

NEANIAS Space - ViaLactea

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Introduction

New approaches to data processing, archiving, analysis and visualization are nowadays mandatory to deal with the data deluge expected in next-generation facilities for astronomy, such as the Square Kilometer Array¹ (SKA). The unprecedented data volumes produced by these facilities will demand not only enhanced visualization capabilities but also efficient extraction of meaningful knowledge, allowing for breakthrough discoveries. To address such needs, Visual Analytics (VA) has emerged as a novel approach to support interactive data exploration and analysis.

In this article we present **ViaLactea**, a Visual Analytics service tailored to the exploitation of multi-wavelength astrophysical surveys of the Galactic Plane to study the star formation process of the Milky Way.

ViaLactea

The **ViaLactea** service² aims to study the process of star formation in our galaxy, the Milky Way. The service consists of two main components: the ViaLactea Knowledge Base [1] and the ViaLactea Visual Analytics [2].

The ViaLactea Knowledge Base (**VLKB**) is a collection of databases, storage facilities and web services. The purpose of the VLKB is to collect meta-data about facilities and catalogs, observational data and the relationships

¹<https://www.skatelescope.org/>

²<https://thematic.neanias.eu/SPACE/space-vis.html>

between these data. The search, access and retrieval services for the resources are based on a service of the International Virtual Observatory Alliance (IVOA) through the Table Access Protocol³ (TAP). The TAP service provides access to information of catalogue content of the VLKB such as compact sources, filament structures and numerical Spectral Energy Distribution (SED) models. The scientific data inside the VLKB are accessible through dedicated search, cutout and merge services for 2D intensity images and 3D radial velocity cubes. The results are obtained in form of an XML file, then the FITS files can be obtained via HTTP connection using a web browser or a command line tool (like *curl*). The VLKB has been deployed to the cloud through the GARR cloud platform service to improve its scalability and portability. However, the VLKB services are not designed to be handled directly by the user but rather by the ViaLactea Visual Analytics.

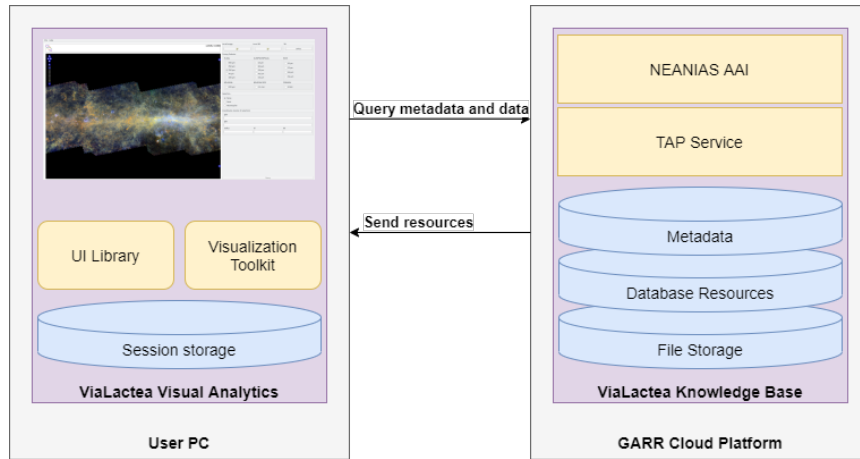


Figure 1: Interaction between the Visual Analytics and the Knowledge Base.

ViaLactea Visual Analytics⁴ (VLVA) is an open-source cross-platform desktop application implemented in C++ extended with the Qt libraries for the GUI and Visualization Toolkit (VTK) for rendering. A short introduction video is available on the official NEANIAS YouTube channel⁵. Precompiled binaries are available for Mac OS and Linux Ubuntu, but a Docker container is also provided for an easy installation on other systems. The tool communicates with the VLKB to obtain user-requested data and offers a visual analytics environment allowing the astronomers to conduct research activities on two-dimensional regions of space and three-dimensional data-cubes. A schematic of the architecture and interaction between VLVA and

³<https://www.ivoa.net/documents/TAP/>

⁴<https://github.com/NEANIAS-Space/ViaLacteaVisualAnalytics>

⁵<https://youtu.be/s4eBq8AFCUY>

VLKB is depicted in Fig. 1.

VLVA also enables the astronomers to work with local files while taking advantage of all the information the VLKB has to offer that corresponds to the region of the imported file. Indeed, the application allows to carry out correlation analysis on the data provided by the VLKB for a region of interest.

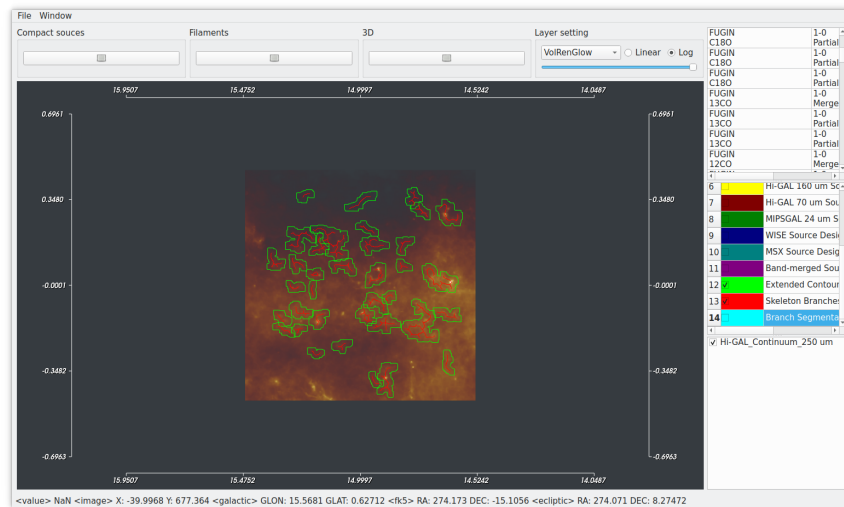


Figure 2: Image rendering with filaments obtained from VLKB

The screenshot in Fig. 2 shows some filament structures obtained from the VLKB using the region's coordinates as query parameters. The table on the top-right panel contains the VLKB items (continuum images and 3D datacubes) related to the visualized region of the space. Each item can be downloaded and visualized just by double-clicking on it.

Fig. 3 shows the visualization window for 3D datacubes. The window simultaneously renders the cube on the left side and the slice on the right side. There are input controls (e.g. slice selection) and basic information on the top panel.

Both VLVA and VLKB have been integrated with some of the services made available by the NEANIAS platform: the Authentication and Authorization Infrastructure (**AAI**), **Logging** and **Accounting** services. The NEANIAS AAI service provides authenticated and authorized access to specific VLKB surveys. The AAI service supports OpenID Connect and currently uses NEANIAS SSO as the Identity Provider. External users can also access the ViaLactea service through the NEANIAS Service Management System using their Microsoft or Google account. Future plans include the integra-

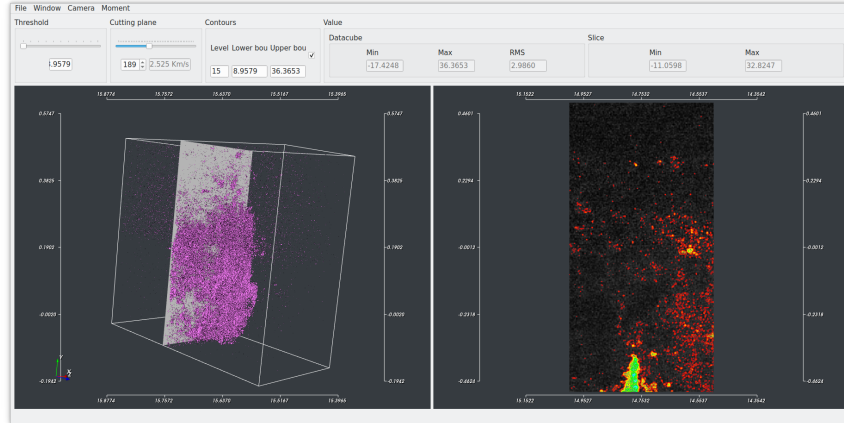


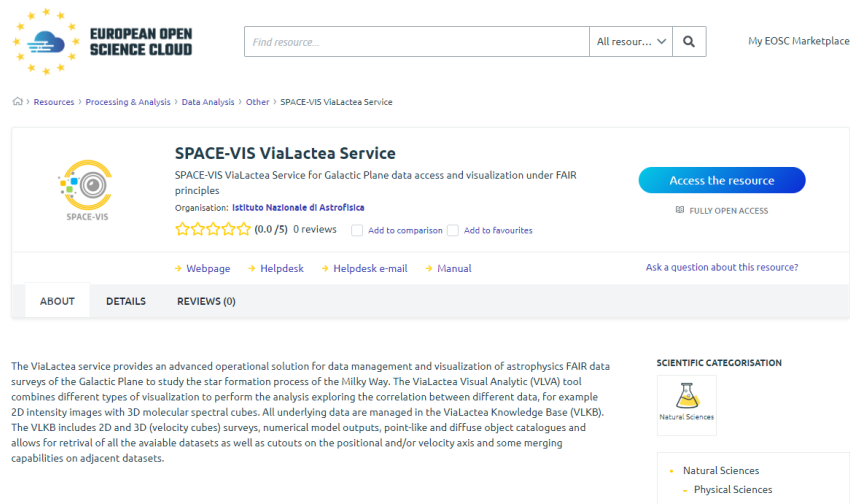
Figure 3: Datacube visualization

tion of EOSC AAI as a supported Identity Provider.

In order to keep track of the service usage, ViaLactea is also integrated with the NEANIAS Logging and Accounting services. These services are supported by the ELK stack (ElasticSearch, Logstash, and Kibana) and allow the NEANIAS services to collect the generated logs and accounting information in a simple and centralized way and to display them later through a web interface. The ViaLactea service, at the current state of integration, logs search, cutout and merge requests sent to the VLKB and the user who requested these operations. The user information is taken from the JWT token that the VLVA client obtains when the user logs in via NEANIAS AAI. The ViaLactea Service has been recently published to the EOSC platform⁶ (see Fig. 4).

The NEANIAS project is now halfway through its duration, during the second half the integration will be completed on the cloud. Future improvements for the ViaLactea service include a greater integration with the EOSC ecosystem, the use of Zenodo repository for open science, and the integration of CAESAR, a source finding service designed to extract and characterize compact and extended sources in radio map.

⁶<https://marketplace.eosc-portal.eu/services/space-vis-vialactea-service>



The screenshot shows the user interface of the SPACE-VIS ViaLactea Service on the European Open Science Cloud (EOSC) Marketplace. At the top, there is a navigation bar with the EOSC logo, a search bar, and a dropdown menu for 'All resour...'. Below the navigation bar, the breadcrumb trail reads: Resources > Processing & Analysis > Data Analysis > Other > SPACE-VIS ViaLactea Service.

The main content area features the SPACE-VIS logo, the service title 'SPACE-VIS ViaLactea Service', and a description: 'SPACE-VIS ViaLactea Service for Galactic Plane data access and visualization under FAIR principles'. The organization is listed as 'Istituto Nazionale di Astrofisica'. There is a rating of 0.0/5 with 0 reviews and options to 'Add to comparison' and 'Add to favourites'. A blue button labeled 'Access the resource' is prominently displayed, with a 'FULLY OPEN ACCESS' label below it.

Below the main content, there are tabs for 'ABOUT', 'DETAILS', and 'REVIEWS (0)'. The 'ABOUT' tab is selected. The text under this tab describes the service: 'The ViaLactea service provides an advanced operational solution for data management and visualization of astrophysics FAIR data surveys of the Galactic Plane to study the star formation process of the Milky Way. The ViaLactea Visual Analytic (VLA) tool combines different types of visualization to perform the analysis exploring the correlation between different data, for example 2D intensity images with 3D molecular spectral cubes. All underlying data are managed in the ViaLactea Knowledge Base (VLKB). The VLKB includes 2D and 3D (velocity cubes) surveys, numerical model outputs, point-like and diffuse object catalogues and allows for retrieval of all the available datasets as well as cutouts on the positional and/or velocity axis and some merging capabilities on adjacent datasets.'

On the right side, there is a 'SCIENTIFIC CATEGORISATION' section with a 'Natural Sciences' icon and a list of categories: 'Natural Sciences' and 'Physical Sciences'.

Figure 4: ViaLactea Service on the EOSC Marketplace

References

- [1] Marco Molinaro et al. "VIALACTEA knowledge base homogenizing access to Milky Way data". In: *Software and Cyberinfrastructure for Astronomy IV*. Vol. 9913. International Society for Optics and Photonics. 2016, 99130H.
- [2] F Vitello et al. "Vialactea visual analytics tool for star formation studies of the galactic plane". In: *Publications of the Astronomical Society of the Pacific* 130.990 (2018), p. 084503.