

# IAEA initiative on open-source tools for nuclear reactor analysis

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Division of Nuclear Power  
Department of Nuclear Energy

2025 ANS Annual Conference

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## Open-source Nuclear Codes for Reactor Analysis (ONCORE)

The Open-source Nuclear Codes for Reactor Analysis (ONCORE) initiative is an IAEA-facilitated international collaboration framework for the development and application of open-source multi-physics simulation tools to support research, education and training for the analysis of advanced nuclear power reactors. Institutions and individuals participating in ONCORE can collaborate in, and benefit from, the development of open-source software in the field of nuclear science and technology.

An international network of research and academic institutions is creating a common platform in the area of *advanced reactor experiments and high-fidelity multi-physics nuclear simulation techniques for open-source code development and validation*. The work focuses on three major areas: modelling and simulations, experimental reactor physics and education and training.

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### Related Stories



IAEA Designates Swiss Ecole Polytechnique Federale de Lausanne as Collaborating Centre

<https://www.iaea.org/topics/nuclear-power-reactors/open-source-nuclear-code-for-reactor-analysis-oncore>

<https://nucleus.iaea.org/sites/oncore>

## IAEA Designates Swiss Ecole Polytechnique Federale de Lausanne as Collaborating Centre

Chirayu Batra, IAEA Department of Nuclear Energy  
Elisabeth Dyck, IAEA Department of Nuclear Energy

JUN  
12  
2019



Mikhail Chudakov, IAEA Deputy Director General and Head of the Department of Nuclear Energy (right) with EPFL's Vice President for Research, Andreas Mortensen (left) and Andreas Pautz, Head of EPFL's Laboratory for Reactor Physics and System Behaviour (middle) after signing the cooperation agreement, Vienna, 12 June 2019. (Photo: S. Krikorian/IAEA)

### Related Stories



New  
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Argentine  
Commission  
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Research

### Related Resources

Collaborative

Ecole Polytechnique  
Federale de Lausanne (EPFL)

Nuclear power

Nuclear Power  
Development

Division of

Department

- Key partner within ONCORE
- Cooperation agreement signed on 12 June 2019:
  - The IAEA designated the Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland, as an IAEA Collaborating Centre to support IAEA Member States in increasing their modelling and simulation capabilities in the field of advanced reactors.
  - **Extended in 2023 until 2026 during the last year GC**

“ Education and training are very important to prepare the next generation of nuclear workforce. The creation of such high performance simulation platforms with modern computational tools will attract many young professionals.

— Mikhail Chudakov, IAEA Deputy Director General,  
Head of the Department of Nuclear Energy

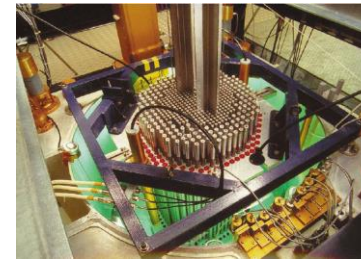


# ONCORE Objectives

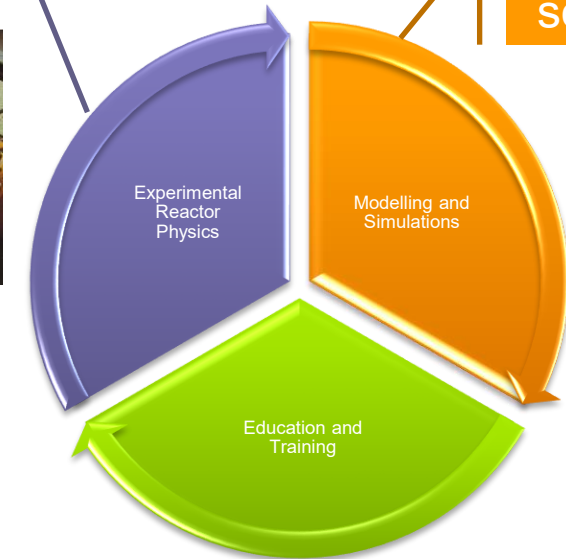
- Build and maintain expertise in open-source simulation codes and data, fostering information exchange in the nuclear science community
- Survey existing open-source codes and data to enhance accessibility
- Establish best practices for collaborative code development
- Identify integration opportunities and gaps in current open-source modules
- Encourage sharing of reference solutions, benchmarks, and input data
- Develop a unified open-source platform, ensuring consistency, verification, and documentation
- Promote the tools and platform for educational and research use
- Organize training and educational activities
- Successful contributions to the Future Global Nuclear Workforce and other IAEA initiatives

# ONCORE Platform

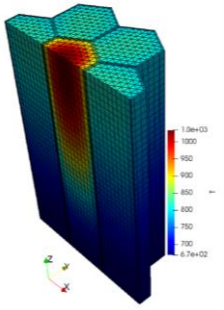
- Common platform in the area of advanced reactor experiments and high-fidelity multi-physics nuclear simulation techniques for open-source code development and validation
- Links to **35+ Open source tools**
  - Neutronics
  - Thermal-hydraulics, system analysis, containment
  - Structural mechanics, Fuel behavior, Materials
  - Multi-physics applications and libraries
  - Data processing, optimization, pre-post processing
  - Application frameworks
- 2 tools hosted and distributed by ONCORE
  - VSOP99/11: HTR pebble-type design and safety analysis
  - STACY: V/HTR safety analyses for the quantification of fission product release from the fuel



Using open access data



Using open-source tools



<https://nucleus.iaea.org/sites/ONCORE>

# Technical Meetings on Development and Application of Open Source Modelling and Simulation Tools for Nuclear Reactors

*Technical Meeting on the Development and Application of Open-Source Modelling and Simulation Tools for Nuclear Reactors*

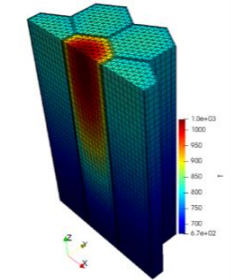
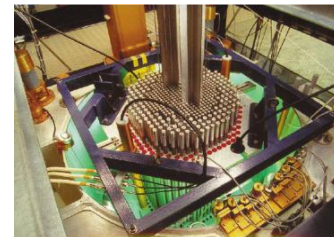
20-24 June 2022  
Milano, Italy

In Publishing (Preprint is available at the IAEA website)

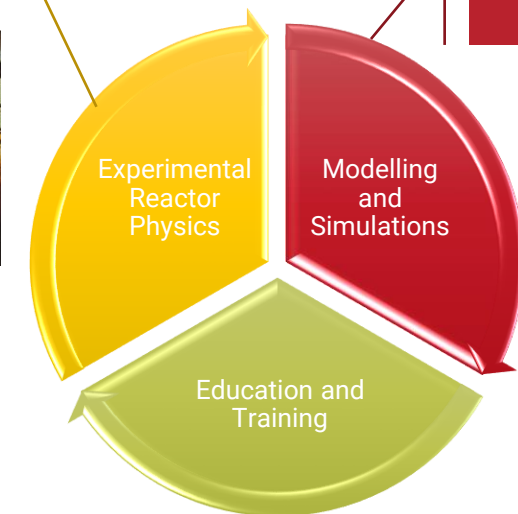
Technical Report Series (TRS)

Development and Application of Open-Source Modelling and Simulation  
Tools for Nuclear Reactor Analysis

Using open access  
data

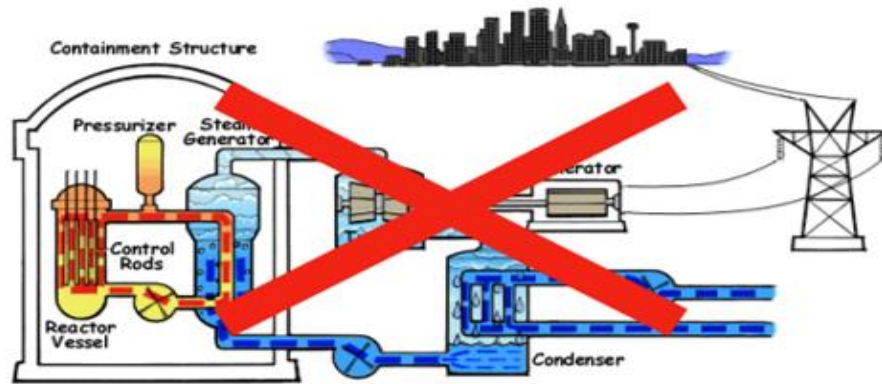


Using open source  
tools





# Modelling and simulation



Multicomponent

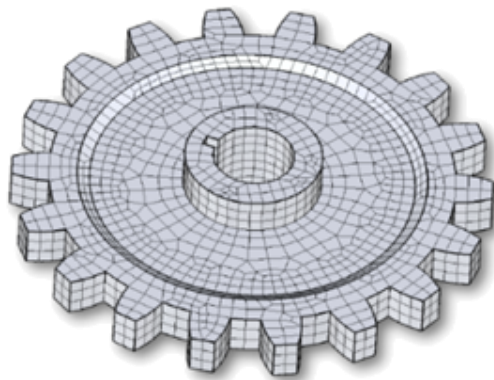
Multidisciplinary

Multiphysics

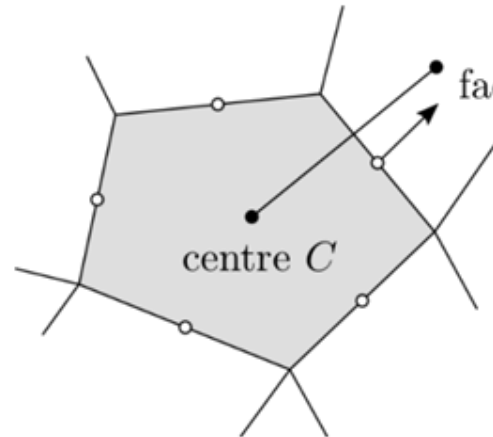
Multiscale

# ONCORE Webinar Series on Multiphysics Modelling of Nuclear Reactors using OpenFOAM

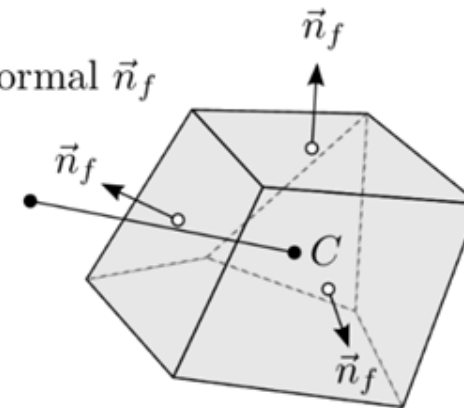
- OpenFOAM\* is a widely-used open-source toolbox for industrial CFD and a library for finite-volume discretization of PDEs in nuclear applications
- Supports ONCORE initiative's education and training.
- The Webinar Series (started in 2022) provided up-to-date insights on OpenFOAM's capabilities, strengths, challenges, and guidelines, helping users make informed decisions and encouraging further independent learning.



Discretized Domain



2D



3D



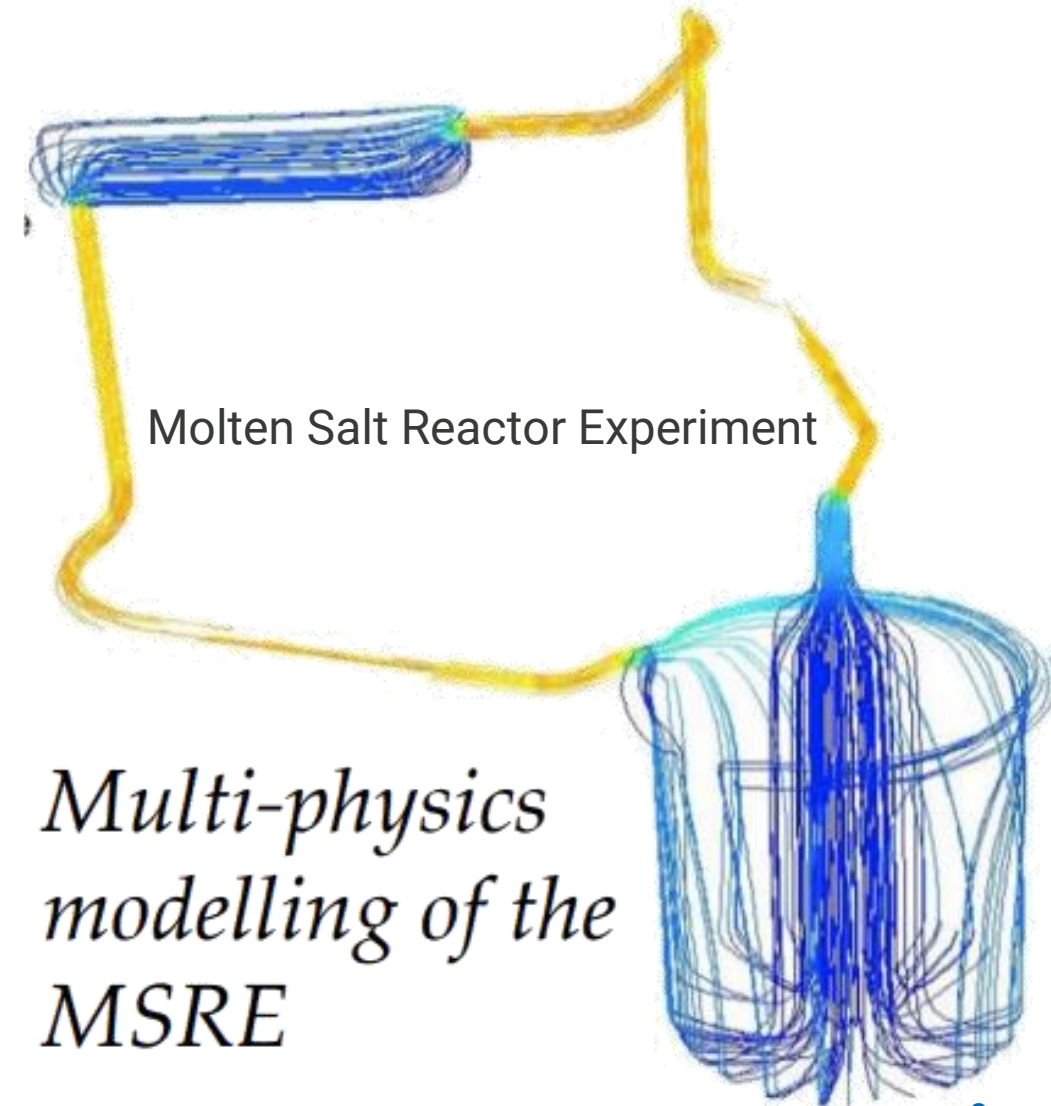
# ONCORE Webinar Series on Multiphysics Modelling of Nuclear Reactors using OpenFOAM

12 lectures in the series covering:

- Overview of using OpenFOAM as a multi-physics library for nuclear reactor analysis
- Brief introduction to the use of finite-volume methodologies
- Basics of Partial Differential Equations (PDEs)
- Problem definition
- Geometry and mesh generation
- Introduction to OpenFOAM's source code and object-oriented programming
- ContainmentFOAM tool for system-scale CFD analysis of containment atmosphere pressurization, H<sub>2</sub>/CO mixing and mitigation.
- GeN-Foam tool as multi-physics solver in nuclear reactor design and safety analysis
- OFFBEAT tool, a solver for fuel behavior analysis in nuclear reactors. As a multi-dimensional code, it allows studying the evolution of the fuel in 1-D, 2-D or 3-D, and it can simulate both transient and steady-state conditions.
- GeN-ROM, a data-driven model-order reduction tool for nuclear applications based on GeN-Foam

Recordings of all lectures available here:

<https://elearning.iaea.org/m2/course/view.php?id=1286>



# ONCORE OpenFOAM Webinar

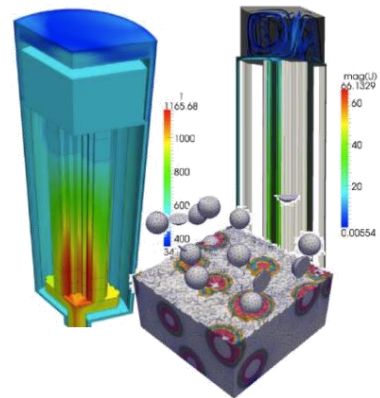
## OpenFOAM: Open Field Operation and Manipulation

## OpenFOAM in Nuclear Applications

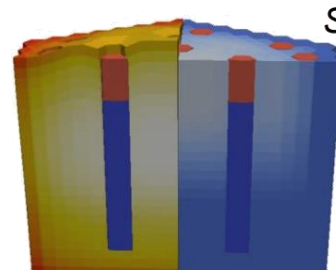
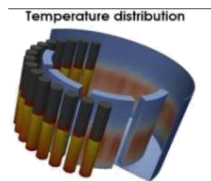
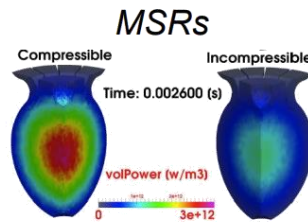
2000-2010  
First activities

2010-2015  
First widespread use

2015-2023  
First coordinated and persistent  
developments

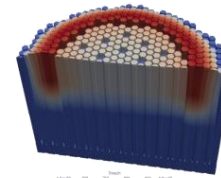
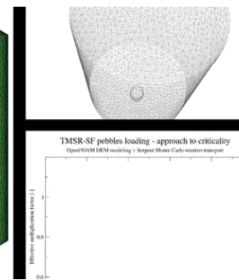


Pebble bed and  
prismatic HTGRs

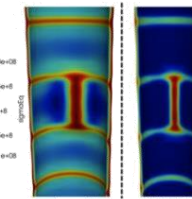


SFRs

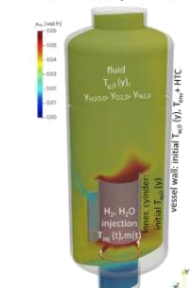
FHRs



GeN-Foam



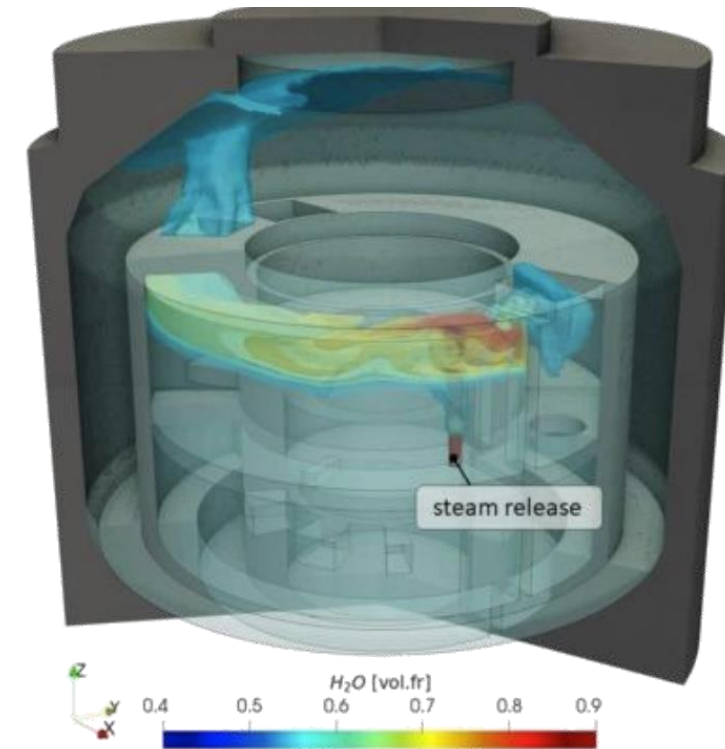
Fuel  
Behaviour  
(OFFBEAT)



Containment Flows  
containmentFoam

OpenFOAM Derivatives

- containmentFoam  
next-generation tool for  
containment analysis



# 2023 Joint ICTP-IAEA Workshop on Open-Source Nuclear Codes for Reactor Analysis

7-11 August 2023 in Trieste, Italy

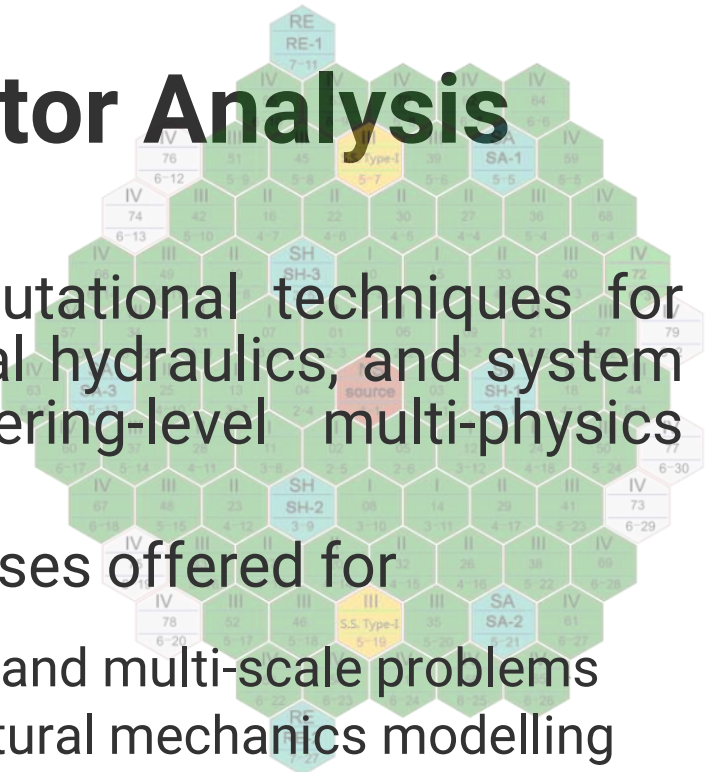
The workshop provided a deep dive into advanced computational techniques for nuclear reactor analysis, covering reactor neutronics, thermal hydraulics, and system analysis. Participants learned how to conduct engineering-level multi-physics simulations through essential stages.

General overview, theoretical background and practical exercises offered for

- **OpenFOAM** and its derivatives for CFD simulation of multi-physics and multi-scale problems
- **GenFOAM** for core thermal hydraulics, neutron transport and structural mechanics modelling
- **Offbeat** for fuel performance simulation
- **ContainmentFOAM** for severe accidents simulation
- **OpenMC** Monte-Carlo neutron transport
- **MOOSE** parallel finite element framework for multi-physics, multi-scale simulations
- **ARMI** Advanced Reactor Modelling Interface

2<sup>nd</sup> **ONCORE Workshop: 22-26 September 2025:**

- apply <https://indico.ictp.it/event/10868>



Joint ICTP-IAEA  
Workshop on Open-Source  
Nuclear Codes for  
Reactor Analysis



7 - 11 August 2023  
An ICTP - IAEA Hybrid Meeting  
Trieste, Italy

Further information:  
<http://indico.ictp.it/event/10199/smr3865@ictp.it>



# Joint ICTP-IAEA Workshop on Open-Source Nuclear Codes for Reactor Analysis



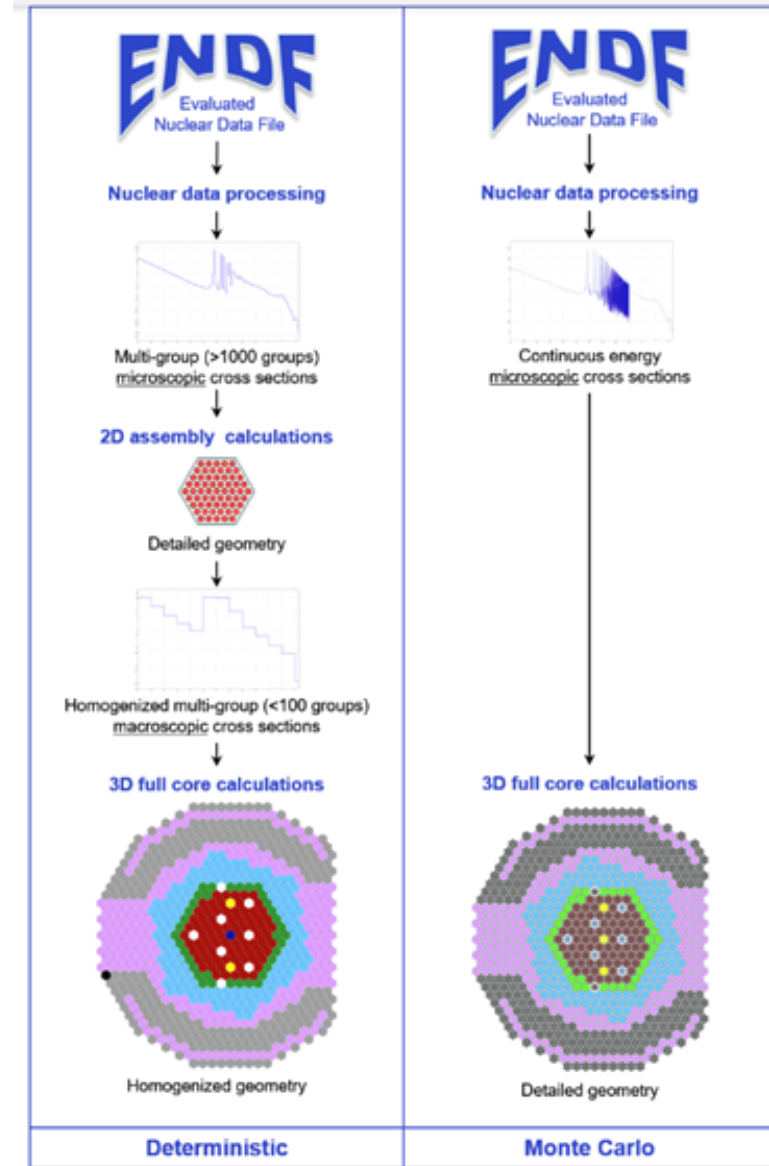
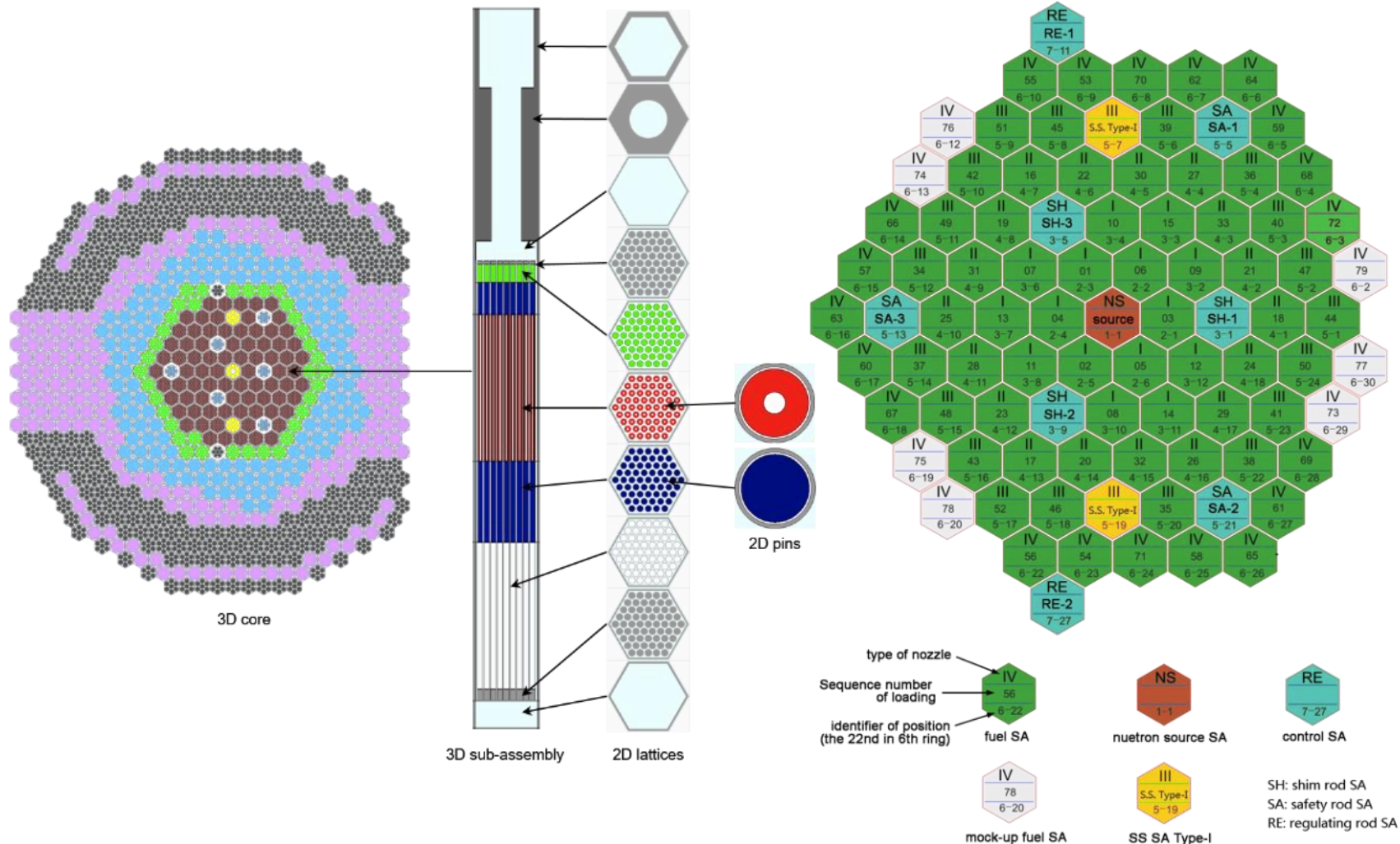
**7 - 11 August 2023**  
**An ICTP - IAEA Hybrid Meeting**  
**Trieste, Italy**







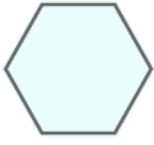
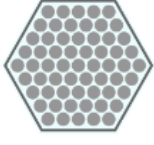
# ICTP-IAEA ONCORE Workshop 2023

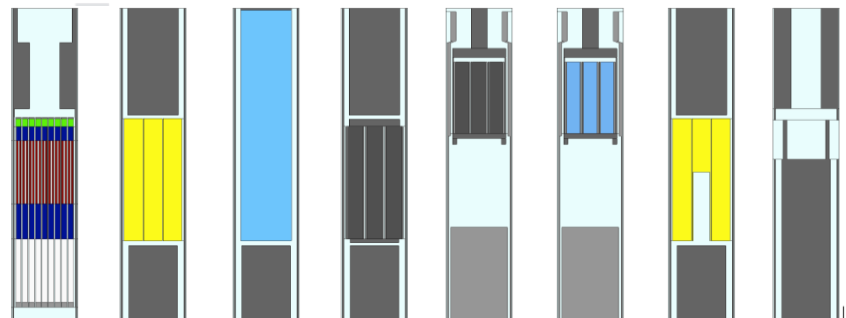
## Application of OpenMC for the analysis of 20 MWe CEFR start-up tests

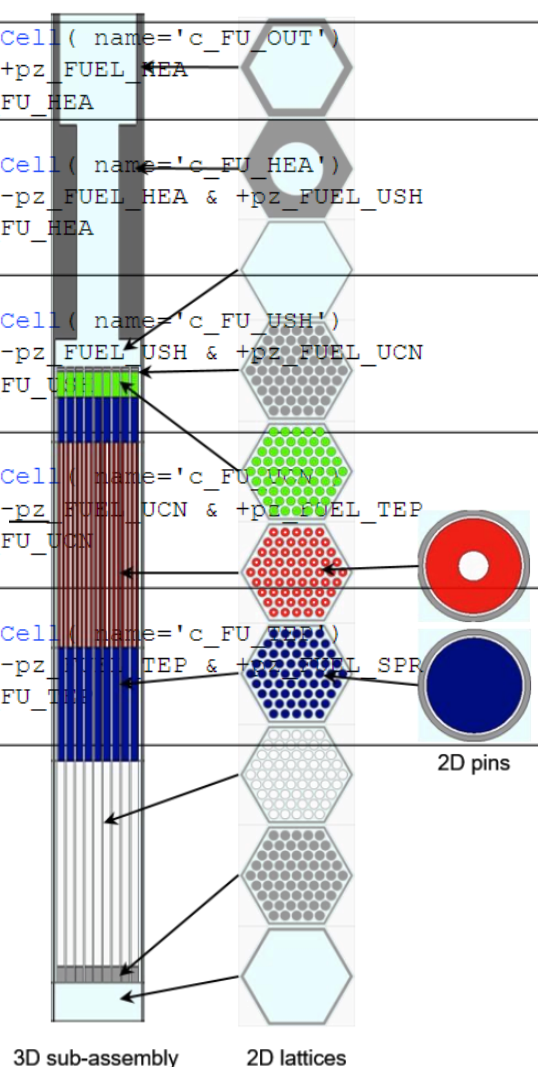


7-11 August 2023, Trieste, Italy<sup>3</sup>

# ICTP-IAEA ONCORE Workshop 2023

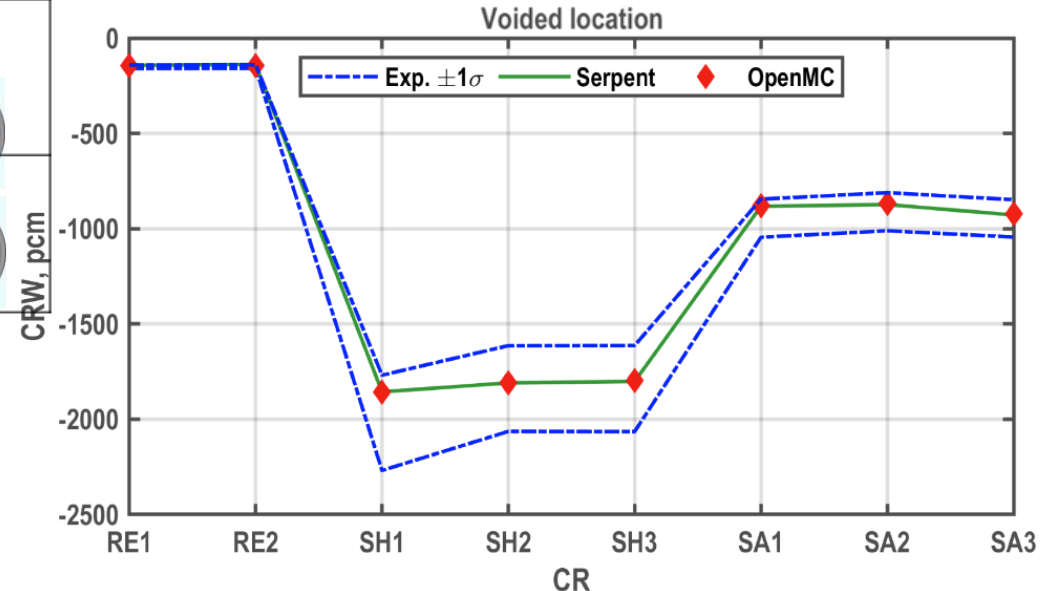
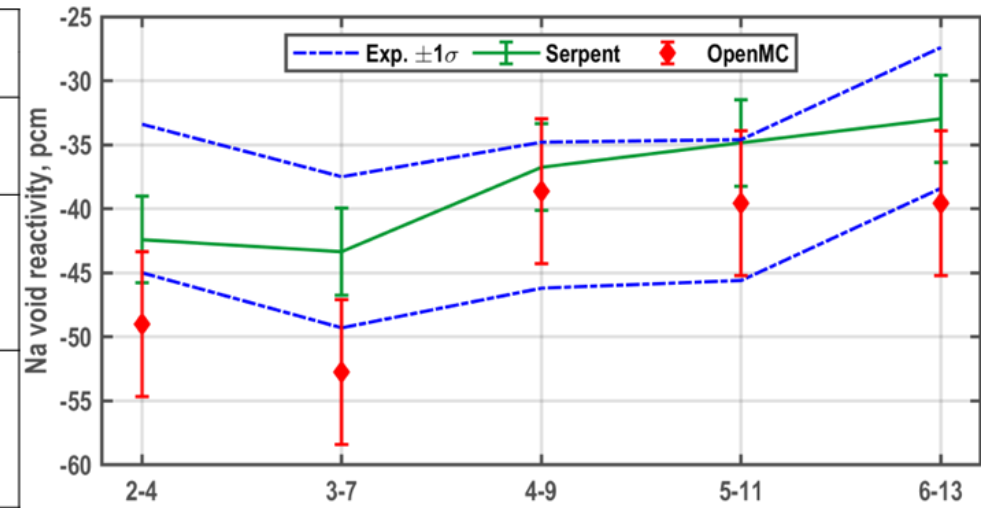
#	2D axial region		OpenMC input
	Content	Snapshot	
0	Outside		<pre>c_FU_OUT = openmc.Cell(name='c_FU_OUT') c_FU_OUT.region = +pz_FUEL_HEA c_FU_OUT.fill = u_FU_HEA</pre>
1	Head		<pre>c_FU_HEA = openmc.Cell(name='c_FU_HEA') c_FU_HEA.region = -pz_FUEL_HEA &amp; +pz_FUEL_USH c_FU_HEA.fill = u_FU_HEA</pre>
2	Upper shield		<pre>c_FU_USH = openmc.Cell(name='c_FU_USH') c_FU_USH.region = -pz_FUEL_USH &amp; +pz_FUEL_UCN c_FU_USH.fill = u_FU_USH</pre>
3	Upper connector		<pre>c_FU_UCN = openmc.Cell(name='c_FU_UCN') c_FU_UCN.region = -pz_FUEL_UCN &amp; +pz_FUEL_TEP c_FU_UCN.fill = u_FU_UCN</pre>
4	Top end plug		<pre>c_FU_TEP = openmc.Cell(name='c_FU_TEP') c_FU_TEP.region = -pz_FUEL_TEP &amp; +pz_FUEL_SPR c_FU_TEP.fill = u_FU_TEP</pre>





2D pins

3D sub-assembly      2D lattices



OpenMC vs. Serpent code



# IAEA ONCORE: Publications and Online Tools

- IAEA Technical Report Series (in printing, **preprint is available**):
  - *Development and Application of Open-Source Modelling and Simulation Tool*  
[https://preprint.iaea.org/search.aspx?orig\\_q=reportnumber:IAEA-PC--9064](https://preprint.iaea.org/search.aspx?orig_q=reportnumber:IAEA-PC--9064)
- IAEA Training Course Series (in printing):
  - *Fundamentals of neutronics simulations of a fast reactor based on IAEA's benchmark of CEFR start-up tests*
- ONCORE Webinar Series on Multiphysics Modelling of Nuclear Reactors using OpenFOAM
  - <https://elearning.iaea.org/m2/course/view.php?id=1286>
- 2023 Joint ICTP-IAEA Workshop on Open-Source Nuclear Codes for Reactor Analysis
  - <https://indico.ictp.it/event/10199>

# ONCORE and R&D declarability

If a State has an Additional Protocol, then some research is required to be declared to the Agency under Article 2.a.(i).

## **NFC-Related R&D (State-sponsored)**

AP, Article 2.a.(i):

“[the State] shall provide the Agency with a declaration containing: A general description of and information specifying the location of nuclear fuel cycle-related research and development activities not involving nuclear material carried out anywhere that are funded, specifically authorized or controlled by, or carried out on behalf of [the State].”

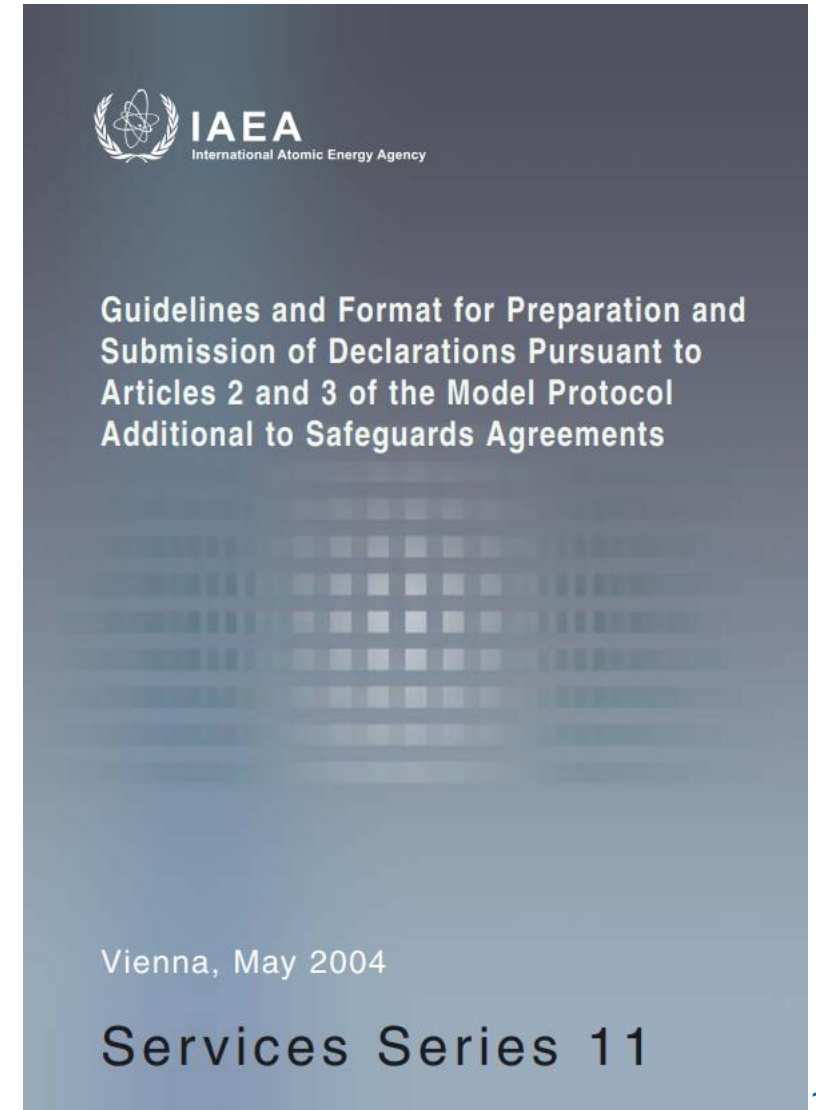
# ONCORE and R&D declarability

Possible examples could include developing simulations models for new reactor designs and reactor core configurations, fuel cycle options and reprocessing schemes.

More information can be found in IAEA Service Series 11, and SG colleagues will be here later in the week.

IAEA Service Series 11

[www-pub.iaea.org/MTCD/Publications/PDF/svs\\_011\\_web.pdf](http://www-pub.iaea.org/MTCD/Publications/PDF/svs_011_web.pdf)





# ONCORE and Export control

A group of 48 countries have entered into an international agreement through the Nuclear Suppliers Group (NSG) to coordinate export control practices.

The NSG has two sets of guidelines that govern the exports of nuclear-related technology, INFCIRC/254 Part 1 and Part 2. The export control practices in individual NSG Member States are usually aligned with these international agreements.

*Development and Application of Open-Source Modelling and Simulation Tool*  
[https://preprint.iaea.org/search.aspx?orig\\_q=reportnumber:IAEA-PC--9064](https://preprint.iaea.org/search.aspx?orig_q=reportnumber:IAEA-PC--9064)



# Thank you!

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