Introduction to open source CFD

Session 3/4

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Introduction to open source CFD
Outline

- Think of a project
- Meshing with snappyHexMesh
- Vertical hot plate

PROJECT WORK

Project work

- Passing based on presence and project work
- Pick something you like and/or need
- Projects are presented in a small seminar
- We need to agree on a
  - topic
  - date

SNAPPYHEXMESH

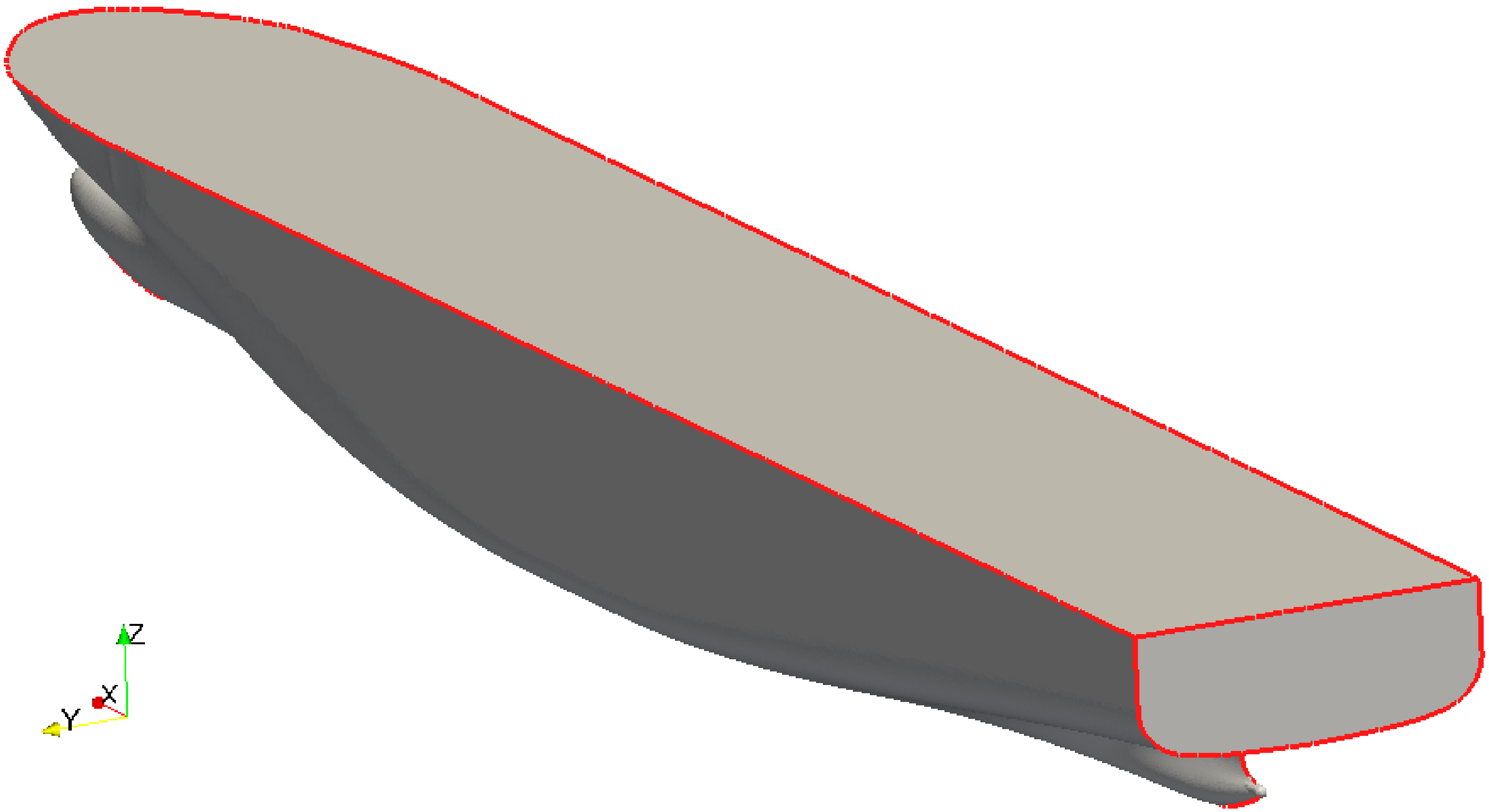
Advanced meshing
snappyHexMesh

- Meshing in OpenFOAM can be doen by
  - blockMesh
  - snappyHexMesh
  - Conversion

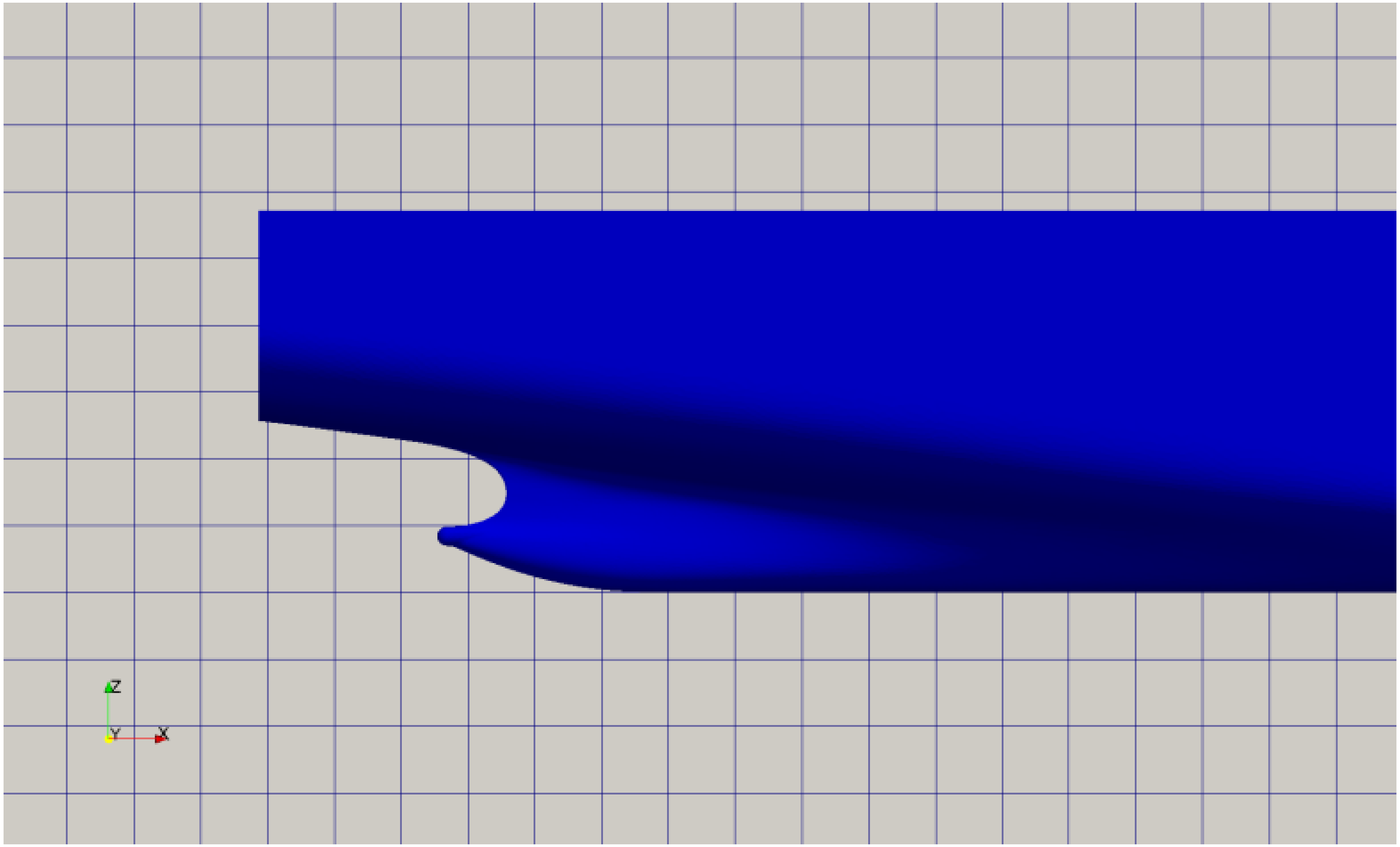
Advanced meshing
snappyHexMesh: process

- Get/create a triangulated surface (e.g. stl/obj)
- (Extract feature edges) (`surfaceFeatureExtract`)
- Gerenate a background mesh (`blockMesh`)
- Run snappyHexMesh in three stages
  - Generate castellated mesh
  - Snapping to surfaces and edges
  - Layer addition and clean-up

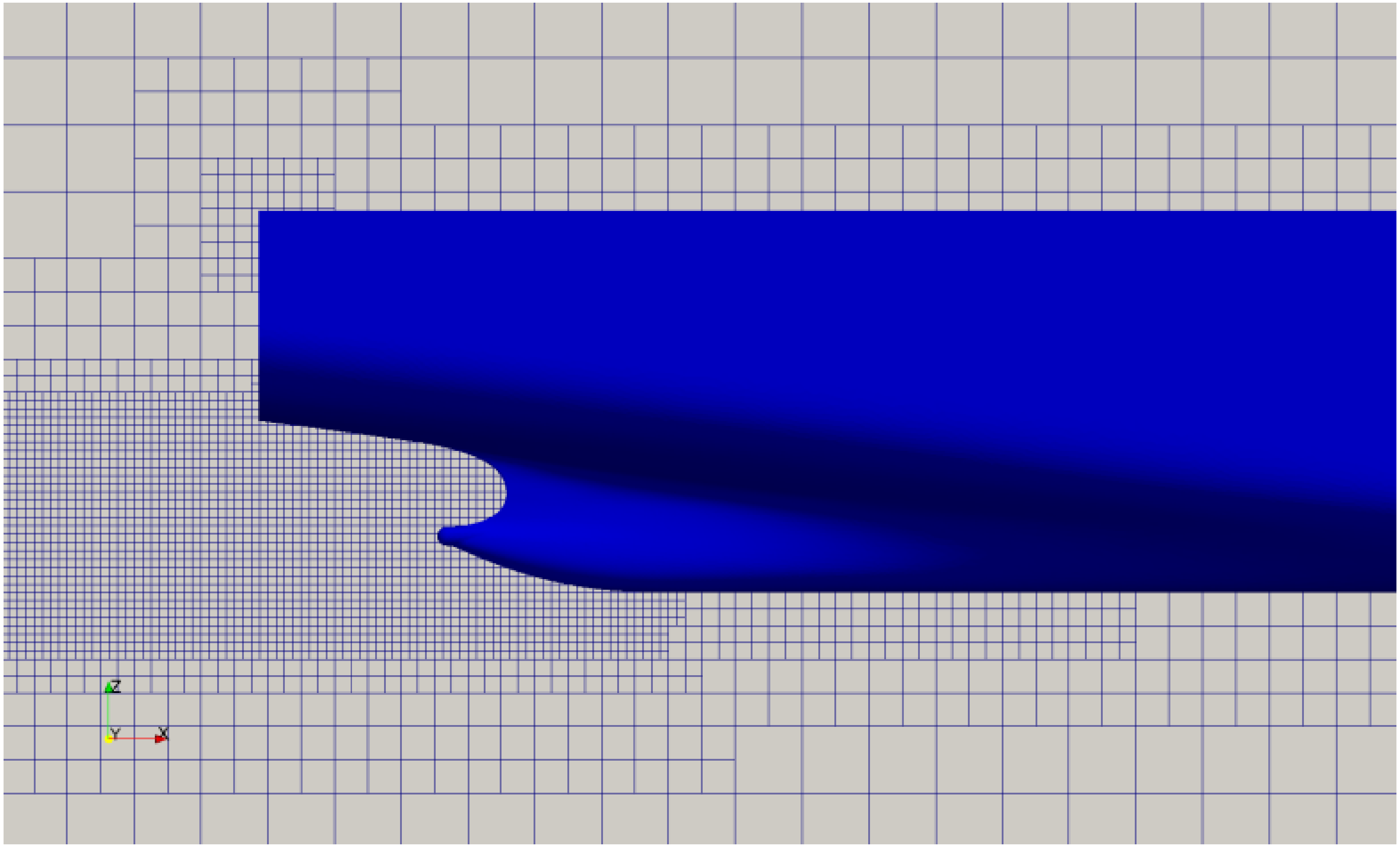
Advanced meshing
snappyHexMesh: feature edges



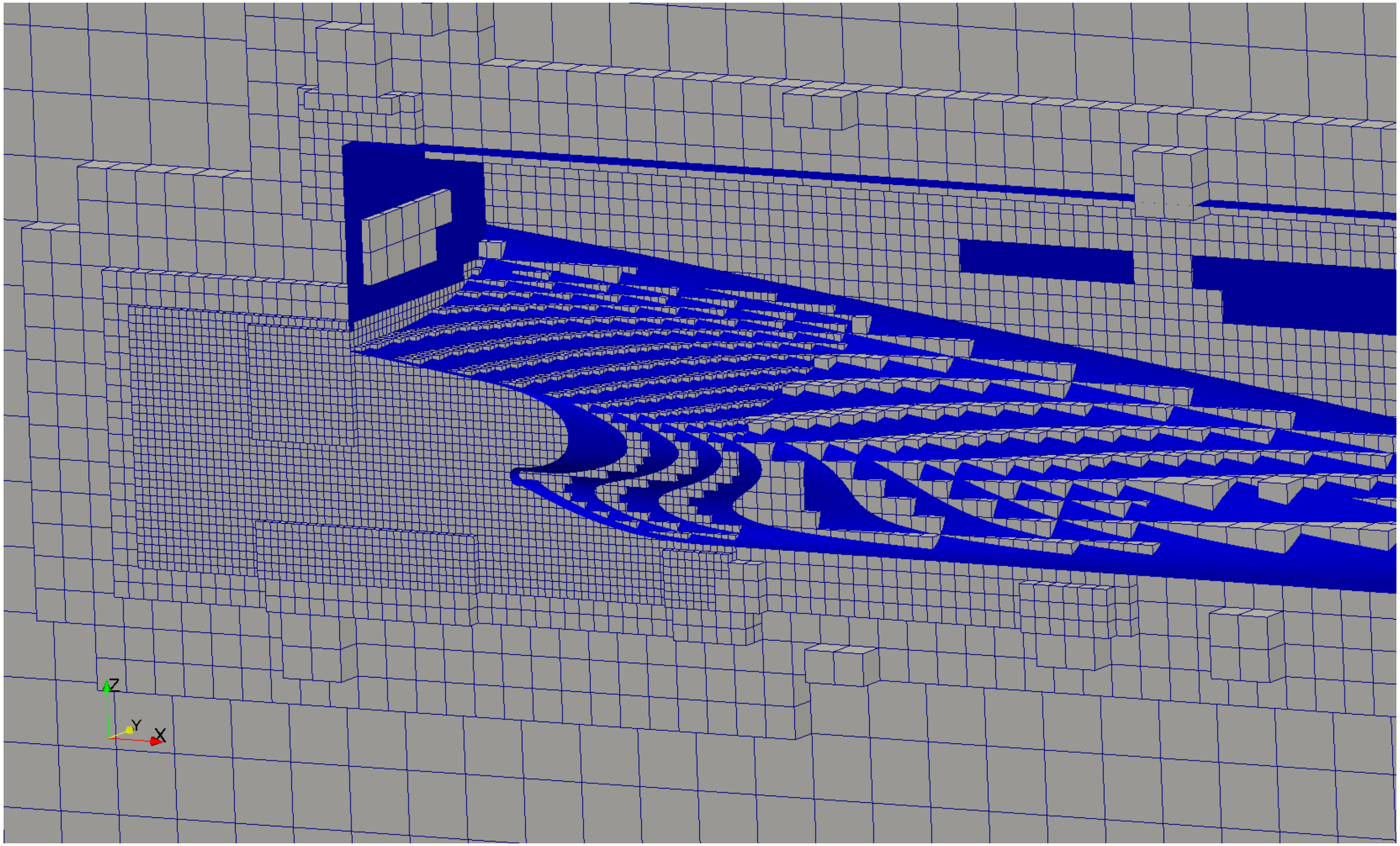
Advanced meshing
snappyHexMesh: background mesh



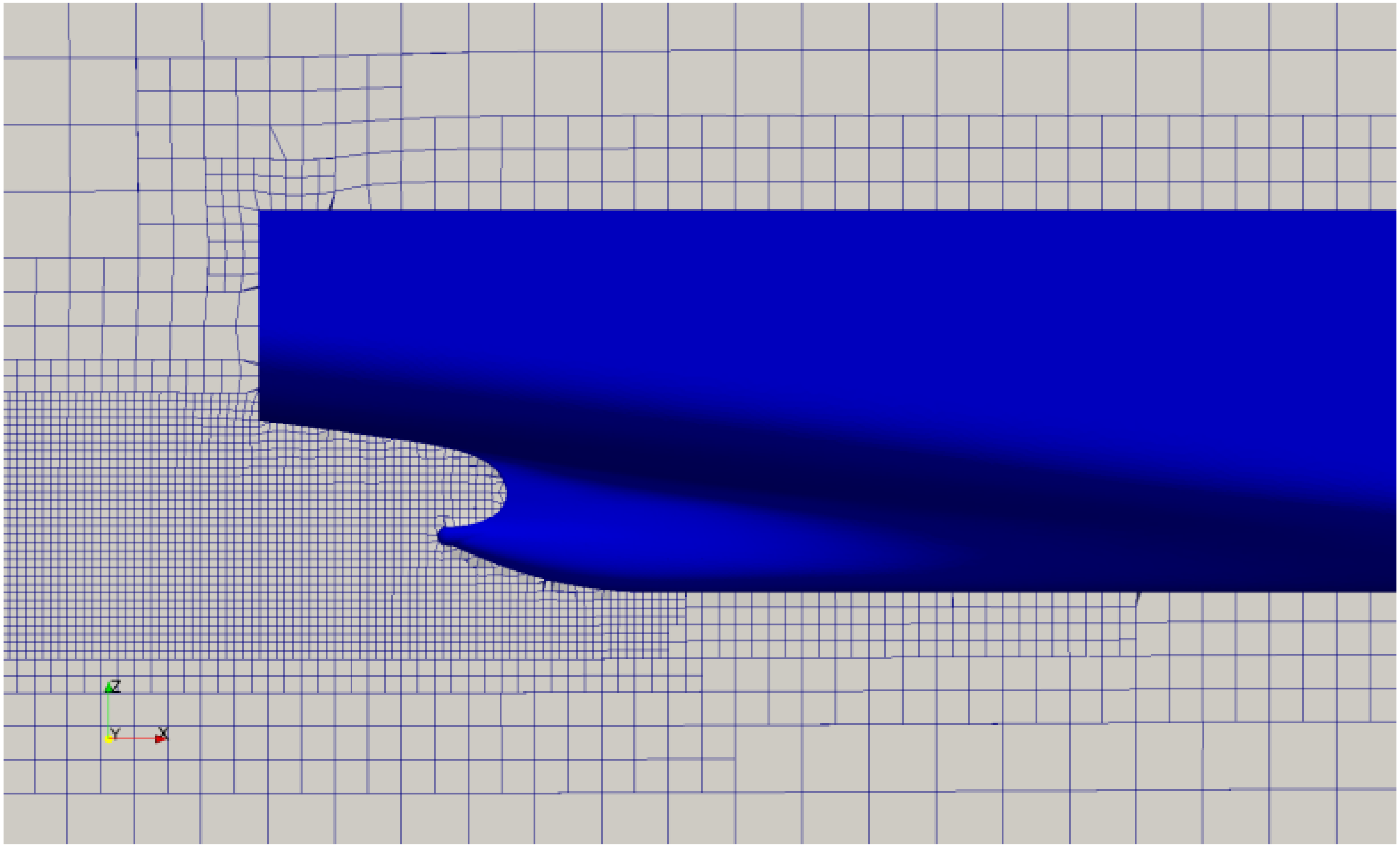
Advanced meshing
snappyHexMesh: castellated mesh



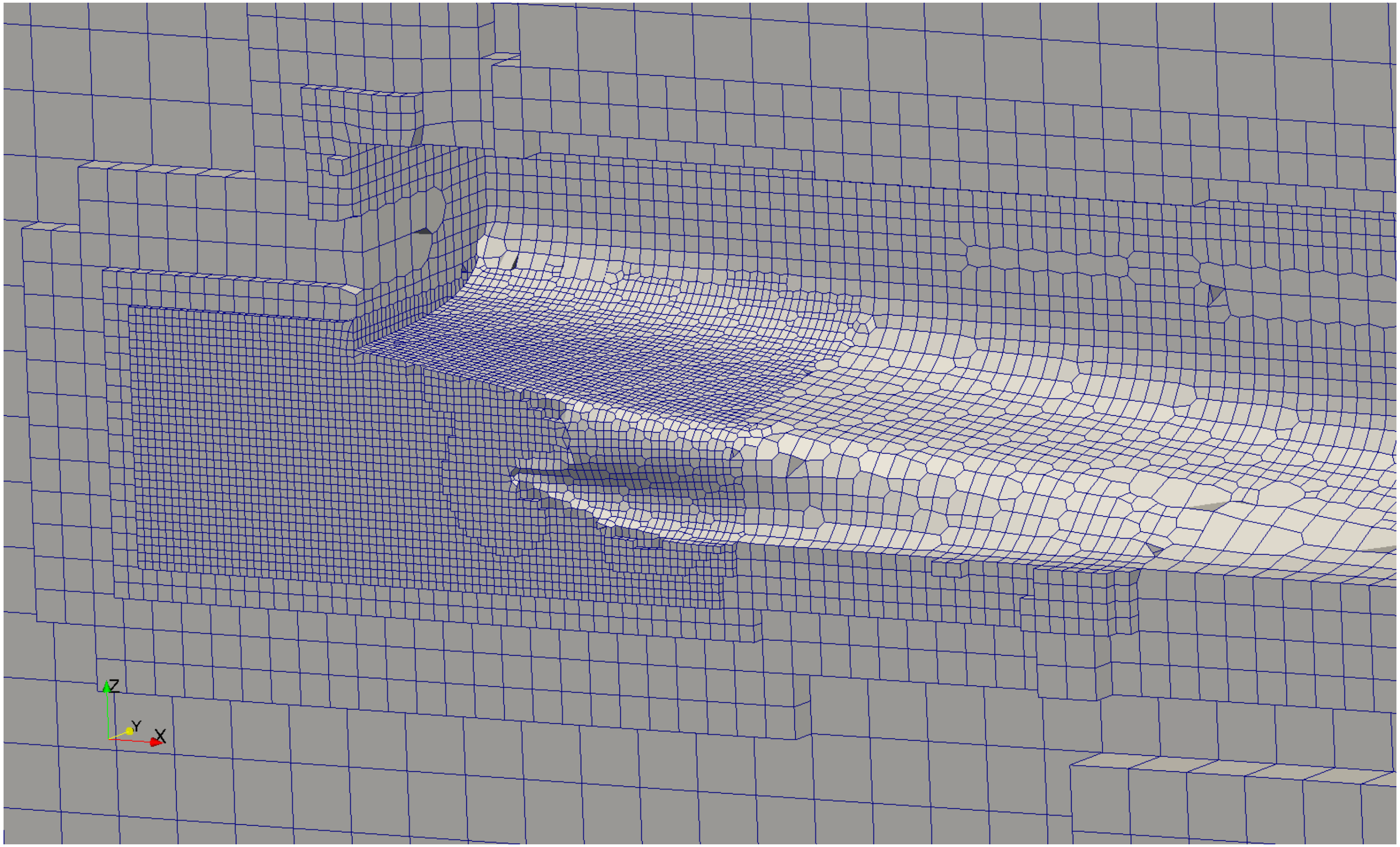
Advanced meshing
snappyHexMesh: castellated mesh



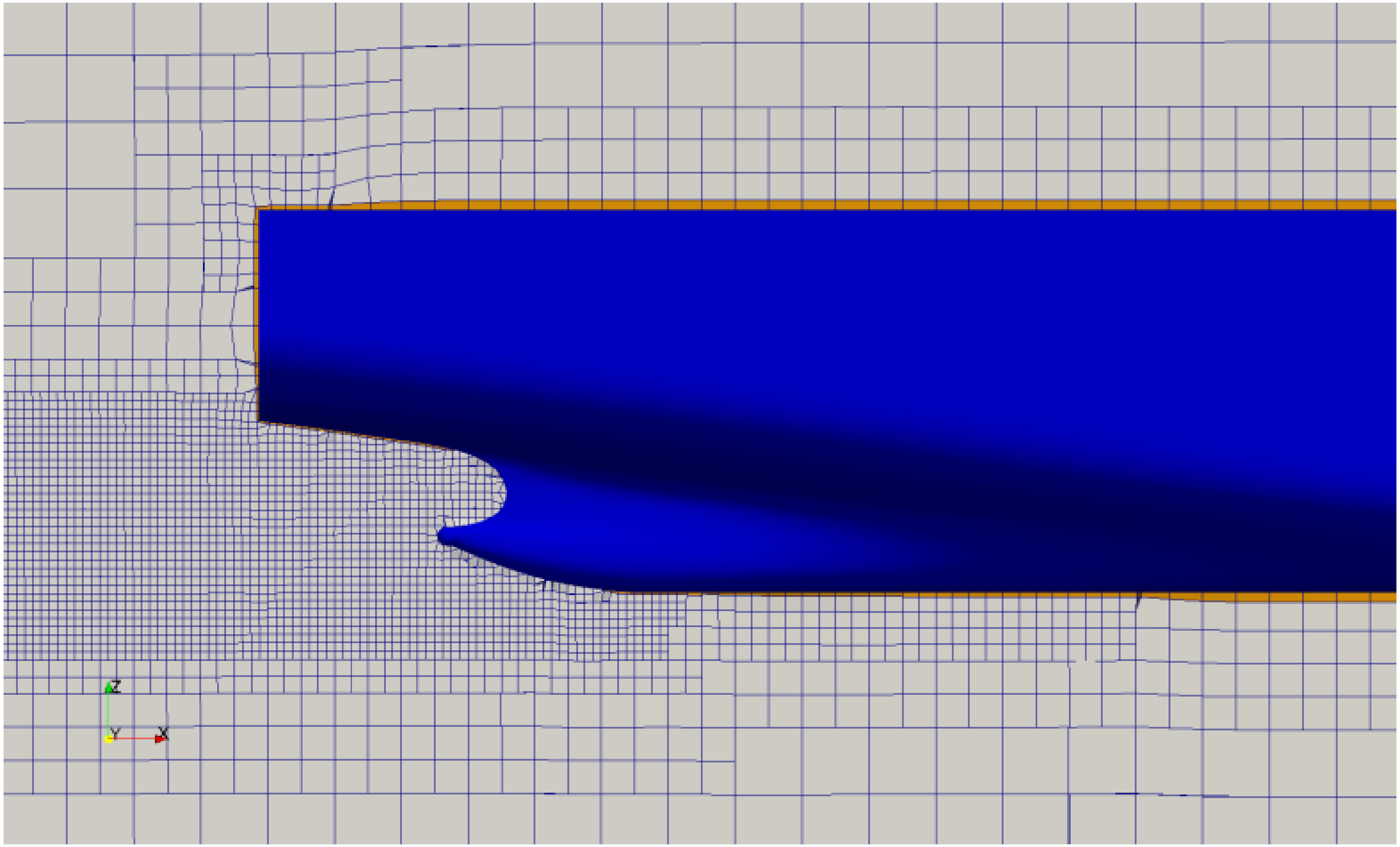
Advanced meshing
snappyHexMesh: snapping



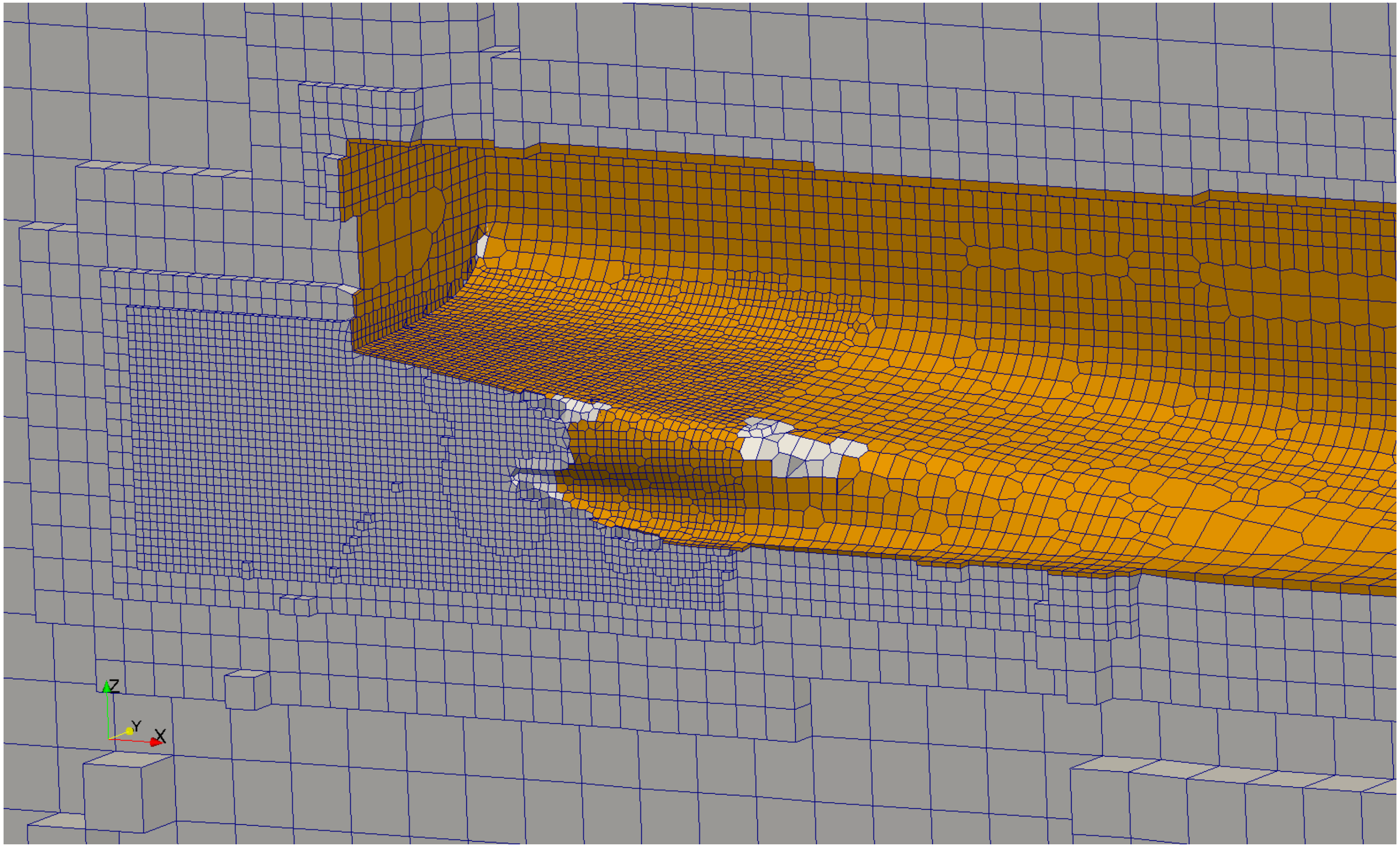
Advanced meshing
snappyHexMesh: snapping



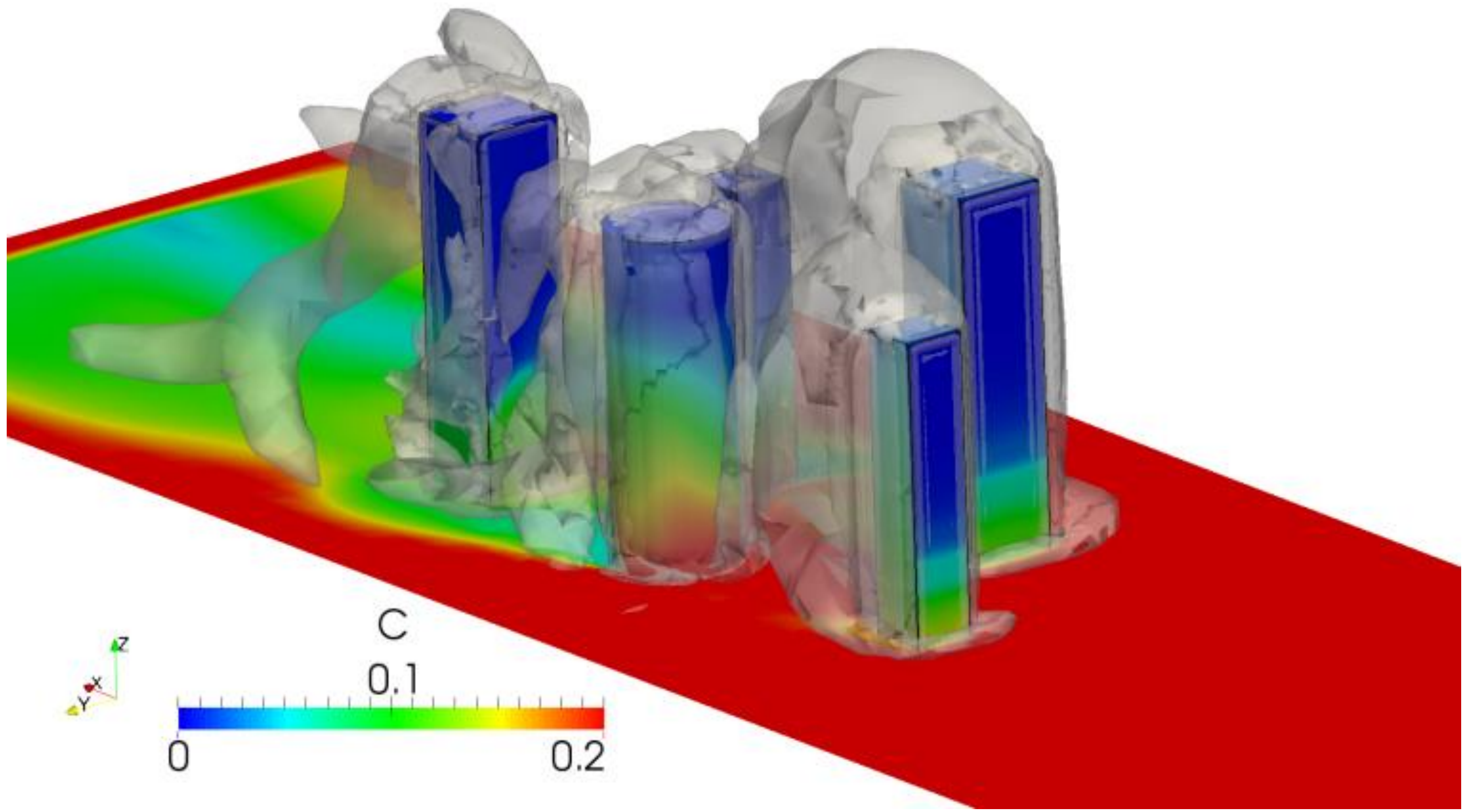
Advanced meshing
snappyHexMesh: layer addition



Advanced meshing
snappyHexMesh: layer addition



Dust in desert city
Modelling desert dust as massless species



Dust in desert city

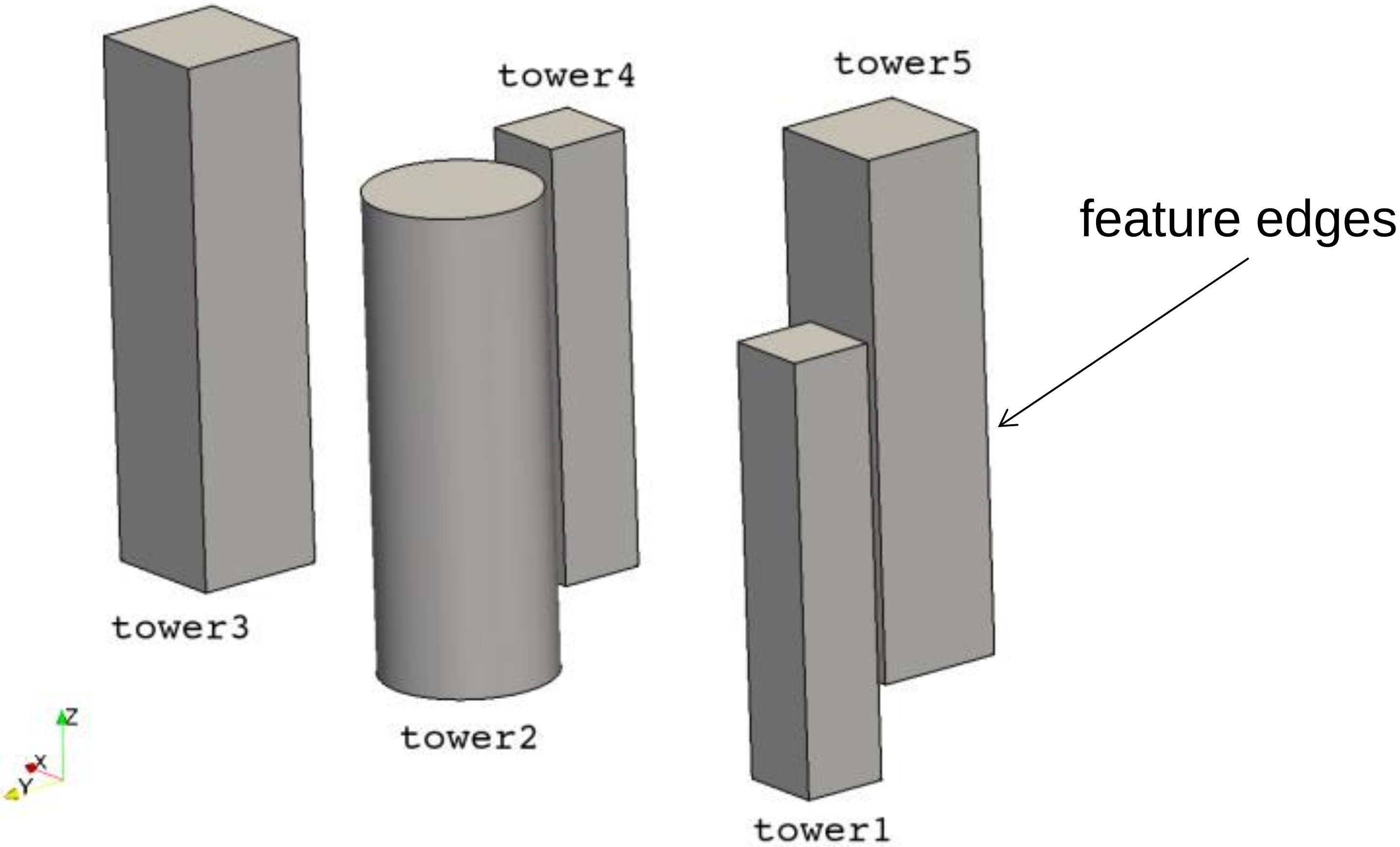
Background mesh and feature edges

- Run `blockMesh` to generate the background mesh (see `constant/polyMesh/blockMeshDict`)
- Run `surfaceFeatureExtract` to extract surface features from the triangulated surface. These edges can be used by `snappyHexMesh` for edge snapping. (see `system/surfaceFeatureExtractDict`)

```
> blockMesh
> surfaceFeatureExtract
```

Dust in desert city

Background mesh and feature edges

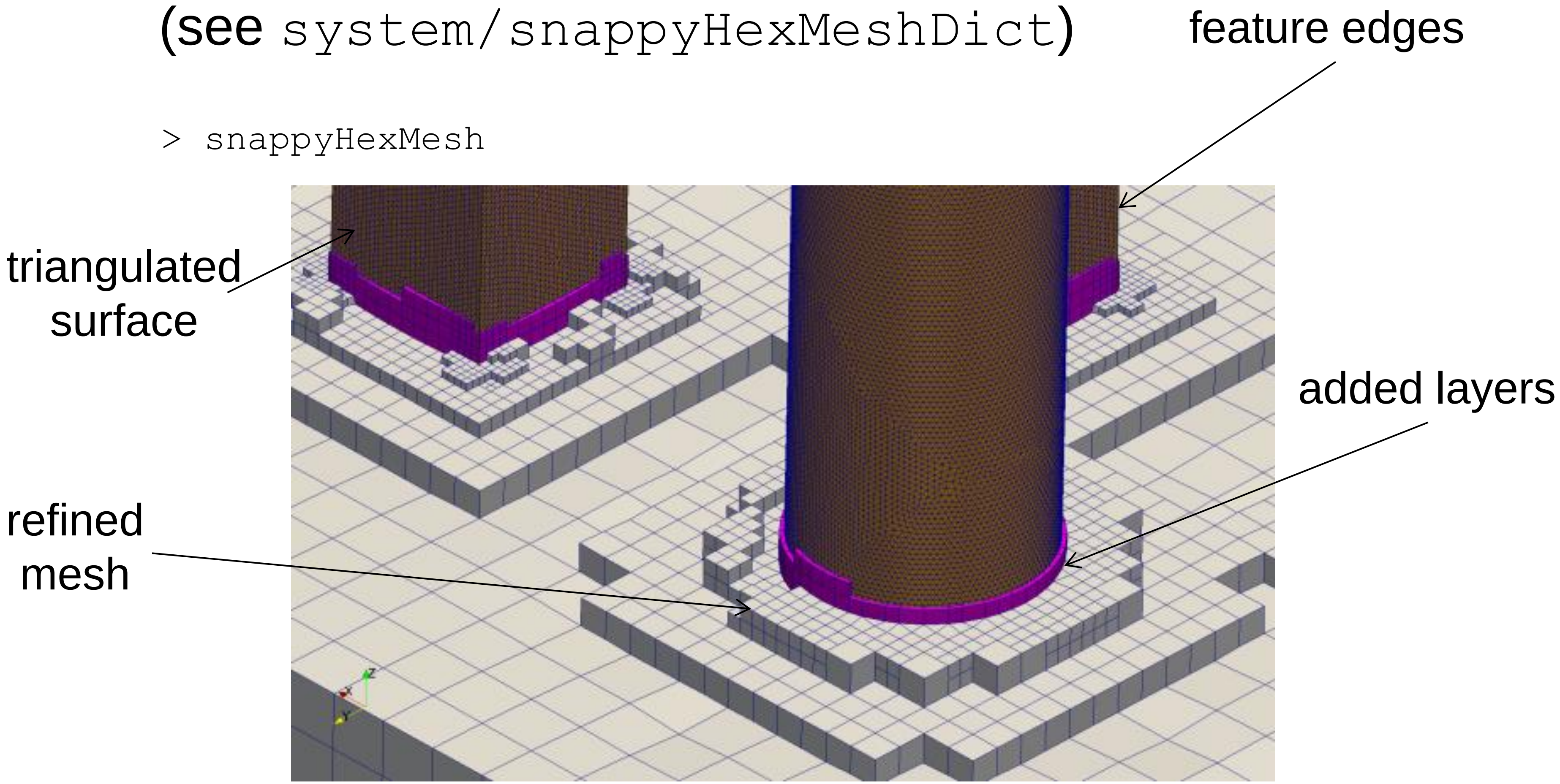


Dust in desert city
Background mesh and feature edges

- Now run `snappyHexMesh`

  (see `system/snappyHexMeshDict`)

```
> snappyHexMesh
```



Dust in desert city
Rough wall function

- To model the desert floor we use `nutkRoughWallFunction` on the ground patch (see file `0/nut`)

$$\frac{U_P}{u^*} = \frac{1}{\kappa} \ln\left(\frac{Ey}{C_s K_s}\right) \qquad u^* = C_\mu^{0.25}\sqrt{k}$$

```
ground
{
    type      nutkRoughWallFunction;
    Ks        uniform 0.003; // sand-grain height (m)
    Cs        uniform 0.5;   // rougness constant (0.5-1)
    value     uniform 0;     // dummy value
}
```

Dust in desert city

Dust in Desert City

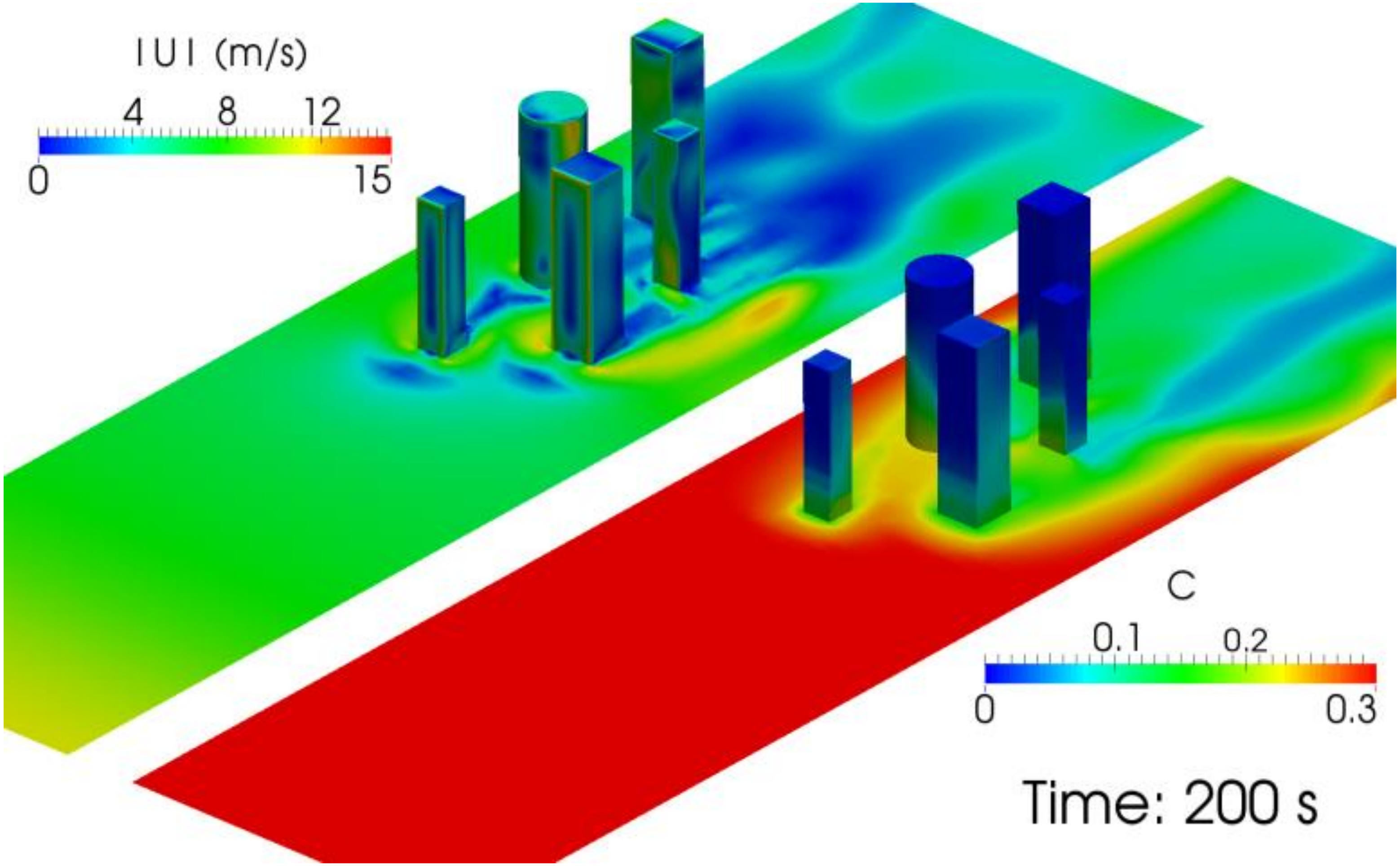
- Copy the initial fields

```
> cp -r 0.org 0
```

- Run the solver

```
> pimpleSpeciesTransportFoam
```

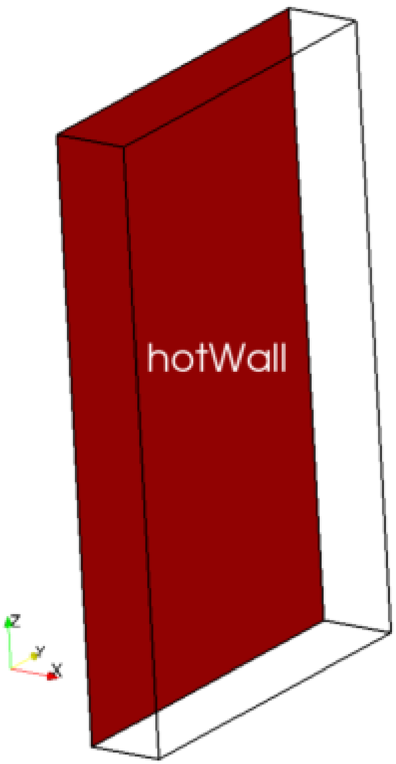
Dust in desert city
Dust in Desert City



HEAT TRANSFER

Heat transfer
Hot plate

- Worked example in VDI Wärmeatlas
- Vertical wall with open domain
  - Plate is 0.5 m wide, 0.8 m high
- Wall temperature fixed
  - High density boundary layer
  - Parametrization
  - Robust and simple meshing
- Copy the case and create the mesh




```
> run
> export HT="$OSCCAR_TUTORIALS/heatTransfer"
> cp -r $HT/buoyantBoussinesqPimpleFoam/veritcalHotPlate .
> cd verticalHotPlate
> blockMesh
```

Heat transfer

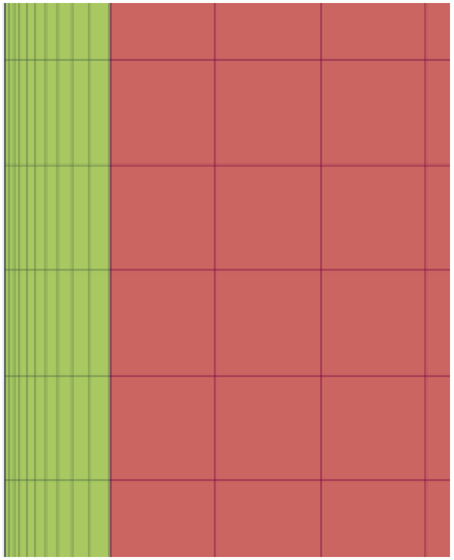
Hot plate: blockMeshDict

```
convertToMeters 1;

vertices
(
    (0     0.25 -0.4) //  0
    (0.01  0.25 -0.4) //  1
    (0.1   0.25 -0.4) //  2
    (0    -0.25 -0.4) //  3
    (0.01 -0.25 -0.4) //  4
    (0.1  -0.25 -0.4) //  5
    (0     0.25  0.4) //  6
    (0.01  0.25  0.4) //  7
    (0.1   0.25  0.4) //  8
    (0.1  -0.25  0.4) //  9
    (0.01 -0.25  0.4) // 10
    (0    -0.25  0.4) // 11
);

blocks
(
    hex (3 4 1 0 11 10 7 6) (10 50 80) simpleGrading (5 1 1) // Boundary layer
    hex (4 5 2 1 10 9 8 7)  (9 50 80)  simpleGrading (1 1 1) // Main domain
);

edges
(
);
```



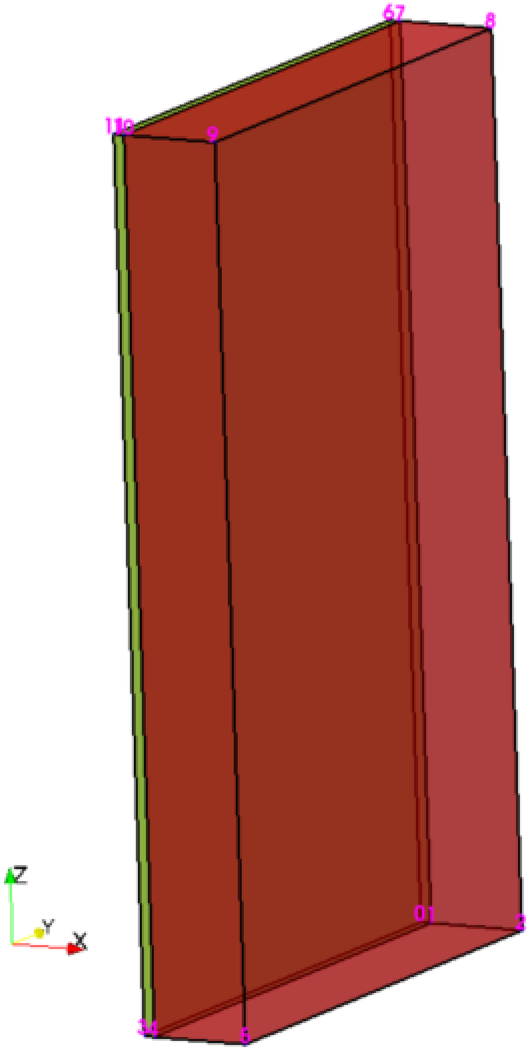
Heat transfer

Hot plate: blockMeshDict

```
boundary
(
    hotWall
    {
        type wall;
        faces
        (
            (0 3 11 6)
        );
    }

    sides
    {
        type patch;
        faces
        (
            (3 4 10 11) // Front BL
            (0 6 7 1)   // Back BL
            (4 5 9 10)  // Front main domain
            (1 7 8 2)   // Back main domain
            (2 8 9 5)   // Right side main domain
        );
    }
     ...
);

mergePatchPairs
(
);
```



Heat transfer
Run the solver and sample U and T

- Now run the solver
  `> buoyantBoussinesqPimpleFoam`

- View the results in ParaView
  `> paraFoam`

- Sample velocity and temperature
  `> gedit system/sampleDict`

```
interpolationScheme cellPoint;

        setFormat       raw;

        sets
        (
            sampleLine
            {
                type    face;
                axis    x;
                start   ( 0 0 0 );
                end     ( 0.1 0 0 );
            }
        );

        fields ( U T );
```

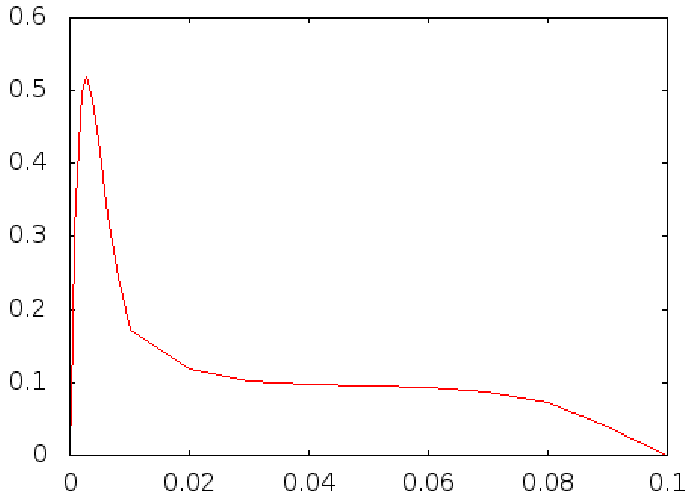
Heat transfer
Post-processing

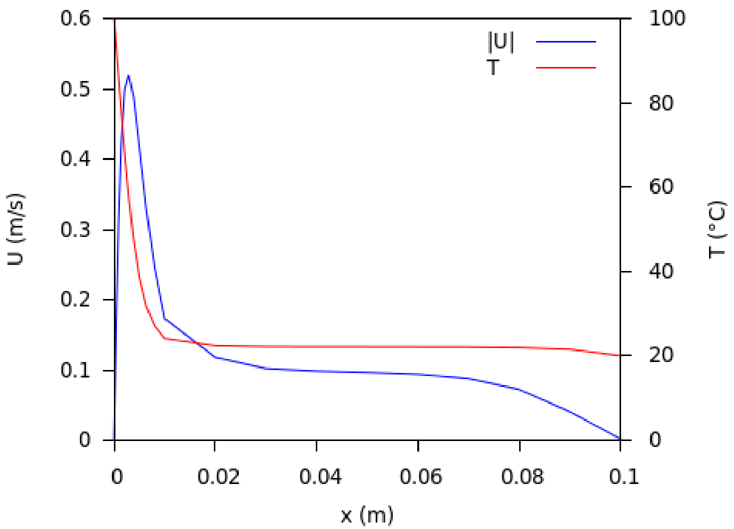
- `sample` writes data to `postProcessing/<setFormat>/<time>`

```
> ls postProcessing/sets/5
sampleLine_T.xy  sampleLine_U.xy
```

- Plot e.g. Uz using gnuplot

```
> gnuplot
gnuplot> plot "postProcessing/sets/5/sampleLine_U.xy" \
         using 1:4 with lines notitle
```





Heat transfer
Post-processing

- Use OSCCAR‘s incompressible wallHeatFlux utility.
  Make sure it is compiled:

```
> wmake $OSCCAR_UTILITIES/postProcessing/wall/wallHeatFluxIncompressible
```

- Add thermophysical poperties to the case

```
> export OUTIL=$OSCCAR_UTILITIES/postProcessing/wall/wallHeatFluxIncompressible
> gedit \
    $OUTIL/thermophysicalProperties constant/thermophysicalProperties &
```

- Make sure thermopyhsical properties are in right range:

```
CpRef  = 1005  [J/kgK]
RhoRef = 1.2   [kg/m3]
Pr     = 0.715 [-]
Prt    = 0.85  [-]
```

Heat transfer
Post-processing

- Use the incompressible wallHeatFlux utility and write to log file

```
> wallHeatFluxIncompressible |& tee log.wallHeatFlux
```

- Filter the log file, create data file with time and heat flux

```
> grep "Time =" log.wallHeatFlux | cut -d' ' -f3 > time.tmp
> grep hotWall log.wallHeatFlux | cut -d' ' -f2 > Q.tmp
> paste time.tmp Q.tmp > wallHeatFlux.dat
> rm *.tmp
```

- Now plot from the data file

```
> gnuplot
gnuplot> plot "wallHeatFlux.dat" \
         with lines title "CFD",\
         32 with lines title "Correlation"
```