RENUDA
FLUID SOLUTIONS

2019 *Code_Saturne* User Meeting

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Cleaning Up with *Code_Saturne* and SALOME

R&D and Clean Tech CFD applications

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Outline

1. Renuda at a glance
2. R&D projects
3. Clean Tech applications
4. Conclusions and future work

1. Renuda at a glance

- **Blue Chip Clients**
  - Applications from single phase pipe flow to turbomachinery, multiphase flow, coupled heat transfer, mechanical calculations
  - Industries: transport, automotive, processing, nuclear, power generation, civil engineering

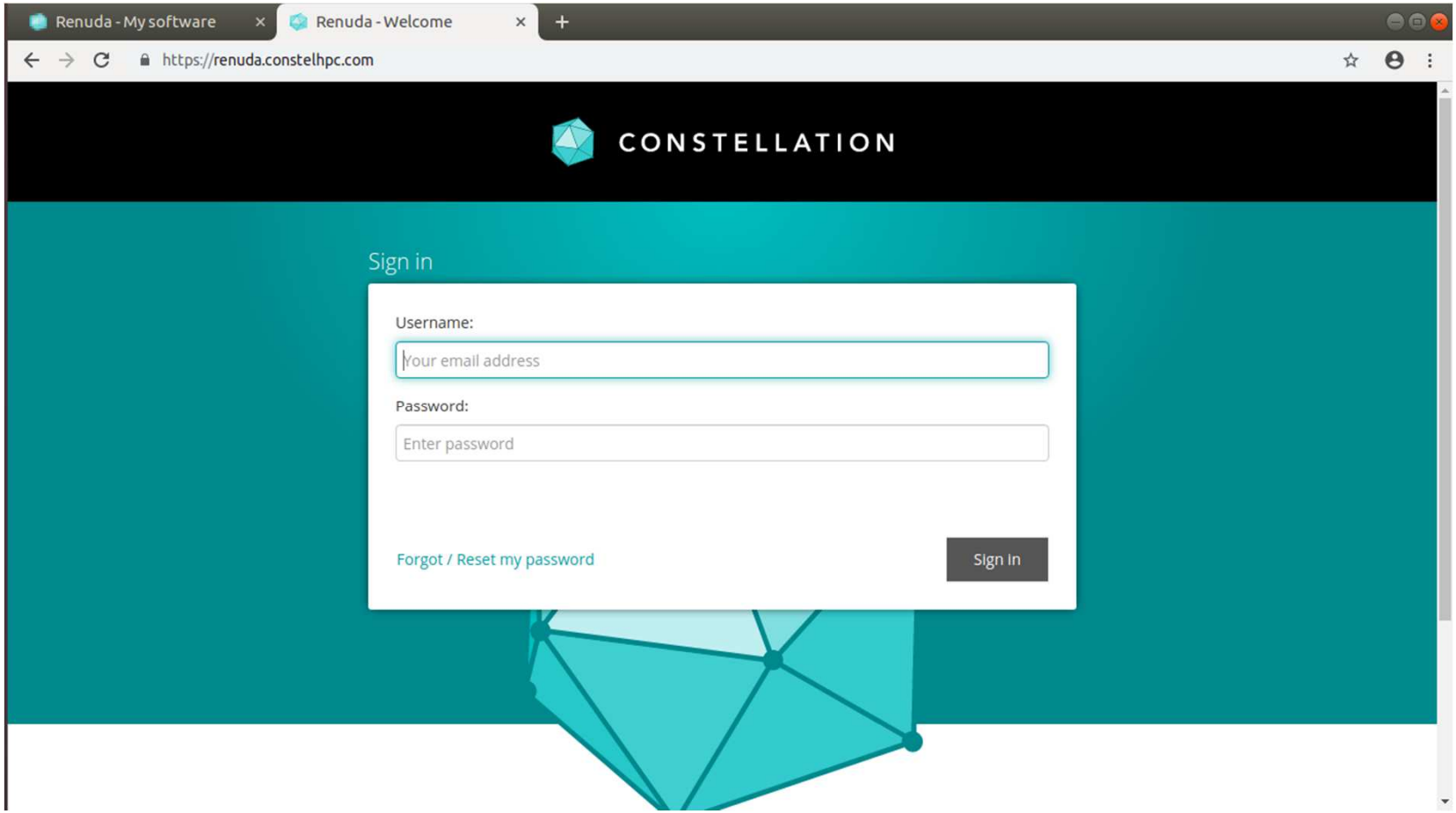
Software and Hardware Tools

- Commercial software

- **Open source software chains**
  - CAD: **SALOME**
  - Mesh: **SALOME, incl. Distene's MeshGems**, and snappyHexMesh
  - CFD: *Code_Saturne*
  - Analysis: **Paraview**

- Mix of local and remote computing
  - Local multi-core PCs
  - Access to HPC on hundreds of compute cores at the Hartree Centre, UK
  - **Constelcom's Constellation™** platform for easy access to HPC

Constellation



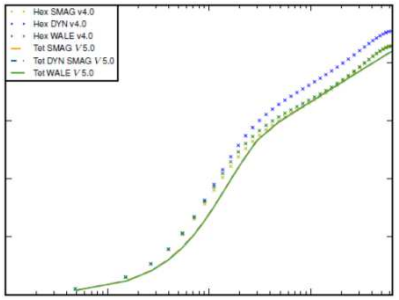
Research Partnership And Collaborations

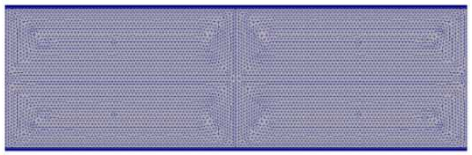
- Research and development is very important
- Collaborative research relationship with EDF R&D on the development of *Code_Saturne*
- Collaboration with the SALOME teams:
  - Development of module for specialised steam turbine code
- Part of the UK Consortium on Turbulent Reactive Flow
  - SiG on Sprays
  - SiG on Combustion
- NAFEMS CFD Working Group
- Collaboration with different universities and research labs
  - University of Manchester
  - Daresbury Laboratory (Science and Technology Facilities Council) – HPC research and application
  - University of Edinburgh (software parallelisation)

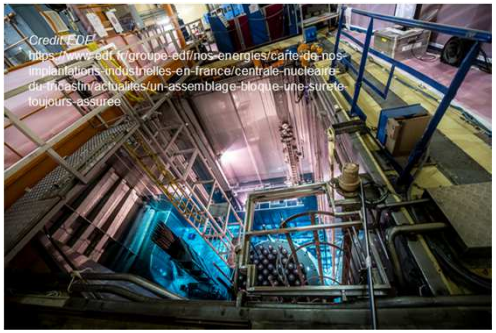
2. R&D Projects

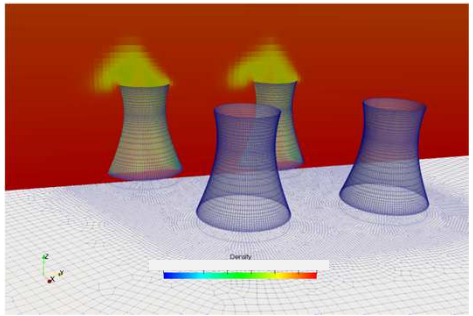
R&D

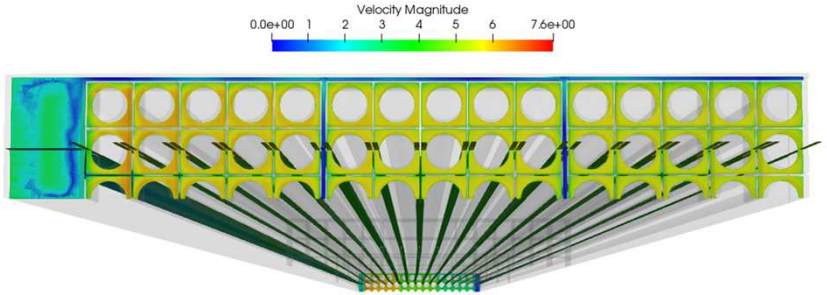
- Continued collaborative efforts with EDF R&D to develop *Code_Saturne*
- Turbulence on tetrahedral meshes
  - From classic cases to validation with experimental setups
  - Numerics
  - Models
- Multi-physics
  - Cooling Tower module validation
  - Merging with the Atmospheric module



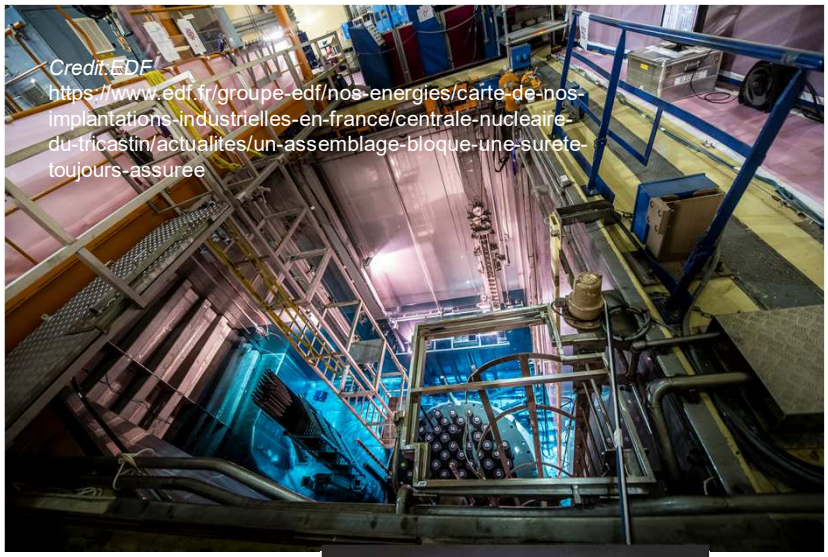








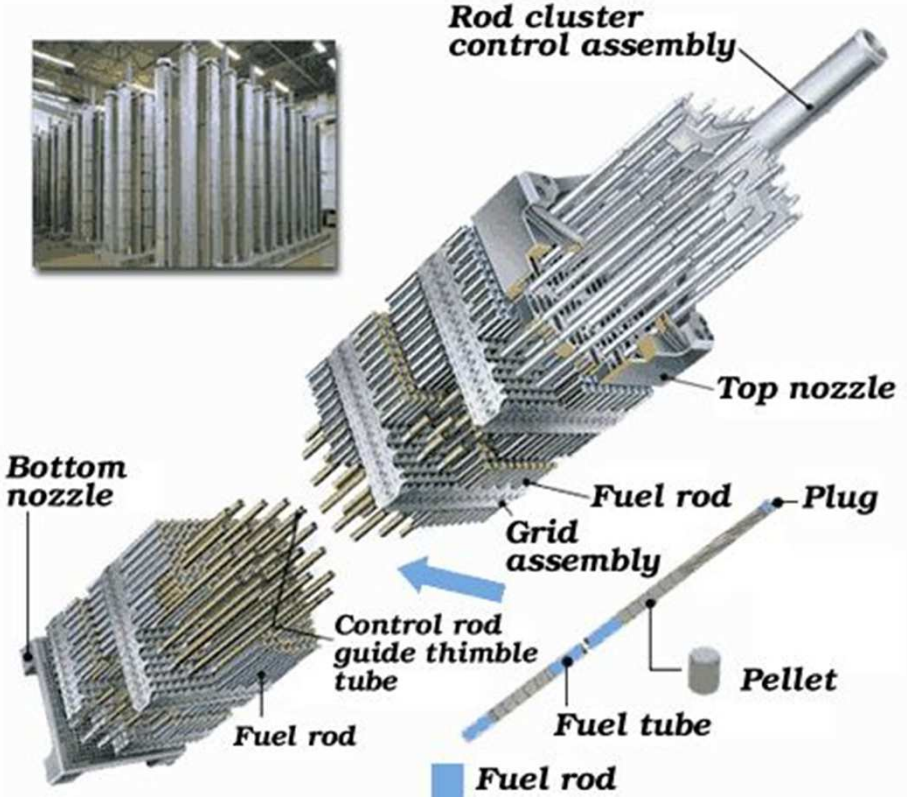
PWR Nuclear Fuel Assemblies



Credit:EDF
https://www.edf.fr/groupe-edf/nos-energies/carte-de-nos-implantations-industrielles-en-france/centrale-nucleaire-du-tricastin/actualites/un-assemblage-bloque-une-surete-toujours-assuree

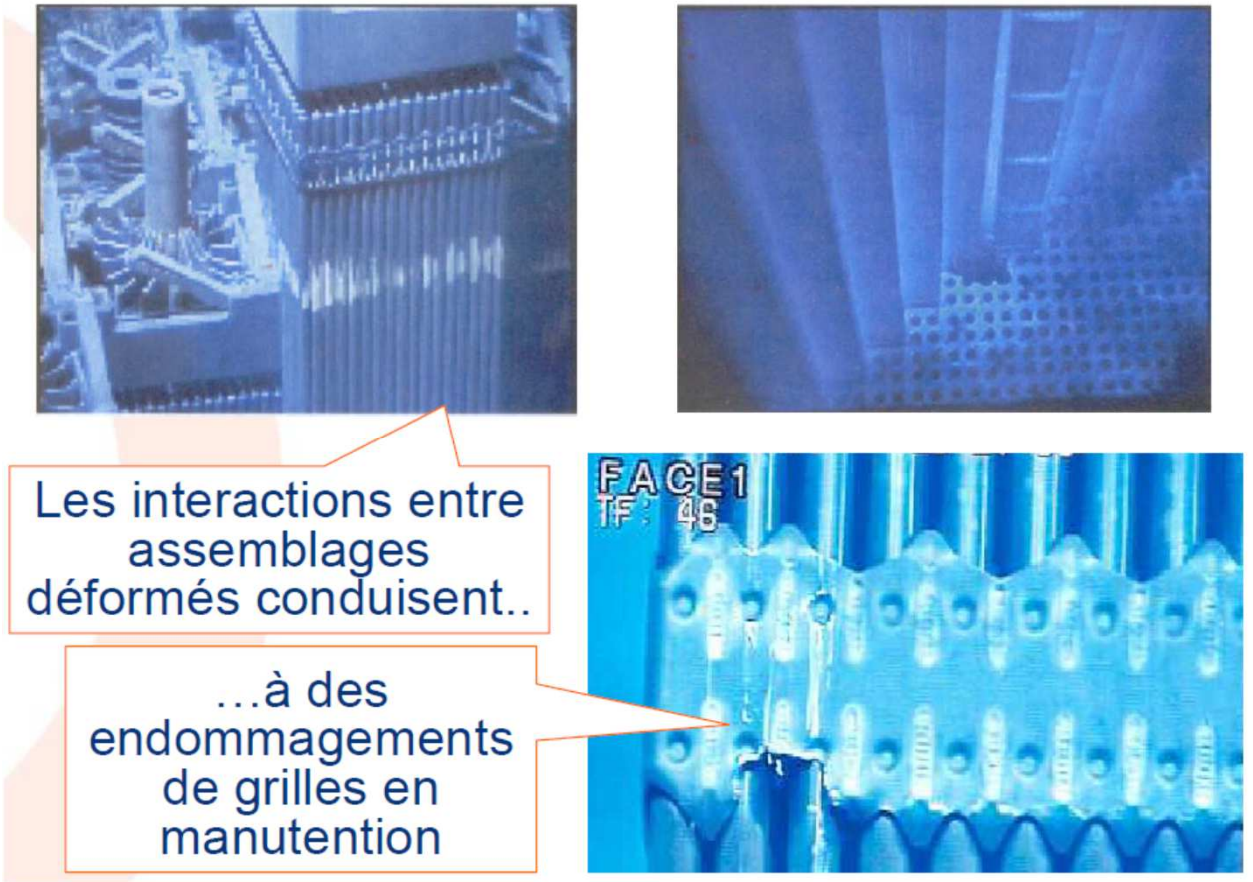
Credit:ASN
https://www.asn.fr/Lexique/A/Assemblage-combustible

Credit: World Nuclear Association
http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/conversion-enrichment-and-fabrication/fuel-fabrication.aspx



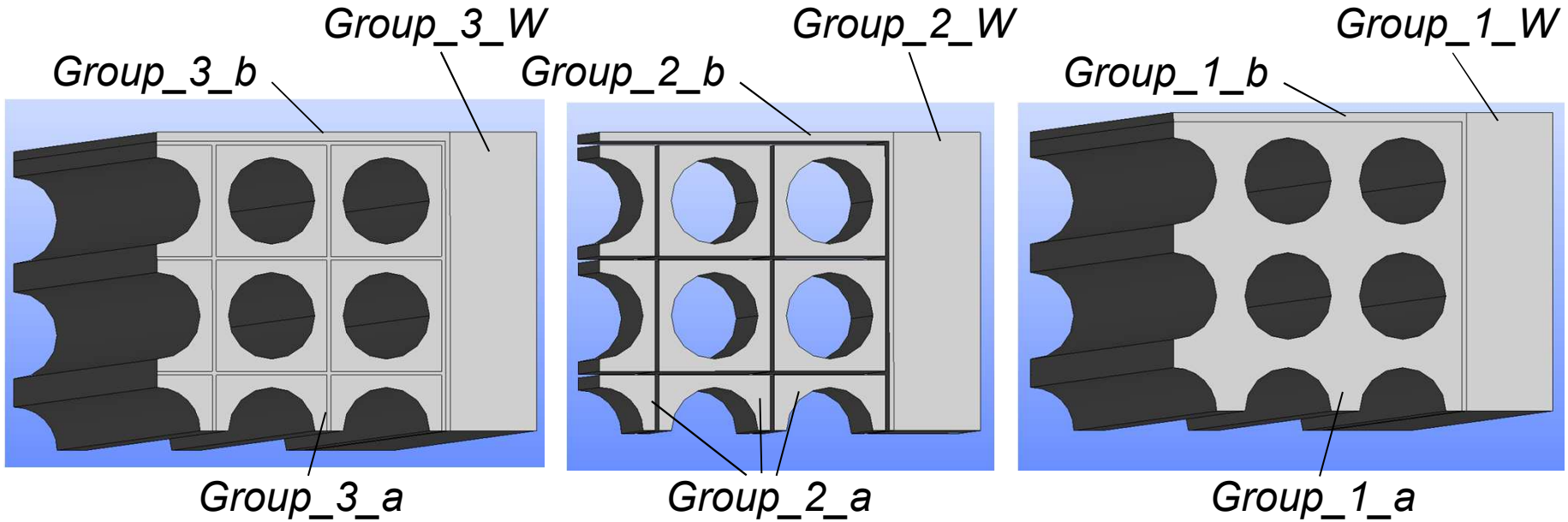
Deformation

- Slide reproduced from the presentation: *“Les Gestions des coeurs et les perspectives”, Nicolas Waeckel (EDF-SEPTEN), Convention annuelle de la SFEN, 11-12 mars 2009*
- *https://inis.iaea.org/collection/NCLCollectionStore/_Public/42/026/42026961.pdf*



Volume sub-decomposition

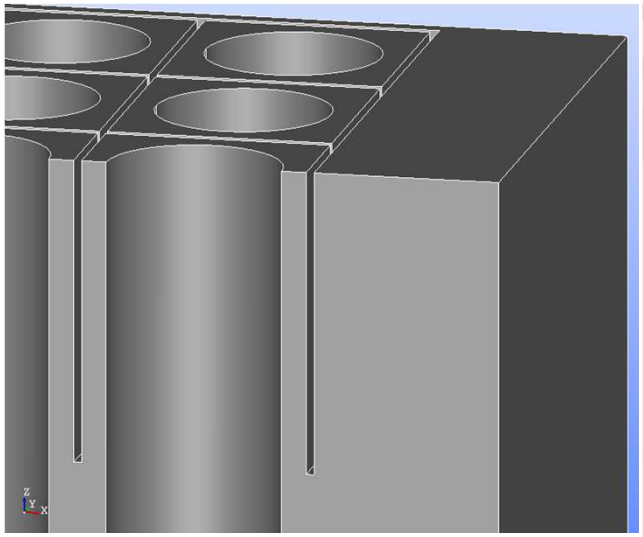
- The main brick is further decomposed in elements which can be used later to represent the different configurations desired



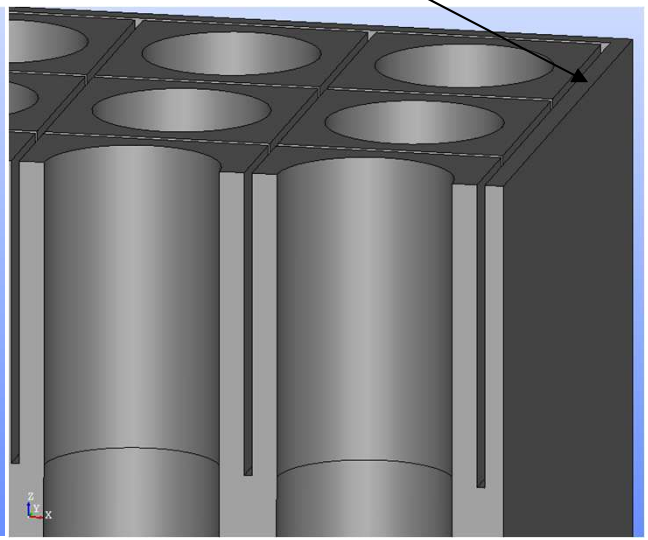
Deformation Scenarios

- Zoom on the top part to show the displacement and contact

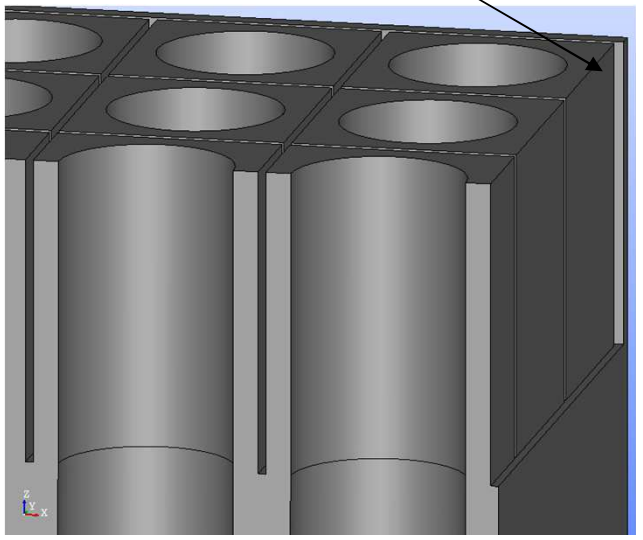
No deformation



Reduced gap

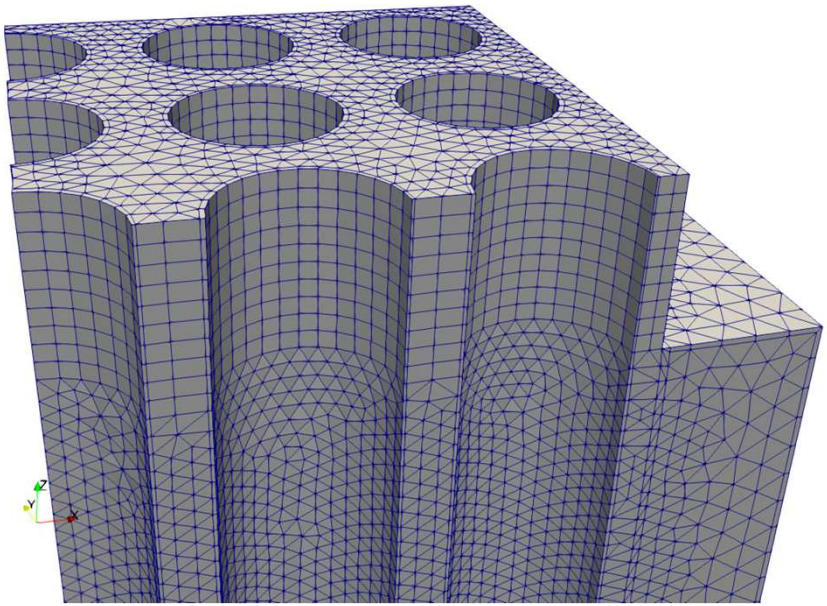


Full contact



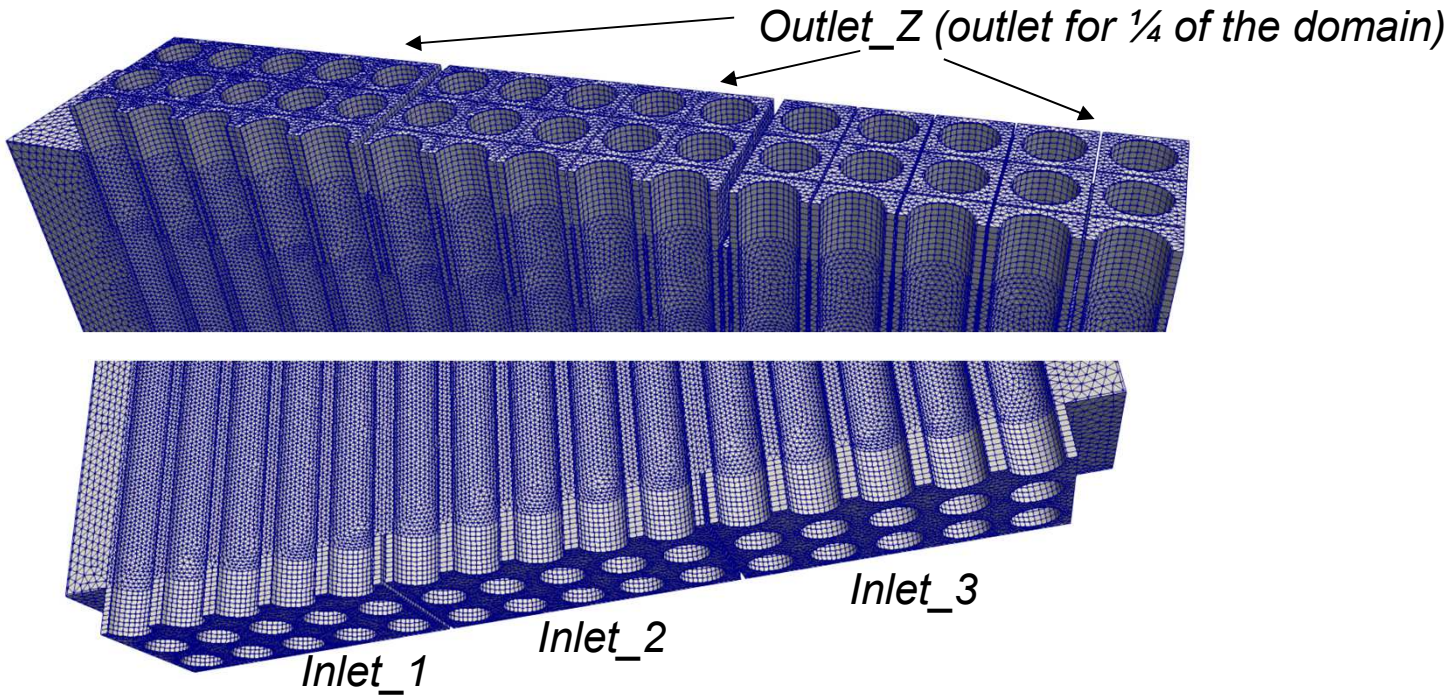
Utilising *Code_Saturne* for Meshing

- *Code_Saturne* is applied to the complete mesh in order to create both
  - The wall layers
  - The extrusions to represent the inlets and outlets
- The entire meshing process is parametrised



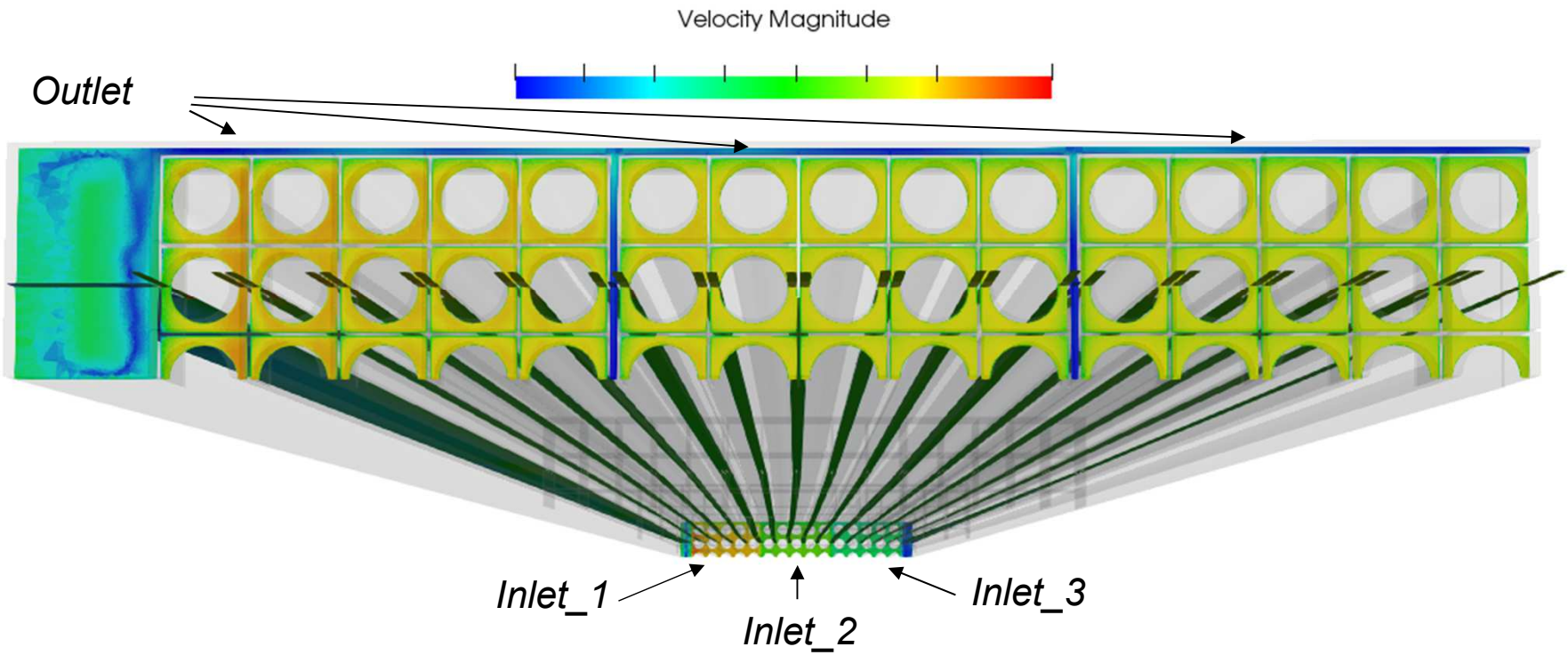
Final Mesh

- Illustration of the final, extruded mesh for the full-contact configuration



Process validation: CFD

- Verification over a few tens of iterations with *Code_Saturne*

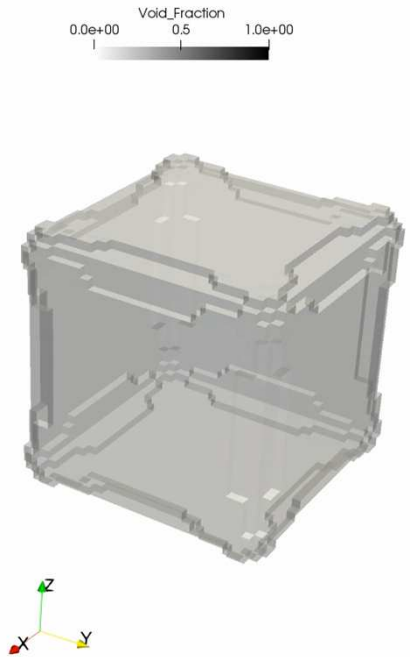


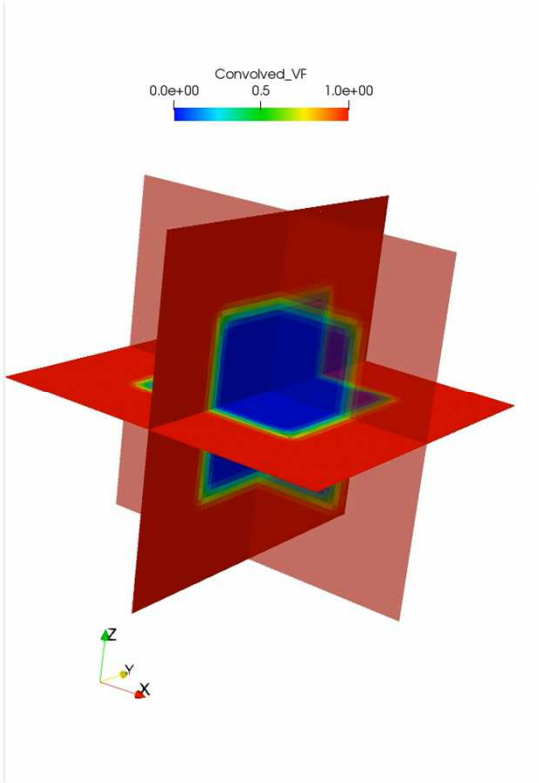
VoF – Superficial force

- Implementation of a model to account for interfacial surface tension effects in the VoF algorithm
  - Surface curvature – convolution method for general meshes

Hexahedral mesh

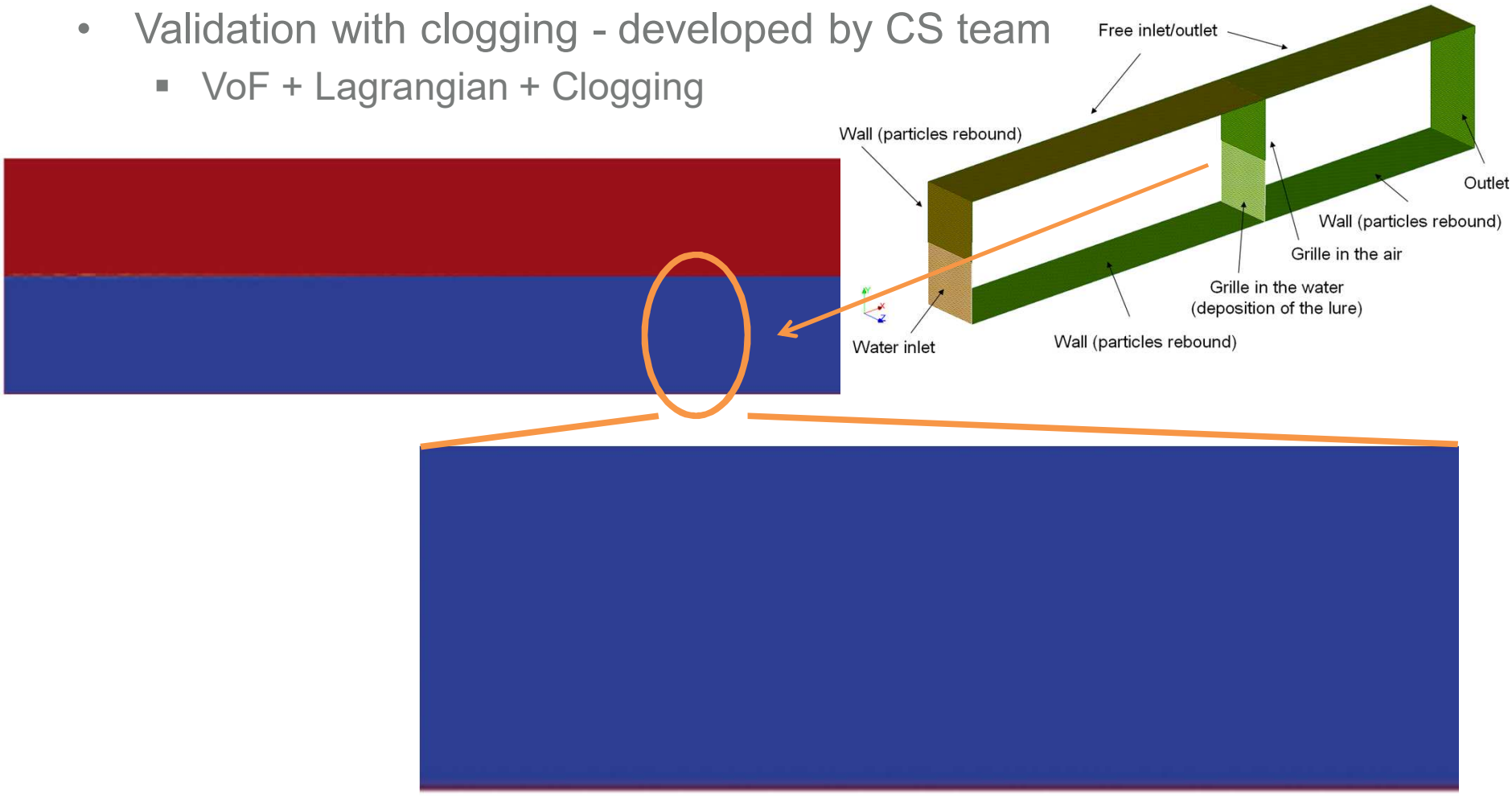
Tetrahedral mesh





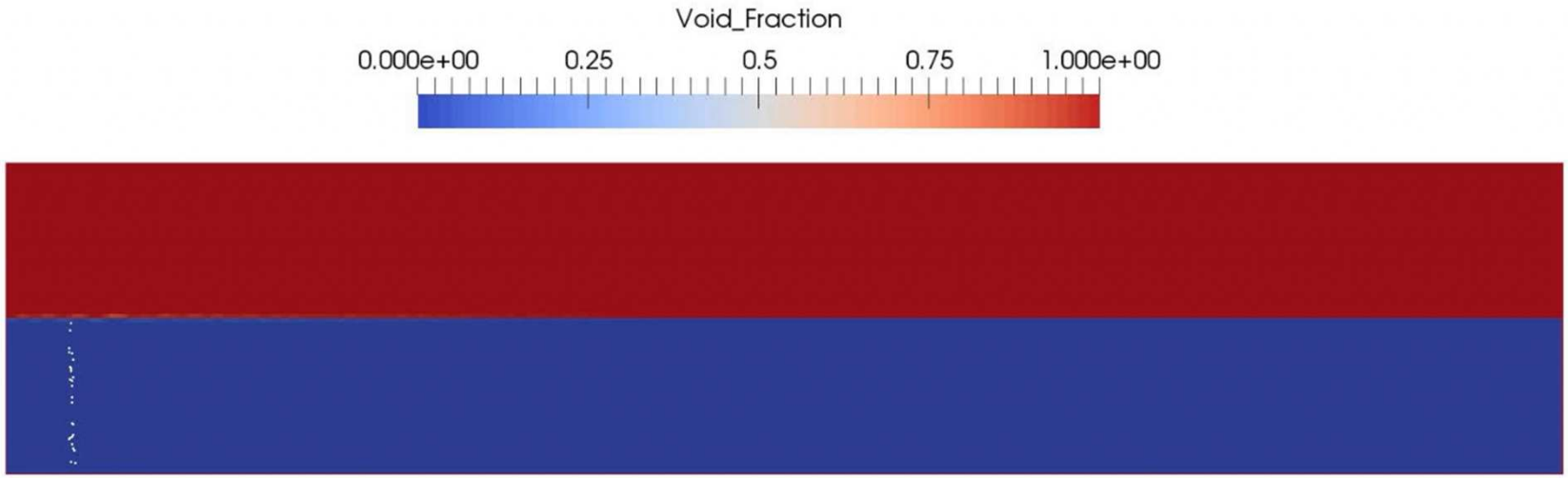
VoF + Lagrangian

- Validation with clogging - developed by CS team
  - VoF + Lagrangian + Clogging



VoF + Lagrangian

- With a different density ratio, the particles clog up the entire height of the grille, forcing the flow to spill over the grille



3. Clean Tech Projects

CleanTech

- Optimisation of resources and growing concerns for the environment are pushing the utilisation of digital modelling such as CFD in industries which might have been relying on more traditional methods in the past
- Examples abound, from the Mining industry to Oil and Gas, Manufacturing and Waste water treatment
- Here, we present as illustrations two projects in which CFD has been at the core of the design and analysis
  - Water treatment plant in Ivory Coast
  - Plywood manufacturing

Water Treatment plant

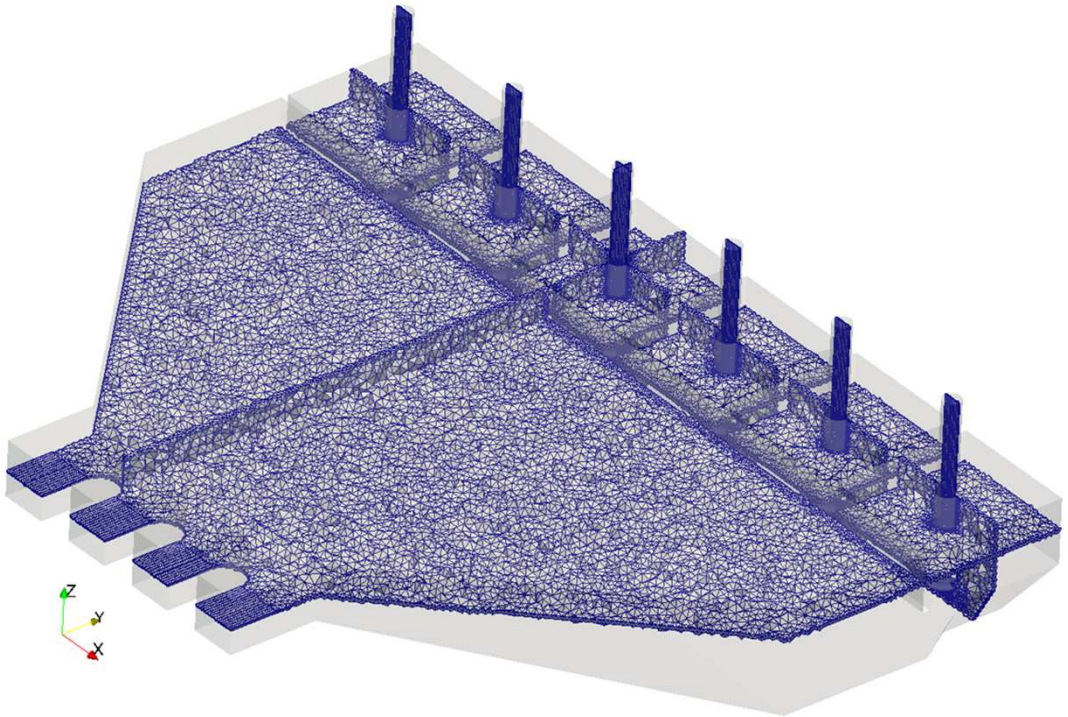
- Plant planned in Ivory Coast to supply drinking water
- Treat water from the river Mé to strengthen the supply of drinking water to the city of Abidjan

Credit: BESIX Group
https://press.besix.com/besix-in-ivory-coast-civil-engineering-works-for-a-drinking-water-treatment-plant

Challenge: Limit the amount of pre-rotation upstream of the pumps

Raw Water Collection

- Analysis of the design of the raw water collection station
- Series of calculations and analysis showing first large recirculations, then redesign, adding structures to distribute the flow more evenly



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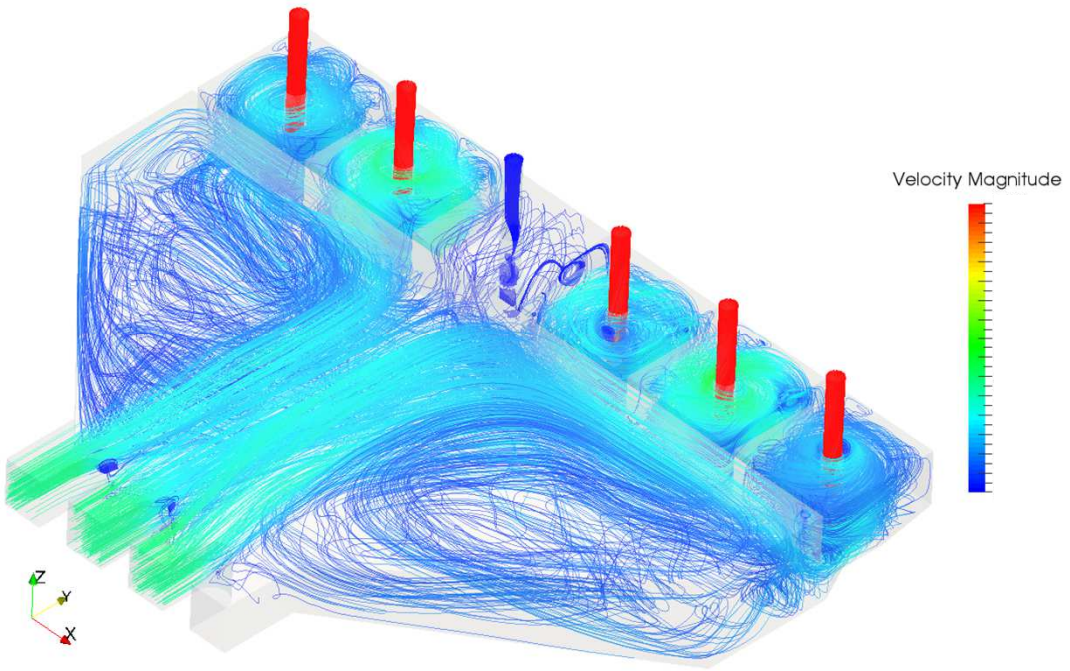
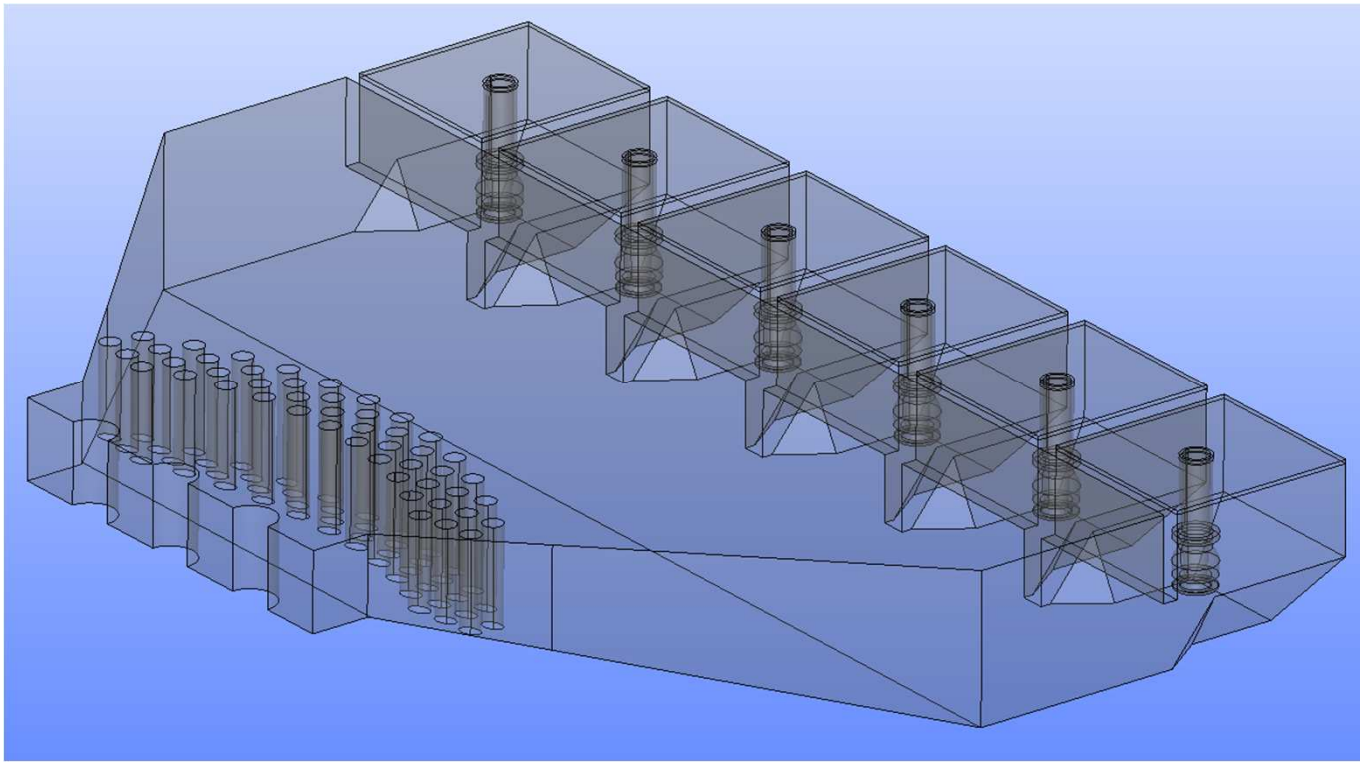


Raw Water Collection – Design 2

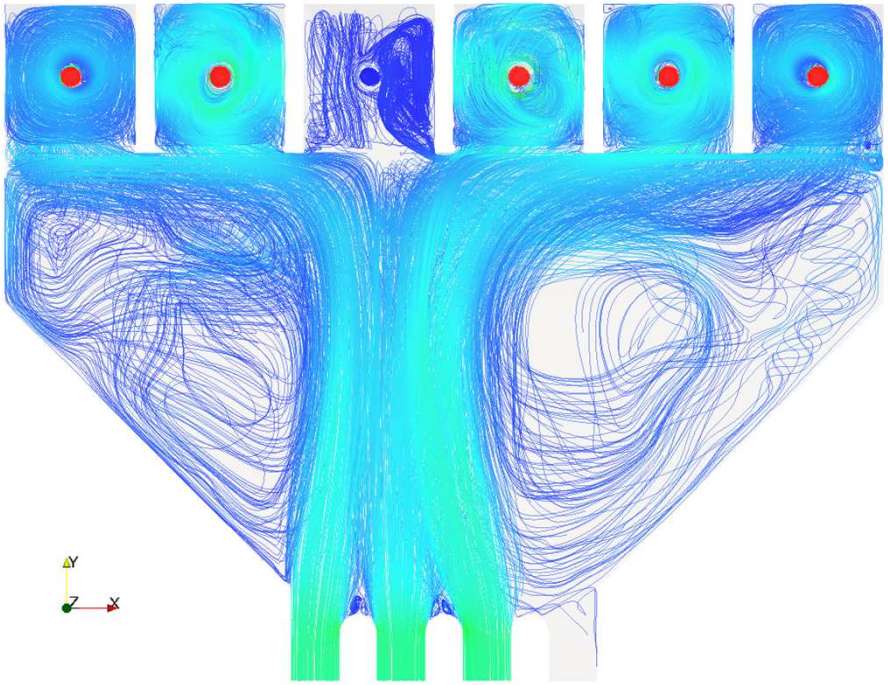
- Addition of a network of columns to diffuse the flow



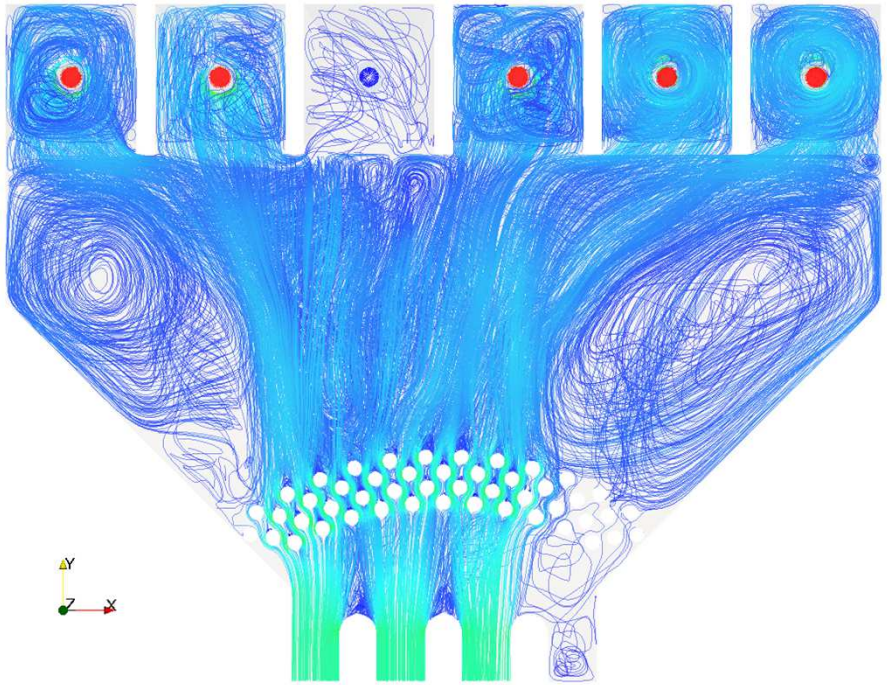
Comparison

- The columns contribute to diffusing the flow sideways and the pre-rotation in the pump chambers is significantly reduced

Initial design

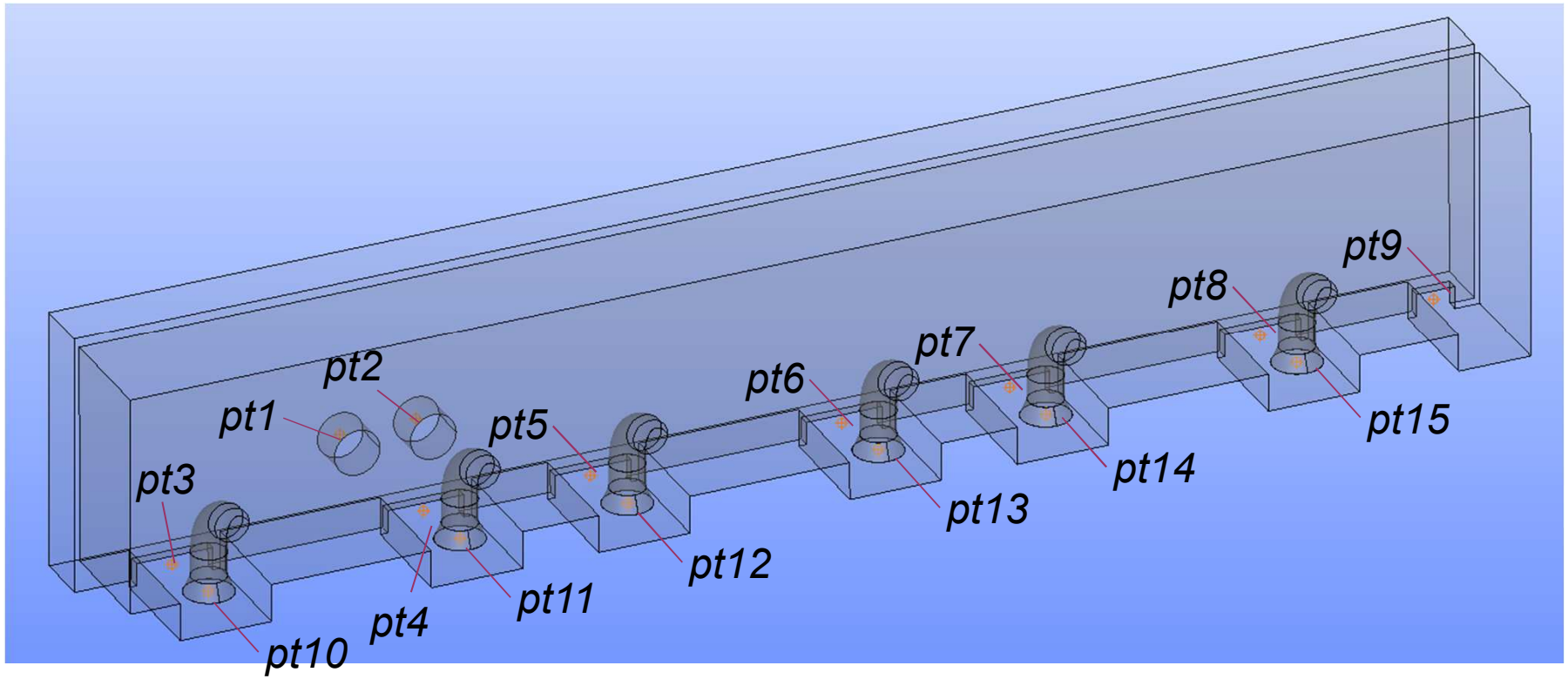


With the added columns



Treated Water Pumping Station

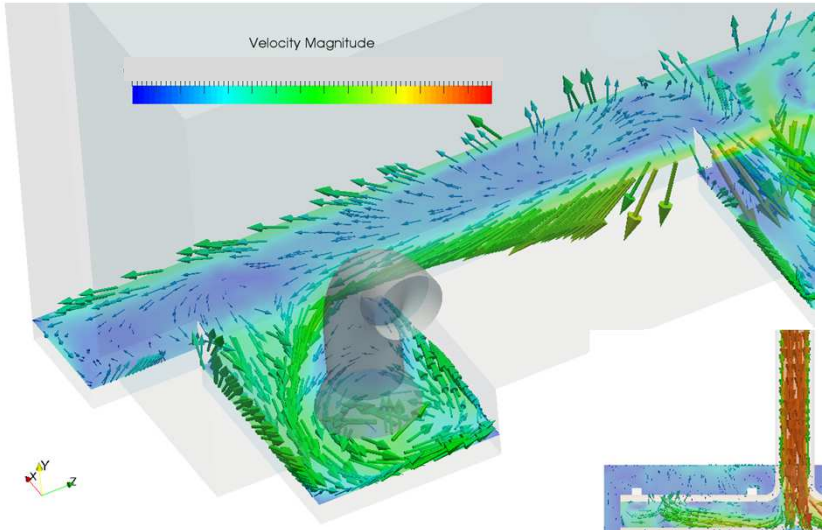
- Similarly, for the treated water pumping collection pre-rotation in the pump chambers must be limited



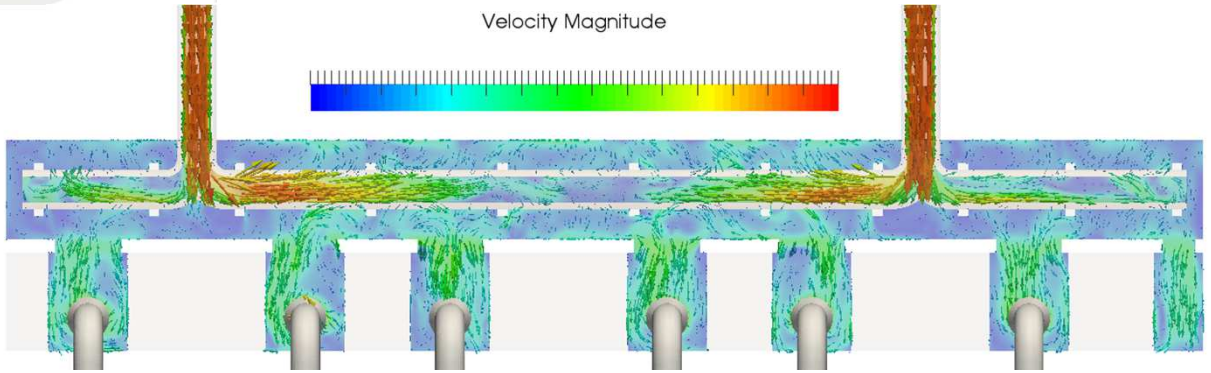
Treated Water Pumping Station

- Go through a series of designs to limit the vortices under the pumps

Initial design

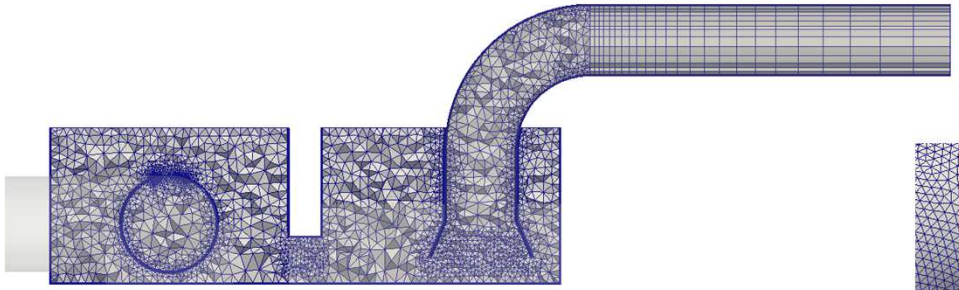


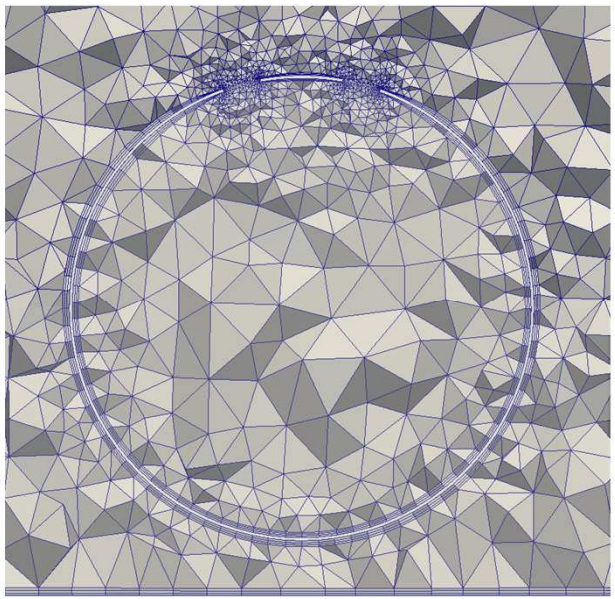
Third design

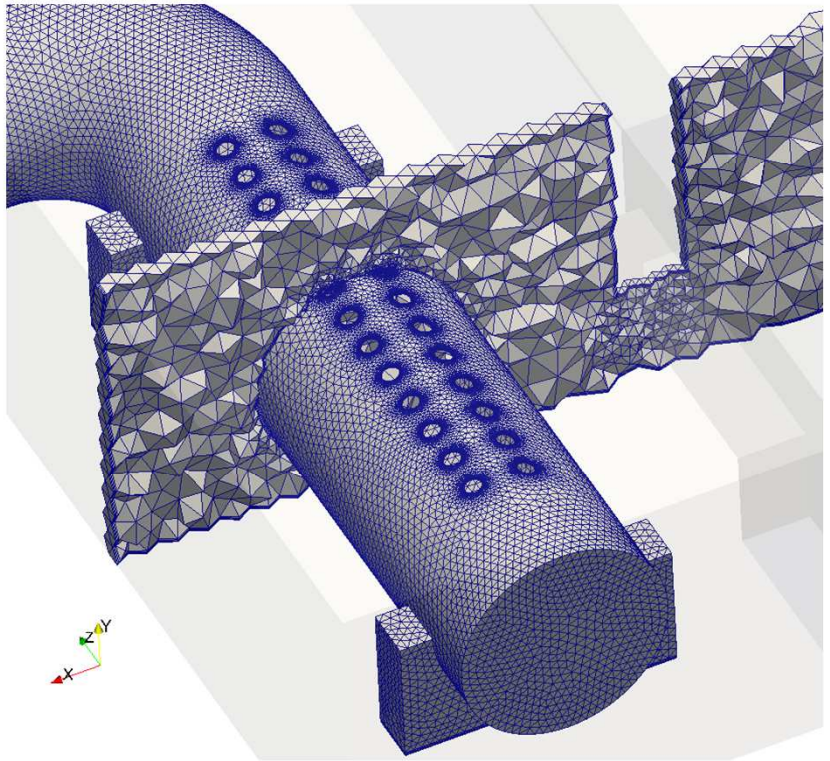


Treated Water Pumping Station

- Extrusion and wall layers all built in *Code_Saturne*





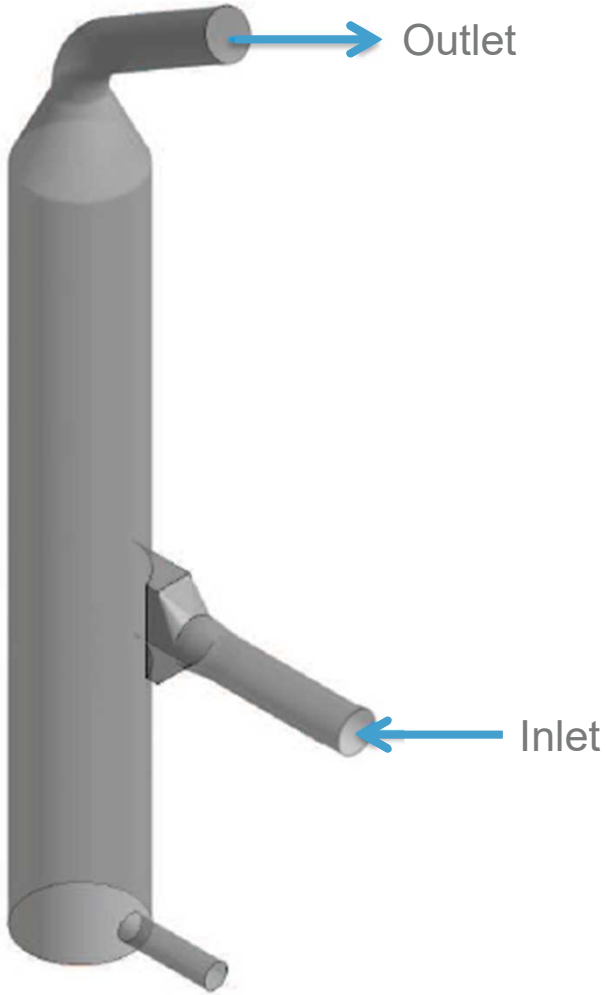


Wood Particles Removal

- Siempelkamp Group is a very large manufacturer:
  - Siempelkamp machine and plant engineering: wood-based panels, metal forming, composite and rubber
  - Siempelkamp foundry: castings
  - Siempelkamp NIS Ingenieurgesellschaft mbH: components and services for the Nuclear industry

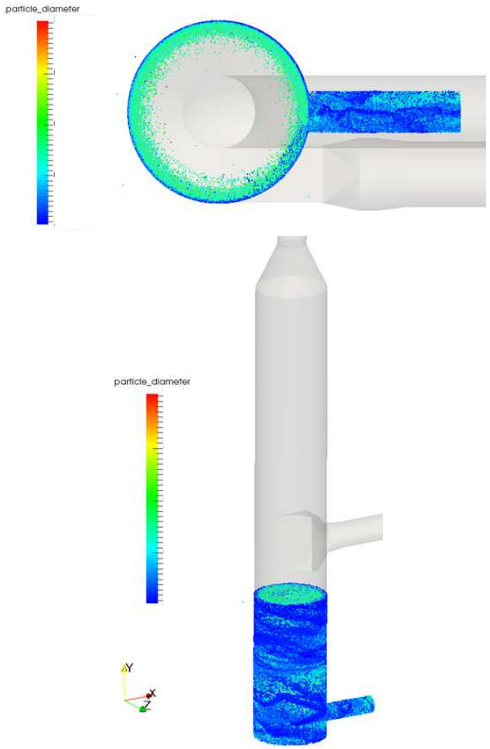
Scrubber

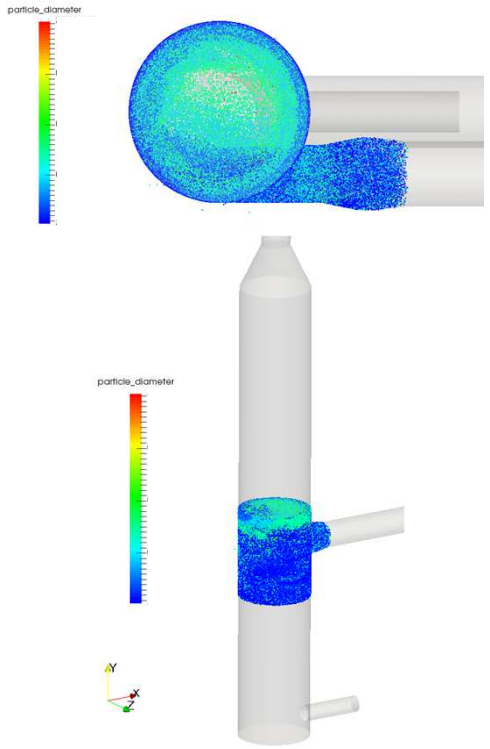
- Filtration system to clean the ventilation air
  - Extract the left-over wood particles
- CFD modelling to analyse the flow field and improve the system if required

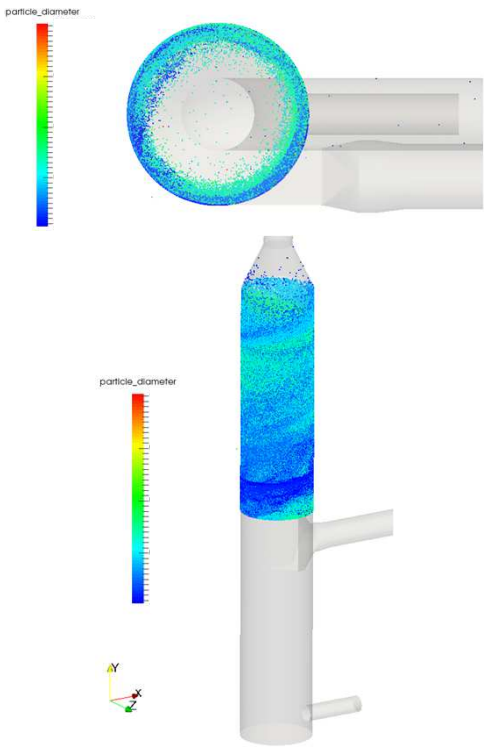


Lagrangian Two-Way Modelling

- Series of CFD calculations indicates a higher concentration of particles in the central part of the system
  - System augmented with downward water sprays

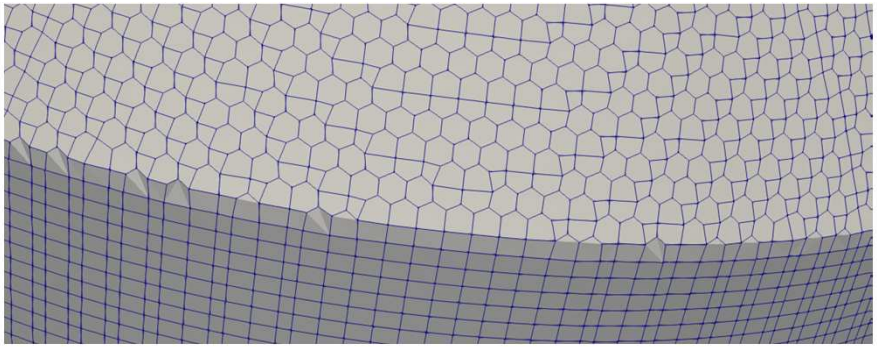


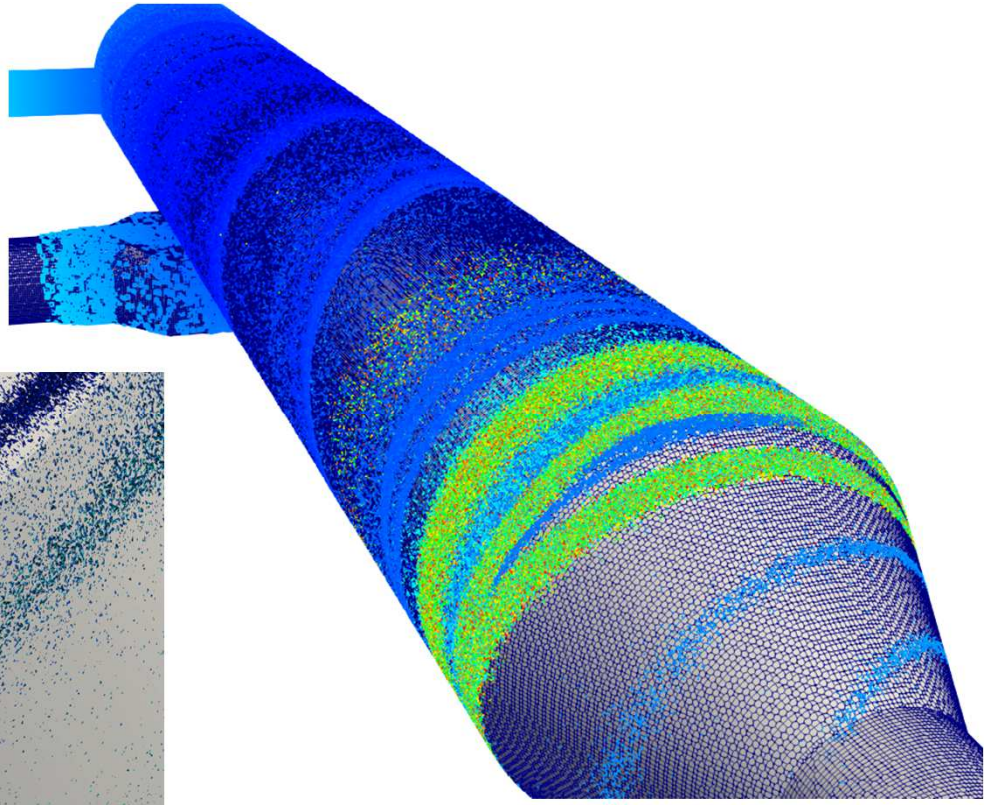


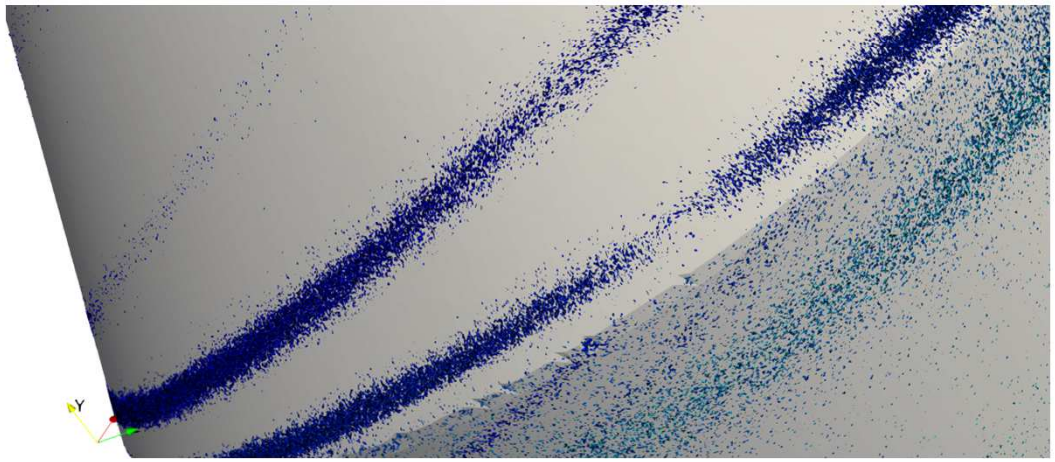


Wood Particles Removal

- Significant increase of robustness by the *Code_Saturne* team to tolerate particle interactions with deformed boundary faces







3. Conclusions and Future Work

Conclusions and Future Work

- *Code_Saturne* and SALOME form a very powerful combination, which Renuda is applying in very different industrial settings and purposes. Renuda is also participating in its development
- Through the availability of multi-physics models and HPC, *Code_Saturne* can be applied to problems which are further away from the Nuclear industry
- Usability features are also essential in order for the eco system to be adopted by an increasing number of users. For example, extrusion layers and restarts on different meshes are very useful
- Digitalisation is of interest to all industries, pursuing similar goals of efficiency, optimisation and innovation
- We look forward to participating in the continued development of *Code_Saturne* to address upcoming challenges, not just machines or systems but human and societal ones

Societal Challenges

- Can *Code_Saturne* help with Brexit?

Societal Challenges

- Can *Code_Saturne* help with Brexit?

Grand Challenges

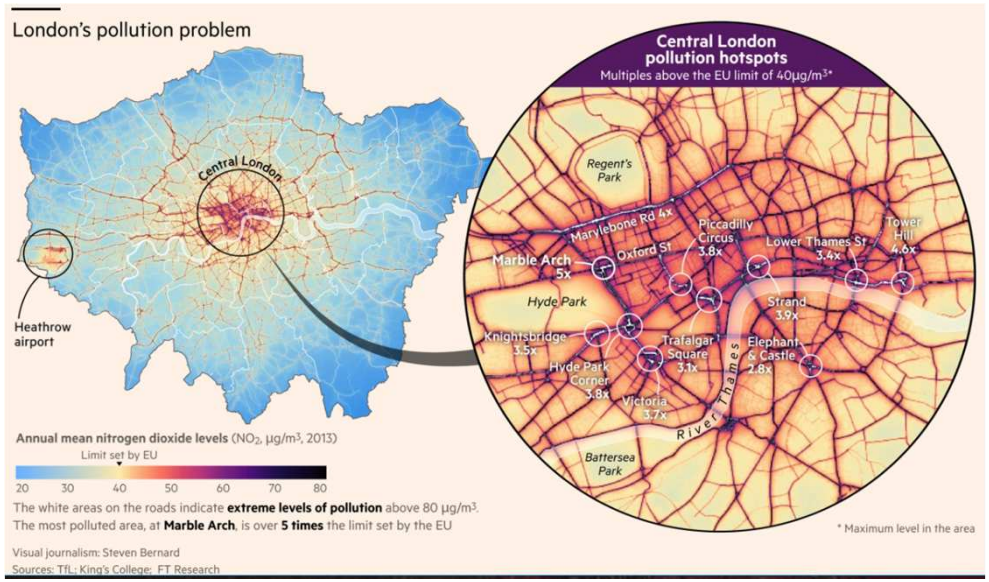
- Environment
- Fires
- Physics and speed

Source: Evening Standard
https://www.standard.co.uk/news/london/revealed-the-dossier-of-deadly-failures-at-grenfell-tower-a3814871.html

London

Ella Kissi-Debrah: new inquest granted into 'air pollution' death

Nine-year-old from London died after asthma attack possibly linked to pollution



Source: Financial Times
https://www.ft.com/content/9c2b9d92-a45b-11e8-8ecf-a7ae1beff35b