

Context

Hydrofoils are subjected to flow induced vibrations.

⇒ **Structural fatigue + acoustic noise**

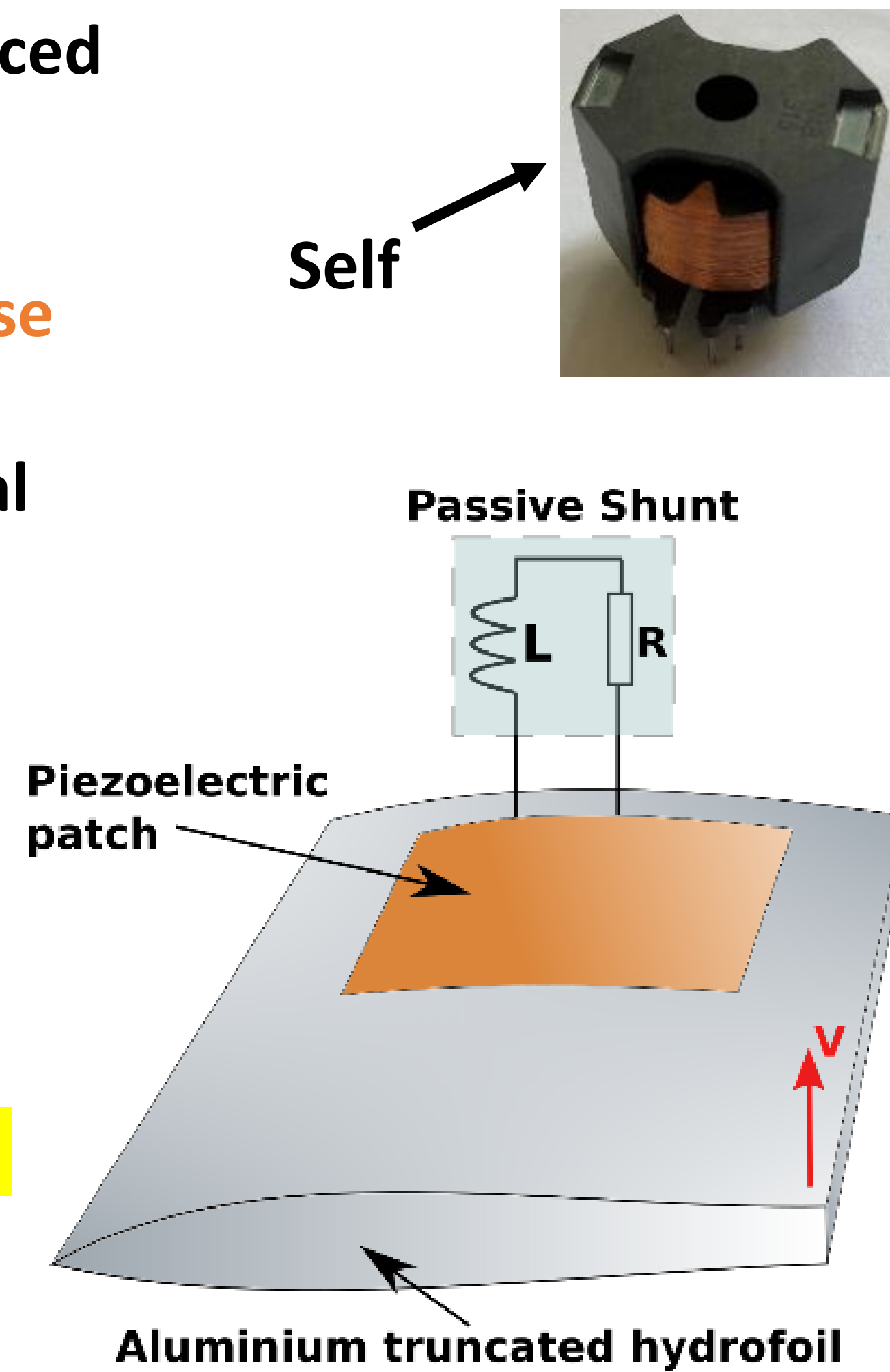
If vortex shedding frequency = natural frequency.

⇒ **Resonance**

⇒ **High amplitude vibrations**

Objective

Use a resonant piezoelectric shunt to mitigate flow induced vibrations at resonance



Methodology

Hydrodynamic tunnel

$U_0 = 3.0$ to 5.5 m/s

$Re = 2.40 \times 10^5$ to 4.40×10^5

Incidence = 0°

Laser Vibrometry + TR-PIV + POD

Hydrofoil natural frequencies

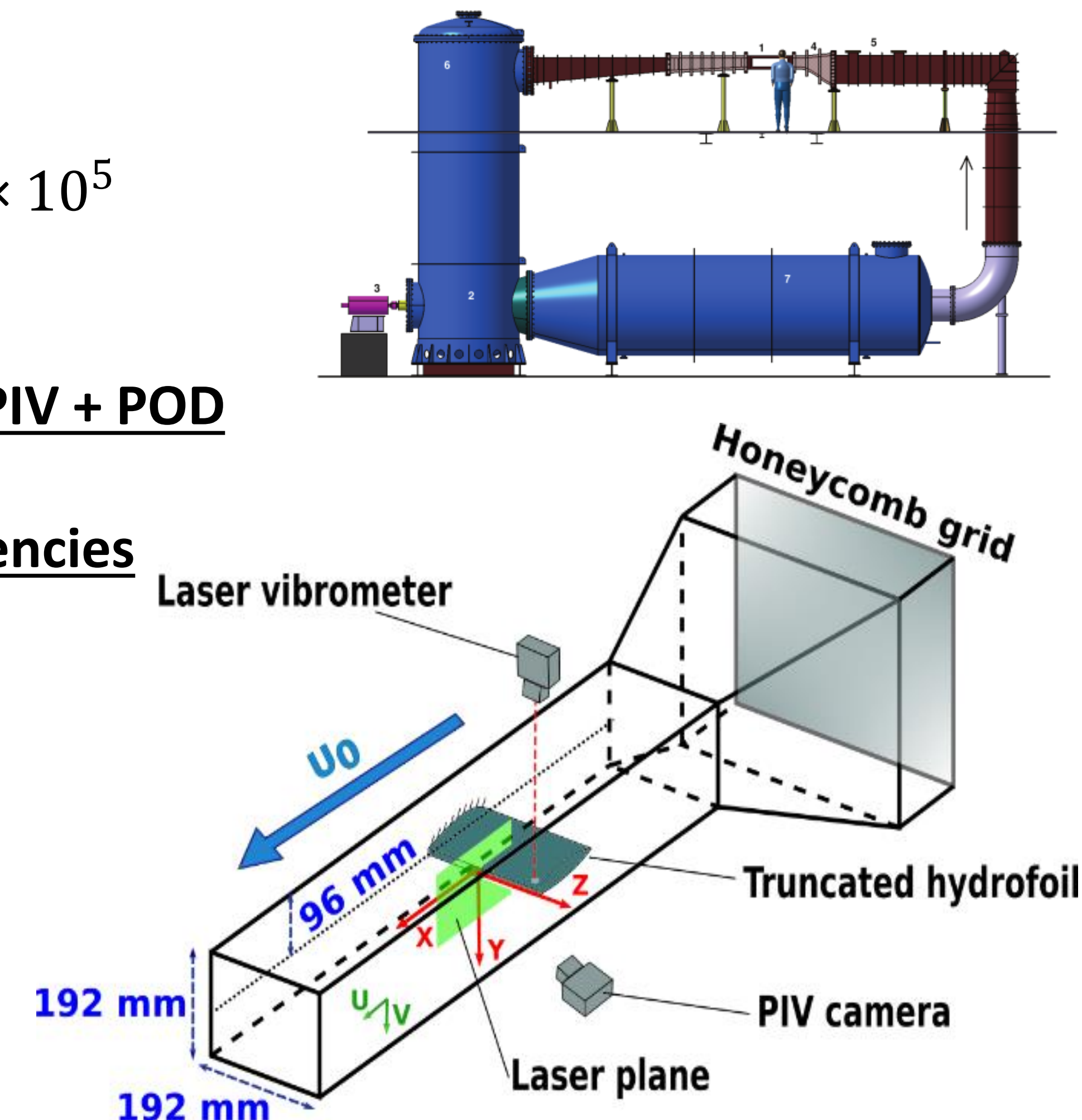
$f_1 = 40$ Hz : Bending

$f_2 = 282$ Hz : Twisting

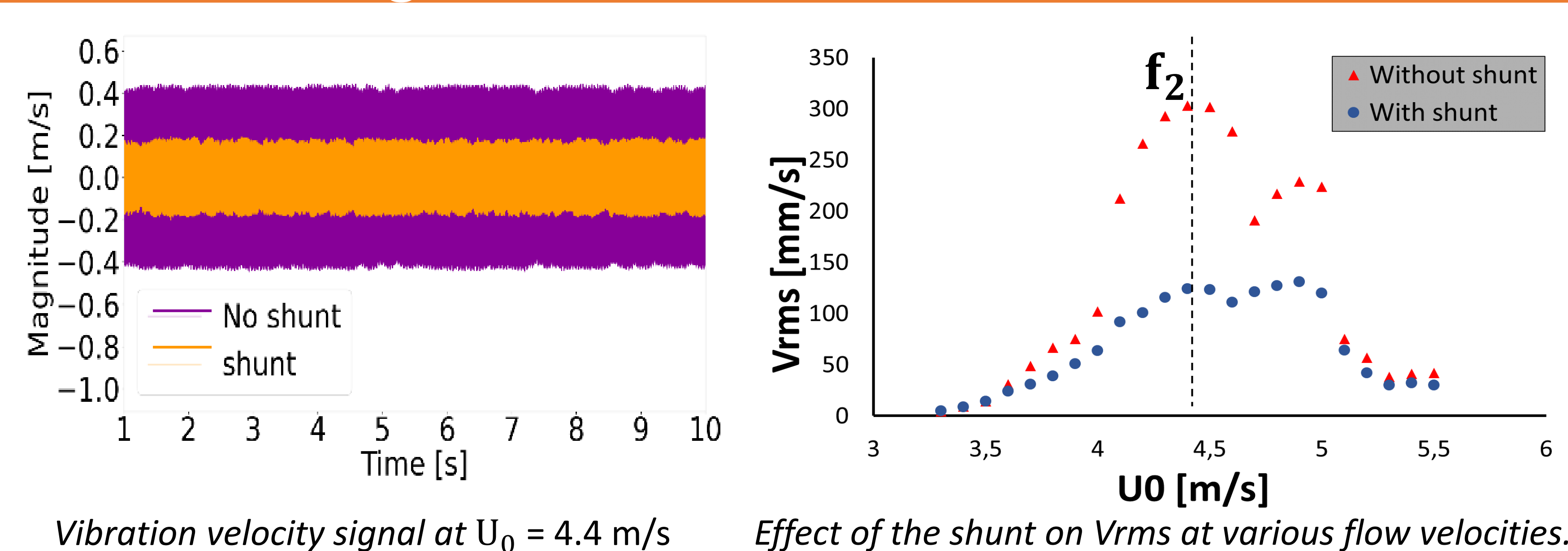
$f_3 = 320$ Hz: Bending

Shunt tuning

At twisting mode frequency (f_2)



Vibration mitigation



⇒ **High vibration level reduction at resonance (50 % on V_{rms}).**

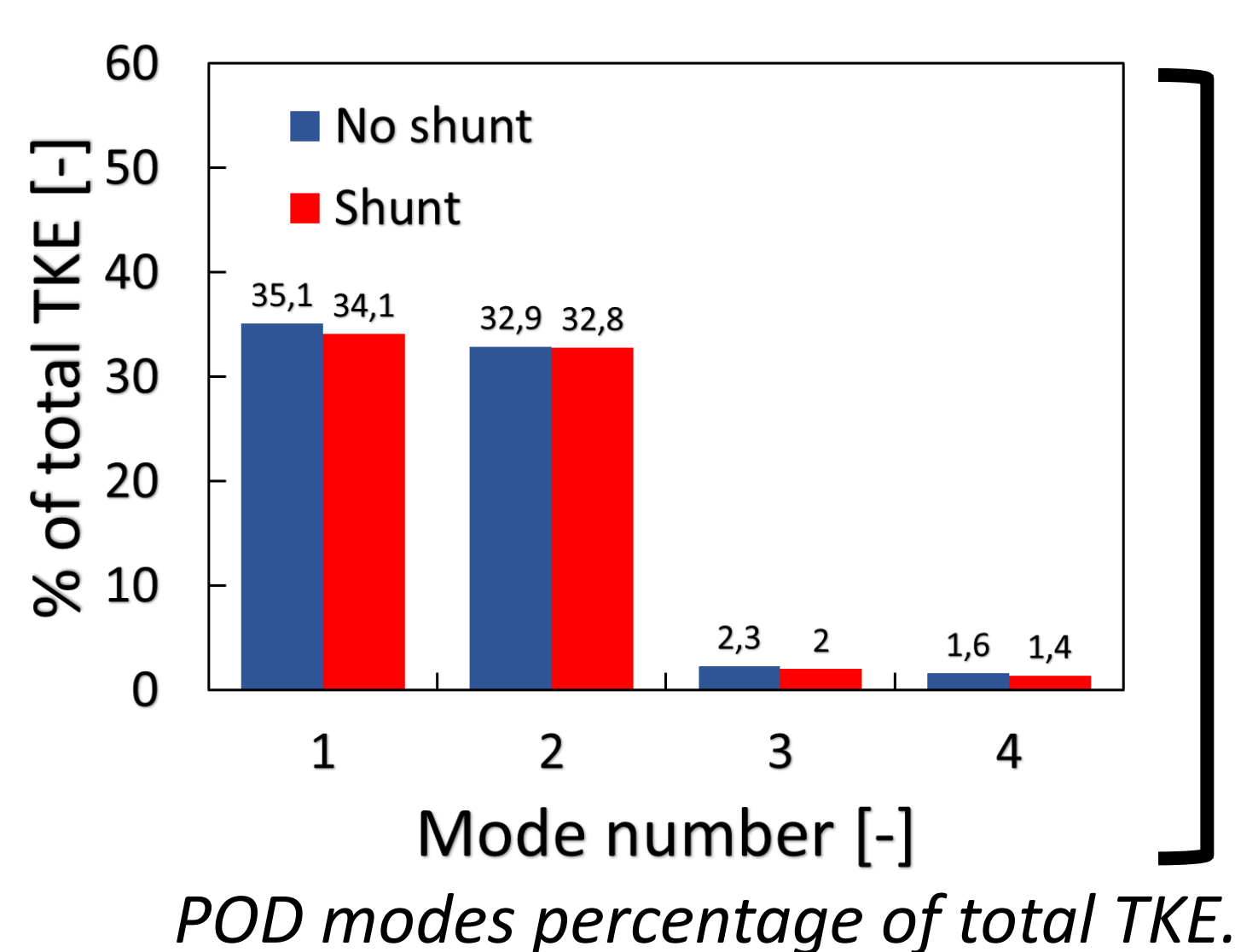
⇒ **Twisting mode resonance observed at $U_0 = 4.4$ m/s.**

⇒ **Bending mode resonance at $U_0 = 4.9$ m/s.**

⇒ **Impact of the shunt from 4.0 to 5.0 m/s.**

Impact on the wake at twisting resonance, $U_0 = 4.4$ m/s

Turbulent Kinetic Energy (TKE)

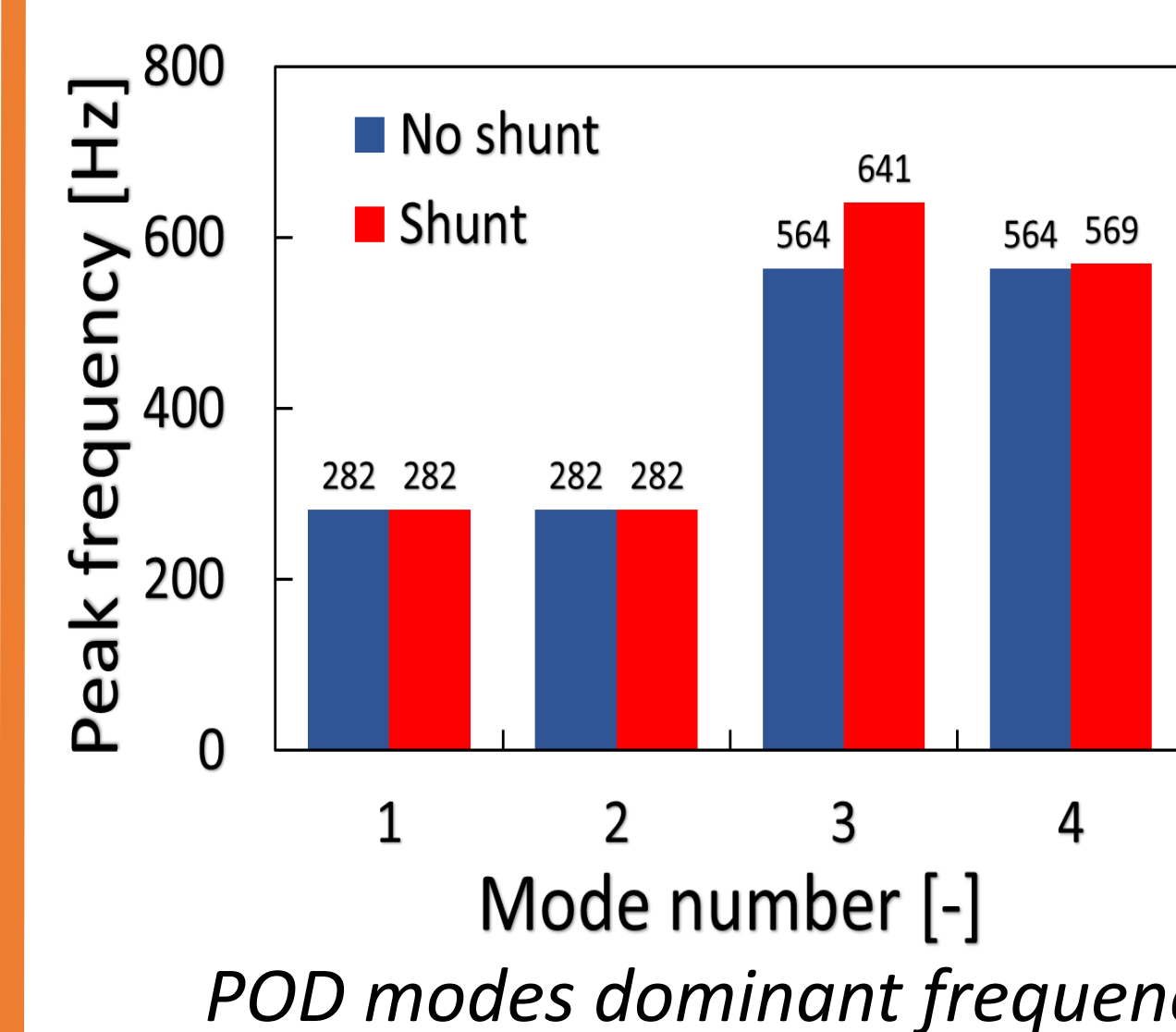


⇒ **Modes 1 and 2 : High TKE**

⇒ **Modes 3 and 4 : Low TKE**

⇒ **Weak impact of shunt on TKE**

Modes dominant frequencies

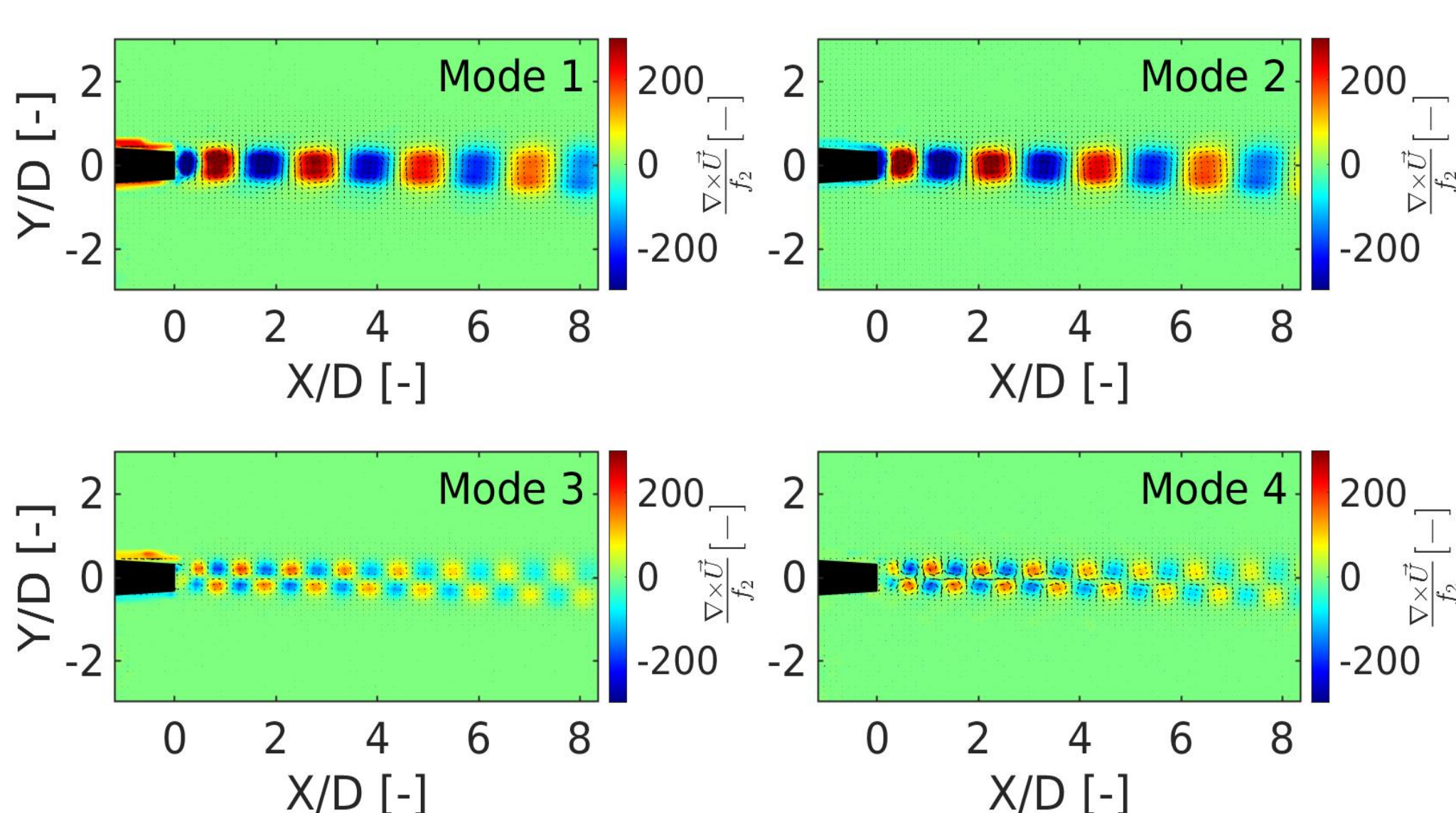


⇒ **$f_2 = 282$ Hz : twisting frequency, Karman modes.**

⇒ **$2 \times f_2 = 564$ Hz : Harmonic of twisting frequency.**

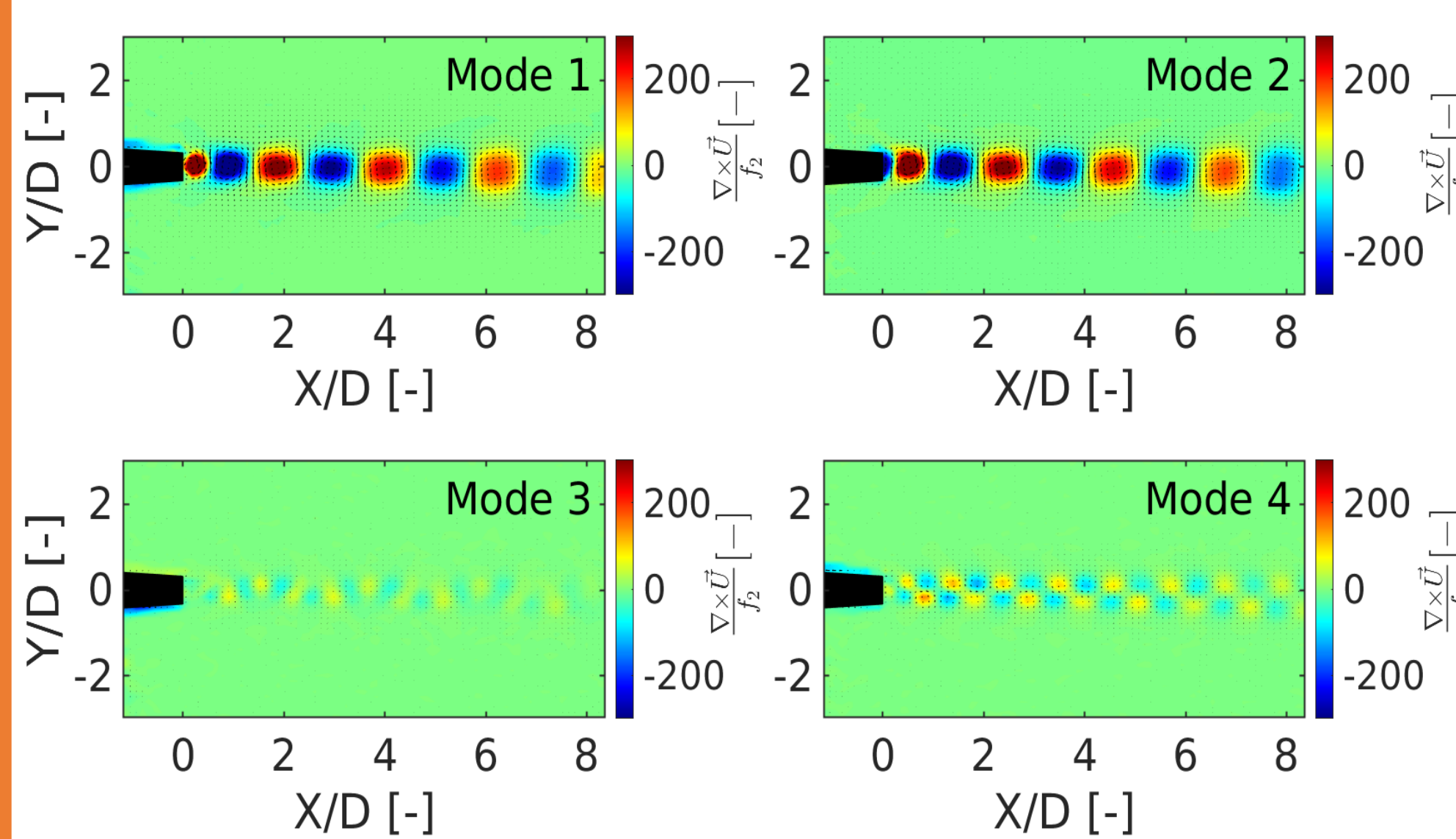
⇒ **$2 \times f_3 = 641$ Hz : Harmonic of bending frequency.**

POD spatial modes, without shunt



(x,y) cartography of vorticity at $U_0 = 4.4$ m/s, without shunt.

POD spatial modes, with shunt



(x,y) cartography of vorticity at $U_0 = 4.4$ m/s, with shunt.

⇒ **Modes 1 and 2 : Karman type coherent structures, no alteration by the shunt.**

⇒ **Modification of spatial modes 3 and 4 by the shunt.**

Further work

⇒ **Investigate the impact of the shunt on the wake by vortex detection algorithm.**

⇒ **Apply POD to various main flow velocities.**

Reference

- L. Pernod, B. Lossouarn, J.-A. Astolfi, J.-F. Deü, Vibration damping of marine lifting surfaces with resonant piezoelectric shunts, JSV, 2021

- Y. Watine, C. Gabillet, J.-A. Astolfi, L. Pernod, B. Lossouarn, J.-F. Deü. Vortex Induced Vibrations Analysis of a Cantilevered Blunt Plate by Proper Orthogonal Decomposition of TR-PIV and Structural Modal Analysis. Proc. ASME-FEDSM 2020