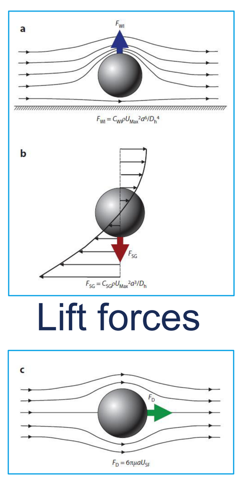
FACING THE CHALLENGES OF OUR TIME

Multiphysics Inertial Particle Focusing (IFP) Model Validation Workflow for 3D Microfluidic Geometries

G. Spinola Durante, D. Bayat

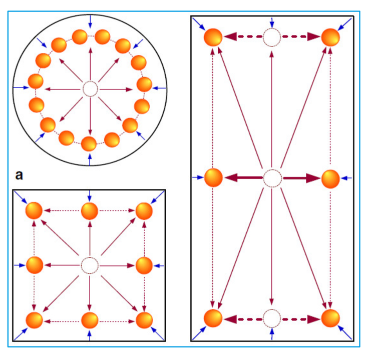
This paper demonstrates the use of COMSOL Multiphysics® to accurately model and simulate fluid channels with non-parallel walls in 3D and includes a thermal field and fluid-particle interaction. The results are compared to existing experimental and numerical data, and the model proves reliable for designing and optimizing 3D-microfluidic apparatus for particle focusing inside the fluid streams.

Inertial focusing of particles 2D model

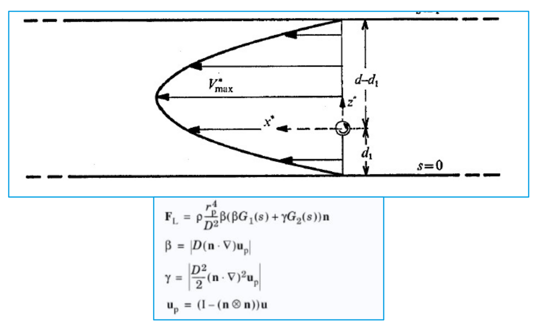


Lift forces

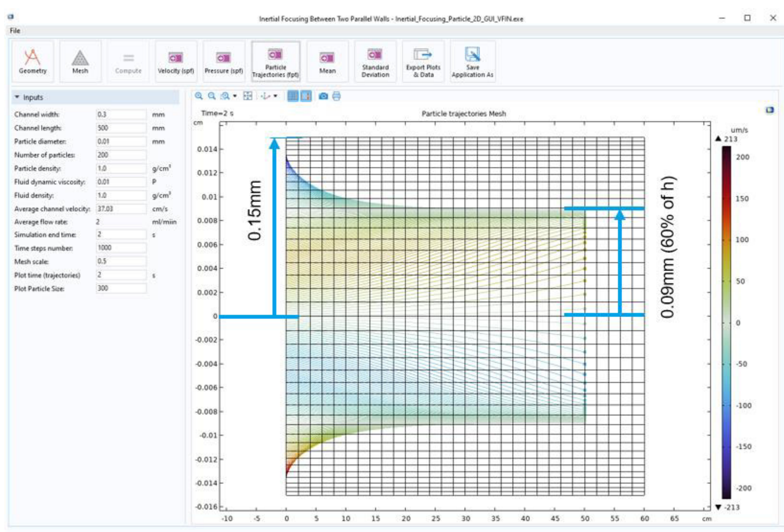
Fluid drag



Typical focusing patterns for particles in fluid flow (fluid channel cross-section)

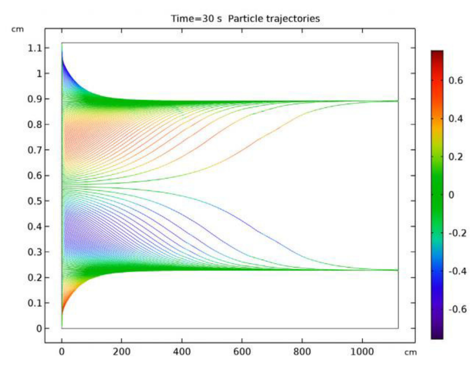


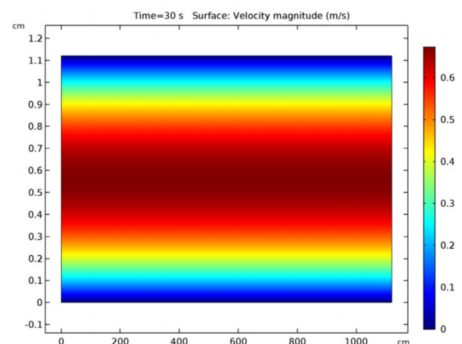
Comsol implementation



COMSOL 2D model -> turned into GUI

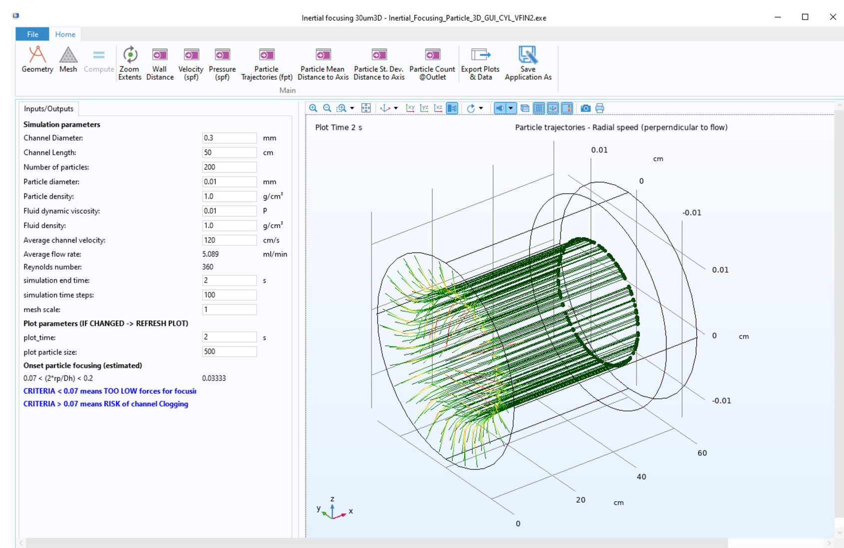
Segre-Silberberg effect

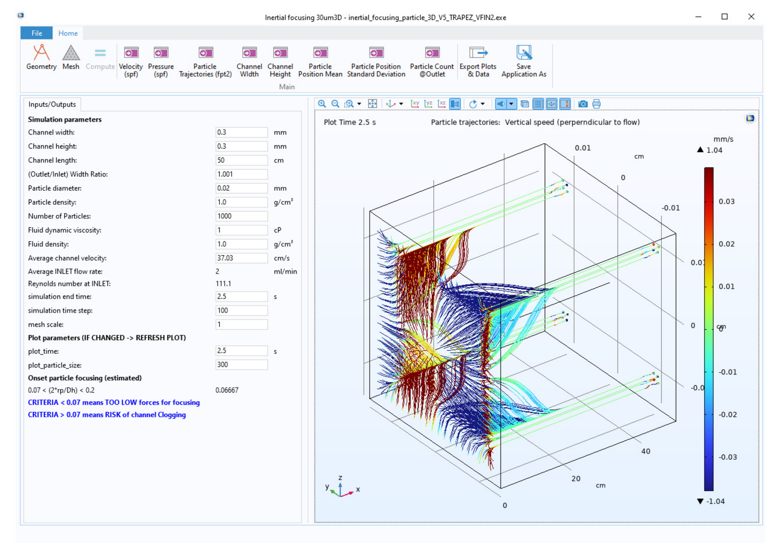




Comsol 2D validated model

Extension to 3D models



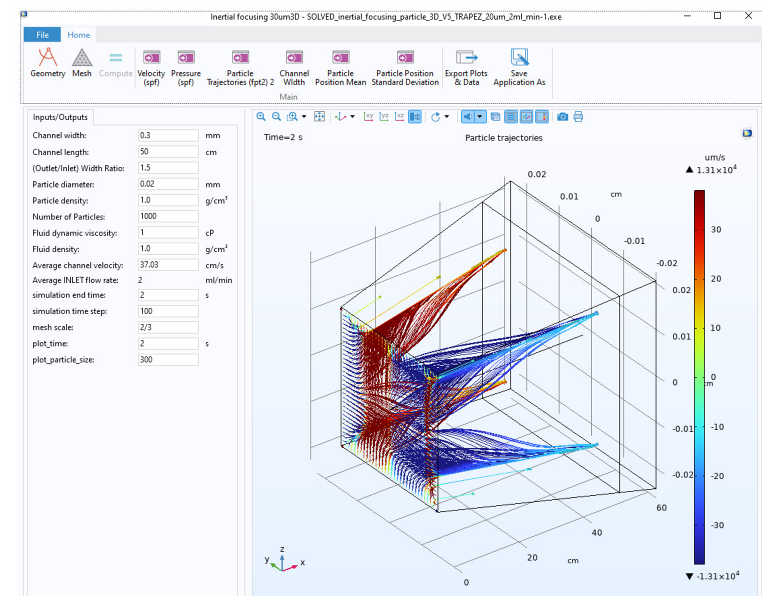


Our approach:

1. Start from COMSOL® validated 2D model
2. Use wall-interface to computed distance to wall and feed it to the lift force B.C. computation

Models implemented:

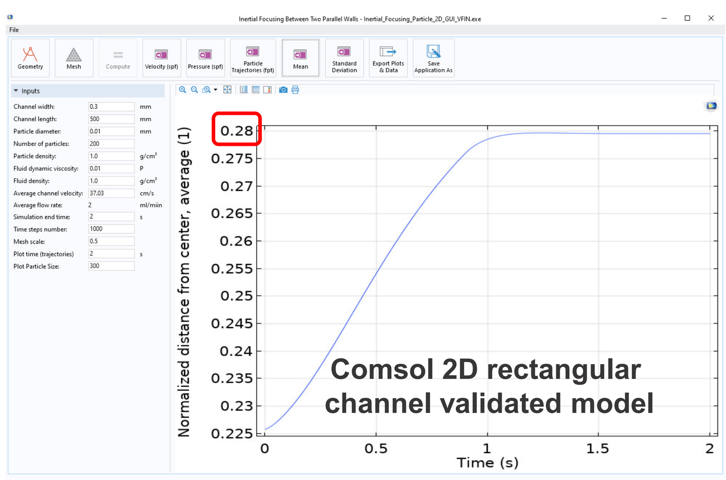
- 3D cylindrical model
- 3D rectangular cross section model
- 3D trapezoidal model

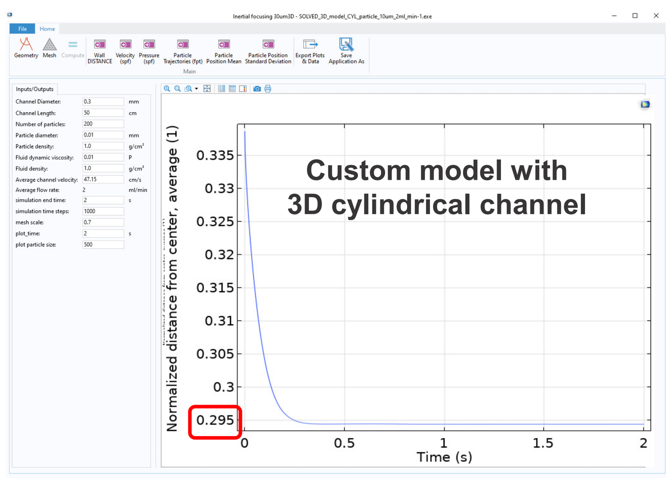


Validation of IFP models / Comsol APP for fluidic design

Stategy:

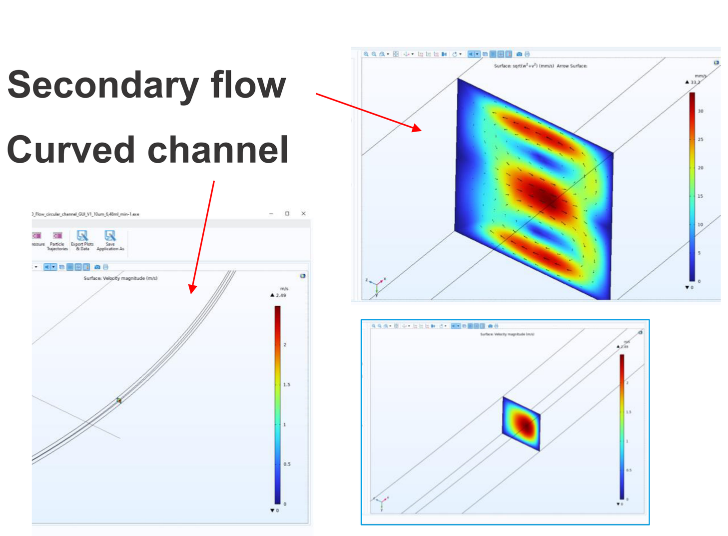
1. Compare 2D/3D resulting averaged particle distance from channel axis asymptotic values
2. Check impact of secondary flow (Dean number) on particle spiraling along the channel

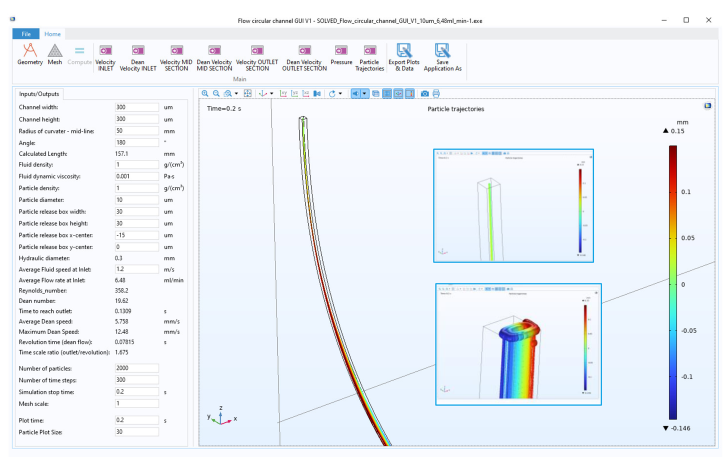




Secondary flow

Curved channel

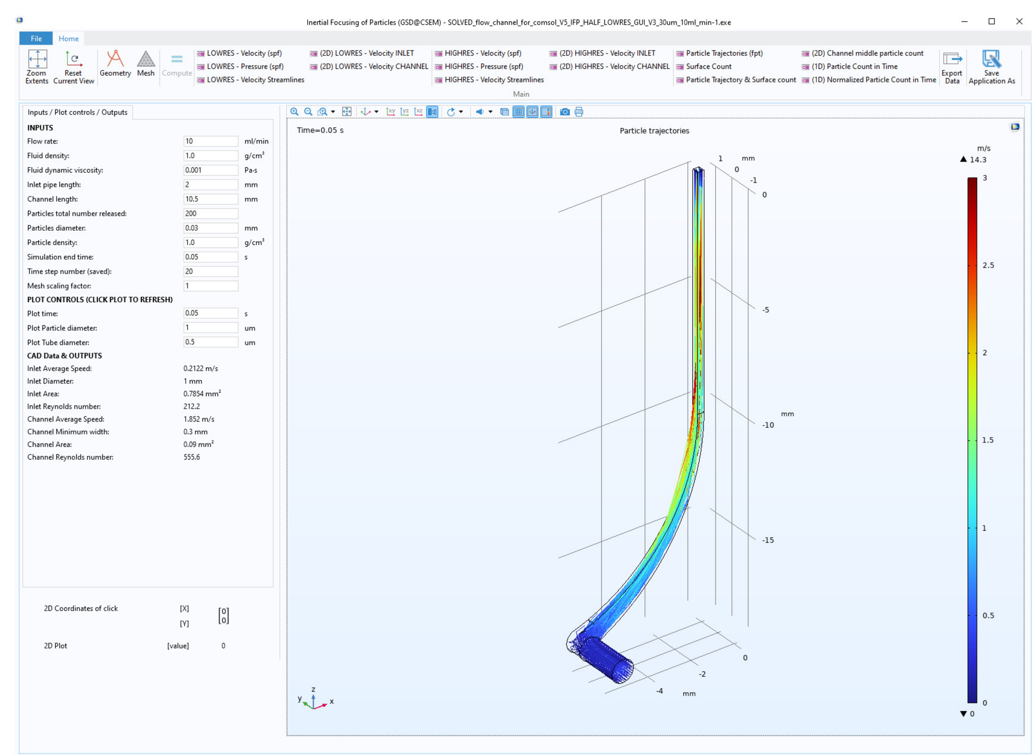


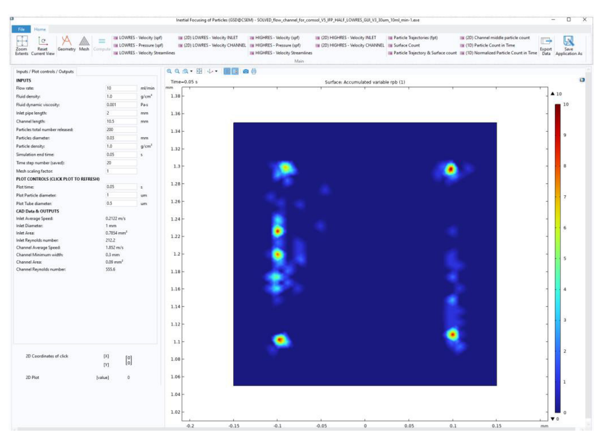


Spiral flow of particles

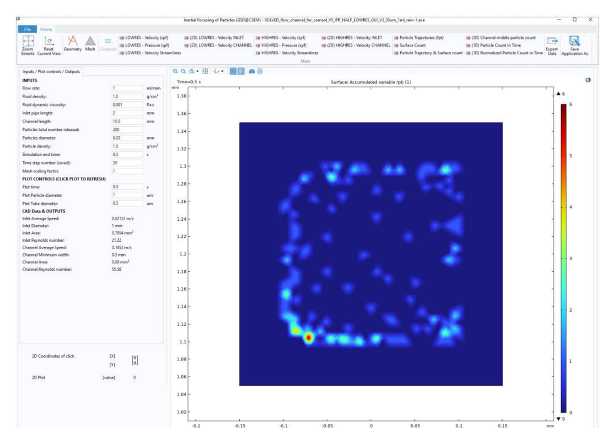
Comsol APP

- Realistic fluidic channel, model can suggest what to expect in terms of particle focusing at the outlet
- Curve effect (secondary flow) and non-constant fluid channel section are modeled
- Features parametric inputs
- **Non-dimensional numbers calculation to estimate both flow & focusing regimes**
- Allows to plot graphs and export data & picking values directly from the plot.





Dp=30um, Q=10ml/min



Dp=30um, Q=1ml/min

Conclusions and next steps

Main results

- Lift force implemented for 3D round and (gently curved) non-parallel walls 3D rectangular fluidic channels.
- GUI implemented for a realistic 3D application to quantitatively showcase inertial focusing of particles at the fluidic outlet.

Next steps

- Extend validation including timing for focusing
- Fully coupling the thermal field to the flow/particle simulaiton
- Extend lift force calculation to highly curved fluidic channel geometries (non-parabolic flow profile)

Excerpt from the Proceedings of the COMSOL Conference 2023 Munich

Contact us now

info@csem.ch • www.csem.ch