Introducing the SSIG

B. Cecconi
+ IPDA and Europoplanet Teams

Context

- **IVOA**: planetary community regularly attending and actively participating to Interop Meetings since 2012.

- **IPDA** (International Planetary Data Alliance) re-initiated discussions for interaction with IVOA in 2014.

- **Europlanet**: EU funded project developing a Planetary science VO project VESPA (Virtual European Solar and Planetary Access), mostly based on IVOA standards.

Charter

The **Solar System Interest Group** (SSIG) will aim at reviewing IVOA standards in the scope of Solar System sciences. The SSIG will work with all IVOA working groups to review, assess and propose IVOA standard adjustments for Solar System sciences. The standard assessments, reviews and potential evolutions will be proposed to relevant working groups keeping in mind two main ideas:

- *re-use of IVOA standards with as little changes as possible*

- *modifications with a topical scope as wide as possible*

Objectives (1/2)

The preliminary IPDA-IVOA interaction study conducted in 2015 highlighted the following focus topics for the SSIG:

- Standard **List Coordinate Systems and Reference Frames**. Link with NASA/NAIF SPICE system for possible implementation in STC.

- Standardization of **planetary observation geometry** (linked with the OGC/GIS community), covers semantics, data model and implementation

- Consolidation of **EPN-TAP** (Solar System flavor of ObsTAP, developed by Europlanet/VESPA). Adjustments of TAP and ADQL.
  Currently tested by ESA/PSA and NASA/JPL teams.
  Future IVOA standard?

- Standard **List of Ground Observatories and Space Missions**.

Objectives (2/2)

- Work with **Astronomy Data Centers** to enhance the distribution of their **planetary products** (ESO, CADC, HST…)
- **Cross-matching of registries** (IVOA, SPASE, NASA/PDS…), at least on Dublin Core.
- Promoting and extending **SAMP** (Simple Application Messaging Protocol), adding new message types (e.g., NASA/PDS, netCDF, HDF5…)
- Reviewing and extending **IVOA Data Models and Semantics** to Solar and Planetary Sciences.
- Proposing **new serialization examples for IVOA standards** with file formats used in solar and planetary sciences (HDF5, netCDF…)
- **FITS keyword standardization for Planetary targets** (ongoing work within VESPA and USGS)
- **VOEvent** for “Space Situational Awareness” (SSA) for Earth and planetary events.
- **Exoplanetary** sciences (using planetary standards for exoplanetary data to enhance comparative analyses)

Planned activity

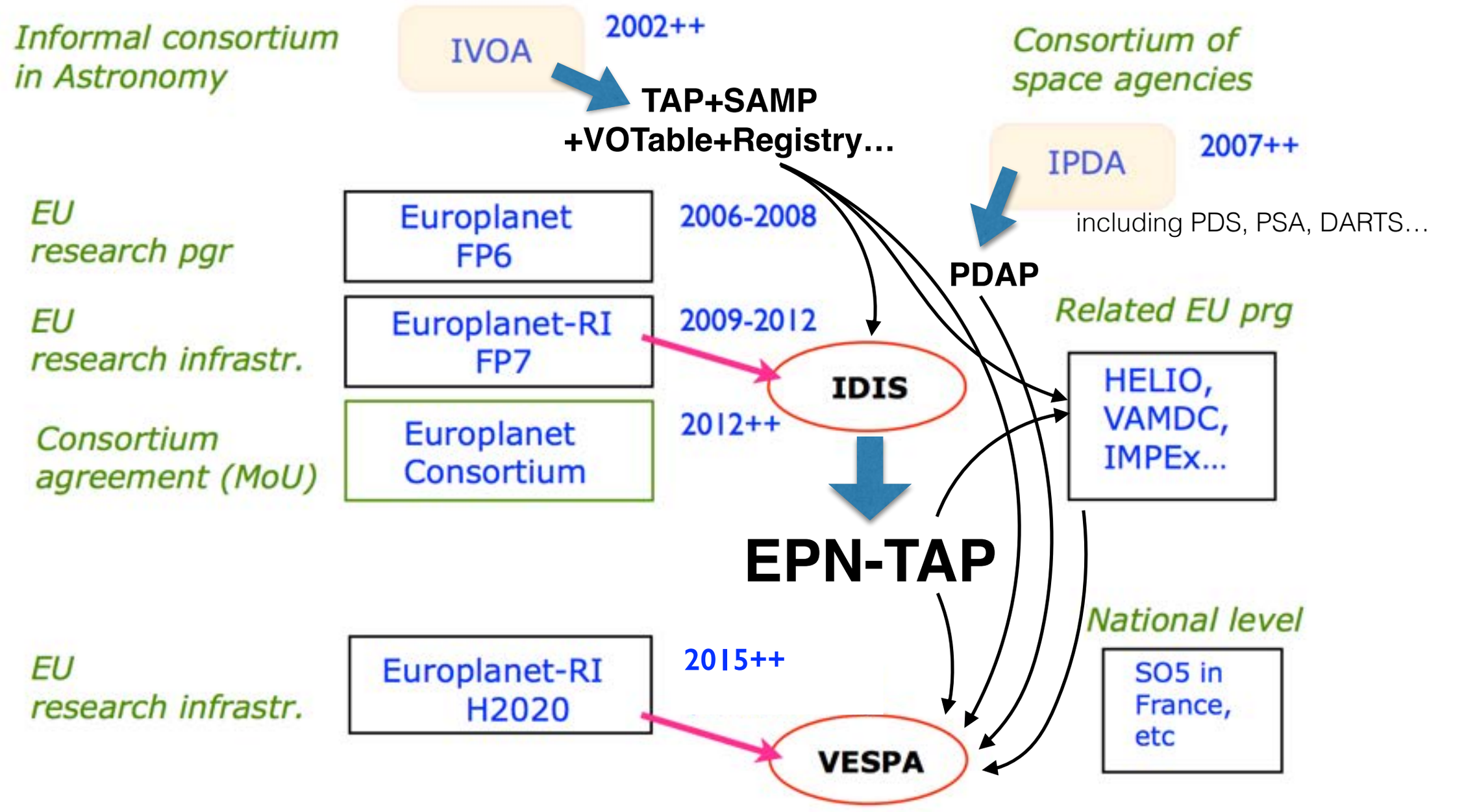
The SSIG will this specifically (but not restrictively) work on the following topics:

- Semantics (facility nomenclature, thesaurus and unified content descriptors)
- Space Time Coordinates (solar and planetary reference frames and targets)
- Data Access Layer (TAP, ADQL, Datalink, SODA)
- Applications (SAMP)
- Data Models and serializations
- Time Domain (Solar and Planetary observations are all time tagged)

Interoperability alliances relevant fo Solar System Sciences

Name	Domain	Infrastructure
IVOA	Astronomy	Data Models, Protocols, Semantics, Registry, Tools
IPDA	Planetary Sciences (Space agencies)	Archive, Data Model, Semantics, Registry, Protocols
SPASE	Sun, Heliosphere, Magnetospheres	Registry, Data Model, Semantics, Protocols, Tools
OGC/GIS	Earth and Planetary Surfaces	Protocols, Tools

Short history of the planetary virtual observatory



Semantics

- Ongoing actions to add new terms in the IVOA Unified Content Descriptor (UCD) keywords. Several additions already accepted.

- Nomenclature of observation facilities and instruments.
  - IPDA would curate planetary space missions.
  - IVOA would curate astronomy space missions and observatories.

- UAT (Unified Astronomy Thesaurus)
  - IPDA: planetary sciences concepts

- Discussion on instrument type ontology/thesaurus ?

Reference Frames

- Space Time Coordinate (STC) data model is specifically designed for astronomy (RA and Dec are deeply built-in).
  A few solar system reference frames are already included, but many are missing.

- This is required to be able to correctly describe observation geometry in IVOA protocols.

- Preliminary study from VESPA team:
  https://voparis-confluence.obspm.fr/pages/viewpage.action?pageId=563390

Data Models

- Most IVOA data models have been built for astronomy measurements (source at infinity identified by sky coordinates, source emitting light).

- Some (little) adjustments are needed to be used for solar and planetary observations, where the observation geometry can be complex, and where the observed flux is often a reflectance.

- This includes solid or gas spectroscopic measurements, but also any other type of detector (in-situ/remote, passive/active, photons/waves/particles/samples…).
  Links with solid spectroscopy in labs.

Standards and Protocols

- TAP (Table Access Protocol)
  - used in EPN-TAP (some requirement already included, e.g., lower/upper case conversion)
  - using TAP and ADQL on top of PostGIS ?

- SAMP (Simple Application Messaging Protocol)
  - additions of planetary sciences file formats and products (GeoJson, PDS3 or PDS4 products…)

- Registry
  - linking between IVOA registry and PDS4 registry would increase basic interoperability (data product, data collection or data services discovery)

- Include IVOA standards in existing Solar system and Planetary tools:
  - WebGeoCalc (NASA/NAIF) currently implementing VOTable output.
  - Autoplot (Univ. Iowa) has implemented SAMP support

Exoplanets

- Observations of exoplanets will be more and more comparable to planetary remote observations.
- New challenge for IPDA and IVOA
- All shall be done

VESPA presentation

B. Cecconi, S. Erard (Observatoire de Paris, France)
and the VESPA team (http://europlanet-vespa.eu)

Introduction
Data providers
User interface
Associated tools
Demos

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VESPA
Virtual European Solar and Planetary Access

Introduction

- VESPA = a Virtual Observatory in Planetary Science

- Easy search, discovery, and display of planetary science data products

- Tools & tutorials for providers and users

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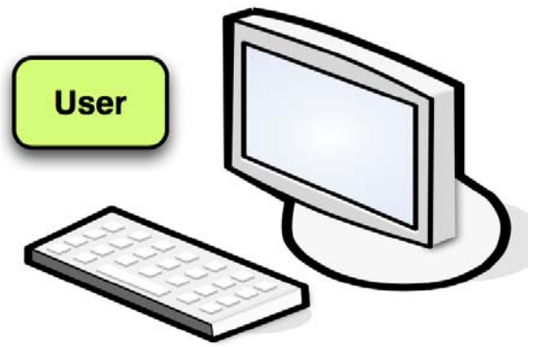
User Experience



Queries

Answers

Catalogue / Registry

Data access

SSODnet

GhoSST
KIDA

PSA

AMDA…

EPN

PDS

Data bases

Space agency archives

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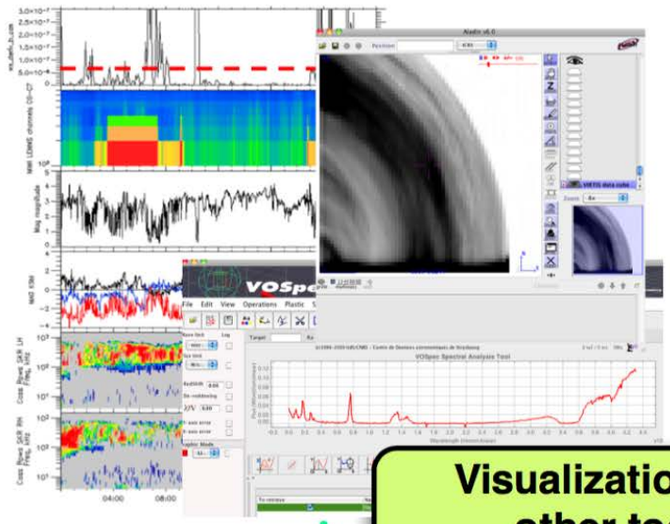
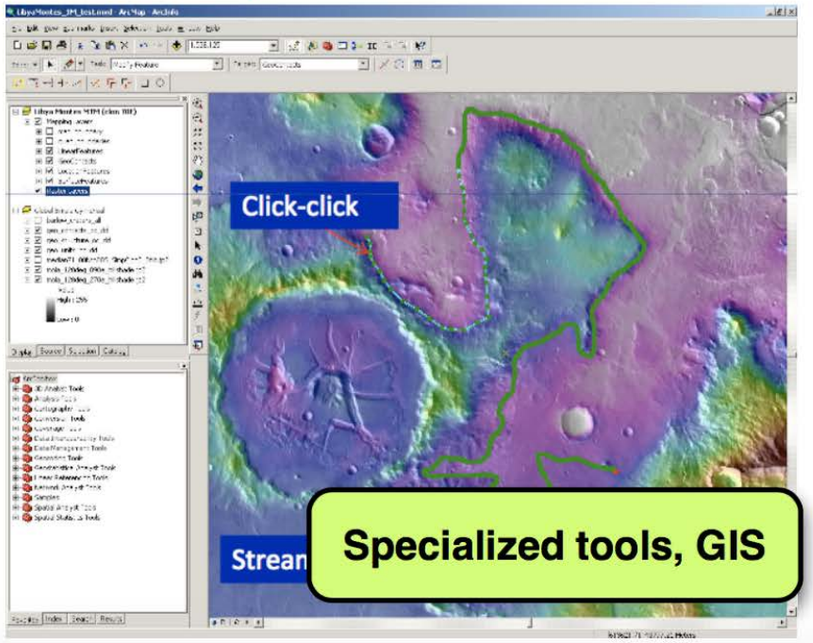


Data
exchange

Visualization and
other tools



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- **Such a system has been designed already**

  => Infrastructure adapted from the Astronomy Virtual Observatory (IVOA):

- A set of standards to describe data contents, identify them in sparse archives, and retrieve them

- tools able to plot, analyze, exchange, and combine the data

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Developments in Europlanet-2020 (Sept-2015 => Aug-2019)

- **VESPA main objectives**
  - Make more useful data available => ***new data services***
  - Improve user experience => ***protocol, interfaces & tools***
  - Build a user community => ***training***
  - Prepare sustainability => ***standards & networking***
  - Improve interfaces with other fields => ***standards & tools***

(Astro + Heliophysics + Atomic & Molecular Physics, Space Agency Archives...)

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Variety of data / specificities

- Scope of data to be accessed
  - Ground-based: moving objects on dark sky
  - Space-borne (PSA/PDS), including HR imaging in various frames
  - Time series, Parameter lists, Atmospheric / 3D, Volume...
  - Variations with time (secular, seasonal, local time)
  - Experimental / lab support data

- Published data:
  Main issue: existing PDS-3 archives (no generic software)
  FITS (sometimes)
  CDF (plasma physics)
  + funny formats

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VESPA provides

- An easy way to search in Planetary Science databases based on physical / observational parameters
  (EPN-TAP = TAP protocol + EPNCore data model)

- A consistent way to search many databases at once
  (VESPA user interface & registry + EPN-TAP library in some tools
  + TAP access always possible)

- A straightforward interface to access VO tools for Planetary Science
  (via SAMP & VOTables + extra functions implemented in existing tools)

=> Access to many data for researchers
=> Major return for data providers

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VESPA relies on international standards

- **IPDA** - International Planetary Data Alliance
  Consortium of national space agencies, focuses on access to space mission archives

- **IVOA** - International Virtual Observatory Alliance
  Consortium of national VO actions - provides interoperability standards

- **IAU** - International Astronomical Union
  Provides standards for nomenclature, physical quantities, coordinate systems, FITS data format, etc.

- **SPASE** - Space Physics Archive Search Extract
  Provides interoperability standards for planetary plasmas

- **OGC** - Open Geospatial Consortium
  Provides industry standards for GIS

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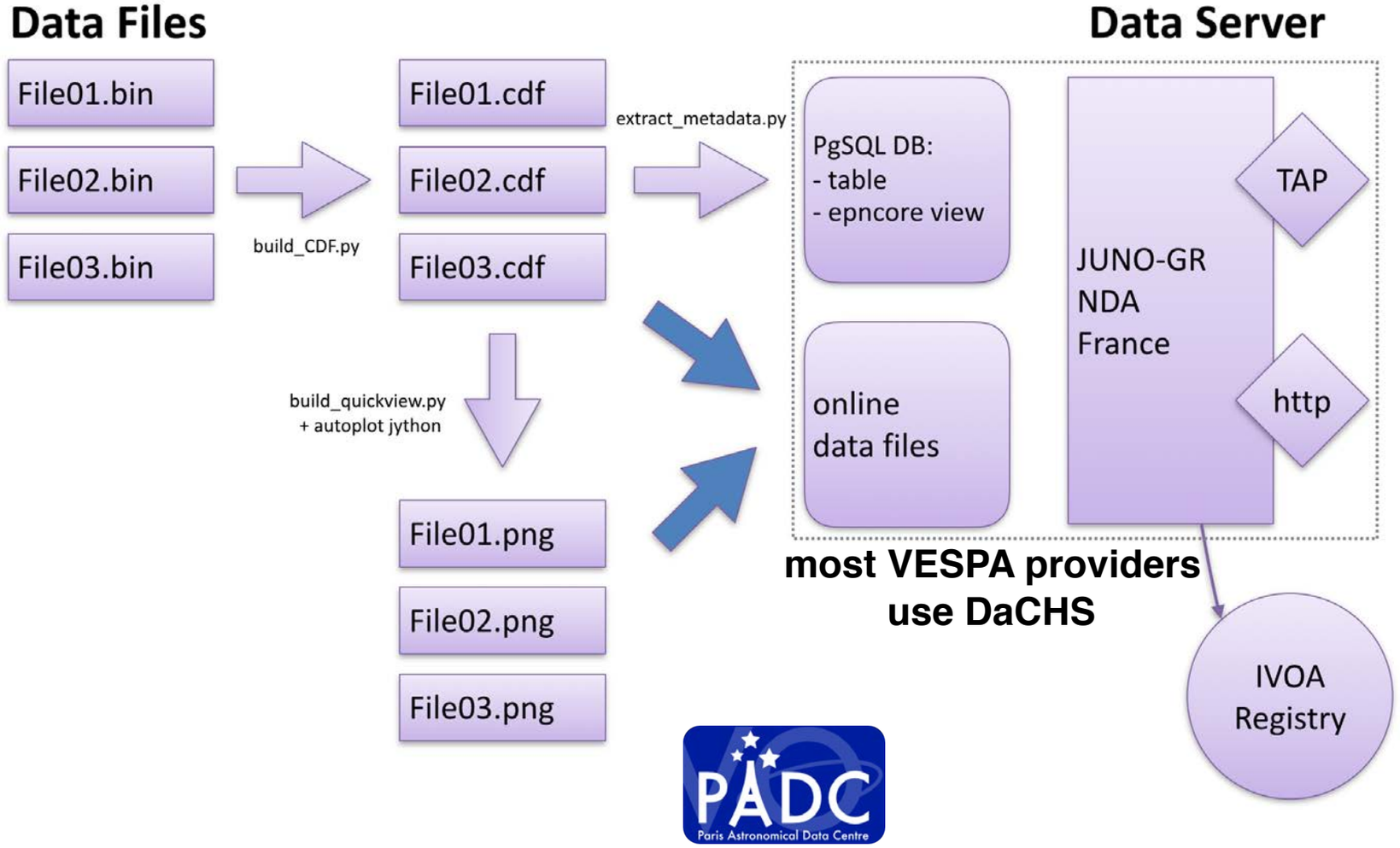
Data Providers

- **VESPA data services = metadata catalogue of your data products**
  - A table describing each of the service files (using std parameters)
  - Stored in PostgreSQL + TAP-handling application at the institutes
  - Searches through an optimized interface, connected to VO tools



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EPNcore metadata

- Coverage: temporal, spectral, spatial (range, sampling, resolution)
- Target: name, class, region, feature
- Instrument: name, host name, measured quantity
- Geometry: incidence, emergence, phase, local time, season, distance
- Access: URL, size, creation date, modification date, thumbnail
- Reference: publisher, bibliographic reference…

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Preparing a data service

- Define data products you want to share.

- Define how users will search for or filter on your products. Identify relevant metadata in this context.

- Extract or define your data product's metadata. Map your metadata with the VESPA metadata.

Setting up a data service

- Install a VESPA server (TAP enabled distribution)

- Create your VESPA metadata table,
  or map your metadata to an EPNcore view.

- Publish your service and play.

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Resources for data providers

- Implementation tutorials
  https://voparis-confluence.obspm.fr/display/VES/Implementing+a+VESPA+service

- EPNcore documentation
  https://voparis-confluence.obspm.fr/display/VES/EPNcore+v2

- Annual workshop:
  Selected external teams invited (trip+daily expenses covered)
  Next workshop in Prag, Czech Rep, April, 2018.

- Support by VESPA team (support-vespa@obspm.fr)

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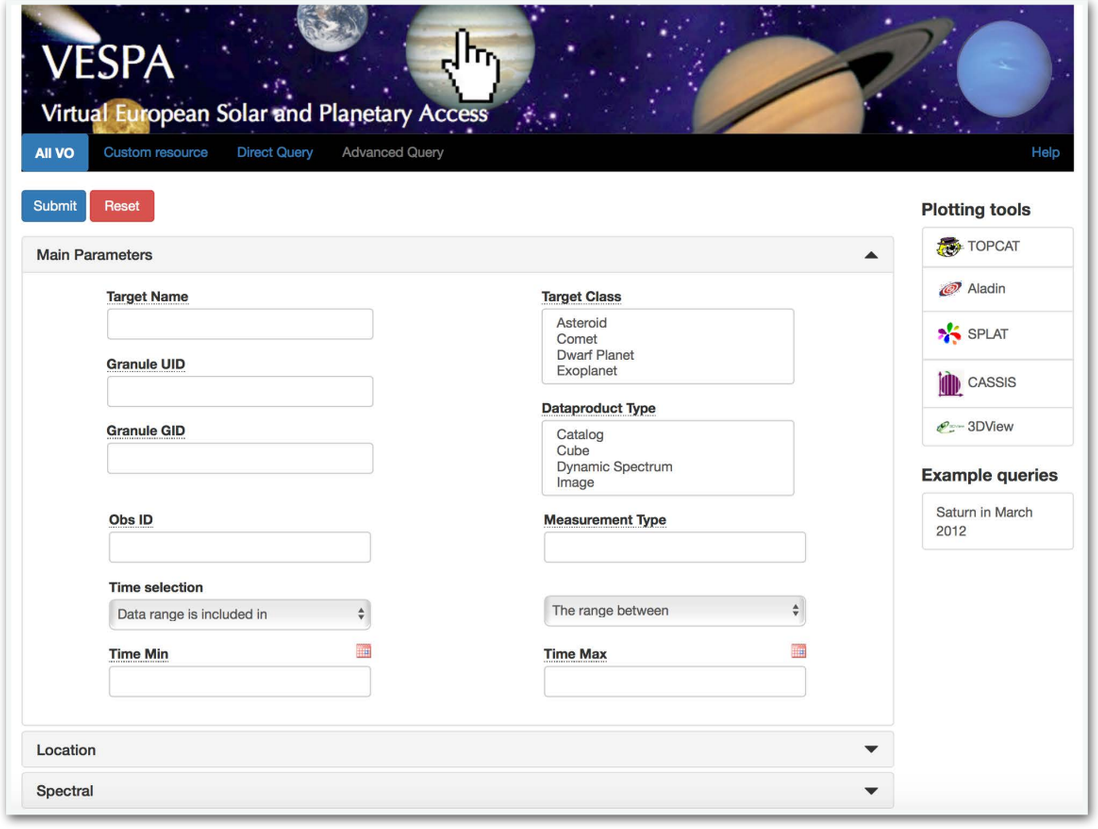
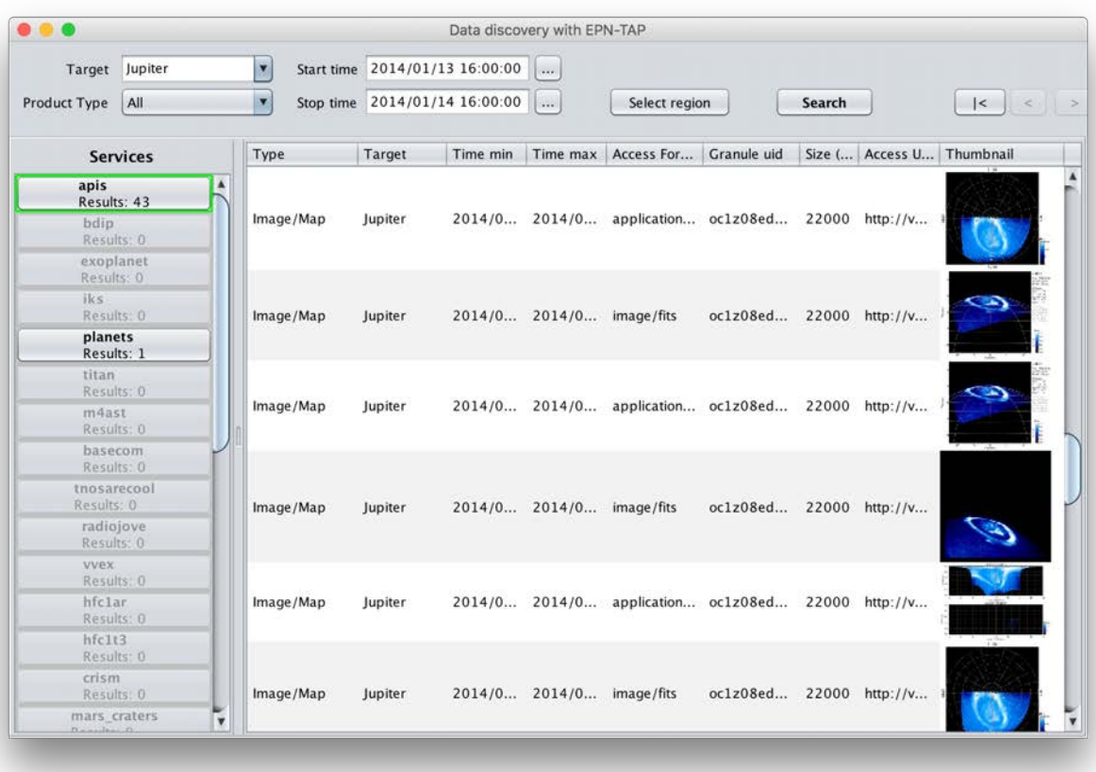
User Interfaces

Global search interface for Planetary Science services
- Main query interface: http://vespa.obspm.fr
- Supports EPN-TAP + PDAP

+ Dedicated search interfaces to be included into tools (EPN-TAP client libraries).





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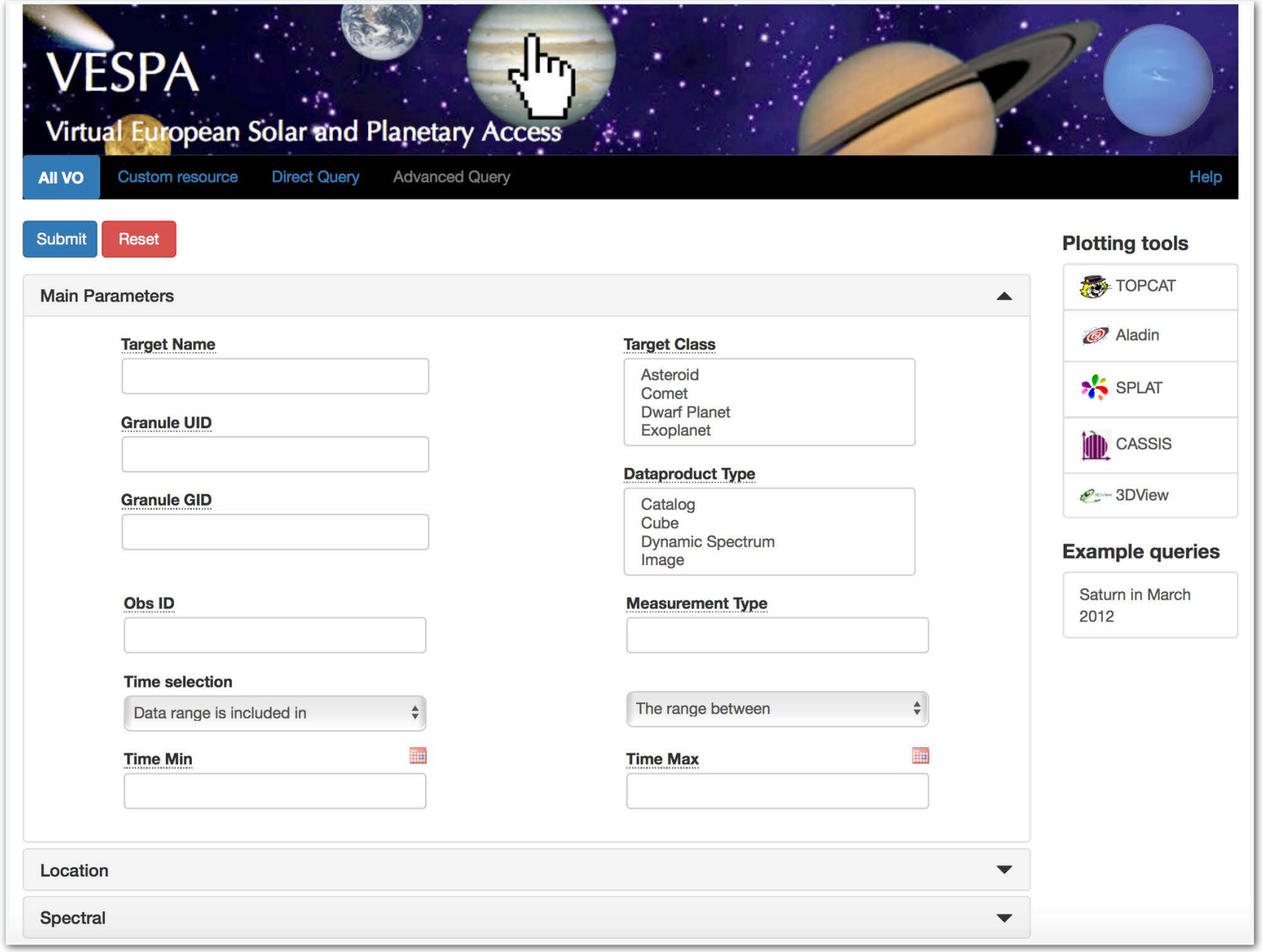

Main query portal: http://vespa.obspm.fr

All VO | Custom resource | Direct Query | Advanced Query | Help

EPN Resources

- **abs_cs - Data for numerical modeling of planetary atmospheres** 13 results
- **AMDA - CDPP AMDA DataBase** 892514 results
- **APIS - Auroral Planetary Imaging and Spectroscopy** 32045 results
- **BASECOM - The Nançay Cometary Database** 15611 results
- **BDIP - Base de Données d'Images Planétaires** 16906 results
- **BIRA-IASB TAP - Profiles from SPICAV-SOIR/VEx** 1612 results
- **CLIMSO - CLIMSO coronagraphs at pic du midi de Bigorre** 95737 results
- **CRISM - CRISM data from Earth Server 2** 2669 results
- **DynAstVO - Asteroid orbital database and ephemerides** 17911 results
- **ExoPlanet - Extrasolar Planets Encyclopaedia** 3578 results
- **HFC1AR - Heliophysics Feature Catalog active regions** 948627 results
- **HFC1T3 - Heliophysics Feature Catalog type 3 radio bursts** 90845 results

Plotting tools

- TOPCAT
- Aladin
- SPLAT
- CASSIS
- 3DView

Example queries

Saturn in March 2012

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Results in service APIS

Show 10 entries

Column visibility | Show all | Hide all | Reset Selection

granule_uid	dataproduct_type	target_name	time_min (d)	time_max (d)	access_url
ocvq06ddq_x2d	image	Saturn	2016-08-19T22:18:30.002	2016-08-19T23:03:30.203	http://voparis-si
ocvq06ddq_proc_pdf	image	Saturn	2016-08-19T22:18:30.002	2016-08-19T23:03:30.203	http://voparis-si
ocvq06ddq_proc	image	Saturn	2016-08-19T22:18:30.002	2016-08-19T23:03:30.203	http://voparis-si
ocvq06ddq_pol_s_pdf	image	Saturn	2016-08-19T22:18:30.002	2016-08-19T23:03:30.203	http://voparis-si
ocvq06ddq_pol_n_pdf	image	Saturn	2016-08-19T22:18:30.002	2016-08-19T23:03:30.203	http://voparis-si
ocvq06ddq_cyl_pdf	image	Saturn	2016-08-19T22:18:30.002	2016-08-19T23:03:30.203	http://voparis-si
ocvq05dbq_x2d	image	Saturn	2016-08-19T20:43:06.002	2016-08-19T21:28:06.202	http://voparis-si
ocvq05dbq_proc_pdf	image	Saturn	2016-08-19T20:43:06.002	2016-08-19T21:28:06.202	http://voparis-si
ocvq05dbq_proc	image	Saturn	2016-08-19T20:43:06.002	2016-08-19T21:28:06.202	http://voparis-si
ocvq05dbq_pol_s_pdf	image	Saturn	2016-08-19T20:43:06.002	2016-08-19T21:28:06.202	http://voparis-si

Showing 1 to 10 of 32,045 entries 1 row selected

Page 1 of 3205

First | Previous | Next | Last

Data Selection | Metadata Selection | All Data | All Metadata

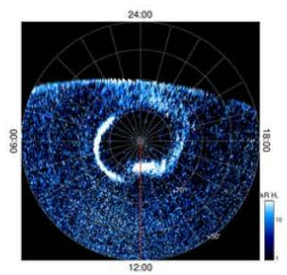
Footprints

Plotting tools

- TOPCAT
- Aladin
- SPLAT
- CASSIS
- 3DView

Example queries

Saturn in March 2012



Afficher un menu

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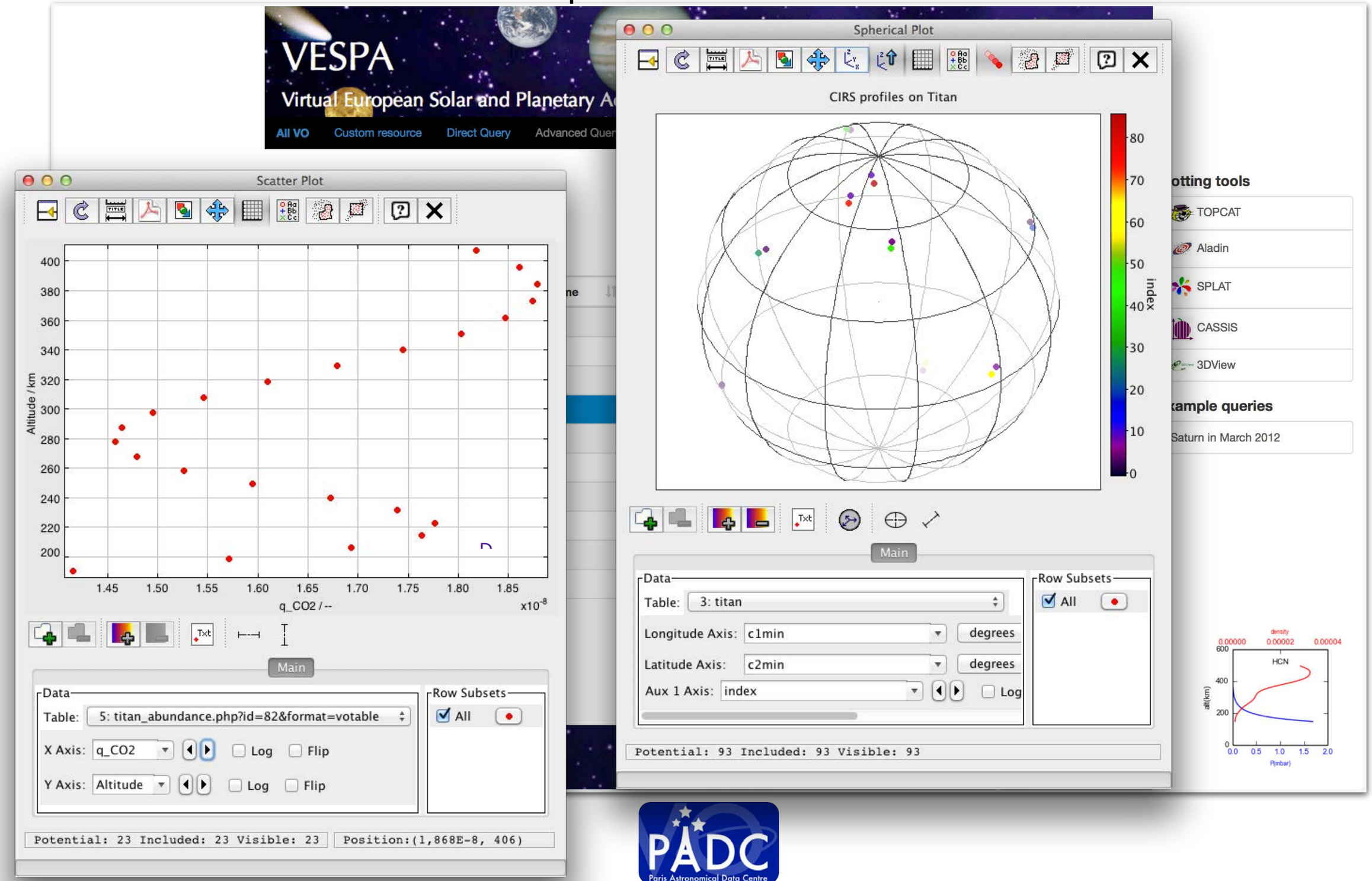
Titan profiles database



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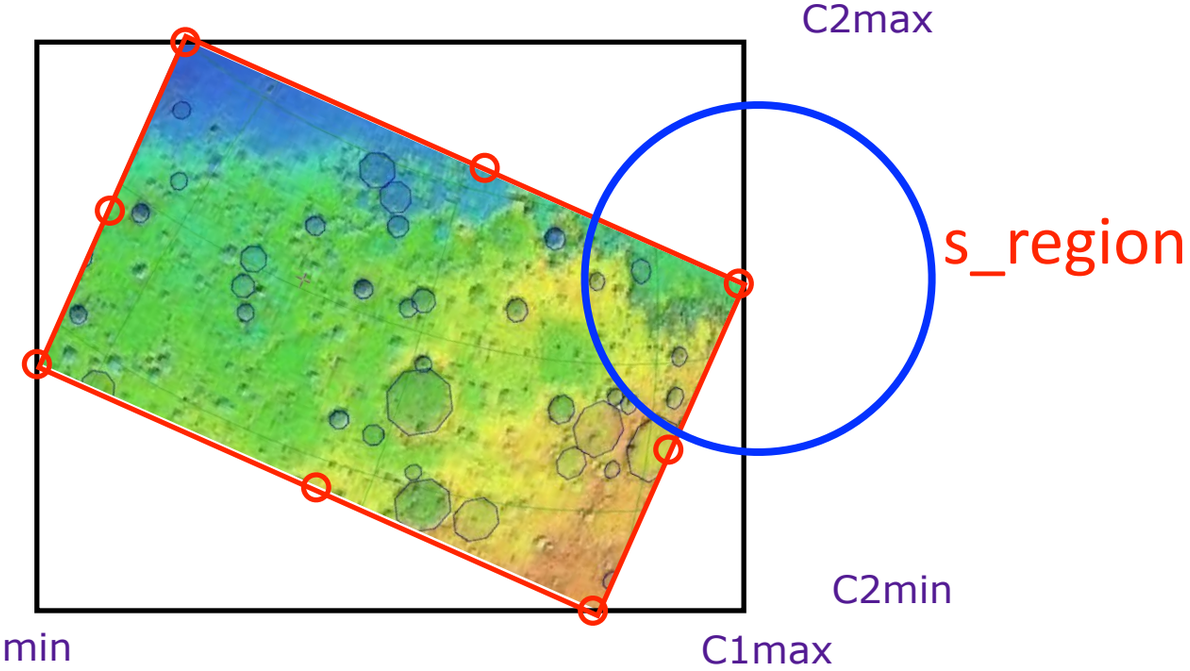
footprint formats

C1/C2 min/max
coordinates
in body-fixed frame



- PDS3-like limits

  => provide very rough estimate of footprint as a lon/lat bounding box

- IVOA's s_region parameter (sampling the contour)

  => provides much more accurate footprints with tunable resolution

  + support for footprint shape, polar views, etc

  + allows for very powerful searches on intersections, etc

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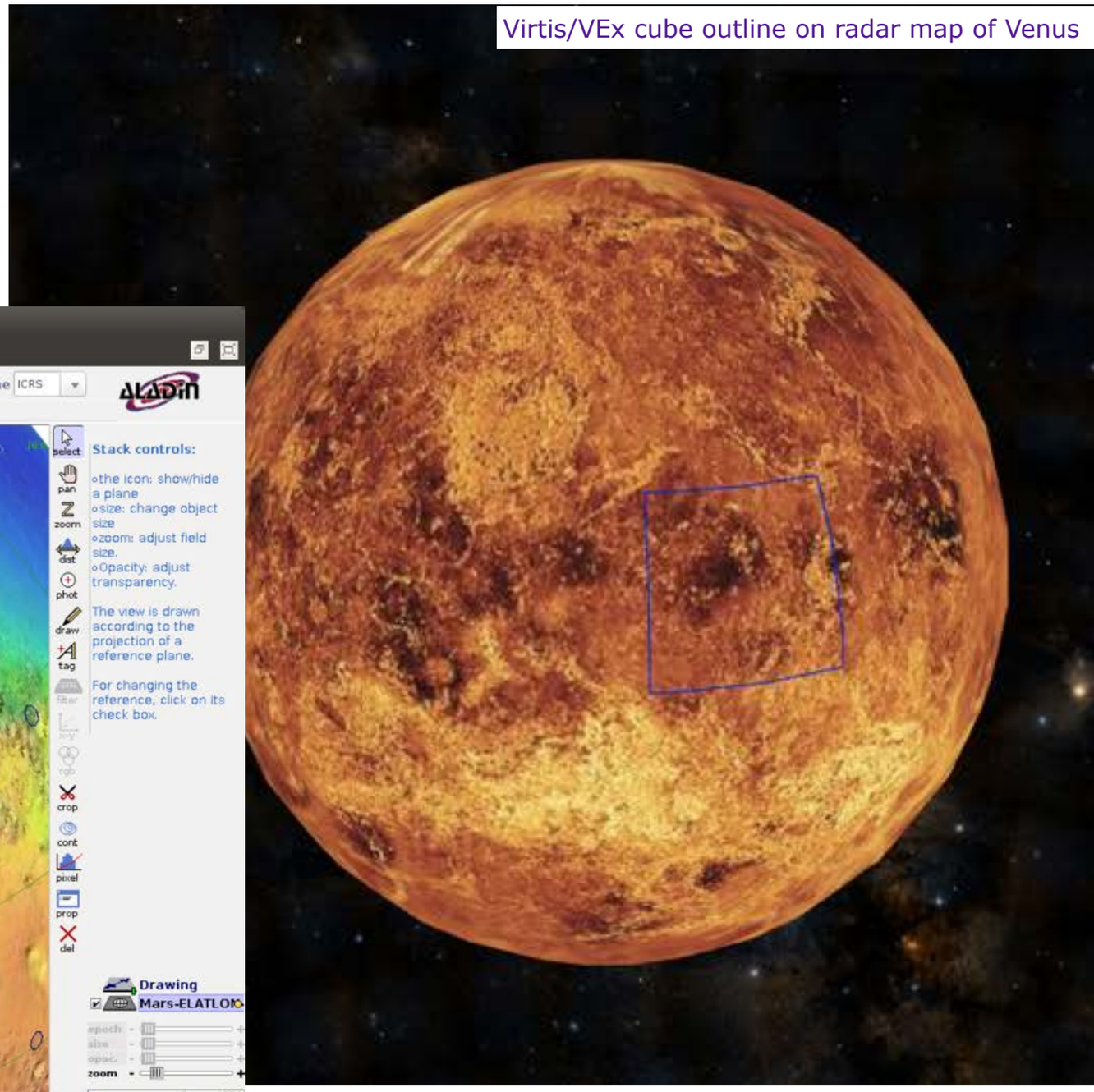
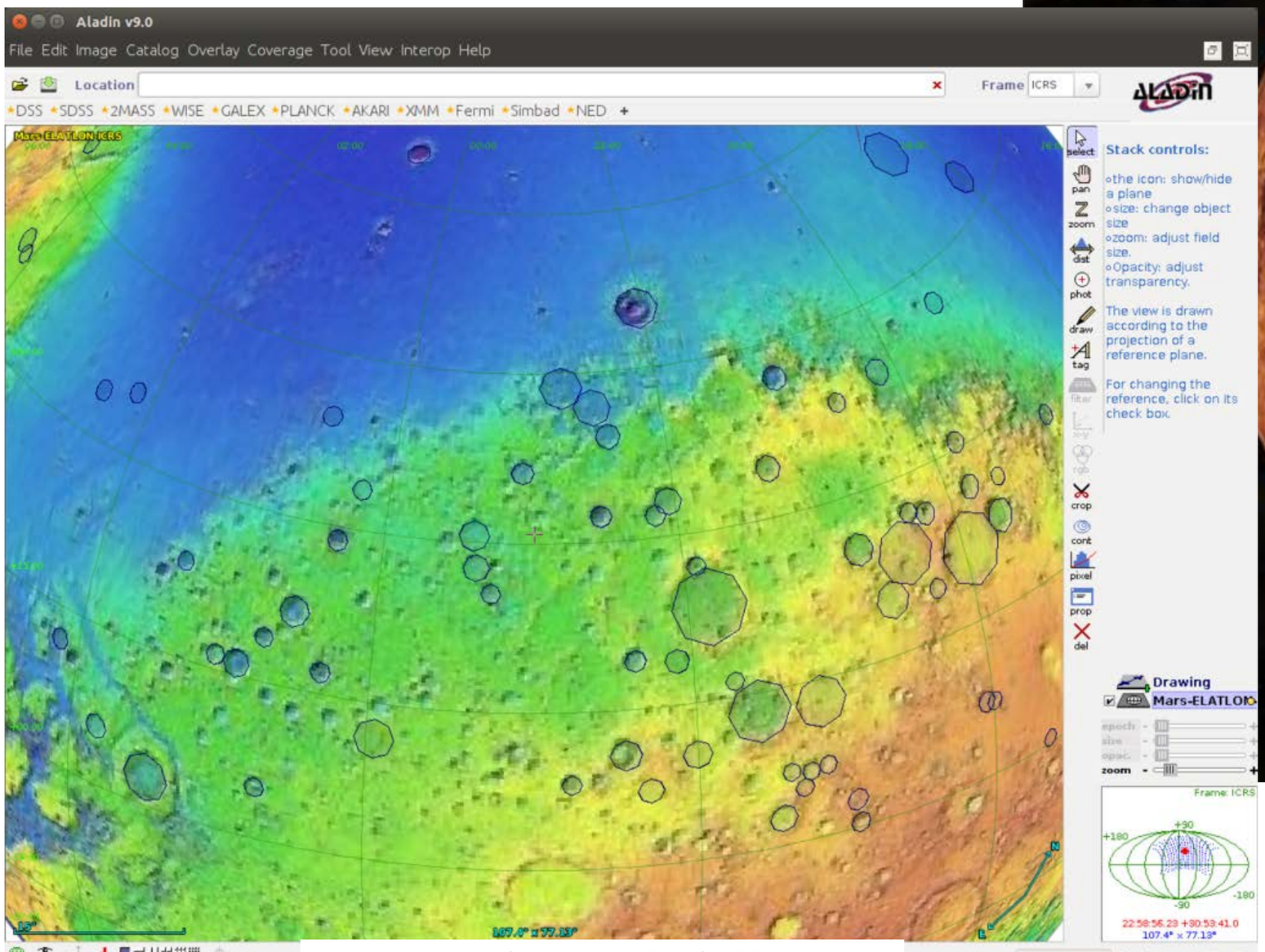
footprints display on planets

Virtis/VEx cube outline on radar map of Venus



Mizar: overplots

PDS footprints on 3D maps on CNES tool



Mars crater catalogue on MOLA/MGS map

Aladin: adapt IVOA footprints

to planetary bodies, with some OGC-like processing

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Data services connected via EPN-TAP / field

Atmospheres

- Titan profiles - CIRS (Cassini, LESIA)
- *Venus spectroscopy - VIRTIS (VEx, LESIA)*
- Mars Climate Database (modeling, LMD-LESIA)
- Venus profiles - SPICAV/SOIR (VEx, IASB-BIRA)
- Mars profiles - SPICAM (MEx, LATMOS)
- *All MEx derived atmospheric products (via MEx IDS)*
- *EuroVenus derived products (via C. Wilson)*

Small bodies

- M4ast - (ground based spectroscopy, IMCCE)
- 1P/Halley spectroscopy - (IKS / Vega-1, LESIA)
- BaseCom - (Nançay obs, LESIA)
- TNO - (Herchel & Spitzer + compilation, LESIA & LAM & Utinam)
- Cometary lines catalogue (IAPS)
- Vesta & Ceres spectroscopy - VIR (DAWN, IAPS)
- Small bodies orbital catalogues:

DynAstoVO: NEO refined parameters (IMCCE)
MPCorb (MPC / Heidelberg)

- Rosetta ground-based support (via C. Snodgrass)
- Support for 3D shape models (IMCCE)
- 67P illumination config (IRAP)

Surfaces

- ***Mars GIS (CRISM, Marsis… Jacobs, GEOPS)***
- ***Mars craters (Jacobs, GEOPS)***
- OMEGA data (MEx, IAS, via SItools2)
- *MarsSI GIS (Lyon)*

Magnetospheres / radio

- APIS - HST (LESIA)
- Jupiter DAM (Nançay, LESIA)
- *AMDA (CDPP / IRAP)*
- MAG data (VEx, IWF Graz)
- ***MASER & Juno support (LESIA, Tohoku Univ)***
- RadioJove (LESIA & US amateur network)
- ***Juno Ground support (Kharkiv, Ukr.)***
- Coupled Giant Planet Systems (modeling, UCL)
- Generic wave polar. & propag. (modeling, IAP Prague)
- Interface with IMPEx models (IRAP, IWF Graz)
- ***Hisaki (Tohoku Univ.)***

Generic

- BDIP (LESIA)
- Planets, then satellites characteristics (LESIA/IMCCE)
- PVOL (EHU Bilbao & network)
- Gas absorption cross-sections (Granada)
- ***Nasa dust catalogue (IAPS)***
- Stellar spectra, support for observations & exopl. (LESIA)
- *Telescopic planetary spectra collection (LESIA)*
- ***PSA complete archive (ESA)***
- *DARTS (JAXA - currently via PDAP)*
- *On-going discussions with PDS & IPDA*

Exoplanets

- Encyclopedia of exoplanets (compilation, LUTH/LESIA)
- Transit observations (Bern)
- *Interface with DACE (Geneva)*

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Interdisciplinary

- HELIO solar features catalogues (LESIA)
- *Bass2000 (LESIA)*
- *Radio Solar db (Nançay, LESIA)*
- Climso (IRAP, Pic du Midi)
- *Interface with VAMDC (TBD)*

Solid spectroscopy

- ***SSHADE: ices & minerals (IPAG & network)***
- Minerals emission db (DLR)
- PDS/MRO support db (LESIA)

Open
In development
Scheduled
Being studied
Indicated for tutorials

Currently under development (ongoing assessment by IPDA)

Associated Tools

Search interface:
- VESPA portal: http://vespa.obspm.fr

Display tools:
- CASSIS. Spectral analysis: http://cassis.irap.omp.eu
- Apericubes. Hyper-spectral tool: http://voparis-apericubes.obspm.fr/apericubes/js9/demo.php
- Aladin. Imaging: http://aladin.u-strasbg.fr
- TOPCAT. Tables: http://www.star.bris.ac.uk/~mbt/topcat/
- 3Dview. 3D imaging: http://3dview.cdpp.eu
- AMDA. Plasma times series suite of tools: http://amda.cdpp.eu

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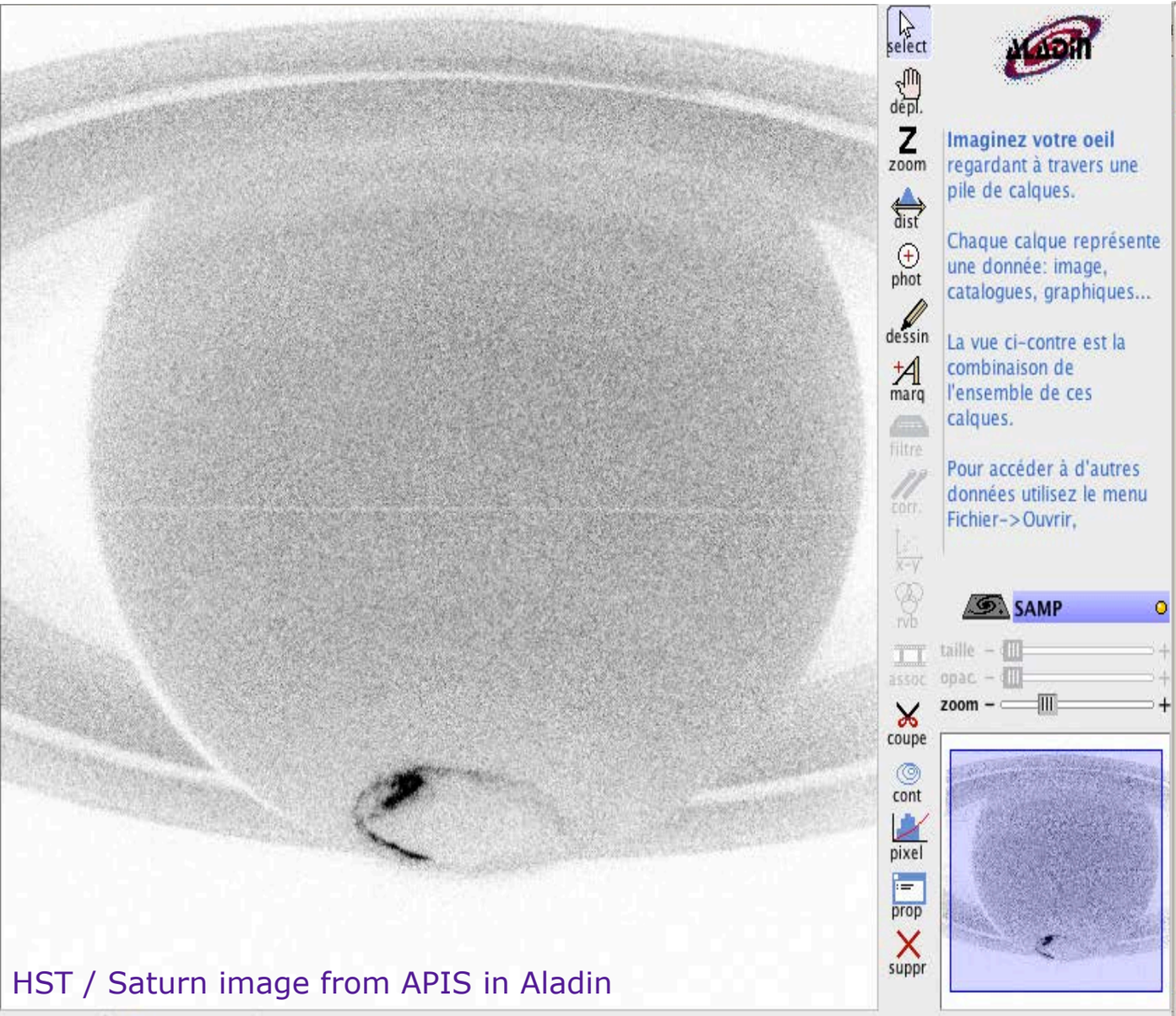
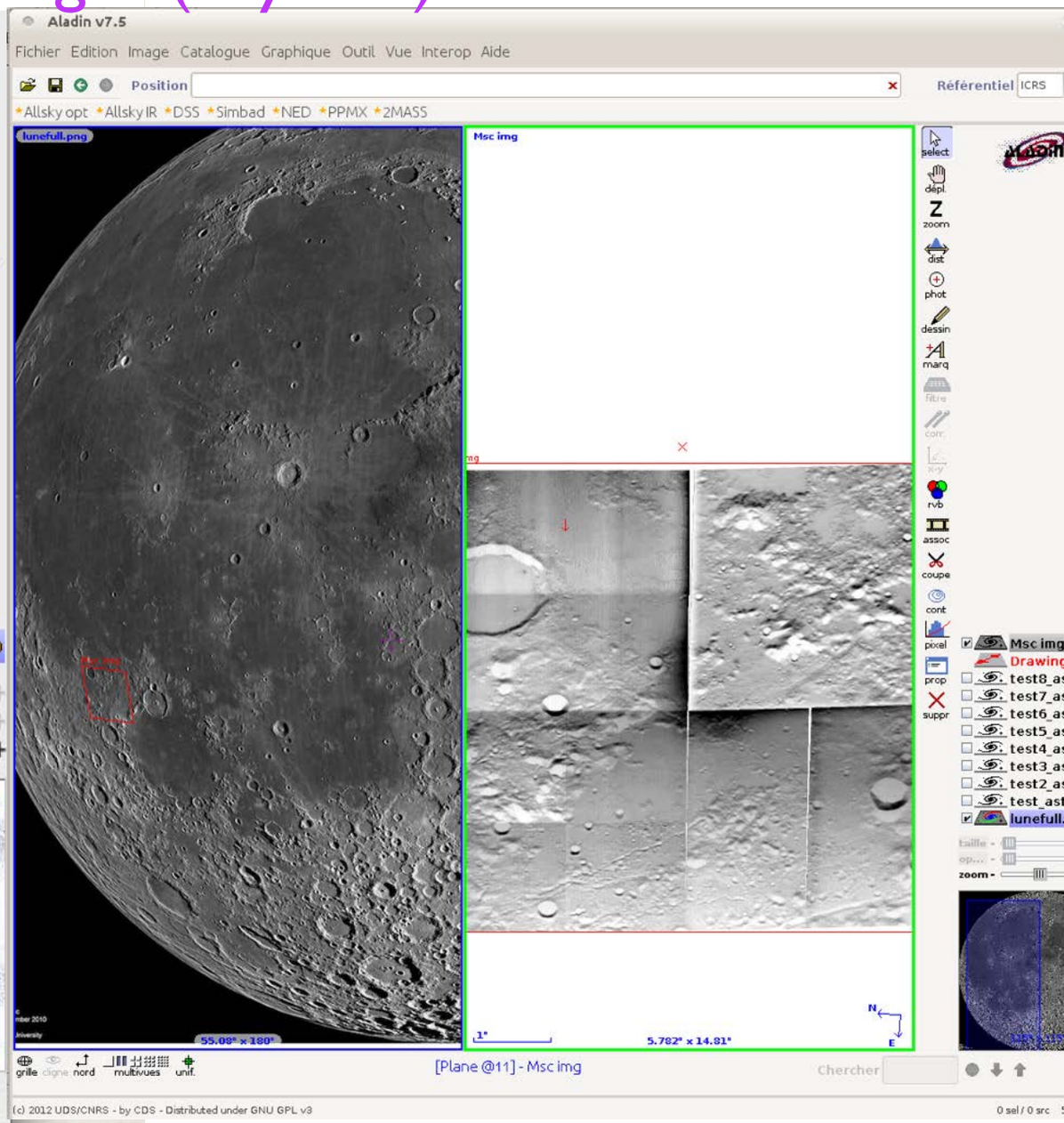
Visualization tools: adapt IVOA tools

Aladin:

- plots images/cubes
- handles sky/spheroid coordinates
- can build image mosaics
- can handle object catalogs
- Solar System bodies tracking on sky images (SkyBoT)



HST / Saturn image from APIS in Aladin

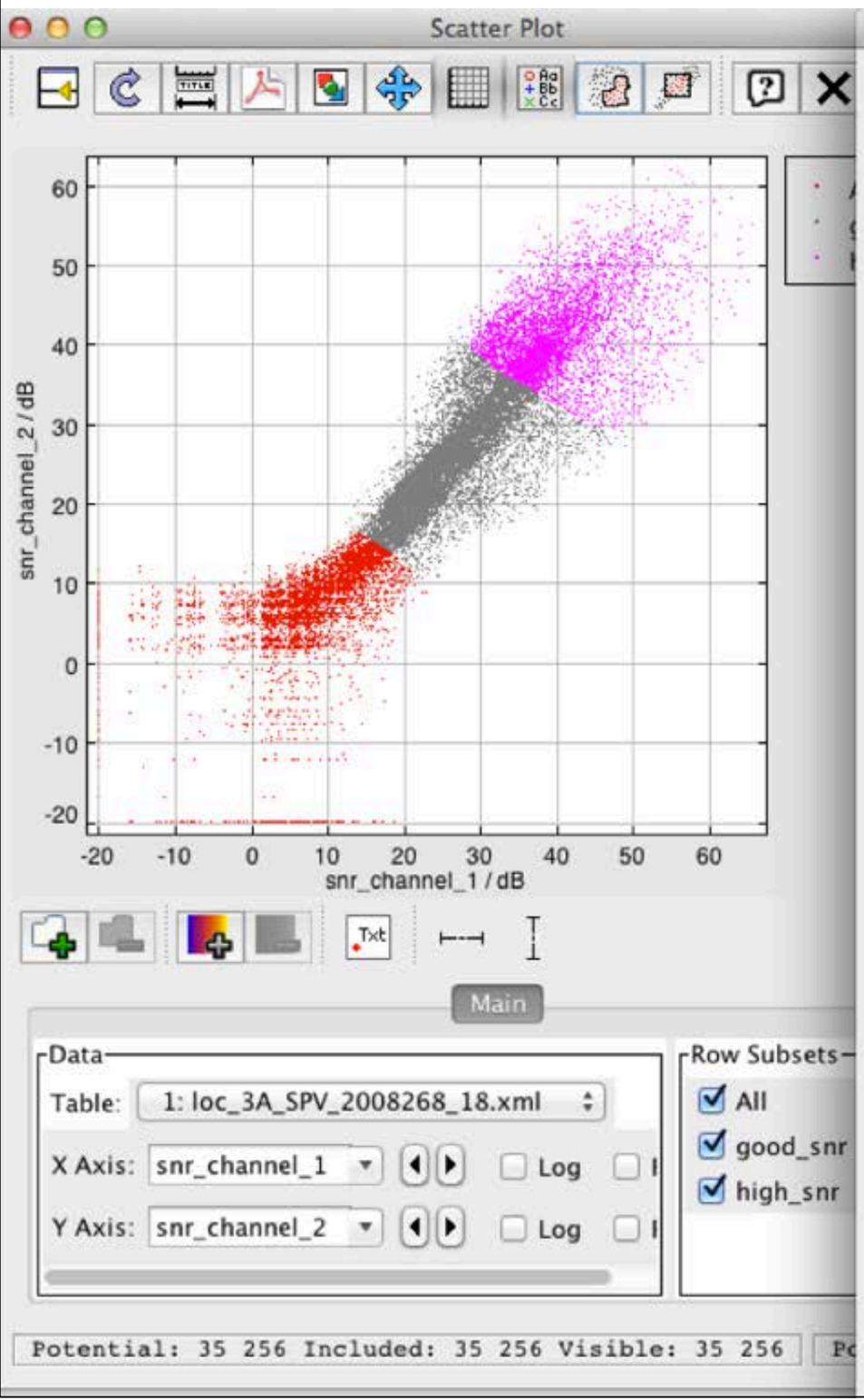


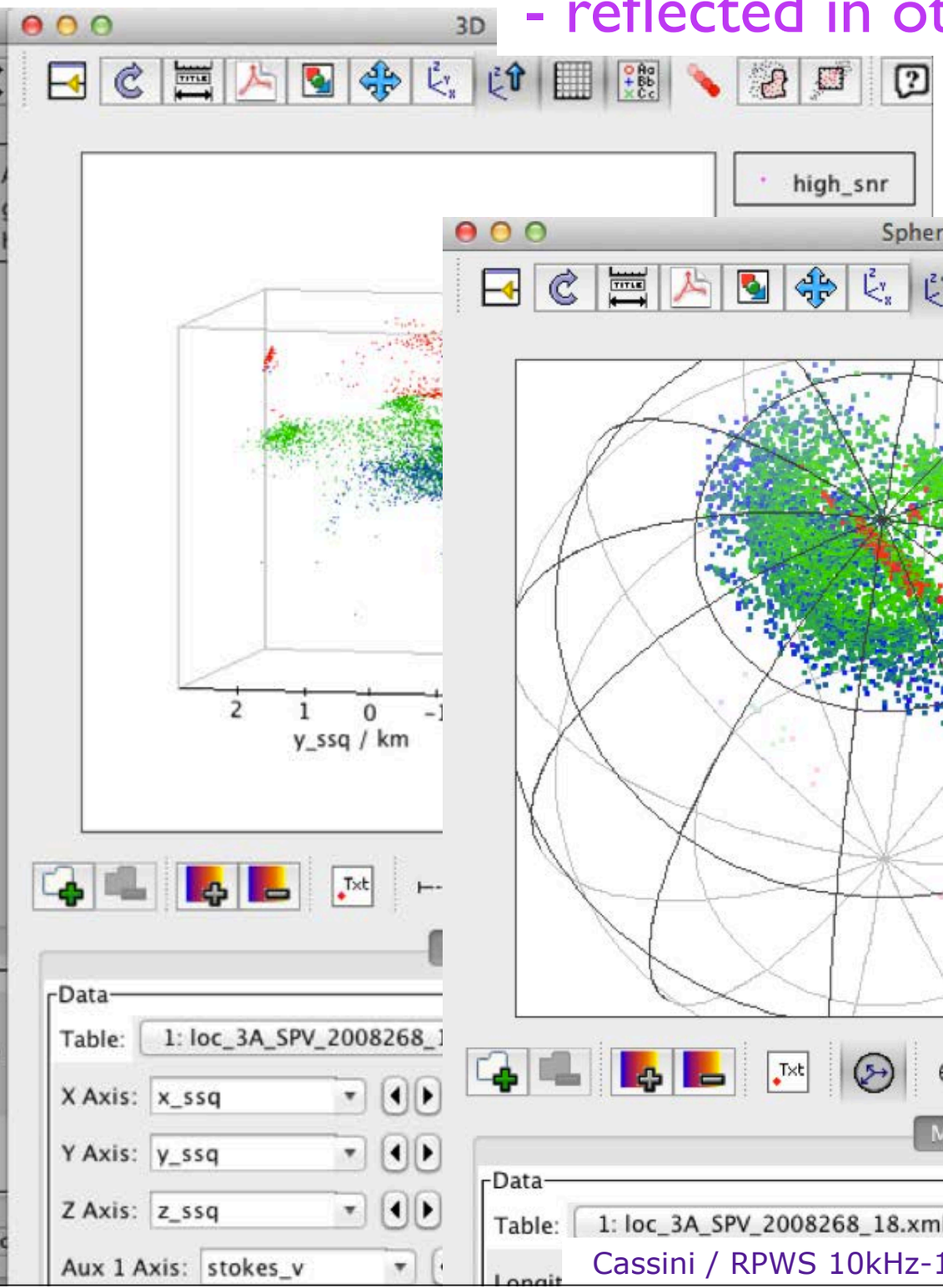
AMIE/Smart-1 image frames & footprint in Aladin

TOPCAT:

Allows data selection

- by formula or graphically
- reflected in other plots





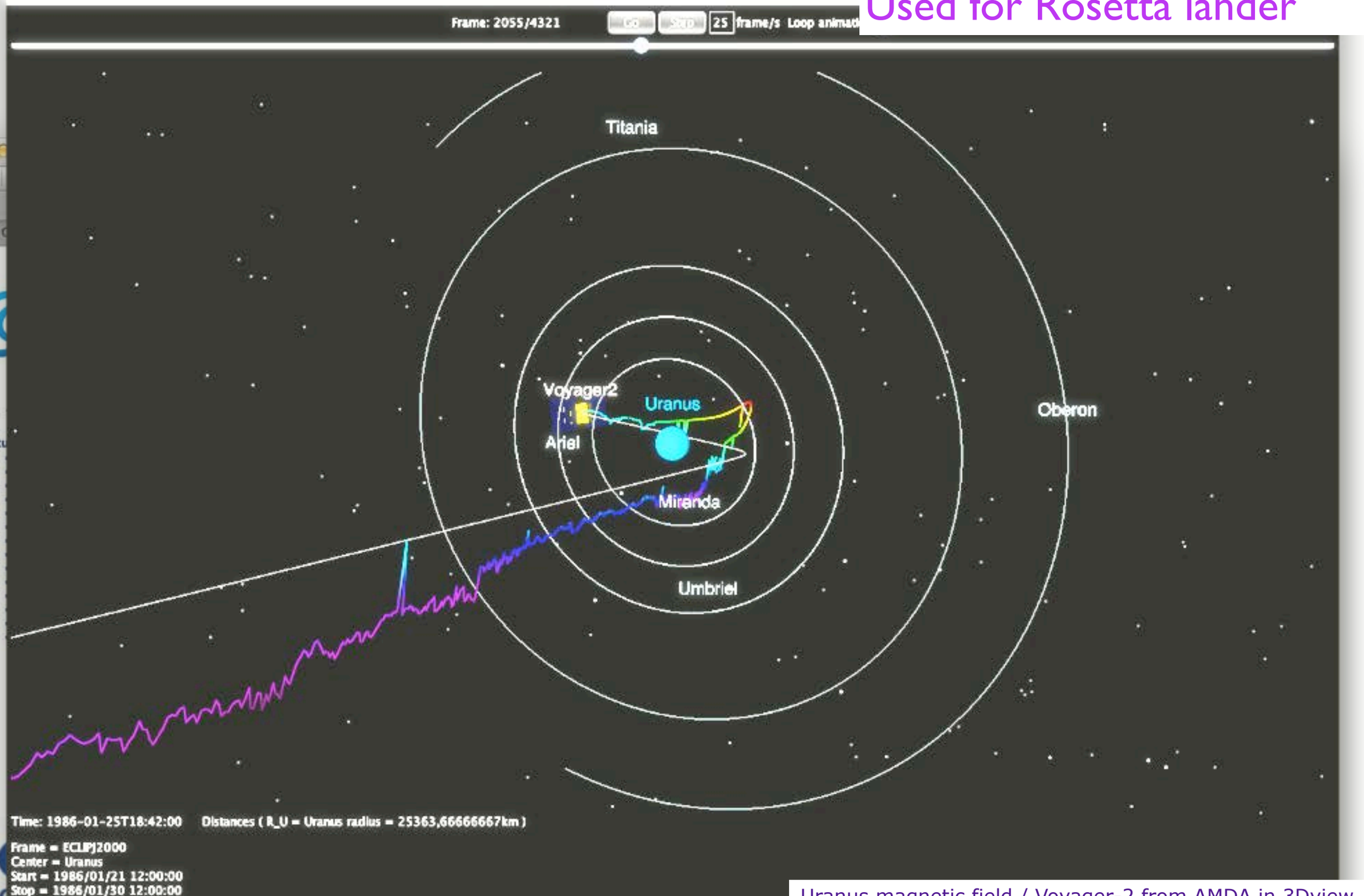
Cassini / RPWS 10kHz-1 MHz radio data in TOPCAT

Visualization tools:
adapt other existing tools

3Dview / CNES:

Spacecraft trajectories+data

Used for Rosetta lander



Uranus magnetic field / Voyager-2 from AMDA in 3Dview

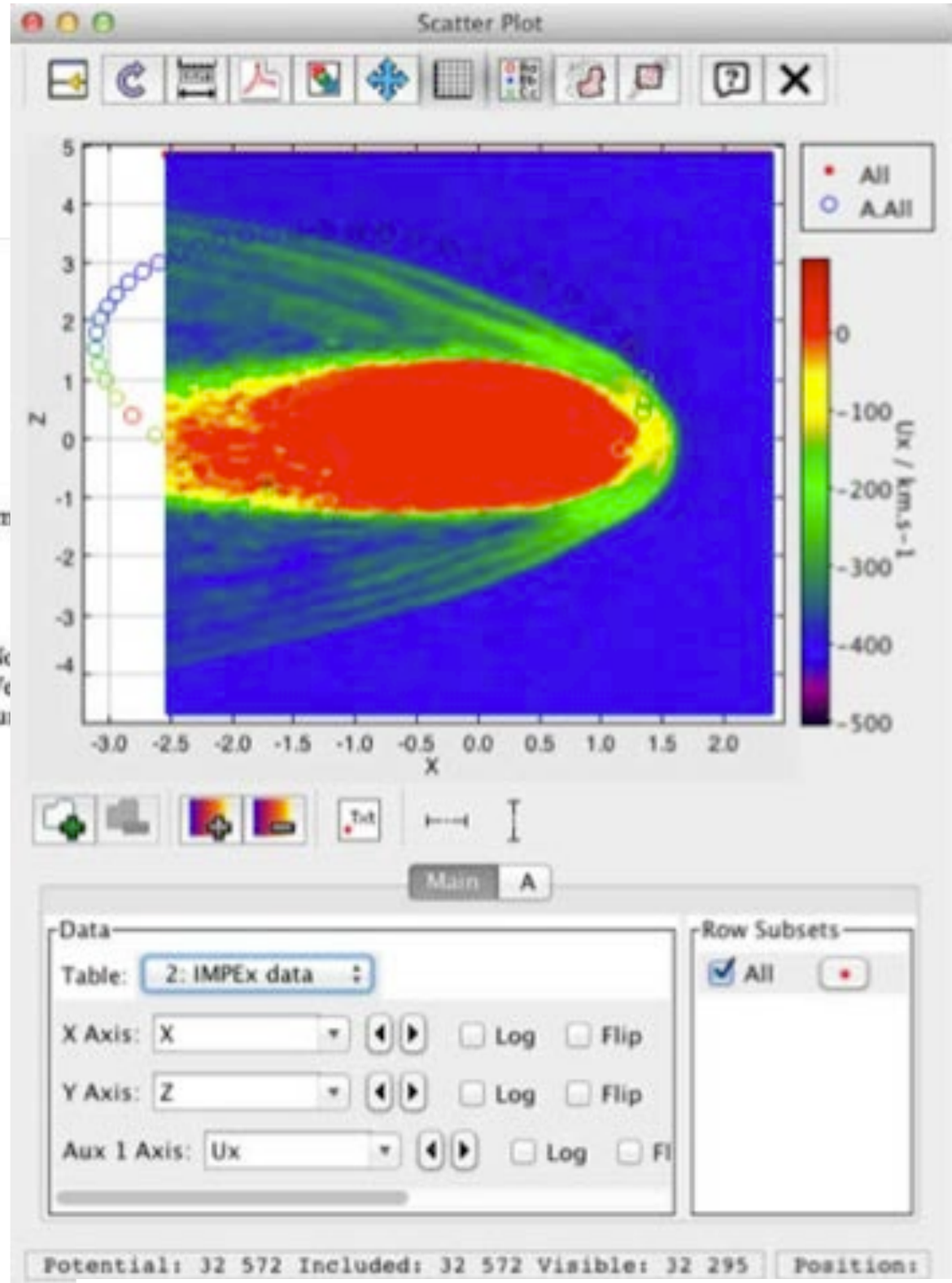
Integrated services & tools

LatHyS / LATMOS:

Plasma simulations

AMDA / CDPP:

Observational archive



Plasma velocity at Mars: map = simu, dots = MarsExpress

Integrated services & tools

GhoSST / IPAG:

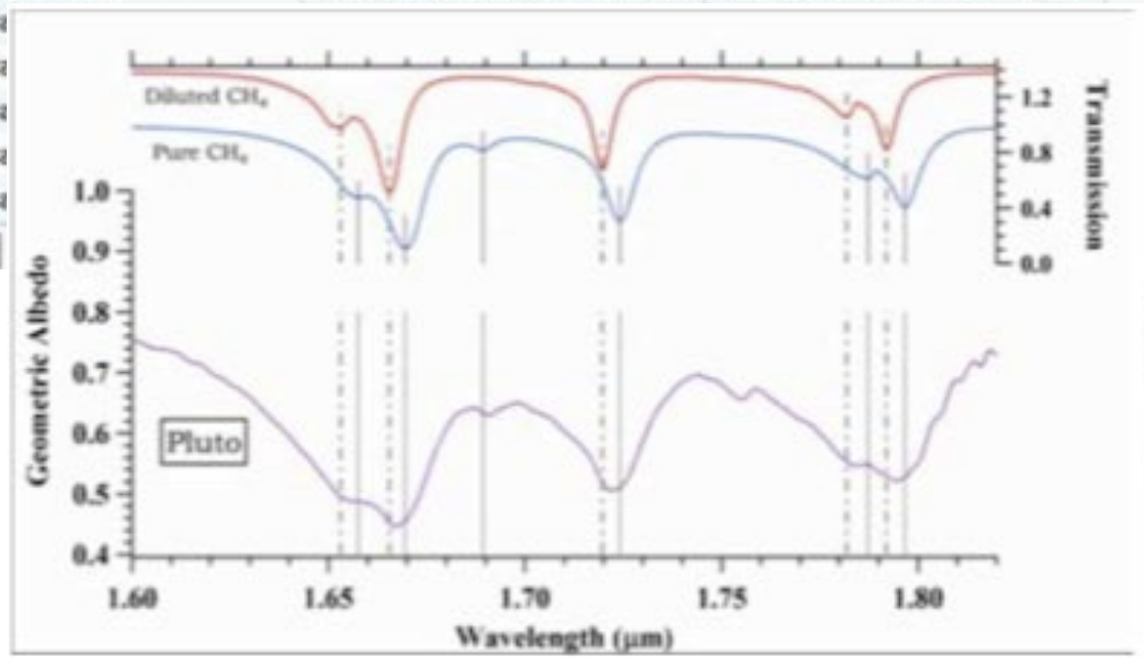
Spectroscopy / ices

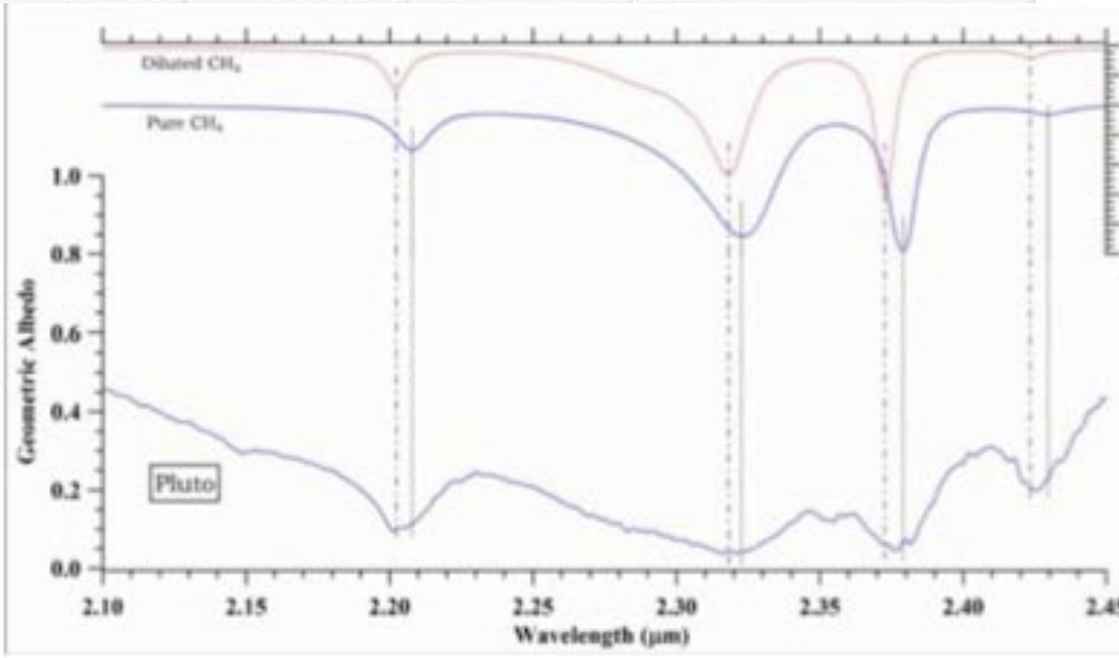
Spectrum

Request on CH_4 in NIR range

			ID	Type	Title	Sample	Spectral range min.	Spectral range max.	Sample temperature (K)	Species
			469	optical constants	NIR Optical constants spectrum of (	CH4 in beta-N2 crystalline	2000 cm-1	10000 cm-1	36.5	N2, CH4, CO2
			470	optical constants	NIR Optical constants spectrum of (	CH4 in beta-N2 crystalline	2000 cm-1	2235 cm-1	38	N2, CH4, CO2
			471	optical constants	NIR Optical constants spectrum of (	CH4 in beta-N2 crystalline	2000 cm-1	2235 cm-1	41	N2, CH4, CO2
			472	optical constants	NIR Optical constants spectrum of (	CH4 in beta-N2 crystalline	2000 cm-1	2235 cm-1	43	N2, CH4, CO2
			474	optical constants	NIR Optical constants spectrum of (	CH4 in alpha-N2 crystalline	2520 cm-1	2985 cm-1	35	N2, CH4, CO2
			506	absorption coefficient	Vis-NIR absorption coefficient spect	CH4 liquid	2380 cm-1	2970 cm-1	93	CH4, CO2
			518	absorption coefficient	Vis-NIR absorption coefficient spect	CH4 crystalline I	2000 cm-1	2986 cm-1	30	CH4, CO2
			519	absorption coefficient	Vis-NIR absorption coefficient spect	CH4 crystalline I	2000 cm-1	2983 cm-1	40	CH4, CO2
			520	absorption coefficient	Vis-NIR absorption coefficient spect	CH4 crystalline I	2475 cm-1	2979 cm-1	50	CH4, CO2
			521	absorption coefficient	Vis-NIR absorption coefficient spect	CH4 crystalline I	2000 cm-1	2976 cm-1	60	CH4, CO2
			522	absorption coefficient	Vis-NIR absorption coefficient spect	CH4 crystalline I	2000 cm-1	2973 cm-1	70	CH4, CO2
			523	absorption coefficient	Vis-NIR absorption coefficient spect	CH4 crystalline I	2000 cm-1	2971 cm-1	80	CH4, CO2
			524	absorption coefficient	Vis-NIR absorption coefficient spect	CH4 crystalline I	2000 cm-1	2968 cm-1	90	CH4, CO2
			526	absorption coefficient	Vis-NIR absorption coefficient spect	CH4 crystalline II	2000 cm-1	3002 cm-1	20	CH4, CO2
			572	transmission	MIR Transmission spectrum of 0.27	CH4 crystalline II - film 0.275µm	490 cm-1	6500 cm-1	15	CH4
			573	tra						
			574	tra						
			575	tra						
			576	tra						
			577	tra						

<< < Page 1 / 2 > >>





Fitting Pluto telescopic spectra

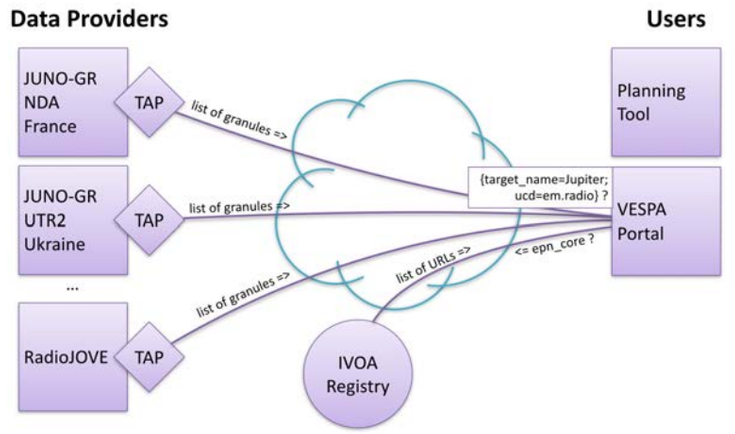
VESPA

Virtual European Solar and Planetary Access

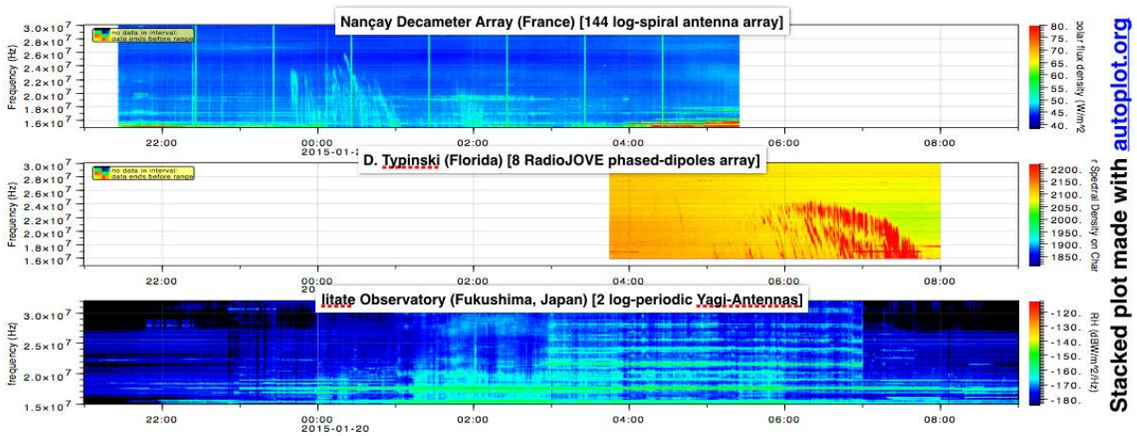
Science Team Using VESPA

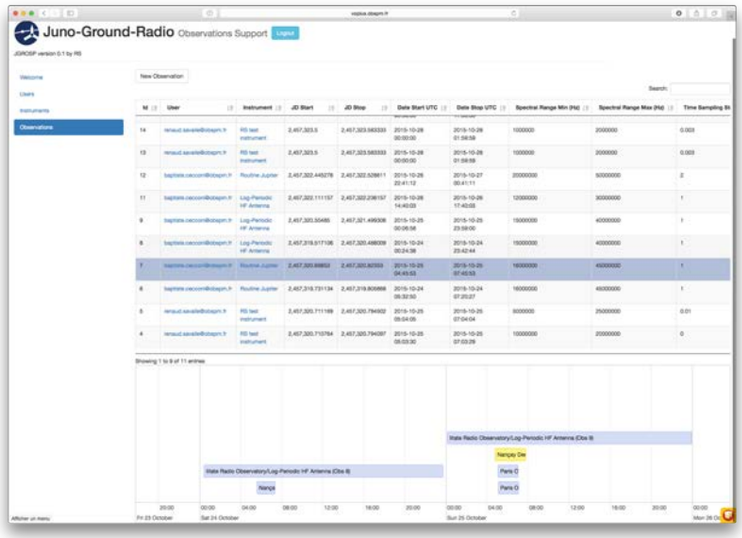
The **Juno**-Ground-Radio team is using VESPA as its underlying infrastructure.

LF Radio observatories (Nançay-France, LOFAR-Europe, UTR2-Ukraine, Iitate-Japan, LWA1-USA, RadioJOVE) are sharing their data in a common format (CDF), with identical metadata model (ISTP+PDS4+EPNcore), through VESPA EPN-TAP servers.



Easy to query all services at once.





VESPA
Virtual European Solar and Planetary Access

Tutorials and more info

- Main search interface
- Solar Wind interaction at Saturn (early 2004)
- Titan CIRS atmospheric profiles
- Hyper-spectral cube analysis
- HST Auroral images on 3Dview

More info

- On our web site: http://www.europlanet-vespa.eu/
- On our GitHub: https://github.com/epn-vespa
- Search interface: http://vespa.obspm.fr
- Slack: https://vespa-epn.slack.com

PADC
Paris Astronomical Data Centre

3DView CDPP - Scene 1

File Media Camera Options Science Interoperability

Remote data (IMPEx)
Remote data (VESPA)
Models
Time Tables ▶
Load map
Load Carrington map

99/500 Go Step 25 frame/s Loop animation

Add projection map

Body: Saturn

Choose a map from those available on server

Default Standard colored texture

Auroral images from APIS

Found 3 APIS maps Show maps

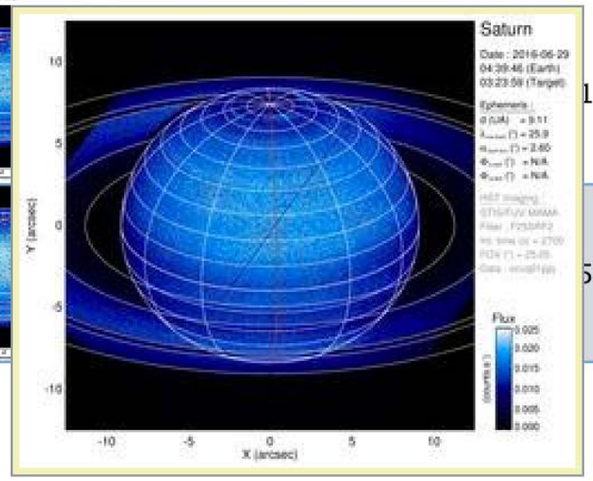
Load a map file (Equirectangular projection)

Auroral images from APIS

ocvq01pjq_proc 2016/06/29 04:39

15

50



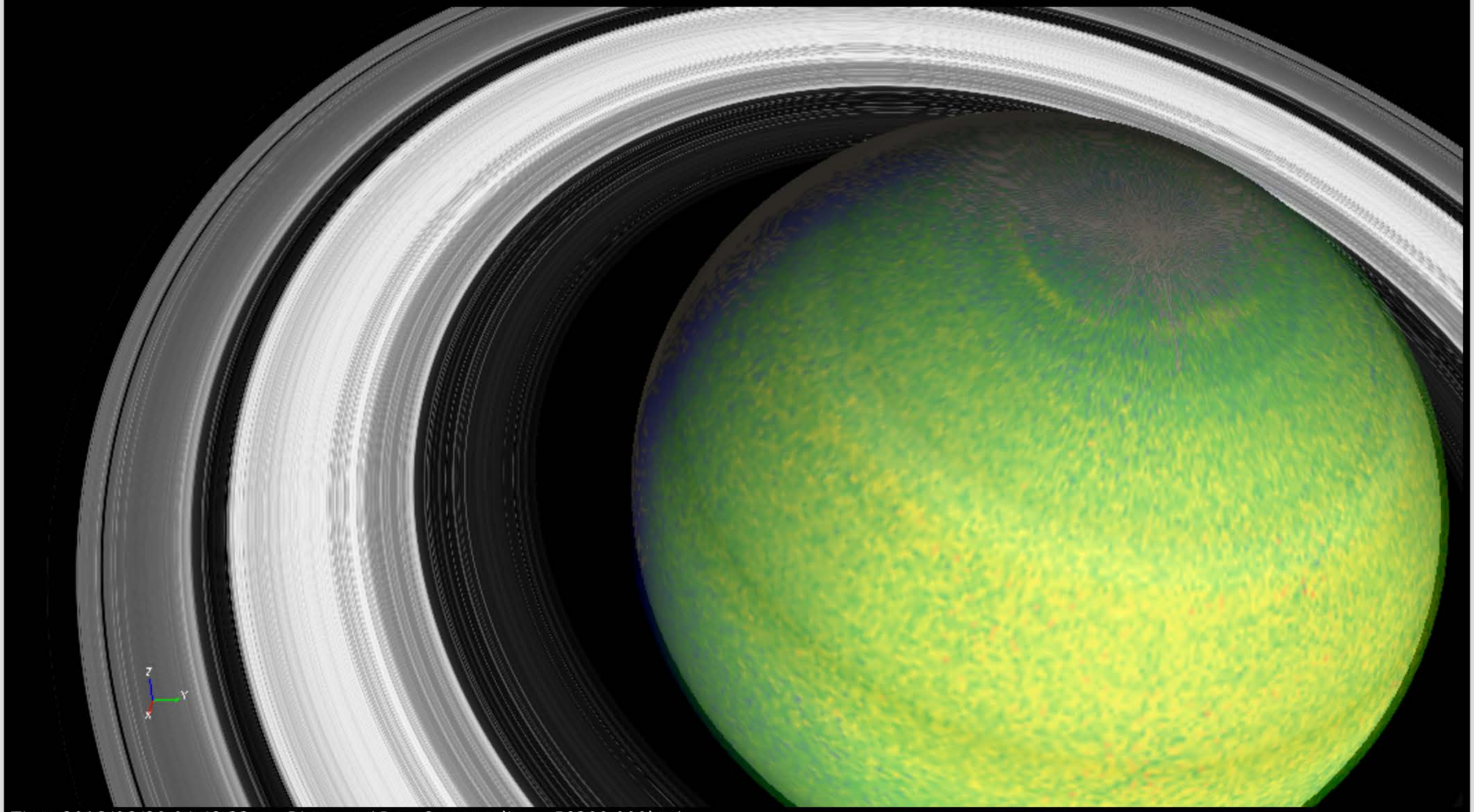
Cassini

urn radius = 58300.000km)

3DView CDPP - Scene 1

File Media Camera Options Science Interoperability

Frame: 99/500 Go Step 25 frame/s Loop animation



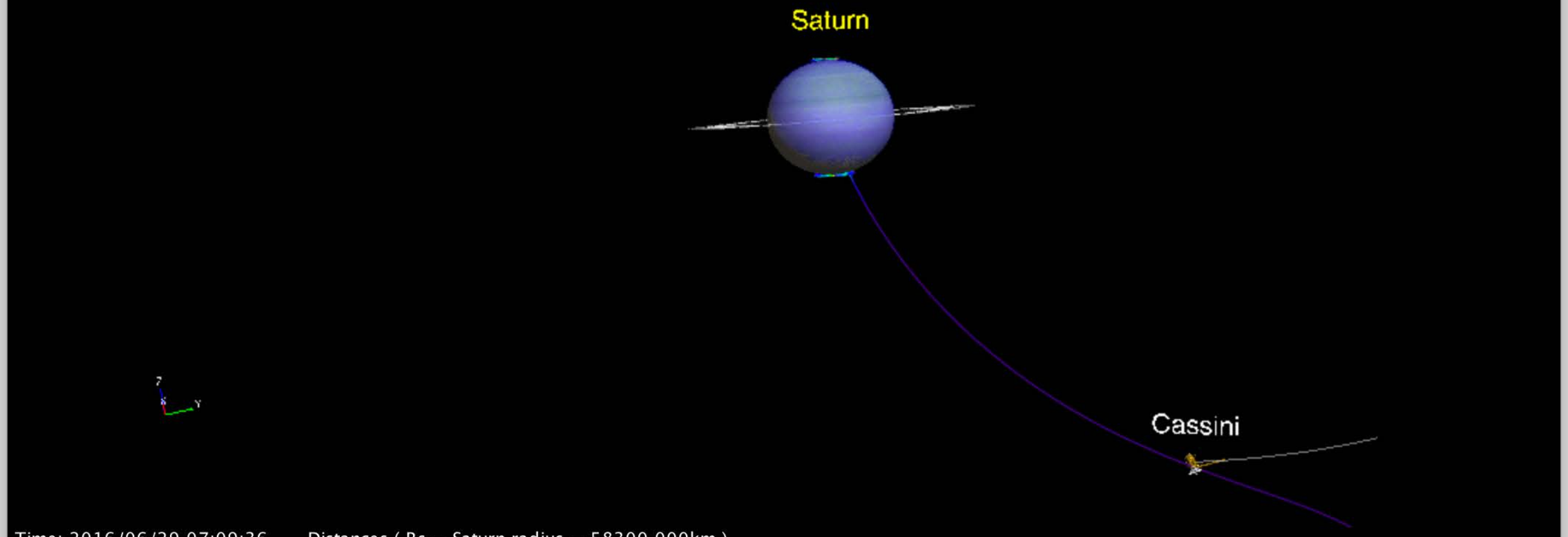
Time: 2016/06/29 04:42:33 Distances (Rs = Saturn radius = 58300.000km)

Frame = KSO
Center = Saturn
Start = 2016/06/29 00:00:00
Stop = 2016/06/30 00:00:00

3DView CDPP - Scene 1

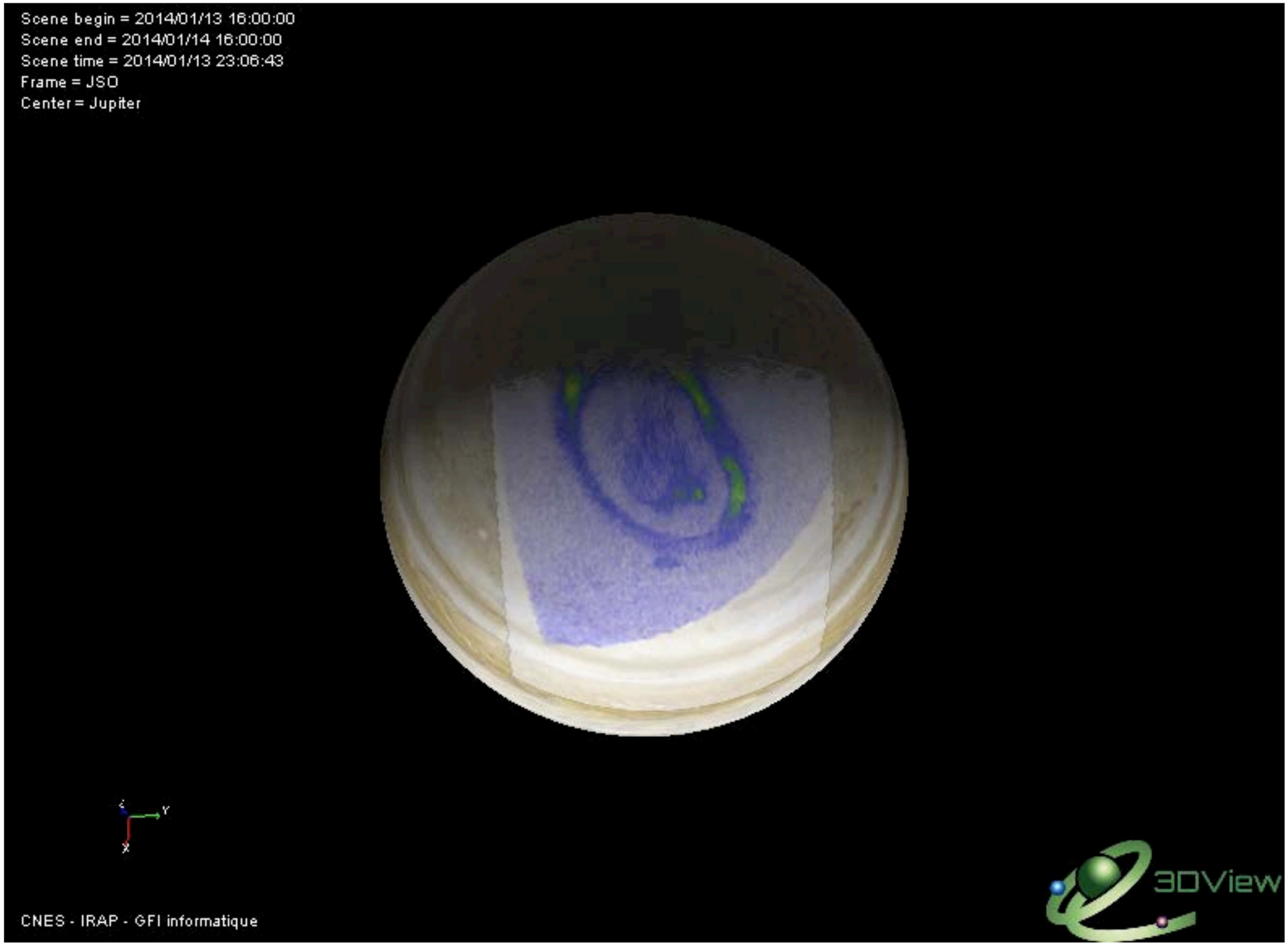
File Media Camera Options Science Interoperability

Frame: 150/500 Go Step 25 frame/s Loop animation



Time: 2016/06/29 07:09:36 Distances (Rs = Saturn radius = 58300.000km)

Frame = KSO
Center = Saturn
Start = 2016/06/29 00:00:00
Stop = 2016/06/30 00:00:00


Scene begin = 2014/01/13 16:00:00
Scene end = 2014/01/14 16:00:00
Scene time = 2014/01/13 23:06:43
Frame = JSO
Center = Jupiter
Z
Y
X
CNES - IRAP - GFI informatique
3DView

Next talks

- Pierre Le Sidaner:
  VESPA portal, TAP and validators

- Markus Demleitner:
  Using DaCHS for Solar System sciences

- Michel Gangloff:
  VESPA Users Tutorials

- Discussion

- Baptiste Cecconi:
  Summary of Working and Interest Groups: SSIG