




# University of Twente


## Structural Dynamics & Acoustics

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 University of Twente  
The Netherlands



 **Impact**  
Institute of Manufacturing, Processes and Control - Twente

 University of Twente  
The Netherlands

## Structural Dynamics and Acoustics Research areas

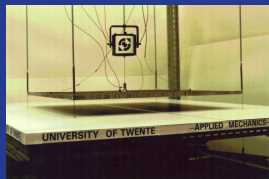
- Acoustics
  - Interaction of vibrating structures with vibrating medium (air, water) = **Vibro- acoustics**
  - Flame-acoustics (**Thermal Engineering**)
  - Aero-Acoustics (**Engineering Fluid Dynamics**)
  - Electroacoustics (**Signal & Systems, EWI**)

## Acoustics: Projects

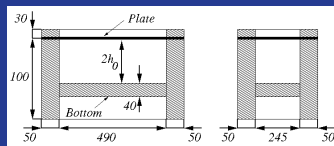
- Inverse Acoustics (René Visser, Jelmer Wind, **STW**)
- Visco-Thermal wave propagation and acousto-elastic interaction (Marco Beltman, Frits v.d. Eerden, Tom Basten)
- FACE (Marieke Hannink, **EU 5<sup>th</sup> Framework Programme**)
- Reduction of noise in PCs (Marten Nijhof, **Intel**)
- Hybrid Isolation of Construction (Clemens Beijers, **TNO**)
- Active Structural Acoustic Control (Marco Oude Nijhuis, Peter Sloetjes)
- Receiver performance (Ronald Kampinga, **Sonion**)
- Tyre-road noise (Arjan Schutte, **TNO, Vredestein**)

## Viscothermal wave propagation

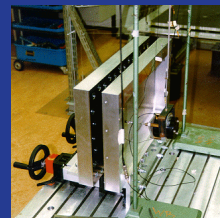
From fluid model



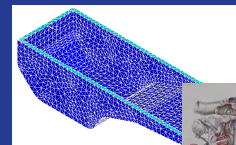
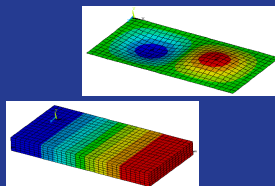
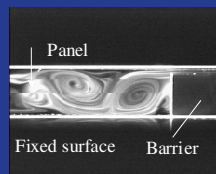
to fluid/structure interaction



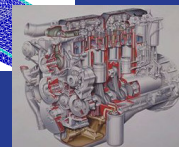
to acoustics



to advanced insights



and applications



## Viscothermal wave propagation

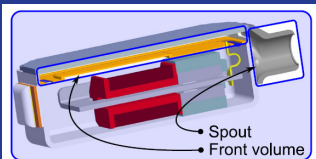


Figure 1 : Cross section c

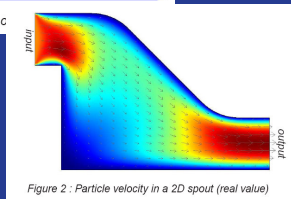


Figure 2 : Particle velocity in a 2D spout (real value)

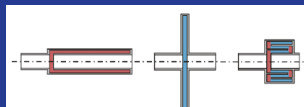
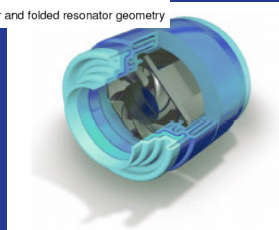


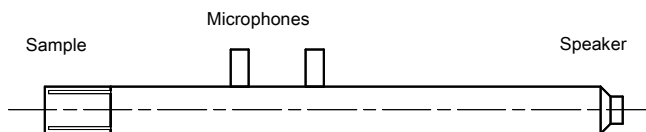
Fig.1) Cylindrical, circular and folded resonator geometry

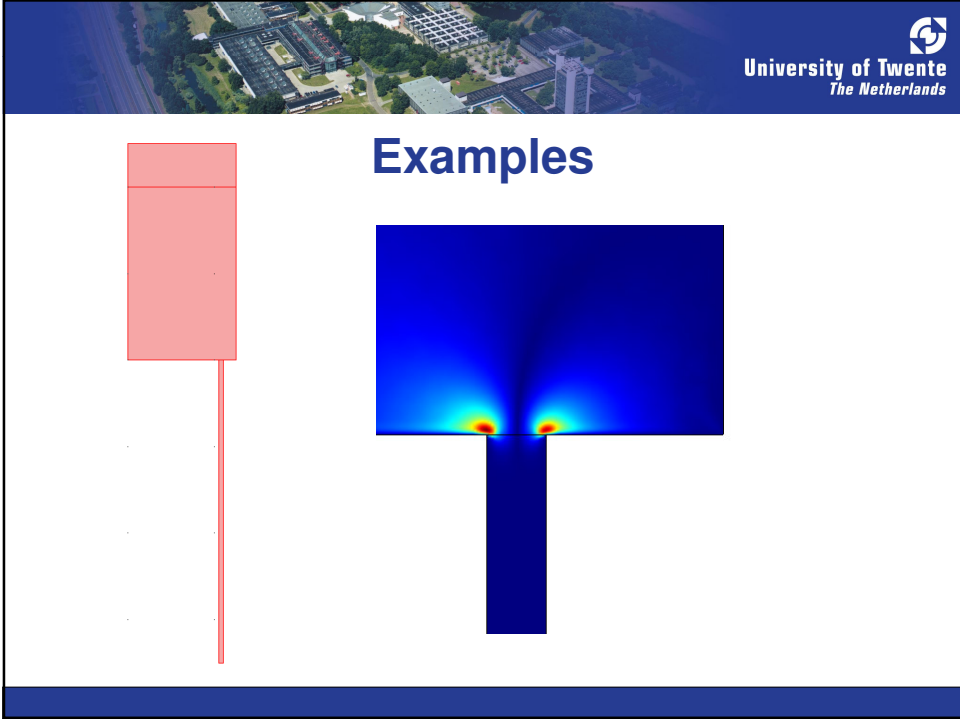
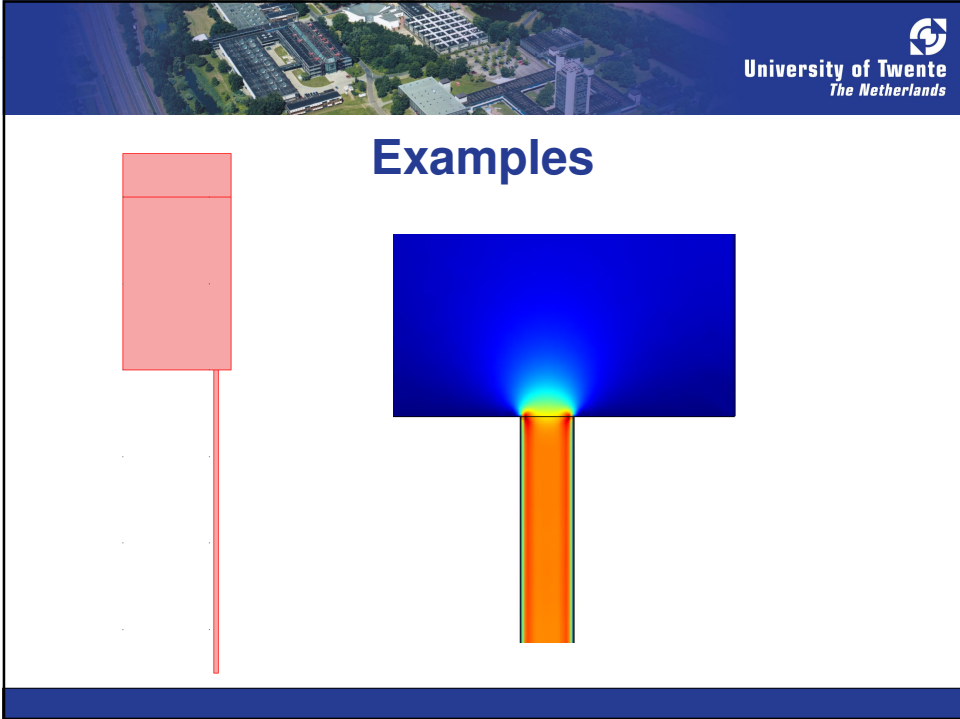


Hearing aid loudspeaker  
Together with Sonion and Intel.

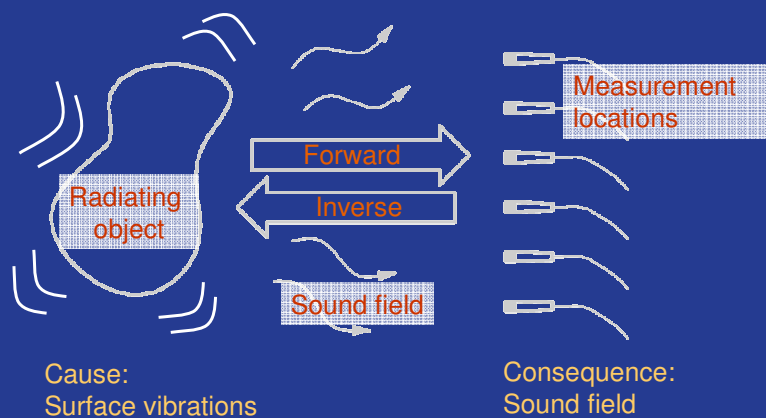
Side resonator to reduce fan-noise in PC's

## Example

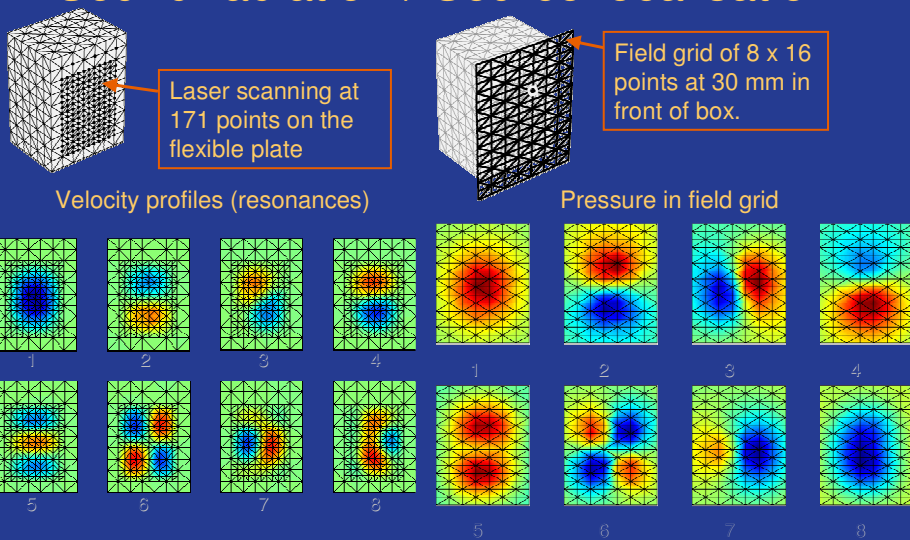




## Sound radiation / Source localisation

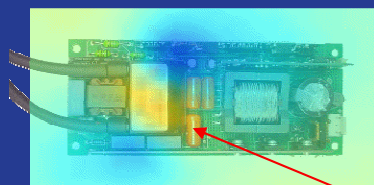


## Sound radiation / Source localisation

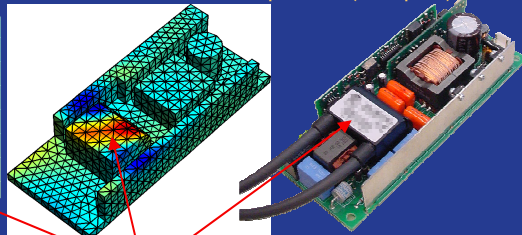


## Source localisation

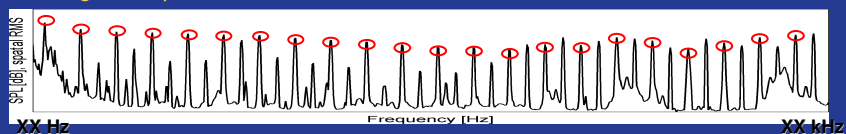
Pressure field



Reconstructed vibration pattern (real part)

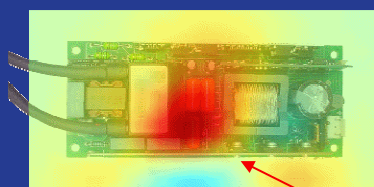


At all odd multiples of the base frequency, sound is radiated by one single component.

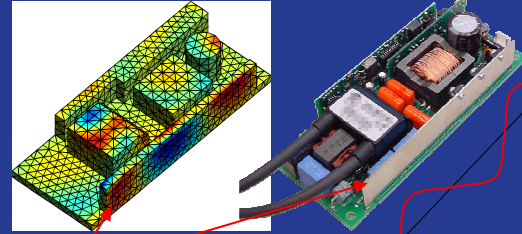


## Source localisation

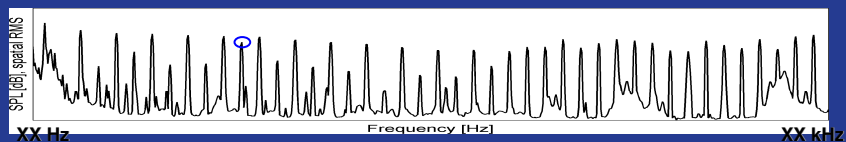
Pressure field



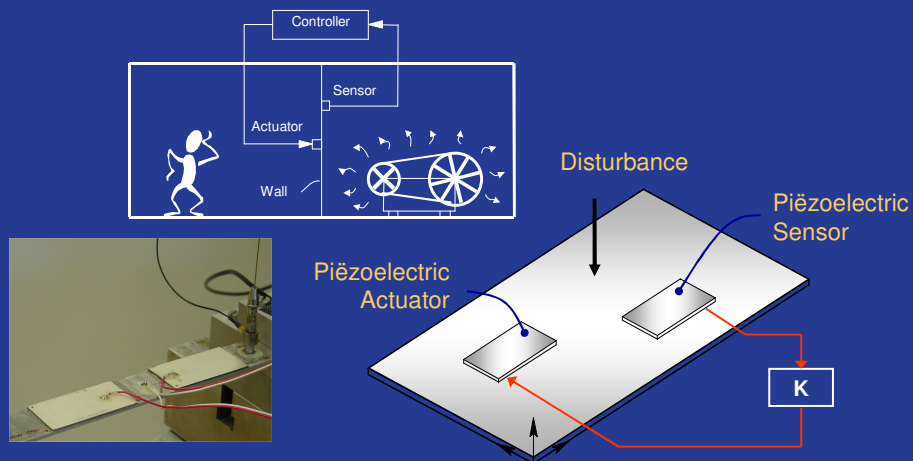
Reconstructed vibration pattern (Re)



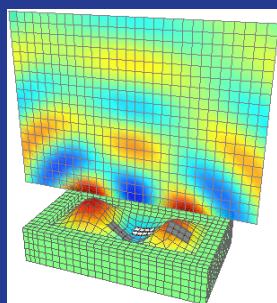
Third bending mode of the Al-strip.



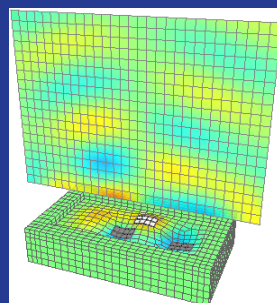
## Active noise control



## Active noise control



No control



With control  
(amplified 10 times)

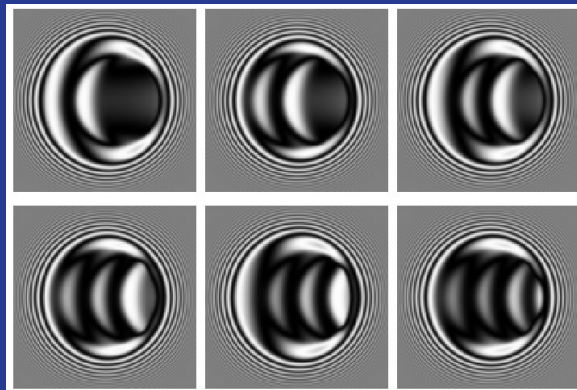
## Tyre/road noise

- Tyre:
  - Numerical (FEM) models valid at high frequencies
  - Material models (rubber)
- Road:
  - Accurate description of geometry / roughness (excitation tyre)
  - Acoustic properties (noise absorption)
- Contact:
  - Accurate friction model
  - Fast algorithms
- Noise radiation
  - Numerical model (BEM)

Adopt multigrid techniques  
as used in elasto-hydrodynamic  
lubrication ...

## Tyre/road noise

- **Film thickness between rolling element and raceway (pseudo-interference) for vibrating rolling element**

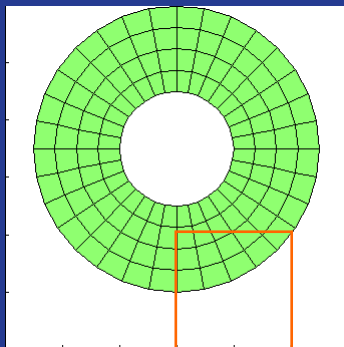




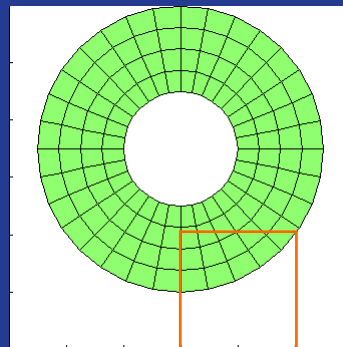
## Tyre/road noise

- **Prerequisite for a multigrid algorithm**
  - Iterative solver with excellent 'smoothing' properties
  - 'Local' contact algorithm
    - Iterate on element matrix / discrete points level
- **Objective**
  - Development of a (general purpose) contact algorithm that can be incorporated in a multigrid algorithm

## Bouncing ring

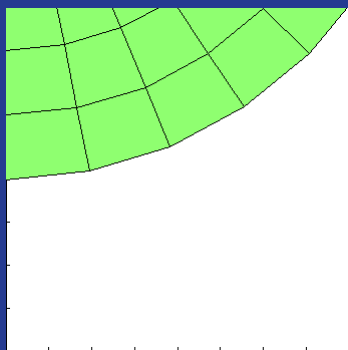


$\mu = 0$

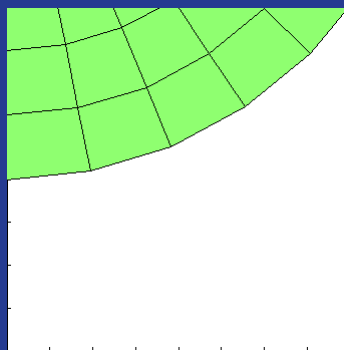


$\mu = 1$

## Bouncing ring



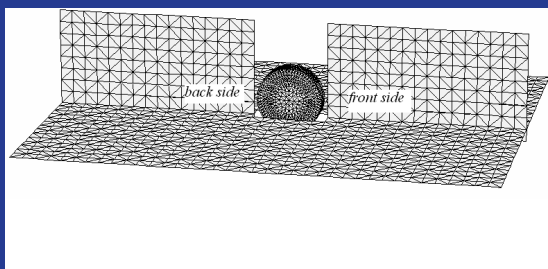
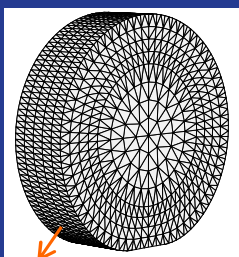
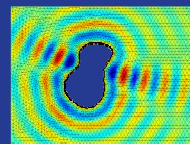
$$\mu = 0$$



$$\mu = 1$$

## Tyre/road noise

- **Radiation model**
  - Boundary Element Model 3D (BEMSYS)



# Tyre/road noise

- Radiation

