Testcase C 3.1
MDA 30P-30N

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DLR Braunschweig (AS - $C^2A^2S^2E$)

DLR

DG discretization

Basis functions

- non-parametric ortho-normal basis functions
- directly formulated in physical space
- also referred to as Taylor-DG
- need to be evaluated for each mesh element

RANS equations

- SA turbulence model (negative SA)
- second scheme of Bassi and Rebay (BR2) for viscous terms
- Roe flux as a convective flux, based on an eigen-decomposition of the full jacobian

2D high lift airfoil MDA 30P 30N

- Mach number $M = 0.2$,
- Reynolds number $Re = 9 \cdot 10^6$,
- angle of attack $\alpha = 16°$.

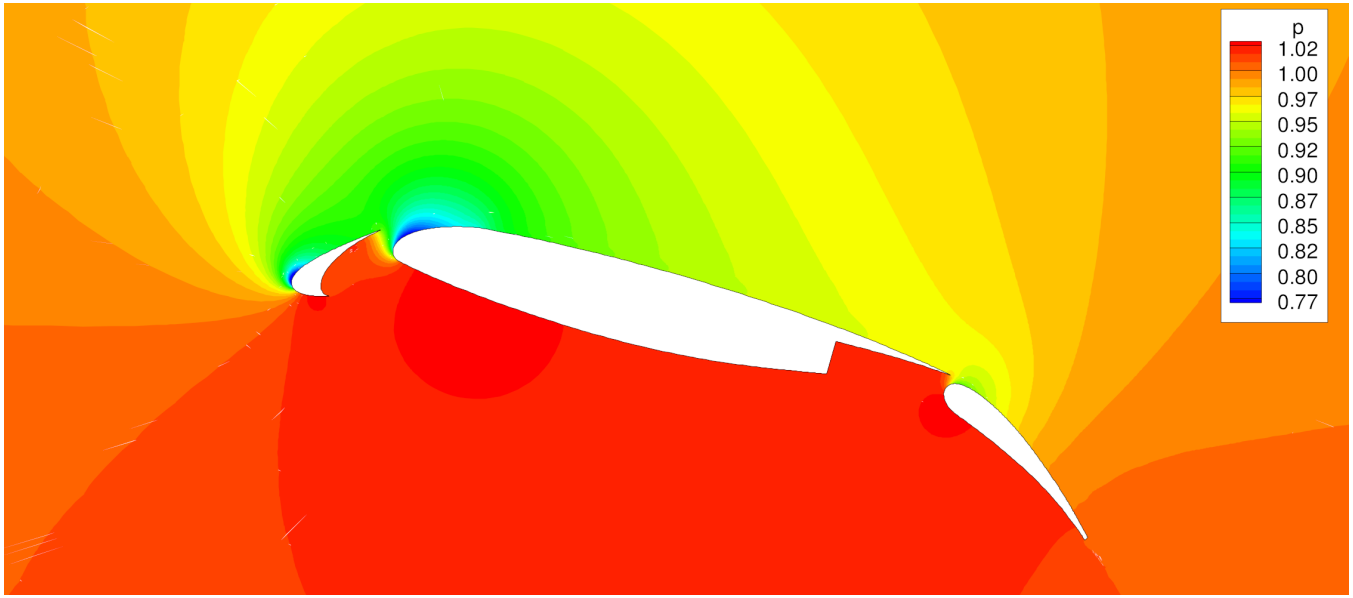


Figure : Pressure for a $p = 2$ solution on 33 728 elements mesh.

Testcase 3.1

Mesh hierarchy with own meshes (DLR):

- (structured) quadrilateral meshes with piecewise quartic boundaries
- farfield distance approx. 50 chord lengths
- 2 108, 8 432, 33 728 and 134 912 elements

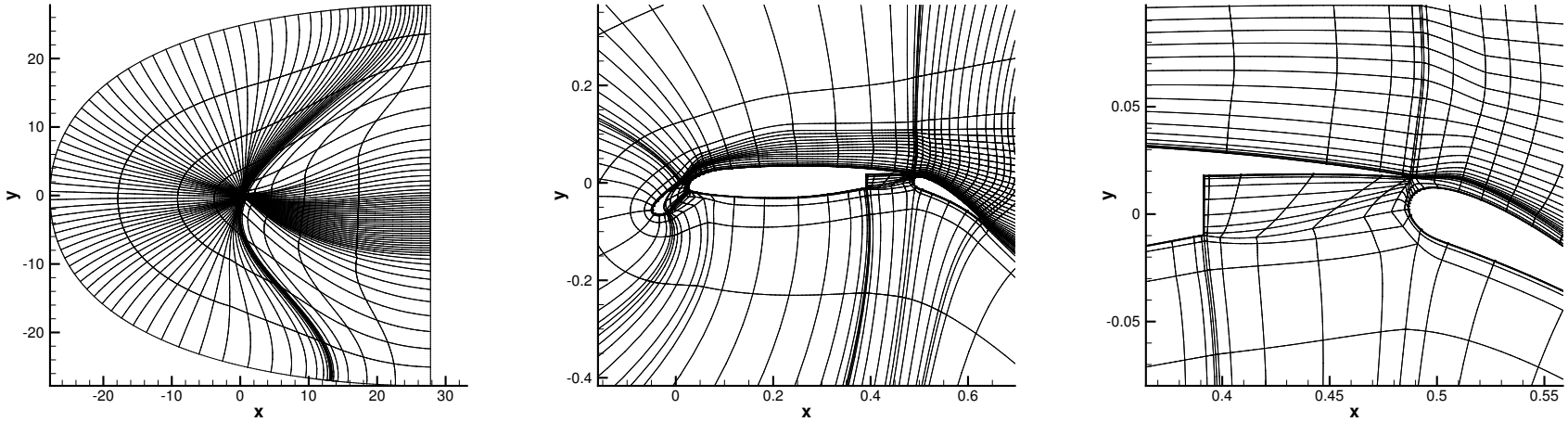
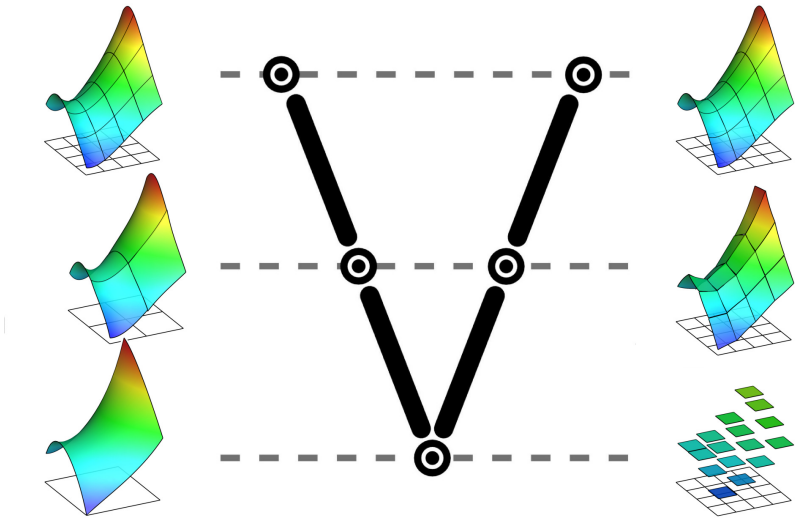
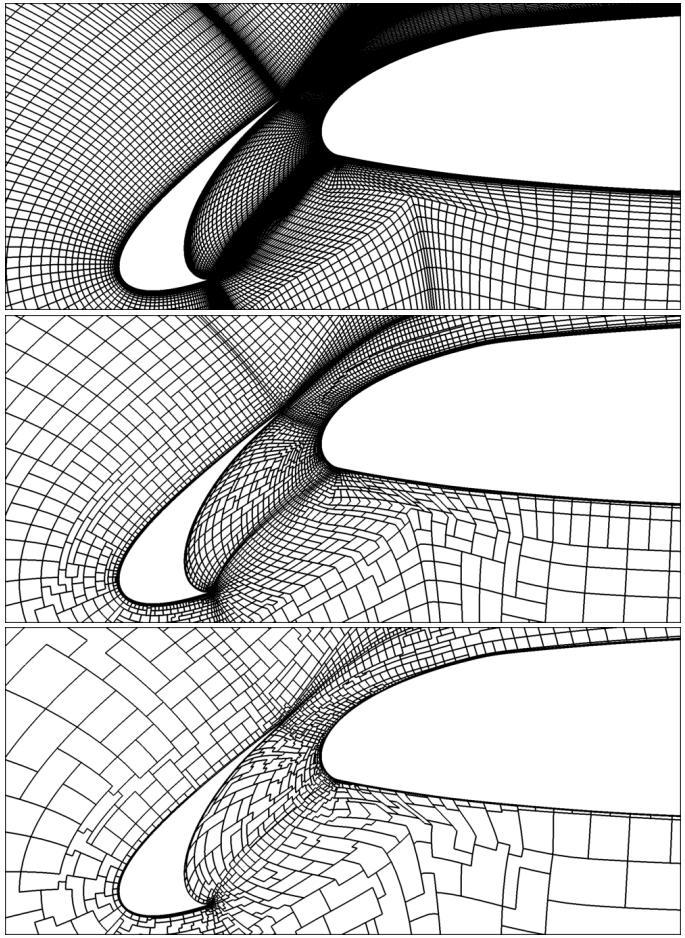


Figure : Coarsest mesh with 2 108 elements.

Numerical algorithms: Multigrid





- *p*-MG
- *h*-MG based on unstructured agglomeration

Numerical algorithms

possible solver choices

- single grid Backward-Euler
- start up strategy in mesh or order sequencing for improved initial conditions
- linear MG as preconditioner
- non-linear MG (FAS) to accelerate process in pseudo-time
- non-linear MG with linear MG on each level

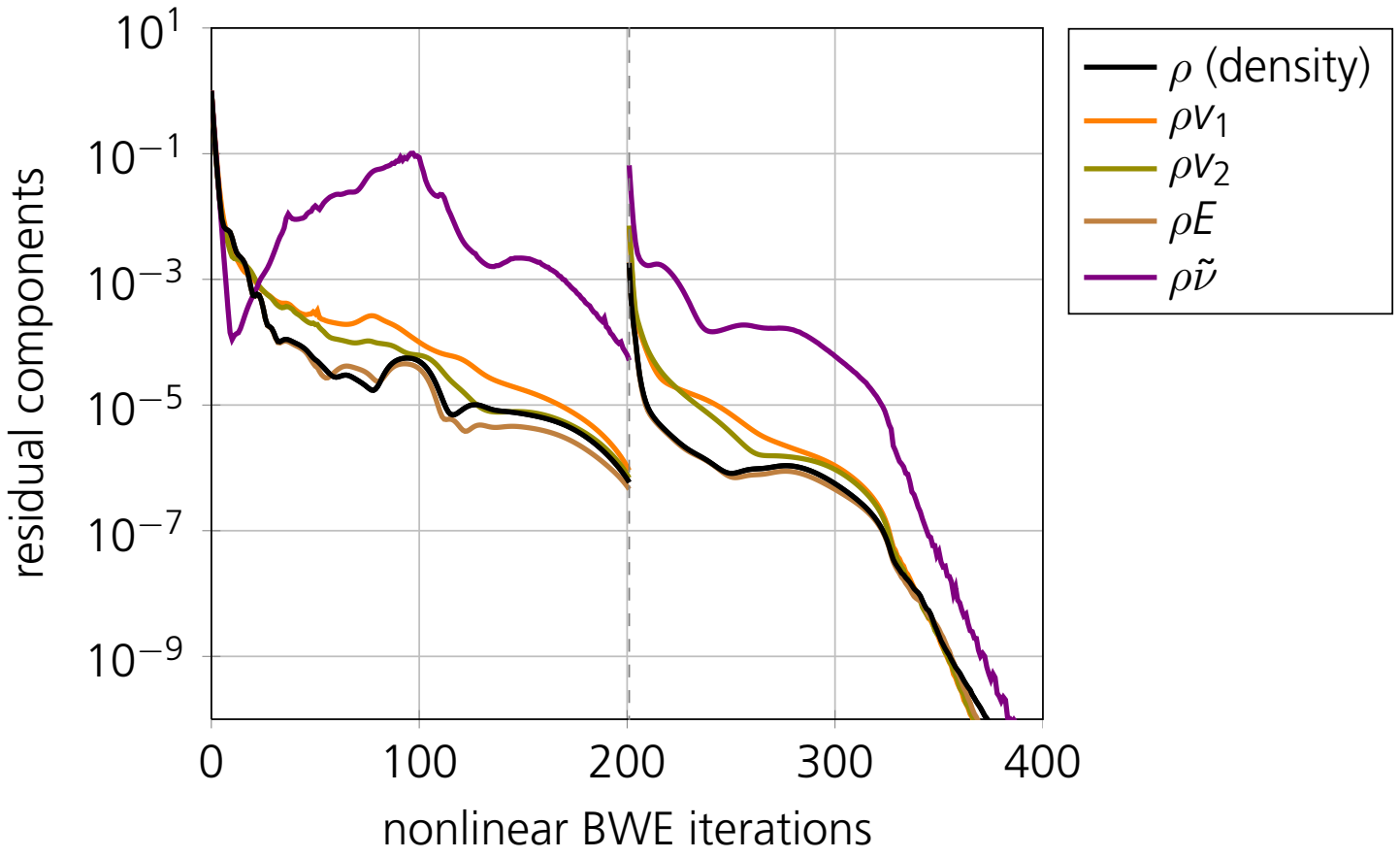


Figure : Convergence of all residual components for an MDA 30P-30N *SA*-computation with $p = 2$ on the 134 912 element mesh.

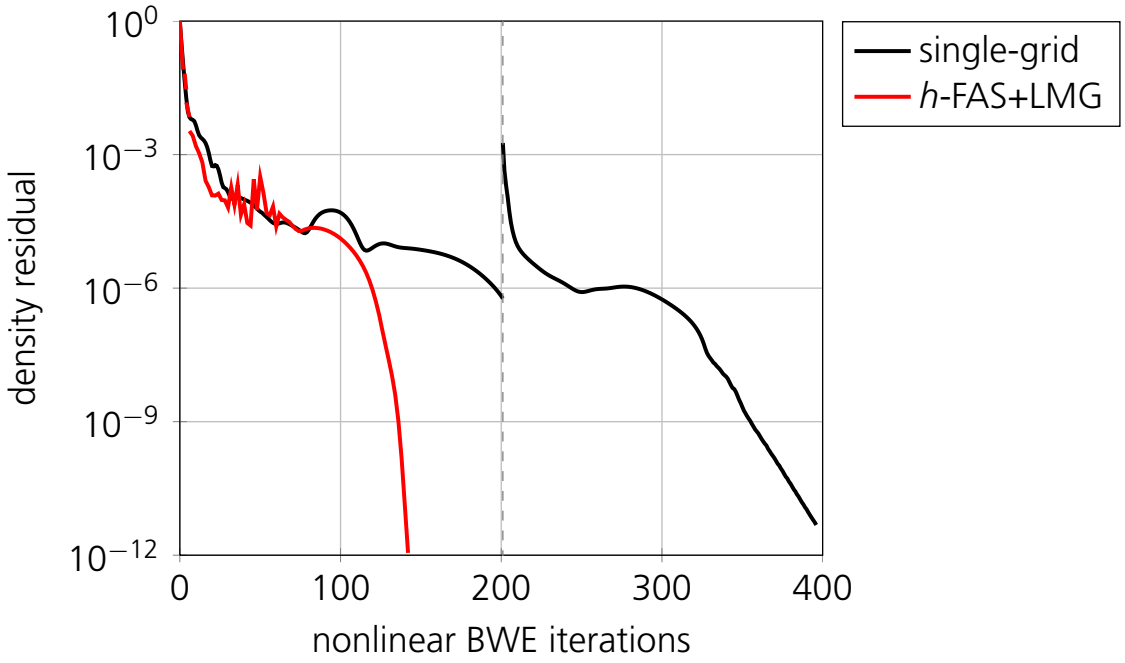
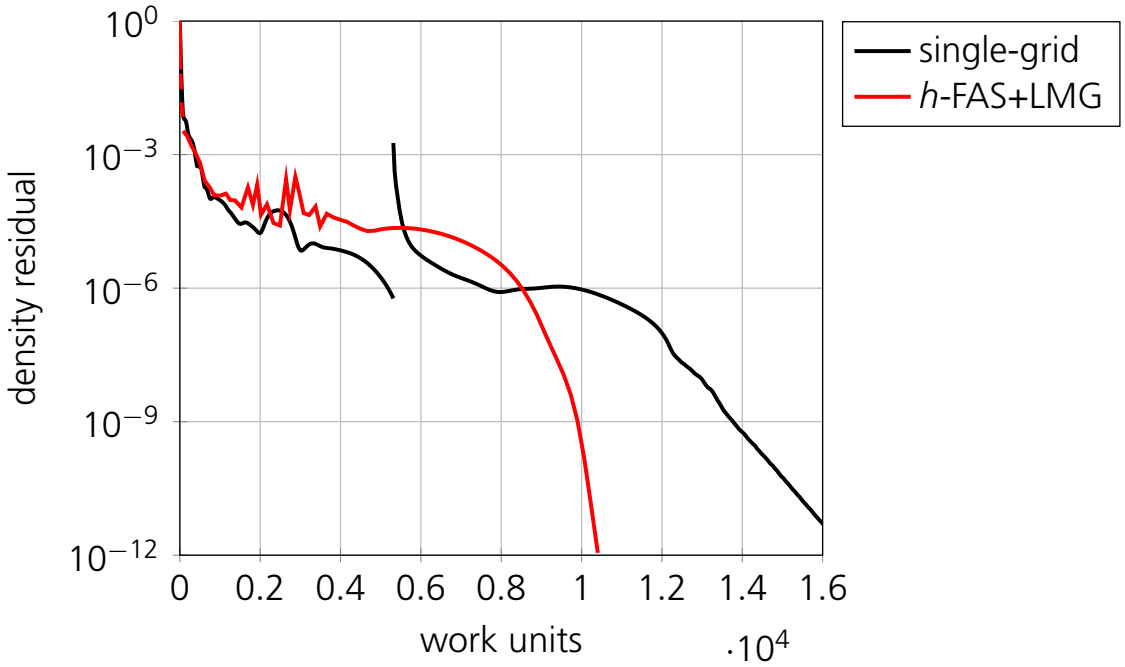


Figure : Convergence of the density component for an MDA 30P-30N *SA*-computation with $p = 2$ on the 134 912 element mesh.



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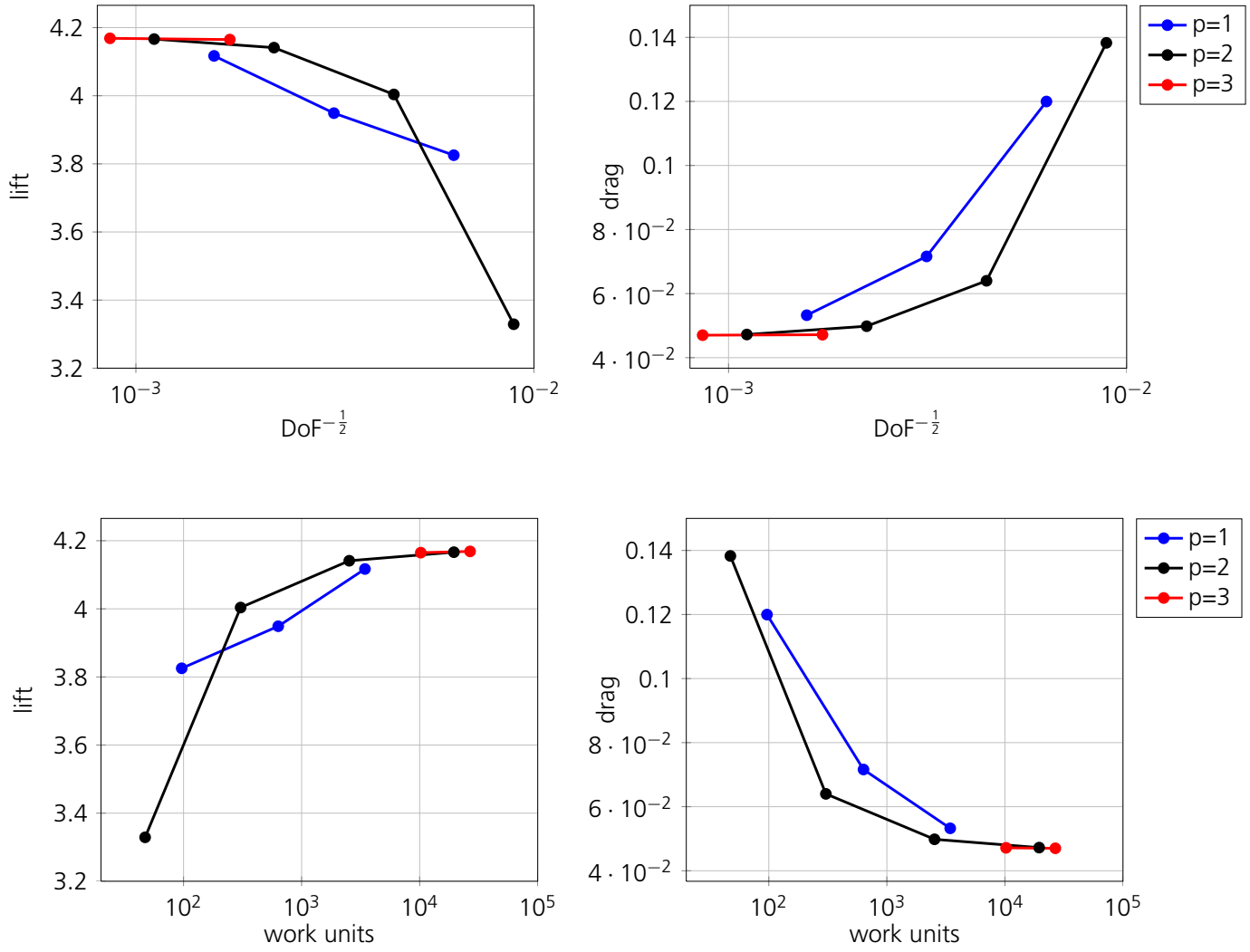

lift
drag
DoF$^{-\frac{1}{2}}$
work units
p=1
p=2
p=3

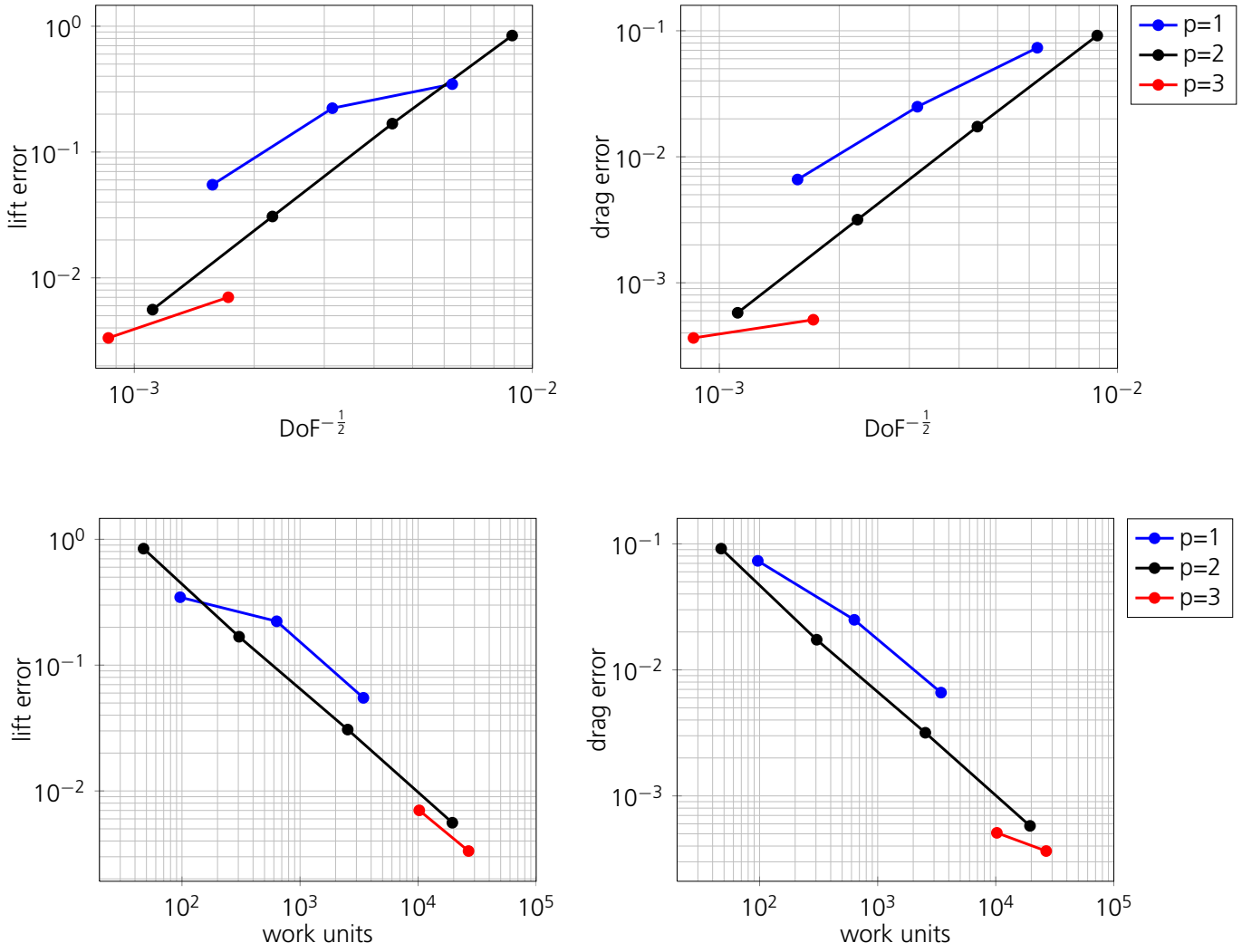
Reference values

Assuming idealized error behavior

$$C_L = C_L^{\text{ref}} + \varepsilon \cdot N^{-\frac{\alpha}{d}}$$

the p=2 results on the finest three meshes have been exploited to obtain

- $C_L^{\text{ref}} = 4.1719$
- $C_D^{\text{ref}} = 0.04665$
- observed order $\alpha = 2.5$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