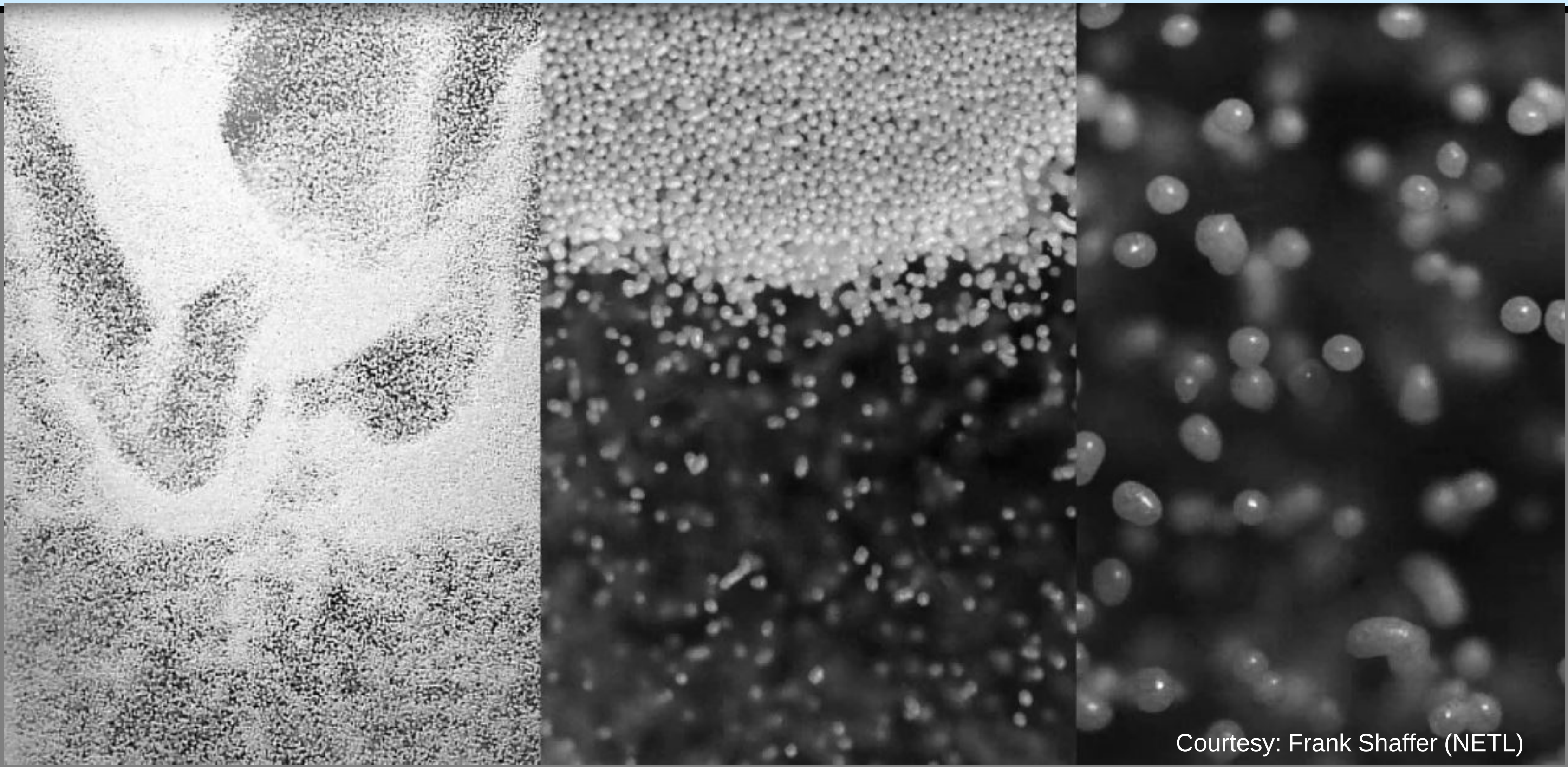
Driving Innovation ♦ Delivering Results



Courtesy: Frank Shaffer (NETL)

Understanding particulate flow physics by visualizing large simulation data sets

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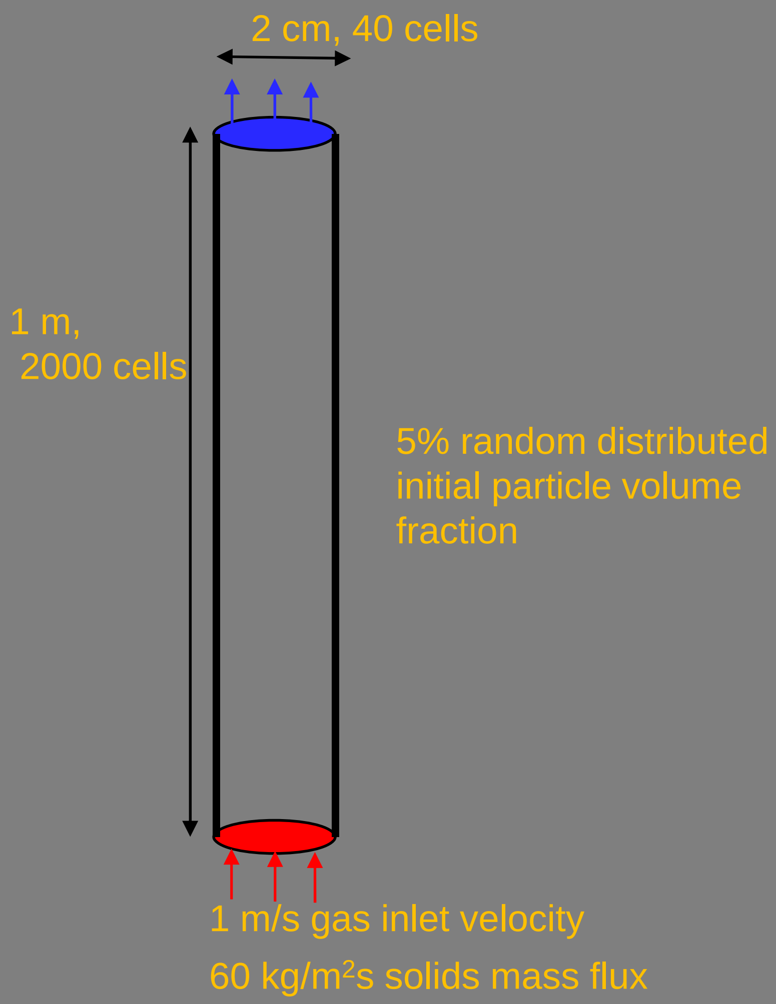
Content

- **Simulation results of square and cylindrical risers**
- **Gas particles flow in a vortex chamber**

Details of riser simulation set-up

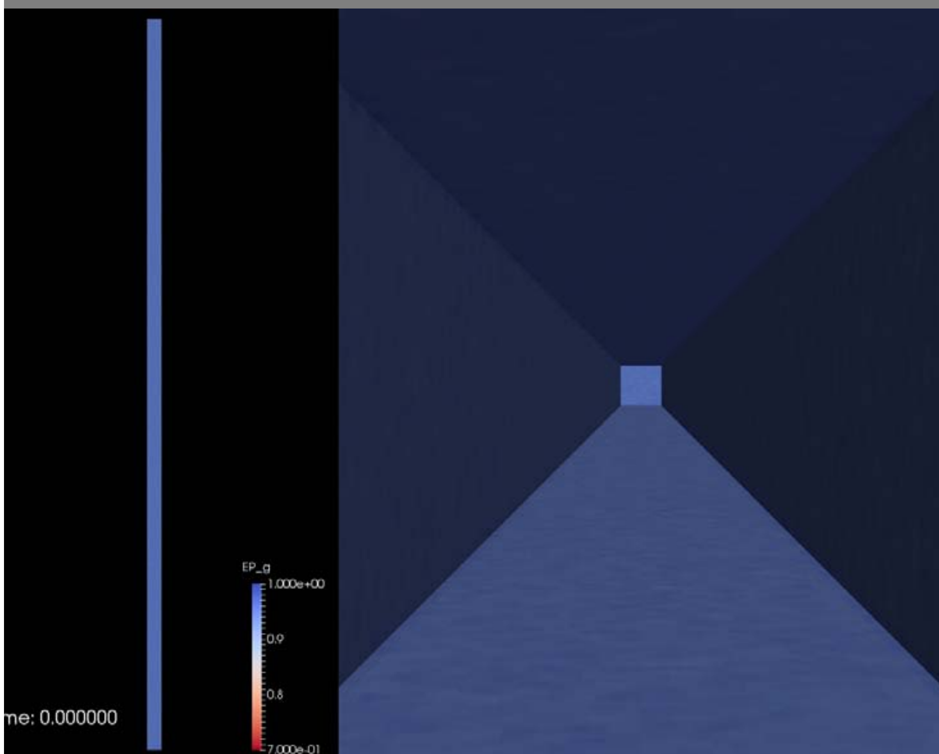
- DPM approach with 3 particle sizes averaging 75 micron.
- Simulations use 100-130 M particles.
- 3.2 M cells to compute fluid flow.



Clusters flow patterns at the wall of the riser seen from both outside and inside

The observer is fixed in space and looking down from the outlet

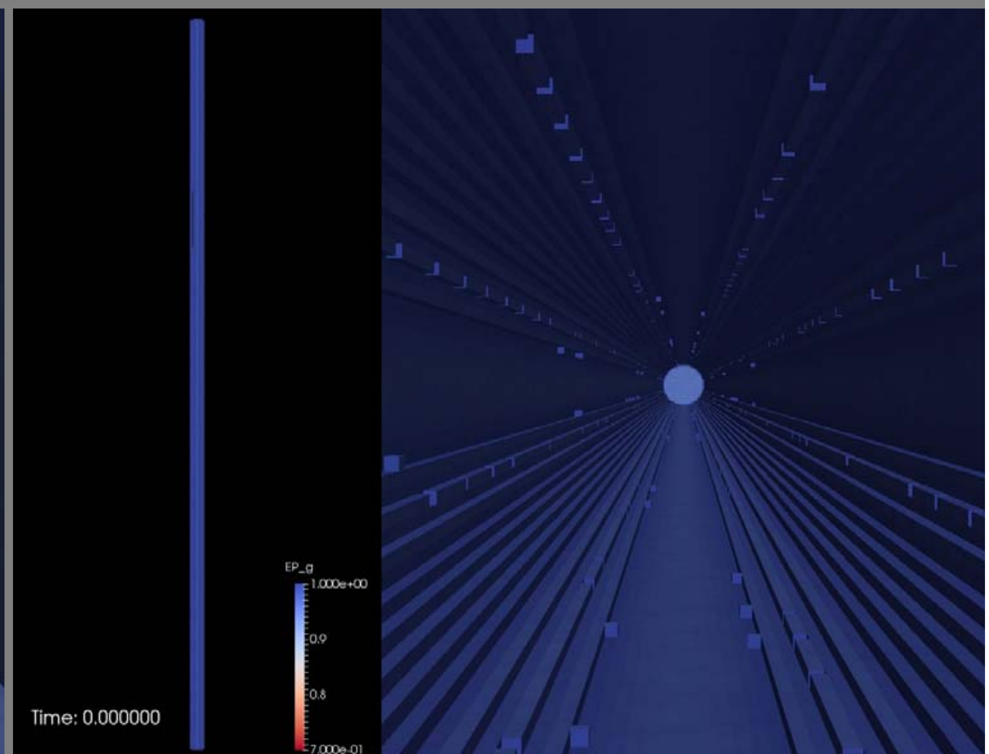
Square riser



View of the full riser from outside

Inside view of the riser walls

Cylindrical riser

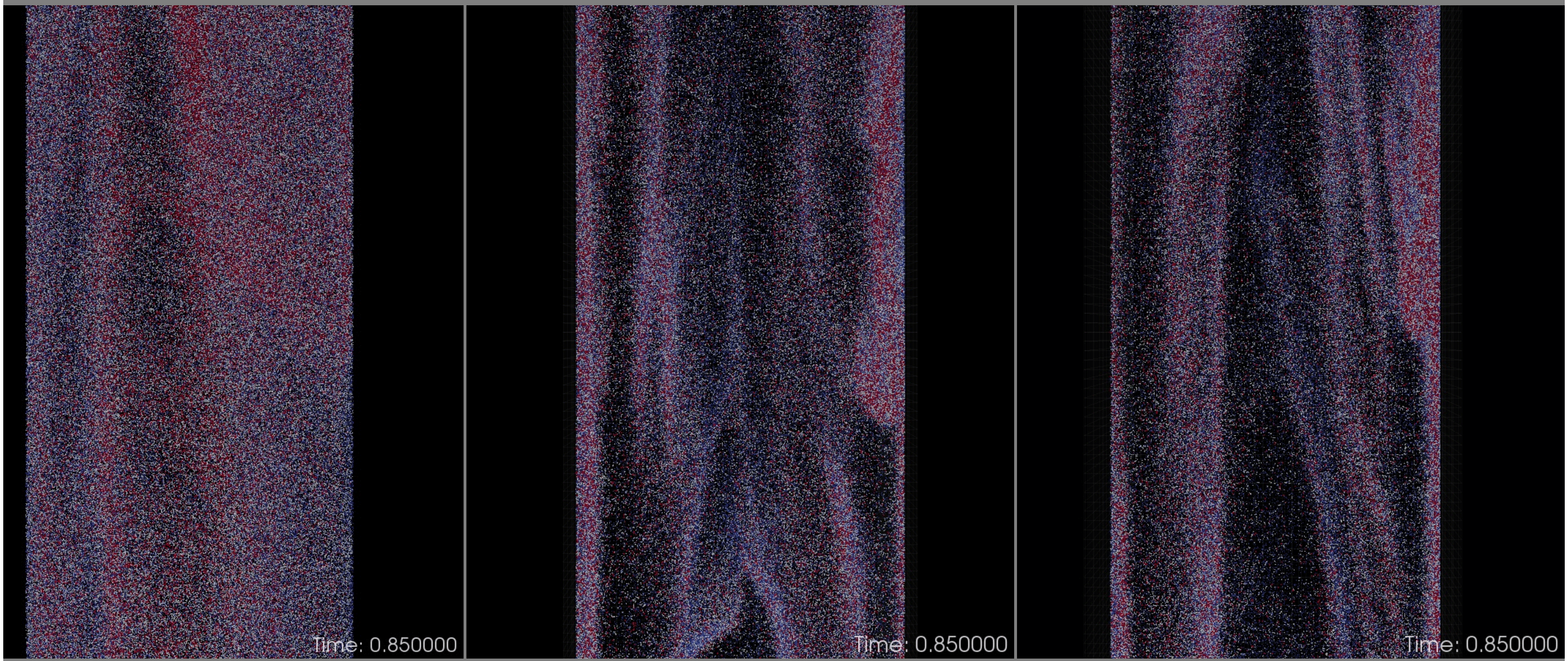


View of the full riser from outside

Inside view of the riser walls

Particles flow behavior in small region in the *square* riser

Red particles of 100 micron diameter
White particles of 75 micron diameter
Blue particles of 54 micron diameter



Riser wall

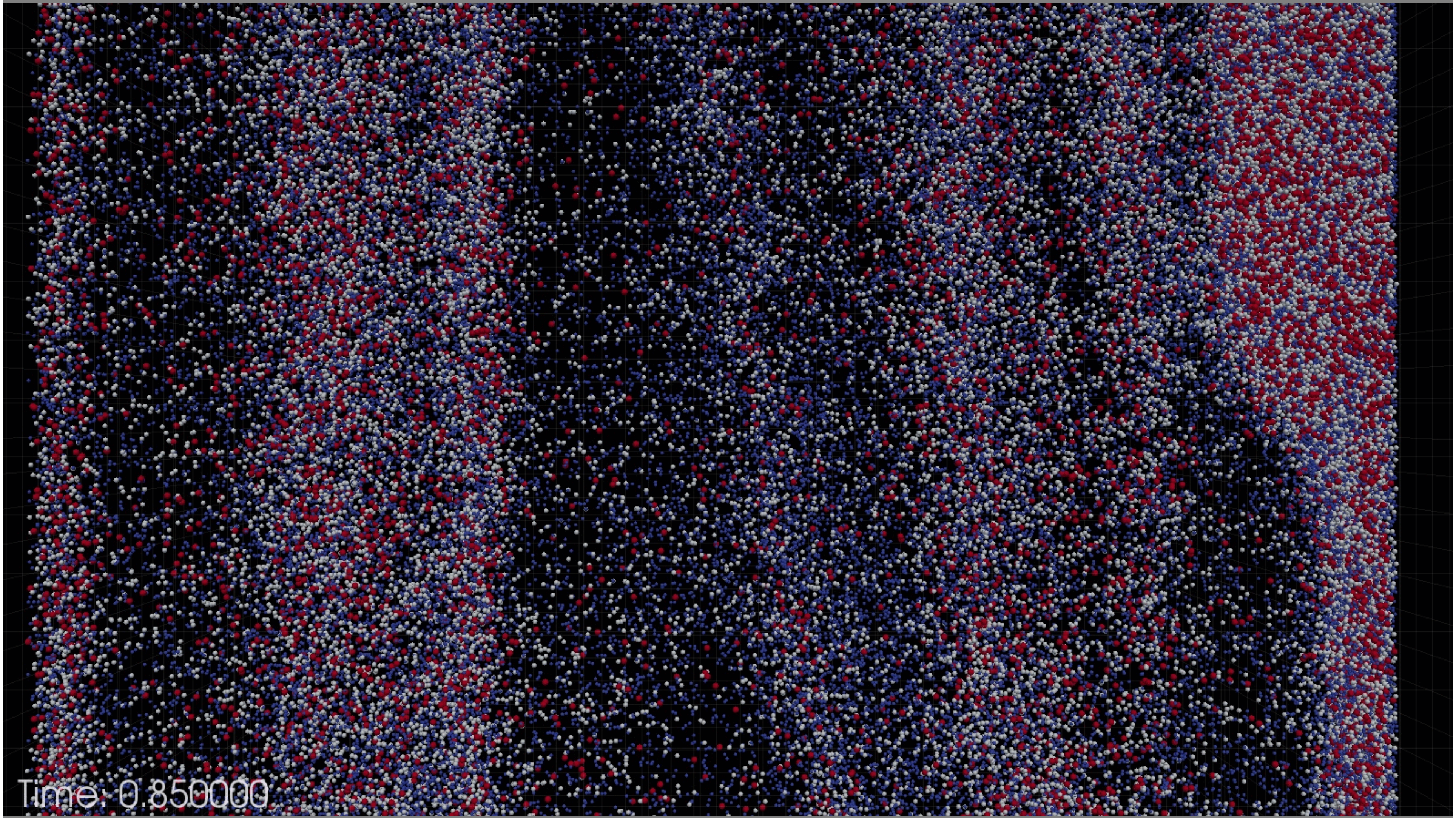
Half-way between middle plane and wall

Middle plane inside the riser

The thin slices shown above are all located in the middle of the riser (about 0.5 m) and are 4-cm long, 2-cm wide, and 1-mm thick

Zooming on a smaller region of riser shows dynamics of cluster downflow

Red particles of 100 micron diameter
White particles of 75 micron diameter
Blue particles of 54 micron diameter



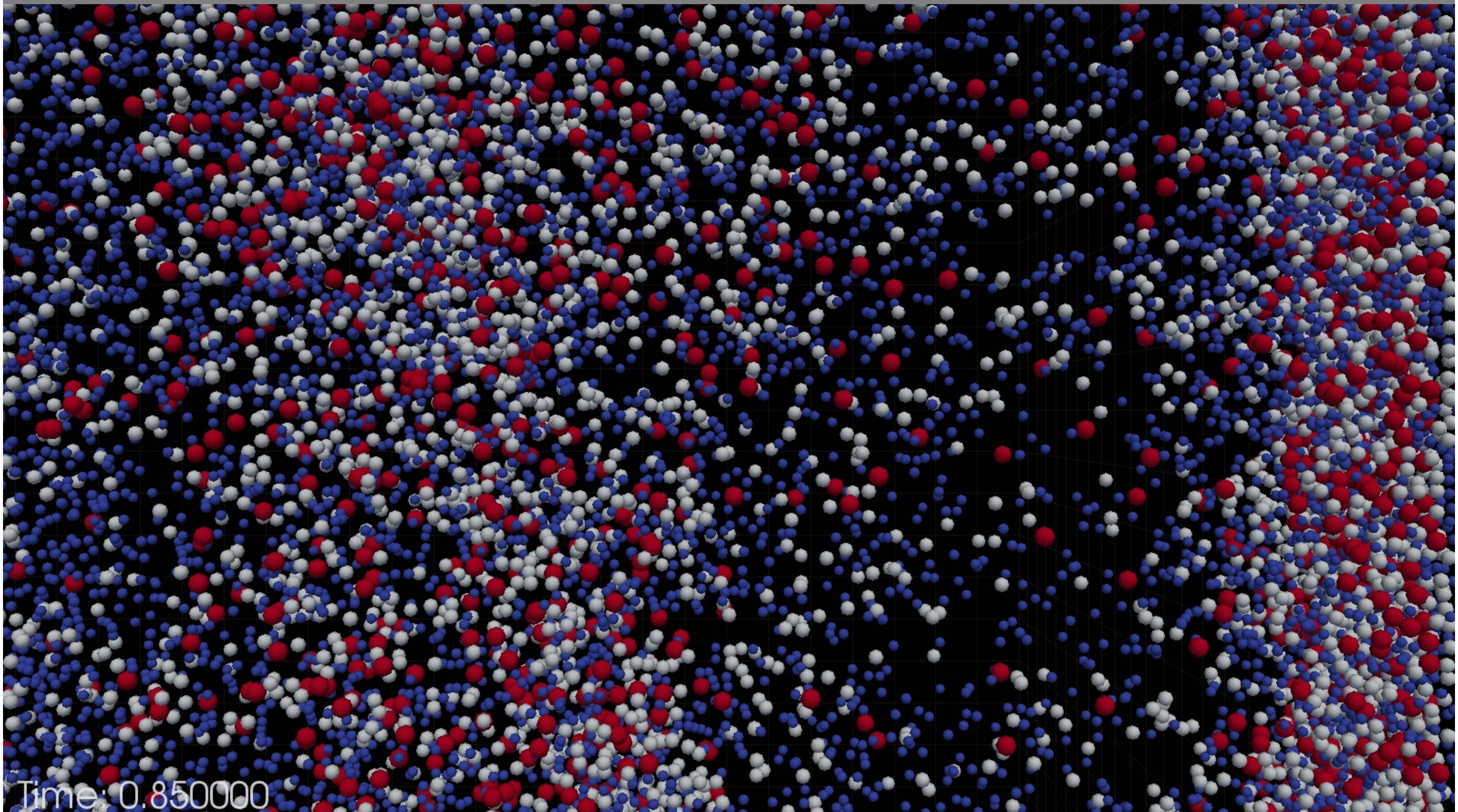
The thin slices shown above are all located in the middle of the riser (about 0.5 m) and are 4-cm long, 2-cm wide, and 1-mm thick

Detailed view of a sheet of particles interacting with a large cluster

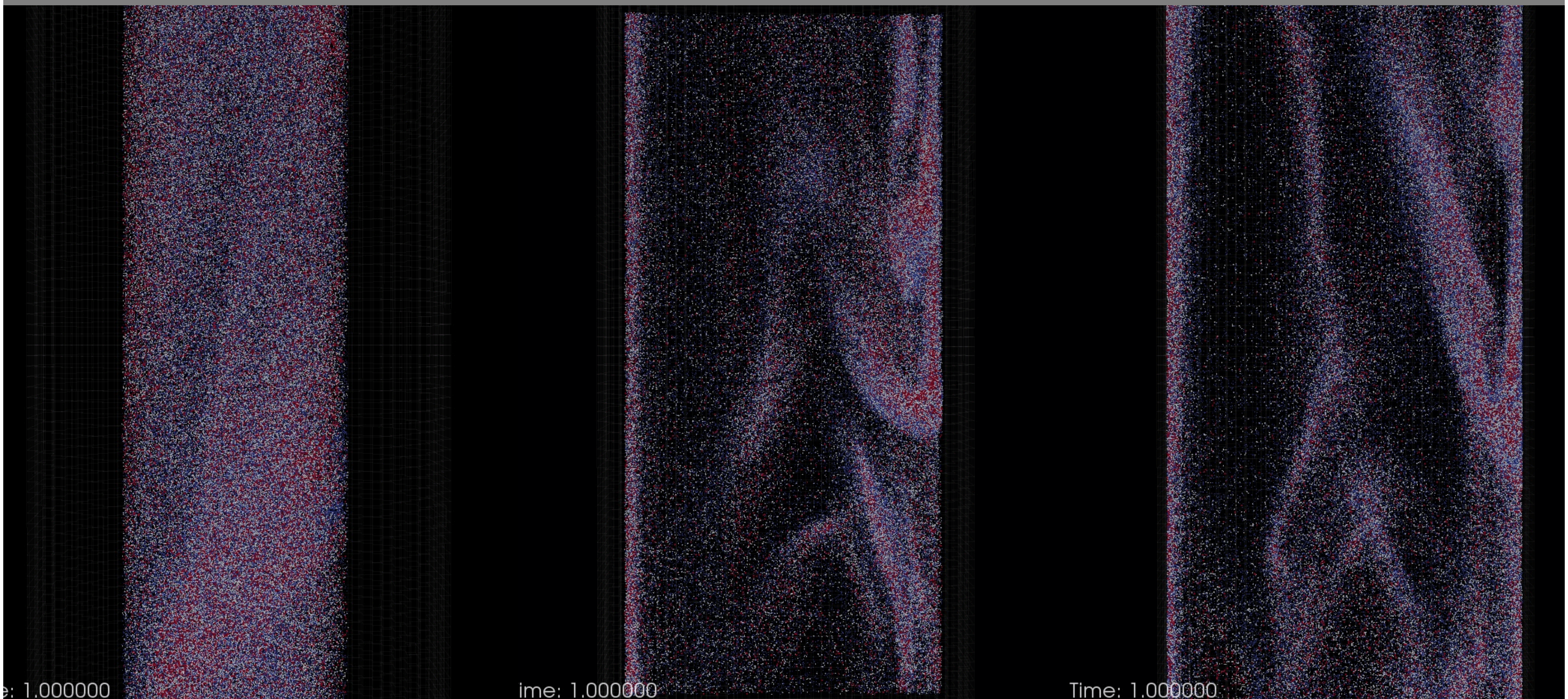
Red particles of 100 micron diameter

White particles of 75 micron diameter

Blue particles of 54 micron diameter



Particles flow behavior in small region in the *cylindrical* riser



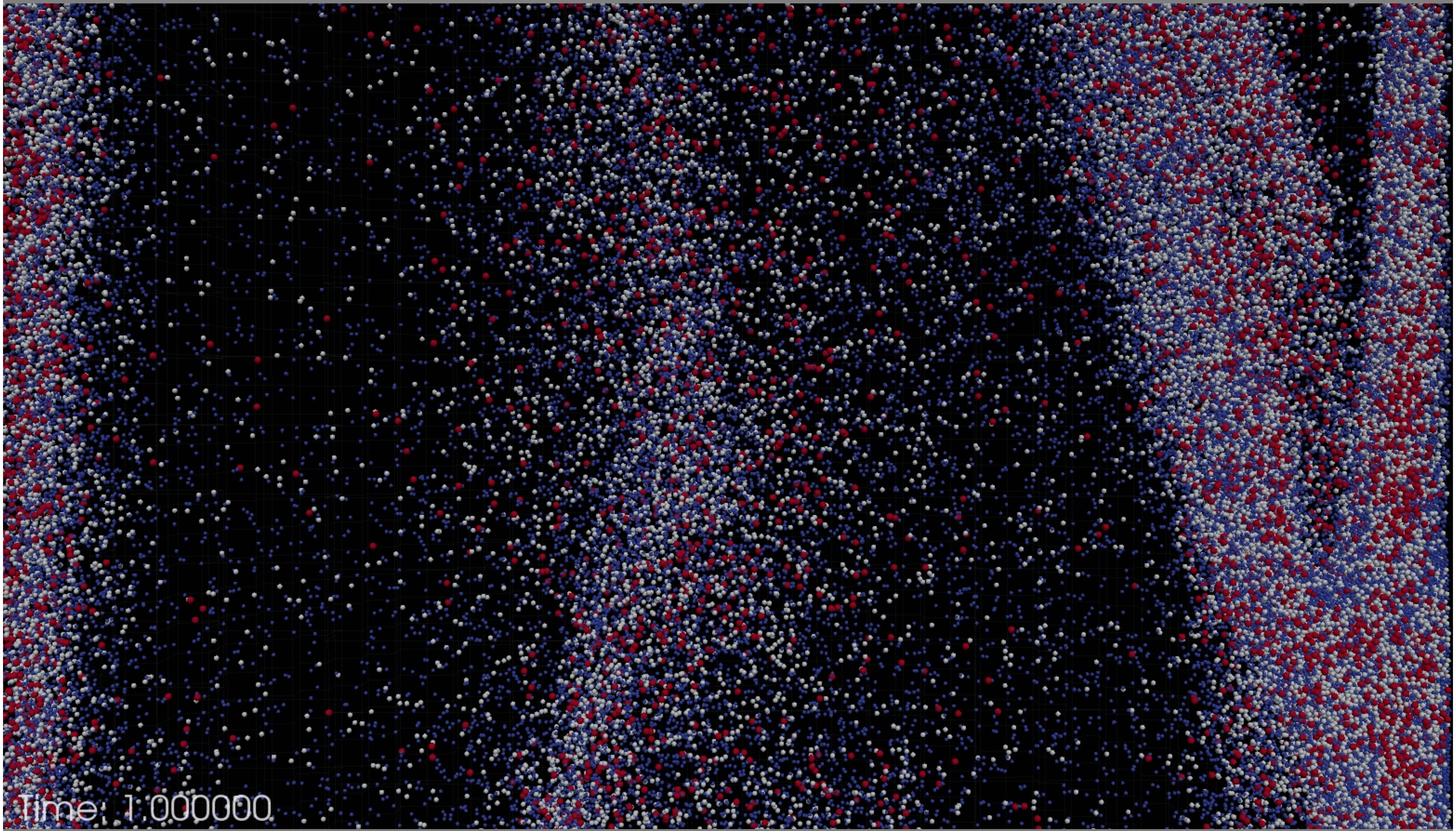
Riser wall

Half-way between
middle plane and wall

Middle plane inside the riser

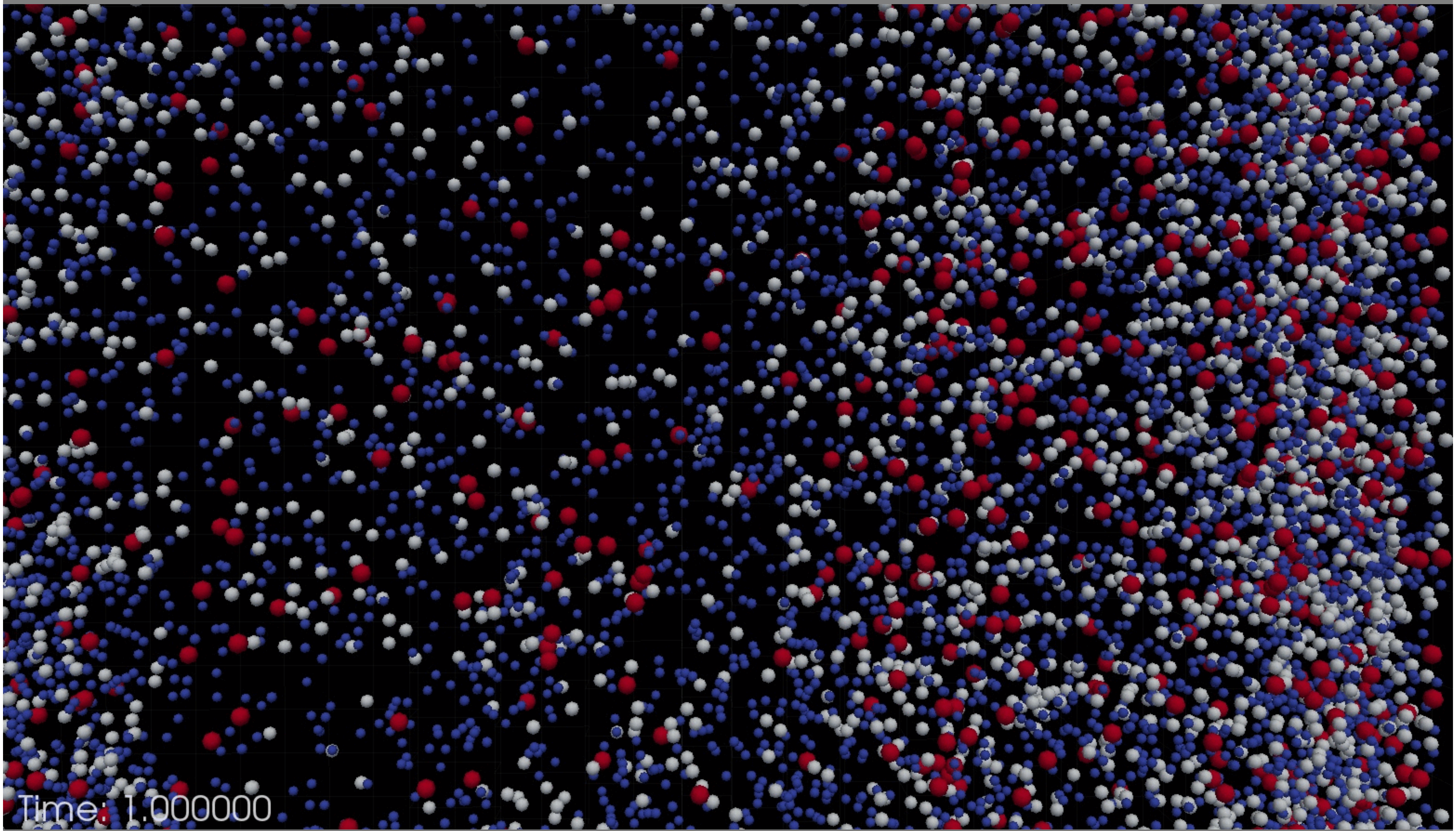
Zooming on a smaller region of cylindrical riser shows dynamics of cluster downflow

Red particles of 100 micron diameter
White particles of 75 micron diameter
Blue particles of 54 micron diameter



Detailed view of gas upflow and cluster downflow interactions

Red particles of 100 micron diameter
White particles of 75 micron diameter
Blue particles of 54 micron diameter



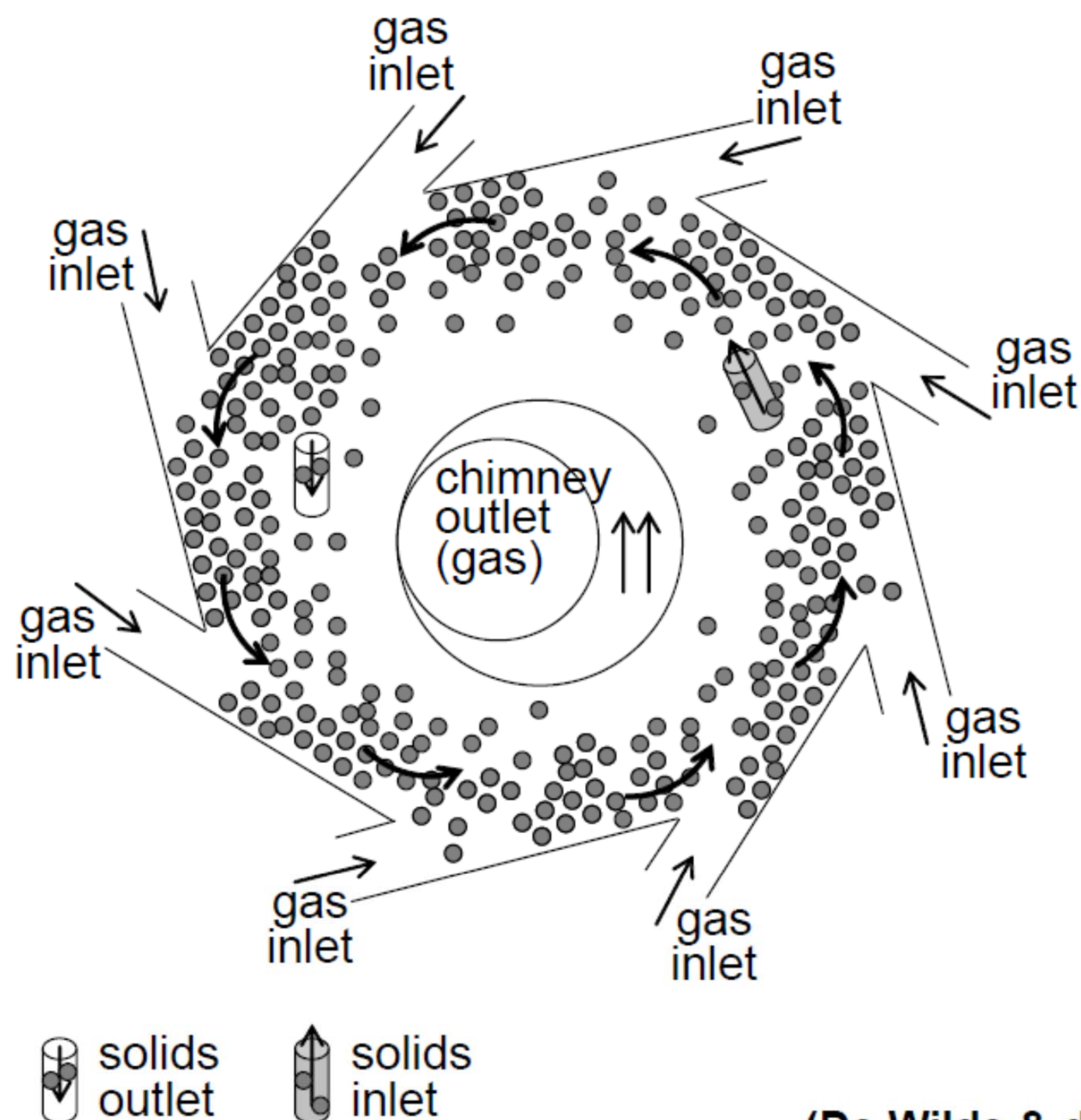
Part 2:

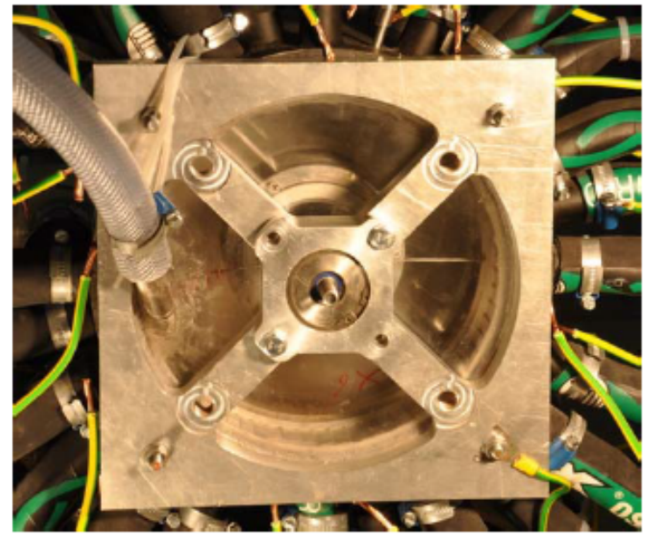
Rotating fluidized bed in a static vortex chamber

Rotating fluidized bed in a static vortex chamber

- **Vortex chamber is designed to create high slip velocity and efficient gas-particle contacts.**
- **Potential application to chemical looping combustion with in-situ separation of large oxygen-carrier and small ash particles.**

Rotating Fluidized Bed in Static Vortex Chamber (RFB-SG)

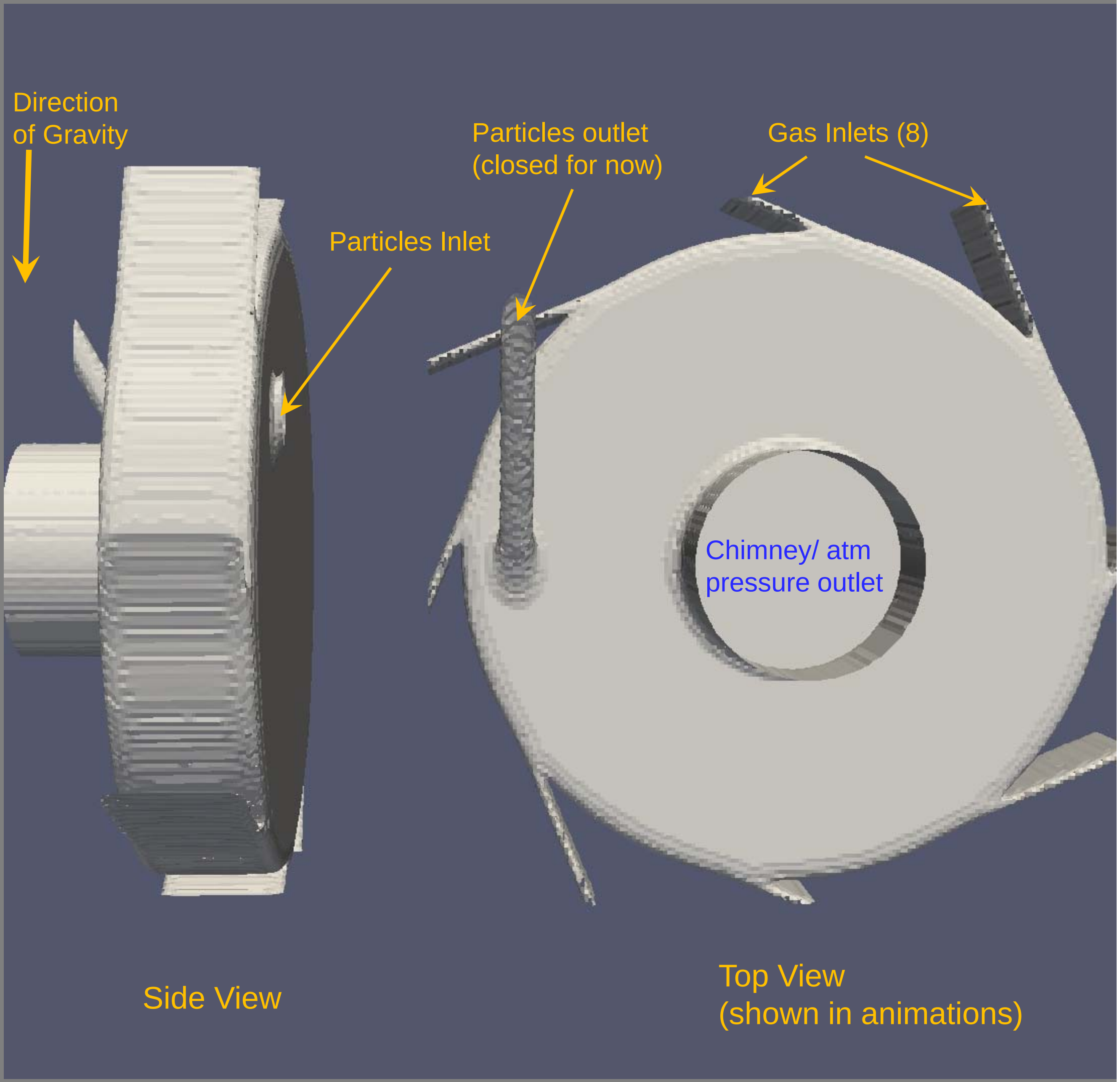




(De Wilde & de Broqueville, AIChE J., 2007)

Geometry set-up based on Cartesian cut-cell technique

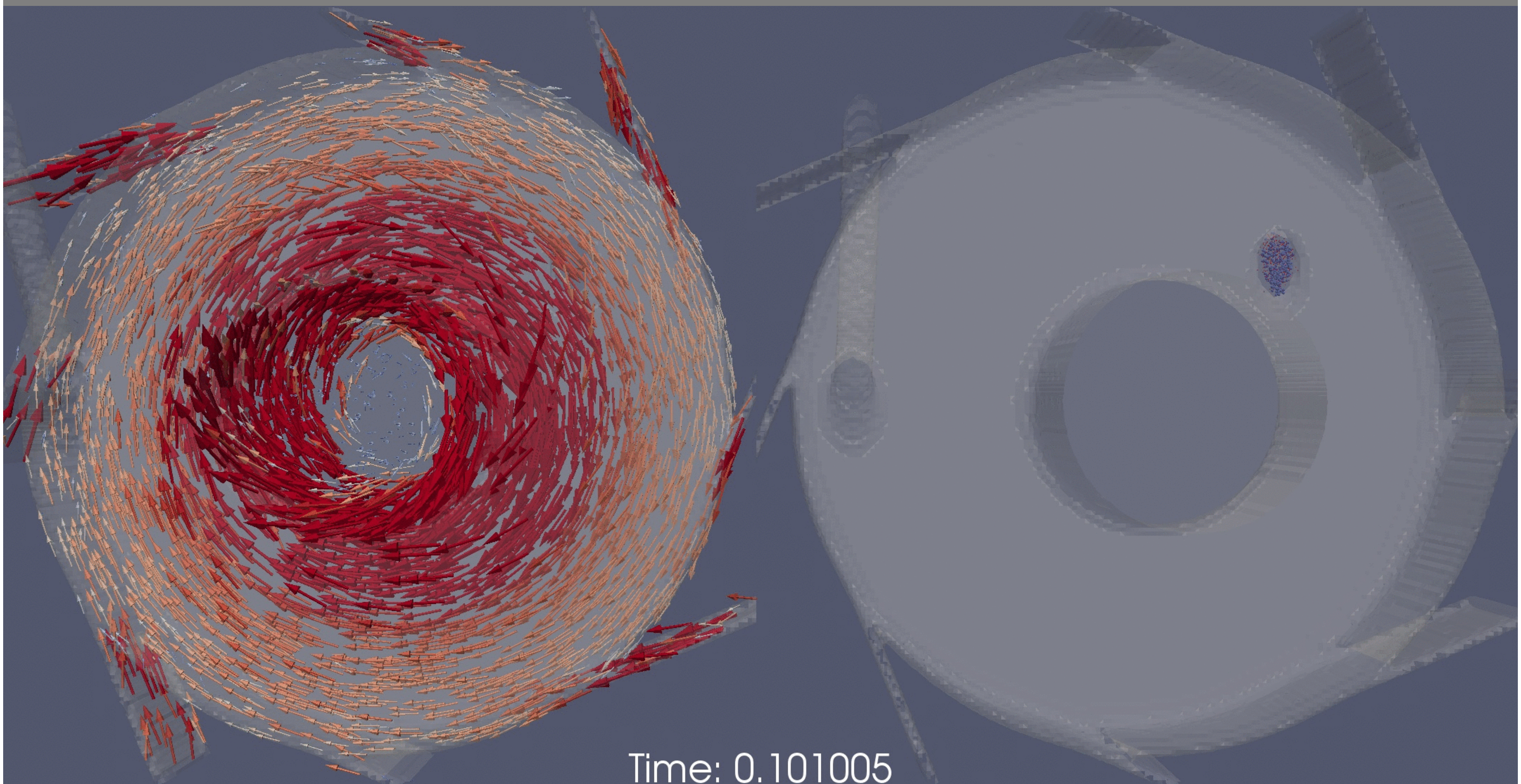
- Complex geometry meshed using Cartesian cut cells (2.5 M)
- DPM with 2 particle sizes (1 & 0.4 mm) and densities 2.7 & 0.2 g/cm^3.
- 0.2 to 0.5 M particles simulated.



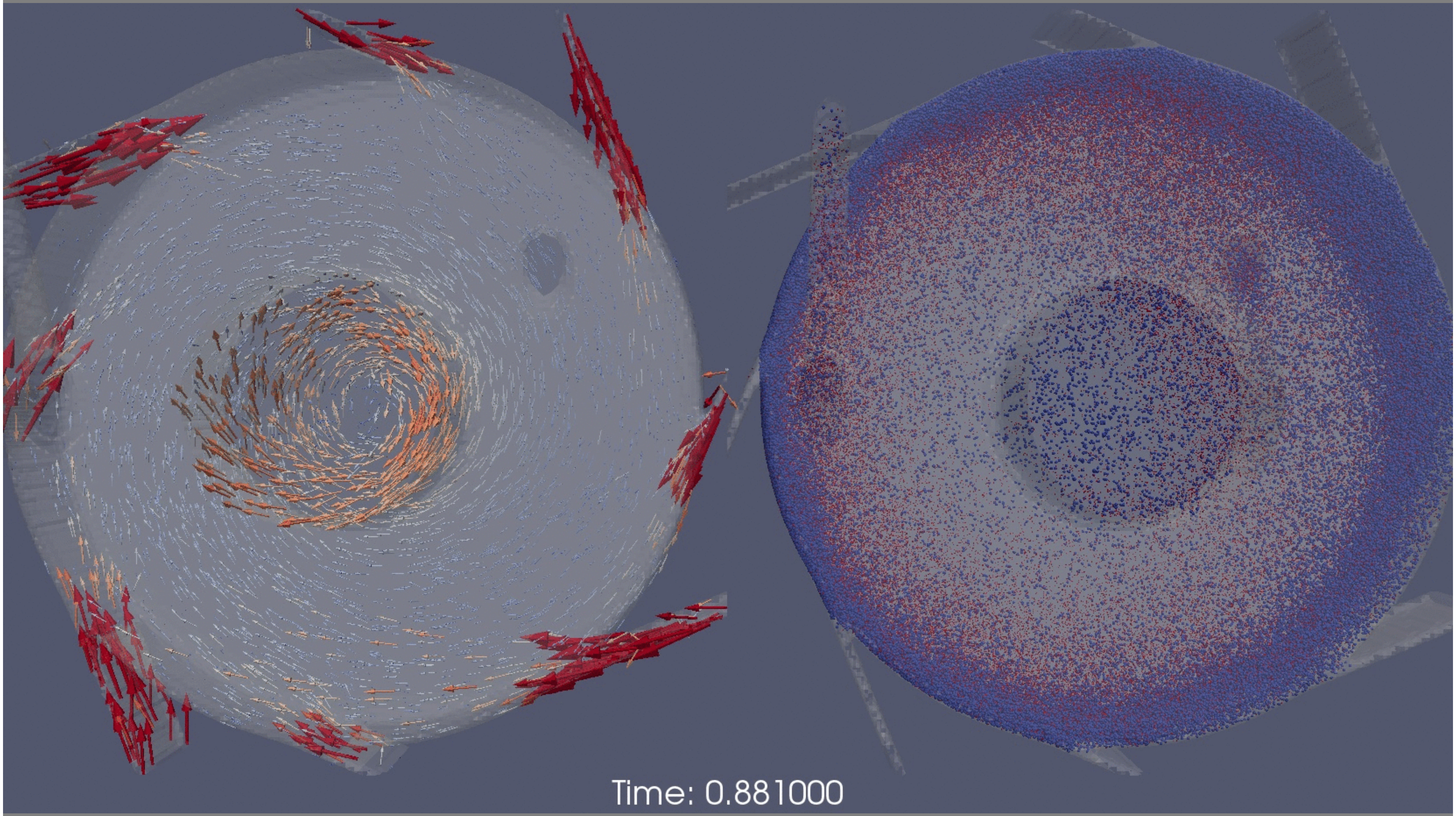
Vortex Chamber with 4-mm gas inlet slots (35 m/s)

Large blue particles of 1 mm diameter and 2.9 g/cm^3 density

Small red particles of 0.4 mm diameter and 0.2 g/cm^3 density

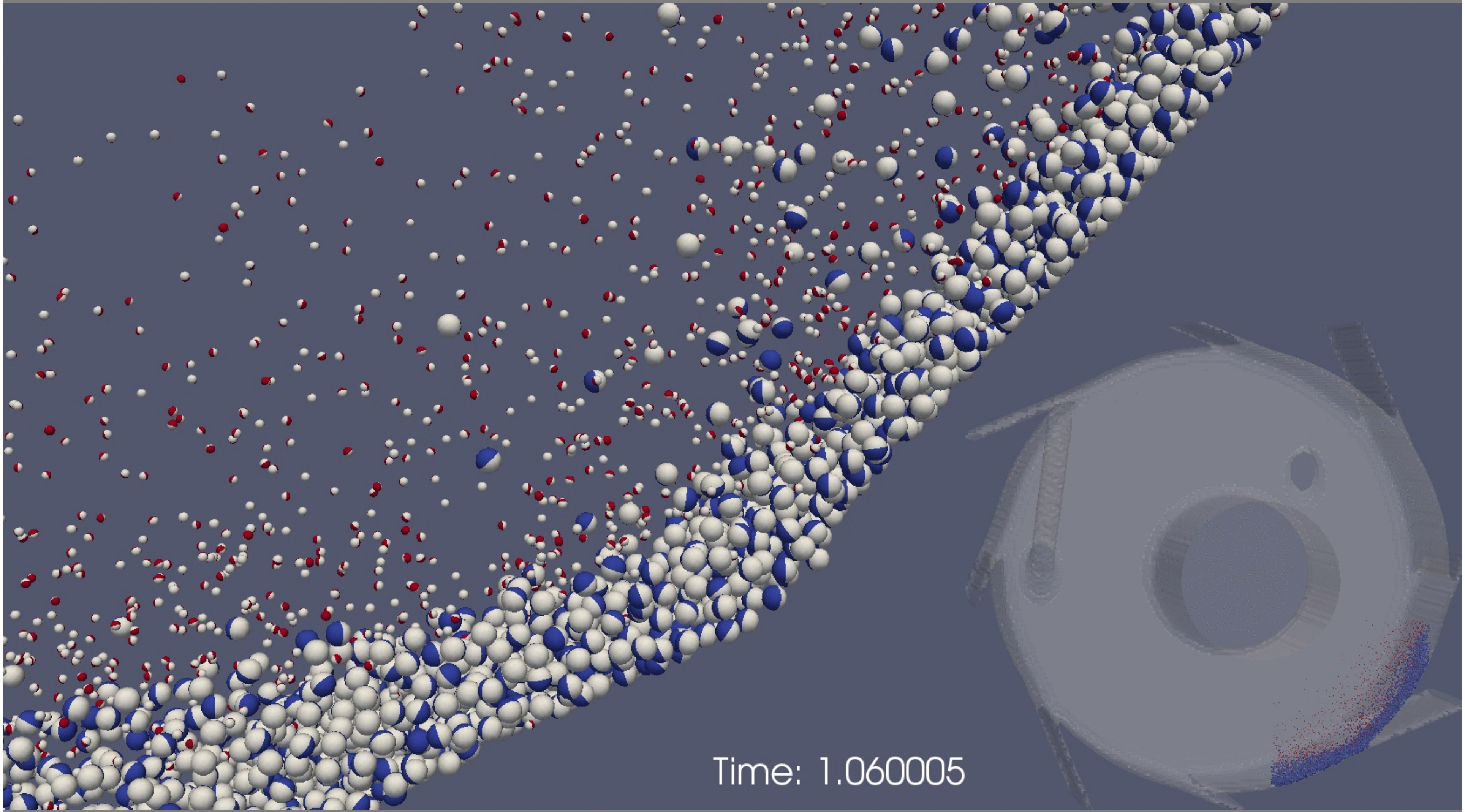


Stop feeding particles to the system: Particles separation & steady flow are achieved



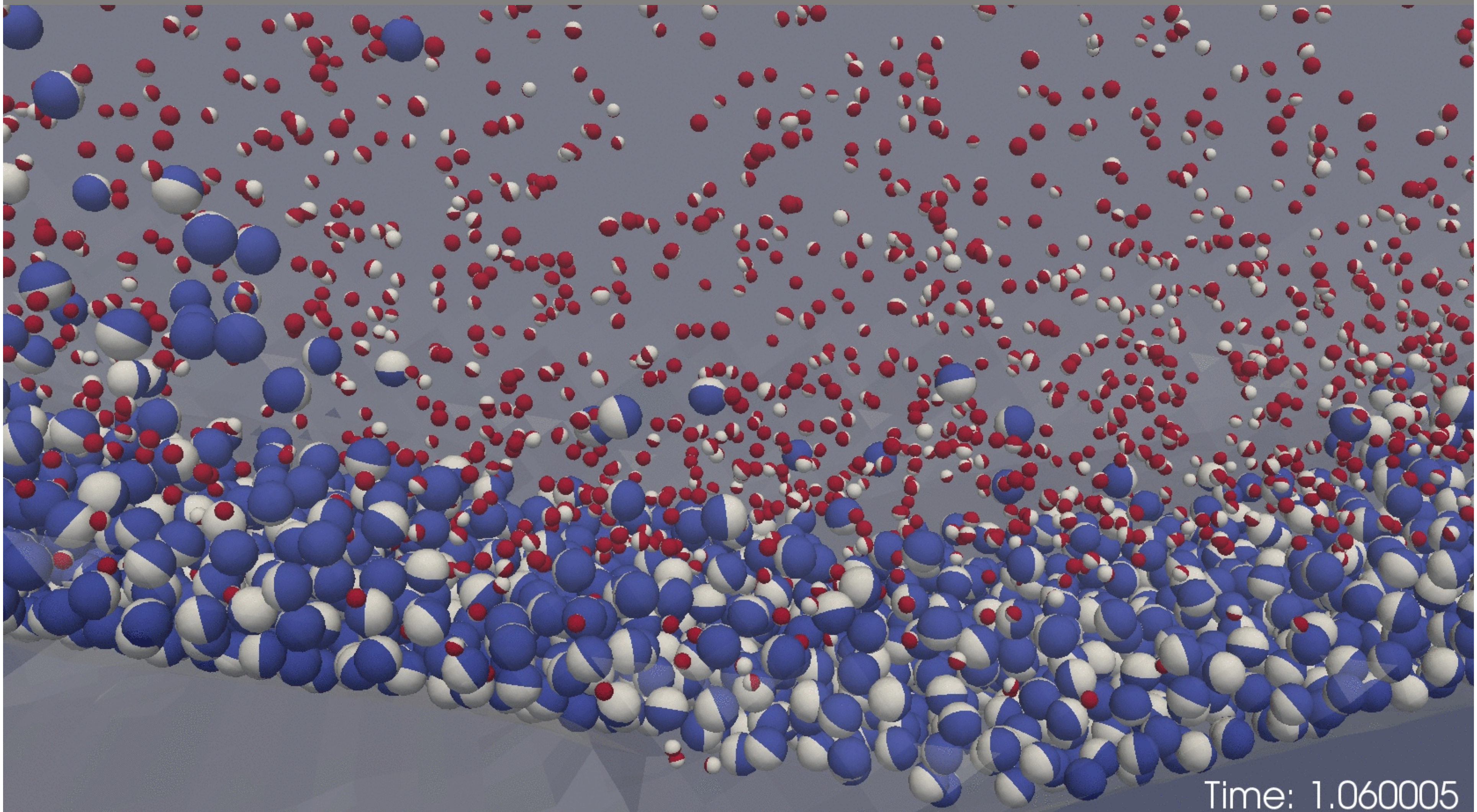
When free vortex is established, large particles circulate at about 4 rps or ***8 g***
and small particles (mass ratio of 200) at 8 rps or ***32 g***

Close-up look at particles behavior near a gas inlet slot



Top-face side

Close-up look at particles behavior near a gas inlet slot



Bottom-face side

Conclusion

- **Visualization of complex particulate flows is crucial to understanding their behavior and interactions.**