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https://airthium.com/

CANUM 2020

Utilisations industrielles et interfaçage de FreeFEM

S. Garnotel, Airthium SAS

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About us

Small enterprise – 12 team members

- 5 Ph. D., 2 in Applied Mathematics
- 3 Mechanical Engineers
- IT, Electronics, Management

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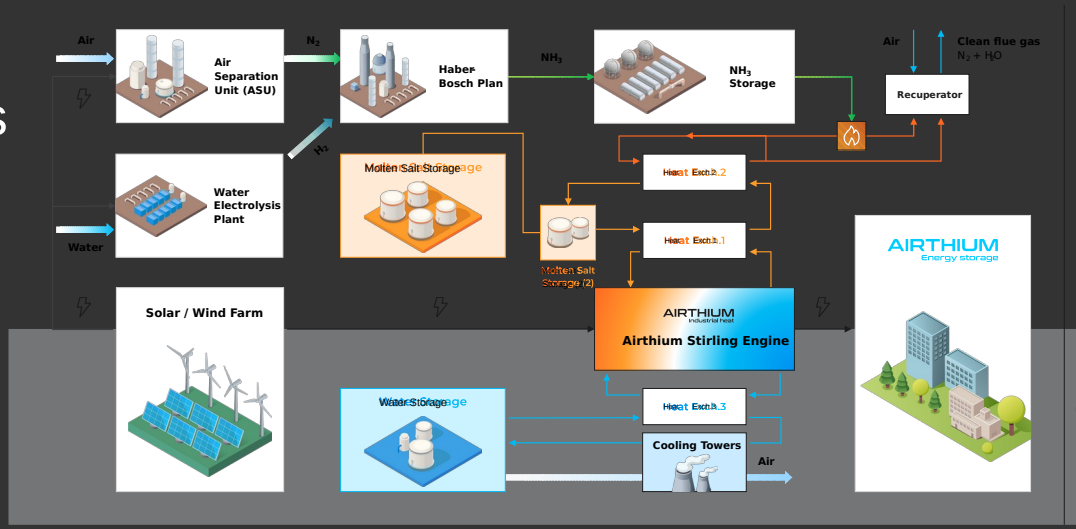
Goal

High efficiency heat pump
for seasonal energy storage



Source: https://airthium.com/

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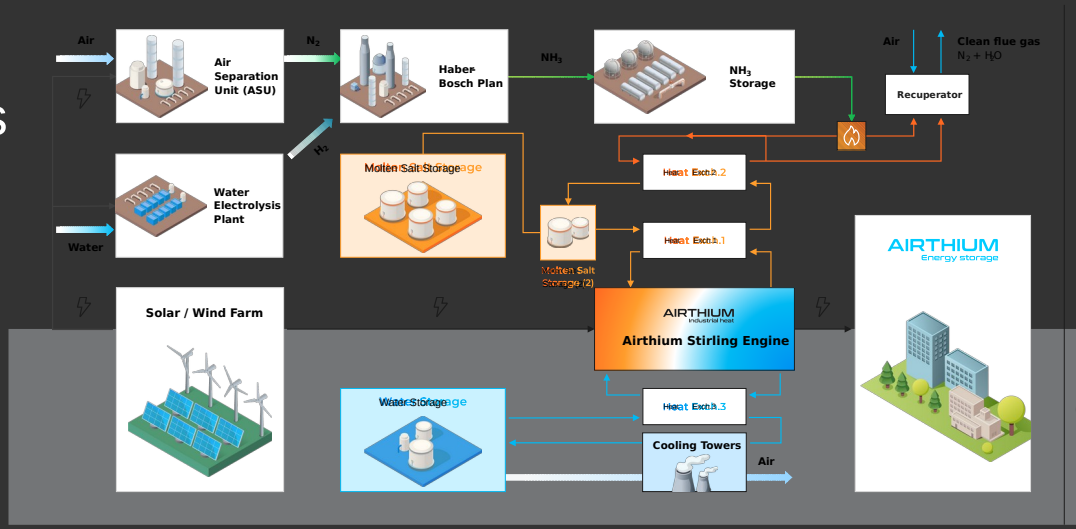

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→ **Need of multiples physics simulations**

1. Solid mechanics (linear elasticity, contact, ...)
2. Fluid mechanics (laminar, turbulent)
3. Couplings, …

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Framework choice

- Commercial simulation software, $$$, black box
- Open source software, $, customizable
  - → FreeFEM

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Problem

Mechanical Engineers does not know maths, programming, …
Unable to write and/or modify a FreeFEM script! (without breaking all)

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Solution

Build a FreeFEM graphical interface to allow engineers to parameterize, select the boundary conditions, run a simulation and post-process the results

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Needs

- **Only click**
- **No code**
- Geometry integration from STEP, DXF (CAD software format)
- Automatic meshing
- Easy parameterize (material, physics parameters, mesh adaptation, solver parameters)
- Easy boundary conditions definition and selection
- Easy run (meshing + simulation)
- Post-processing (warp, stream lines, isolines, …)

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Framework

Web-based application (React (javascript) client, NodeJS server)

→ Cloud deployment, Cluster deployment, Electron app

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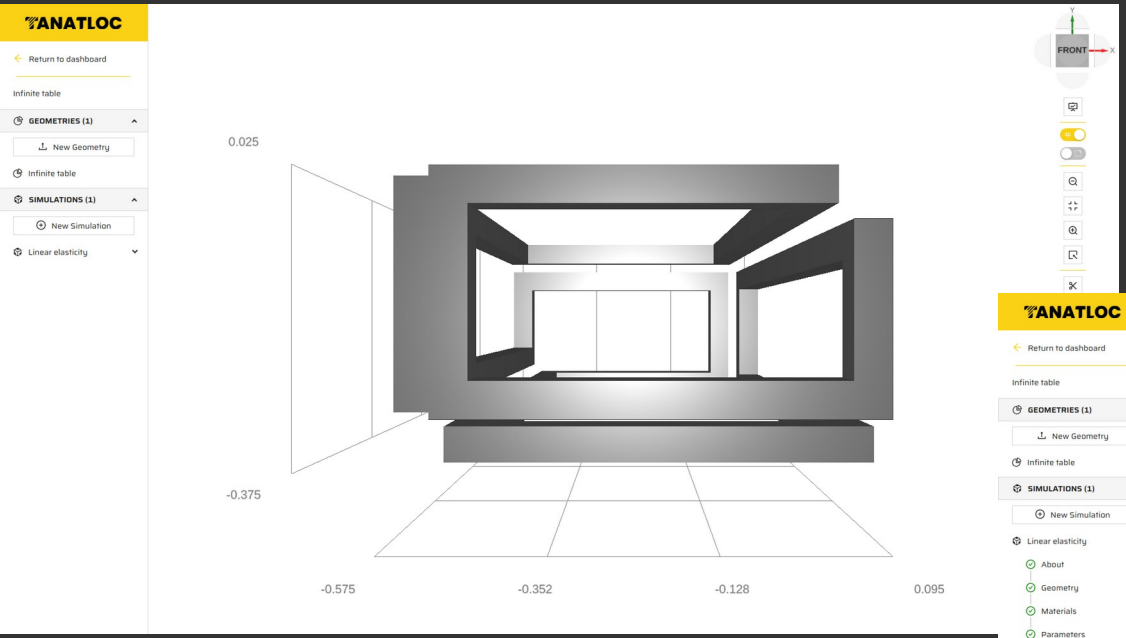
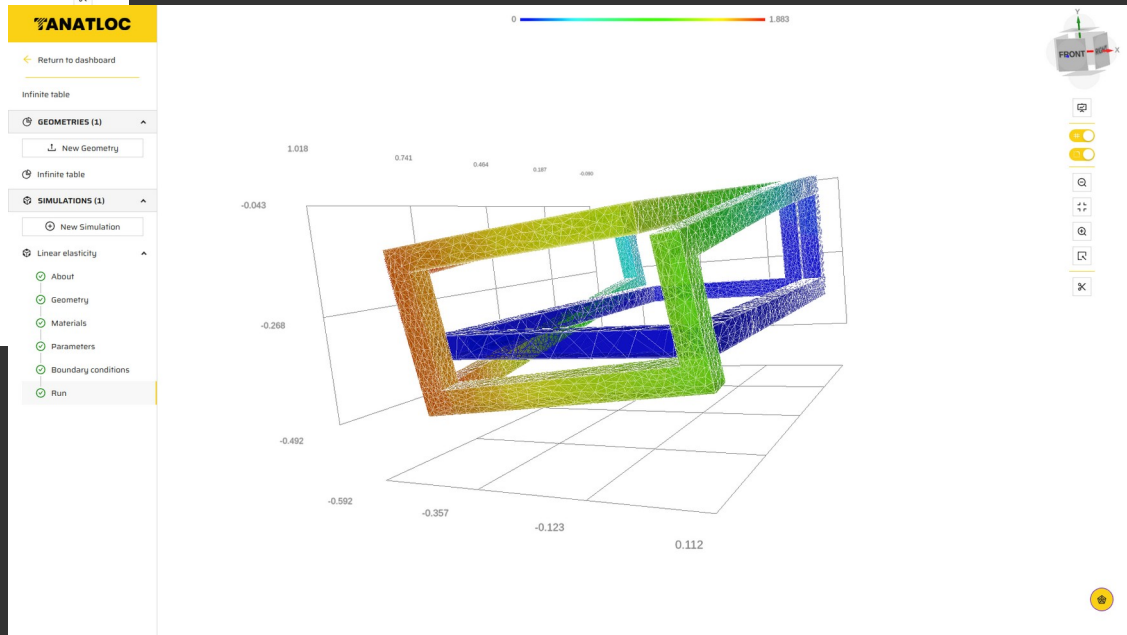
TANATLOC by AIRTHIUM





https://tanatloc.com/
Available soon

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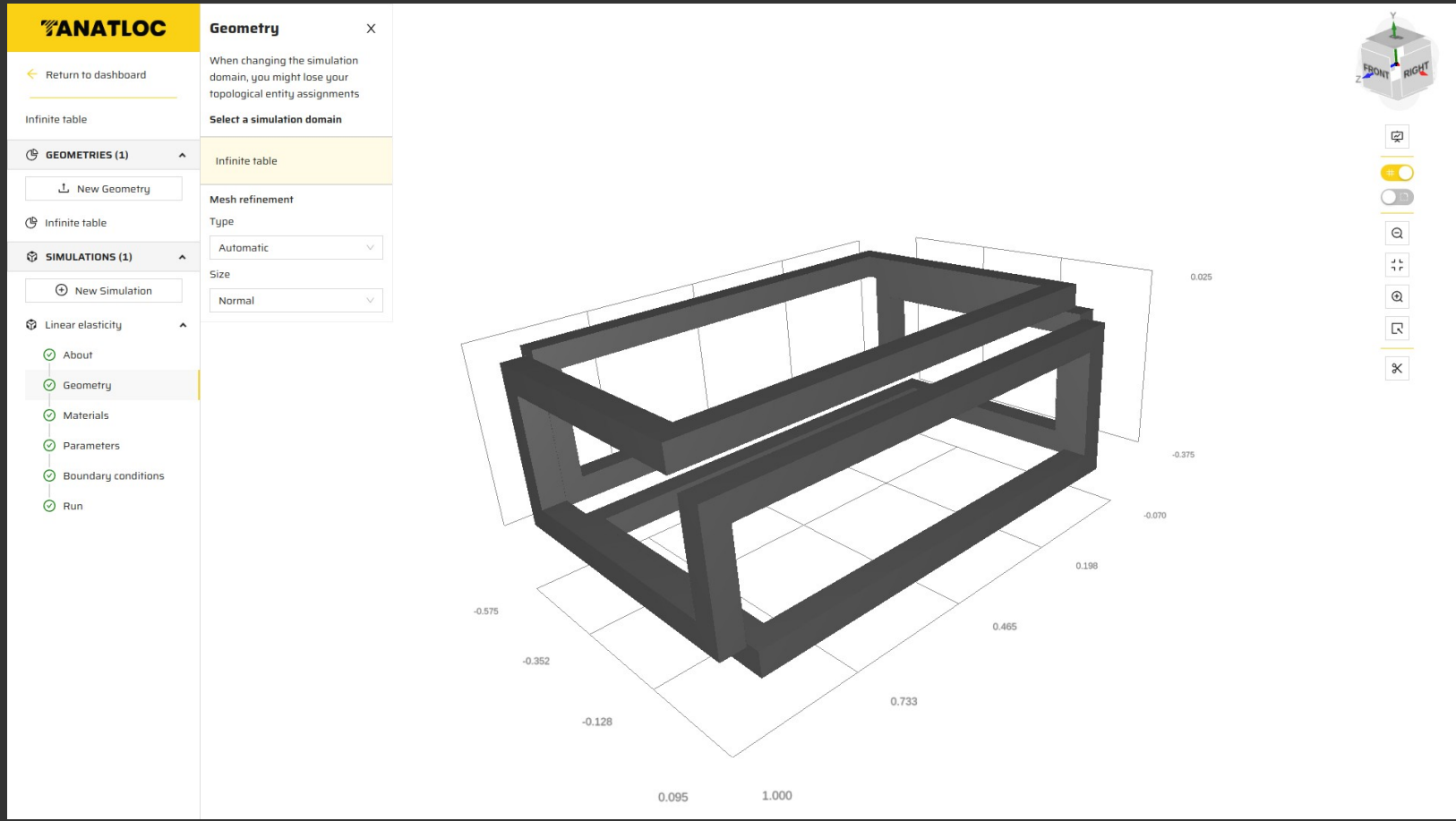
Geometry (+ mesh)



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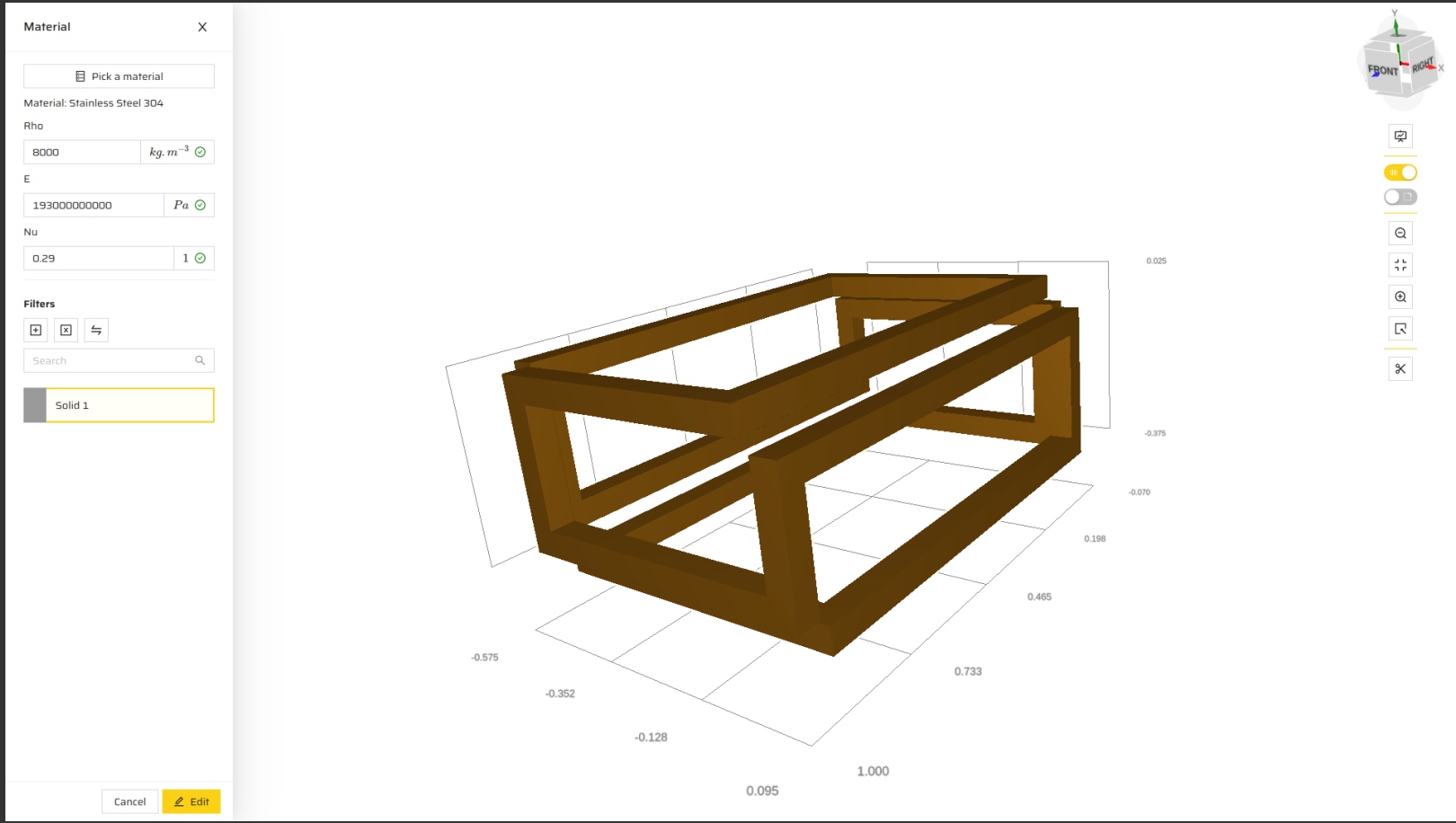
Materials



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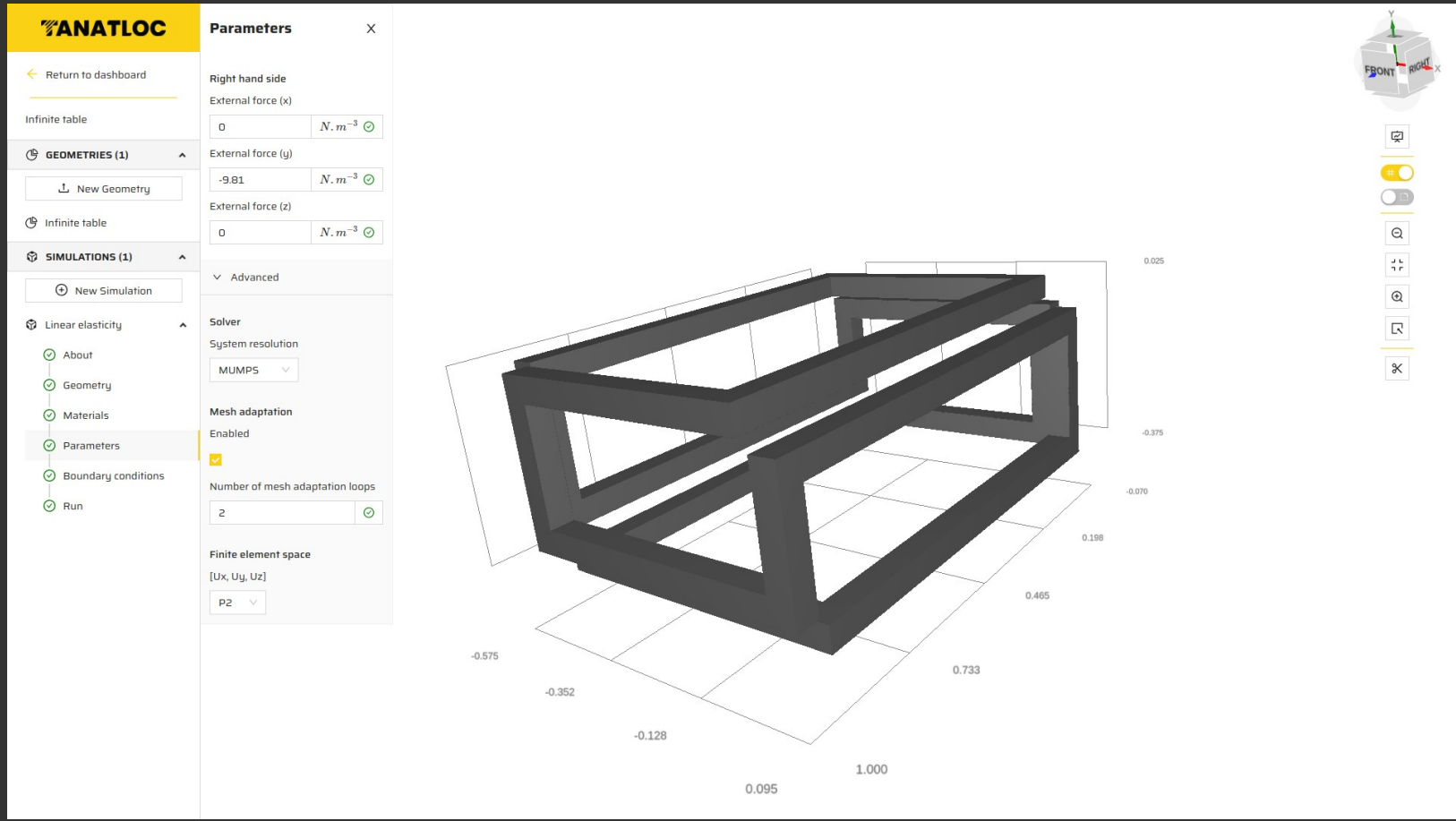
Parameters



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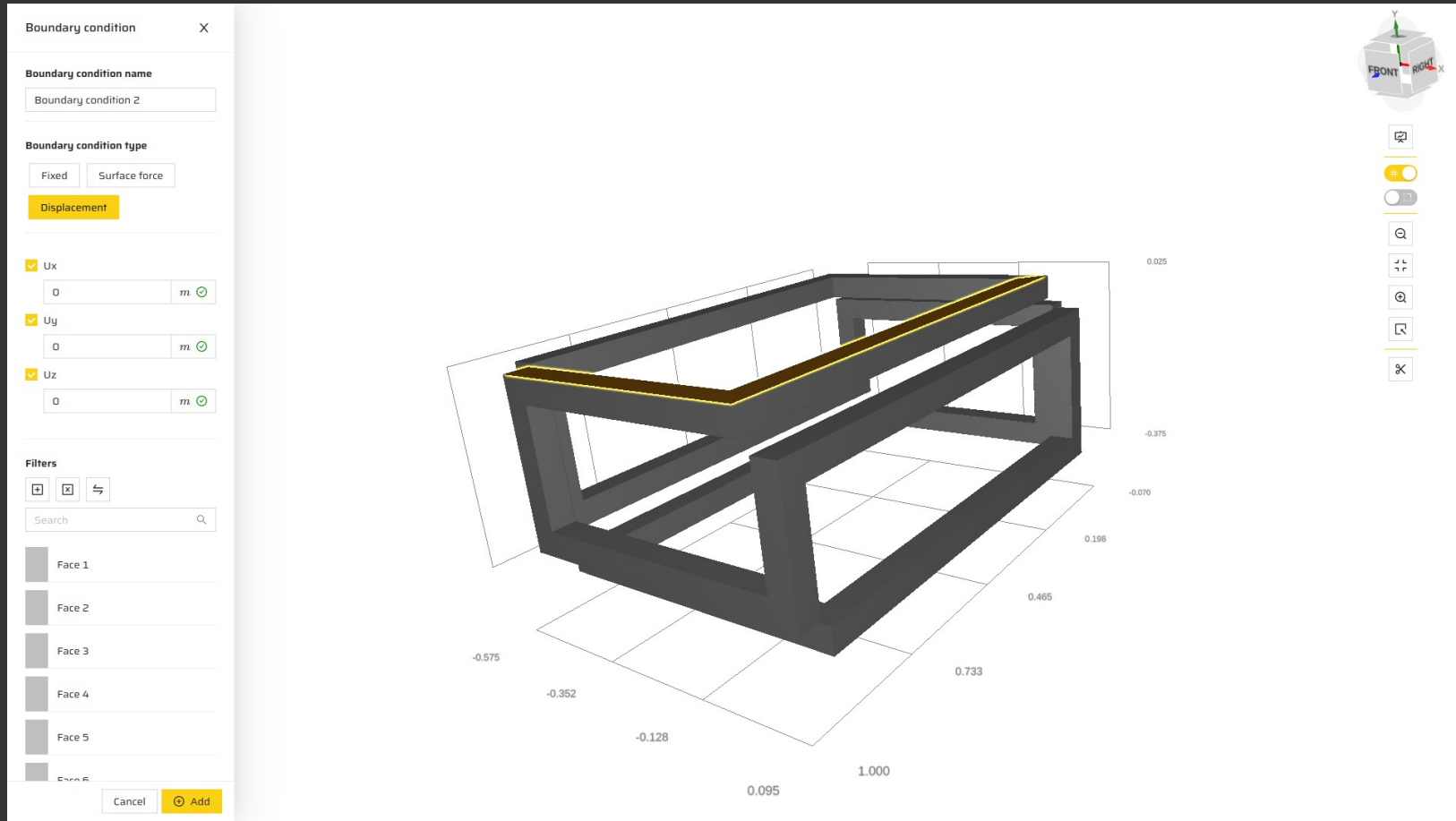
Boundary conditions



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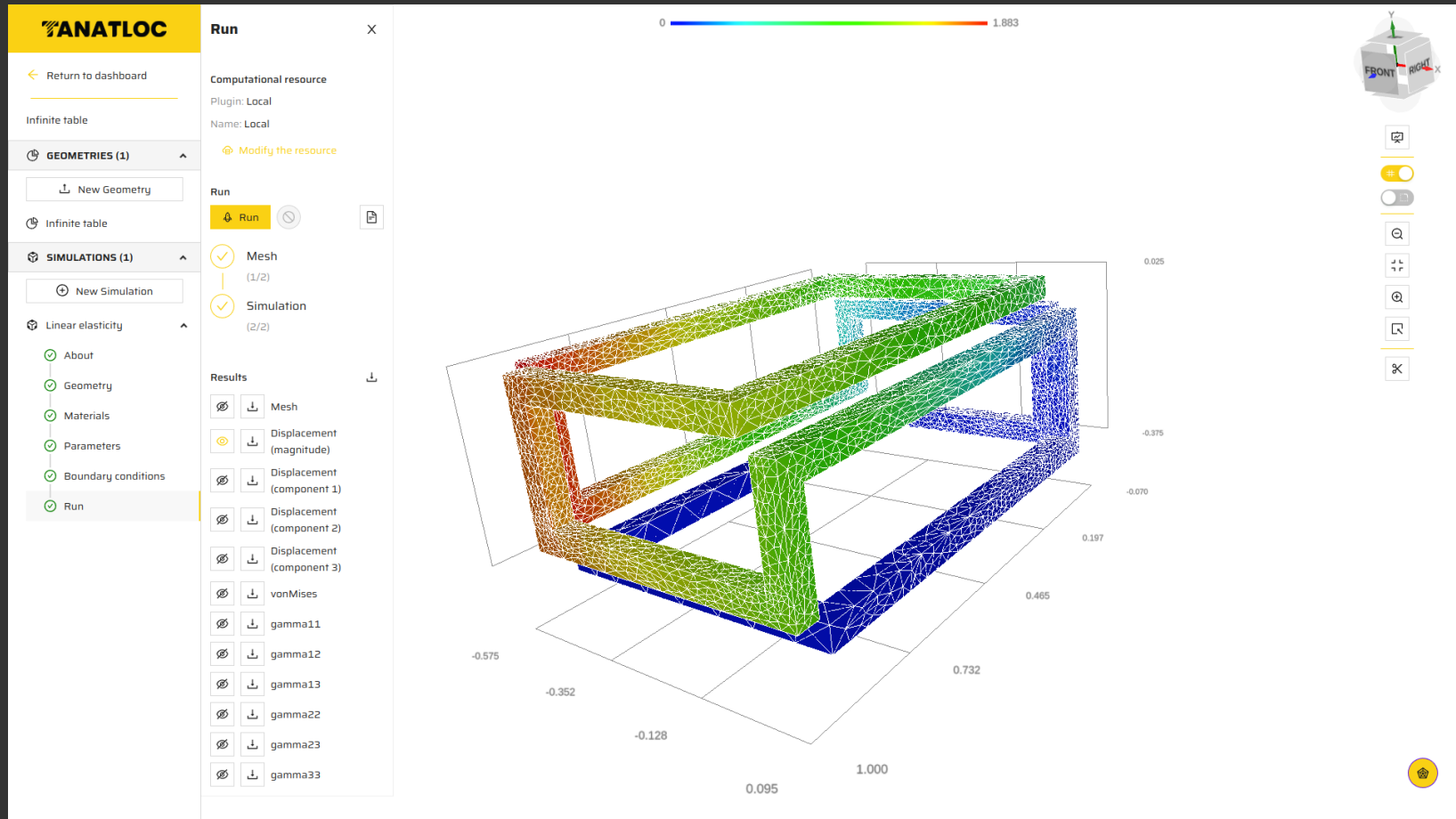
Run
+ Results



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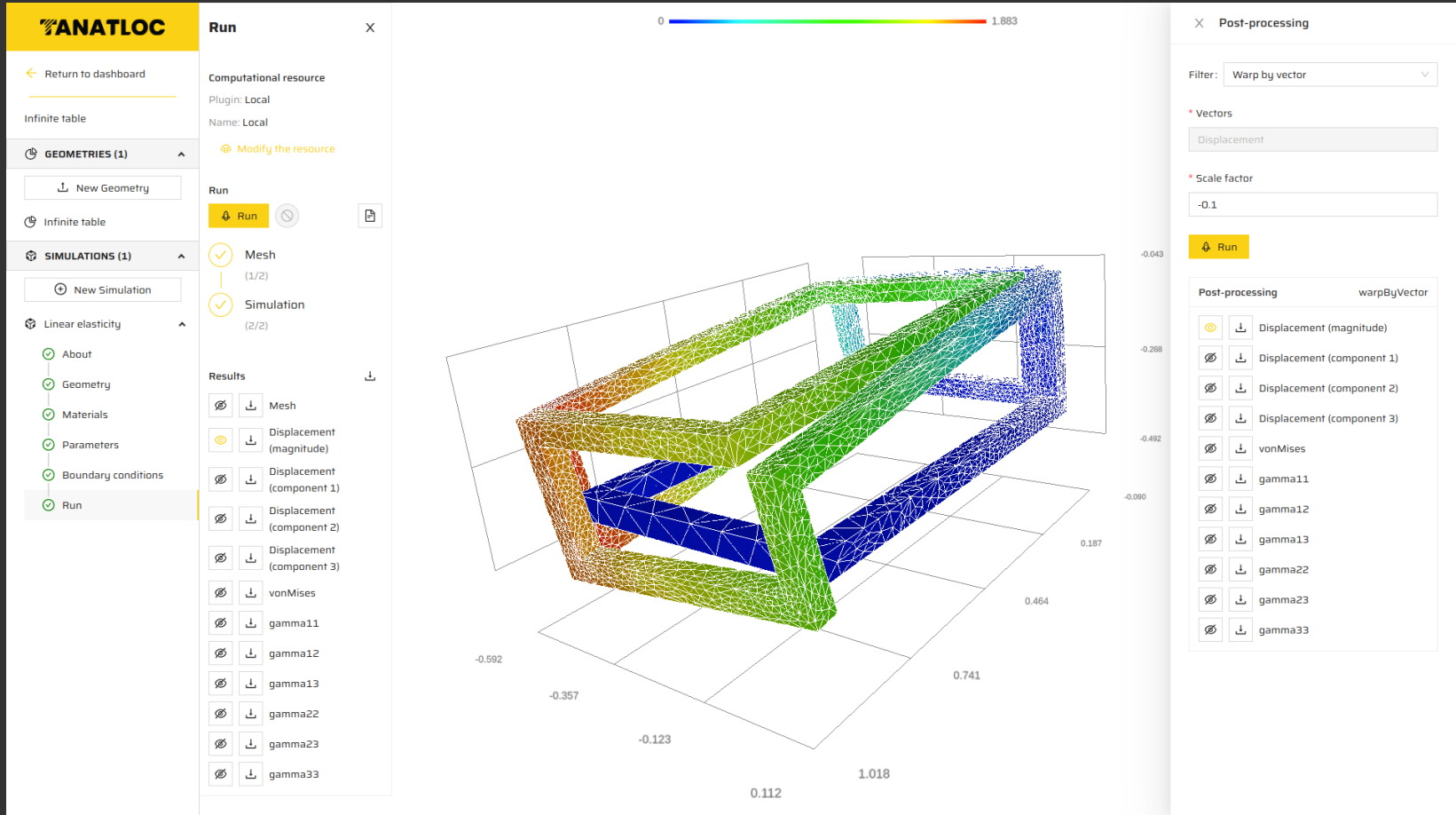
Post-processing



Basic behavior

A word of templates

Meshing tool: Gmsh

→ Gmsh script template

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Basic behavior

A word of templates

Meshing tool: Gmsh

→ Gmsh script template

Simulation tool: FreeFEM

→ FreeFEM script template

```
<%# Problem -%>
<%
const dirichlet = boundaryConditions.dirichlet.values || []
const neumann = boundaryConditions.neumann.values || []
const rhs = parameters.rightHandSide.children[0]
const rhsValue = rhs.value ?? rhs.default
-%>
// Problem
appendLog("Define the problem...");

varf vLaplacian (u, uh)
    = intN(Mesh)(
        grad(u)' * grad(uh)
    )
<% for (const d of dirichlet) { -%>
    + on(<%= d.selected.map(s => s.label).filter(s => s).join() -%>, u=0)
<% } -%>
    ;

varf vLaplacianRHS (u, uh)
    = intN(Mesh)(
        (<%- rhsValue -%>) * uh
    )
<% for (const n of neumann) { -%>
    - intN1(Mesh, <%= n.selected.map(s => s.label).filter(s => s).join() %>) {
        (<%- n.values[0].value ?? n.values[0].default %>) * uh
    }
<% } -%>
<% for (const d of dirichlet) { -%>
    + on(<%= d.selected.map(s => s.label).filter(s => s).join() -%>, u=<%- d.values[0].value ?? d.values[0].default -%>)
<% } -%>
    ;

<%# Solver -%>
<% const solver = parameters.solver.children[0].value ?? parameters.solver.children[0].default -%>
<%- include('/blobs/solver.edp.ejs', {
    solver
}) -%>

<%# Solve -%>
// Solve
appendLog("Solve the problem...");

matrix Laplacian = vLaplacian(<%= finiteElementSpace.name -%>, <%= finiteElementSpace.name -%>, solver=solver);
real[int] LaplacianRHS = vLaplacianRHS(0, <%= finiteElementSpace.name -%>);
u[] = Laplacian^-1 * LaplacianRHS;
```

Basic behavior

A word of templates

Meshing tool: Gmsh

→ Gmsh script template

Simulation tool: FreeFEM

→ FreeFEM script template

Post-processing tool: Paraview (pvpython)

→ Python script

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Main target Engineers

Easy access to simulations

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Next steps

→ Public access (only Airthium and Denso for now)

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→ Open-source (??? GPL3 + specific terms)

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Main target Engineers

Easy access to simulations

Next steps

- → Public access (only Airthium and Denso for now)
- → Open-source (??? GPL3 + specific terms)
- → Code template editor

  Your FreeFEM code integrated in Tanatloc, shareable with other researchers, students, … through *Organization*

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Thank you
for your attention

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