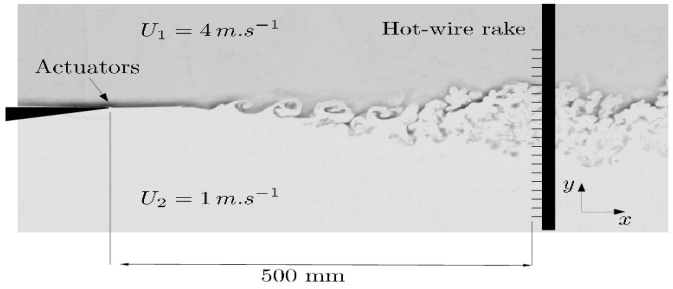
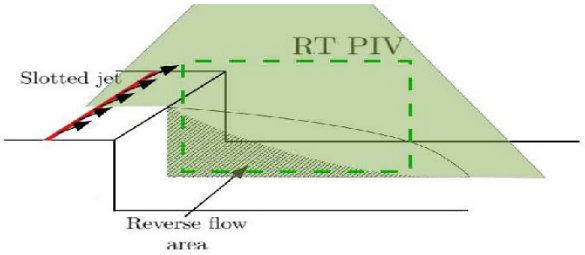
TUCOROM mixing layer



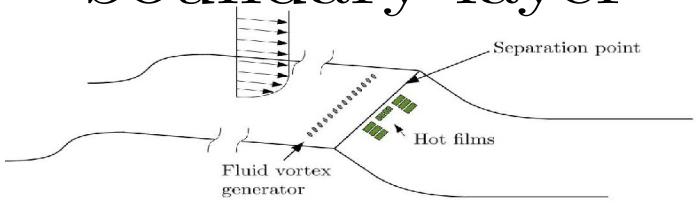
Facility:	Wind-tunnel
Objecive:	Mixing enhancement
Sensors:	Rake of 24 hot wires
Actuators:	96 pulsed jets
Reynolds number	2000

PMMH backward facing step



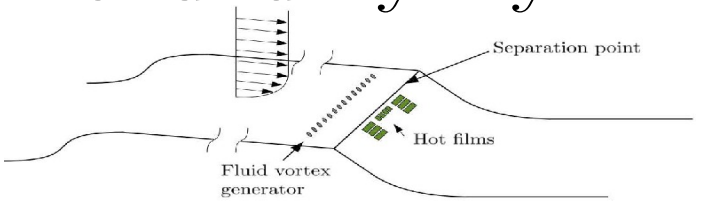
Facility:	Water-tunnel
Objecive:	Recirculation reduction
Sensors:	Real-time PIV
Actuators:	Blowing or sucking jet
Reynolds number	1350

LML separating boundary layer



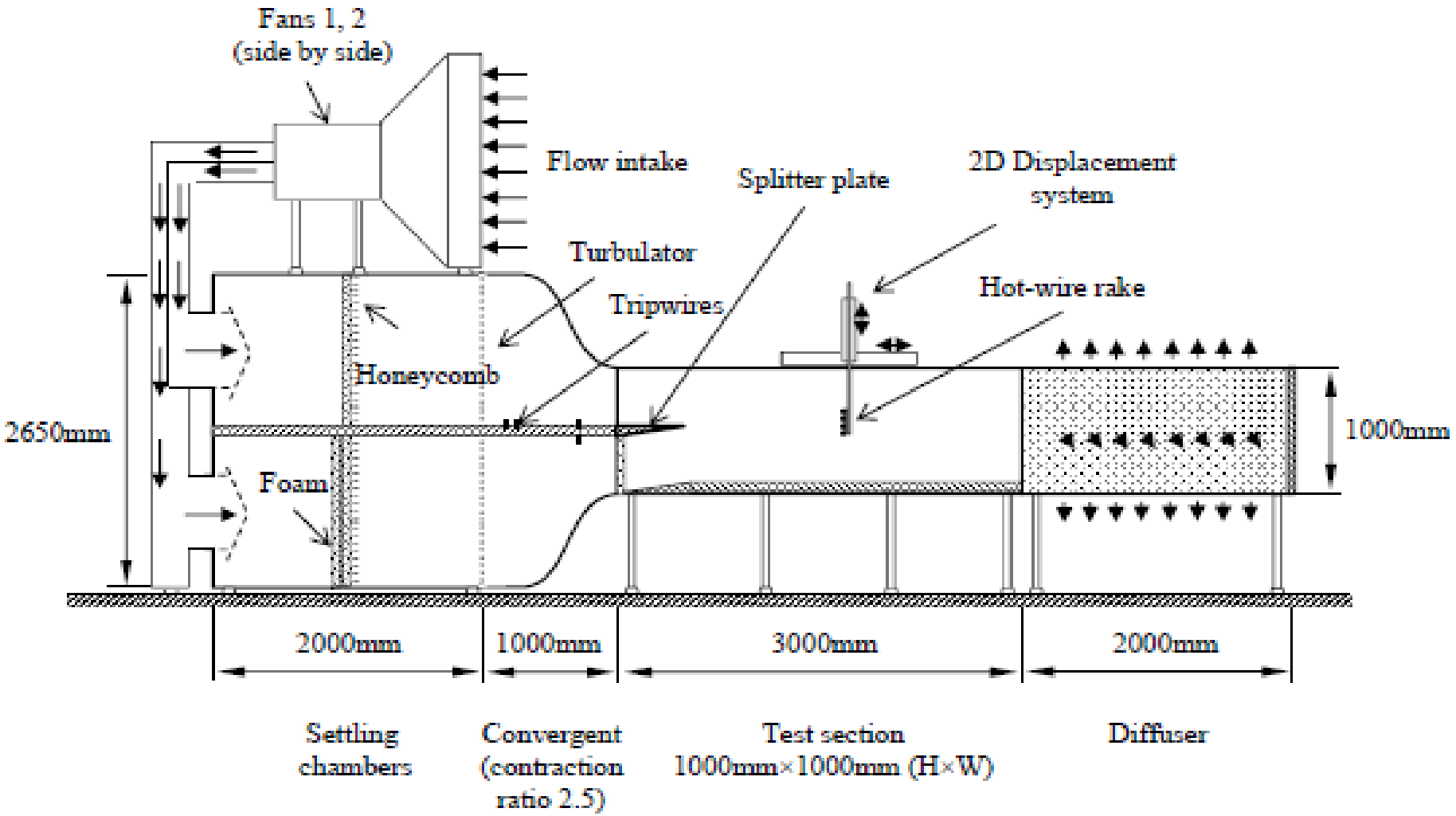
Facility:	Wind-tunnel
Objecive:	BL reattachment
Sensors:	3 hot films
Actuators:	Active Vortex generators
Reynolds number	13000

PRISME separating boundary layer

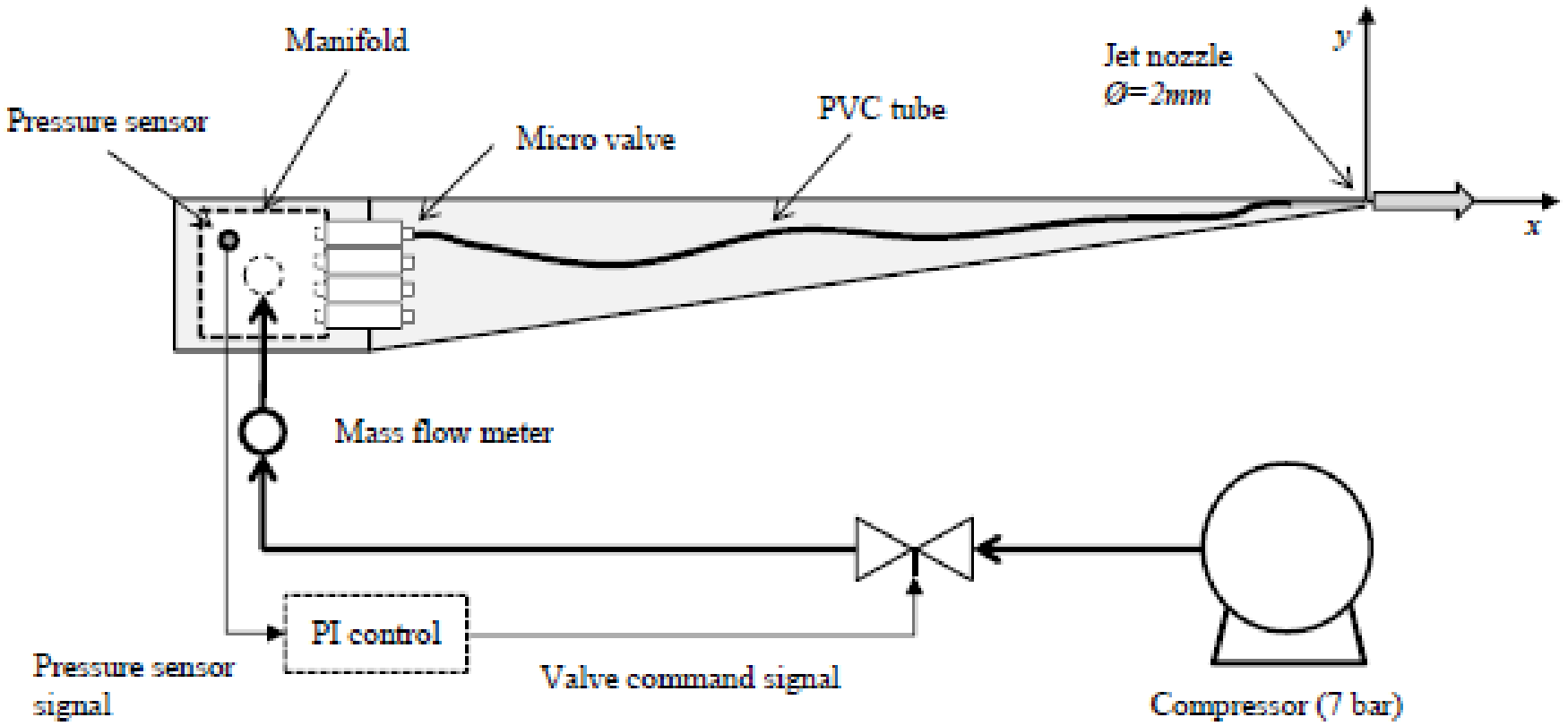


Facility:	Wind-tunnel
Objecive:	BL reattachment
Sensors:	3 hot films
Actuators:	Active Vortex generators
Reynolds number	130000

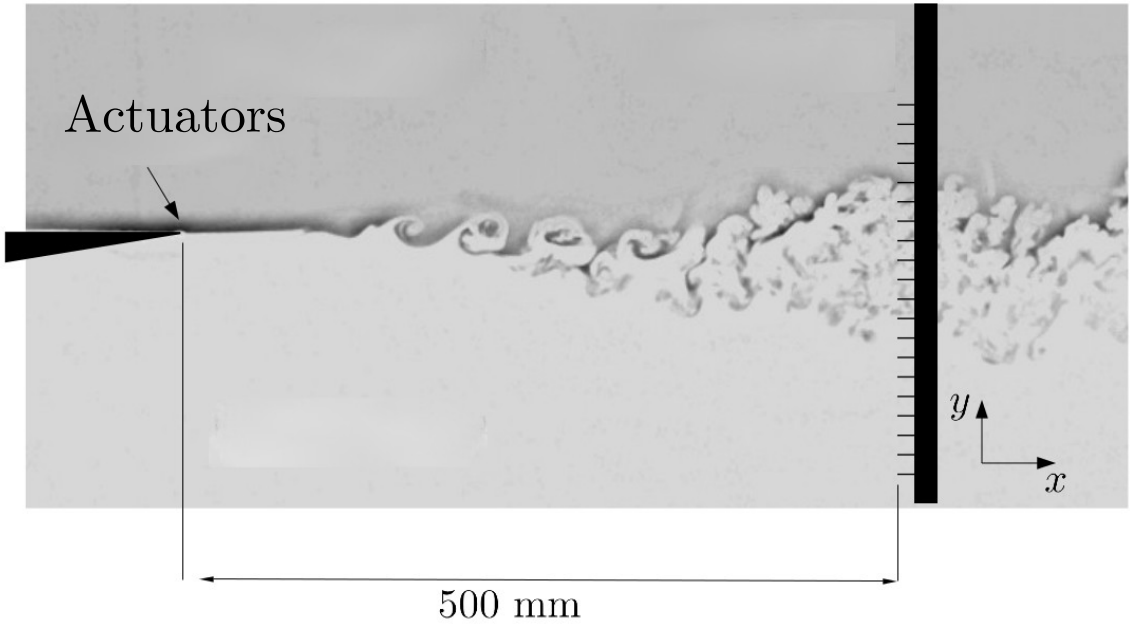
TUCOROM mixing layer

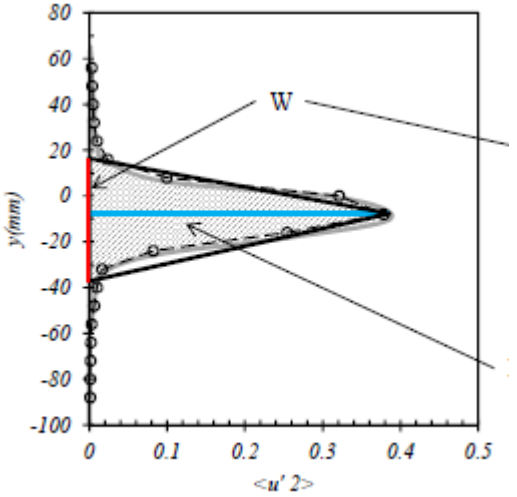


TUCOROM mixing layer



Turbulent mixing layer control





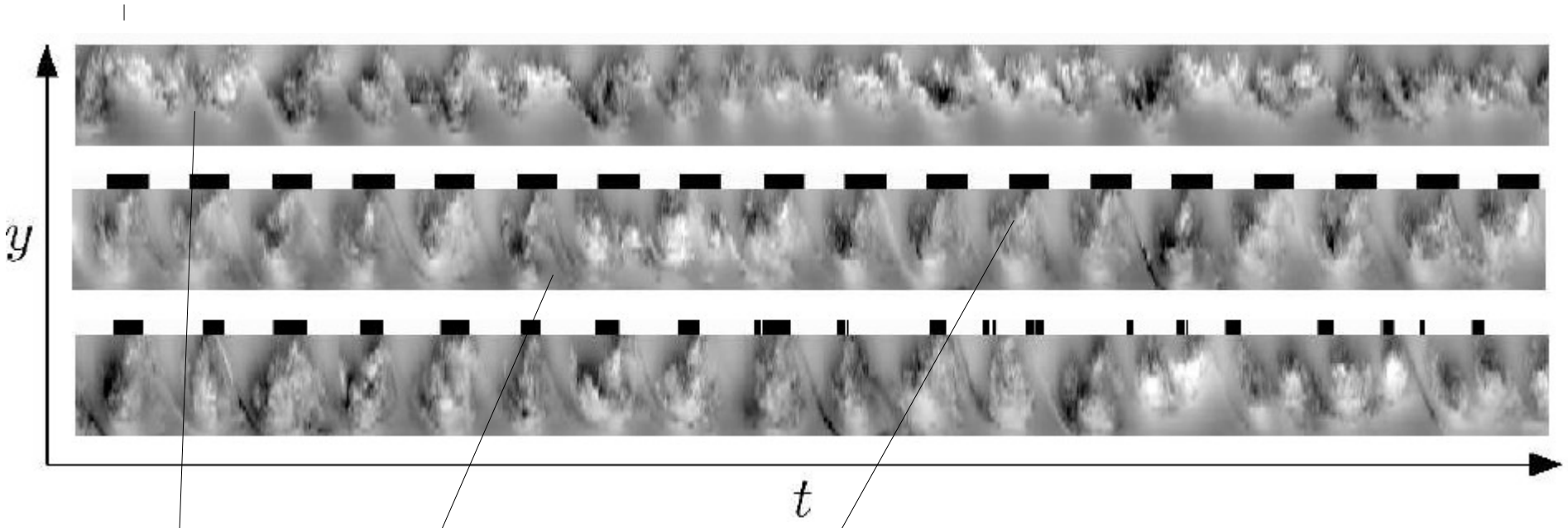
$$J = \frac{1}{W}, \text{ with } W = \frac{\left\langle \left[\sum_{i=1}^{24} s'^2_i(t) \right] \right\rangle_T}{\max_{i \in [1,24]} \left(\langle s'^2_i \rangle_T \right)},$$

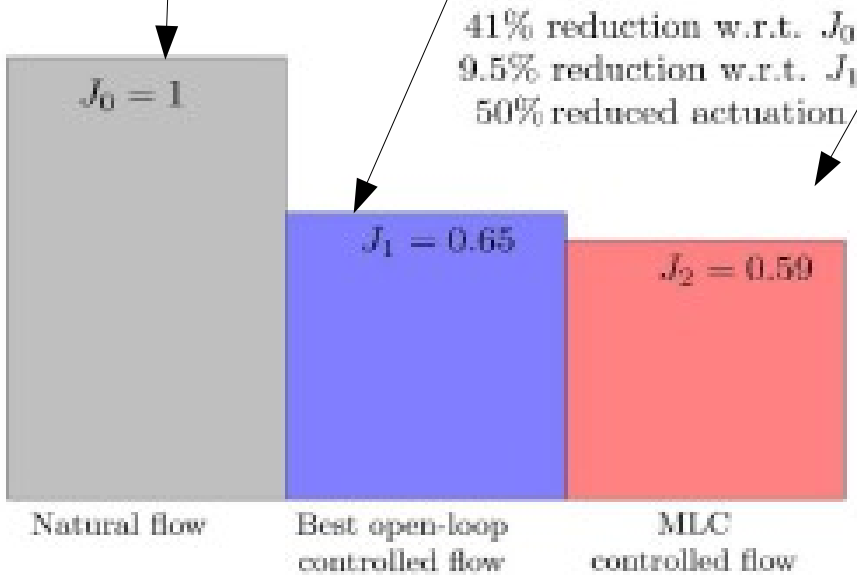
Turbulent mixing layer control

MLC parameters:

- 100 individuals, 8 generations
- 9 sensors for closed-loop control
- 24 sensors for evaluation
- 10% replication, 25% mutation, 65% crossover

Turbulent mixing layer control

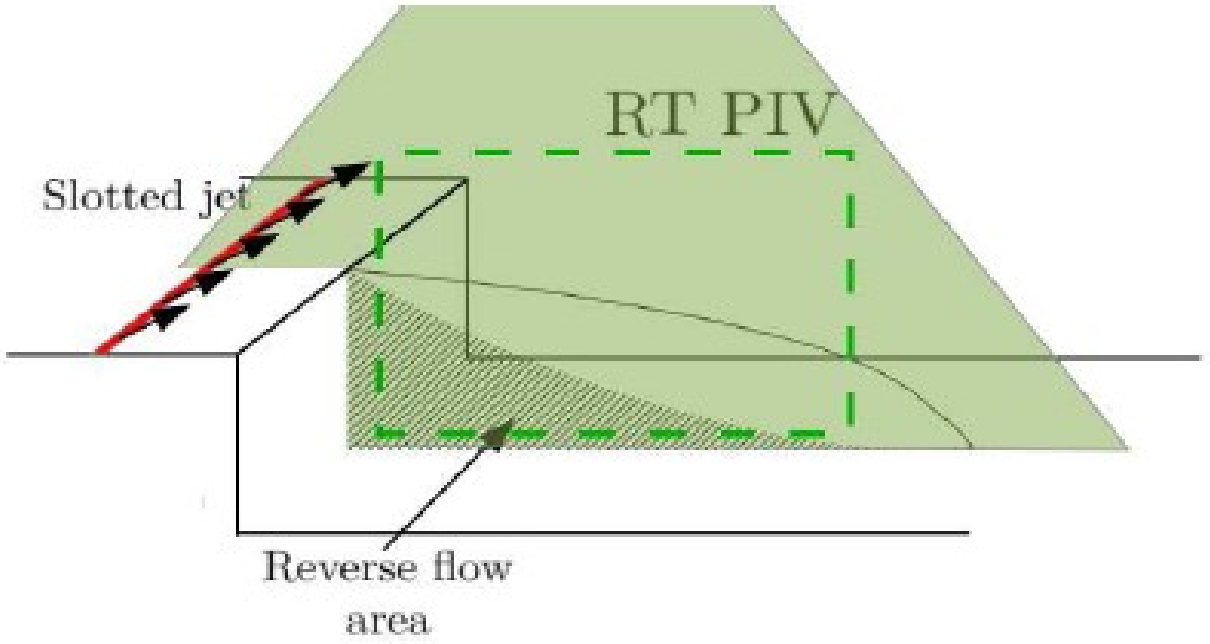




- Result is reproducible: several runs leads to the same kind of solution.
- The best individual is robust, it is still effective with different Reynolds number.

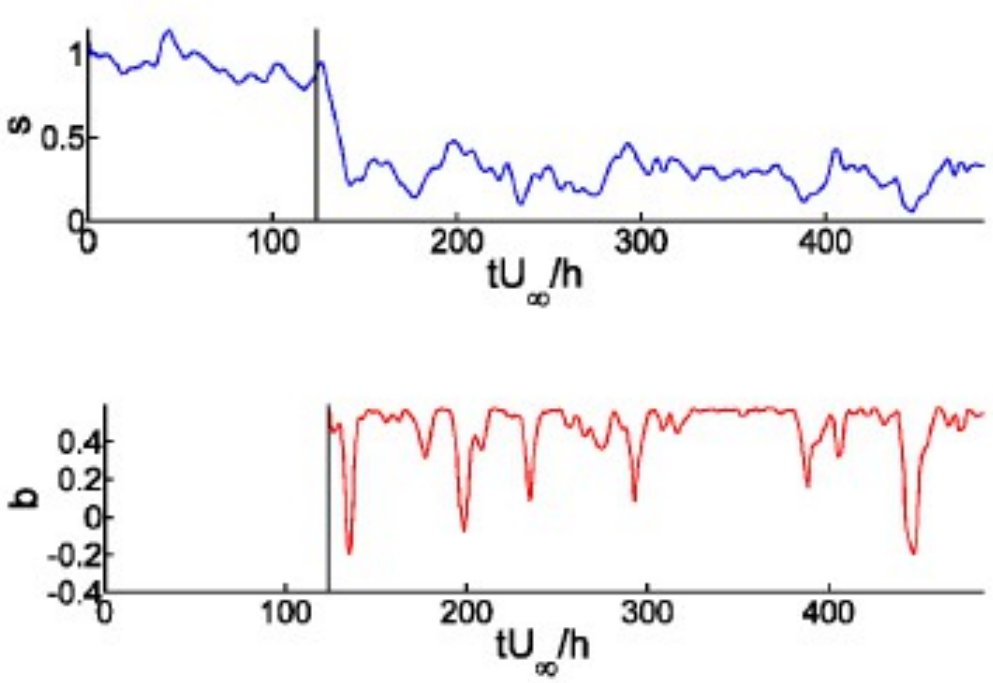
PMMH Görtler water tunnel

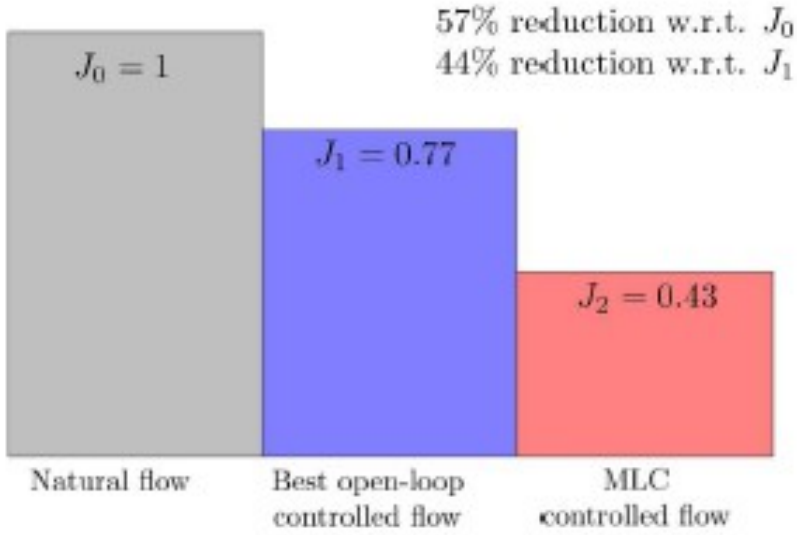
BFS separation control



$$s(t) = \frac{\int H(-u(t))(x,y)\,\mathrm{d}x\mathrm{d}y}{A_0}, \qquad J = \langle s \rangle_T + \gamma \langle |b| \rangle_T^2,$$

BFS separation control





BFS separation control

- Best individual exploits a different mechanism than the best open-loop control
- Best individual is robust, it is still higly effective over a wide range of Reynolds number

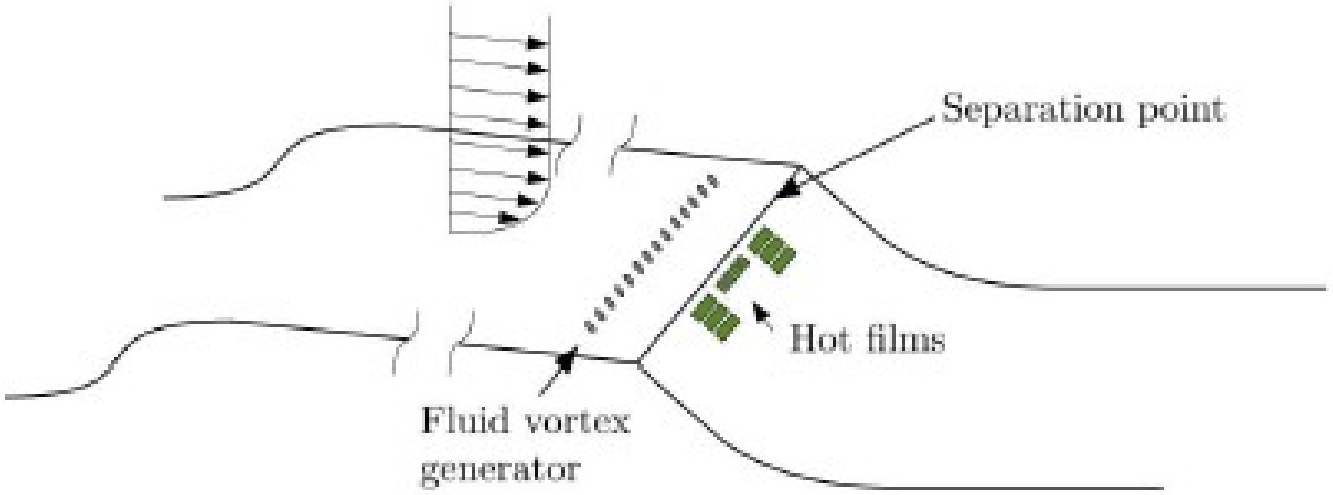
N. Gautier, J.-L. Aider, T. Duriez, B. R. Noack, M. Segond, and M. Abel

“Closed-loop separation control using machine learning"

J. Fluid Mech. 2015.

LML wall turbulence wind-tunnel

Separation control on AVERT model



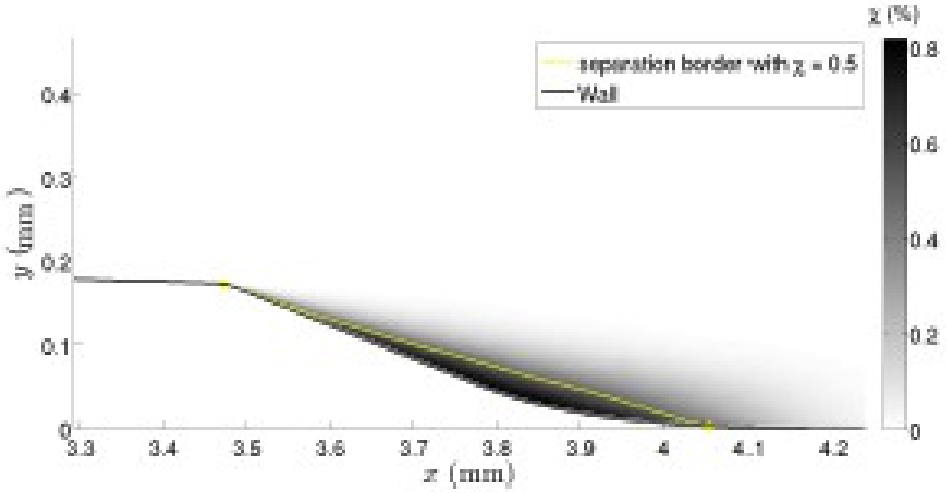
$$s_i = \frac{h_i - h_{i0}}{h_{i,max} - h_{i0}},$$

$$J = \left(\frac{1}{3} \sum_{i=(A,B,C)} \langle s_i \rangle_T^2 \right)^{-1} + \gamma \langle b \rangle_T^2$$

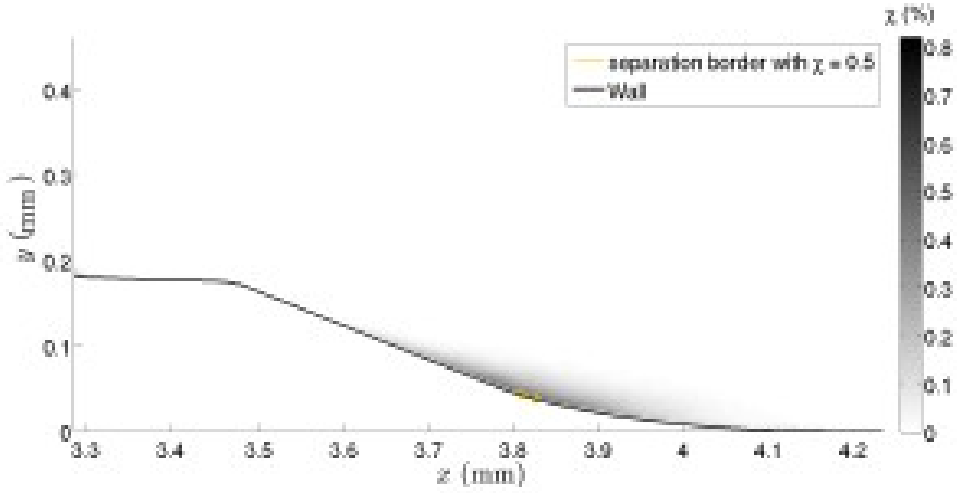
Separation control on AVERT model

Back-flow coefficient

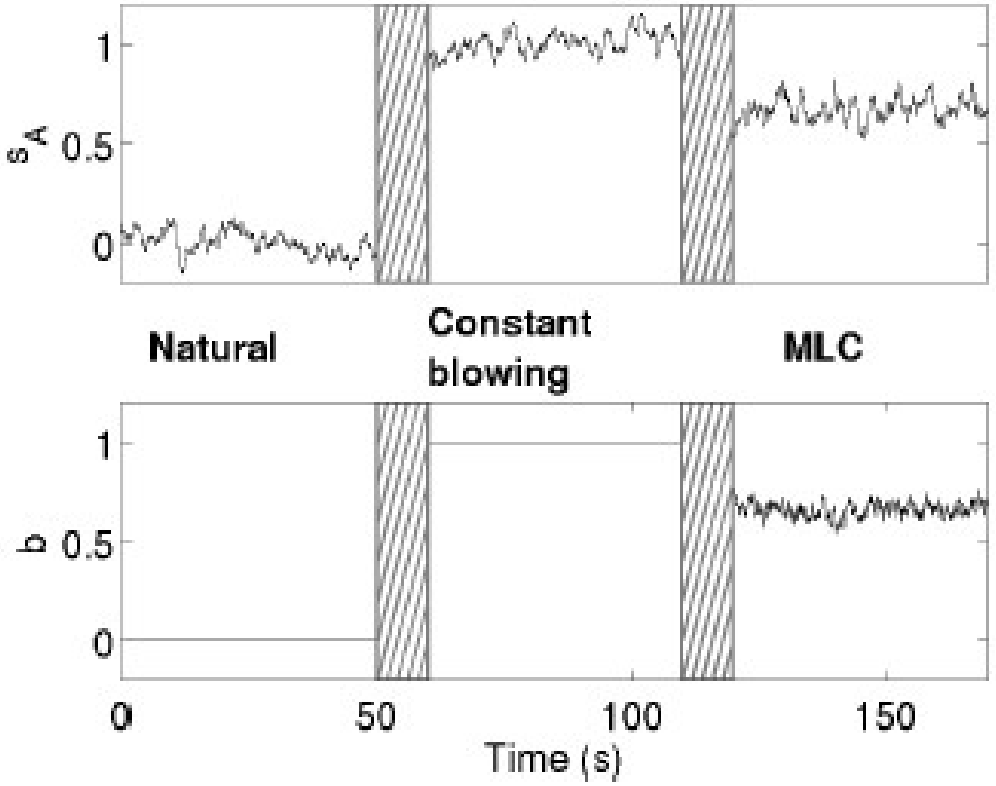
Uncontrolled

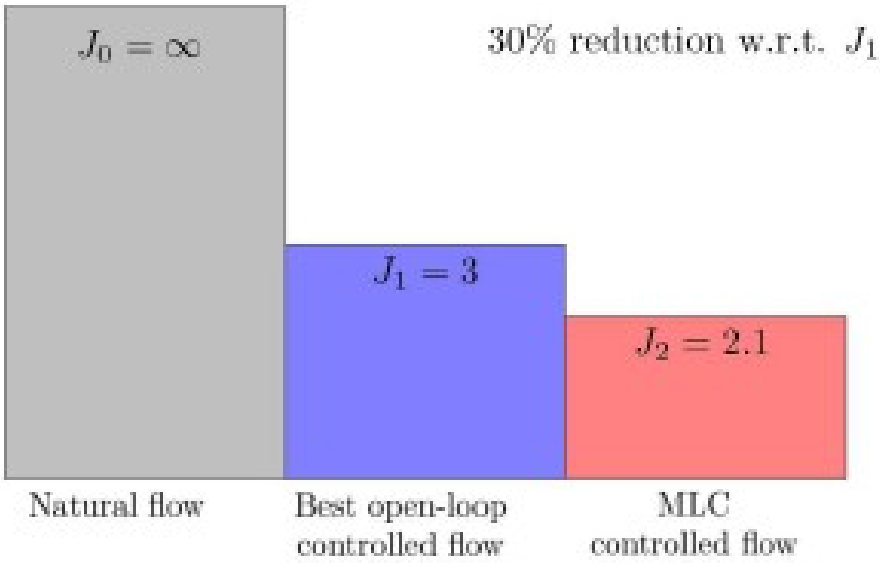


MLC controlled



Separation control on AVERT model





- MLC finds the most cost-effective control.
- Setup not optimal for closed-loop control.