

# **Capture and enrichment of bacteria using acoustic forces**

Martyn Hill

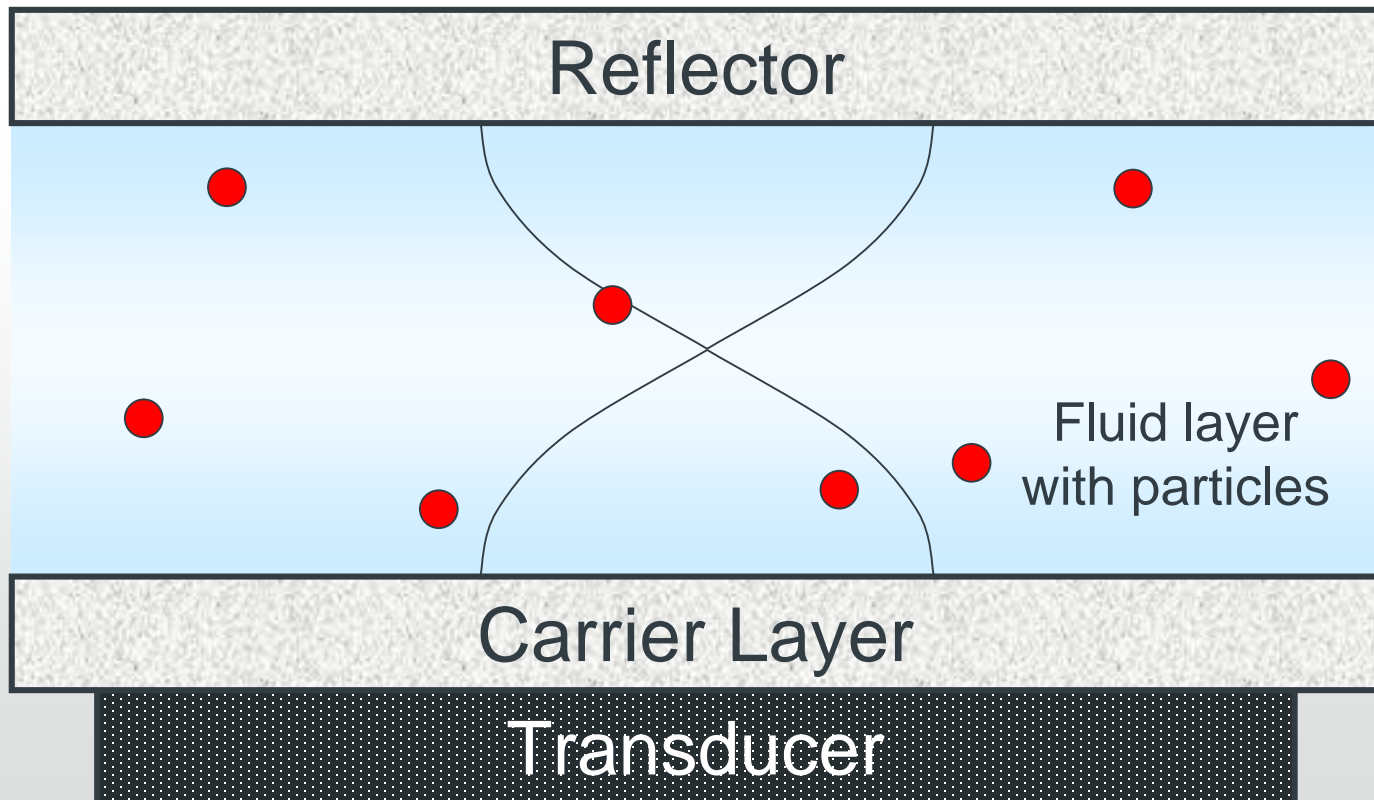
5 March 2018

# Outline

- Background
- Applications:
  - cell concentration
  - assay enhancement:
    - bead-based assays
    - surface assays
  - cell imaging

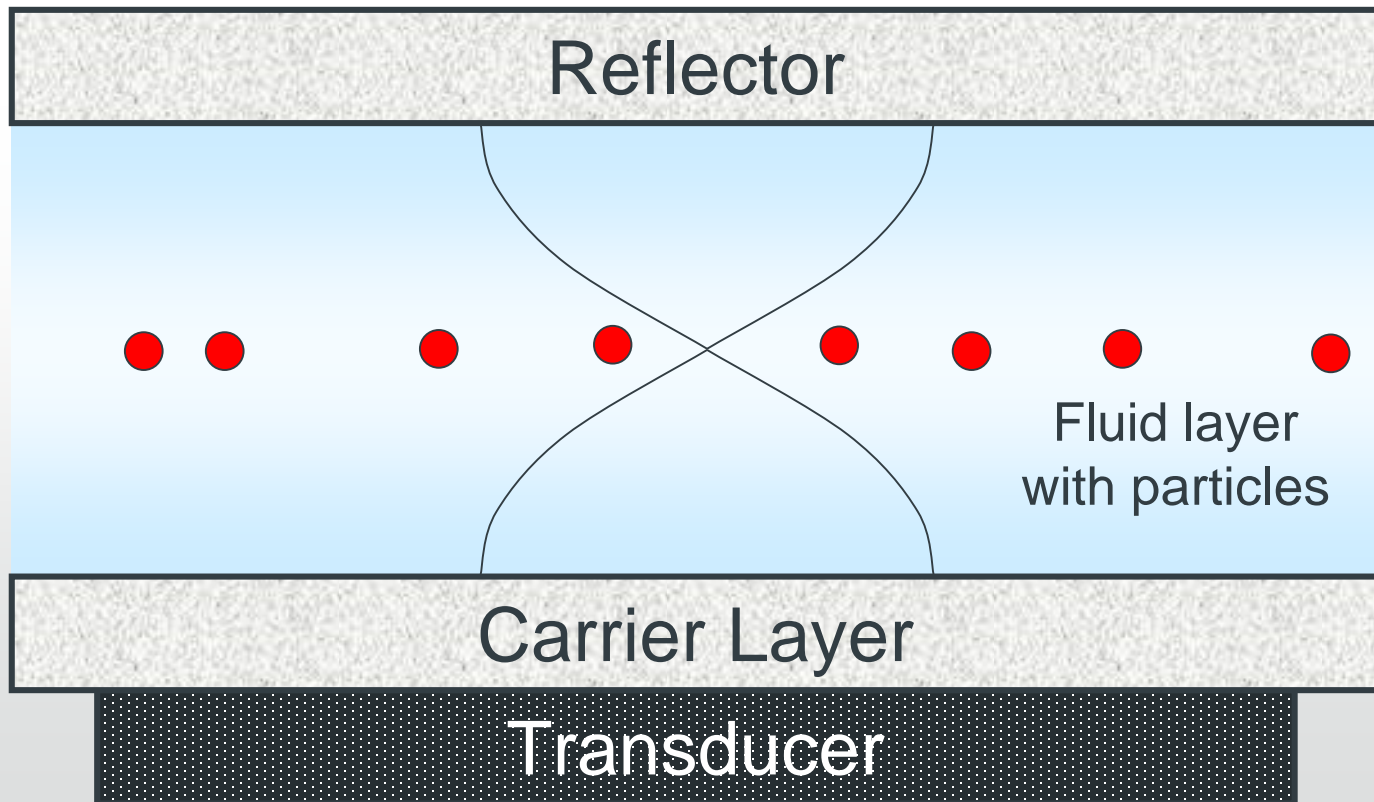
# Move cells into bands

- Layered resonator approximating a 1D resonance
- Acoustic pressure gradients provide axial forces



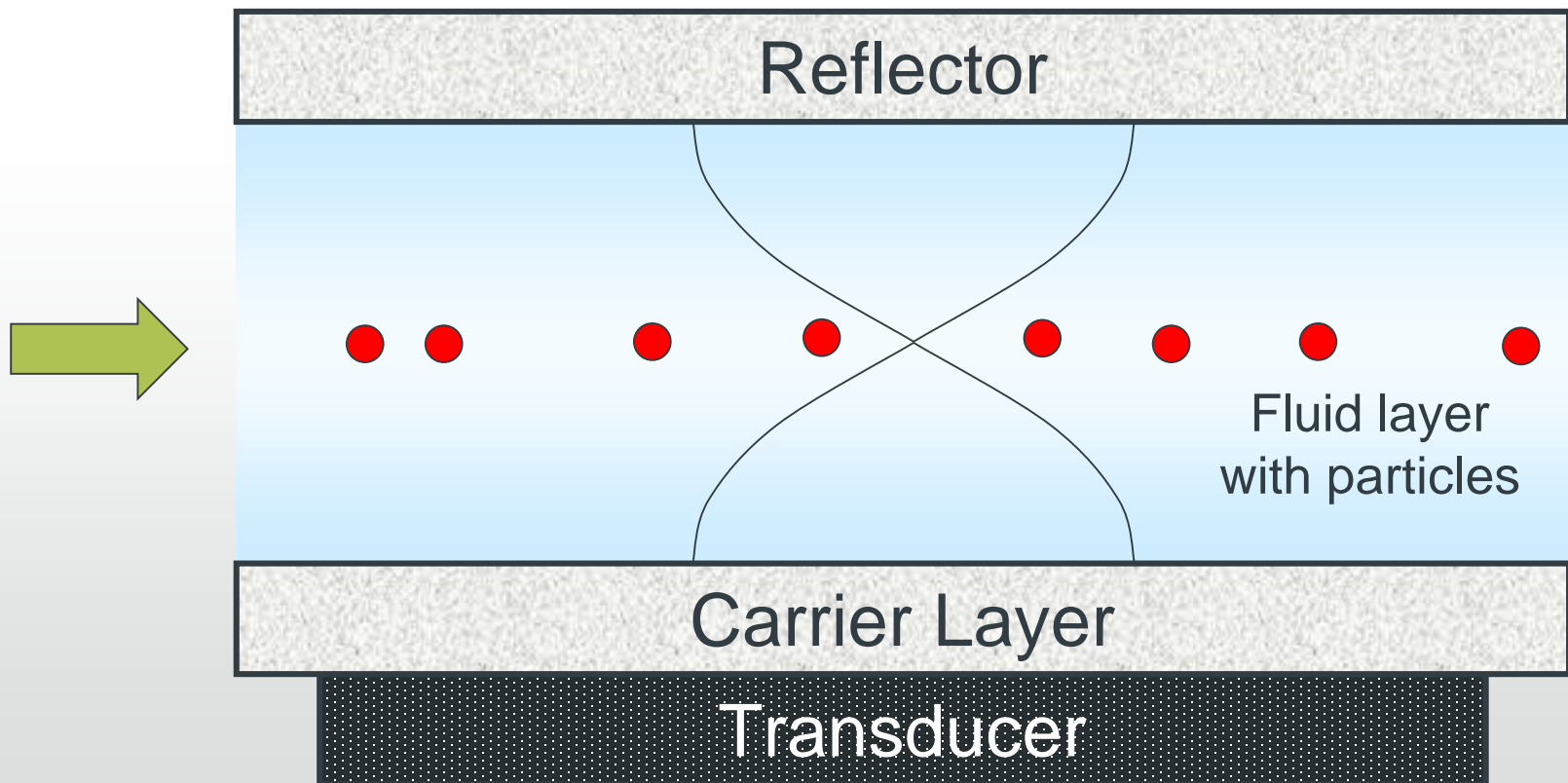
# Move cells into bands

- Particles/cells move to pressure node



# Move cells into bands

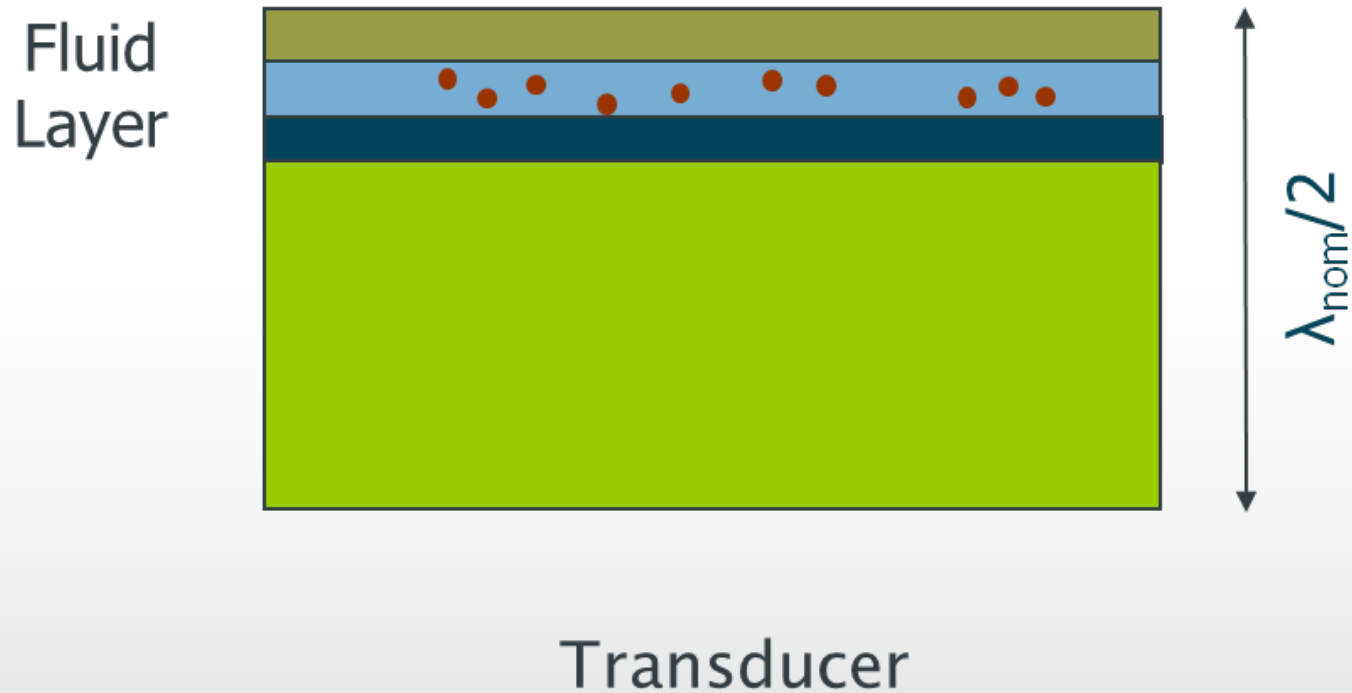
- Looking from side



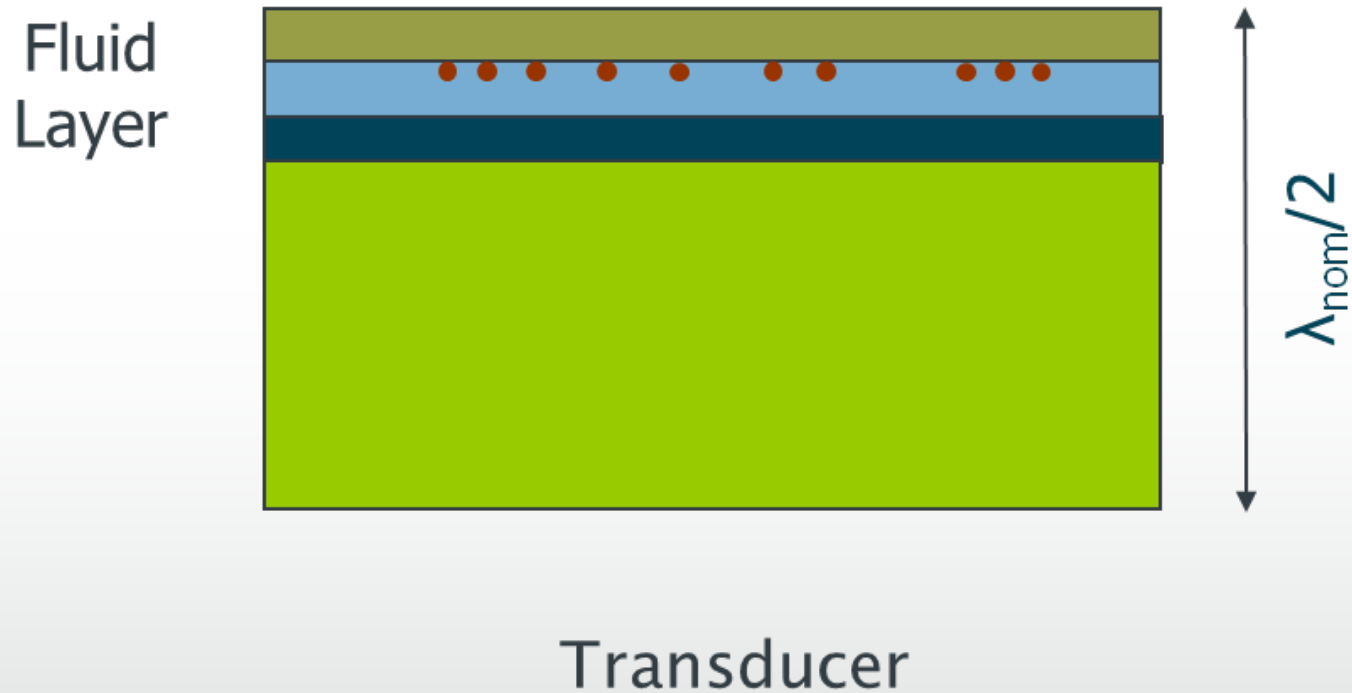
# Axial forces on *Euglena* micro-organisms



# Move cells to a surface



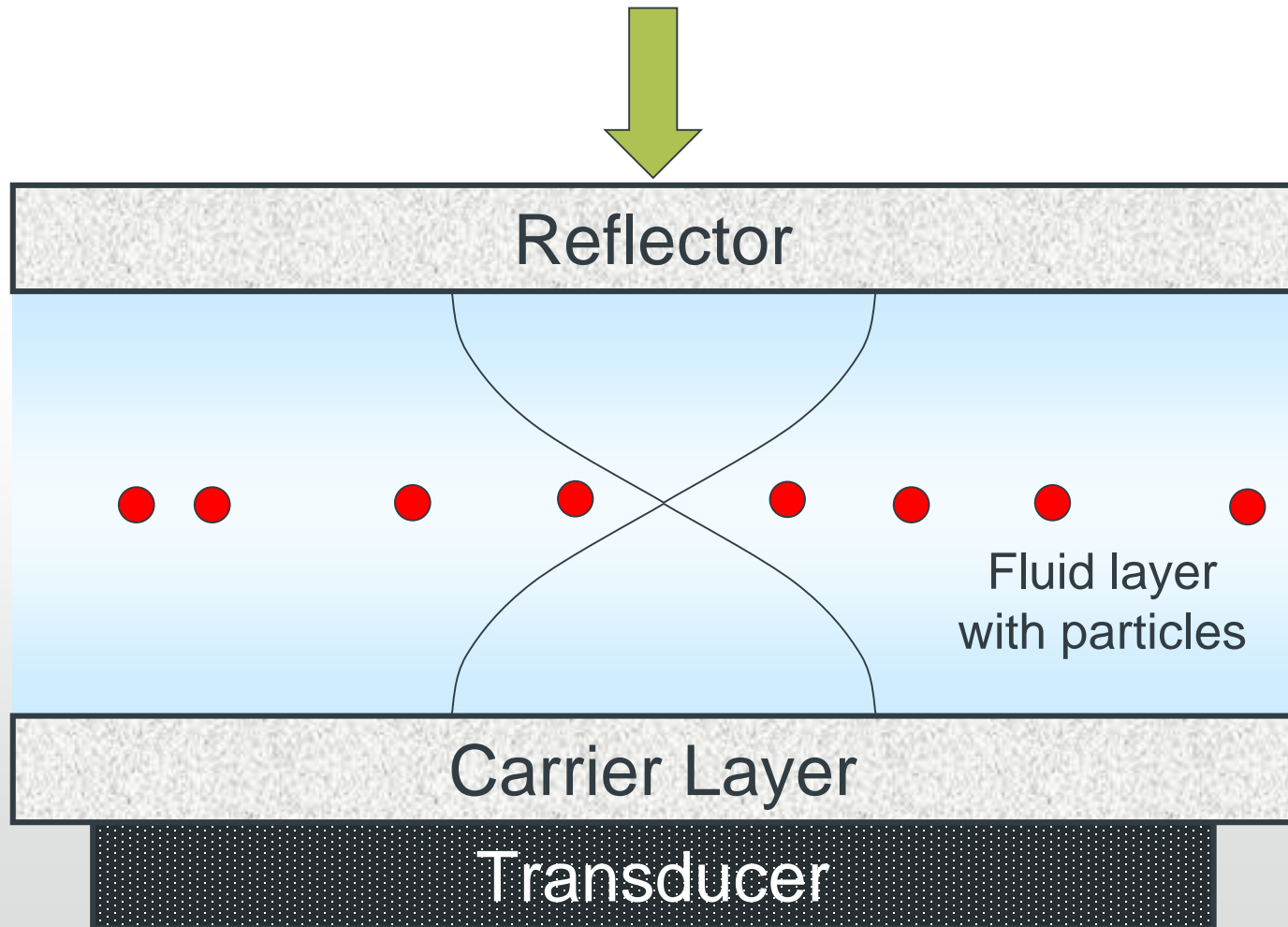
# Move cells to a surface





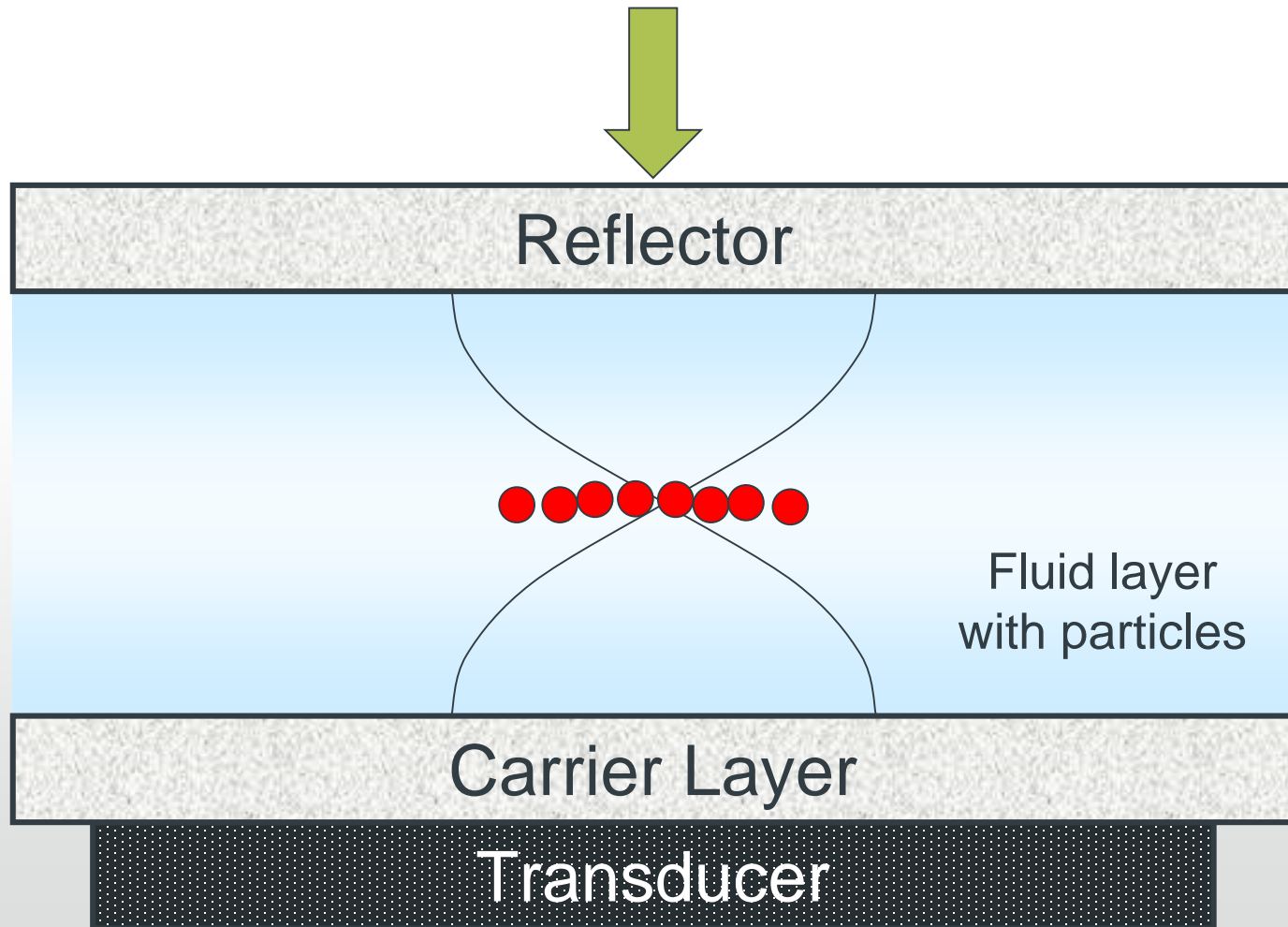
# Bring cells together

- Looking from above

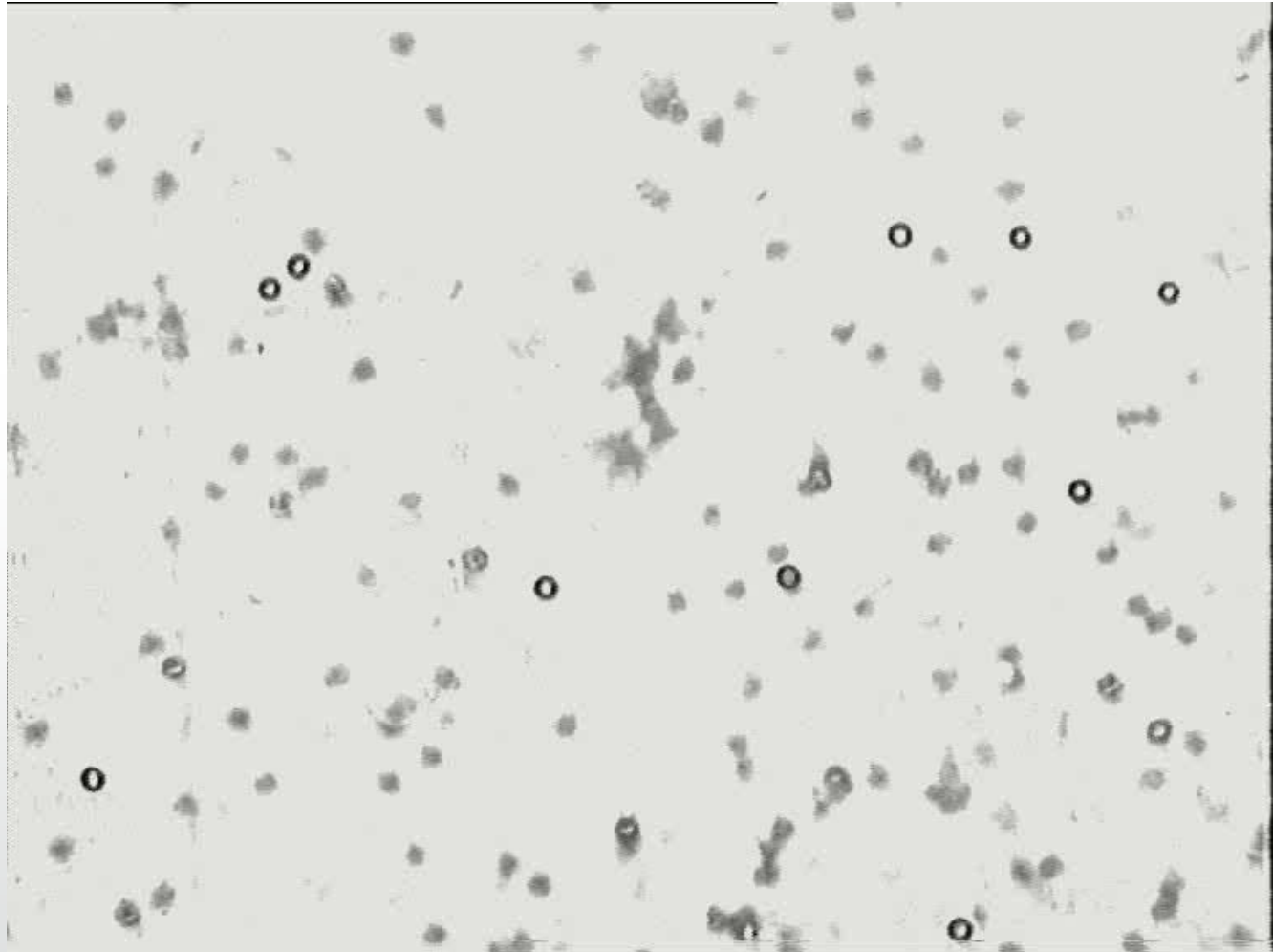


# Bring cells together

- Looking from above



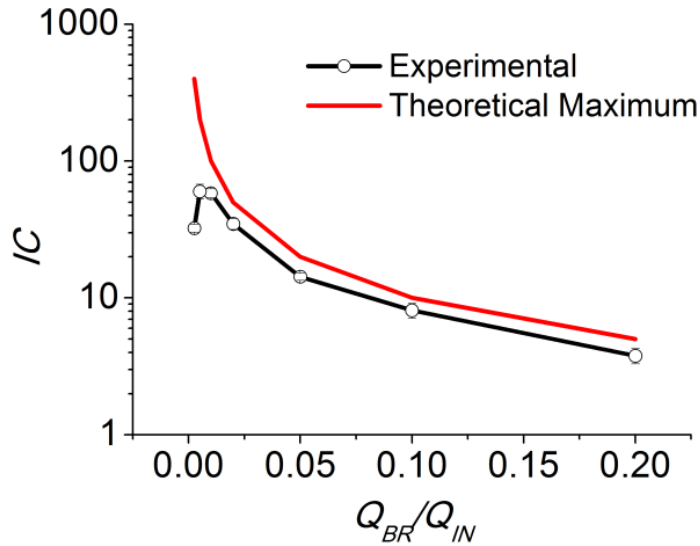
# Lateral movement of levitated beads



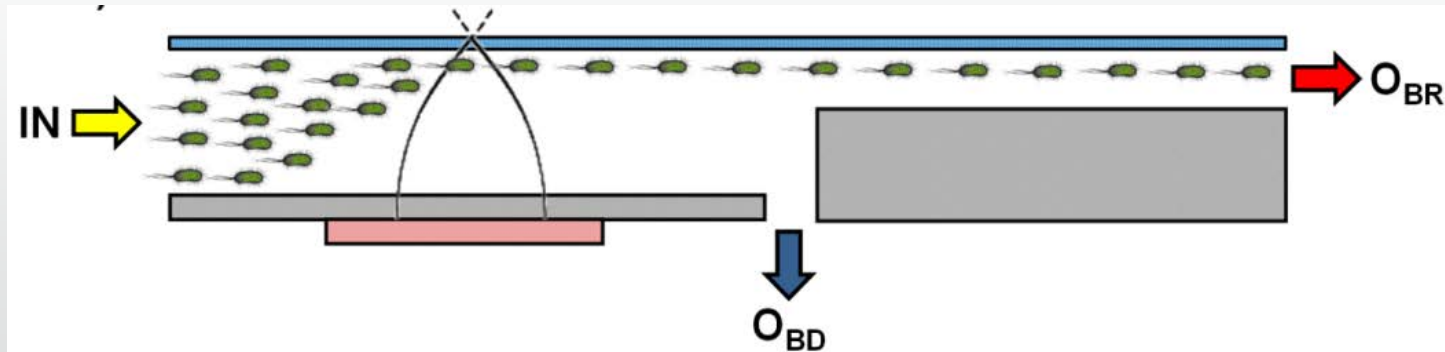
*With permission of Coakley and Hawkes*

# Applications: concentration.

# Bacterial concentration

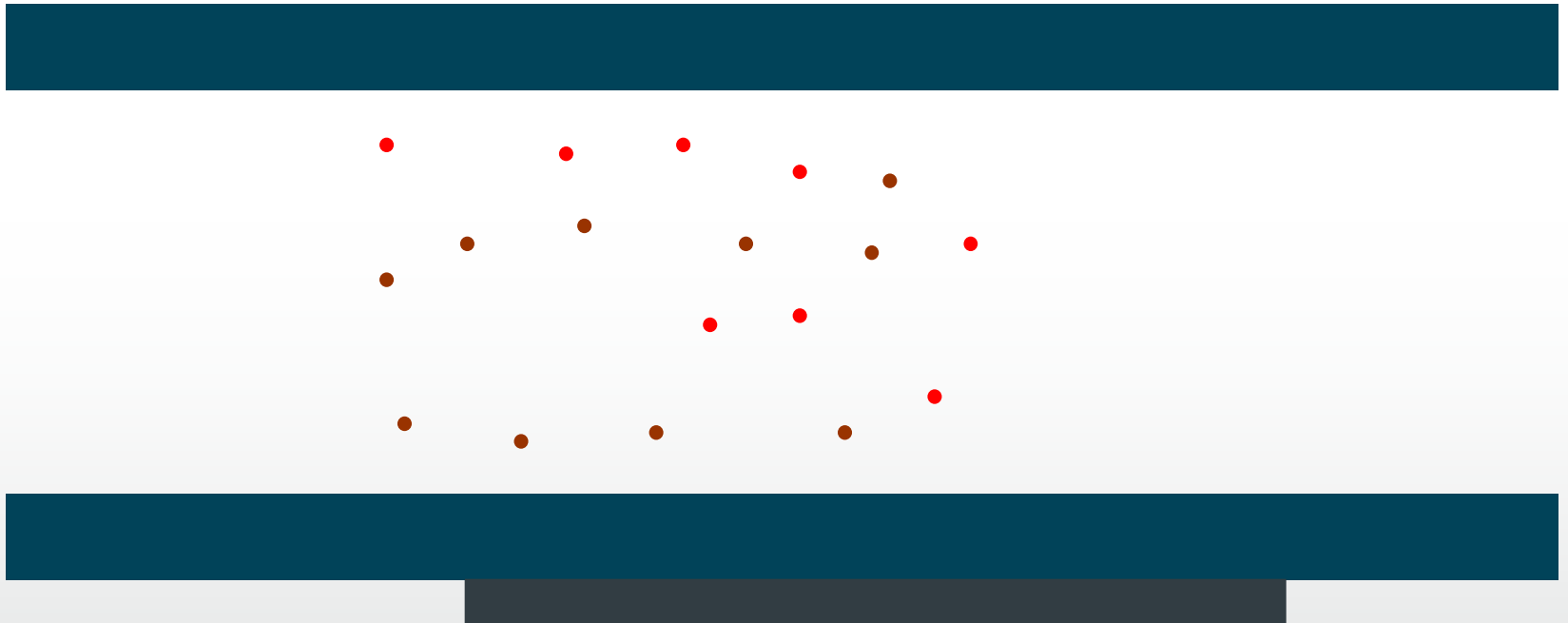


- $Q_{IN} = 20$  ml/h
- $C_{IN} = 10^4$  CFU/ml
- Max. concentration increase 60x
- Demonstrated with
  - *S. epidermidis*
  - *E. coli*

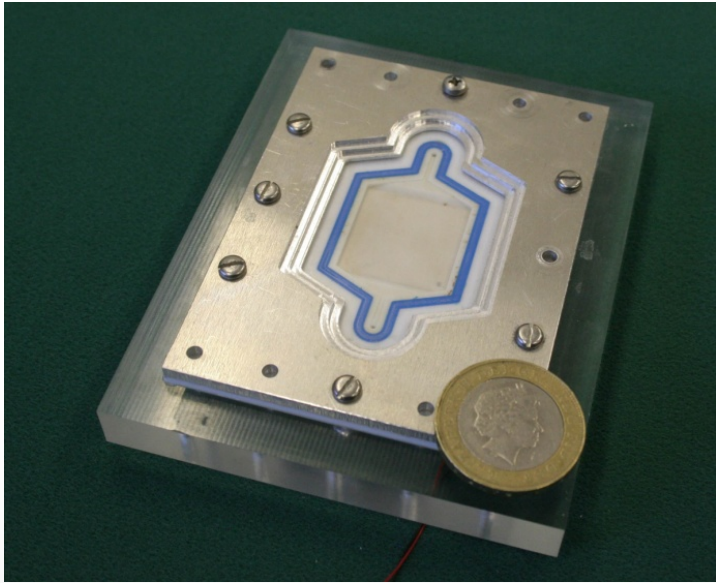


# Applications: bioassay enhancement.

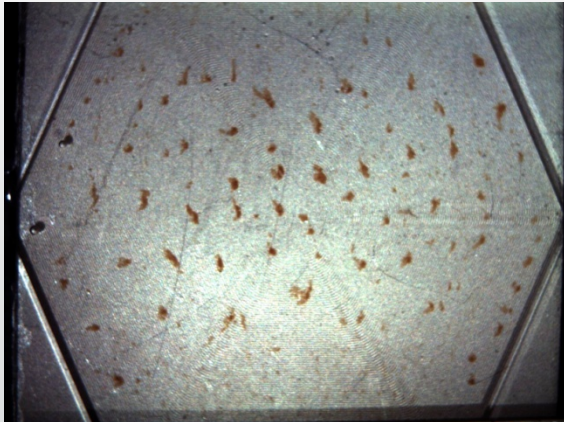
# Bead-based assays



# Enhancing bead assays



- Magnetic bead assay for TB detection
- Initial agglomeration improved
- Washing by cycling levitation & sedimentation
- Sample re-suspension and elution improved
- Low-cost polymer version

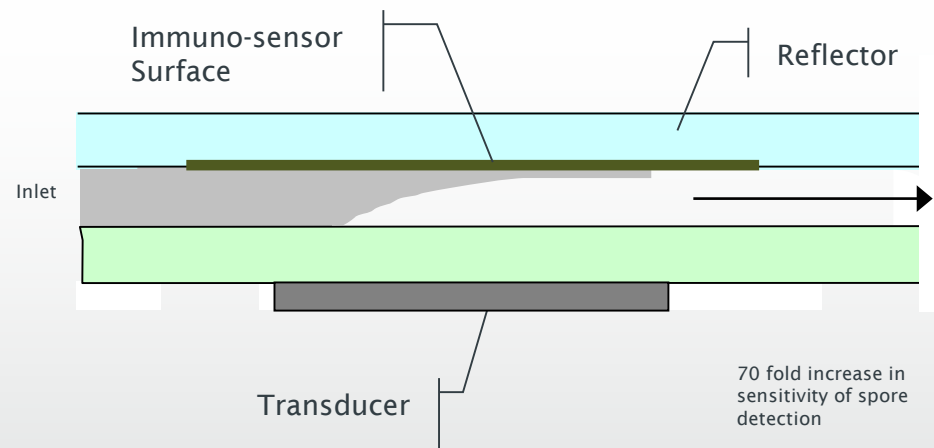




# Enhancing surface assays



- Increase transport to surface
- Reduce non-specific binding?

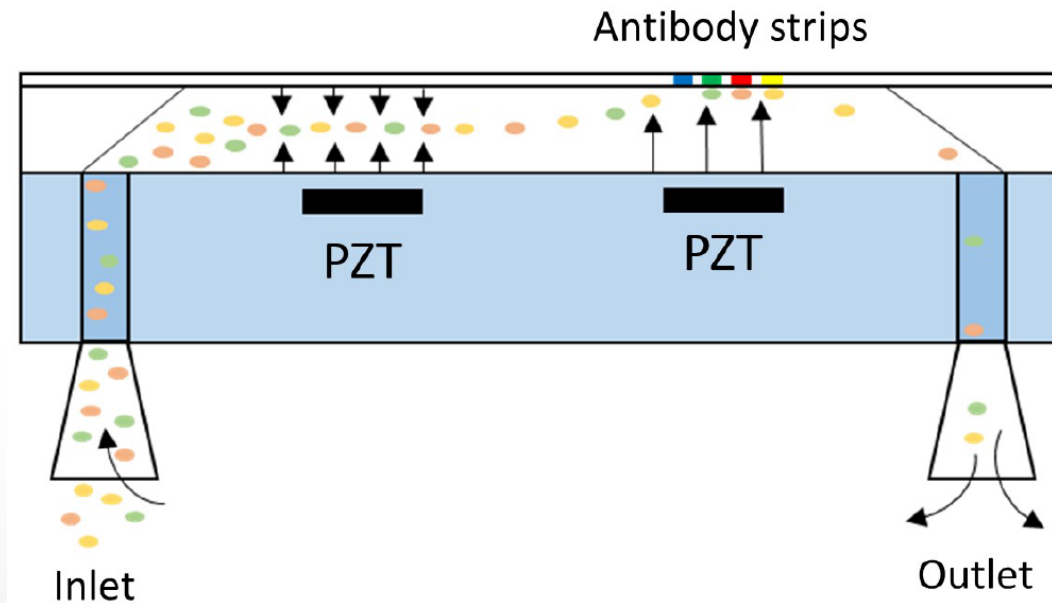


*Biosens & Bioelect, 2005*

*Analytical Sciences 2009*

*Ultrasonics, 2010*

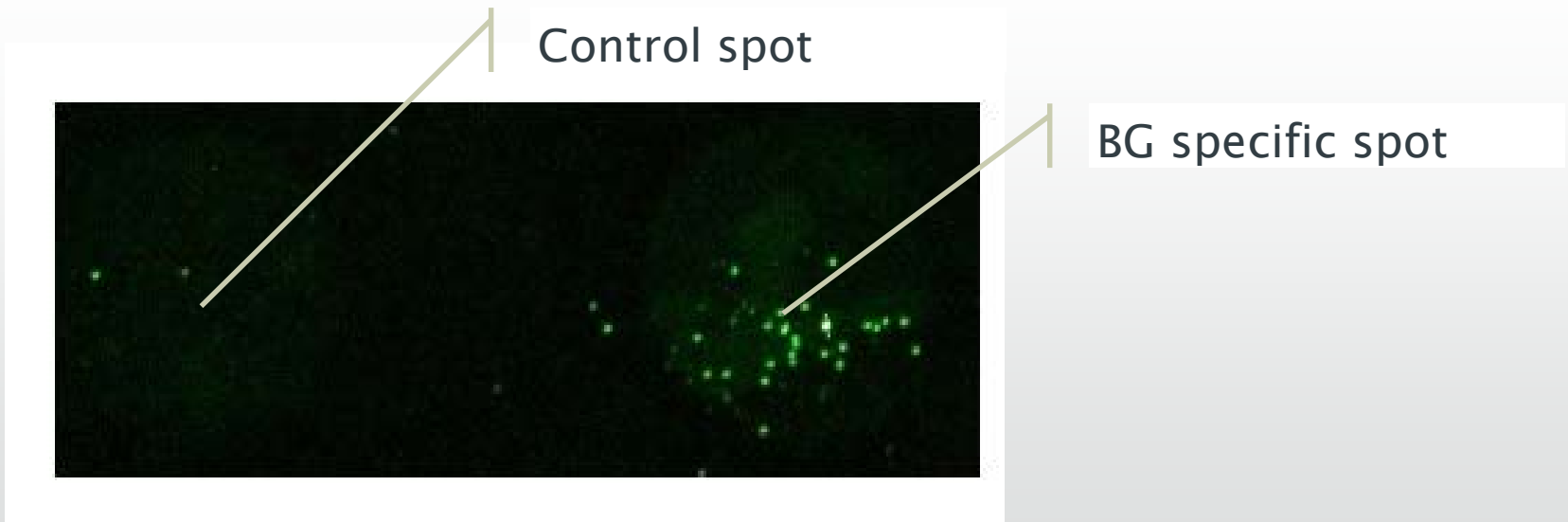
# Surface assays: bacterial spores



- Identification of aerosol-captured airborne spores
- Primary target anthrax detection
- Half-wave and thin reflector modes

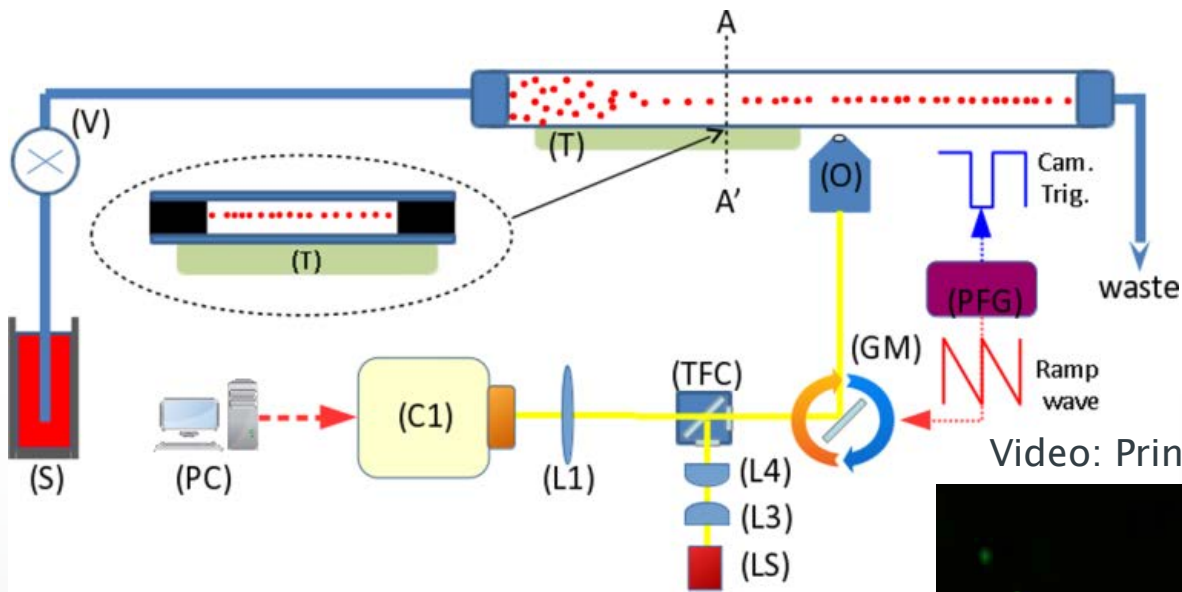
# Surface assays: bacterial spores

- Tested with 1  $\mu\text{m}$  beads and BG spores
- Bead capture  $\sim 95\%$  at 30 ml/hr
- BG capture at  $10^4$  spores/ml for 10 mins:



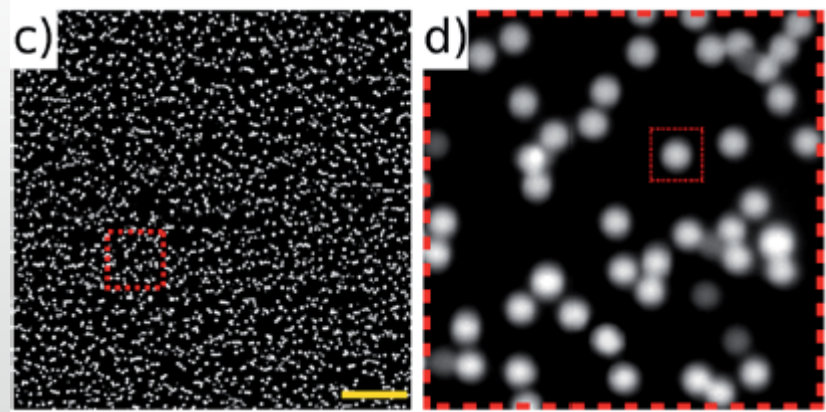
# Applications: cytometry

# Imaging cytometer for cancer cell detection

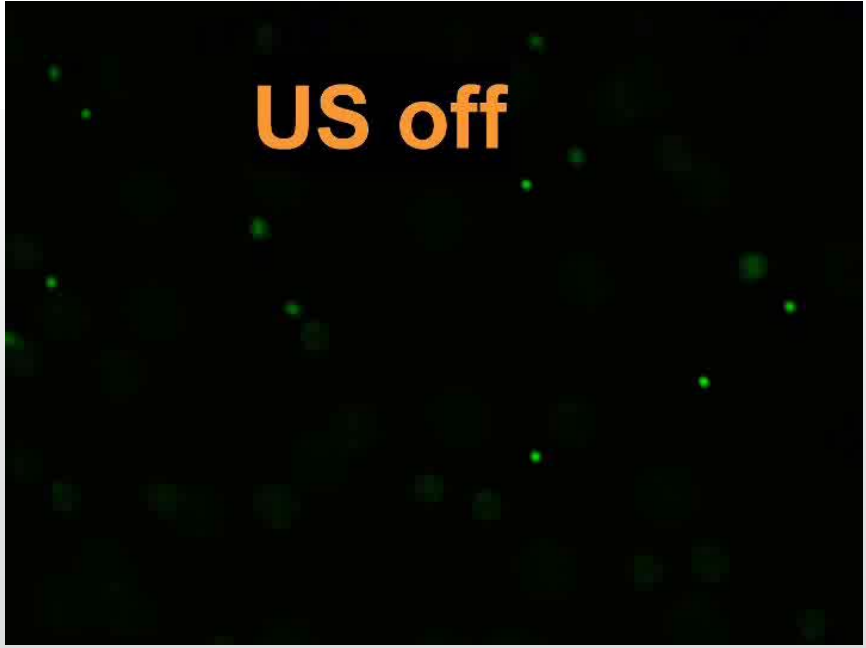


Zmijan *et al.*(2015). *RSC Advances*,

Video: Principle demonstrated with beads



Beads imaged at 200k beads/sec



# Cytometry with compression?

Mishra *et al.*(2014).  
*Biomechanics*,

Axial component  
of radiation  
force squashes  
cell

