Dedicated to innovation in aerospace

Lokaliseren van geluidsbronnen

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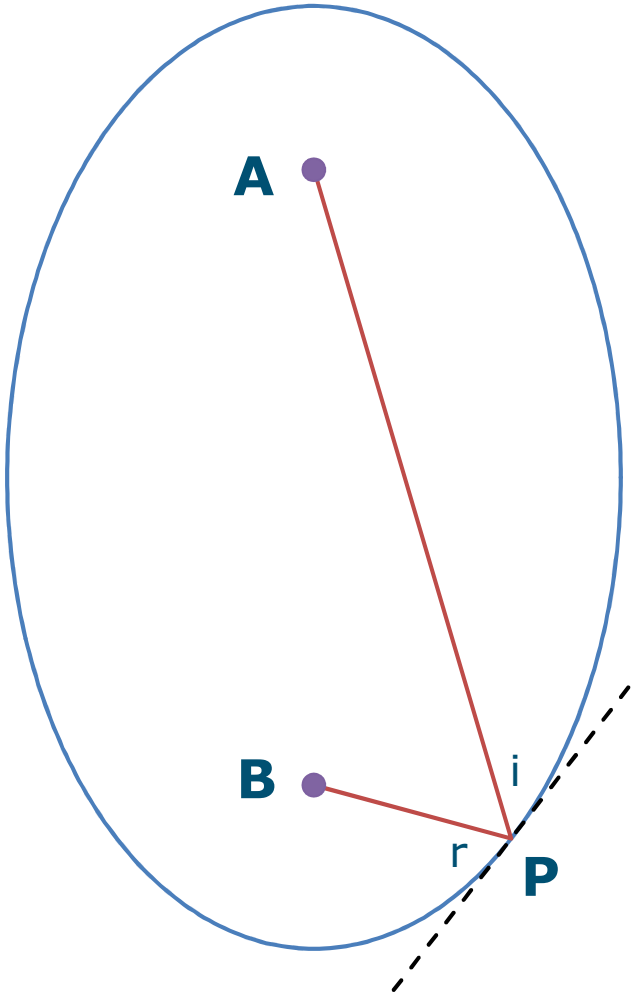
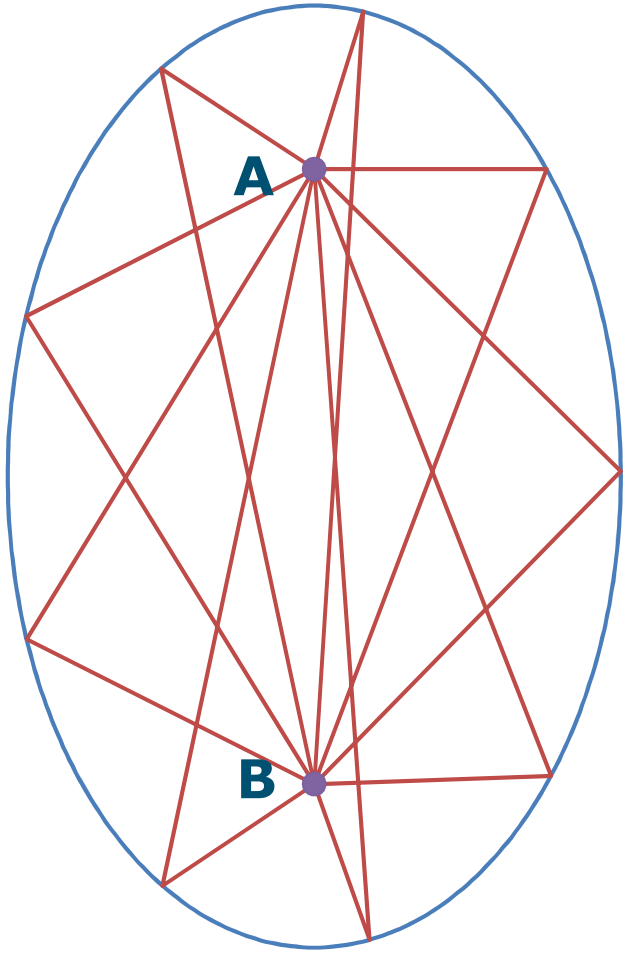
Ellips (1)

- 2 brandpunten (A,B)
- Lengte APB altijd gelijk
- Hoek van inval (i) = hoek van reflectie (r)



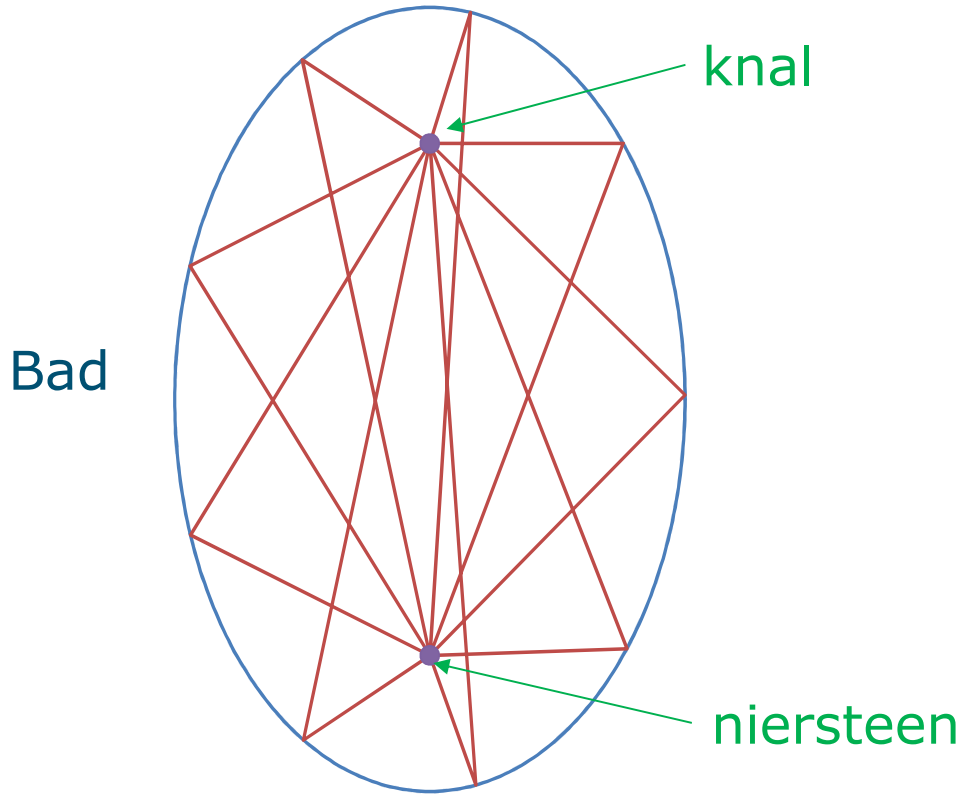
Ellips (2)

- **Geluidsbron in A:**
  - Al het uitgestraalde geluid komt terecht in B
  - Al het uitgestraalde geluid komt tegelijk aan
- **Geluidsbron niet in A:**
  - Geluid komt nooit in B



Ellips: toepassingen (1)

Niersteenvergruizer

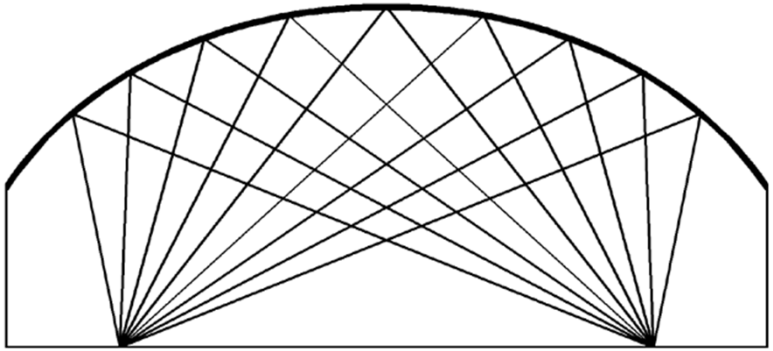


Ellips: toepassingen (2)

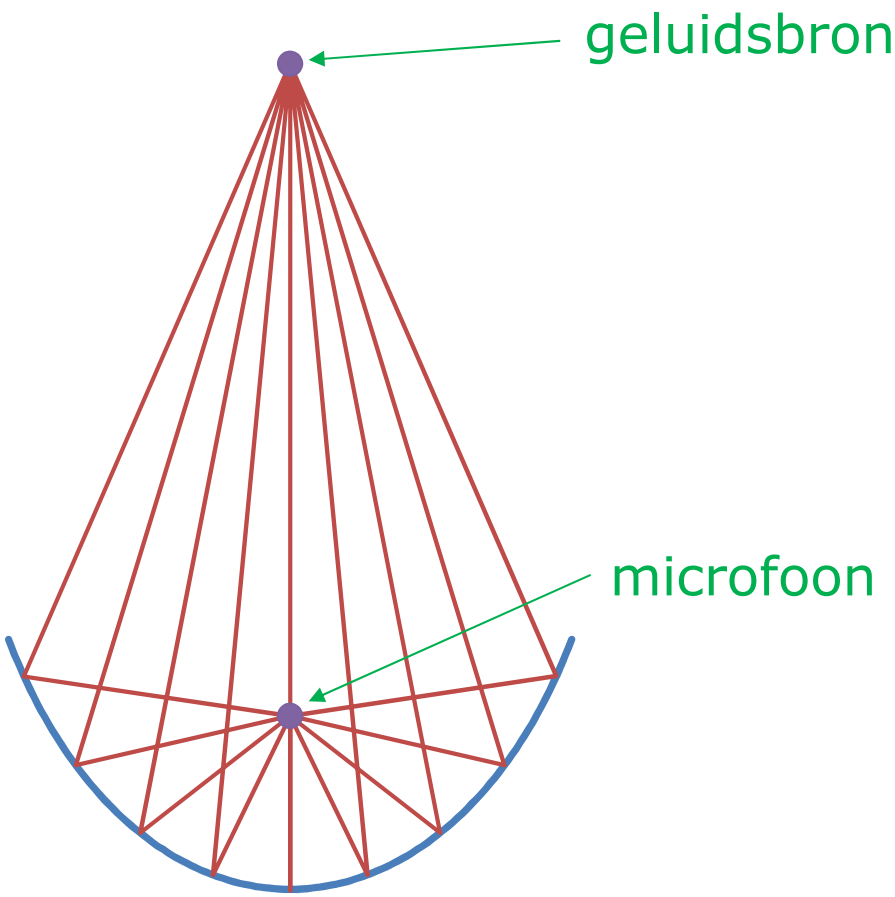
Capitool (Washington)

“Statuary hall”

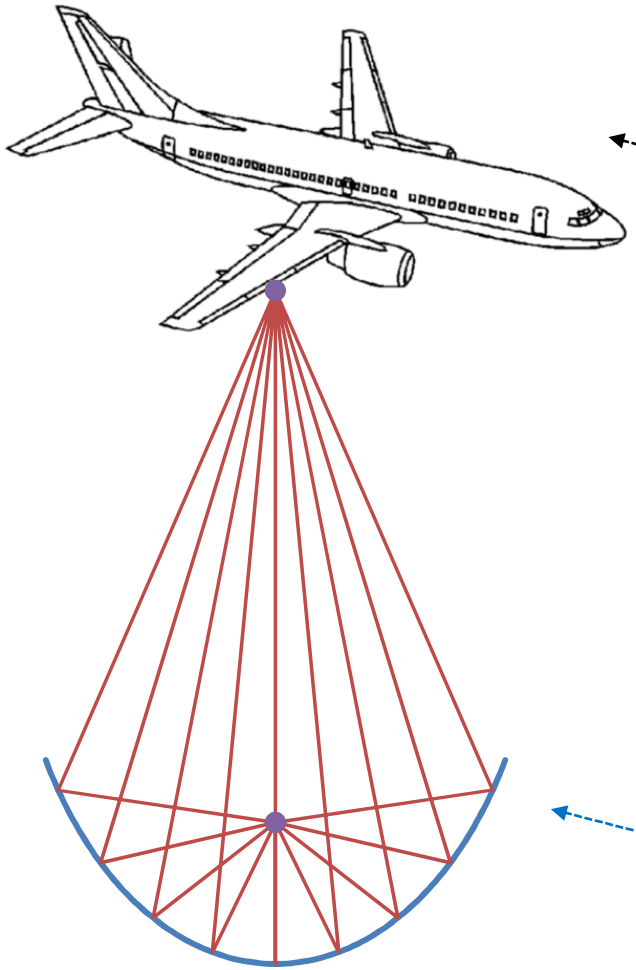
Elliptisch plafond



Ellips: akoestische metingen



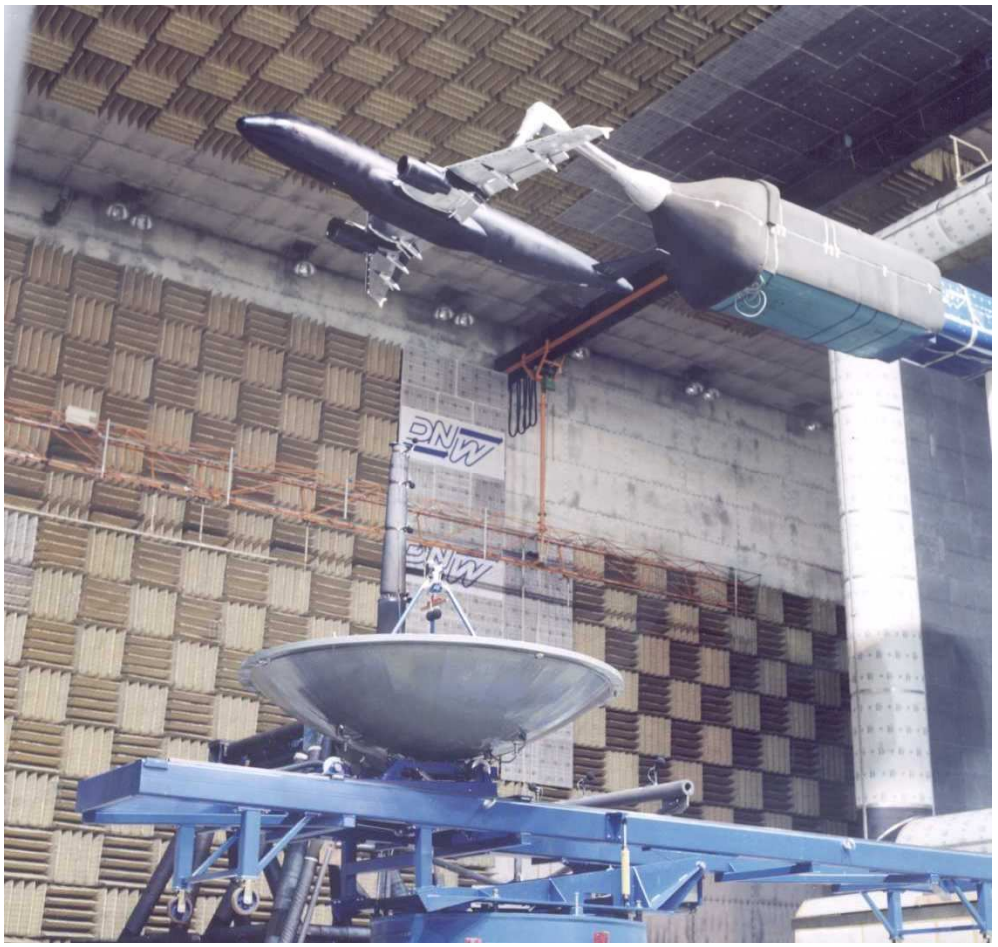
Ellips: lokaliseren van geluidsbronnen



scannen d.m.v. traverseren

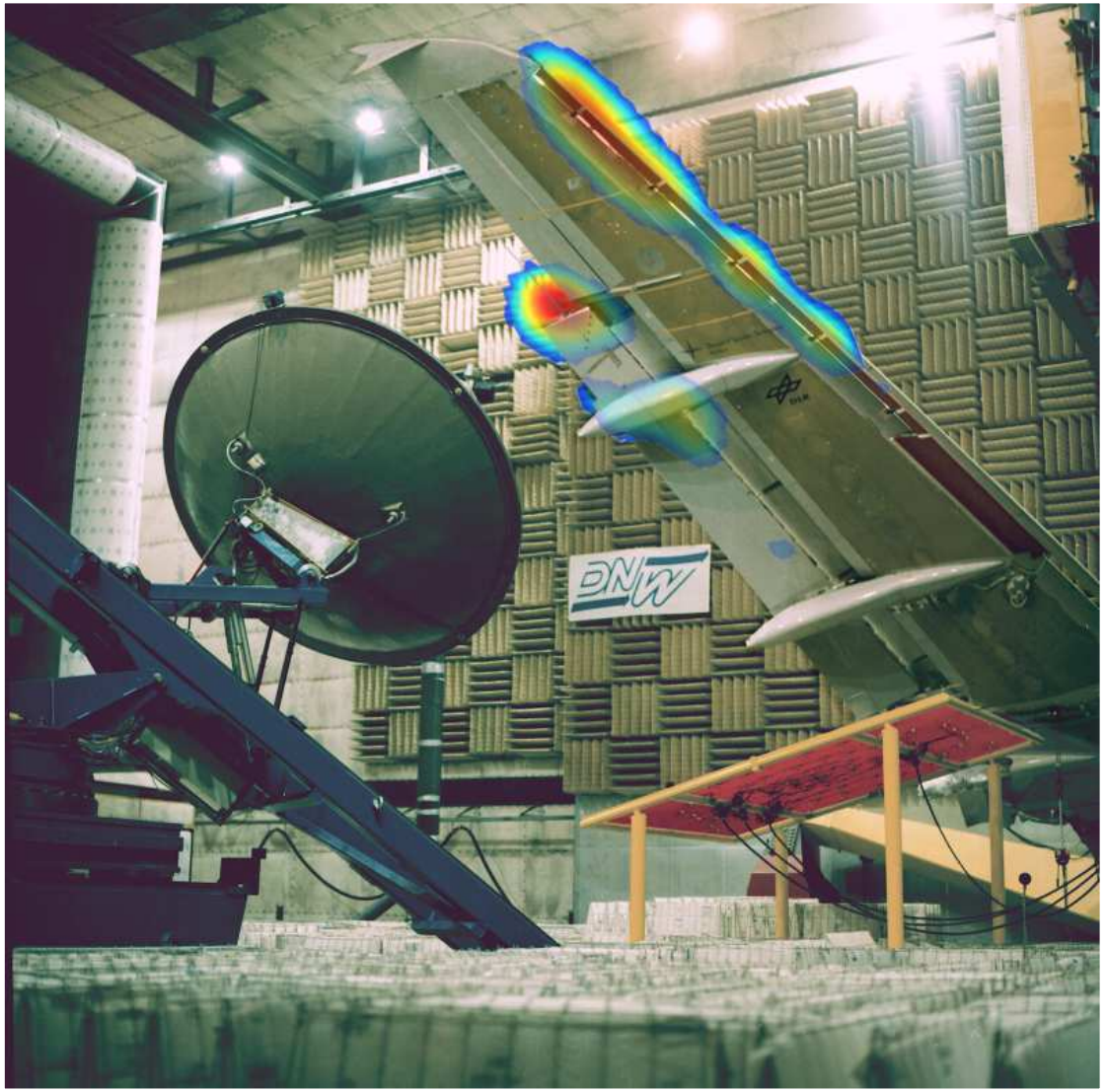
scannen d.m.v. traverseren

Metingen met elliptische spiegel (1)

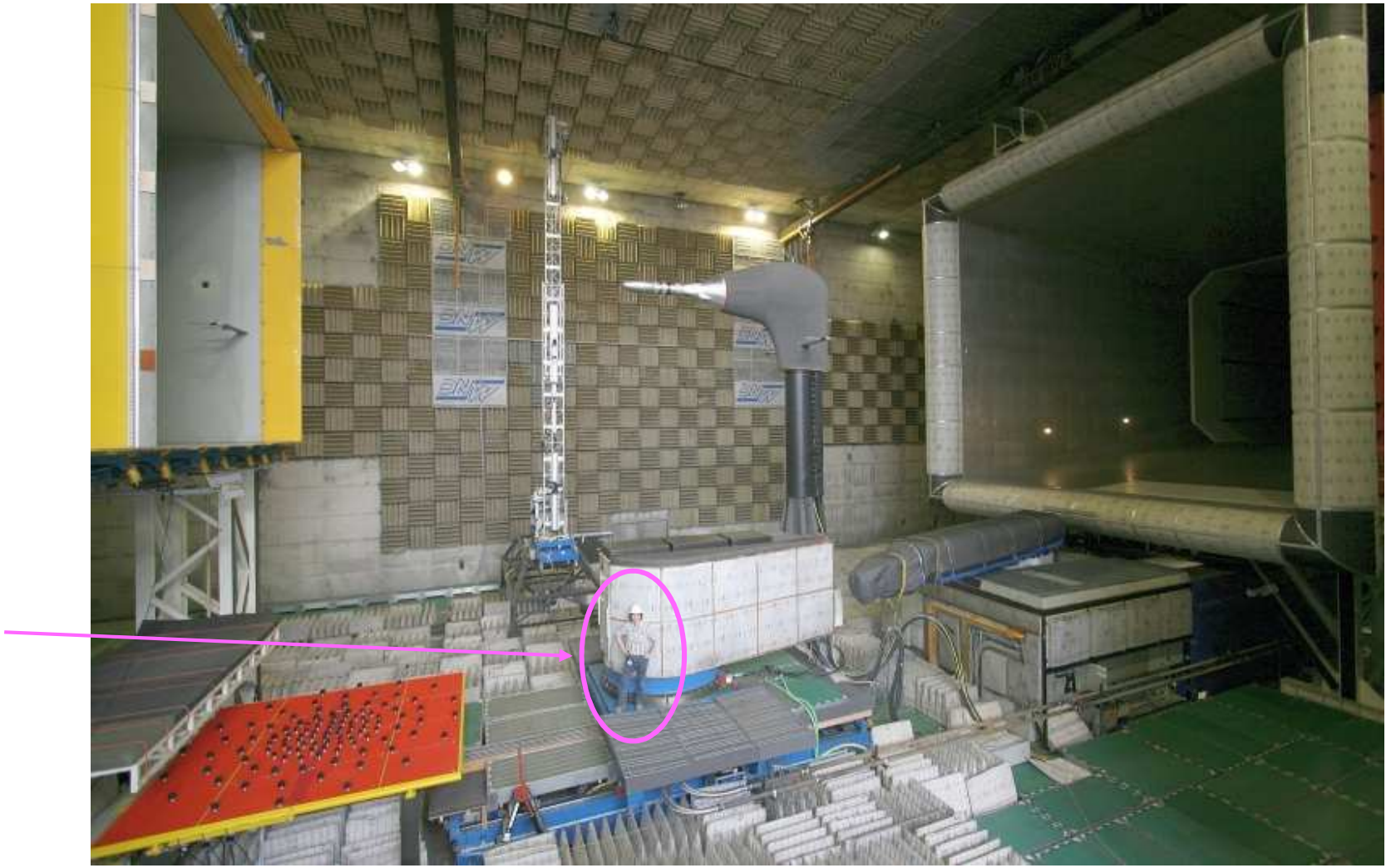


Metingen met elliptische spiegel (2)

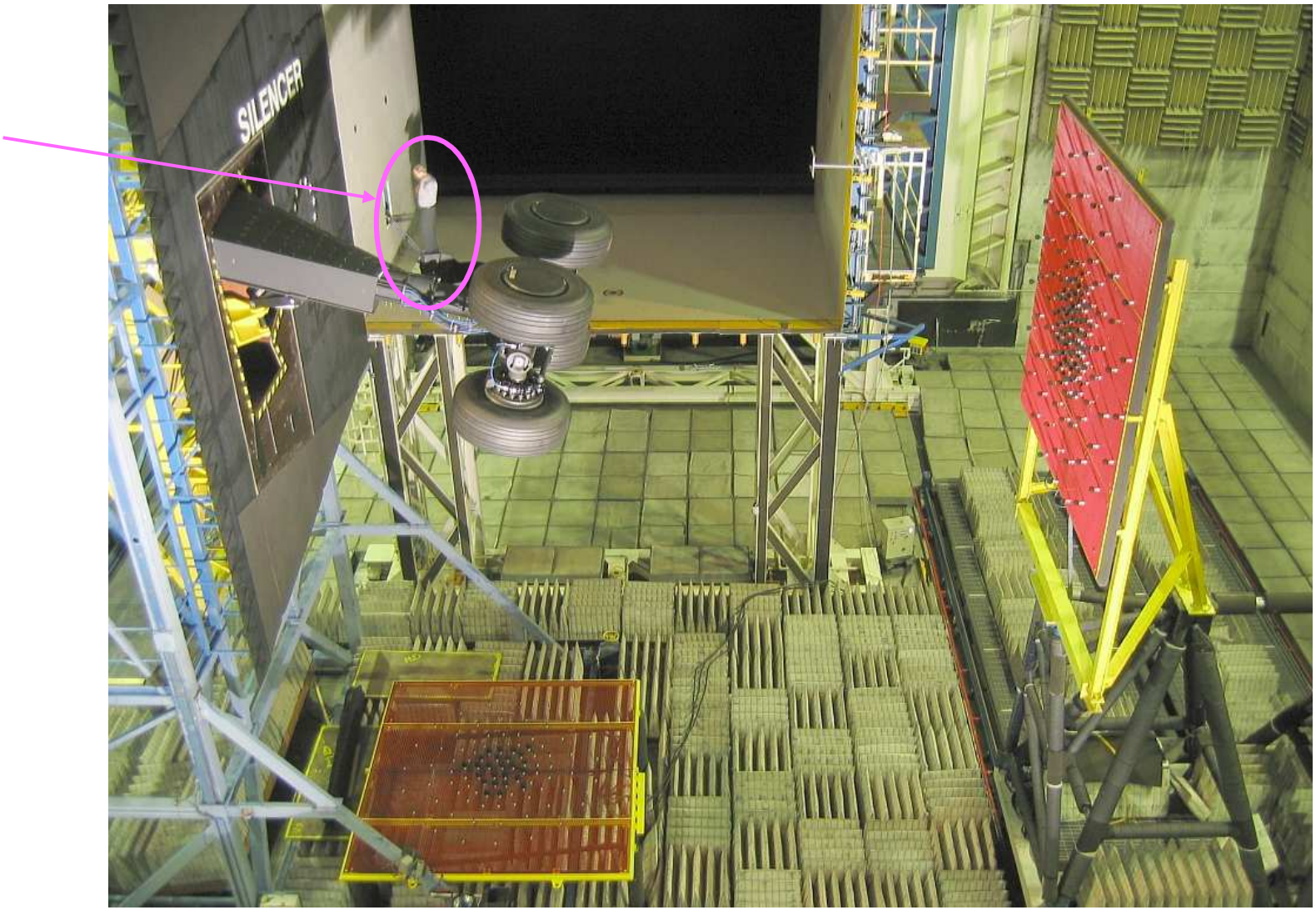
A320 vleugel



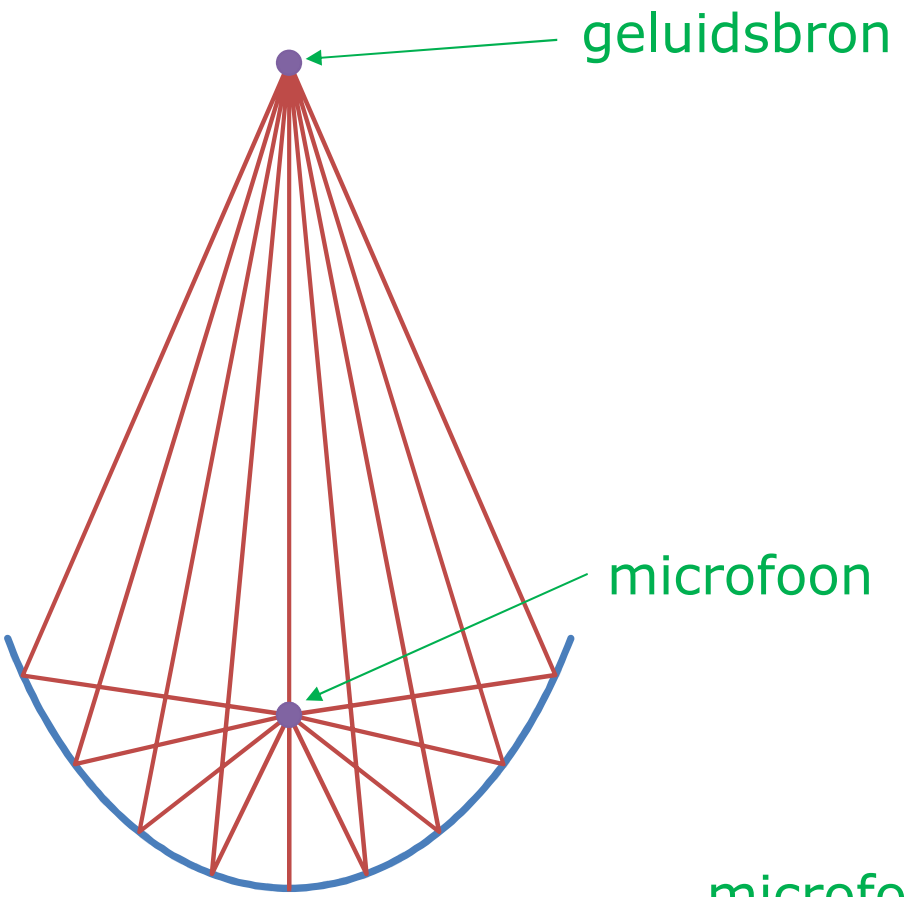
DNW-Large Low-speed facility (1)



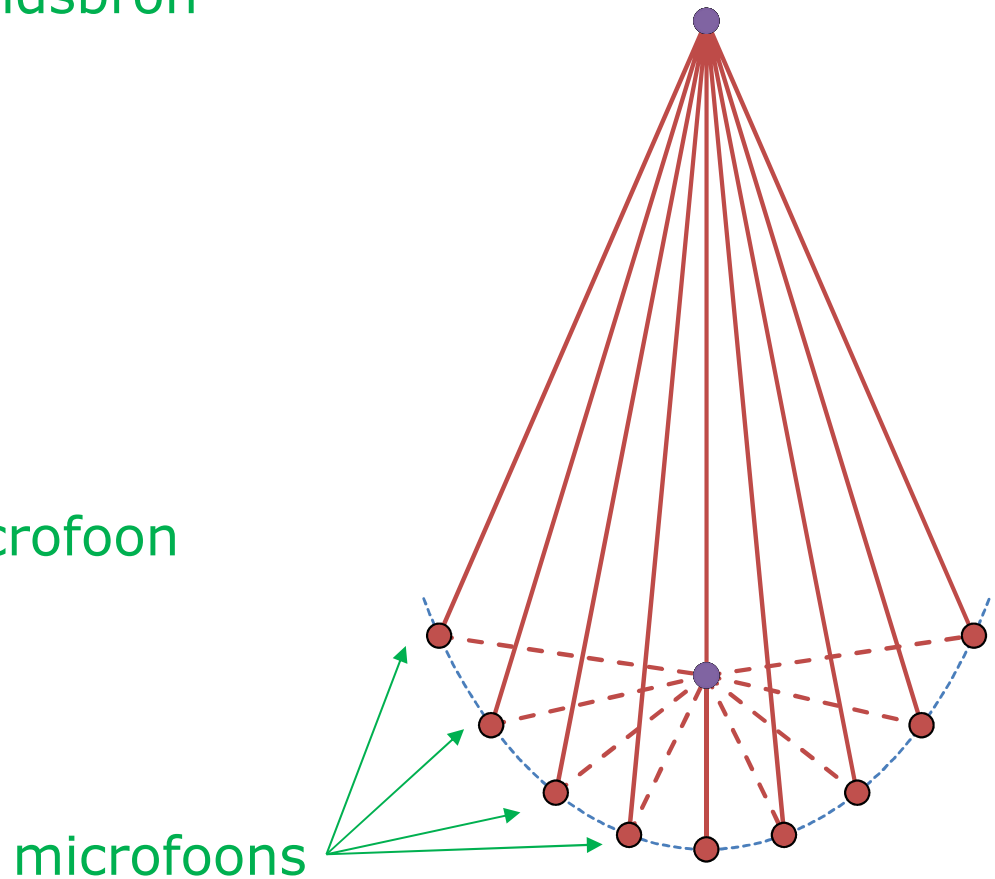
DNW-Large Low-speed facility (2)



Introductie microfoon array

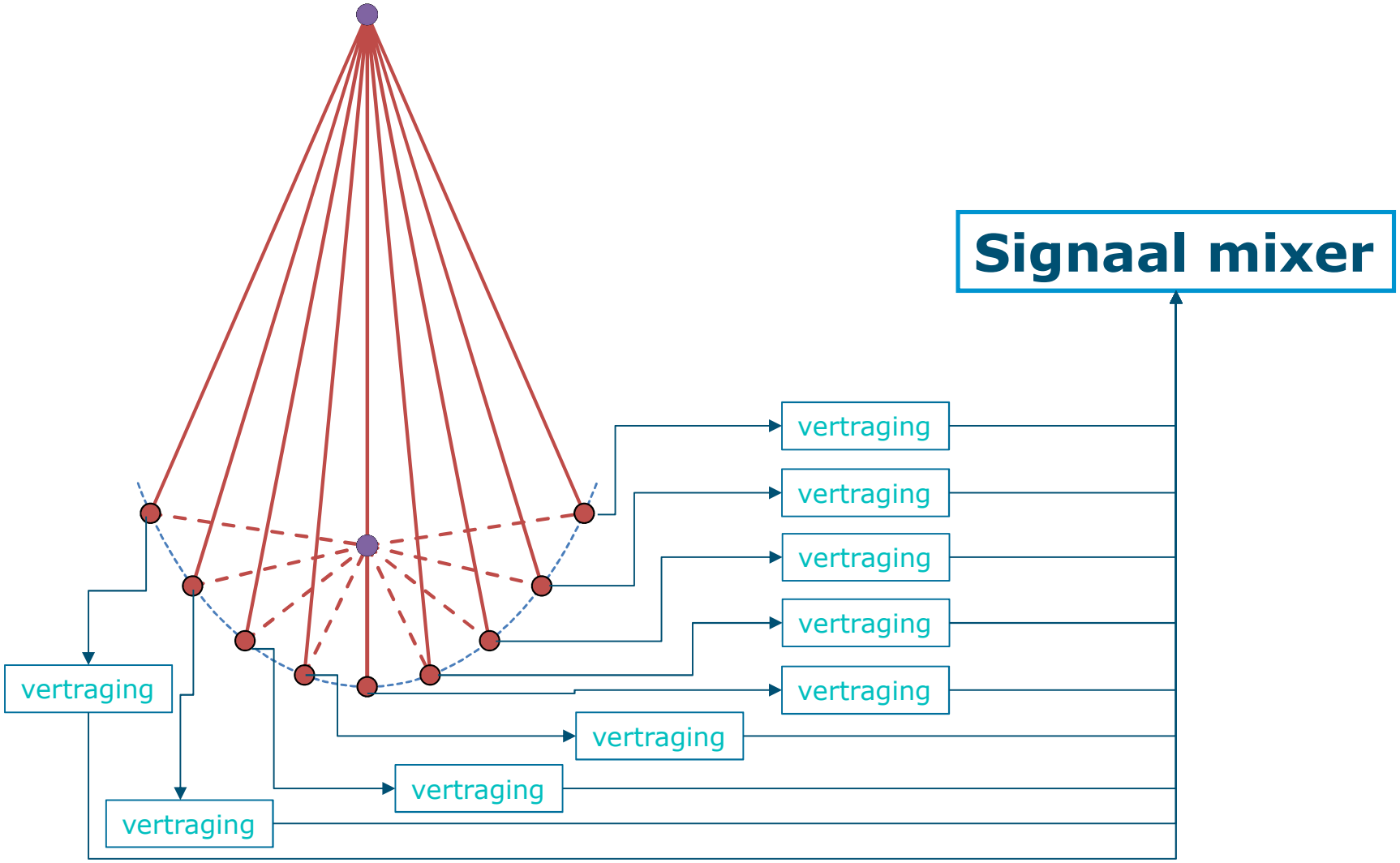


Elliptische spiegel

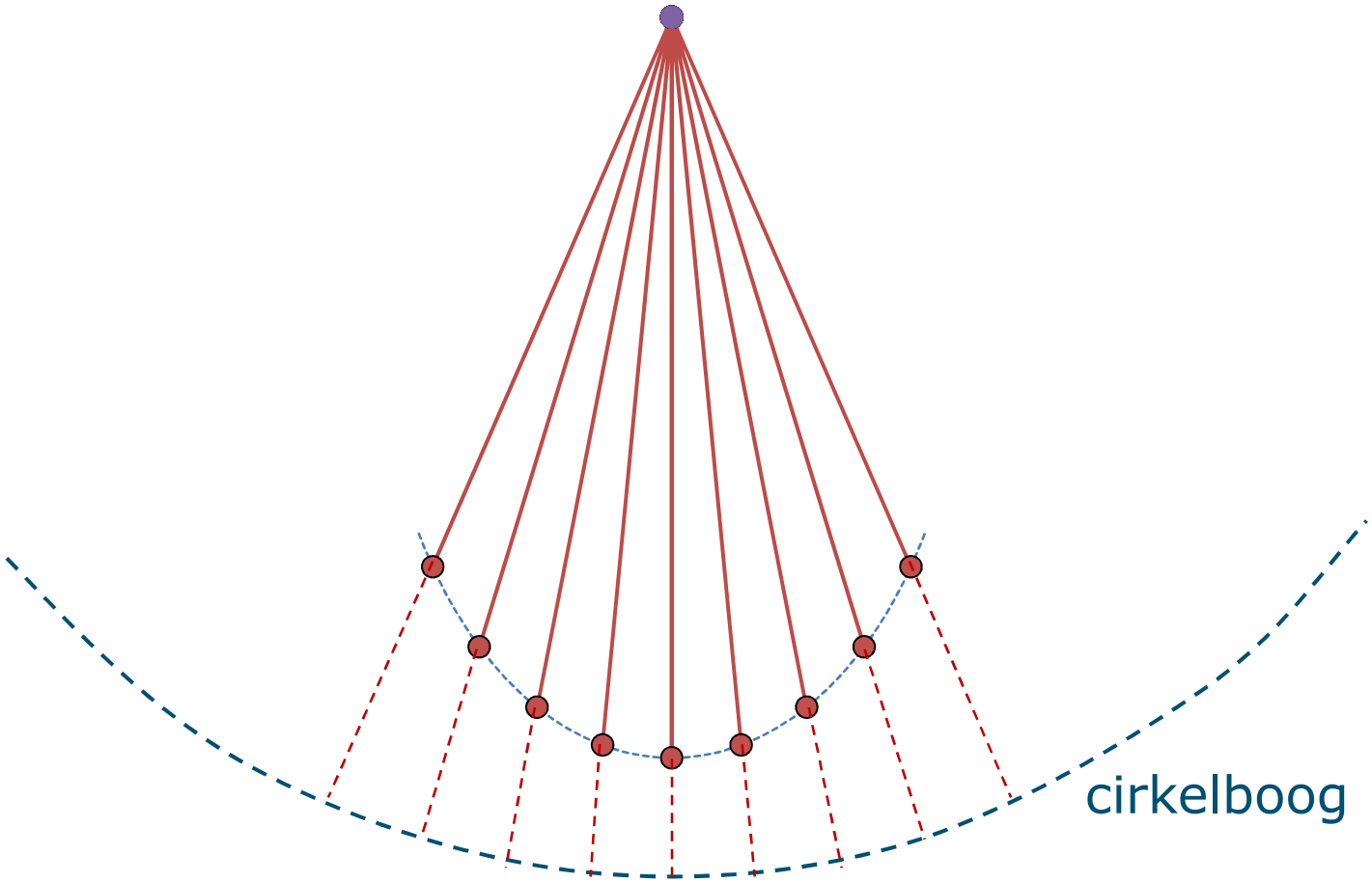


Microfoon array

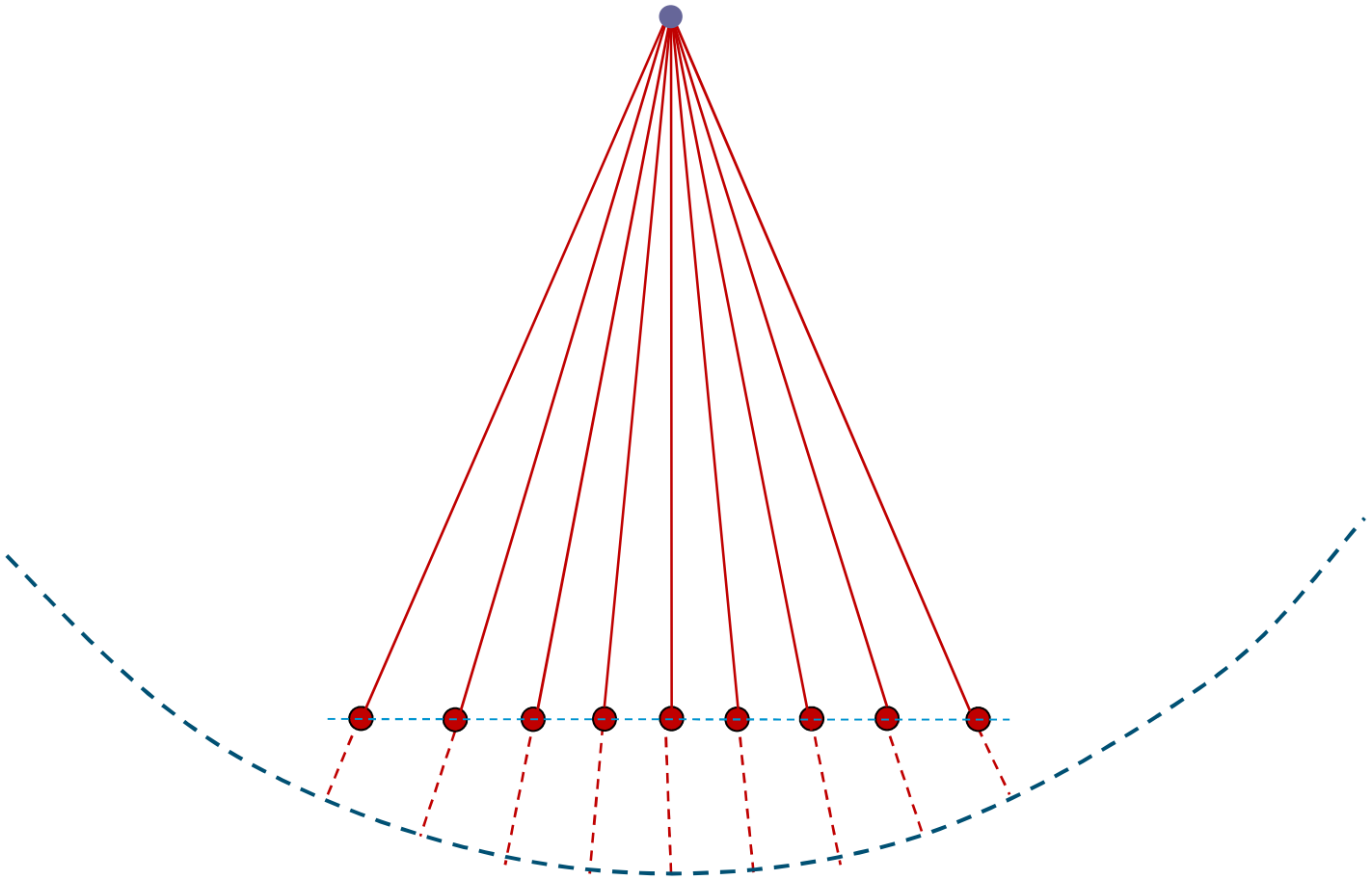
Microfoon array = synthetische telescoop



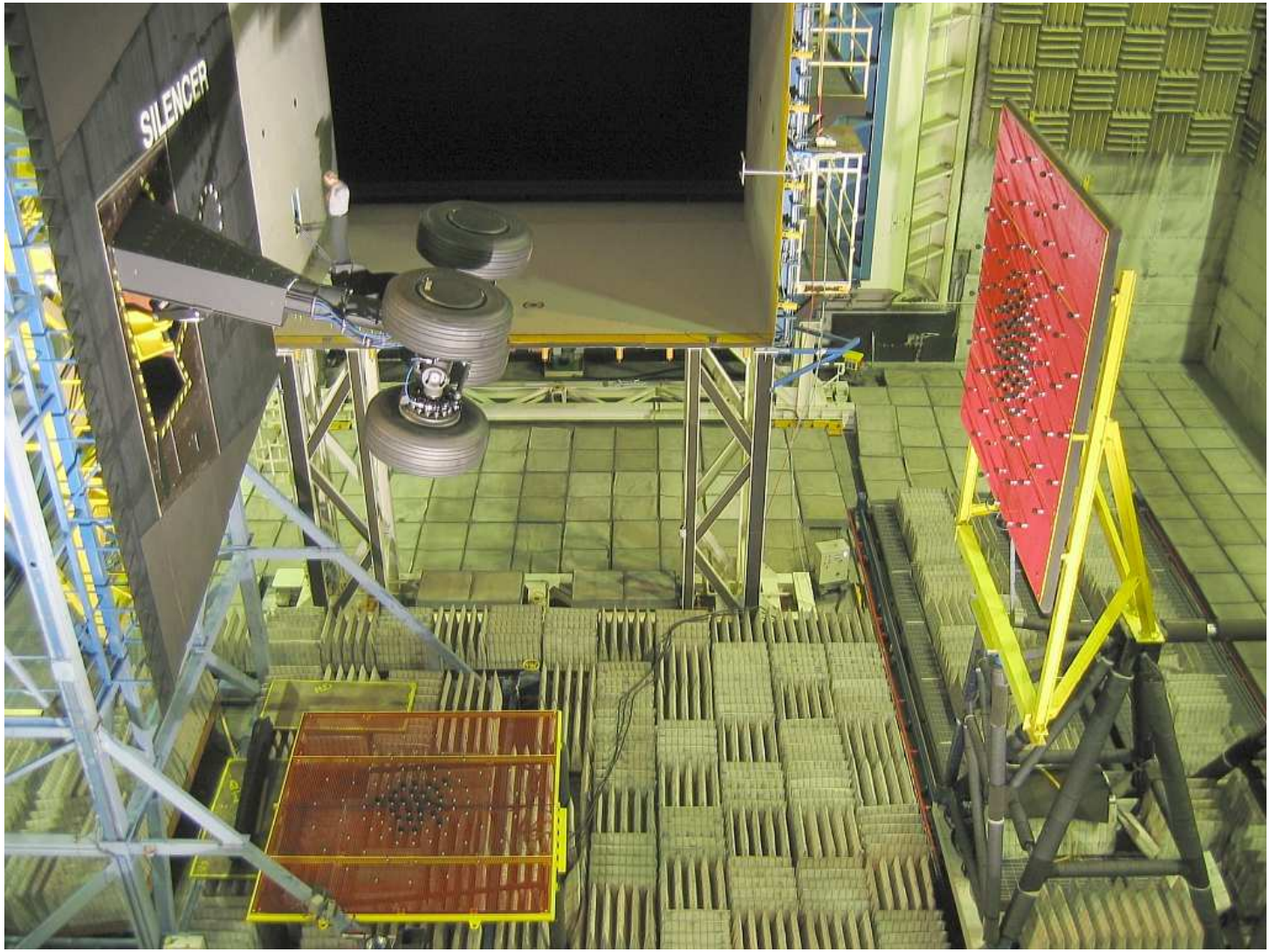
Equivalent



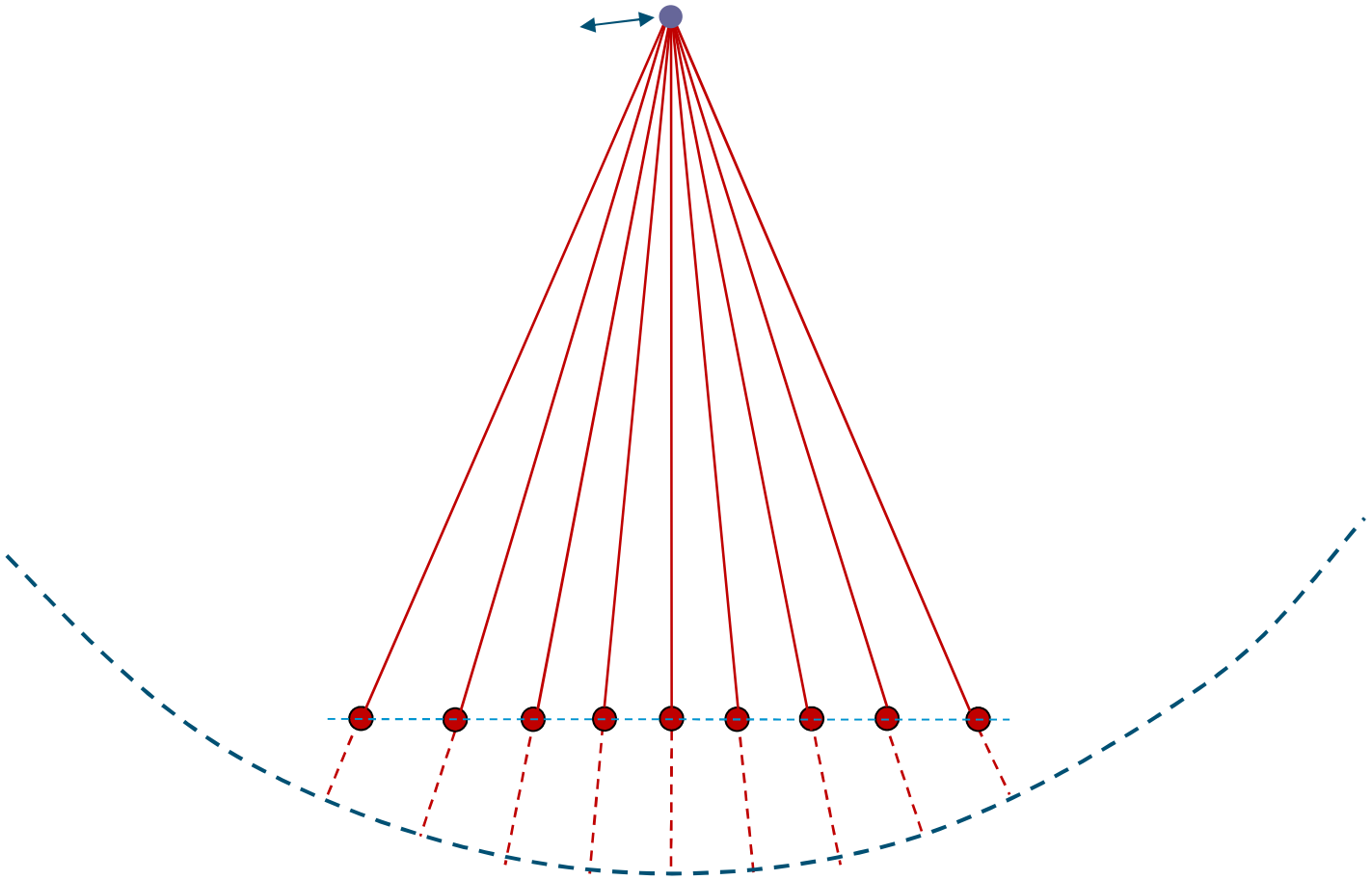
Vlak array



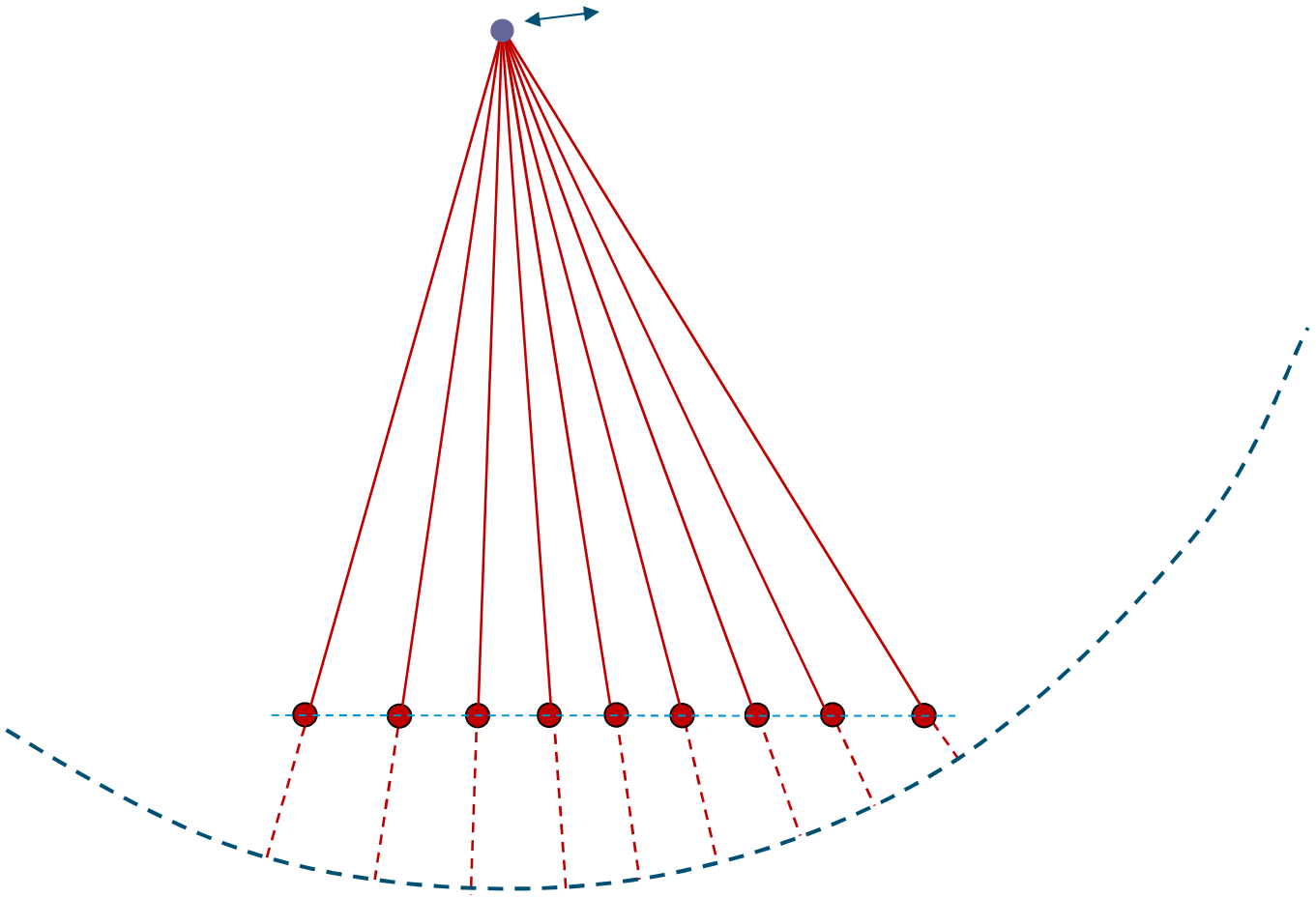
Voorbeelden



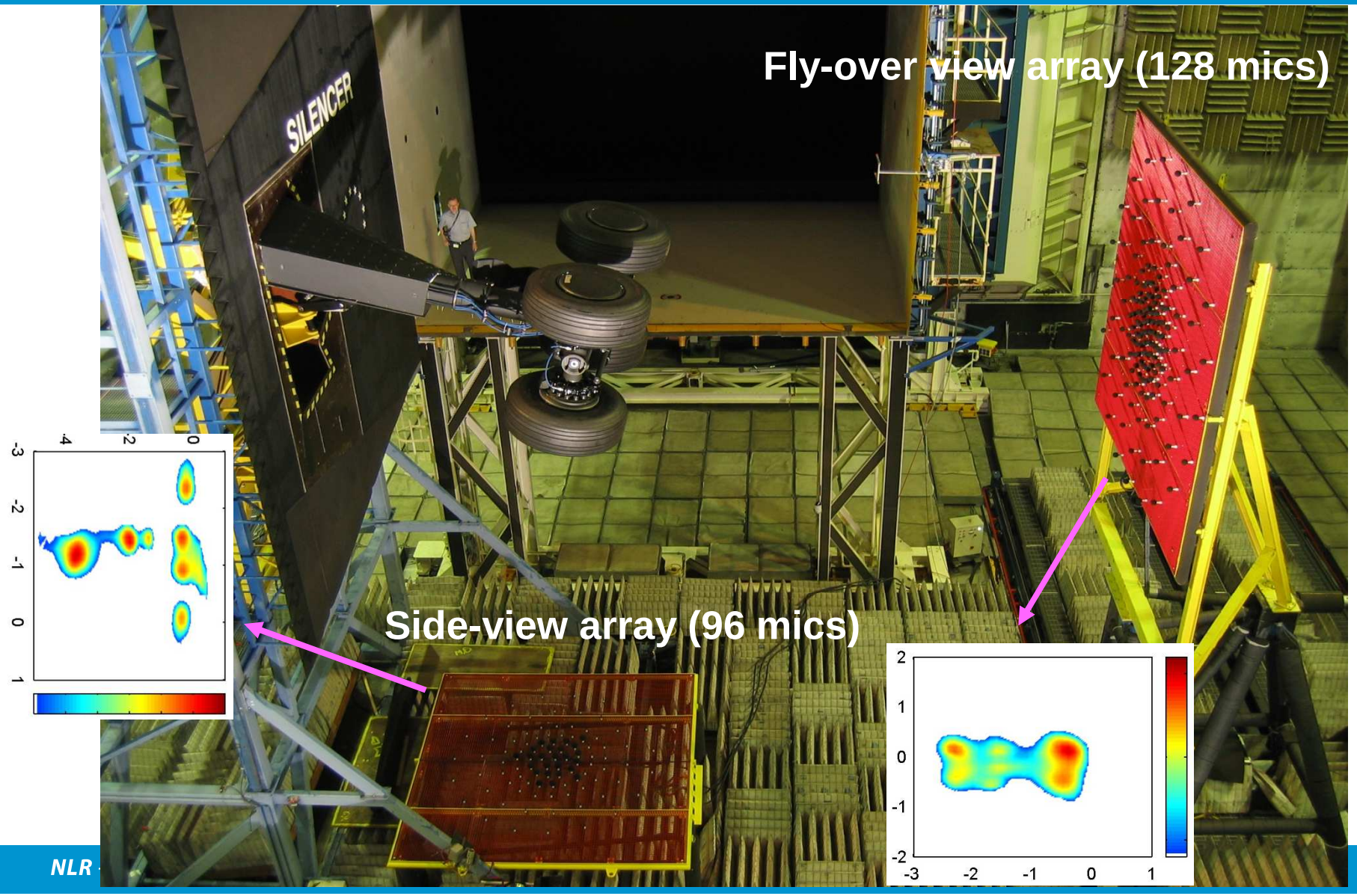
Verschuiven scanpunt (brandpunt)



Verschuiven focus (brandpunt)



Voorbeeld: Airbus A340 landingsgestel



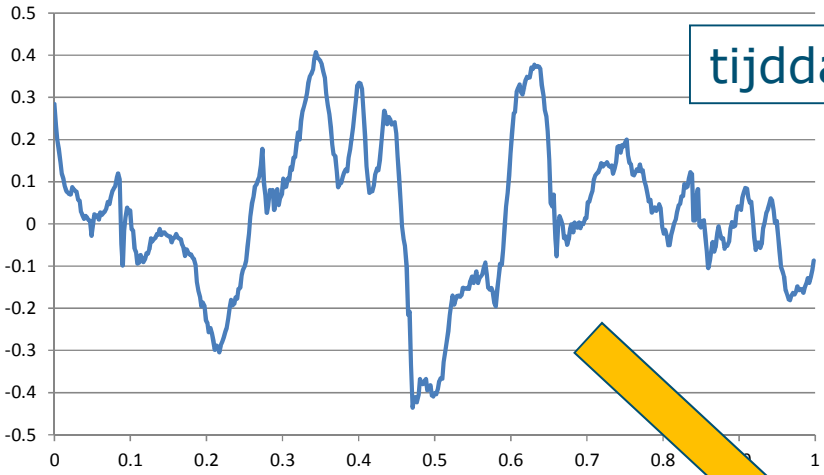
Elliptische spiegel vs microfoon array

- **Voordelen microfoon array**
  - Fysiek scannen niet nodig
    - Kan na afloop d.m.v. software
  - Enorme tijds- en kostenreductie bij windtunnelmetingen
  - Meer flexibiliteit

- **Nadelen microfoon array**
  - Spiegelvlak vervangen door eindig aantal microfoons
  - Verlies aan ruimtelijke resolutie

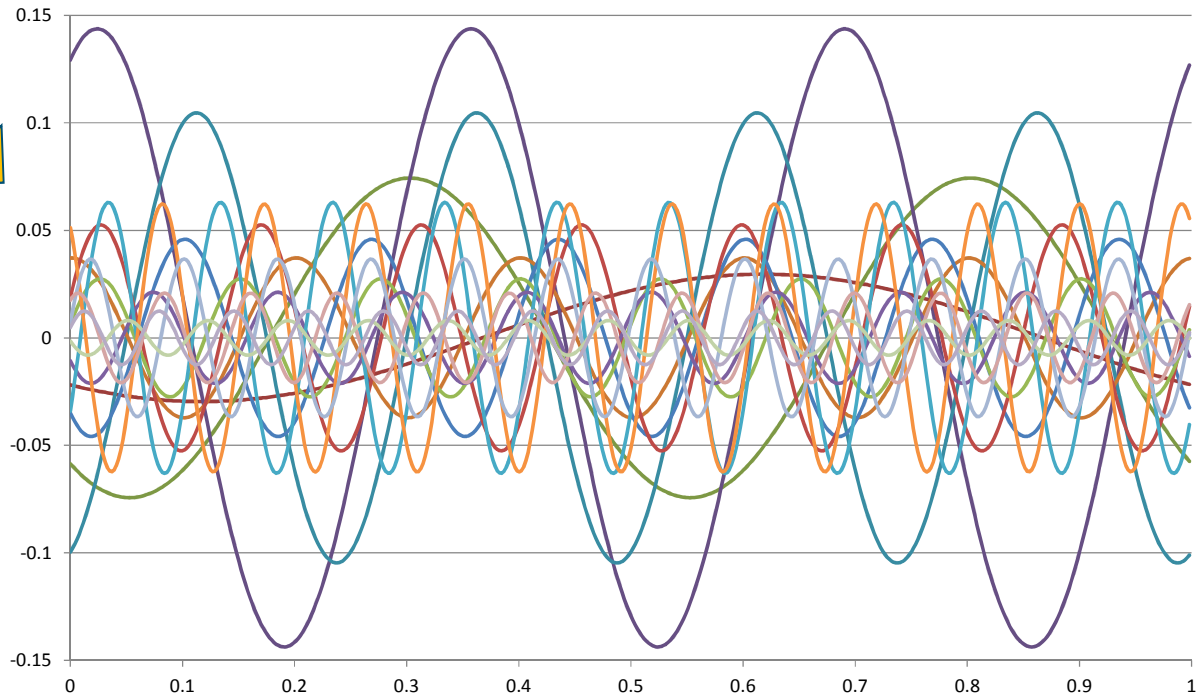
- **Nadelen kunnen worden opgevangen door**
  - Grote aantallen microfoons
  - Slimme positionering microfoons
  - Slimme algoritmes

Fourier transformatie

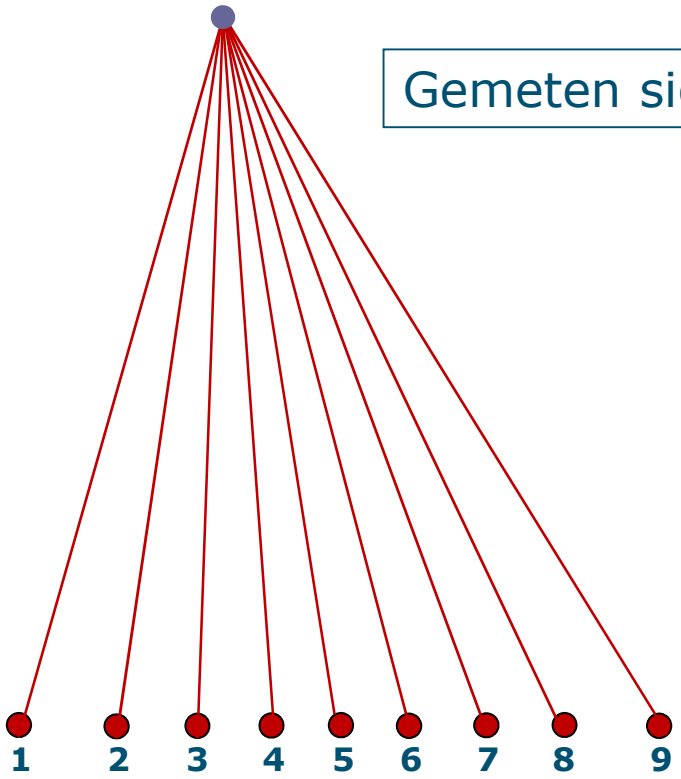


tijddata

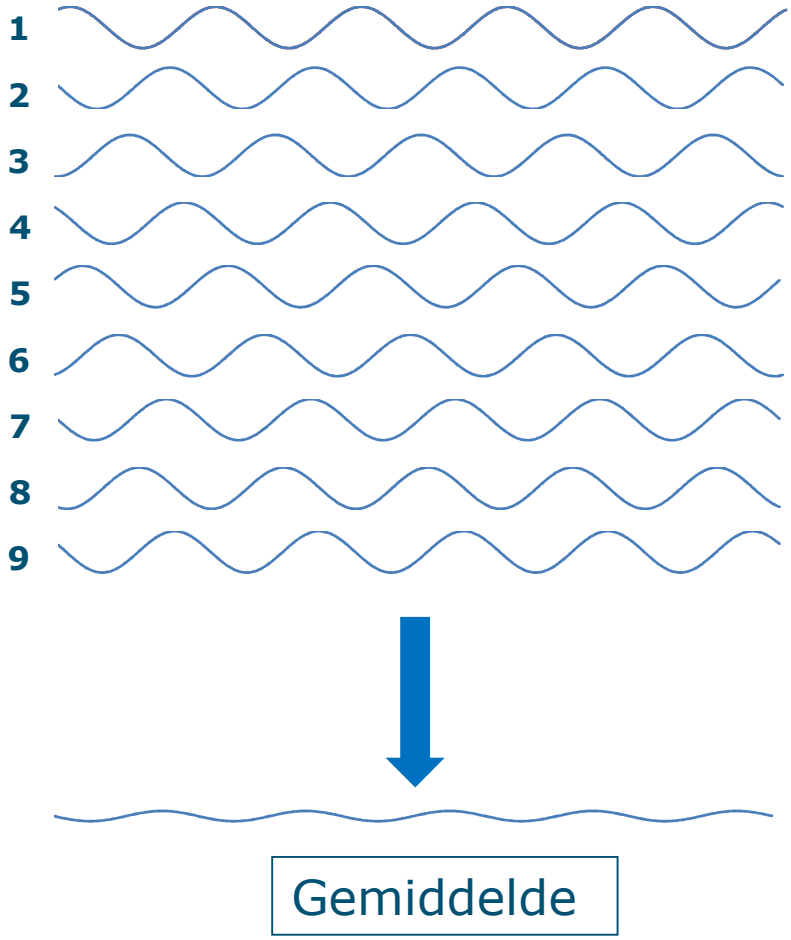
Fourier componenten (tonen)



Vaste geluidsfrequentie (toon)

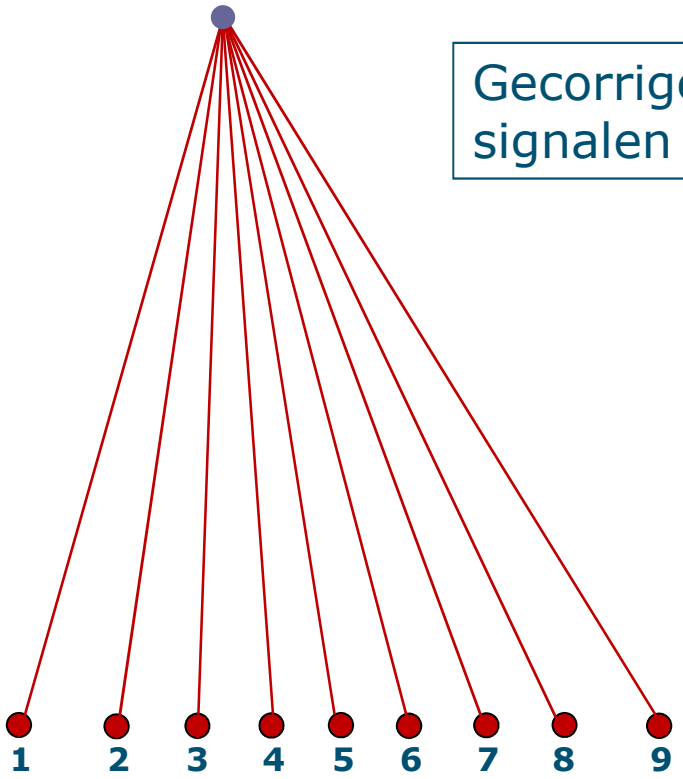


Gemeten signalen

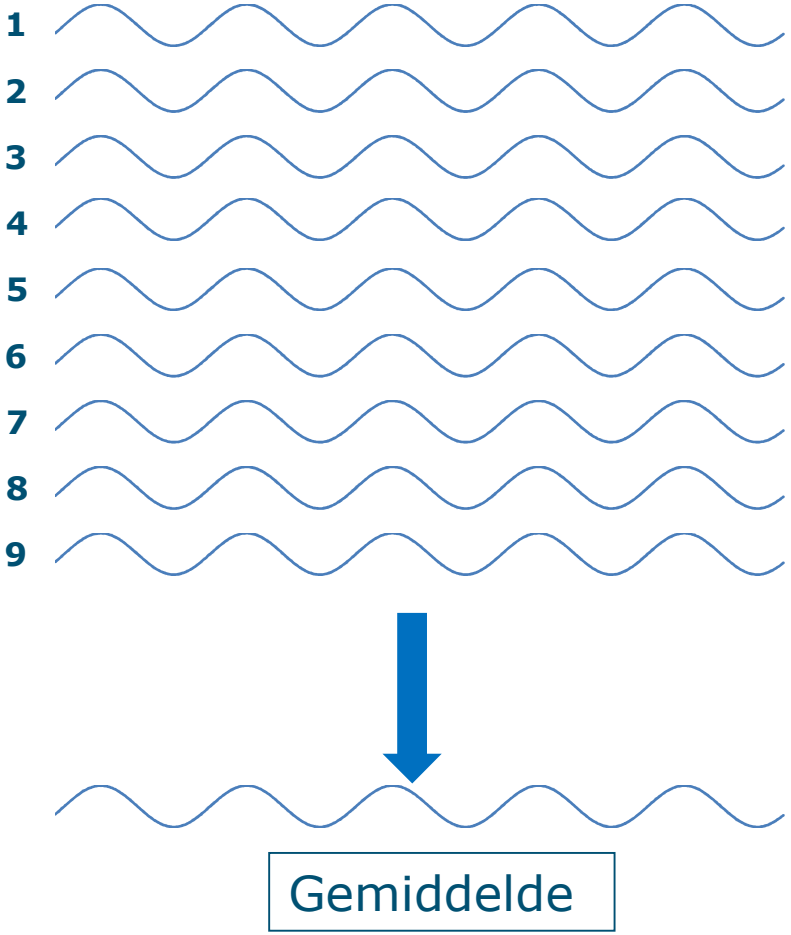


Gemiddelde

Vaste geluidsfrequentie (toon)

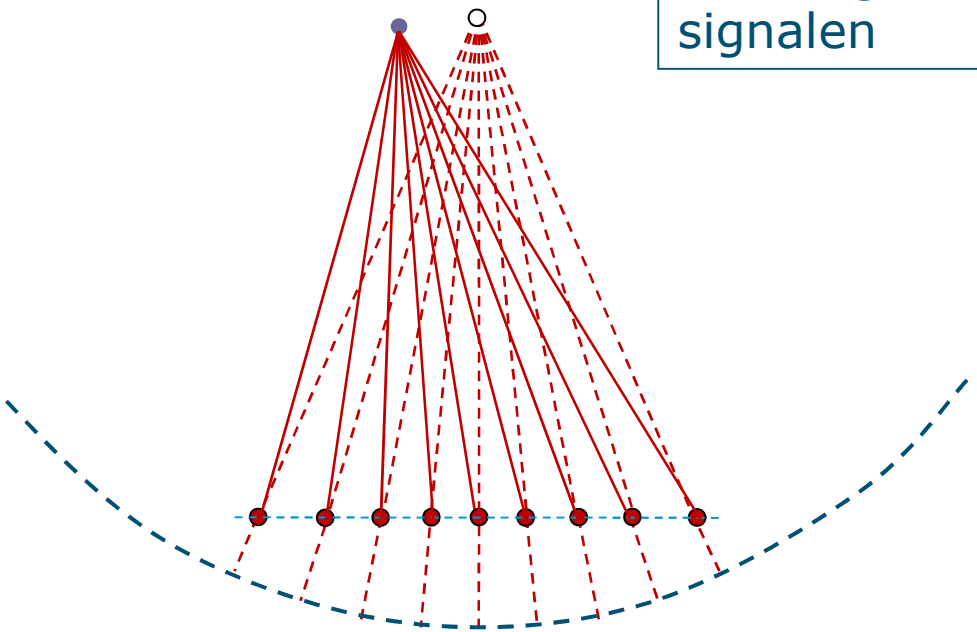


Gecorrigeerde signalen



Gemiddelde

Bron niet in focus



Gecorrigeerde signalen

1 $\sin\left(2\pi f\left(t+\Delta t_1\right)\right)$

2 $\sin\left(2\pi f\left(t+\Delta t_2\right)\right)$

3 $\sin\left(2\pi f\left(t+\Delta t_3\right)\right)$

4 $\sin\left(2\pi f\left(t+\Delta t_4\right)\right)$

5 $\sin\left(2\pi f\left(t+\Delta t_5\right)\right)$

6 $\sin\left(2\pi f\left(t+\Delta t_6\right)\right)$

7 $\sin\left(2\pi f\left(t+\Delta t_7\right)\right)$

8 $\sin\left(2\pi f\left(t+\Delta t_8\right)\right)$

9 $\sin\left(2\pi f\left(t+\Delta t_9\right)\right)$

$$\frac{1}{9}\sum_{n=1}^{9}\sin\left(2\pi f\left(t+\Delta t_n\right)\right)$$

Gemiddelde

Array output (1)

$$\frac{1}{N}\sum_{n=1}^{N}\sin\left(2\pi f\left(t+\Delta t_n\right)\right)=$$

$$\frac{1}{N}\sum_{n=1}^{N}\left\{\sin\left(2\pi ft\right)\cos\left(2\pi f\Delta t_n\right)+\cos\left(2\pi ft\right)\sin\left(2\pi f\Delta t_n\right)\right\}=$$

$$\frac{1}{N}\left\{\sin\left(2\pi ft\right)\sum_{n=1}^{N}\cos\left(2\pi f\Delta t_n\right)+\cos\left(2\pi ft\right)\sum_{n=1}^{N}\sin\left(2\pi f\Delta t_n\right)\right\}=$$

$$\frac{1}{N}\left\{A\sin\left(2\pi ft\right)+B\cos\left(2\pi ft\right)\right\}=$$

$$\frac{1}{N}\sqrt{A^2+B^2}\left\{\frac{A}{\sqrt{A^2+B^2}}\sin\left(2\pi ft\right)+\frac{B}{\sqrt{A^2+B^2}}\cos\left(2\pi ft\right)\right\}=$$

$$\frac{1}{N}\sqrt{A^2+B^2}\left\{\cos\left(\theta\right)\sin\left(2\pi ft\right)+\sin\left(\theta\right)\cos\left(2\pi ft\right)\right\}$$

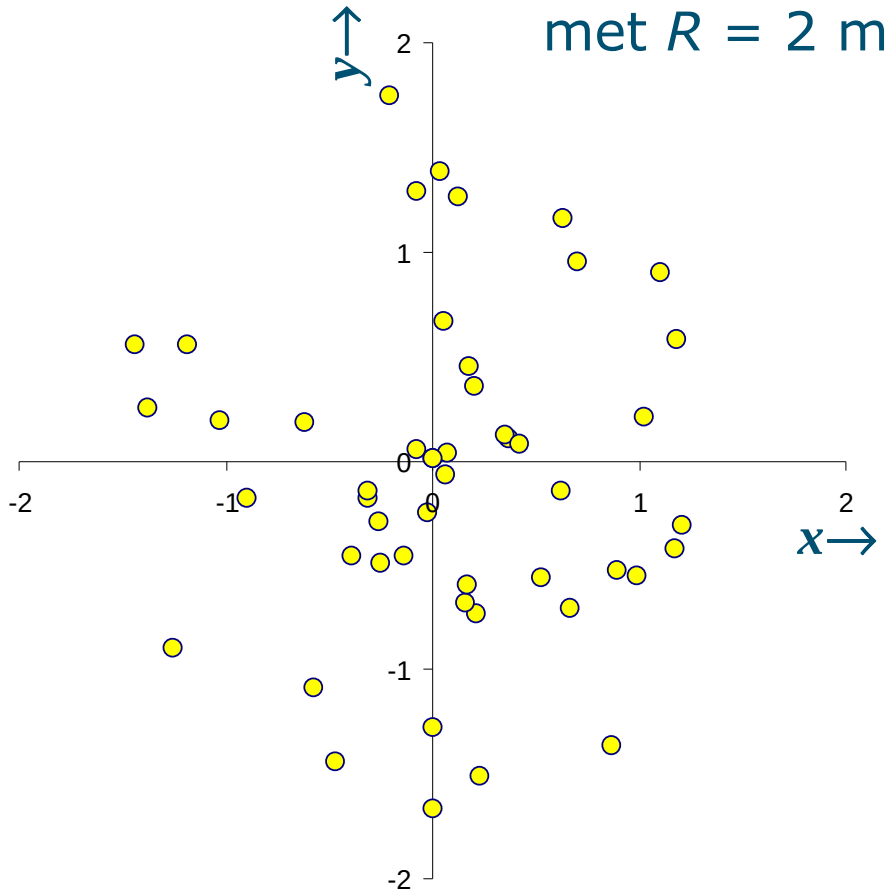
$$\frac{1}{N}\sqrt{A^2+B^2}\sin\left(2\pi ft+\theta\right)$$

Array output (2)

$$C = \frac{1}{N}\sqrt{A^2 + B^2} = \frac{1}{N}\sqrt{\left[\sum_{n=1}^{N}\cos\left(2\pi f \Delta t_n\right)\right]^2 + \left[\sum_{n=1}^{N}\sin\left(2\pi f \Delta t_n\right)\right]^2}$$

- altijd geldt: $C \leq 1$
- als $\Delta t_n = 0$ dan: $C = 1$
- als Δt_n klein is (kleine mismatch) dan: C bijna 1
- hoe groter N, hoe kleiner C (tenzij $\Delta t_n = 0$)

Voorbeeld met random array

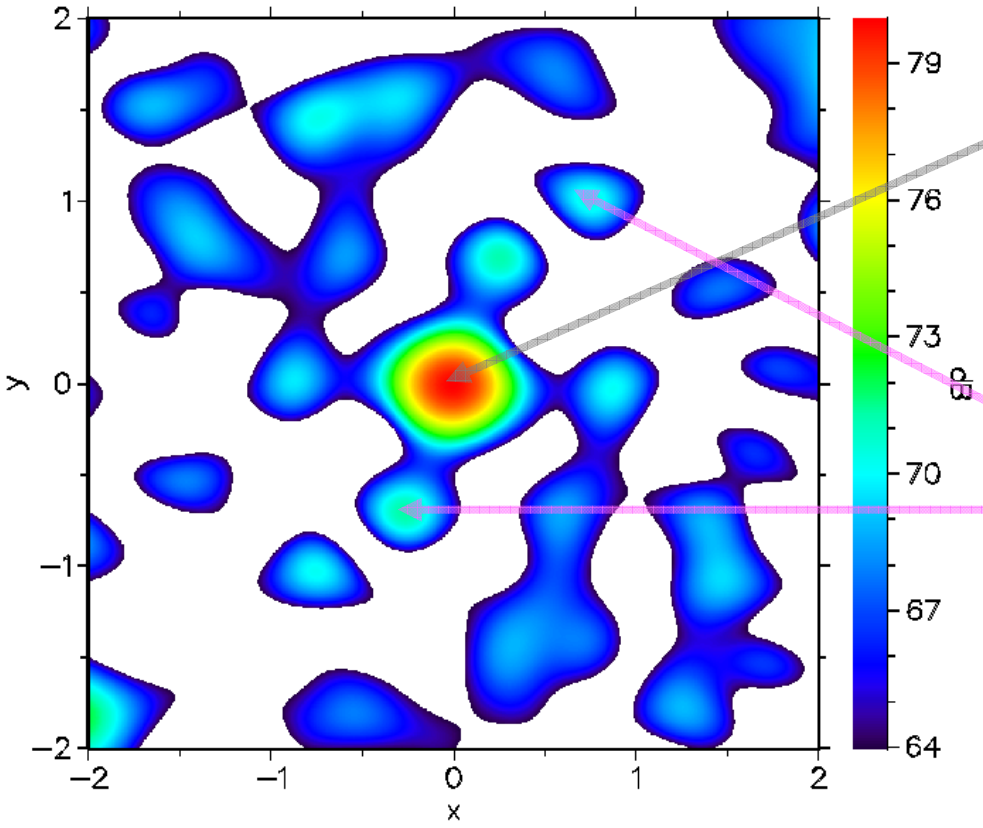


Array van 50 microfoons in een schijf met R = 2 m, in het vlak z = 0

Bron in (0,0,6)
f = 2000 Hz

Voorbeeld met random array

Akoestische scan in vlak (*x*,*y*,6)

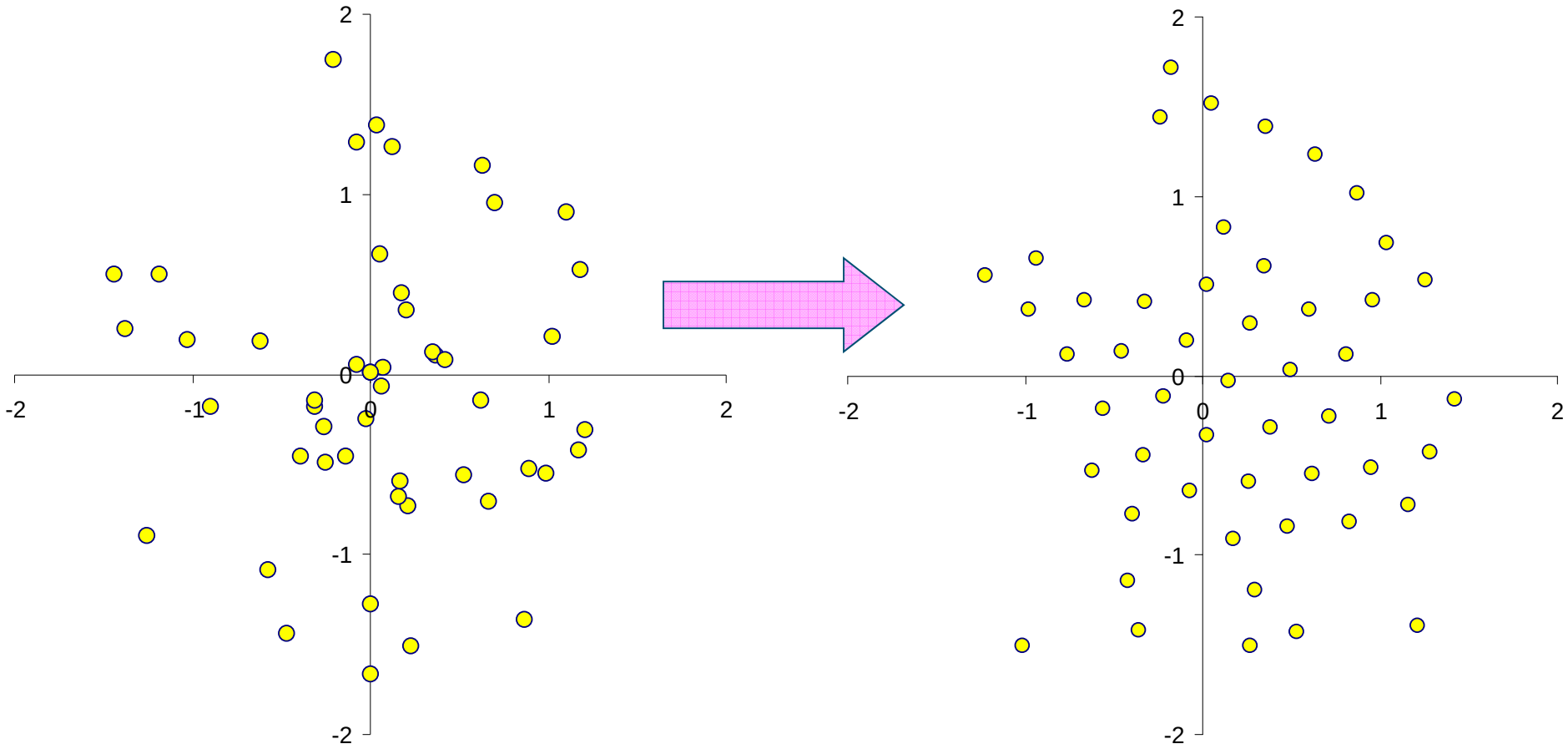


hoofdlob

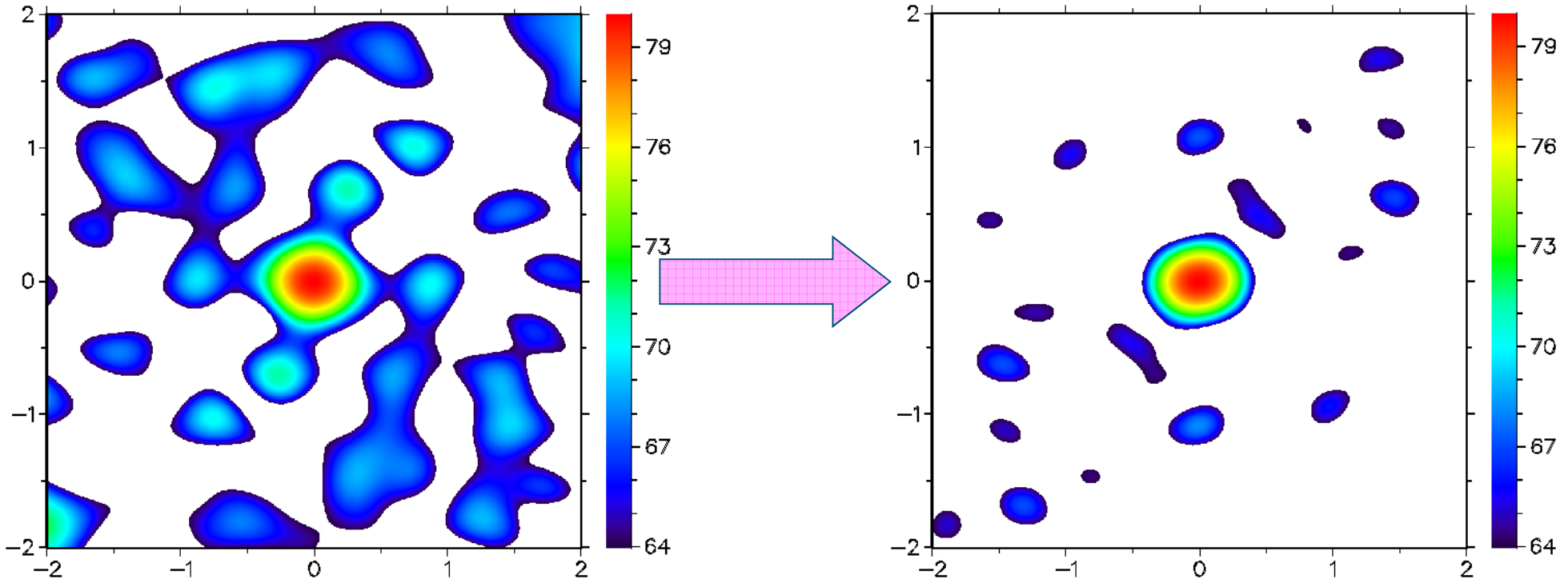
zijlob

zijlob-niveau ≈ -8.5 dB ; $C \approx 0.37$

Verbeteren van array configuratie (1)



Verbeteren van array configuratie (2)

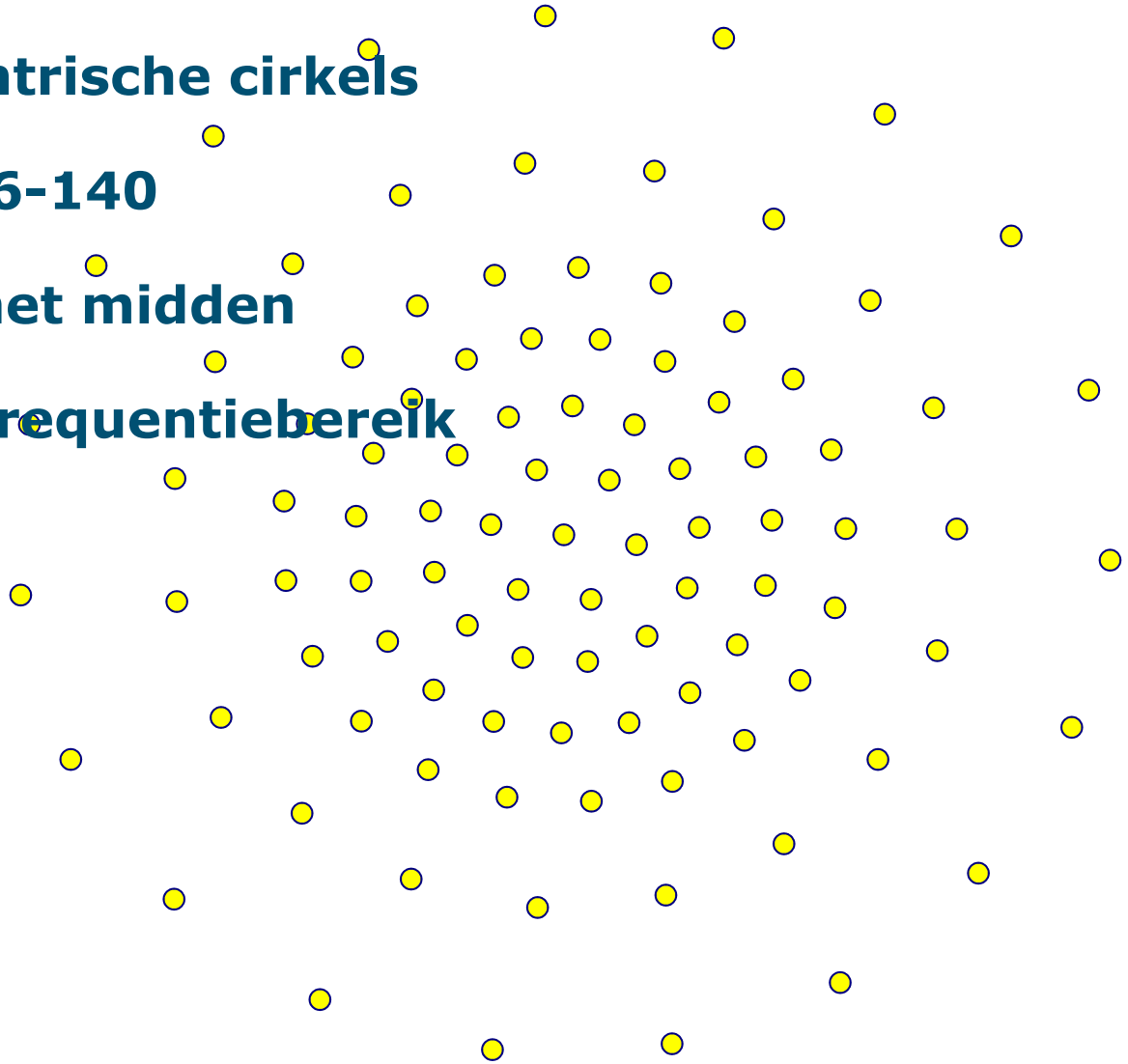


zijlob-niveau ≈ -8.5 dB ; $C \approx 0.37$

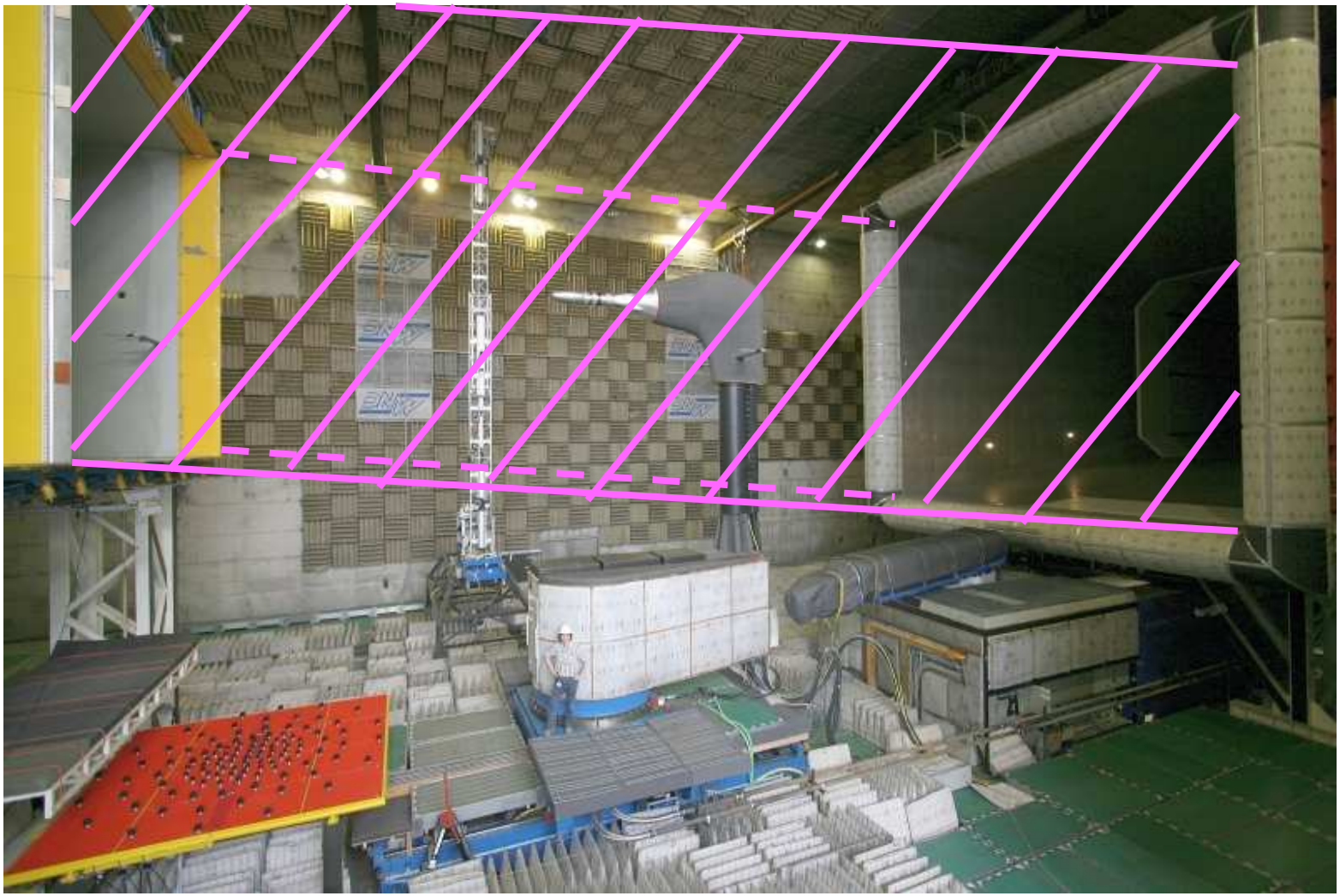
zijlob-niveau ≈ -12.5 dB ; $C \approx 0.24$

Array configuraties bij DNW

- Microfoons op concentrische cirkels
- Aantal microfoons: 96-140
- Hogere dichtheid in het midden
- Geschikt voor groot frequentiebereik
- Zijlobniveau: -13 dB

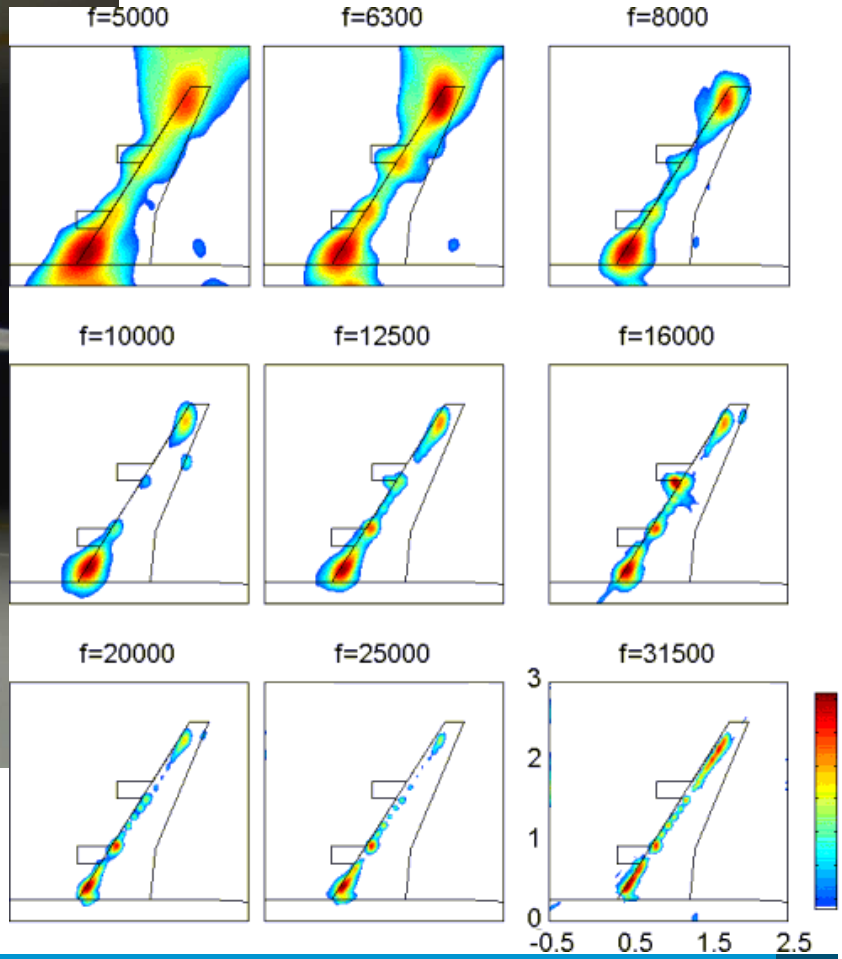


Andere toepassingen



Arrays in gesloten meetplaats (1)

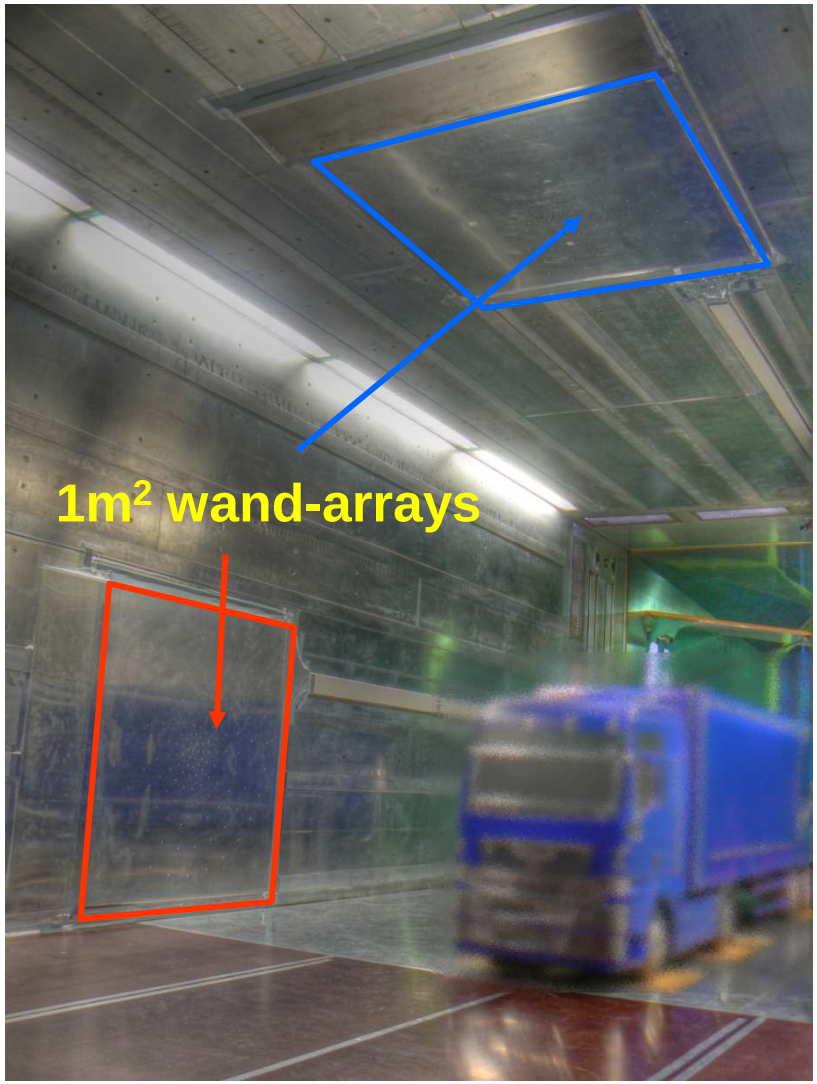
Arrays op de vloer

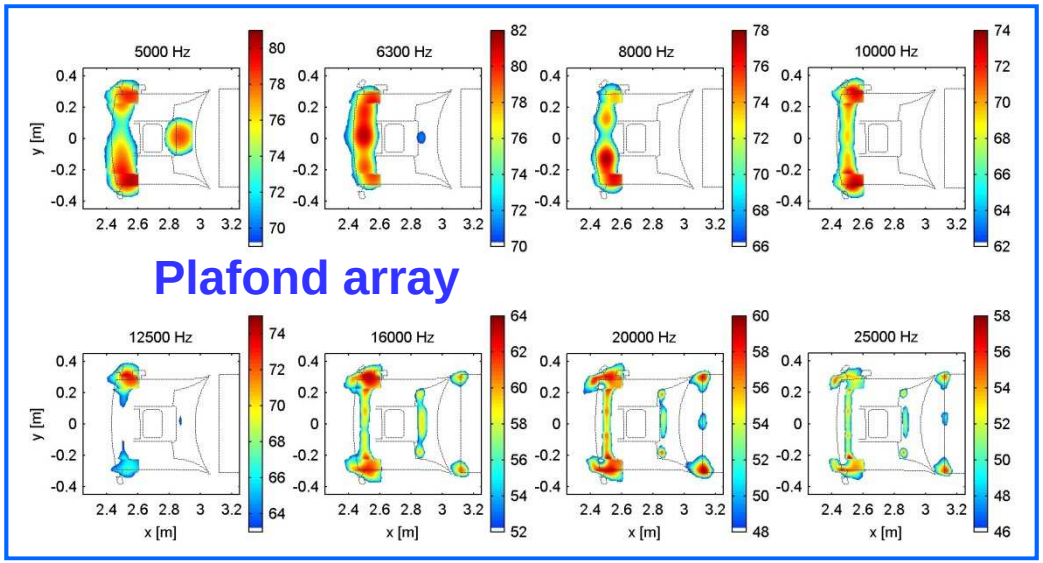


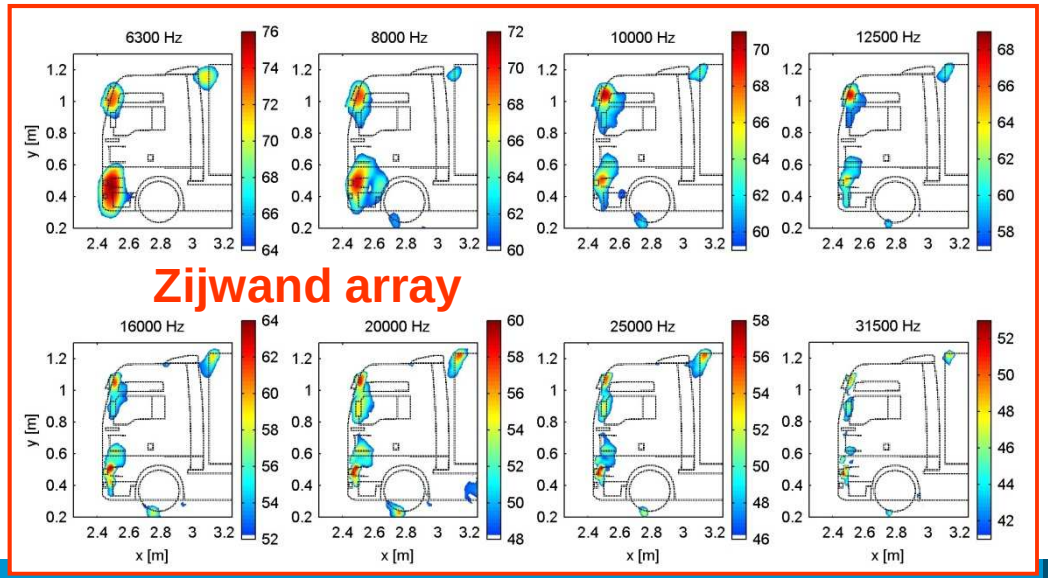
Arrays in gesloten meetplaats (2)

Fokker 100 halfmodel

Arrays in gesloten meetplaats (3)

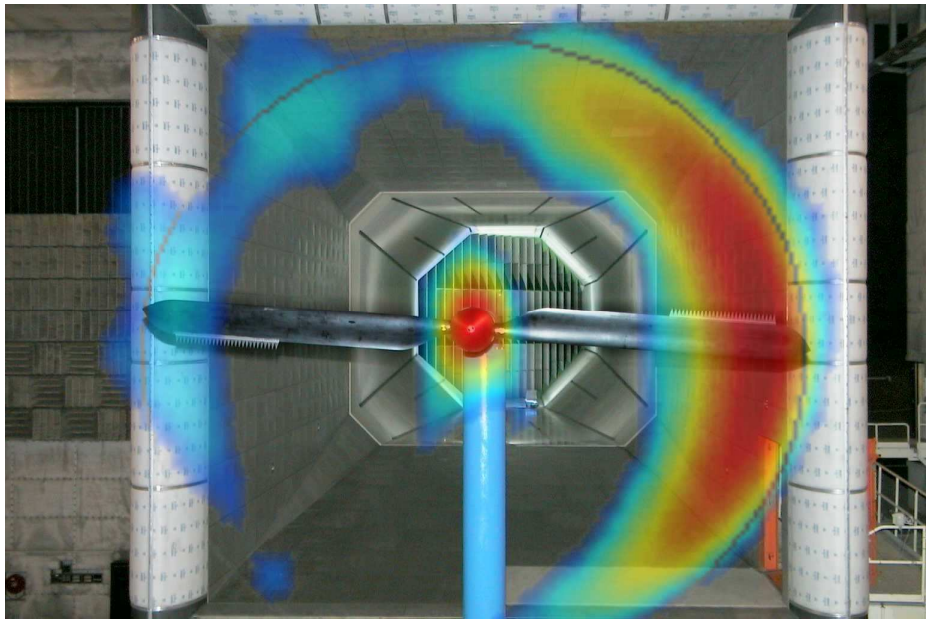






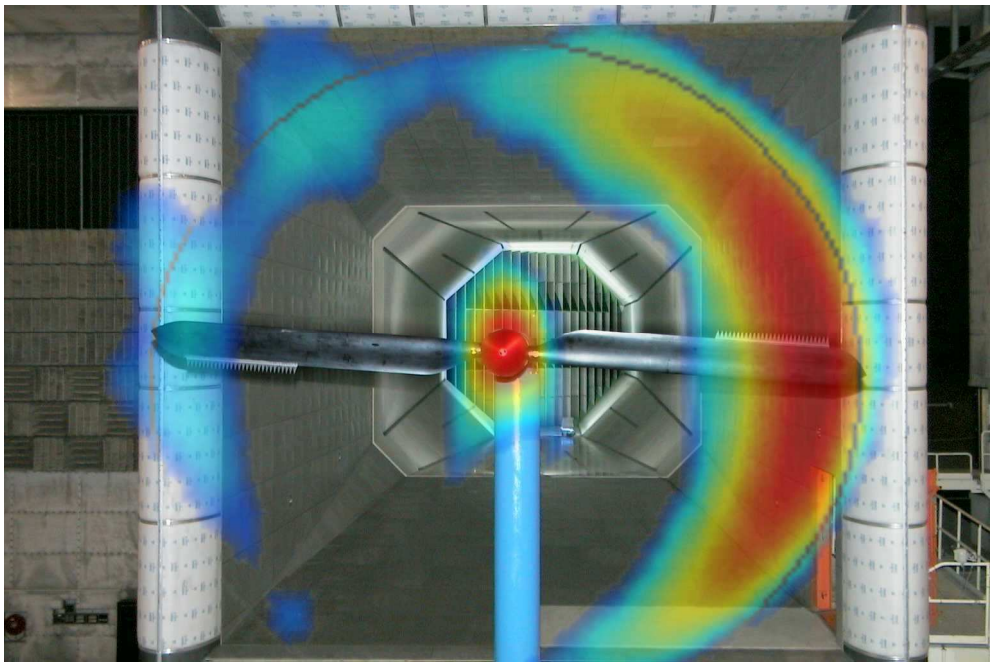
Bewegende bronnen (1)

wind turbine model in DNW-LLF

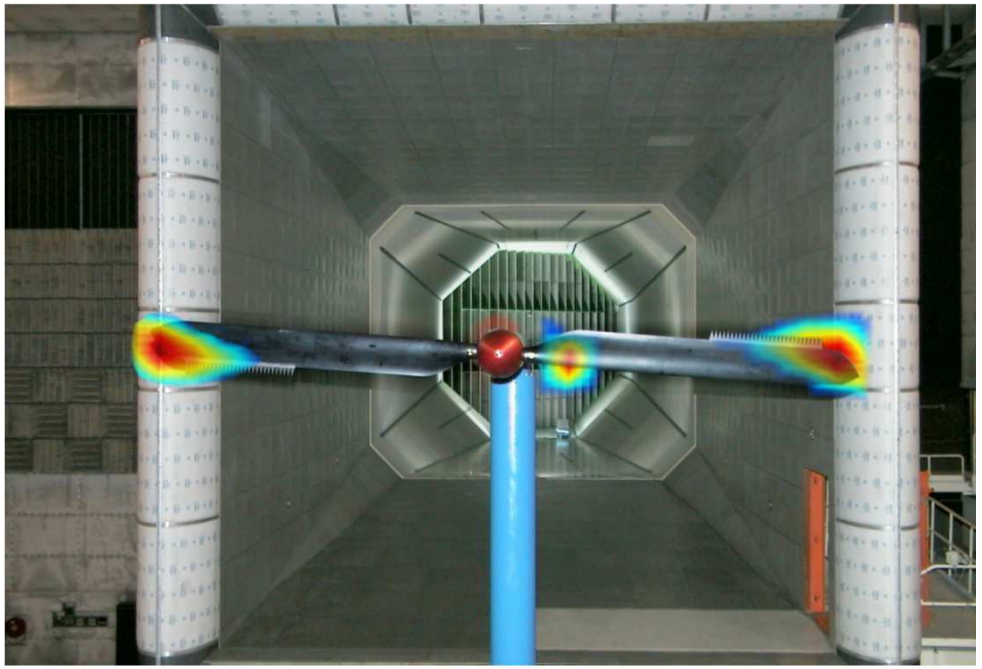


Akoestische scan in rotorvlak

Bewegende bronnen (2)



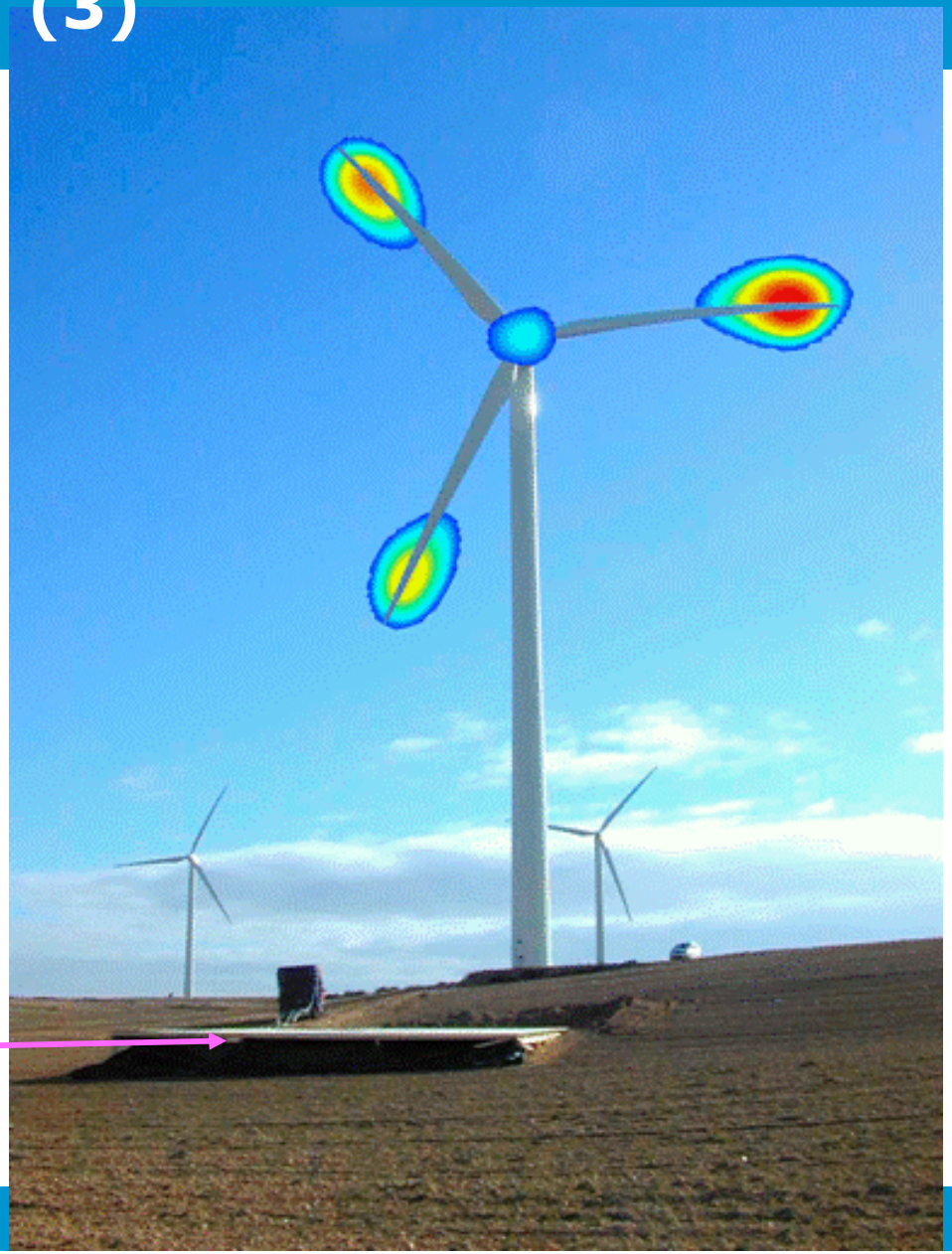
gewoon beamforming



Beamforming op bewegende bronnen

Bewegende bronnen (3)

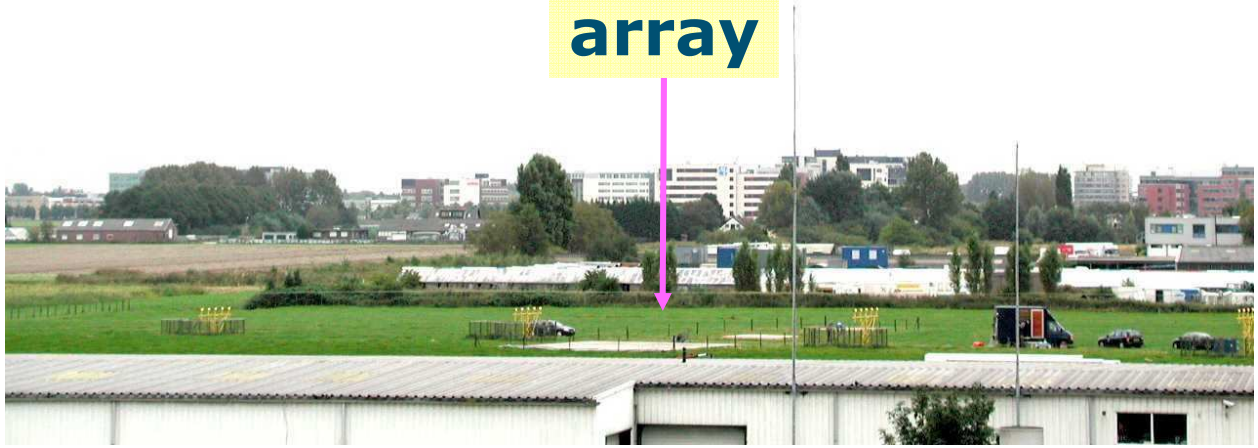
"veld"metingen



Metingen op Schiphol (1)

landende vliegtuigen

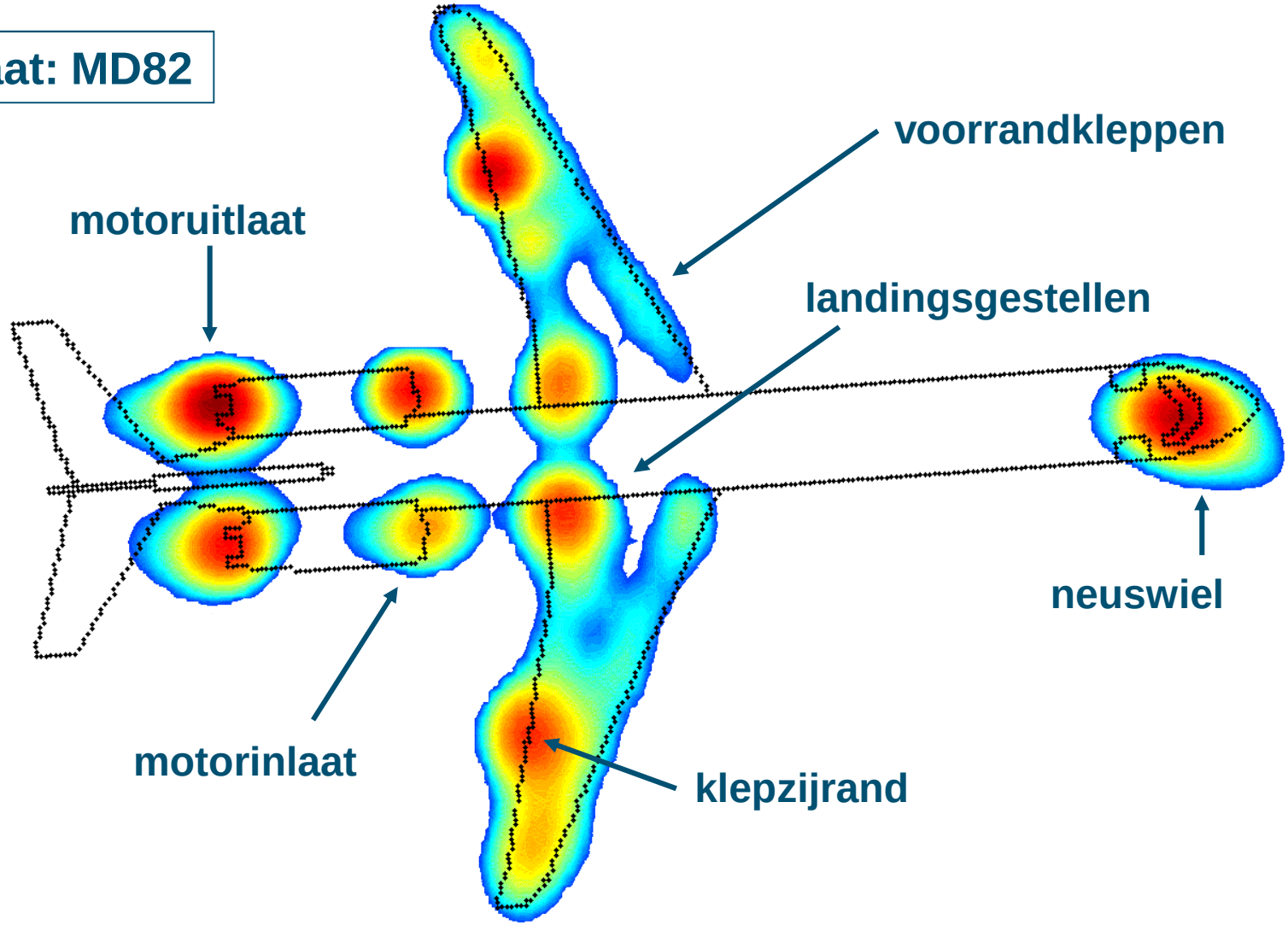
array



Metingen op Schiphol (2)

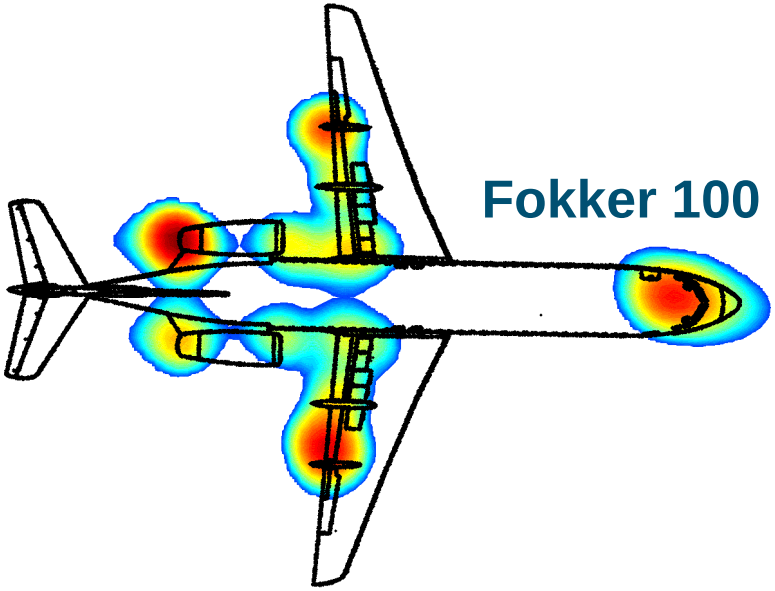
Metingen op Schiphol (3)

Typisch resultaat: MD82

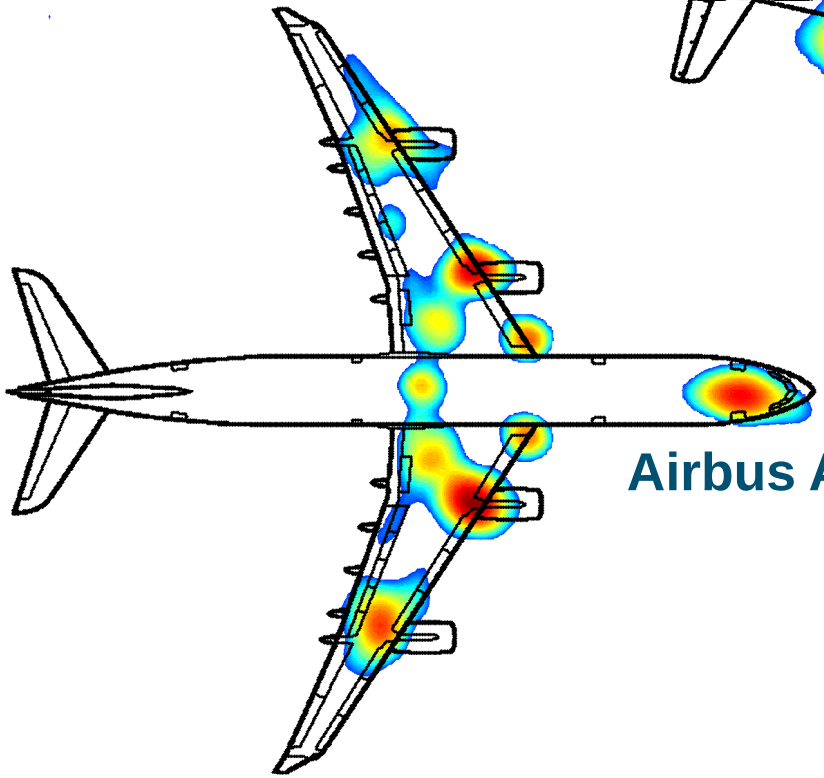


Metingen op Schiphol (4)

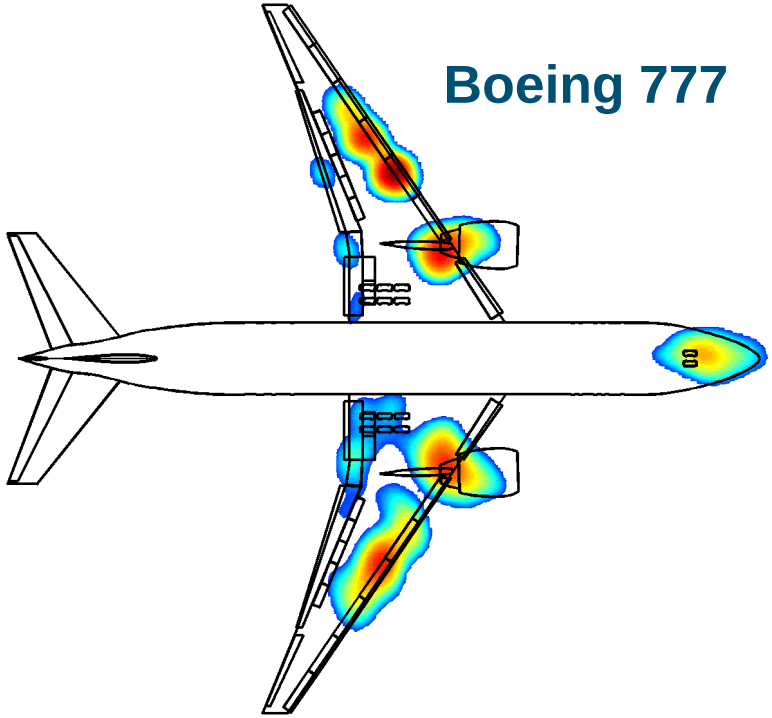
Andere resultaten



Fokker 100

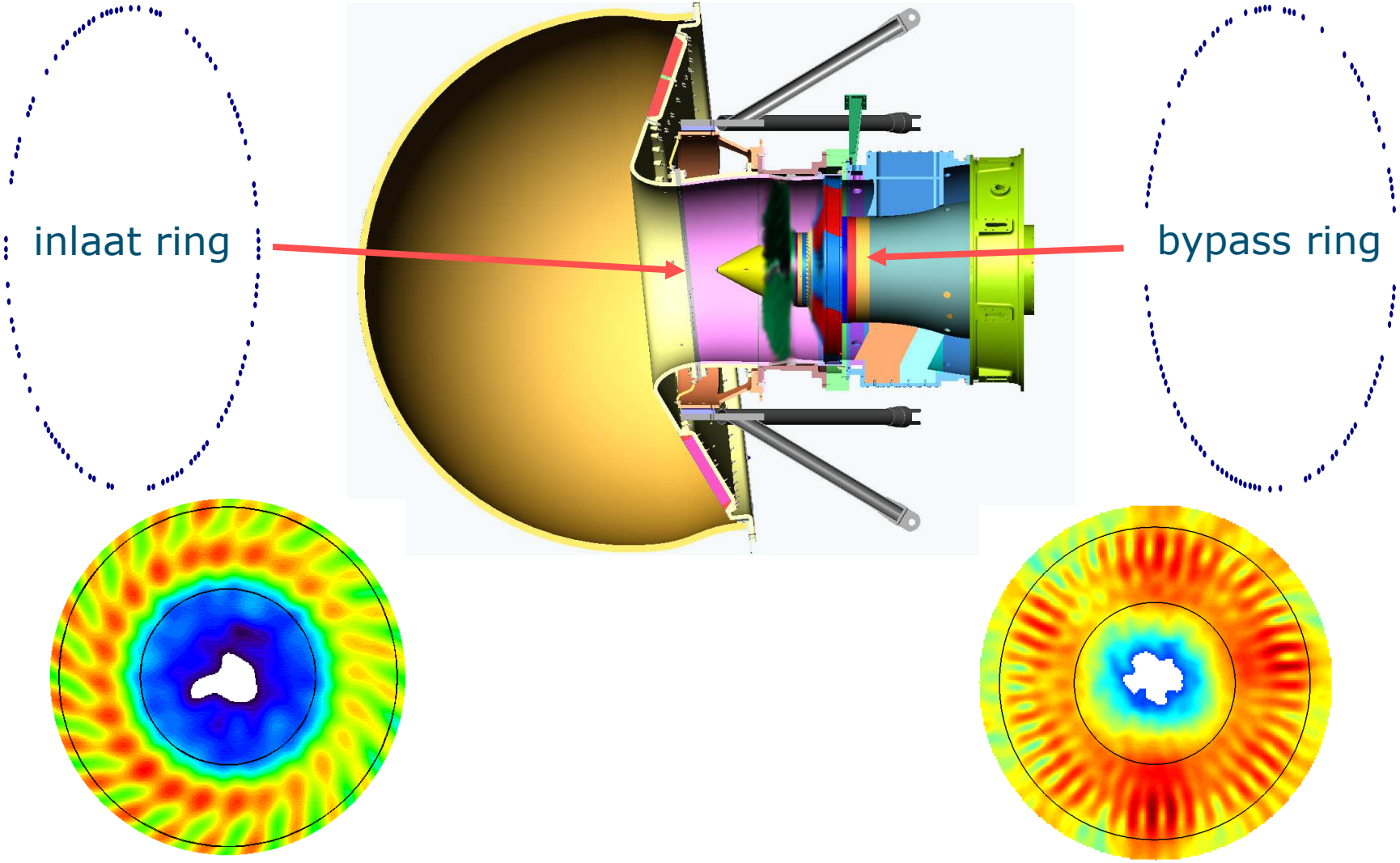


Airbus A340



Boeing 777

Metingen in een vliegtuigmotor



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