Impact and compensation of an intrusive sensor on discharge in open channels

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Plan of the presentation

1. Context and Objectives
2. Methodology
3. Results
4. Conclusion and outlook

Context

Flow rate measurement in sewer systems

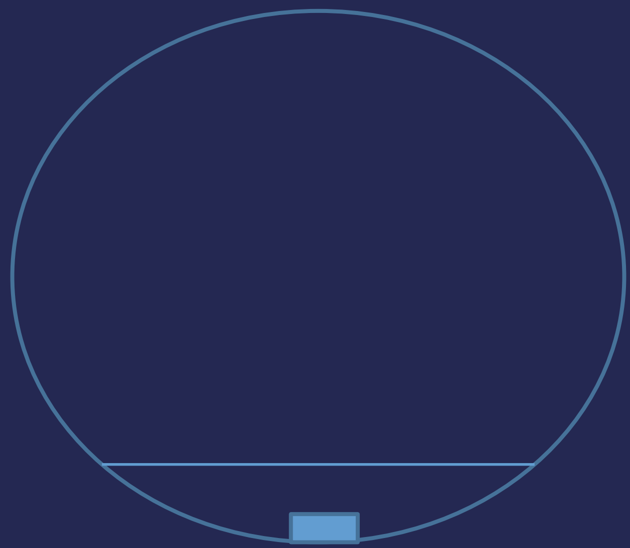
- European water guidelines
- Diagnostic
  - Permanent measurements
  - Measurements campaigns
- Use of ultrasounds techniques
  - CW Doppler
  - **Profiler (here cross correlation)**
  - Transit time
- Focuses on smaller dimensions
  - From DN 250
  - 5 cm< Water level < 50 cm

Illustration

Context

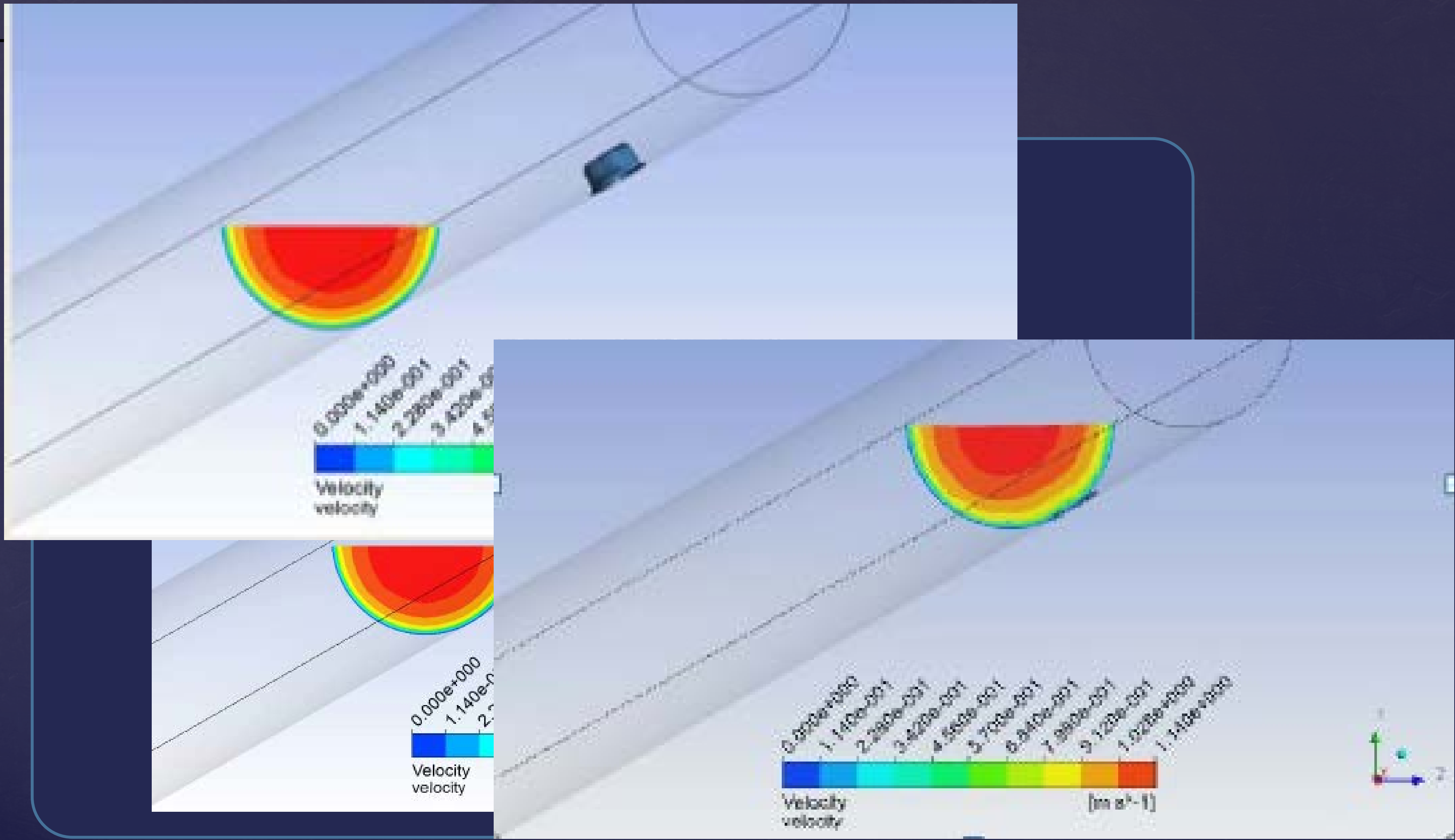
Sensor Development

Characteristics



Context:

Illustration of the influence of the sensor body

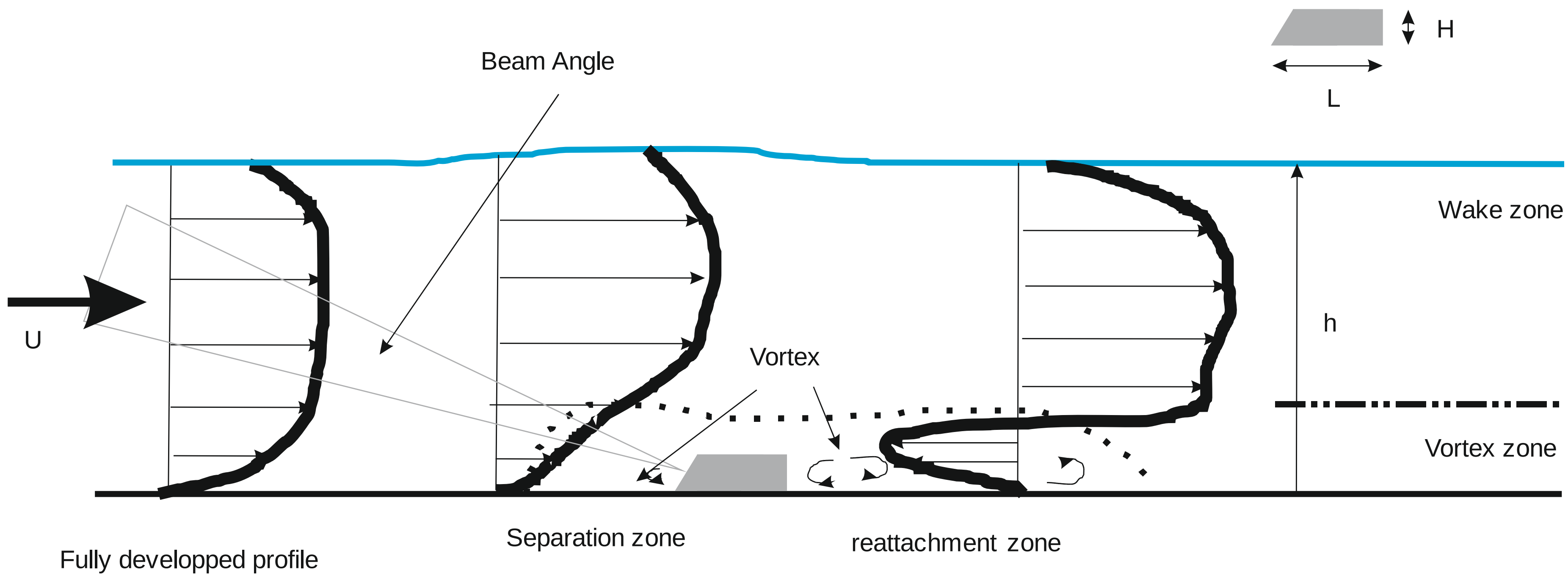


Objectives

- **Methodology of evaluation of the influence of the sensor**
  - *Phenomenology*
  - *Methodology (CFD)*
- **Development of a correction method**
  - *CFD observations*
  - *Mathematical function*
  - *Validation*

Influence of an obstacle

Description and phenomenology



Influence of an obstacle

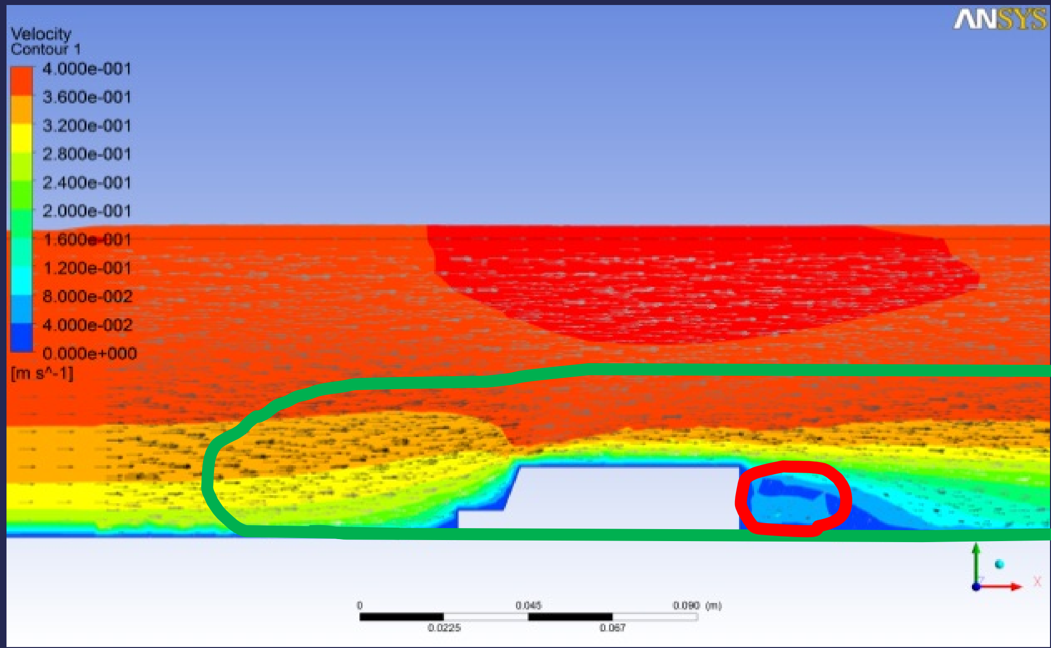
Methodology

- Hypothesis: The influence of obstacle body is depending on a certain number of parameters :
  - flow field (level, velocity distribution, gravity),
  - channel dimensions,
  - sensor dimensions,
  - sensor position
- Reproduction of phenomenon in different cases with CFD modeling of a test rig
  - Different water depths
  - Different Froude number Fr (definition of the flow nature): sub-critical

CFD Modeling
Methodology

Definition

- Turbulence model : RSM
- Surface model: VOF
- Meshing: tetrahedral closer the sensor, hexahedral. Particular attention to the wall condition.
- Numerical scheme: second order except HRIC method for the VOF model.



Statistical Model

Observations (from CFD)

- The sensor influence is significant (>5%) closed to the sensor.
- For higher level, the impact is reduced.
- When the Froude number is high, the influence is lower

Hypothesis after CFD investigations

The sensor influence function I_{sensor} is supposed to be dependent on:

- water level h and froude number fr
- sensor height H
- Y the depth position

Statistical model

$$I_{sensor} = \frac{U_{sensor} - U_{FD}}{U_{FD}} = f\left(\frac{y}{H}, \frac{h}{H}, Fr\right)$$

a_i, b_i, c_i constant values

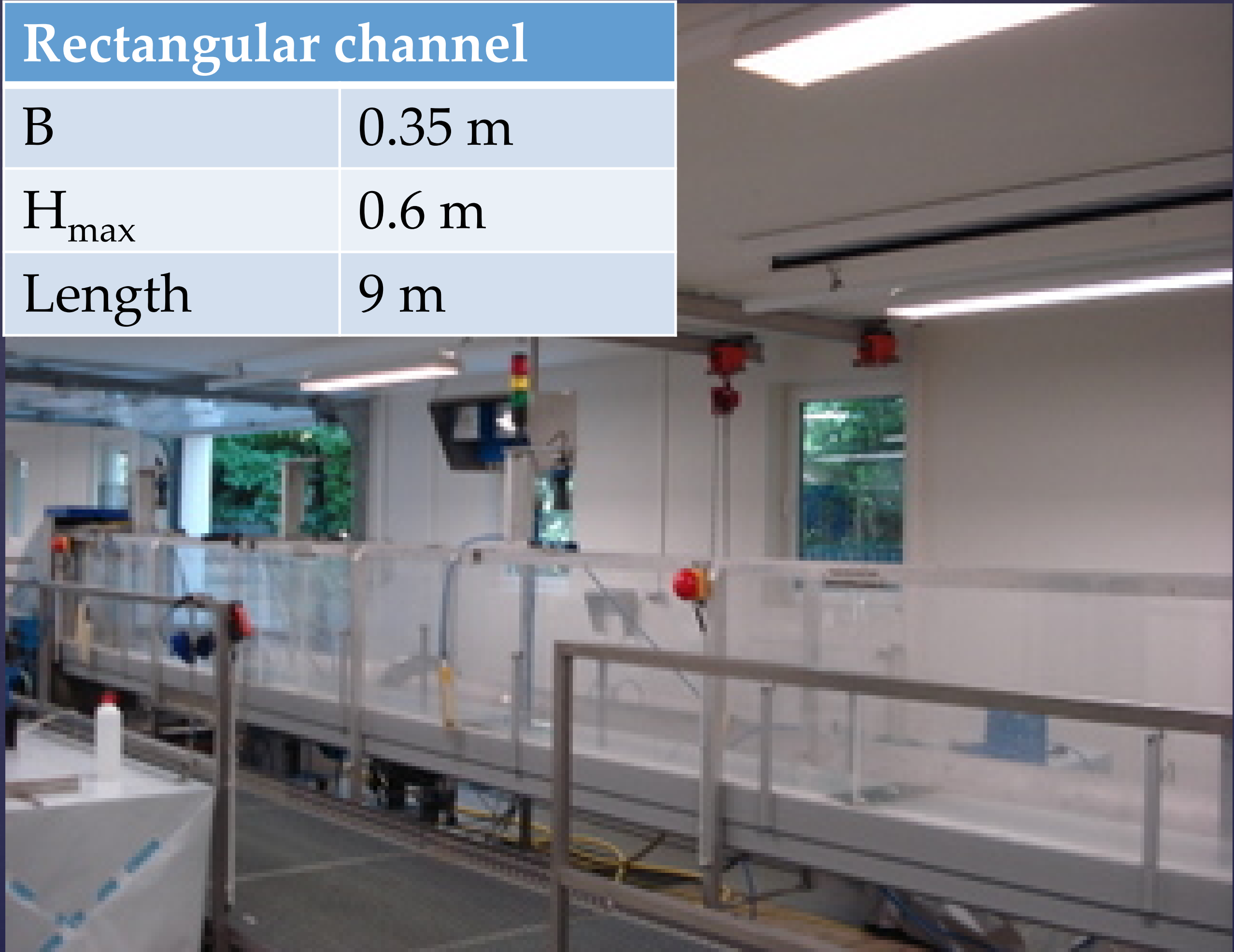
$$I_{sensor} = \sum_{i=0}^{3} a_i \cdot Fr^{b_i} \cdot \left(\frac{h}{H}\right)^{c_i} \cdot \left(\frac{y}{H}\right)^{i}$$

$y/H<10$

Validation

Experimental conditions

Rectangular channel	
B	0.35 m
H_{max}	0.6 m
Length	9 m



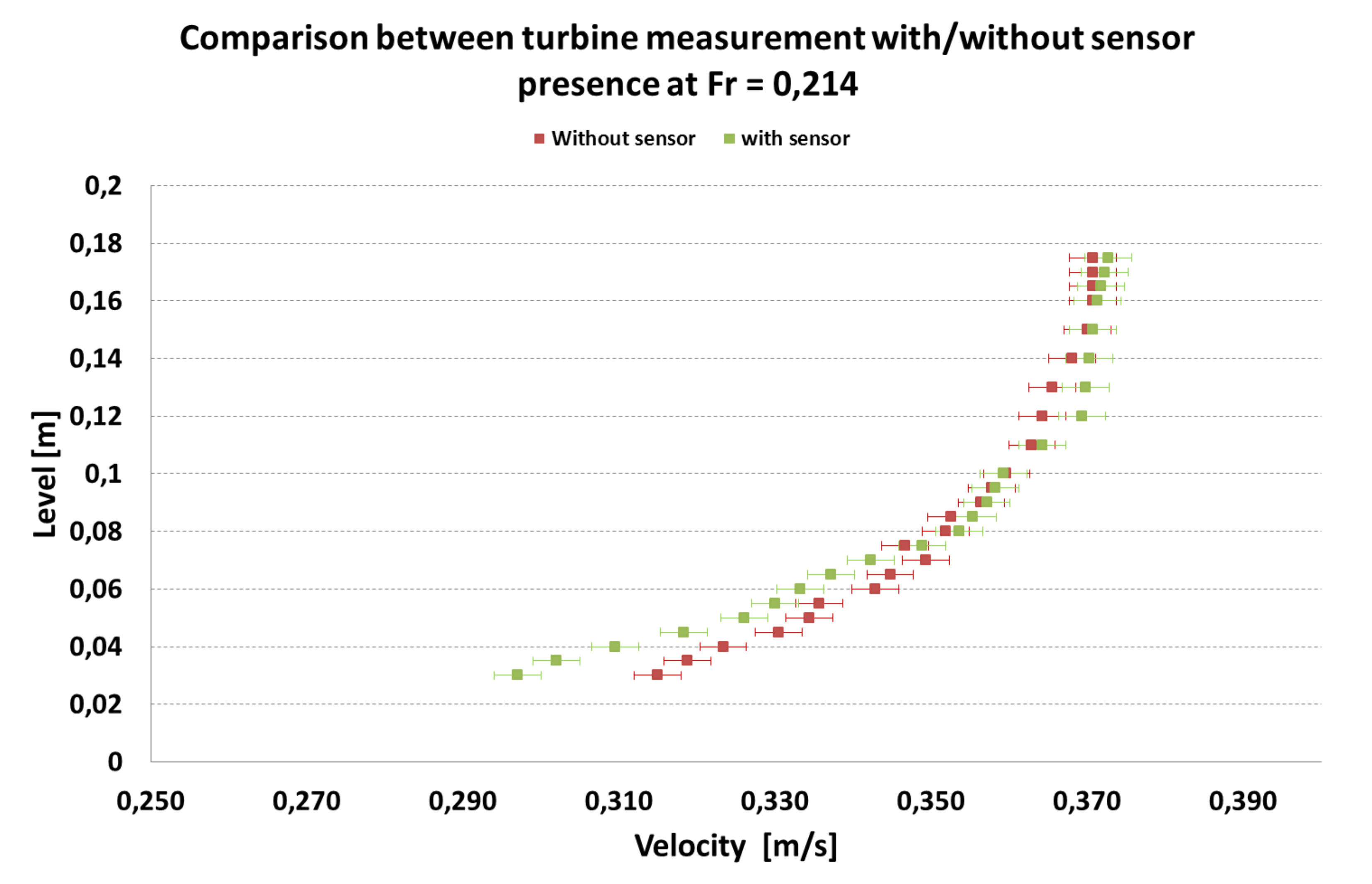
Turbine

Sensor position

Magmeter

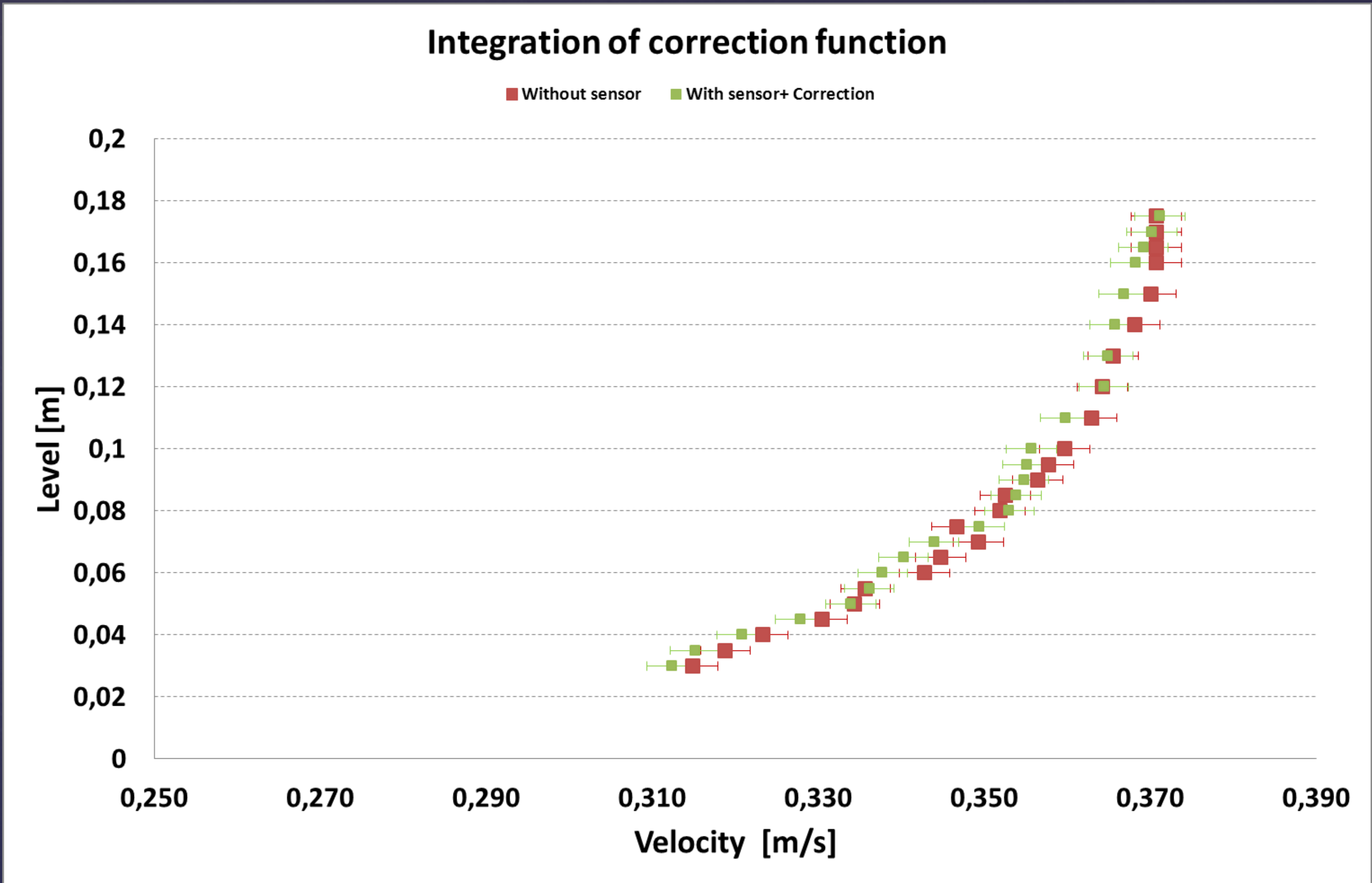
Validation

Measurement comparison: with/without sensor



Validation

Measurement comparison: application of the correction function



Influence of the sensor on the flow rate

Q/h	Without integration	With integration
23l/s	-6%	-2 %
50l/s	2%	0,6%
70l/s	2,4%	2,4%

Conclusion and Outlook

Conclusion

- Interest of CFD to solve 3D flow field problem
- The sensor body has an effect on the velocity profile and give wrong readings
- The sensor body has an effect on the flow rate
- The correction function is compensating these effects.

Outlook

- Extension of the CFD library to supercritical flows
- Extension to other dimensions and geometry (circular)
- Extension to a more general function
- Extension to side mounting sensor

Thanks for your attention

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