Virtual European Solar & Planetary Access (VESPA) 2025: Reload

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Ricardo Hueso — EHU/PVU, Bilbao
Anni Määttänen — IPSL/CNRS (LATMOS), Paris
Ehouarn Millour — IPSL/CNRS (LMD), Paris
Frédéric Schmidt — IPSL/CNRS (GEOPS), Paris
François Andrieu
Ann Carine Vandaele — IASB-BIRA, Brussels
Loïc Trompet
Mario d'Amore — DLR, Berlin
Ingo Waldman — UCL, London
Nicolas Manaud — SpaceFrog, Toulouse
Pierre Fernique — CDS/CNRS, Strasbourg
Thomas Boch
Gilles Landais
Markus Demleitner — Heidelberg Univ
Mark Taylor — Bristol Univ
Chiara Marmo — oudeis.io / Univ Paris-Saclay

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8 Sept 2025

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VESPA in a nutshell

- **Activity in successive Europlanet programmes, started 2011**
- **Provide Open access to Solar System data:**
  - Open Science policy
  - Contributive system open to the community
  - FAIR principles: Findable / Accessible / Interoperable / Reusable
- **Uses the Virtual Observatory framework**

=> The core VESPA team is still active beyond Europlanet *programmes*, in the Europlanet Society

Currently 94 data reviewed EPN-TAP services (cross-searchable from tools and portals)

- 30+ contributing institutes worldwide

- ESA's Planetary Science Archive (PSA, 37 Mfiles), some NASA / PDS assets

- Results from 10+ European programmes

- Derived data from ~ 12 space borne instruments

- Pro-Am network activities — e.g., Europlanet Telescope Network

Spectra vs geologic units

1- Set the VESPA geoportal to Mercury (MESSENGER MDIS)

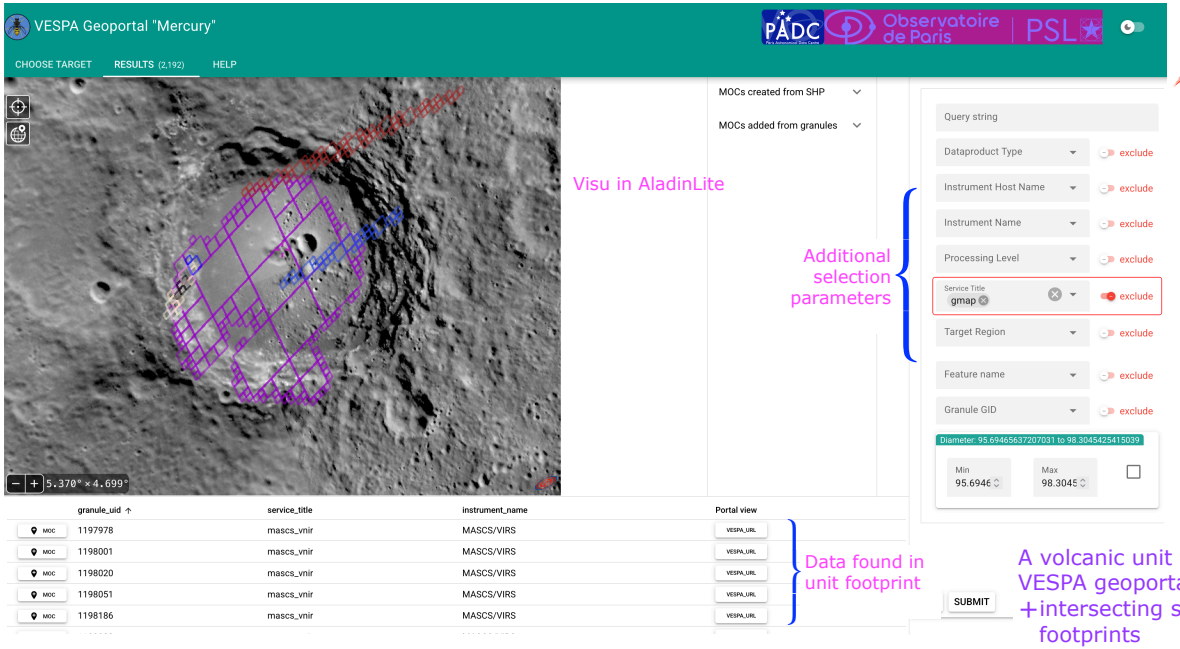
2- Drop a shapefile of a Mercury pyroclastic deposit (Leon-Dasi et al 2023, from analysis of MESSENGER images) **=> converts to MOC**

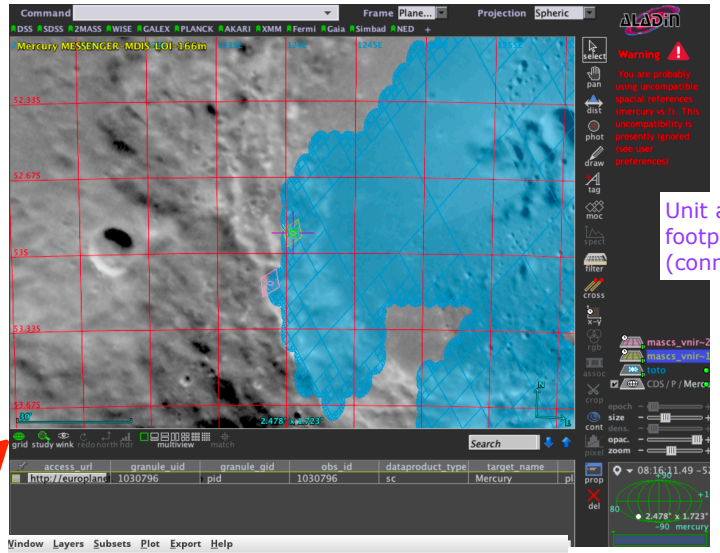
=> identifies all MESSENGER spectra in this unit, with footprint and conditions

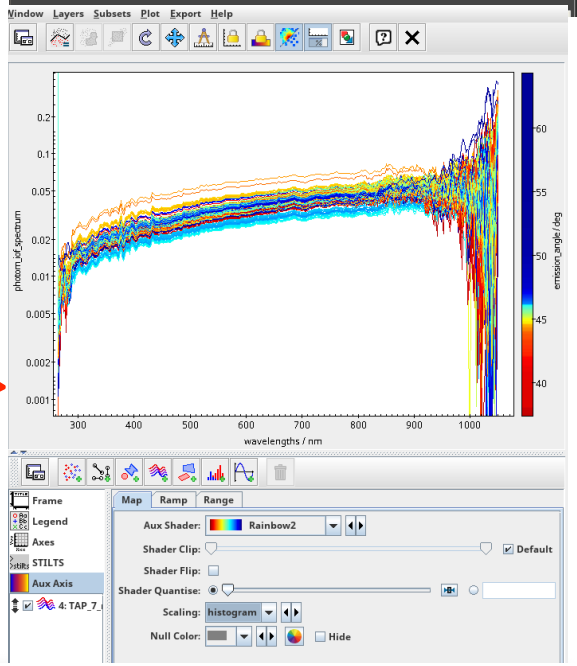
3- Send the unit MOC and spectrum footprints to Aladin

4- Send all spectra to TOPCAT

=> average spectrum and variability, possibly with selection on illumination angles





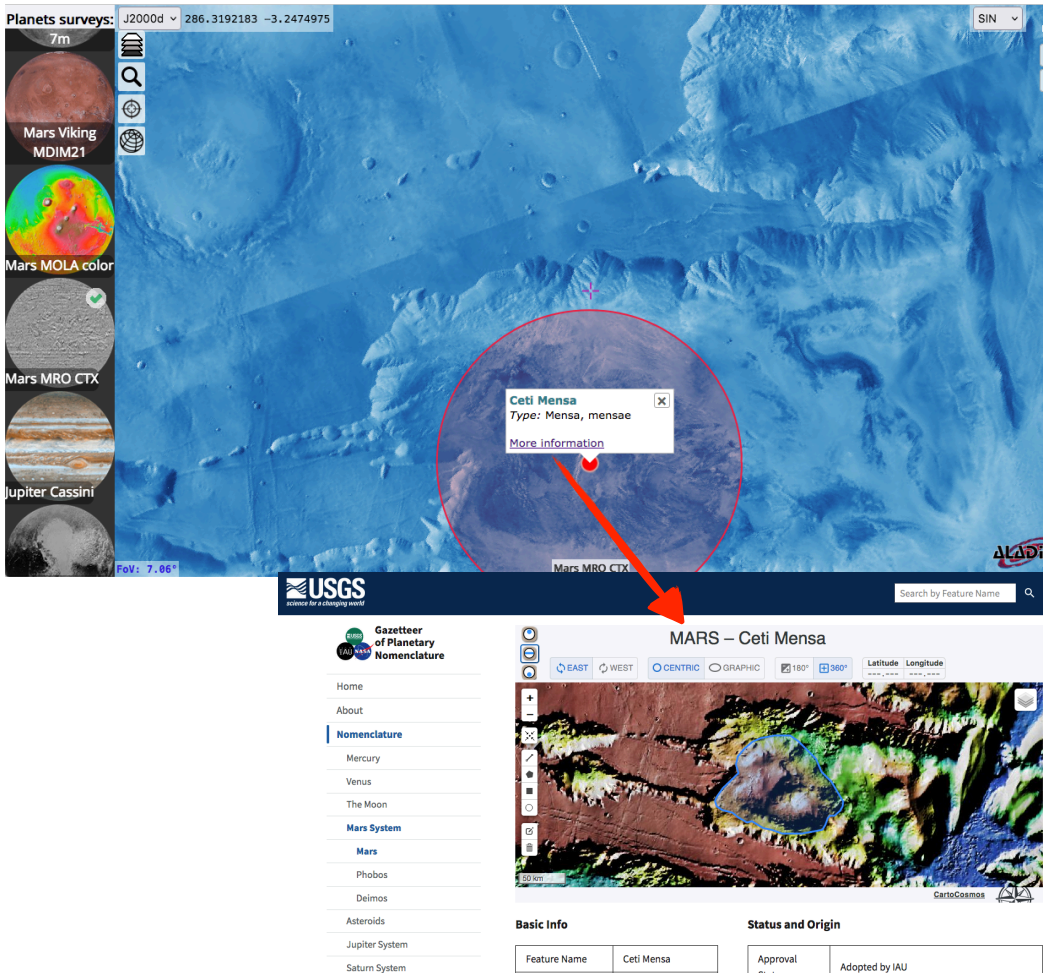


Other uses of the geoportal / HiPS / MOC

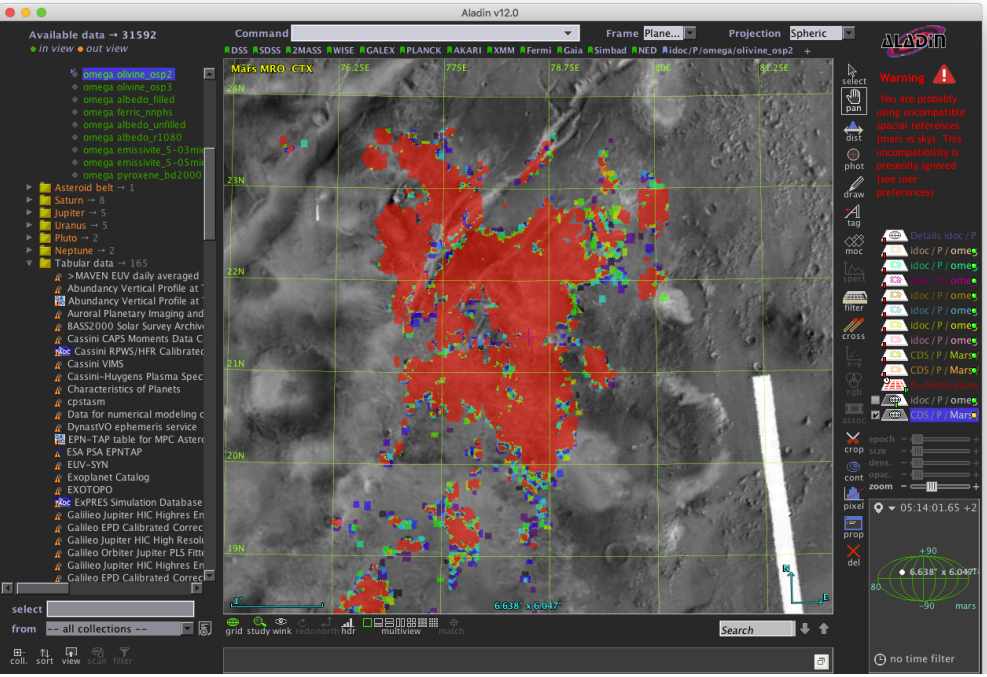
- **Readily identifies overlapping observations**
- **Multi-resolution maps (HiPS) can be used as data source, e.g. for mineral abundance**
- **Connection with IAU nomenclature and USGS services from AladinLite**

(replace calls to SIMBAD when in planetary mode)

AladinLite planets explorer
https://aladin.cds.unistra.fr/AladinLite/planets-explorer



OMEGA olivine map over CTX/MRO HiPS
in Jezero crater area, in Aladin



Spectra of TNOs

1- Select TNOs or family of interest from a specialized service:

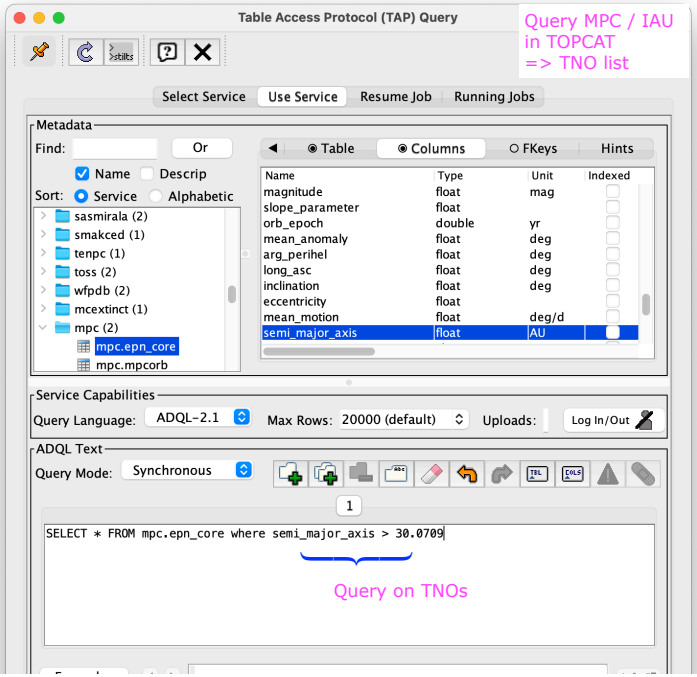
EPN-TAP (MPCorb, NEOCC, MP3C, DynAstVO…) [external APIs (SsODNet, JPL SBDb, Lowell Astorb…) may be OK for small populations]

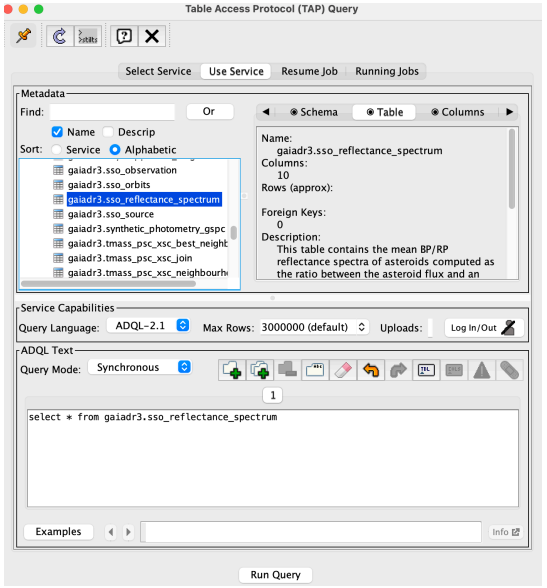
=> list of targets with names in TOPCAT

2- Query an asteroid spectra service: EPN-TAP (spectro_asteroids, M4ast…) or TAP (Gaia)

3- Cross match in TOPCAT (or via TAP upload) based on name

=> average spectrum and variability / further classification





Query Gaia in TOPCAT
=> retrieve all spectra

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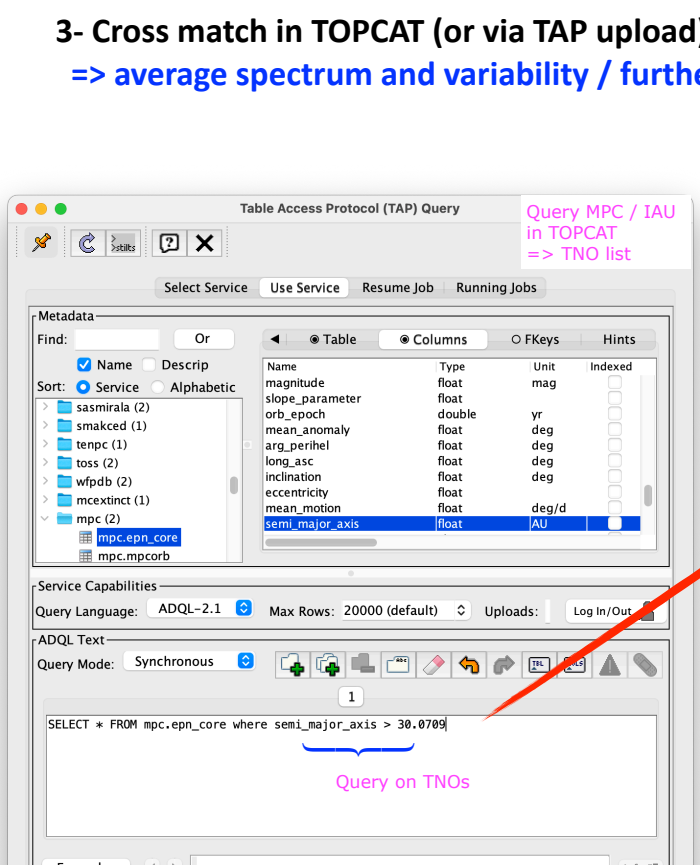
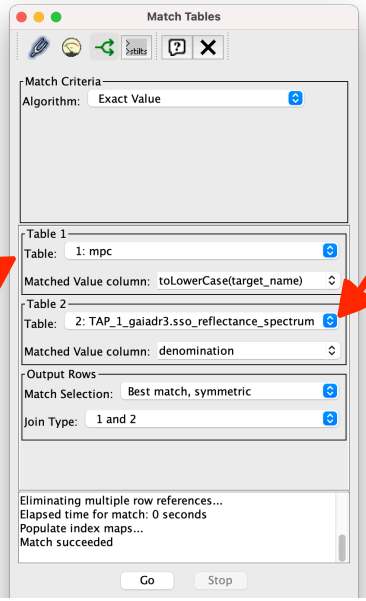
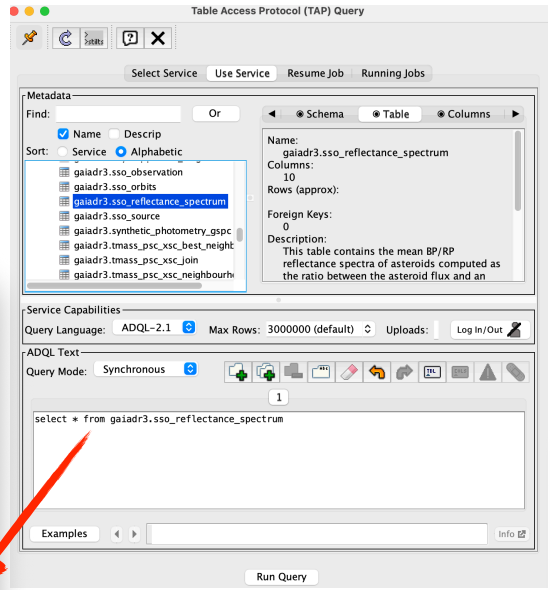
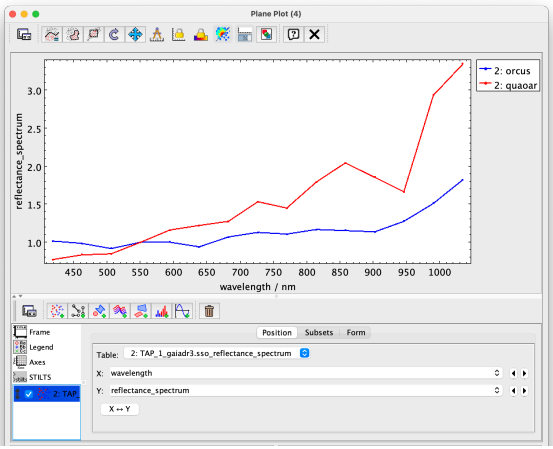






Much easier with EPN-TAP services ;)



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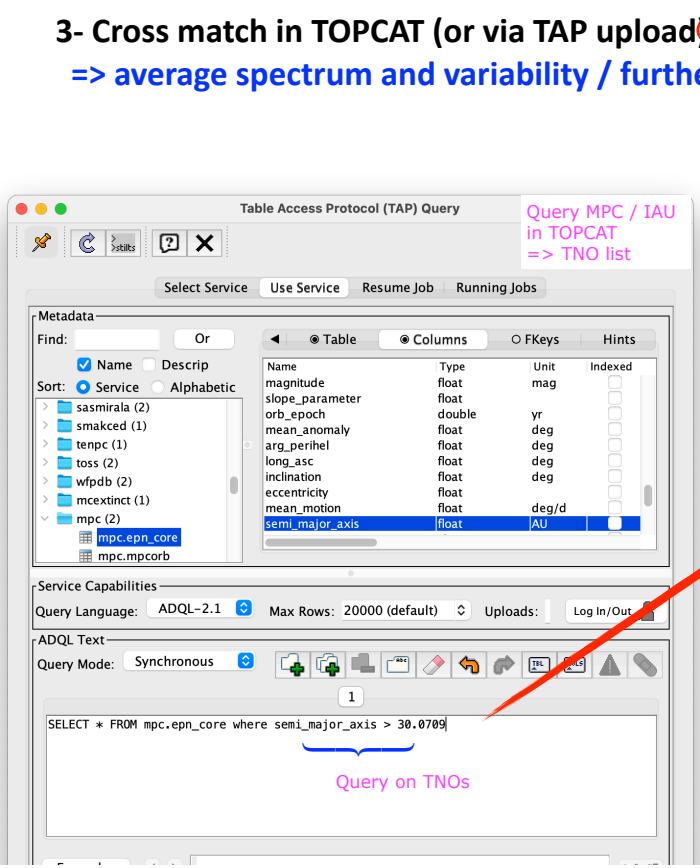

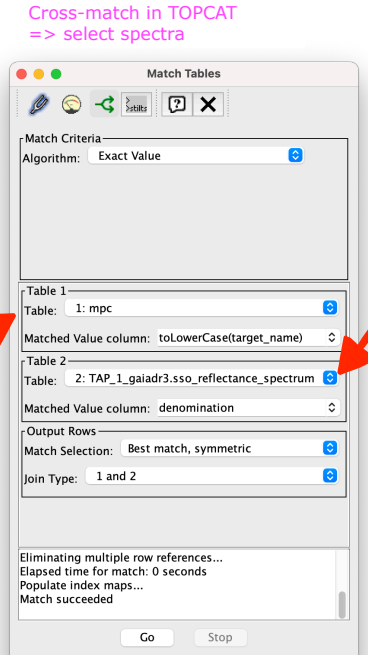

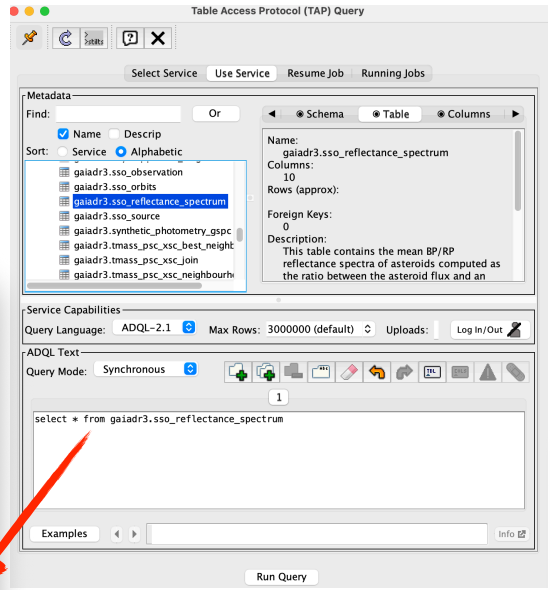

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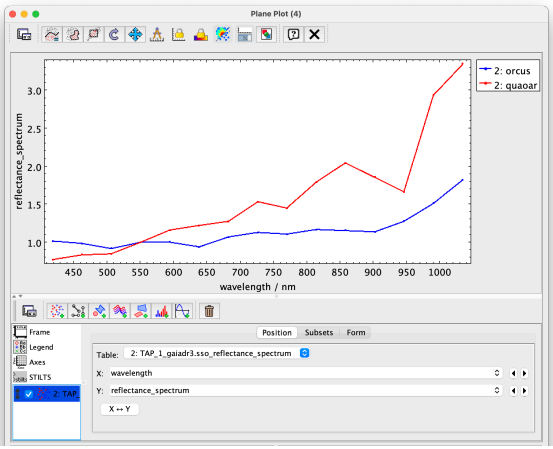


Images on shape models

1- Load a 3D shape model of the target in TOPCAT (implemented for VESPA)

Direct support of .ver files (ESA, PDS, DAMIT) or conversion from SPICE DSK (command line)

=> Plot as point cloud or plate model

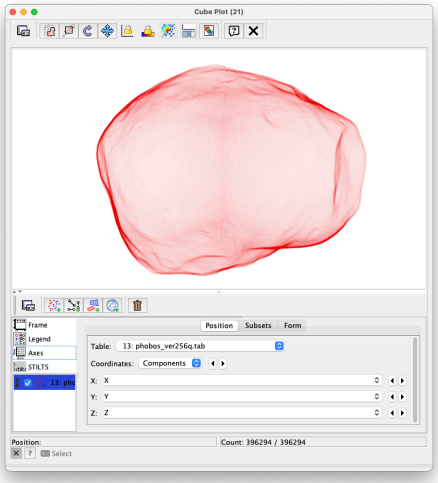
2- Query a image / cube service: EPN-TAP (VIRTIS Rosetta…) or direct upload from Jupyter notebook (PDS4)

3- Overplot on central coordinate (for quicklook) or plates (figures)

Support for space experiment in operation, or thermal simulations

Retrieve shape model
from PDS, ESA, DAMIT…

Phobos shape as point cloud in TOPCAT



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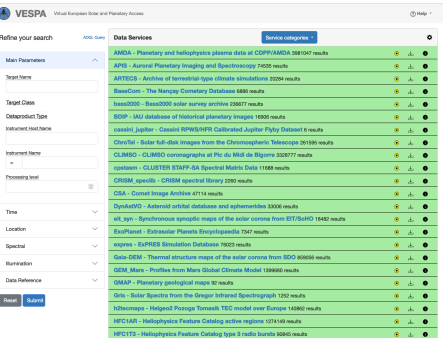

Select data files from
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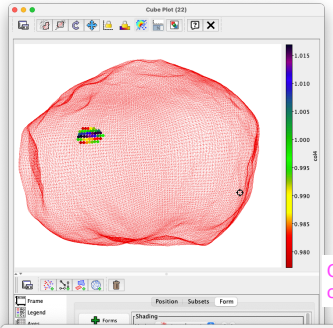
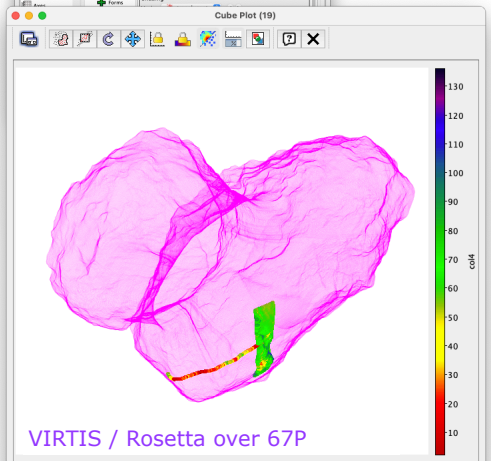


Overplot data with
central (x,y,z) coordinates



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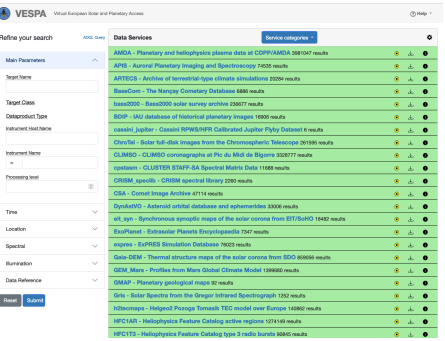

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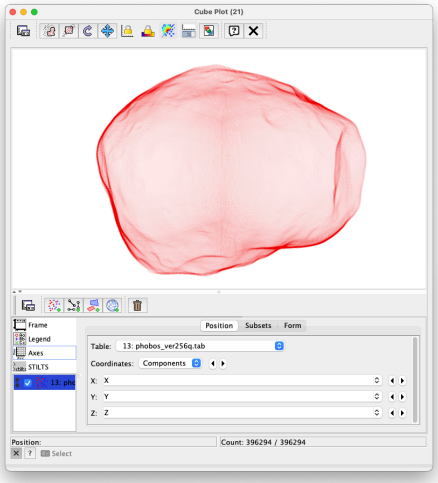

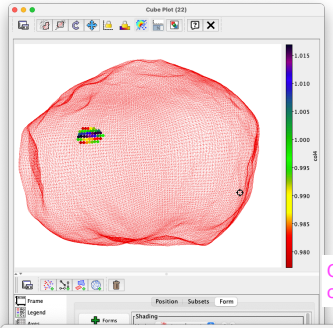

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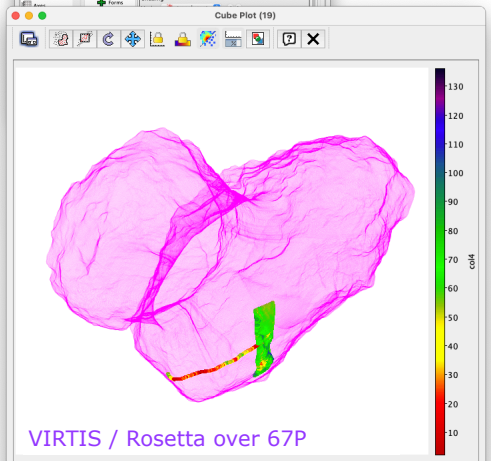
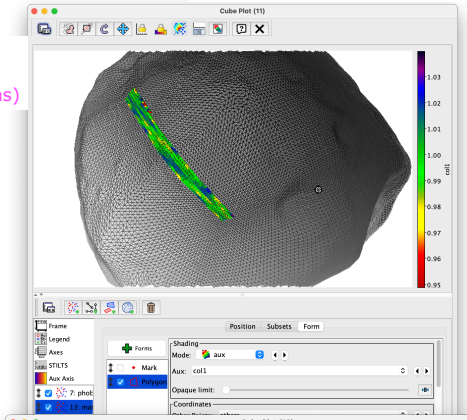
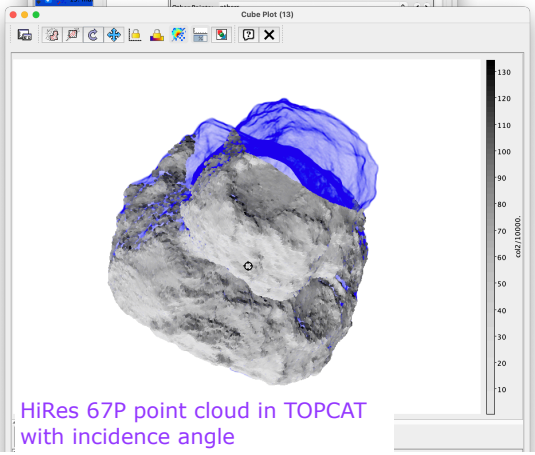


VIRTIS / Rosetta over 67P

Overplot data with plate coordinates (e.g. for simulations)

Shape as plate model in TOPCAT





HiRes 67P point cloud in TOPCAT with incidence angle

Comparing observations and reference lab spectra

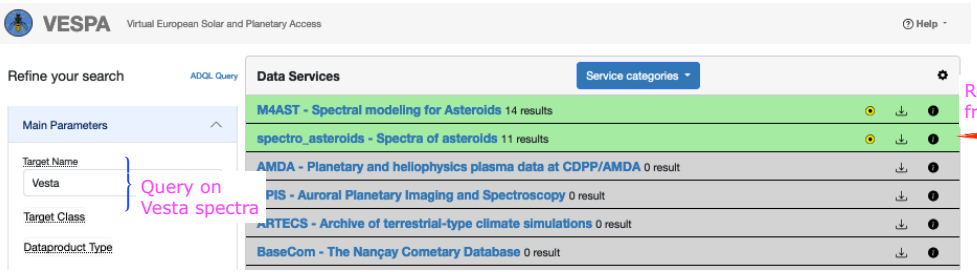
1- Locate spectra of (4) Vesta from the VESPA portal => results found in M4ast & spectro_asteroids

Send spectra to CASSIS *(or TOPCAT or SPLAT-VO)* from service result page

2- Query the VESPA portal for spectra of SNC meteorites => CRISM_speclib and SSHADE

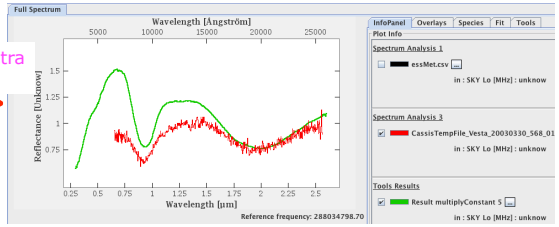
In CRISM_speclib search for *sample_classification like "%snc%"*

3- Send selected results to CASSIS => analysis, best matches — can support unmixing, classification, etc in Jupyter notebooks



Retrieve selected spectra from VESPA portal

Selected Vesta spectra in CASSIS



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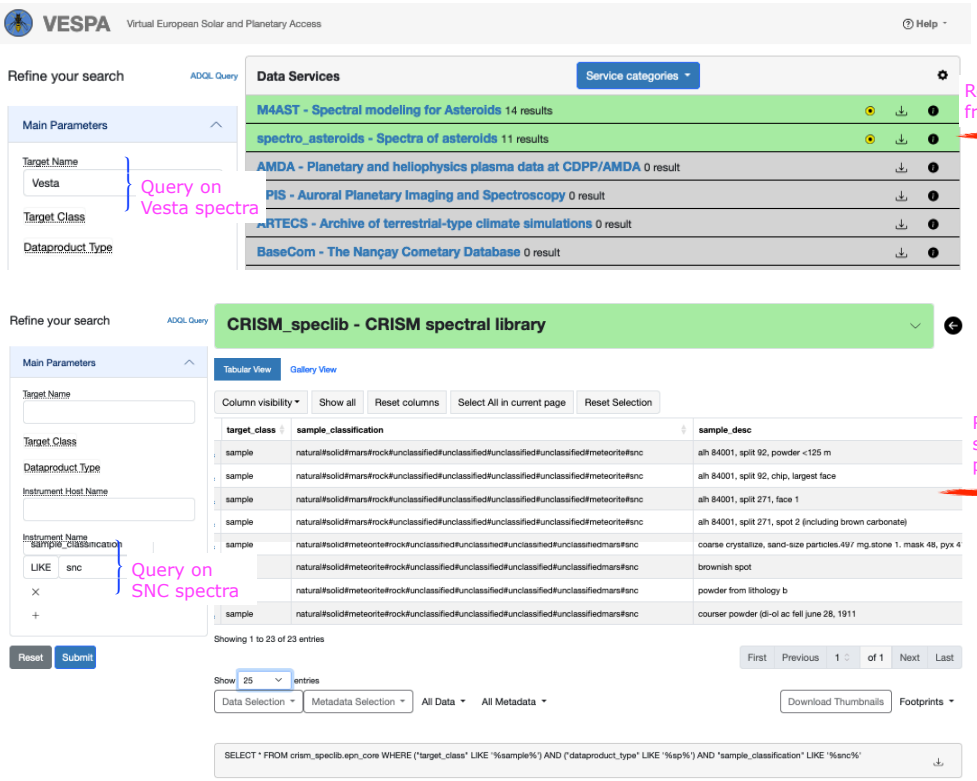

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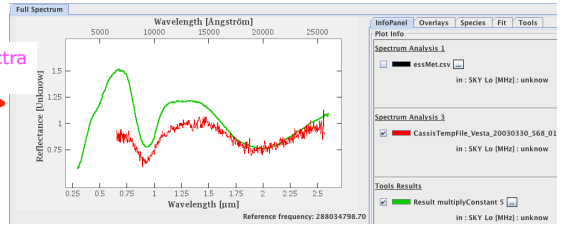

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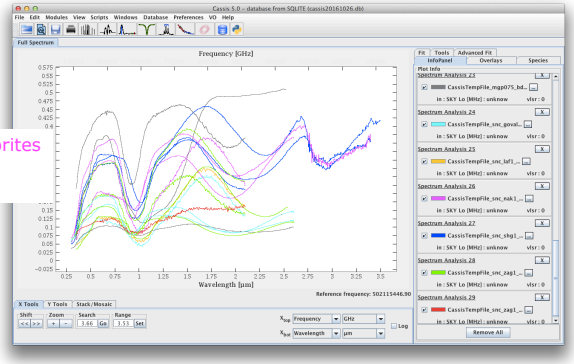

Processing or comparison in CASSIS (best fit to come)

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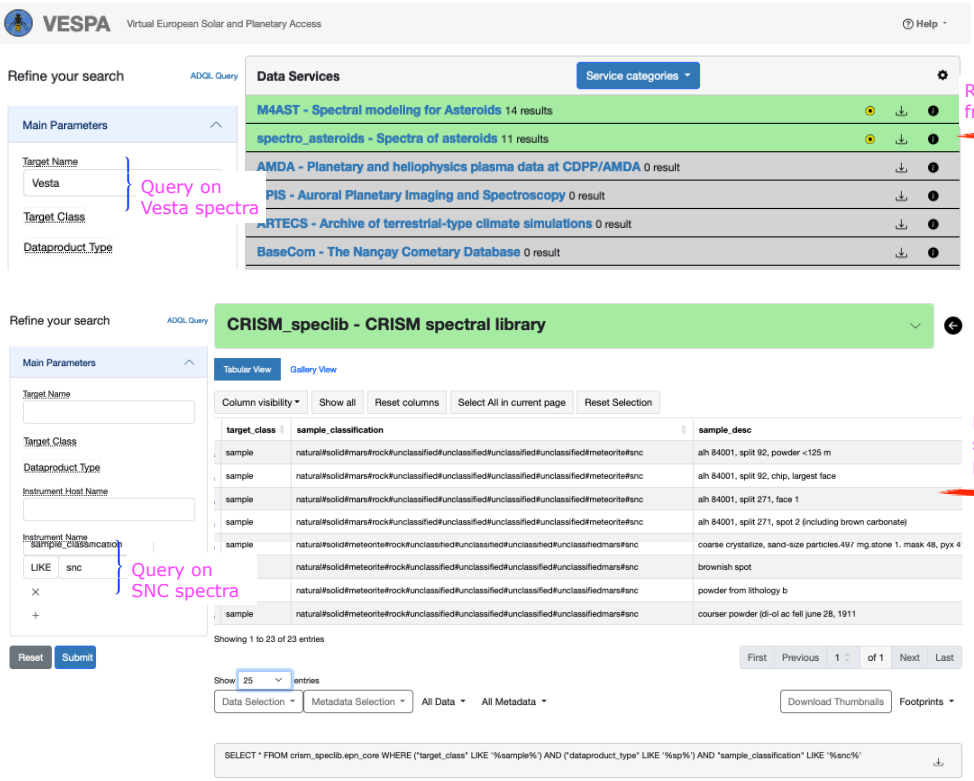

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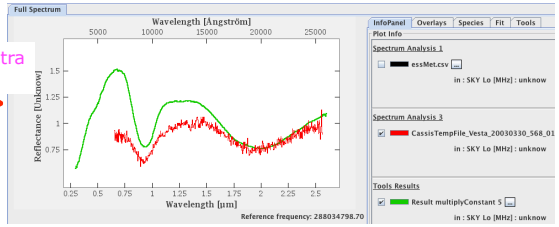

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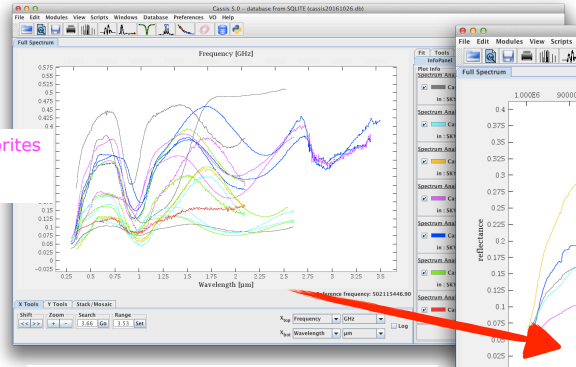

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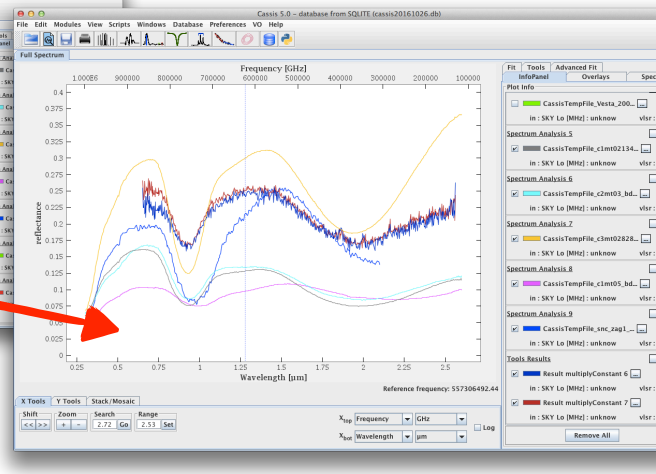
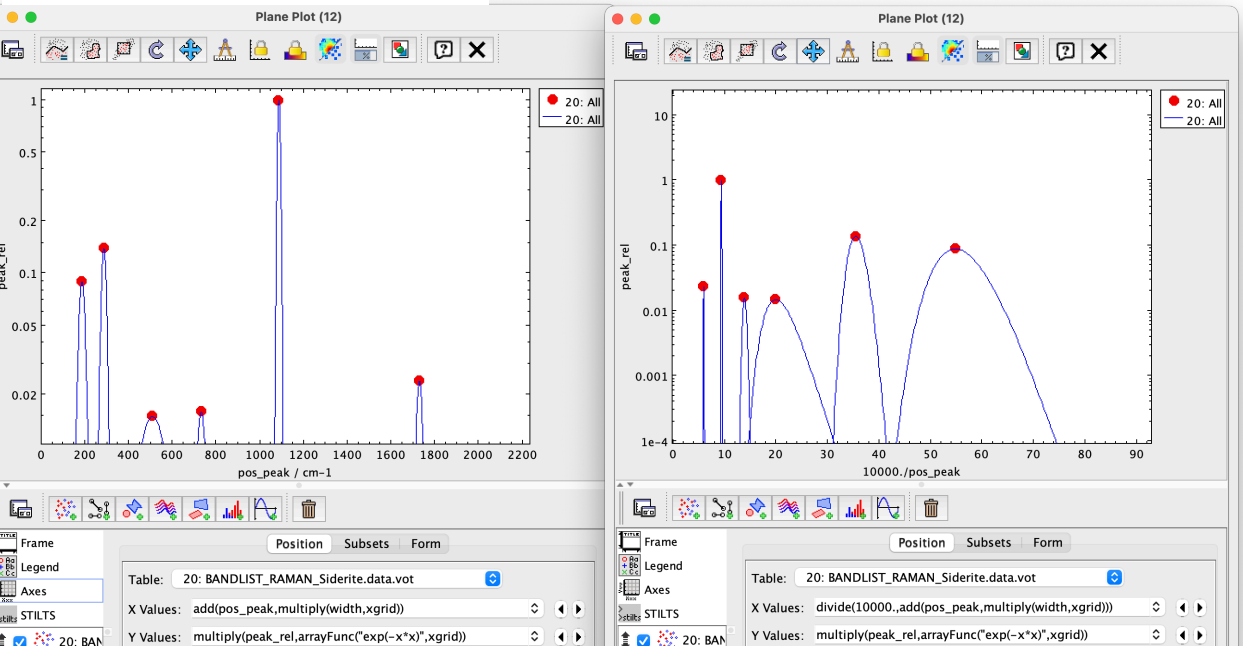
Best fit spectra in CASSIS



Other spectral analyses

- **Get band lists of solids from SSHADE (minerals & ices)**
- **Use them to model spectra and fit observations in workflows / Jupyter notebooks**

Bands from a SSHADE siderite sample in TOPCAT, in wavenumber and wavelength



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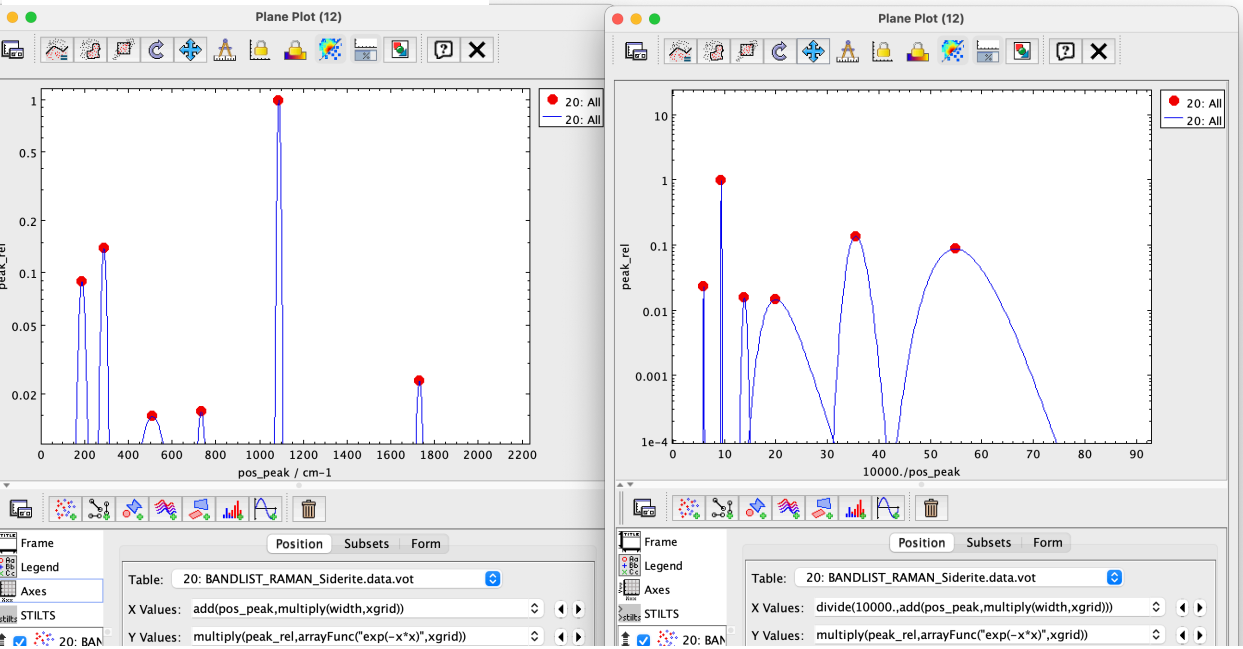


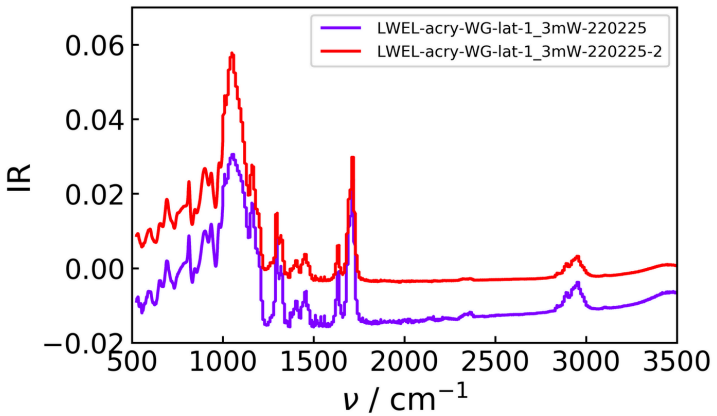
Spectral simulation
or
Extraction of bands from observations
& comparison in notebook

```
for peak in peaks:
    temp=data_select.index
    wav.append(temp[peak])
print(wav)
```

```
[814.0, 901.0, 1050.0, 1300.0, 1710.0]
```

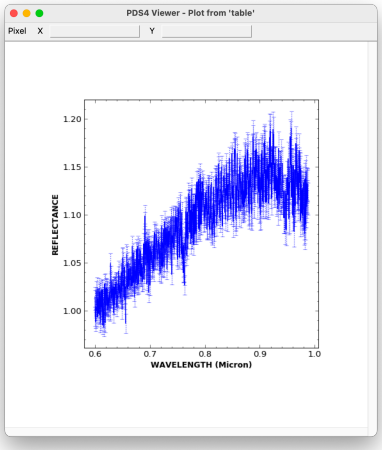
In [65]:

```
# plot data
with rc_context(fname=rc_fname):
    for i in fn:
        temp=data_fitted_SG[i]
        plt.plot(temp,lw=1.5,color=colors[i],label=fn[i])
    #plt.bar(wav,0.01,width=20,color='black')
    plt.xlim(500,3500)
    plt.ylim(-0.02,0.07)
    plt.xlabel('$\\nu$ / cm$^{-1}$')
    plt.ylabel('IR')
    plt.legend(fontsize=8,frameon=True)
```

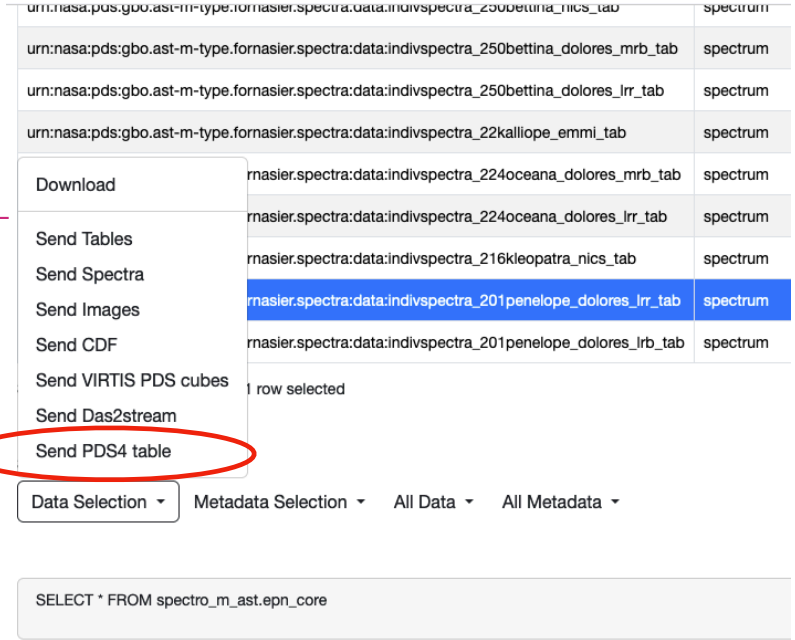


PDS4 tables are supported by TOPCAT

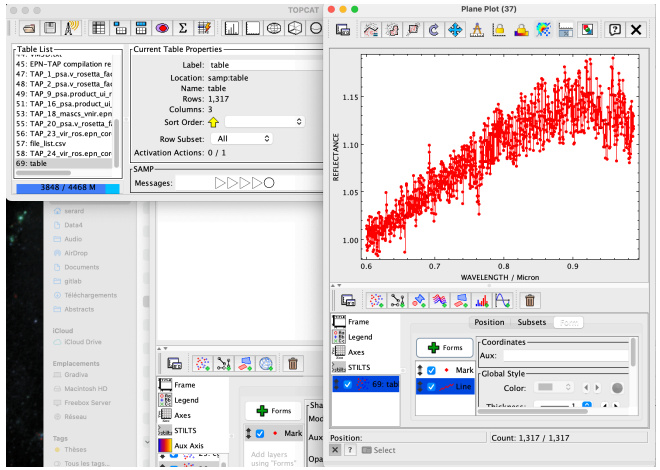
Other PDS4 datatypes can be plotted with PDS4_viewer (manual connection for now)



Copy/Paste URL



SAMP

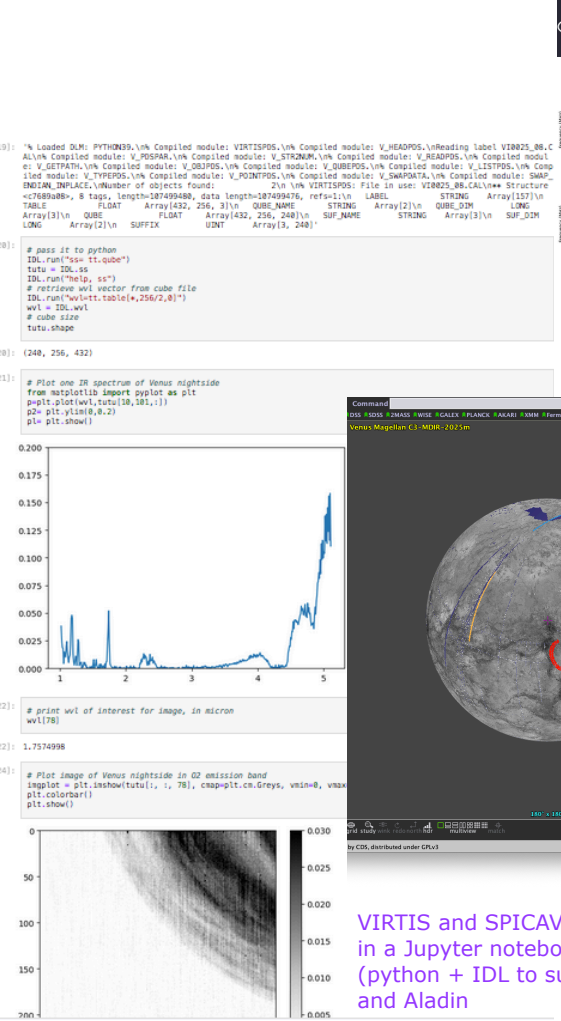


PDS4_viewer (NASA)

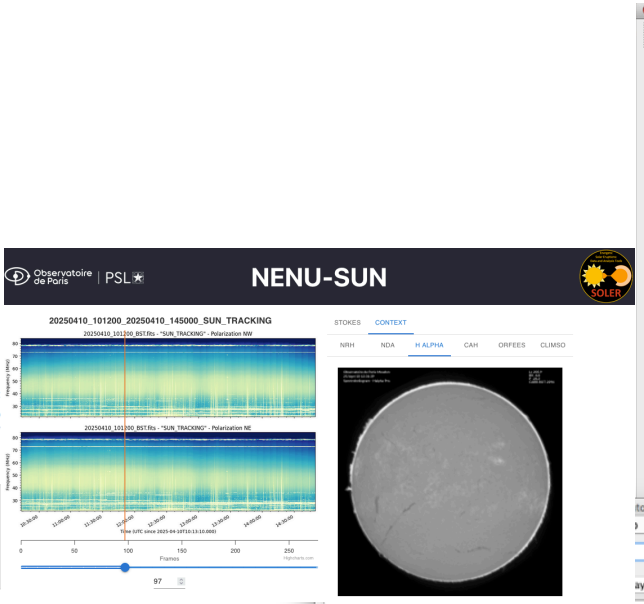
VESPA portal

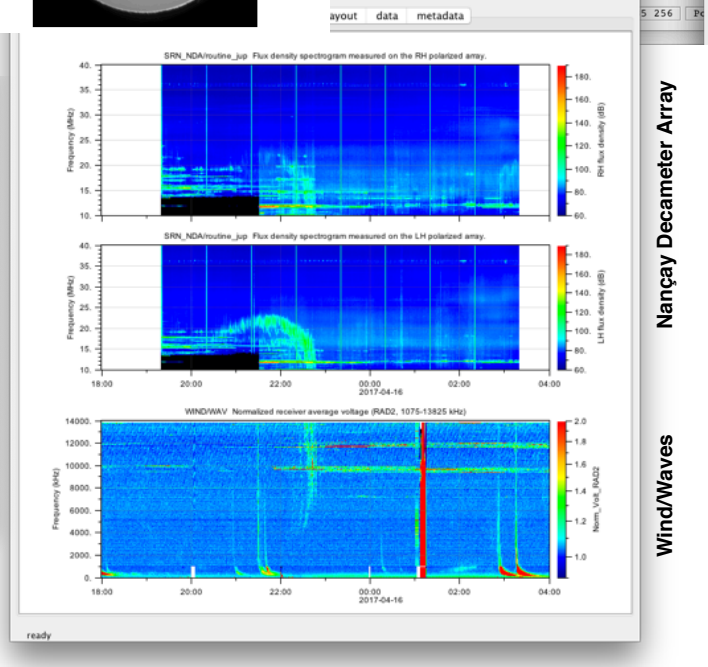
TOPCAT

Other use cases

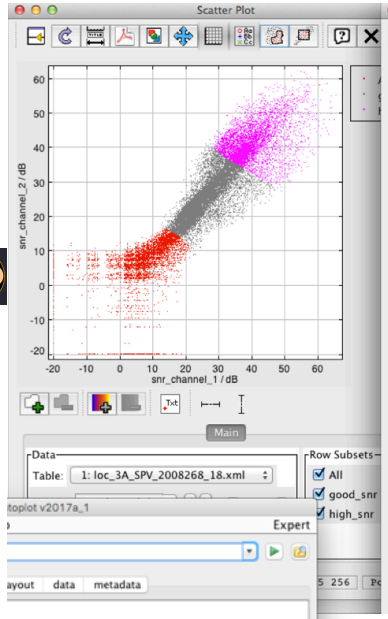


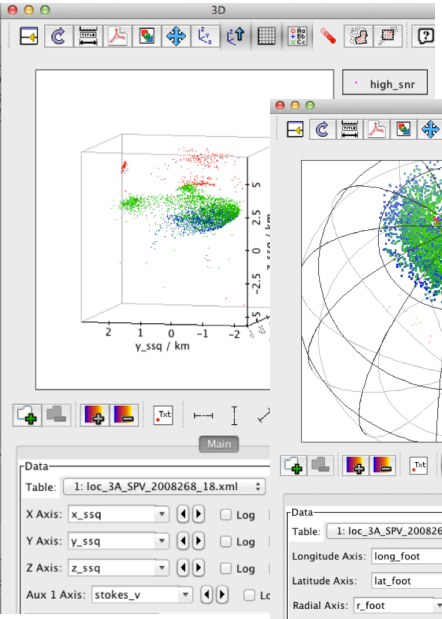
VIRTIS and SPICAV data
in a Jupyter notebook
(python + IDL to support PDS3)
and Aladin



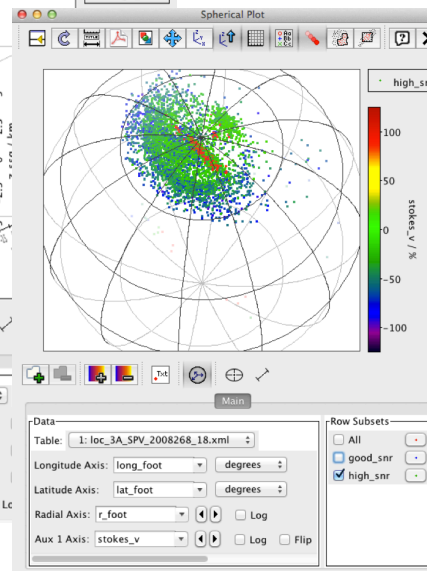


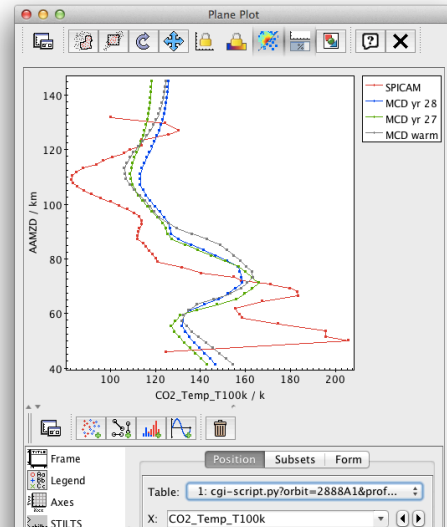
Comparison of radio dynamic spectra (ground/space) in Autoplot





Cassini radio
measurements
in TOPCAT

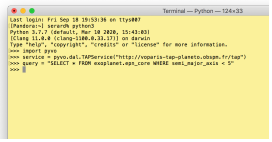




SPICAM and
MCD atmospheric
profiles in TOPCAT
(several scenarios)

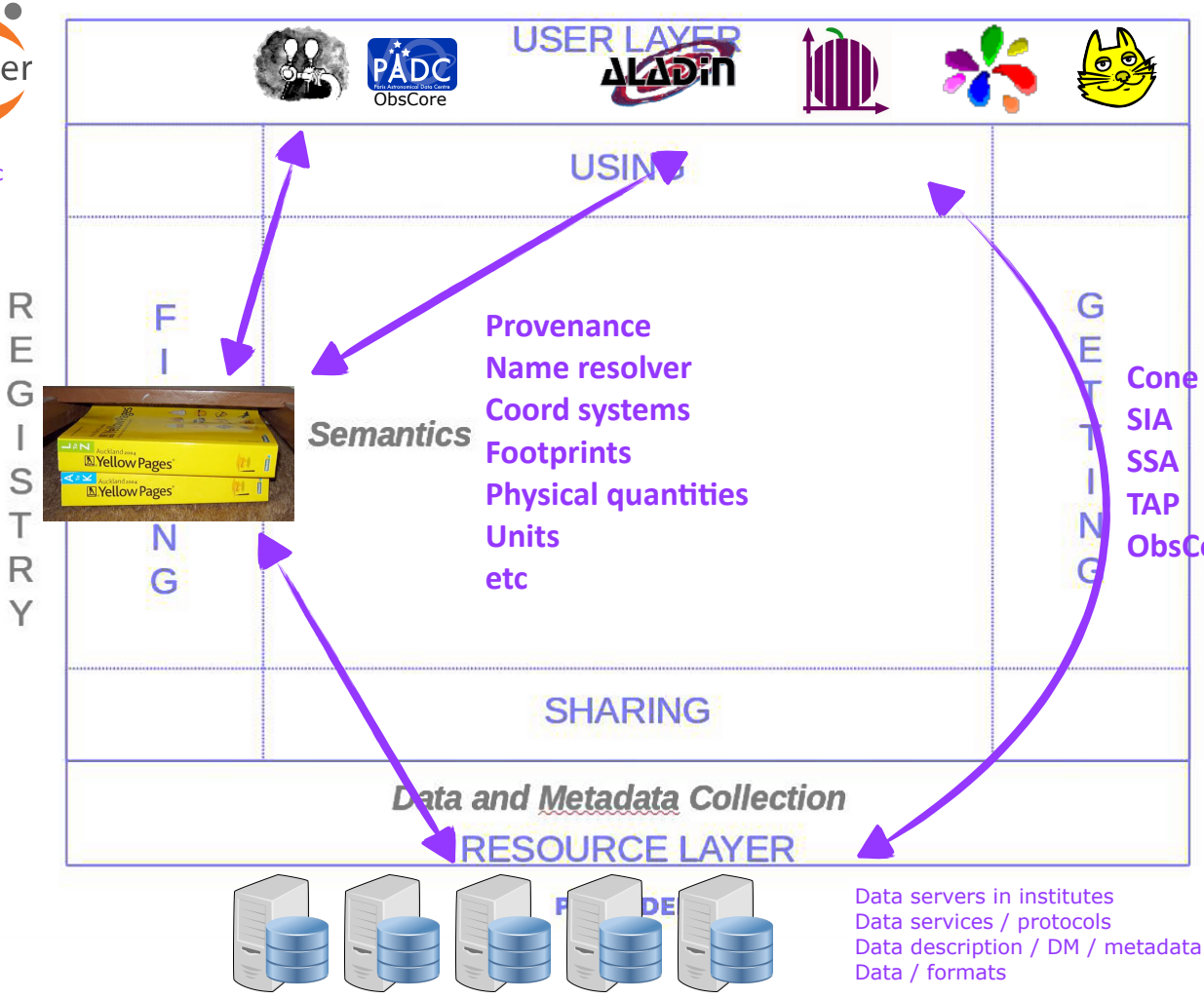
VESPA & IVOA infrastructure

Command line & Notebooks | Portals | SAMP connectivity | USERS | Desktop applications



jupyter

Python libraries: astropy, pyvo, etc



Data servers in institutes
Data services / protocols
Data description / DM / metadata
Data / formats

Virtual Observatory

VESPA & IVOA infrastructure

VO connection of Open Source applications

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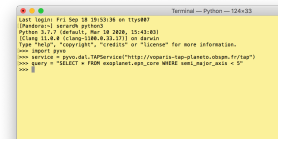
SAMP connectivity



jupyter

Python libraries: astropy, pyvo, etc

Contribution to astropy

VESPA portal & geoportal

PADC ObsCore

USER LAYER

ALADIN

New support functions for Solar System data

USING

REGISTRY

FINDING

Semantics

- Provenance
- Name resolver
- Coord systems
- Footprints
- Physical quantities
- Units
- etc

New specific standards

Existing web services

GETTING

Cone Search

SIA

SSA

TAP

ObsCore

EPN-TAP

DATA ACCESS PROTOCOLS

SHARING

Data and Metadata Collection

RESOURCE LAYER

New data providers
New services

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EPNCore

Contribution to fits

- 3DView
- APERICUbes
- QGIS
- JHelioviewer
- ImageJ, AstroImageJ
- Autoplot

Virtual Observatory

VESPA contribution

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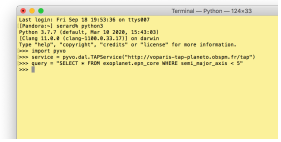

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Installation procedures

+ Workshops

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New services

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EPNCore
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VESPA contribution

New services in VESPA

Data

Currently 94 data reviewed EPN-TAP services (cross-searchable from the portal)

- **NEOCC from ESA is published** (@ESRIN)
- **NEOROCKS (European programme) under review** (@ASI)
- **Ongoing: patrimonial Small Body data from ObsParis** (including from PDS SBN datasets, @ObsParis)
- **Two VIRTIS / Rosetta services (**@ObsParis)
    - **Comet phase: complete EPN-TAP table with illumination, linking to the PSA archive**
    - **Recalibrated dataset: M-channel, comet phase linking to data at ObsParis**

Tools

- **Big and beautiful upgrade of main portal** — gallery view, global result table, PDAP dropped
- **Geospatial portal now open for feedback**
- **Shape models in TOPCAT**
- **NenuSun tool for heliophysics**

Prospects

- **EPN-TAP provides interoperability to ~ half of these services (scriptable API)**

  => allows cross-searches among services (and other services worldwide)

  => improves content of databases & services

This was possible thanks to Europlanet programmes

- **VESPA provides functionalities to display and analyse Solar System data** (planetary science / heliophysics / exoplanets)

  and a framework for processing pipelines & workflows, including on EOSC

- **VESPA also provides a simple data sharing procedure to any research team**

  => distributed infrastructure open to the community

VESPA is really the extension of the VO to the Solar System

Can be used to manage space instruments or ground / lab experiments

Study for the ground segment of MIRS / MMX at LIRA

Main portal: https://vespa.obspm.fr/

Geospatial portal: https://padc-findme.obspm.fr

Tutorials: https://github.com/epn-vespa/tutorials

Web site: http://www.europlanet-vespa.eu/