

E4

COMPUTER
ENGINEERING

WHEN PERFORMANCE MATTERS

Emerging Technologies for Next Generation Big Science Experiment: The Einstein Telescope

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Nikhef, Amsterdam 14 APR 2026

European Projects and Quantum Computing Team

CONFIDENTIAL

www.e4company.com

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- Company at a Glance
- ASTRI Mini Array Experience
- Emerging Technologies for Big Science
- RISC-V for N-Body problem
- Team

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HQ Scandiano (RE)
New Lab Rubiera (RE)

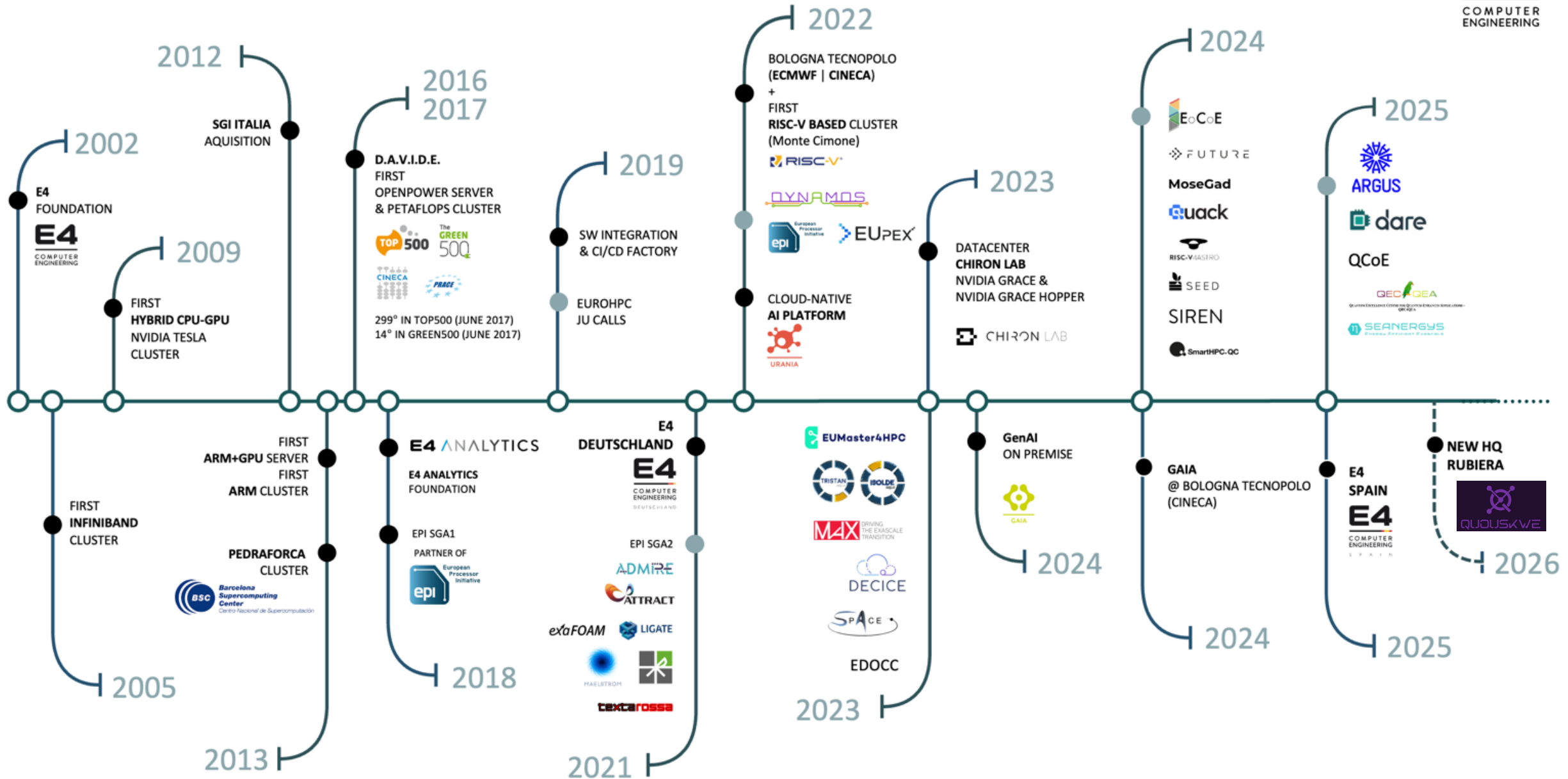
Sulmona (AQ)

Pula (CA)

E4 Computer Engineering designs and manufactures highly technological solutions for HPC Clusters, Cloud, Data Analytics, Artificial Intelligence, Hyper-Converged infrastructure for the Academic and Industrial markets. We have been collaborating for years with the main research centers at national and international level (CINECA, CERN, ECMWF, LEONARDO) and we are involved in national and European projects in the HPC, AI and Quantum Computing fields.



E4 INNOVATION HISTORY





Year 2024-2025 (active)

Customer INAF @Teide observatory

Solution Design, Installation

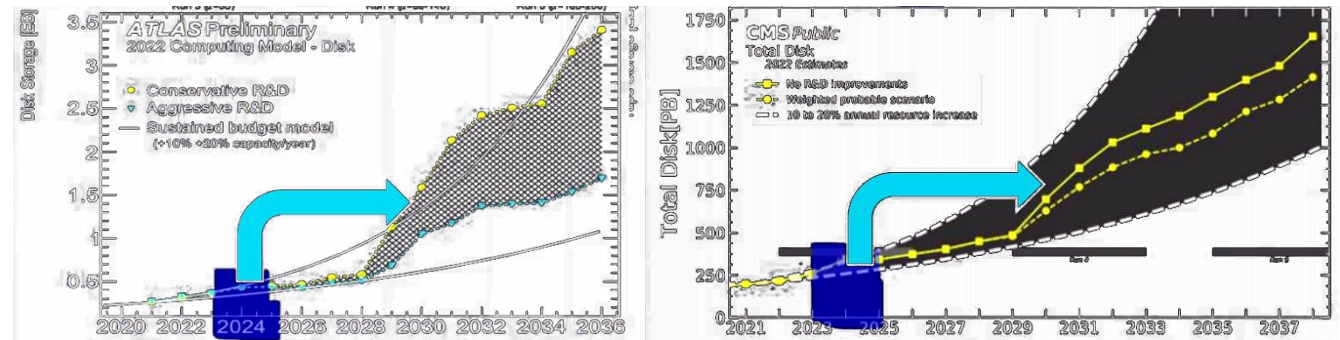
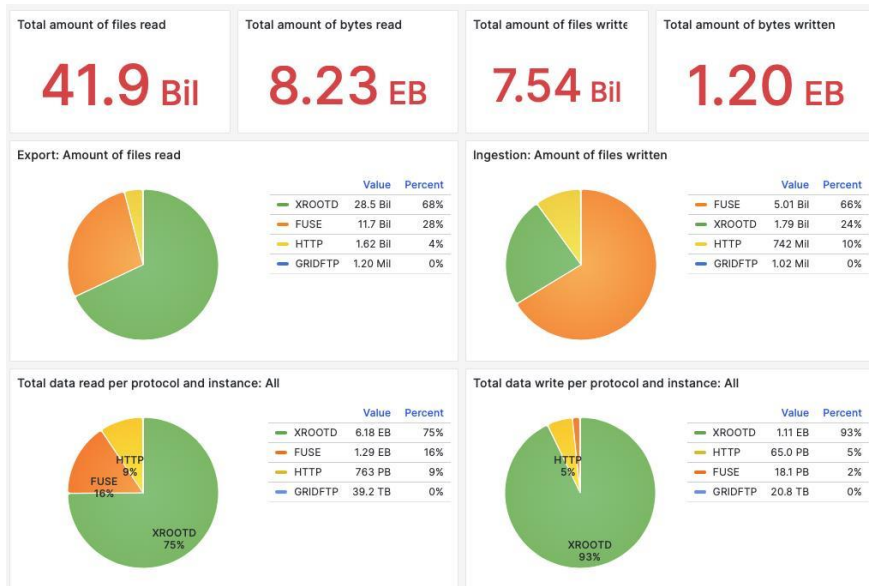
The **ASTRI Mini-Array** is an INAF-led project to build nine double-mirror Čerenkov telescopes to study astrophysical sources emitting high-energy gamma photons with the goal of measuring the energy, direction, and arrival time of gamma photons arriving on Earth from astrophysical sources, by exploiting the Čerenkov atmospheric imaging technique

E4 has designed and installed an infrastructure to manage and monitor an array of nine Čerenkov telescopes and process the data collected in real time

<https://www.youtube.com/watch?v=lTh2nV6lBtU&t=13s>

<https://doi.org/10.1117/12.3018973>

DAQ requires Fast Storage, Size matters also for online. Next Generation Experiments need exabyte of storage and long time custodial.



In ~2030 CERN IT will need to provide ~3-4x more of the current storage capacity to LHC Experiments

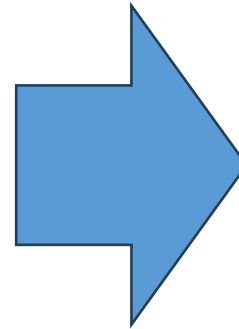
Note: capacity does not automatically translate into required performance!

Flash-based storage offer better latency and bandwidth than traditional HDDs

Expecting more random access (both reads and writes) to storage in the future

e.g. ML and AI applications with unusual IO patterns

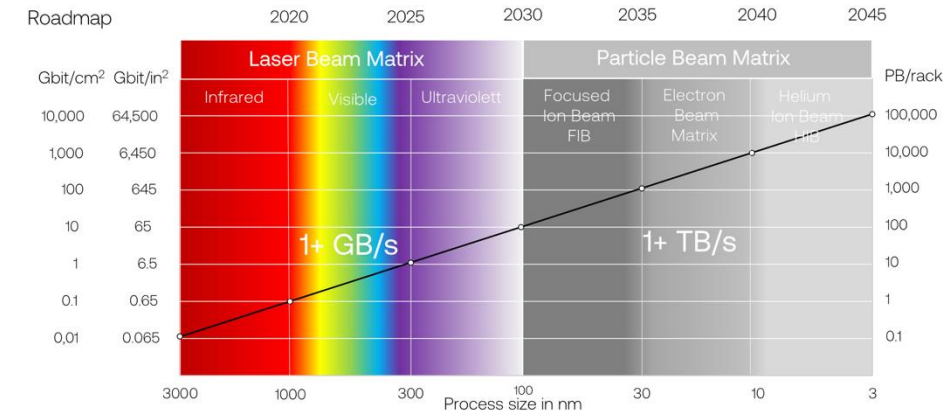
DAQ requires Fast Storage, Size matters also for online. Next Generation Experiments need exabyte of storage and long time custodial.



Square glass carrier with dark ceramic coating

Cerabyte is developing Ceramic Nano Memory. The ceramic is deposited on both side of a flexible ultra-thin planar substrate with only 100 μm thick flexible glass.

Tape Library is the technology commonly adopted for LTDP



CREDITS CERABYTE <https://www.cerabyte.com/>

Best quantum directions for the gravitational N-body problem

A realistic roadmap from NISQ subroutines to quantum-native reformulations



SHORT TERM — Quantum Poisson solvers on reduced PM / TreePM blocks

The most credible near-term direction is to test variational or NISQ-oriented Poisson solvers on small, structured mesh subproblems. This does not replace production HPC solvers, but it is the cleanest entry point because the Poisson block is already a structured linear problem.



MID TERM — Grover-like search for spatial and neighbor-search subroutines

Going in the FTQC direction, the next strong target is structured search: neighbor search, tree opening, and short-range candidate selection. Here the value is not in porting the full N-body loop, but in accelerating search-dominated subroutines with amplitude-amplification-style methods.

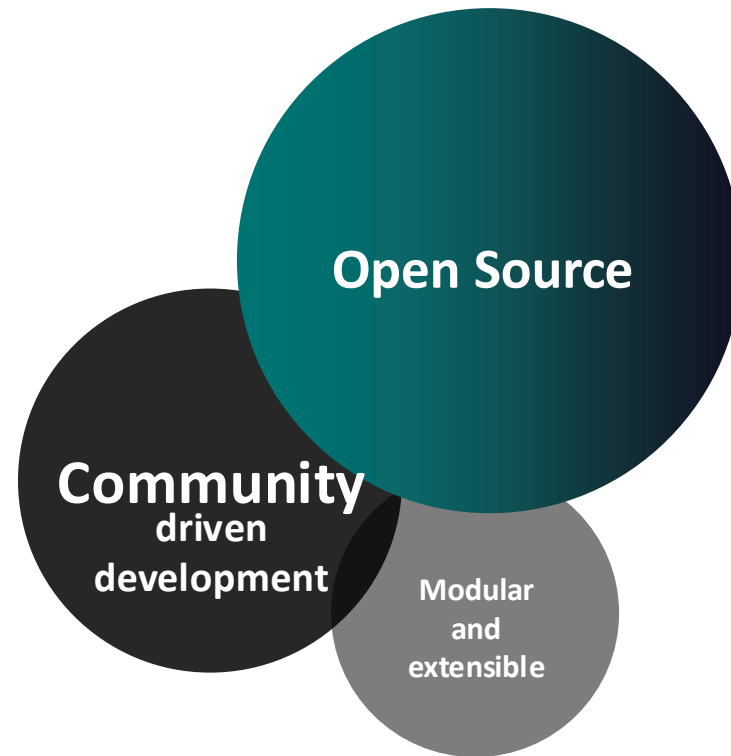


LONG TERM — Reformulate the physics: Vlasov/Boltzmann or Schrödinger–Poisson

The most strategic long-term path is not to quantize a classical particle code, but to move to formulations that are more native to quantum evolution. Vlasov/Boltzmann and Schrödinger–Poisson are the strongest candidates for a genuinely quantum-native treatment of self-gravitating dynamics.

Not the right target today: a direct end-to-end replacement of a production TreePM / FMM code with a QPU.

RISC-V: AN OPEN STANDARD ISA



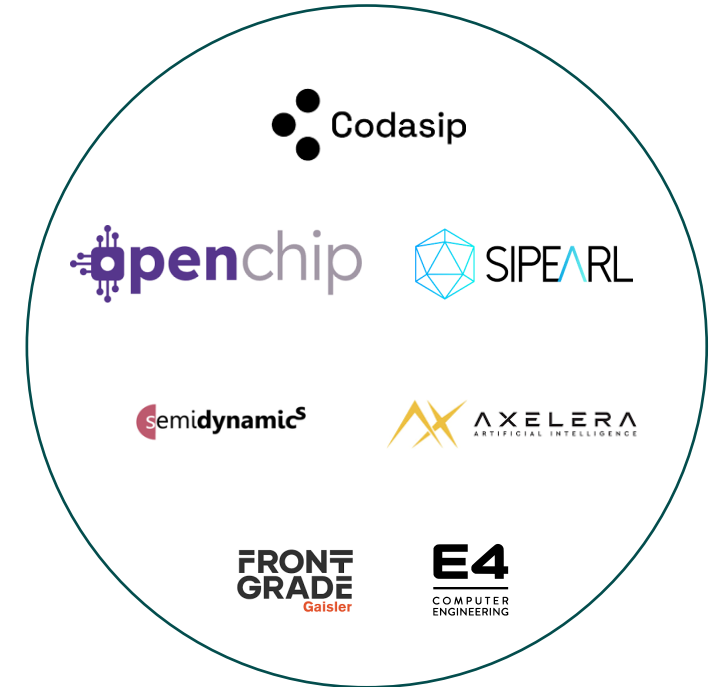
RISC-V: ENABLING EUROPE DIGITAL SOVEREIGNTY



**EU AGENCIES INVOLVED
IN RISC-V DEVELOPMENT**



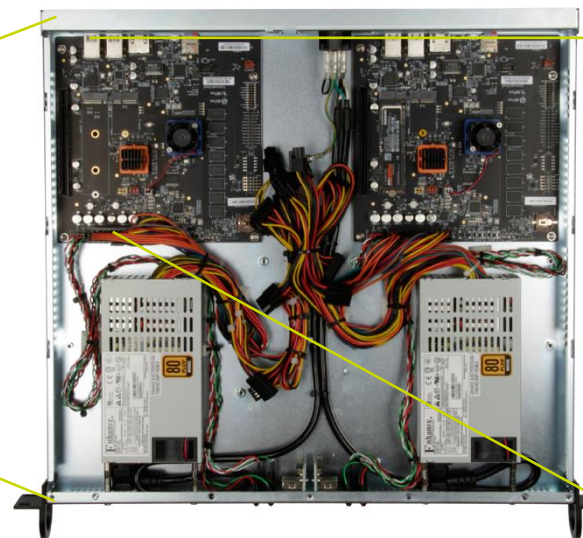
**EU PROJECTS
FOR RISC-V DEVELOPMENT**



**EU COMPANIES
DEVELOPING OR SUPPORTING
RISC-V**

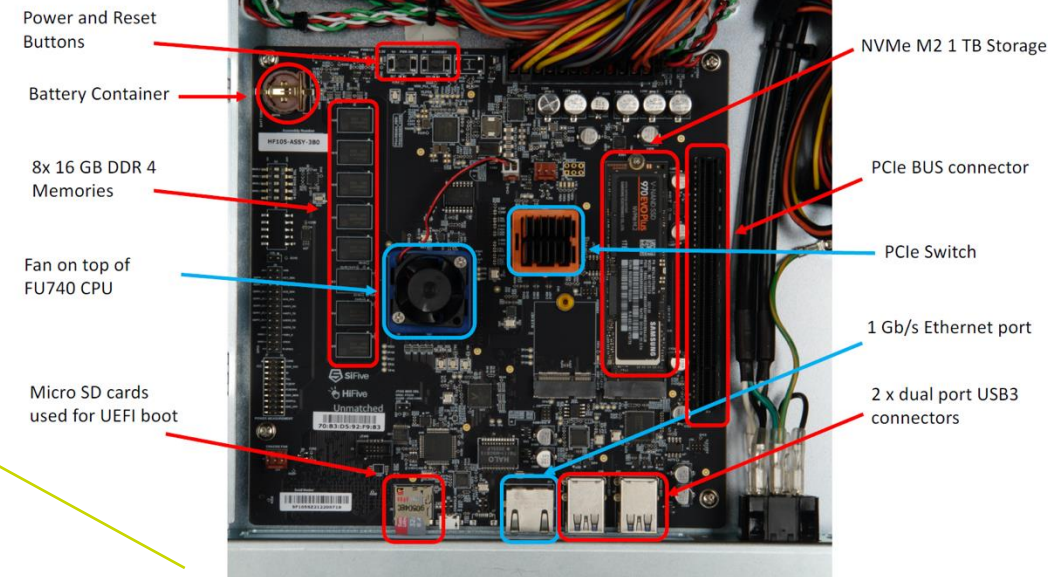
MONTE CIMONE: THE FIRST RISC-V HPC CLUSTER

A. Bartolini et al. (2022), arXiv pre-print, arXiv:2205.03725



E4 RV007
1U Custom Server Blades

SiFive HiFive Unmatched board



HW characteristics:

- 4x E4 RV007 1U Custom Server Blades
- 2x SiFive U740 SoC with 4x U74 RV64GCB cores
- 16GB of DDR4
- 1TB node-local NVME storage
- PCIe expansion card w/InfiniBand HCAs
- Ethernet + IB parallel networks

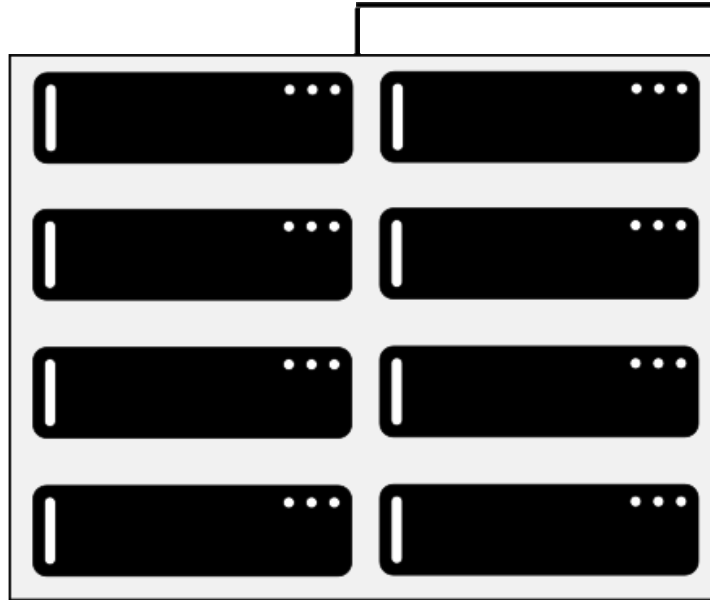
SW characteristics:

- Ubuntu 20.04
- SLURM
- Spack
- GNU compiler suite 10.3.0
- OpenMPI 4.1.1
- OpenBLAS 0.3.18
- FFTW 3.3.10
- Netlib Lapack 3.9.1
- Netlib Scalapack 2.1.0
- HPL 2.3
- Stream 5.10
- www.e4company.com
- quatumEspresso 6.8

FROM MONTE CIMONE TO MONTE CIMONE 2

E. Venieri et al. (2025), arXiv pre-print, arXiv:2503.18543

Login node x86



Partition 1:
8 SiFive



Partition 2:
3 Milk-V + 1 E4 RSV10



Sophon SG2044 CPU



 SOPHGO
SG2044
 RISC-V 64core and Vector 1.0
 8x DDR Control
 RISC-V Core 64core Vector 1.0 DDR Bandwidth 3X PCI-e 2X

Tenstorrent Wormhole (n300) accelerator



Wormhole™
 The Wormhole™ n150 and n300 PCIe boards are flexible, scalable processors built with RISC-V cores. Each includes a compute unit, software-on-chip, local cache and "baby RISC-V" cores, coexisting in powerful data movement through the chip.
 Wormhole™ offers superior performance for cost compared to traditional CPUs, and broad data precision format support.

OpenFOAM: an open source CFD application

Based on the cell centered finite volume method

Written in c++

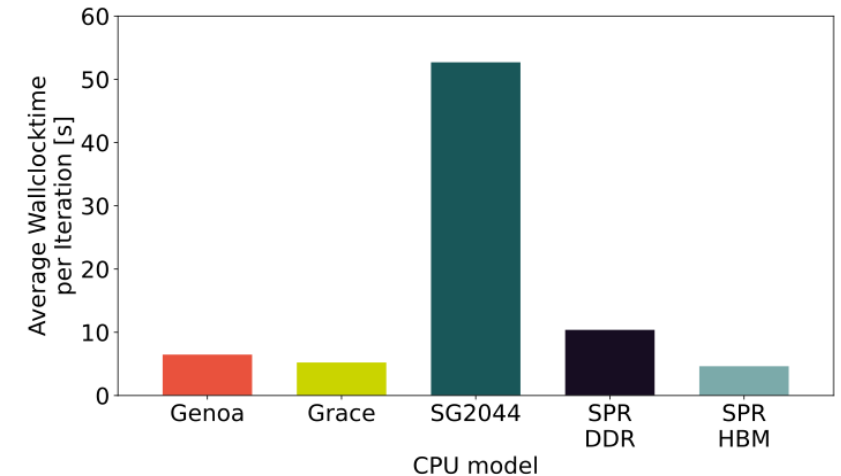
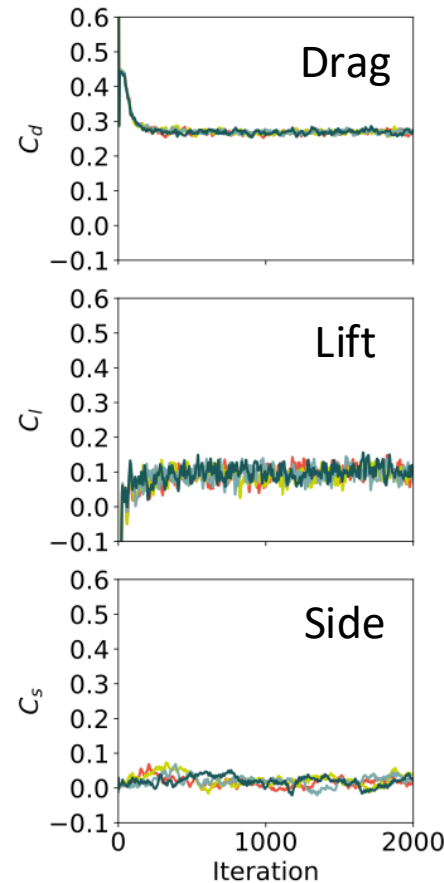
Parallelised with MPI

Simulation: Open-closed cooling DrivAer

Compiler: GNU 14.2.0, OpenMPI 5.0.6

Flags: -O3 -march=rv64gcv1p0 -ftree-vectorize

Processor	Architecture	Cores/node
AMD Genoa	x86_64	128
NVIDIA Grace	ARM	144
INTEL SPR HBM	x86_64	96
INTEL SPR DDR	x86_64	96
SOPHON SG2044	RISC-V	64



THE BAD NEWS: PERFORMANCE TRAILS BEHIND

L.Riha et al. (2025), In Proceedings of the 22nd ACM International Conference on Computing Frontiers. ACM, New York, NY, USA, 150–156.

Siesta: a code for ab initio molecular dynamics

Based on density-functional theory (DFT)

Written in Fortran

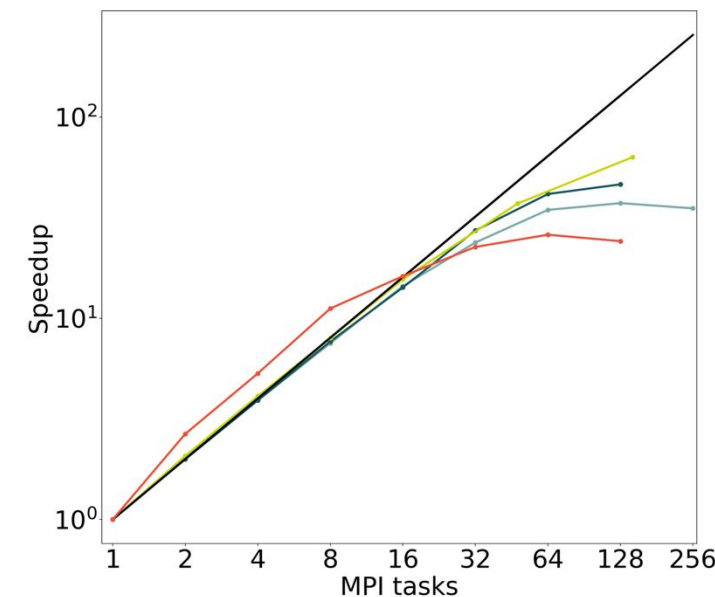
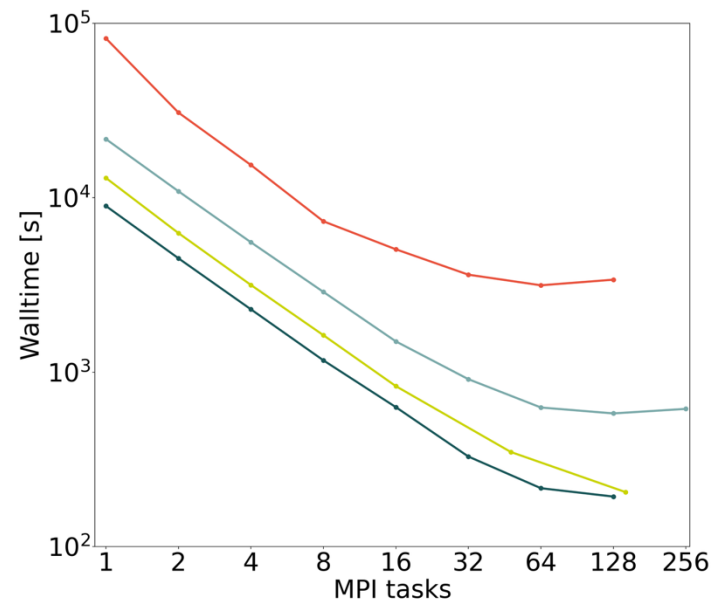
Parallelised with MPI and OpenMP

Uses BLAS, LaPACK, ScaLAPACK, and ELSI

Simulation: quantum dot

Compiler: GNU 13.2.1, OpenMPI 4.1.4

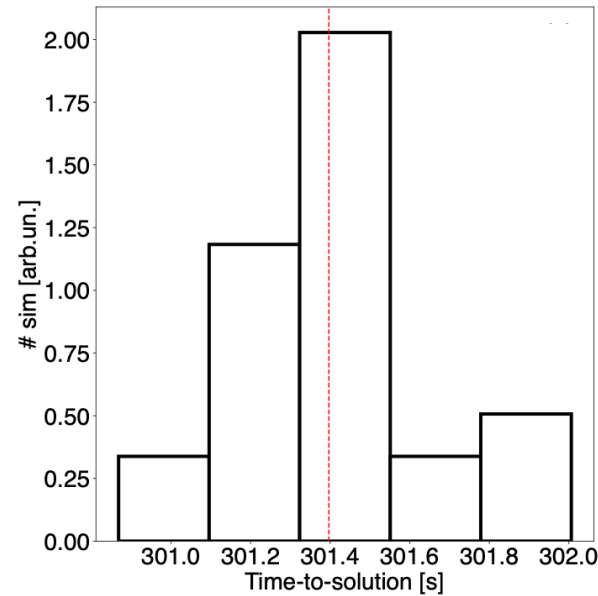
Flags: -O3, -march=rv64imafdc_zicsr_zifencei



-- SOPHON SG2042, -- AMD GENOA,
-- AMPERE ALTRA MAX, -- NVIDIA GRACE

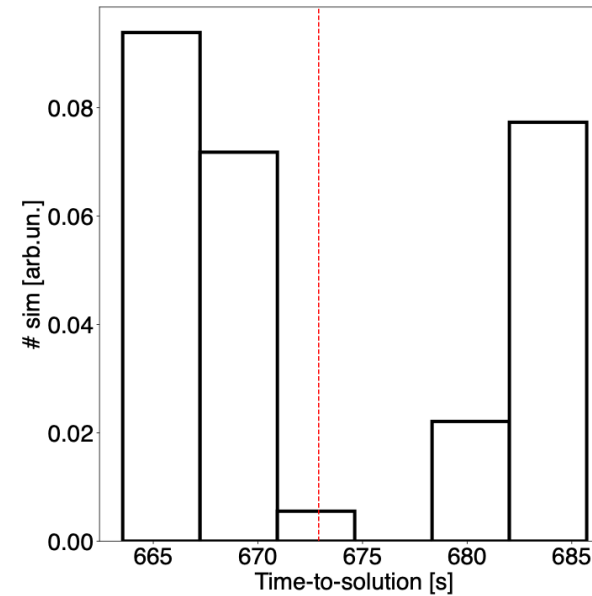
J.L. Almerol et al. (2025), arXiv pre-print, arXiv:2509.19294

Time-to-solution (TTS) over ~50 simulations



1 MPI task +
1 OMP thread +
1 Tenstorrent n300

$$TTS_{avg} = 301.40 \pm 0.24 \text{ s}$$

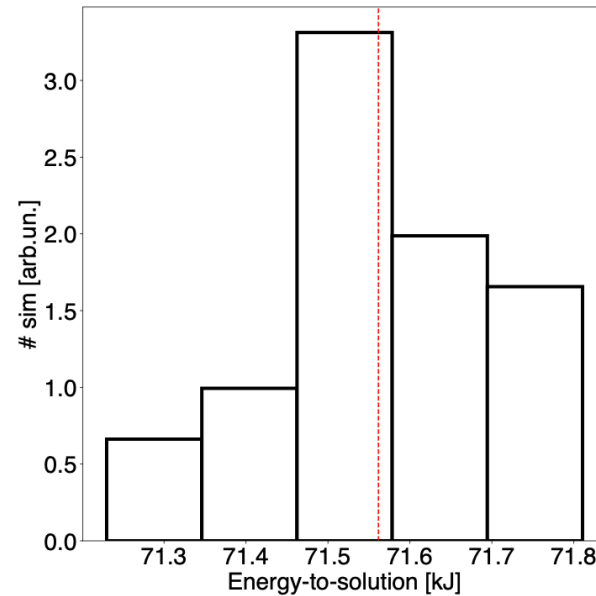


1 MPI task +
32 OMP threads +
AVX-512 intrinsics

$$TTS_{avg} = 672.90 \pm 7.83 \text{ s}$$

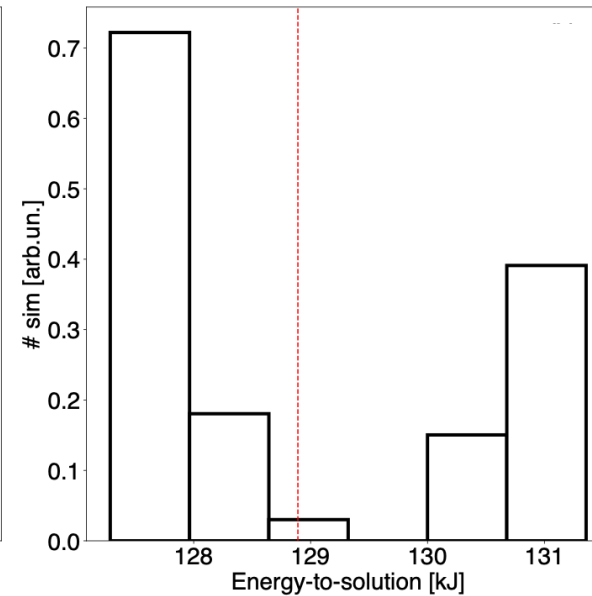
J.L. Almerol et al. (2025), arXiv pre-print, arXiv:2509.19294

Energy-to-solution (ETS) over ~50 simulations



1 MPI task +
1 OMP thread +
1 Tenstorrent n300

$$ETS_{avg} = 71.56 \pm 0.13 \text{ kJ}$$



1 MPI task +
32 OMP threads +
AVX-512 intrinsics

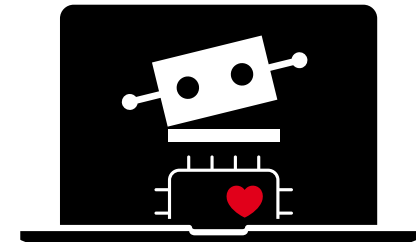
$$ETS_{avg} = 128.89 \pm 1.52 \text{ kJ}$$

TEAM



SUMMARY & PERSPECTIVES

- New material could be used for Storage system, in particular for WORM technologies
- Current Quantum Computing (NIST) could be adopted to investigate potential improvement in Nbody codes and GW detection
- We tested parallel legacy scientific applications on nodes powered by RISC-V-based CPUs.
- While raw performance still trails established architectures, successful compilation and numerically correct results confirm a mature and dependable software stack.
- RISC-V accelerators achieve impressive results, with over 2× faster execution and about 2× higher energy efficiency compared to x86.
- Next steps:
 - Further studies of impact of RVV1.0 on SG2044 CPU;
 - Test of N-body code on Tenstorrent P150 accelerators.



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THANKS!