

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

BSC y lo que la supercomputación puede hacer por nosotros

Prof. Mateo Valero
BSC Director

erc

X ANIVERSARIO DE CénitS - COMPUTAEX
10 Años de Supercomputación en Extremadura

03/2019

COMPUTAEX
Fundación Computación y Tecnologías Avanzadas de Extremadura

CÉNITS
Centro Extremeño de iNvestigación, Innovación Tecnológica y Supercomputación

LUSITANIA
Supercomputación en Extremadura

Mi vida como investigador

Prof. Mateo Valero, UPC, Barcelona

Master en Gestió I Política Universitaria
Barcelona 5 de Julio de 2004

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Historia

- Nacido en Alfamén, Zaragoza, 6 de Agosto de 1952
- Escuela en Alfamén, 1956-1961
- Bachillerato: Padres Escolapios, Zaragoza, 1961-1968
- Ingenieria de Telecomunicación:
  - Universidad de Zaragoza, 1969-1970
  - ETSIT, Madrid 1970-1974
- Profesor de la ETSIT de Barcelona, UPC, 1974- ahora
  - Tesis: 1974-1980
    - Mucha dificultad
- Profesor de la Facultad de Informática, UPC, 1980-ahora
  - Crear departamento: asignaturas, contratar,..
  - Empezar a investigar
  - Situación española... no hay $, no existe nada,... CICYT
- Decisiones Estratégicas:
  - Arquitectura de Computadores
  - Supercomputadores... CEPBA, C4, CIRI y BSC

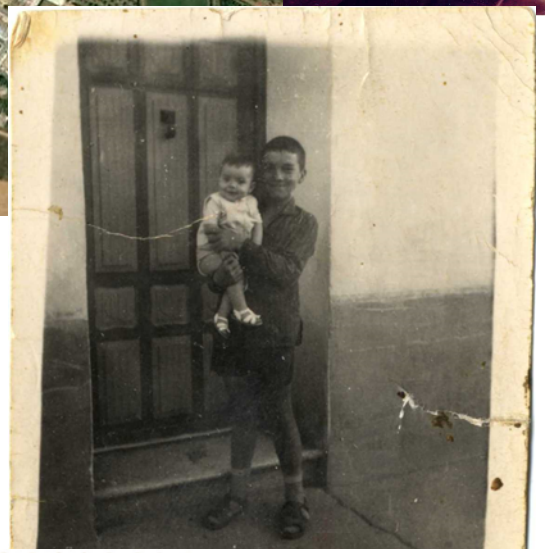

Golfo de Vizcaya
Burdeos
Grenoble
Nimes
Marsella
Toulouse
Gijon
La Coruña
Oviedo
Bilbao
San Sebastián
Andorra
Santiago de Compostela
León
Vitoria-Gasteiz
Gerona
Pontevedra
Orense
Vigo
Alfamén
Barcelona
Valladolid
Tarragona
Oporto
Salamanca
Madrid
Castellón de la Plana
Mar Balear
Coimbra
Toledo
Valencia
Palma de Mallorca
Portugal
España
Benidorm
Lisboa
Badajoz
Alicante
Murcia
Córdoba
Argel
Sevilla
Granada
Huelva
Almeria
Albufeira
Málaga
Faro
Gibraltar
Mar de Alborán


Alfamén
Casa de Mateo
Colegio Mateo Valero














Escuelas Plaza de Zaragoza. Internos. Curso. 1º
1948


AMBAR




C.E.I.P.
MATEO VALERO











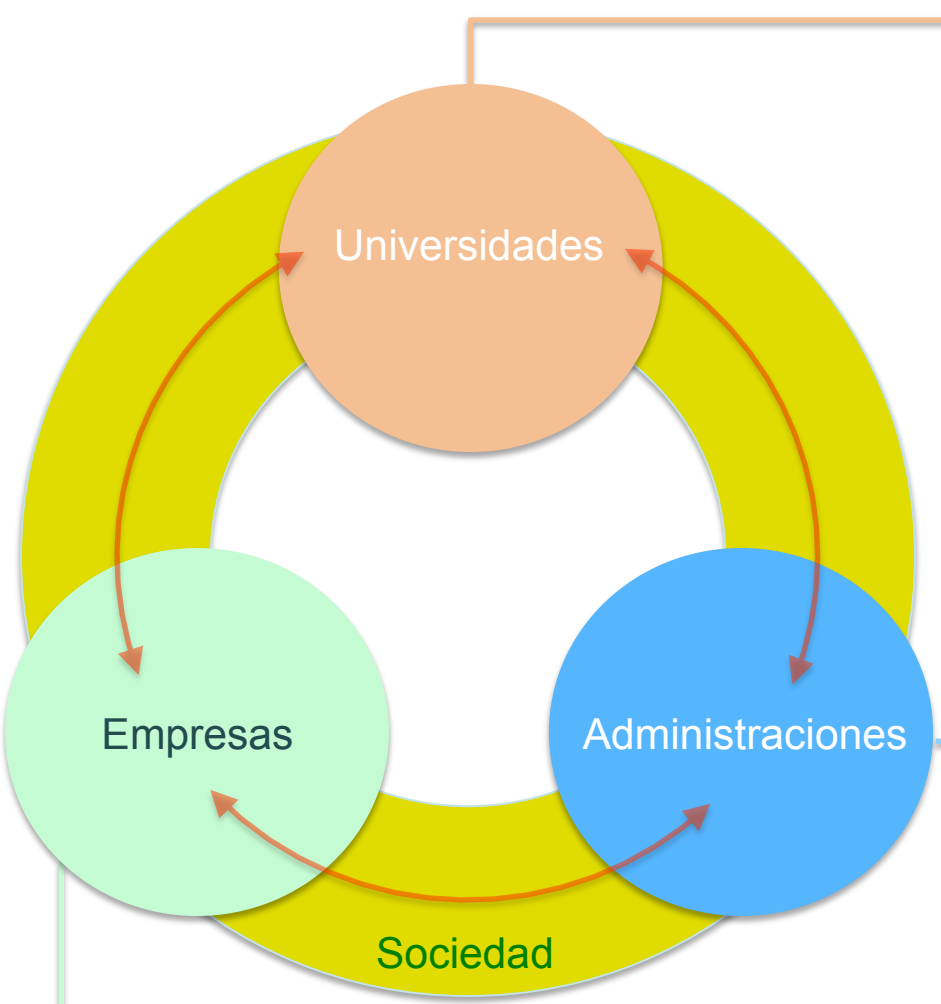


Honoris Causa Universidad Zaragoza 2011





Ecosistema de la investigación



- Hemos avanzado mucho (CE)
- Formar buenos investigadores
- Investigar, obligación del profesorado
- Financiación = ϕ(investigación)
- Internacionalización (EU, máster, PhD)
- Atraer capital humano
- Atraer/crear empresas

- Reconocimiento

  recursos → investigación → recursos
- Países ricos/pobres
- Constancia en los recursos
- Gestión eficiente de recursos
- Simplificar/facilitar procesos
- Pacto de Estado para la Ciencia

- Gran avance colaboración Universidad/Empresa
- Receptora de doctores (publicaciones/ patentes)
- Financiación de la investigación
- Incentivos fiscales
- Capital Riesgo

Investigar es ……

- Cumplir con una obligación laboral
- Mejorar la docencia
- Promoción
- Ser independiente
- Un lujo al alcance de pocos
- Producir riqueza
- Estar enamorado de tu trabajo

Mateo Valero: Mi vida como investigador, 2004

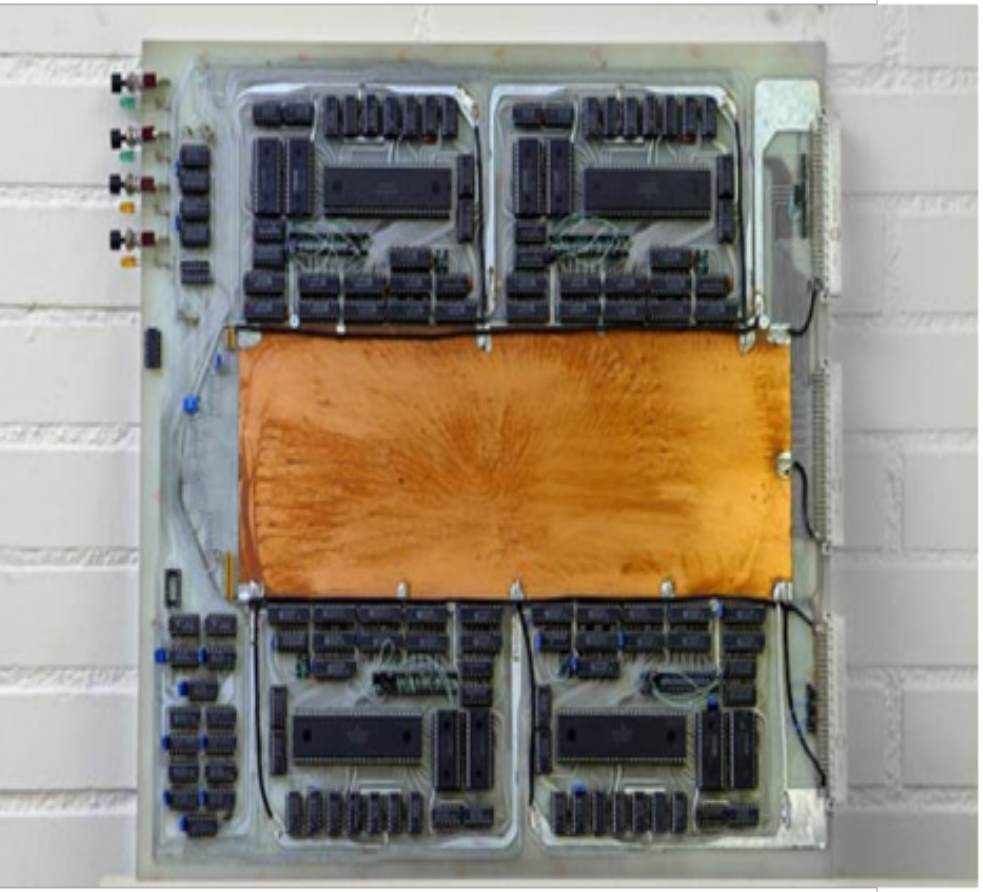
Conceptos Básicos sobre Investigación

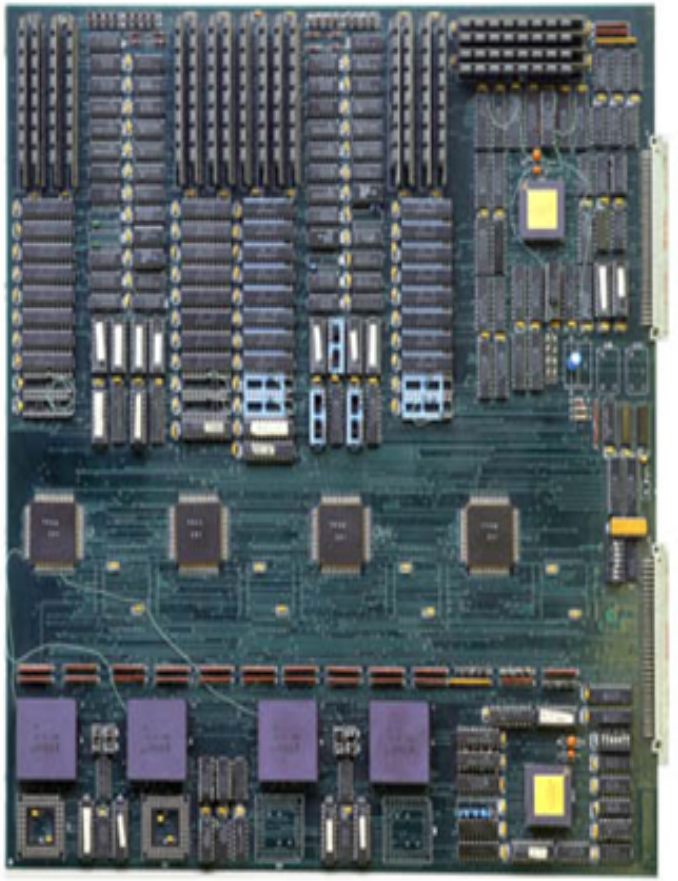
- Investigación Básica/Fundamental versus Investigación Aplicada
- Investigación Buena versus Mala
- La buena investigación produce siempre riqueza
  - Investigación a corto/medio y largo plazo
- Resultados de una buena investigación:
  - Artículos y patentes
  - Gente formada
- Una buena formación académica es fundamental
- La cooperación entre los grupos de investigación y las empresas son la otra parte de la película
- Hacer una buena investigación es el único camino que tenemos en Europa para ser competitivos en un futuro a medio/largo plazo

Mateo Valero: Mi vida como investigador, 2004

Once upon a time …

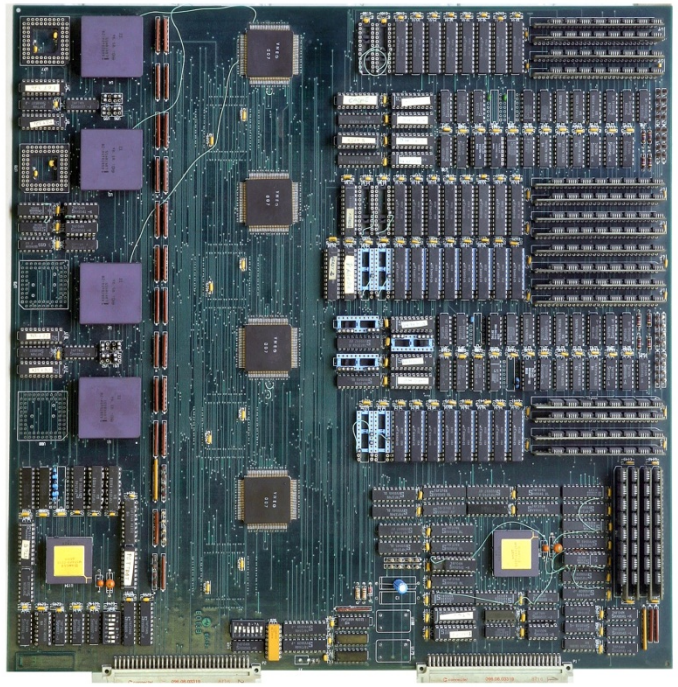
1986 and 1988 , UPC multiprocessor prototypes

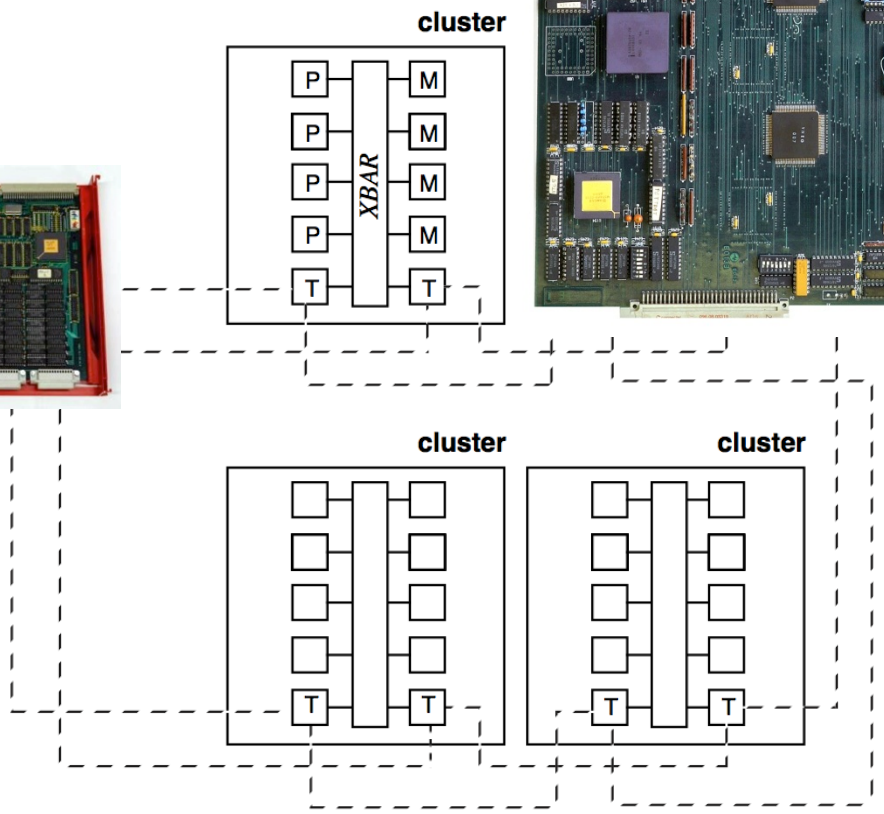




ICT386 multiprocessor architecture







4 x CPU module
- i386/i387
- no private cache memory

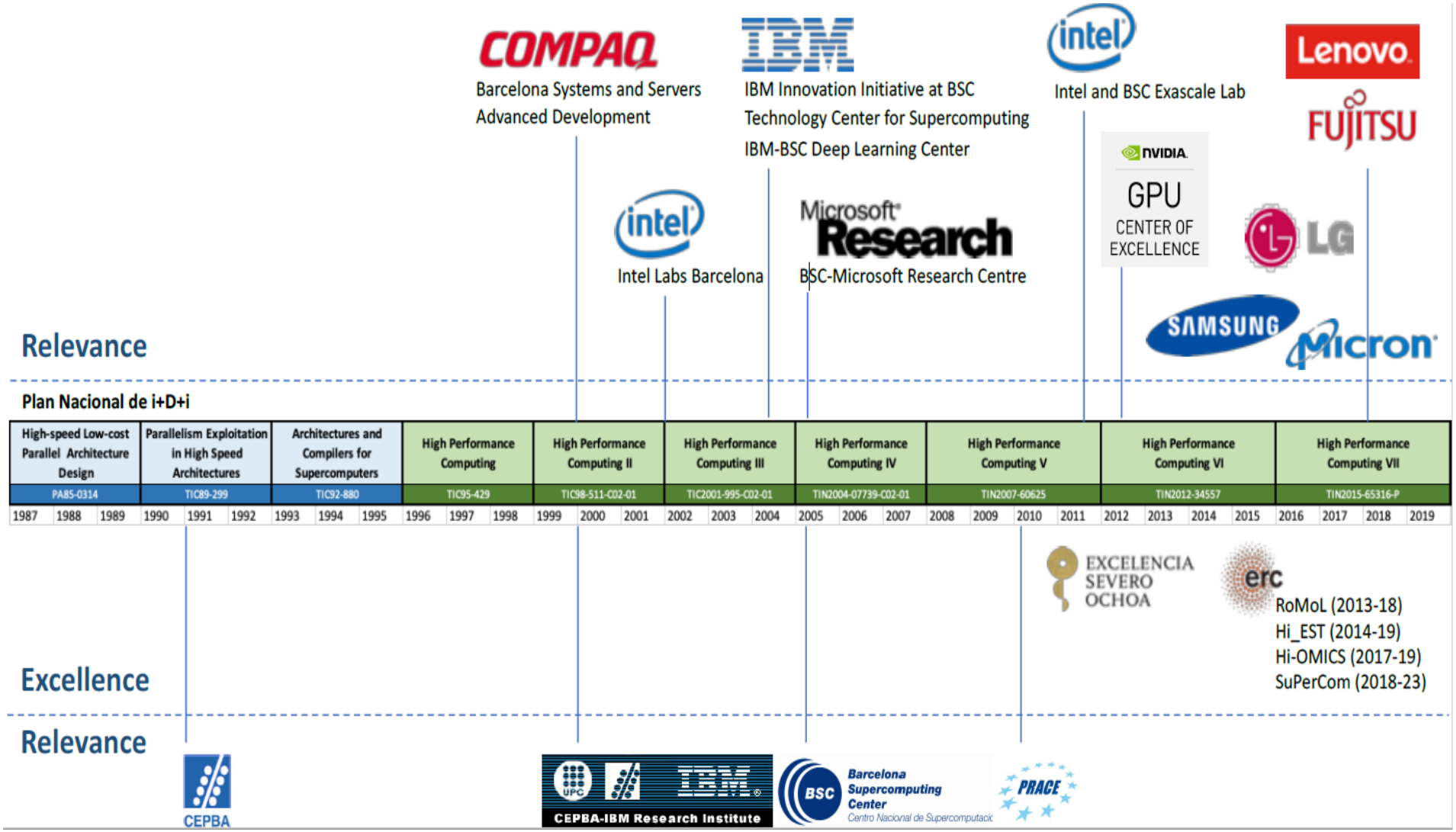
4 x Memory module
- 4 MB DRAM (100 ns)
- 64 KB **shared cache**
- (25 ns, direct-mapped

Professor Tomas Lang



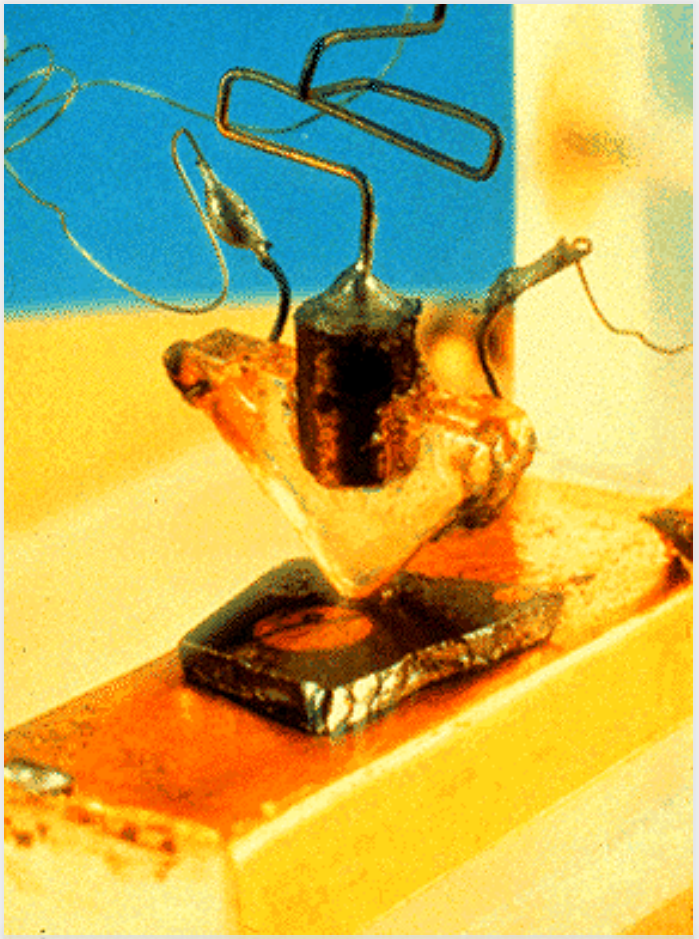
Our Origins.....Plan Nacional de Investigación

High-performance Computing group @ Computer Architecture Department (UPC)

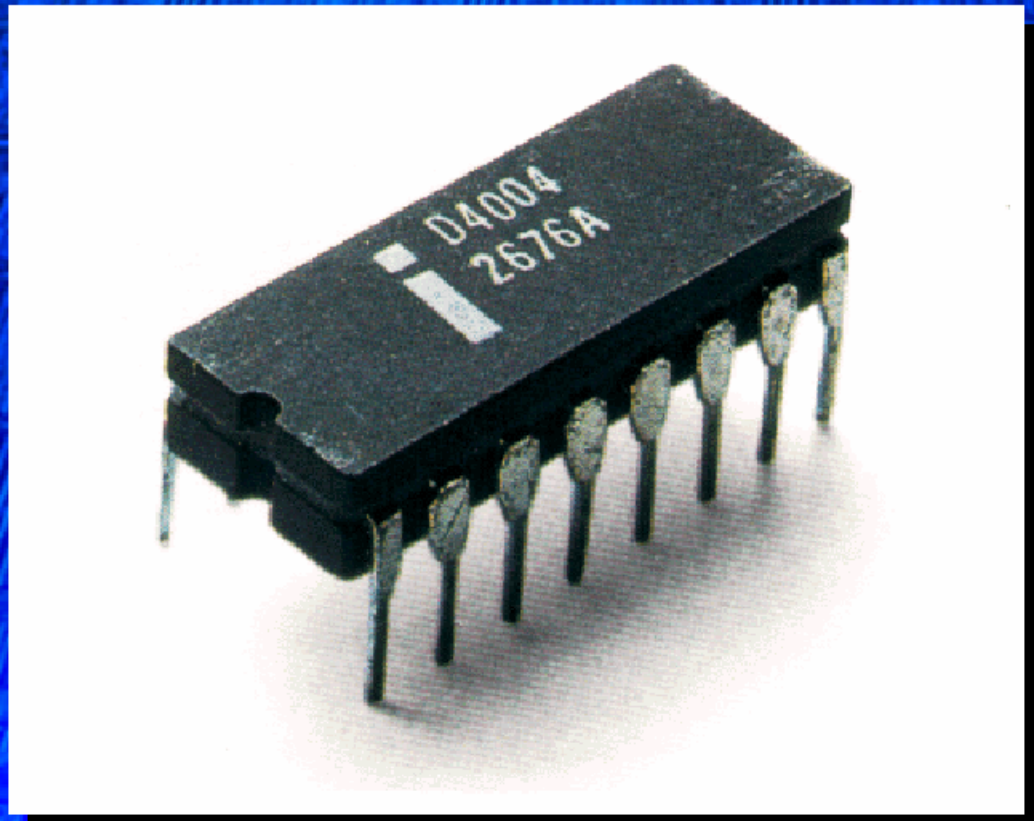


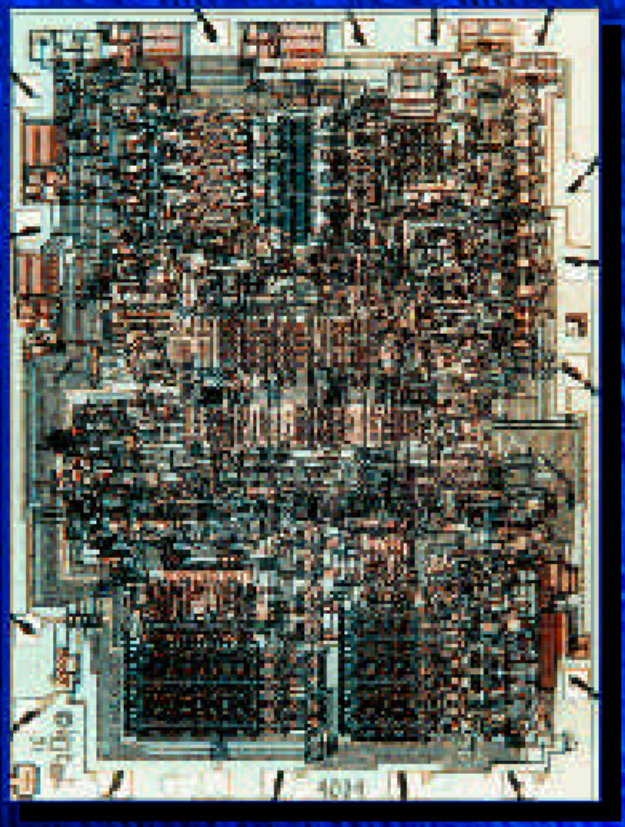
Technological Achievements

- Transistor (Bell Labs, 1947)
  - DEC PDP-1 (1957)
  - IBM 7090 (1960)
- Integrated circuit (1958)
  - IBM System 360 (1965)
  - DEC PDP-8 (1965)



Birth of the Revolution -- The Intel 4004





Introduced November 15, 1971

108 KHz, 50 KIPs , 2300 10μ transistors

ANNOUNCING TESLA V100

GIANT LEAP FOR AI & HPC
VOLTA WITH NEW TENSOR CORE

21B xtors | TSMC 12nm FFN | 815mm^2

5,120 CUDA cores

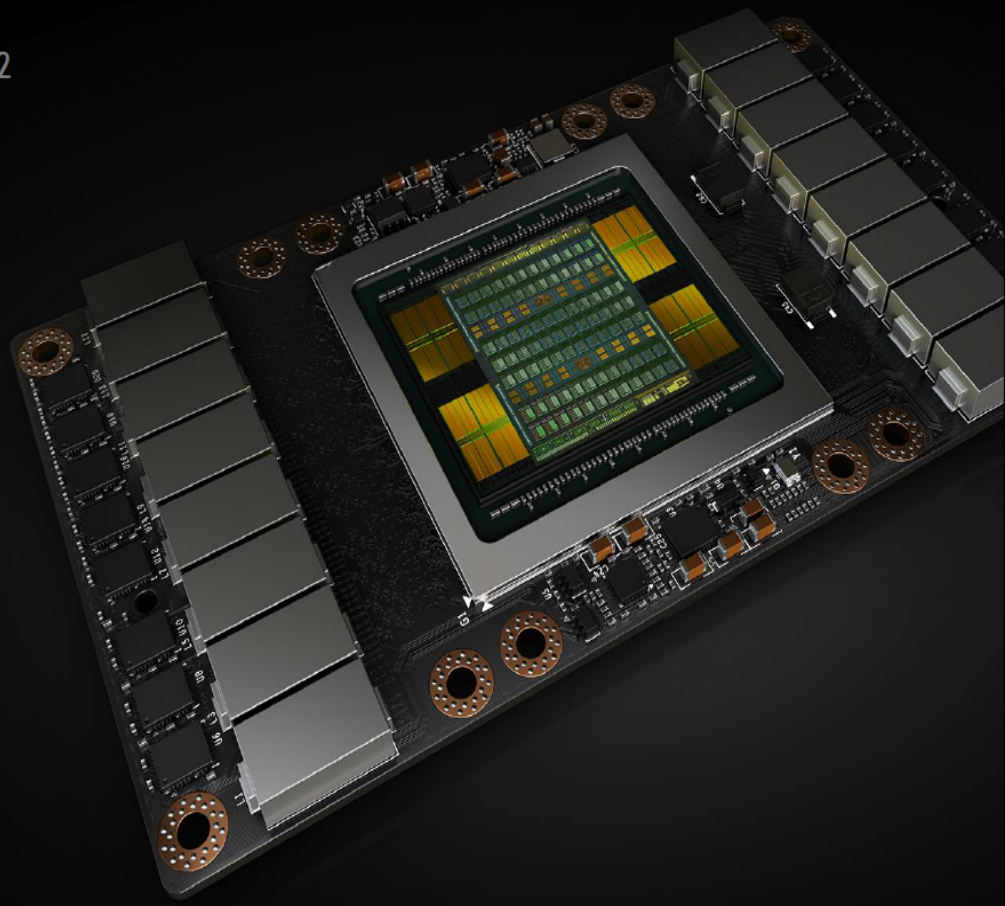
7.5 FP64 TFLOPS | 15 FP32 TFLOPS

NEW 120 Tensor TFLOPS

20MB SM RF | 16MB Cache

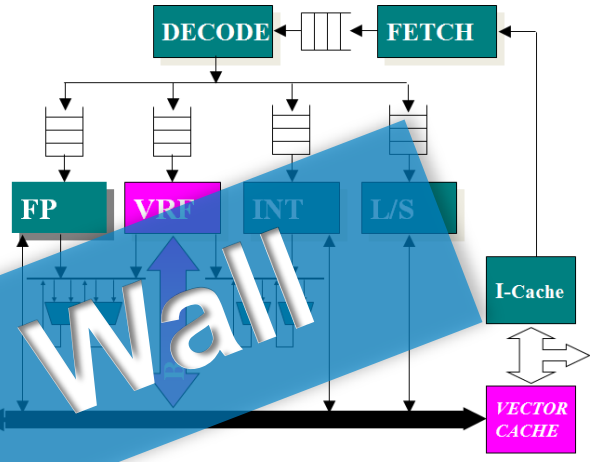
16GB HBM2 @ 900 GB/s

300 GB/s NVLink



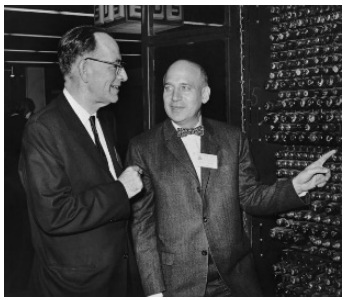
Vector Architectures… Memory Latency and Power ☺☺☺

- Out-of-Order Access to Vectors (ISCA 1992, ISCA 1995)
- Command Memory Vector (PACT 1998)
  - In-memory computation
- Decoupling Vector Architectures (HPCA 1996)
  - Cray SX1
- Out-of-order Vector Architectures (Micro 1996)
- Multithreaded Vector Architectures (HPCA 1997)
- SMT Vector Architectures (HICS 1997, IEEE MICRO J 199)
- Vector register-file organization (PACT 1997)
- Vector Microprocessors (1999, SPAA 2001)
- Architectures with Short Vectors (PACT 1997, ICS 1998)
  - Tarantula (ISCA 2002), Knights Corner
- Vector Architectures for Multimedia (HPCA 2001, Micro 2002)
- High-Speed Buffers Routers (Micro 2003, IEEE TC 2006)
- Vector Architectures for Data-Base (Micro 2012, HPCA2015,ISCA2016)



Power, Latency Wall

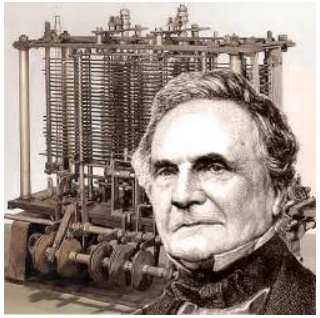
Awards in Computer Architecture



Eckert-Mauchly: IEEE Computer Society and ACM:…… ***"For extraordinary leadership in building a world class computer architecture research center, for seminal contributions in the areas of vector computing and multithreading, and for pioneering basic new approaches to instruction-level parallelism."*** **June 2007**



Seymour Cray: IEEE Computer Society:…… "In recognition of seminal contributions to vector, out-of-order, multithreaded, and VLIW architectures." November 2015



Charles Babbage: IEEE Computer Society: ….."For contributions to parallel computation through brilliant technical work, mentoring PhD students, and building an incredibly productive European research environment.". April, 2017

Eckert-Mauchly Award 2007



Seymour Cray 2015




MATEO VALERO
2015

National Research Awards

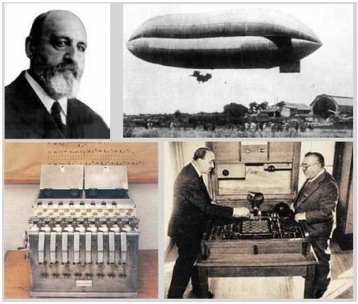


Rey Jaime I Award in Basic Research: **.... is given by the "Generalitat de Valencia" and was presented by the Queen of Spain. This is one of the most prestigious awards in Spain. Several Nobel Prizes Laureates are members of the Jury. November 1997.**



D. JULIO REY PASTOR
Catedrático de análisis matemático de la Universidad Central, que ha obtenido el premio de 12.000 pesetas en el concurso abierto por la Real Academia de Ciencias para recompensar inventos que no se refieran á medios de destrucción

Julio Rey Pastor Award : **….This is the first Spanish National Award to recognize research in Mathematics and/or IT Technologies. The Award is given by the Spanish Ministry of Science and Technology, and was presented by the King of Spain. October, 2001**



Leonardo Torres Quevedo Award: **....that recognizes the engineering 2006. This recognition is awarded for the Spanish Ministresearch in the ry of Science and Technology, and was presented by the king of Spain. January 2007.**

Advanced ERC - Riding on Moore's Law



European Research Council

Established by the European Commission

- 5-year ERC Advanced Grant
- Idea: a radically new conception of parallel architectures, built using a higher level of abstraction
- Objective: ensure continued performance improvements by riding on Moore's Law.

- Holistic approach with parallel architecture partially implemented as a software runtime management layer
- Multicore architecture with vector accelerators exploiting both thread and data level parallelism to optimize data movement
- Handling parallelism, the memory wall and the power wall, in application domains from mobile to supercomputers .



Centro Europeo de Paralelismo de Barcelona

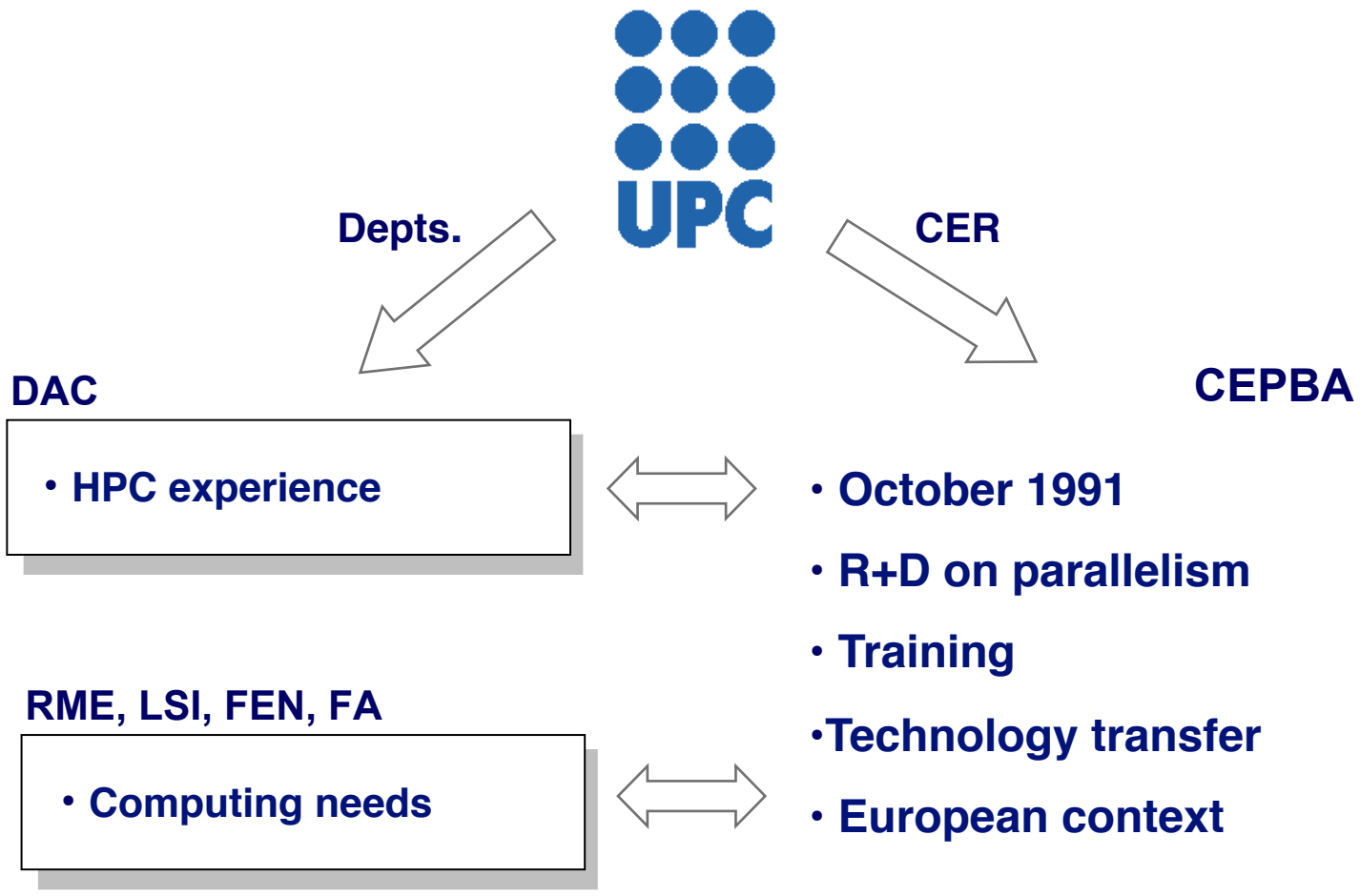
CEPBA

Technology Transfer Research Training Mobility of Researchers

User Support Education HPC Facilities Parallel Expertise

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

CEPBA


UPC
Depts.
CER
DAC
• HPC experience
RME, LSI, FEN, FA
• Computing needs
CEPBA
• October 1991
• R+D on parallelism
• Training
•Technology transfer
• European context

CEPBA inauguración

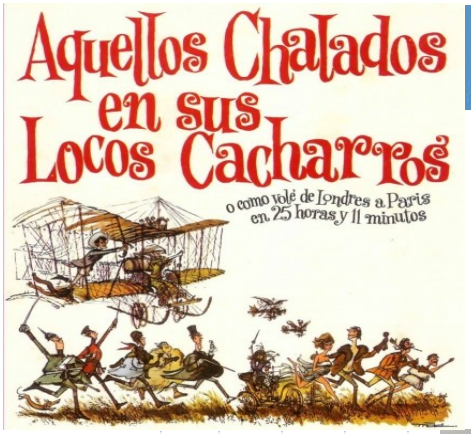








Venimos de muy lejos …















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

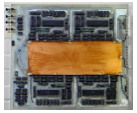


SGI Altix 4700
819.2 Gflops



SL8500
6 Petabytes





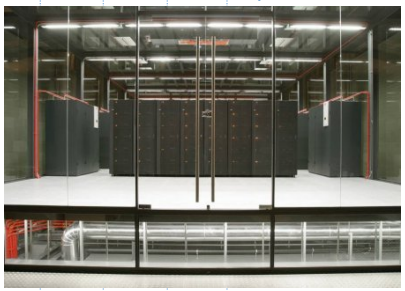
Research prototypes



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

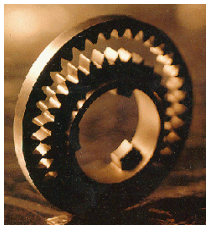
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010

Venimos de muy lejos …

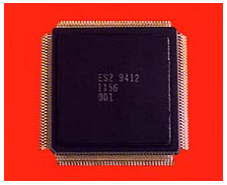
Ayto. Barcelona
Uitesa
UPC-EIO



AMES, CIMNE



TGI
UPM-DATSI



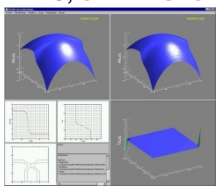
Hesperia
Neosystem
s
UPC-EIO







INDO, CEPBA-UPC



Soler y Palau
CIMNE
CEPBA-UPC

Torres
Soft Greenhouse
CEPBA-UPC



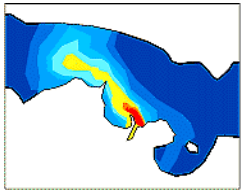
CEPBA
CESCA
UMA
UNICAN
UPM



Metodos Cuantitativos
Gonfiesa
CESCA, CESGA



Tecnatom, UMA



AZTI
UPC-LIM

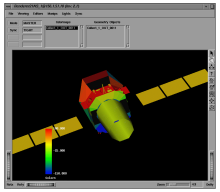
Iberdrola, Uitesa, UPV





BCN COSIVER
Mides
UPC-EIO

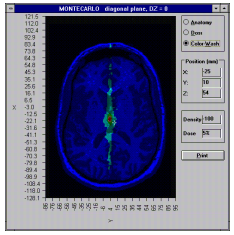
CASA
Envision
GTD
Intespace
RUS

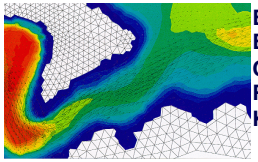






Ospedali Galliera
Le Molinette
Parsytec
PAC
EDS



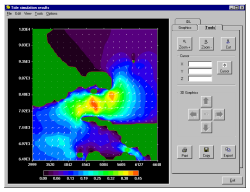


ENEL
EDF
CSR4
Reiter
Kenijoki

Ferrari, Genias, P3C







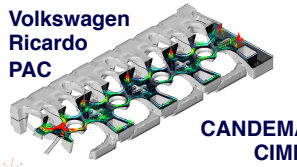
ST Mecanica
DERBI
AUSA
CEPBA-UPC

SENER
CIC
UNICAN

Intera SP
Intera UK
UPC-DIT
CEPBA-UPC

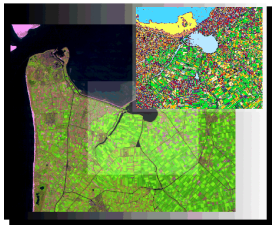


Volkswagen
Ricardo
PAC



CANDEMAT
CIMNE
CEPBA-UPC

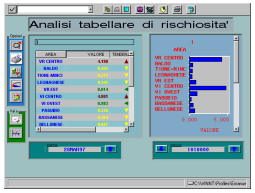
Italeco
Geospace
Intecs
Univ. Leiden

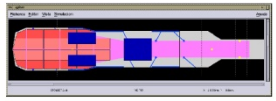


CEBAL-ENTEC
NEOSYSTEMS



Cari Verona
AIS
PAC
Univ.
Cat. Milan





Cristaleria Española
UNICAN
CEPBA-UPC

Inisel Espacio
Infocarto
UPC-TSC
CEPBA-UPC





Iberdrola
SAGE
CEPBA-UPC

History / Strategy



PERMPAR ~1994

GridSs ~2002



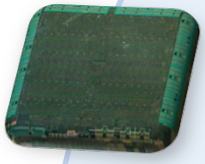
COMPSs ~2007

COMPSs ServiceSs ~2010

COMPSs ServiceSs PyCOMPSs ~2013

CellSs ~2006

GPUSs ~2009



StarSs ~2008

StarSs

SMPSs V1 ~2007

SMPSs V2 ~2009

DDT @ Parascope ~1992

NANOS ~1996

OmpSs ~2008

Forerunner of OpenMP

OpenMP ... 3.0 .... 4.0 ....

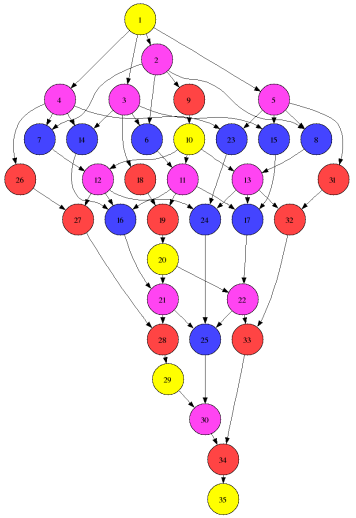
2008 2013

Computer Science: towards Exascale systems

Programming models and runtime

OmpSs

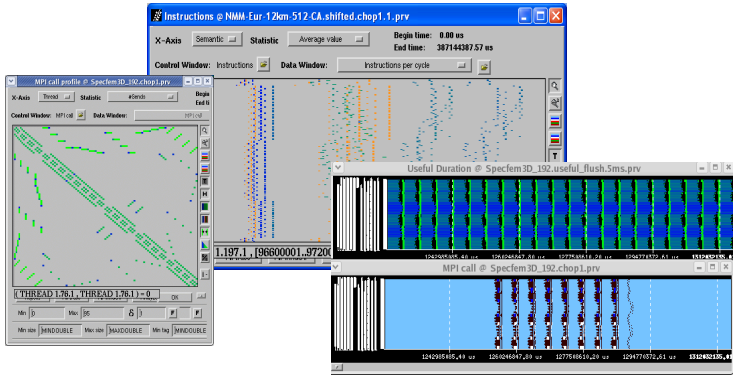
- Simple data directionality annotations for tasks
- Asynchronous data-flow, intelligence to the runtime
- Dynamic Load Balancing (**DLB**)
- Influencing/leveraging standards (OpenMP)
- **MPI + X**, interoperability with accelerator models (CUDA, OpenCL, OpenMP4.0)



Performance analysis tools

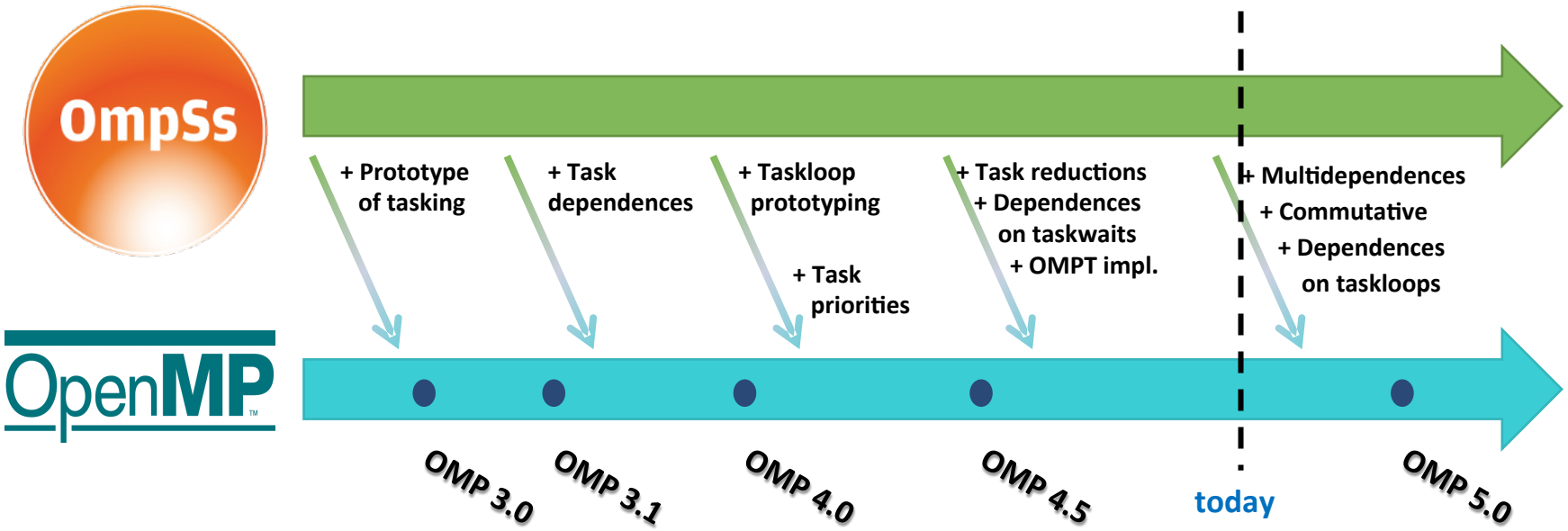
BSCTools

- Extrae, Paraver and Dimemas
- Performance analytics: intelligence, insight
- Methodologies for the performance analyst



OmpSs

A forerunner for OpenMP



Barcelona Supercomputing Center
Centro Nacional de Supercomputación
RoMoL Project

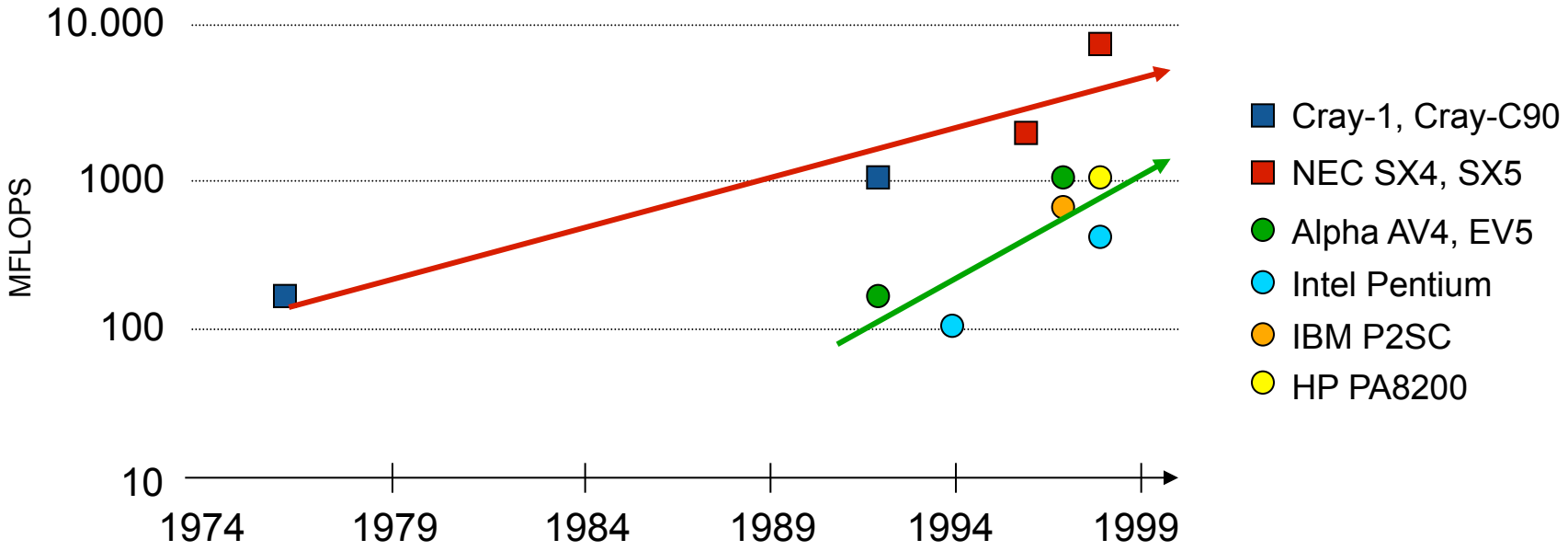
1st European researcher to receive Ken Kennedy Award



2017 Ken Kennedy Award Recipient

"For his contributions to programming models and performance analysis tools for High Performance Computing."

“Killer microprocessors”



- Microprocessors killed the Vector supercomputers
  - They were not faster ...
  - ... but they were significantly **cheaper** and **greener**
- 10 microprocessors approx. 1 Vector CPU
  - SIMD vs. MIMD programming paradigms

M. Valero. “Vector Architectures: Past, Present and Future”. Keynote talk. ICS-11. IEEE-ACM. Melbourne, 1998

Then, commodity took over special purpose





- ASCI Red, Sandia
  - 1997, 1 Tflops (Linpack),
  - 9298 processors at 200 MHz,
  - 1.2 Terabytes
  - Intel Pentium Pro
    - Upgraded to Pentium II Xeon, 1999, 3.1 Tflops

- ASCI White, Lawrence Livermore Lab.
  - 2001, 7.3 TFLOPS,
  - 8192 proc. RS6000 at 375 MHz,
  - 6 Terabytes,
  - IBM Power 3
  - (3+3) MWats

Message-Passing Programming Models

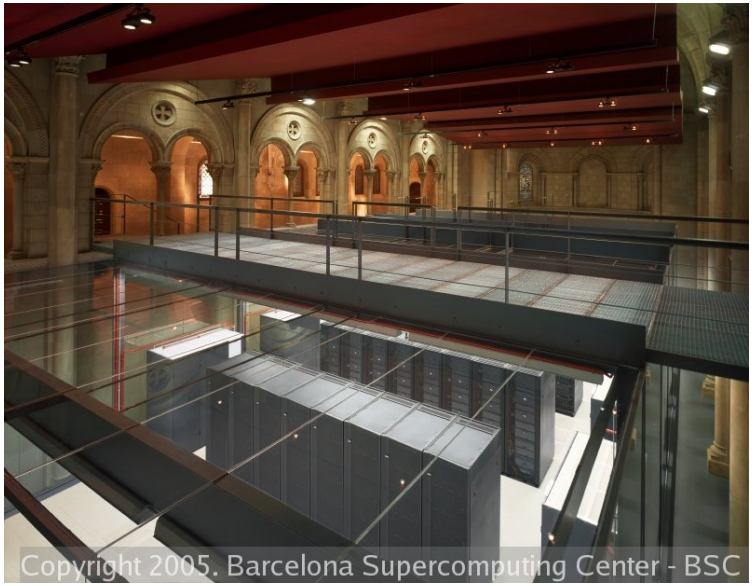
35

Finally, commodity hardware + commodity software

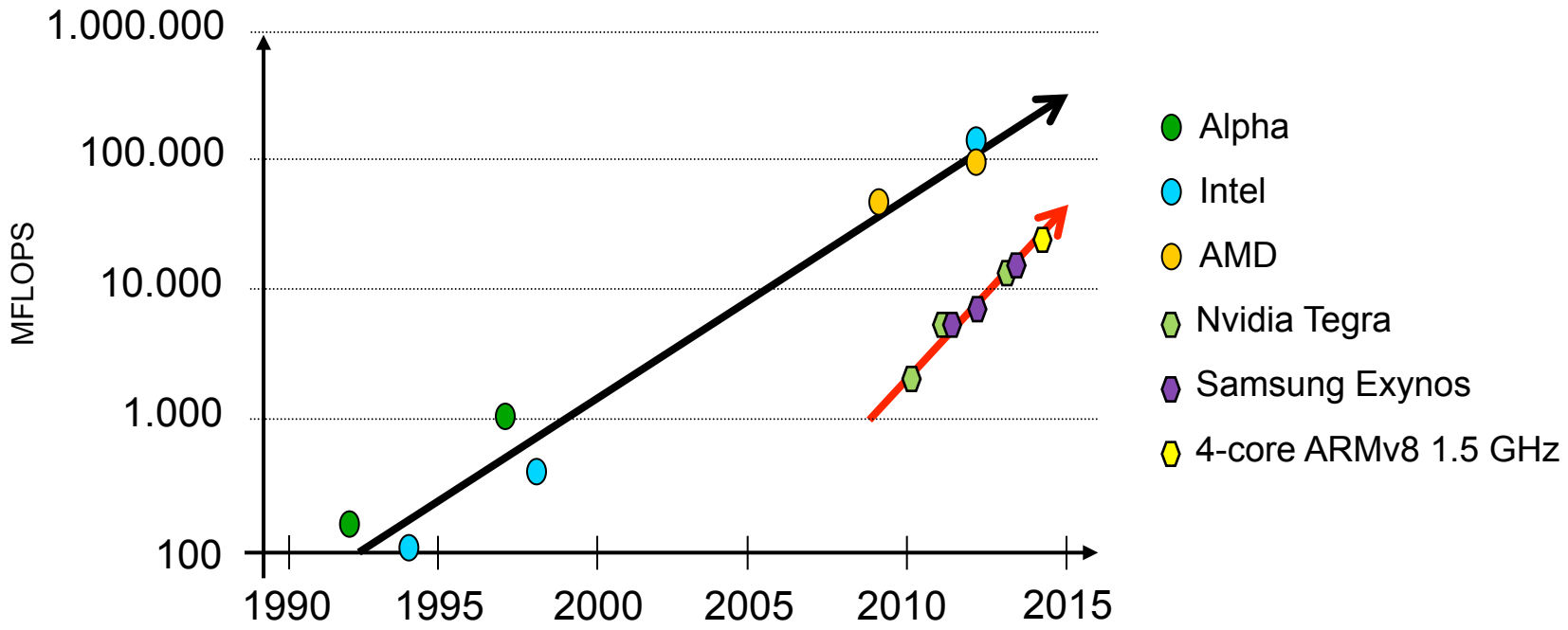
- MareNostrum
  - Nov 2004, #4 Top500
    - 20 Tflops, Linpack
  - IBM PowerPC 970 FX
    - Blade enclosure
  - Myrinet + 1 GbE network
  - SuSe Linux







The Killer Mobile processors™



- Microprocessors killed the Vector supercomputers
  - They were not faster ...
  - ... but they were significantly cheaper and greener
- History may be about to repeat itself ...
  - Mobile processor are not faster ...
  - ... but they are significantly cheaper and greener

10+ year Horizon Future

- CMOS technology will continue to dominate the market for the next 25 years
  - However, we must be ready for CMOS alternatives
    - Quantum computing, Molecular computing, …
- Europe is well positioned in embedded processors, applications and technology
  - Tomorrow's embedded processor are today's high-performance processors
- Europe need to remain the leader in the future embedded domain

HiPEAC Objectives

- to help companies identify and select the best architecture solutions for scaling up high-performance embedded processors in the coming years
- to unify and focus academic research efforts through a processor architecture and compiler research roadmap
- to address the increasingly slow progression of *sustained* processor performance by jointly developing processor architecture and compiler optimizations
- to explore novel approaches for achieving regular and smooth scaling up of processor performance with technology, and to explore the impact of a wide range of post-Moore's law technologies on processor architecture and programming paradigms.

Mateo Valero: Future research in Europe, 1998

Partners

Leading partner per country
- Chalmers University, Sweden
- CNRS, France
- Delft University, The Netherlands
- Edinburgh University, UK
- Ghent University, Belgium
- INRIA, France
- University of Augsburg, Germany
- University of Patras, Greece
- University of Pisa, Italy
- UPC Barcelona

Industrial
- STMicro, Switserland
- Infineon, Germany
- Ericsson, Sweden
- Virtutech, Sweden
- IBM Haïfa, Israel
- Kayser Italia, Italy
- Philips Research, The Netherlands



Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Steering Committee

Josep Llosa
Spain





Olivier Temam
France



Per Stenström
Sweden

Mike O'Boyle
UK



Coordinator



Mateo Valero
UPC



Theo Ungerer
Germany



Stamatis Vassiliadis
The Netherlands



Koen De Bosschere
Belgium



Antonio Prete
Italy



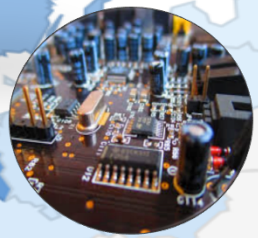
Stefanos Kaxiras
Greece

Network of c.2,000 European R+D experts in advanced computing: **high-performance** and **embedded** architecture and compilation

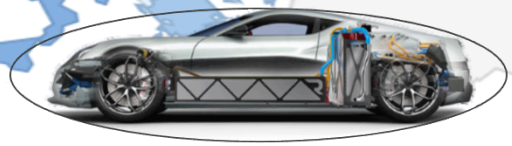
720 members, 449 affiliated members and **871 affiliated PhD students** from **430** institutions in **46** countries.











hipeac.net

HiPEAC has received funding from the European Union's Horizon2020 research and innovation programme under grant agreement number 779656.


C4
Centre de
Computació i
Comunicacions de
Catalunya
CEPBA
CESCA

CEPBA-IBM Research Institute



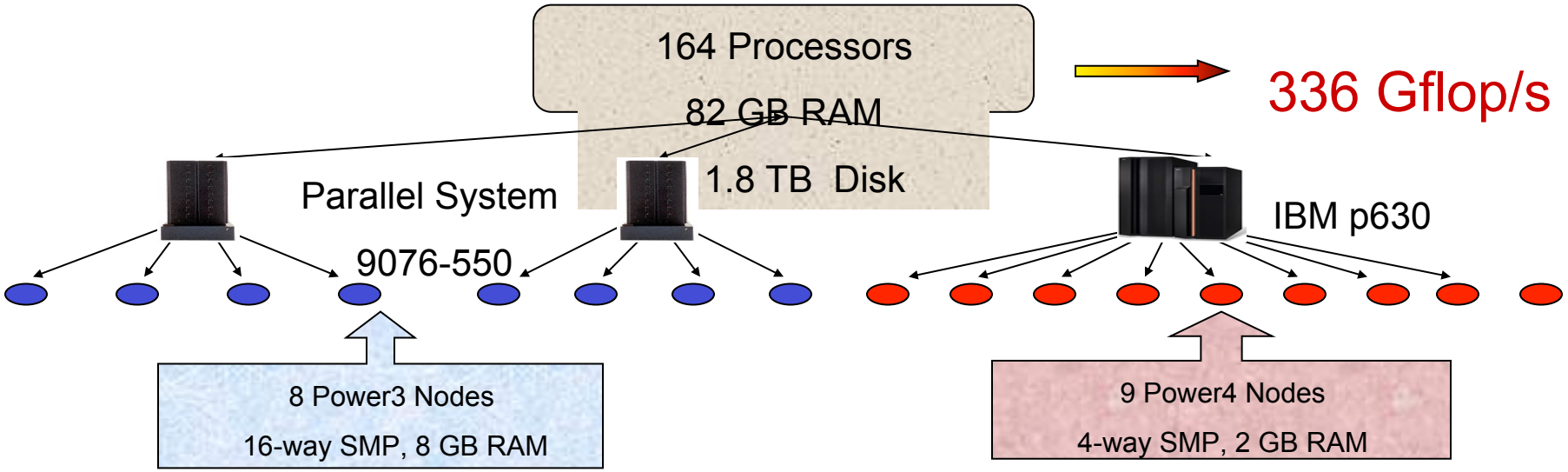
CIRI's mission

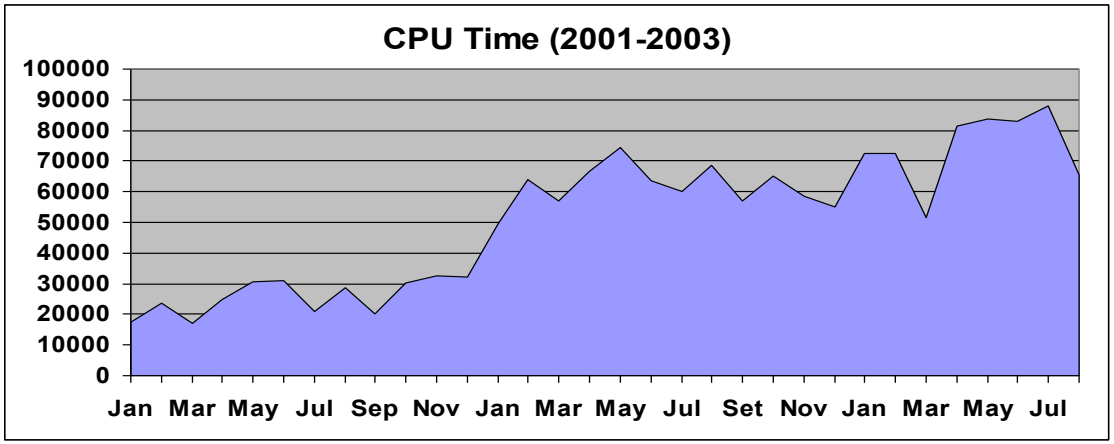
CEPBA-IBM Research Institute (CIRI) is a research and development partnership between UPC and IBM.

- Established in October 2000 with an initial commitment of four years.
- Its mission is to contribute to the community through R&D in Information Technology.
- Its objectives are:
  - Research & Development
  - External R&D Support
  - Technology Transfer
  - Education

- CEPBA (European Center for Parallelism Barcelona) is a deep computing research center, at the Technical University of Catalonia (UPC), which was created in 1991.

Resources / CPU user time evolution



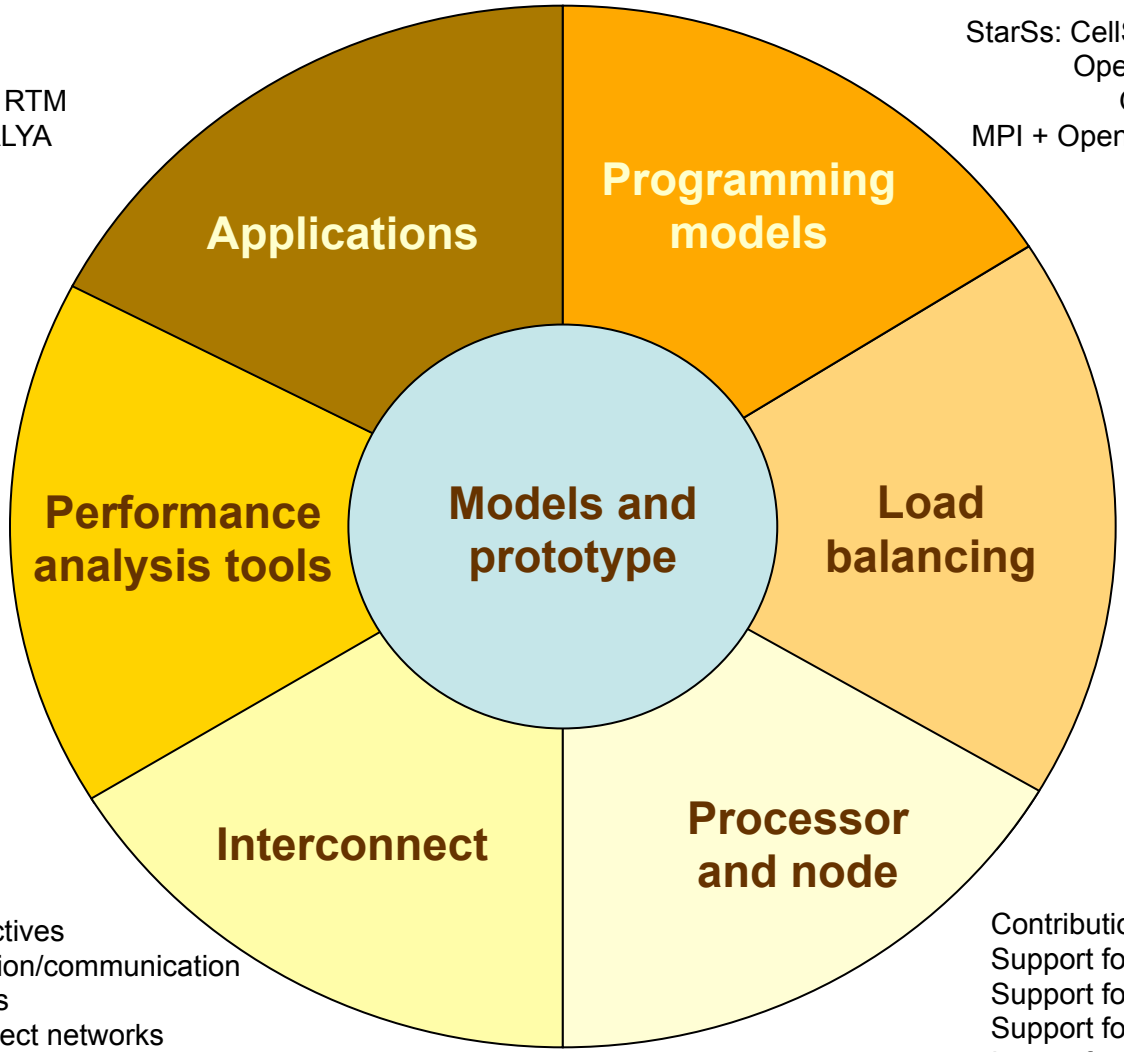


MareIncognito: Project structure

4 relevant apps:
- Materials: SIESTA
- Geophisics imaging: RTM
- Comp. Mechanics: ALYA
- Plasma: EUTERPE

General kernels

StarSs: CellSs, SMPSs
OpenMP@Cell
OpenMP++
MPI + OpenMP/StarSs



Automatic analysis
Coarse/fine grain prediction
Sampling
Clustering
Integration with Peekperf

Coordinated scheduling:
Run time,
Process,
Job
Power efficiency

Contention, Collectives
Overlap computation/communication
Slimmed Networks
Direct versus indirect networks

Contribution to new Cell design
Support for programming model
Support for load balancing
Support for performance tools
Issues for future processors

CIRI

- El CEPBA-IBM Research Institute fue creado en Octubre del 2000.



CESBA… luego BSC

- Centro Español de Supercomputación de Barcelona

Centro Español de Supercomputación

La creación de un Centro Nacional de Supercomputación, con capacidad de I +D en Tecnologías de la Información y de soporte a la I+D de la comunidad científico-técnica española, contribuirá de forma significativa al desarrollo de la ciencia en España, obtendrá economías de escala en la capacidad de computación, sinergias científico-técnicas y racionalización de costes.

El Centro contribuirá a impulsar un entorno tecnológico adecuado en el que las administraciones públicas, los centros de investigación y las empresas puedan beneficiarse de las ventajas de la supercomputación, y tratar de resolver los problemas científicos más acuciantes de nuestros días.

Supercomputación

La Supercomputación es una herramienta de ayuda al desarrollo de la ciencia y la ingeniería, concretamente en las áreas de simulación y modelización.

Casos concretos:

• ciencias de la vida, ayuda a mejorar la salud humana gracias a la simulación virtual de los procesos que suceden en el cuerpo humano

• ciencias del medio ambiente, herramienta para combatir tres de las grandes amenazas del s.XXI: la falta de agua, la extensión de las enfermedades infecciosas y el cambio climático

•ciencias químico-físicas, nuevos materiales y nuevos diseños en aeronáutica, o automoción , (aplicación al barco español, si participamos en la Copa del América?)

La Supercomputación es una herramienta poderosa para aumentar la competitividad científica, tecnológica e industrial de las comunidades que invierten en ella.

Beneficios para la Comunidad Científica

El Centro Nacional de Supercomputación permitirá a los científicos españoles acceder a recursos de los que hoy sólo disponen en centros internacionales, ampliando el espectro de proyectos abordables y acelerándose los ciclos de investigación actuales.

El superordenador estará disponible también para la comunidad científica internacional, ayudando a aumentar la ventaja competitiva de nuestro país en el nuevo mundo tecnológico.

El uso del supercomputador del Centro se establecerá en base a un protocolo abierto de acceso disponible para todos los investigadores españoles. Un Consejo Científico independiente priorizará los proyectos de investigación a aceptar según su valor científico y su necesidad real de supercomputación.

Previsión para el siguiente TOP500 (Nov. 2004)

El Superordenador tendrá una capacidad de proceso de 40 TFlop/s pico (>20 sustained) y constará aproximadamente de 4.500 procesadores, 128 TeraBytes de disco y 9.0 TeraBytes de memoria principal.

System	Make	Procs	Description	Type	Linpack TFlops	MW	Country
#1 Blue Gene L (1/2)	IBM	64k	750 MHz POWER	special purpose	100	.8	USA
#2 Earth Simulator	NEC	5120	500 MHz NEC	special purpose	35.9	5.1	Japan
#3 or #4 Red Storm	CRAY	10k	2 GHz Opteron	special purpose	20-35 (40 Peak)	< 2	USA
#4 or #3 Mare Nostrum	**IBM**	**4500**	**2.2 GHz POWER**	**general purpose**	**20+**	**<0.3**	**Spain**
#5 ASCI Q	HP	8192	1.25 GHz Alpha	special purpose	13.9	2	USA
#6 Big Mac	Apple	2200	2 GHz POWER	homebuilt	9.8	< 1.5	USA

MareNostrum

- MareNostrum fue instalado en 2004 a partir de la firma entre el Gobierno de España e IBM de 10 de marzo de 2004.



MareNostrum

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BSC-CNS

- El Barcelona Supercomputing Center – Centro Nacional de Supercomputación (BSC-CNS) fue constituido el 1 de Abril de 2005



BSC-CNS

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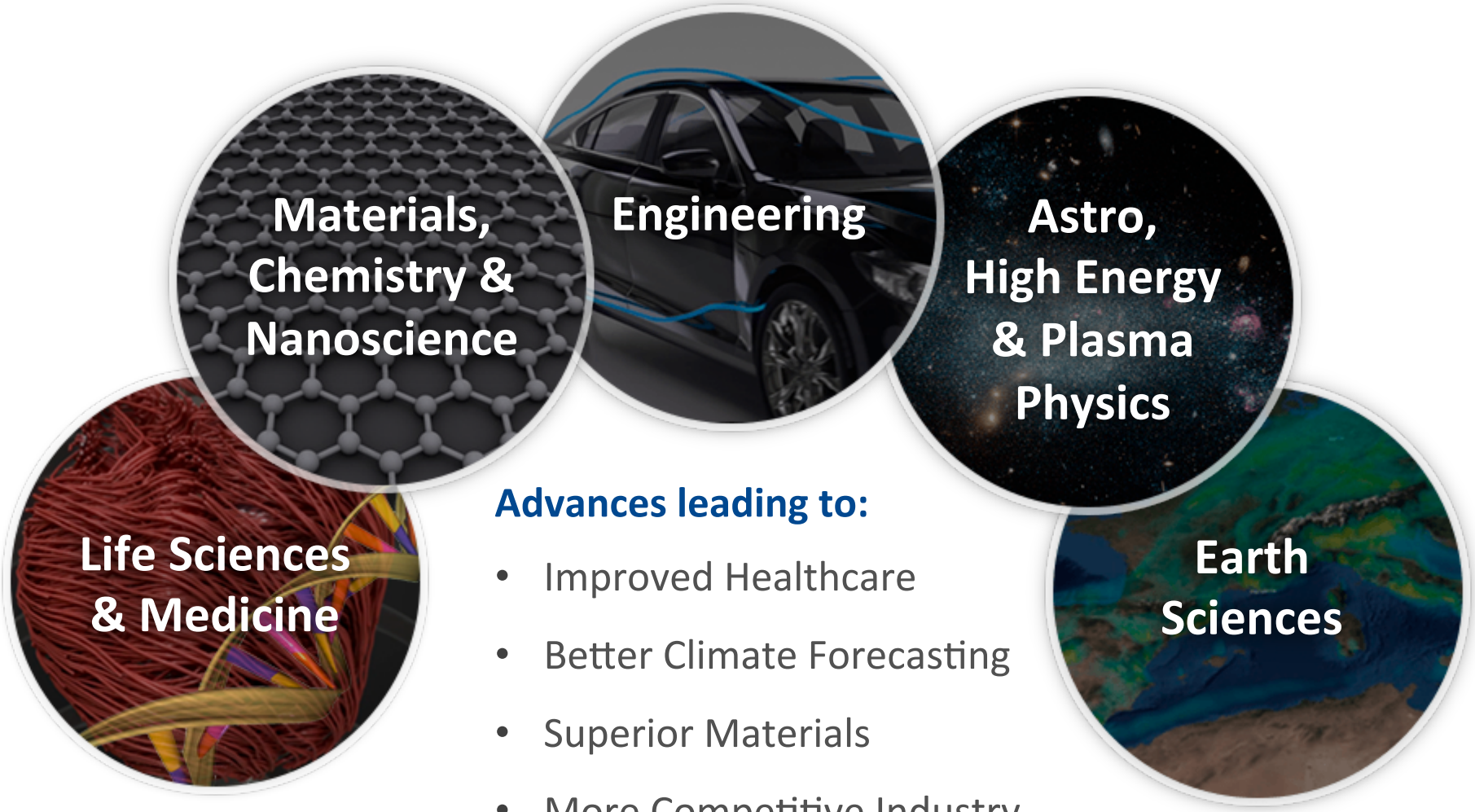
The evolution of the research paradigm



Numerical simulation and Big Data analysis

- Reduce expense
- Avoid suffering
- Help to build knowledge where experiments are impossible or not affordable

HPC: An enabler for all scientific fields



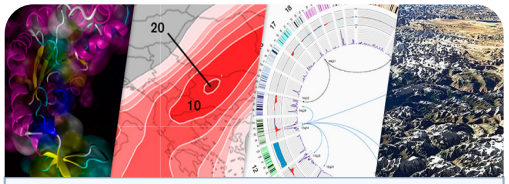
Advances leading to:

- Improved Healthcare
- Better Climate Forecasting
- Superior Materials
- More Competitive Industry

Barcelona Supercomputing Center
Centro Nacional de Supercomputación



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%**	GOBIERNO DE ESPAÑA · MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
Catalonian Government	**30%**	Generalitat de Catalunya Departament d'Empresa i Coneixement
Univ. Politècnica de Catalunya (UPC)	**10%**	UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

MareNostrum4

Total peak performance: **13,7** Pflops		
General Purpose Cluster:	11.15 Pflops	(1.07.2017)
CTE1-P9+Volta:	1.57 Pflops	(1.03.2018)
CTE2-Arm V8:	0.5 Pflops	(????)
CTE3-KNH?:	0.5 Pflops	(????)



MareNostrum 1
2004 – 42,3 Tflops
1st Europe / 4th World
New technologies

MareNostrum 2
2006 – 94,2 Tflops
1st Europe / 5th World
New technologies

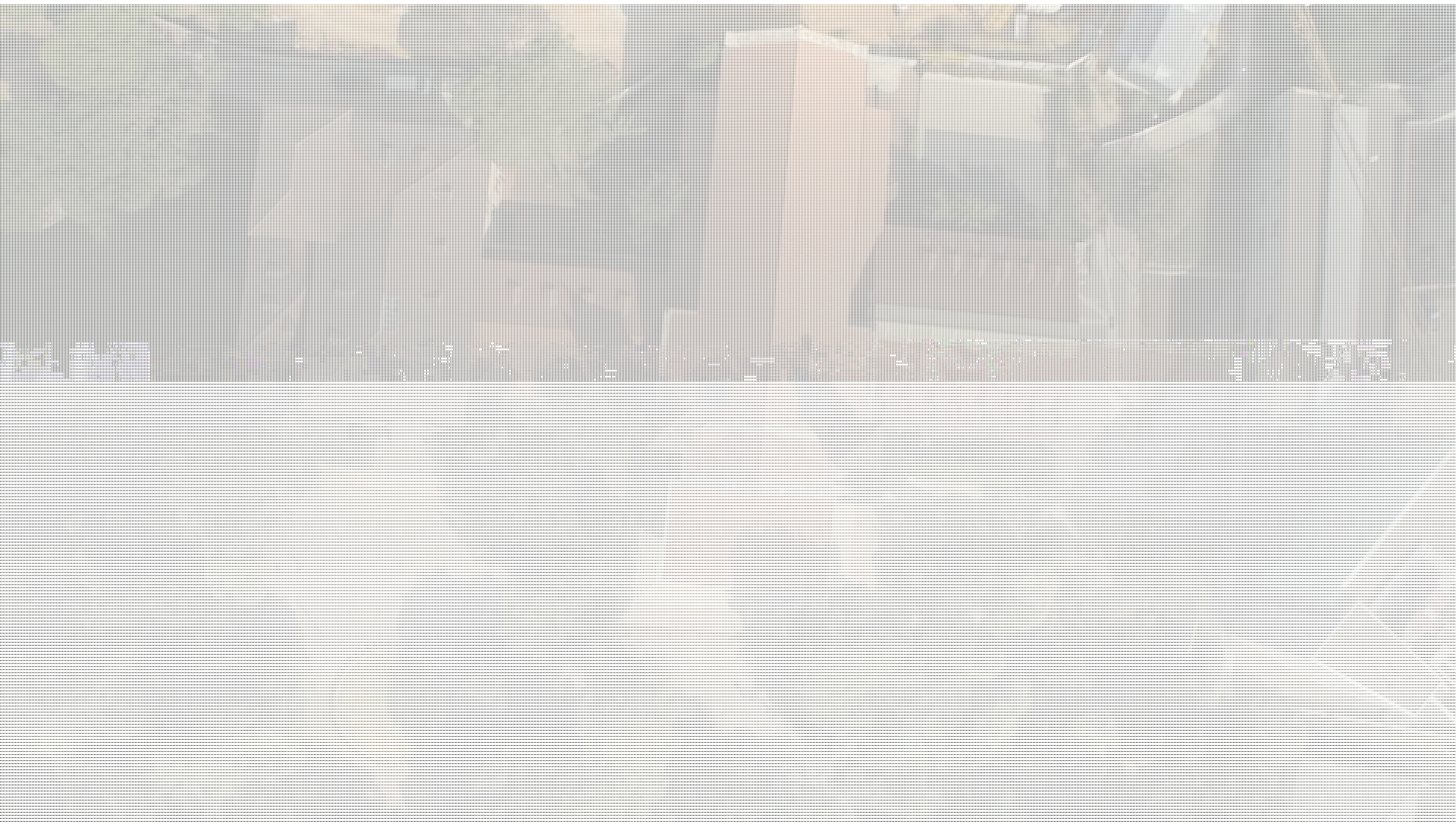
MareNostrum 3
2012 – 1,1 Pflops
12th Europe / 36th World

MareNostrum 4
2017 – 11,1 Pflops
2nd Europe / 13th World
New technologies

Top10, Nov 2018

Rank	Name	Site	Manufacturer	Country	Cores	Accelerators	Rmax [TFlop/s]	Rpeak [TFlop/s]	GFlops /Watts
1	Summit	DOE/SC/Oak Ridge National Laboratory	IBM	US	2,397,824	2,196,480	143,500	200,795	14.67
2	Sierra	DOE/NNSA/Lawrence Livermore National Lab.	IBM/NVIDIA	US	1,572,480	1,382,400	94,640	125,712	12.72
3	Sunway TaihuLight	National Supercomputing Center in Wuxi	NRCPC	China	10,649,600		93,015	125,436	6.05
4	Tianhe-2ª	National Super Computer Center in Guangzhou	NUDT	China	4,981,760	4,554,752	61,445	100,679	3.33
5	Piz Daint	Swiss National Supercomputing Centre	Cray Inc.	Switz	387,872	319,424	21,230	27.154.3	8.90
6	Trinity	DOE/NNSA/LANL/SNL	Cray Inc.	US	979,072		20,158,7	41,461	2.66
7	AI Bridging Cloud Inf.	National Inst. of Adv Industrial Science & Tech.	Fujitsu	Japan	391,680	348,160	19,880	32,577	12.05
8	SuperMUC-NG	Leibniz Rechenzentrum	Lenovo	Germany	305,856		19,477	28,872,86	
9	Titan	DOE/SC/Oak Ridge National Laboratory	Cray Inc.	US	560,640	261,632	17,590	27,113	2.14
10	Sequoia	DOE/NNSA/Lawrence Livermore National Lab.	IBM	US	1,572,864		17,173	20,133	2.18
25	MareNostrum	Barcelona Supercomputing Center	Lenovo	Spain	153,216		6,471	10,296	3.97

MareNostrum 4



From MN3 to MN4

MareNostrum 4, chosen as the most beautiful data centre in the world

11 December 2017

The award, organised by DataCenter Dynamics, has been granted by popular vote.



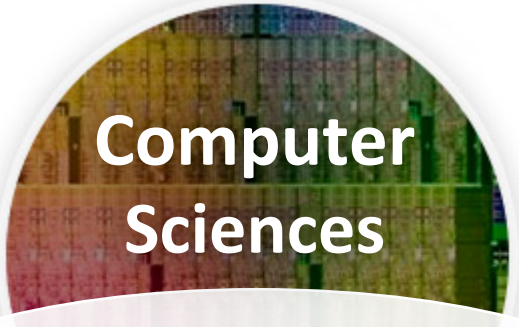
MareNostrum 4 supercomputer has been the winner of the Most Beautiful Data Center in the world Prize, hosted by the Datacenter Dynamics (DCD) Company.

There are 15 prizes in different categories, besides the prize for the most beautiful data centre, which is elected by popular vote. MareNostrum 4 competed with such impressive facilities as the Switch Pyramid in Michigan, the Bahnhof Pionen in Stockholm or the Norwegian Green Mountain. BSC supercomputer has prevailed for its particular location, inside the chapel of Torre Girona, located in the North Campus of the Universitat Politècnica de Catalunya (UPC).

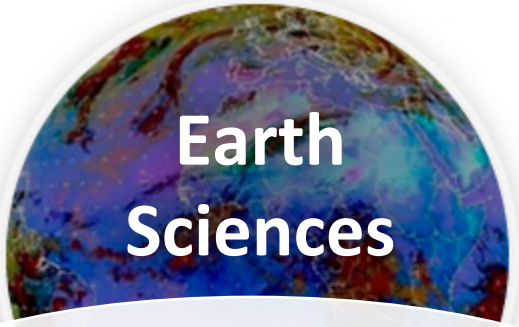
The awards ceremony took place on December 7th in London and both Mateo Valero, BSC Director, and Sergi Girona, Operations department Director, received the prize.

About MareNostrum 4

Mission of BSC Scientific Departments



To influence the way machines are built, programmed and used: programming models, performance tools, Artificial Intelligence, computer architecture, energy efficiency



To develop and implement global and regional state-of-the-art models for short-term air quality forecast and long-term climate applications

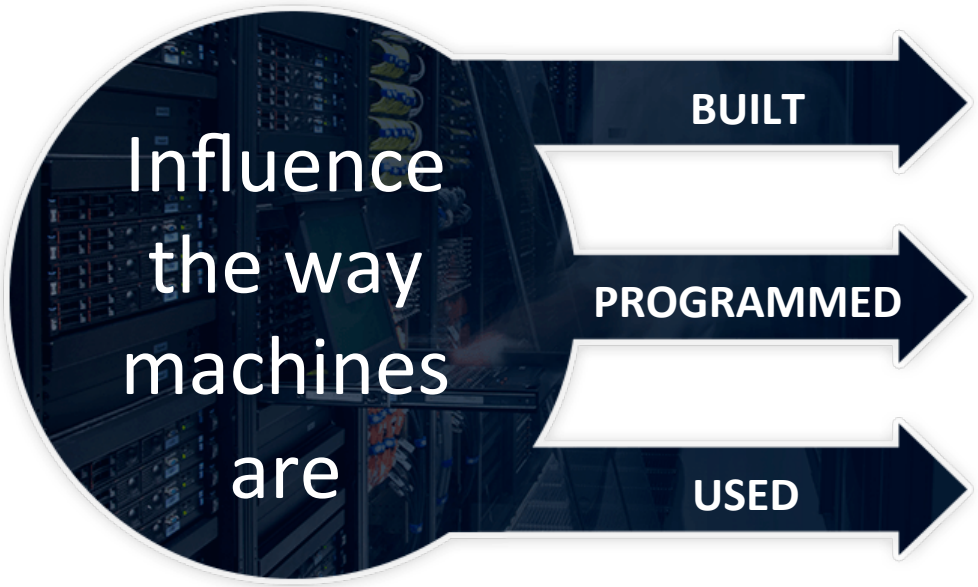


To understand living organisms by means of theoretical and computational methods (molecular modeling, genomics, proteomics)



To develop scientific and engineering software to efficiently exploit super-computing capabilities (biomedical, geophysics, atmospheric, energy, social and economic simulations)

Computer Sciences



Holistic Computer Architecture Research

20 years innovating in Programming Models

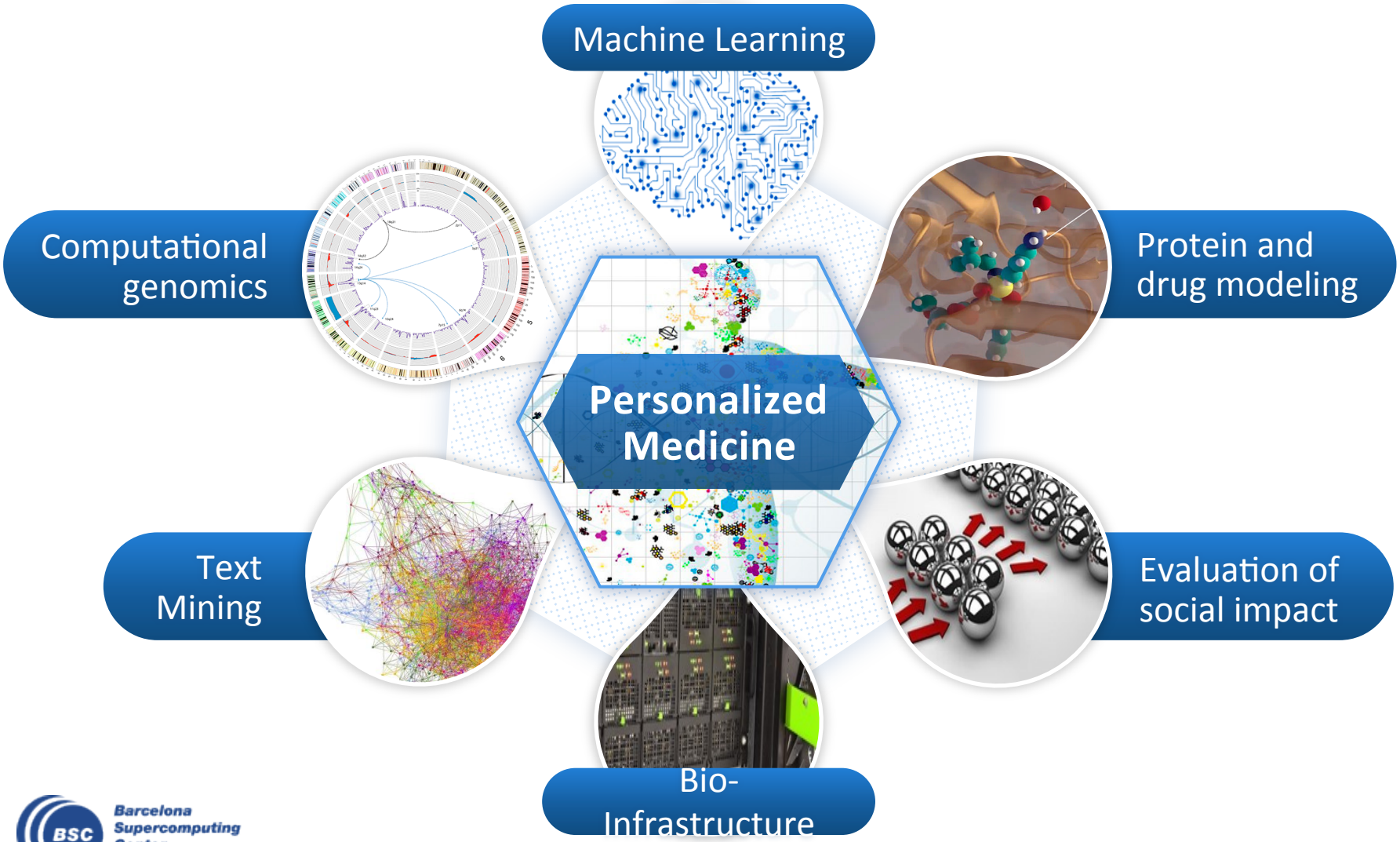
Performance Analytics Tools: From Data to Insight

In the context of

- Race towards Exascale
- HPC and Big Data convergence
- Artificial Intelligence era
- Multiple architectures for different applications domains

Life Sciences

Understanding living organisms by theoretical and computational methods



Earth Sciences

Environmental modelling and forecasting, with a particular focus on weather, climate and air quality

Modeling **air quality** and **Sand and Dust Storms** Processes from urban to Global and the impacts on weather, health and ecosystems

Research and Forecasts

Climate predictions system from subseasonal-to-decadal forecasts

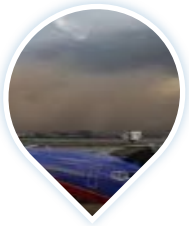
Service Users Sectors


Infrastructures


Solar Energy



Urban development


Transport


Wind Energy


Agriculture

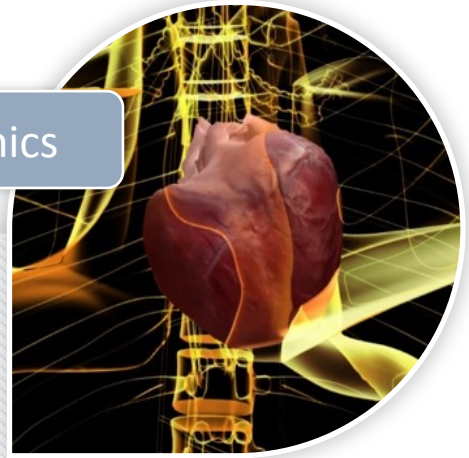

Insurance

Computional Applications for Science and Engineering



Energy

Biomechanics

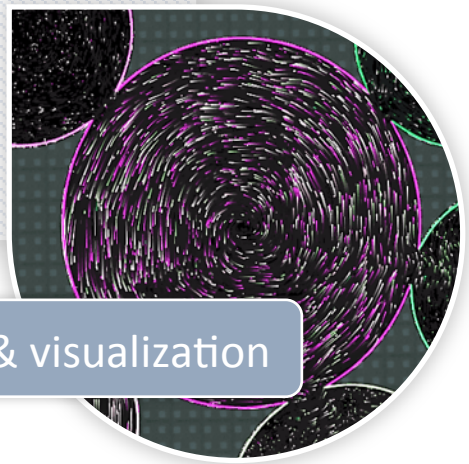


INDUSTRY ORIENTED DEPARTMENT

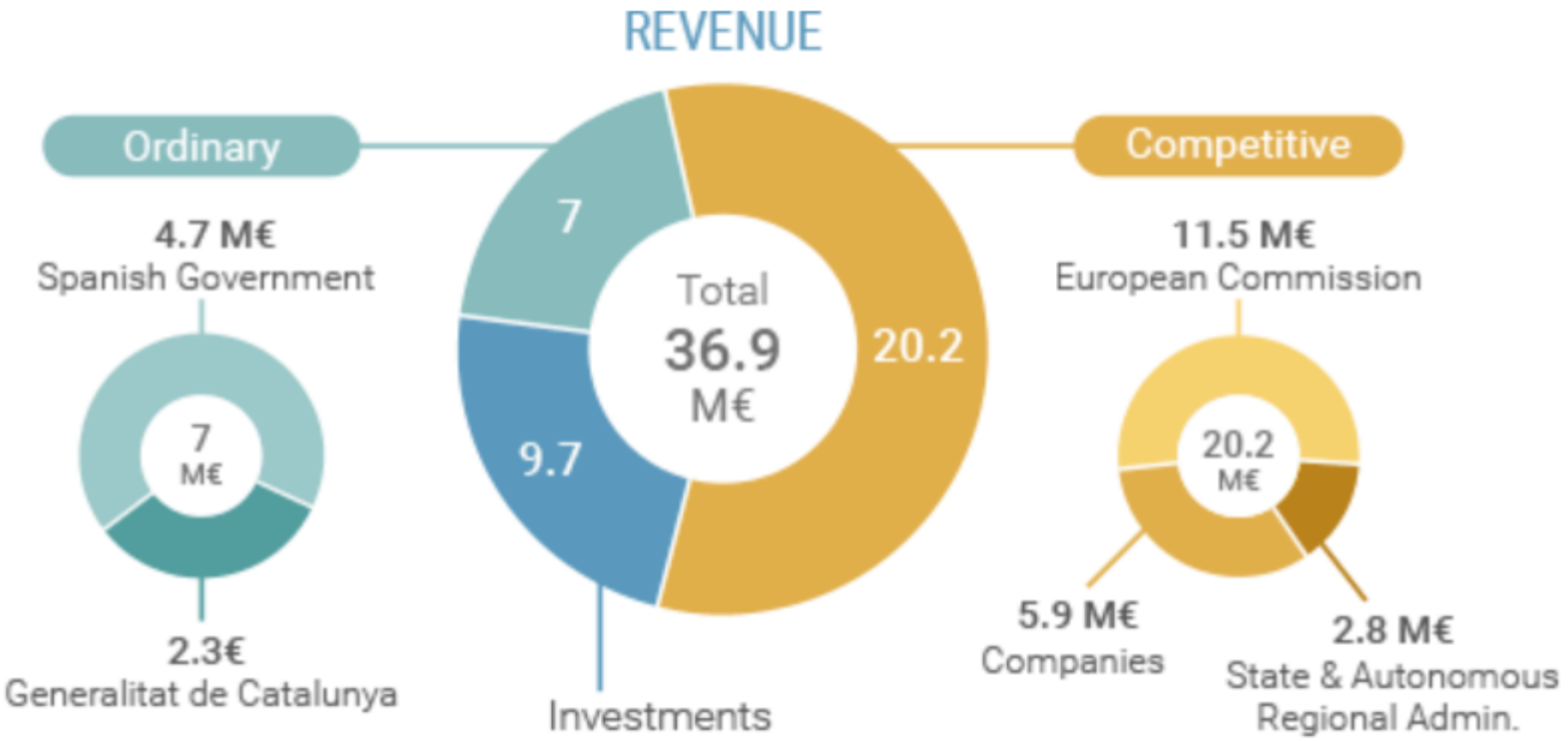


Smart & resilient cities

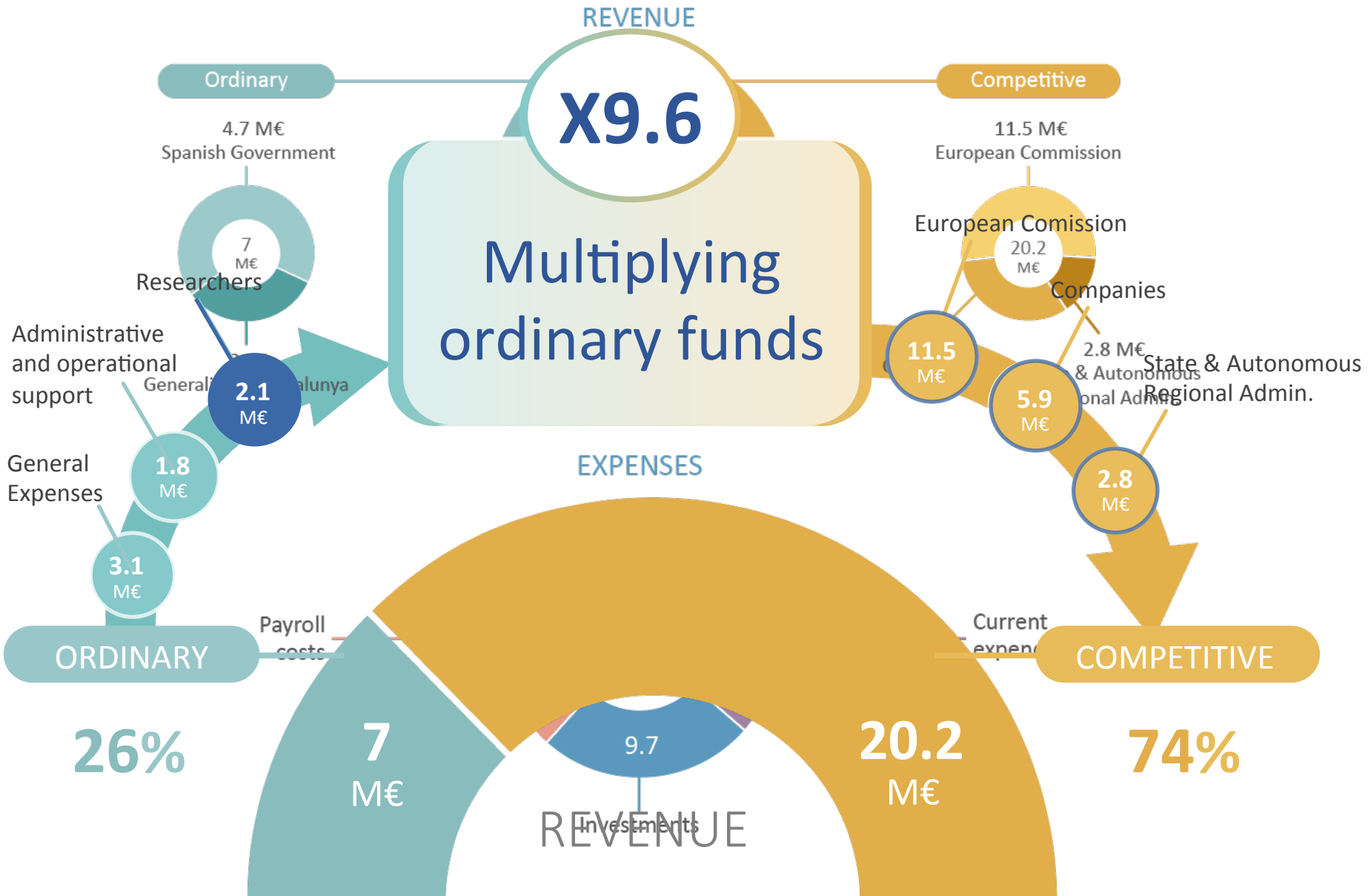
Data analytics & visualization



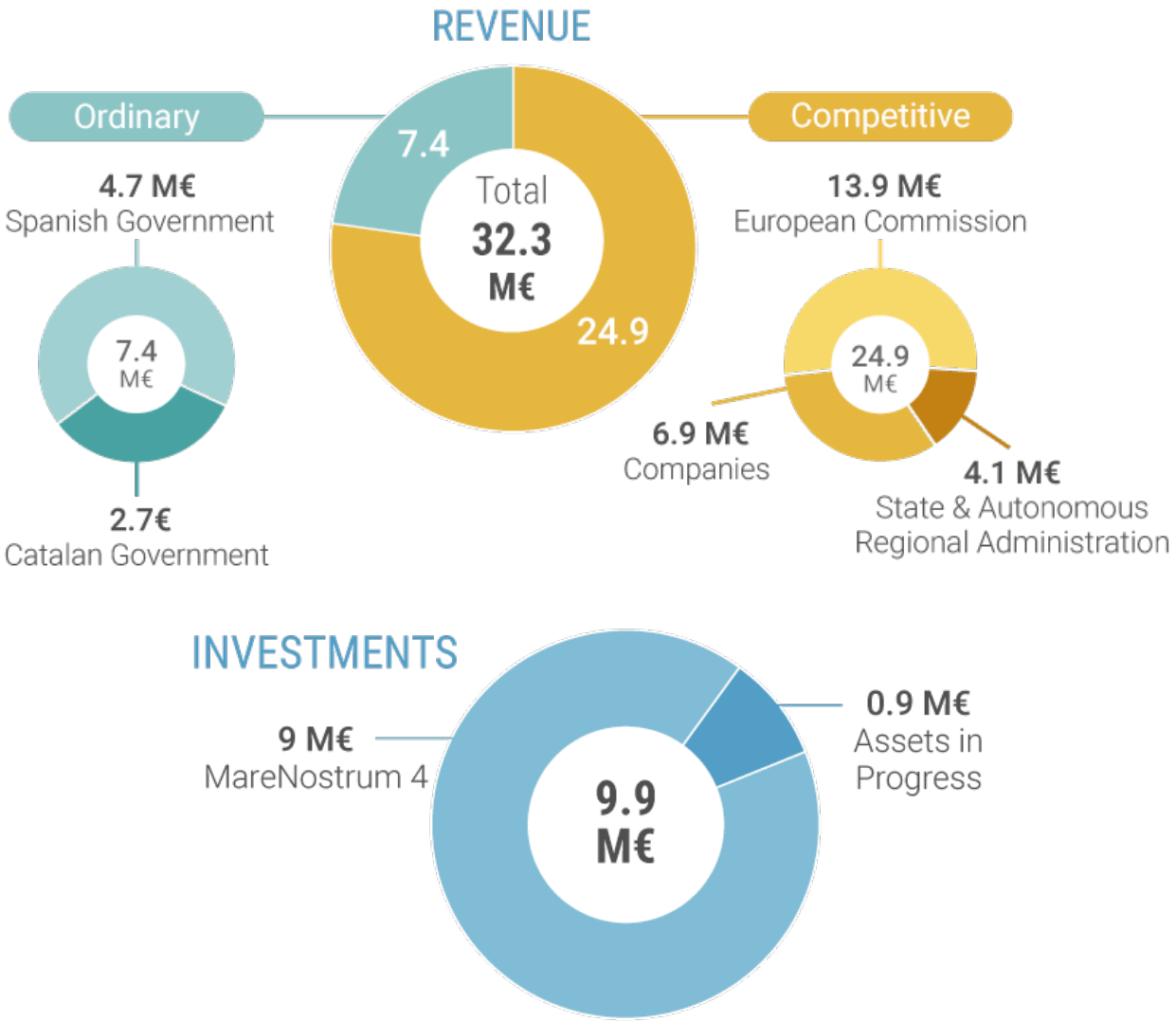
BSC Funding 2017



BSC Resources *2017 executed budget*



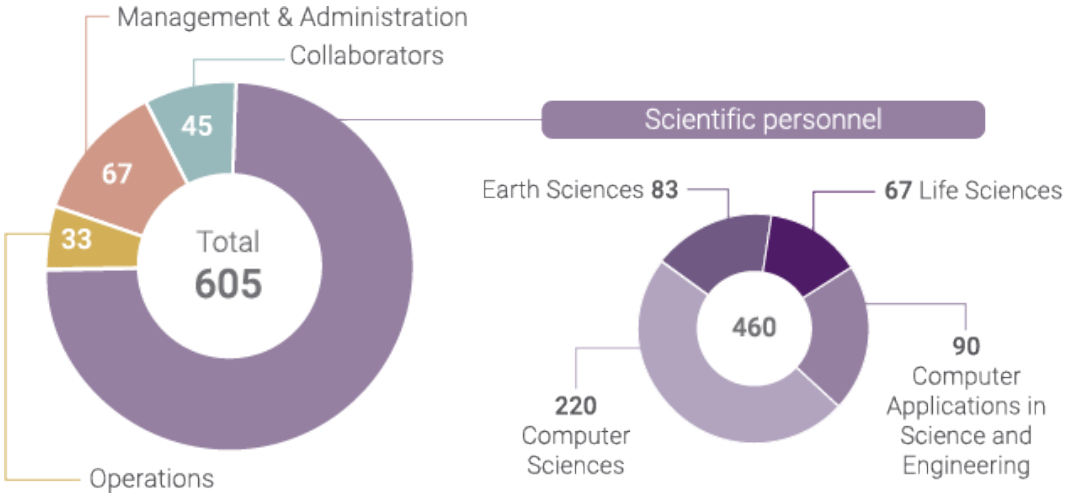
BSC Funding 2018

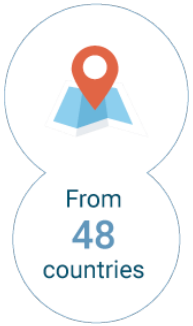


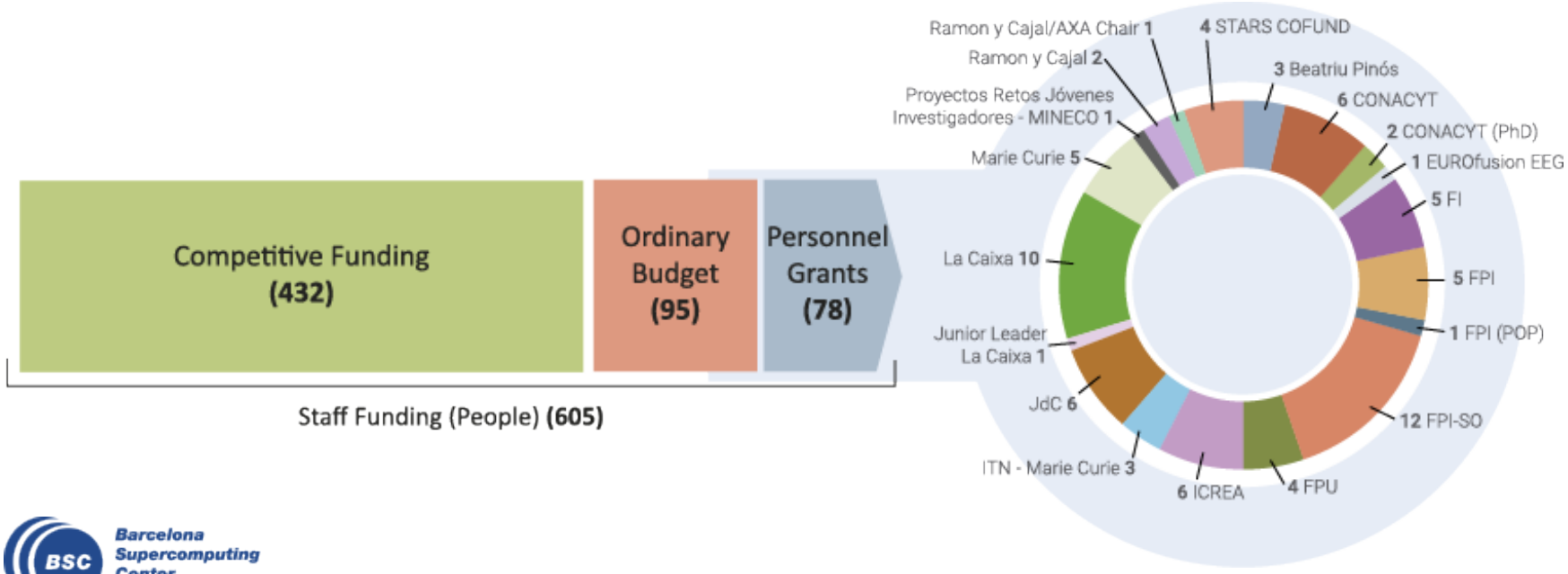
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Estimated executed budget at December 31, 2018

People







Barcelona Supercomputing Center
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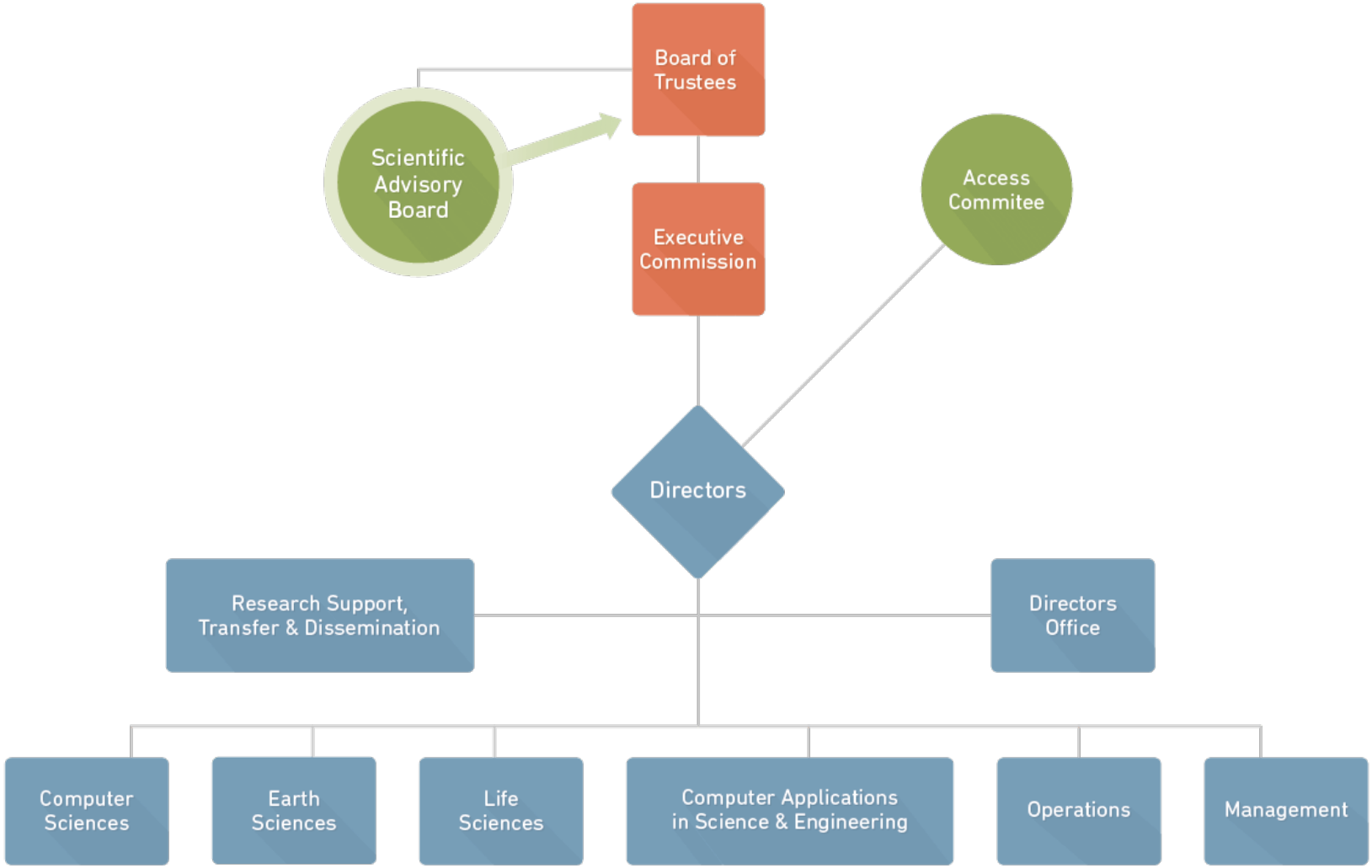
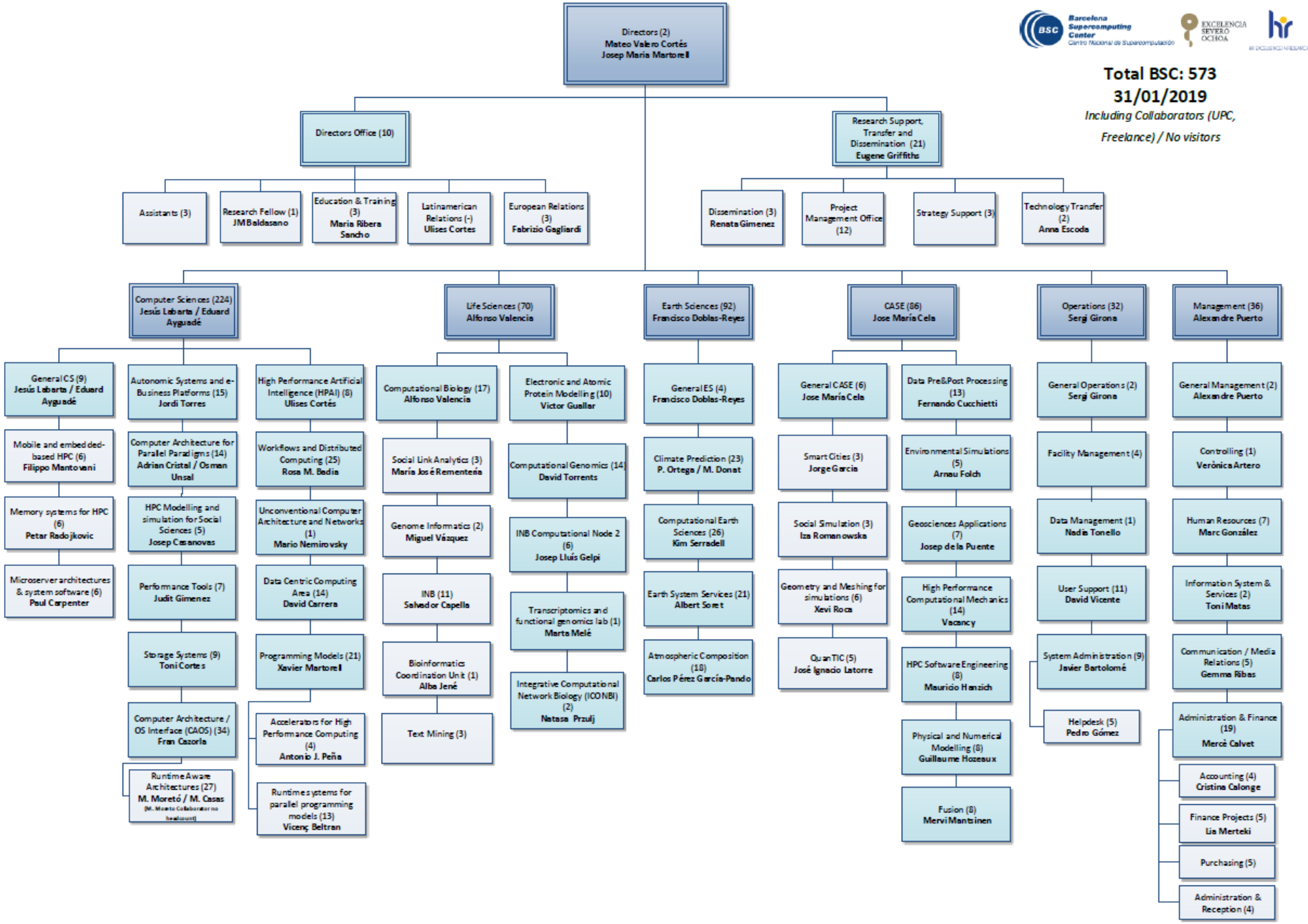
Data as of October 31, 2018

Organization updated





Total BSC: 573

31/01/2019

Including Collaborators (UPC, Freelance) / No visitors

ERC and ICREA at BSC



Mateo Valero
research in microarchitecture, runtime systems, compilers and programming languages



Xevi Roca
research in best curved adapted meshes for space-time flow simulations



Fran Cazorla
research in Sustainable Performance for High Performance Embedded Computing Systems



David Carrera
research in holistic integration of emerging supercomputing technologies



Victor Guallar
research in electronic and atomic protein modelling



Nataša Pržulj
research in biological network topology as a complement of genome biological information



Toni Gabaldón
research in reticulate evolution: patterns and impacts of non-Vertical inheritance in eukaryotic genomes



Alfonso Valencia
Research in text mining technology and protein interaction networks applied to Precision Medicine



David Torrents
research in computational genomics



Mervi Mantsinen
research in numerical modelling of experiments in magnetically confined fusion devices



Francisco J Doblas-Reyes
research in earth software, Climate Change and seasonal-to-decadal predictions



Vassil Alexandrov
research in extreme computing



Mario Nemirovsky
research in unconventional computer architecture and networks

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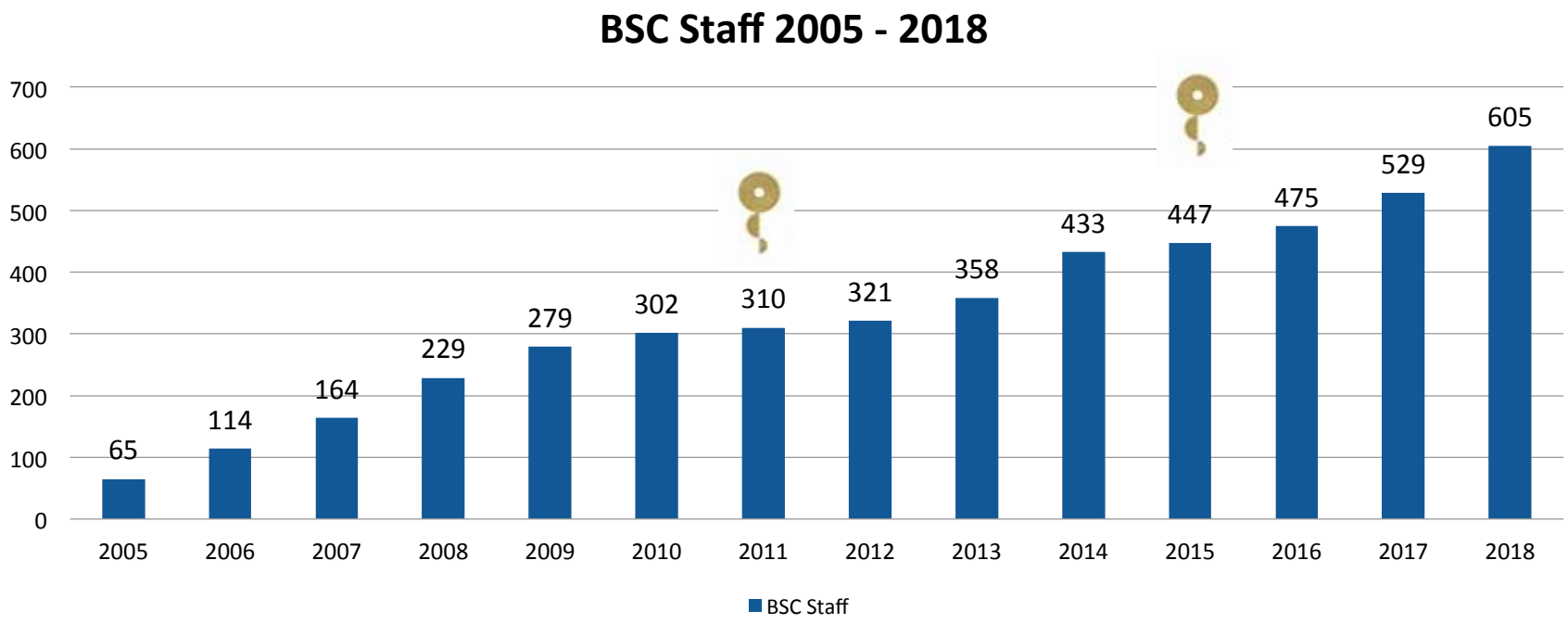
People evolution



RES: HPC Services for Spain

RES now made up of **thirteen** supercomputers

RED ESPAÑOLA DE SUPERCOMPUTACIÓN



- **Finis Terrae II**, Centro de Supercomputación de Galicia (CESGA);
- **Pirineus**, Consorcio de Servicios Universitarios de Cataluña (CSUC);
- **Lusitania**, Fundación Computación y Tecnologías Avanzadas de Extremadura;
- **Caléndula**, Centro de Supercomputación de Castilla y León,y
- **Cibeles**, Universidad Autónoma de Madrid



Access www.res.es

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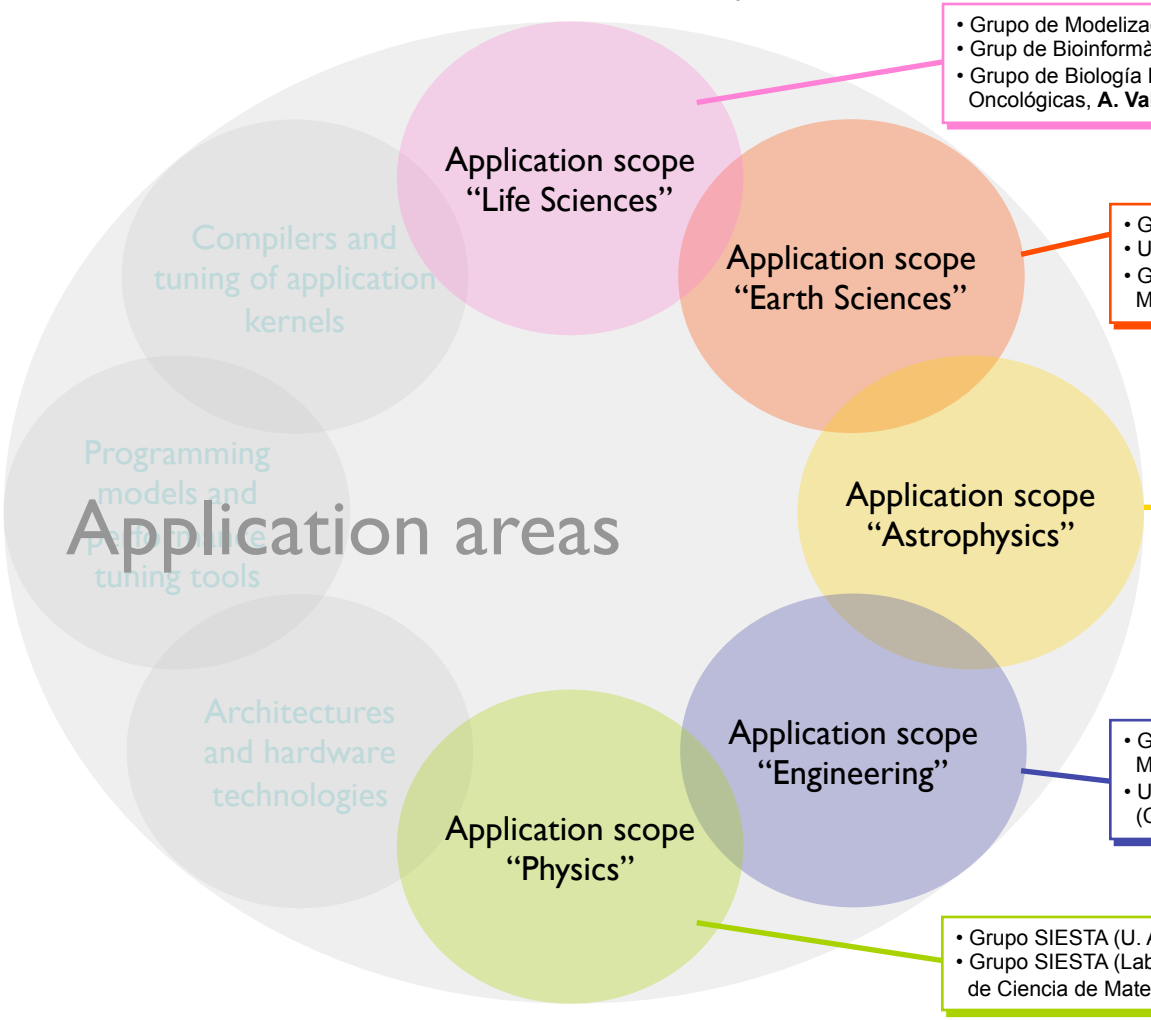
Centro Nacional de Supercomputación

Consolider

El BSC-CNS coordina un programa Consolider de supercomputación y e-Ciencia, que une a grupos de investigación expertos en aplicaciones que requieren supercomputación y a grupos expertos en el diseño del hardware y software de base de los supercomputadores.



- Grupo de Modelización Molecular y Bioinformática (U. de Barcelona, **M. Orozco**)
- Grup de Bioinformàtica del Genoma (Centre de Regulació Genòmica, **R. Guigó**)
- Grupo de Biología Estructural Computacional (Centro Nacional de Investigaciones Oncológicas, **A. Valencia**)

- Grupo de Ciencias de la Tierra (BSC-CNS, **J. M. Baldasano**)
- Unidad de Contaminación Atmosférica (CIEMAT, **F. Martín**)
- Grupo de Diagnóstico y Modelización del Clima (U. Complutense de Madrid, **R. García-Herrera**)

- Grupo de Astrofísica Relativista y Cosmología (U. de Valencia, **J. M. Ibáñez**)
- Grupo de Simulación Numérica de Procesos Astrofísicos (Instituto de Astrofísica de Canarias, **F. Moreno**)
- Grupo GAIA de Astronomía Galáctica (U. de Barcelona, **J. Torra**)
- Grupo de Cosmología Computacional (U. Autónoma de Madrid, **G. Yepes**)

- Grupo de Mecánica de Fluidos Computacional (U. Politécnica de Madrid, **J. Jiménez Sendín**)
- Unidad de Simulación Numérica y Modelización de Procesos (CIEMAT, **M. Uhlmann**)

- Grupo SIESTA (U. Autónoma de Madrid, **J. M. Soler**)
- Grupo SIESTA (Laboratorio de Estructura Electrónica de los Materiales del Instituto de Ciencia de Materiales de Barcelona ICMAB-CSIC, **P. J. Ordejón**)

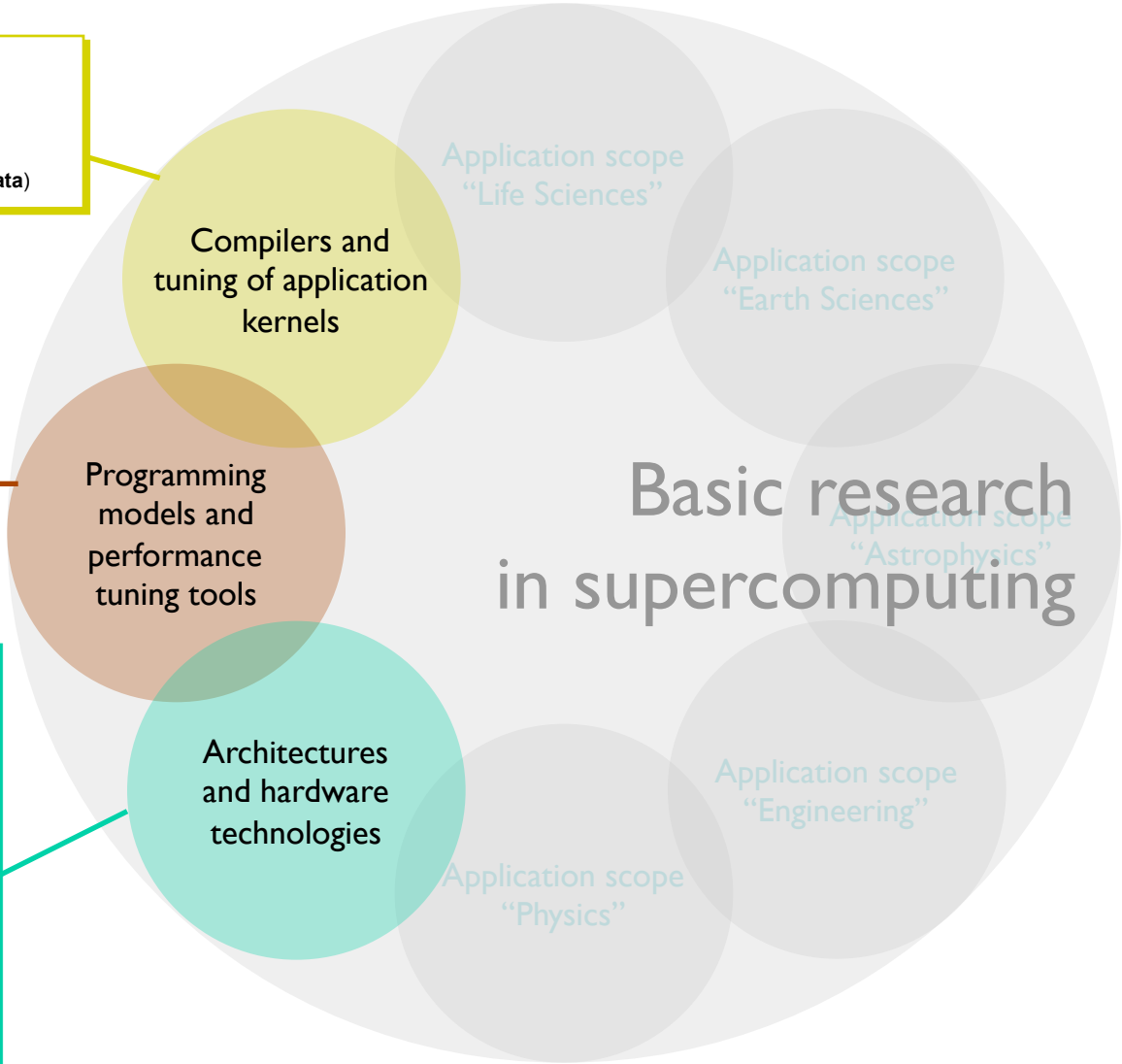
Consolider (2)



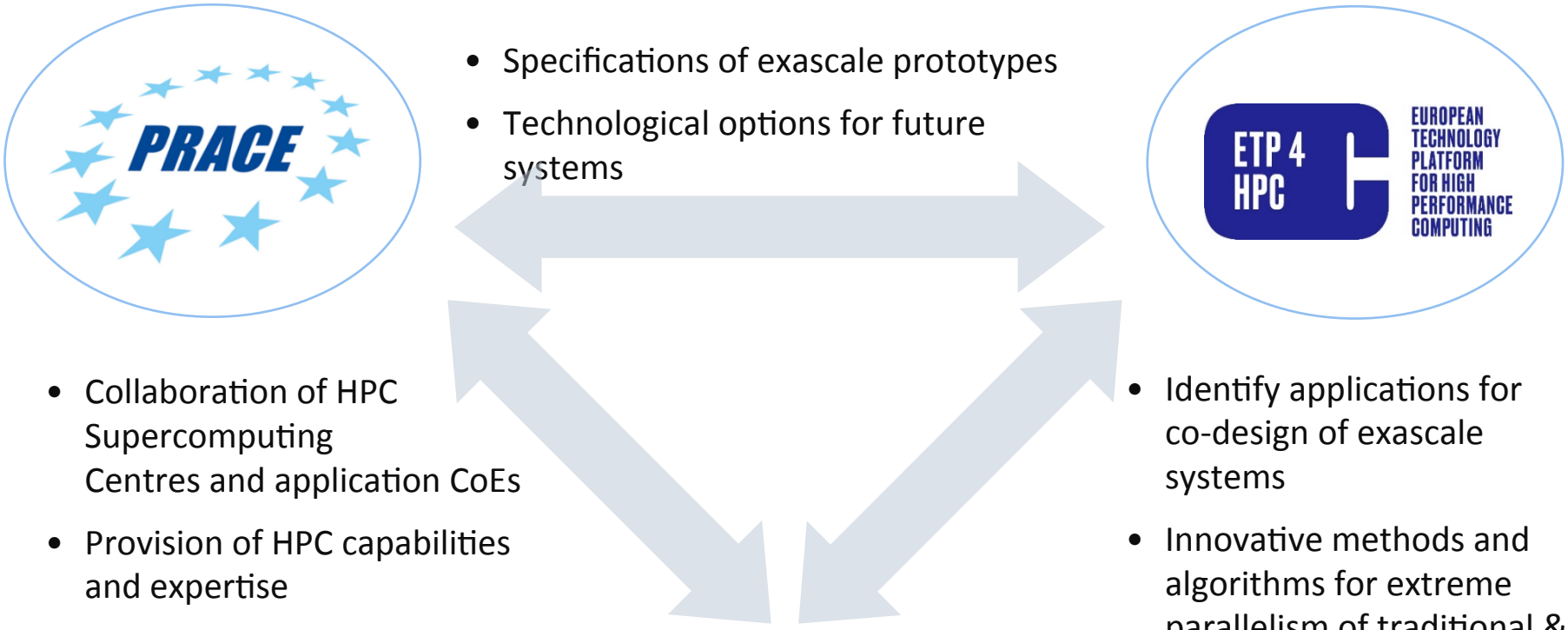
- Departamento de Tecnologías de la Información (BSC-CNS, **M. Valero**)
- Grupo Computación de Altas Prestaciones (U. Politècnica de Catalunya, **J. M. Llabería**)
- Grupo de Arquitectura y Tecnología de Sistemas Informáticos (U. Complutense de Madrid, **F. Tirado**)
- Grupo de Arquitectura de Computadores (U. de Malaga, **E. López Zapata**)

- Departamento de Tecnologías de la Información (BSC-CNS, **M. Valero**)
- Grupo Computación de Altas Prestaciones (U. Politècnica de Catalunya, **J. M. Llabería**)
- Parallel Processing and Distributed Systems group (U. Autónoma de Barcelona, **A. Ripoll**)

- Departamento de Tecnologías de la Información (BSC-CNS, **M. Valero**)
- Grupo Computación de Altas Prestaciones (U. Politècnica de Catalunya, **J. M. Llabería**)
- Grupo de Arquitectura de Computadores (U de Zaragoza, **V. Viñals**)
- Grupo de Arquitectura y Tecnología de Sistemas Informáticos (U. Complutense de Madrid, **F. Tirado**)
- Grupo de Arquitectura y Tecnología de Computadores (U. de Cantabria, J. R. **Beivide**)
- Grupo de Arquitectura de Computadores (U. de Malaga, **E. López Zapata**)
- Grupo de Arquitectura de Computadores (U. de Las Palmas de Gran Canaria, Instituto Universitario de Ciencias y Tecnologías Cibernéticas, **E. Fernández**)



EU HPC Ecosystem



- Specifications of exascale prototypes
- Technological options for future systems

- Collaboration of HPC Supercomputing Centres and application CoEs
- Provision of HPC capabilities and expertise

- Identify applications for co-design of exascale systems
- Innovative methods and algorithms for extreme parallelism of traditional & emerging applications

Centers of Excellence in **HPC applications**

bioexcel · E-CAM · POP · EoCoE · MaX · esiwace (Centre of Excellence in Simulation of Weather and Climate in Europe) · CompBioMed · CoeGSS (Centre of excellence for Global Systems Science)

Distributed Supercomputing Infrastructure

25 members, including

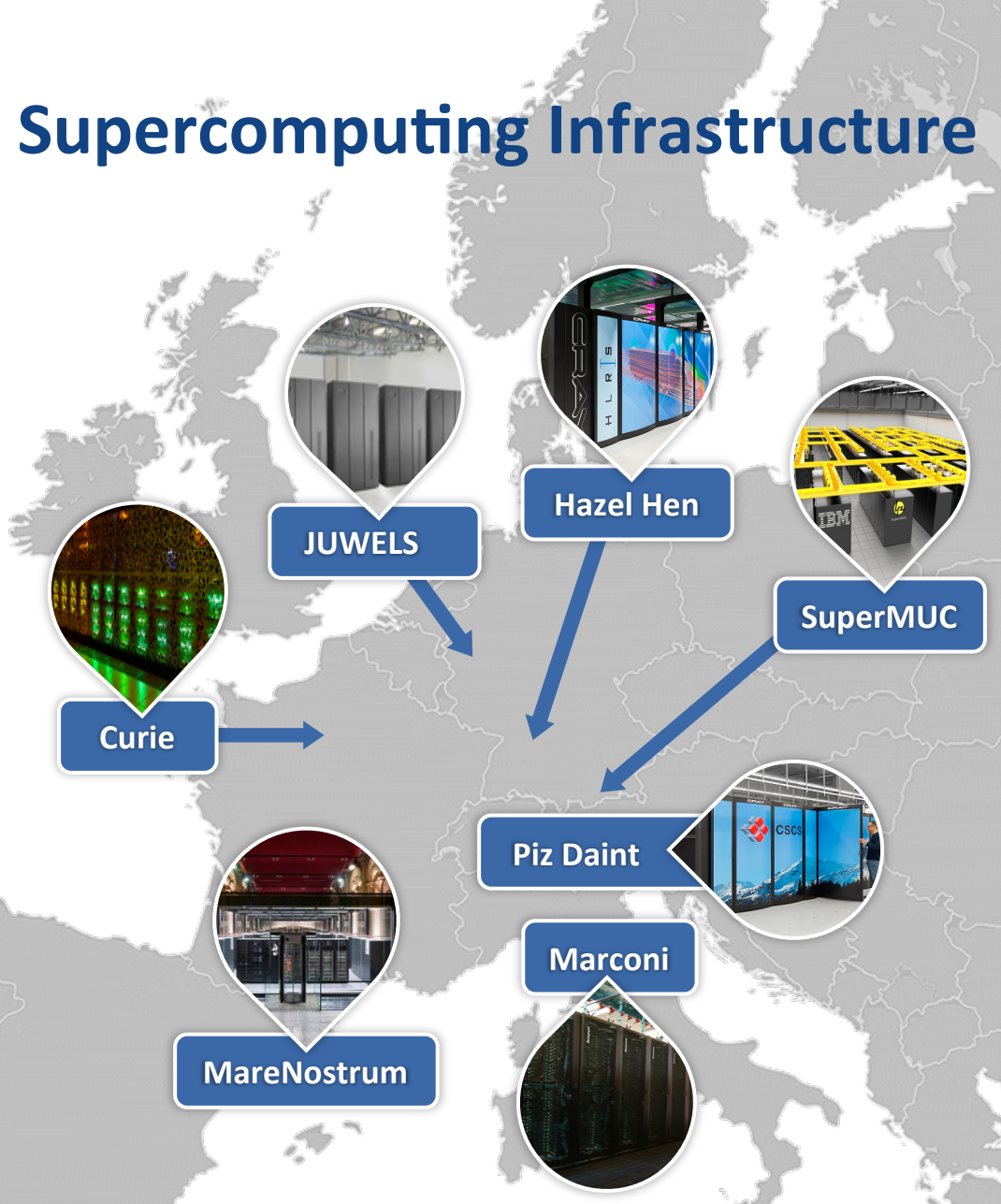
5 Hosting Members

(Switzerland, France, Germany, Italy and Spain)

610 scientific projects **enabled**

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

>11.500 people trained by **6 PRACE Advanced Training Centers** and others events



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Access prace-ri.eu/hpc_acces

Centers of Excellence in HPC applications

Ten new Centres of Excellence (CoEs) will help strengthen Europe's leadership in HPC applications and cover important areas, providing services such as: developing, optimising and scaling HPC; co-design of hardware, software and codes; consultancy to industry and SMEs; research in HPC Applications.



The BSC – CNS participates in 8 out of 9 and leads 2 of them

Open Project Portfolio December 2018

(includes H2020 projects in negotiation and national projects beginning soon)

234 running projects, total budget of over 97M€*

106 H2020/FP7 projects running or in negotiation (11 as coordinator)	62M€
39 running contracts, mostly with companies	12M€
52 projects with Spanish and Catalan public funding	16M€
17 projects funded through other EU programmes (incl. Copernicus)	3M€
17 projects funded through other sources	3M€
3 strategic self-funded projects	1M€

Plus:

65 personnel grants (national funding plus CONACYT programme)	7M€

Does not include ICREA, UPC, MSC,

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

*** Budget for full term of project – normally multi-annual**

TOP-10 Spanish Organizations in Horizon 2020

Legal name	EU Contribution (€)	Project Participations
CSIC	200,046,801 €	476
Tecnalia	97,873,597 €	219
Barcelona Supercomputing Center	68,326,411 €	123
ATOS	53,654,875 €	134
Universitat Pompeu Fabra	53,189,145 €	96
Universitat Politècnica de Catalunya	52,595,046 €	147
ICFO	50,390,271 €	72
Universidad Politécnica de Madrid	47,743,995 €	138
Universitat Politècnica de València	47,435,147 €	124
Universitat Autònoma de Barcelona	46,478,150 €	99

Source:
European Commission, Participant Portal H2020 Projects
Updated March 2019

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

European Commission

TOP-10 Catalan Organizations in Horizon 2020

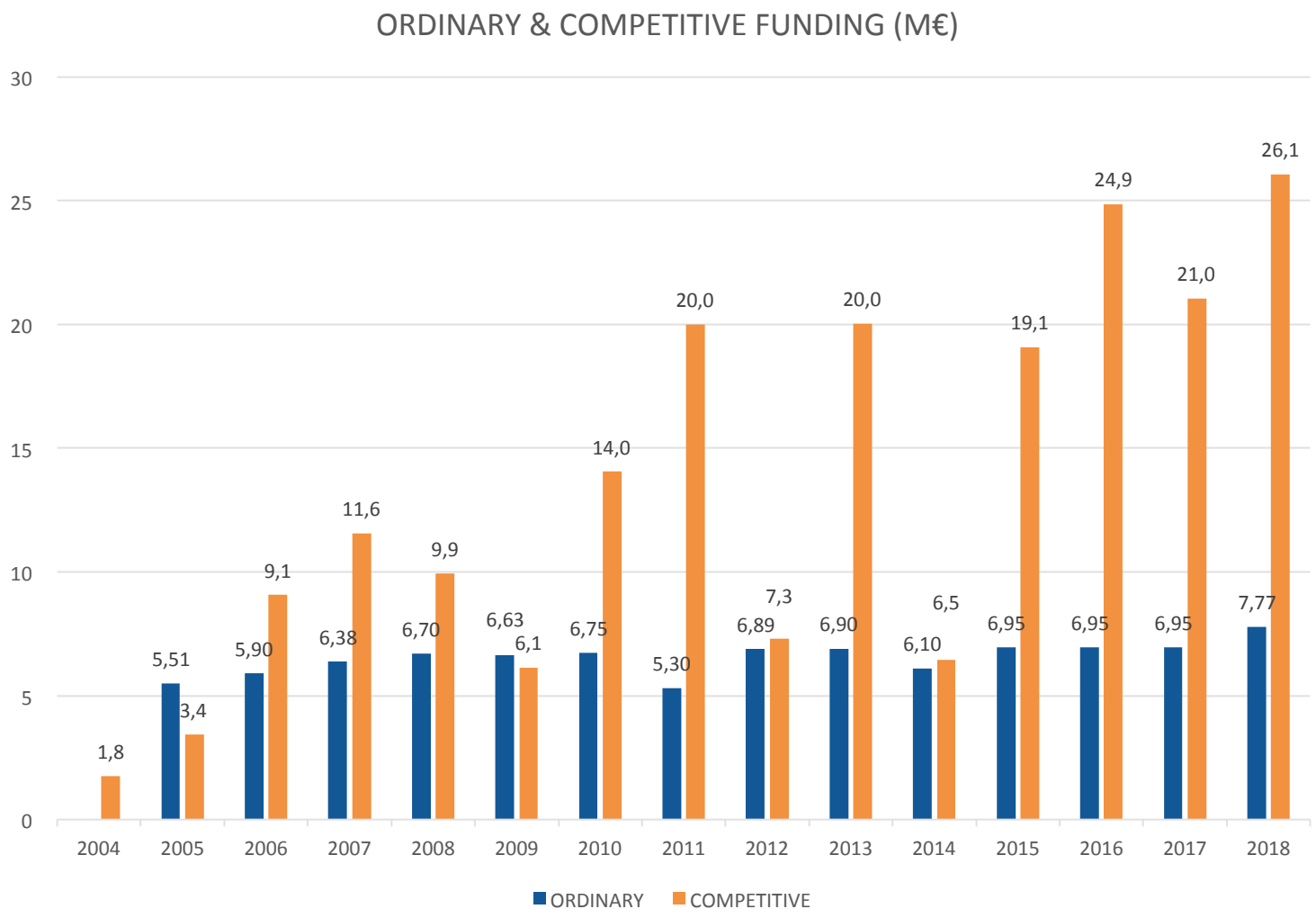
Legal name	EU Contribution (€)	Project Participations
Barcelona Supercomputing Center	68,326,411 €	123
Universitat Pompeu Fabra	53,189,145 €	96
Universitat Politècnica de Catatalunya	52,595,046 €	147
ICFO	50,390,271 €	72
Universitat Autònoma de Barcelona	46,478,150 €	99
Universitat de Barcelona	43,292,105 €	120
CRG	36,333,838 €	62
LEITAT	26,988,611 €	60
EURECAT	25,713,104 €	60
IDIBAPS	17,874,593 €	35

Source:
European Commission, Participant Portal H2020 Projects
Updated March 2019

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

European Commission

Evolution of funding



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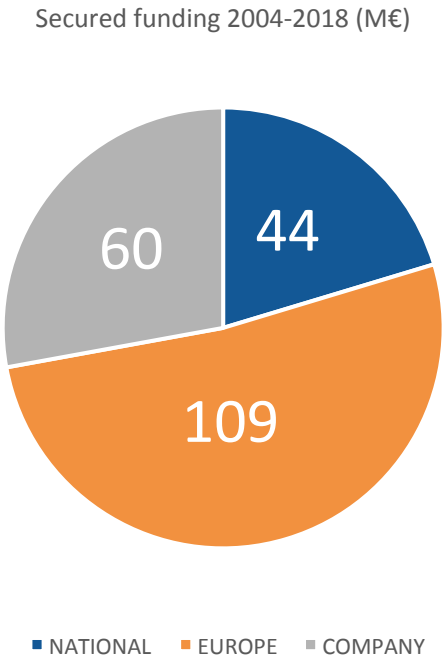
Centro Nacional de Supercomputación

Secured funding



Total: 213 M€

Data : 31st december 2018

Investments



New building

30,8 M€ (2009-2019)



MareNostrum 4

34 M€ (2016-2020)



StarLife

1,5 M€ (2016-2017)



Site MareNostrum 5

14 M€ (2019-2020)



Temporary computer room

1,6 M€ (2018)



Long-term storage

8 M€ (2019-2020)

New Computer Room













StarLife

138,2 Teraflops
of calculation power

9,5 PB of storage

9,1 Tbytes of RAM



A unique infrastructure to improve the competitiveness of Barcelona biomedical pole

New facilities in 2020







Una infraestructura abierta al público



RISC Project

1. Identified research clusters for targeted research collaboration
2. Produced a Green Paper on HPC Drivers and Needs in Latin America
3. Produced a Roadmap for HPC strategic R&D in Latin America
4. Enhanced HPC R&D policy dialogue between policymakers and stakeholders

LATIN AMERICA

- Universidad Veracruzana
- Universidad de Chile
- Universidad de Buenos Aires
- Universidad Autónoma de Manizales
- Coppetec Fundaçao do Río de Janeiro



EUROPE

- BSC
- CINECA
- UPM
- Menon
- Uni Coimbra

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High Performance Computing for Energy

- *H2020-EUB-2-2015: High Performance Computing*
- *01/12/2015 - 30/11/2017*
- *2 M Euro for European partners – 2M Euro for Brazilian partners*







"Apply Exascale HPC technology to energy industry simulations"

Wind + Oil and Gas + Biomass

EU-Brazil OpenBio

EU-Brazil ***Open Data and Cloud Computing e-Infrastructure for Biodiversity***

Combining ***Biodiversity Science*** and the ***Open Access Movement to deploy a joint European and Brazilian e-Infrastructure*** of ***open access resources*** supporting ***the needs of the biodiversity scientific community***.



Two biodiversity use cases

Computing resources & SW platforms

Further **EU-Brazil collaboration** in support of the **biodiversity area & infrastructures**

Who benefit from EUBrazilOpenBio?

- **EU & Brazilian biodiversity scientific communities**
- **Data and resource managers & Open Access community**
- **European & Brazilian policy and funding bodies**

EUBrazilCC federated infrastructure

EU Brazil Cloud Connect
EU Brazil Cloud Computing for Science

European Commission
Information Society and Media

COOPERATION

Ciência e Tecnologia
Ministério da Ciência e Tecnologia
CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

- The main objective is the creation of a **federated e-infrastructure** for research using a user-centric approach.
- To achieve this, we need to pursue three objectives:
  - **Adaptation** of existing applications to tackle new scenarios emerging from cooperation between Europe and Brazil relevant for both continents and with high social impact and innovation.
  - Integration of frameworks and **programming models** for scientific gateways and complex workflows addressing not only the requirements of the selected use cases, but a potentially much larger user community.
  - **Federation of resources**, to build up a general-purpose infrastructure comprising existing and heterogeneous resources
- Active and intense **dissemination campaign**, it will analyse innovation, and it will foster the involvement of Brazilian institutions in cloud standards definition. It will also be the first example of the **internationalisation of the EU Cloudscape series**.

EUBRA BIGSEA

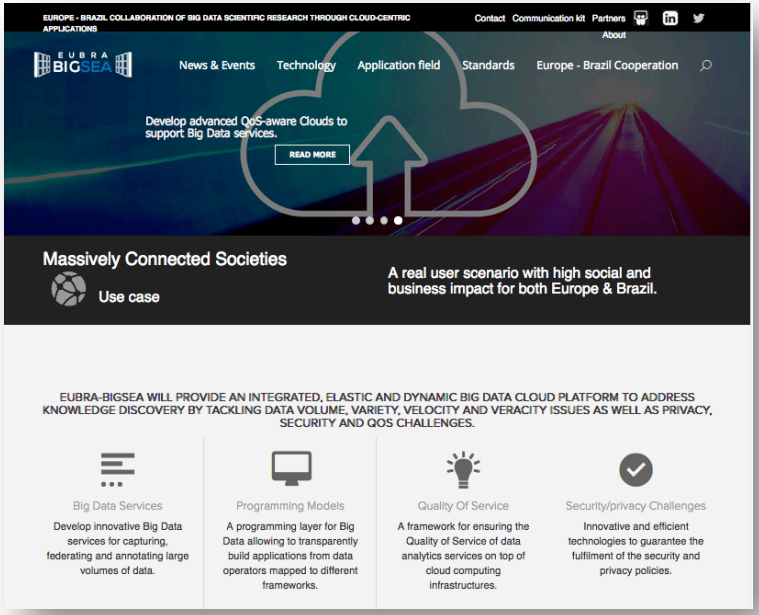
EUROPE - BRAZIL COLLABORATION OF BIG DATA SCIENTIFIC RESEARCH THROUGH CLOUD-CENTRIC APPLICATIONS

EUBra-BIGSEA Project

A European-Brazilian Consortium aiming at

- The development of QoS and secure cloud services to support Big Data.
- The development of Big Data services for capturing and annotating large data
- The use of efficient technologies for guaranteeing the fulfilment of the security and privacy policies
- The transfer of this technology to a real user scenario with high social & business impact for both EU and BR

www.eubra-bigsea.eu



UNIVERSITAT POLITÈCNICA DE VALÈNCIA

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

Barcelona Supercomputing Center Centro Nacional de Supercomputación

POLITECNICO DI MILANO

Trust IT

UNIVERSIDADE DE COIMBRA

UNIVERSIDADE FEDERAL DE MINAS GERAIS

Universidade Federal de Campina Grande

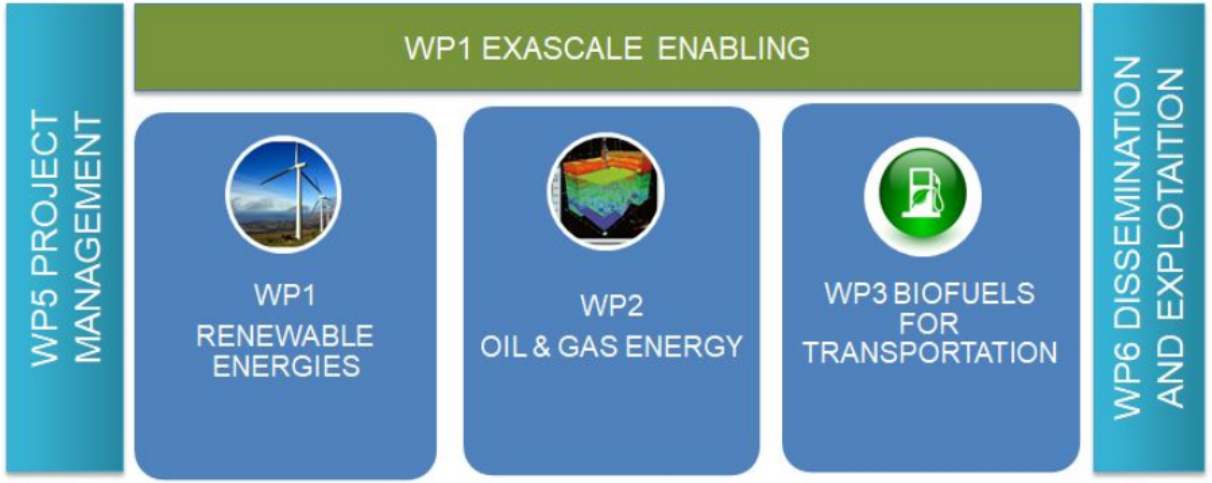
UTFPR Universidade Tecnológica Federal do Paraná

UNICAMP Universidade Estadual de Campinas

IBM

Barcelona Supercomputing Center Centro Nacional de Supercomputación

ENERXICO: H2020 EU-México project



2M€ 2M€

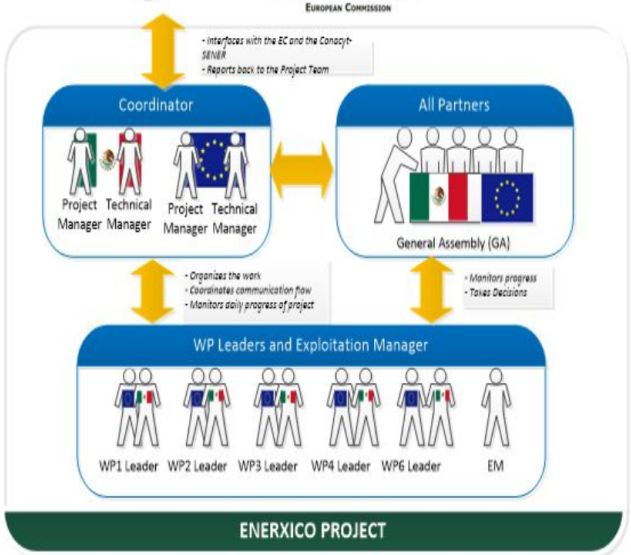
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

instituto nacional de investigaciones nucleares

Technische Universität München
REPSOL
UNIVERSITAT POLITÈCNICA DE VALÈNCIA
Bull atos technologies
IBERDROLA
UNIVERSITÉ Grenoble Alpes
Ciemat

PEMEX EXPLORACION Y PRODUCCION
Universidad Autónoma Metropolitana
IMP INSTITUTO MEXICANO DEL PETRÓLEO
Centro de Investigación en Computación Instituto Politécnico Nacional
INSTITUTO DE INGENIERÍA UNAM
CINVESTAV
ESCUELA SUPERIOR DE INGENIERÍA Y ARQUITECTURA UNIDAD ZACATENCO

SENER SECRETARÍA DE ENERGÍA
EUROPEAN COMMISSION



BSC Academic liason with Mexico

MÉXICO
PRESIDENCIA DE LA REPÚBLICA

ESTADOS UNIDOS MEXICANOS

CONACYT
Consejo Nacional de Ciencia y Tecnología

- BSC and CONACyT (National Council of Science and Tecnnoıogy) nave a long-term academic liaison
  - An annual call for up-to 5 post-doc positions at BSC for Mexican researchers, of up-to 2 years each. This call will be published annually from 2016 -2020.
    - It started in 2012
    - 11 postdocs now.
  - 2017 call to be open soon.
  - **BSC agrees to not hire PhD or Post-docs from these groups as a first option.**
  - Among those 4 are already back in Mexico (ITESM, ITL, UAEMeX, UV**)**
  - An annual call for ten, three-year PhD scholarships for Mexican students. This call will be published annually from 2016 -2020.



Honoris Causa Universidad Veracruzana, Mexico, 2010



Honoris Causa CINVESTAV 2017



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Centro Nacional de Supercomputación



“Por su destacada contribución al desarrollo científico en México, en particular al área de la computación de alto rendimiento, el Gobierno de los Estados Unidos Mexicanos reconoció al Dr. Mateo Valero Cortés, Catedrático de la Universidad Politécnica de Cataluña y Director del Centro Nacional de Supercomputación de Barcelona, España, con la Orden Mexicana del Águila Azteca.”





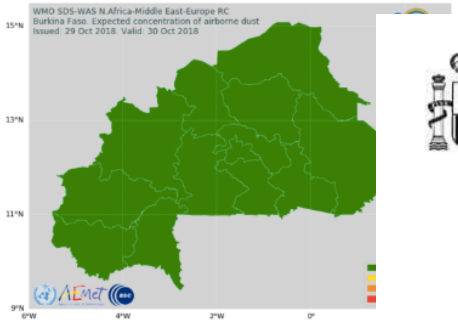


Medio propio de la AGE

BSC and AEMET operate the new Early Warning Advisory System for Sand and Dust Storm in Burkina Faso

30 October 2018

This system has been released by the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS).



MINISTERIO
PARA LA TRANSICIÓN ECOLÓGICA

AEMet
Agencia Estatal de Meteorología

RESOLUCIÓN Nº 86/2018 DE ENCARGO AL BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACIÓN (BSC-CNS) PARA LA REALIZACIÓN DE ACTIVIDADES DE DESARROLLO Y MEJORA DE LOS PRODUCTOS Y SERVICIOS SUMINISTRADOS POR LOS CENTROS REGIONALES DE TORMENTAS DE POLVO Y ARENA DE LA ORGANIZACIÓN METEOROLÓGICA MUNDIAL (OMM). **EXPEDIENTE: 201800005089**

Título del Servicio:

RESOLUCIÓN Nº 86/2018 DEL PRESIDENTE DE LA AGENCIA ESTATAL DE METEOROLOGÍA (AEMET) POR LA QUE SE ENCARGA AL "BARCELONA SUPERCOMPUTING CENTER – CENTRO NACIONAL DE SUPERCOMPUTACIÓN (BSC-CNS) EL DESARROLLO Y MEJORA DE LOS PRODUCTOS Y SERVICIOS SUMINISTRADOS POR LOS CENTROS REGIONALES DE TORMENTAS DE POLVO Y AERENA DE LA ORGANIZACIÓN METEOROLÓGICA MUNDIAL (OMM).

Air Centre

AIR CENTRE
ATLANTIC INTERNATIONAL RESEARCH CENTRE

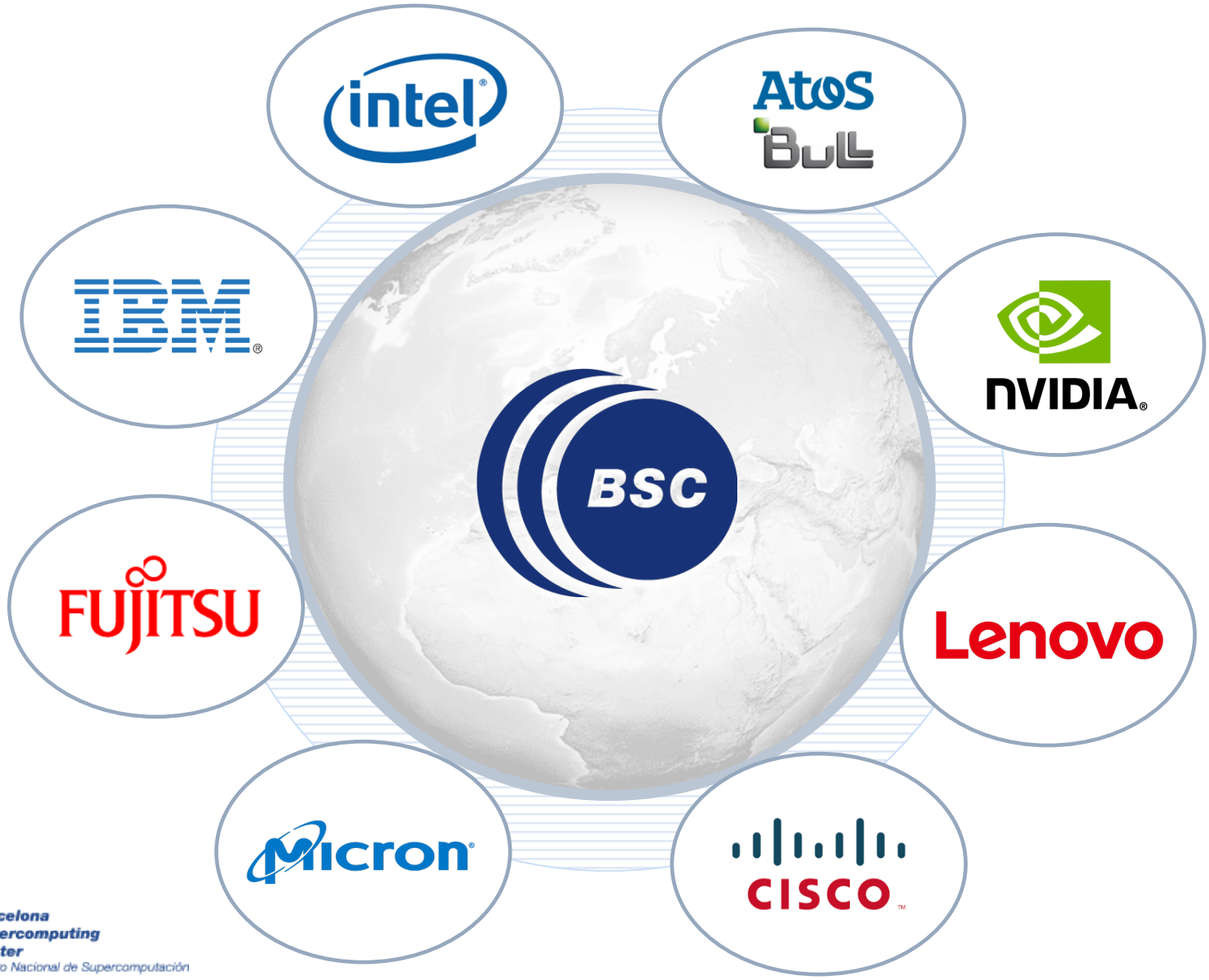
The AIR Centre is a network for international cooperation along and across the Atlantic, with an integrative approach to the advance and sharing of knowledge of space, atmosphere, oceans, climate change, energy and data science, as well as their interactions. Its central theme is North-South and South-North, East-West and West-East cooperation.

Integrating Space, Atmosphere, Ocean, Climate, Energy and Data Science to address the Global Challenges of the Atlantic



Barcelona Supercomputing Center
Centro Nacional de Supercomputación

BSC & The Global IT Industry 2018



BSC's spin-offs in brief



NOSTRUM BIODISCOVERY, S.L.

Applies supercomputing **TO SPEED UP DRUG DISCOVERY**

For the:

- **PHARMA INDUSTRY**
- **BIOTECH COMPANIES**



MITIGA SOLUTIONS, S.L.

Provides operational solutions **TO MINIMIZE THE IMPACT OF VOLCANIC ASH HAZARDS**

For the:

- **AVIATION INDUSTRY**
- **ENGINE MANUFACTURES**
- **CONSULTING SECTORS**



ELEM BIO, S.L.

Provides **BIOMECHANICS SIMULATIONS,** offering software-as-a-service simulation tool focused on cardiovascular and respiratory systems

For the:

- **PHARMA INDUSTRY**
- **MEDTECH COMPANIES**
- **PUBLIC HEALTH**
- **EDUCATION**



NEARBYCOMP, S.L.

Provides **FOG COMPUTING FOR IOT,** delivering customization services for different scenarios of FOG computing

For the:

- **5G**
- **IOT**
- **SMART CITIES**

The 25 Severo Ochoa Centres



















































Resultados provisionales 2017

Education: Engagement with Universities

MSc in Innovation and Research in Informatics - HPC at FIB (UPC) Msc in Artificial Intelligence at FIB (UPC)

- Curriculum design
- Providing access to the BSC HPC facilities through internships
- BSC experts lecturing
- Advising Master Thesis
- Intensification on **HPC for AI** (forthcoming 2019-2020)

Double Diploma Agreement CIC(IPN-MEX)-FIB(UPC)

- Providing Master Thesis co-advising.

Doctoral Program Affiliation (main programs)

- Applied Math Program (UPC)
- Artificial Intelligence (UPC)
  - Double diploma (IPN-UPC) (forthcoming 2019-2020)
- **Computer Architecture Doctoral Program** (UPC)
  - Double diploma (IPN-UPC) (forthcoming 2019-2020)
- Environmental Engineering Doctoral Program (UPC)
- Biomedicine Doctoral Program (UB)
- Chemistry Doctoral Program(UB)

Post-Doctoral Programme CONACyT-BSC (2012-2020)

Bachelor Degree in Bioinformatics (UPF+UPC)

- Curriculum Design
- BSC experts lecturing



STARS

POST-DOCTORAL PROGRAM

- Acronym for *SUPERCOMPUTING AND RELATED APPLICATIONS* International Post-Doctoral program, co-funded by BSC and the European Commission.

- STARS aims at attracting excellent postdoctoral fellows at BSC, fostering their **training in all fields of High Performance Computing and related applications,** in a stimulating, **international** and **interdisciplinary** environment, with the goal to boost their career perspectives as successful independent researchers

STARS

POST-DOCTORAL PROGRAM

- Total duration of the program : 5 years
- Started on 01.01.2018
- Nr of fellows to be recruited: 20 in 2 batches
- Duration of 1 fellowship: 24 months
- Eligible only if they have not spent more than 12 months of the last 36 before the deadline in Spain
- **Next call for 12 fellows opens in July 2019**:

  on www.bsc.es



Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Summary



MOBILITY: EEBB-FPI/FPU, Jose Castillejo, Salvador Madariaga

Predoctoral Grants

GOBIERNO DE ESPAÑA – MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

GOBIERNO DE ESPAÑA – MINISTERIO DE EDUCACIÓN, CULTURA Y DEPORTE

AGAUR – Agència de Gestió d'Ajuts Universitaris i de Recerca

MARIE CURIE ACTIONS

CTT Transferència de Tecnologia – Universitat Politècnica de Catalunya

Obra Social Fundación "la Caixa"

CONACYT – Consejo Nacional de Ciencia y Tecnología

Postdoctoral Grants

Juan de la Cierva Programa

BEATRIU DE PINÓS PROGRAMME

MARIE CURIE ACTIONS

FUNDACIÓN RAMÓN ARECES

EMBO – excellence in life sciences

AXA Research Fund

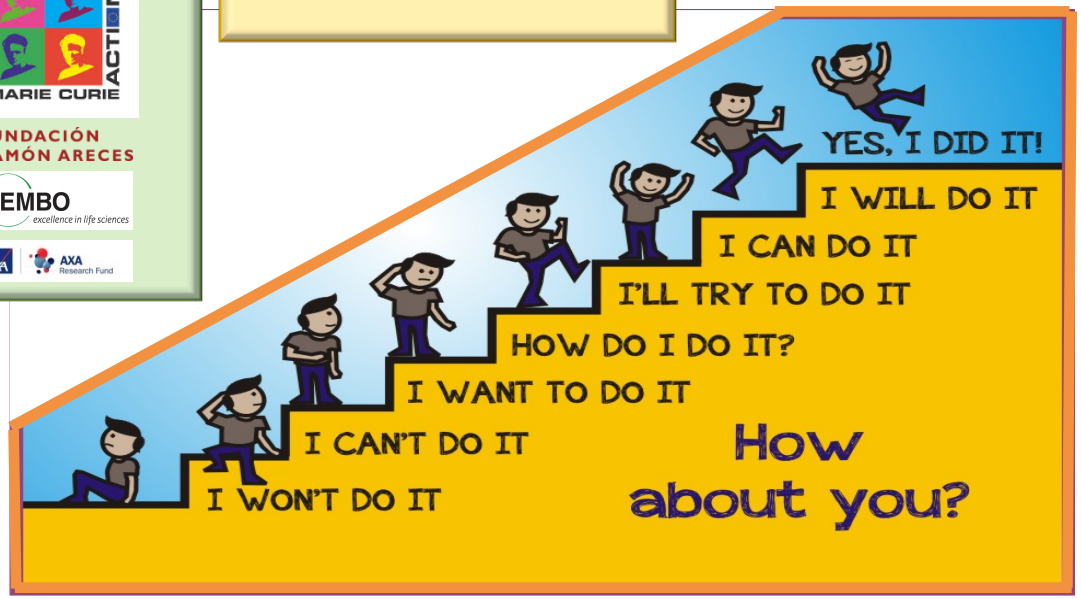
Ramón y Cajal



Programa I3

ICREA

ICREA



Years of experience

Continue international collaborations: Joint Laboratory on Extreme Scale Computing



In June 2014, the University of Illinois at Urbana-Champaign, INRIA, Argonne National Laboratory, Barcelona Supercomputing Center and Jülich Supercomputing Centre formed the Joint Laboratory on Extreme Scale Computing.

The Joint Laboratory focuses on software challenges found in extreme scale high-performance computers.

Researchers from the different centers regularly meet for workshops, and in the last one, in November 2014, researchers from Riken AICS also took part.

Benchmarking

Barcelona Supercomputing Centre 2017

Staff	Articles per year	Peak performance	H2020 and ERC Coordinated projects	Ongoing externally funded projects
529	170	11.1 Petaflops	10	157

Jülich Supercomputing Centre 2017

Staff	Articles per year	Peak performance	H2020 and ERC Coordinated projects	Ongoing externally funded projects
219	90	12 Petaflops	13	67

Proyecto “Somos Investigadoras”



Canción “MareNostrum” a cargo del grupo Macedònia

Visitas “en femenino” para alumnas de primaria

(6.000 el curso 2018-19)

Inicio 3 de octubre 2018



Visitas guiadas por educadoras formadas en computación

Presencia mayoritaria de mujeres en los materiales educativos





8 actividades lúdicas de introducción a la supercomputación



Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Ajuntament de Barcelona


SUPERGEEK
Mateo Valero
FRAGIL

High Performance Artificial Intelligence

Artificial Intelligence has become a new big trend covering almost all our fields of expertise.

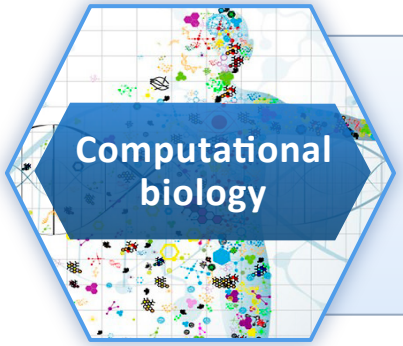


BSC will be very active in AI research

- from the HPC/AI convergence (based on a co-design vision that embraces novel algorithms, system software and architectural support, with the aim of driving the adoption of AI technologies in future simulation frameworks)

- to its application to the priority areas of the Severo Ochoa Strategic Plan (Health, Energy and Environment).

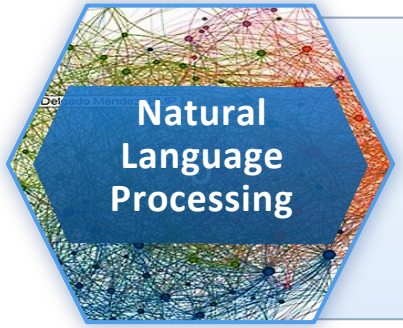
Boosting new research groups



Creating and boosting Life Sciences new research groups: Computational Biology, Integrative Computational Network Biology, Computational Regulatory Genomics and Comparative Genomics, and 4 new units



- Strategies to exploit small and medium size quantum computers
- Adapt realistic problems to quantum annealing
- Develop a quantum OS to run a small quantum device
- Build a small-sized quantum processor
- Implement quantum algorithms on it to run aplications on optimization, quantum simulation and machine learning



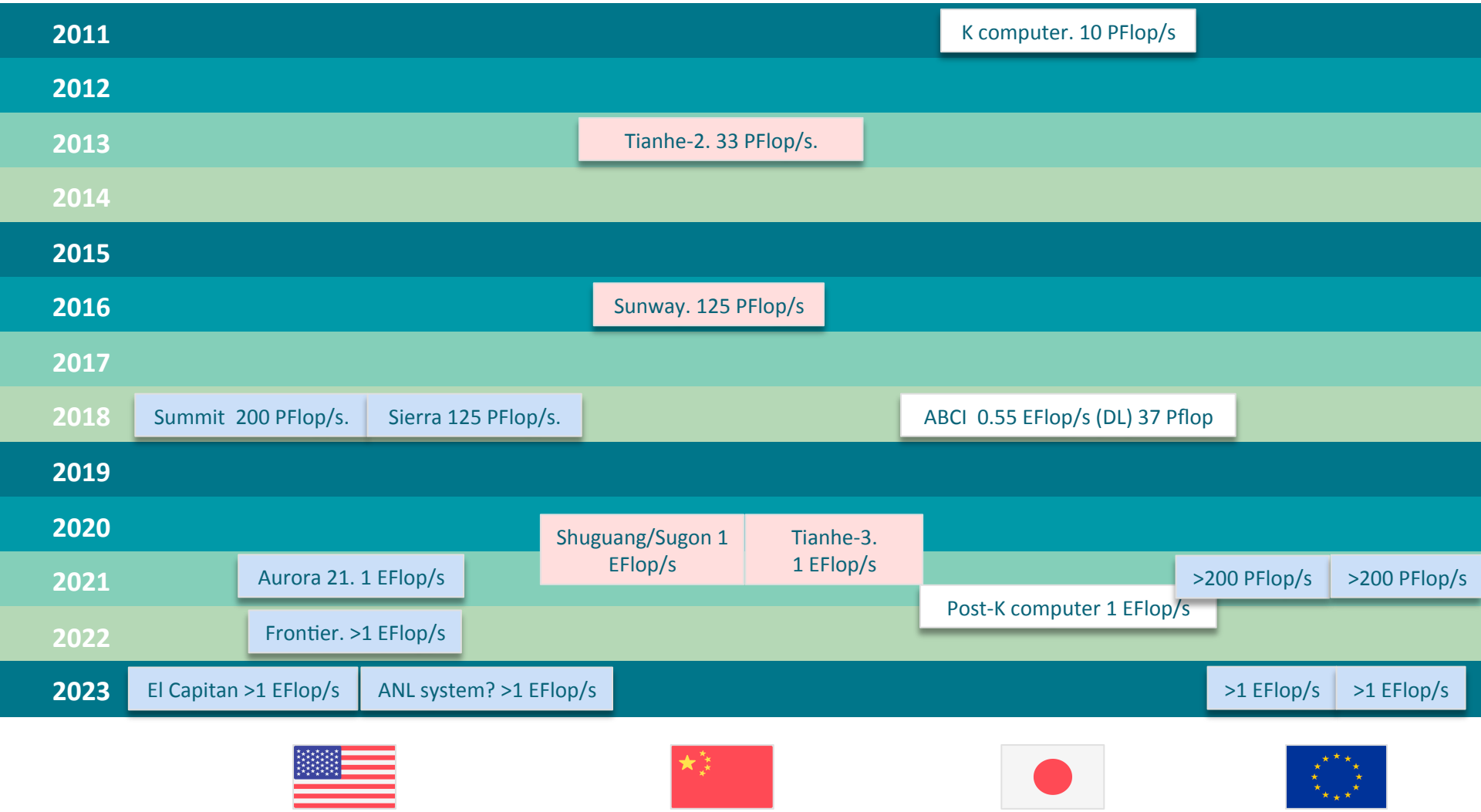
- Projects combining Natural Language Processing (NLP), HPC and AI and Machine Learning techniques, in areas from cybersecurity to toxicology, including social impact.
- BSC to become the coordinator of the Spanish national plan for language technologies (SEAD) creating an NLP platform for health, law and public administration

The European Processor Initiative (EPI)



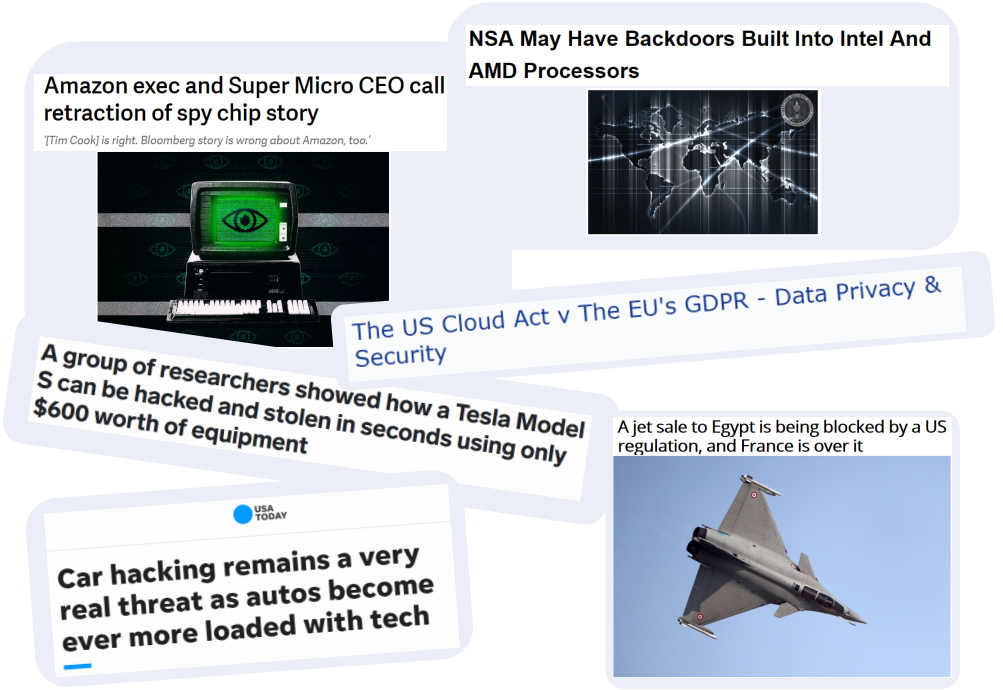
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

La hoja de ruta internacional hacia la exaescala



Why Europe needs its own Processors

- Processors now control almost every aspect of our lives
- **Security** (back doors etc.)
- Possible **future restrictions on exports to EU** due to increasing protectionism
- **A competitive EU supply chain** for HPC technologies will create jobs and growth in Europe



Images courtesy of European Processor Initiative

Where Europe needs to be stronger

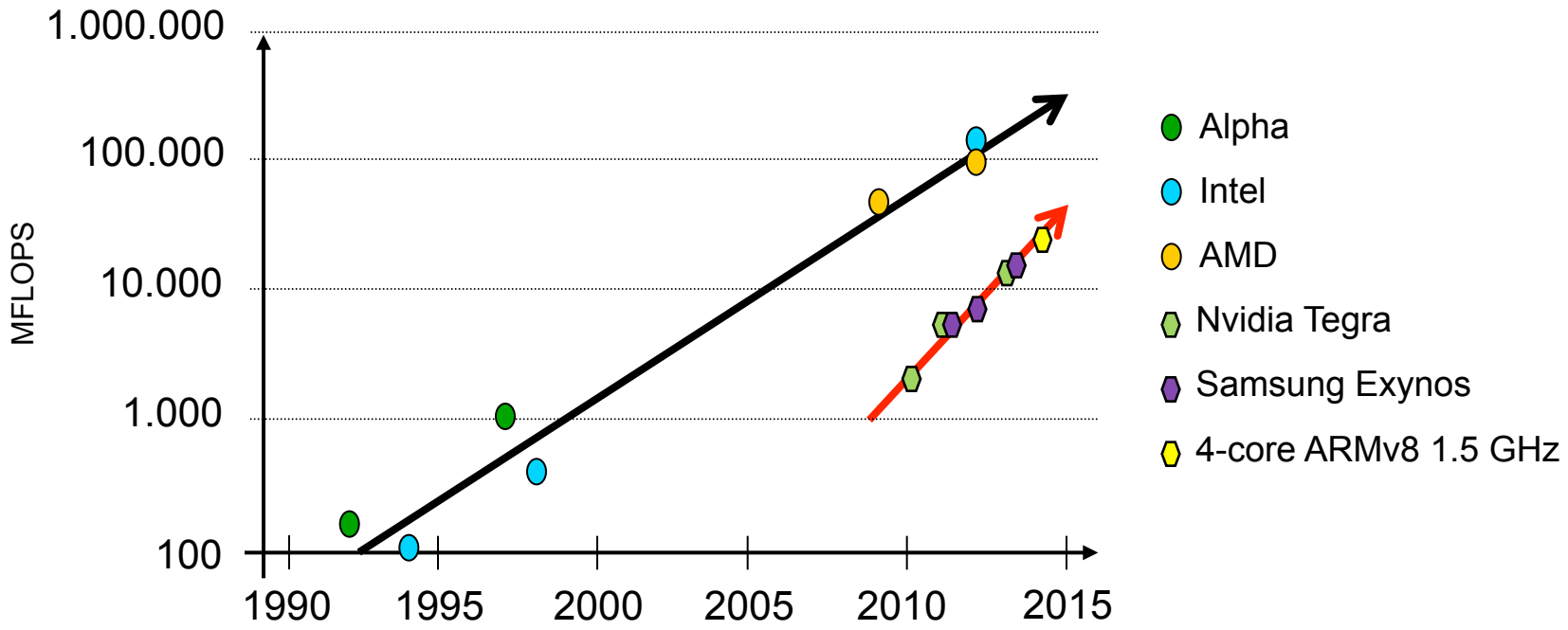
- Only 1 of the 10 most powerful HPC systems is in the EU
- HPC codes must be upgraded
- Vital HPC hardware elements are missing: General Purpose



Processor and Accelerators

EU needs its own source of as many of the system elements as possible

The Killer Mobile processors™



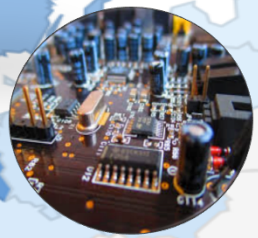
- Microprocessors killed the Vector supercomputers
  - They were not faster ...
  - ... but they were significantly cheaper and greener
- History may be about to repeat itself ...
  - Mobile processor are not faster ...
  - ... but they are significantly cheaper and greener

Network of c.2,000 European R+D experts in advanced computing: **high-performance** and **embedded** architecture and compilation

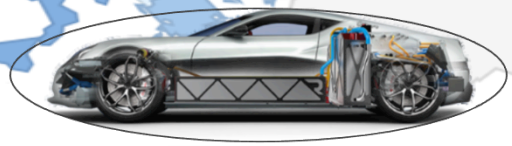
720 members, 449 affiliated members and **871 affiliated PhD students** from **430** institutions in **46** countries.











hipeac.net

HiPEAC has received funding from the European Union's Horizon2020 research and innovation programme under grant agreement number 779656.



2011
Tibidabo

ARM multicore

2012
KAYLA

ARM + GPU
CUDA on ARM

2013
Pedraforca

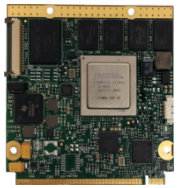
ARM + GPU
Inifinband
RDMA

2014
Mont-Blanc

Single chip ARM+GPU
OpenCL on ARM GPU

PRACE PRACE PRACE MONT BLANC

Tibidabo: The first ARM HPC multicore cluster



Q7 Tegra 2
2 x Cortex-A9 @ 1GHz
2 GFLOPS
5 Watts (?)
0.4 GFLOPS / W



Q7 carrier board
2 x Cortex-A9
2 GFLOPS
1 GbE + 100 MbE
7 Watts
0.3 GFLOPS / W



1U Rackable blade
8 nodes
16 GFLOPS
65 Watts
0.25 GFLOPS / W



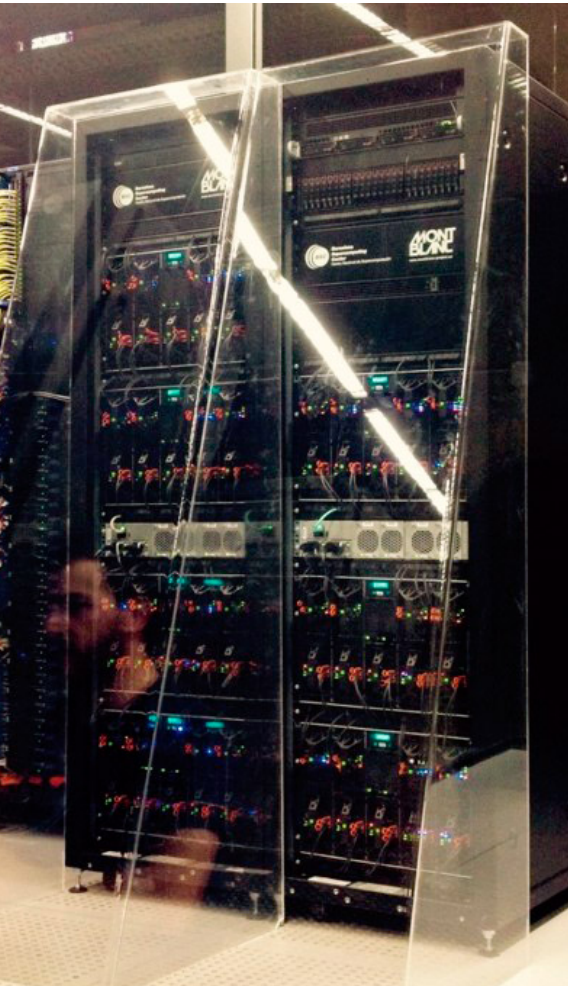
2 Racks
32 blade containers
256 nodes
512 cores
9x 48-port 1GbE switch

512 GFLOPS
3.4 Kwatt
0.15 GFLOPS / W

PRACE

- Proof of concept
  - It is possible to deploy a cluster of smartphone processors
- Enable software stack development

Mont-Blanc HPC Stack for ARM



Industrial applications

Pharmacelera, MUREX, DASSAULT AVIATION, AVL, Termo Fluids, Cenaero, ROLLS ROYCE

Applications

GENCI, CINECA, UNI GRAZ, HLRS, University of BRISTOL

System software

ARM, ETH zürich, Inria, BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación, JÜLICH FORSCHUNGSZENTRUM, Bull atos technologies

Hardware

ARM, BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación, Bull atos technologies, cea, UC UNIVERSIDAD DE CANTABRIA

BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación

Press Impacts

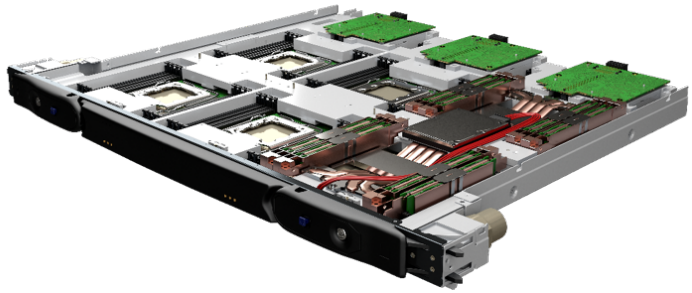


BullSequana compute blade: X1310 Marvell ThunderX2™ (ARMv8) processor

MONT-BLANC
EUROPEAN APPROACH TOWARDS ENERGY EFFICIENT HIGH PERFORMANCE

BSC

Bull
atos technologies



- **Atos and ARMv8**
  - Atos is the industrial pivot of MontBlanc3
  - ARM is one of the Atos strategic directions for the next years
  - Europe is leading in ARM development
  - Montblanc project is proceeding as expected

- **BullSequana X1310 blade**
  - Up to 288 nodes in one BullSequana X1000 and up to 96 nodes in one BullSequana XH2000 with:
  - 3 compute nodes with 2 Marvell ThunderX2 (ARMv8) processors
  - Up to 1024 GB of Memory per node – DDR4 @2666 MT/s (w/64GB DIMMs)
  - High-speed Ethernet, InfiniBand EDR, HDR or HDR100 on the mezzanine interconnect
  - Up to 192 cores per blade

311 TFops

cea



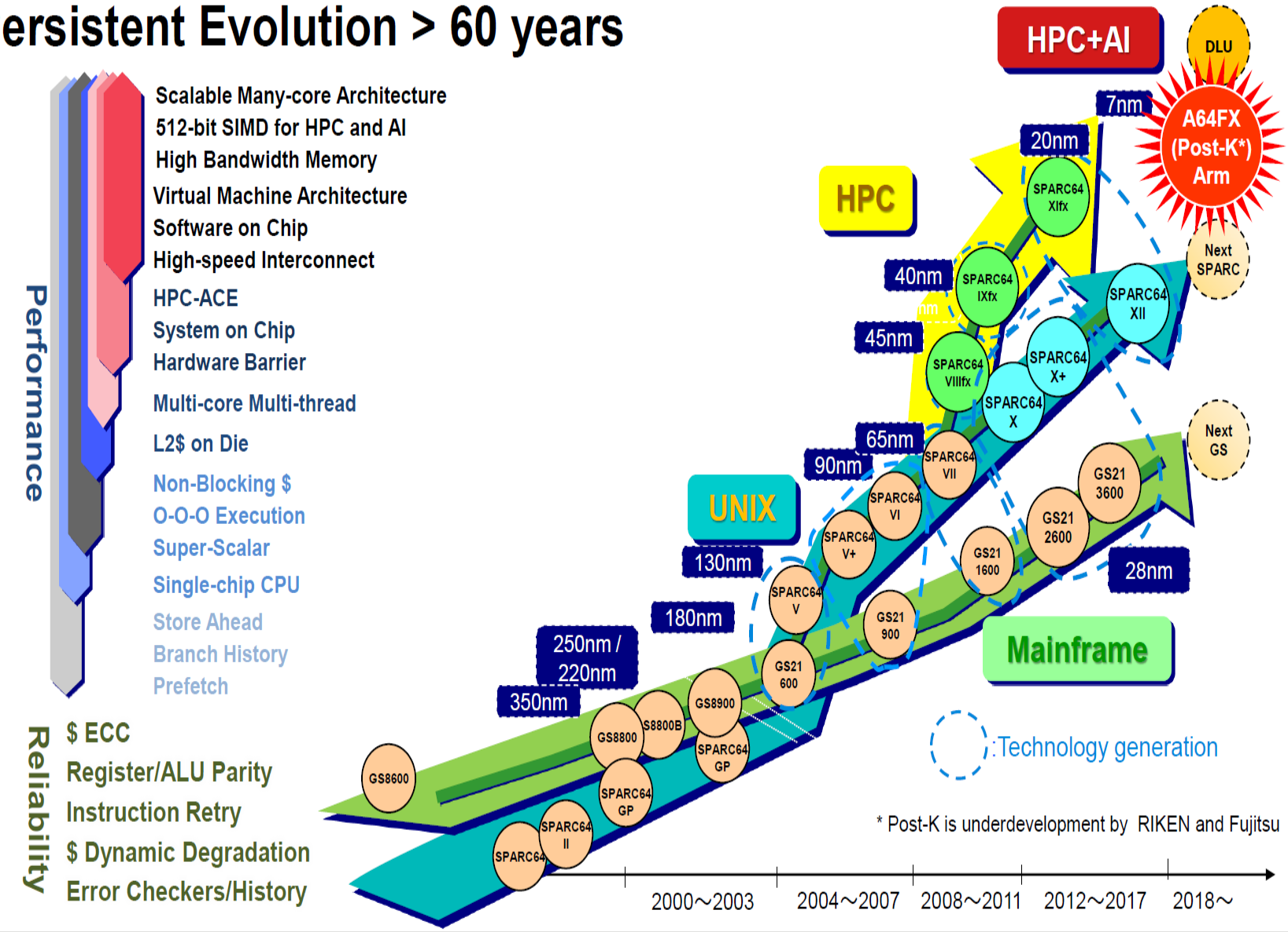
92 BullSequana X1310 blades, three compute nodes per blade, dual Marvell ThunderX2 processors of 32 cores @ 2.2 GHz, based on the Armv8-A instruction set, with 256 GB per node and Infiniband® EDR interconnect.

ARM processor – a credible alternative to X86 processor clusters

Atos

Fujitsu Processor Development

Persistent Evolution > 60 years



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USA

Sandia Labs:

- HPE, Astra Supercomputer
- 2592 nodes, 28 core dual
- 2.3 petaflops/peak, 1.529, Linpack)
- # 203, Top500 (Nov. 2018)
- #36, HPCG (Nov. 2018)



Others: (smaller systems)

- Nercs Labs: Cray, 1080 cores
- Argonne Labs: HPE, Comanche system

European technologies & infrastructures

EuroHPC Joint Undertaking

1 billion € 2019-2020

To build and deploy 4 world-class supercomputers for scientific and industrial users

To develop supercomputing hardware and software technologies



300 M€ until 2020

To create a single online platform where all European researchers will be able to:

- Find, access and re-use data produced by other scientists.
- Deposit, analyse and share data they have been paid to produce.

The new European framework

Horizon Europe | The EU's next research and innovation programme (2021 – 2027)

EuroHPC Joint Undertaking

EUROPEAN CLOUD INITIATIVE
UNLOCKING THE POWER OF BIG DATA FOR OPEN SCIENCE

EuroHPC Activities 2019-2020



- **The Infrastructure Pillar**

  Procurement of ≥2 pre-exascale machines and ≥2 petascale machines

- **The Research and Innovation Pillar**

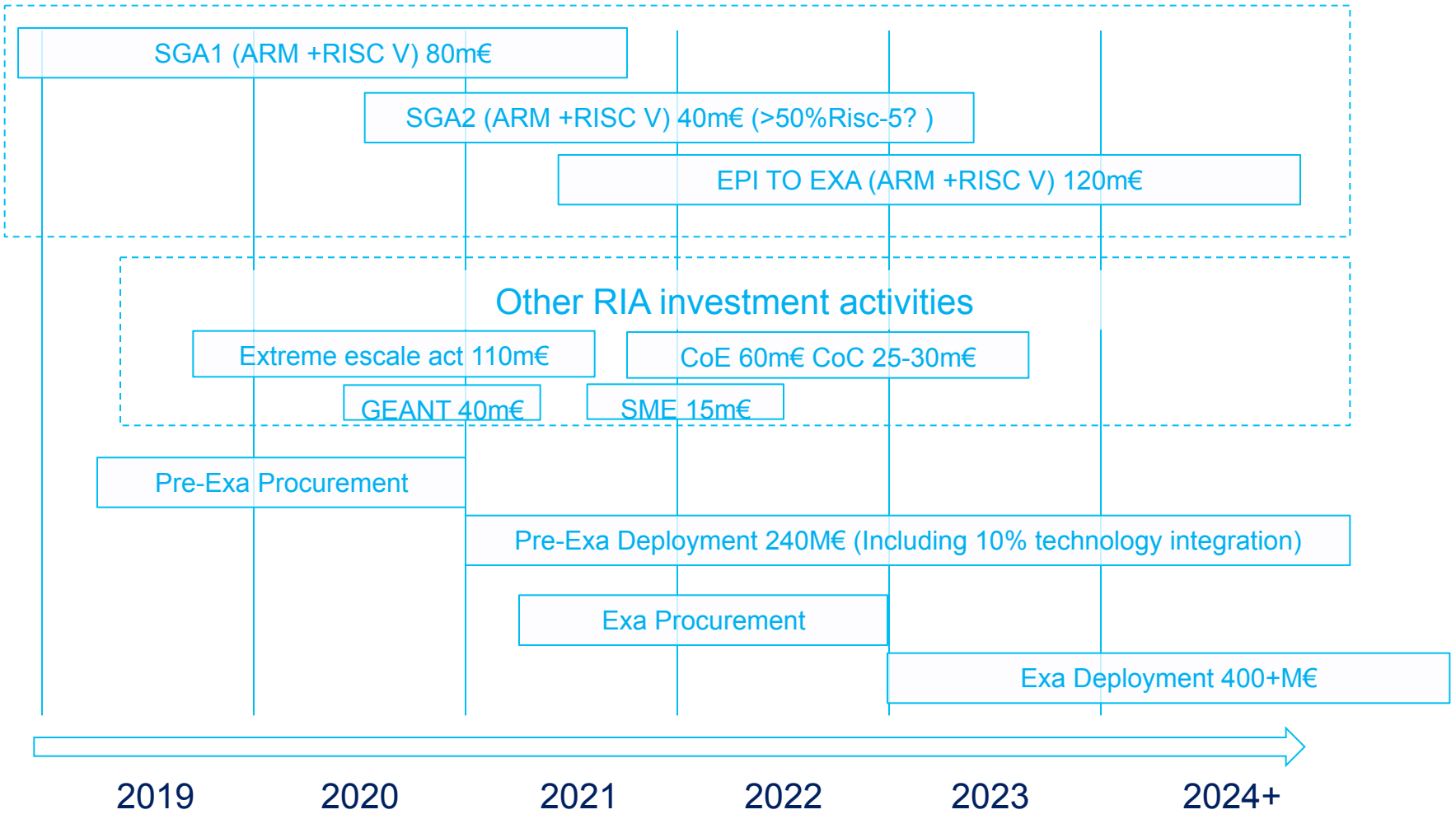
  R&I, exascale technologies and systems (incl. low-power processor); applications; skills

- **JU Admin/running costs**

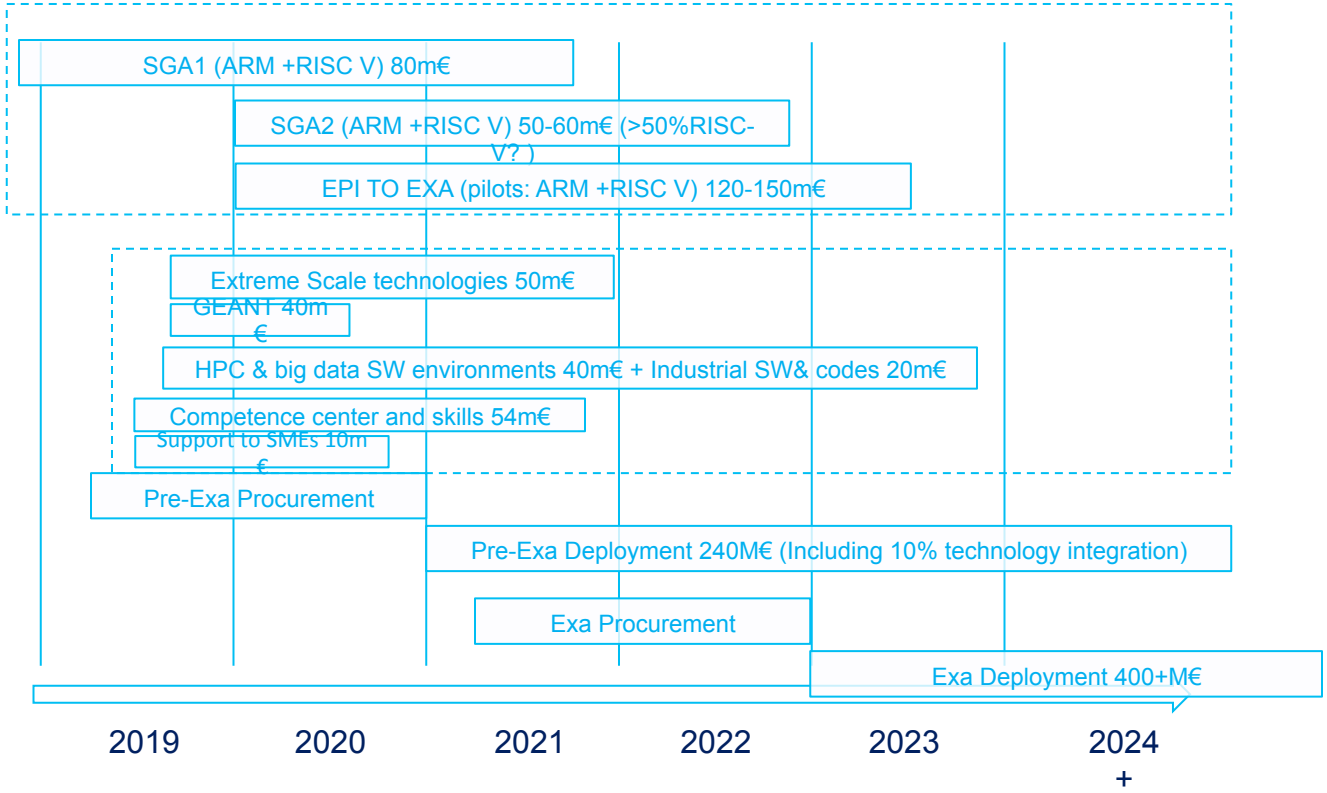
Indicative figures only! M€

~270	min 180	10	486	EC
~290	~186	10	486	Participating States (PS)
560	392	20	972	Total
0	~420 (in kind)	2	422	Private Members

HPC Roadmap


SGA1 (ARM +RISC V) 80m€
SGA2 (ARM +RISC V) 40m€ (>50%Risc-5?)
EPI TO EXA (ARM +RISC V) 120m€
Other RIA investment activities
Extreme escale act 110m€
CoE 60m€ CoC 25-30m€
GEANT 40m€
SME 15m€
Pre-Exa Procurement
Pre-Exa Deployment 240M€ (Including 10% technology integration)
Exa Procurement
Exa Deployment 400+M€
2019
2020
2021
2022
2023
2024+

HPC Roadmap


SGA1 (ARM +RISC V) 80m€
SGA2 (ARM +RISC V) 50-60m€ (>50%RISC-V?)
EPI TO EXA (pilots: ARM +RISC V) 120-150m€
Extreme Scale technologies 50m€
GEANT 40m €
HPC & big data SW environments 40m€ + Industrial SW& codes 20m€
Competence center and skills 54m€
Support to SMEs 10m €
Pre-Exa Procurement
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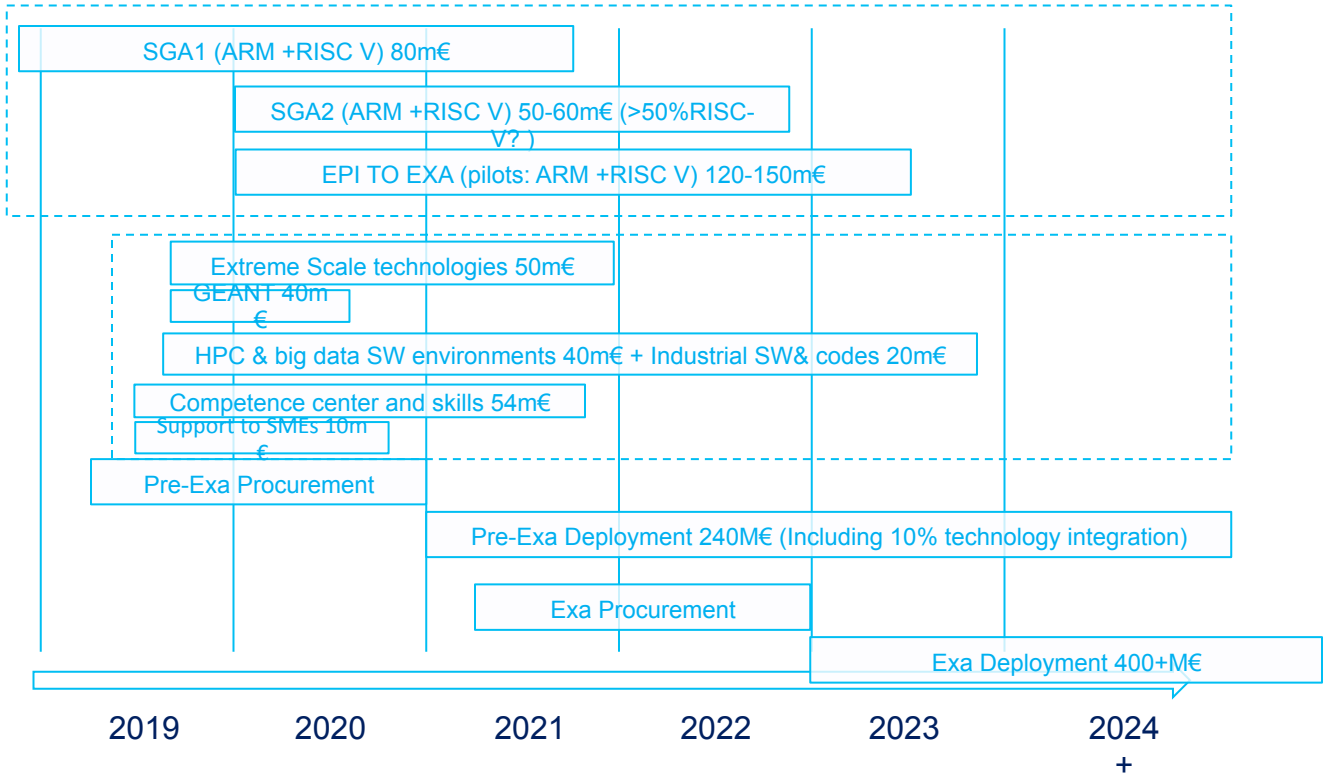
HPC Roadmap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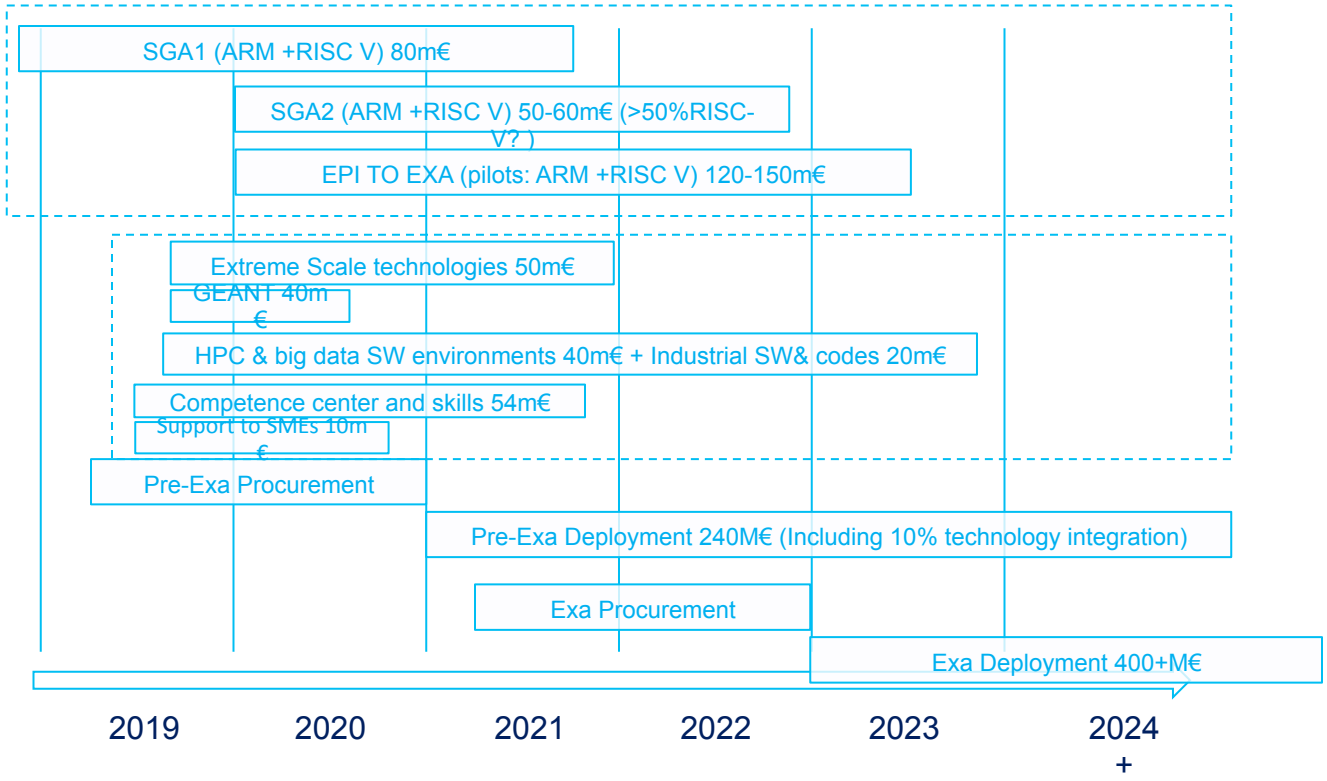
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Exa Deployment 400+M€
2019
2020
2021
2022
2023
2024 +

How EuroHPC will help to make us stronger

- Developing a new European supercomputing ecosystem: HPC systems, network, software, applications, access through the cloud
- Making HPC resources available to public and private users, including SMEs.
- Stimulating a technology supply industry

EuroHPC
Joint Undertaking



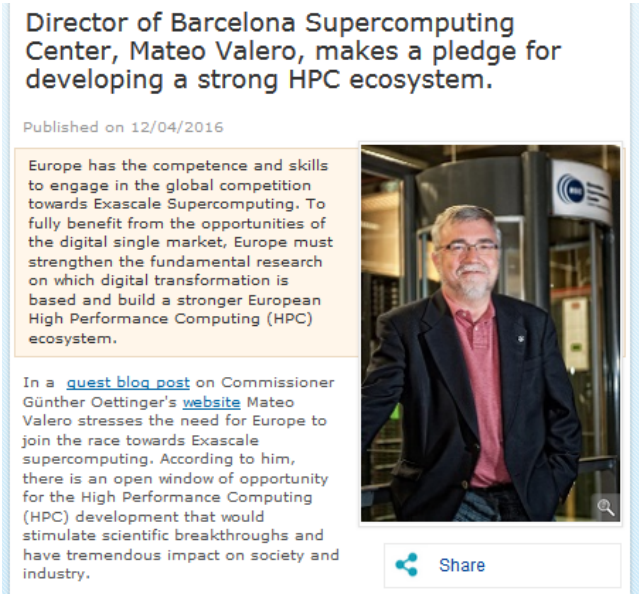
BSC and the EC



Final plenary panel at ICT - Innovate, Connect, Transform conference, 22 October 2015 Lisbon, Portugal.

the transformational impact of excellent science in research and innovation

“"Europe needs to develop an entire domestic exascale stack from the processor all the way to the system and application software", Mateo Valero, Director of Barcelona Supercomputing Center



Director of Barcelona Supercomputing Center, Mateo Valero, makes a pledge for developing a strong HPC ecosystem.

Published on 12/04/2016

Europe has the competence and skills to engage in the global competition towards Exascale Supercomputing. To fully benefit from the opportunities of the digital single market, Europe must strengthen the fundamental research on which digital transformation is based and build a stronger European High Performance Computing (HPC) ecosystem.

In a quest blog post on Commissioner Günther Oettinger's website Mateo Valero stresses the need for Europe to join the race towards Exascale supercomputing. According to him, there is an open window of opportunity for the High Performance Computing (HPC) development that would stimulate scientific breakthroughs and have tremendous impact on society and industry.

Share

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

HPC is a global competition



"Our ambition is for Europe to become one of the top 3 world leaders in high-performance computing by 2020".

European Commission President
Jean-Claude Juncker (27 October 2015)

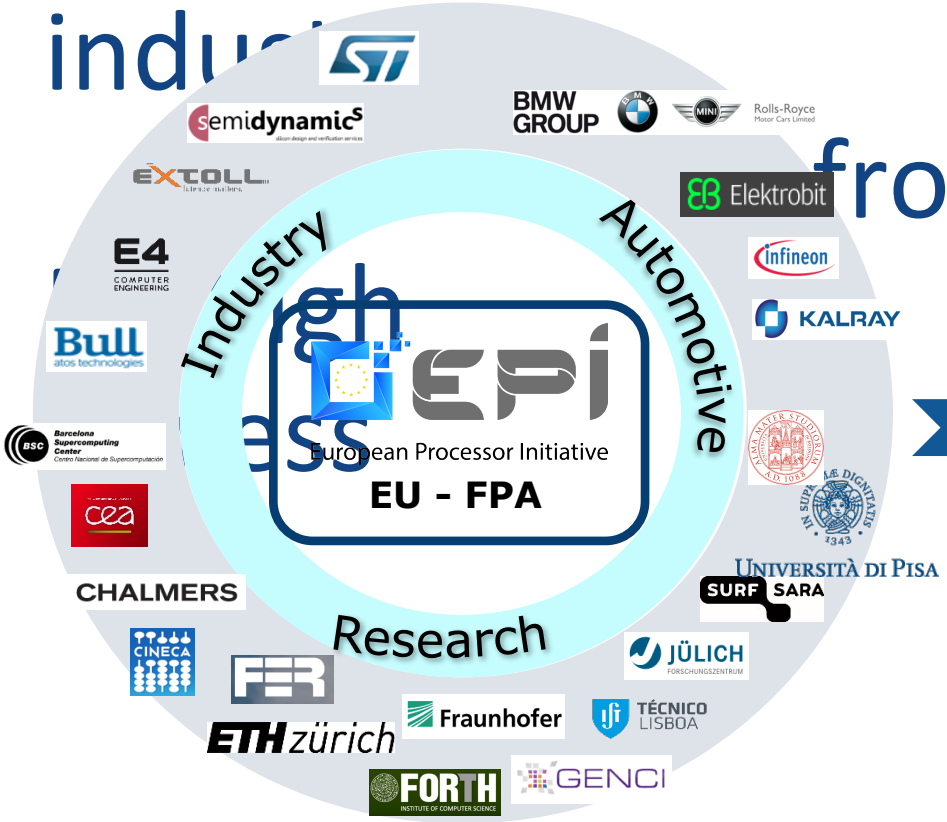
"With the EuroHPC initiative we want to give European researchers and companies world-leading supercomputer capacity".

European Commission Vice President
Andrus Ansip (11 January 2018)




Barcelona Supercomputing Center
Centro Nacional de Supercomputación
MONT BLANC
www.montblanc-project.eu

EPI 23 partners, from research to indu… from consortium to tech



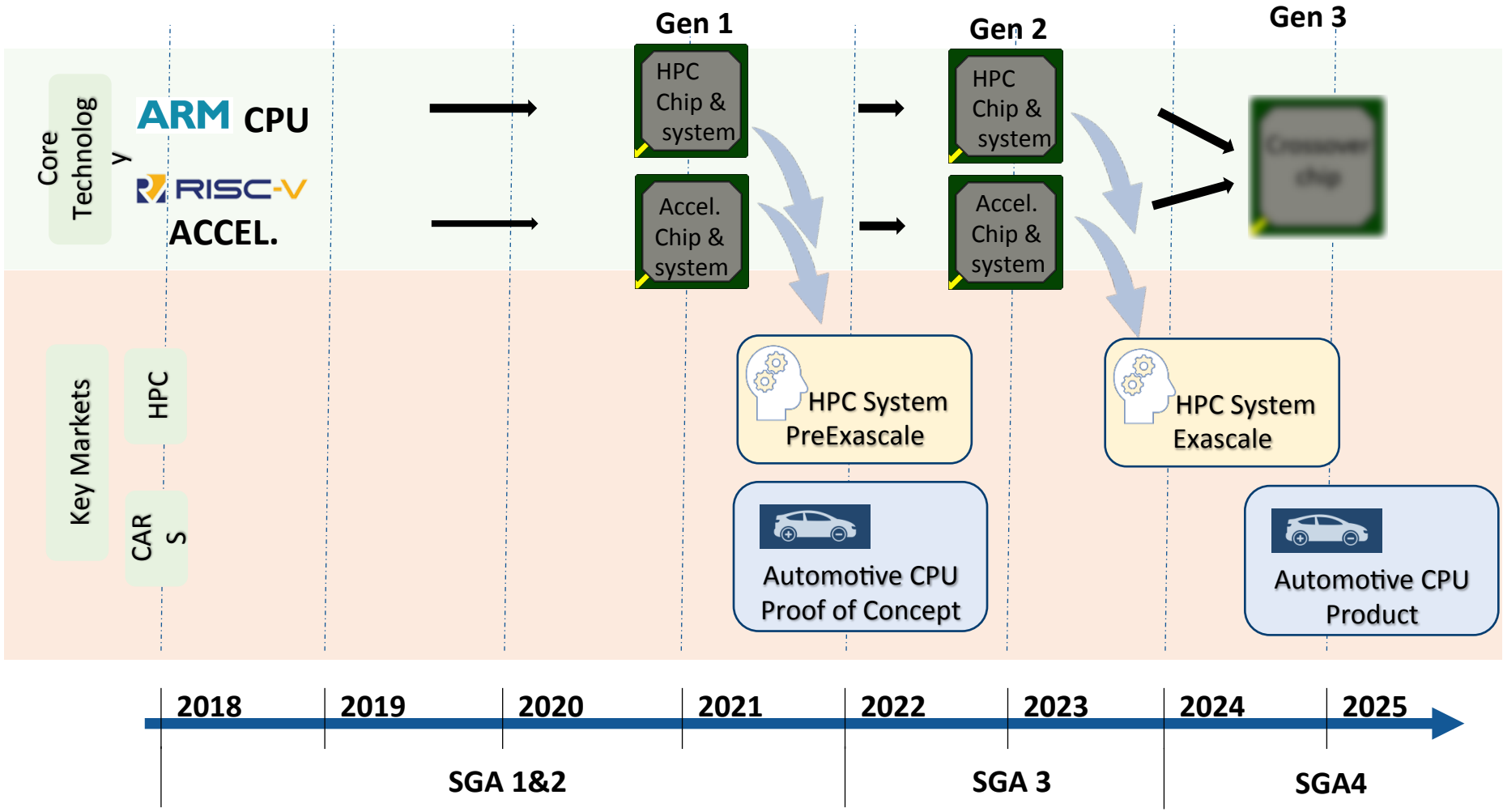
EPI Semiconductor

Fabless company
Industrial hand of EPI
Incorporated by a couple EPI members and external investors

EPI Common Platform

1st EPI production

EPI ROADMAP



Barcelona Supercomputing Center
Centro Nacional de Supercomputación

European Processor Initiative

Long-term Strategic European Projects

AIRBUS

imi innovative medicines initiative

GALILEO



Mare Nostrum RISC-V inauguration 202X







Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Thank you

mateo.valero@bsc.es

10/2018