

EURO²

Introduction to HPC

By EuroCC Belgium

Outline

PART 1

- Introduction
 - Example of uses
 - The EuroHPC joint undertaking the EuroCC project
- Current status of the supercomputing infrastructures
 - Performance and the TOP500 list
 - Supercomputers in Europe and in Belgium

PART 2

- Understand how a supercomputer works:
 - Architecture & Components
 - Interacting with supercomputers
- Understand how program can use such large resources, and what are the issues that needs to be overcome:
 - Parallelism
 - Parallelization issues

PART 1

What is High Performance computing (HPC)?

- Aggregation of computer power (in the form of supercomputer or *clusters*) to deliver high computational performances, in order to solve large problems.
- *Clusters* are linked computers (= nodes) that work together, so that, for many aspects, they look like one single computer (*more on that latter*).
- The work is distributed across workers (*more on that latter*).

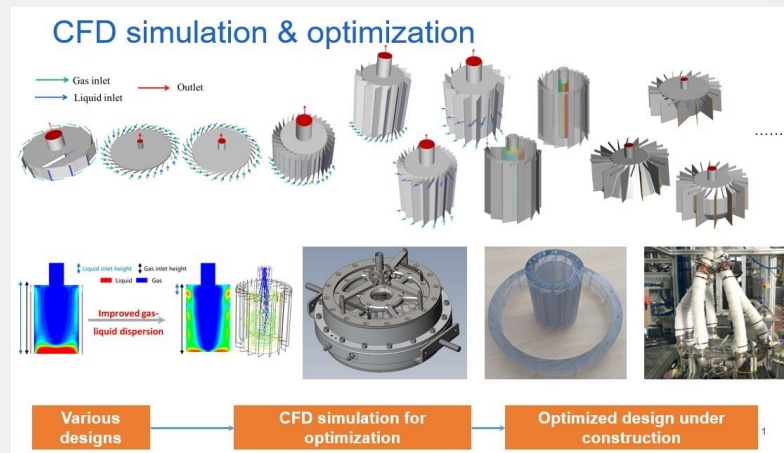
Examples of HPC uses

Have a look at www.enccb.be/stories



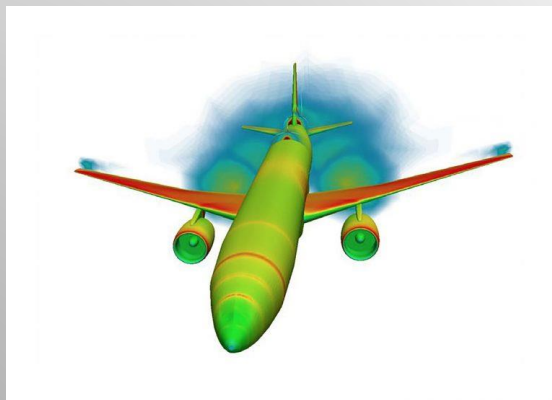
Examples: fluid dynamics (CFD)

Optimization of a vortex unit for CO₂ capture



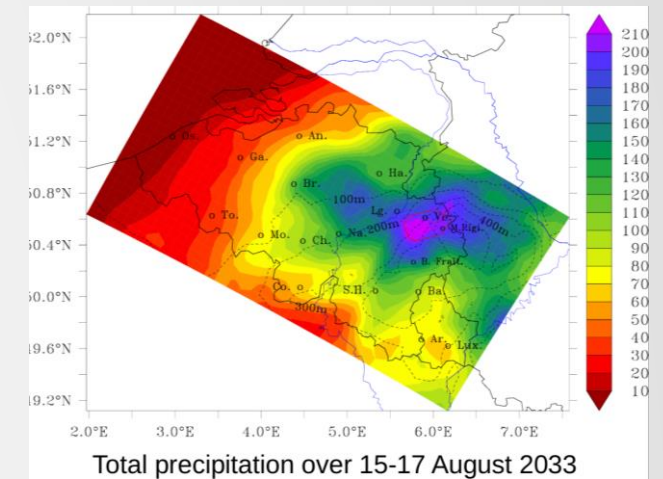
<https://www.enccb.be/usvortexunit>

Aircraft design



<https://prace-ri.eu/automating-aircraft-design-and-optimisation/>

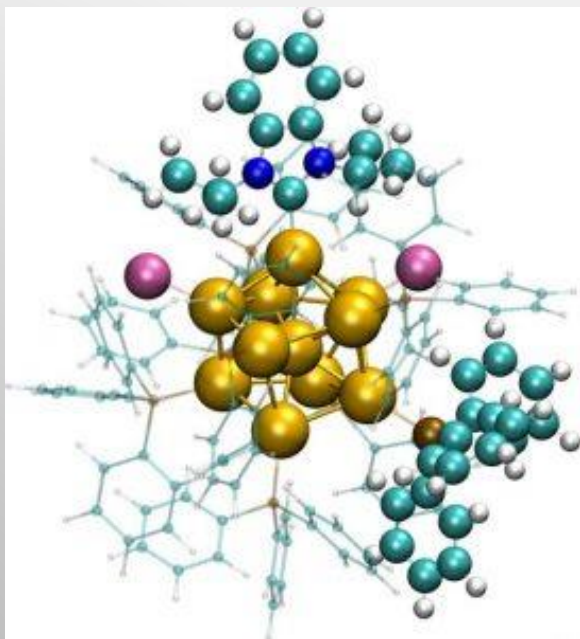
Predicting the climate



<https://www.enccb.be/usxavierfettweis>

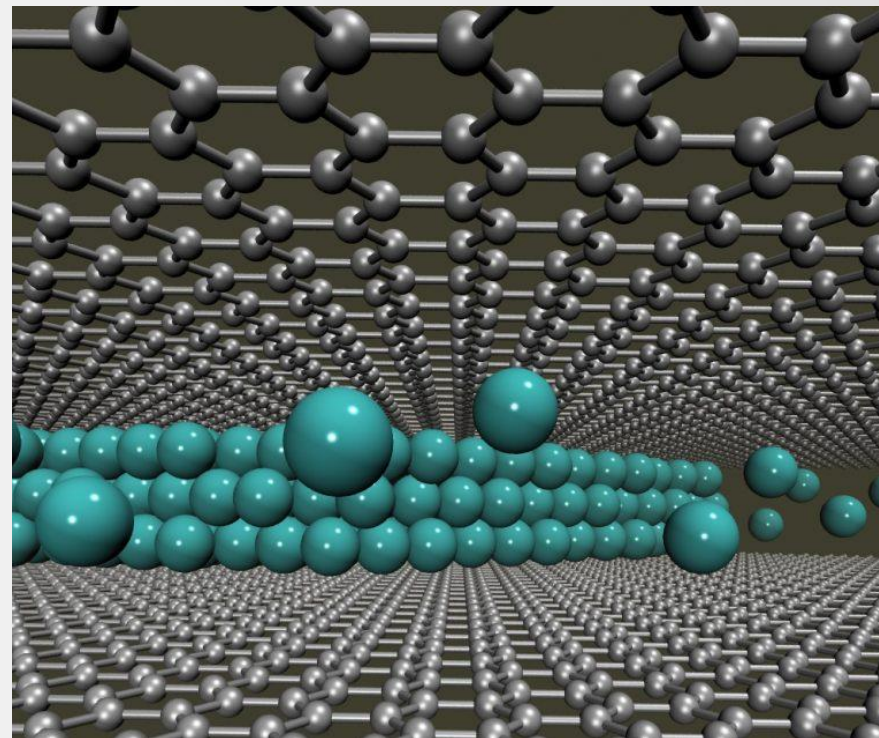
Examples: materials

**Predicting the structure of gold clusters that
chops carbon dioxide**



<https://prace-ri.eu/computer-simulations-gold-cluster/>

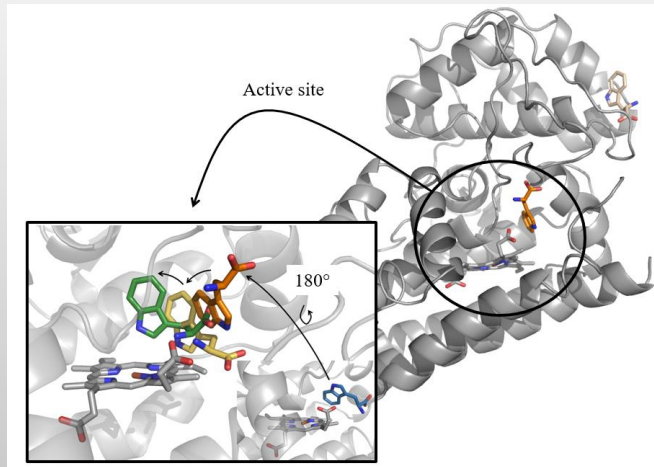
Tailoring the properties of 2D materials



<https://prace-ri.eu/simulations-help-to-tailor-the-properties-of-2d-materials/>

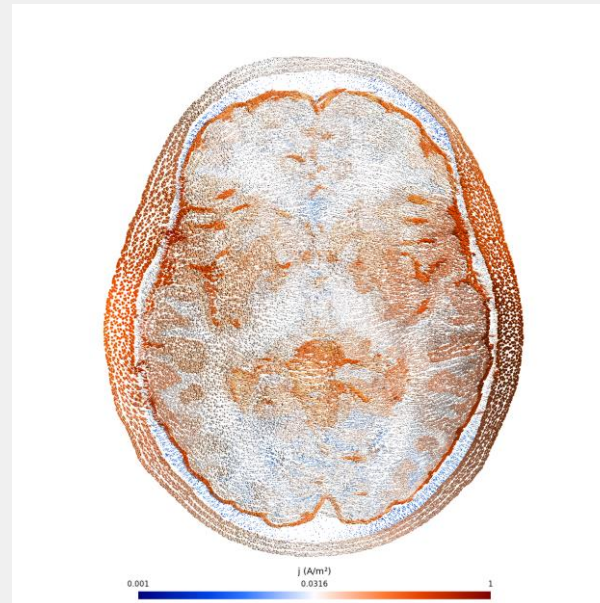
Examples: Biology

Unraveling the behavior of the hIDO1 protein



<https://www.enccb.be/usmanonmirgaux>

Understanding how radio waves propagate in the head with Shamo



<https://www.enccb.be/usshamo>

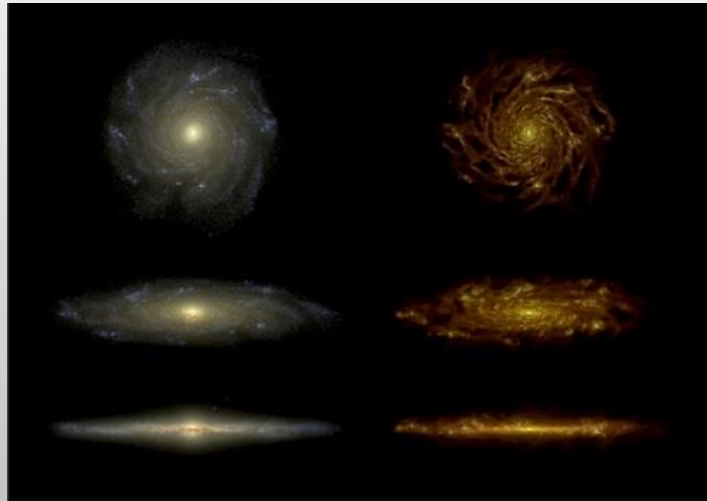
Improving chocolate with supercomputing



<https://www.enccb.be/uschocolate>

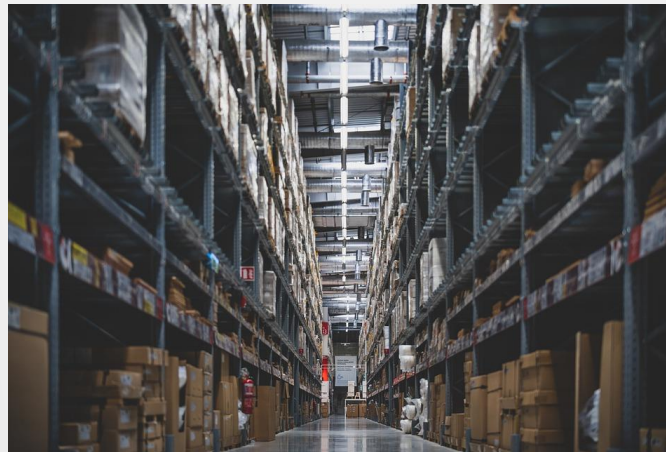
Examples: physics, mathematics, engineering,...

Simulating Galaxies



<https://www.enccb.be/usuniverse>

Outsmarting NP-hardness



<https://www.enccb.be/uslogisticsnphardness>

Optimizing particle processes through simulation with MPacts

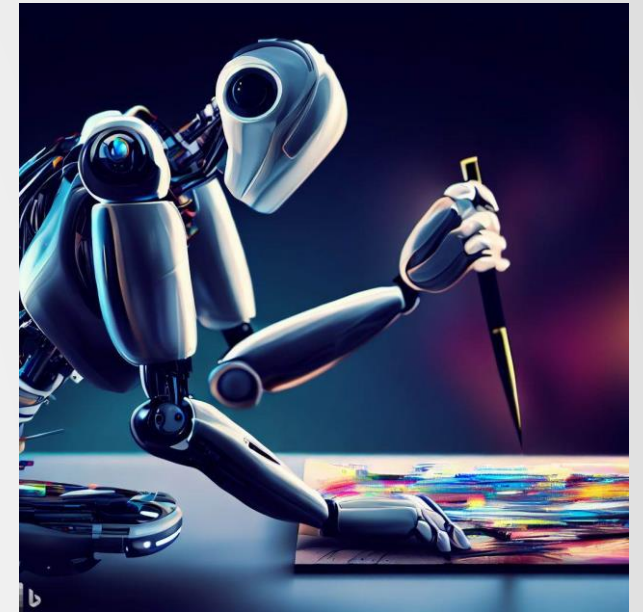
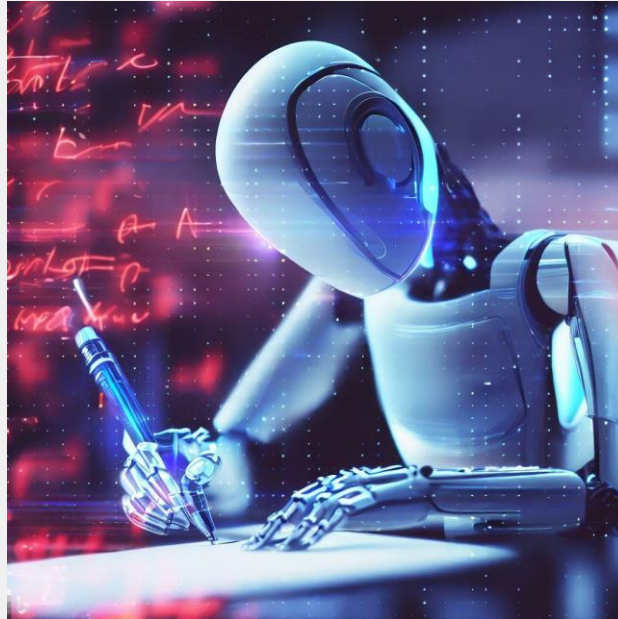


<https://www.enccb.be/usmpacts>

Examples

But also:

- Artificial intelligence
- Machine learning
- Data analysis
- ...



What is EuroCC?

- EuroHPC Joint Undertaking (JU) is a joint initiative between the EU (European countries) and private partners to develop a world-class supercomputing system in Europe.
- EuroCC is a project of EuroHPC-JU, which tasks each participating country to create a national competence center (NCC) in the area of HPC. They coordinate activities in the HPC/HPDA/AI fields and serve as contact point.
→ More information on <https://www.enccb.be/>.
- Different missions, including contact with industry, raising awareness and organizing trainings.

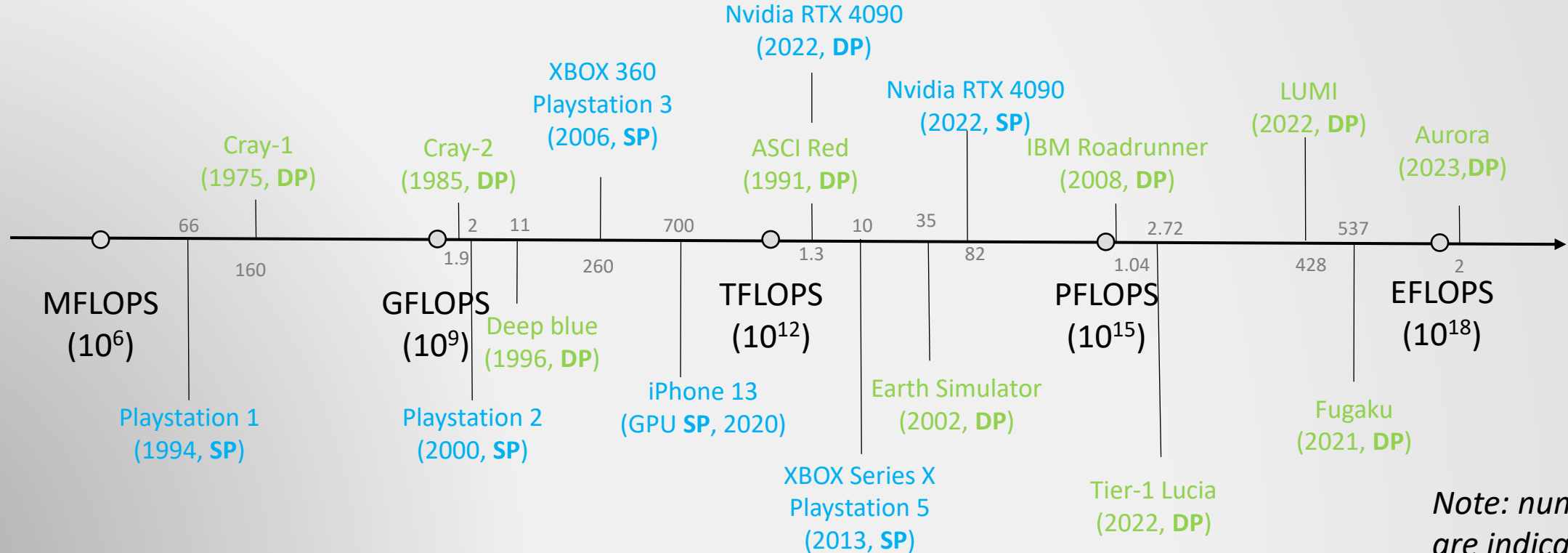


Where are we today?

Which supercomputers for Belgium?

Performances

- One of the measurement is FLOPS = floating point operations per second (\approx speed)
- Note that it depends on single (SP, 32 bits) or double (DP, 64 bits) precision!

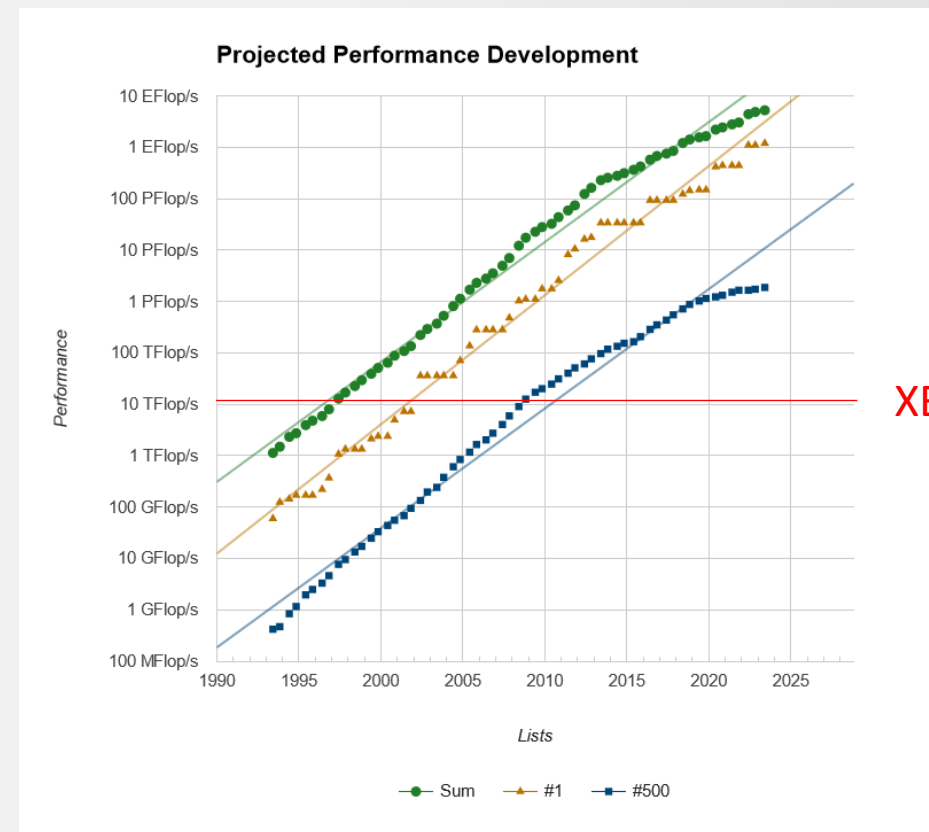


Note: numbers are indicative

The TOP500

The TOP500 is a list of the fastest supercomputer in the world

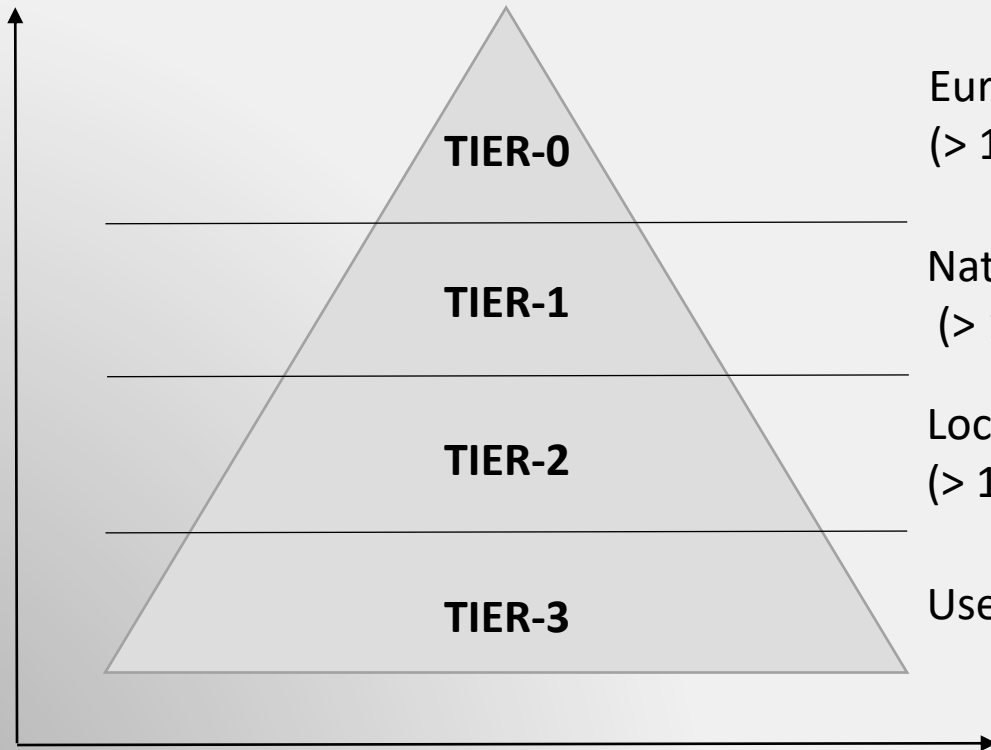
Rank	System	Cores	Rmax (PFlop/s)	Rpeak (PFlop/s)	Power (kW)
1	Frontier - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE DOE/SC/Oak Ridge National Laboratory United States	8,699,904	1,194.00	1,679.82	22,703
2	Supercomputer Fugaku - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848	442.01	537.21	29,899
3	LUMI - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE EuroHPC/CSC Finland	2,220,288	309.10	428.70	6,016
4	Leonardo - BullSequana XH2000, Xeon Platinum 8358 32C 2.6GHz, NVIDIA A100 SXM4 64 GB, Quad-rail NVIDIA HDR100 Infiniband, Atos EuroHPC/CINECA Italy	1,824,768	238.70	304.47	7,404
5	Summit - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM DOE/SC/Oak Ridge National Laboratory United States	2,414,592	148.60	200.79	10,096
6	Sierra - IBM Power System AC922, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM / NVIDIA / Mellanox DOE/NNSA/LLNL United States	1,572,480	94.64	125.71	7,438



XBOX - PS5

Supercomputers in Europe

Capability (~FLOPS)



European centers
(> 100 PFLOPS)

National centers
(> 1 PFLOPS)

Local (academic) centers
(> 100 TFLOPS)

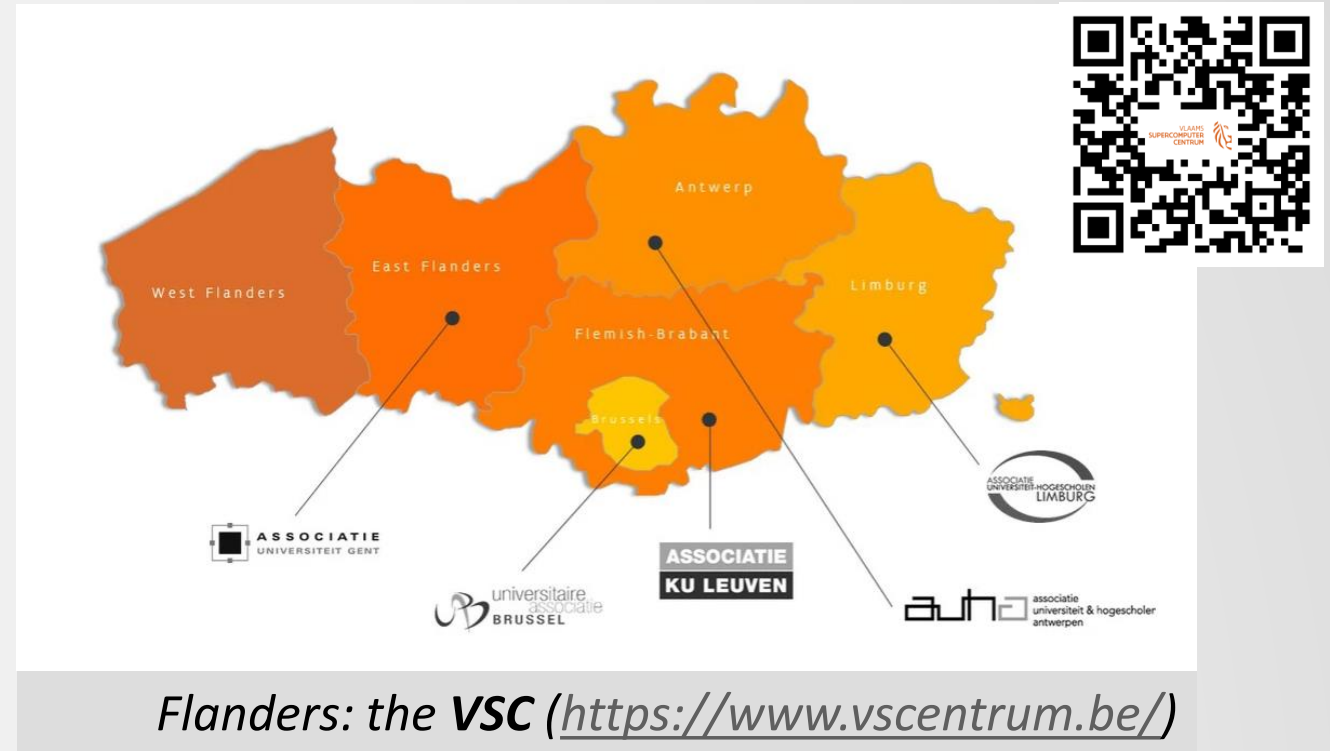
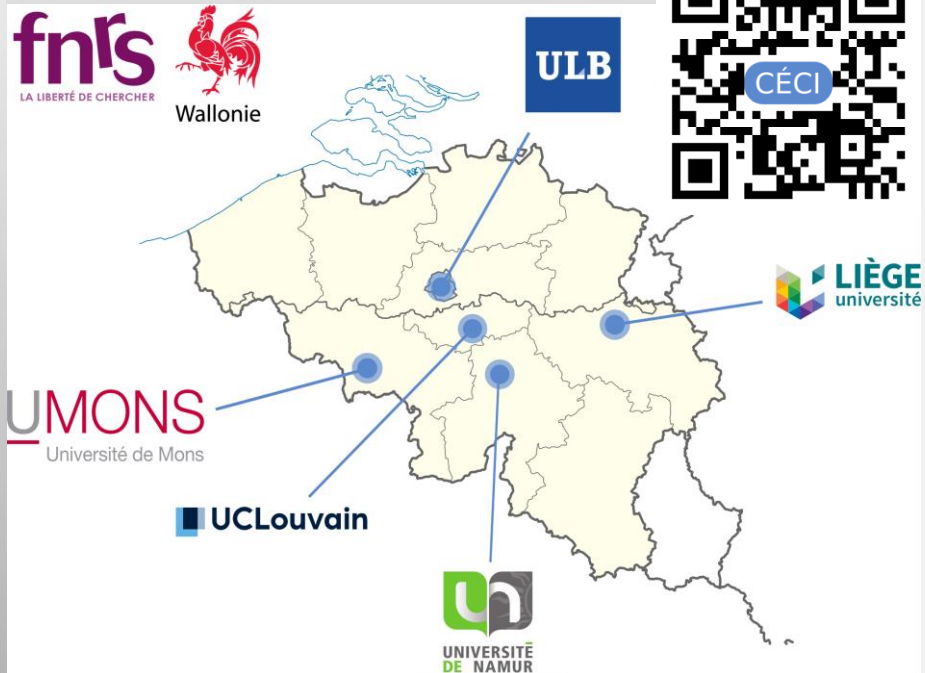
User workstation

Number of systems

Note: getting access to the top TIER requires to demonstrate scalability on the previous ones

TIER-2 in Belgium (academic level)

Wallonia: the **CÉCI** (<http://www.ceci-hpc.be/>)



Flanders: the **VSC** (<https://www.vscentrum.be/>)

Accessible for every researchers of the corresponding universities. **Trainings** are also provided

TIER-1 in Belgium

*HORTENSE, managed by the VSC
(<https://www.vscentrum.be/>)*



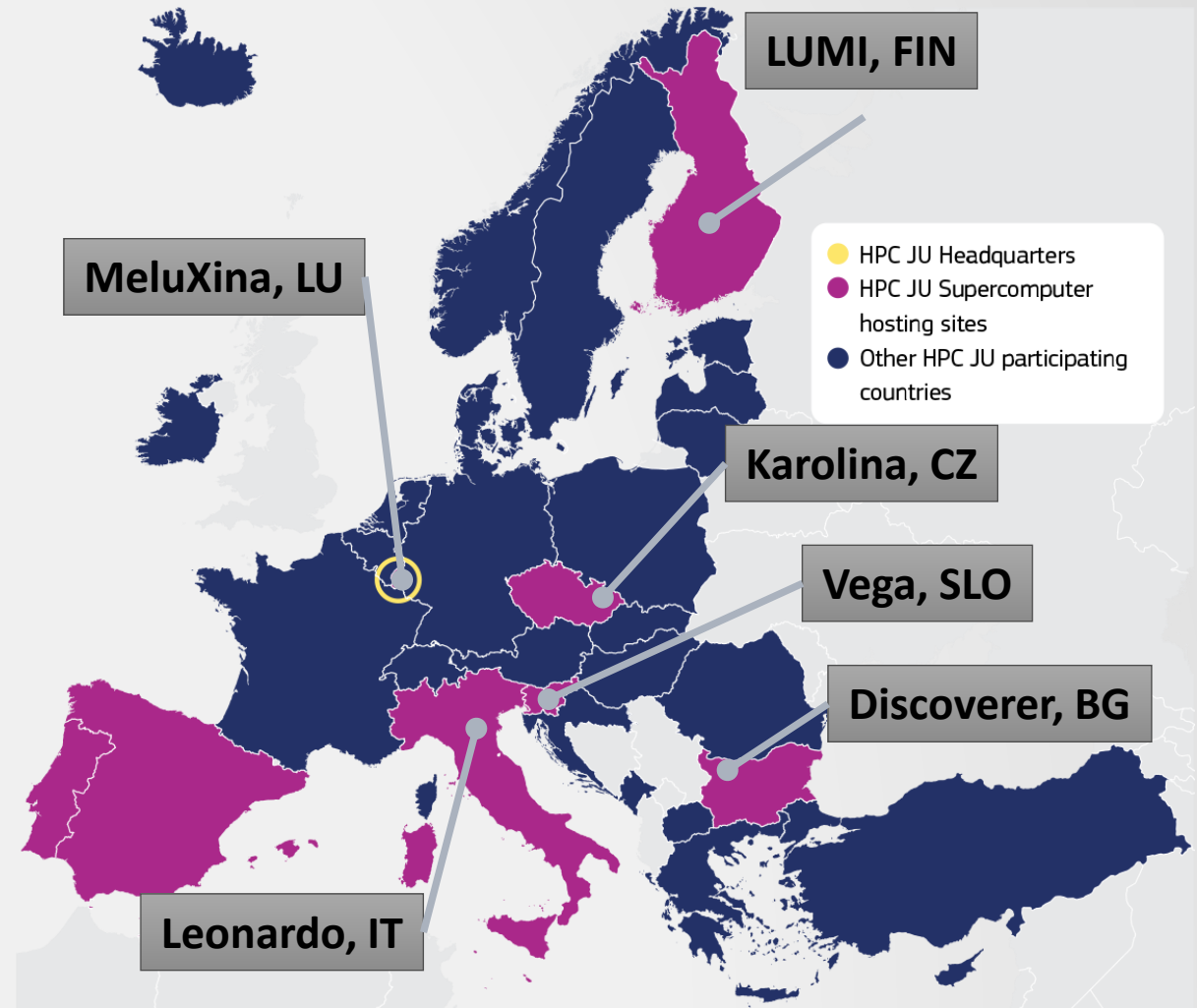
*Lucia, managed by Cenaero
(<https://www.cenaero.be/>)*



© Maxime Prokaz

Provides **access** (through calls) and **support**.

European infrastructures (TIER-0)



LUMI



<https://www.lumi-supercomputer.eu/>
<https://www.enccb.be/LUMI/>

- First european pre-exascale supercomputer
- 100% hydropowered energy
- Regular trainings in Belgium

Conclusions

Conclusions

- HPC is important for actual and future research
- HPC is an active field in Belgium
- We have plenty of supercomputing resources in Belgium
- Don't hesitate to contact us, we're here to help!

→ More information on

- <https://www.enccb.be/>
- <https://www.cec-hpc.be/>
- <https://www.vscentrum.be/>



Thanks!


EURO²



Funded by
the European Union



Avec le soutien de
la



EuroHPC
Joint Undertaking



Wallonie

Funded by the European Union. This work has received funding from the European High Performance Computing Joint Undertaking (JU) and Germany, Bulgaria, Austria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Italy, Lithuania, Latvia, Poland, Portugal, Romania, Slovenia, Spain, Sweden, France, Netherlands, Belgium, Luxembourg, Slovakia, Norway, Türkiye, Republic of North Macedonia, Iceland, Montenegro, Serbia under grant agreement No 101101903.