

# From van Karman to Magnus with COMSOL Multiphysics

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Month/Year

Univerza v Ljubljani



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## COMSOL Multiphysics

- multi physics → tightly coupled PDEs
  - e.g.: fluid structure interaction, heat or electrical/magnetic

## COMSOL Multiphysics

- multi physics → tightly coupled PDEs  
e.g.: fluid structure interaction, heat or electrical/magnetic
- COMSOL:  
FEM for all types of physics

ANSYS: coupling FVM–FEM  
Fluent, cfx ... FVM  
Mechanical ... FEM

- AC/DC
- Acoustics
- Chemical Species Transport
- Electrochemistry
- Fluid Flow
- Heat Transfer
- Optics
- Plasma
- Radio Frequency
- Semiconductor
- Structural Mechanics
- $\Delta u$  Mathematics

predefined physics

+

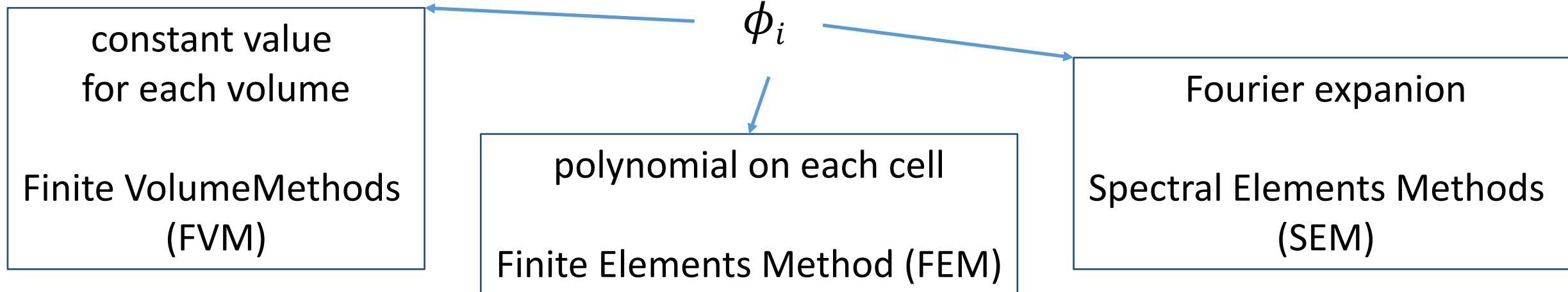
flexible PDE+ODE-Modules

▼  $\Delta u$  Mathematics

- $\Delta u$  PDE Interfaces
- $\frac{d}{dt}$  ODE and DAE Interfaces
- $\nabla^2$  Optimization and Sensitivity
- $\nabla^2$  Classical PDEs
- Moving Interface
- Deformed Mesh
- Wall Distance (wd)
- Mathematical Particle Tracing (pt)
- Curvilinear Coordinates (cc)

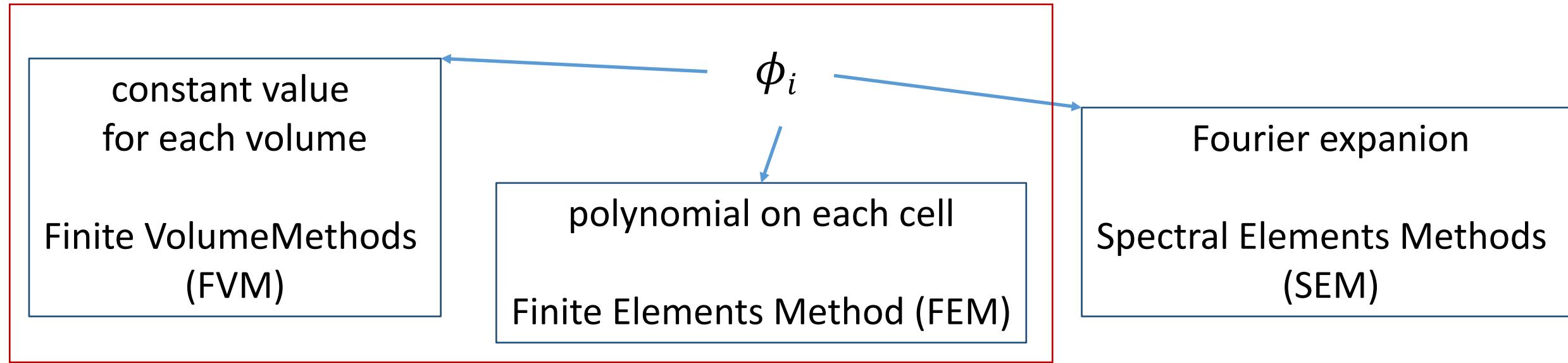
## Why FEM ?

$$P(\partial_x, \partial_t)u = F, \quad u_0 = f, \quad Bu = g, \quad \text{assumption : } u \approx u = \sum u_i \phi_i$$



## Why FEM ?

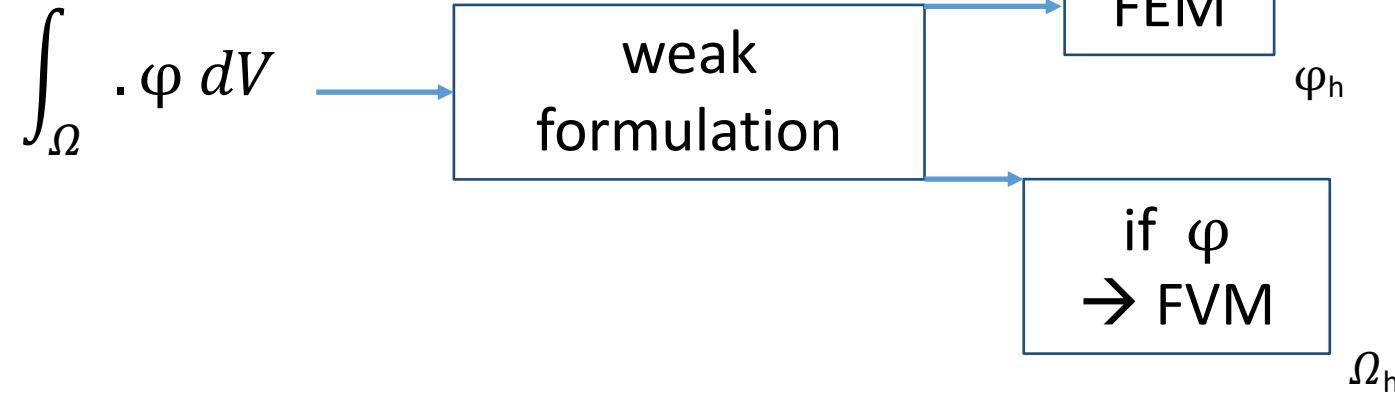
$$P(\partial_x, \partial_t)u = F, \quad u_0 = f, \quad Bu = g, \quad \text{assumption : } u \approx u = \sum u_i \phi_i$$



mathematical model & governing equations → precision

$$\partial_t u + \partial_x \Gamma = F \quad \text{in. } \Omega$$

$u$  ... conserved quantity  
 $\Gamma$  ... flux,     $\Omega$  ... volume

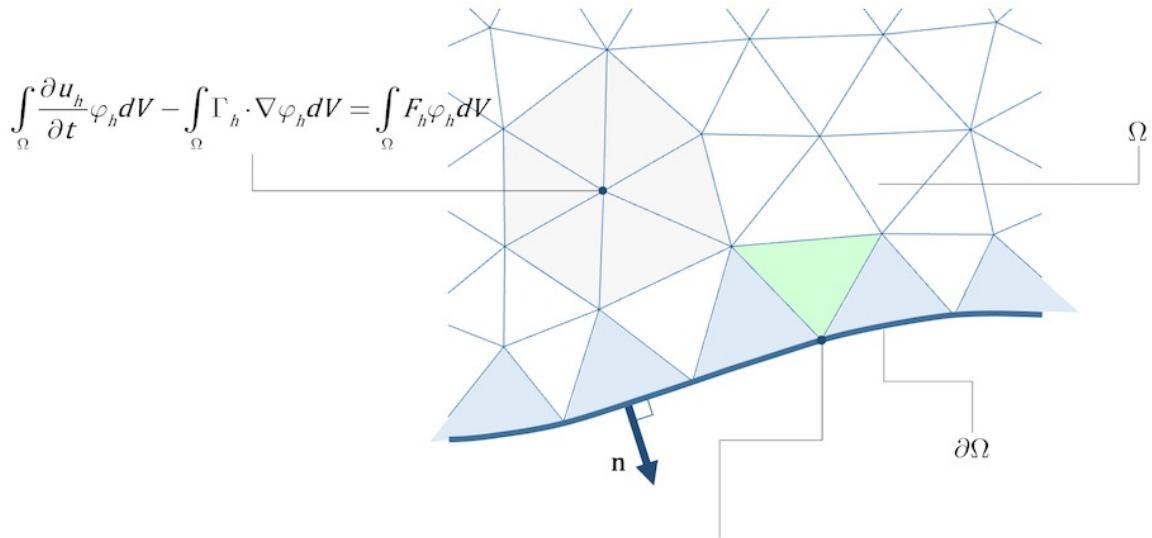


see <https://www.comsol.de/blogs/fem-vs-fvm/>

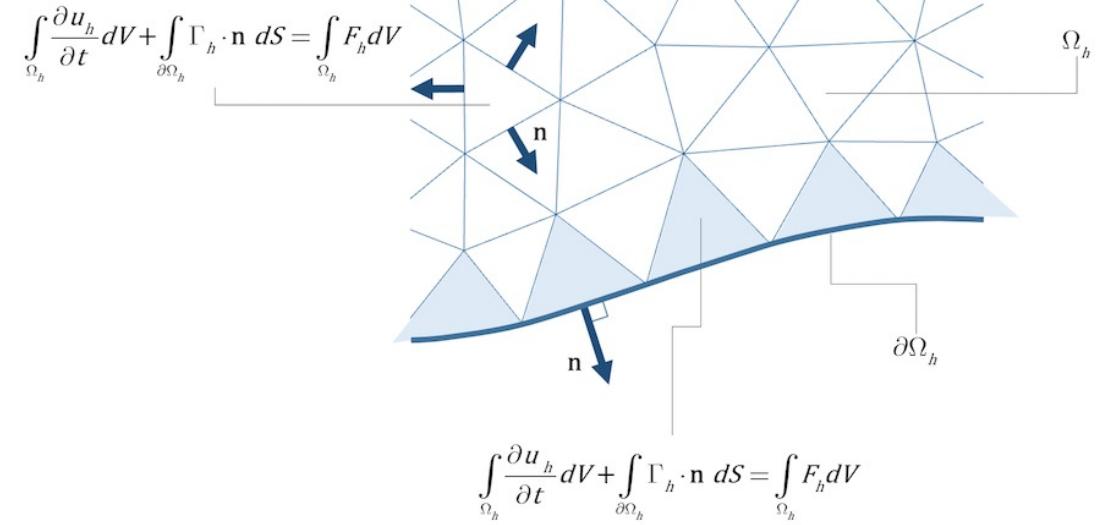
**Conservation Law:** The sum of all drawbacks stays constant.

# FEM and FVM

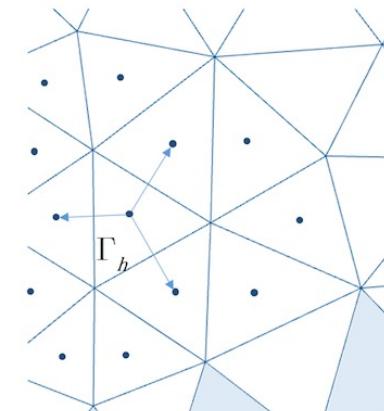
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FEM



FVM



**Conservation Law:** The sum of all drawbacks stays constant.

## FEM:

higher order → straight forward  
→ adaptive mesh refinement

unphysical oscillation

conservation:  
globally satisfied  
locally:

with continuous functions not satisfied  
COMSOL → discontinuous Galerkin (DG)

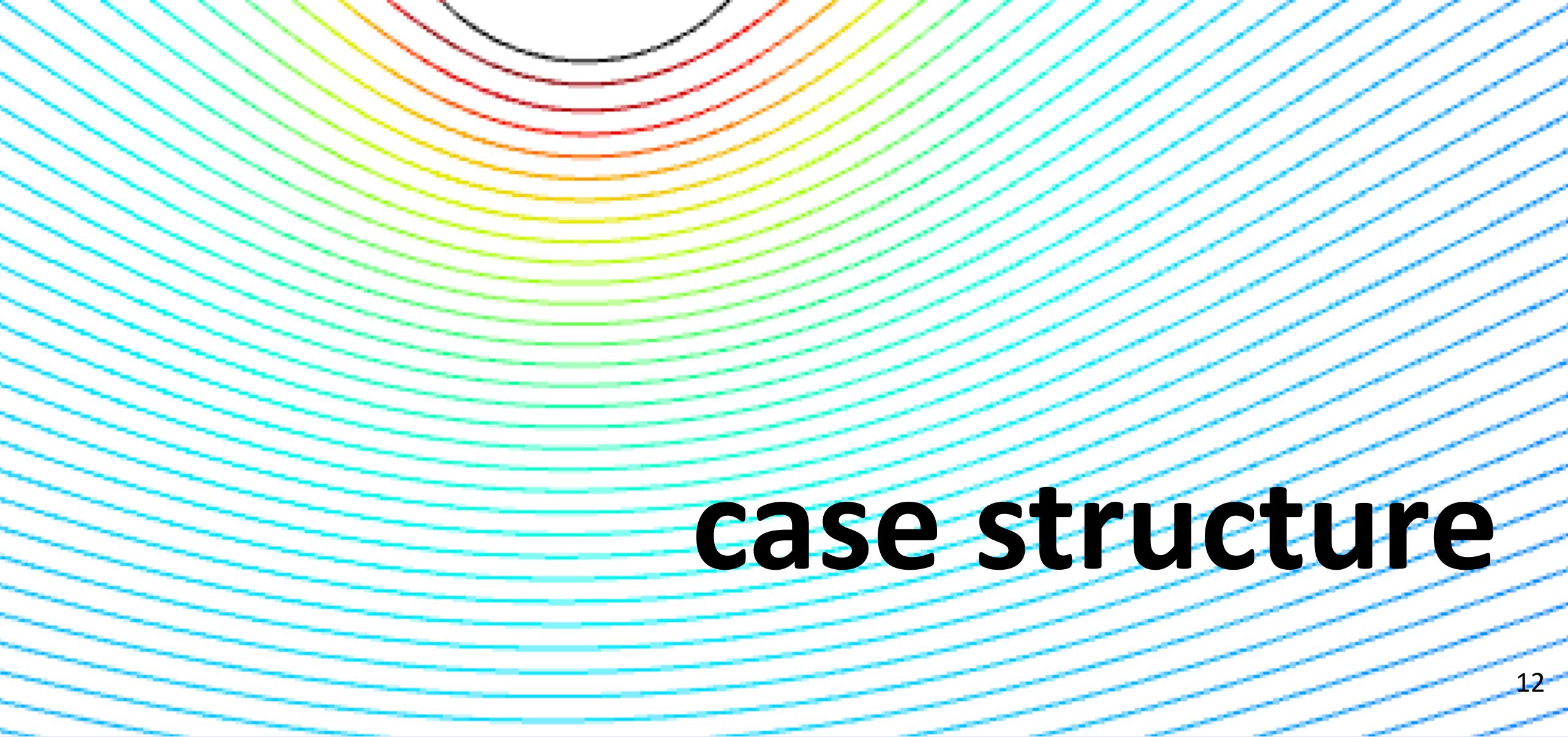
## FVM:

higher order:  
method becomes less local

high numerical diffusion

conservation:  
by default locally satisfied

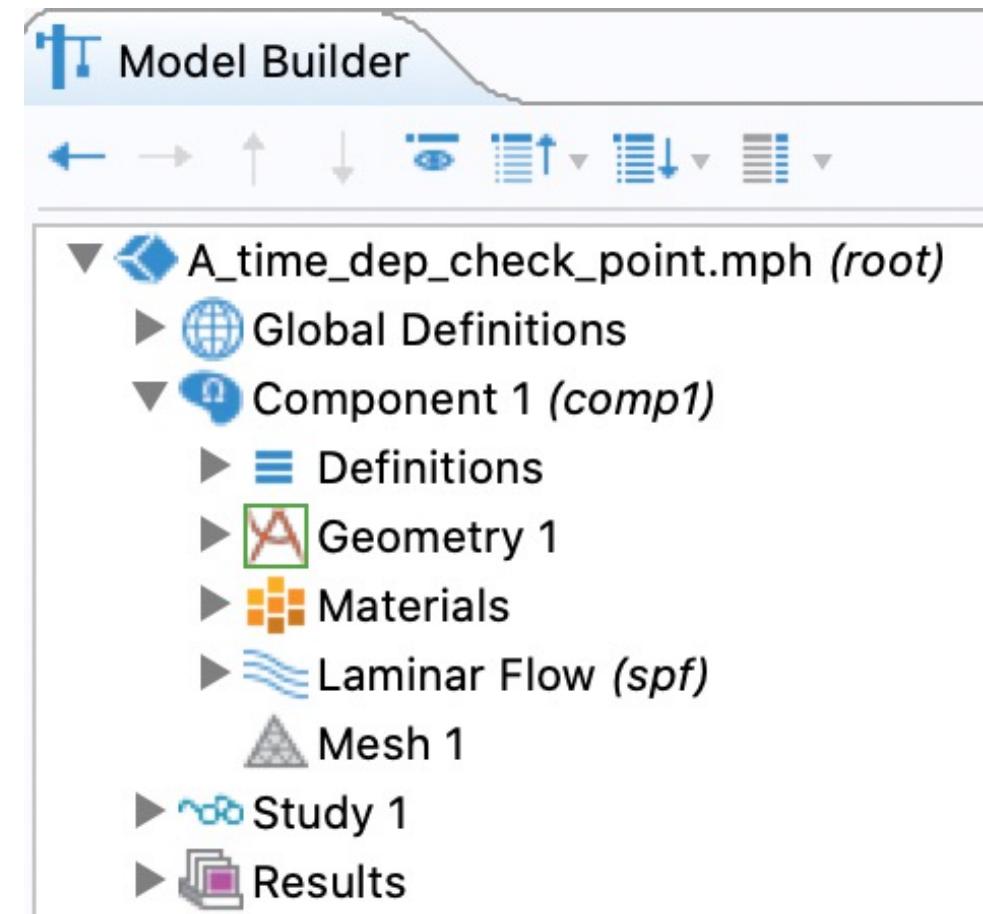
**Conservation Law:** The sum of all drawbacks stays constant.

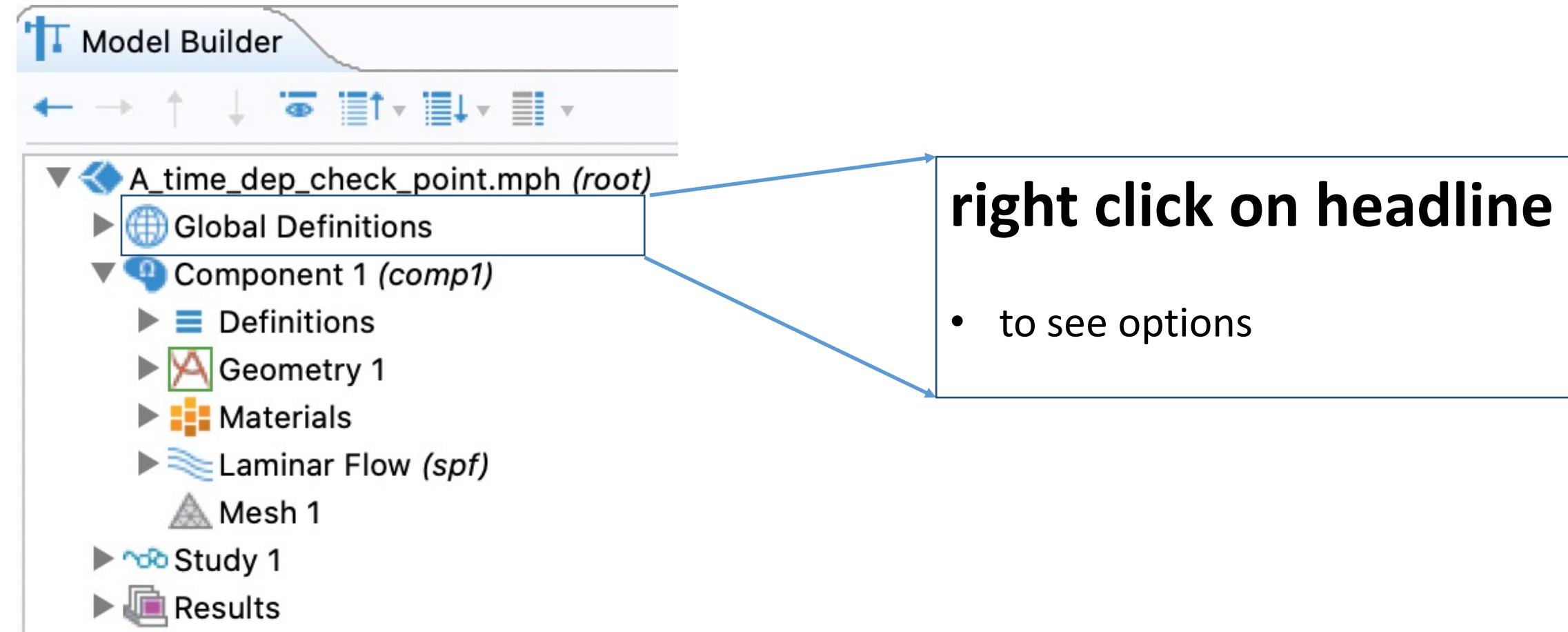
The background of the slide features a complex geometric pattern. It consists of numerous thin, parallel lines that curve upwards from left to right. These lines are colored in a gradient, transitioning through various hues including cyan, green, yellow, orange, red, and black. In the lower right quadrant, the word "case structure" is overlaid in a large, bold, black sans-serif font.

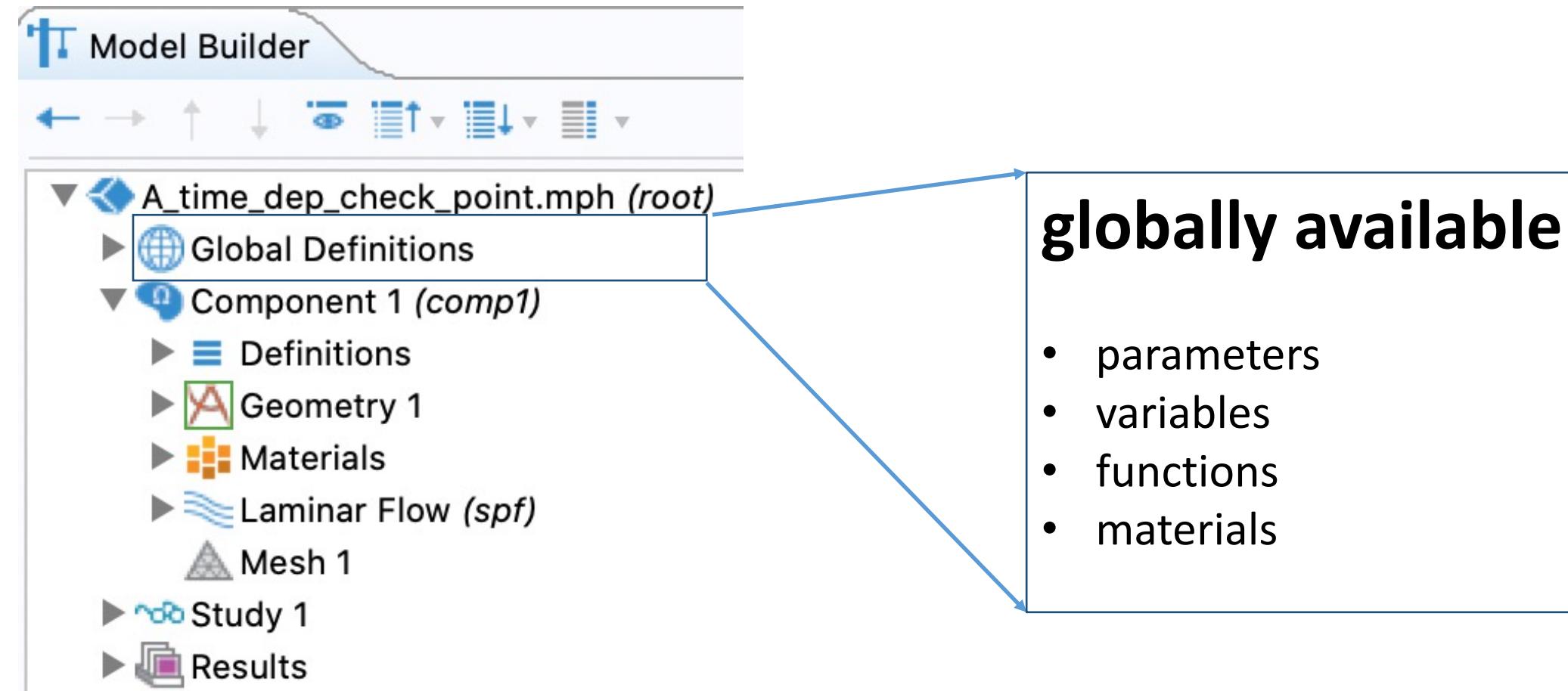
case structure

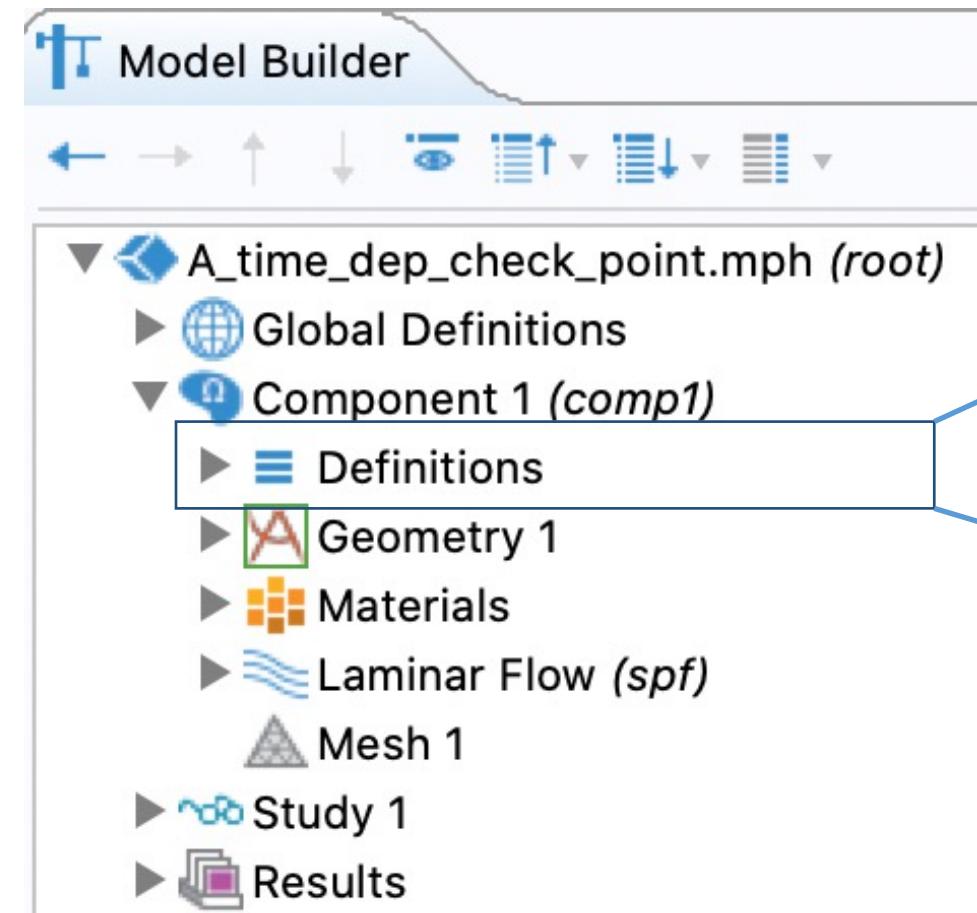
# Case structure

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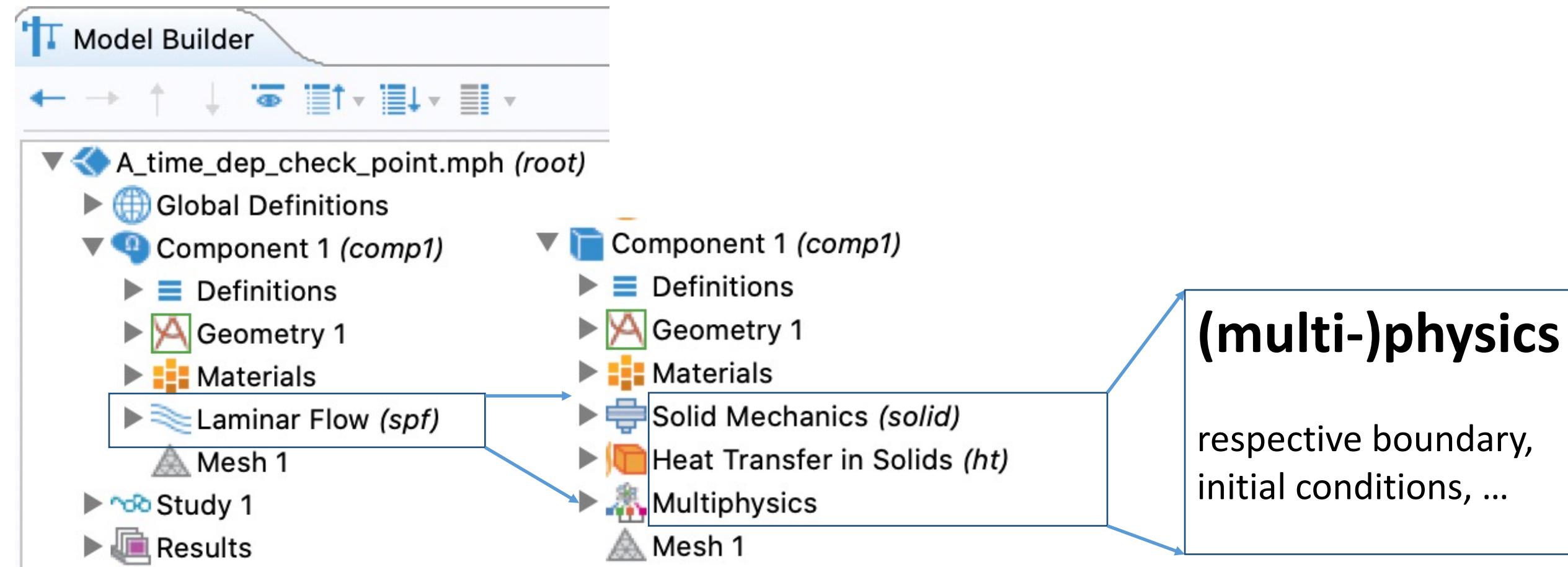


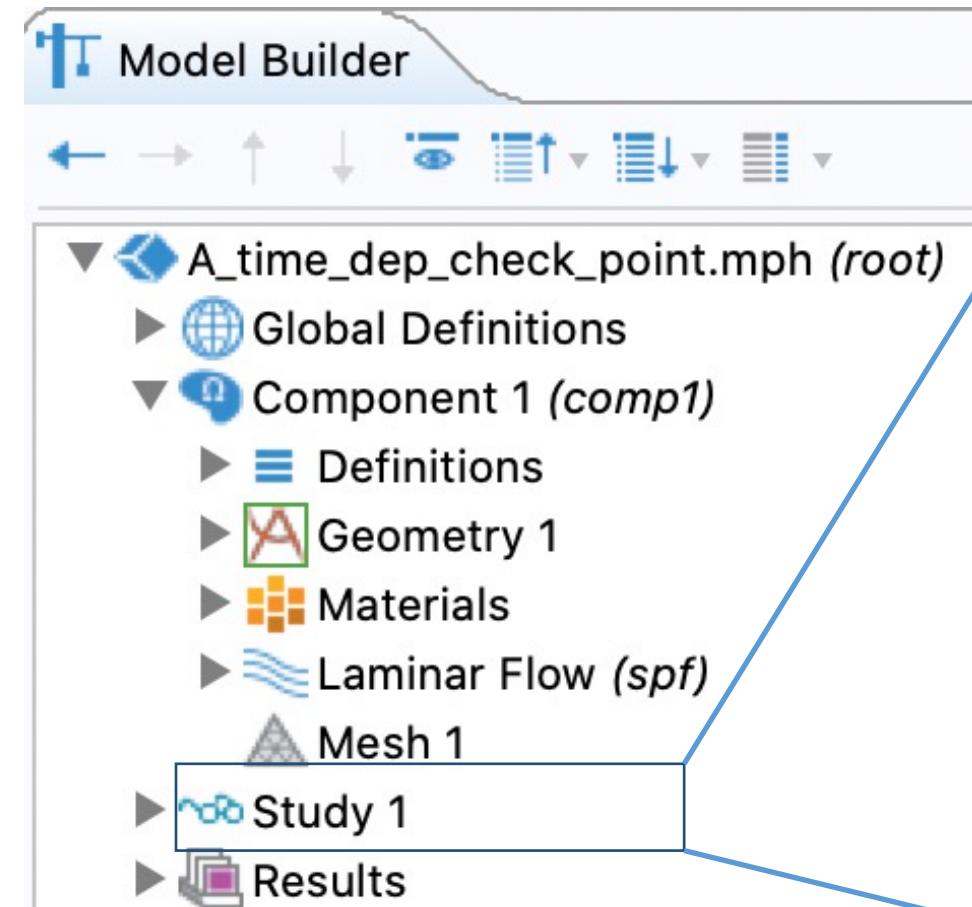
**definitions available  
to comp1**

probes, contact areas, ...

# Case structure

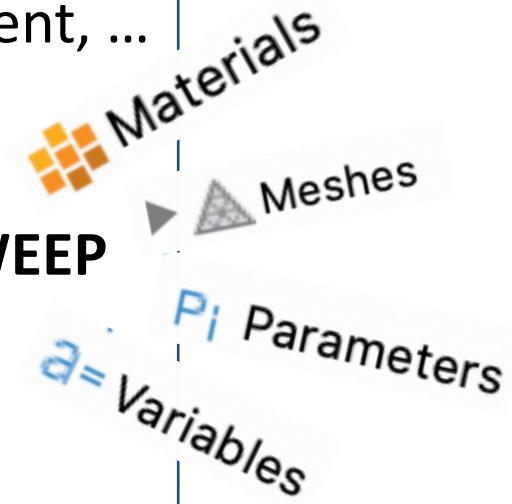
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## compute

- stationary, time-dependent, ...
- $A = 3, 3.2, 3.4, \dots$
- modify boundary conditions, solver config, ...

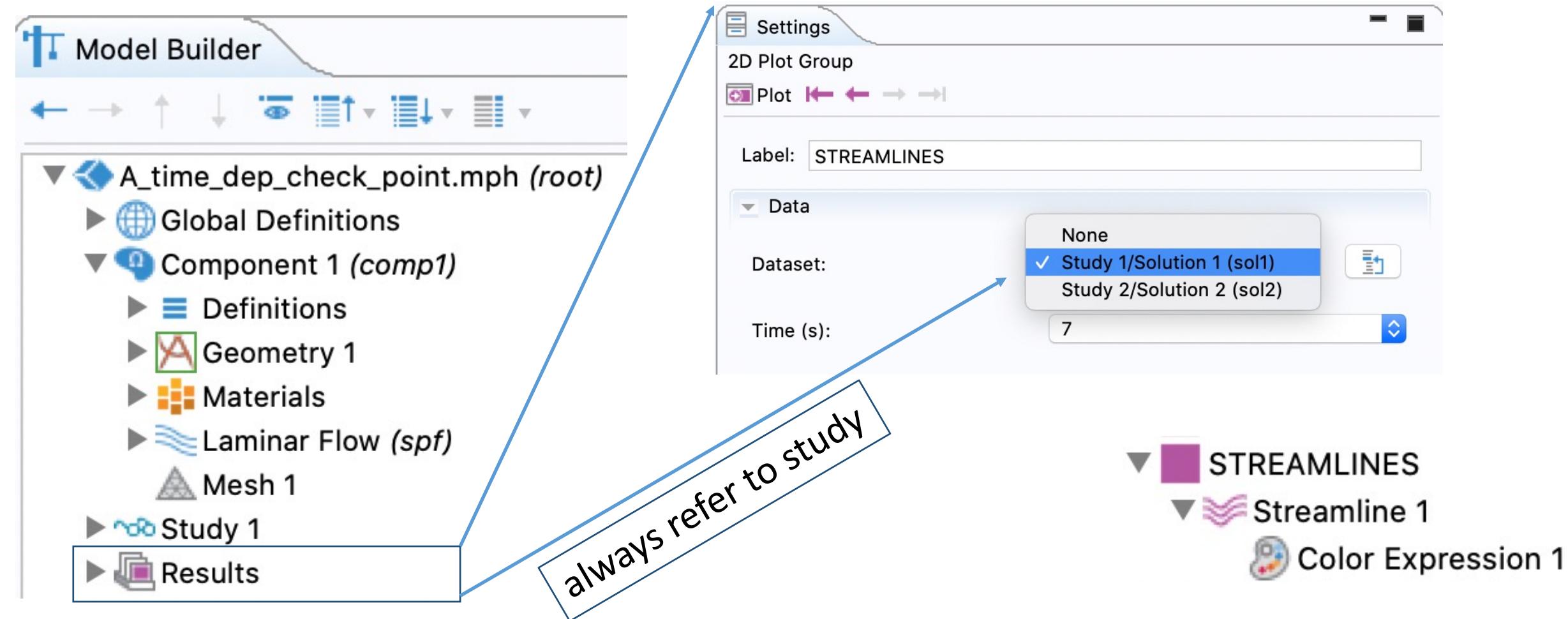


Show Default Solver

# Case structure

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# Case structure

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Trees

*further options → sub - menus*

- ▼ ▲ Meshes
  - ▲ Mesh 1
  - ▼ ▲ Mesh user defined
- ▼ ▲ Size
- ▼ □ Mapped 1
  - Distribution 1
  - Distribution 2
  - Distribution 3

# Case structure

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■ 2D Plot Group 6

Trees

*further options → sub - menus*

- ▼ ▲ Meshes
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# Case structure

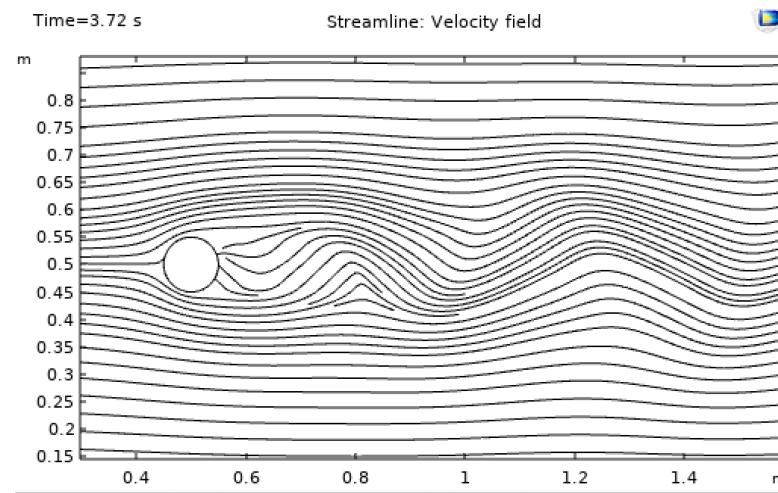
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Trees

*further options → sub - menus*

- ▼  STREAMLINES
- ▼  Streamline 1



- ▼  Meshes
-  Mesh 1
- ▼  Mesh user defined
-  Size
- ▼  Mapped 1
-  Distribution 1
-  Distribution 2
-  Distribution 3

# Case structure

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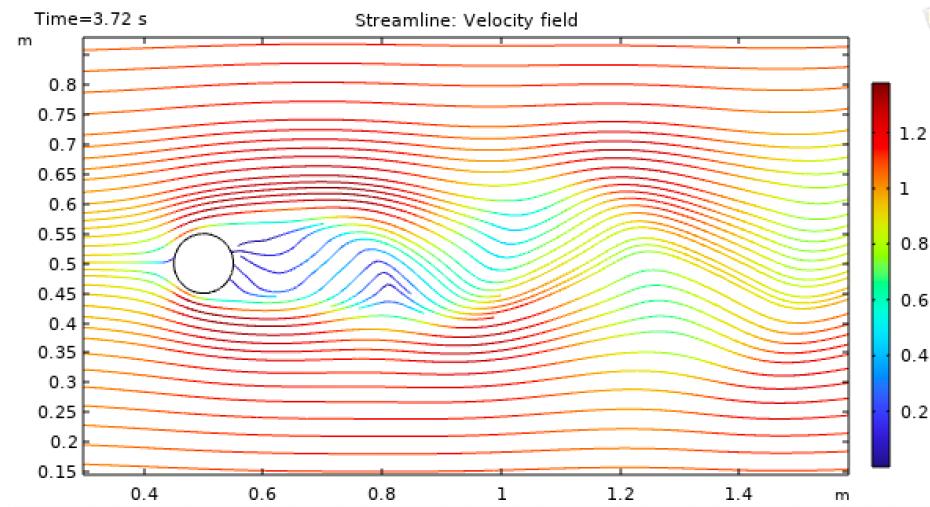
Trees

*further options → sub - menus*

▼ STREAMLINES

▼ Streamline 1

Color Expression 1



- ▼ Meshes
  - Mesh 1
  - ▼ Mesh user defined
- ▼ Size
- ▼ Mapped 1
  - Distribution 1
  - Distribution 2
  - Distribution 3

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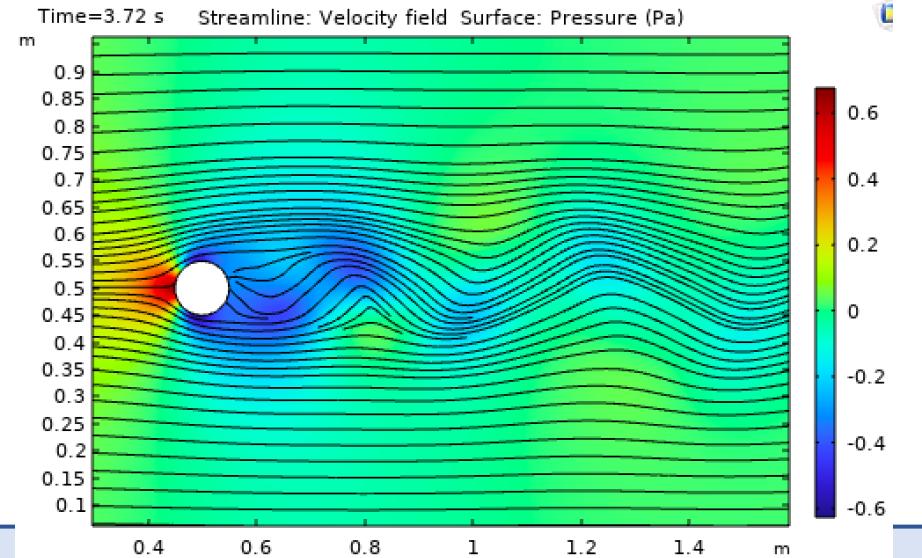
*further options → sub - menus*

▼ STREAMLINES

▼ Streamline 1

Color Expression 1 |

Surface - p



- ▼ Meshes
  - Mesh 1
  - ▼ Mesh user defined
- ▼ Size
- ▼ Mapped 1
  - Distribution 1
  - Distribution 2
  - Distribution 3