John Glenn
Biomedical Engineering Consortium

Rapid Design and Simulation Tools for Space-Bound Biochip Devices
Status Report

Summary of Accomplishments During Last Quarter:

- Additional prototype simulations with CFD-ACE and FIDAP.
- Initiated new collaborative relationships with other NASA groups and biochip manufacturers.
- Identified specific areas where biochip devices can be of immediate use to NASA.
- Started working with CFDRC to develop a system-level model of a biochip device using the 1-D simulation capability of CFD-ACE+.

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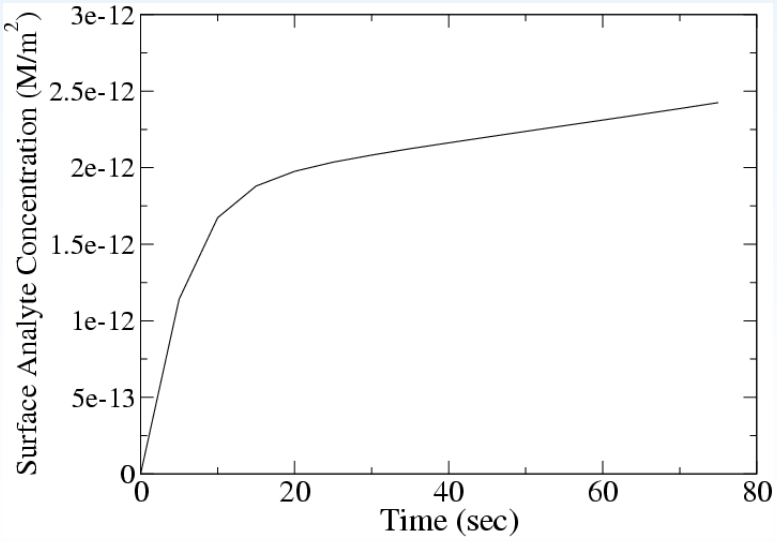
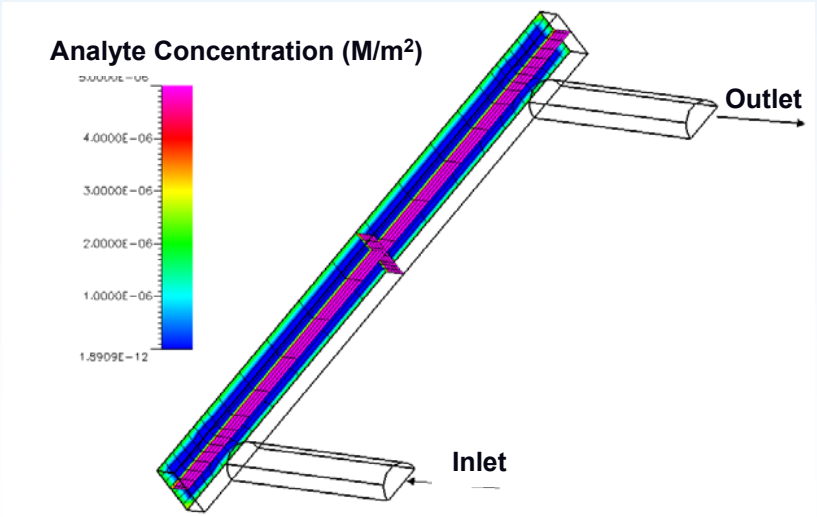
Spreeta Biosensor:

- A commercial biosensor built by Texas Instruments.
- Measures binding kinetics using surface plasmon resonance.
- Dimensions of chamber are: 0.5 mm x 2 mm x 11.2 mm





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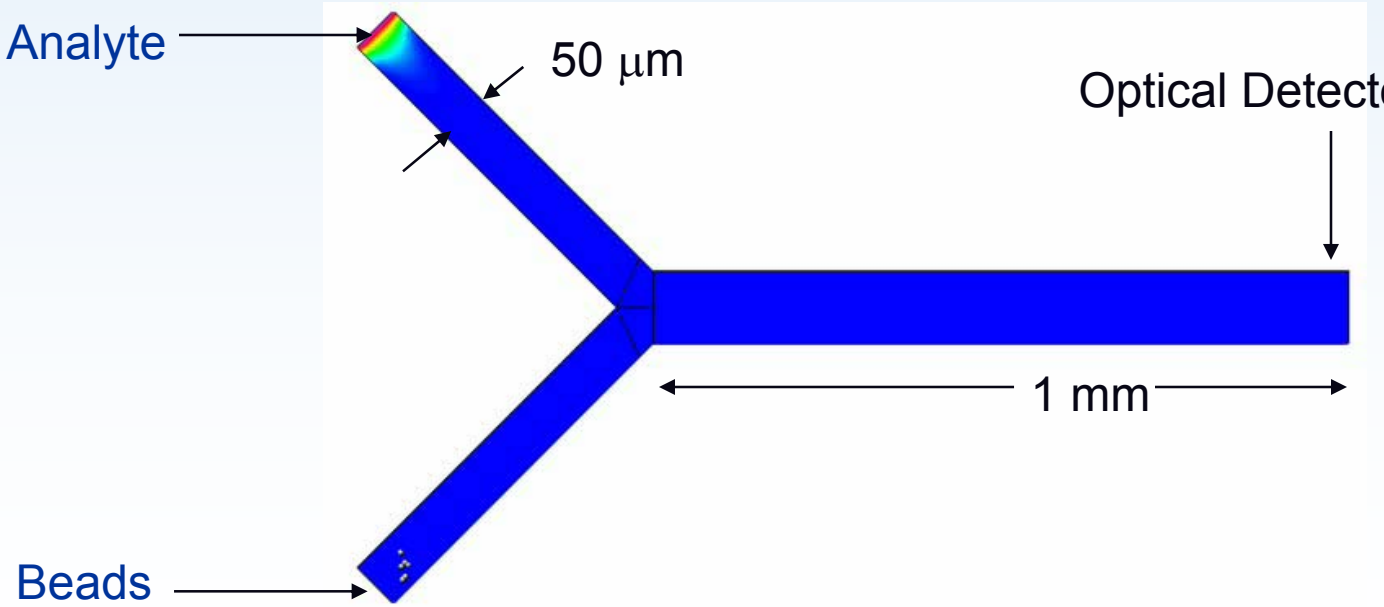
Microbead Based Immunoassay in a Y-Channel

- Microbeads are coated with special fluorescent receptors.
- Mixed with an analyte in a 1 mm long channel.
- Particles are much smaller (5 mm diameter) than the channels.



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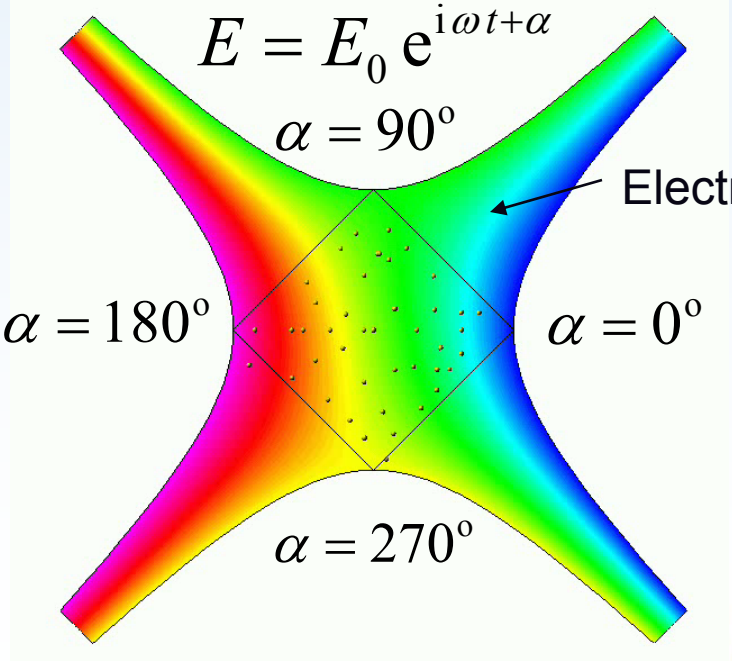
Dielectrophoresis Particle Focusing

- Quadrupole electrode configuration generates rotating electric field.
- Solid particles are suspended in water and initially randomly distributed.
- Particles are repelled into the center by negative DEP force.

- E_0 = 10 V, ω = 20 Hz.
- Electrical permittivity:

  $\varepsilon_L / \varepsilon_0 = 74$, $\varepsilon_P / \varepsilon_0 = 1$.
- Electrical conductivity $(\Omega m)^{-1}$:

  $\sigma_L = 0.01$, $\sigma_P = 0.001$
- Center chamber width: 400 μm
- Particle diameter: 5 μm
- Simulation time: 0.1 sec.



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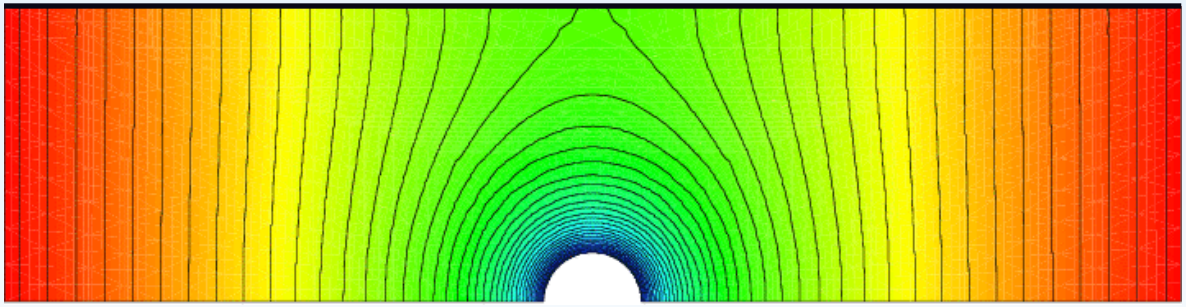
Protein Crystal Growth in a Microchannel

- Spherical Lysozyme protein crystals (250 mm diameter).
- These results are obtained by using commercial FEM code FIDAP.
- For a wide channel, protein concentration still uniform around crystal:



- For a narrow channel, protein concentration becomes non-uniform:

- Crystals grown in microchannels may be irregular due to variations in the crystallization rate caused by the confined geometry.

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Future Work (Near Term):

- Several validation tests are being developed.
  - These tests will compare the filling of a 3-D rectangular channel as predicted by the VOF capability of CFD-ACE with the experimental results of Jeff Allen (NCMR). Of particular interest is the prediction of the observed wicking effect in the channel corners.
- As a result of recent collaborations, a specific biochip device will be proposed to solve a particular need within NASA's life support technology group.

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Status Report

Future Work (Mid-Term):

- Additional validation tests are being planned to further scrutinize the accuracy of the VOF method.
- Based upon the results of the validation tests, any deficiencies in CFD-ACE+ will be identified and steps will be taken to correct them if they exist.
- If deemed necessary, a recently developed dynamic contact line model will be incorporated into the code.
- A system-level model of the specific biochip device will be used to determine whether the device will achieve the desired objectives in a microgravity environment.

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Issues:

- There are no serious issues impeding our progress.