Korea-EU Horizon Europe
researchers networking forum
07/03/2025

KANG LAB

PRECISION BIOINSTRUMENTATION LAB

Integrating MEMS, microfluidics and optics, we develop precision healthcare technologies that leverage the physical properties and mechanical responses of living cells

Joon Ho Kang

Department of Mechanical Engineering,
Interdisciplinary Program in Bioengineering
Seoul National University

Joon Ho Kang

Position

Assistant Professor
Department of Mechanical Engineering,
Interdisciplinary Program in Bioengineering

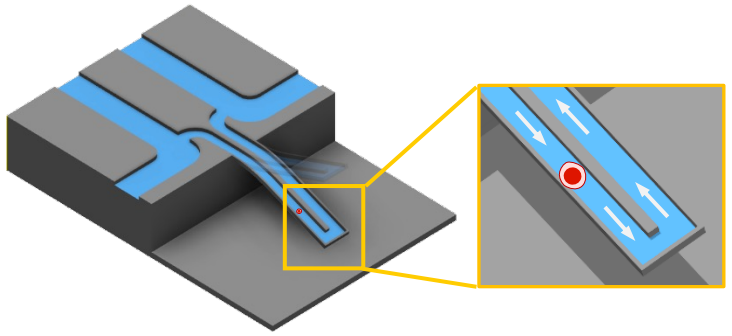
Education

Ph.D., Physics, MIT (2019)
B.A., Physics, Columbia University (2012)

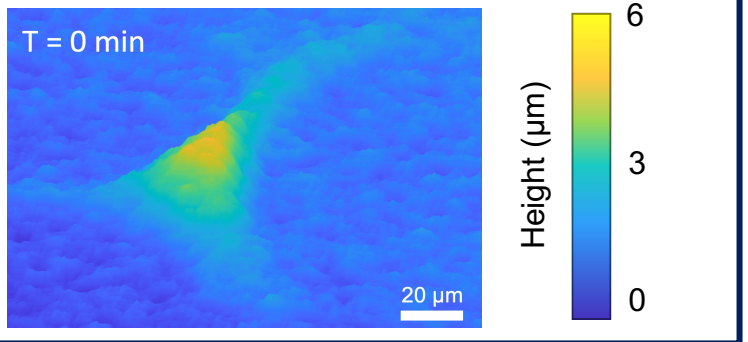
Research Area

Bioinstrumentation and Biosensing
Single-cell biophysics

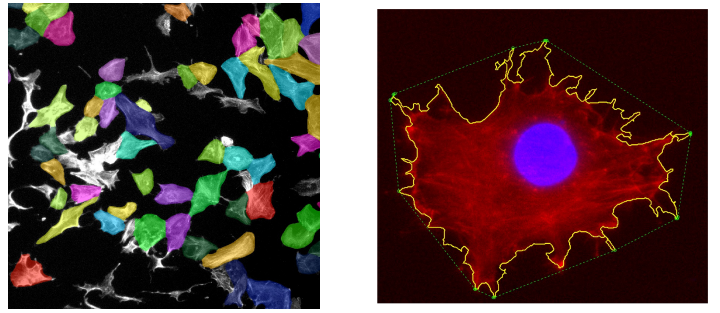
Contact: joonhokang@snu.ac.kr



Mechanical Biosensors:
Suspended Microchannel resonator (SMR) for single-cell physical properties



Optical Biochip:
3D live-cell morphology monitoring system

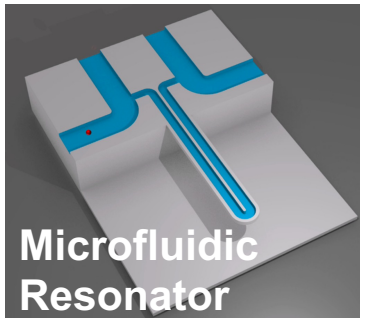


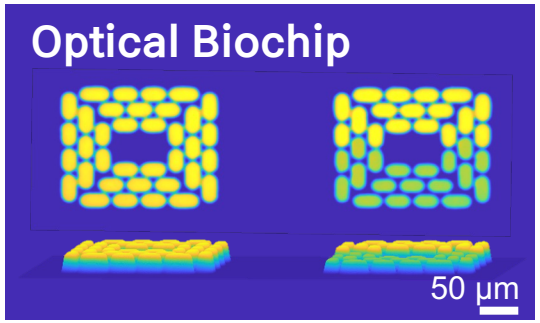
Single-cell analysis:
Computational modeling and AI powered methodologies

Research area

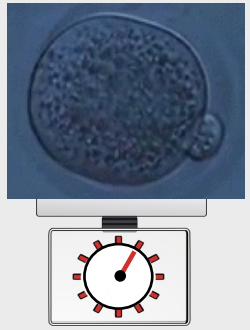
Bioinstrumentation for precision healthcare

Precision measurements



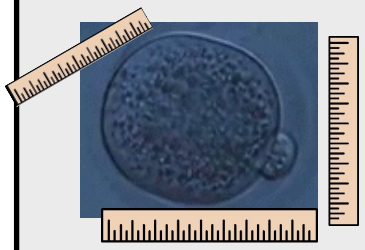


Mass



eLife (2019).
PNAS (2020).

Density, Volume



JCB (2015).

Stiffness

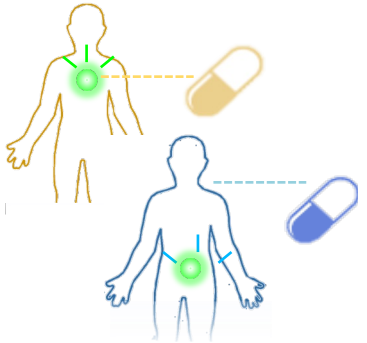
Nature Methods (2019).

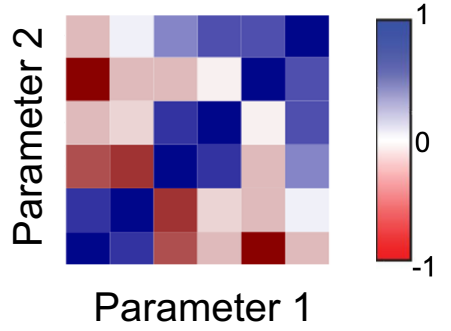
Bioenergetics

Nature Communications (2020).

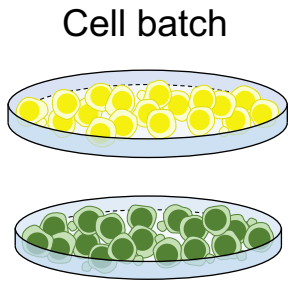
Application

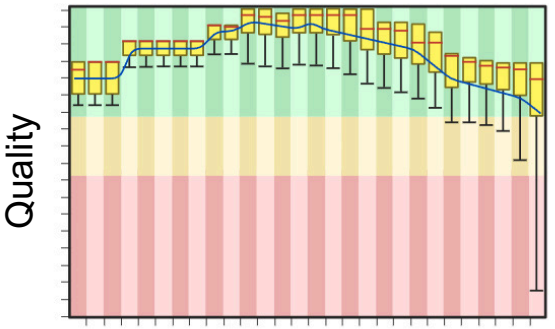
1) Precision medicine & disease diagnostics





2) Cell quality control (QC)

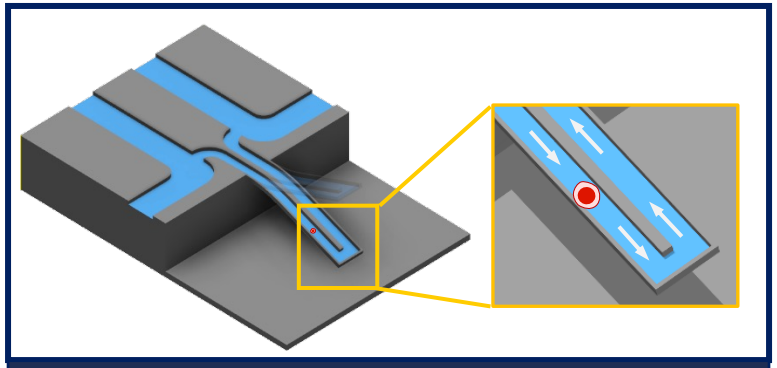




Research area

Bioinstrumentation and Biosensing for precision healthcare

Research overview



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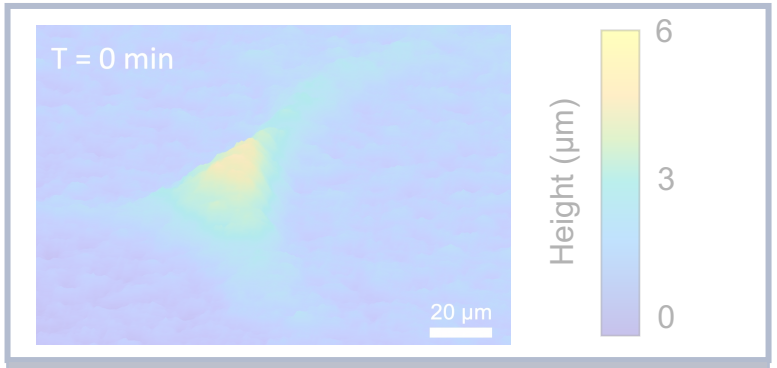
Microfluidic resonator for measuring single-cell physical properties



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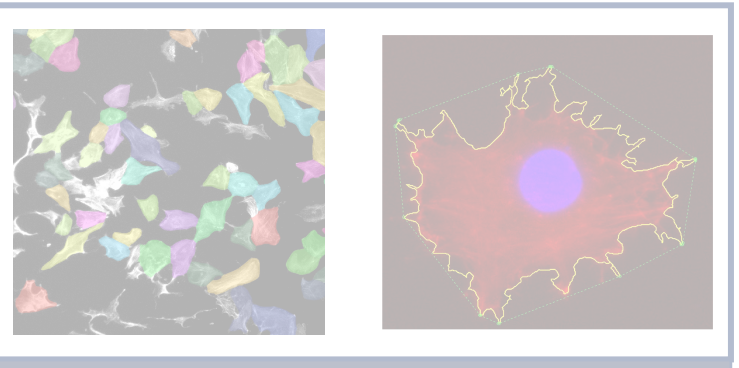
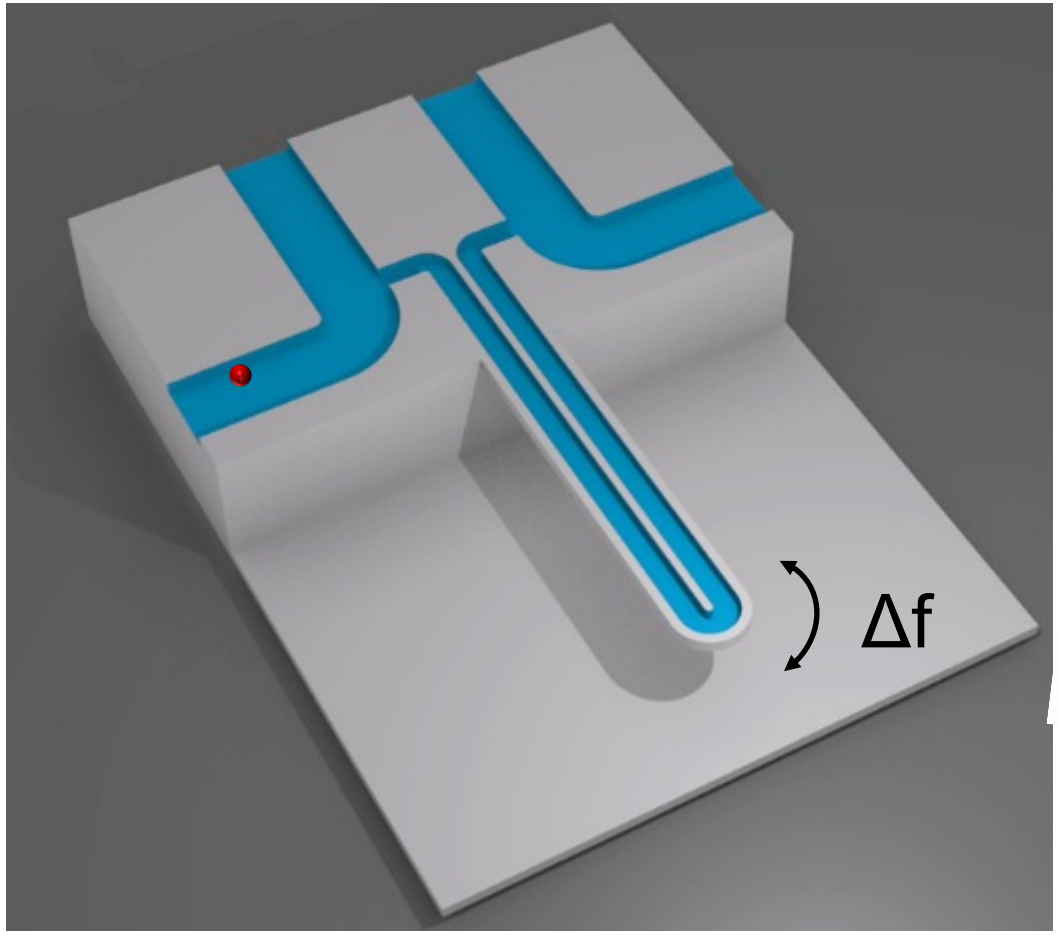
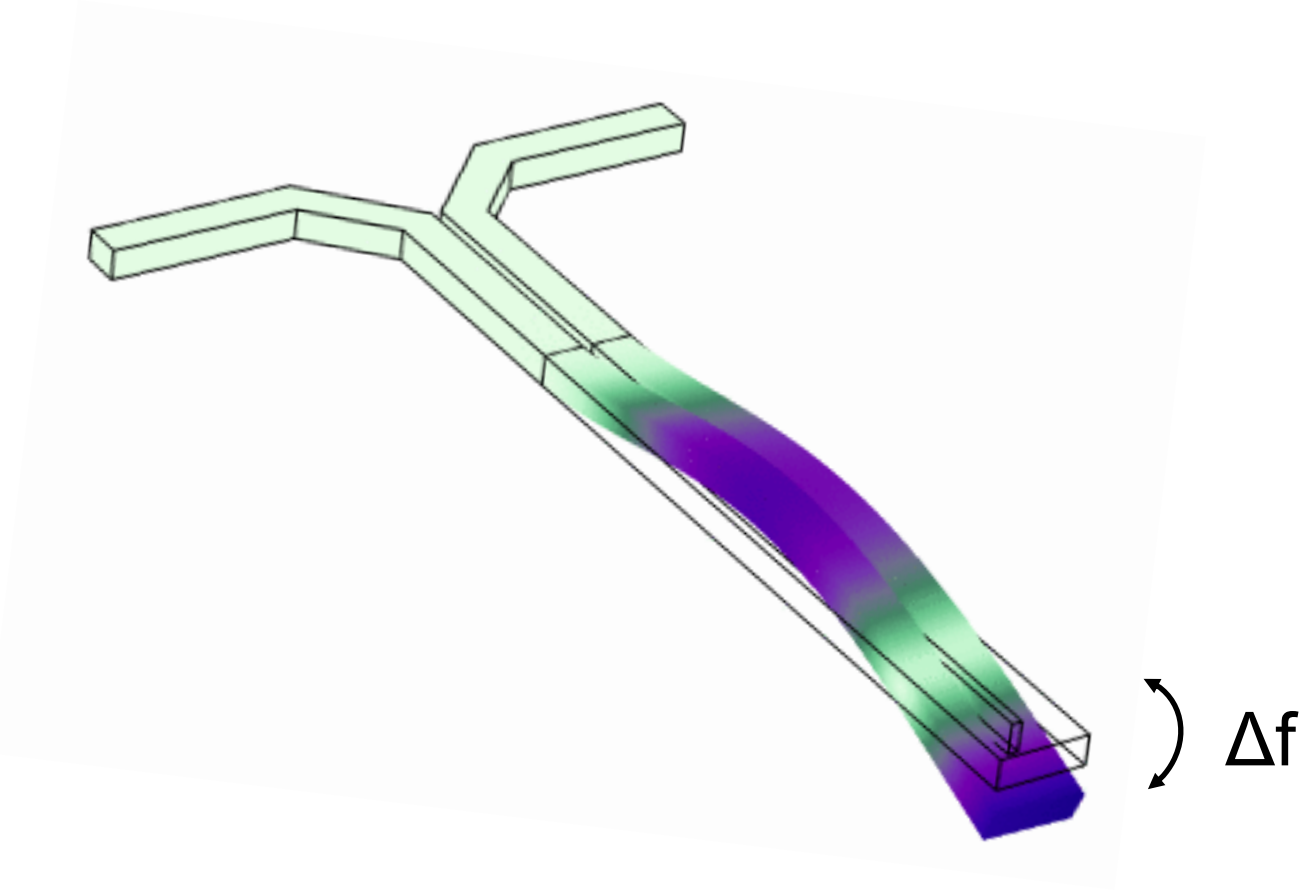
3D live-cell morphology monitoring system



Single-cell analysis:
Computational modeling and AI powered methodologies

Suspended microchannel resonator **(SMR)**: Weighing single cells with a diving board





Burg et al. *Nature* (2007)

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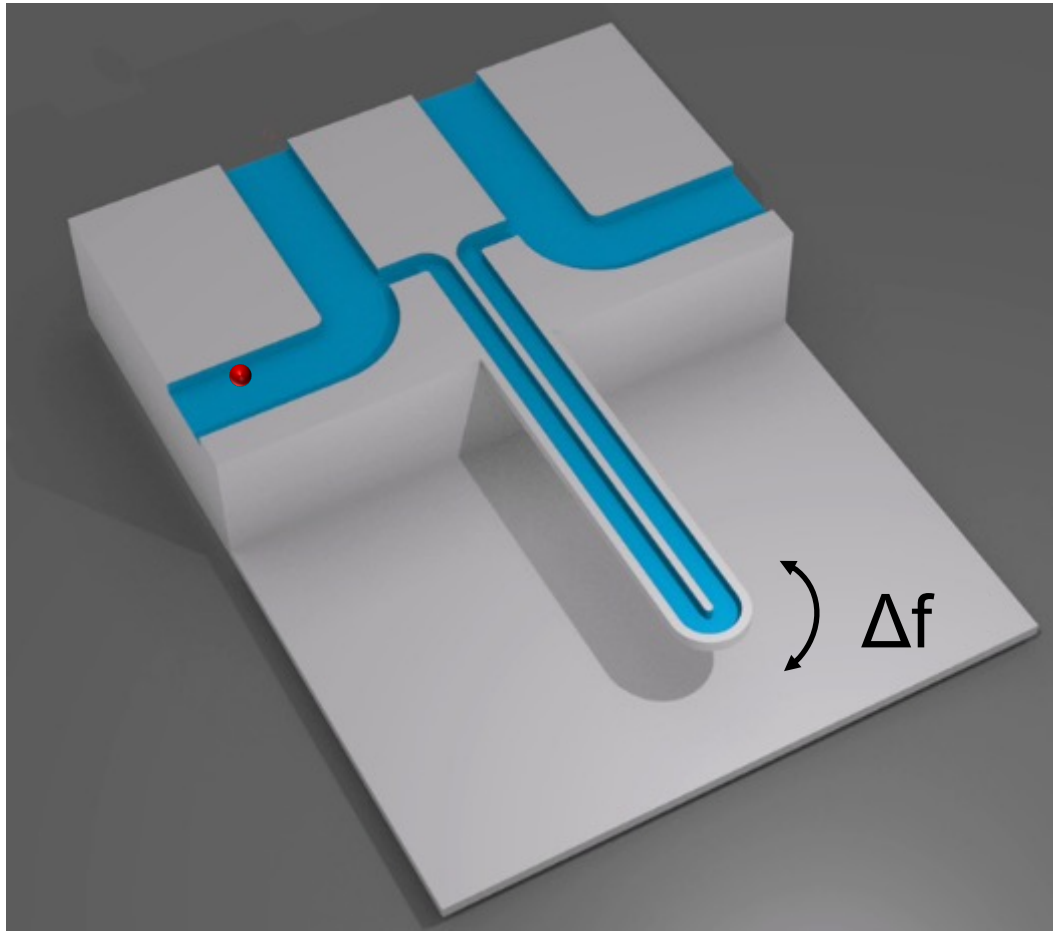
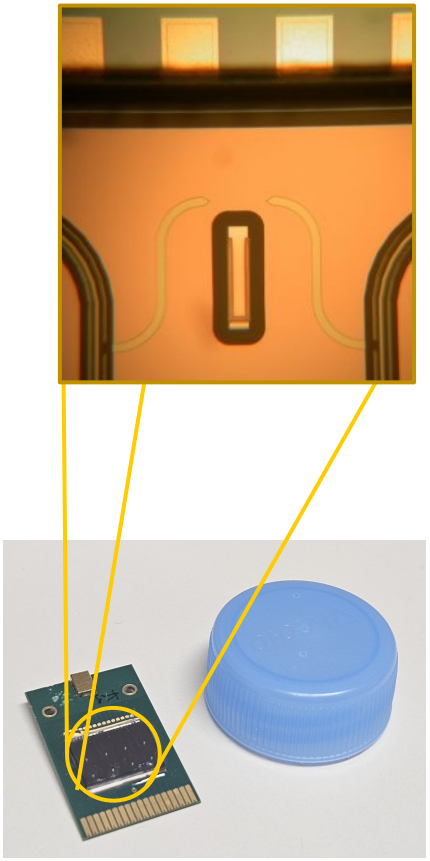
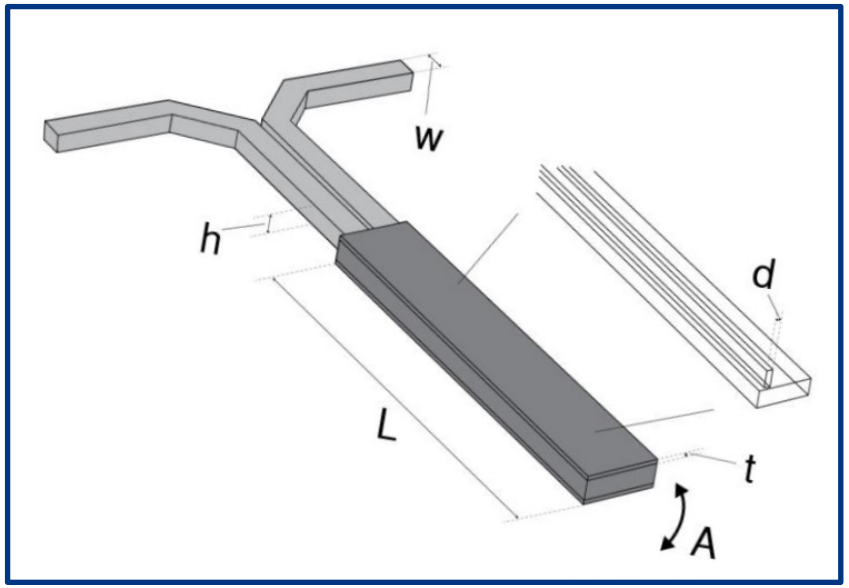


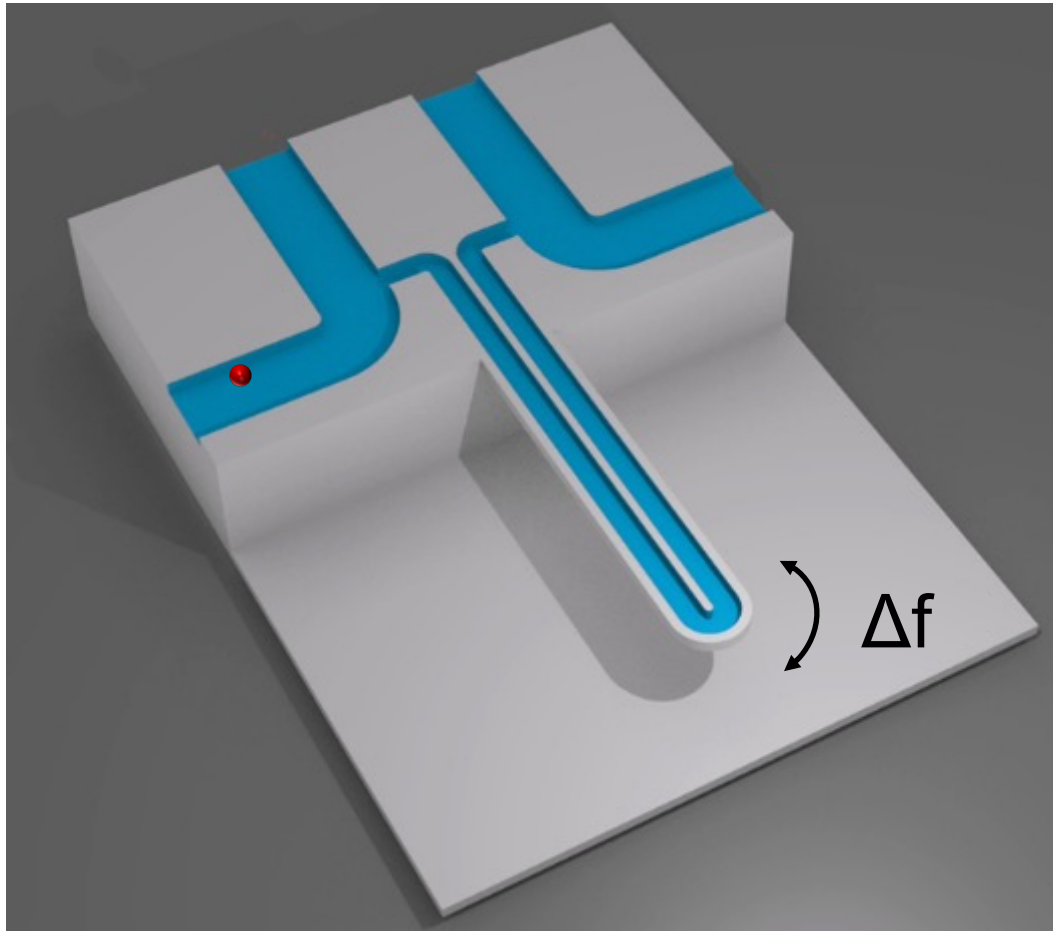
▼ SMR Chip

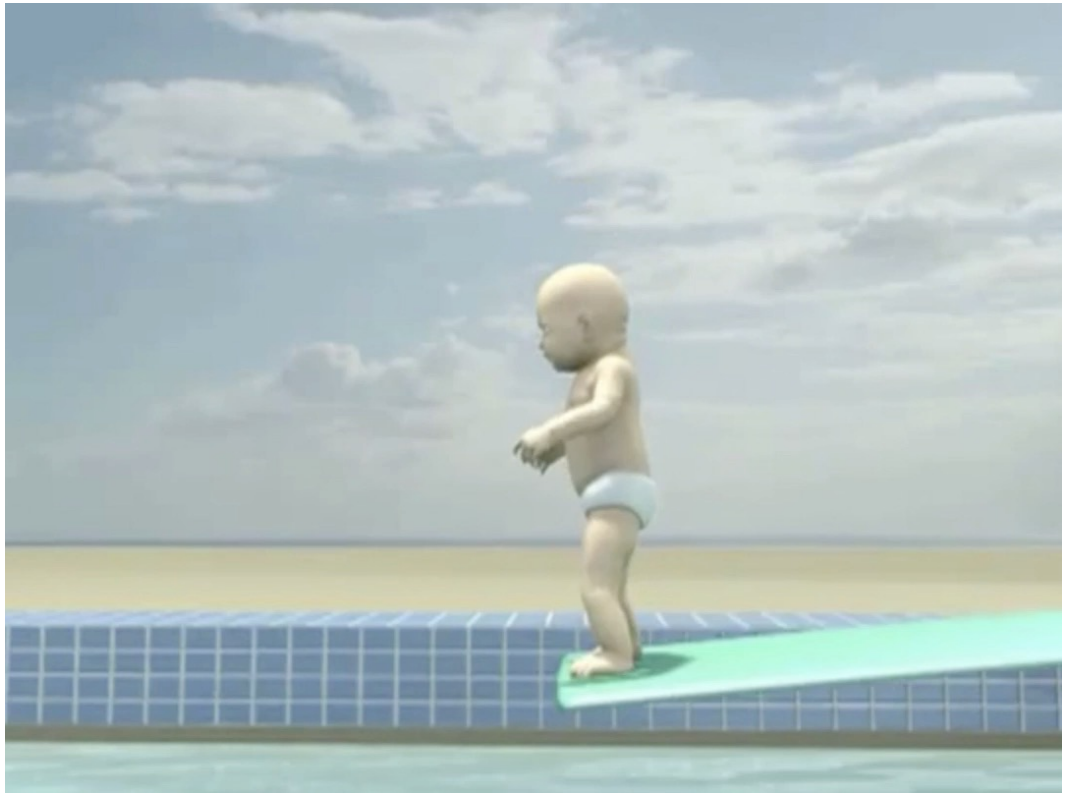




Burg et al. *Nature* (2007)

Suspended microchannel resonator **(SMR)**: Weighing single cells with a diving board

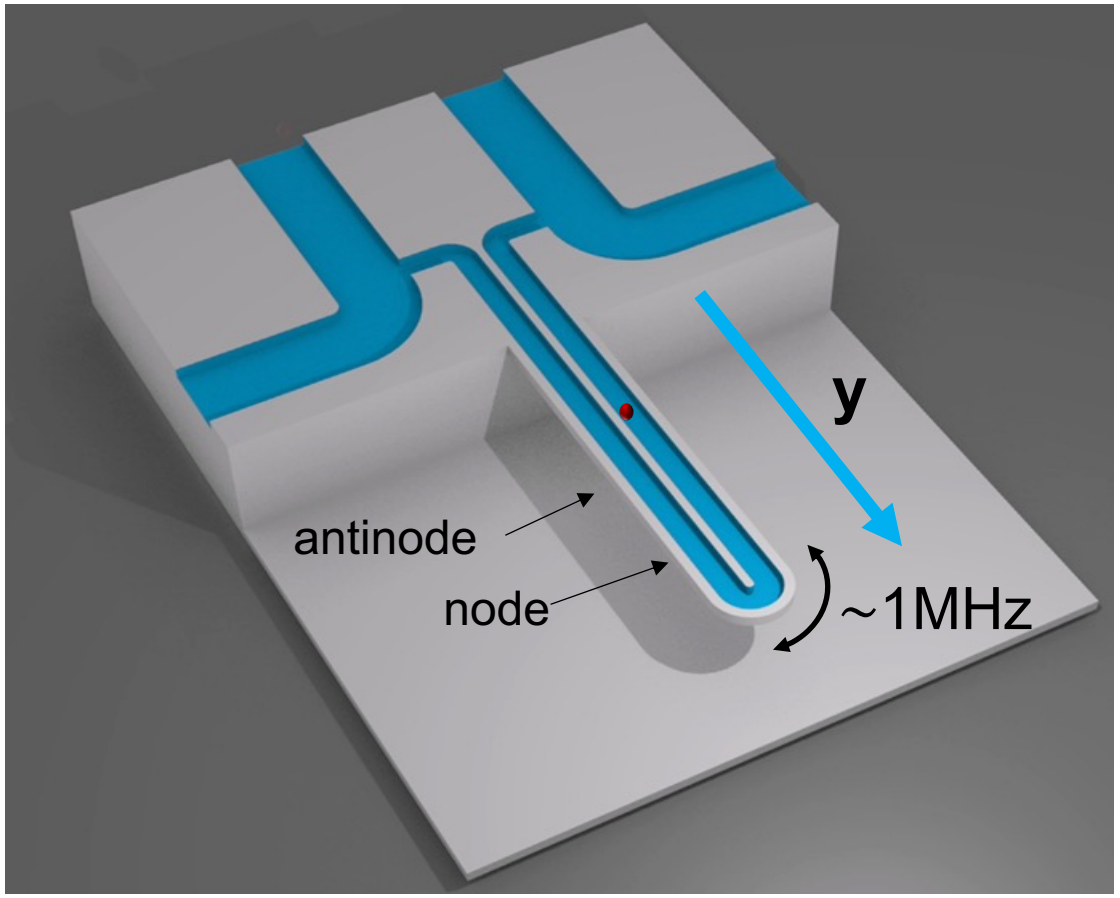


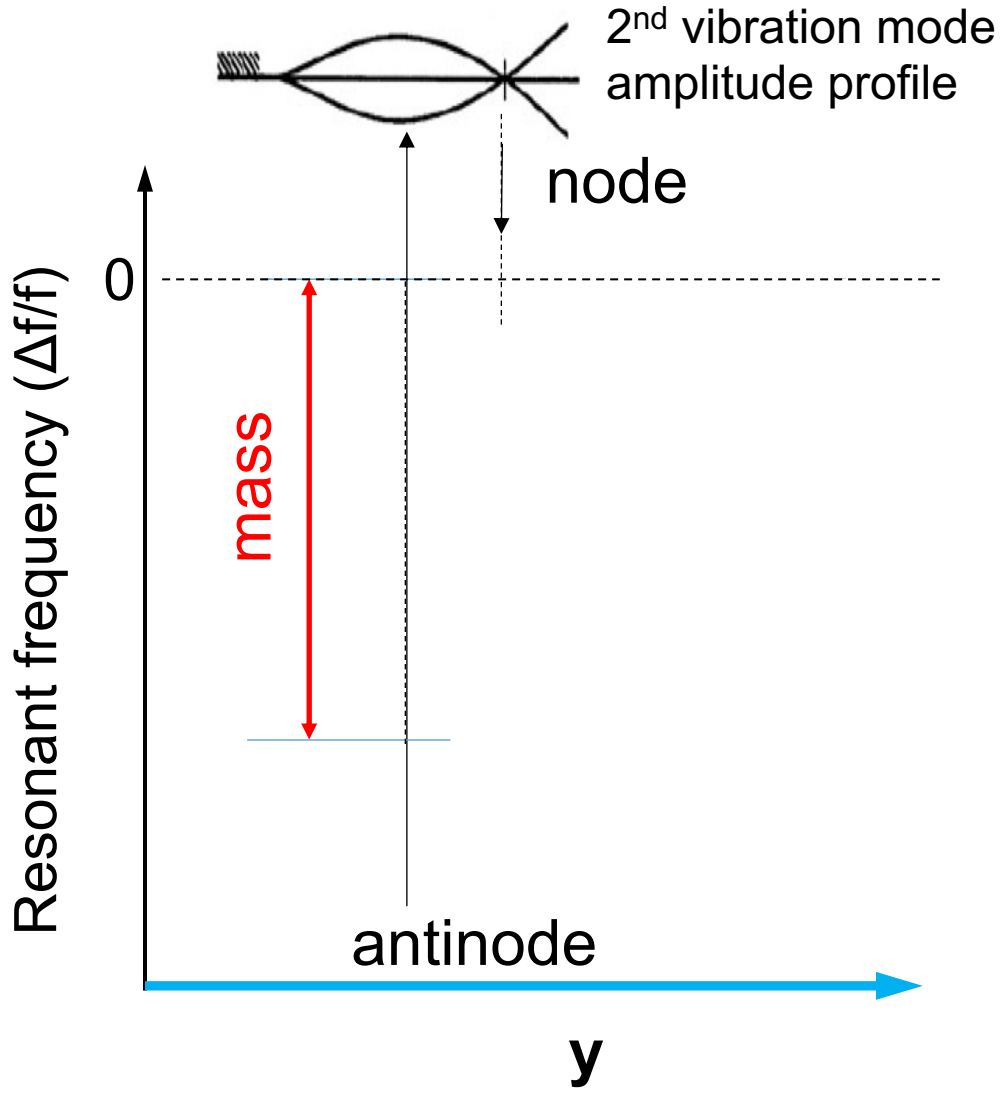


A diving board vibrates more slowly (lower frequency) when weight is added to it.

Burg et al. *Nature* (2007)

SMR measures buoyant mass of single cells by change in the resonant frequency

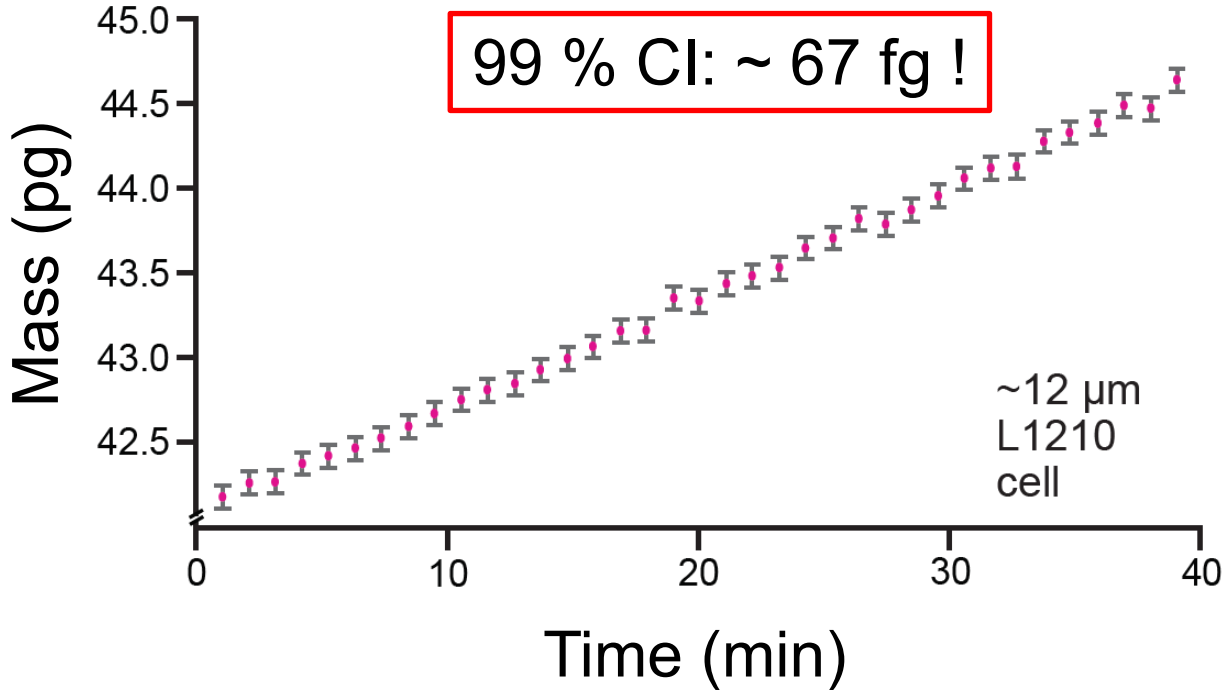




Lee et al. *Rev. Sci. Instrum.* (2011)
Kang et al. *Nat. Methods* (2019)

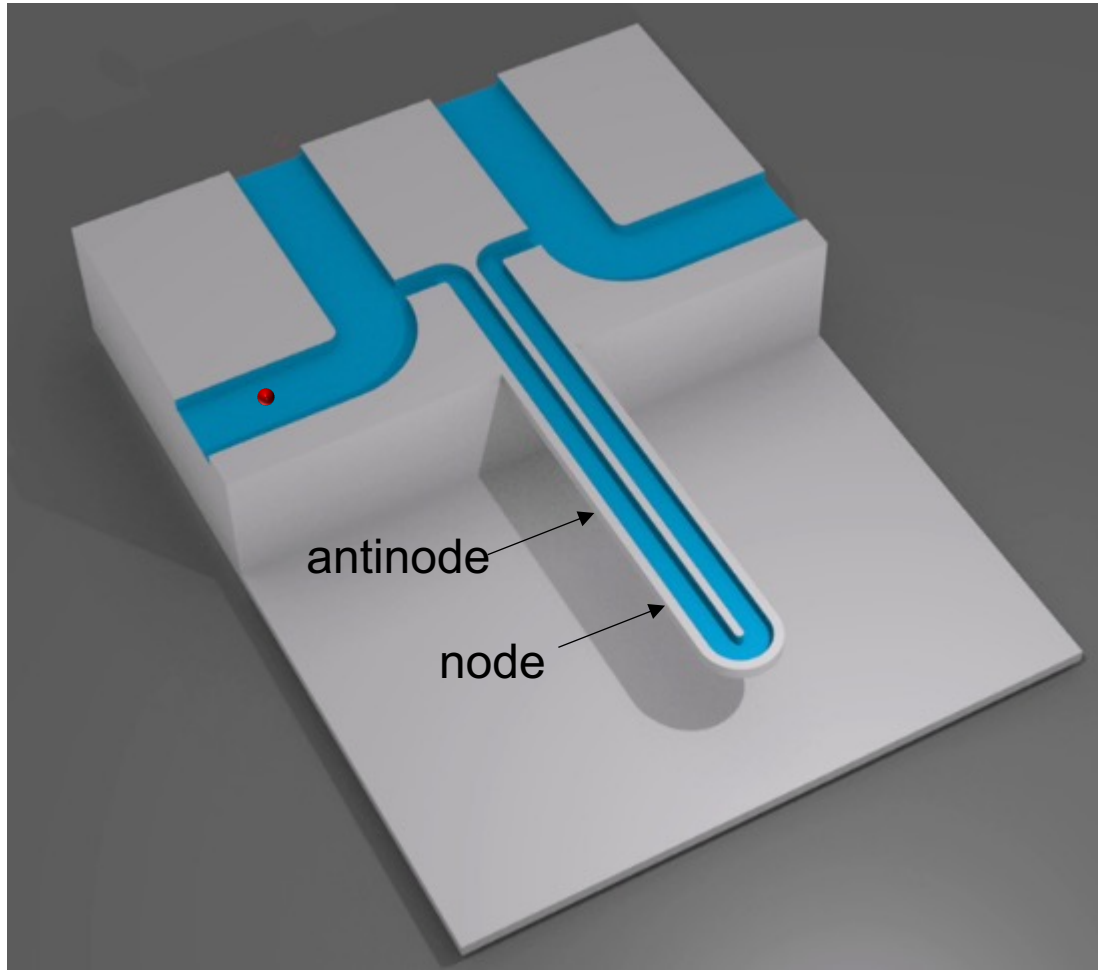
Femto-scale SMR mass resolution

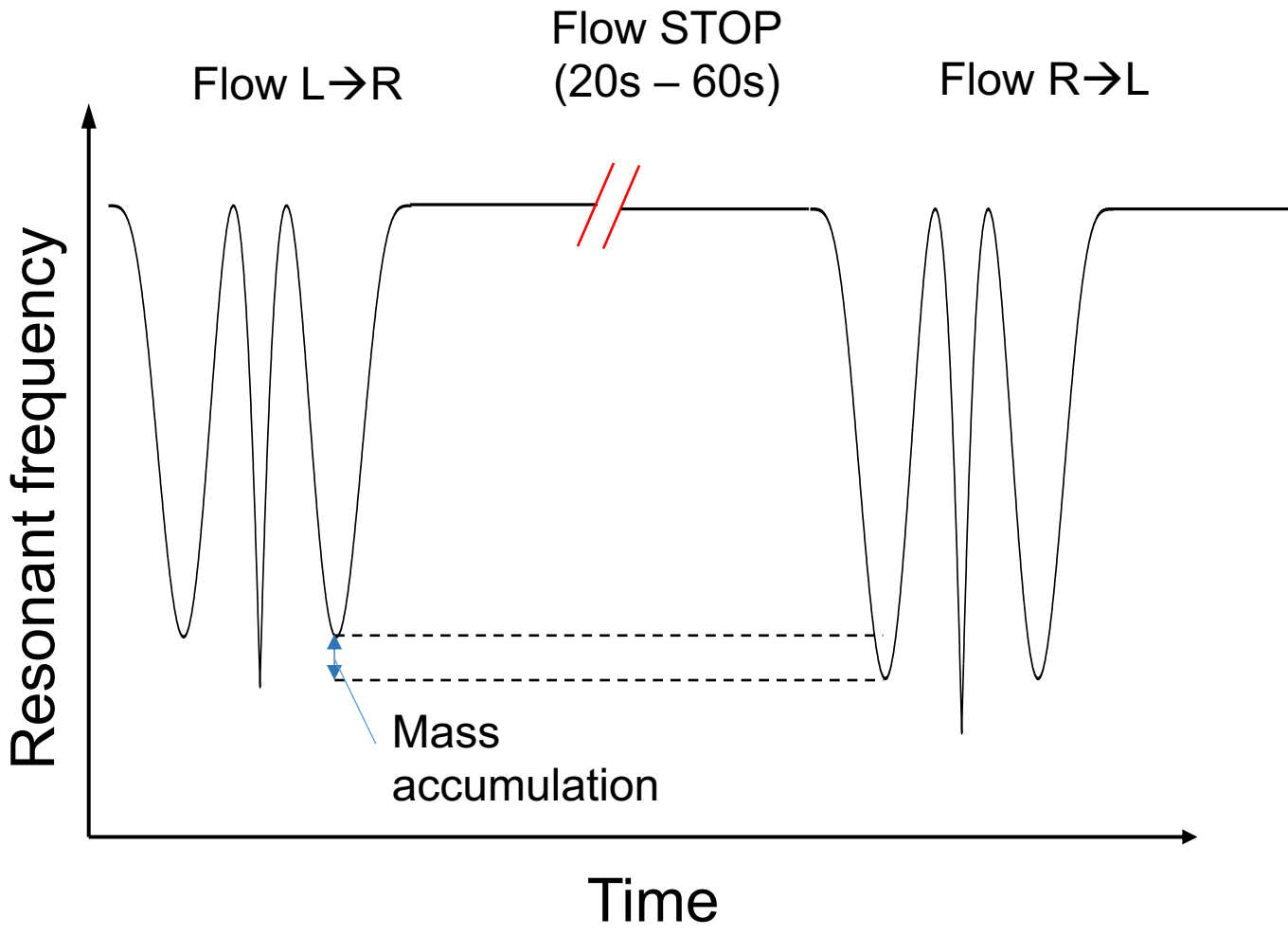
- A typical SMR resolution <100 fg
  → this corresponds to ~5 nm change in a spherical cell diameter
- Nearly 100-fold more precise than quantitative phase microscopes.



Miettinen*, Kang* et al. *eLife* (2019)
Mu*, Kang* et al. *PNAS* (2020)

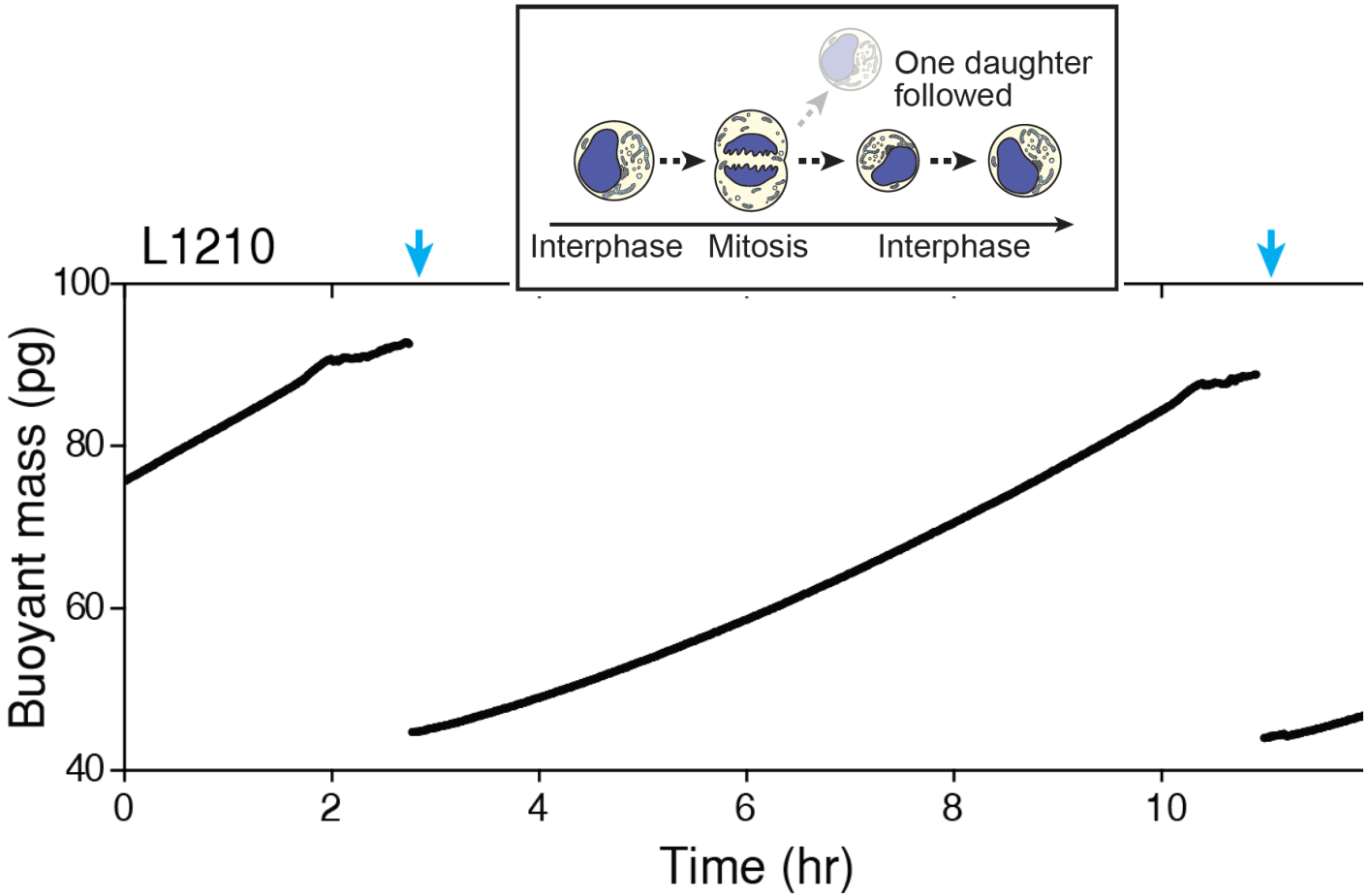
Continuous monitoring of single cells

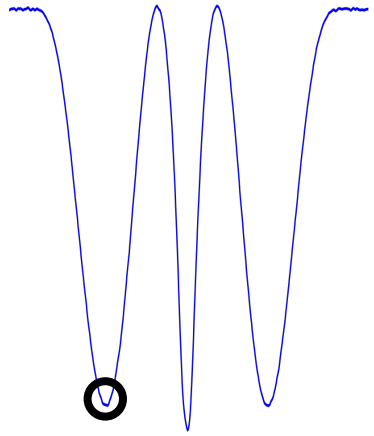




Son et al. *Nat. Methods* (2012), Son*, Kang* et al. *JCB* (2015),
Miettinen*, Kang* et al. *eLife* (2019), Kang*, Katsikis* et al. *Nat. Commun.* (2020)
Mu*, Kang* et al. *PNAS* (2020)

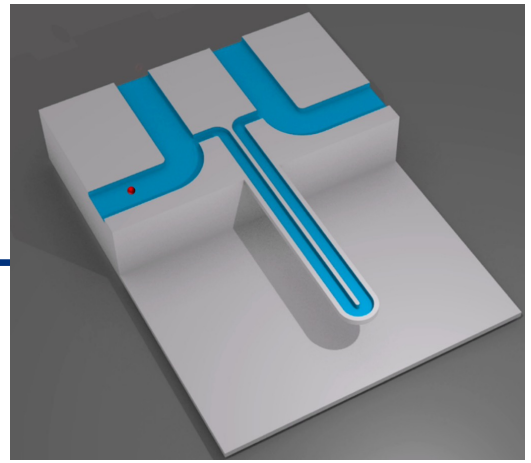
Monitoring single-cell mass during cell cycle



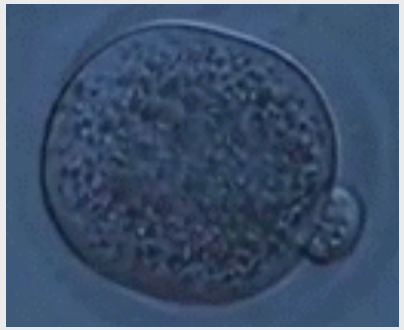


mass
@antinode

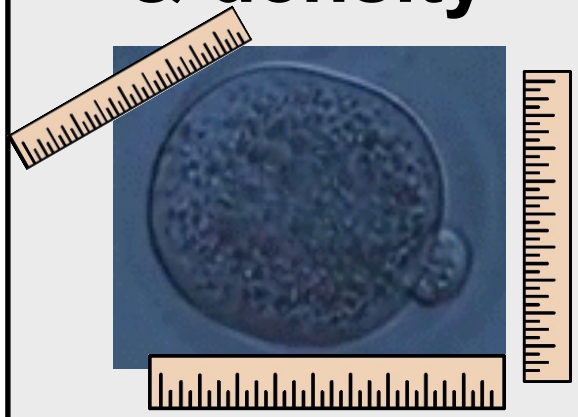
Multi-biophysical properties



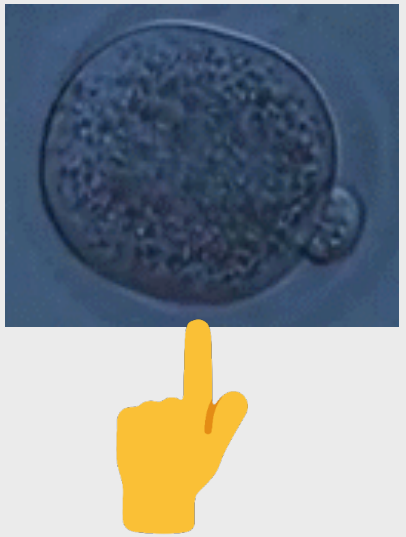
Mass



Volume & density

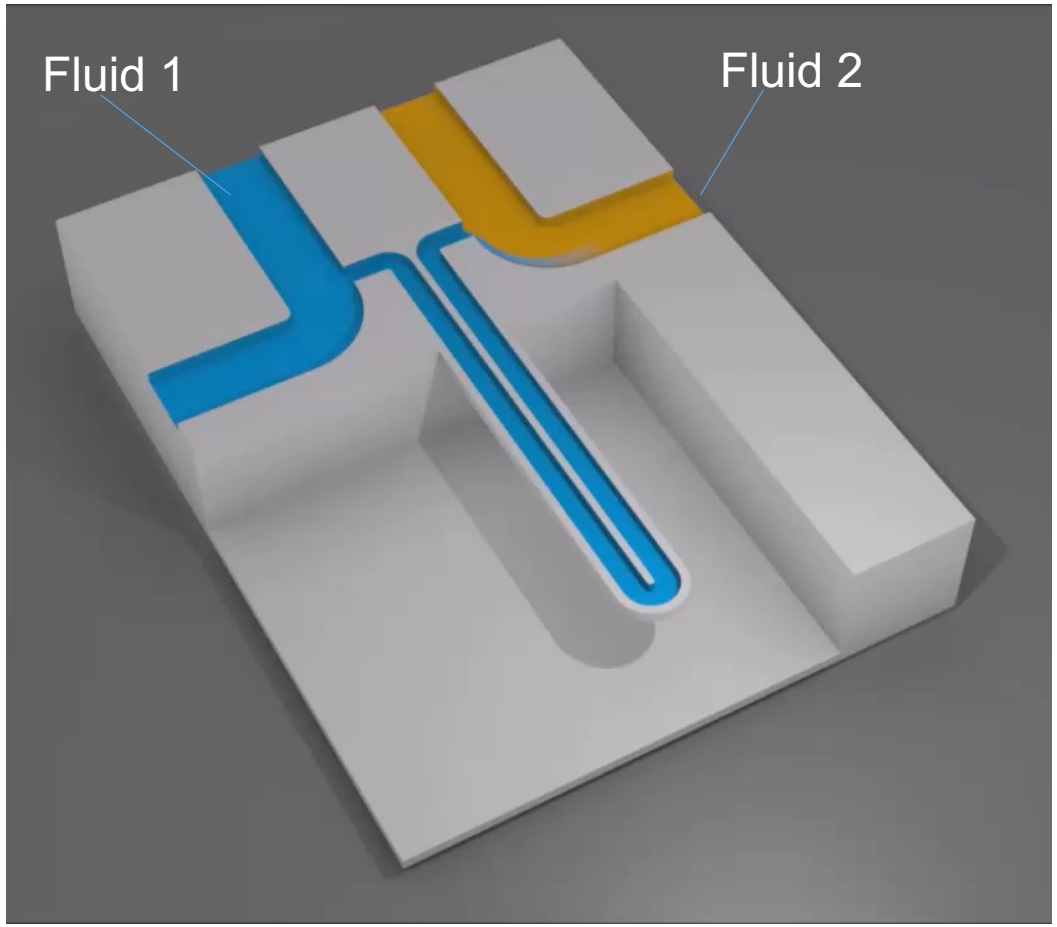


Stiffness



Bioenergetics

Fluid exchange and applying Archimedes' principle



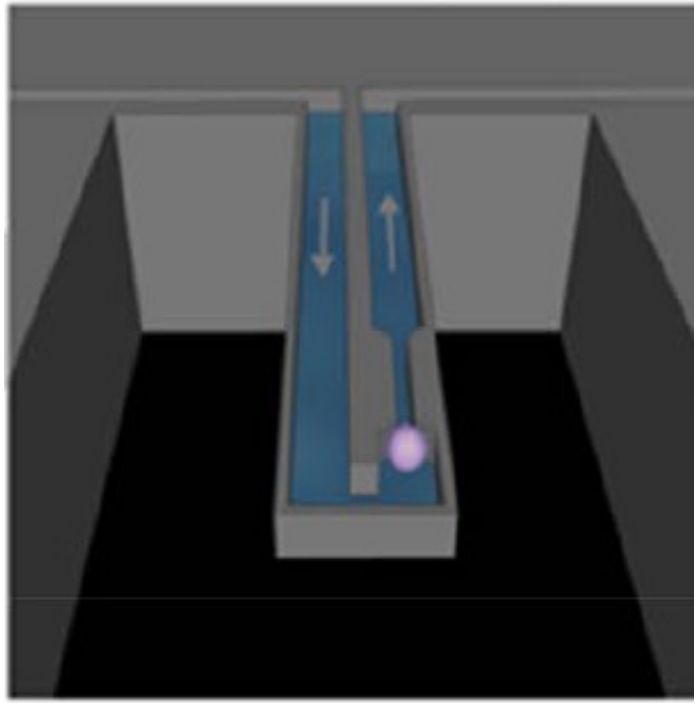
$$\text{Buoyant mass } \mathbf{1} = \text{Cell volume} \times (\text{cell density} - \text{fluid } \mathbf{1} \text{ density})$$

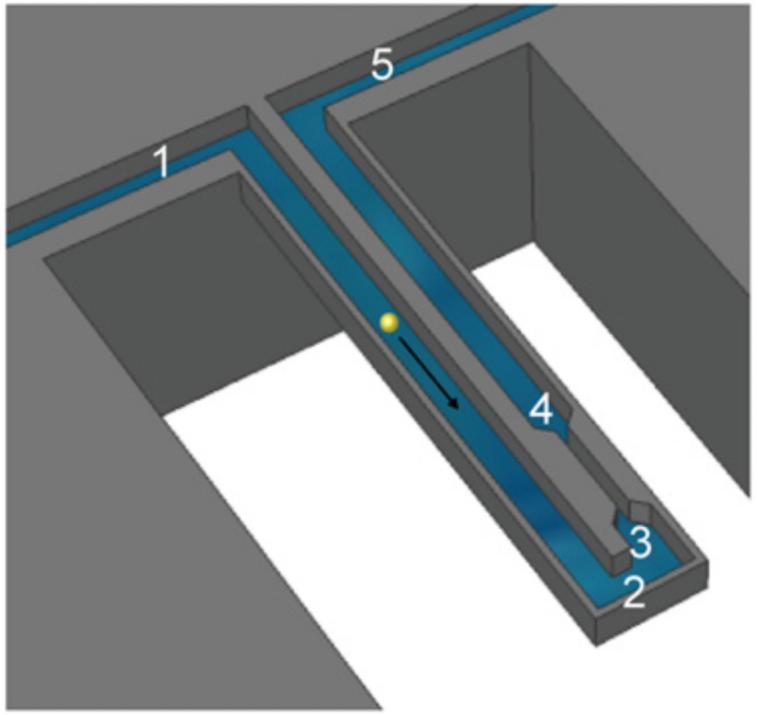
$$\text{Buoyant mass } \mathbf{2} = \text{Cell volume} \times (\text{cell density} - \text{fluid } \mathbf{2} \text{ density})$$

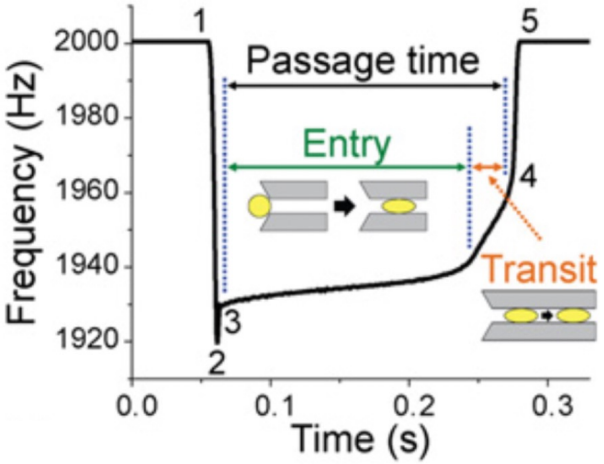
→ Volume & density

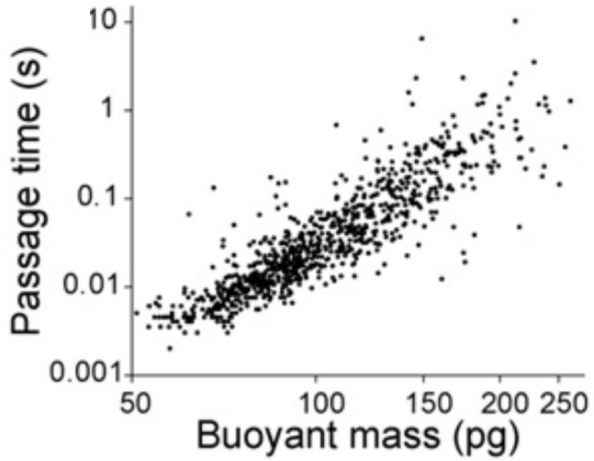
Grover*, Bryan* et al. *PNAS* (2011)

SMR with constriction mechanically squeezes cell





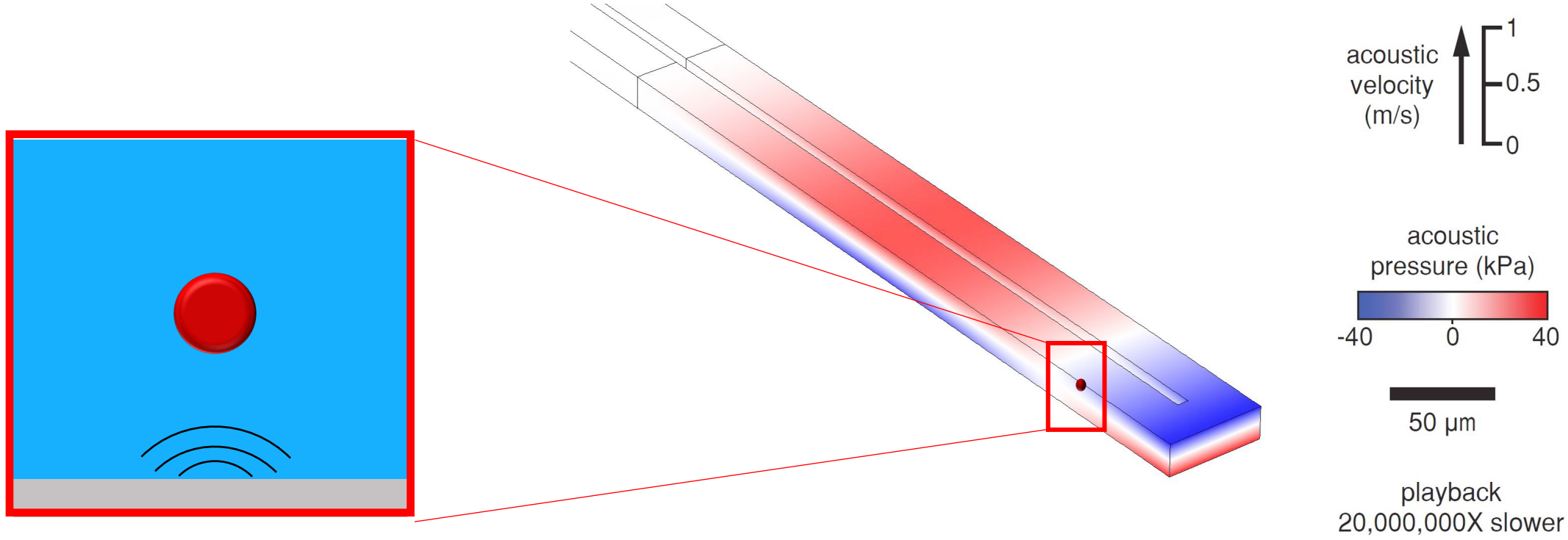




Deformability & Friction

Byun et al. *PNAS* (2013)

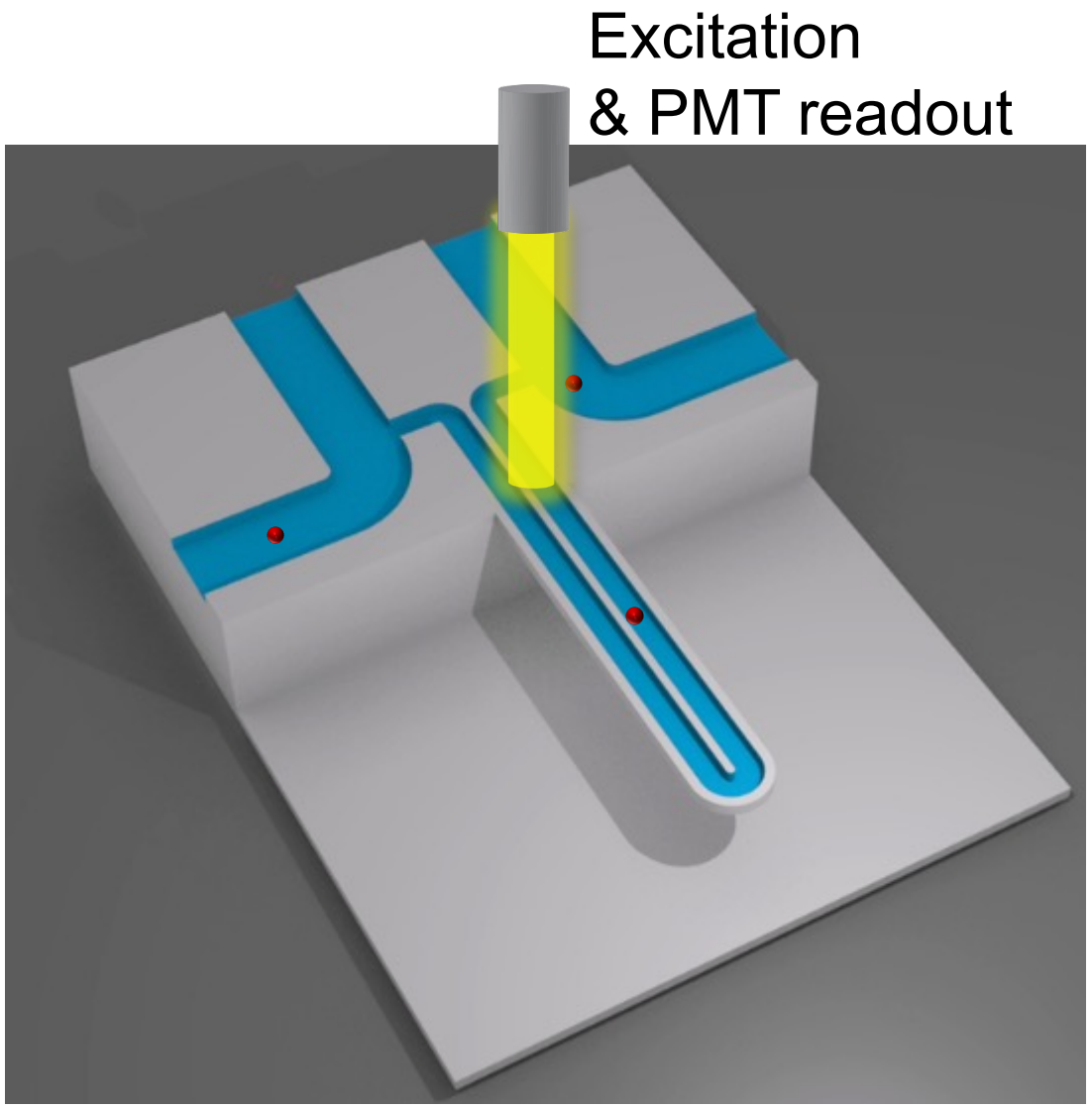
Cells' mechanical response to acoustic standing waves indicate cell stiffness

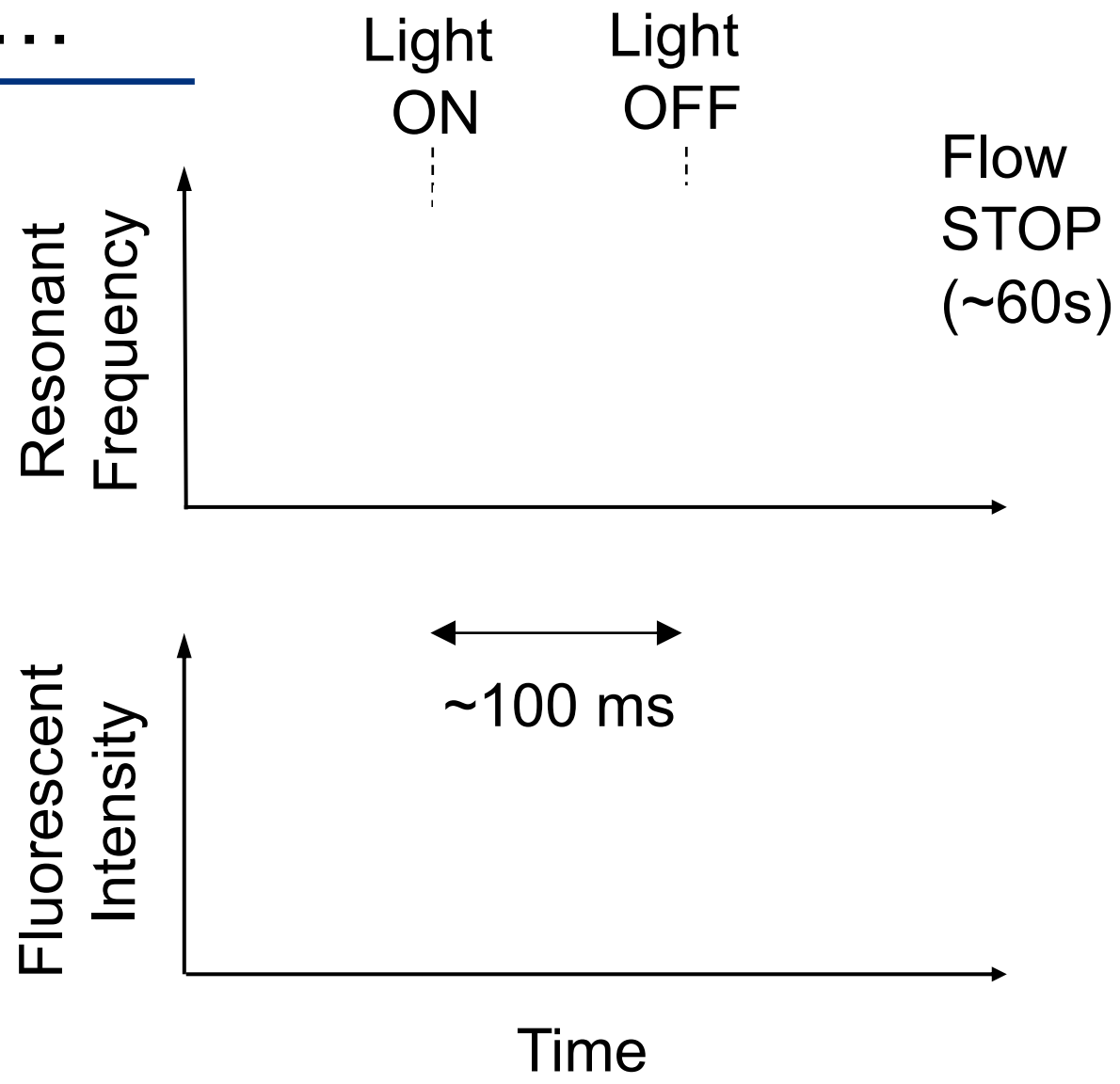


Acoustic scattering

Kang et al. *Nat. Methods* (2019)

Mitochondrial membrane potential of single cells can be precisely monitored…



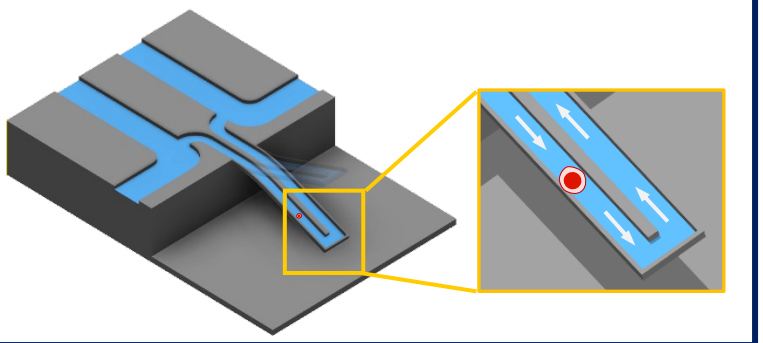


Kang et al., *Nat. Commun.* 2020

Combining SMR with Machine Learning

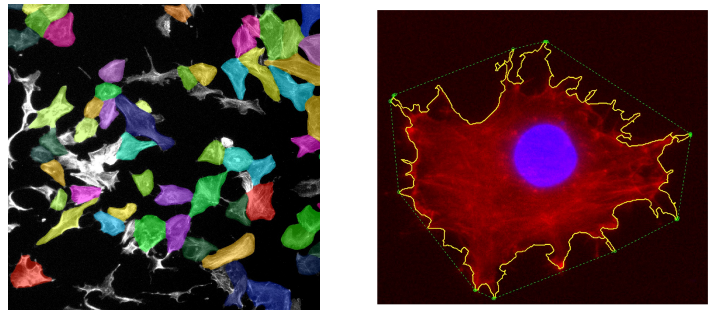
Bioinstrumentation and Biosensing for precision healthcare

Research overview



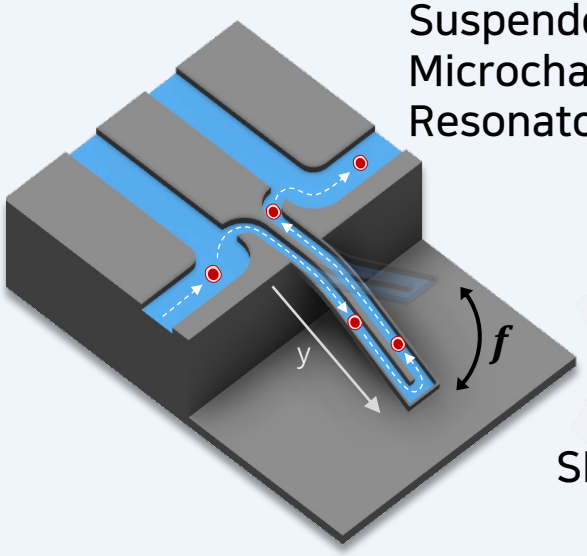
Mechanical biosensors:
Microfluidic resonator for measuring single-cell physical properties

+



Single-cell analysis:
Computational modeling and
AI powered methodologies

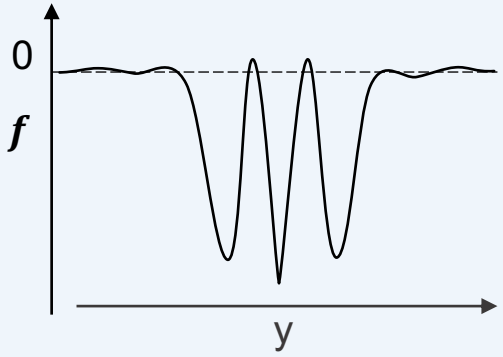
Clustering individual cells based on **Machine learning** assisted frequency response analysis



Suspended Microchannel Resonator (SMR)

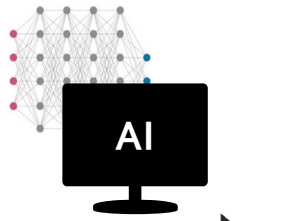
SMR frequency

Single-cell biophysical measurements

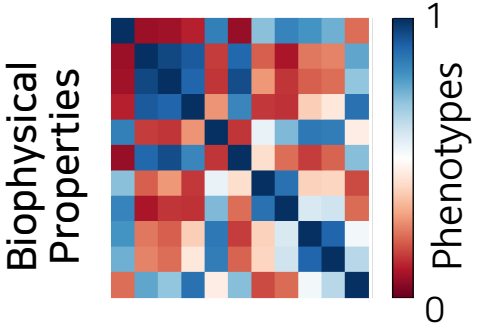


- **High-precision (<0.1 pg)**
- **>10 cells / second**
- **Label-free and Non-invasive**

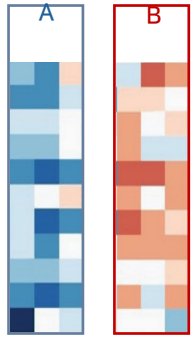
Bioenergetics, Mass, Viscosity, Deformability, Volume, Density, Stiffness

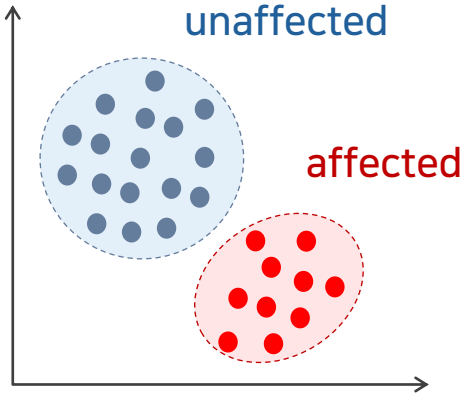


Biophysical Properties



Single-cell level cell state analysis



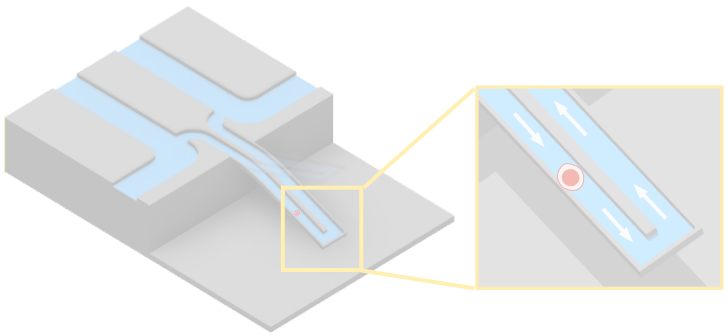


Research area

Bioinstrumentation and Biosensing for precision healthcare

Research overview

Measurement parameters:
3D morphology (height, volume of adherent cells/tissue)



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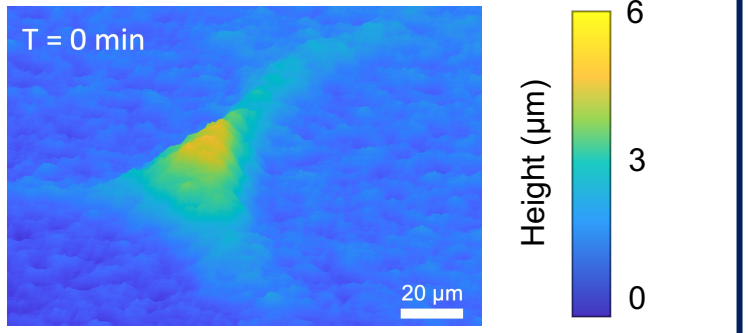

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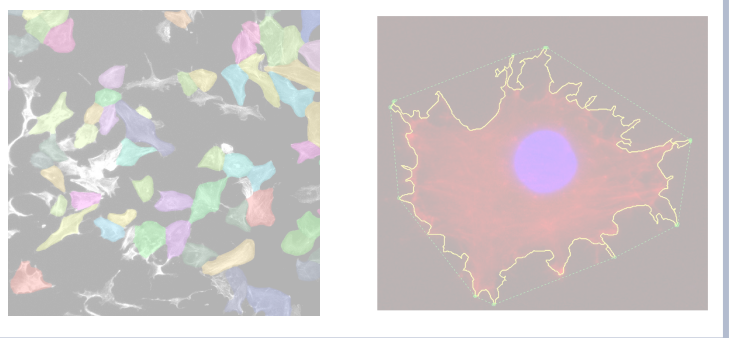

Single-cell analysis:
Computational modeling and AI powered methodologies

EU-Horizon calls we are interested in..

- HORIZON-HLTH-2025-01-TOOL-01: Enhancing cell therapies with genomic techniques
- HORIZON-HLTH-2025-01-TOOL-05: Boosting the translation of biotech research into innovative health therapies

….

But hopefully many more on ‘DISEASE’ and other ‘TOOL’ secitions…!

We would offer ‘label-free’, ‘high-throughput’, ‘versatile’ and ‘reliable (high precision)’ measurements for

- Overall cell quality control’,
- Novel cell type or subtype identification
- Disease diagnosis and treatment response

Thank you