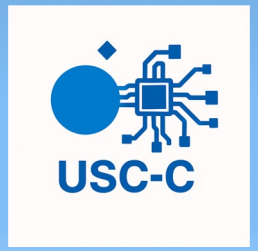
Giornate INAF della RSN 1

The Computing Facilities (USC-C)

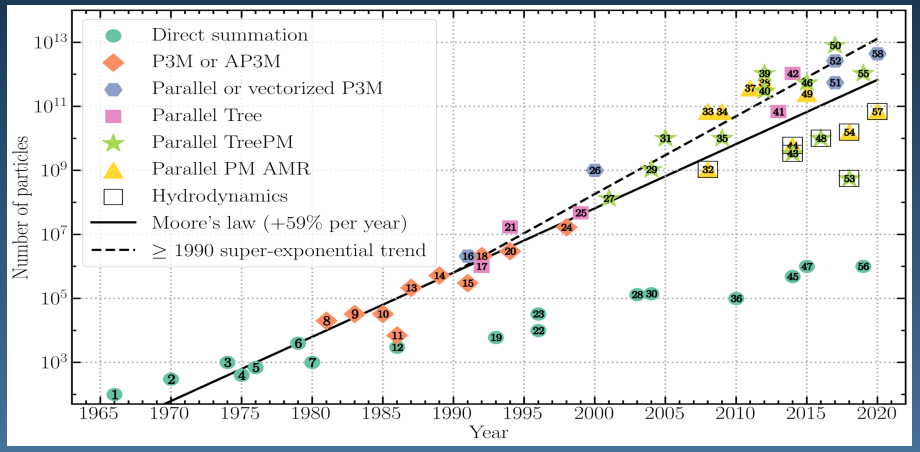


Andrea Possenti

Neaples - OACN - 09 Feb 2026

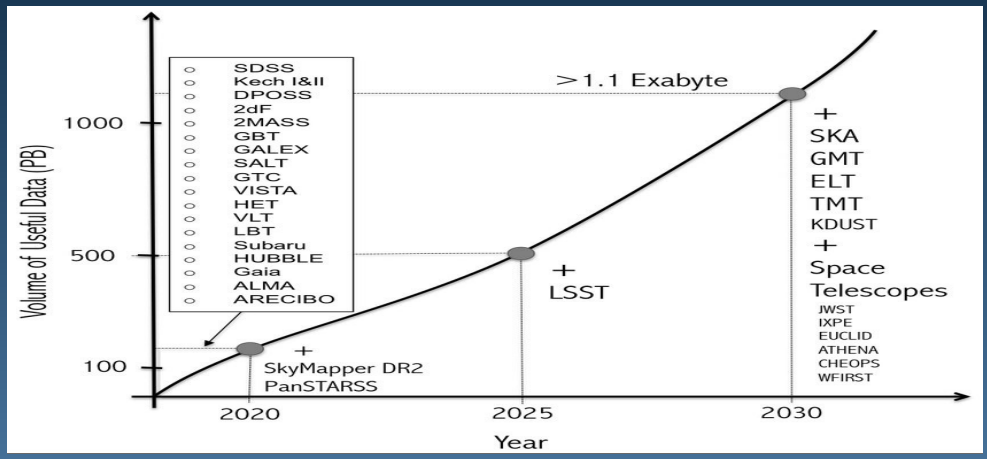
… the Challenges

[F. Leclercq 2023]



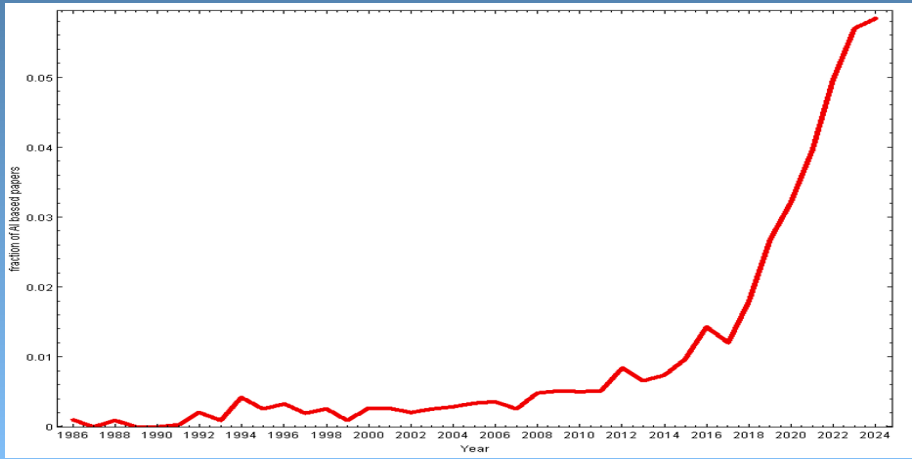
High Performance Computing

[R. Rosa 2021]

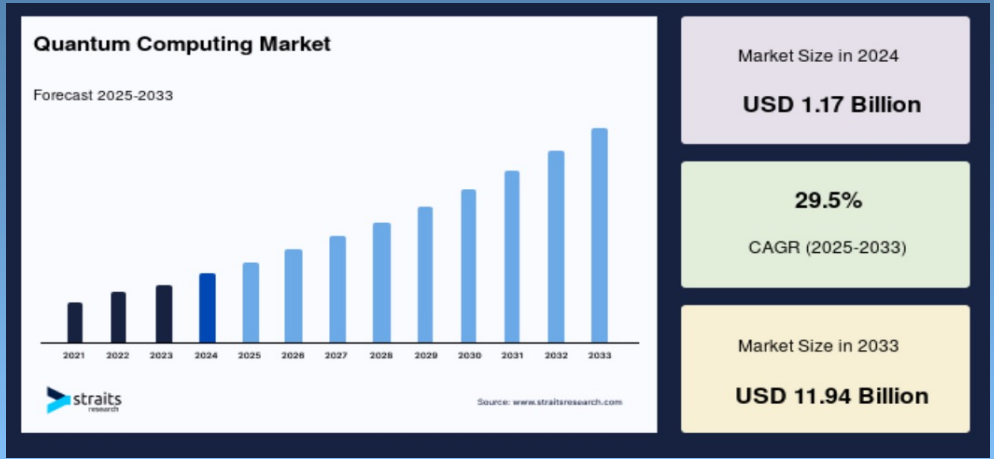


Data handling & Archiving

[S. Cavuoti 2025]



Machine Learning & AI



Quantum Computing

USC-C

INAF

Main Aims of USC-C

The main medium-long term objective of USC- C is **the creation of a computing ecosystem for INAF**, capable of supporting, for the next few decades, the current very high competitiveness of the members of INAF in the international arena

Implementing step 1:

Growing the hardware capabilities (Computing and Archiving), available to the INAF community, and optimized to support the large international projects in which INAF is involved

The already available INAF national facility: Pleiadi

- Provides computing resources for simulations, data analysis, modelling, and large-scale processing for research projects (INAF, PRIN, European projects, missions, etc.).
- Integrates HPC/HTC compute, data storage/work storage, and long-term data preservation capabilities.
- User access **via competitive call process** **(call #7 - deadline 28 Feb 2026!)**

Core Components

- Compute infrastructure
  - PLEIADI CPU clusters
  - PLEIADI-GPU clusters for GPU-accelerated workloads
  - Access to CINECA's Leonardo BOOSTER (Tier-0 class HPC) via MoU
- Archiving & Data Services
  - Work storage tied to active projects
  - Long-term data preservation services (IA2) – tape-based, FAIR-aligned

USC-C

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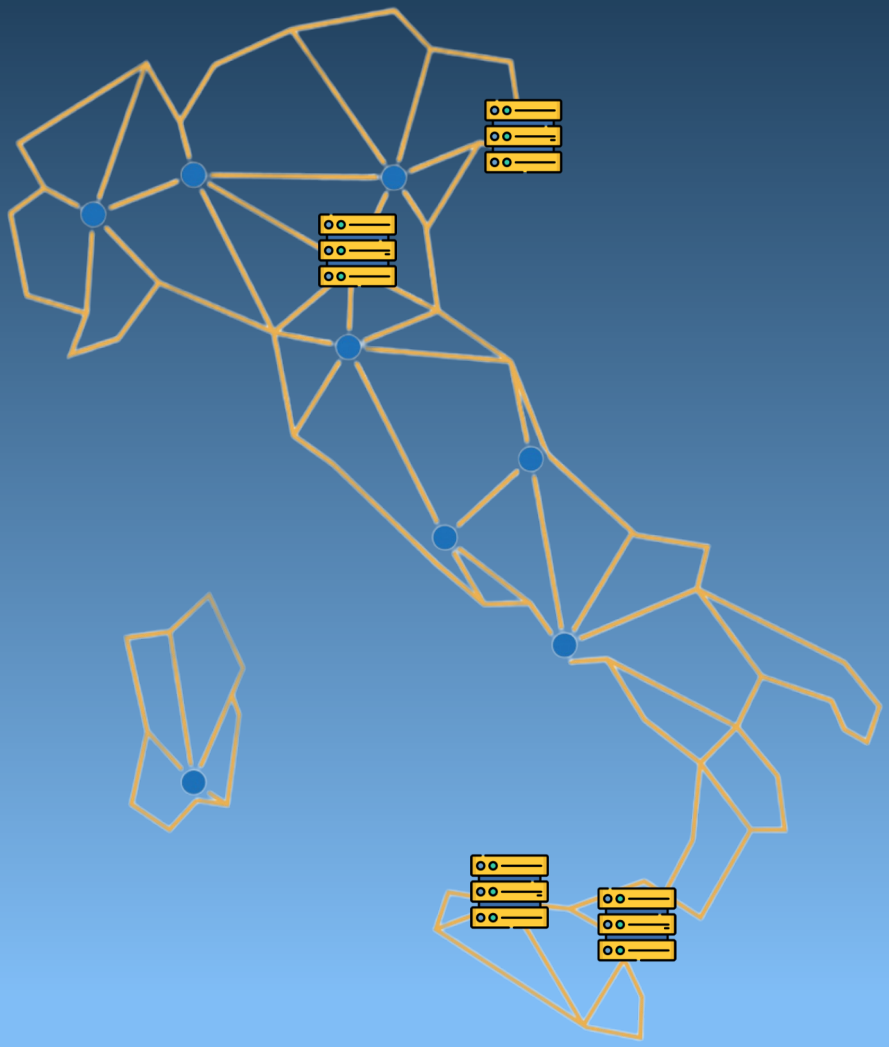
Distributed Architecture/ Resources

PLEIADI is **distributed across four INAF sites**:

- IRA Bologna (CPU nodes)
- OA Catania (CPU & GPU nodes)
- OA Trieste (CPU & GPU nodes)
- OA Palermo (GPU nodes)

Architecture Highlights

- Each site hosts:
  - Login/frontend node(s)
  - Compute nodes
  - Parallel file system storage
  - High-speed interconnection
- Workload managed by **SLURM** for job scheduling and resource allocation



Leonardo Booster (CINECA)

Leonardo is the Italian national Tier-0 high-performance computing system hosted at CINECA and **one of the most powerful supercomputers in Europe**.

Key characteristics

- Pre-exascale class HPC system
- Optimized for large-scale parallel and data-intensive workloads
- Designed for advanced simulations, AI, and high-end scientific applications

Integration with PLEIADI

- Access provided through the **INAF-CINECA agreement**
- Resources allocated within the same call framework as PLEIADI
- Leonardo BOOSTER is the reference partition for INAF users
  - 1 Standard Hour = 1 Core Hour on Leonardo BOOSTER

Scientific value

- Enables scalability beyond INAF internal infrastructure
- Complements PLEIADI for:
  - Large-scale simulations
  - Highly parallel workloads

The cases from RSN1

Project Title	Computing e-infra Request
N-body simulations for segregated Globular Clusters: tests with GPUs	Computing (Pleiadi-GPU)
Deep Polarization Observations of the GOODS-N Field with LOFAR	Long term Storage (IA2)
GADGET-BoxTree	Computing (Pleiadi-GPU)
Particle acceleration in large-scale filaments connecting merging galaxy clusters	Computing (Cineca)
Exa-scale ready Tree for N-boby codes	Computing (Pleiadi)
A new Scalable tree for N-body on GPUs	Computing (Cineca)
Reconstructing tSZ signal using generative neural networks and SBI	Computing (Cineca)
Toward a Fully GPU-Resident PINOCCHIO code	Computing (Cineca)
Simulating and analysing the Euclid universe	Computing (Pleiadi)
Galaxies in the very-high redshift Universe: insights from GAEA	Computing (Pleiadi)
Investigating the evolution of Compact Symmetric Objects	Computing (Cineca)
Resolving stellar populations in galaxies with Euclid	Computing (Pleiadi)
Cosmological dependence analysis Euclid Galaxy Clusters Selection Bias	Computing (Cineca)
Mocking the Universe with GAEA	Computing (Pleiadi)
Simulazioni cosmologiche zoom-in di gruppi e ammassi di galassie….	Computing (Pleiadi)
Analyzing Unusual Radio Outflows in extended RAdio-galaxies (AURORA -- III….	Computing (Cineca)
DEMNUni recovery	Computing (Pleiadi)

44% of all approved requests at the regular "Pleiadi" call #6 (Aug 25-Feb 26)

+

an handful of "a sportello" requests

The Data Curation Pillar: IA2

- Italian Astronomical Archives (IA2) and services https://www.ia2.inaf.it/ institutional actions:
  - **Distributed storage** for telescopes, instruments, satellites or collaborations;
  - **Storage of science products** and preservation
    - http://vospace.ia2.inaf.it/ui/ ; https://www.ia2.inaf.it/index.php/ia2-services/data-sharing-preservation)
  - **Support services** (Workflow management Systems, Twiki, DOI, preservation, user home access);
  - **Science gateway** (connection of analysis tools to archives and vice versa - Data Flow - Connection with Services) - under deployment;
  - Local Archives support (help in definition of services and politics);
  - Support for the definition of Data Models and Data Management Plans;
  - Data access and data secure access
    - Development of Web interfaces;
    - Development of Authentication & Authorization tools;
    - Studies for the Data transfer optimization;
- **Open Access (Data) and FAIR**
  - Implementation of Open Data policies;
  - Implementation of Findable Accessible Interoperable Reusable principles;
  - DOI INAF domain;
- Virtual Observatory http://www.vobs.it/en/
- Training :
  - Data Management Plans;
  - Data Models;
  - Data organization, data preservation;
  - Data management and transfer;
  - Introduction to the Virtual Observatory;
  - Data Bases.
- Working team: 8 staff (Trieste, OARoma, IRA-Bo) + 1 collaborator
- Affiliates: > 10 staff (Trieste, OAPa, IRA-Bo, OACa, OAPd, OARoma, OAAb, OATo, IAPS Roma, OACapodimonte…)

HW:

- OATs :
  - 2 PB on line,
  - 2,5 PB on tape,
  - 100 TB flash system transfer node,
  - 3 servers (for Virtualization) 1TB ram, 2x32 core
  - 2 servers (DB) 2x32 core) 256GB RAM 3.5 TB all flash
  - 3 servers fir small runs CPU 2TB ram (Git Runner & K8)
  - 1 server for small runs CPU 2 TB ram + L40 GPU
- IRA:
  - server with storage functionality,
  - tape library 400TB
  - disks for support of radio archives
- Cagliari
  - servers with storage functionalities,
- Asiago/OAPd:
  - servers for virtualization
- OATo:
  - ODA

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IA2: Services

VOSpace v1.0

Small computation:

- GITLab Runner;
- K8 connected to storage space;

Tested and under deployment

Perspective:

- Science gateway (computation connected to archives and vice versa with the use of effective services like K8, Notebooks etc..);
- DOI Self generation in VOSpace;
- Bibliography into the Data Archives (telbib like)

- USC-C services (on IA2 infrastructure)
  - Hosted web pages
  - owncloud (130 users)
  - redmine (~350 users)
  - gitlab (~250 users / ~ 370 projects)
  - indico (~ 1100 inaf; ~700 external)
  - DOI service https://doi.ict.inaf.it/
  - INAF Open Access
  - Hosted VMs
  - Licence server

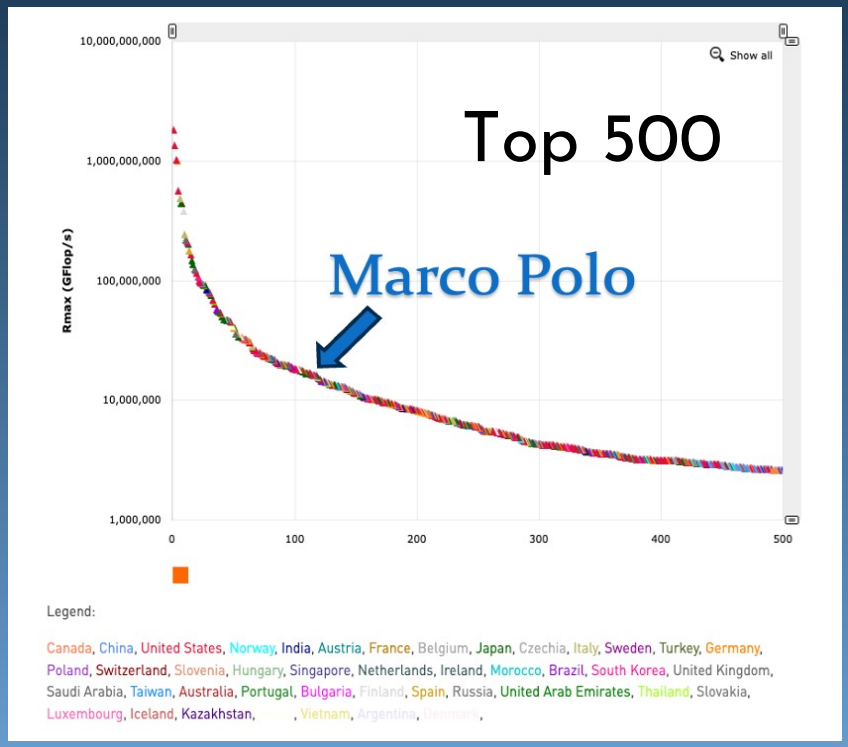
Two or more webinars within the next 2 months to explain the use of INAF services and of open-source codes to all INAF personnel

Incoming (2026+) INAF Resources

- **Computing power**
  - 55 nodes of the Marco Polo CPU partition
  - 33% of the Marco Polo GPU partition
  - 100% of Tier3 (still to be renamed)
- **Storage**
  - 5 PB of on-line storage
  - ~17 PB of long-term storage
  - Access to 10 PB Scratch NVME Storage (Marco Polo scratch area)
- **Network**

  ≥200 Gb/s high-speed internal network interconnecting compute and storage systems +

  100 Gb/s external connectivity to the Internet



Timeline

- December 2025 – March 2026: system software set-up by Cineca
- April 2026: system in production (computing + on-line scratch)
- **Computing available for call#8**
- **End 2026: long-term storage also available**

Marco Polo Tier 1 system

The Marco Polo system is composed by two partitions:

- **CPU Partition**
- **GPU Partition**

CPU Partition:

- LENOVO ThinkSystem SD665 V3
- 221 nodes AMD EPYC 9745 (Turin-Zen5c)
- **Core per node: 128**
- Frequency: 2.3 GHz
- Node Power: 400 W
- Node **RAM Memory: 768 GB** DDR5
- Network:
  - 2 × ConnectX-7 NDR200 dual-port × node (Infiniband for computing)
  - 2 × 100 Gb Ethernet per node (I/O)
- HPL (High-Performance Linpack) ~ 3.9 PFlops

GPU Partition:

- LENOVO ThinkSystem SD650-N V3
- 90 nodes Intel Emerald Rapids 8592+
- **Core per node:** 64 × 2 sockets (**128 tot**)
- Frequency: 1.9 GHz
- Node RAM Memory: 512 GB DDR5
- **4 GPUs per node Nvidia H100** SXM5
  - **Memory HBM3 per GPU: 80 GB**
  - Interconnect: NVLink 4.0
- Network:
  - 4 × NDR200, each directly linked to GPU (Infiniband for computing)
  - 2 × 100 Gb Ethernet per node (I/O)
- Node Power: 3317 W (700 W per GPU)
- HPL ~ 15.24 PFlops

INAF Tier 3 system

The INAF dedicated Tier-3 system is composed by:

- **21 FAT CPU nodes**
- **4 GPU accelerated nodes**
- **5 PBytes on-line fast storage**
- **~ 17 PBytes long-term storage**

CPU Nodes:

- **21 nodes** AMD EPYC 9745 (Turin-Zen5c)
- **Core per node: 128**
- Frequency: 2.3 GHz
- Node Power: 400 W
- Node **RAM Memory: 1.152 TB** DDR5
- **HPL ~ 0.1 PFlops**

GPU Nodes:

- **4 nodes** Intel Emerald Rapids 8592+
- **Core per node**: 64 × 2 sockets (**128 tot**)
- Frequency: 1.9 GHz
- Node RAM Memory: 512 GB DDR5
- **4 GPUs per node Nvidia H100** SXM5
  - **Memory HBM3 per GPU: 80 GB**
  - Interconnect: NVLink 4.0
- Node Power: 3317 W (700 W per GPU)
- **HPL ~ 1 PFlop**

Storage:

- On-line storage
  - Huawei OceanStor Pacific
  - **HDD 5 PB capacity**
- Long-term data storage
  - Huawei OceanStor Arctic
  - **~ 17 PB capacity**
  - Magneto-electric tape techonlogy

Multi-tired fully integrated system

USC-C

INAF

Main Aims of USC C-C

The main medium-long term objective of USC-C is **the creation of a computing ecosystem for INAF**, capable of supporting, for the next few decades, the current very high competitiveness of the members of INAF in the international arena

Implementing step 2:

Coordination and synergy of the work of the excellent skills in the field already present in the INAF Structures in the context of the national/international) initiatives devoted to Computing & Big Data

Thematic teams

The thematic teams (so-far)

Data Management Systems
Standards and interoperability
HPC and Computing
Predictive Maintainance
Scientific Visualization
AI (Machine Learning)
Quantum Computing

It is a bottom-up process for which we expect proposals also from you!

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Thematic teams

Aims:

- Knowledge spreading in INAF
  - (e.g. Sharing of technologies/software/solution of common problems)
- Dissemination and training Organization of workshops/schools/conferences
- Promote collaborations and synergies between different INAF offices/infrastructures
- Critical mass for the preparation of EU/national or INAF projects (e.g. Large/Tec/Data Analysis grants) and applications for use of INAF machines
- Joint publications, collaborative development of software or datasets
- Critical mass to promote INAF personnel recruitment policies (e.g. calls for AI-specialist, data analyst) or university positions (e.g. PhD positions)

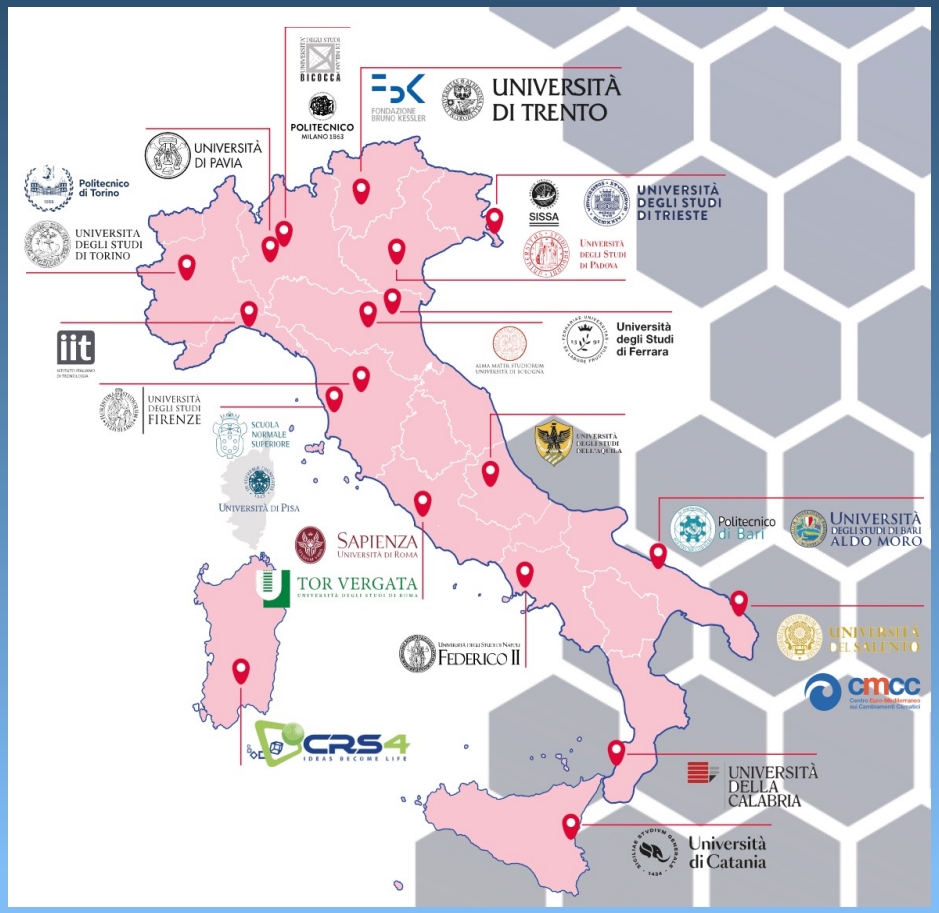
The INAF involvement in ICSC

INAF was among the 12 Research Institutions which founded the Center on Sept 2022

Leader of Spoke 3: Astrophysics and Cosmos Observations
Co-Leader of Spoke 2: Fundamental Research and Space Economy
Participant in Spoke 1: Future HPC & Big Data
Participant in Spoke 10: Quantum Computing

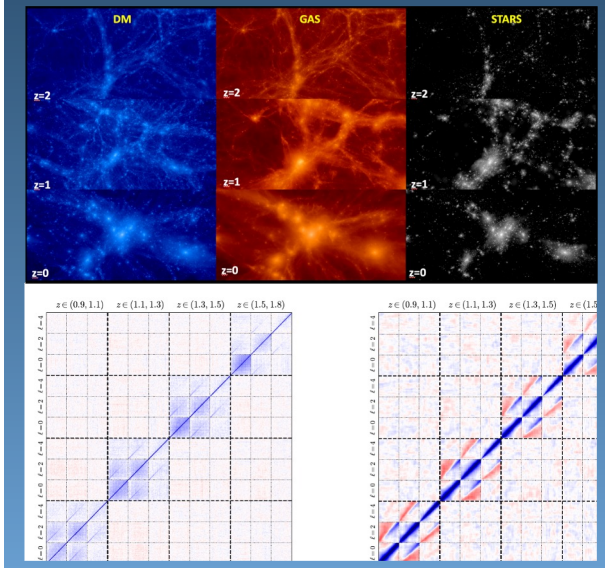
+ involvement of INAF in «innovation» industrial-linked projects

+ INAF «cascade» projects



Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

ICSC - INAF RSN1-field KSPs



KSP1 - EAGER: Evolution of gAlaxies and Galaxy clustErs in high-Resolution cosmological simulations

KSP2 - SLOTH: Shedding Light On dark matter wiTH cosmological simulations

Excellence of results achieved in the Spoke 3: simulations with the OpenGADGET3 code of the Formation of cosmic structures at different scales and epochs

KSP3 - EuMocks: Simulating thousands of Euclid skies

Excellence of results achieved in the Spoke 3: PINOCCHIO code used for producing thousands of simulations of the spectroscopic sample of Euclid and now optimized on Leonardo supercomputer -

KSP4 - Multi-tracer inference of the first billion years

Excellence of results achieved in the Spoke 3: Creation of the largest and most updated database of simulations of the integalactic medium and high-redshift galaxies –

⇒ Paving the way for the development of AI methodologies of simulation-based inference applied to Cosmology

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

INAF «people» in CN-HPC

49 total positions

All fixed-term staff (TD), research fellows (AdR), technical staff (CTER/TD), and grant holders were **extended until the project's end date of 31/12/2025**

The project's financial commitment, including mission expenses, event organization, sponsorships, and dissemination activities, resulted at the end of 2025 in a cash surplus of approximately €1,500,000 (unrestricted funds).

ACTION n. 1 ➔ INAF Residual CN-HPC 2022-2025 funds

Recruitment for 2026 of 17 fixed-term staff TD (almost completed): coordinated program with 3 main objectives

Objective 1: High Performance Computing (HPC) for Numerical Astrophysics (6 positions)
Objective 2: Artificial Intelligence, Machine Learning and advanced techniques for the analysis of large volumes of scientific or territorial monitoring data. (9 positions)
Objective 3: Quantum Computing (2 positions)

ACTION n. 2 ➔ DD 307
New recruitment on April 2026

440 Keuro for 6/9 fixed-term staff TD

INAF: OACT, OAPA, IASF/PA, OACN, OACA, IRA

2027 onward? ICSC-2? Likely but still to be finalized

Finanziato dall'Unione europea NextGenerationEU
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Main Aims of USC-C

The main medium-long term objective of USC-C is **the creation of a computing ecosystem for INAF**, capable of supporting, for the next few decades, the current very high competitiveness of the members of INAF in the international arena

Implementing step 3:

Reaching, supporting and training INAF personnel

The USC-C website

Sport - La Repubblica | usc8.inaf.it/

usc8.inaf.it 90% Cerca

a/Cinema | News | TRASPORTI | SRT+OAC | Missioni | webOAC | ePAS | OA@INAF | Gmail | Drive | Maps | Astrophysics | MyTIM | AstroPhysCalc | PICA

NEWS

Second General Assembly of the INAF Central Scientific Unit -Computing

In Meetings, News

From the 9th to the 13th of March 2026, at

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Call for Paper Workshop "Scientific HPC in the pre-Exascale era"

In News

2nd edition in Turin The workshop "Scientific HPC in the pre-Exascale era," 2nd edition, is now open forsubmission. It will be held during the 4th ITALIAN CONFERENCE ON BIG DATA AND DATASCIENCE (ITADATA2025) between September 9th and 11th, 2025. To participate in the workshop, each participant must send a title, abstract, and proceeding,either a short paper (5 to 9 pages) or a regular paper (at least 10 pages) in a preliminary stage. A scientific program committee will revise the proceeding, which can be modified untilthe camera-ready submission deadline. Proceedings should be published online toCEUR-WS.org, a free open-access platform for computer scienceworkshop proceedings. The paper template

READ MORE →

Corso Containerizzazione del software per il calcolo scientifico e le infrastrutture, Torino 12-14 maggio 2025

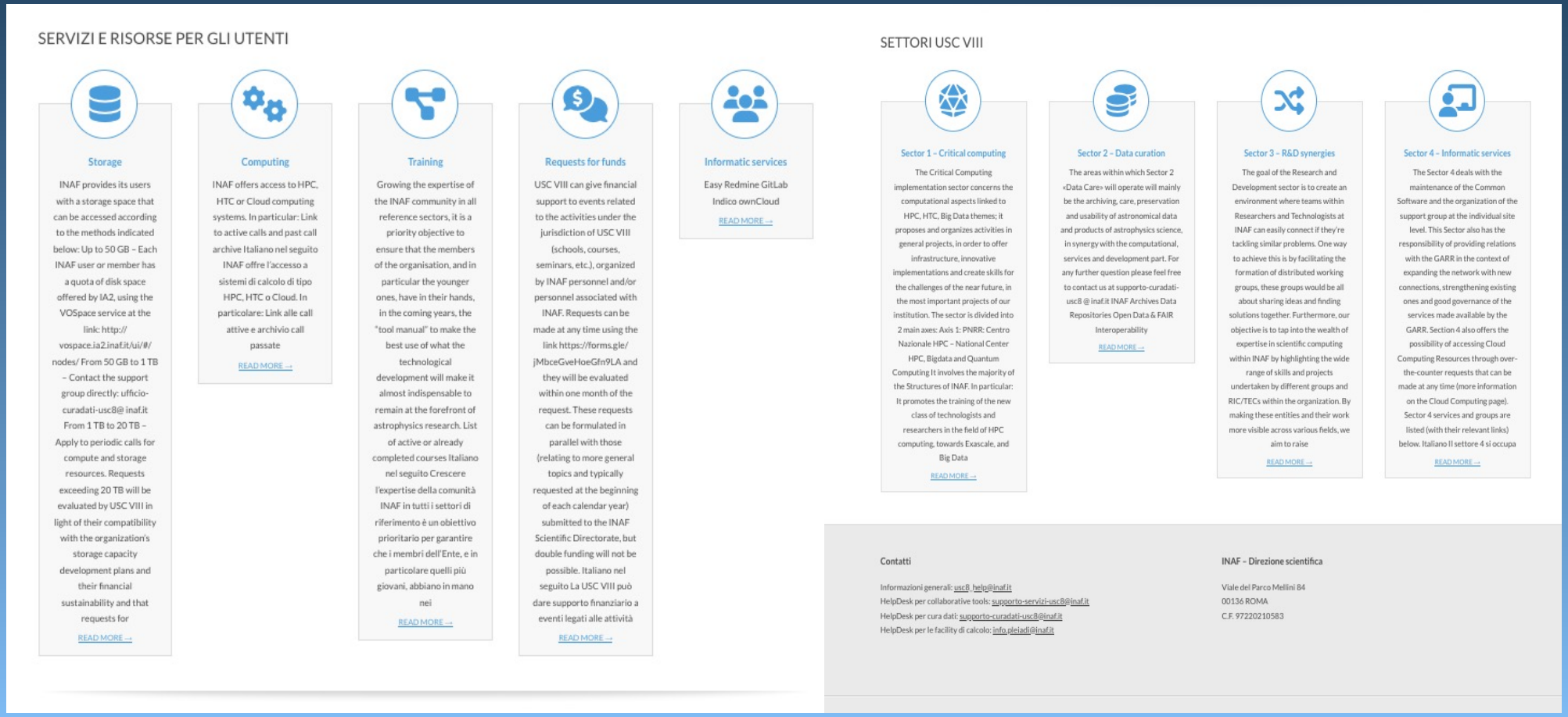
In Corsi, Formazione, News

Siamo lieti di annunciare che l'USC-C (precedentemente nota come USC VIII) organizza il secondo corso in presenza (con possibilità di seguire da remoto) sulla containerizzazione del software per il calcolo scientifico e le infrastrutture. Il corso introdurrà i fondamenti della containerizzazione del software, insieme a concetti più avanzati rilevanti sia per il calcolo scientifico che per i servizi IT. L'evento si terrà dal 12 al 14 maggio 2025 presso l'Osservatorio Astrofisicodi Torino. La pagina web è disponibile QUI Il corso è gratuito e limitato a 40 persone. Anche le pause caffè e il pranzo del 13 maggio sono offerti dall'organizzazione.La scadenza per le iscrizioni è

READ MORE →

USC-C | INAF – Istituto Nazionale di Astrofisica – National Institute for Astrophysics

The USC-C website



The services/resources and the 4 USC-C sectors

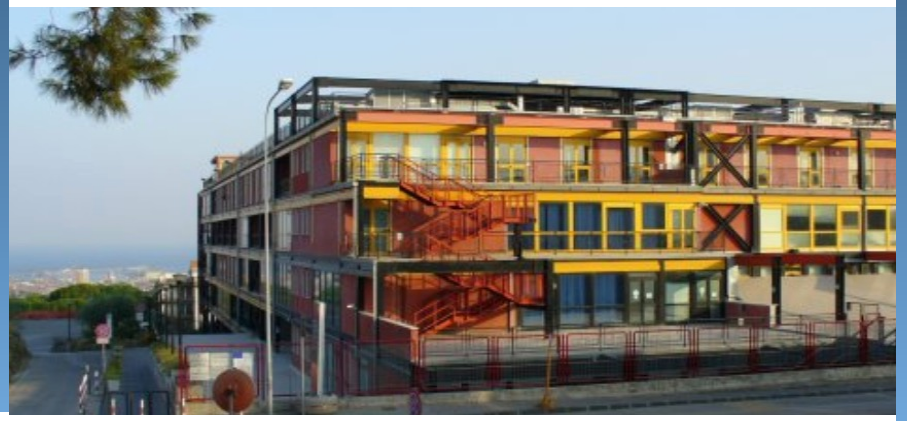
USC-C workshops

Workshop Archivi

E' uscito l'annuncio per il workshop "Archives and Data Management Systems", che si svolgerà dal 26 al 28 febbraio prossimi presso l'Area della Ricerca di Bologna. Esso è il terzo di una serie dedicata alla gestione e cura dei dati nell'epoca dei Big Data.Modalità di partecipazione: ibrida Location: Bologna – CNRDate: 26-28/02/2025Website: https://indico.ict.inaf.it/e/archives_dms ********** English version below ********** Dear colleagues,The announcement of the "Archives and Data Management Systems" workshop, which will take place from 26th to 28th of February at the Research Area of Bologna, is now shared. This meeting is the third in a series dedicated to data management and curation in the era

ML4Astro

8-12 July 2024 – Catania – The 2nd edition of the International Conference on Machine Learning for Astrophysics (ML4ASTRO2) aims to unite leading researchers actively engaged in applying machine learning to astrophysical studies. Following the success of the first edition, this international conference is dedicated to exploring the challenges and opportunities presented by the impending Big Data era in astronomy. Focusing on the integration of ML/DL techniques with astrophysics, the event will showcase cutting-edge AI methodologies tailored for addressing key open problems in this field. Engaging discussions will revolve around the innovative application of AI models to observational and simulation data. We welcome submissions of abstracts for Oral Presentations or



Workshop sul calcolo critico a Catania

Il primo evento organizzato dalla USC VIII, un "Workshop di due giorni dedicato al Calcolo Critico" si è svolto con successo il 15-16 Giugno a Catania, utilizzando gli spazi messi a disposizione dal locale Dip di Fisica. Oltre 70 persone hanno presenziato al meeting, che è stato caratterizzato da un elevato grado di interazione fra i presenti e da discussioni utilmente vivaci. I contributi possono essere scaricati al link https://indico.ict.inaf.it/event/2366/contributions/

USC-C training activities

Corso Computing and High Performance Computing in Astronomy and Astrophysics, Catania 22-26 Settembre 2025

INAF/USC-C è lieto di annunciare il corso "Computing and High Performance Computing inAstronomy and Astrophysics", che si terrà a Catania dal 22 al 26 Settembre 2025, pressol'Osservatorio Astrofisico di Catania, in Via Santa Sofia 78, 95123 Catania (CT). Il Calcolo ad Alte Prestazioni (High-Performance Computing, HPC) rappresenta un elementofondamentale dell'Astrofisica e della Cosmologia moderne, essenziale per la modellizzazione di sistemi dinamici, l'analisi delle osservazioni e la formulazione di previsioni teoriche. L'enormequantità di dati complessi raccolti dagli osservatori di ultima generazione richiede strumentiteorici e computazionali innovativi per investigare i fenomeni fisici con un dettaglio senzaprecedenti.Il corso è pensato per fornire ai giovani ricercatori in Astronomia e

Computing and High Performance Computing in A&A

24 June – 05 July 2024 Bologna – Area di ricerca CNR – Overview In Astrophysics and Cosmology (A&C) numerical algorithms based on High-Performance Computing (HPC) are essential for modelling complex dynamic systems, interpreting observations, and making theoretical predictions. Contrasting the results from numerical codes with the torrent of complex observational data that the new generations of ground- and space-based observatories will produce will be a fundamental channel to provide new insights into astronomical phenomena, the formation and evolution of the universe and the fundamental laws of physics. The outstanding quality and volume of observational data generated by the current and next generation of instruments

Container Fundamentals applied to scientific research

13 Dec 2023 – 14 Dec 2023 Cupola Fiore (OA Brera) OverviewModern scientific research challenges require new technologies, integrated tools, reusable and complex experiments in distributed computing infrastructures. But above all, computing power for efficient data processing and analyzing. Container technologies have emerged as a new paradigm to address such intensive scientific applications problems. Their easy deployment in a reasonable amount of time and the few required computational resources make them more suitable. Containers enable performance isolation and flexible deployment of complex, parallel, and high-performance systems. Moreover, they gained popularity to modernize and migrate scientific applications in computing infrastructure management. Additionally, they reduce computational time

Annuncio Scuola GIT

Corso di formazione intermedio su GIT, GITLab e la CI/CD in presenza (con possibilità di seguire anche da remoto) presso l'Area della Ricerca di Bologna – CNR il giorno 25 febbraio 2025. Il corso in presenza sarà a numero chiuso con un massimo di 40 partecipanti. Per informazioni, logistica e registrazioni -> https://indico.ict.inaf.it/e/gitlab

Fundamentals of Data Management Plan and Data Models applied to science

25-26 January 2024 – Trieste – Osservatorio Astronomico di Trieste – Il corso si prefigge come obiettivo di fornire ai ricercatori gli strumenti per comprendere e utilizzare i Data Management Plan e per strutturare le collezioni dei dati scientifici. Queste conoscenze, valide sia per dati osservativi che da simulazione, sono di supporto alle necessità di salvaguardia e distribuzione aperta e aderente ai principi FAIR, così come comunemente richiesto nei bandi di finanziamento istituzionali, nazionali ed europei. Inoltre, un'accurata preparazione dei dati è funzionale a una pubblicazione curata, comprensibile nel tempo, riutilizzabile e interoperabile, così come espresso dai paradigmi dell' Open Science, Open Data e dai principi FAIR

Corso Containerizzazione del software per il calcolo scientifico e le infrastrutture, Torino 12-14 maggio 2025

Siamo lieti di annunciare che l'USC-C (precedentemente nota come USC VIII) organizza il secondo corso in presenza (con possibilità di seguire da remoto) sulla containerizzazione del software per il calcolo scientifico e le infrastrutture. Il corso introdurrà i fondamenti della containerizzazione del software, insieme a concetti più avanzati rilevanti sia per il calcolo scientifico che per i servizi IT. L'evento si terrà dal 12 al 14 maggio 2025 presso l'Osservatorio Astrofisicodi Torino. La pagina web è disponibile QUI Il corso è gratuito e limitato a 40 persone. Anche le pause caffè e il pranzo del 13 maggio sono offerti dall'organizzazione.La scadenza per le iscrizioni è

USC-C

INAF – Istituto Nazionale di Astrofisica – National Institute for Astrophysics

Courses for students, and structured personnel on individual specific topics: eg. porting of codes to HPC, methodologies for Machine Learning, exploitation of GPUs, use of containerization, continuous integration etc...

USC-C events

USC-C General Assemblies:

USCVIII General Assembly

This is the first general meeting of the recently instituted INAF Central Scientific Unit VIII-Computing (USC VIII-Computing). More details at https://indico.ict.inaf.it/event/2870/

Second General Assembly of the INAF Central Scientific Unit -Computing

From the 9th to the 13th of March 2026, at the SAVOIA Excelsior Palace in the seashore of Trieste city center. Session and trainings on Information Technology! More info @ https://indico.ict.inaf.it/event/3368/

Support for events

In addition to the events directly organized by USC-C, an online form is available
https://forms.gle/jMbceGveHoeGfn9LA
to request support (economic or practical) at USC-C in organizing "events" (meant in a large sense) that have to do with USC-C activities

Thank you all !!