



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*).

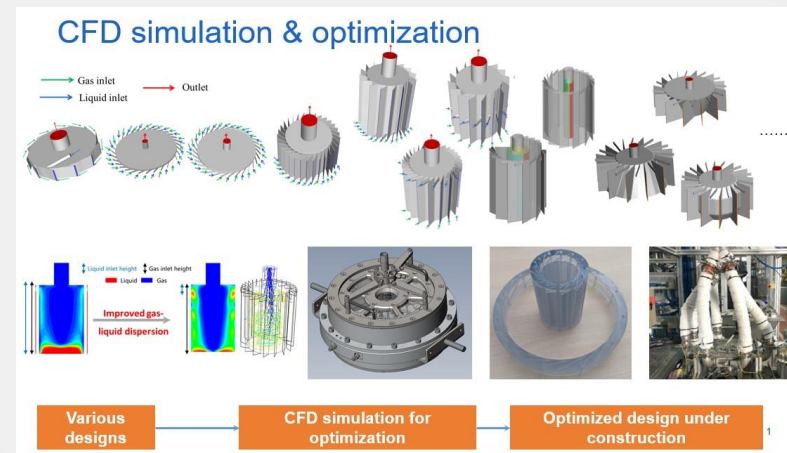
Examples of HPC uses

Have a look at www.enccb.be/stories



Examples: fluid dynamics (CFD)

Optimization of a vortex unit for CO₂ capture



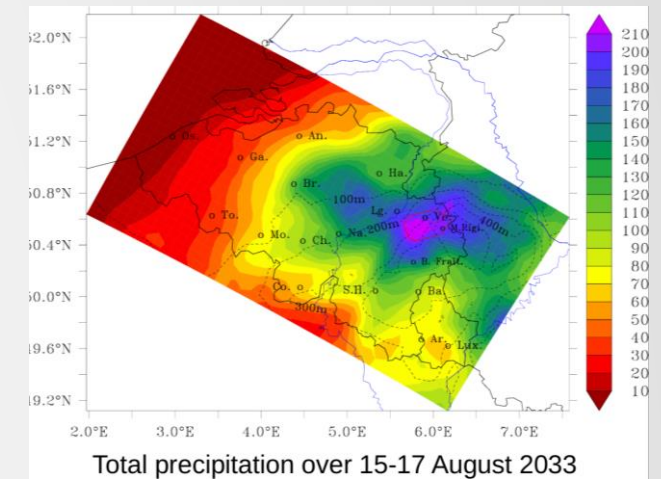
<https://www.enccb.be/usvortexunit>

Aircraft design



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

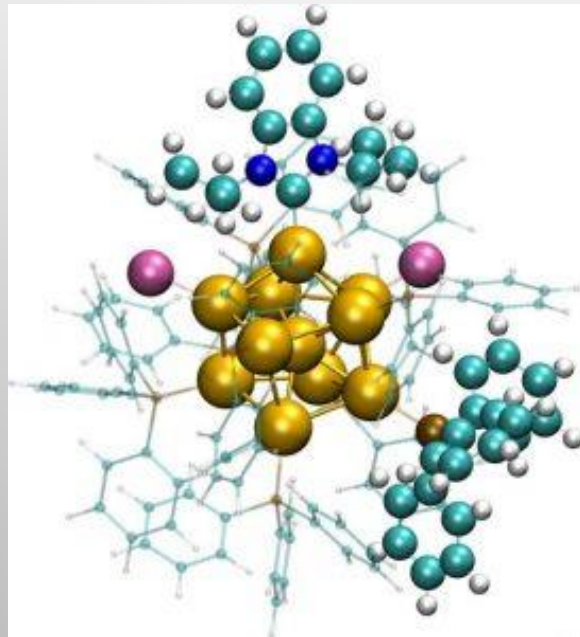
Predicting the climate



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

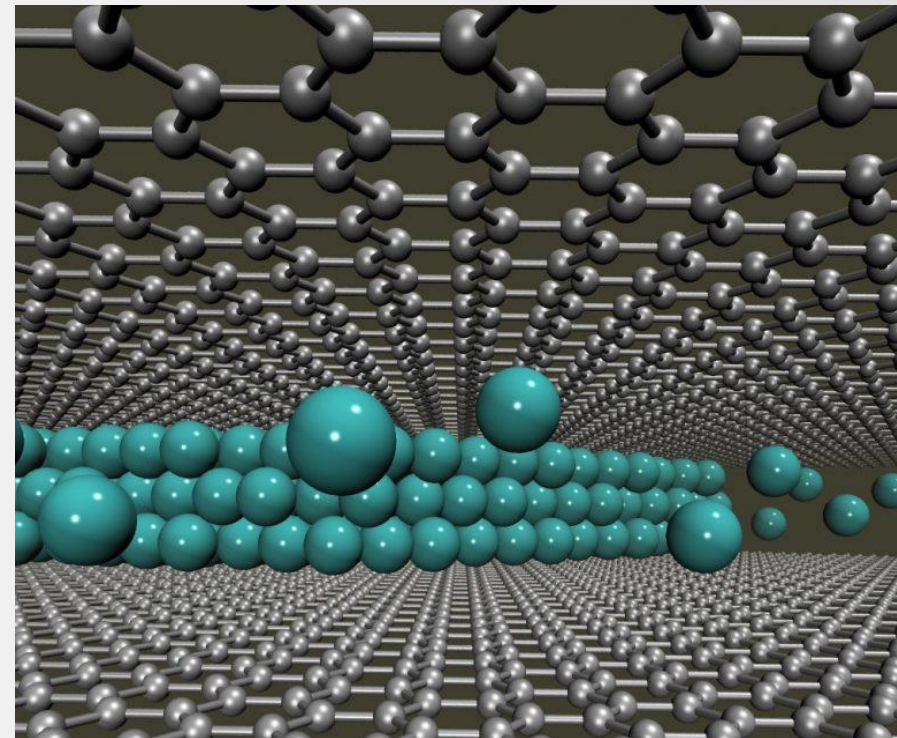
Examples: materials

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



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

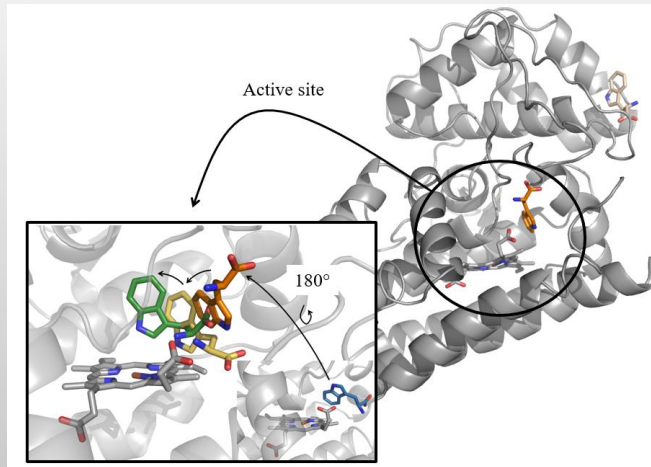
Tailoring the properties of 2D materials



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

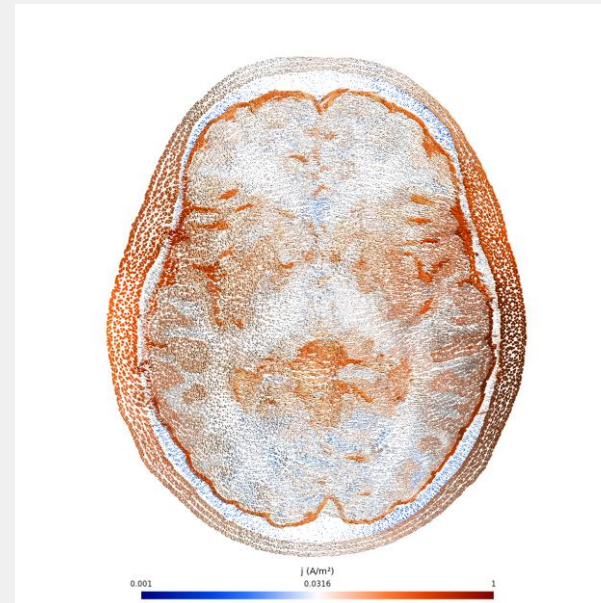
Examples: Biology

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>

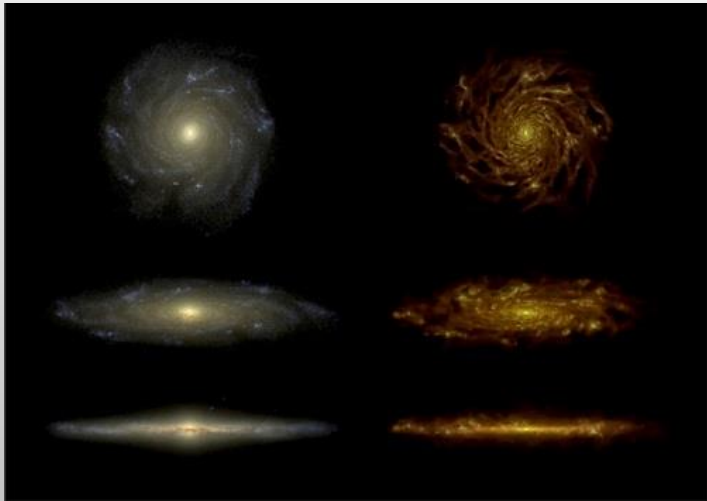
Improving chocolate with supercomputing



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

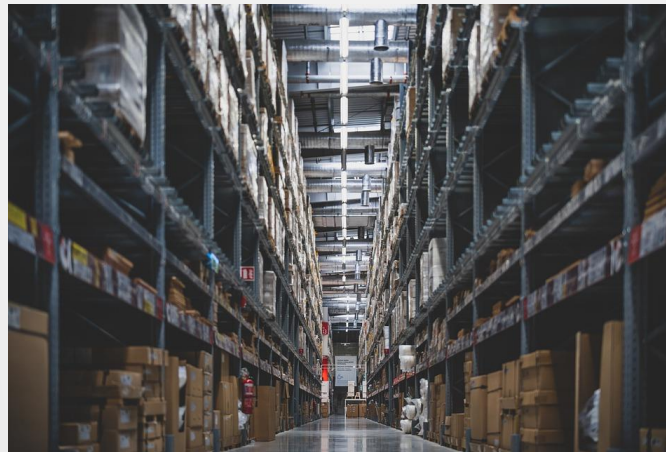
Examples: physics, mathematics, engineering,...

Simulating Galaxies



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

Outsmarting NP-hardness



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

Optimizing particle processes through simulation with MPacts

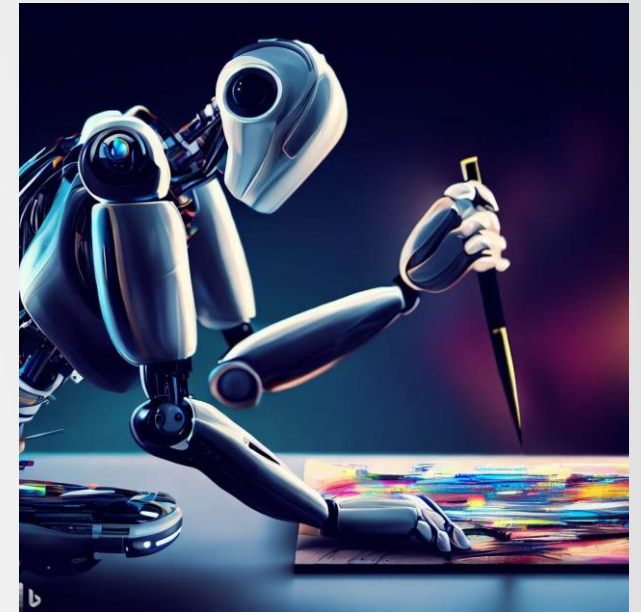


<https://www.enccb.be/usmpacts>

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.

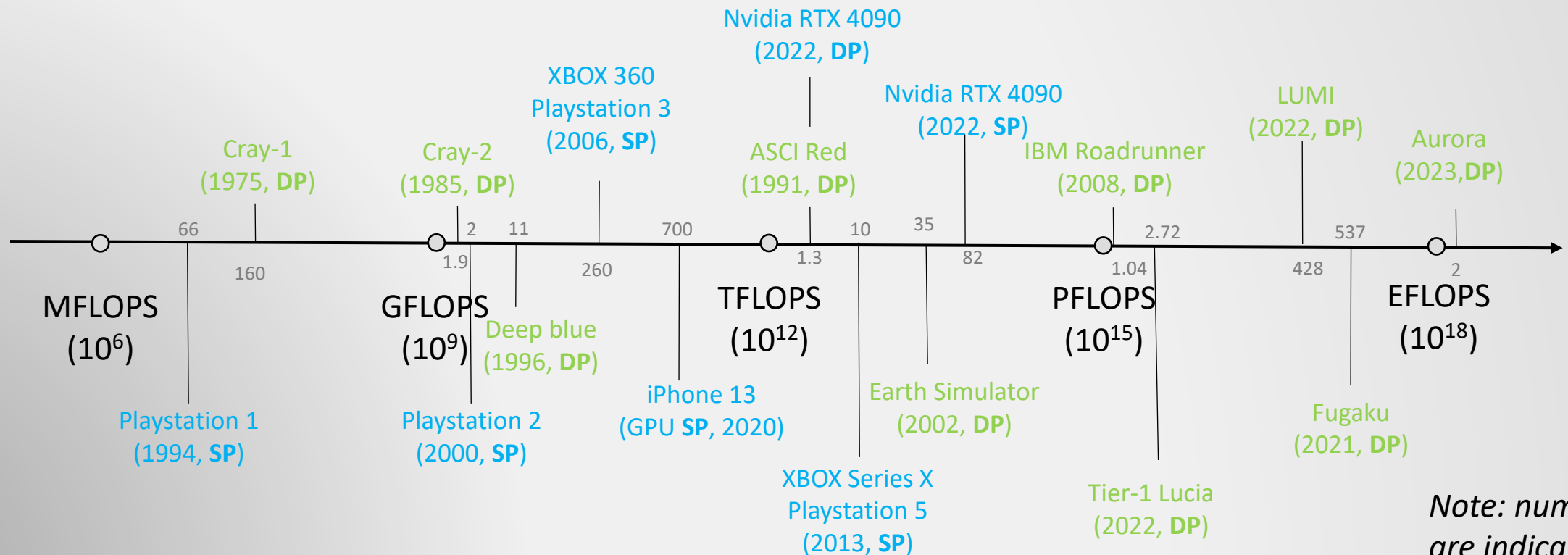


Where are we today?

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!

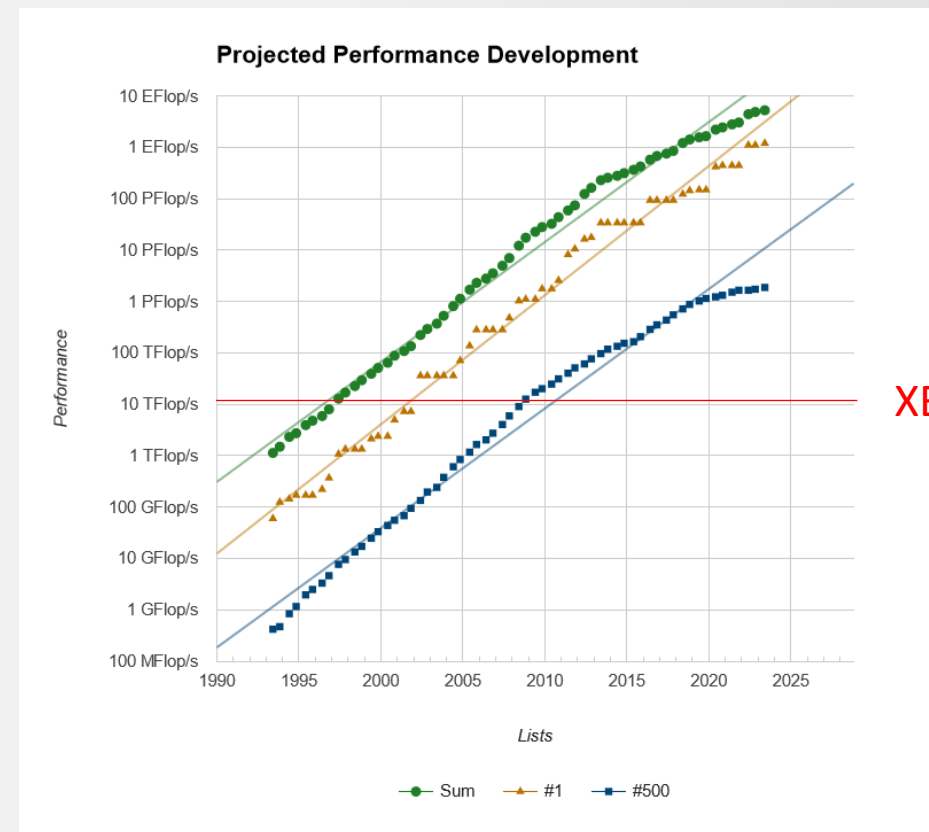


Note: numbers are indicative

The TOP500

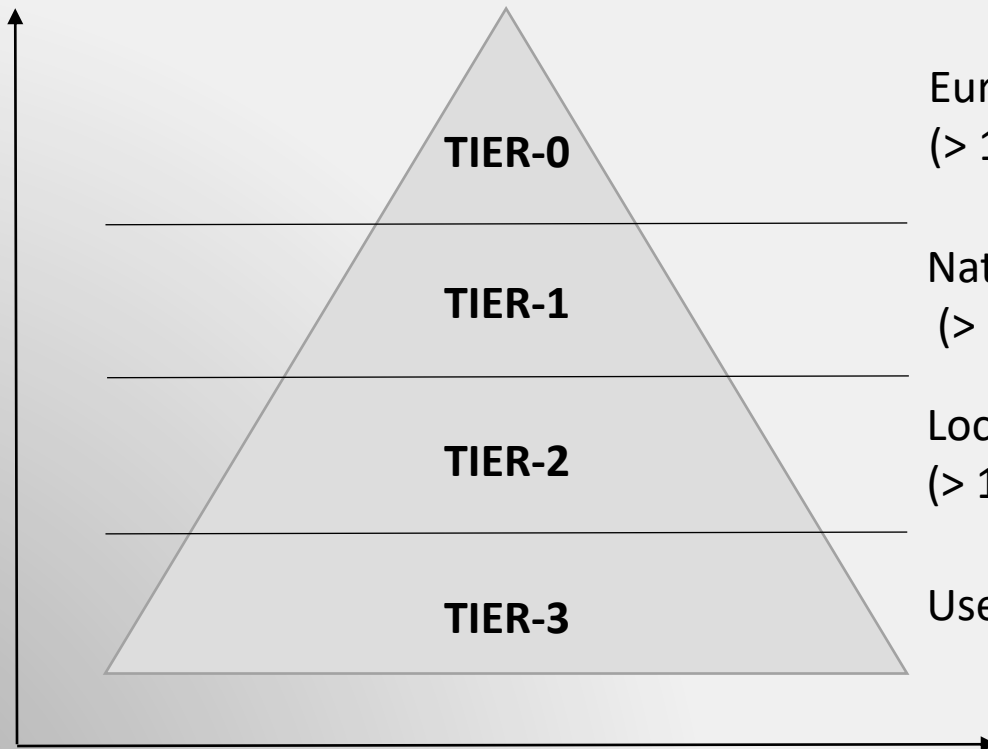
The TOP500 is a list of the fastest supercomputer in the world

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



Supercomputers in Europe

Capability (~FLOPS)



European centers
(> 100 PFLOPS)

National centers
(> 1 PFLOPS)

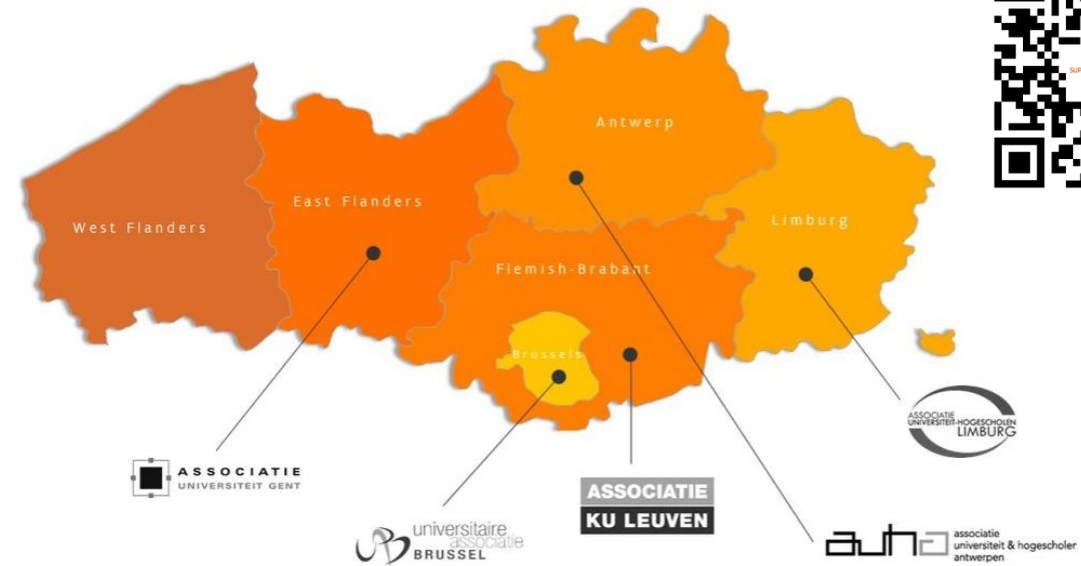
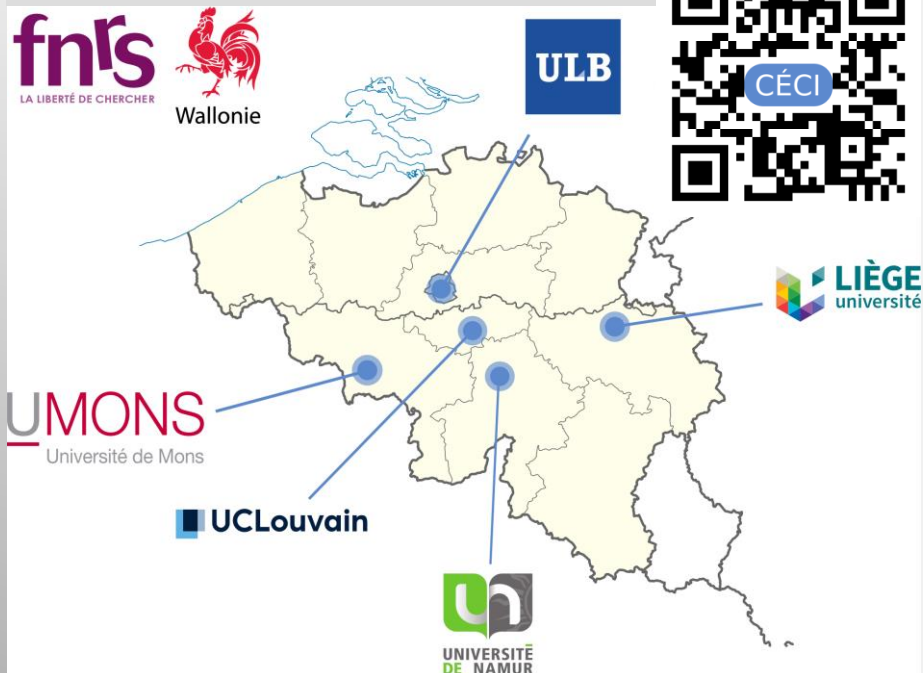
Local (academic) centers
(> 100 TFLOPS)

User workstation

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.cec-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/>)*



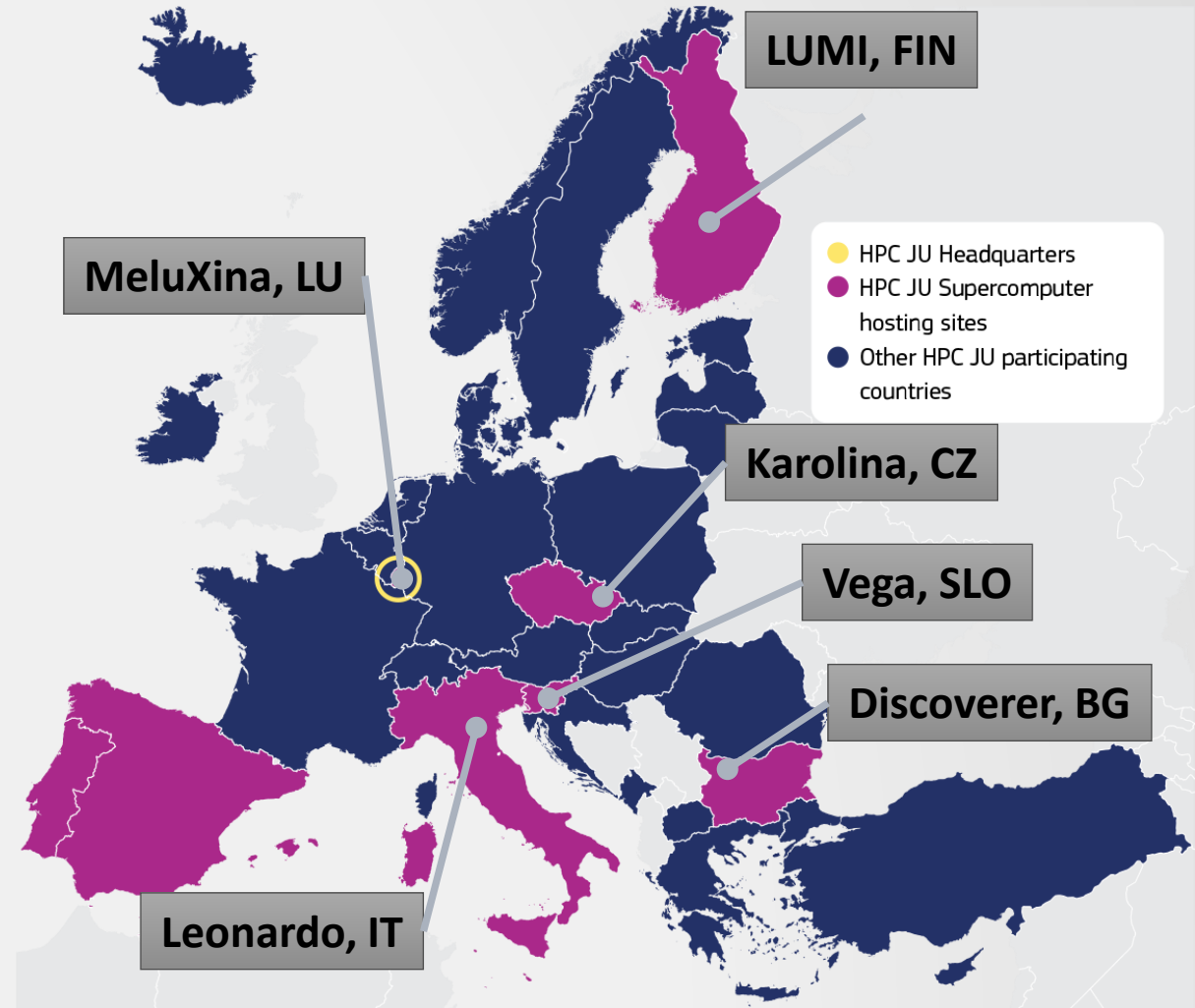
Provides **access** (through calls) and **support**.

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



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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!



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EuroHPC
Joint Undertaking



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