

# Virtual European Solar & Planetary Access (VESPA)

## Providing access to Solar System & heliophysics data

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Bristol Univ  
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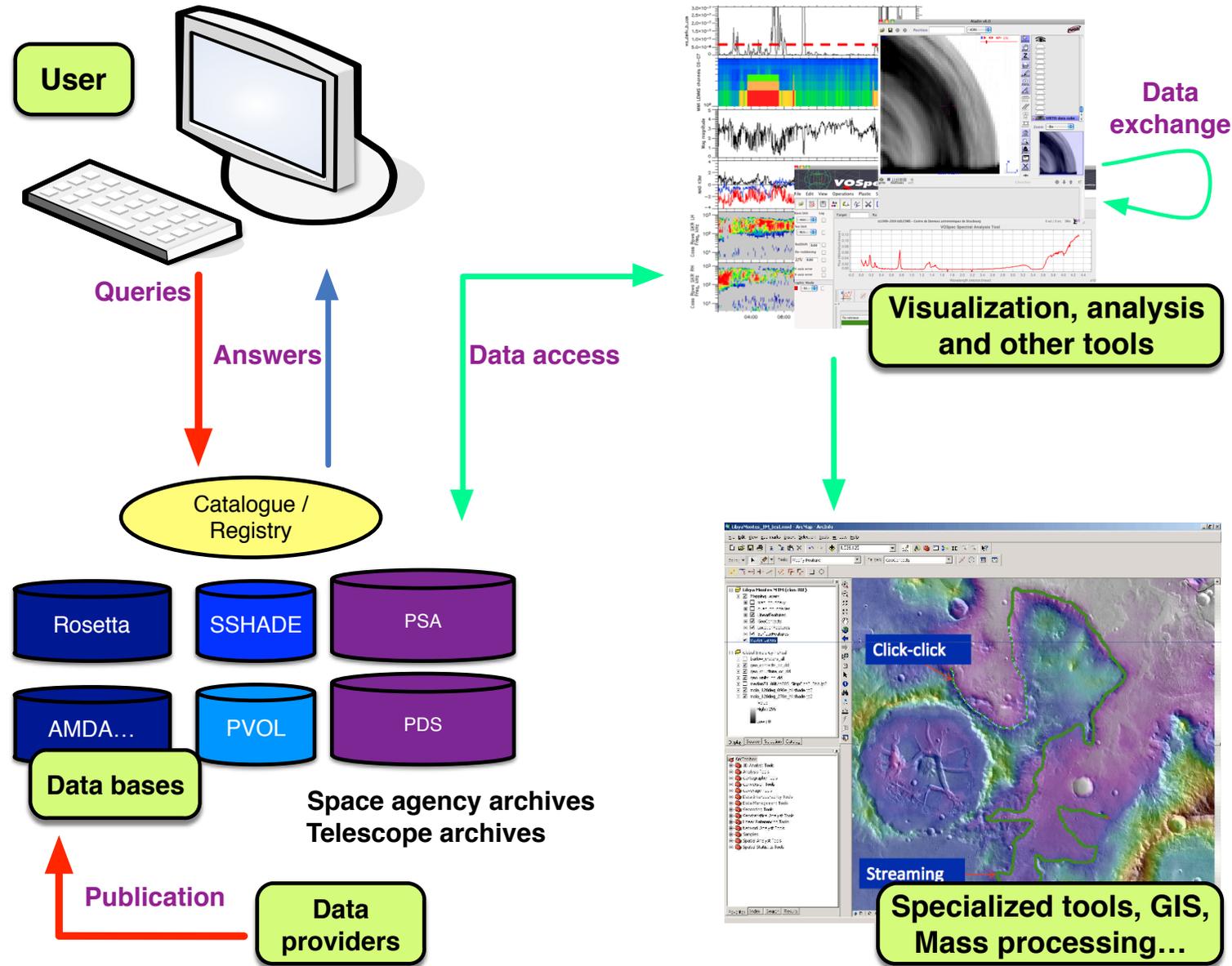
VESPA ASTRO-CC workshop 2026

25-27 mars 2026  
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Science users, but also education / outreach  
=> FAIR access

Scope:  
Planetary Science  
Heliophysics  
Exoplanets

Research teams, institutes  
EU projects  
=> Open Science



## What VESPA provides to the community

1- A vocabulary to describe physical & observational parameters making sense to researchers:

EPNCore metadata

Very broad scope: surfaces, atmospheres, small bodies, magnetospheres, heliophysics

2- A user interface to search data based on science-relevant parameters:

VESPA portal (other access modes are available)

3- Data services provided by VESPA participants and other teams:

Currently 95 data services open (much more in progress) and ~70 planetary HiPS

+ New or updated data infrastructures: SSHADE, PVOL, AMDA, MASER

4- Connection / adaptation of powerful display and analysis tools:

Tools from astronomy (VO, with planetary science updates) + GIS and others + Jupyter notebooks

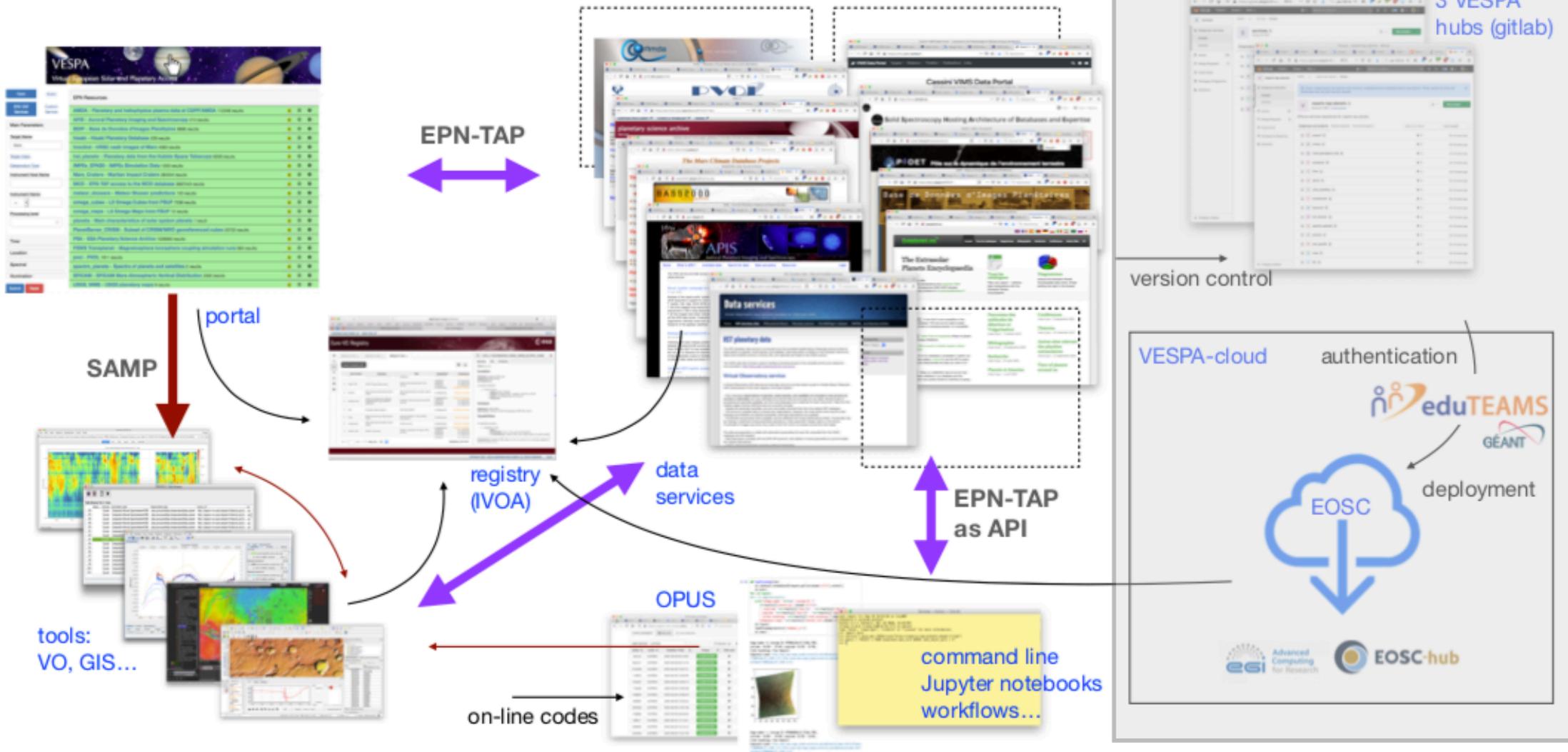
=> Contributive, interoperable, Open Science system, providing FAIR access to the data

This data system is available for - users *to access* data

- science teams *to distribute* data

# VESPA: infrastructure

Maintenance functions



# VESPA service (as seen in the portal)

A table providing description of each file / data element

## Results in service apis

Show  entries

Column visibility

Describing parameters

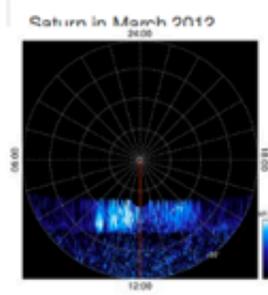
granule_uid	dataprodukt_type	target_name	time_min	time_max	access_url	granule_gid	obs_id	ta
o4bd01ycq_cyl_pdf	image	Saturn	1997-10-11T03:53:03.524	1997-10-11T04:09:43.724	<a href="#">o4bd01ycq_cyl.pdf</a>	cylindric_proj	o4bd01ycq	pl
o4bd01ycq_pol_n_pdf	image	Saturn	1997-10-11T03:53:03.524	1997-10-11T04:09:43.724	<a href="#">o4bd01ycq_pol_n.pdf</a>	polar_proj_north	o4bd01ycq	pl
o4bd01ycq_pol_s_pdf	image	Saturn	1997-10-11T03:53:03.524	1997-10-11T04:09:43.724	<a href="#">o4bd01ycq_pol_s.pdf</a>	polar_proj_south	o4bd01ycq	pl
o4bd01ycq_proc	image	Saturn	1997-10-11T03:53:03.524	1997-10-11T04:09:43.724	<a href="#">o4bd01ycq_proc.fits</a>	processed_data	o4bd01ycq	pl
o4bd01ycq_proc_pdf	image	Saturn	1997-10-11T03:53:03.524	1997-10-11T04:09:43.724	<a href="#">o4bd01ycq_proc.pdf</a>	processed_data	o4bd01ycq	pl
o4bd01ycq_x2d	image	Saturn	1997-10-11T03:53:03.524	1997-10-11T04:09:43.724	<a href="#">o4bd01ycq_x2d.fits</a>	original_data	o4bd01ycq	pl
o4bd01yeq_cyl_pdf	image	Saturn	1997-10-11T04:15:43.524	1997-10-11T04:28:37.134	<a href="#">o4bd01yeq_cyl.pdf</a>	cylindric_proj	o4bd01yeq	pl
o4bd01yeq_pol_n_pdf	image	Saturn	1997-10-11T04:15:43.524	1997-10-11T04:28:37.134	<a href="#">o4bd01yeq_pol_n.pdf</a>	polar_proj_north	o4bd01yeq	pl
o4bd01yeq_pol_s_pdf	image	Saturn	1997-10-11T04:15:43.524	1997-10-11T04:28:37.134	<a href="#">o4bd01yeq_pol_s.pdf</a>	polar_proj_south	o4bd01yeq	pl
o4bd01yeq_proc	image	Saturn	1997-10-11T04:15:43.524	1997-10-11T04:28:37.134	<a href="#">o4bd01yeq_proc.fits</a>	processed_data	o4bd01yeq	pl

Data elements

### Plotting tools

- TOPCAT
- Aladin
- SPLAT
- CASSIS

### Example queries



Showing 1 to 10 of 15,506 entries

## Example EPN-TAP request:

Typical for surfaces (assuming all data are correctly described):

Mars, a given region (Tharsis volcanoes area)

Illumination conditions ( $i \leq 20^\circ$  / phase)

Local time or season, etc

Results from all services  
=> need to be described at similar level

Footprints can be sent to plotting tools  
from the portal

<https://vespa.obspm.fr>

The screenshot shows the VESPA Query Interface in a browser window. The URL is [vespa.obspm.fr/planetary/data/?f-url\\_op=&f-schema\\_op=&f-target\\_name](https://vespa.obspm.fr/planetary/data/?f-url_op=&f-schema_op=&f-target_name). The page features a header with the VESPA logo and the text "Virtual European Solar and Planetary Access". Below the header, there are two tabs: "Form" and "Query". The "Form" tab is active, showing a "Main Parameters" section with the following fields:

- Target Name: Mars
- Target Class: (empty)
- Dataproduct Type: (empty)
- Instrument Host Name: (empty)
- Target Class: (empty)
- Dataproduct Type: (empty)
- Instrument Host Name: TAP query
- Instrument Name: (empty)
- Processing level: (empty)

The "Query" tab is also visible, showing a list of "EPN Resources" with the following entries:

- hrsc3nd - HRSC nadir images of Mars 6 results
- omega\_cubes - L3 Omega Cubes from PSUP 70 results
- PlanetServer\_CRISM - Subset of CRISM/MRO georeferenced cubes 48 results
- abs\_cs - Data for numerical modeling of planetary atmospheres 0 result
- AMDA - Planetary and heliophysics plasma data at CDDP/AMDA 0 result
- APIS - Auroral Planetary Imaging and Spectroscopy 0 result
- BASECOM - The Nançay Cometary Database 0 result
- bass2000 - Bass2000 solar survey archive 0 result
- BDIP - Base de Données d'Images Planétaires 0 result

Below the resources list, there is a section for "Generated WHERE clause of ADQL statement:" with the following SQL query:

```
SELECT * FROM ... WHERE ((c1min <= c1max AND c1min <= 265.0 AND c1max >= 235.0) OR (c1min > c1max AND (c1min <= 265.0 OR c1max >= 235.0))) AND c2max >= -15.0 AND c2min <= 15.0 AND (1 = ivo_hashlist_has(lower("target_name"), lower('Mars')) OR 1 = ivo_hashlist_has(lower("target_name"), lower('4')) OR 1 = ivo_hashlist_has(lower("target_name"), lower('499')) AND "incidence_min" <= 20.0 AND "spatial_frame_type" = 'body')
```

At the bottom of the page, there is a section for "EPN-TAP compilation results" and "PDAP Resources (by dataset)".

# VESPA portal

Redesigned from UX analysis

Refine your search

ADQL Query

Data Services

### Main Parameters

#### Target Name

#### Target Class

#### Dataproduct Type

#### Instrument Host Name

#### Instrument Name

#### Processing level

#### Time

#### Location

#### Spectral

#### Illumination

#### Data Reference

#### Optional

Reset

Submit

**abs\_cs - Data for numerical modeling of planetary atmospheres** 13 results

**APIS - Auroral Planetary Imaging and Spectroscopy** 74175 results

**BaseCom - The Nançay Cometary Database** 6886 results

**bass2000 - Bass2000 solar survey archive** 357033 results

**BDIP - IAU database of historical planetary images** 16906 results

**cassini\_jupiter - Cassini RPWS/HFR Calibrated Jupiter Flyby Dataset** 7 results

**CLIMSO - CLIMSO coronagraphs at Pic du Midi de Bigorre** 1021345 results

**cpstasm - CLUSTER STAFF-SA Spectral Matrix Data** 11688 results

**DynAstVO - Asteroid orbital database and ephemerides** 29733 results

**eit\_syn - Synchronous synoptic maps of the solar corona from EIT/SoHO** 18482 results

**ExoPlanet - Extrasolar Planets Encyclopaedia** 5177 results

**Exotopo - Simulated Topography of Exoplanets** 1800 results

**expres - EXPRES Simulation Database** 38946 results

**Gaia-DEM - Thermal**

**HFC1AR - Heliophy**

**HFC1T3 - Heliophy**

**hisaki - Hisaki Plan**

**hrsc3nd - HRSC na**

**litateHF - litate HF**

**IKS - IR spectrosc**

**ILLU67P - Illuminat**

**Results in service VVEx**

Show 10 entries

Column visibility Show all Hide all

Select All in current page Reset Selection

id	dataprodct_type	target_name	time_min (s)	ti	
V0026_07G	spectral_cube	Venus	2006-05-16T17:12:20.414	2f	
V0026_07C	spectral_cube	Venus	2006-05-16T17:12:20.414	2f	
V0026_07G	spectral_cube	Venus	2006-05-16T17:12:20.424	2f	
V0026_07C	spectral_cube	Venus	2006-05-16T17:12:20.424	2f	
V0026_08C	spectral_cube	Venus	2006-05-16T17:27:48.478	2f	
V0026_08G	spectral_cube	Venus	2006-05-16T17:27:48.478	2f	
V0026_08G	spectral_cube	Venus	2006-05-16T17:27:48.672	2f	
V0026_08C	spectral_cube	Venus	2006-05-16T17:27:48.672	2006-05-16T17:38:31.453	ftp://psa.esac.esa.L...
VT0027_00C	spectral_cube	Venus	2006-05-18T01:25:15.669	2006-05-18T02:01:54.510	ftp://psa.esac.esa.L...
VT0027_00G	spectral_cube	Venus	2006-05-18T01:25:15.669	2006-05-18T02:01:54.510	ftp://psa.esac.esa.L...

Showing 91 to 100 of 15,882 entries

Page 10 of 1569

First Previous Next Last

Earth Footprints

Refine your search

ADQL Query

[Back To Services Results](#)

### PVOL - Amateur images database

Tabular View

Gallery View

Select All in current page Reset Selection

#### gallery\_view



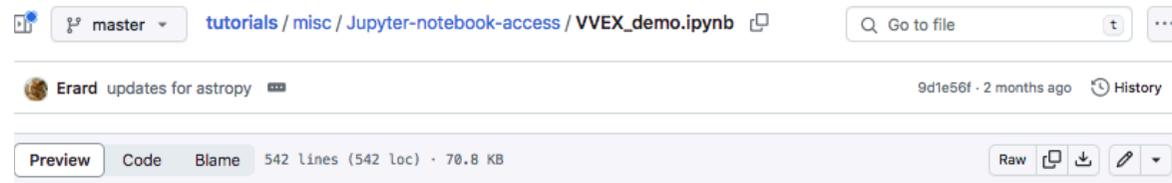
## Alternative access:

**VESPA portal:** Queries all services, discovery tool

**VO tools** (internal clients)

**Other TAP web clients** (taphandle, etc)

**Jupyter notebook, command line** (python libs)



master tutorials / misc / Jupyter-notebook-access / VVEX\_demo.ipynb

Erard updates for astropy 9d1e56f · 2 months ago History

Preview Code Blame 542 lines (542 loc) · 70.8 KB Raw

### Access to public EPN-TAP data services through Jupyter notebook

```
In [1]: import pyvo as vo
from matplotlib import pyplot as plt
from astropy.table import Table
import urllib
# beware that this is incompatible with IDLpy
from astroquery.utils.tap.core import TapPlus
import astropy.io.votable as vot
```

#### 1- Search an EPN-TAP data service

Example from VIRTIS / Venus-Express

Here we search a service in the registry from keywords.

```
In [2]: # Search the VO registry for TAP services about the VIRTIS instrument
```

```
In [3]: tap_services = vo.registry.search(servicetype='tap',keywords=['VIRTIS'], includeaux=True)
print(tap_services.to_table)

print('pyvo version: '+vo.__version__)
# will work in pyvo 1.5:
#r2 = vo.registry.search(datamodel="epntap")
#r2
```

```
<bound method DALResults.to_table of <Table length=3>
  ivoid          res_type      ... intf_roles
  ...
  object         object       ... object
-----
ivo://cds.vizier/j/a+a/585/a53 vs:catalogservice ... std
ivo://cds.vizier/j/a+a/647/a119 vs:catalogservice ... std
ivo://padc.obspm.planeto/vvex/q/epn_core vs:catalogresource ... std>
pyvo version: 1.4.1
```

We manually choose a service that uses the epn-tap data model (can be automatized in pyvo 1.5)

```
In [4]: tap_services = vo.registry.search(servicetype='tap',keywords=['VIRTIS'], ivoid='ivo://padc.obspm.planeto/vvex/q/epn_core')
resource = tap_services[0]
mytable = list(resource.get_tables().keys())[0]
print('schema and table to query:',mytable)
myurl = resource.access_url
print('url of the TAP service:',myurl)
query = 'SELECT top 100 * FROM ' + mytable
```

schema and table to query: vvex.epn\_core

**Main portal:** <https://vespa.obspm.fr/>

**Geoportal:** <https://padc-findme.obspm.fr>

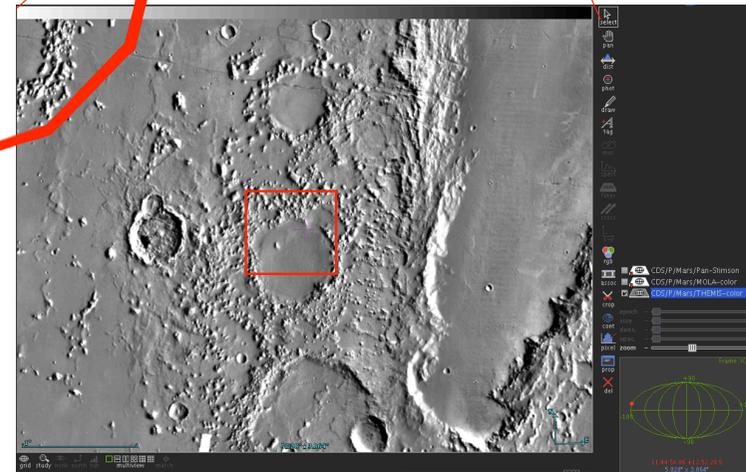
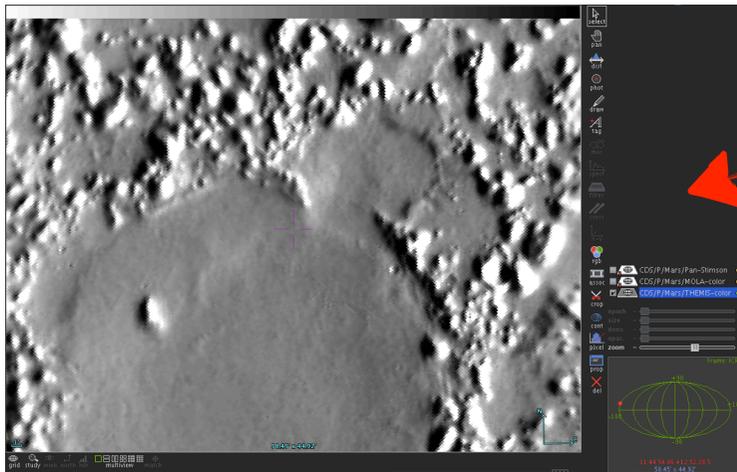
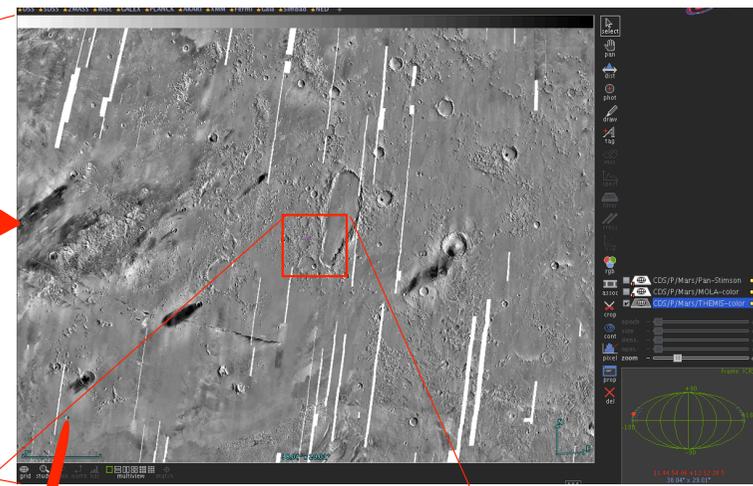
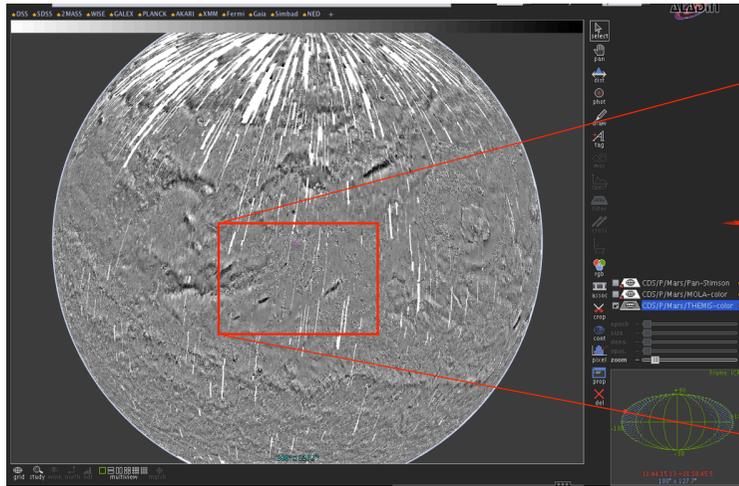
**Tutorials:** <https://github.com/epr-vespa/tutorials>

**Web site:** <http://www.europlanet-vespa.eu/>

**Intermission: Using VO tools in practical Planetary Science situations**

## VESPA and VO tools: images and maps

## Multiresolution maps (**HiPS**) in Aladin



<http://aladin.u-strasbg.fr/AladinLite/doc/API/examples/mars-visualisation/>

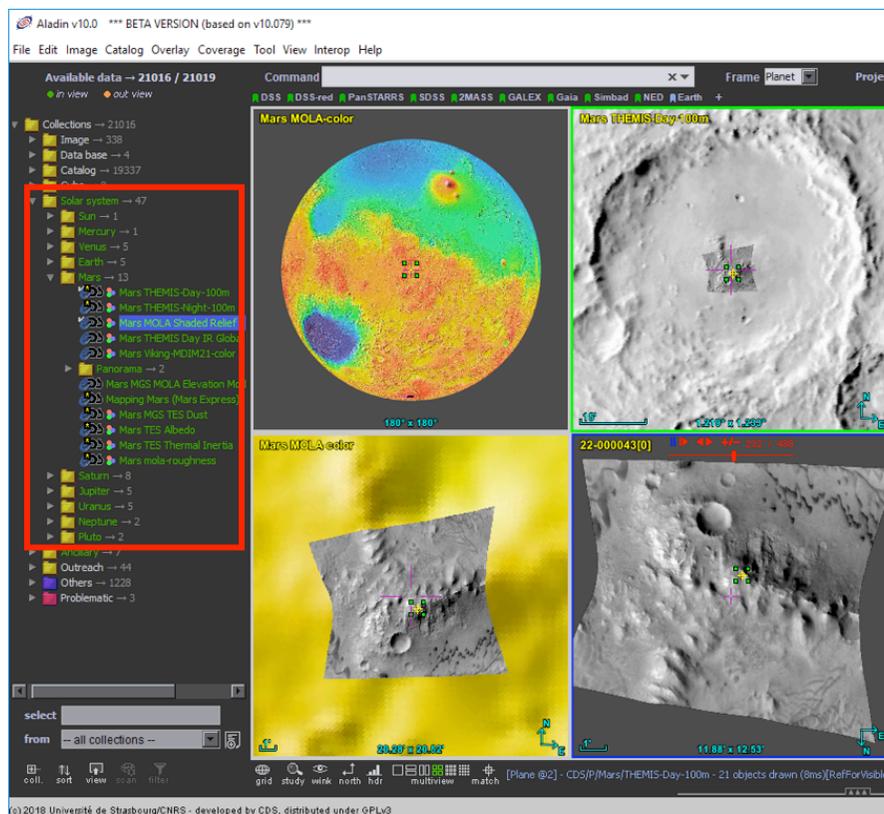
Currently 68 planetary HiPS available for use (from USGS maps and more)

# VESPA and VO tools: overplotting elements

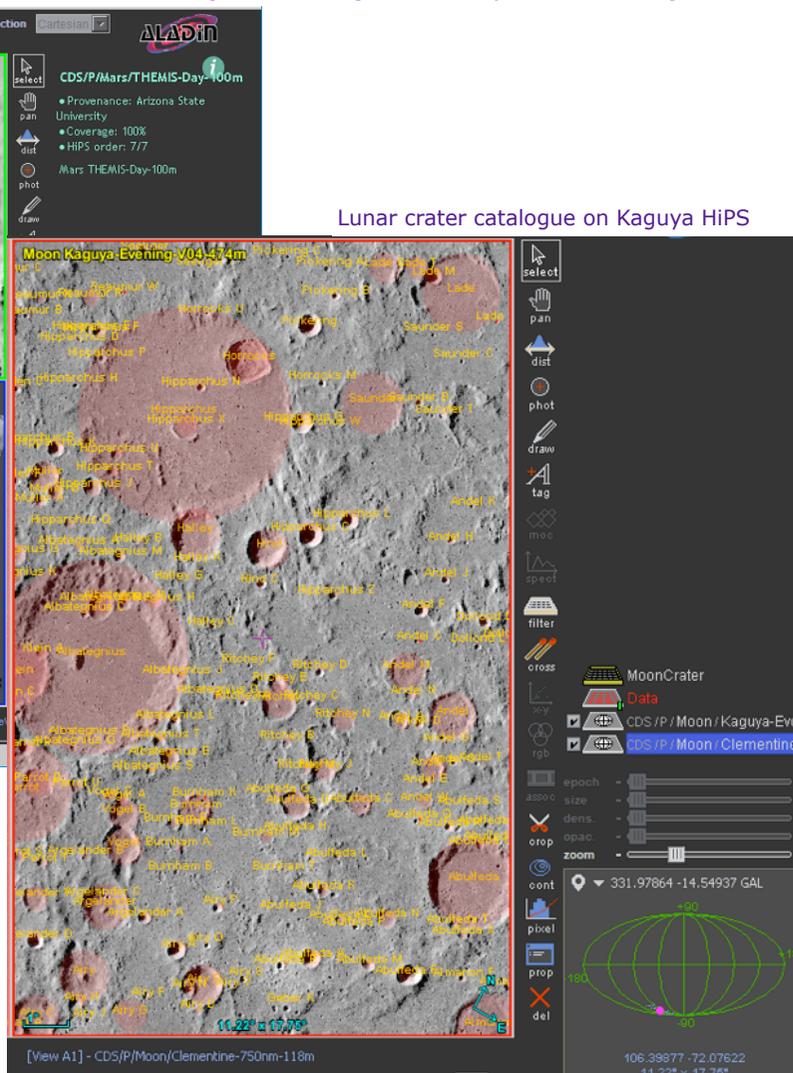
## Aladin (CDS/CNRS):

Georeferenced images + objects superpositions

70 planetary HiPS (USGS maps and more)



CRISM cubes on MOLA HiPS



Lunar crater catalogue on Kaguya HiPS

Relies on IAU planetary coordinate frames (fits' WCS)

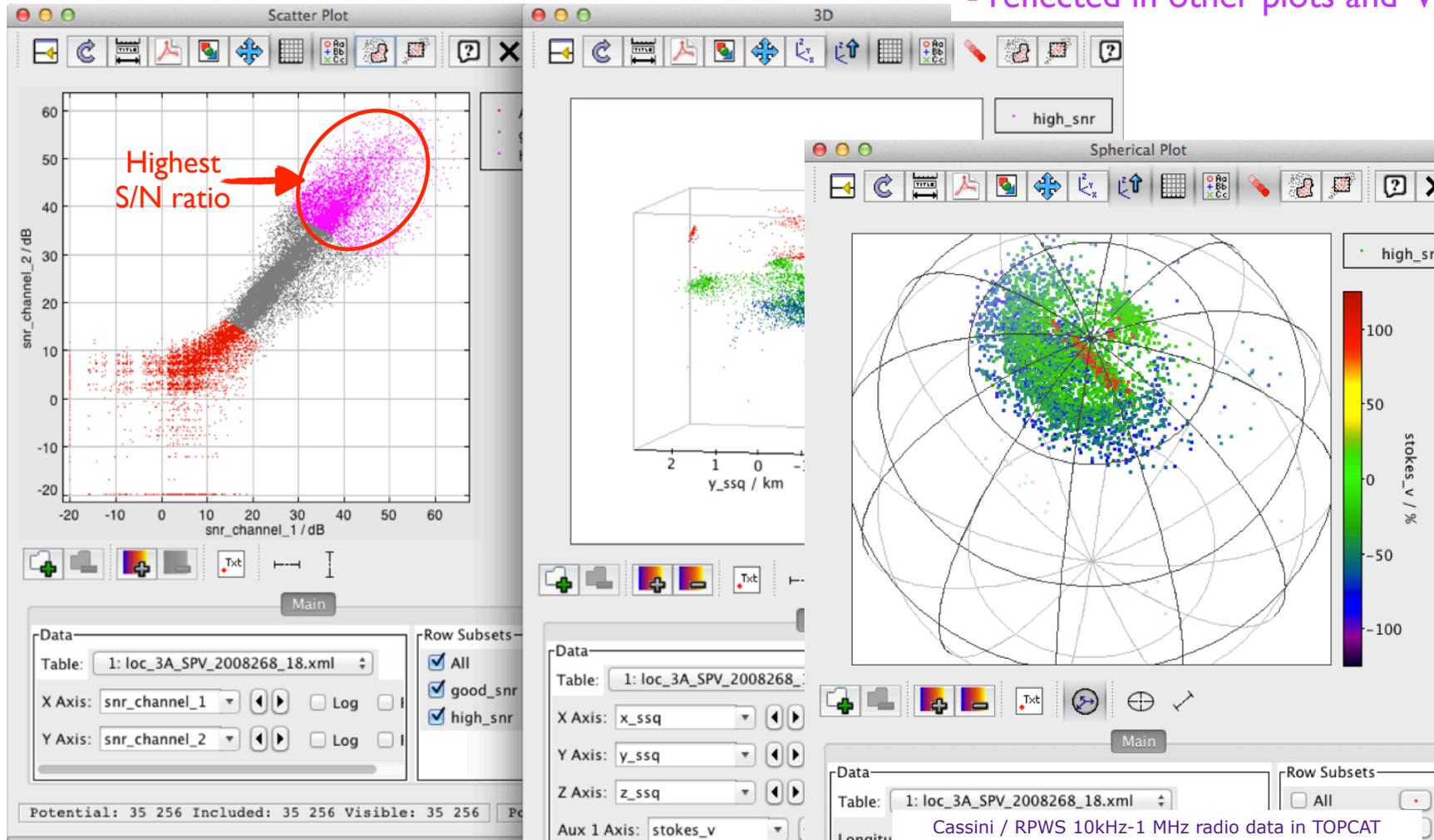
## VESPA and VO tools: tabular data

## TOPCAT (Bristol Univ):

Allows data selection

- by formula or graphically

- reflected in other plots and VO tools

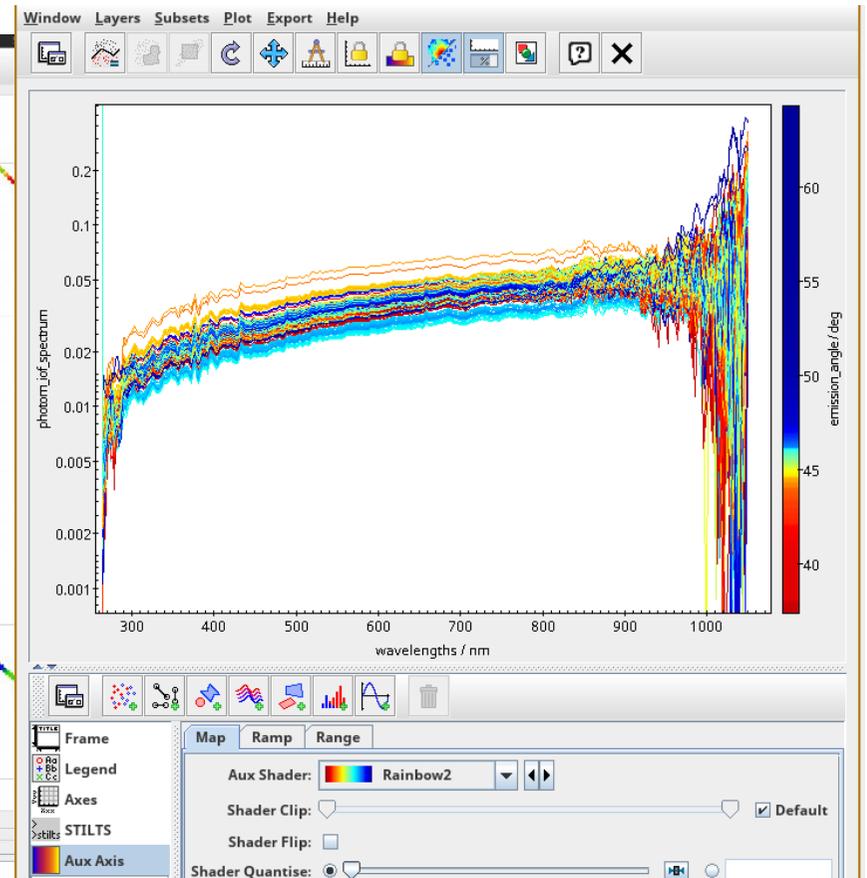
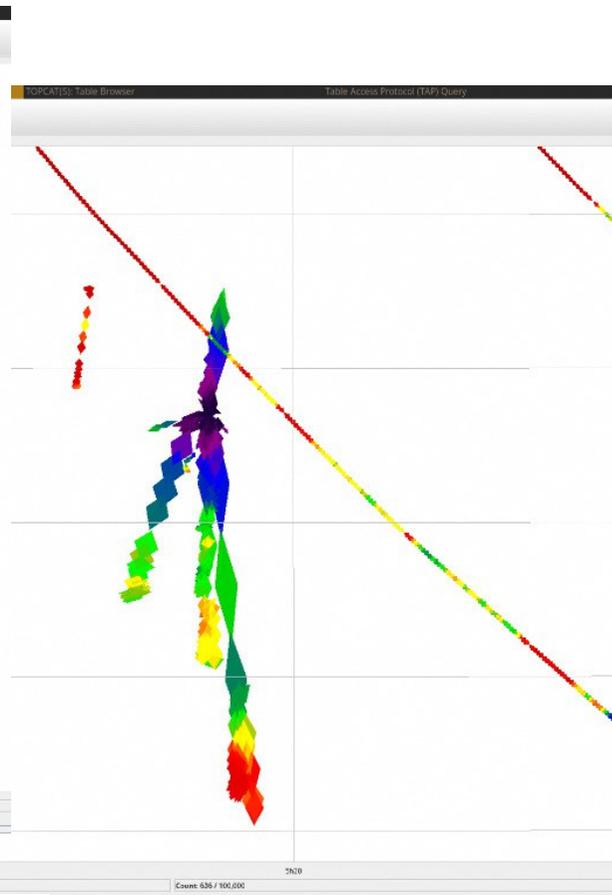
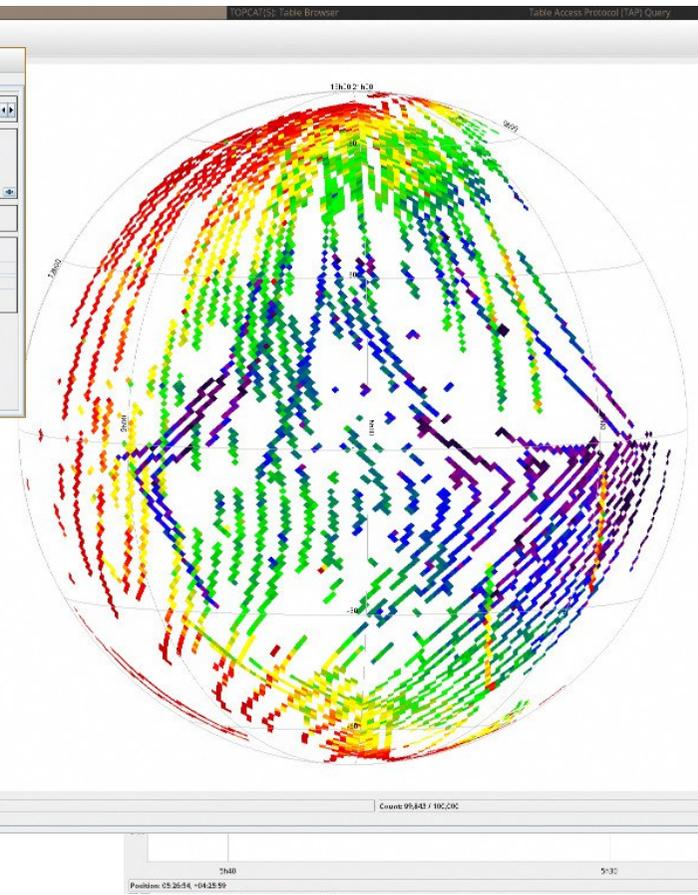


# VESPA and VO tools: spectra support

## TOPCAT (Bristol Univ):

New graphic functions

- MOC and datalink support
- Can now include spectra in tables (powerful, but demanding)

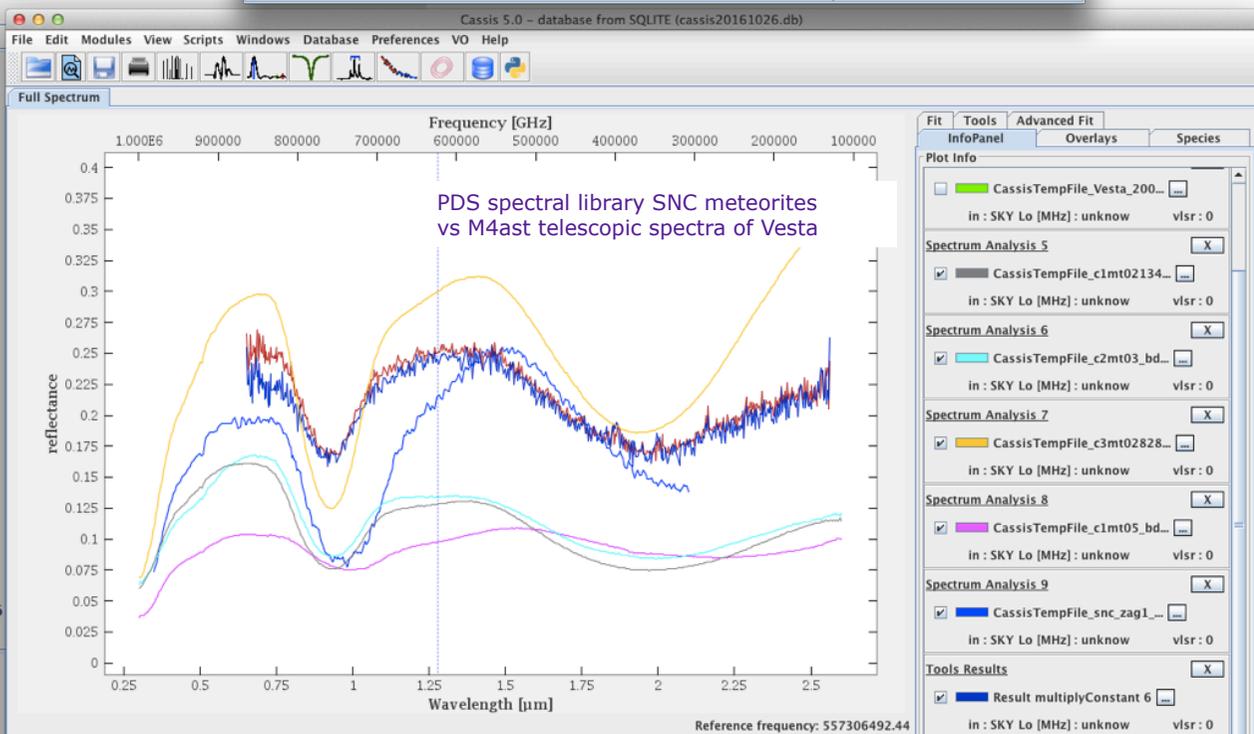
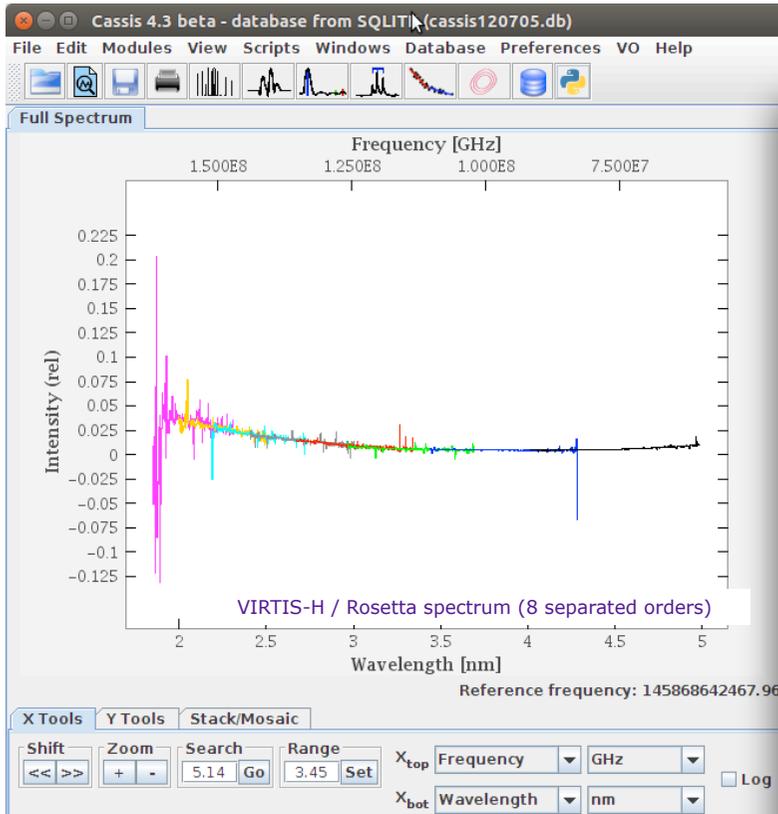
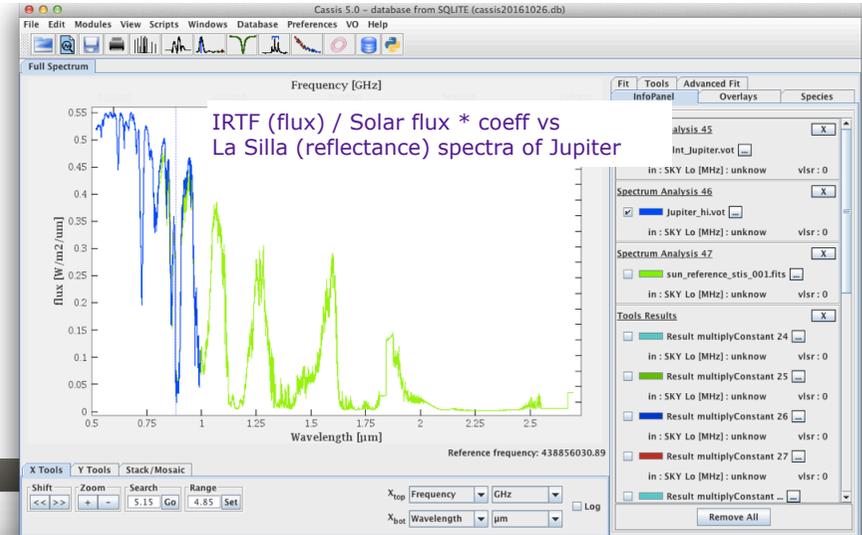


Mercury MESSENGER footprints (MOCs) and spectra in TOPCAT

# VESPA and VO tools: spectroscopy

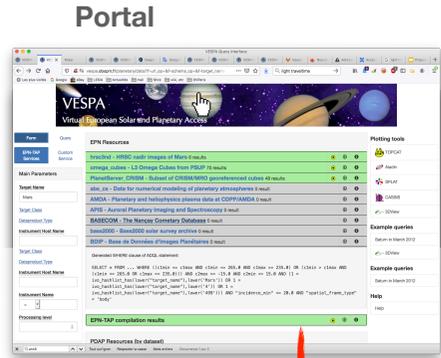
## CASSIS from v6 (IRAP/CNRS)

- Supports data in flux & various types of reflectance (scaling)
- Auto converts spectral axis & flux
- Supports échelle spectra



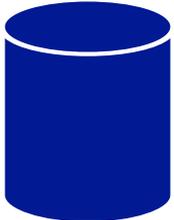
# VESPA VO-GIS bridge

service with fits images & spectra



Portal

EPN-TAP query



TAP servers

Results in service VEX

grainid_srl	instrument_type	target_name	time_min_00	time_max_00	access_url
V0008_070	spectral_cube	Venus	2006-06-16T17:23:03.414	2006-06-16T17:23:03.437	ftp://open.vexac.org...
V0008_070C	spectral_cube	Venus	2006-06-16T17:23:03.414	2006-06-16T17:23:03.437	ftp://open.vexac.org...
V0008_070	spectral_cube	Venus	2006-06-16T17:23:03.424	2006-06-16T17:23:03.466	ftp://open.vexac.org...
V0008_070C	spectral_cube	Venus	2006-06-16T17:23:03.424	2006-06-16T17:23:03.466	ftp://open.vexac.org...
V0008_080	spectral_cube	Venus	2006-06-16T17:27:48.478	2006-06-16T17:30:31.261	ftp://open.vexac.org...
V0008_080C	spectral_cube	Venus	2006-06-16T17:27:48.478	2006-06-16T17:30:31.261	ftp://open.vexac.org...
V0008_090	spectral_cube	Venus	2006-06-16T17:23:04.672	2006-06-16T17:30:31.433	ftp://open.vexac.org...
V0008_090C	spectral_cube	Venus	2006-06-16T17:27:48.472	2006-06-16T17:30:31.433	ftp://open.vexac.org...
VT0027_000	spectral_cube	Venus	2006-06-16T02:01:54.510	2006-06-16T02:01:54.510	ftp://open.vexac.org...
VT0027_000	spectral_cube	Venus	2006-06-16T02:01:54.510	2006-06-16T02:01:54.510	ftp://open.vexac.org...

link:  
geofits image,  
spectrum

Results in service VEX

grainid_srl	instrument_type	target_name	time_min_00	time_max_00	access_url
V0008_070	spectral_cube	Venus	2006-06-16T17:23:03.414	2006-06-16T17:23:03.437	ftp://open.vexac.org...
V0008_070C	spectral_cube	Venus	2006-06-16T17:23:03.414	2006-06-16T17:23:03.437	ftp://open.vexac.org...
V0008_070	spectral_cube	Venus	2006-06-16T17:23:03.424	2006-06-16T17:23:03.466	ftp://open.vexac.org...
V0008_070C	spectral_cube	Venus	2006-06-16T17:23:03.424	2006-06-16T17:23:03.466	ftp://open.vexac.org...
V0008_080	spectral_cube	Venus	2006-06-16T17:27:48.478	2006-06-16T17:30:31.261	ftp://open.vexac.org...
V0008_080C	spectral_cube	Venus	2006-06-16T17:27:48.478	2006-06-16T17:30:31.261	ftp://open.vexac.org...
V0008_090	spectral_cube	Venus	2006-06-16T17:23:04.672	2006-06-16T17:30:31.433	ftp://open.vexac.org...
V0008_090C	spectral_cube	Venus	2006-06-16T17:27:48.472	2006-06-16T17:30:31.433	ftp://open.vexac.org...
VT0027_000	spectral_cube	Venus	2006-06-16T02:01:54.510	2006-06-16T02:01:54.510	ftp://open.vexac.org...
VT0027_000	spectral_cube	Venus	2006-06-16T02:01:54.510	2006-06-16T02:01:54.510	ftp://open.vexac.org...

link:  
WMS/WCS query

service with OGC-type products

OGC servers

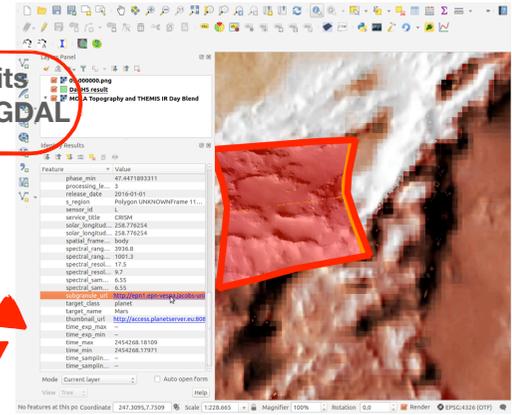


Std OGC query

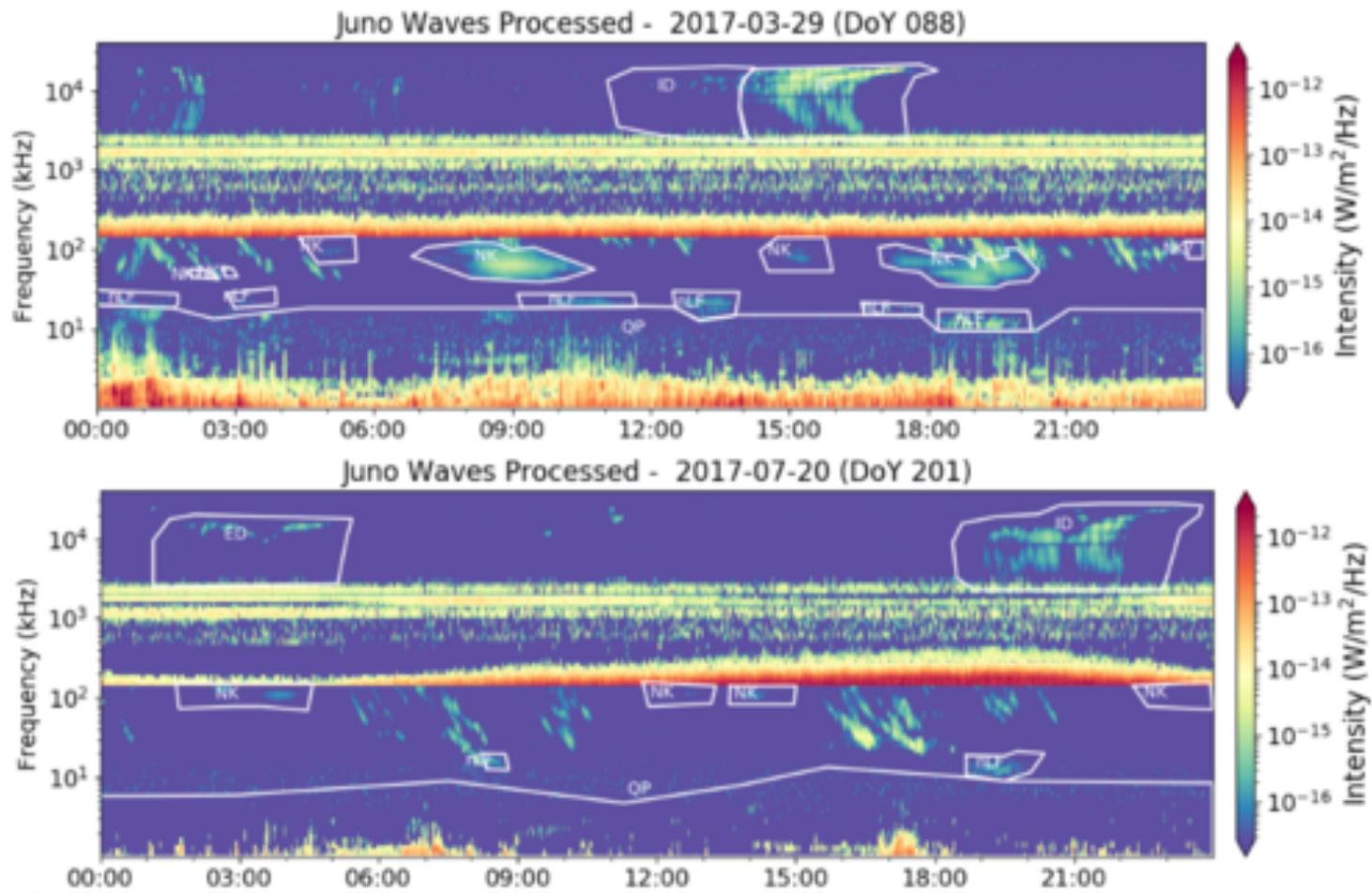
SAMP interface

Geofits driver / GDAL

QGIS



## Locating features in dynamical spectra: TFCat

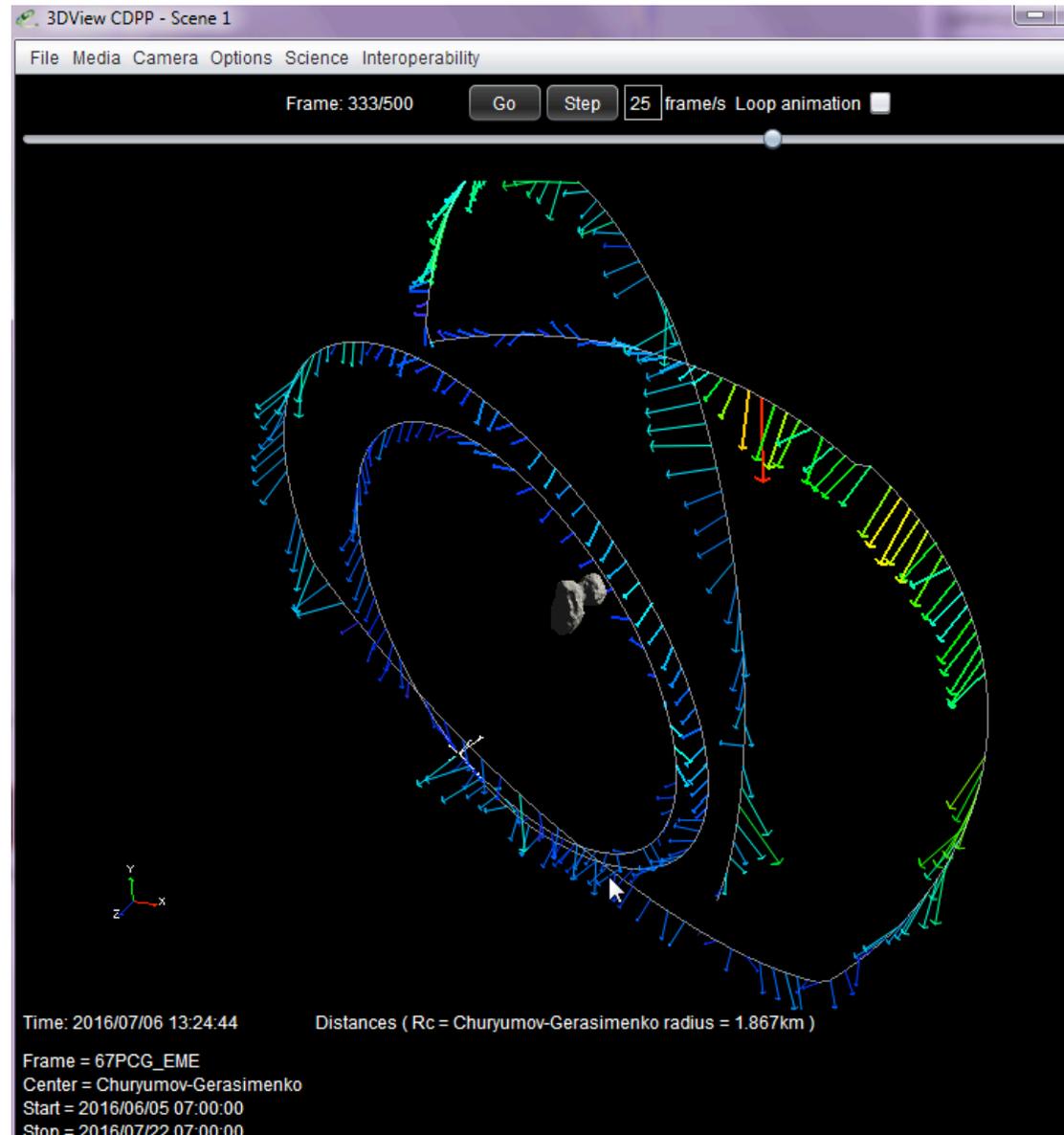


Jupiter radio emissions identified in Juno/Waves data (dynamical spectra), in Autoplot

## VESPA and VO tools: space borne data

### 3Dview (CNES/IRAP):

- Spice kernels from all space missions
- image projection capacities
- Better Spice support from collaboration with ESA

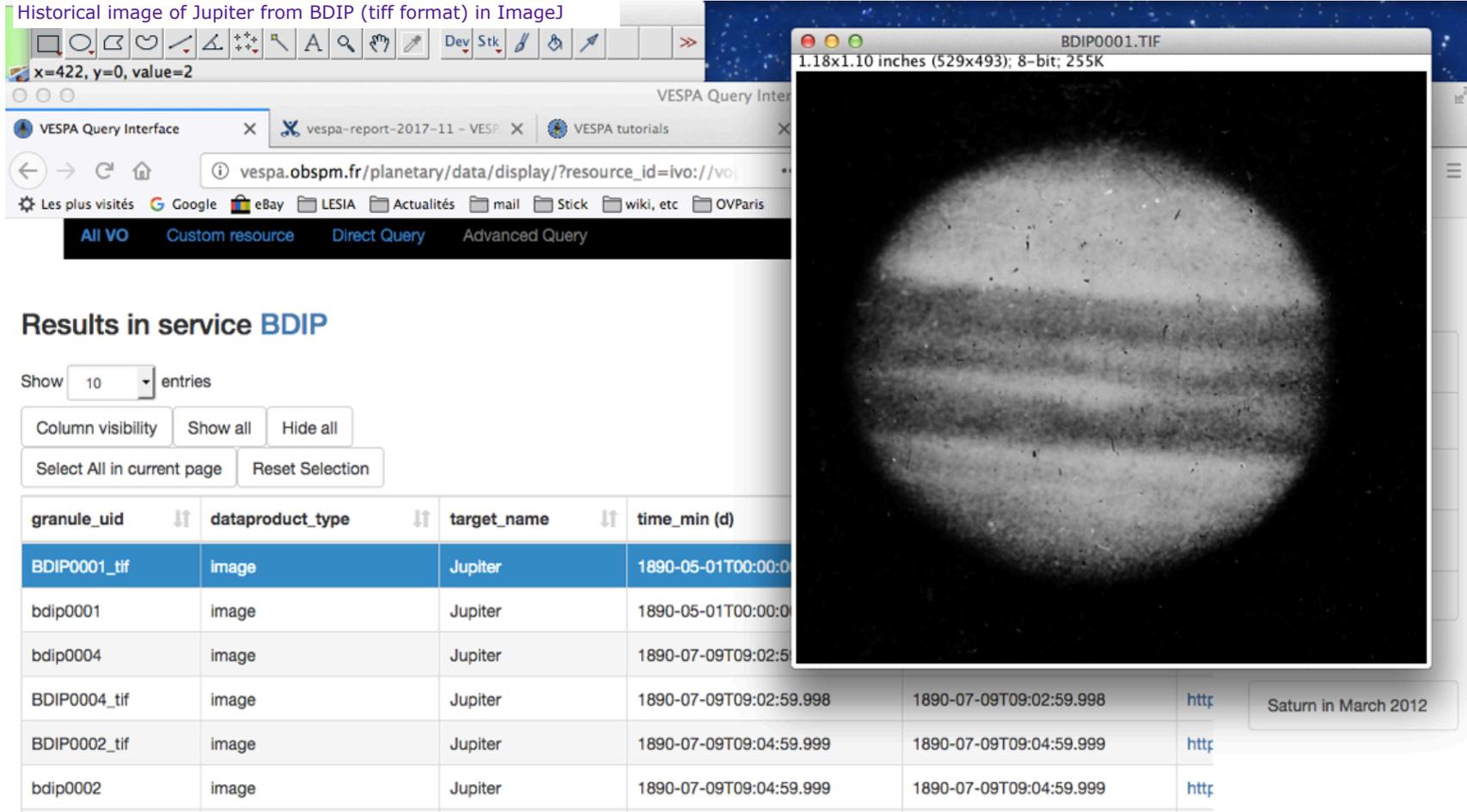


## VESPA and VO tools: image processing interface

### ImageJ (open source):

- SAMP connection installed (input only)
- Provides support for unusual data types (TIFF...) & format conversion
- Provides image processing functions in the VO

Historical image of Jupiter from BDIP (tiff format) in ImageJ

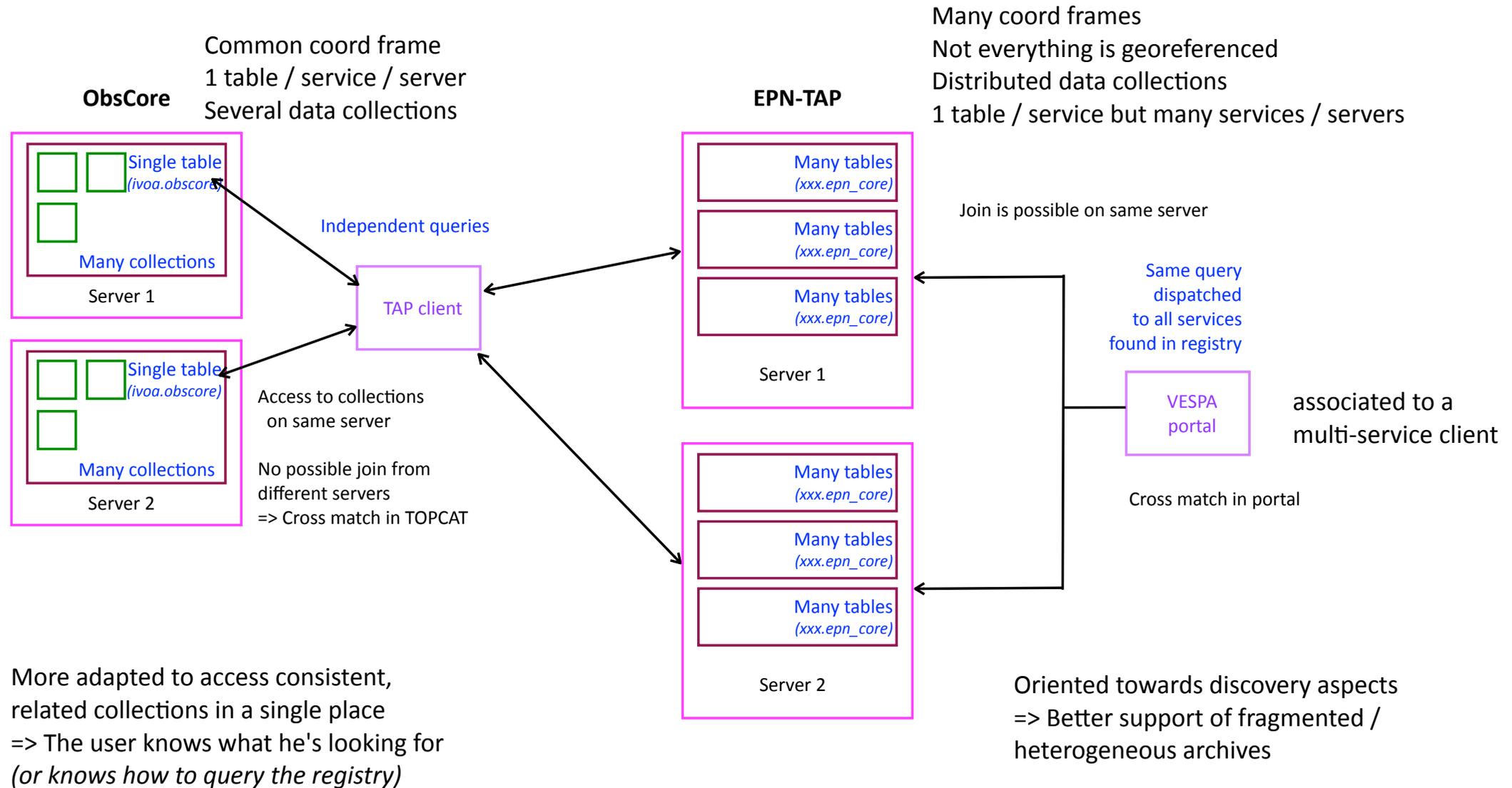


The screenshot displays the VESPA Query Interface in a web browser. The browser address bar shows the URL: `vespa.obspm.fr/planetary/data/display/?resource_id=ivo://vo/`. The interface includes a search bar and navigation options like "All VO", "Custom resource", "Direct Query", and "Advanced Query". Below the search bar, the results are displayed under the heading "Results in service BDIP". A dropdown menu shows "10" entries. There are buttons for "Column visibility", "Show all", "Hide all", "Select All in current page", and "Reset Selection". The results table has the following columns: `granule_uid`, `dataproduct_type`, `target_name`, and `time_min (d)`. The first row is highlighted in blue and shows `BDIP0001_tif`, `image`, `Jupiter`, and `1890-05-01T00:00:00`. Other rows include `bdip0001`, `bdip0004`, `BDIP0004_tif`, `BDIP0002_tif`, and `bdip0002`. To the right of the table, there is a preview window titled "BDIP0001.TIF" showing a grayscale image of Jupiter with a diameter of 1.18x1.10 inches (529x493) and 8-bit, 255K. The preview window also shows a button labeled "Saturn in March 2012".

granule_uid	dataproduct_type	target_name	time_min (d)
BDIP0001_tif	image	Jupiter	1890-05-01T00:00:00
bdip0001	image	Jupiter	1890-05-01T00:00:00
bdip0004	image	Jupiter	1890-07-09T09:02:59.998
BDIP0004_tif	image	Jupiter	1890-07-09T09:02:59.998
BDIP0002_tif	image	Jupiter	1890-07-09T09:04:59.999
bdip0002	image	Jupiter	1890-07-09T09:04:59.999

## **Service implementation**

# ObsCore vs EPN-TAP



## VESPA service installation

### 1- Install data server

- Preferred solution:** DaCHS - in a VM or container
- will handle internal database and registration

### 2- Design data service

Identify EPN-TAP parameters of interest, gather information, organize

### 3- Set up data service

Write a configuration file, ingest data, make data available

### 4- Tests, tests, tests

- **Compliance with EPN-TAP standard** (use taplint validator)
- **Check this actually provides a service to the users**
- **Publish when OK**

## VESPA service installation

### Pre-requirements:

#### 0a- Access to VESPA wiki

<https://voparis-wiki.obspm.fr>

You may have access already - drop a line if not

#### 0b- Backing up your work

**Service definition files** (not the data) will be stored in a common gitlab at Paris Observatory

<https://voparis-gitlab.obspm.fr/vespa>

This ensures sustainability and simplifies interactions / support

This also makes it simple to deploy the service on a final server when ready

Consider this as your own backup space on a common server - requires an invitation

=> Send your email, we will sent back an invitation to eduTEAMS VESPA Virtual Organisation  
when validated, log in the gitlab to create your account, we'll provide access

## VESPA service installation

**1- Install the TAP server** (currently Debian 12, DaCHS on port 80, awstats, postgres...)

=> clone [https://voparis-gitlab.obspm.fr/vespa/dachs/docker\\_dachs\\_server](https://voparis-gitlab.obspm.fr/vespa/dachs/docker_dachs_server)

then edit the `.env` file with your info

then type `cd conf`

`docker up -d`

**Options** (in dev):

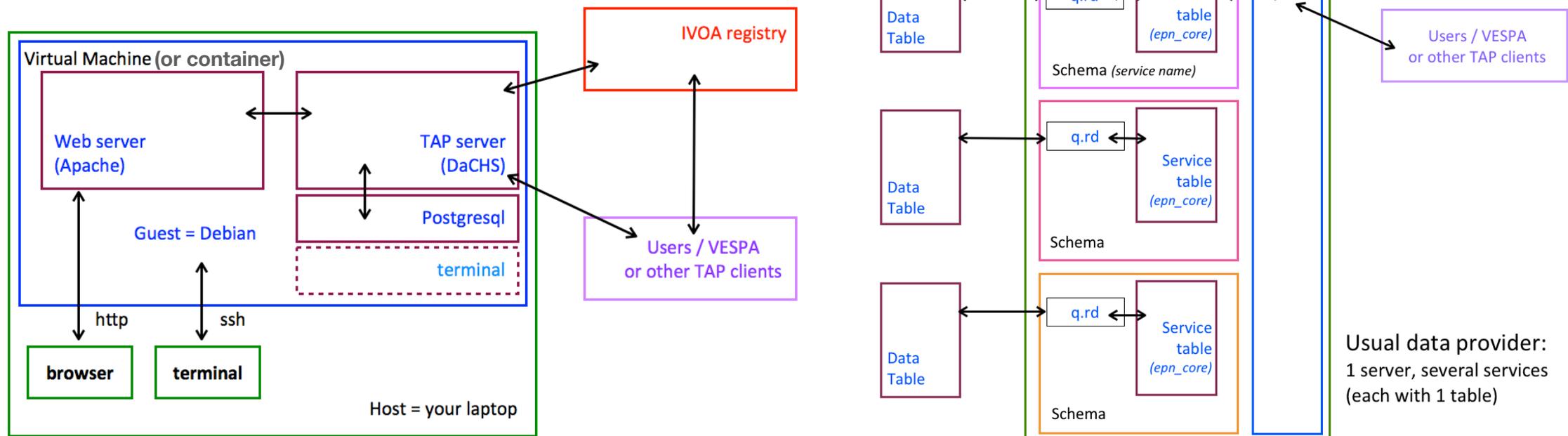
- host on EOSC VM (one example running)
- host at PADC: you're still in charge, DaCHS is updated via CI on updates; Ifs possible
- private services: required to handle PI experiments (ground segment of space instrument)  
private VESPA portal available for cross-matches

# VESPA service installation

## 1- Install data server

**Preferred solution:** DaCHS 2.6+ - in a VM or container

- will handle internal database and registration



## VESPA service installation

### 2- Design data service

Identify EPN-TAP/ EPNCore parameters, gather information, organize

**EPN-TAP services consist in 1 table** describing

- a series of elements (granules) - rows
- with standard parameters - columns (some are mandatory)

**=> need to identify**

- granules / granularity (usually: files)
- If there are natural / convenient ways to group them
- values of EPN-TAP mandatory parameters
- quantities of interest (search and descriptive parameters) and how to store them in EPN-TAP parameters

This is science, not technical work — you must know or imagine how users want to access your data

=> Make it as complete as possible, remain consistent with existing services!

## Typical metadata from EPNCore

### EPNCore vocabulary:

A core of ~ 40 columns / parameters always present (can be empty)

~ 180 standard columns / parameters available to chose from (new ones are possible)

### 1- Basic info

Target name or ID + class, time, data IDs, release date, etc

### 2- Provenance info

Instrument, Observer, etc + possibly processing history

### 3- Link to the data

File (URL + format) or scalar quantities (eg, orbital parameters)

Thumbnail if possible (used in the portal)

### 4- Coverages

Spatial, temporal, spectral, illumination conditions; possibly other ones

- beware that units / scales are predefined

## VESPA service installation

### 2- Design data service

Identify EPN-TAP/ EPNCORE parameters, gather information, organize  
- examples are available from voparis-gitlab

=> *Docs:*

<https://ivoa.net/documents/EPNTAP/>

*Detailed vocabularies:*

[http://www.europlanet-vespa.eu/EPN\\_TAP.shtml](http://www.europlanet-vespa.eu/EPN_TAP.shtml)

=> *Template / guide (XLS sheet):*

[https://voparis-wiki.atlassian.net/wiki/download/attachments/56898983/EPN-TAP\\_parameters\\_List\\_template.xlsx?version=2&modificationDate=1713947811158&cacheVersion=1&api=v2](https://voparis-wiki.atlassian.net/wiki/download/attachments/56898983/EPN-TAP_parameters_List_template.xlsx?version=2&modificationDate=1713947811158&cacheVersion=1&api=v2)

=> *Complete example (and links to shorter ones):*

<https://voparis-wiki.obspm.fr/display/VES/Setting+up+an+EPN-TAP+service+in+EPN-2024>

## VESPA service installation

### 3- Set up data service

Write a configuration file (q.rd), with support from VESPA teams

Ingest data (various possible situations, the simplest one is via a CSV file)

Includes general info describing the service itself (for the registry)

### 4- Validation

Test, check data access, review

Publish (*both* in the IVOA registry and the VESPA portal)

Docs:

<https://voparis-wiki.obspm.fr/display/VES/Building+the+resource+descriptor+for+your+EPN-TAP+service+in+DaCHS>

<http://docs.g-vo.org/DaCHS/tutorial.html#epn-tap>

**Main portal:** <https://vespa.obspm.fr/>

**Geoportal:** <https://padc-findme.obspm.fr>

**Tutorials:** <https://github.com/epr-vespa/tutorials>

**Web site:** <http://www.europlanet-vespa.eu/>