

Overall Effectiveness of a Conducting Gas Turbine Endwall with Internal Jet Impingement and Film Cooling



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Motivation and Objective

Develop endwall cooling designs that provide good performance even when subjected to high levels of contaminant depositions.

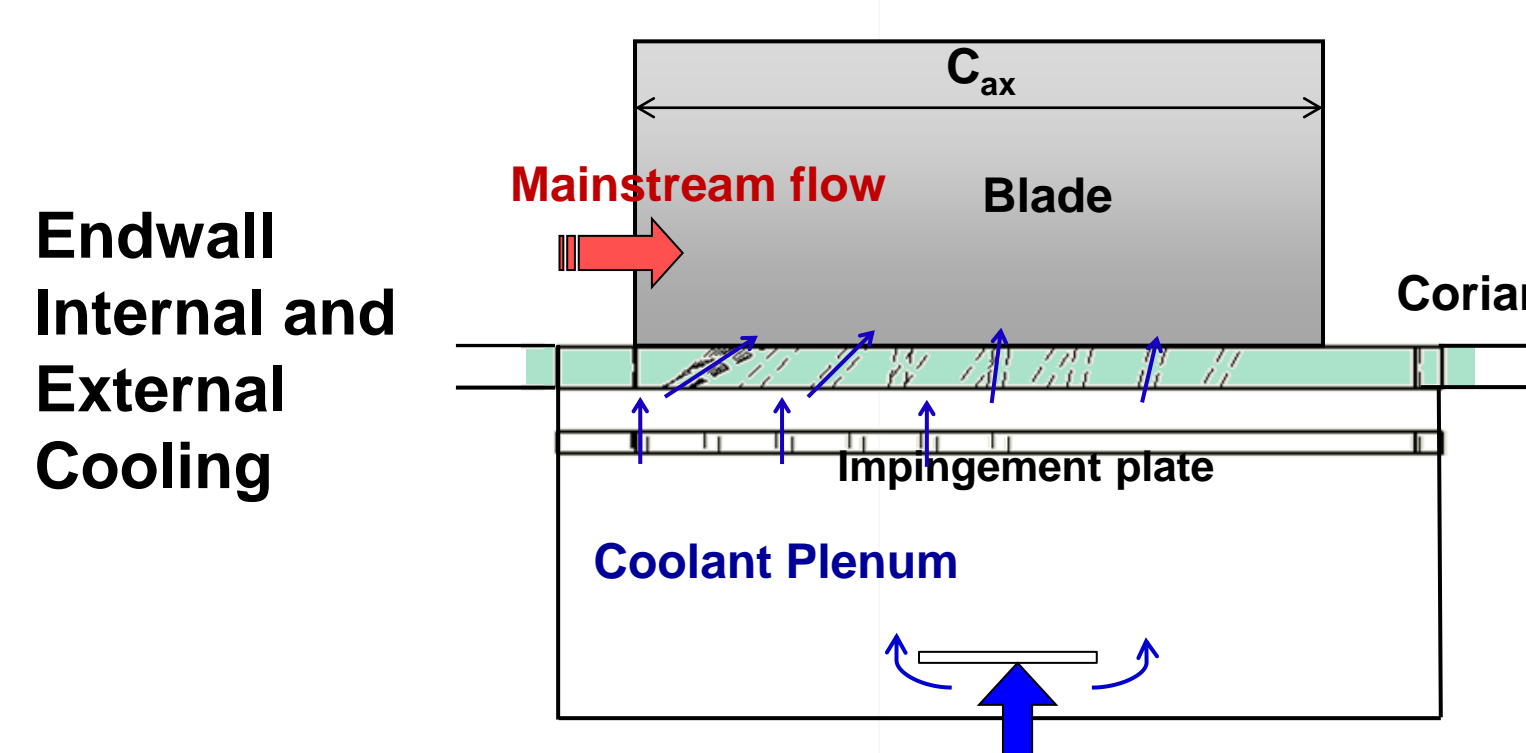
Examples of Turbine Hardware Damage and Deposition



[Ai et al., 2008]

Approach

Metal temperature can be directly measured with a conjugate heat transfer experimental model if Bi and h_{∞}/h_i are matched.

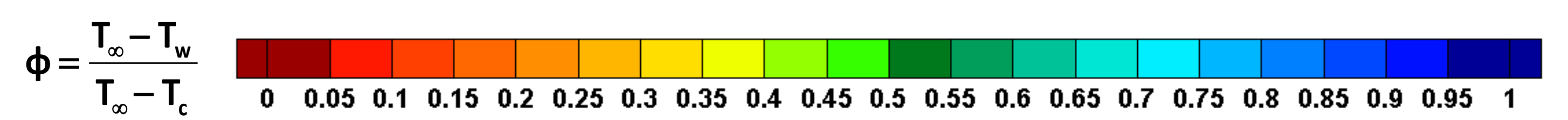


Overall Effectiveness/Metal Temperature

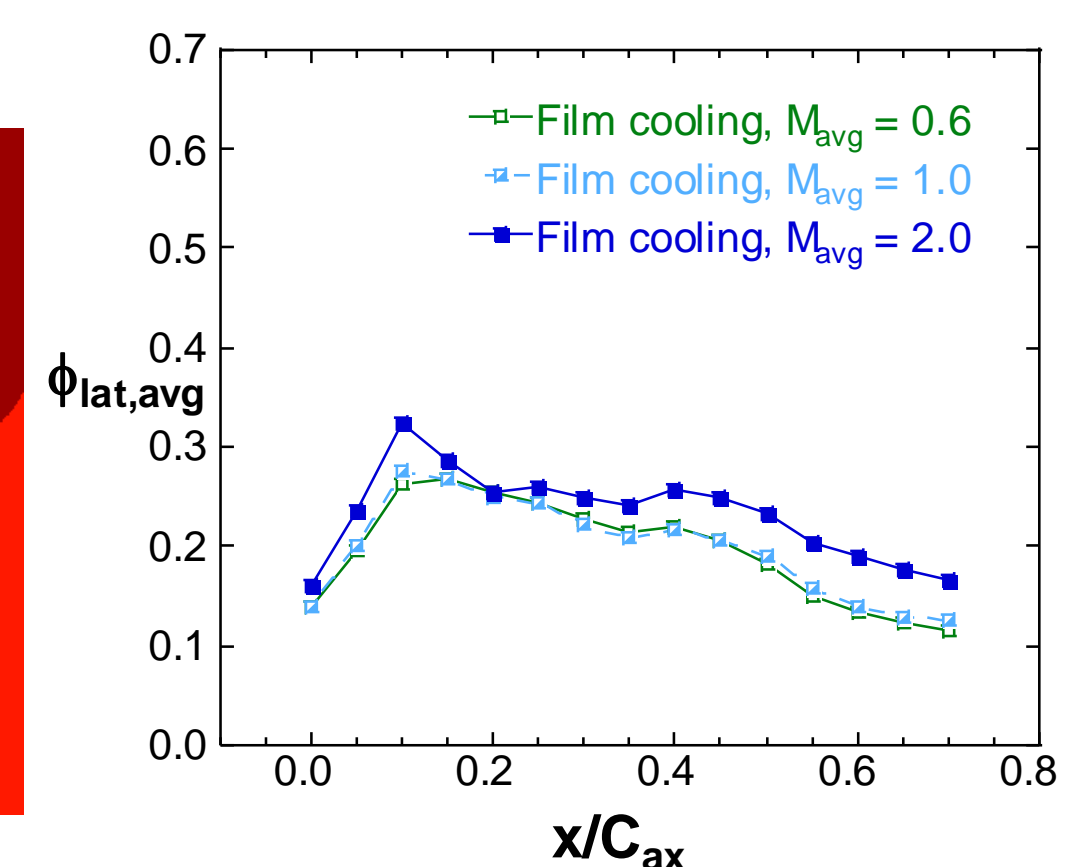
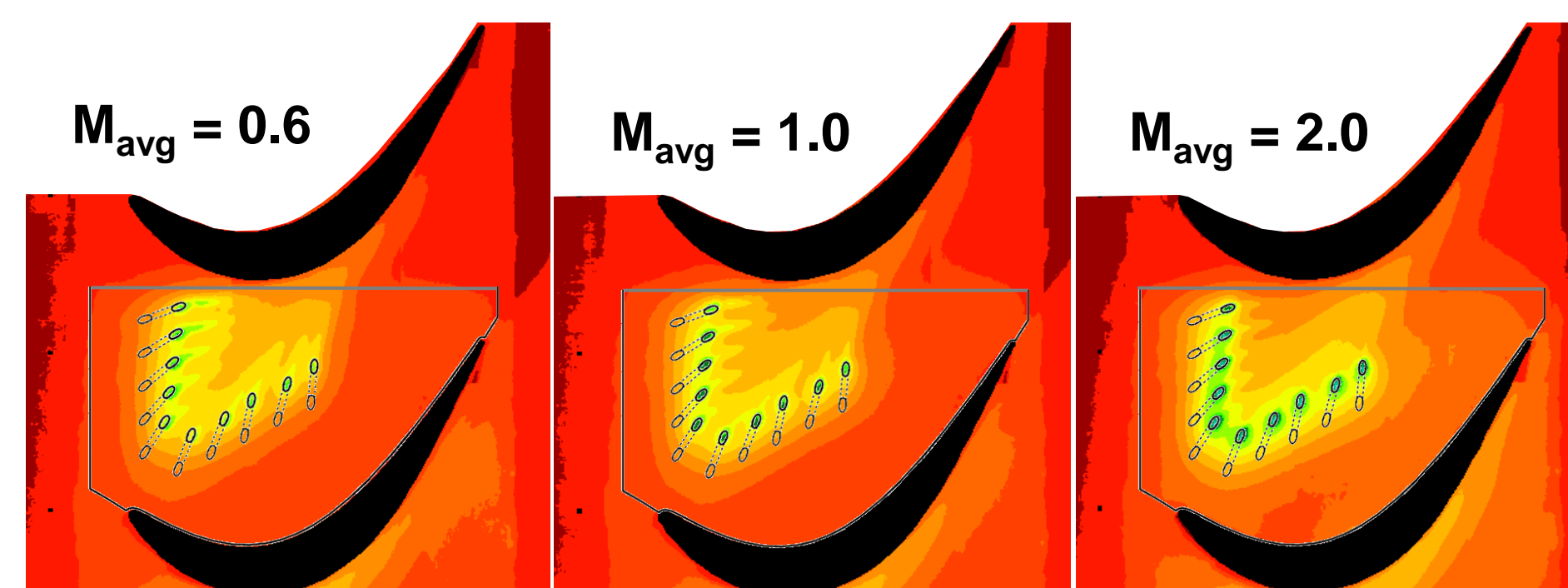
$$\phi = \frac{T_{\infty} - T_{wall}}{T_{\infty} - T_c} = \frac{1 - \eta}{1 + Bi + h_{\infty}/h_i} + \eta$$

$$\eta = \frac{T_{\infty} - T_{aw}}{T_{\infty} - T_c} \quad Bi = h_{\infty} t / k_{wall}$$

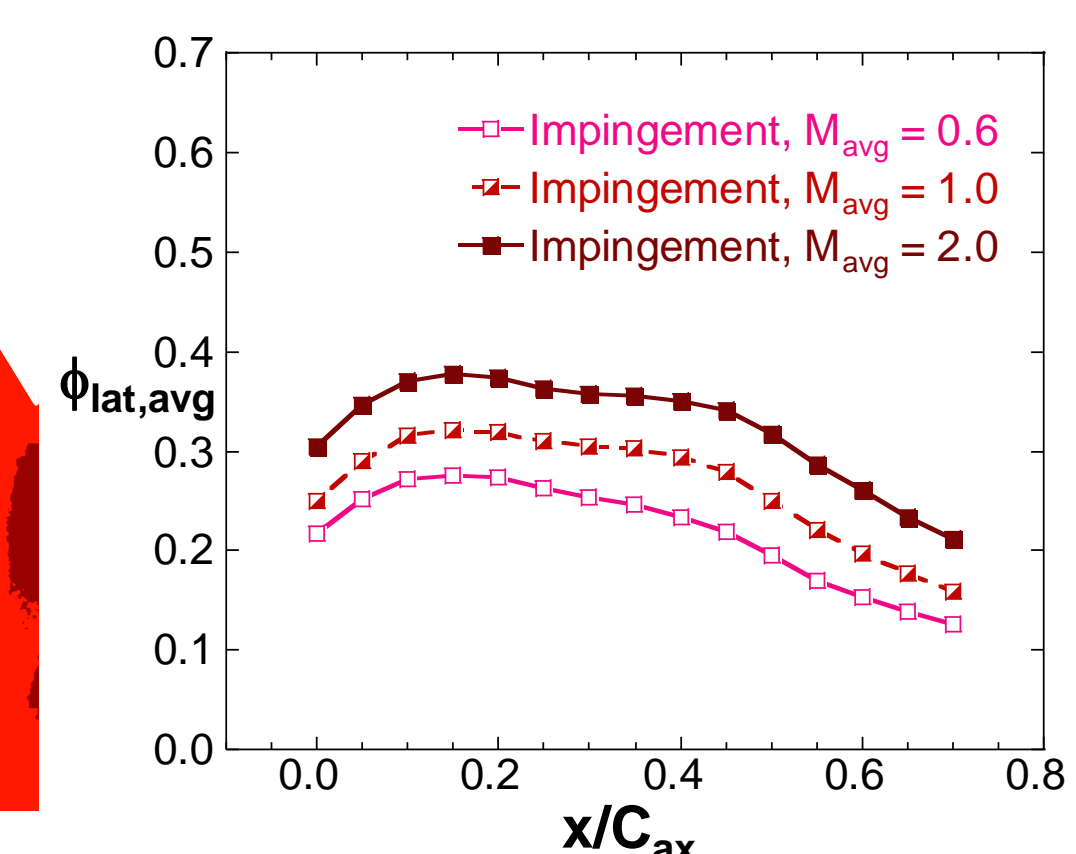
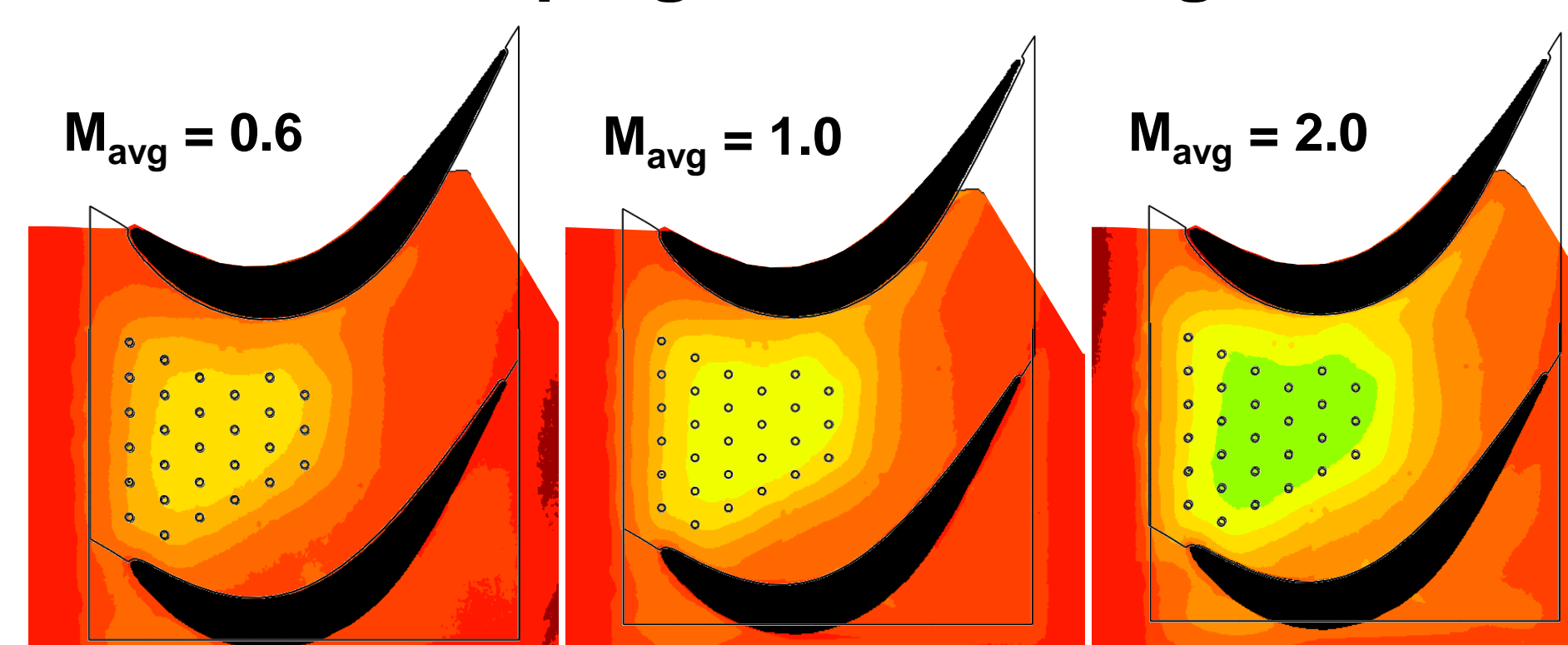
Overall Effectiveness Baseline Results



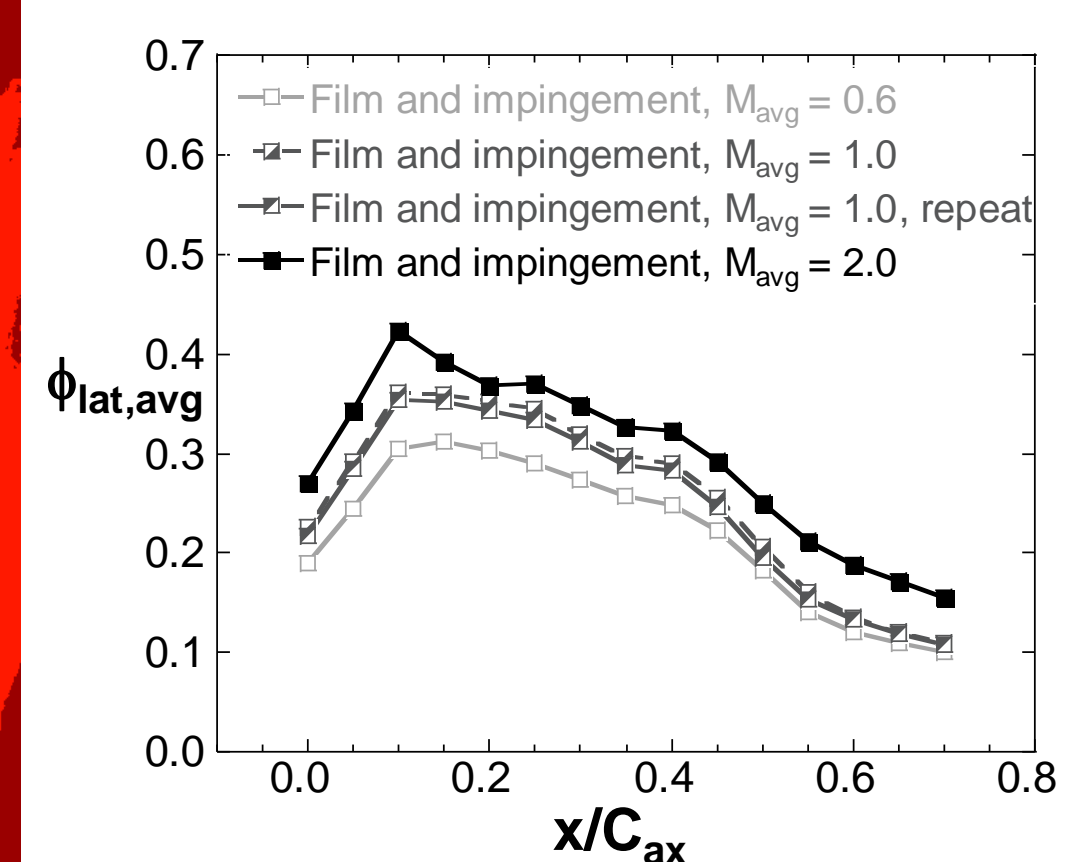
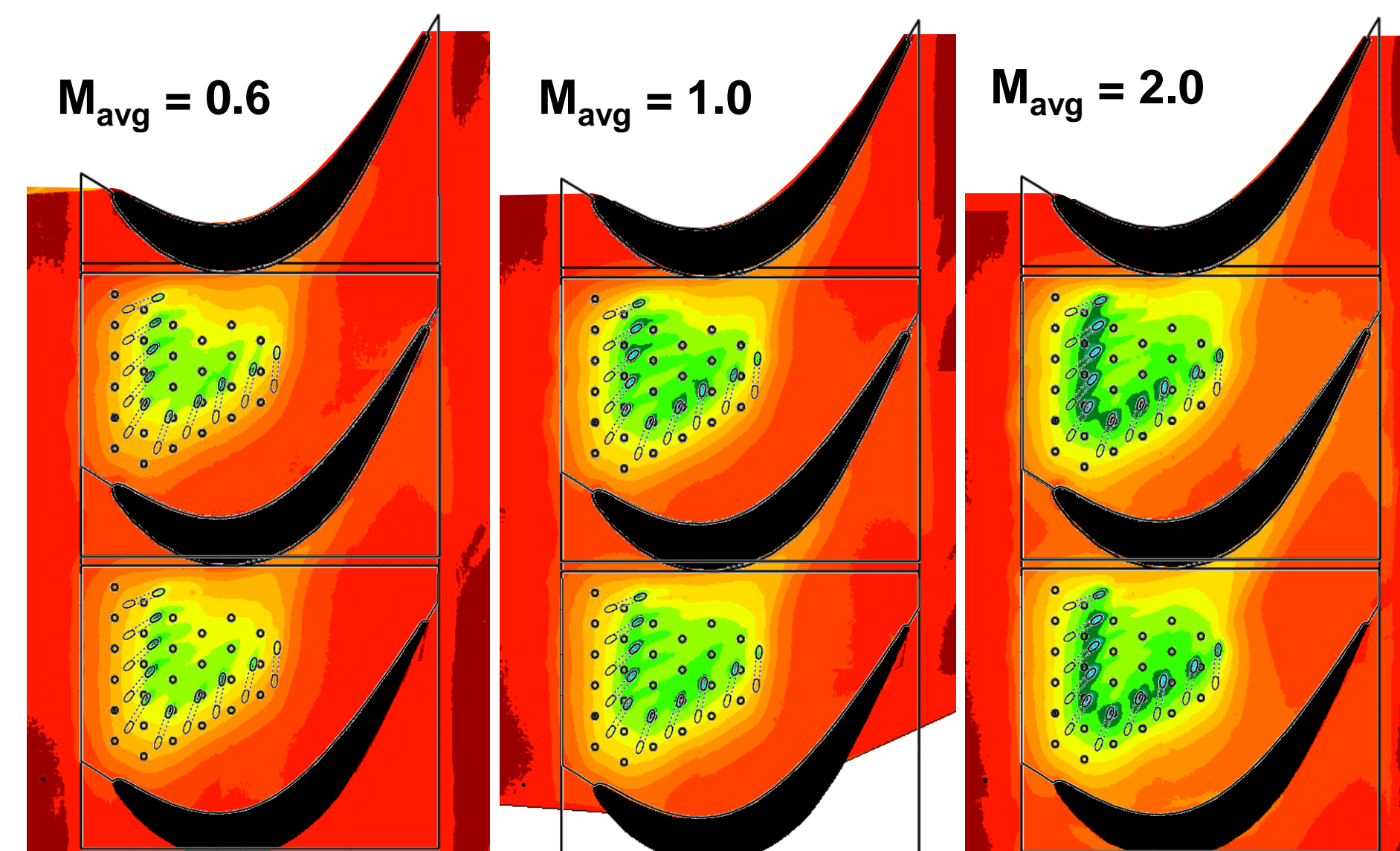
Film Cooling



Impingement Cooling

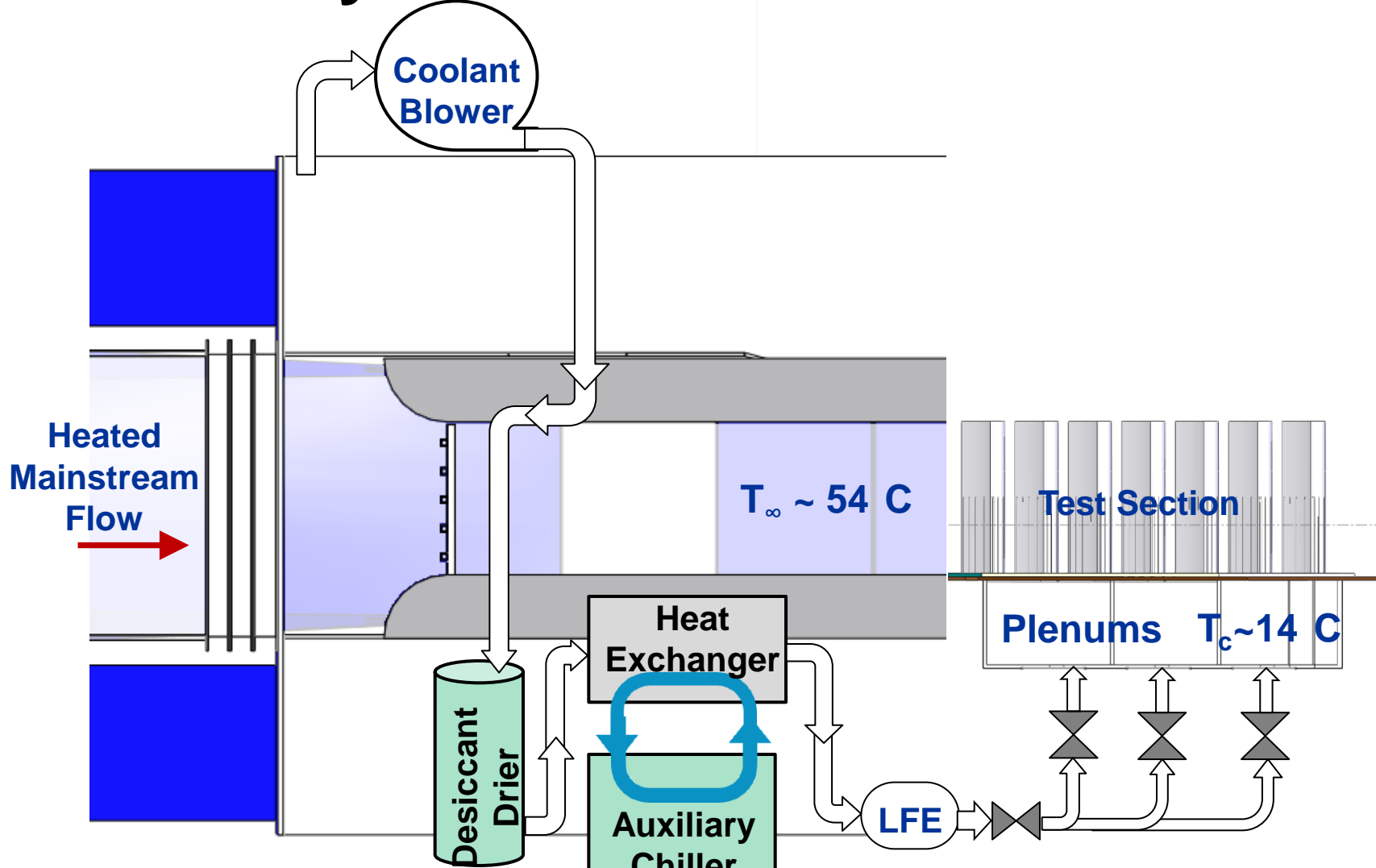


Combined Film and Impingement Cooling



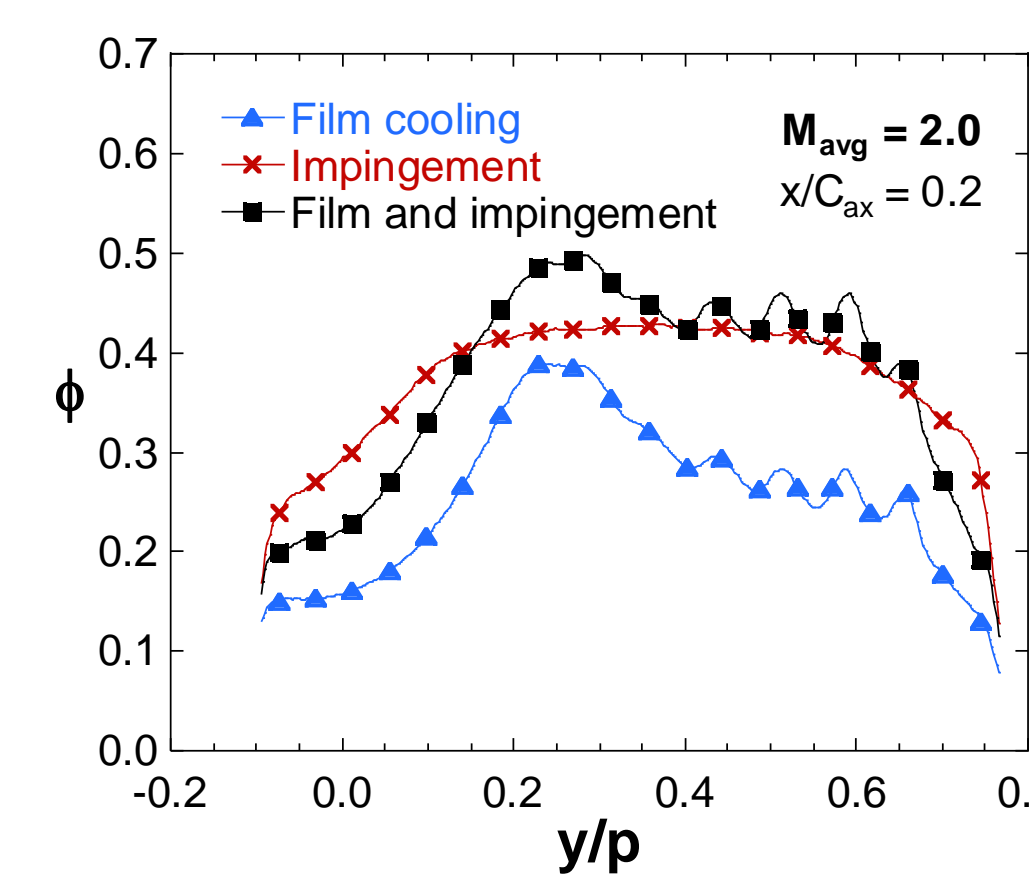
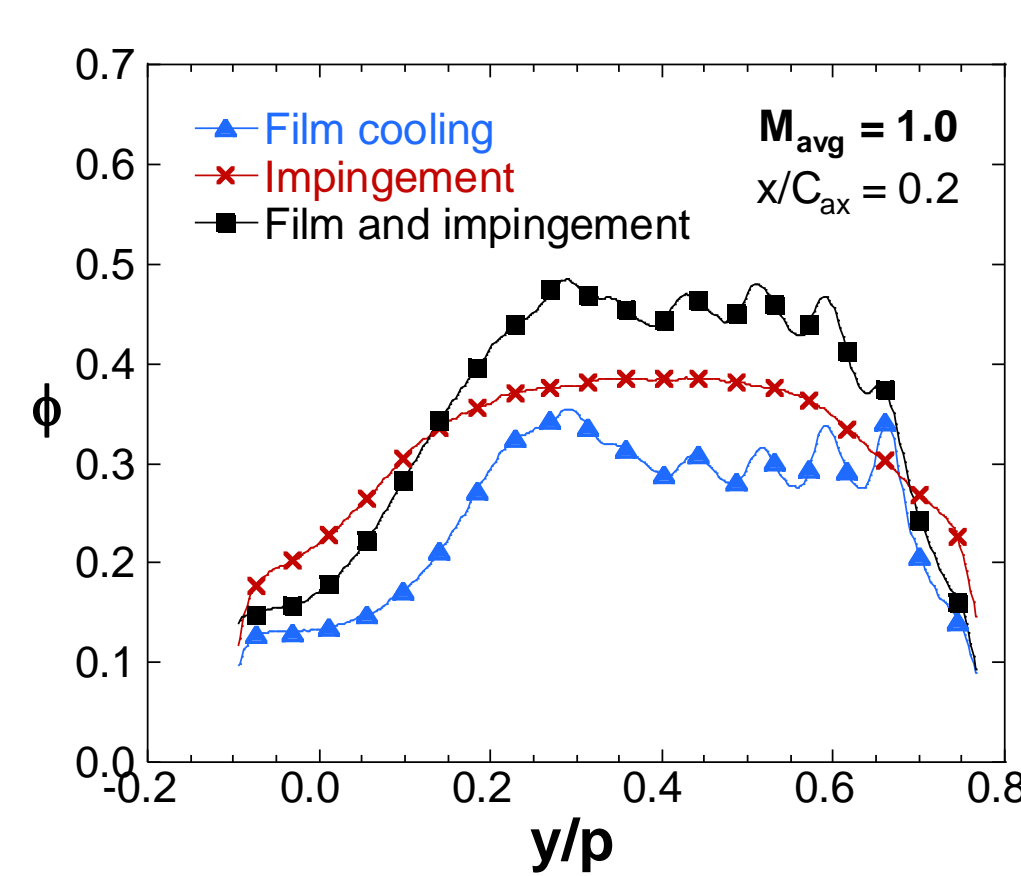
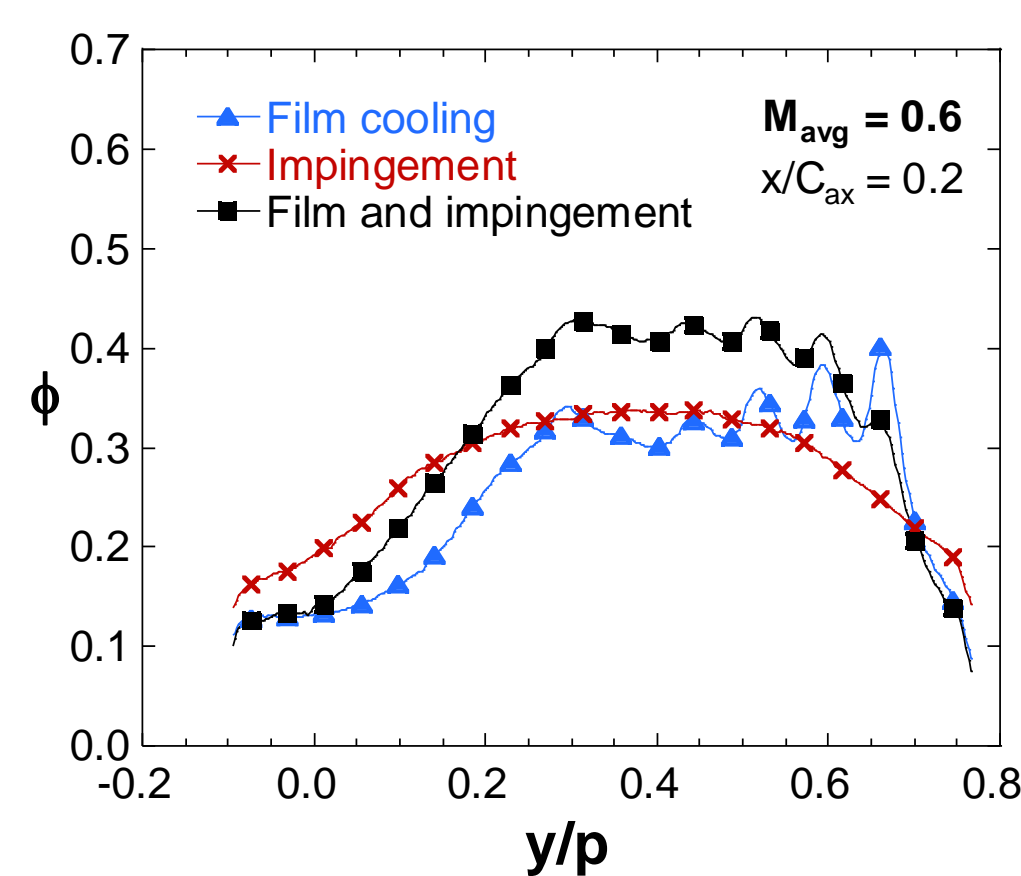
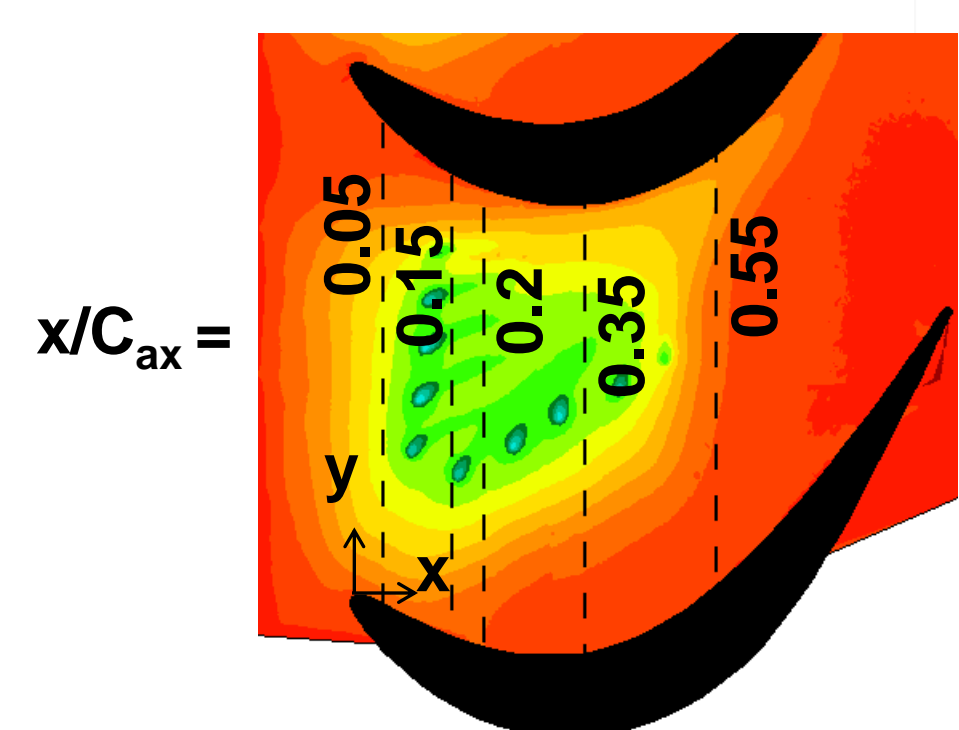
Experimental Facilities

Large-scale, sub-sonic, recirculating wind tunnel supplies a heated mainstream flow at matched Re and a cooled secondary flow for coolant.



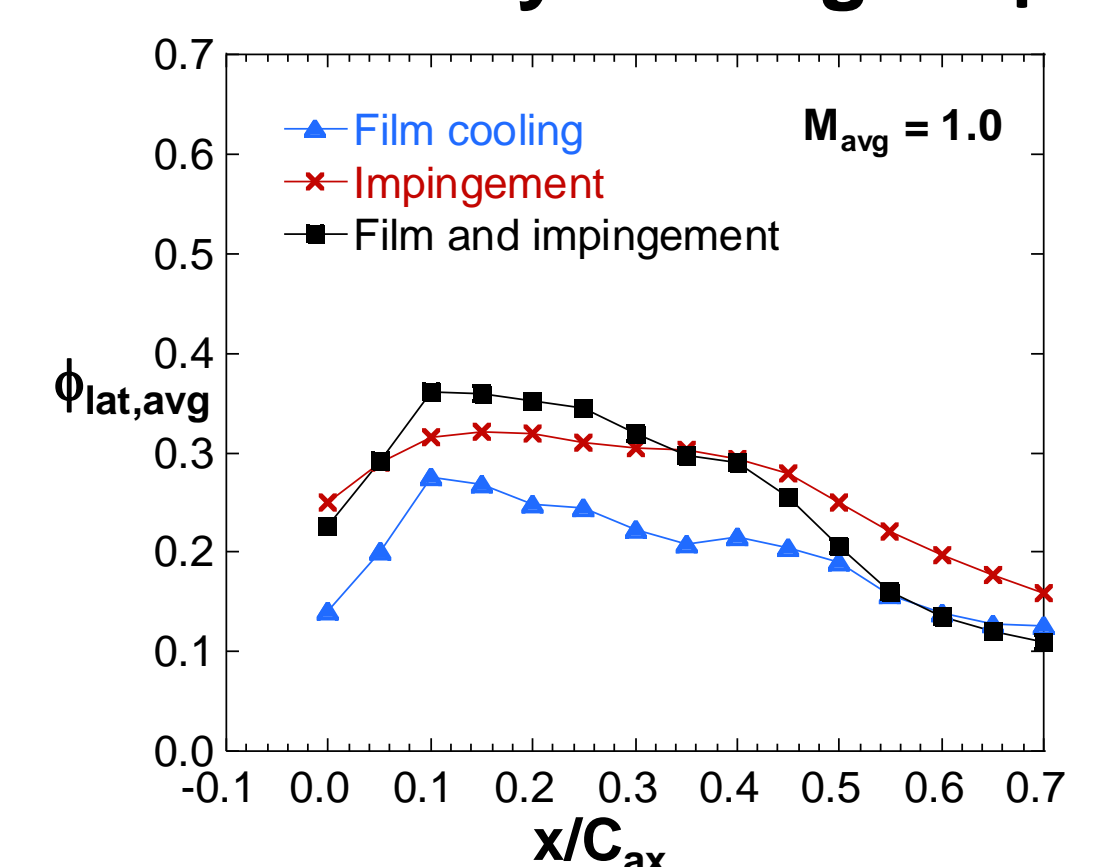
Pack B Linear Cascade - Flat Endwall

Comparison of Results



At $x/C_{ax} = 0.2$, the effects of film cooling jets and impingement can be seen.

Laterally Averaged ϕ



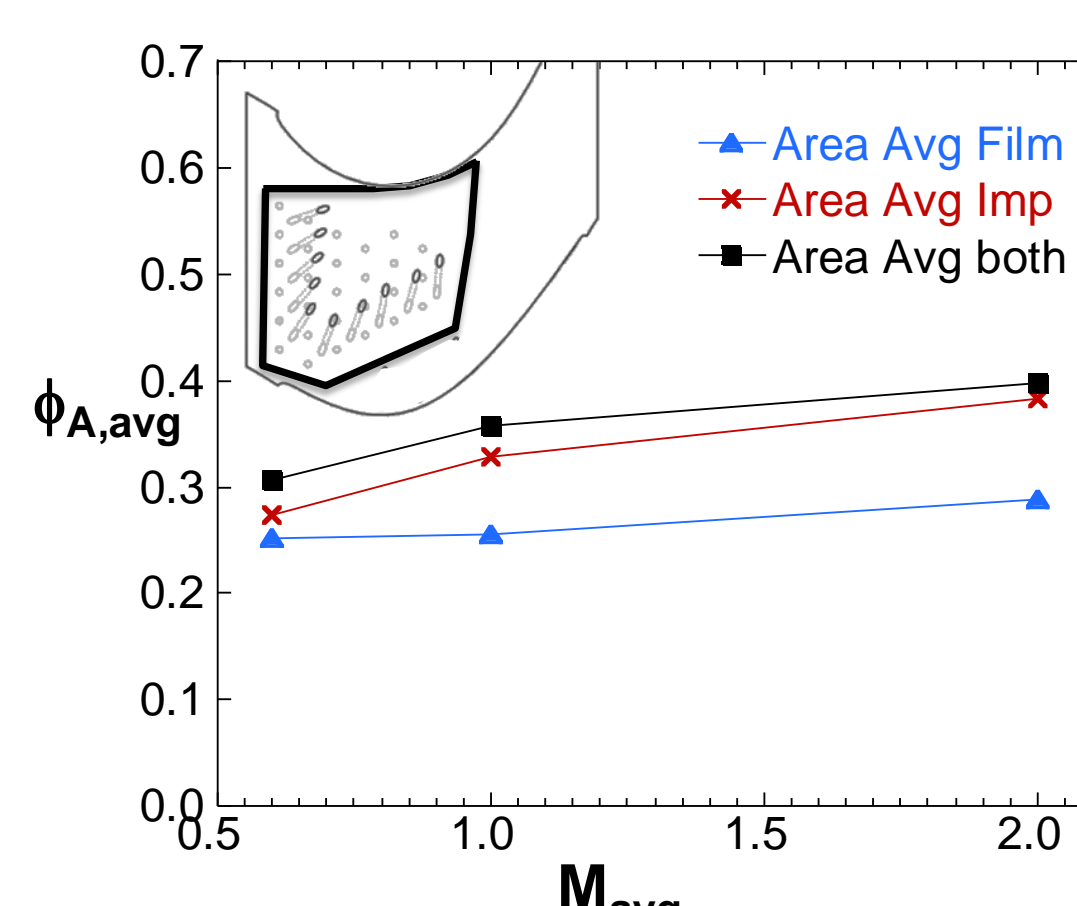
Summary and Conclusions

The influence of conduction and convective cooling within the film cooling holes was evident.

Increasing blowing ratio increased effectiveness for impingement cooling more than film cooling.

Acknowledgments

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Future Work

Next, both a flat and contoured endwall will be tested with simulated contaminant deposition with wax.

Wax Deposition on an Adiabatic Wall

[Lawson et al., GT2012-68174]

