# Scale Effects in Urban Flows (TWT4): Insights & challenges

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# Structure of the presentation

- Scientific goals
- Geometry & model configuration
- Test Matrix (NTUA & TU Delft)
- Experimental setup
- Insights & challenges
- Dissemination
- Conclusions

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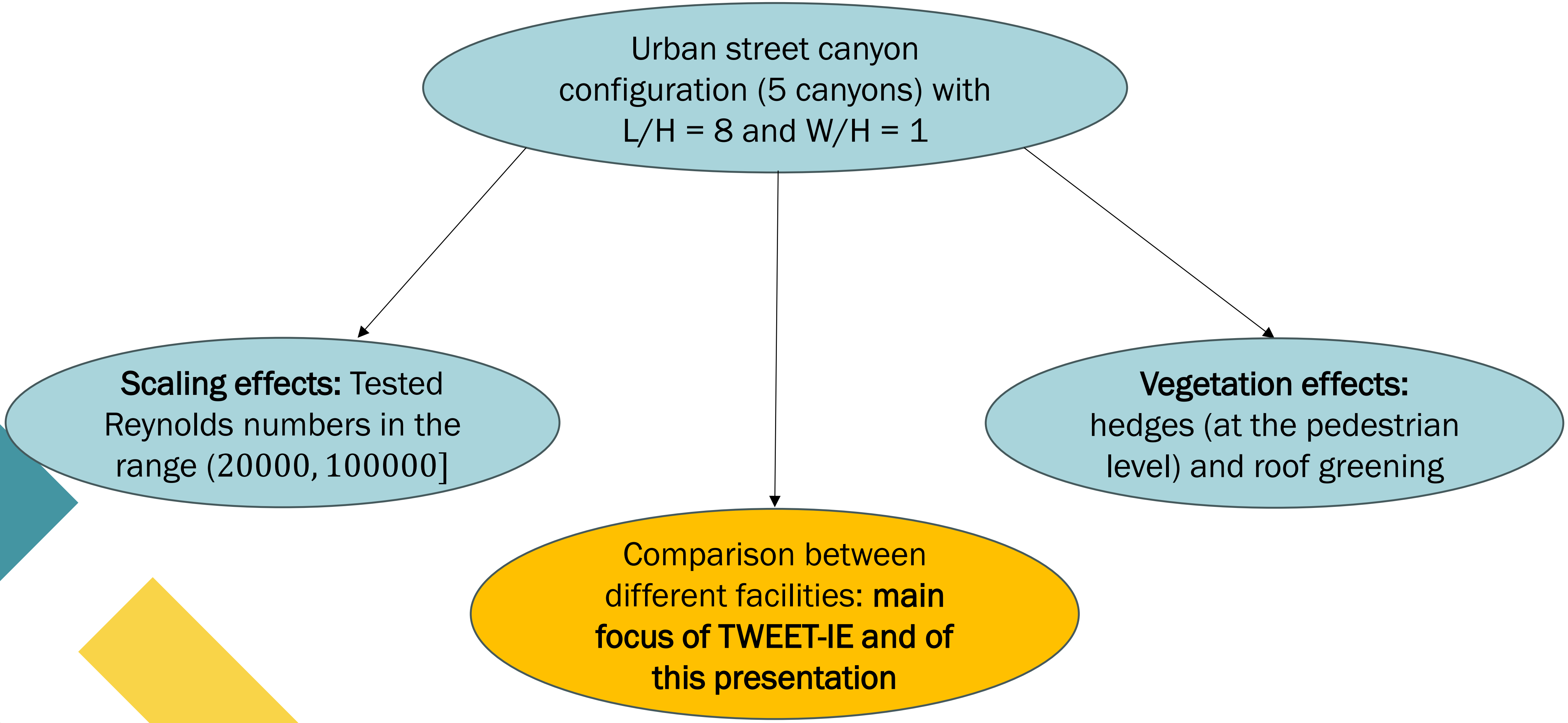
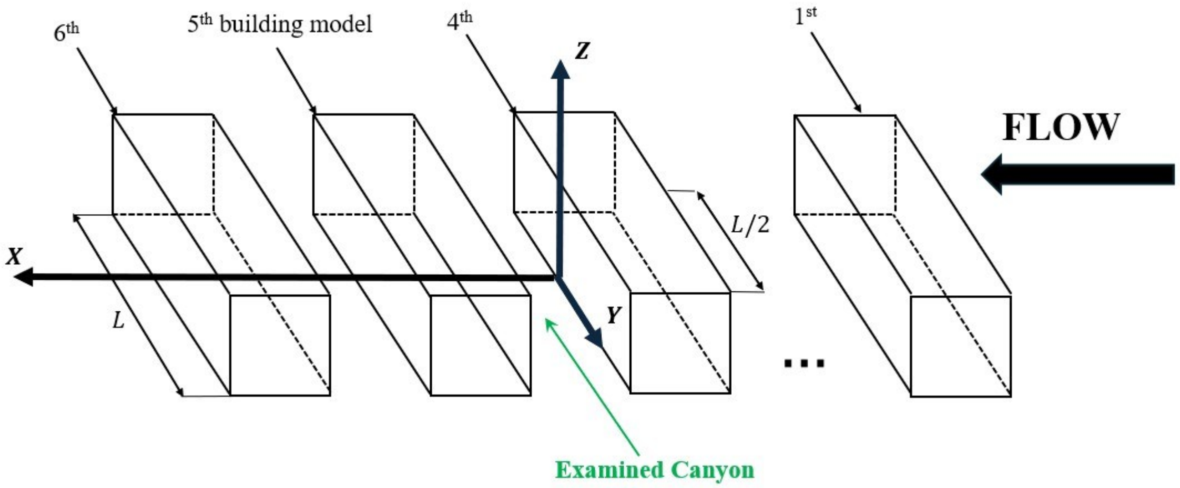
# Scientific goals

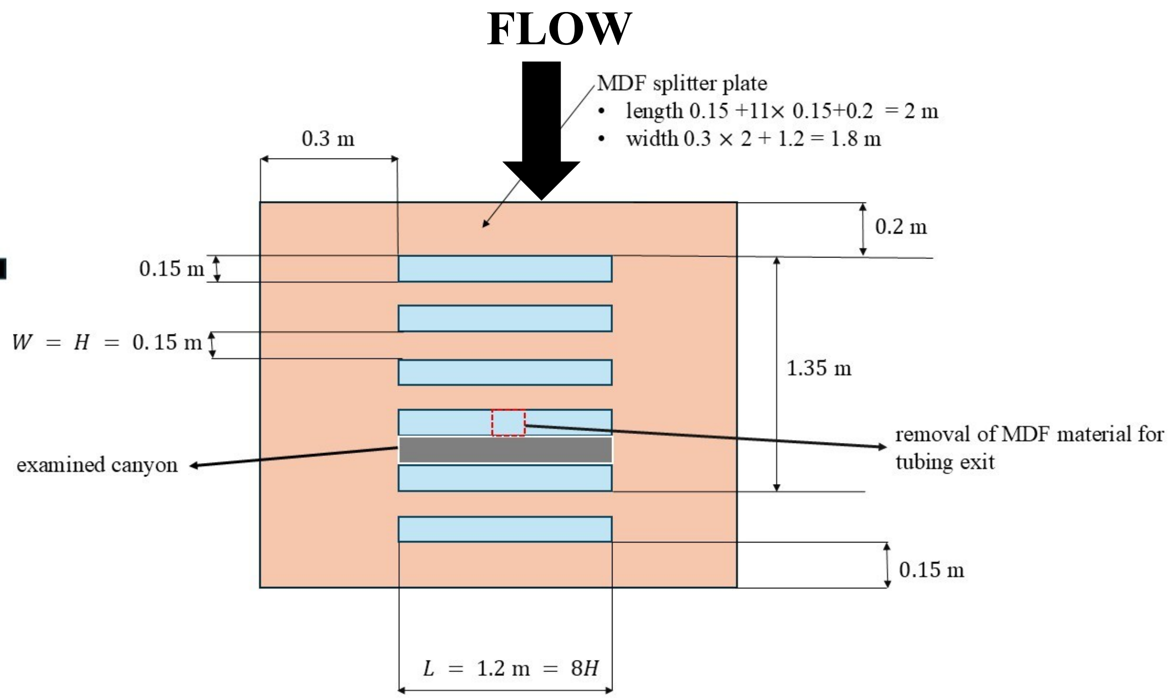


# Geometry & model configuration

## 3D VIEW




## TOP VIEW

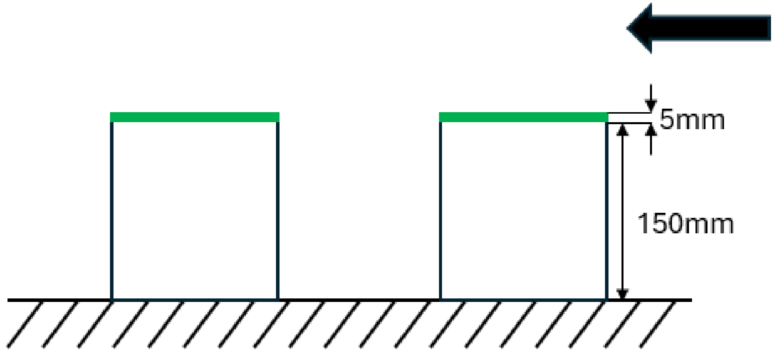


# Geometry & model configuration

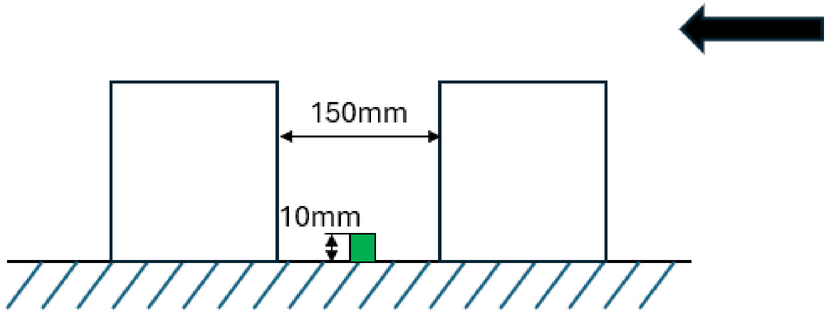
➢ Vegetation

- **PPI20** (i.e. 20 pores per inch)
- pressure loss coefficient **500** $\boldsymbol{m}^{-1}$

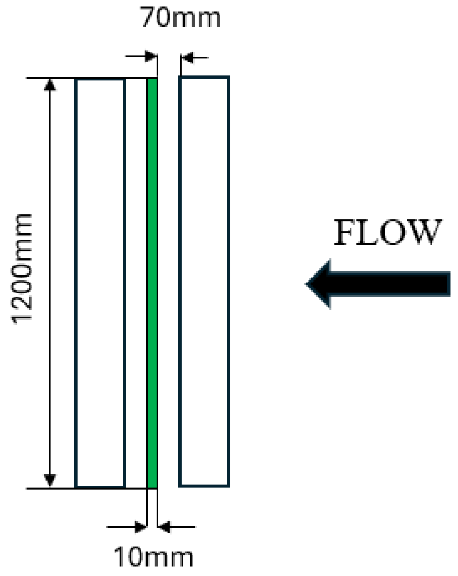
Roof greening




Hedges (side view)




Hedges (top view)



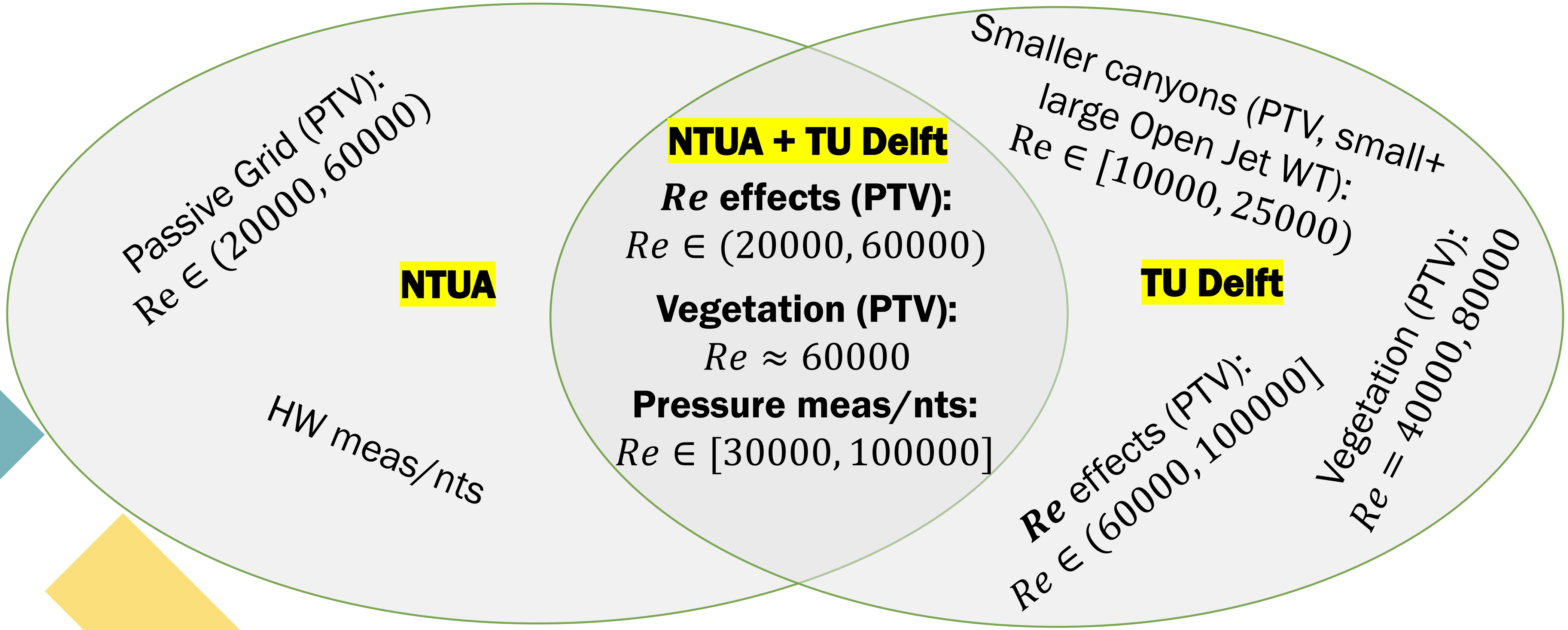
# Geometry & model configuration

➢ Assuming a scale factor of 1:200:

- Building's height = building's width = canyon's width = 30 m, length = 240 m.
- Height of roof greening: 1 m, height/width of hedges: 2 m.
- Pressure loss coefficient at full scale $\lambda_{fs} = 2.5\ \mathrm{m}^{-1} \xrightarrow{C_D \approx 0.3} \mathrm{LAD}_{fs} = \lambda_{fs}/C_D = 8.33\ \mathrm{m}^2\mathrm{m}^{-3}$.
- According to Pappa et al. (2023)[1], $\mathrm{LAD}_{fs} = 8.33\ \mathrm{m}^2\mathrm{m}^{-3}$ → real ivy greening, $\lambda_{fs} = 2.5\ \mathrm{m}^{-1}$ → foliated state of field maple shelterbelts.
- ABL scaling is not relevant since no ABL was applied as inlet. So, the 1:200 scale factor was arbitrarily chosen.

1. Pappa, V., Bouris, D., Theurer, W., & Gromke, C. (2023). A wind tunnel study of aerodynamic effects of façade and roof greening on air exchange from a cubic building. *Building and Environment*, *231*, 110023.

# Test Matrix (NTUA & TU Delft)

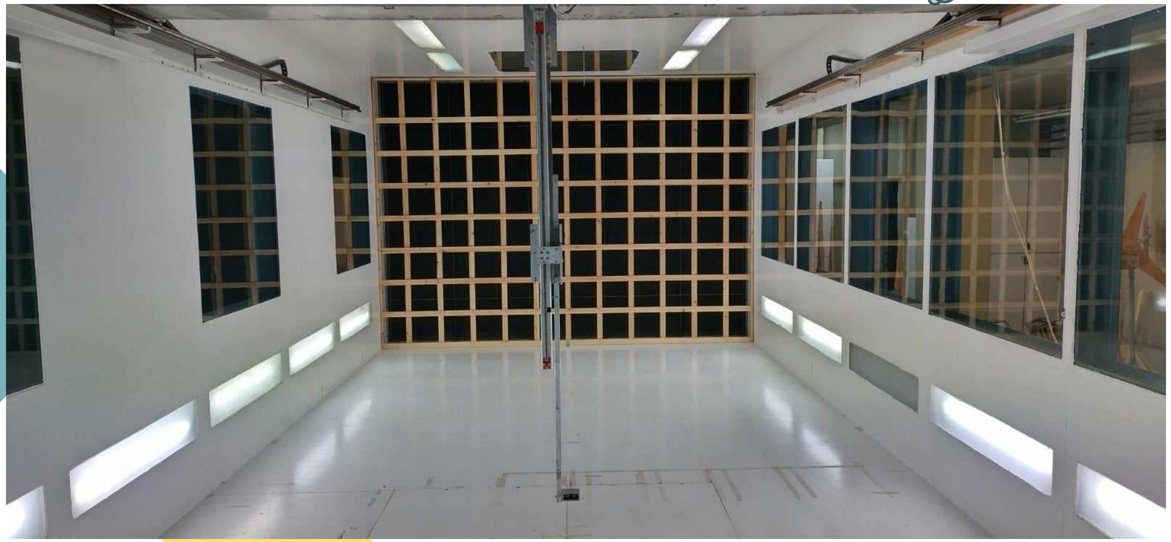


# Experimental Setup

- A “peek” into the test sections:

NTUA

NTUA: closed-type WT
TU Delft: open jet WT (OJF)



TU Delft

# Experimental Setup

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NTUA: closed-type WT
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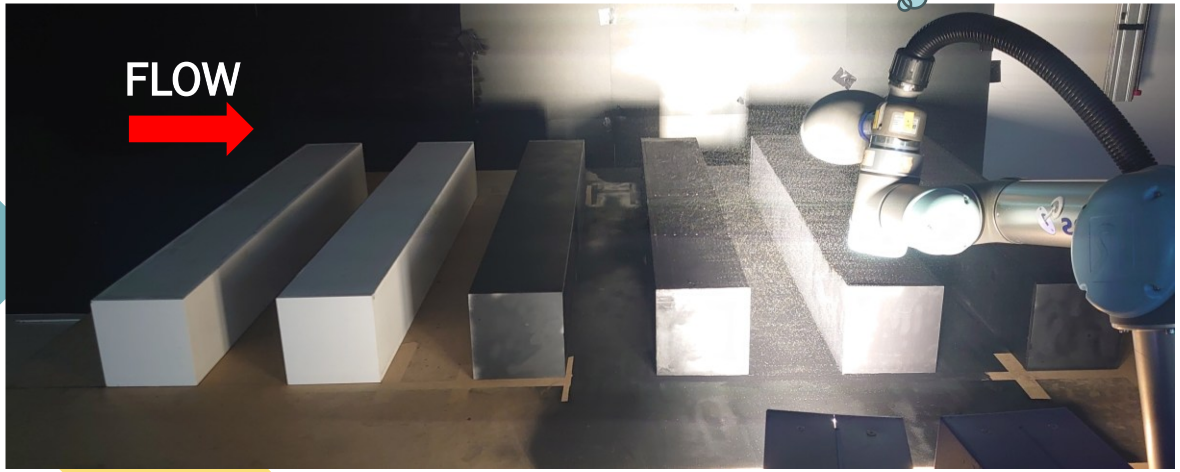
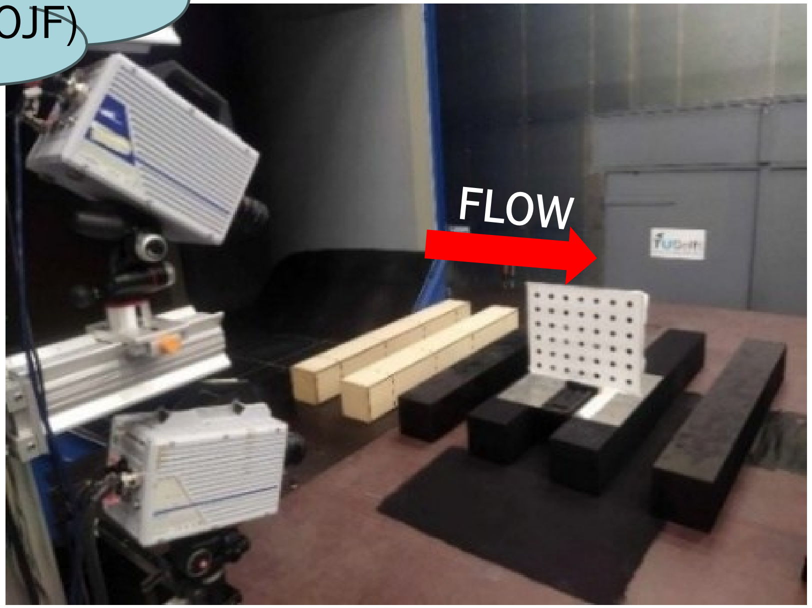
NTUA

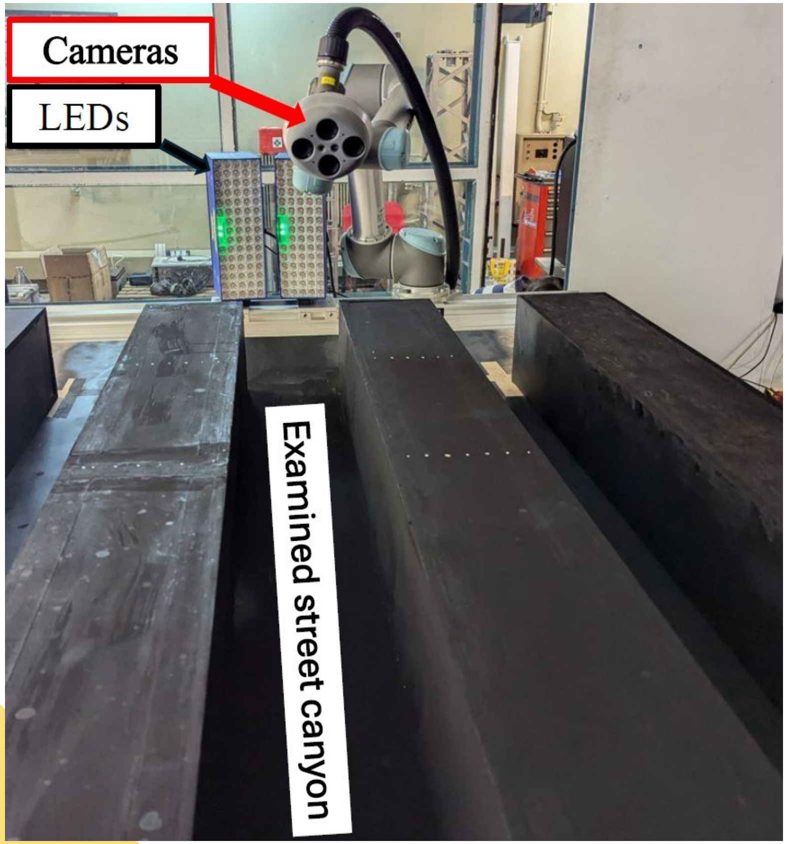


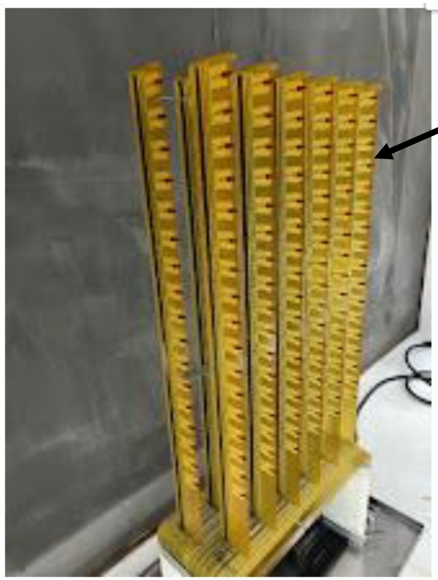

TU Delft



# Experimental Setup

➢ NTUA setup:



Seeding rake connected to an FSU (Fluid Supply Unit)

Adjustable to keep #Vortex turnovers~80

| | |
|---|---|
| Maximum sampling frequency ($f_s$) | 727 HZ |
| Focal length | 4.1mm |
| Magnification Factor | 0.008 |
| Numerical aperture | 11 |

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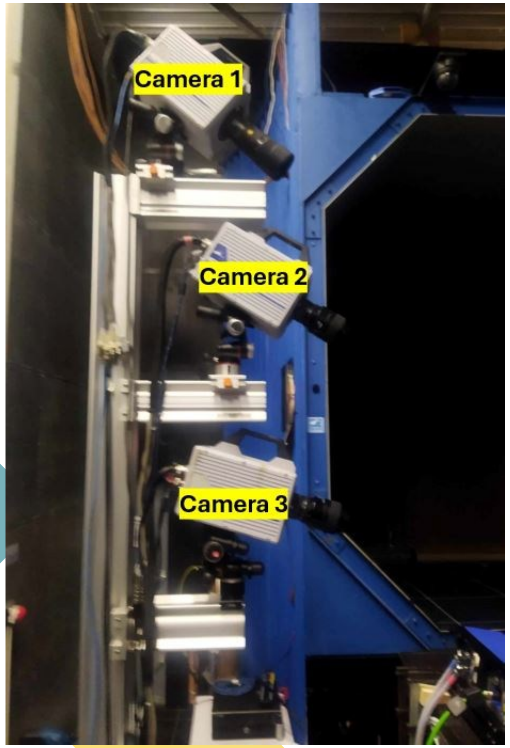
# Experimental Setup

- TU delft setup:



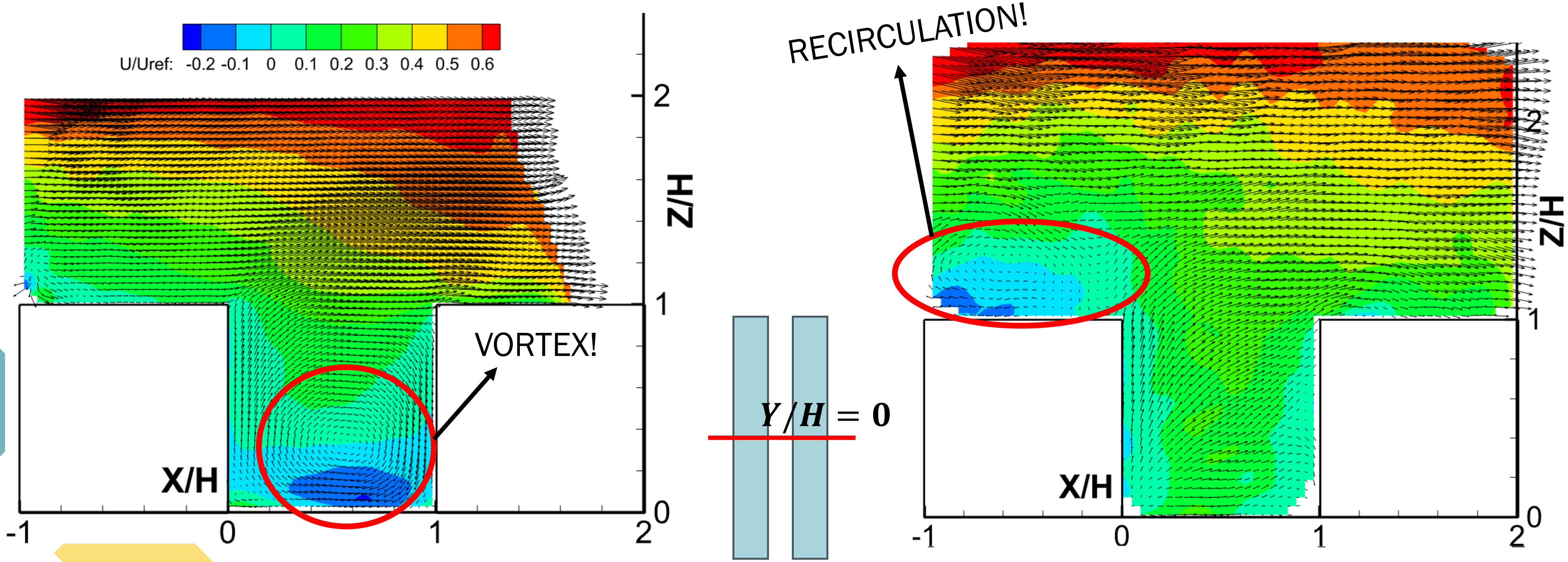

| Case | Camera 1 | Camera 2 | Camera 3 |
|---|---|---|---|
| large models.: FoV1 + FoV2 | 50 mm | 35 mm | 35 mm |
| small models: one half of the canyon | 180 mm | 105 mm | 105 mm |

| Case | $f\#$ | $M$ | pixel/mm |
|---|---|---|---|
| large models: FoV 1 (edge of the canyon) | 16 | 0.04 | 1.98 |
| large models: FoV 2 (centre of the canyon) | 16 | 0.03 | 1.52 |
| small models: half of the canyon | 22 | 0.08 | 4 |

- Sensor resolution: 1024x1024, pixel size: 20x20μm, max $f_s = 5400\ Hz$ but again adjustable → #Vortex turnovers~95 (acquired, NOT processed).
- Same LEDs, calibration target and seeding (Helium-filled soap bubbles) in both facilities.

# Insights & challenges

- **Important question:** are the results between NTUA and TU Delft directly comparable?

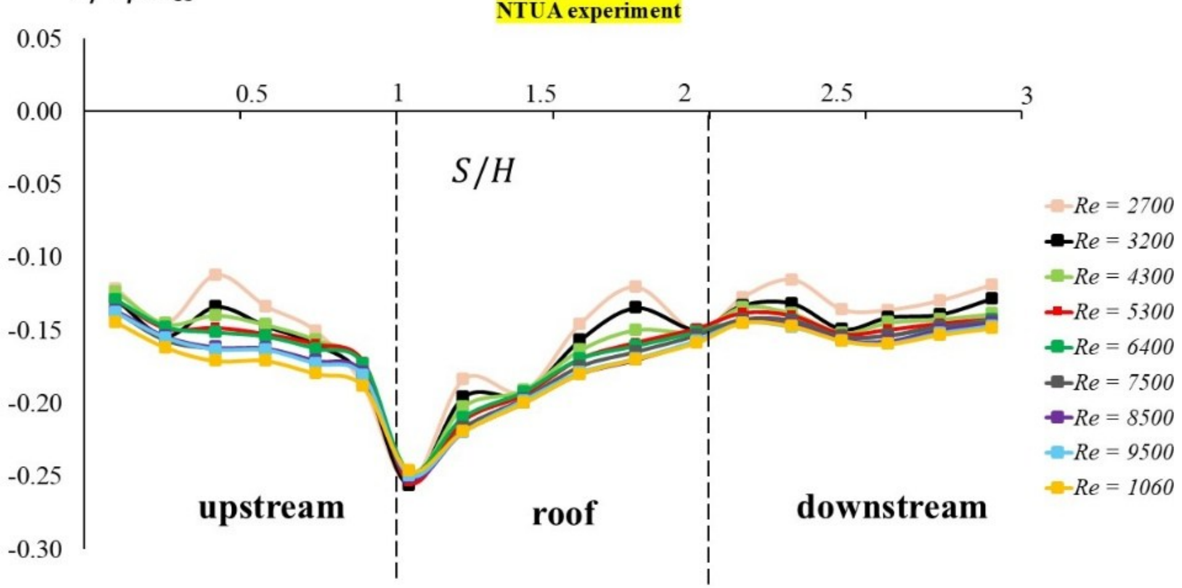



**NTUA** ($Re \approx 60,000$) **TU Delft** ($Re = 60,000$)

# Insights & challenges

- **Important question:** are the results between NTUA and TU Delft directly comparable?

$$C_P = \frac{\bar{P} - \overline{P_{st}}}{1/2\rho U_\infty^2}$$

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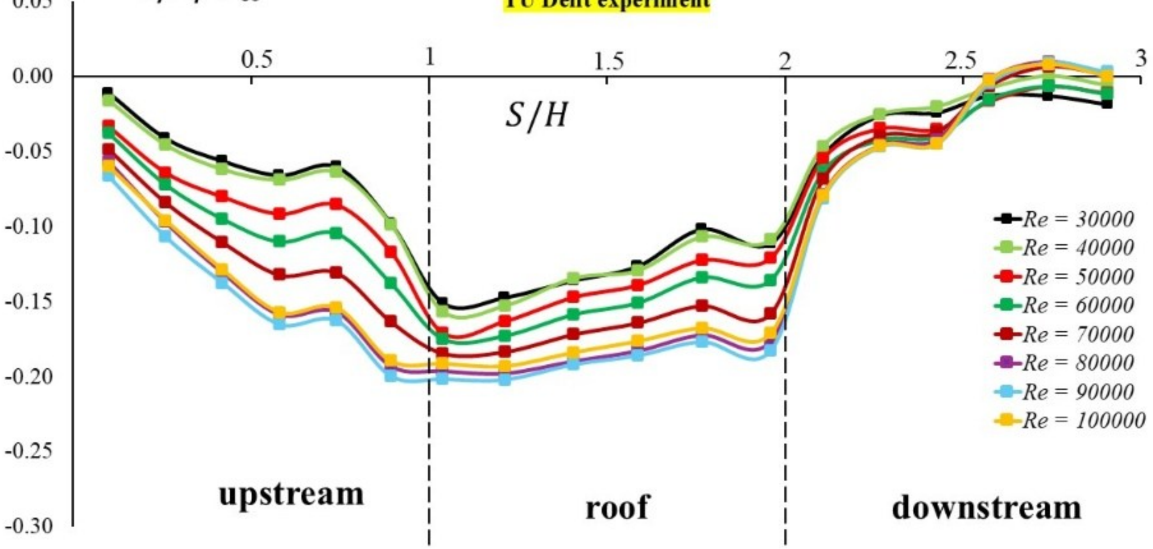


# Insights & challenges

- **Important question:** are the results between NTUA and TU Delft directly comparable?

  **Answer:** in the region around the centre-plane there is a drastically different flow structure between the two facilities (verified by surface pressures and PTV results).

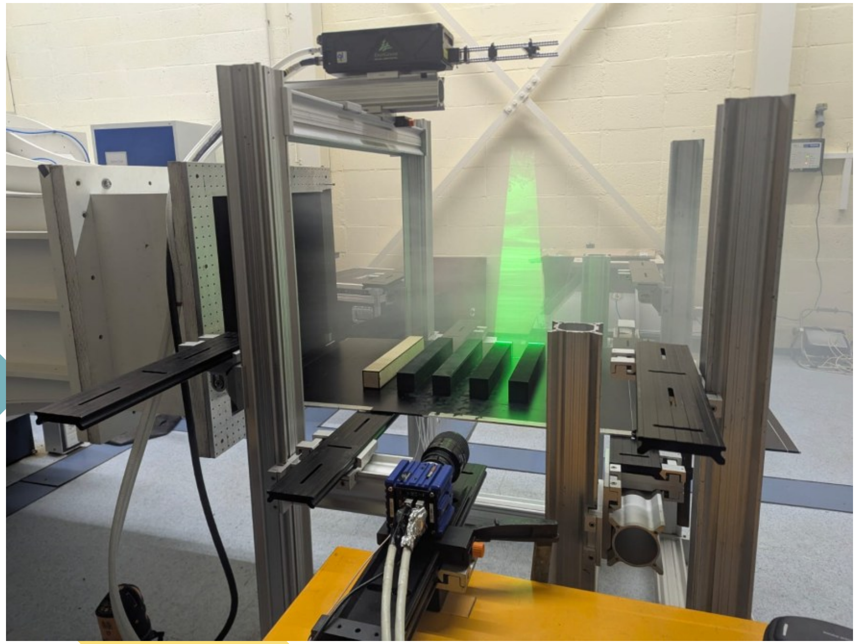
  - **What's the source of this behaviour then**? An explanation can be sought in the different type of facilities i.e. **enclosed test section** at NTUA and **OJF** at TU Delft.

  - **But how** the different type of facilities could be responsible for such noticeable differences in the flow structure**?**

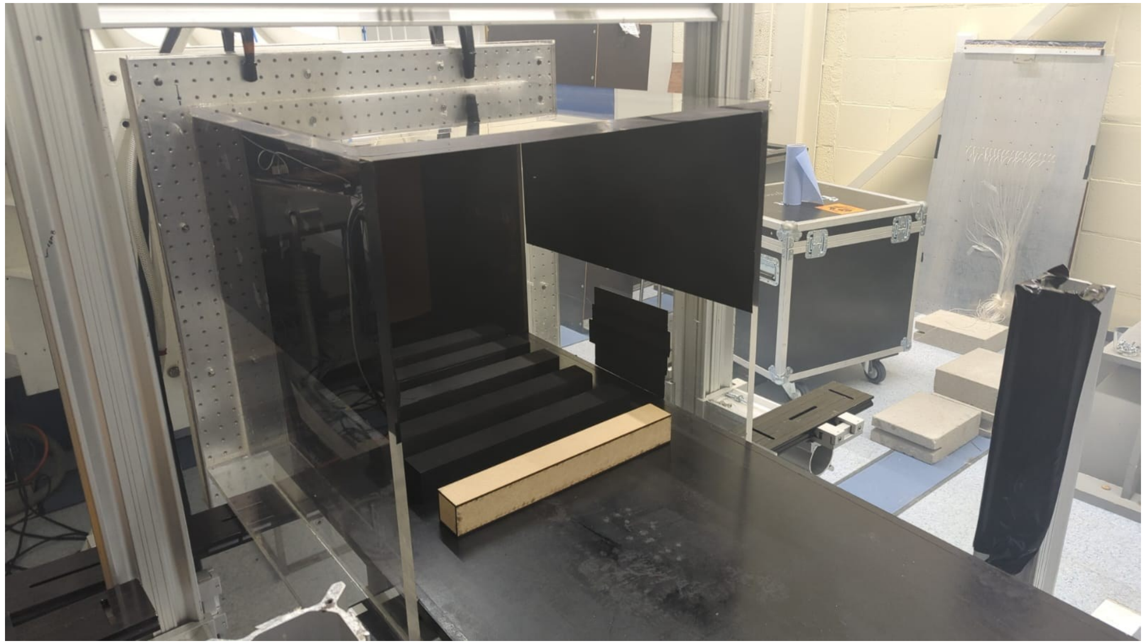
# Insights & challenges

- Planar-PIV conducted by Brian Dsouza and Andrea Sciacchitano at TU Deft (**models scaled-down by a factor of 3**):

**Initial setup (open jet)**



**Final setup ("closed section")**



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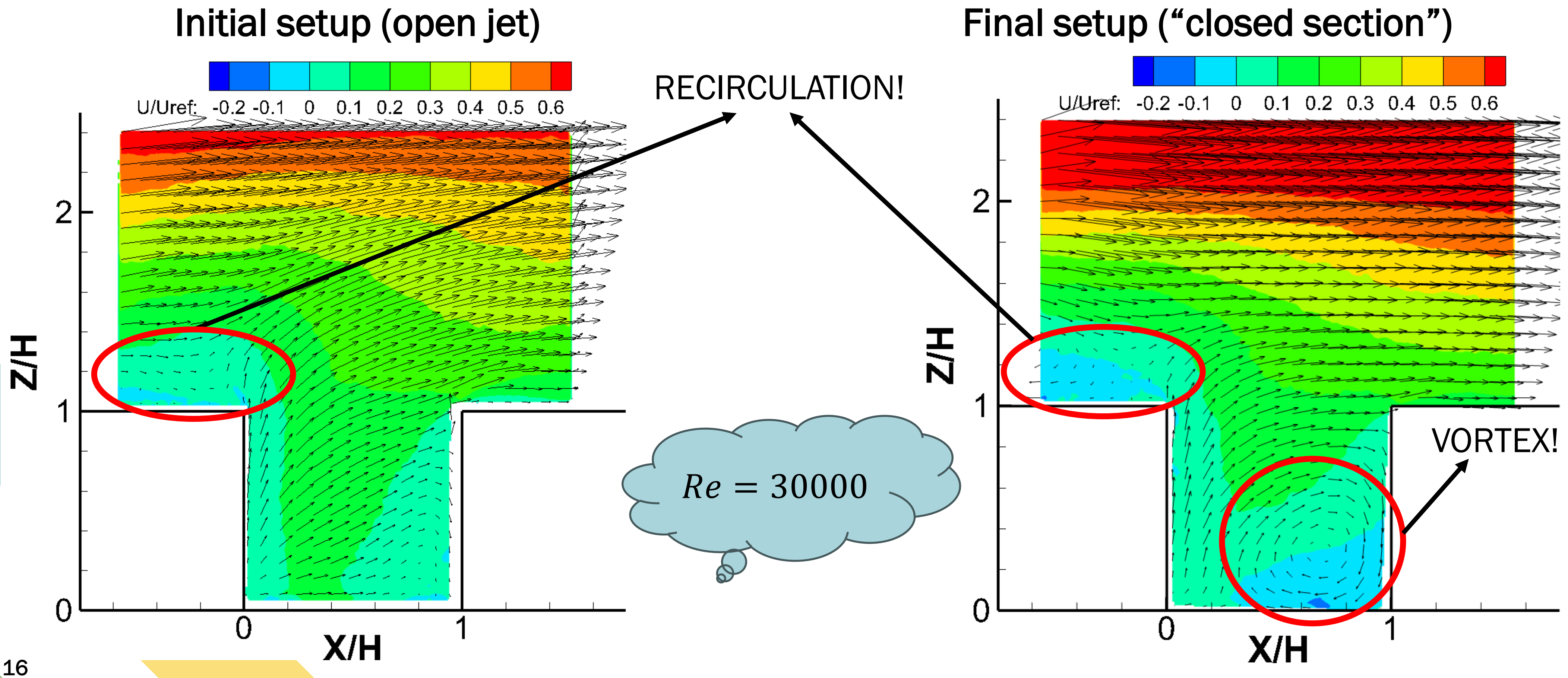

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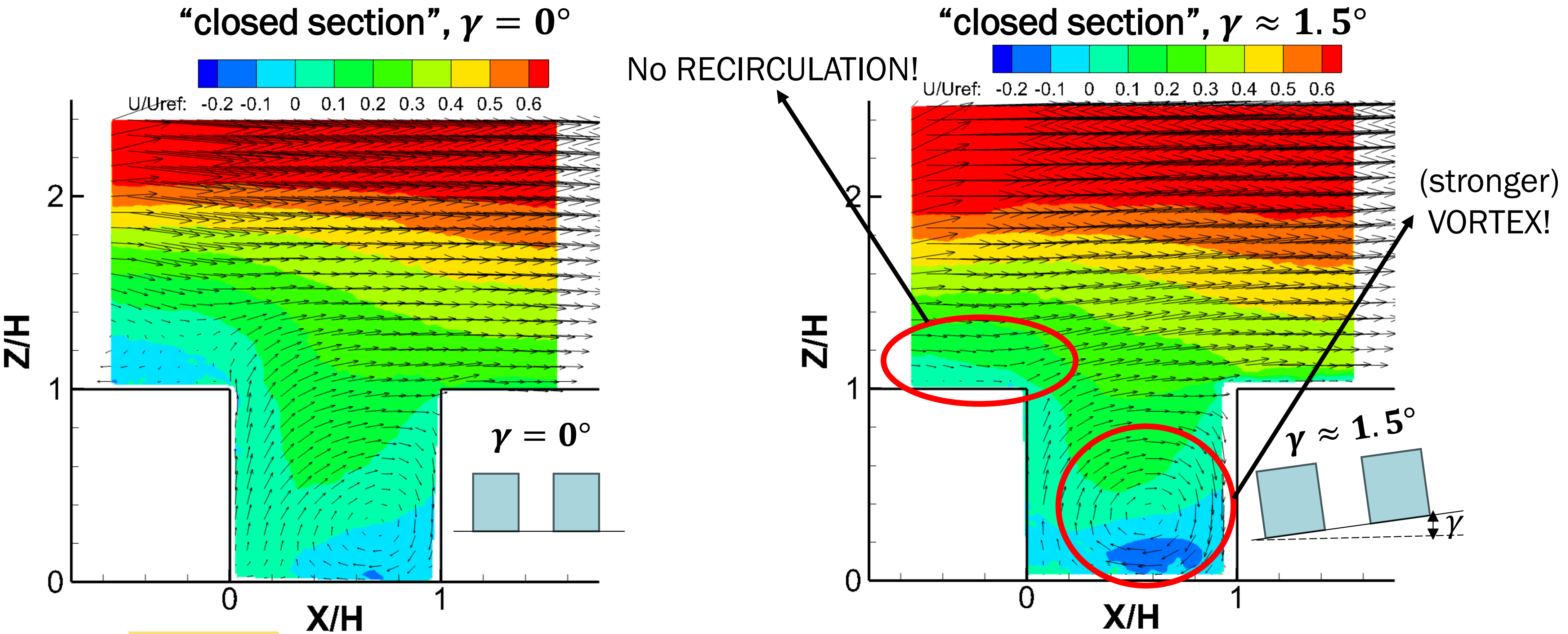
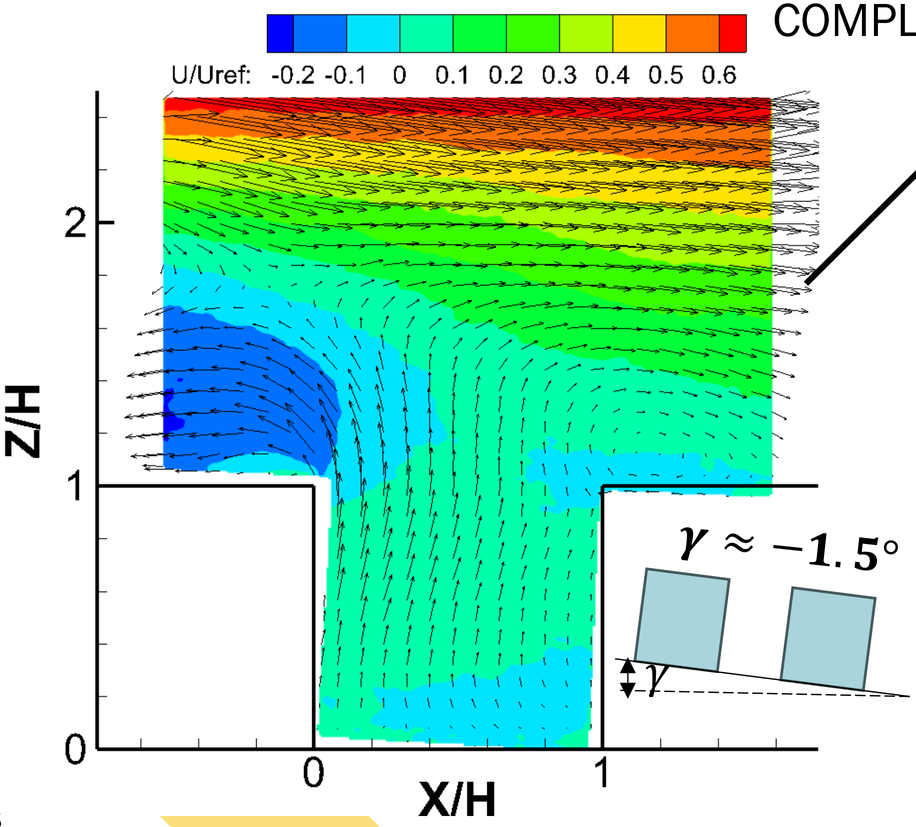


# Insights & challenges

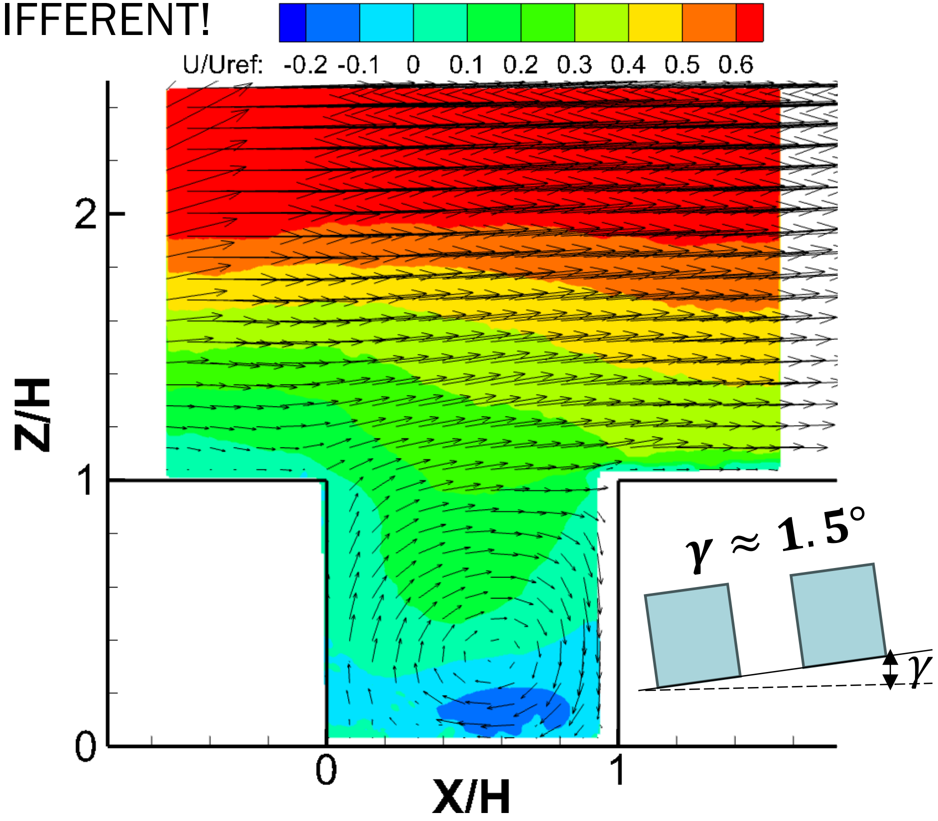
- Planar-PIV conducted by Brian Dsouza and Andrea Sciacchitano at TU Deft :

"closed section", $\gamma \approx -1.5°$




COMPLETELY DIFFERENT!

"closed section", $\gamma \approx 1.5°$



# Dissemination

- **Lisbon conference proceedings (TU Delft partners):** Dsouza, B., Sciacchitano, A. & Yu, W. (2024). Reynolds Number Independence In An Urban Street Canyon Using 3D Robotic Particle Tracking Velocimetry. 21st International Symposium on Applications of Laser and Imaging Techniques to Fluid Mechanics, Lisbon, 08-11 July 2024.
- **9th European-African Conference on Wind Engineering (to be presented):** Pallas, N.P., Dsouza, B., Bouris, D., Sciacchitano, A. & Gromke, Christof. (2025). **Twin wind tunnel investigation** of the scale effects on a street canyon flow, 9th European-African Conference on Wind Engineering, Trondheim, Norway, 16-19 June 2025. What should we include?
- Article draft written by Dsouza on Delft small canyon data. Any updates?
- Article draft written by Pallas on NTUA high turbulence data.
- Any other ideas for future articles?

# Conclusions

- Significant differences in the flow structure between the two facilities. **But why?** Planar-PIV experiments conducted by the partners from TU Delft revealed the following:
    - "Closing" an open jet facility leads to more similar results between the two facilities i.e. open jet (TU Delft) and enclosed test section (NTUA).
    - Imposing a "favourable" pressure gradient in the streamwise direction (by pitching down the splitter plate on which the models are mounted) leads to even greater similarity. This kind of pressure gradient is unavoidable in NTUA's test section.
    - Pitching up or down the splitter plate by as little as $\pm 1.5°$ drastically affects the flow structure at the centre-plane of the canyon.
- Is the **pressure gradient** in the streamwise direction the key to explaining these differences?

# Thank you

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