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 - Pittsburg

Nov/24/2013

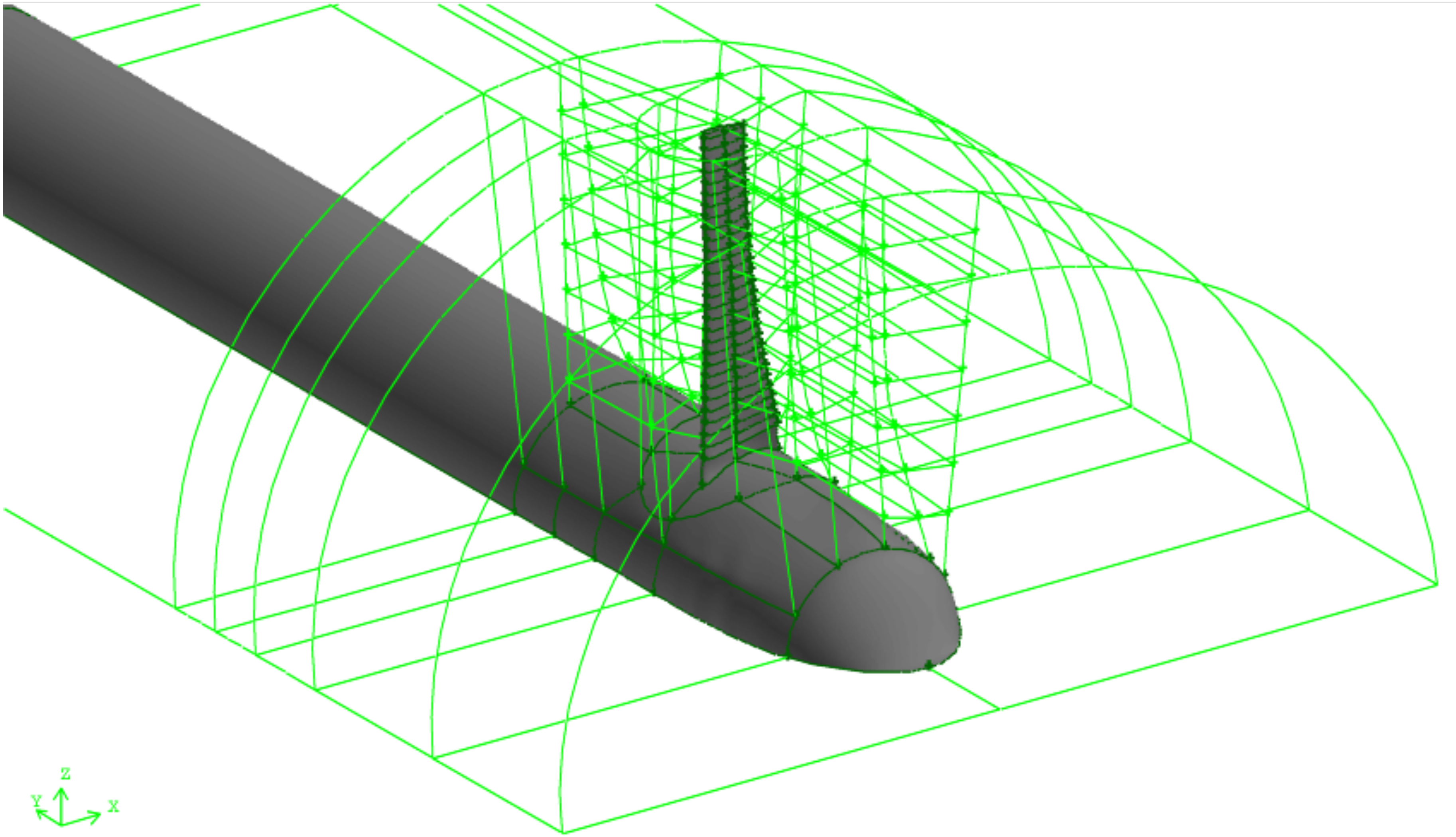
Motivations & Goals

- **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.**

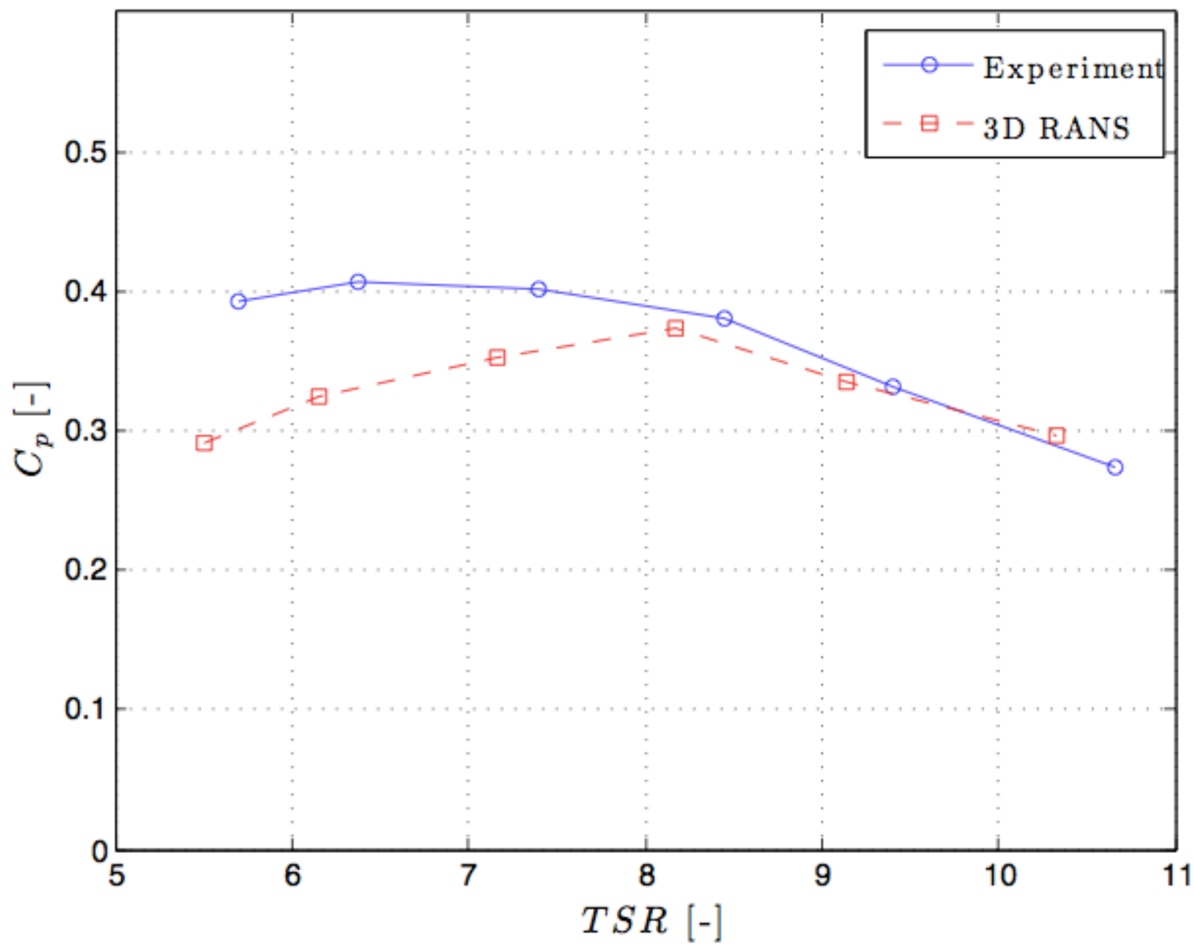
Numerical Methodology

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

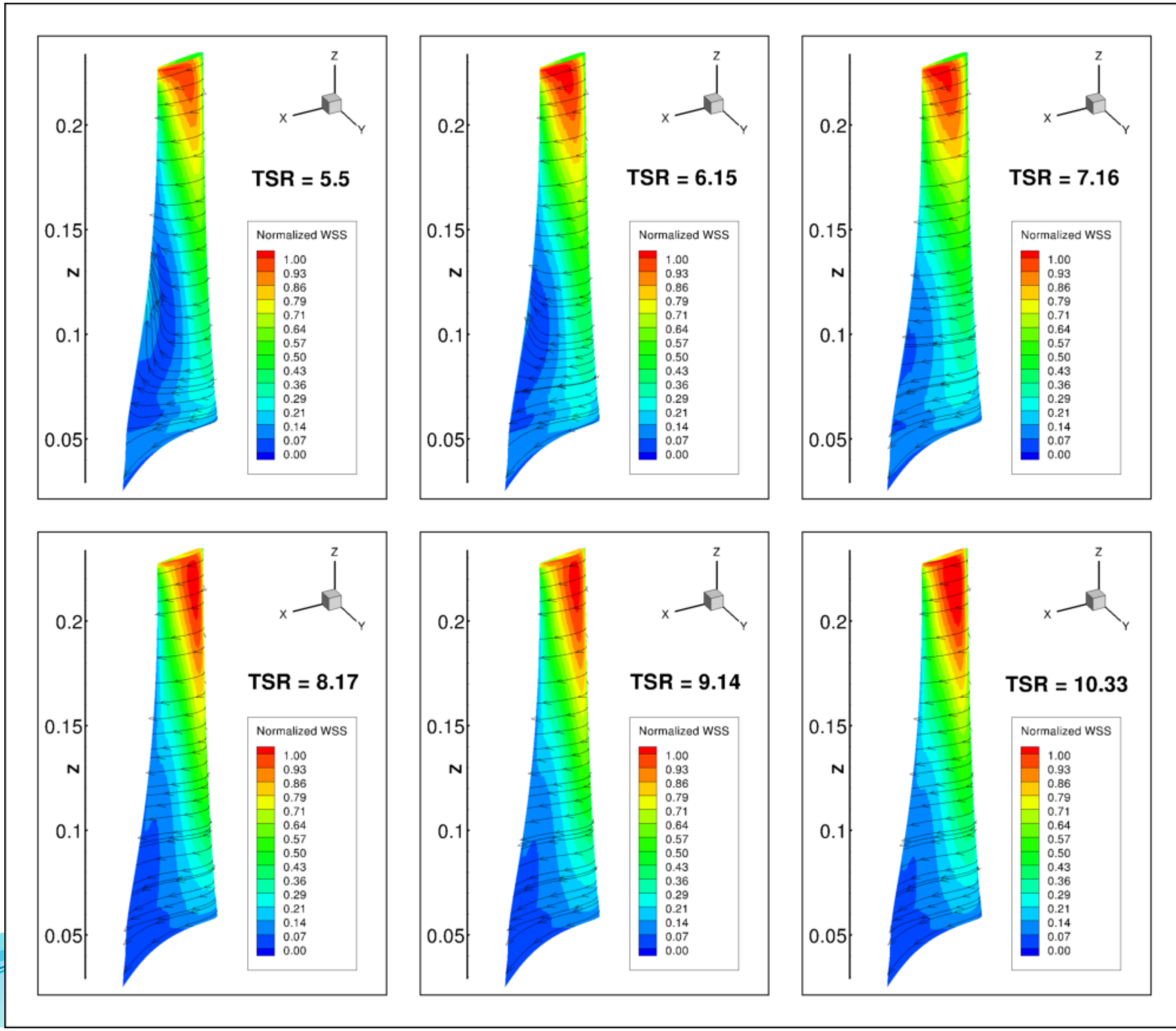
Rotating Reference Frame Model Computational Domain (Zoomed-in)



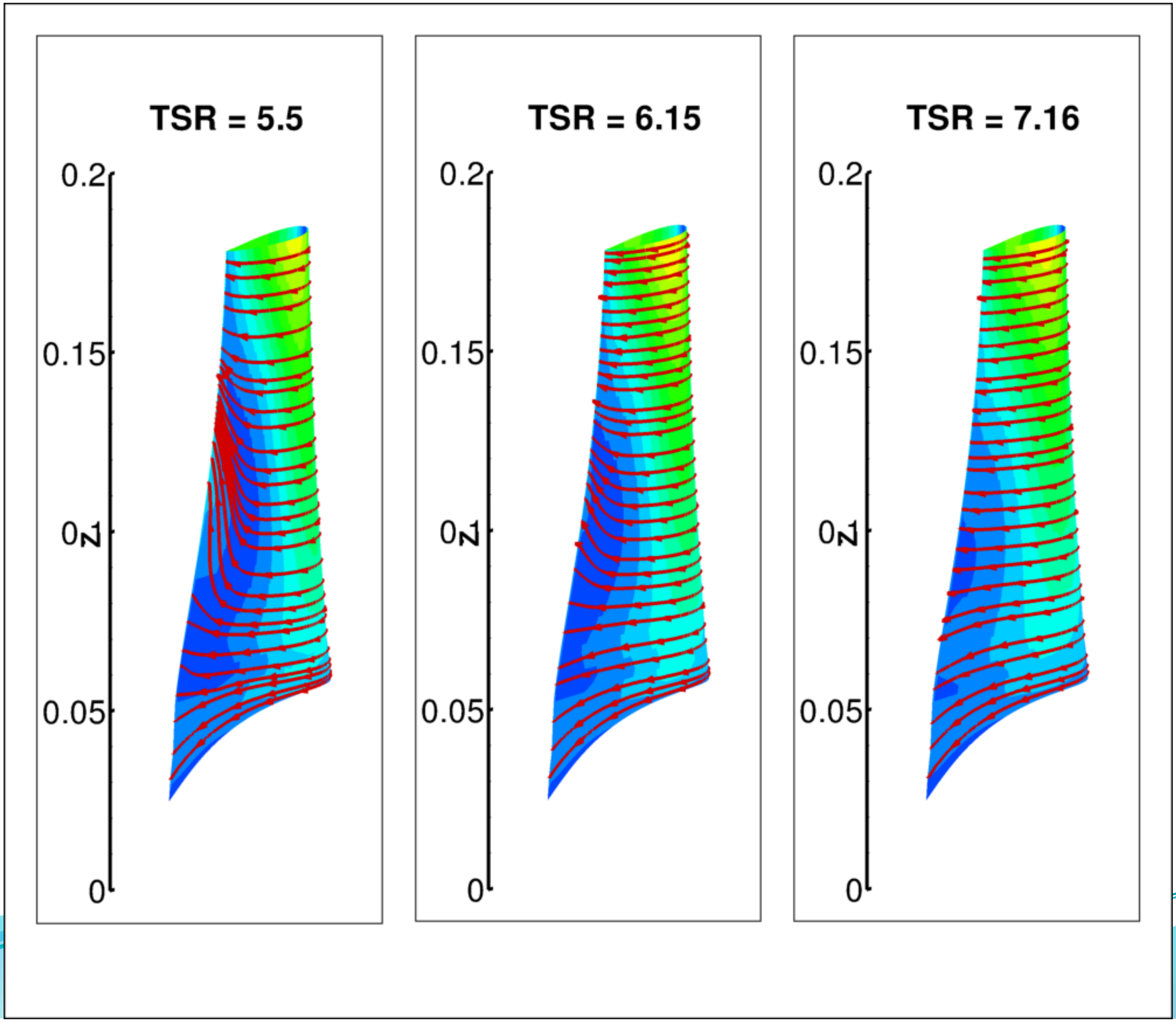
Numerical vs. Experimental Results
Efficiency (C_p) – Tip Speed Ratio (TSR) Curves



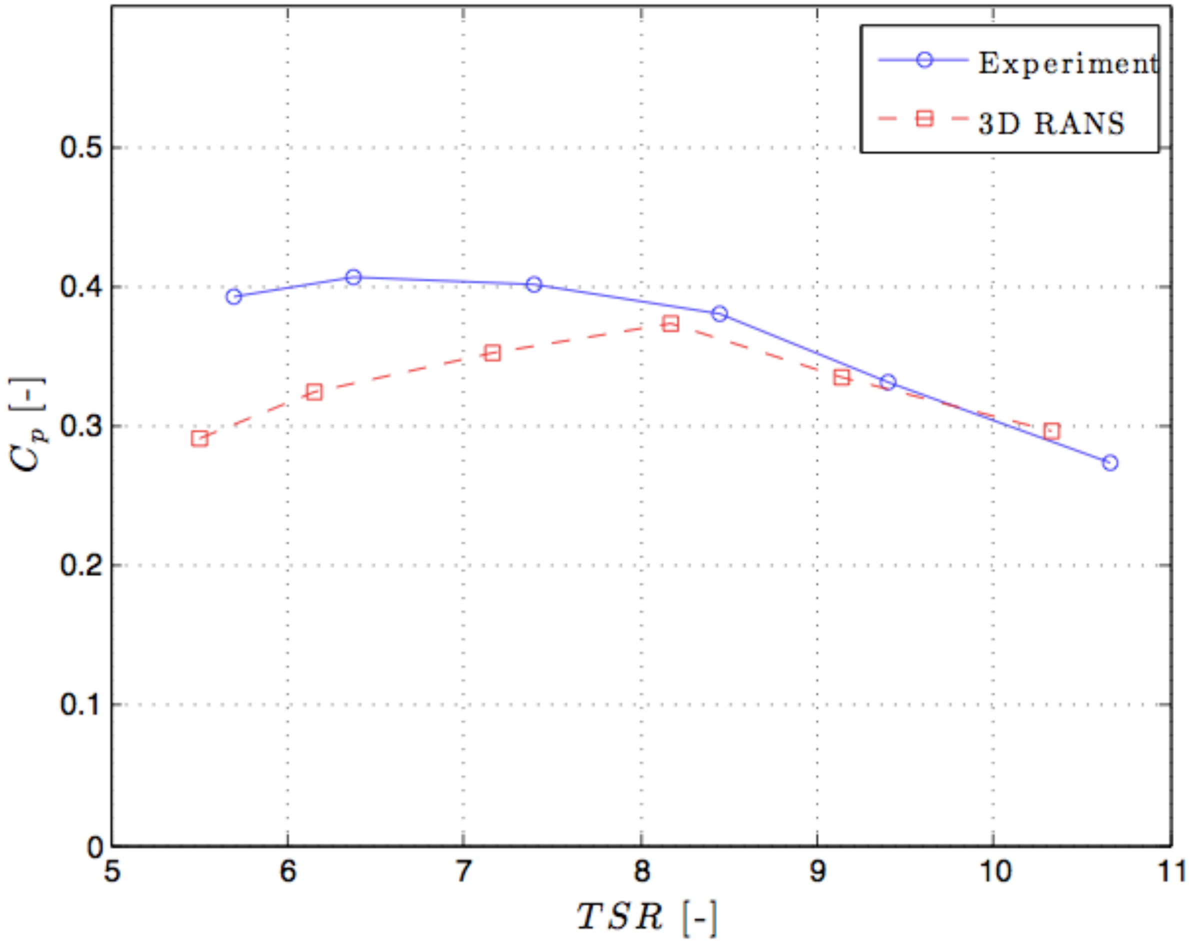
Limited Streamlines + Wall Shear Stress along the Blade



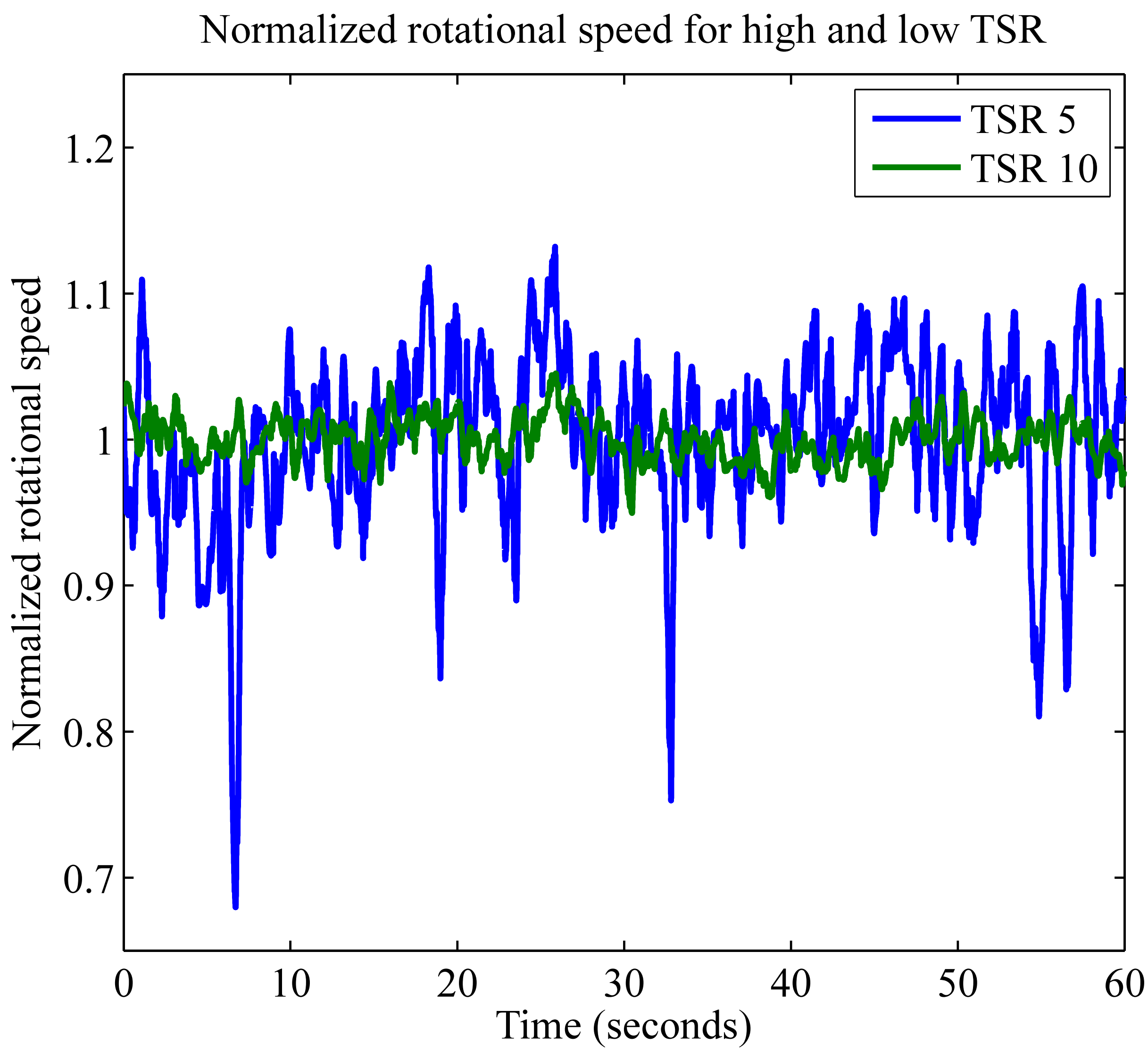
Limited Streamlines + Wall Shear Stress along the Blade



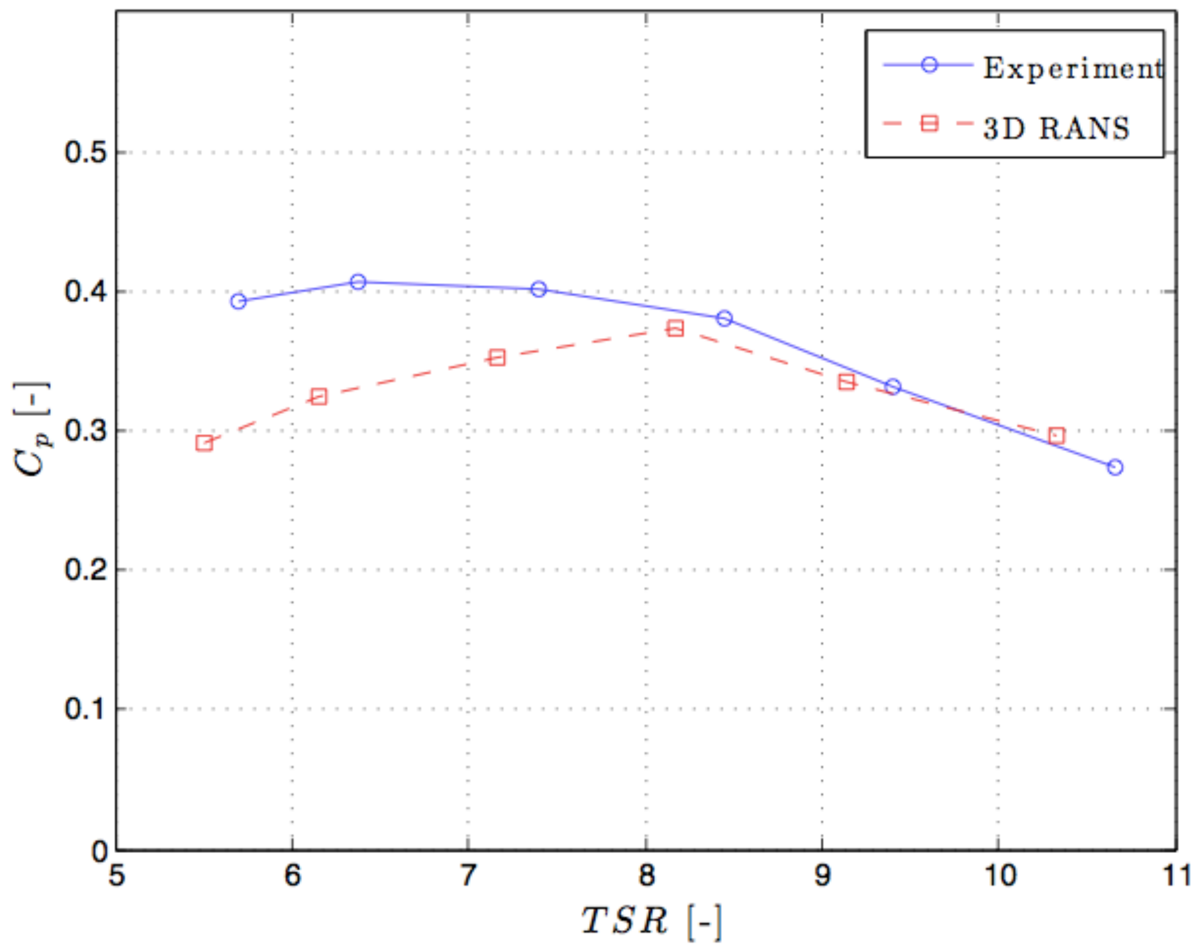
Numerical vs. Experimental Results
Efficiency (C_p) – Tip Speed Ratio (TSR) Curves



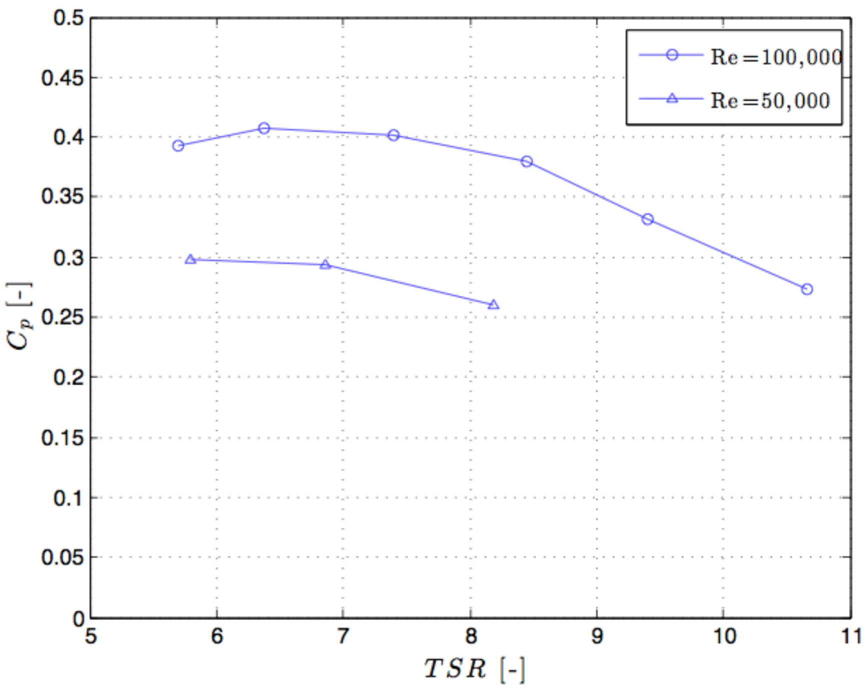
Dynamic Fluctuations in Experiment at Low TSRs



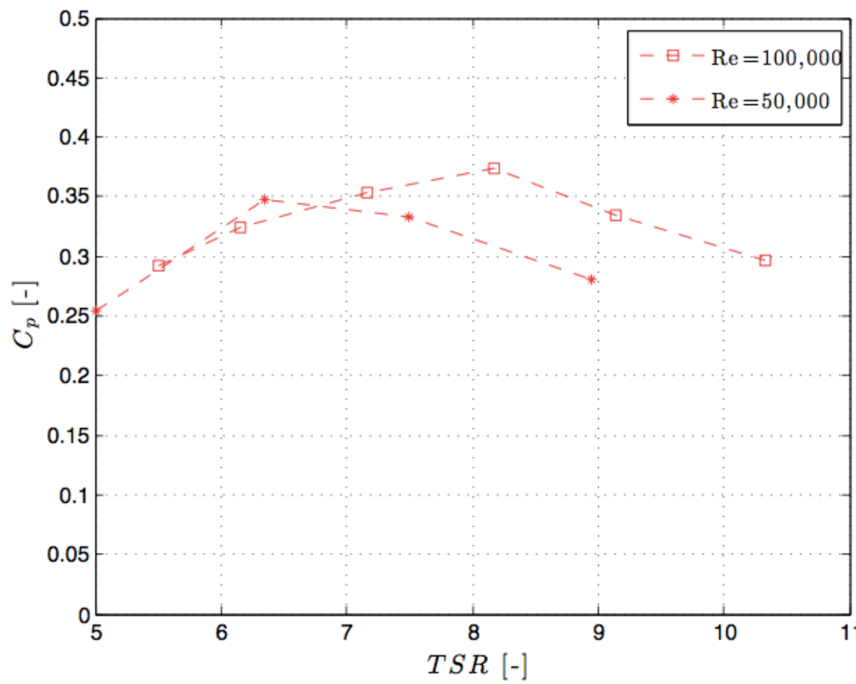
Numerical vs. Experimental Results
Efficiency (C_p) – Tip Speed Ratio (TSR) Curves



Numerical vs. Experimental Results
Reynolds Number Effect

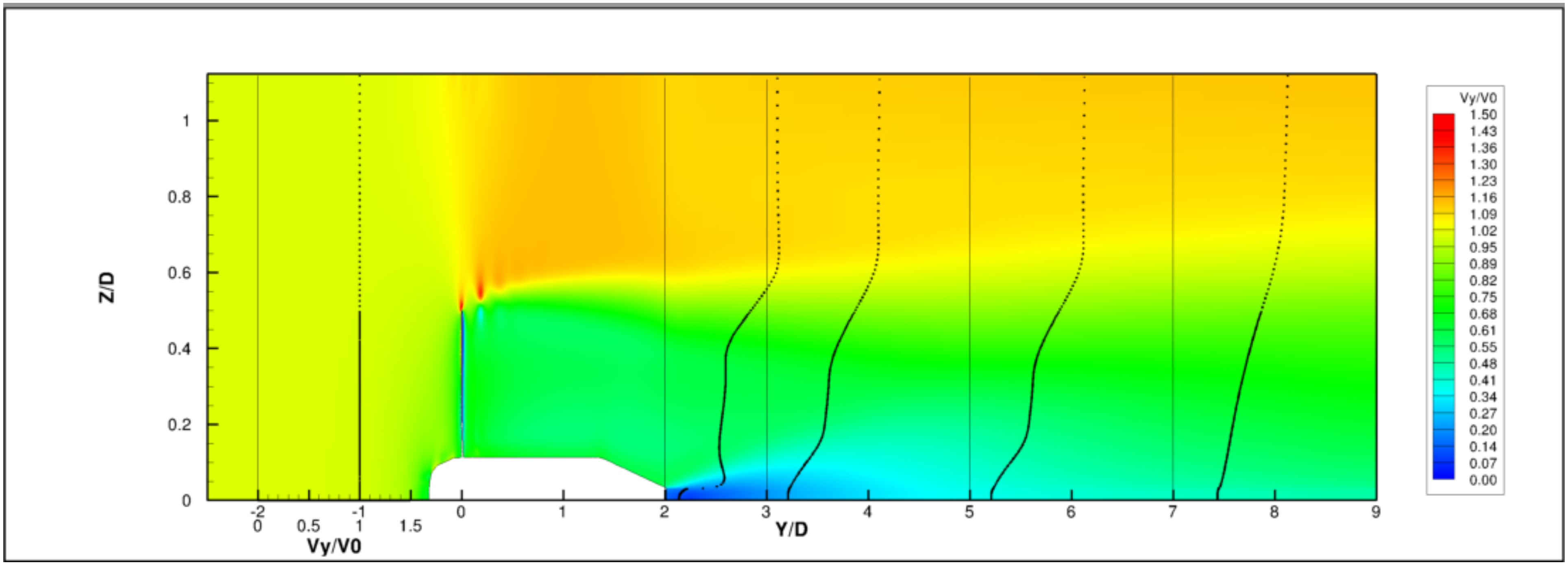


Experimental



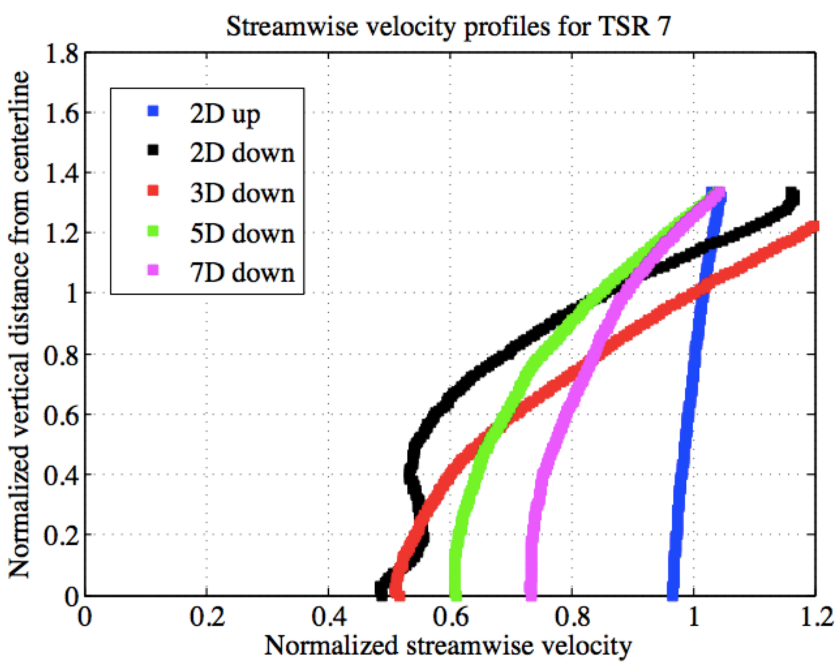
Numerical

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

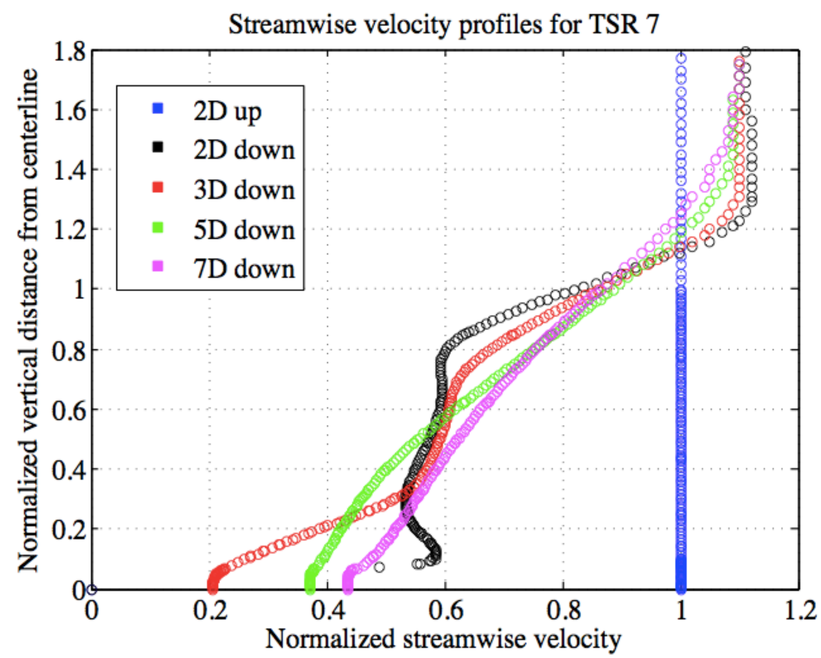


W OSU

Numerical vs. Experimental Results
Velocity Deficit Profiles

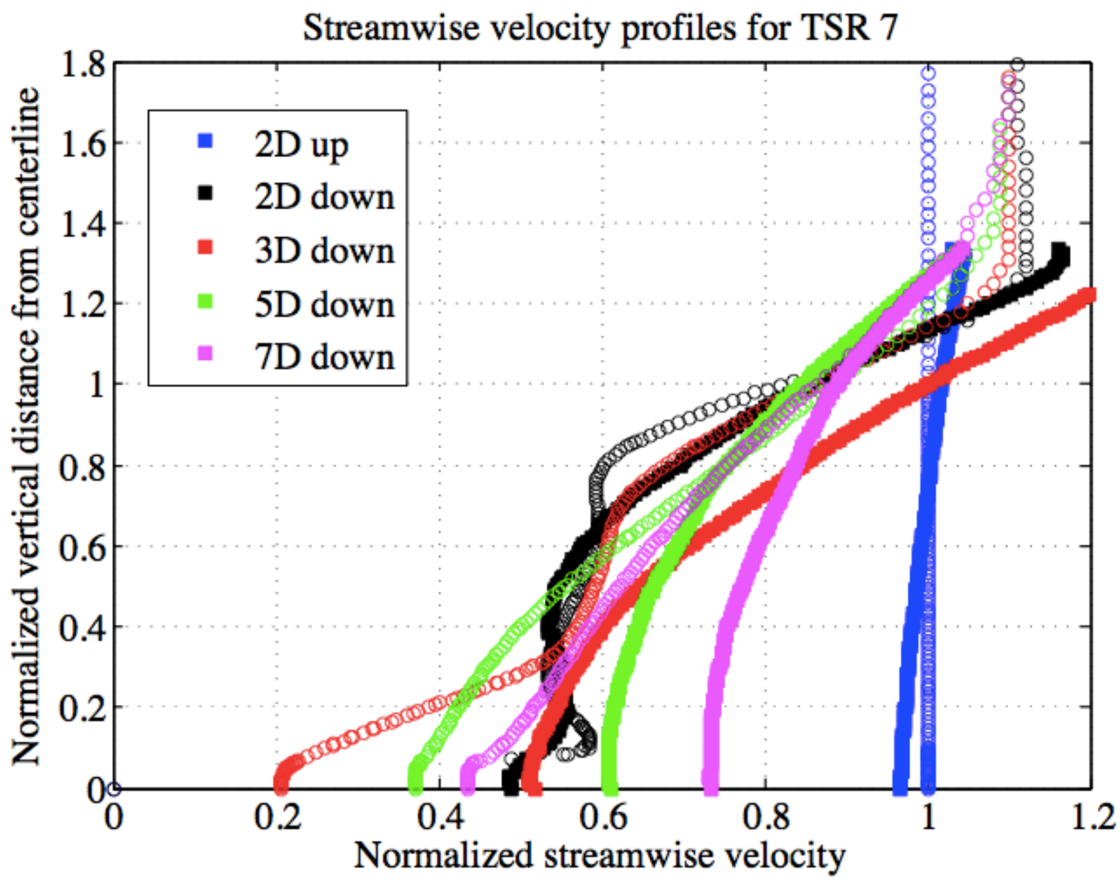


Experimental



Numerical

Numerical vs. Experimental Results
Velocity Deficit Profiles



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

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

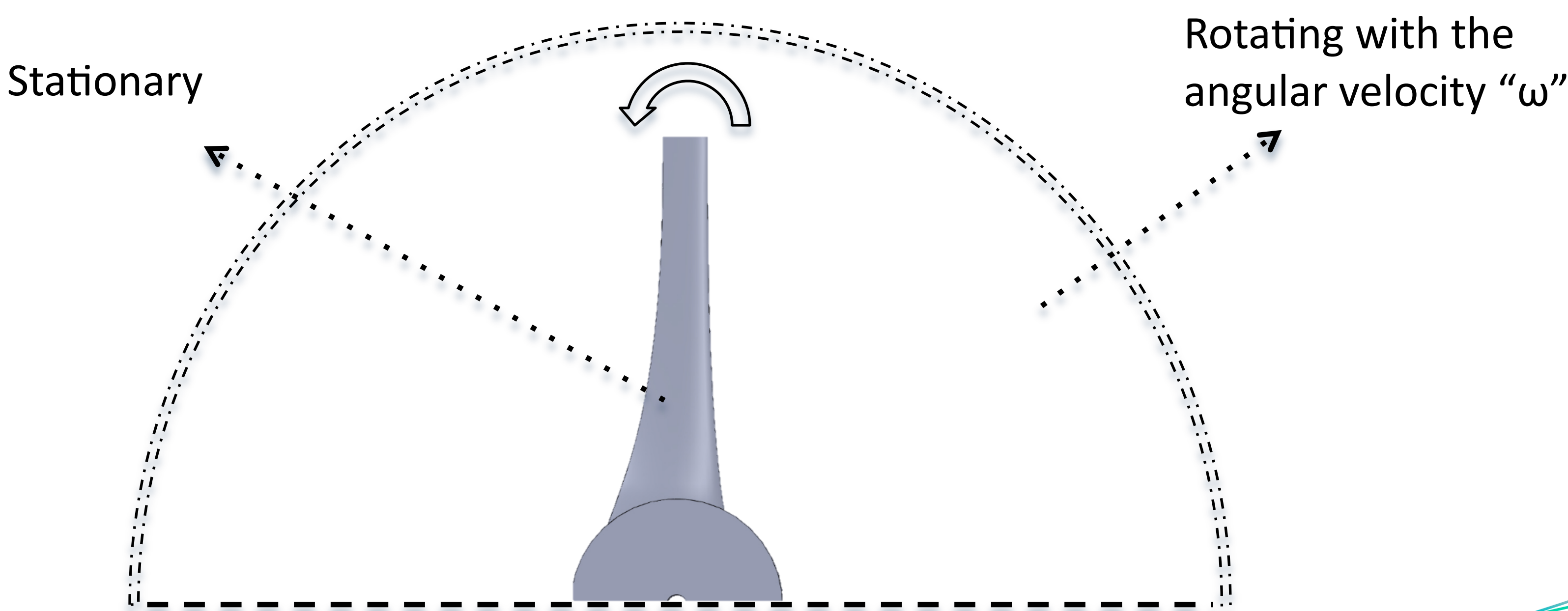
Summary & Conclusions

- 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.

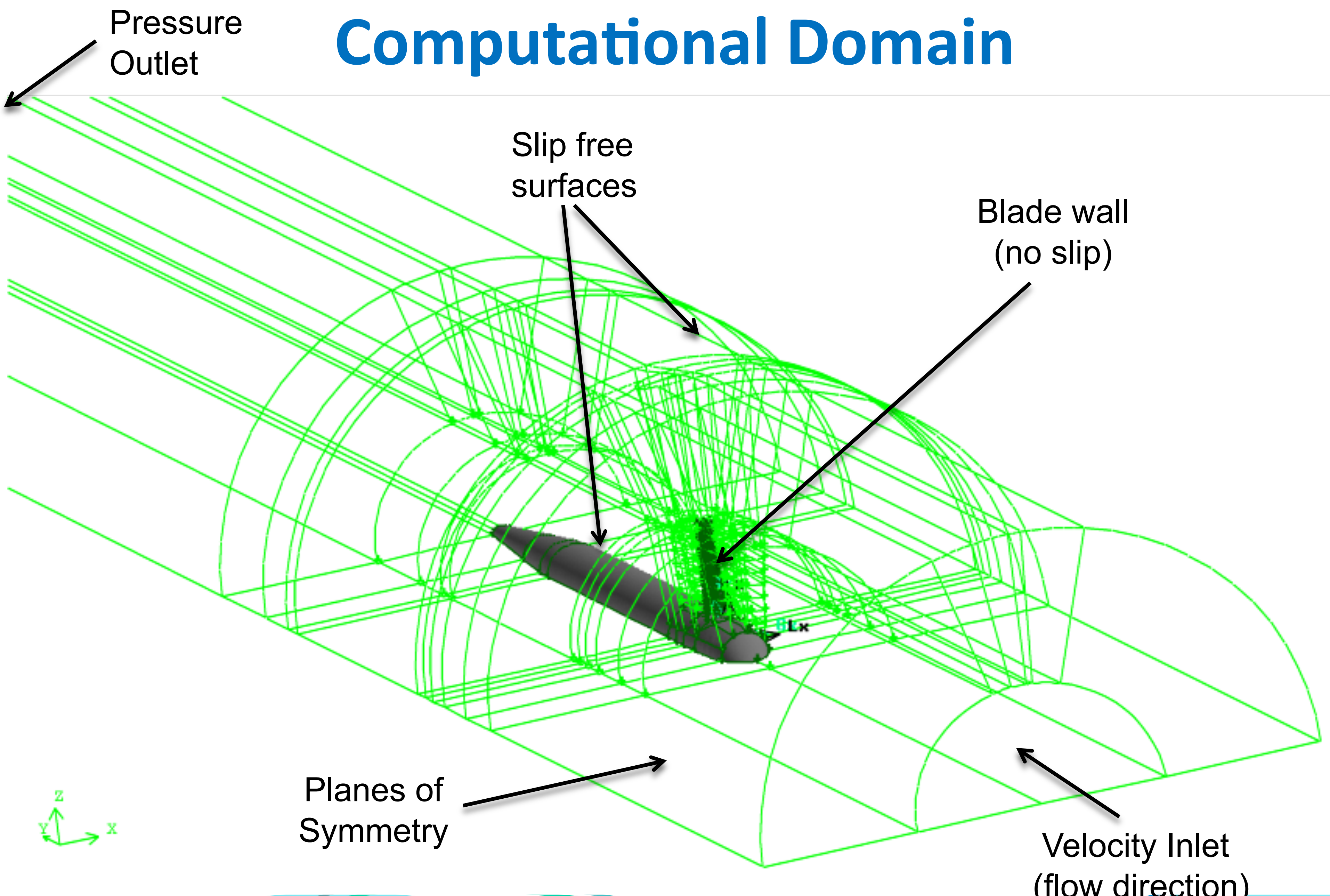
Single Rotating Reference (SRF)

- **The idea is to render an unsteady problem in the fixed ref. frame into a steady problem in the rotating ref. frame.**

- **RANS equations are solved in the rotating reference frame.**



Computational Domain



Lift/Drag Coefficients and AOA along the Blade Span (TSR=7.16)