RMIT / ANSYS Contribution to the Buffet Working Group

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7-Jun-26

What's next...

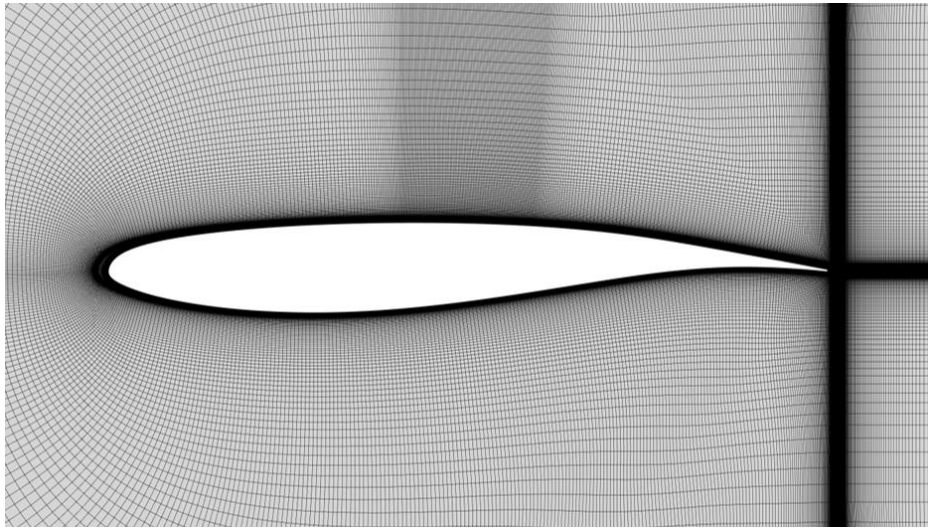
Despite working on it for over one year, we are only now ready to take a stab at test case 2… ☺

Recap: Test Case 1B

Test Case 1B

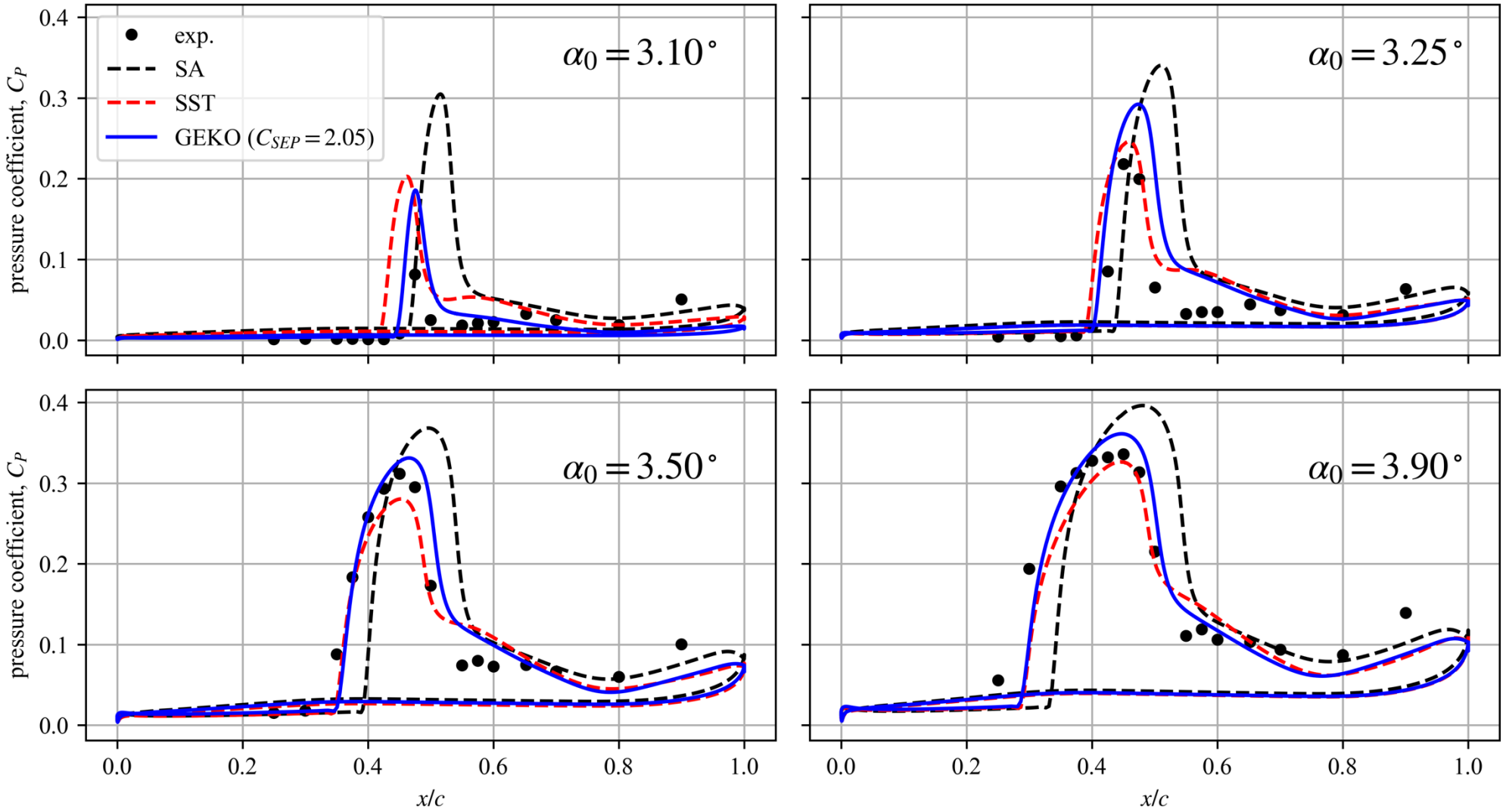
- Prediction of 2D transonic shock buffet on ONERA OAT15A airfoil model [1].
- $M_\infty = 0.73, p = 71{,}800\ \text{Pa}, Re_c \approx 3M$
- $\alpha_0 = 3.1^\circ, 3.25^\circ, 3.4^\circ, 3.5^\circ, 3.6^\circ\ 3.9^\circ$

- Fluent 2024 R2.
- Coupled pressure-based solver.
- SO-upwind spatial discretization.
- Bounded SO-implicit temporal discretization.
- SA, SST $k-\omega$ and GEKO.
- 200 timesteps per CTU.

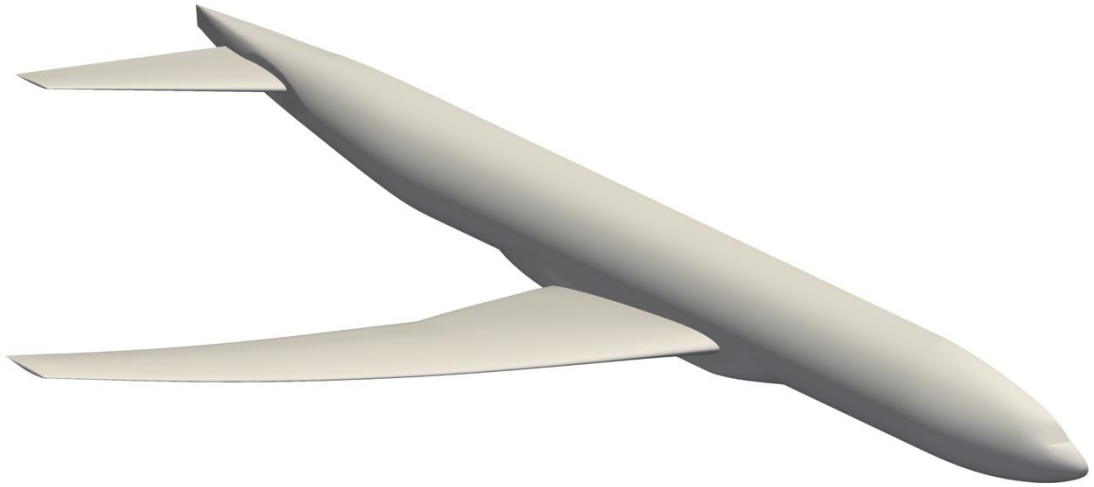


[1] Jacquin, L., Molton, P., Deck, S., Maury, B., and Soulevant, D., "Experimental Study of Shock Oscillation over a Transonic Supercritical Profile," AIAA Journal, Vol. 92, No. 9, 2009, pp. 1985–1994.

BWG – AOA Sweep (RMS C_p)



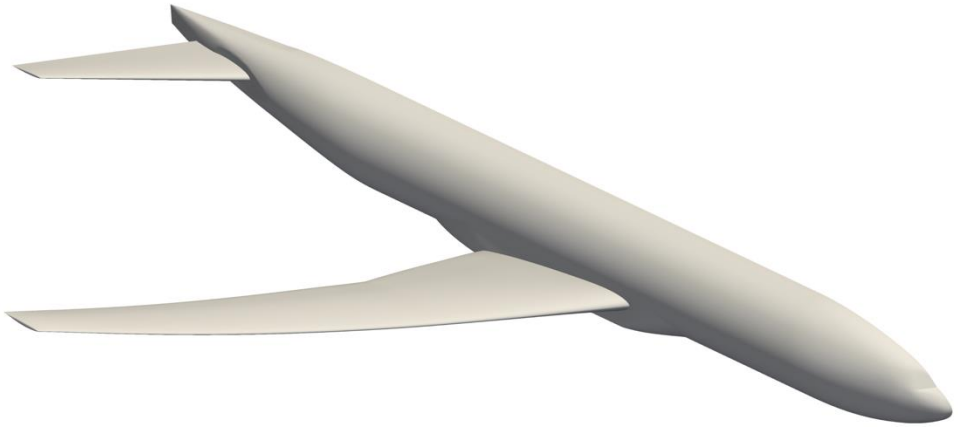
OAT15A: RMS pressure coefficient comparing different turbulence models for AOA sweep



Test Case 2

NASA Common Research Model

- 80% CRM tests conducted at JAXA.
- Objective is to model the 3D shock buffet using CFD and validate against experiments.
- Collaboration with ANSYS to:
  A. Test Case 2: Benchmark Fluent for rigid wing buffet response.
  B. Test Case 3: Benchmark PyFSI for elastic wing buffet response.



	Mach	Re_c	AOA	Notes
Test Case 2	0.85	1.515M	1.22°, 2.29°, **4.84°, 5.89°**	• Cadence grids. • Rigid wing only.
Test Case 3	0.85	2.27M	3.05°, 3.61°, **4.71°**	• Cadence grids. • Rigid wing. • Elastic wing (currently running).

Journey

Start extreme(?)

TEST CASE 2
$M = 0.85, Re \approx 1M$
$AOA = 5.89°$

SST $k-\omega$
- Default
- Curv. cor.
- Comp. cor.
- Transition model:
  - Algebraic
  - One eqn.
- SO-Upwind
- MUSCL

NO BUFFET*

RSM (Stress−ω)
- Default

BUFFET
(too aggressive)

RSM (Stress−ω)
- Default
- Limiters

NO BUFFET

RSM (Stress−ω)
- Shear cor. OFF

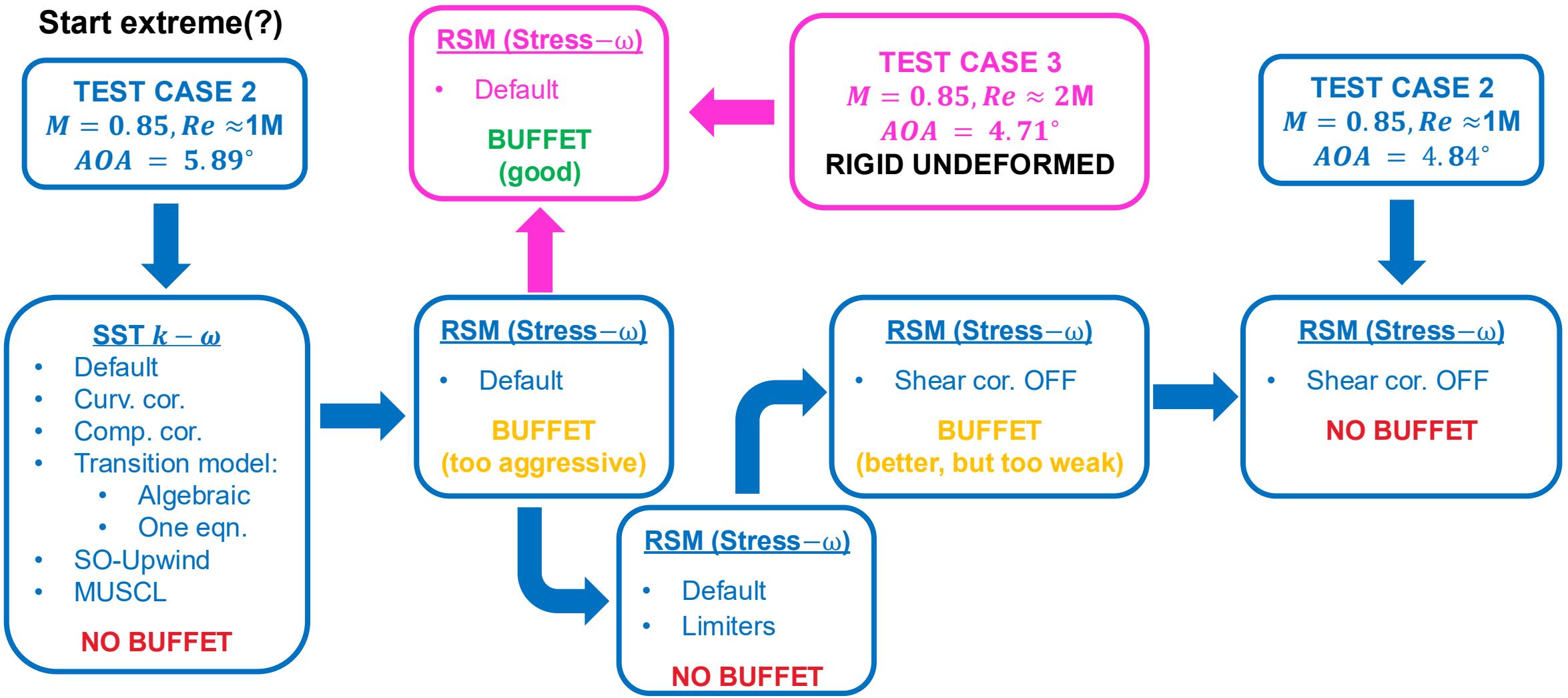
BUFFET
(better, but too weak)

TEST CASE 2
$M = 0.85, Re \approx 1M$
$AOA = 4.84°$

RSM (Stress−ω)
- Shear cor. OFF

NO BUFFET

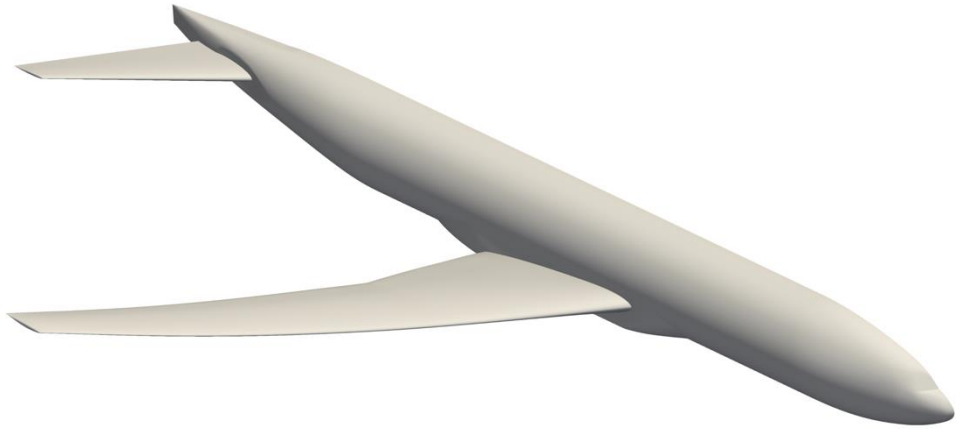
Journey



CFD Solver

CFD Solver Overview

- Fluent 2025 R2.
- Coupled pressure-based solver.
- Reynolds Stress Model (stress-ω)
- 200 timesteps per CTU ($\Delta t = 2.645 \times 10^{-6}$s)
- 20 sub-iterations / timestep
- Residuals 1e-5 – 1e-7



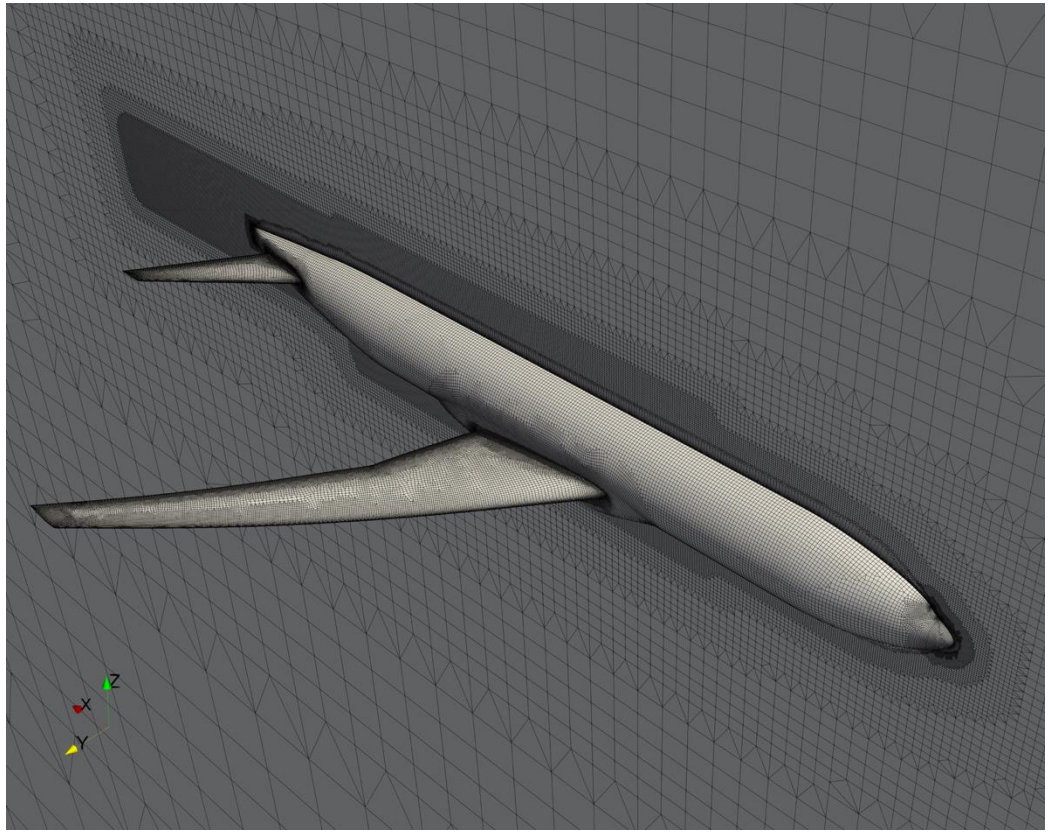
Configuration 1

- **Closure:** Reynolds Stress Model (stress-ω)
- **Options:** Shear flow correction ON.
- **Convective fluxes:** SO-upwind.
- **Time integration:** Bounded SO-implicit

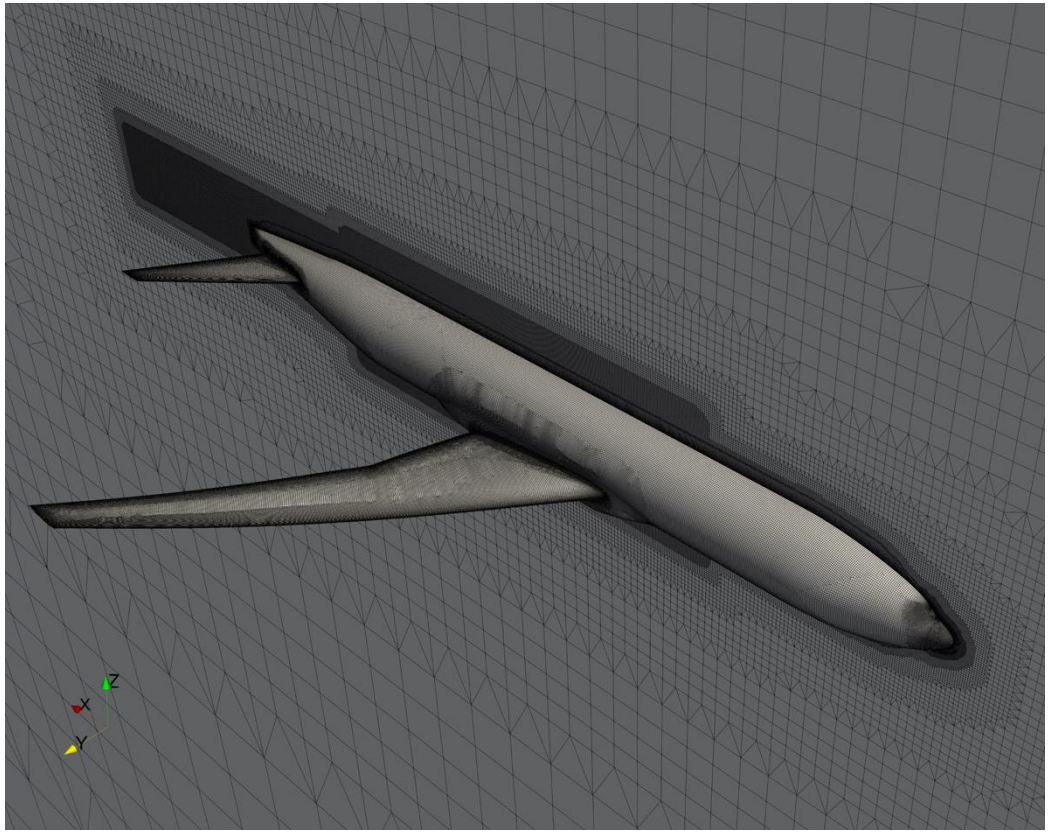
Configuration 2

- **Closure:** Reynolds Stress Model (stress-ω)
- **Options:** Shear flow correction OFF.
- **Convective fluxes (mean flow + ω):** SO-upwind
- **Convective fluxes (Reynolds Stress):** MUSCL
- **Time integration:** SO-implicit

Computational Grids: Cadence



NASA CRM Grid Level 1 (tiny) ~34M cells

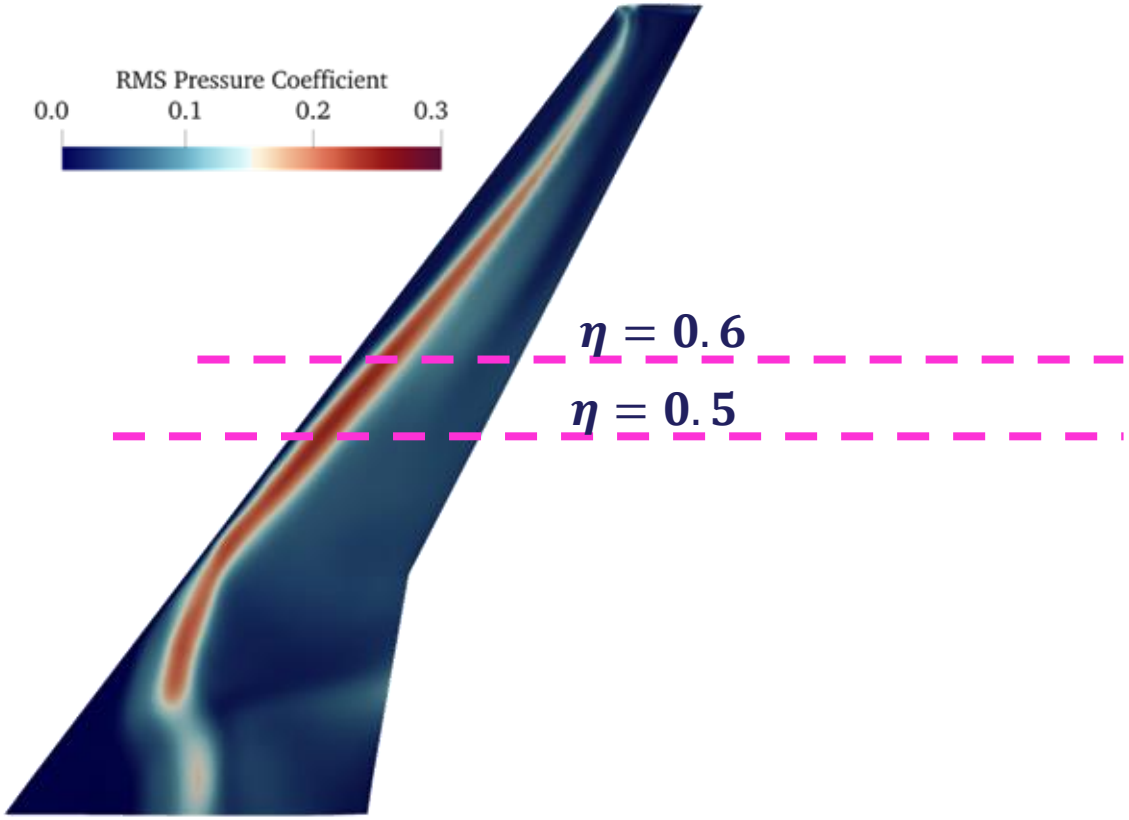


NASA CRM Grid Level 3 (medium) ~155M cells

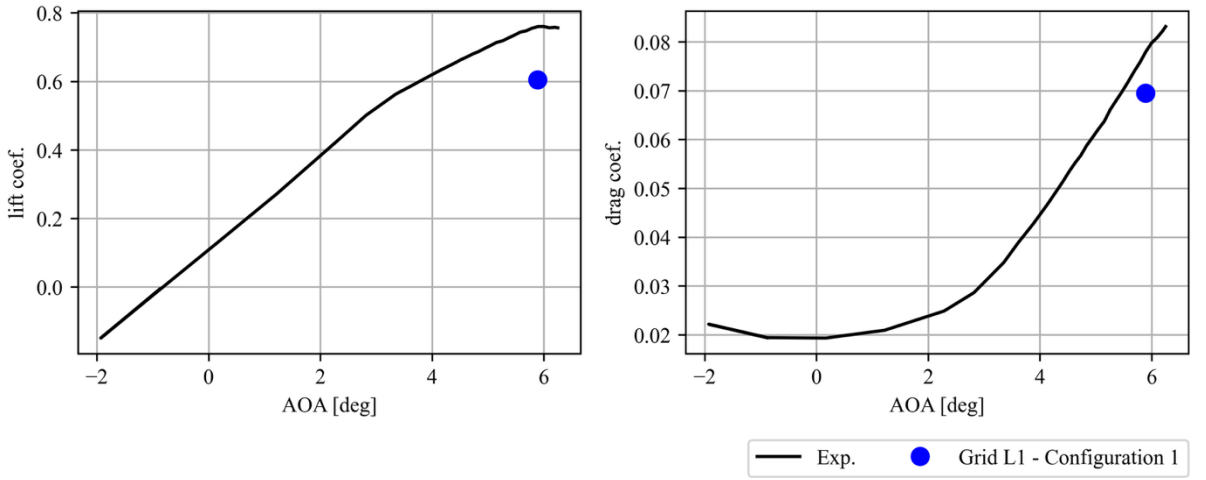
Test Case 2

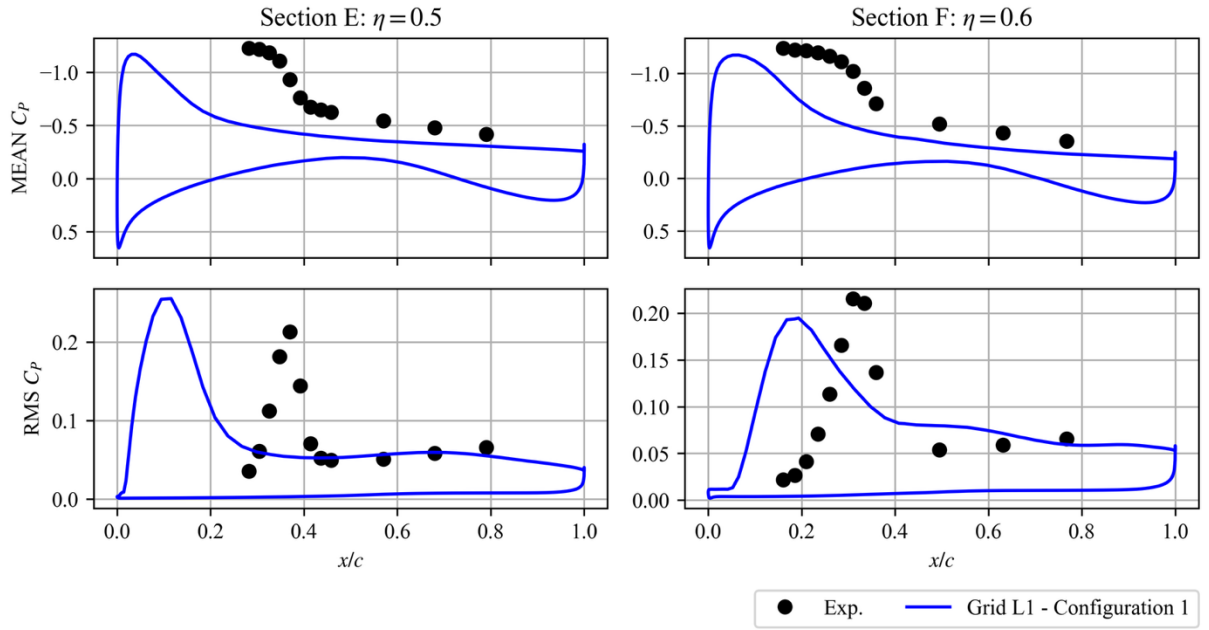
AOA = 5.89°, Configuration 1 (L1 vs L3)

SHEAR FLOW CORRECTION ON



Grid L1

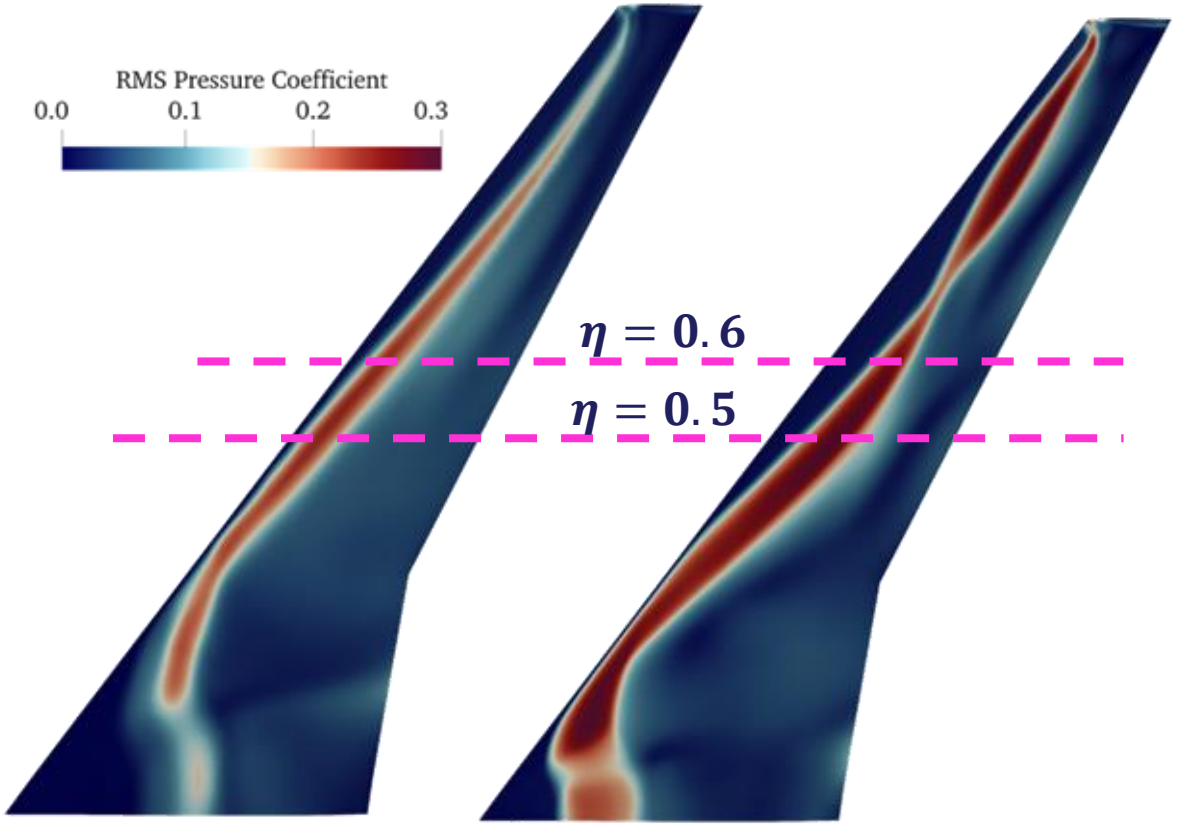


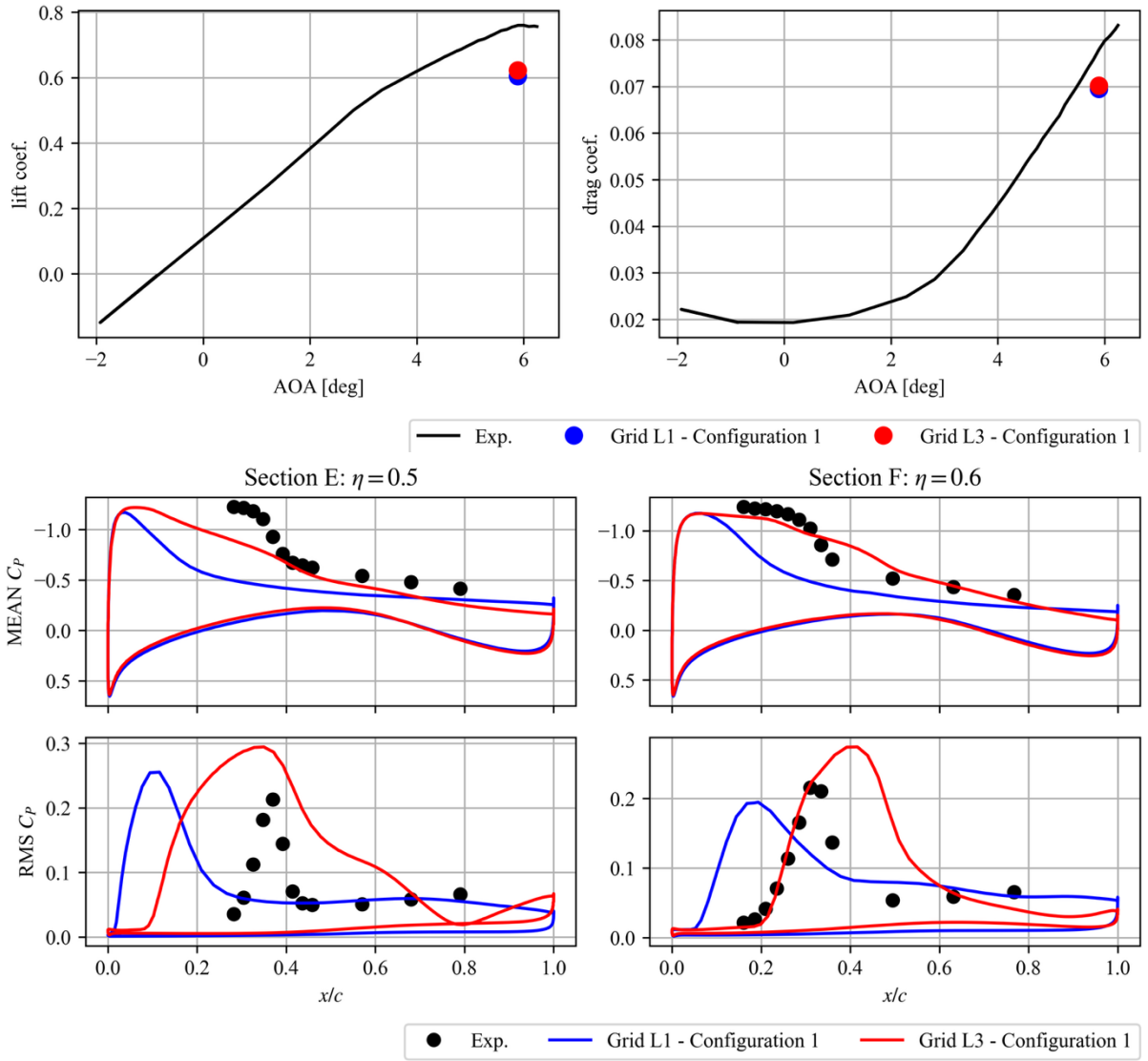


Test Case 2

AOA = 5.89°, Configuration 1 (L1 vs L3)

SHEAR FLOW CORRECTION ON

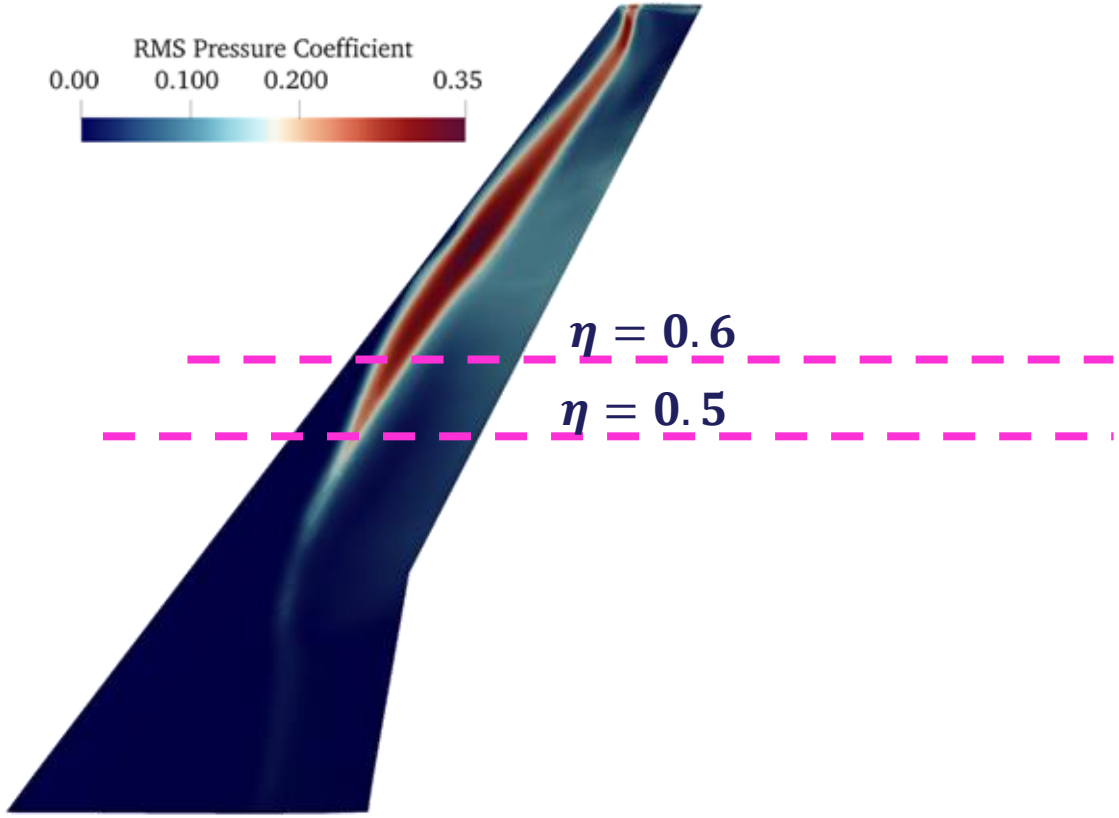




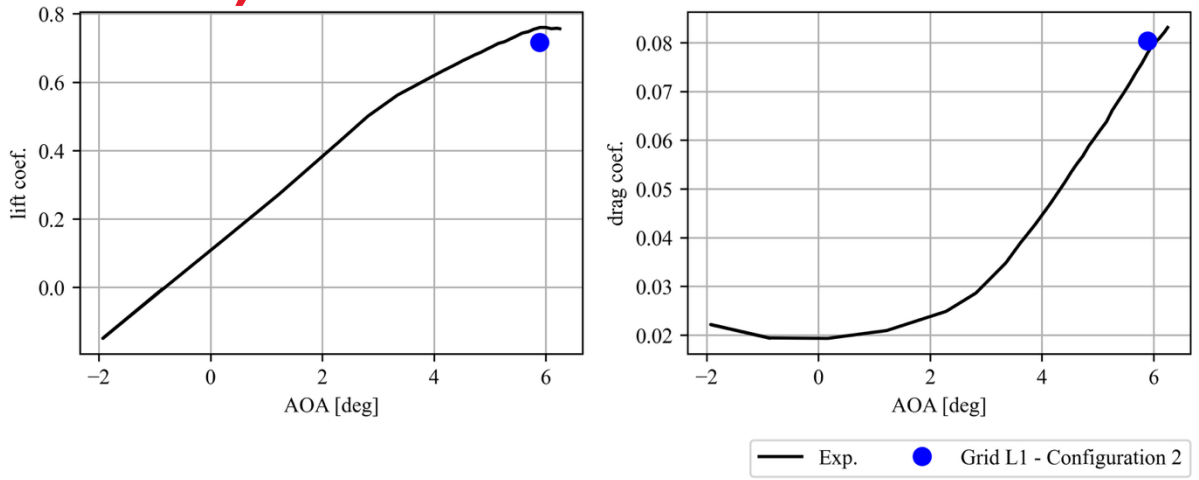
Test Case 2

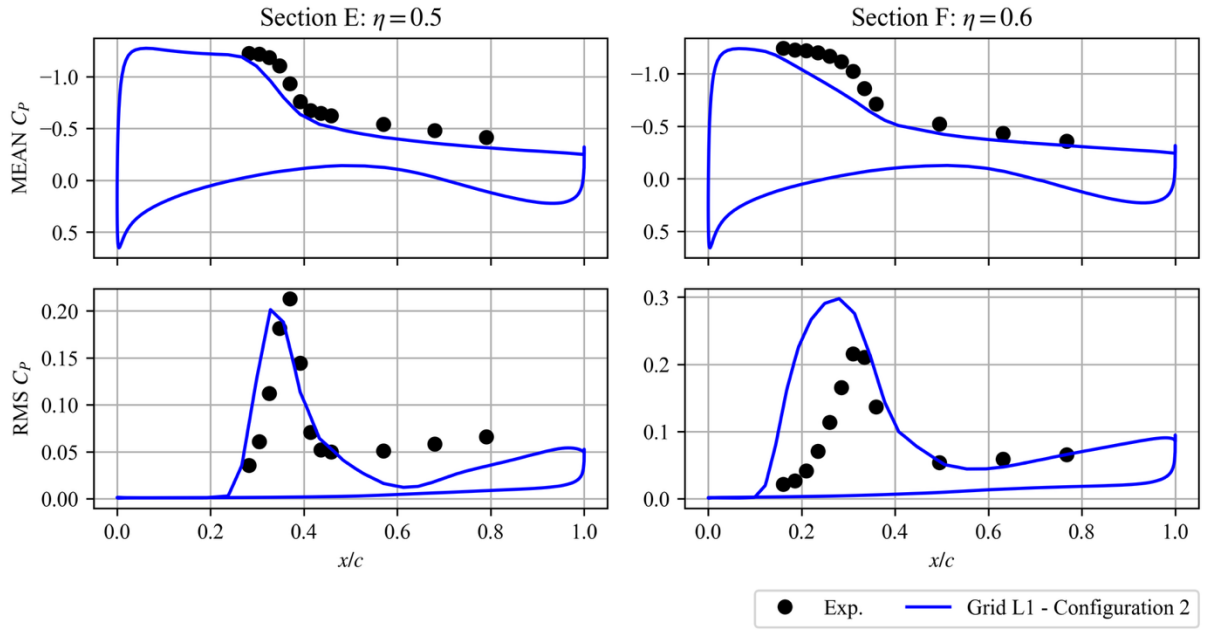
AOA = 5.89°, Configuration 2 (L1 vs L3)

SHEAR FLOW CORRECTION OFF



Grid L1

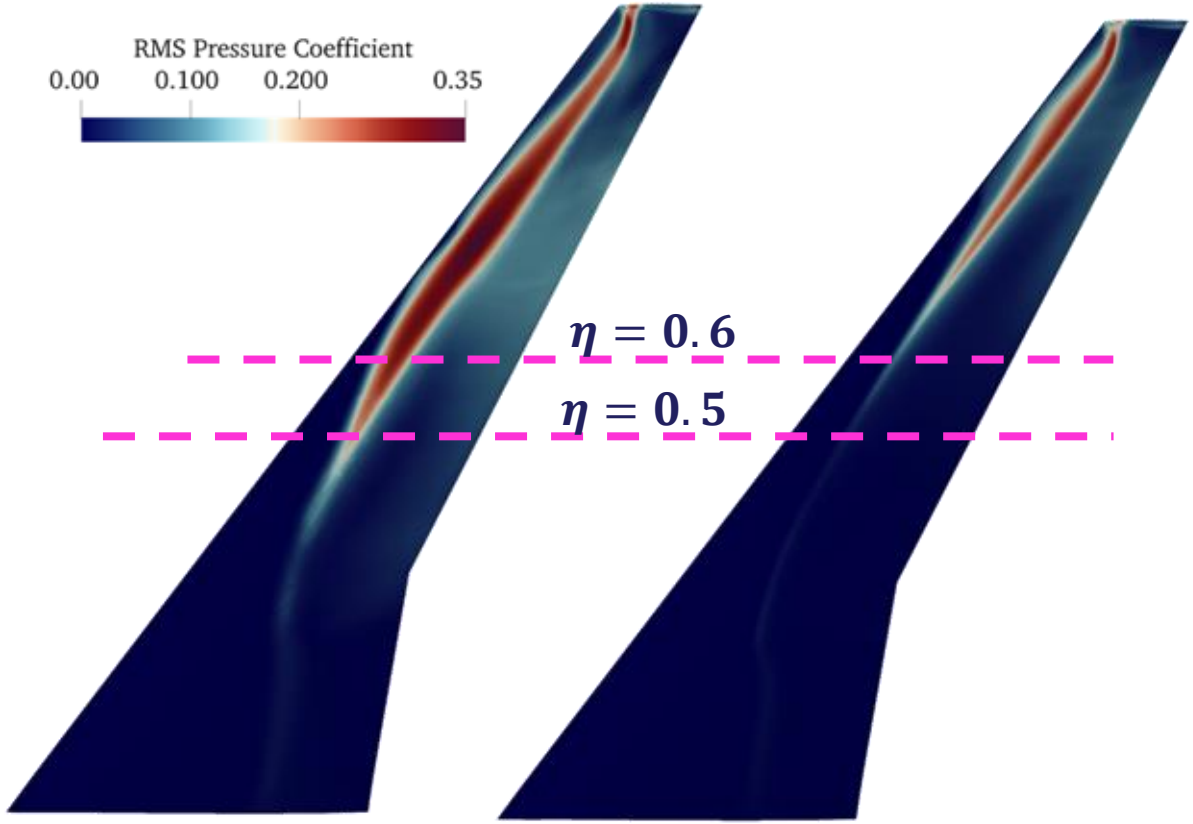


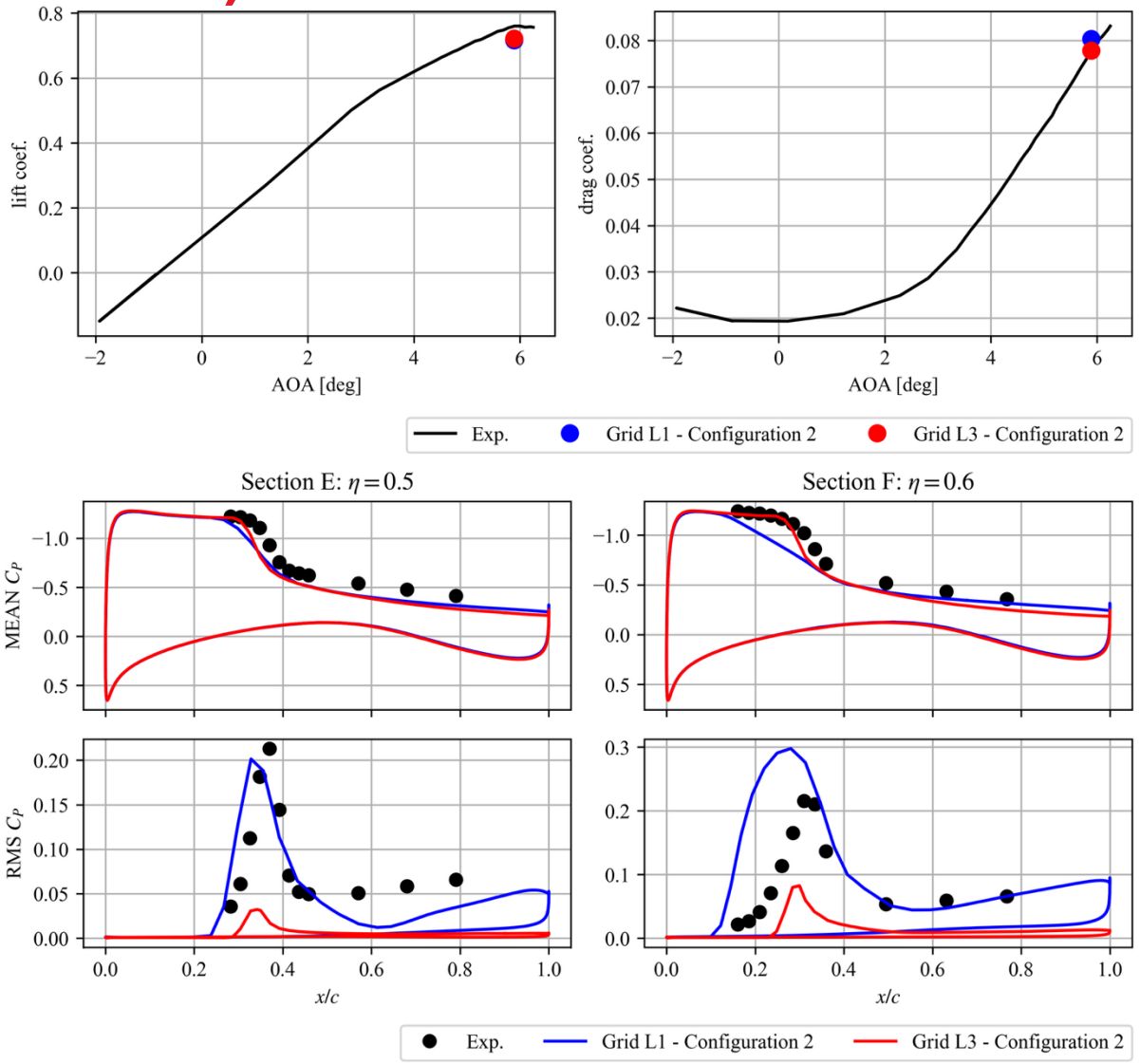


Test Case 2

AOA = 5.89°, Configuration 2 (L1 vs L3)

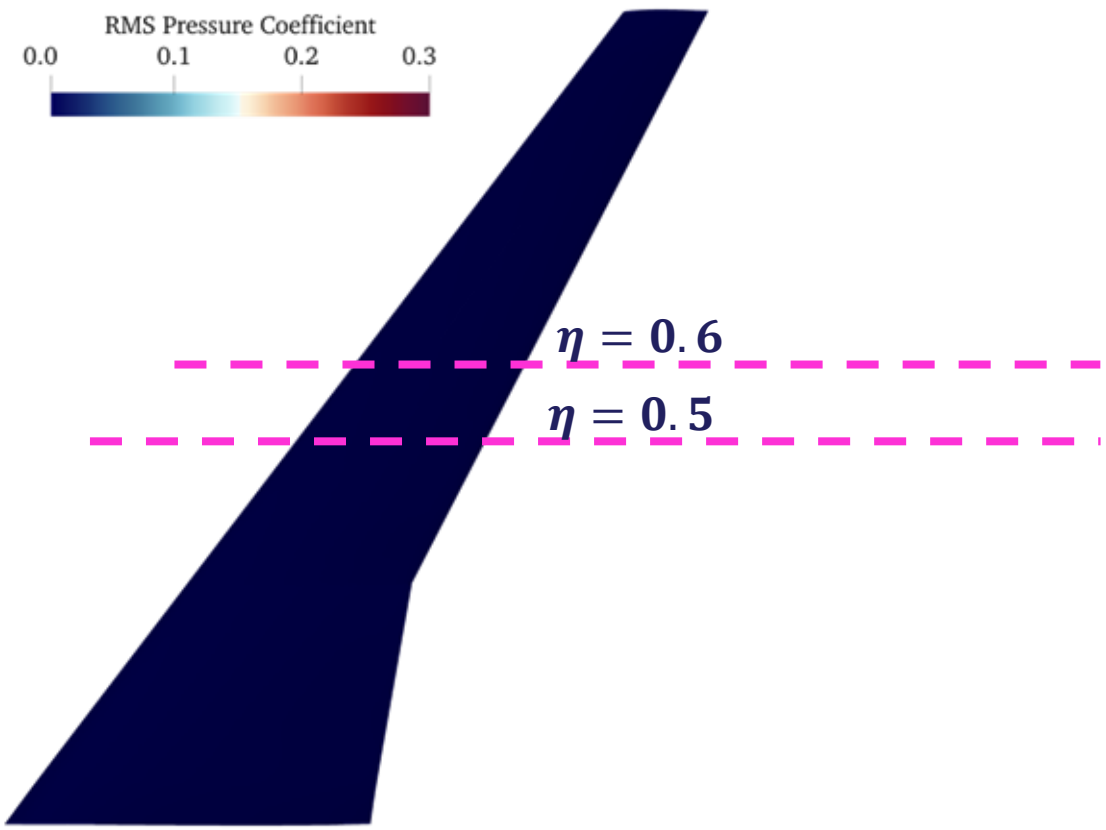
SHEAR FLOW CORRECTION OFF

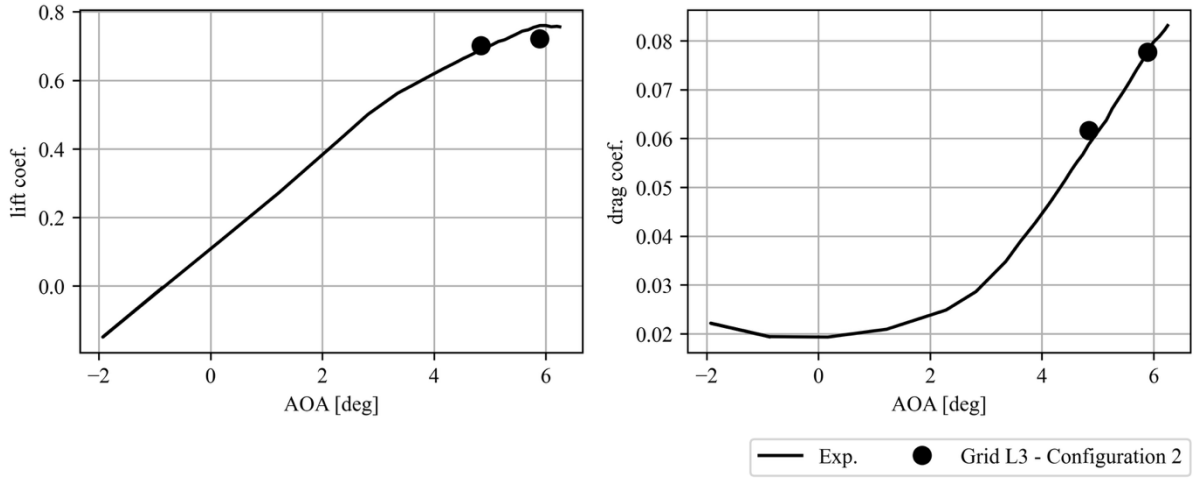


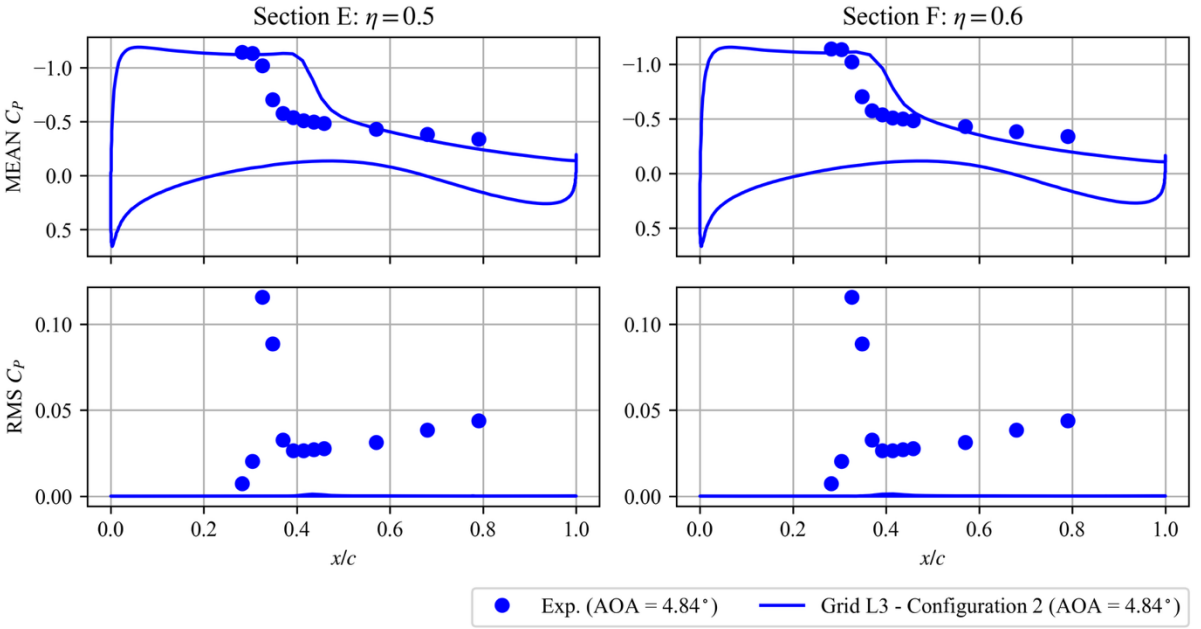


Test Case 2

AOA = 4.84°, Configuration 2, L3

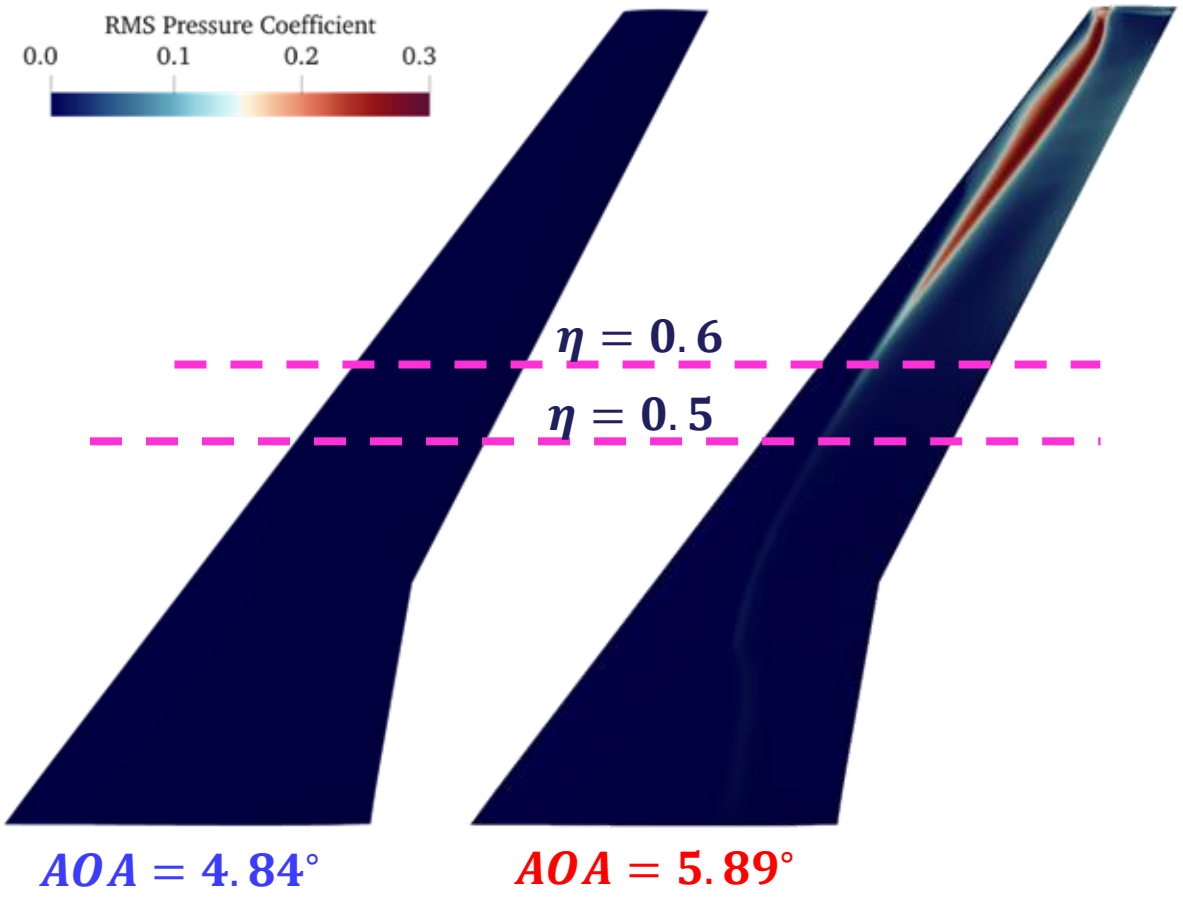


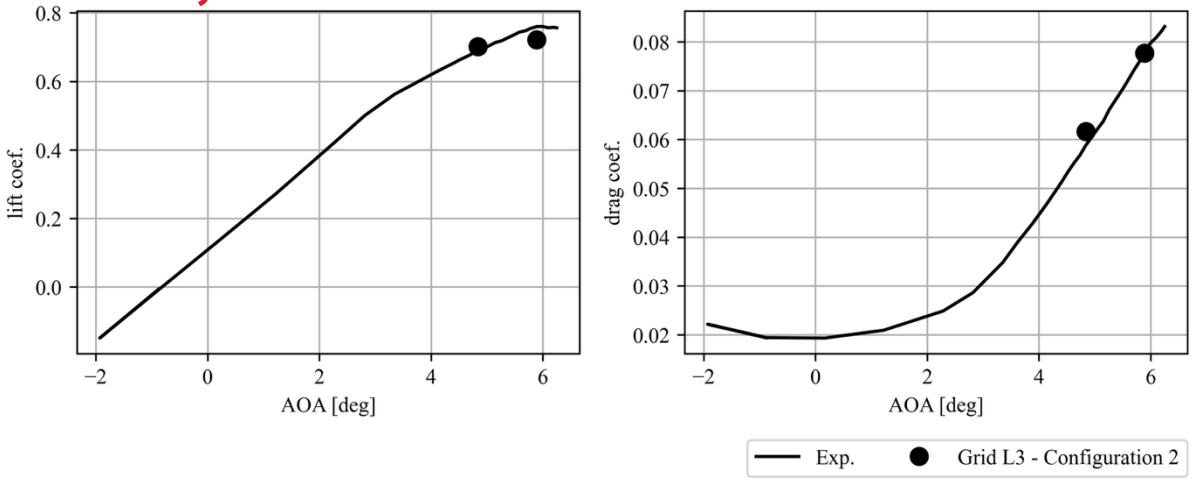


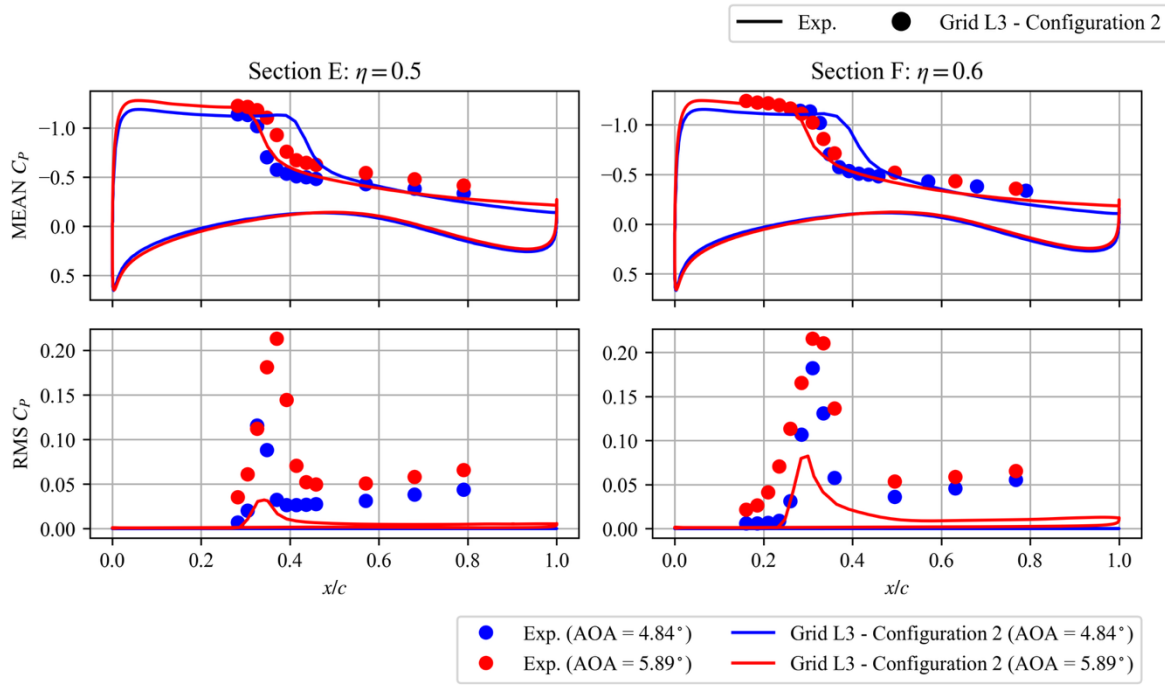


Test Case 2

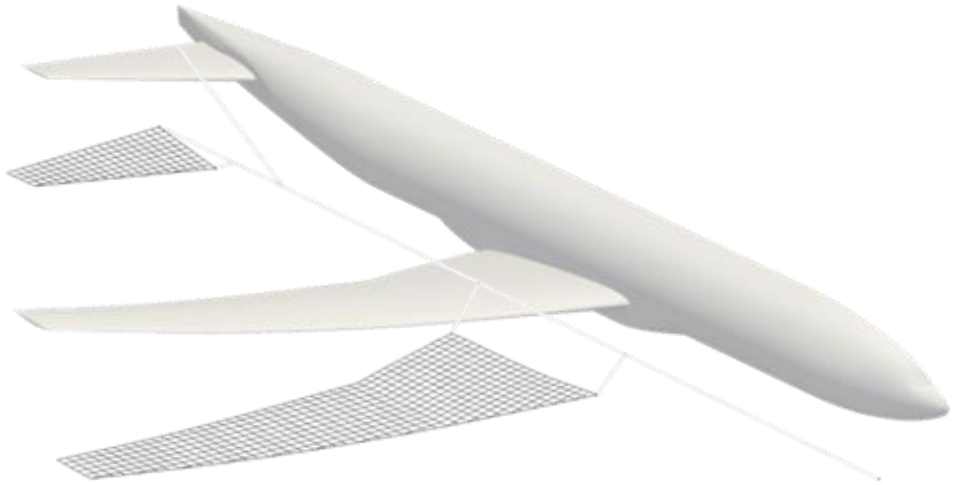
AOA = 4.84° vs 5.89°, Configuration 2, L3





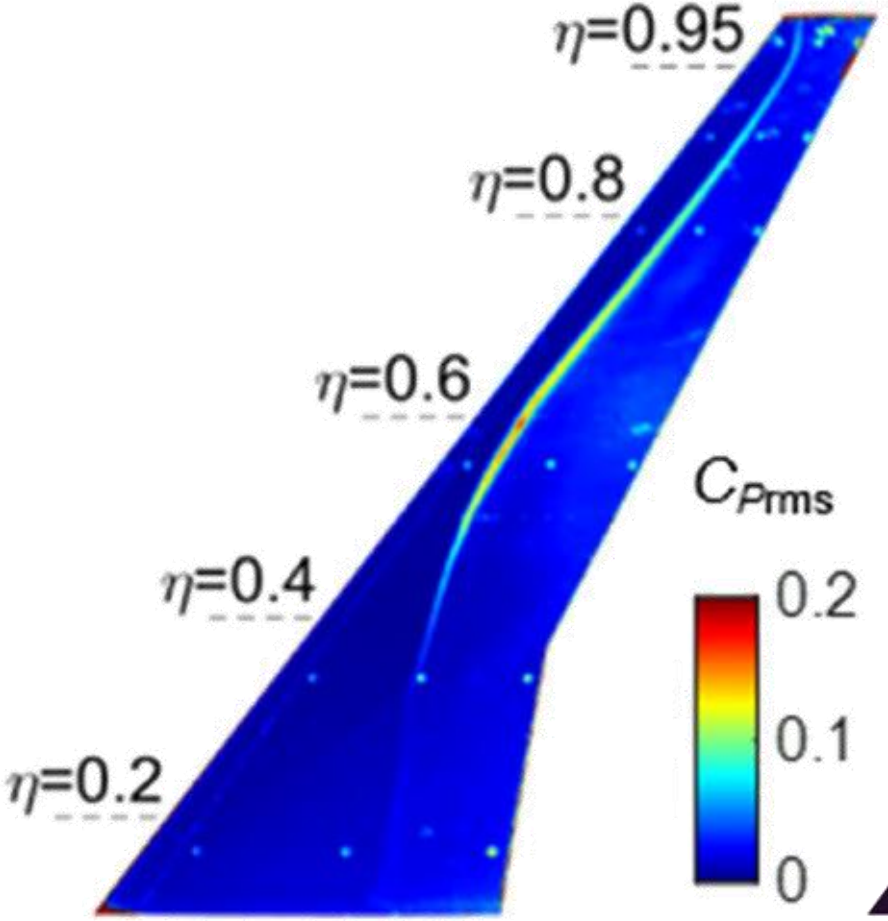


Test Case 3

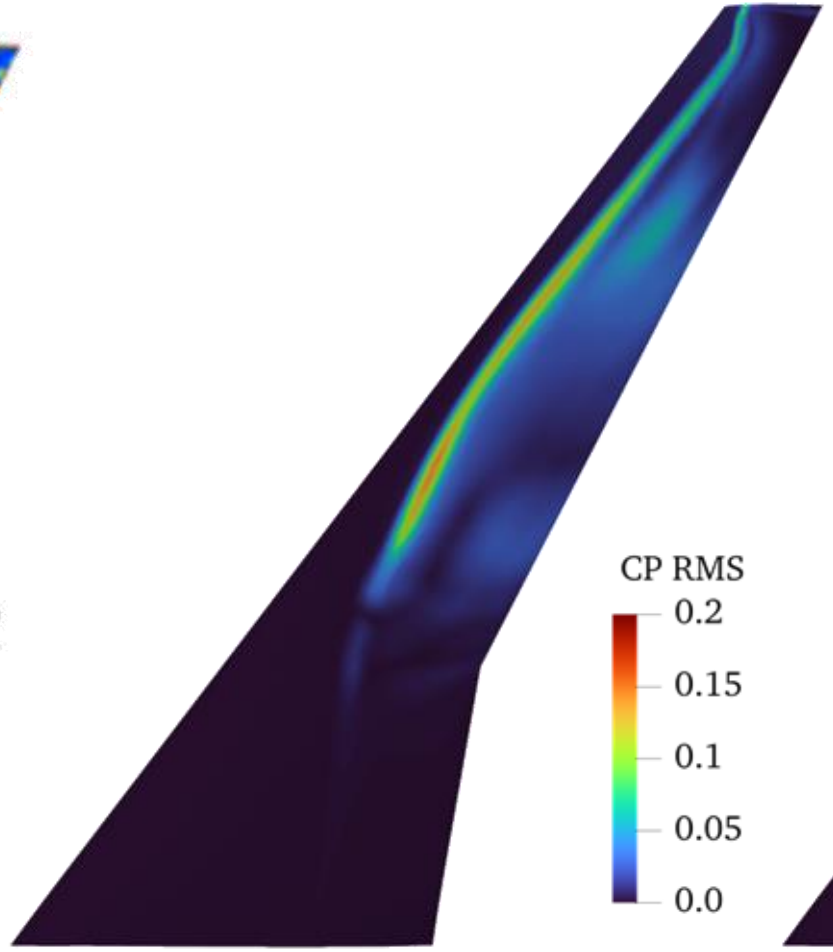


Test Case 3 (rigid)

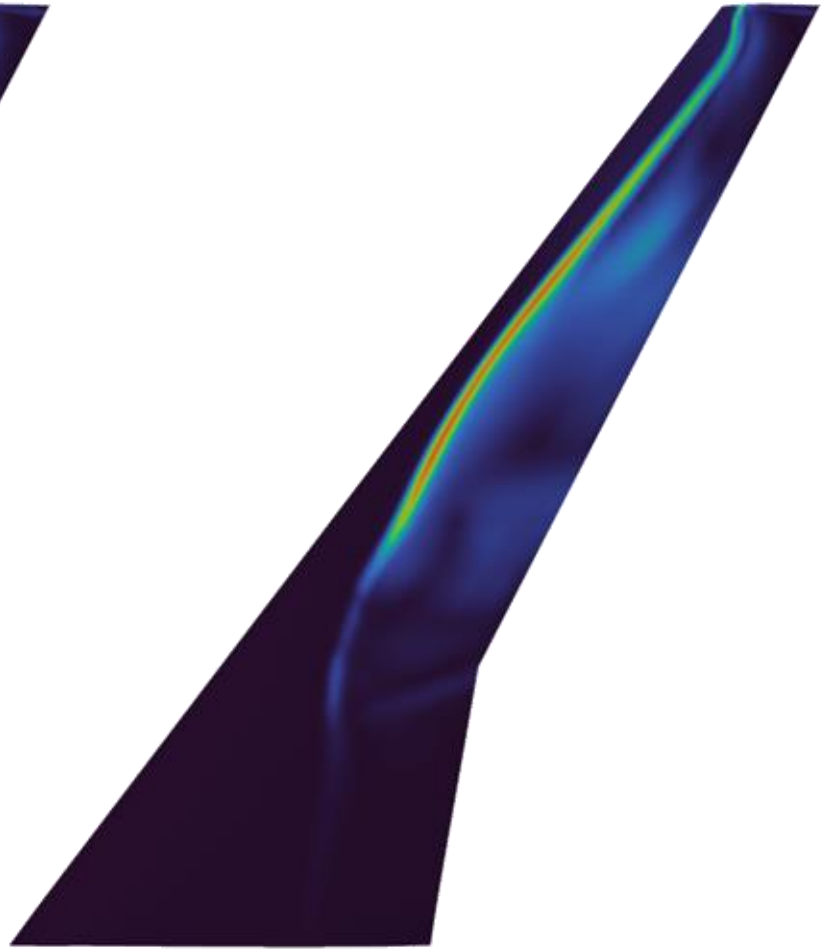
AOA = 4.71°, Configuration 1



Experiment



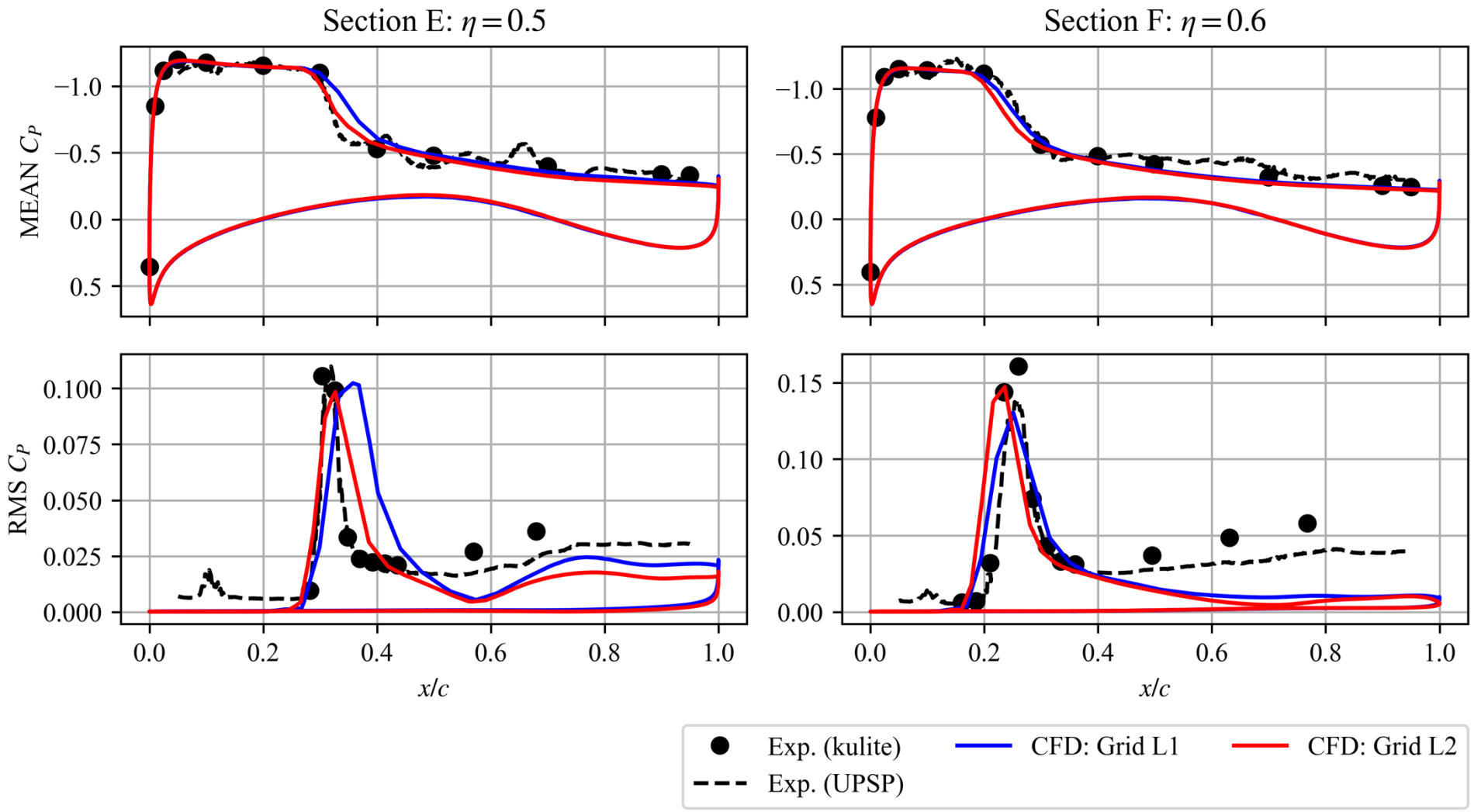
Grid L1



Grid L2
(PRELIMINARY RESULT)

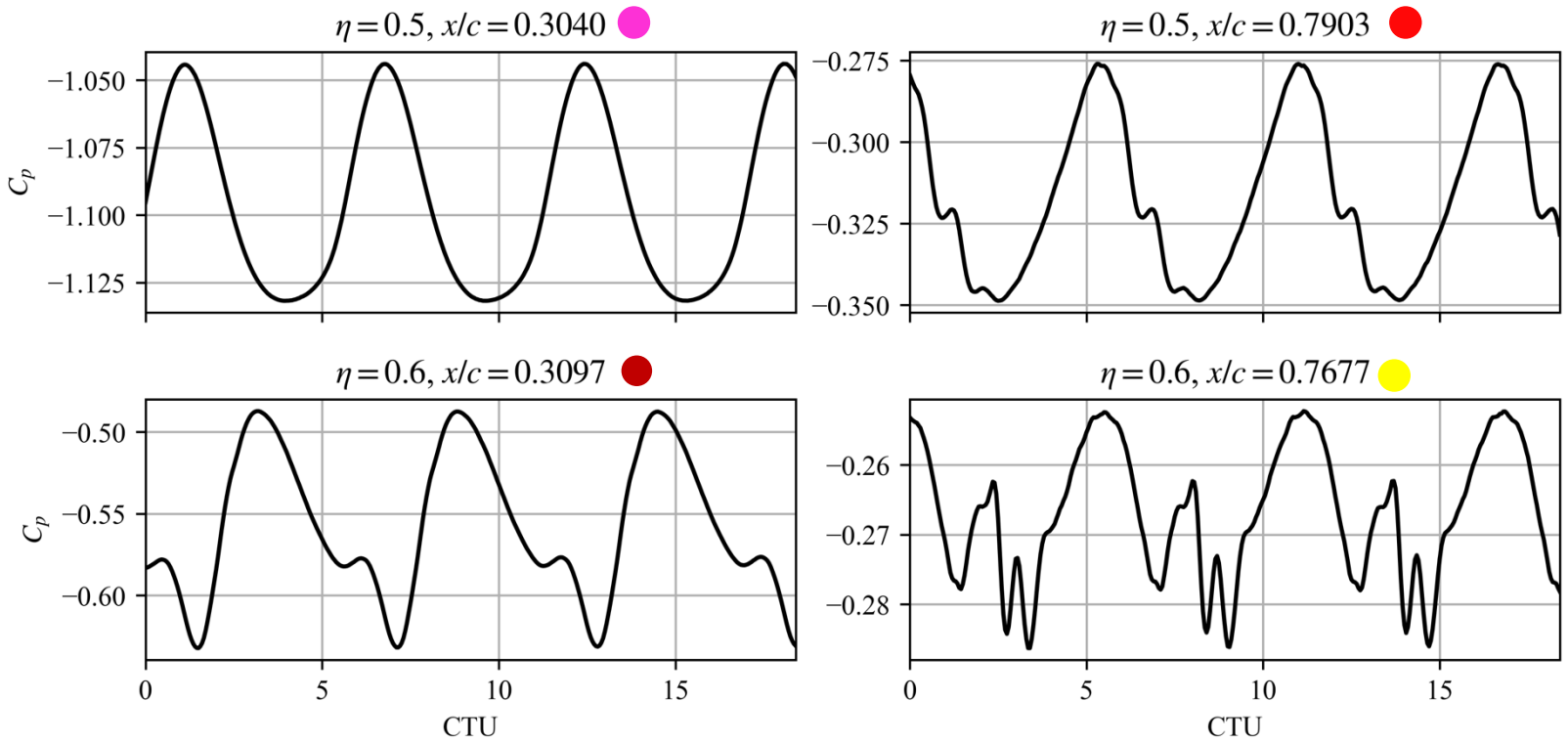
Test Case 3 (rigid)

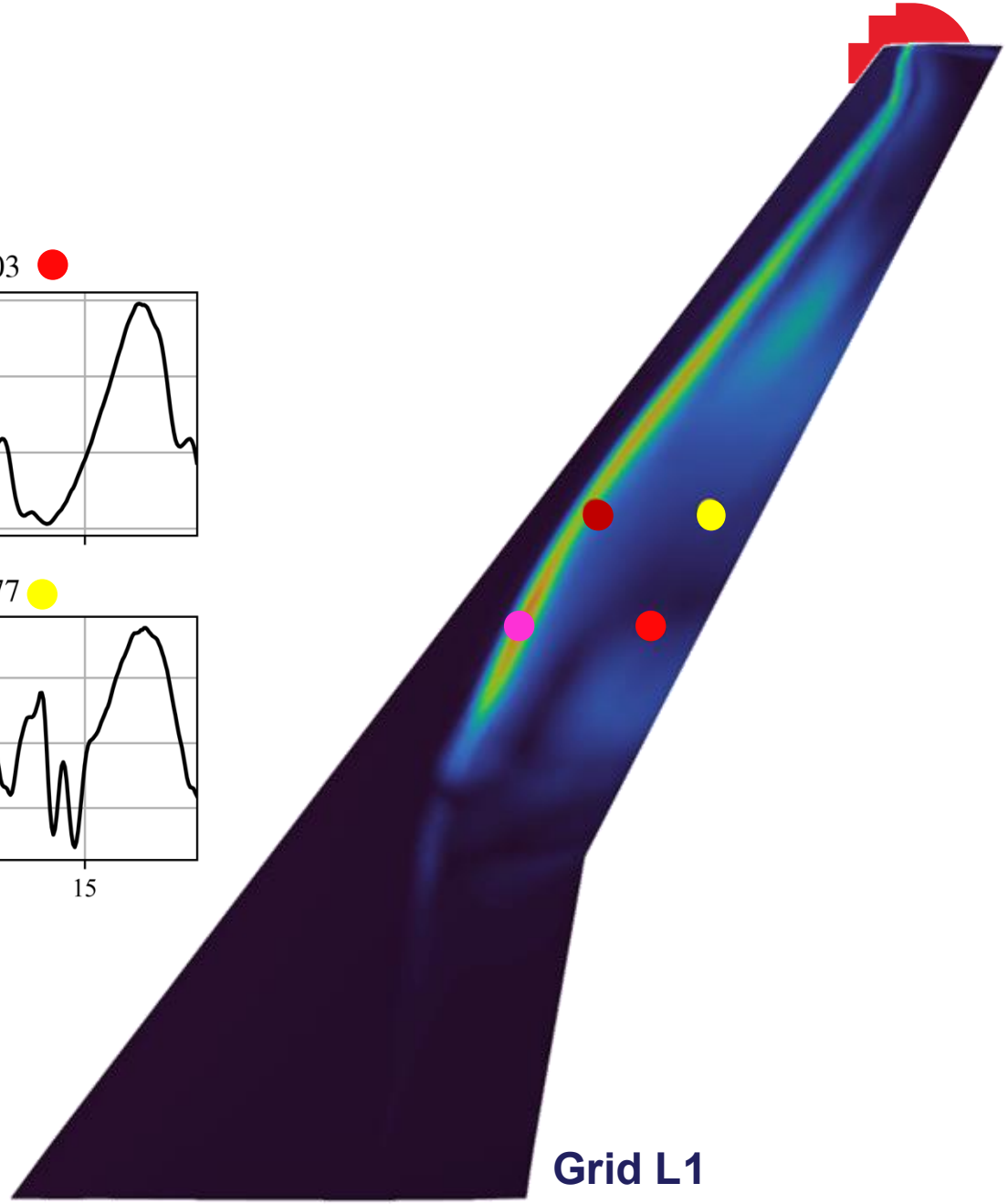
AOA = 4.71°, Configuration 1



Test Case 3 (rigid)

AOA = 4.71°, Configuration 1

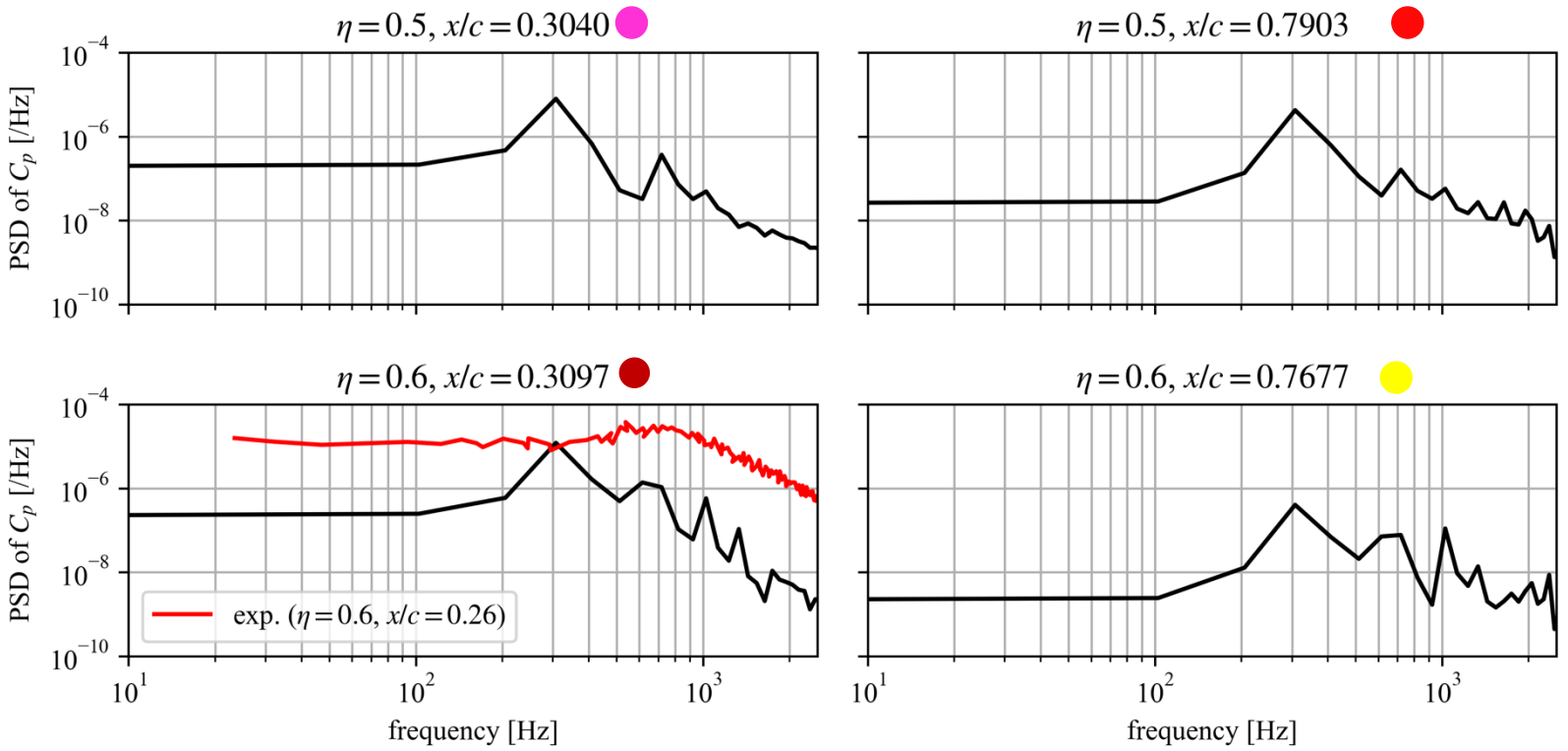


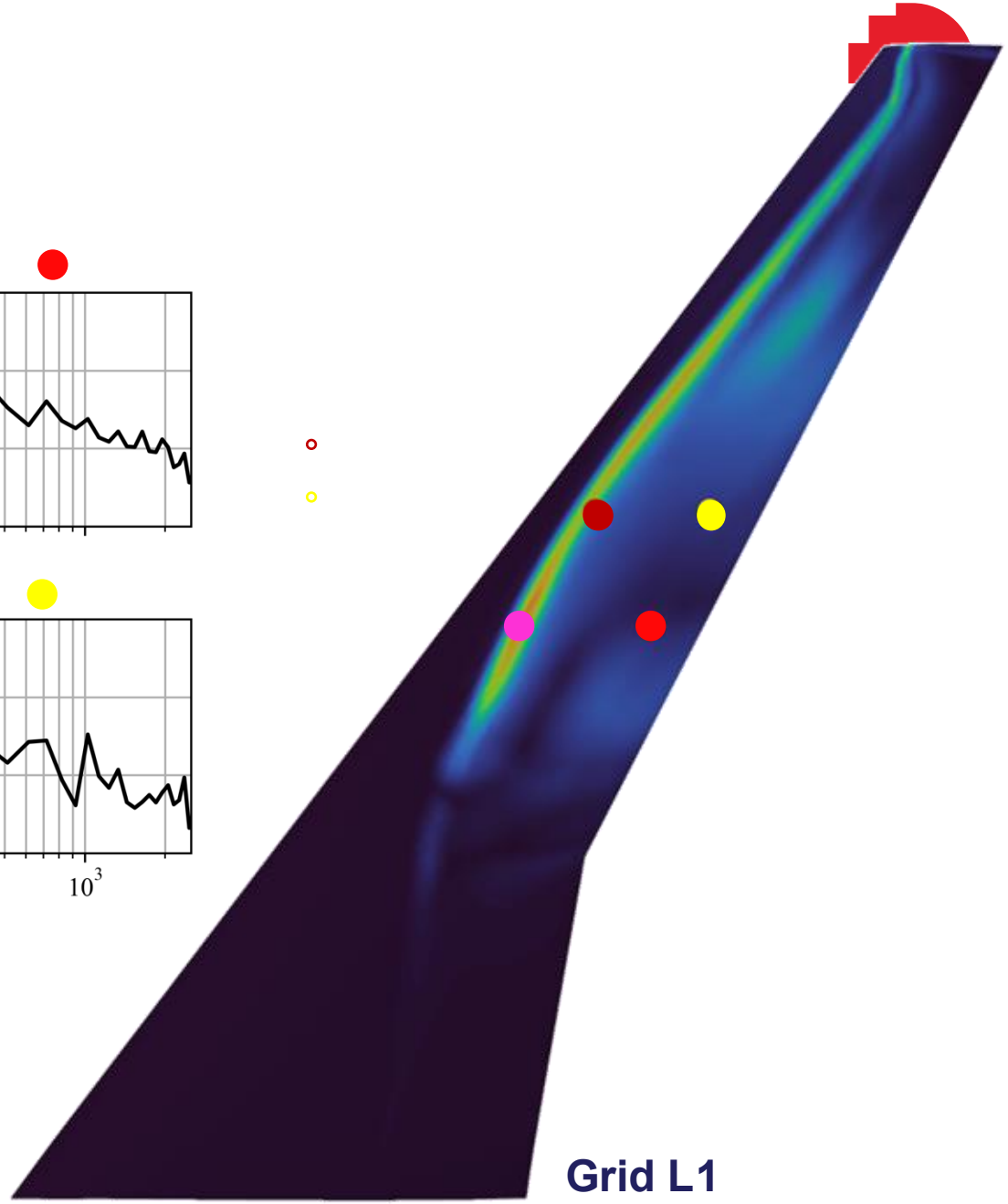


Grid L1

Test Case 3 (rigid)

AOA = 4.71°, Configuration 1

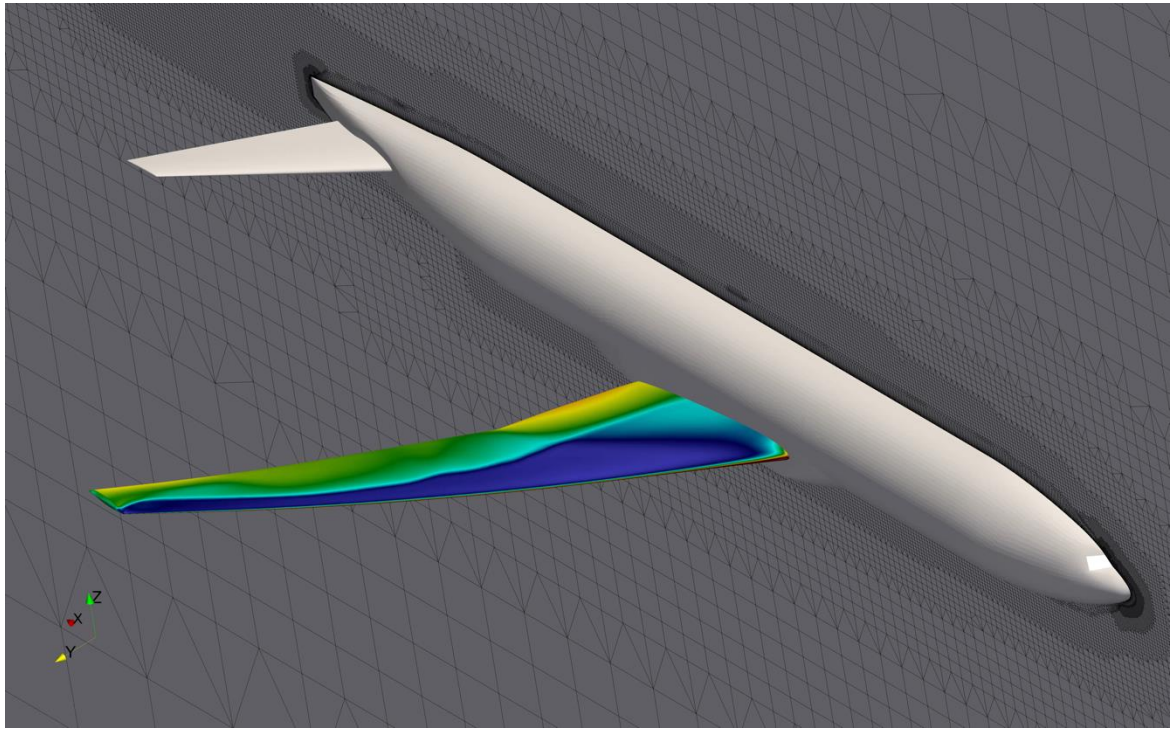




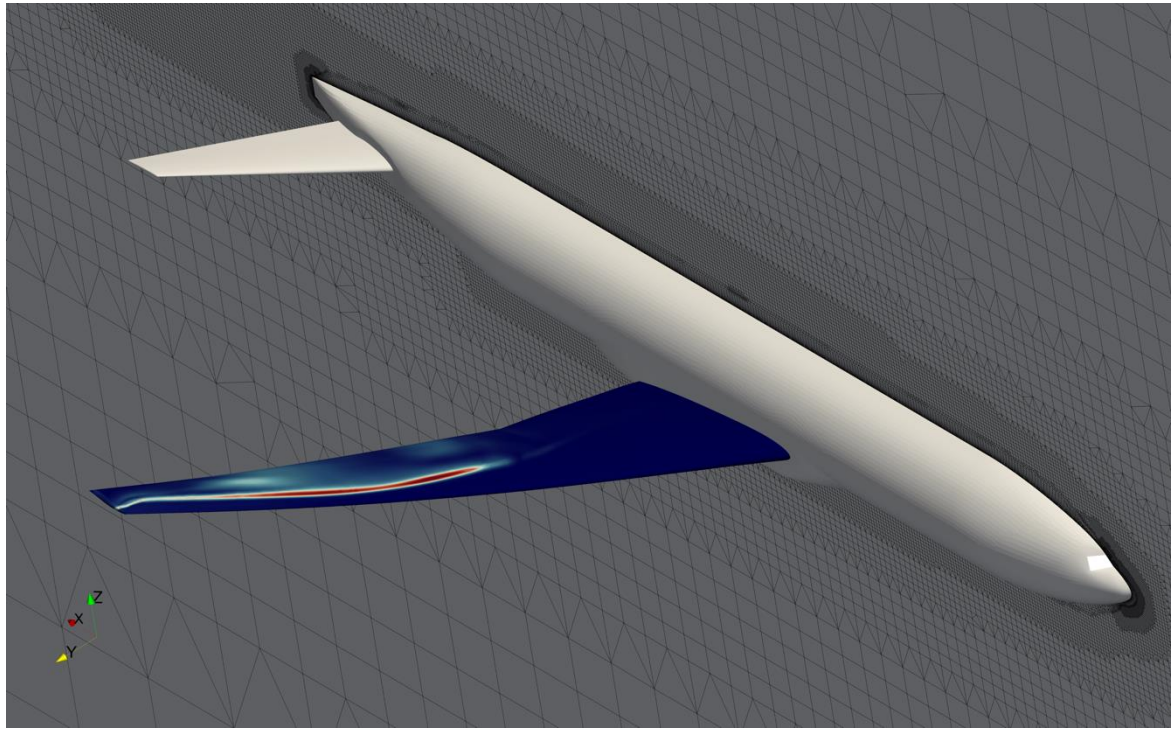
Grid L1

Test Case 3

AOA = 4.71°, Configuration 1



Pressure Coefficient



RMS Pressure Coefficient

Final Remarks

- Modeling buffet on real-world configurations is hard.
- Eddy-viscosity models struggle.
- RSM seems to be okay up to a point (more testing needed).
- URANS is not completely useless..!
- Directions:
  - **Test Case 2:** re-do full AOA sweep with RSM Default.
  - **Test Case 3:** aeroelastic (running now) and aeroelastic stability.

Test Case 3

AOA = 4.71°, Configuration 1