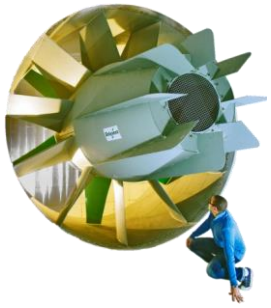
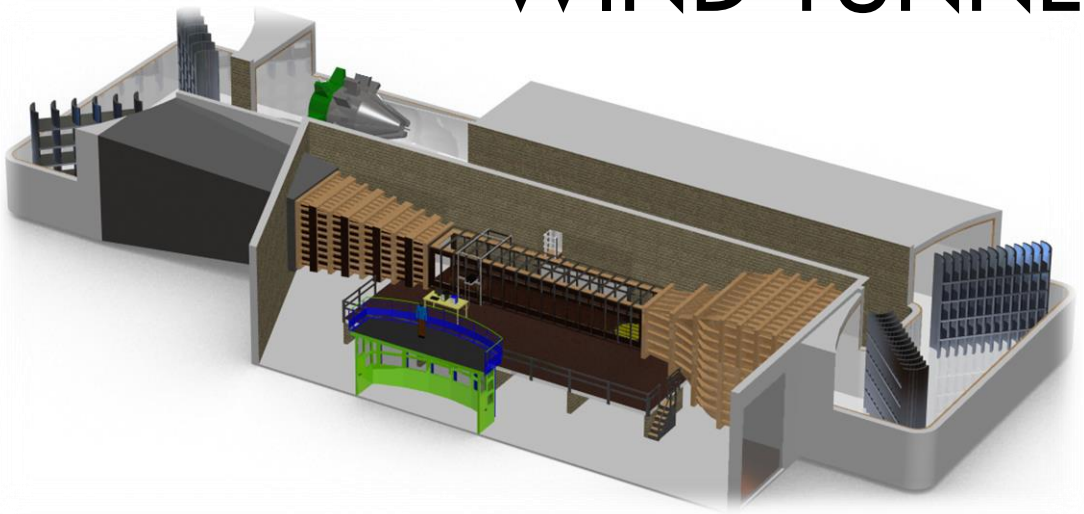
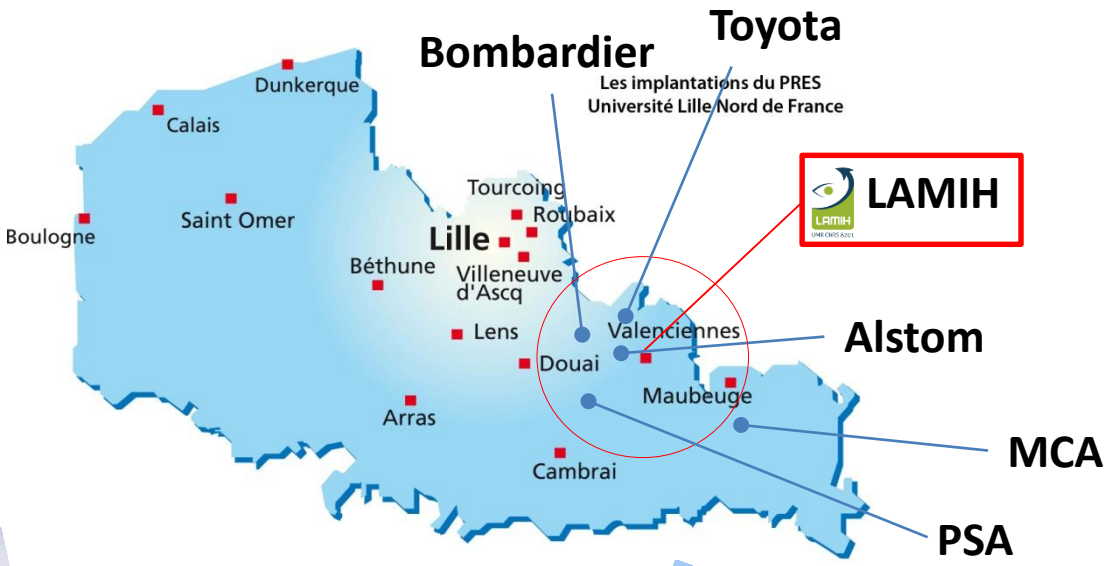


WELCOME

to the WIND TUNNEL



Transport Industry



Railway Industry

10 000 employment

1st European Region for Railway

4 International manufacturers leaders

1 Billions Euros Sales Revenue

Car Industry

36 000 employment

1st French Region for Car Industry

3 Cars Manufacturers

550 000 Vehicles

7 production plants

Logistics

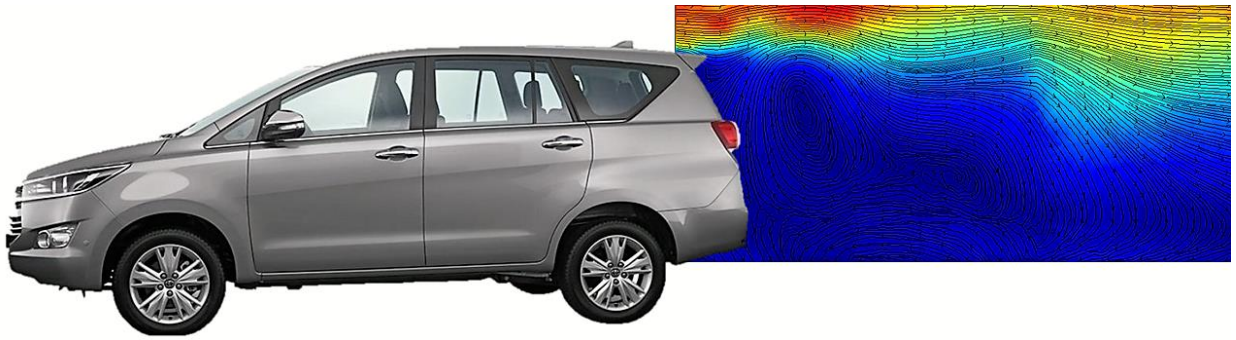
41 500 employment

3rd French Region for Logistics

1st French Harbor platform (Boulogne, Calais, Dunkerque)

500 000 m² last generation warehouses

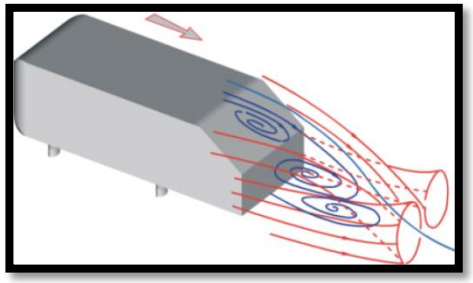
Automative Problematic

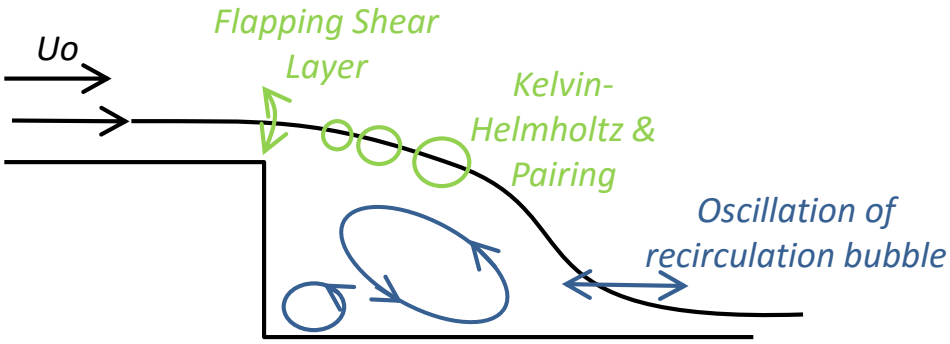


PROBLEM

Increase Pressure in the wake of the car

- FLOW STRUCTURE





- CONTROL STRATEGIES

BOUNDARY LAYER SEPARATION (Recirculation Bubble)

LONGITUDINAL VORTICES

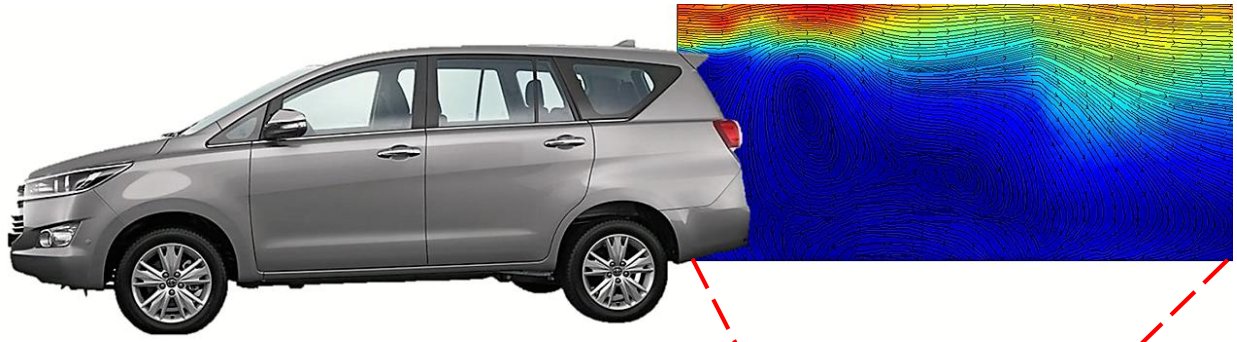
- METHODS OF FLOW CONTROL

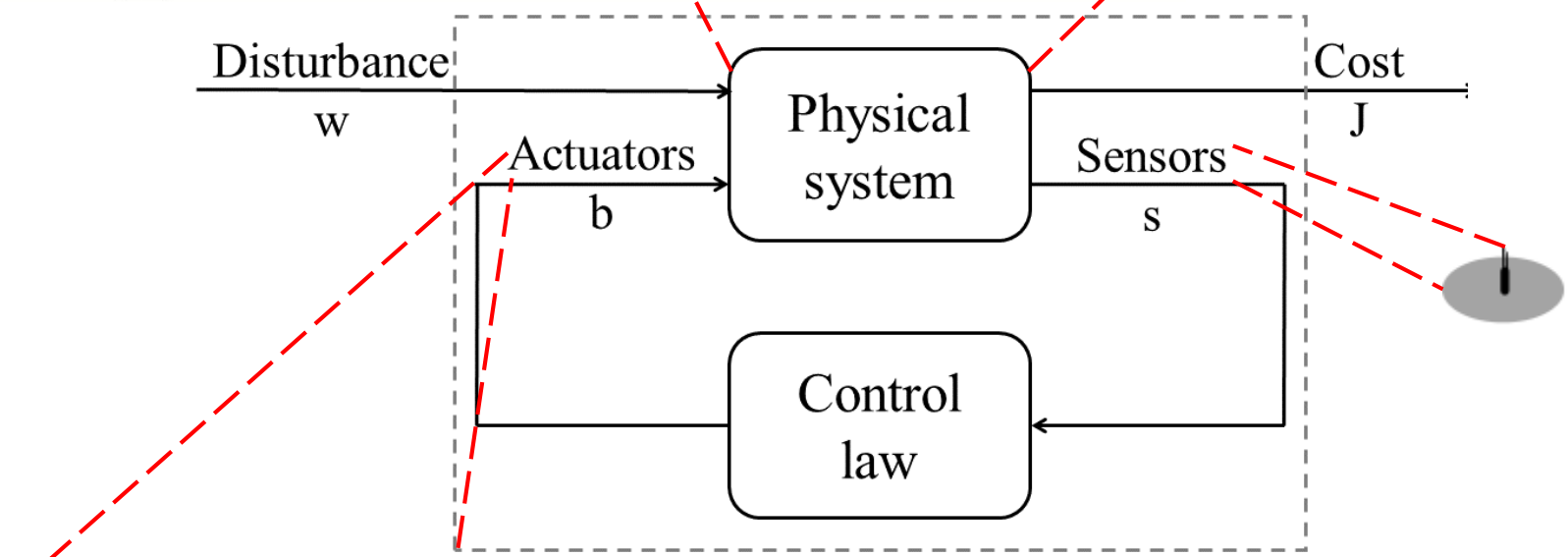
PASSIVE CONTROL (Geometric Configuration)

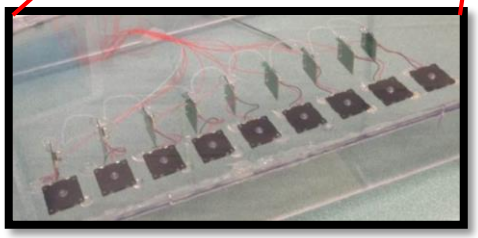
ACTIVE CONTROL (Injection of Momentum)

C_AIR LOUNGE

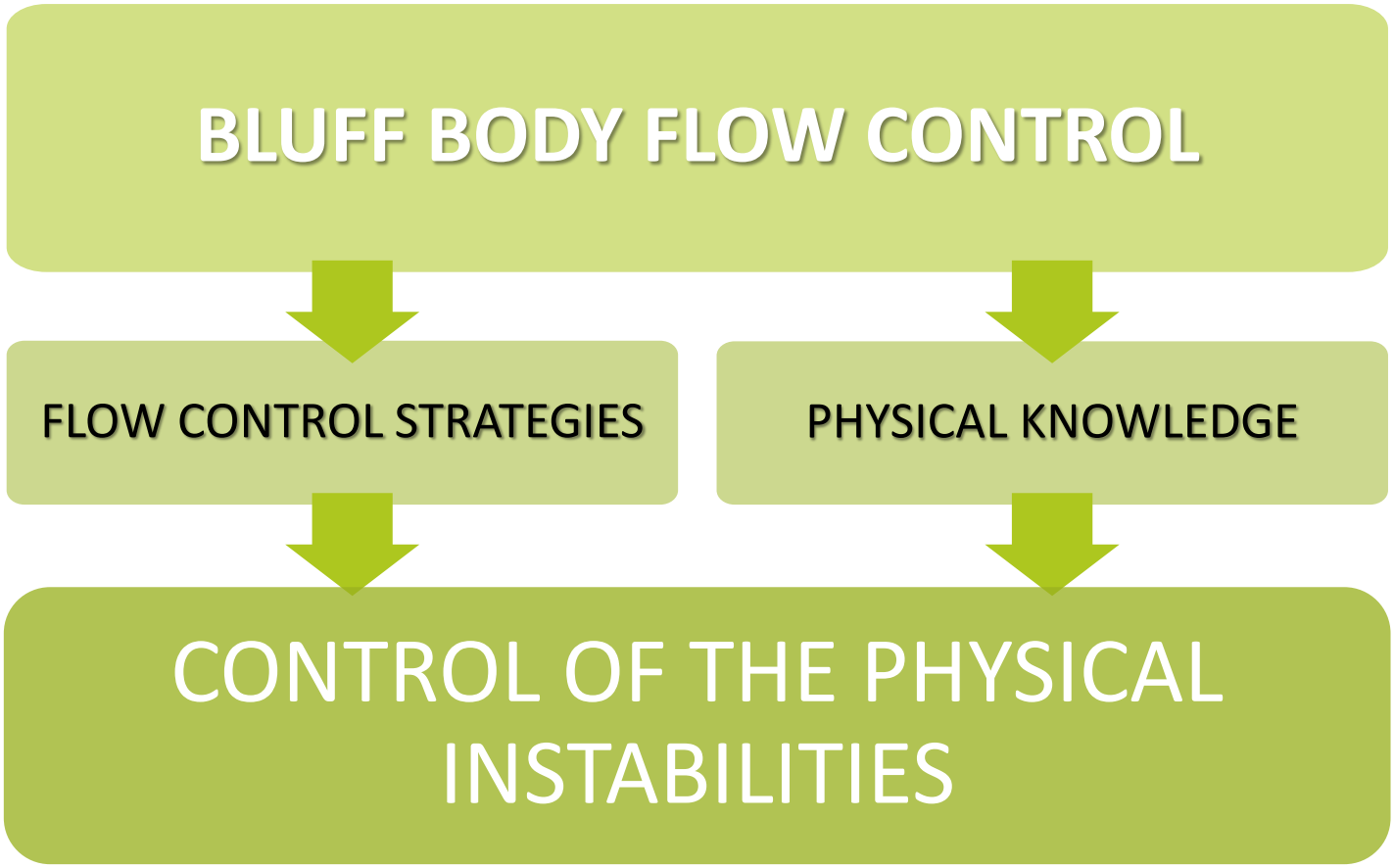
Automative Problematic







Automative Problematic



ARI 2016 : Multidisciplinary Development within LAMIH UMR 8201

Projet **DÉSIRÉ** **DE**velopment of **I**nnovative **S**trategies for **R**eactive **F**low **C**ontrol «**DÉ**veloppement de **S**tratégies **I**nnovantes de contrôle **R**éactif d'**É**coulements»

INTERNAL

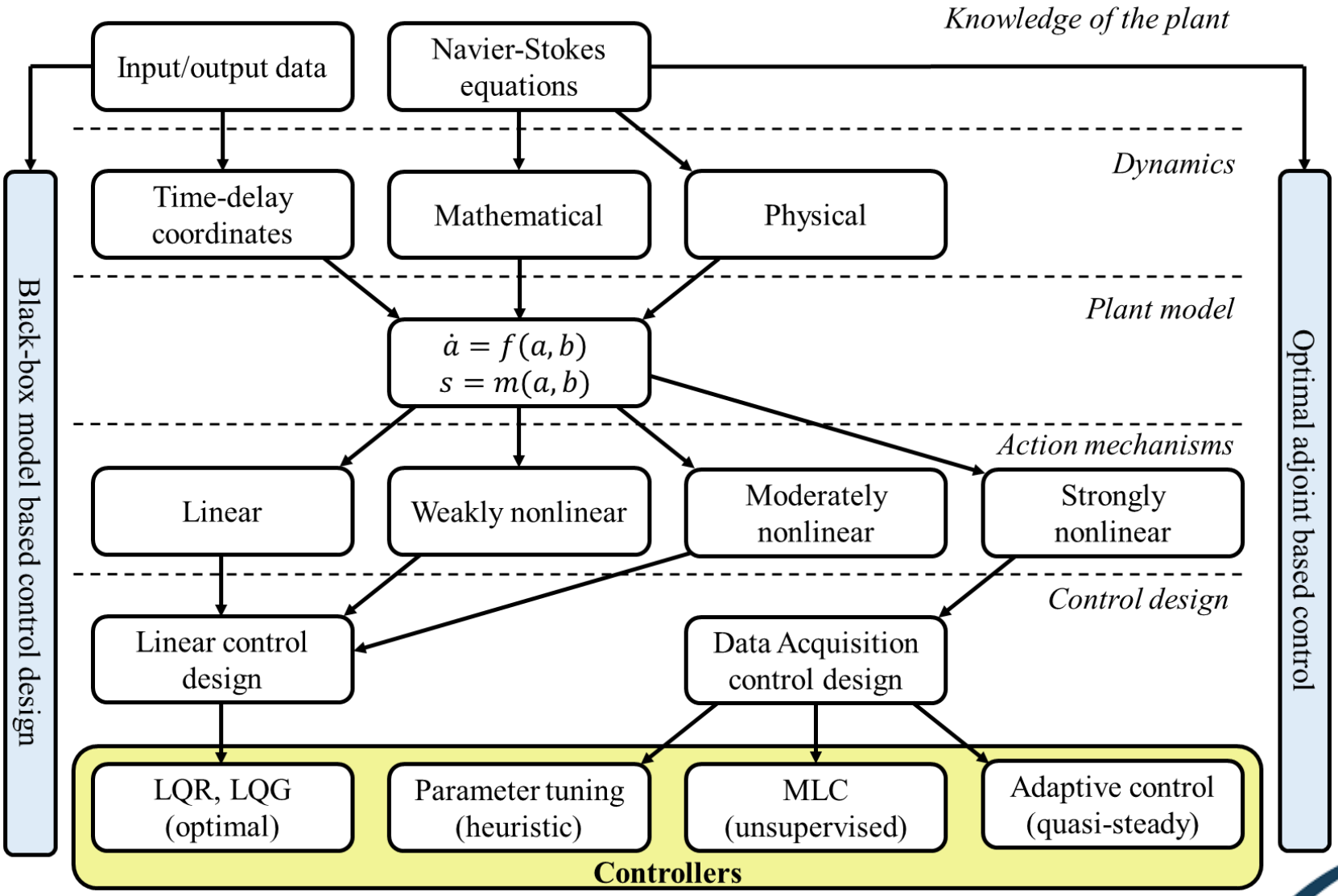
- **Collaboration between the Mechanic and Automation and Control Department in LAMIH (Closed-loop flow control)**

EXTERNAL

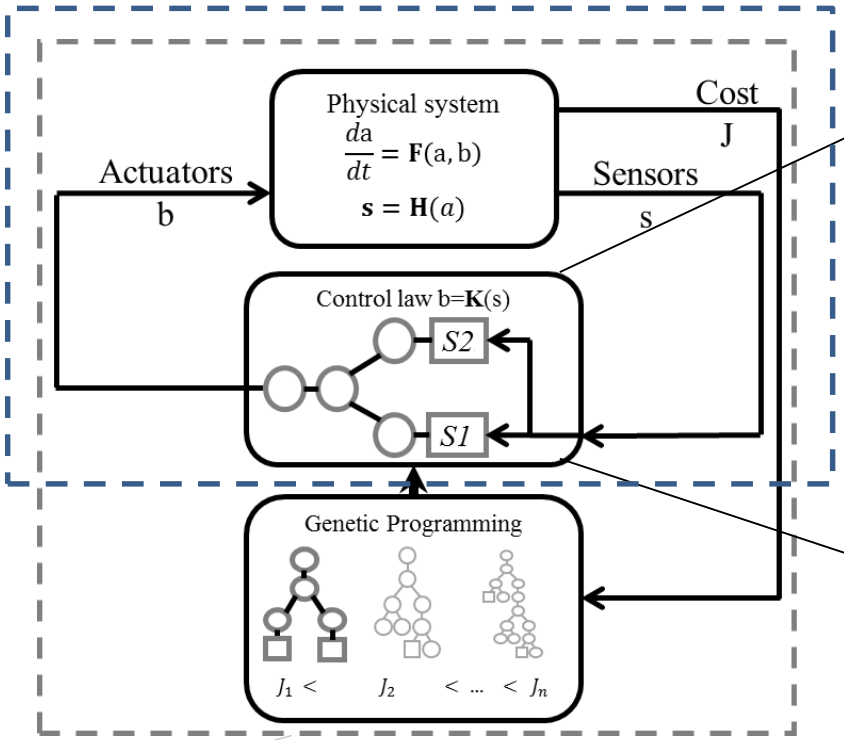
- Invitation of Foreign Personalities
  - **Bernd Noack** (University d'Orsay, France/University of Braunschweig, Germany) ✓
  - **Steven L. Brunton** (University de Washington, USA)
  - **Thomas Duriez** (University of Buenos Aires, Argentine)

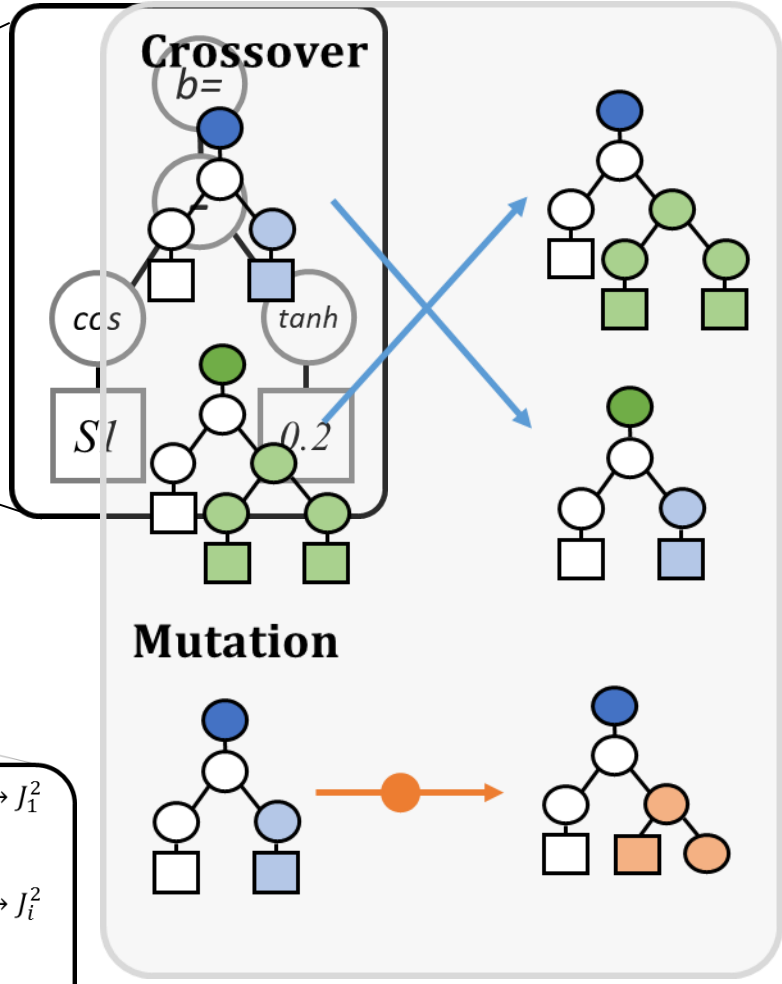
2nd Workshop on Machine Learning Control Feb. 2017

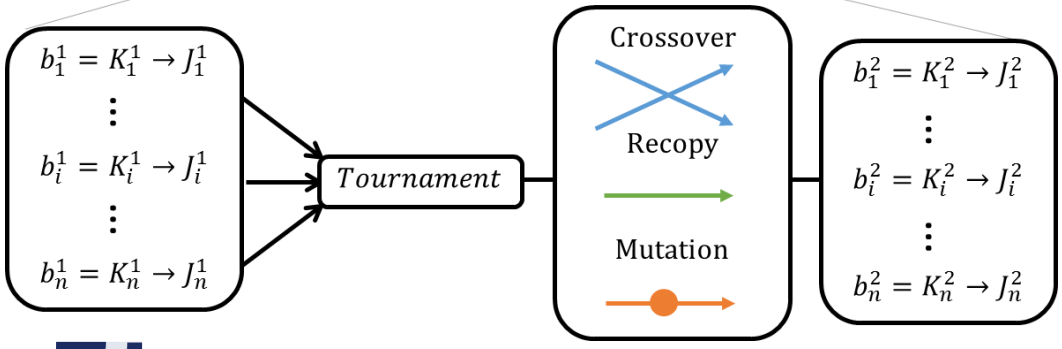
Flow Control Strategies



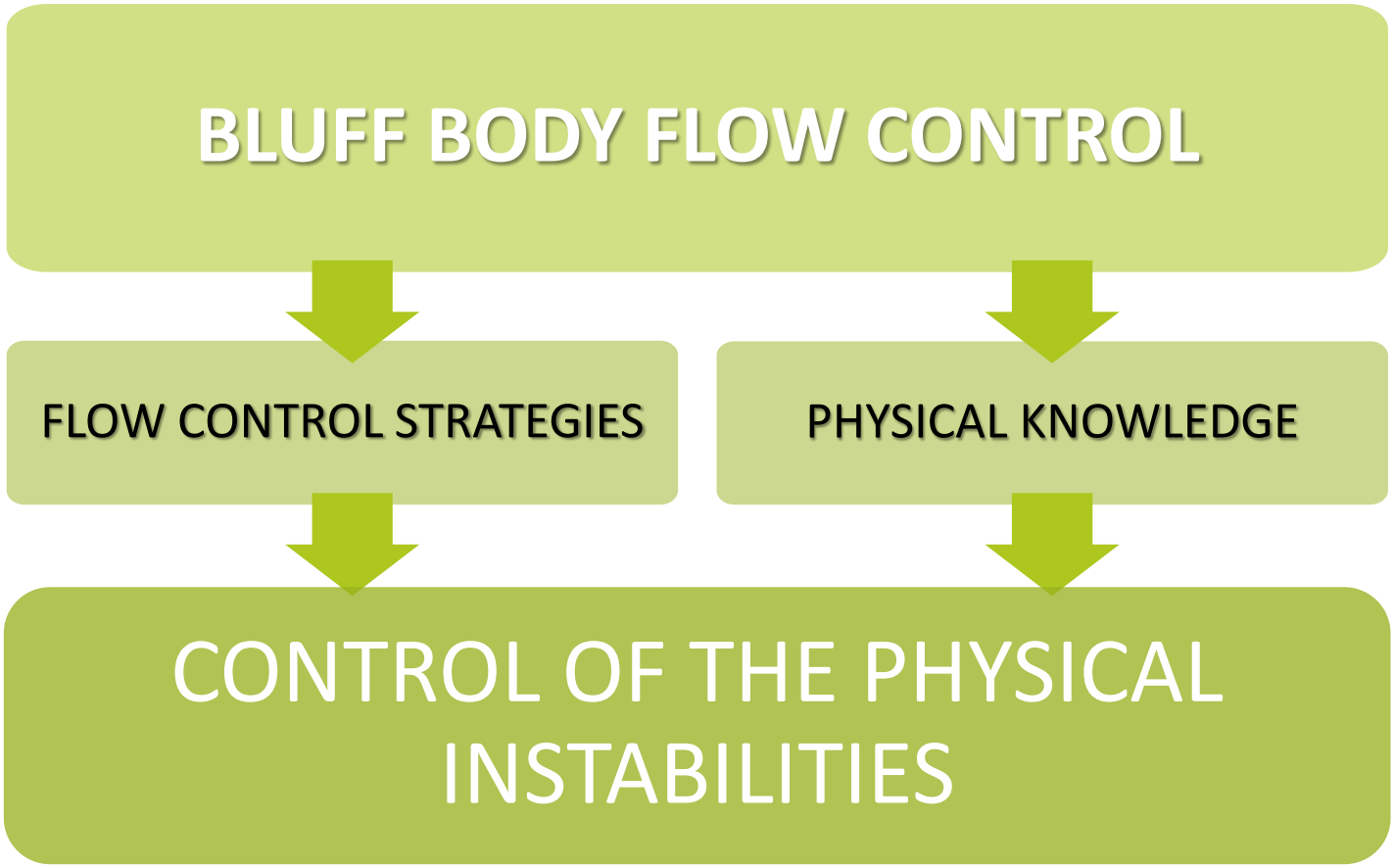
Flow Control Strategies MLC







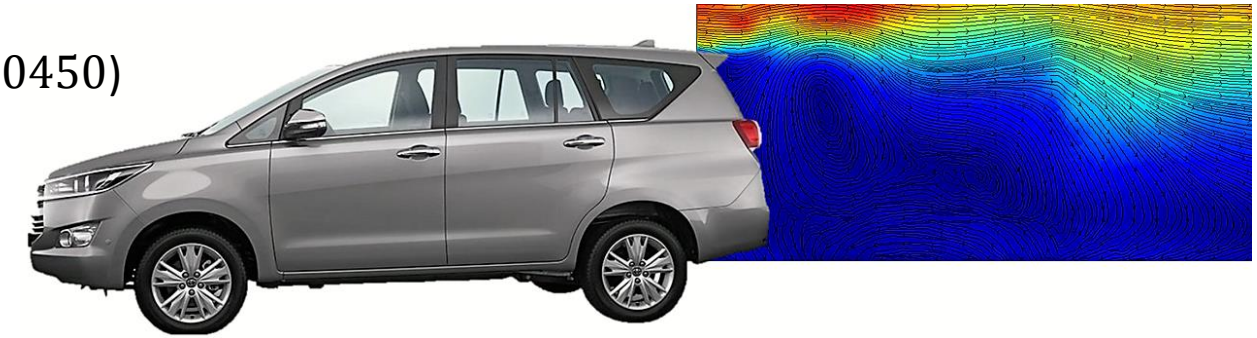
Automative Problematic

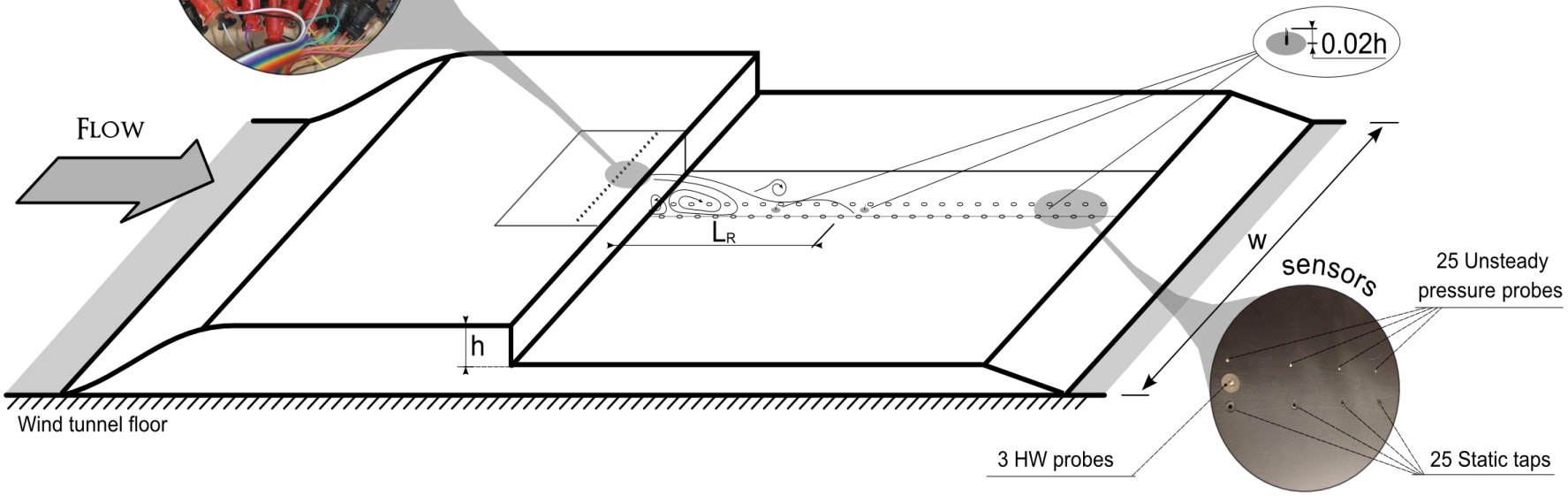


Physical System

h=83mm

Uo=5.5m/s ($Re_h = 30450$)

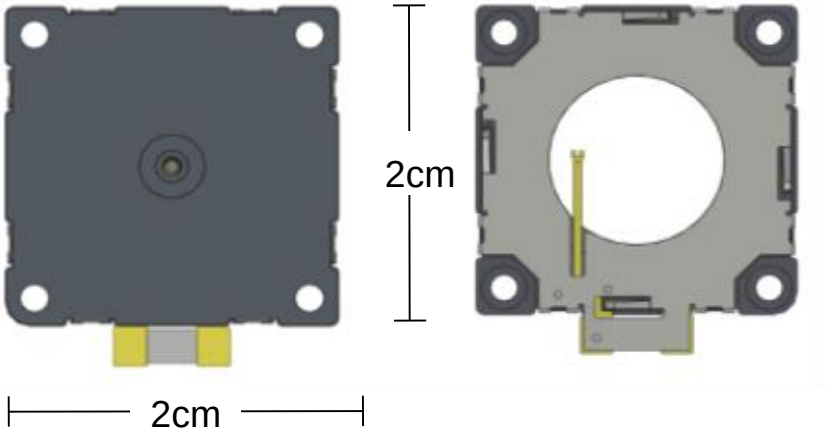


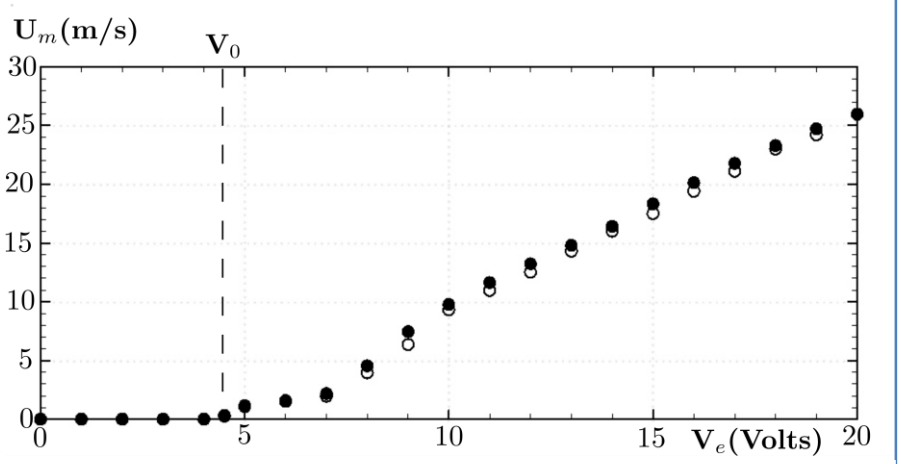


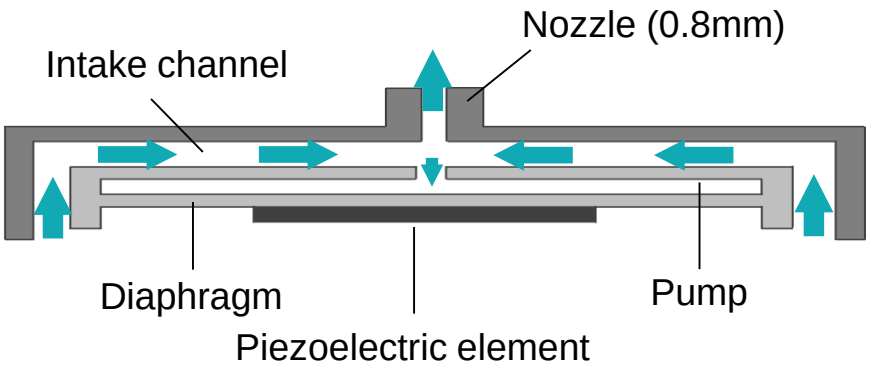
Physical System

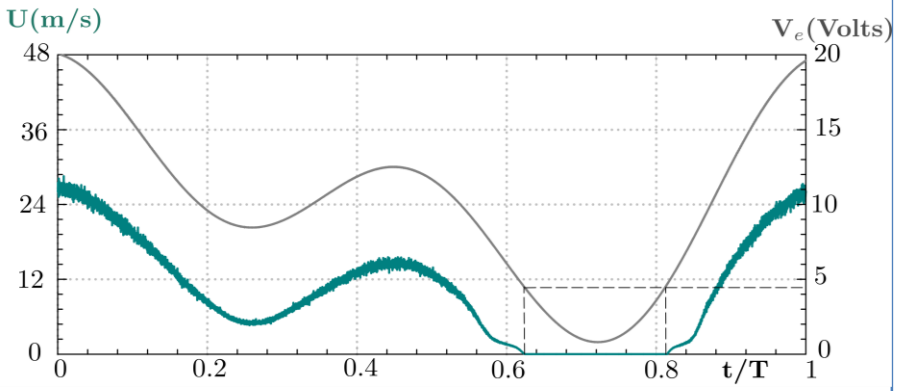
Dynamic characterization of row of piezoelectric micro-blowers for separated air flow control.

C. Chovet[a,*], M. Lippert, L. Keirsbulck, J-M. Foucaut . (Sensor and Actuators)



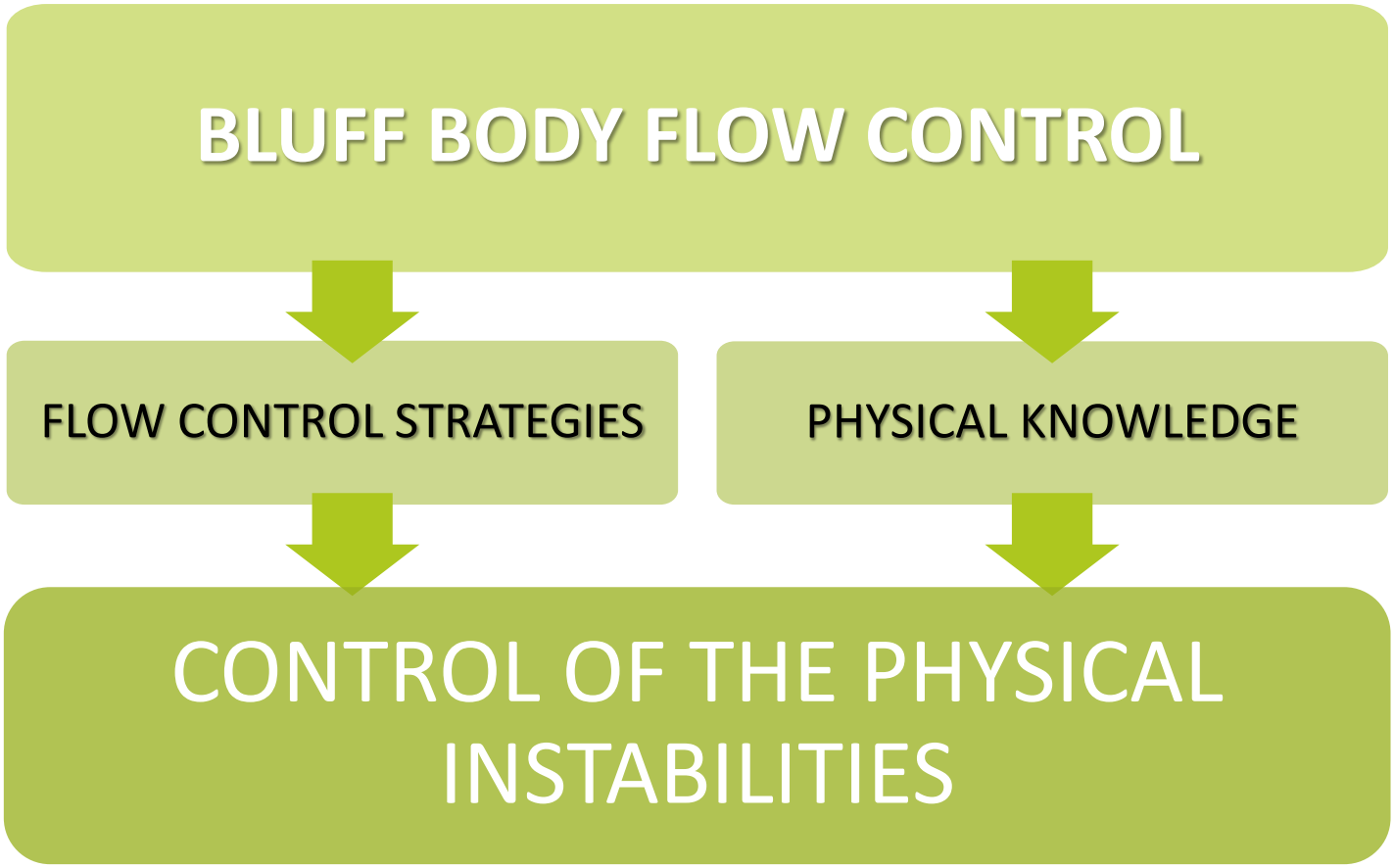




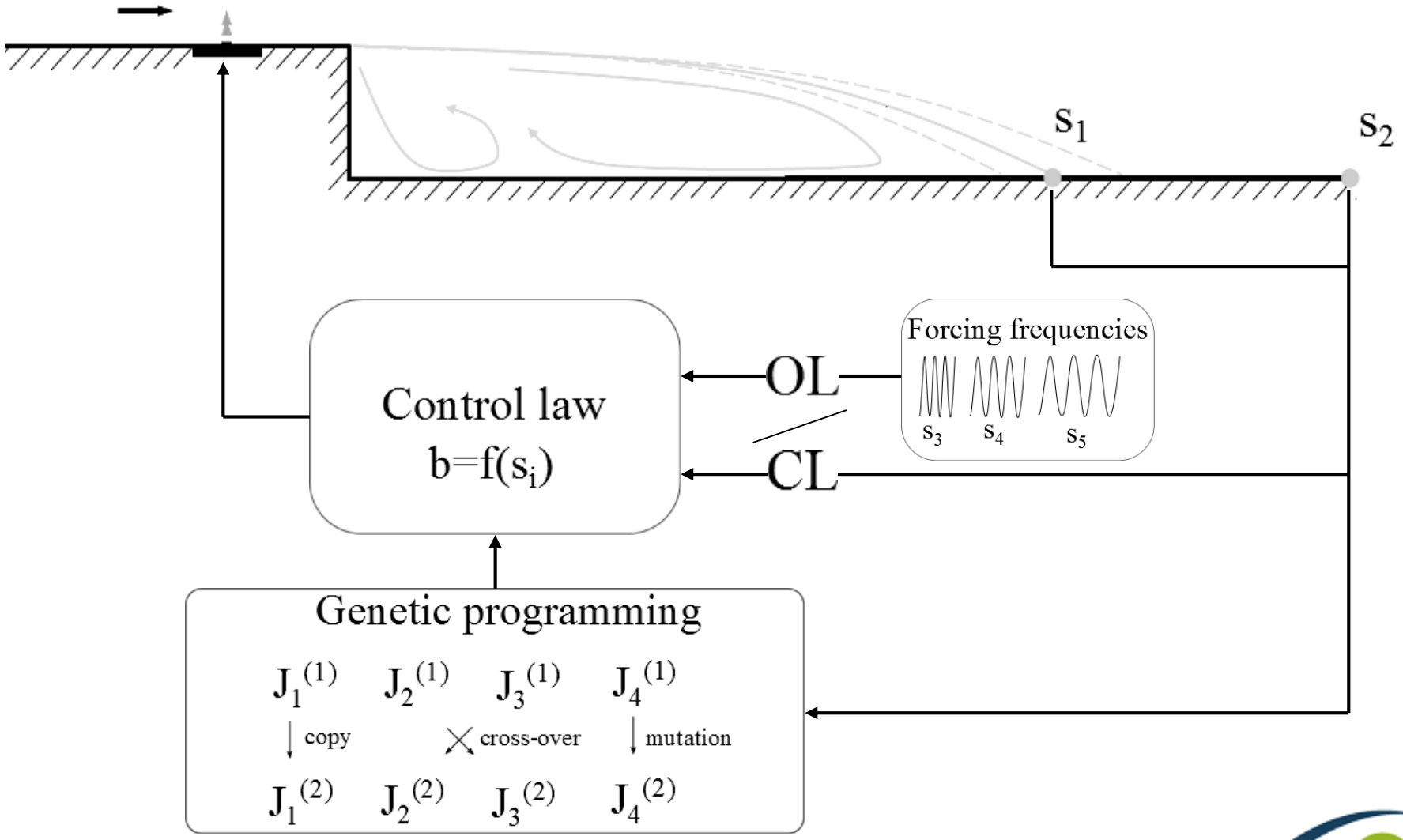


- Intrinsically non-zero-net-mass-flux.(double cavity).
- Combination of a disc-shaped piezoelectric element and a metal diaphragm (Vibrations 26 kHz).
- Air discharges up to 1 l/min.
- Low Power Consumption.

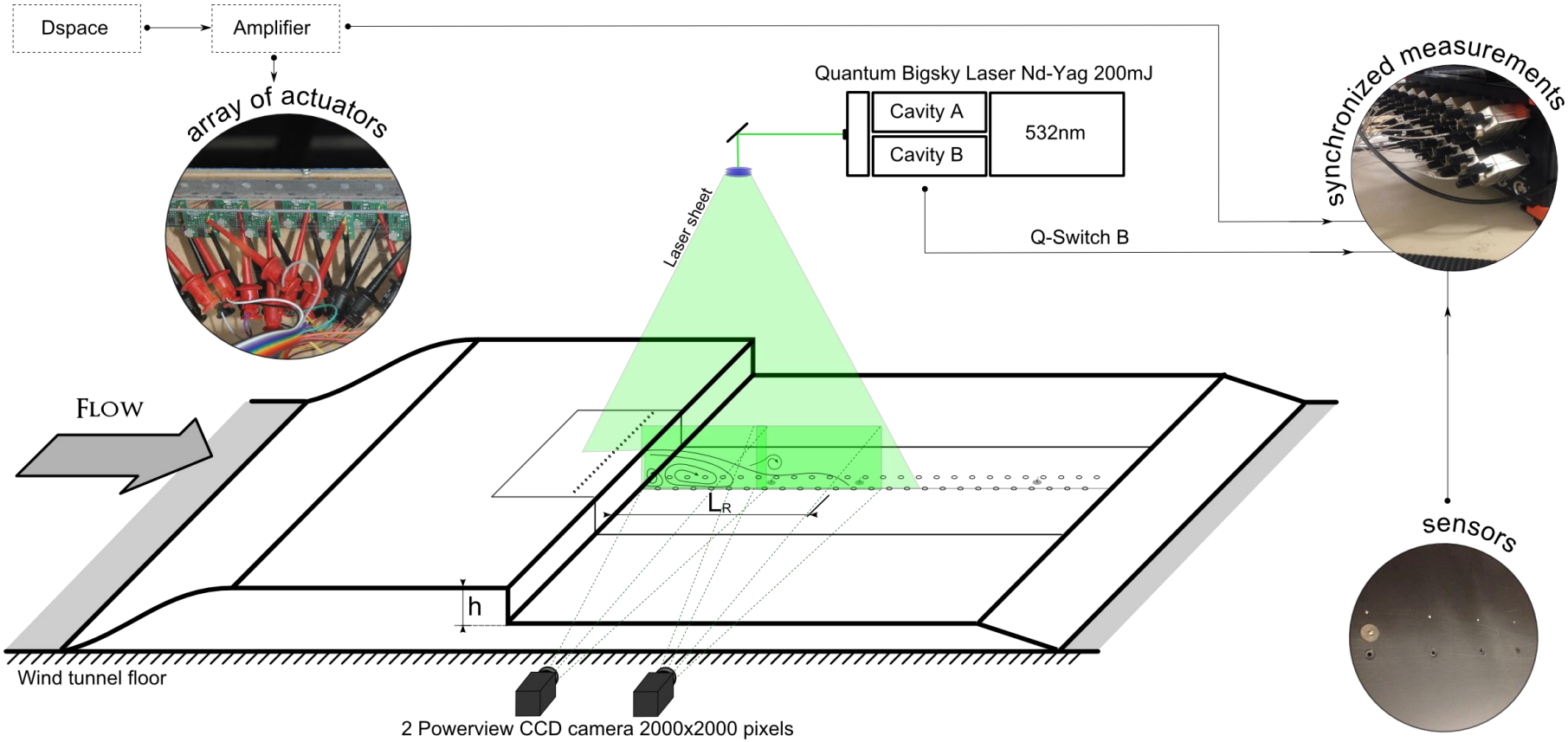
Automative Problematic



Control of the physical Instabilities



Control of the physical Instabilities



Control of the physical Instabilities

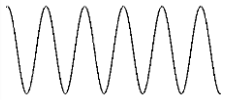
$$J = \left(\sum_{i=n} < Si >_T^2\right)^{-1} + \gamma < b >^2 \qquad < Si \geq = \frac{HWPmax - HWPi}{HWPmax - HWPmin}$$

Natural Flow

$\frac{\Delta Ar}{Ar} = 0\%;\ \frac{\Delta Lr}{Lr} = 0\%;\ \boldsymbol{J_o = 1}$

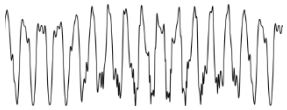
Manual forcing frequency

$\frac{\Delta Ar}{Ar} = -25\%;\ \frac{\Delta Lr}{Lr} = -5\%;\ \boldsymbol{J_o = 0.8}$



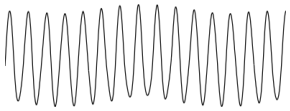
MLC OL

$\frac{\Delta Ar}{Ar} = -21\%;\ \frac{\Delta Lr}{Lr} = -6\%;\ \boldsymbol{J_o = 0.2}$



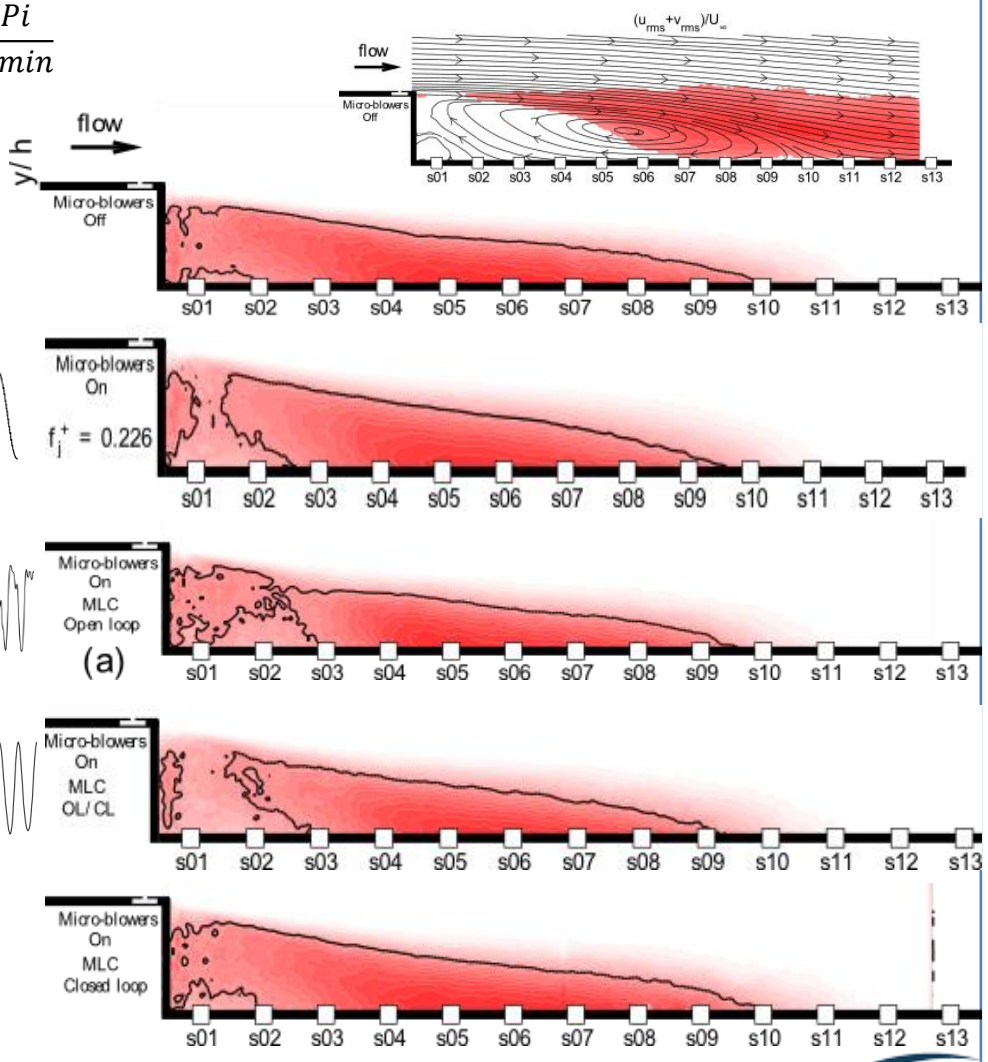
MLC OL&CL

$\frac{\Delta Ar}{Ar} = -32\%;\ \frac{\Delta Lr}{Lr} = -8\%;\ \boldsymbol{J_o = 0.08}$

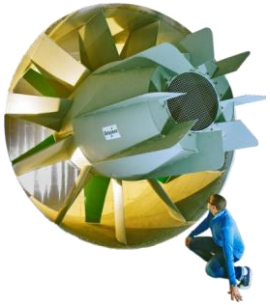


MLC CL

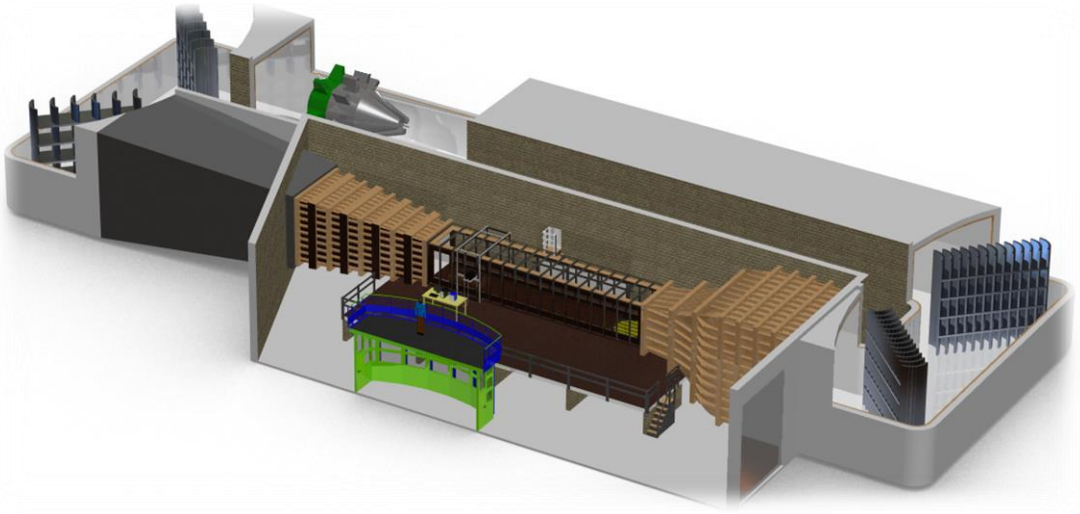
$\frac{\Delta Ar}{Ar} = -3\%;\ \frac{\Delta Lr}{Lr} = 0.7\%;\ \boldsymbol{J_o = 1}$



Back Flow Probability



THANK YOU
MERCI



QUESTIONS