Computational modelling of jet-wing installation noise

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Outline

- **Motivation**
- **Jet-wing configuration from the TsAGI experiment**
- **Computational results**
  - **Aerodynamics**
  - **Acoustical modelling**
- **Conclusion**

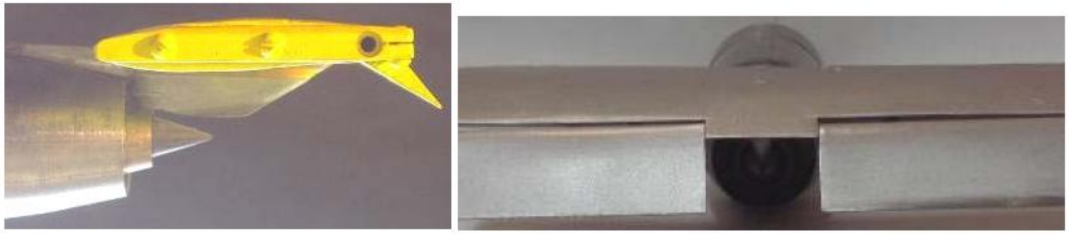
Jet installation effects are becoming increasingly important

C.A. Brown, Technical Working Group Meeting, 15-16 April 2014, Langley, VA

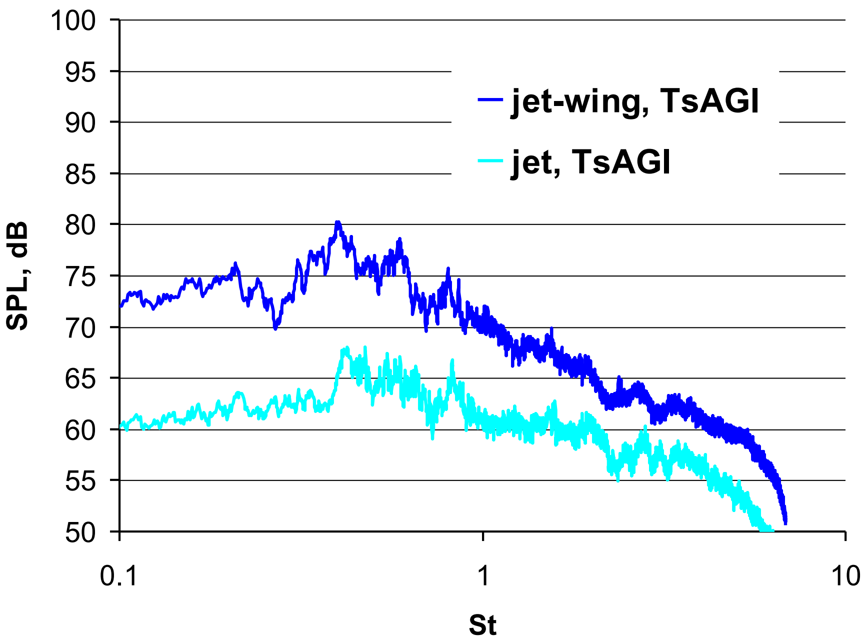
Jet-wing interaction effect: experimental evidence

TsAGI jet-wing configuration (AIAA 2013)

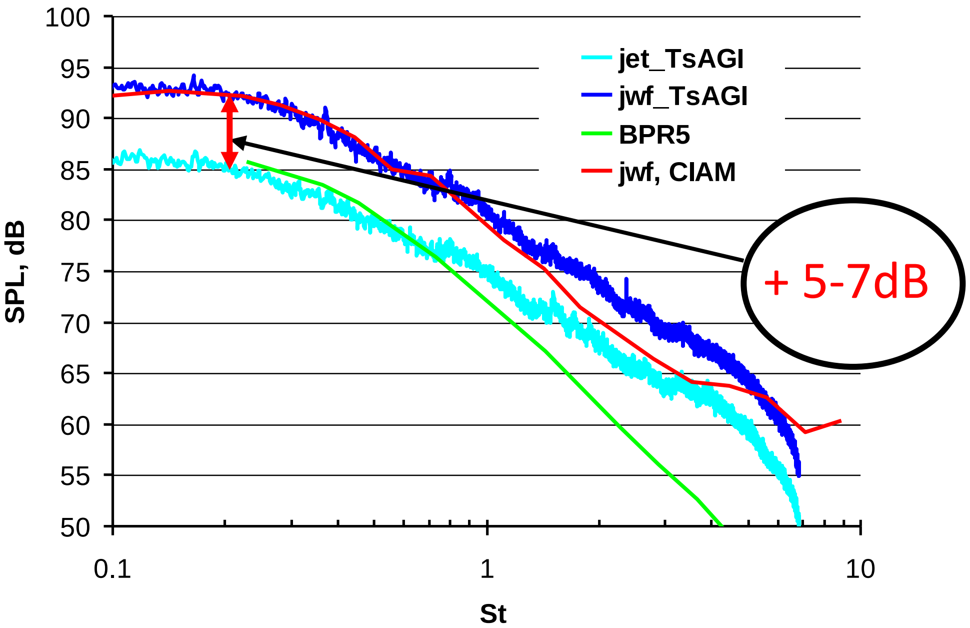
CIAM jet-wing-flap configuration (Mironov et al, 2012)



90 degrees



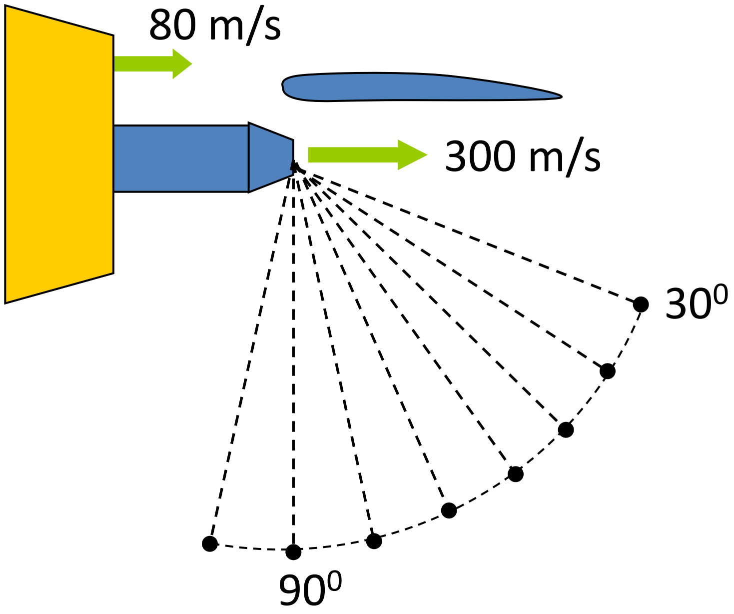
30 degrees



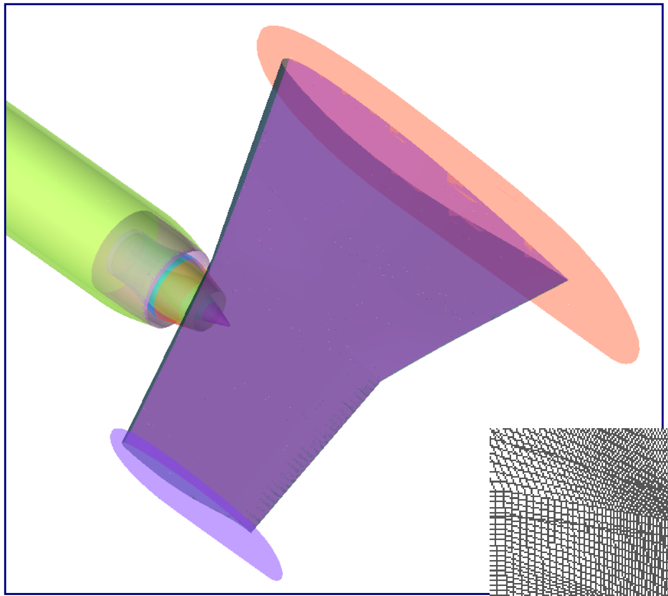
TsAGI jet-wing experiment

Dual-stream jet + swept wing:

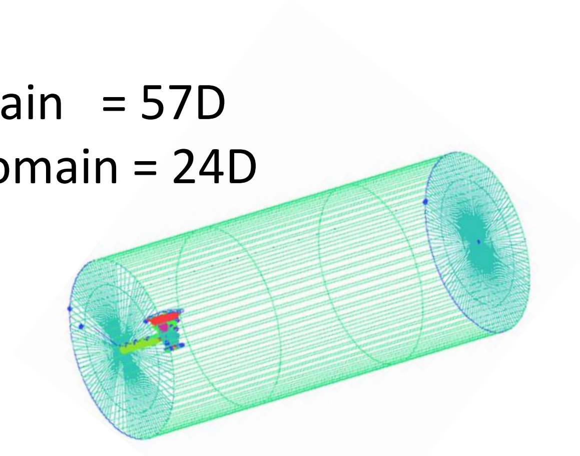
Co-flow 80 m/s
Jet flow 300 m/s

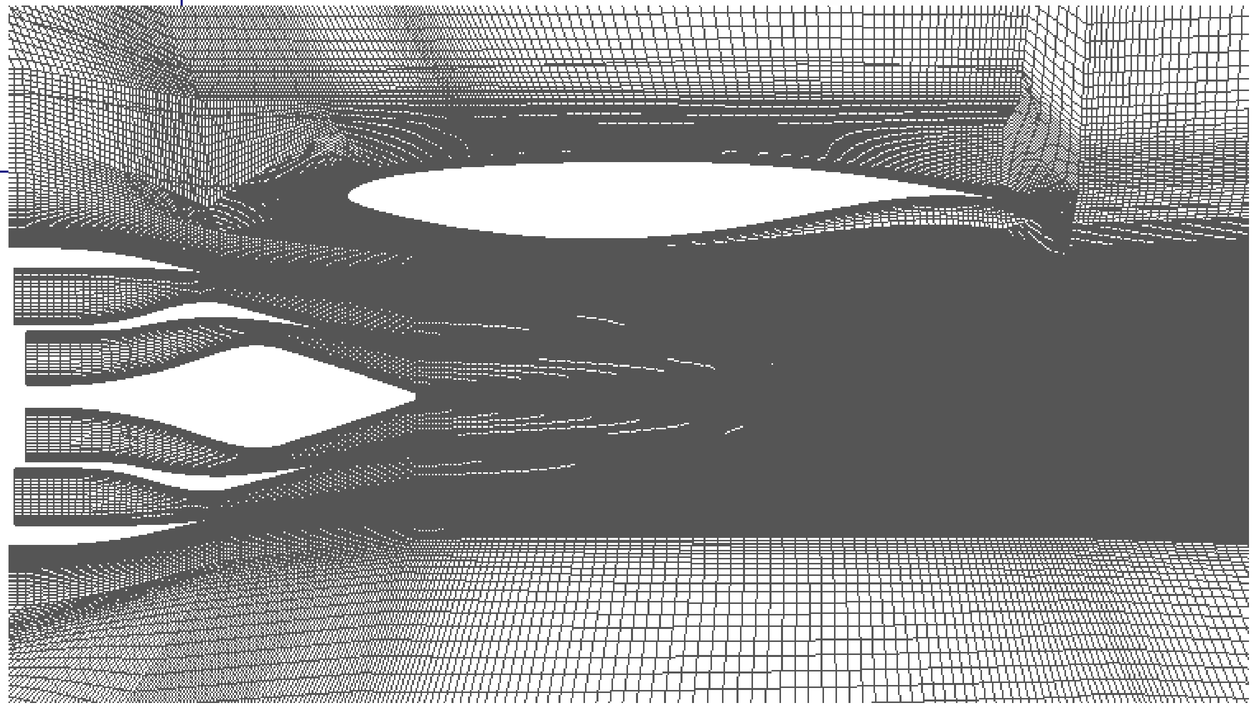


Geometry of the TsAGI jet-wing configuration



Length of the domain   = 57D
Diameter of the domain = 24D

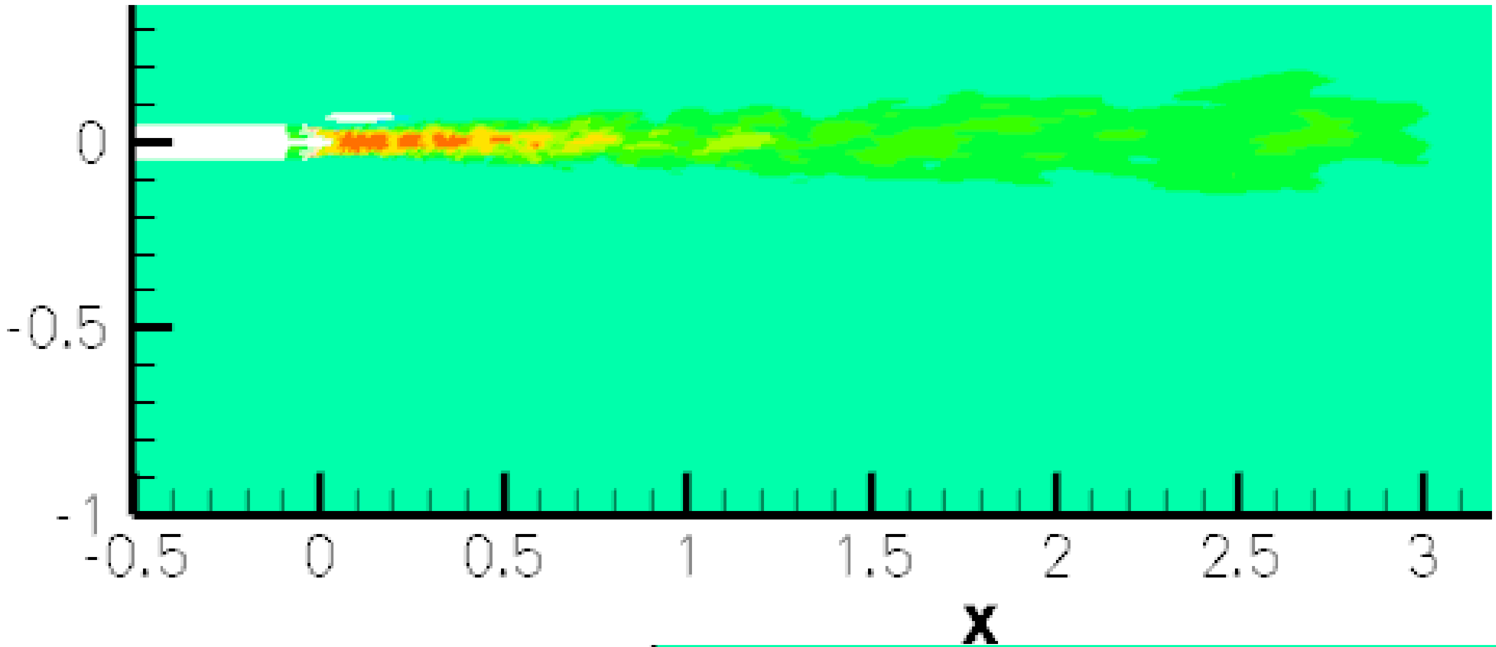




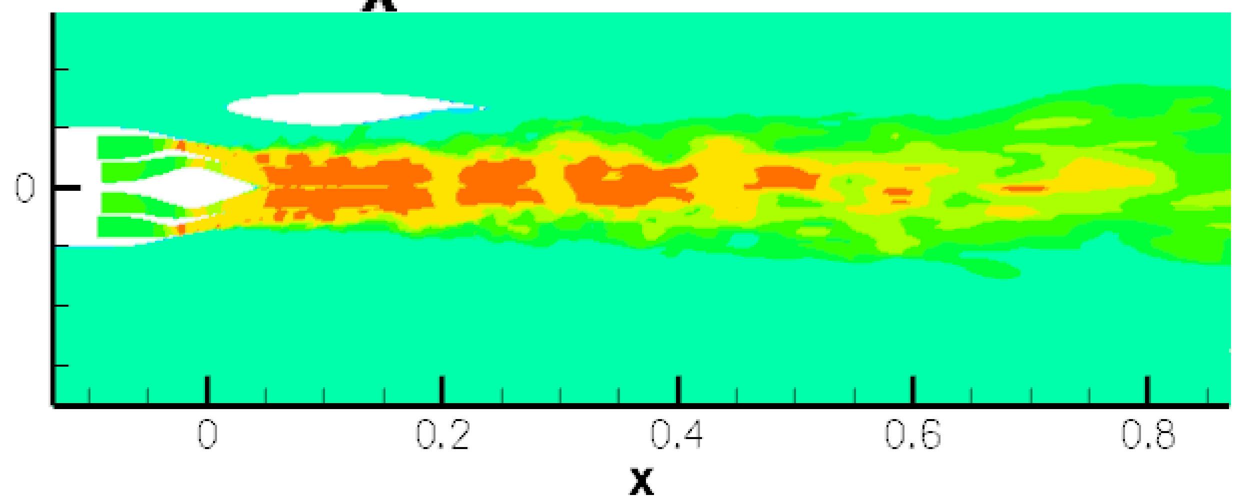
~12 mln cells
992 cores

Aerodynamics: MILES
(~12 mln. grid cells, 992 MPI cores)

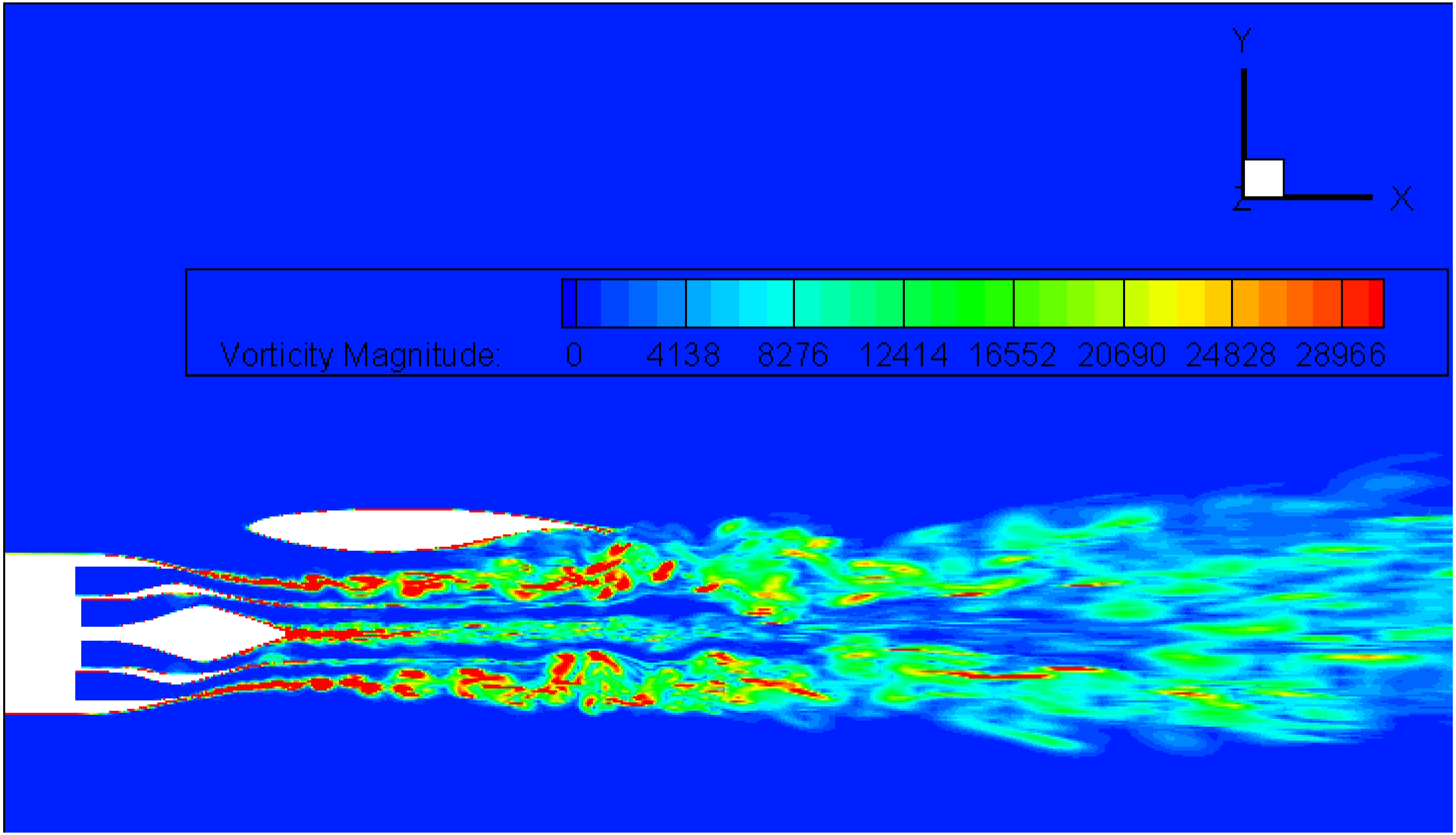
Instantaneous x-velocity component Oxy plane



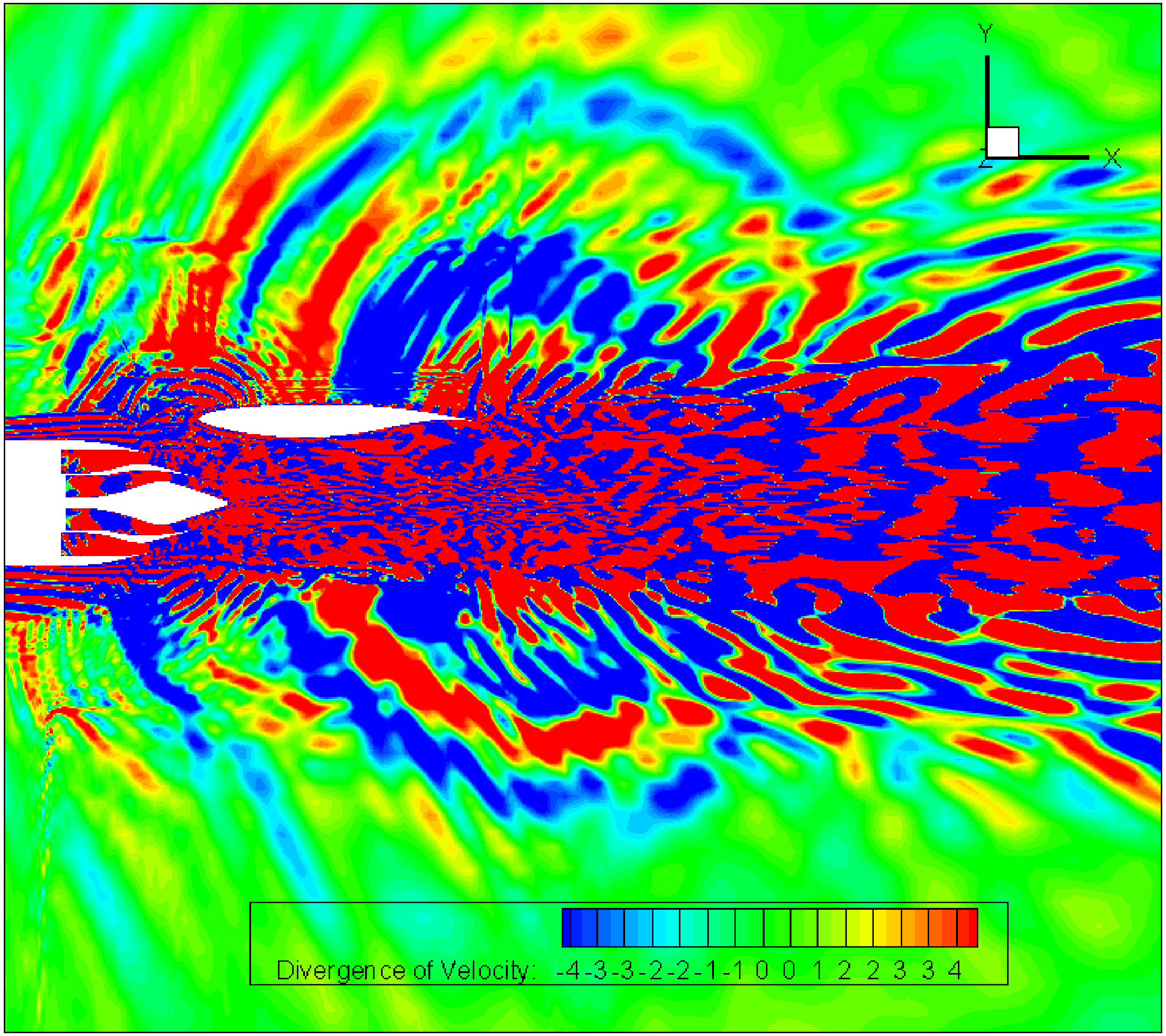
No experimental flow data are available at present



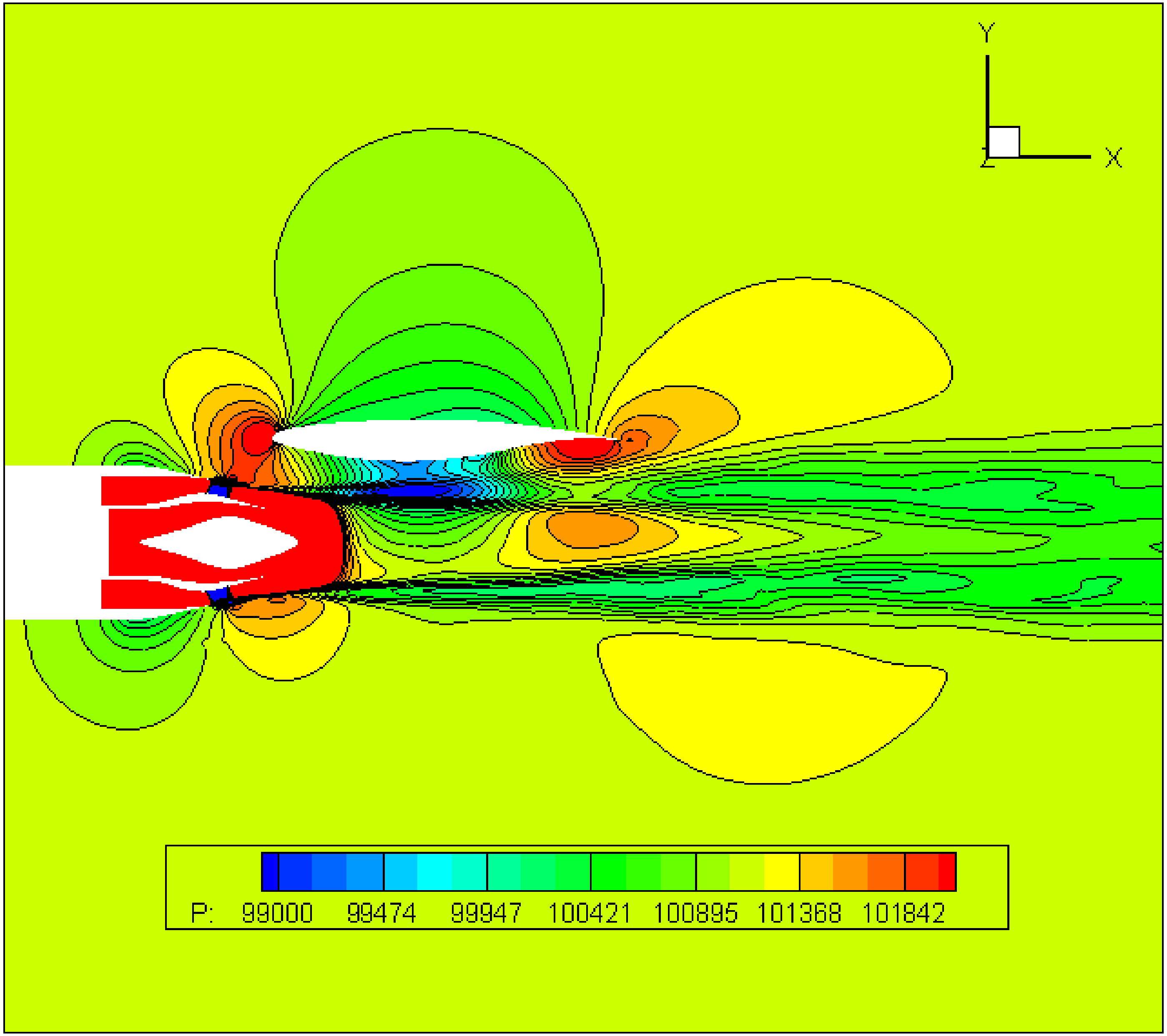
Instantaneous vorticity magnitude, OXY plane



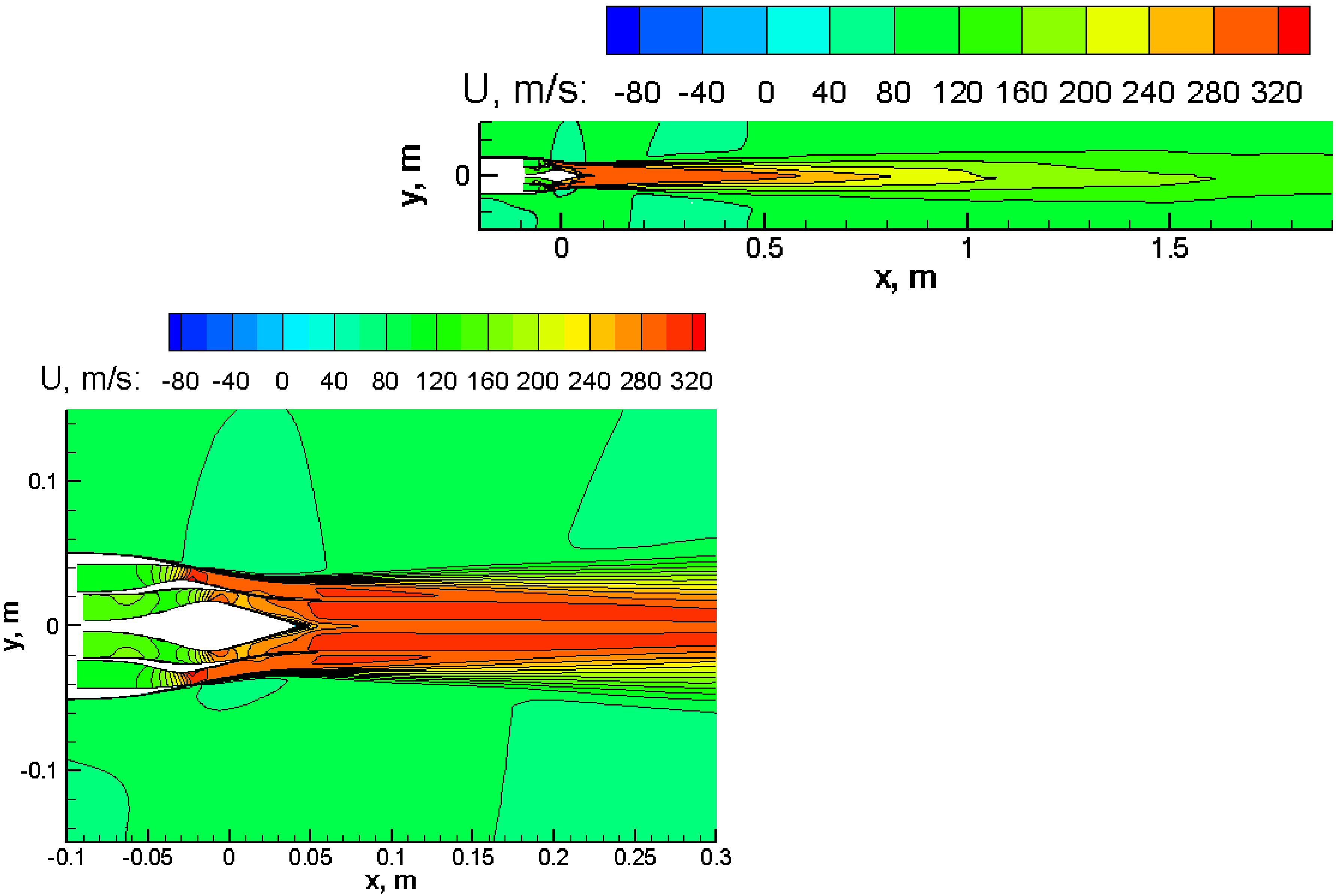
Instantaneous dilatation field



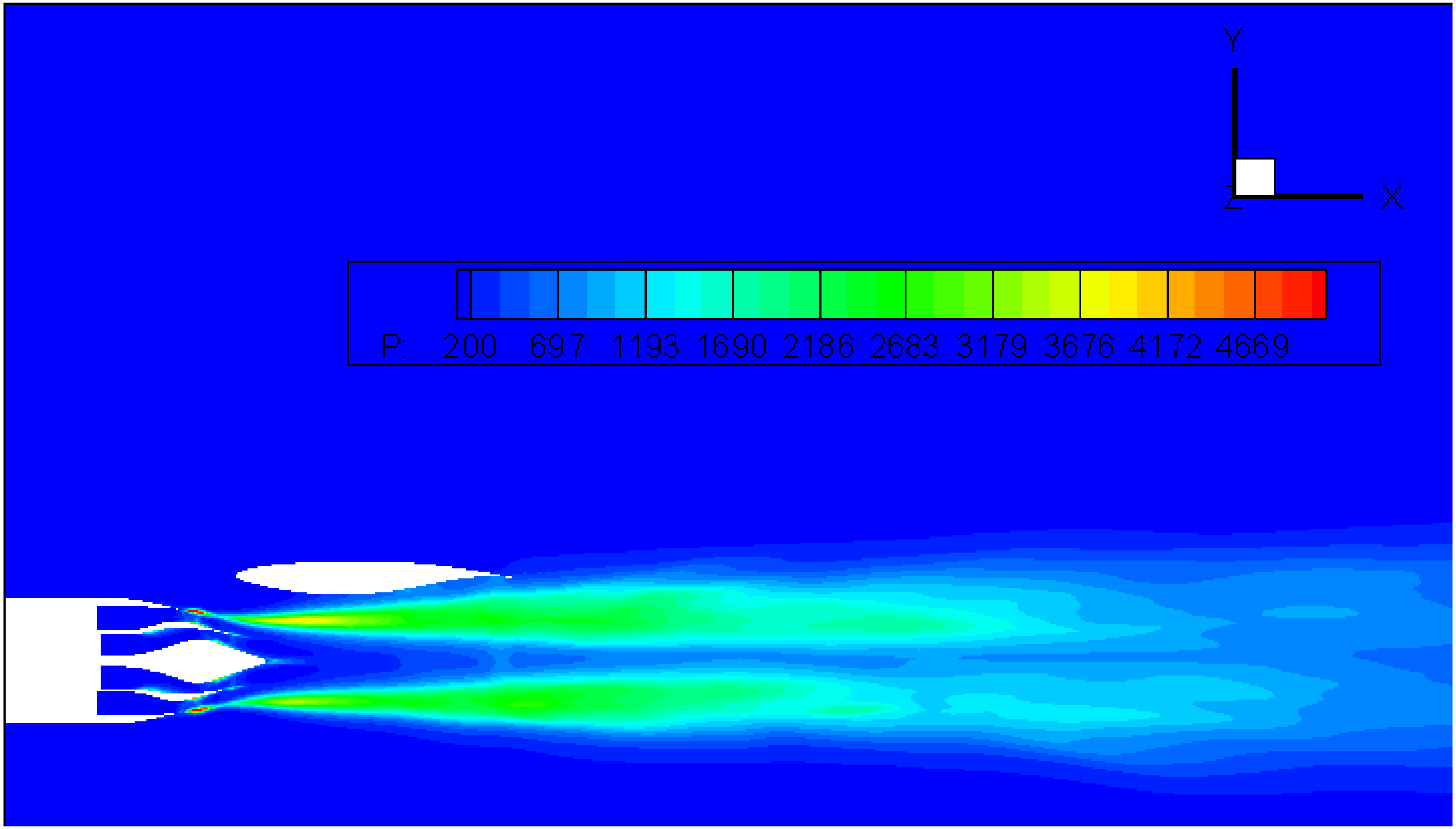
Mean pressure field, OXY



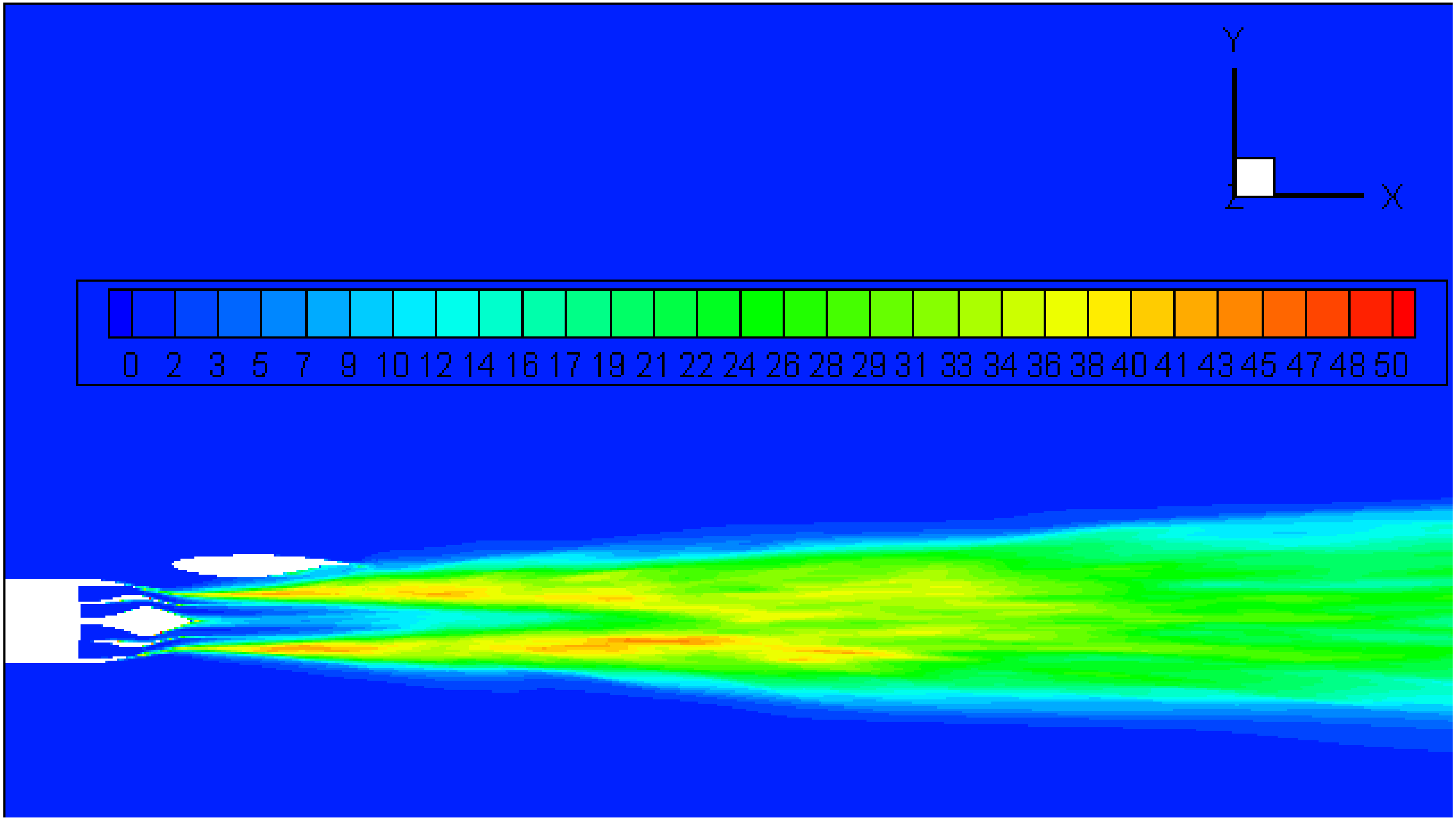
Mean x-velocity component, OXY



RMS pressure fluctuations, Oxy

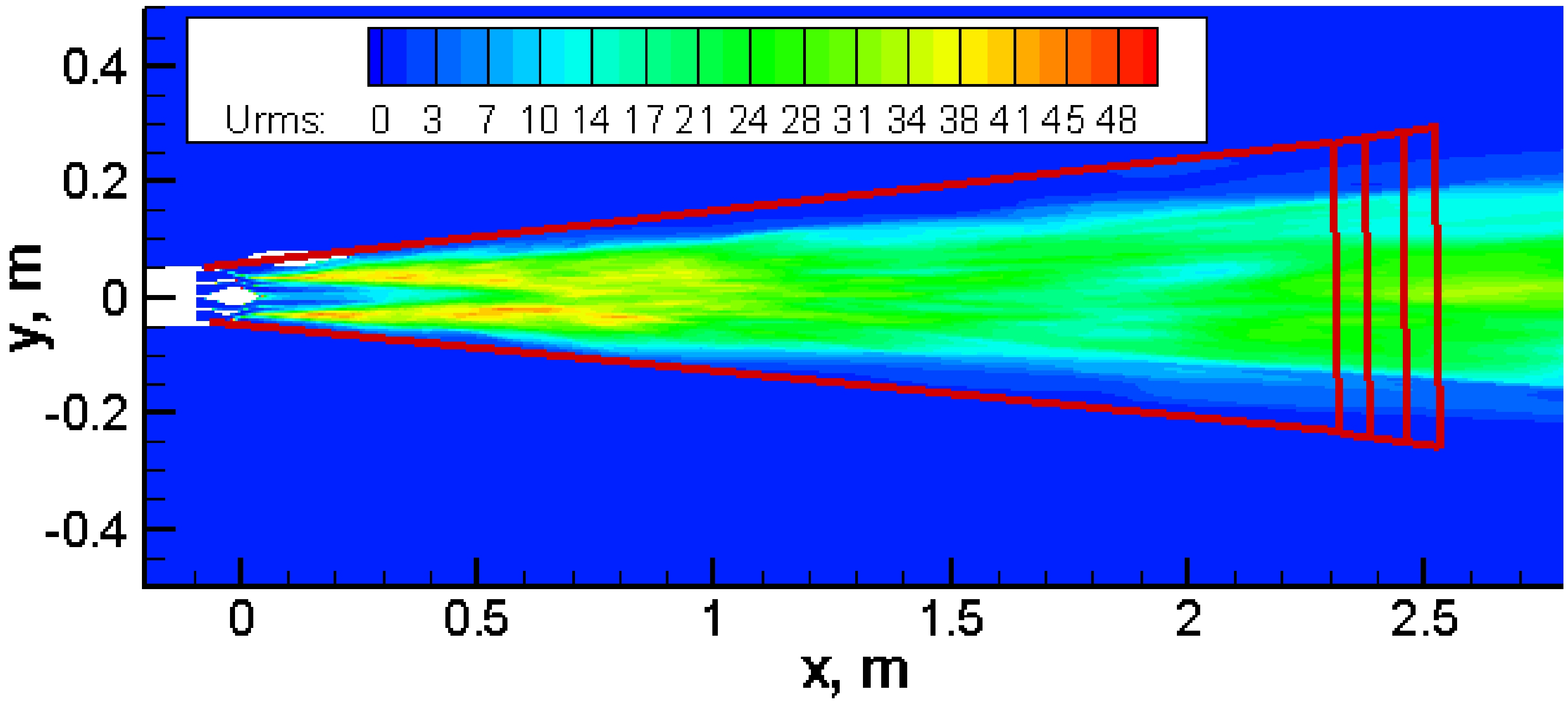


RMS x-velocity fluctuations, Oxy



Acoustics: FW-H

FW-H surfaces



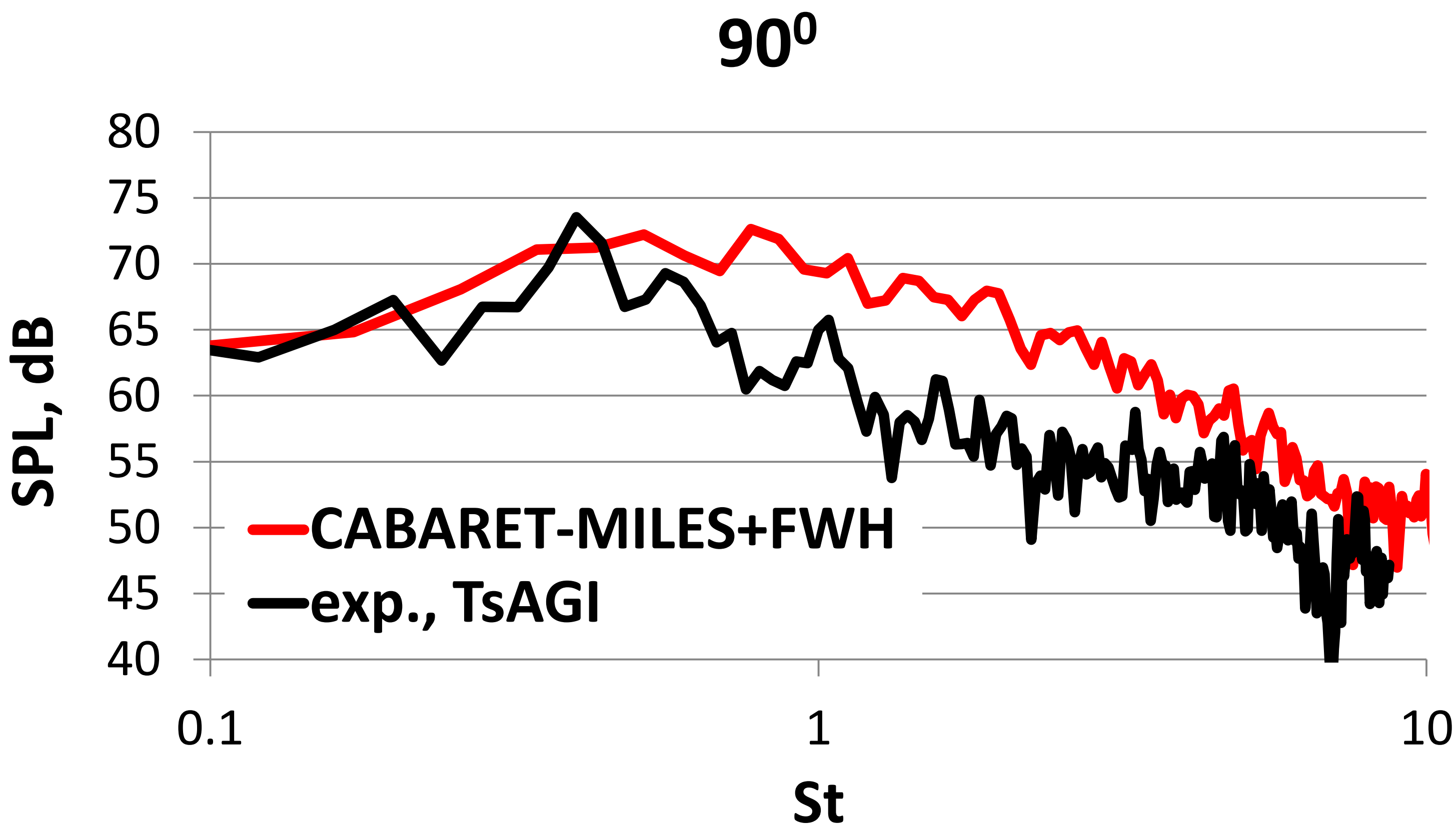
FW-H surfaces have 4 closing disks at the outlet;

R_0=0.051m, R_1=0.277m, L=2.4m

Parameters of the FW-H surfaces used:

Lengths = 20D and 25D, radius variation = +/-10%

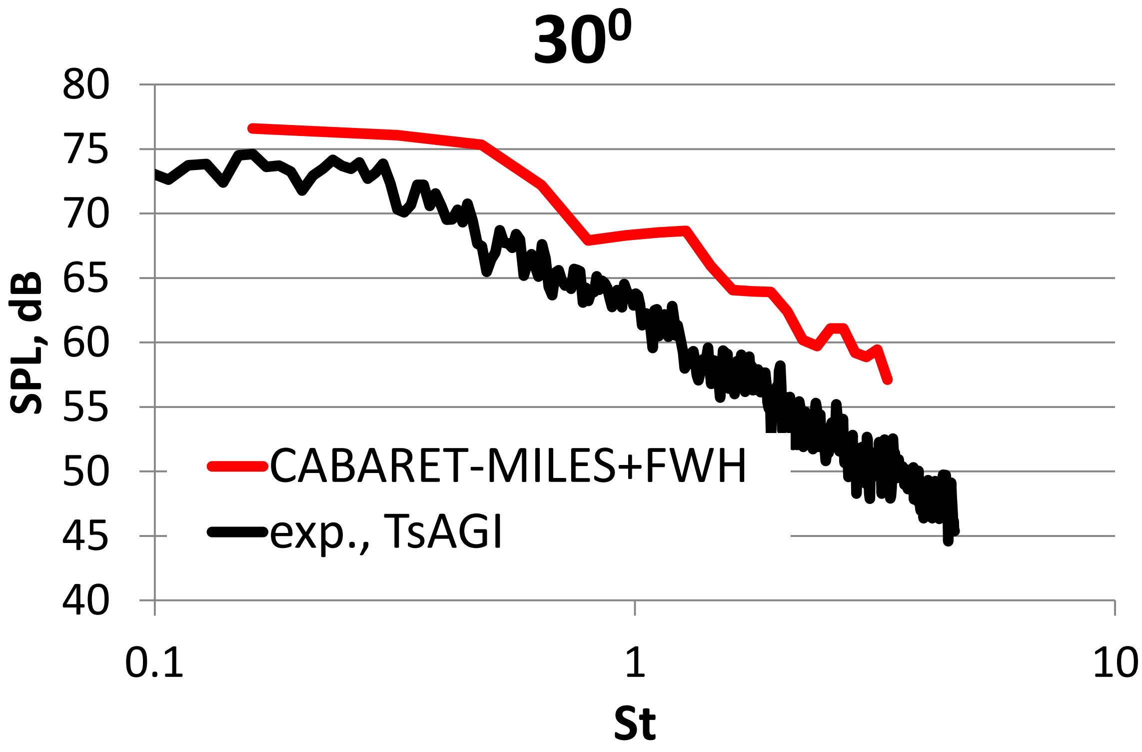
The FW-H results are based on the free-space Green's function



~4-5dB difference in the absolute predictions

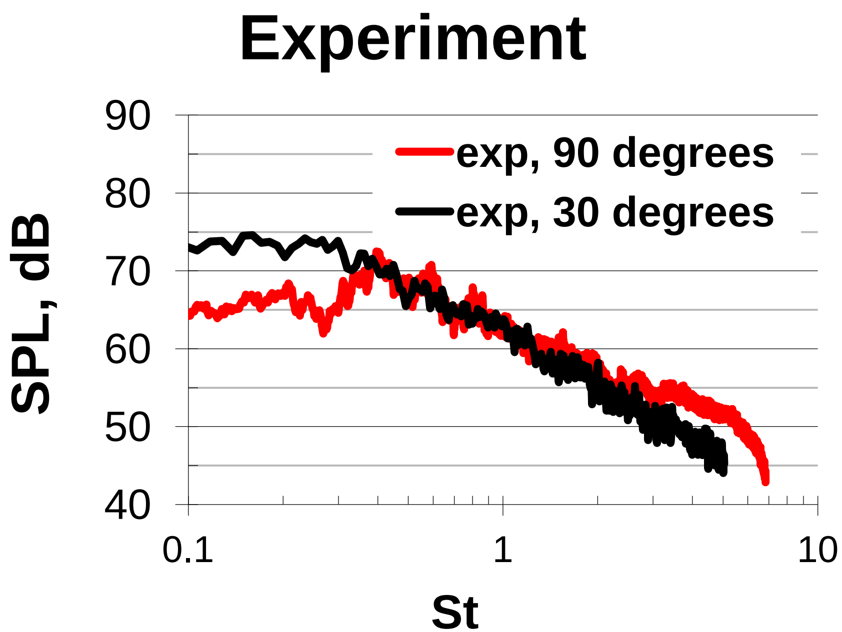
The FW-H results are based on the free-space Green's function

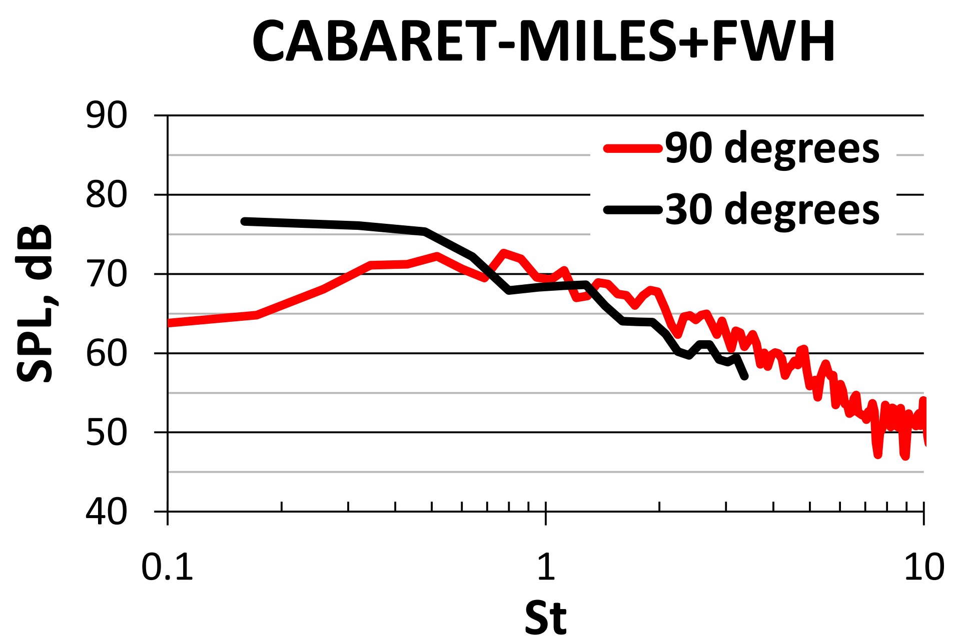
Same ~4-5dB difference in the absolute predictions



Offset of the spectra frequency between the experiment and the computation?

Small angle/large angle comparison between the simulation and the experiment



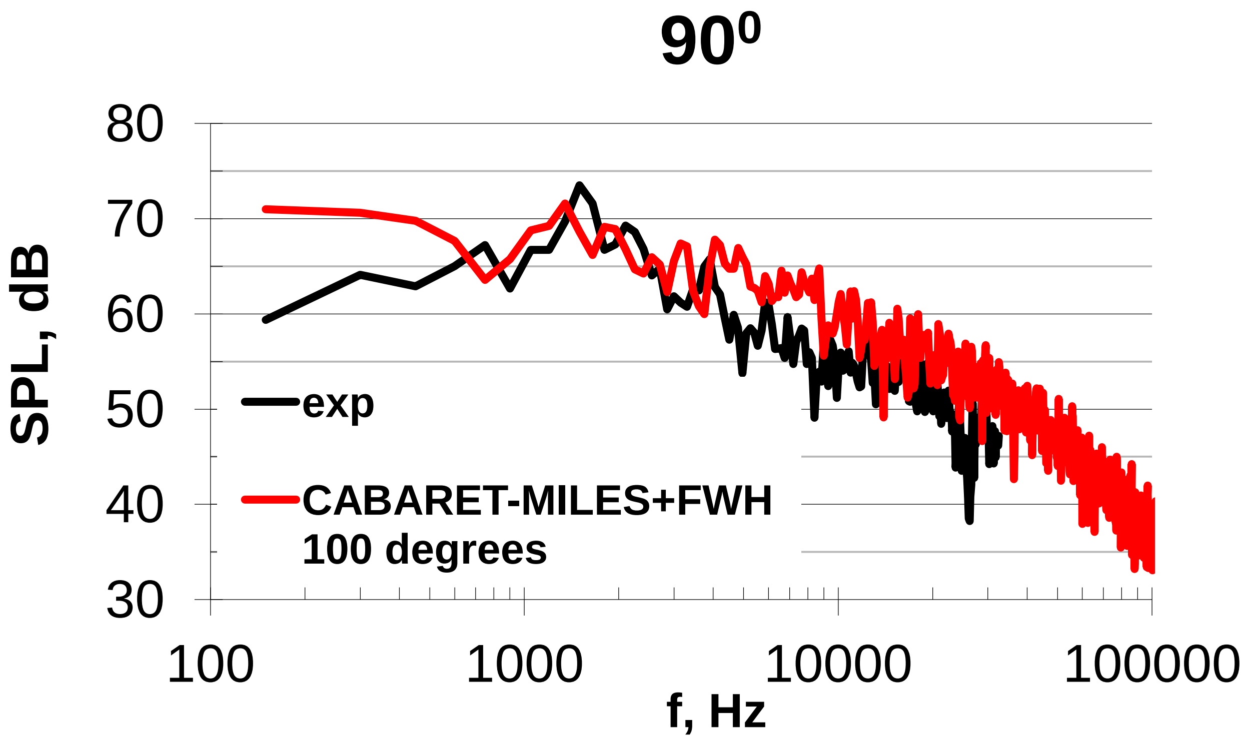


Qualitatively similar behaviour at high vs low frequencies

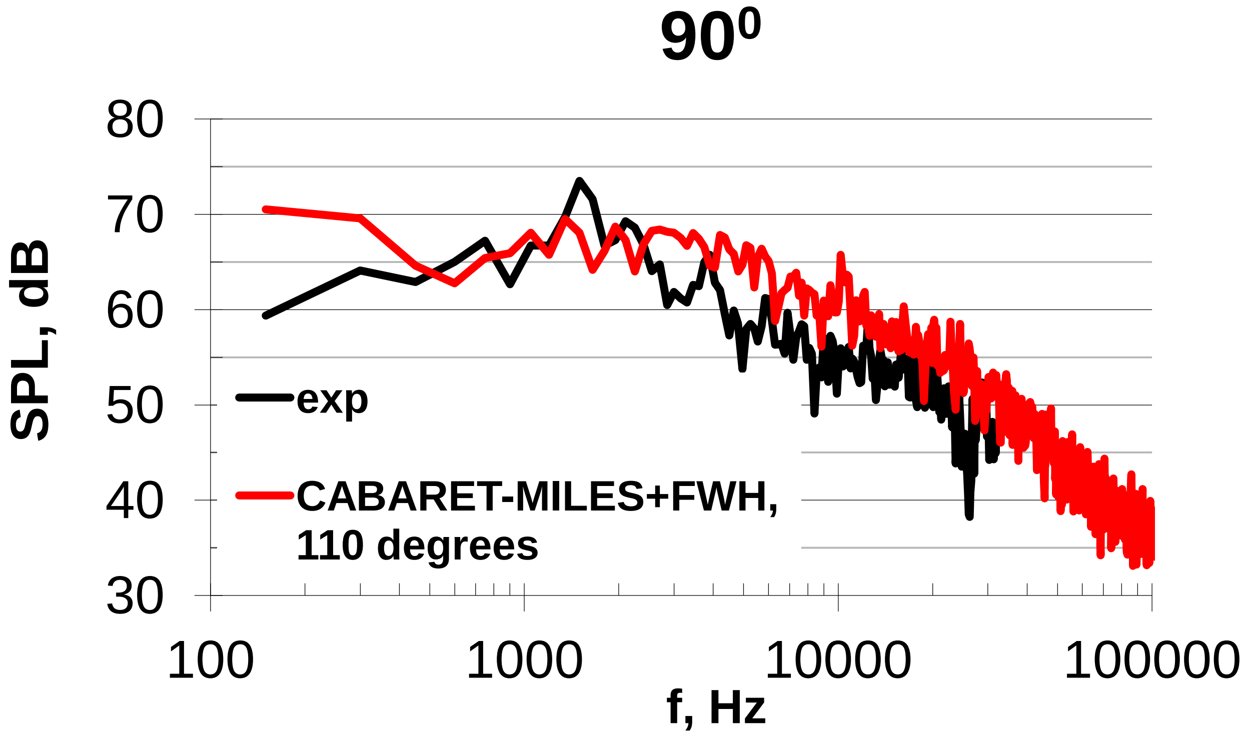
Possible reasons for the discrepancies?

- 1. LES/CAA
  - 1.1 the LES grid is not fine enough
  - 1.2 Sensitivity to the FWH-surface location
  - 1.3Discrepancy in the jet inlet parameters
- 2. Interpretation of the experimental results
  - 2.1 Sound refraction by a non-uniform free stream of plug flow type

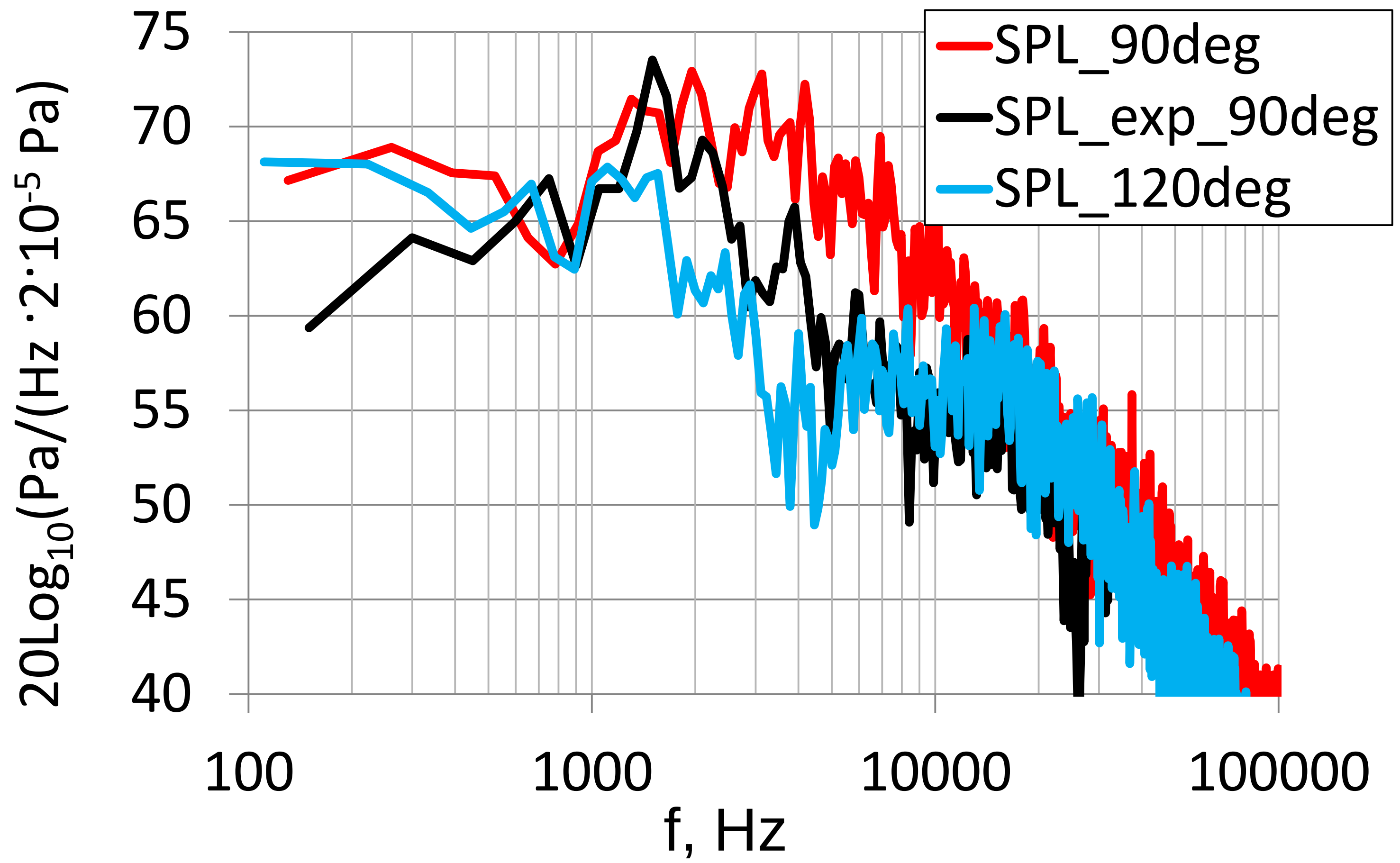
Sensitivity to the effective emission angle: experiment (90^0) vs MILES+FW-H (100^0)



Sensitivity to the effective emission angle: experiment (90^0) vs MILES+FW-H (110^0)



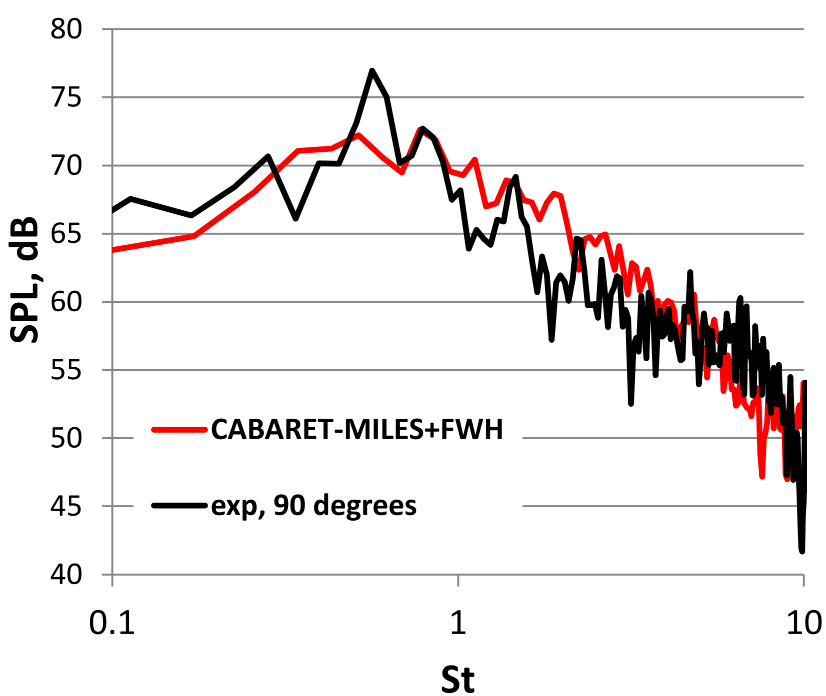
Sensitivity to the effective emission angle: experiment (90^0) vs MILES+FW-H (90^0 &120^0)



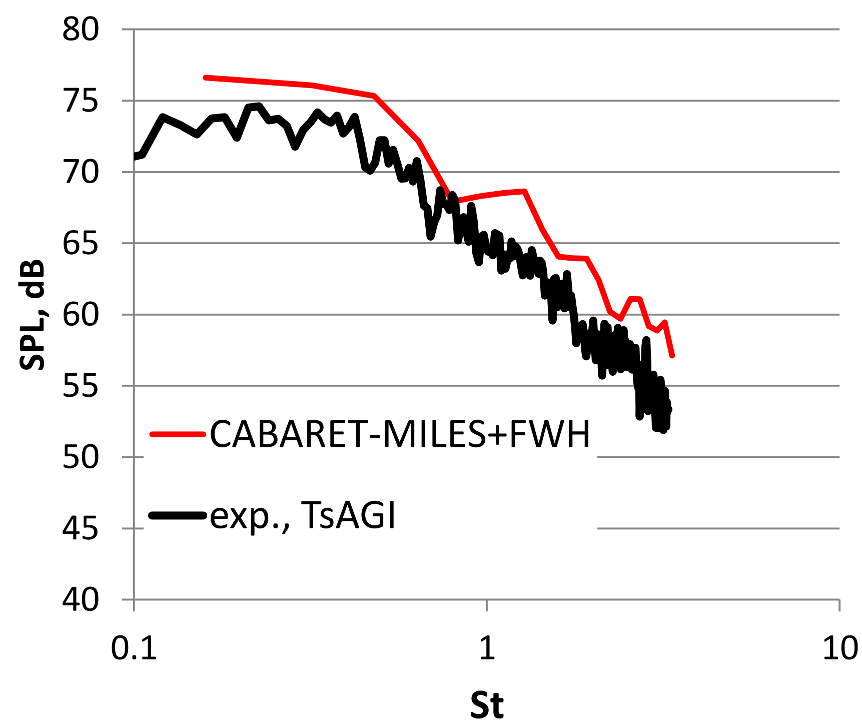
Sensitivity to the operating conditions

The scaling applied is based on the classical v^8 law and the jet volume

90^0, assumption Dsim/Dexp=1.2, Vsim/Vexp=0.85



30^0, assumption Dsim/Dexp=1.2, Vsim/Vexp=0.85



2-3dB difference between the simulation and the experiment for most frequencies

Conclusion (I)

- MILES simulation shows a strong effect of the jet on the potential flow field of the wing

- A comparatively similar behaviour of the sound spectra for 30^0 and 90^0 angles to the jet is demonstrated, however, in absolute values the discrepancy between the MILES+FW-H sound predictions and the experiment are in order of 5dB

Conclusion (II)

- Possible reasons for the discrepancy are the sound propagation effects in the non-uniform co-flow (effective emission angle change) and discrepancy in the operating conditions (no flow data at present between the experiment and the calculation); for the scaled operating conditions the computational predictions and the experiment agree within 3dB for both 30^0 and 90^0 angles

- Further work will include implementing a FW-H method with the Lilley's Green's function, comparison with the flow data once they become available, and replacing FW-H with the Goldstein acoustic analogy