SPACE CoE

Workshop on Critical Computing
June 15-16th @ Catania

Giuliano Taffoni, INAF - Technical Manager
Luca Tornatore – Scientific Coordinator

Co-funded by the European Union

Funded by the European Union. This work has received funding from the European High Performance Computing Joint Undertaking (JU) and Belgium, Czech Republic, France, Germany, Greece, Italy, Norway, and Spain under grant agreement No 101093441.

EuroHPC Joint Undertaking

https://www.space-coe.eu/

Scalable Parallel Astrophysical Codes for Exascale

1st January 2023 → **31st December 2027**
we started slightly late due to issues with national fundings

15 partners from 8 countries

What is a CoE?

"The European Centres of Excellence (CoEs) for High Performance Computing (HPC) applications [...] promote the use of upcoming exascale and extreme performance computing capabilities and scale up existing parallel codes towards exascale scaling performance."

https://eurohpc-ju.europa.eu/

The SPACE CoE

(1) The main SPACE CoE goal is to **evolve** 8 among the most used and wide-spread **European AAC codes to the exascale paradigms**

(2) to evolve accordingly the **data analysis and visualization** ecosystem

(3) to develop **ML techniques** for post-processing and (possibly) on-line coupling

(4) to address the **Energy Efficiency** Issue

(5) to **federate** the A&C community

The SPACE Partners and budget

HORIZON EUROHPC-JU 2021-COE-01

15 partners:

- Research **institutes**
- **Supercomputing centers**
- HPC **companies**

from **8 different countries**

Total Budget ~8MEuro (50% EU +50% National)

The SPACE Partners

UNIVERSITÀ DI TORINO

INAF ISTITUTO NAZIONALE DI ASTROFISICA

UNIVERSITY OF OSLO

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

cnrs CRAL CENTRE DE RECHERCHE ASTROPHYSIQUE DE LYON

KU LEUVEN

HITS Heidelberger Institut für Theoretische Studien

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

FORTH FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS

9

Research Institutes

from 6 countries

The SPACE Partners

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FORTH FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS

9
Research Institutes
from 6 countries

3
Computing Centers
from 3 countries

CINECA

IT4I

BSC Barcelona Supercomputing Center
Centro Nacional de Supercomputación

The SPACE Partners

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FORTH FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS

9 Research Institutes *from 6 countries*

3 Computing Centers *from 3 countries*

CINECA

IT4I

BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación

3 HPC Companies

E4 COMPUTER ENGINEERING

ENGINSOFT

Atos

INAF Co-leading role in concept and writing

- **Project Manager:** Eva Sciacca, OACt
- **Scientific coordinator:** **Luca Tornatore,** OATs
- **Technical Manager:** Giuliano Taffoni, OATs
- **WPs**
  - **WP1 leader** (L. Tornatore)
  - **WP4 deputy** (G. Taffoni)

OpenGadget L. Tornatore (+ LMU)
RAMSES C. Gheller (+ CRNS)
VisIVO E. Sciacca, UBE, F. Vitello

Budget: 600Keuro (50% Eu + 50% MIMIT)

The SPACE rationale: the framework

MeerKAT

Precision Cosmology and forthcoming data torrent: **outstanding quality and volume of data**

exceptional challenges to their theoretical interpretation

e.g. 8 - 9 orders of magnitude in dynamic range with very different physical processes at different scales

The SPACE rationale

Nowadays, a limited number of numerical applications, several of which are developed and maintained in Europe, represent the state-of-the-art in A&C simulations.

However, although they are fully-productive codes used to produce cutting-edge simulations, they also require a substantial effort to evolve their computational paradigms from the petascale to the exascale era.

The SPACE rationale

outstanding quality and volume of observational data

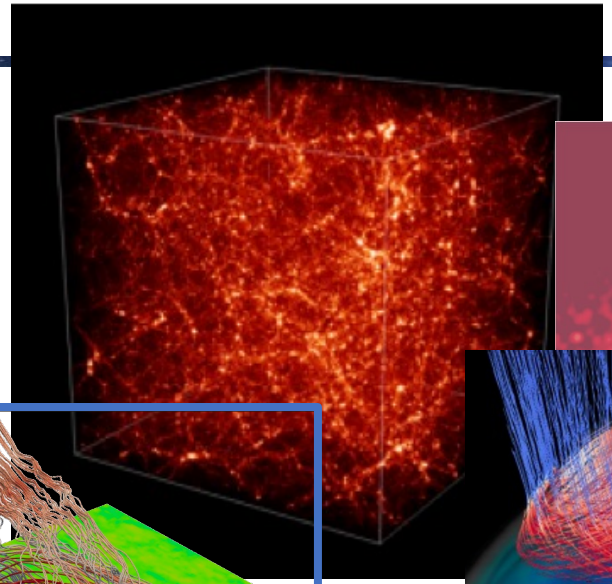
exceptional challenges to their theoretical interpretation

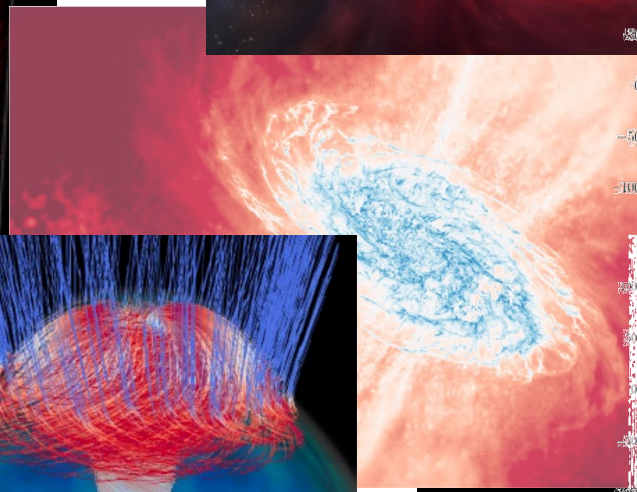
require **novel** theoretical and **numerical laboratories** (codes, algorithms and tools)

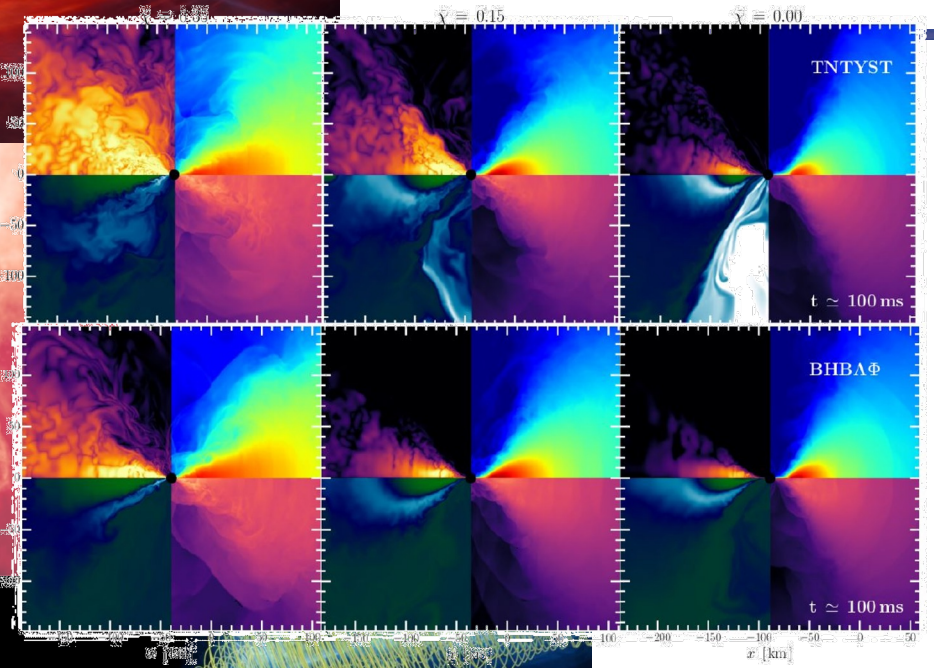
high-performance and real-time **extreme data analysis** and **visualization**

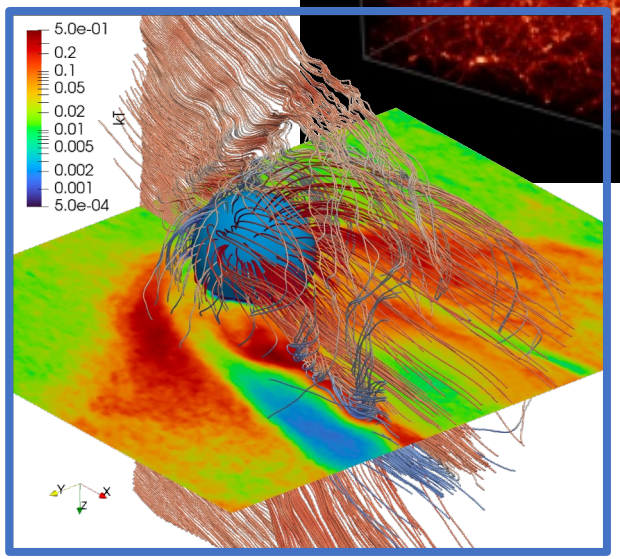
innovative programming paradigms and sw solutions for the efficient and effective **exploitation of exascale** (and beyond) **computing capabilities**

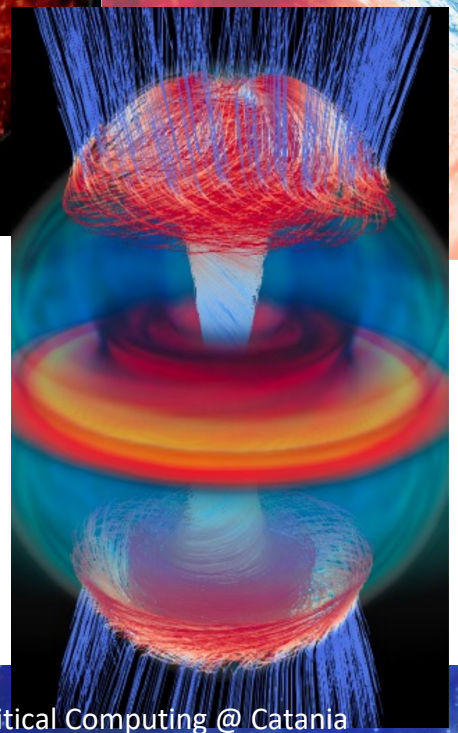
The 8 SPACE codes

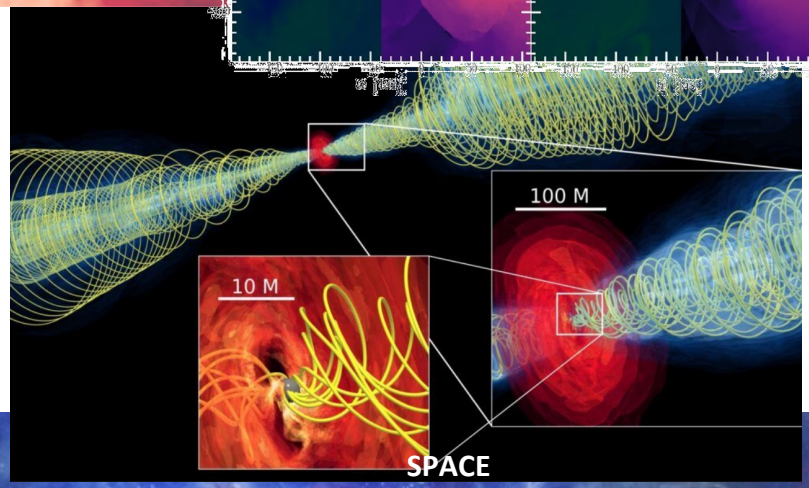












The 8 SPACE codes

Particle-based

Grid-based

Large-scale Cosmology and Astrophysics:

OpenGADGET ChaNGa

RAMSES

Fully-Relativistic small-scale Astr & MHD:

PLUTO WhiskyTHC BHAC Frankfurt/Illinois GRMHD

Particle-in-Cell multi-scale plasma

iPic3d

Scientific cases

- N-body hydro simulations of large volumes of the Universe, or single zoomed-in objects, or planetary formation
  with MHD, cosmic rays, star formation, stellar evolution & feedback, dust formation, Black-Holes accretion and feedback, ...

- Relativistic MHD simulations of compact objects
  (Neutron stars, BHs, Supernovae, Gravitational waves; merging of compact objects; accretion flows on compact objects)

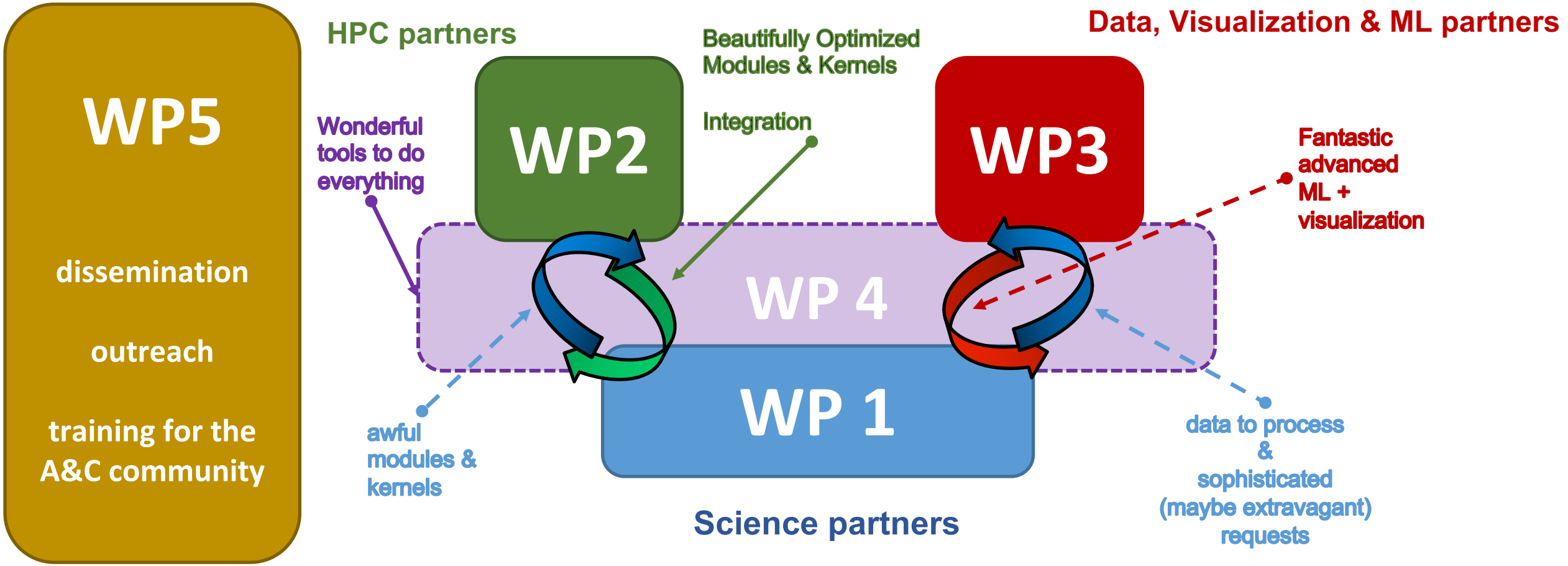
- Multi-level multi-domain plasma simulations with magnetic and electric fields

The SPACE How-To

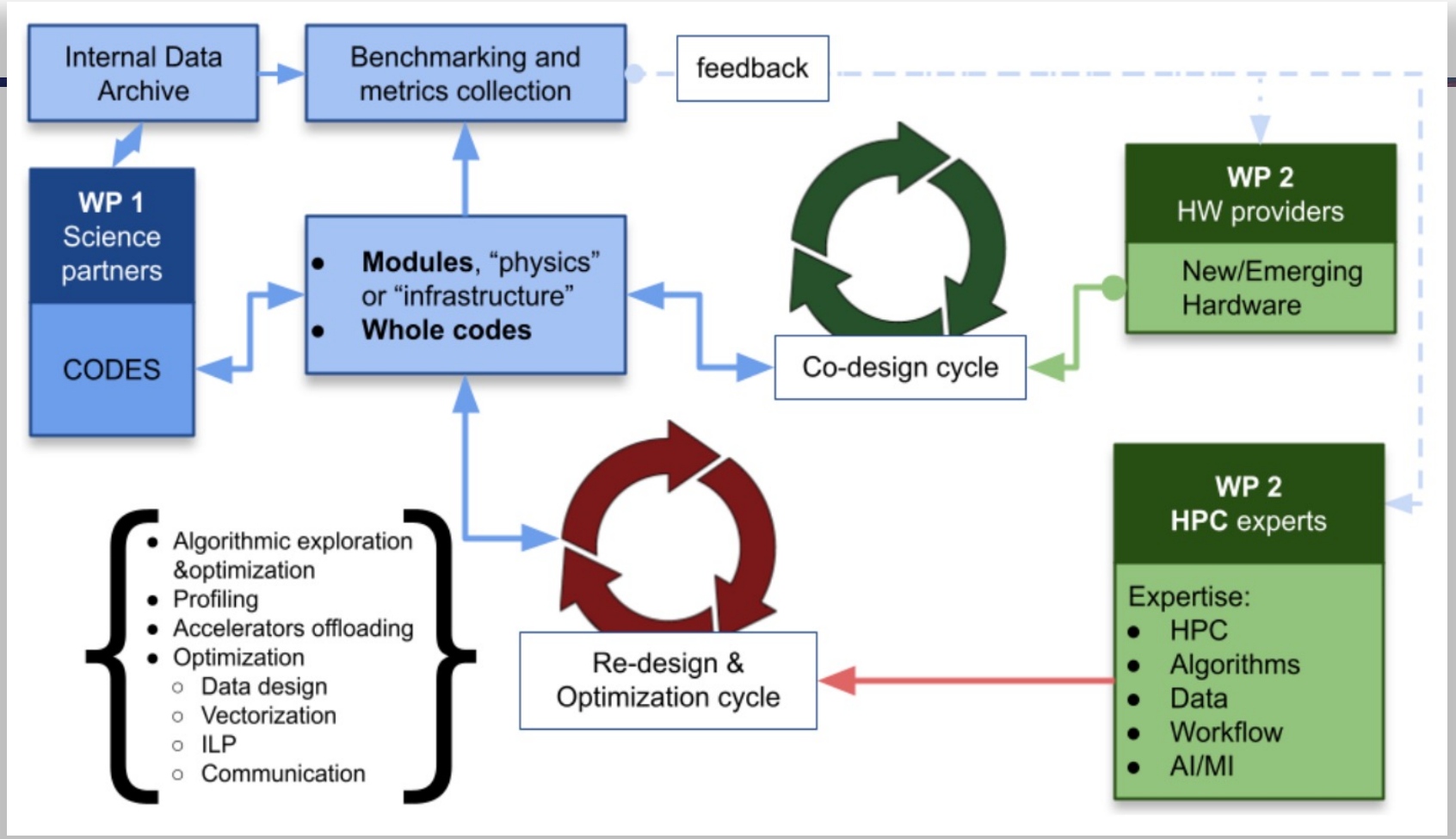
A multi-disciplinary environment that associates the following expertise and knowledge:

- Science and HPC-related from the A&C application domain
- HPC expertise from four HPC EU centers that are either hosting EU pre-exascale facilities (CINECA and BSC) or a petascale facility (IT4I@VSB, LRZ)
- Cutting-edge technologies know-how and availability (FORTH, E4, BULL)
- workflow integration (UniTo)
- Machine Learning (BSC and HITS)
- Visualization (INAF, BSC)

The SPACE workflow *(simplistic view)*



The SPACE workflow *(WP1 <-> WP2 detail)*



Thanks for your attention!

Acknowledgement & Disclaimer

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