APIS : a VO-compliant data service based on (UV) auroral observations of solar system bodies

http://apis.obspm.fr

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R. Romagnan, N. Moreau et al. (Obs. Paris)

T. Kimura et al. (Tohoku University)

IVOA meeting

APIS team and collaborations

l'Observatoire de Paris | LESIA

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Responsable SNO
Responsabilité scientifique des données, Chaine de traitement, Production
Astronome Adjoint au LESIA

Expertise scientifique et OV :
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Nicolas Moreau
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Ingénieur d'études au LERMA

External collaboration :
I. Busko (STSci)

Recent

External databases :
T. Kimura et al. : Hisaki/Exceed (UV)
G. Orton et al. : IRTF (IR)

PADC Paris Astronomical Data Centre

l'Observatoire de Paris | LERMA

APIS team and collaborations

Uses/Interfaced with a variety of VO tools

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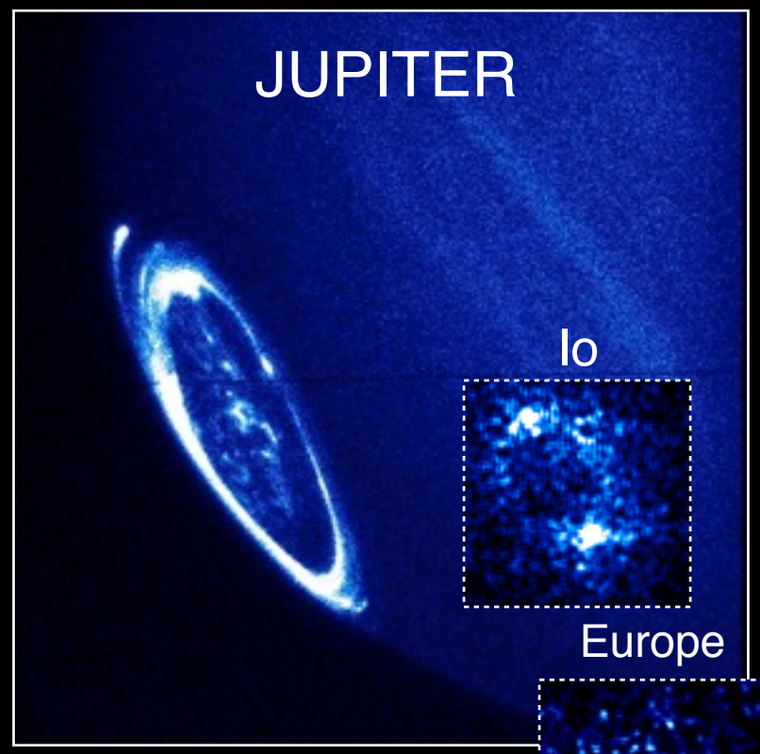
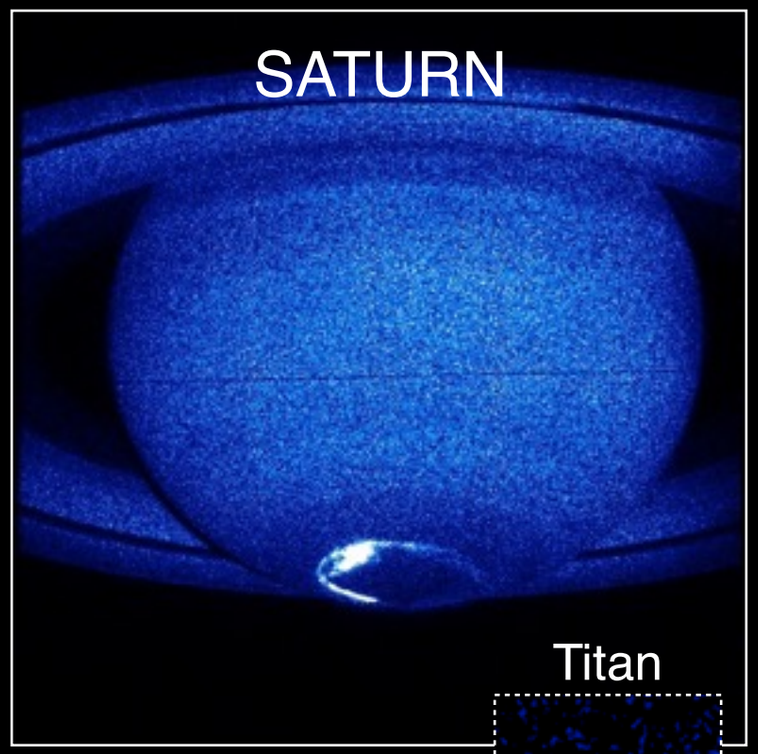
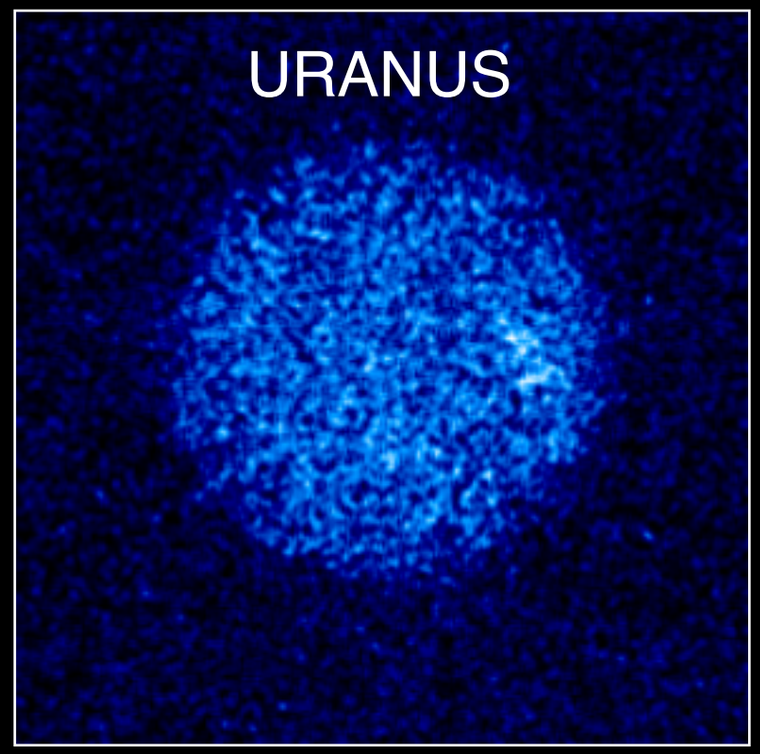
Specview

External databases :
T. Kimura et al. : Hisaki/Exceed (UV)
G. Orton et al. : IRTF (IR)



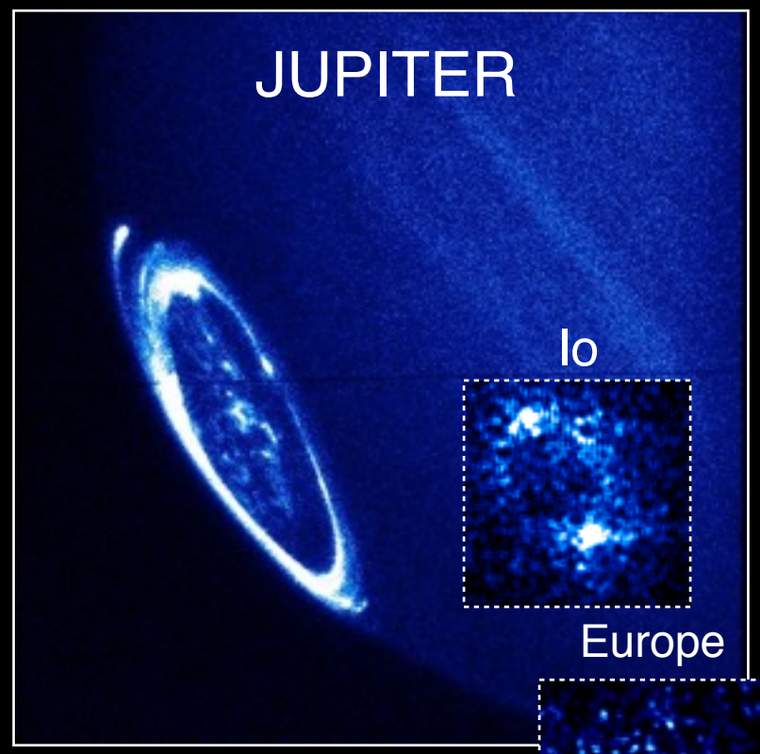


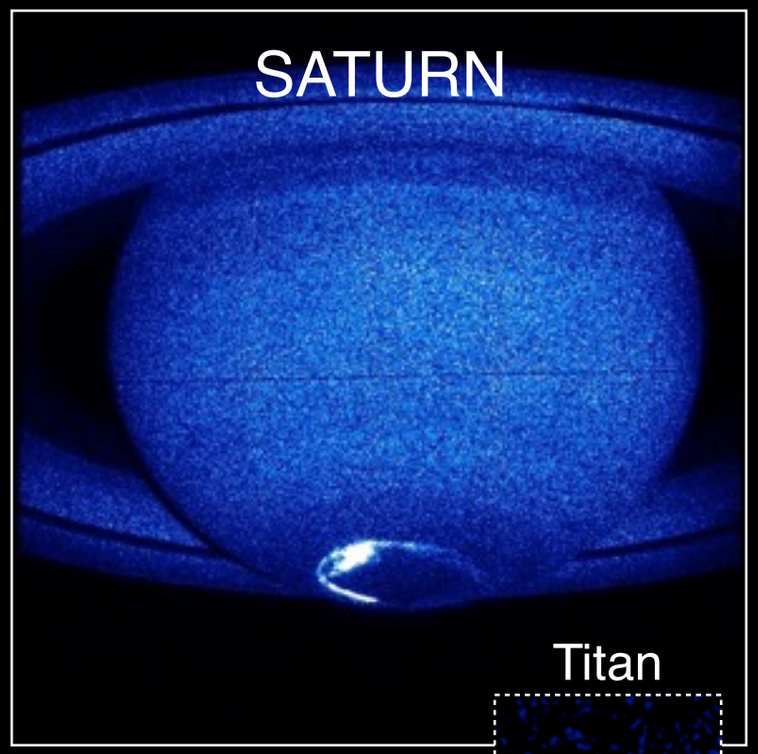


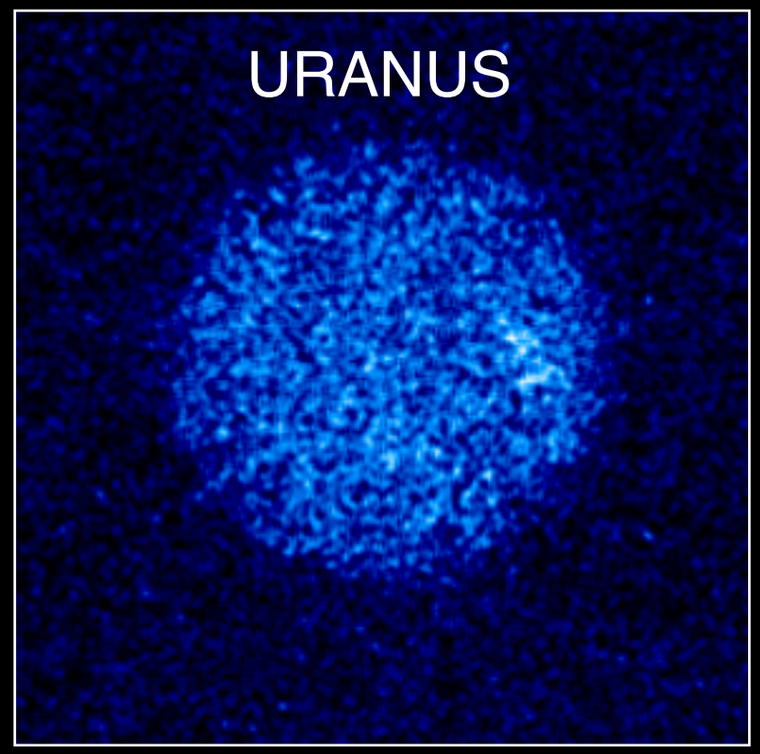
Outline

1- A high level database (UV)
2- An efficient search interface
3- A VO-compliant service

[Lamy et al., Astronomy and Computing, 2015]





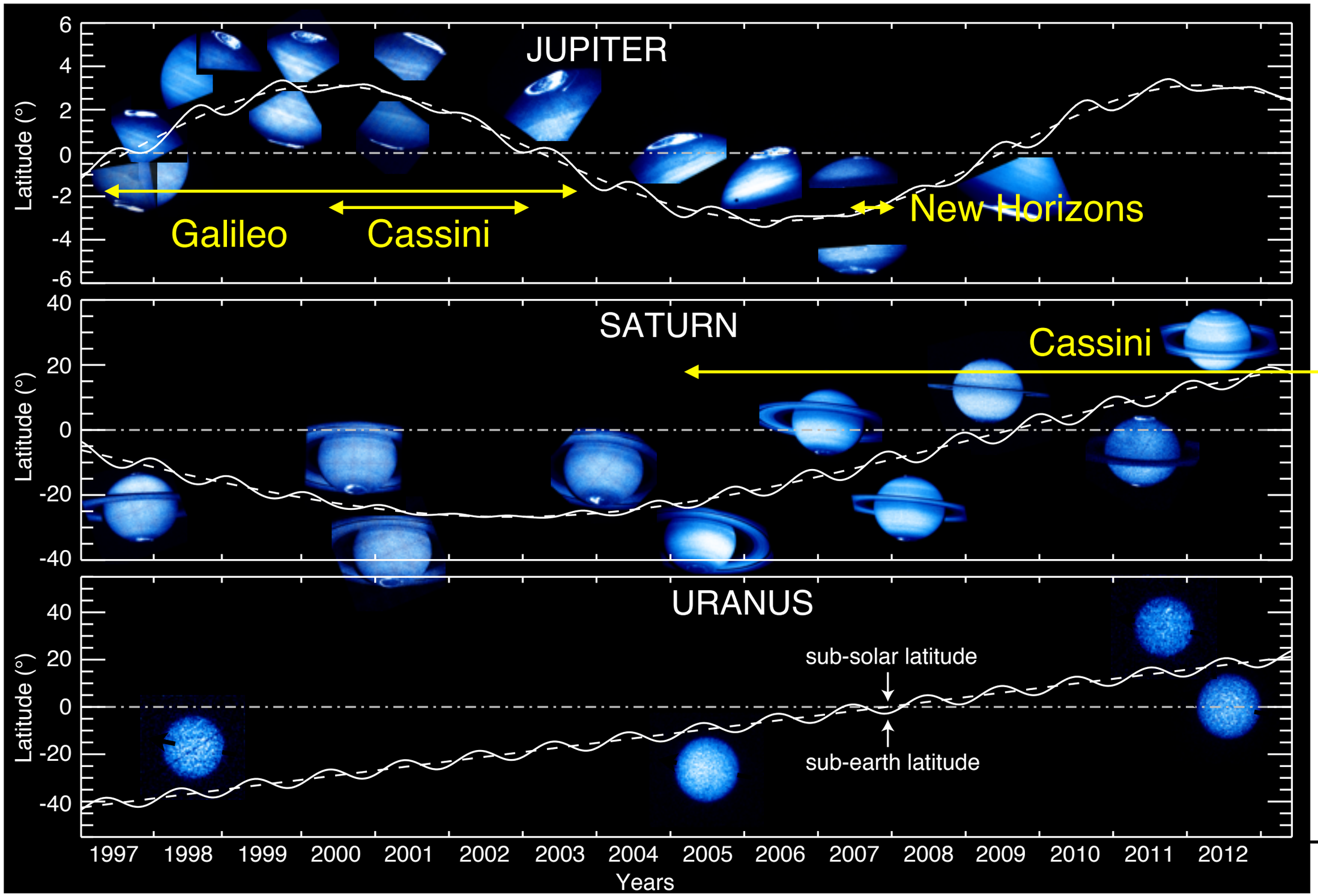


The physics behind UV data

Interest of the UV window (80-180nm) :

- Solar reflected light (albedo) : clouds/surface, rings/satellites
- Planetary emissions (H, H_2, O, N_2 …) :
  - (1) Aurora (precipitation of high energy electrons) : tracer of the magnetosphere, ionosphere, solar wind
  - (2) Airglow (precipitation of low energy electrons)

A (rich) high level database : Hubble



A (rich) high level database : Hubble

JUPITER :
Jupiter, Mar. 1997-Jan. 2001 (STIS, 30 images, 13 spectra)
Jupiter, Jan. 1999 (STIS, 3 images, 6 spectra)
Jupiter, Aug. 1999 (STIS, 31 images, 5 spectra)
Jupiter, Aug. 1999-Nov. 2000 (STIS, 28 images, 35 spectra)
Jupiter, Dec. 2000-Jan. 2001 (STIS, 88 images, 29 spectra)
Jupiter, Feb. 2003 (STIS, 13 images)
Jupiter, Jan.-May 2005 (ACS, 106 images)
Jupiter, Feb.-Apr. 2006 (ACS, 75 images)
Jupiter, Feb.-Jun. 2007 (ACS, 1845 images)
Jupiter, Aug.-Sept. 2009 (STIS, 3 images)
Jupiter, Nov. 2012-Jan. 2014 (STIS, 19 images, 2 spectra)
Jupiter, Jan. 2014 (STIS, 27 images, 14 spectra)
Jupiter, Jan.-Mar. 2014 (STIS, 4 long exposure spectra)
Jupiter, May.-Jul. 2016 (STIS, 45 images, 3 spectra)
Jupiter, Nov. 2016-Sept. 2018 (STIS, 198 images, 8 spectra)

SATELLITES :
Io, Sept.-Oct. 1997 (STIS, 8 spectra)
Io, Aug. 1998 (STIS, 2 images, 18 spectra)
Io, Sept. 1999-Feb. 2000 (STIS, 2 images, 92 spectra)
Io, Dec. 2001 (STIS, 4 spectra)
Io/Ganymede/Europa, Feb. 2007 (ACS, 20 images)
Ganymede, Oct. 1998 (STIS, 8 spectra)
Ganymede/Europa, Oct. 1999-Dec. 2000 (STIS, 13 spectra)
Ganymede, Nov.-Dec. 2003 (ACS/STIS, 4 images, 4 spectra)
Ganymede, Sep. 2010-Oct. 2011 (STIS, 20 spectra)
Ganymede, Jan.-Feb. 2014 (STIS, 8 spectra)
Europa, Nov.-Dec. 2012 (STIS, 19 spectra)
Europa, Nov. 2014 (STIS, 60 spectra)
Callisto, Dec. 2011 (STIS, 20 spectra)
Titan/Saturn, Jan.-Feb. 2009 (ACS, 117 images)

SATURN :
Saturn, Oct.-Dec. 1997 (STIS, 9 images, 1 spectrum)
Saturn, Dec. 2000 (STIS, 2 images, 4 spectra)
Saturn, Jan. 2001 (STIS, 4 images, 8 spectra)
Saturn, Jan. 2004 (STIS, 51 images)
Saturn, Oct.-Nov. 2005 (ACS, 72 images)
Saturn, Jan. 2007-Feb. 2008 (ACS, 1008 images)
Saturn, Jan.-Feb. 2009 (ACS, 1017 images)
Saturn, Feb.-Mar. 2009 (ACS, 400 images)
Saturn, Apr. 2011 (ACS, 115 images)
Saturn, Jan.-May. 2011 (STIS, 8 images, 8 spectra)
Saturn, Mar.-Jun. 2012 (ACS, 230 images)
Saturn, Apr.-May 2013 (ACS, 345 images)
Saturn, Feb.-Jun. 2014 (STIS, 45 images)
Saturn, Jun.-Aug. 2016 (STIS, 6 images)
Saturn, Feb.-Sep. 2017 (STIS, 24 images, 1 spectrum)

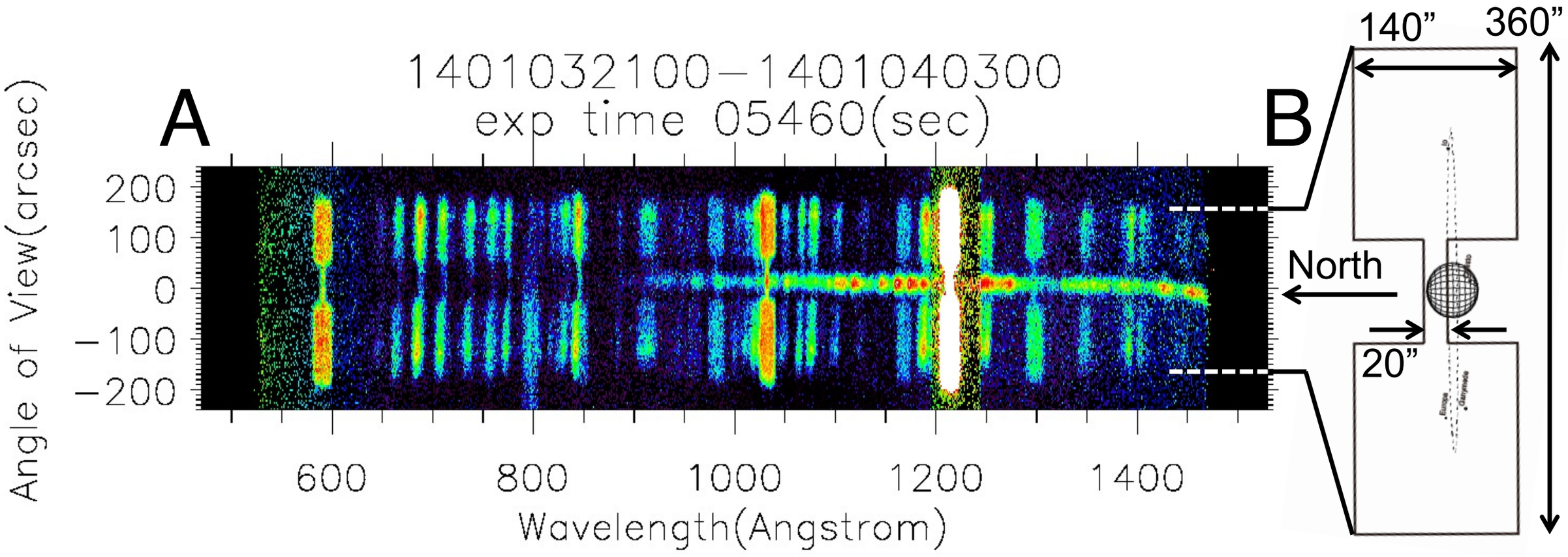
URANUS :
Uranus, Jul.-Sept. 1998 (STIS, 4 images, 8 spectra)
Uranus, Aug. 2005 (ACS, 64 images)
Uranus, Aug.-Sept. 2011 (STIS, 4 spectra)
Uranus, Nov. 2011 (ACS/STIS, 73 images, 9 spectra)
Uranus, Sept.-Oct. 2012 (ACS/STIS, 23 images, 3 spectra)
Uranus, Nov. 2014 (STIS, 12 images)

MARS :
Mars,Oct.-Nov. 2007 (ACS, 181 images)

Internal database :
~ 6700 individual HST observations

A (rich) high level database : Hubble and Hisaki

- Database :
  (1) HST Far-UV observations of Jupiter, Saturn, Uranus and their satellites + Mars from 1997 to 2018 ~ 6700 individual observations = **internal database**
  (2) Hisaki/Exceed EUV observations of Jupiter, Saturn, Mars, Venus since 2014 ~ 1300 individual observations = **external database** (queried via EPN-TAP since 2017)



Example of Hisaki/Exceed observations of Jupiter

[Kimura et al., GRL, 2015]

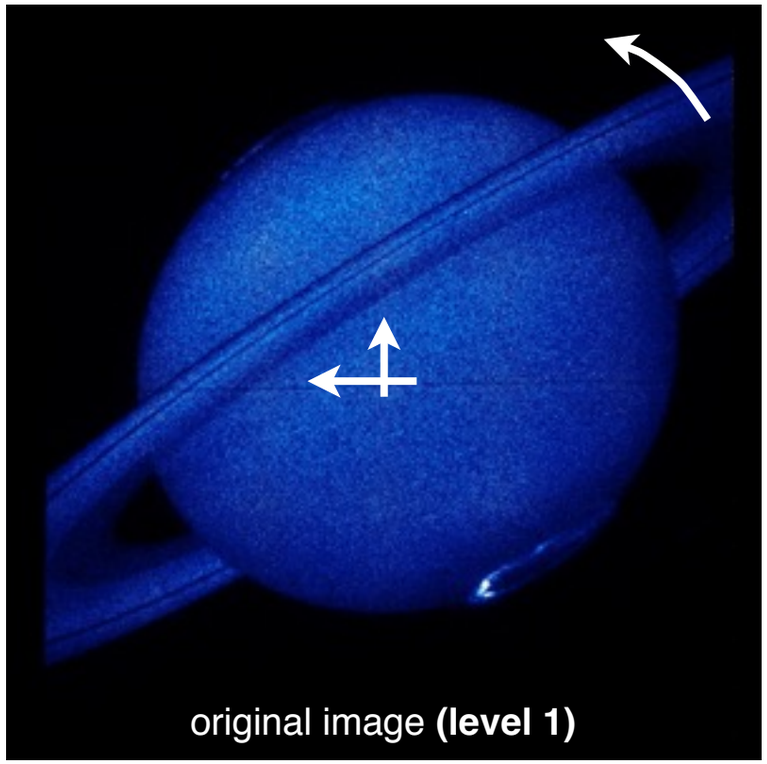
A (rich) high level database

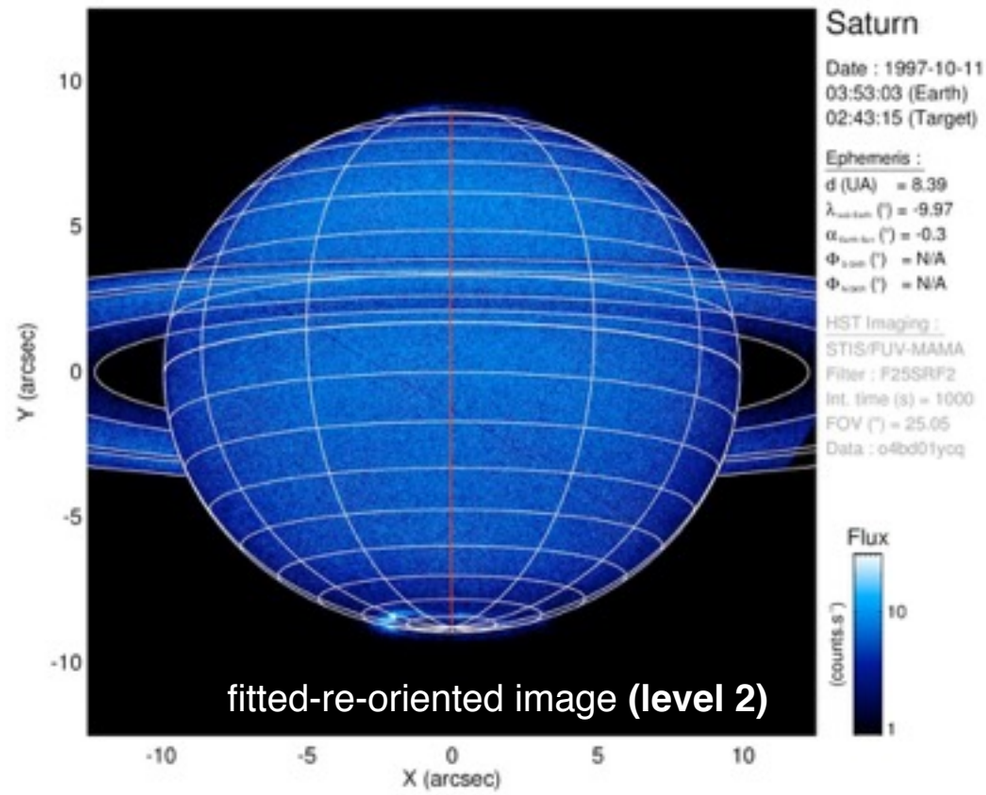
- Database :
    (1) HST Far-UV observations of Jupiter, Saturn, Uranus and their satellites + Mars from 1997 to 2018 ~ 6700 individual observations = **internal database**
    (2) Hisaki/Exceed Extreme-UV observations ~ 1300 individual observations = **external database** (queried through EPN-TAP since late 2017)

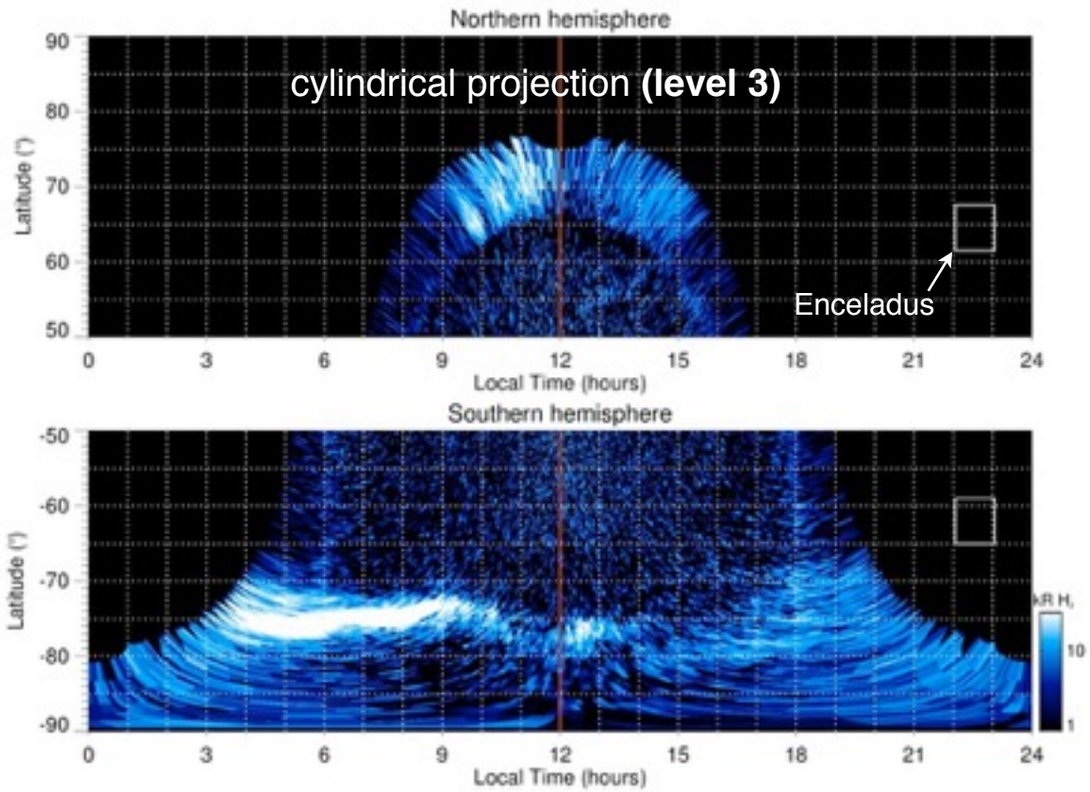
- Data levels :
    * « raw » data (level 1) : archive STSci (pre-calibrated)
    * « processed data » (level 2,3) : fitted/re-oriented images + backgroud-subtracted projections in physical units, recalibrated spectra

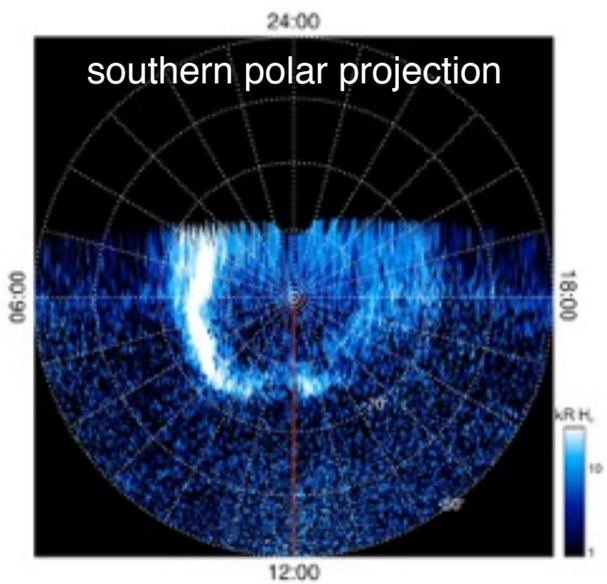
A (rich) high level database : Saturn HST image

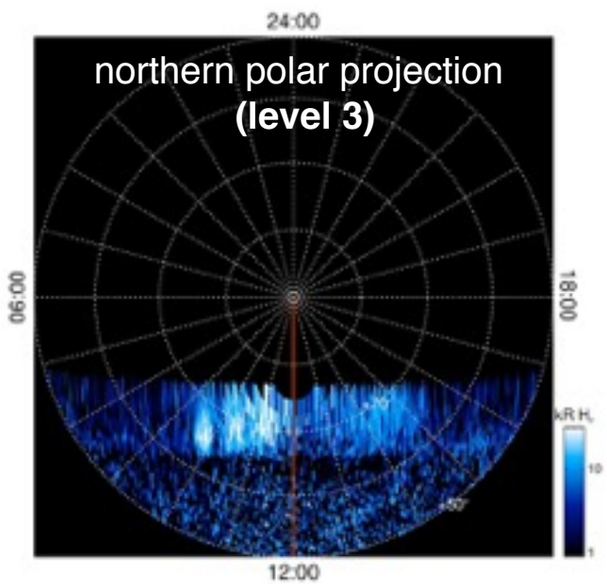
Images





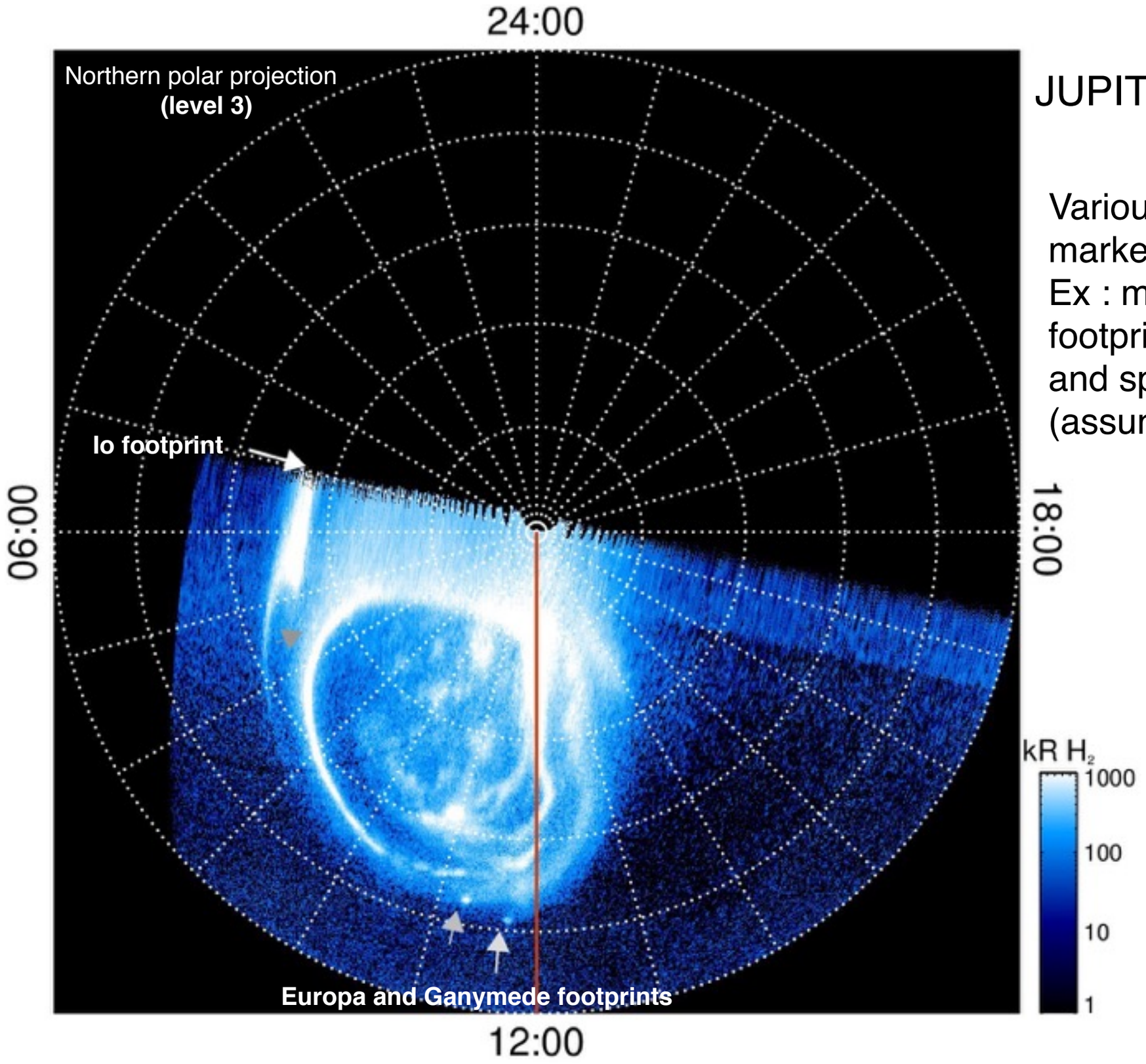






A (rich) high level database : Jupiter HST image

Images

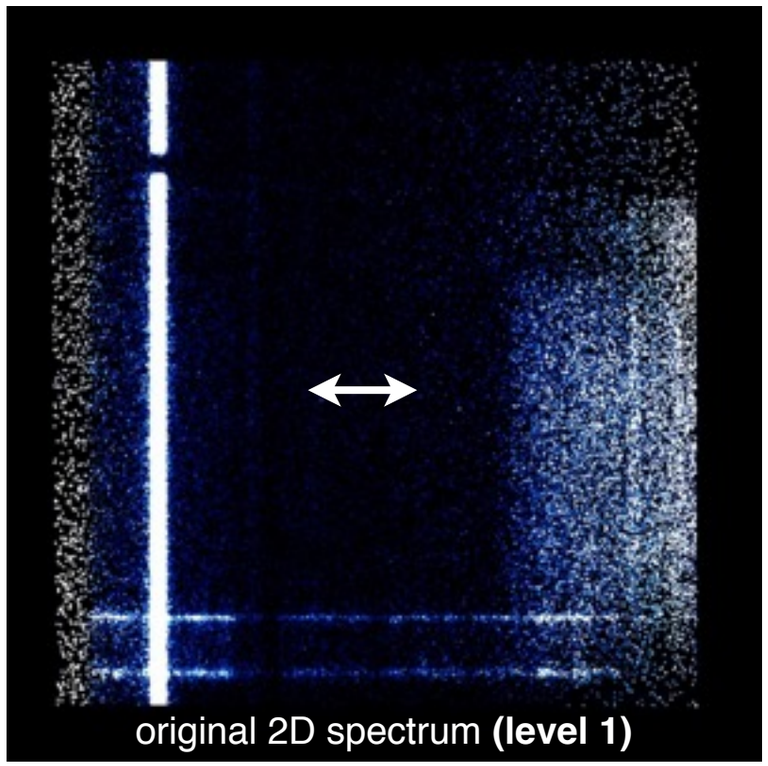


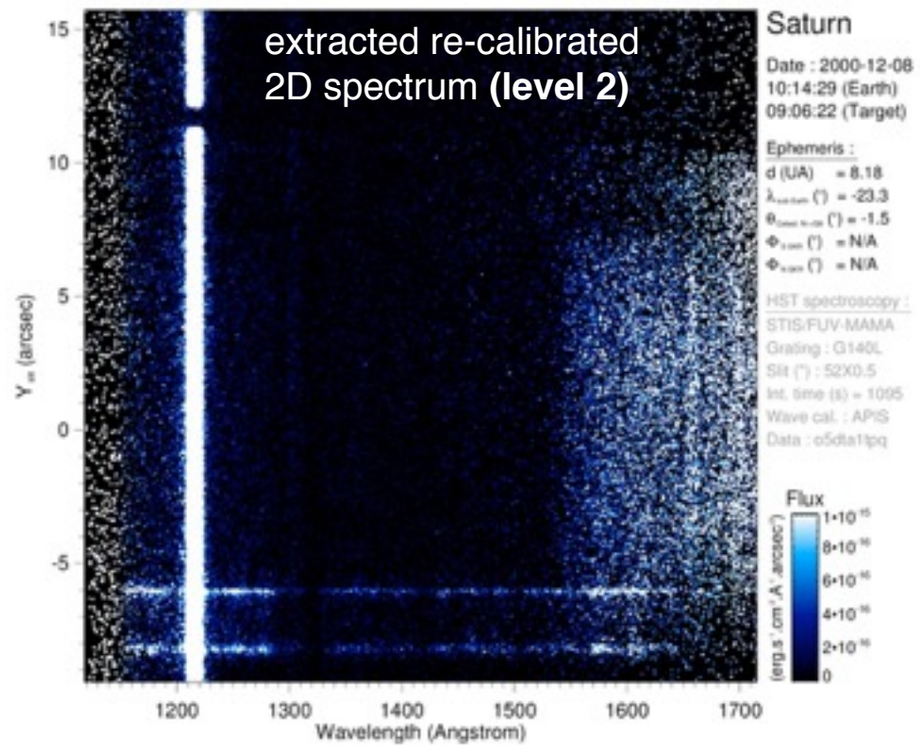
JUPITER

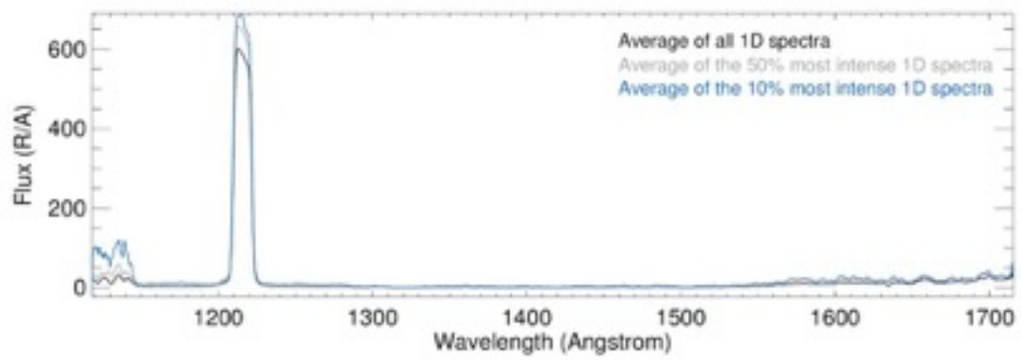
Various value-added markers.
Ex : magnetic footprints of moons and spacecraft (assumes B model)

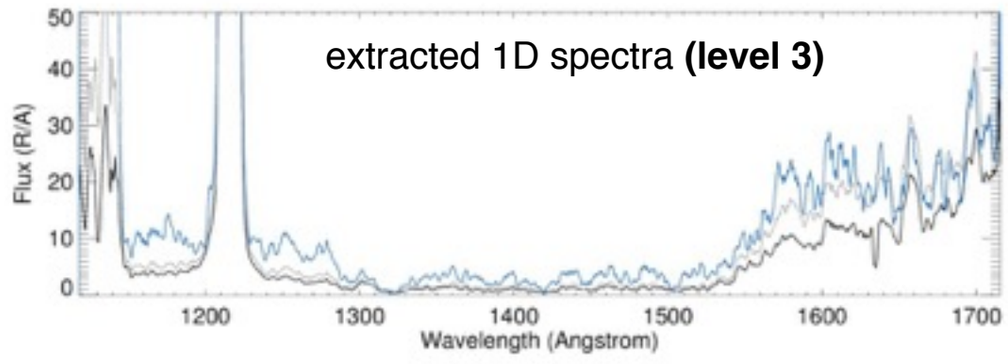
A (rich) high level database : Saturn HST spectrum

Spectres









A (rich) high level database

- Database :
    (1) HST Far-UV observations of Jupiter, Saturn, Uranus and their satellites + Mars from 1997 to 2018 ~ 6700 individual observations = **internal database**
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- Data levels :
    * « raw » data (level 1) : archive STSci (pre-calibrated)
    * « processed data » (level 2,3) : fitted/re-oriented images + backgroud-subtracted projections in physical units, recalibrated spectra

- Data formats :
    * jpg/pdf (quicklooks) for direct use
    * fits for further scientific use (extensions include the processed data + pixel coordinates + value-added ephemeris informations within the header)

- Meta-database : EPN-TAP (Europlanet - Table Access Protocol) standard
    [Erard et al., Astron. & Comp., 2014]

An efficient search interface

Home | What is APIS ? | Data levels | **Search for data** | Data use policy | Resources | Login

Target | Telescope: HST | Instrument | Observation type | Filter or aperture

Date interval: 2000-12-07 11:30:03 — 2000-12-08 13:19:19
(YYYY-MM-DD or YYYY-MM-DD HH:MM:SS)

Observing campaign: Saturn - 2000 07-08 Dec

Dataset name

Advanced research +

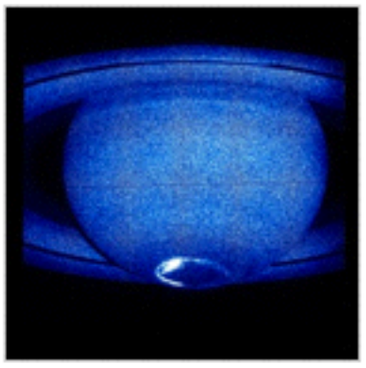
Search | Reset | Clear | Clear date | All results

8 results.

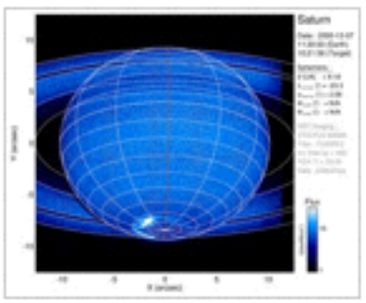
Observation summary	Original data	Derived products		
		Processed data	*Cylindrical projection*	*Southern polar projection*

Target : Saturn
Start date : 2000-12-07
Start time : 11:30:03
Int. time : 480.01975 s
Instrument : HST / STIS
Obs. type: IMAGING
Filter : F25SRF2
Dataset : o5dta2nyq

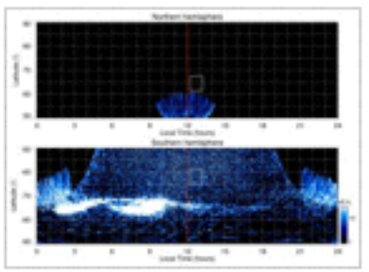
Detailed information



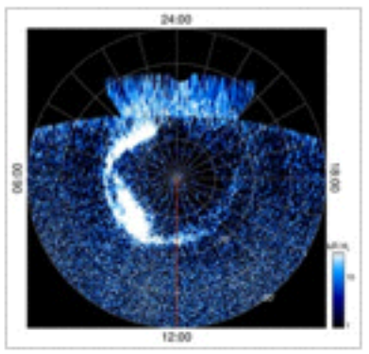
FITS | JPG
Display with : Aladin



FITS | PDF | JPG
Display with : Aladin



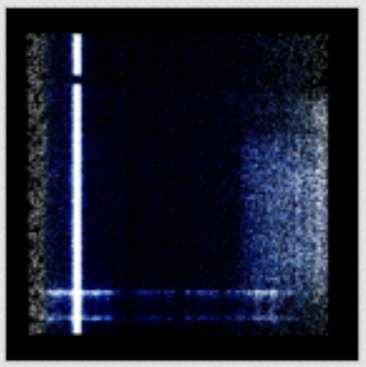
PDF | JPG



PDF | JPG

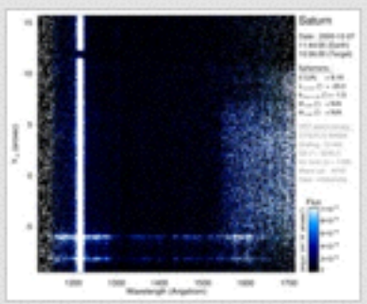
Target : Saturn
Start date : 2000-12-07
Start time : 11:44:05
Int. time : 1095.1937 s
Instrument : HST / STIS
Obs. type: SPECTROSCOPIC
Grating / slit : G140L / 52X0.5
Dataset : o5dta2o0q

Detailed information



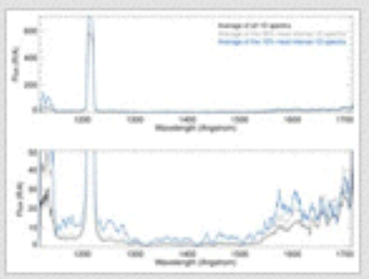
FITS | JPG
Display with : Aladin / SpecView

Processed data



FITS | PDF | JPG
Display with : Aladin

1D spectrum



FITS | PDF | JPG
Display with : SpecView

An efficient search interface

Home | What is APIS ? | Available data | **Search for data** | Data use policy | Resources | Login

Target | Telescope: HISAKI | Instrument | Observation type | Filter or aperture

Date interval: 2018-01-01 00:00:42 — 2018-02-01 00:00:00
(YYYY-MM-DD or YYYY-MM-DD HH:MM:SS)

Observing campaign: Jupiter long-term 2018

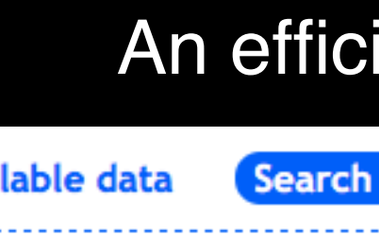
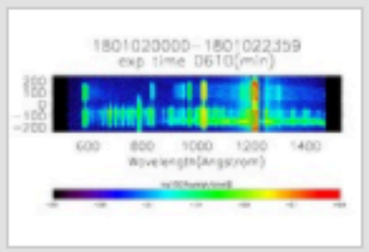
Dataset name

Advanced research +

Search | Reset | Clear | Clear date

100 items per page

32 results.

Observation summary	Original data	Derived products	
		Processed data	*1D spectrum*
Target : Jupiter Start date : 2018-01-01 Start time : 00:00:42 Int. time : 60 s Instrument : HISAKI / EXCEED Obs. type : SPECTROIMAGING Grating / slit : DUMBBELL Dataset : exeuv.jupiter.mod.20.20180101.lv.02.vr.00 **Detailed information**	 **FITS** | **JPG**	No data	No data
Target : Jupiter Start date : 2018-01-02 Start time : 00:00:00 Int. time : 60 s Instrument : HISAKI / EXCEED Obs. type : SPECTROIMAGING Grating / slit : DUMBBELL Dataset : exeuv.jupiter.mod.20.20180102.lv.02.vr.00 **Detailed information**	 **FITS** | **JPG**	No data	No data

An efficient search interface

Home | What is APIS ? | Available data | **Search for data** | Data use policy | Resources | Login

Target: Jupiter | Telescope | Instrument | Observation type | Filter or aperture

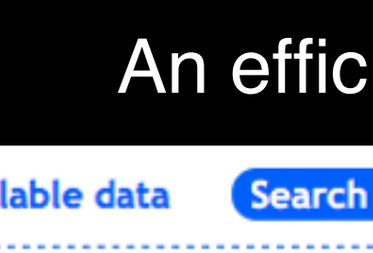
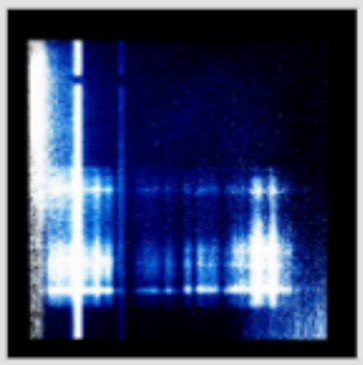
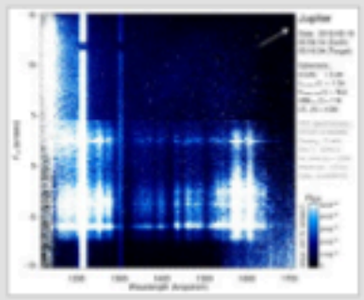
Date interval: 2016-05-19 00:42:50 — 2016-05-31 17:40:05
(YYYY-MM-DD or YYYY-MM-DD HH:MM:SS)

Observing campaign | Dataset name

Advanced research +

Search | Reset | Clear | Clear date | 100 items per page

29 results.

Observation summary	Original data	Derived products	
		Processed data	*1D spectrum*
Target : Jupiter Start date : 2016-05-19 Start time : 00:42:50 Int. time : 60 s Instrument : HISAKI / EXCEED Obs. type : SPECTROIMAGING Grating / slit :DUMBBELL Dataset : exeuv.jupiter.mod.03.20160519.lv.02.vr.00 Detailed information	 FITS | JPG	No data	No data
Target : Jupiter Start date : 2016-05-19 Start time : 00:59:14 Int. time : 2509.1924 s Instrument : HST / STIS Obs. type : SPECTROSCOPIC Grating / slit :G140L / 52X0.5 Dataset : ocx806010 Detailed information	 FITS | JPG Display with : Aladin / SpecView	*Processed data*  PDF | JPG Display with : Aladin	*1D spectrum* No data

Cross-query of both databases

An efficient search interface

Home | What is APIS ? | Data levels | **Search for data** | Data use policy | Resources | Login

Target | Telescope: HST | Instrument | Observation type | Filter or aperture

Date interval: 2000-12-07 11:30:03 — 2000-12-08 13:19:19 *(YYYY-MM-DD or YYYY-MM-DD HH:MM:SS)*

Observing campaign: Saturn – 2000 07-08 Dec

Dataset name

Advanced research

Data levels: All products

Integration time: from 480 to 1351 *(in seconds)*

Main hemisphere: Any

Subsolar latitude: from to *(in degrees)*

Solar phase angle: from to *(in degrees)*

Longitude system

Central meridian longitude or phase: from to *(in degrees)*

Moon longitude system

Moon longitude or local time: from to *(in degrees or hours)*

Spacecraft

S/C-Planet distance: from to *(in planetary radii)*

sub-S/C latitude: from to *(in degrees)*

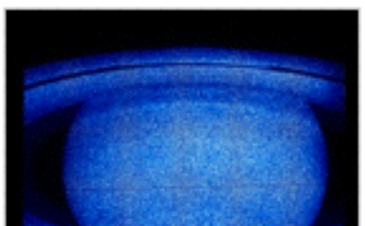
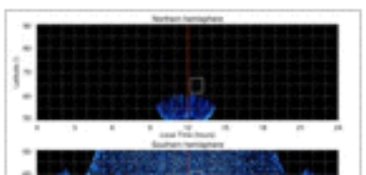
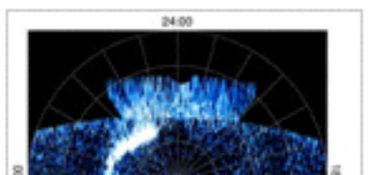
sub-S/C local time: from to *(in degrees)*

Search criteria aimed at fulfilling the needs of the magnetosphere/ heliosphere community

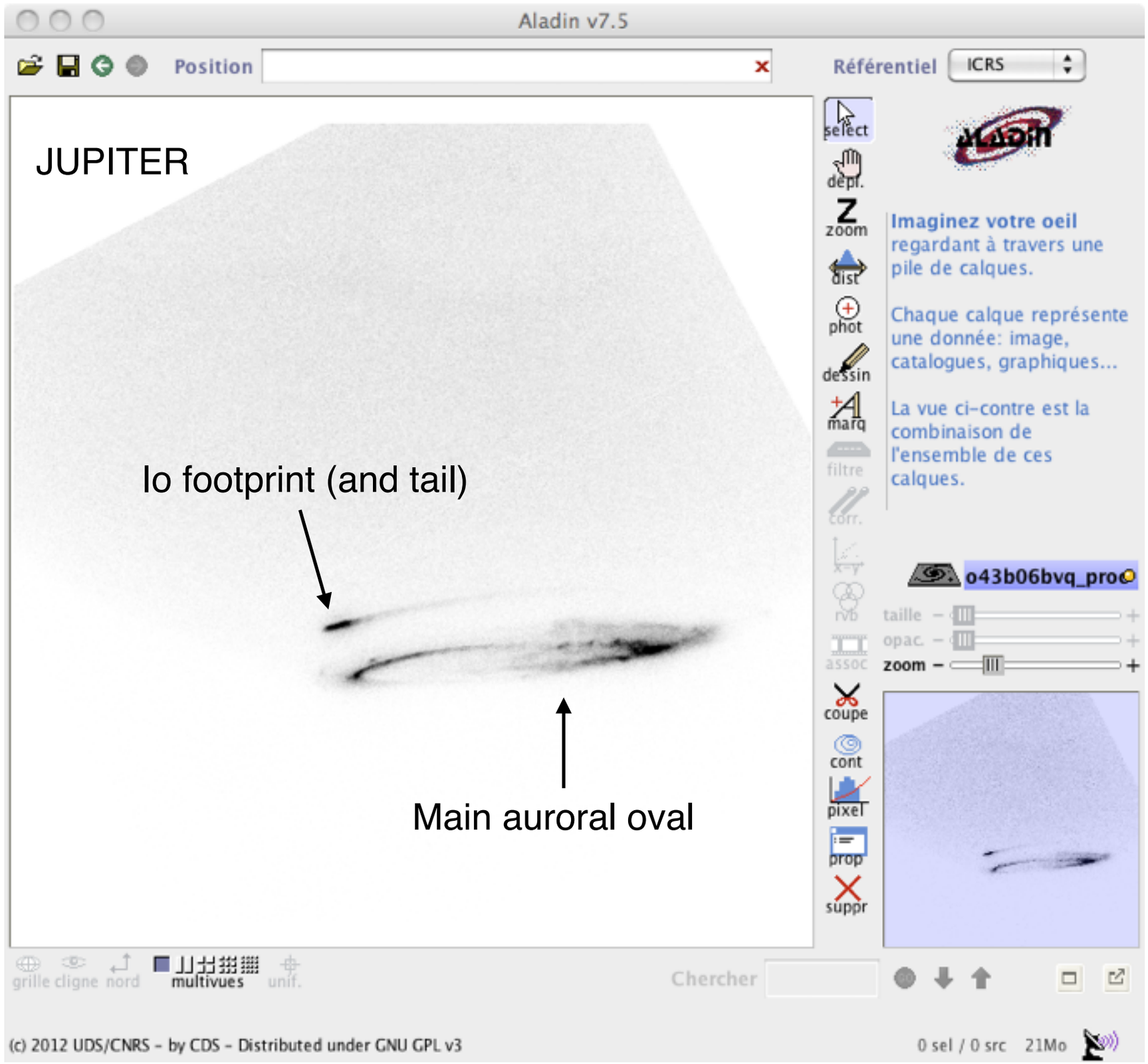
Search | Reset | Clear | Clear date

All results

8 results.

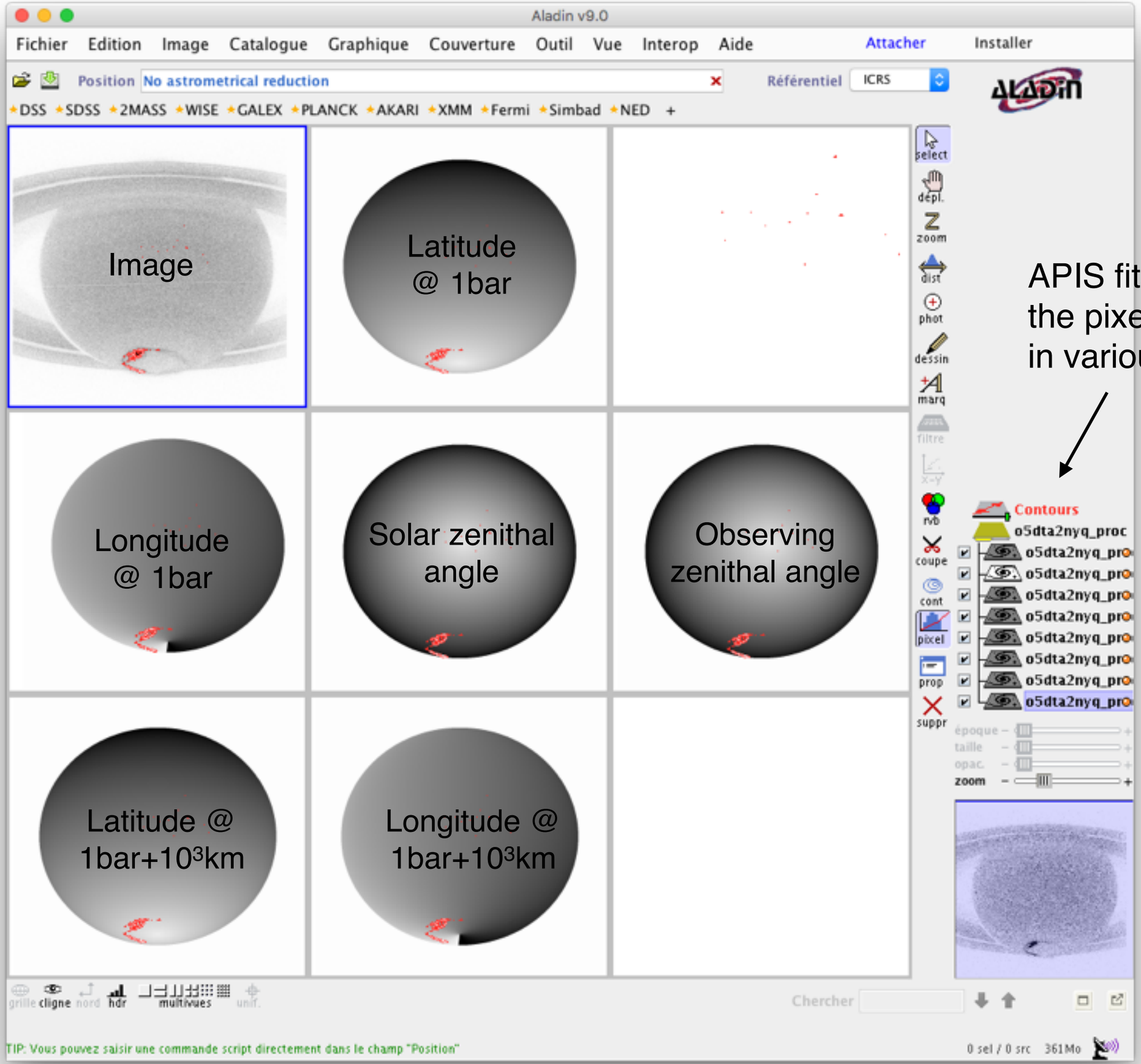
Observation summary	Original data	Derived products		
		Processed data	*Cylindrical projection*	*Southern polar projection*
Target : Saturn Start date : 2000-12-07 Start time : 11:30:03 Int. time : 480.01975 s Instrument : HST / STIS				

Interactive use through VO-tools



Aladin (CDS) via SAMP (Simple Application Messaging Protocol)

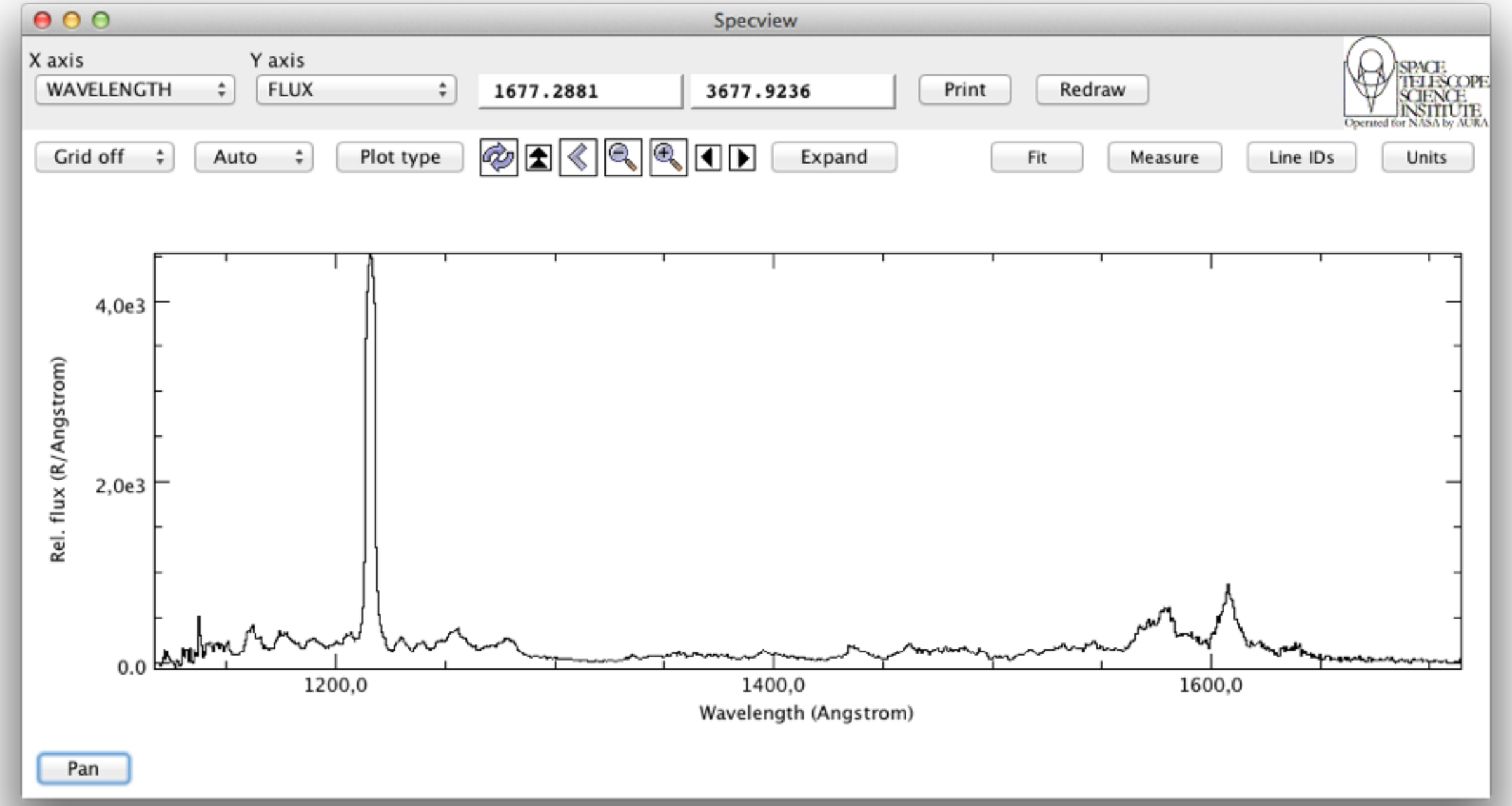
Interactive use through VO-tools



APIS fits files contain the pixel coordinates in various frames

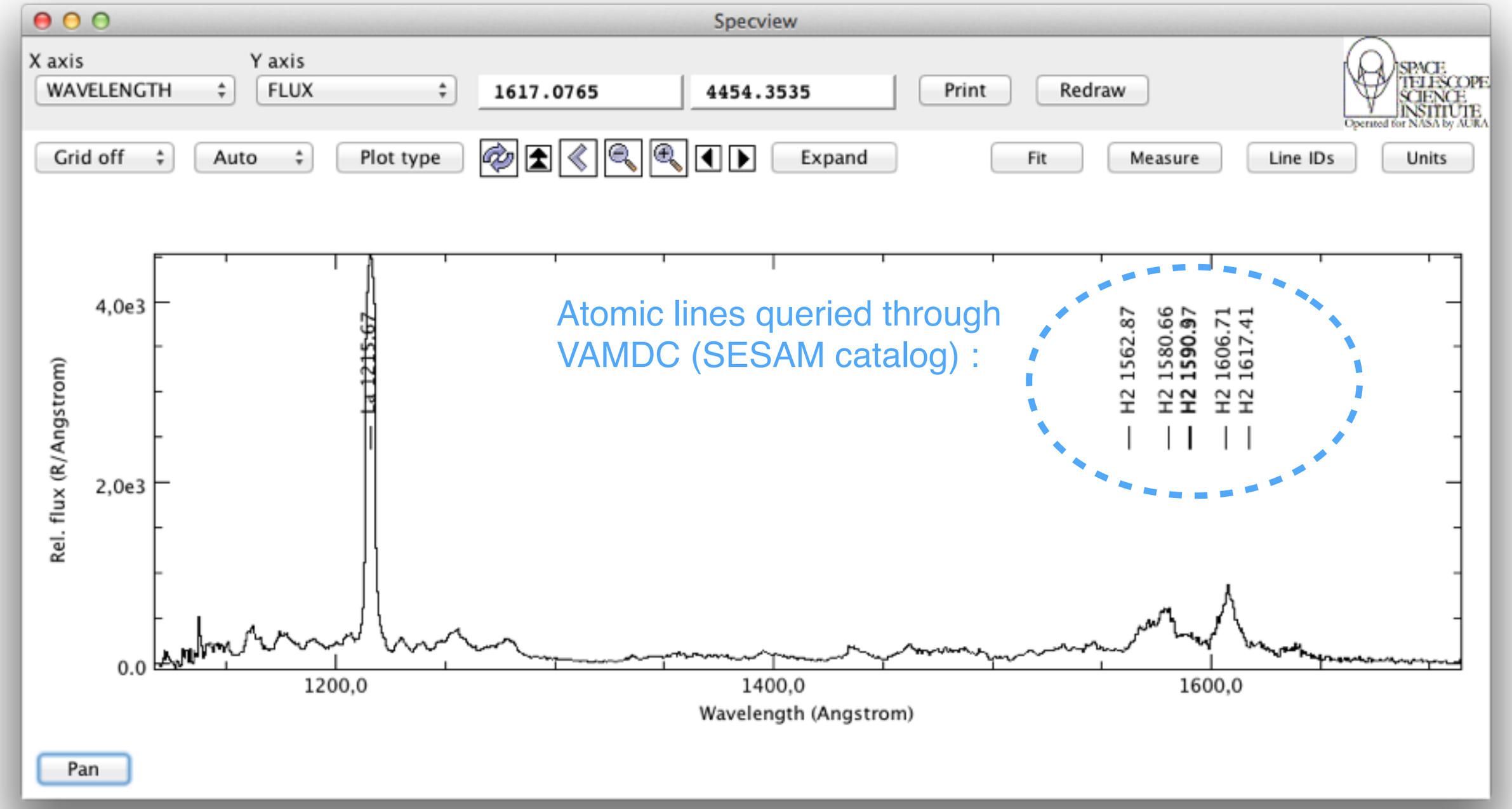
Interactive use through VO-tools

Specview (STSci) via SAMP



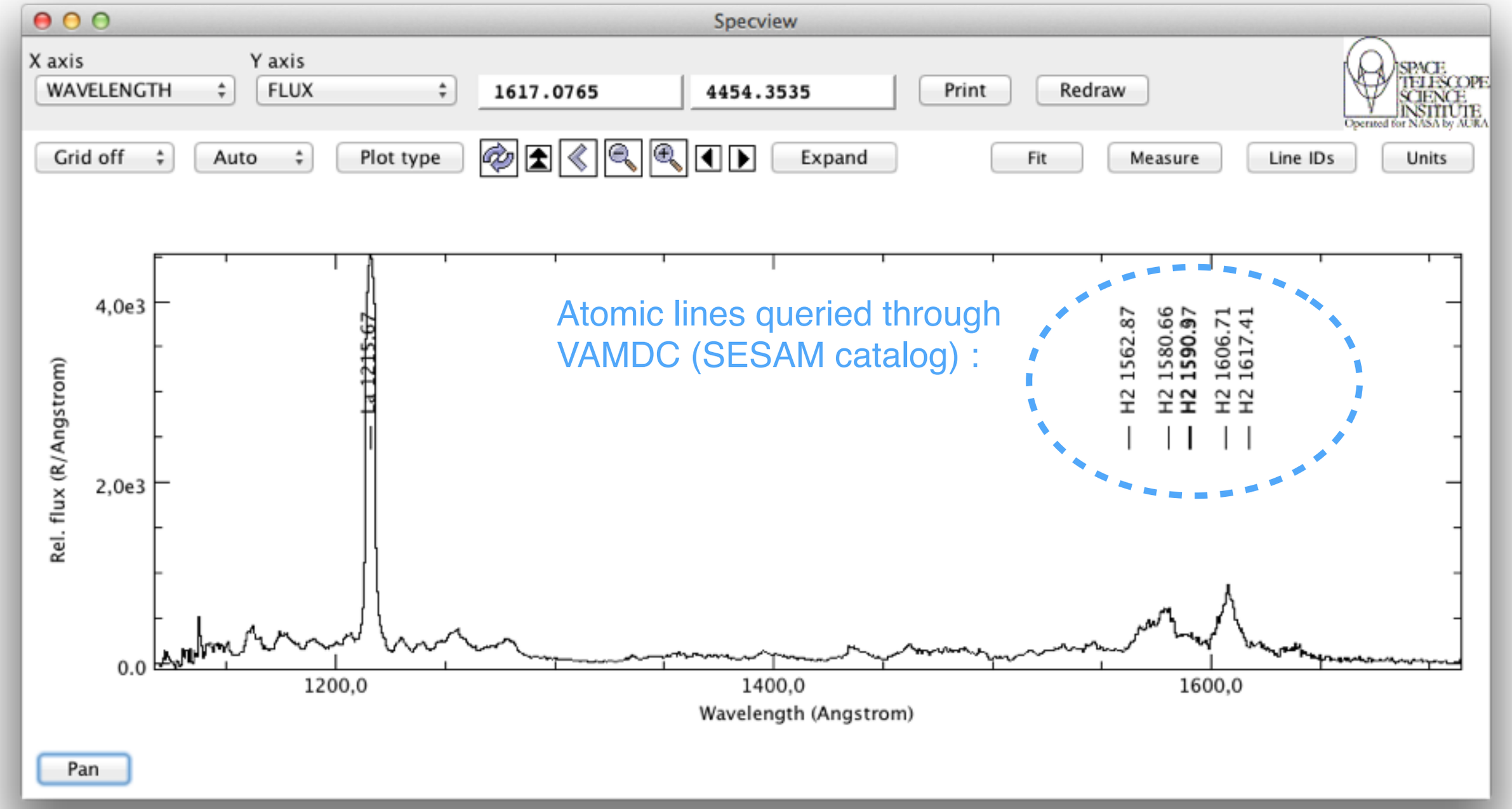
Interactive use through VO-tools

Specview (STSci) via SAMP



Interactive use through VO-tools

Specview (STSci) via SAMP

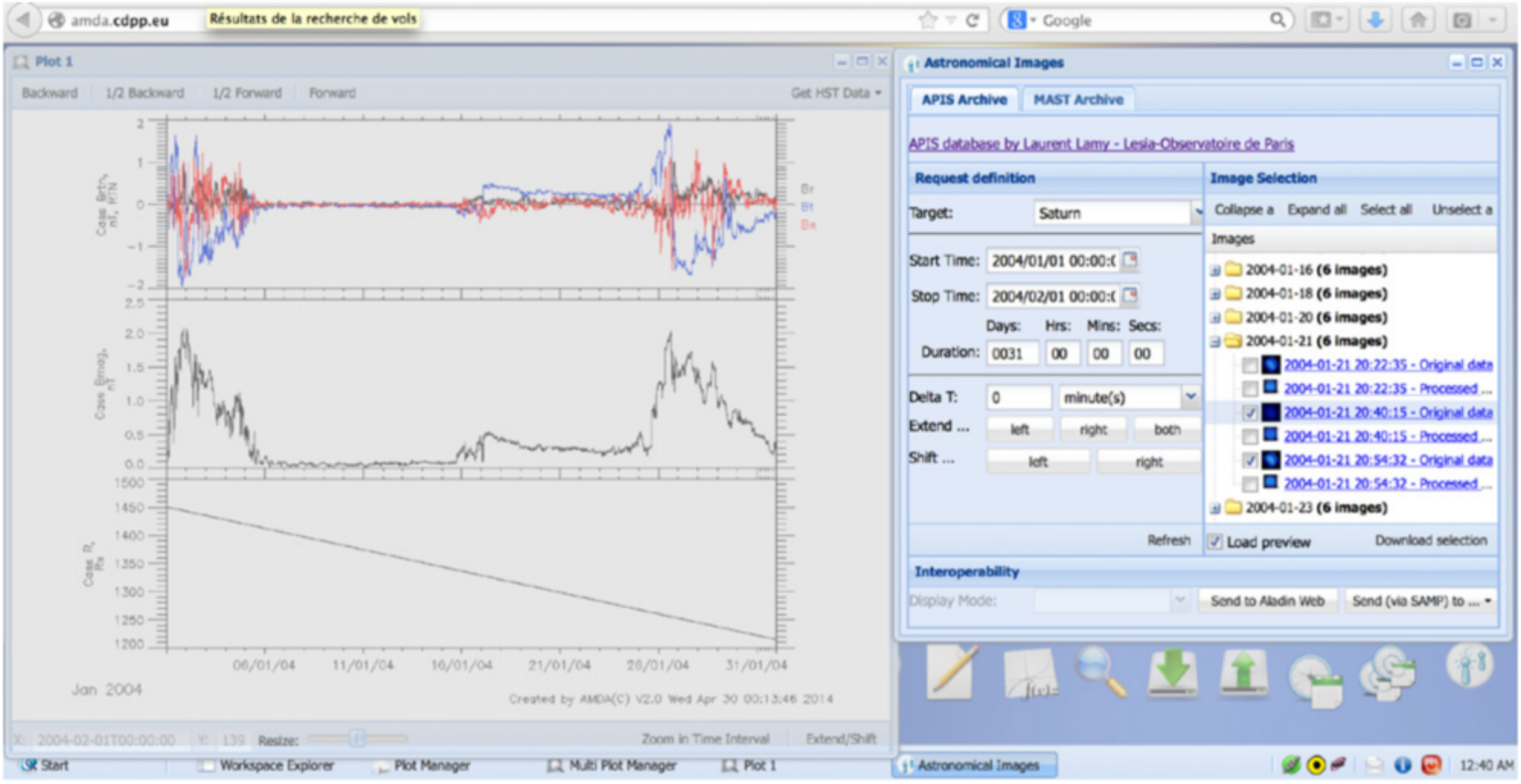


- Ongoing : similar interconnexion of APIS spectra with the Cassis reading tool

VO interoperability with distant portals : VESPA

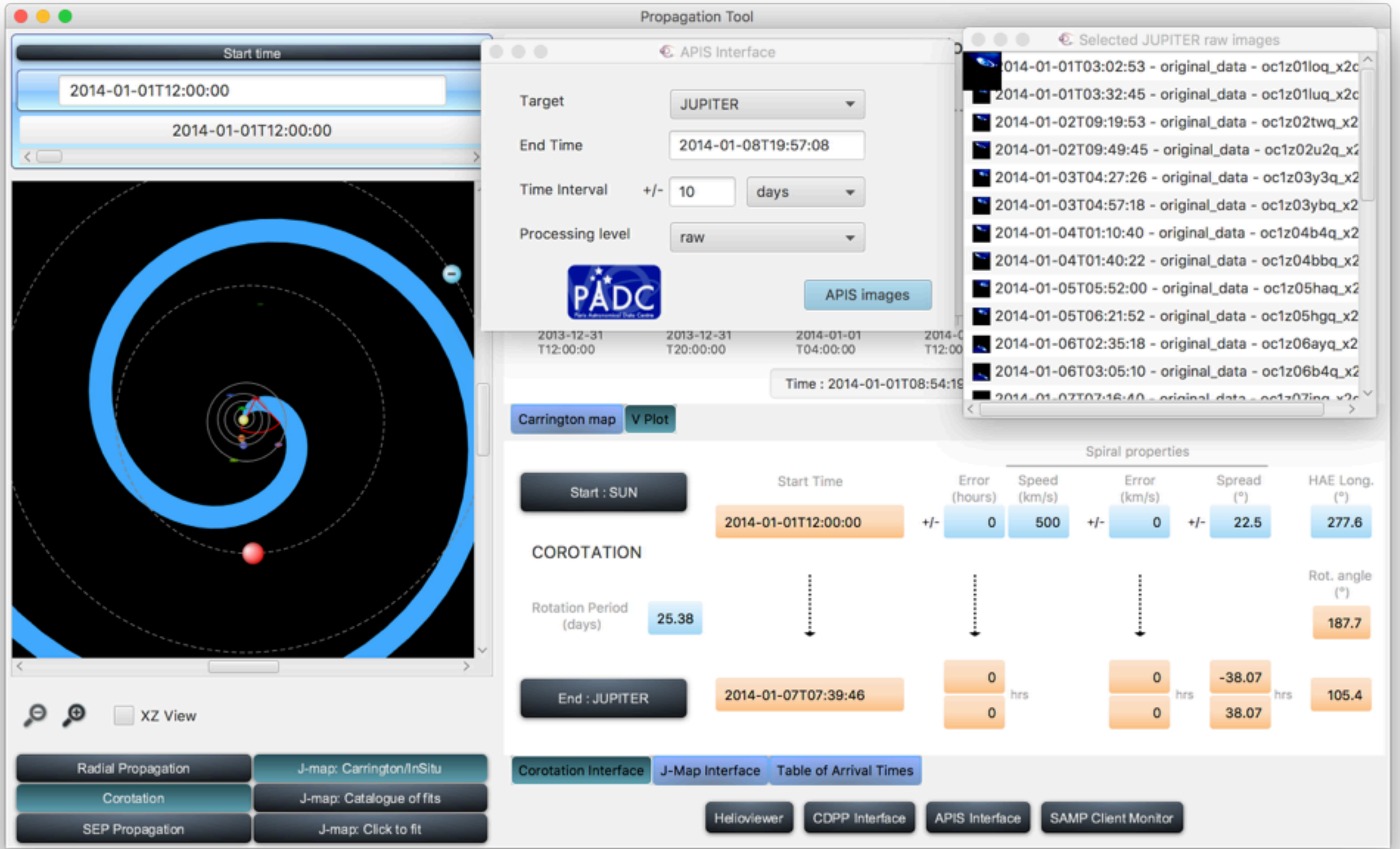
[Erard et al., Astron. & Comp., 2014b]

VO interoperability with distant portals : CDPP/AMDA

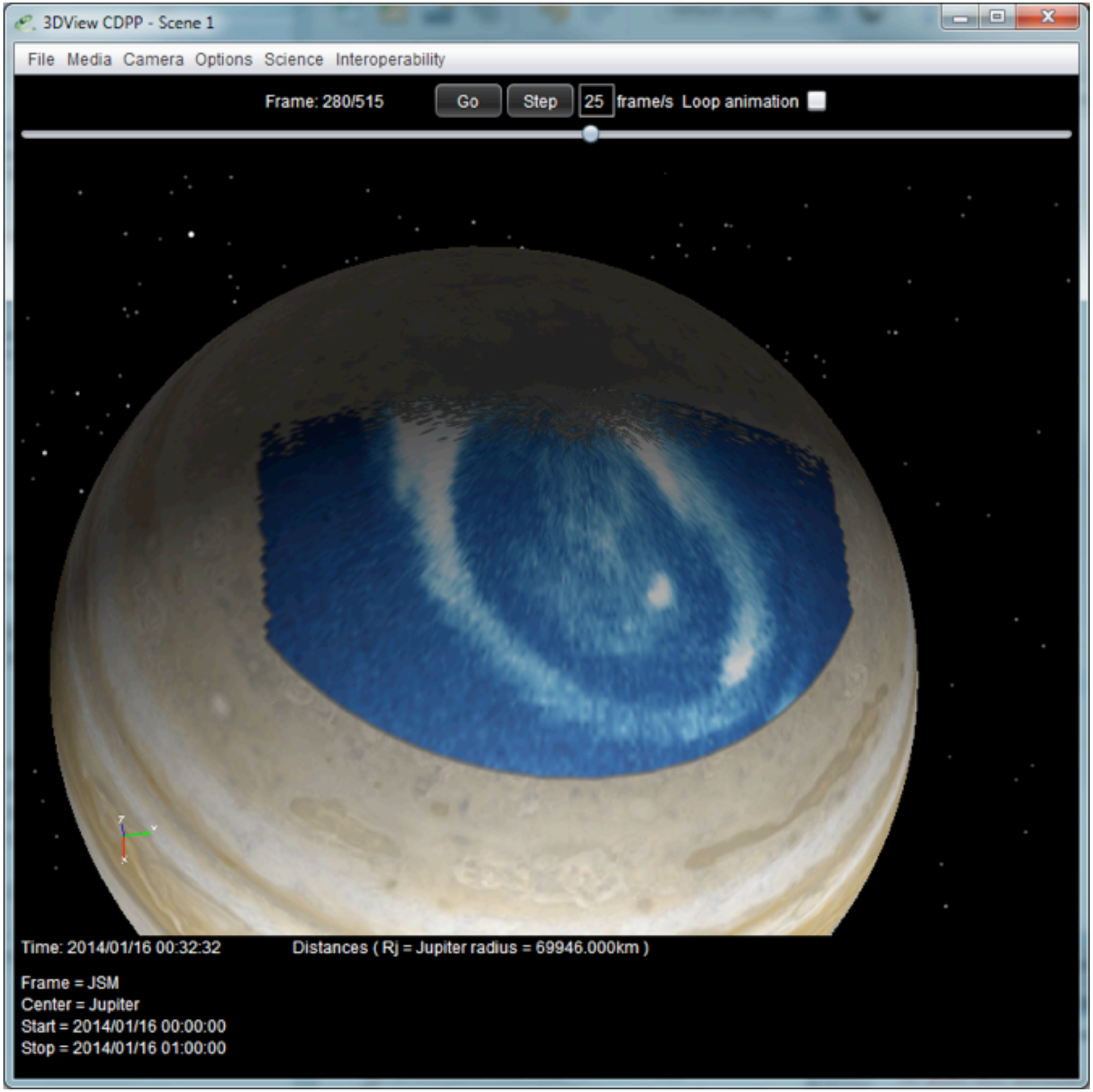


[Génot et al., Astron. & Comp., 2014]

VO interoperability with distant portals : CDPP/PropTool

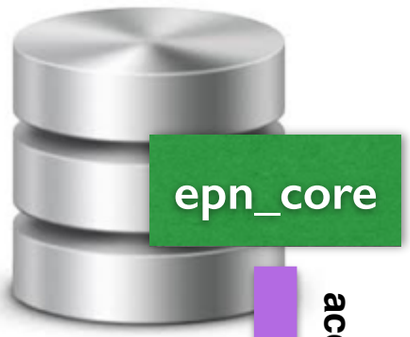


VO interoperability with distant portals : CDPP/3DView



Framework behind APIS

Hisaki database in Japan



access

Hisaki TAP server interface

VOTable

ADQL

TAP client

Adding extra ephemeris metadata

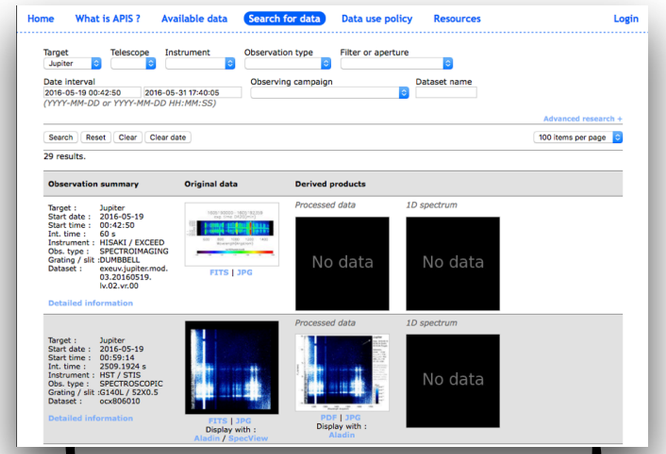
ingest

APIS Internal database

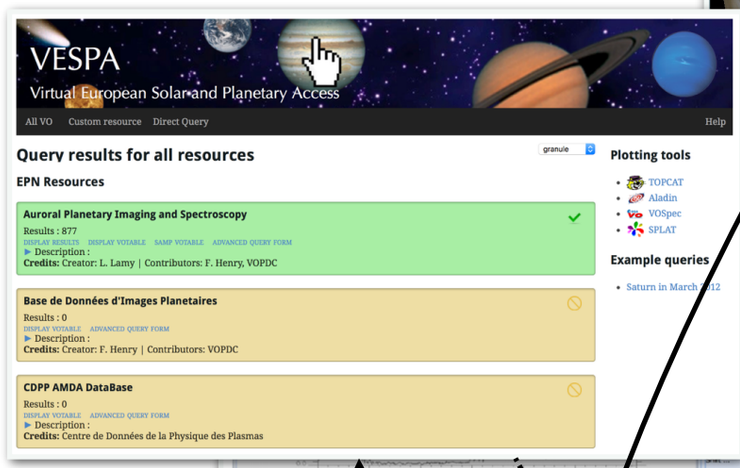
access

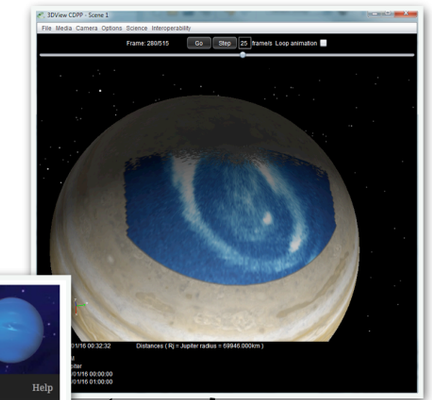
access

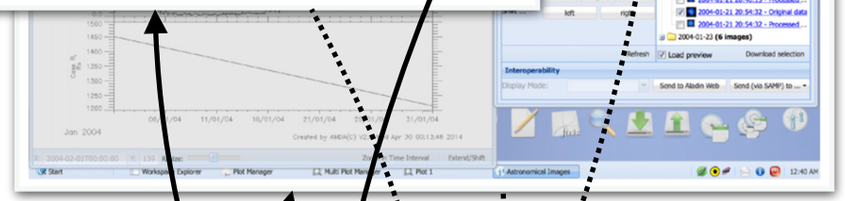
APIS Web Query Interface



External tools







TAP server interface

Summary

*** APIS today :**

- Service fully operational since 2013
- Relies on : internal HST database + search interface + VO-compliance
  => labelled as a « national observation service » by CNRS in 2015
  => demonstrator for the EPN-TAP protocol within PADC
  => uses or interfaced with many VO-tools (ephemeris, protocols, plotting tools …)
  => acknowledged as a high level database by STSci
- Since 2017 : interconnects external databases with the APIS search interface
  => successful query of Hisaky/Exceed level 1 data (T. Kimura et al.)

*** APIS tomorrow ?**

- Continuous development : ingestion of regular HST observations, VO-compatibility
- Complementing the internal database :
  => with Cassini/UVIS observations of Jupiter/Saturn : Post-doc starting in Sept.
  => with VLT and Gemini IR observations of Uranus : Master 2 internship in progress
- Querying additional external databases :
  => IRTF observations of Jupiter (G. Orton et al.) : in progress
  => Chandra/XMM-Newton X-rays observations of the giant planets (A. Branduardi, W. Dunn et al.)