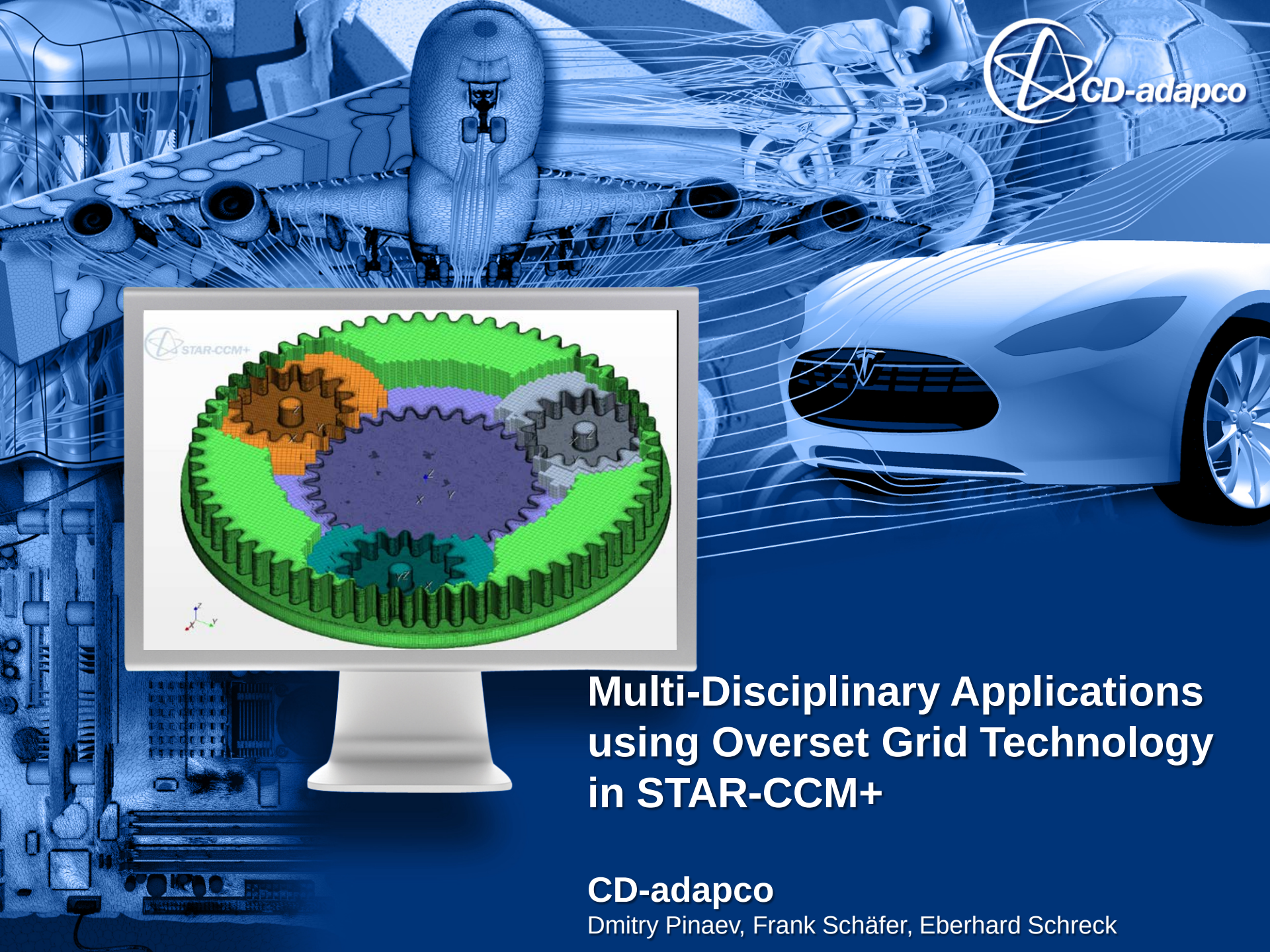


Multi-Disciplinary Applications using Overset Grid Technology in STAR-CCM+

CD-adapco
Dmitry Pinaev, Frank Schäfer, Eberhard Schreck

Outline

1. **STAR-CCM+**
   1. Capabilities and the Overset Framework
   2. Setting up simple simulation
2. **Implementation details**
   1. Grid layers
   2. Cell type, cell status
   3. Algorithms & data structures
3. **Scenarios and applications**
   1. Multiple Overset
   2. Multiple Overset + Dynamic Overset Walls
   3. Overset Film
   4. Multiple Overset Film
   5. Multiple Overset Film + Lagrangian Phase
4. **Questions**

STAR-CCM+

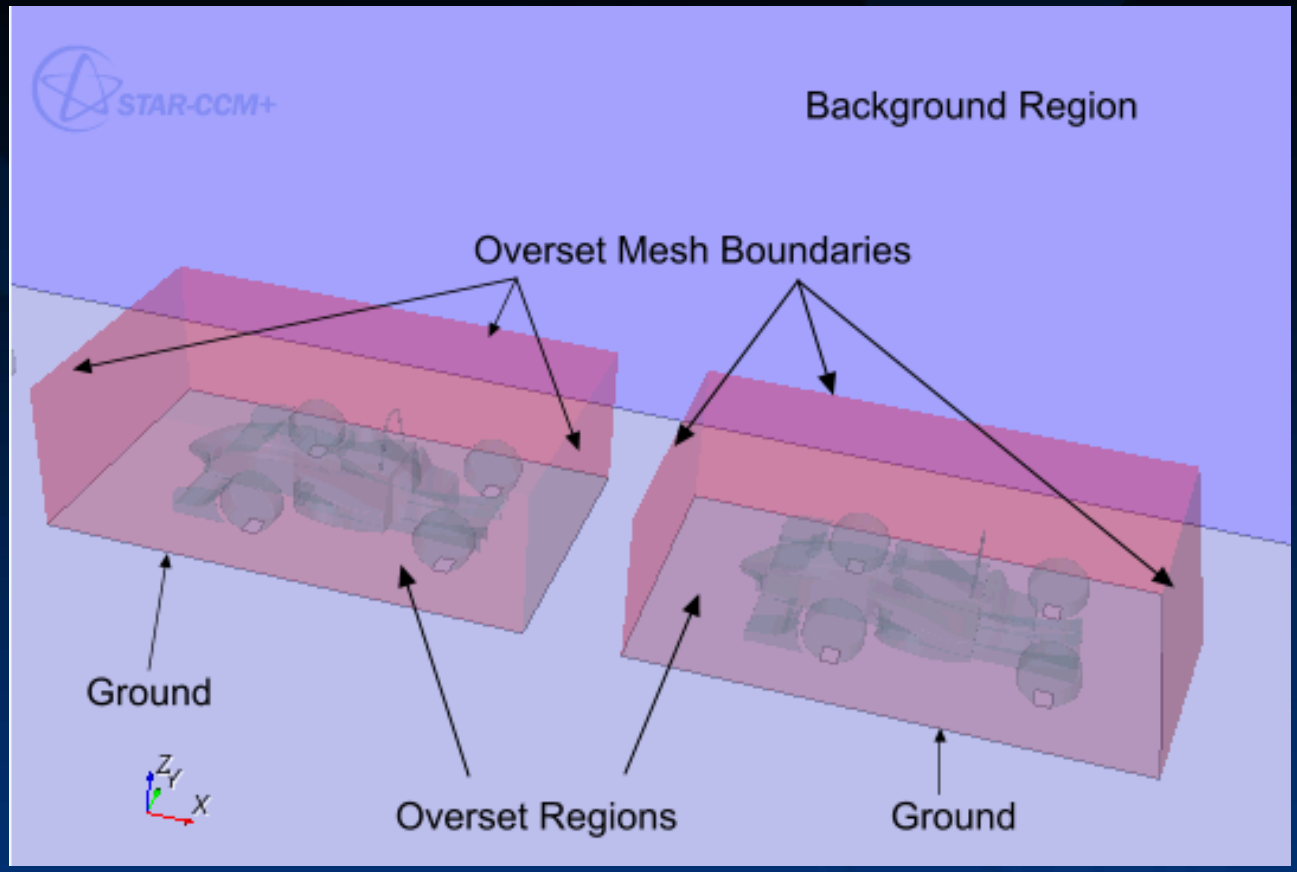
What distinguishes STAR-CCM+ most from other codes?

- **User interface**
- **Meshing tools**
  - Surface wrapping
  - Surface remeshing
  - Automatic volume meshing and mesh design
  - Process automation
- **All the physical models you might probably need**
  - Turbulence
  - Fluid Film
  - Lagrangian Phase
  - etc
- **No difference in setup between parallel and serial run**

Everything should work automatically with overset meshes

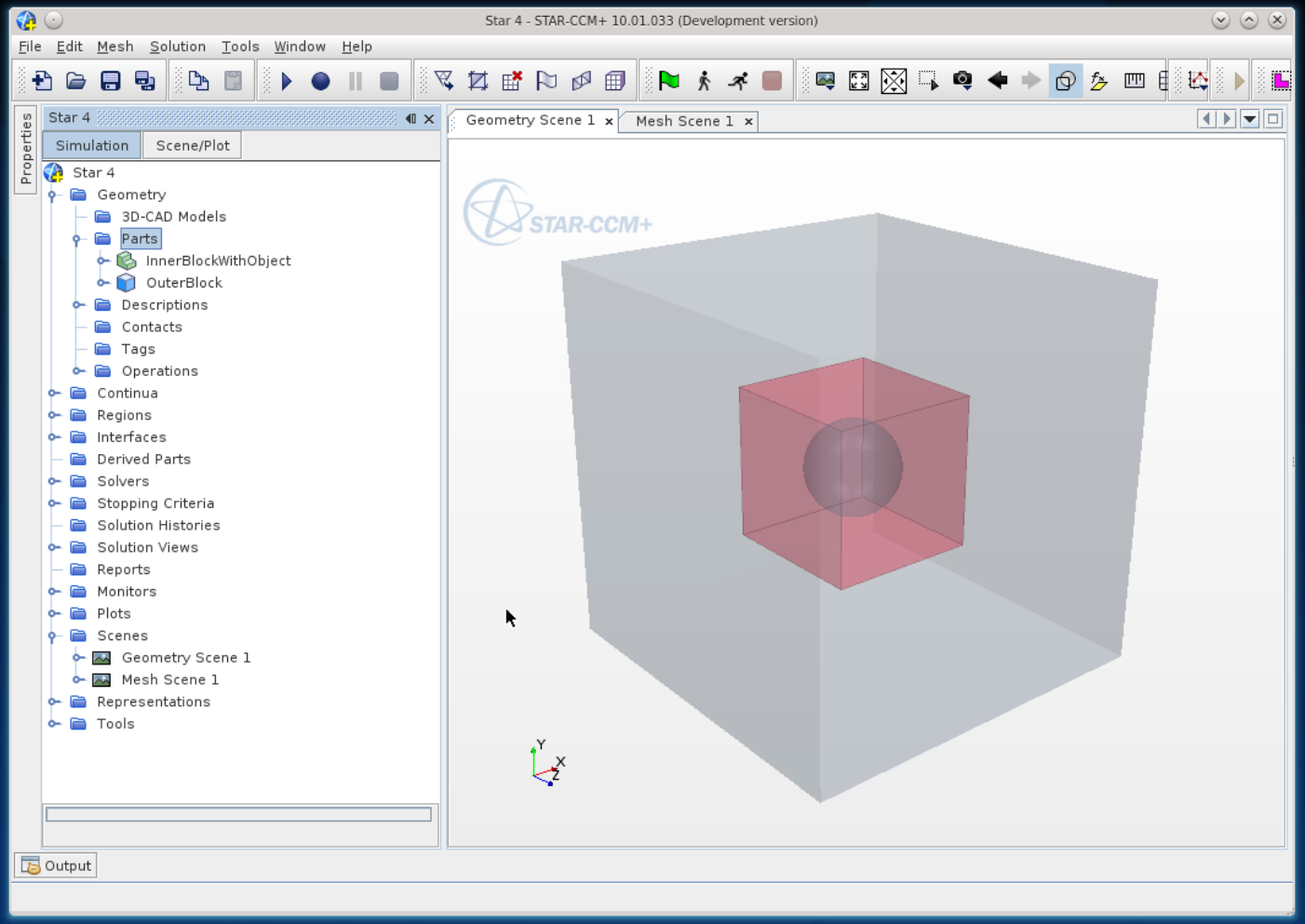
Overview

What is Overset Mesh?



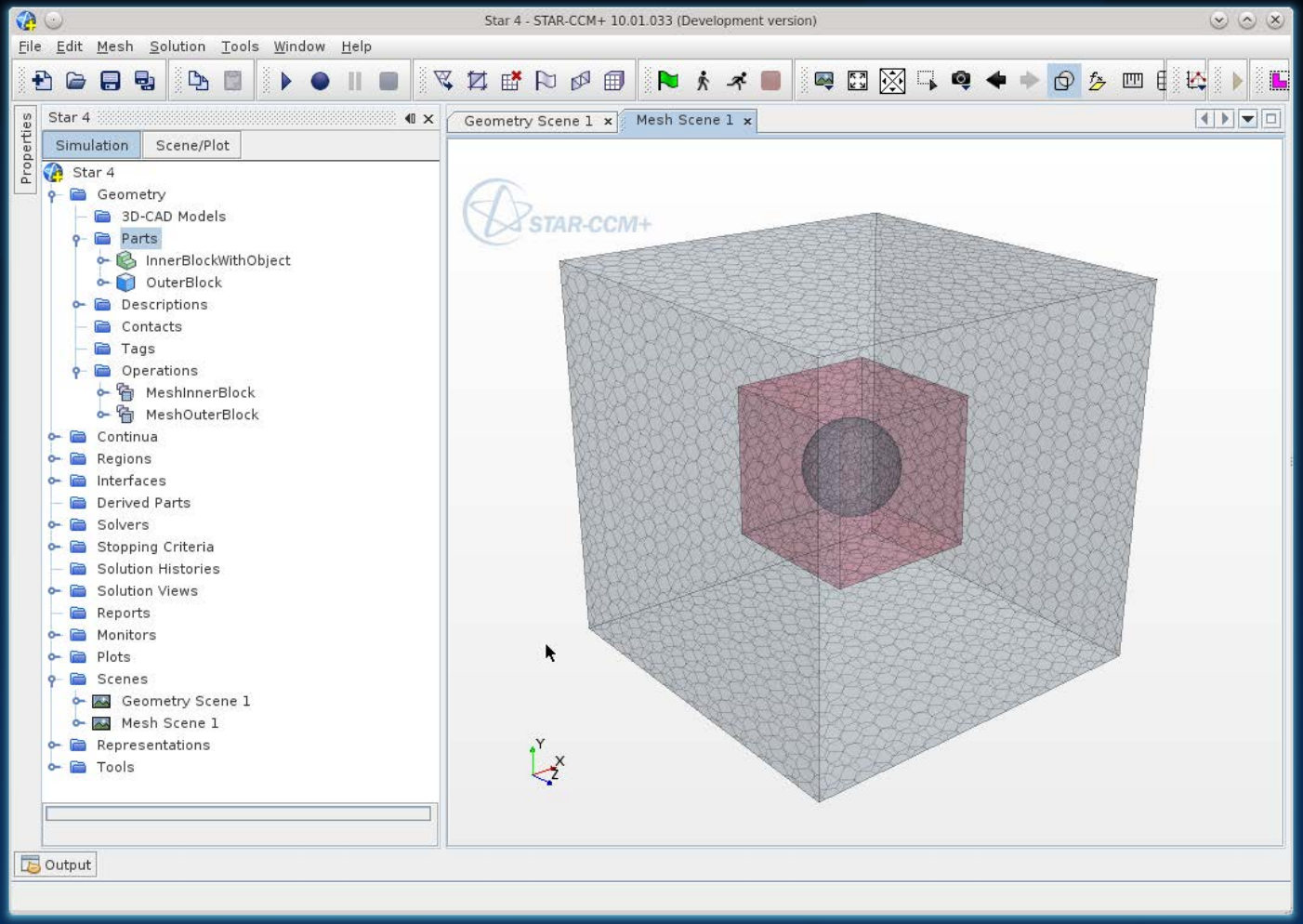
Simple simulation in STAR-CCM+

- Create/import objects



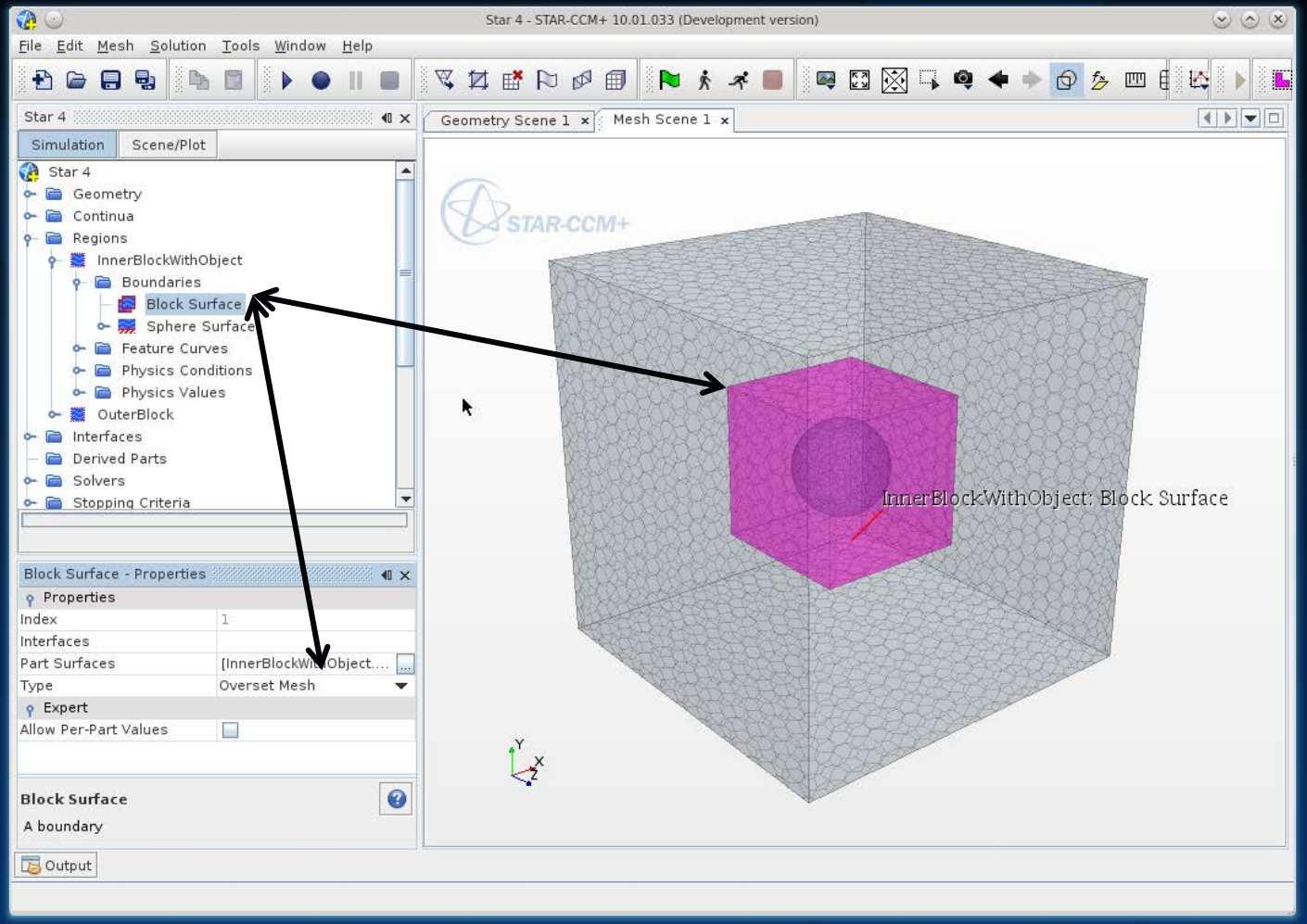
Simple simulation in STAR-CCM+

- Create/import objects
- Make mesh



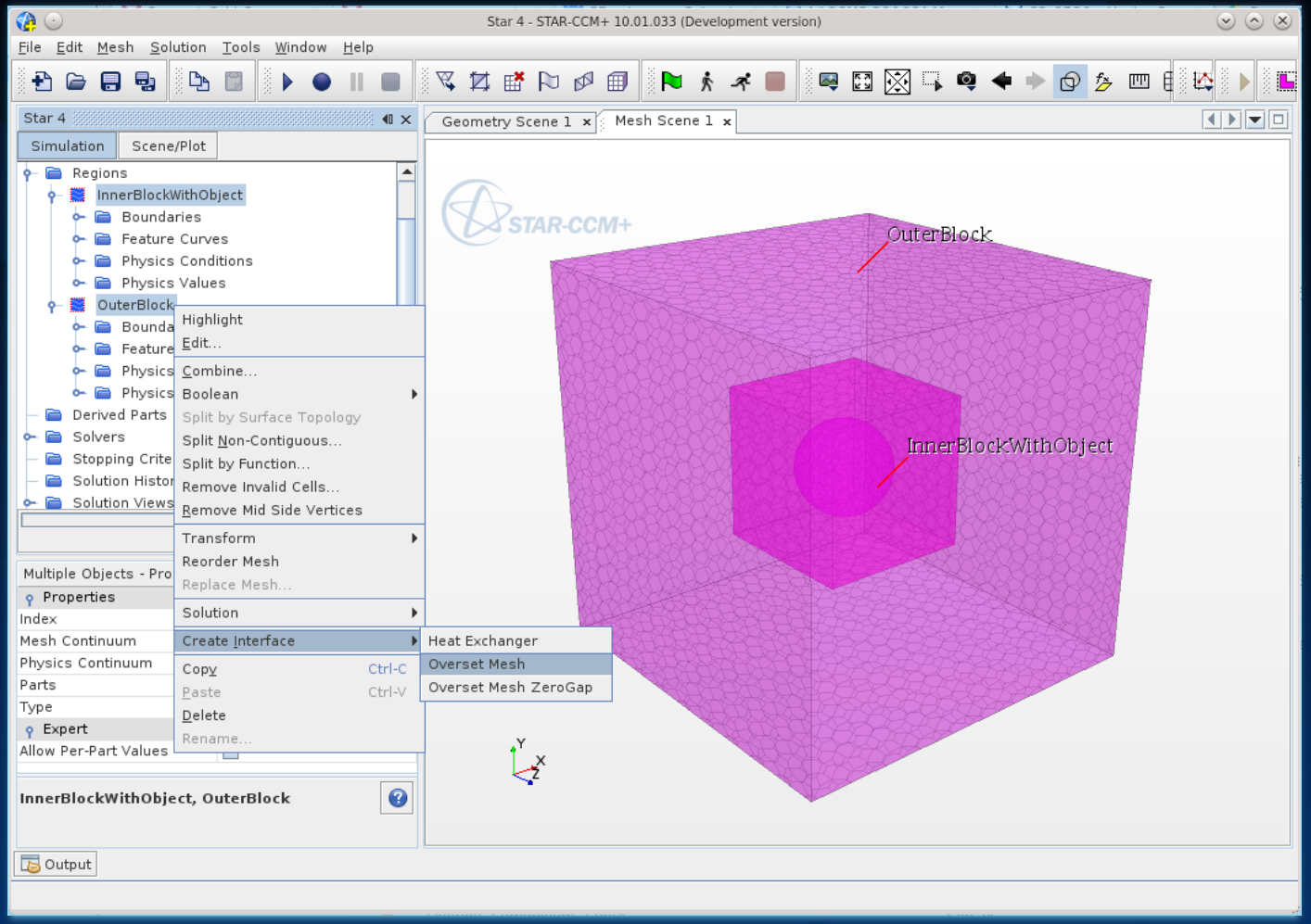
Simple simulation in STAR-CCM+

- Assign overset type to boundary



Simple simulation in STAR-CCM+

- Assign overset type to boundary
- Create an Overset Interface (new type of interface)



Simple simulation in STAR-CCM+

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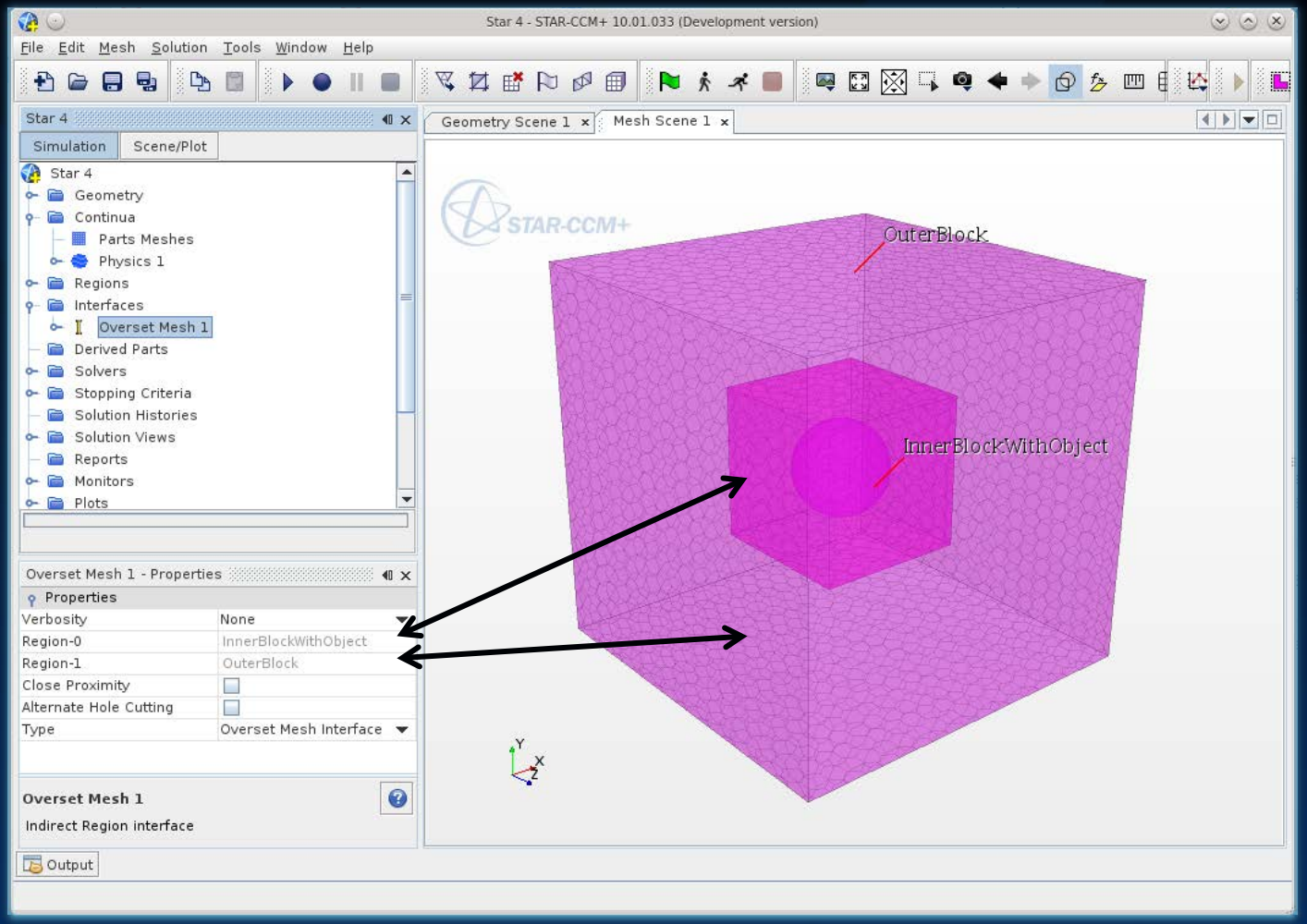
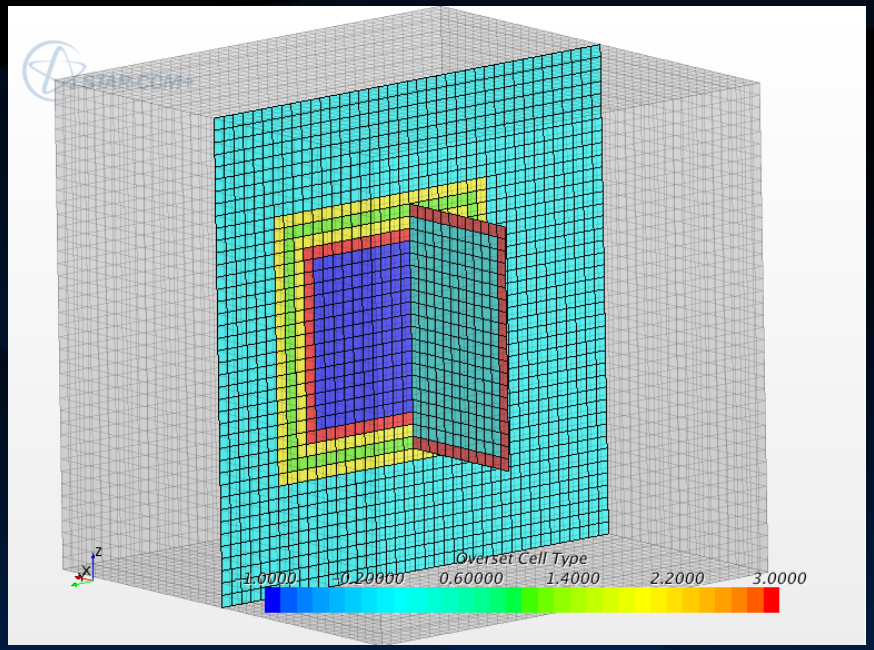


Simple simulation: under the hood



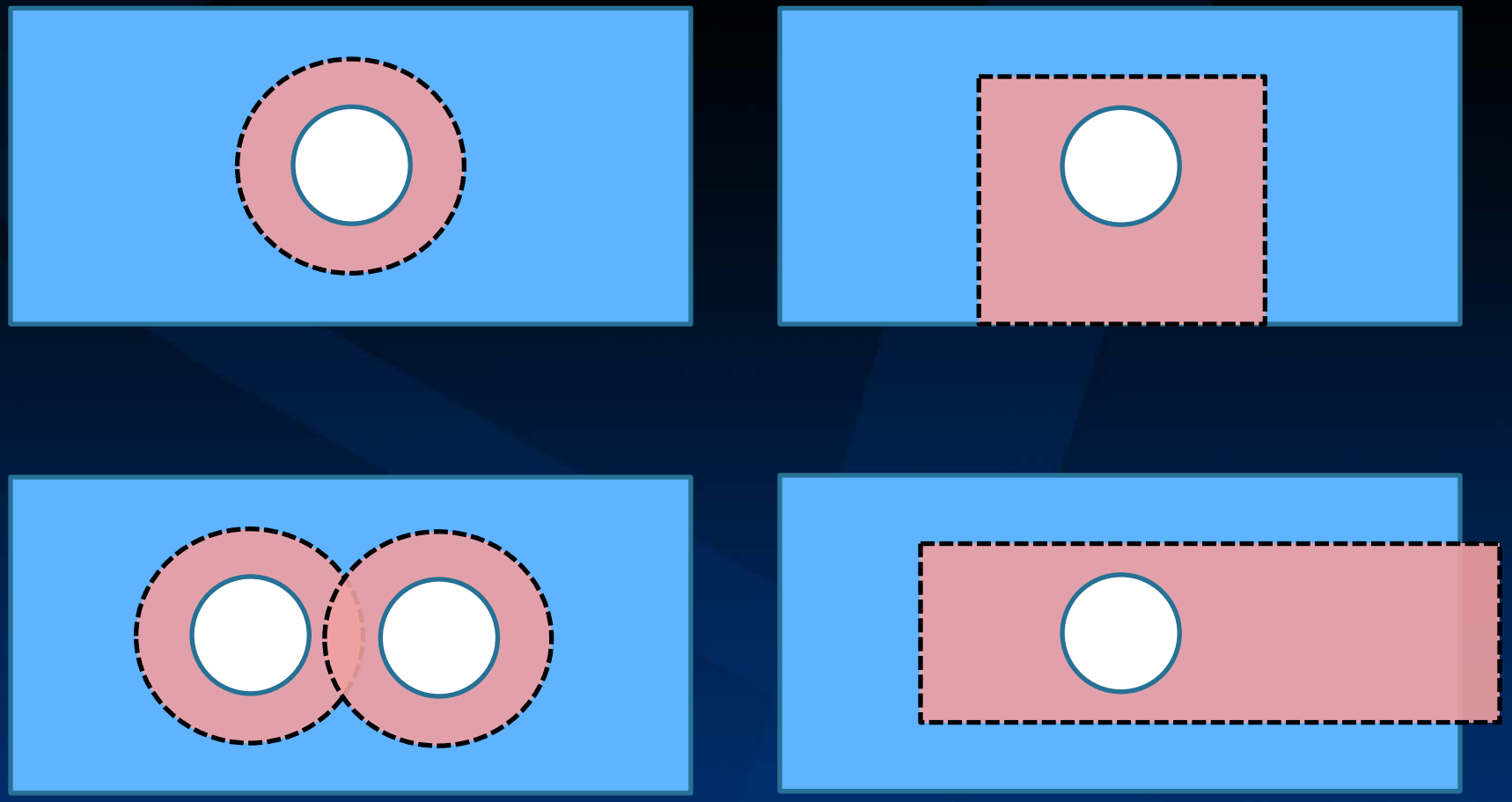
OversetCellType codes

- **3 – acceptor** — red
- **1,2 – active donor cells** — green
- **0 – active cell** — cyan
- **-1 – inactive cell** — blue

Intersection Workflow

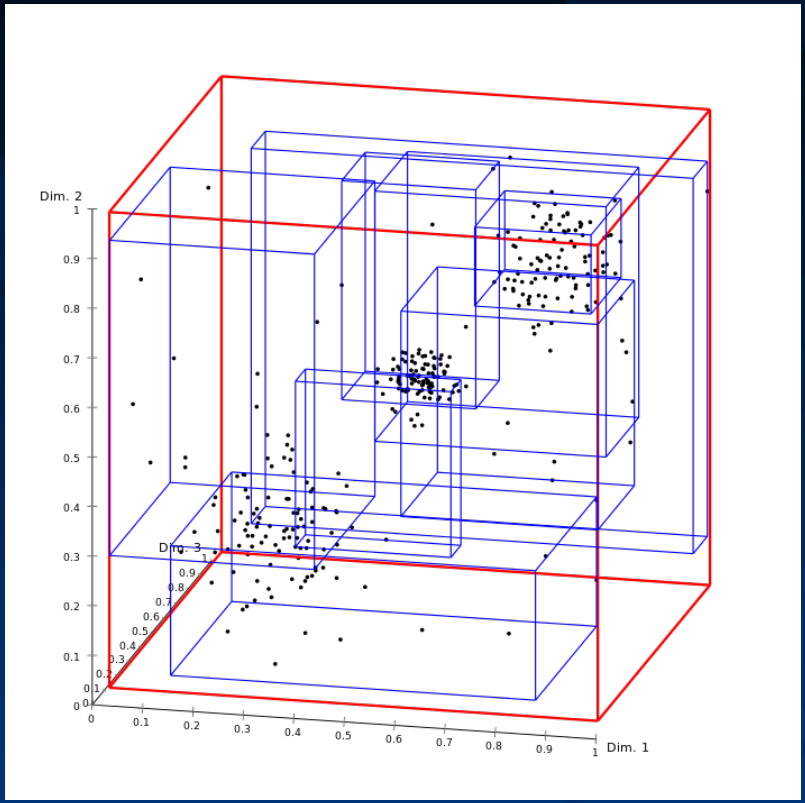
1. Mark cells along the overset boundary as “acceptors” (3)
2. Find corresponding donor in the other region
3. Mark inactive cells in the background
4. Add background acceptors and find donors for them

Valid configurations: “Overset” boundary



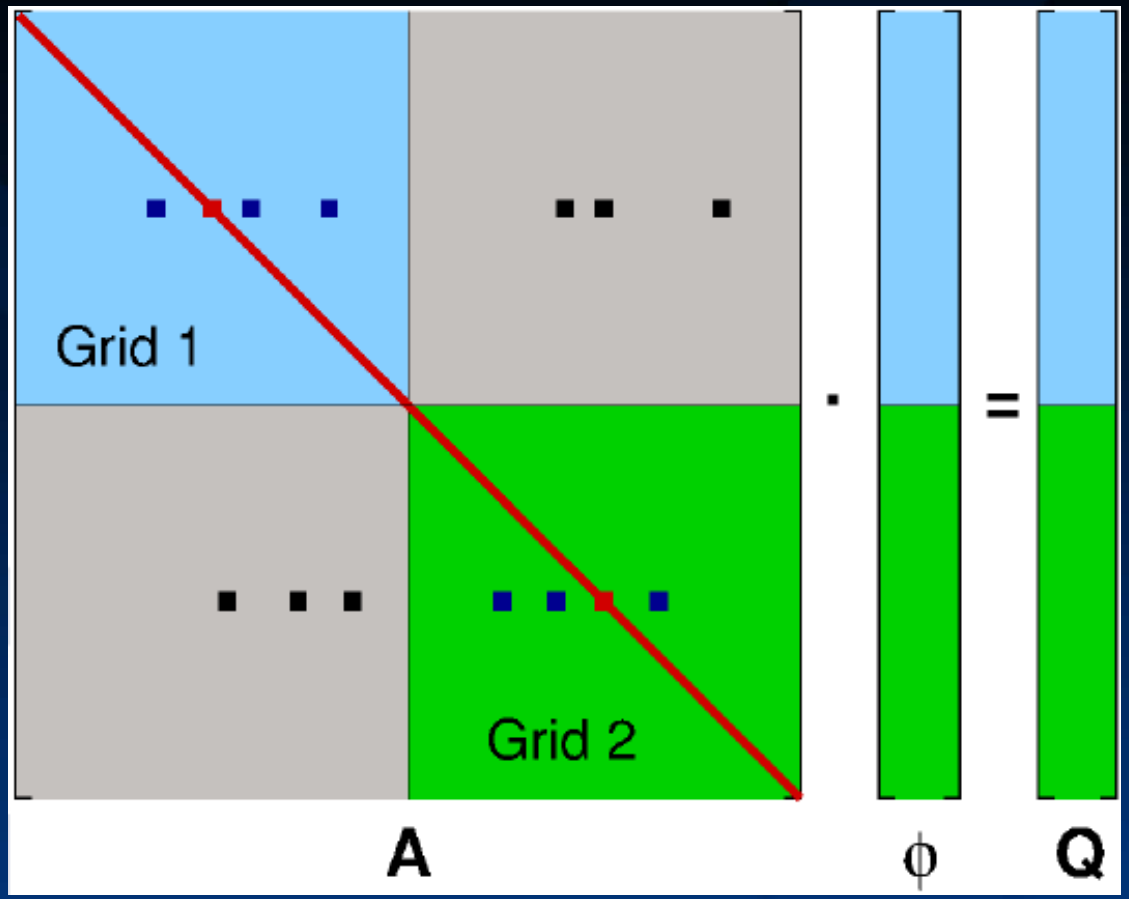
Implementation: Overlapping

- Triangulated surfaces for internal objects, active cells for inside/outside testing
- R-Tree for quick point location
- Bounding boxes for coarse point location



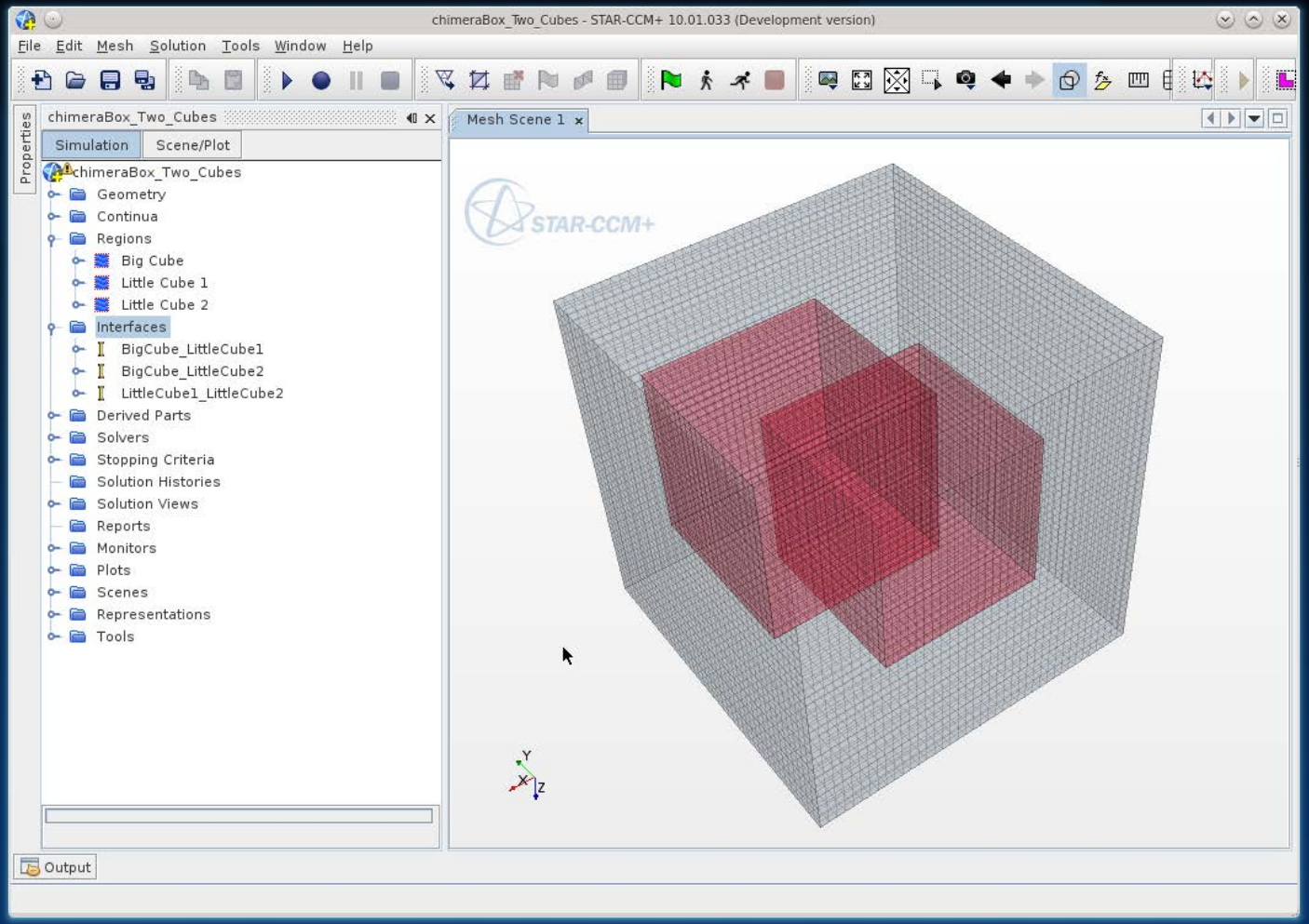
Implementation: Solver side

- Interpolation coefficients are computed and embedded into a linear system
- Interpolation work simultaneously with solving a linear system
- Grids are implicitly coupled through the linear equation system matrix.



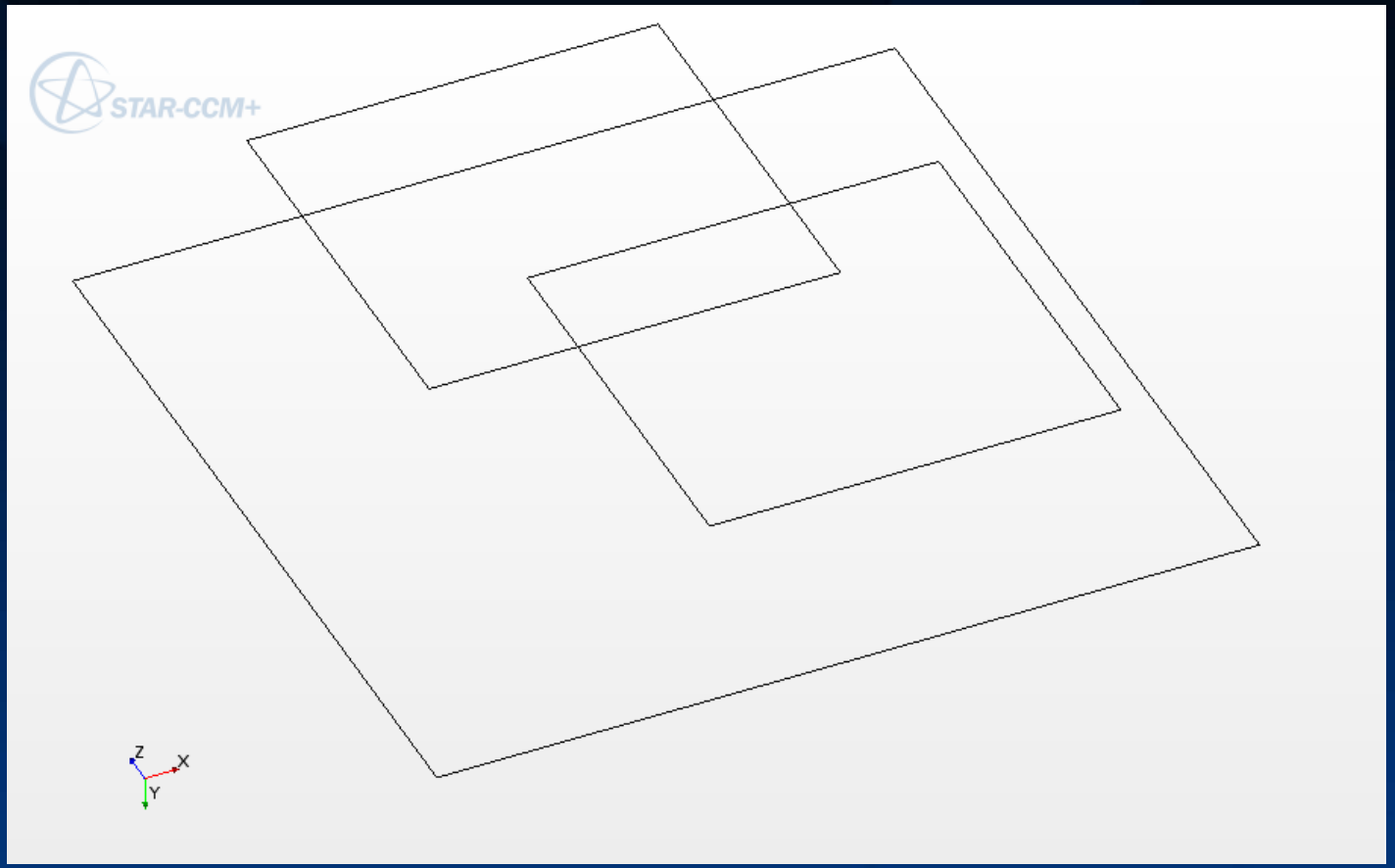
Simple simulation: multiple overset case

- Several overlapping regions
- One background region
- Extension by creating additional overset interfaces



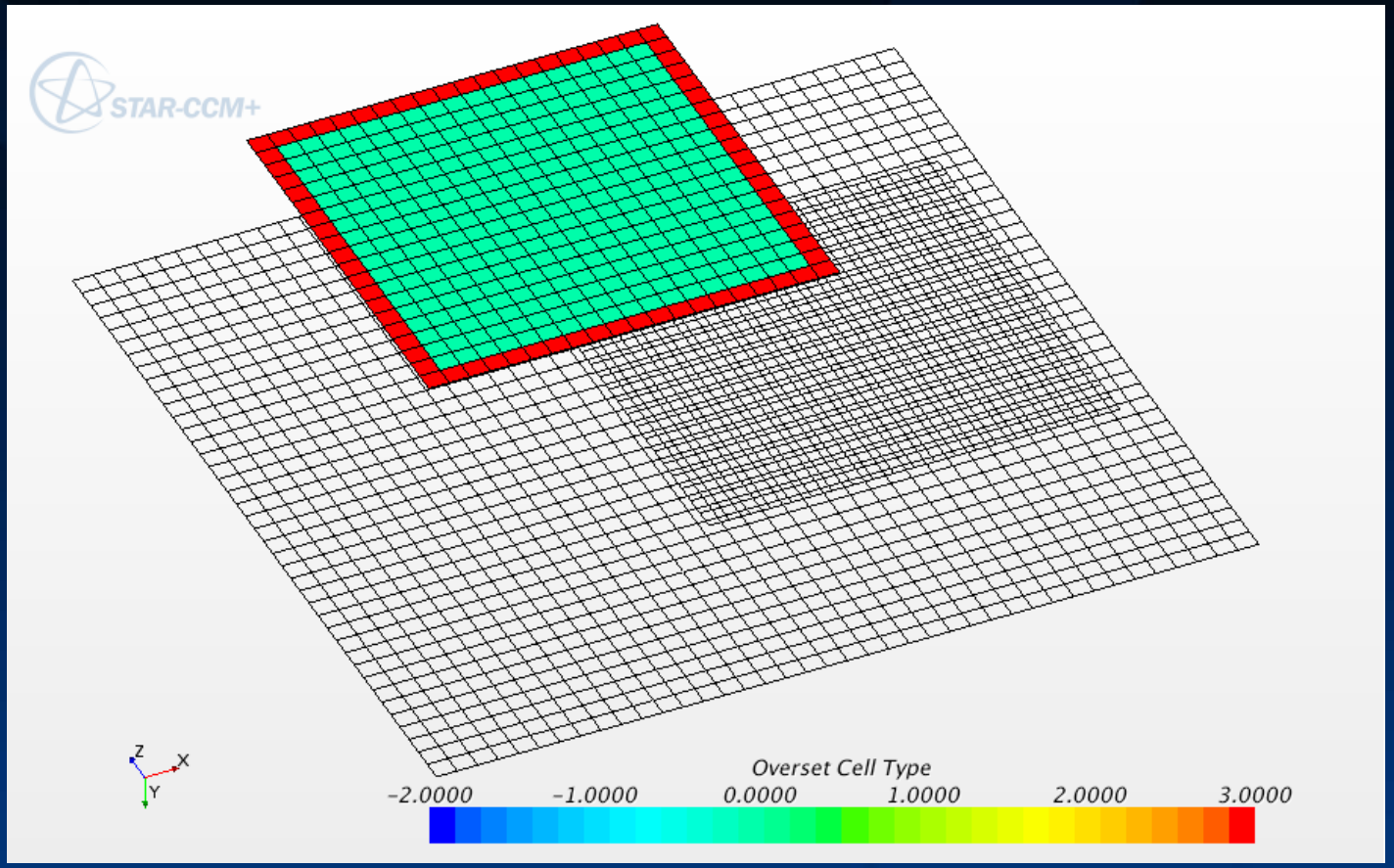
Simple simulation: multiple overset case

- Sort regions according to the number of connected regions
- Create hierarchy of regions based on side of interface



Simple simulation: multiple overset case

- Sort regions according to the number of connected regions
- Create hierarchy of regions based on side of interface
- Intersect region from top to bottom with everything below



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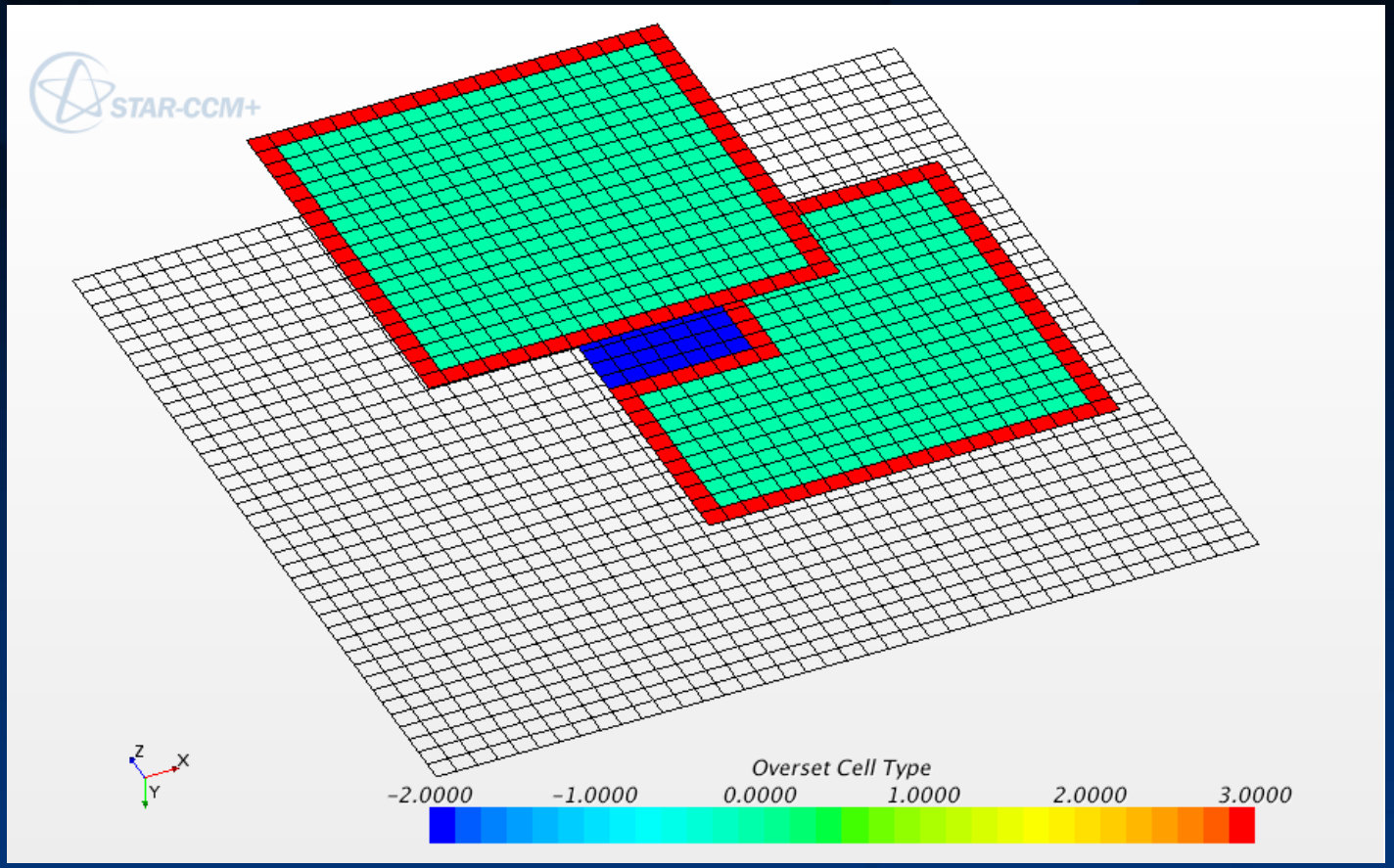
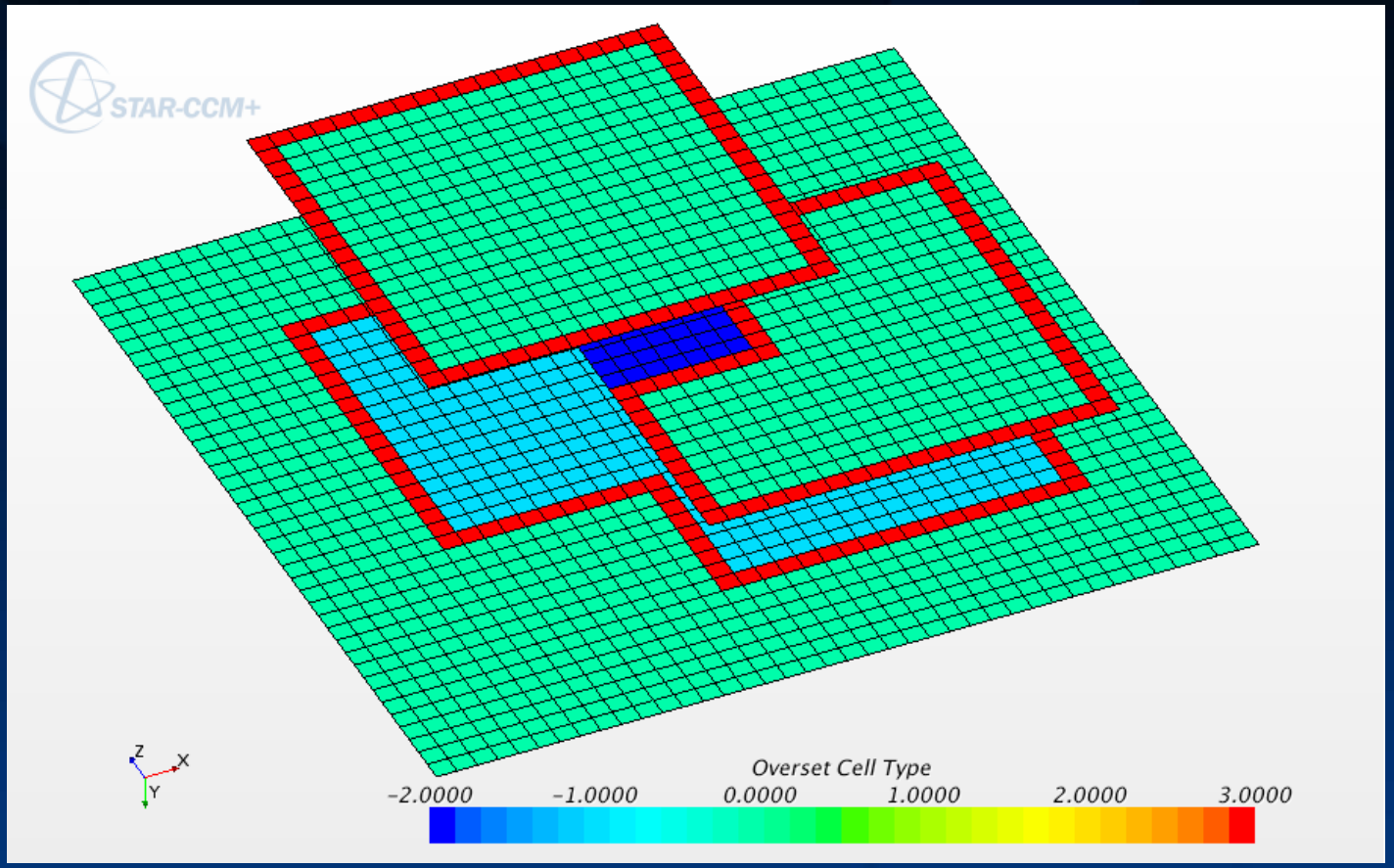


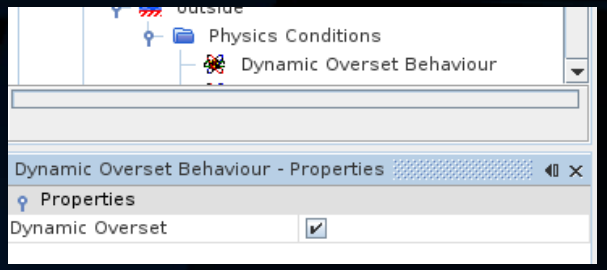
Simple simulation: multiple overset case

- Sort regions according to the number of connected regions
- Create hierarchy of regions based on side of interface
- Intersect region from top to bottom with everything below
- Intersect with background in the least



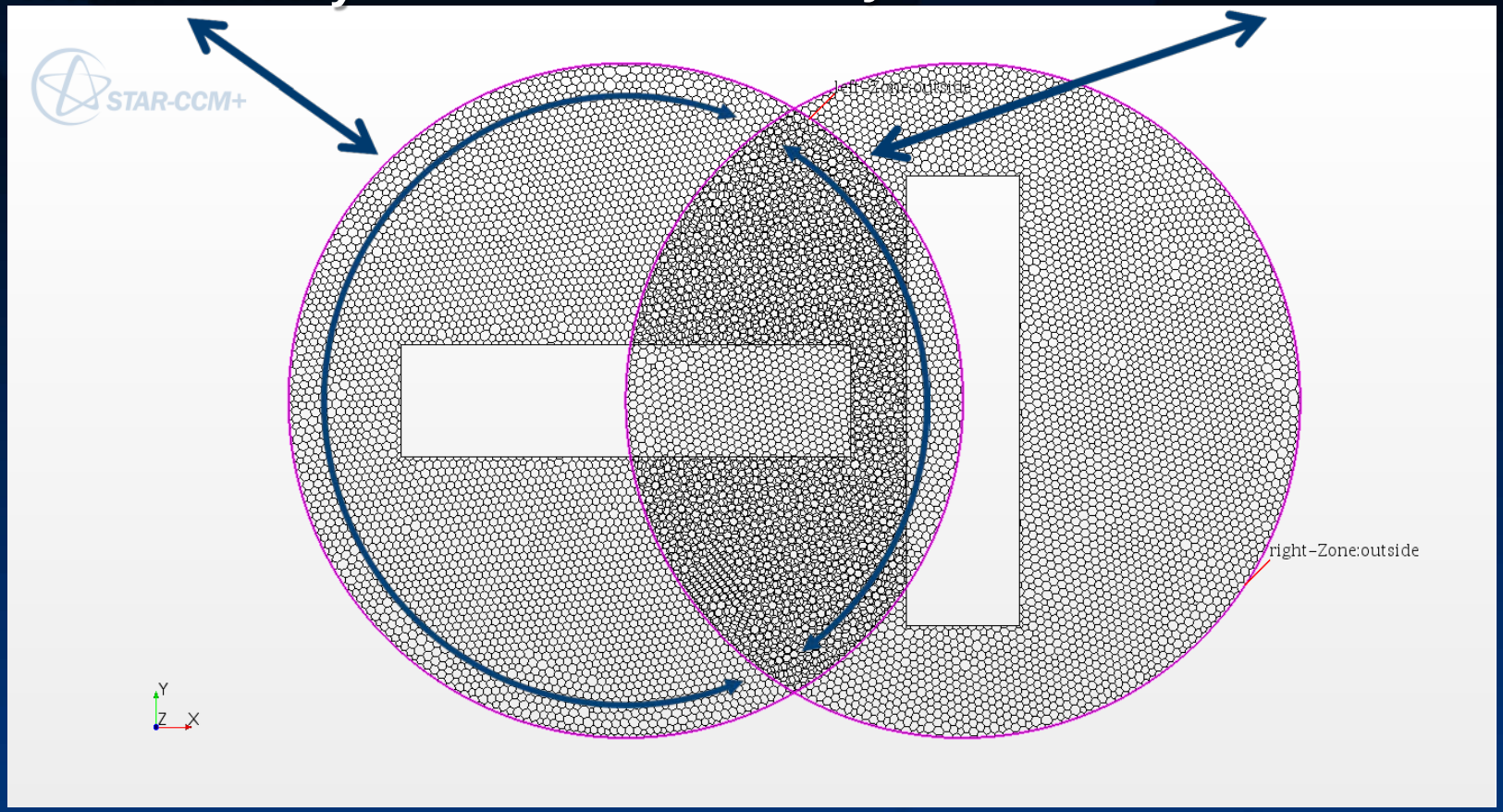
Multiple overset with dynamic overset boundary

- Dynamic overset behavior of a boundary
- Face-based switching
- Motion-based intersection

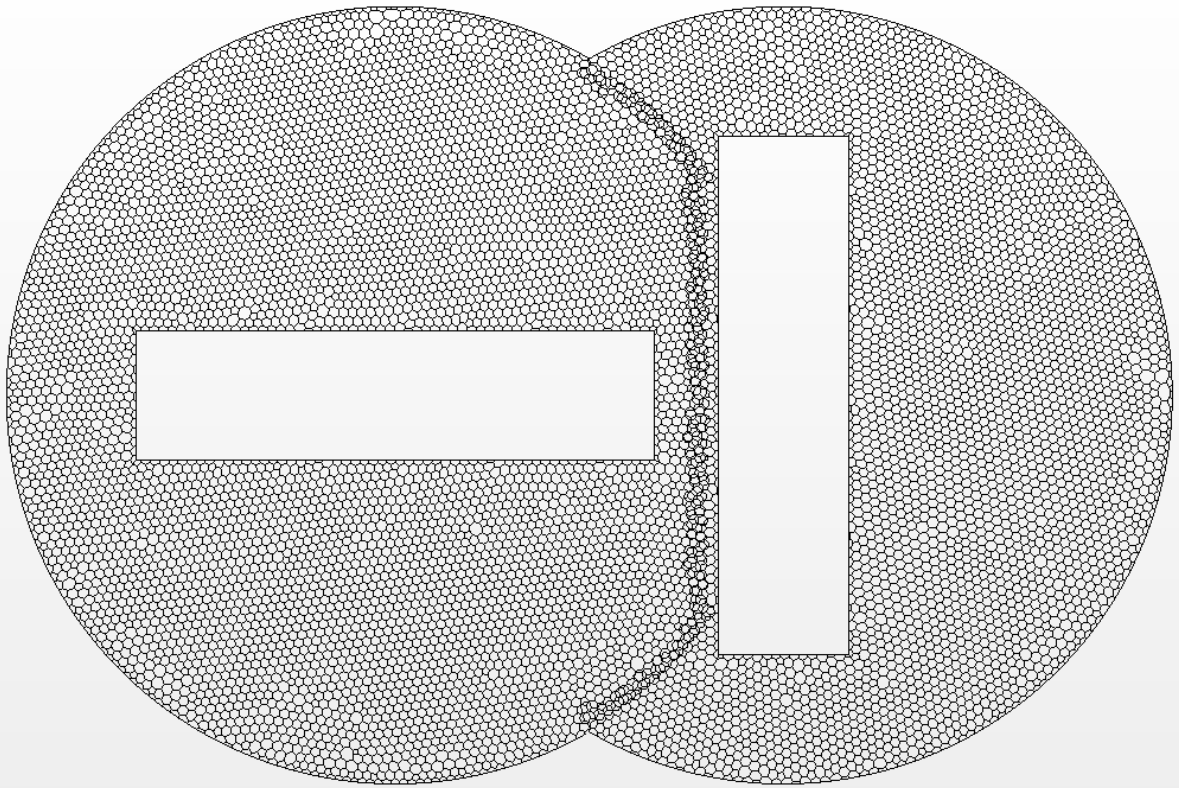


Wall Boundary

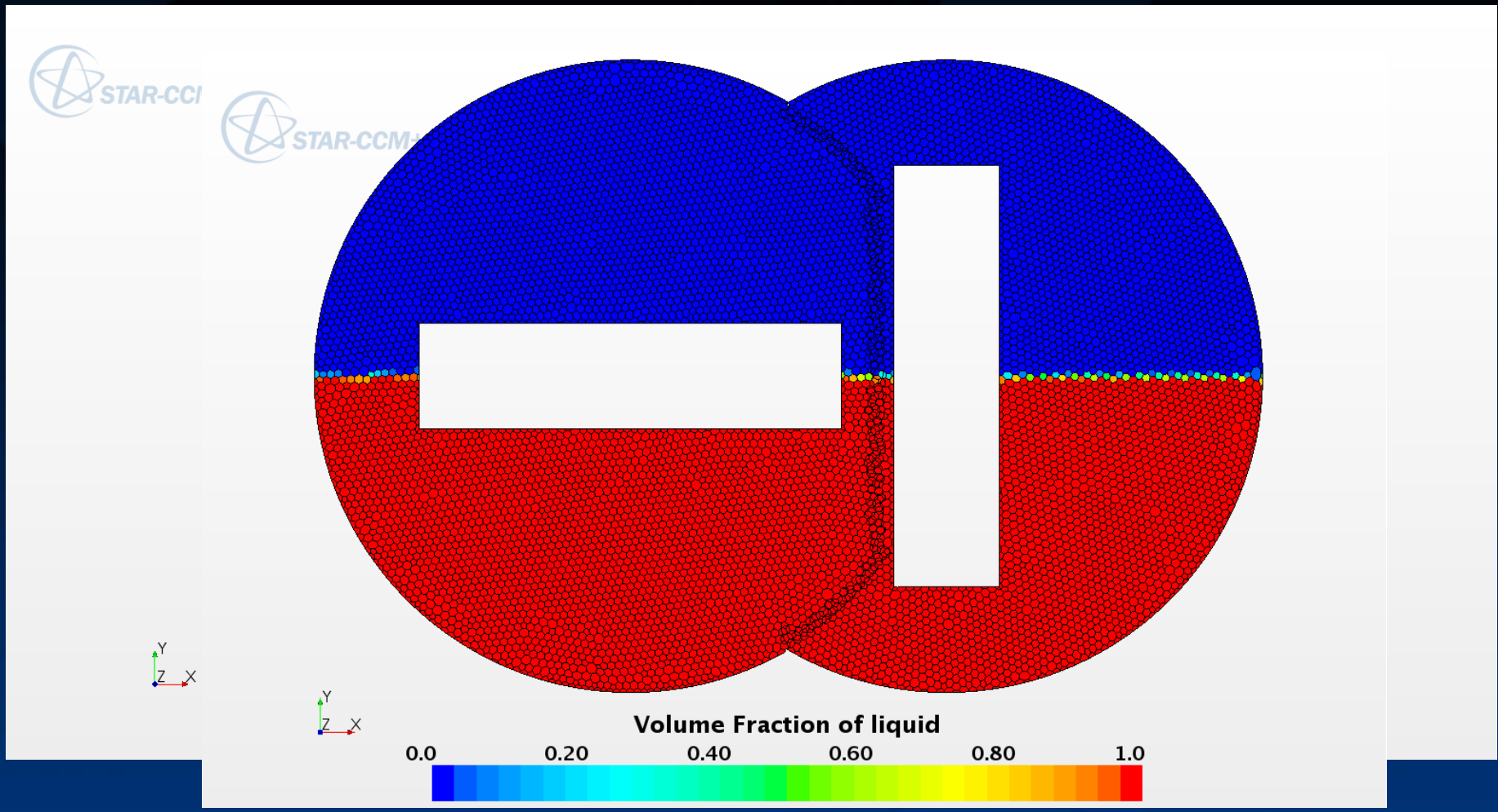
Dynamic Overset Wall Boundary



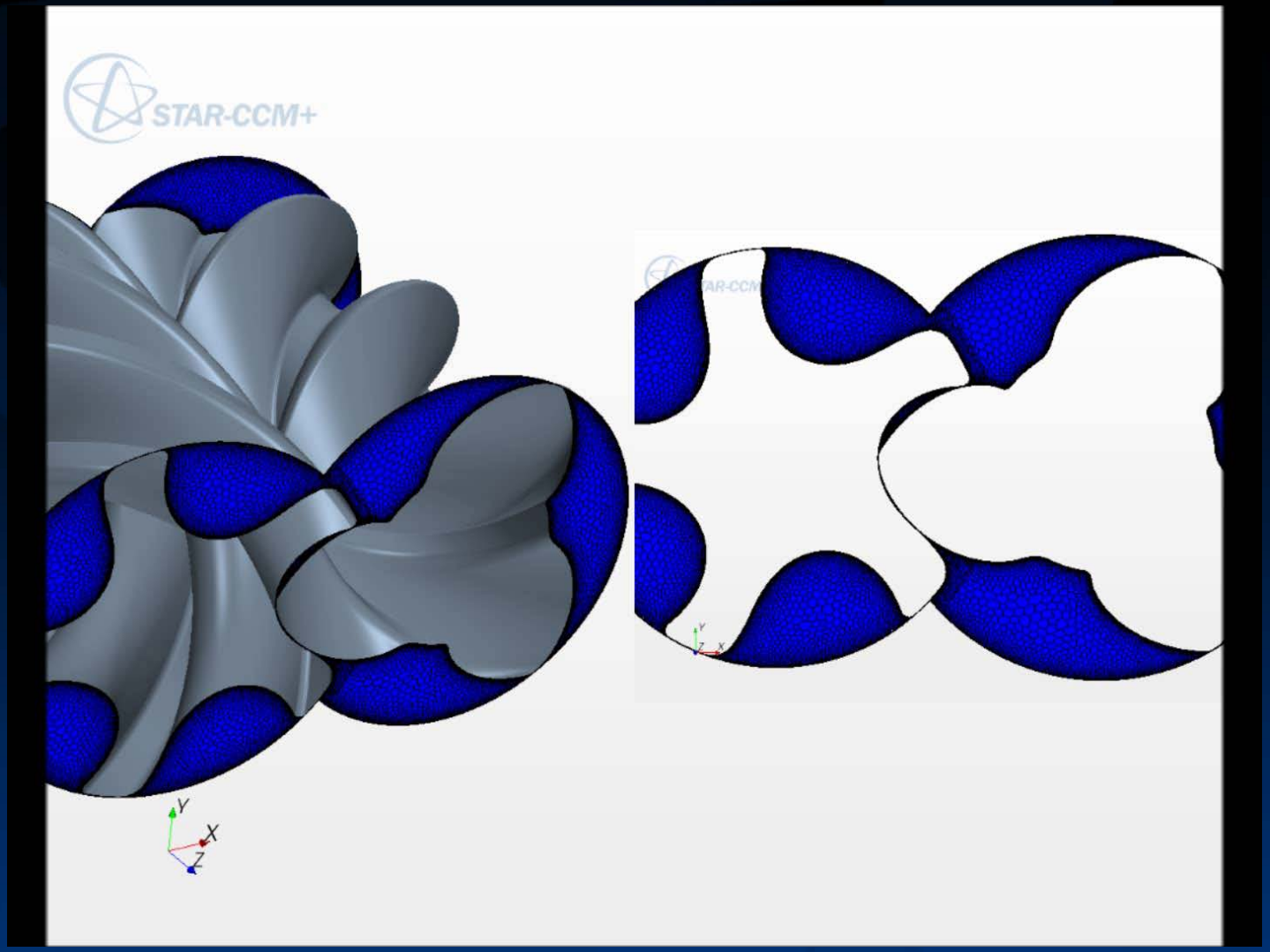
Multiple overset with dynamic overset boundary



Multiple overset with dynamic overset boundary

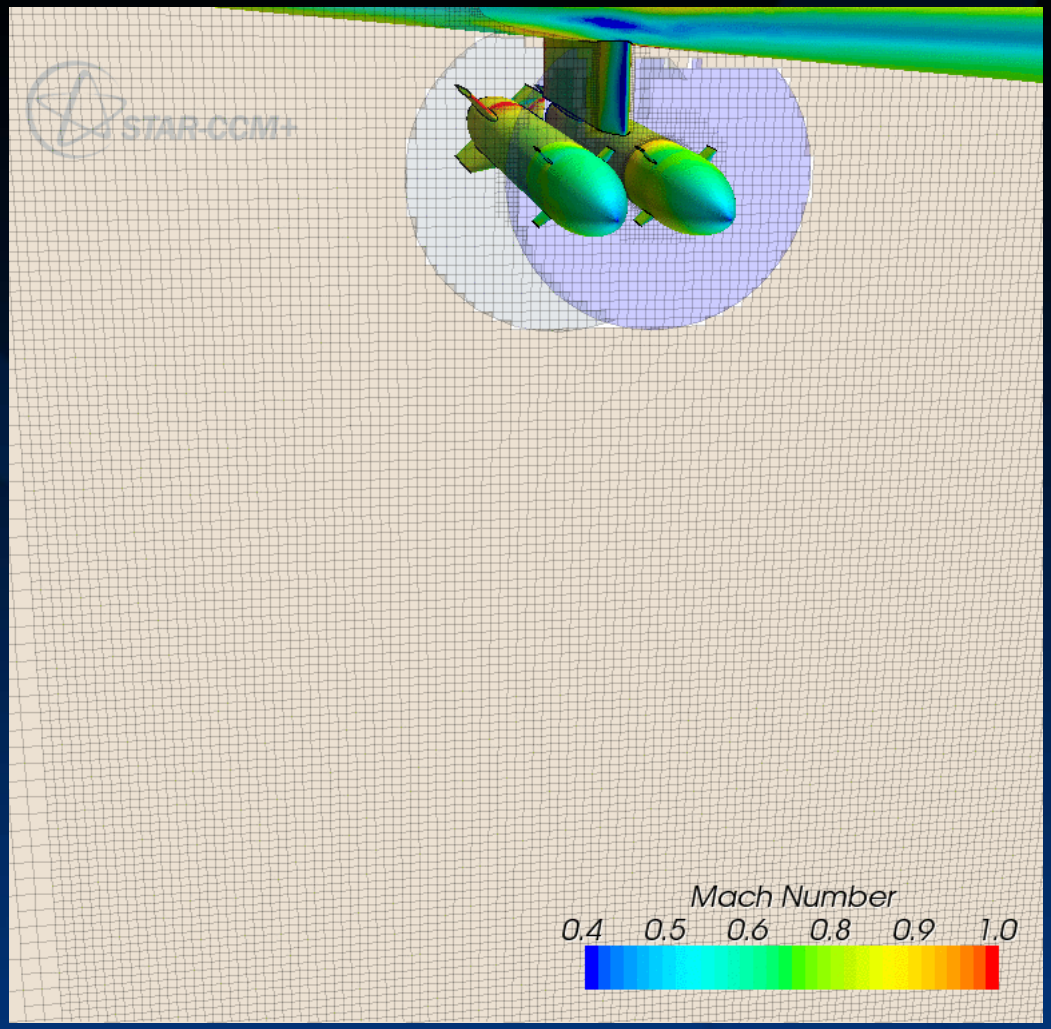


Screw compressor



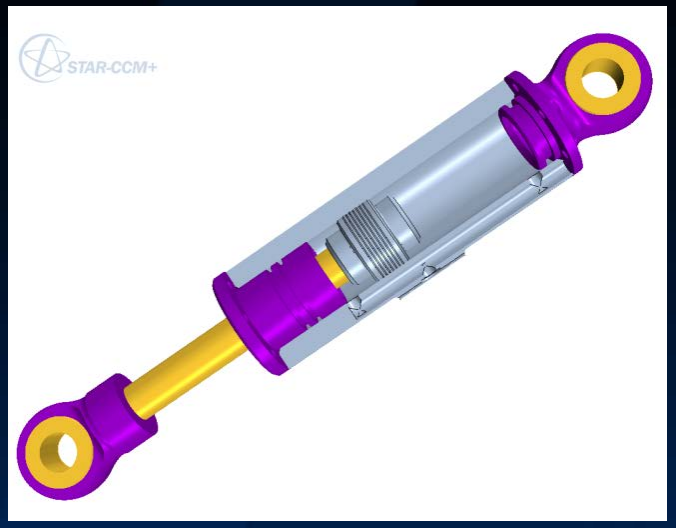
Courtesy of CITY UNIVERSITY LONDON

Multiple overset: store separation



Hydraulic Damper

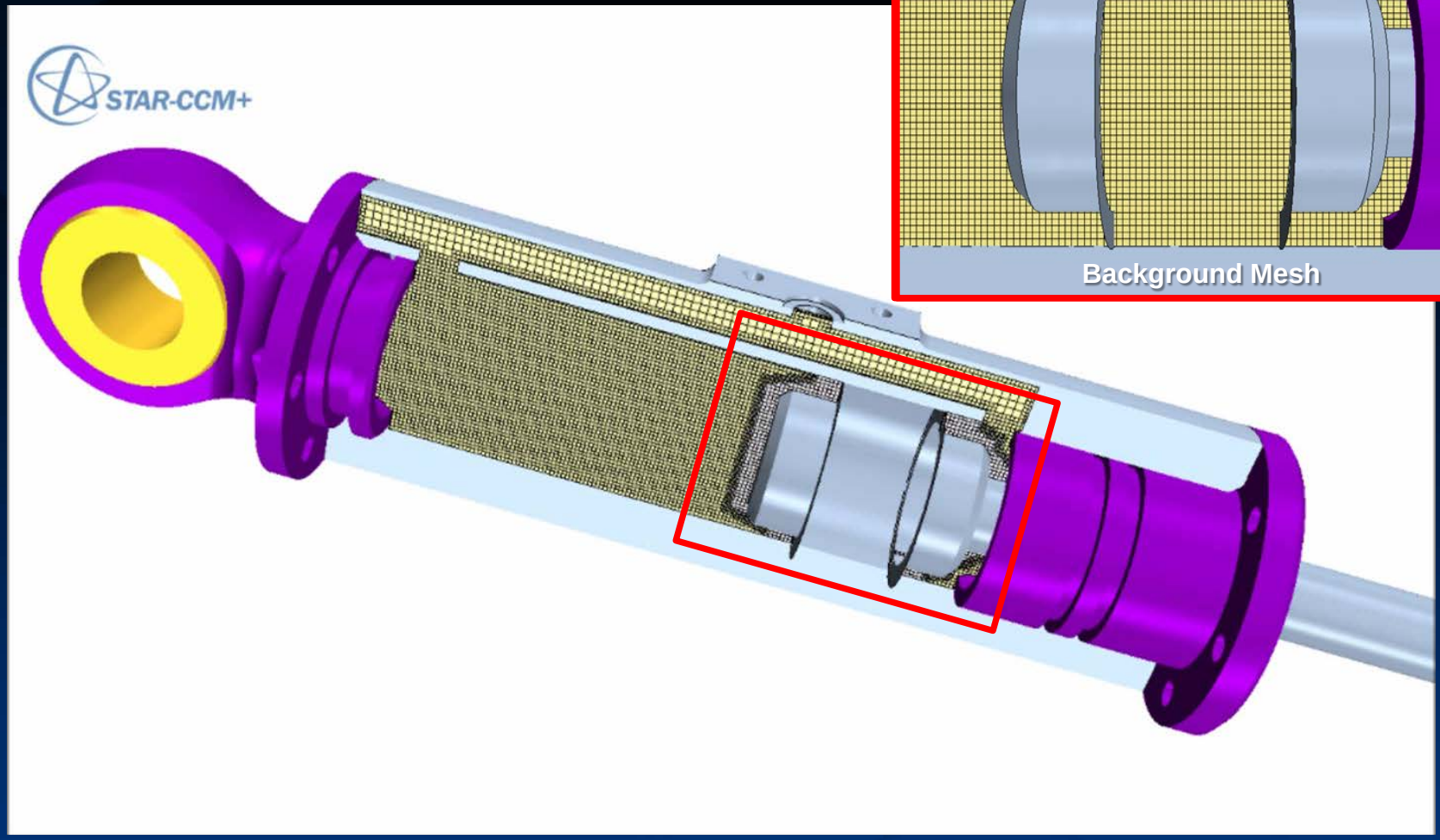
- **Dampers are used to safely control the speed of moving masses. Damping in both directions is possible**



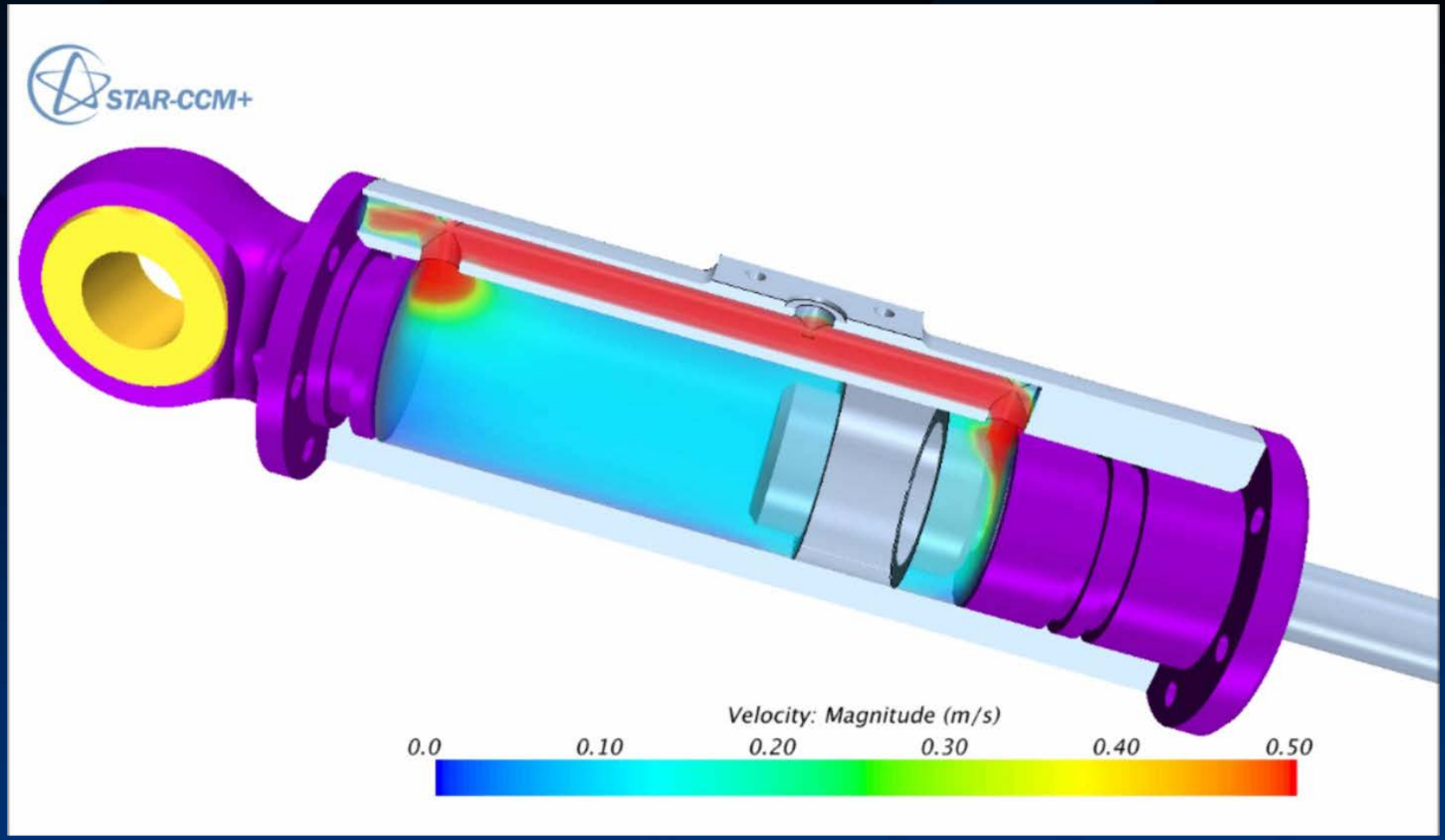
- **With STAR-CCM+ it is possible:**
  - To have an insight in the fluid flow
  - To generate performance charts of different damper geometries
  - To investigate inner fluid forces acting on the solid parts (can be used for stress analysis)

Hydraulic Damper: Overset Mesh

- Mesh Plot



Hydraulic Damper: Overset Mesh



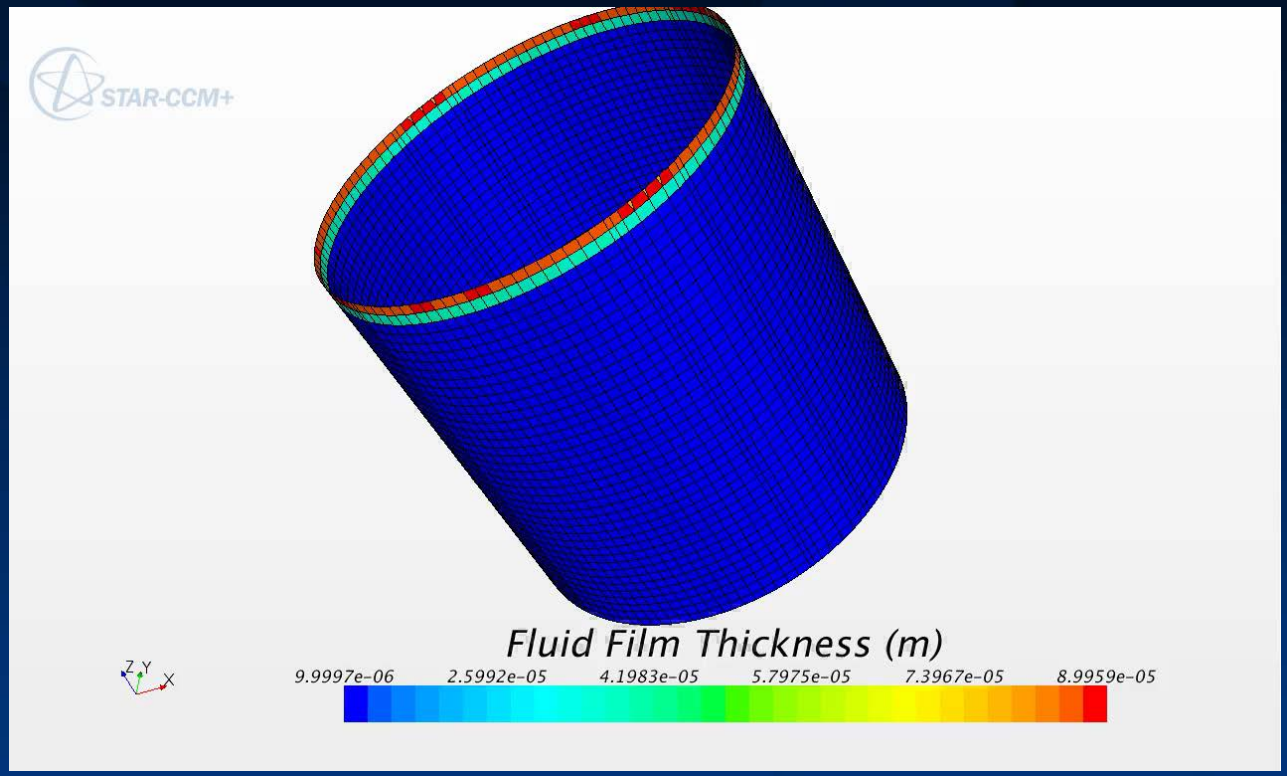
Models and study cases

- **Overset Framework must support most of the models available in STAR-CCM+**
- **Typically the framework takes care of all the variables to be interpolated**

- **Some of the models compatible with Overset Framework require special attention:**
  - Fluid Film model
  - Lagrangian Phase

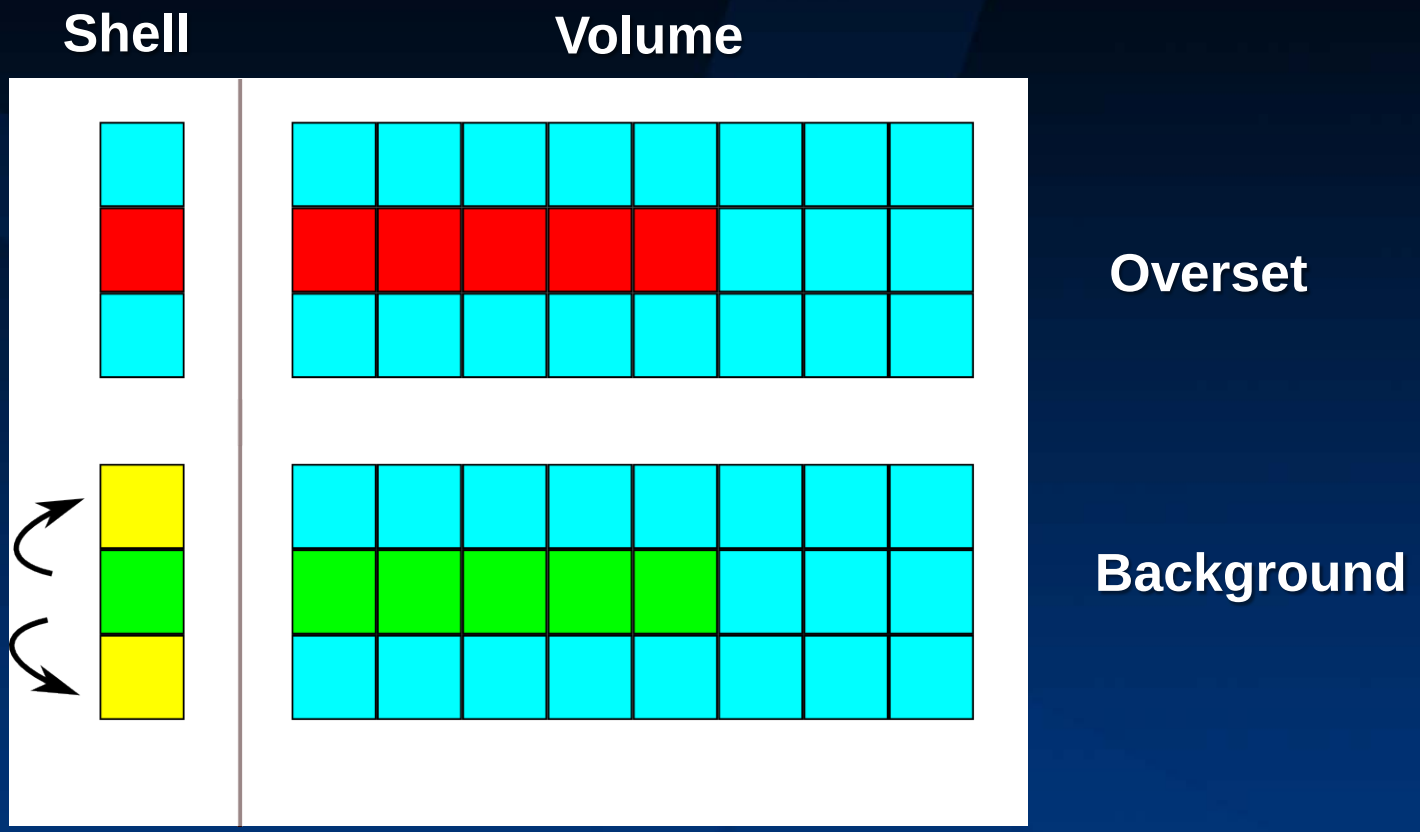
Fluid Film model

- Accounts for transport of conserved quantities with film and its interaction with surroundings
- Assumptions:
  - Thin film for laminar boundary layer approximations
  - Attached to boundary with preset separation
  - Parabolic velocity profile



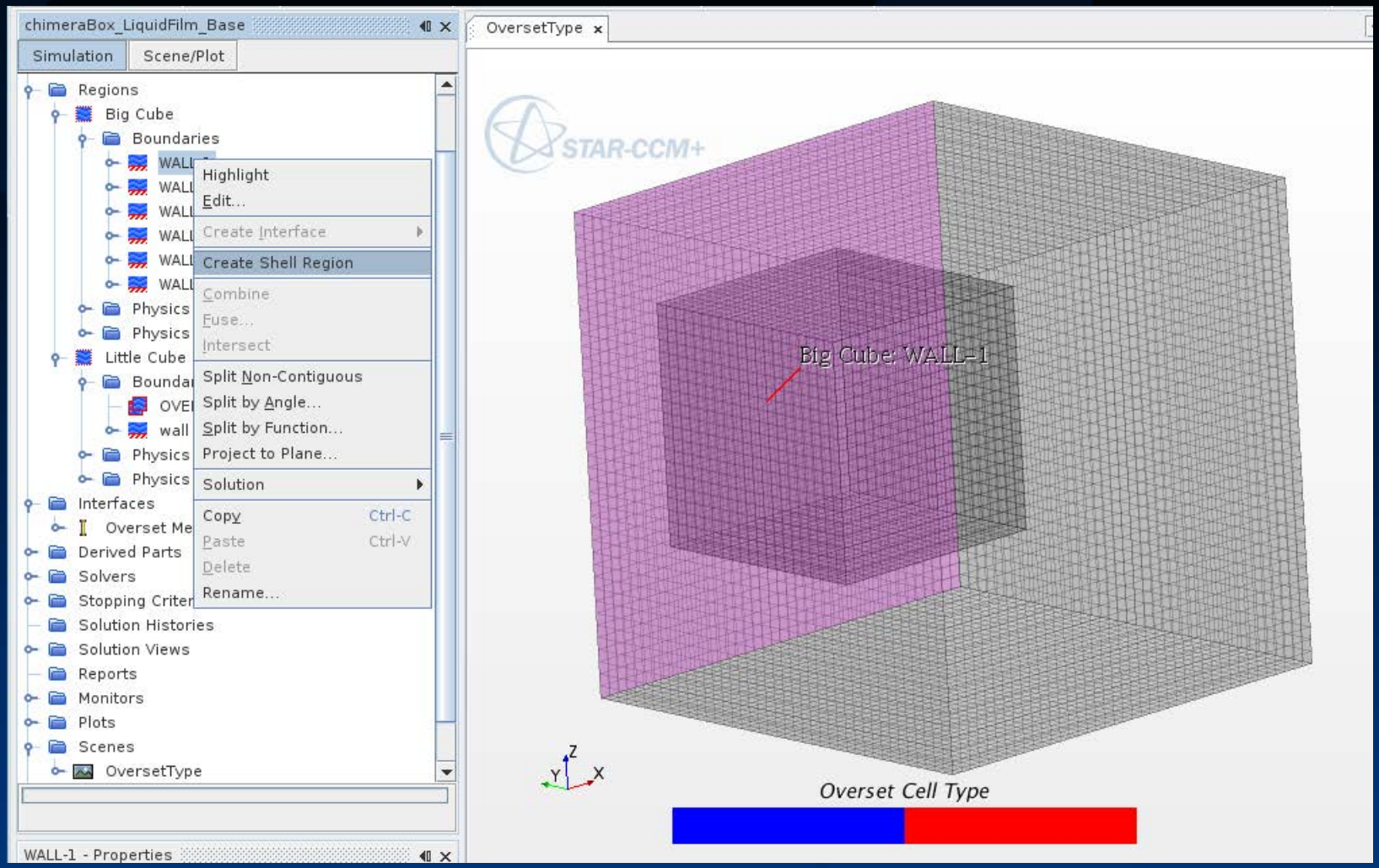
Fluid Film model & Overset grids: donor search

- Initial state: volumes intersected
- Copy acceptor information
- Copy “first” donor information
- Find additional donors for interpolation



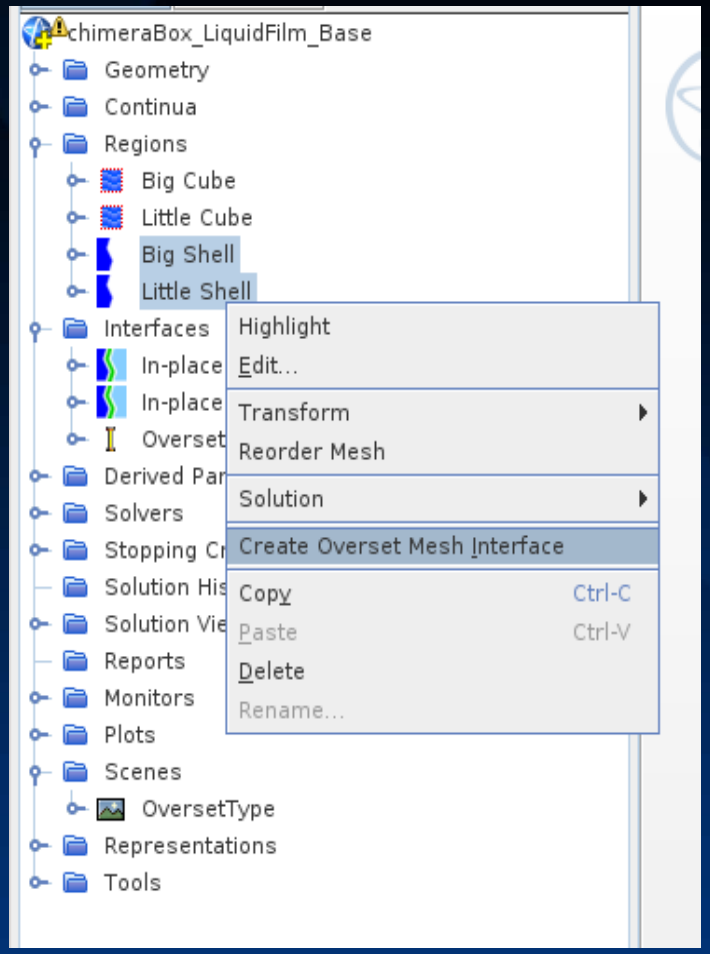
Fluid Film model & Overset grids

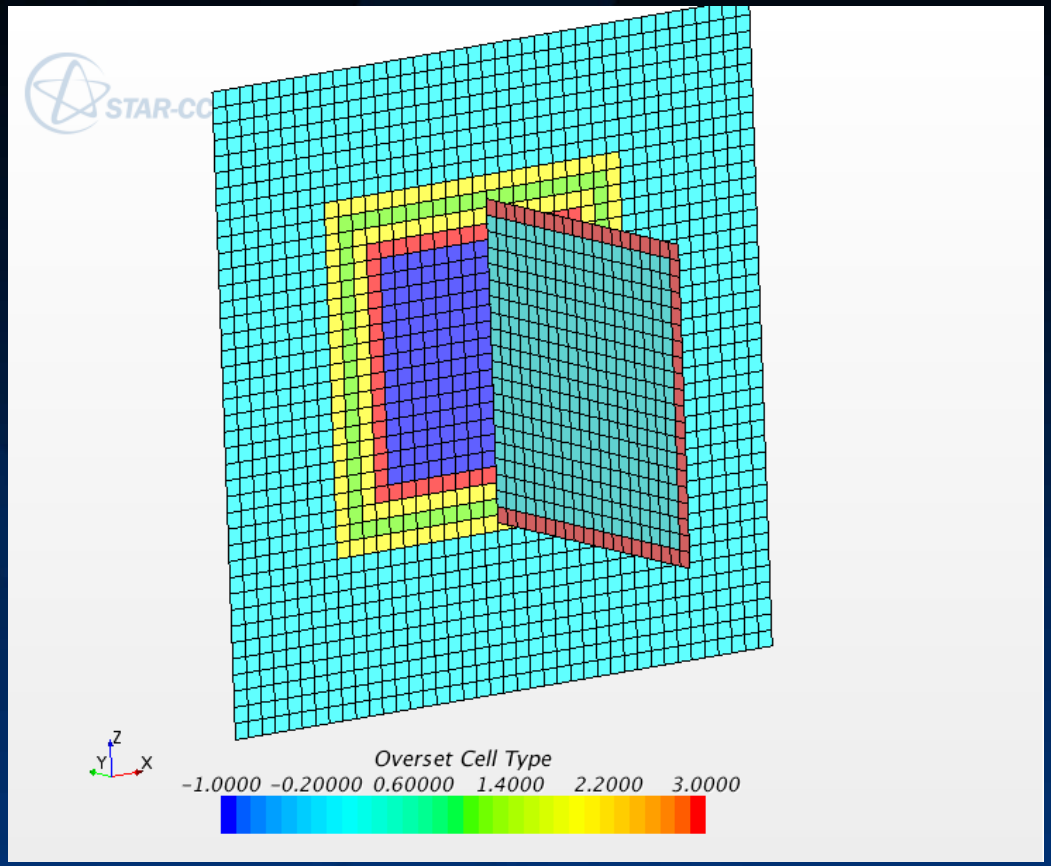
1. Move small cube towards the wall of the big one
2. Create shell regions



Fluid Film model & Overset grids

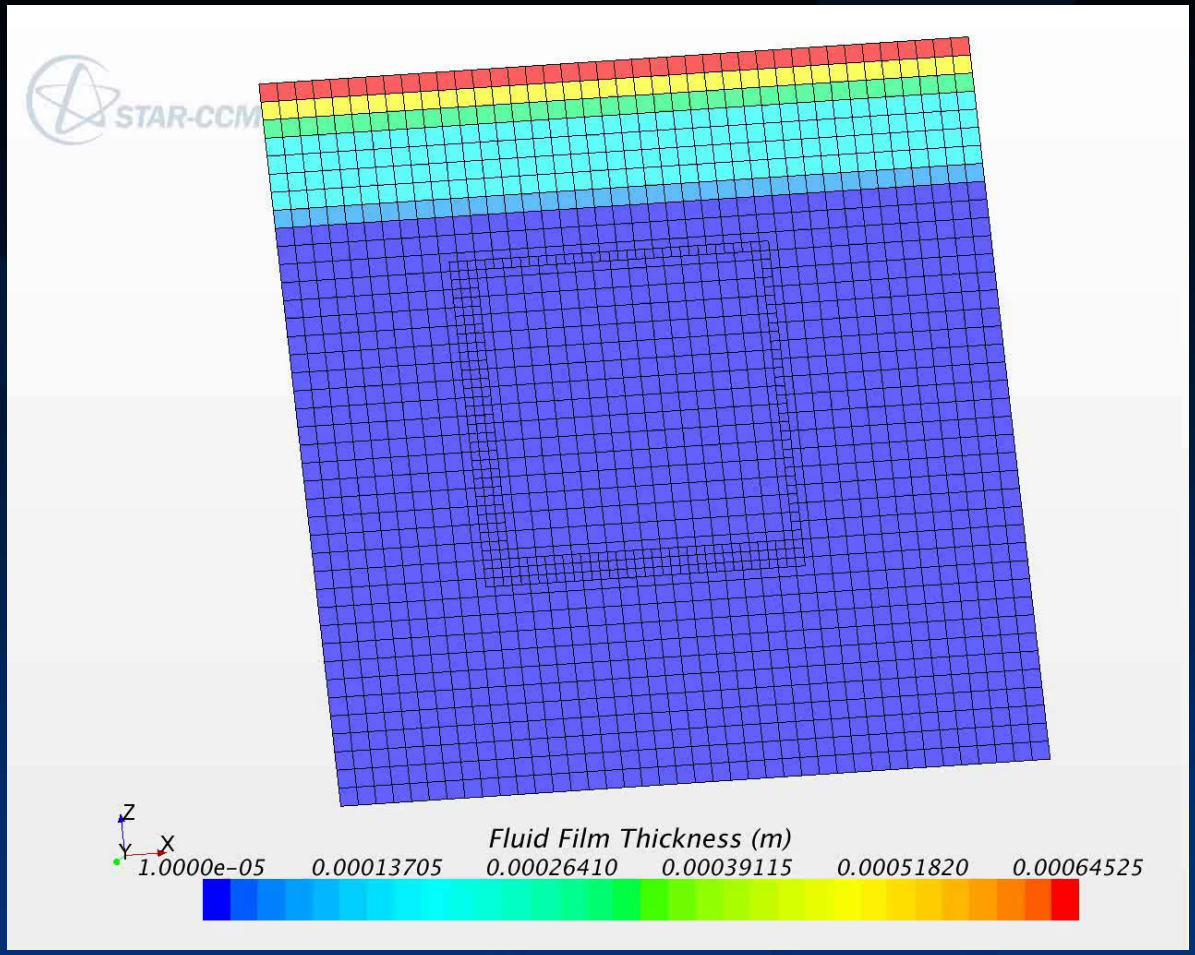
3. Create Overset Interface between shells
4. Setup boundary conditions and initialize





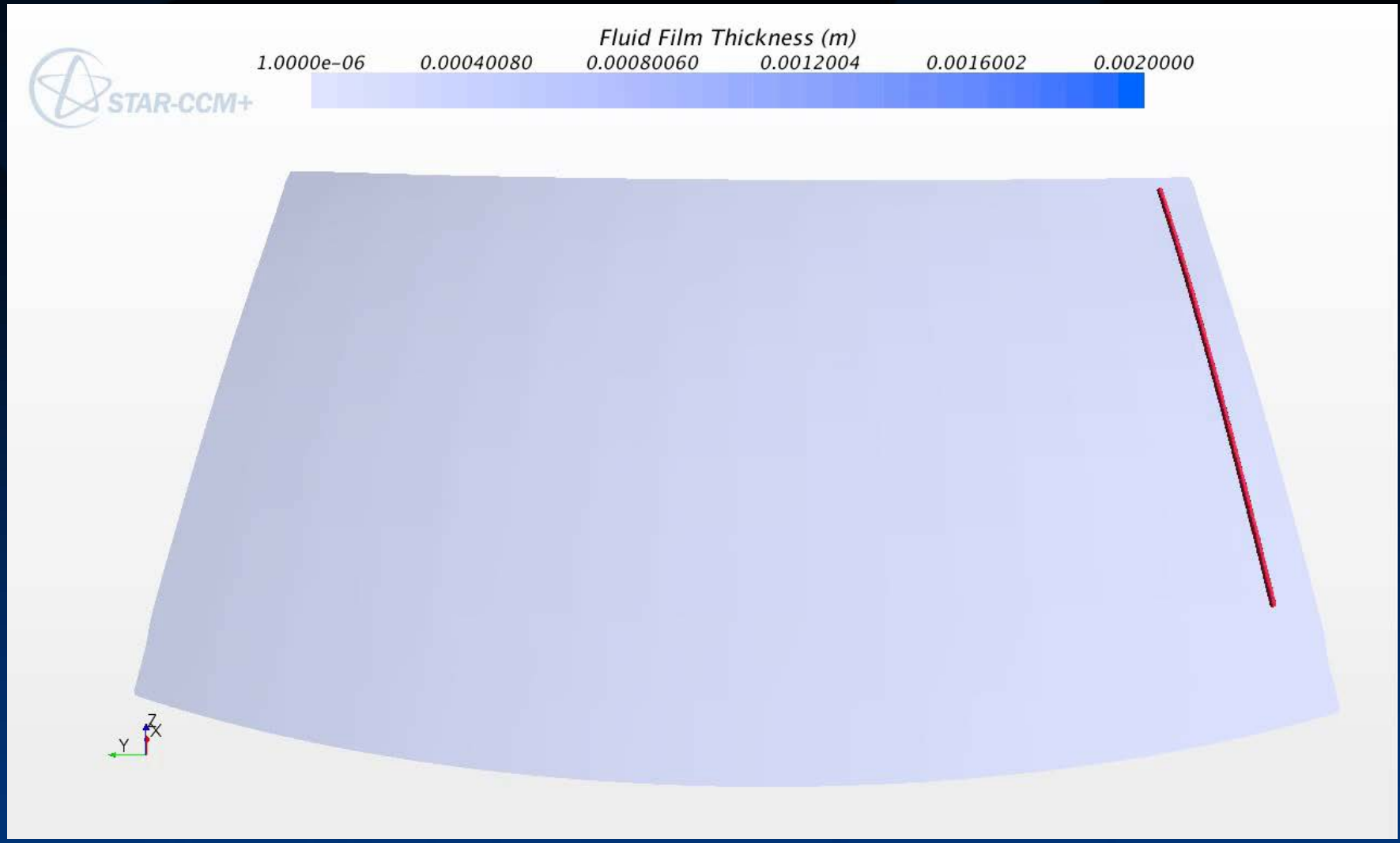
Fluid Film model & Overset grids

Gravity driven Fluid Film flow



Fluid Film model & Overset grids

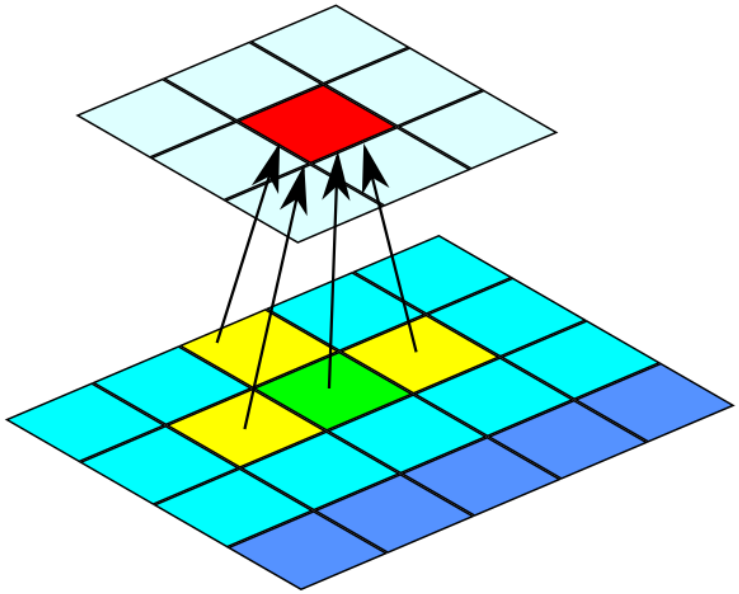
Windshield Wiper



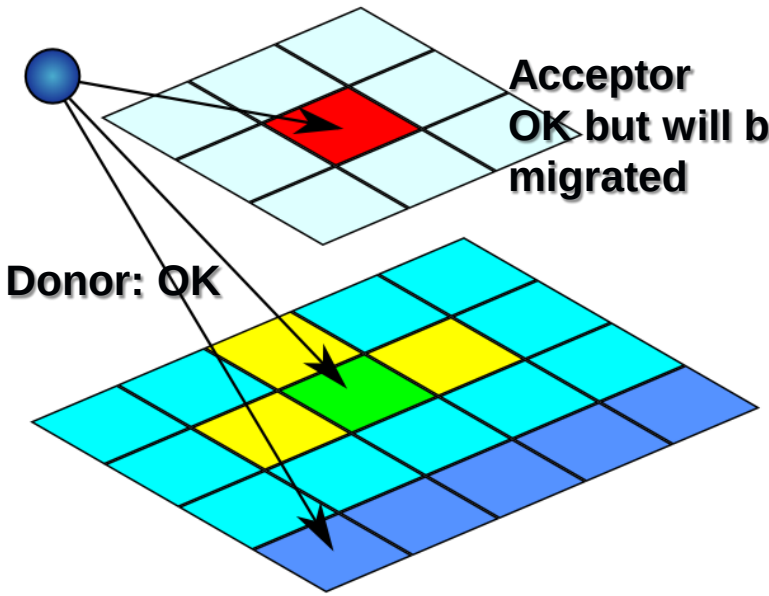
Lagrangian phase & Overset grids

- Translation of solid particles, liquid droplets, gas bubbles
- No interaction between droplets
- Can interact with continuous phase (volume, fluid films)
- Requires particle tracking and overset region migration

Interpolation from donor cell to acceptor

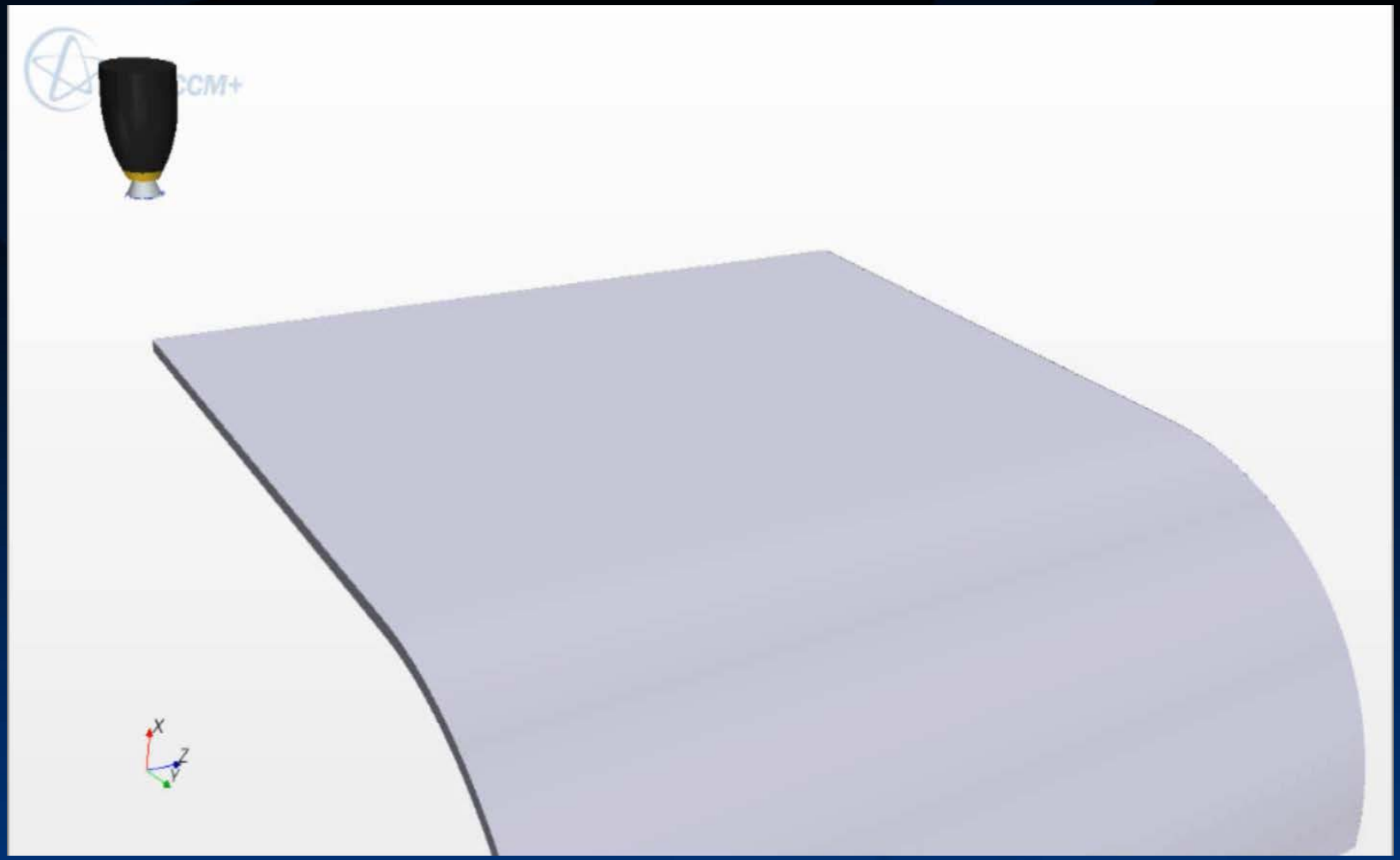


Particle injection



Inactive cell: no injection

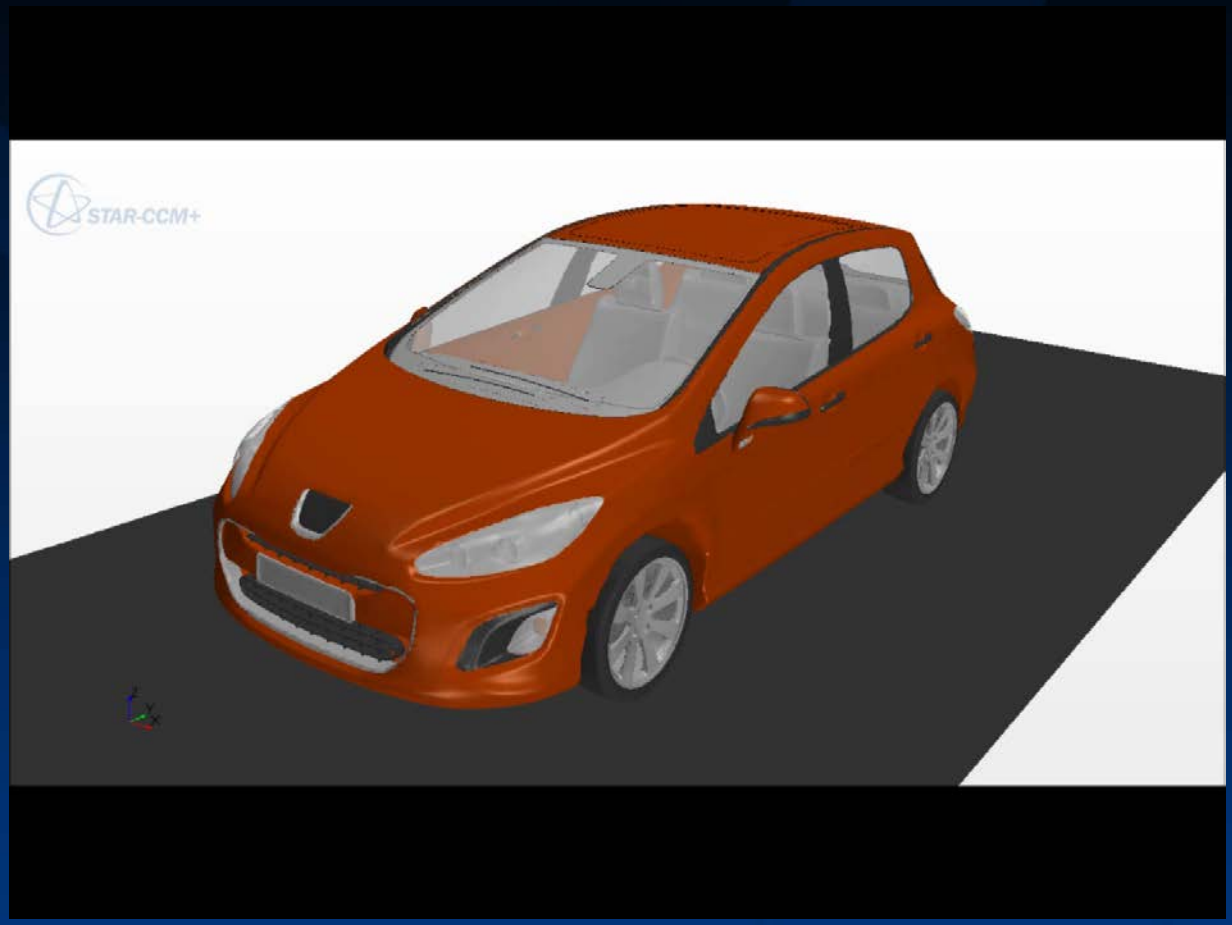
Lagrangian phase & overset



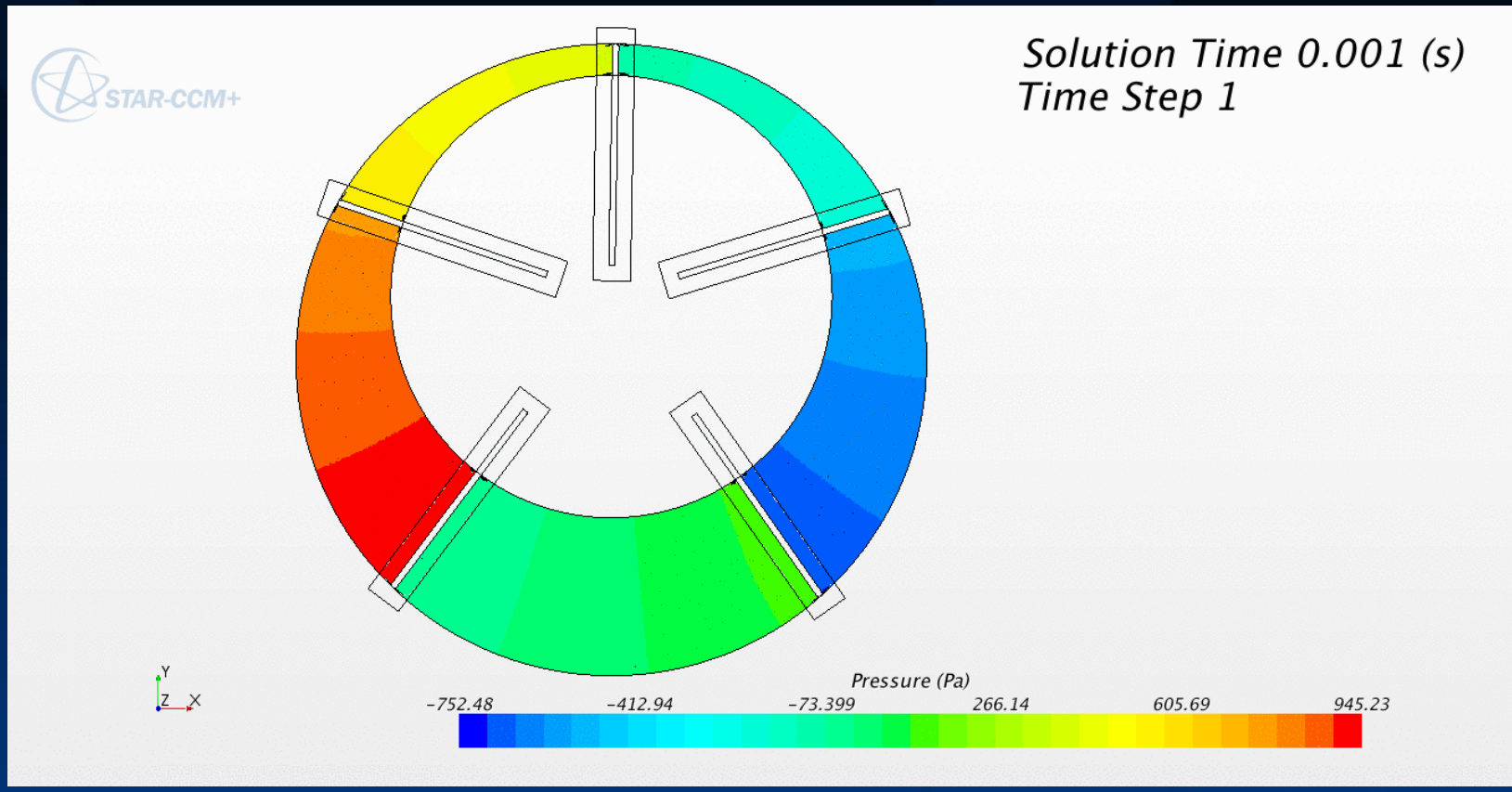
Multiple Overset Fluid Film & Lagrangian Phase

Physics:

- **Droplet impingement with Film**
- **Edge stripping from Film**
- **Moving mesh**



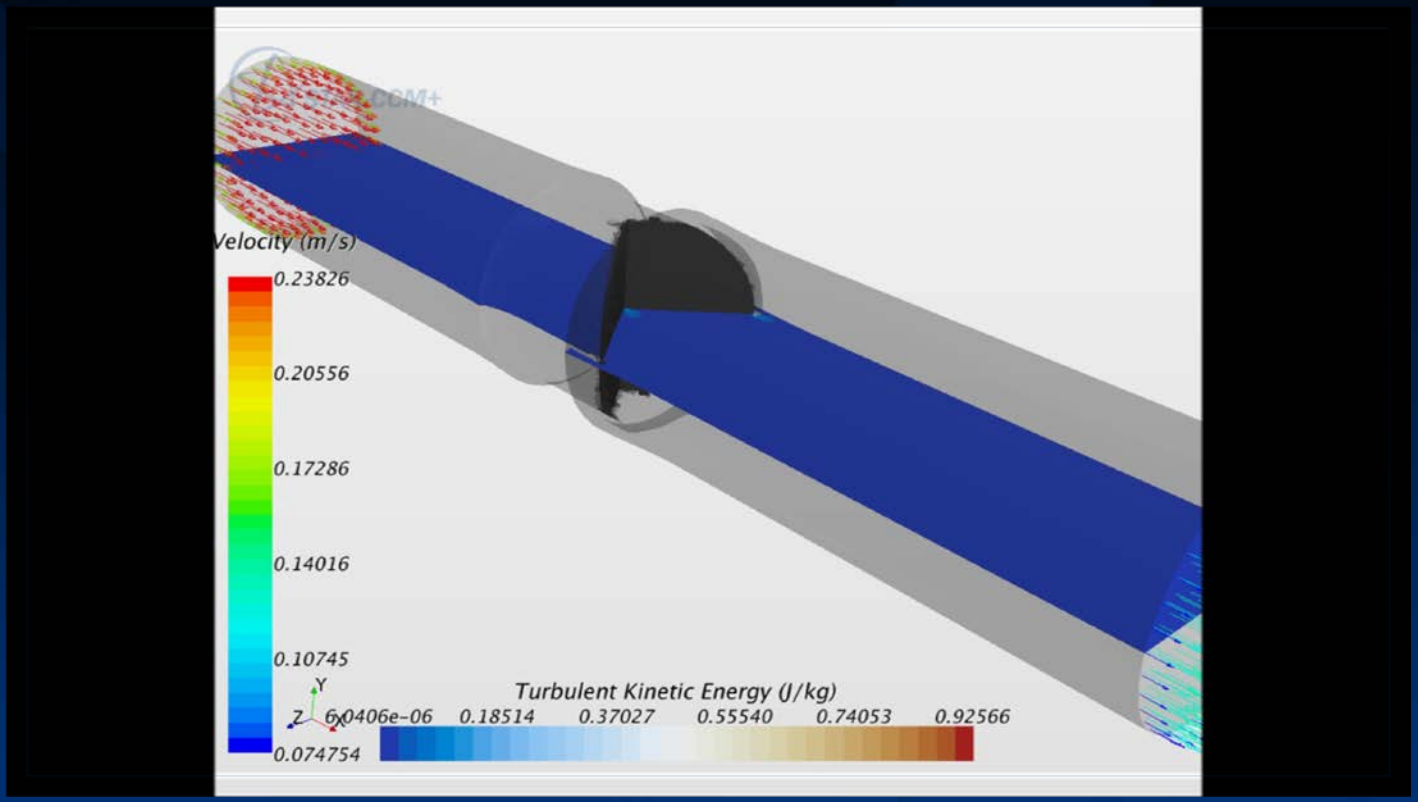
Vane Compressor: Overset with Zero Gap



Vascular Valve

Physics:

- **Multiple overset meshes**
- **6DOF**
- **Fluid-structure interaction**



Summary

There is ongoing development in STAR-CCM+

- More models compatible with Overset Grids
- More topological configurations
- Better performance and parallelization

The motto of the last version: “Simulating systems”

- Diversity in physics
- Simulation of the whole assembly, not the parts