Optimization of relaxation factor for simple solver

Masashi Imano (OCAEL Co.Ltd.)

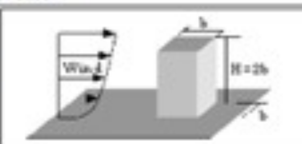
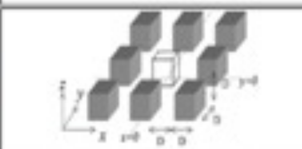
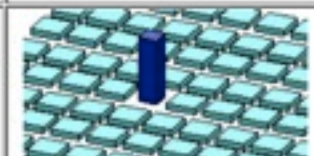
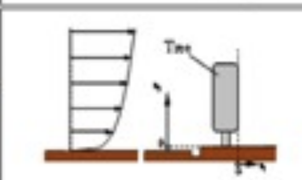
Guideline for Practical Applications

Working Group in Architectural Institute of Japan

Akashi Mochida, Yoshihide Tominaga, et al.

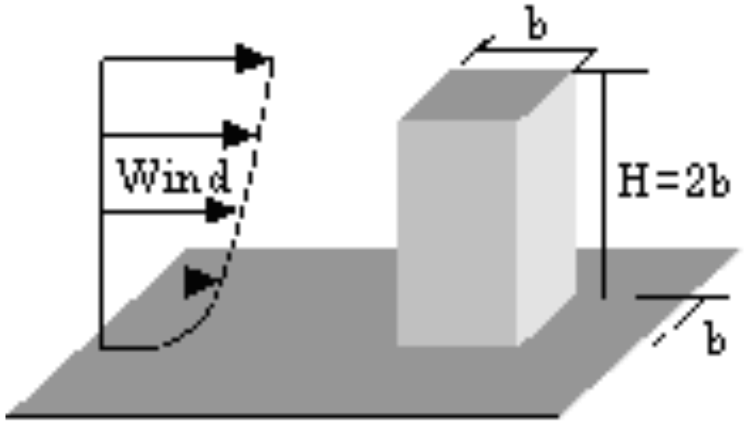
“Guidebook for Practical Applications of CFD to Pedestrian Wind Environment around Buildings”

(in Japanese)

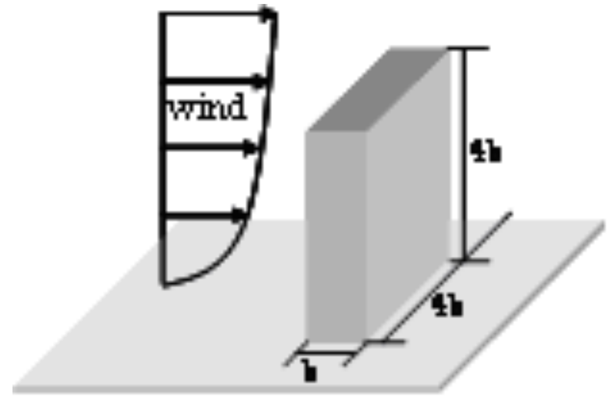
	test case		dataset	Ref.
A	2:1:1 shape building model		Data file :CaseA(1_1_2).xls	[1]
B	4:4:1 shape building model		Data file : CaseB(4_4_1).xls	[2][3]
C	Simple Building blocks		Data file : CaseC(City_blocks).xls	-
D	A high-rise building in city blocks		Data file : CaseD(Highrise+Blocks).xls CAD File(DXF) : CaseD_dxf.zip CAD File(MCD) : CaseD_mcd.zip	[5]
E	Building complexes with simple building shape in actual urban area (Niigata)		Data file : CaseE(Niigata).xls CAD File(DXF) :CaseE_dxf.zip CAD File(MCD) : CaseE_mcd.zip	[6]
F	Building complexes with complicated building shape in actual urban area (Shinjuku)		Data file : CaseF(Shinjuku).xls CAD File(DXF) :CaseF_dxf.zip CAD File(MCD) : CaseF_mcd.zip CAD File(STL) : CaseF_stl.zip	[6]
G	Two-dimensional pine tree		Data file : CaseG(Tree).xls	[7]

Web site **(in Japanese and English)**

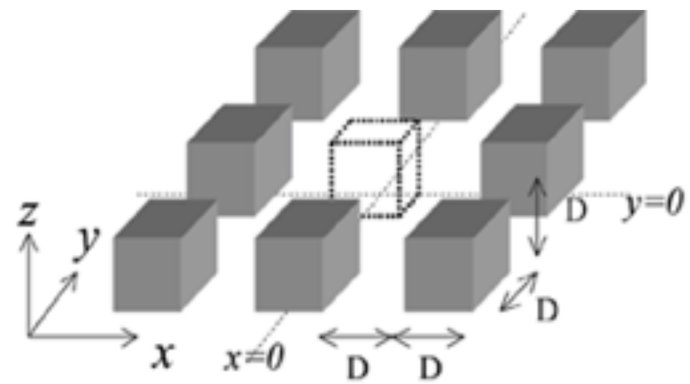
Benchmark tests



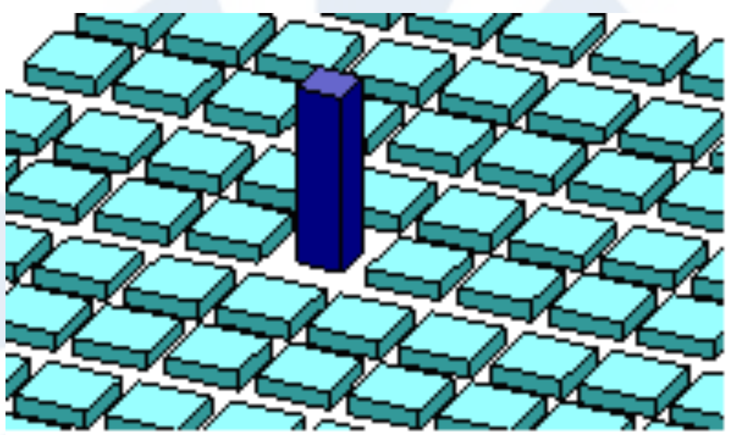
Case A
(2:1:1 shape)



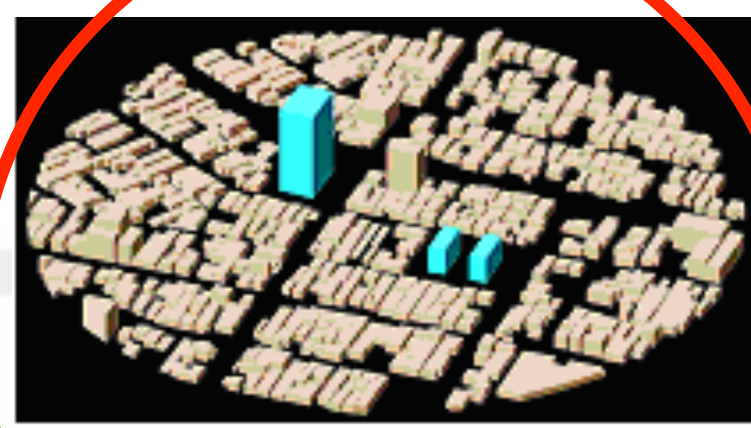
Case B
(4:4:1 shape)



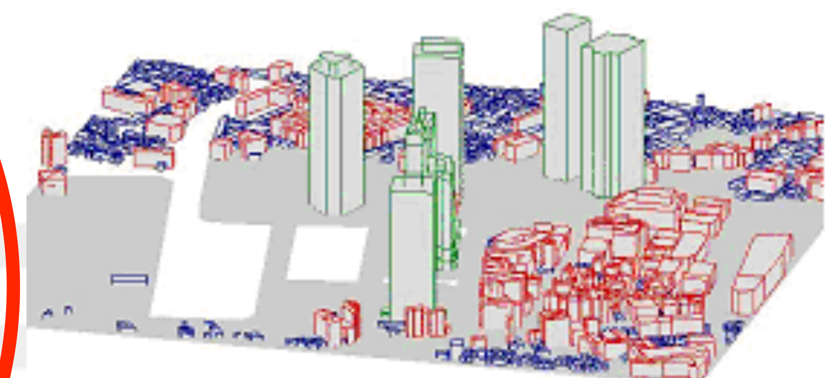
Case C
(Simple blocks)



Case D
(High-rise bldg.)



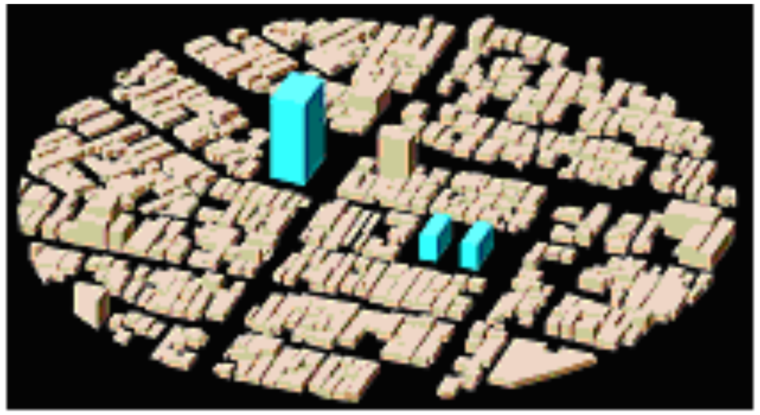
Case E
(Niigata)



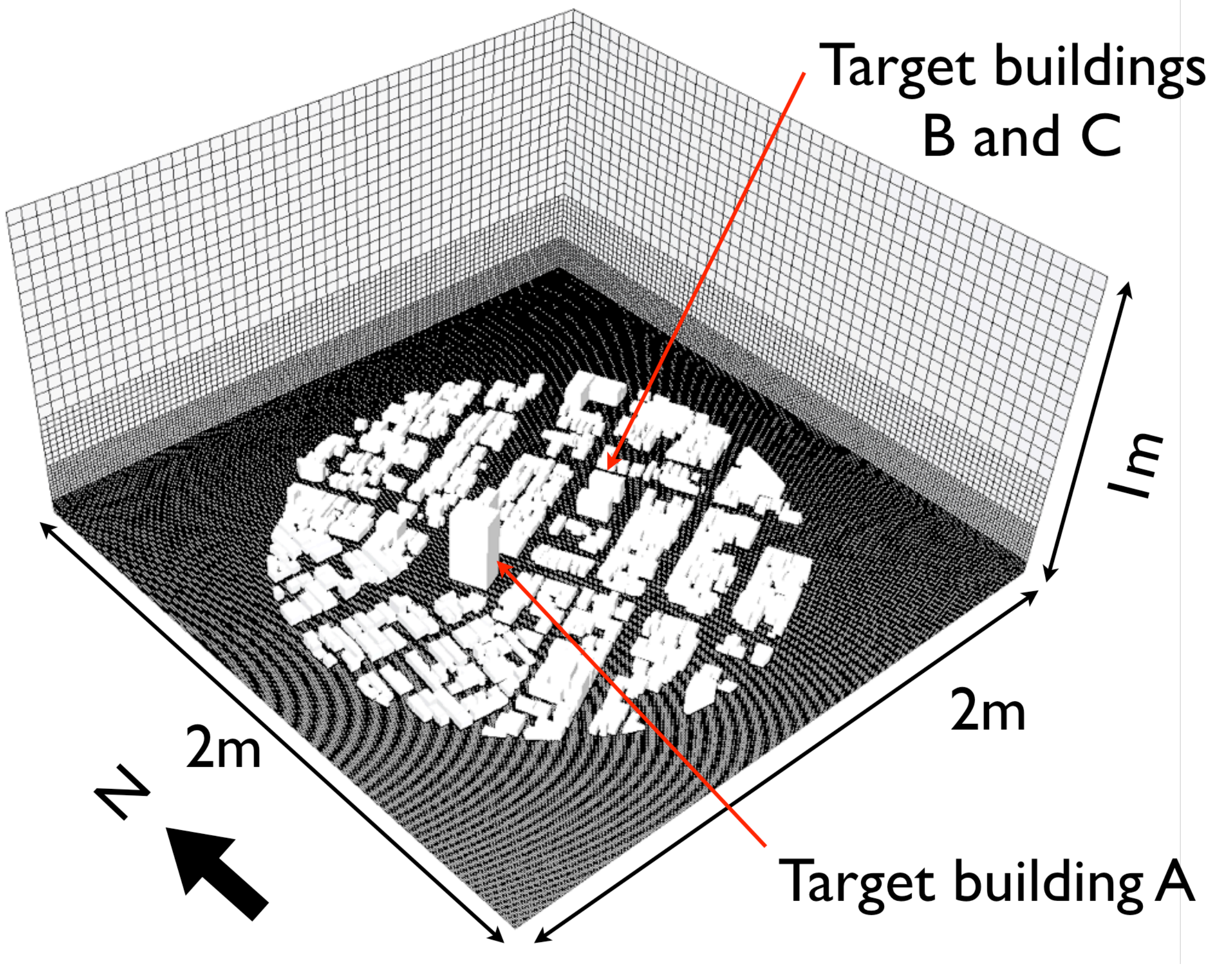
Case F
(Shinjuku, Tokyo)

Case E - Calculation condition

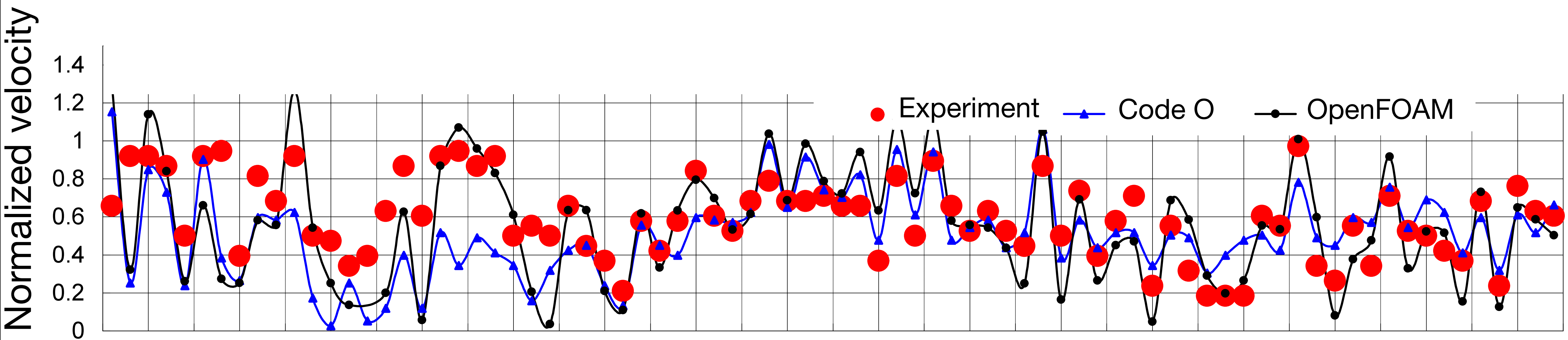
Mesh	Cartesian mesh (snappyHexMesh)
Inflow	Interpolate from wind tunnel results
Top & Side wall	Zero gradient
Ground and bldg. wall	Generalized log law for a smooth wall
Turbulence model	Standard k-epsilon
Advection scheme	Upwind
Algorithm	SIMPLE (simpleFoam)
Wind direction	**NNE**

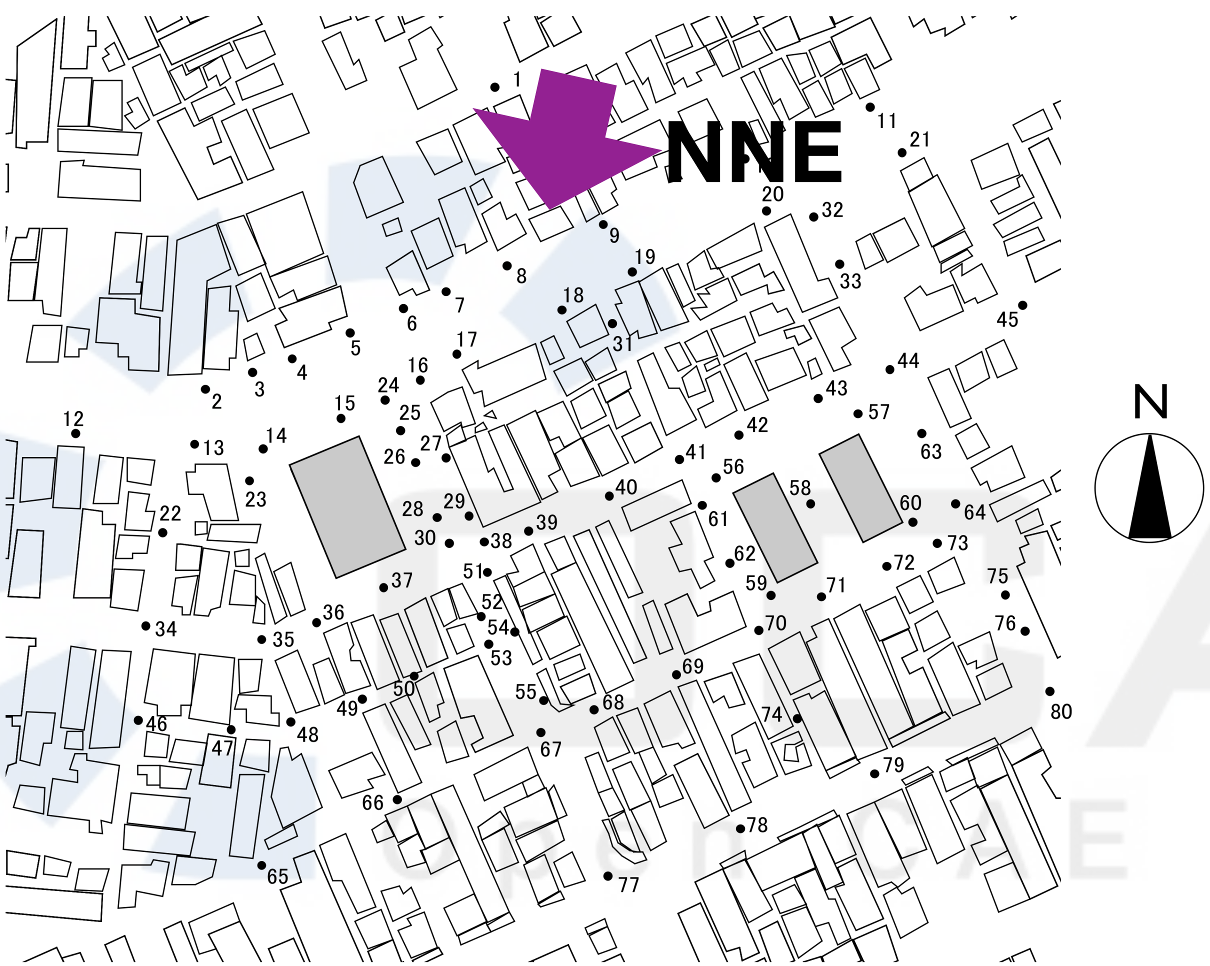


Building complexes with simple building shape in actual urban area (Niigata)



Case E - Validation





RMSE(Root Mean Square Error)

Code O(Overlapping structured grid)
0.24

OpenFOAM (Unstructured grid)
0.22

Test cluster condition

- **Project XL server @ Hokkaido University**
- **Hardware:** HITACH BladeSymphony BS 2000
- **CPU:** Intel Xeon E7-8870 2.4GHz, 10 cores
- **Node:** 4CPUs (40 cores)
- **Memory:** 128GB/node
- **HDD:** 2TB/node
- **OS:** Any OS (root account is available)
- **Rental fee:** 21,000 yen/month
- **Other project server:**
  - ✓ **L server:** 10 cores(1CPU), 5,250 yen/month

Accelerate simple solver

- **Relaxation parameters for pressure and velocity are important for steady state incompressible flows**
(solver: simpleFoam)

system/fvSolution:

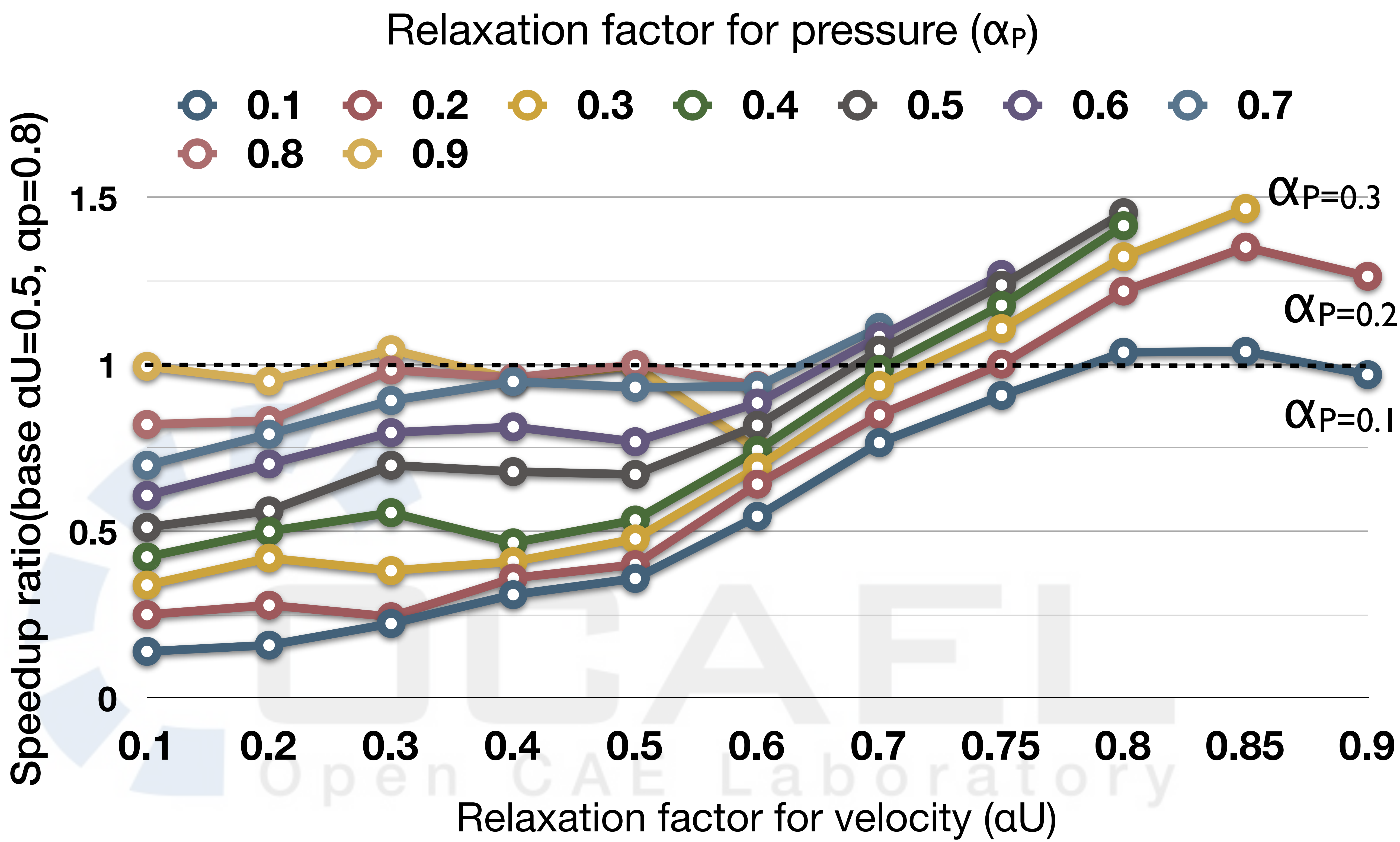
```
relaxationFactors // 0 < relaxationFactors <= 1
{
    p         0.3; // for pressure (important)
    U         0.5; // for velocity vectors (important)
    k         0.5; // for turbulence kinetic energy
    epsilon   0.5; // for turbulence kinetic energy
                   // dissipation rate
}
```

Convergence criteria

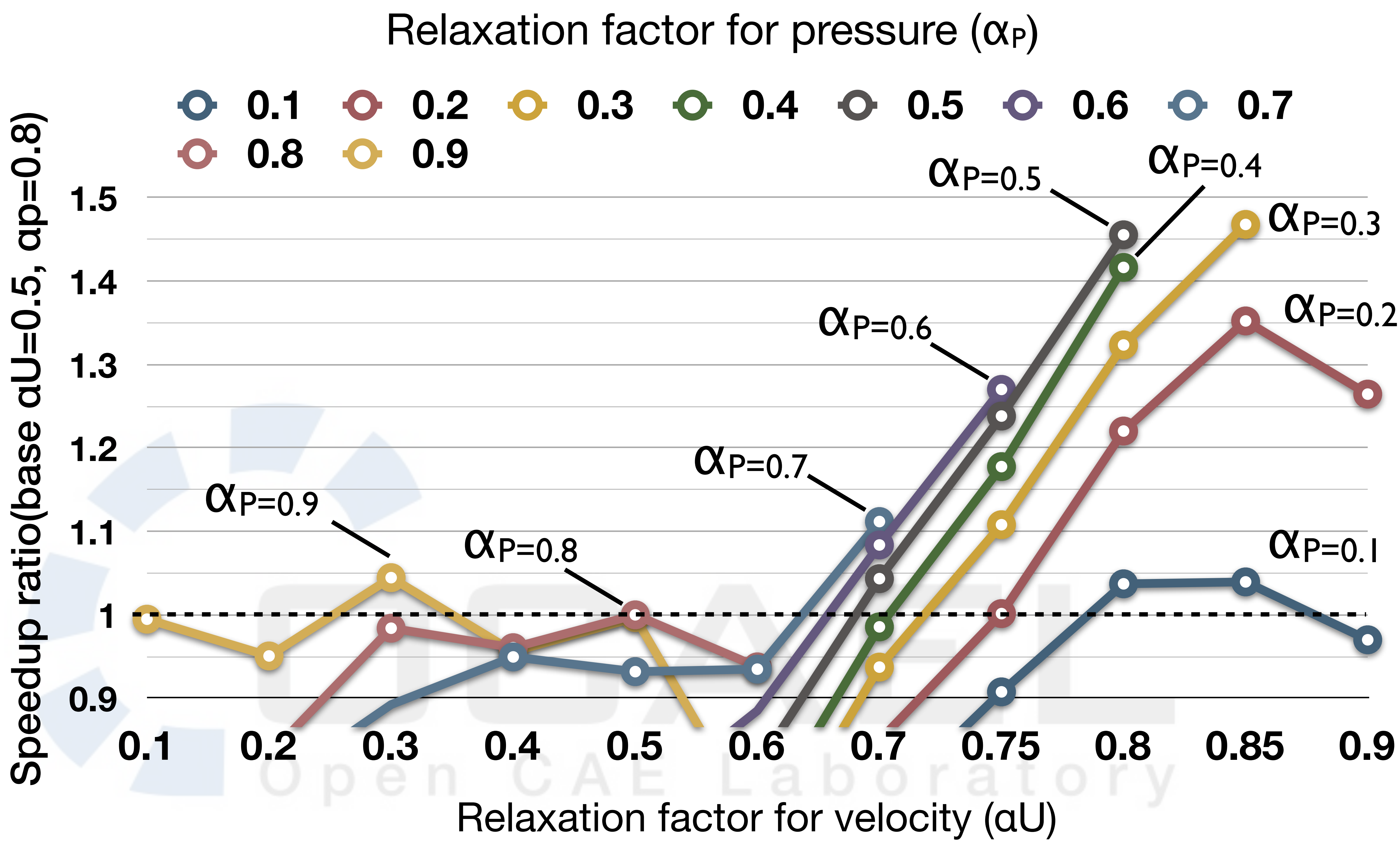
system/fvSolution:

```
SIMPLE
{
    nNonOrthogonalCorrectors 0;
    residualControl // convergence criteria
    {
        "(p|U|k|epsilon|omega)" 2e-3;
    }
}
```

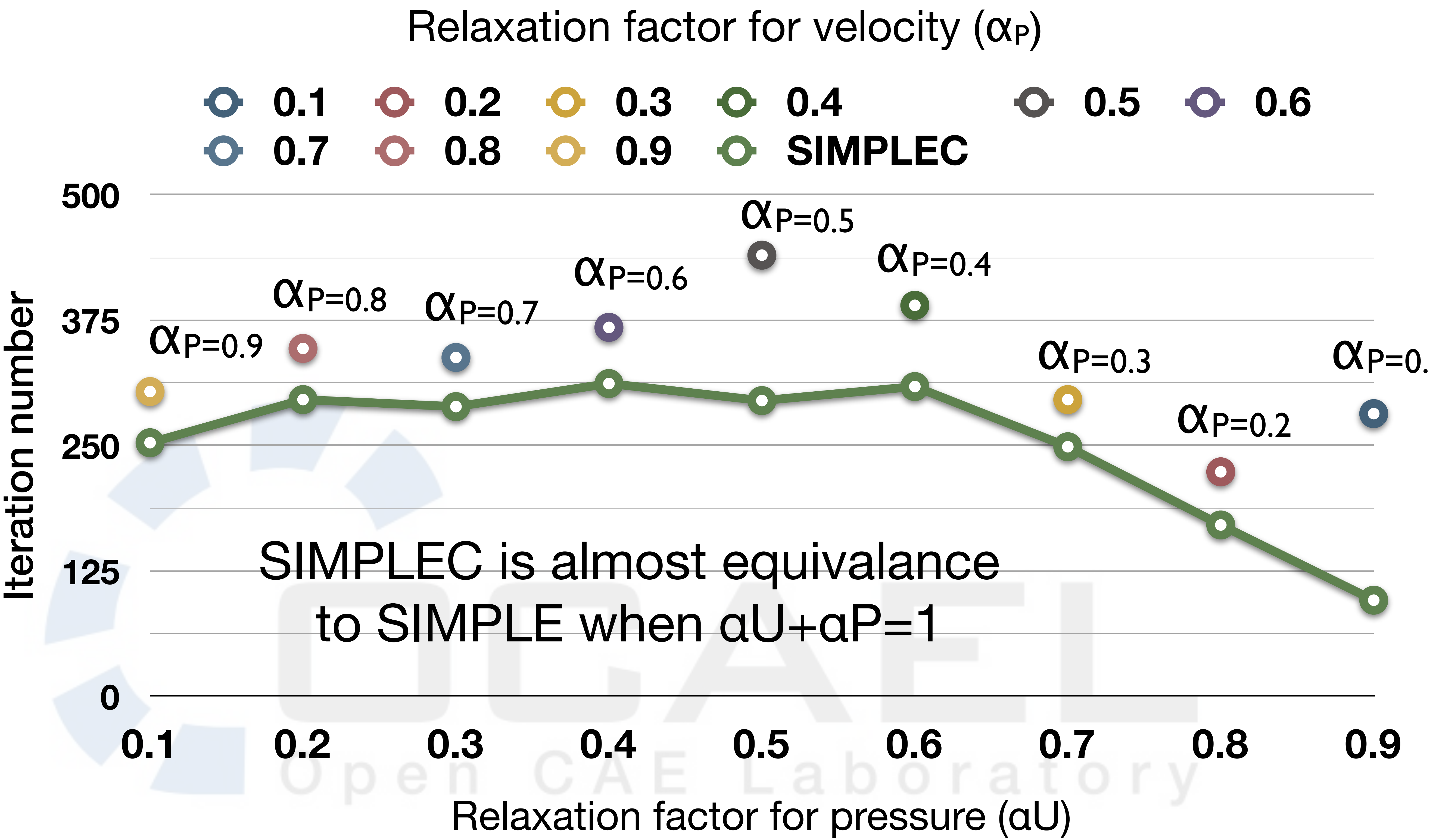
Results of speedup in SIMPLE 1



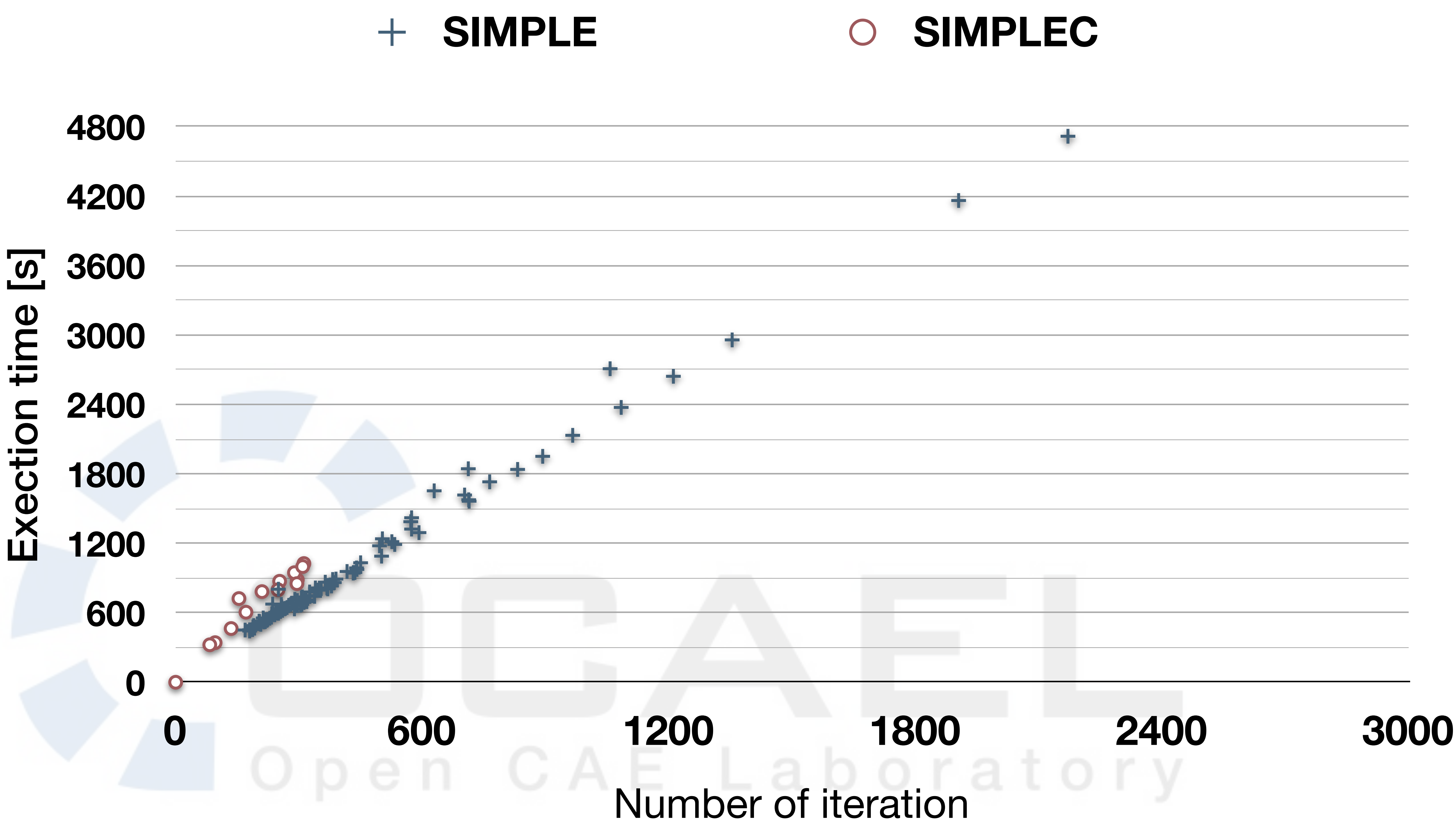
Results of speedup in SIMPLE 2



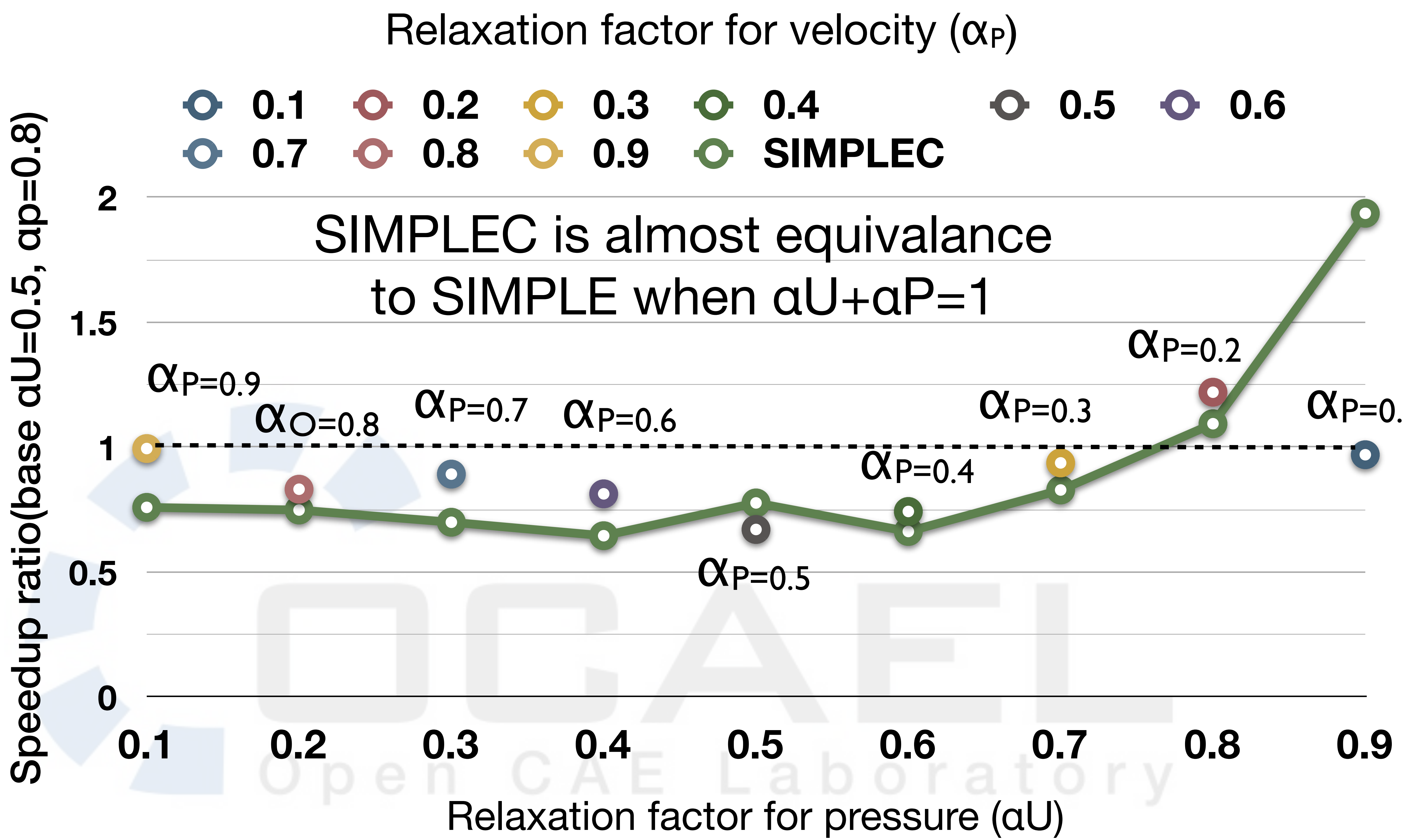
Results of speedup in SIMPLEC



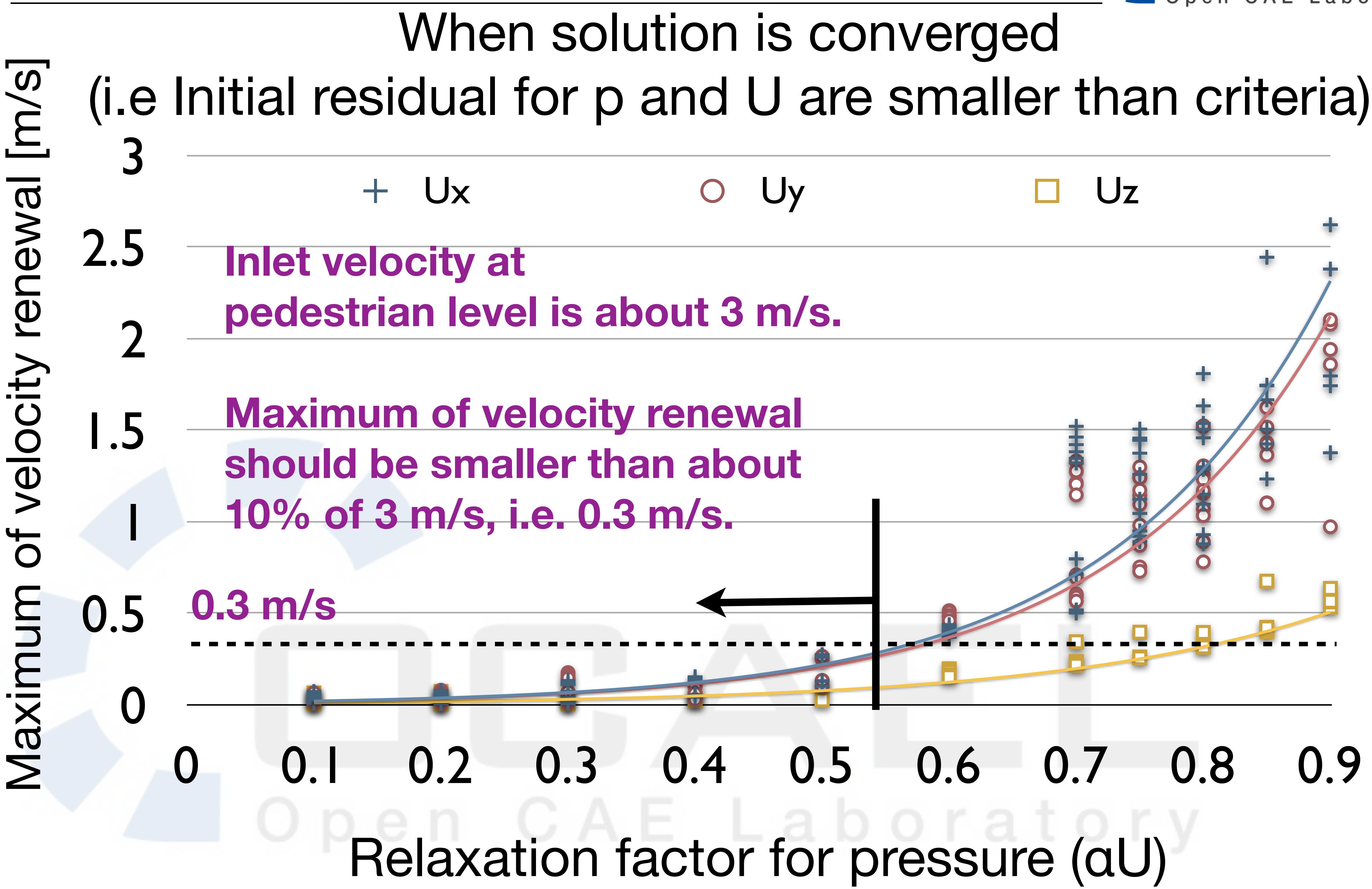
Execution time per iteration



Results of speedup in SIMPLEC 2

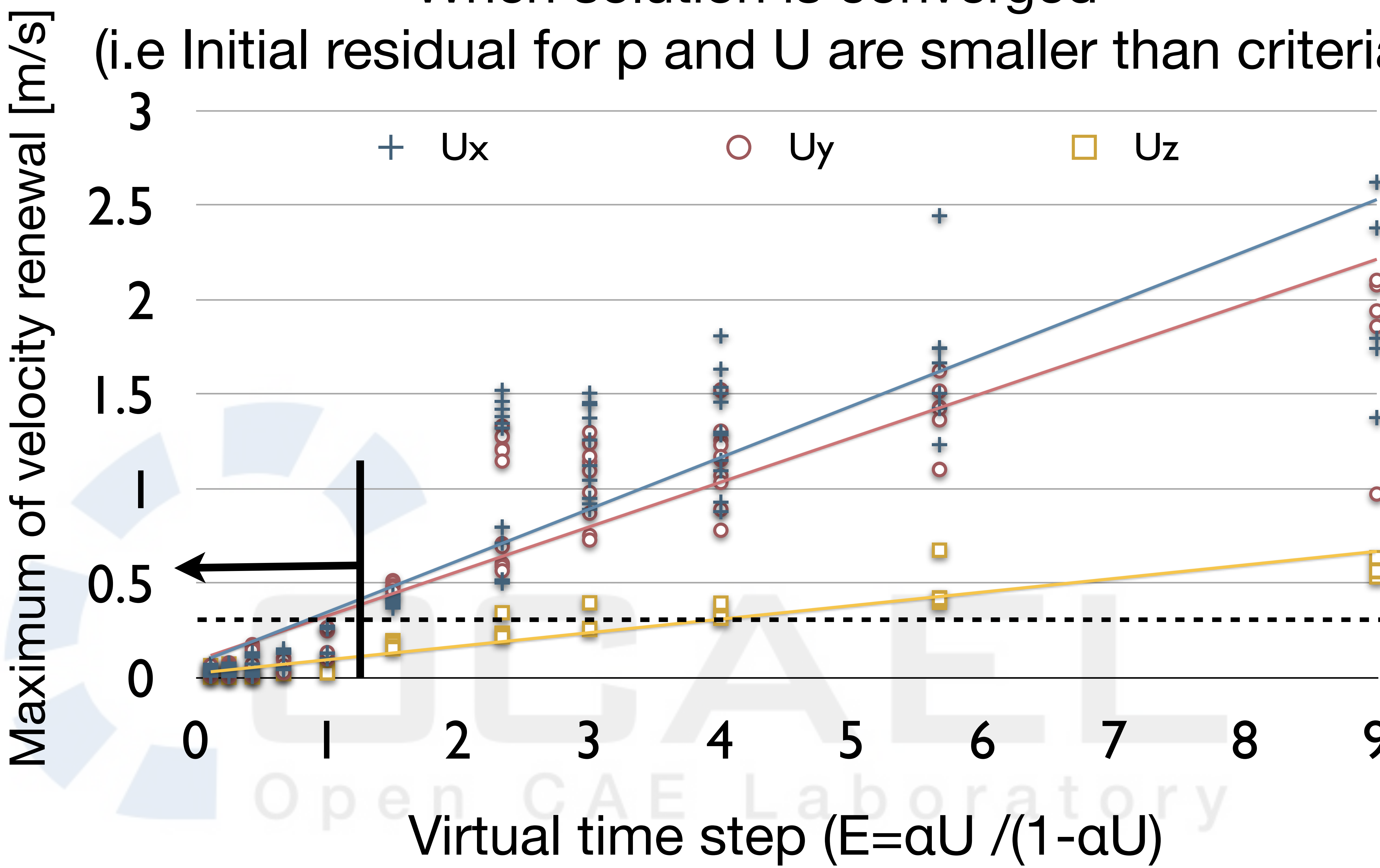


Maximum of velocity renewal 1



Maximum of velocity renewal 2

When solution is converged
(i.e Initial residual for p and U are smaller than criteria)



Any Questions?