VisIVO Science Gateway

User Manual

VisIVO Team

INAF Osservatorio Astrofisico di Catania

Version 2.0

Table of Contents

About this manual

The **VisIVO Science Gateway User Manual** is a detailed guide and description of VisIVO Science Gateway at user level. The VisIVO Science Gateway, developed by INAF Osservatorio Astrofisico di Catania, supported by the SCI-BUS project[1] which provides the generic-purpose gateway technology as a toolset to access to the major computing, data and networking infrastructures and services in Europe including clusters, supercomputers, grids, desktop grids, academic and commercial clouds.

VisIVO Science Gateway is a web-based workflow-enabled portal for integrating large-scale multidimensional datasets and applications for visualization and data filtering on Distributed Computing Infrastructures (DCIs). Advanced users are enabled to create, change, invoke, and monitor workflows while standard users are provided with easy-to-use specific web based user interfaces hiding all the technical aspects of the visualization software and DCIs configurations and settings.

[1] http://www.sci-bus.eu/

Release Notes

Release Notes Version 2.0

The current version of the portal supports the usage of WS P-Grade/gUSE Version 3.5.2. It contains the following new portlets under the menu "Community":

- Muon Portal: this portlet was developed to support the Muon Portal project which aims at detecting nuclear threat carried into cargo containers exploiting the muon particles coming from the secondary radiation of the sun.
- LasMoG: this portlet was designed to submit a workflow comparing the modified gravity models (i.e. without introducing dark energy) with the standard dark energy models.
- FRANEC: this portlet was designed to run FRANEC numerical code. This code is perfectly suited for computing evolutions of stars on the basis of a number of different physical inputs and parameters.

Release Notes Version 1.0

The version 1.0 of the portal supports the usage of WS P-Grade/gUSE Version 3.4.4. It contains the following portlets:

- VisIVO Importer: converts user datasets into VisIVO Binary Tables (VBTs) internal format and extract all necessary meta data providing the dataset for further exploration to the portal.

- VisIVO Filters: converts imported datasets from an original data table into a new one performing several operations (e.g. can create a Volume from a table)

- VisIVO Viewer : display customized views of 3D renderings.

- Properties : displays the meta data of the imported datasets and produced images.

- Data Management : allows the management of imported datasets and produced images and movies and allows the navigation within the different services offered by the portal.

- Panoramic and Dynamic Movie : creates scientific movies starting from a produced image.

- Custom Movie : creates scientific movies starting from all produced images from an imported dataset.

1 Introduction

In astronomy visualization-based knowledge discovery occupies a critical role. Collaborative visualization enables multiple users to share a visualization experience interacting simultaneously with a dataset giving feedbacks on what the other participants are doing/seeing. Moreover, workflow-driven applications allow the reproduction of specific visualization results which represent a challenging task since the election of certain visualization parameter is not usually a straightforward process.

VisIVO Science Gateway is a web-based workflow-enabled framework for integrating large-scale multidimensional datasets and applications for visualization and data filtering on Distributed Computing Infrastructures (DCIs). Advanced users are enabled to create, change, invoke, and monitor workflows while standard users are provided with easy-to-use specific web based user interfaces hiding all the technical aspects of the visualization software and DCIs configurations and settings.

Cosmological simulations produce many-terabyte of datasets, and the highest-resolution simulation codes executed on next generation supercomputers will result in petabytes of data. Furthermore petabytes of observational data are already stored in archives (e.g. LSST, LOFAR or SDSS). Such data volumes pose significant challenges for data analysis, storage and access; and a critical step in understanding, interpreting, and verifying the outcome is represented by scientific visualization. Visualization is lead as an interactive process including qualitative, comparative and quantitative stages to analyze data, present results, and also to engage the public.

Gaining a comprehensive insight into large-scale multi-dimensional datasets typically requires very sophisticated statistical and data analysis algorithms. Often, several data exploration and visualization tools are employed for visual discoveries in order to identify regions of interest. These stages involve distributed data and computing resources and require collaboration among astrophysicists. Recently, scientific workflows have become a popular approach to model and organize such kind of processes explicitly specifying the dependencies between processes within an experiment and orchestrating the distributed resources.

2 Main goal

VisIVO Science Gateway is developed on top of WS-PGRADE, an highly flexible, cooperative, graphical user interface for the grid User Support Environment. The gateway provides access to VisIVO Server tools, enabling the execution of a comprehensive collection of modules for processing and visualization of astrophysical datasets on DCIs. Several customized workflows were configured to allow different basic tasks such as datasets local or remote upload and creation of scientific movies. These workflows are provided with specific user interface portlets to enable easy parameter setting for standard users to hide the complexity of the underlaying system and infrastructure. The advanced users are able to adapt the basic workflows to his/her specific problem. This modularity, achieved by subdividing the workflow into different tasks, ensures the re-usability of the subtasks and provides more flexibility for the user.

The gateway is connected to data repositories and workflows via a mobile application for astrophysical visualization named VisIVO Mobile. The mobile application share the same accounts of the gateway and offers research groups and communities an exciting possibility to share results and experiences of analysis and exploration of astrophysical datasets within a collaborative visualization environment.

2.1 WS-PGrade/gUSE

WS-PGRADE/gUSE provides a collaborative, community-oriented application development environment, where developers and end users can share layered and parameter sweep enabled workflows, workflow graphs, workflow templates, and ready-to-run workflow applications via a repository. It is integrated with the popular portal framework Liferay which is highly customizable thanks to the adoption of the portlet technology defined in the Java Specification Request (JSR 168 and 286) and it is compatible with the most modern web applications.

gUSE is a virtualization environment providing a large set of high-level Distributed Computing Infrastructures (DCI) services by which interoperation among classical service and desktop grids, clouds and clusters, unique web services, and user communities can be achieved in a scalable way. Internally, gUSE is implemented as set of Web services, which dynamically provide user services in DCI and/or Web services environments.

WS-PGRADE uses the client APIs of gUSE services to turn user requests into sequences of gUSE specific Web service calls. WS-PGRADE hides the communication protocols and sequences behind portlets and its GUI can be accessed via Web browsers.

Please refer to WS-PGRADE/gUSE web page and sourceforge project for a detailed users' guide. The tools to create, configure and submit workflows are available into VisIVO Gateway under the "Advanced Tools" menu.

2.2 VisIVO Tools

VisIVO is an integrated suite of tools and services for effective visual discovery in currently available (and next-generation) large-scale astrophysical datasets.

VisIVO consists of VisiVO Desktop - a stand alone application for interactive visualization on standard PCs, and VisIVO Server - a grid-enabled platform for high performance visualization.

The main characteristic of VisIVO is to support high-performance, multidimensional visualization of very large-scale astrophysical datasets. Users can obtain meaningful visualizations rapidly while preserving full and intuitive control of the relevant visualization parameters. This section focuses on VisIVO Server allowing intuitive visual discovery with 3D views being created from data tables. VisIVO Server can be installed easily on any web server with a database repository.

VisIVO Server consists of three core components: VisIVO Importer, VisiVO Filter and VisIVO Viewer. To create customized views of 3D renderings from astrophysical data tables, a two-stage process is employed. First, VisIVO Importer is utilized to convert user datasets into VisIVO Binary Tables (VBTs). Then, VisIVO Viewer is invoked to display customized views of 3D renderings.

A VBT is a highly-efficient data representation realized through an header file (extension .bin.head) containing all necessary metadata, and a raw data file (extension .bin) storing actual data values.

VisIVO Importer converts user-supplied datasets into VBTs without imposing any limits on sizes or dimensionality. It supports conversion from several popular formats such as: ASCII and CSV, VOTables or FITS Tables. VisIVO Filter is a collection of data processing modules to modify a VBT or to create a new VBT from existing VBTs. The filters support a range of operations such as scalar distribution, mathematical operations or selections of regions. For example decimation or randomization are typically employed for constructing reduced VBTs to perform a sub-sampling in order to fit it in the available RAM memory. VisIVO Viewer is based on the Visualization ToolKit library for multidimensional visualization. It creates 3D images of datasets rendering points, volumes and isosurfaces within a bounding box used for representing the coordinate system employed. Moreover there is support for customized look up tables for visualization using a variety of glyphs, such as cubes, spheres or cones.

The VisIVO Library was developed to port VisIVO Server on gLite middleware. It allows a job running on a grid node to produce a set of images or movies directly using VisIVO with its internal data arrays without the need to produce intermediate files. This is particularly important when running on the grid, where the user wants to have a quick look of the results during the data production phase. The images in this way can be produced directly in the grid catalogue, while the user code is running in a system that cannot be directly accessed by the user (a worker node).

3 Who can use the portal

VisIVO Science Gateway is suited for scientists aiming to investigate large-scale datasets with the possibility to create movies and complex views of multidimensional datasets.

VisIVO Gateway offers new, exciting and easily accessible opportunities not only to specialized users, e.g. astrophysical researchers, but also to the wider public, e.g. high-school education or innovative citizen science for new scientific developments.

3.1 Registering and logging in

The VisIVO Science Gateway offers role-based authorization modules and supports the login with user name and password.

Users can also login using their Facebook or OpenID accounts.

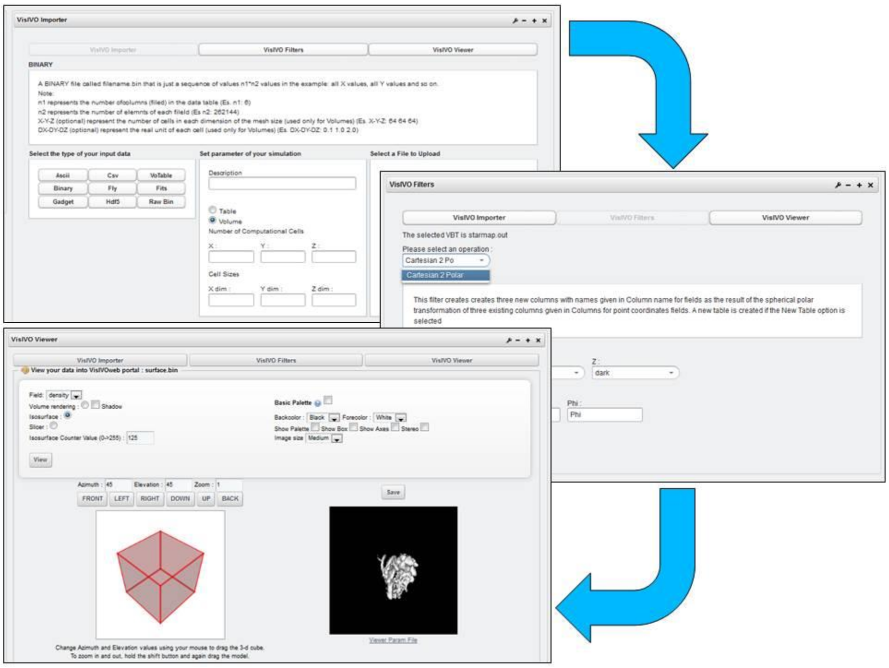
Three main roles are provided: guests, standard and advanced users.

Guests lack of any account for the science gateway. However, they can obtain information about the VisIVO project and the main features offered by the gateway. A new account for standard and advanced user can be created by an unknown user or an existing Facebook or OpenId account can be leveraged to access the portal.

Standard users are enabled to choose pre-defined workflows to become acquainted to the tools and specific workflows. The latter are offered via intuitive graphical user interfaces which lowers the barrier for utilizing the tools as well as using them on high-performance computing facilities and DCIs. The users are allowed to change input and parameters, to invoke and monitor workflows.

Advanced users can access to additional features to create and change workflows and to set configurations of grid infrastructures. These tools are also available to standard users to not pose any a priori limitation on the workflow technology usage.

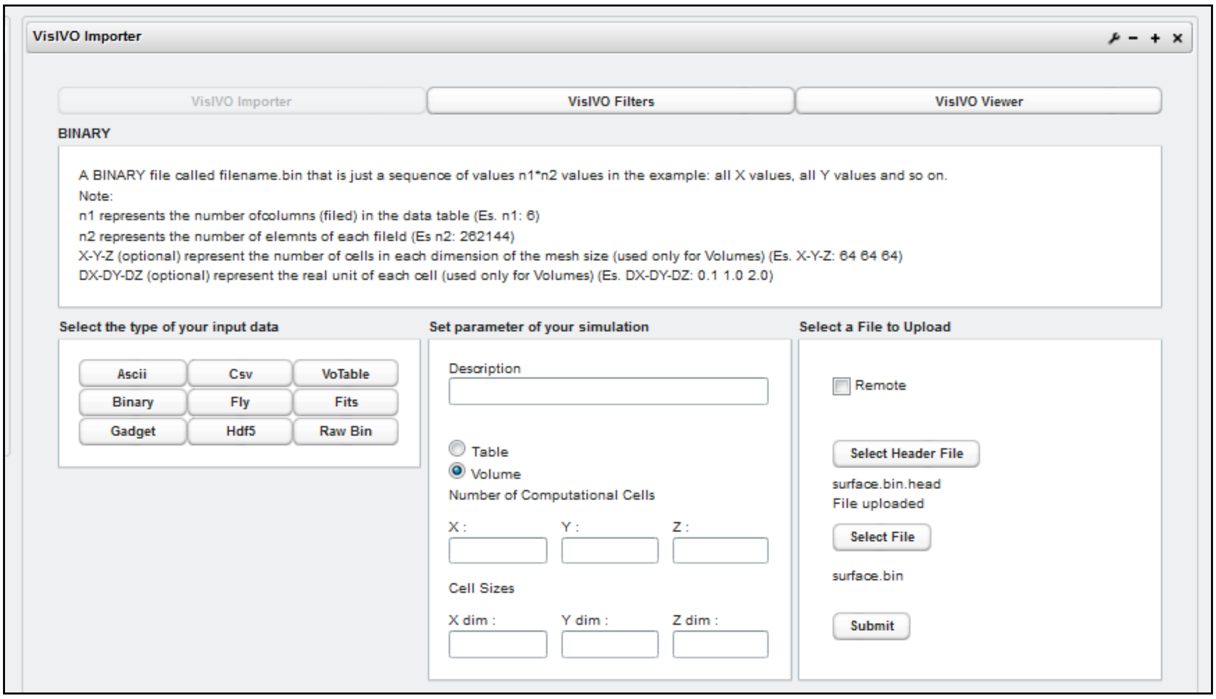
Standard users can upload and manage their datasets through portlets without any knowledge about the totally hidden grid-infrastructure and middleware. By using interactive widgets user can construct customized renderings, or storing data analysis and visualization results for future reference. The datasets are managed internally through a relational database for preserving their metadata and maintaining data consistency. Figure below shows the main portlets of the Gateway connecting to VisIVO Importer, Filters and Viewer services accessible by the menu "VisIVO Tools".



4 Using the portal

4.1 VisIVO Importer

VisIVO Importer converts user-supplied datasets into a VBT. VBTs are used by VisIVO Filters for data processing and the VisIVO Viewer for display. The conversion is independent of data dimensionality.



The following file formats can be imported:

ASCII files are expected to be in tabular form. An ASCII file may contain values for N variables organized in columns. The columns are typically separated by whitespace characters, e.g. spaces or tabs. The first row of an ASCII file lists the N variables names explicitly.

CSV is a delimited data format that has fields/columns separated by the comma character and records/rows separated by newlines. Fields that contain a special character (such as comma, newline, or double quote) must be enclosed in double quotes. However, if a line contains a single entry that happens to be the empty string, it may be enclosed in double quotes. If a field's value is a double quote character, this is dealt with by placing another double quote character next to it. The CSV file format does not require a specific character encoding, byte order, or line terminator format.

NOTE: The Importer automatically skips all the lines starting with # character. If the first line contains column names starting with #, this character will be removed, and the columns names will be given without it.

Binary format is supposed to be the Internal Binary Table. Assuming that a VBT is to be processed. Note that the files VBTUserFileName.bin and VBTUserFileName.bin.head must be (either local or remote) existing files. In case this header file resides remotely, a complete copy is created within the VisIVO Server output directory.

FLY is code that uses the tree N-body method, for three-dimensional self-gravitating collisionless systems evolution. FLY is a fully parallel code based on the tree Barnes-Hut algorithm; periodical boundary conditions are implemented by means of the Ewald summation technique.
FLY is based on the one-side communication paradigm for sharing data among processors, accessing remotely private data without synchronism.
The FLY output format is a binary sequence of values of n data points as follows: X1,Y1,Z1, X2,Y2,Z2 ,.... Xn,Yn,Zn, Vx1,Vy1,Vz1, Vx2,Vy2,Vz2, ... Vxn,Vyn,Vzn.

FITS table format is a codification into a formal standard, by the NASA/Science Office of Standards and Technology (NOST), of the FITS rules (http://fits.gsfc.nasa.gov) endorsed by the IAU. FITS supports tabular data with named columns and multidimensional rows. Both binary and ASCII FITS table versions have been specified. The data in a column of a FITS table can be in a different format from the data in other columns. Together with the ability to string multiple header/data blocks together, by using FITS files it is possible to represent entire relational databases.

GADGET is freely-available code for cosmological N-body/SPH simulations on massively parallel computers with distributed memory. GADGET uses an explicit communication model that is implemented with the standardized MPI communication interface. The code can be run on essentially all supercomputer systems presently in use, including clusters of workstations or individual PCs. VisIVO Importer will produce a VBT for each species in the gadget file supplied.

The HDF5 FORMAT (hierarchical Data Format) is a library and multi-object file format for the transfer of graphical and numerical data between computers. It was created by the NCSA, but is currently maintained by The HDF Group. The freely available HDF distribution consists of the library, command-line utilities, test suite source, Java interface, and the Java-based HDF Viewer (HDFView). HDF supports several different data models, including multidimensional arrays, raster images, and tables. Each defines a specific aggregate data type and provides an API for reading, writing, and organizing data and metadata. New data models can be added by the HDF developers or users. This importer can be used with the datasetlist option. When the datasetlist option is not given all datasets in the hdf5 will be considered forming the VBT.

The options must be given as follows:

The **hyperslab** option must be given as:
nameOfDataset offset count
where offset and counts are the same of the hdf5 file and must be comma separated values.
If count exceeds the size of dataset, it is automatically adjusted up to the end of hyperslab.
If offset and/or count contains lower values than the dataset dimension, not specified ***offset*** are put to **0** and ***count*** to the **dimension** of the dataset. But this fact could give some unexpected behaviors and it is **strongly recommended** giving all parameters of offset and dimension.

The offset and dimension values must be equal to the number of rank. If rank=3 offset/dimension must contain 3 separated comma values (one for each rank) if offset/dimension contains only two values the third value is assumed to be equal to the size of the dataset.

NOTE: in case of volume with more than one hyperslab: users are strongly suggested to give the same hyperlab extension (count). In case of volume with specified hyperslab the – computational cells x-y-z values are ignored. Datasets with different numbers of rows will

produce columns with the number of rows equal to the maximum number of rows. The rows will be pads with ***missingvalue*** parameter. Datasets with rank greater than 1000 cannot be read.
Datasets can represent tables or volumes. If a dataset represents a volume the dataset rank **must** be equal to 3 and the *--volume* option must be given.

A table dataset with rank > 1 will produce different columns in the VBT. If a dataset is a table and it has rank=3 and hyperslab offset=0,0,0 count=15,10,1000, it will produce 15*10 columns each having 1000 elements. The columns names will be datasetname_0_0 datasetname_0_1 datasetname_0_2.... datasetname_14_9.

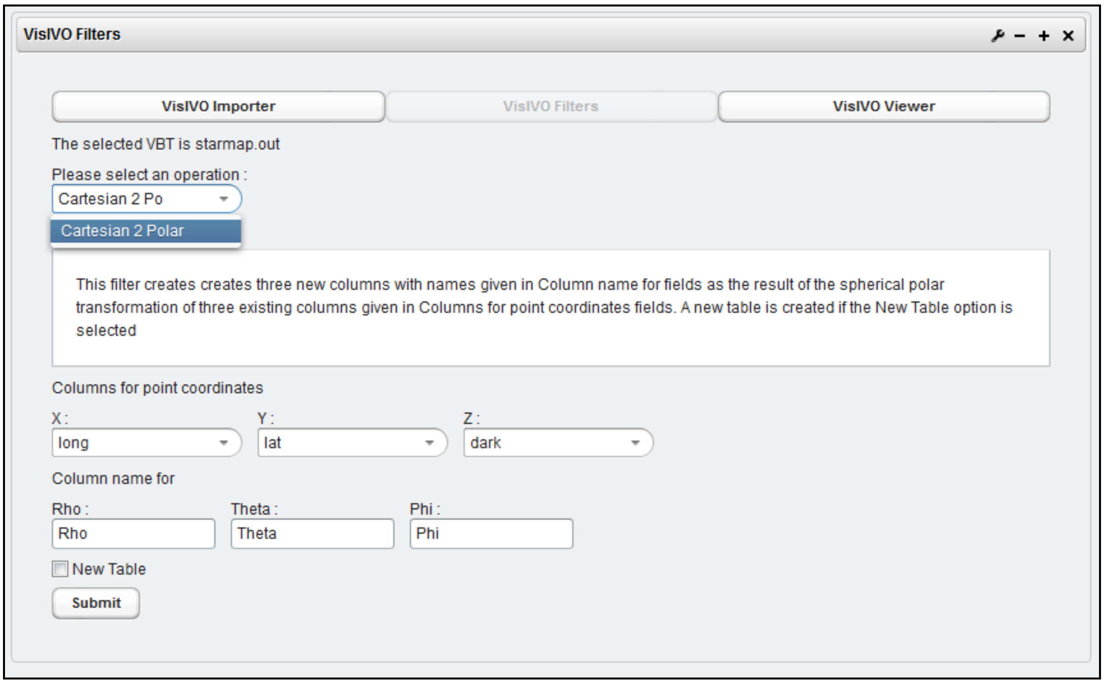
The volume dataset rank must be equal to 3. If the dataset represents a volume the --volume option must be given. In this case the hyperslab dimension (if given) represents the volume dimension and the --compx –compy --compz options are ignored. More datasets can be given, but in this case they **must** have the same hyperslab dimension
(the first hyperslab sets the volume resolution)

RAW Binary FORMAT files are simply a binary dump of the memory for data points. The content of the Raw Binary data points file is a sequence of x,y and z coordinate for each point, then a sequence of fields, one scalar for each data point. VisIVOImporter reads a descriptor file. More than one raw data file name can be described.

VOTable format is an XML standard for the interchange of data represented as a set of tables. In this context, a table is an unordered set of rows, each having a uniform format, as specified in the table metadata information. Each row in a table is a sequence of table cells, and each of these contain either a primitive data type or an array of such primitives. It can also contain a link to an external file, that the XML part describes. No VOTables with binary values are supported in VisIVO. The file sizes that can be processed by the VisIVO Server are only limited by the underlying parsing libraries. This reader has no limit on VOTable size, but can read only ascii data.

4.2 VisIVO Filters

VisIVO Filters convert imported data from an original data table (internal data format table) into a new one or can create a Volume from a table.



The following filter operations are available:

Add Identifier
adds a column tag to a table. This filter adds a new column with a sequence of Ids in the input data table. Default start value is 0. Only an int value can be given. Column name of the new id column should be given. Default name is Id.

Append Tables
creates e new table appending data from a list of existing tables. Append Filter can append up to 100 tables with the same number of Columns. The column names are copied from the first table. An error is given if tables contain different numbers of columns.

Cartesian2polar
creates three new fields as the result of the polar transformation. This operation creates three new fields in a data table as the result of the spherical polar transformation of three existing fields. Column name of the new fields should be given. Default names are: rho, theta and phi.

Coarse Volume
produces a coarse sub-volume with plane extraction from the original volume. A percentage (from 0.0 to 100.0) sub-volume will be produced. Default value produces a sub volume that could be directly uploaded and visualized with VisIVOViewer.
List of columns contained in the original file should be given. Default: all columns will be extracted. A sub-volume with new resolution will be produced. No default is given. This parameter is ignored if *percentage* option is given.

Cut
sets to a given threshold, column values included in a given interval.

Decimator
creates a sub-table as a regular subsample from the input table. Values are extracted in a regular sequence, skipping step element every time. The skip value is an integer number > 1 and represents the number of skipped values. In the above example only one element every 10 elements will be reported in the output file.

Extract Subregion
creates a new table from an input table of a sub-box or of a sphere. The extraction mode and the sub-volume size are:
RADIUS: a sphere centered in the given values will be extracted
CORNER: a rectangular region having the lower corner at the given values will be extracted
BOX: a rectangular region centered in the given values will be extracted.

Extract Subvolume
produces a table which represents a sub-volume from the original volume.

Grid2Point
distributes the values of an input grid to a point distribution in the same domain using the NGP/CIC/TSC algorithm. This operation distributes a volume property to a point data set on the same computational domain using a field distribution (CIC/NGP/TSC algorithm) on a regular mesh.
CIC is the default adopted algorithm. The Cell geometry is considered only to compute the cell volume value in this operation.
This filter produces a new table or adds a new field to the input table. The operation performs the following:
1) It loads a volume (input volume data table) and a table with a point distribution in the same volume
2) It computes, using a CIC or NGP or TSC algorithm, a value (assumed density) for each data point, considering the cells value where the point is spread. The grid points density values are multiplied for the cell volume and assigned to the point. If the density option is given the cell volume is assumed =1;

Math. Operations
creates a new field in a data table as the result of a mathematical operation between the existing fields. It is based on Function parser for C++ v2.83 by Warp (http://iki.fi/warp/FunctionParser/) with some minor modifications.

Merge Tables
creates a new table from two or more existing data tables.

Point Distribute
creates a volume using a field distribution (CIC/NGP/TSC algorithm) on a regular mesh.

Point Property
assigns a property to each data point on the table

Randomizer
creates a random subset from the original data table.

Select Columns
creates a new table using one or more columns of a data table.

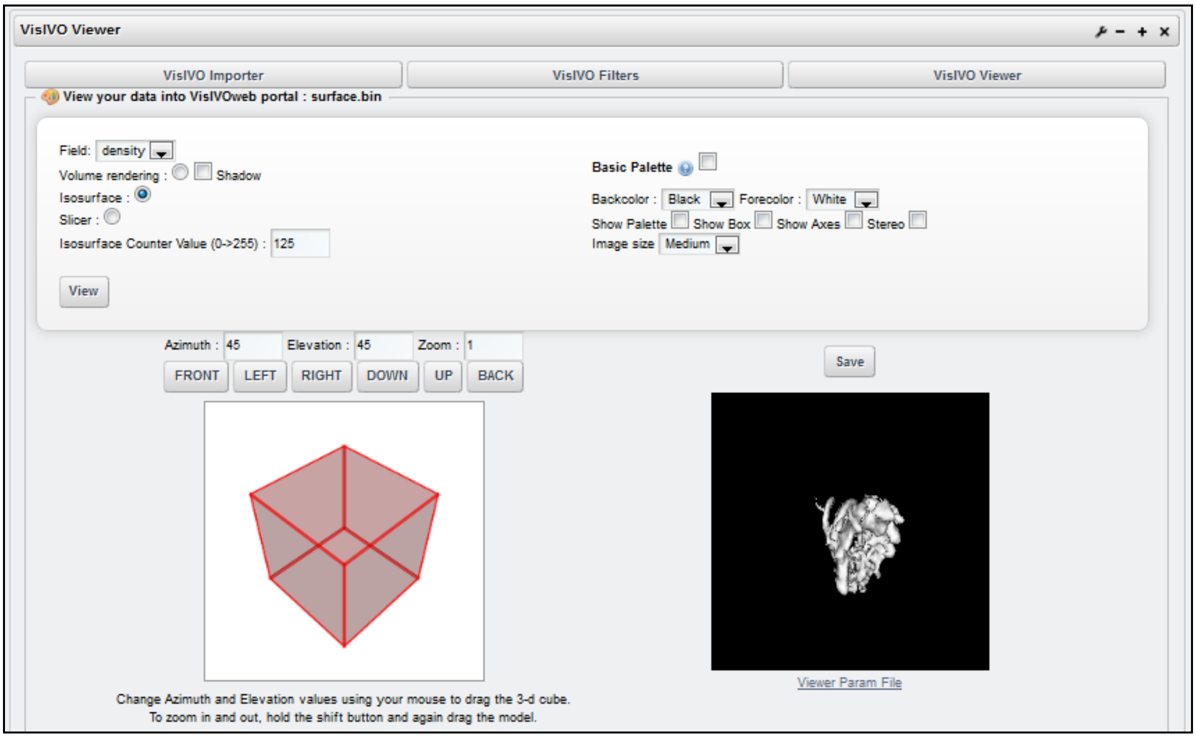
Select Rows
creates a new table using limits on one or more fields of a data table.

Sigma Contours
creates a new table where one or more fields of a data table have values within N sigma contours. The filter can be applied on fields that have a Gaussian distribution. For the selected fields, the filter prints in the stdout the average and the sigma values of the distributions.

Split Table
splits an existing table into two or more tables.

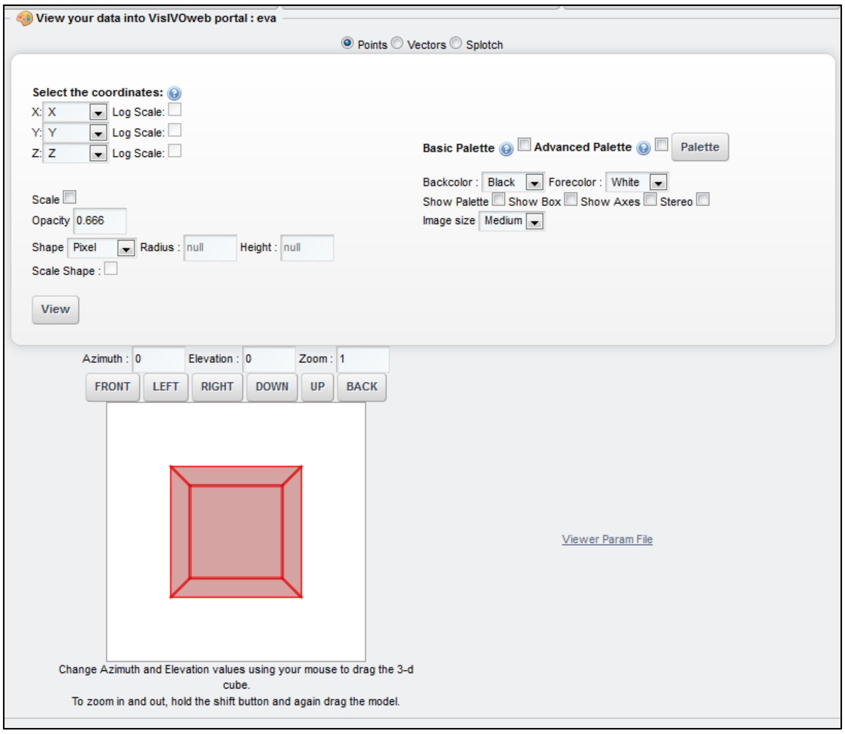
4.3 VisIVO Viewer

VisIVOViewer creates views from the input data file. The input data file must be in the Internal Binary format. The input data file must fit the available RAM. VisIVOViewer produces png images given camera position values of Azimuth, Elevation and Zoom.
NOTE: the camera of the Viewer at the default position (Azimuth=0 Elevation=0) is looking the box from the top (z plane).



4.3.1 Data Points Visualization

When the imported datasets is a table the following options should be selected:



Azimuth Elevation Zoom. Position and zoom factor of the camera. The camera position (Azimuth=0 Elevation=0) is looking the box from the top (i.e. the last z plane)

Scale. The axes are scaled. To be checked for not uniform system coordinates.

Basic Palette. Check the box to choice a pre-defined palette color table (**Color Table**).

Color Scalar Table. The Palette is associated to a field of a table.

Log Scale. Applies a logarithmic scale for the palette.

Advanced Palette. Check the box to create or to upload a customized color palette.

Palette Range. Set the limits for the palette color range. Default values are the minimum and maximum value of the **Color Scalar Table** field.

Opacity. Assign an opacity factor to the displayed elements: from 0.0 to 1.0. It is suggested to use a low opacity factor when many data points are requested to be displayed.

Shape. Points are displayed as Pixel. Others geometrical forms can be requested, In this case the **Radius** and **Height** values could be requested. **Shape** is ignored for more than 1000 points to be displayed.

Scale Shapes. If geometrical forms are requested the radius and height may be scaled with a field of the table (**Radius Scalar** and **Height Scalar**).

Backcolor. Background color of the image

Forecolor. Foreground color when the color palette is not selected.

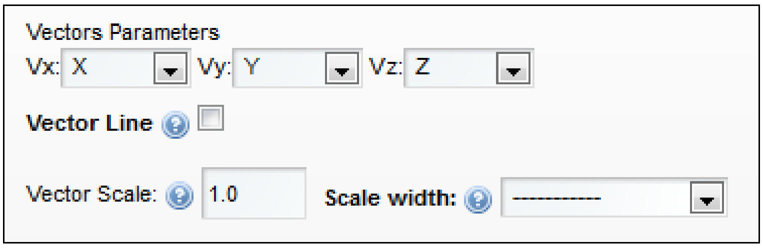
Show Palette, **Show Box** and **Show Axes.** Create the image with Palette, Box and Axes.

Image Size. Set the image dimension.

4.3.2 Vectors Visualization

VisIVOViewer creates a view of vectors created from the input data file that contains data points. The input data file must fit the available RAM.

If **Vectors** is selected, the vectors are displayed: **X Y** and **Z** are the application point coordinates and **Vx Vy** and **Vz** are the three vector components.

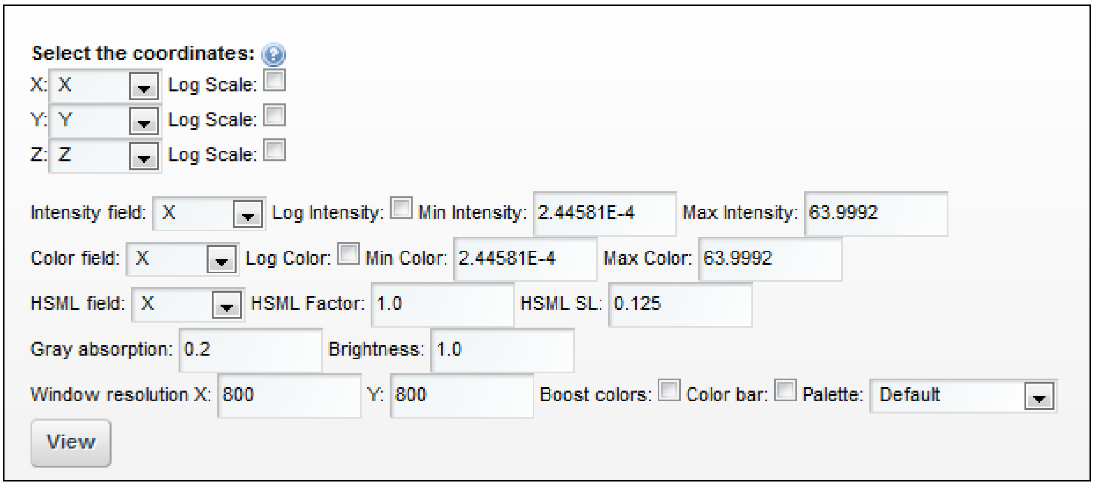


Vector Line enables vector representation with lines. Default representation is the arrows.

Vector Scale is a scale factor for vector representation. It is suggested to don't use this field or to use it carefully. A number is expected in this field. **Scale with:** vectors may be not scaled (default) or scaled with the vector magnitude or with another field of the first table: **Active Scalar.**

4.3.3 Splotch Visualization

This section creates 3D view from the input tables using Splotch: a ray tracing rendering tool.



X Y and **Z** are columns of **X-Y-Z Table**. The X-Y-Z Tables must have the same number of rows.

Intensity field. It is the name of column to be used for Intensity.

Log Intensity. If it's checked use the logarithm scale for Intensity field.

Min/Max Intensity. This value fix the extreme values for intensity. Default value are obtained through VisIVO Filtert statistic op.

Color field. It is the name of column to be used to give the color to the particles using the palette.

Log Color. If it's checked use the logarithm scale for Color field.

Min/Max Intensity. This value fix the extreme values for color. Default value are obtained through VisIVO Filtert statistic op.

HSML field. Column name of the quantity to use for the smoothing of particles.

HSML Factor. It is the fixed smoothing length. If this value is >0 use this value as radius for particles.

HSML SL. It is the scale factor applied for the smoothing of particles.

Palette. It is the color table used to give the color to the particles.

Advanced Palette. Clicking this button user can create or upload customized color palette.

Gray absorption. It is the opacity factor.

Brightness. It is a factor applied to the intensity: increase the brightness for each point.

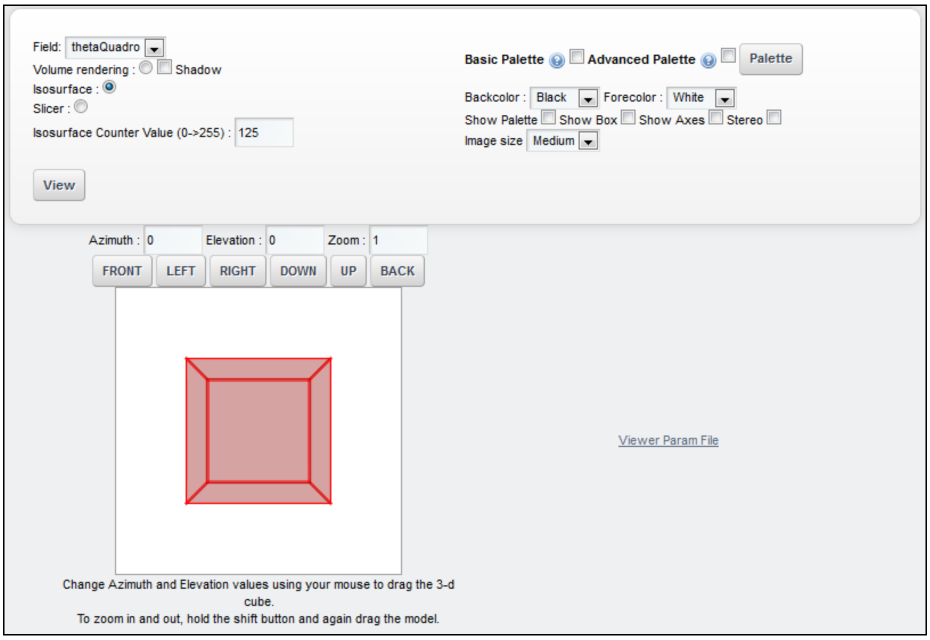
Window resolution. It is the image size in pixel.

Color bar. If it's checked show color bar in image.

Azimuth Elevation Zoom. Position and zoom factor of the camera. The camera position (Azimuth=0 Elevation=0) is looking the box from the top (i.e. the last z plane).

4.3.4 Volume Visualization

This portlet creates 3D views from **Field** of the input tables. The **View** button creates the image. Volumes are displayed in a new window.



Azimuth Elevation Zoom. Position and zoom factor of the camera. The camera position (Azimuth=0 Elevation=0) is looking the box from the top (i.e. the last z plane)

Scale. The axes are scaled. To be checked for not uniform system coordinates.

Basic Palette. Check the box to choice a pre-defined palette color table (**Color Table**).

Log Scale. Applies a logarithmic scale for the palette.

Advanced Palette. Check the box to create or to upload a customized color palette.

Palette Range. Set the limits for the palette color range. Default values are the minimum and maximum value of the **Field**.

Volume Rendering This option creates the image with the volume rendering technique.

Shadow (optional) enables shadow view in the image.

Isosurface This option creates the image of the volume isosurface. The **Isosurface Contour Value** fixes the isocontour.

Slicer. This option creates the image of the intersection plane with the volume.

ORTHOSLICE: the plane is orthogonal to the Volume box. **Image**. Creates an image. **Slice**. The plane is parallel to the X or Y or Z plane. **Position**. Position of the plane inside the volume. If the volume is 64X64X64 mesh the plane position 32 is in the box center.

GENERIC PLANE: the plane is inside the Volume box. **Image**. Creates an image. **Point**. The three coordinates of a point in the plane **Orthogonal**. The three coordinate fixing the normal axes to the plane in the point fixed by Point option. It is suggested to visualize the Box for a better visualization of the plane in the volume.

Backcolor. Background color of the image

Forecolor. Foreground color when the color palette is not selected.

Wireframe (optional) visualize the isosurface with wireframe.

Smooth. It smooth the isosurface visualization

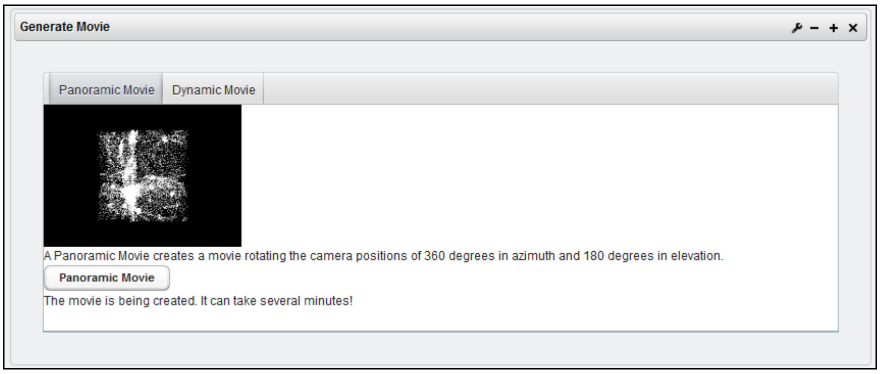
Show Palette, **Show Box** and **Show Axes**. Create the image with Palette, Box and Axes.

Image Size. Set the image dimension.

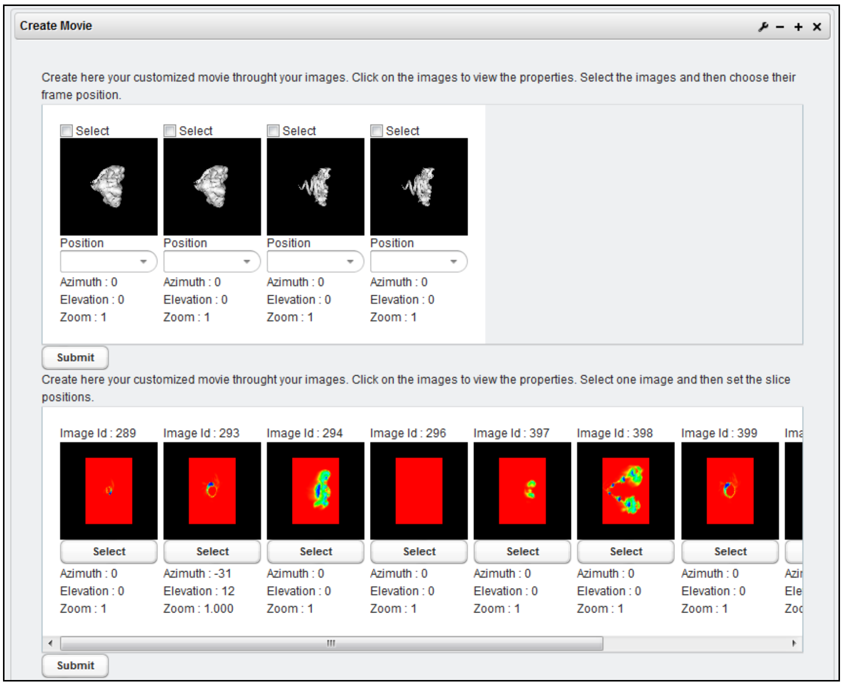
4.4 Scientific Movies

VisIVO Gateway allows users to generate scientific movies. Scientific movies are useful not only to scientists to present and communicate their research results, but also to museums and science centres to introduce complex scientific concepts to a general public audience.

Users can create a **Panoramic Movie** by moving a camera along a motion path of 360° in azimuth and +/- 90° in elevation within the domain of a dataset.



Customized Movies can be produced by intermediate snapshots specified as camera positions/orientations and the gateway generates a movie with a camera path containing the specified positions/orientations.



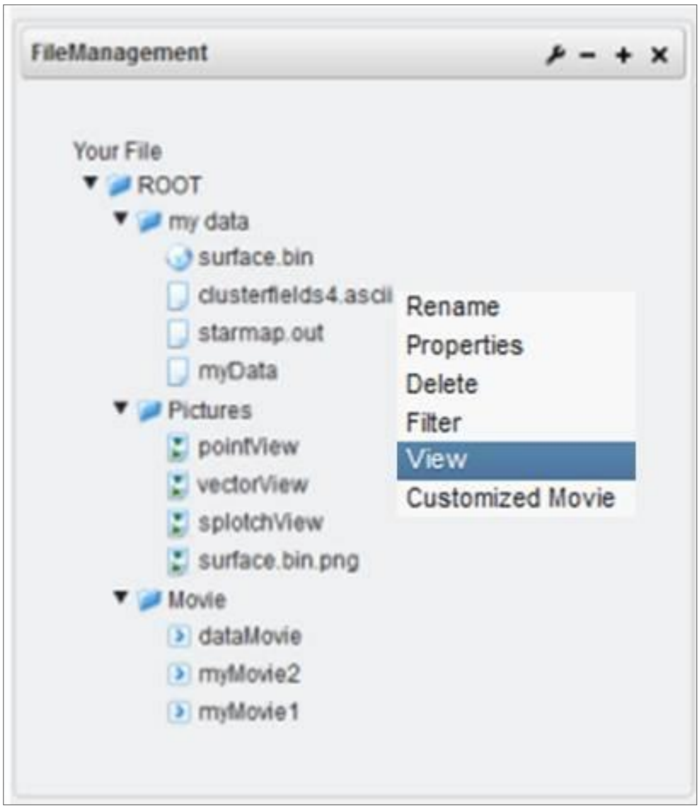
Dynamic Movies can be created by interpolating several steps of a time evolution of a cosmological dataset. The user can browse a cosmological time evolution and choose two or more coherent datasets. The designed workflow will then produce the necessary number of intermediate VBTs by calculating particle positions and applying boundary conditions as necessary. This approach can be very useful, e.g. in revealing galaxy formation or large-scale structures such as galaxy clusters.

The creation of a movie represents a significant challenge for the underlying computational resources as often hundreds or thousands high quality images must be produced. For this reason Parameter Sweep (PS) workflows are employed. PS workflows are executed in distributed parallel computations.

The gUSE/WS-PGRADE infrastructure supports special ports (generator and collector ports) which enables the PS elaboration of a workflow: a single set of input files containing more than one element associated by a port - or several input ports having this feature - may trigger the proper number of submissions of the associated job.

5 Data Management

VisIVO Science Gateway provide a **Data Management portlet** which allows users the reusability of their private staging area within the system for managing their datasets as well as images and movies produced from such datasets. The interaction with the Data Management portlet allows the navigation within the different services offered by the portal mainly the VisIVO Viewer and Filter portlets and the scientific movie creation portlets.



Different icons differentiate the different items types:

 for folders;

 for table datasets (point VBTs);

 for volume datasets (volume VBTs);

 for images;

 for scientific movies.

Users can create new folders, move items inside and outside a folder, rename and delete folders and items. Right clicking on an item the user can access the Portal services performing the filtering and visualization actions and accessing to the possibility of creating scientific movies.

Each imported VBT and generated image is associated to several meta data which can be inspected and edited in the **Properties** portlet as shown in the following figure.

The Properties portlet is easily reachable clicking on the item from the Data Management portlet.

6 Community

A number of challenging workflows has been prototyped to support highly specialised scientific communities mainly in astrophysics. This section discusses the visualisation-oriented applications ***Muon Portal*** and ***LasMOG***, and the simulation-oriented workflow ***FRANEC***. The former are deployed for detecting nuclear threat materials and investigating large-scale modified gravity models respectively. The latter is exploited for carrying out stellar evolution simulations. These workflows will be supported in ER-flow project[2] so that they can be stored into the SHIWA workflow repository together with related meta-data, allowing investigation of their interoperability and dissemination across relevant communities through the SHIWA simulation platform.

Advanced users can exploit such workflows as templates for building new customized workflows to suit particular requirements of scientific communities, e.g. by modifying appropriately constituent building blocks customized LasMOG workflows can be generated. Standard users can then execute these workflows in an interactive and user-friendly way by means of the supplied portlets. Any user can submit jobs to the underlying DCIs without requiring a priori any specific technical expertise related to the particulars of the DCI configuration.

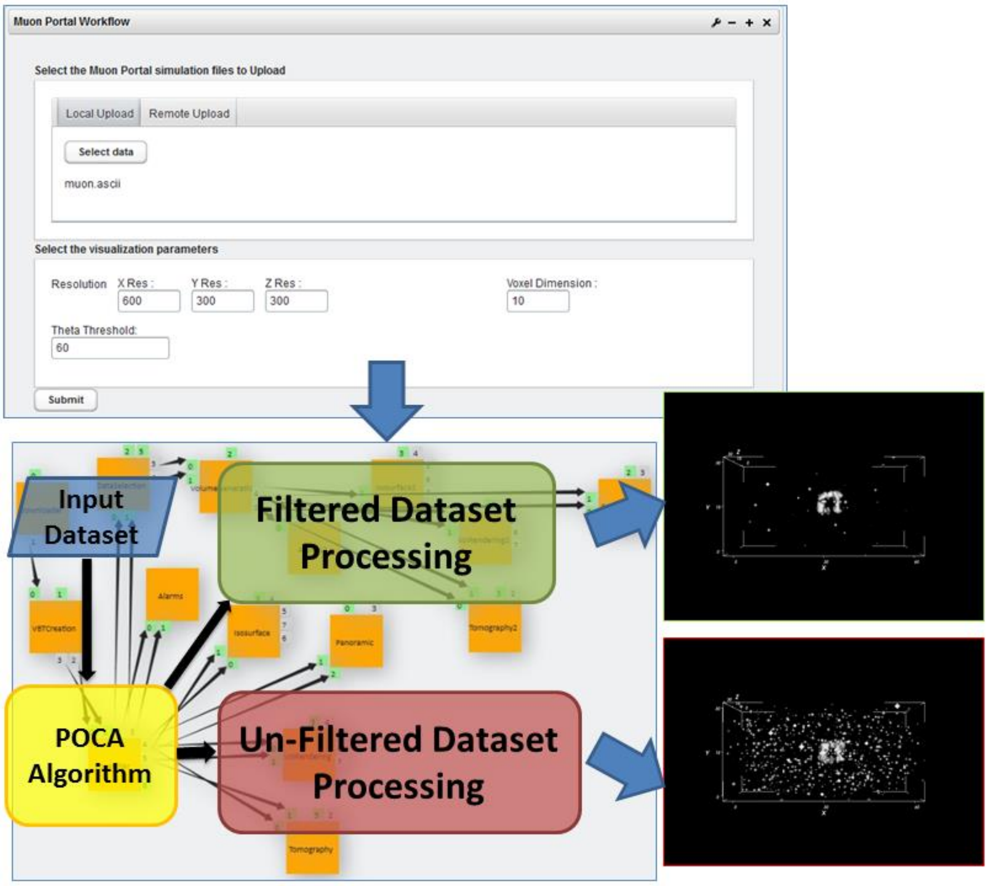
6.1 Muon Portal

The deflection of muonic particles present in the secondary cosmic radiation results from crossing high atomic number materials (such as uranium or other fissile materials). This can significantly improve on the success rate of current nuclear threat detection methods which are based on X-ray scanners, especially in terms of capacity for identification and location of illicit materials inside cargo containers, even considering the possibility of screens designed to mask their existence. It has been developed a visualisation-oriented workflow suitable for inspection of cargo containers carrying high atomic number materials, by displaying tomographic images.

The datasets containing coordinates of the muon tracker planes are first uploaded to our gateway and filtered by using the Point of Closest Approach (POCA) algorithm to create a representation containing the scattering deflection of cosmic radiations. The result is then visualized using point rendering.

Further processing is then applied based on user-defined thresholds, followed by conversion into data volumes using the deflection angle field distribution by employing the 3D Cloud-in-Cell (CIC) smoothing algorithm. Finally, a tomography is performed for inspection.

[2] http://www.erflow.eu/



The Figure above shows the most recent development and results of the entire computational process starting from:

a) parameter setting through the supplied portlet, then

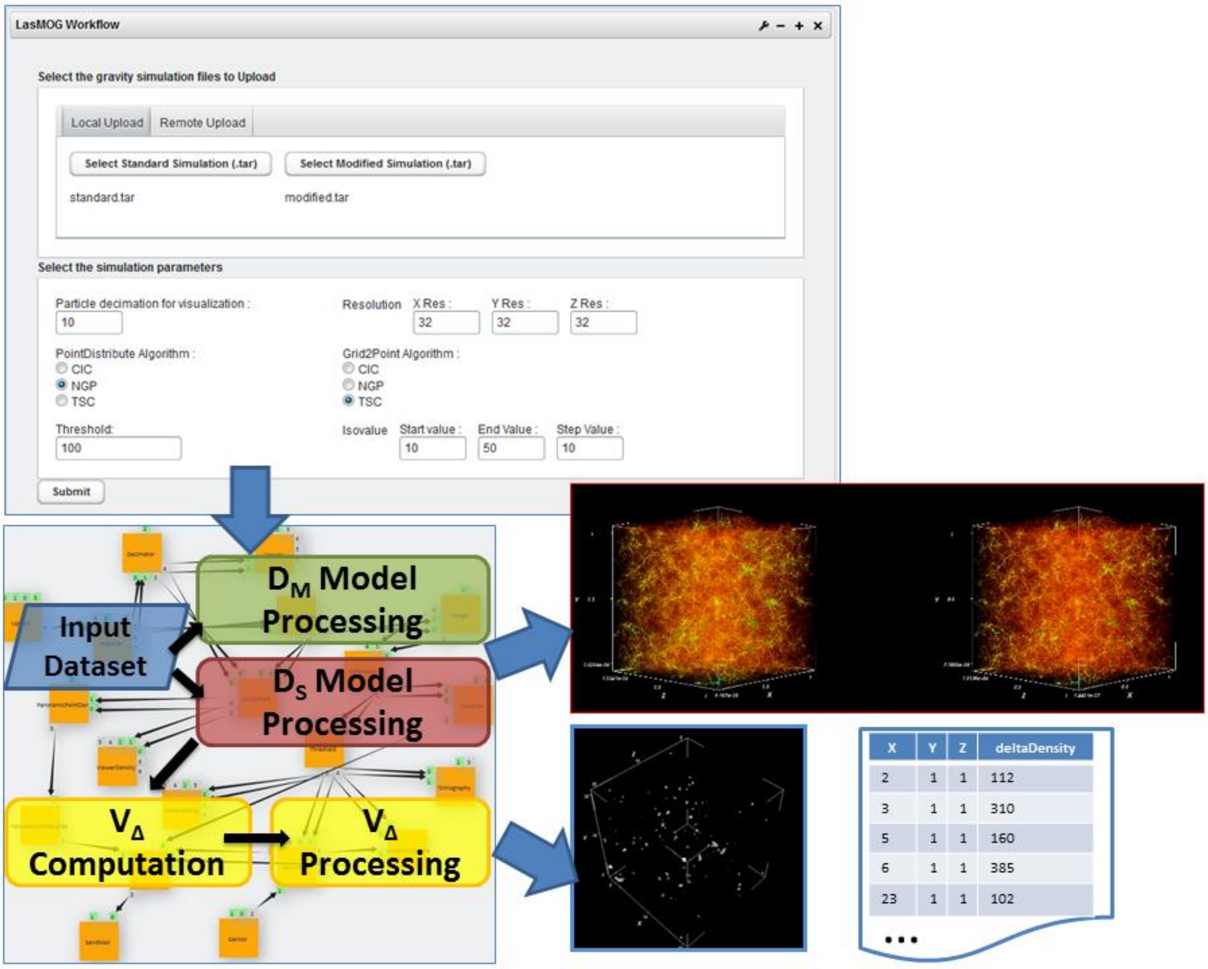
b) submitting the implemented workflow, and finally

c) outputting resulting images obtained using isosurface rendering for the filtered (top image) and raw (bottom image) datasets respectively.

6.2 LaSMoG

The acceleration of the Universe is one of the most challenging problems in cosmology. In the framework of general relativity (GR), the acceleration originates from dark energy. However, to explain the current acceleration of the Universe, the required value of dark energy must be incredibly small. Recently efforts have been made to construct models for modified gravity (i.e. without introducing dark energy) as an alternative to dark energy models.

Observing the large scale structure of the universe could in principle provide new test of GR on cosmic scales. This kind of test cannot be done without the help of simulations as the structure formation process is highly non-linear. Large-scale simulations are thus performed for modified gravity models, e.g. from the Large Simulation for Modified Gravity(LaSMoG) consortium.



The workflow shown in Figure above implements a customized visualization for aiding analysis of modified GR simulations, more specifically inspecting datasets to discover anomalies by comparing appropriately with datasets coming from standard GR models. The main computational steps are summarised as follows:

- Two datasets corresponding to snapshots of standard gravity (D_S) and modified gravity (D_M) model simulations are processed.
- Sub-samples of the point distributions with a reduced number of points in the two datasets are generated. Then, for each of these sub-samples a panoramic movie is created (as shown in the resulting top image of Figure).
- A point distribute operation is performed on D_S and D_M to create new volume datasets (V_S and V_M respectively) using a field distribution algorithm on a regular mesh.
- A volume property on the same computational domain is distributed on a regular mesh producing a density field.
- A new volume V_Δ is computed where each of its voxels shows a difference of values in the density between V_S and V_M. It is then filtered with a lower bound threshold and all the voxels satisfying the filters are saved in a text file for further analysis purposes (as shown in the resulting bottom image of Figure).
- Several renderings of V_Δ are performed:
  - Volume rendering;

- Isosurface rendering of the density field to produce panoramic movies using different isovalues (as shown in the resulting bottom image of Figure);
- Ortho-slice rendering i.e. orthogonal slice planes through the volume dataset.

6.3 FRANEC

FRANEC is a state-of-art numerical code for stellar astrophysics. This code is perfectly suited for computing the evolution of a star on the basis of a number of different physical inputs and parameters. Parameters are listed in one input file. A single run of FRANEC produces one synthetic model (SM). To produce an isochrone, for a given chemical composition, through a FIR (Full Isochrone Run), it is necessary to execute a large number of SMRs (SM runs) varying the initial mass of the stellar models. Once these evolutionary tracks and isochrones (as well as additional data describing the simulated stellar structures) are computed, they can be distributed in datasets over different sites.

The simulations of stellar models produce simulation output files with a set of associated metadata. Such metadata are linked to all parameters concerning the numerical evolutionary code. In this way it is possible to store and easily search and retrieve the obtained data by many set of stellar simulations, and also get access to a huge amount of homogeneous data such as tracks and isochrones computed by using FRANEC.

From the FRANEC portlet, see the following Figure, the FRANEC Workflow will be submitted.

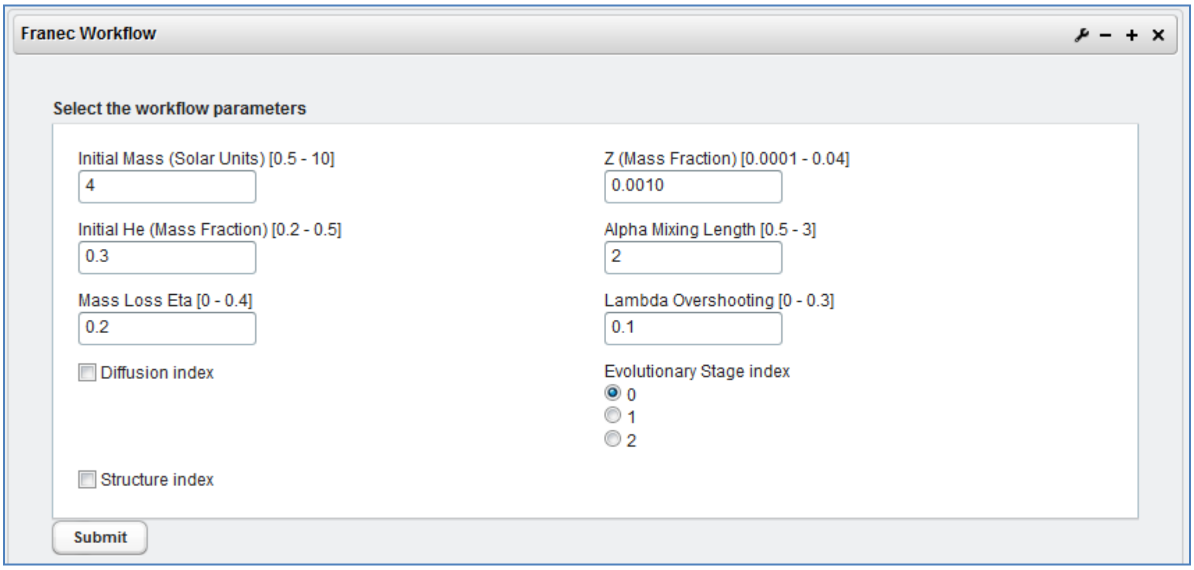
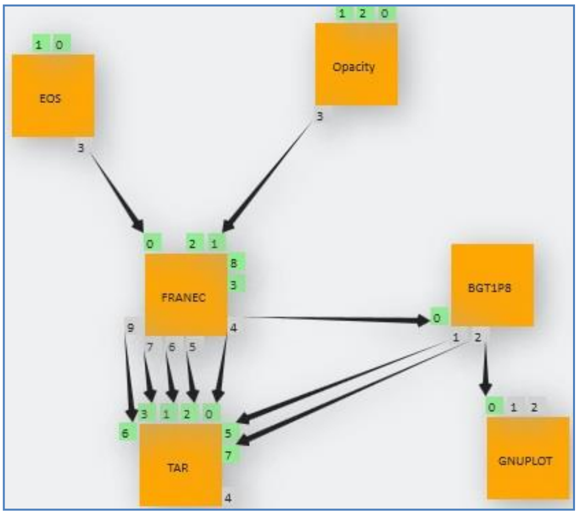


Figure 1: FRANEC Portlet

The following input parameters are required:

- **Initial Mass** (Solar Units) [0.5 - 10] : It is the mass (in Solar Units) of the structure.
- **Initial He** (Mass Fraction) [0.2 - 0.5] : The mass fraction of the initial helium.
- **Z** (Mass Fraction) [0.0001 - 0.04] : The mass fraction of the heavy elements abundance.
- **Alpha Mixing Length** [0.5 - 3] : The efficiency of superadibatic convection.
- **Mass Loss Eta** [0 - 0.4] : Mass loss according to the Reimers (1975) law.

- **Lambda Overshooting** [0 - 0.3] : Core convective overshooting during the H-burning phase. The value adopted for the overshoot is taken from the classical Schwarzschild convective boundary.
- **Diffusion index** : Check to include diffusion.
- **Evolutionary Stage index** : Set index : 0 = no limit, 1 = end phase central burning of H, 2 = end phase central burning of RGB for small masses.
- **Structure index** : Check to print structures into the file "stampe" every 30 models otherwise the file will be overwritten.



FRANEC Workflow

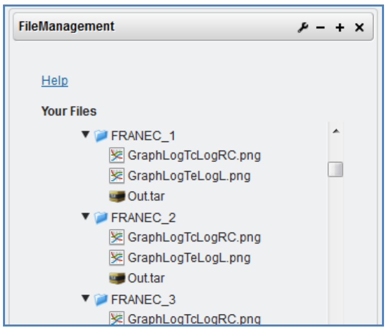
When selecting the input parameters clicking on the “Submit” button the Franec workflow will be submitted.

The FRANEC workflow (as depicted in Figure) has a typical modular architecture; it is easy to identify its modules that can be reused to build other workflows. Modules can be identified on the basis of the function they provide.

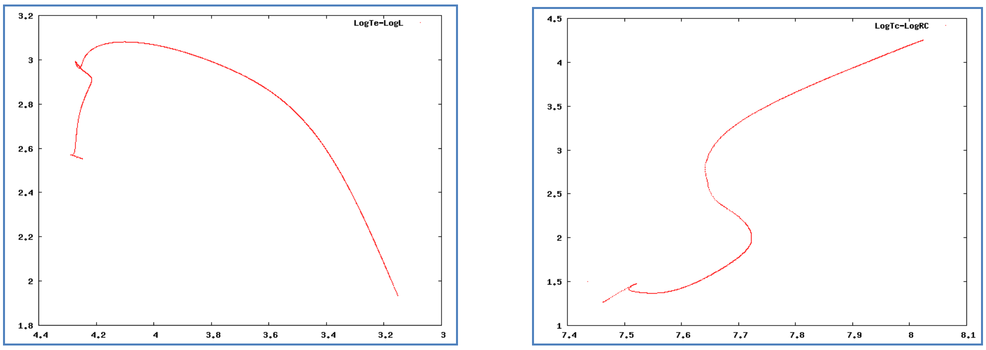
- ***EOS*** module provides the Equation of State in tabular form. The input values are the Metallicity Z and the type of mixture (combination of chemical elements heavier than helium).
- ***OPACITY*** module produces a table of Opacity from pre-calculated tables. Given the Metallicity value Z and the type of mixture it obtains a new table of opacity which is interpolated from the pre-calculated ones.
- ***FRANEC*** is the core module of the workflow. It produces the models of stellar evolution starting from the output of the two modules EOS and OPACITY and a set of input parameters given by the user to perform the evolution. It produces a set of parameter values varying in relation to time, quantities varying in relation to the radius of the model, the chemical composition of the core (vs. time), surface chemicals (vs. time), and energy resolution Flows(vs. time).
- ***TAR*** produces an archive of the main outputs.
- ***GNUPLOT*** produces the output plots.

When the workflow execution reach the Finished status the output will be stored into the FileManagement Portlet (see Figure) with a new folder containing the output archive

("Out.tar") and two plots named "GraphLogTCLogRC.png" and "GraphLogTELogL.png". Two exemplificative plots are shown in Figure.



FRANEC Output



FRANEC Output plots

7 VisIVO Mobile

VisIVO Science Gateway is fully integrated with VisIVO Mobile application. This application allows smartphone devices to exploit VisIVO Gateway functionalities to access large-scale astrophysical datasets residing on a server repository for analysis and visual discovery. Through interactive widgets, customized visualizations (images or movies) can be generated and stored on the remote server.

The application notifies users when requested visualizations are available for retrieving on their smartphones and allows easy sharing of data, images and movies via e-mail or common social networks.

Contacts

For general information on the VisIVO Science Gateway and support request please contact:

visivo-support@oact.inaf.it

If you have any concerns and questions on WS-PGRADE/gUSE technologies please use the Forum:

https://www.sci-bus.eu/message-board