SNETP
Sustainable Nuclear Energy Technology Platform

SNETP Forum 2021

Technical Session 8 Synthesis

Online

Chairs: **Ferry Roelofs (NRG) & Didier Banner (EDF)**
roelofs@nrg.eu / didier.banner@edf.fr

Contents

- Digitalisation, Modelling & Simulation
- Code Development, Machine Learning, Qualification, Uncertainty Quantification
- Multi-scale & Multi-physics
- Digital Twins & Virtual Reactors
- Summary of Ongoing Projects and New Idea

RÉACTEUR NUMÉRIQUE

CORTEX
Core monitoring techniques and experimental validation and demonstration

NUCLEAR VIRTUAL ENGINEERING CAPABILITY

MATHYS

GeN-Foam

OFFBEAT

AC²

salome_meca
EXPERIENCE OPEN SIMULATION

Nuclear Modelling & Simulation

SNETP
Sustainable Nuclear Energy Technology Platform

IAEA | Open-source Nuclear Codes for Reactor Analysis

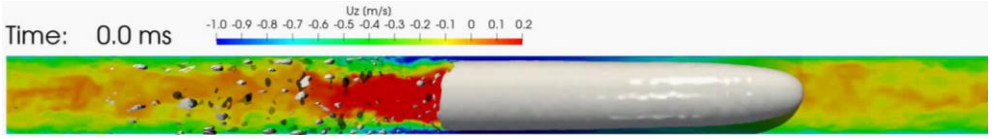
Digitalisation, Modelling & Simulation

- Relatively new field of expertise
- Many aspects
  - Code Development
  - Machine Learning
  - Code Qualification
  - Uncertainty Quantification
  - Code Coupling
  - Digital Twins
  - Virtual Reactors

SNETP
Sustainable Nuclear Energy Technology Platform

Code Development & Machine Learning

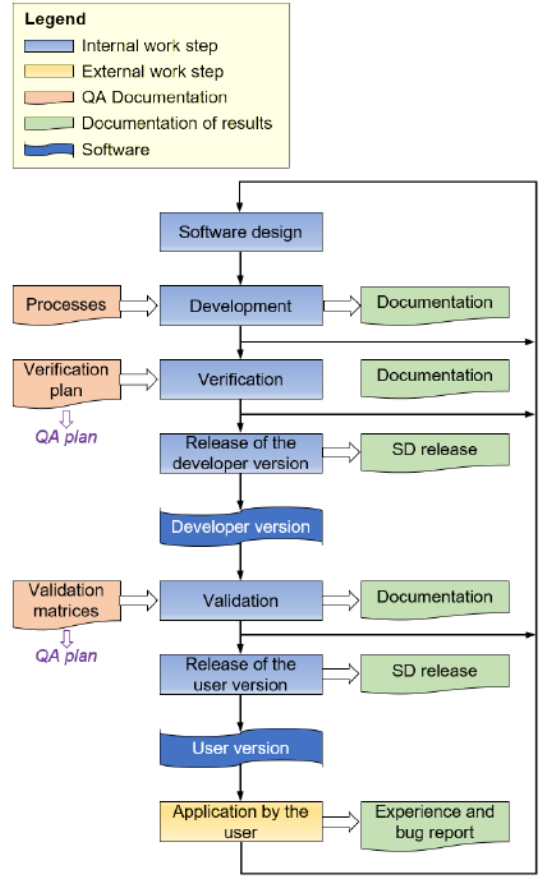
- Codes were developed since the dawn of nuclear, still it remains important
  - To cover new challenges
  - To increase accuracy
  - Comply with VVUQ requirements
- Need to understand physics
- Model development
- High fidelity simulations to complement experiments are gaining importance
- Commercial packages and open source tools
  - OpenFOAM, GeN-FOAM, OFFBEAT, SALOME-MECA



SNETP
Sustainable Nuclear Energy Technology Platform

Qualification

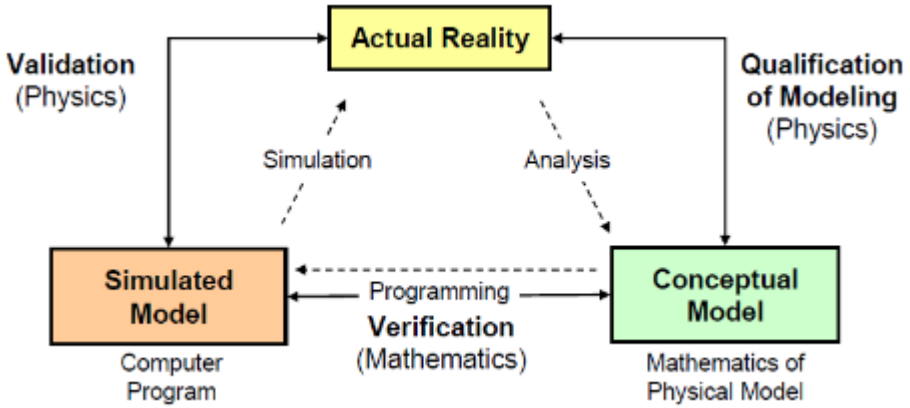
- Proper code qualification essential for safety analyses and licensing
  - Good practices by IAEA
  - New challenges for
    - Passive systems
    - Innovative components
    - New working fluids and materials
  - International collaboration essential
    - IAEA
    - OECD/NEA
    - European Commission - Euratom



SNETP
Sustainable Nuclear Energy Technology Platform

Uncertainty Quantification

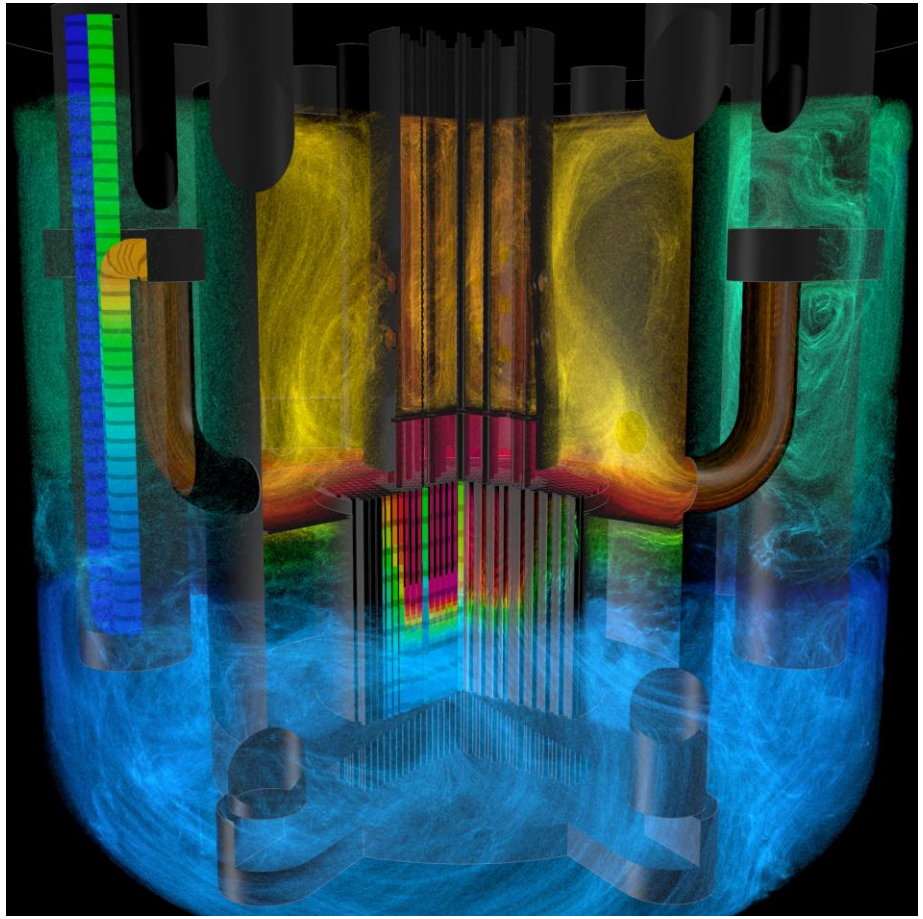
- Important for acceptance of simulation results by a regulator
  - Simulations with long run time
    - PIRT: understand potential sensitivities
    - Monte-Carlo: not feasible
    - Polynomial Chaos Expansion: still costly
    - Deterministic sampling: limited amount of computations
    - ASME VVUQ
      - Method to determine modelling uncertainty



SNETP
Sustainable Nuclear Energy Technology Platform

Multi-scale

- Combining simulations at various scales
  - Subcomponent to plant scale
    - Design optimization
    - Reducing conservatism
  - Qualification
    - Multi-scale coupled codes will be treated as a single code
    - Separate effect tests depend on one scale (aready covered)
    - Need for integral effect tests
  - Developments needed for two-phase flow

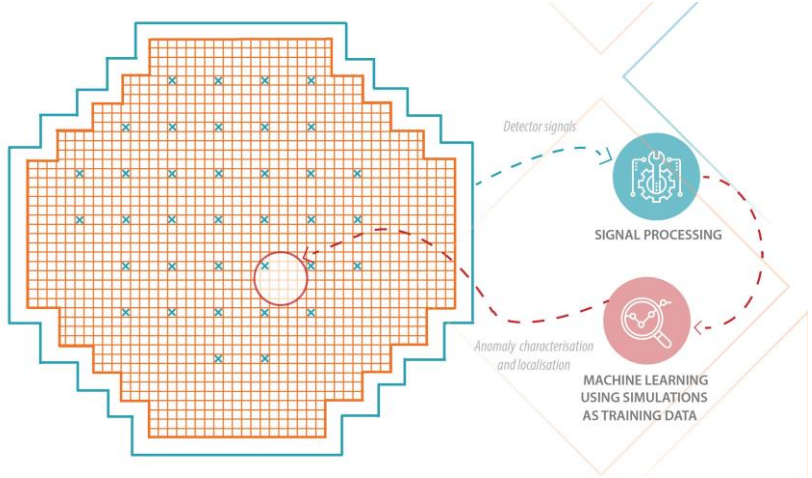


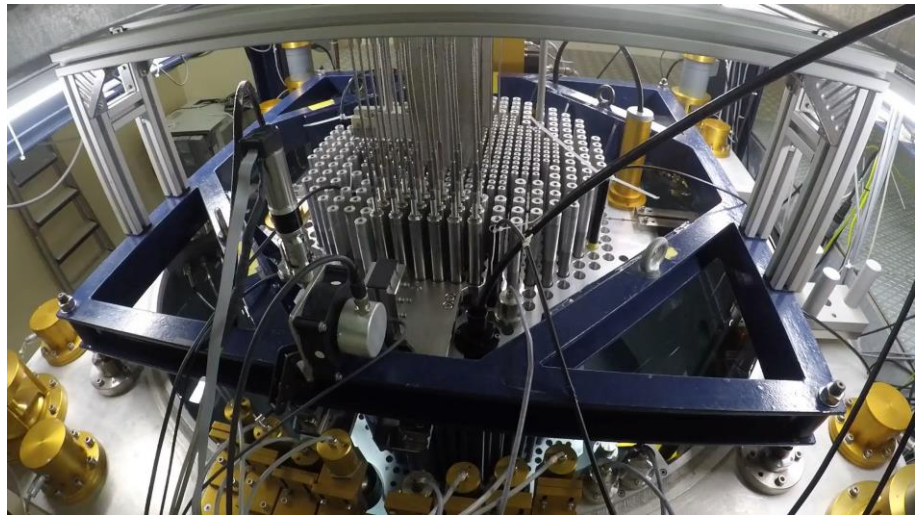
SNETP
Sustainable Nuclear Energy Technology Platform

Multi-physics

CORTEX
Core monitoring techniques and experimental validation and demonstration

- Combining various physics in one simulation
  - Thermal Hydraulics
  - Structural Mechanics
  - Reactor Physics
  - Chemistry
- Artificial Intelligence
  - Big Data
  - Machine Learning
- GeN-FOAM open source development
- Exploratory work in H2020 CORTEX



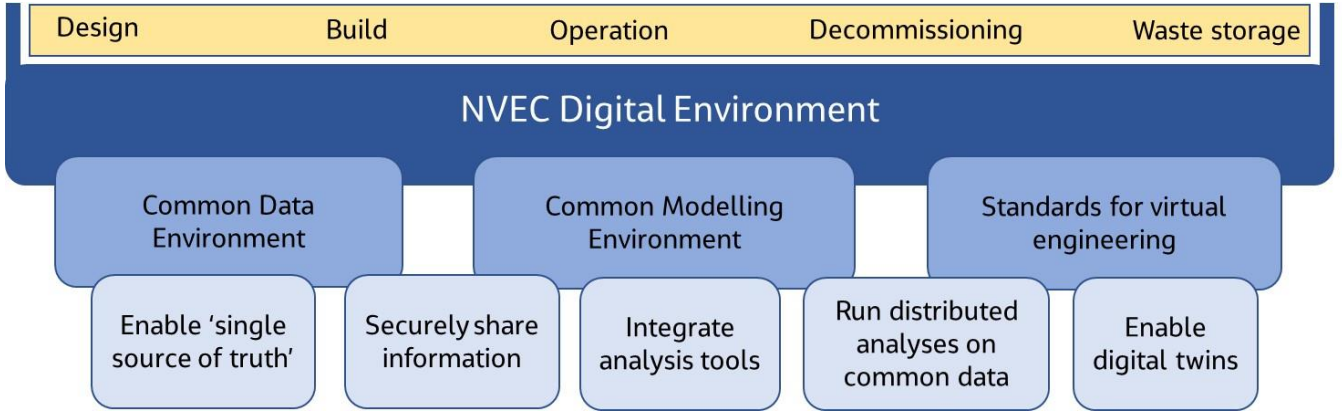


SNETP
Sustainable Nuclear Energy Technology Platform

Digital Twins

- Virtual copy of existing or new reactors
  - Real time simulators
  - Multi-scale simulations
  - Multi-physics simulations
  - Interactive visualization
  - Plant-life management system

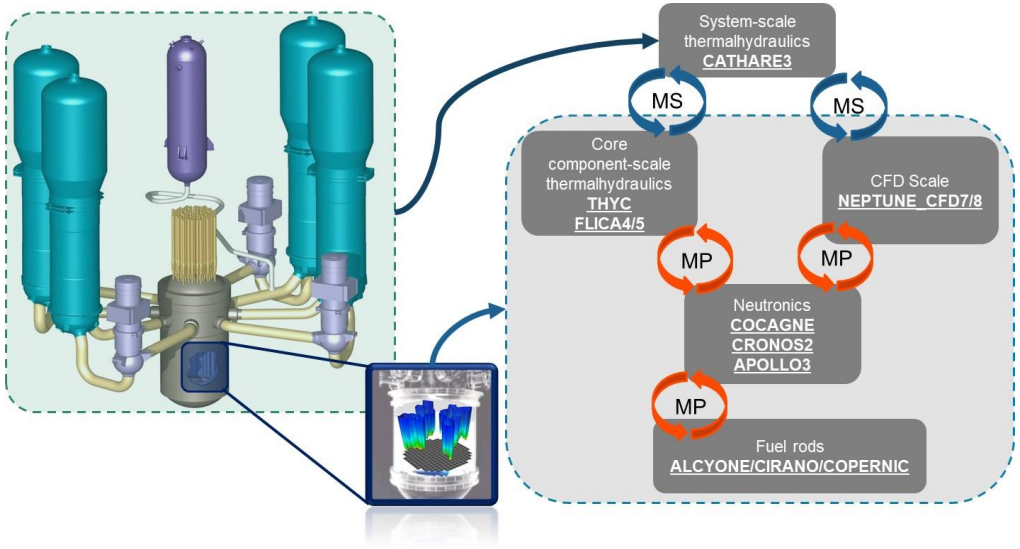
NUCLEAR VIRTUAL ENGINEERING CAPABILITY



SNETP
Sustainable Nuclear Energy Technology Platform

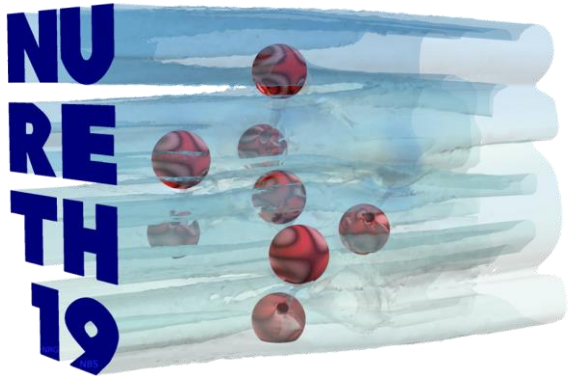
Digital Nuclear Reactor Initiative

- **Virtual reactor**
  - Support multi-scale multi-physics simulation
  - Modular and easy configurable
  - Single digital portal
- **ALICES platform for simulators**
  - Full scope simulation
  - Backbone of control room simulator
  - Design and optimization studies



Summary of Ongoing Projects and New Idea

- Ongoing projects
  - H2020 CORTEX
  - GeN-Foam (EPFL)
  - ONCORE (IAEA)
    - Open source code database
  - Digital Nuclear Reactor Initiative / Réacteur Numérique (France)
  - Nuclear Virtual Engineering Capability project (UK)
- Project idea
  - Combine Experiments and High-Fidelity Simulation for Development of Engineering Models
    - Covering single & multi-phase flow
    - Including Uncertainty Quantification & Machine Learning



19th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-19)

March 6 - 11, 2022 • Brussels, Belgium • The Square

ABSTRACT DEADLINE: FEBRUARY 14, 2021

FEBRUARY	SUBMISSION OF ABSTRACTS: **February 14, 2021**
APRIL	ABSTRACT ACCEPTANCE: **April 30, 2021**
JUNE	DRAFT PAPER SUBMISSION: **June 30, 2021**
AUGUST	PAPER REVIEW NOTIFICATION: **August 31, 2021**
SEPTEMBER	FINAL PAPER SUBMISSION: **September 30, 2021**

SPECIAL EVENTS

- CONFERENCE DINNER
- TECHNICAL TOURS
- AWARD CEREMONY
- POSTER COMPETITION
- MOVIE COMPETITION
- YOUNG GENERATION EVENT
- ATOMIC JOGGING

www.nureth19.com

LEAD THE FLOW

Contact us

www.snetp.eu

secretariat@snetp.eu

www.linkedin.com/company/snetp

@SNE_TP

SNETP
Sustainable Nuclear Energy Technology Platform