9th International Conference on Urban Drainage Modelling – Belgrade 2012

Optimization of a hydrodynamic separator using a multiscale CFD approach

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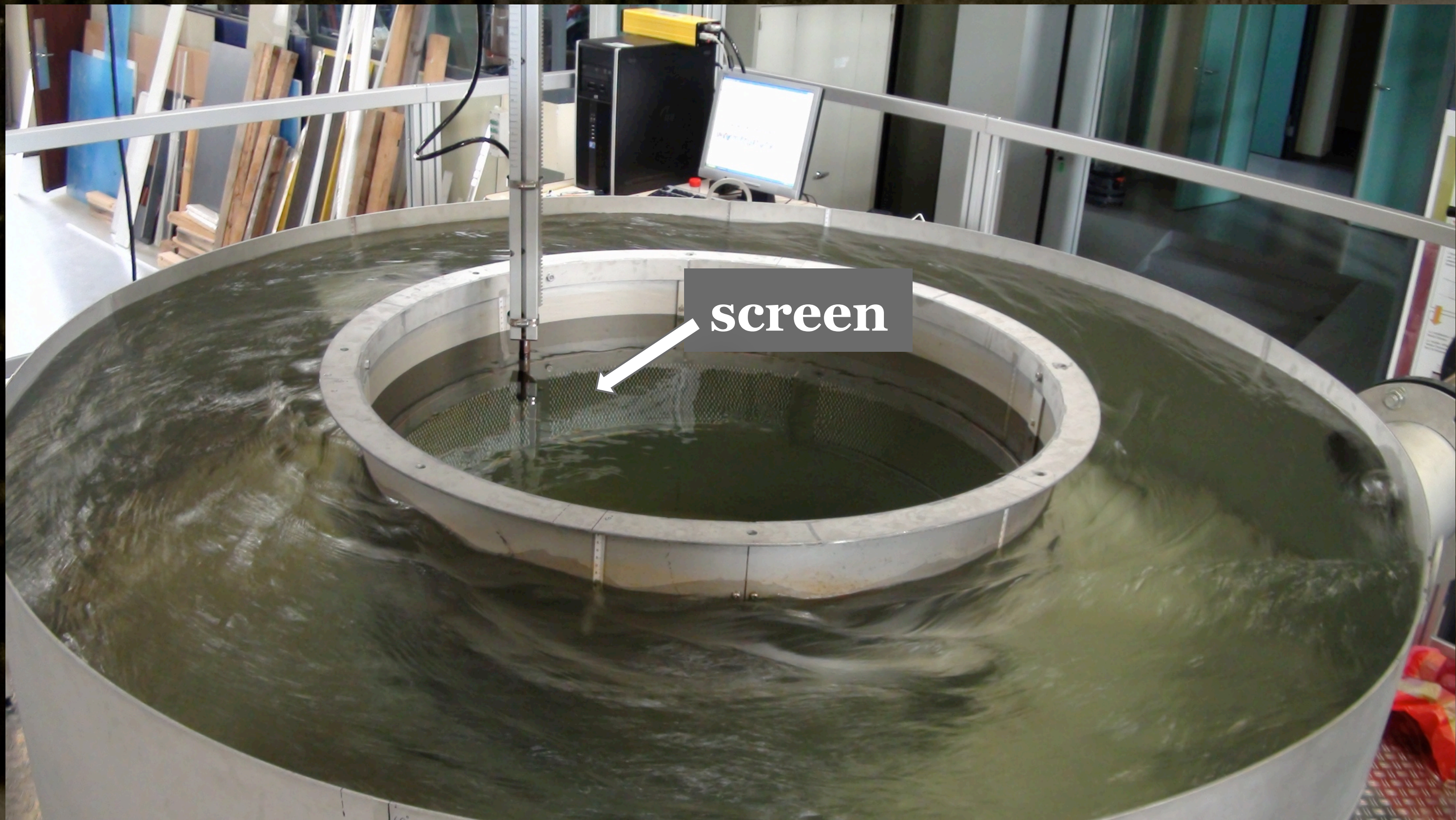
1. Introduction

2. Objectives
3. Methods
4. Results
5. Conclusion

- Stormwater pollution :
  - plastic debris
  - coarse sediments
  - large particles

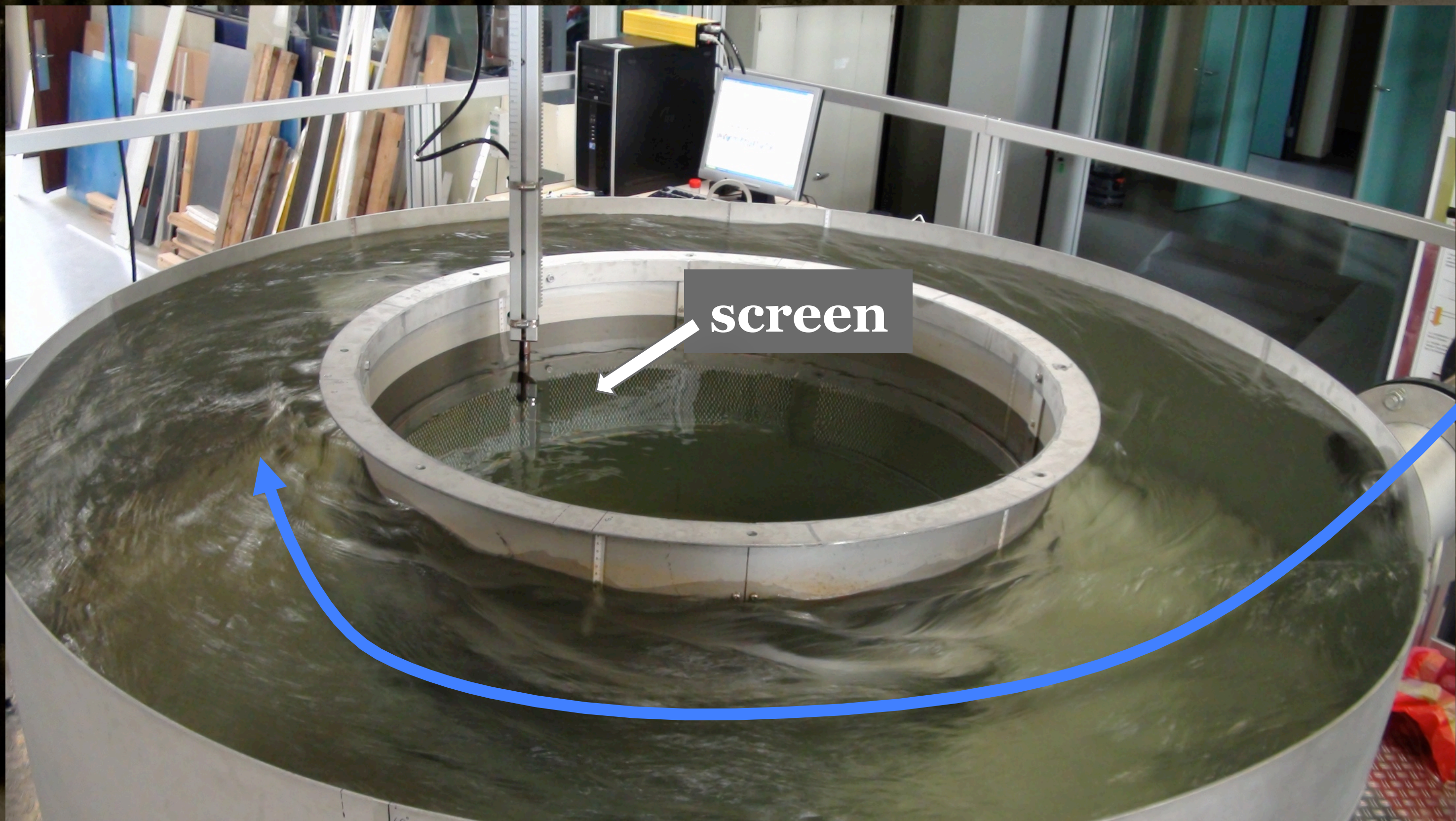
- Hydrodynamic separator :
  - structure used to remove gross pollutants from water

- The CycloneSep® : the pilot of IMFS lab



$h = 1$ m ; $D_{screen} = 1$ m ; $D_{ext} = 2$ m

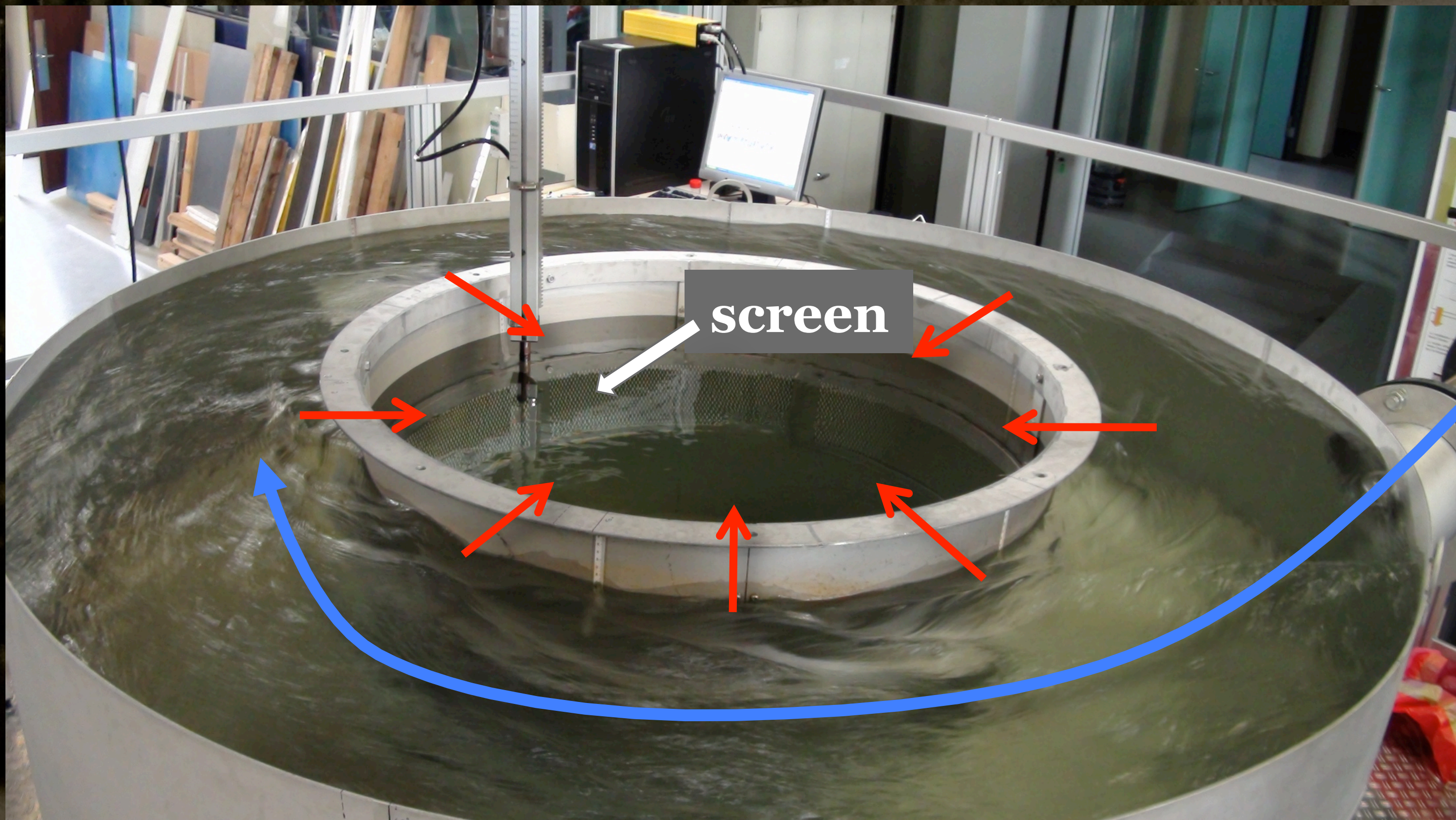
- The CycloneSep® : the pilot of IMFS lab



inlet pipe

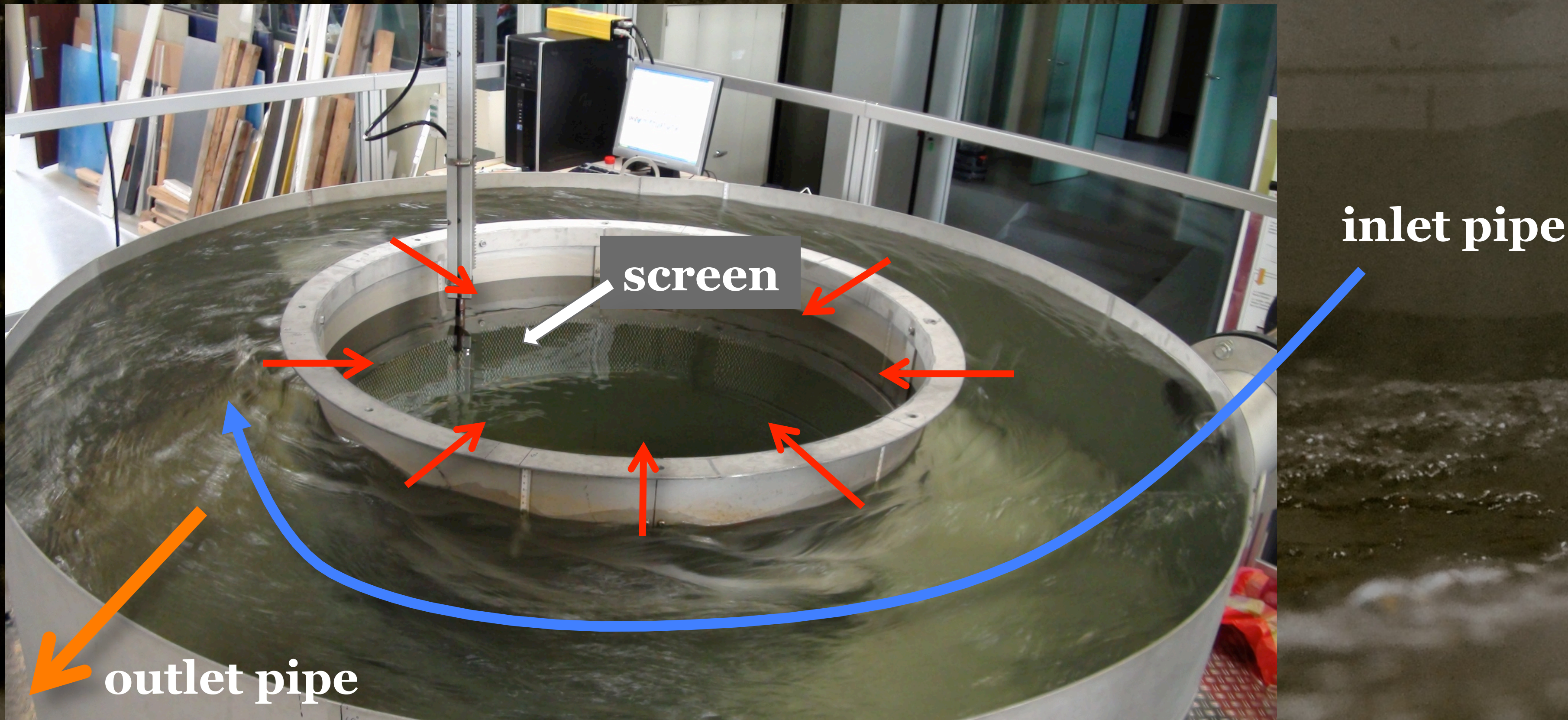
$h = 1\ \mathrm{m}\ ;\ D_{screen} = 1\ \mathrm{m}\ ;\ D_{ext} = 2\ \mathrm{m}$

- The CycloneSep® : the pilot of IMFS lab



h = 1 m ; D_{screen} = 1 m ; D_{ext} = 2 m

- The CycloneSep® : the pilot of IMFS lab



$h = 1\ m\ ;\ D_{screen} = 1\ m\ ;\ D_{ext} = 2\ m$

- The CycloneSep: large waste in rotation

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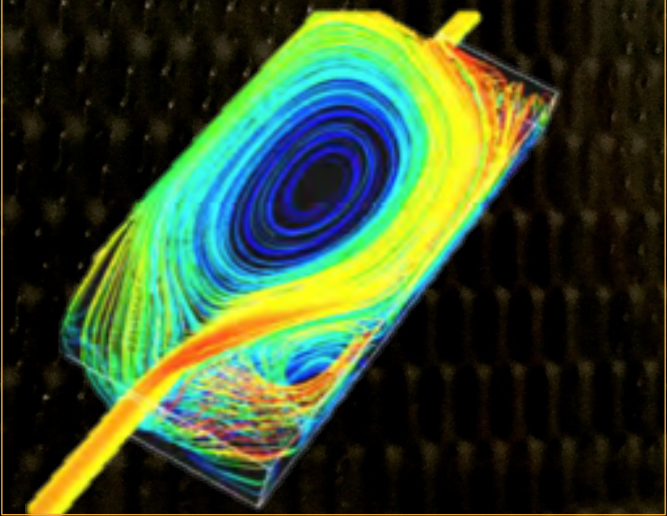
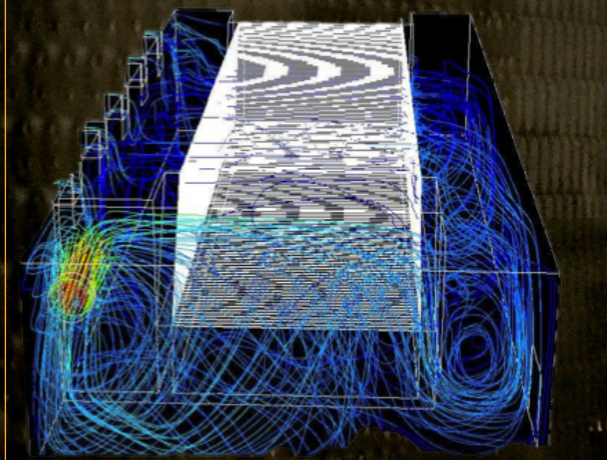
- Computational Fluid Dynamics : hydrodynamic visualization

Storage tank



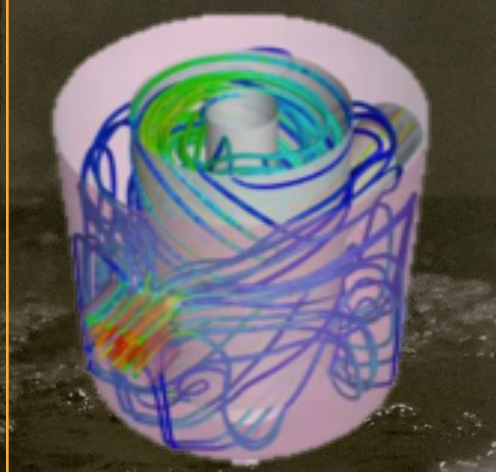
Dufresne et al. 2008

Lamella settlers



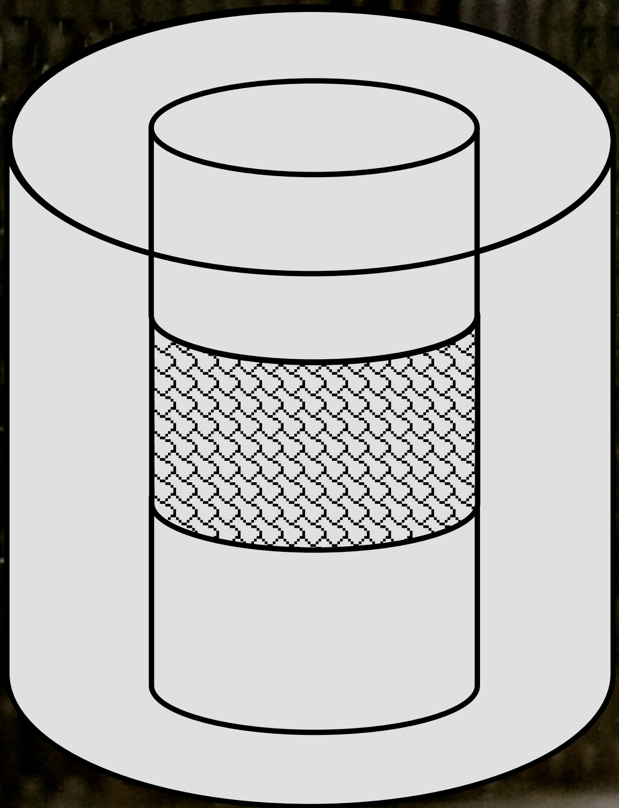
Vazquez et al. 2008

Hydrocyclone

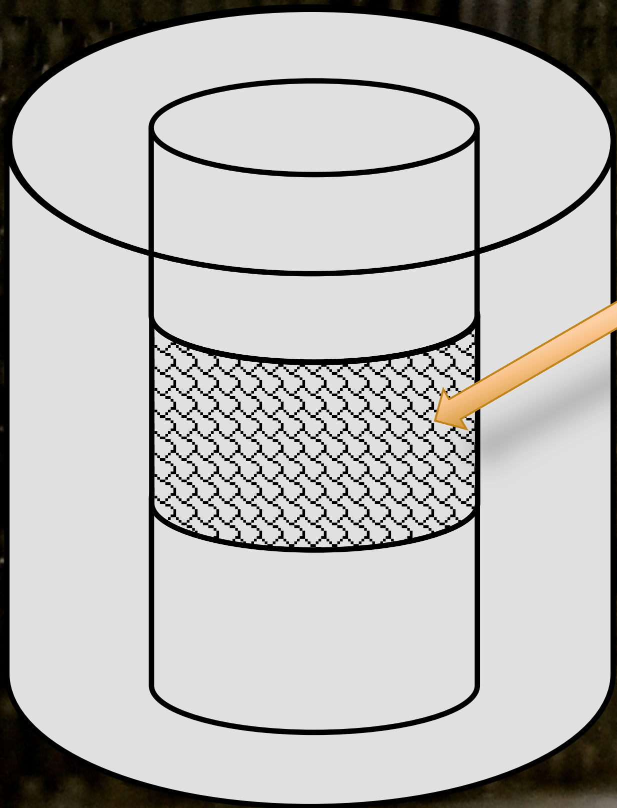


Lee et al. 2010

Discretization of the domain

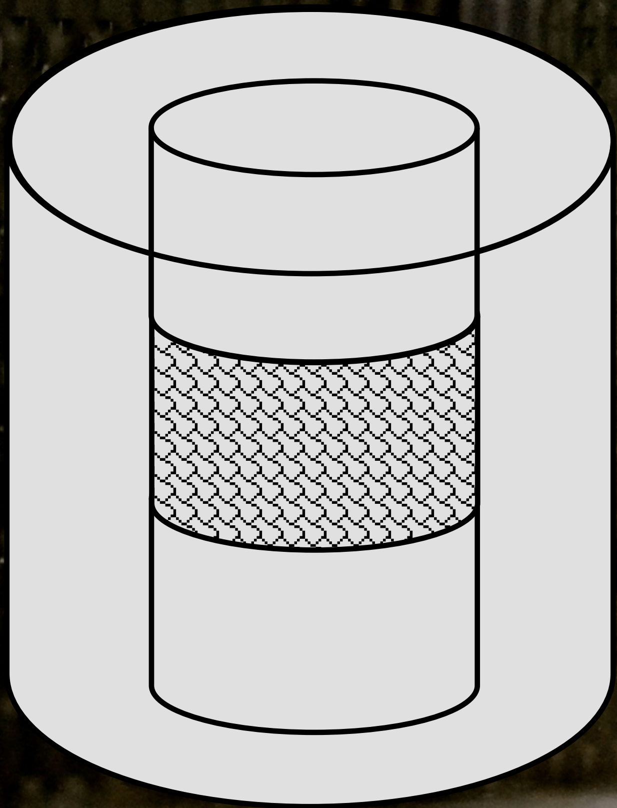


Discretization of the domain



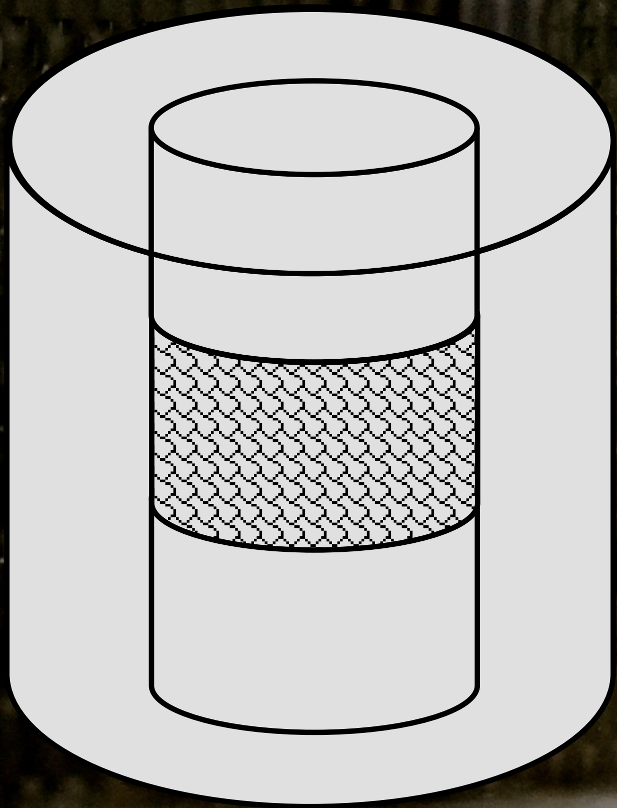
fine mesh nearby the screen

Discretization of the domain:



discretization of the volume

Discretization of the domain



fine mesh nearby the screen

+

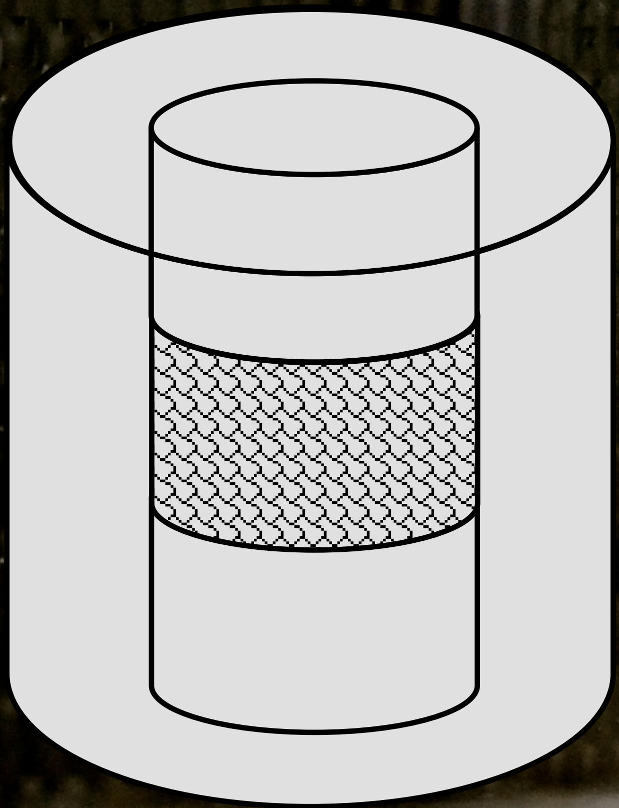
discretization of the volume

=

➔ Difficulties in mesh generation

➔ Too long computational time

Discretization of the domain



fine mesh nearby the screen

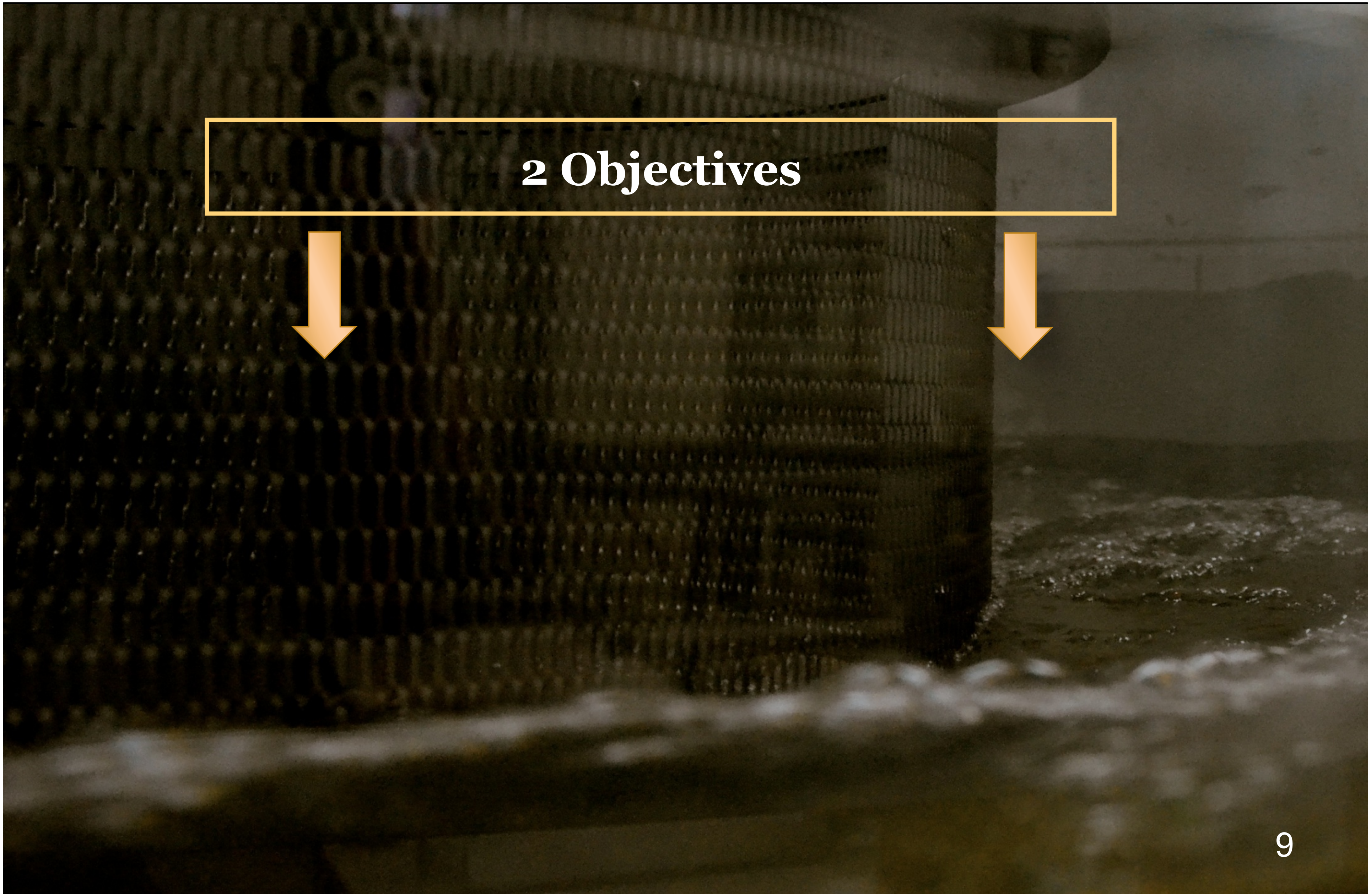
+

discretization of the volume

=

- Difficulties in mesh generation
- Too long computational time

Multiscale approach



2 Objectives

2 Objectives

Engineering

Optimization

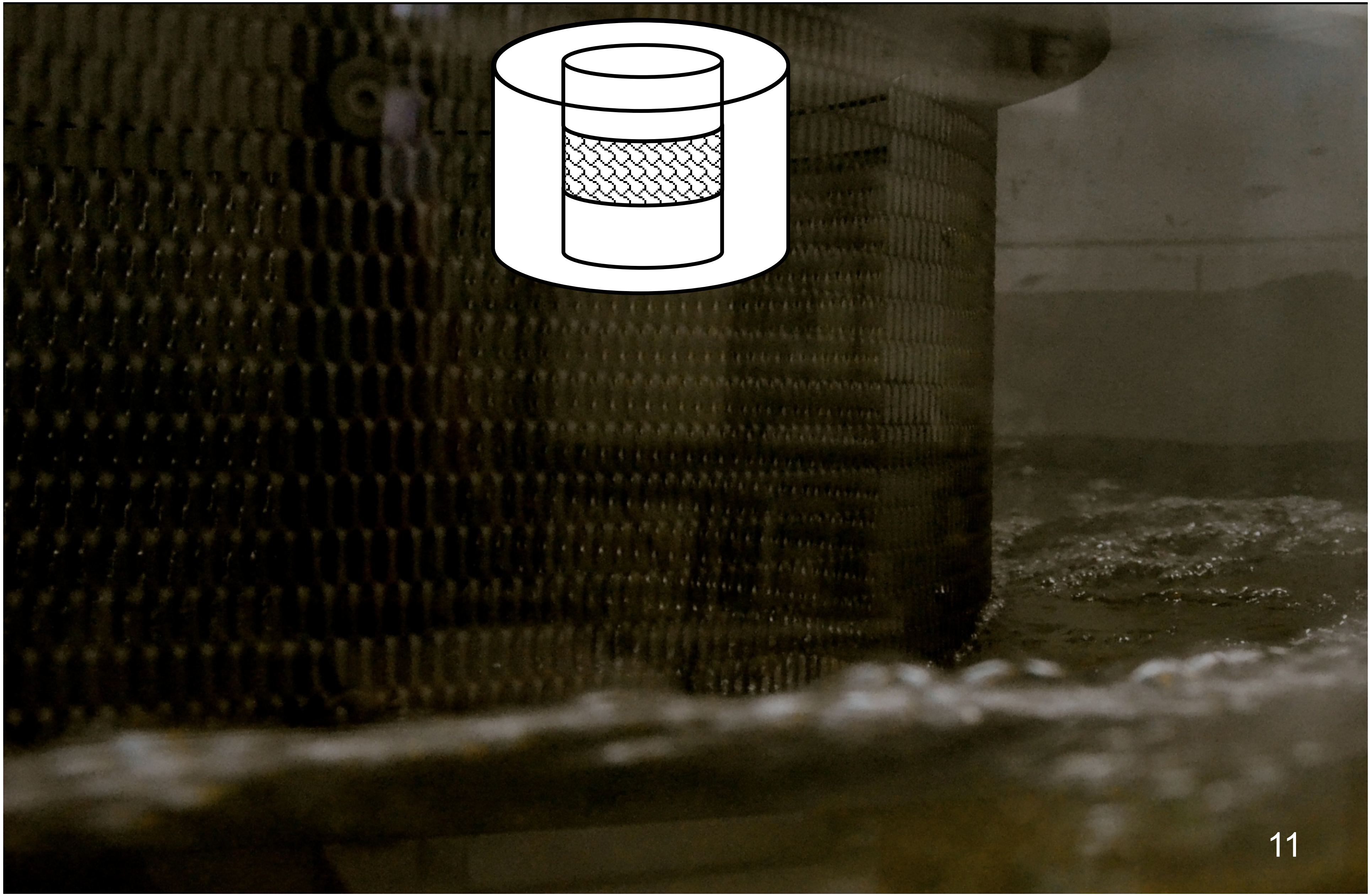
2 Objectives

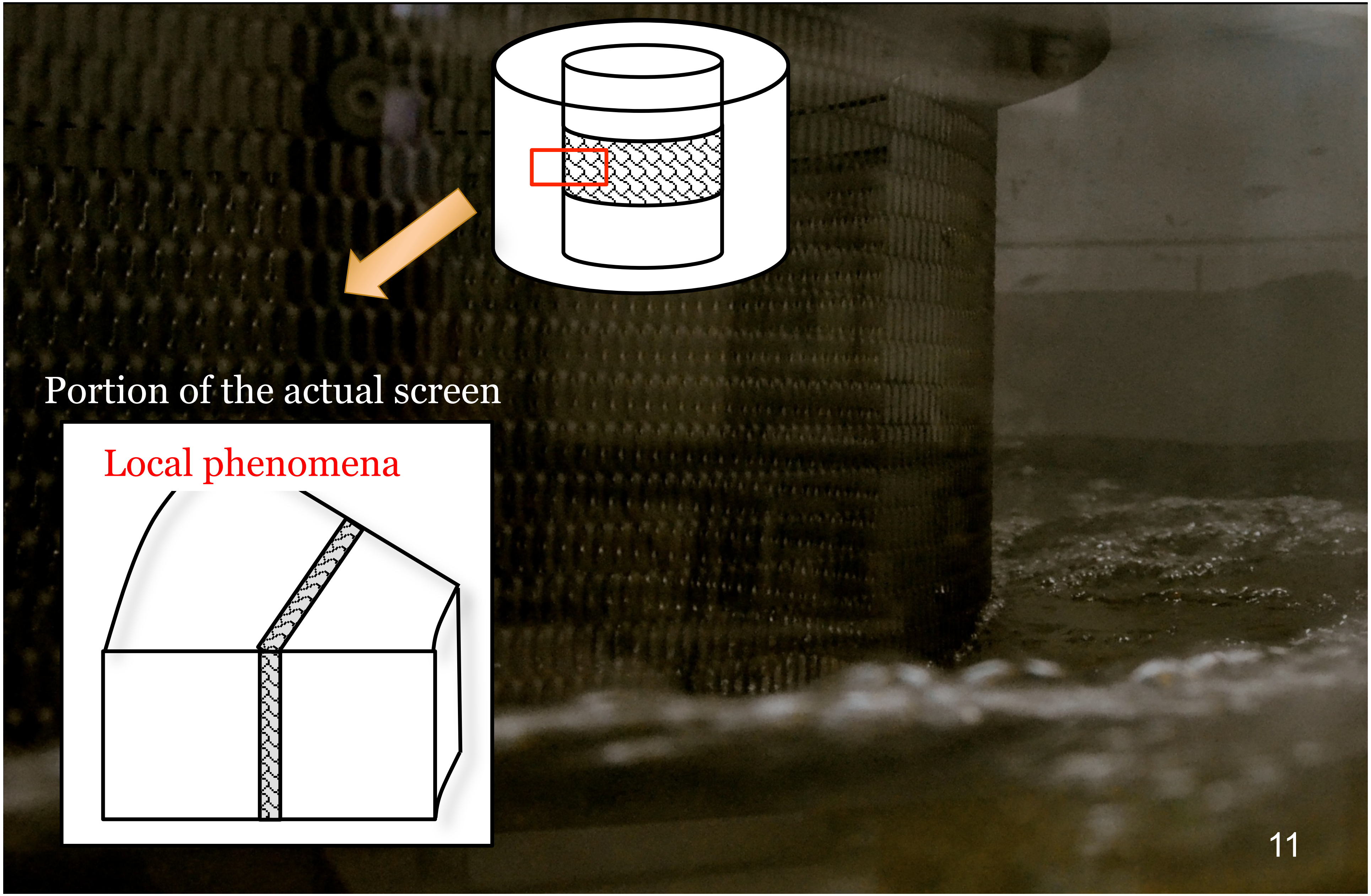
Engineering

Optimization

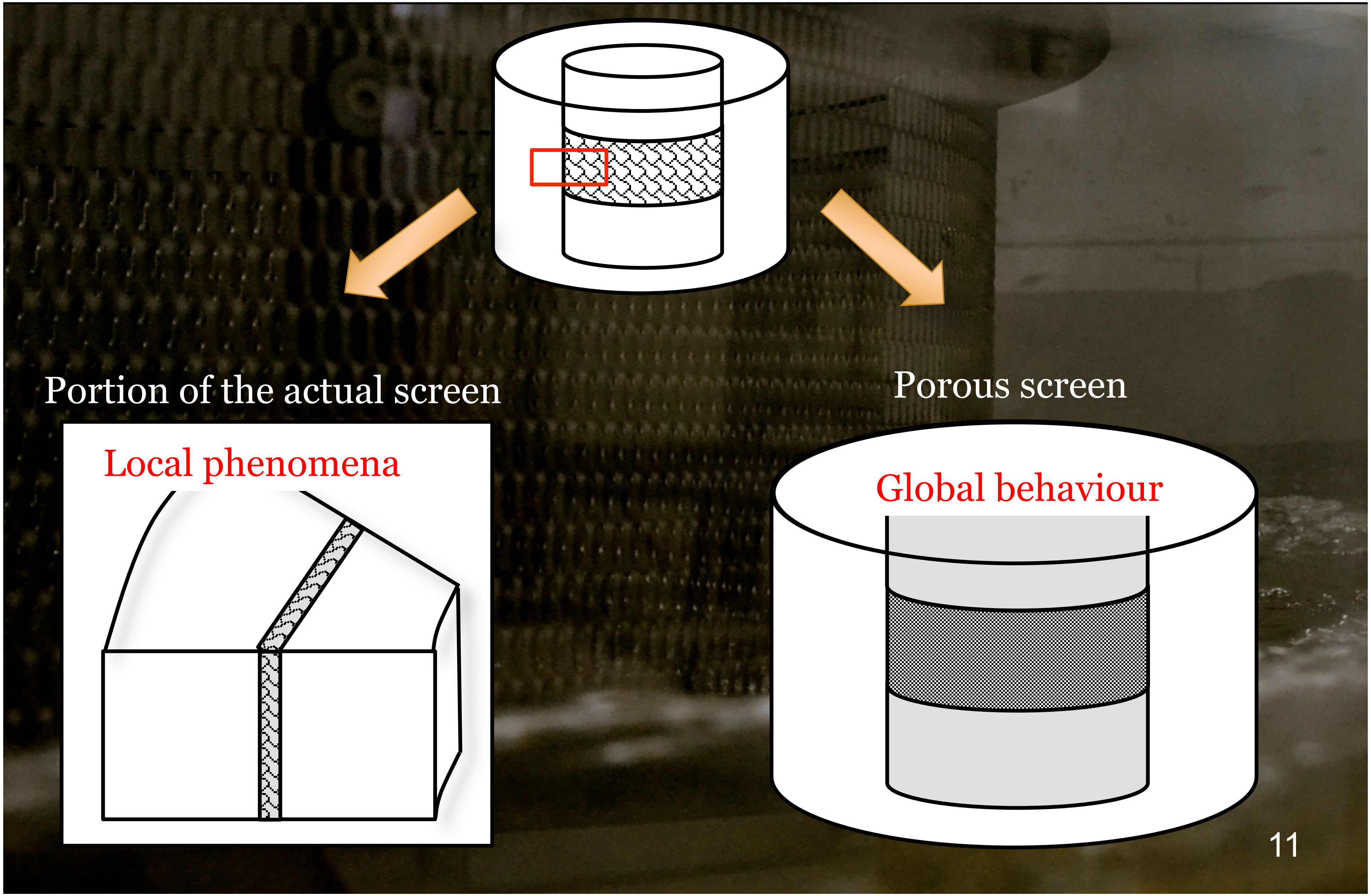
Research

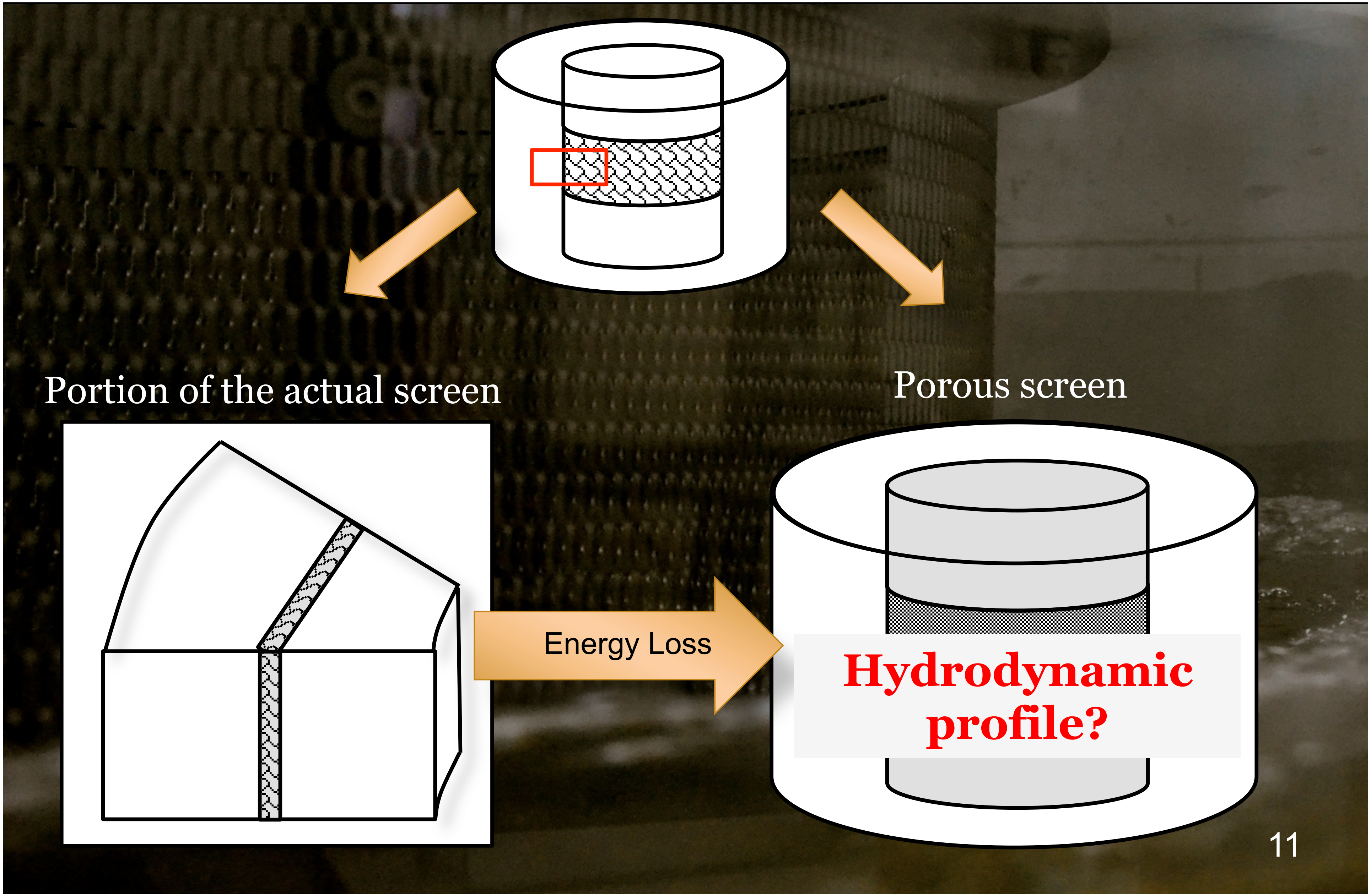
Multiscale method





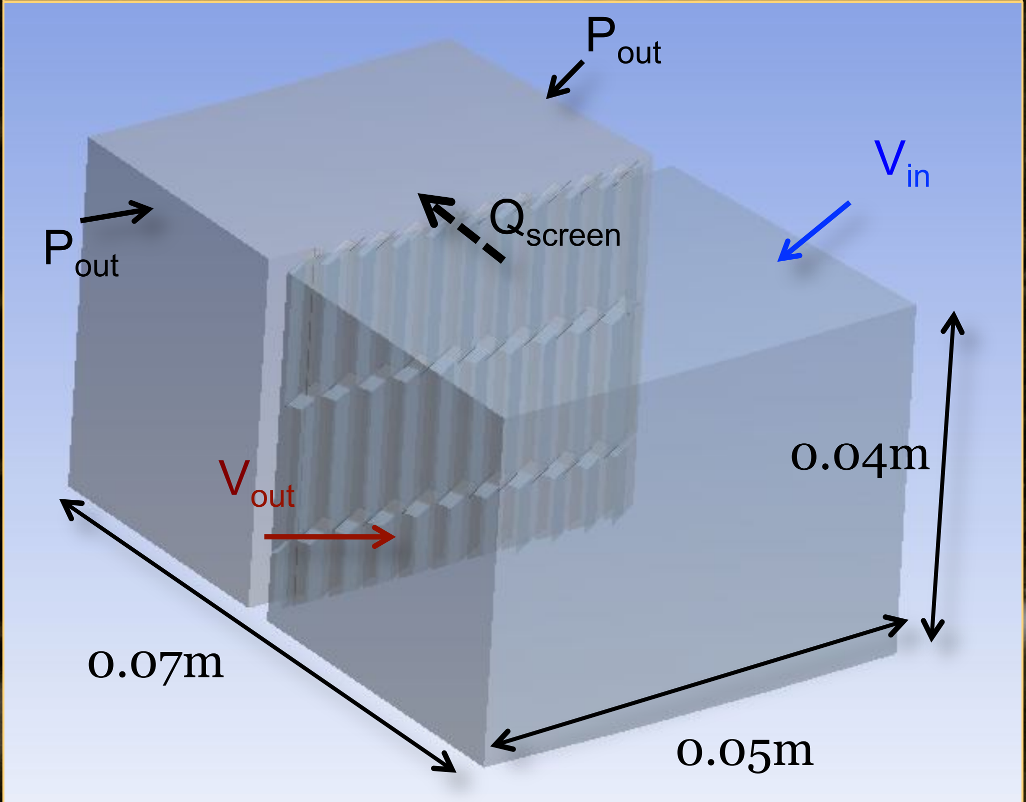
Portion of the actual screen


Portion of the actual screen
Local phenomena
Porous screen
Global behaviour


Portion of the actual screen
Porous screen
Energy Loss
Hydrodynamic profile?

Boundary conditions

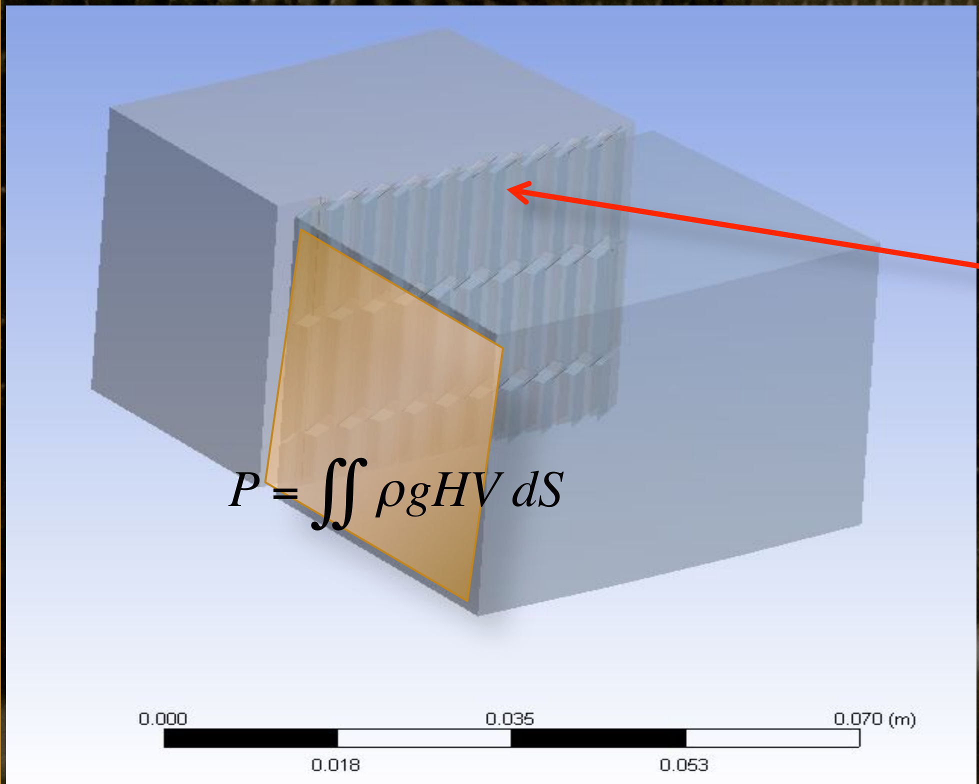
Local Model :
Actual screen



- $V_{out} - V_{in} \rightarrow Q_{screen}$

- Estimation of the energy loss caused by the screen

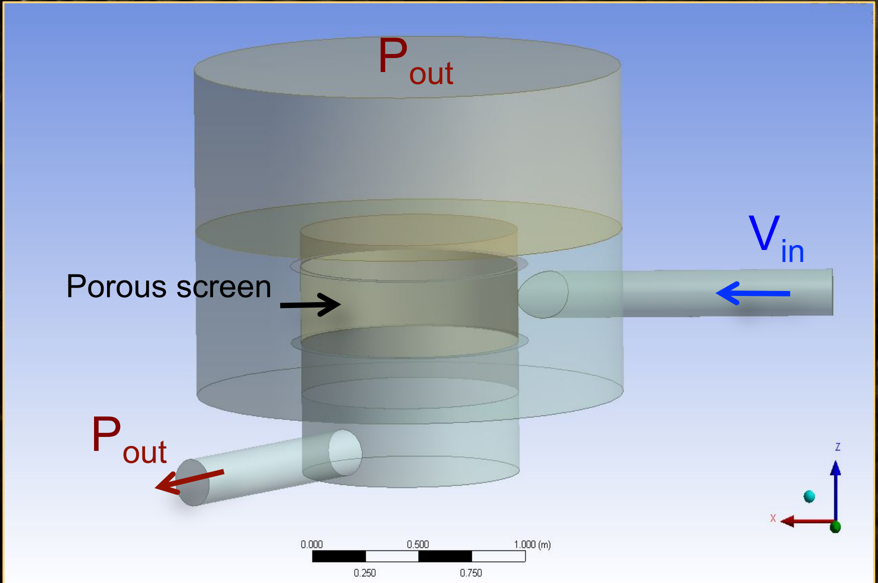
Local Model



$$\Delta H = \boxed{K} \frac{\left(\frac{Q^2}{S^2}\right)}{2g}$$

Boundary conditions

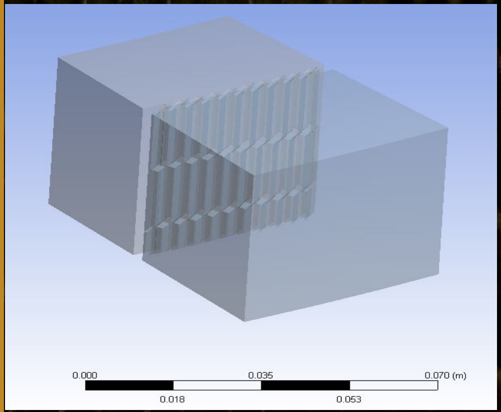
Global Model : Porous screen



- V_{in} impose the discharge
- P_{out} impose the downstream water level

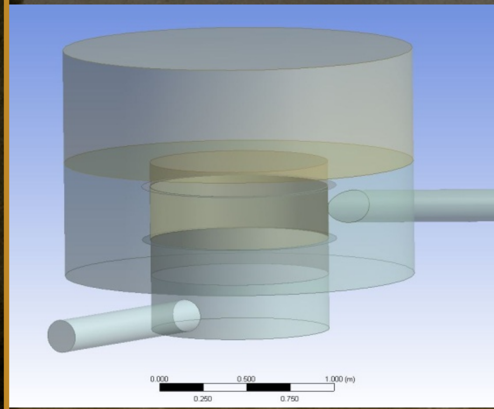
- Reproduction of the Energy loss in the global model

Local Model



K →

Global Model



- Source term in the CFD code:

$$S_i = -\left(\frac{K}{\Delta m}\frac{1}{2}\rho v_{mag} v_i\right)$$

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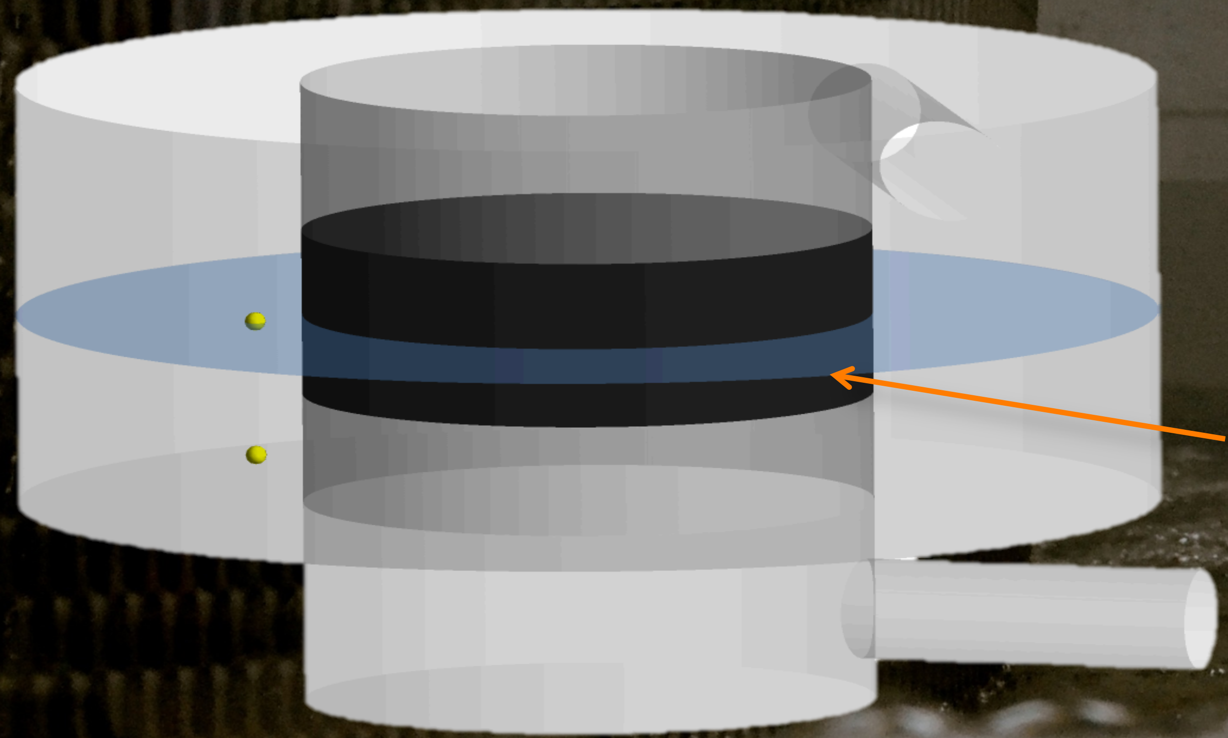
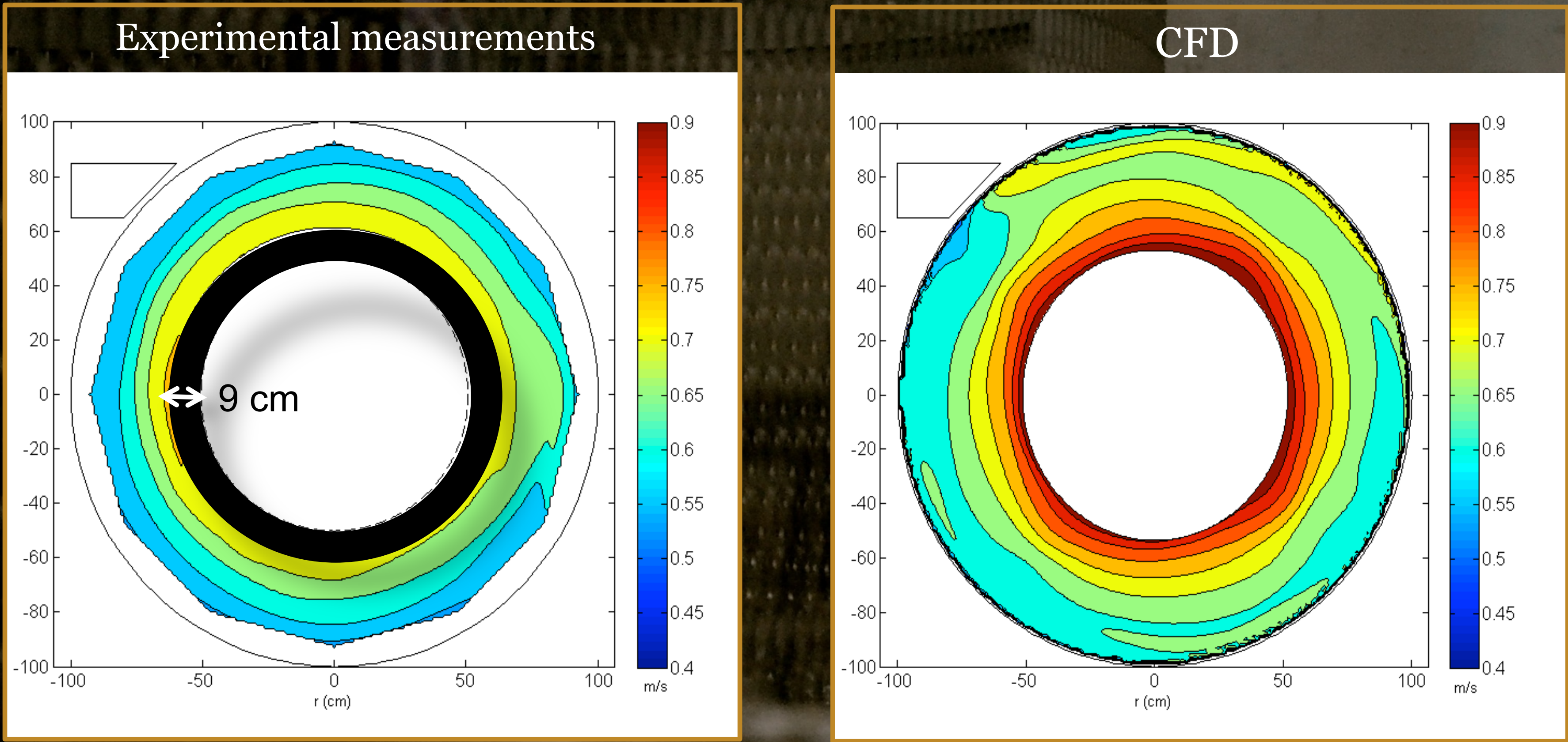
- *Validation of the method*
- *Optimization*

5. Conclusion

- Comparison: CFD/ Measurements

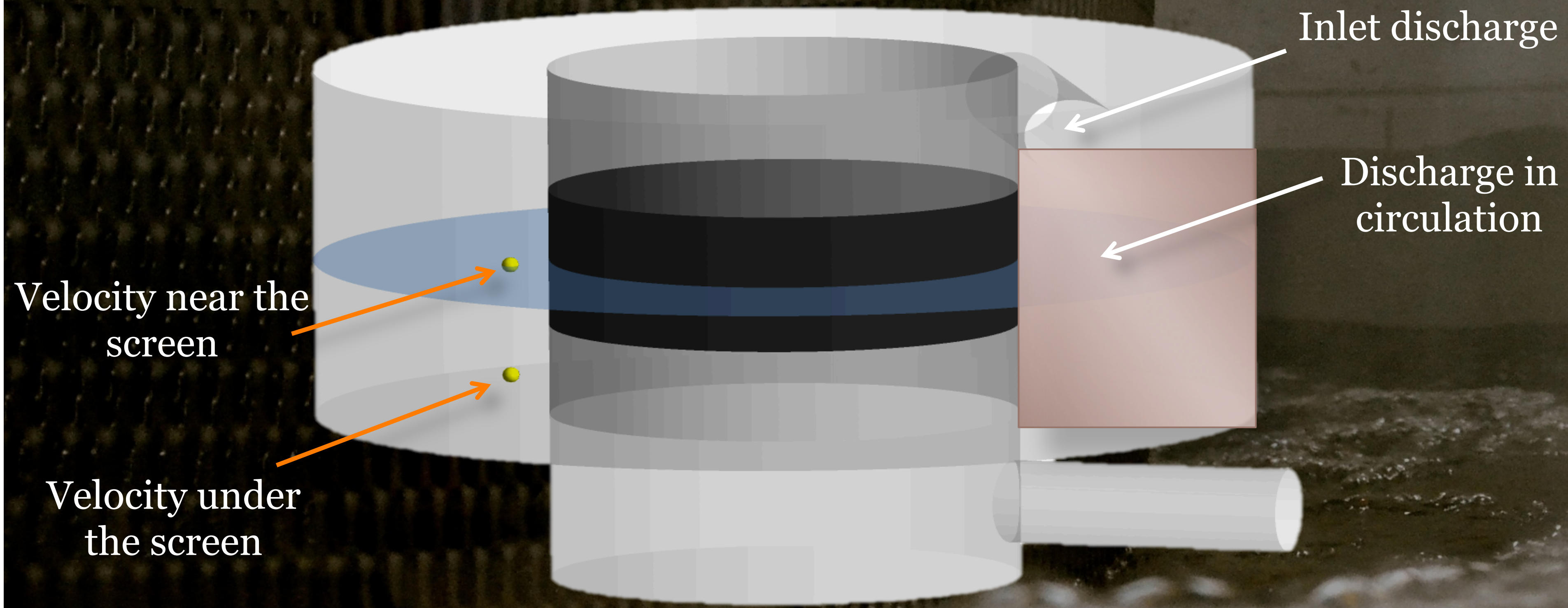


Velocity fields



Comparison of the velocity field for a flow rate equal to 25 L/s at z = 38cm

- Comparison: CFD/ Measurements

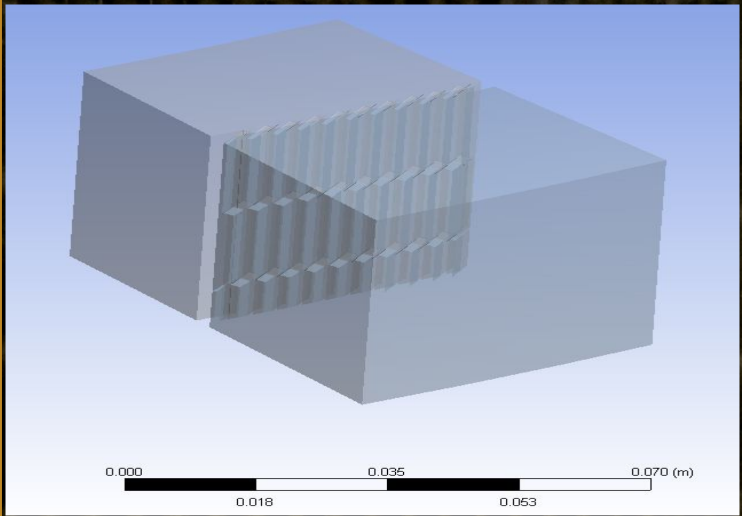


- Global/local values:

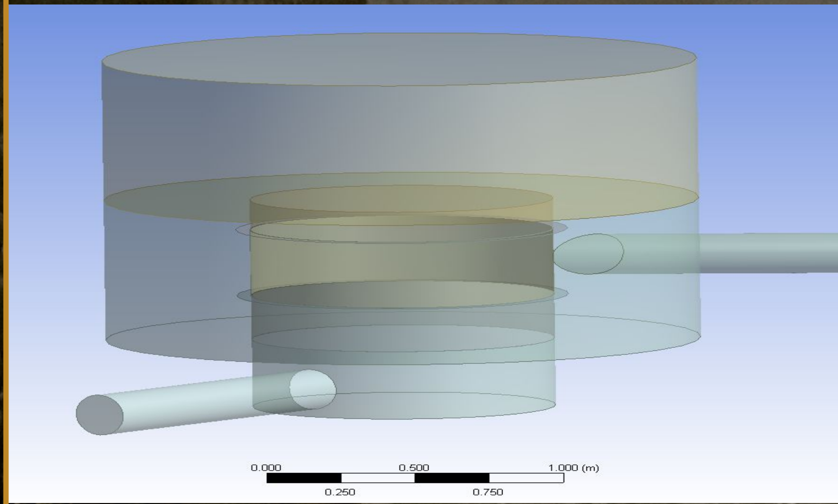
	Discharge ratio $Q_{circulation}/Q_{inlet}$	V_{grid} (m/s)	V_{under_grid} (m/s)
Measurements	10,1	0,73	0,76
CFD	10,1	0,84	0,82
Error	0,1%	15%	8%

Comparison for a flow rate equal to 25 L/s

Local Model



Global Model

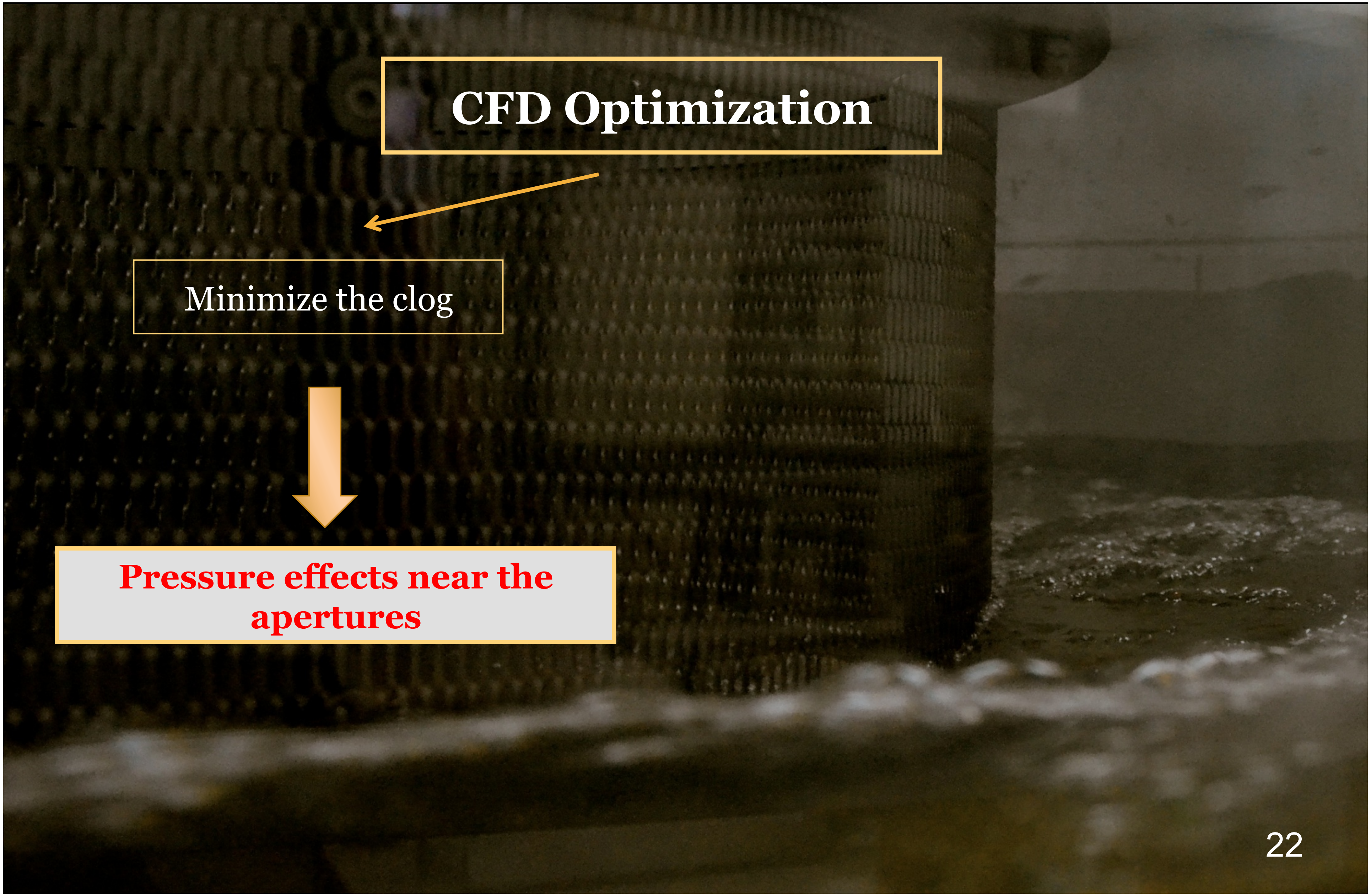


Local phenomena

Global behaviour

CFD Optimization

Minimize the clog


CFD Optimization
Minimize the clog
Pressure effects near the apertures

CFD Optimization

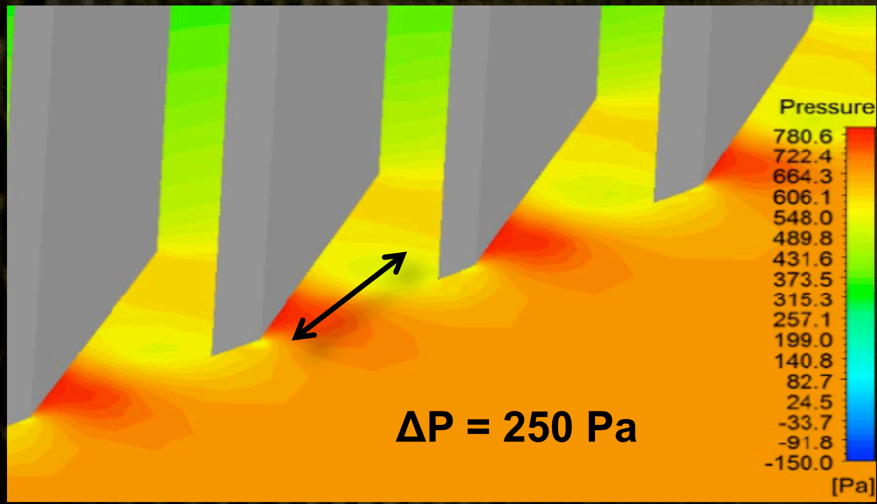
Minimize the clog

Pressure effects near the apertures

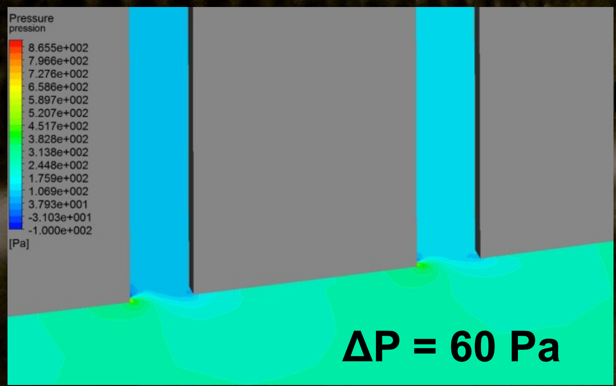
Testing different parameters

- **Shape comparison** : expanded metal VS perforated screen

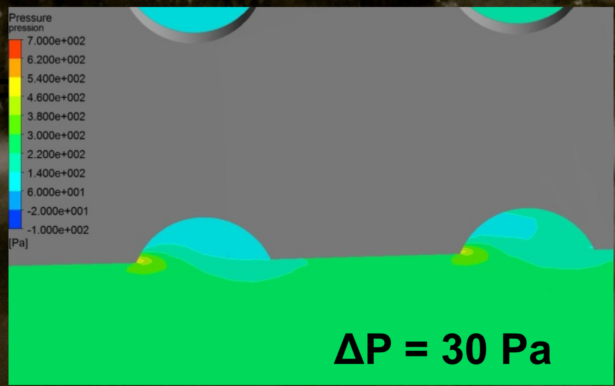
CycloneSep screen



Hexagonal holes

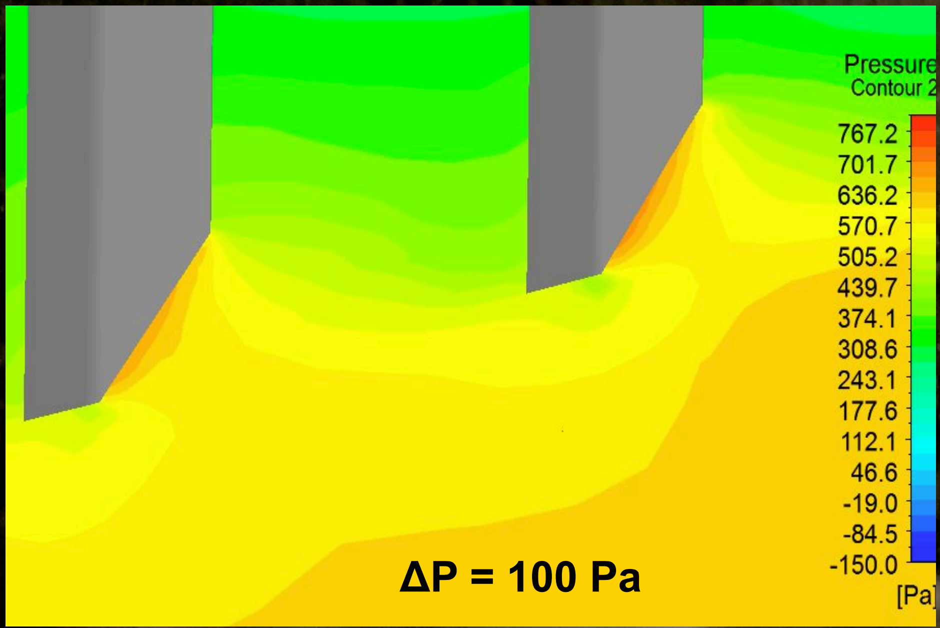


Circular holes

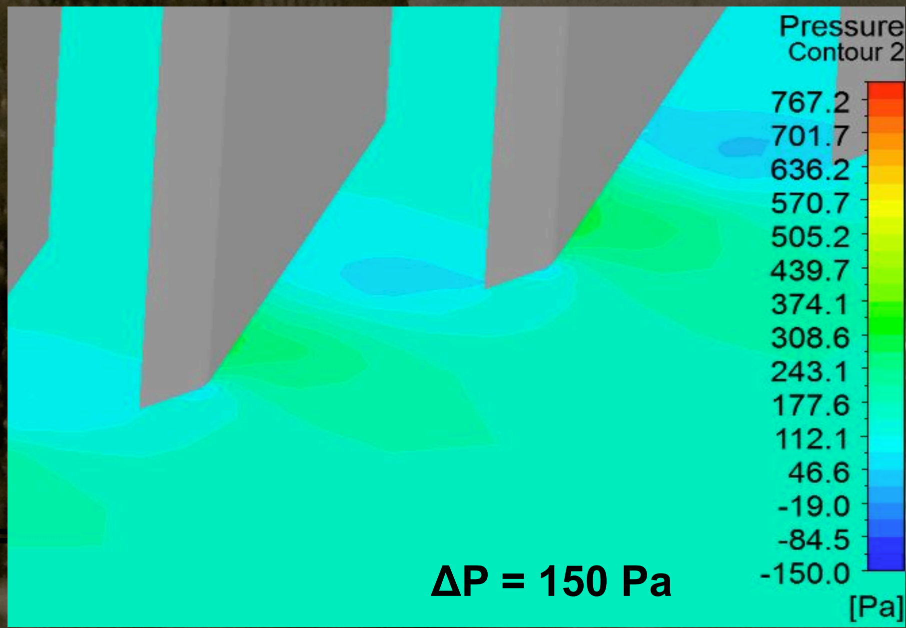


Shape comparison : influence of hole size

45° 25mm x 5,2mm

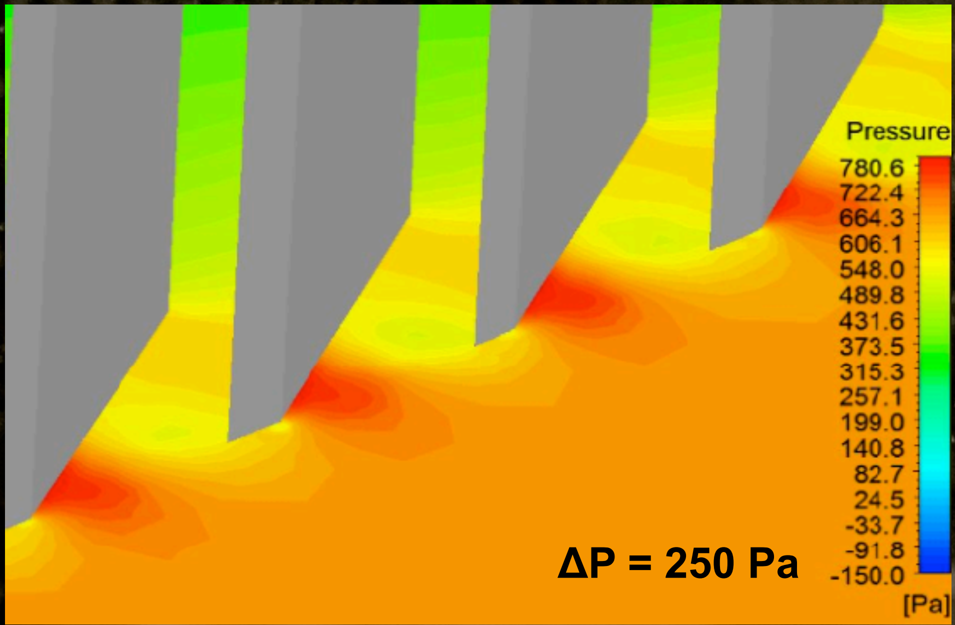


45° 17mm x 1,65mm

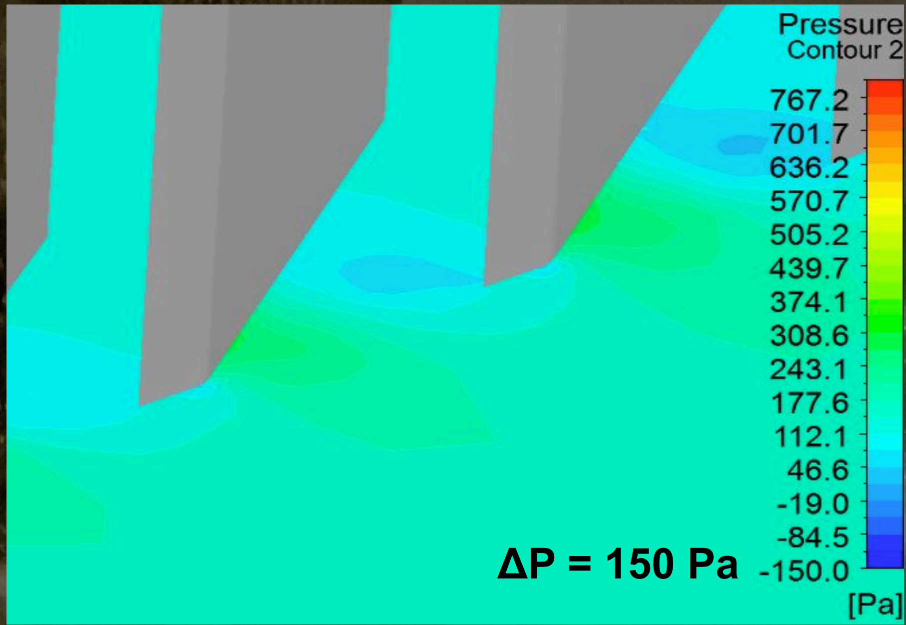


Shape comparison : influence of metal inclinaison

60° 17mm x 1,65mm



45° 17mm x 1,65mm



CFD Optimization

Minimize the clog

Control the hydrodynamic behaviour

CFD Optimization

Minimize the clog

Control the hydrodynamic behaviour

Maximize velocity near the screen
Minimize velocity under the screen

CFD Optimization

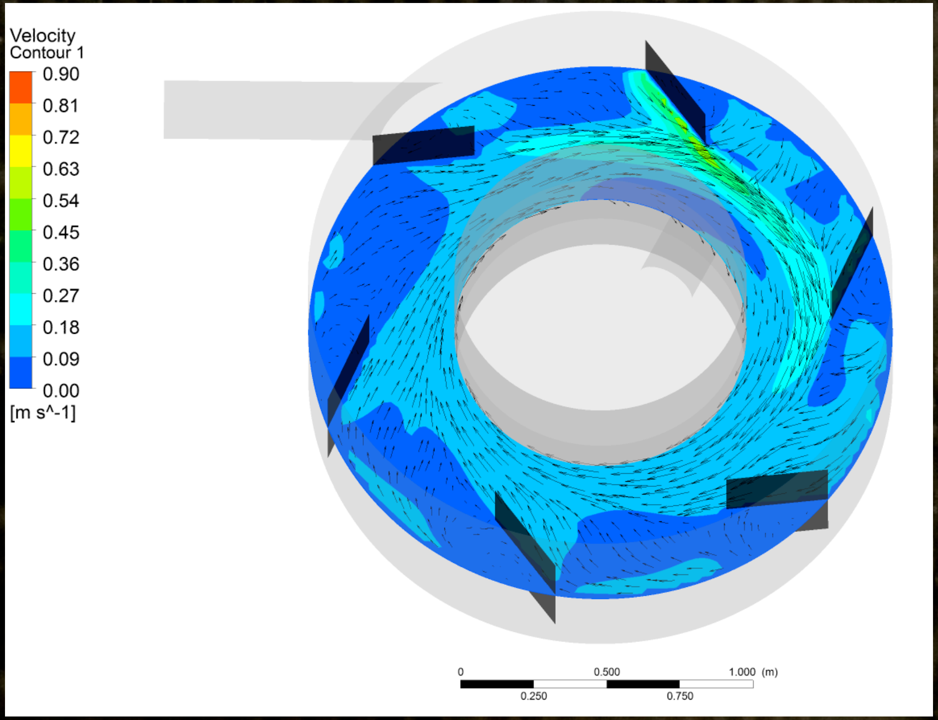
Minimize the clog

Control the hydrodynamic behaviour

Maximize velocity near the screen
Minimize velocity under the screen

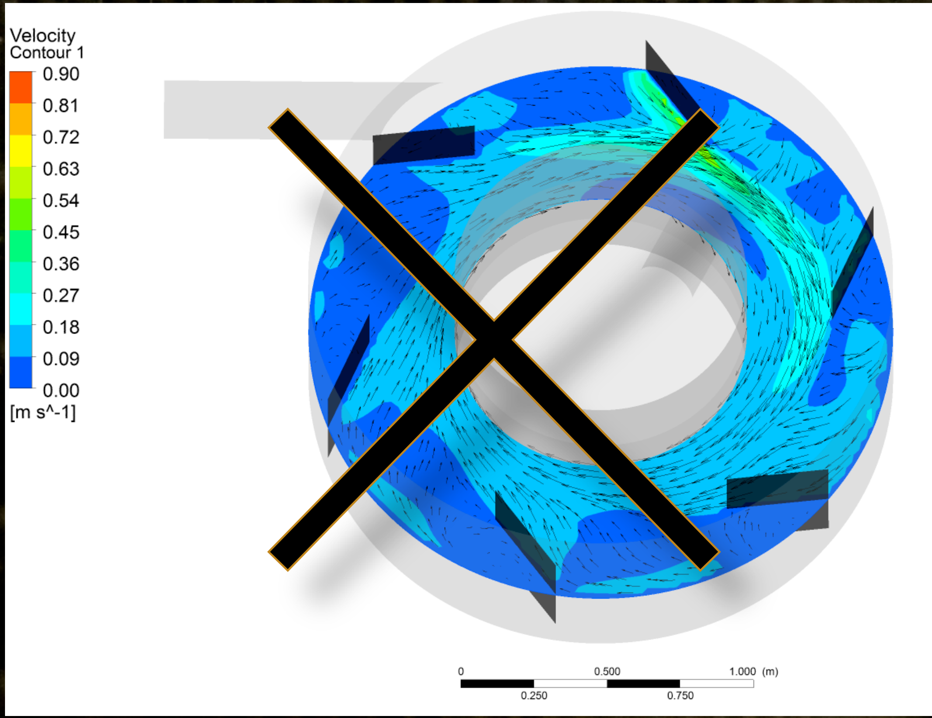
Installation of singularities

Optimization of the device : (Q=25L/s)

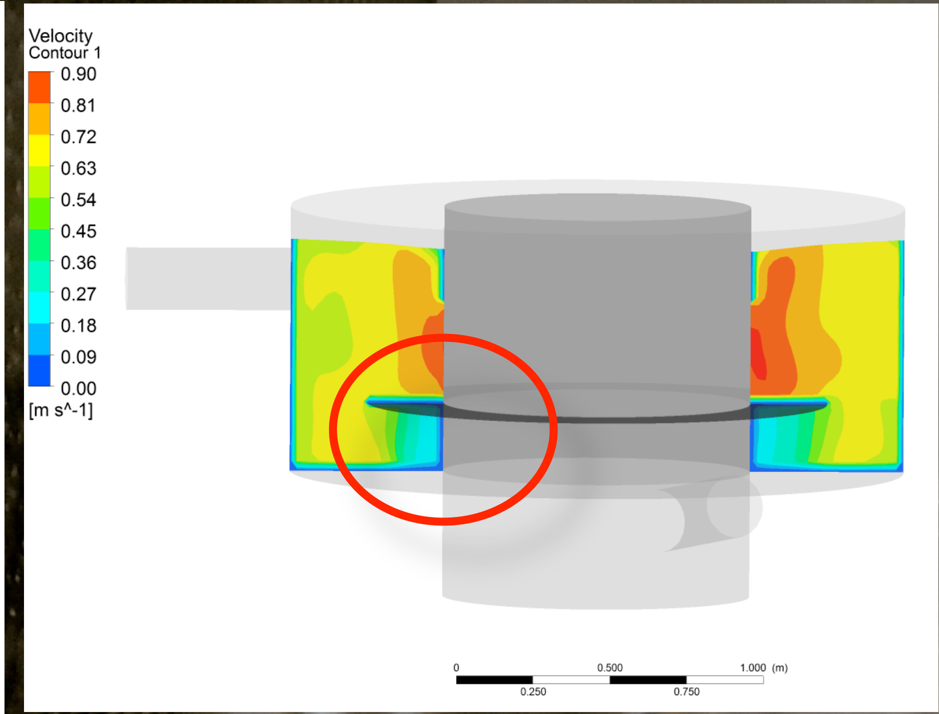


6 deflectors

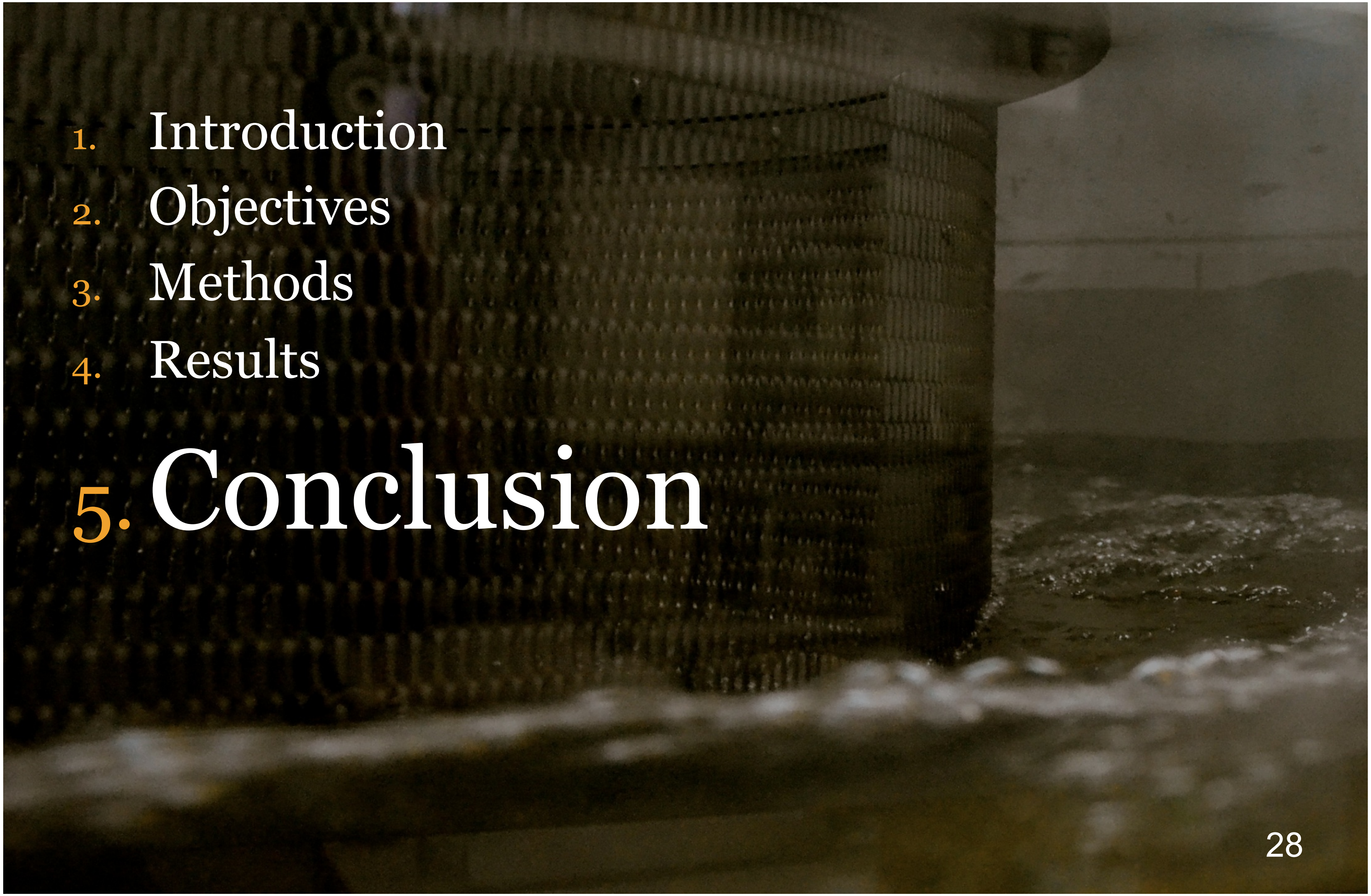
- Optimization of the device : (Q=25L/s)



6 deflectors



Disk plate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- CFD multiscale approach is a good alternative to optimize a device at different scale

Avoid the clog

Local model → expanded metal screen

Global model → installation of a disk plate

THANK YOU FOR YOUR ATTENTION

contact : vivien.schmitt@engees.unistra.fr

- CFD simulations:
  - 2 500 000 cells for the local model
  - 1 200 000 cells for the global model
  - Turbulence model: RSM
  - Discretization scheme: 2nd order

- Validation of the local model
  - $K_{exp} = 1700$
  - $K_{cfd} = 1900$

Q (L/s)	H_{exp} (m)	H_{cfd}(m)
15	0.028	0.017
25	0.054	0.55
50	0.203	0.225

- CycloneSep Trouville/Mer (France)