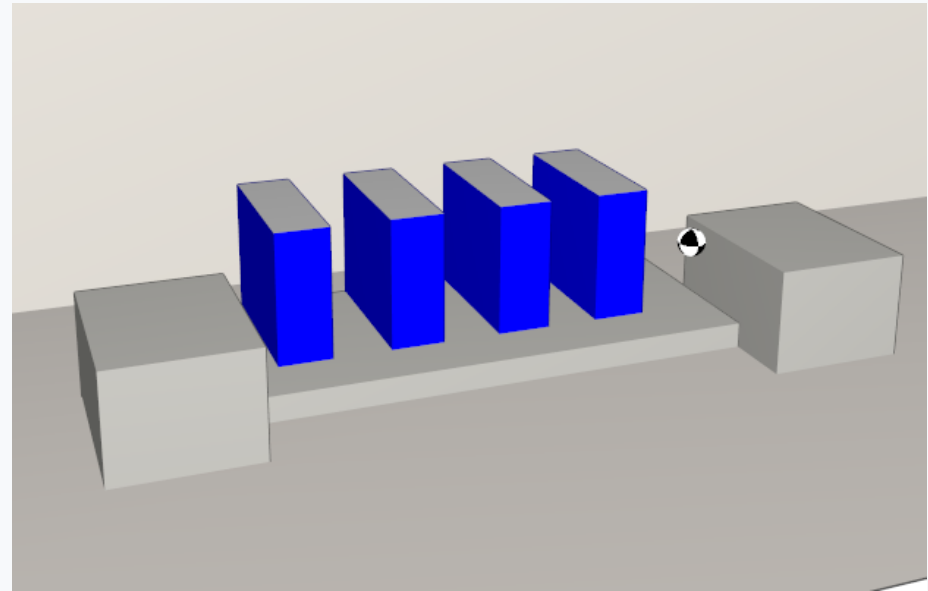
Noise map with all relevant reflections



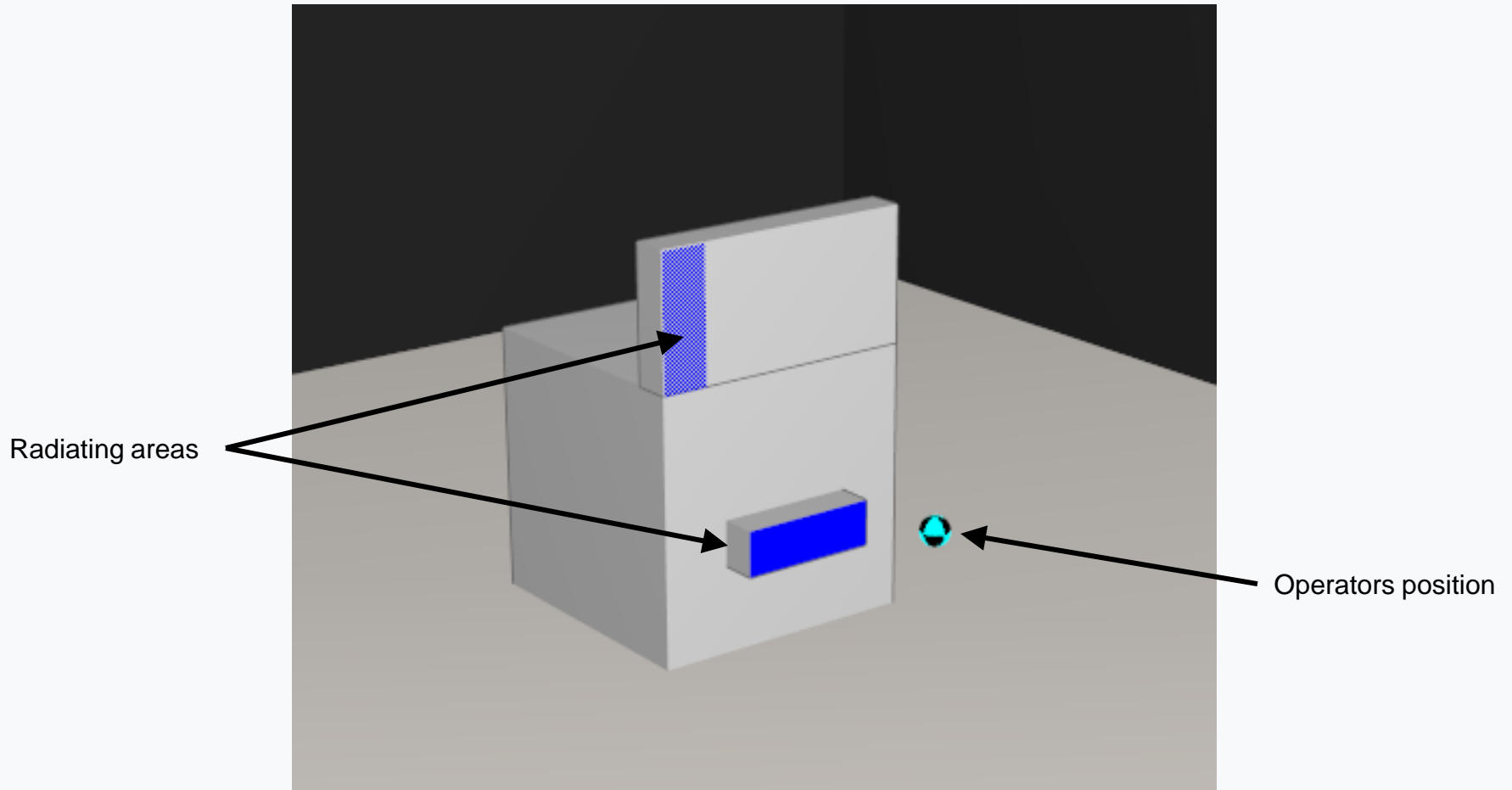
Modeling of a complex machine as a box (equal to reference surface acc. to ISO 3744)



Gravure printing machine

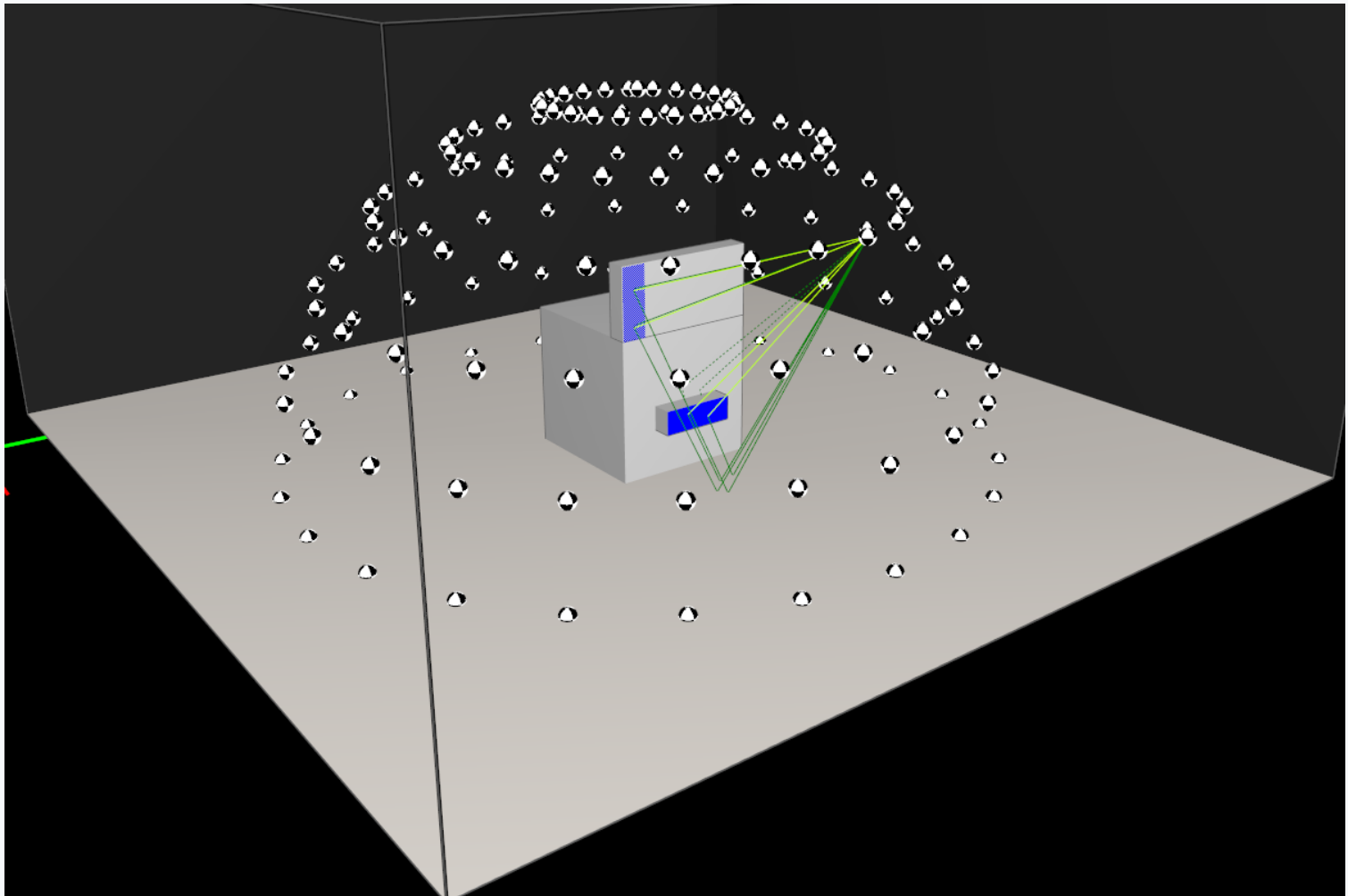


Simulation with 4 radiating stations

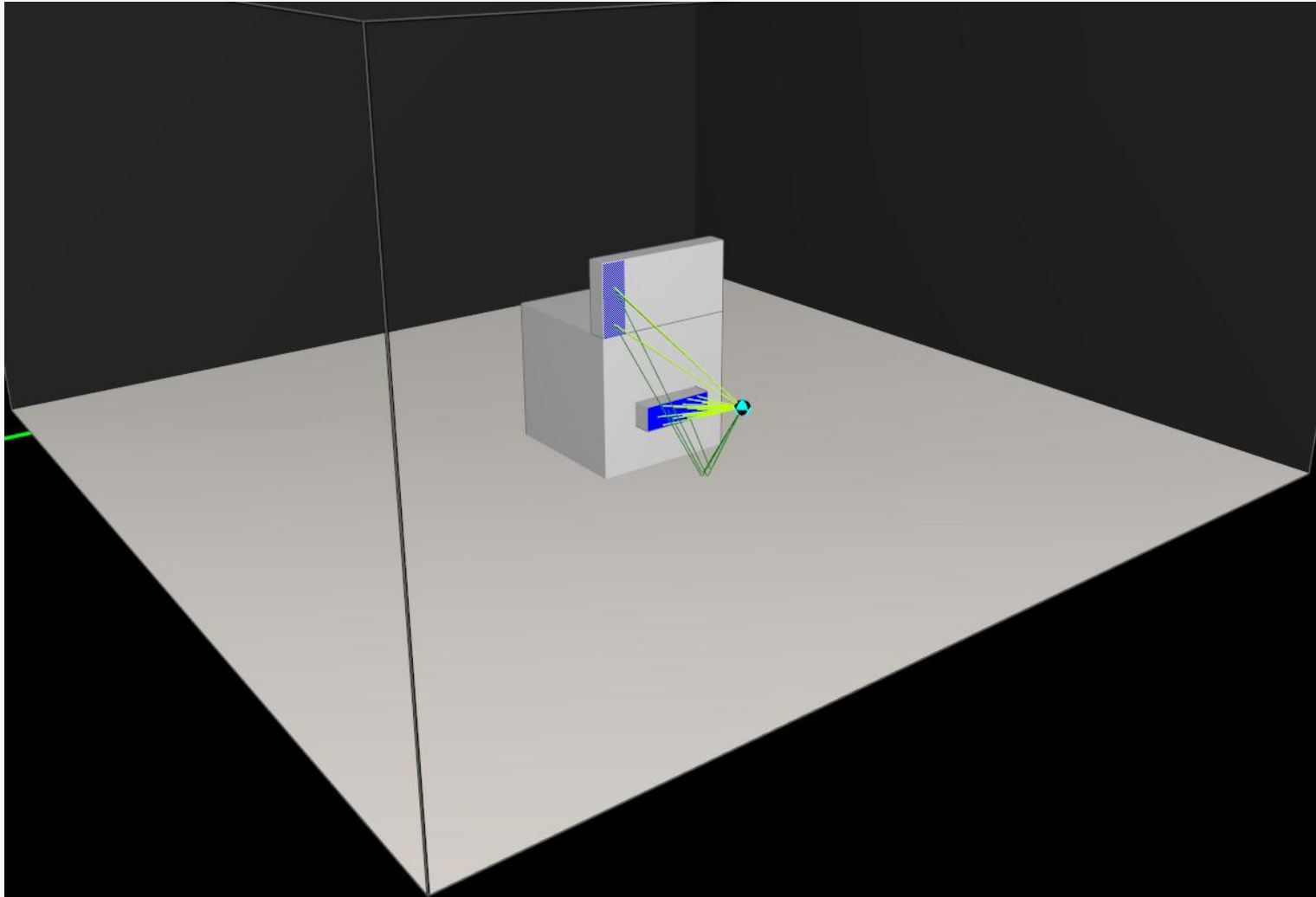


Emission values  $L_{WA}$  and  $L_{pA}$  → Declaration according to machine directive

Radiating areas and source distribution → Inspection



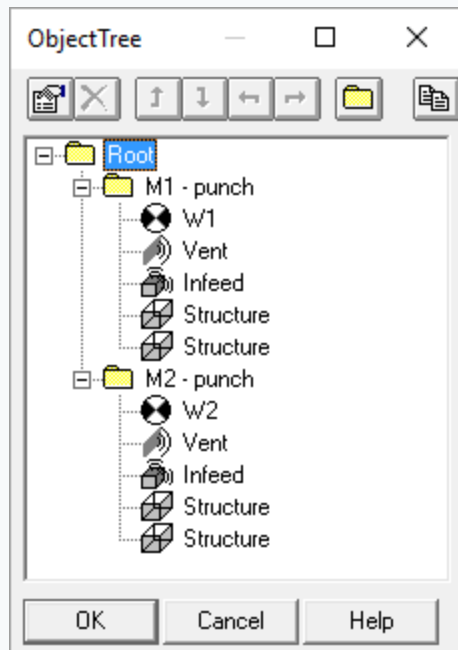
Determination of effective radiated sound power level by simulating the enveloping surface method with receivers on half sphere surface



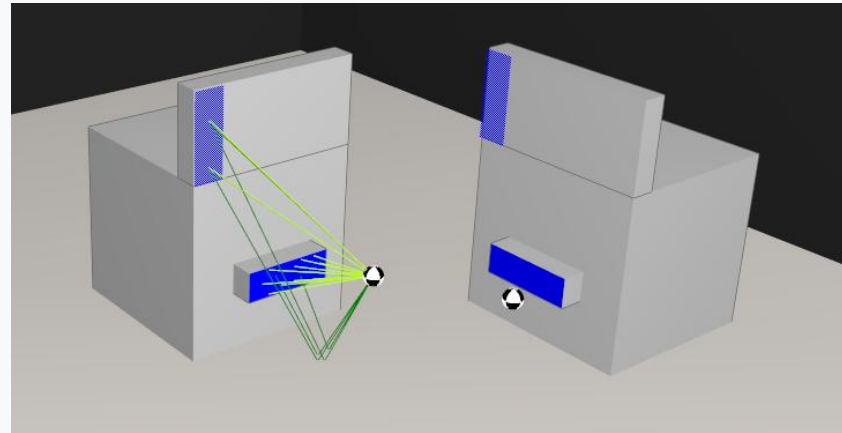
SERT-calculation of the level with semi-free-field conditions at the operators position  $\rightarrow L_{pA,sim}$

Emission sound pressure level known (e.g. declared by manufacturer)  $\rightarrow L_{pA}$

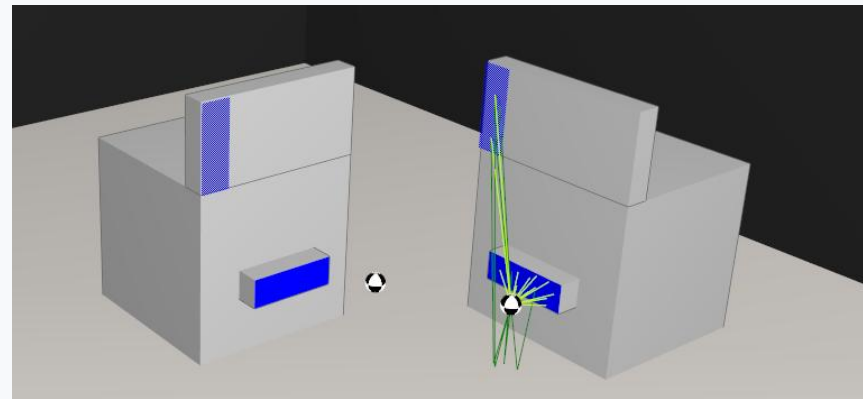




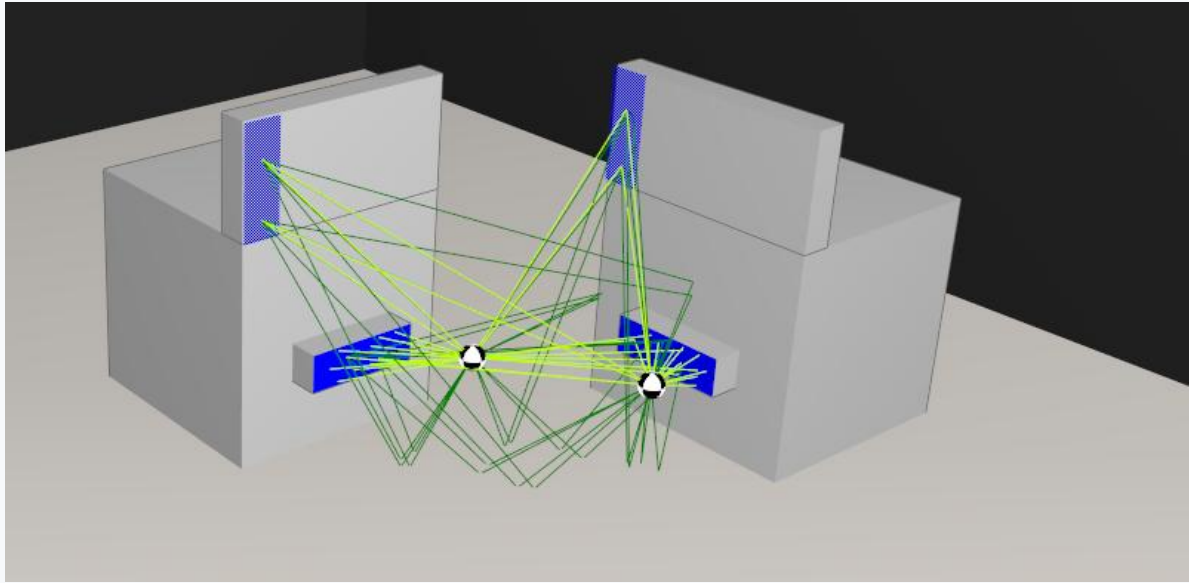
Data-organisation in object-tree



Calculation  $L_{pA,sim}$  for M1



Calculation  $L_{pA,sim}$  for M2

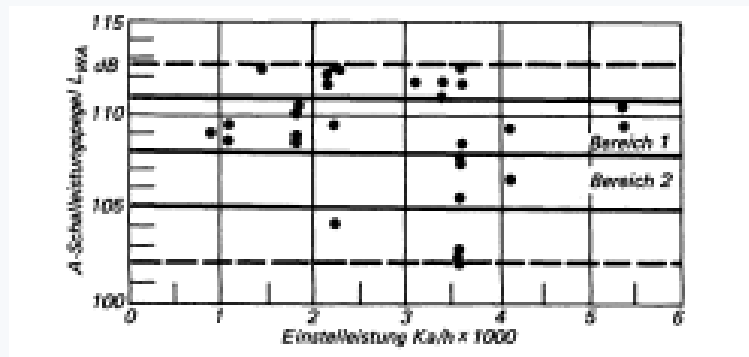
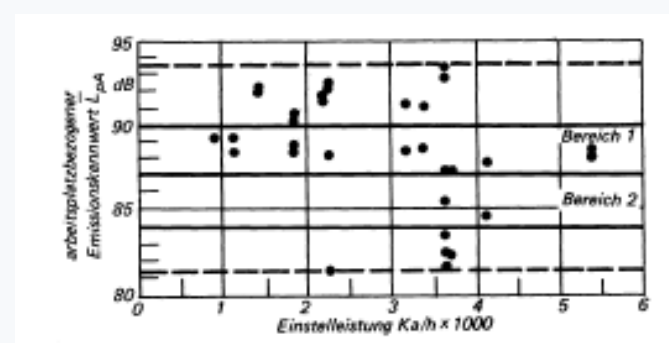


Calculation  $L_{Ap,sim}$  for M1 and M2 (reflections at room surfaces neglected to keep presentation simple)

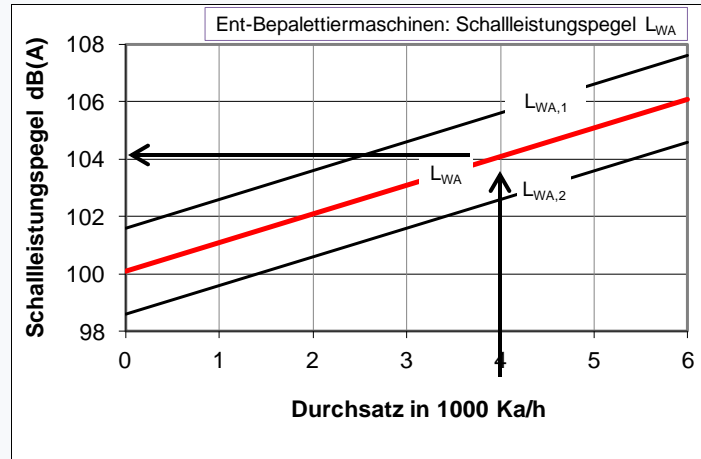
For each receiver at a workplace with declared  $L_{pA}$ :

$$L_{AP} = 10 \cdot \log(10^{0,1 \cdot L_{AP,sim}} - 10^{0,1 \cdot L_{pA,sim}} + 10^{0,1 \cdot L_{pA}}) \text{ dB}$$

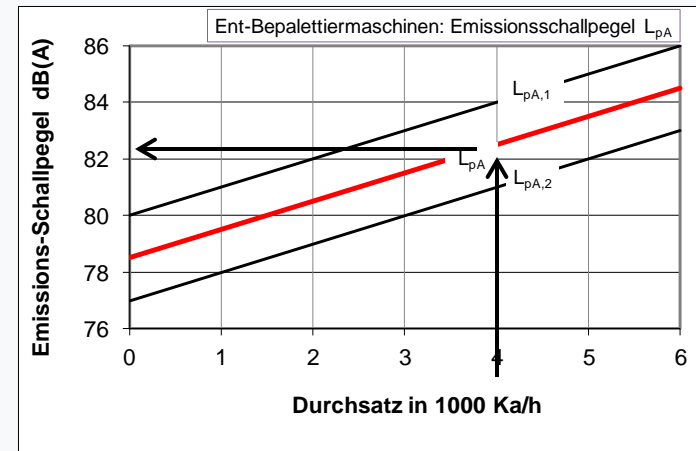
<b>VEREIN DEUTSCHER INGENIEURE</b>	<b>Emissionskennwerte technischer Schallquellen Maschinen in Flaschen-Abfüllanlagen</b>	<b>VDI 3741</b>
Characteristic noise emission values of technical sound sources Bottle filling plants		<i>Diese Richtlinie wurde mit Ankündigung im Bundesan- zeiger 31 (1979) Nr. 119 vom 30.6.1979, S. 5, einem öffentlichen Einspruchsverfahren unterworfen.</i>

 Sound power level  $L_{WA}$ 

 Emission sound pressure level  $L_{pA}$ 


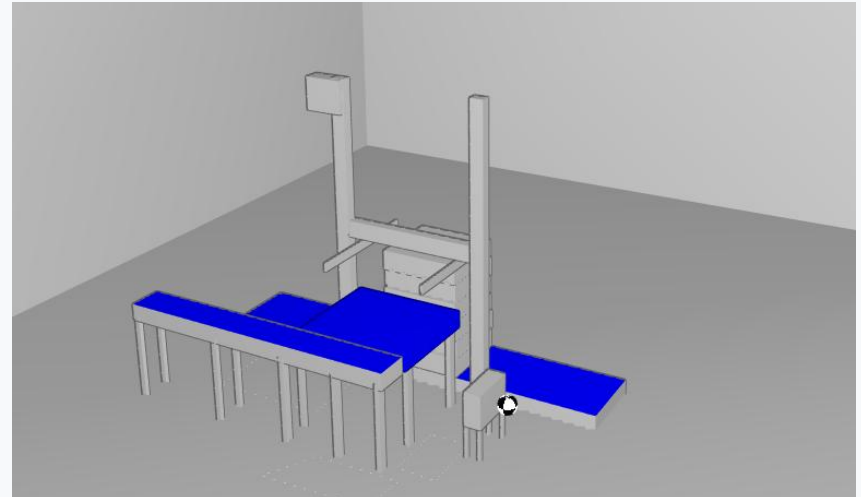
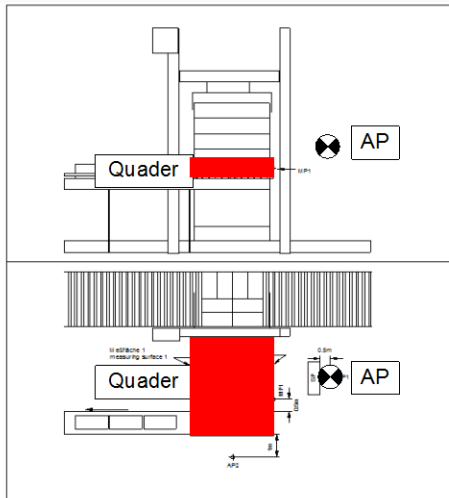
## Sound power level $L_{WA}$

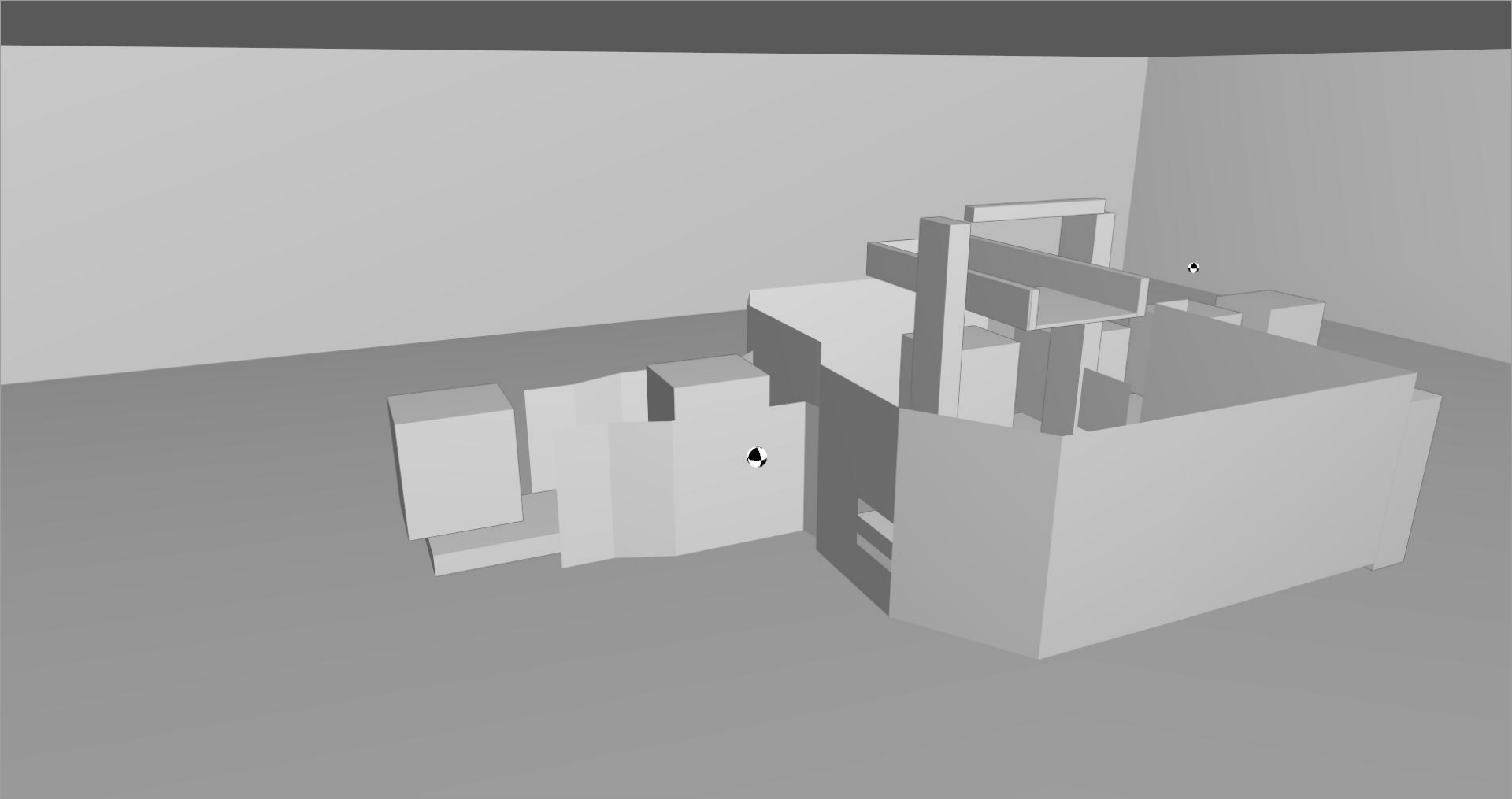


## Emission sound pressure level $L_{pA}$



## Advices for modelling and source distribution (default)





Acoustic model of the palletizer machine

CadnaR 3D-View (F12 for help) (99997 particles, t = 0.0278 s [- 9.53 m], order 0 - 359, speed factor = 0.0000, Mem = 76 MB) (30.3 fps)

Close! Representation Camera Video Help!



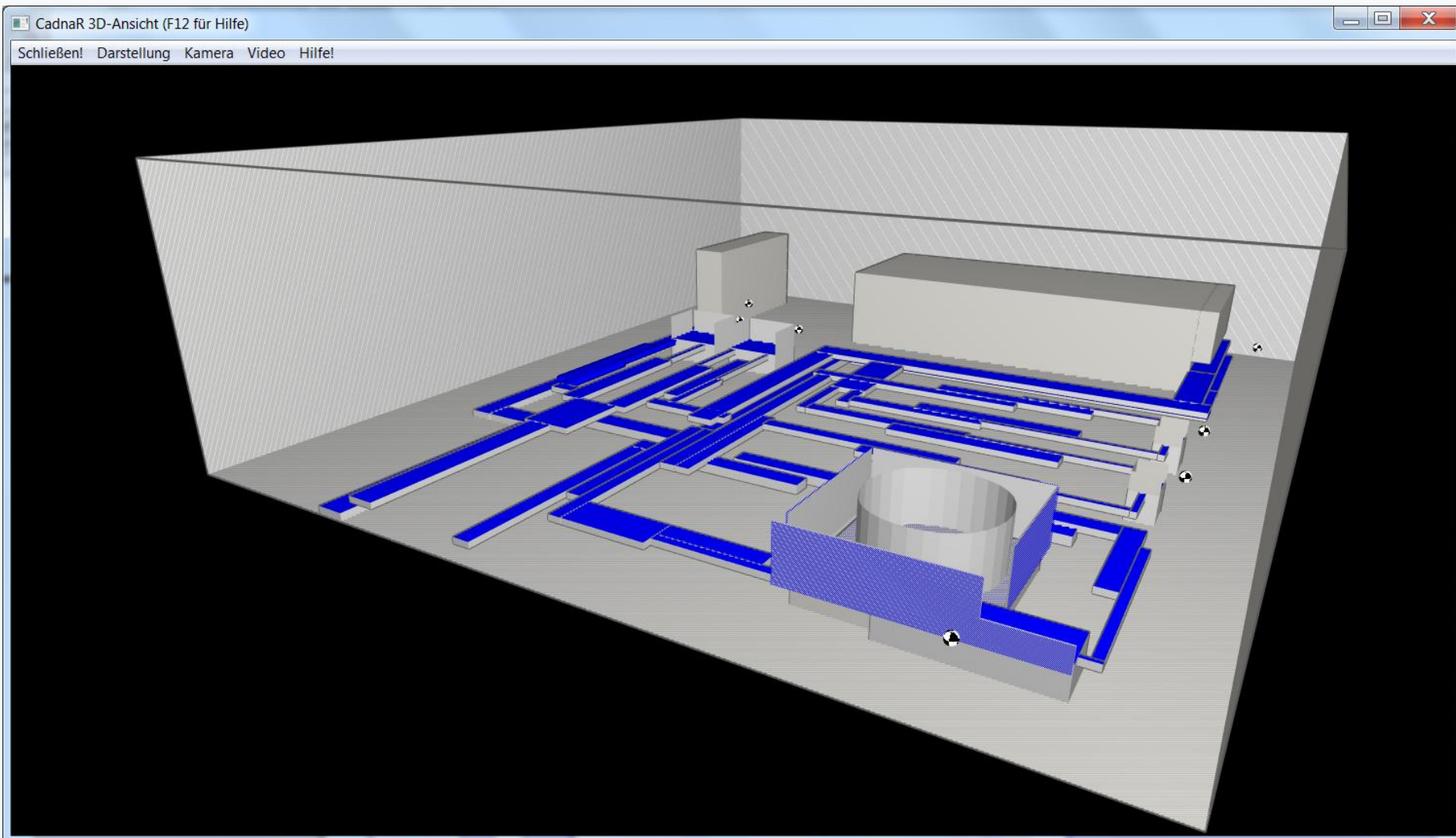
Visualization of sound particles radiated by the palletizer ( $L_{WA}$  104 dB,  $L_{pA}$  82 dB)

CadnaR 3D-View (F12 for help) (99997 particles, t = 0.0432 s [~ 14.85 m], order 0 - 1442, speed factor = -0.0001, Mem = 76 MB) (10.4 fps)

Close! Representation Camera Video Help!



Result from SERT-calculation in room with 6 m height → Level at operators position is 87.3 dB(A)

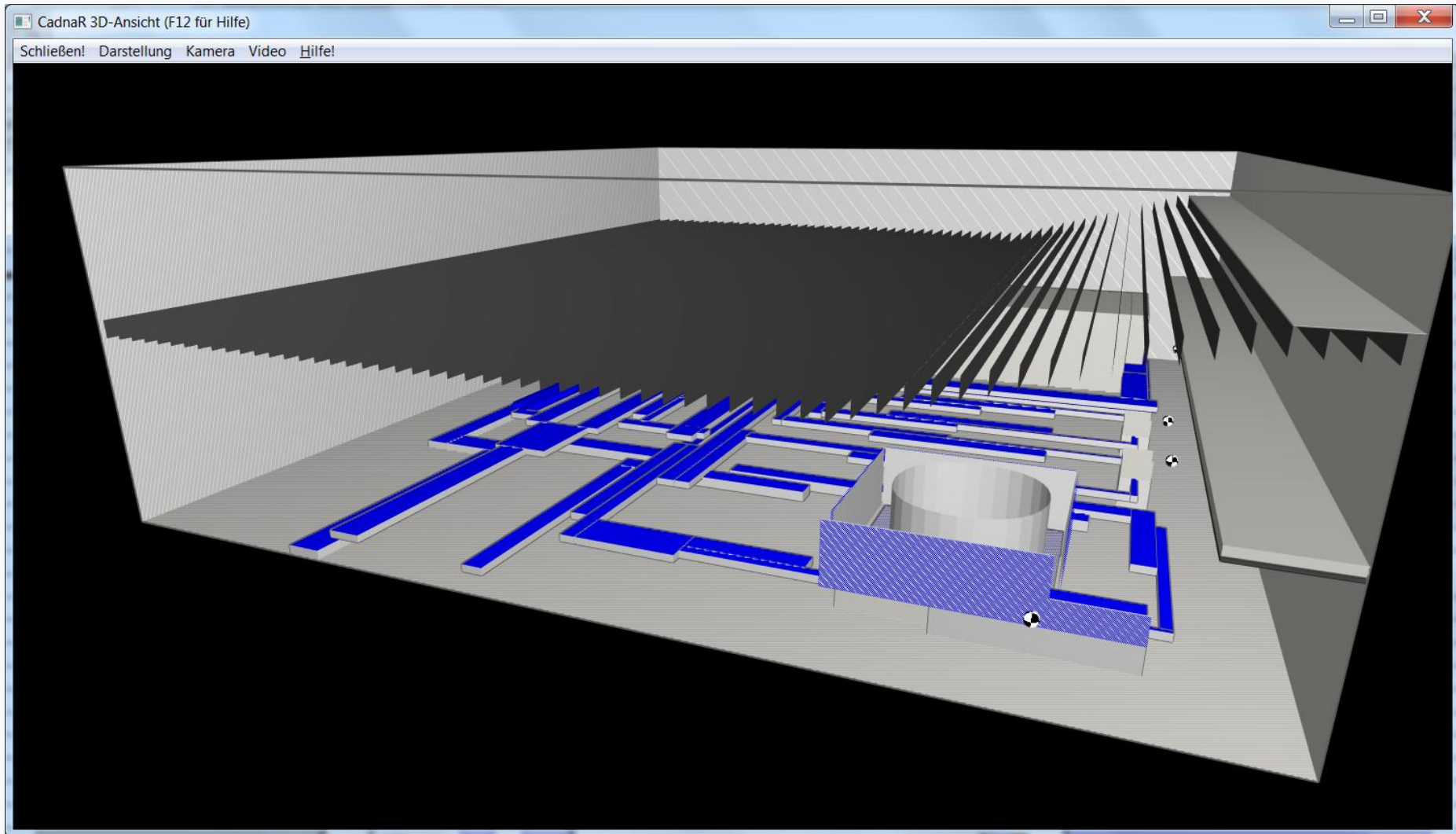


Simulation of a complete plant with machinery and transport-systems





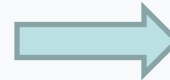
Absorbing baffle system at the ceiling



Absorbing baffle system at the ceiling integrated in the model

What is needed:

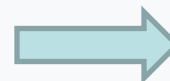
Production-line X13		
Machine	$L_{WA}$	$L_{pA}$
Cooler CX14	96	-
Cleaning O+H	104	86
Inspection KR10C	101	84
Filler HuK236	104	83
Labeller KS 45C	99	82
Conveyor 128	108	-
Conveyor 129	101	-
:	:	:
:	:	:



Emission values guaranteed by the manufacturer

The result determined by SERT - simulation:

Production-line X13			
Machine	$L_{Ap}$	+MPack1	+MPack2
Cleaning O+H	89	87	84
Inspection KR10C	88	86	85
Filler HuK236	86	85	84
Labeller KS 45C	86	85	83
:	:	:	:
:	:	:	:



If the predicted  $L_{Ap}$  values are exceeded, measurement of  $L_{pA}$  in accordance with ISO 11204

Prediction in the planning phase – from declared emission values to the expected levels at the workplaces

Thank you for your attention