



Sorama

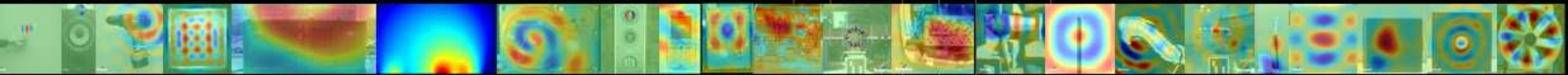
visualising sound and vibrations



Sorama

visualising sound and vibrations

Sound Camera



A Holographic Perspective

Dr. Rick Scholte

TANGO Outreach - Munich 30 January 2014

Sound Imaging, why?



Case: ICE hydraulic generator

ICE Power Pack RF550

diesel engine & hydraulic pumps



Problem:

Generator does not comply to new EU noise emission standards

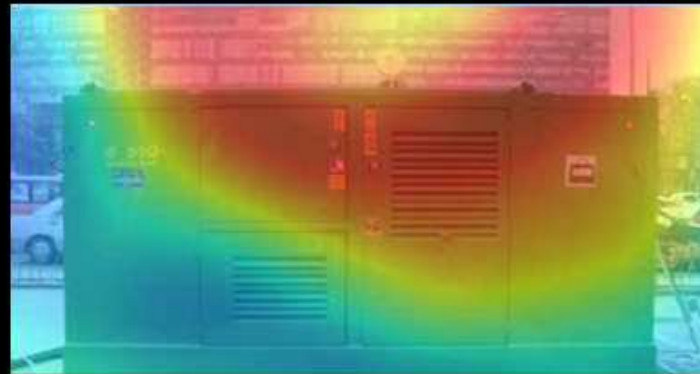
Goal:

- Lower total noise level
 - ✓ Localize major sources
 - ✓ Visualize source behavior
 - Take reduction measures ?

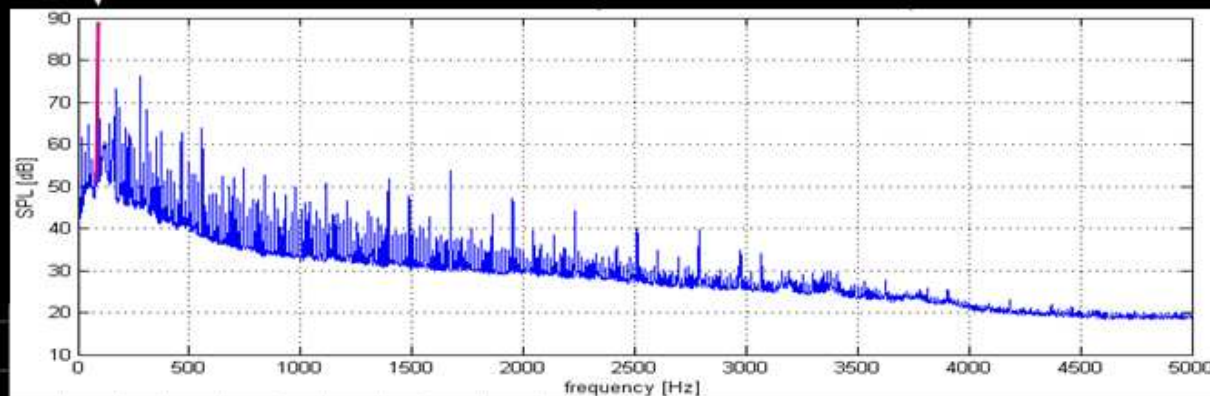
Case: ICE hydraulic generator

ICE Power Pack RF550

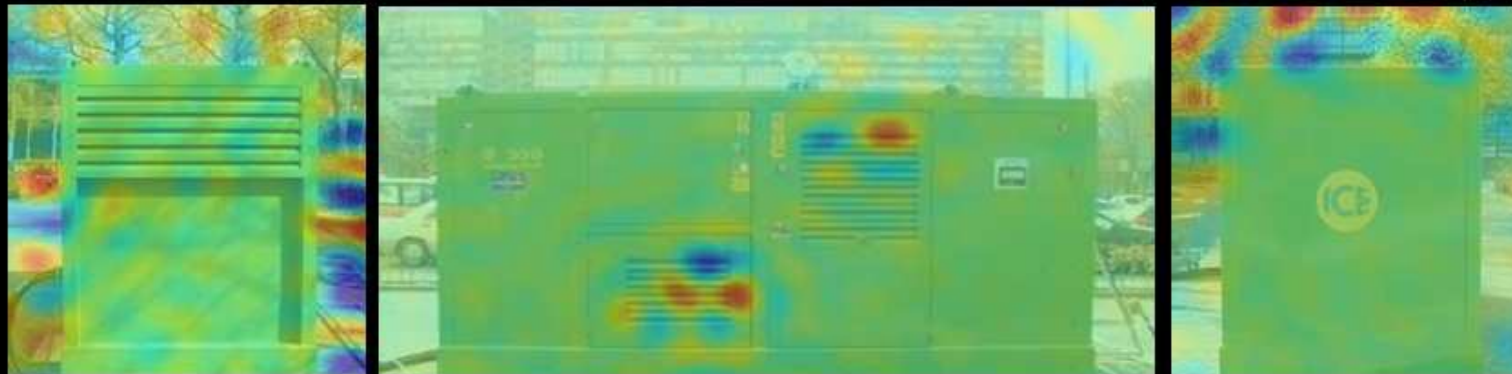
source identification: engine exhaust on roof



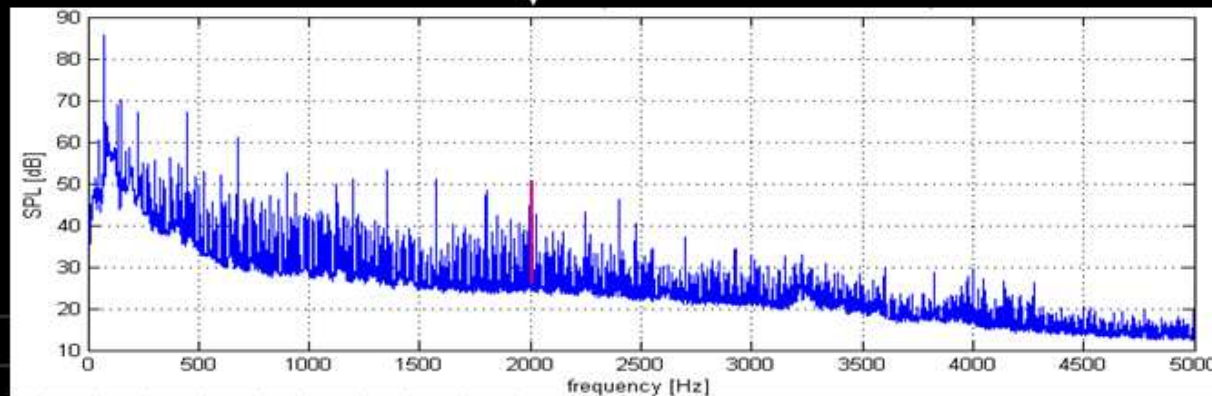
$f=93\text{Hz}$ ($3 \times 1860/60$)



Case: ICE hydraulic generator
ICE Power Pack RF550
source identification: ventilation brackets



$f=2000\text{Hz}$



Sound Imaging Source Analysis



Problem:

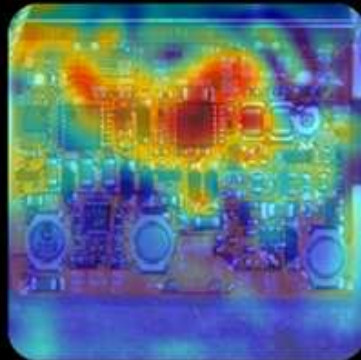
Generator does not comply to new EU noise emission standards

Goal:

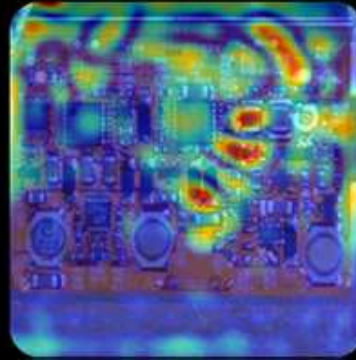
- Lower total noise level
 - ✓ Localize major sources
 - ✓ Visualize source behavior
 - Take reduction measures
 - Exhaust damper
 - Fixate ventilation rosters
 - Less absorption material required
→ more effectively placed

Case: Mini-SMD Printed Circuit Board

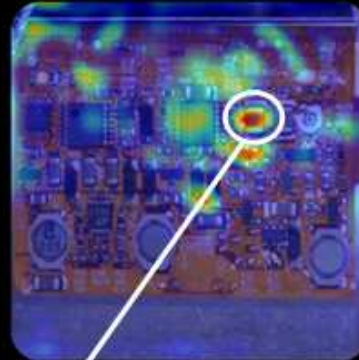
sound pressure



particle velocity

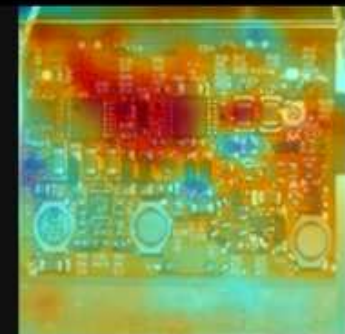


intensity

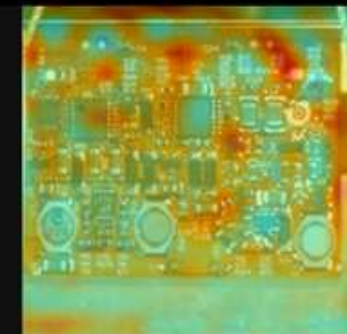


Source: Piëzo Electric Capacitor

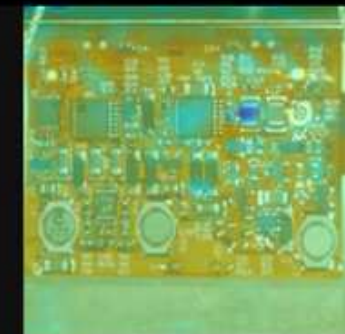
sound pressure



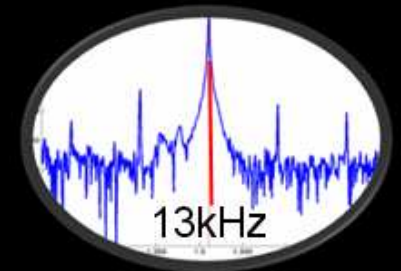
particle velocity



intensity

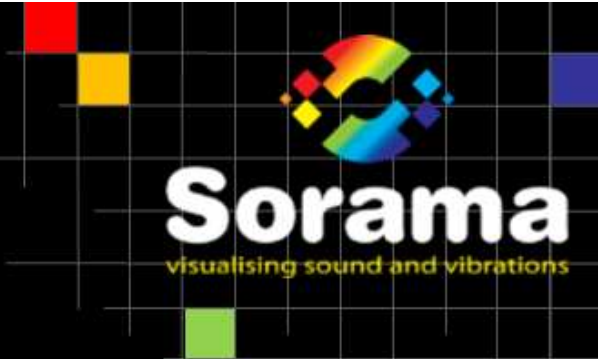


Resolution < 2mm
Aperture 4 x 4 cm
32 x 32 positions

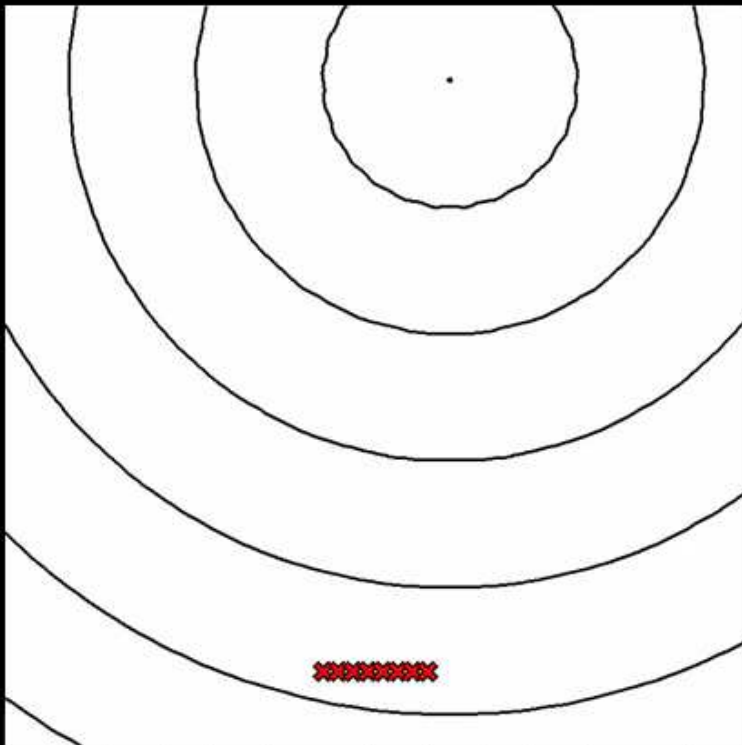


(Source: Philips Applied Technologies)

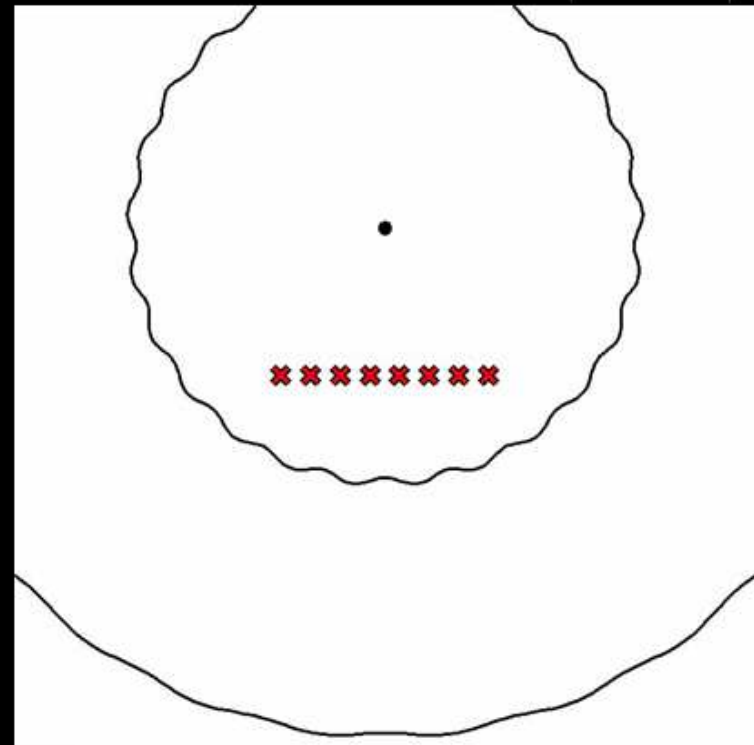
Acoustic Waves



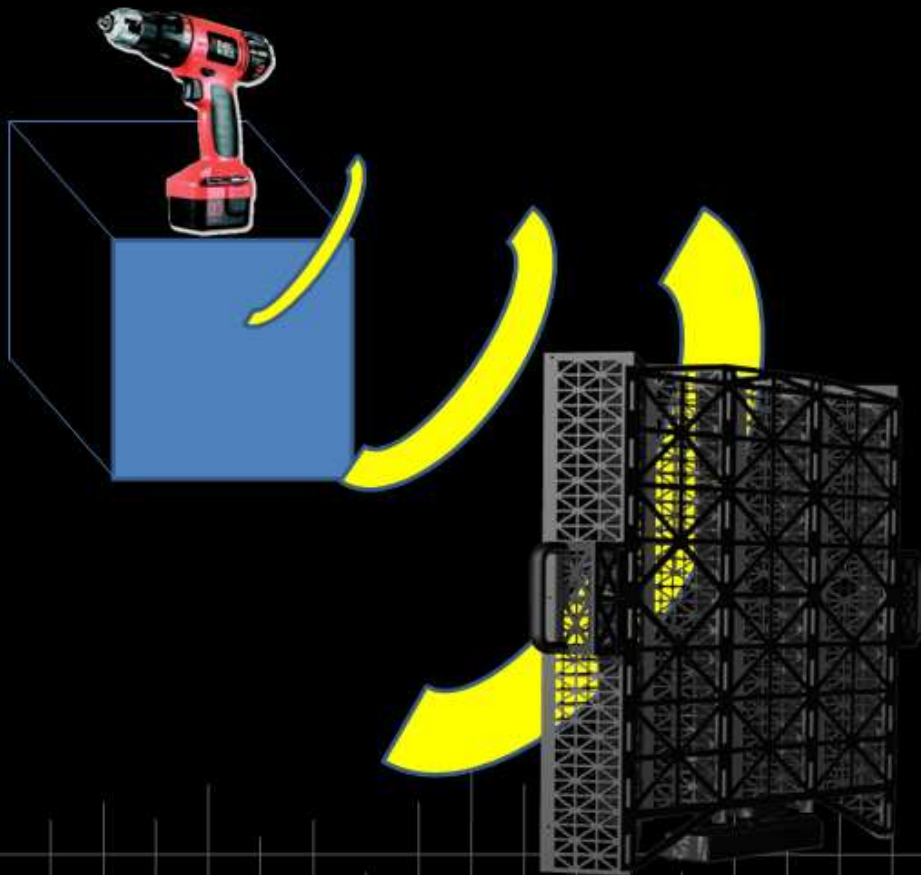
Far-field



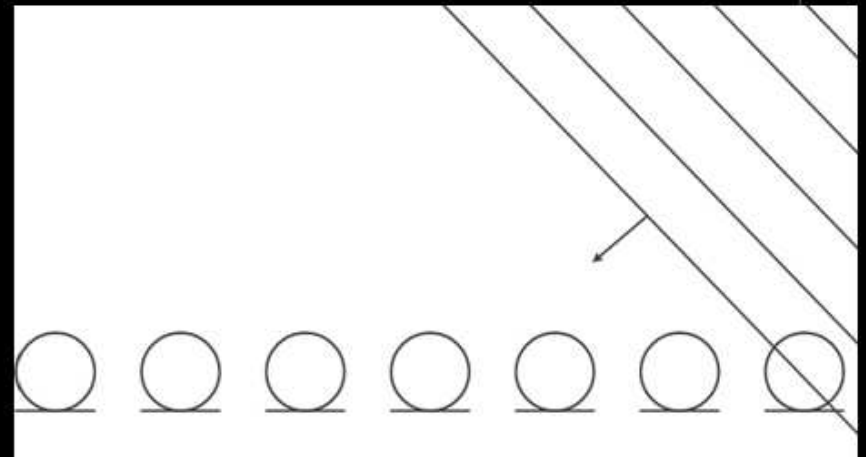
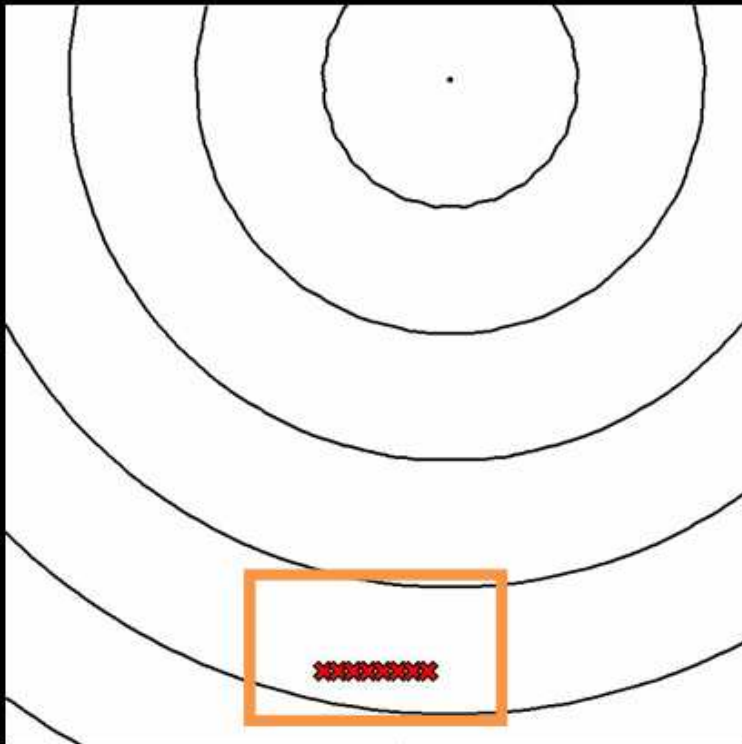
Near-field



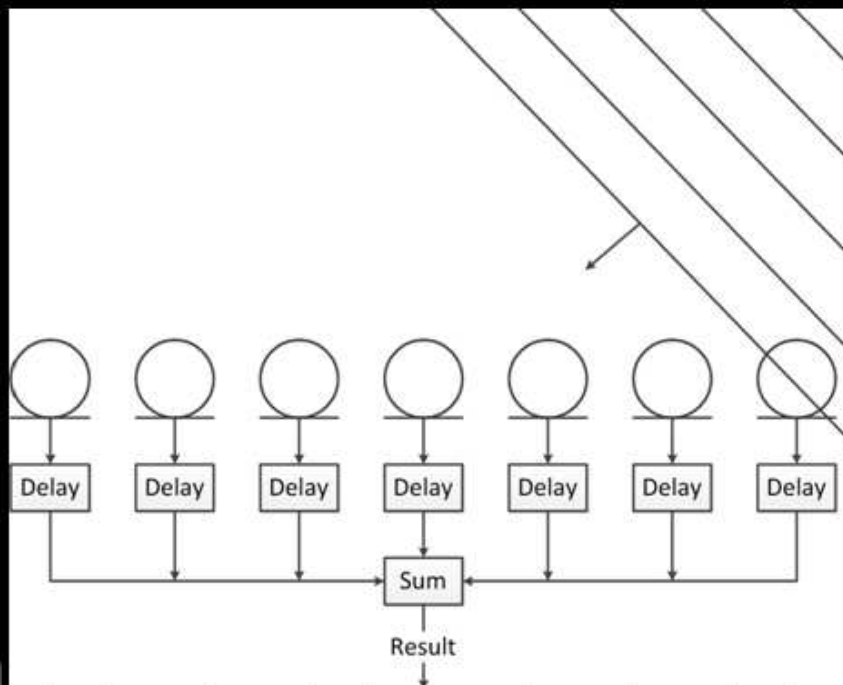
Localization (Far-field)



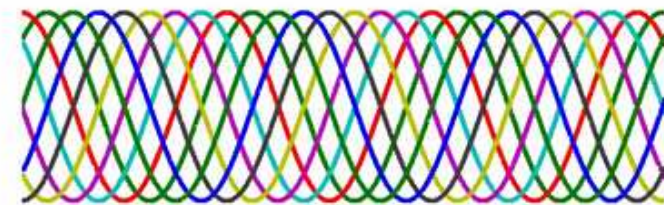
Beam-forming



Delay-and-Sum Beam-forming



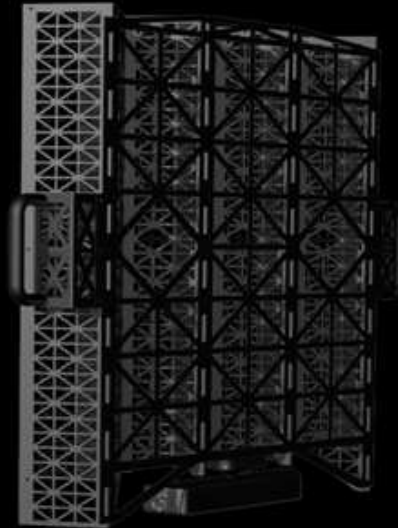
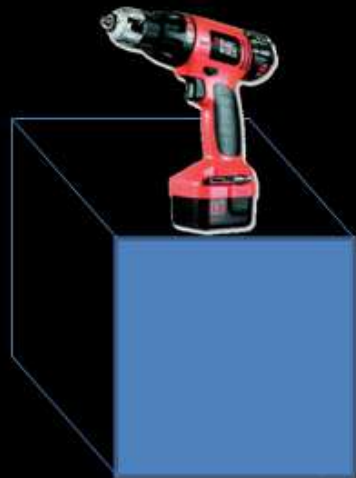
Delayed Signals



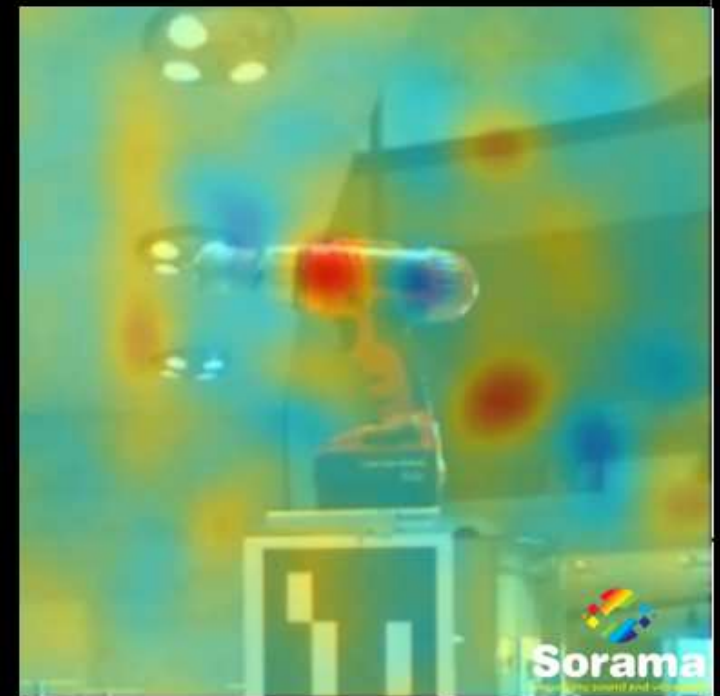
Sum



Observation (Near-field)

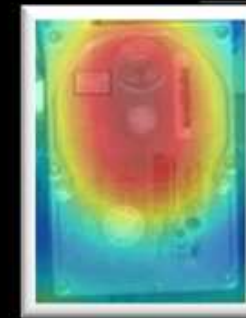


Near-field

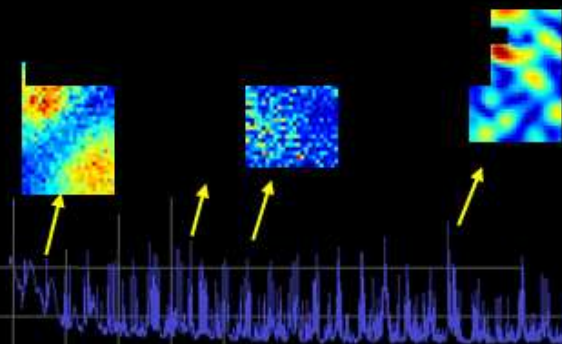
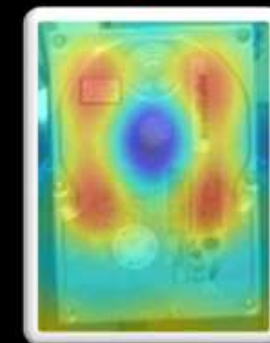


Hologram to Source

hologram

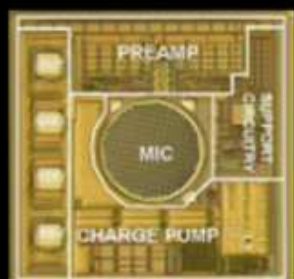


source

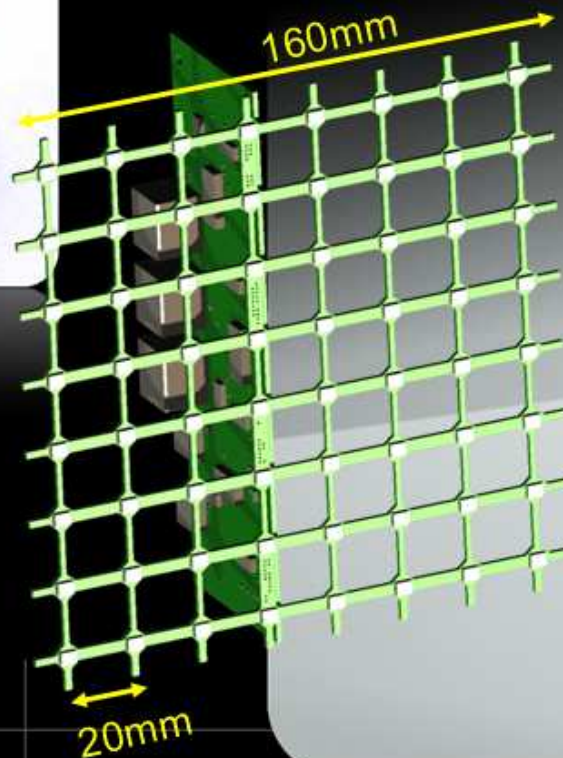
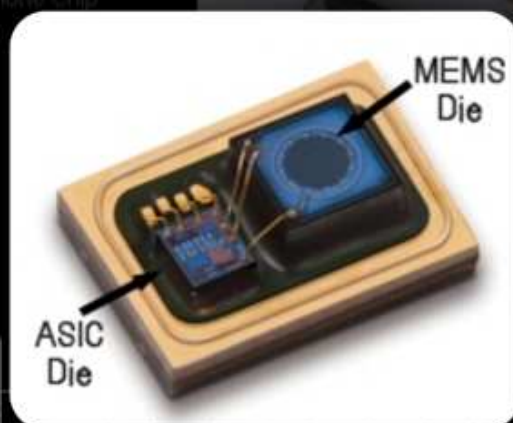
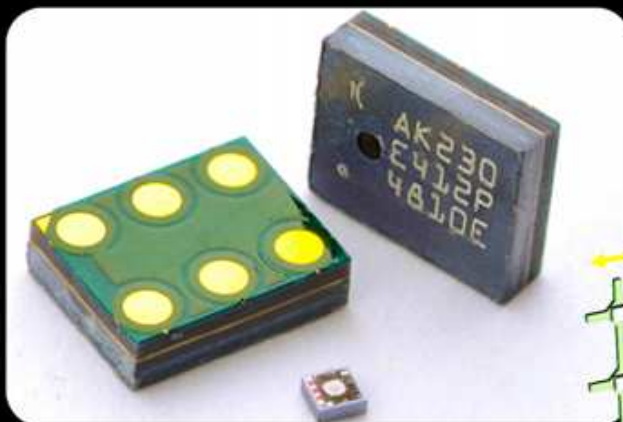


Digital MEMS microphone array

64-1024 multiplexed channels



Monolithic CMOS MEMS
Microphone Chip



Near-Field Acoustic Holography (NAH)

Spatial sampling



Important factors:

- aliasing
- leakage
- sensor dimensions

Pre-Fourier data-handling



2D Fourier Transformation

$$x(t) \rightarrow A(k_x, k_y)$$

Inverse calculation



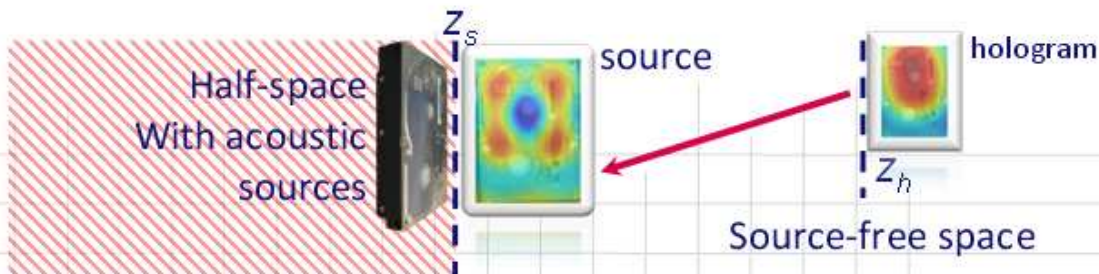
$$f(x, y, z) = a_0 + \sum_{n=1}^{\infty} (a_n \cos(k_n x) + b_n \sin(k_n x)) e^{-k_n z}$$

Regularisation in k-space

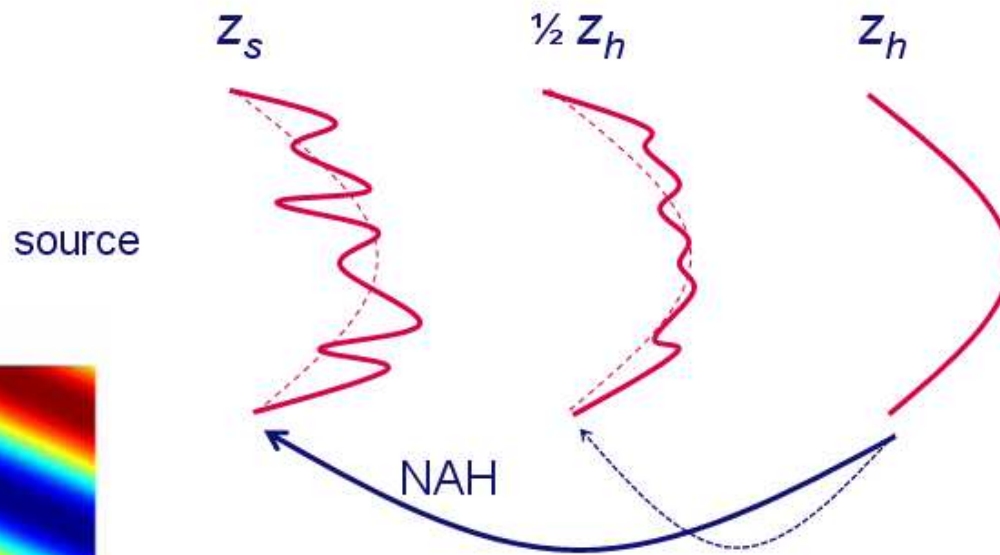


guilt automatic
noise suppression

Inverse Fourier Transformation



Near-Field Acoustic Holography (NAH)

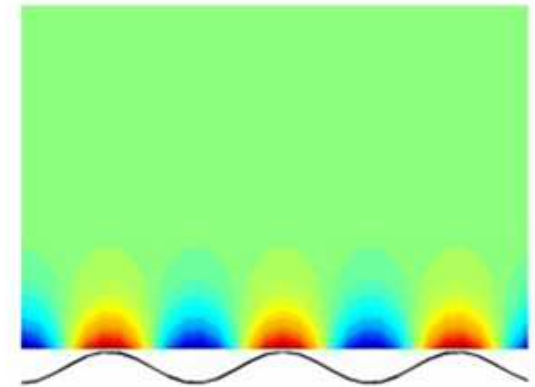
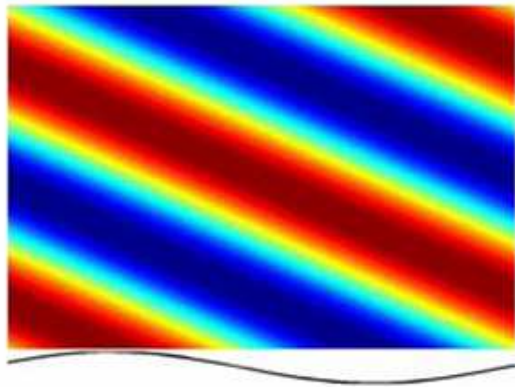


Near-field: propagating & evanescent waves

no decay
phase change



exponential
decay



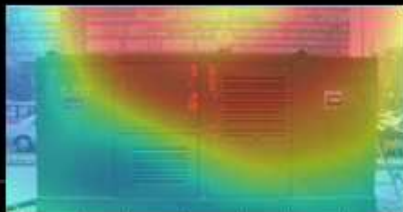
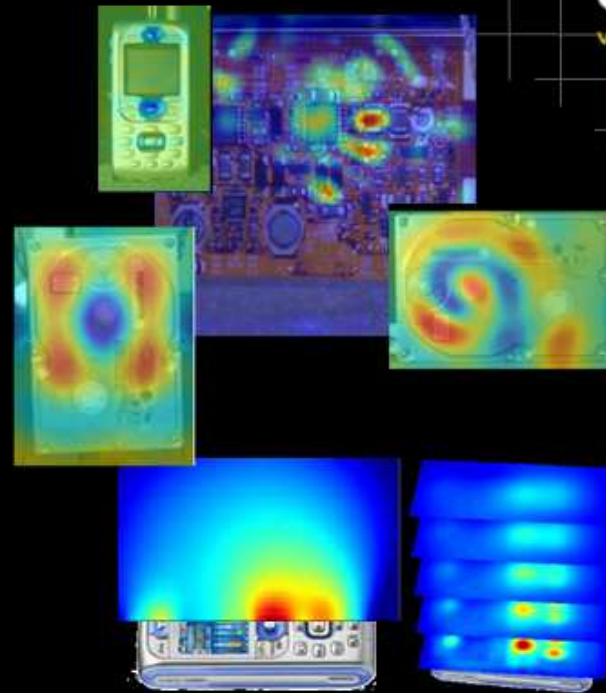
Sound Imaging Analysis

Sound source identification & location
Sound source behavior in time & space
3D sound propagation
Structural vibration analysis
One Hologram results in:

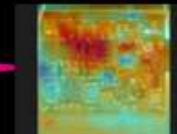
3D

Sound Pressure
Particle Velocity
Sound Intensity

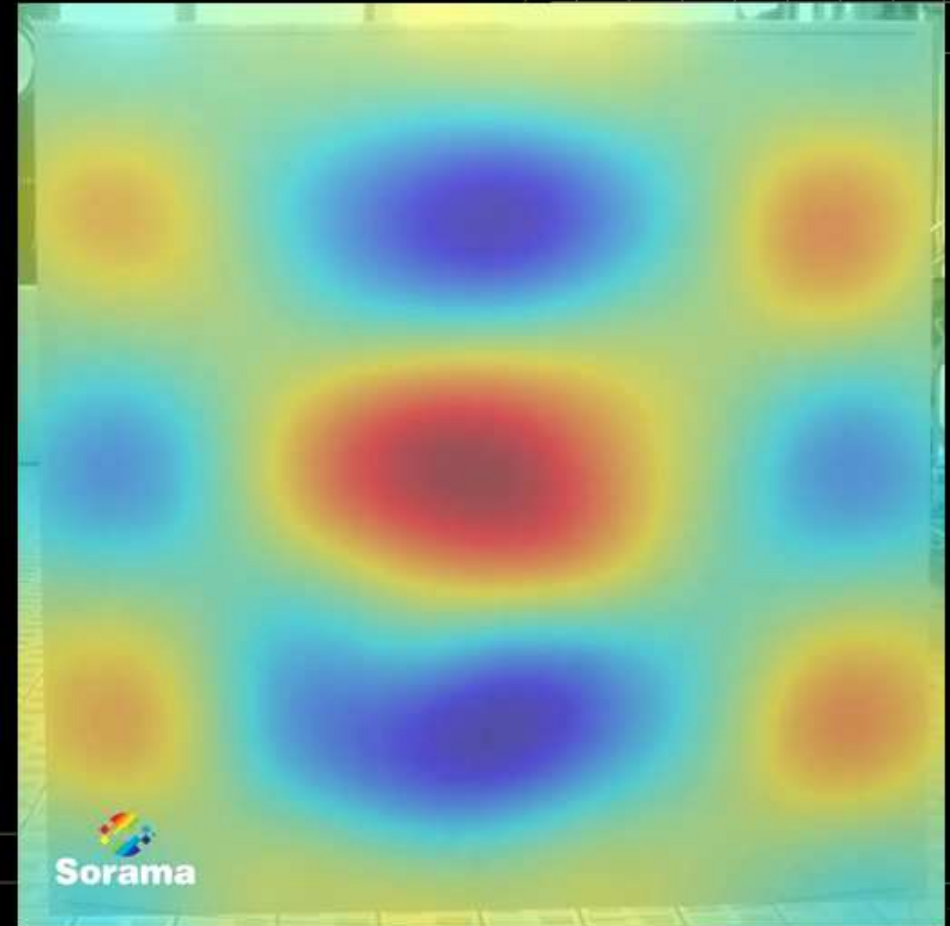
over a desired frequency band



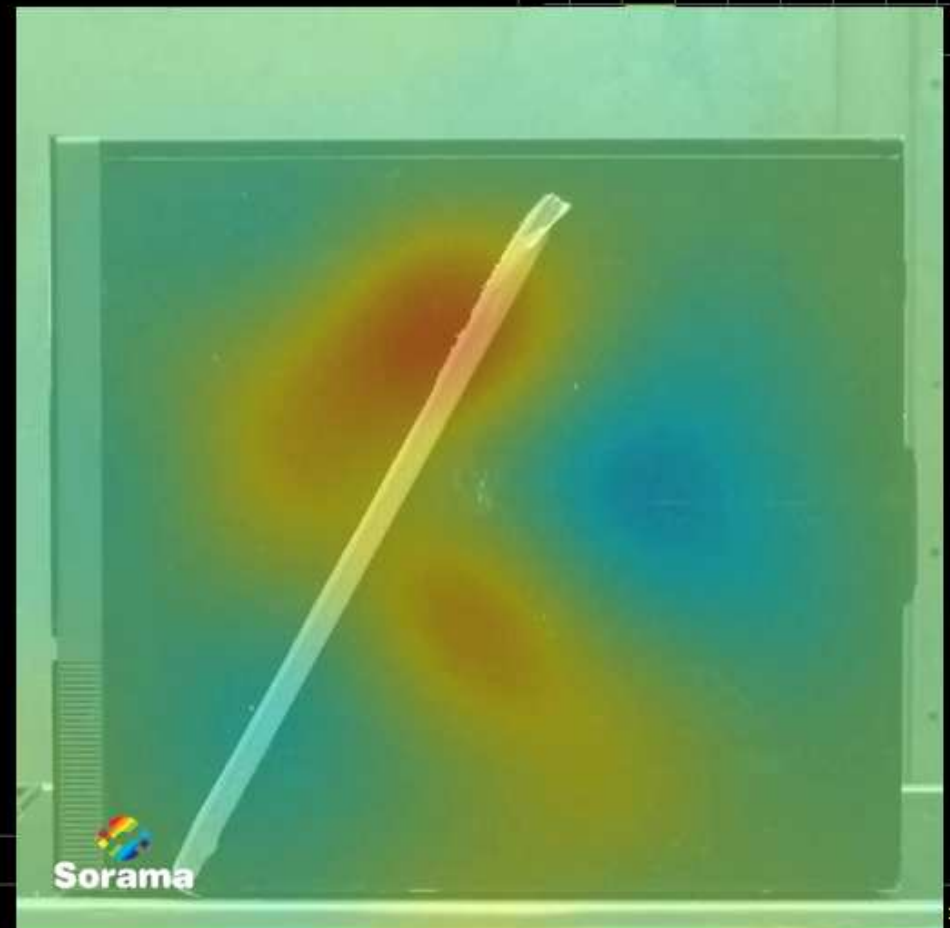
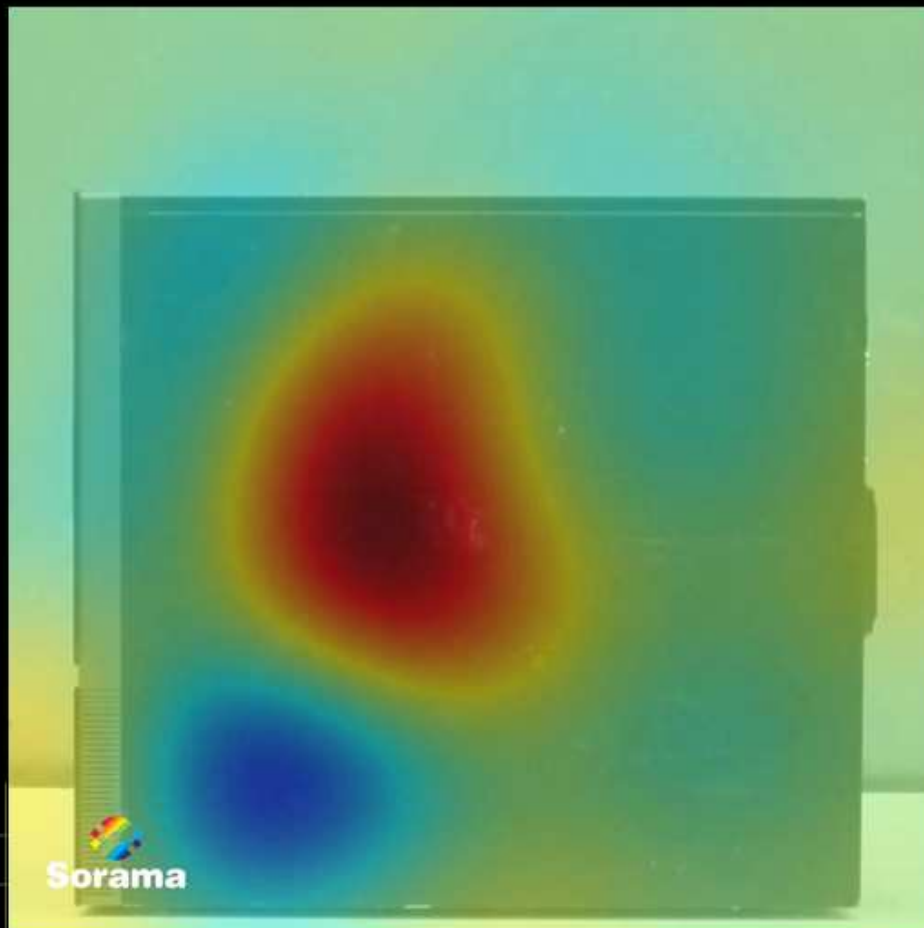
large product range



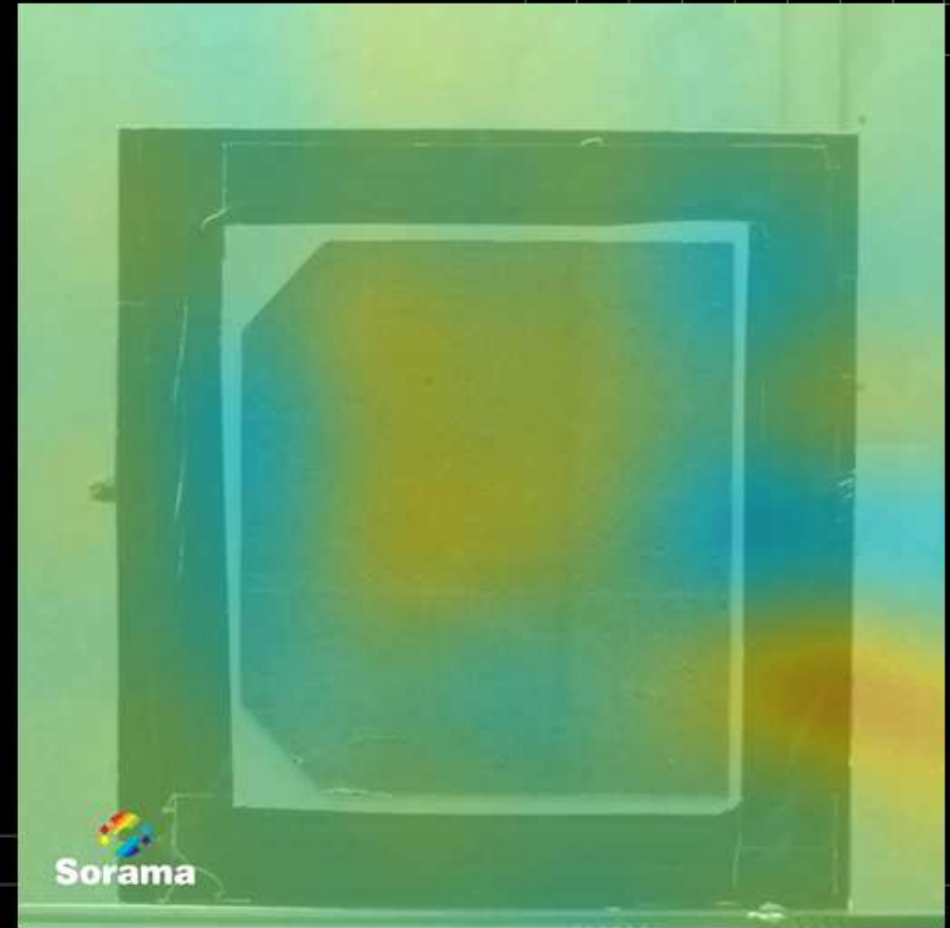
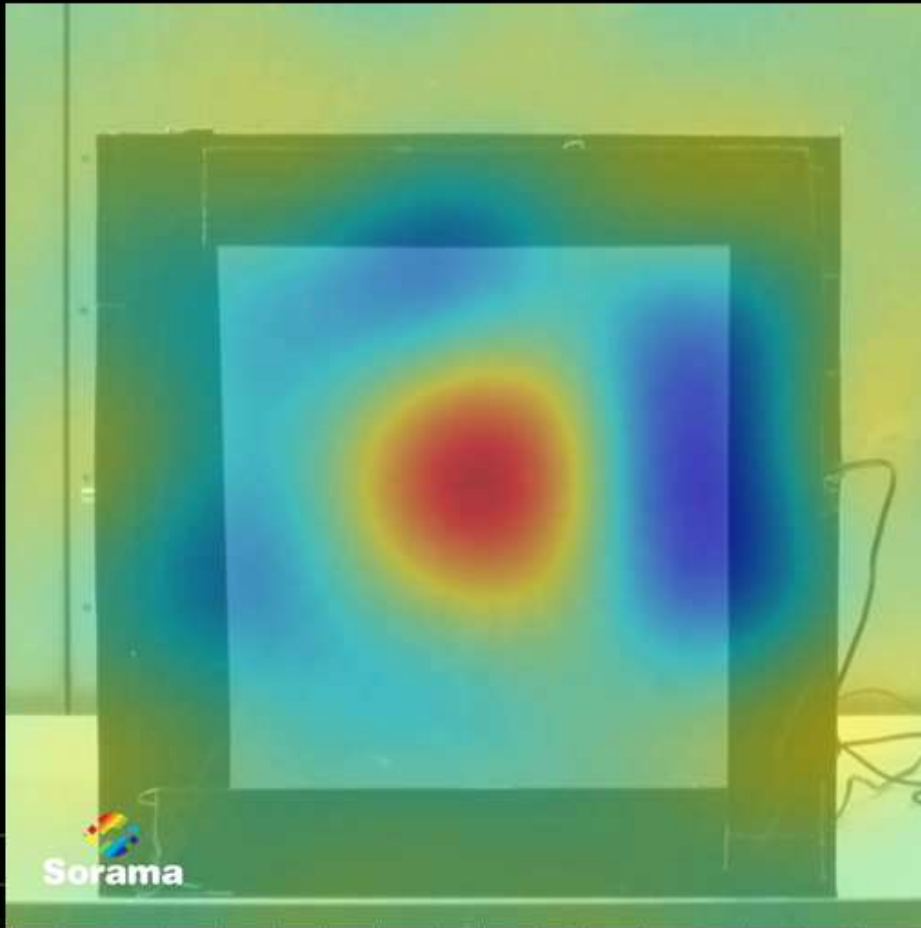
Tuning fork vibrations



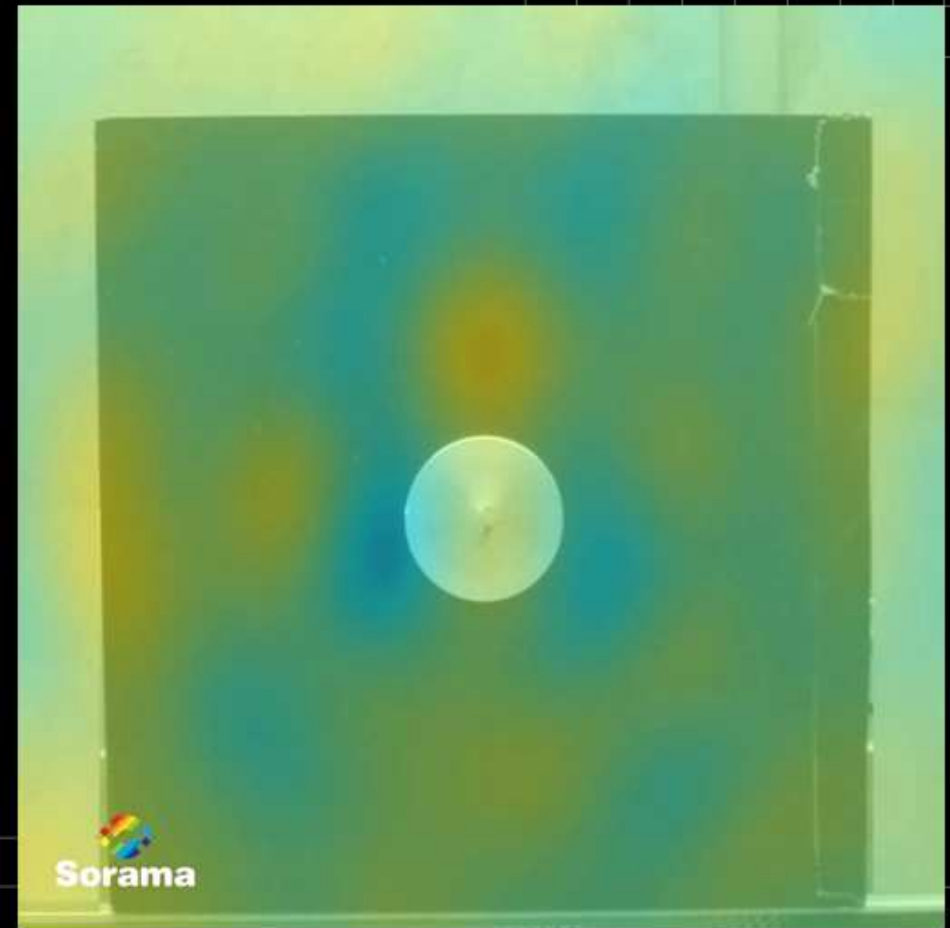
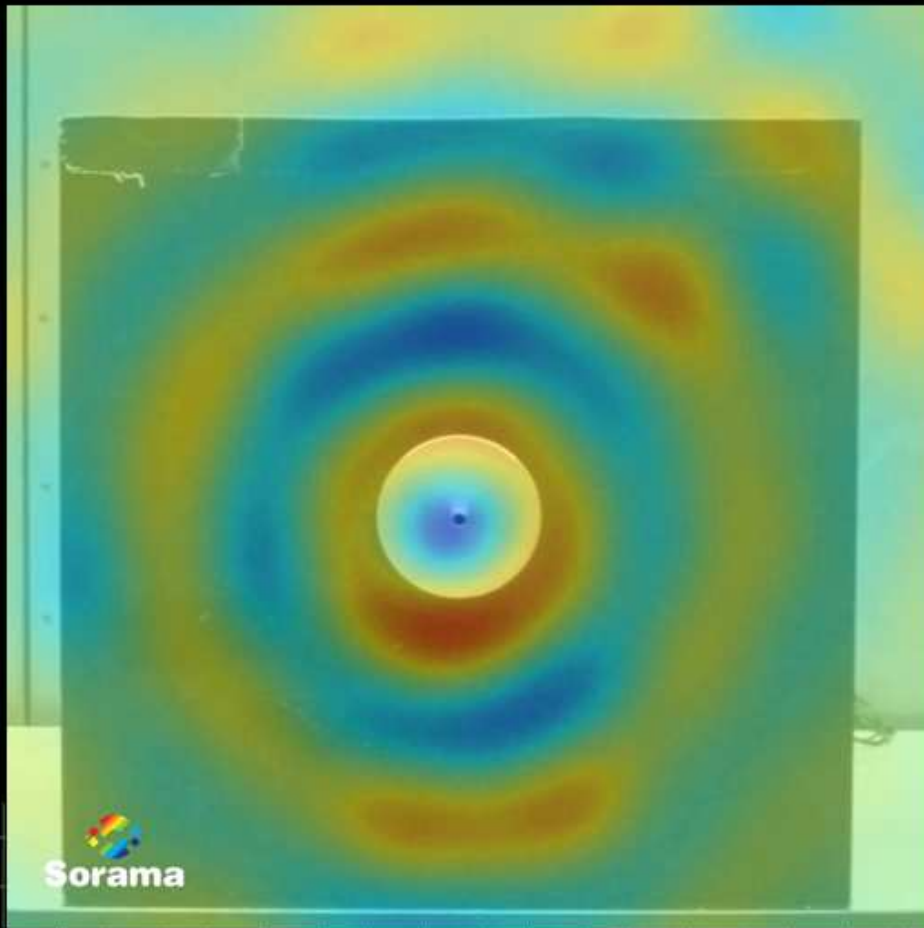
Stiffening



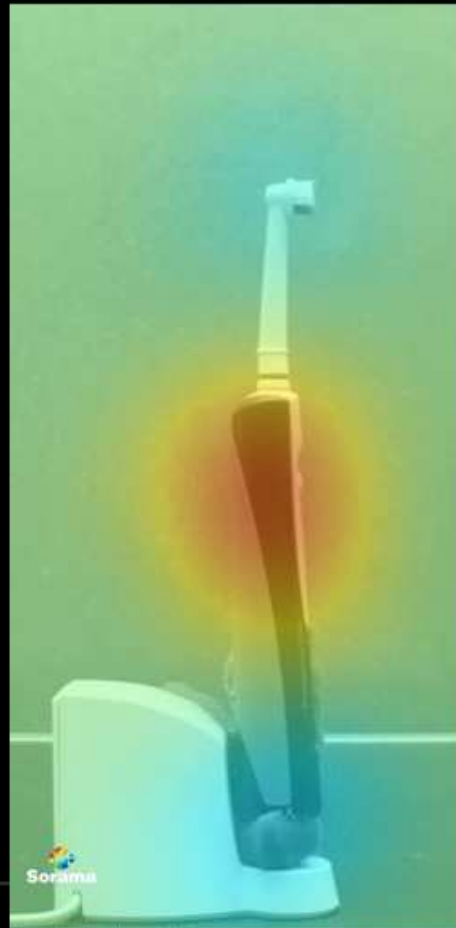
Damping



Absorption



Source path analysis



Integration: Sorama Portal



Multi platform

Webshop

Project management

Online expertise

work@home

Web-based

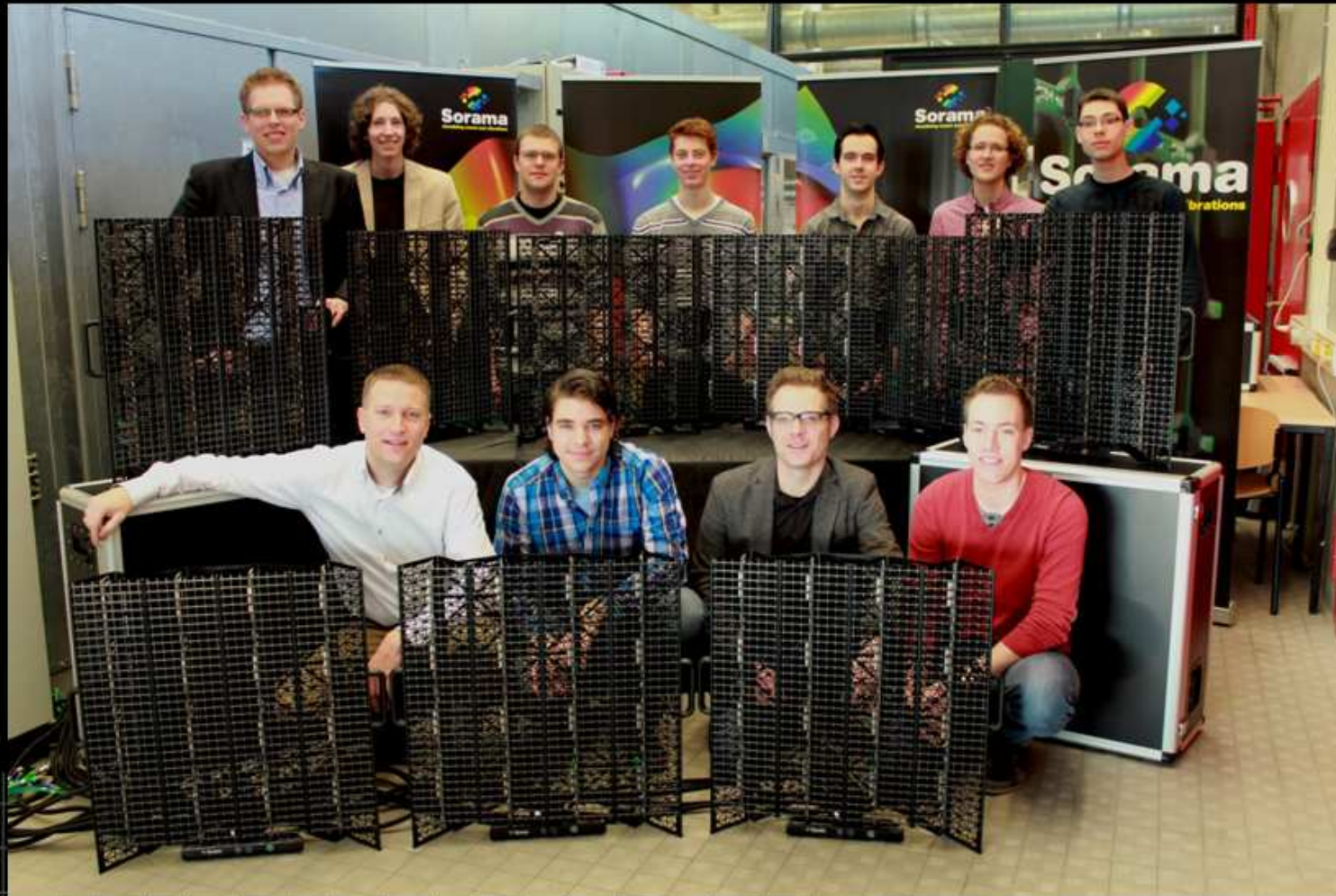
Sound Imaging

File sharing

Outreach



Outreach





De stilte in beeld



Alu 1: Standaard PVC



Alu 2: DykaSono



Wij de ontwikkeling van DykaSono is gebruik gemaakt van de nieuwe, gepatenteerde technologie van Sorama, waarmee worden geluid en trillingen in beeld gebracht.



Sorama Cam pilot

