Modelling Floating Wind Turbines in an Atmospheric Boundary Layer

Benyamin Schliffke

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Schedule

Basic Information

Floateole Project

Figure: FLOATGEN, the prototype floating offshore wind turbine, used as a reference in this thesis. Source: https://sem-rev.ec-nantes.fr/eolienne-flottante-floatgen/ (visited on 18/02/2019 at 17:19)

- Hub height: 60 m
- Diameter: 80 m
- Floater: 36 m $\times$ 36 m $\times$ 10 m

- Duration Floateole project: 2017-2021
- Work includes wind tunnel experiments (PhD) and field measurements (LIDAR, Post-Doc)
- Comparison of measurements, when both data sets are available

The Atmospheric Boundary Layer

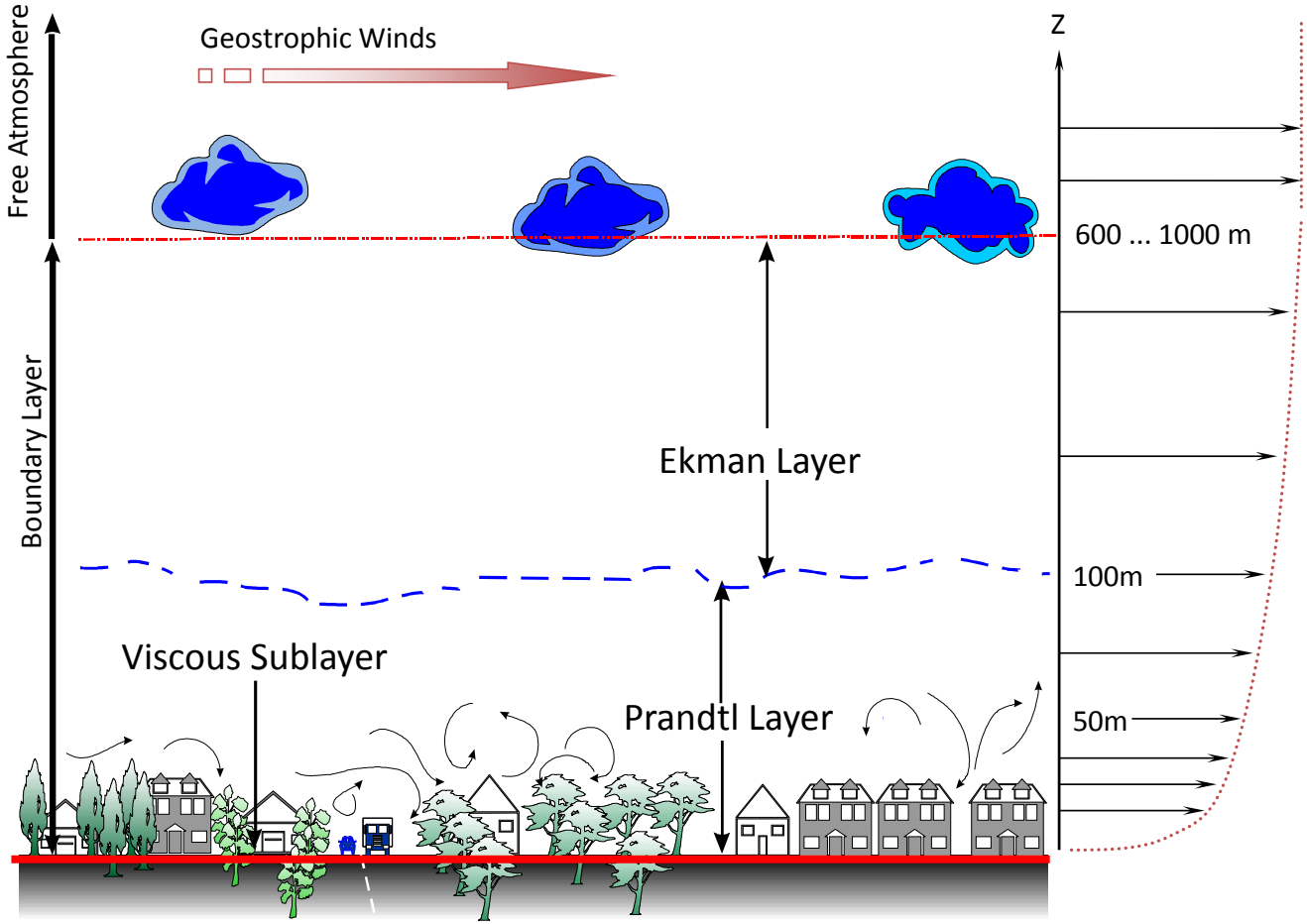


Figure: Modified from Harms (2010)

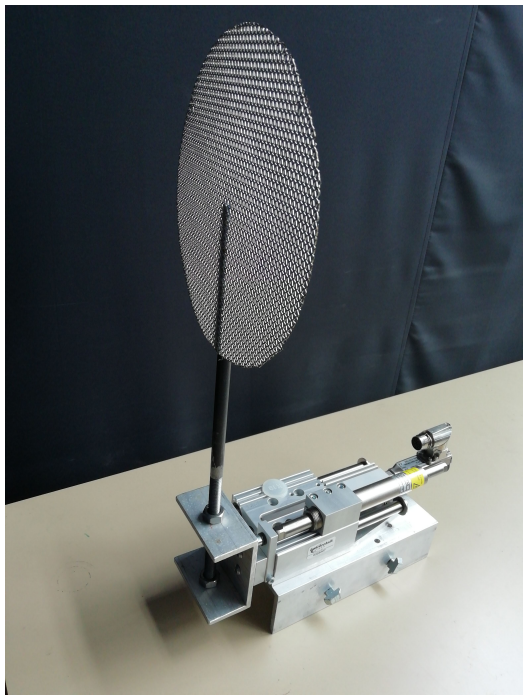
Main Questions

- How do we accurately reproduce the floaters motion in the wind tunnel?
- Can the floaters frequencies be found in the behaviour of the wake?
- What is the effect of the motion on the wake development?

Answers?

- ...model the motion of the floater.
- ...develop a motion system for the model turbine.
- ...develop a maritime boundary layer in the wind tunnel.
- ...conduct experiments with idealised motions first, becoming more realistic.
- ...study the wake of the moving turbine model.

Reducing the Scale

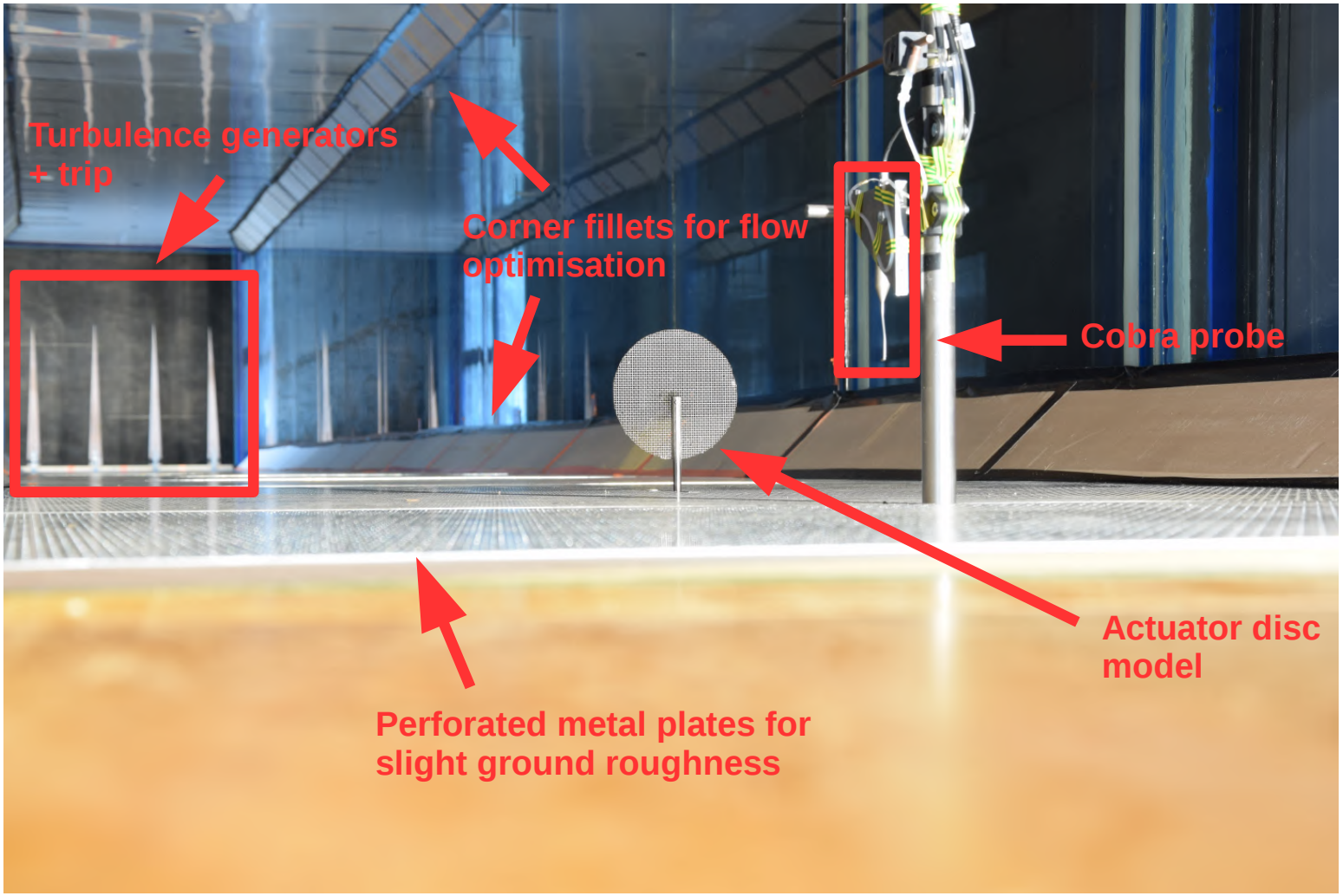


- geometric scale: 1:500
- time scale: 200

	Full scale	Wind tunnel	Name
Nacelle height	60 *m*	12 *cm*	h
Rotor diameter	80 *m*	16 *cm*	D
Char. distance	10 *m*	2 *cm*	L
Char. frequency	0.01 *Hz*	2 *Hz*	f_{char}

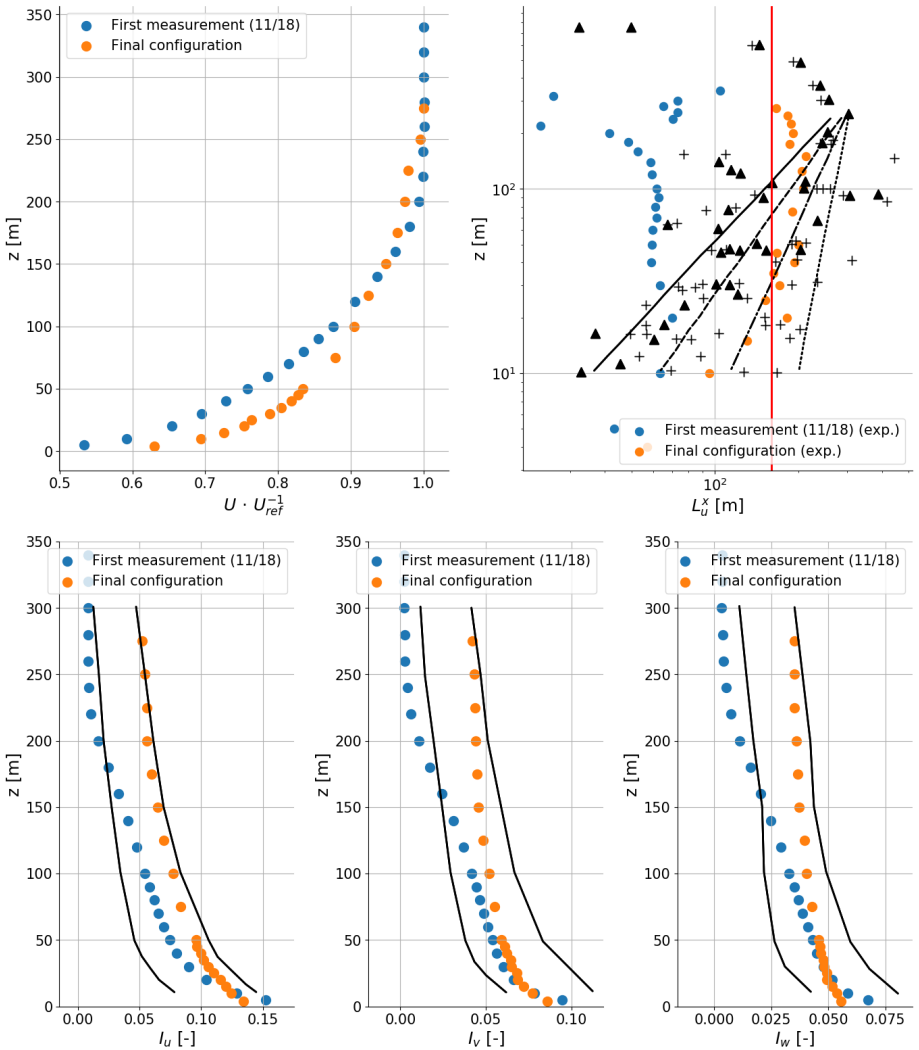
Results

Boundary Layer Generation

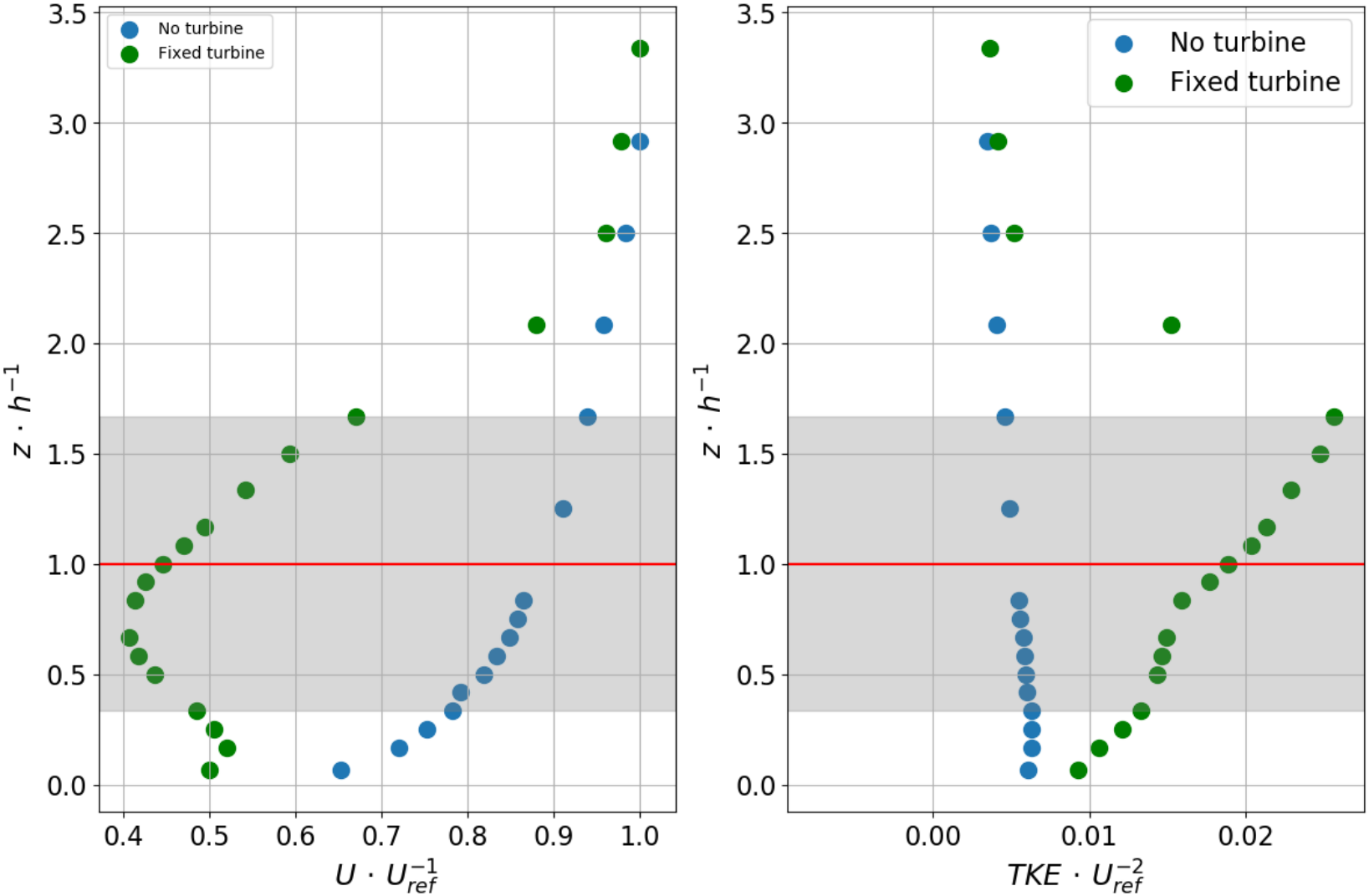


Modelled Boundary Layer

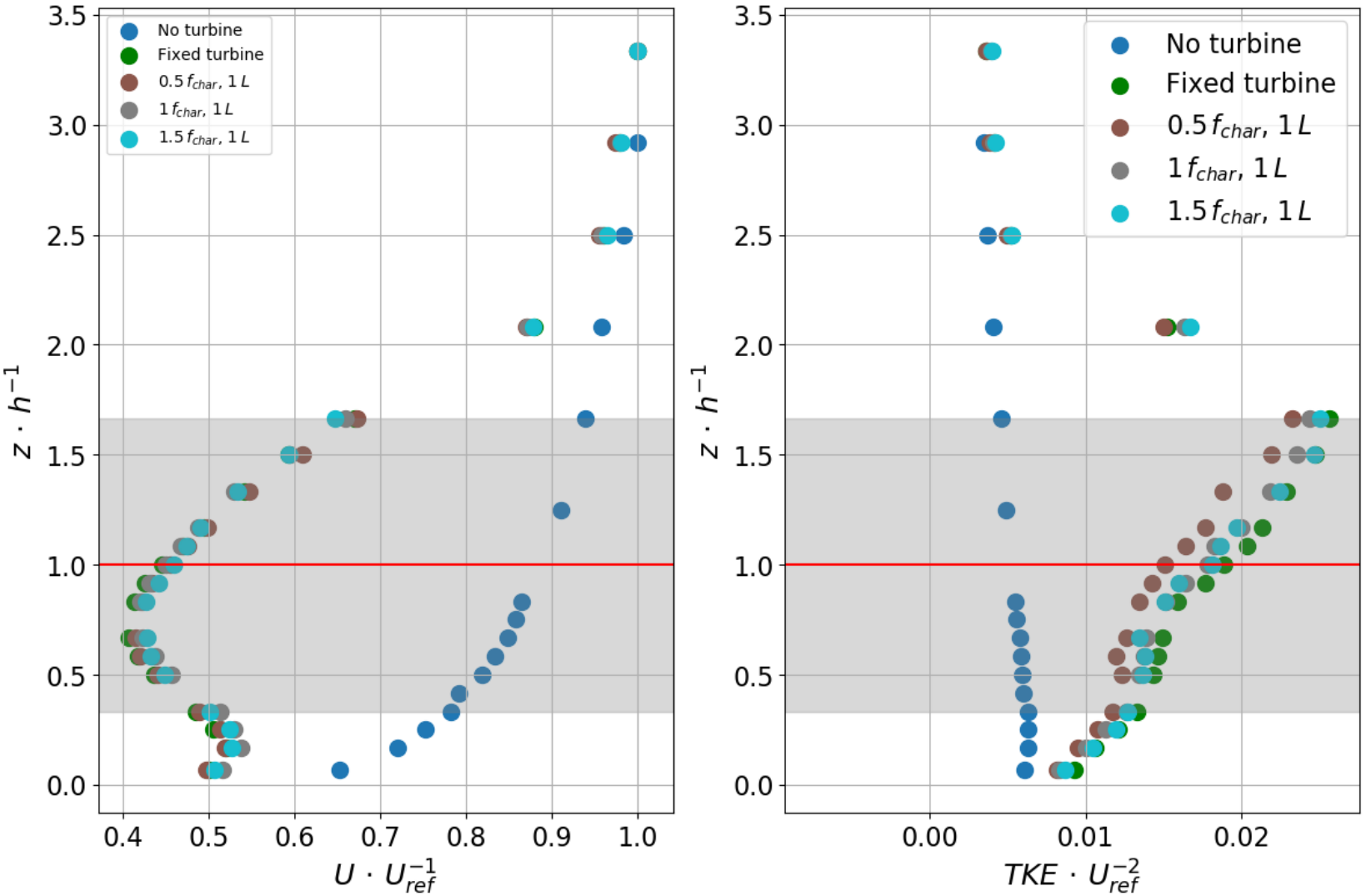
- $z_0\,[m] \approx 5.5 \cdot 10^{-6}$
- $\alpha \approx 0.11$



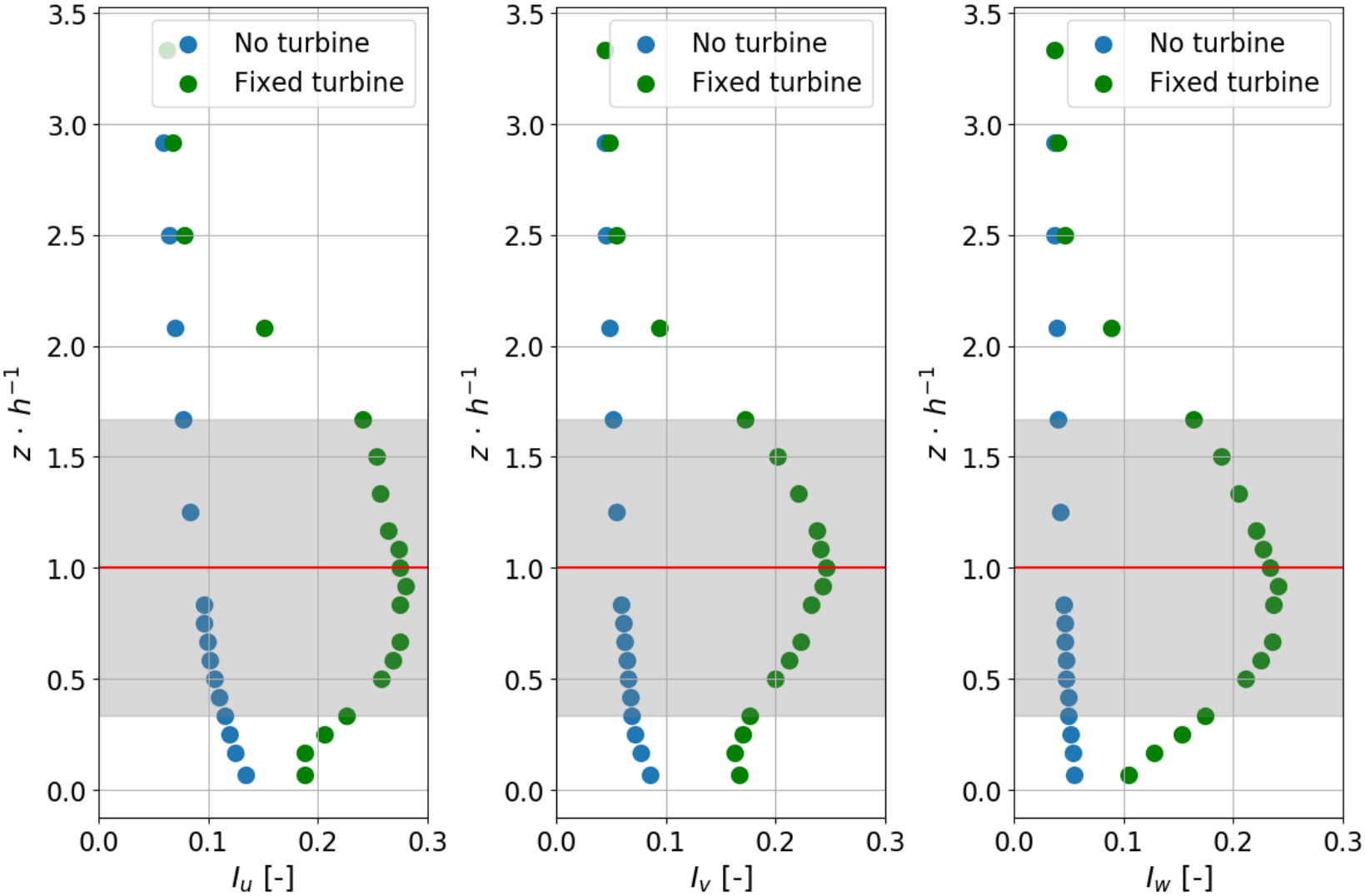
Velocity Profile



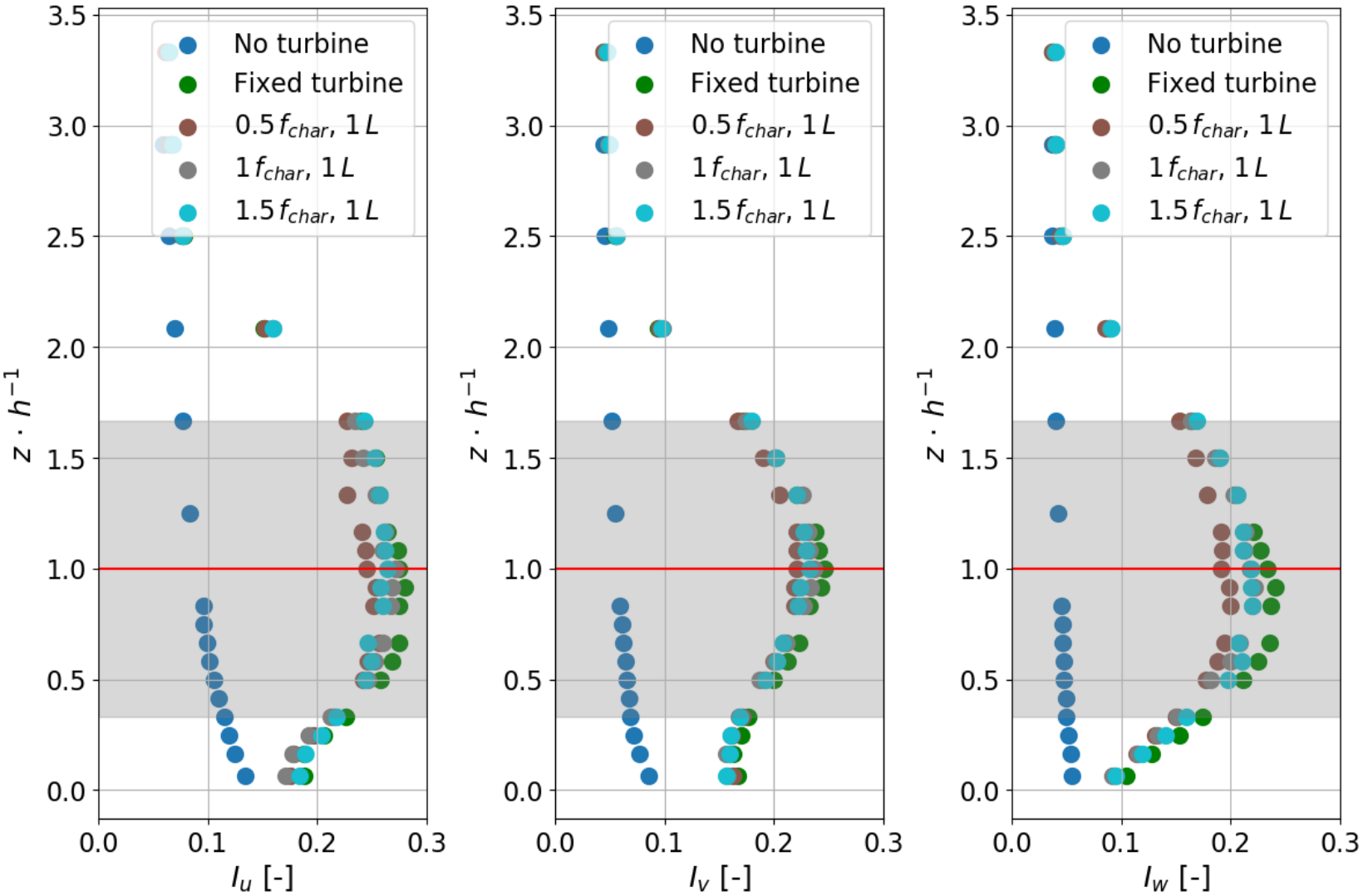
Velocity Profile - Motion



Turbulence Intensity



Turbulence Intensity - Motion



Conclusion & Outlook

Conclusion

Conclusion:
Introducing idealised surge motion appears to ...

- hardly decrease the velocity loss in the wake.
- slightly reduce the turbulence intensity.

Outlook

- How do these profiles compare to an analytical model for fixed turbines (eg. Bastankhah and Porté-Agel (2014)?
- Can the spectral content of the flow confirm the findings?
- How does the motion affect the lateral behaviour?
- What are the spatial characteristics of the wake (lateral and vertical)?
- What characteristics change when complex motion is introduced?

References

Bastankhah, M. and Porté-Agel, F. (2014). A new analytical model for wind-turbine wakes. *Renewable Energy*, 70:116–123.

Harms, F. (2010). *Systematische Windkanaluntersuchungen zur Charakterisierung instationärer Ausbreitungsprozesse einzelner Gaswolken in urbanen Rauigkeitsstrukturen*. PhD thesis, Meteorologisches Institut Universität Hamburg.

Appendix

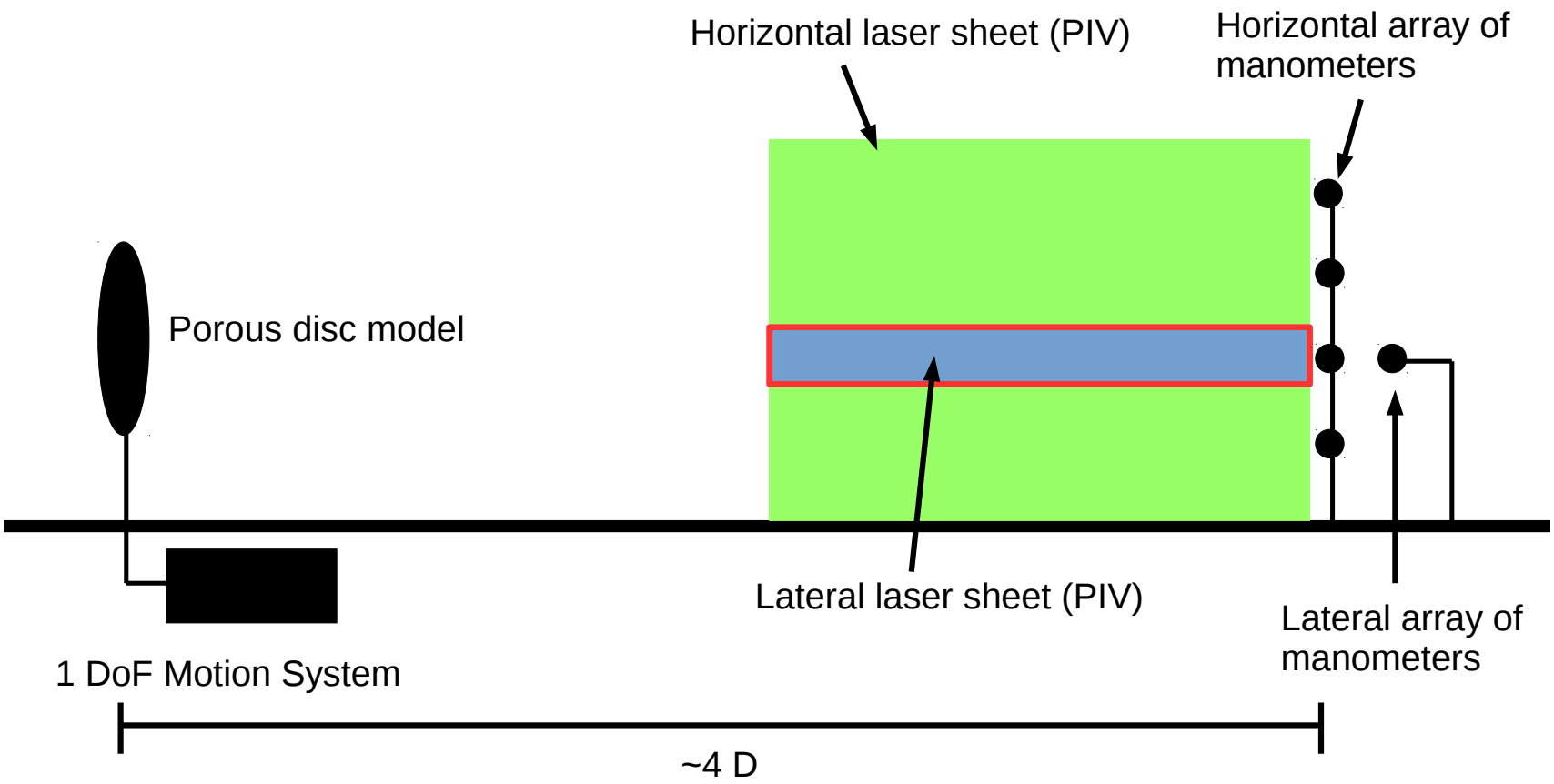


Figure: Test set-up to be used for lateral measurements.

Table: Excerpt from VDI Guideline 3783. z_0 is the roughness length, α the exponent coefficient and d_0 the zero plane displacement. Added values for the modelled boundary layer.

Roughness class	slightly rough	modelled
Type of terrain	ice, snow, water surface	offshore
z_0 $[m]$	10^{-5} to $5 \cdot 10^{-3}$	5.5×10^{-6}
α	0.08 to 0.12	0.11
d_0 $[m]$	≈ 0	0