VisIVO Visual Analytics: Recent Updates and New Features

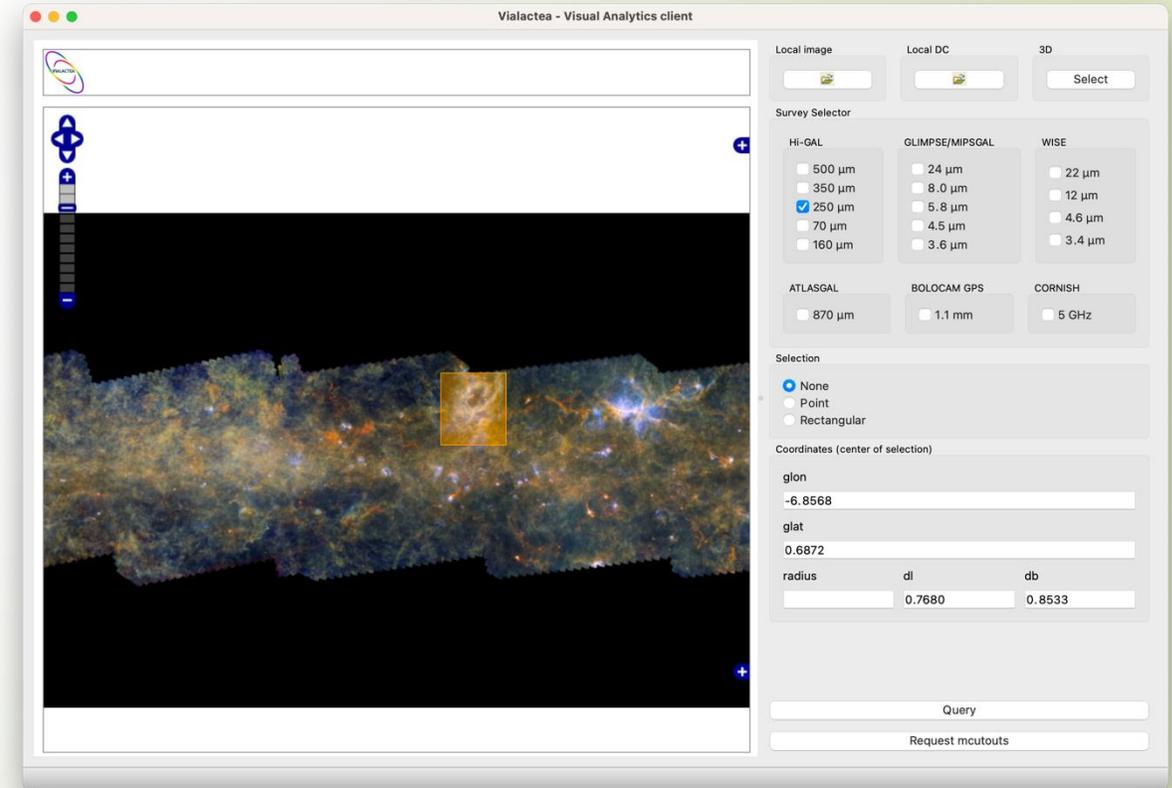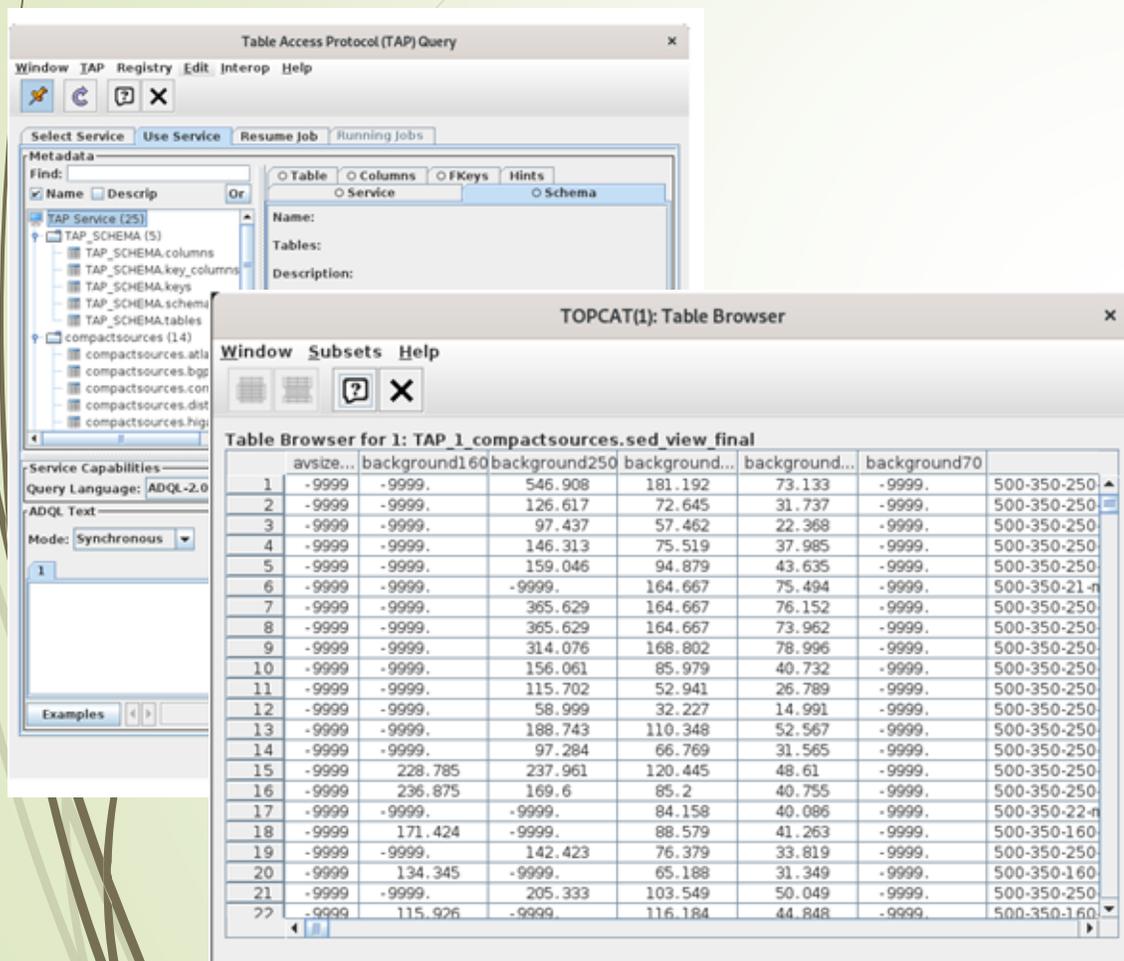Giuseppe Tudisco – INAF OACT

VisIVO Visual Analytics

Development started in 2015.

Open-source desktop application that provides a visual analytic environment to analyze the correlation between different kinds of data.

Supported by many projects during past years (FP7 ViaLactea, H2020 NEANIAS, INAF PRIN CIRASA, ERC ECOGAL, ICSC).

ViaLactea Knowledge Base (VLKB)

- Provides discovery services and access to data collections and catalogues of the galactic plane.

- Accessible through a Virtual Observatory enabled infrastructure.

- Data access available through REST-API services: search, cutout and merge.

- Secured under Authentication and Authorization Infrastructure (AAI).

VLKB Services API

➡ VLKB Search & Cutout services are no longer served using custom APIs but are based on IVOA protocols specifications.

➡ Data Discovery is now a IVOA Simple Access Image (SIAv2) service.

➡ Cutout Service (SODA) now follows IVOA Specification for Input Parameters.

Name	Description
ID	Data identifier of the file to be accessed
POS	Positional region to be extracted from the data (one of CIRCLE, RANGE, POLYGON)
BAND	Wavelength interval to be extracted from the data
TIME	Time interval to be extracted from the data
POL	Polarization states (Stokes) to be extracted from the data
POSSYS*	WCS for sky area
BANDSYS*	Barycentric reference frame
PIXELS*	Allows cut by pixels coordinates following FITS-extended syntax conventions

Additional (and optional) parameters, not defined in the standard specification

New VLKB Inventory window

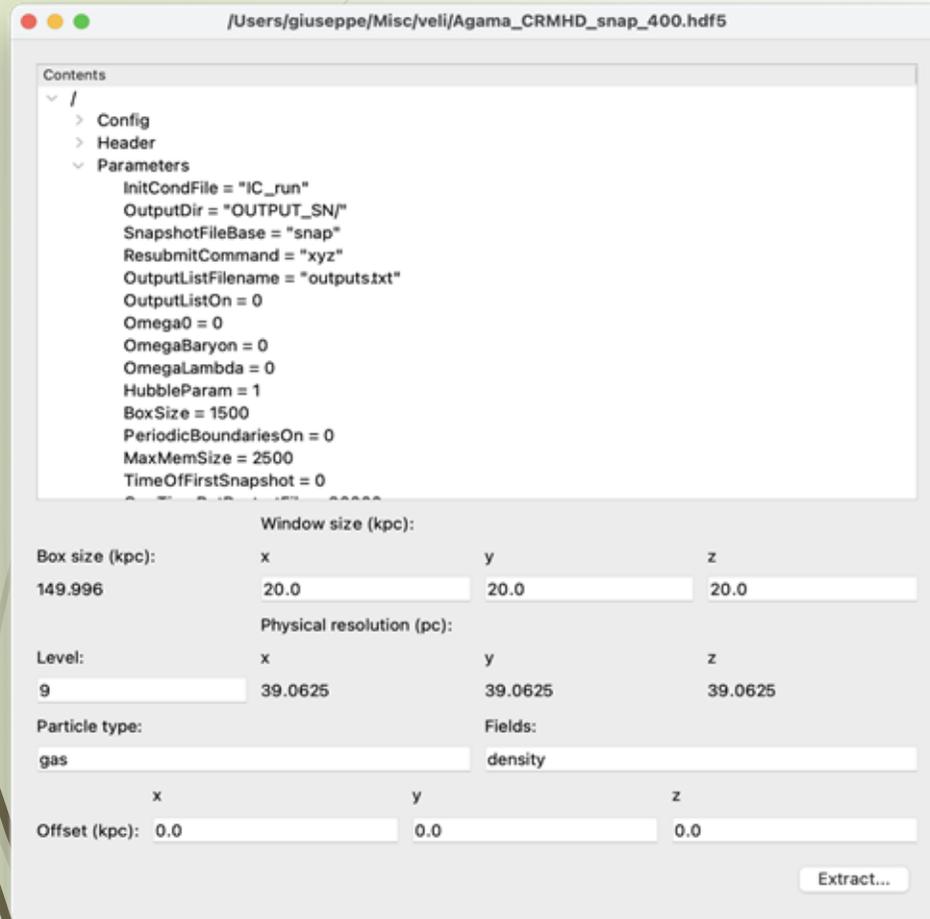The 'VLKB Inventory' is now a detached widget. The list of available datasets is organized in a hierarchical tree structure, grouped by data type, wavelength range, molecular lines...
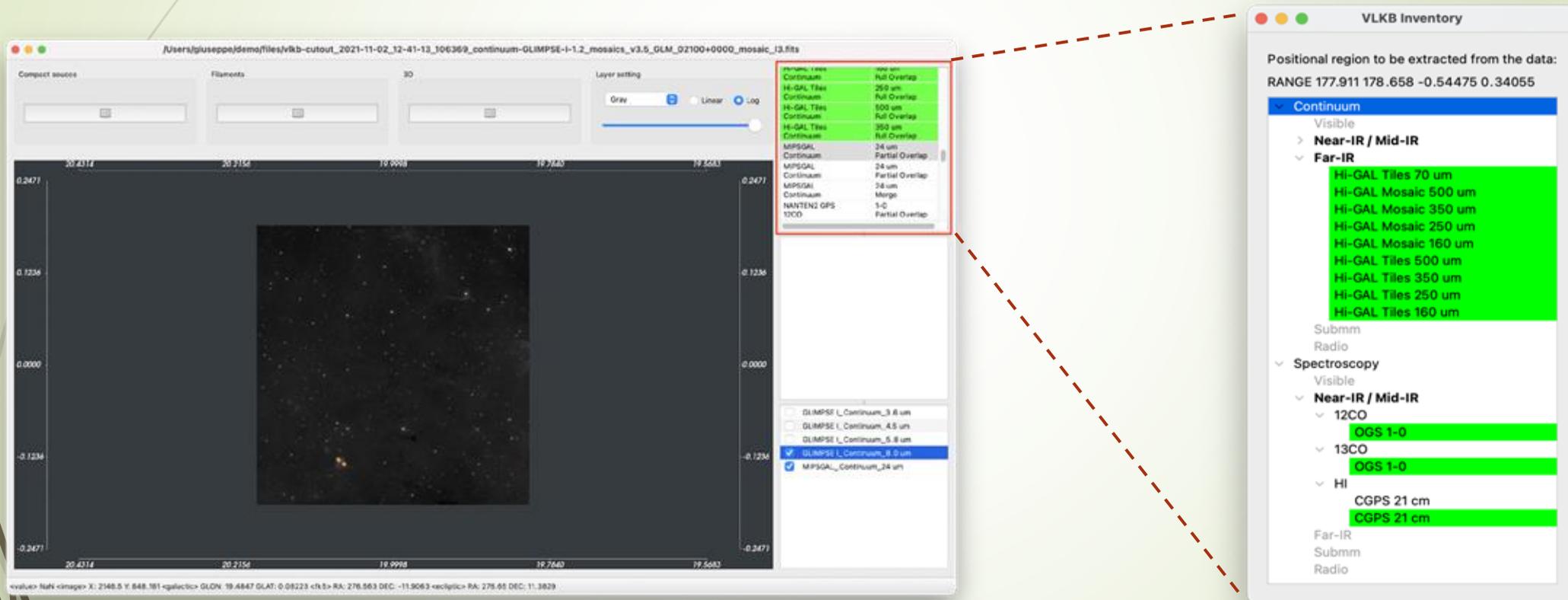
Supporting simulations data (AREPO)

Arepo is a numerical simulation code for gravitational N-body systems and magnetohydrodynamics, designed to model the formation and evolution of cosmic structures.

Arepo is optimized for, but not limited to, cosmological simulations of galaxy formation.

Added functionalities:
- to load Arepo simulation outputs (in HDF5 format),
- extract sub-cubes from snapshots,
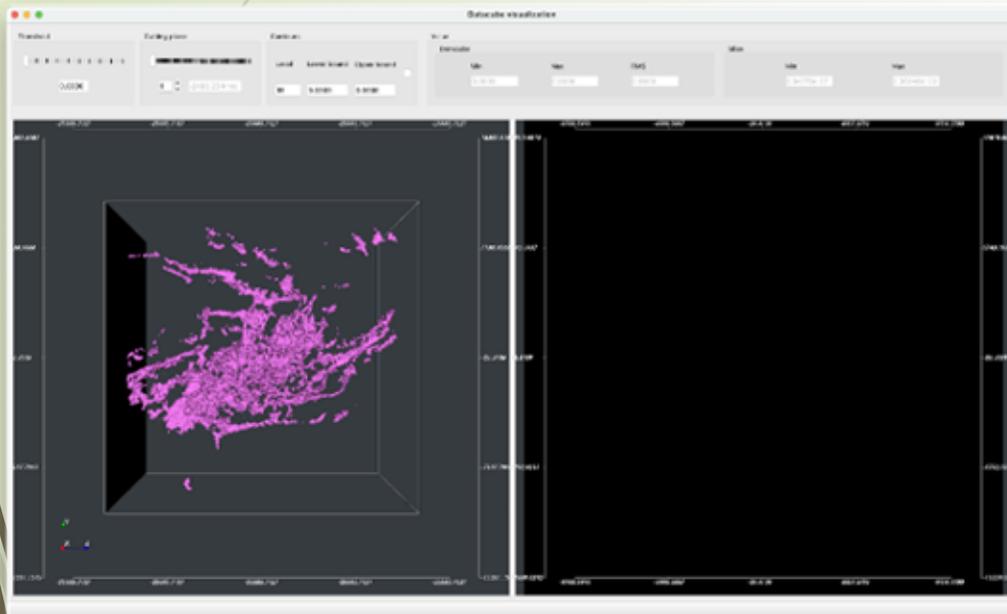
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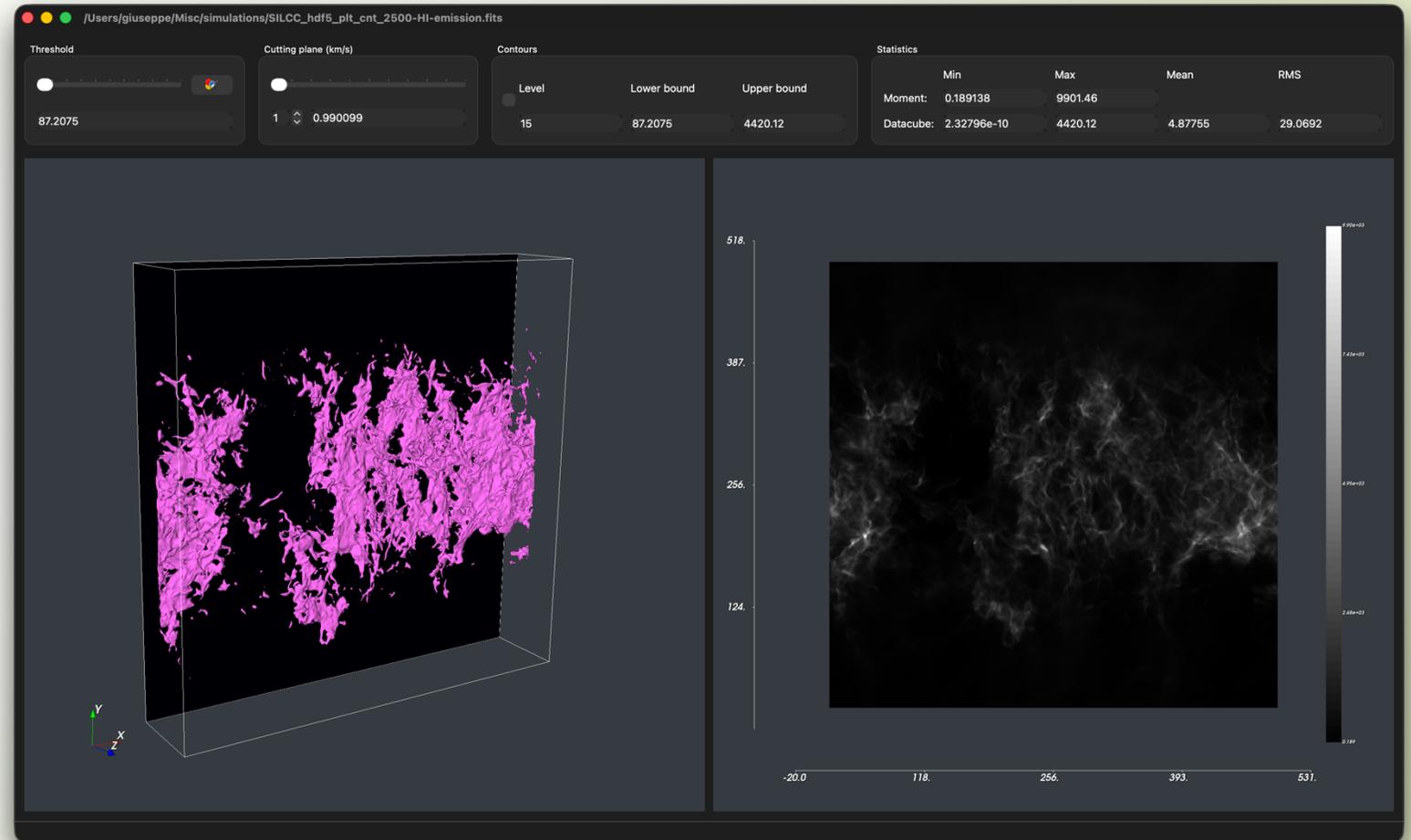
Added functionalities:
-   to load Arepo simulation outputs (in HDF5 format),
-   extract sub-cubes from snapshots,
-   convert to FITS,
-   visualize products.

Isosurface-based visualization

Surfaces representing constant scalar values in the volume.

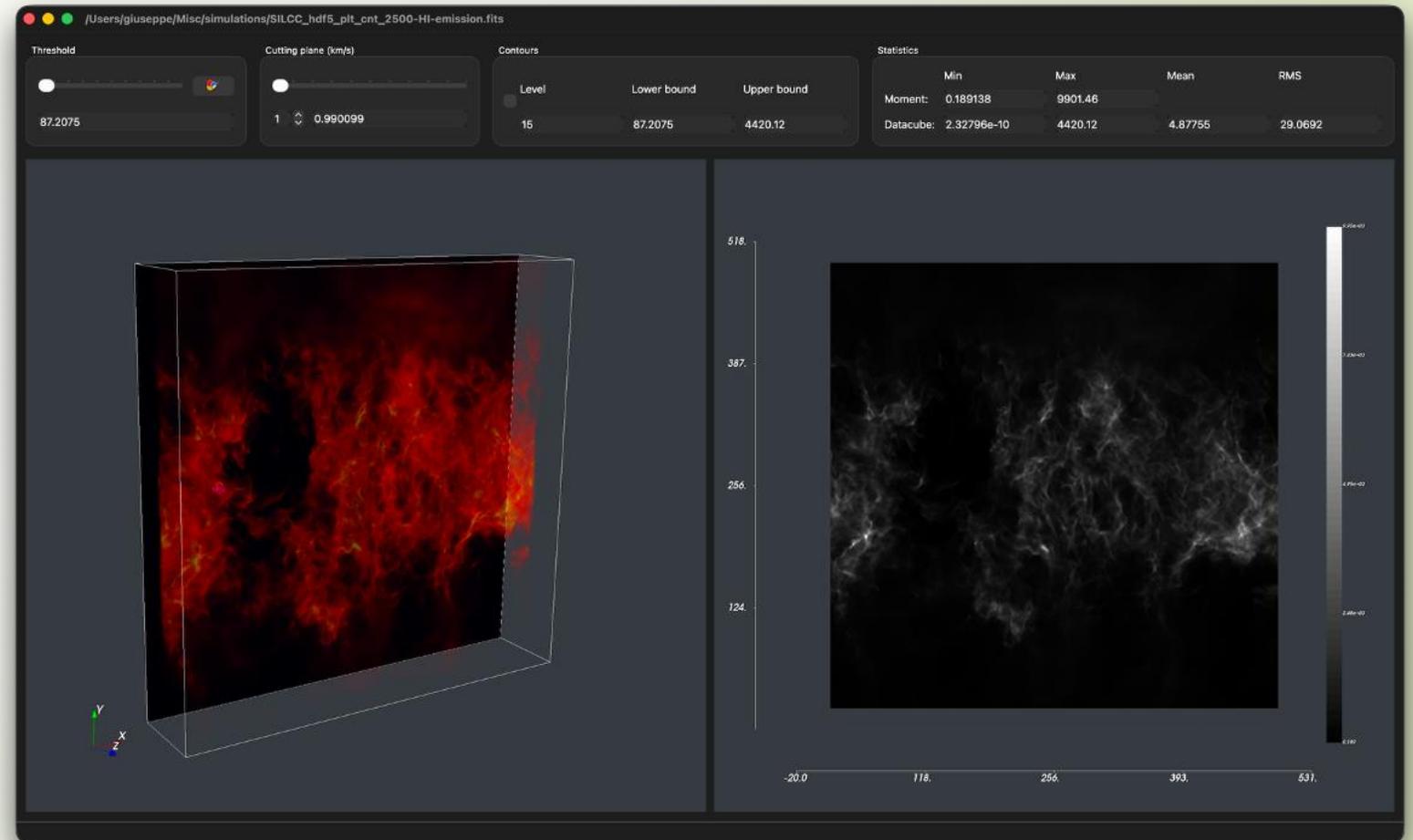Useful to highlight structures and interfaces in 3D data.

New volume rendering pipeline

Complements isosurface visualization.

Displays the full scalar field instead of extracted surfaces.

Reveals internal structures through color and opacity mapping.

Deployment on CANFAR Science Platform

Science Platforms are used for:

- **Scalable execution of containerized workloads on Kubernetes**, enabling efficient use of CPU/GPU resources for scientific, data-intensive, and AI/ML applications
- **Reproducible and portable environments**, using container technologies to ensure consistency across development, testing, and production
- **Automated orchestration and lifecycle management**, including job scheduling, pipelines, monitoring, and integration with distributed storage

VisIVO has been containerized for deployment on **CANFAR** SP (Canadian Advanced Network for Astronomical Research):
- Dynamically use node resources as needed
- Browser-native access
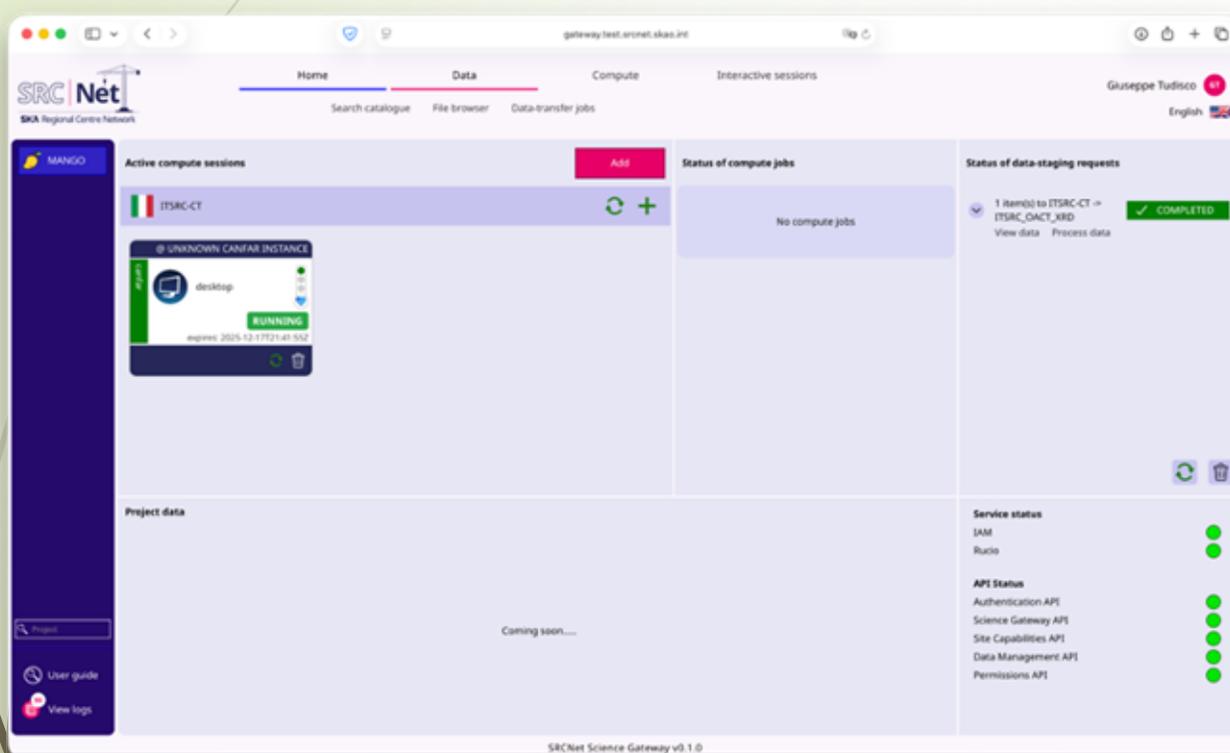- Integrated storage with cavern (VOSpace implementation)
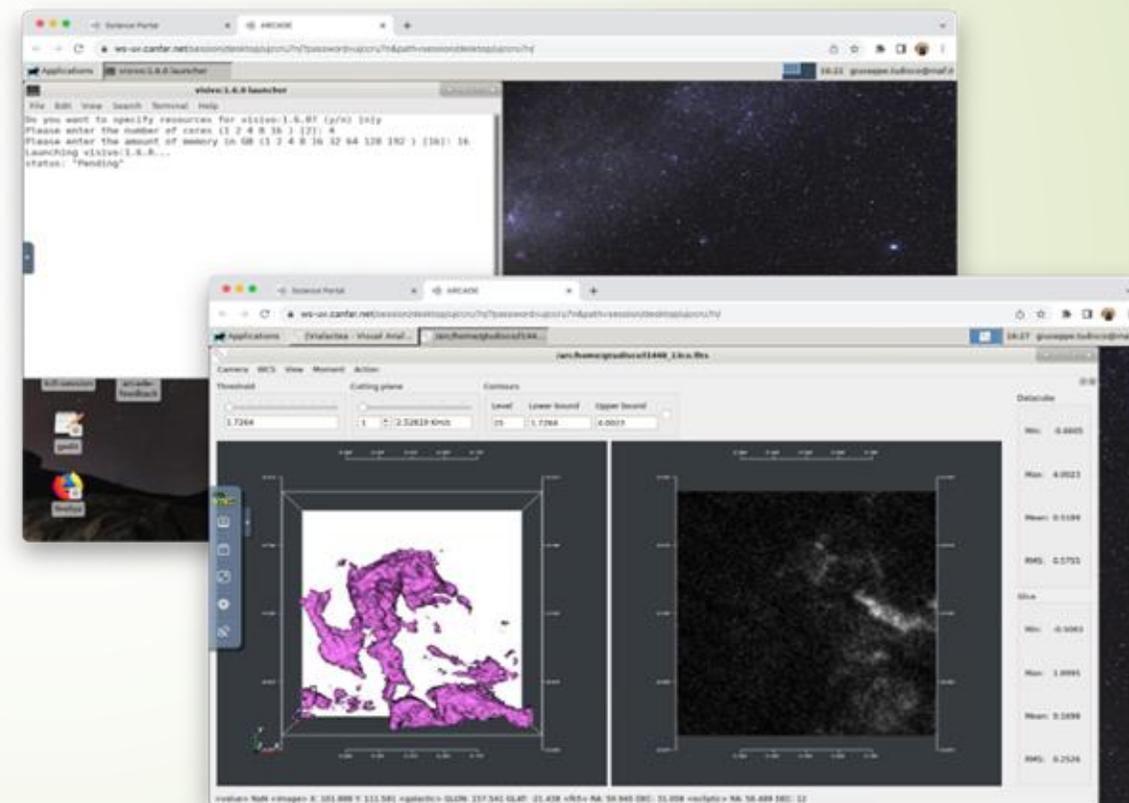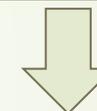
SRCNet v0.1 workflow
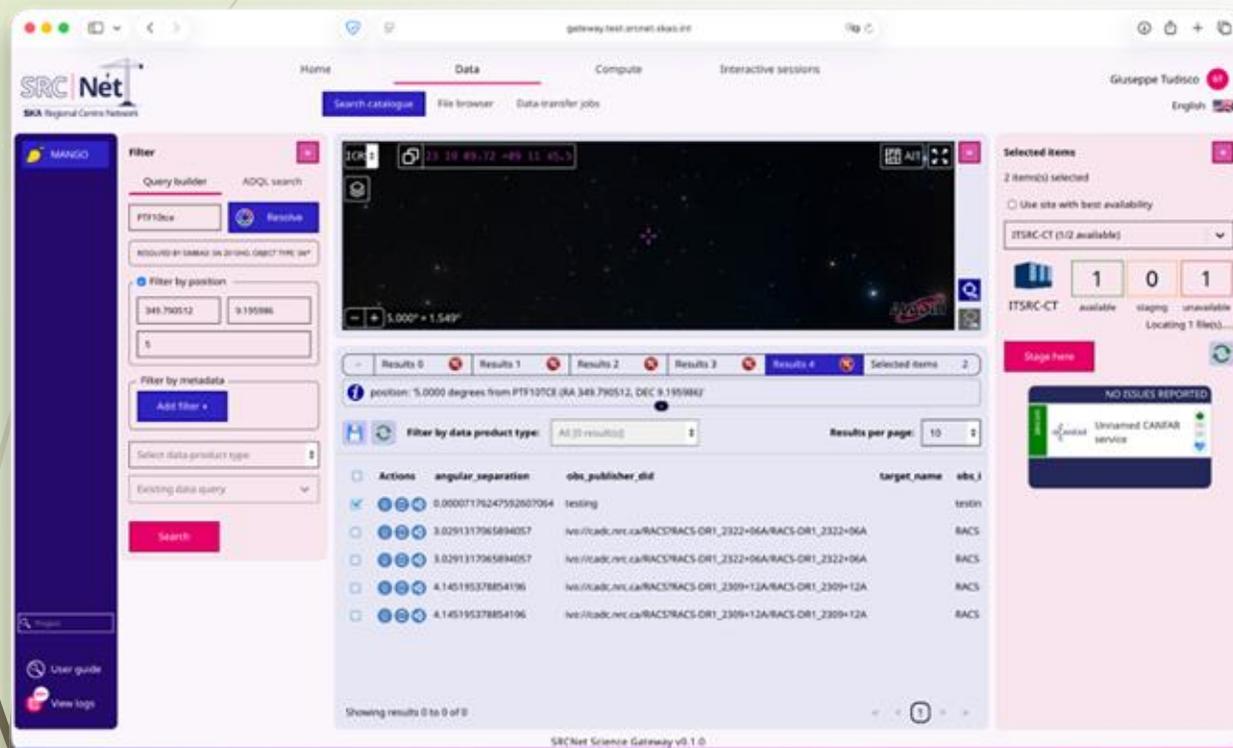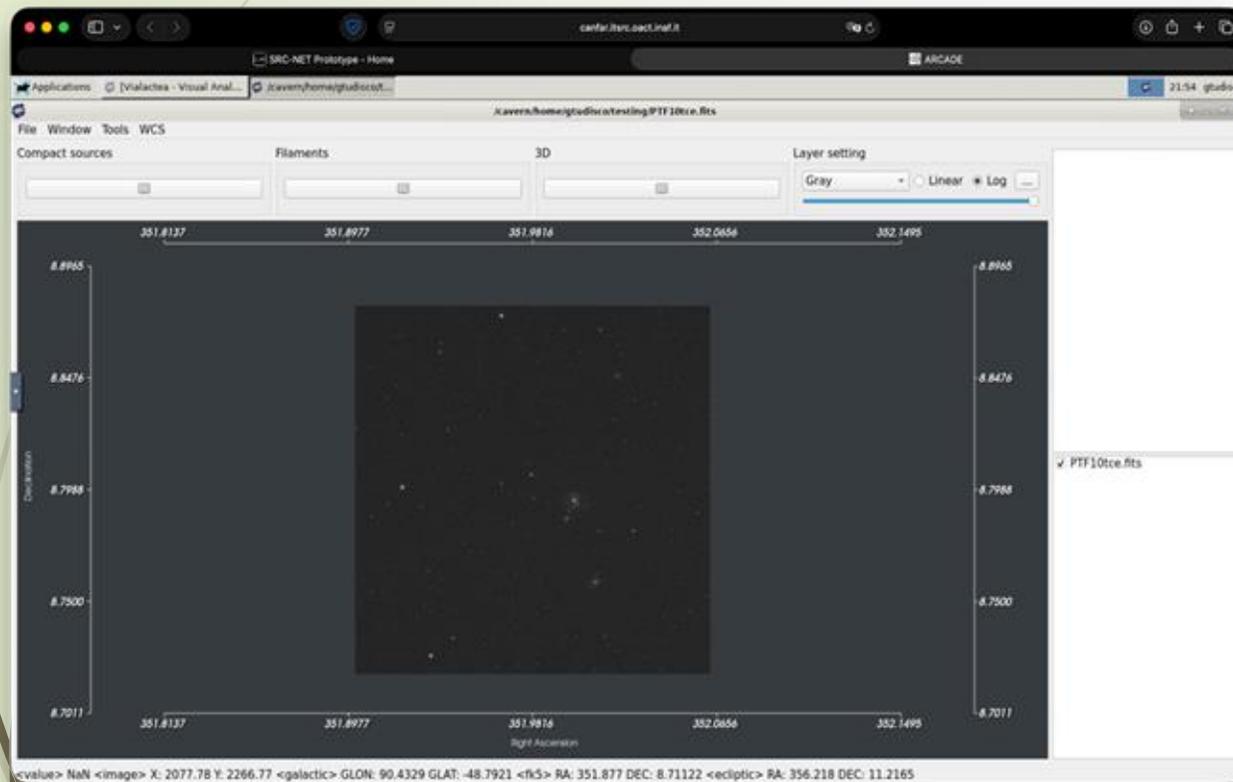

Data Discovery

SRCNet v0.1 workflow
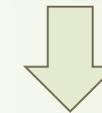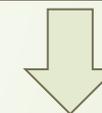

Data Discovery

Data Staging

SRCNet v0.1 workflow
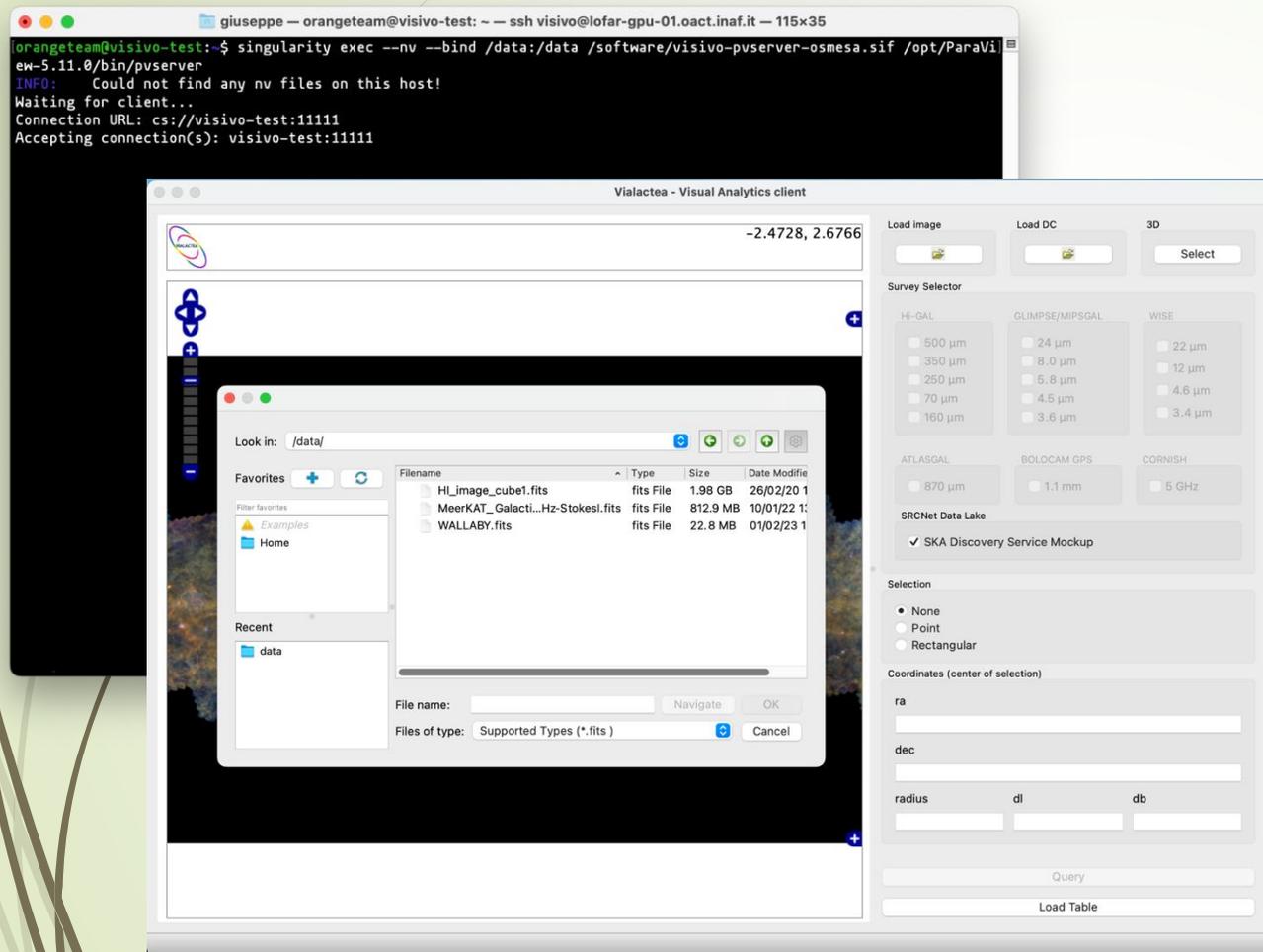

Data Discovery

Data Staging

Data Visualization

VisIVO ParaView flavour

Extends existing software design built with Qt (GUI) & VTK (visualization pipelines).
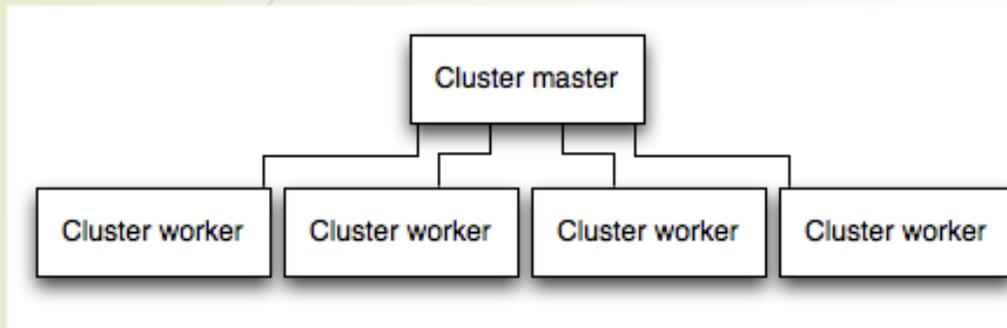
Based on ParaView model:
- a data server, to read and process datasets;
- a render server, which renders results;
- a client, responsible for user interface.

VisIVO ParaView flavour

Extended readers and filters with **MPI** and **vtkSMP** (STDThread, OpenMP, TBB) for enabling multi-thread and multi-node parallelisation


```
Function RequestData():
    // Get Data Extent assigned to this process
    ProcId ← ProcInfo.GetPartitionId();
    dataExtent[6], nels ← outVector.GetInformationObject(ProcId);
    // Allocate subcube
    ptr ← new float[nels];
    fptr ← fits_open(FileName, READONLY);
    // Read the extent from the FITS file
    firstP, lastP, inc ← GetExtentBounds(dataExtent, ScaleFactor);
    fits_read_subset(fptr, firstP, lastP, inc, ptr);
    // Set output
    data ← new vtkImageData;
    data.SetExtent(dataExtent);
    data.SetOrigin(0.0, 0.0, 0.0);
    data.SetSpacing(ScaleFactor, ScaleFactor, ScaleFactor);
    data.SetScalars(ptr);
    return data;
```
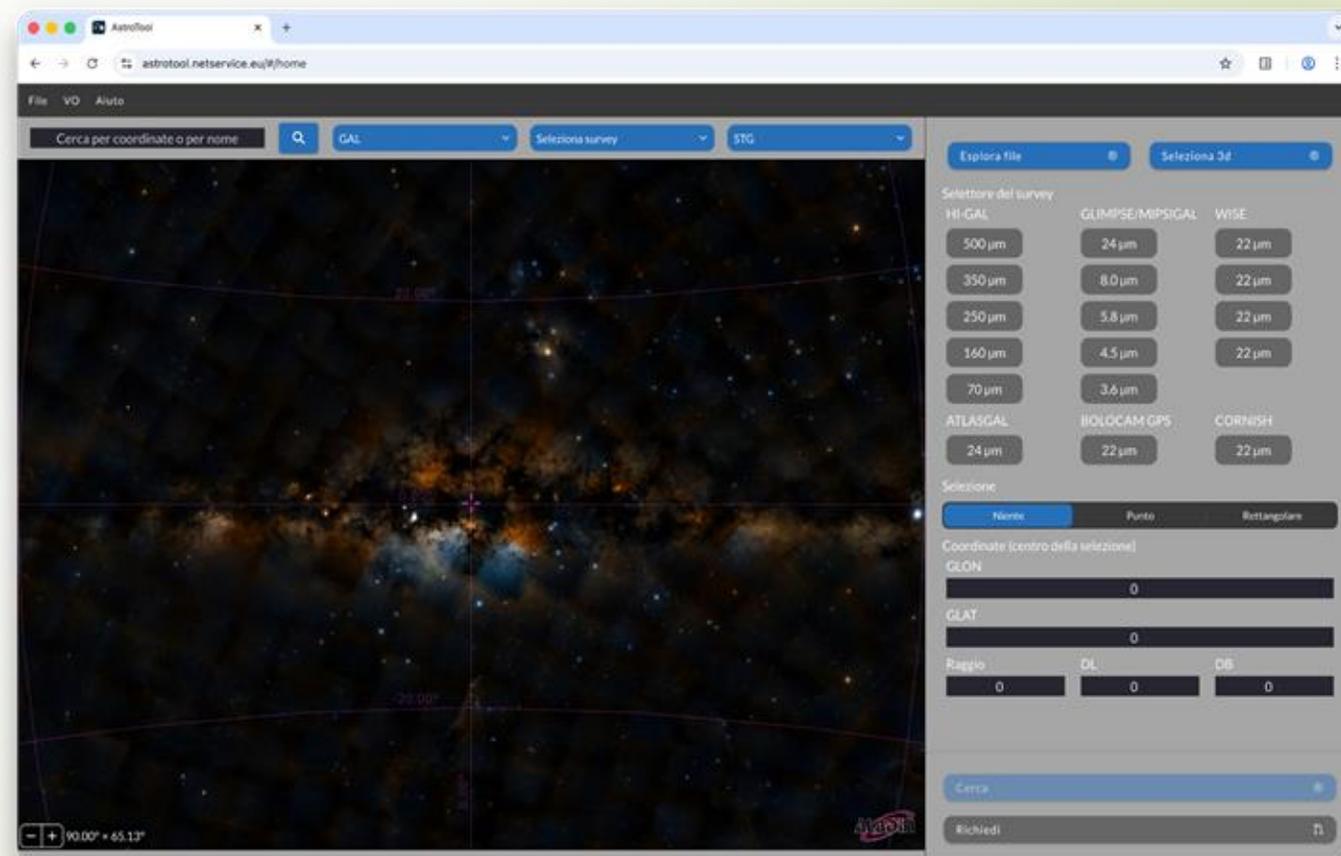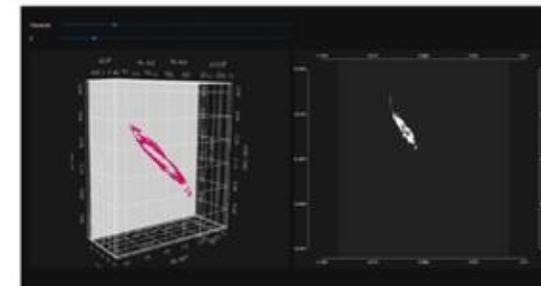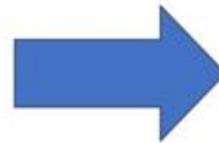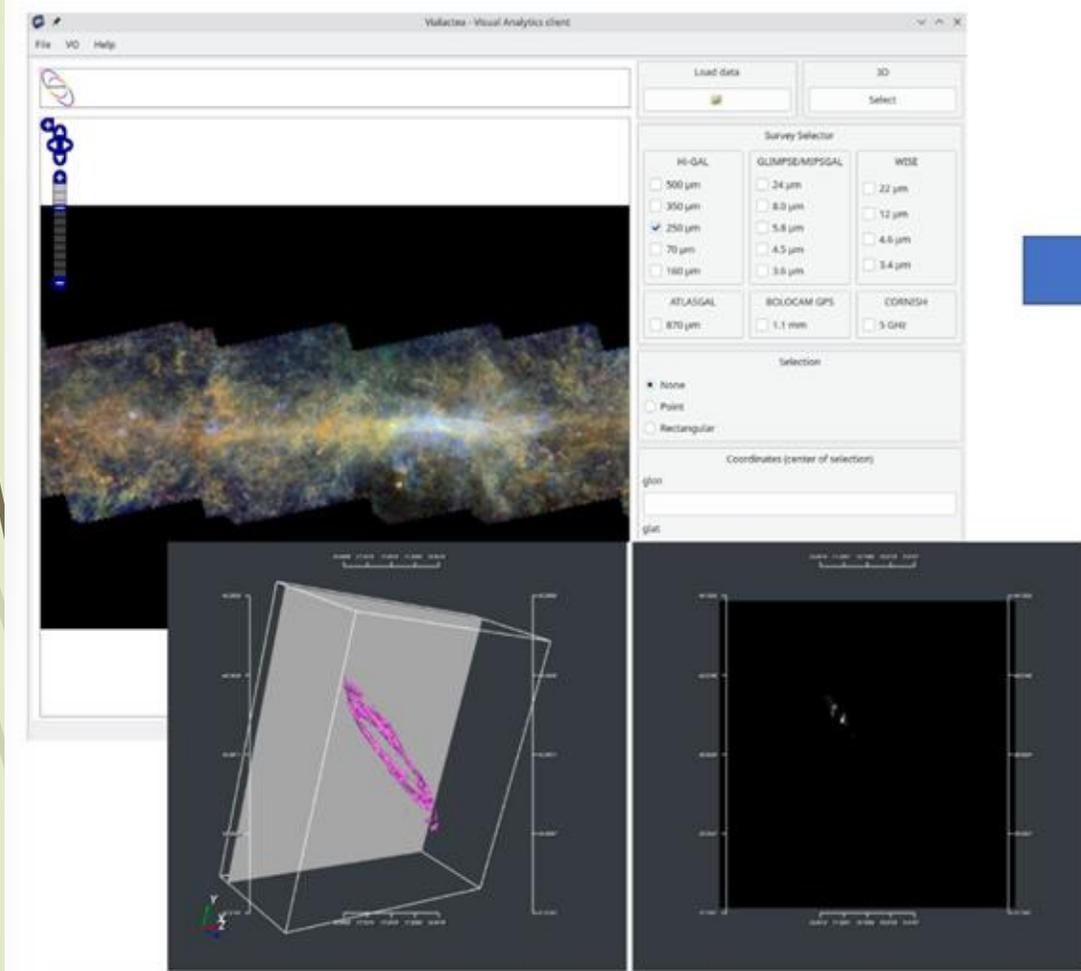
AstroTool Project
CN HPC, Big Data & QC Cascade Funding project

Main goals

- Achieve and validate a platform for **efficiently visualize** Astrophysical Big Data, using remote HPC resources,
- **easily customizable** to work in various Astrophysic Areas
- flexible enough to be **evolved and reuse** in Geophysical applications in the near future

AstroTool: revisited UI/UX

AstroTool Architecture
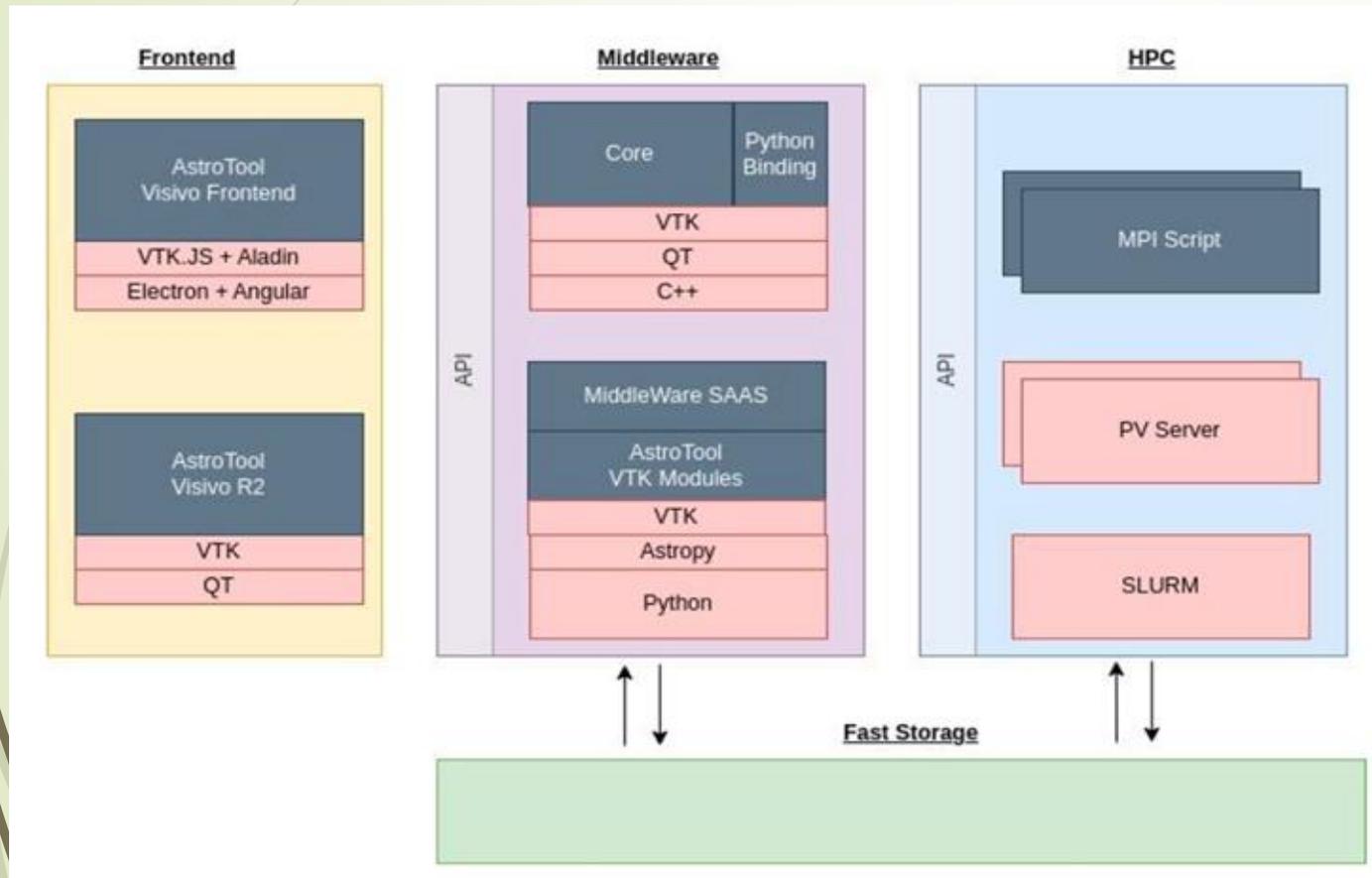
3-Layers Architecture:
- Client (Web Frontend and Electron app)
- Middleware (**Core libraries** & **HPC Connector**)
- HPC (**Pre-processing pipelines**)

Pre-generation of VTIs and compressed isosurfaces on HPC

AstroTool results

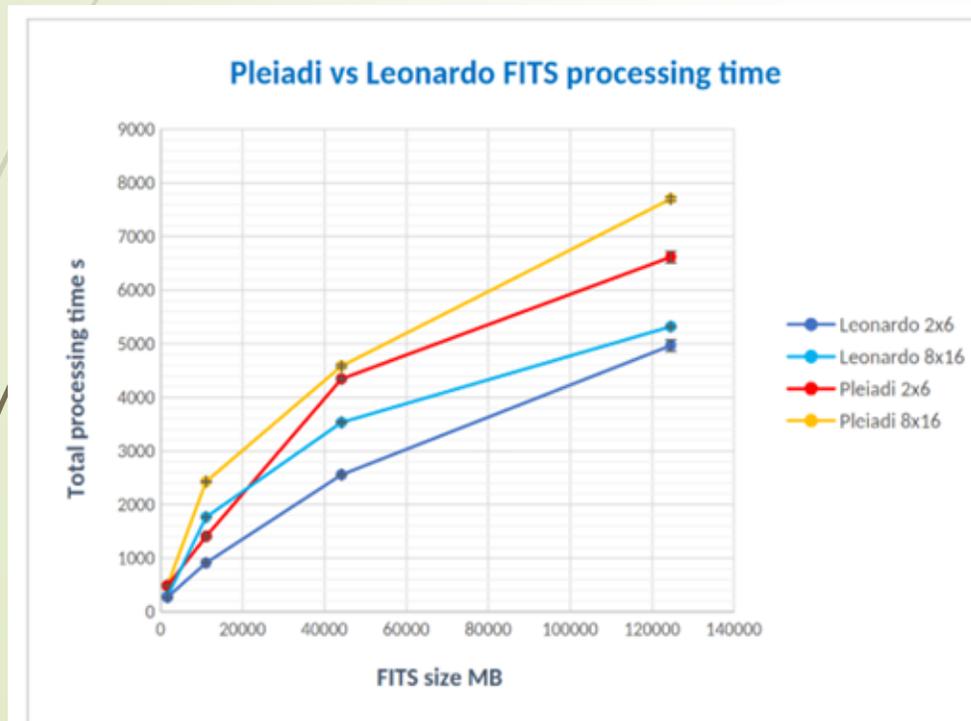Benchmarks on Pleiadi cluster (OACT) and Leonardo
Performance decreases on 8x16 configurations due to I/O overhead

Dataset	Extent	Size (MB)
ATCA	1046×952×398	1548
Sky	643×433×6668	11028
Sky40	1286x1286x6668	44110
Sky124	2001x2001x7776	124540.5

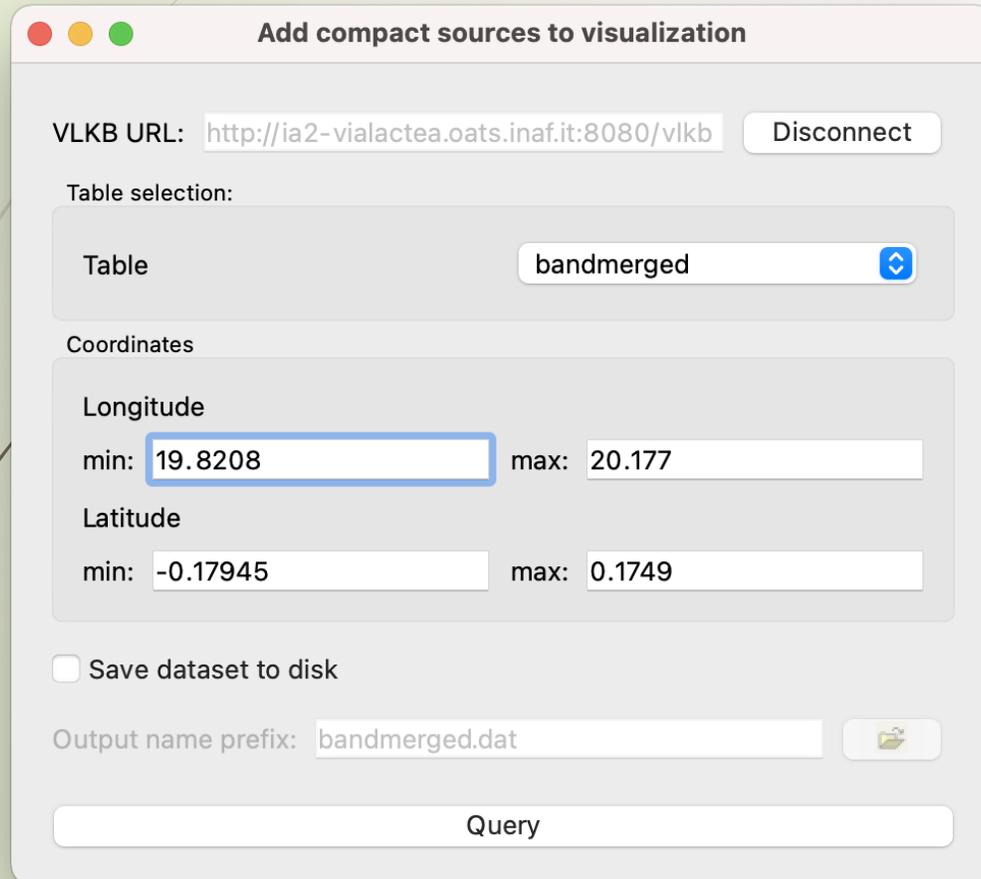# Feature roadmap: HiPS
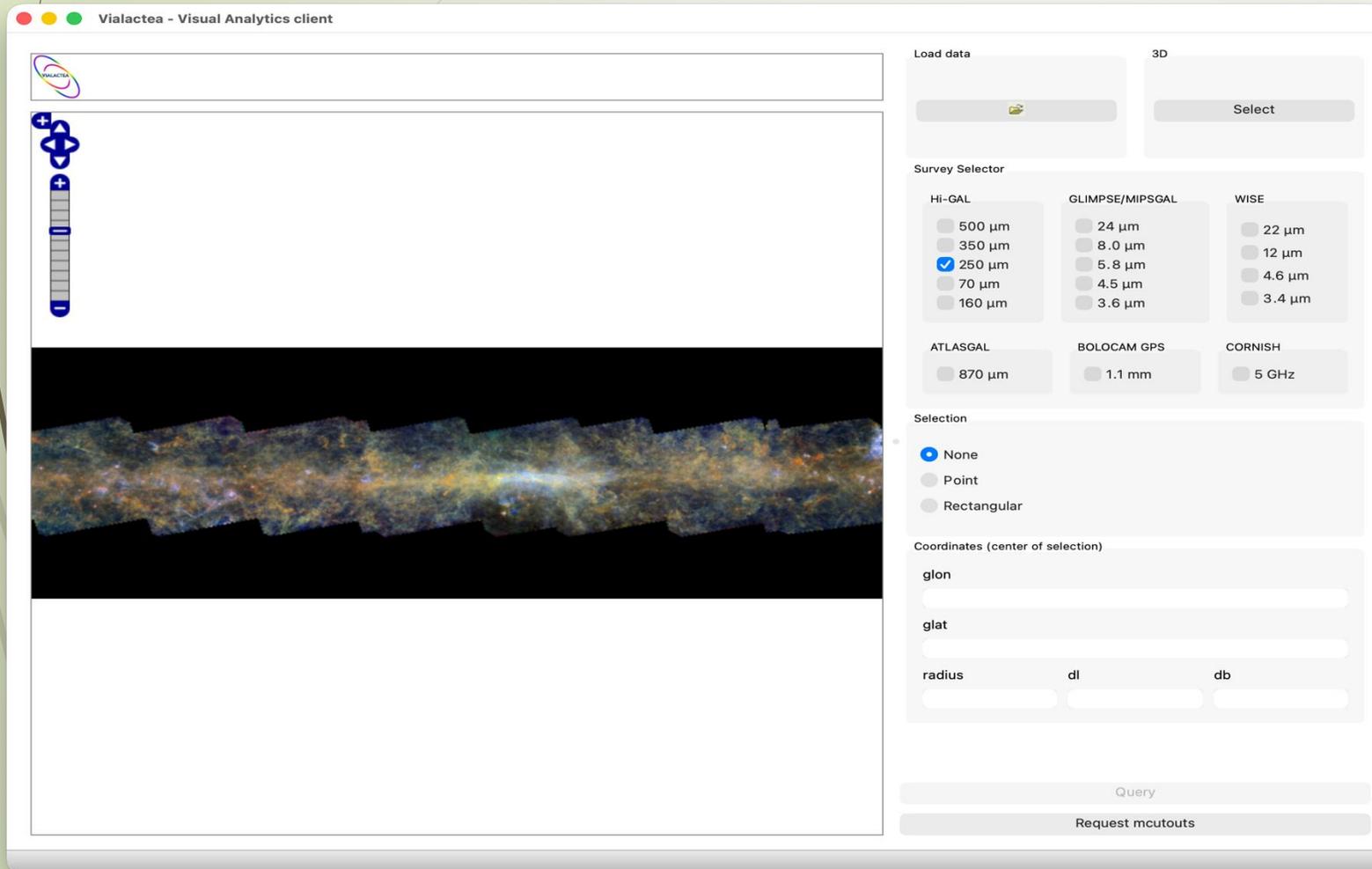
Redesign the main window

Replace Galactic Plane View with HiPS Visualizer

Feature roadmap: interact with external catalogues

Add compact sources to visualization

VLKB URL: http://ia2-vialactea.oats.inaf.it:8080/vlkb   Disconnect

Table selection:

Table   bandmerged

Coordinates

Longitude

min: 19.8208   max: 20.177

Latitude

min: -0.17945   max: 0.1749

☐ Save dataset to disk

Output name prefix: bandmerged.dat

Query

Currently limited to VLKB TAP.

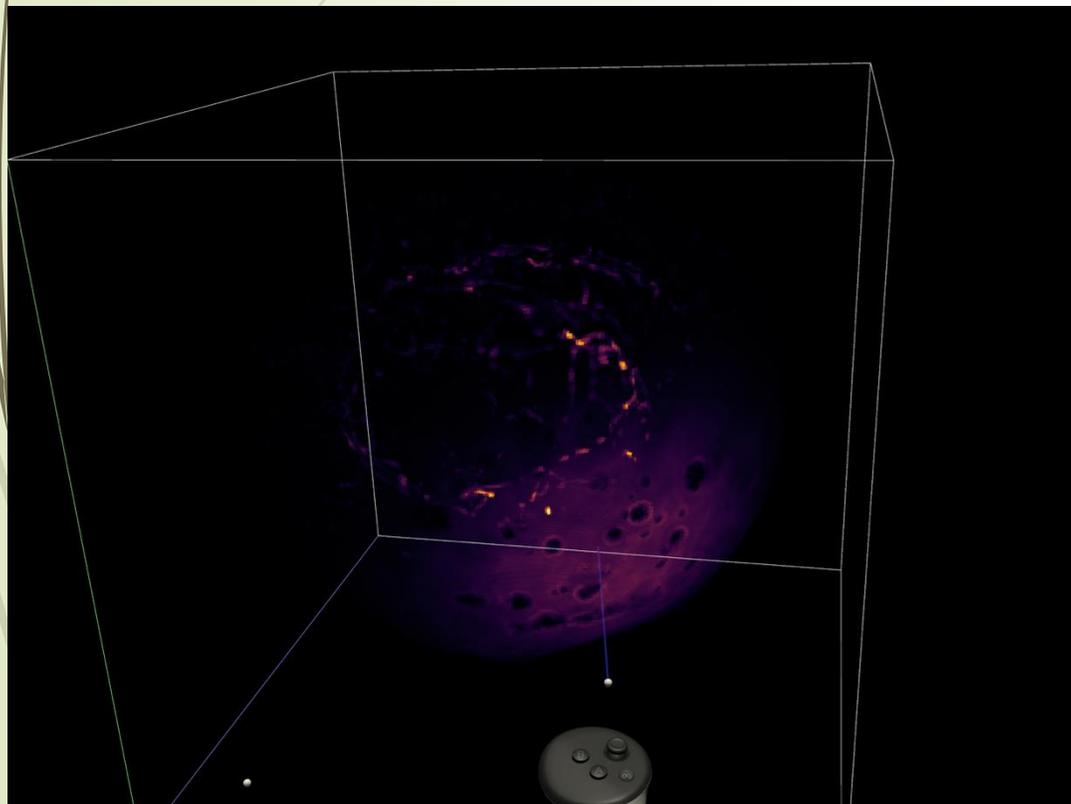Importing catalogues from external VO services.

Adding a catalogue editor.

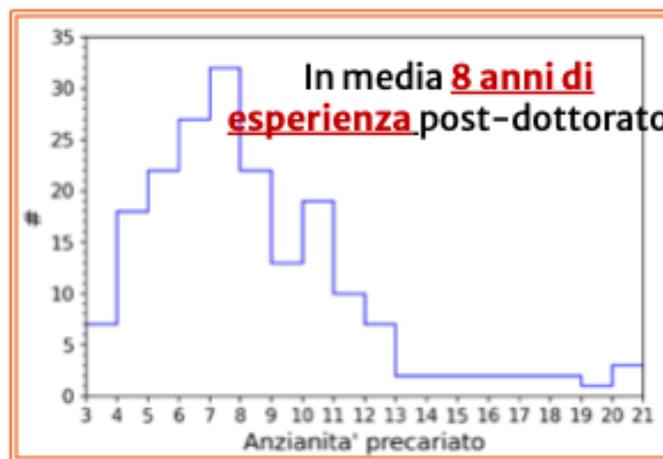Visualization laboratory at the Catania Astrophysical Observatory.

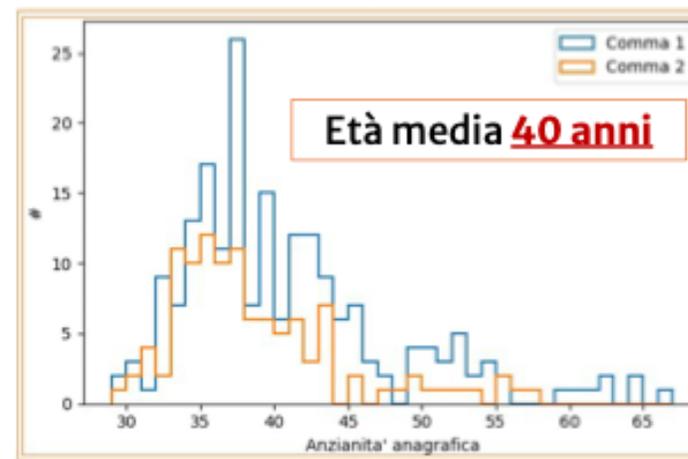Working also on VR Tools for immersive data analysis and visualization.

La situazione del personale precario in INAF è **INSOSTENIBILE**!

1.200 Tempo Indeterminato Vs 650 precari: più di 1 precario ogni 2 persone di ruolo

In media **8 anni di esperienza** post-dottorato

Età media **40 anni**

Plot di un campione rappresentativo dei precari INAF al 31/12/2024

Dei **650**, **287** possono essere stabilizzati:
173 tramite chiamata diretta (comma 1)
114 tramite concorsi riservati (comma 2)

Entro l'anno, l'attuale situazione determinerà l'esodo di > 100 lavoratori altamente qualificati e il MUR se ne lava le mani

È **URGENTE** che INAF **PROCEDA ORA** con le **STABILIZZAZIONI TRAMITE MADIA:** unica soluzione per questa emergenza

Molti colleghi (972) hanno già firmato, per sostenerci e aggiungere il nome alla lista del QR, contattaci a **retestabilizzandi1.inaf@gmail.com**

Thank you all for the attention