



**Barcelona
Supercomputing
Center**
Centro Nacional de Supercomputación



Generalitat de Catalunya
**Departament de Recerca
i Universitats**



GOBIERNO
DE ESPAÑA
MINISTERIO
DE CIENCIA
E INNOVACIÓN



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH



UNIÓN EUROPEA
Fondo Europeo de Desarrollo Regional



**Barcelona
Supercomputing
Center**

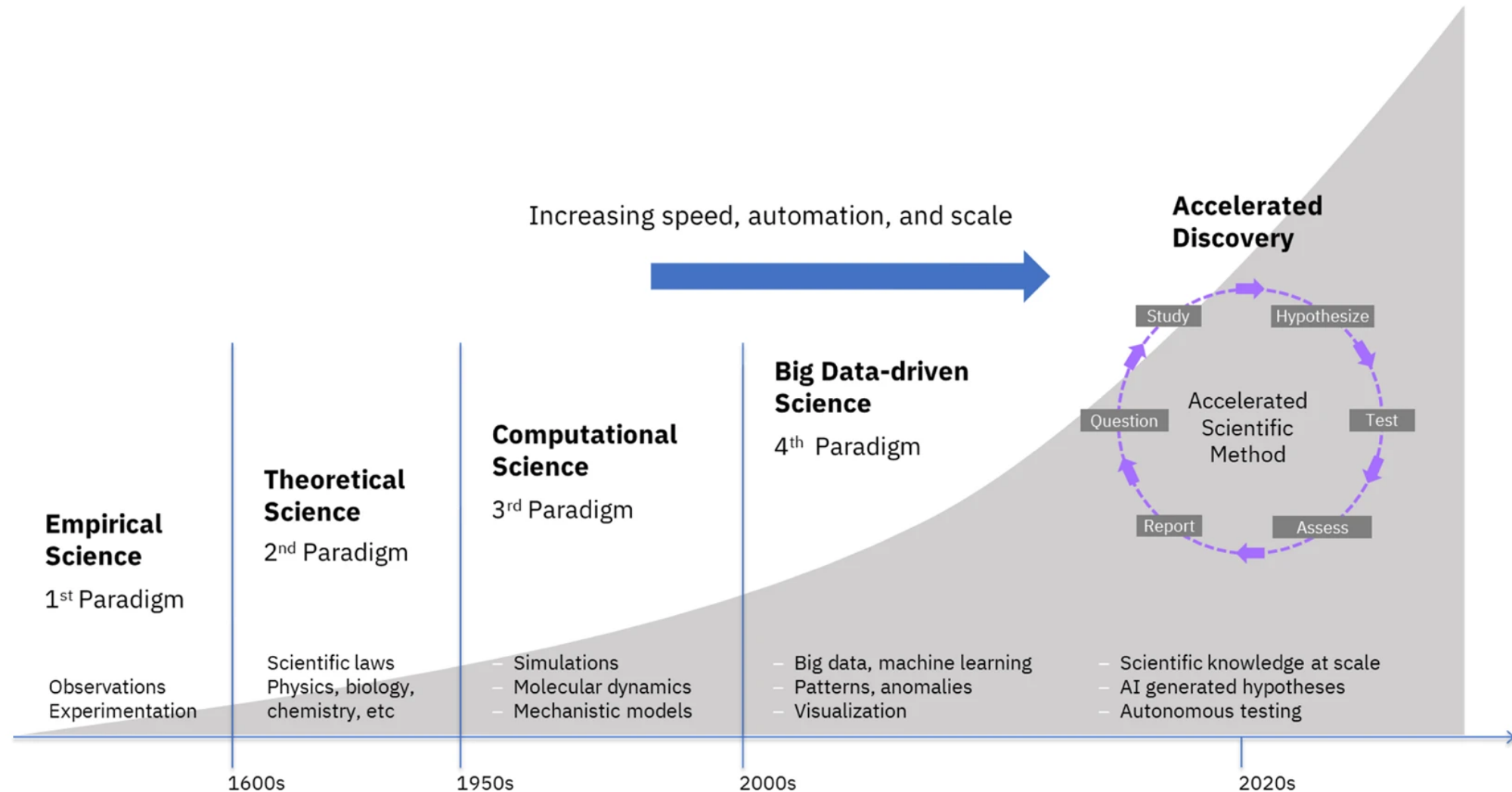
Centro Nacional de Supercomputación

BSC: Europa y la Supercomputación

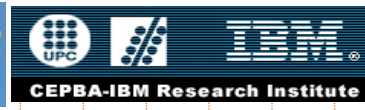
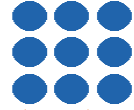
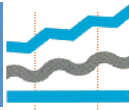
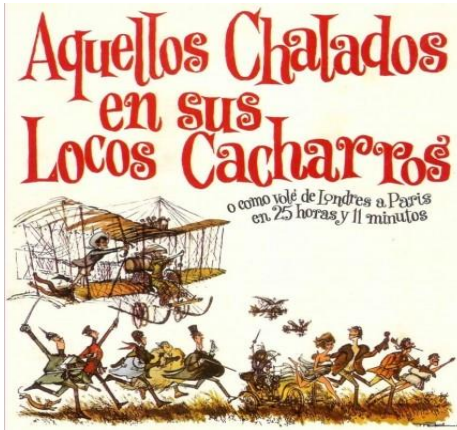
Prof. Mateo Valero
Director

México, 12 de junio 2025

The Evolution of the Research Paradigm



Venimos de muy lejos ...



Barcelona Supercomputing Center
Centro Nacional de Supercomputación



Parsys Multiprocessor



Parsytec CCI-8D
4.45 Gflop/s



Compaq GS-140
12.5 Gflop/s



Compaq GS-160
23.4 Gflop/s



BULL NovaScale 5160
48 Gflop/s



Maricel
14.4 Tflops, 20 KW



Transputer cluster



Convex C3800



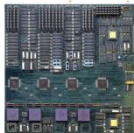
SGI Origin 2000
32 Gflop/s



SGI Altix 4700
819.2 Gflops



SL8500
6 Petabytes



Research prototypes



Connection Machine CM-200
0.64 Gflop/s



IBM RS-6000 SP & IBM p630
192+144 Gflop/s



IBM PP970 / Myrinet
MareNostrum
42.35, 94.21 Tflop/s



Barcelona Supercomputing Center
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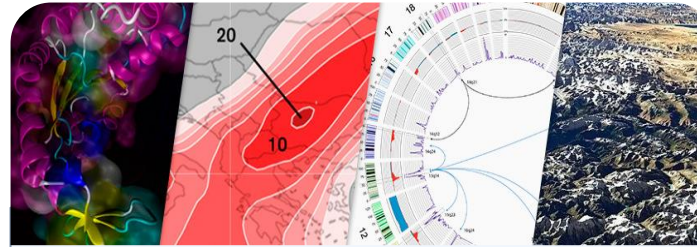
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010

Barcelona Supercomputing Center Centro Nacional de Supercomputación

BSC-CNS objectives



Supercomputing services
to Spanish and EU researchers



R&D in Computer, Life, Earth and
Engineering Sciences



PhD programme, technology
transfer, public engagement

**BSC-CNS is
a consortium
that includes**

Spanish Government

60%



Catalan Government

30%



Univ. Politècnica de Catalunya (UPC)

10%



EuroHPC: towards European HPC technologies

#EuroHPC Joint Undertaking

The European High Performance Computing Joint Undertaking (EuroHPC JU) will pool European resources to develop top-of-the range exascale supercomputers for processing big data, based on competitive European technology.

Member countries are Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Türkiye and United Kingdom.



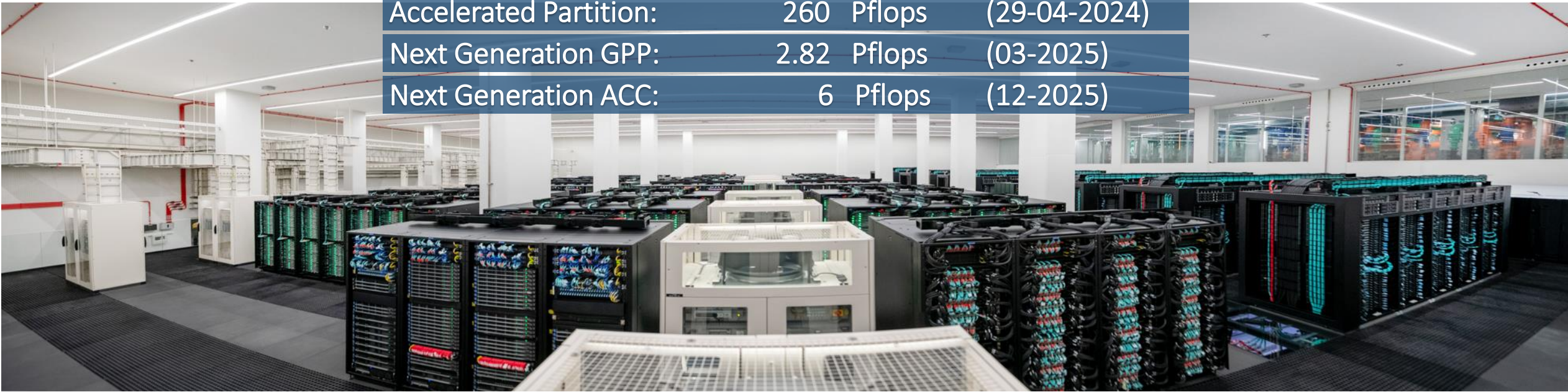
“A new legal and funding structure – the EuroHPC Joint Undertaking – shall acquire, build and deploy across Europe a world-class High-Performance Computing (HPC) infrastructure.

It will also support a research and innovation programme to develop the technologies and machines (hardware) as well as the applications (software) that would run on these supercomputers.”

MareNostrum 5

Total peak performance: **315.2 Pflops**

General Purpose Partition:	46.4 Pflops	(29-04-2024)
Accelerated Partition:	260 Pflops	(29-04-2024)
Next Generation GPP:	2.82 Pflops	(03-2025)
Next Generation ACC:	6 Pflops	(12-2025)



MareNostrum 1

2004 – 42.3 Tflops

1st Europe / 4th World

New technologies

MareNostrum 2

2006 – 94.2 Tflops

1st Europe / 5th World

New technologies

MareNostrum 3

2012 – 1.1 Pflops

12th Europe / 36th
World

MareNostrum 4

2017 – 11.1 Pflops

2nd Europe / 13th
World

New technologies

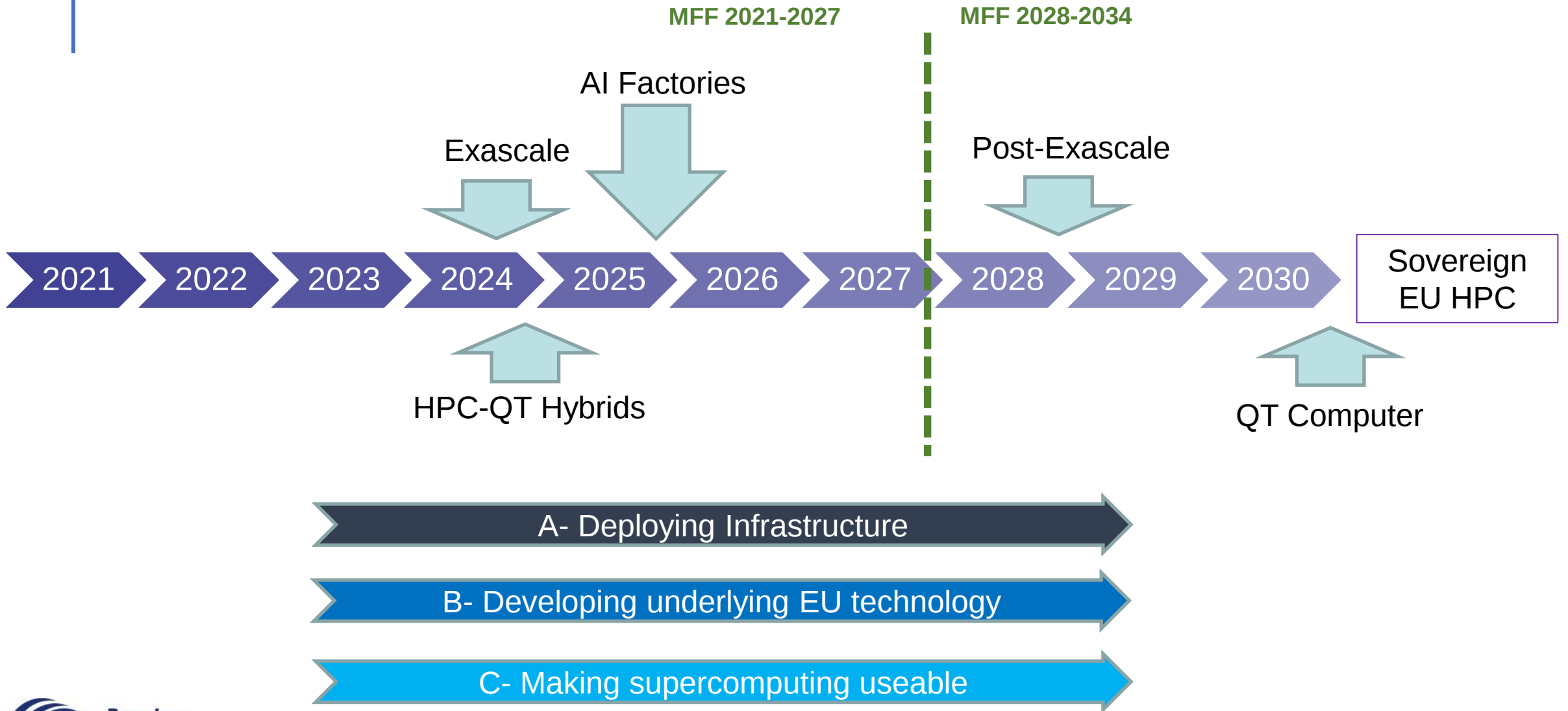
MareNostrum 5

2022

260 + 46.4 Pflops

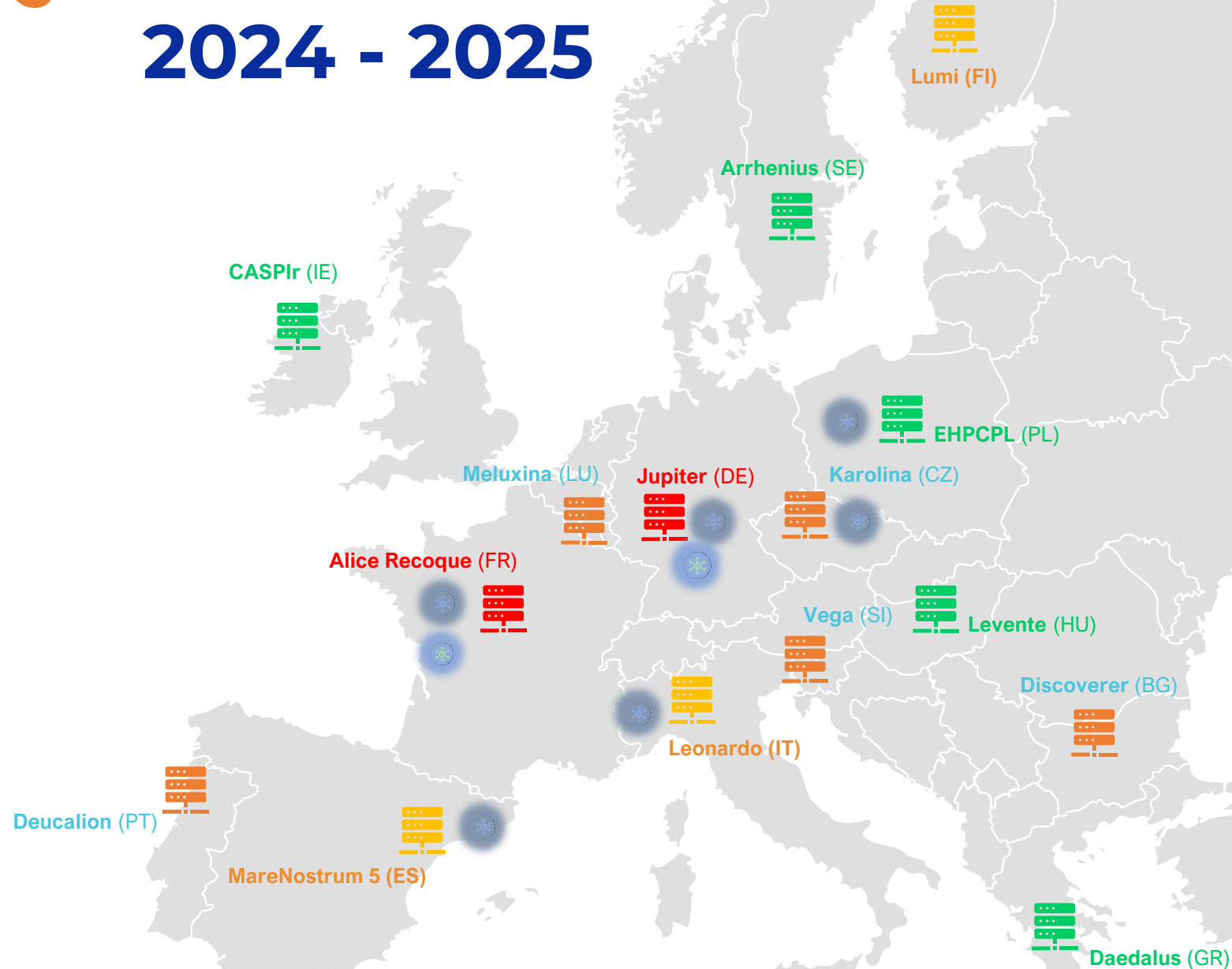
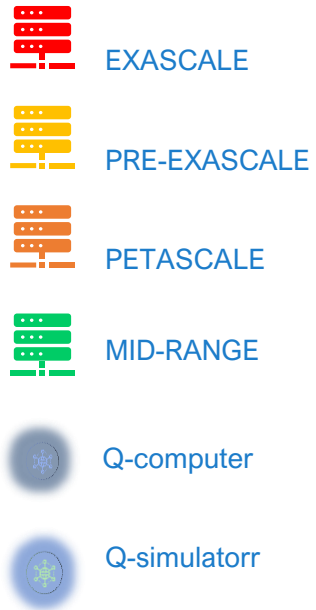
8th and 19th World
3rd and 7th Europe

EuroHPC Roadmap 2025 - 2027



HPC – Quantum infrastructure

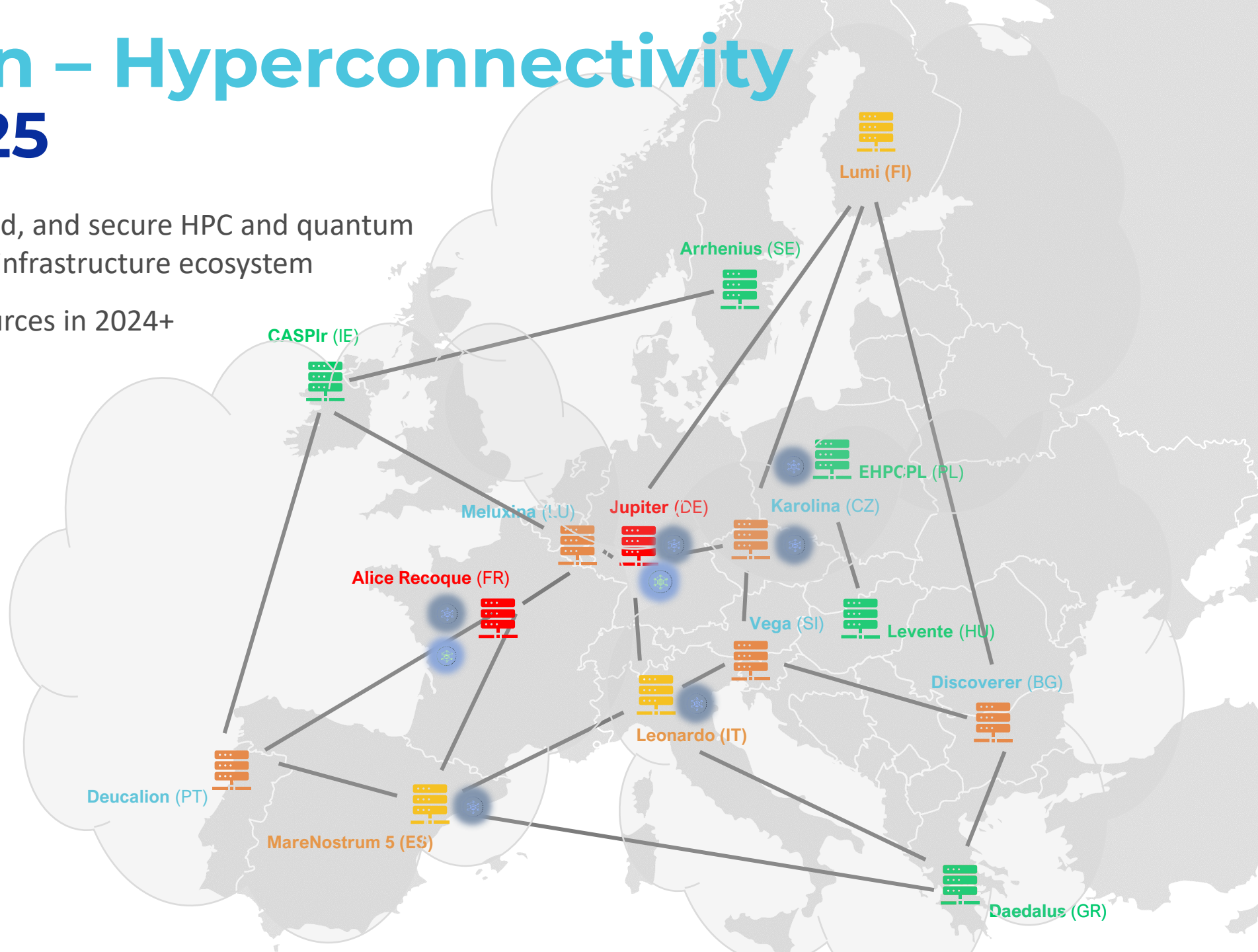
2024 - 2025



Federation – Hyperconnectivity

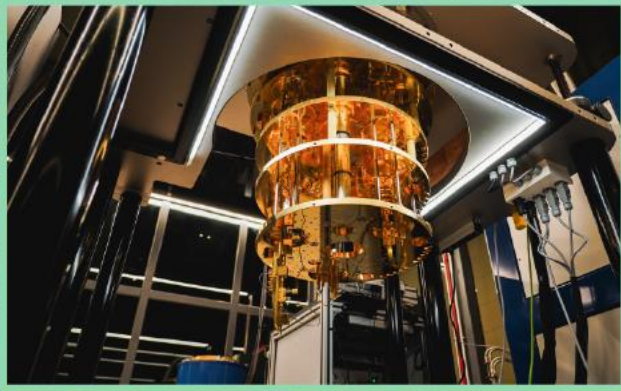
2024+ / 2025

- A hyper-connected, federated, and secure HPC and quantum computing service and data infrastructure ecosystem
- Federation of EuroHPC resources in 2024+
- Hyperconnectivity in 2025



MareNostrum 5 - ONA

The Quantum partition



BSC in numbers

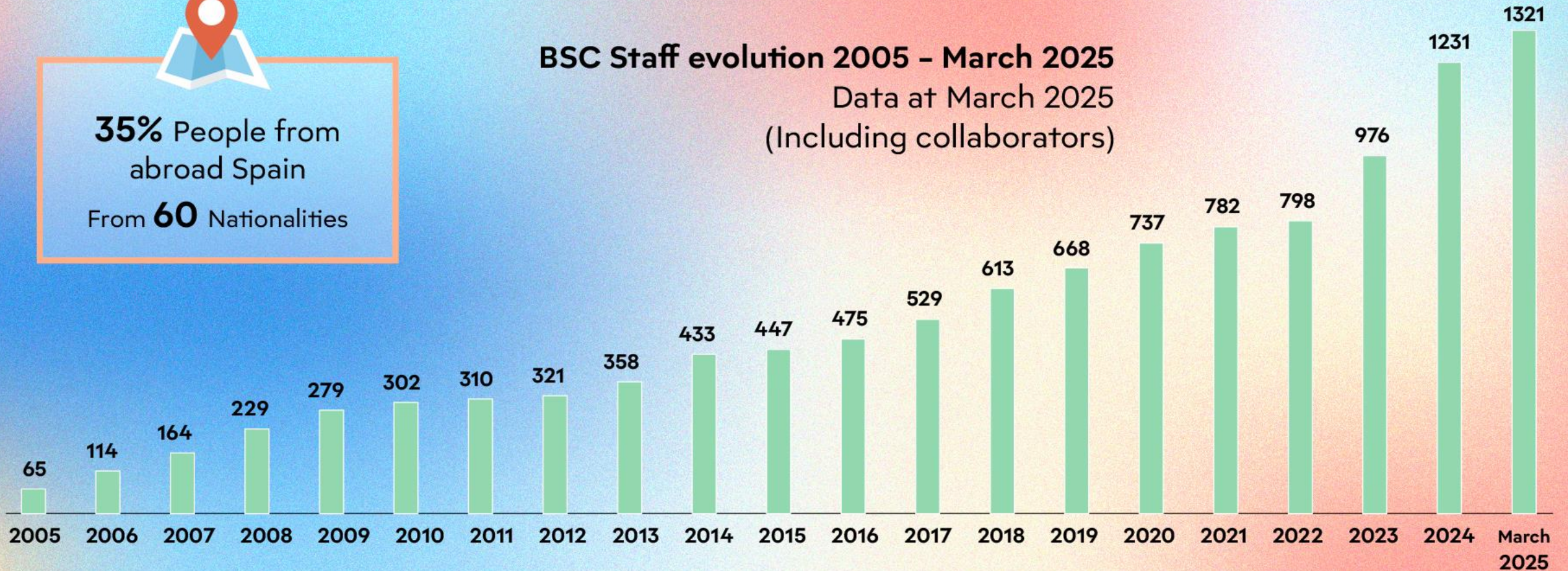
People



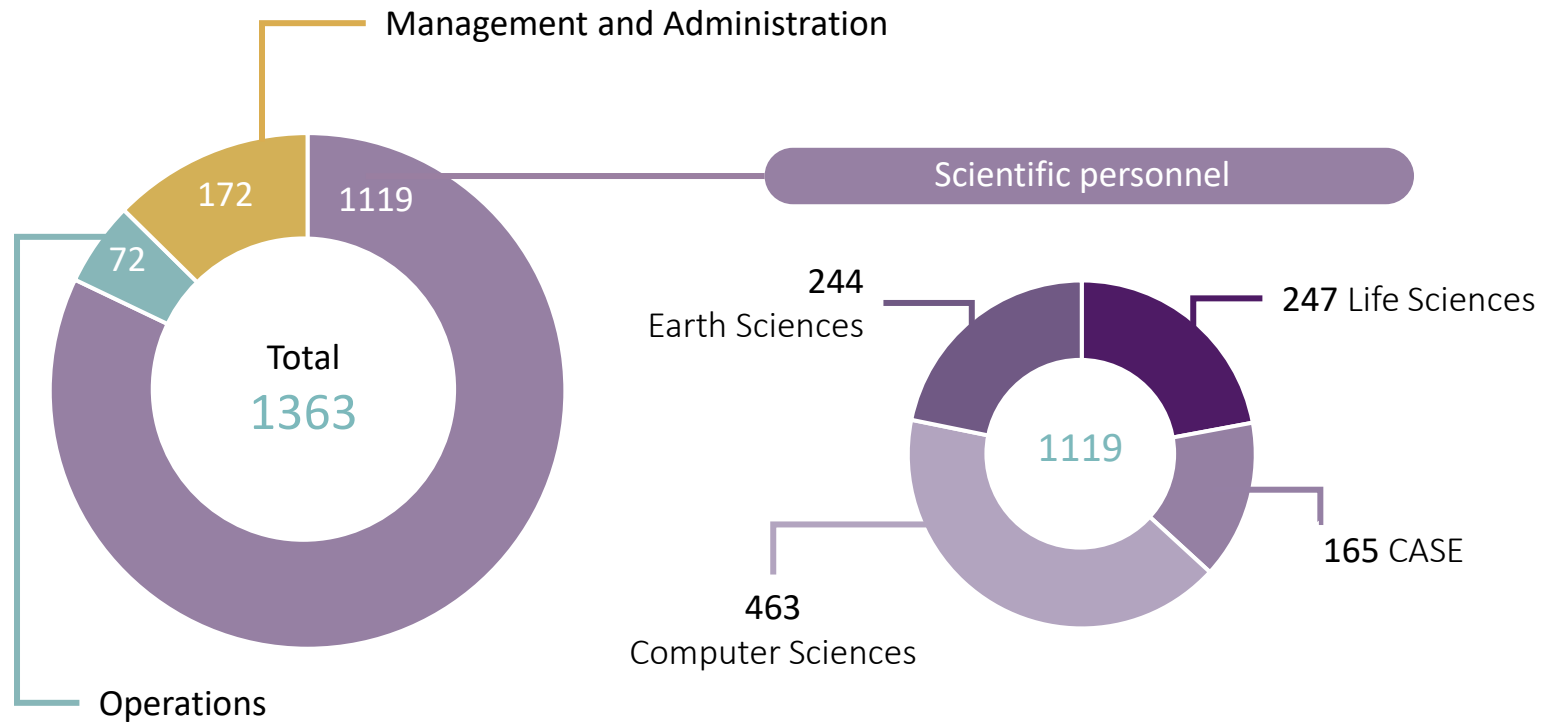
35% People from
abroad Spain
From **60** Nationalities

BSC Staff evolution 2005 - March 2025

Data at March 2025
(Including collaborators)



BSC in numbers



Spanish Supercomputing Network (RES), since 2006

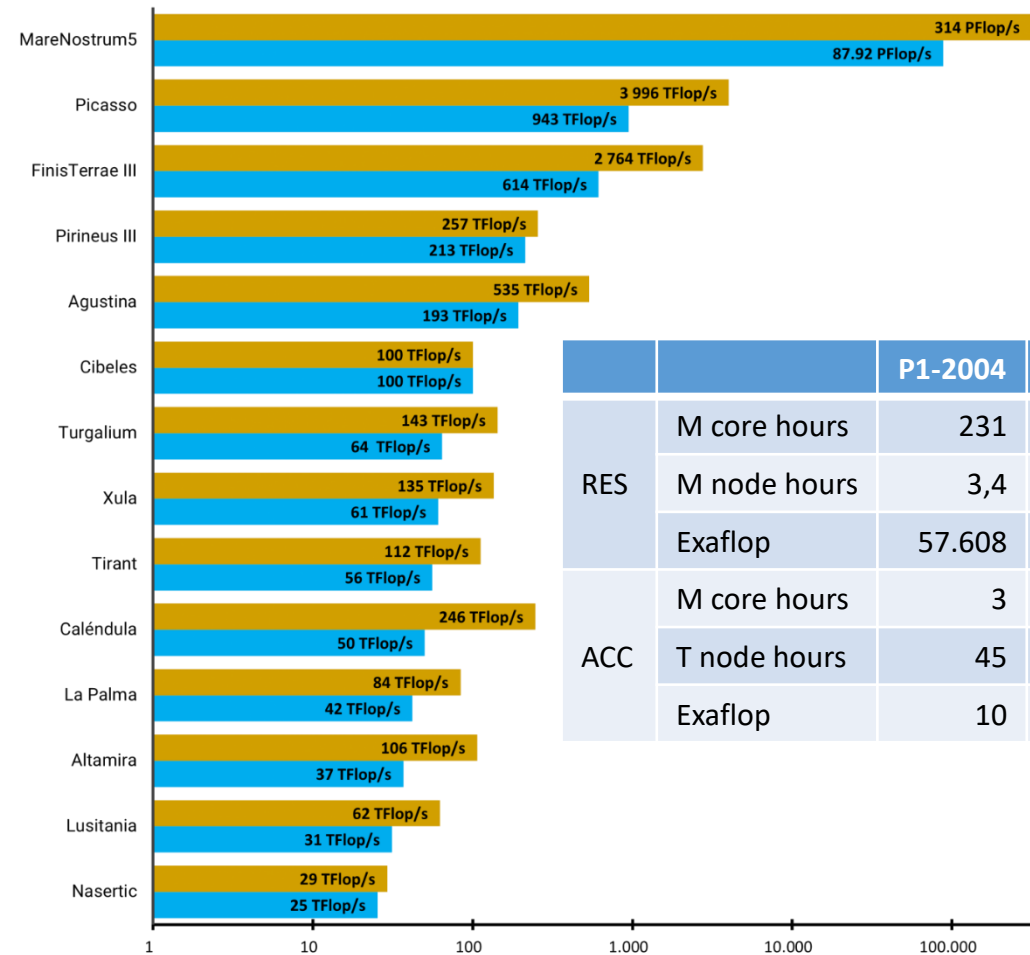


*HPC and data management resources
for the scientific community*

- 14 institutions
 - 16 supercomputers
 - 9 data management centres
- +320 PFlop/s combined capacity
- +180 PB storage in 2022 (and growing)
- +1.500 million CPU hours/year ²⁰²⁴
- +1.000 regular users
- +200 scientific papers annually
- 3 HPC/AI calls per year
- 1 Data call per year
- Continuous call for AI small access
- Applications Support Teams
- Member of Spanish Unique Scientific and Technical Infrastructure network (ICTS)
- Access Committee and Users Committee
- EuroHPC National Competence Centre
- Coordinated by **BSC-CNS**



Spanish Supercomputing Network



		P1-2004	P2-2004	factor
RES	M core hours	231	580	x 2,51
	M node hours	3,4	5,7	x 1,68
	Exaflop	57.608	497.000	x 8,63
ACC	M core hours	3	58	x 19,33
	T node hours	45	745	x 16,56
	Exaflop	10	383	x 38,30

Access to Computing (and AI) services

COMPETITIVE ACCESS TO LIMITED RESOURCES

→ Competitive calls (~50% success rate):

- 3 calls/year; around 1.500 M CPU h allocated per year
- 4 month access period to HPC resources
- Awards based on scientific excellence

→ Open to:

- Academic and public administration researchers
- SME researchers for open R&D projects
- Support to new EU projects
- Novel users without prior HPC experience

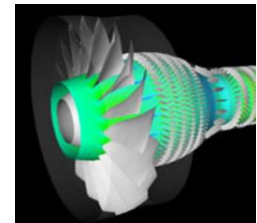
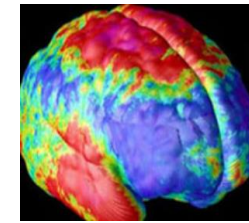
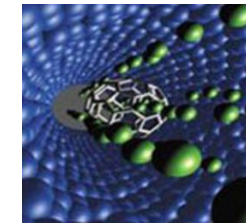
→ Please acknowledge RES in publications

SCIENTIFIC AREAS

Open to all science areas

Dedicated evaluation panels for:

- Astronomy, Space and Earth Sciences
- Physics
- Mathematics and Engineering
- Life and Health Sciences
- Homogeneous Chemistry
- Heterogeneous Chemistry and Solids



Access to Data Management services

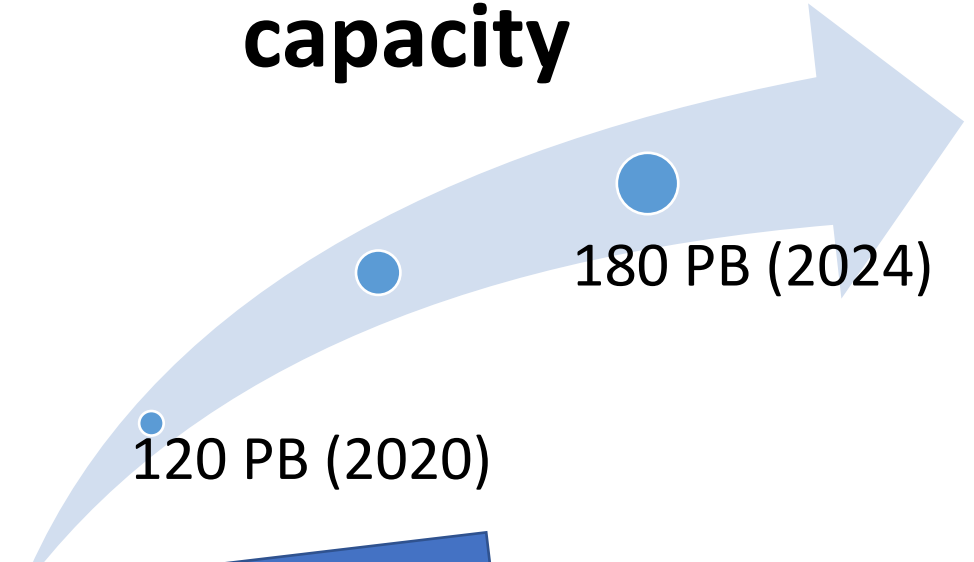
COMPETITIVE ACCESS TO LIMITED RESOURCES

- Service provided to store, share, publish, or connect large data sets with data and/or computing services on all the RES's nodes.
- Open to scientific groups with the need to store large volumes of data associated with their exploitation services can respond to the call.
- One yearly call:
 - RES resources are awarded according to criteria of excellence and impact of the research activity and are free for all research groups
- Specialized support service

200 TB to 1 PB
3 to 5 years

Next call opening in
November 2023

Data storage capacity



120 PB (2020)

180 PB (2024)

Access to Artificial Intelligence services

New
(Sept 2023)

- Hardware and software resources to support AI projects for open R&D&I
 - MareNostrum 5, Finisterrae III, Pirineus III (+new ones soon)
 - Tensorflow, Pytorch, CUDA Toolkit, Pandas, xgboost, scikit-learn, keras, numpy
- Access modes
 - **Large-scale activities**, with submission and review coupled to HPC calls
 - **Mentored activities** that will include expert support
 - **Short-range activities** *detailed in the next slide*



Short-range Artificial Intelligence access

New
(Sept 2023)

- Rolling call, continuously open
- Light application through RES standard forms
 - Administrative and technical evaluation only
 - Limited resources, shared among various users
- Objective: development and validation of models
- Year evaluation of results, with recommendations to be addressed before access renewal



Innovation access for industry

New
(July 2024)

- Under evaluation at BSC/MareNostrum
- Test in Q2 2024, with up to 2 million node hours: CPU or GPU
- Test on BSC Spin-off
- Expected in production for calls in 2025, we need time to understand the quality of the processes proposed

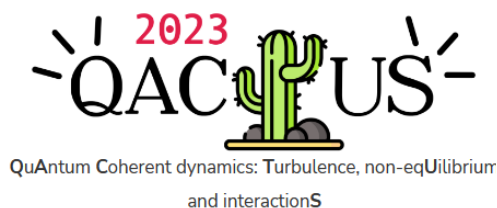


RES events: Networking, training and sharing knowledge

Annual RES Users Conference



Scientific seminars (sponsored by RES)



PUMPS+AI 2023
Summer School
June 26-30th, 2023
Barcelona



Technical training workshops



RISC2

2020 - 2023

RISC2

16 PARTNERS



CeNAT | Cinvestav | COPPETEC Fundação Coordenação de Projetos, Pesquisas e Estudos Tecnológicos do Rio de Janeiro | Laboratório Nacional de Computação Científica (LNCC) | Universidade de Buenos Aires | Universidad de Chile | Universidad Industrial de Santander (UIS) | Universidad de la República (UdelaR) |

Atos | Barcelona Supercomputing Center (BSC-CNS) | Ciemat | CINECA | INESC TEC | Inria | | Jülich | Universidade de Coimbra |



EXPECTED IMPACTS

Develop a realistic HPC research cooperation **roadmap** with clearly identified application areas, hardware/system requirements and funding schemes.

Set up a sustainable **network** focusing on activities to support and promote the coordination of the research and industrial communities using HPC and the policymakers from both regions.

Improve sharing of information and expertise to solve common societal problems with the use of HPC, reflected in **Joint Action Plans**.

Distributed supercomputing infrastructure

26 members, including **5 Hosting Members**
(Switzerland, France, Germany, Italy and Spain)

~ **220 PFlops/s** of peak performance on **7 world-class systems**

> **30.000M core hours** for research awarded

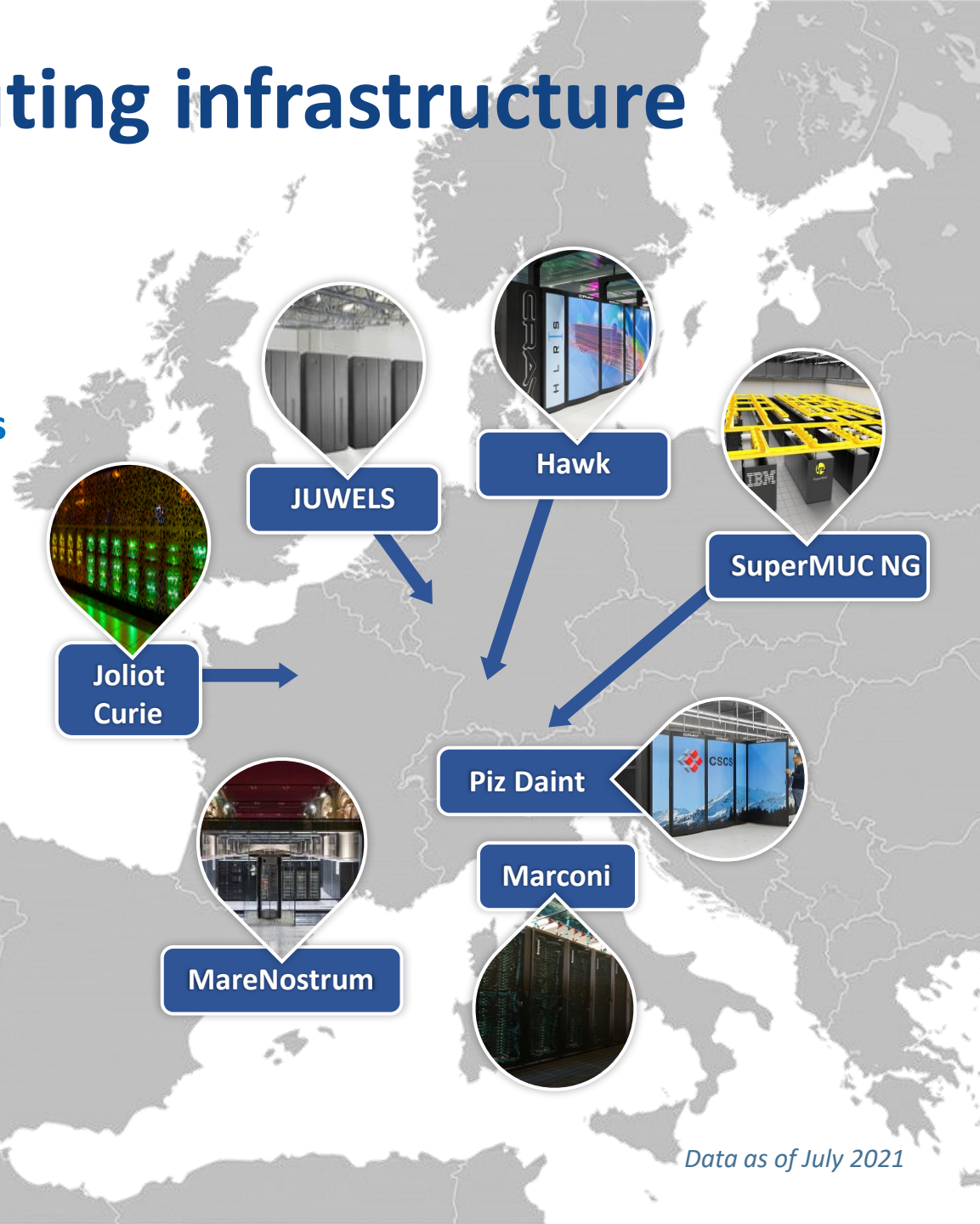
873 scientific projects **enabled**

> **17.000** people trained

> **65** companies supported



Access prace-ri.eu/hpc-access



Centers of excellence in HPC applications

BSC leads



Centre of Excellence in
Combustion



Excellence in
Simulation of Weather
and Climate in Europe



Centre of Excellence in
Personalised Medicine

BSC participates

AISEE

AI and Simulation-
based Engineering
at Exascale



Centre of Excellence
for Biomolecular
Research



Centre of Excellence in
Solid Earth



Centre of Excellence
on Computational
Biomedicine



European Centre of
Excellence for
Engineering
Applications



Materials design at the
eXascale



Novel Materials
Discovery



A path to extreme-
scale computing for
industry and academia

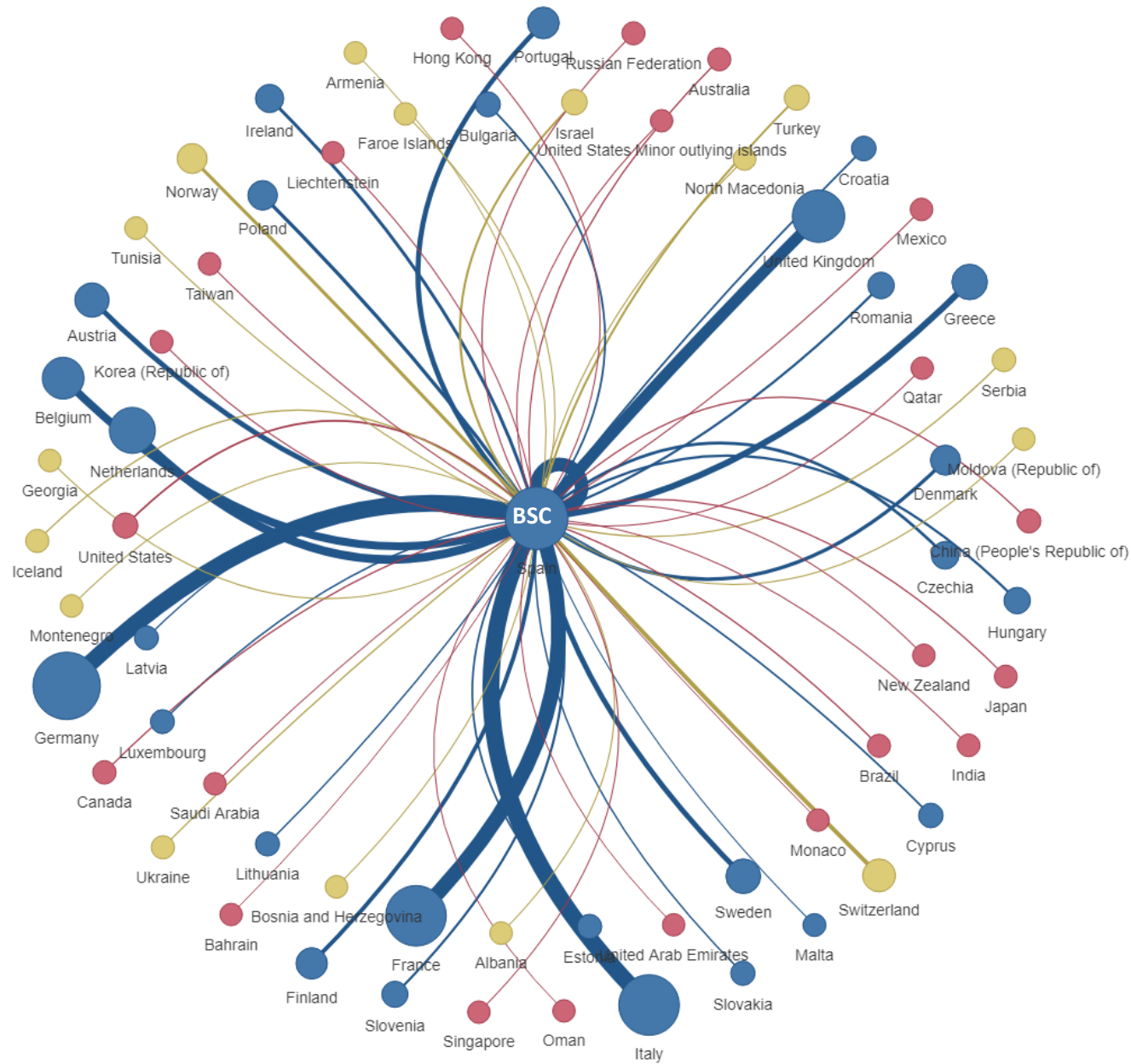


HPC and Big Data
Technologies for
Global Systems



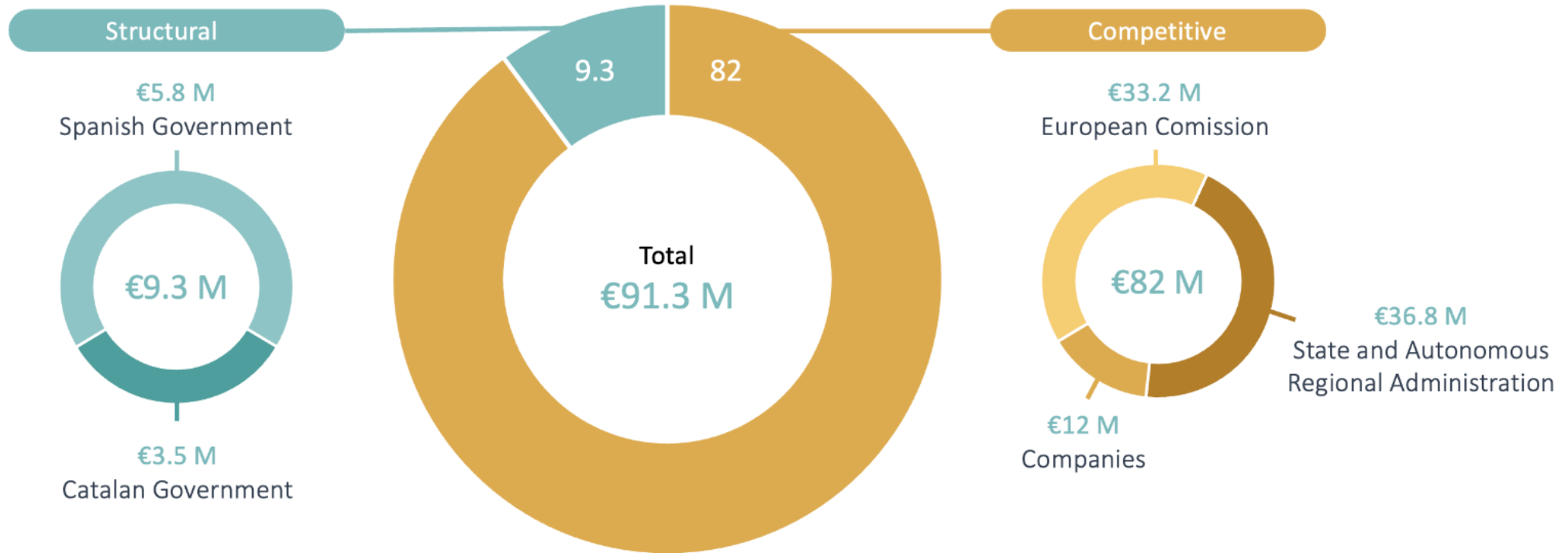
Targeting Real
chemical accuracy
at the EXascale

BSC Collaboration by Country



	Associated Countries
	Member States
	Other Countries wich get Exceptional Funding

BSC in numbers

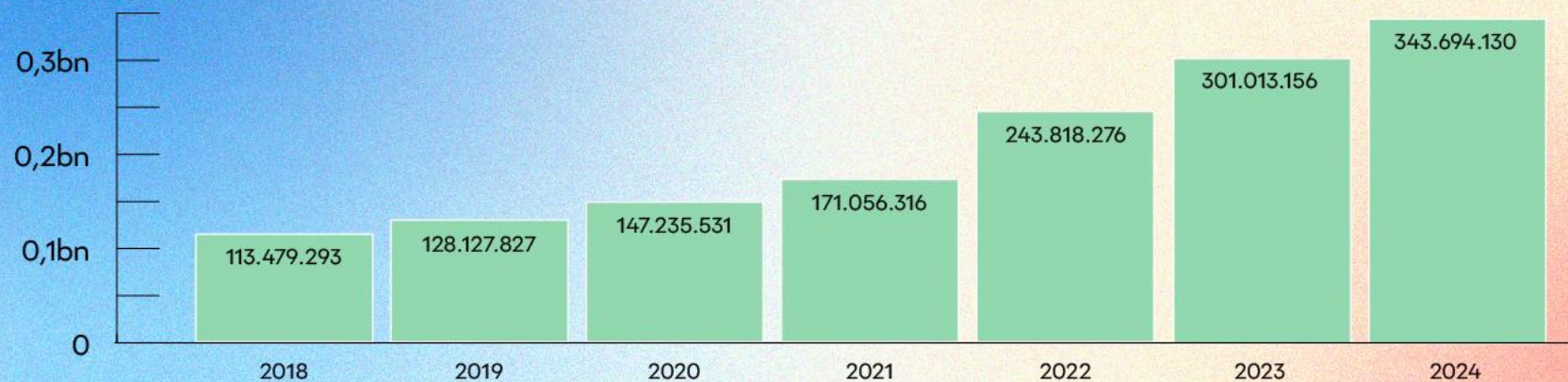


Running Projects

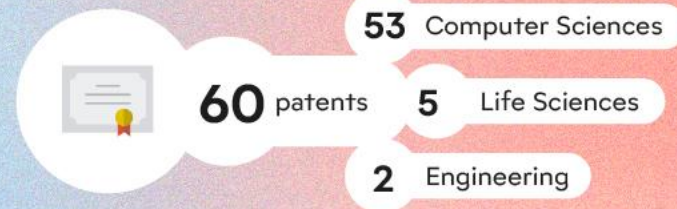
December 2024

Total	Other EU	Horizon Europe	H2020	Others	National	Personnel Grants	Contracts
444 Projects 318.363.794 € BSC Funding	30 Projects 13.083.506 € BSC Funding	112 Projects 61.577.679 € BSC Funding	25 Projects 23.313.399 € BSC Funding	36 Projects 6.853.141 € BSC Funding	130 Projects 184.089.529 € BSC Funding	54 Projects 5.165.994 € BSC Funding	56 Projects 24.280.528 € BSC Funding

Evolution Project Volume in € (Past 7 years)



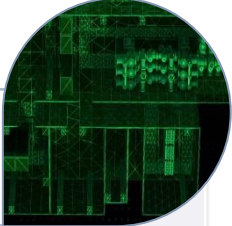
Technology Transfer at BSC



Spin offs



Collaborations with Companies



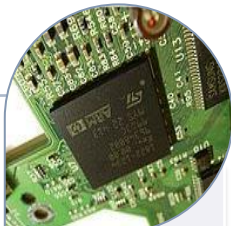
Research in the fields of energy aware scheduling for HPC systems, Hybrid AI for edge computing, and visualization of HPC environment



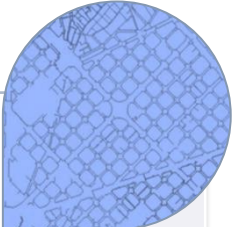
Research performance analysis tools, HPC architectures and application usage on different domains



Collaboration agreement for the development of advanced systems of deep learning with applications to banking services



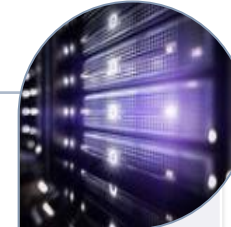
The ARM-BSC Center of Excellence broads the scope of collaboration to HPC for automotive, from scientific computing to real-time systems



BSC and CISCO are collaborating in the fields of Fog computing paradigms, IoT environments and Data Center computing platforms.



Research focus in script language platform, math libraries migration and optimization using OpenMP programming model



Collaboration agreement for collaborative technical development in the areas of programming models and performance tools



BSC's dust storm forecast system licensed to be used to improve the safety of business flights.

Collaborations with Companies



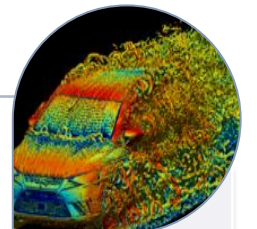
Research into advanced technologies for the exploration of hydrocarbons, subterranean and subsea reserve modelling and fluid flows



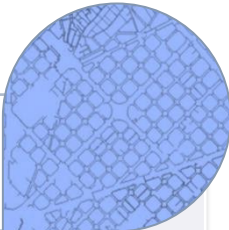
Research on wind farms optimization and wing energy production forecasts



Collaboration agreement for the development of advanced systems of deep learning with applications to banking services



Simulations to improve the understanding of the rotating wheels flow physics and its impact over the aerodynamic performance



Advanced statistical methods to the optimization of maintenance, energy usage, and control of the city's water treatment and supply processes.



Research on efficient data sensing, algorithms for analysis of industrial processes and visualization of large datasets of industrial data



Artificial Intelligence and Big Data techniques to improve the quality of care and personalized diagnosis



BSC and GRIFOLS are collaborating in GRIFOLS-sponsored research related to generation of vaccine for COVID.

BSC Connects



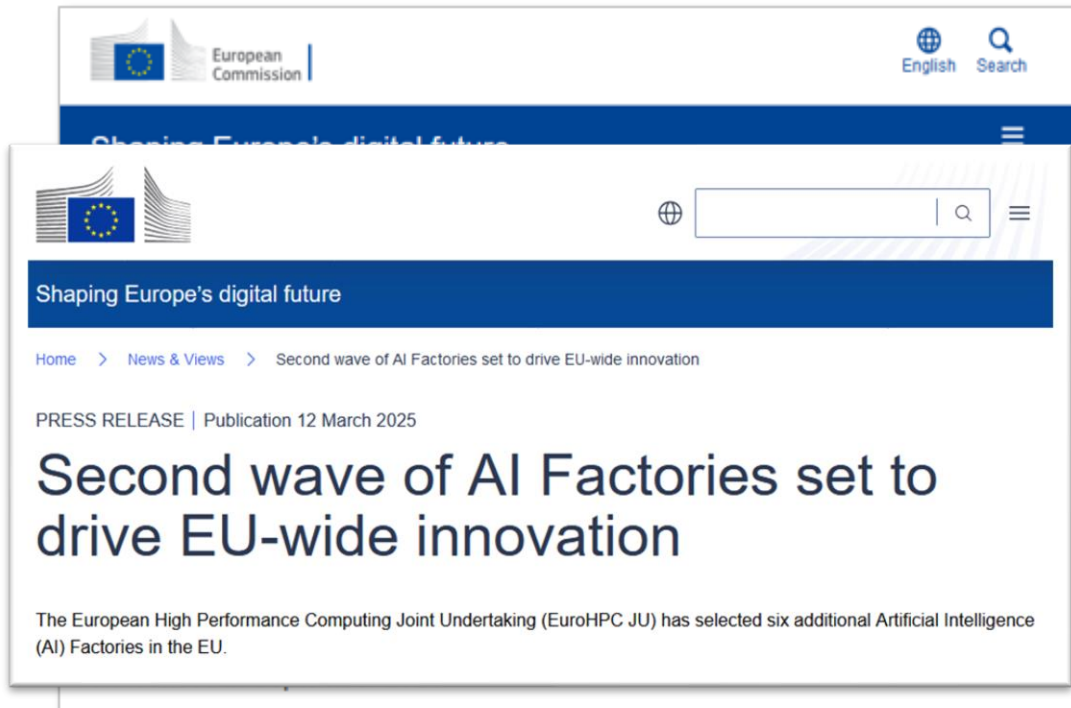
The European AI Factories



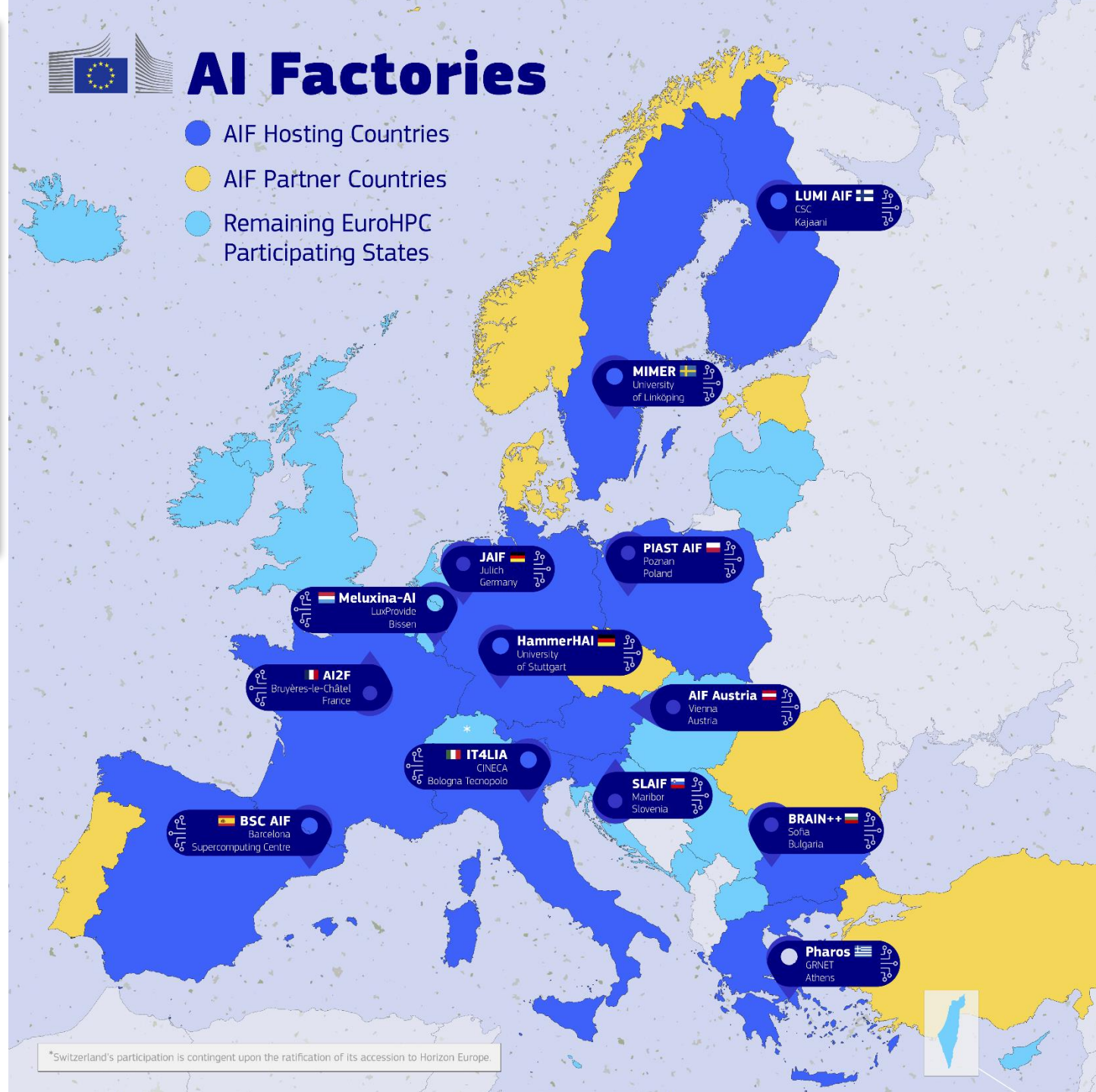
“Europe has some of the world's fastest **public supercomputers**.

We are now putting them at the service of our best start-ups and scientists, so they can forge the AI we need. In just a few months we have set up a record of 13 **AI factories**. And we are investing EUR 10 billion in them. This is not a promise – it is happening right now, and it is the largest public investment for AI in the world, which will unlock over ten times more private investment.

Our goal is that every company, not only the big players, can access the computing power it needs. We want AI developers to compete based on how innovative they are, not just on their access to chips or the size of their financial firepower.”



- **13 AI Factories** across 17 Member States and two EuroHPC Participating States
- Nine new **AI-optimised supercomputers** and one **upgrade**
- Overall investments in supercomputing infrastructures and AI Factories in the EU will reach **EUR 10 billion** over 2021-2027
- AIFs will be **interconnected** and establish a collaborative framework for effective networking



BSC AI Factory



Experimental
Platform
1,28M€

Targeted Industries



Health



Policy-making / Public Administration



Agriculture & climate



Communication & Media



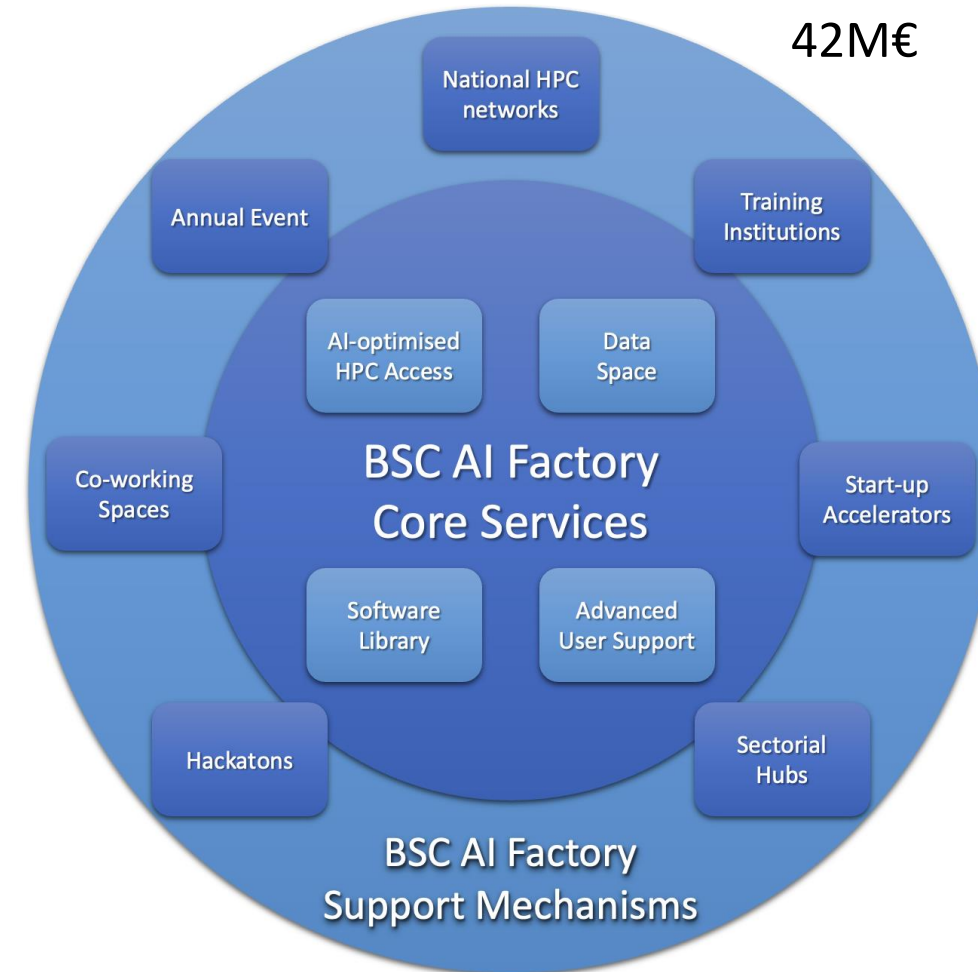
Finance & legal



Energy

BSC AI Factory SERVICES

42M€



BSC AI Factory partners



**Barcelona
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Centro Nacional de Supercomputación



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH



Fundação
para a Ciência
e a Tecnologia



TÜBİTAK



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Centro Nacional de Supercomputación

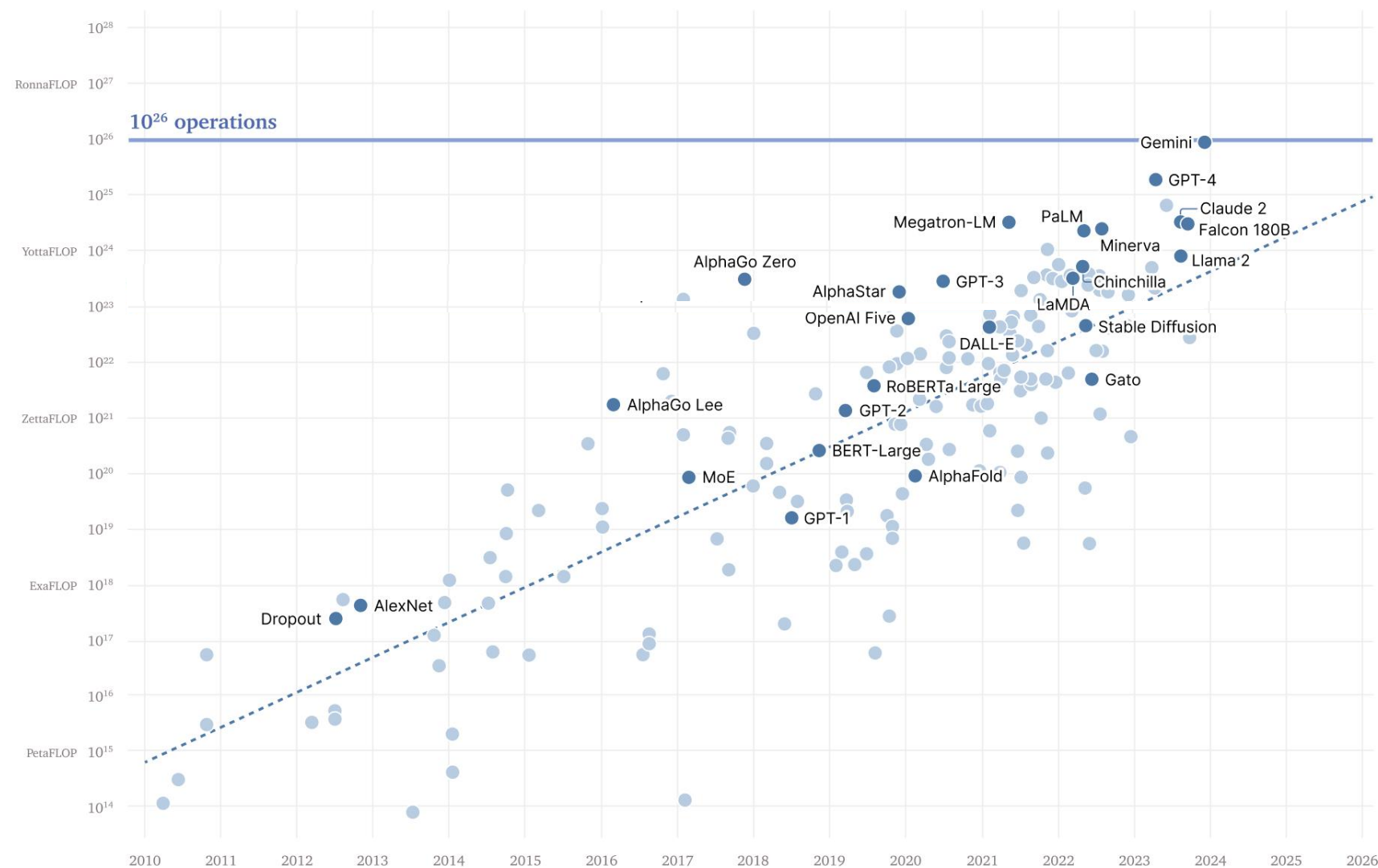
AI Giga Factories



And now we are also bringing AI Factories to the next level, with **AI Gigafactories**. Very large data and computing infrastructure, to train very large models.

We provide the infrastructure for large computational power. Researchers, entrepreneurs and investors will be able to join forces. Talents of the world are welcome. Industries will be able to collaborate and federate their data. We are creating the safe space for them – like the European health data space. Because AI needs competition but also collaboration.

Compute Thresholds in the US Executive Order



AlphaFold has changed the field of structural bioinformatics forever, with immediate implications for biotechnology and drug development.

AlphaFold covers the protein universe >200M proteins

Article

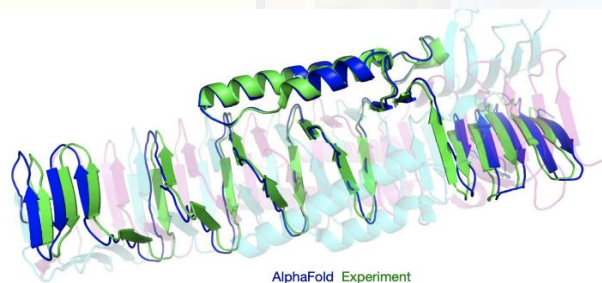
Highly accurate protein structure prediction with AlphaFold

Nature | Vol 596 | 26 August 2021 |

Article

Highly accurate protein structure prediction for the human proteome

Nature | Vol 596 | 26 August 2021



Making AlphaFold's predictions available to scientists around the world

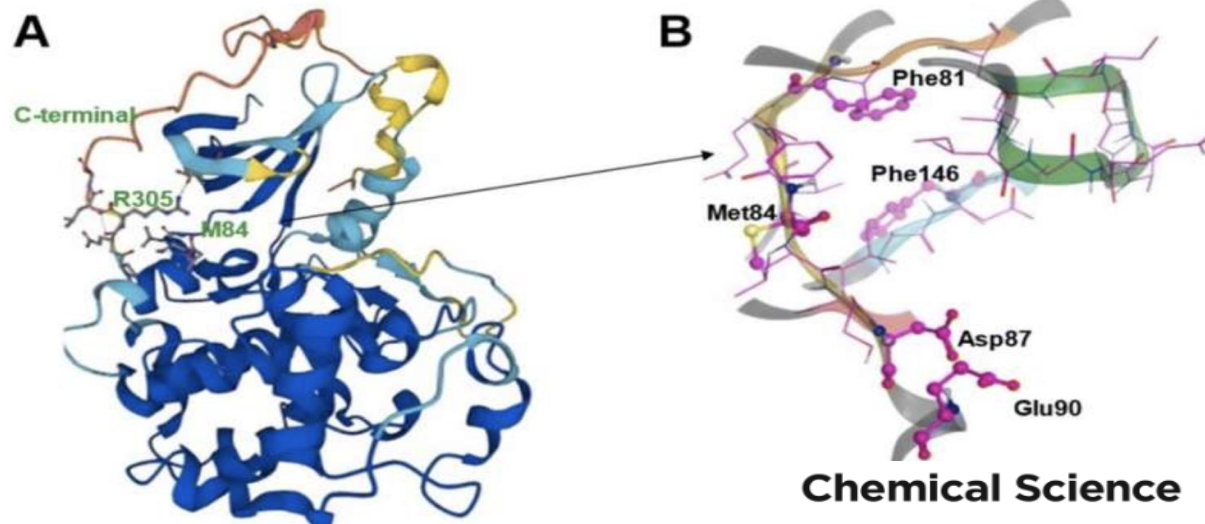
Prof Dame Janet Thornton and Mihaly Varadi are helping transform biology

See the impact of Science at Digital Speed:
unfolded.deepmind.com/#stories

JANUARY 19, 2023

New study uses AlphaFold and AI to accelerate design of novel drug for liver cancer

by University of Toronto



AlphaFold accelerates artificial intelligence powered drug discovery: efficient discovery of a novel CDK20 small molecule inhibitor†

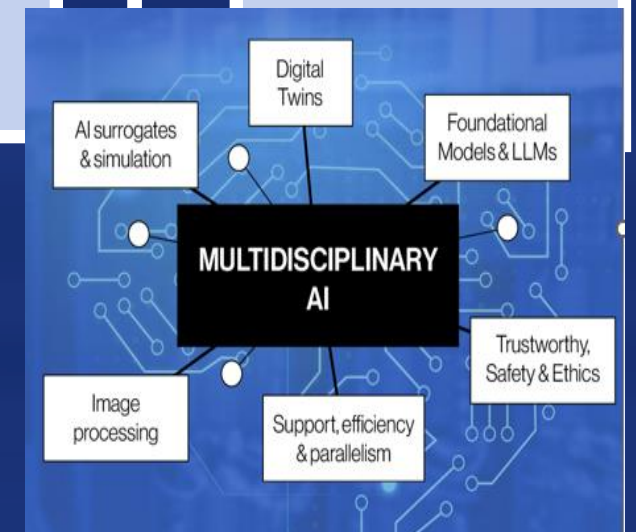
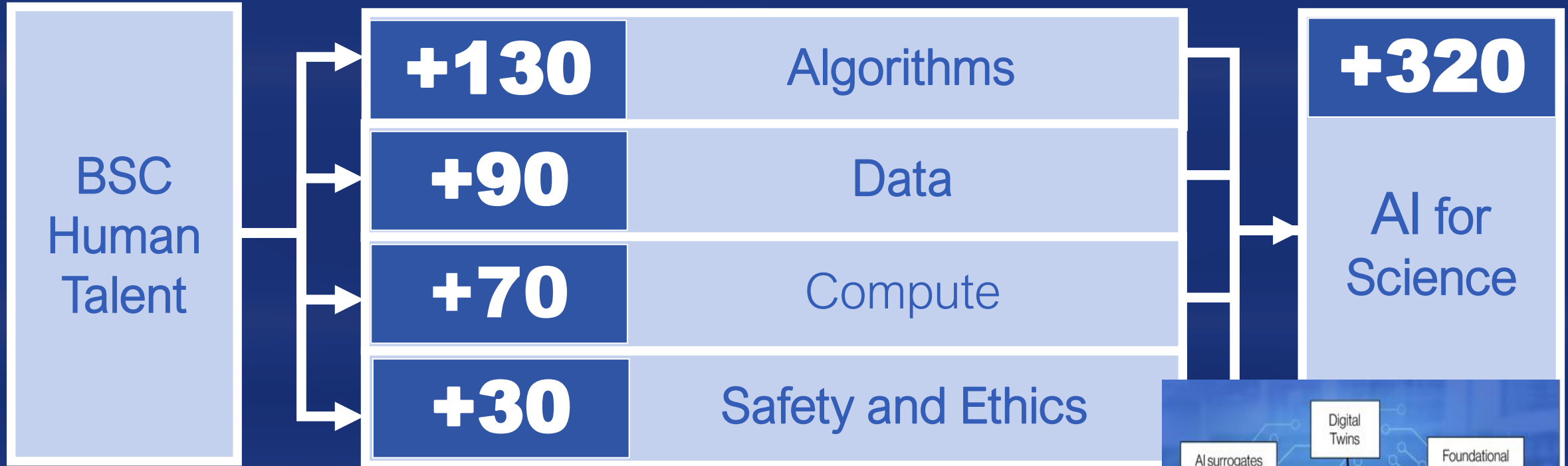
Chemical Science

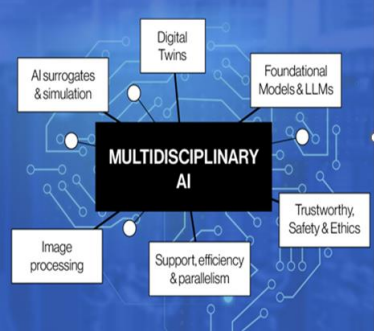
Received 14th October 2022
Accepted 5th January 2023

DOI: 10.1039/d2sc05709c

AI for Science Researchers at BSC

The four key technical inputs to 'AI for Science'

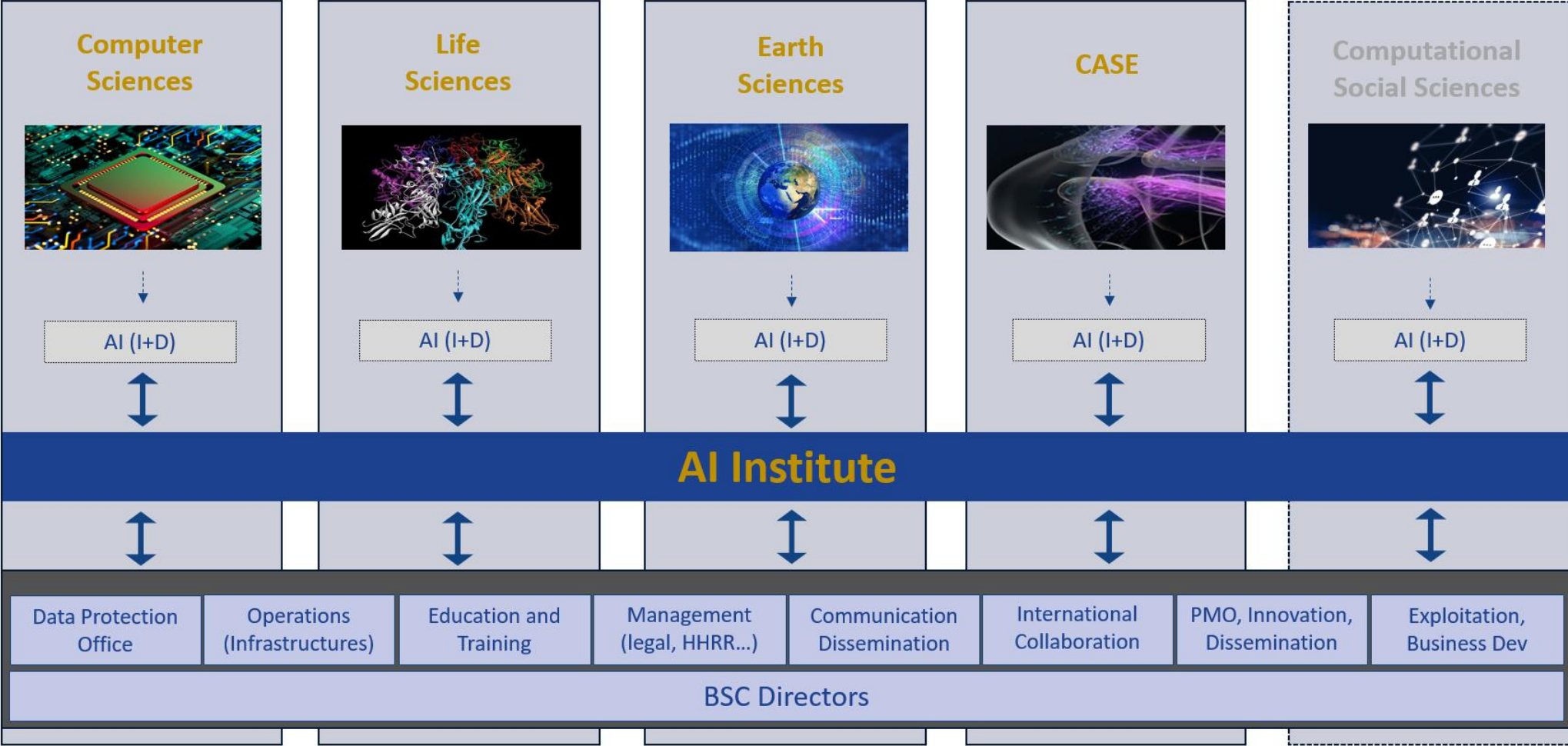




BSC and AI

	CASE	Computer Sciences	Earth sciences	Life sciences
AI surrogates and simulation	Aeronautical design (CFD, Materials), Propulsion technologies (Hydrogen, SAFs)	Generative AI imaging for health	Extreme climate event prediction	Synthetic biomedical data generation (genomes, EHRs, images)
Digital Twins	Urban, Industry, and Human digital twins, Medical applications, Solid Earth and Natural Hazards mitigation	Mobility Edge digital twins	Earth digital twins (Destination Earth and Digital Twin Ocean)	Digital Twins for Human Body. Agent-based multicellular simulations, in-silico drug response screening
Foundational Models and LLMs	Semantic search & Classification Music and voice generation	Healthcare LLM (Aloe 8B & 70B) Foundational model for medical imaging (Aloe Vera)	LLMs for climate change adaptation	Language model AguilA-7B EN/ES/CAT. Translation model Aina ES/CAT/ENG Speech models (TTS & STT)
Image processing	Medical ultrasound images, Radar and thermal images	Embryo selection, atom detection, space exploration, rare liver disease characterization	Detection of undeclared greenhouse gas emission sources	Oncology, virology, risk assessment
Efficiency: architecture and parallelism	Communication Network design	Dislib and pyCOMPSs for hybrid HPC/AI workflows, RISC-V VEC and matrix, OneDNN optimization, homomorphically encrypted DL		
Trustworthy, safety and ethics	Visual explainability methods, AI usability and UX	Explainable AI, Synthetic content detection	Explainability for physical process understanding	Desinformation and biases

BSC AI Institute

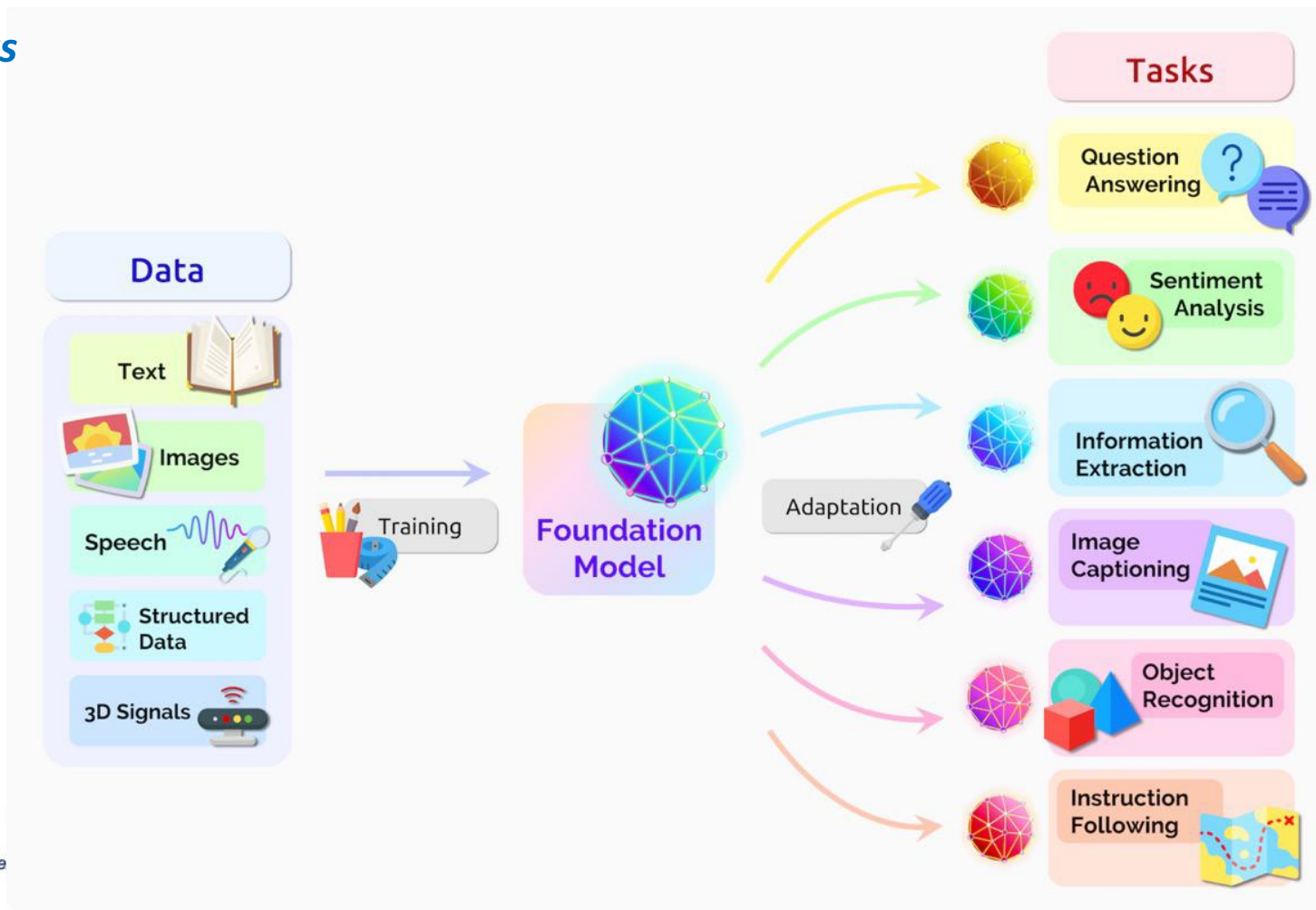


Trillion Parameters Consortium (TPC)

Leveraging Community Efforts to Build Foundation Models for Science

Scientific & Engineering Datasets

Mathematics
Biology
Materials
Chemistry
Particle Physics
Nuclear Physics
Computer Science
Climate
Medicine
Cosmology
Fusion Energy
Accelerators
Reactors



Exemplar Tasks

Scientific Discovery

Digital Twins

Inverse Design

Code Optimization

Accelerated Simulations

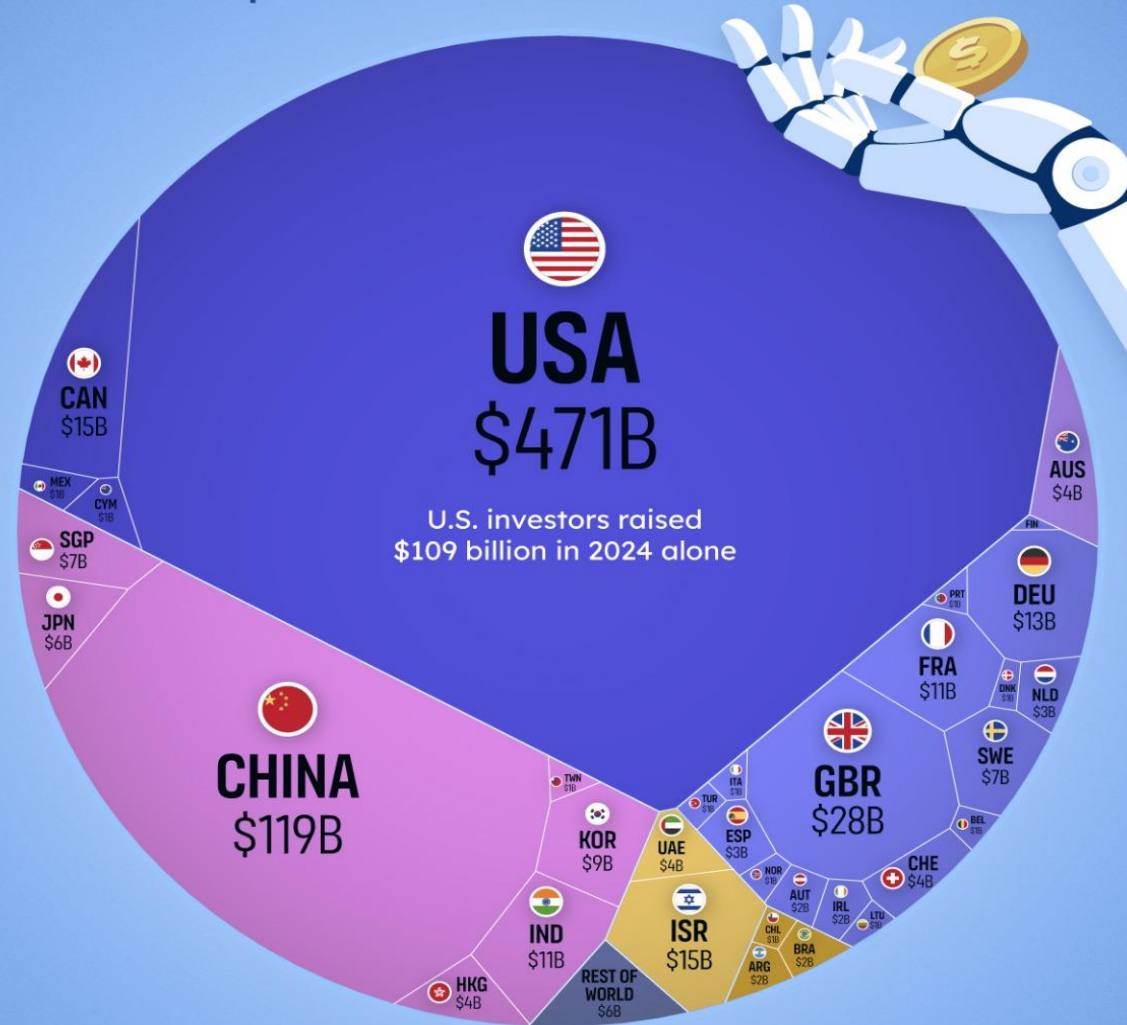
Autonomous Experiments

Secure Data Infrastructure

Co-Design

WHO'S INVESTED THE MOST IN ARTIFICIAL INTELLIGENCE?

Total private investment 2013–2024

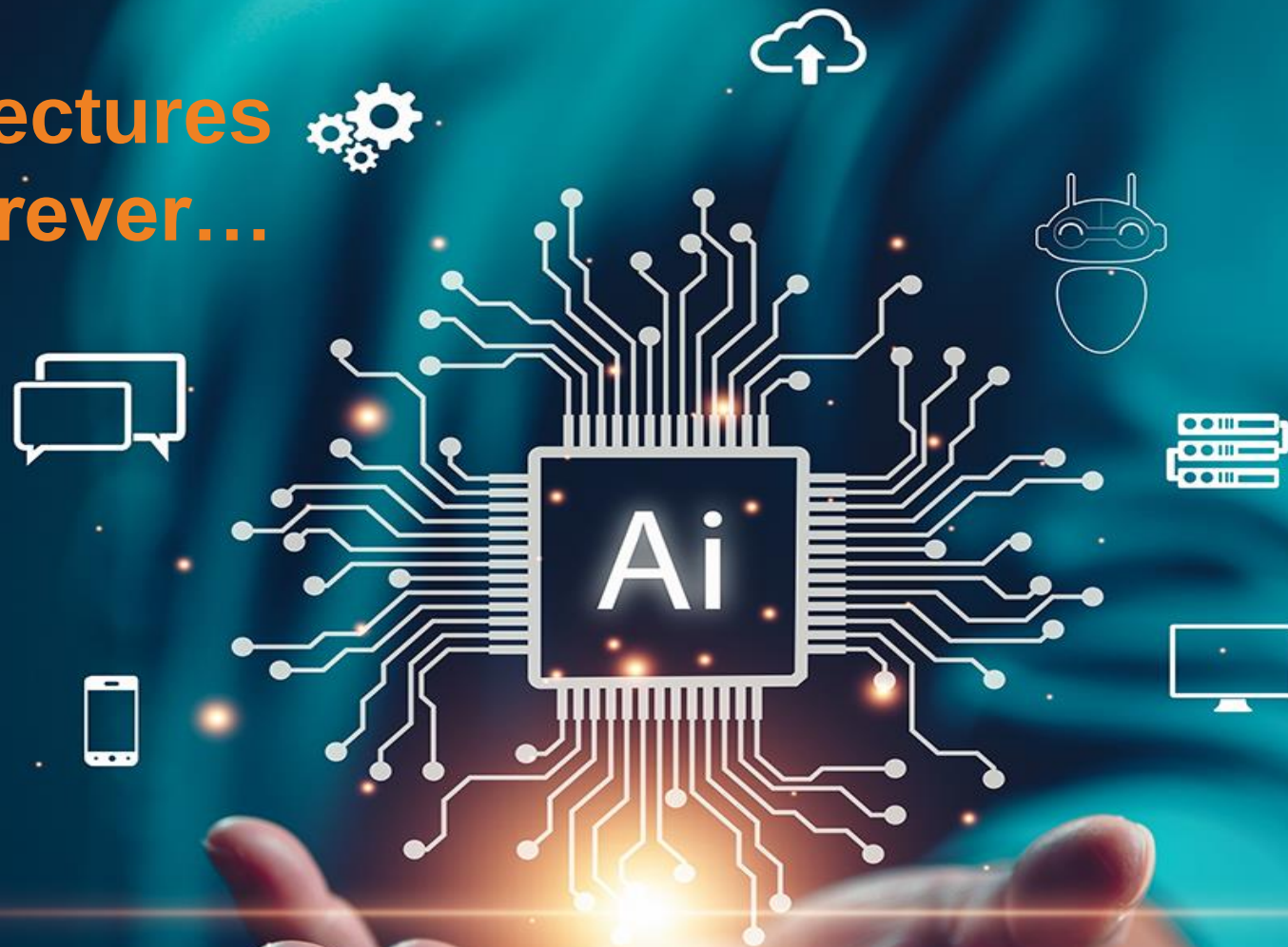


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VISUAL CAPITALIST

Excludes countries where <\$1B was raised
Source: The 2025 AI Index Report

**Compute architectures
are changing forever...**



**... there will be pervasive use
of AI across all applications**

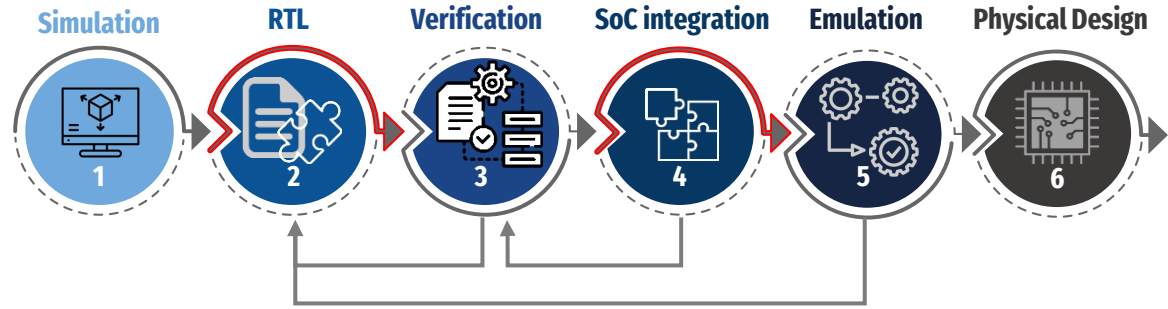
MareNostrum 6



“With MareNostrum5 now successfully installed, our focus has moved to the development of MareNostrum6. Thanks to the unwavering support of the European Commission, the Spanish and Catalan Governments, and the UPC. Plus a strong network of European public and private partners, and the talent of our researchers and collaborators, MareNostrum6 will contain European-designed and owned processors based on RISC-V”

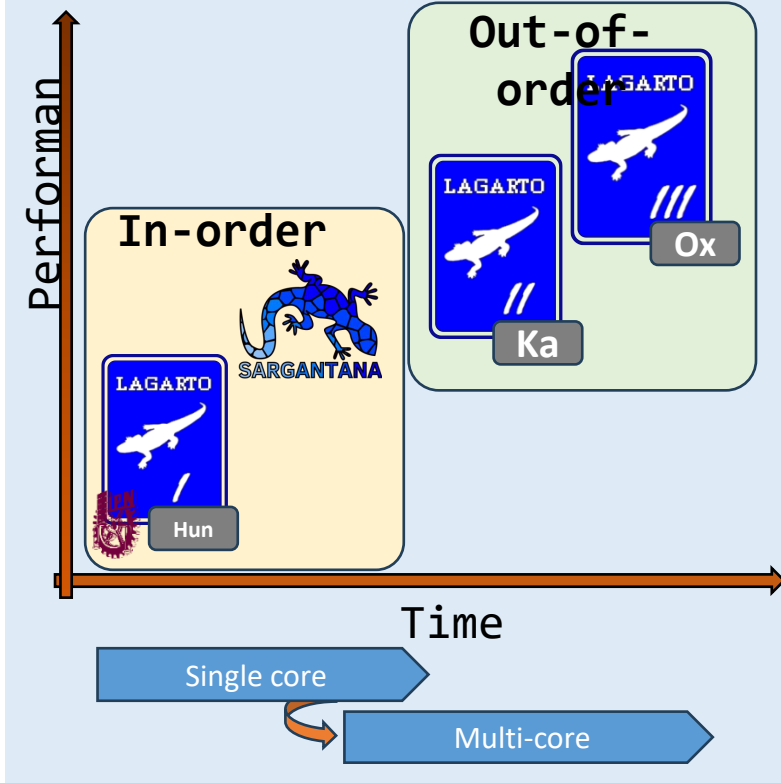
- Mateo Valero

RISC-V@BSC: HW Stack (II)



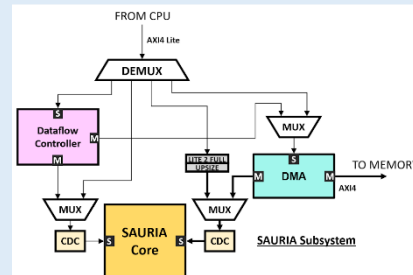
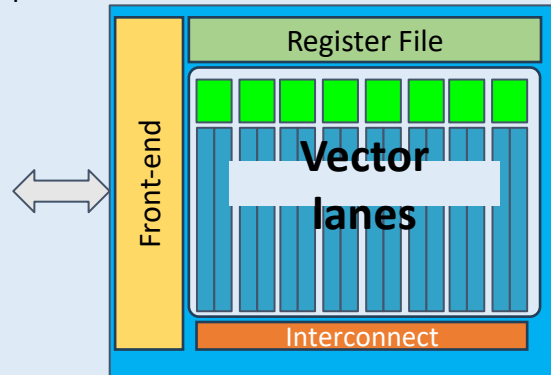
Processors:

RV64G (C, V) RVV0.7.1 / RVV1.0



Co-processors:

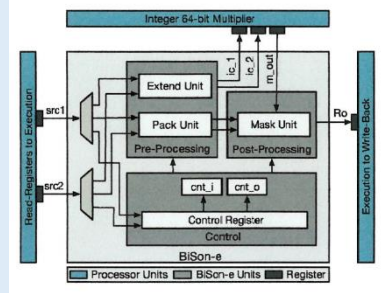
Vitruvius: Vector Processing Unit designed for supporting very long vectors, with 16 lanes, and compatible with RVV 1.0.



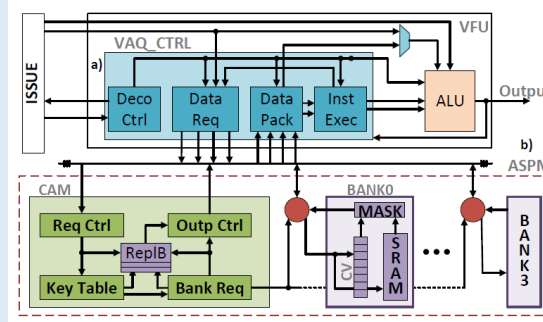
SAURIA: Systolic Array tensor Unit for aRtificial Intelligence Acceleration

Accelerators:

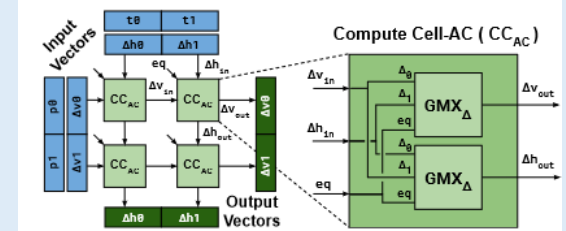
BISON: set of instructions capable of accelerating dense linear algebra operations composed of narrow-integer data types



VAQUERO: vector acceleration for Query Processing that improves the efficiency for DBMS operations such as data aggregation



GMX: set of ISA extensions that enable efficient sequence alignment computations based on Dynamic programming



And more!!

Lagarto RISC-V Tapeouts

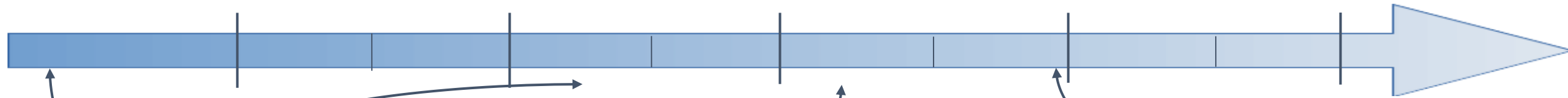
2019

2020

2021

2022

2023

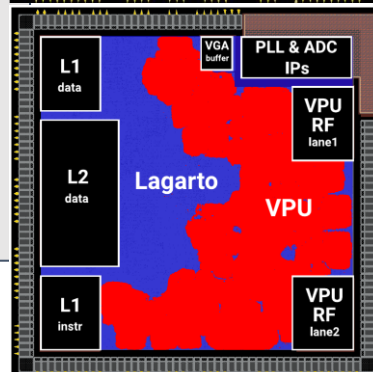
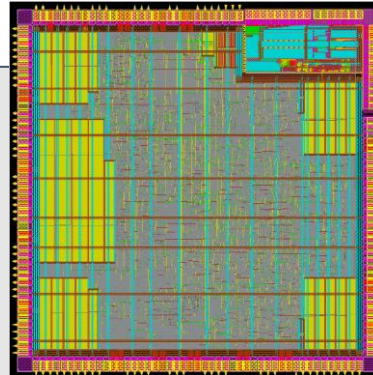


Lagarto (May'19)

- Lagarto Hun 5-stage in-order
- 150MHz (external)
- TSMC 65nm
- 2.5mm²

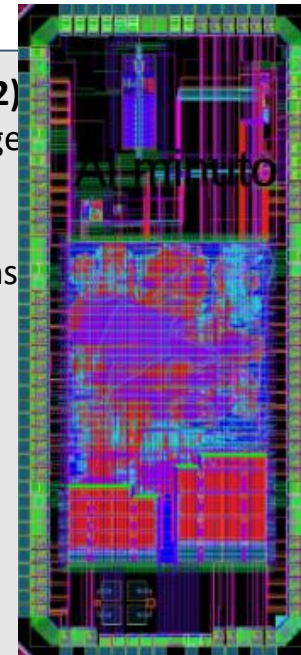
DVINO (Apr'21)

- Lagarto Hun in-order
- VPU
- PLL 600 MHz
- SDRAM mem cont
- HyperRAM
- VGA
- ADC
- TSMC 65nm
- 8mm²



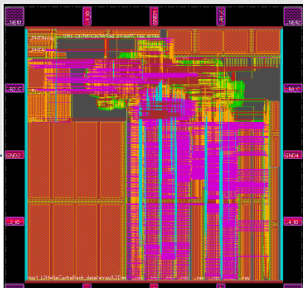
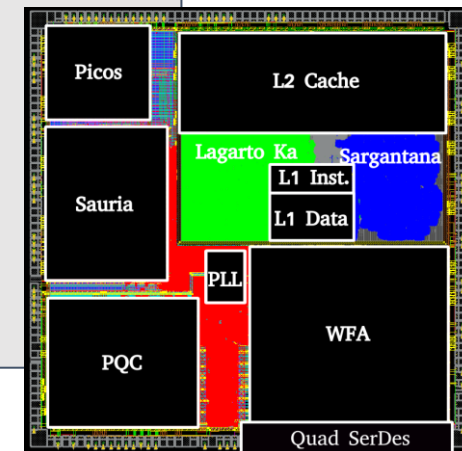
Sargantana (Feb'22)

- Sargantana 7-stage in-order
- PLL 1.2 GHz
- Custom extensions
- SDRAM
- Prototype analog IPs: SerDes 8GHz
- GF 22nm
- Area: 2.9mm²



Kameleon (Dec'22)

- Lagarto Ka 11-stage ooo
- PLL 1.2 GHz
- Automotive Accel
- Crypto Accel
- Genomic Accel
- PICOS Accel
- SerDes 8GHz
- GF 22nm
- Area: 9mm²



RISC-V@BSC: Chip Design



Simulation

RTL spec

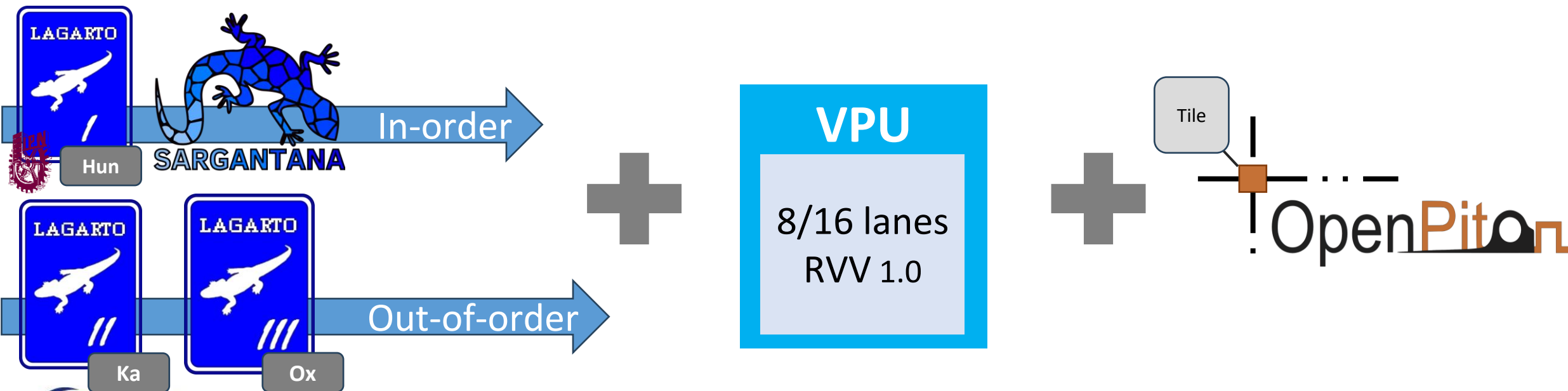
RTL impl

Verification

SoC integration

Emulation

Physical Design

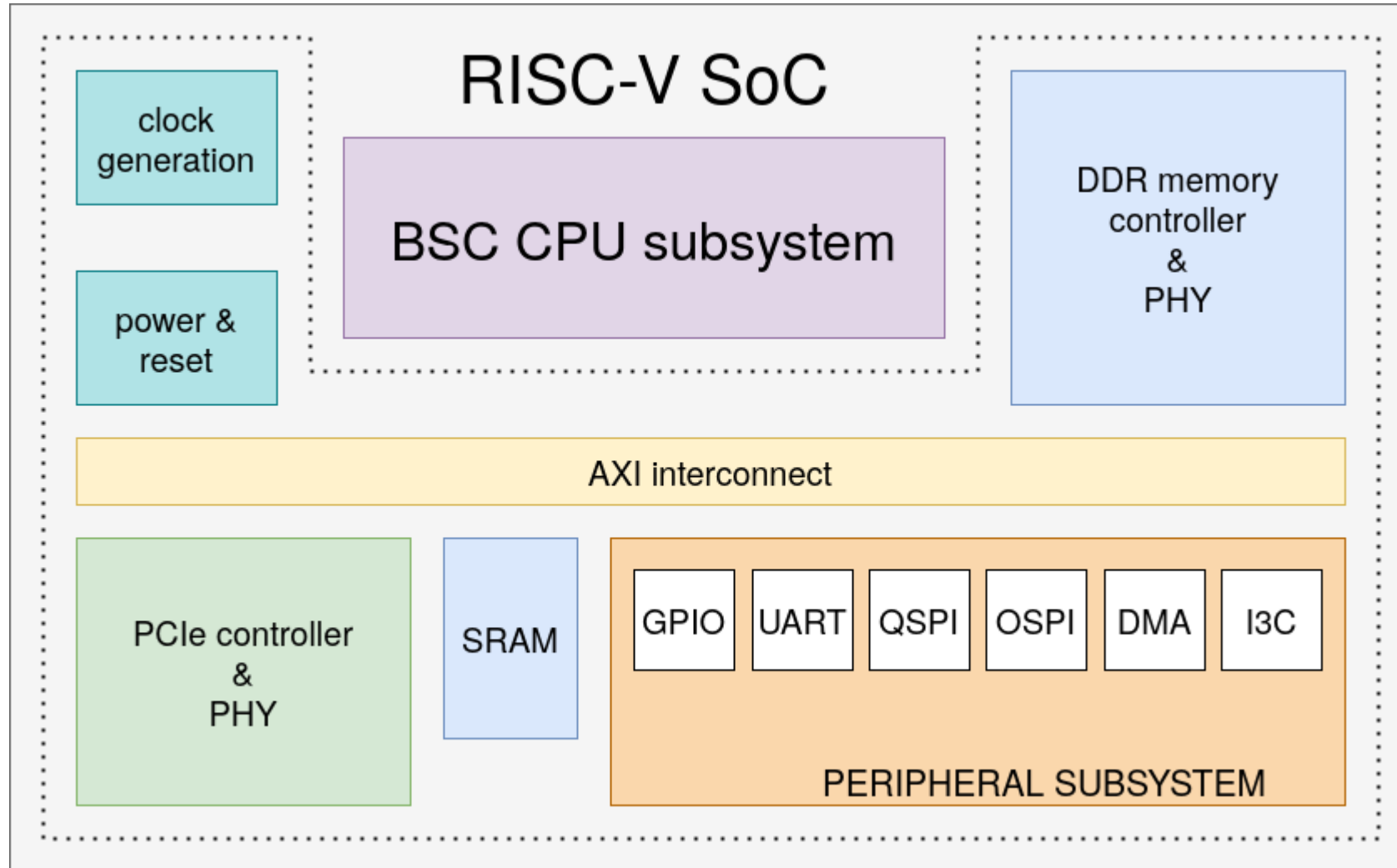


Barcelona Zettascale Lab Project

- Project: Barcelona Zettascale Laboratory
- Dates: 12/2022 – 06/2026 (3.5 years)
- Main goals:
 - Build first BSC-only HPC multicore design based on RISC-V
 - RISC-V general purpose processor
 - VPU accelerator
 - HPC cache hierarchy
 - using an advanced technology node:
 - Two test chips with Intel Foundry Systems (IFS)
 - Intel provides technology-dependent I/Os (memory controller, PCIe, PLL)
- Important milestones:
 - Q4 2024: first tapeout with a reduced number of cores
 - Q4 2025: second tapeout with larger number of cores
- Budget: 50M€

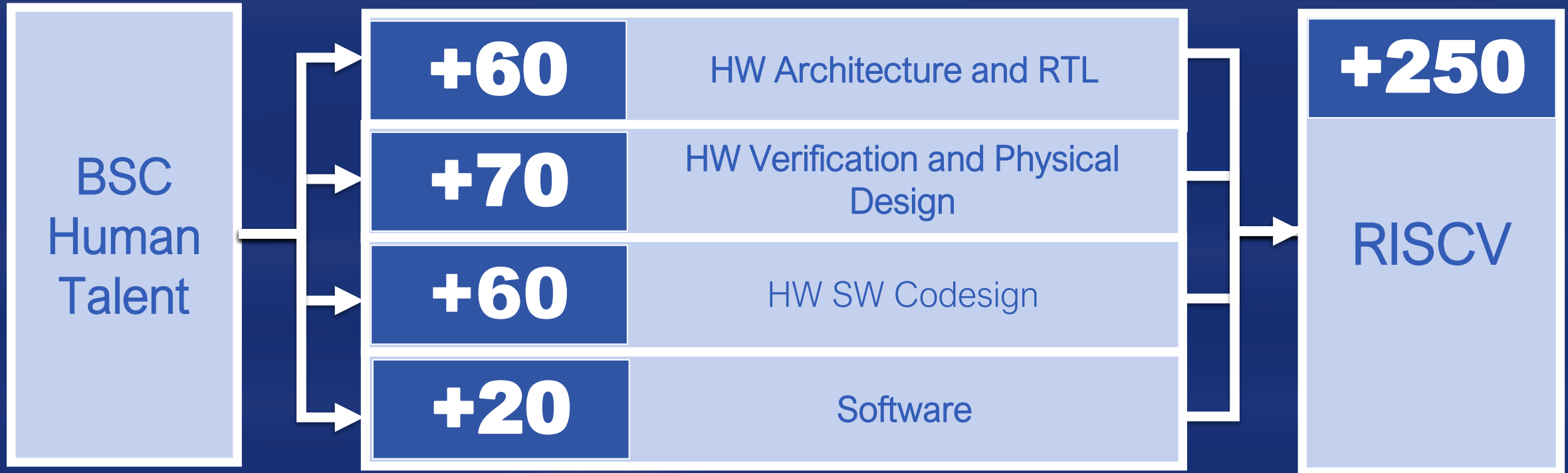


Test Chip 1 (TC1): Cinco Ranch

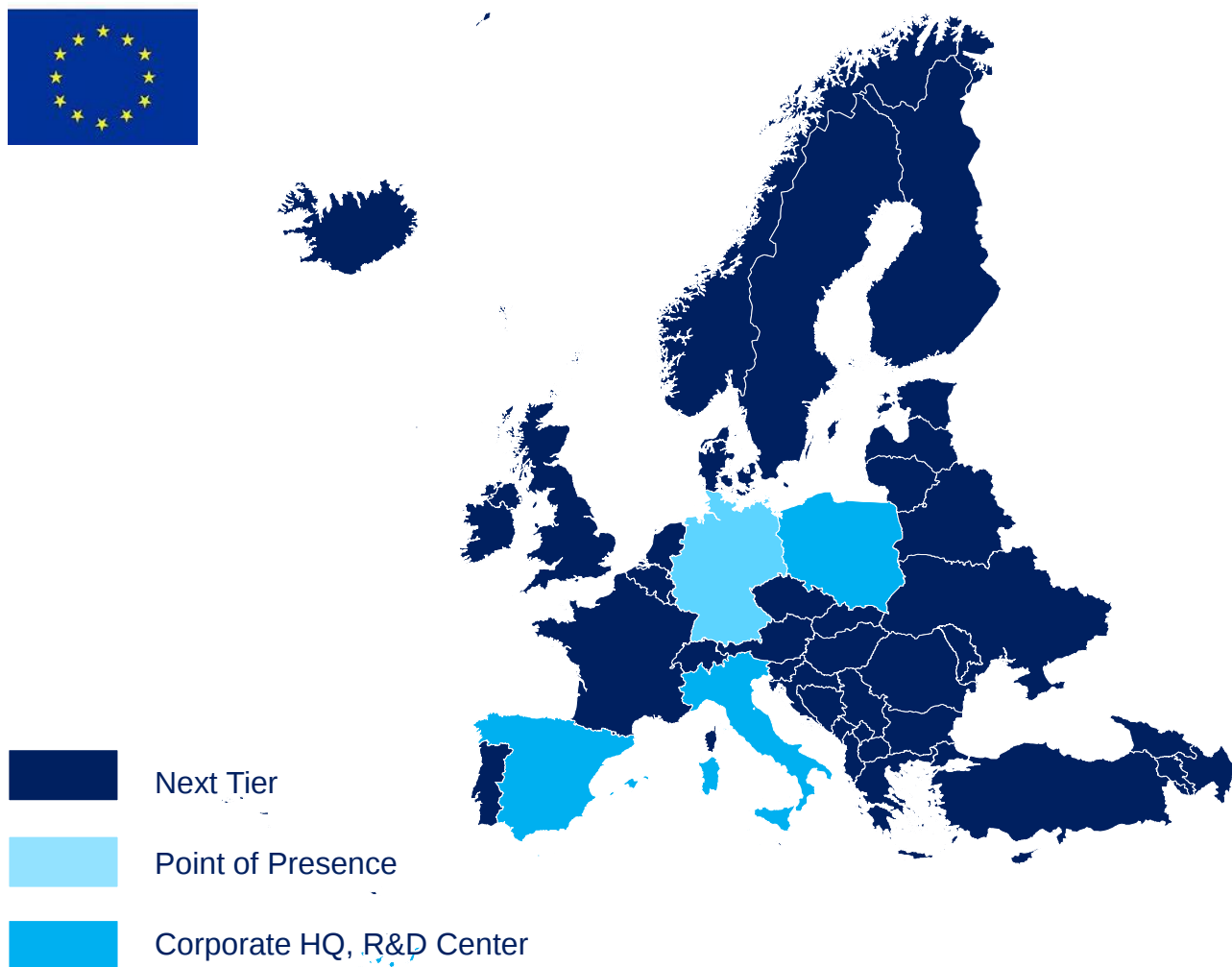


RISCV Hardware and Software Researchers at BSC

The four key technical inputs to RISCV developments



Openchip Strategy to Develop a Global Market



Strategy for European Union Expansion

- Openchip is a Spanish Project truly multinational and multicultural: Europe is in our DNA.
- +120 employees from 15 nationalities: Spain, Italy, Poland, Germany, France, UK, USA, Romania, Armenia, India, Pakistan, Ukraine, Japan, ...
- We are determined to promote the collaboration within EU countries: Hiring a talented team, distributing R&D facilities and having a point of presence next to our priority customers.
- Company HQ is located in Barcelona, Spain, a global hub for business.
- We aim to lead the efforts of **European Union for Digital Sovereignty** and adoption of **RISC-V as the ISA for Supercomputing and Artificial Intelligence**.

DARE FPA and SGA1 towards MNx chip (*)

BSC Coordination

(Roadmap, Technical Coordination, PMO, Diss & Inn)

JSC & BSC Shared Software

CODASIP
REACH GPP

Openchip
VEC Vector
Accelerator

Axelera
AI Inference
Accelerator

IMEC packaging, testing



integrating/scaling BSC's VPU into
new chip with focus on AI

+



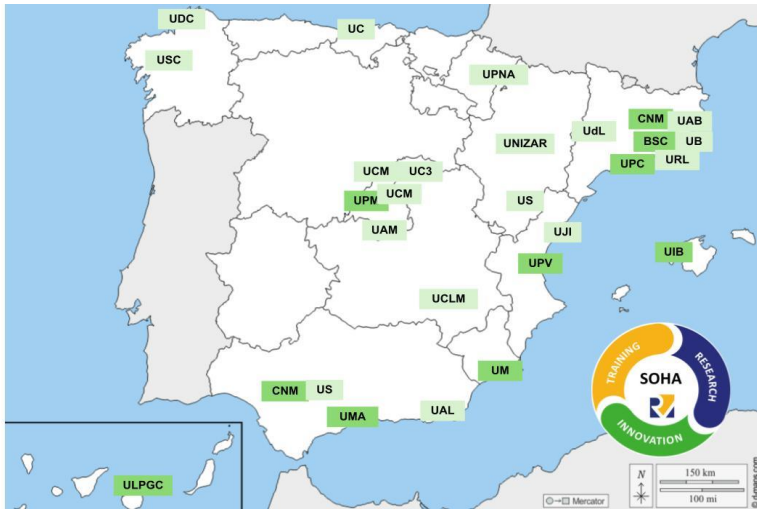
contributing to pathfinding new design for SGA2,
including VPU with IME and AME, memory
hierarchy to support irregular applications, ...



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(*) SGA1 submitted for evaluation september 2024, expected to start by january 25

SOHA (Spanish Open Hardware Alliance)



More than 25 universities and research centers are joining forces to promote the adoption of open architectures, both in academia and industry.

SOHA is in the process of signing agreements with industry associations (AESEMI, AMETIC, etc.)

SOHA Spanish RISC-V (SRISCV) initiative

Provide the Spanish education/research/innovation organizations with the capacity for delivering specific training and **design/verify/tapeout/test chips** for RISC-V systems at professional and practical levels.

Ensure the efficiency for RISC-V of national and European initiatives in the field of chips, to turn Spain into a **pole of attraction for talent and investment** in this technology.

RISC-V has the opportunity to be like Linux. It would be global and go beyond Airbus and Galileo!



EuroHPC
Joint Undertaking





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THANK YOU!

mateo.valero@bsc.es