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# High amplitude/high frequency acoustic field effects on coaxial injection



## 1. Introduction

**High-frequency thermoacoustic instabilities** are one of the biggest issue limiting **liquid rocket engines (LREs)** reliability.

Pressure fluctuations produced by combustion can **couple** with the **resonant mode** of the combustion chamber, leading to the modulation of the local instantaneous rate of the heat release.

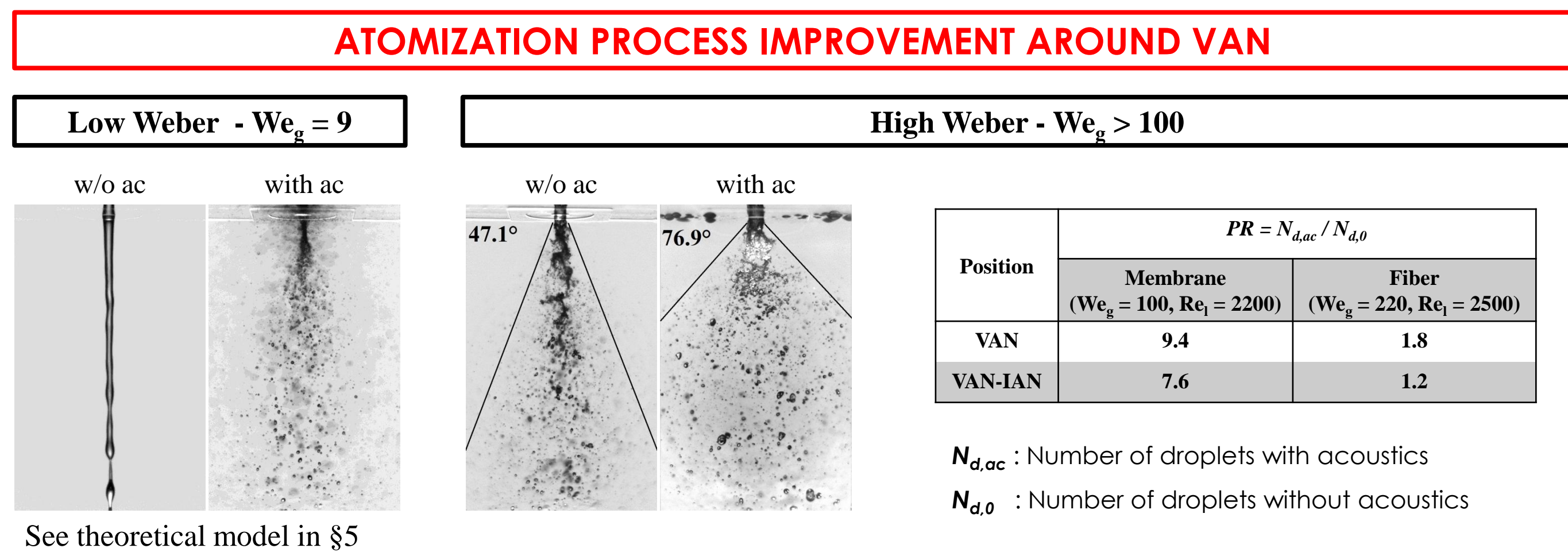
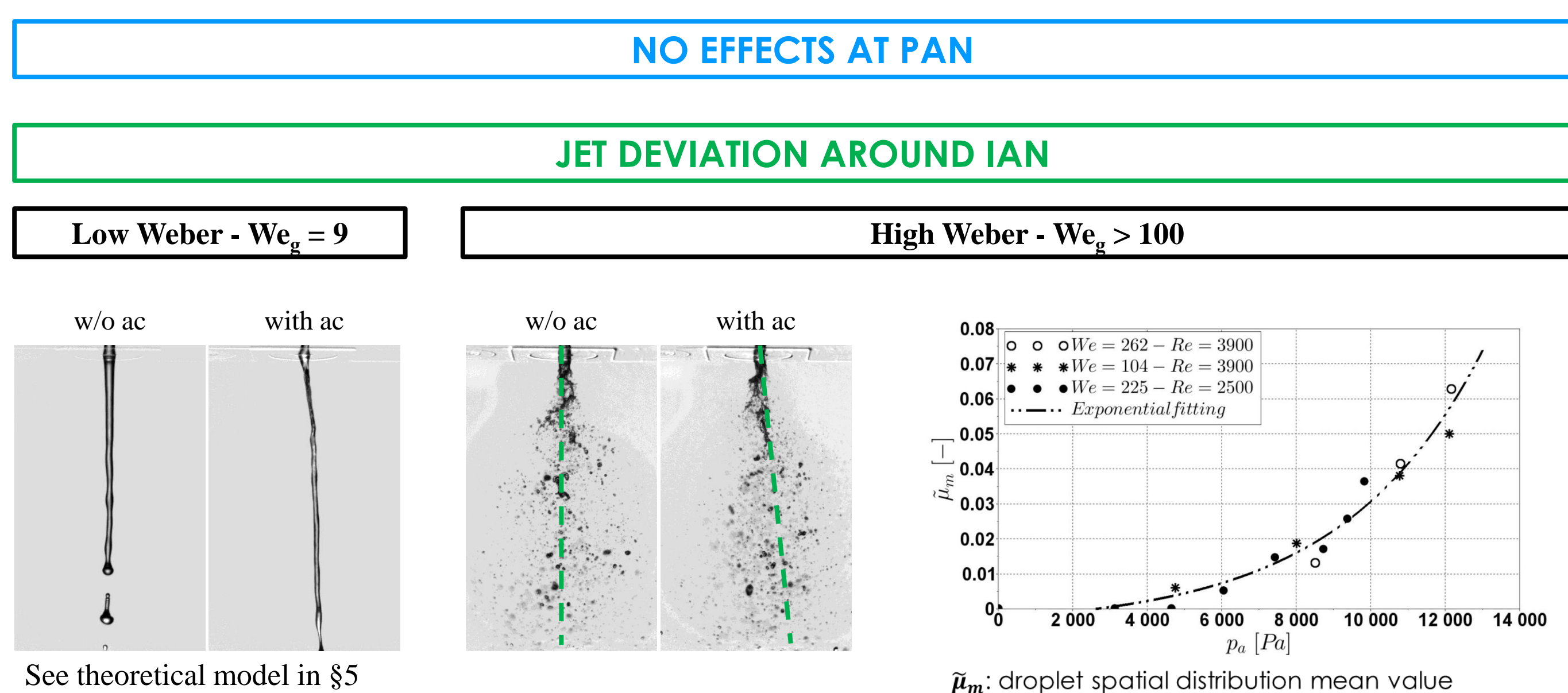
Despite many years of research, the understanding and the capacity of predicting combustion instabilities are still limited. Due to the complexity and multiplicity of the processes involved, a global approach cannot identify the dominant mechanisms and a **local approach** is needed.

## 2. Objectives

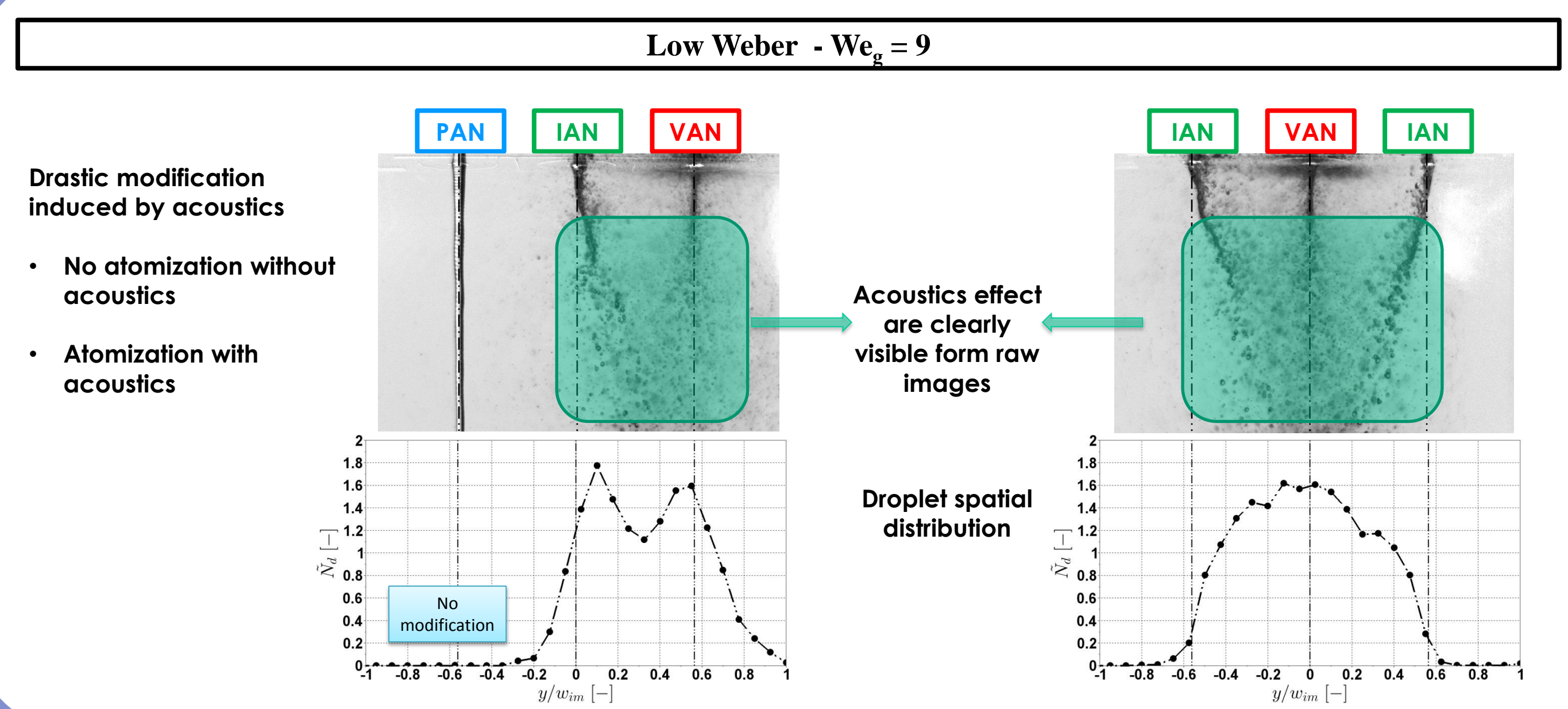
- Investigation of **air-assisted liquid jets response** to the acoustic perturbation
- Validation of a **theoretical model** based on **non-linear acoustics** describing **jet dynamic**

## 4. Air-assisted jets response to the acoustic field

**Jet response** depends on the position in the acoustic field



## 6. Droplet spatial distribution: clustering effect



## 7. Conclusions

- Acoustics can drastically affect jet dynamics according to the position of the injector w.r.t. the acoustic field.
- Two main phenomena have been observed:
  - An **intensification of the atomization process**, particularly strong at VAN;
  - A **deviation toward the velocity anti-node**, nearby IAN.
- Theoretical model based on **radiation pressure** and **radiation force** distribution well describe jet behavior.
  - The model must be completed to take into account different object geometries and the energy balance between flattening and deviation.

## References

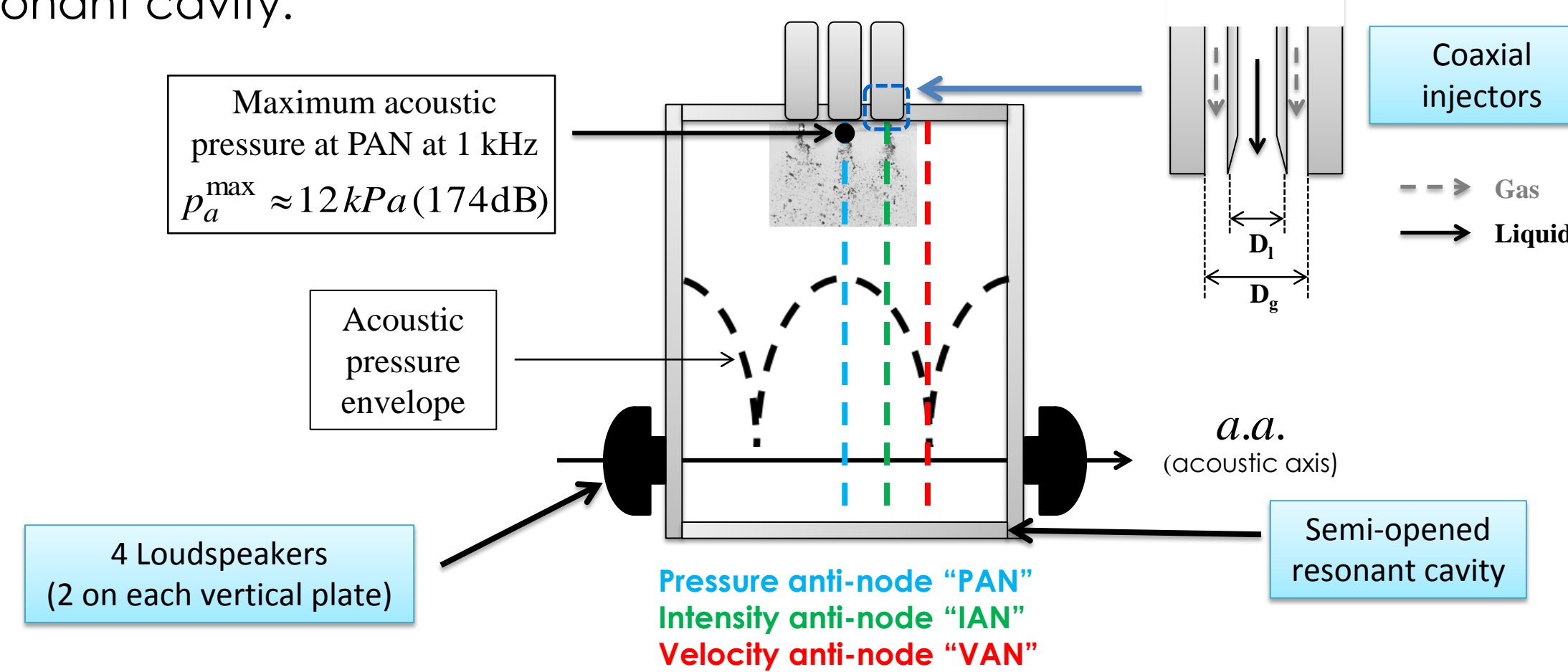
- Yang, V., Anderson, W., *Progress in Astronautics and Aeronautics*, **169**, (AIAA, Washington, DC, 1995).
- King, L.V., *Proceedings of the Royal Society of London A*, **147** (861), 212-240 (1934).
- Zhuk, A. P., *Prikladnaya Mekhanika i Tekhnicheskaya Fizika*, **22**, No. 7, 103-108, (1986).
- Baillot, F., Blaisot, J.B., Boisdron, G., Dumouchel, C., *Journal of Fluid Mechanics*, **640**, 307-344 (2009).
- Baillot, F., Blaisot, Richard, C., Théron, M., 25<sup>th</sup> European Conference on Liquid Atomization and Spray Systems (ILASS), Chania Crete (2013).
- Ficuciello, A., Blaisot, J.B., Baillot, F., Richard, C., Théron, M., 13<sup>th</sup> Triennial International Conference on Liquid Atomization and Spray Systems (ICLASS), Tainan, Taiwan (2015).
- Ficuciello, A., Blaisot, J.B., Baillot, F., Richard, C., Théron, M., International Symposium on Thermoacoustic Instabilities in Gas Turbines and Rocket Engines, Munich, Germany (2016).
- Ficuciello, A., Blaisot, J.B., Baillot, F., Richard, C., Théron, M., AIAA 2016-5085, 52<sup>nd</sup> AIAA/SAE/ASEE Joint Propulsion Conference, Salt Lake City, Utah (2016).

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## 3. Experimental setup and acoustic field

- Semi-opened resonant cavity + compression drivers to reproduce acoustic field similar to what can be found in a combustion chamber
- The **acoustic field** can be approximated as the **2<sup>nd</sup> transverse mode** of the resonant cavity.

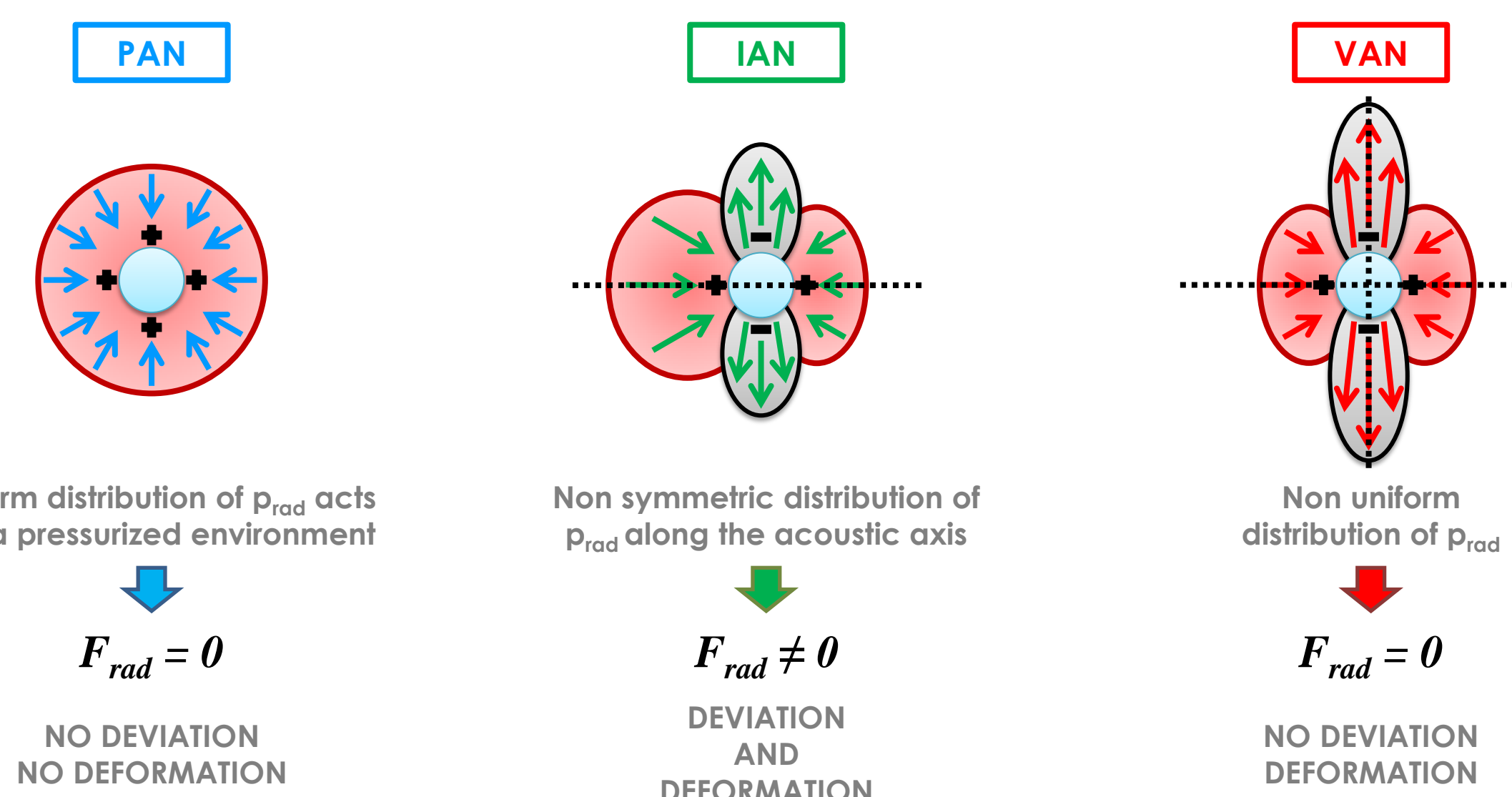


**Anti-node**: spatial location where the amplitude of fluctuations of the considered acoustic quantity (e.g. pressure, velocity or intensity) is maximum.

## 5. Theoretical model

**Nonlinear acoustic** model for cylindrical or spherical objects based on:

- Radiation pressure** distribution:  $p_{rad} = \frac{\langle p_a^2 \rangle}{2\rho_g c^2} - \frac{\rho_g}{2} \langle \dot{u} \dot{u} \rangle$
- Radiation force** effects:  $\vec{F}_{rad} = -\iint_S p_{rad} \cdot \vec{n} dS = G f(\eta) \frac{p_a^2}{4} \sin 2kh \vec{e}$



- Model validation**
- Filled markers: calculation
  - Empty markers: experimental results

