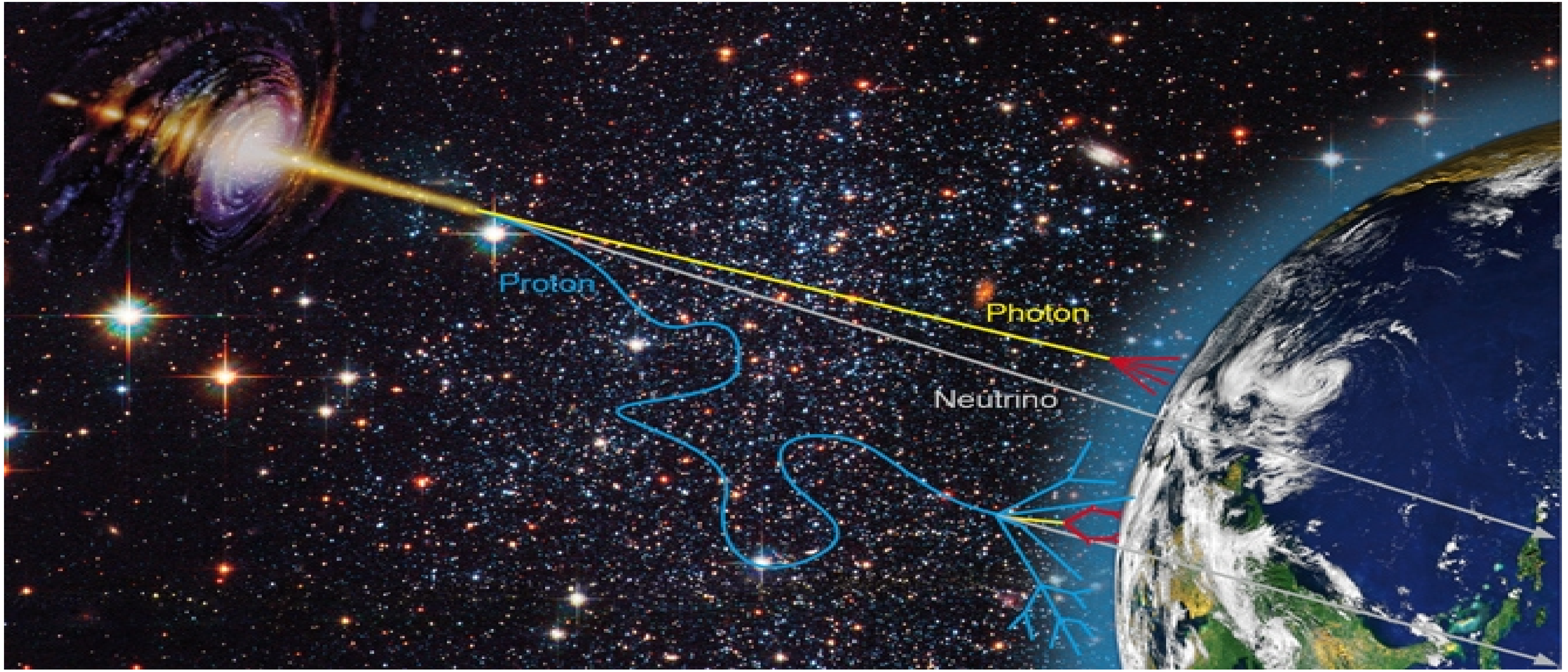
The AMAS - ASTRI Mini-Array Archive System, the Off-Site ICT Infrastructure for the ASTRI Mini-Array Project

Stefano Gallozzi – INAF-Osservatorio Astronomico di Roma

for the ASTRI Project

Workshop “From Science Gateways to Papers” - Palermo 23-26 / 05 / 2022

Imaging Atmospheric Cherenkov Techniques



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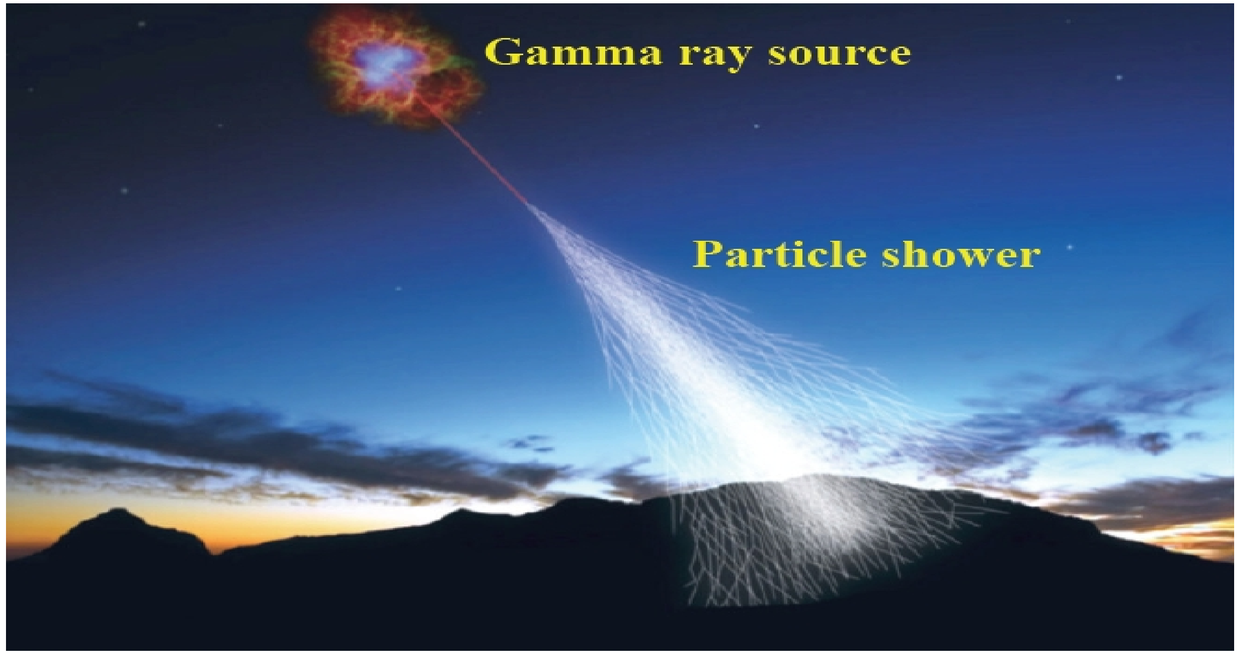
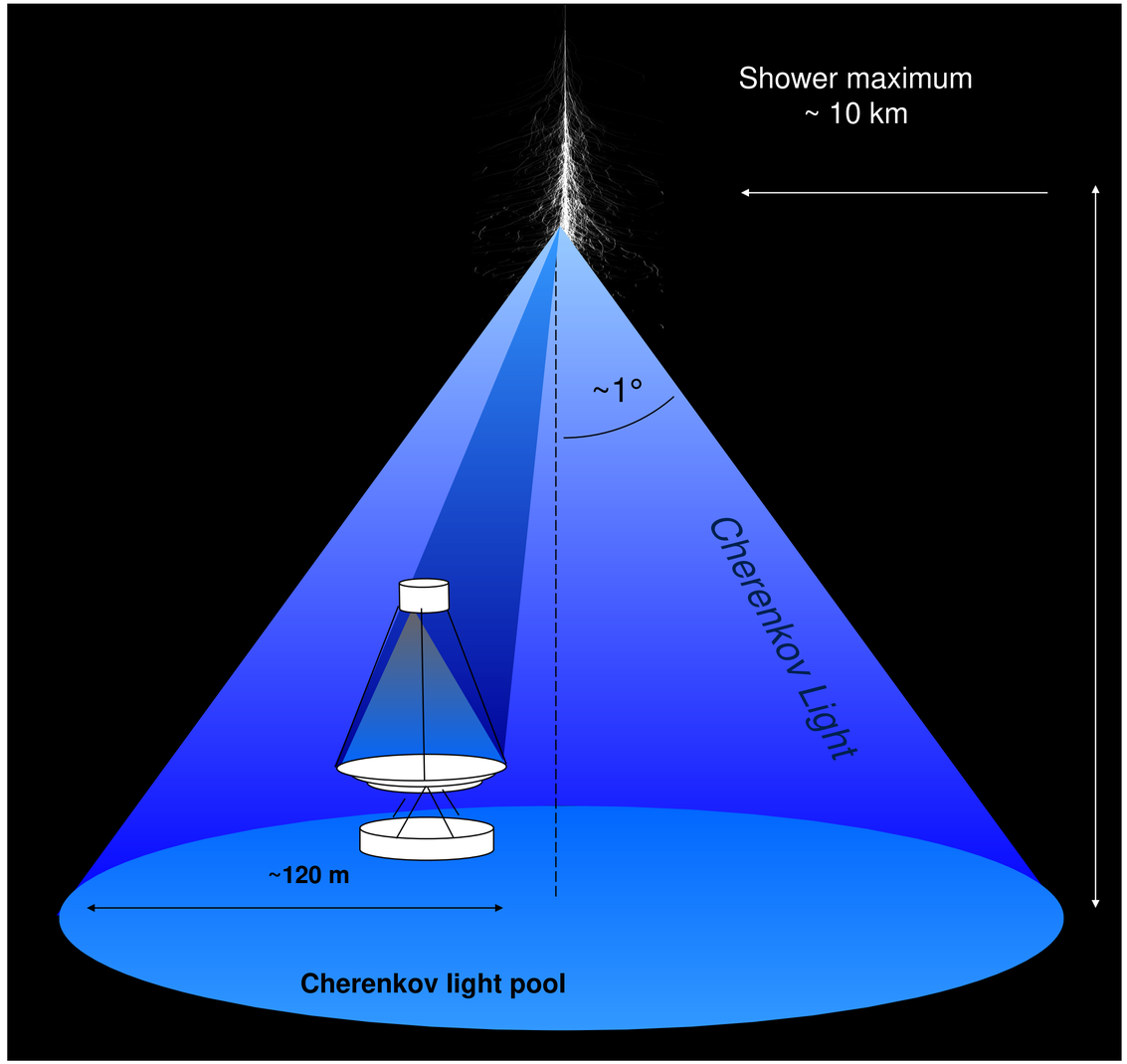
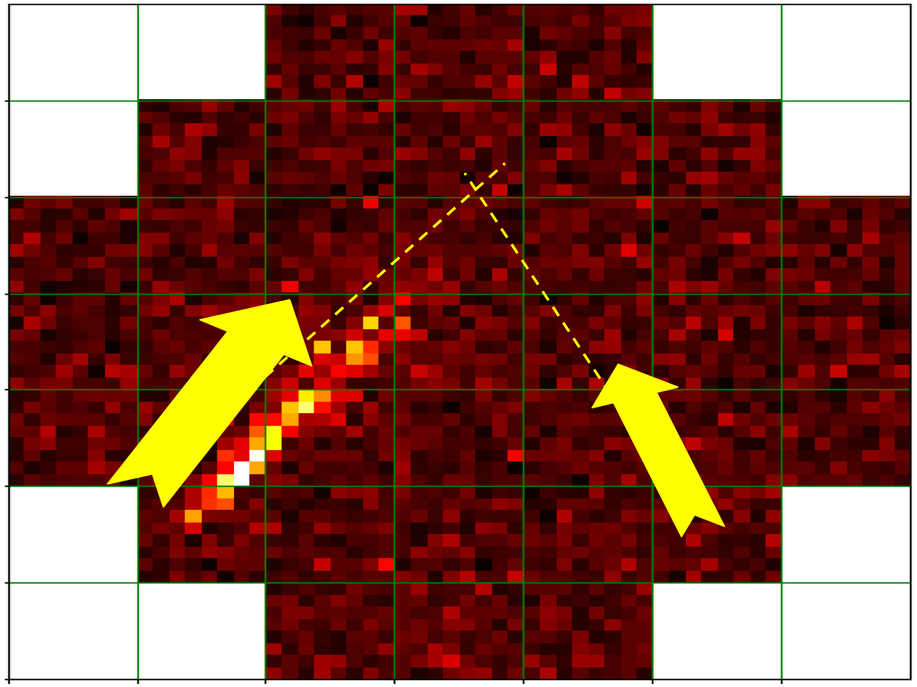


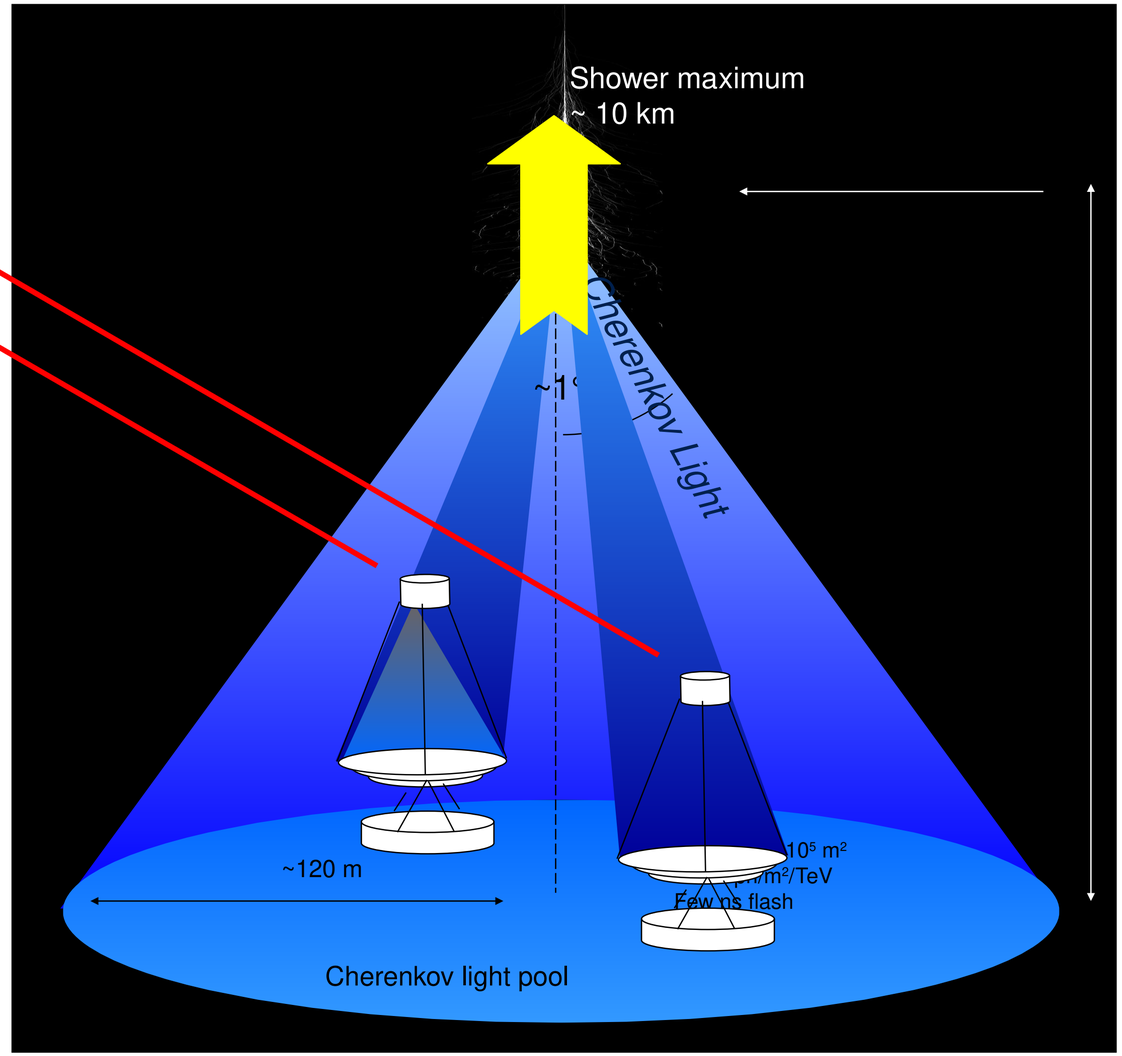


Gamma-rays (and charged cosmic rays) produce showers in the atmosphere. The charged particles in the shower emit Cherenkov light that can be detected by ground-based Cherenkov Telescopes.

- **Imaging Atmospheric Cherenkov Technique (IACT)** to study high energy emission form galactic and extragalactic sources in the TeV band (up to >100 TeV).

Imaging Atmospheric Cherenkov Techniques





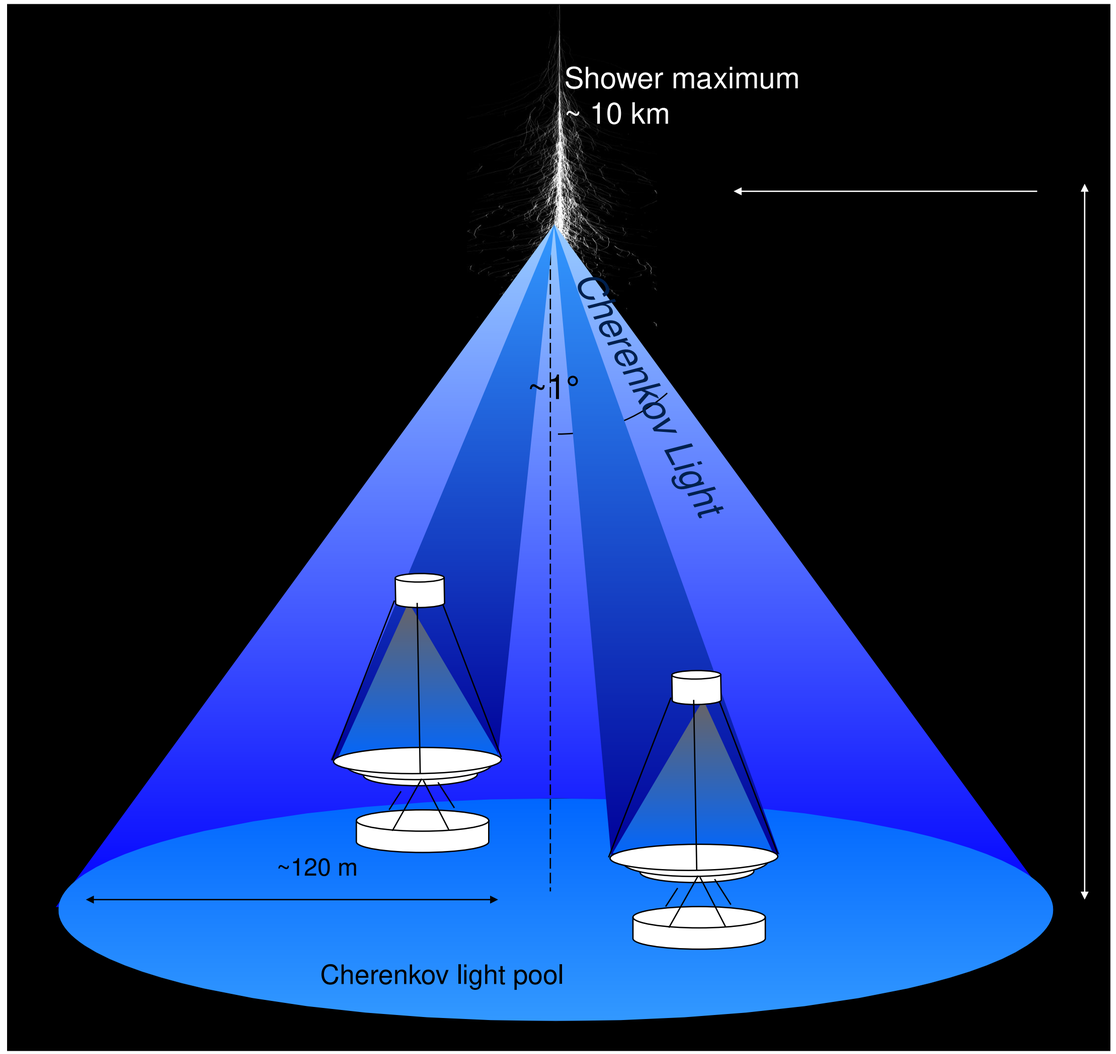
Stereoscopy ➔ better determination of:

- Energy of primary
- Direction of primary
- Kind of primary

➔ **Higher Sensitivity ➔ Less Data Acquired**

Imaging Atmospheric Cherenkov Techniques

- Typical exposures on sources:
  from tens of minutes to hundreds
  of hours (depending on the flux of the sources)
- DAQ rate >~ 10^3 showers/second
- 1 shower ➔ multiple images
  (depending on the number of telescopes and the energy/impact-parameter of the shower)
- 1 image ➔ ~ 10^3 (counts+time) / pixel / telescope
  (number of counts + temporal marcature for each pixels of each triggered telescope)
- $N_{\gamma s}/N_{hadrons}$ <~10^{-4}
  (even for bright sources like the Crab Nebula)
- Monte Carlo simulations
- Data reduction (for each recorded shower):
  - Pixels' signals calibration
  - Images' parametrization of the images
  - Merging of information of different images
  - Reconstruction of the shower properties
  - Selection of gamma-like showers' events
  - High-level scientific products: sky-maps, spectra, light-curves, …



ASTRI Prototype and Mini-Array Project

- The ASTRI Mini-Array is a project whose purpose is to build, deploy and operate an array of

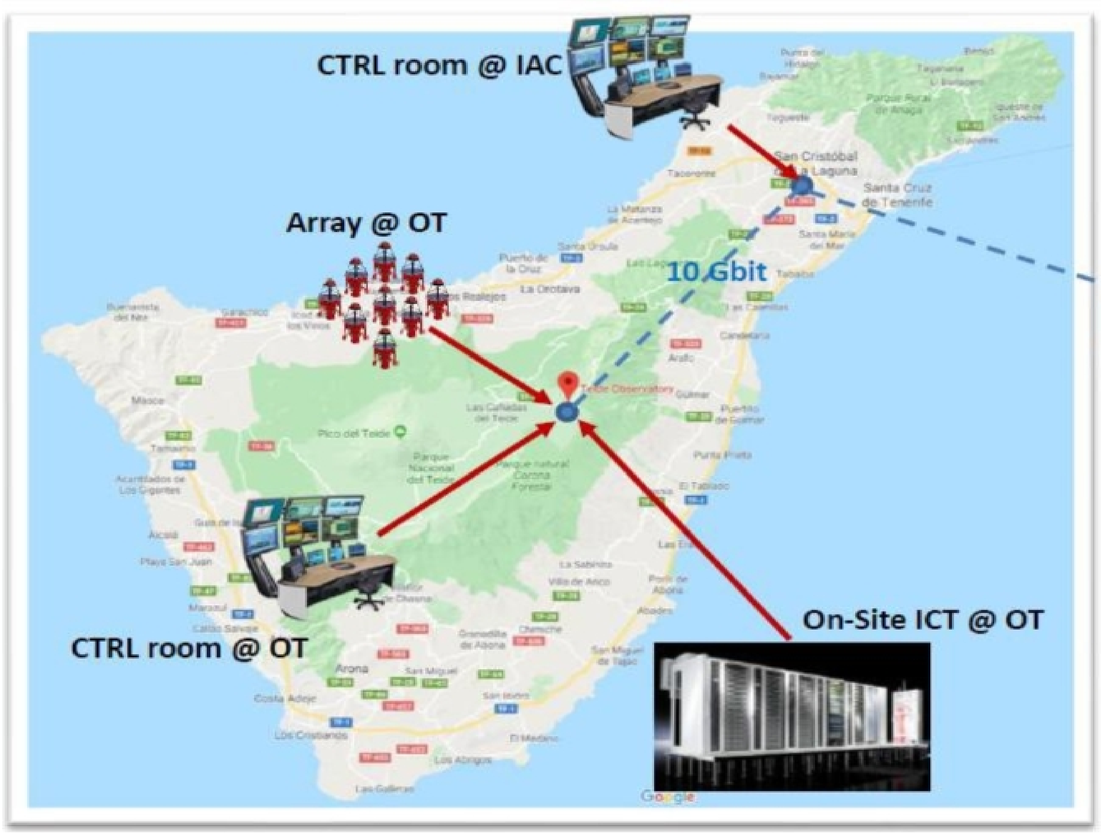
  9 telescopes of the 4 meters class at the Observatorio del Teide in Tenerife in collaboration with IAC [Scuderi et al., doi:10.1016/j.jheap.2022.05.001]
- INAF – IAC Hosting agreement foresees for the ASTRI Mini-Array 4 + 4 years of operations
- More than 150 hundred researchers belonging to
  - INAF institutes (IASF-MI, IASF-PA, OAS, OACT, OAB, OAPD, OAR)
  - Italian Universities (Uni-PG, Uni-PD, Uni-CT, Uni-GE, PoliMi)
  - International Institutions (University of Sao Paulo – Brazil, North-West University – South Africa, IAC – Spain).

ASTRI-Horn Prototype IACT

ASTRI Prototype and Mini-Array Project

The ASTRI Mini-Array in Tenerife

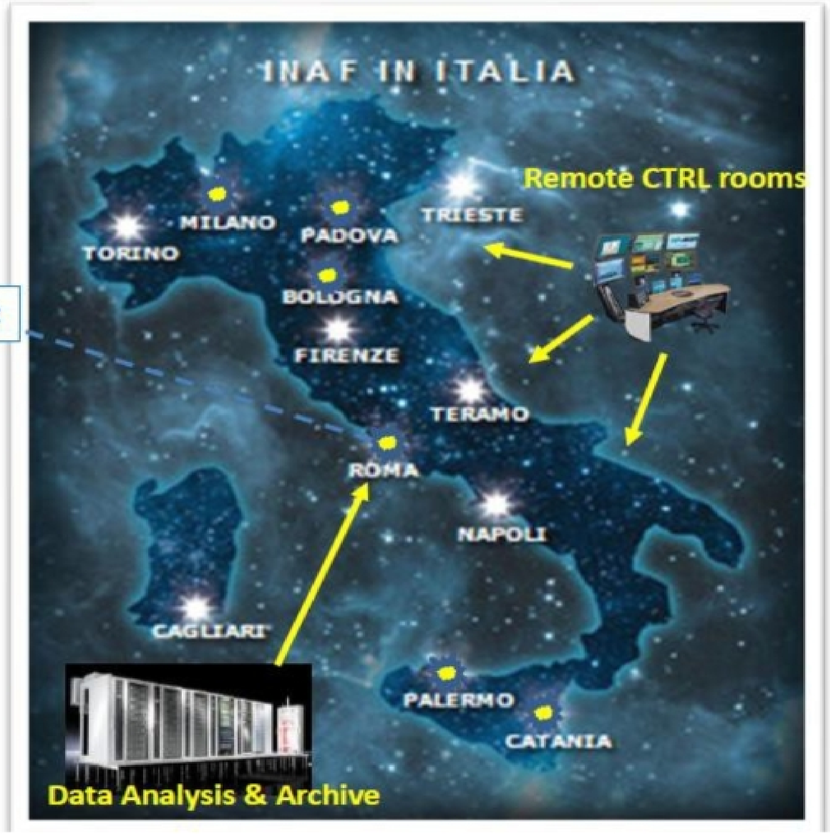
- Telescope Array & auxiliaries (Observatorio del Teide - OT)
- Local Control Room @ THEMIS building (OT)
- On site Data Centre @ IAC Teide Residencia (OT)
- Array operation center @IACTEC in La Laguna



10 Gbit

The ASTRI Mini-Array in Italy

- Data Centre in Rome
- Remote Array operation centers

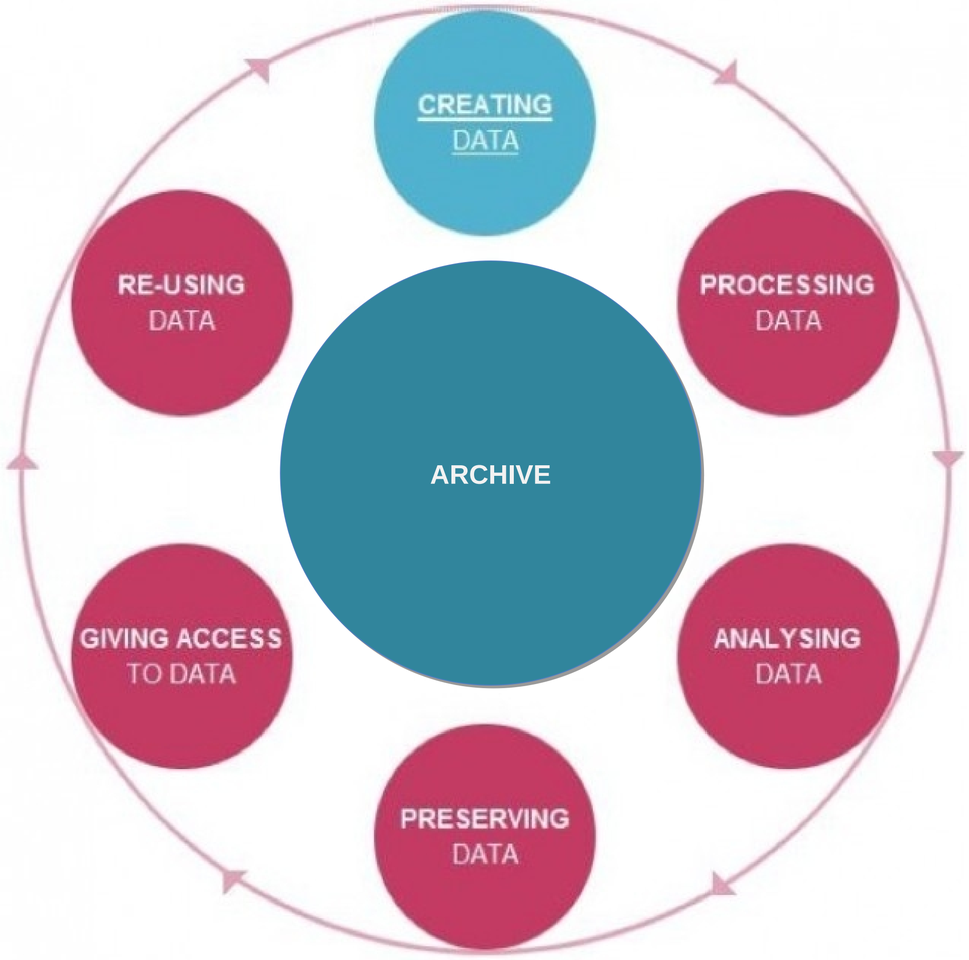


Archive “Role” is central for an Astronomical Observatory

In the scientific data lifecycle of any **OBSERVATORY** the role of the Archive is central.

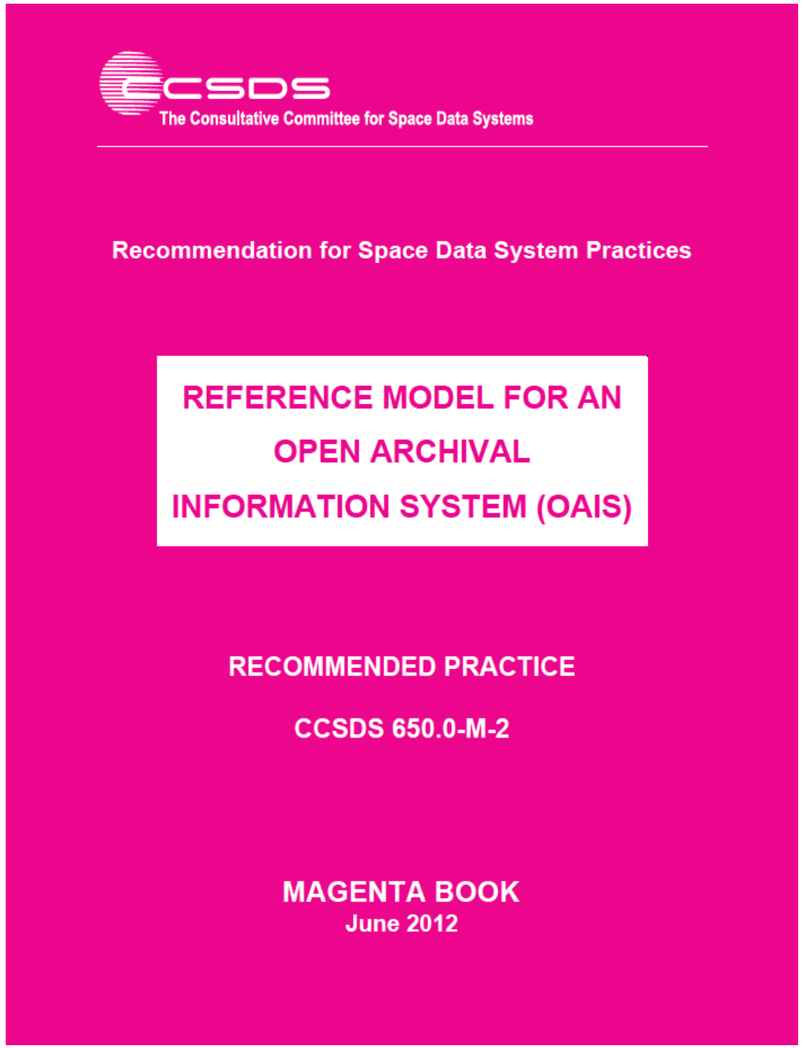
The major aim of a Scientific Archive is to guarantee **data preservation and access** information for the **Long Term** and for **all data science products**.

Archive **MUST** be accessible well beyond the end of the operational life of the observatory

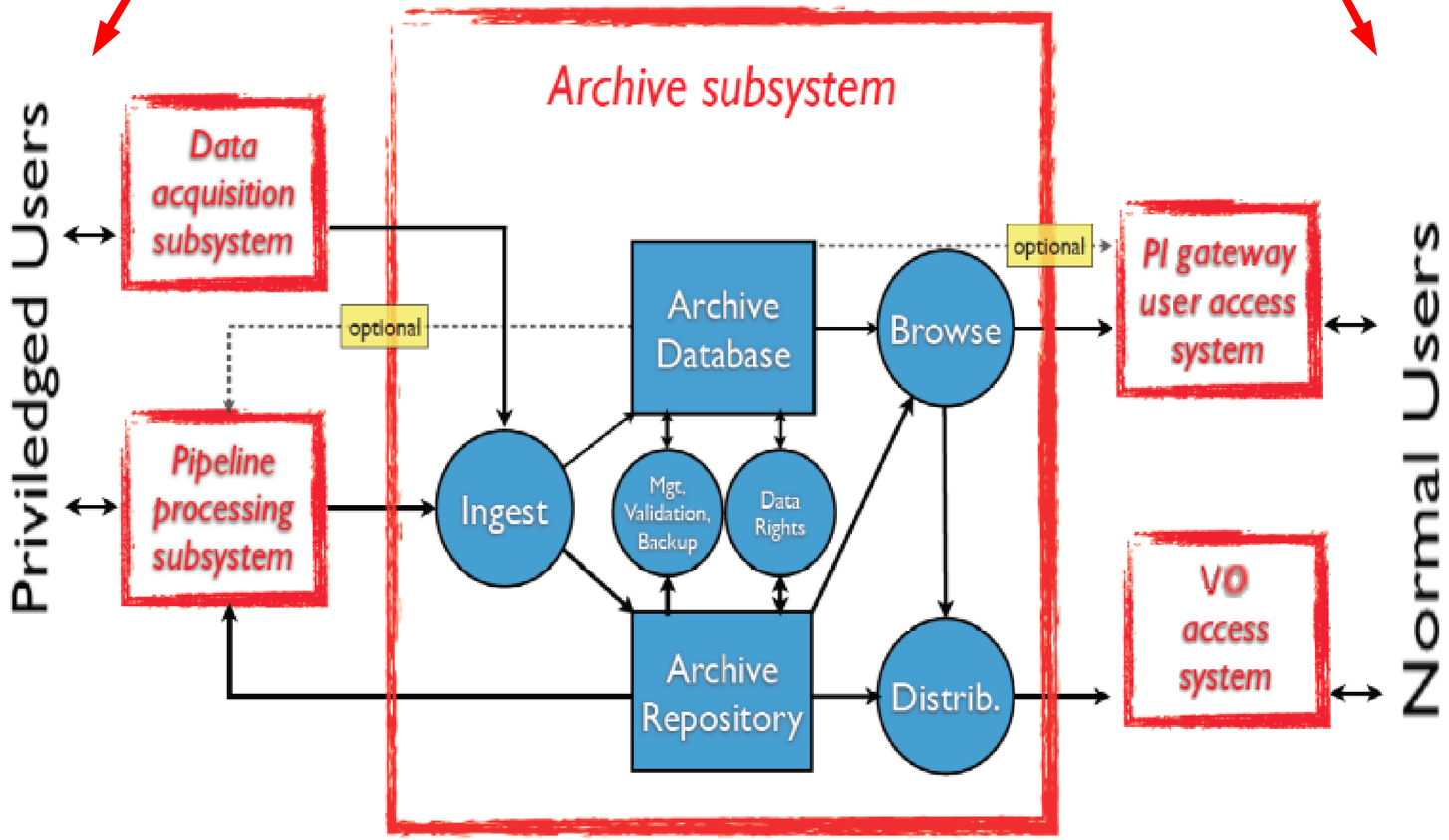


O.A.I.S. Standard Achitecture for an Astronomical Archive

Mini-Array



Data Producers and **Data Consumers**
are rigidly separated by the **Archive System**



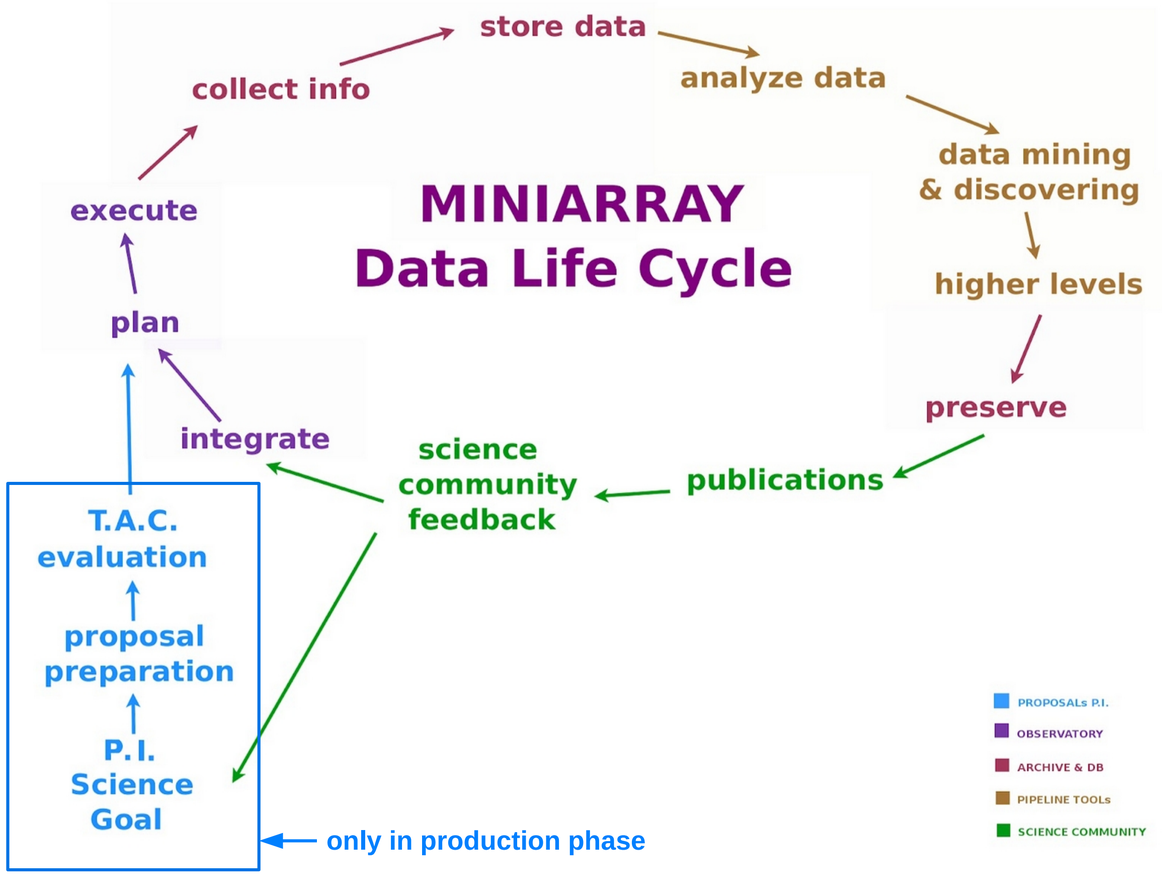
An “end-to-end” Experience to support the Scientist

A.M.A.S.

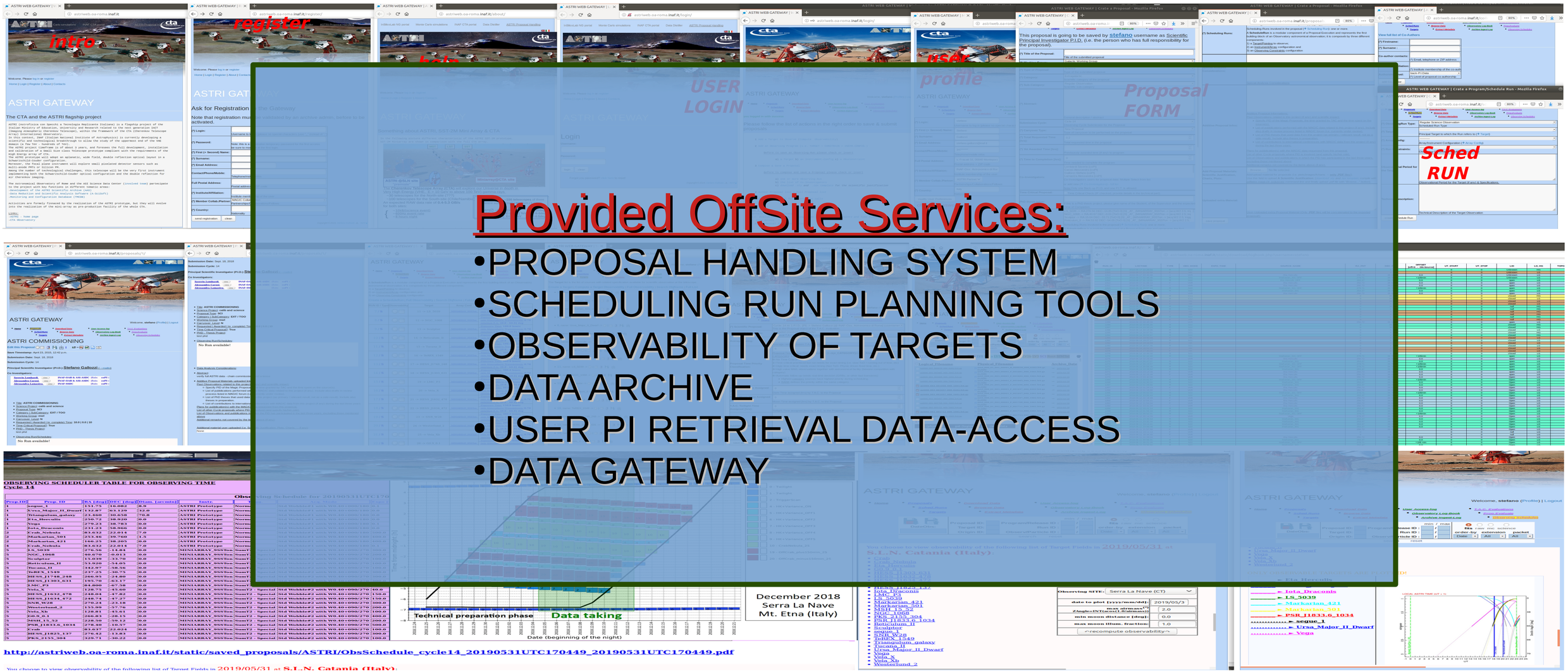
ASTRI & Miniarray

Archive System

From the proposal call & submission and evaluation to the observing plan execution, data acquisition, analisys, reduction and generation of science-ready data to be send to P.I., the archive must provide the physiological environment to store and easily access data at different level and for different scopes, for which data are generated.

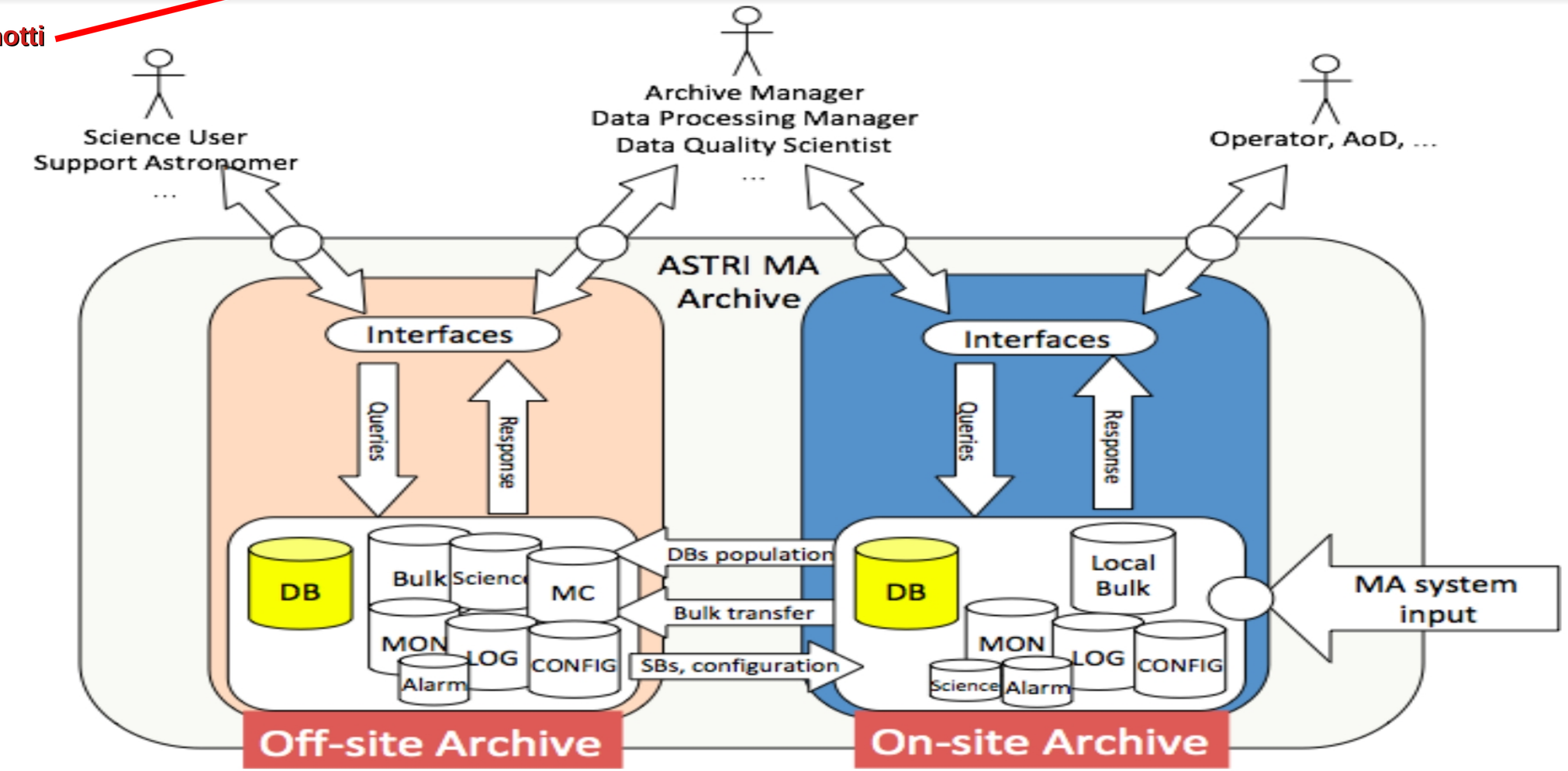


ASTRI Horn prototype: end-to-end Off-site Services



An “interface” from the On-site ICT to the Off-site ICT

see Fulvio Gianotti presentation



AMAS Expected Data to be handled

Considering:
Packet dim. **13.052kB** & **9 telescopes**

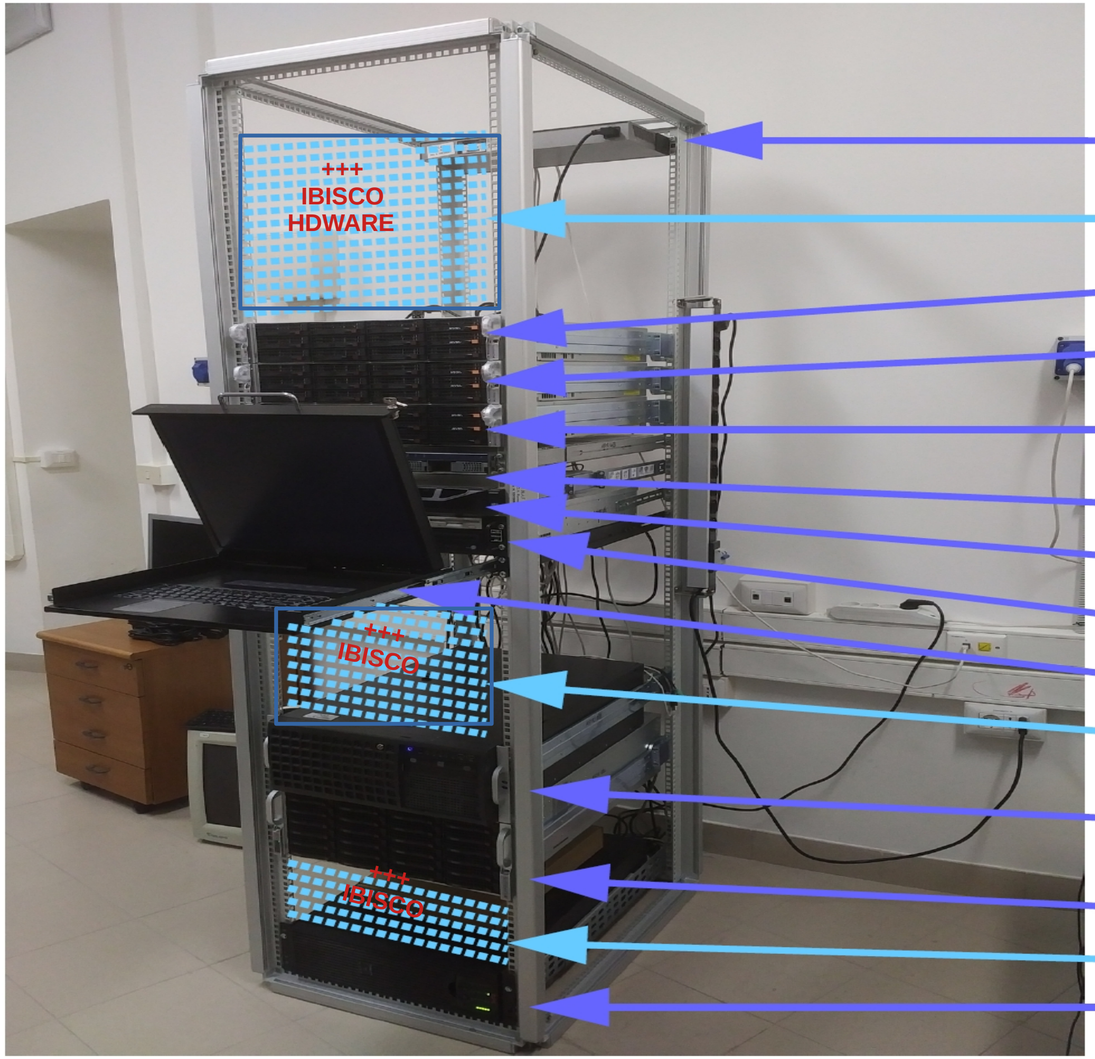
In the **Worst Case**:
-1.0 kHz trigger rate
-11hr acquisition/dd
In the **Average Case**:
-150Hz trigger rate
-8hr acquisition/dd

Optimal **HD Space** (hot+MC [yearly])
~ 0.75 PB

Optimal **Tape Space** (cold + hot+MC [yearly])
~ 1.15 PB [+1.2PB per SI3]

Archive/DB Units	GB/day MAX	GB/day AVG	TOT MAX (AVG) [TB/yr]
Bulk Archive (only RAW)	5117[2]	558[3]	604 (91)[4]
Bulk Archive (DL0 FITS + pipe products)[5]	15680	1710	1853 (278)
Science Archive	250	200	~35 (~25)
Swap-tmp Loc.Repo[6]			200
Simulation Archive (MC)[7]			100
Quality Archive	33	24	3.9 (3.9)
Log / Monitor / Alarm Archive	54	27	~20 (~10)
System Configuration DB	5	4	~0.6 (~0.5)
CALDB			0.2-0.4 (TBD)
Performance DB			0.5-1.0 (TBD)
Interferometry Instrument (SI3)			**1200 (??)**
hot-storage TOTALS:	**5405**	**786**	**~640 (~120)**
cold-storage Backup	**~16000**	**1737**	**~1873 (~290)**

AMAS Hardware Off-Site ICT #1



ASTRI Hardware

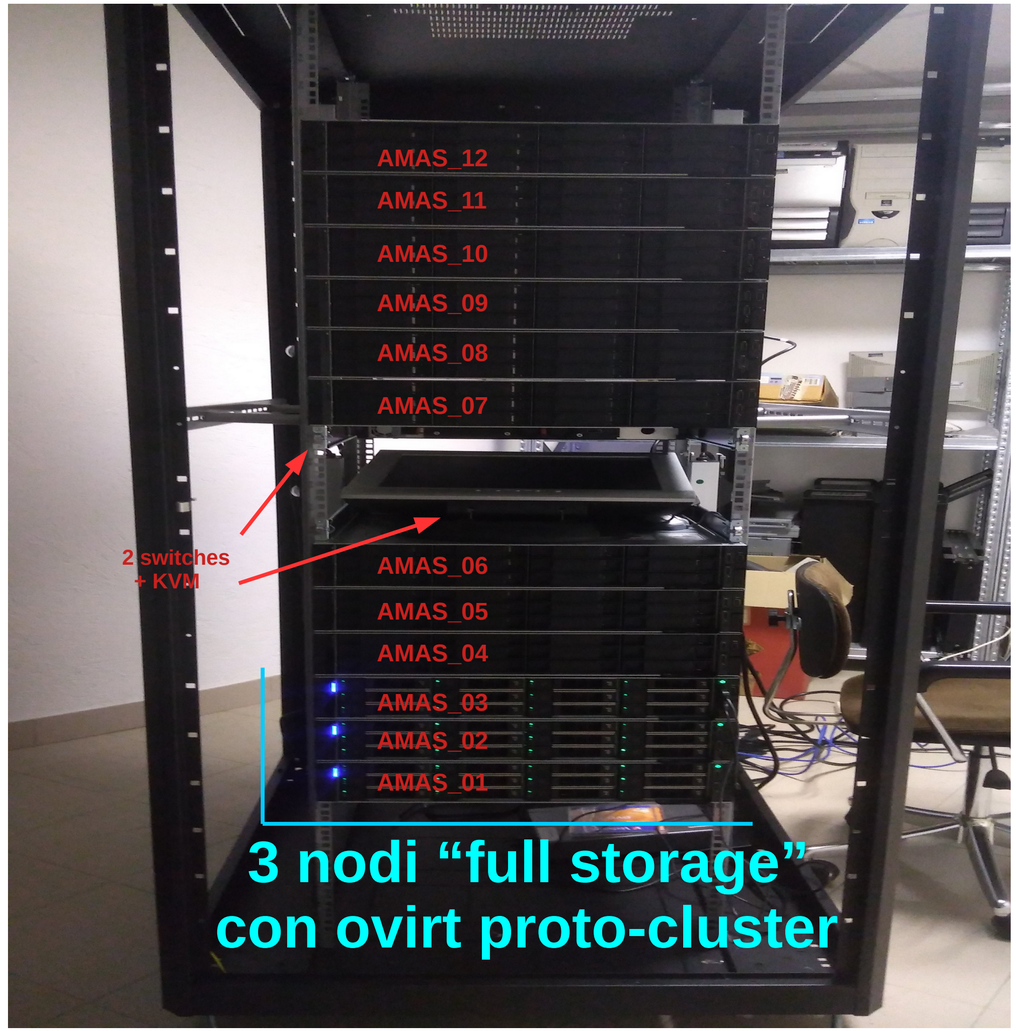
- Switch T.O.R. 1→ 10Gb/s
- Other OneData nodes???
- OneData Provider#3 (@SSDC)
- OneData Provider#2 (@LNF)
- OneData Provider#1 (@OAR-MPC)
- Redundant ASTRI services
- ASTRI Gateway (gitLab & redmine)
- Mirror ASTRI Gateway
- Switch KVM
- Other Computing???
- DBs Service and File Catalogs & Pipeline (devel & Runtime)
- STORAGE (expanding ~1PB)
- Other Storage???
- UPS downstream and stabilized by the Institute's UPS

AMAS Hardware Off-Site ICT #2

EUROPEAN COMPETITION assigned the
21st June 2021 (DD 140/2021)
12 workstations with following tech specifications:

(specificare le caratteristiche tecniche fornite)

Voce	Descrizione	Q.tà
01	Server DELL-EMC PowerEdge R740XD Dual Socket ciascuno con le seguenti caratteristiche: - Chassis RackMount 2U con 12 x 3.5" Bay + 4 x 3.5" Bay on MP + 4 x 2.5" HDD on Flexbay - Nr. 2 CPU Intel Xeon Silver 4214R 2.4G 12C/24T, 9.6GT/s,16,5M Cache Turbo HT (100W) DDR4-2400 - RAM: 384GB DDR4 (12 x 32GB RDIMM 3200MT/S Dual Rank) - PERC H740P Raid Controller 8GB NV Cache - Nr.2 SSD 960GB SATA Read Intensive 6Gbps 512 2.5" Flexbay - Nr.4 16TB HD SAS 12Gbps 7K 512e 3.5" Hot Plug - Intel X710 Dual Port 10GbE SFP+ & Intel i350 Dual Port 1GbE RJ45 - Nr. 2 SFP+ SR Optical Transceiver Intel 10Gb-1Gb - Nr. 2 Bretelle per ottiche SFP+ SR multimodali LC/LC – 5mt - Nr. 2 Bretelle UTP CAT.7 1GbE RJ45 – 5mt - iDRAC9 Datacenterx4 con Open Manage Enterprise Advanced - Dual Hot Plug Redundant Power Supply (1+1)1100W + cavi alimentazione	12
02	Rack Cabinet AIR SOLUTION INTELLINET Standard 19" 42U (800 x 1000). Include: • Nr.4 Multipresa Verticale per Rack 12 Posti Schuko con Magnetotermico • Gruppo di ventilazione 3 ventole • Nottolini di sicurezza su pannelli laterali • Kit di viti per montaggio apparati	01
03	Switch di management Dell Networking N1548, 48x1GbE+4 x 10GbE SFP+ fixed port. Include Nr. 2 Dell Networking Transceiver SFP+ 10GbE SR e cavi necessari (alimentazione, ETH Rame e Fibra)	02
04	Garanzia 7 Anni Prosupport DELL in modalità 24x7 Next Business Day On-Site Service + contributo di ITM Platinum Partner Dell, con tempo di intervento di 4h per le urgenze.	01



AMAS Hardware Off-Site ICT #3

Voce	Codice/Descrizione
01	**O-SL3000-BASE-2EXP-PKG1 (Prodotto ricondizionato)** Tape Library Enterprise Oracle STK SL3000 costituita da un modulo Base e N°2 espansioni PEM (Parking Expansion Module) per un totale di 1000 slots, di cui 700 licenziati, doppia robotica indipendente in modalità Active/Active, dual FC port per il pilotaggio della libreria, 16 drive slots con alimentazione ridondata per l'installazione di tape drive misti fra (LTO4-5-6-7-8 ed Enterprise T1000B-C-D). Licenza per la generazione di librerie logiche fino ad un massimo di 8. Cartridge Access Port con 26 slots. Affidabilità della componente Robotica MEBF/MSBF >1.500.000, Affidabilità hardware della Tape Library >0,9998, Software di controllo e gestione SLC (StorageTek Library Console). Sono inclusi i seguenti servizi tecnici: • Installazione ed integrazione a cura dei Professional Service di ITM. • Training di un giorno sulla SL3000 (Hw e Sw) • Manutenzione 12 mesi on site a cura di ITM inclusa **La SL3000 offerta è integrata dai seguenti Tape Drive e media:** ➢ N°2 x Tape Drive LTO6 FC Full-Height (Ricondizionati) ➢ N°2 x Tape Drive LTO5 FC Full-Height (Ricondizionati) ➢ N°20 cartridge LTO6 con label • Dimensioni fisiche: L. 250cm, H. 200cm, P. 128cm • Assorbimento massimo escluso tape drive <800Watts • Peso complessivo Tape Library + Tape drive (escluse cartridge) c.a.750Kg • Firmware aggiornato alla release che permette l'installazione di tape drive LTO8 • La SL3000 è ulteriormente espandibile fino ad oltre 5900 cartridge. **Sarà fornita inoltre la seguente documentazione:** • Specifiche tecniche del prodotto con Manuale Utente in Italiano • Specifiche di installazione (con schema di cabling, lista di dettaglio della configurazione, Matrice di compliance, piani di accettazione del sistema inclusivi dei test di collaudo • Modalità di richieste di intervento a ITM tramite Mail & Call desk

SL3000 nella configurazione proposta

AMAS Hardware Off-Site ICT #4

From the Cineca donated

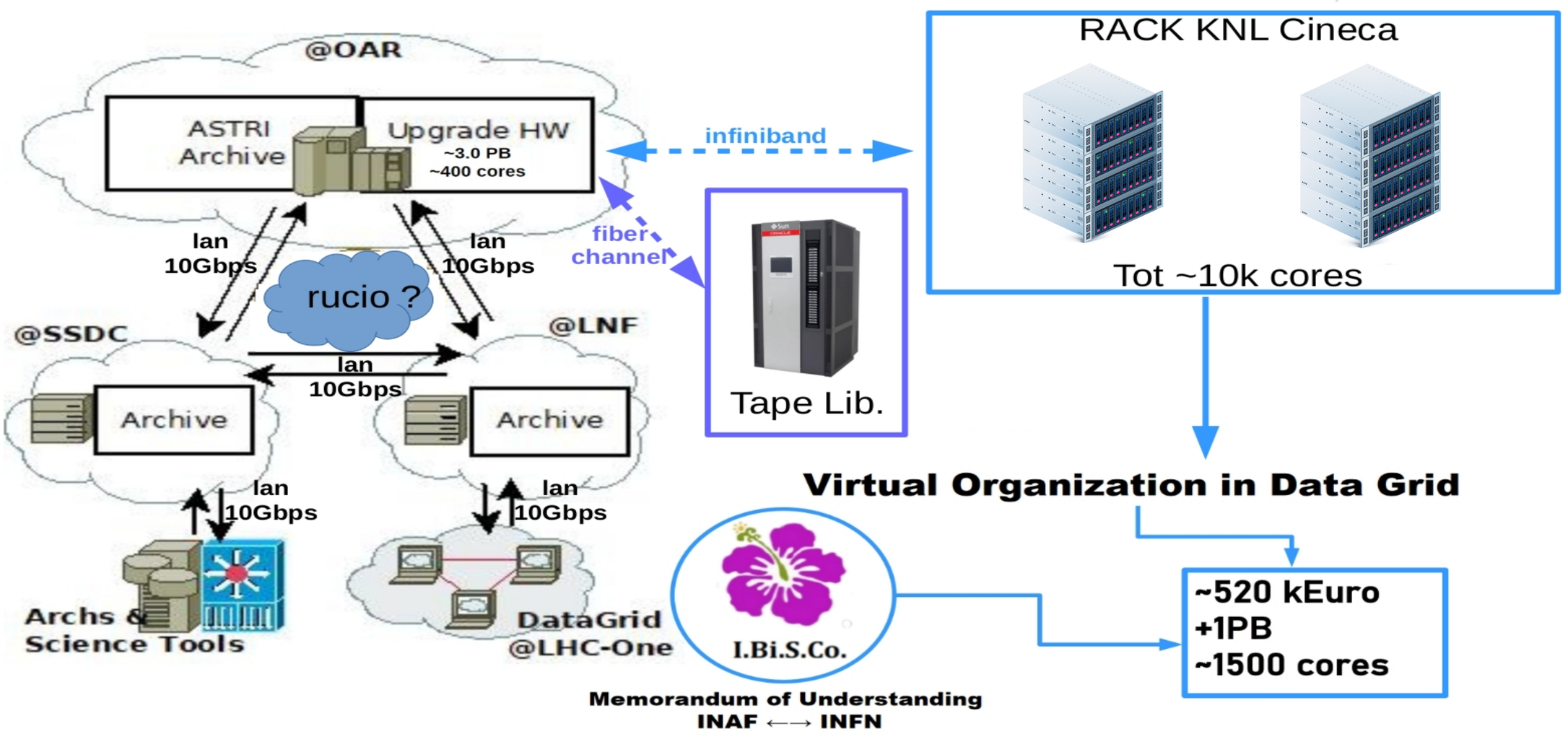
N.2 rack KNL containing:

- **72 nodes** equipped with Knights Landing (68 cores) proc.
  - 16GB MCDRAM
  - 96 GB RAM each
    - 4896 cores
    - >1.15TB MCDRAM
    - >6.9TB RAM

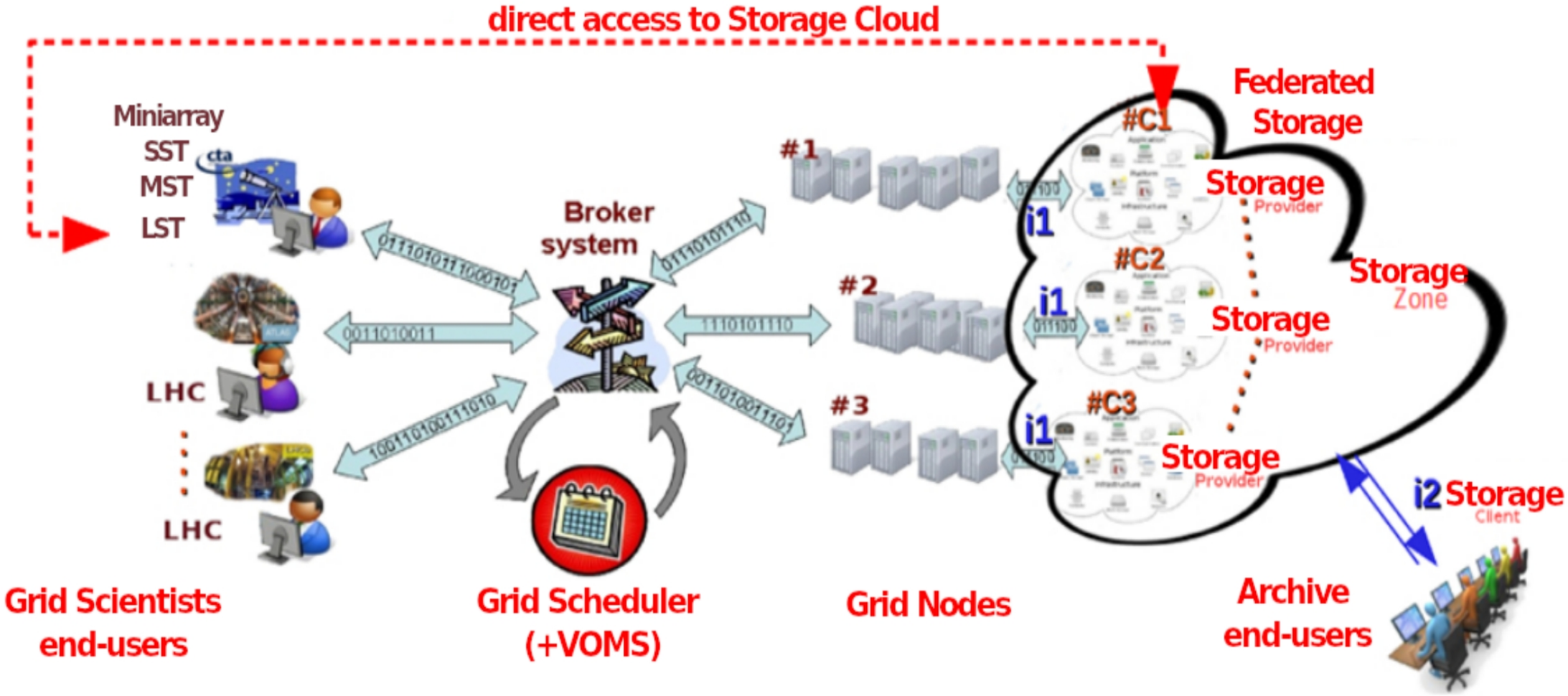
total computing capacity:

- **10k cores**
- +2TB MCDRAM
- +13TB RAM

AMAS Hardware Off-Site ICT



AMAS as Bulk Archive Testbed for C.T.A.



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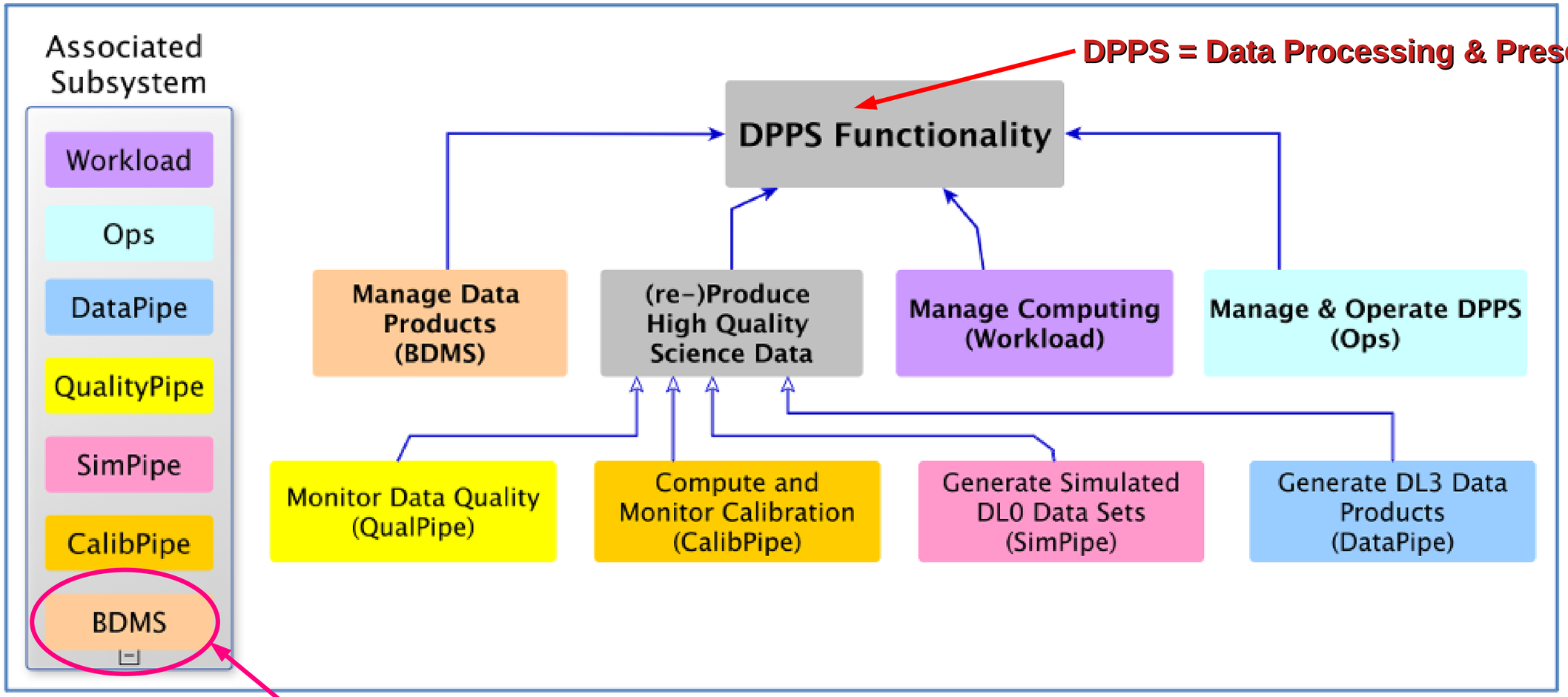
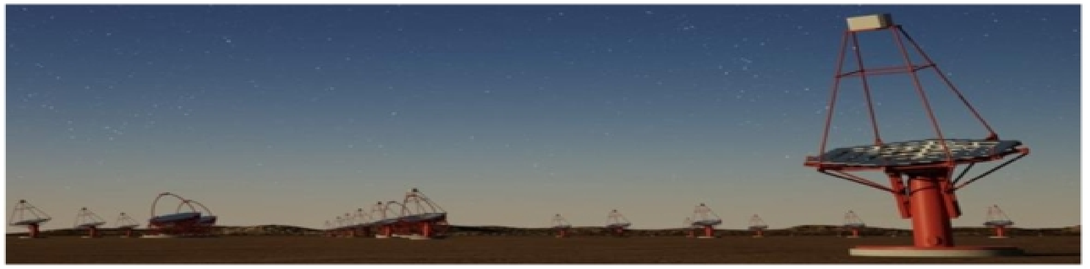


From lev1 to lev3 data

AMAS as Bulk Archive Testbed for C.T.A.



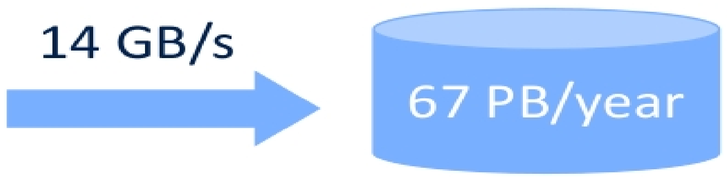
CTAO-North, Canarian island

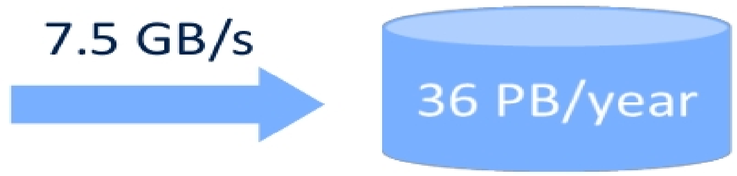
- 4 Large Size Telescopes
- 9 Mid Size Telescopes

CTAO-South - Chile

- 14 Mid Size Telescopes
- 37 Small Size Telescopes

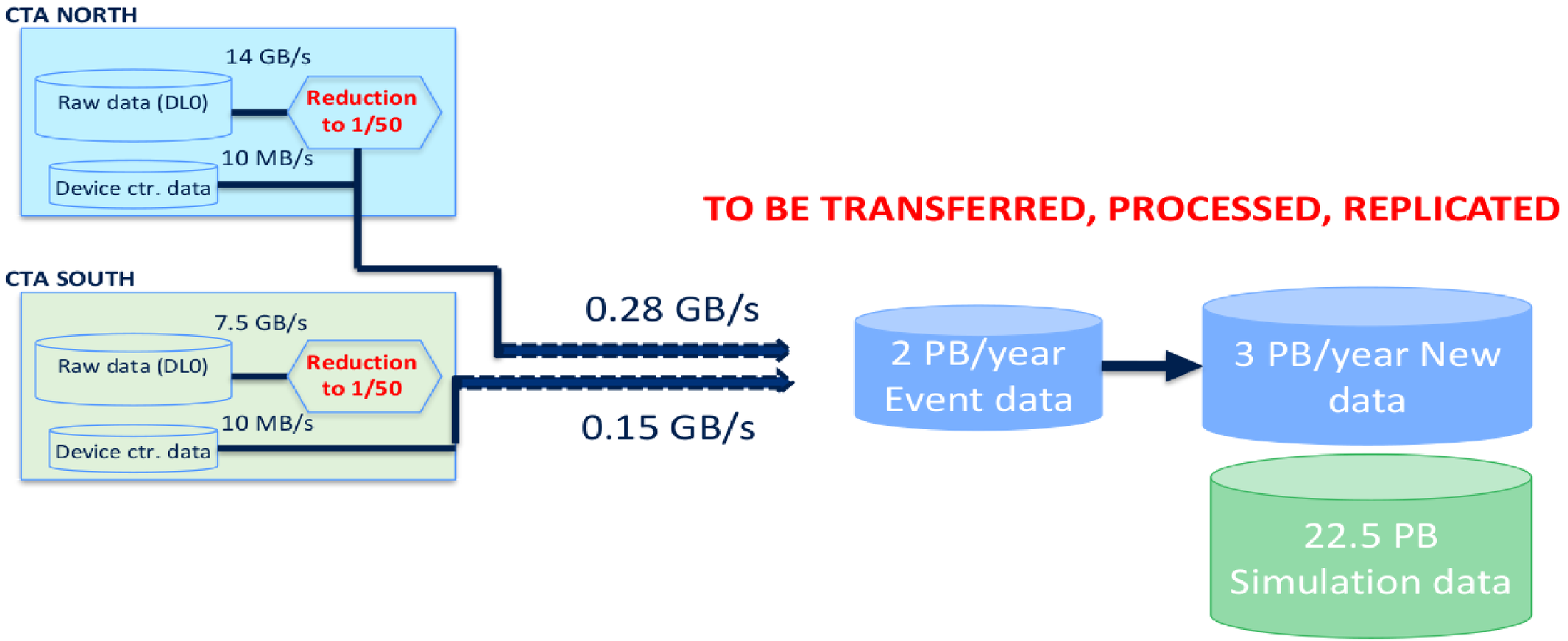
- ❑ 1314 observation hours per year
- ❑ 20% monitoring and service data





AMAS as Bulk Archive Testbed for C.T.A.

Required Data Volume Reduction ratio: 50



AMAS as Bulk Archive Testbed for C.T.A.

Distributed Archive System for CTAO off-site Archive. (it's a "trade-off" between availability level, manageability, shareholders offers and cost was in favor of a 4 academic Data Centres solution with equal distribution of load.

EXPORT the AMAS (Rome-distributed as Frascati Node)

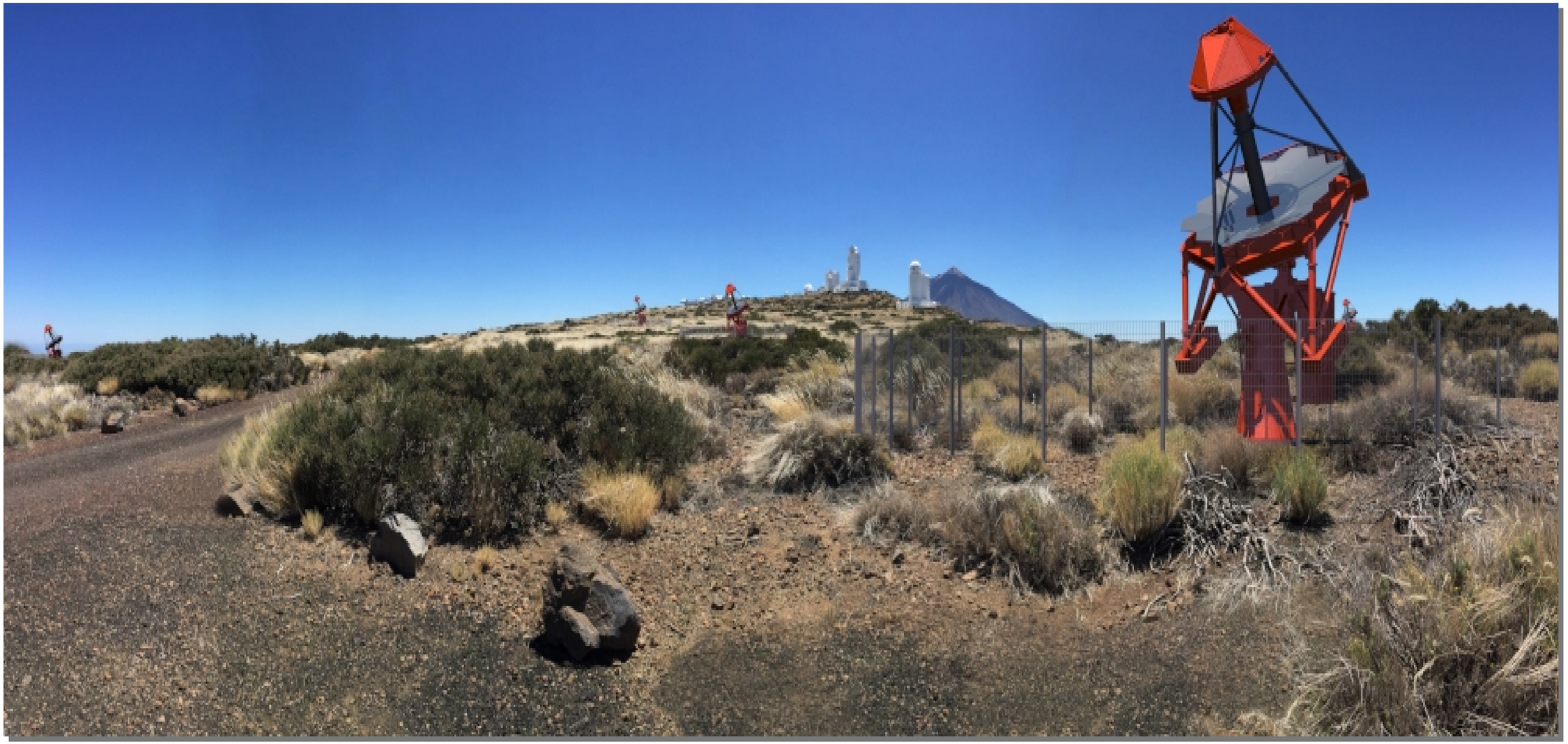
-Storage distributed between hot and cold storage
-Two replica of all data on cold storage
in two different locations (~300 km away)
-One copy on hot storage for science data
-One reprocessing of all previous data per year
-22.5PB fixed storage for Monte-Carlo-sim data
-10GB ethernet connection (minimal & redundant)
-CTAO applications remotely controlled and monitored from the **CTAO Science Data Management Center (SDMC)** with ~1Gbps needed connectivity

Distributed in different "4" EUROPEAN sites:

From the BGR money matrix process, CTAO and BGR members came to the agreement that the four data centres will serve as the data centres in the CTAO Work Package Off-site ICT (P06.11)

- **PIC** in Barcelona, Spain
- **DESY** in Zeuthen, Germany
- Swiss National Supercomputing Centre (**CSCS**) in Lugano, Switzerland
- INAF/INFN in **Frascati**, Italy
- **SDMC in Zeuthen, Germany**

QUESTIONS?



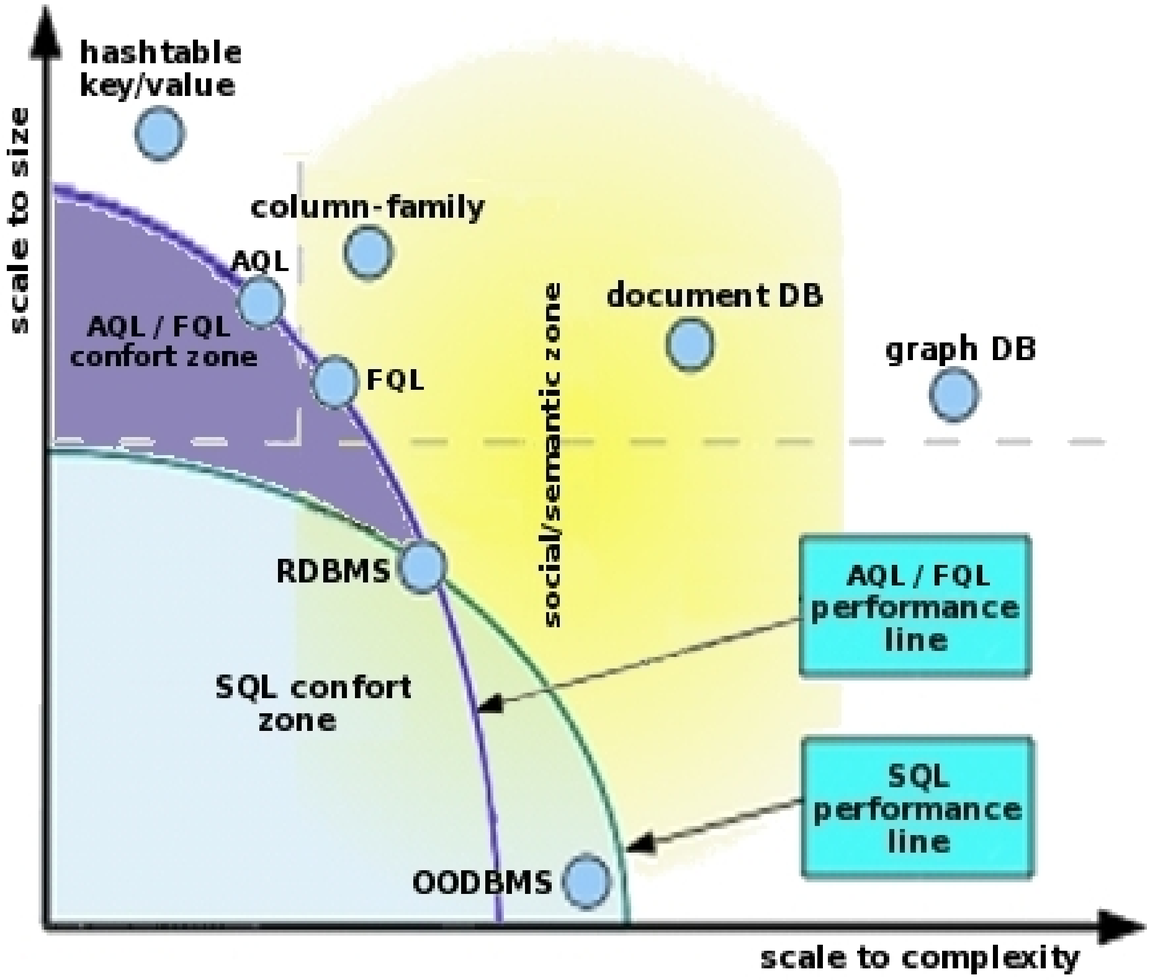
BACKUP SLIDES

DATABASES STUDIES

Mini-Array

Relational DBMS
vs
NO-SQL Approach

Balance if needed a fixed-schema ***Relational DB*** or a versatile approach of a **schema-less NO-SQL**
BUT
keep in mind the
C.A.P. Theorem



DATABASES STUDIES - The CAP Theorem

Consistency

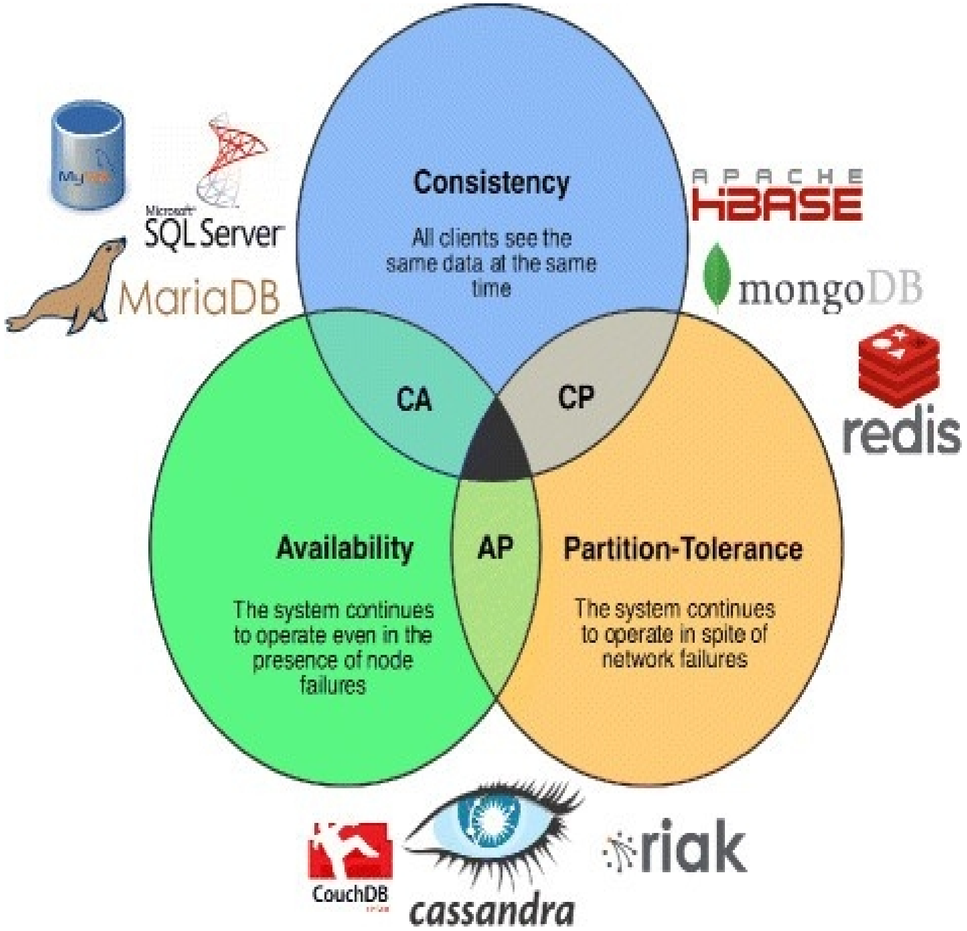
Every read receives the most recent write or an error.

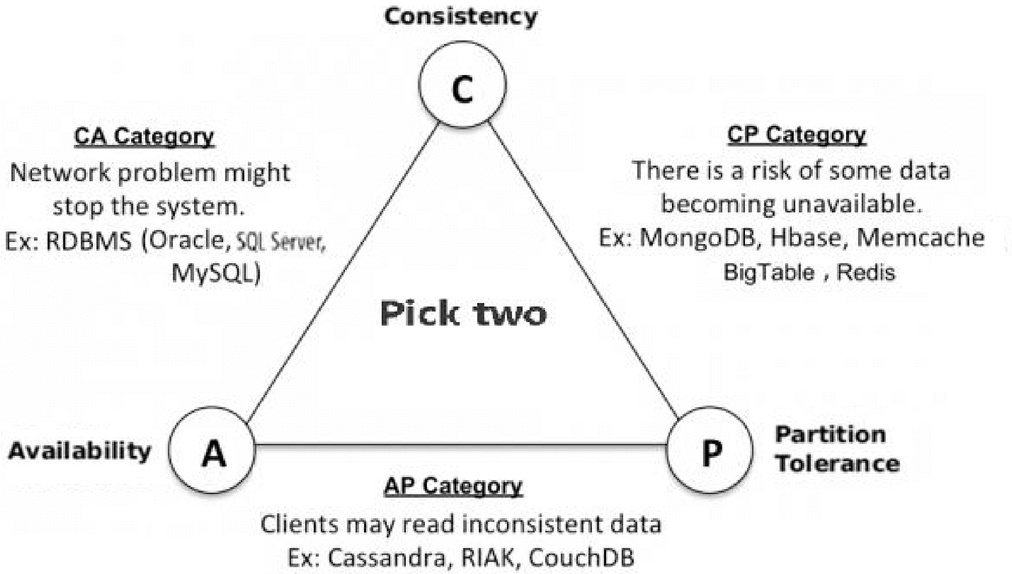
Availability

Every request receives a (non-error) response, without the guarantee that it contains the most recent write.

Partition tolerance

The system continues to operate despite messages being dropped by the network between nodes.

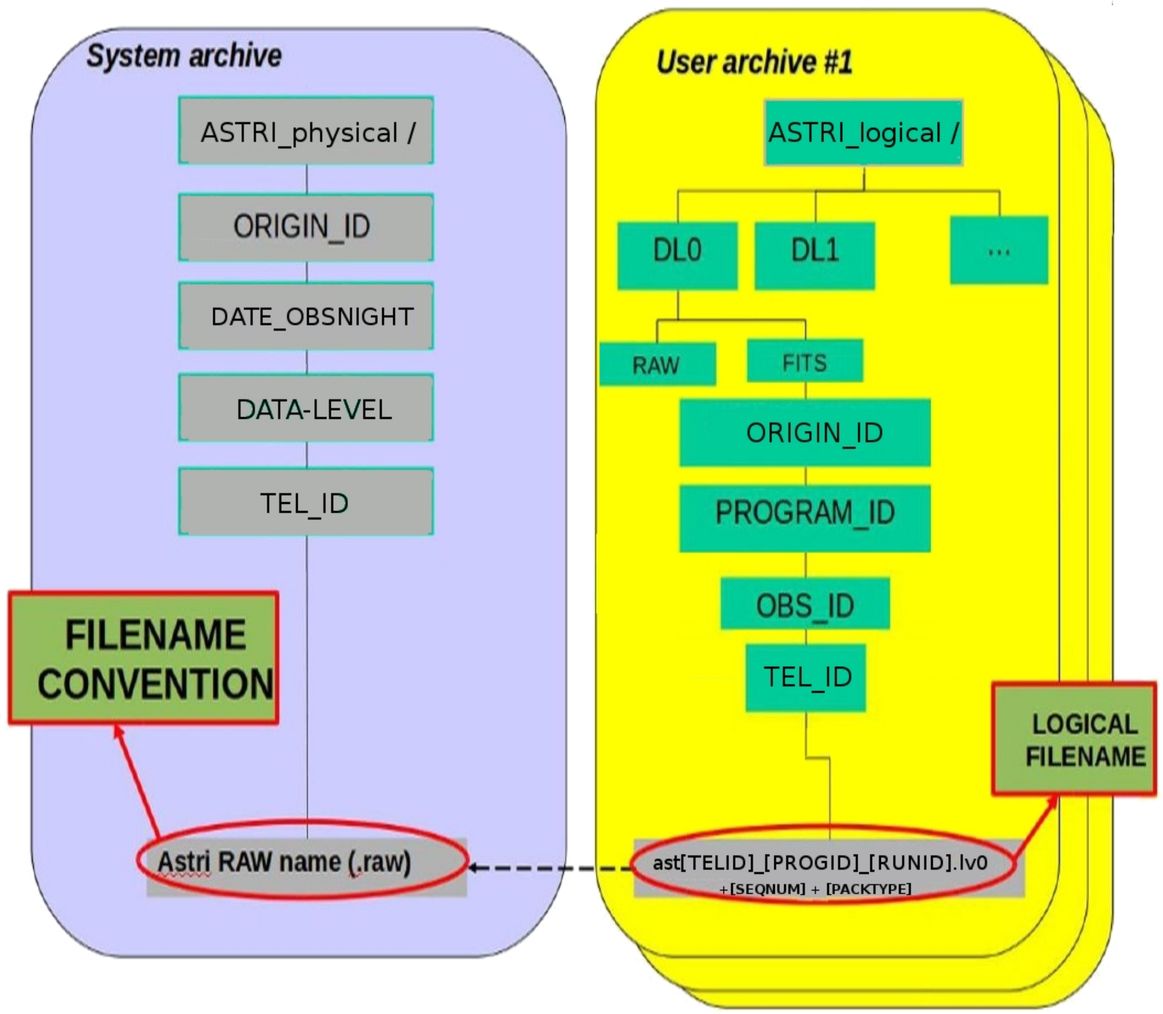




One Physical Archive and few Logical User Archives

User Archives identifies Logical Archives:

A single ***physical* system** archive and a few **logical *user* archives** that reflect the logical organization aligned to the use-cases of the different archive users and the way they access data



Examples of logical “User Archives”