ACH@BSC-CIEMAT: High-Performance Computing

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EUROfusion Advanced Computing Hubs

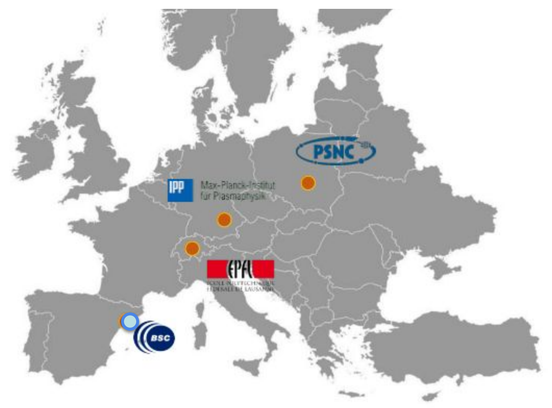
EUROfusion coordinates theory and advanced simulation through two complementary elements:

- **Theory, Simulation, Validation and Verification tasks (TSVV)**, which perform fundamental research and channel scientific insight
- **Advanced Computing Hubs (ACHs)** which provide advanced simulation expertise to TSVVs

ACH Main Activities

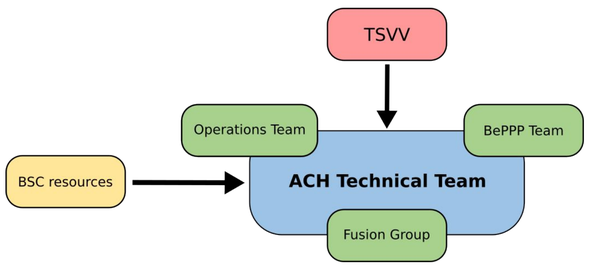
- Performance analysis & optimization of fusion modelling codes
- Refactoring, parallelization & GPU porting for heterogeneous systems
- Software engineering support (Git/GitLab, CI/CD, testing, verification)
- Continuous performance monitoring on reference HPC systems
- User support & technical coordination

ACH Network Map



ACH@BSC-CIEMAT

Provides expert support to users regarding HPC: *scalable algorithms, code parallelization, performance optimization, code refactoring, GPU-enabling, ...*



BePPP Best Practices for Performance and Programmability	Programmability, portability, deep performance analysis tools
Operations	Optimization and scalability study, parallelization assistant
Fusion	GPU porting, parallelization of codes (use of HPC libraries), development of parallel algorithms, performance and scalability analysis

10% Mathematicians
20% Physicists
70% Computer scientists

- Presented works in 7 workshops
- Presented a webinar for the code developers (JOREK)

Published 6 papers

62 meetings with developers

Participated in 6 hackathons (3 BIT1, 2 XTOR-K, 1 ERO2)

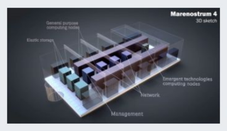
- Chair of the Ticket Committee (TC)
- Member of the Operations Committee (OC)

HPC Platforms

MareNostrum 4 (2017- 2023)

Located in Barcelona (Spain)

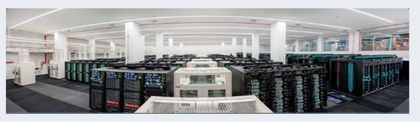
- General Purpose Partition: 3 400 nodes based on Intel Xeon processors (**11 PFLOPS**)
- Emerging Technologies Partition: IBM POWER9 processors and NVIDIA GPUs, Intel Knights Landing (KNL) and Intel Knights Hill (KNH), and 64 bit ARMv8 processors



MareNostrum 5 (2023 -)

Located in Barcelona (Spain)

- General Purpose Partition: 6480 nodes based on Intel Saphire Rapids processors (**46 PFLOPS**)
- Accelerated Partition: 1120 nodes based on NVIDIA H100 GPUs (**260 PFLOPS**)



Leonardo (2023 - 2025)

Located in Bologna (Italy)

Partition: 3456 nodes based on Intel Xeon Ice Lake processors and NVIDIA custom Ampere GPUs (**309 PFLOPS**)

Pitagora (2025 -)

Located in Bologna (Italy)

- General Purpose Partition: 1008 nodes based on AMD EPYC 9745 (Turin) processors (**17 PFLOPS**)
- Accelerated Partition: 168 nodes based on NVIDIA H100 GPUs (**27 PFLOPS**)

Tasks done and on going

2025

10 code requests
8 TSVV + TE + TRED

2026

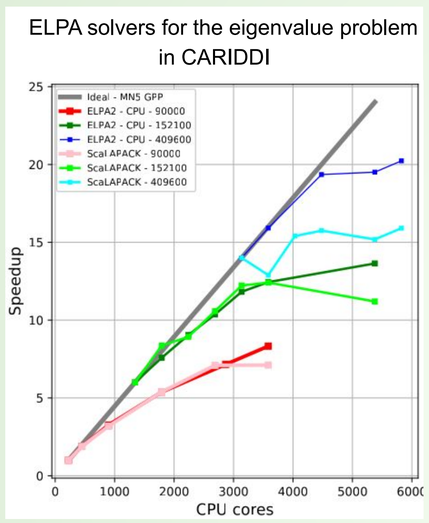
11 code requests
3 new requests for our ACH
1 request from another ACH
6 TSVV + PWIE + TE + TRED

2025	TSSV	2026	TSSV
ERO2.0 BIT1 XTOR-K JOREK SPICE2 SOLPS Stella Alya GENE-x GVEC	TSVV-2 TSVV-4 TSVV-3 TSVV-7 TSVV-8 TSVV-10 TSVV-12 TSVV-13 TE WP TRED (Training and Education)	XTAPAS (JOREK-)DREAM CARIDDI ERO2.0 BIT1 XTOR-K SPICE2 SOLPS Stella Alya	TSVV-F TSVV-C TSVV-B TSVV-D TSVV-G TSVV-J WP-PWIE WPTE WP TRED (Training and Education)
CINCOMP(2025) TC (2023)	AC-HPC	CINCOMP(2025) TC (2023)	AC-HPC

JOREK

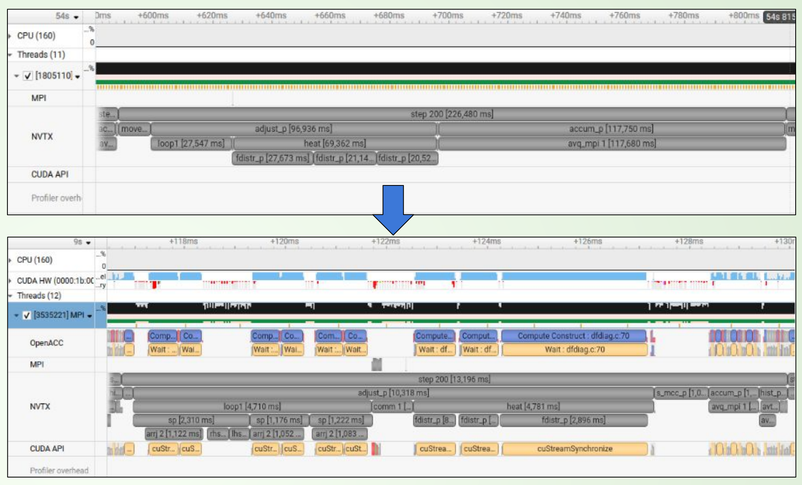
- **Matrix compression in the JOREK-CARIDDI coupling**

ELPA solvers for the eigenvalue problem in CARIDDI



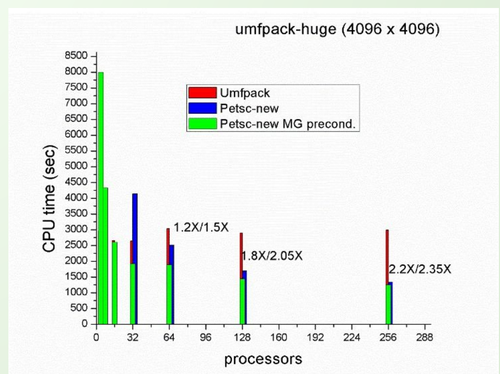
BIT1

- **Porting to GPU (~7× faster)**



SPICE2

- **Parallel solver based on PETSc to simulate larger domains**



ACH@BSC - Key Outcomes and Impact

- **Key HPC enabler for EUROfusion,** providing essential HPC expertise
- **Ensures scalable, exascale-ready fusion codes**, improving code performance
- **Drives innovation through GPUs and AI**
- **Maximizes performance and efficient use of HPC resources**
- **Strengthens the EUROfusion ecosystem,** through coordinated support, training, and collaboration across European HPC centers

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