Stability of a semi-implicit compressible cavitation solver (CPS) in YALES2

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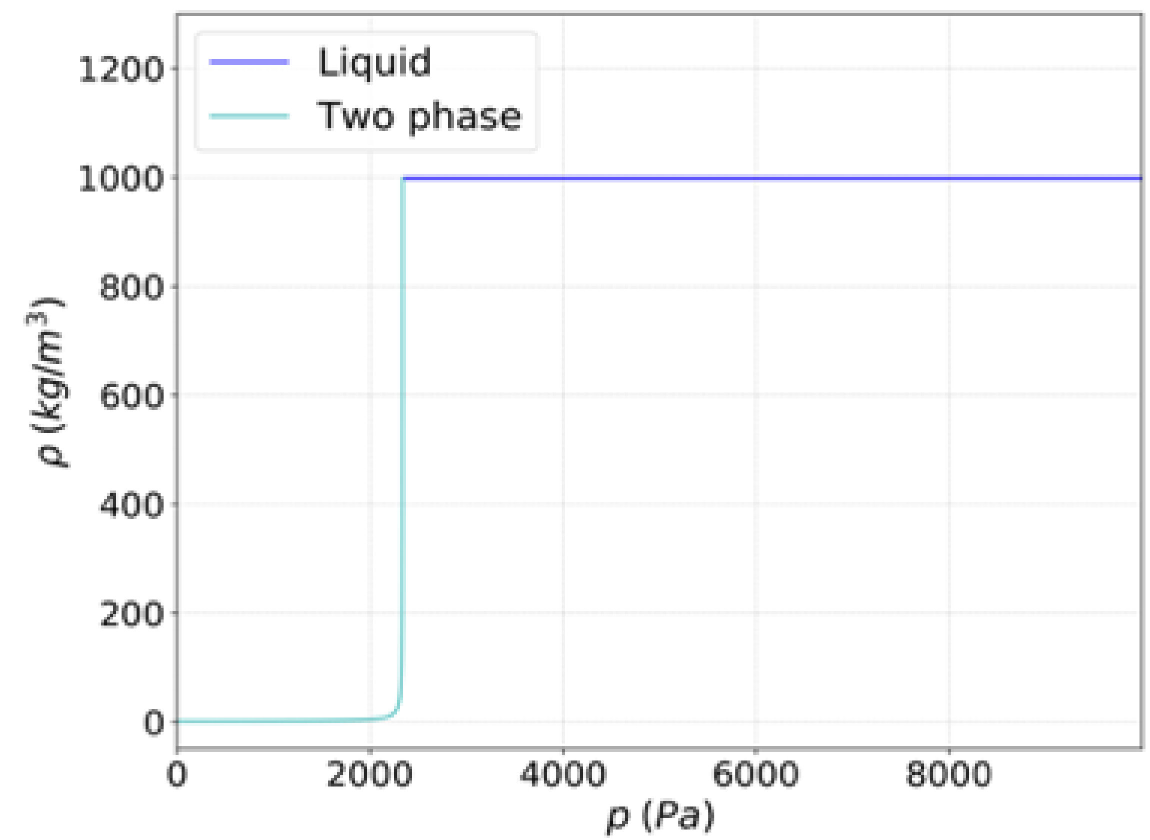
Cavitation model: Single fluid model (mixture of liquid and vapor in two phase regions)



According to Barotropic law: $p = f(\rho)$

We decouple the energy equation from system of equations, and solve only continuity and momentum equation

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \bar{\mathbf{u}}) = 0$$

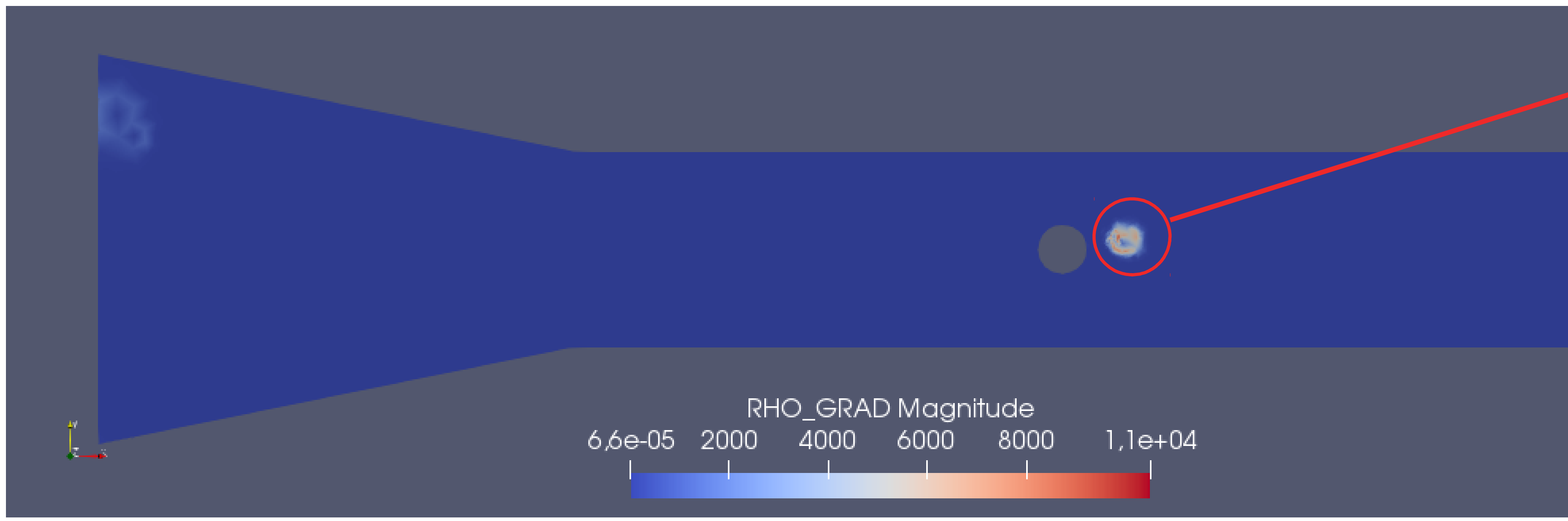
$$\frac{\partial \rho \bar{\mathbf{u}}}{\partial t} + \nabla \cdot (\rho \bar{\mathbf{u}} \otimes \bar{\mathbf{u}}) = -\nabla p + \nabla \cdot \bar{\bar{\tau}}$$

$$\frac{\partial \rho E}{\partial t} + \nabla \cdot (\rho E \bar{\mathbf{u}}) = -\nabla \cdot (p \bar{\mathbf{u}}) + \nabla \cdot (\bar{\bar{\tau}} \bar{\mathbf{u}}) + \nabla \cdot (\lambda \nabla T)$$

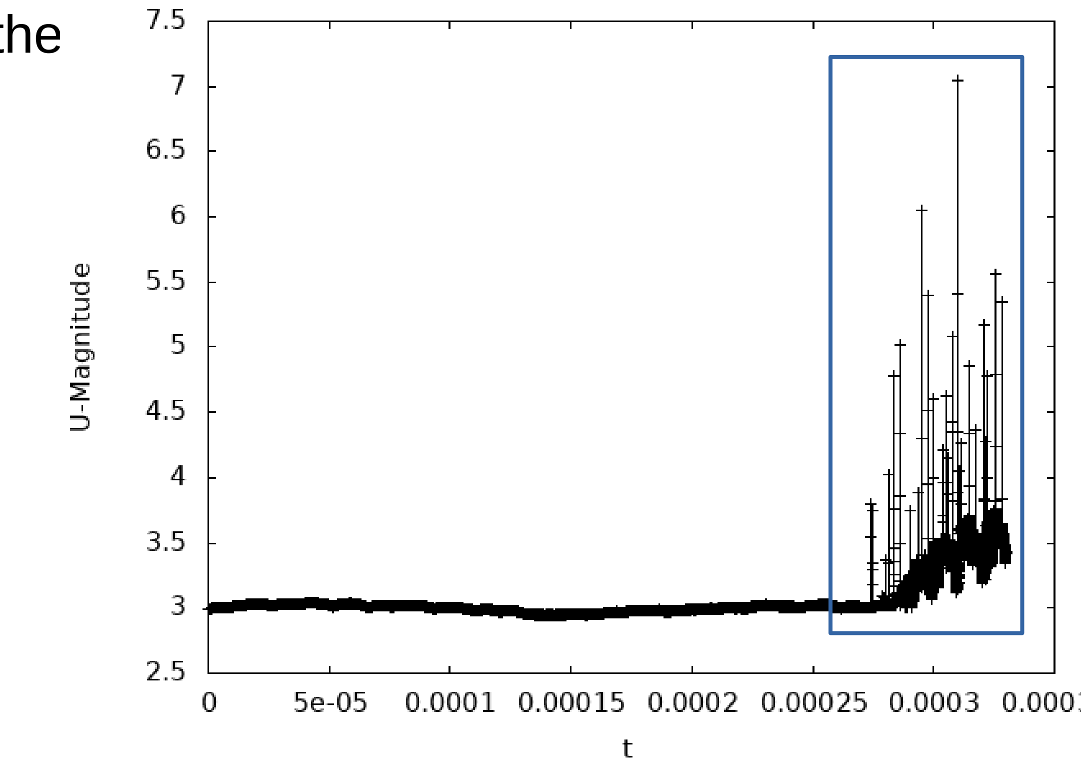
Sarkar P. (2019). “Simulation of cavitation erosion by a coupled CDF-FEM approach” Theses, https://tel.archives-ouvertes.fr/tel-02267374

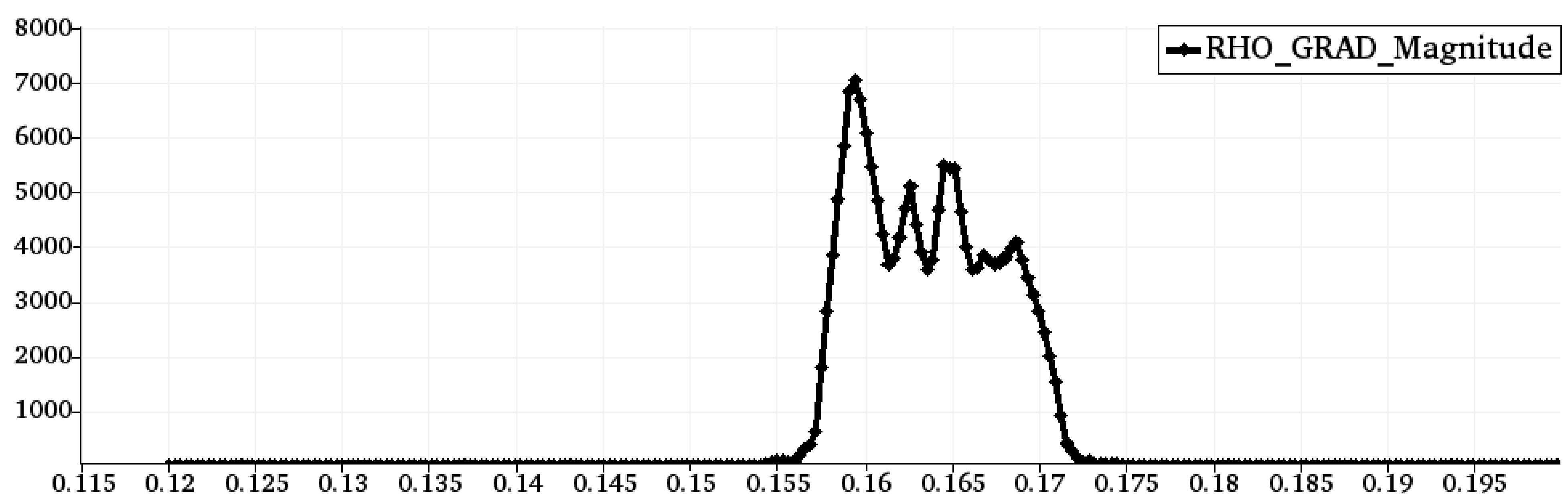
Objective: to study cavitating flows behind obstacles

Problem: Code is highly unstable in the presence of cavitation!!!



Vapor bubble behind the cylinder





Observations:

- **High velocity & steep density gradients** in the presence of cavitation
- Generated shock waves due to cavitation are probably too stiff for inlet and outlet boundary conditions.

Goal:

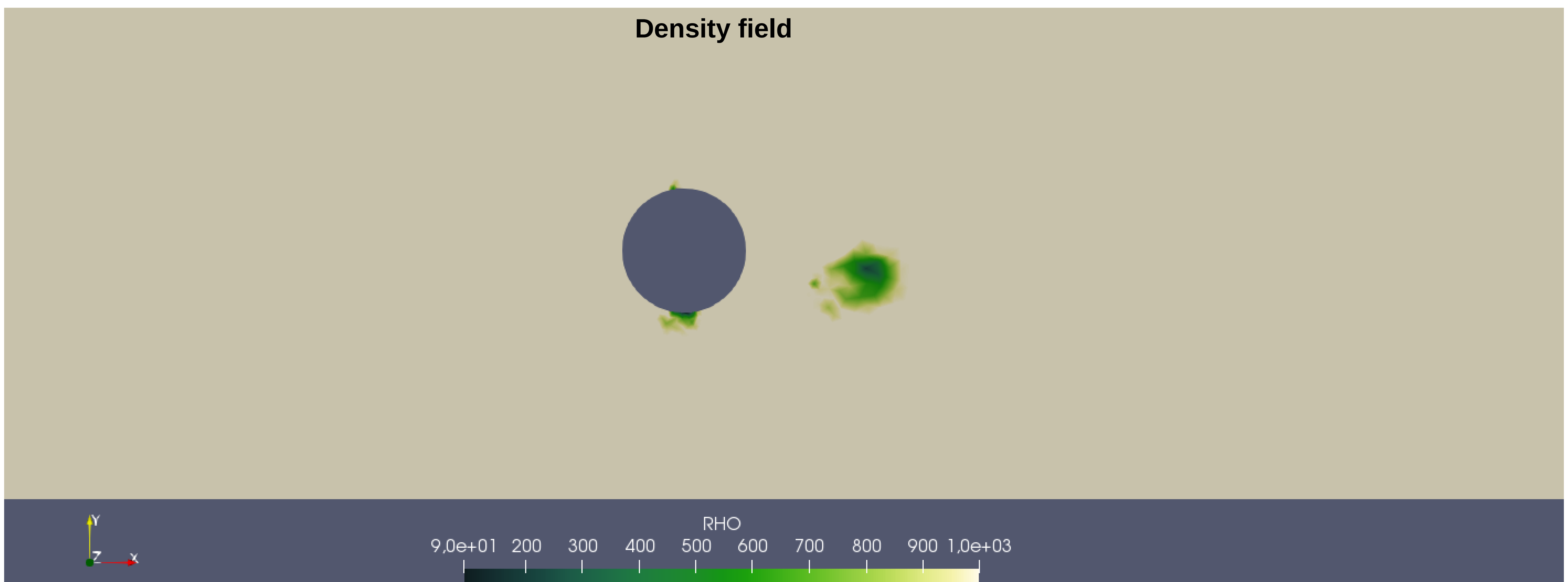
Discretization of steep gradients in time and space accurately!

Objective: to study cavitating flows behind obstacles

Observations/Acheievements:

- Put some limiters on density/pressure, to avoid negative values and results in non-oscillatory behavior.
- Ultimately, cavitating flow behind an obstacle is observed.

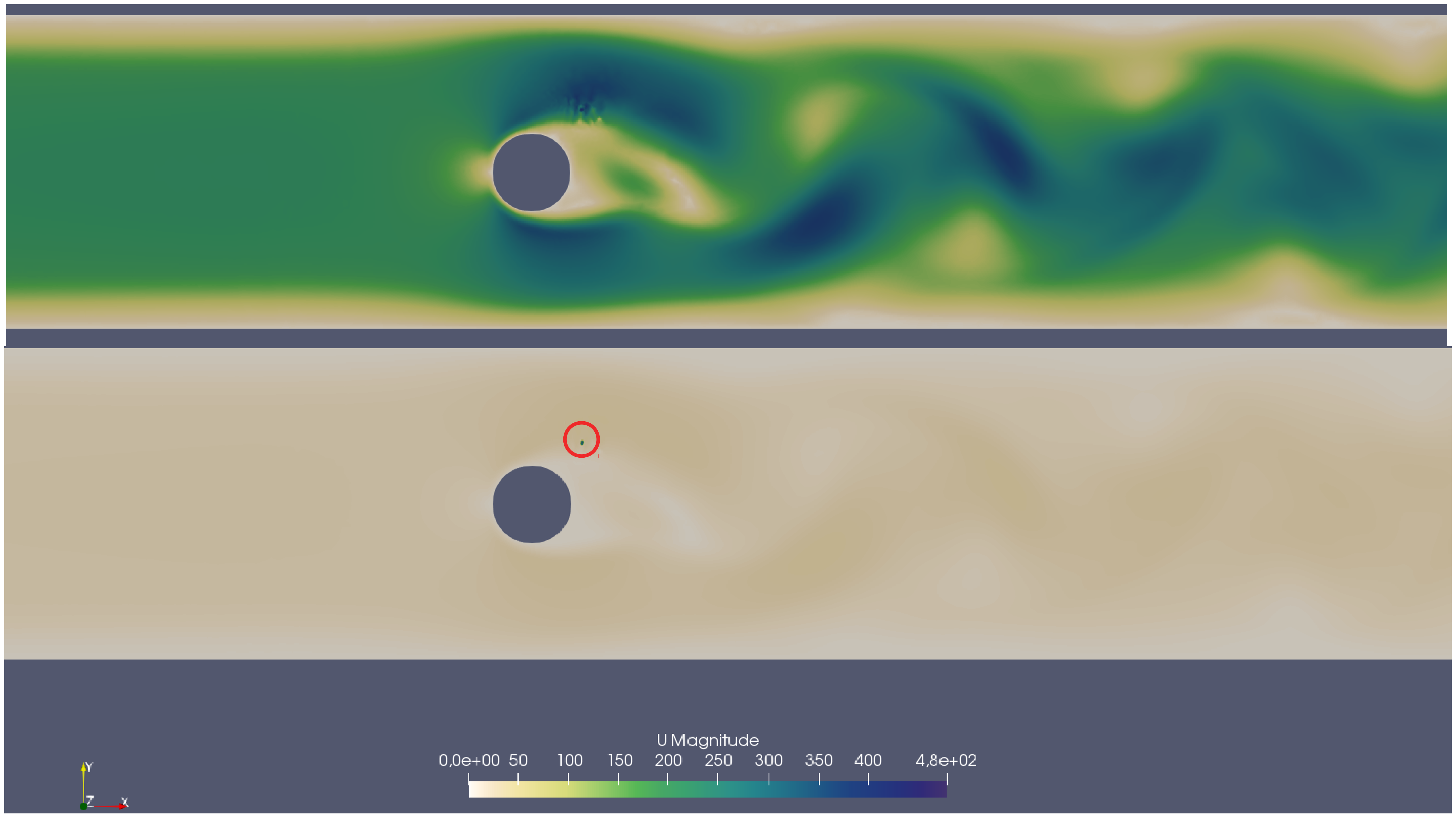
$$ACFL_{BND} = 0.1,\ ACFL = 1,\ dt = 5.268 \times 10^{-8}$$



Ongoing work

Observations/Implementations:

- Despite these stability parameters, we have observed that between one iteration to another, **the code is unstable, due to sudden increase in velocity (locally, at a single node)**



$$U_{max} = 30 \quad t_n$$

$$U_{max} \approx 500 \quad t_{n+1}$$