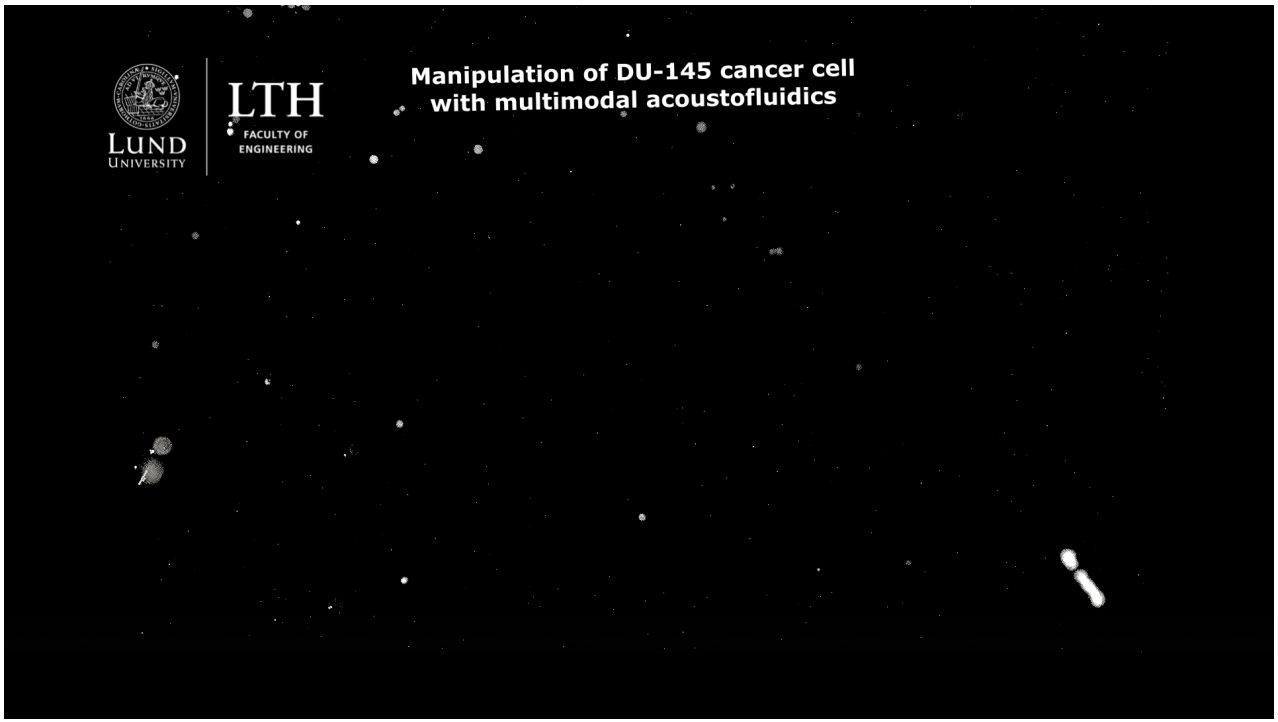
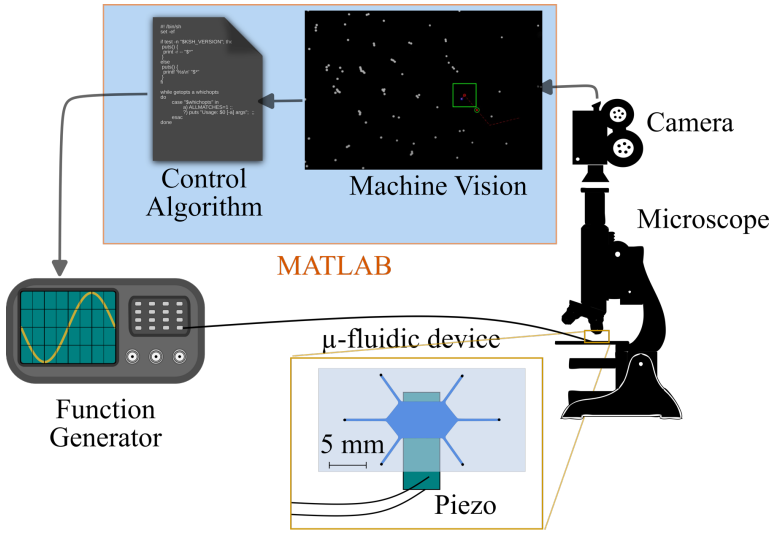
Multimodal Acoustofluidics –
Combining feedback control and ultrasound to move single cells!





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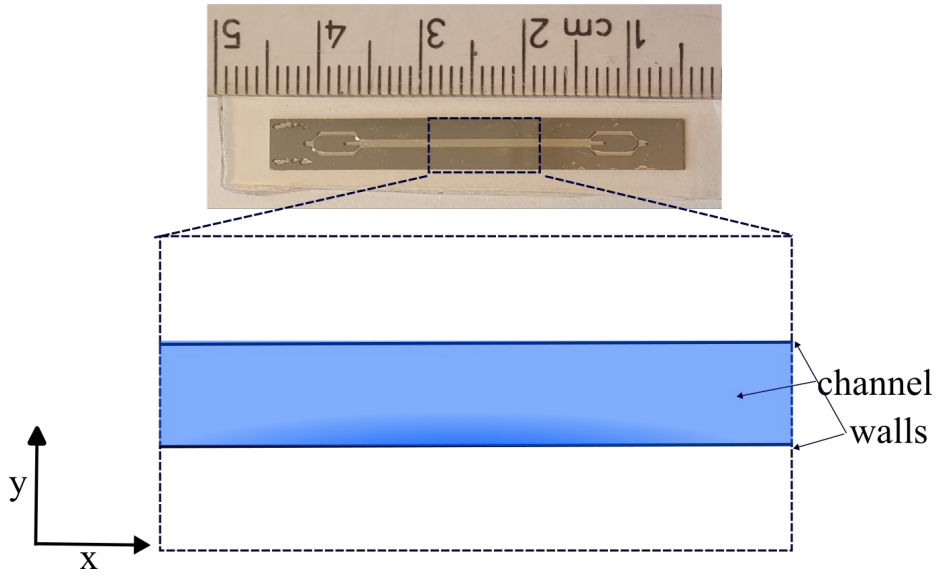
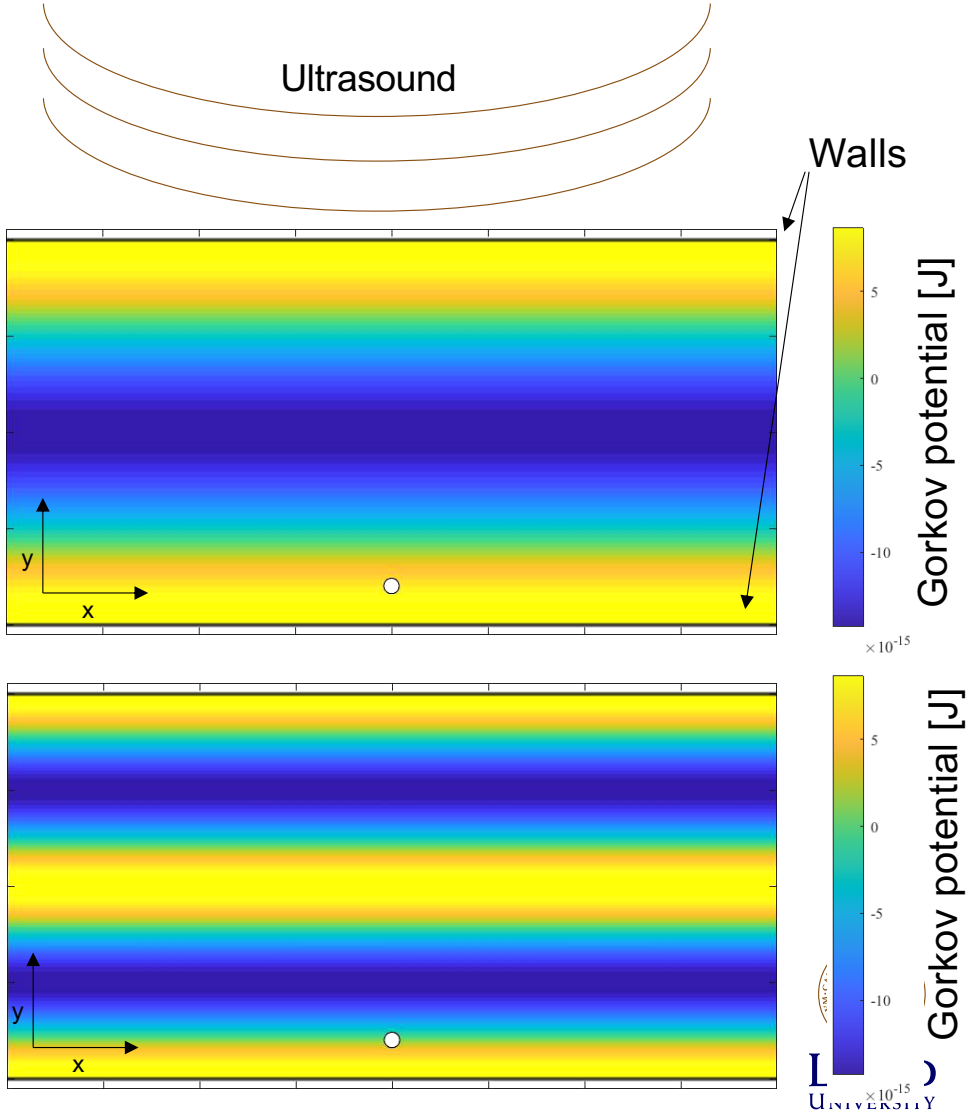
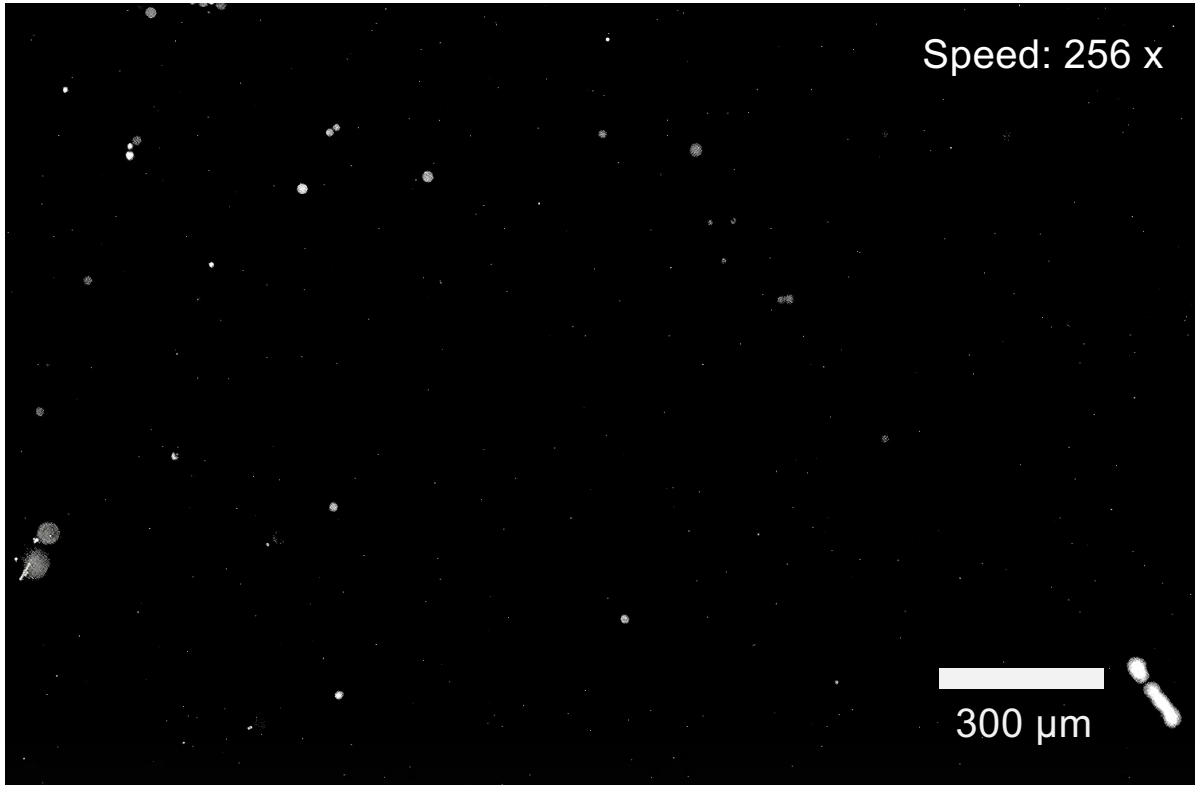
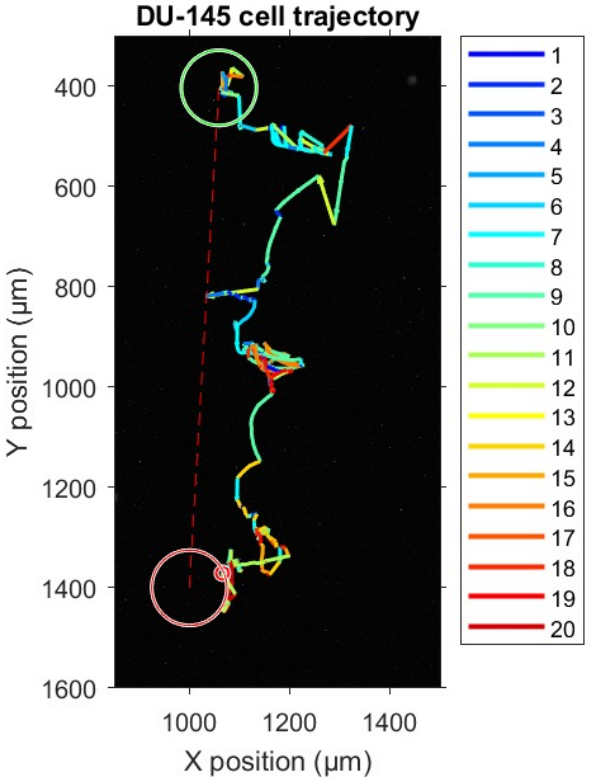
Acoustic forces move cells to the closest potential minima





Multimodal single cell manipulation of calcein-stained cancer cell (DU-145) – First of a kind!





20 frequencies between 2.1 - 2.5 MHz. The experiment took 57 min, or 846 steps. Each step contained a 2s pulse at 5 V_{pp}

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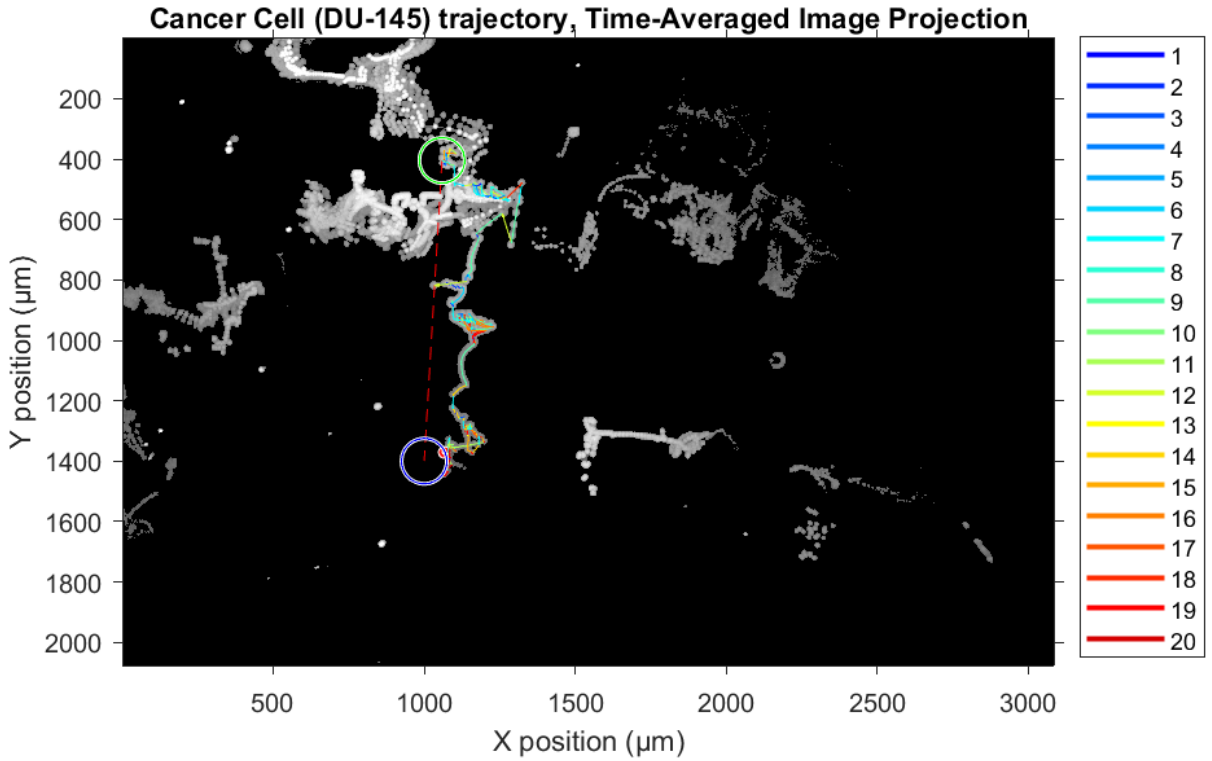
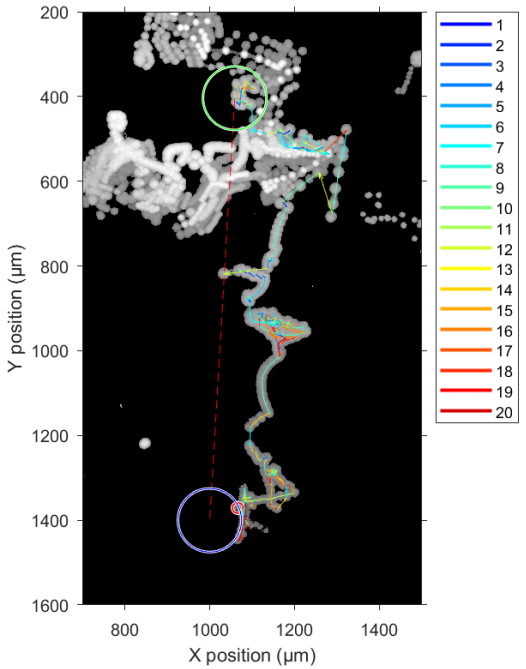
Time averaged image of cancer cell manipulation (with trajectory overlayed)





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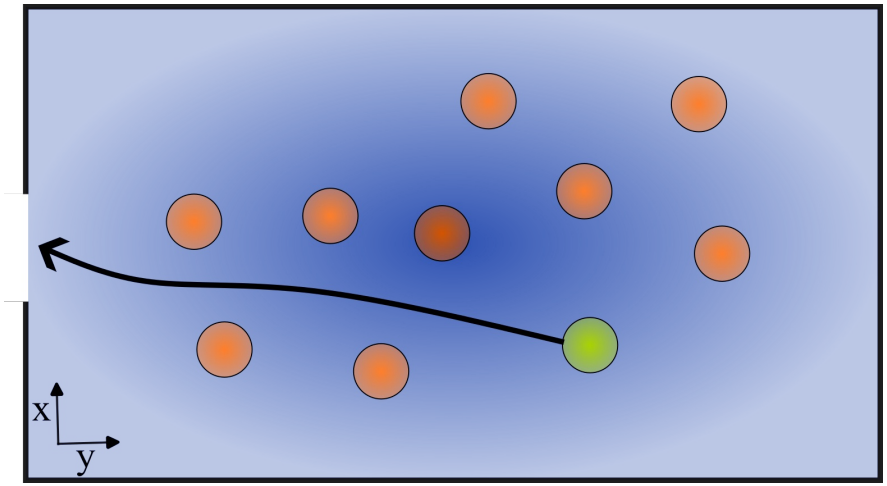
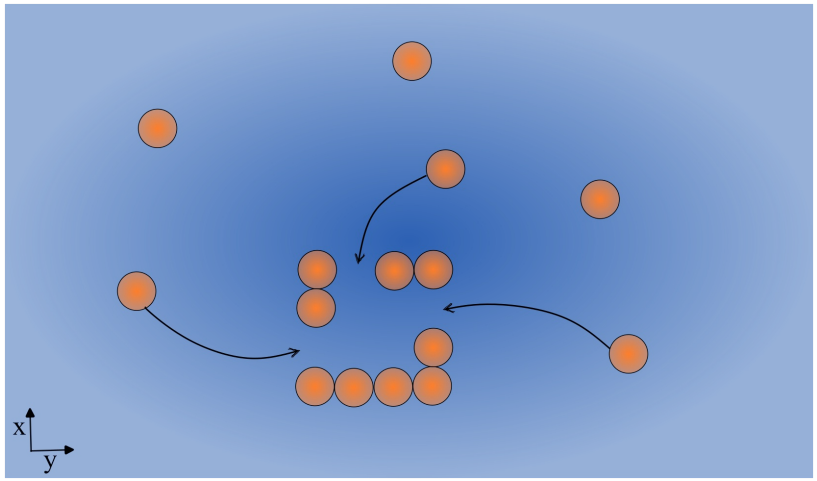
What if individual cells could be moved and manipulated?

Single cell analysis



Possibility 1: Select and extract a single cell from a sample for downstream analysis.

Tissue engineering



Possibility 2: Assemble cells into specific shapes, creating a scaffold.

This requires having precise control!

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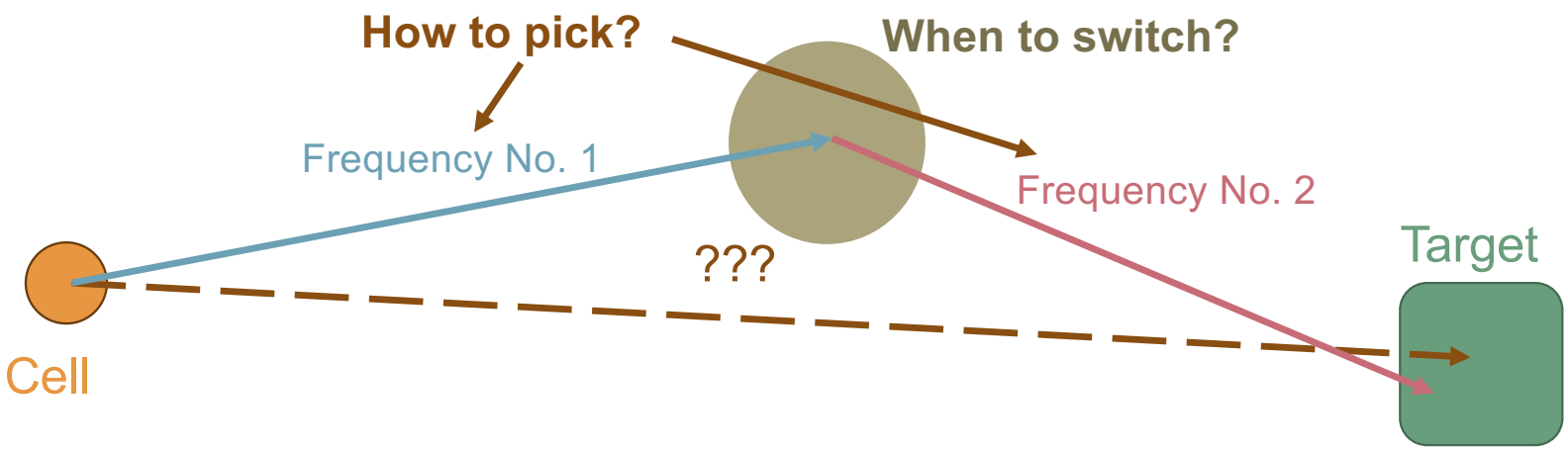
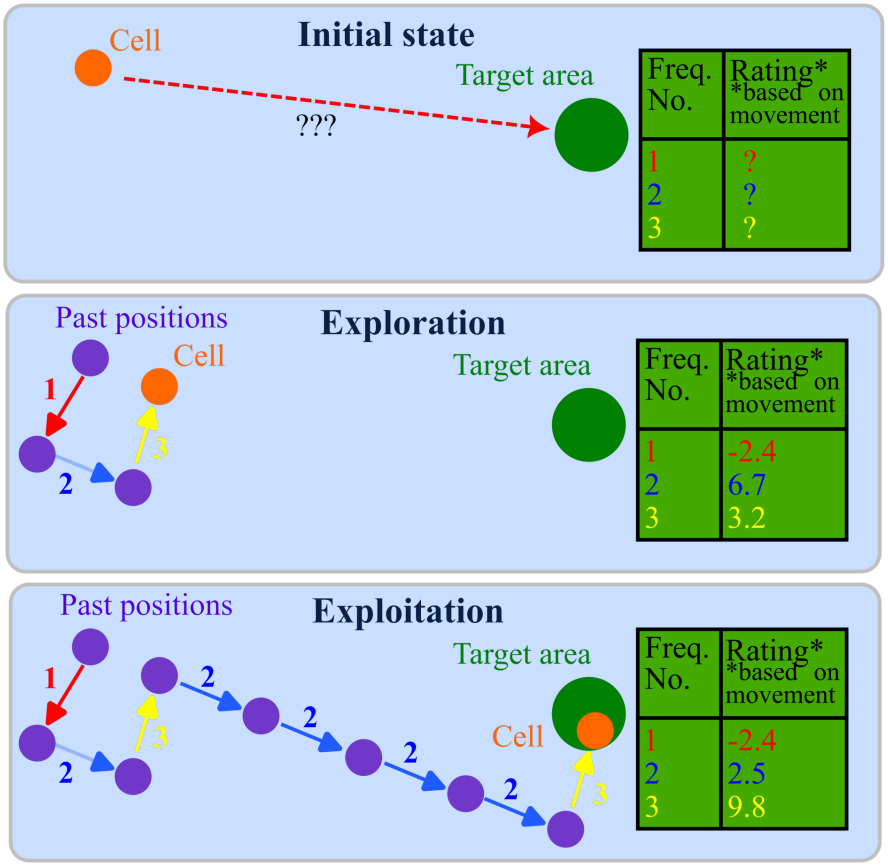
How do we control cell movement?



By applying a machine learning algorithm with feedback control!

The algorithms – Epsilon Greedy



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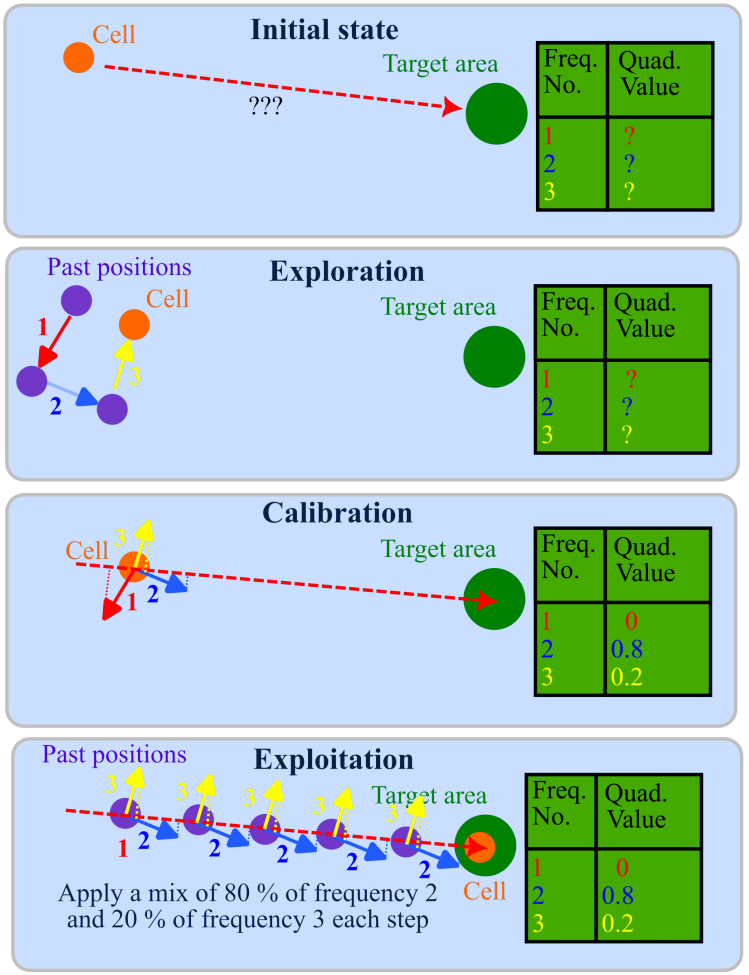
The algorithms – Quadratic Programming



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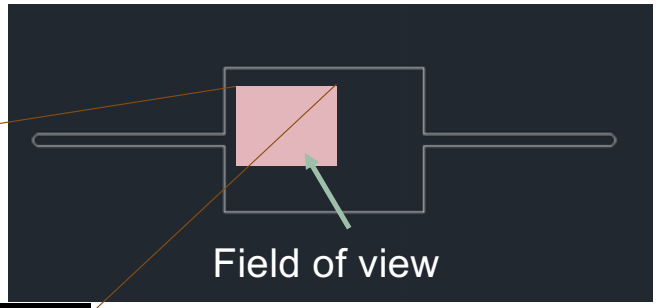
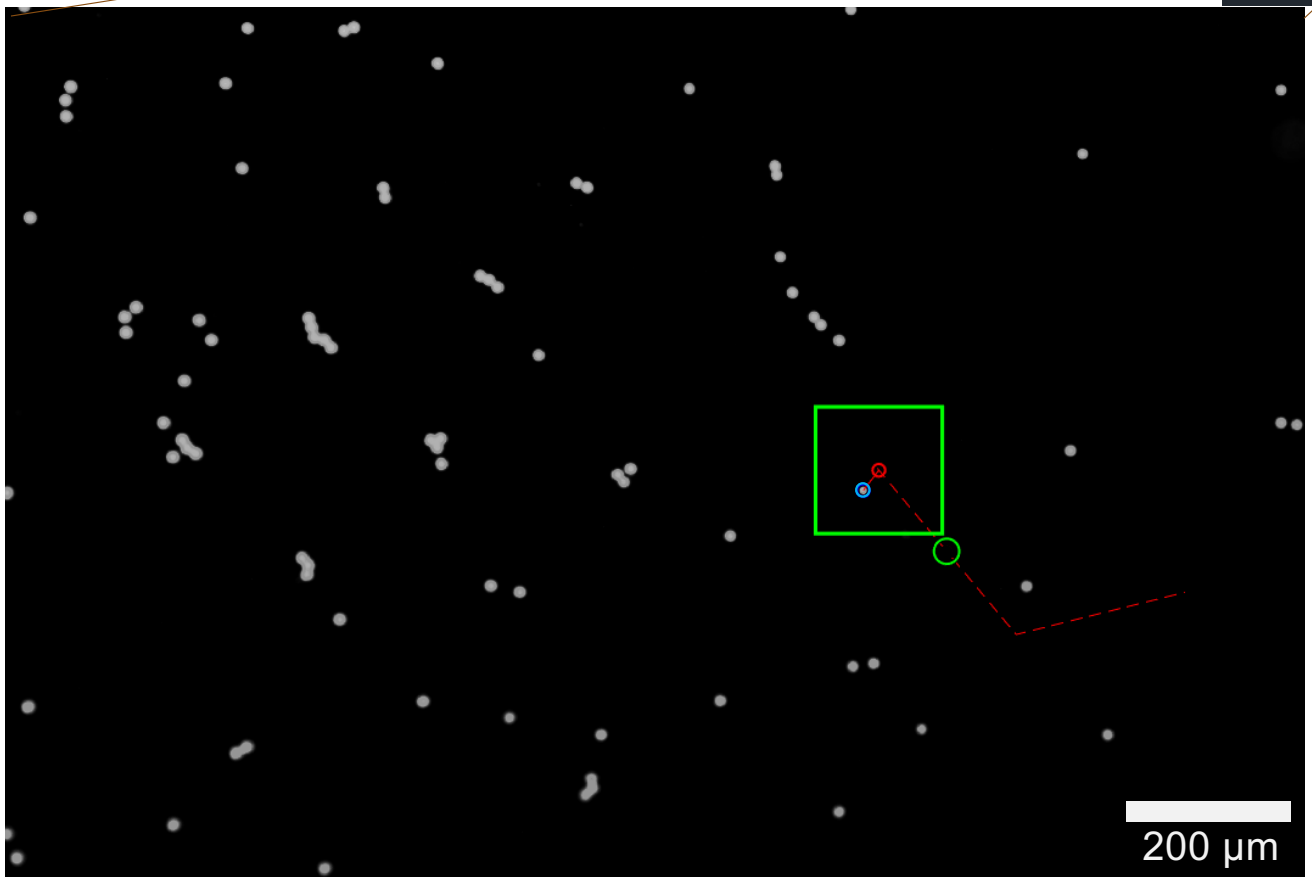
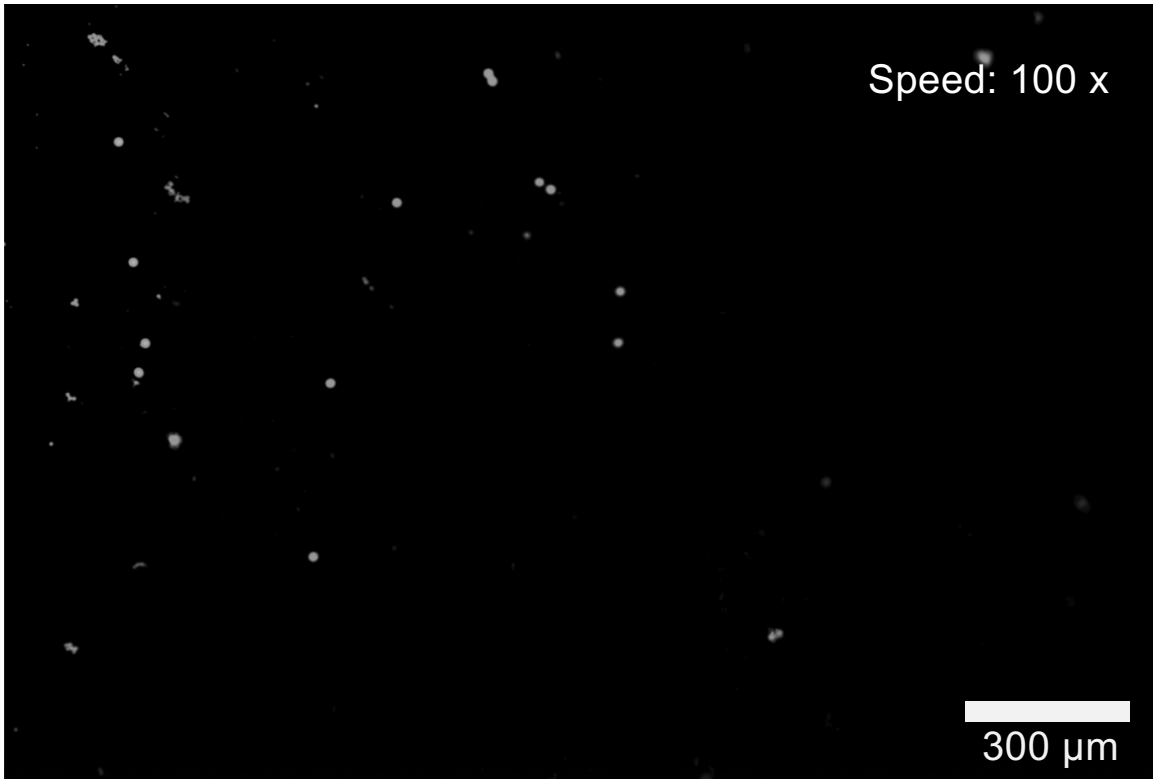
We track the particle/cell for every step that it takes

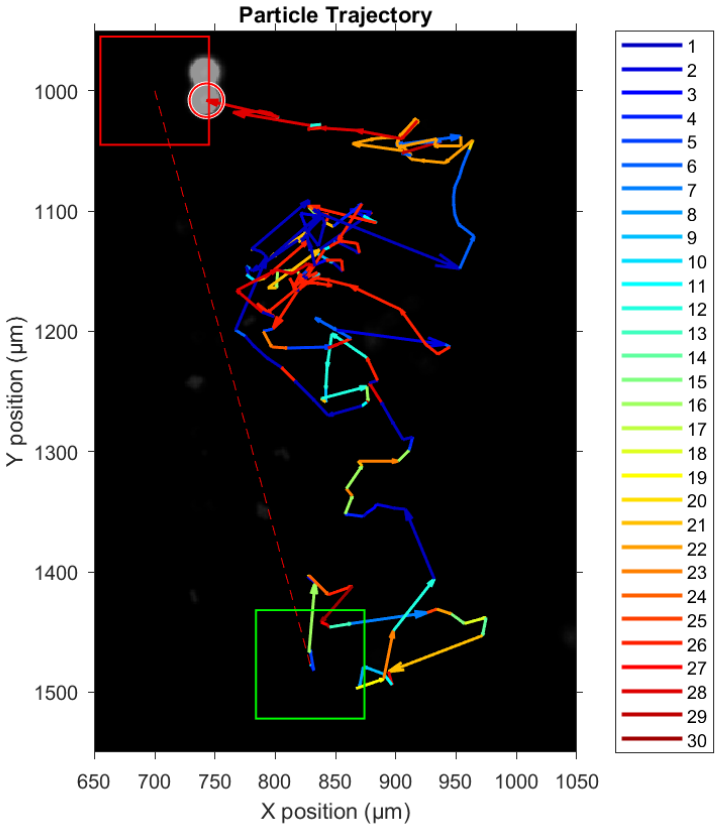




- 20 µm PS particles
- Selected trajectory
- Old particle position
- New particle position
- Target position
- Search area

Single particle manipulation of 20 µm polystyrene





30 modes between 2.1 - 2.6 MHz. The experiment took 13.51 min, or 413 steps. Each step contained a 0.5s pulse at 5 V_{pp}

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