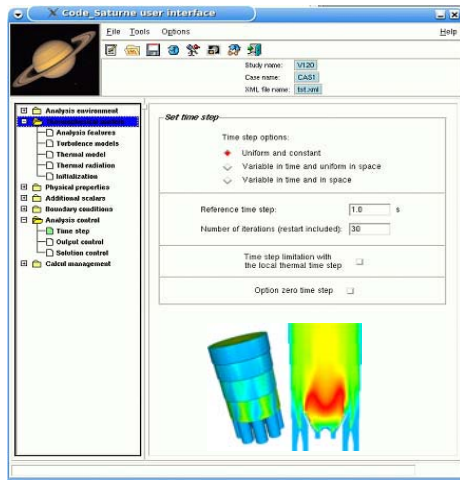


# Code\_Saturne

## EDF's Open Source CFD Solution



### EDF's general purpose computational fluid dynamics software



*Code\_Saturne*<sup>®</sup> is EDF's general purpose computational fluid dynamics software. Developed since 1997 at EDF R&D, it is based on a **co-located Finite Volume** approach that accepts meshes with **any type of cell** (tetrahedral, hexahedral, prismatic, pyramidal, polyhedral...) and **any type of grid** structure (unstructured, block structured, hybrid, conforming or with hanging nodes...).

**Its basic capabilities** enable the handling of either incompressible or expandable flows with or without **heat transfer** and **turbulence** (mixing length, 2-equation models, v2f, Reynolds stress models, Large Eddy Simulations...).

**Dedicated modules** are available for specific physics such as radiative heat transfer, combustion (gas, coal...), magneto-hydro dynamics, compressible flows, two-phase flows (Euler-Lagrange approach with two-way coupling), extensions to specific applications (e.g. for atmospheric environment: code *Mercur*<sub>e</sub>*Saturne*).

**Parallel code coupling capabilities** are provided by the FVM library (EDF's "Finite Volume Mesh" library, under LGPL licence).

*Code\_Saturne* can be coupled to EDF's thermal software *Syrthes*.

It can also be used jointly with EDF's structural analysis software *Code\_Aster*, in particular in the *Salomé* platform.

### Quality Assurance, portability, parallelism

**Quality Assurance** development

**Regular and extensive validation and qualification.**

**Source code : F77, C99, Py**

430,000 lines : 50% Fortran 77, 43% C99, 7% Python

**Portable** on Linux PCs

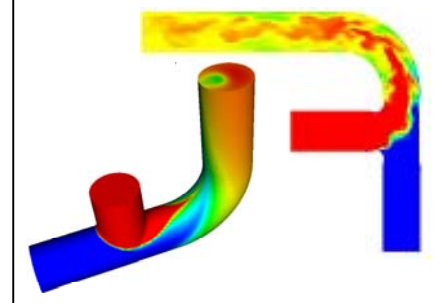
and all Unix platforms tested so far (HP-UX, Solaris, Cray, OSF1...)

**Parallel** on distributed memory machines (MPI)

Origin 2000 and 3000, PC clusters,

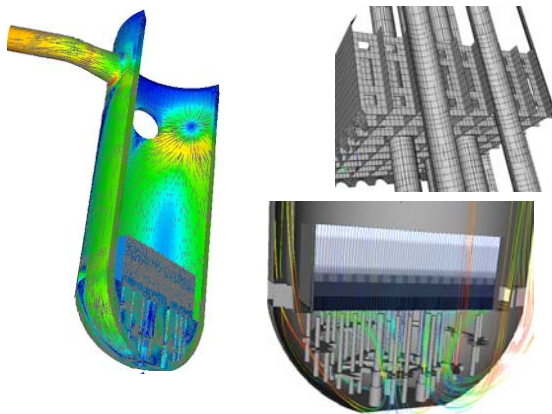
Cray XT-3, IBM Blue Gene, Power PC 970 (Marenostrum)...

Example of a validation test case:  
transient flow in a T-junction.



### Application example

#### LOCAL FLOW CONDITIONS IN A PWR LOWER CORE



In 900 and 1300 MW Pressure Water Reactors, knowledge of flow conditions in the lower core is especially important to study **deformation and fretting of the fuel assemblies**.

*Code\_Saturne* enables the investigation of local flow conditions through **series of calculations**, increasing the geometry detail as the computational domain dimensions decrease.

For this application, the largest domain includes part of the cold legs, downcomer, lower plenum and lower core, while the smallest, more detailed case, is restricted to the neighbourhood of the lower core plate.

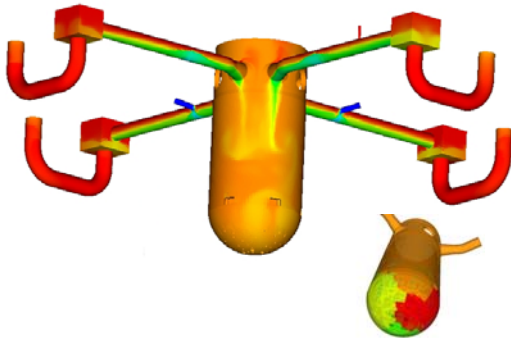
**Contact: saturne-support@edf.fr**

### Applications examples: nuclear and fossil fired furnaces

#### PRESSURIZED THERMAL SHOCK ON A PWR VESSEL

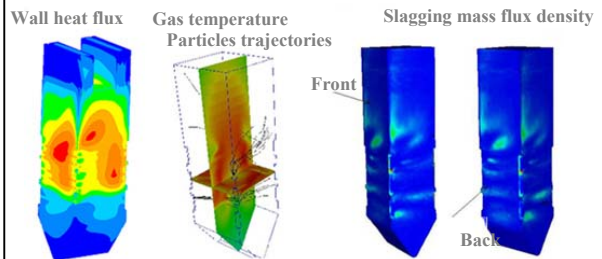
For the Pressure Water Reactor lifetime project, it is crucial to investigate the effect of a safety injection of cold water in the PWR vessel in case of a small break on the hot leg (Loss Of Coolant Accident).

A coupled local 3D approach with *Code\_Saturne* for the fluid and EDF's *Syrthes* code for conjugate heat transfer in the solid enables to determine more precisely the temperature evolution at critical locations in the metal of the vessel: the thermal shock is proved less severe than would be expected from a 1D approach based on correlations.



#### PULVERIZED COAL FURNACE SLAGGING

Ash deposit on shell plates and exchangers reduces the efficiency of Q600-type pulverized coal-fired boilers.

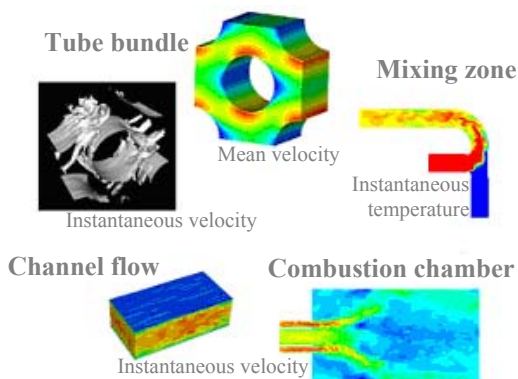


In the hopper and burners region, "slagging" is investigated with *Code\_Saturne* using an **homogeneous Eulerian model** to compute the temperature and flowfield of the carrying phase and a **high accuracy Lagrangian approach** to track pulverized coal particles individually (**wall-interaction** modelling takes into account the surface condition, particle physical properties, velocity and angle of incidence).

It is observed that the ash flux density on the furnace inner walls has a rather heterogeneous distribution, with higher slagging at the burners and at the top of the burners zone, under the exchanger system.

### Applications examples: LES research and HVAC

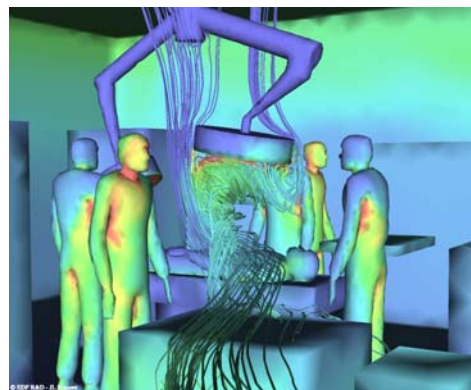
#### LARGE EDDY SIMULATION



**Large Eddy Simulation (LES)** enables a refined description of local and instantaneous variables in turbulent flows (spectral analysis, local extremes) with immediate application to **acoustics, structural analysis and thermal structure loading**.

#### HVAC AND AIR QUALITY IN OPERATING THEATERS

In hospitals and particularly in operating theaters, air quality is crucial since **infections might be transmitted via the airborne route**.



*Code\_Saturne* enables an accurate representation of the **equipment, medical staff, patient and HVAC** (heating, ventilation and air conditioning) in order to determine zones where contamination risks are high and to evaluate the efficiency of the **ceiling ventilation device**.