INAF

UNIT VI ICT

HPC - INAF

Experiences and future perspectives

New challenges in Astrophysics

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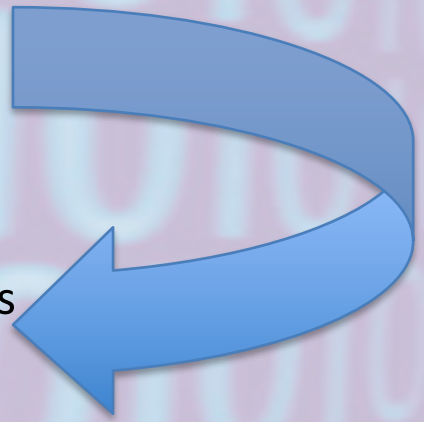
Rome

INAF – Big Science

INAF plays a fundamental scientific role (excellence) in several areas: from ***Computational Astrophysics*** (theoretical modelling in cosmology and astrophysics) to ***very large experiments*** both ground based (i.e.: Alma, SKA, CTA, E-ELT etc.) and space (i.e.: Gaia, Euclid etc.)

The ***new frontiers*** in Astrophysics require HPC and DC infrastructures



HPC represents the current and future platform to obtain scientific results of ***fundamental relevance*** for all the new Astrophysics challenges.

Investments and research projects for the availability and better exploitation of the new HPC generation ***must be considered in the High Priority*** scale for ***INAF to maintain Excellence level*** in many ***Key Projects***, and to allow the researchers to "arrive in time" for the new generation international projects.

INAF – HPC in the past

INAF - CINECA specific Agreements for HPC resources

Computational Astrophysics, Visualization, Archiving and Post-Processing Data Analysis

- 1997 - 2001
- 2001 - 2005
- 2005 - 2007
- 2008 - 2010

In the last period relevant experiments have needed specific computing resources Tier-0 and Tier-1 for the analysis of experimental data also in comparison with simulated data. **New generation of HPC resources for ESA PLANCK mission**

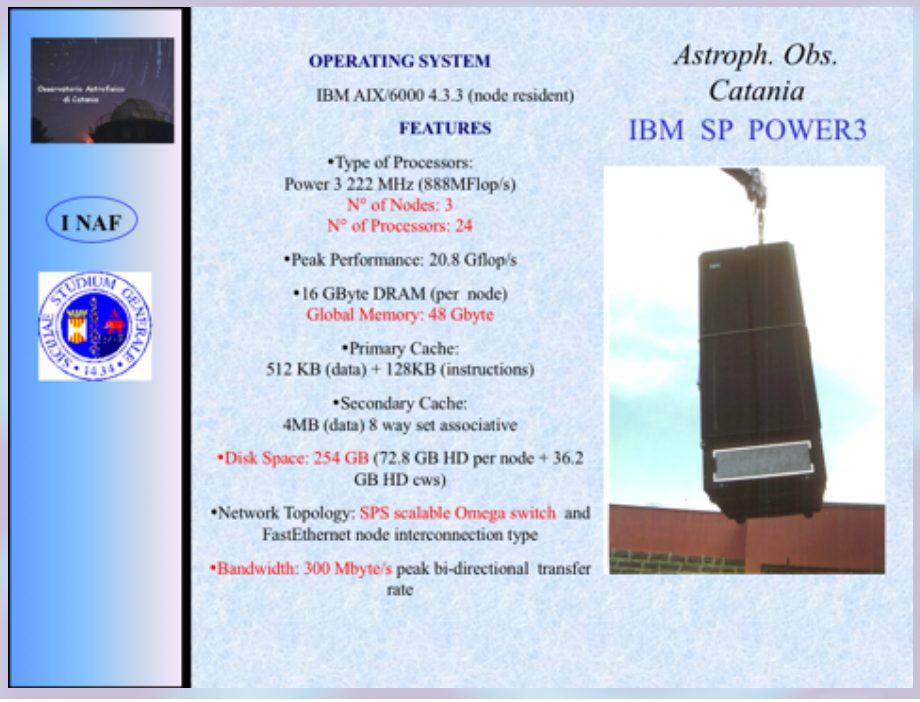
- 2010-2012
- 2012-2014

INAF – HPC in the past

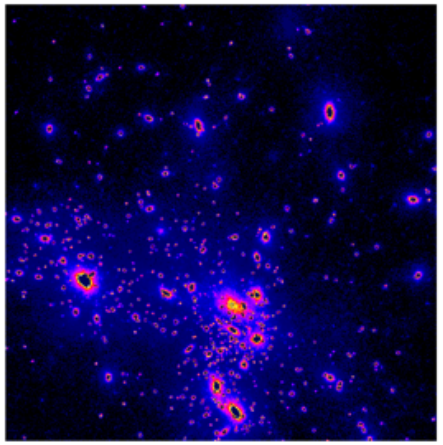
INAF – OACatania – OAPalermo -OACagliari

- ➔ **MIUR (1999-2001) Supercomputing @ OACT**
- ➔ **POR 2005-2007 TRIGRID VL @OACT**
- ➔ **Cometa Consortium (PI2S2 project 2005-2009) (OACT+OAPA)**
- ➔ **Cosmolab Consortium (Cybersar project 2005-2009) (OACA)**

MIUR SuperComputing @ OACT



Simulations of the formation and evolution of the large-scale structure of the Universe



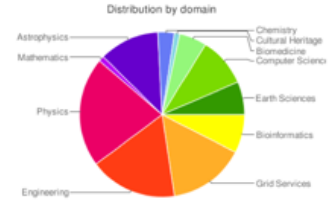
. A cluster of galaxies: Colour scale gives baryonic mass density

The TriGrid Project & PI2S2 Project

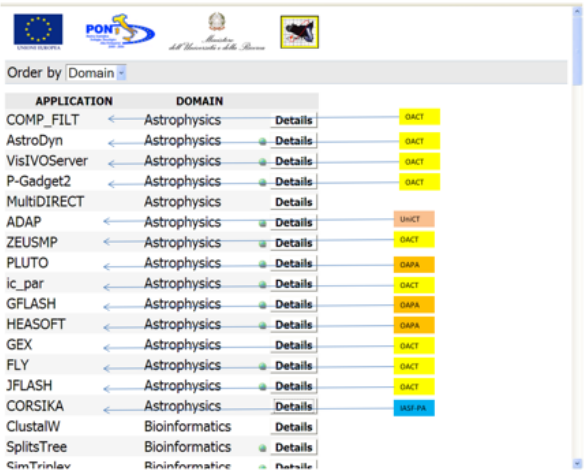
http://www.pi2s2.it
/applications

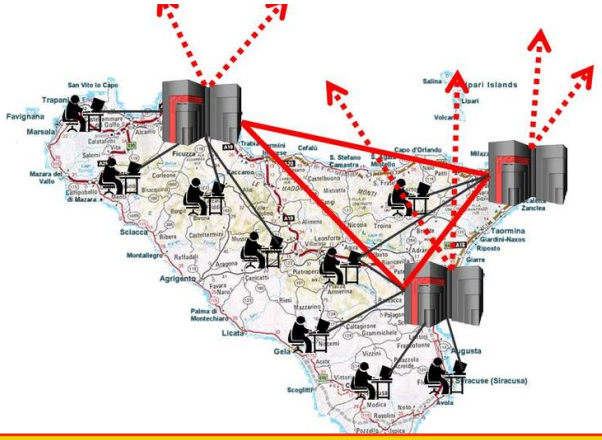
(Some of) The Applications of TriGrid VL

- **Astrophysics**
  - Virtual Observatory
  - Visualizzazione 3D Visualization
  - The GAIA Mission
- **Biomedicine**
  - Analysis and classification of medical images (mammograms, etc.)
- **High Energy Physics**
  - Data analysis of CERN's Large Hadron Collider (LHC) Experiments
  - Theoretical Physics
- **Engineering**
- **Cultural heritage**
- **Analysis and monitoring of environmental risks**
- **Technologies of production**



> 120 Applications

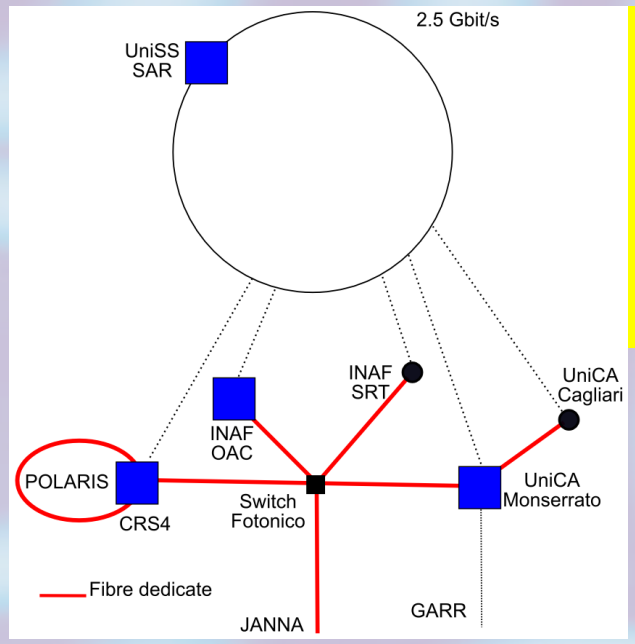




1. 1500+ cores AMD Opteron IBM Blade
2. 250 TB of memory
3. LSF 6.1 HPC everywhere
4. Infiniband-1X for HPC apps.

~15.000.000 € in 3 years!
~300 FTE's ! (2/3 new hired staff)

Cybersar Project



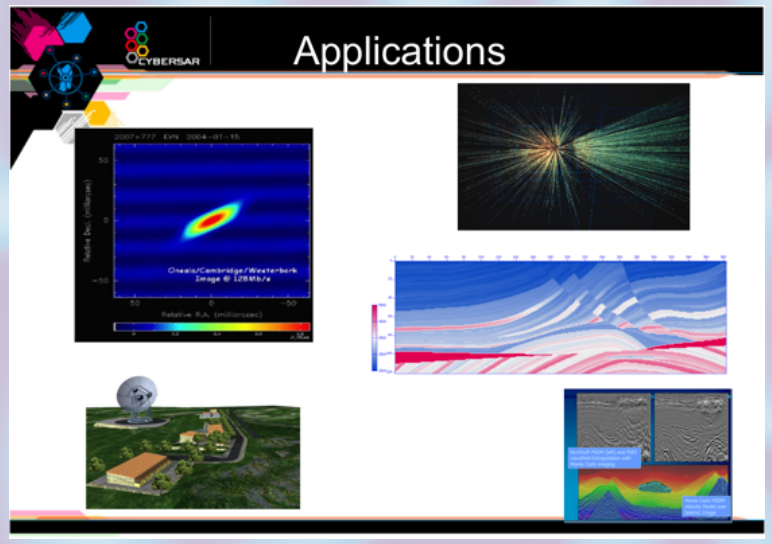
- 4 main sites

Optical link (cold)- λ-Grid

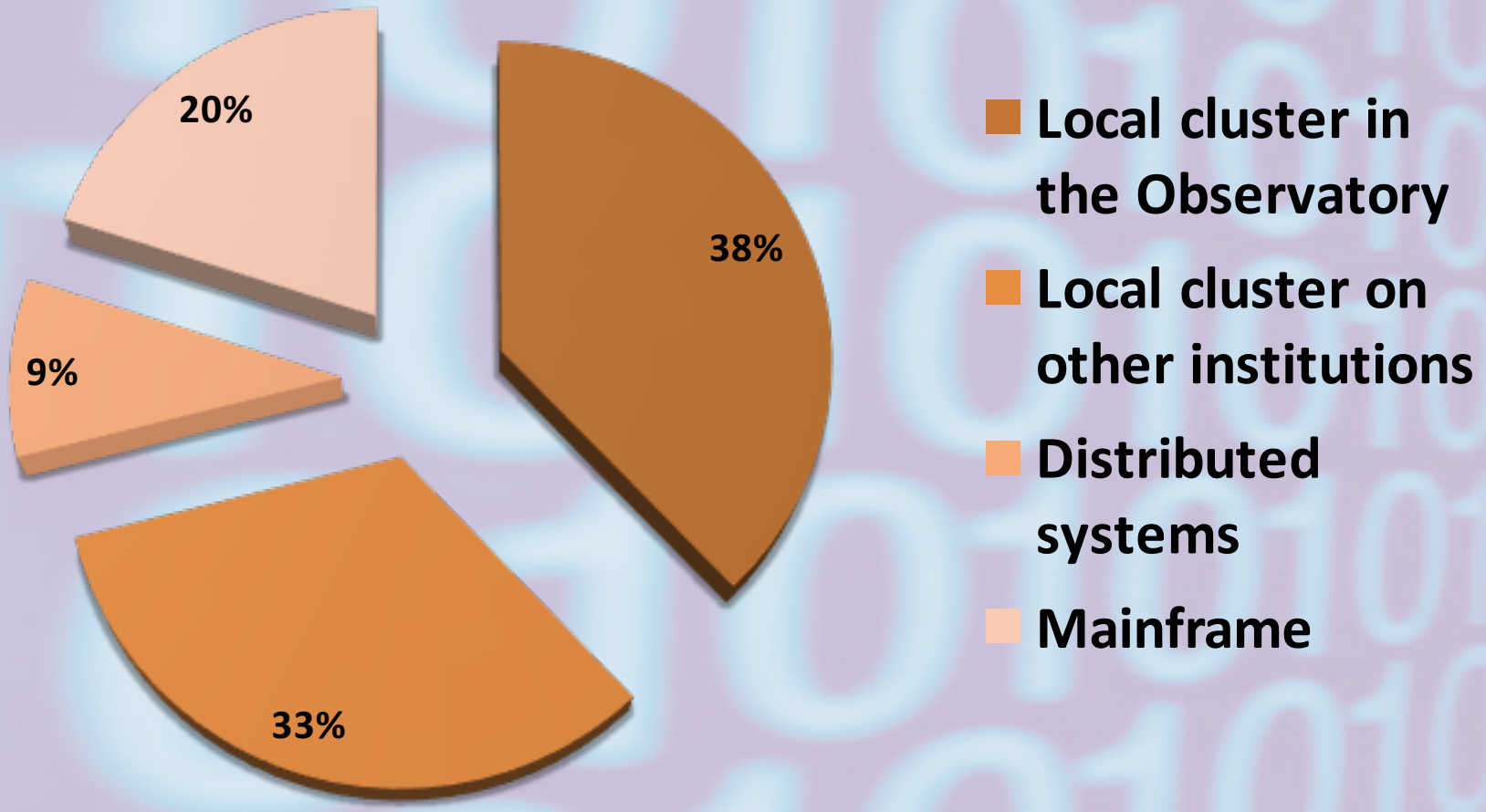
- Optical Switching
- Bandwidth Unlimited Computing
- Application Programmable Computing Resources

	U-CA	CRS4	OAC	Tot
Cpu cores+	408	312	288	1,008
RAM (TB)	0.8	0.8	0.6	2.2
Disk (TB)	70	80	45	195

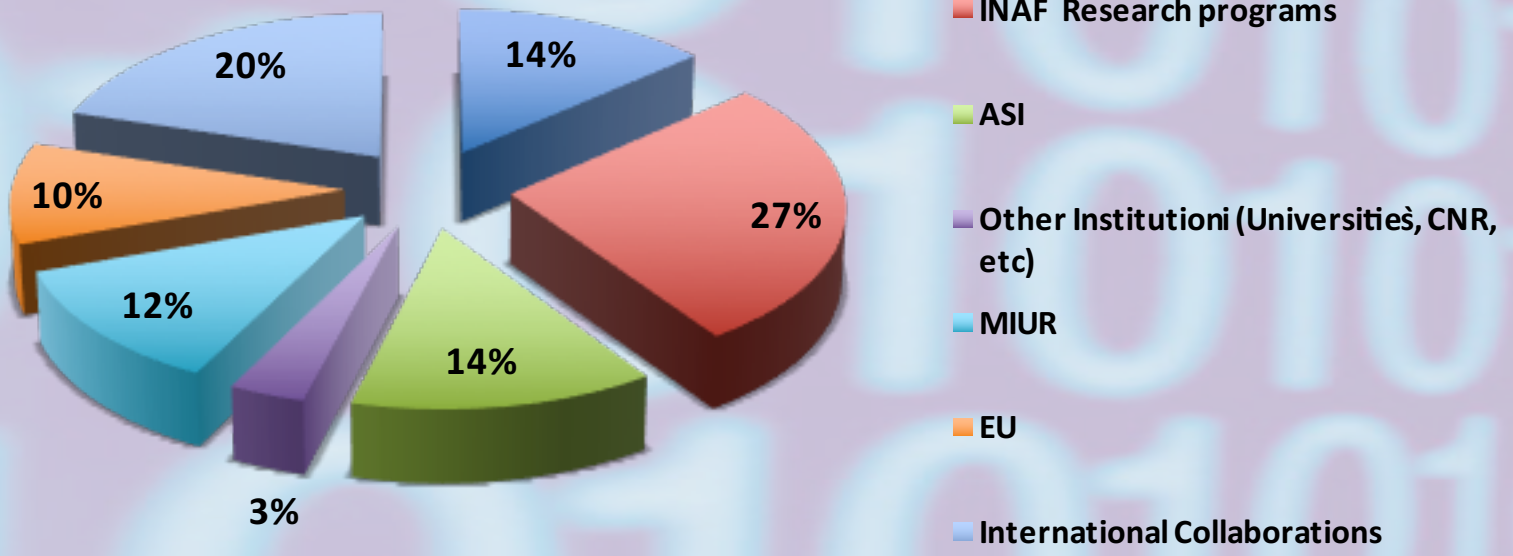
+ AMD dual opteron 28x cpus
•InfiniBand 4xDDR



INAF HPC - Today



Funding Agencies

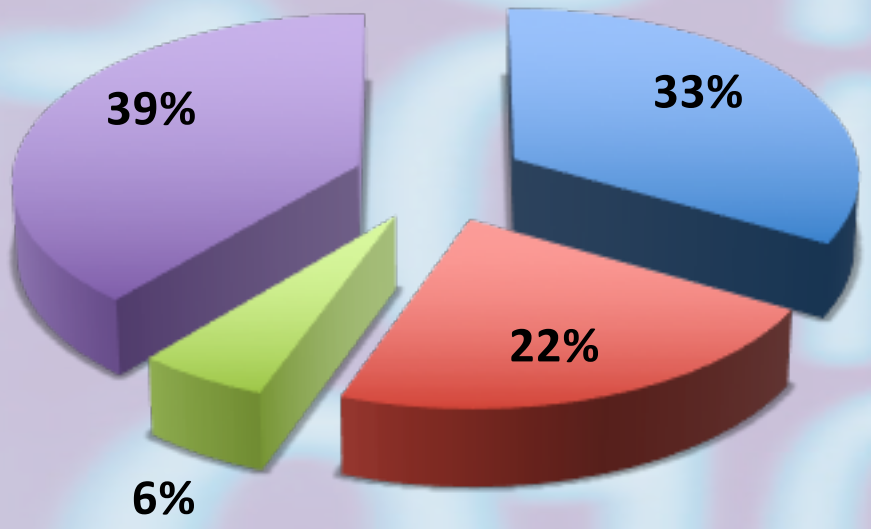


Strength and Weakness

Good competence to obtain funds (86%)

Only 12% are from EU and 41% from INAF directly

Next Future



- Mainframe
- Accelerators (GPUs)
- Cloud Computing
- Cloud Data and Distributed Computing

Others Considerations

- Researchers involved in HPC activities
  - **About 70 researchers (permanent & not-permanent)**
- Total institutes/observatories involved in activities using HPC infrastructure ➔ **9 on 17 globally**
- Number of peer reviewed publications using HPC resources in the last three years ➔ **143**
- Conference reports (last three years) ➔ **129**

The Resources

- Used CPU/core hours in the last three years
- **➔ 255 Millions, globally 68% Cluster (PLX) and IBM BGQ Cineca**
  - **MPI ➔ 55%**
  - **MPI+OMP ➔ 45%**

- CPU/core hours and storage requested for the next three years

  ➔ 550 Millions and 710 TB disk space

- Requested support

  ➔ 65% of the programs requires porting to use the new HPC generation based on accelerators (GPUs)

Esa Gaia Mission

A Stereoscopic Census of our Galaxy

Infrastructure MoU INAF Cineca 2013 - 2021

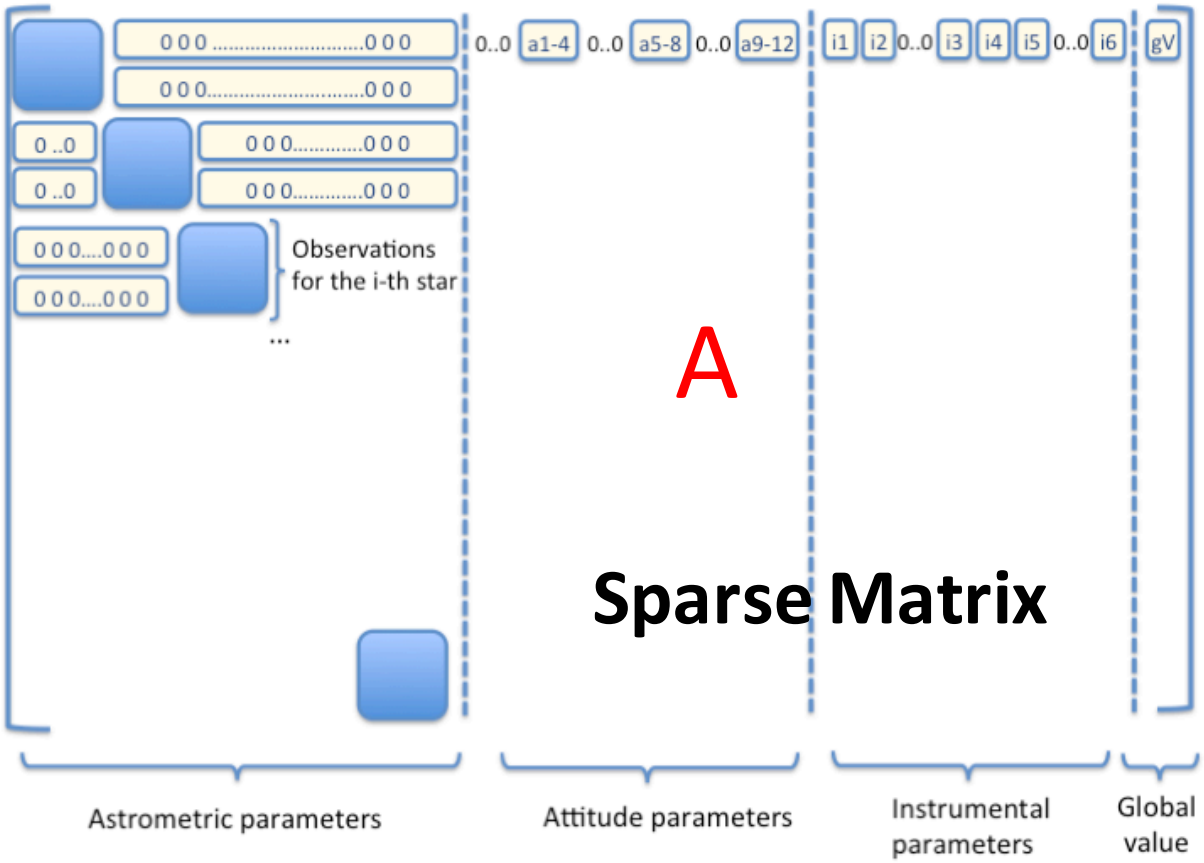
Cineca will support INAF - AVU GSR Solver Module, searching a solution for 100 Million Star ….

FERMI IBM BlueGeneQ

Architecture: 10 BGQ Frames
Processor Type: IBM PowerA2, 1.6 GHz
Computing Cores: 163840
Computing Nodes: 10240
RAM: 1GByte / core
Disk Space: 2.6 PByte of scratch space
Peak Performance: 2PFlop/s

The Global Problem

For each observation, the Total Matrix stores the astrometric, attitude, instrumental parameters and a Global Value coefficient



← *24 non-zero coefficients*

10^8 stars, each star observed **720** times

➔ **$7.2*10^{10}$** equations with 24 parameters for each obs.

➔ **$3*10^{12}$** coeff.

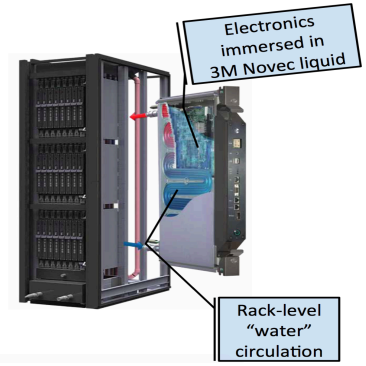
➔ **15** TBytes Ram

Each observation has: **5** astrometric coeff., **12** attitude coeff. (4x3 *equally spaced blocks*) , **6** instrumental coeff., **1** relativistic gamma coeff.

European Exascale System Interconnect & Storage (ExaNeSt) INAF - OATS

- European Funded project (H2020-FETHPC-1-2014) 7M Euros
- Coordinated by *Foundation for Research & Technology – Hellas*
- Develop an European low-power high-performance exascale infrastructure based on ARM-based micro servers.

- **System architecture for datacentric Exascale-class HPC**
  - Fast, distributed *in-node* non-volatile-memory
  - **Storage** Low-latency *unified* **Interconnect** (compute & storage traffic)
- **Extreme compute-power density**
  - Advanced *totally-liquid* **Cooling** technology (ICETOPE)
  - Scalable packaging for 64-bit ARM-based Microservers
- **Real scientific and data-center applications**
  - Applications used to identify system requirements
  - Tuned versions will evaluate our solutions



Conclusion

- INAF have High Competence to obtain grants for HPC resources… but these are not enough for our needs

- New challenges and international projects will require HPC infrastructures
- Some projects already have these needs: Gaia, Euclid, CTA etc. (we need a stable support for these projects)

- INAF is evaluating to sign a new agreement with Cineca to obtain support and computational resources for the new generation HPC infrastructures.

- New H2020 project will allow us to create new competence on the HPC innovative field.