

IAEA-EPFL activities on open-source software development

Carlo Fiorina

- Introduction
- Open-source developments at the EPFL
- The ONCORE initiative

Outline

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Open-source software in NS&T

- Growing activities on open-source codes and open-access data
- Open-source and collaborative software development increasingly perceived as an effective way to stimulate synergies, avoid work duplicates, involve a broader community, multiply V&V efforts, and, ultimately, accelerate innovation
- Often encouraged in publicly-funded projects (e.g., Euratom)

- Several examples
 - OpenMC
 - OpenMOC
 - Raven
 - Dakota
 - Salome
 - Code_Saturn
 - Code_Aster
 - Dragon
 - OpenModelica
 - ...
 - Several OpenFOAM-based tools

- What is OpenFOAM?
 - OpenFOAM = Open Field Operation And Manipulation
 - Essentially a large, well organized C++ library for PDE solution
 - “over 80 solver applications that simulate specific problems in engineering”
 - ~10k to 20k estimated users worldwide

Open  FOAM

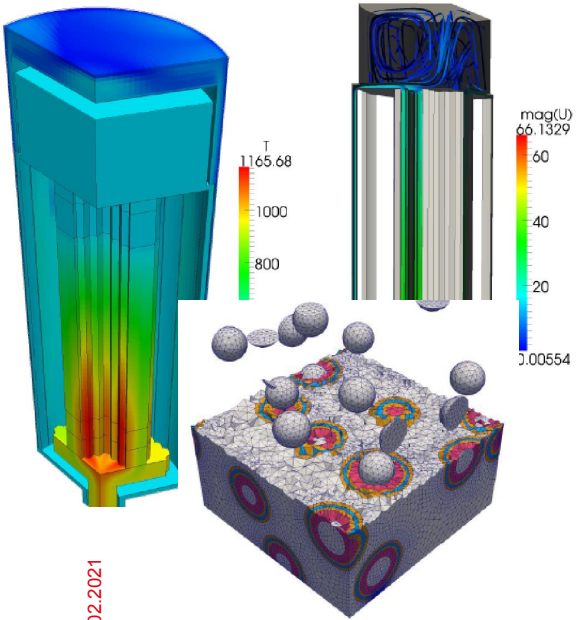
The Open Source CFD Toolbox

- Several attractive features of OpenFOAM as multi-physics library:
 - Intuitive finite-volume formulation
 - Includes advanced and verified CFD solvers
 - Parallelism and geometric flexibility (unstructured mesh)
 - Based on C++
 - Object-oriented: high-level “fail-safe” programming of new solvers, streamlined distribution to other institutions, and straightforward coupling between solvers

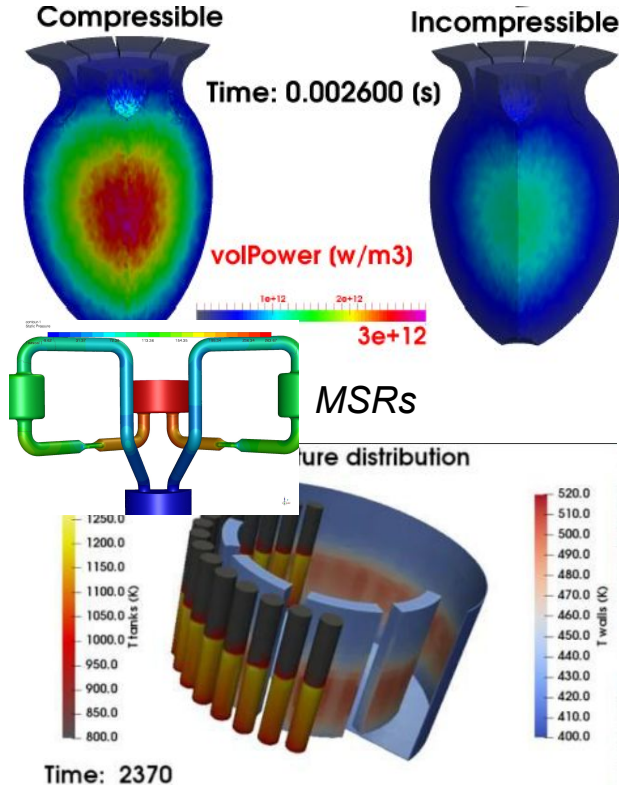
$$\frac{1}{v_i} \frac{\partial \varphi_i}{\partial t} - \Delta(D_i \varphi_i) = S$$

```
fvm::ddt(IV, flux[energyI]) - fvm::laplacian(D, flux[energyI]) = S
```

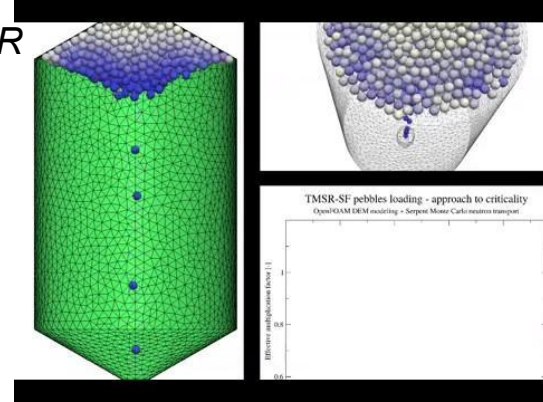
- A wealth of applications in the last 2 decades, and growing



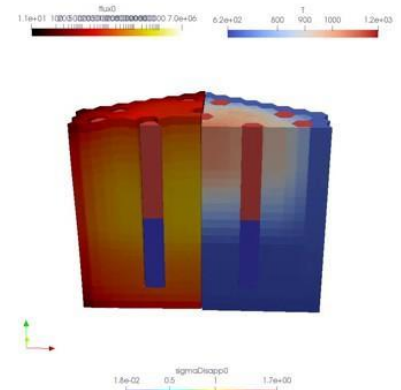
PBMRs and
HTRs



FHR



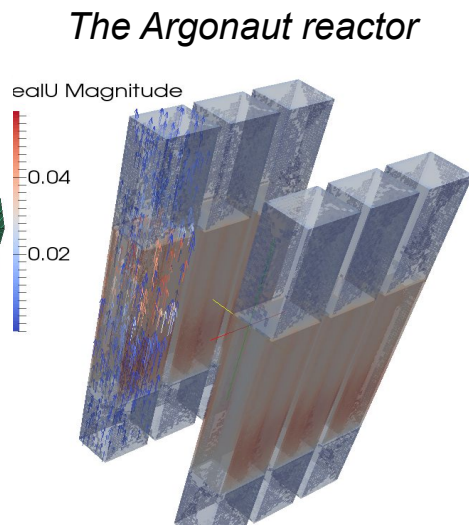
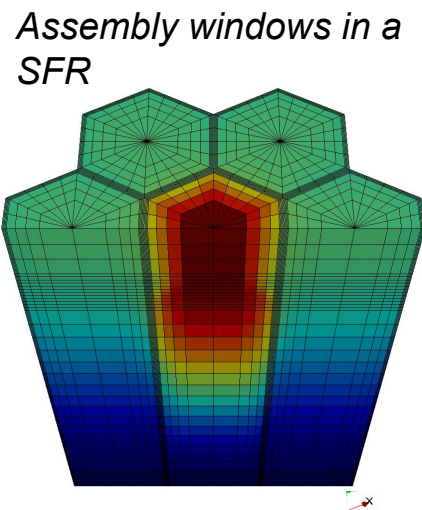
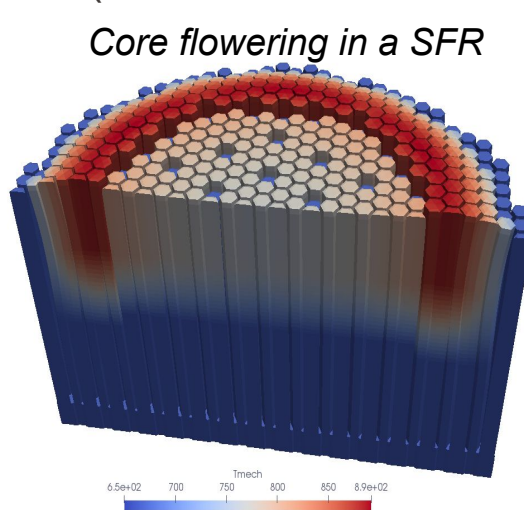
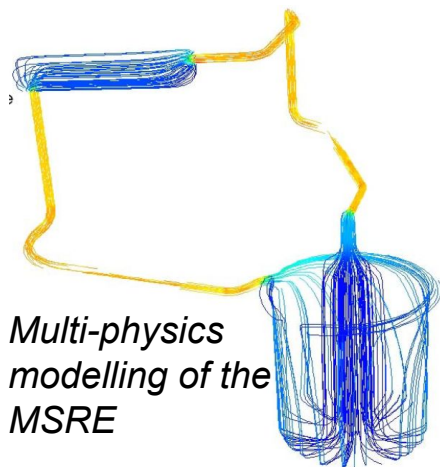
SFRs



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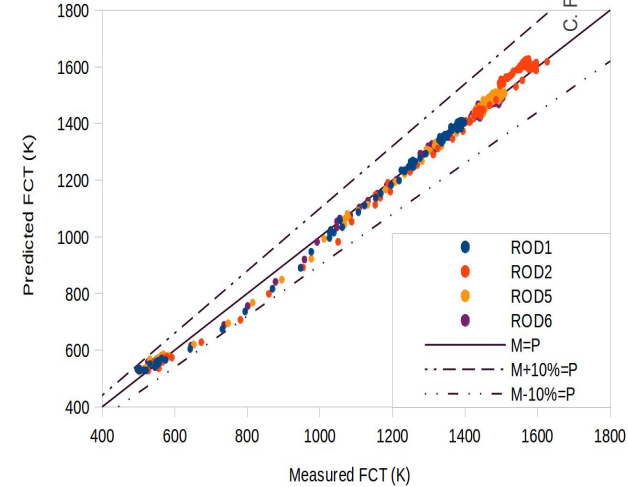
Outline

- The GeN-Foam multi-physics solver:
 - First attempt for a general OpenFOAM-based solver for reactor analysis, built upon previous efforts on HTRs and MSR
 - Developed to complement legacy codes with more flexibility (unstructured meshes, parallel scalability, implicit coupling, code tailoring)
 - Solves for: neutronics (point kinetics, diffusion, SP3, SN), single- and two-phase thermal-hydraulics (fine or coarse mesh), core deformations



- OFFBEAT: OpenFOAM Fuel BEhavior Analysis Tool
 - A new-generation fuel performance code
 - Transient and steady-state
 - Multi-dimensional, from 1.5-D to 3-D
 - Parallel scalability

Validation against
the IFA-432 exp.

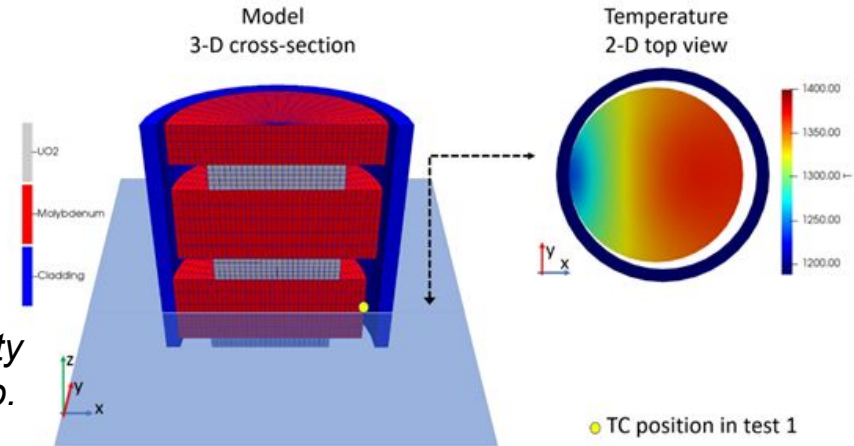


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PCI and missing
pellet surface

Pellet eccentricity
in the HBRP exp.



■ GeN-Foam

- pre-distribution phase
- already available at <https://gitlab.com/foam-for-nuclear/GeN-Foam/-/tree/develop>
- Already including a simple documentation (wiki of gitLab) and several commented tutorials
- “Official distribution” via IAEA ONCORE initiative before summer 2021

■ OFFBEAT

- Less mature than GeN-Foam
- Under heavy development
- Currently distributed to collaborating institutions
- Public distribution in 2022? (via the IAEA, and maybe as plugin for TRANSURANUS)

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EPFL The ONCORE initiative: overview

- IAEA recognizing large open-source developments, and need for coordination
- EPFL as collaborating center in the field
- ONCORE: Open-source Nuclear Codes for Reactor Analysis
- Objective: Development and application of open-source multi-physics simulation tools in support of research, education, and training in NS&T
 - Build and preserve knowledge in the field
 - Facilitate the exchange of information
 - Define best practices for collaborative open-source code development

Founding members: IAEA, OECD/NEA, Switzerland (EPFL, PSI), US (ANL, TAMU, NCSU, ORNL), Germany (FZJ, GRS), UK (UCam), Italy (PoliMi), France (LPCS Grenoble, IRSN)

<https://nucleus.iaea.org/sites/oncore/SitePages/Home.aspx>

EPFL The ONCORE initiative: in practice

- Expert group (being defined) + IAEA secretariat to
 - coordinate the activities
 - organize outreach and E&T events
 - assess existing research and provide guidelines for new research
- Main expected short-term outcomes:
 - List of available open-source codes
 - Selection of codes for direct download
- In the longer term
 - Consistent platform(s) for modelling and simulation

EPFL The ONCORE initiative: ongoing activities

- Preliminary list of codes
- First development guidelines
- E&T
 - First IAEA Webinar in March (provided by EPFL and Chalmers), possibly followed by a series of 4
 - Summer school (Trieste?) to be organized (waiting for the pandemics to end...)
 - Workshop at Physor 2022
- Outreach:
 - Website and SharePoint
 - First position papers presented at Physor 2020 and at CFD4NRS
 - IAEA Technical meeting in November 2021
 - Special session at Physor 2022

EPFL The ONCORE initiative: get involved

- How?
 - website as main contact point
 - (or me, carlo.fiorina@epfl.ch)

- Why?
 - “ONCORE promotes collaboration and sharing of resources, materials and tools for research and education. ONCORE members actively contribute to the development of new software, receive community support for the use of available software and participate in the organization of training events and outreach activities.”
 - Or as code contributor (direct download or link)

**Thank
you**

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