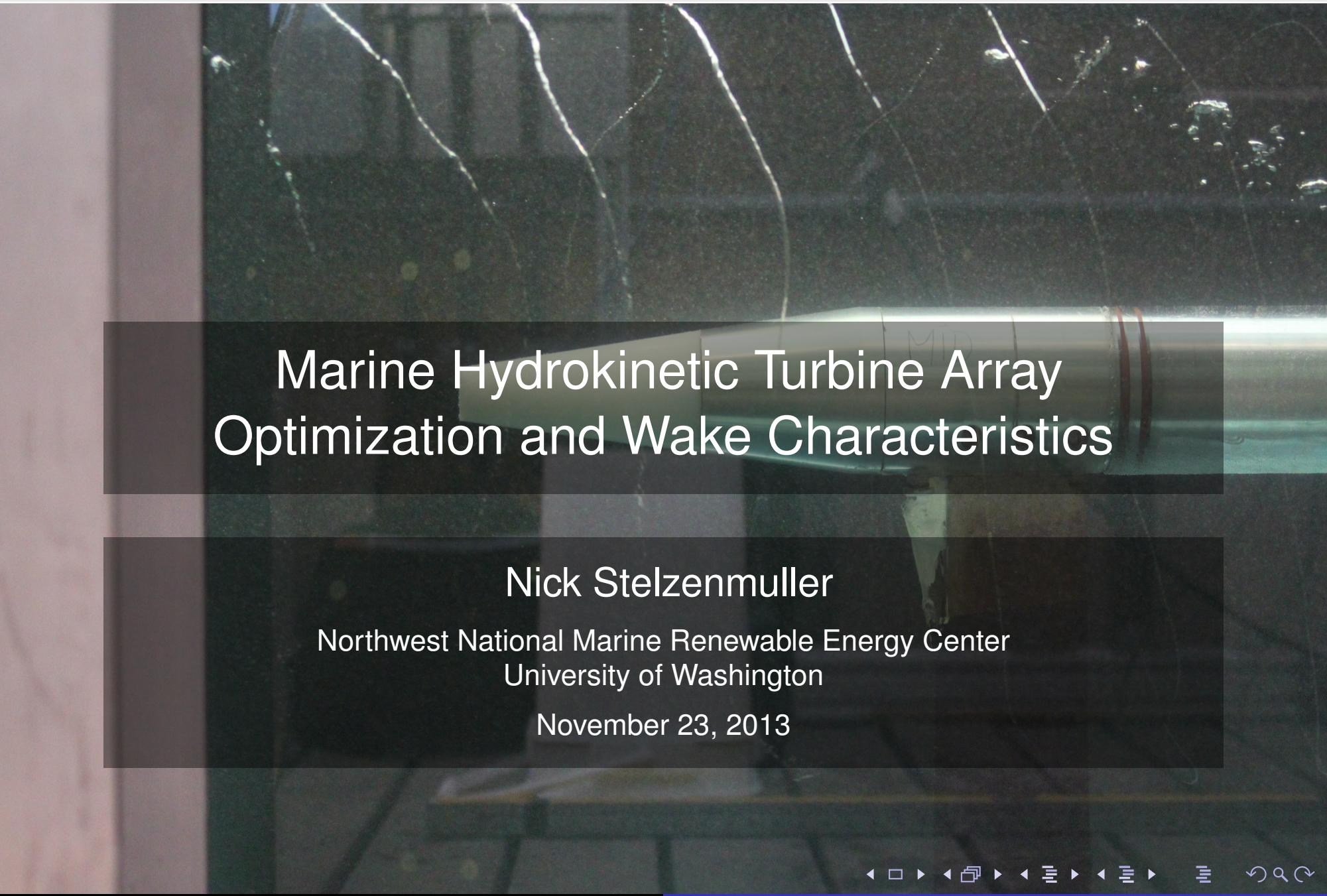

Marine Hydrokinetic Turbine Array Optimization and Wake Characteristics

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Research goals

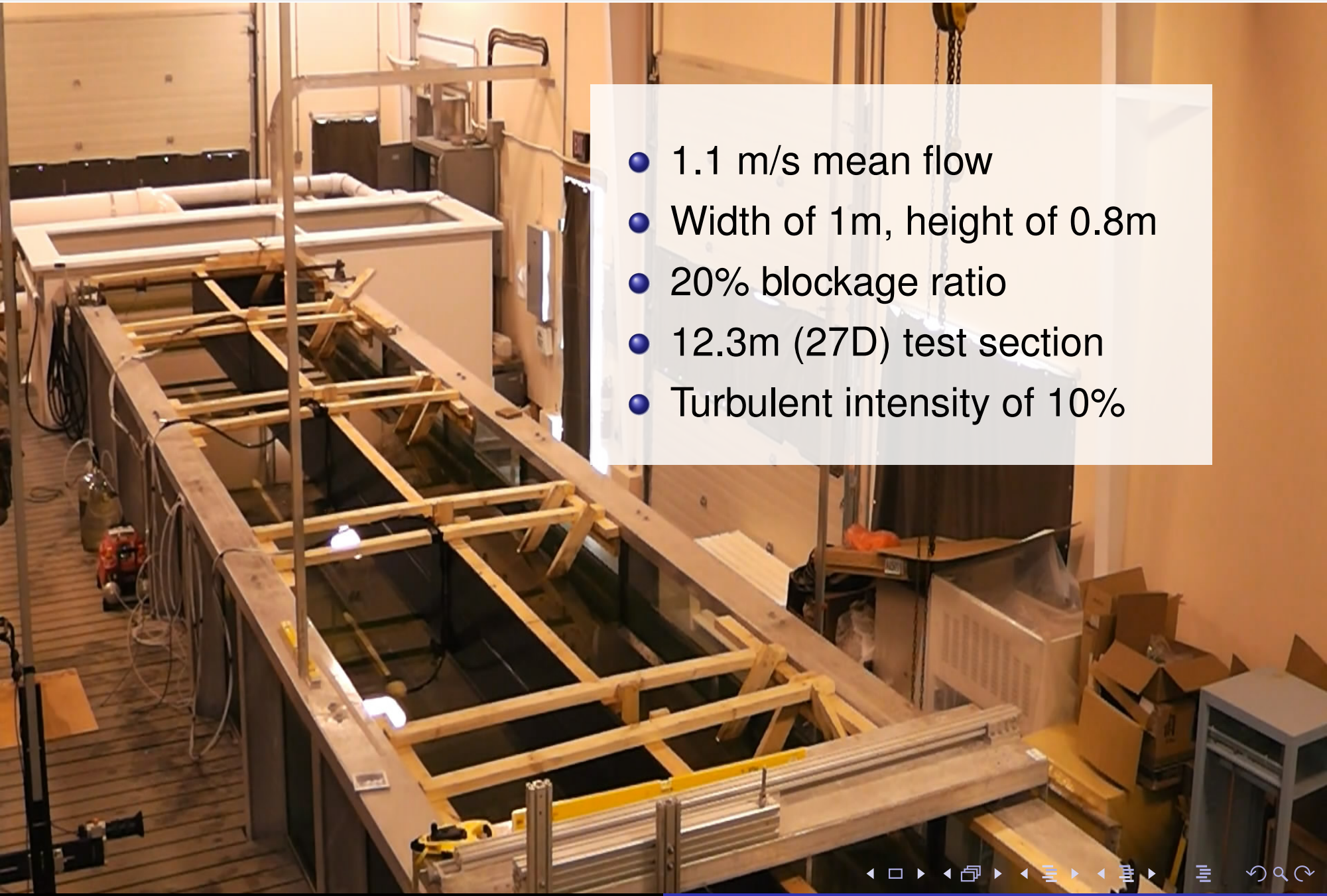
- Design and test a scale model turbine with similar performance characteristics to full scale
- Build a database of experimental results for model validation
- Explore the effect of spacing on turbine array performance and wake development
- What are the key properties of the flow that determine turbine performance?

Laboratory-scale turbine geometry

- Attempt to match power extraction and wake characteristics at scale, not geometry
- Maximize chord-based Reynolds number
- Choose foil to minimize Reynolds number effects
- Match performance and optimum tip speed ratio with blade-element-momentum design code

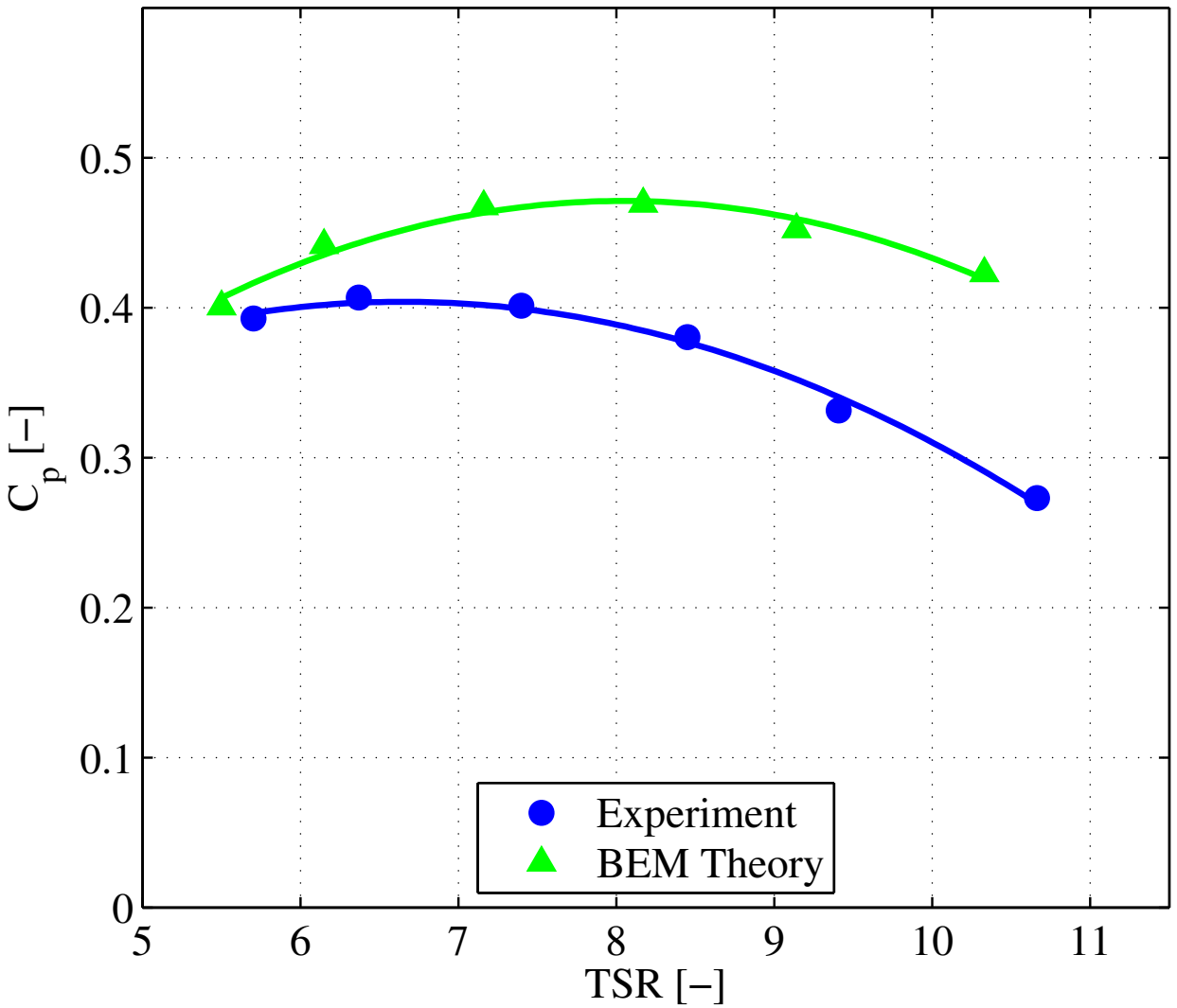
Laboratory-scale turbine

45 cm diameter rotor with the nacelle

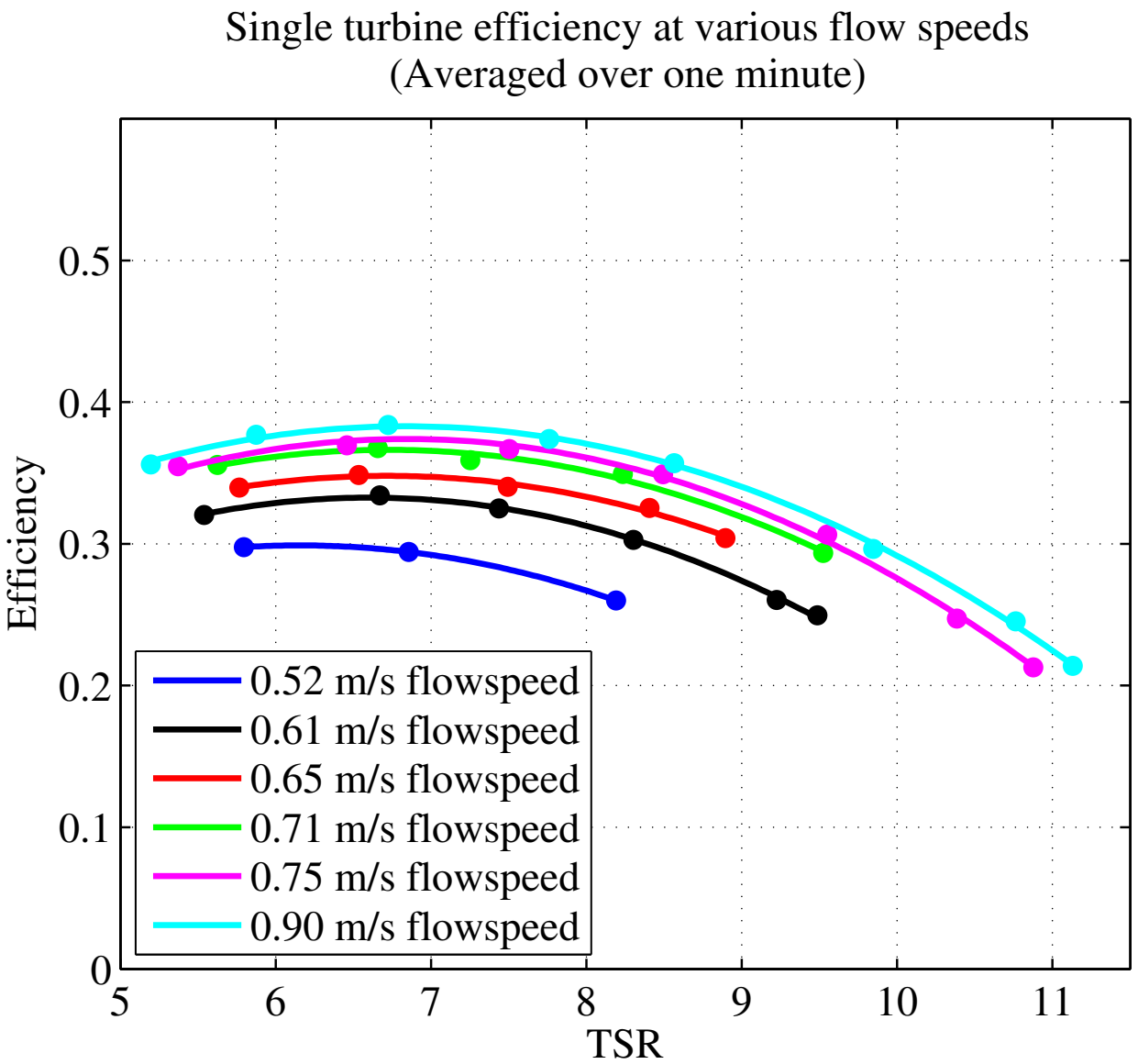


- 1.1 m/s mean flow
- Width of 1m, height of 0.8m
- 20% blockage ratio
- 12.3m (27D) test section
- Turbulent intensity of 10%

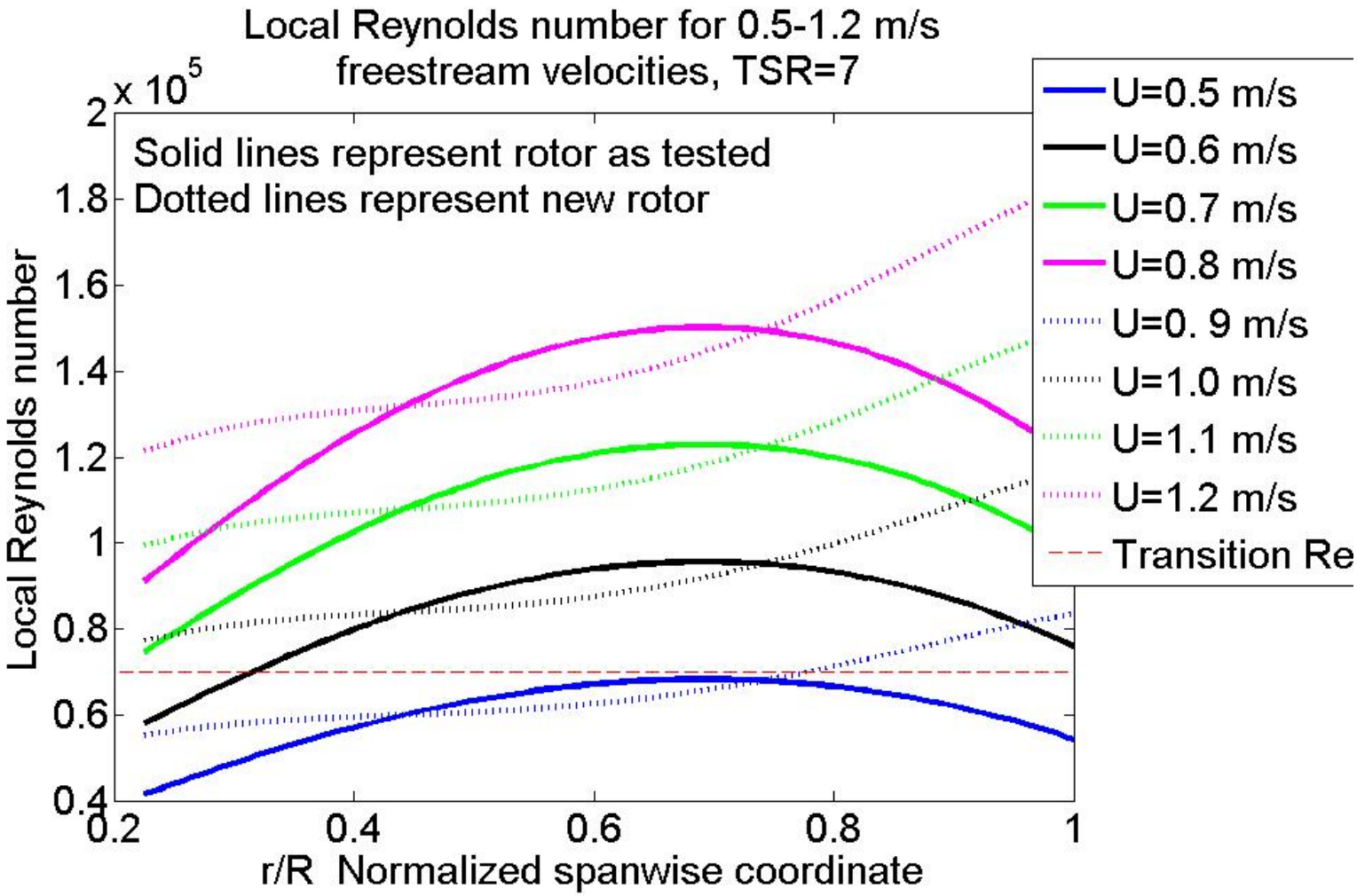
Single Turbine Performance



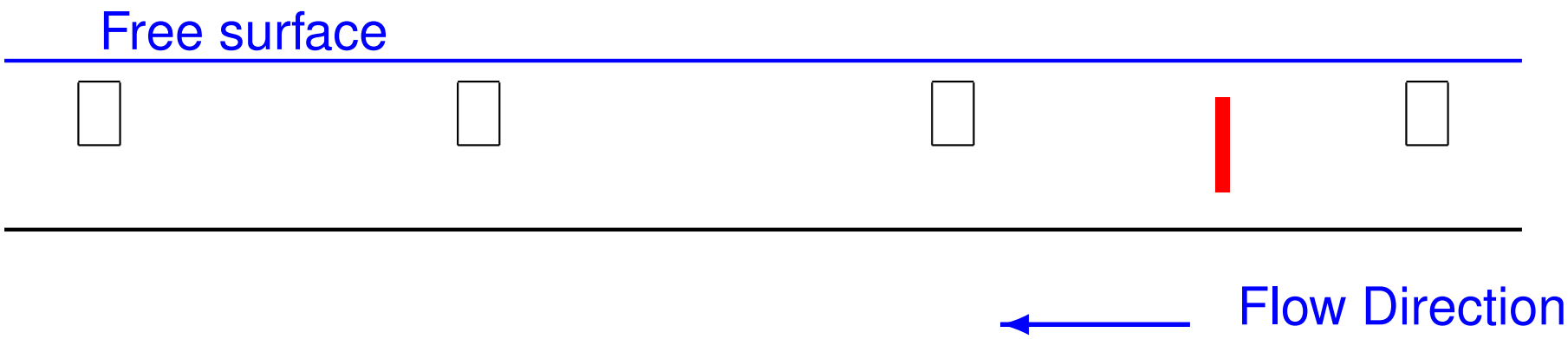
Reynolds number effects



Chord-based Reynolds numbers

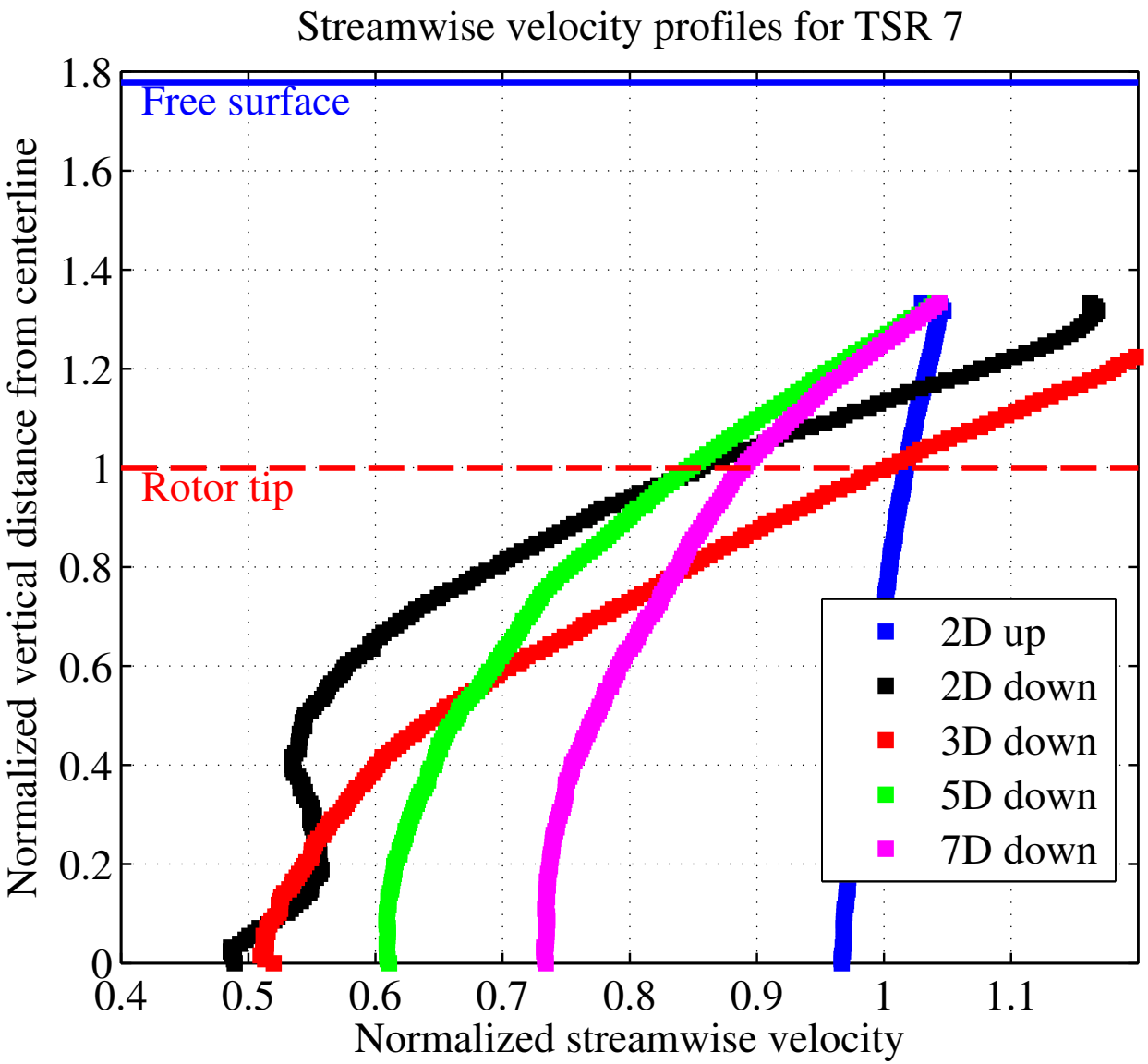


Flow measurement around a single turbine

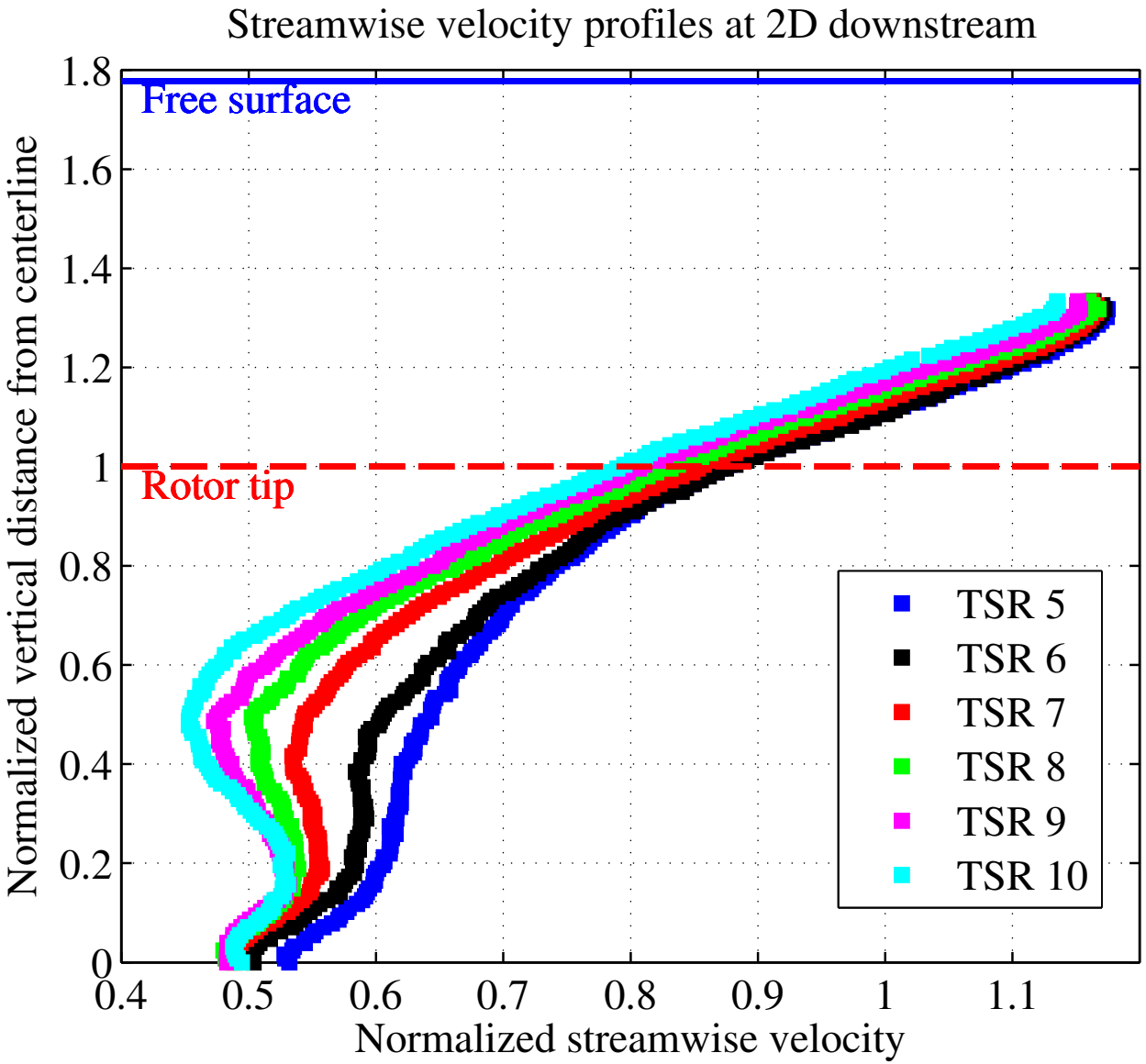


- Interrogation windows located on turbine axis
- Only upper half of water column
- FOV is 30 cm by 20 cm
- Image acquisition rate is 5 Hz

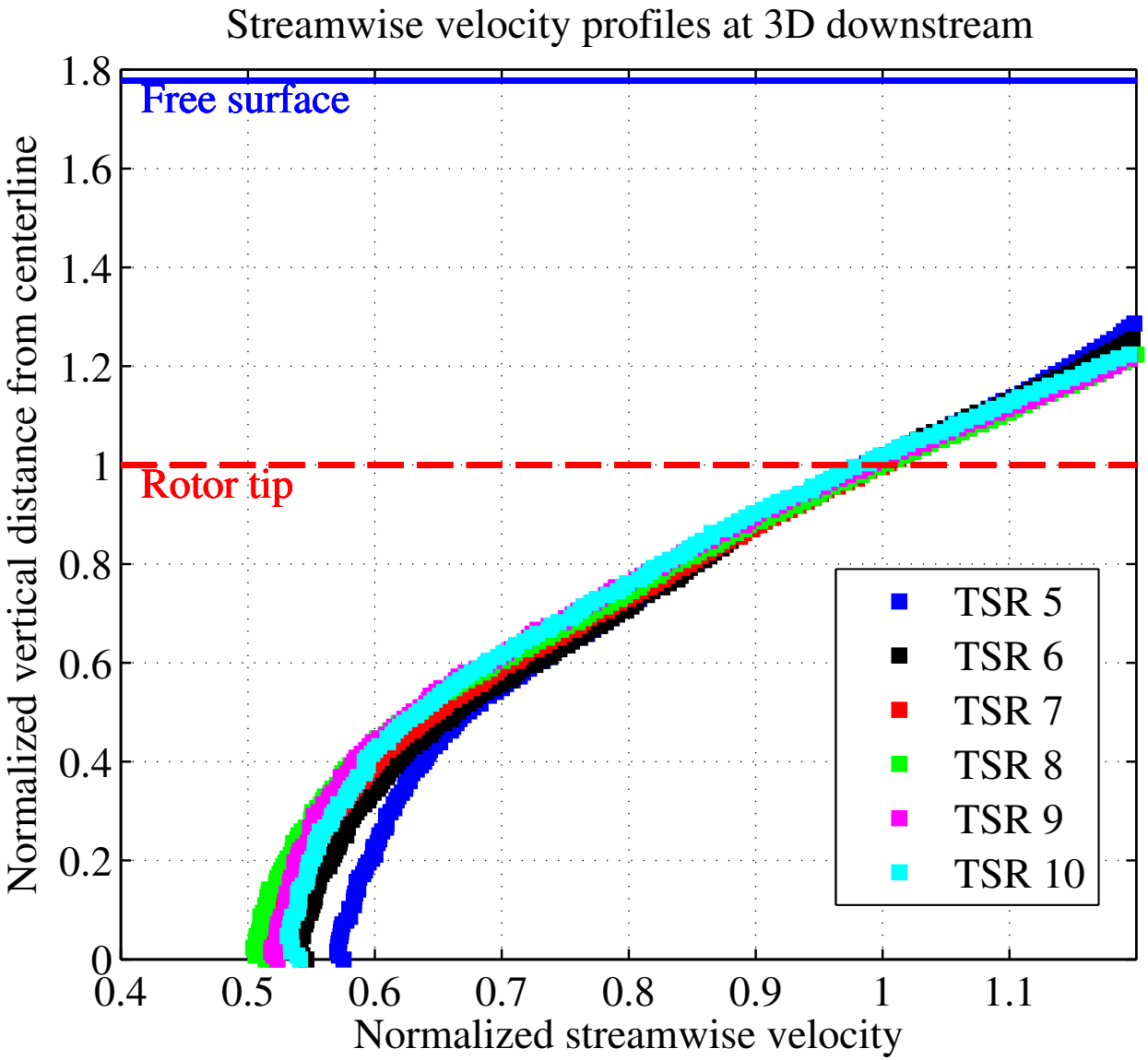
Mean velocity profiles



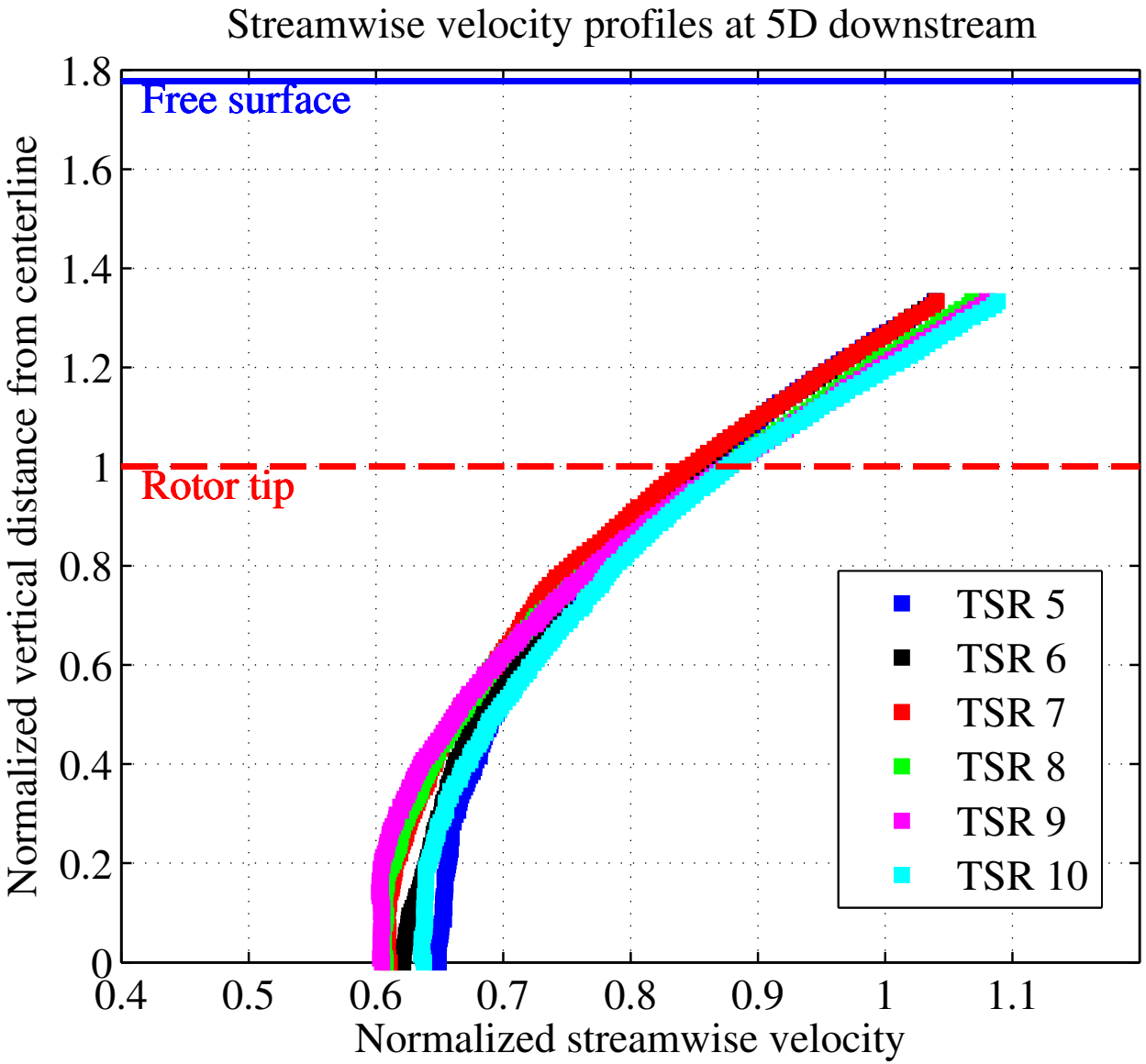
Mean velocity profiles at different TSR



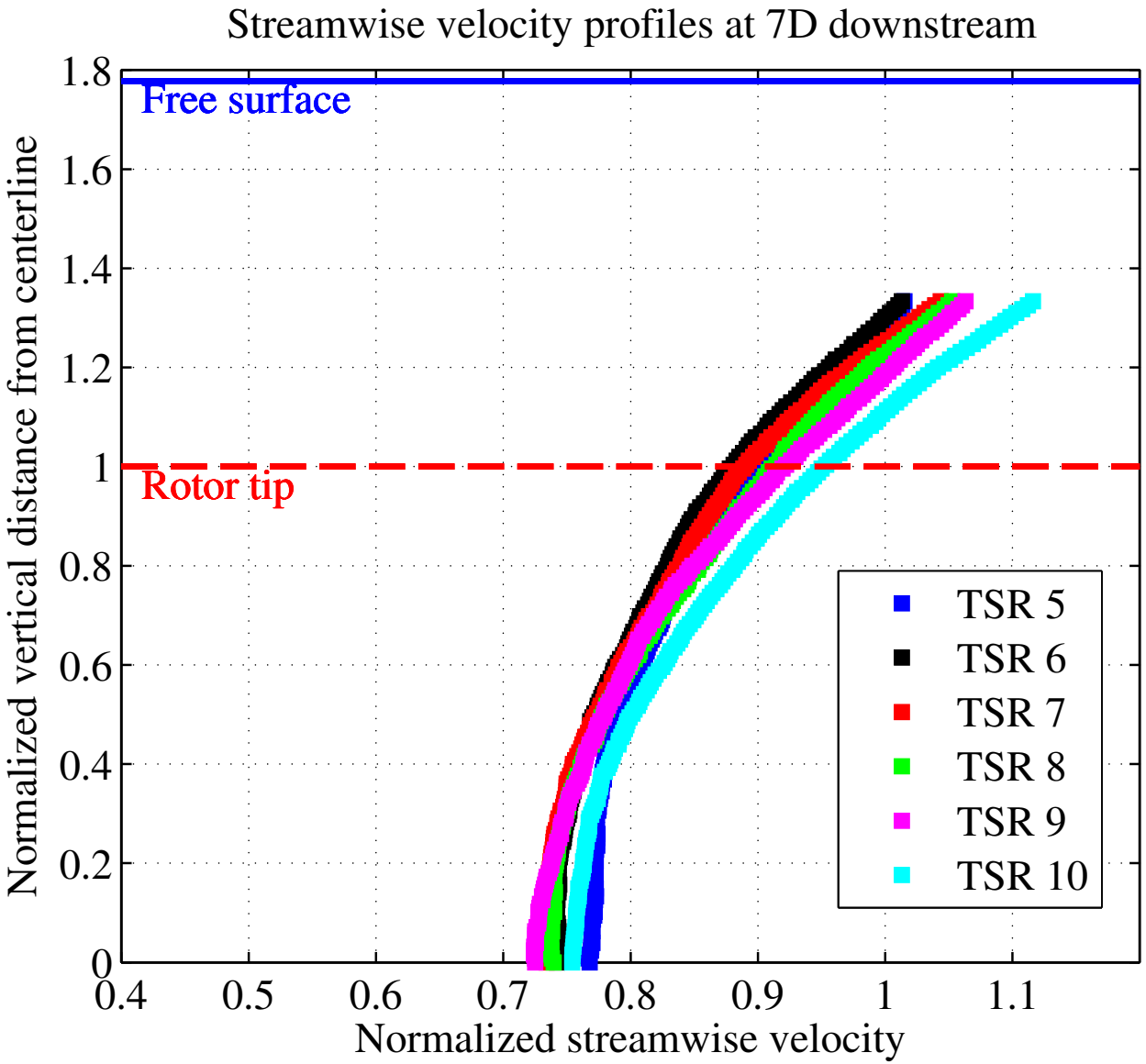
Mean velocity profiles at different TSR



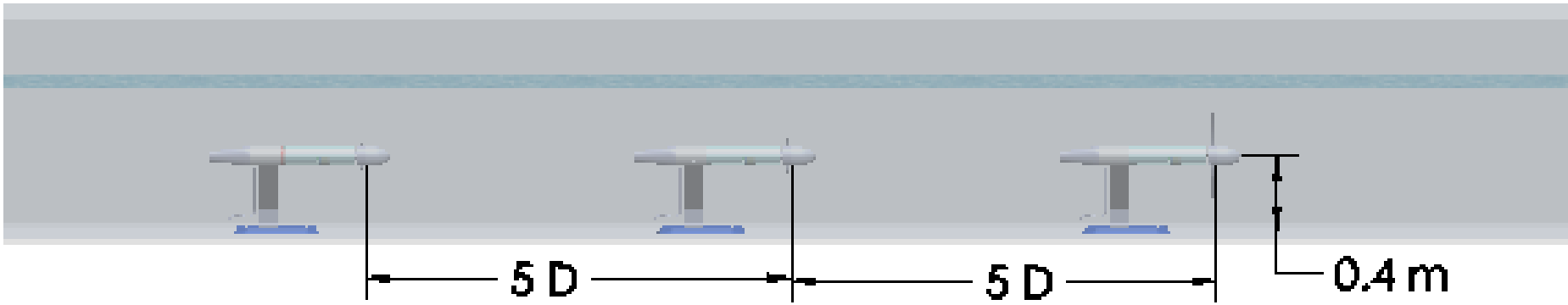
Mean velocity profiles at different TSR

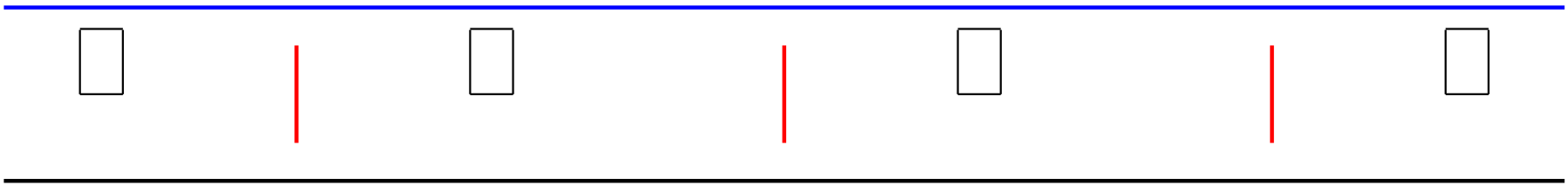


Mean velocity profiles at different TSR

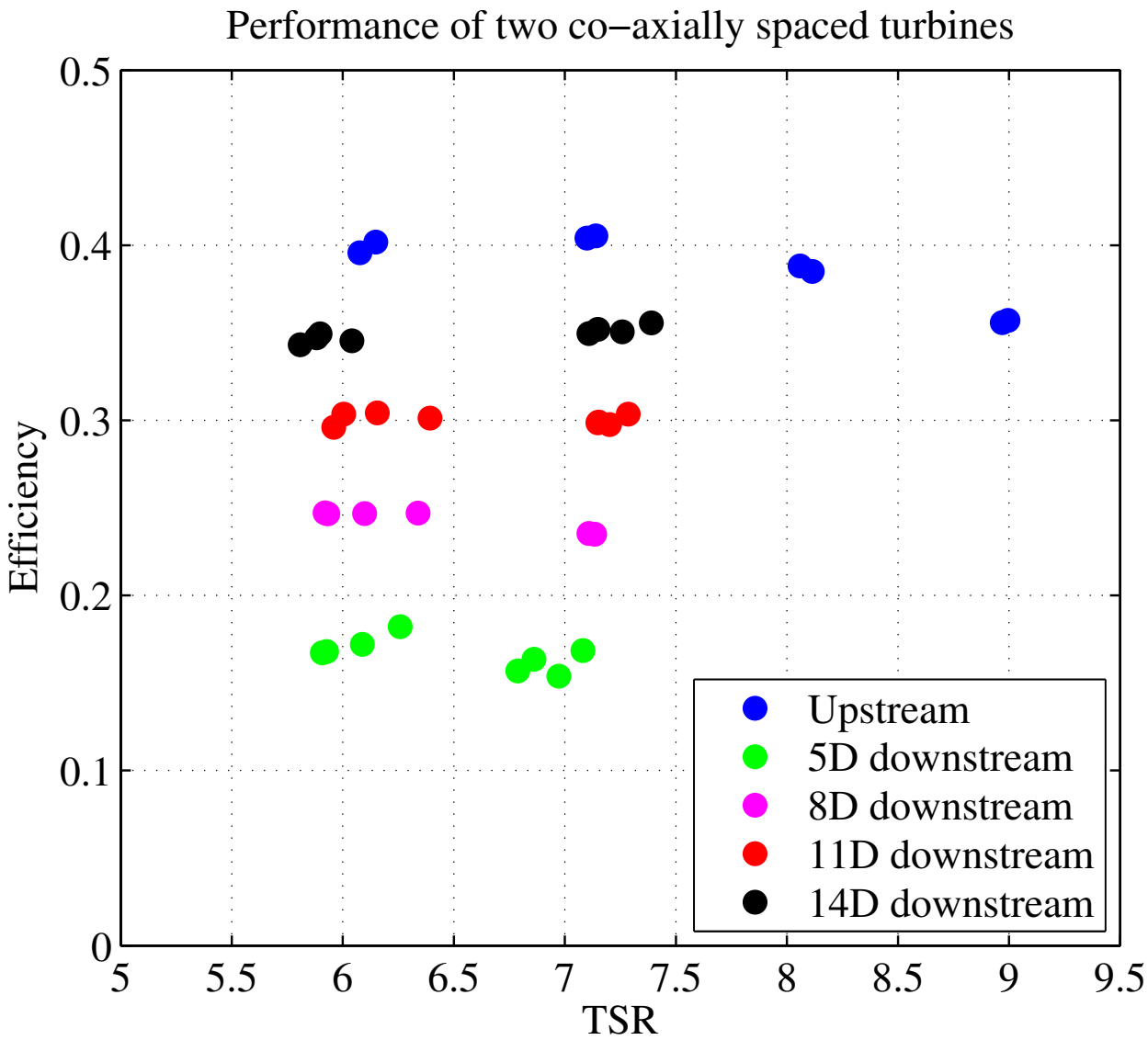


Turbine configuration

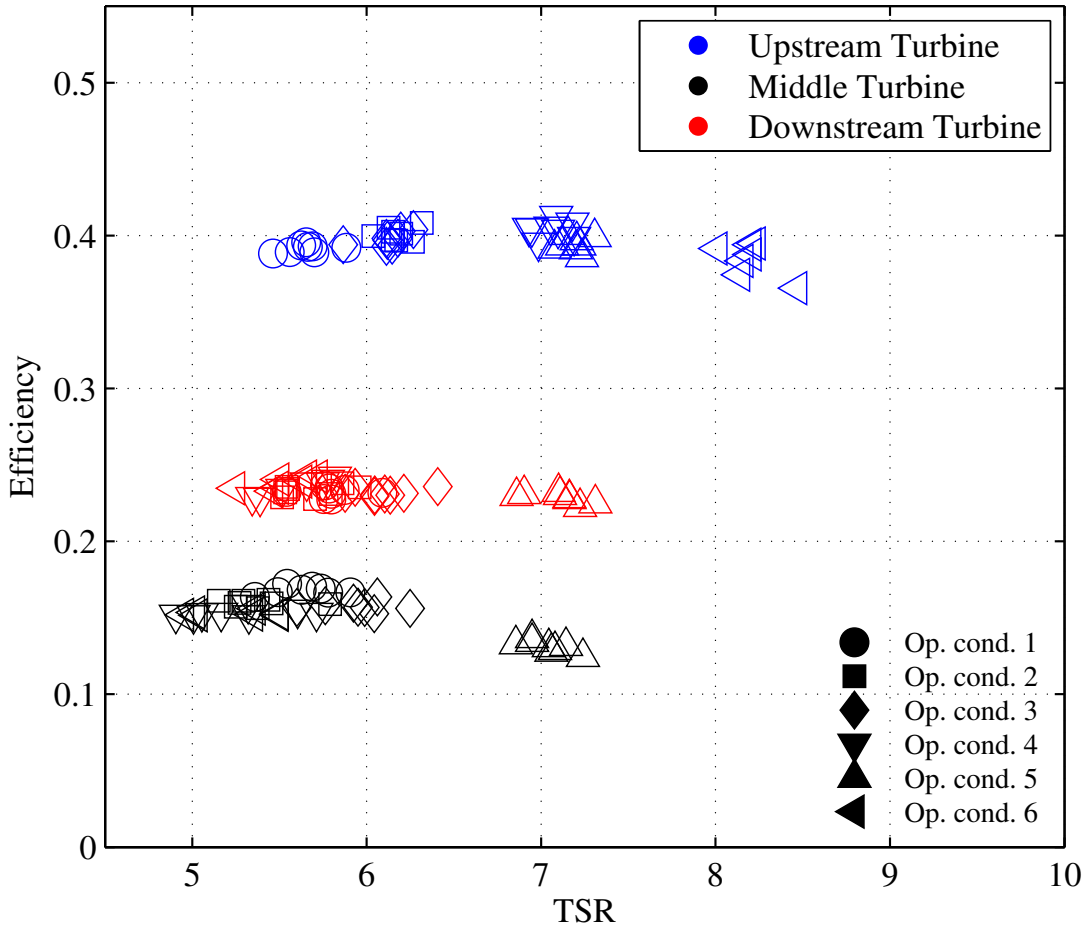




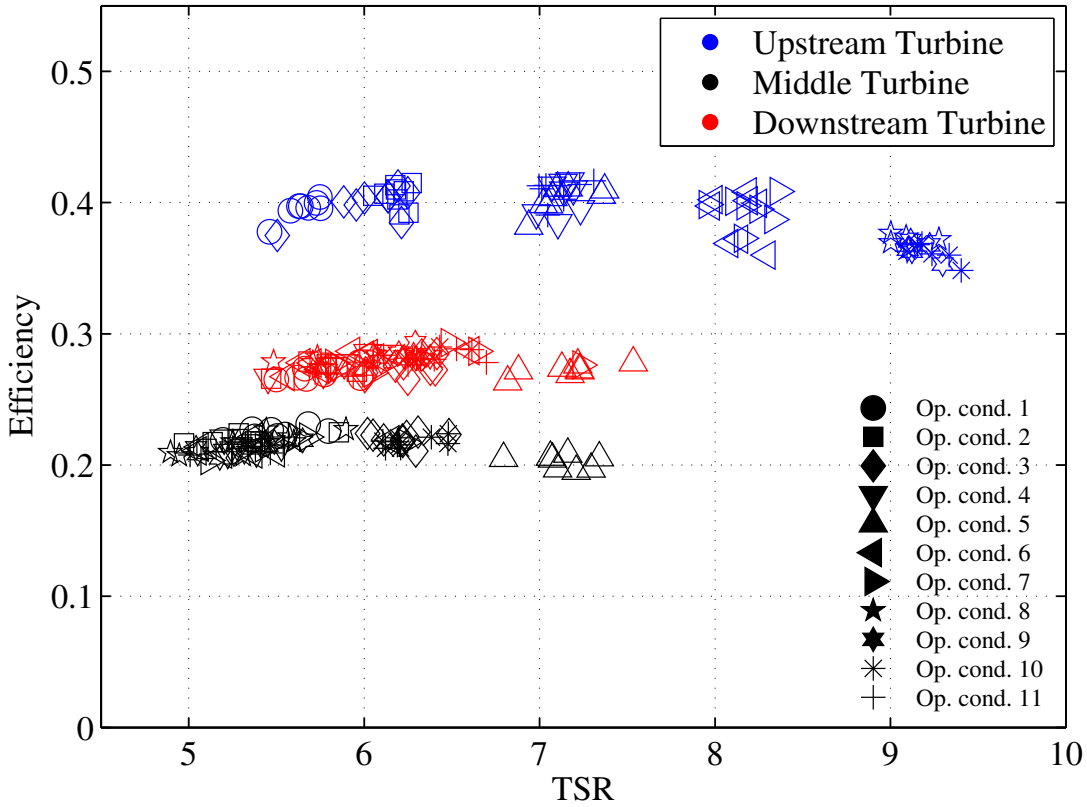
Two co-axial turbines at various spacing



Three turbines separated by 5 diameters co-axial



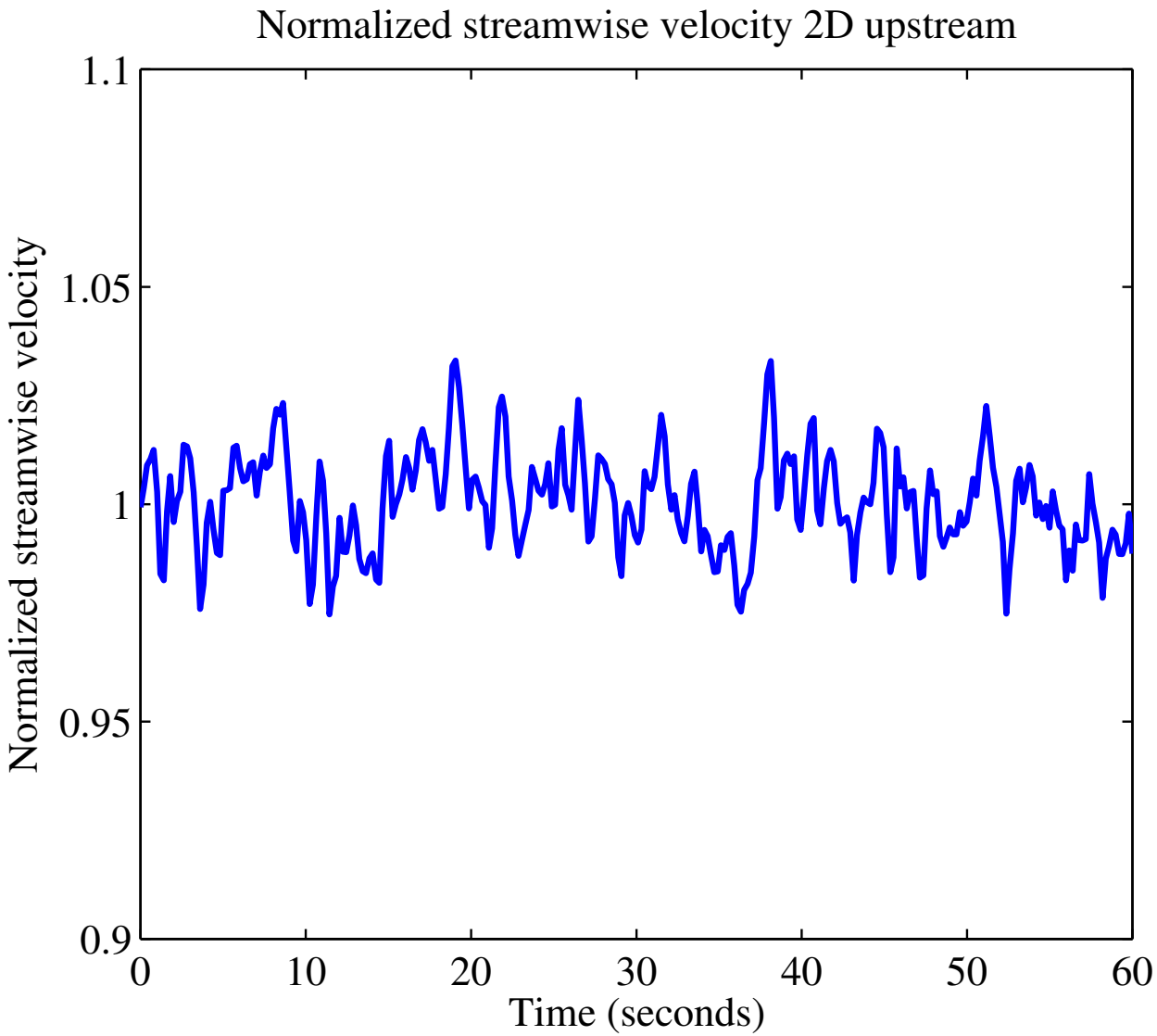
Three turbines separated by 7 diameters co-axial



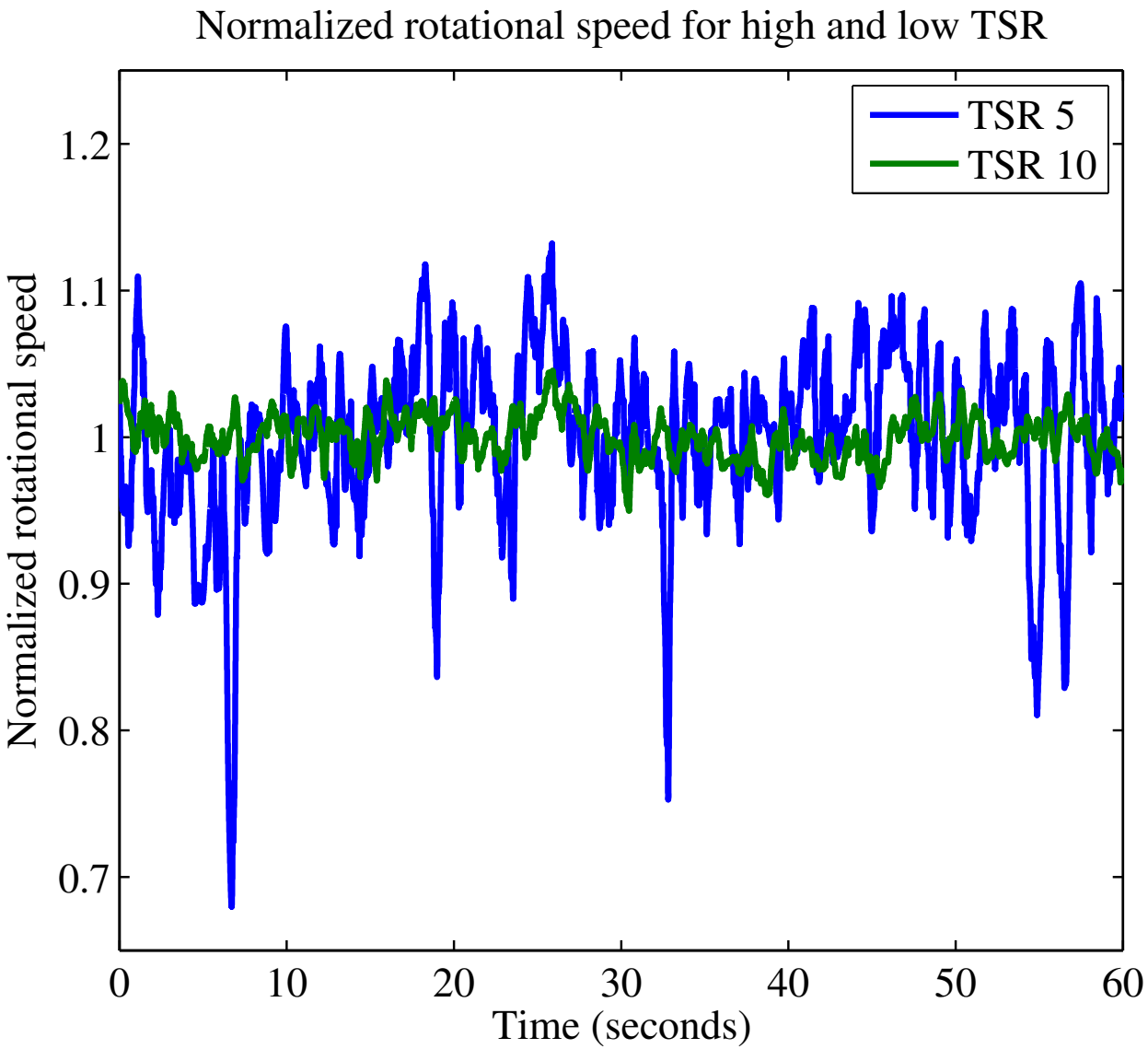
Summary

- A rotor was designed for laboratory-scale testing
- This rotor was tested as a single turbine and in configurations of two and three turbines
- The resulting dataset is being used to validate numerical models

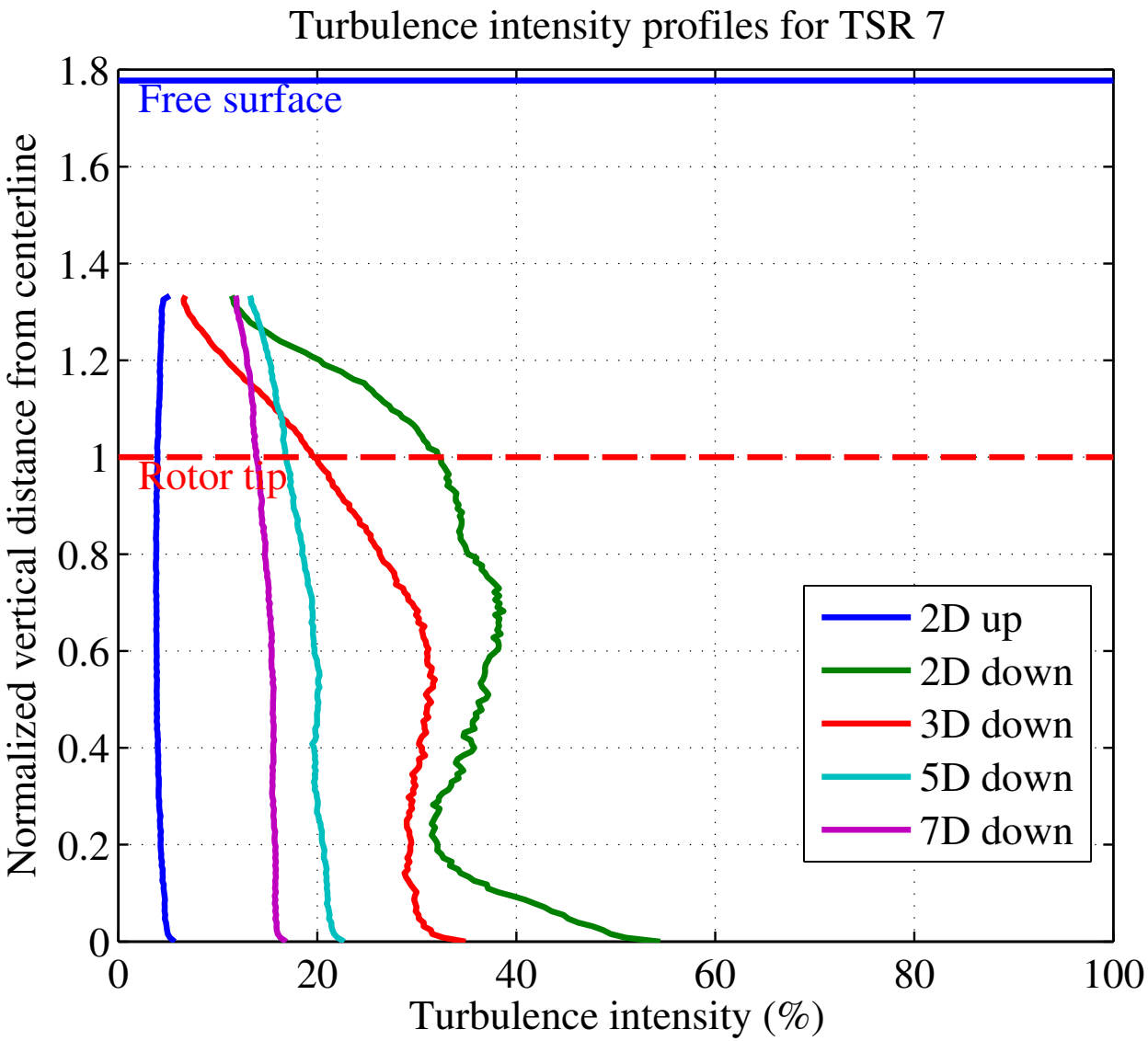
Freestream variability



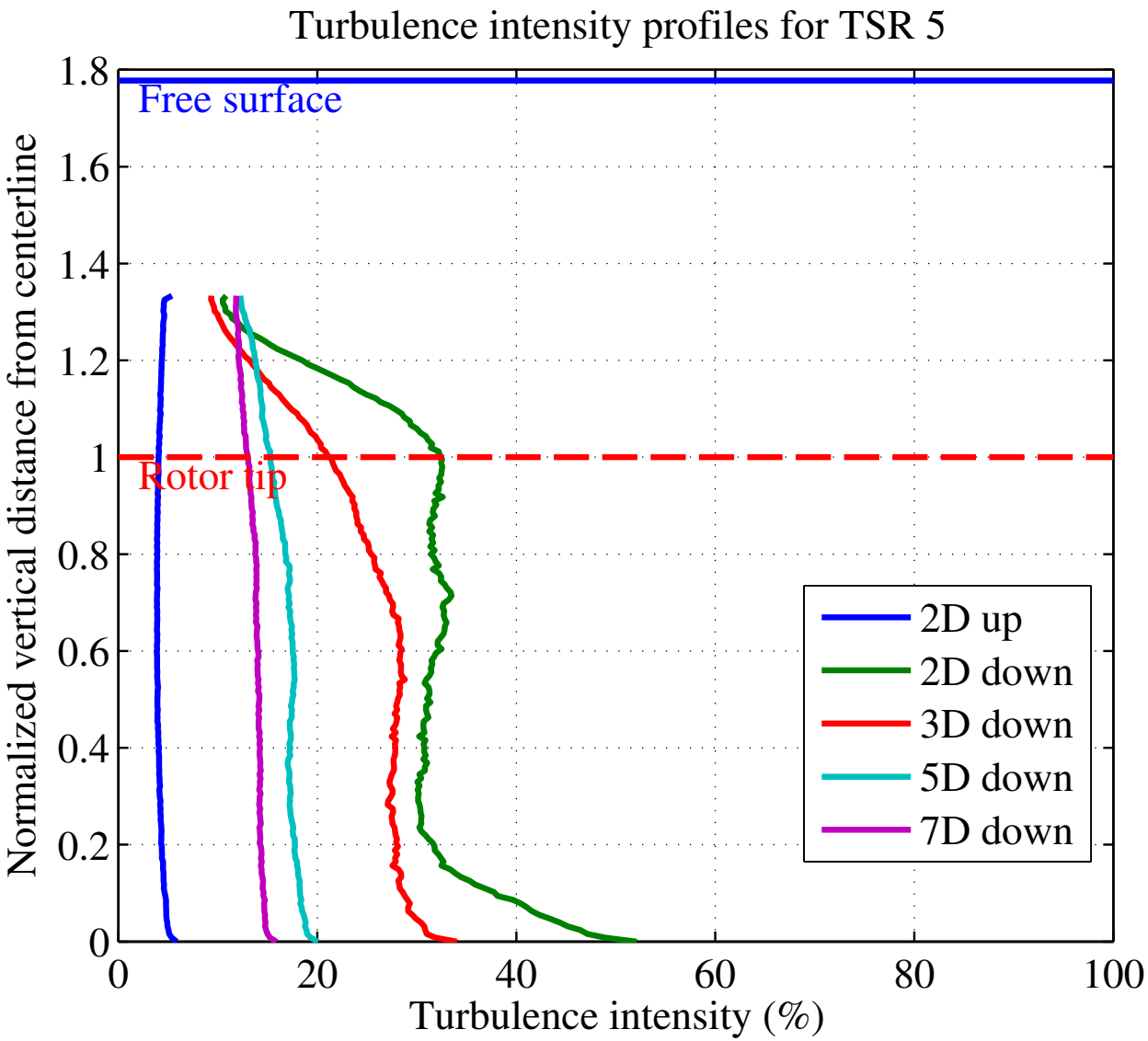
TSR variability



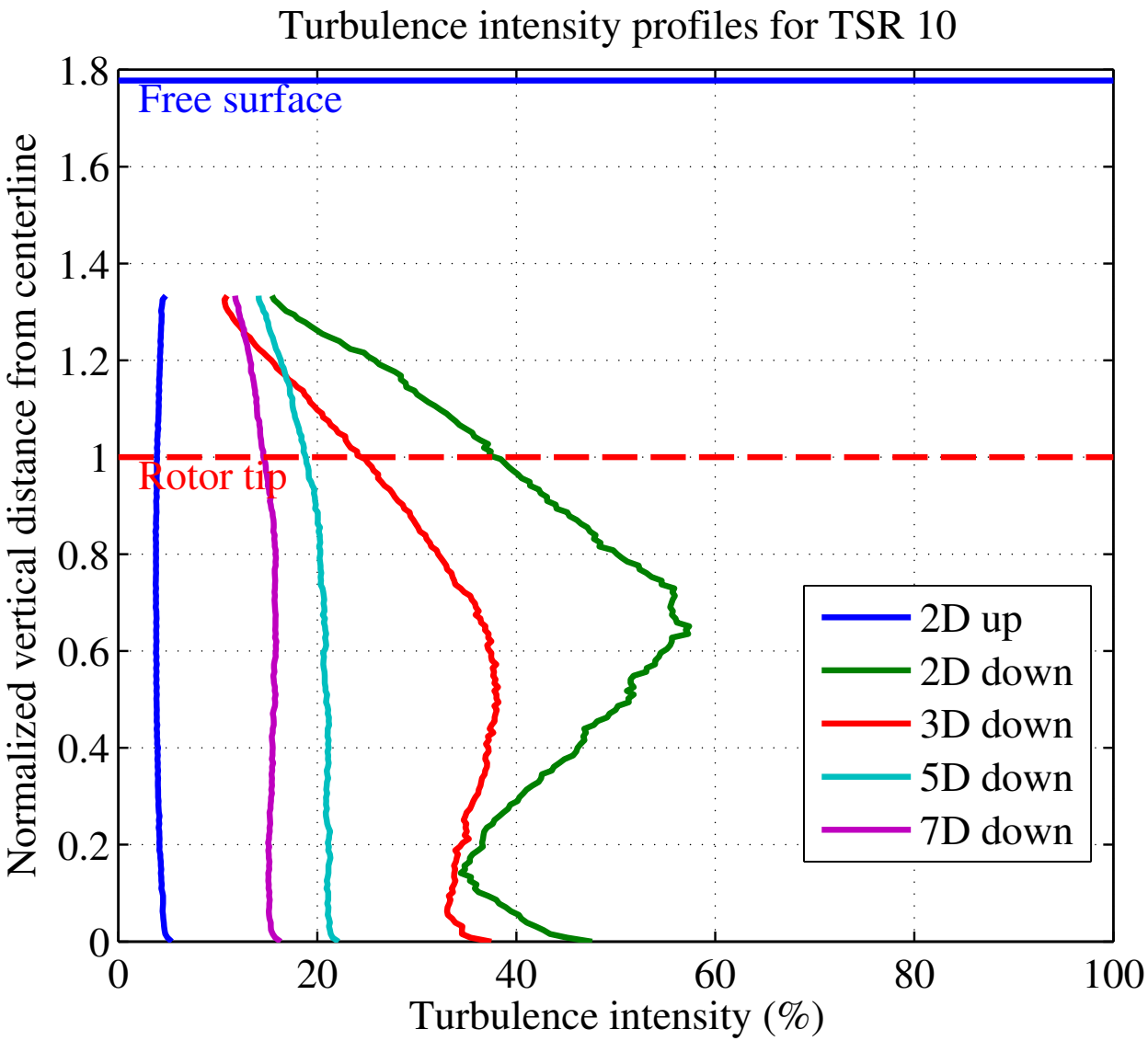
Turbulence intensity profiles



Turbulence intensity profiles

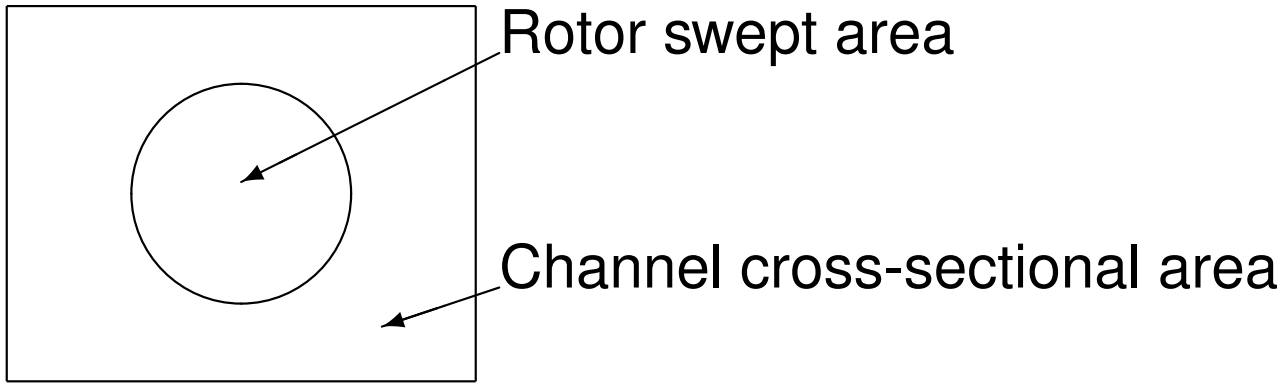


Turbulence intensity profiles



Blockage Effects

$$\text{Blockage ratio} = \frac{\text{swept area of rotor}}{\text{channel cross-sectional area}} = 20\%$$



- Blockage increases turbine performance
- Blockage restricts wake expansion
- Blockage effects are dependent of freestream velocity (Optimum TSR shifting)
- Blockage correction methods are not settled