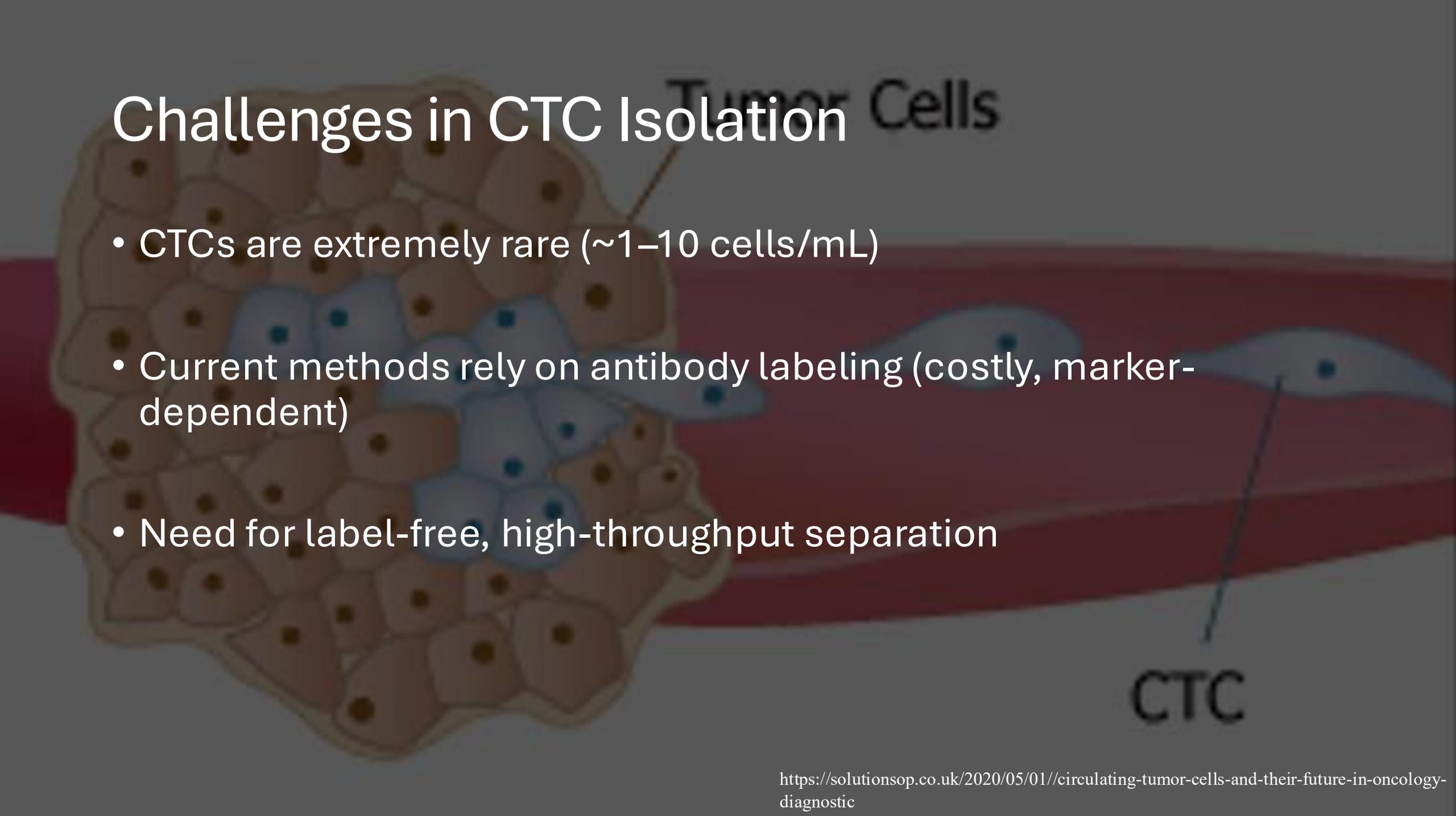# Dual-Field Microfluidic Chip for Label-Free CTC Isolation

Integrating Inertial Focusing and Acoustophoresis

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Culver Academies

Challenges in CTC Isolation

- CTCs are extremely rare (~1–10 cells/mL)

- Current methods rely on antibody labeling (costly, marker-dependent)

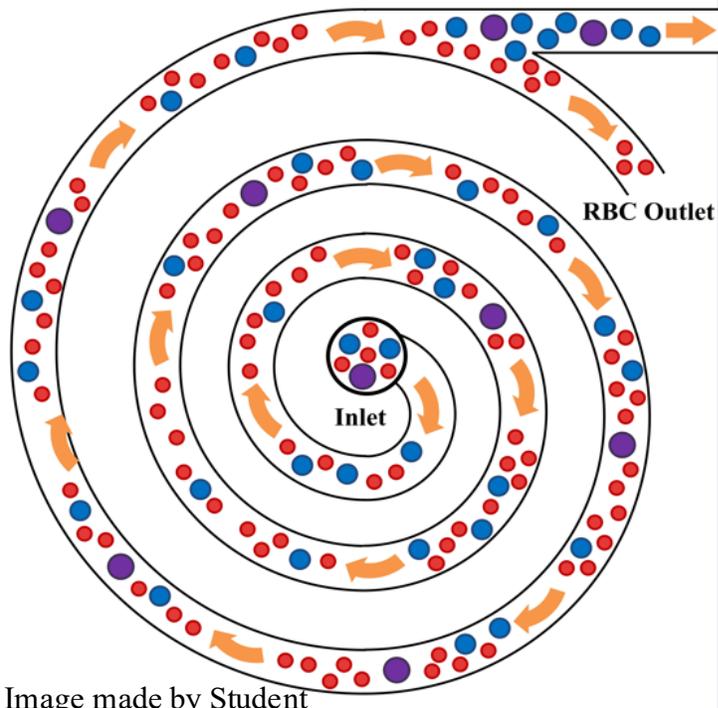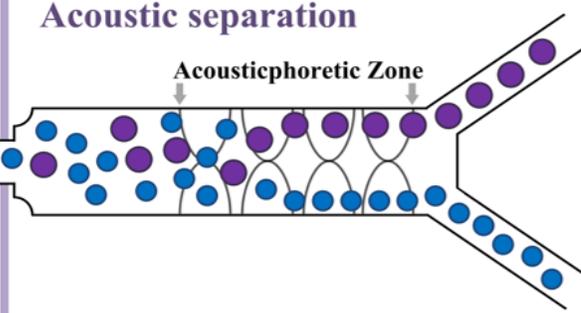- Need for label-free, high-throughput separation

Inertial separation

Acoustic separation

Acousticphoretic Zone

RBC Outlet

Inlet

Image made by Student

- RBC (red blood cell): 6-8
- WBC (white blood cell):
- CTC (circulating tumor

- Combine inertial microfluidics + acoustic separation

- Sequential, dual-field design

- Add anti-adhesion strategy

- Sequential physical separation improves both efficiency and stability.

Engineering Approach

Chip Design Overview

- Spiral channel (inertial)
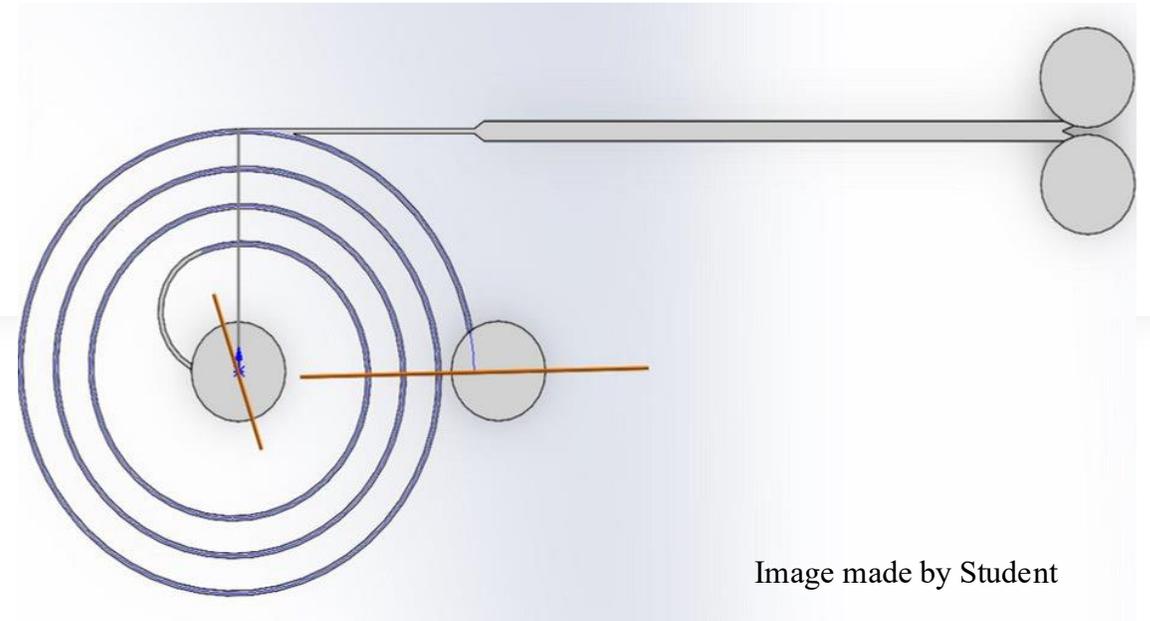
- Straight channel (acoustic)

- PZT transducer

- Outlet

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Stage 1: Inertial Focusing

$$Re = \frac{\rho U D_h}{\mu}$$
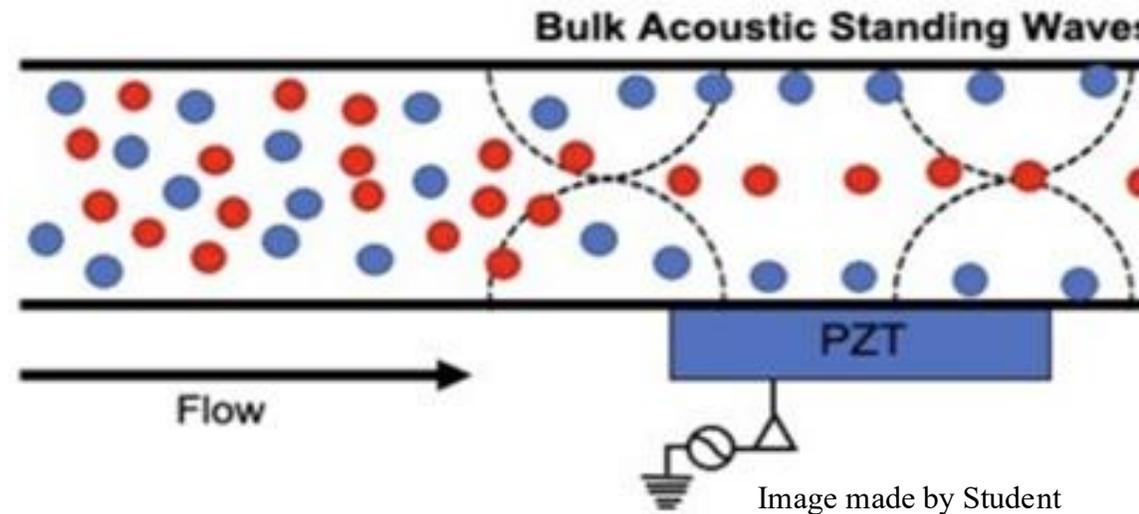
- Dean flow in spiral channel

- Size-dependent lateral migration

- Larger particles move toward equilibrium positions
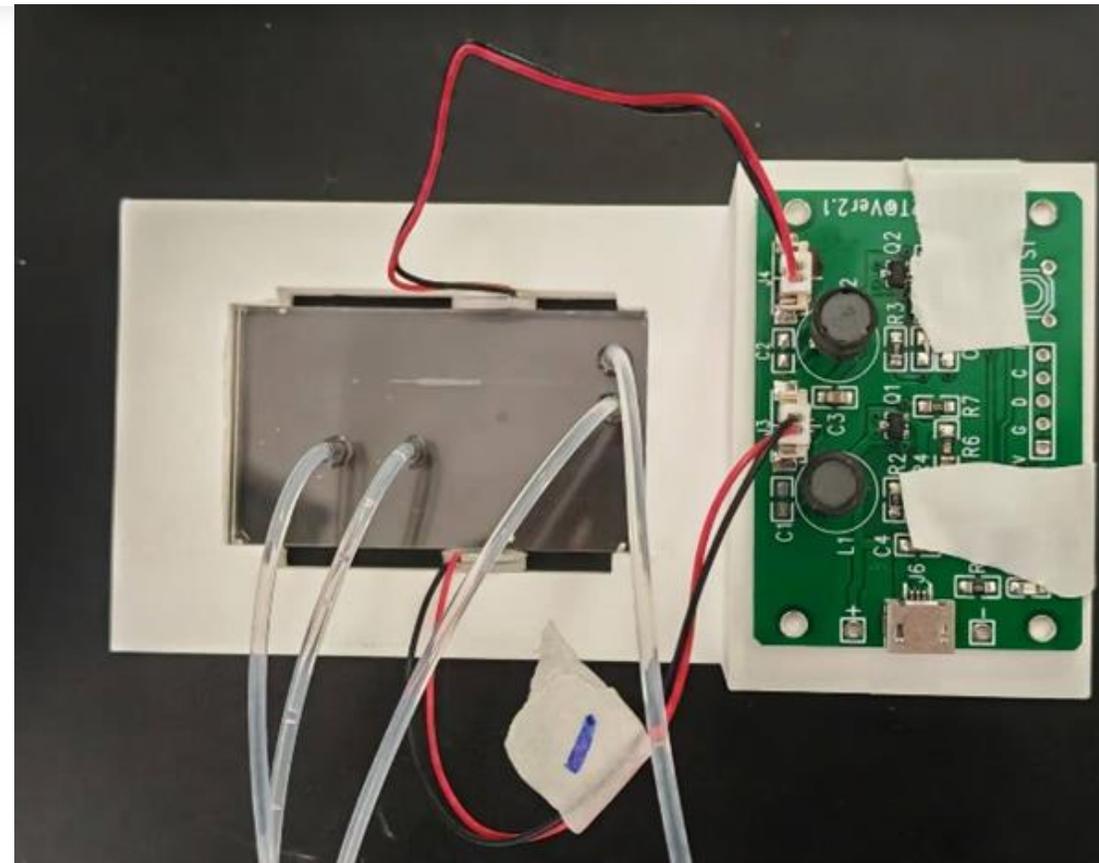
- Lift force $\propto$ particle size^4

Image made by Student

$$F_L \propto \rho U^2 a^4 / D_h^2$$

Stage 2: Acoustic Separation

Bulk Acoustic Standing Wave
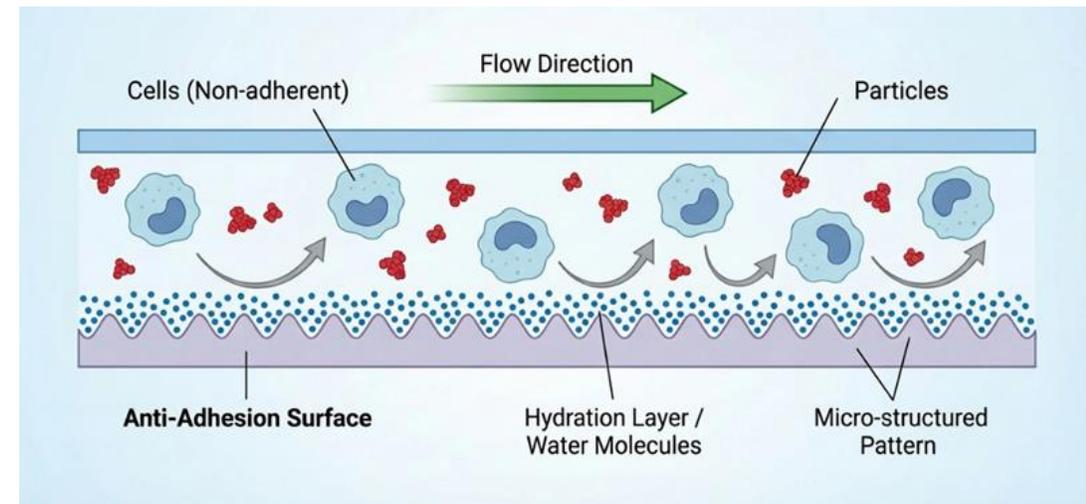
PZT

Flow

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- Standing wave field

- Acoustic radiation force

- Larger particles migrate to pressure nodes

Anti-Fouling Strategy

- SiO_2 micropillar structures

- PEG coating

- Reduces particle-wall adhesion

- Improves long-term stability

Experimental Results

- Inertial:
  - 96% enrichment
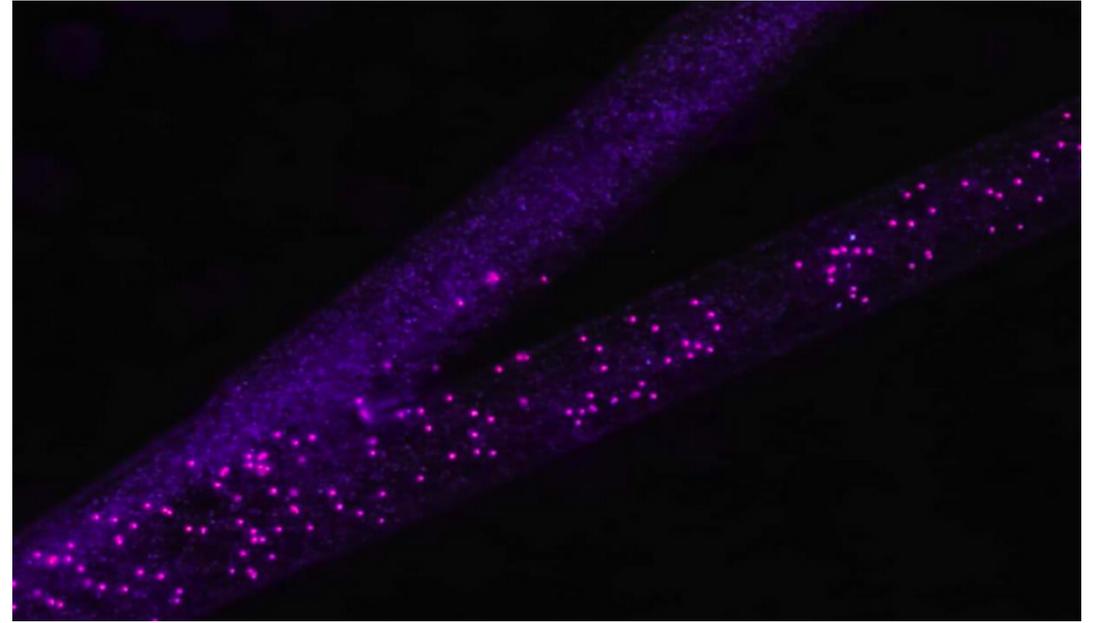 - Stable flow behavior

- Acoustic:
  - OFF → mixed distribution
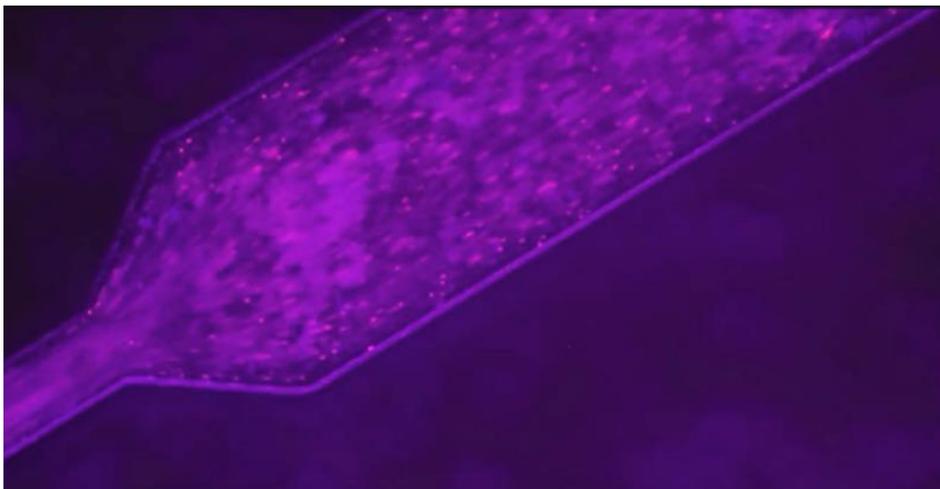 - ON → clear focusing
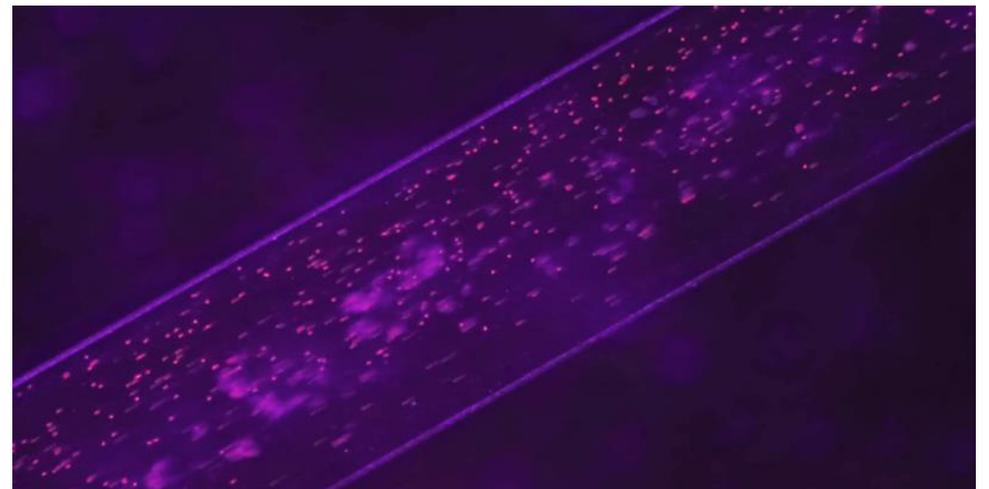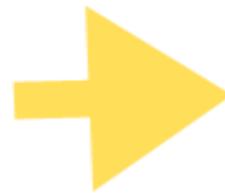

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Limitations & Future Work

- No live-cell validation yet

- Need statistical analysis (larger sample size)

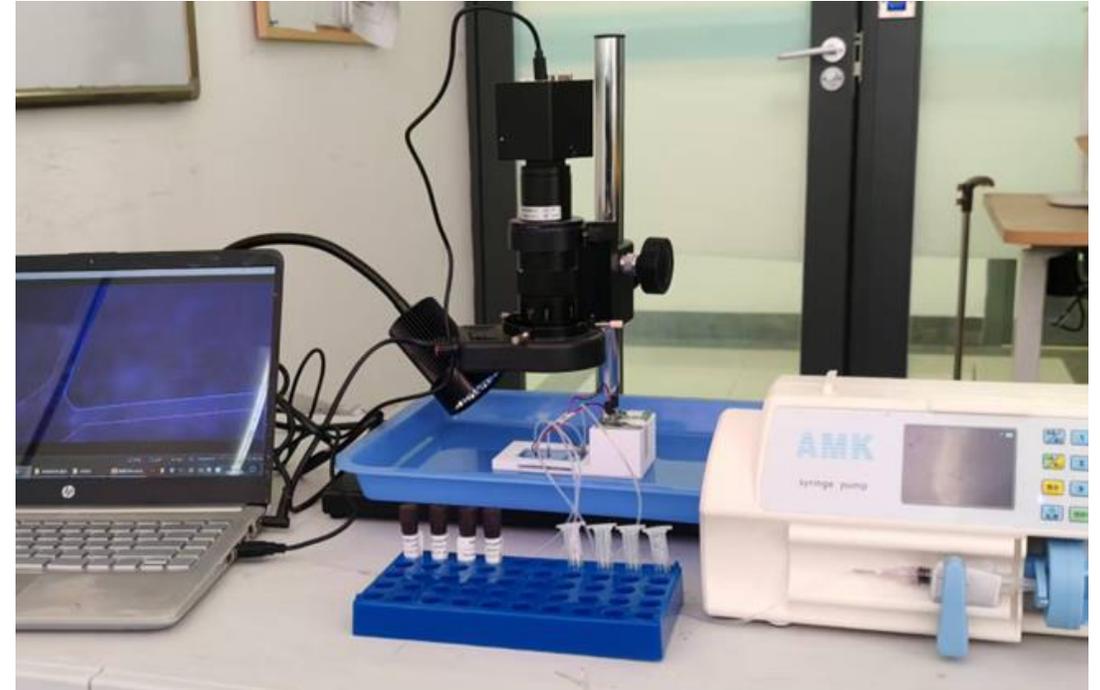- Optimize acoustic parameters

- Future: clinical testing

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Conclusion & Impact

- Label-free separation platform

- Scalable, cost-effective
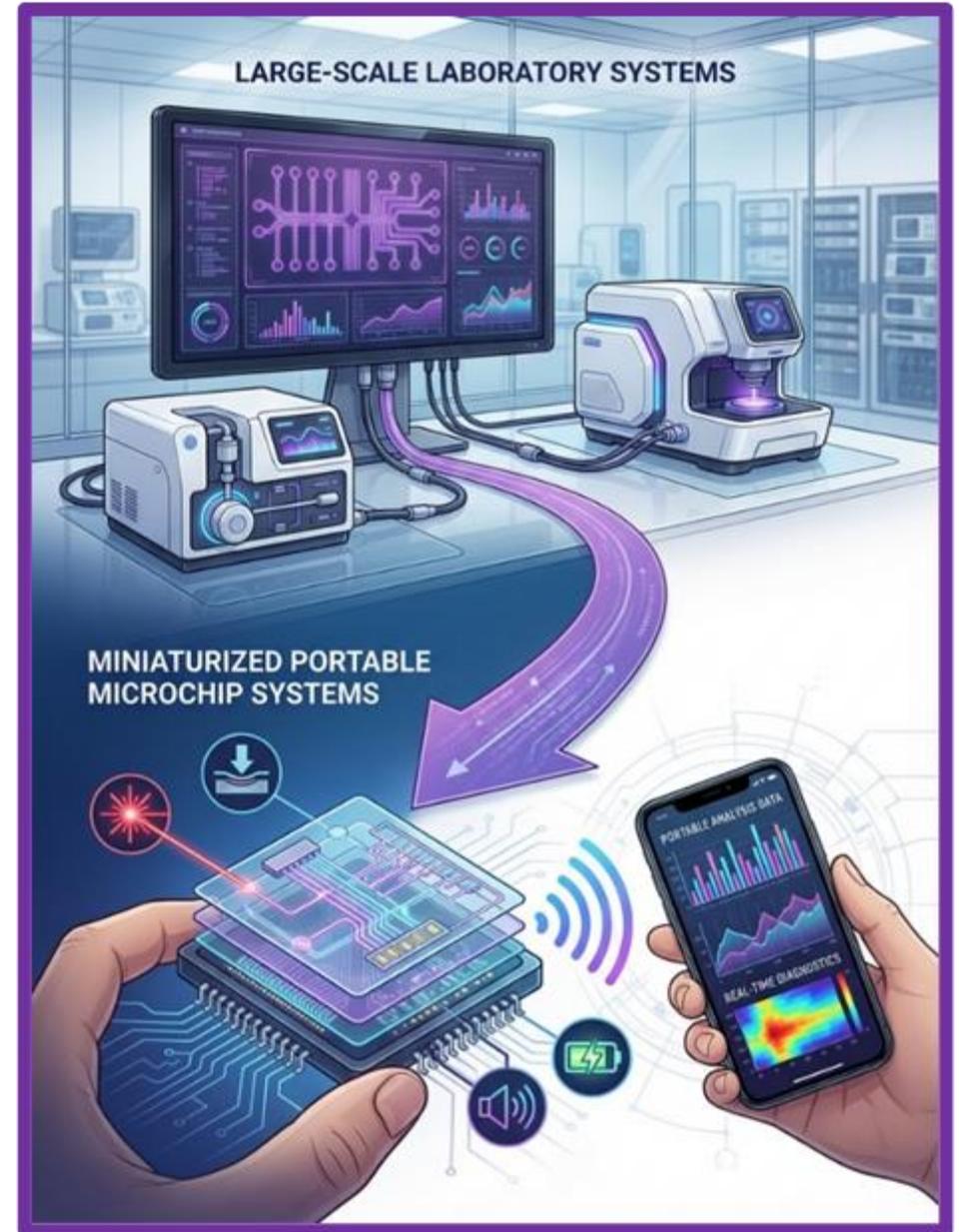
- Potential for precision medicine

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