

# Space Science 101 – Fluid Physics & Complex Fluids

## Why are Fluids Physics and Complex Fluids important to Space Research?

- Life support systems transport gases and liquids throughout the spacecraft and range from dealing with condensing exhaled water vapor, to collecting and processing urine to recycle water.
- Handling the positioning and delivery of fuels to spacecraft engines reliably is necessary.
- The most effective means of removing waste heat generated by instruments, machinery and crew from the spacecraft.

## Why is Space Research important to Fluids Physics and Complex Fluids ?

- “Settling” does not occur among heavier and lighter objects or phases minimizing compaction and/or coalescence of phases..
- Droplets do not sag under their own weight and bubbles are not squashed by the surrounding liquid.
- Behavior becomes 3-dimensional as opposed to planar
- Flows tend to be unidirectional.
- Elimination of hydrostatic pressure effects.

## Why are Fluids Physics and Complex Fluids Space Research important to Earth?

- Gravity dominates fluid motion and behavior and can mask secondary forces and their effects.
- “Microfluidic” and “atomic” systems can be examined at an observable scale.
- Self-assembly and crystallization of molecules can be studied to advance knowledge of phase transitions.
- Study fluid systems with the elimination of gravity driven flows based on subtle density differences such as near critical points.
- Elimination of drainage of liquid films to ascertain phenomena that negatively impact foam stability and aging of gels.

## Important Questions – what do we need to know about Fluids Physics and Complex Fluids to support space exploration?

**Phase Change:** What conditions are required to initiate boiling such as minimum heating and for how long? What is maximum heating that can be sustained without drying out the heater surface? What methods can be used to remove either vapor bubbles, or for that matter, liquid condensate?

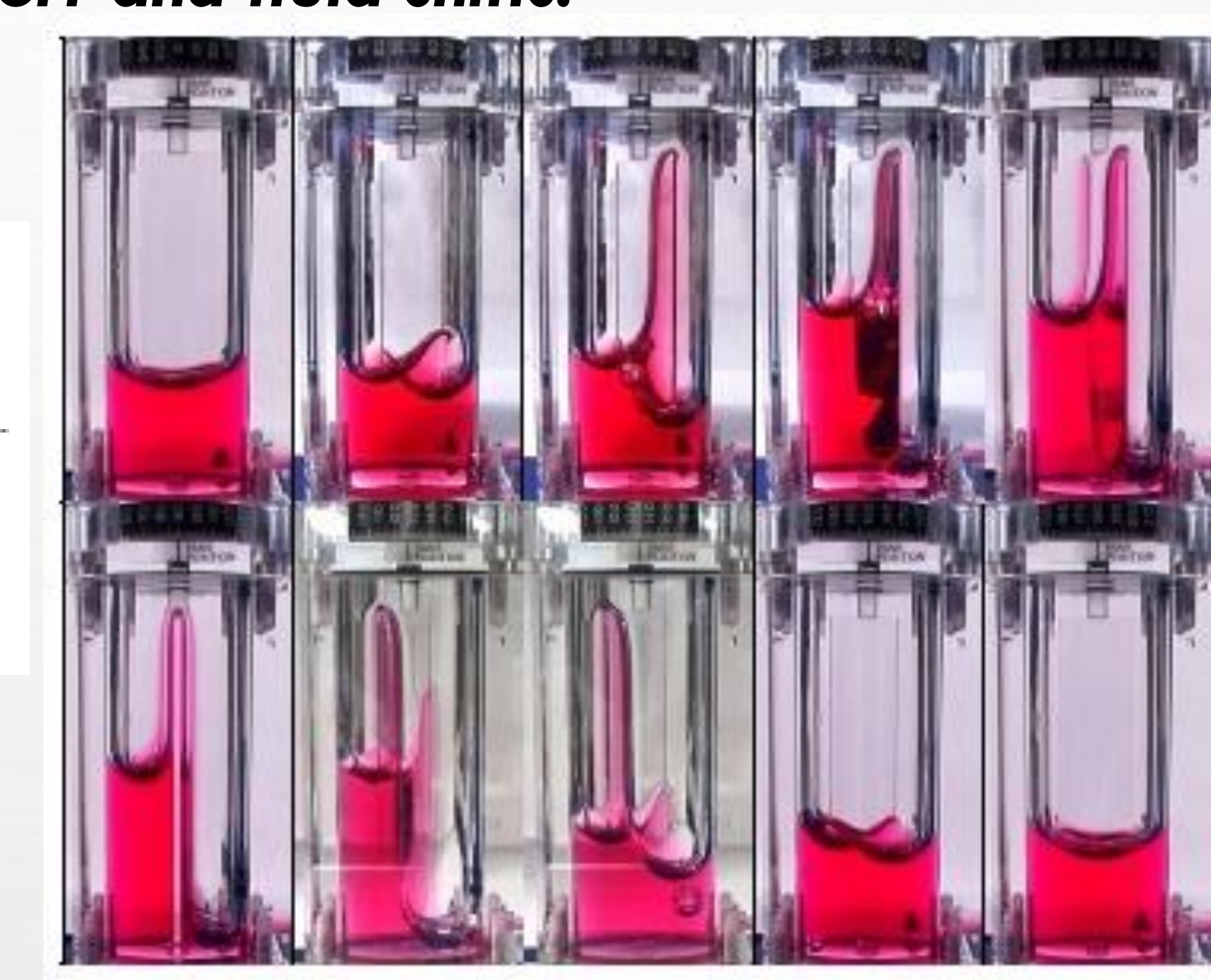
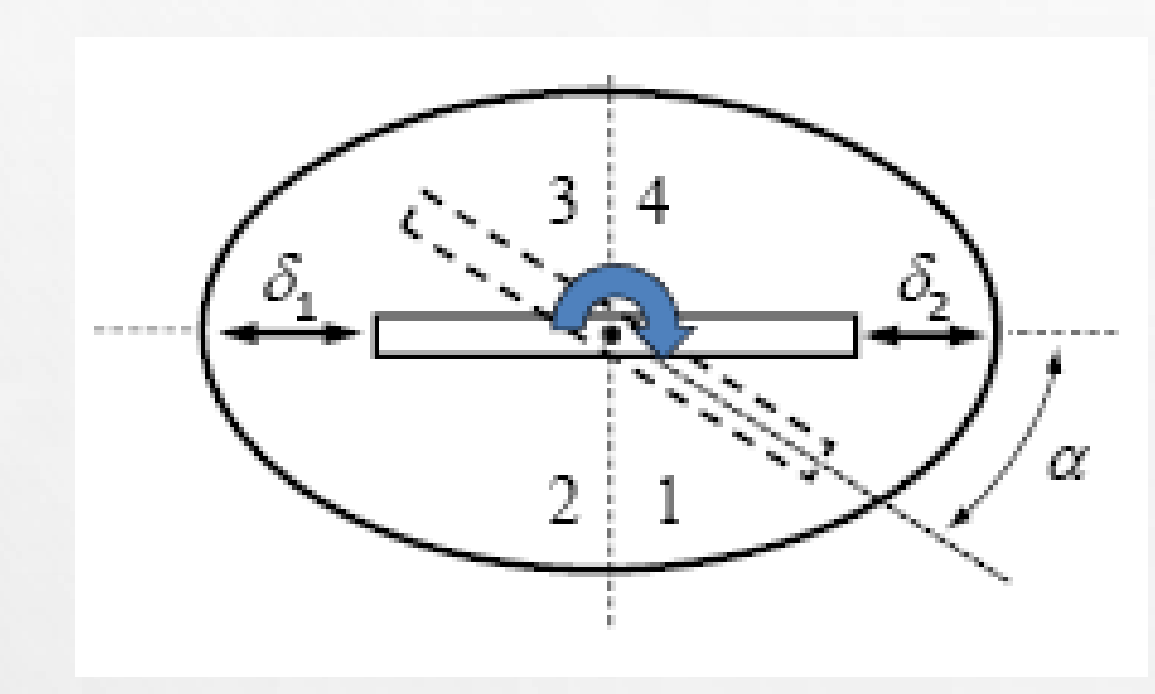
**Mixing:** How fast and how long does mixing need to occur to effectively homogenize a liquid solution.

**Separations:** Most terrestrial processes rely heavily on gravity to separate chemical reaction products. What other means can be used and what is the impact of reduced gravity on their efficacy.

**System Stability:** While the ability to reliably start up, shutdown and handle changes in operational setpoints are necessary, the unintentional accumulation of compressible and noncompressible phases can exacerbate the steady operation of these systems.

## One interesting thing about Fluids Physics and Complex Fluids relevant to spaceflight:

*Spacecraft and astronaut performance are affected by fluid behavior including the propulsion system, cooling systems, life support and fluid shifts.*



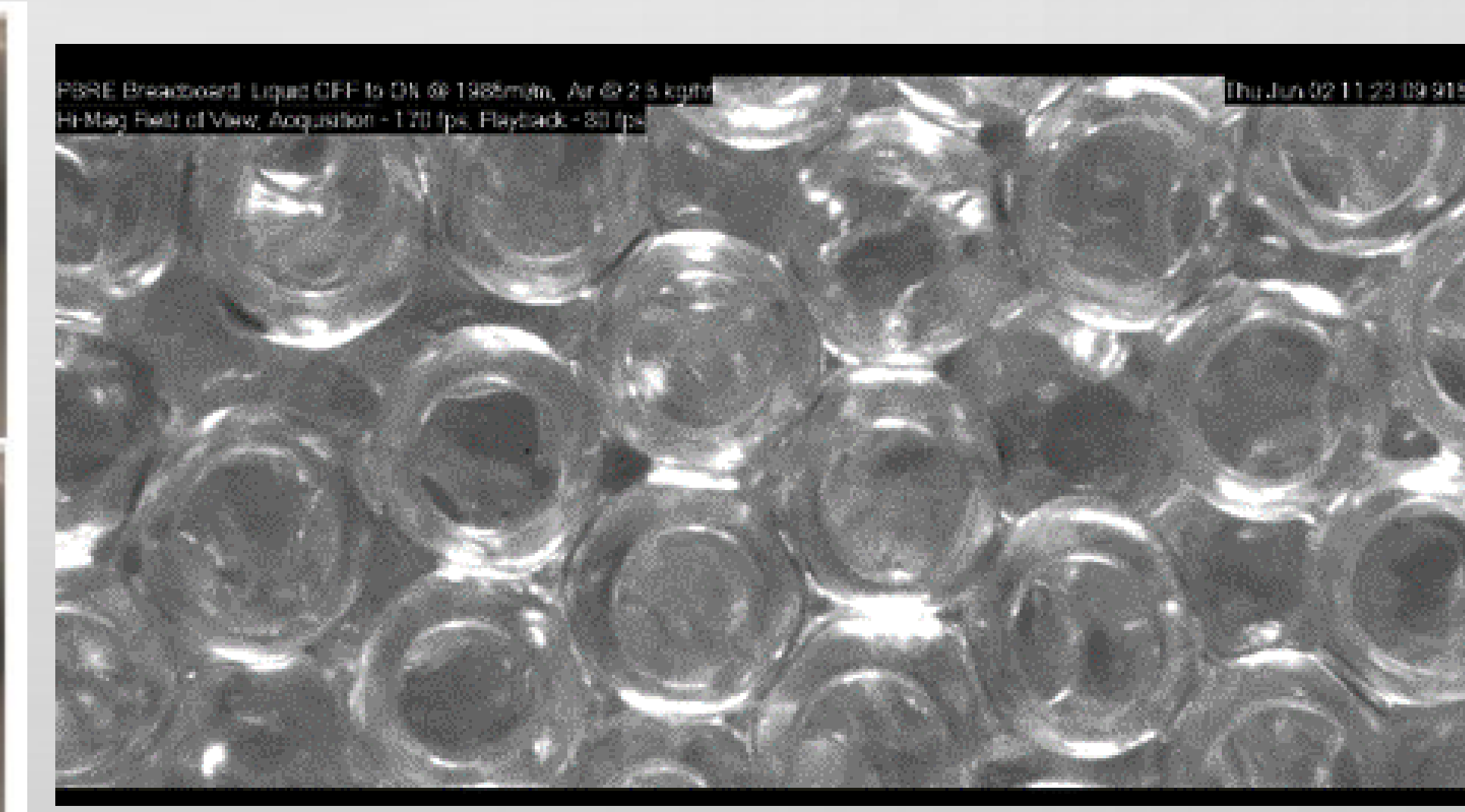
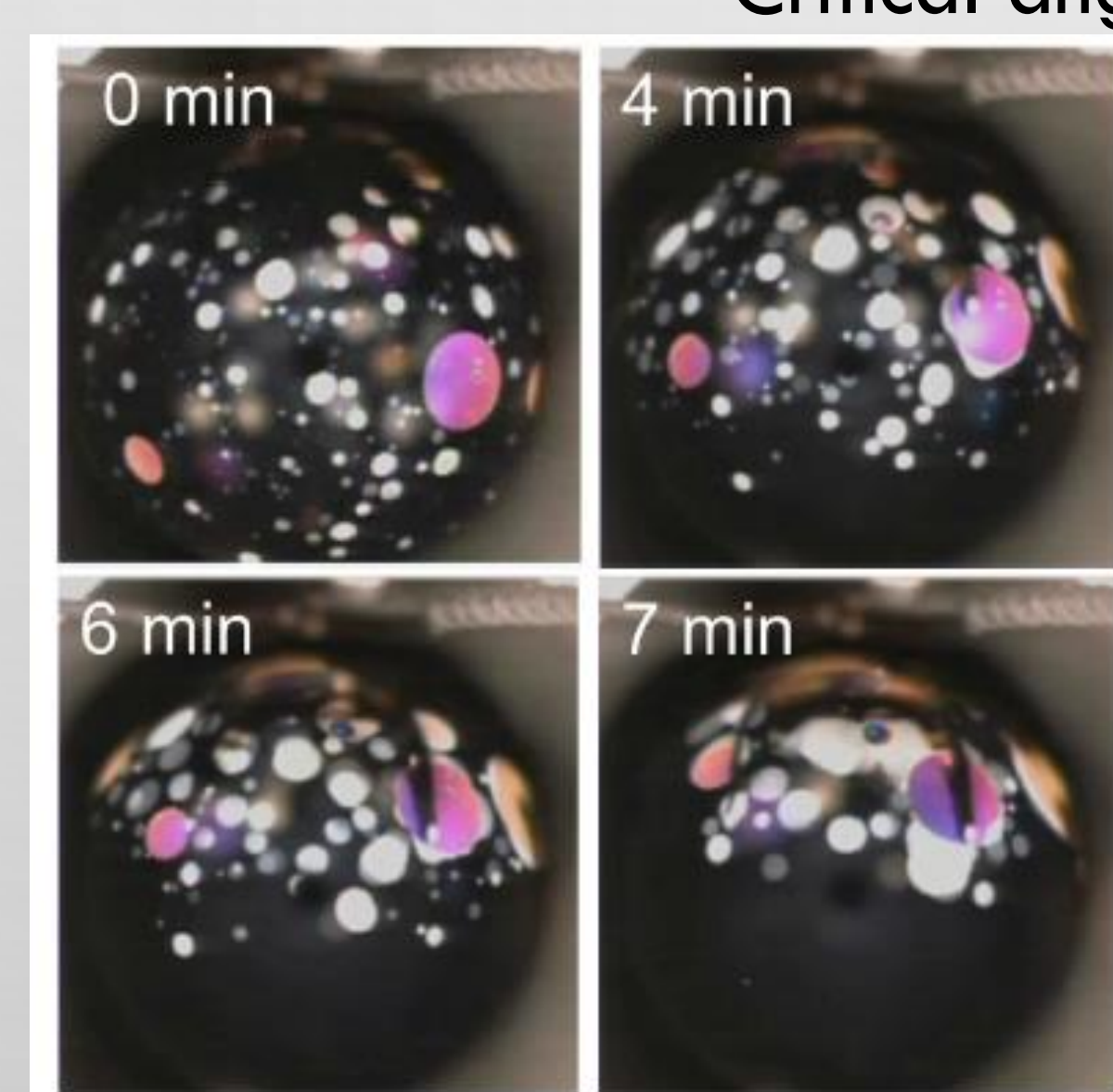
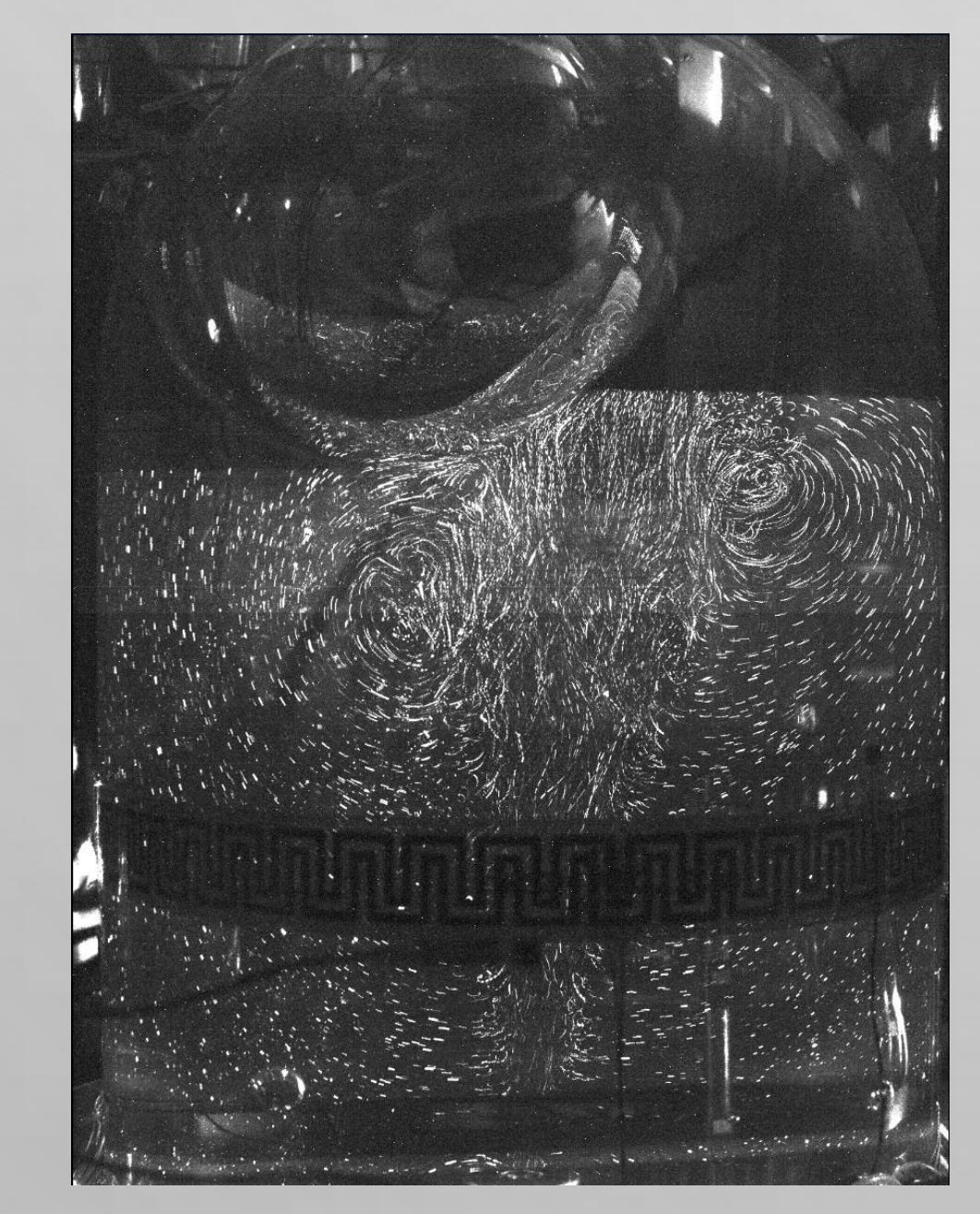
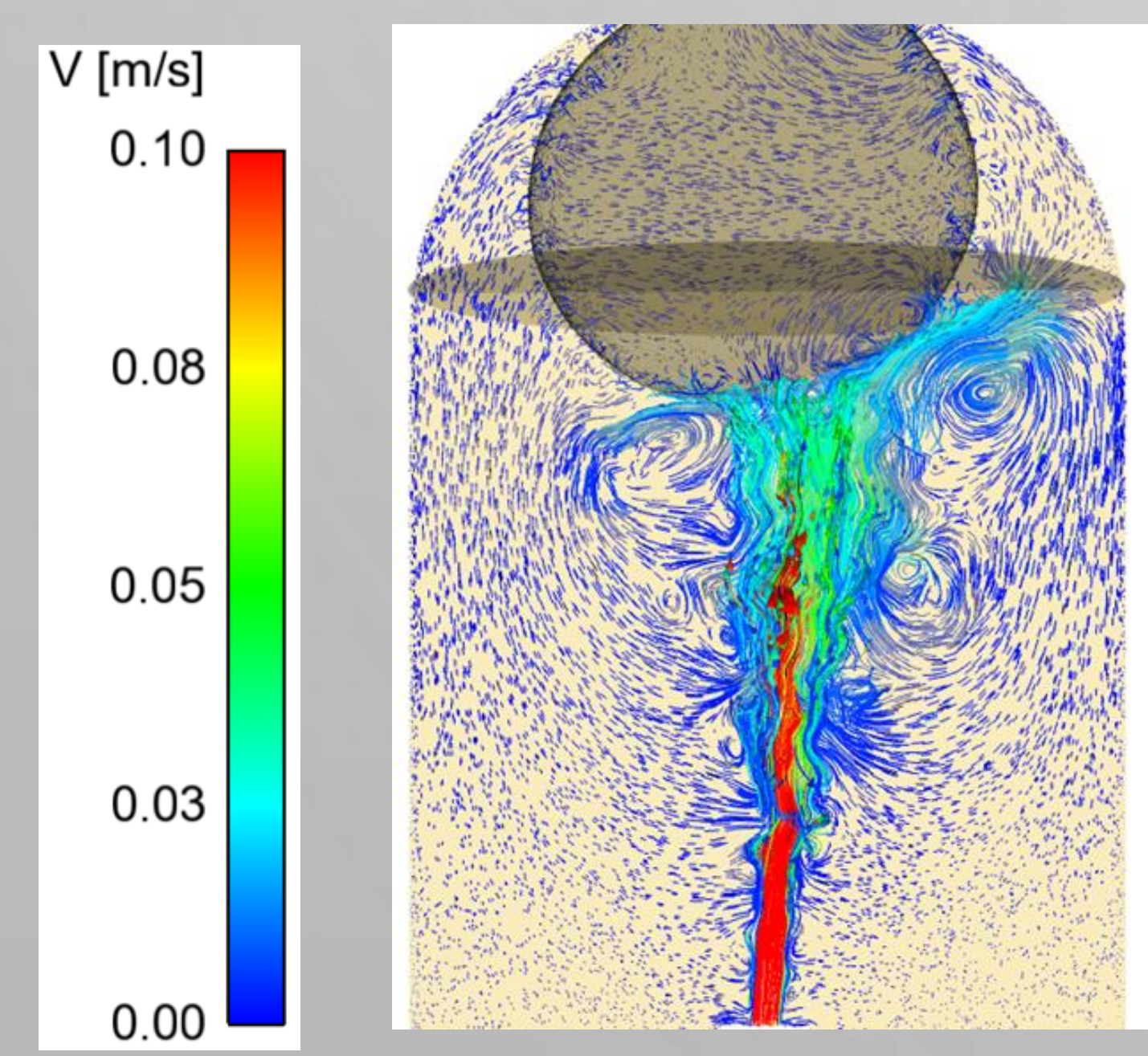
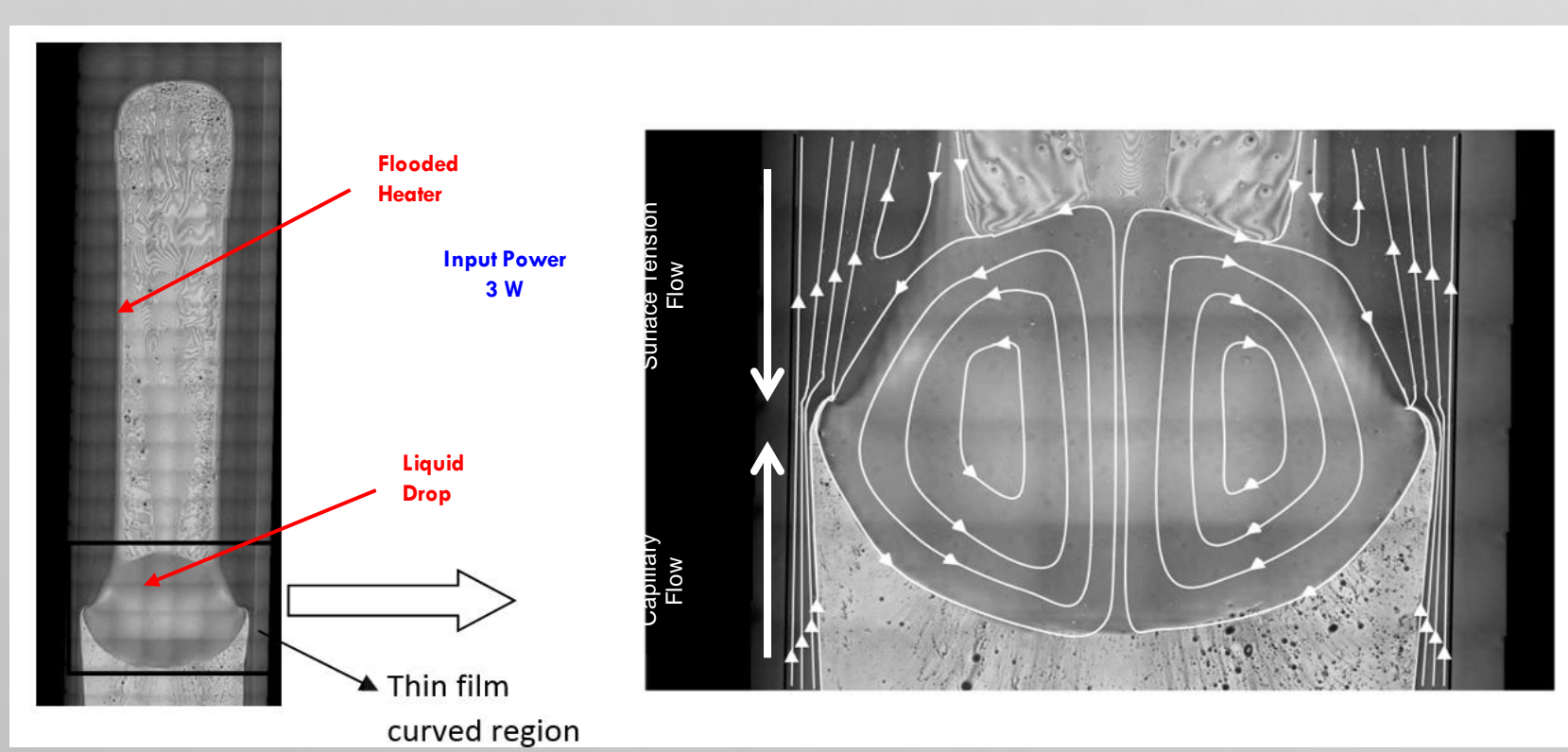
*Slight changes in geometry may cause profound fluid shifts*

Internal cross-section of cylinder was elliptical.

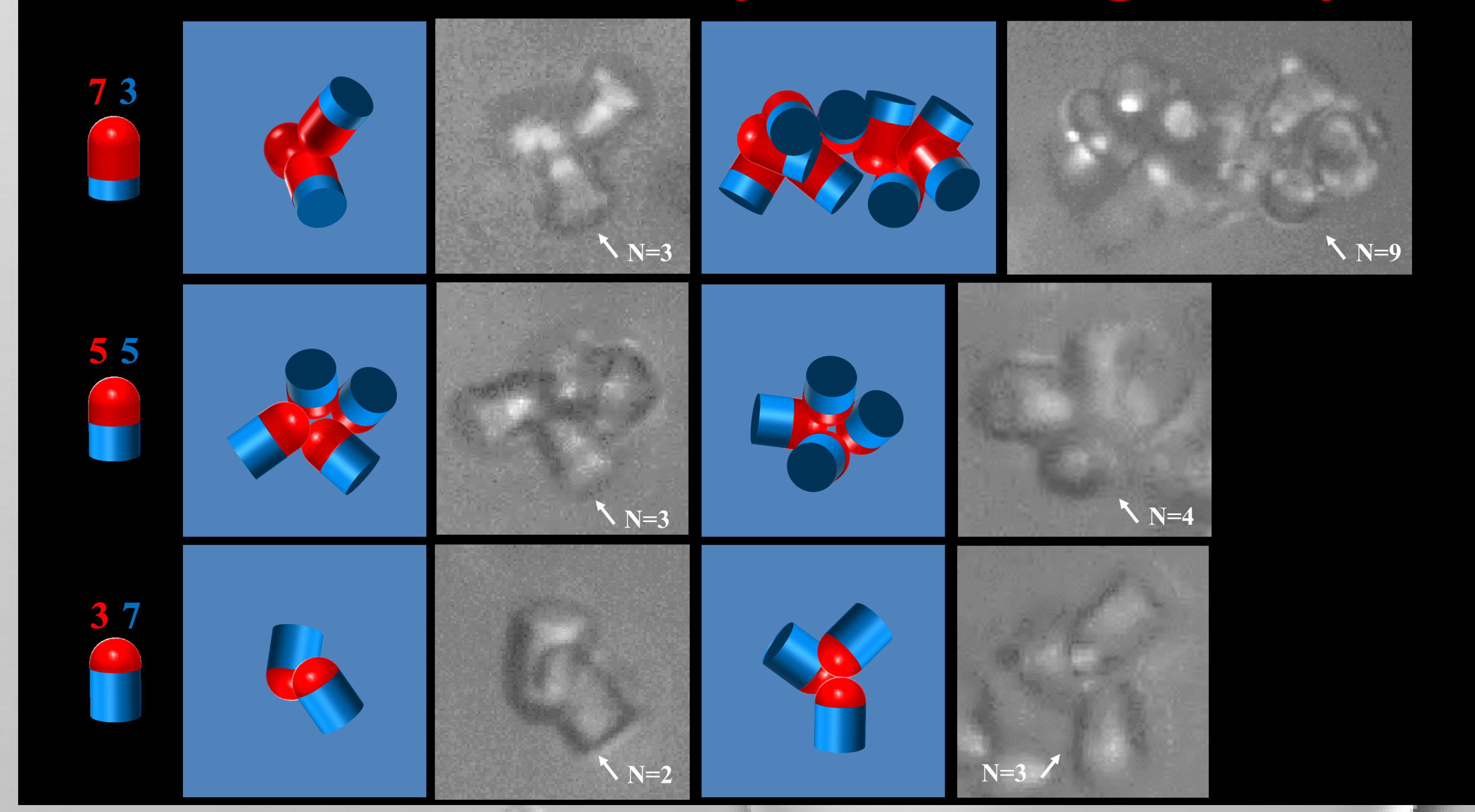
Vane design allows two gap sizes to be tested for each vane angle test point

Vane was rotated through 180°

Critical angle resulted in fluid shifts.



## “ 3D Self-Assembly in microgravity ”





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