Numerical / Experimental Comparison of a Scaled Model Horizontal Axis Marine Hydrokinetic (MHK) Turbine

Teymour Javaherchi, Nick Stelzenmuller

Joseph Seydel and Alberto Aliseda

Northwest National Marine Renewable Energy Center
University of Washington

APS – DFD 2013

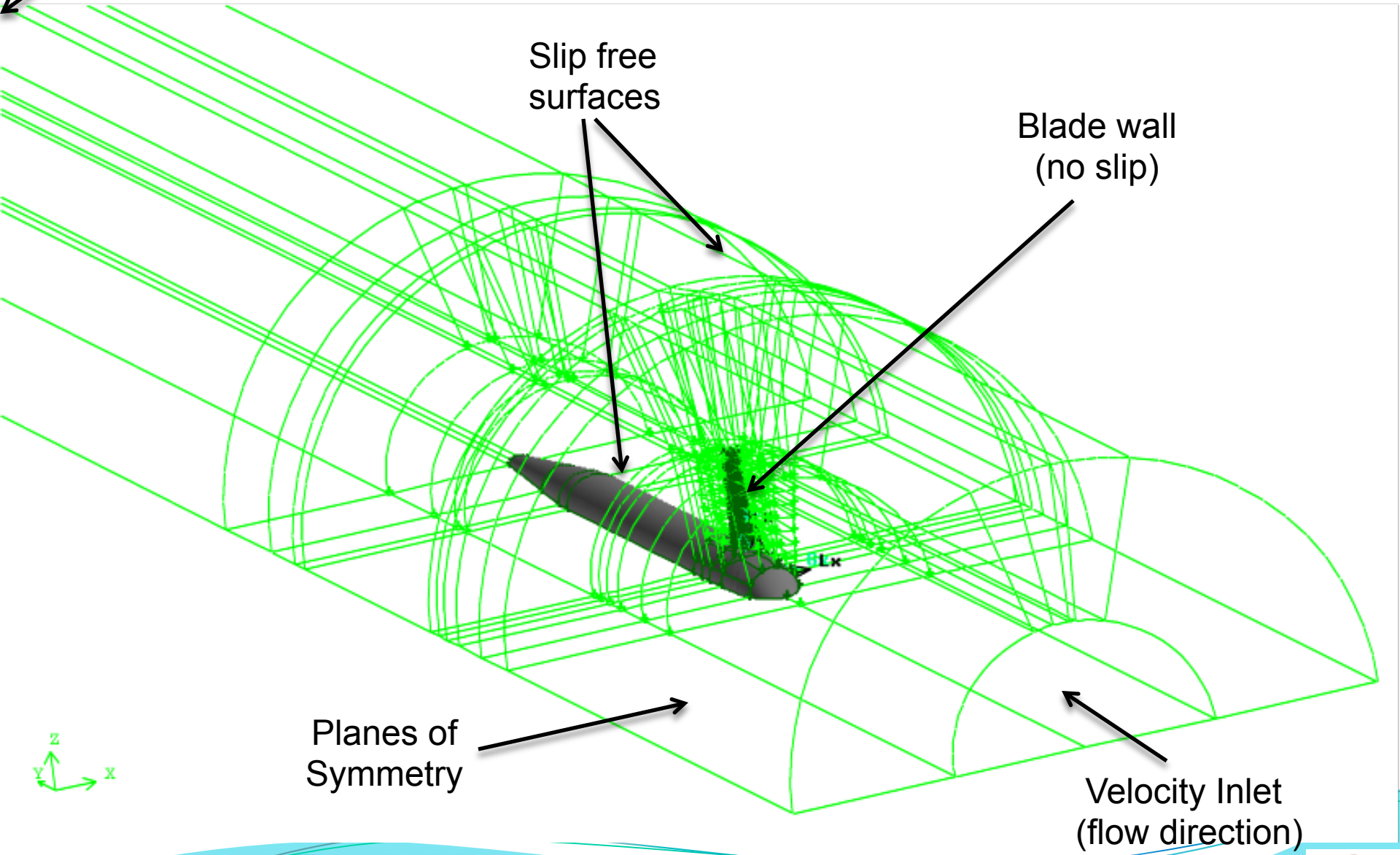
Motivations & Goals

- Need for an experimental database to benchmark numerical methodologies to model MHK turbines.
- Understand the trade offs in numerical models to simulate the flow field of MHK turbines.
- Develop a validated numerical methodology to support design of full-scale horizontal axis MHK turbines.

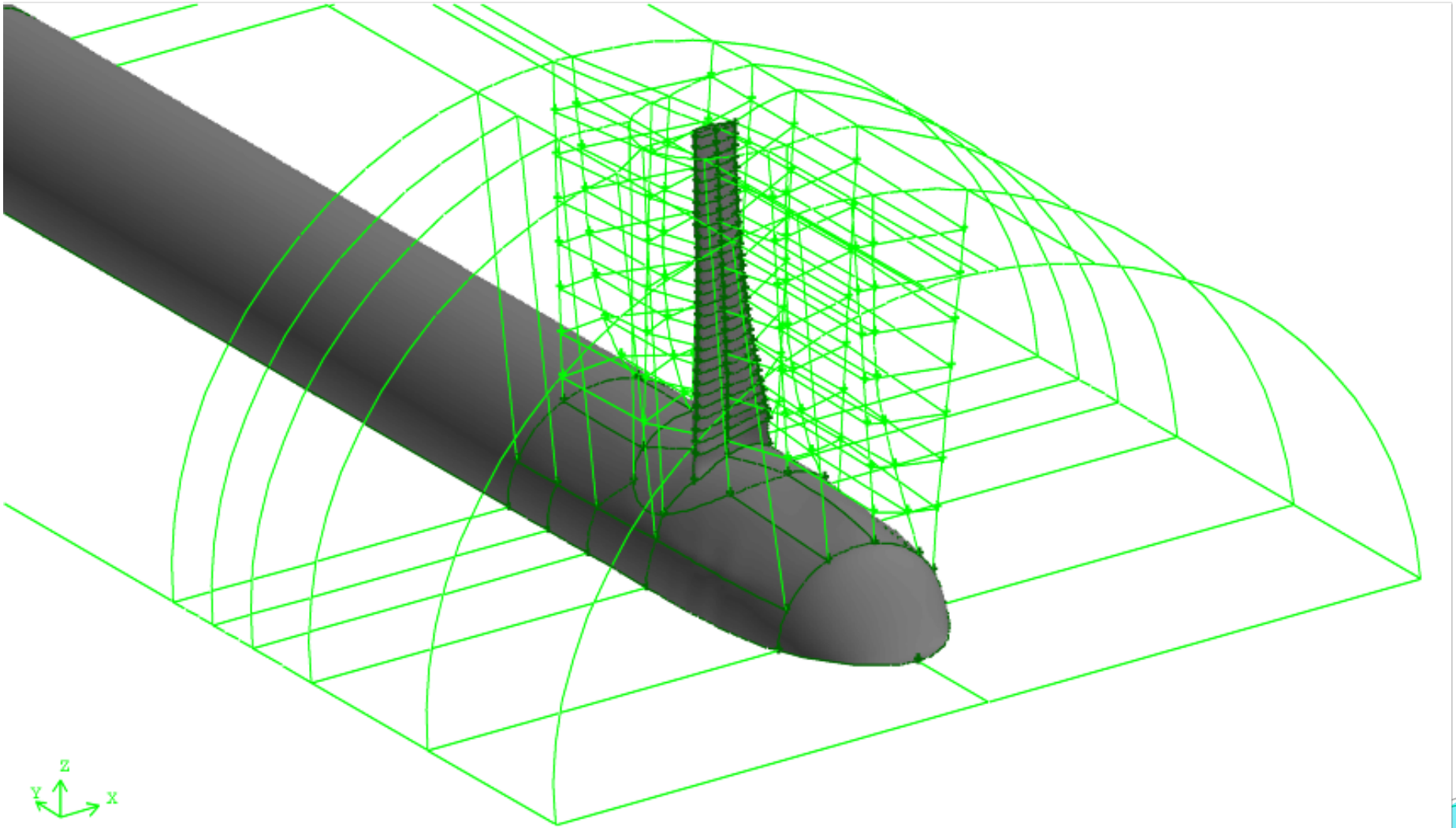
Numerical Methodology

1. Sliding Mesh Model
2. Rotating Reference Model
3. Blade Element Theory
4. Actuator Disk Theory

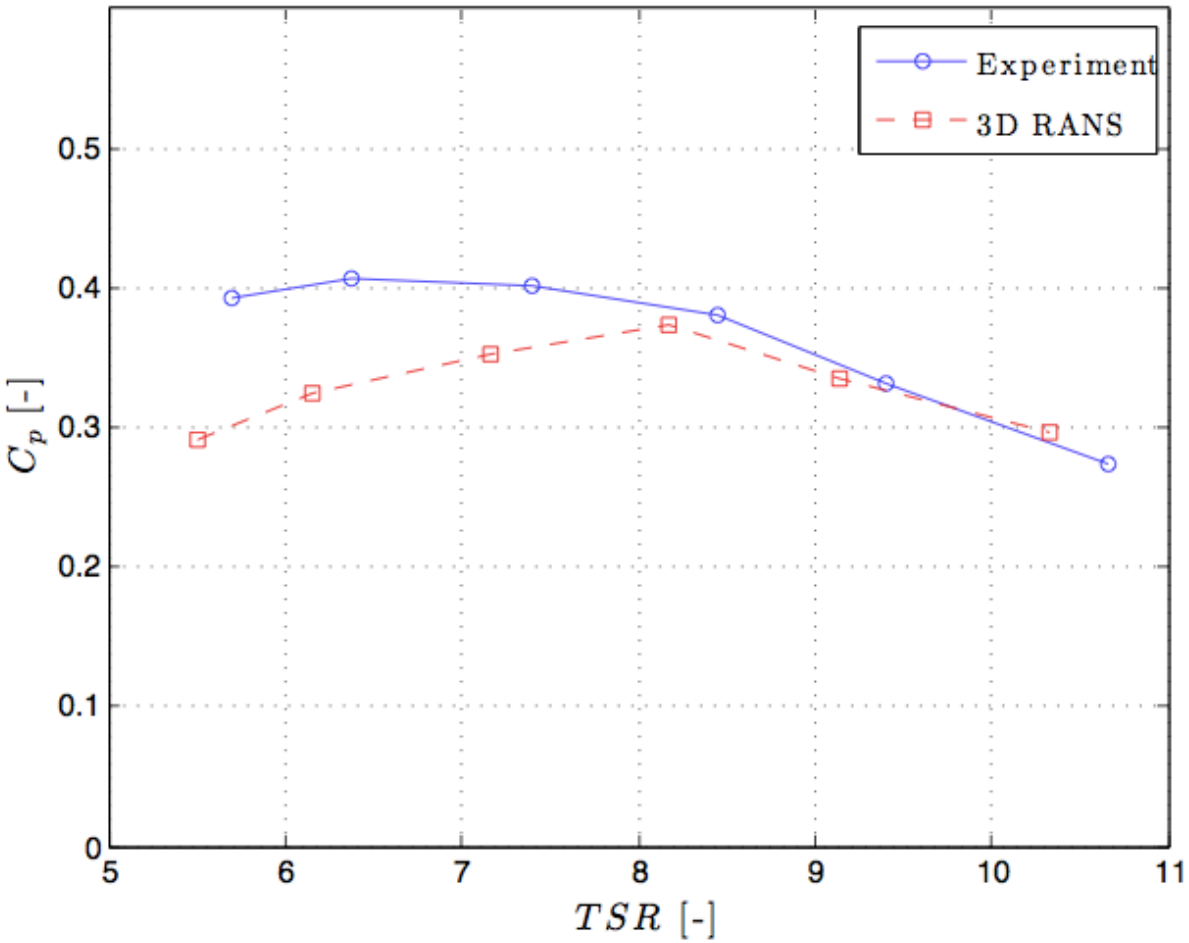
Computational Domain



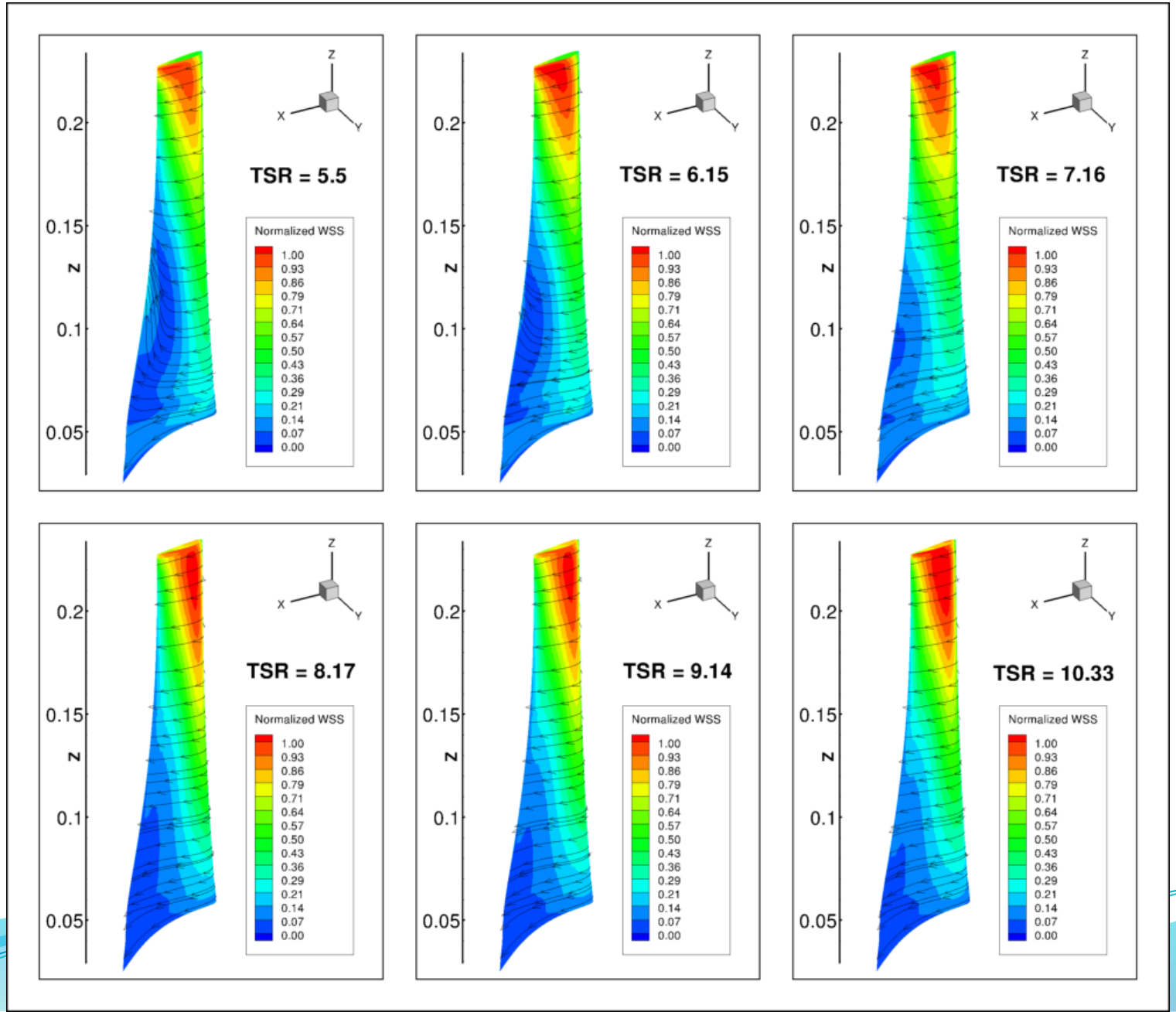
Rotating Reference Frame Model
Computational Domain (Zoomed-in)



Numerical vs. Experimental Results
Efficiency (C_p) – Tip Speed Ratio (TSR) Curves



Limited Streamlines + Wall Shear Stress along the Blade



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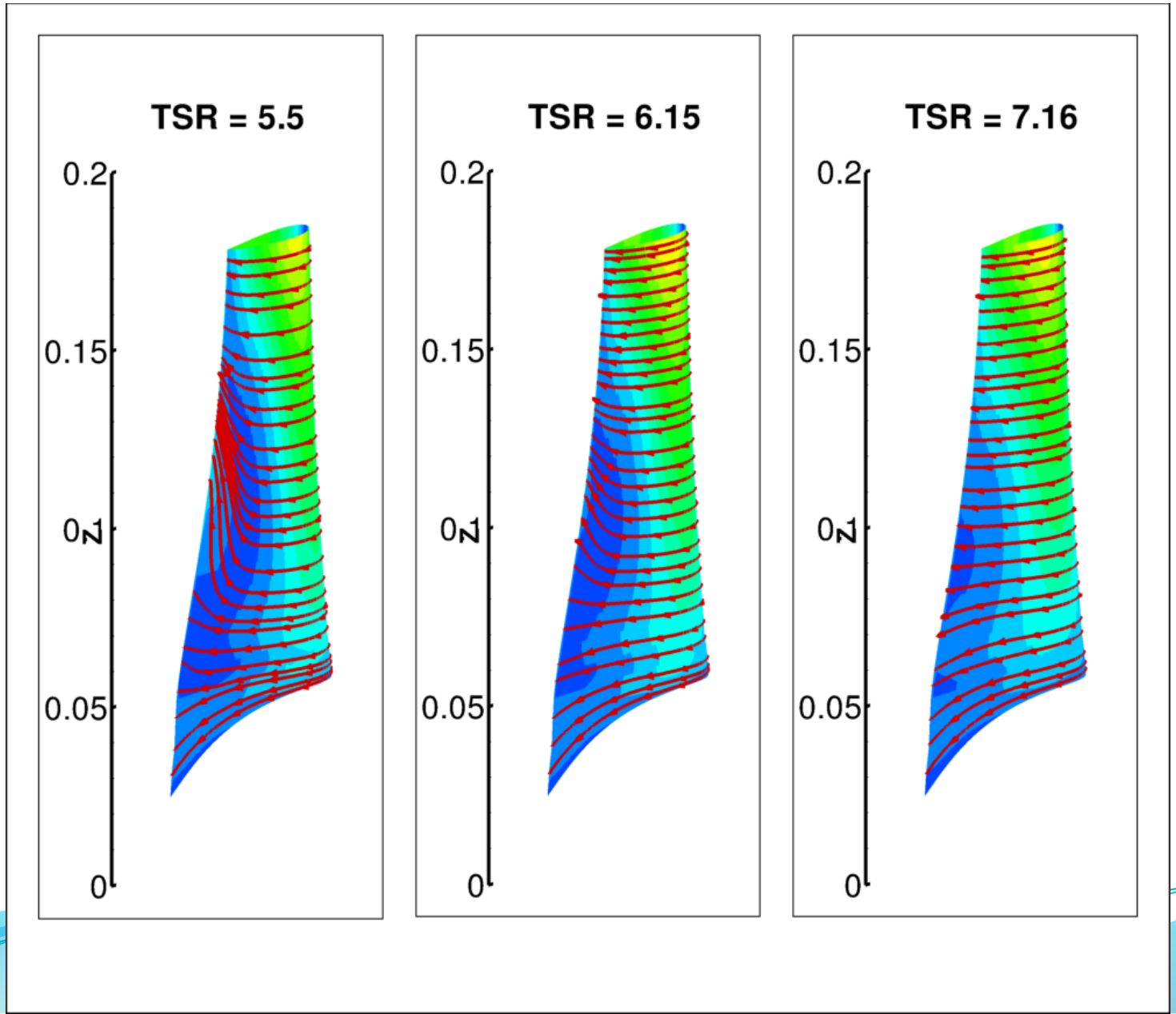

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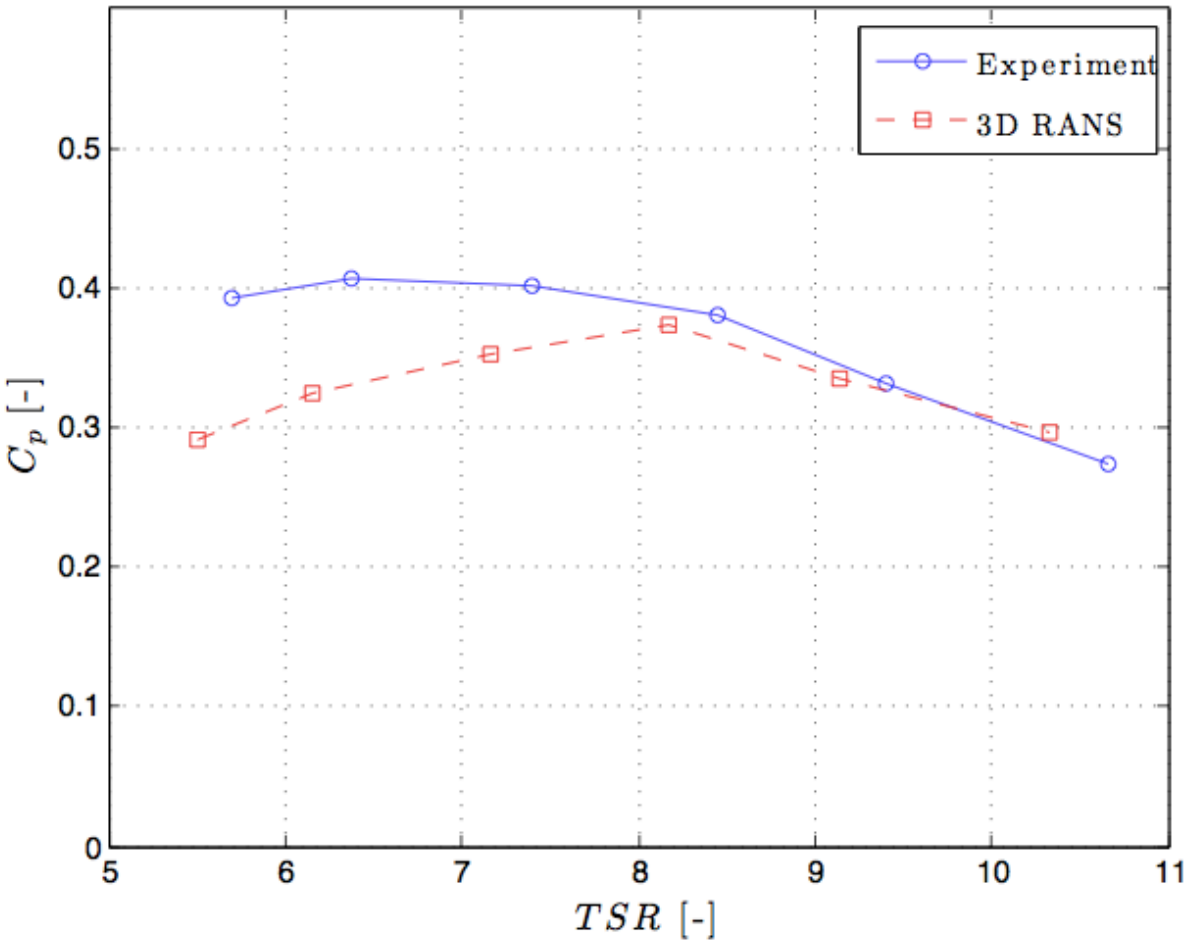
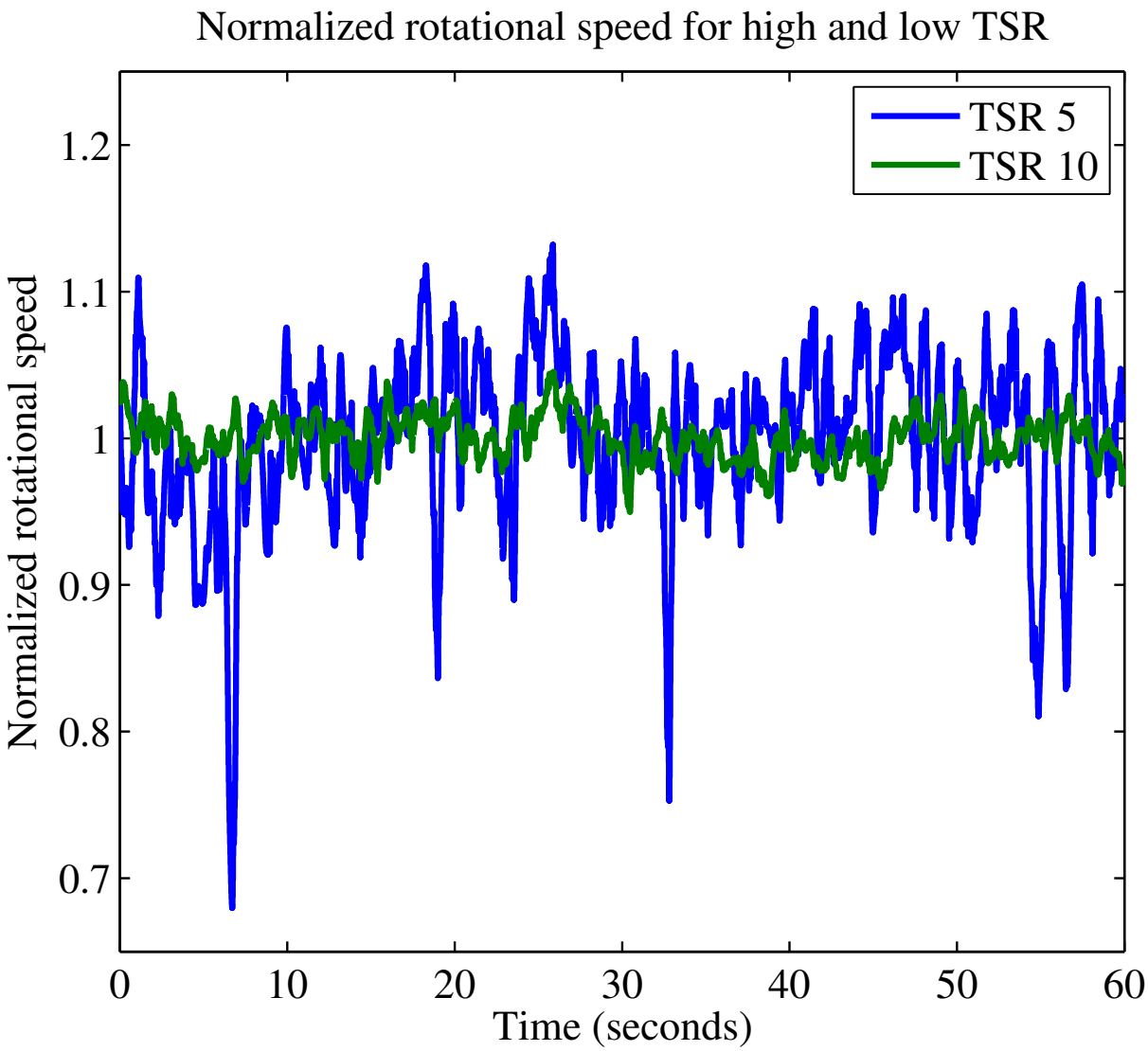


Dynamic Fluctuations in Experiment at Low TSRs



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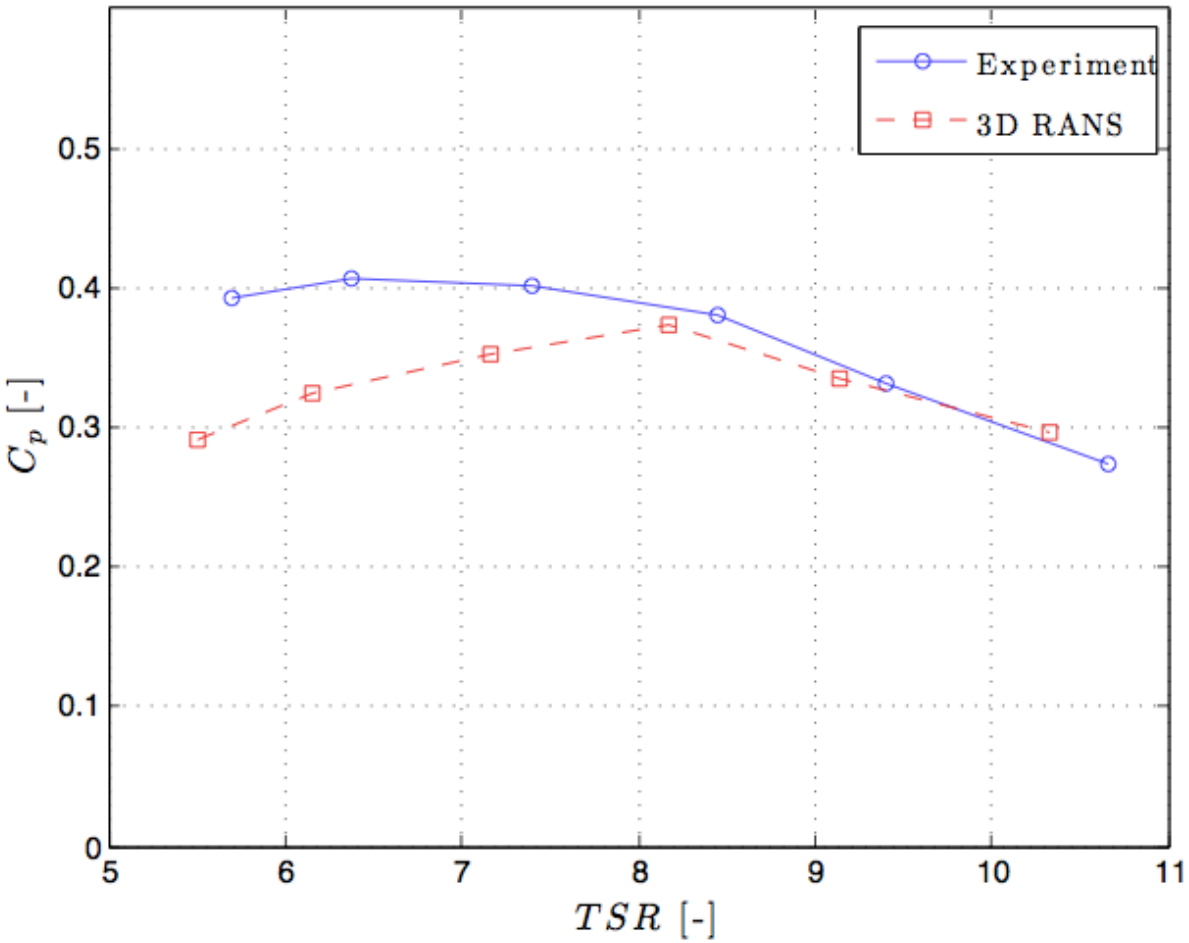
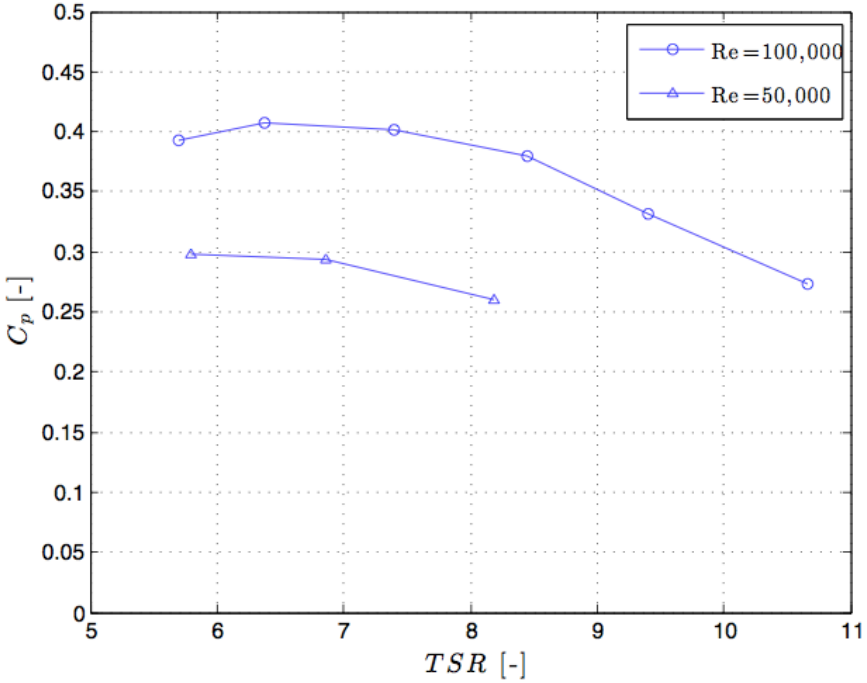
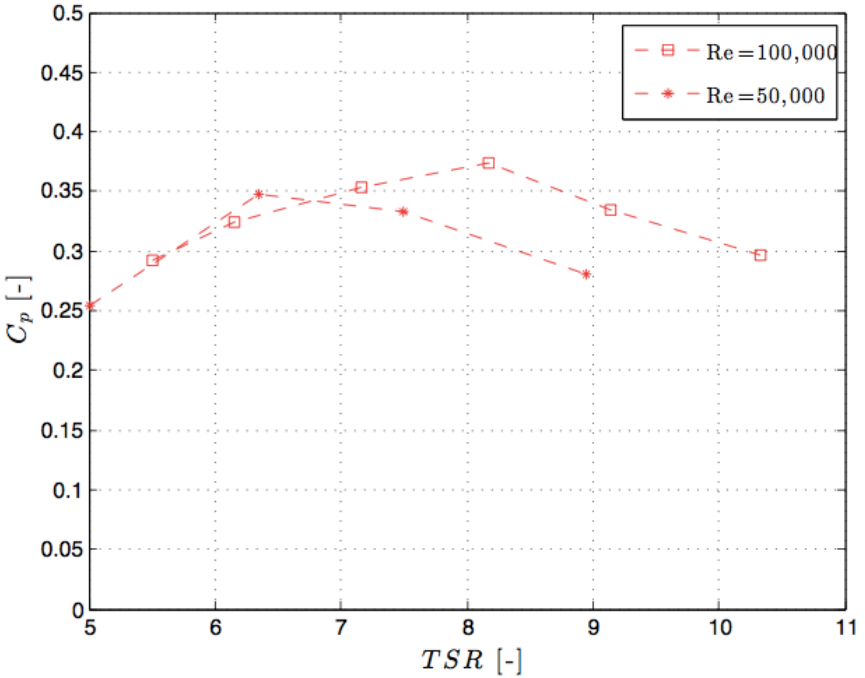
Efficiency (C_p) – Tip Speed Ratio (TSR) Curves



Numerical vs. Experimental Results
Reynolds Number Effect





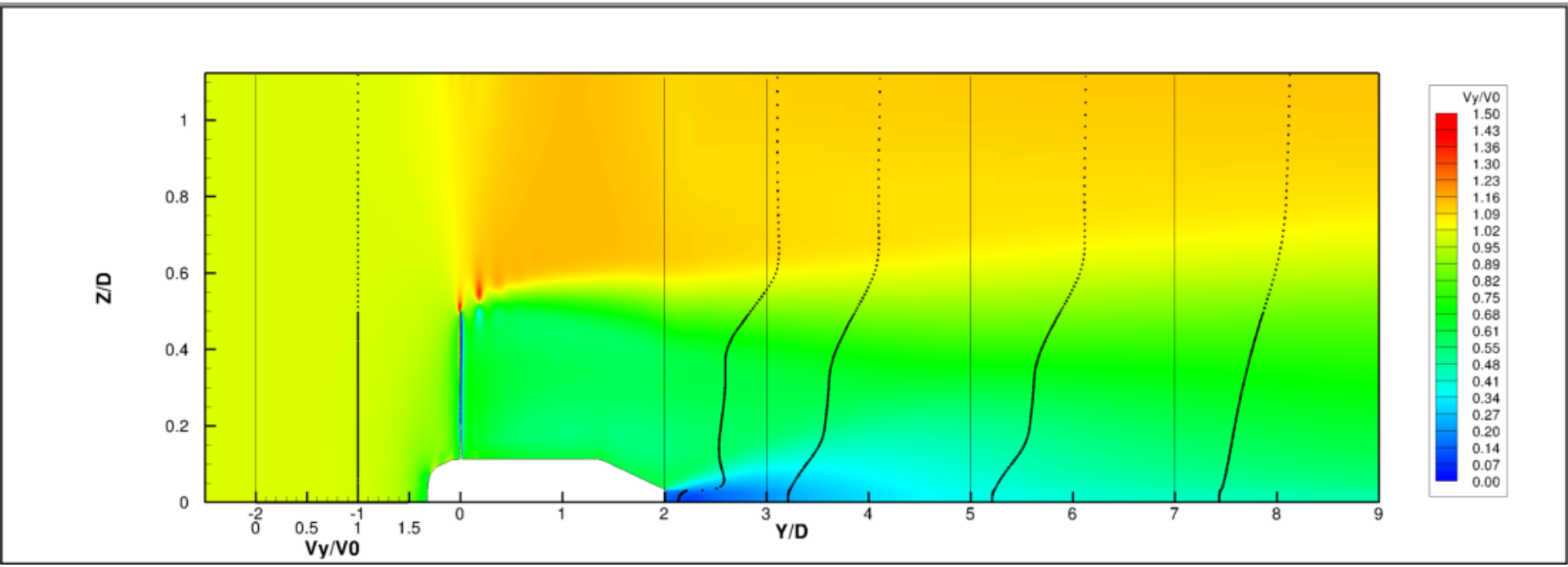
Experimental

Numerical

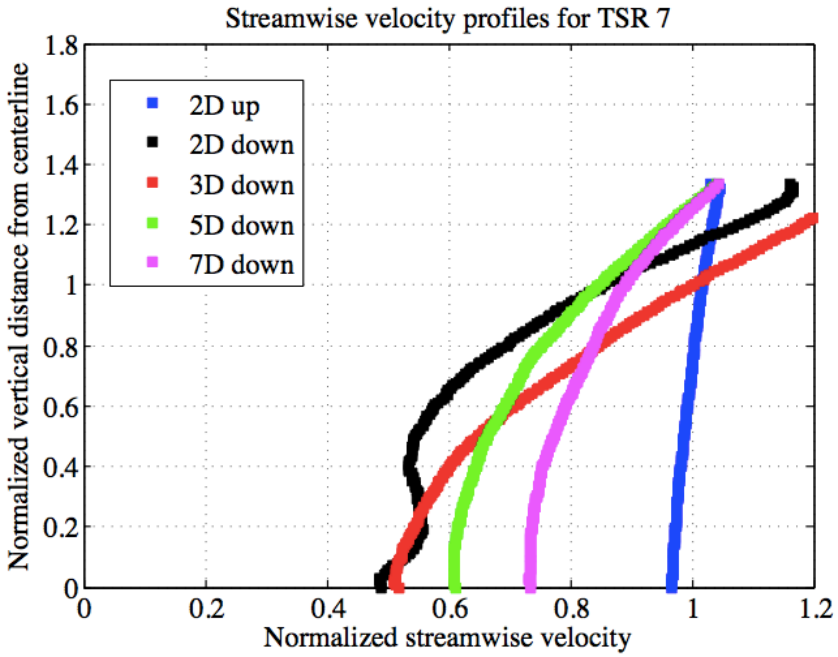
Numerical vs. Experimental Results Sliding Mesh Model – TSR=8.17

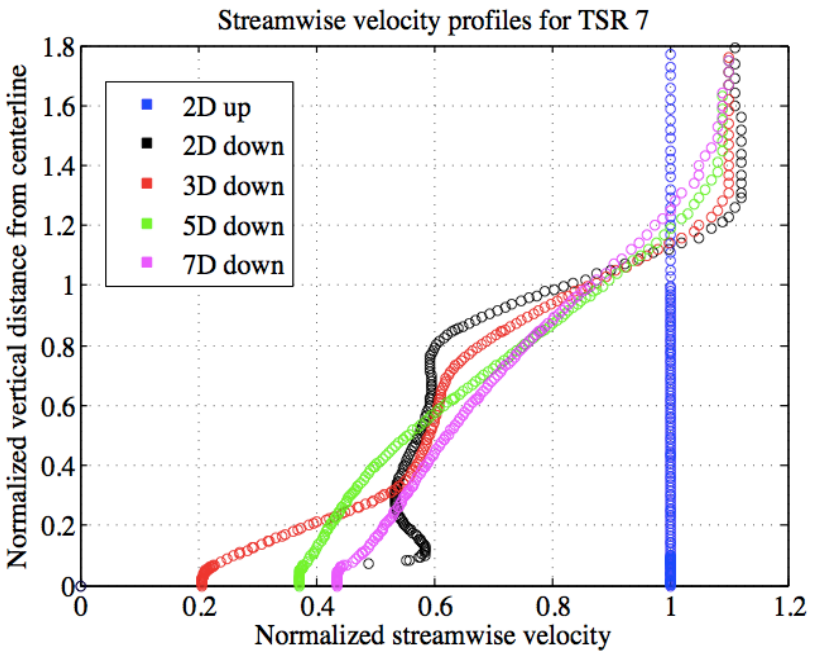
	Efficiency [-]
Experiment	0.38
Sliding Mesh Model	0.38
Rotating Reference Model	0.37

Numerical Results – Velocity Field (TSR=7.16 , Re=100,000)



Numerical vs. Experimental Results
Velocity Deficit Profiles





Experimental

Numerical

Numerical vs. Experimental Results
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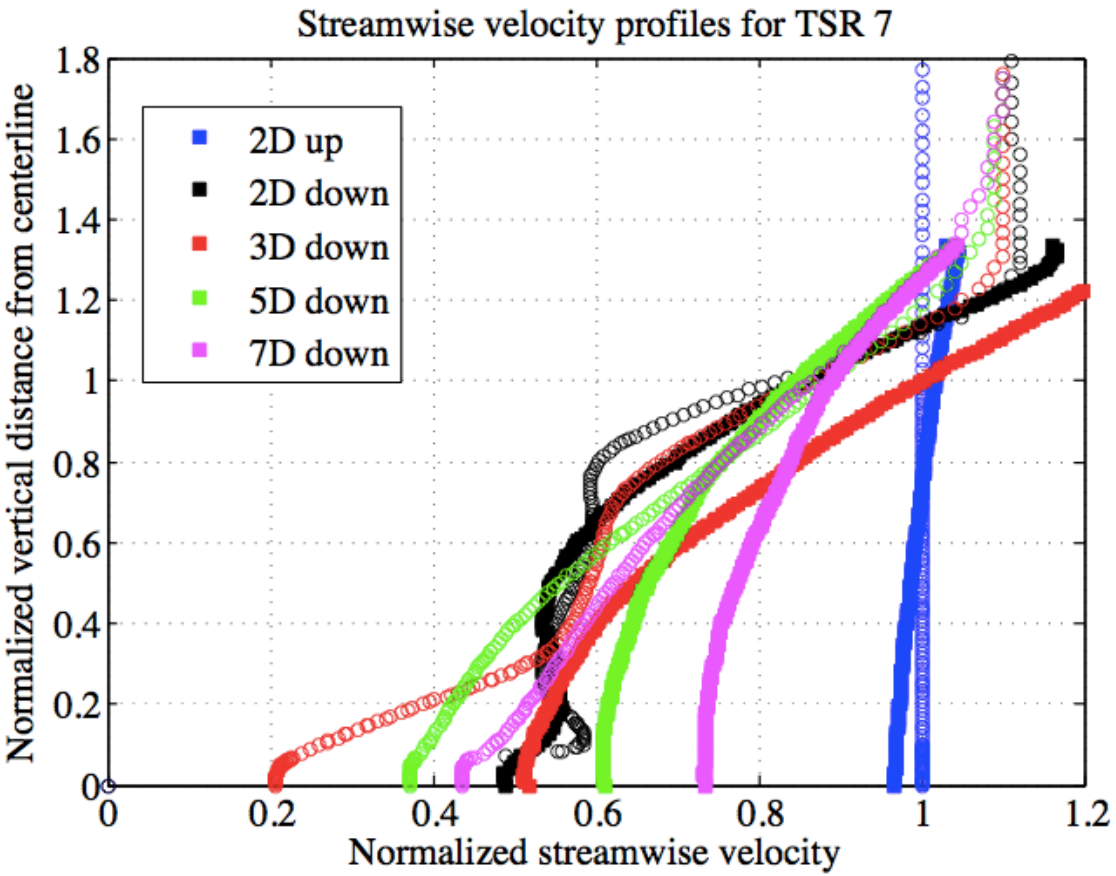
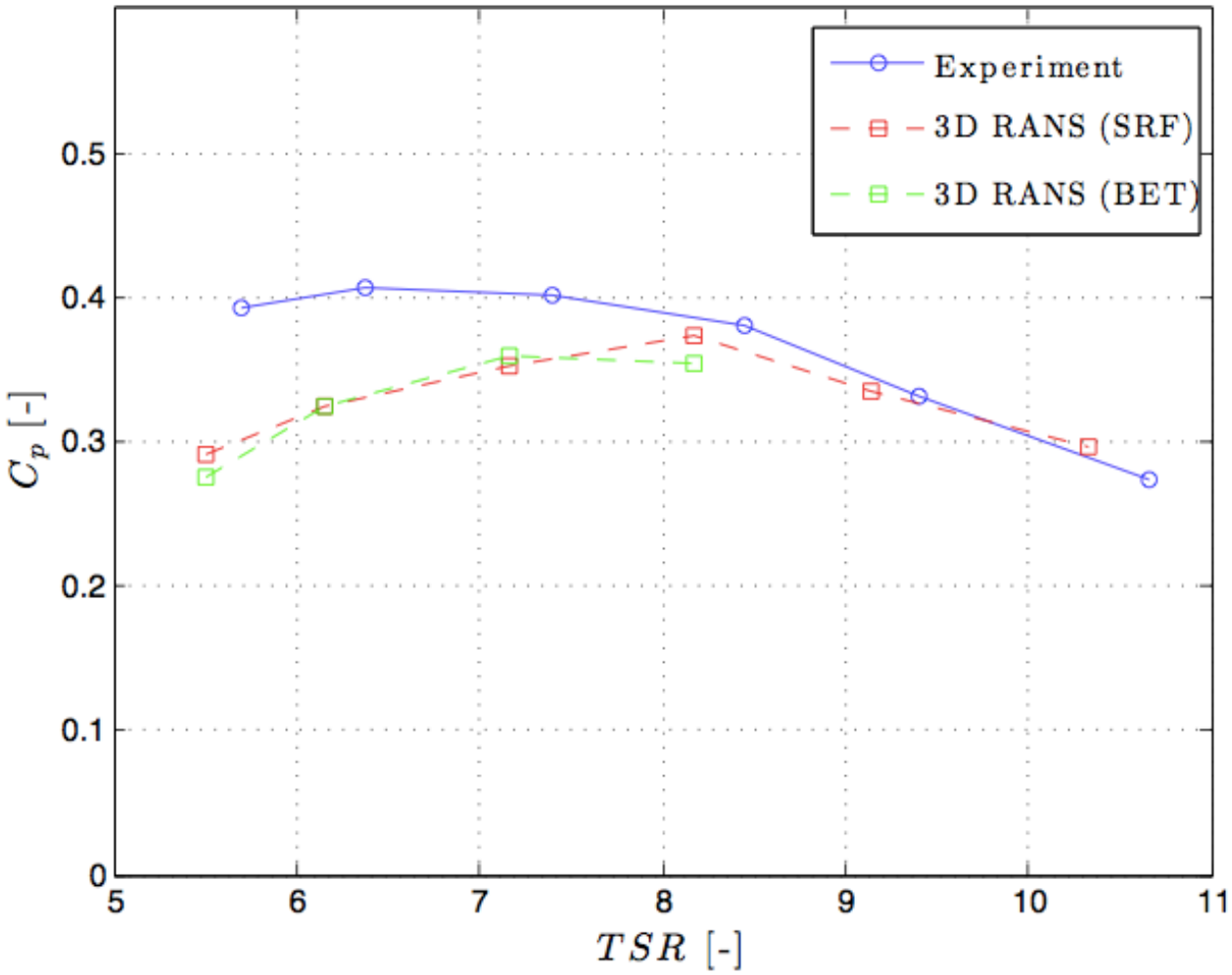


Numerical vs. Experimental Results
BET - SRF - Experiment



Summary & Conclusions

- 3D RANS numerical models are validated to characterize the performance of a scaled model MHK turbine.
- The error between the measured and predicted power values was between 1% to 25%.
- 3D RANS predicted better results in flow fields with high Reynolds number and not existing or small flow separation.
- Experiment shows that the wake of nacelle enhances velocity deficit recovery, but the current 3D RANS model is limited to capture this physical phenomenon.