

Dan slovenskega superračunalniškega omrežja, MREŽA ZNANJA
16. november 2023

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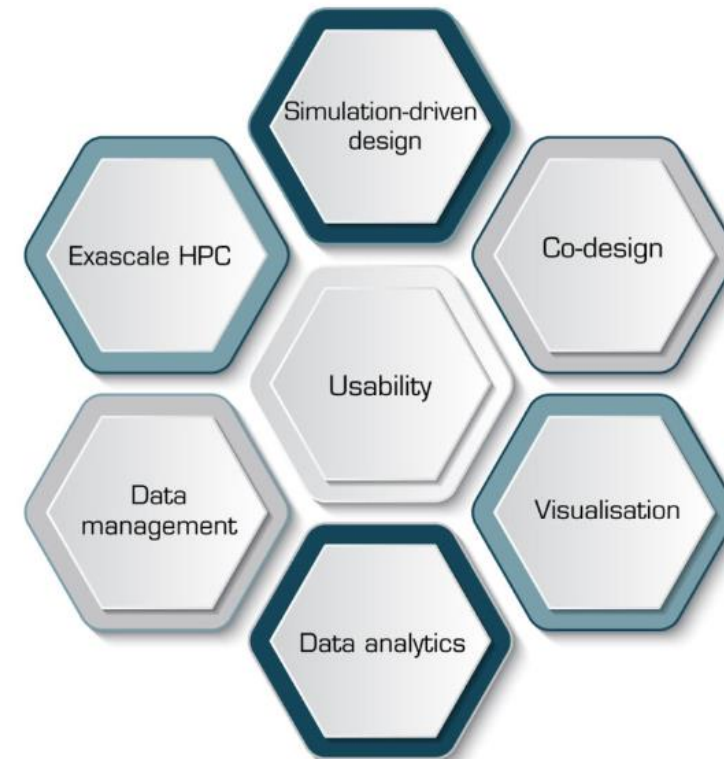
SLING

Excellerat: Evropski center odličnosti za inženirske aplikacije

Prezenter: Tina Črnigoj Marc, Arctur d.o.o. in Matic Brank, UL-LECAD



- 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



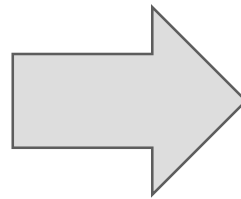
The goal of EXCELLERAT is to enable the European engineering industry to advance towards Exascale technologies and to create a single entry point to services and knowledge for all stakeholders of HPC for engineering:

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



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



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.



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](#)



The European Centre of Excellence for Engineering Applications



Application Software



Tools



Datasets



Consulting



Training



Materials

Partners



Determination of requirements



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

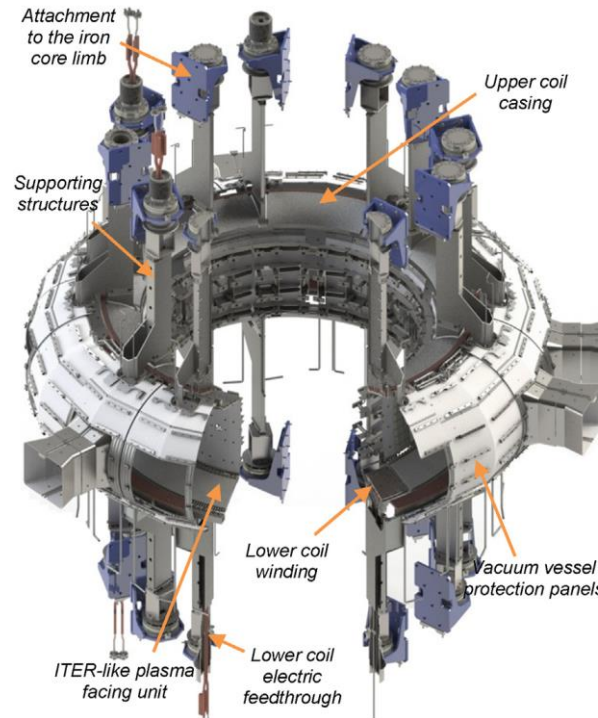


Fig. 1: Example of tokamak structure (WEST).

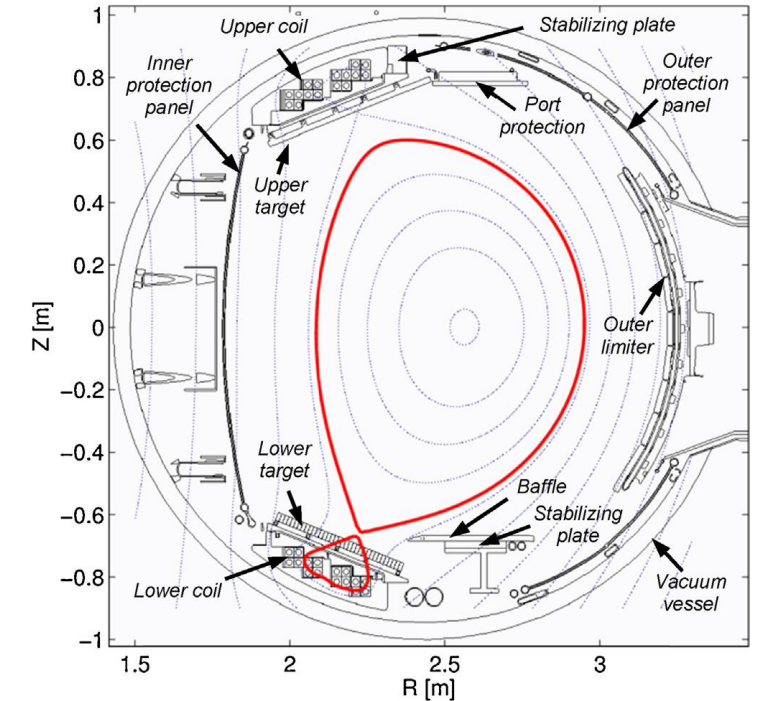


Fig. 3: Poloidal cross-section of WEST tokamak with contours of magnetic flux and main inner components of the tokamak.

Progress monitoring

- 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

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

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

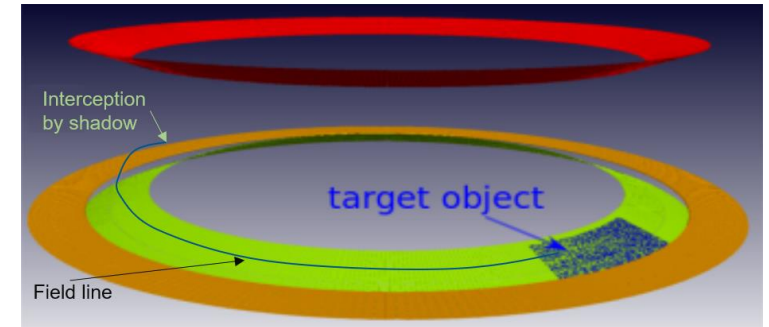


Fig. 1: Example of field line trace from target object (triangles).

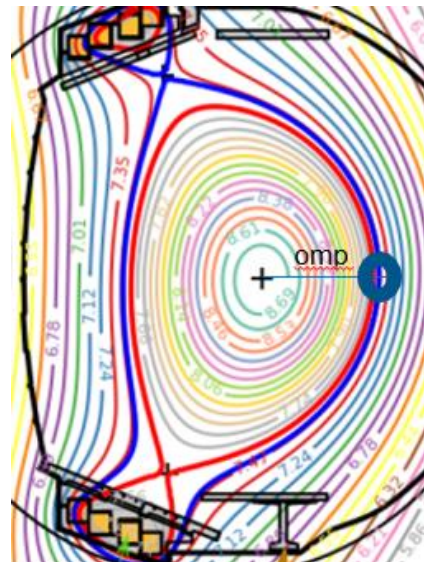
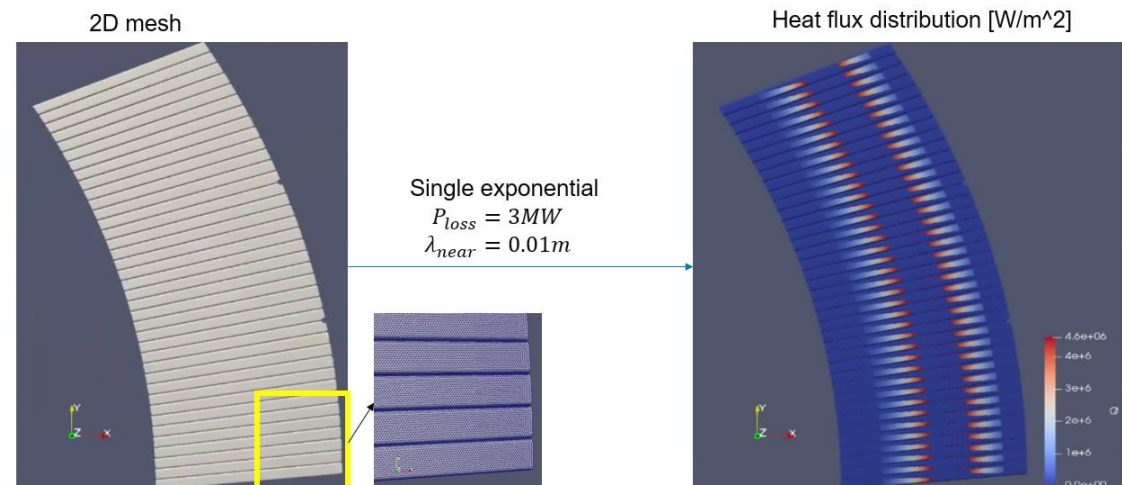


Fig. 2: Outer midplane point is located on intersection of Z-plane, going through plasma centre, and first separatrix.

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



Progress monitoring



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

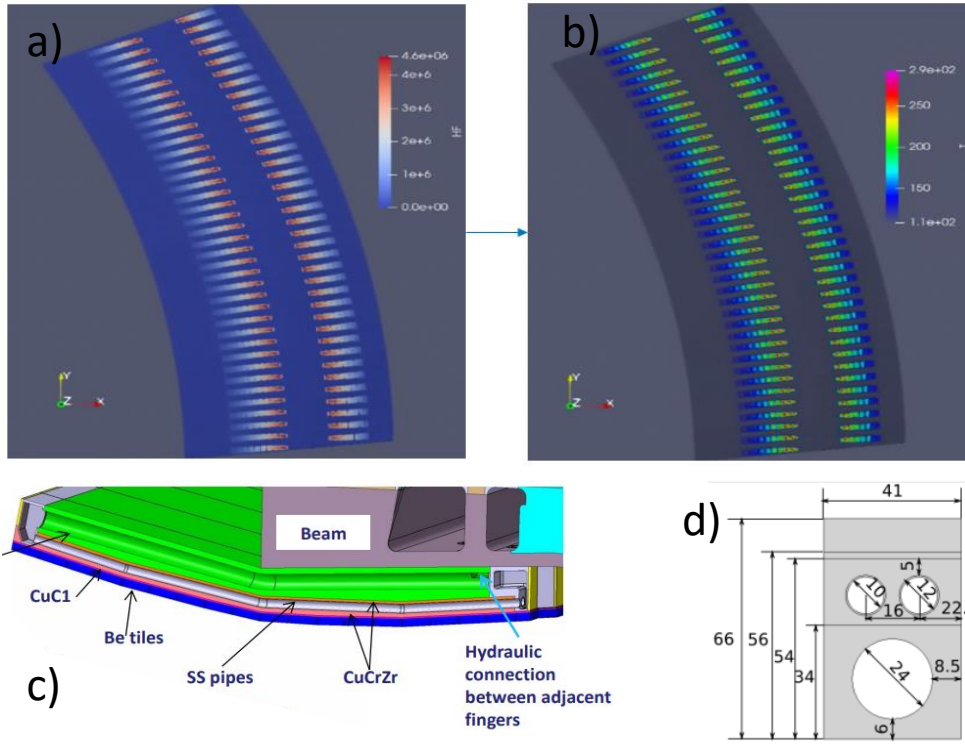


Fig. 1: (a) Heat fluxes (from FLT simulation) (b) Corresponding temperatures (OpenFOAM) (c) cross-section of ITER first wall (d) corresponding dimensions of ITER first wall

- 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

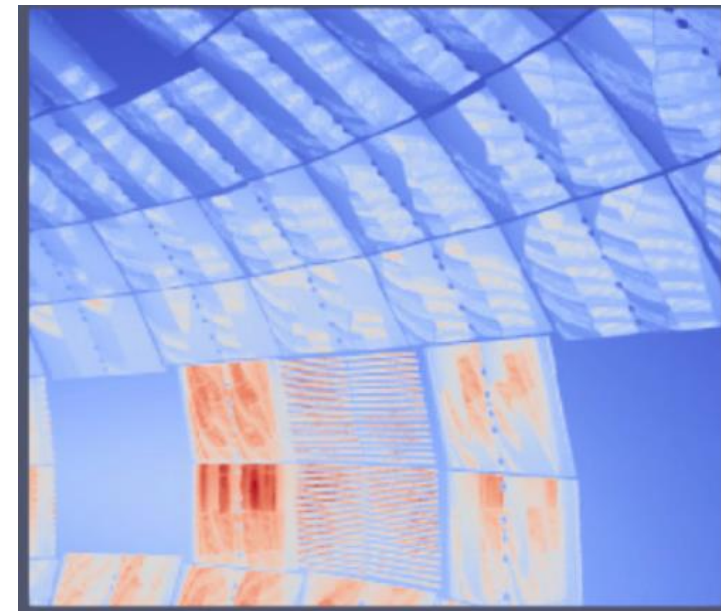


Fig. 2: Example of camera view in the ITER tokamak

Output generation



- 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 account 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.



Hvala!

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