Moving from Spheres to Soft Bacteria: Shape and Softness Alter particle

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What is this poster about?

Biological particles vary in shape —one of the key physical traits for their separation and diagnosis[1,2]. This poster explores how particle shape and softness-for a bacteria sample-influence their separation in deterministic lateral displacement devices (DLD). We started with solid spheres and progressing to non-spherical beads. At the end, we used soft bacterial chains and clusters as the test sample. DLD is a passive, continuous-flow technique that sorts particles based on size, shape, and deformability. DLD devices feature arrays of obstacles (posts) that interact with particles of different sizes, shapes, and softness guiding them along distinct trajectories and enabling their separation.

[1] *P. Beech, et al., Lab on a Chip, 2012, 12, 1048–1051.* [2] *J. P. Beech, et al., Analytica Chimica Acta, 2018, 1000, 223–231.*

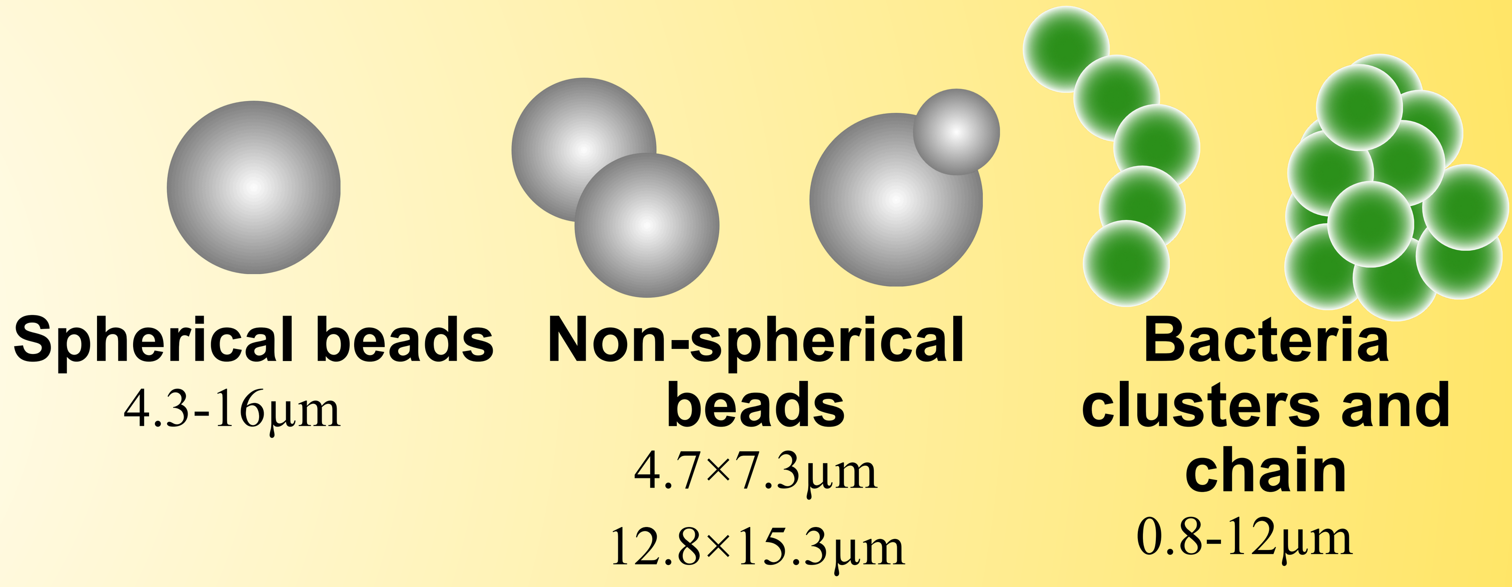


Figure 1) Particle of various shape used in this study

Result (1): Non-spherical beads and bacteria do not follow the same trajectories in DLD devices as spherical, solid beads.

By tracking the cyclic pattern of particles' positions as they pass between DLD arrays we understood that Even though spherical and non-spherical particles and bacteria chains share one identical dimension, their trajectories differ within the arrays. ***Why? The explanation follows in Result (2).***

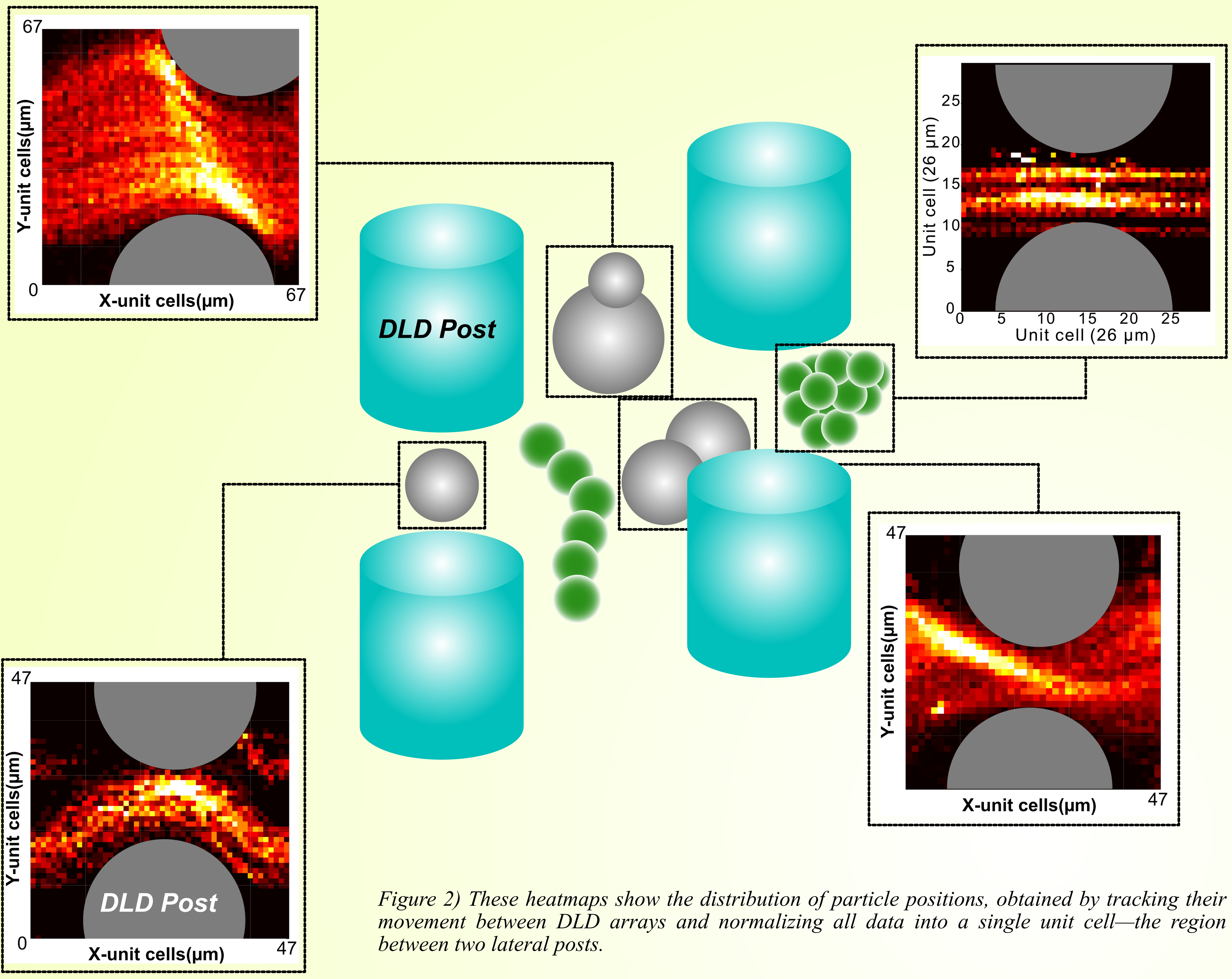


Figure 2) These heatmaps show the distribution of particle positions, obtained by tracking their movement between DLD arrays and normalizing all data into a single unit cell—the region between two lateral posts.

Result (2): Does rotation of non-spherical beads have anything to do with their sorting result?

Like the position of non-spherical particles, their rotation also follows a cyclic path in DLD arrays. When they move over the tops of the DLD posts, they orient in a way that interact with DLD posts by their shortest axis with, causing them to deviate from the trajectory of their corresponding spherical beads. ***But how about the final sorting result? Check Result (3)!***

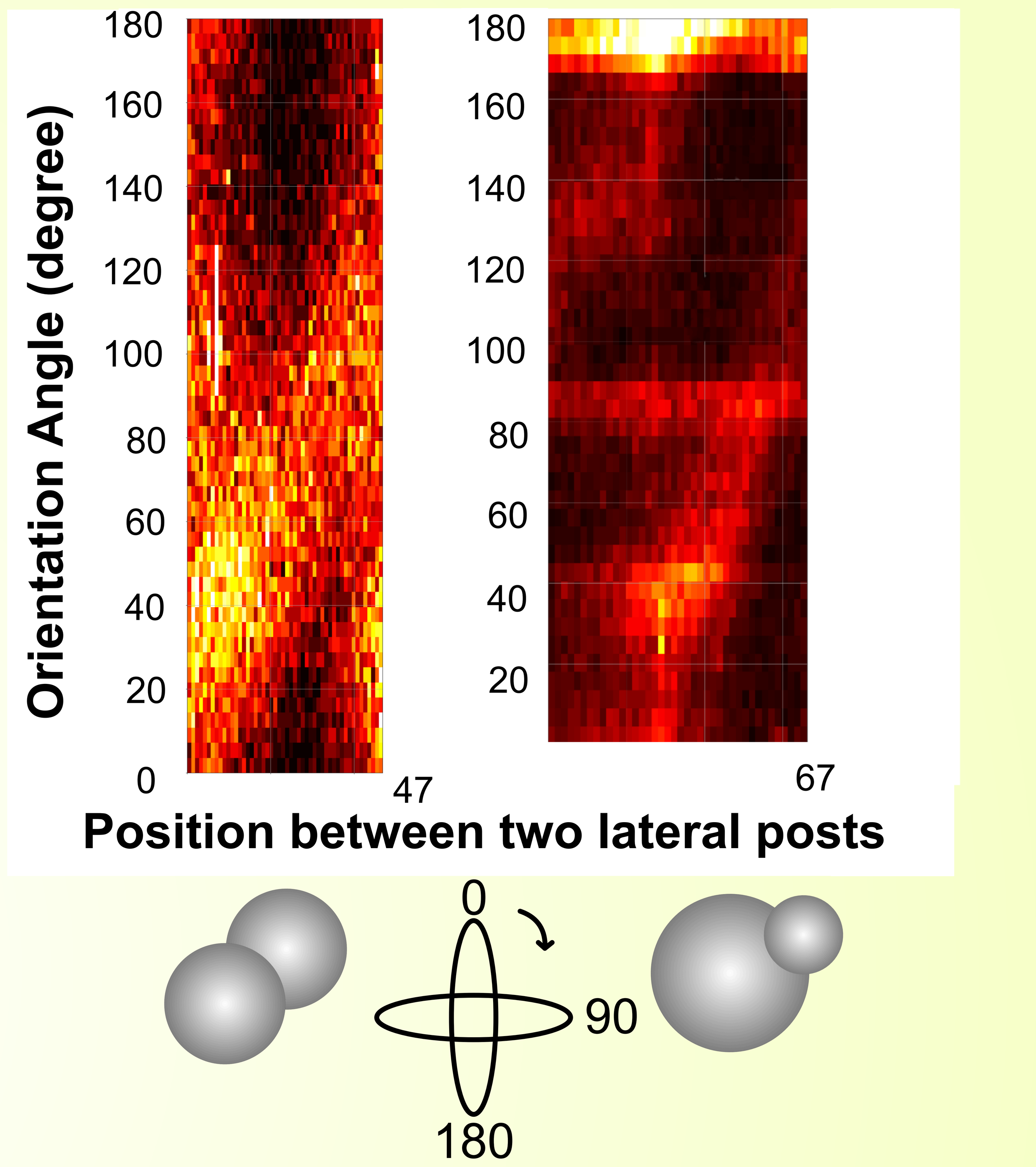
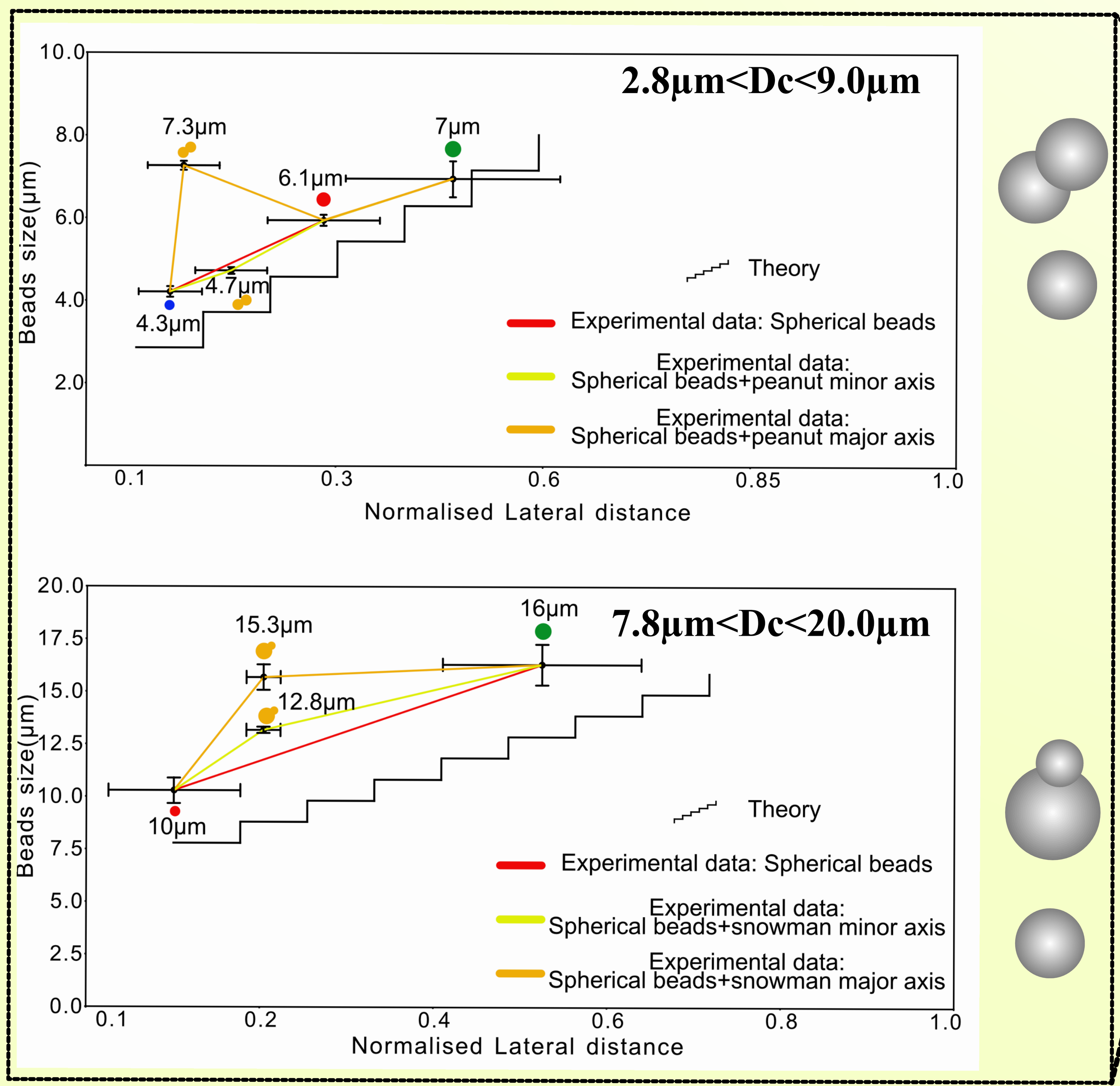


Figure 3) These heatmaps show the distribution of rotation angles for non-spherical particles, obtained by normalizing all data into a single unit cell—the region between two lateral posts.

Result (3): Non-spherical beads ended up in different outlets than they would have if they were spherical.

In DLD, it is expected that as particle size increases, their trajectories deviate further from the straight path of the fluid flow. A greater lateral distance at the channel outlets indicates more deviation, which should increase with particle size. This trend holds true for spherical beads; however, non-spherical beads do not follow this pattern. It shows the strong effect of shape and orientation on sorting.



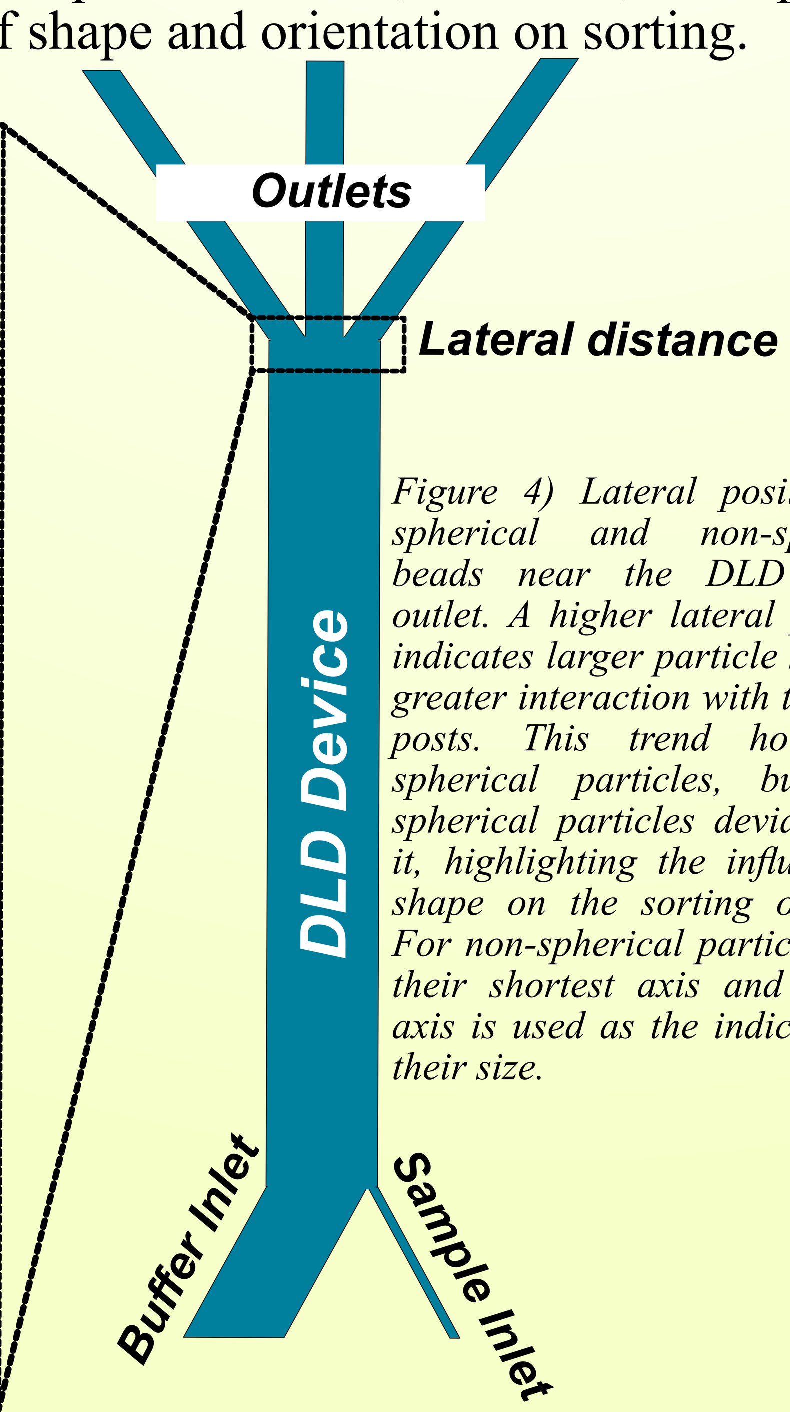


Figure 4) Lateral positions of spherical and non-spherical beads near the DLD device outlet. A higher lateral position indicates larger particles and greater interaction with the DLD posts. This trend holds for spherical particles, but non-spherical particles deviate from it, highlighting the influence of shape on the sorting outcome. For non-spherical particles both their shortest axis and longest axis are used as the indication of their size.

Result (4): Bacterial sample: Shape induces rotation, while softness alters morphology. Separation is influenced by a combination of shape, size, and softness.

After sorting, two distinct subpopulations of bacterial chains and clusters emerged. In one region of their property distribution, their sizes (longest axis) overlapped, but their shapes differed—particles in the larger-particle outlet were more elongated (lower circularity). By tracking shape changes through the DLD posts, we found that these bacteria appeared more circular while on top of the posts, effectively increasing their size and influencing sorting through shape and deformability.

Figure5-A) Size (major axis length) and shape (circularity) of bacteria after sorting into two different subpopulations. B-1) Change in bacterial shape (circularity) while moving on top of and interacting with the DLD posts. B-2) Images showing that bacterial chains and clusters deform as they interact with DLD posts.