Planetary Science & Provenance

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(and the VESPA team)

LESIA / Observatoire de Paris-PSL

Workshop Provenance in practice

14-15 dec 2021

The Europlanet-2024 Research Infrastructure project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.

Planetary Science data use cases

Two examples of common situations

- **Space borne observations**:
  examples of VIRTIS on Venus-Express and Rosetta

- **Data services**:
  VO services on small bodies

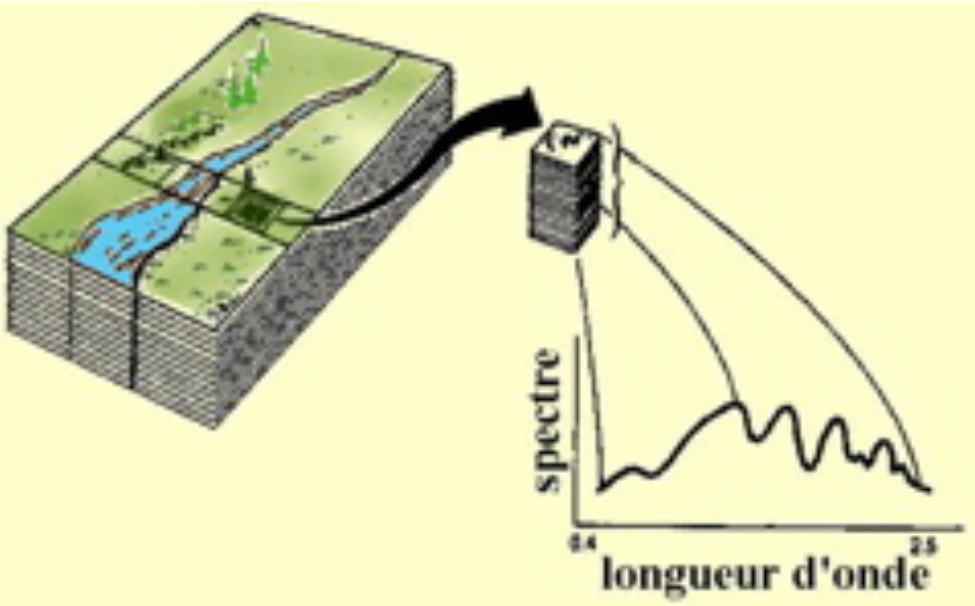
Focus here on VESPA — EPN-TAP data services

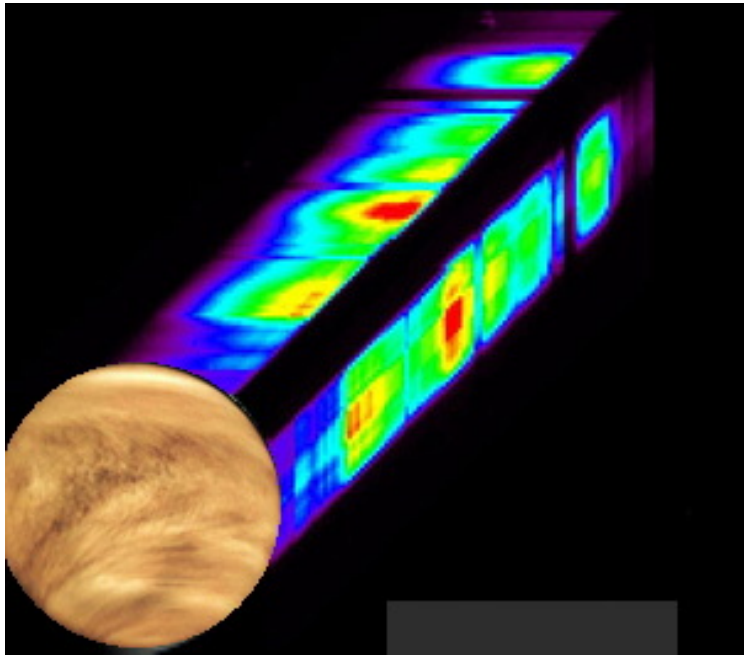
Space-borne observations

- **During acquisition/processing phase:**
- Raw data retrieved in instrument team, validated by agency
- Calibration performed locally, often many successive versions
- Alternative pipelines to test further techniques
- Calibrated products eventually provided to space agency (PSA or PDS), available there
- Ancillary data computed in PI team (coordinates, illumination angles, etc) => in PSA / PDS
- **Derived products:**
- can be composited from many calibrated products

VIRTIS / Rosetta

- **Imaging spectrometers**
  including VIRTIS-M (Venus-Express, Rosetta)

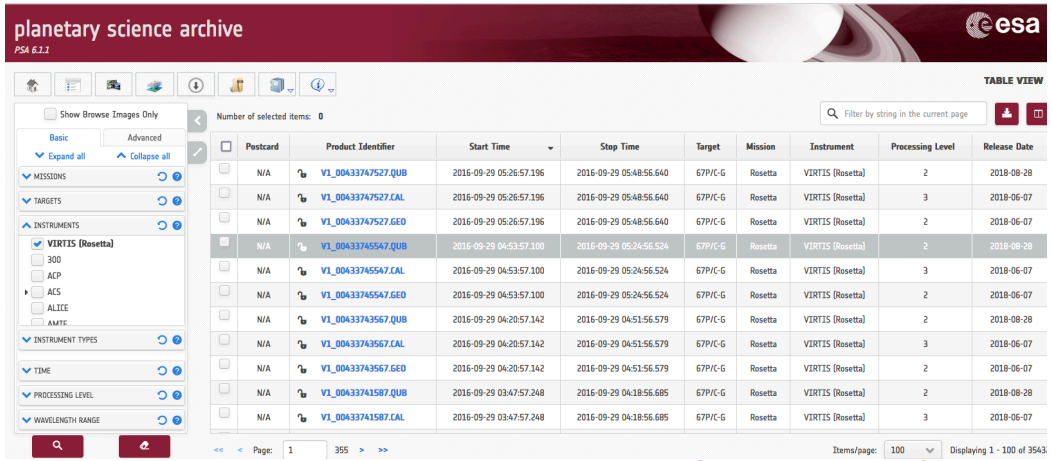




- **VIRTIS-H: Echelle spectrometer**
  2 spectral dimensions

VIRTIS / Rosetta & VEx

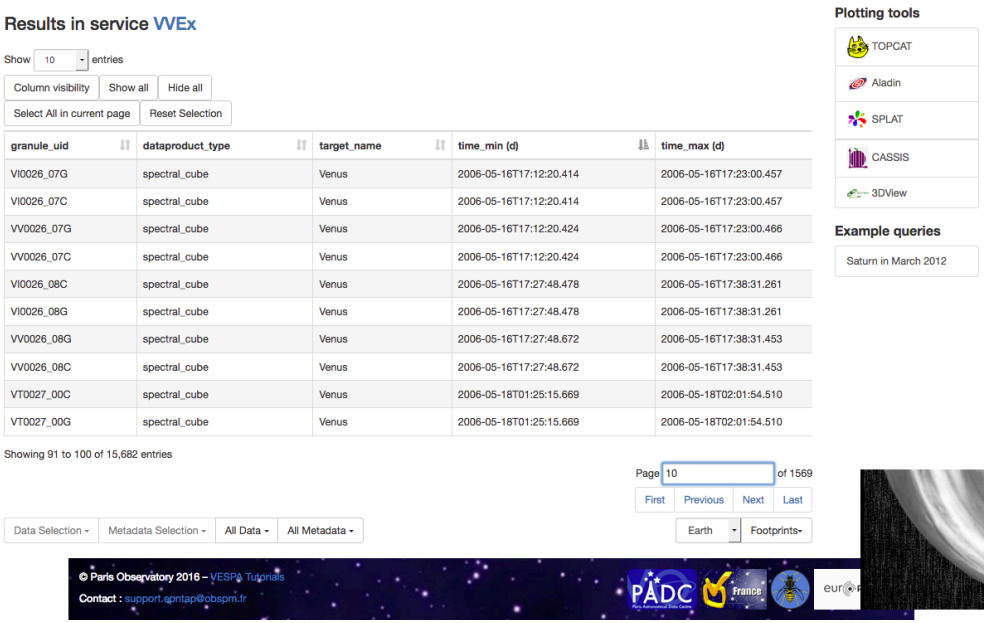
- Raw and calibrated data + geometry typically distributed by Space agencies



PSA search interface

- Derived products, available in teams and (sometimes) data access systems such as VESPA

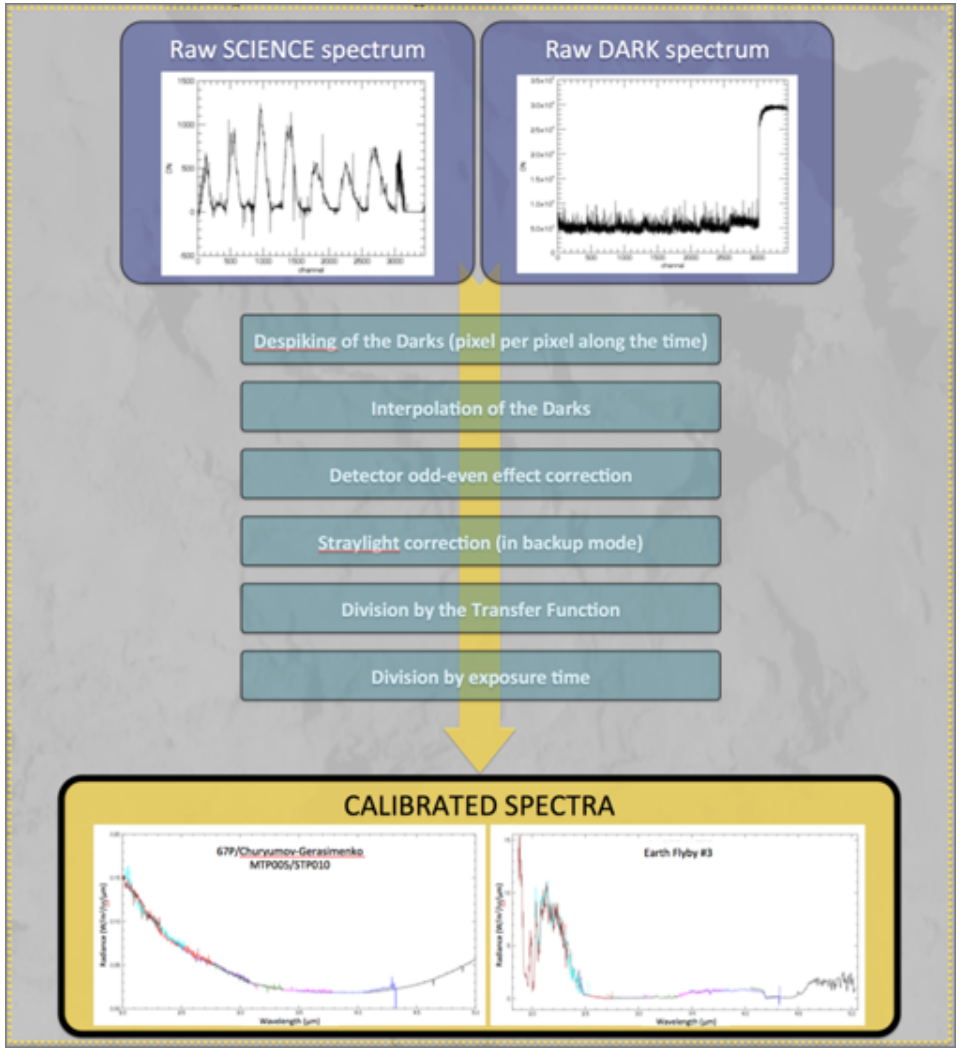
VESPA search interface



VIRTIS-H / Rosetta

- **Echelle spectrometer**
  on Venus-Express
  and Rosetta

  1) Nominal pipeline
  Uses:
  Raw data
  Averaged dark
  Normalized flat field
  Spectral map
  Spectral registration
  Spectral transfer function
  Despiking method with coef
  Division by solar flux / normalization



=>References stored in metadata

PDS(3) labels in data products

Calibrated

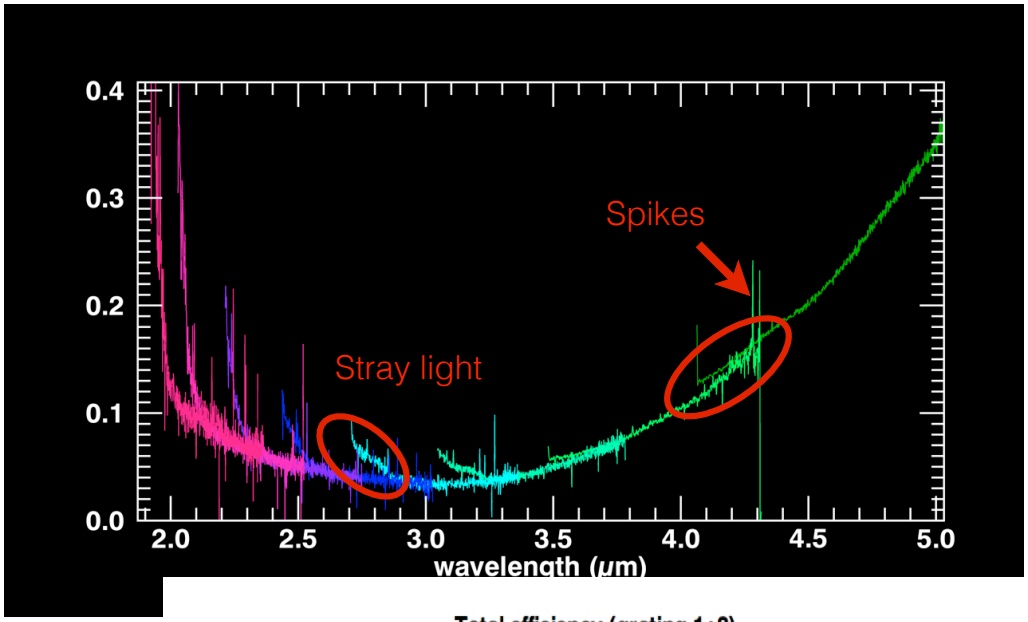
```
PDS_VERSION_ID       = PDS3
LABEL_REVISION_NOTE  = "SE-MTC, 16/12/2015"

      /* File format and length */
PRODUCT_ID      = "T1_00426059346.CAL"
ORIGINAL_PRODUCT_ID  = "PTG72500.QUB"
RECORD_TYPE     = FIXED_LENGTH
RECORD_BYTES    = 512
FILE_RECORDS    = 8757
LABEL_RECORDS   = 31
FILE_STATE      = CLEAN

      /* Pointers to data objects */
^HISTORY     = 32
^TABLE       = 33
^QUBE        = 114

      /* Producer information */
PRODUCER_ID                = ROSETTA_VIRTIS_TEAM
PRODUCER_FULL_NAME         = "CAPACCIONI"
PRODUCER_INSTITUTION_NAME  = "OBSERVATOIRE DE PARIS-LESIA"
PRODUCT_CREATION_TIME      = 2017-06-08T16:23:03.00
TELEMETRY_SOURCE_ID        = "VIRTIS_EGSE3"
SOFTWARE_VERSION_ID        = {"VirtisRos SW v.4.10", "EGSE_SOFT_7.4",
 "PDS_CONVERTER_7.4","EGSE2PSA_LBL_1.2.2", "GEOROS_7.2", "V_GEOLABEL_6",
 "GEOROS_7.2", "V_GEOLABEL_6", "CALIBROS_1.2_150126", "V_CONVLABEL_2.3"}

      /* Data description parameters */
DATA_SET_NAME          = "ROSETTA-ORBITER 67P VIRTIS 3 EXTENDED 3 MTP031 V1.0"
DATA_SET_ID            = "RO-C-VIRTIS-3-EXT3-MTP031-V1.0"
PRODUCT_TYPE           = RDR
PROCESSING_LEVEL_ID    = 3
STANDARD_DATA_PRODUCT_ID  = "VIRTIS DATA"
MISSION_NAME           = "INTERNATIONAL ROSETTA MISSION"
MISSION_ID             = ROSETTA
INSTRUMENT_HOST_NAME   = "ROSETTA-ORBITER"
INSTRUMENT_HOST_ID     = RO
MISSION_PHASE_NAME     = "ROSETTA EXTENDED 3 MTP031"
PI_PDS_USER_ID         = CAPACCIONI
INSTRUMENT_NAME        = "VISIBLE AND INFRARED THERMAL IMAGING SPECTROMETER"
INSTRUMENT_ID          = "VIRTIS"
INSTRUMENT_TYPE        = "IMAGING SPECTROMETER"
^INSTRUMENT_DESC       = "RO_VIRTIS_EAICD.ASC"
ROSETTA:CHANNEL_ID        = "VIRTIS_H"
PHOTOMETRIC_CORRECTION_TYPE  = NONE
DATA_QUALITY_ID        = 1
DATA_QUALITY_DESC      = "0:INCOMPLETE ; 1:COMPLETE"

      /* Science operations information */
TARGET_TYPE              = "COMET"
TARGET_NAME              = "67P/CHURYUMOV-GERASIMENKO 1 (1969 R1)"
START_TIME               = 2016-07-02T05:03:15.574
STOP_TIME                = 2016-07-02T09:17:35.285
```

Raw

```
PDS_VERSION_ID  = PDS3
LABEL_REVISION_NOTE  = "SE-MTC, 11/12/2015"

 /* File format and length */
PRODUCT_ID  = "T1_00426059346.QUB"
ORIGINAL_PRODUCT_ID  = "PTG72500.QUB"
RECORD_TYPE  = FIXED_LENGTH
RECORD_BYTES  = 512
FILE_RECORDS  = 5076
LABEL_RECORDS  = 12
FILE_STATE  = CLEAN

 /* Pointers to data objects */
^HISTORY  = 13
^QUBE  = 14

 /* Producer information */
PRODUCER_ID  = ROSETTA_VIRTIS_TEAM
PRODUCER_FULL_NAME  = "CAPACCIONI"
PRODUCER_INSTITUTION_NAME  = "ISTITUTO NAZIONALE DI ASTROFISICA"
PRODUCT_CREATION_TIME  = 2017-06-08T15:35:11.00
TELEMETRY_SOURCE_ID  = "VIRTIS_EGSE3"
SOFTWARE_VERSION_ID  = {"VirtisRos SW v.4.10", "EGSE_SOFT_7.4",
"PDS_CONVERTER_7.4","EGSE2PSA_LBL_1.2.2", "GEOROS_7.2", "V_GEOLABEL_6",
"GEOROS_7.2", "V_GEOLABEL_6"}

 /* Data description parameters */
DATA_SET_NAME  = "ROSETTA-ORBITER 67P VIRTIS 2 EXTENDED 3 MTP031 V1.0"
DATA_SET_ID  = "RO-C-VIRTIS-2-EXT3-MTP031-V1.0"
PRODUCT_TYPE  = EDR
PROCESSING_LEVEL_ID  = 2
STANDARD_DATA_PRODUCT_ID  = "VIRTIS DATA"
MISSION_NAME  = "INTERNATIONAL ROSETTA MISSION"
MISSION_ID  = ROSETTA
INSTRUMENT_HOST_NAME  = "ROSETTA-ORBITER"
INSTRUMENT_HOST_ID  = RO
MISSION_PHASE_NAME  = "ROSETTA EXTENDED 3 MTP031"
PI_PDS_USER_ID  = CAPACCIONI
INSTRUMENT_NAME  = "VISIBLE AND INFRARED THERMAL IMAGING SPECTROMETER"
INSTRUMENT_ID  = "VIRTIS"
INSTRUMENT_TYPE  = "IMAGING SPECTROMETER"
^INSTRUMENT_DESC  = "RO_VIRTIS_EAICD.ASC"
ROSETTA:CHANNEL_ID  = "VIRTIS_H"
DATA_QUALITY_ID  = 1
DATA_QUALITY_DESC  = "0:INCOMPLETE ; 1:COMPLETE"

 /* Science operations information */
TARGET_TYPE  = "COMET"
TARGET_NAME  = "67P/CHURYUMOV-GERASIMENKO 1 (1969 R1)"
START_TIME  = 2016-07-02T05:03:15.574
STOP_TIME  = 2016-07-02T09:17:35.285
SPACECRAFT_CLOCK_START_COUNT  = "1/0426056508.37679"
SPACECRAFT_CLOCK_STOP_COUNT  = "1/0426071768.18408"
```

VIRTIS-H / Rosetta

- **Echelle spectrometer**
  on Venus-Express
  and Rosetta



2) Complementary steps

May include:

Correction of darks

Odd-even correction

Stray light correction

depend on Sun position wrt FOV

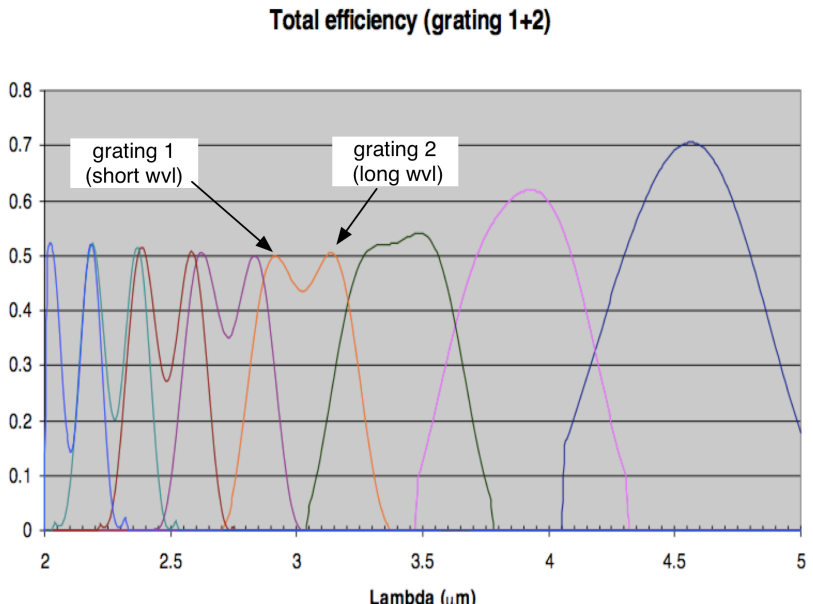
Strabismus correction

depend on illumination / pointing

Photometric corrections

model-depend => parameters

=>References difficult to handle



VIRTIS / Rosetta

- **Imaging spectrometer**
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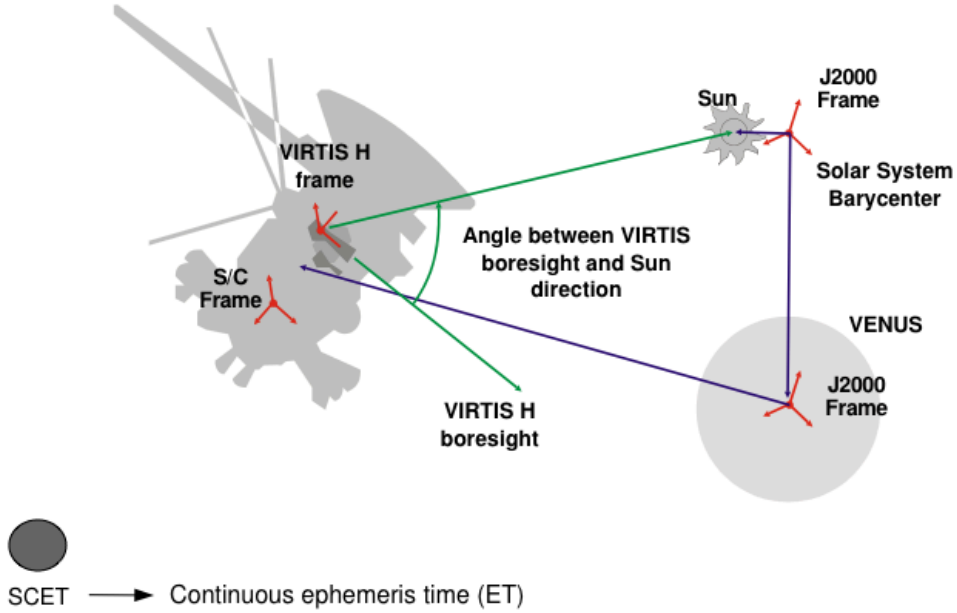


3) Geometry data

Computed for each pixel

Uses:

On-board time

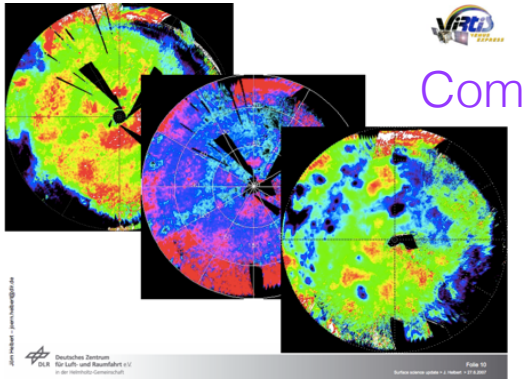
Spice kernels provided by ESA & JPL
(geometry of instrument, trajectory, orbits, rotation)

Software library (JPL) + dedicated routines (team)

=>References stored in metadata / labels

VIRTIS / Venus-Express

- **Imaging spectrometer**
  on Venus-Express
  and Rosetta



Composite maps

4) Derived products

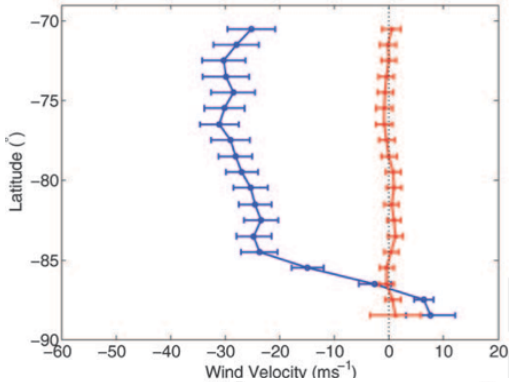
Many types, but need to track:

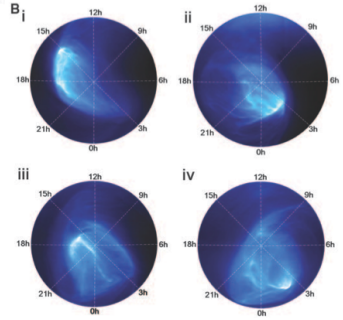
Original files used (may be 100s)

Calibration version

Additional steps/algorithm
(mosaicking, composing…)

Vertical profiles





Movies

=>Difficult to document in final products

Planetary Science data use cases

Two examples of common situations

- **Space borne observations**:
  examples of VIRTIS on Venus-Express and Rosetta

→ • **Data services**:
  VO services on small bodies

Small body services

Many services in VESPA

- Observations
- Derived quantities / classifications / compilations / computed
- Difficulty to provide bib references for all parameters / all versions

Form | Query

EPN-TAP Services | Custom Service

Main Parameters

Target Name

Target Class
- [x] Asteroid
- [ ] Calibration
- [ ] Comet
- [ ] Dwarf Planet
- [ ] Exoplanet
- [ ] Intplanet. Medium

EPN Services

DynAstVO - Asteroid orbital database and ephemerides 26761 results
hst_planeto - Planetary data from the Hubble Space Telescope 208 results
M4AST - M4AST - Modeling for Asteroids 6298 results
mpc - Minor Planet Center - Asteroid Orbital Data 1152519 results
PSA - ESA Planetary Science Archive 52009 results
SBNAF - Small Bodies Near and Far 170445 results
spectro_asteroids - Spectra of asteroids 451 results
tnosarecool - TNOs are Cool 630 results
USGS_WMS - USGS planetary maps 1 result
VizieR_planets - VizieR Solar system catalogues (B/planets) 180 results

orbital param
observations
properties

Download VOTable

Plotting tools
- TOPCAT
- Aladin
- SPLAT
- CASSIS
- 3DView

Example queri
Saturn in March 2

Help

Small body services

Services complement each other

- Minor Planet Centre and MP3C (to come) provide global properties, families, taxonomical classes…
- Big issue with names / ID => name resolver required (Quaero at IMCCE)

Form | Query

EPN-TAP Services | Custom Service

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orbital param
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- CASSIS
- 3DView

Example queri
Saturn in March 2

Help

Small body services

Several general EPNCore keywords:

- *instrument_name / instrument_host_name*, etc
- *service_title / granule_uid* => call-back mechanism
- *bib_reference* => to papers

Services with history of values

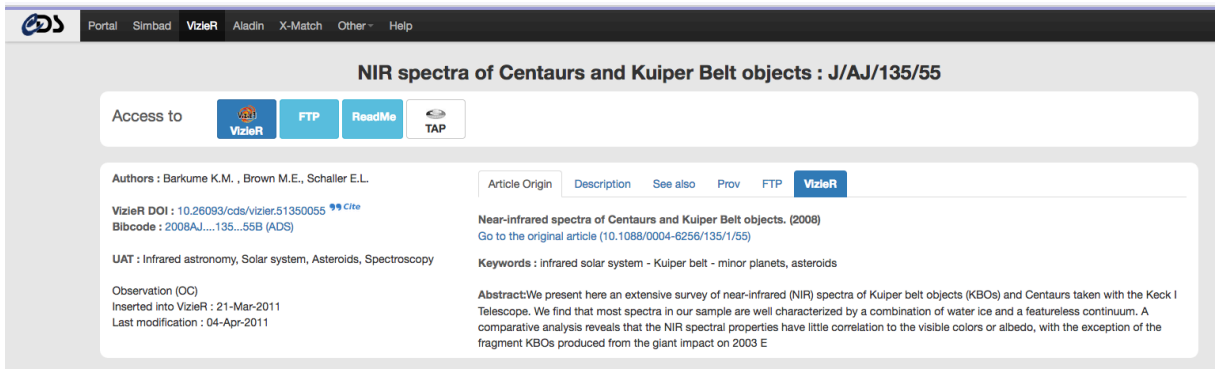
- Especially orbital parameters, change over time

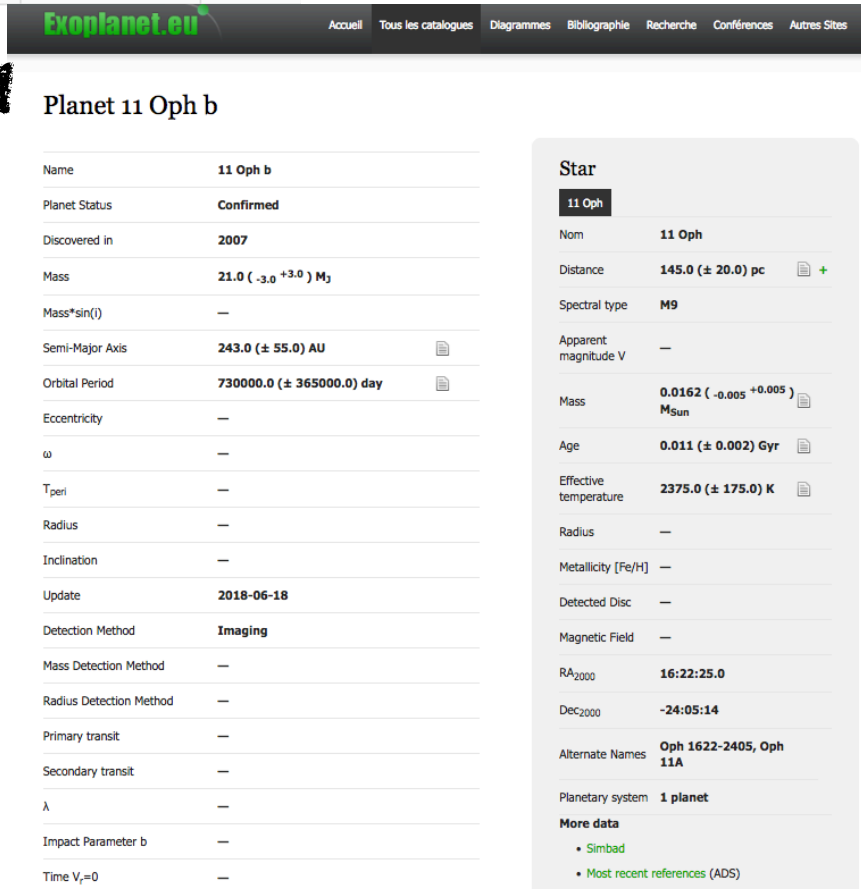
- Some services
have very complete web sites field with information on individual targets
Ex: MP3C, spectro_asteroids, VizieR_planets
(but also Exoplanets, vims_satellites in other fields)
=> referred to through *external_link* parameter

Small body (and other) services

	thumbnail_url	publisher	bib_reference	file_name	external_link	magnitude	sun_dist
106	http://voparis-srv-p...	LESIA	2008AJ....135...55B	Varuna_hk.vot	https://cdsarc.unist...		
0	http://voparis-srv-p...	LESIA	2008AJ....135...55B	Quaoar_hk.vot	https://cdsarc.unist...		
	http://voparis-srv-p...	LESIA	2008AJ....135...55B	Pholus_hk.vot	https://cdsarc.unist...		
5	http://voparis-srv-p	LESIA	2008AJ....135...55B	Okyrhoe_hk.vot	https://cdsarc.unist		

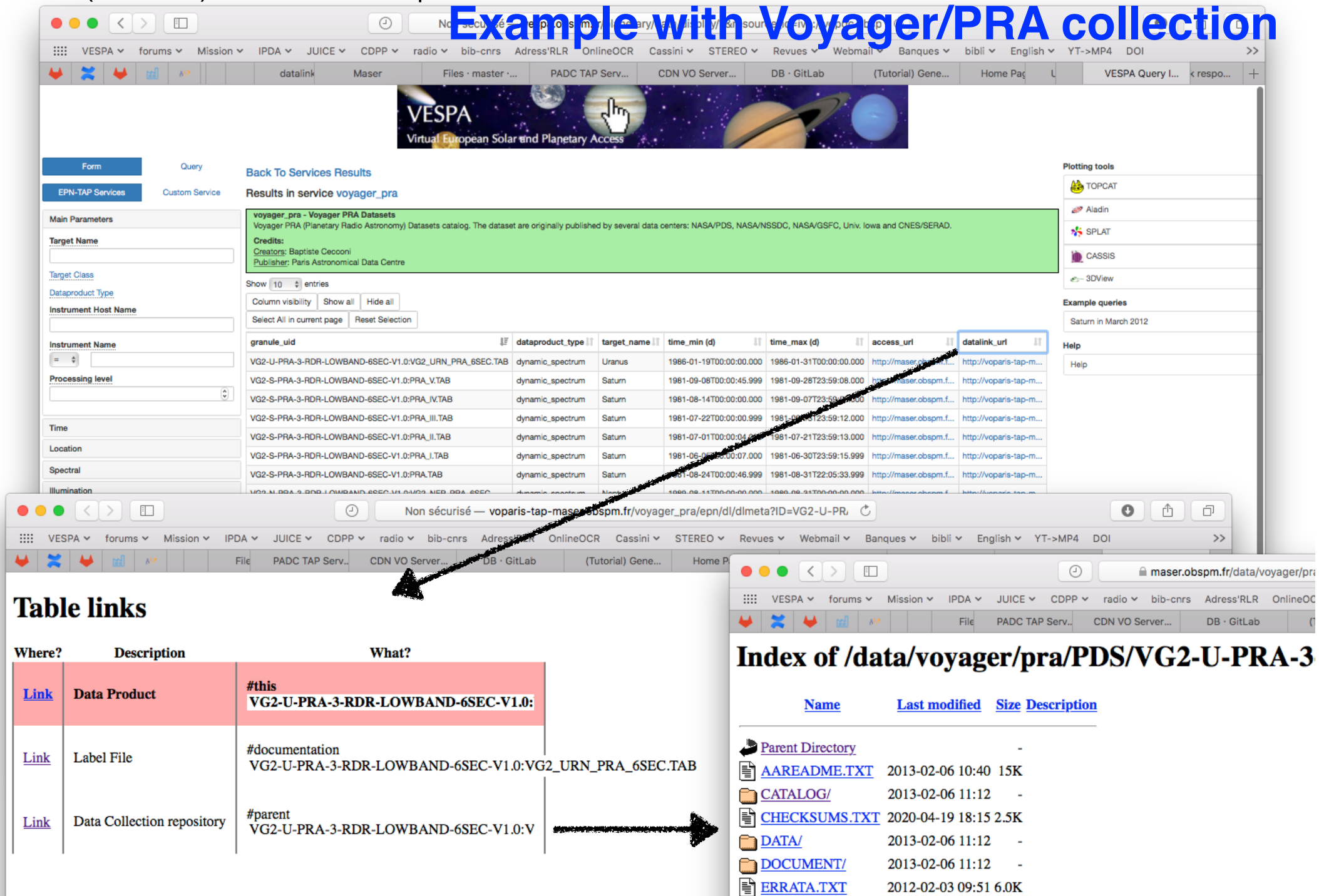
product list in VESPA portal





- *Datalink* can also be used to associate documentation, large metadata sets (labels), a related space archive, etc

Example with Voyager/PRA collection



Summary

- Space experiments:
  Need to keep track of detailed processing
  - calibration, but also further processing

- EPN-TAP:
  Focus on search metadata associated to data products
  Little room for extensive Provenance info

- Datalink and references to detailed web sites provide a solution