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Excellerat: Center of Excellence for engineering applications

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EXCELLERAT CoE

- The **EXCELLERAT CoE** is a single point of access for expertise on how data management, data analytics, visualisation, simulation-driven design and Co-design with high-performance computing (HPC) can benefit **engineering**, especially in the **aeronautics, automotive, energy and manufacturing** sectors.

EXCELLERAT CoE

The goal of EXCELLERAT is to enable the European engineering industry to advance towards Exascale technologies and to create a single entry point to services and knowledge for all stakeholders of HPC for engineering:

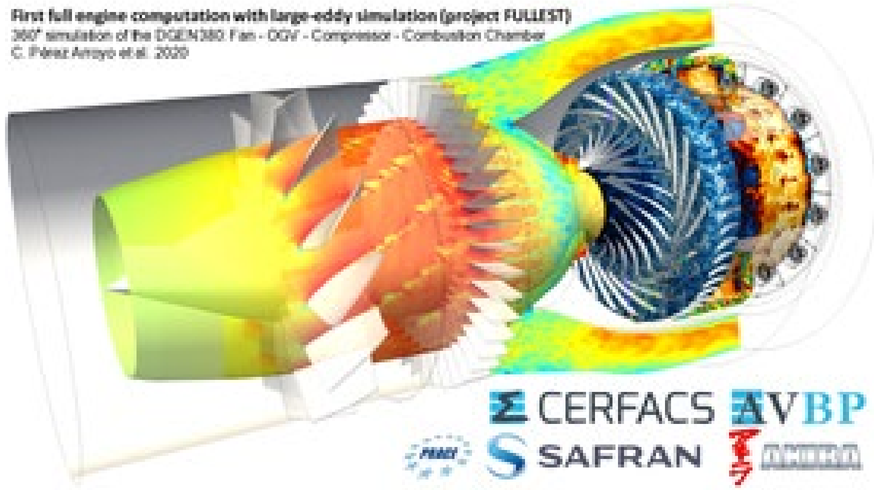
- **Industrial end-users**
- **ISVs**
- **Technology and HPC providers**
- **Academics**
- **Code developers**

EXCELLERAT CoE

In a holistic approach, EXCELLERAT analyses and optimises **eight core codes** according to the engineering lifecycle.

- Alya
- Neko
- Coda
- AVBP
- ElmerFEM
- FLEW
- m-AIA
- OpenFOAM

Application in
7 Use Cases



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EXCELLERAT SERVICE PORTAL

EXCELLERAT *Centre of Excellence* - Service Portal

EXCELLERAT offers cross-cutting support for various engineering sectors, like manufacturing, automotive, energy, aerospace, chemistry, biology and climate.

Tackling the next generation engineering challenges, those requiring an unprecedented amount of computational power, requires a new frame of skills and resources. EXCELLERAT mission is to provide support and consulting services at different levels to cover all the engineering lifecycle. To facilitate the access to the services that really matter to you, we divided their presentation into three dashboards aimed to different roles.

EXCELLERAT

The European Centre of Excellence for Engineering Applications

Community dashboard

Start here if you are interested in the future of engineering or want to know more about the project activities and success stories. You will know about the next events and training and consult our public material.

— Read more

Engineer dashboard

Start here if you are an end-user fighting with exciting engineering challenges. You will know how we dealt with similar challenging use-cases, how we developed new tools and how we might support you to solve your problem.

— Read more

Developer dashboard

Start here if you are developing or updating engineering software. You will know how we optimized popular software codes to make them exascale-ready and how we might support your development effort.

— Read more

- Application Software
- Tools
- Datasets
- Consulting
- Training
- Materials

EXCELLERAT P2

https://www.excellerat.eu/

EXCELLERAT Partners

ARCTUR	BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación	CERFACS	CINECA
DLR Deutsches Zentrum für Luft- und Raumfahrt	E4 COMPUTER ENGINEERING	Fraunhofer SCAI	HLRS
KTH VETENSKAP OCH KONST	RWTH RHEINISCH-WESTFÄLISCHE TECHNISCHE HOCHSCHULE AACHEN	SICOS	SIPEARL
SSC	Teratec	University of Ljubljana	SAPIENZA UNIVERSITÀ DI ROMA

EXCELLERAT Use Case in Nuclear Fusion

Development of full scale 3D simulation package for synthetic diagnostics in nuclear fusion reactors:

- Taking into account full 3D geometry of nuclear fusion reactor (tokamak)
- Parallelization of field line tracing codes to estimate power loading on tokamak wall
- Demonstrate high scalability of thermal modelling package to estimate temperature distribution on tokamak's inner wall
- Parallelization of optical simulations to obtain camera signal from temperatures

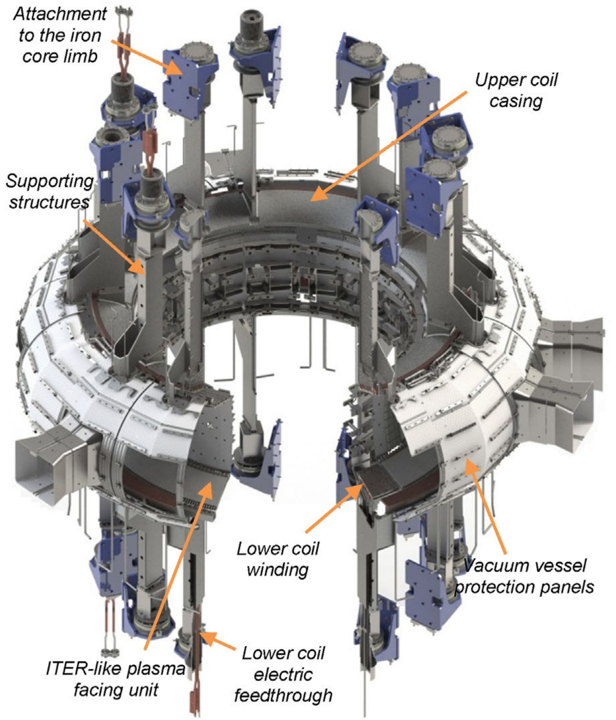

Fig. 1: Example of tokamak structure (WEST).

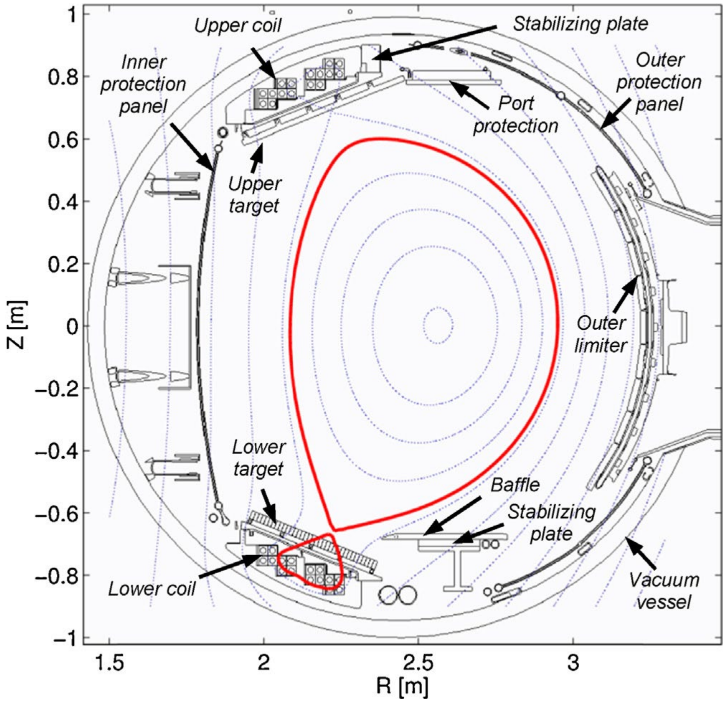

Fig. 3: Poloidal cross-section of WEST tokamak with contours of magnetic flux and main inner components of the tokamak.

EXCELLERAT Use Case in Nuclear Fusion

- Scalability of thermal modelling package to model first wall
  - Steady state (ElmerFEM)/transient (OpenFOAM)

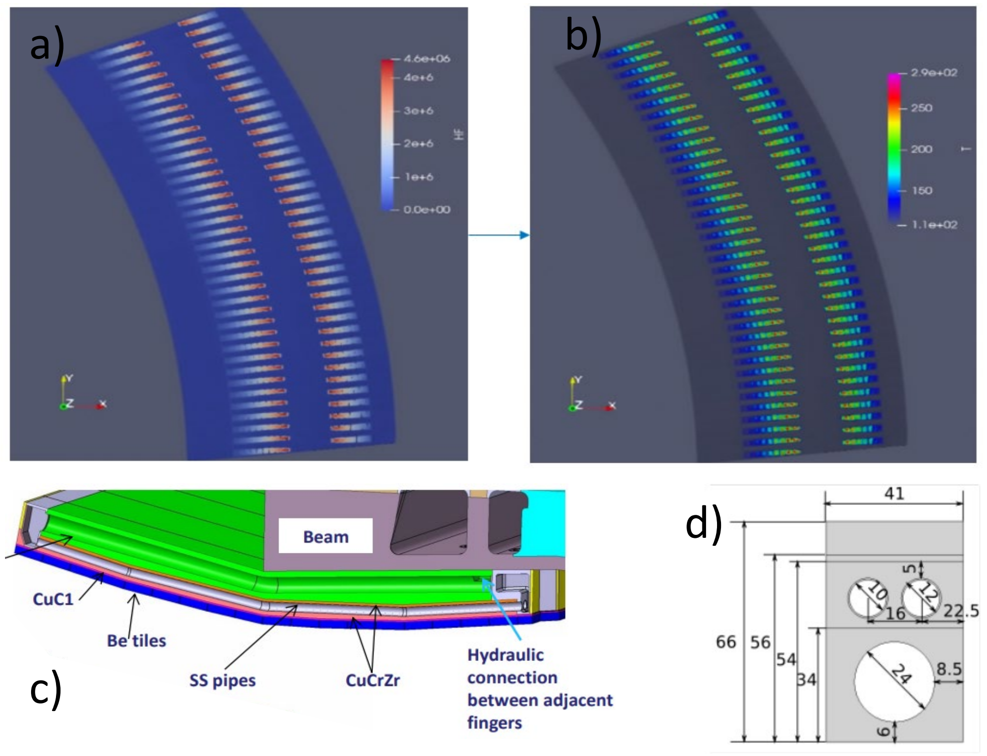

Fig. 1: (a) Heat fluxes (from FLT simulation) (b) Corresponding temperatures (OpenFOAM) (c) cross-section of ITER first wall (d) corresponding dimensions of ITER frst wall

- Scalability of optical simulations
  - Use of ray tracing algorithms (codes Raysect, Minerva,…)
  - Take into account full 3D field of distributed temperatures and calculate corresponding radiance on the IR cameras in fusion reactors

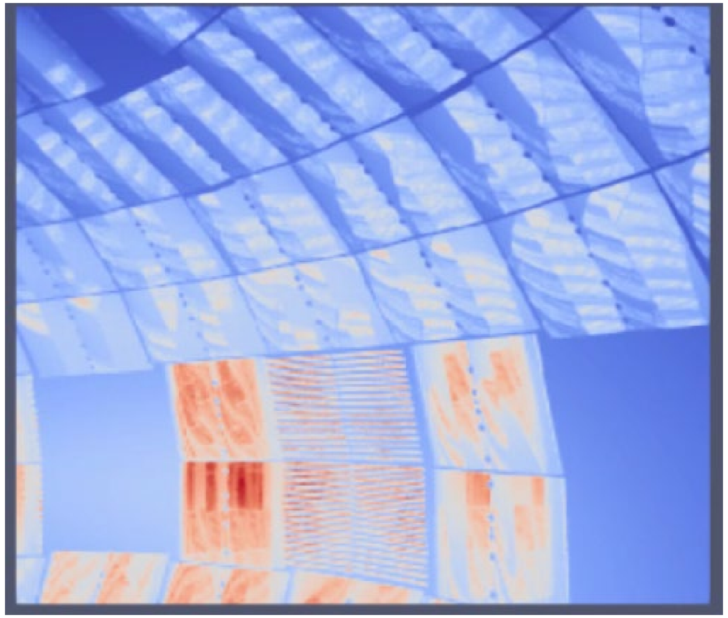

Fig. 2:Example of camera view in the ITER tokamak

EXCELLERAT Use Case in Nuclear Fusion

- Parallelisation and scaling of field line tracing codes of particles conducted along magnetic field lines to estimate power loading on tokamak wall
  - Particle tracing through magnetic field lines

    $$B_R = -\frac{1}{R}\frac{\partial \Psi}{\partial Z}, B_T = -\frac{I}{R}, B_Z = \frac{1}{R}\frac{\partial \Psi}{\partial R}$$

  - Calculation of power deposition on tokamak inner walls
    - Based on impact angle of field line and different plasma parameters

    $q_{||s}(r) = q_{||,omp} \exp\left(-\frac{R-R_m}{\lambda_m}\right)$ (parallel heat flux based on outer midplane point - OMP)

    $q_{\perp}(\Psi) = \frac{F P_{loss}}{2\pi R_m \lambda_m B_{pm}} \mathbf{B}.\mathbf{n}\, exp\left(-\frac{\Psi - \Psi_m}{R_m \lambda_m B_{pm}}\right)$ (single exponential profile)

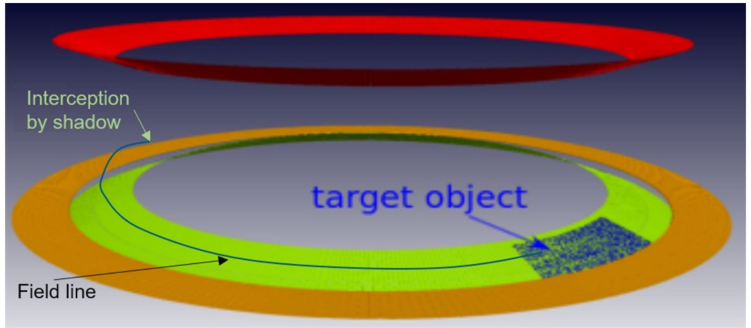

Fig. 1: Example of field line trace from target object (triangles).

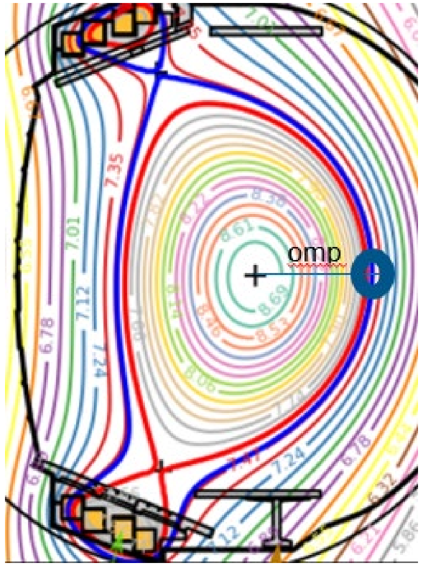

Fig. 2: Outer midplane point is located on intersection of Z-plane, going through plasma centre, and first separatrix.

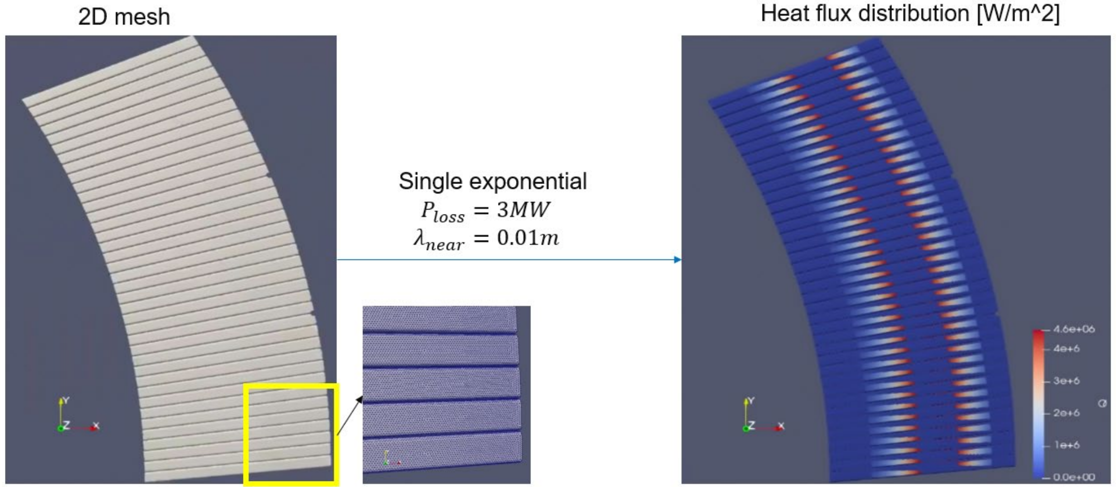

Fig. 3: calculation of heat fluxes on divertor baffle (tokamak inner wall).

EXCELLERAT Use Case in Nuclear Fusion

- Scalability of digital twin of processes in fusion reactor:
- Test case is given for integration of 3D magnetic field to calculate stream flow of particles
- Thermal modelling of large 3D structures taking into accout time and space dependent heat fluxes from plasma
- Optical simulations of millions of rays to generate camera output based on surface radiation and reflections
- Cases strive towards more detailed simulation setups and more efficient workflow execution to acquire simulation results that will better explain physical processes around the inner wall during the fusion reactions and improved workflow execution that will drastically shorten time to solution of this computations and therefore pave the path towards real-time control of fusion reaction, which is needed for stable fusion.

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MINISTRY OF HIGHER EDUCATION, SCIENCE AND INNOVATION

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