Smart Mitigation of flow-induced Acoustic Radiation and Transmission for reduced Aircraft, Surface traNSport, Workplaces and wind enERgy noise

Development Rod-Linear Cascade Model for Fan-Wake/OGV Interaction Noise Studies

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TU Delft/3DS Workshop, 14 September 2018

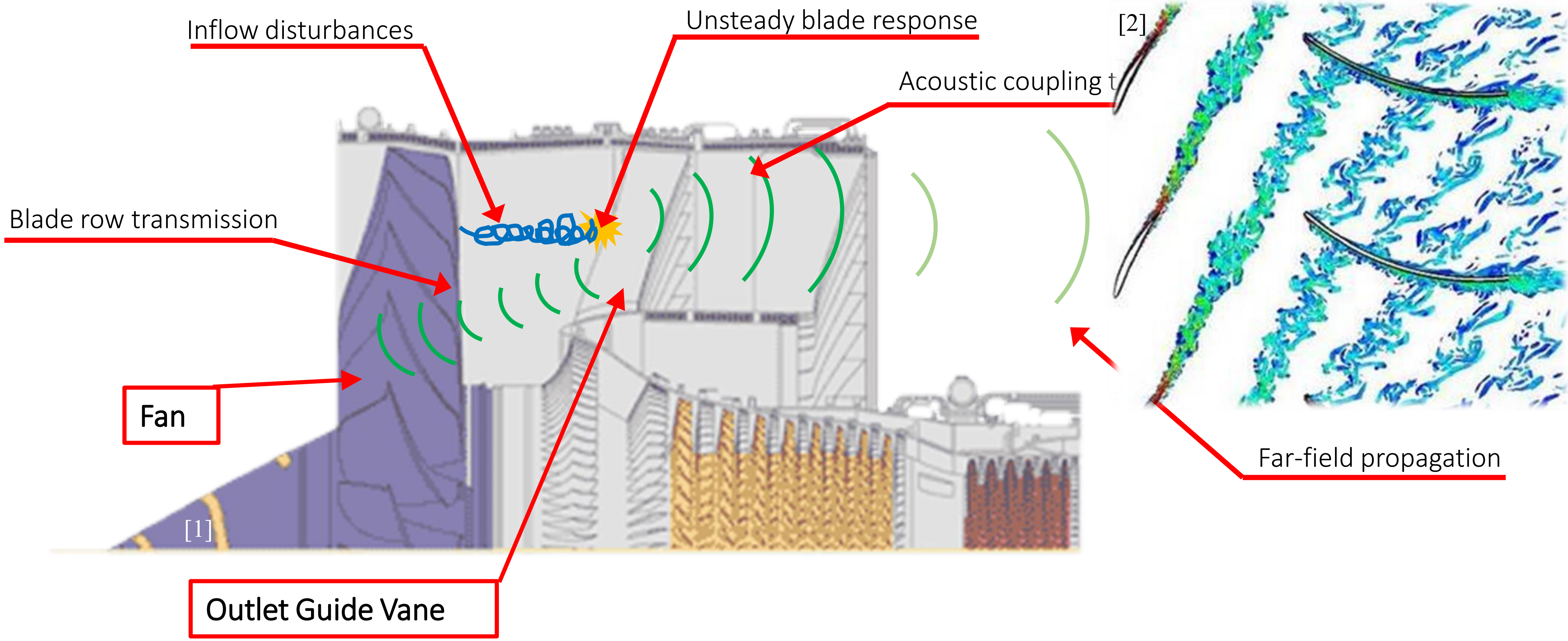
H2020 MARIE SKŁODOWSKA-CURIE ACTIONS

Agenda

- Introducing The Rod – Linear Cascade Test Rig
- Preliminary Computational Results using PowerFLOW
- Noise Mitigation Strategies and Outlook
- Q&A session

I. ROD – LINEAR CASCADE

Mimicking Fan wake – OGV *TIN**



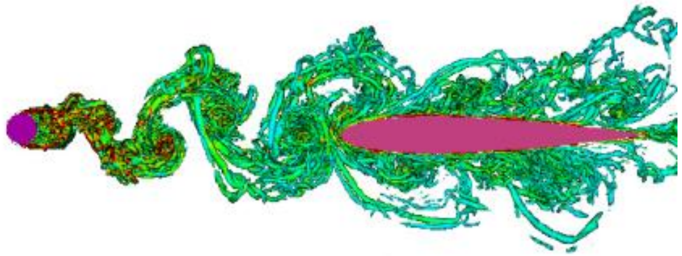
A simplified **test model** which **replicates the turbulence impingement mechanism** would be advantageous for **parametric studies** and **noise mitigation applications**.

* Turbulence Impingement Noise

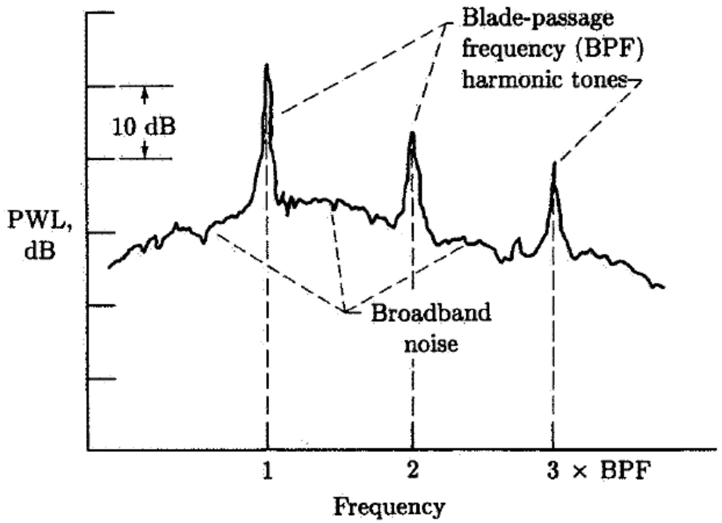
[1] https://www.behance.net/gallery/27888995/How-does-a-turbofan-engine-work
[2] Enghardt, L. Improvement of Fan Broadband Noise Prediction: Experimental Investigation and Computational Modelling. *Final Project Report: Proband-DLR-WP1-Task*, *1*. 2008.

Mimicking Fan wake – OGV *TIN*

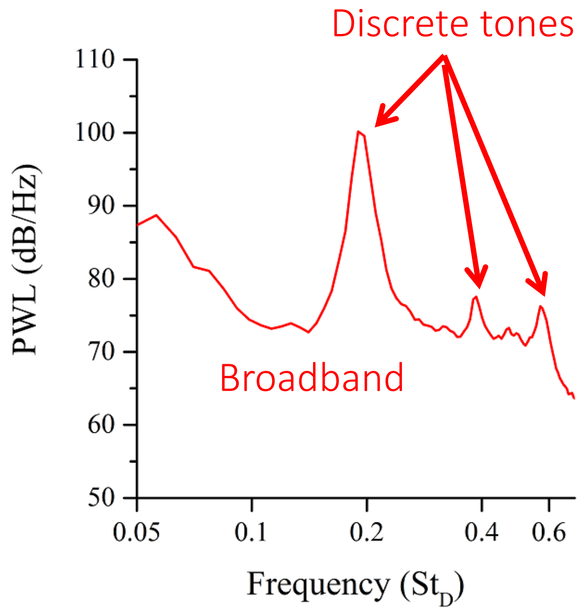
KLM Embraer 190 , powered by GE CF34-10E5



Rod-airfoil configuration



Typical turbofan noise power spectra [1]

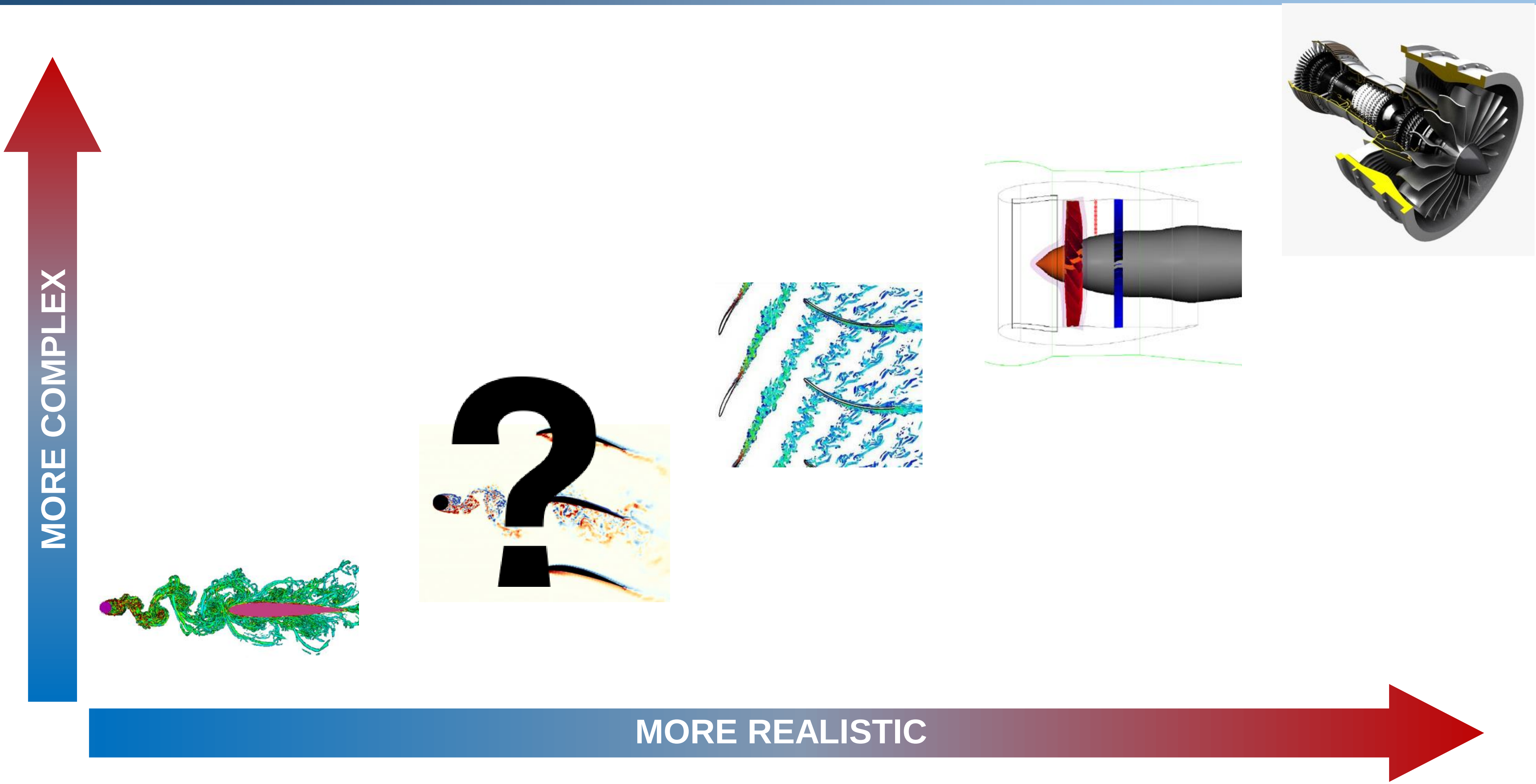


Typical rod-airfoil configuration noise power spectra

[1] Hubbard, H. H.. *Aeroacoustics Of Flight Vehicles: Theory And Practice. Volume 1. Noise Sources* (No. NASA-L-16926-VOL-1). NASA Langley Research Center Hampton, VA. 1991.

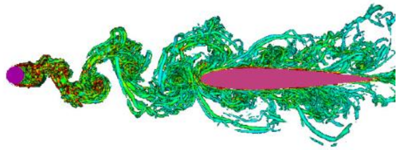
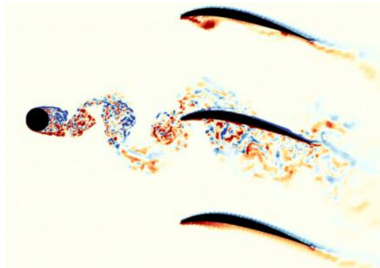
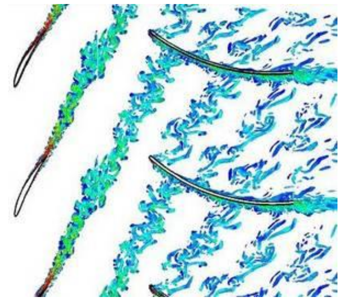
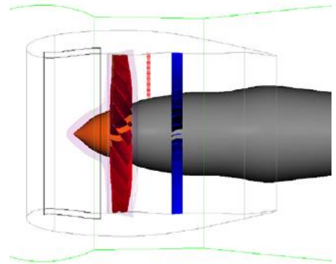
Why Rod-Linear Cascade?

THE BRIDGE TOWARDS REALISM

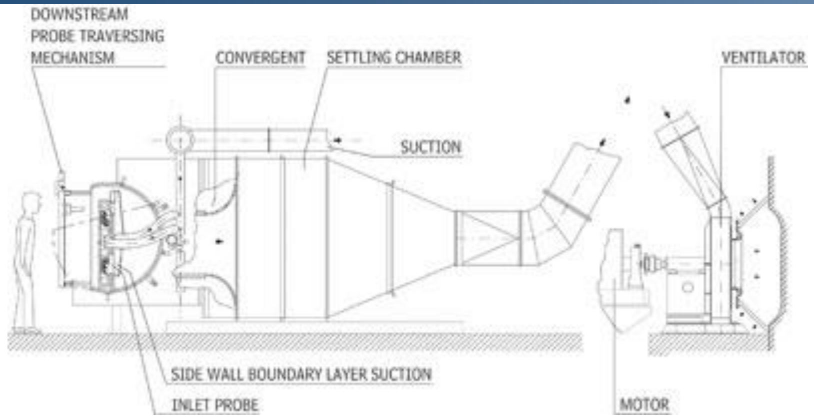


Why Rod-Linear Cascade?

A CONFIGURATION TO FILL THE GAP

				
Tonal and broadband excitation as source	✓	✓	✓	✓
Flow deflection (cascade flow field) and acoustic-blade interaction	✗	✓	✓	✓
Multiple blade excitation and source phase interference	✗	✗	✓	✓
Rotor swirl and duct mode propagation	✗	✗	✗	✓

CASCADE / HIGH-DEFLECTION WIND TUNNEL



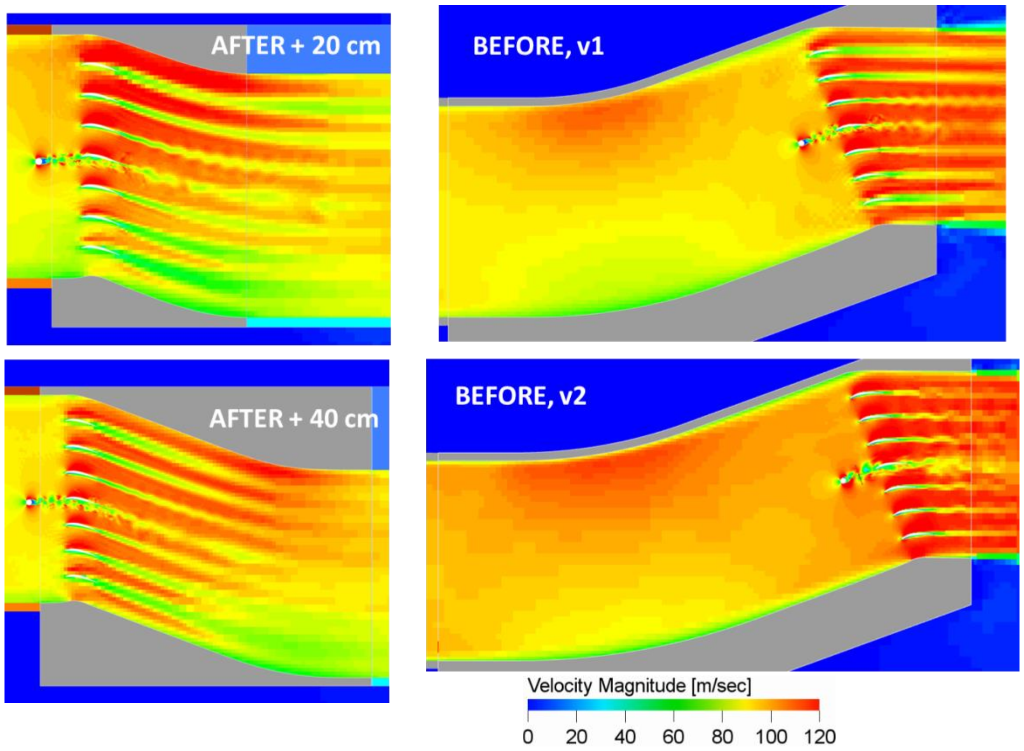
C-1 Wind Tunnel, VKI, Belgium [1]

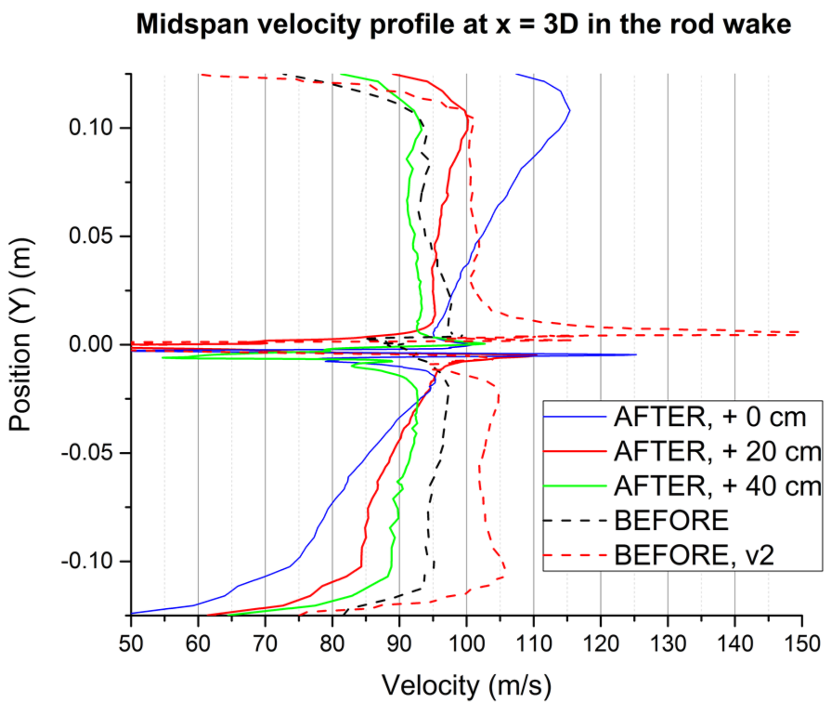
NGG Tunnel, DLR, Germany [2]

[1] https://www.vki.ac.be/index.php/research-consulting-mainmenu-107/facilities-other-menu-148/turbomachinery-other-menu-174/86-low-speed-cascade-wind-tunnel-c-1
[2] https://www.dlr.de/at/en/desktopdefault.aspx/tabid-1562/2429_read-3782/.

DEFLECT THE FLOW BEFORE OR AFTER THE CASCADE?

- Flow exiting the test section must be aligned with the collector downstream.





Parametric simulations to achieve acceptable flow uniformity within the test section

Experimental Platform Design

Test section flange

- Linear cascade deflects the flow towards the collector downstream

Test section

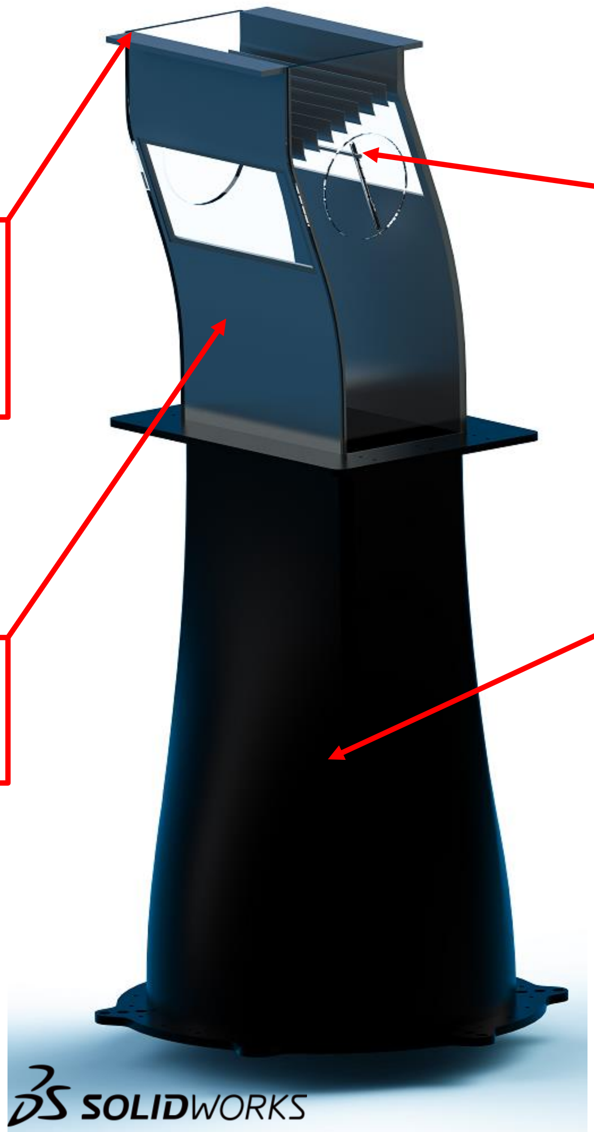
- 400 mm wide and 250 mm high

Rod-linear cascade model

- Inclined against the inflow axis

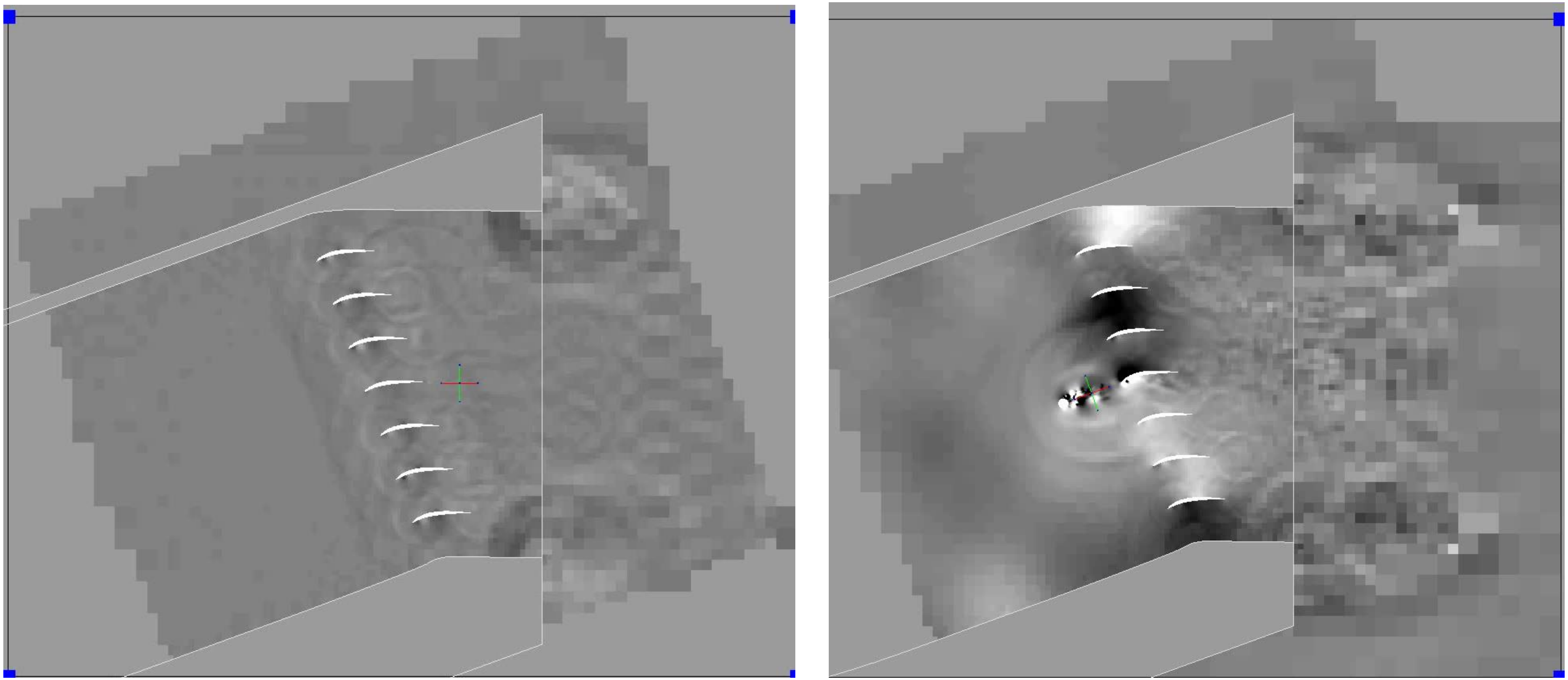
Wind tunnel contraction

- Ø60 mm to 400 mm x 250 mm



Rod-linear cascade experimental rig

ONE ROD TO MAKE THE DIFFERENCE

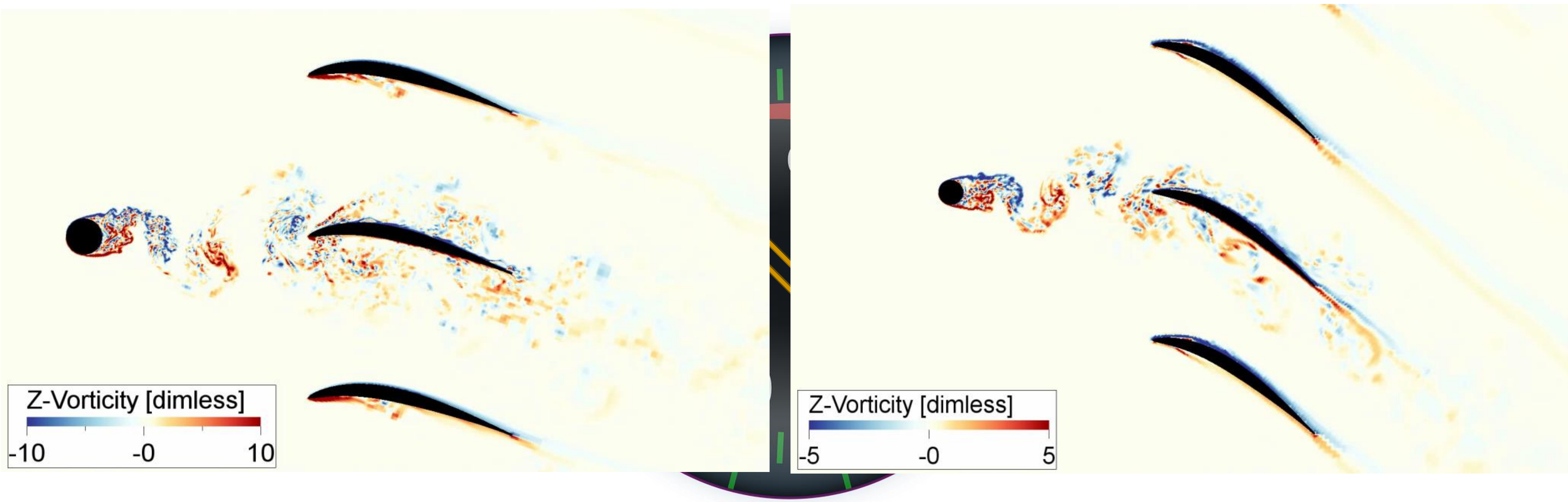


Comparison of linear cascade acoustics response with and without rod-wake excitation

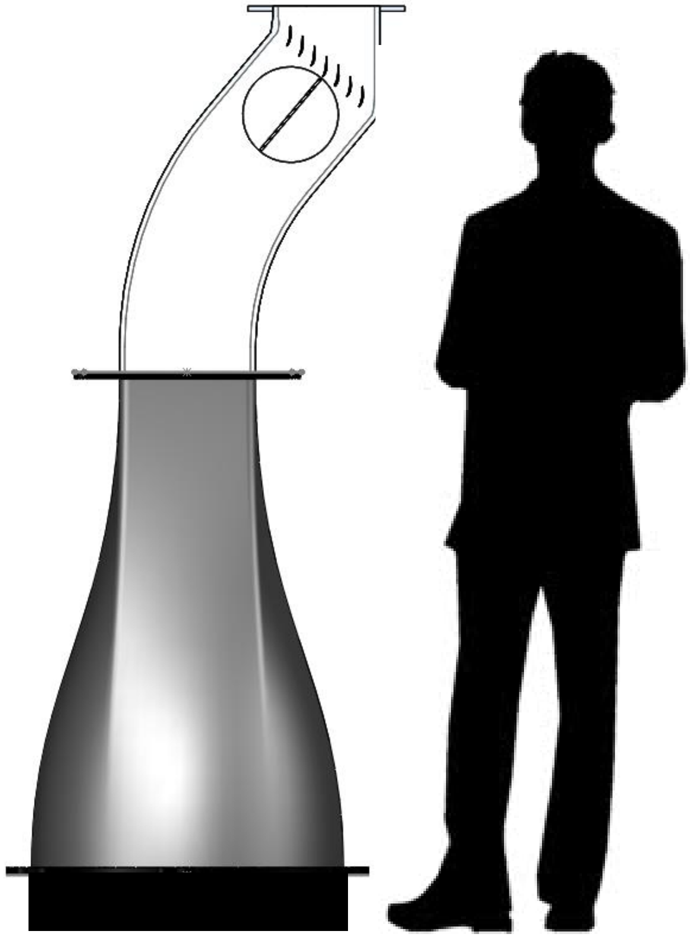
Experimental Platform Design

- Overestimated wind tunnel capability
  → Freestream velocity is readjusted from 100 m/s to 75 m/s

- Unwanted separation on the cascade blade
  → Cascade incidence is increased from 10.5° to 30° (operational condition)



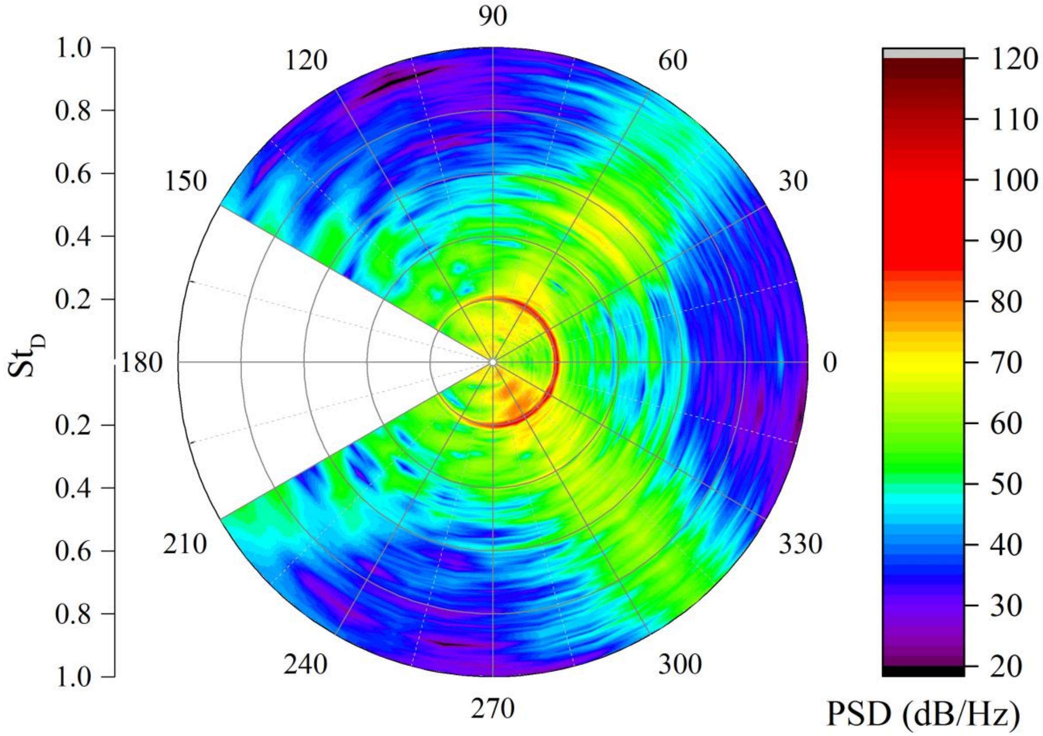
FULLY-MODULAR TEST RIG



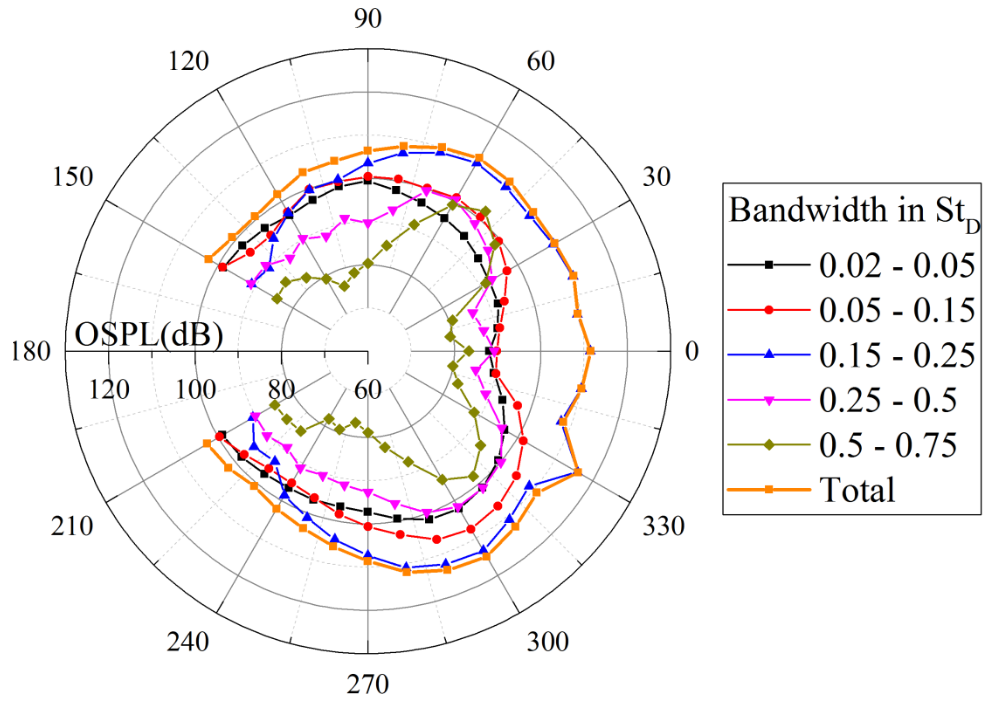
The test rig to human scale comparison

II. PRELIMINARY RESULTS

Spectra Directivity



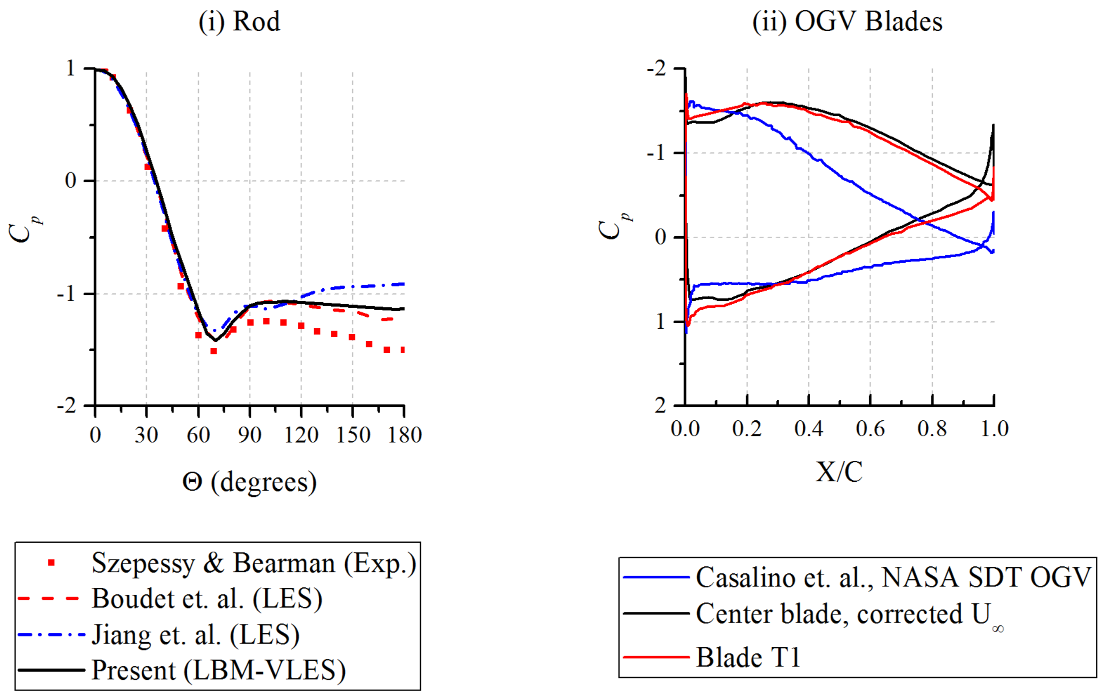
Power Spectral Density Directivity

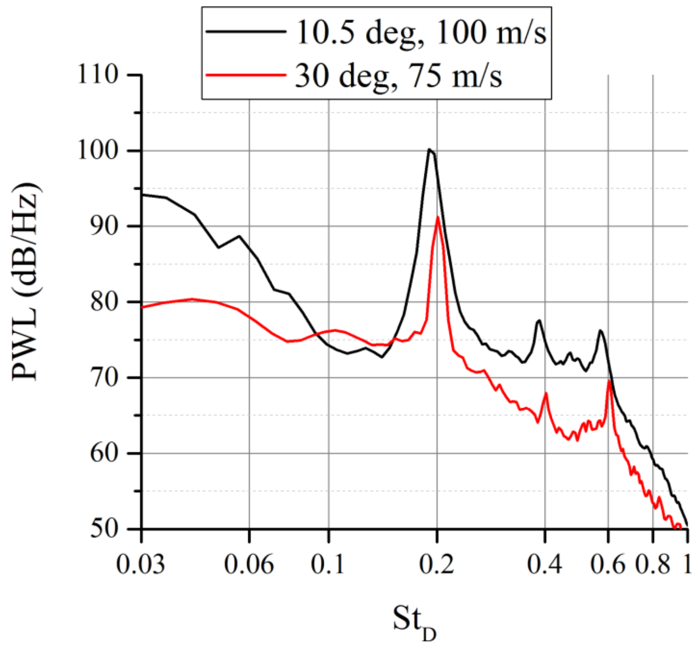


Narrowband OSPL Directivity

- The narrowband at the **BPF dominates the OSPL** in most direction.
- **Very narrow directivity** for the broadband components **at higher frequency ranges**, which may corresponds to the **diffraction of turbulent eddies** by the blade edges.

PWL and Pressure Distribution



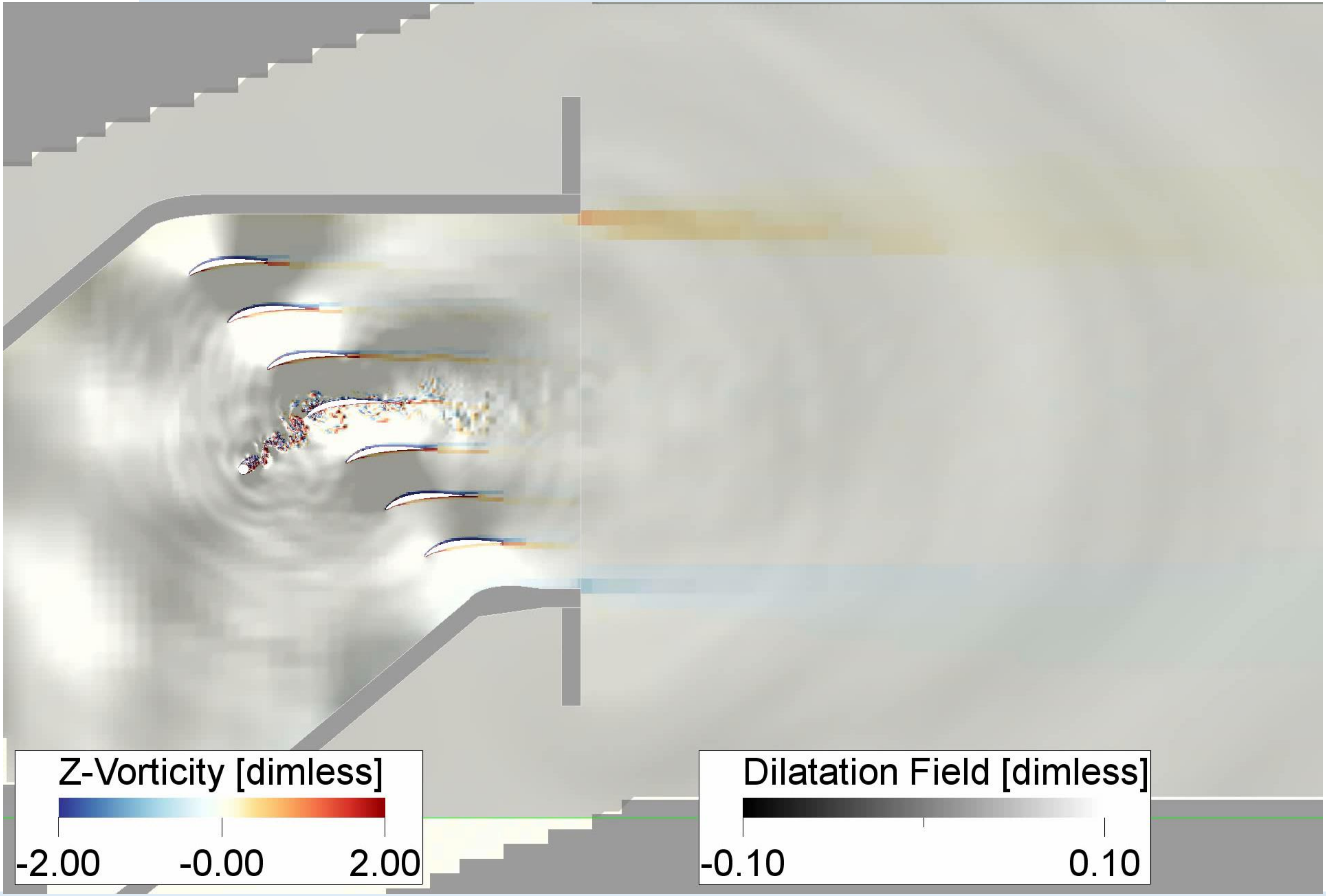


Pressure distribution on rod and OGV surface

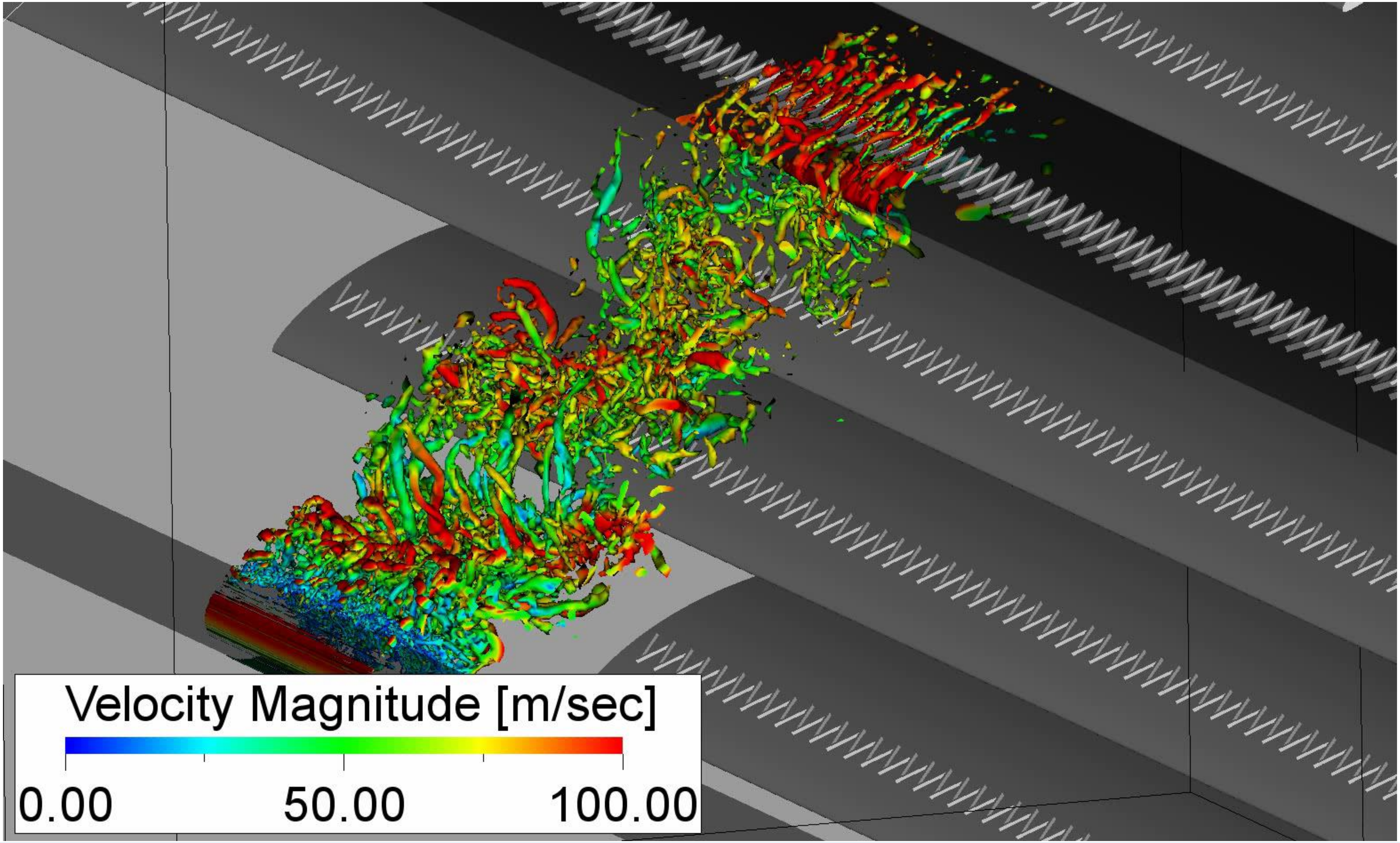
Source power level comparison

- **Source PWL is reduced** due to **lower freestream velocity**. Better SNR at the BPF due to weaker low-frequency contents.
- **Discrepancy** in the **blade pressure distribution** is very likely due to **stagger angle difference**.

Flowfield Visualization



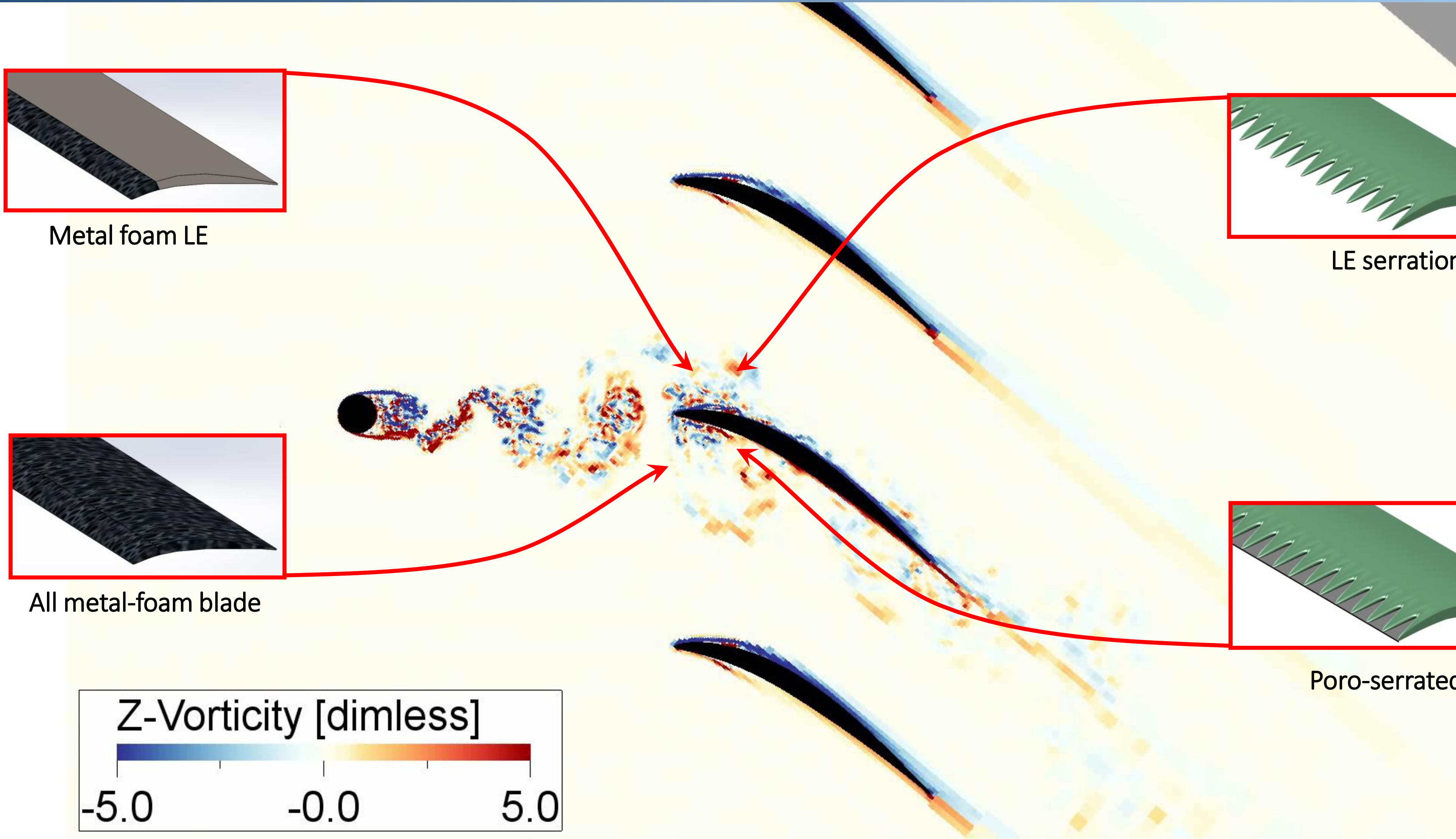
Flowfield Visualization



European Commission
Science for Environment Policy
FUTURE BRIEF:
Noise abatement approaches
April 2017
Issue 17

V. OUTLOOK

A FLEXIBLE PLATFORM FOR *TIN* MITIGATION STUDIES



What's Next?

- Experimental campaign to verify the simulations.

- The inclusion of leading edge serration to the OGV as baseline noise mitigation strategy and to investigate its impacts on performance.

- Characterization of metal-foam sample with PowerFLOW porous media models.

Smart ANSWER

HORIZON 2020 — THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

MARIE CURIE ACTIONS

Thank you for your attention !

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