Biosensori e Microsistemi
A.A. 2005-2006

an introduction to
Comsol FemLab

(in just four slides)

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Summary

What it is all about?
- Initial steps (down-top approach)
- Set up physiscs (modular approach)
- Solution (top-down approach)

Today's simulation
- Aim
- What we would like to obtain
- Physics
- Hypothesis

Physics modelling

Two things to keep in mind

What it is all about?

Initial steps (down-top approach)

1. Decide “how much physics” you need
2. Simplify the problem
3. Draw and/or import the geometry in FemLab
4. Simplify the geometry (maybe 3D to 2D is enough...)
5. Simplify the model (we want the model to be simple and scalable)

Set up physiscs (modular approach)

1. Boundary settings and initial conditions
2. Domain settings (material properties, forces...)
3. Interconnect equation blocks (physics coupling)

Solution (top-down approach)

1. It's time to solve the model! Choose a solver (linear, NL...), choose if you need time (stationary or time dependent)
2. At this point the model should be “ok”... Let's **try** to solve it!
3. If the model is too heavy or “unstable”:
   a. scale down the complexity (geometry and mesh)
   b. play with solvers
4. **GOTO 2**

Today's simulation

Aim

Today I'll show you how to simulate a (micro)fluidic system.

We would like to obtain

1. the velocity field profile of the fluid
2. the concentration profile of a given chemical

Physics

1. Incompressible Navier-Stokes (**NS**)
2. Convection and Diffusion (**CD**)

Hypothesis

Global:

1. Geometry is known

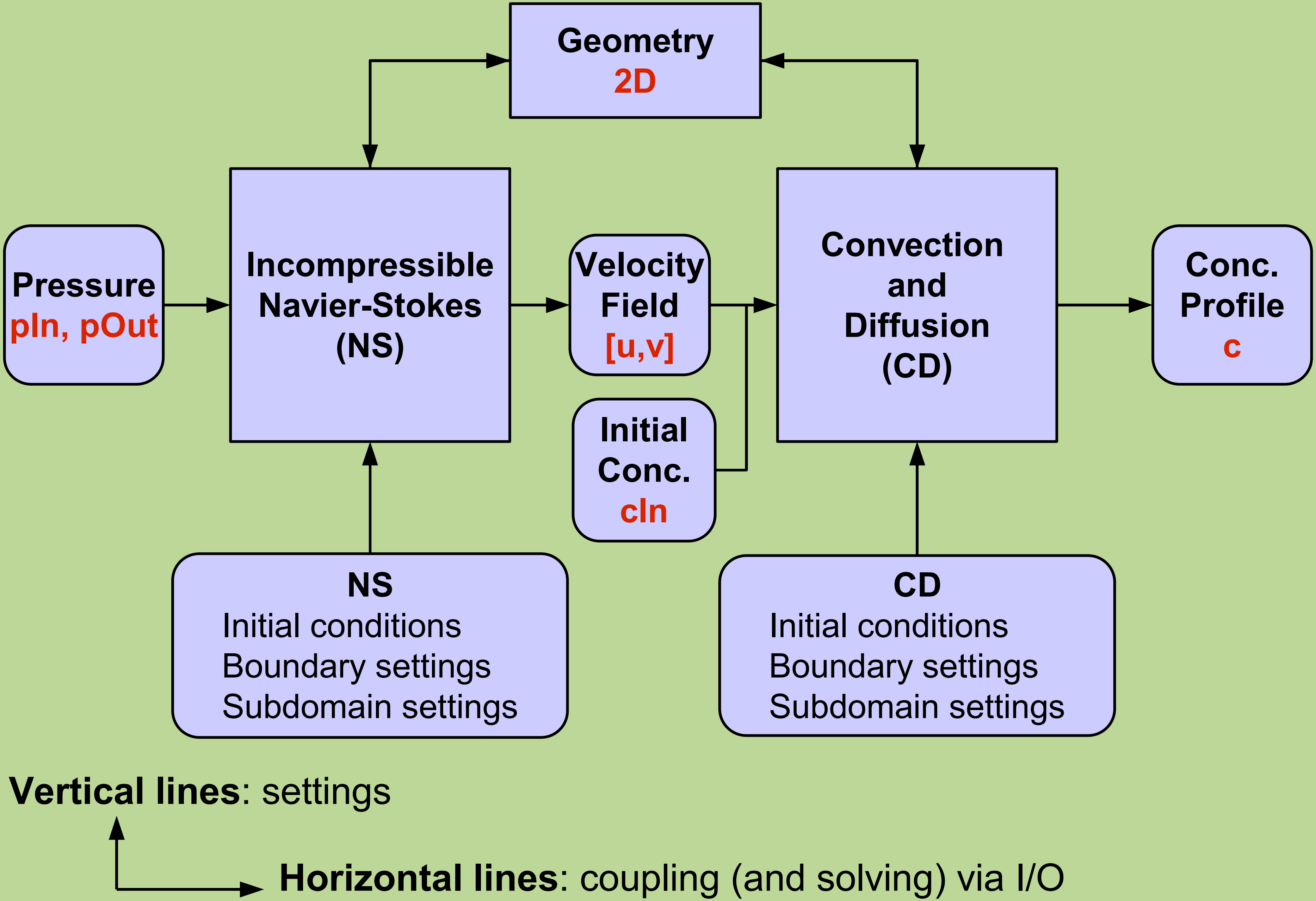
For NS:

2. Fluid properties are known (Density and Dynamic viscosity)
3. Inlet and outlet pressures are known

For CD:

4. Chemical properties are known (Diffusion coefficient)
5. Initial concentration of the chemical is known

Physics modelling



Physics modelling

Incompressible Navier-Stokes

No forces applied (*Fx* = *Fy* = 0), no initial velocity, zero pressure

Bondary settings

Inlet	Normal flow/pressure	*p0*	= **pIn**	= 2	[$M\ L^{-1}\ T^{-2}$]
Outlet	Normal flow/pressure	*p0*	= **pOut**	= 0	[$M\ L^{-1}\ T^{-2}$]
Other	NoSlip				

Subdomain settings

	Density	*rho*	= **rho0**	= 1e-3	[$M\ L^{-3}$]
	Dynamic viscosity	*eta*	= **eta0**	= 1e3	[$M\ L^{-1}\ T^{-1}$]

Convection and Diffusion

No forces applied (*Fx* = *Fy* = 0)

Bondary settings

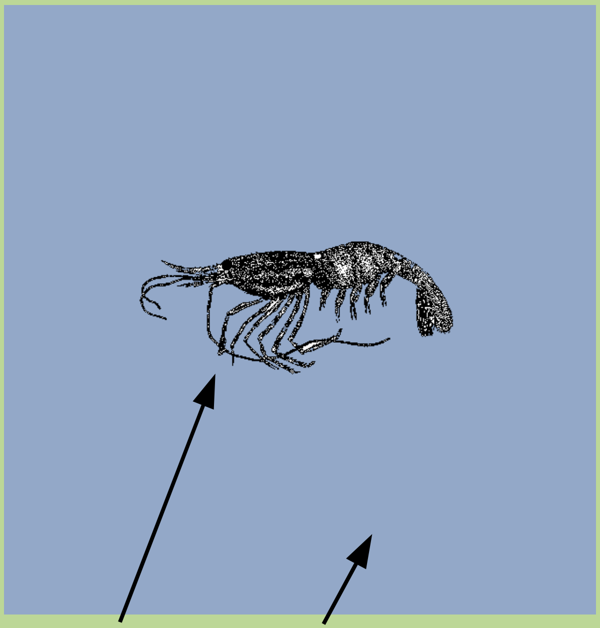
Inlet	Concentration	C*0*	= **CIn**	= 6e17	[$M\ L^{3}$]
Outlet	Convective flux				
Other	Insulation/Simmetry				

Subdomain settings

	Diffusion coefficient	*D*	= **D0**	= 1e-10	[$L^{-2}\ T^{-1}$]

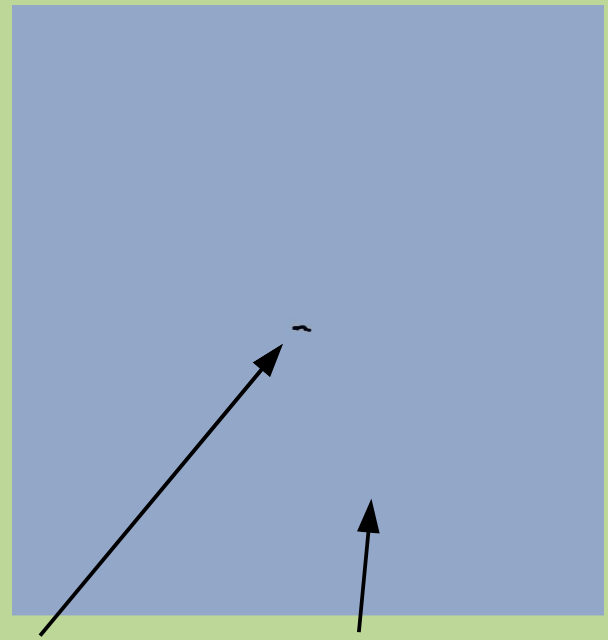
Two things to keep in mind

1. Keep the geometry simple! It's gonna be faster to simulate your model!
   a. FemLab is programmed in Java and does require a lot of memory!
   b. Let's say I would like to know the vorticity of the water around a shrimp swimming:



shrimp + **acquarium** model

or

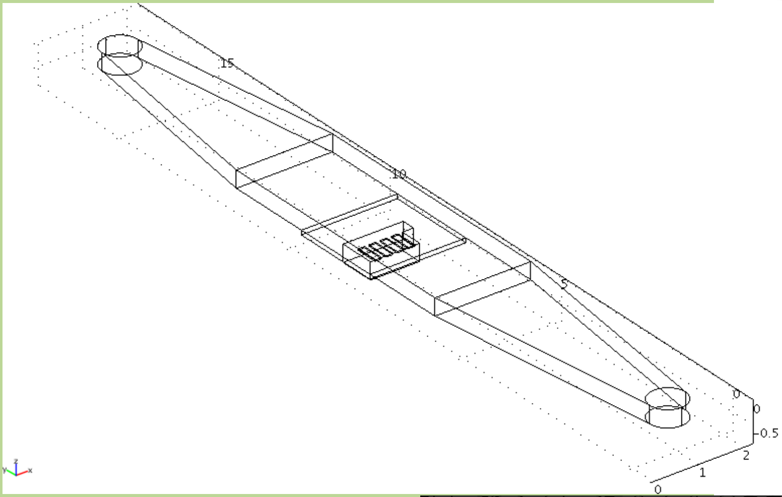


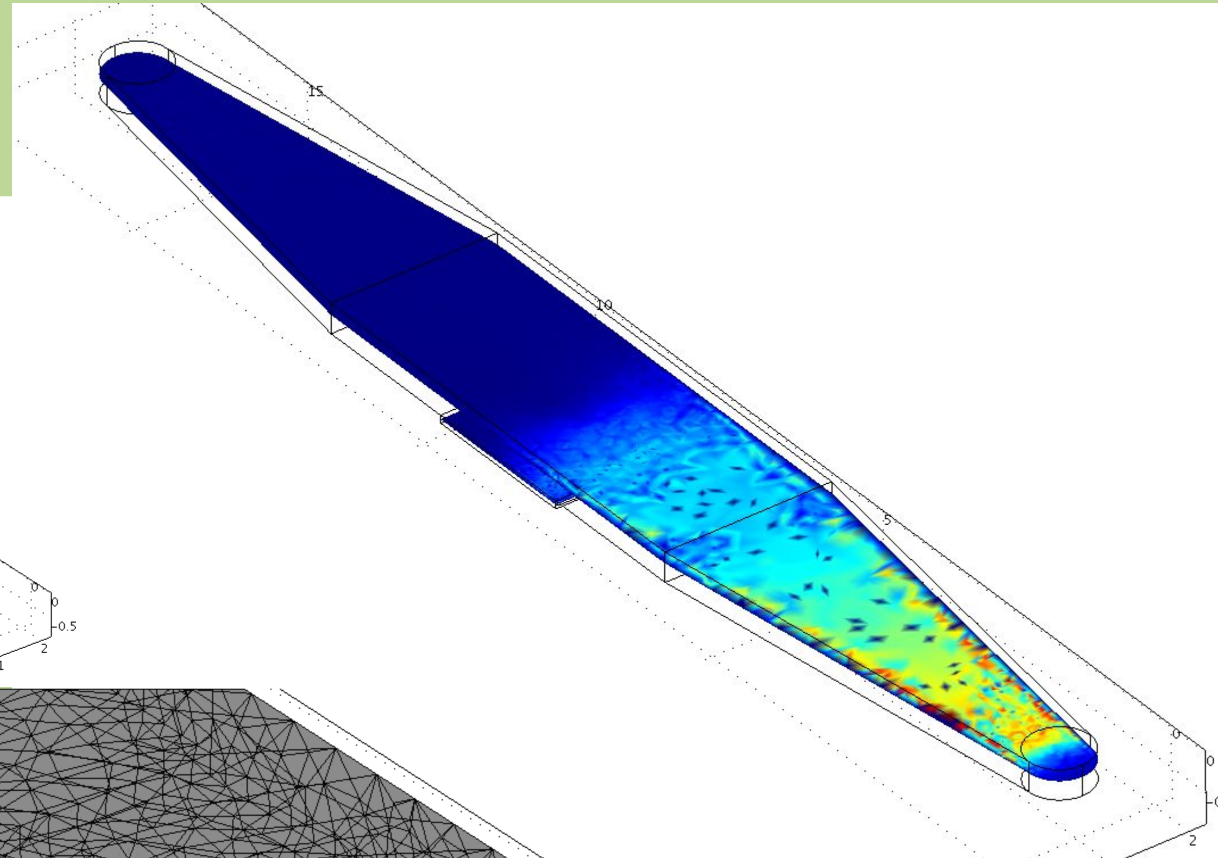
shrimp + **Gulf of Genoa** model

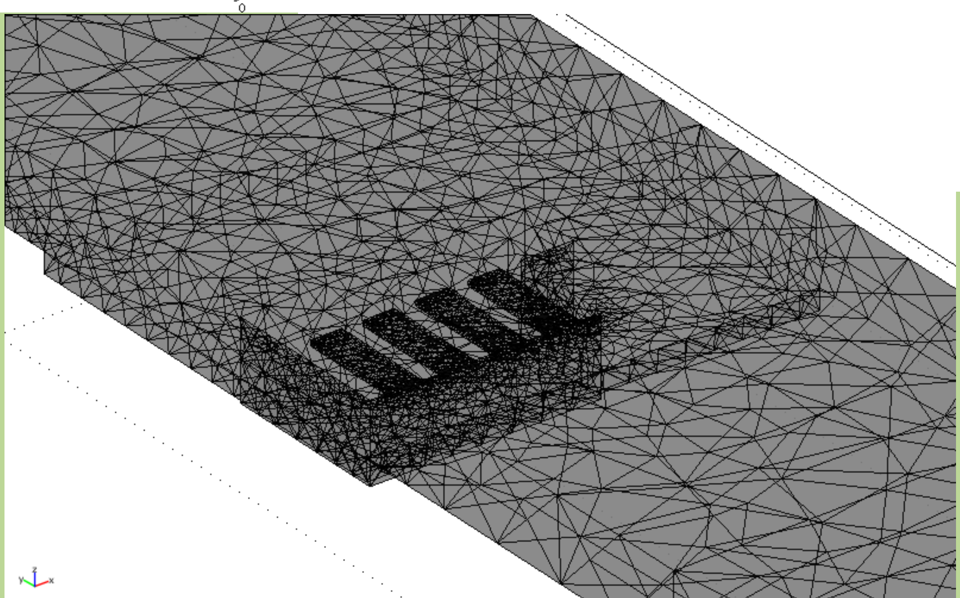
In other words: be sure you model **JUST** what you need!
This is more a joke than an example, but there is no linear relationship between “model complexity” and “solving complexity”.

2. Be sure you have a FemLab-geek friend near you for tricks and guidance

The microfluidic cell







Done...

Thank you for your attention