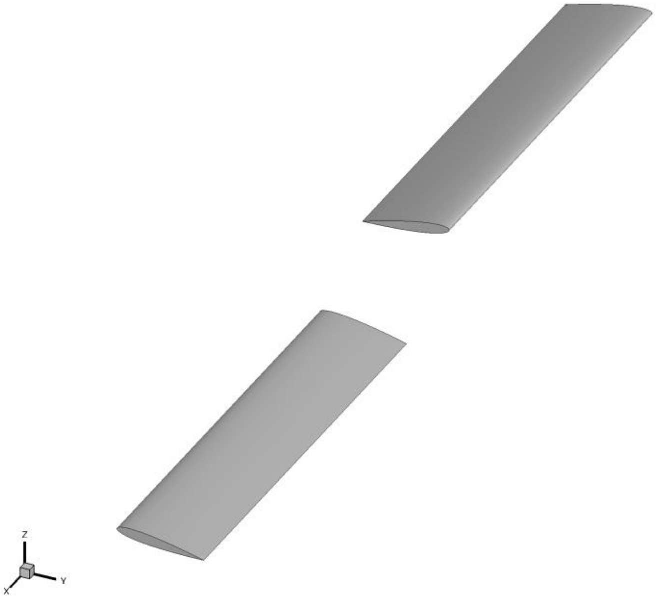
MP1.1
Caradonna-Tung rotor*

NOise of **R**otating **Ma**chines **(NORMA)**

WP1 Evaluation of hybrid RANS-LES methods of scale-resolving simulation of turbulent flows developed by partners, their further development and adaptation to the problems of turbulent flow past rotating rotor blades of helicopters.

*Caradonna F. X., Tung C. Experimental and analytical studies of a model helicopter rotor in hover: tech. rep. ; NASA. — Ames Research Center, Moffett Field, California, Sept. 1981. — NASA-TM-81232.

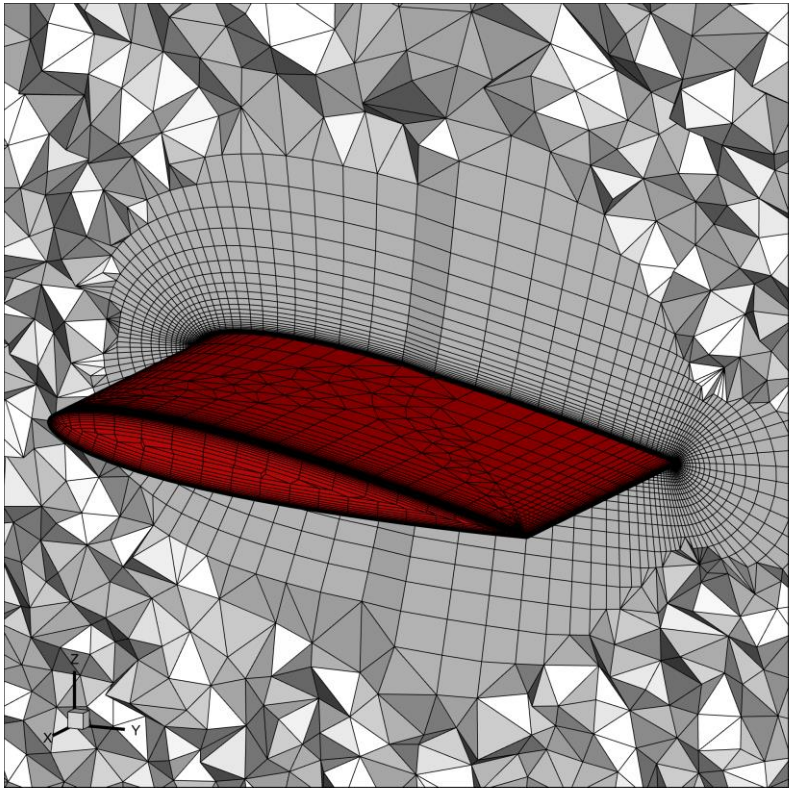
Case description

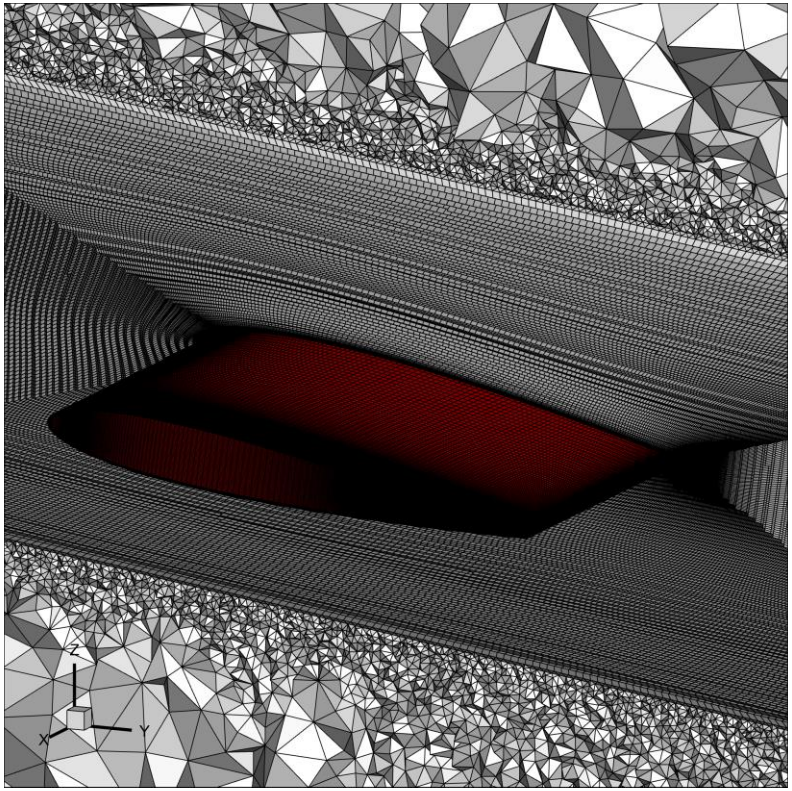


$$\rho_0 = 1.2041\ \mathrm{kg/m^3}$$
$$\mu_0 = 1.827 \times 10^{-5} \mathrm{N \cdot s/m^2}$$
$$\mathrm{Re} = \frac{\rho_0 V_{tip} b}{\mu_0} = 0.97 \times 10^6$$

N – blades number	**2**
R – rotor radius	**1.143 m**
b – blade chord length	**0.1905 m**
blade base airfoil	**NACA-0012**
pitch angle	**8º**
rotation speed	**650 RPM**
blade tip velocity V_{tip}	**77.8 m/s**
tip Mach	**0.228**
blade-passing frequency (BPF)	**21.67 Hz**

RANS & IDDES

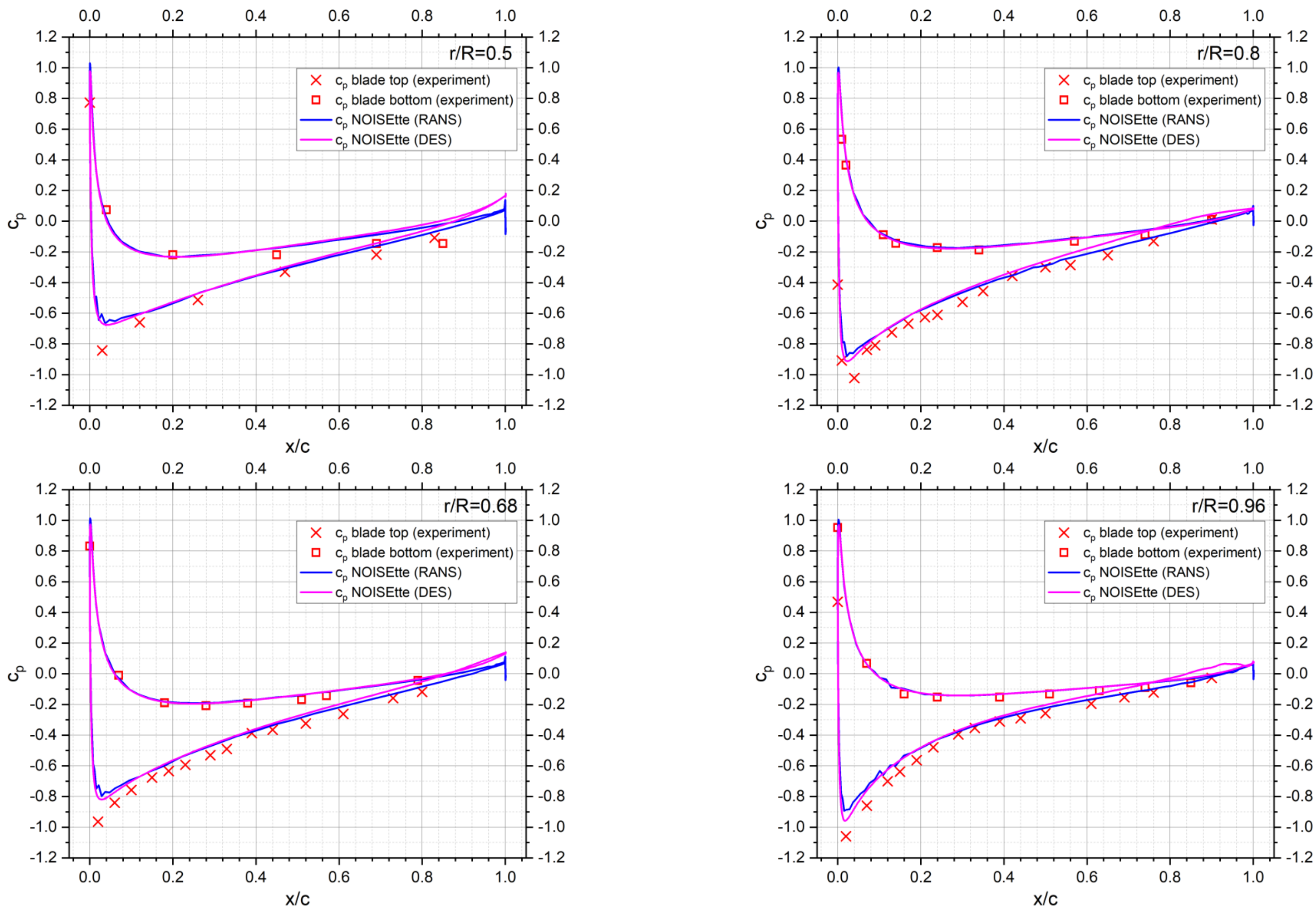




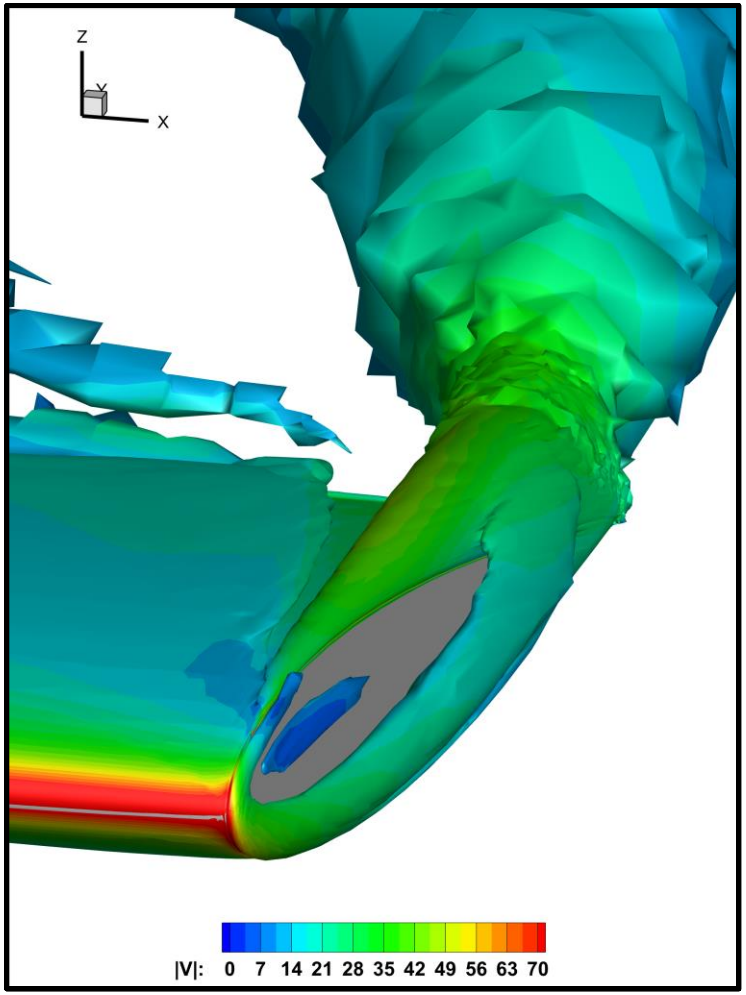
RANS (SA)
rotor: **11.5K** (single blade)
total nodes: **1.3M** (half-cylinder)

IDDES
rotor: **570K** (2 blades)
total nodes: **92.5M** (full cylinder)

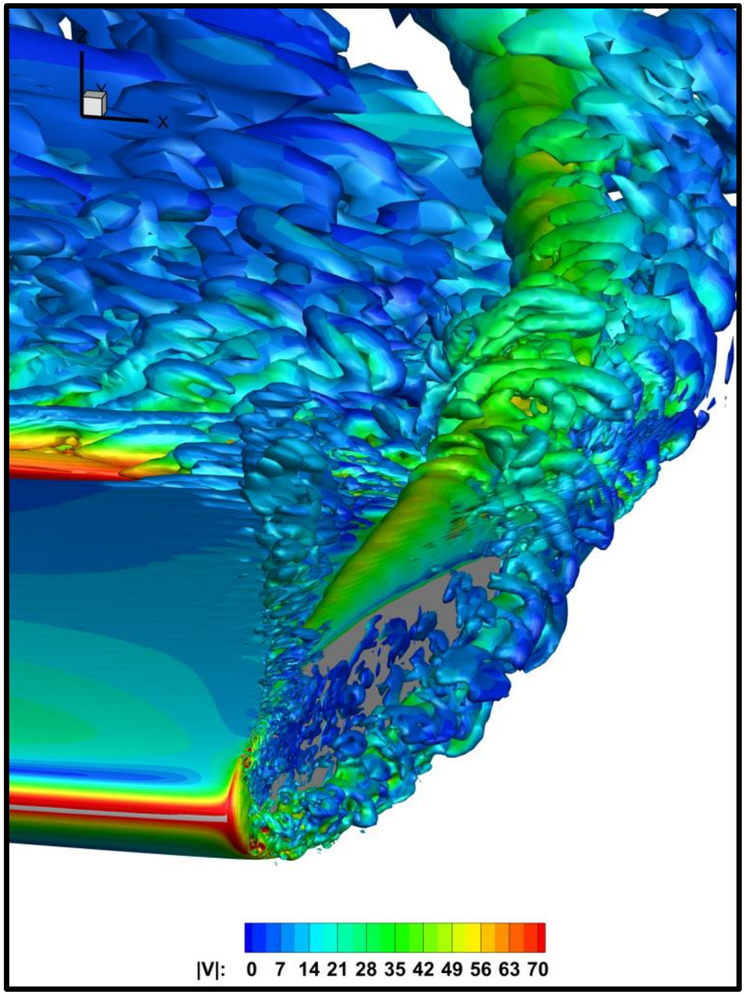
Aerodynamics: RANS vs. IDDES



Aerodynamics: RANS vs. IDDES

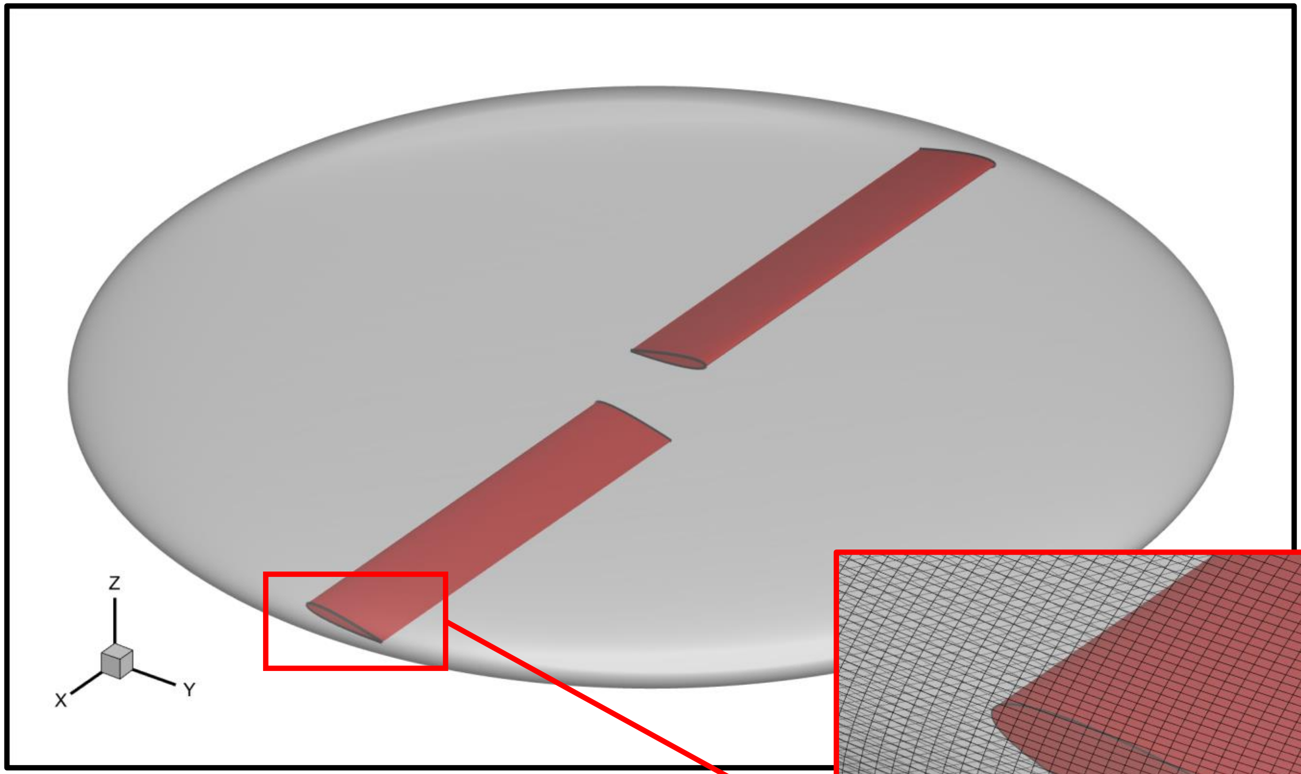


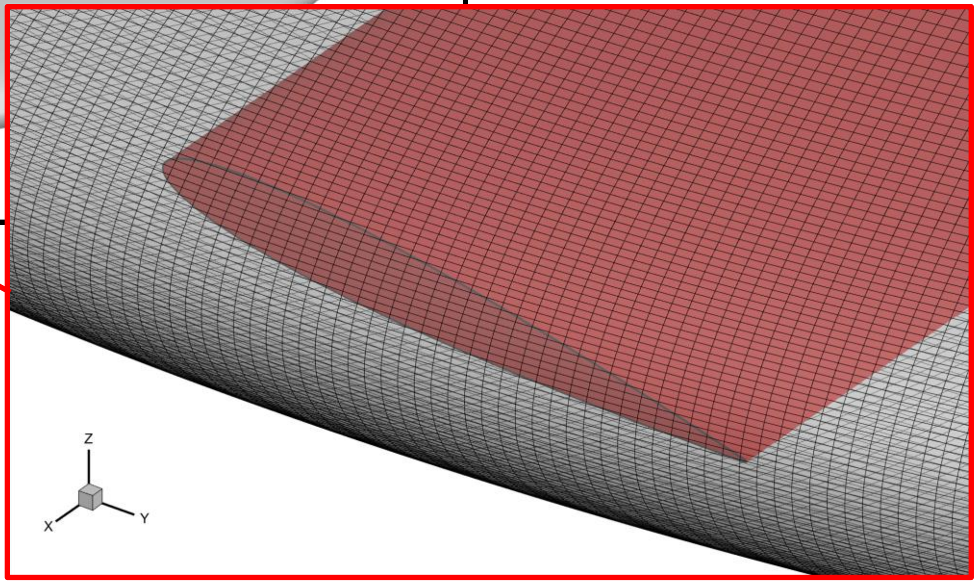
RANS



IDDES

Acoustics: FWH control surface

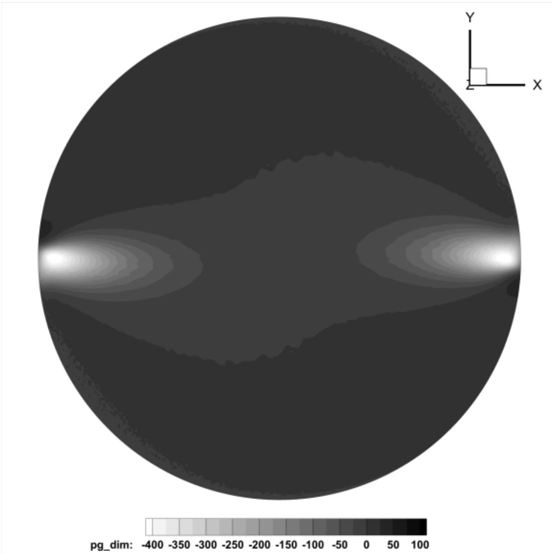




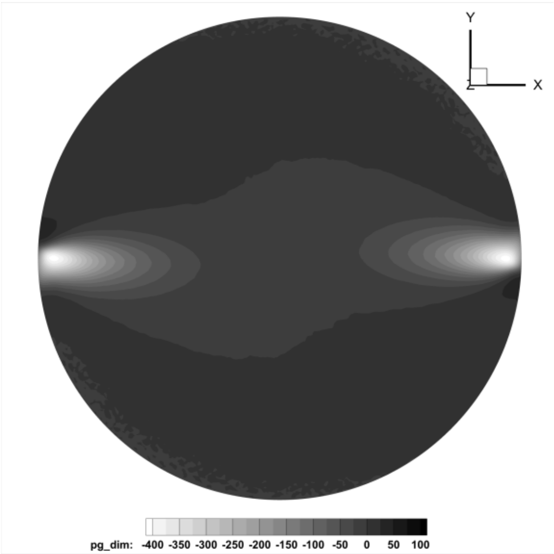
1440 × 300
(azimuthal × radial)
430K nodes

Acoustics: FWH control surface

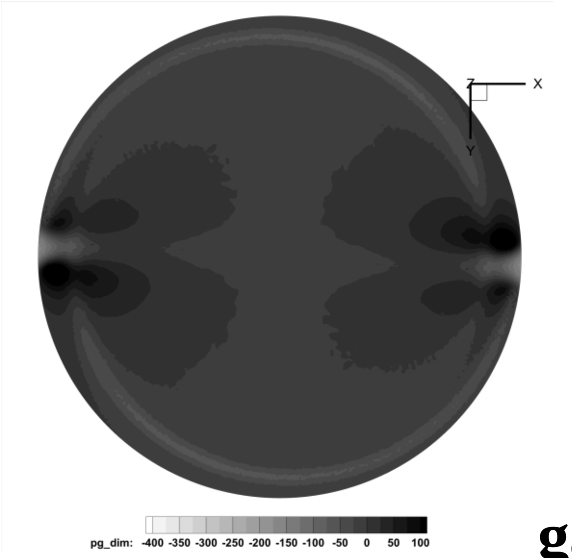
RANS



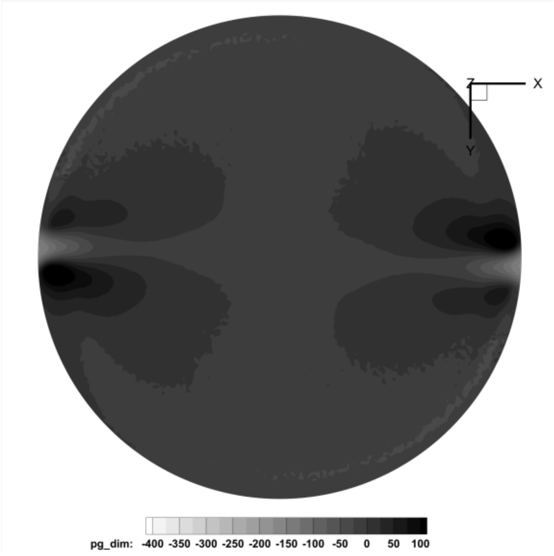
top view



IDDES



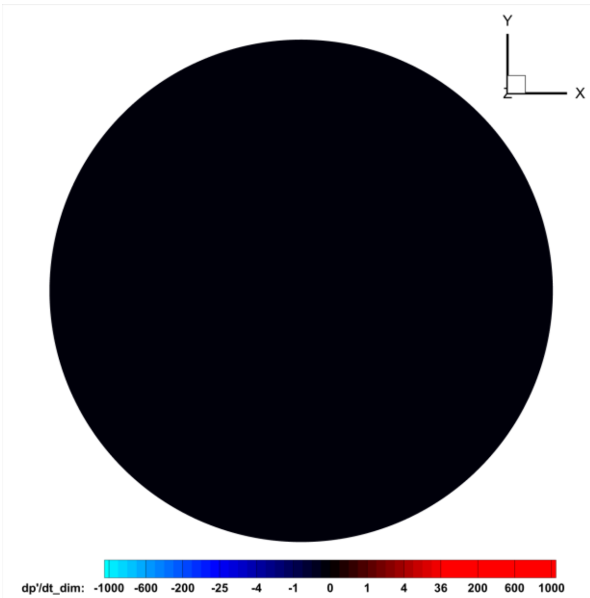
bottom view



gauge pressure

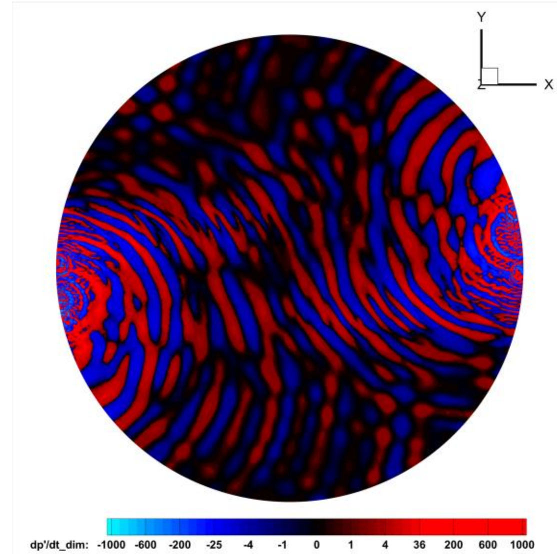
Acoustics: FWH control surface

RANS

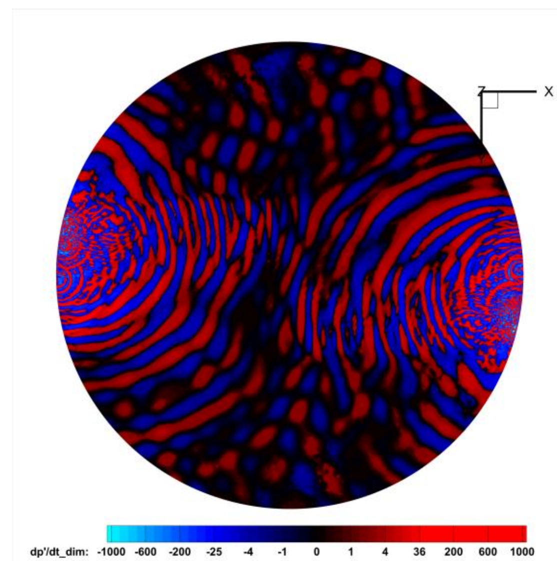


IDDES

top view

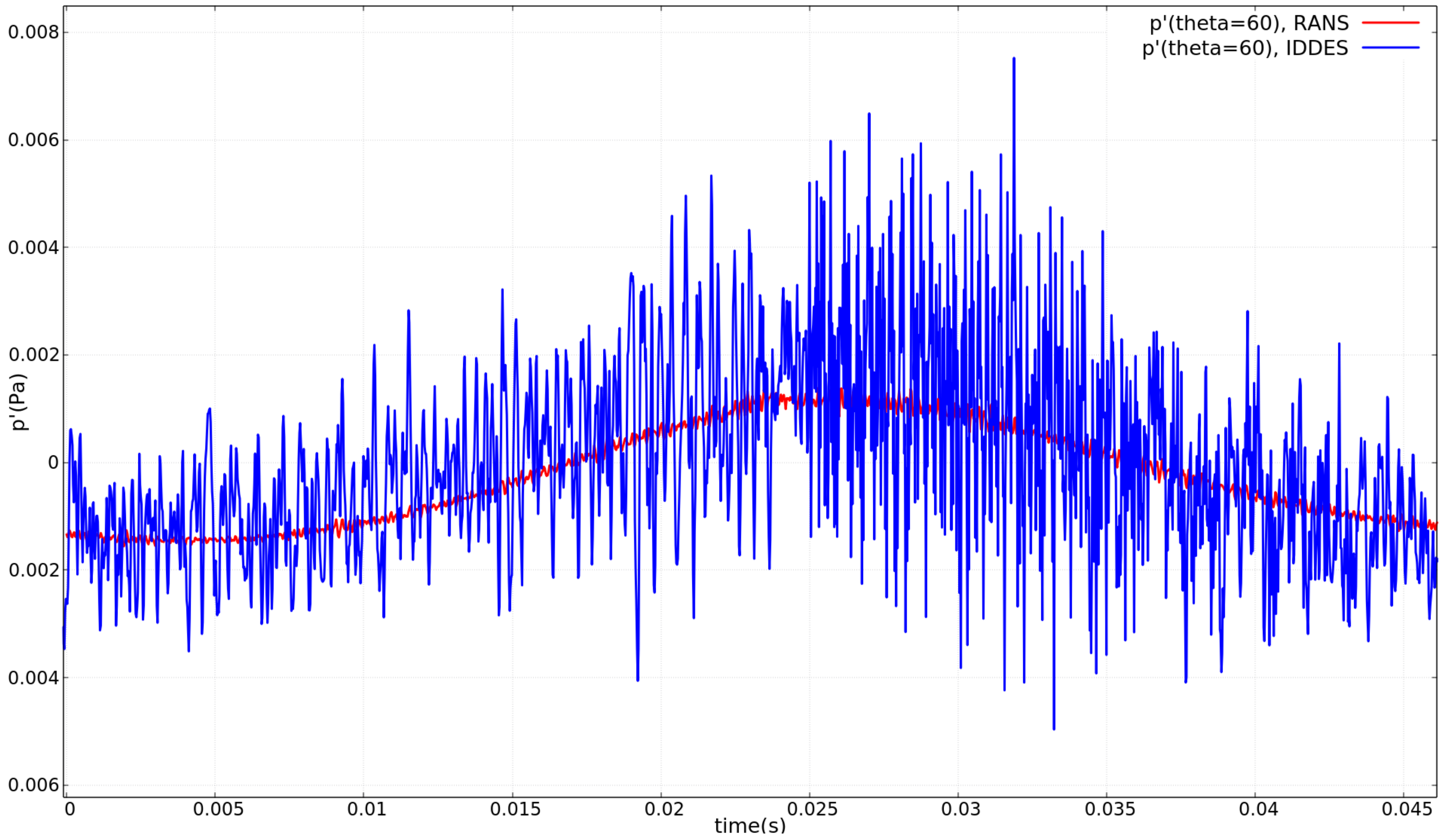


bottom view



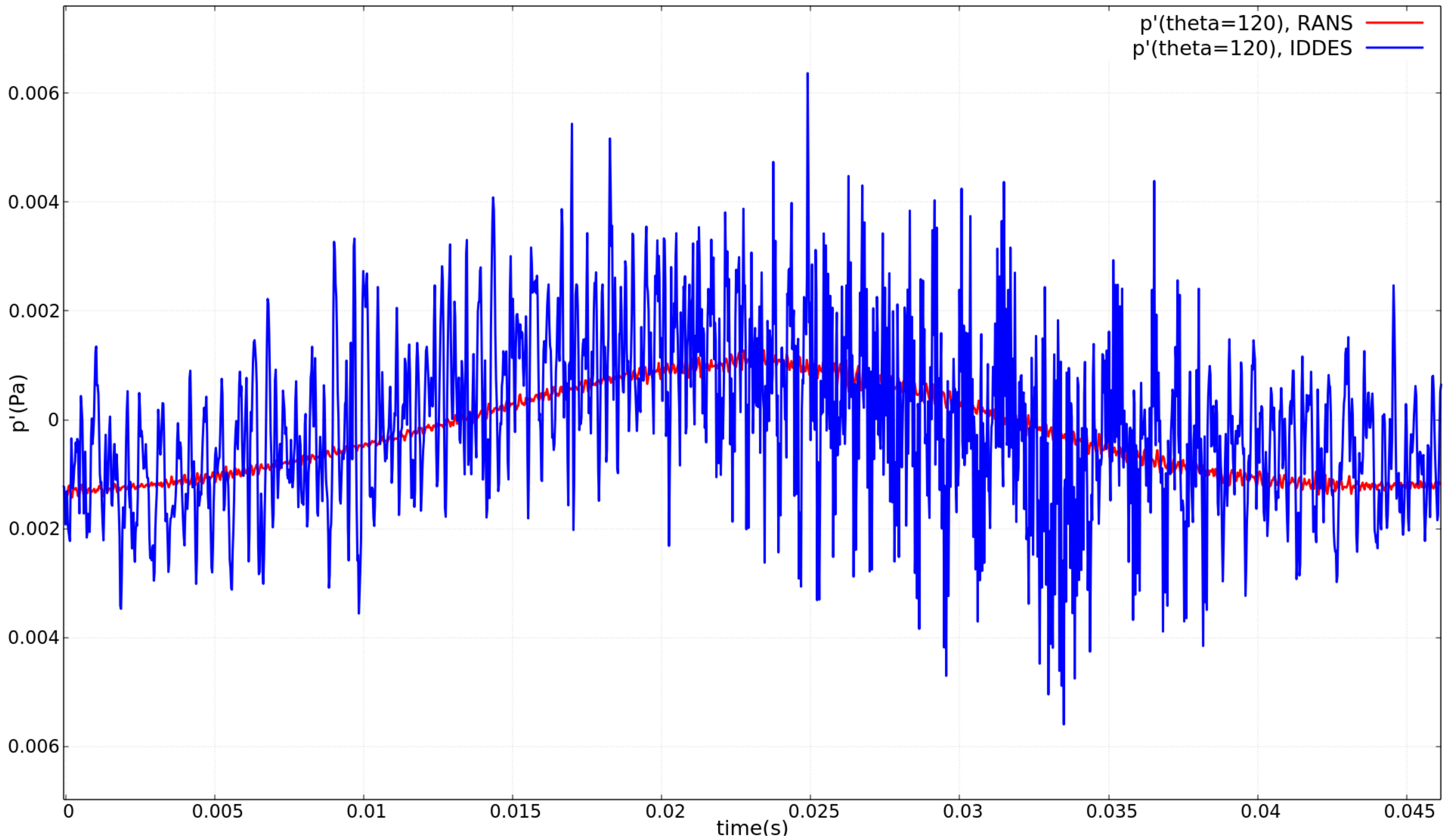
dp`/dt

Acoustics: signals



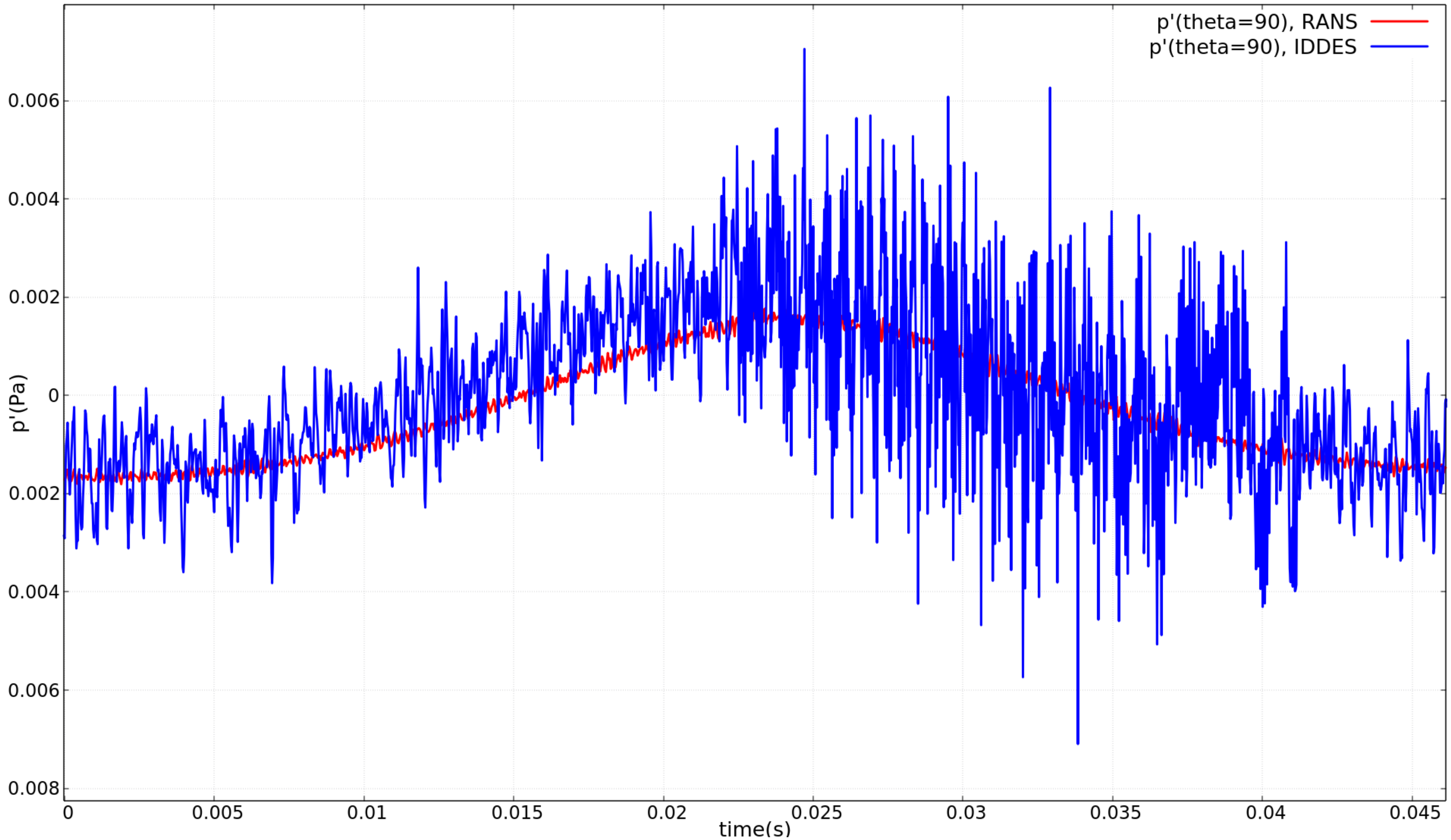
direction: $\theta = 60°$

Acoustics: signals



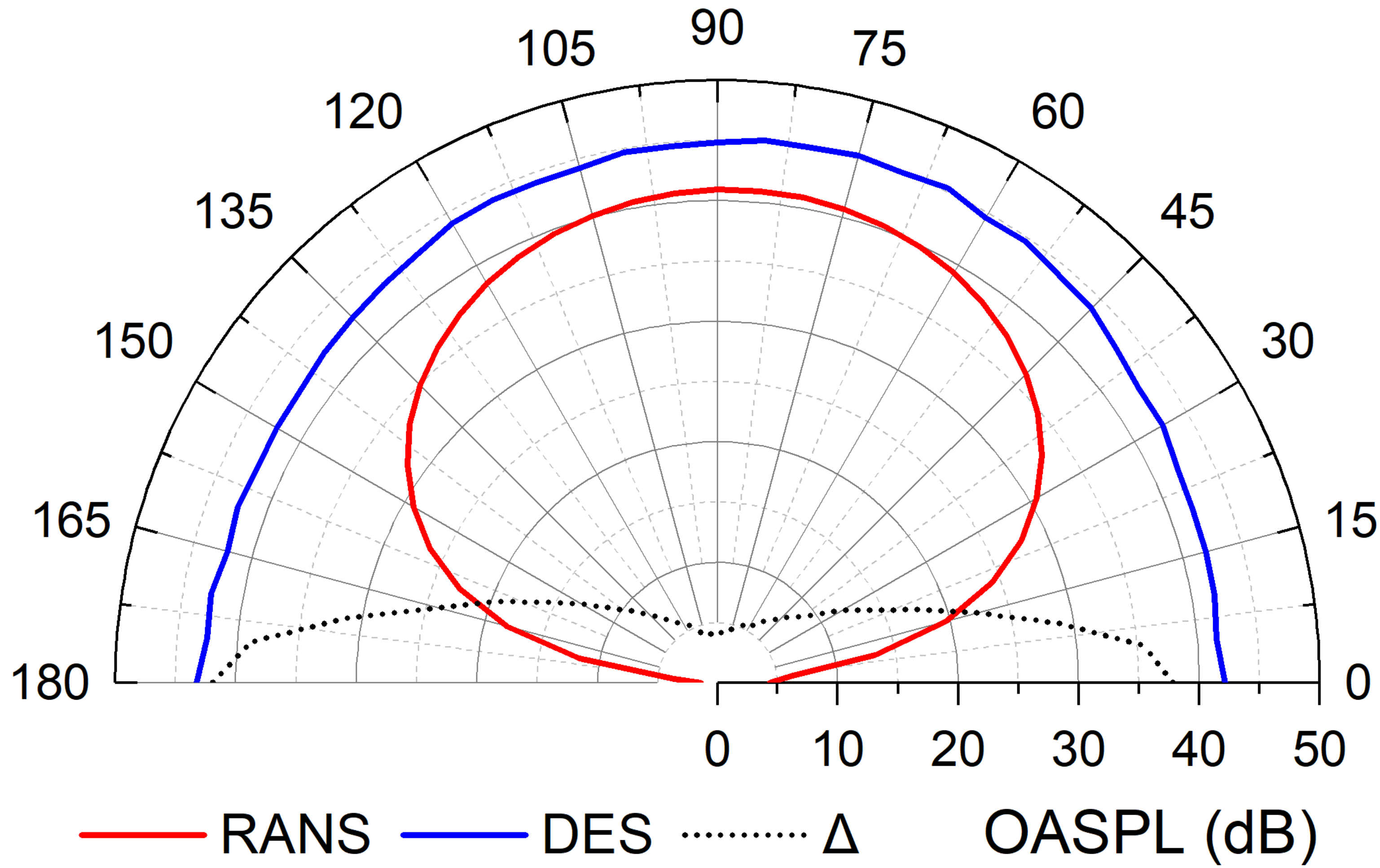
direction: $\boldsymbol{\theta = 120^\circ}$

Acoustics: signals

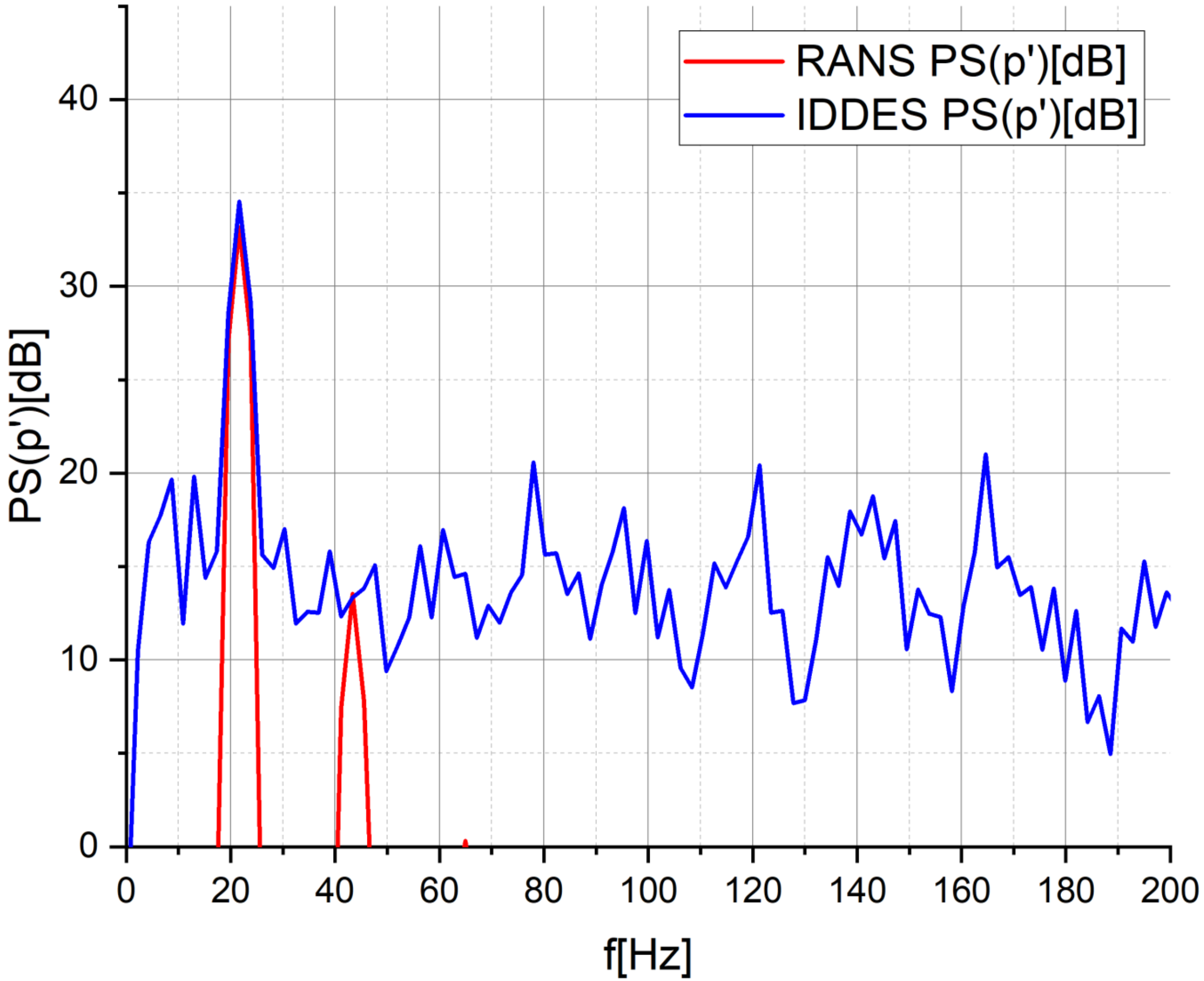


direction: $\theta = 90°$

Acoustics: OASPL

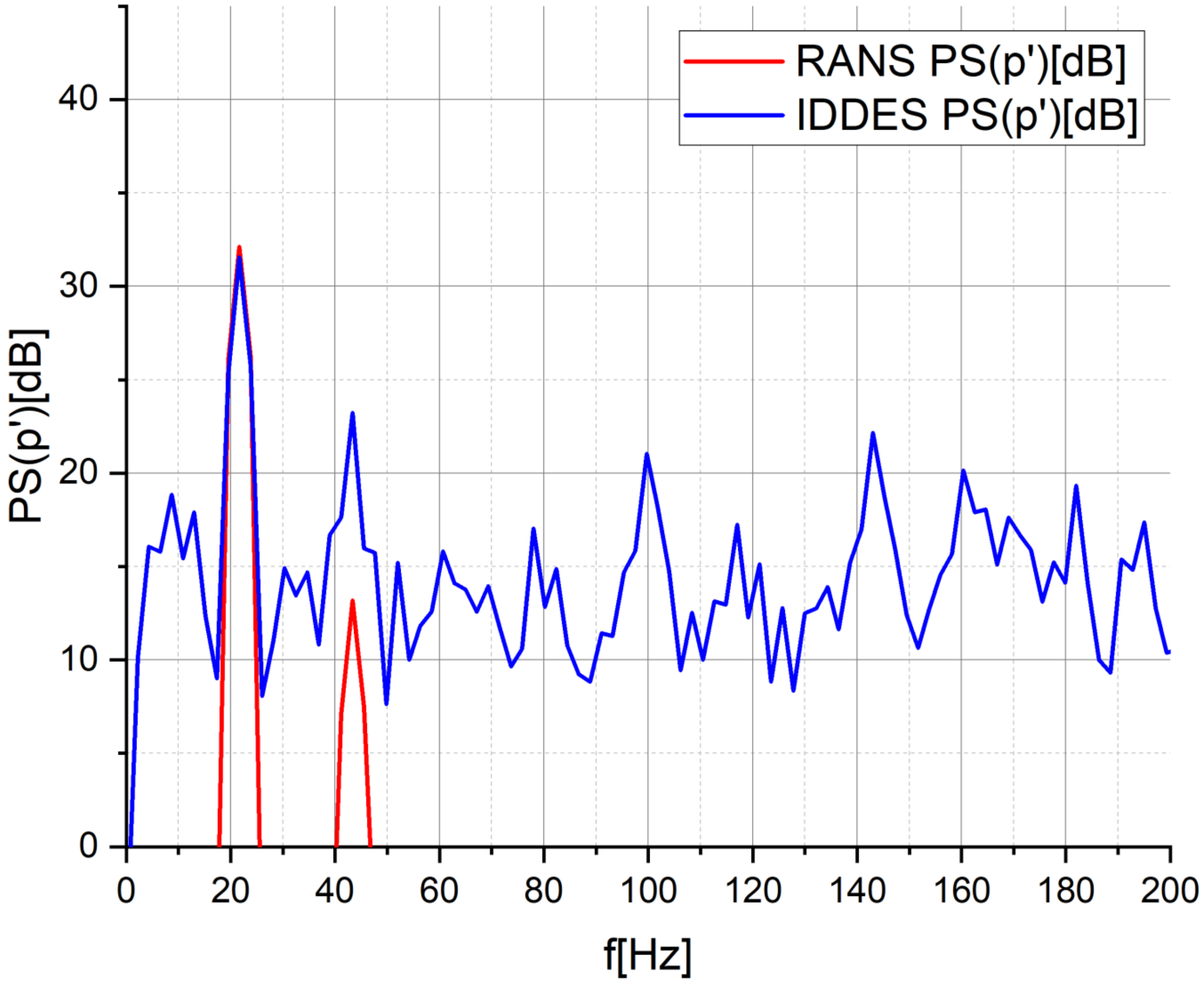


Acoustics: spectra



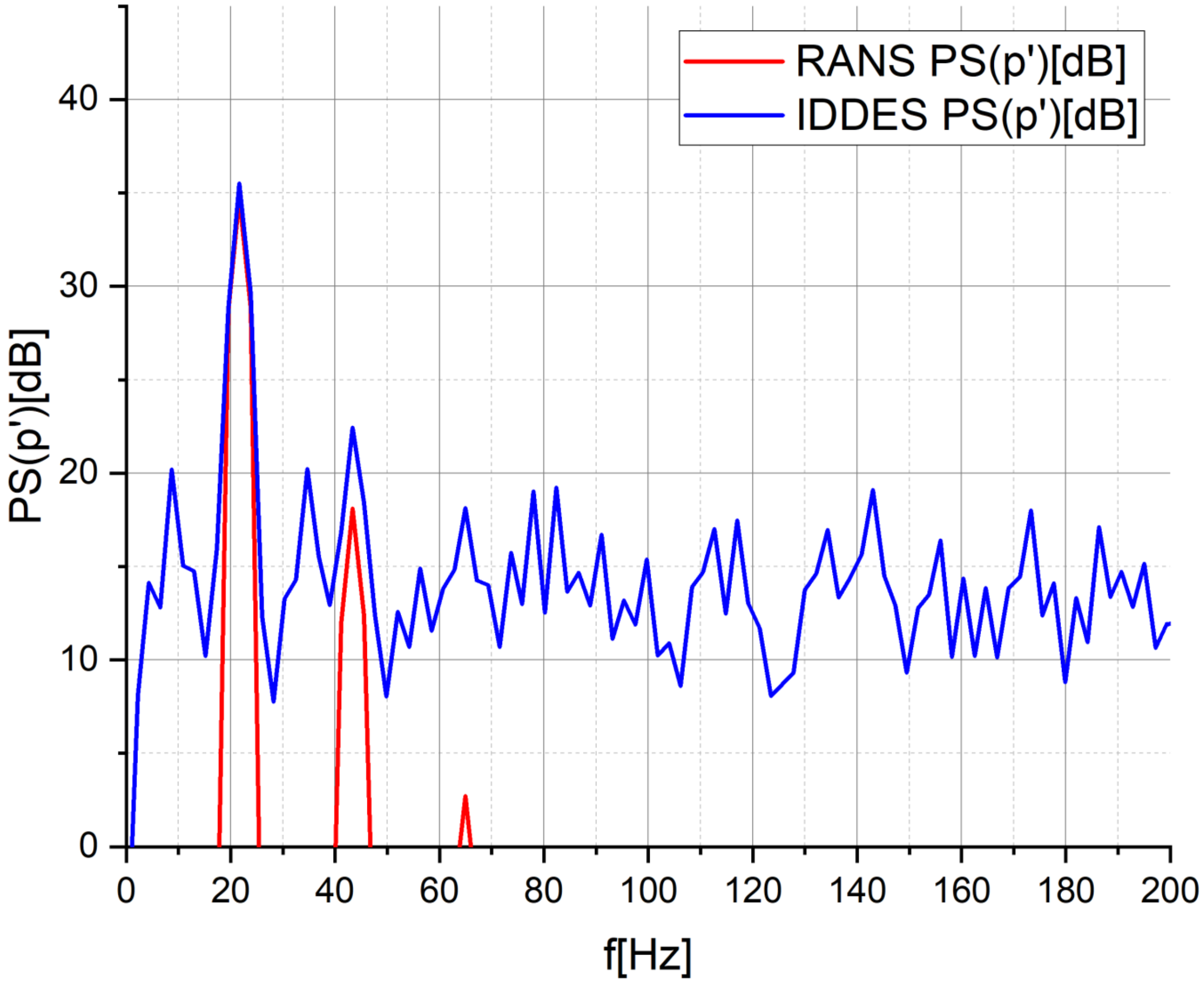
direction: $\theta = 60°$

Acoustics: spectra



direction: $\theta = 120°$

Acoustics: spectra



direction: $\theta = 90°$

Workflow: MP1.2/3