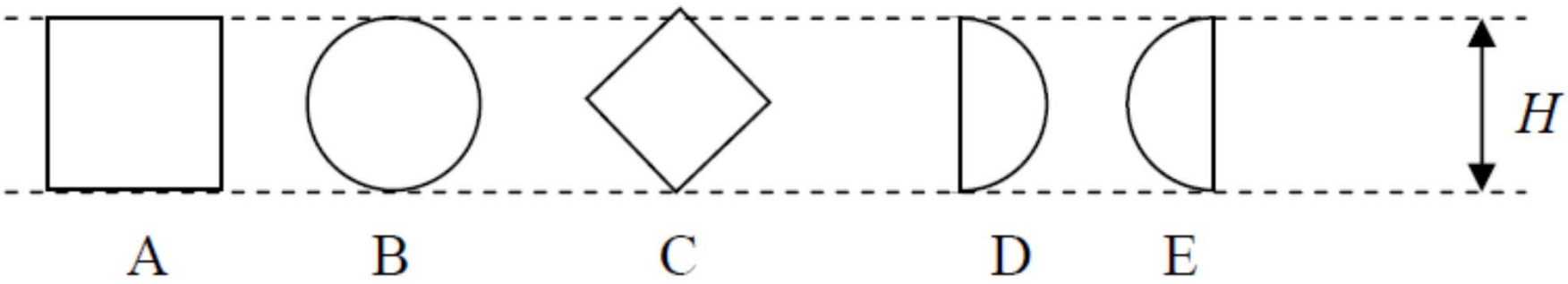
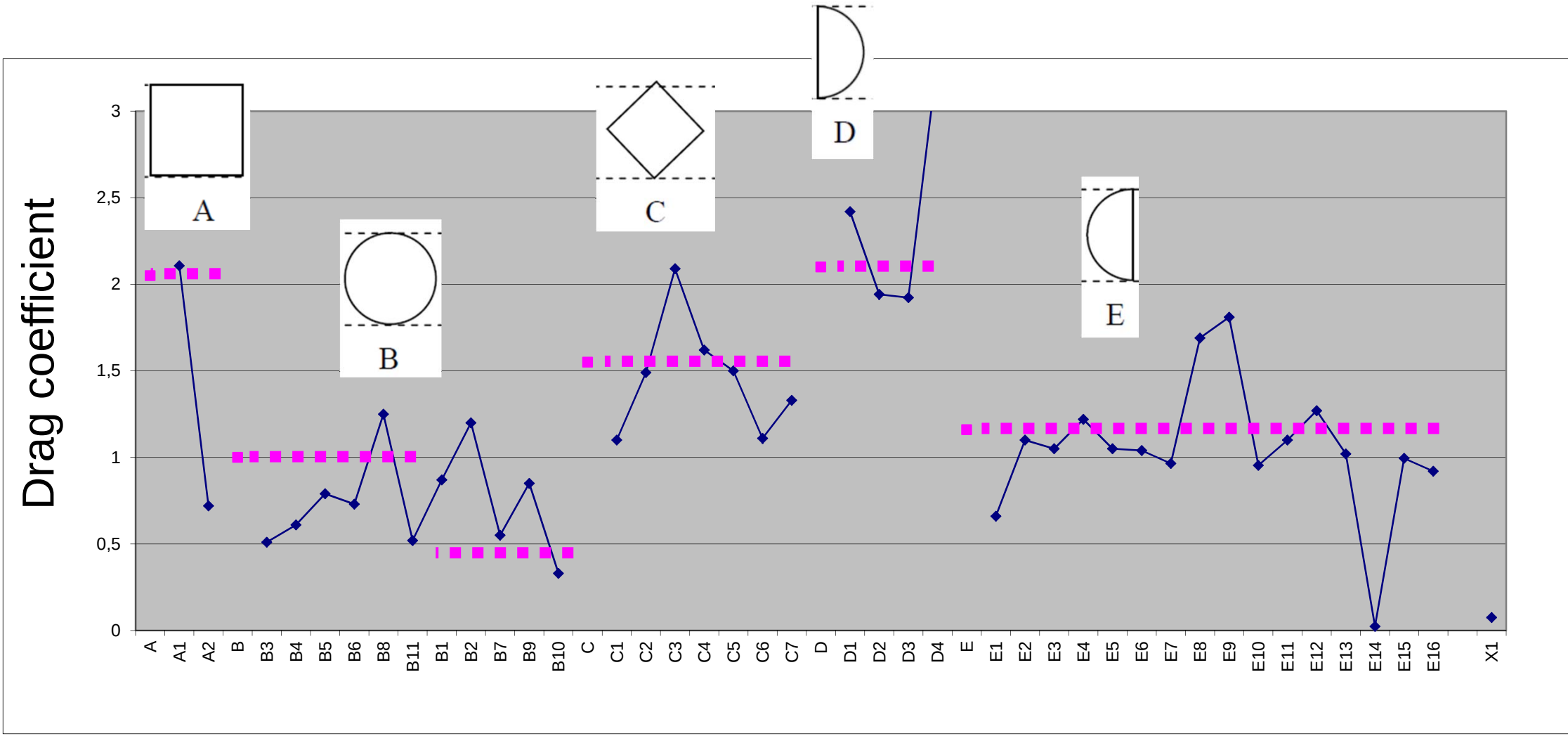
Individual task

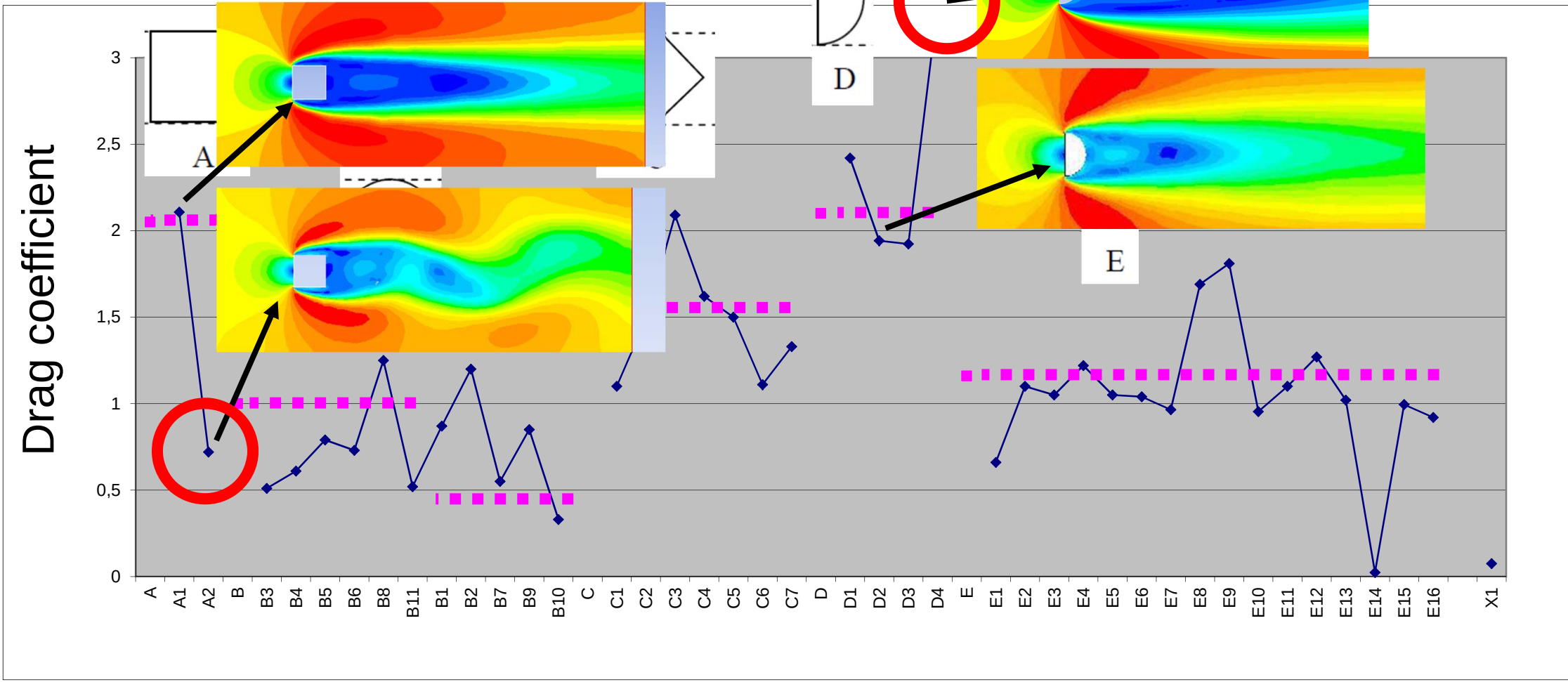
- **Feedback**



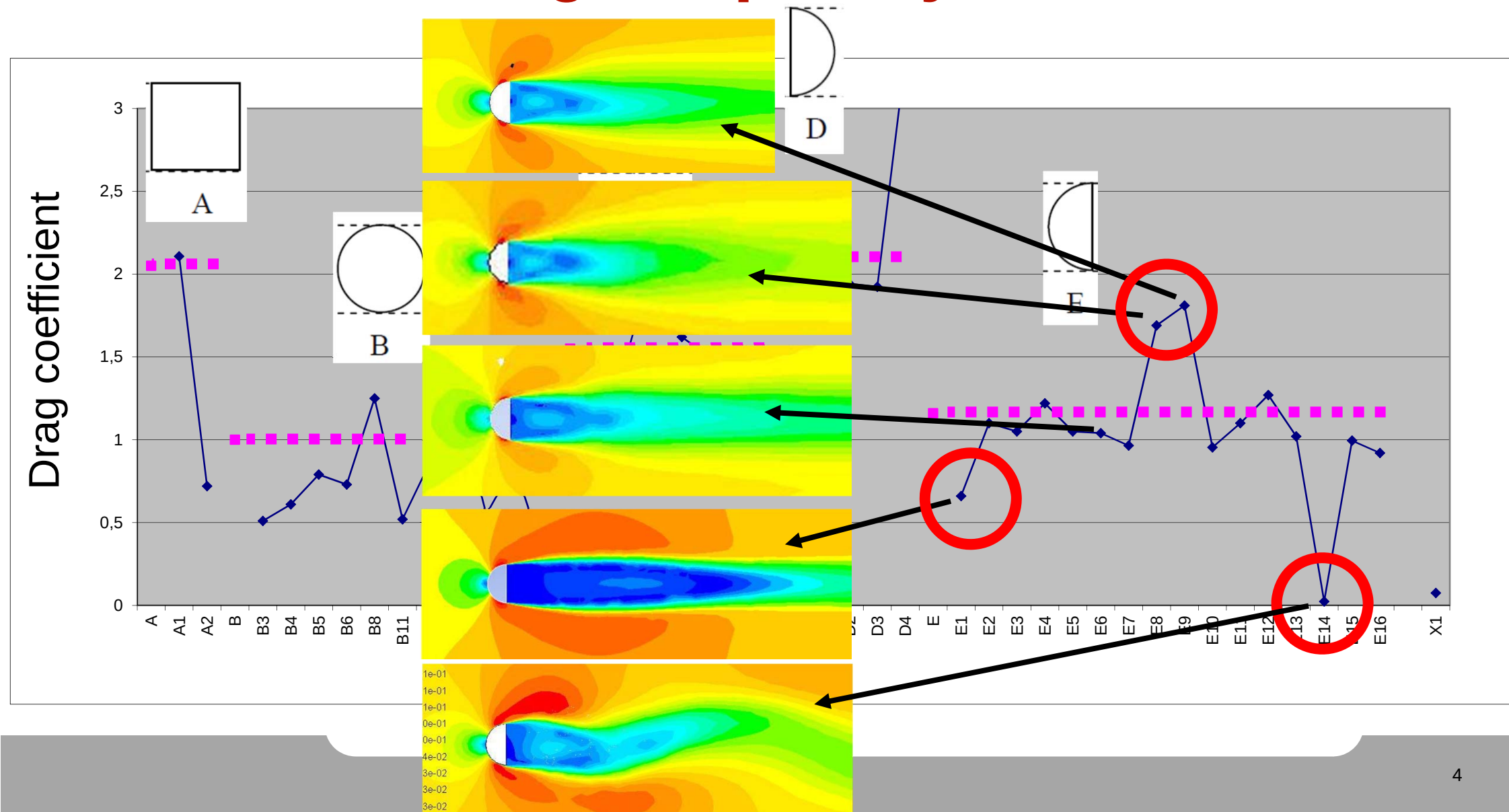
What can we learn?



Scaling?


Drag coefficient
3
2,5
2
1,5
1
0,5
0
A
D
E
A A1 A2 B B3 B4 B5 B6 B8 B11 B1 B2 B7 B9 B10 C C1 C2 C3 C4 C5 C6 C7 D D1 D2 D3 D4 E E1 E2 E3 E4 E5 E6 E7 E8 E9 E10 E11 E12 E13 E14 E15 E16 X1

Scaling or quality?



What is the question?

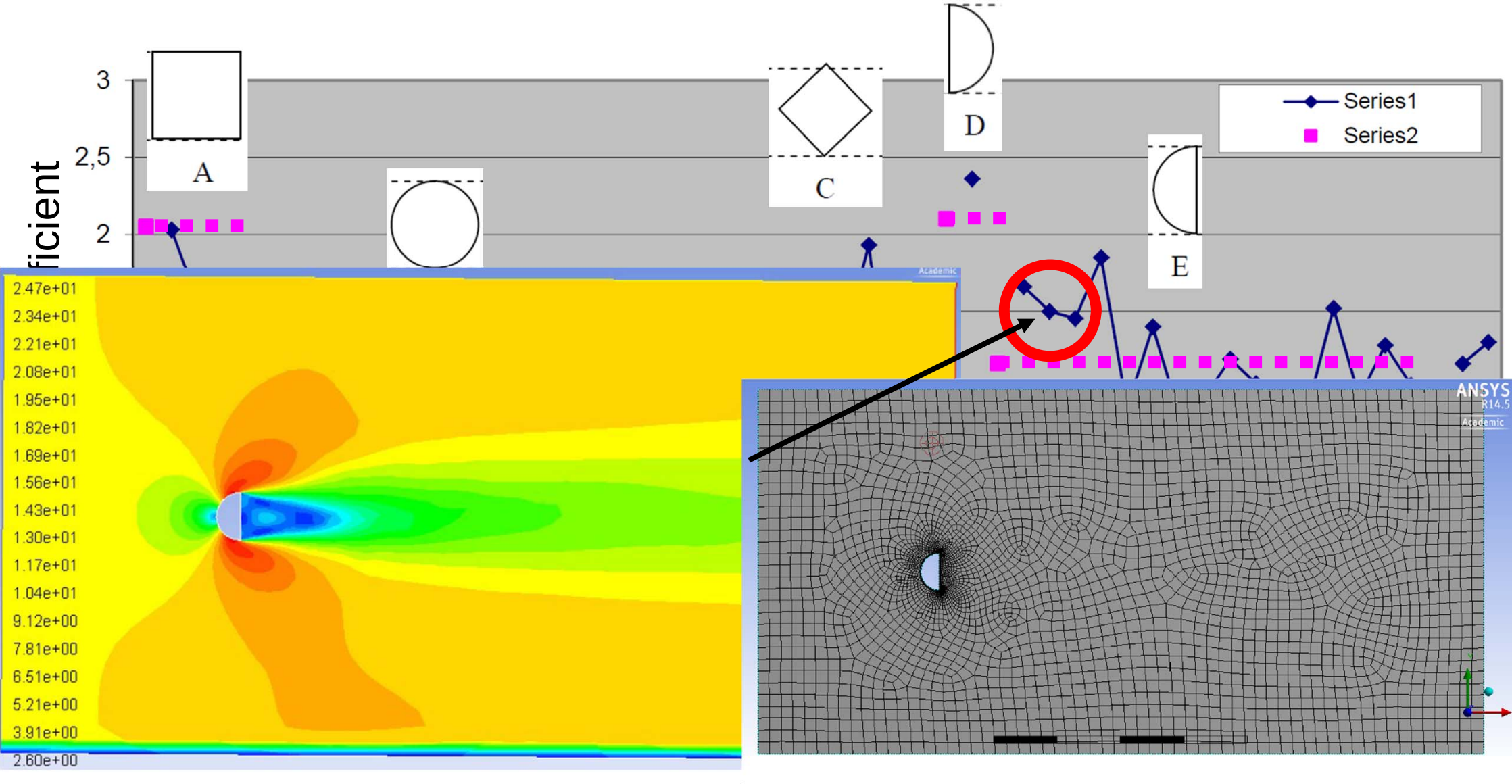
- Drag coefficient

$$C_D = \frac{2D}{\rho U^2 H}$$

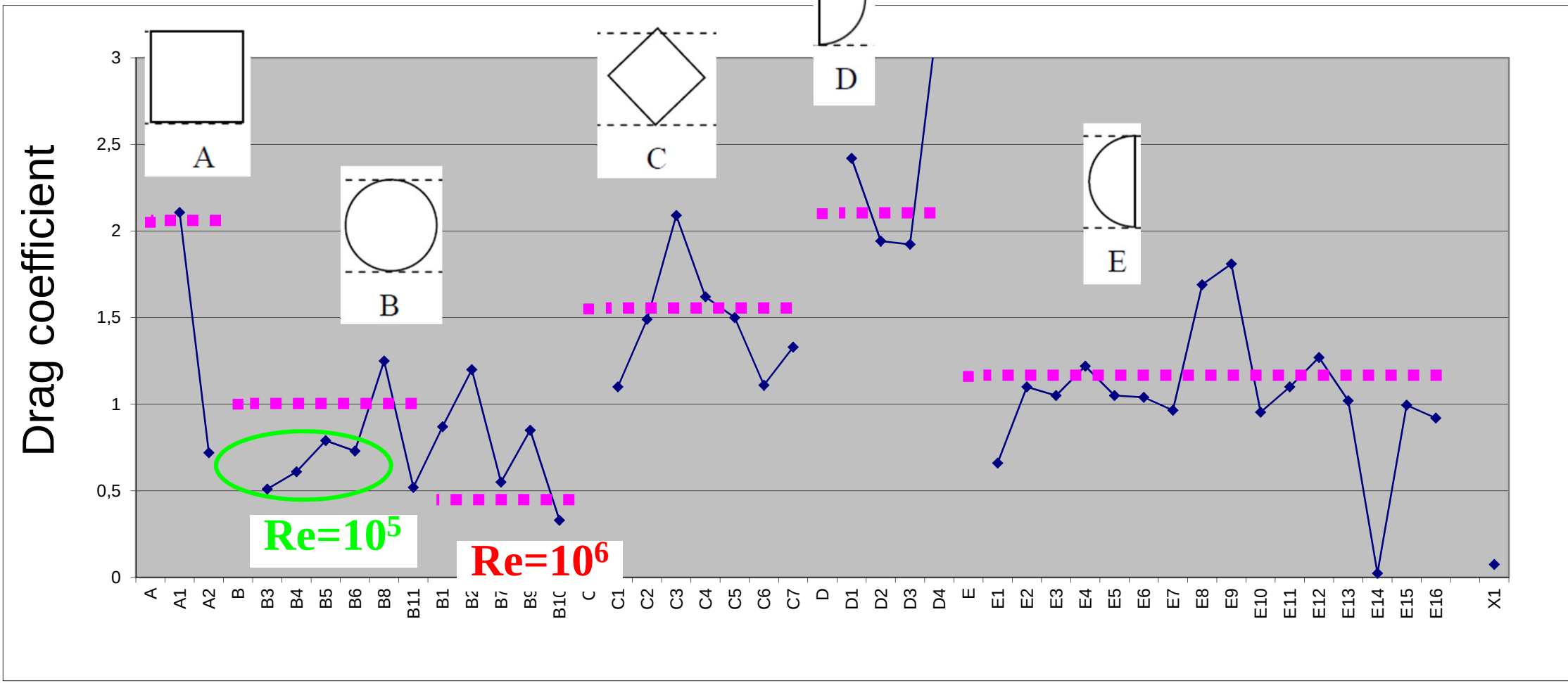
- D=1.2, ρ=1.2, U=2, H=0.5 -> Cd=1.0, not 2.0 or 1.2

```
Forces

                         Forces (n)
Zone                     Pressure                                        Viscous
object                   (1.2247356 -0.056028187 0)                      (-0.0087259216 4.0672516e-05
------------------------ ----------------------------------------------- ----------------------------
Net                      (1.2247356 -0.056028187 0)                      (-0.0087259216 4.0672516e-05

Forces - Direction Vector (1 0 0)
                         Forces (n)                                      Coefficients
Zone                     Pressure        Viscous         Total           Pressure        Viscous
object                   1.2247356       -0.0087259216   1.2160097       1.9995684       -0.01424640
------------------------ --------------- --------------- --------------- --------------- -----------
Net                      1.2247356       -0.0087259216   1.2160097       1.9995684       -0.01424640
```

Setup (also from 2014)?

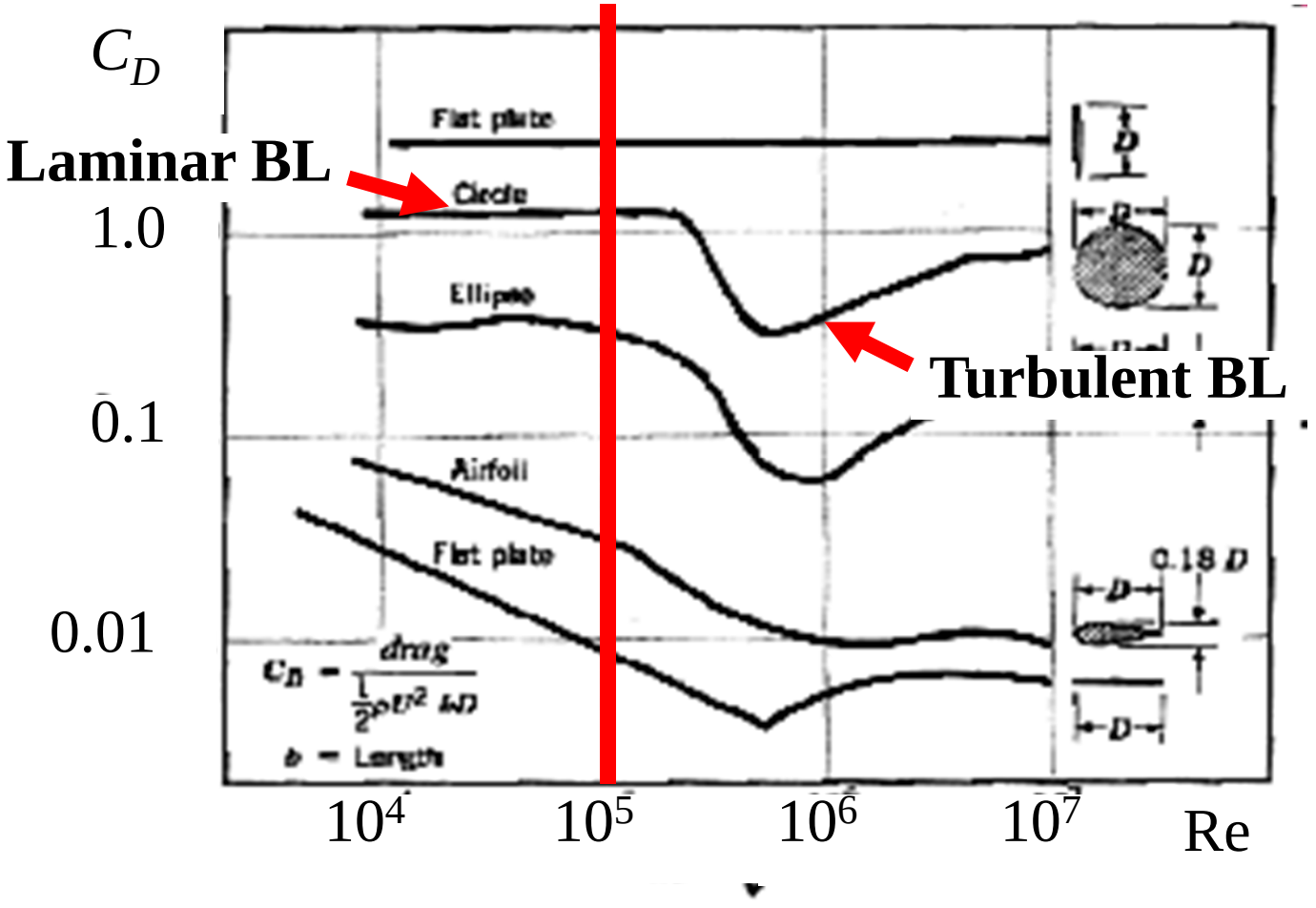


Systematic error?



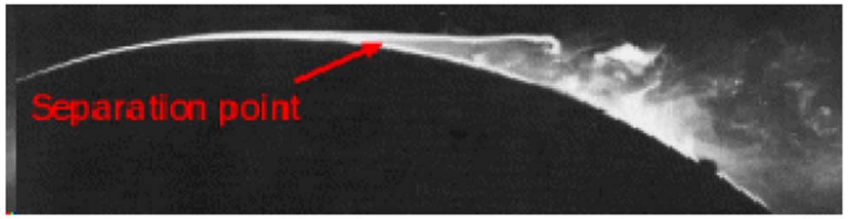
Transition?

- Reynolds number L=1m, U=1m/s, air -> Re~10^5

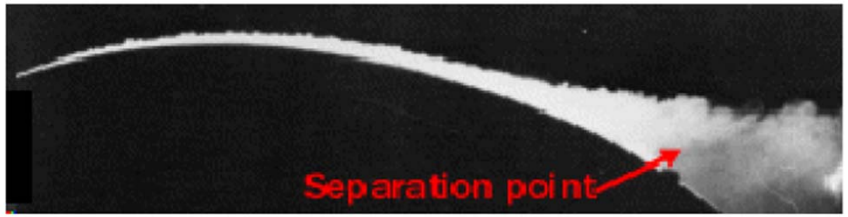


Transition?

- Subcritical $Re \lesssim 200.000$
  - Laminar boundary layer
  - Early separation
- Supercritical $Re \gtrsim 400.000$
  - Turbulent boundary layer
  - Late separation
- RANS model
  - Cannot predict transition
  - Often assumed fully turbulent
  - No difference between $Re = 10^5$ or 10^6
- LES (or DNS)
  - Expensive 3D and time dependent
  - Can predict transition and Re effect

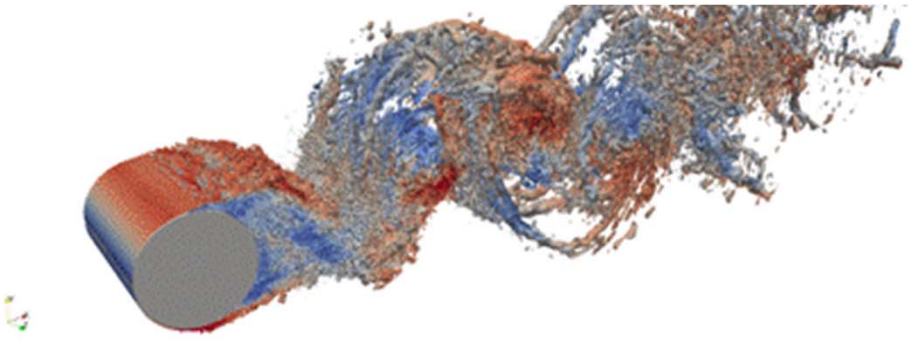


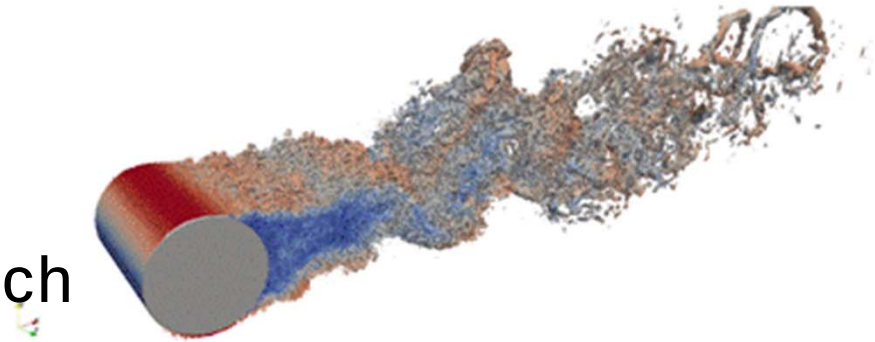
Laminar Separation

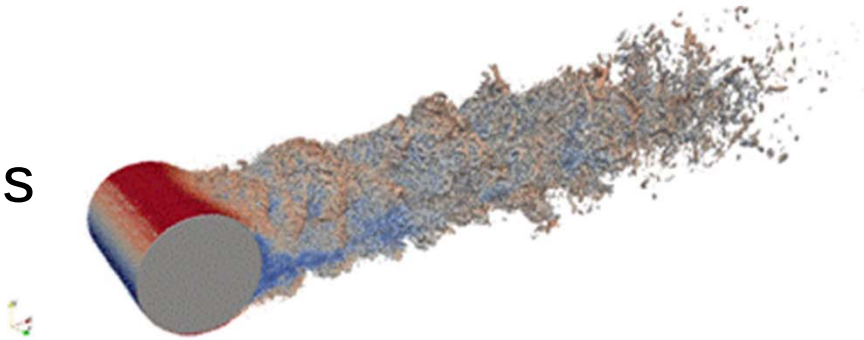


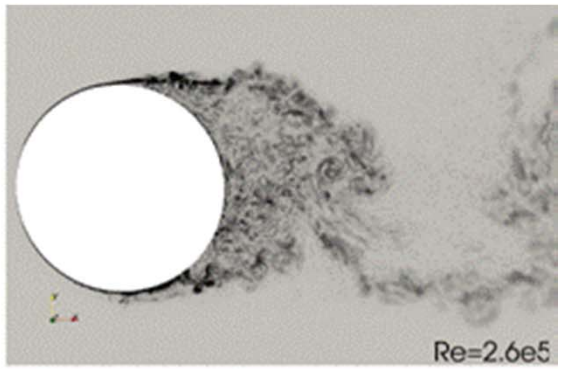
Turbulent Separation

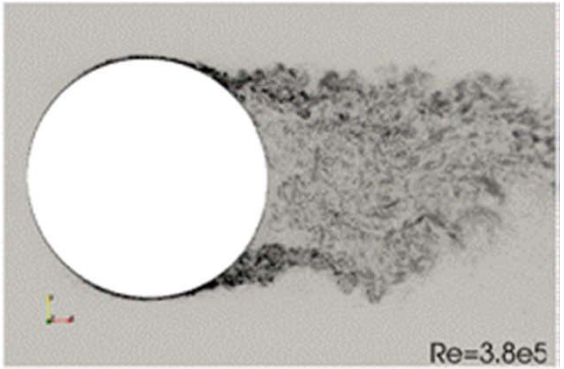
LES – cylinder drag

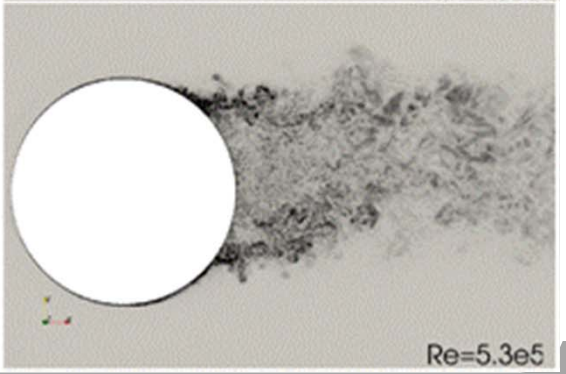










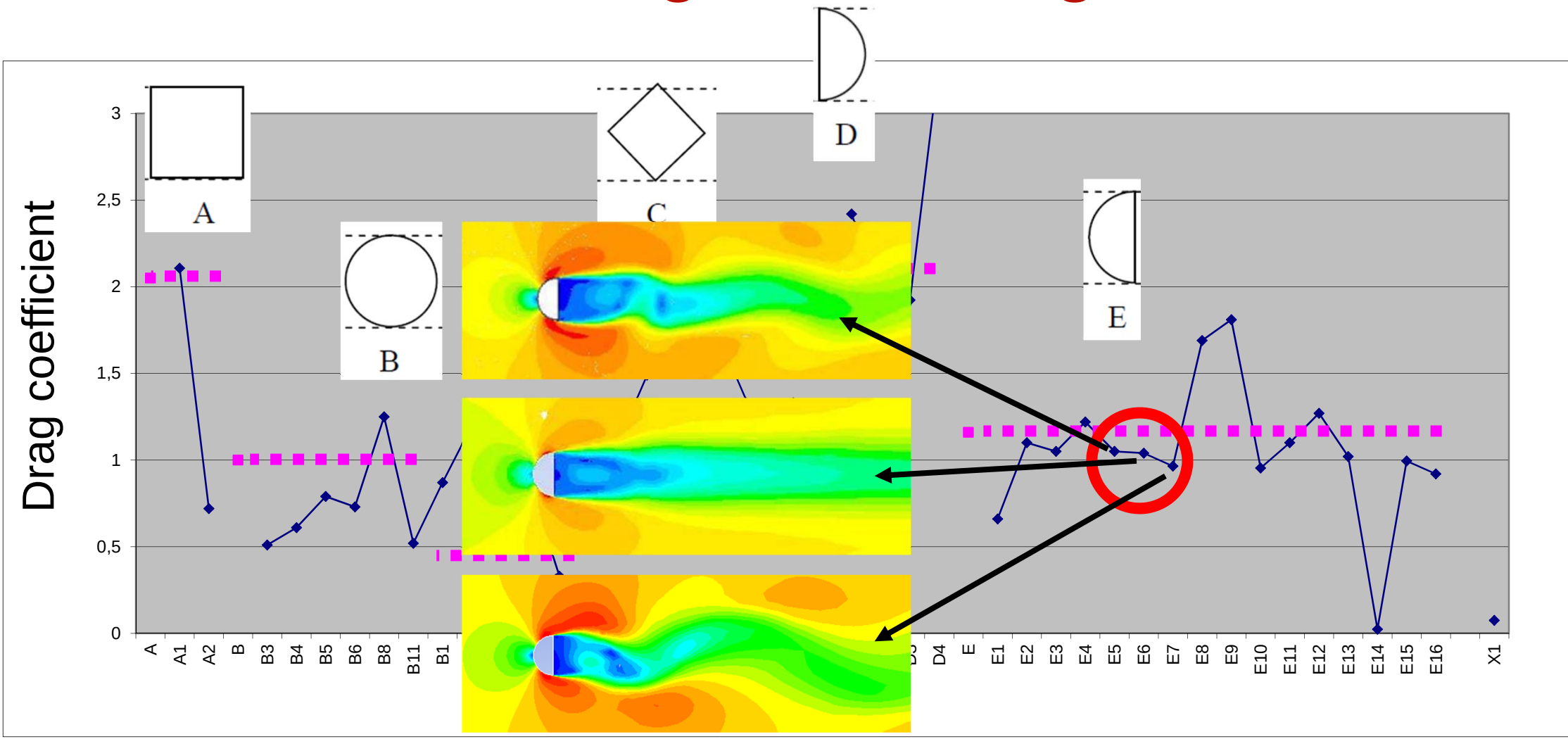


LES at Polytech University of Catalonia

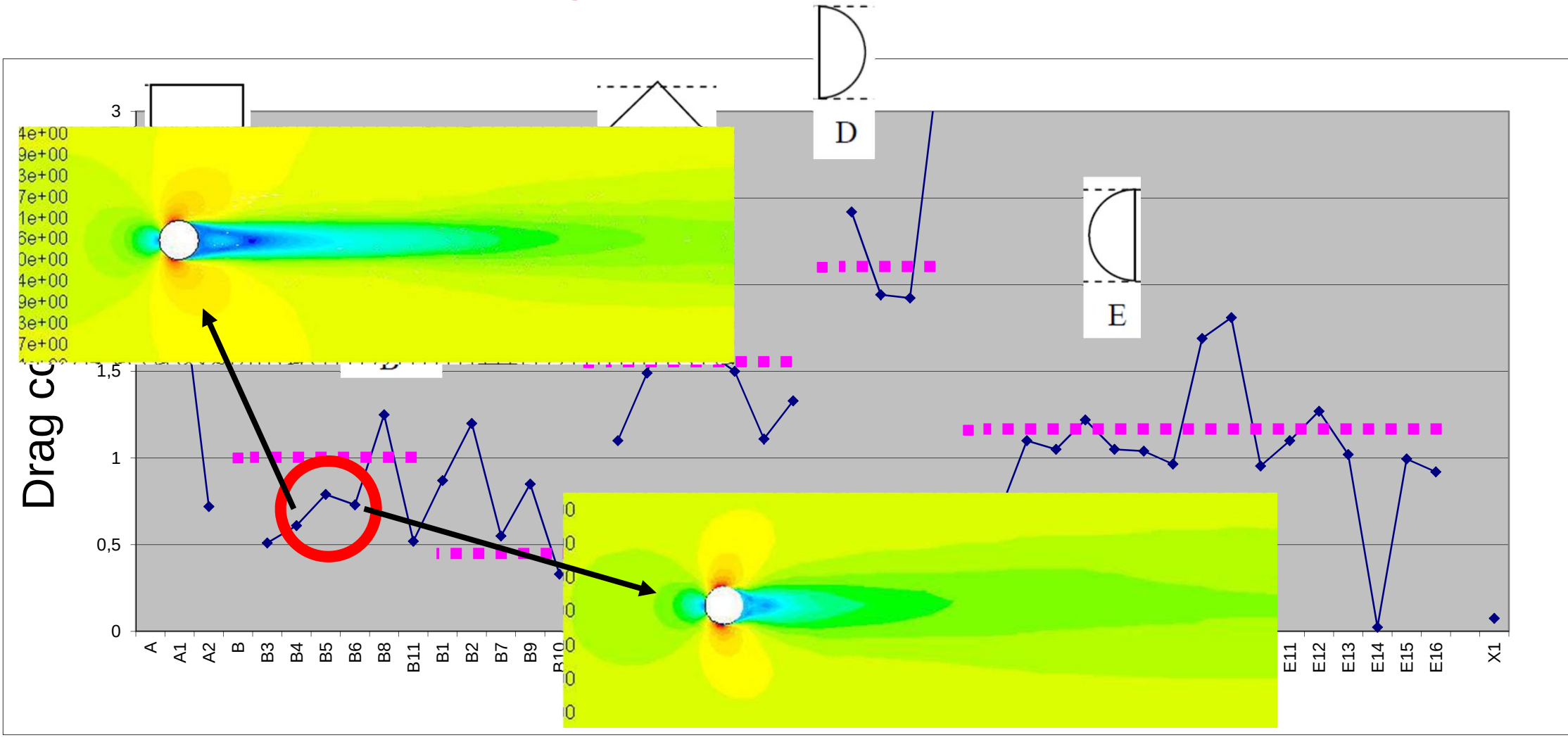
~100 M nodes

~1000 CPUs

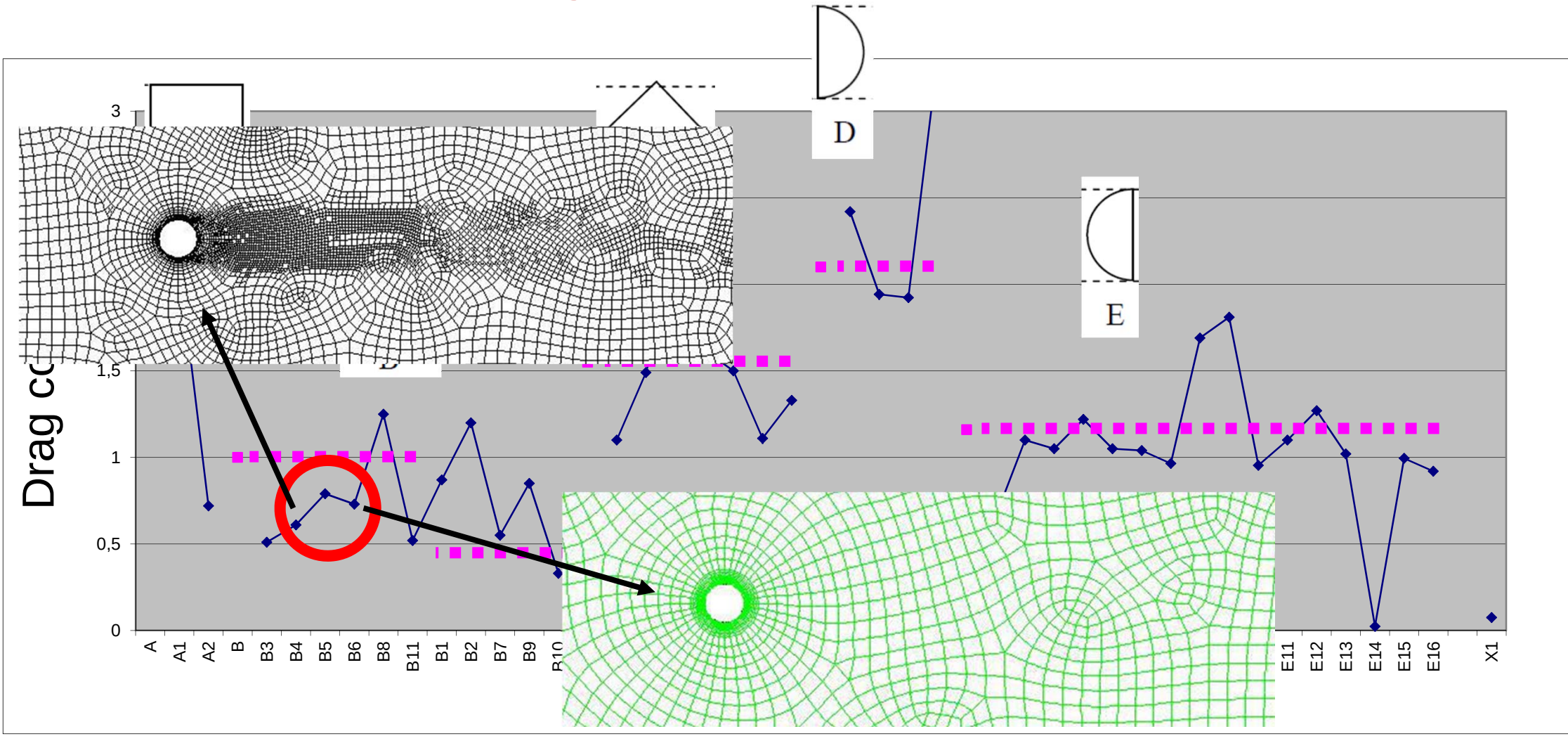
Modelling / resolving?



Quality?


Drag co
3
1,5
1
0,5
0
D
E
A
A1
A2
B
B3
B4
B5
B6
B8
B11
B1
B2
B7
B9
B10
E11
E12
E13
E14
E15
E16
X1

Quality?


D
E
3
1,5
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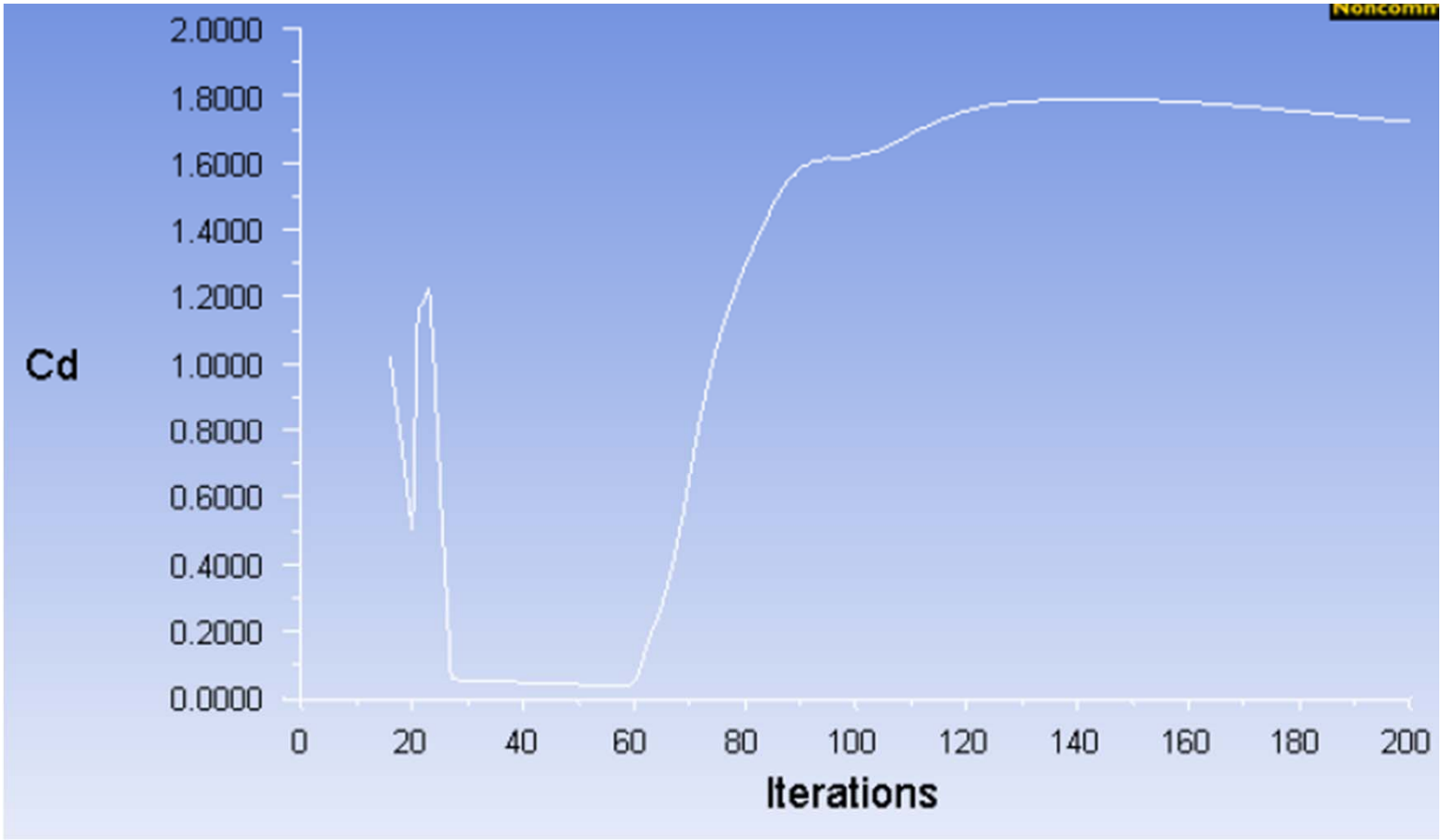
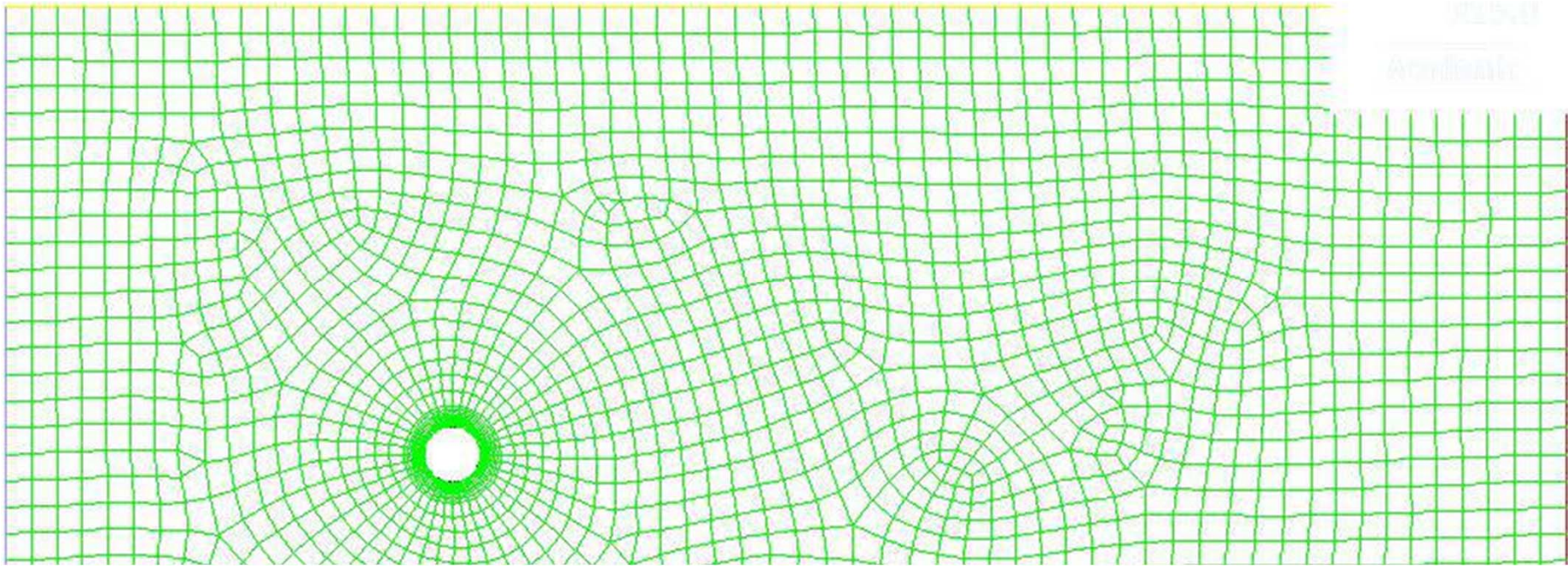
A
A1
A2
B
B3
B4
B5
B6
B8
B11
B1
B2
B7
B9
B10
E11
E12
E13
E14
E15
E16
X1

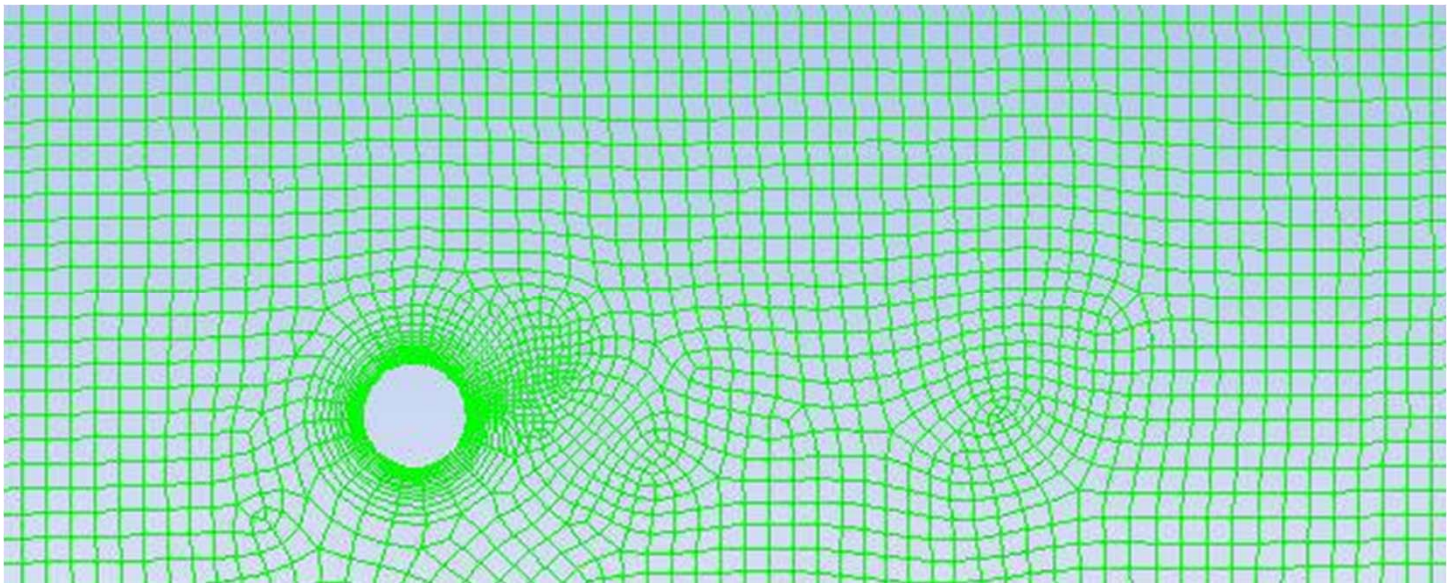
Convergence?

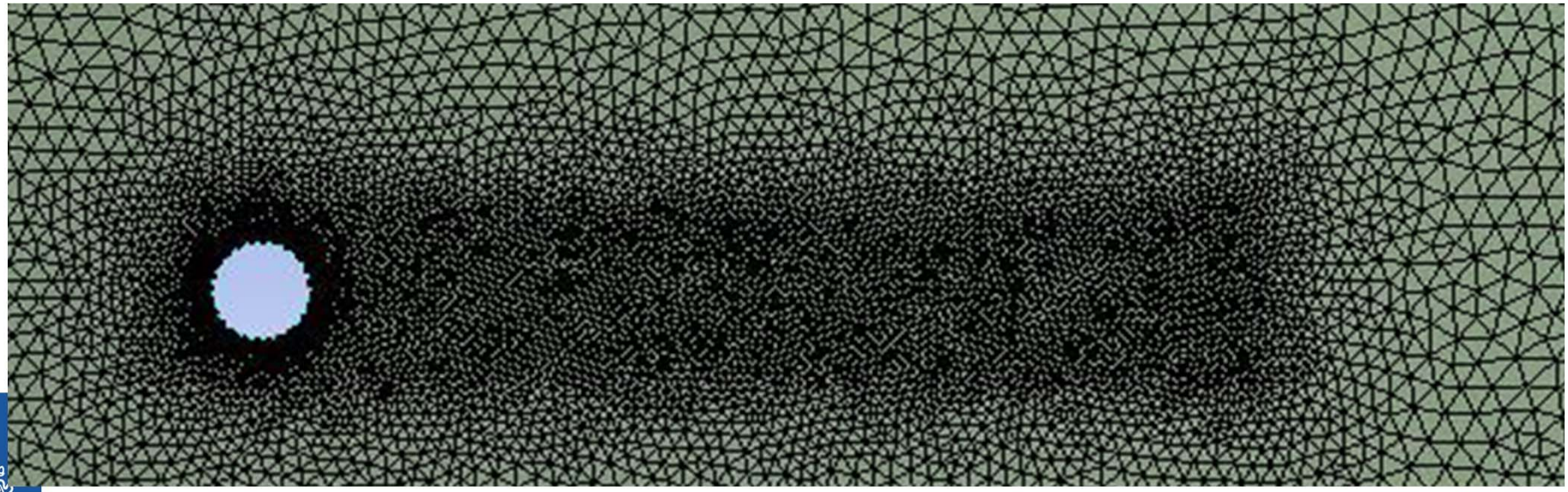
- Quantities of interest should not change with iteration

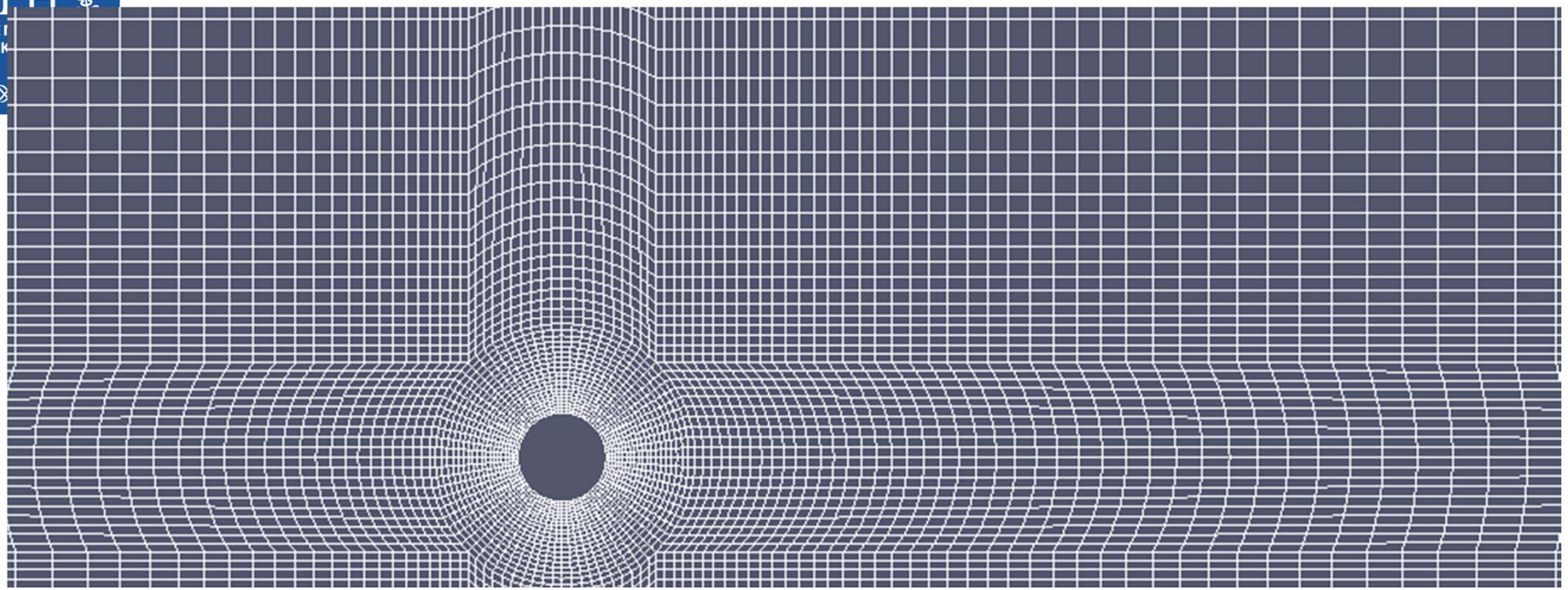


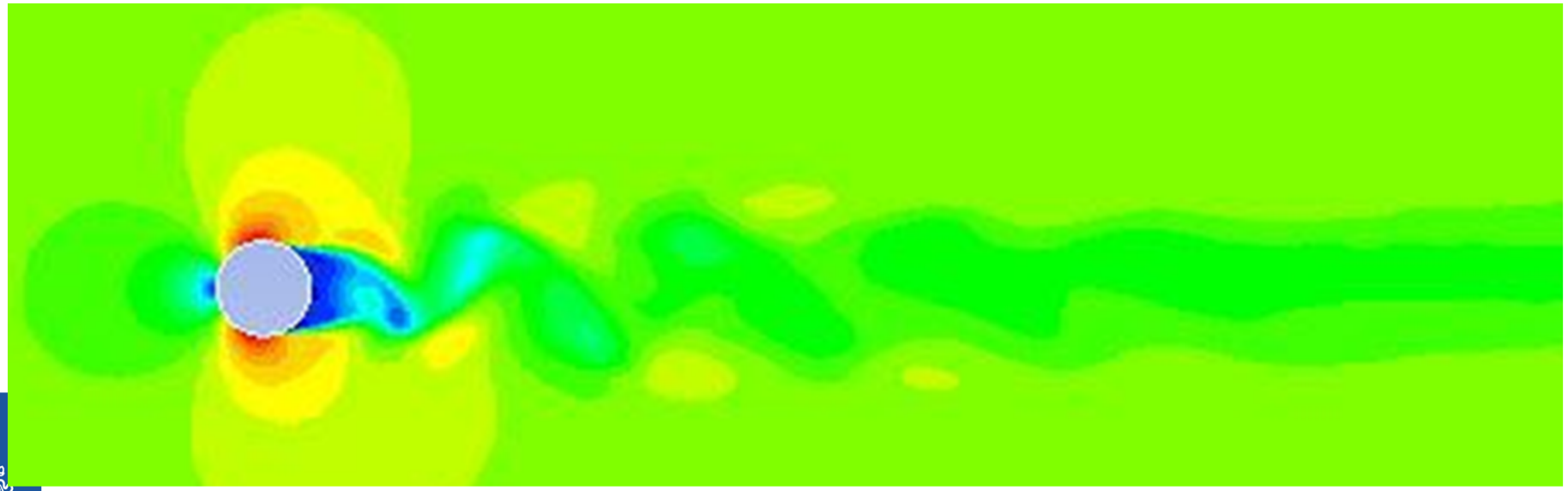
Grids

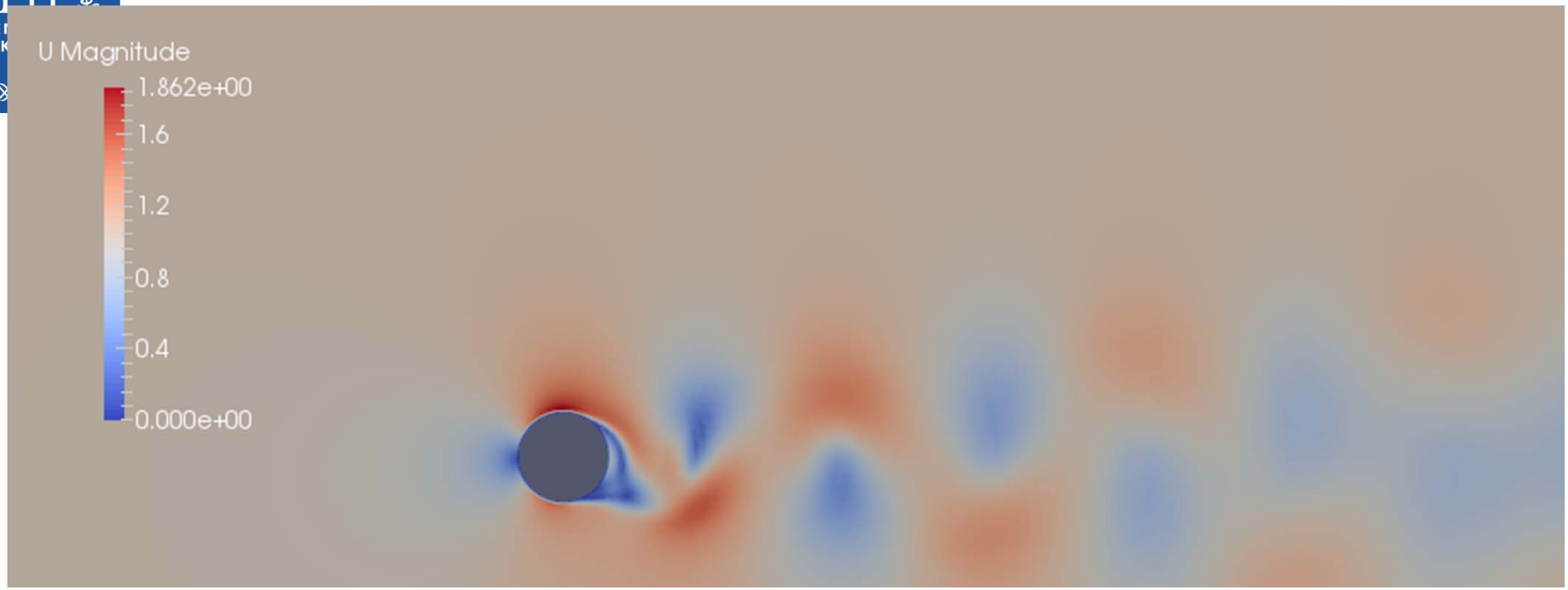


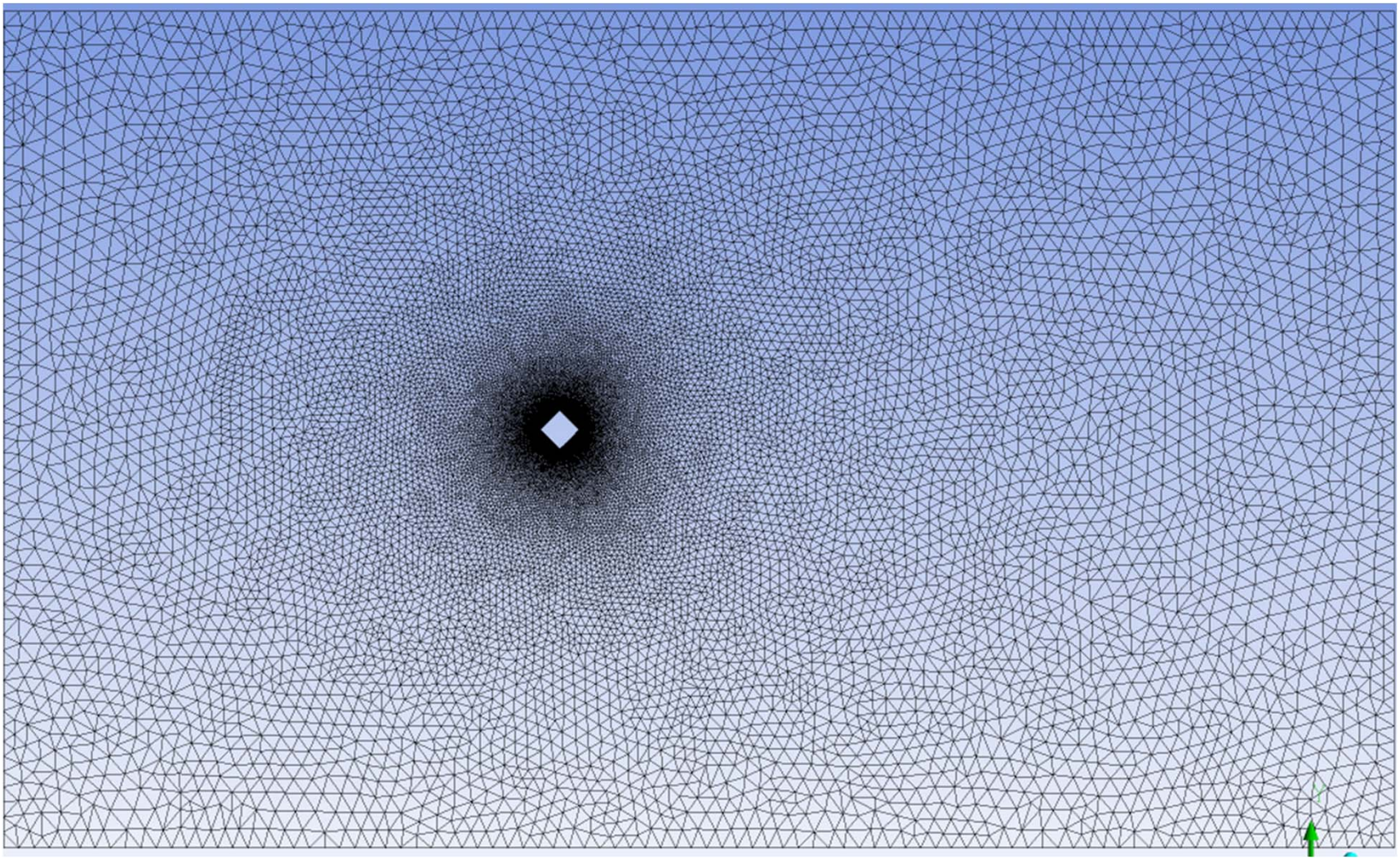


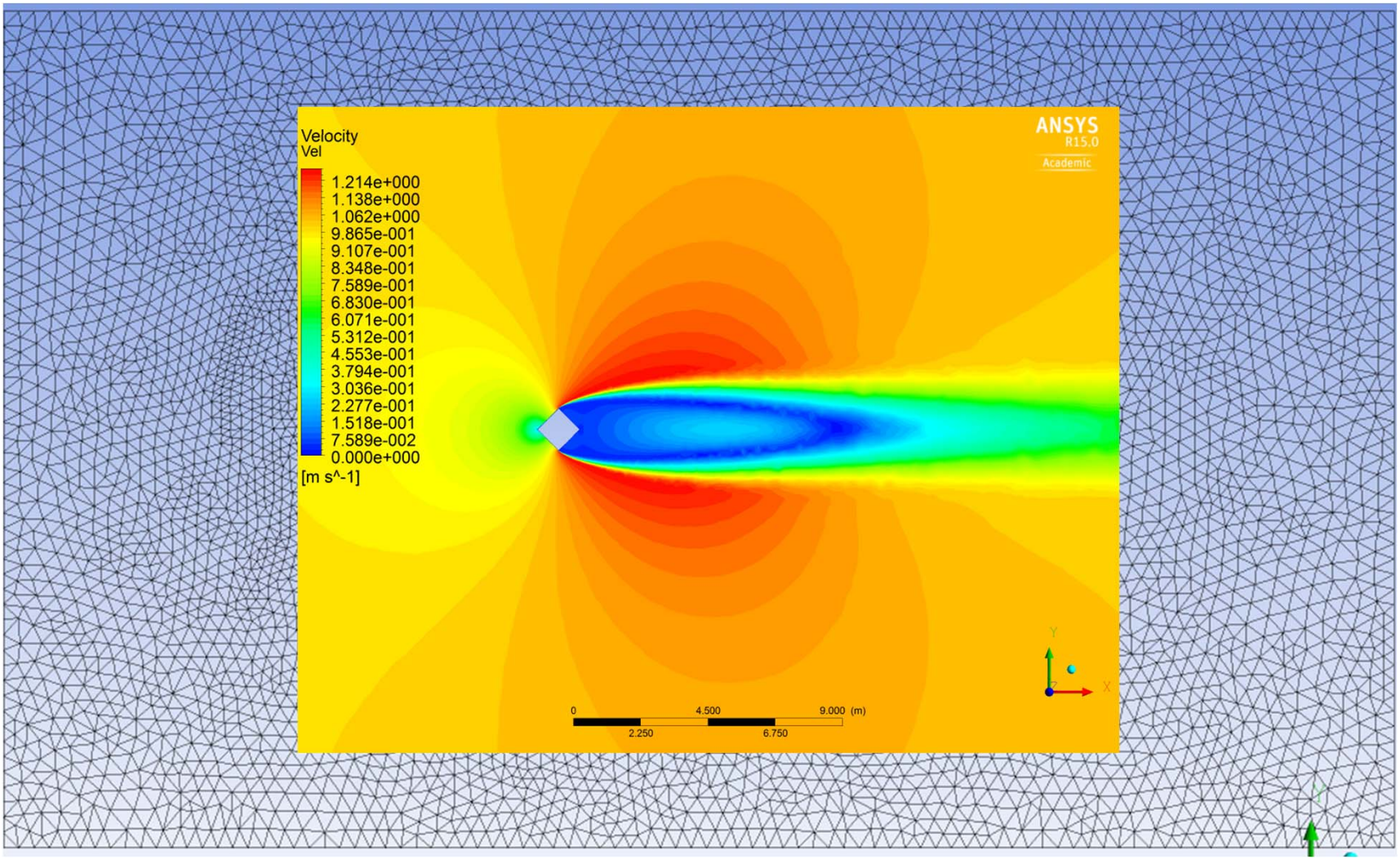







U Magnitude
1.862e+00
1.6
1.2
0.8
0.4
0.000e+00




Velocity
Vel
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1.138e+000
1.062e+000
9.865e-001
9.107e-001
8.348e-001
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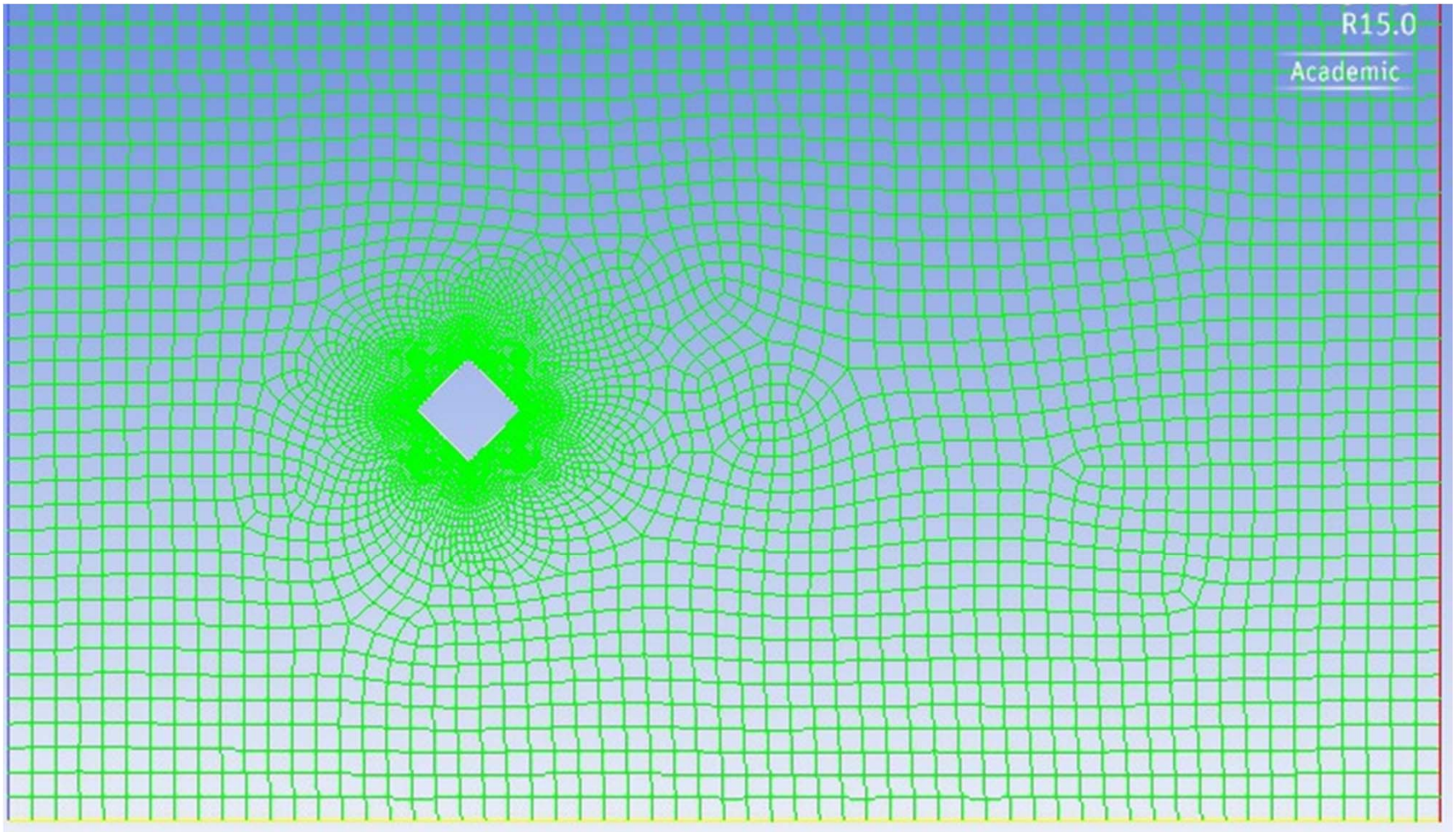
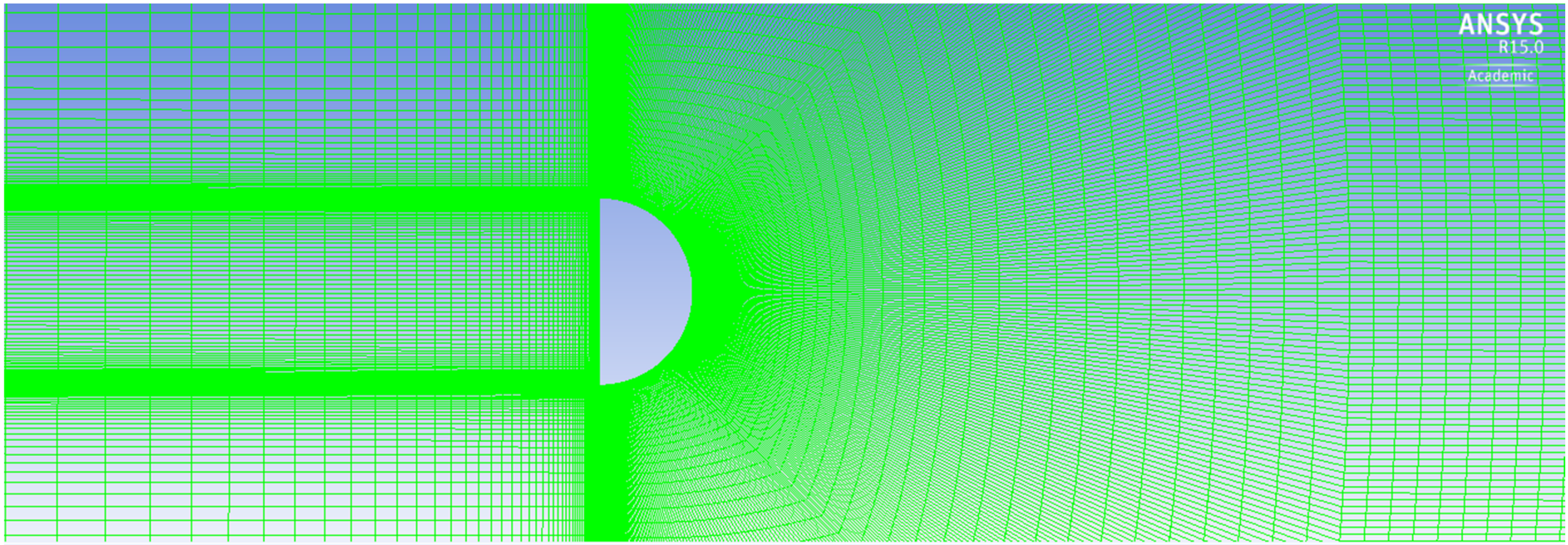
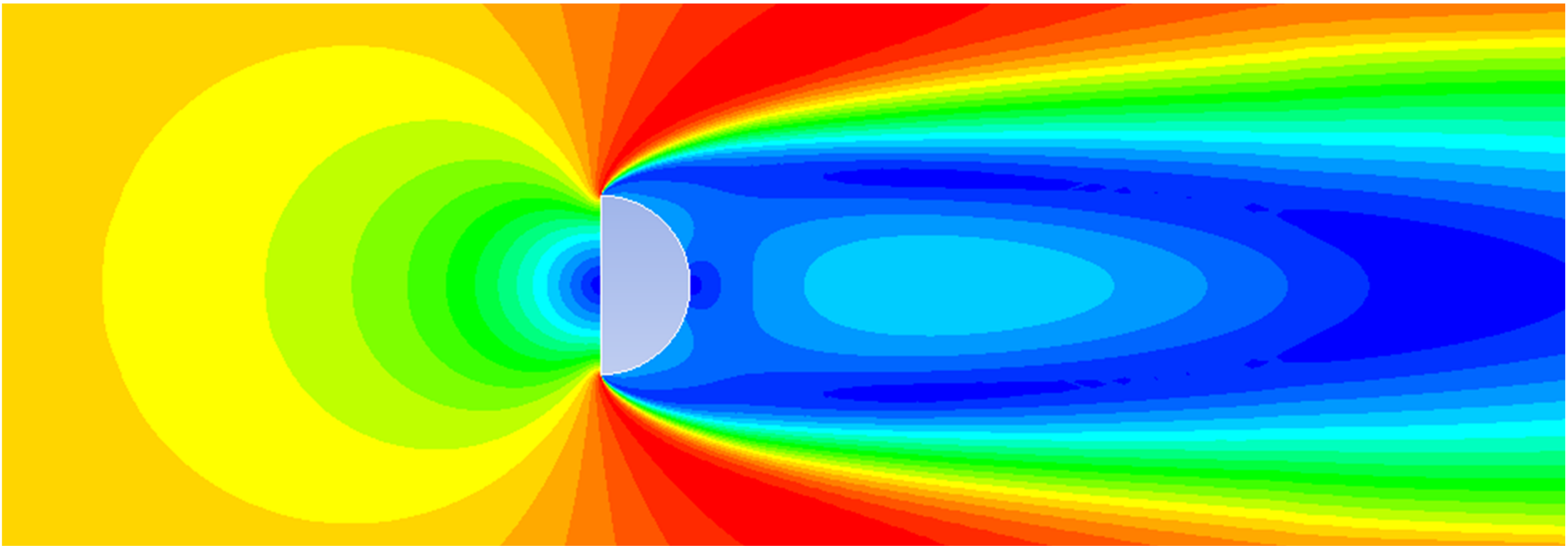
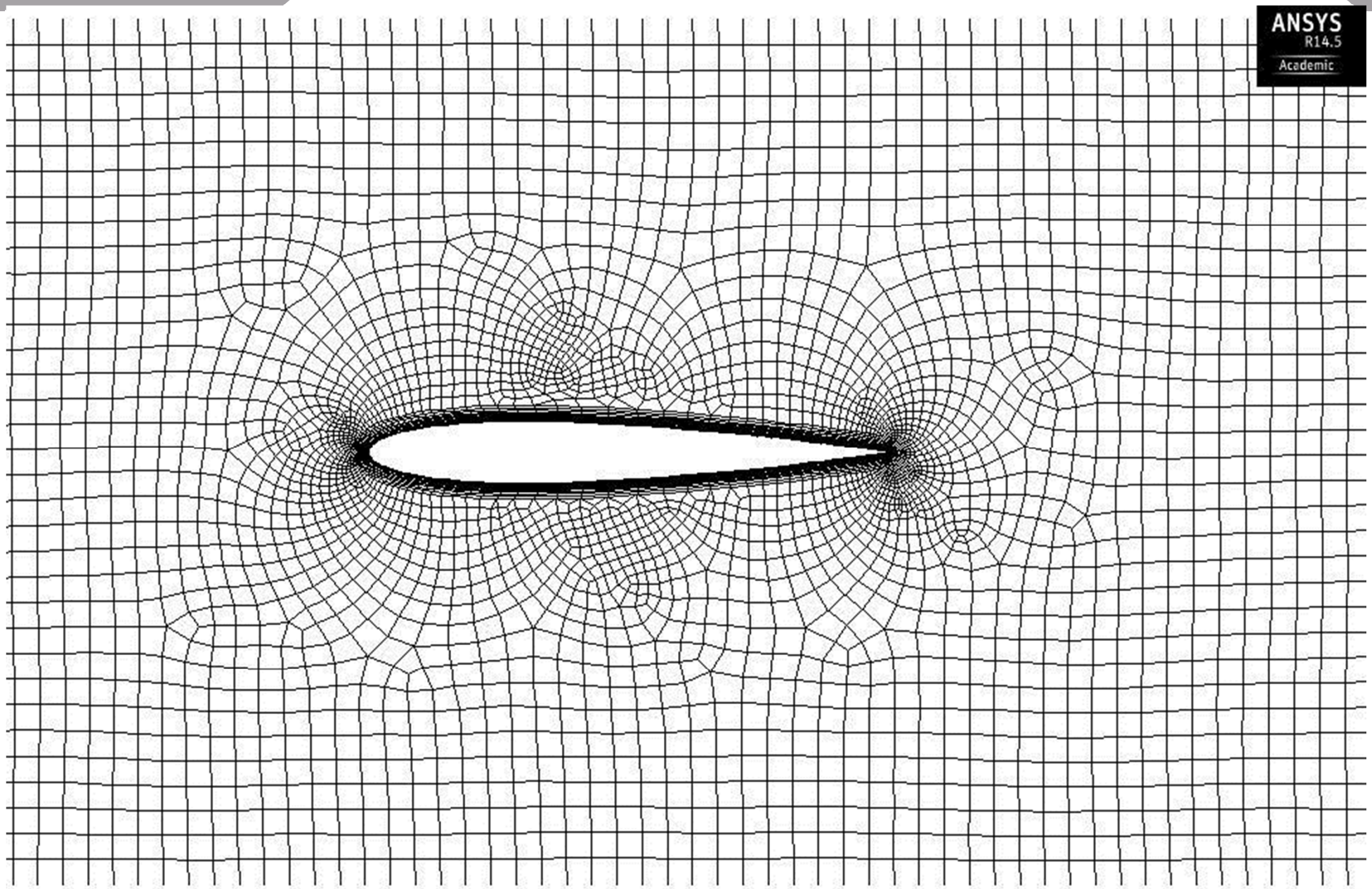
6.830e-001
6.071e-001
5.312e-001
4.553e-001
3.794e-001
3.036e-001
2.277e-001
1.518e-001
7.589e-002
0.000e+000
[m s^-1]
ANSYS
R15.0
Academic
0
4.500
9.000 (m)
2.250
6.750
Y
Z
X


R15.0
Academic


ANSYS
R15.0
Academic

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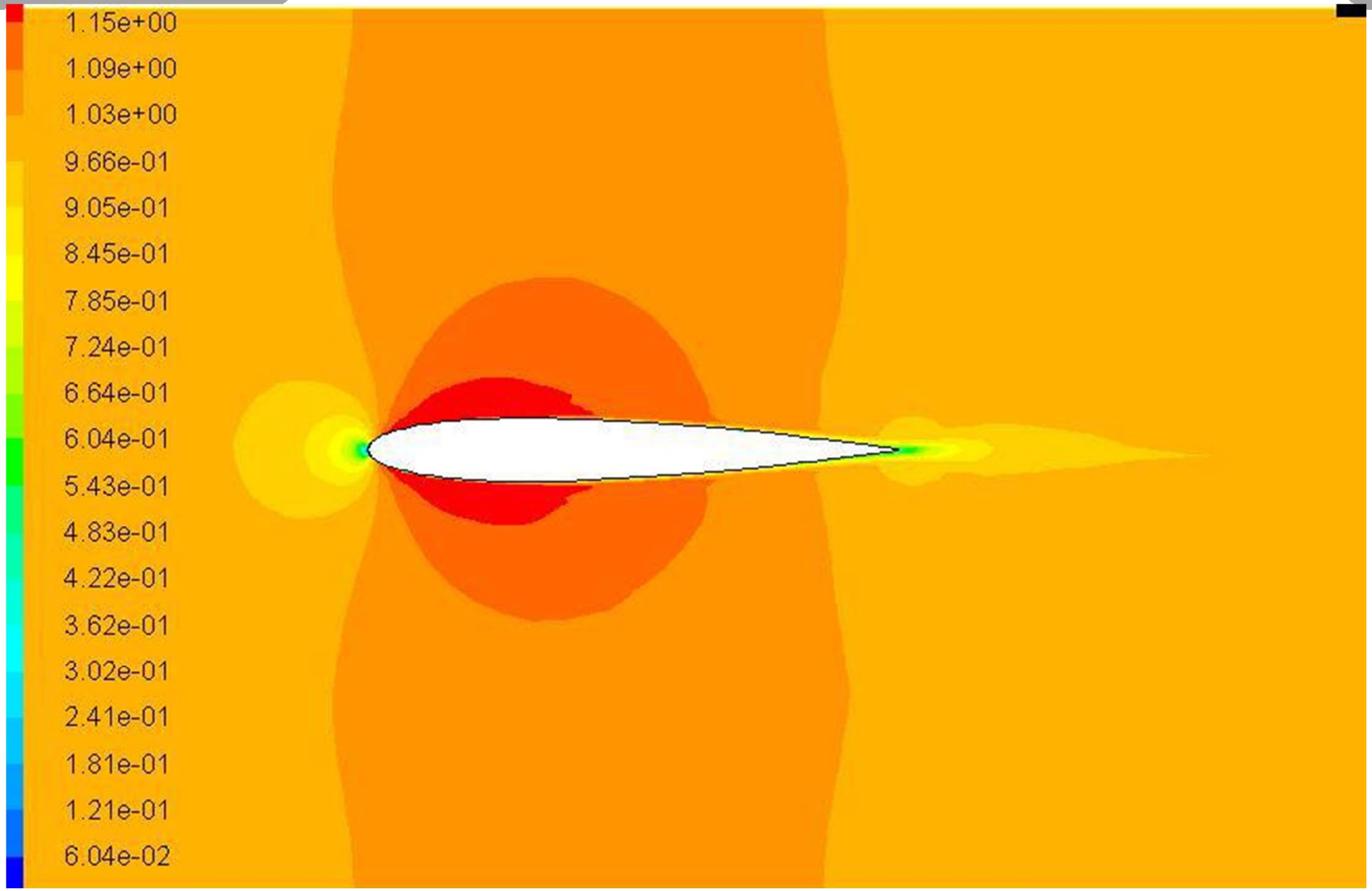
1.15e+00
1.09e+00
1.03e+00
9.66e-01
9.05e-01
8.45e-01
7.85e-01
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6.64e-01
6.04e-01
5.43e-01
4.83e-01
4.22e-01
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3.02e-01
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1.81e-01
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