



THE NURESIM PROJECT

NURESIM = NUclear REactor SIMulation

OUTLINE

1. The NURESIM roadmap

- ✓ A single platform
- ✓ Successive European projects

2. The NURESIM project

- ✓ Partners
- ✓ Organization
- ✓ Subprojects

www.nuresim.com

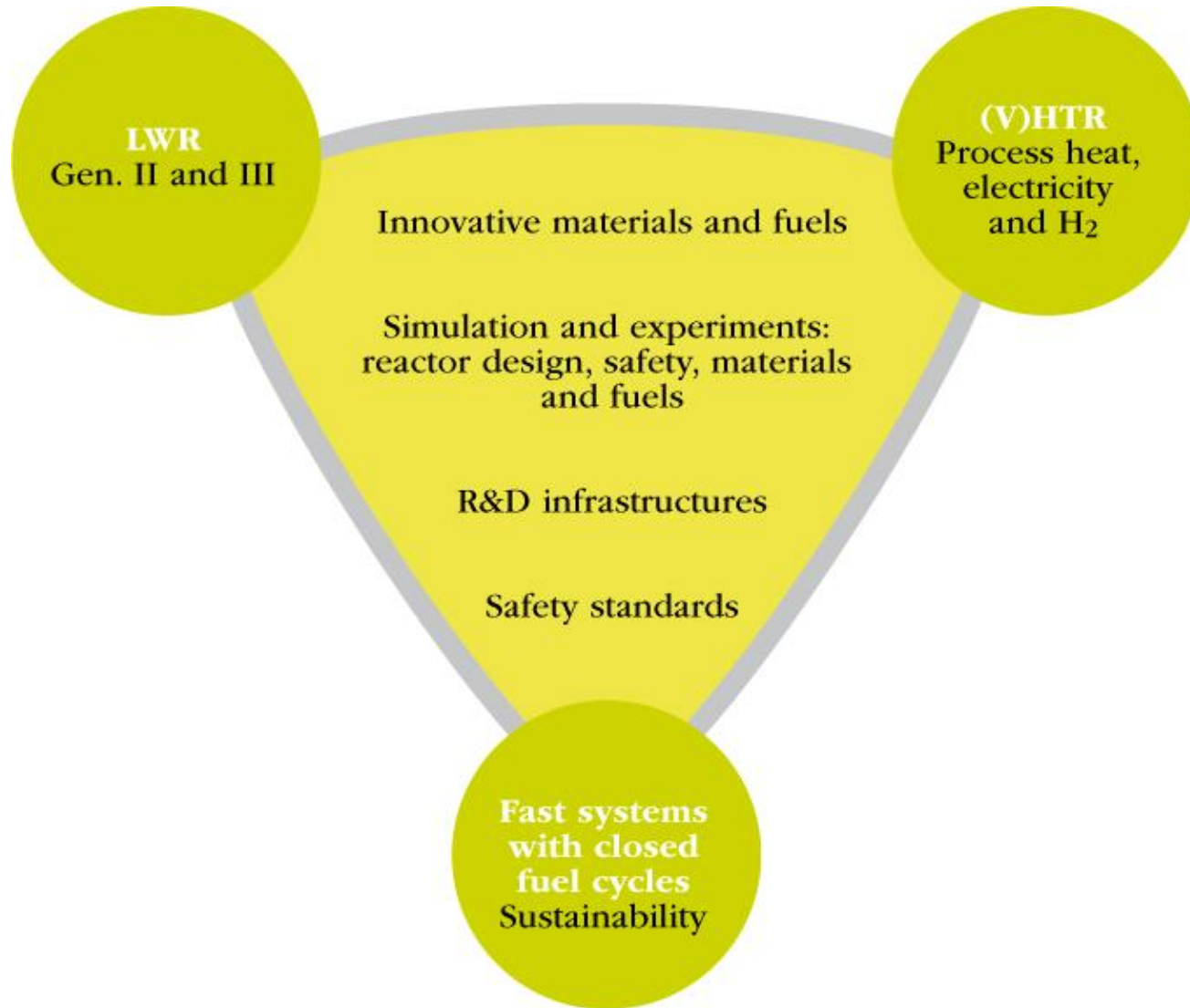
Contact: christian.chauliac@cea.fr

CONTEXT

- **SNETP:** Sustainable Nuclear Energy Technology Platform

TARGET

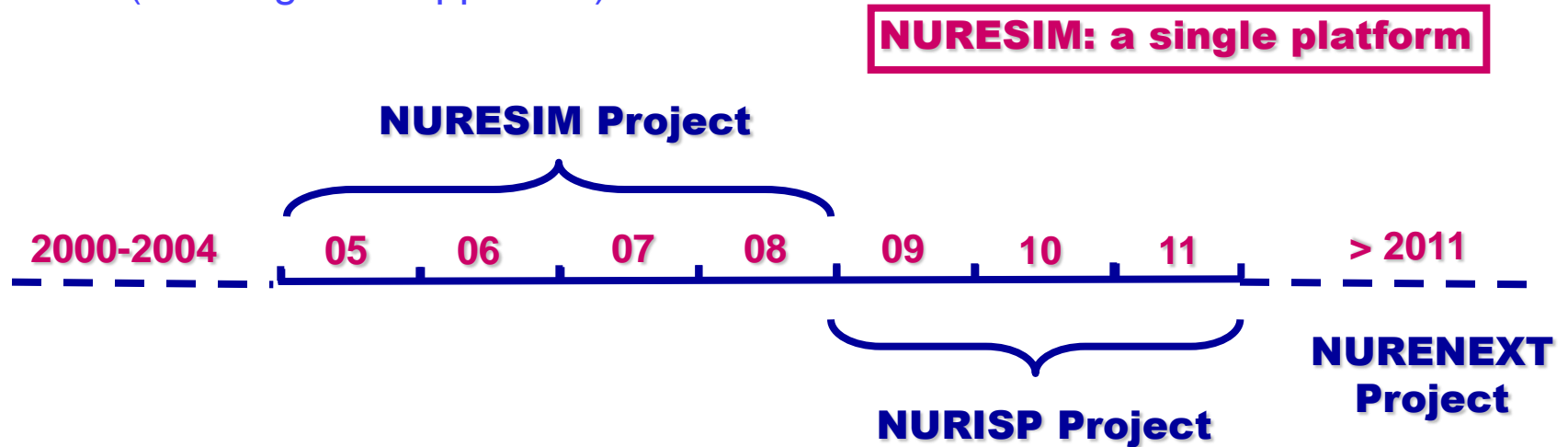
- **Integrated Platform**
 - ✓ Common functions, multiscale, multiphysics, user friendly
- **Reference**
 - ✓ An optimized set of codes, beyond SOA, well validated, with standardization, with capacity to connect external codes
- **European**
 - ✓ A joint European effort, a European product
- **For Simulation of Nuclear Reactors**
 - ✓ Gen-II to Gen-IV, Users' Group with the Industry





The NURESIM roadmap

- **2000 – 2004: Genesis**
 - ✓ 2000 – 2002: EUROFASTNET
→ 44 industrial needs for T/H R&D
 - ✓ 2001 – 2004: genesis of NURESIM
(an integrated approach)



- **NURESIM Project: basis towards the target with first significant possibilities**
- **NURISP: consolidation + extension**
- **NURENEXT: confirmation + rationalization + further extension**



The objectives for the NURESIM project are:

- To build a united team of top international level experts gathered within a single project where barriers are broken down
- To integrate a first set of codes into the NURESIM platform and get experience feedback for the definition of integration standards
- To improve methods and develop advanced models in Core Physics and Thermal-Hydraulics
- To develop generic functions for multiphysics coupling, to make some first demonstrations of their application and to show the potential of the method
- To implement a first set of S&U methods
- To validate the platform through comparison to experiments and benchmarking
- To make significant advances meeting industrial needs

A first step within the NURESIM roadmap



NUclear **R**eactor **I**ntegrated **S**imulation **P**roject

- **Continuity: a project based on the NURESIM platform and the results of the NURESIM project**
- **More: accurate physics, multiscale and multiphysics, S&U, integration**
- **New field: fuel**
- **Application to LWR (Gen-II and Gen-III): PWR, VVER, BWR**
- **Links with other European Projects : PRACE**

- ***Partners : the NURESIM team + 4 new partners***



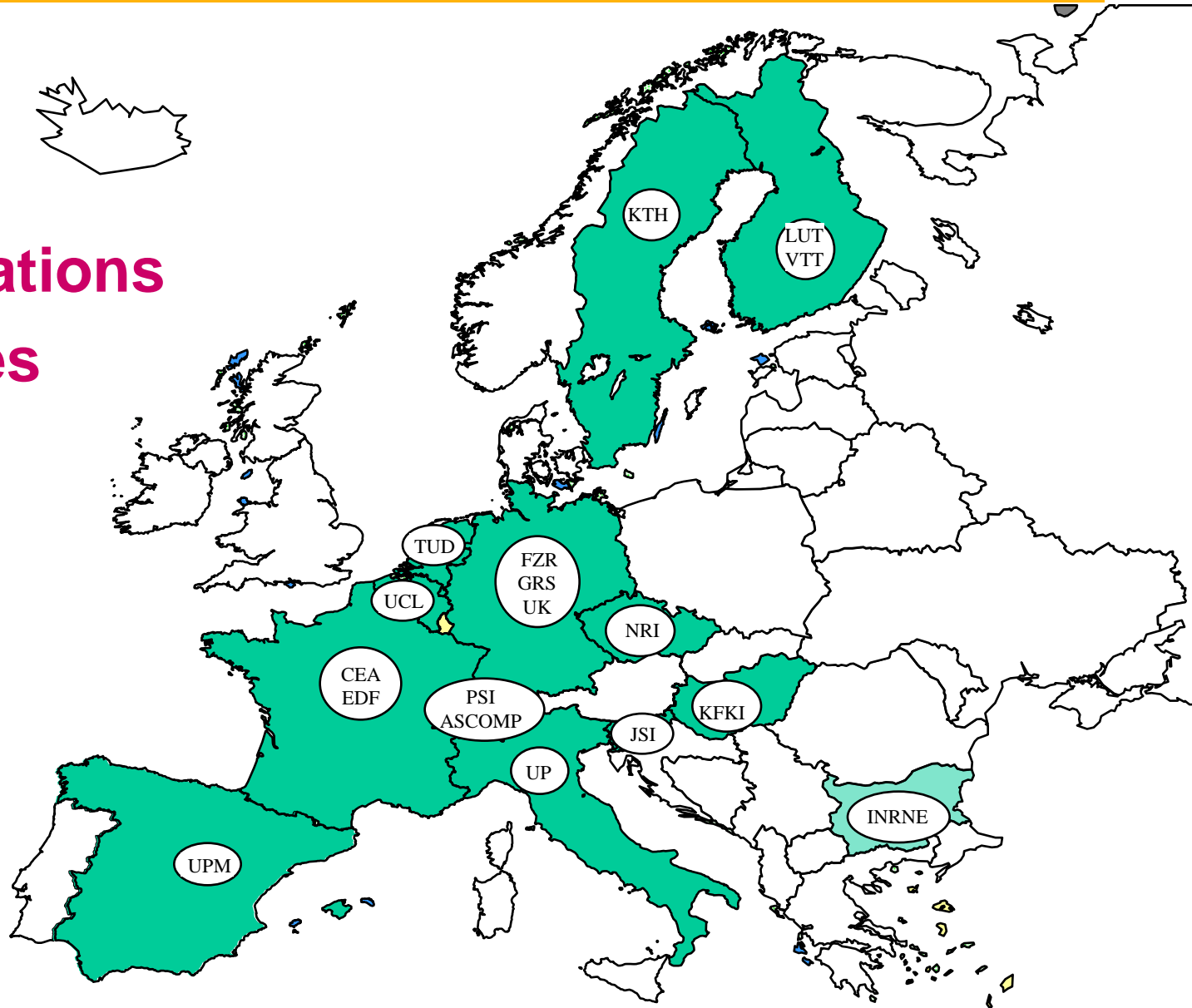
Detailed objectives of NURISP

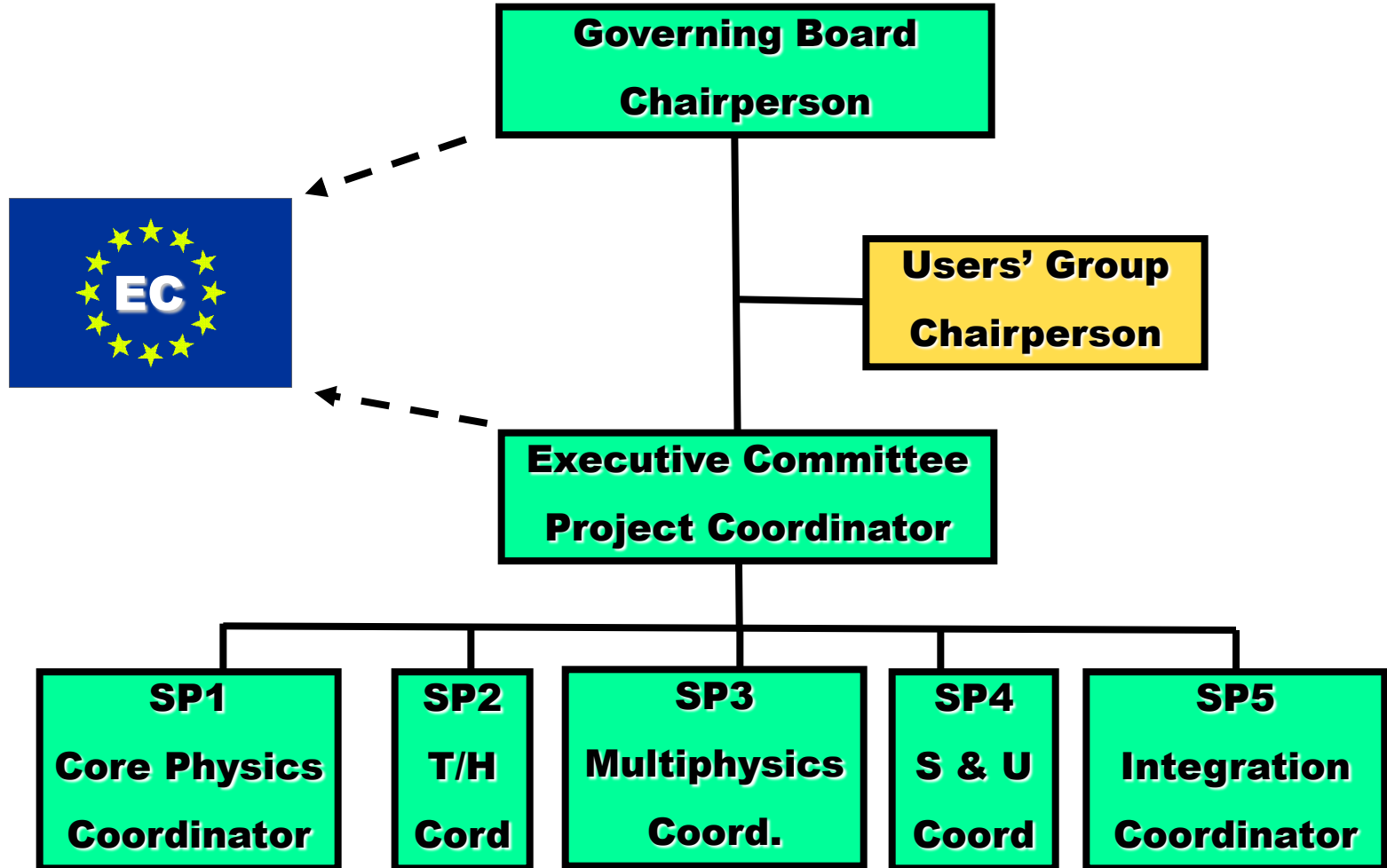
- To further integrate the first set of codes into the NURESIM platform, to add new codes (T-H and fuel codes) and to complement the integration standards
- To improve the usability and the consistency of the core physics codes, to define and test well established calculation routes,
- To enlarge the T-H developments to system codes, LOCA and multiscale coupling through the platform
- To put more emphasis on multiphysics and S&U
 - ✓ To add new generic functions for multiphysics coupling, to further test nodal and pin level coupling with different levels of refinement of neutronics and T-H
 - ✓ To test the first set of S&U methods and add new ones
- To further validate the platform through comparison to experimental results and benchmarks
- To make new significant advances for industrial issues

A second step (after NURESIM) within the roadmap

- NURESIM and NURESP are mainly focussed on Gen-II and Gen-III, but some of their codes have generic capacities for Gen-IV
- NURENEXT will enlarge the scope specifically to **Gen-IV**, consistently with the beginning of the detailed design of Gen-IV reactors after 2012
- Through interaction with the Users' Group, previous developments will be made more **robust** and the **validation** will be further improved
- **New disciplines** such as structural mechanics will be added to the platform
- The platform will converge towards an **optimum** set of codes, but connection of external codes to the platform will be easy

18 Organizations
13 Countries

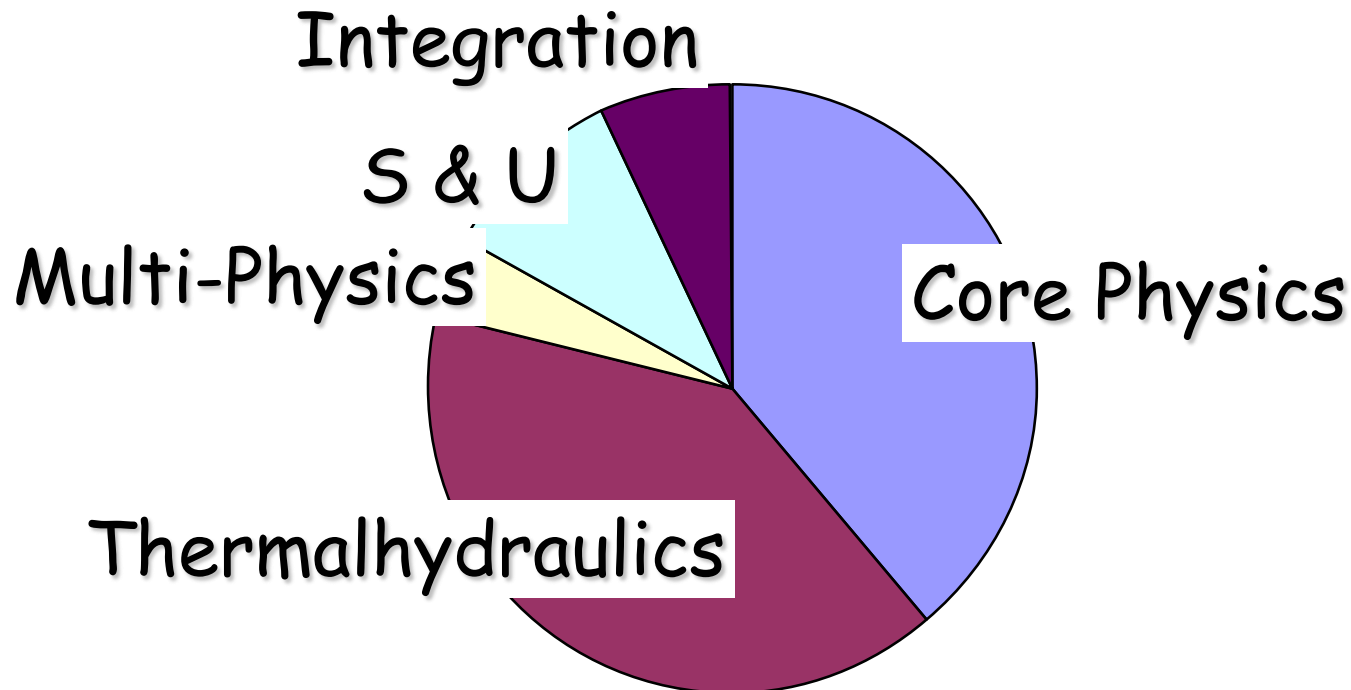






NURESIM USERS GROUP (NUG)

- AREVA-NP
- TRACTEBEL Engineering
- FORTUM
- IRSN
- TÜV SÜD
- FZK



Total EC Funding: 4.5 M€
Total Manpower: 73 p*y



Global infrastructure

User environment, management of studies, coupling

SHARED
(Open-Source
or Partnership)

Correlations, data, closure laws, calculation routes,...

PROPRIETARY

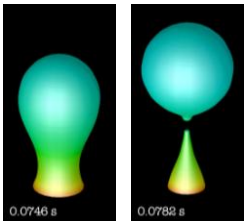
Toolbox of solvers (Neutronics, T/H,...), data

SHARED
(Open-Source
or Partnership)

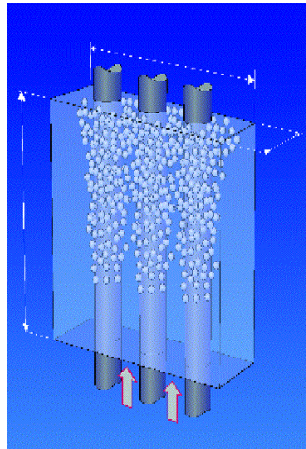
- **Two main areas**
 - ✓ Advanced Monte-Carlo Methods
 - ✓ Advanced Deterministic Methods
- **Three main topics**
 - ✓ Integration of the existing codes and modules into the platform
 - ✓ Benchmarks
 - ✓ Improvement of the codes and modules

Two main topics:

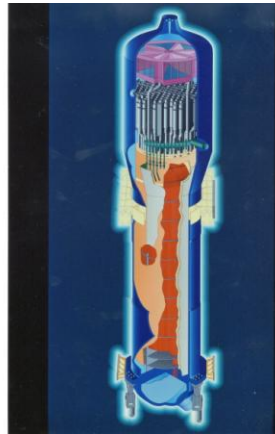
- PTS
- CHF



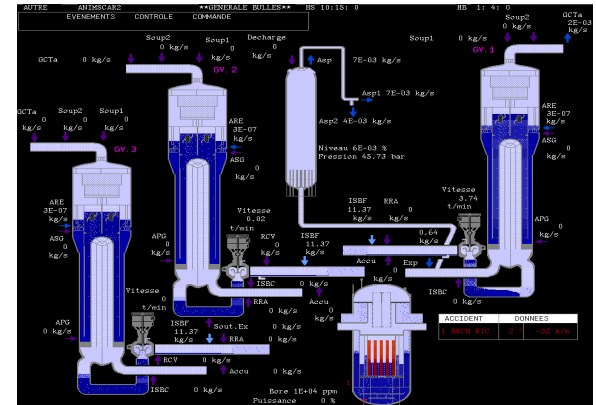
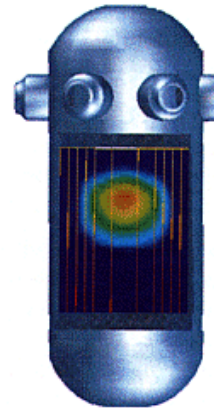
DNS SCALE



CMFD IN OPEN MEDIA

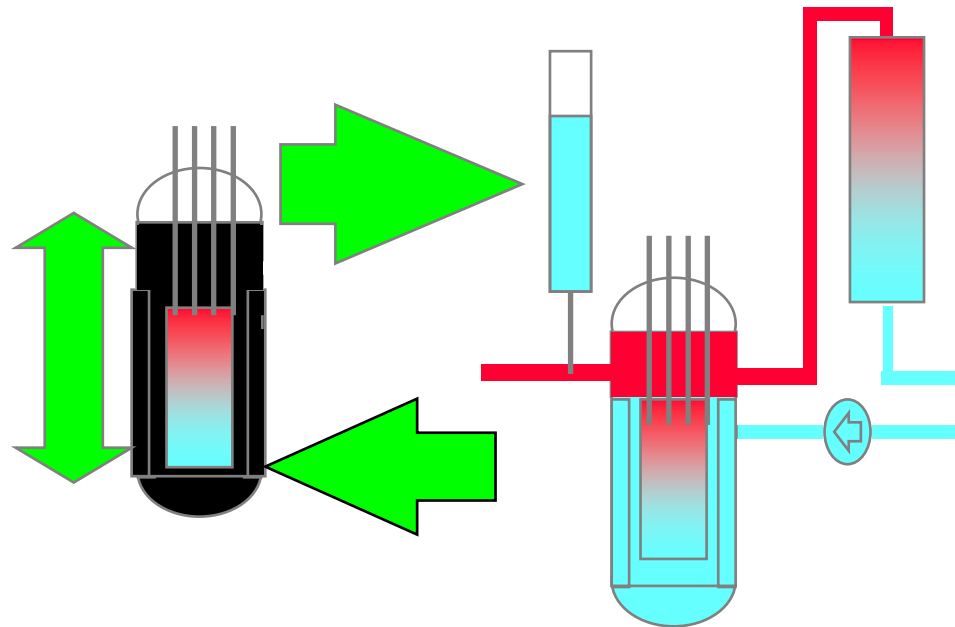


CFD IN POROUS MEDIA



SYSTEM SCALE

Critical review of experimental data, improvement of models and modules, assessment and benchmarking



- **Interpolation and averaging schemes and data transfer**
- **Coupling schemes**
 - ✓ At the nodal level (fuel assembly)
 - ✓ At the sub-node level (pin)
- **Application to benchmarks**

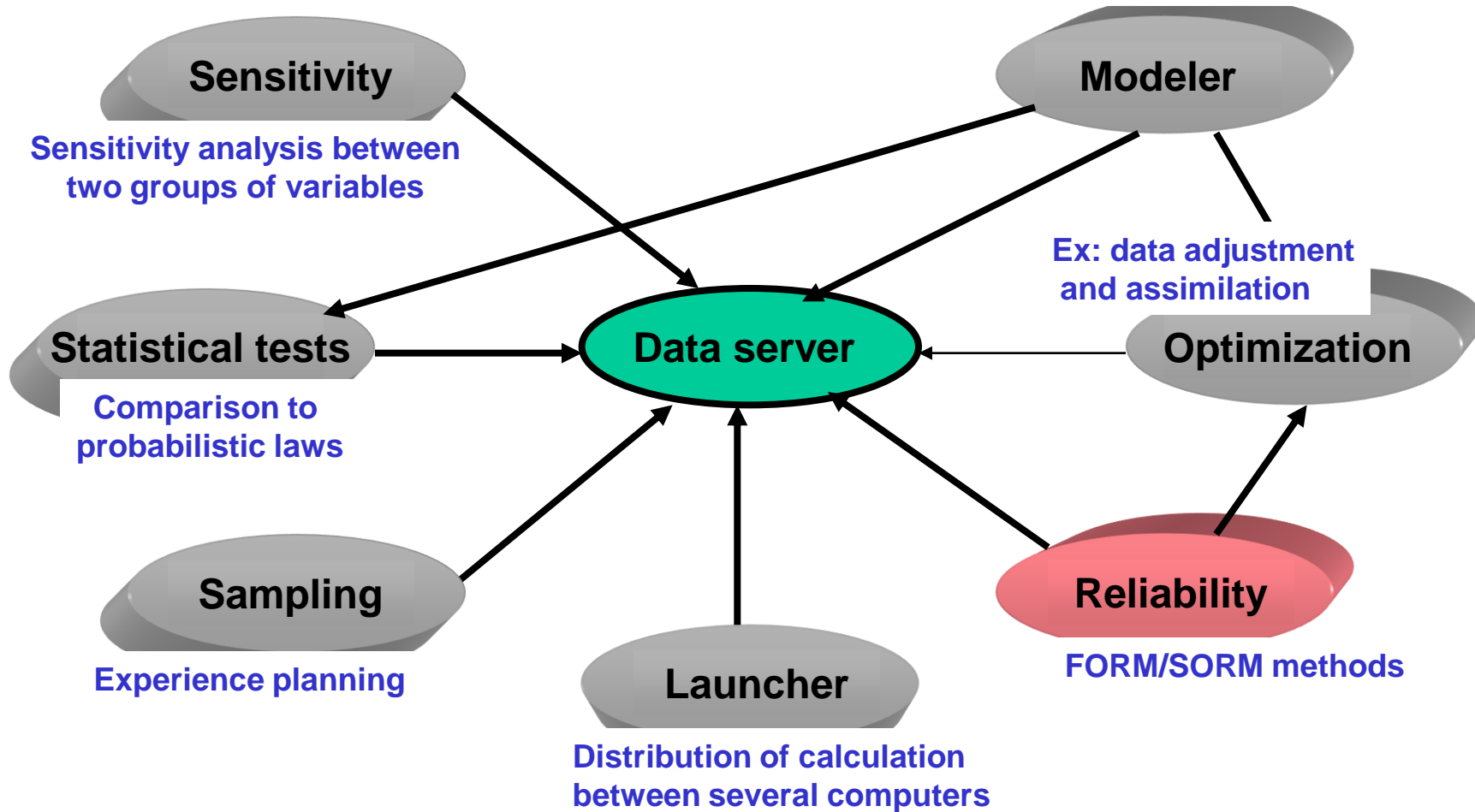


SP4: SENSITIVITY AND UNCERTAINTY

- **Deterministic and statistical methods for multiphysics modules**
- **Implementation within the NURESIM platform of procedures for propagation of uncertainties**

Origin = Root (developed by CERN)

Building a relation between 2 groups of variables (ex: neuronal networks)



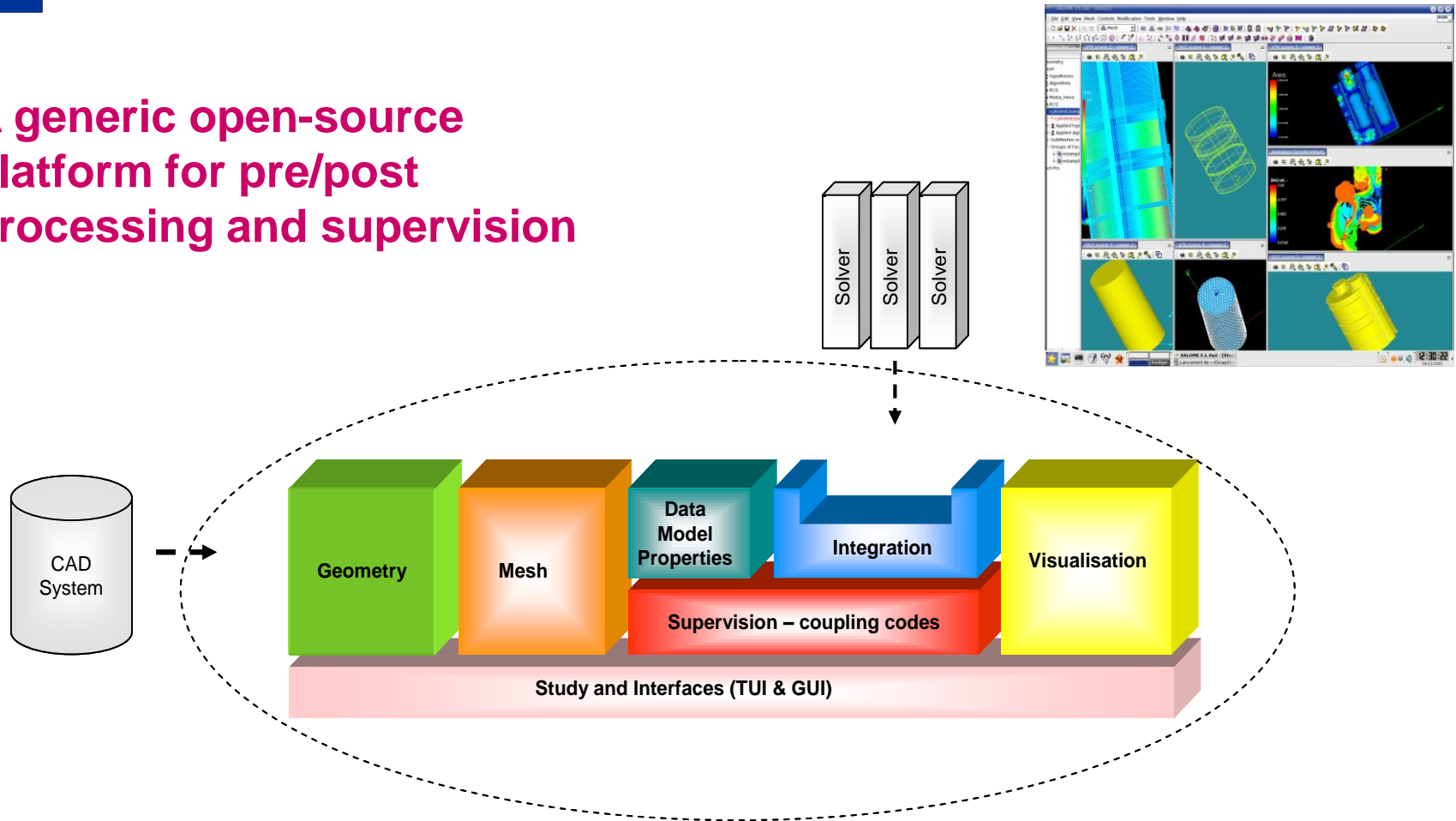
The screenshot displays the Uranie Data Analysis Platform interface. On the left, a 'Project' tree shows a 'Demo' folder containing 'DataManager', 'Macro manager', 'Functions', 'Libraries', 'Macros', 'Divers', 'Modeler', 'ANN', 'Splines', 'Sampler', 'Sensitivity', and 'Tester'. The 'Functions' folder is expanded, showing 'thermo.C' selected. Three plots are visible: 'X1' (a histogram of 'htemp' with Mean 2.743e-05 and RMS 0.7661), 'X3' (a histogram of 'htemp' with Mean 0.4885 and RMS 0.9819), and 'X3:X1' (a scatter plot). A fourth plot shows a fitted curve with the equation $0.32 \cdot x_3^4 + x_3^3 - 1.57 \cdot x_3 + 0.6 \cdot x_1 \cdot x_3$. A message log at the bottom shows execution details for various macros.

Data,
functions,
models,
...

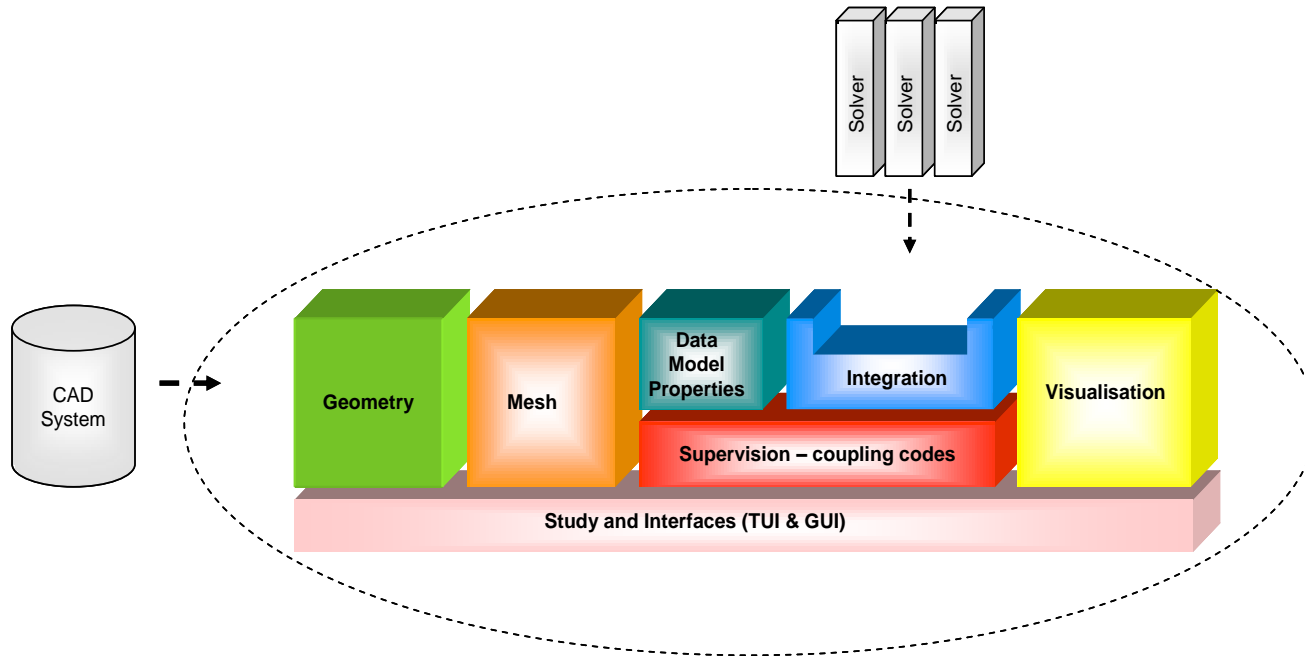
Edition and
visualization

Display of
messages

A generic open-source platform for pre/post processing and supervision

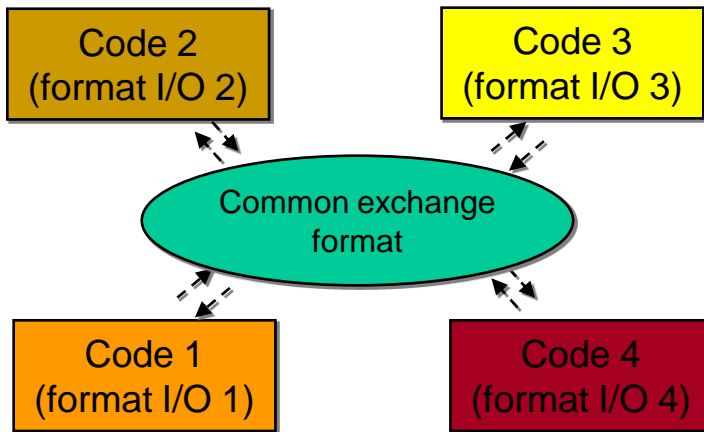


<http://www.salome-platform.org>



- ***Import/export of geometries, repairing/cleaning of geometries, creating/modifying***
- ***Meshing of the geometric elements, controlling quality, importing/exporting***
- ***Handling physical or numerical properties of geometrical elements***
- ***Performing a computing step using a solver: input of data, configuration of the solver, output of the result field***
- ***Implementing chaining/coupling between solvers***
- ***Visualizing/post-processing the results fields***

Data Exchange Model for mesh & field (MED/DEM)



➤ A common format to facilitate exchanges between solvers

➤ all integrated solvers are able to import/export data in a common format

➤ possibility of sharing high-level services on meshes and fields

➤ A memory layer with a set of services :

➤ Localisation, interpolation, norms of fields, logical operations on field supports, arithmetic operations on fields, geometric measurements, import/export different solver formats ... (**MEDMemory**)

➤ classes to make easier distributed computations – optimization of interaction of distant objects within the local solver (**MEDClient**)

➤ A file layer for persistency of meshes and fields (use of the portable **HDF Library**)



THANK YOU FOR YOUR ATTENTION!