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The characteristics and spatial structure of wall pressure fluctuations in a flow over steps

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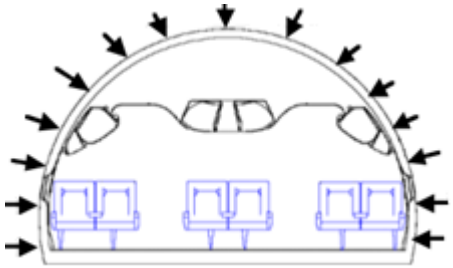
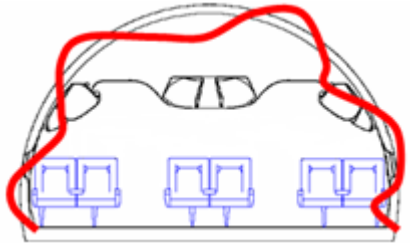
Introduction to the problem

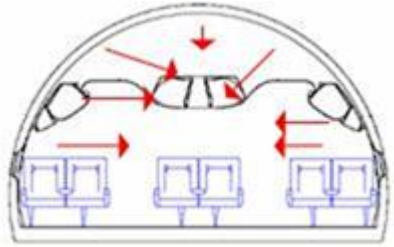
Wall pressure fluctuations



Structural vibrations



Internal noise



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Current affairs

- Wall pressure fluctuations in an undisturbed turbulent boundary layer have been studied to a large extent
- However, on the surface of a modern airliner there are additional perturbations

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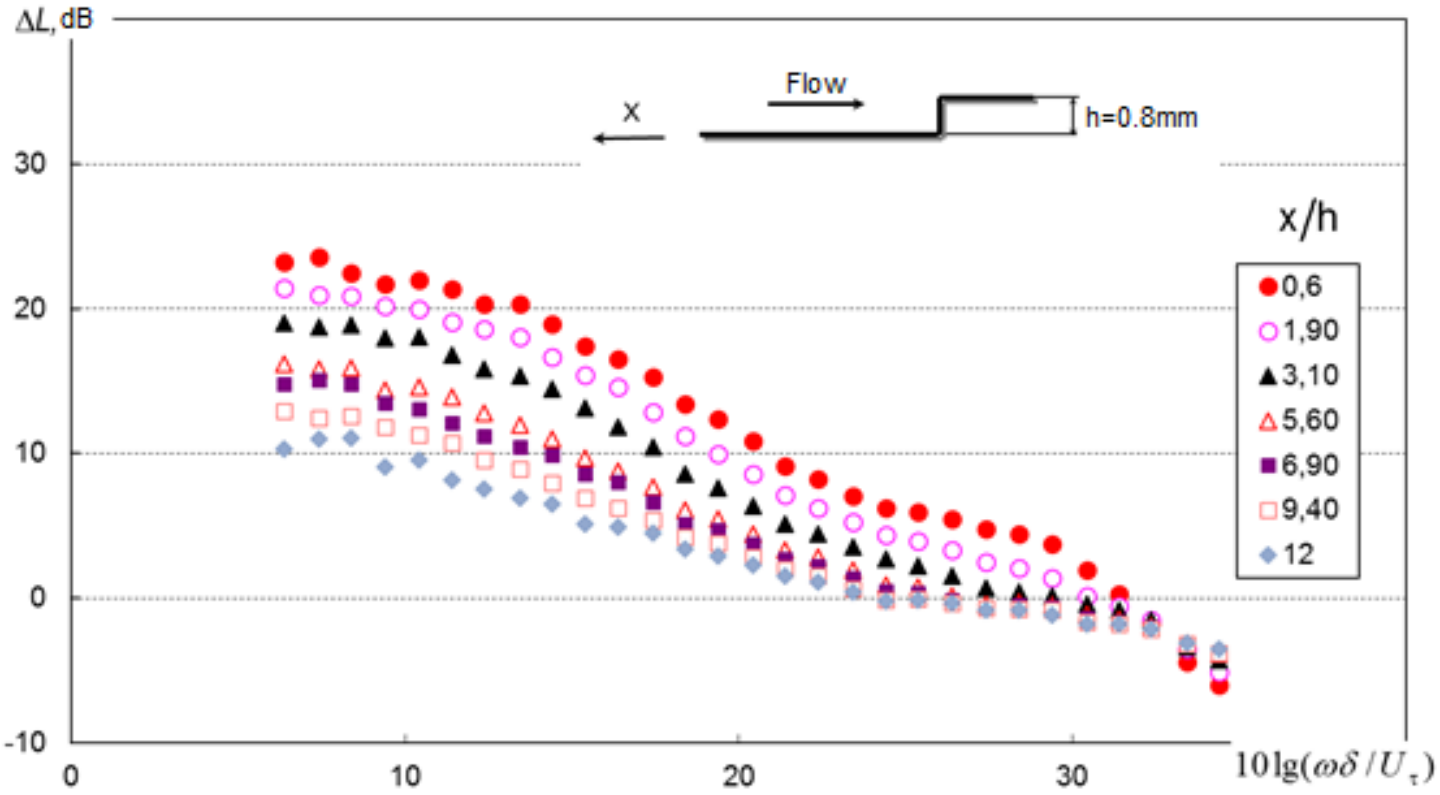
Forward-facing step

Excess over TBL at various distances from the edge



Source: Efimtsov B.M., Kozlov M.N., Kravchenko S.V. Andersson A.O. Wall pressure-fluctuation spectra at small forward-facing steps // AIAA paper 99-1964. 11p.

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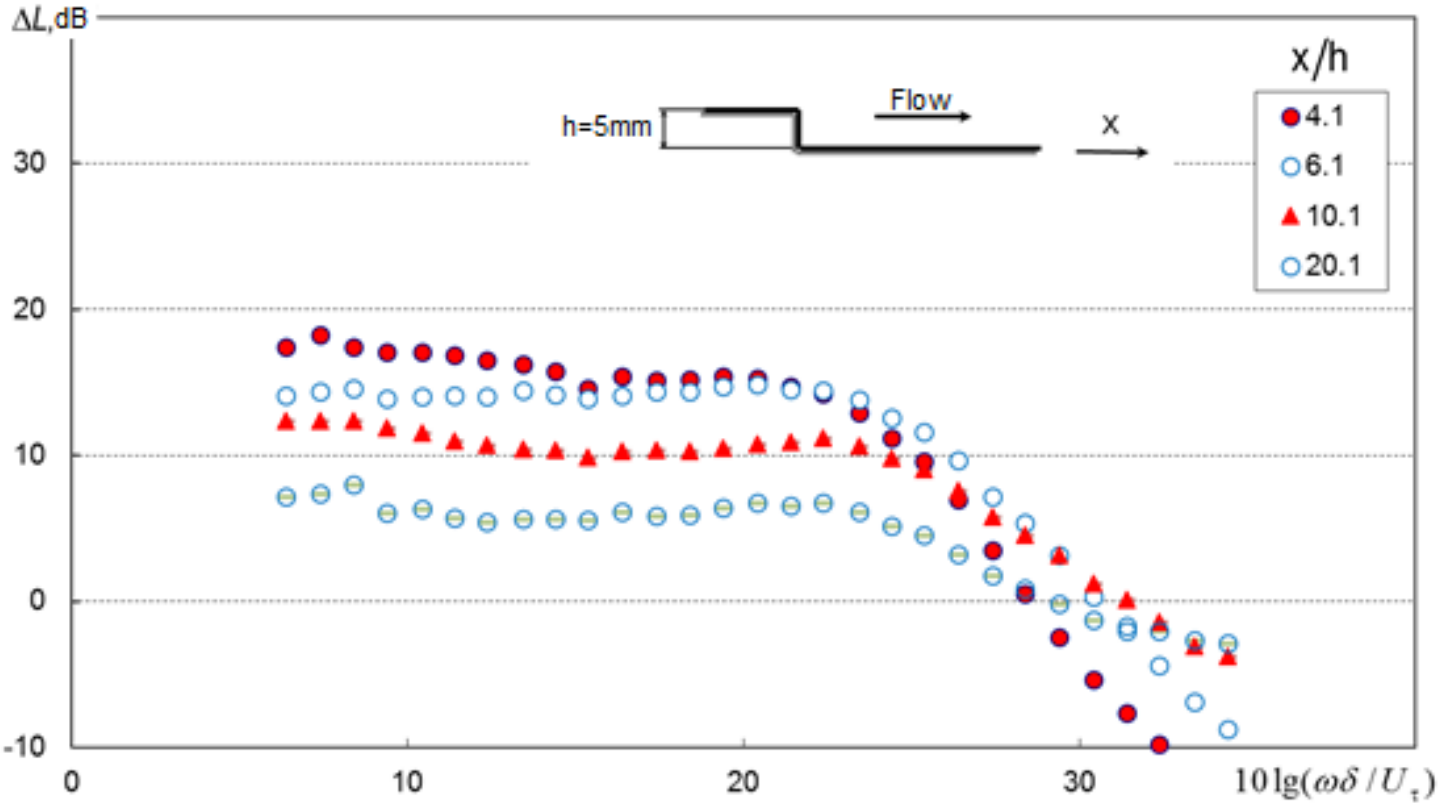
Backward-facing step



Excess over TBL at various distances from the edge

Source: Efimtsov B.M., Kozlov M.N., Kravchenko S.V. Andersson A.O. Wall pressure-fluctuation spectra at small backward-facing steps // AIAA paper 2000-2053. 10p.

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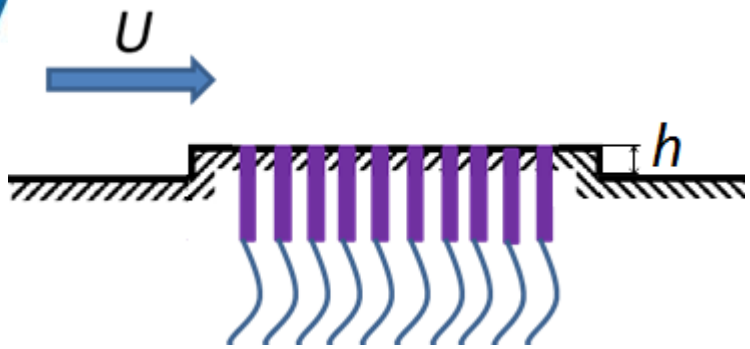
Experimental setup

Pressure transducers setup

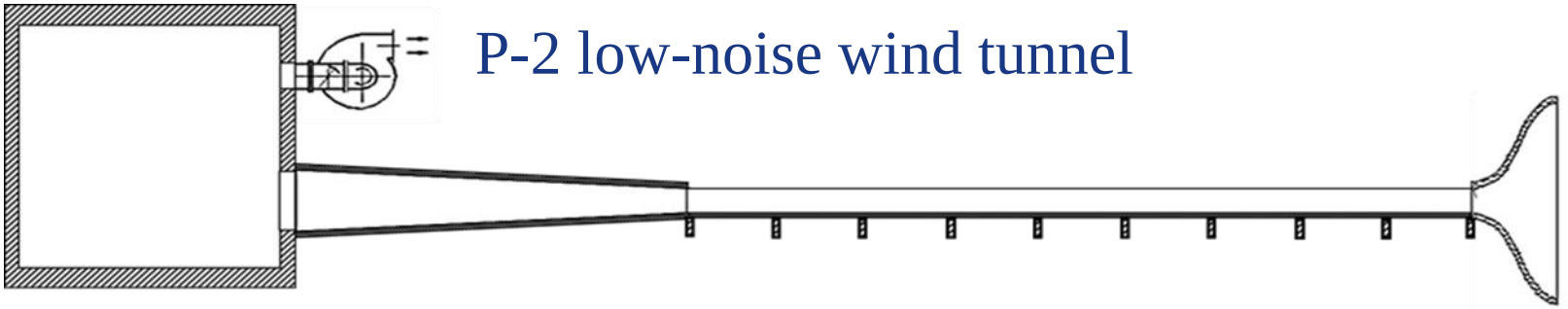


U = 45 m/s

h = 2, 5, 10 mm

δ = 37, 70 mm

$0.03 < h/\delta < 0.27$



P-2 low-noise wind tunnel

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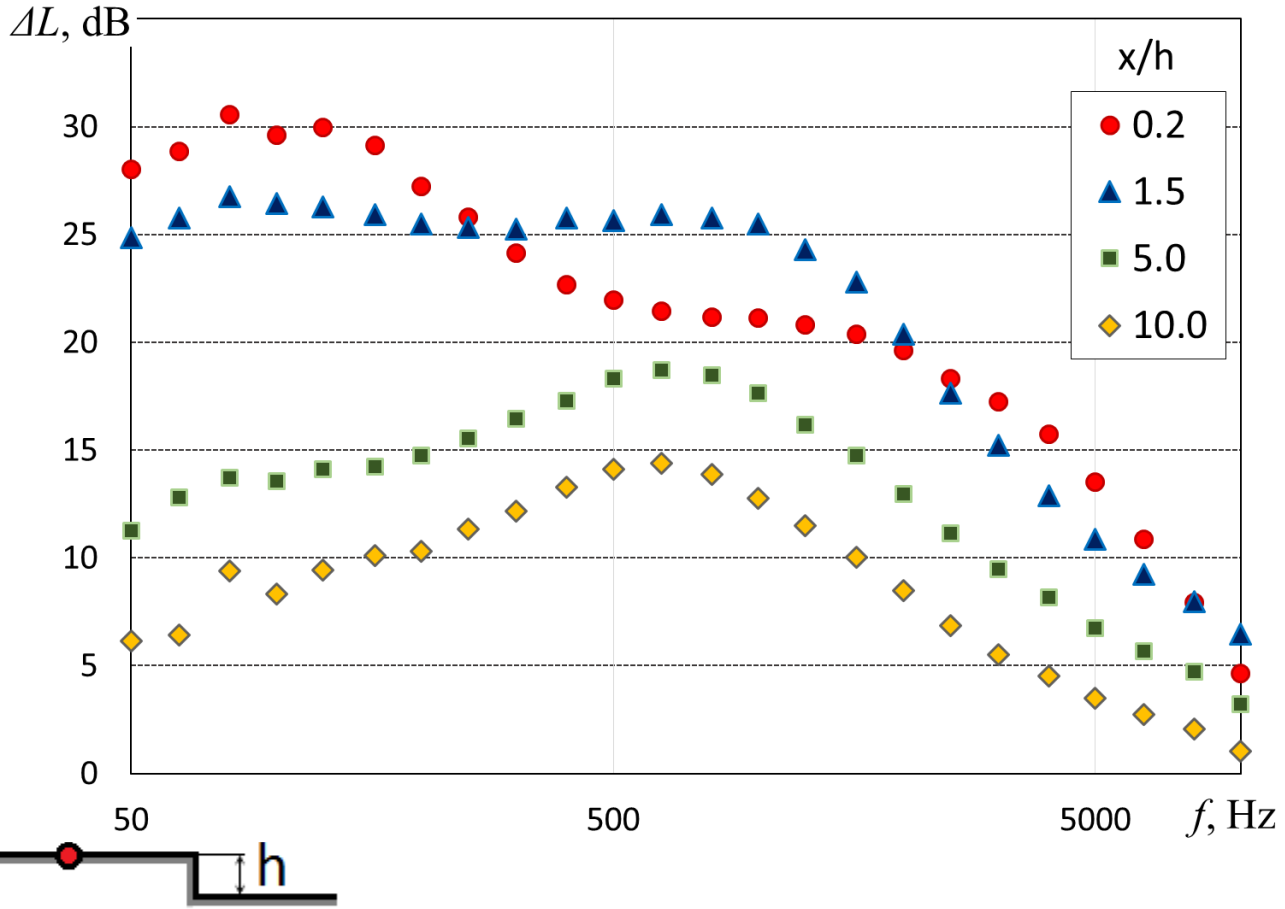
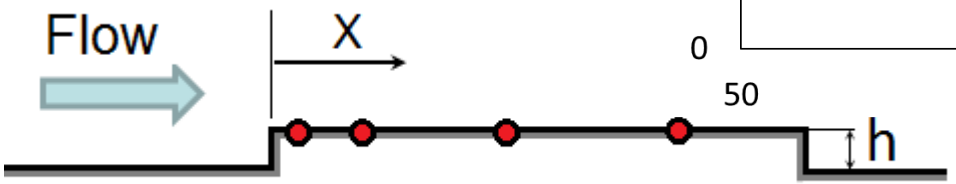
Comparison with undisturbed TBL

Step height
h = 10 mm





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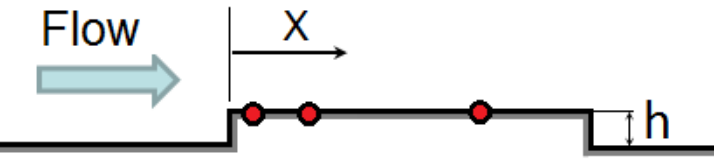
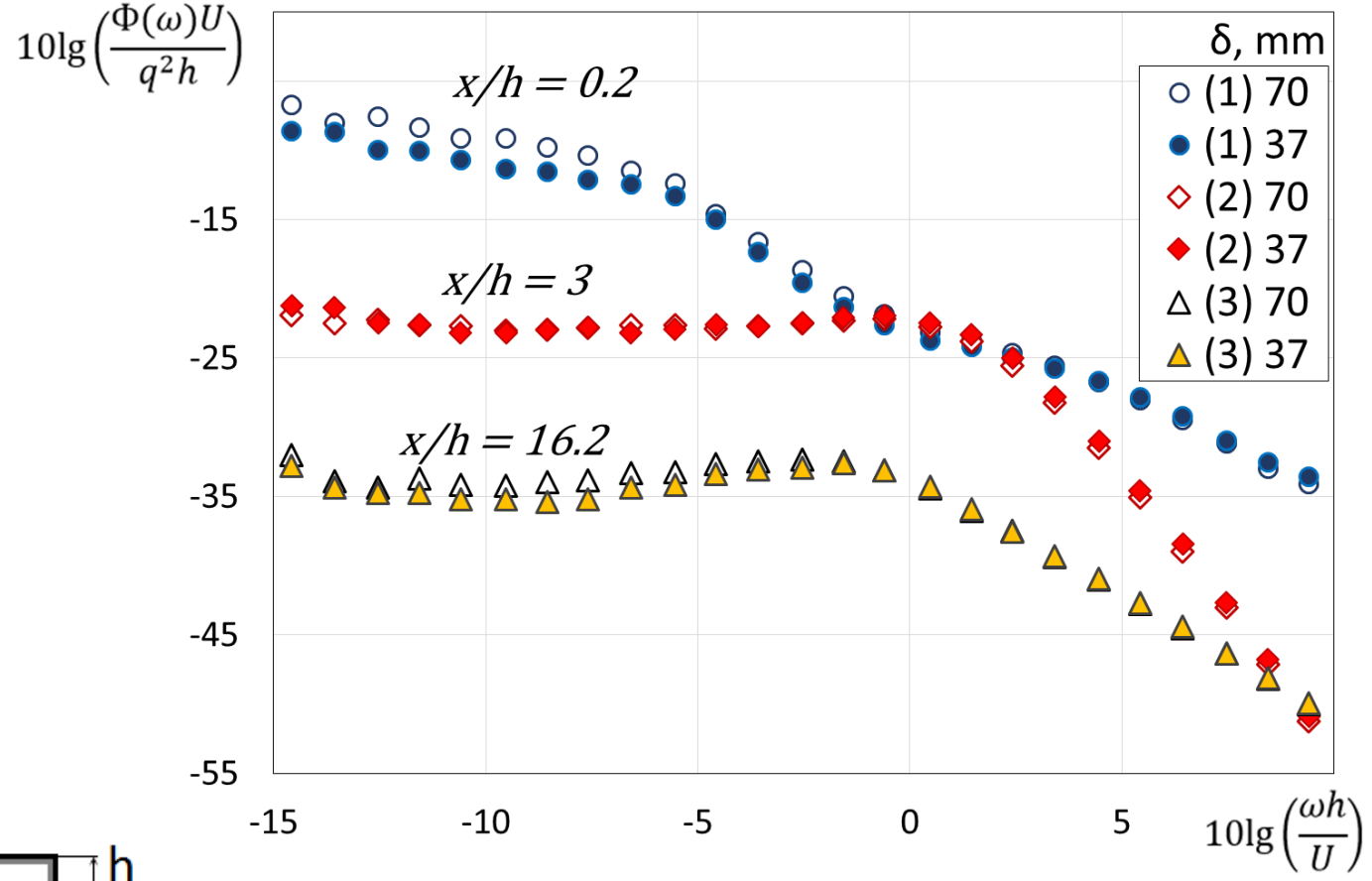
Influence of the BL thickness

2x variation of the BL thickness

Step height
h = 5 mm





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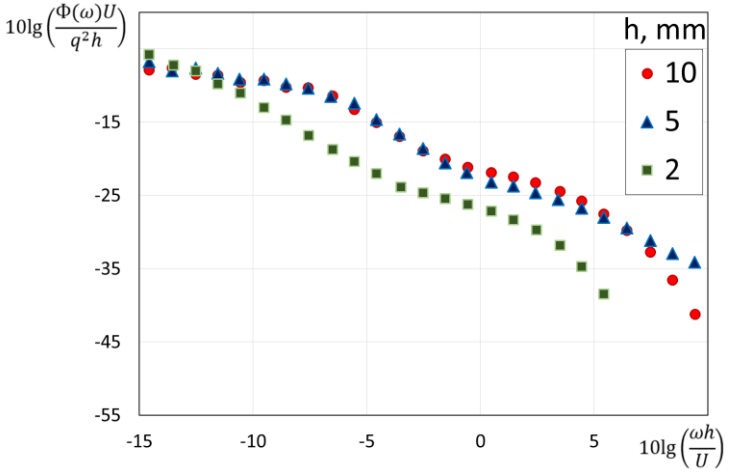
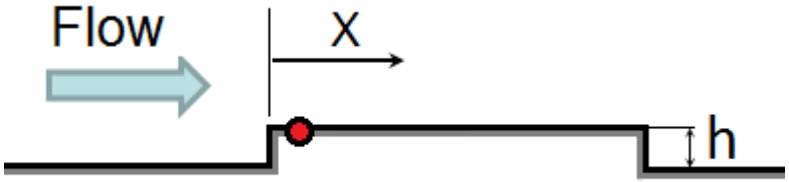
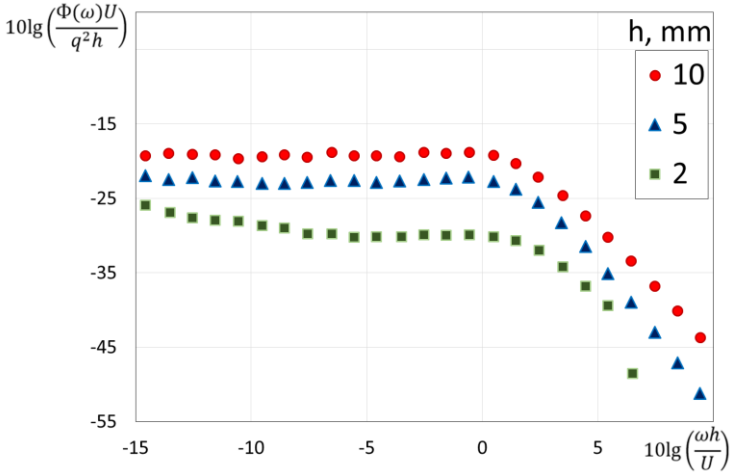
Influence of the step height

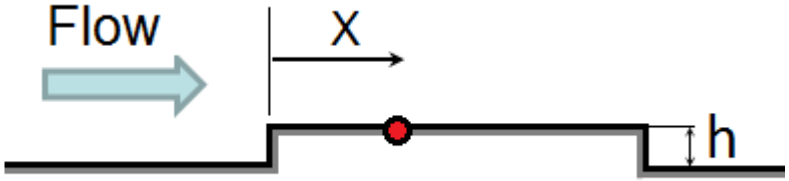


Measurement at x/h ~ 0





Measurement at x/h = 3



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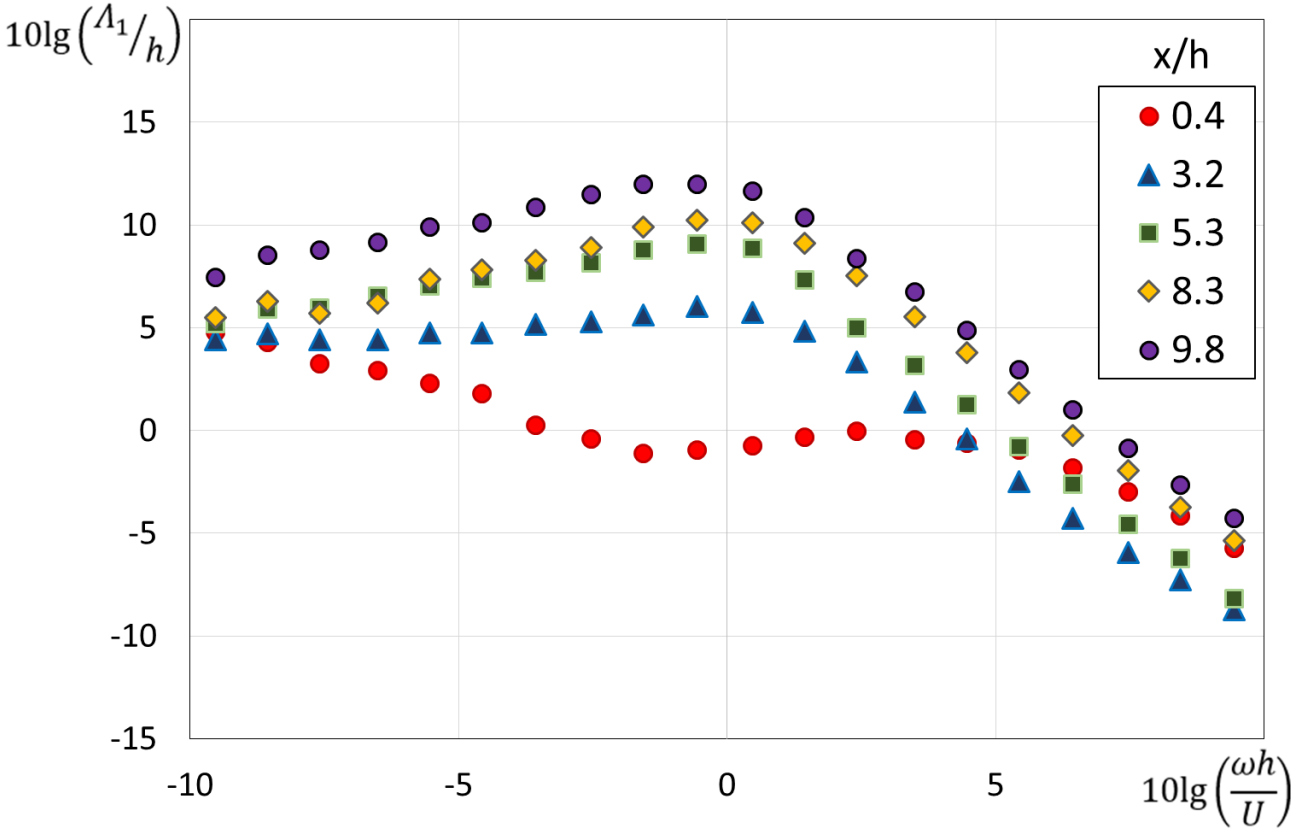
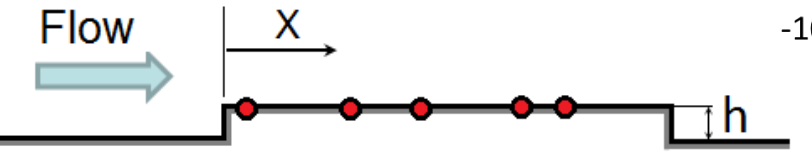
Local streamwise correlation scale

Step height
$h = 5\ mm$





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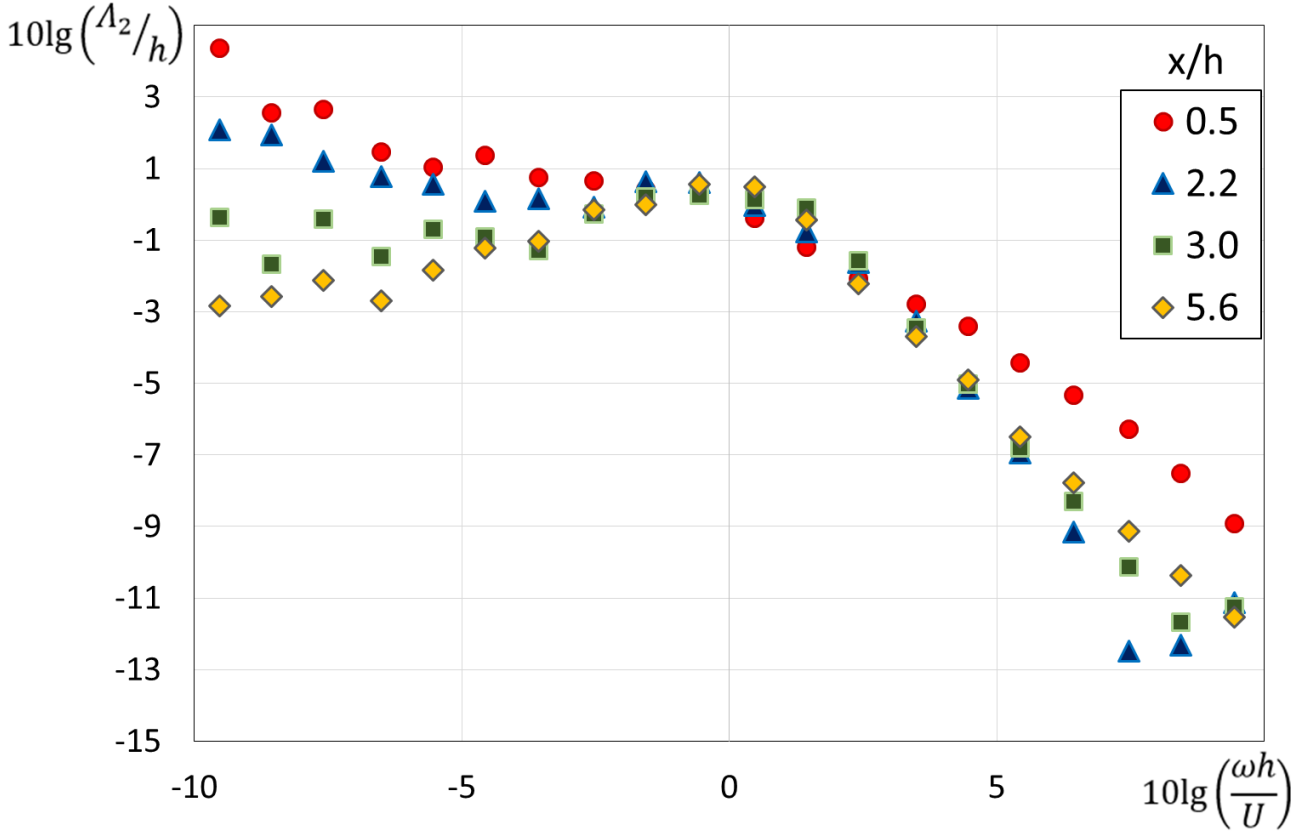
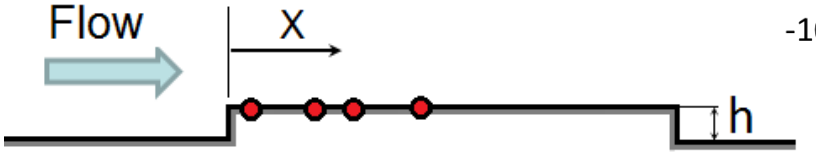
Local spanwise correlation scale

Step height
$h = 5\ mm$





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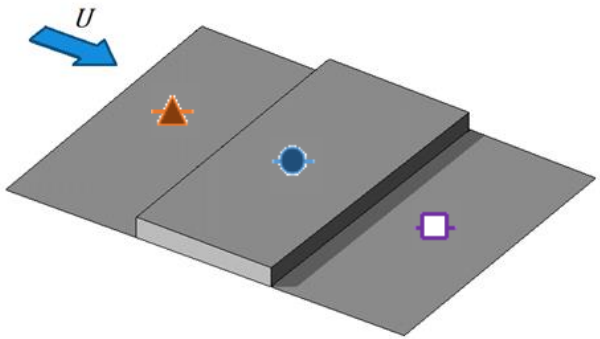
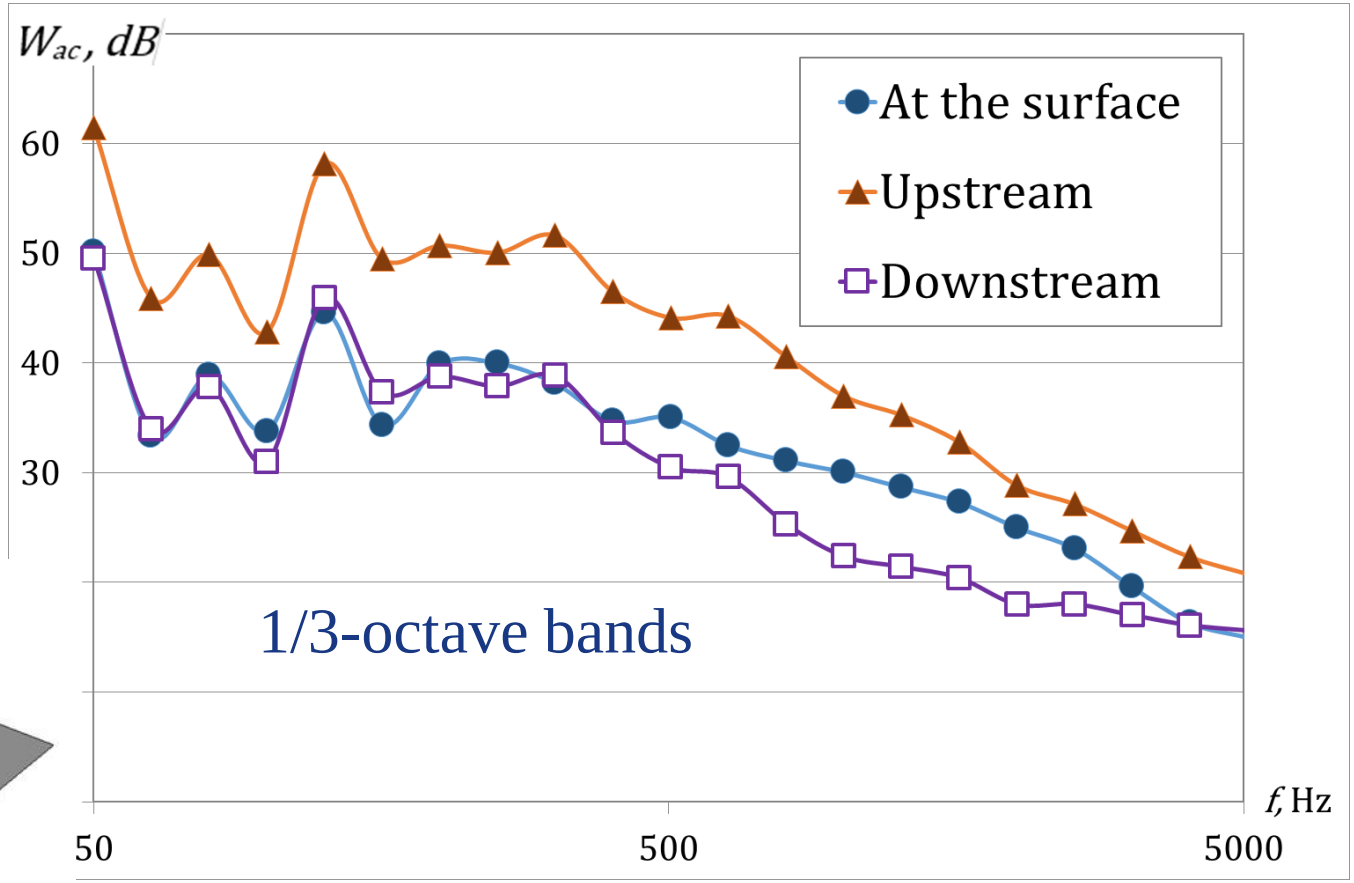
Estimation of sound radiation

Step height
$h = 2\ mm$





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Conclusion

- Wall pressure fluctuation levels are 20-30 dB higher than in TBL
- Boundary layer thickness is far less influential parameter than the height of the step for configurations with relative height $0.03 < h/\delta < 0.27$
- Local correlation characteristics are substantially non-uniform in the streamwise direction
- Wall pressure fluctuations field at the surface of the step has a comparable with the other fields contribution in sound radiation

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Thanks for your attention!