2nd International Workshop on High-Order CFD Methods

Summary of the C1.1 test case results

R. Abgrall and D. De Santis

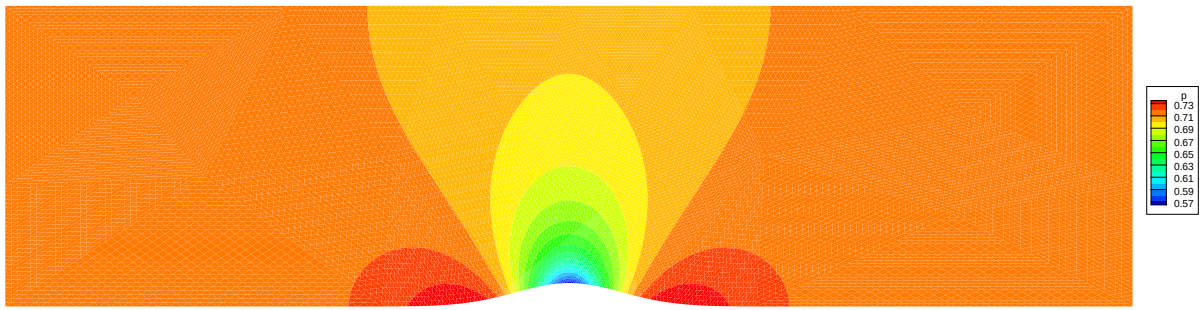
Team Bacchus, INRIA Bordeaux Sud-Ouest

Cologne, May 27-28, 2013

Test case C1.1

Internal inviscid flow over a smooth bump

- Inviscid flow at $Ma = 0.5$, with 0 angle of attack
- L2 norm entropy error as accuracy indicator
- Data available from
  - INRIA Bordeaux
  - NUMECA
  - Politecnico di Torino
  - RWTH Aachen
  - University of Michigan
  - University of Toronto & Rensselaer Polytechnic Institute
  - University of Twente & University of Bergen
- Many different curved meshes (quadrilaterals, triangles)



Test case C1.1

Internal inviscid flow over a smooth bump

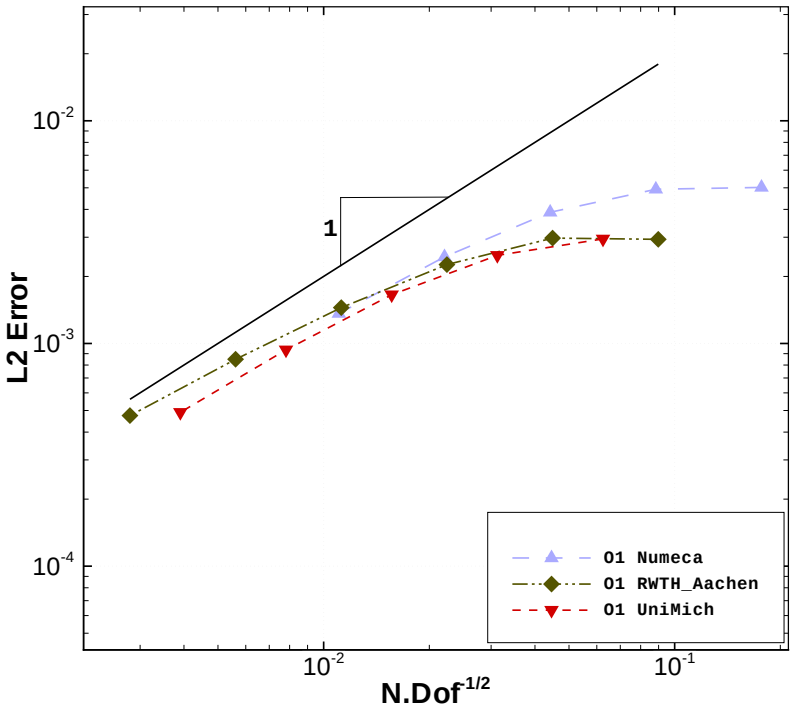
	Discretization	Solver	Convergence
INRIA	Residual Distribution	Newton (Matrix-Free)	$L2_\rho$ (10^{-10})
NUMECA	Flux Reconstruction	Explicit	-
PoliTo	Discontinuous Galerkin	Explicit RK	$L2_\rho$ (10^{-10})
RWTH Aachen	Hybridized DG	Newton (GMRES)	$L2_{\mathbf{u}}$ (10^{-12})
UniMich	Discontinuous Galerkin	Newton (GMRES)	$L1_{\mathbf{u}}$ (10^{-10})
UniToro (*)	SBP Finite Difference	Newton (FGMRES)	$L2_{\mathbf{u}}$ (10^{-10})
UniTwente	SBP Finite Difference	Newton (GMRES)	$L2_\rho$ (10^{-10})

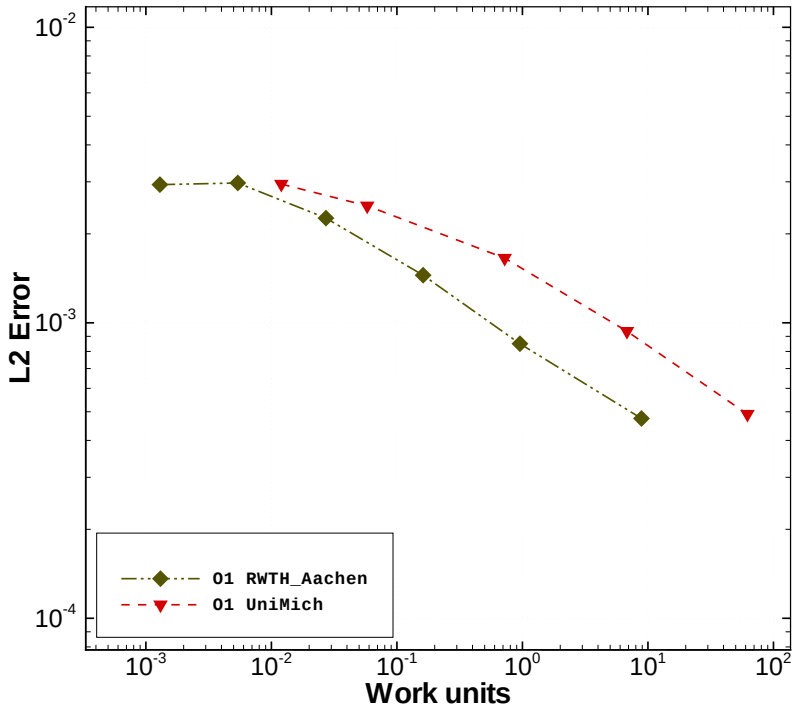
(*) Larger domain

Different strategies: Uniform initialization, grid/order sequencing

Test case C1.1

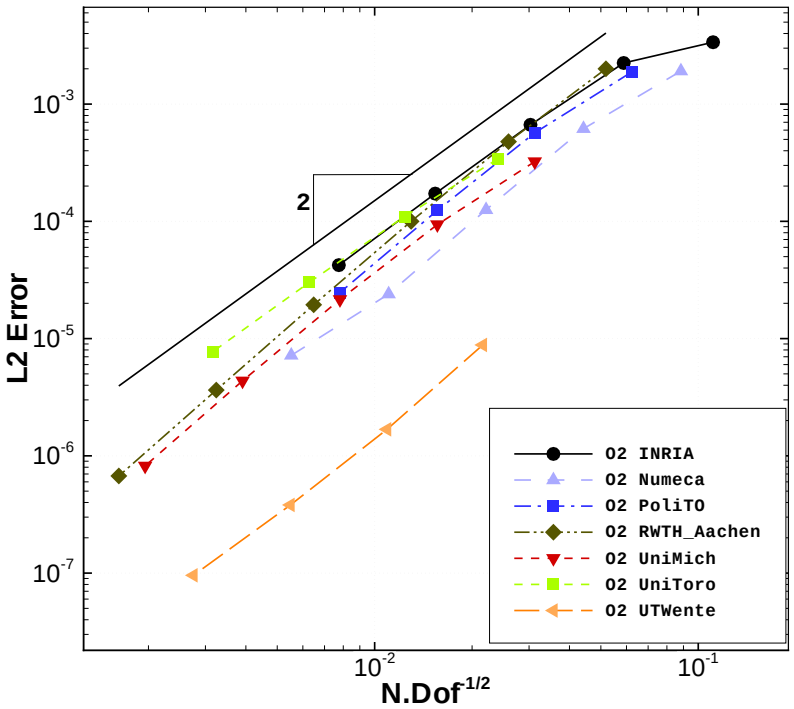
Uniform h refinement: 1st Order results

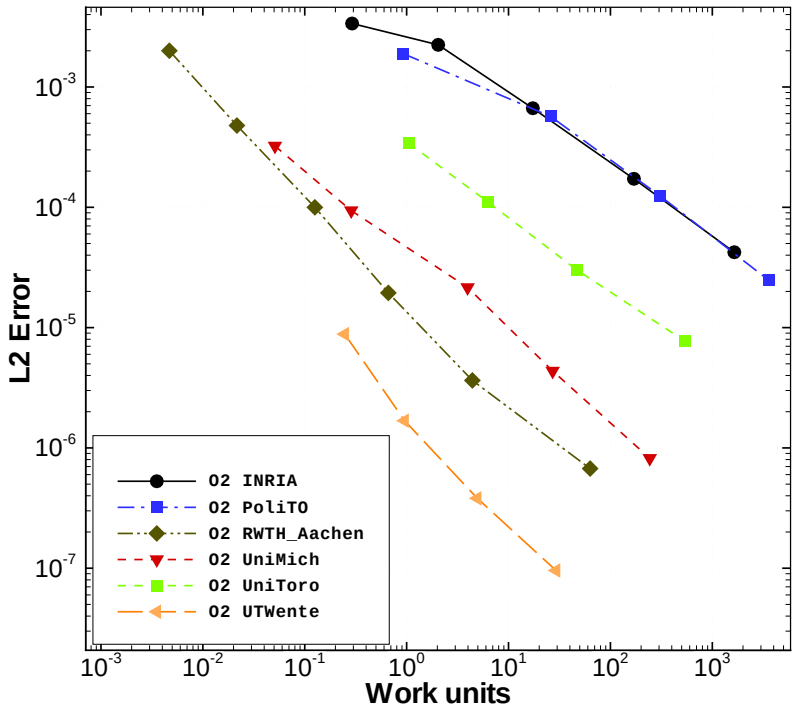




Test case C1.1

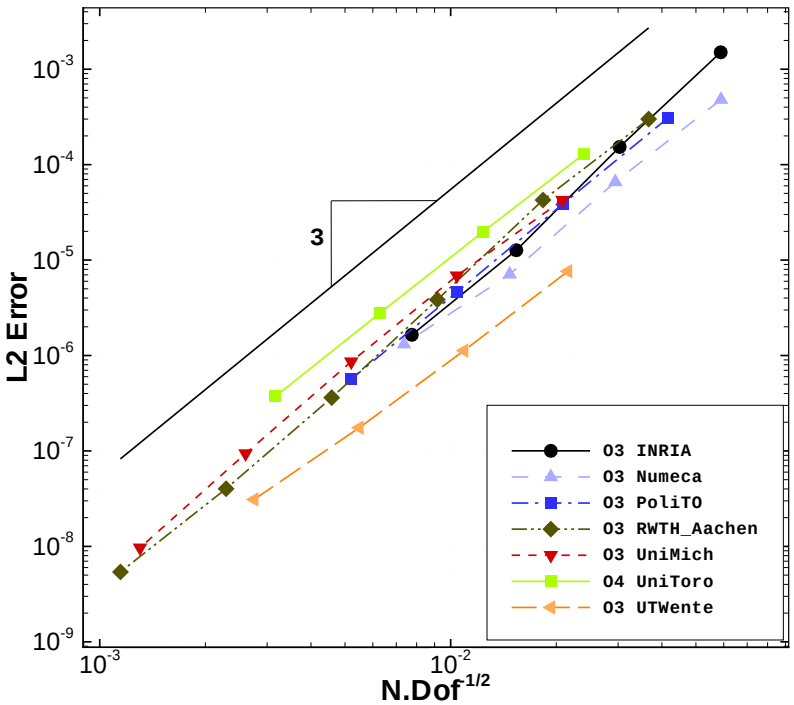
Uniform h refinement: 2nd Order results

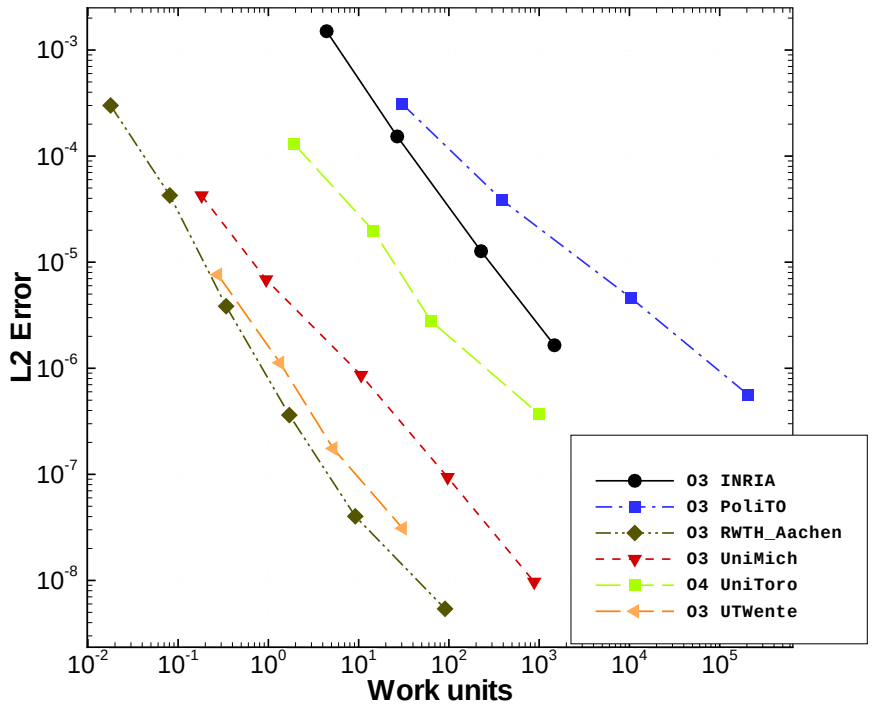




Test case C1.1

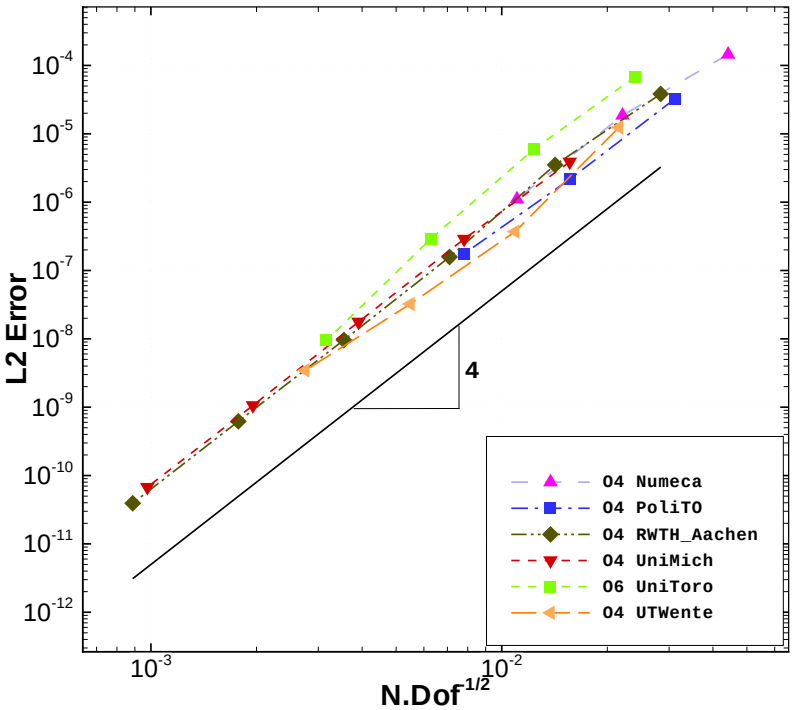
Uniform h refinement: 3rd Order results

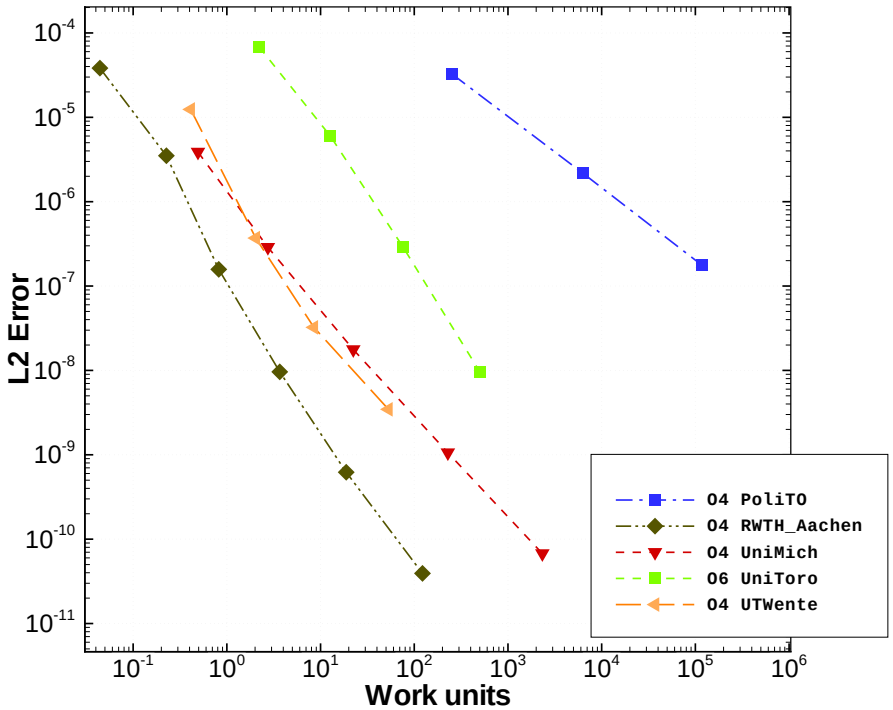




Test case C1.1

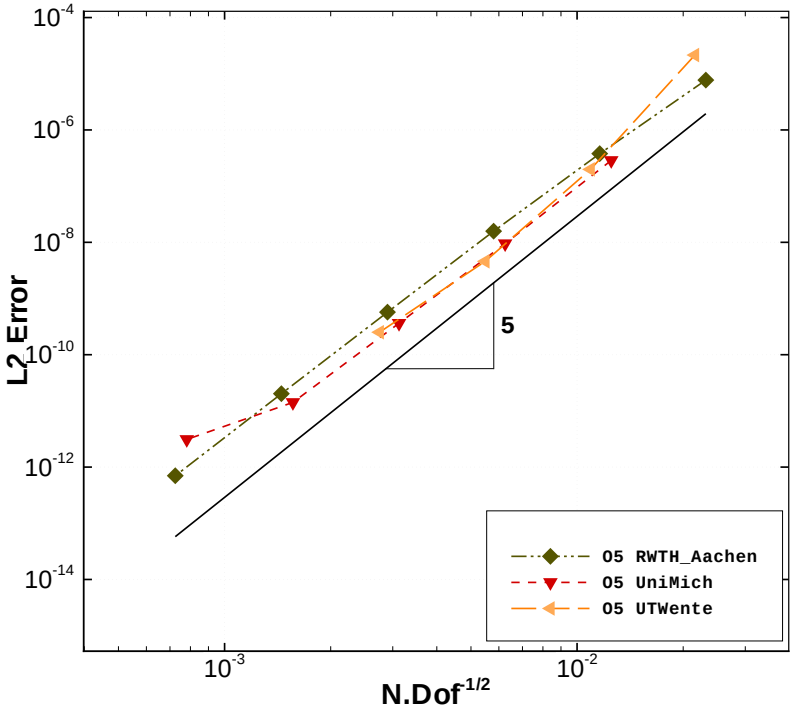
Uniform h refinement: 4th Order results

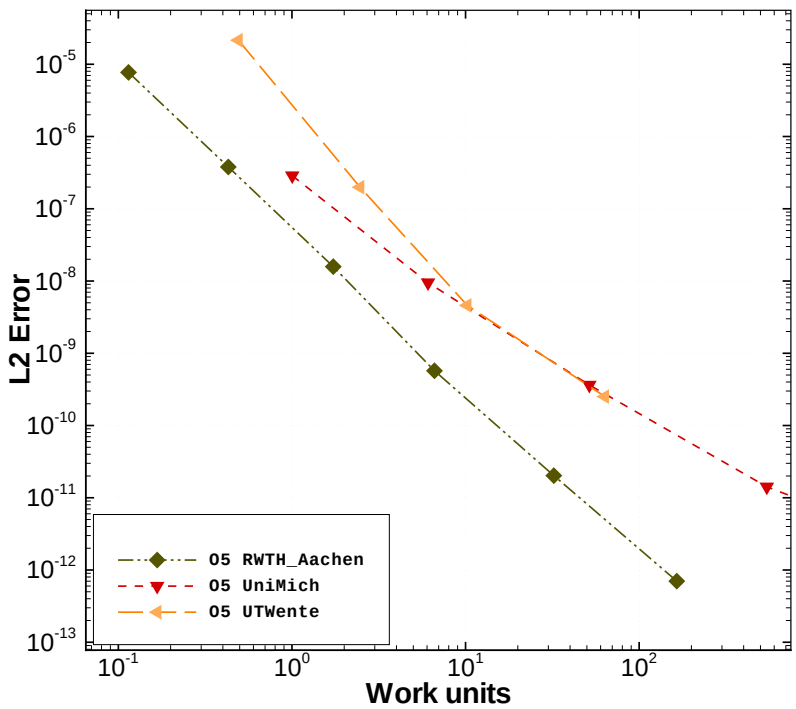




Test case C1.1

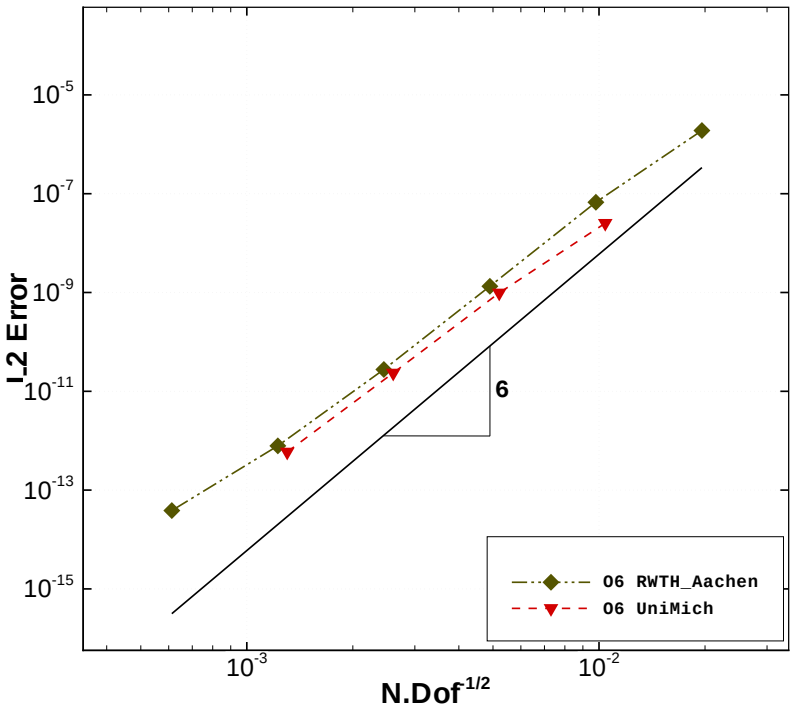
Uniform h refinement: 5th Order results

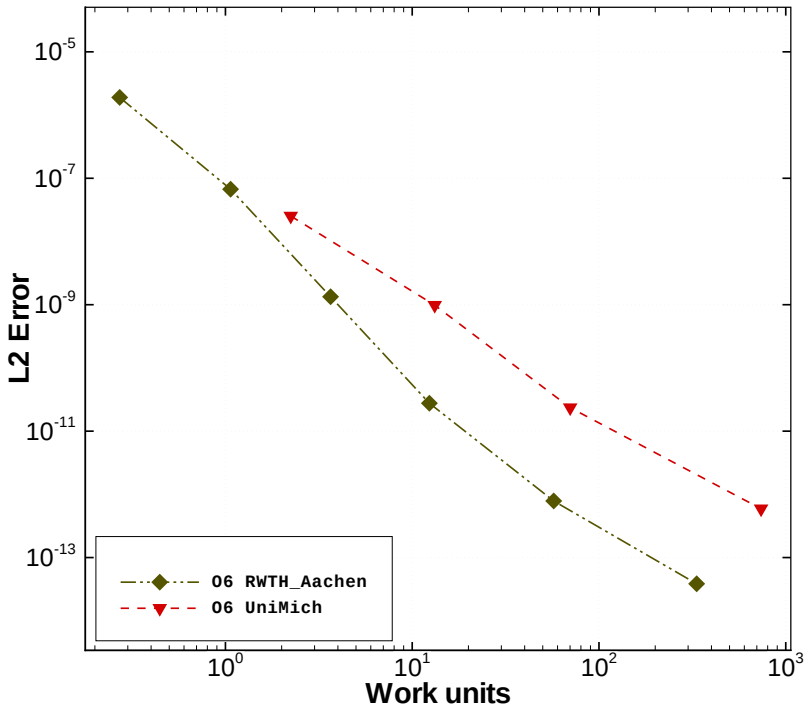




Test case C1.1

Uniform h refinement: 6th Order results





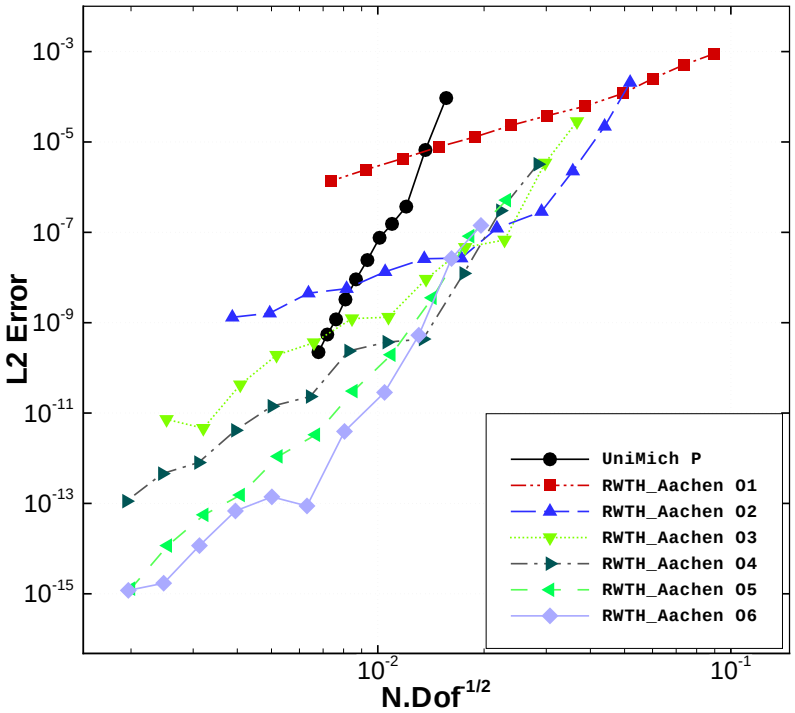
Test case C1.1
Adaptive h/p refinement

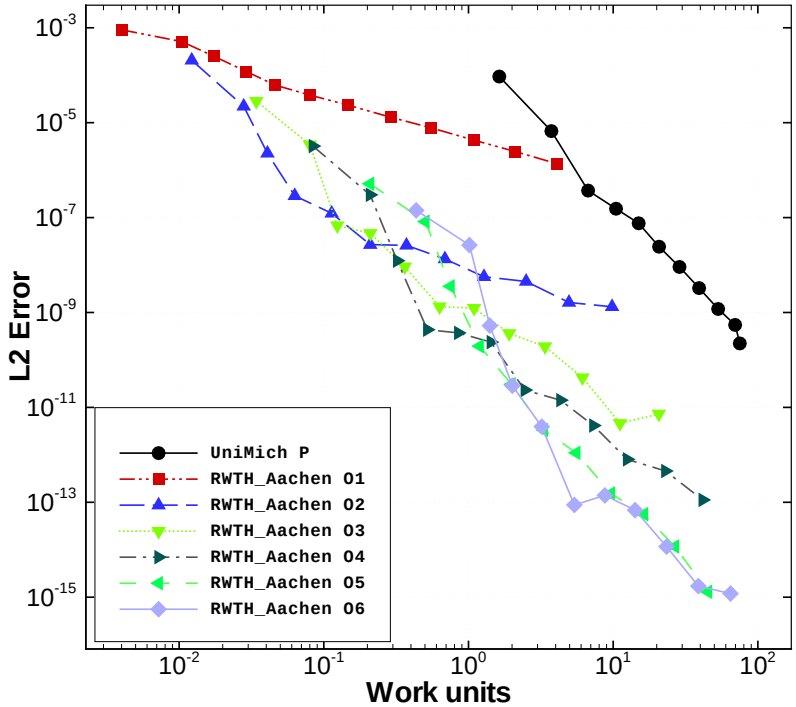
Adaptive h/p refinement for DG based solvers

- RWTH Aachen (Hybridized Discontinuous Galerkin)
  - Adjoint based adaptation + corrected error (1)
  - Adjoint based adaptation (2)
- UniMich (Discontinuous Galerkin)
  - Adjoint for the entropy error (1)
  - Entropy production (2)
  - Entropy variables (2)
  - Unweighted residuals (2)

Test case C1.1

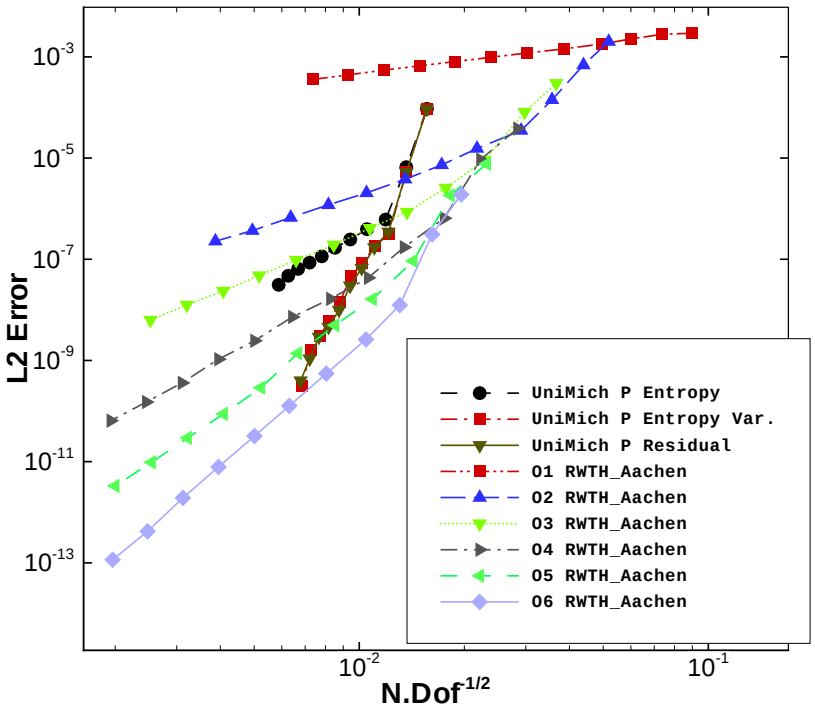
Adaptive h/p refinement (1)

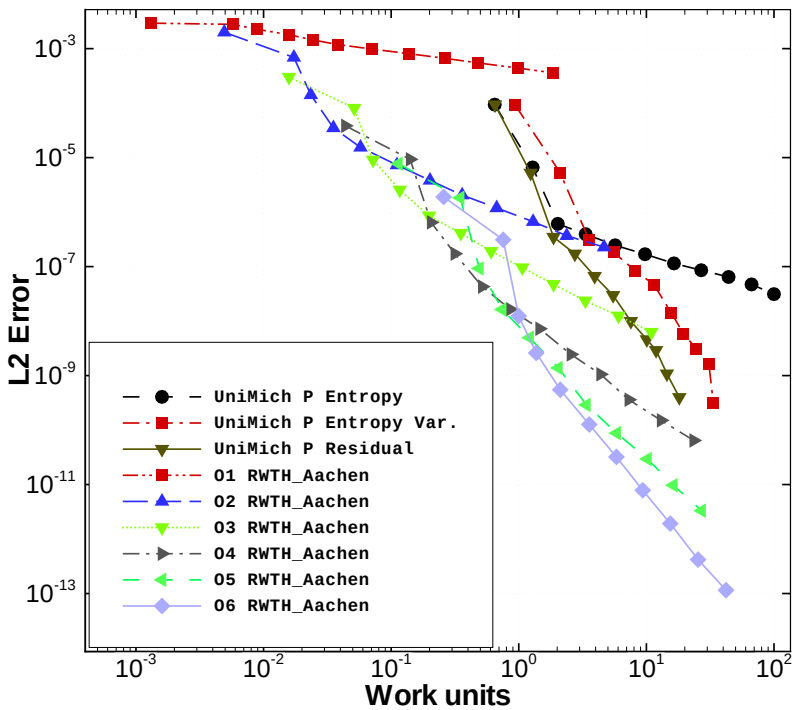




Test case C1.1

Adaptive h/p refinement (2)





Test case C1.1
Conclusion

- Continuous and discontinuous methods
- Comparable accuracy of the methods for uniform h/p refinement
- More flexibility of DG method (adaptive refinement)
- Very difficult to establish conclusions about computing time (efficiency)
  - Different initialization (uniform and grid/order sequencing)
  - Different convergence criteria