

Needs for future experimental testing in Aeroacoustics

– DNW Symposium Future Needs - The next 20 years –
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Jan Delfs

Technical Acoustics, AS-TEA

Institute of Aerodynamics and Flow Technology



Knowledge for Tomorrow



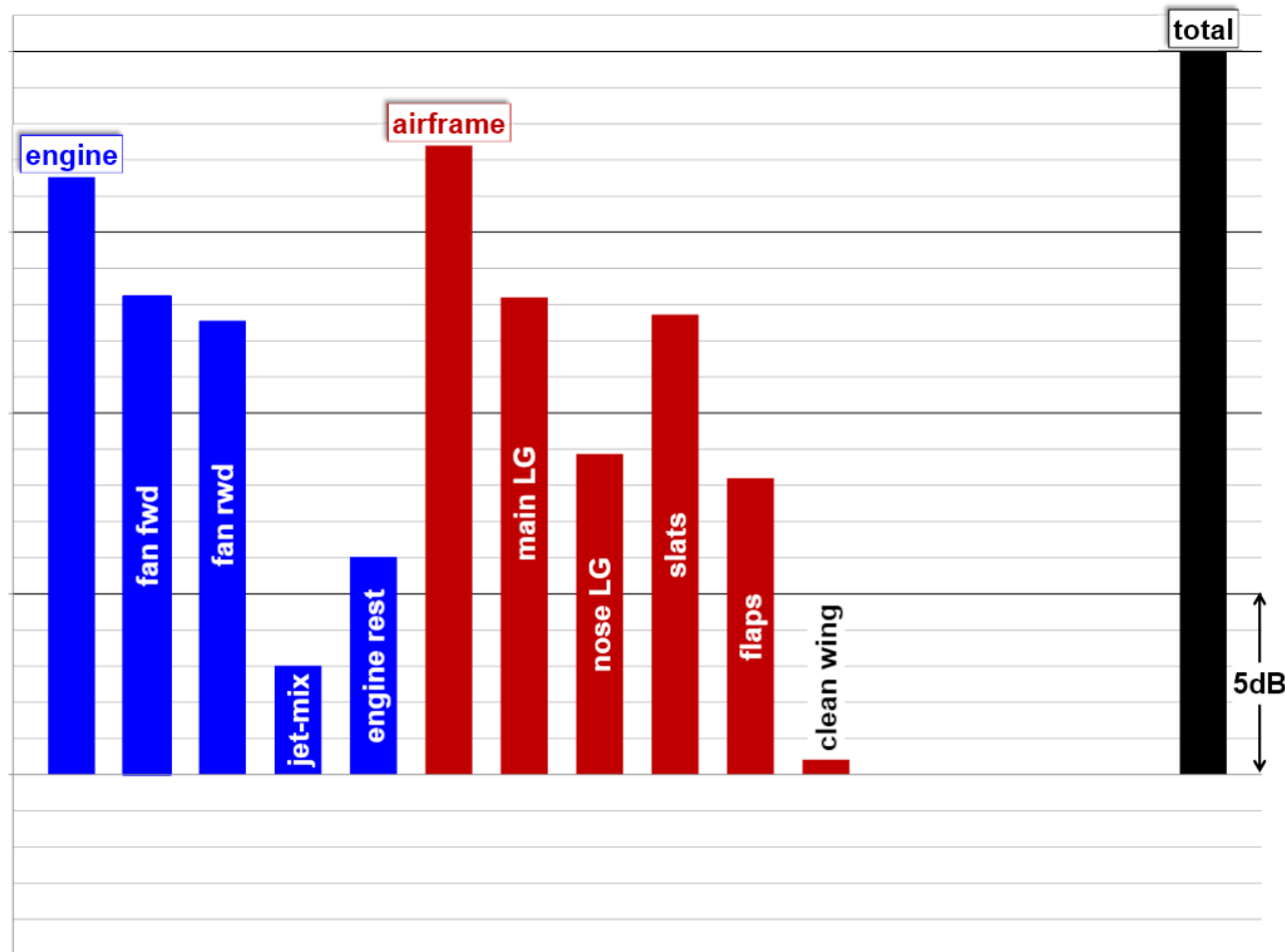
Outline

- **Future challenges in aircraft noise**
- **Needs for future aeroacoustic testing**
 - facility wise
 - process-wise: is it necessarily “experiment” vs. “numeric”?
- **Conclusions**



Noise sources – the classical view on modern tube&wing a/c configurations

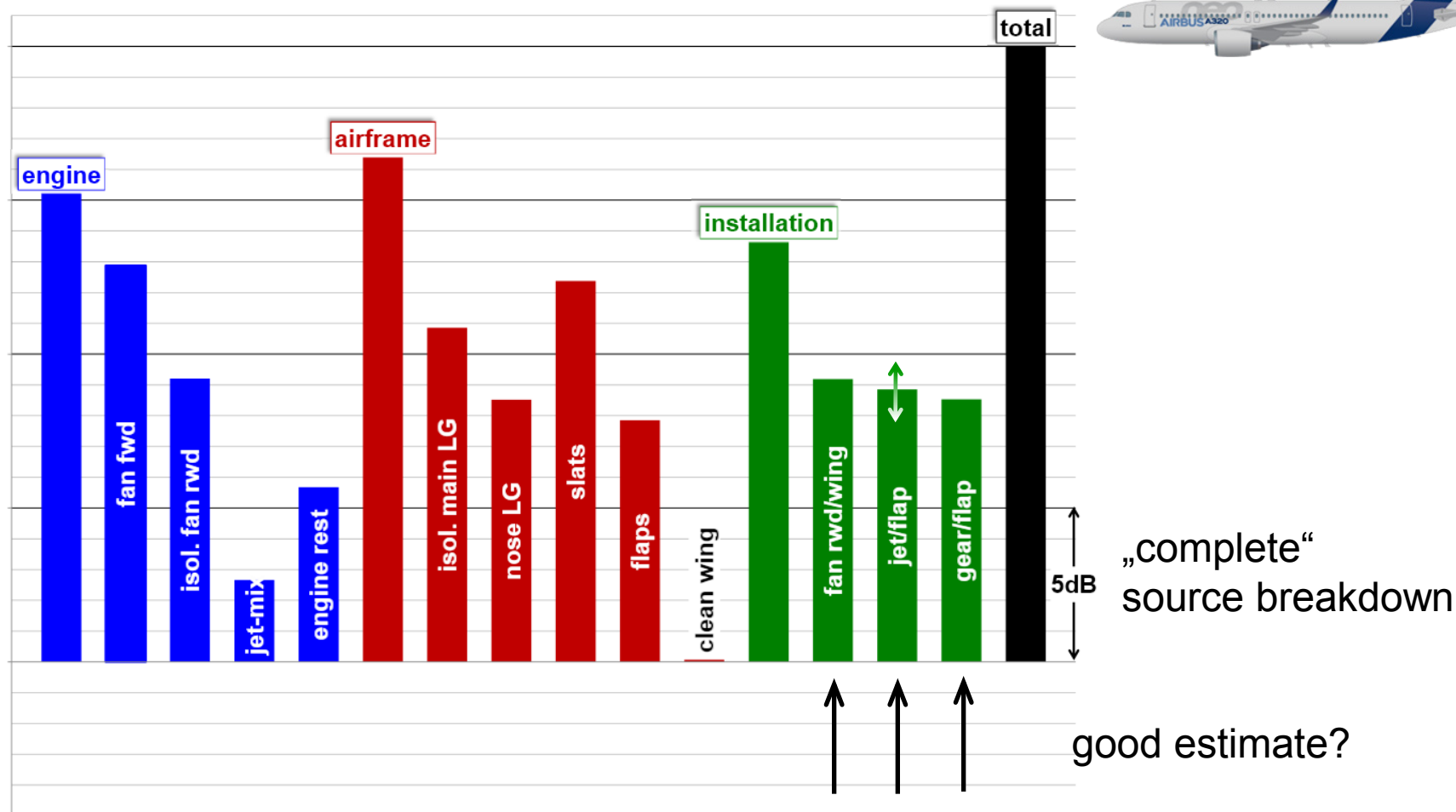
Short to medium range aircraft, BPR 10-12, approach



„classical“
source breakdown

Installation sources – a view on modern tube&wing a/c configurations

Short to medium range aircraft, BPR 10-12, approach

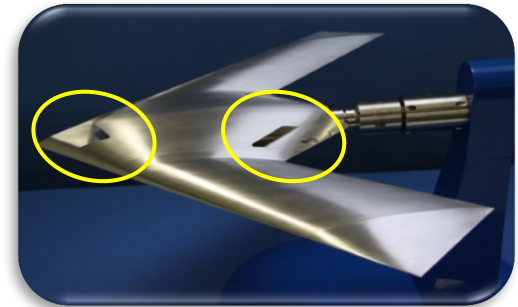
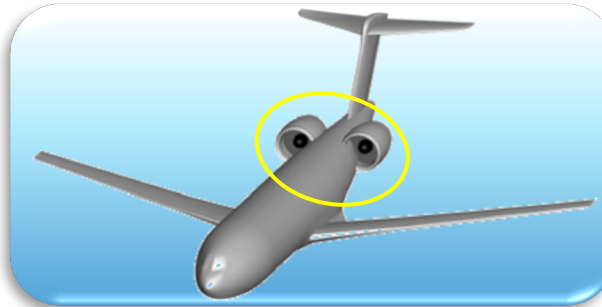


Classical component noise research – sufficient?

- ? How does the generation sound at components change when operated under actual a/c installation conditions?
 - ? What is single component noise reduction technology worth if installation is ignored?
 - ? How does the presence of an actual a/c change the radiation of the component sources? i
 - ! Component source testing important but insufficient.
 - ! Installation effects (source wise + radiation wise) need to be considered too.
- ⇒ **(best)** use very large acoustic facilities to arrange for representative
- * aerodynamic interactions of components (moderate requirement on wt size)
 - * acoustic radiation effects (severe requirement on wt size)
- ⇒ **(alternative)** think of new ways of using mid size facilities

How about true a/c noise reduction / FP2050 goals?

- ! a/c noise reduction limited when restricting to low noise component technology at conventional aircraft i
- ! Drastic a/c noise reduction realistic only if aircraft configuration is taken into account : a/c configuration \leftrightarrow noise reduction technology
- ? How do we know whether our guesses (based on preliminary design empirical models) are correct for „cool“ low noise a/c?
- \Rightarrow High fidelity simulation of complete a/c (!extreme challenge to HPC!)
- \Rightarrow Experimental simulation of complete a/c (!extreme challenge for model technology!)

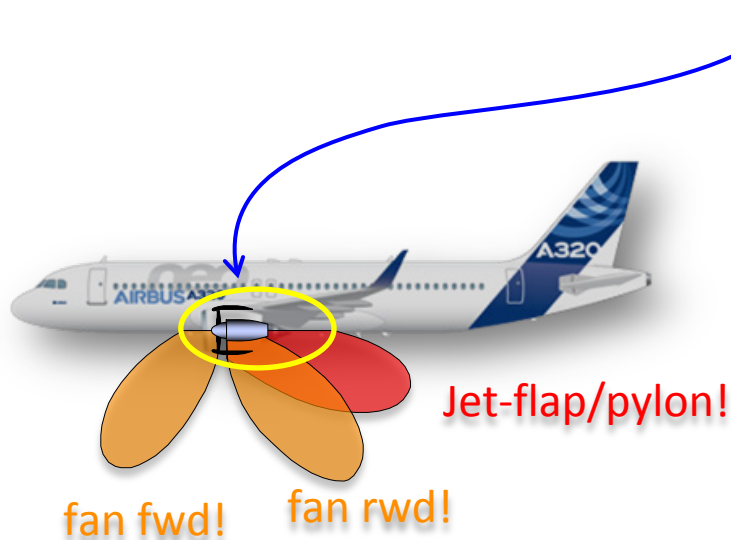


Testing complete aircraft noise in wt

! Test environment for the investigation of Noise and Performance of complete aircraft including new aircraft configurations

! Key technologies:

- Acoustic windtunnel of excellent quality and sufficient size ($\geq 3\text{m}$)
- **aeroacoustically similar turbofan simulators (ATS)**
- **pressurized air** for the operation of **ATS**



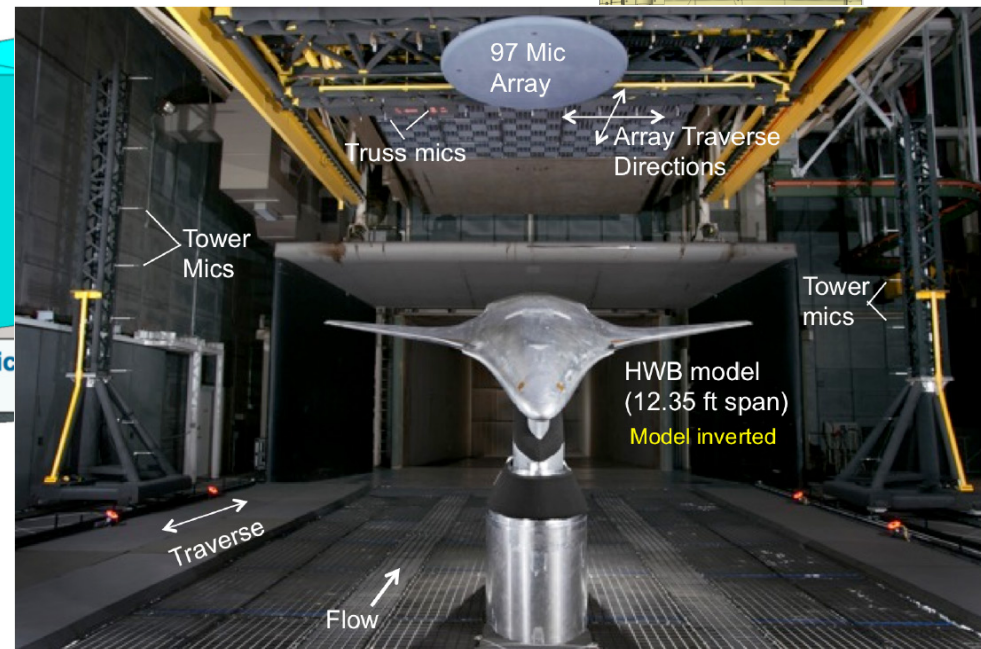
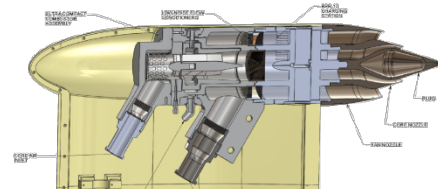
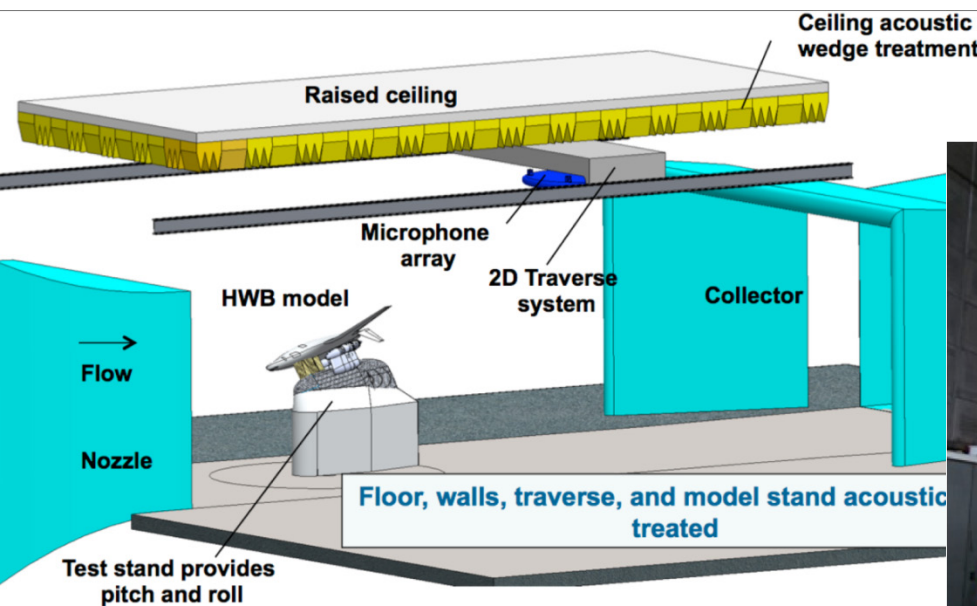
Example: Installed CROR in DNW-LLF
(**aeroacoustically similar CROR!**)



Testing on complete aircraft for selected sources in wt

NASA ERA program: low noise N2A HWB aircraft validation test

- NASA LaRC 14x22 tunnel equipped with treatment
- aeroacoustically similar jet noise simulators (hot dual stream), „CJES“
- displacement body instead of nacelle: no fan source

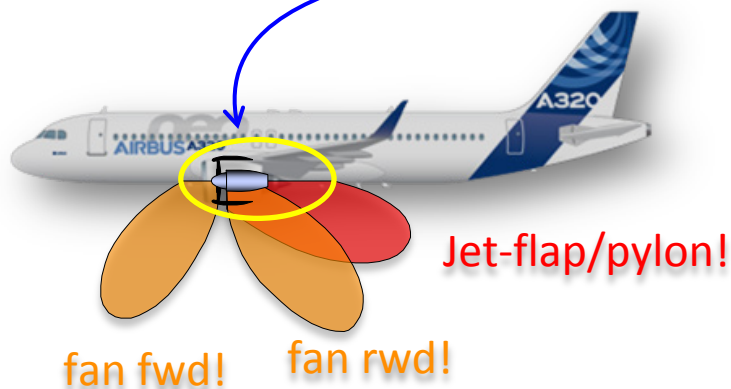


Testing complete aircraft noise on half model in wt

! Test environment for the investigation of Noise and Performance of complete aircraft including new aircraft configurations

! Key technologies:

- Acoustic windtunnel of excellent quality and sufficient size ($\geq 3\text{m}$)
- aeroacoustically similar turbofan simulators (ATS)
- pressurized air for the operation of ATS

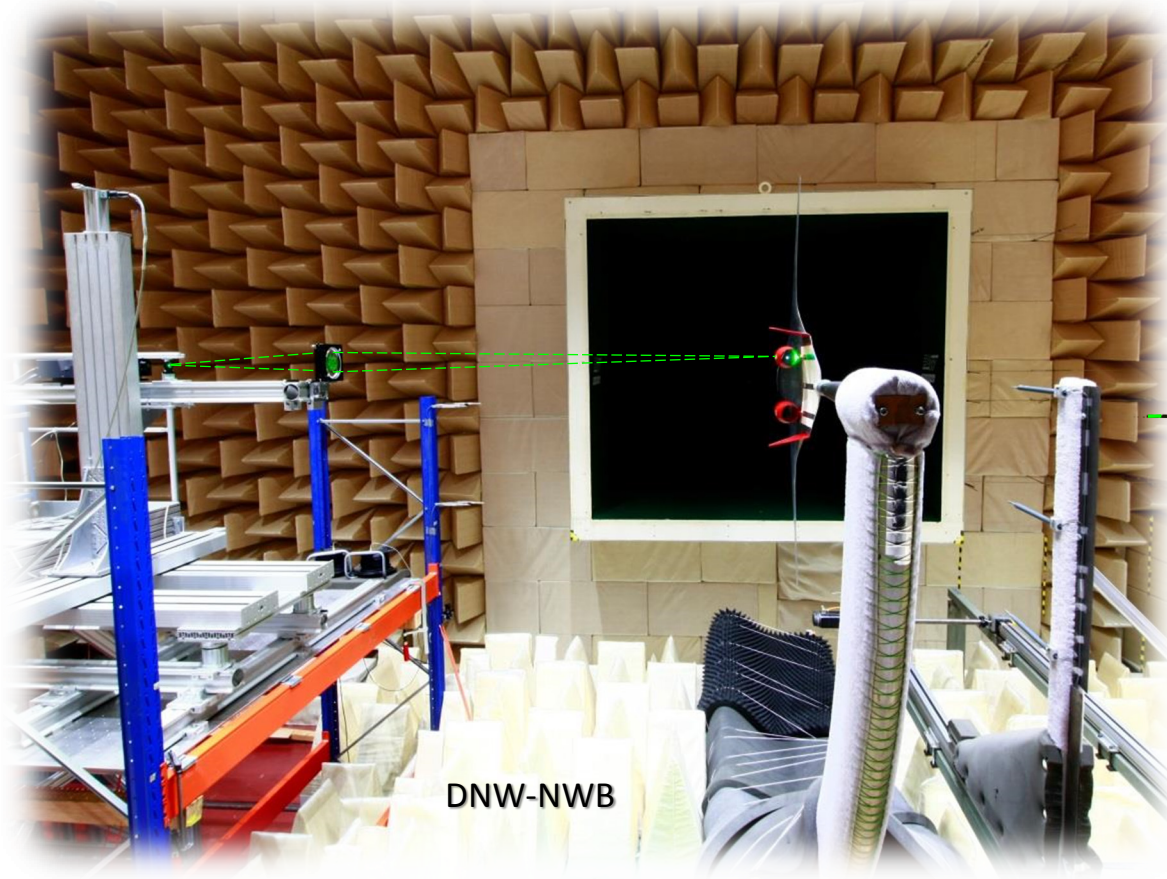


Example: aircraft in DNW-NWB

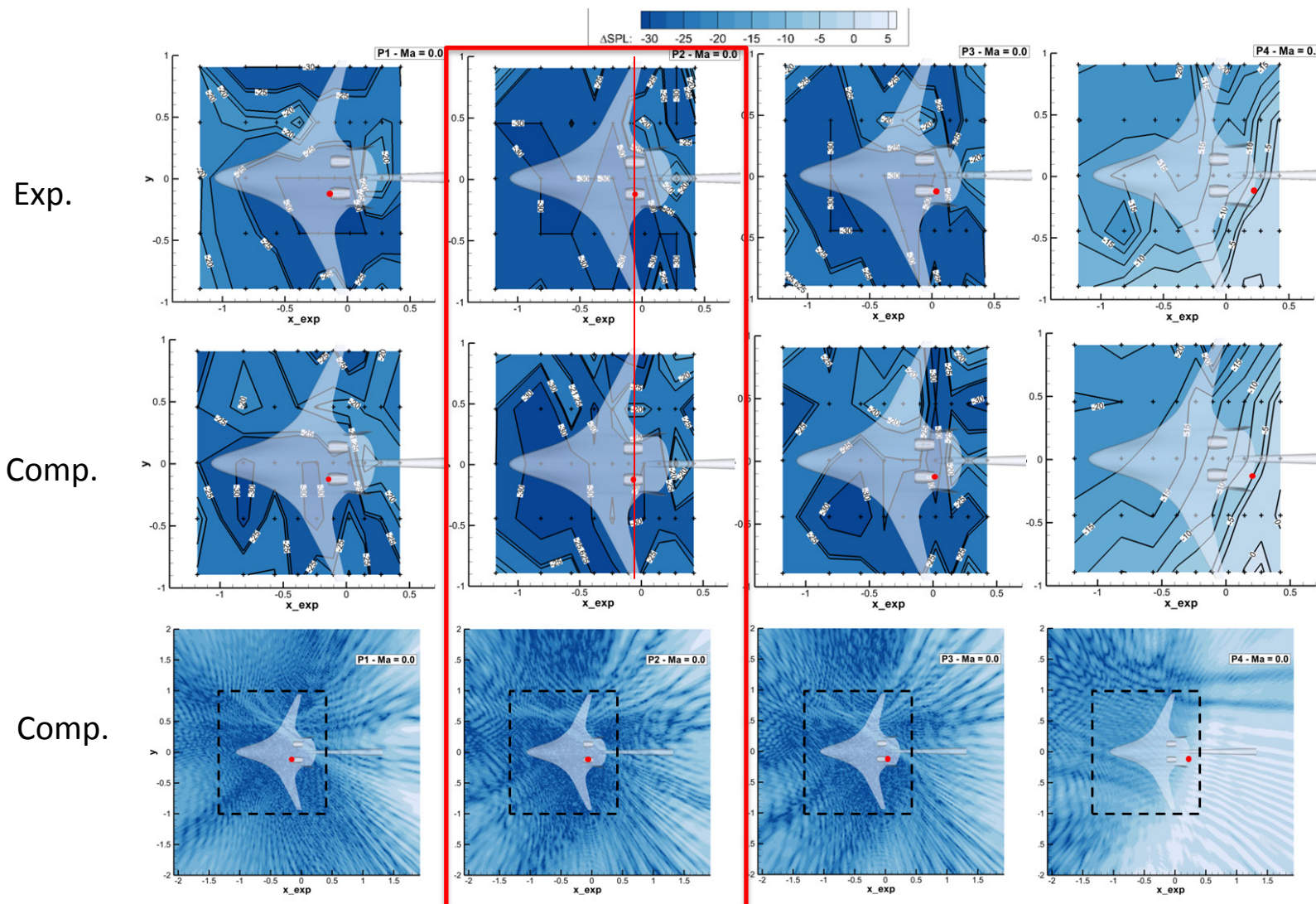


Testing on complete aircraft for generic sources in wt

Acoustic Shielding NATO AVT 233

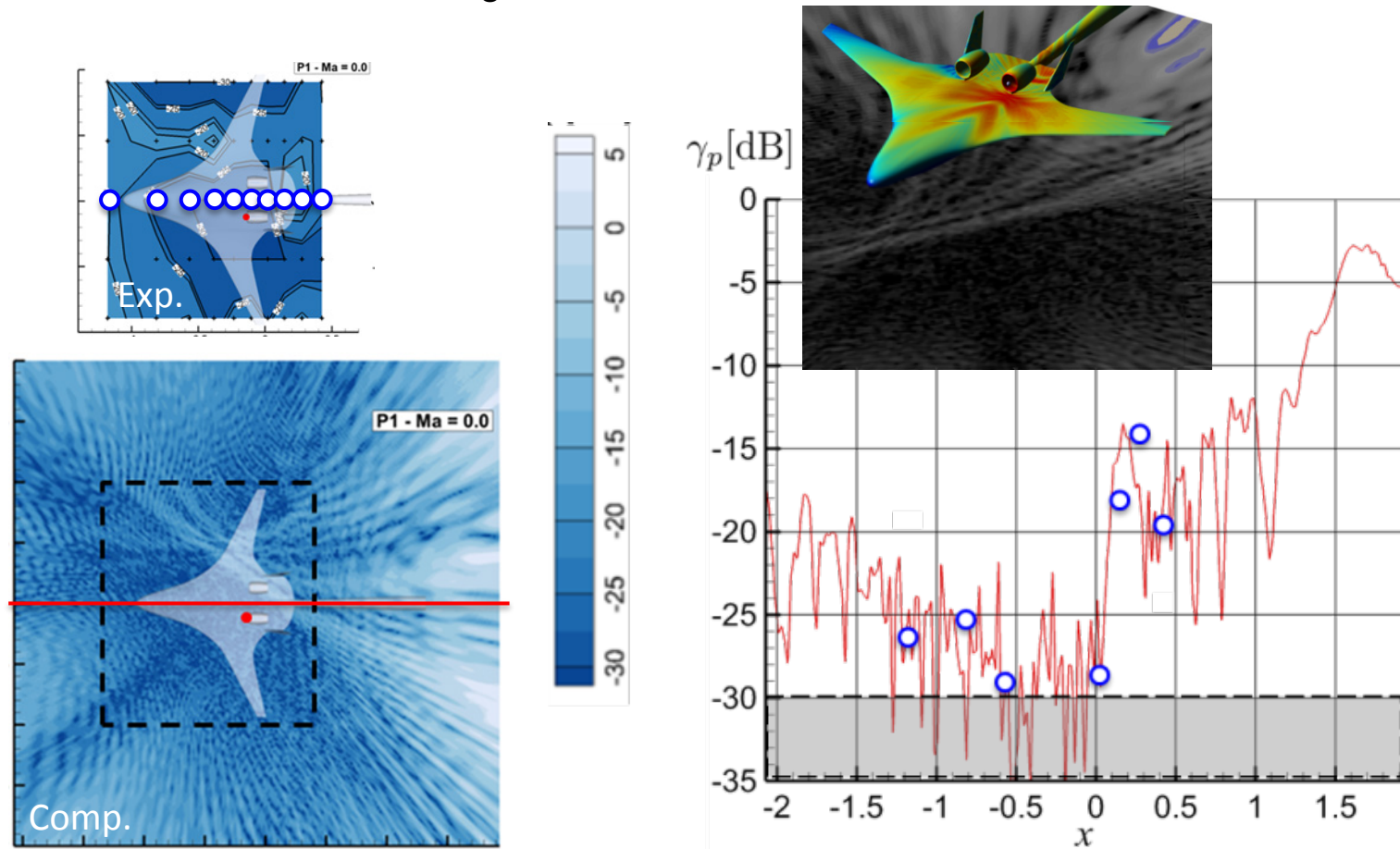


Testing on complete aircraft for generic sources in wt



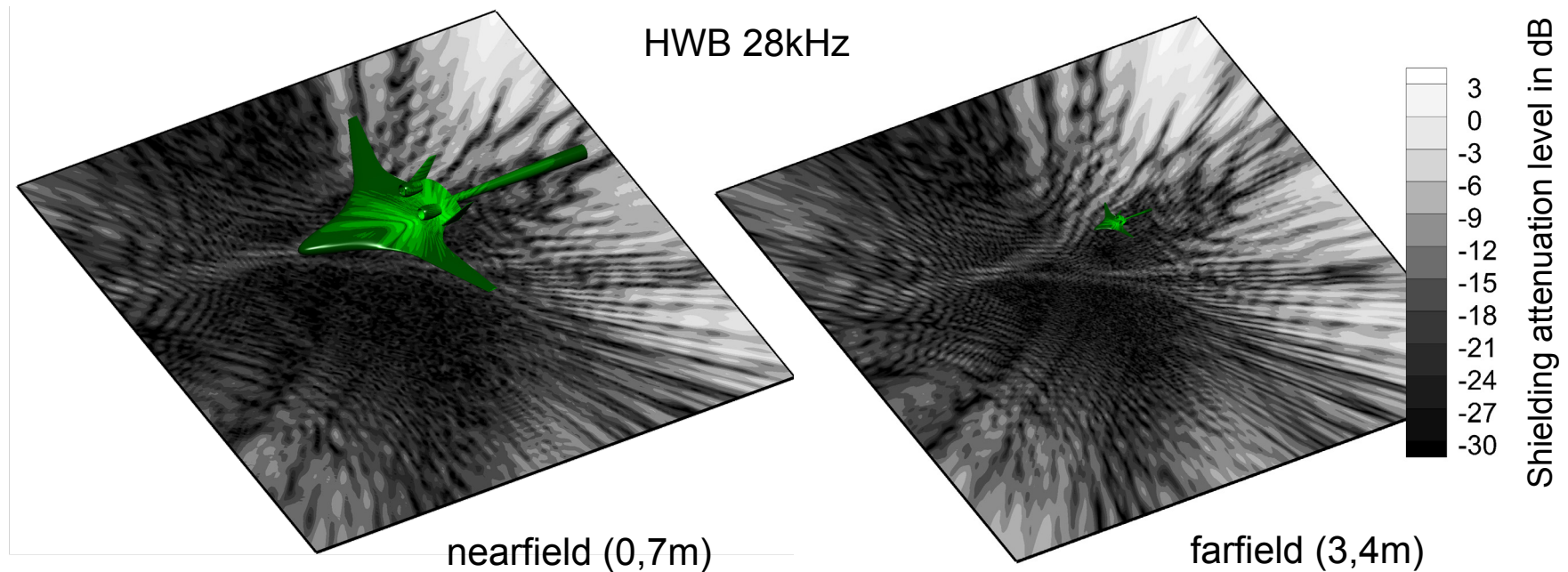
Testing on complete aircraft for generic sources in wt

Acoustic Shielding NATO AVT 233



Near field measurement?

- complete a/c models (incl. model turbofans) in acoustic wt / closed section wt:
⇒ small scales ⇒ very high frequencies ⇒ inflow mics ⇒ geom. Nearfield
- requires inflow mics with omnidirectional characteristics!



⇒ measure + validate in nearfield, simulate farfield

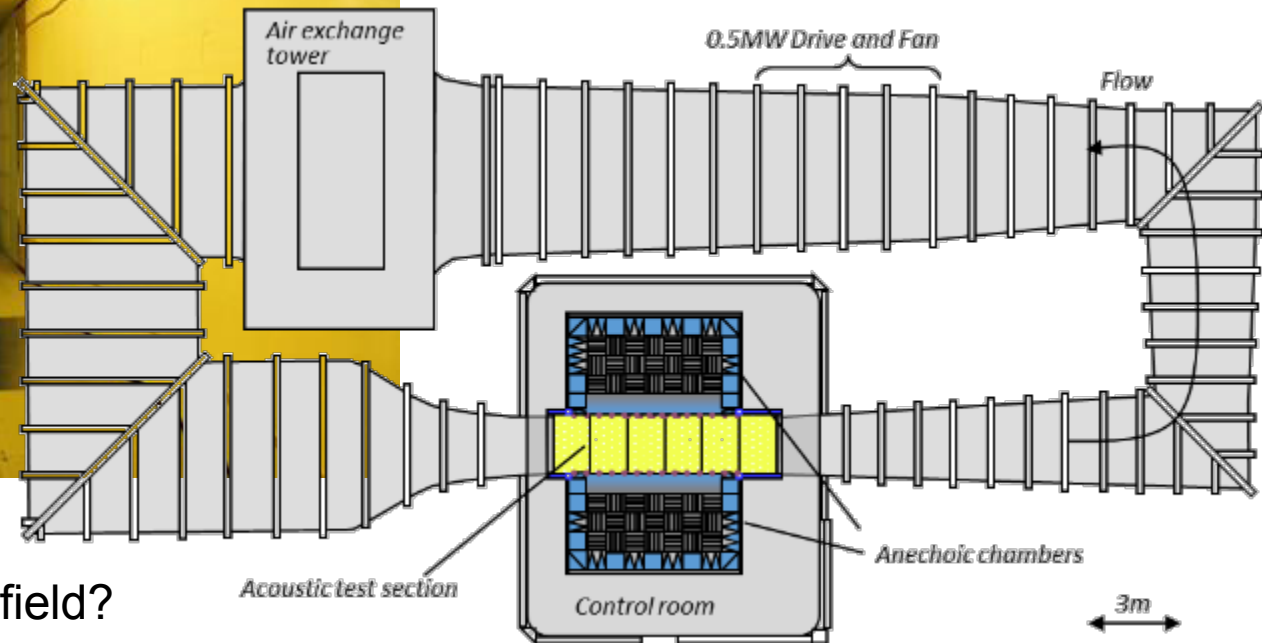


Future Aeroacoustic Test facility = Kevlar walled tunnels?

! Hybrid wind tunnel concepts: acoustically transparent walls.



Virginia Tech Stability WT

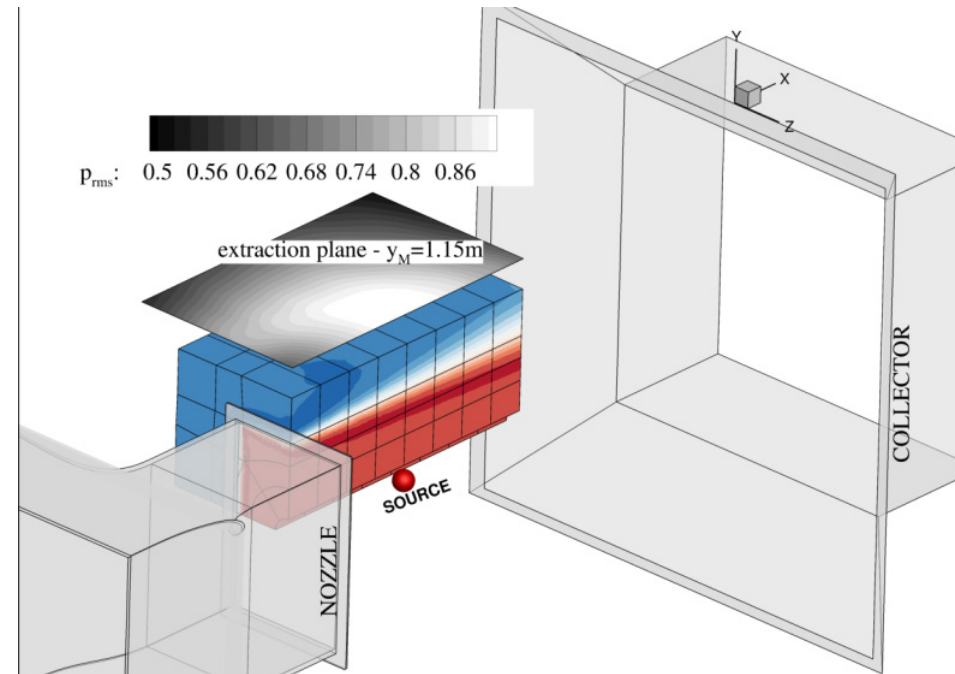


- ⇒ potential to measure in farfield?
- ⇒ complete Kevlar cage test section?
- ⇒ why does this exist in US and Asia only?

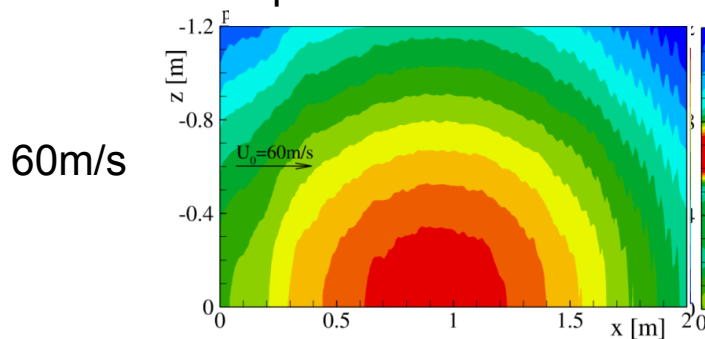
CAA based acoustic open wt corrections (AWB)

use numerical simulation +
HPC to correct for
(un)steady WT shear layer
effects

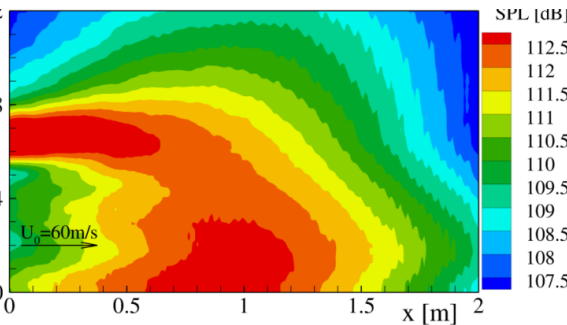
**Extend range of receiver
positions** by exploitation of
numerical simulation



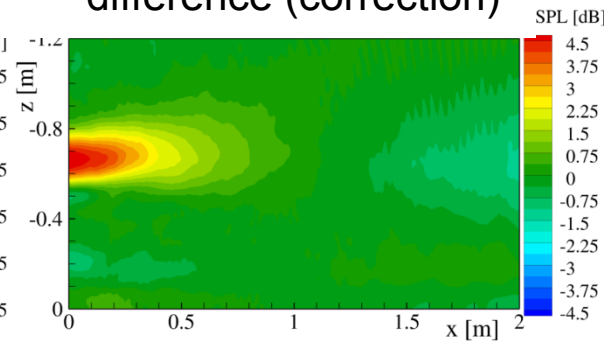
planar shear flow



AWB shear flow

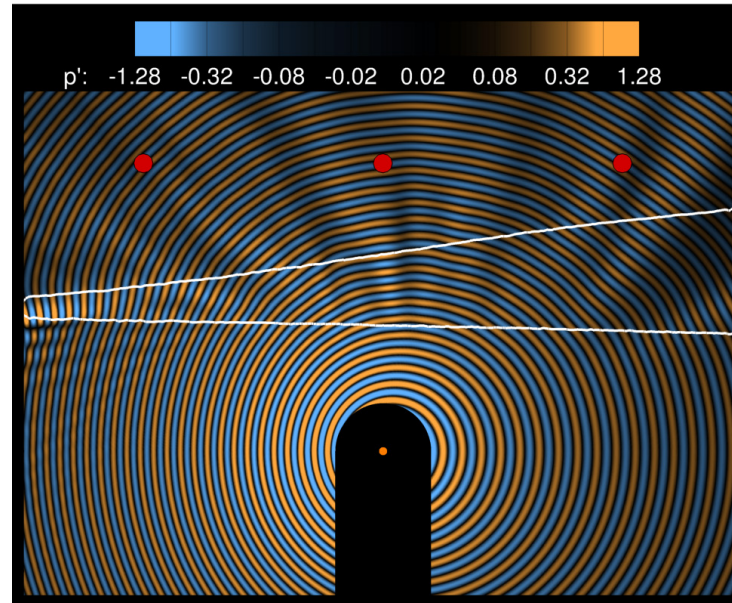
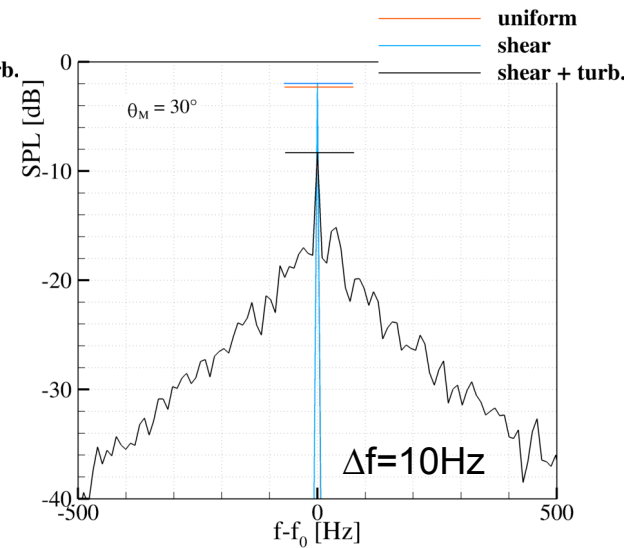
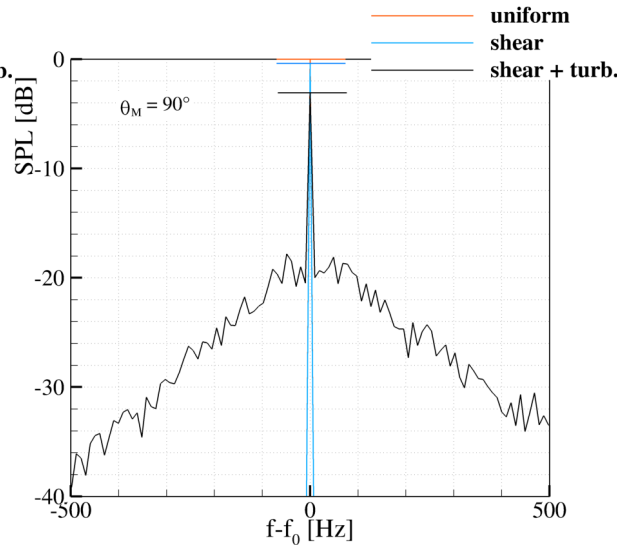
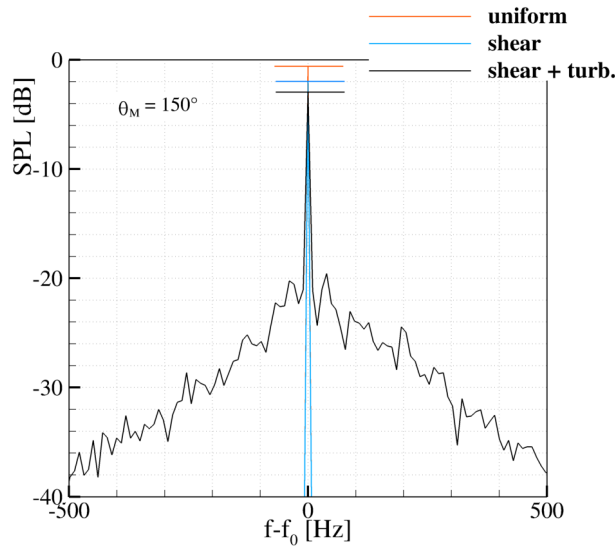


difference (correction)



$f = 10\text{kHz}$

Acoustic open wt corrections (AWB) using CAA

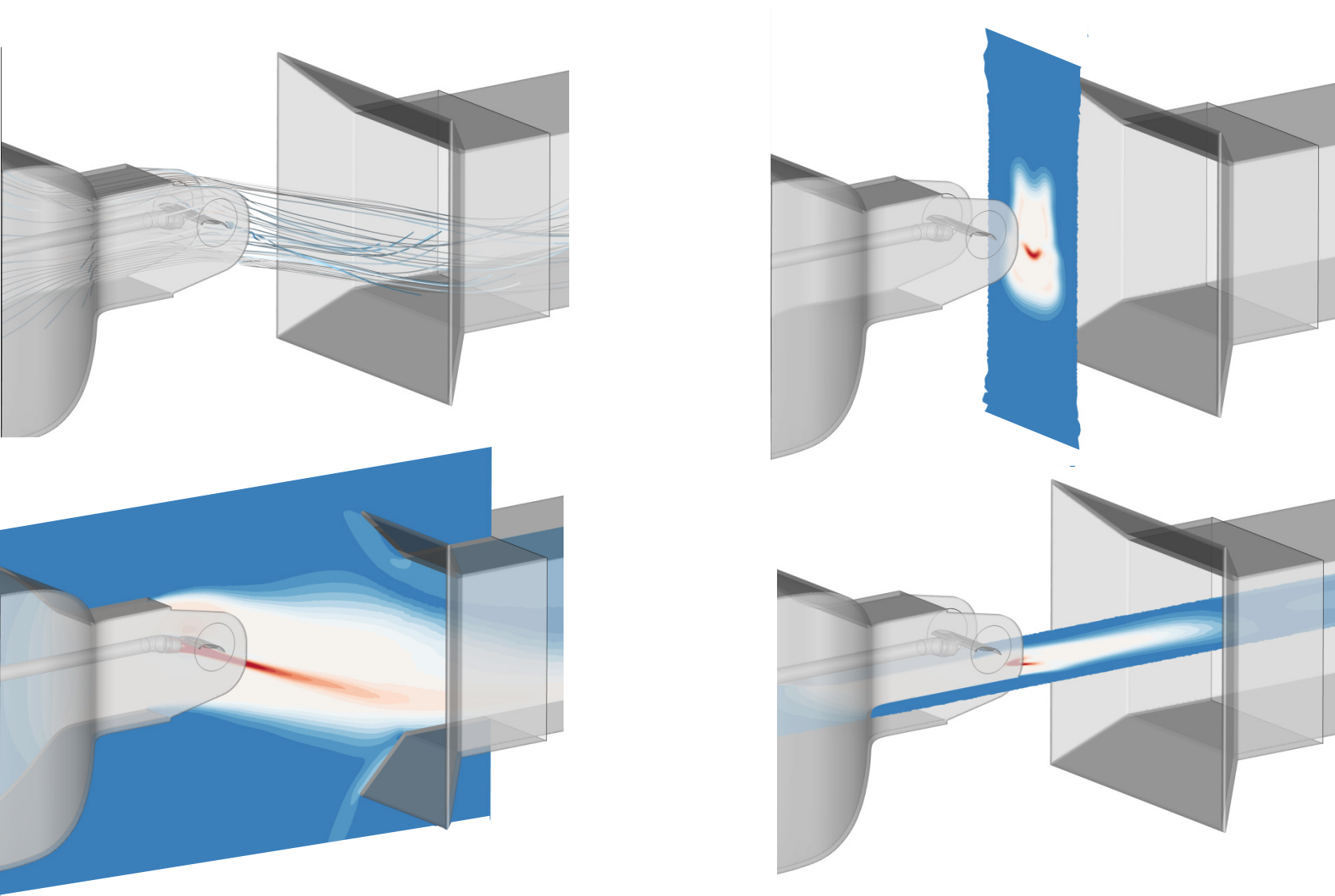


use numerical
simulation+HPC
to correct for
(un)steady WT
shear layer effects

Include tone **corrections**
from scattering **based**
on numerical simulation

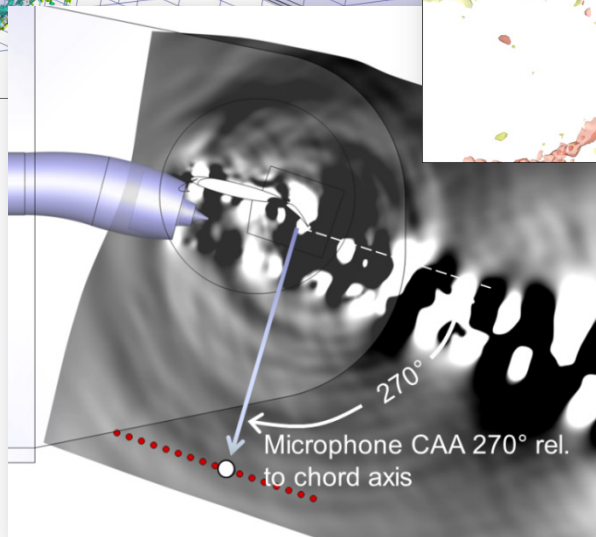
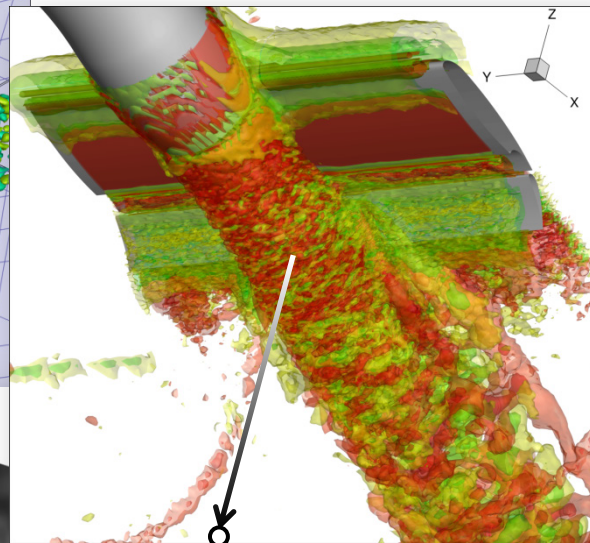
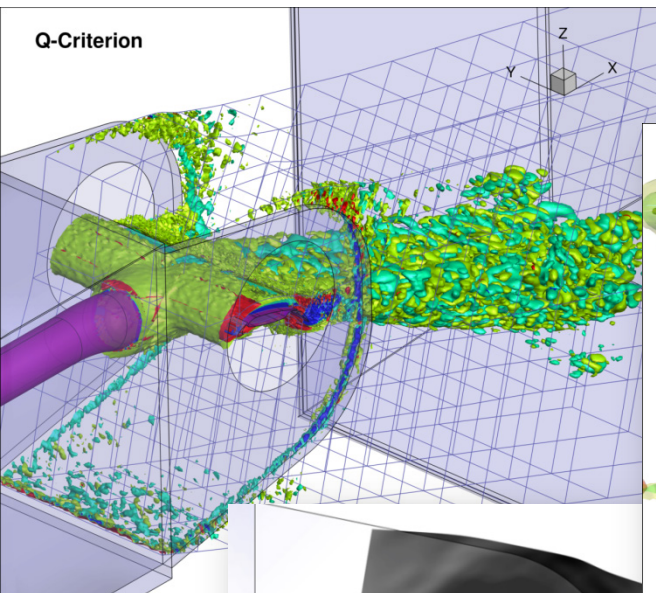
TAU + FRPM+PIANO

Large component acoustic testing in open wt



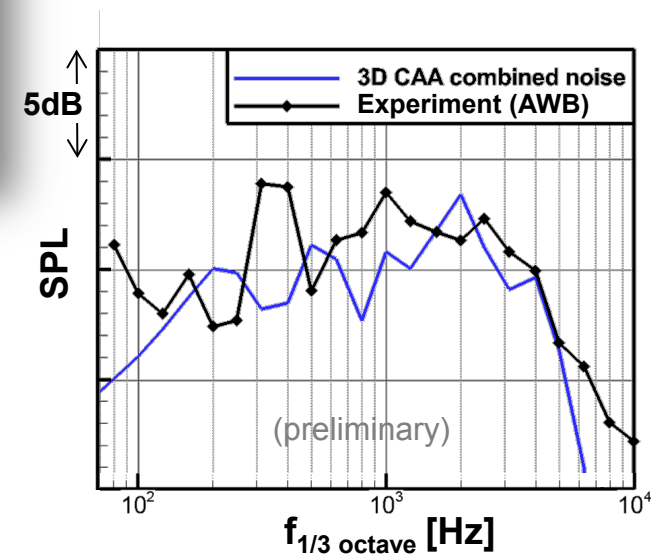
Large component acoustic testing in open wt – validation

CAA of UHBR dual stream jet combined with 2D high-lift wing incl. AWB



PIANO: FES=„Forced Eddy Simulation“

simulate model + test environment
validation on raw data
„do the whole thing“

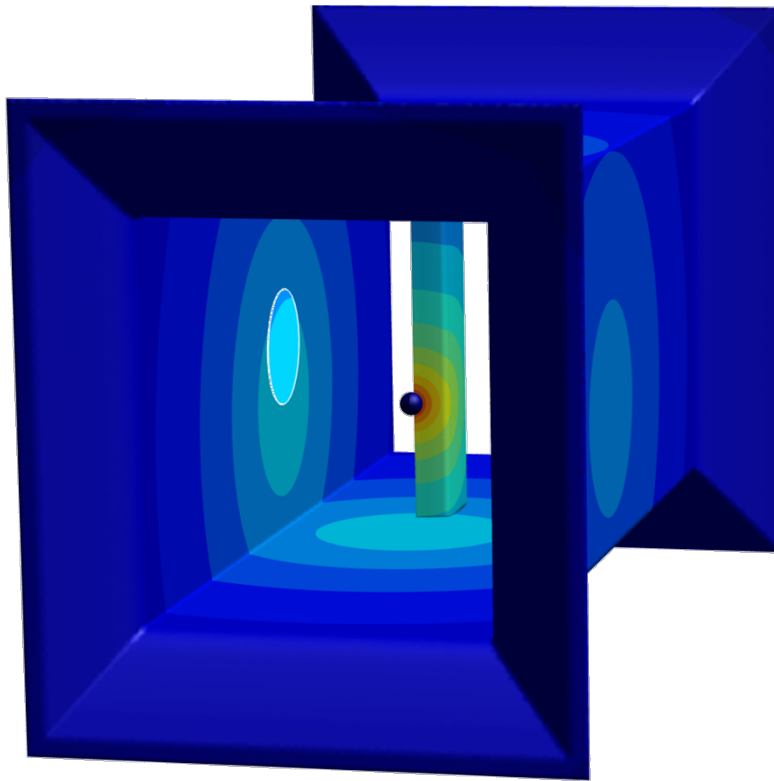


Large component acoustic testing in closed wt

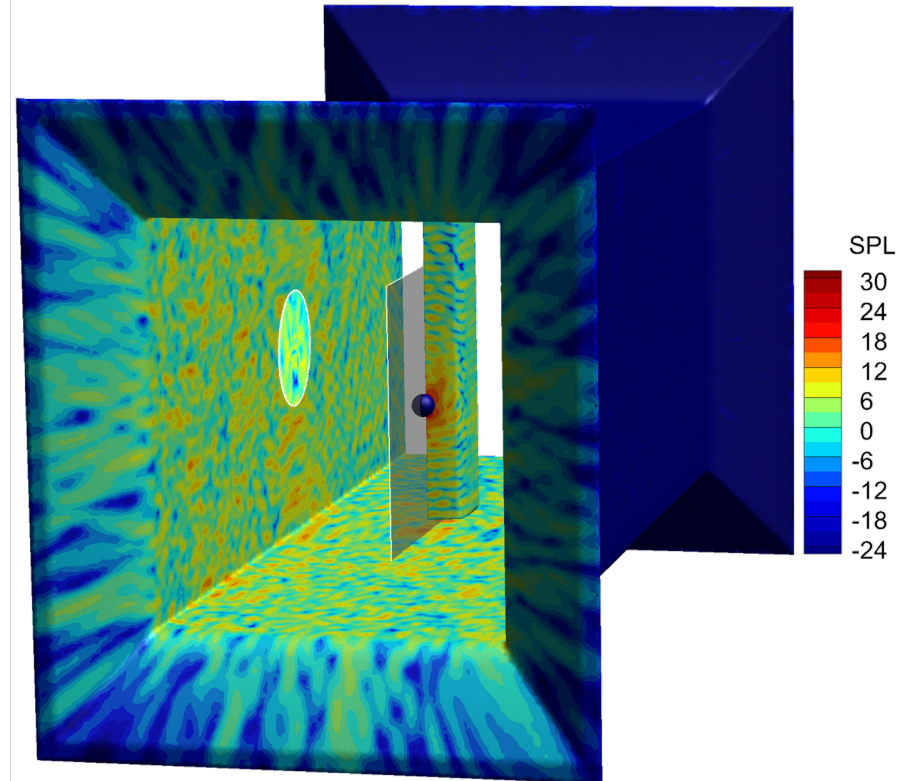
wall array measurements

incident surface pressure

actual surface pressure



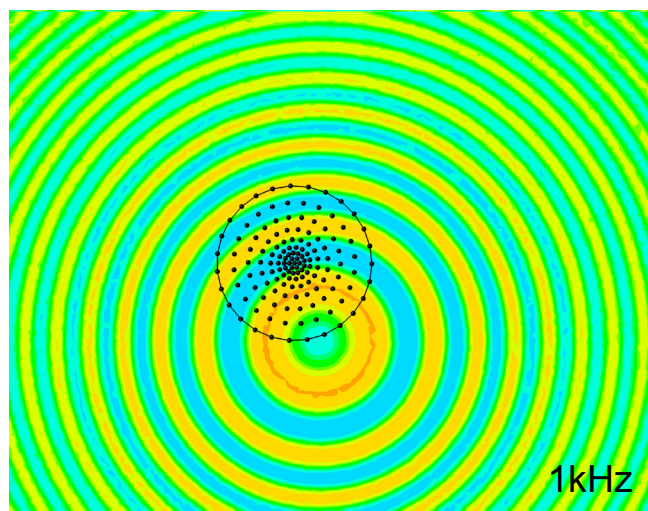
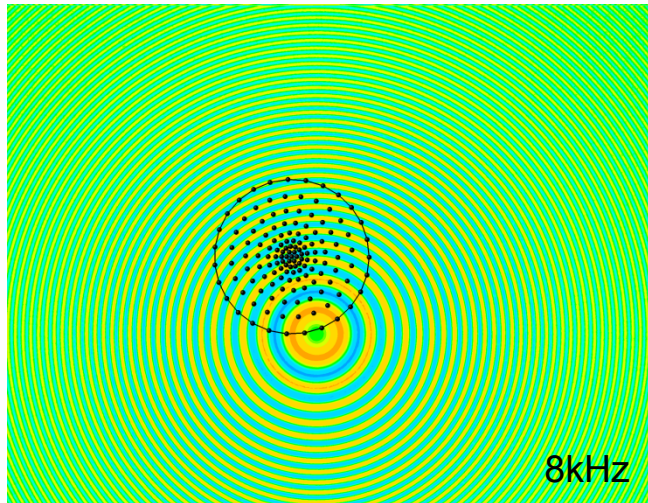
Monopole - 1000 Hz



Monopole - 1000 Hz

Large component acoustic testing in closed wt

incident surface pressure

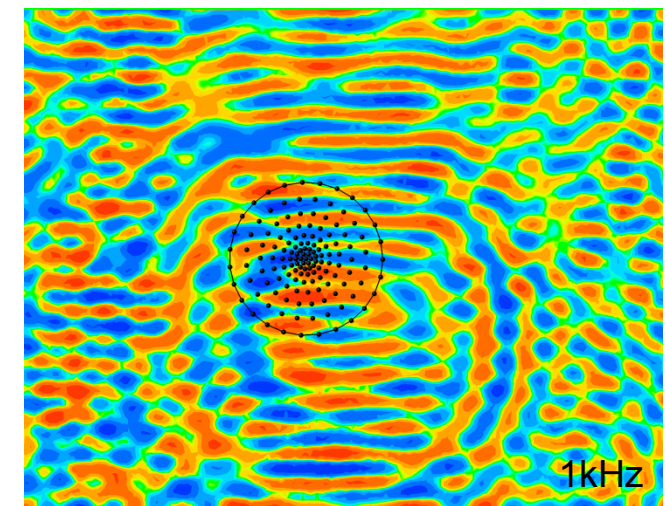
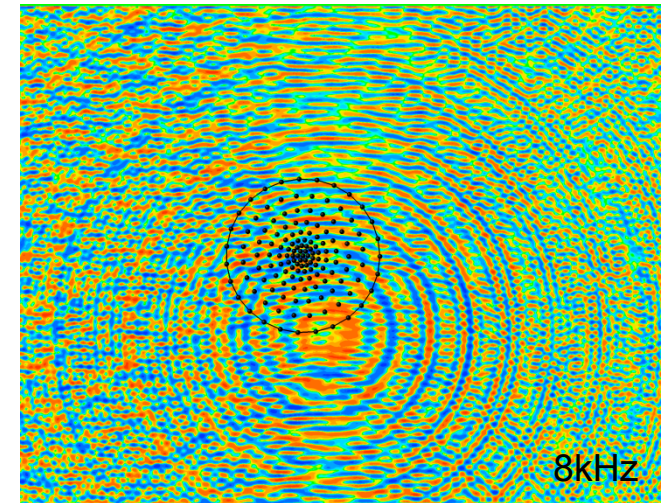


Fast Multipole
BEM (FMCAS)



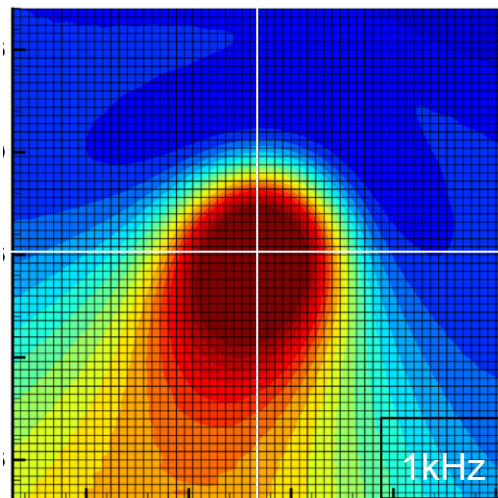
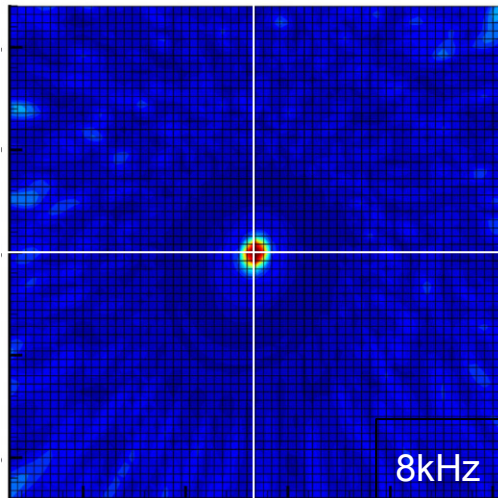
use numerical
simulation+HPC
to **clean up**
WT effects

actual surface pressure

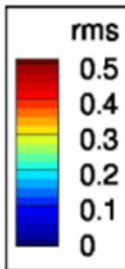
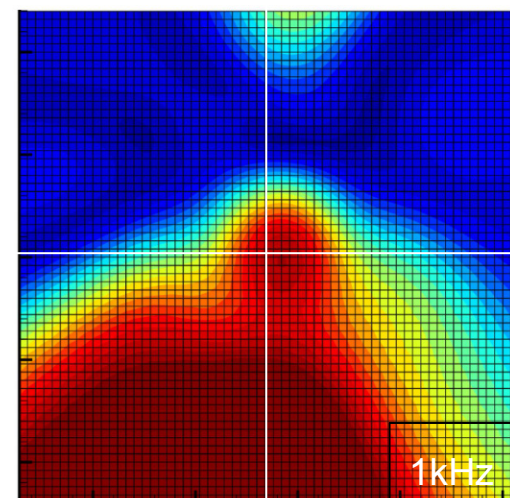
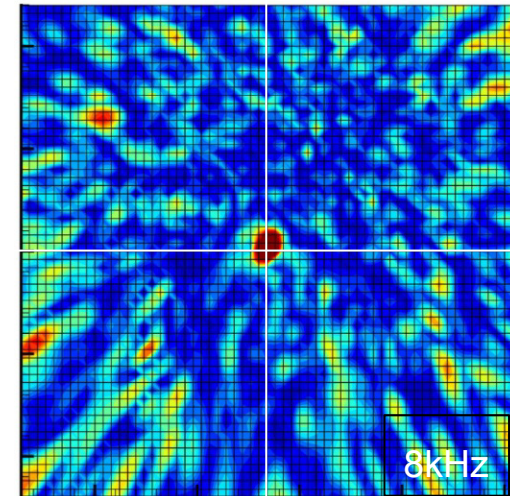


Large component acoustic testing in closed wt

incident pressure input



actual wall array pressure input



Fast Multipole
BEM (FMCAS)

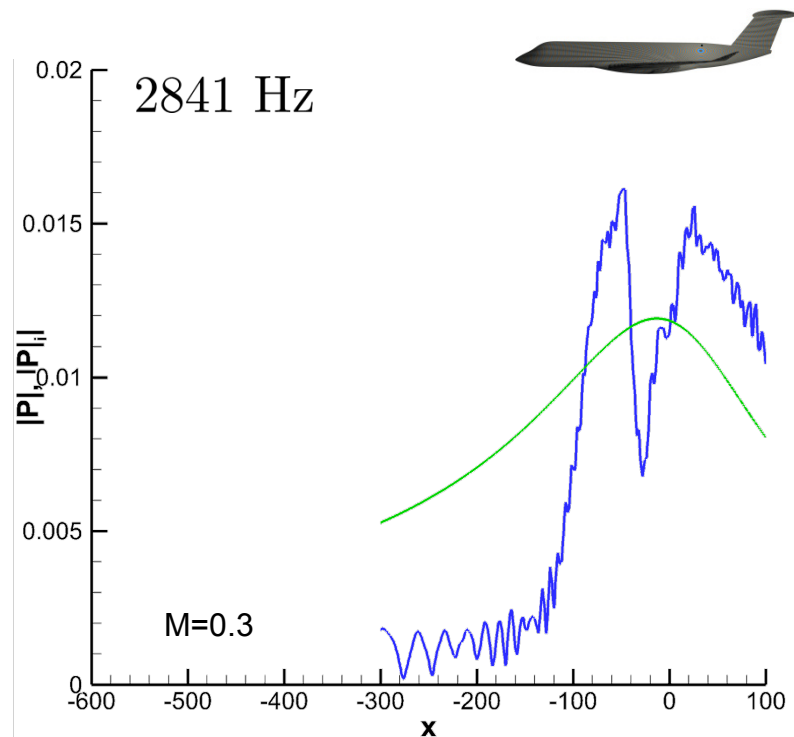


use numerical
simulation+HPC
to **clean up**
WT effects

Outlook/ more open questions



Is noise reduction by shielding always „good“?



- ? is rapid (temporal) change of signal amplitude more relevant for perception than a reduction in SPL?
- ? For tone components installation creates strong amplitude fluctuations: problem?
- ! Realistic acoustic installation of tone sources important to assess noise impact
- Tone testing in acoustic wind tunnels extremely high challenge

Summary

- low noise a/c component technology remains important, but insufficient
- Installation effects influence overall aircraft noise significantly - source wise and radiation wise
- exp. validation of low noise impact a/c requires realistic engine (tone) sources
- validation of low noise a/c design: new challenges on exp. and num. side
 - more than one component needs to be considered (large domains)
 - small scale aeroacoustically similar turbofan simulators needed
- relevant farfield only by computation (wt tests to validate codes in nearfield)
- numerical Simulation / HPC may be used to „map test conditions to reality“



Conclusions

- Future progress for low noise a/c only when considering complete a/c
- Need possibility to experimentally simulate complete a/c noise in wt!
 - for realistic installation sources and radiation
 - for validation of new a/c concepts w.r.t noise and performance
 - key elements: Acoustic WT, Acoustic Turbofan Simulator, HPC
- Why don't we blend more experimental and numerical techniques?
 - simulate actual measurement situation (aero + acoustics)
 - improve wind tunnel correction with numerics and HPC
 - reduce ad-hoc assumptions in beamforming, by enriching with num. sim.
 - use PIV/STB to determine surface pressures from NS equations;
use numerical simulation to determine sound field



