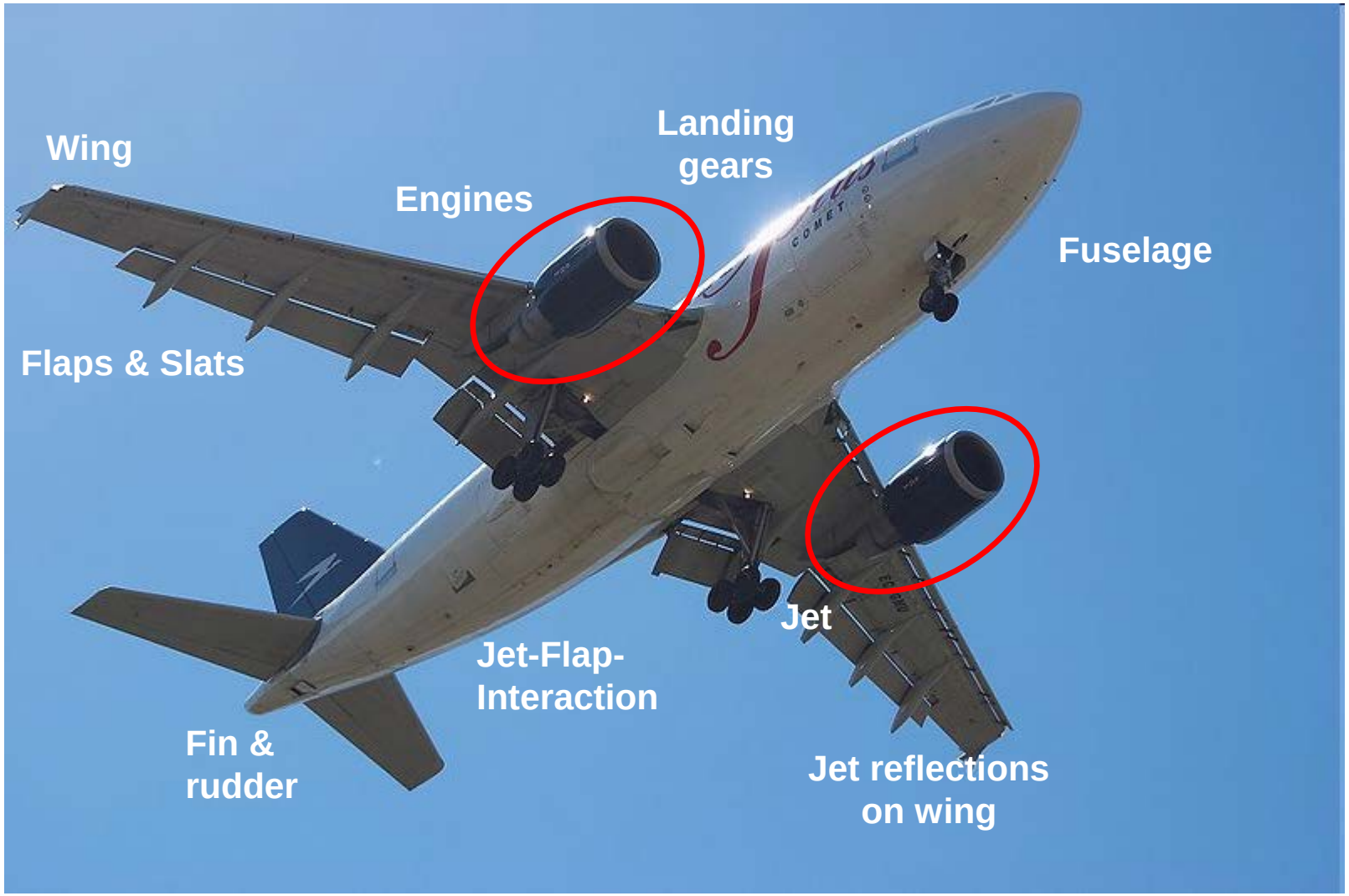
Gegenschall: Eine wichtige Methode im Kampf gegen Lärm aus Flugzeugtriebwerken

Lars Enghardt
DLR, Institut für Antriebstechnik, Triebwerksakustik, Berlin

ICANA, 24.11.2016, Frankfurt

Noise sources of civil aircraft



Bildquelle: Wikimedia Commons

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Major Engine Noise Sources

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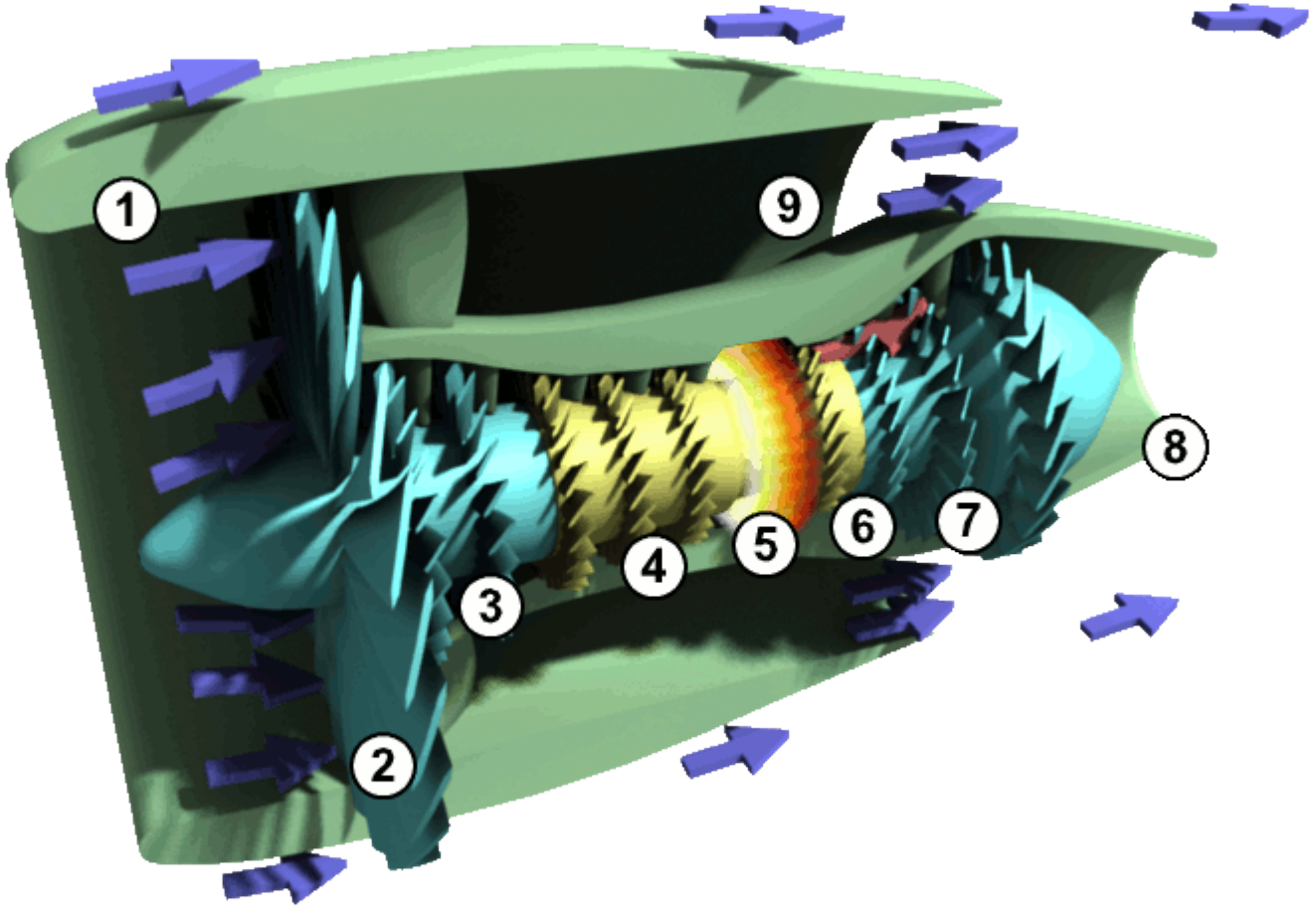
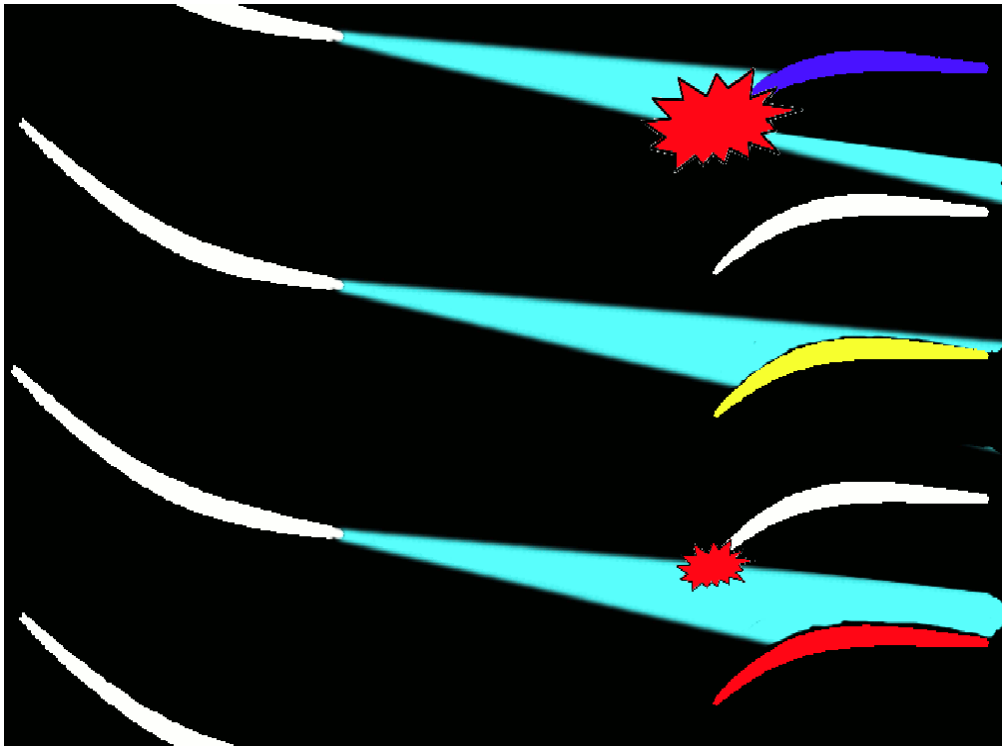
(Bypass-)Turboengine



Source: Wikimedia Commons

Fan Noise

- **Rotor-Stator-Interaction**
  - Wakes (spiraling) of the rotor blades
    impinge on the stator leading edges, causing fluctuating forces



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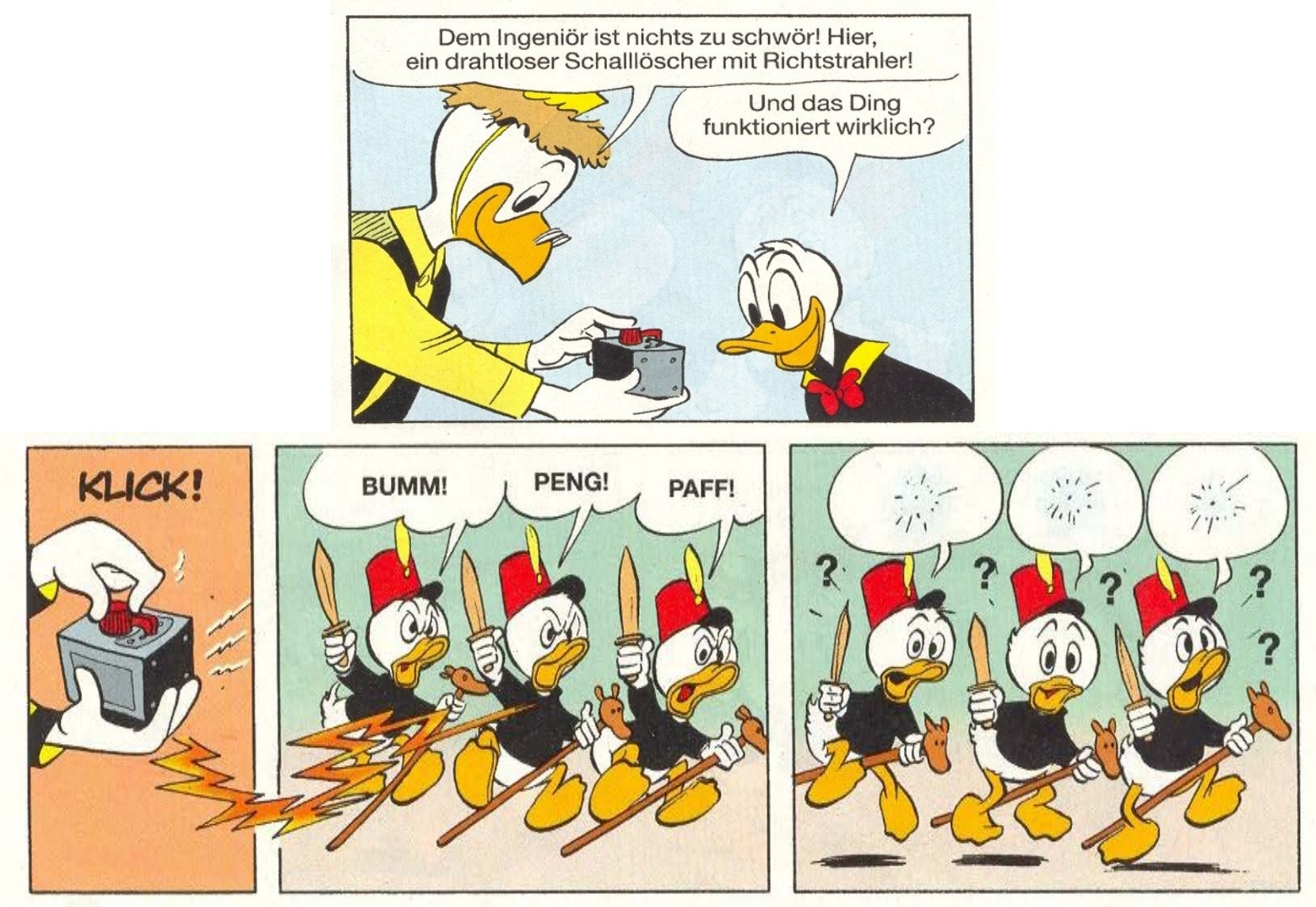
Jet Noise

JW Nichols, CTR, 2013

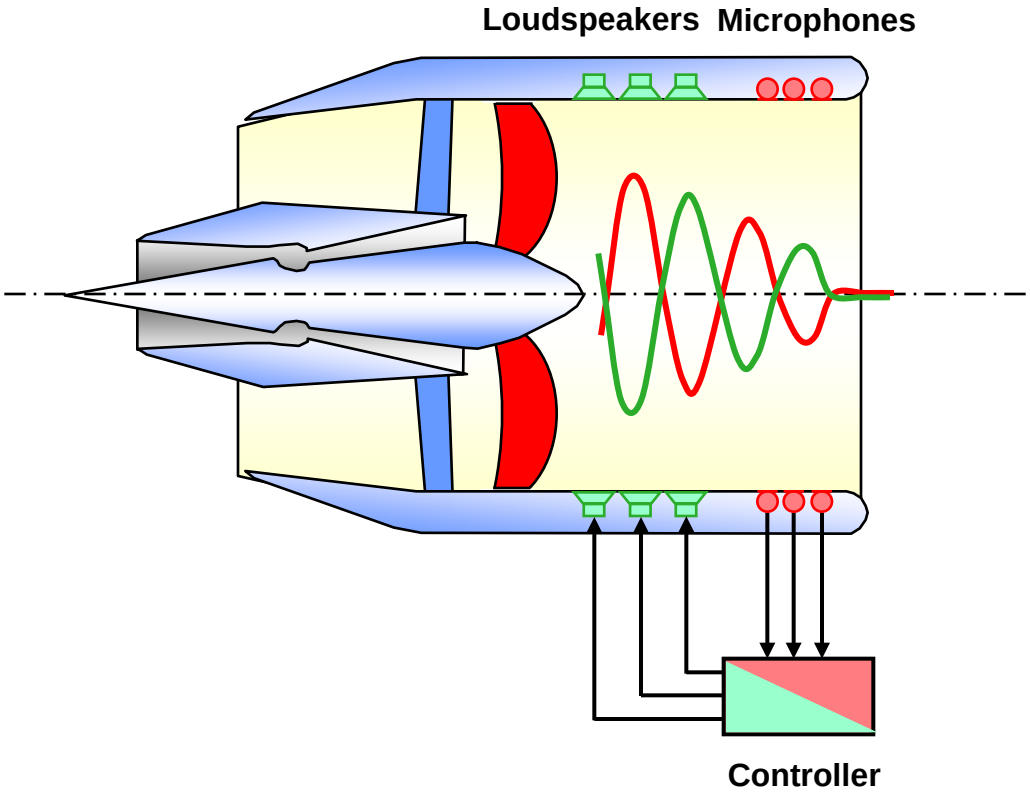
Pressure (grey), Temperature (coulored)

Future Perspectives

Active Noise Control – is it an easy task?



Active Noise Control (ANC) in Aeroengines



Sound field - analysis

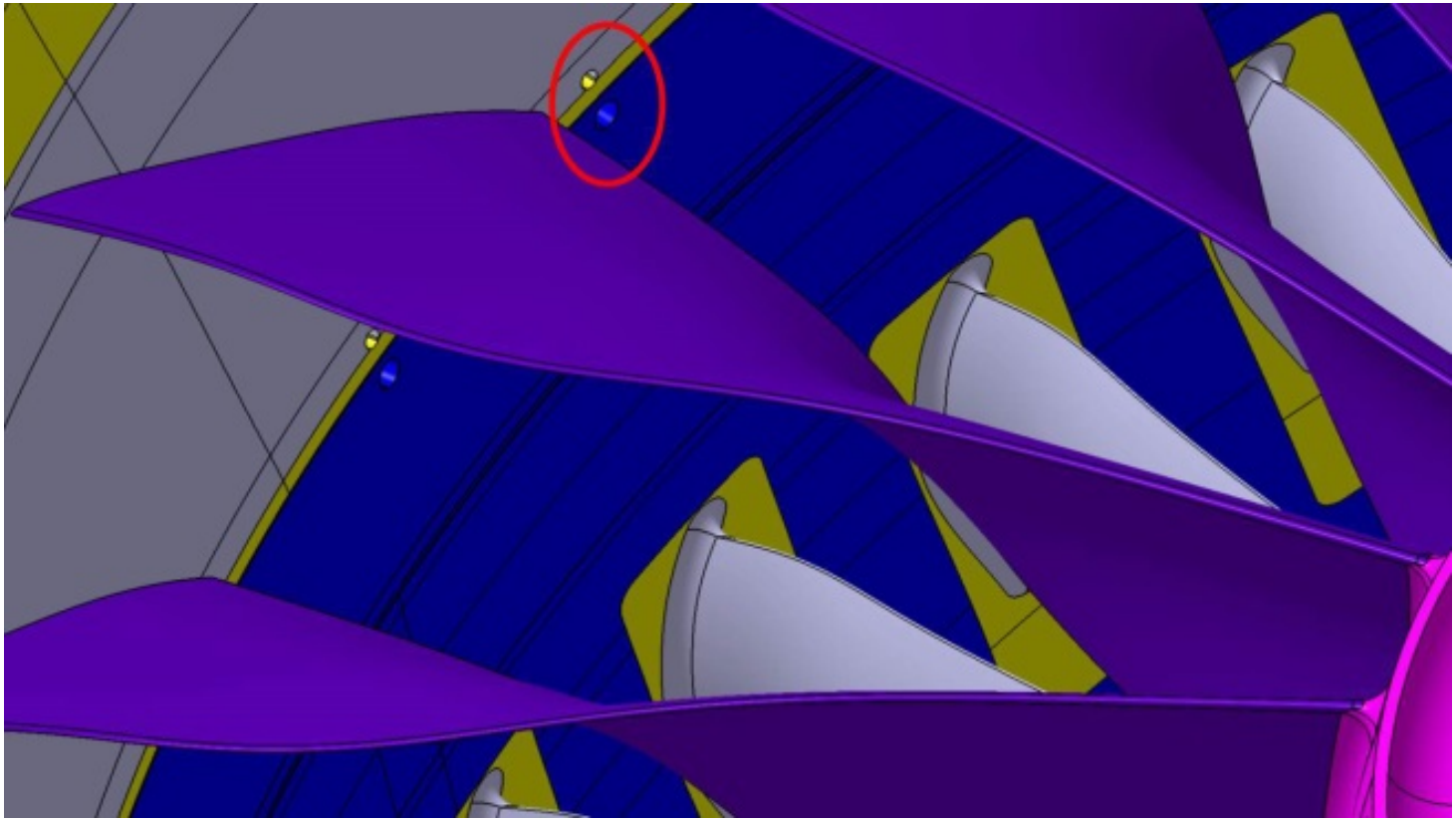
Control

Sound field - synthesis

Active blowing: concept I

ANC with flow-induced secondary sound sources

- Reduction of the rotor-stator-interactions (primary field) by means of superposition of a secondary sound field in anti-phase
- Stationary blowing of pressurized air between rotor and stator → interference of the potential field at the rotor tips → excitation of the secondary sound field



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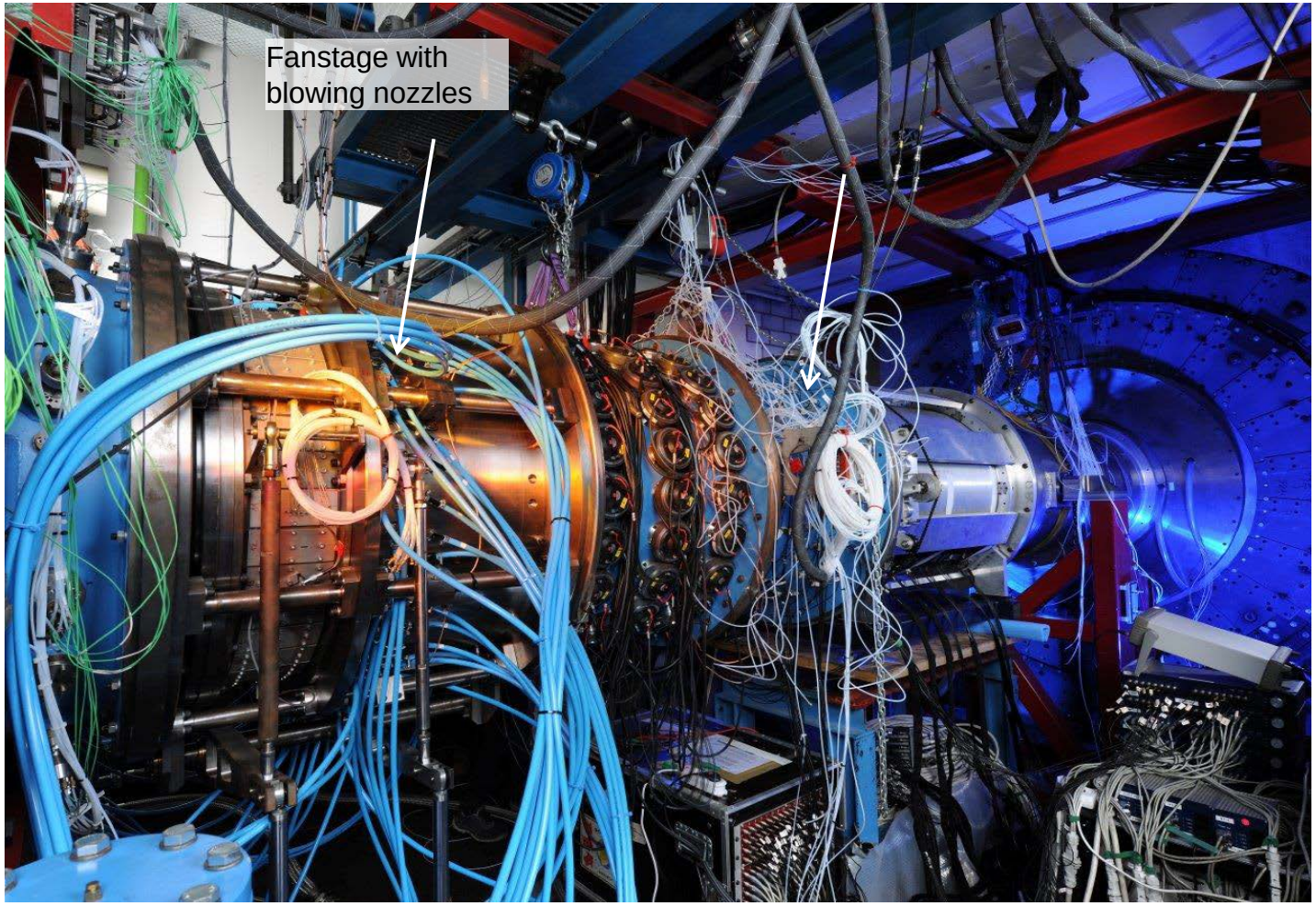
LuFo IV, LeiLa

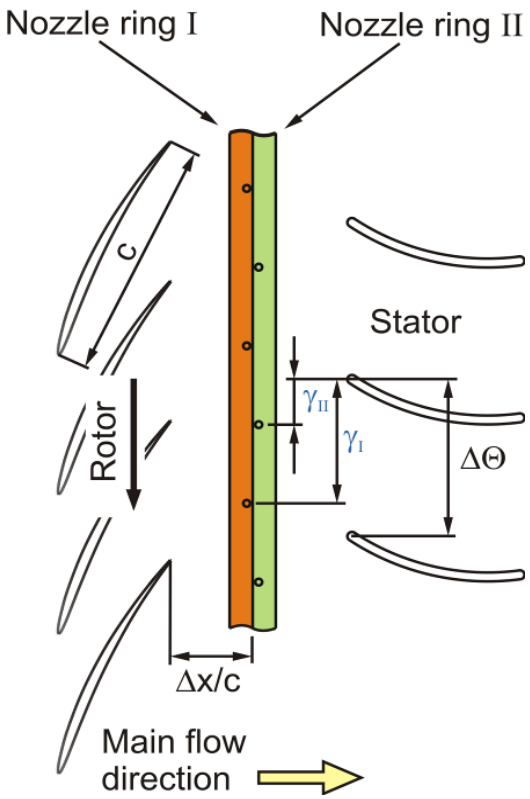
Experimental demonstration at large scale



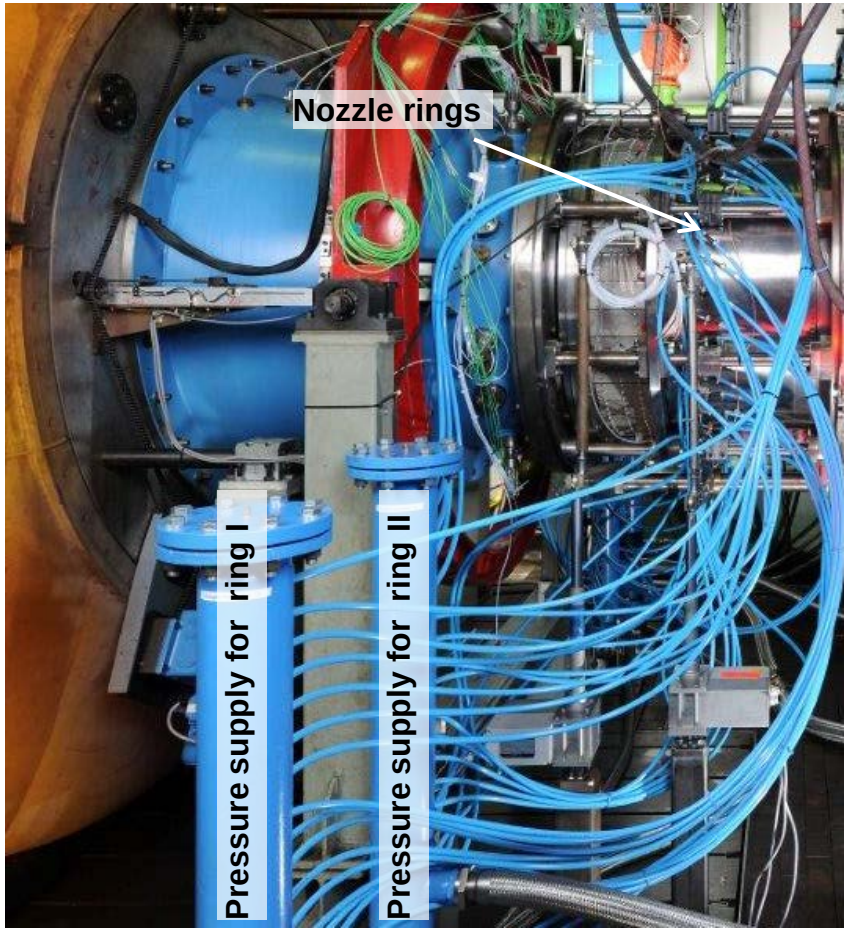
Multistage twoshaft axial compressor rig (M2VP)

ANC Principle

- Application of two rotatable nozzle rings, each equipped with 38 nozzles
- Active control of the azimuthal positions and the air mass flow

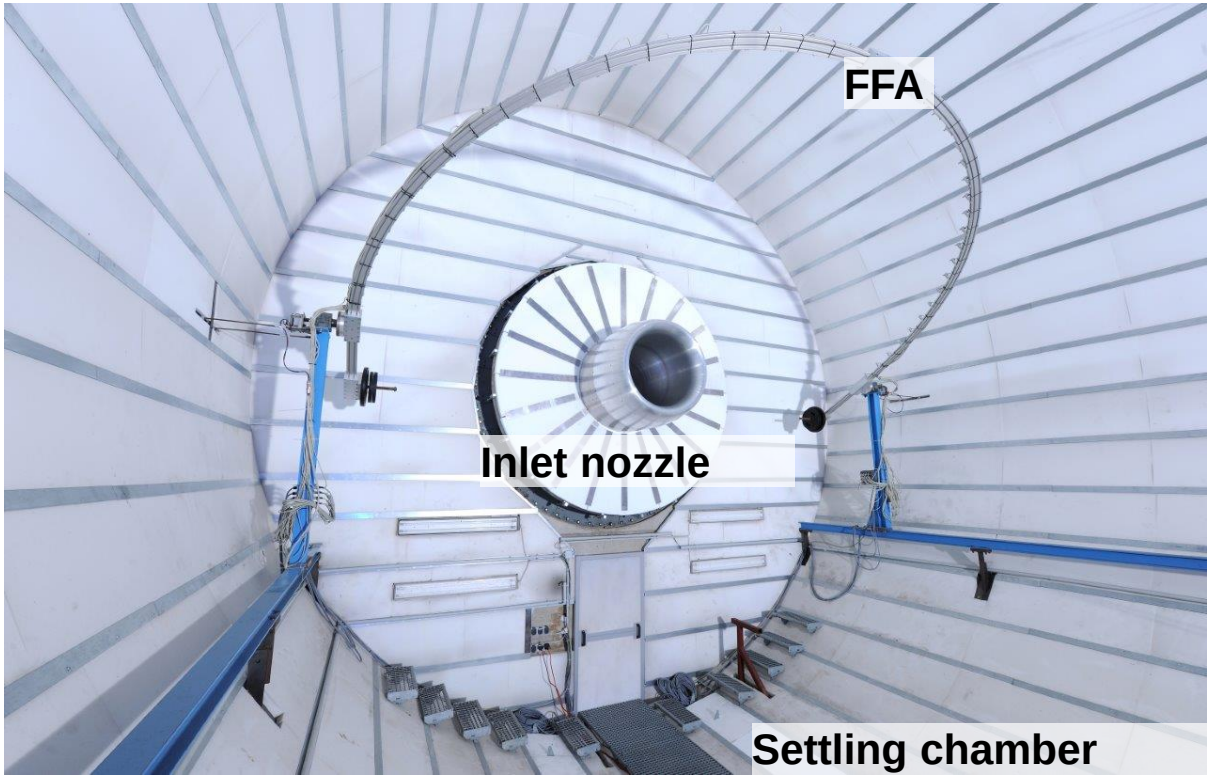


Δx_1 = X mm
Δx_2 = X mm



Far field antenna

- Acquisition of the sound field in the settling chamber by means of a traversable far-field antenna equipped with 40 microphones
- Traverse of the FFA over 180°



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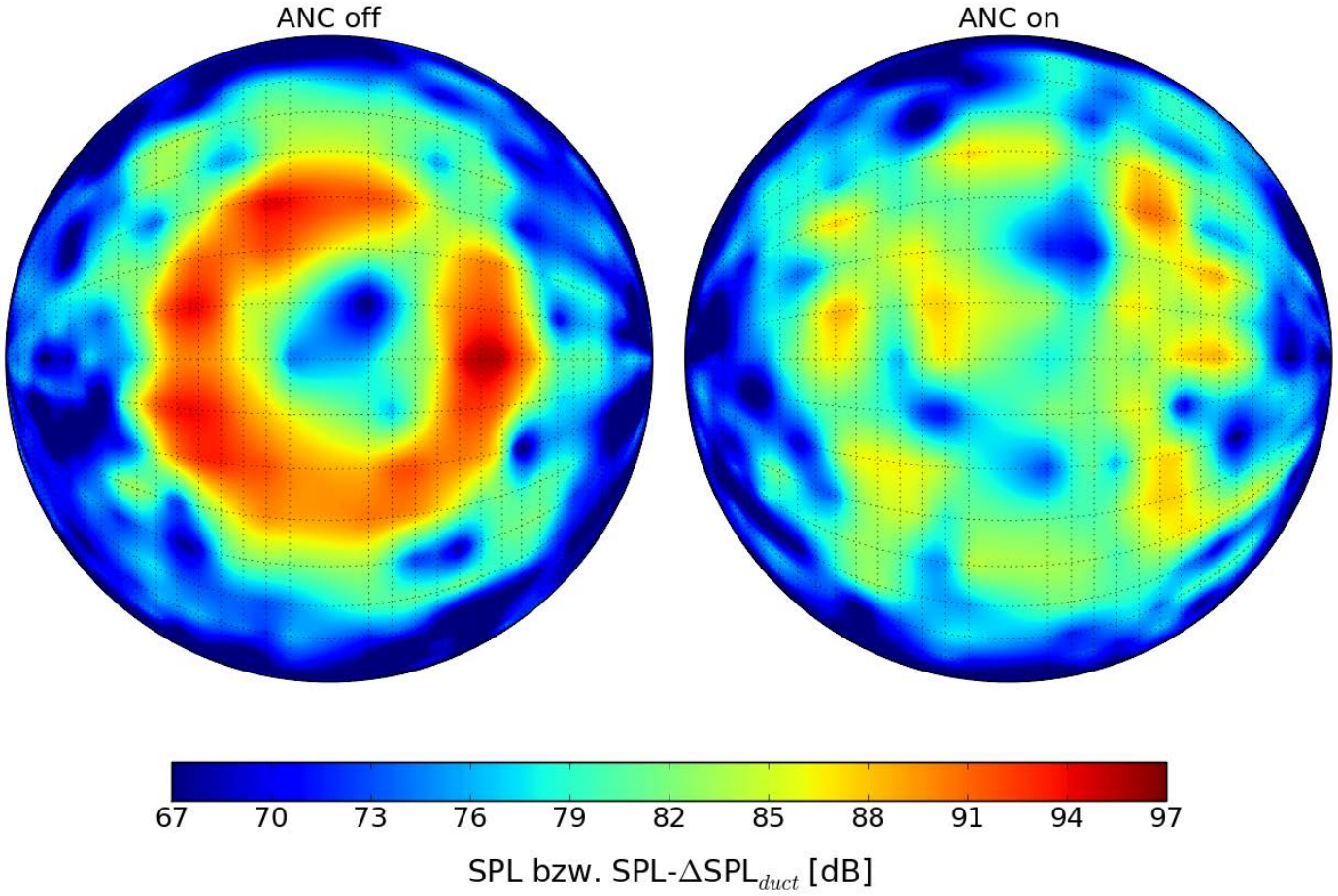
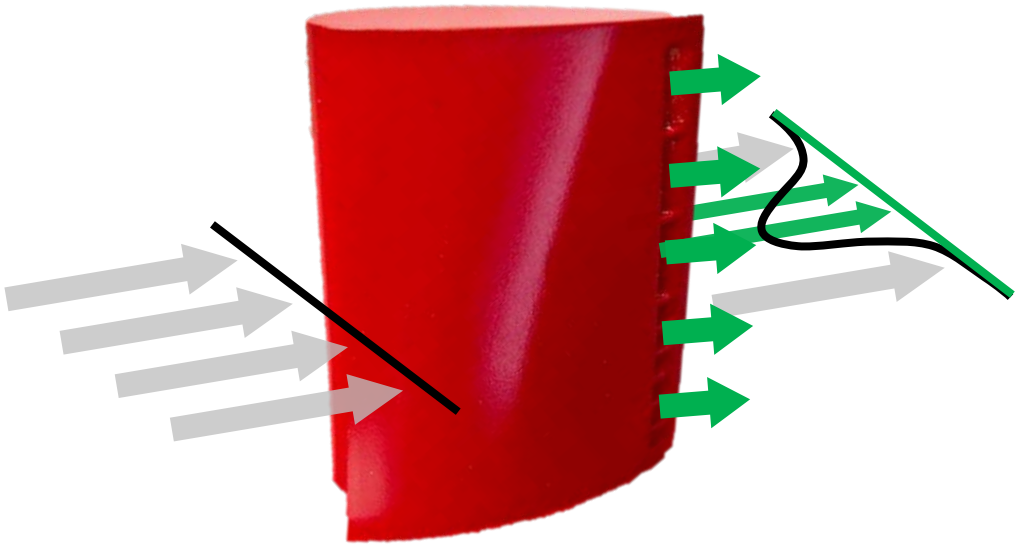
Control result

SPL reduction of up to 10dB in main polar radiation sector



Active blowing: concept II

Illustration of the trailing edge blowing concept



ANC Off - On

Forschungsprojekt in Zusammenarbeit mit der
Universität Siegen, Prof. Dr.-Ing. Th. Carolus

FLOCON 2007 - 2013 UNIVERSITÄT SIEGEN

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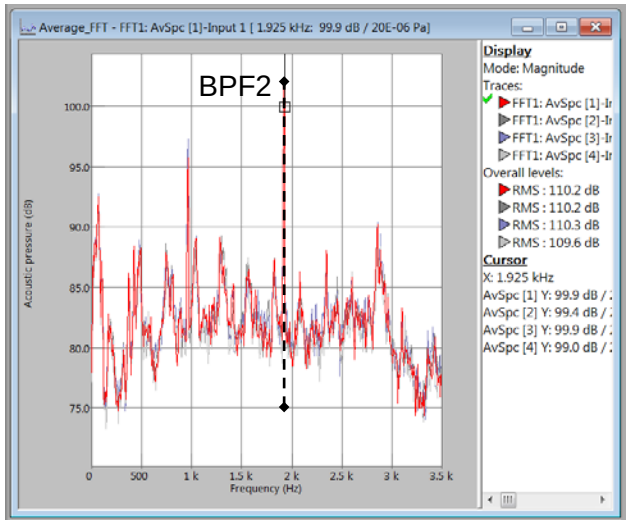
ANC – Off (reference case)

spectrum

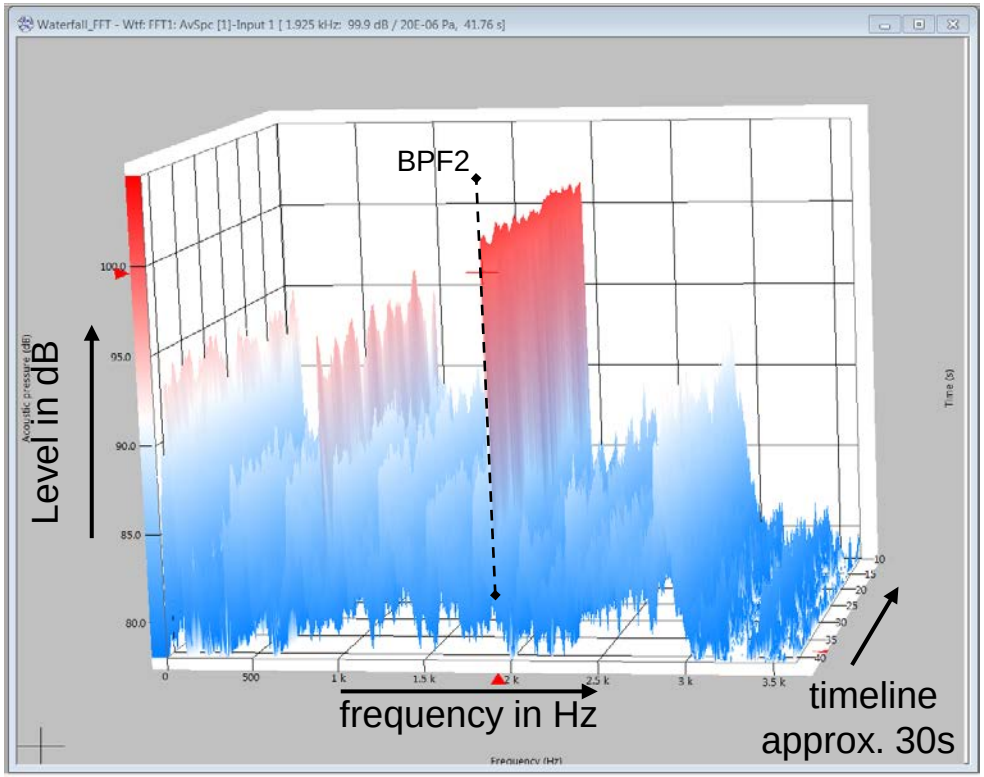
Blade passing frequency
BPF2 at 1920 Hz



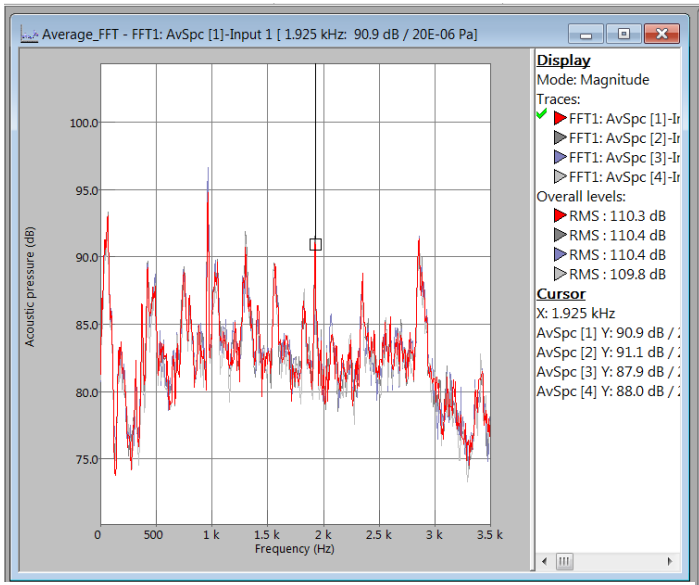
Level in dB

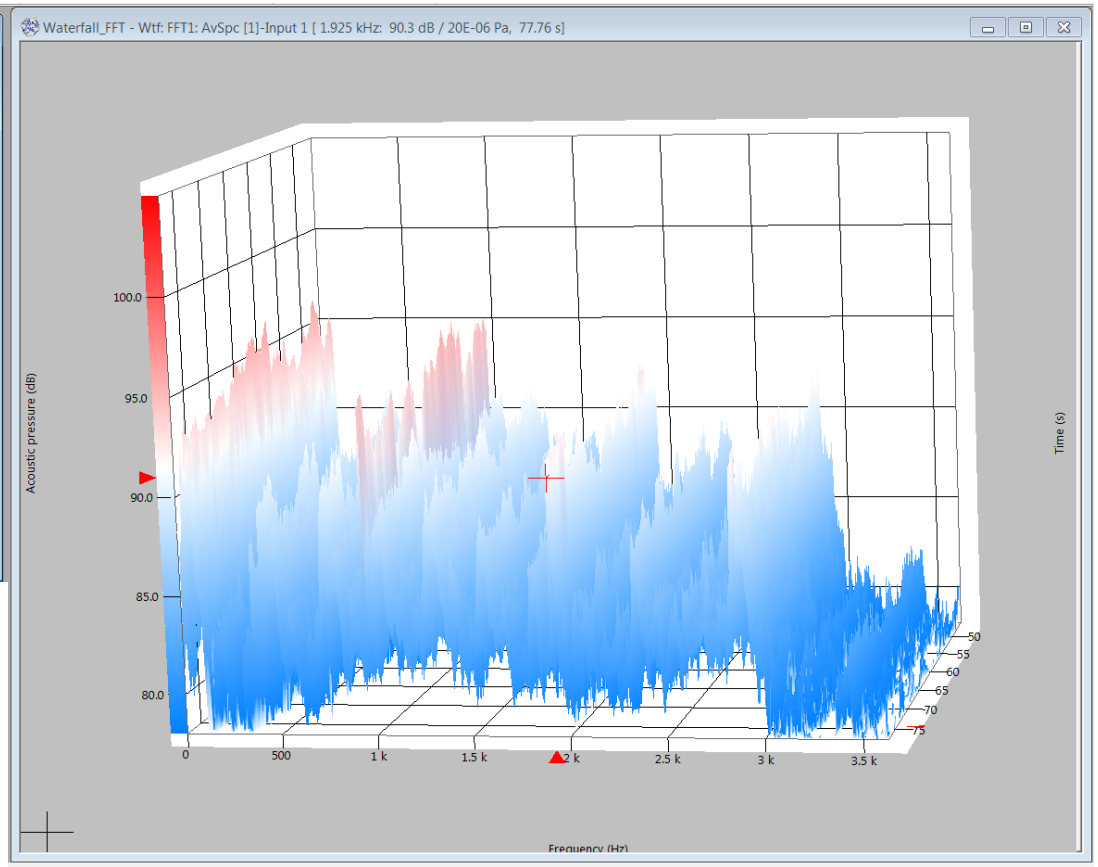
frequency in Hz

waterfall diagram

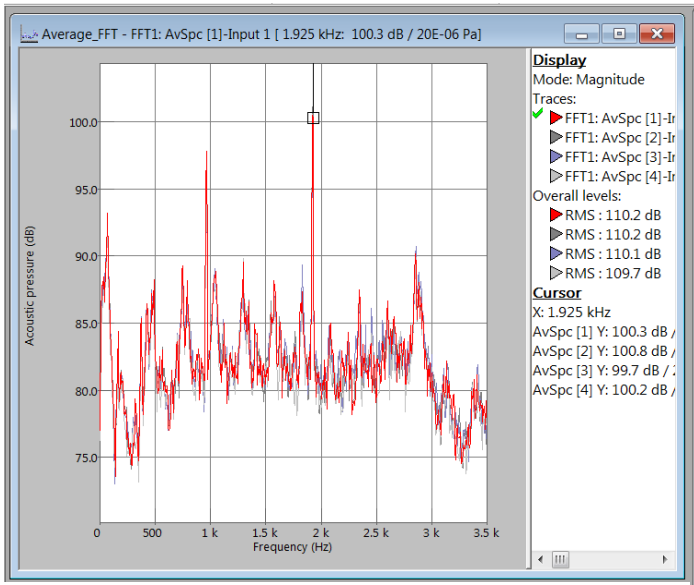


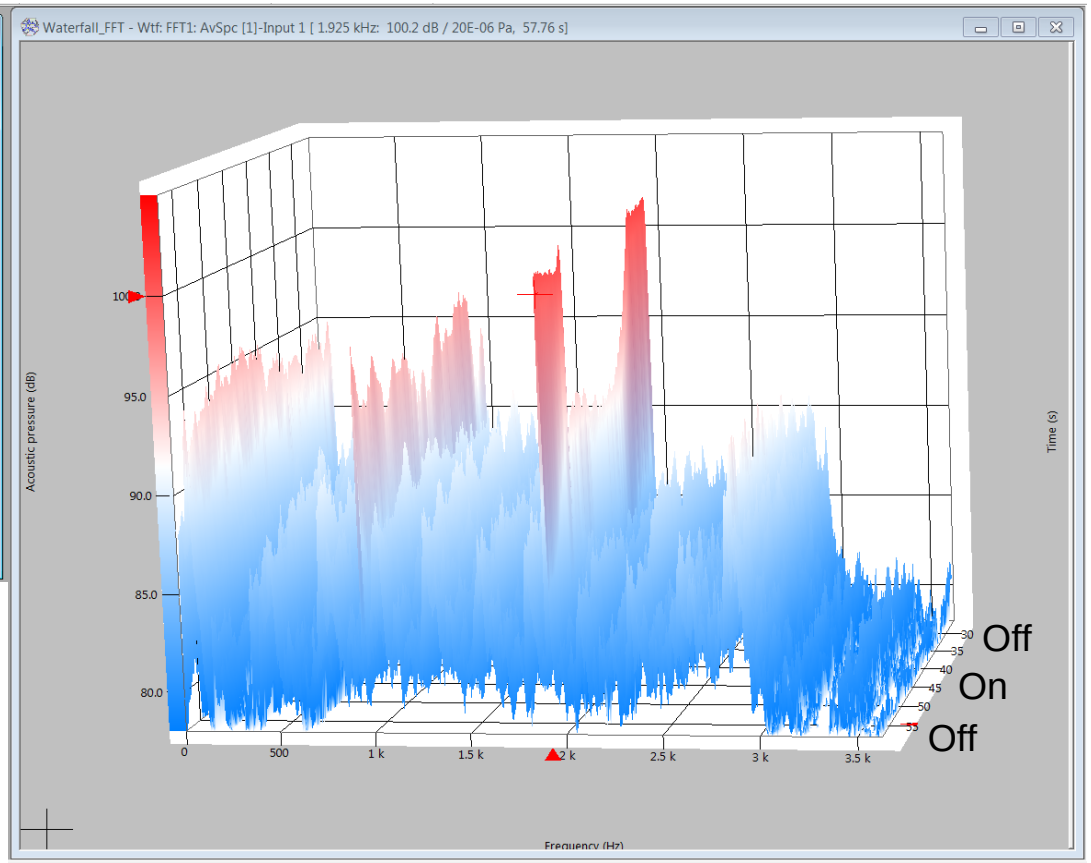
ANC – On (trailing edge blowing)





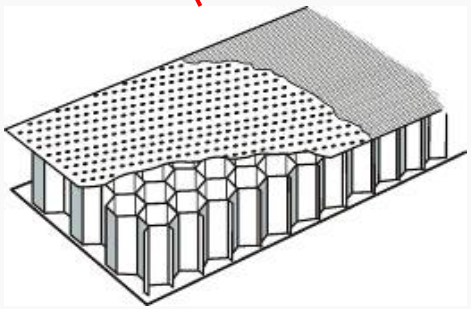
ANC Off – On – Off

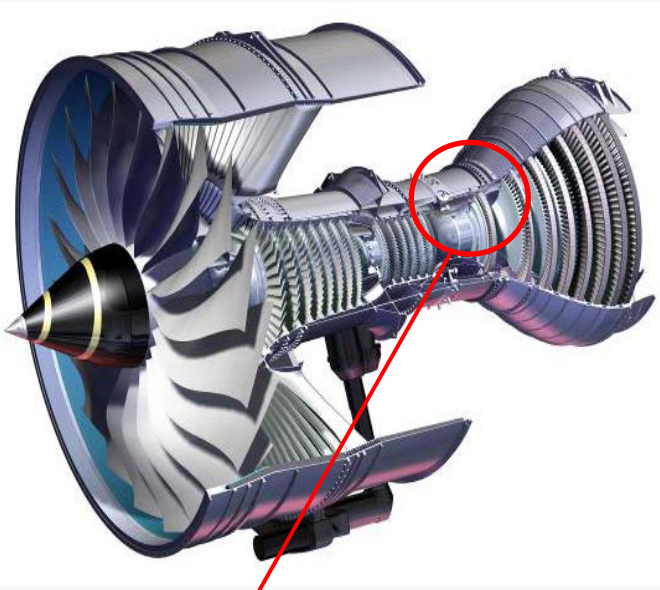


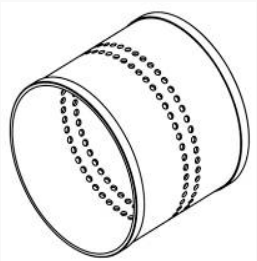


Active liners

Acoustic lining in aero engines







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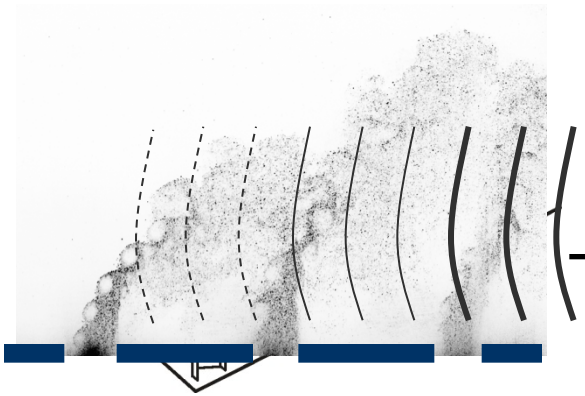
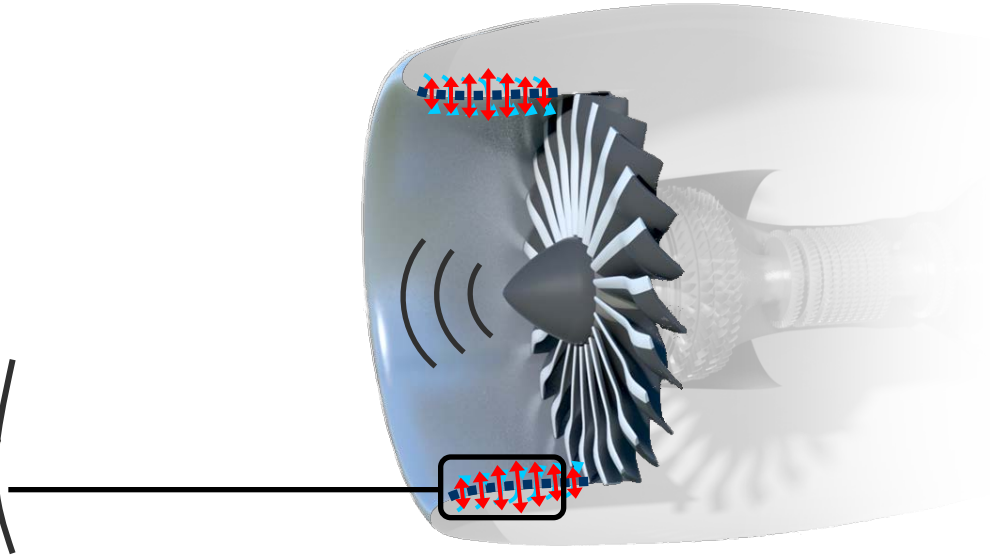
Sound absorber in Aero Engines

- Sound absorption with perforated wall elements (Liner)
  - **passive** (conventional liner design)
  - **active blowing** (high energy comsumption)
  - **periodically active blowing**

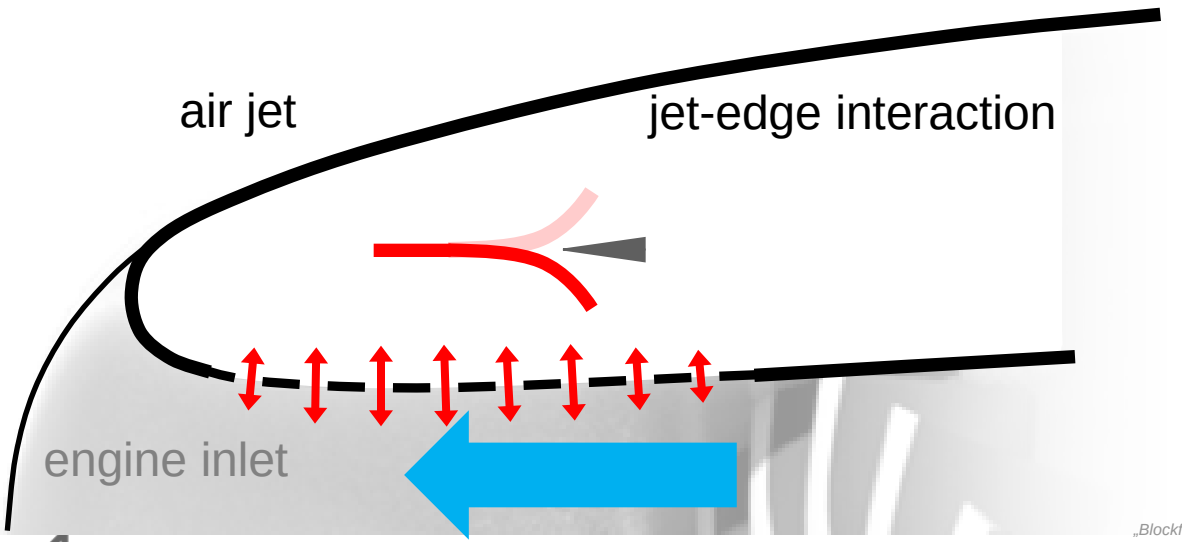




„Schnittdarstellung eines Turbofan-Triebwerkes“
von www.mikejamesmedia.com online 5.11.2011

The whistling liner

- **Flute-like principle** generates periodic pressure fluctuations
- Jet-edge tone excitation - no moving parts
- Simple and robust technology
- Sound attenuation by interaction with fluctuating cross flow

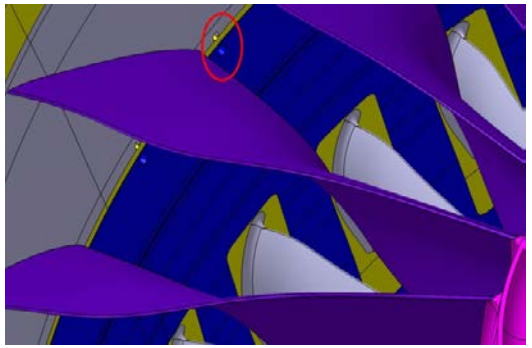


„Blockflöte“ www.kreativschule-4k.de online 5.11.2011

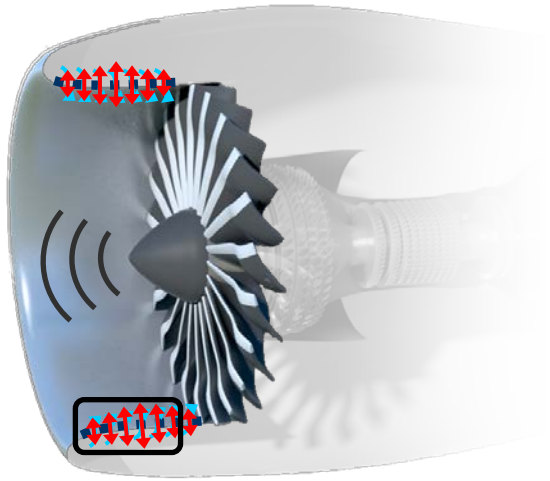
Wrap up

Technologies for future low-noise aero engines

- High-bypass-engines and Chevron-nozzles to reduce jet noise
- Low speed fans to reduce fan noise
- Highly accurate computer-aided acoustical simulation tools for tailored design of low-noise engine components („Design-to-Noise“)
- Highly efficient liners also for low frequencies
- Miniaturisied sound sources to generate anti-noise („Active Noise Control“)
- All-new aircraft design with partly buried aero-engines



Fan equipped with ANC-system



Whistling liner

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