



Connecting the CDPP/AMDA service and IVOA tools

A Science Case: Auroral Campaign Observations of Jupiter and Saturn

E. Pallier¹, N. André¹, C. Jacquy¹, L. Lamy², B. Cecconi², E. Budnik³, R. Hitier⁴, V. Génot¹, M. Gangloff¹, F. Topf⁵, H. Rucker⁵, M. Khodachenko⁵, W. Baumjohann⁵, F. Dériot⁶, D. Heulet⁶

¹CDPP, CNRS/Université Paul Sabatier, 9, avenue du colonel Roche, 31028 Toulouse, France (nicolas.andre@cesr.fr)

²LESIA, Observatoire Paris Meudon, Meudon, France

³NOVELTIS, 2 Avenue Europe, 31520 Ramonville Saint Agne, France

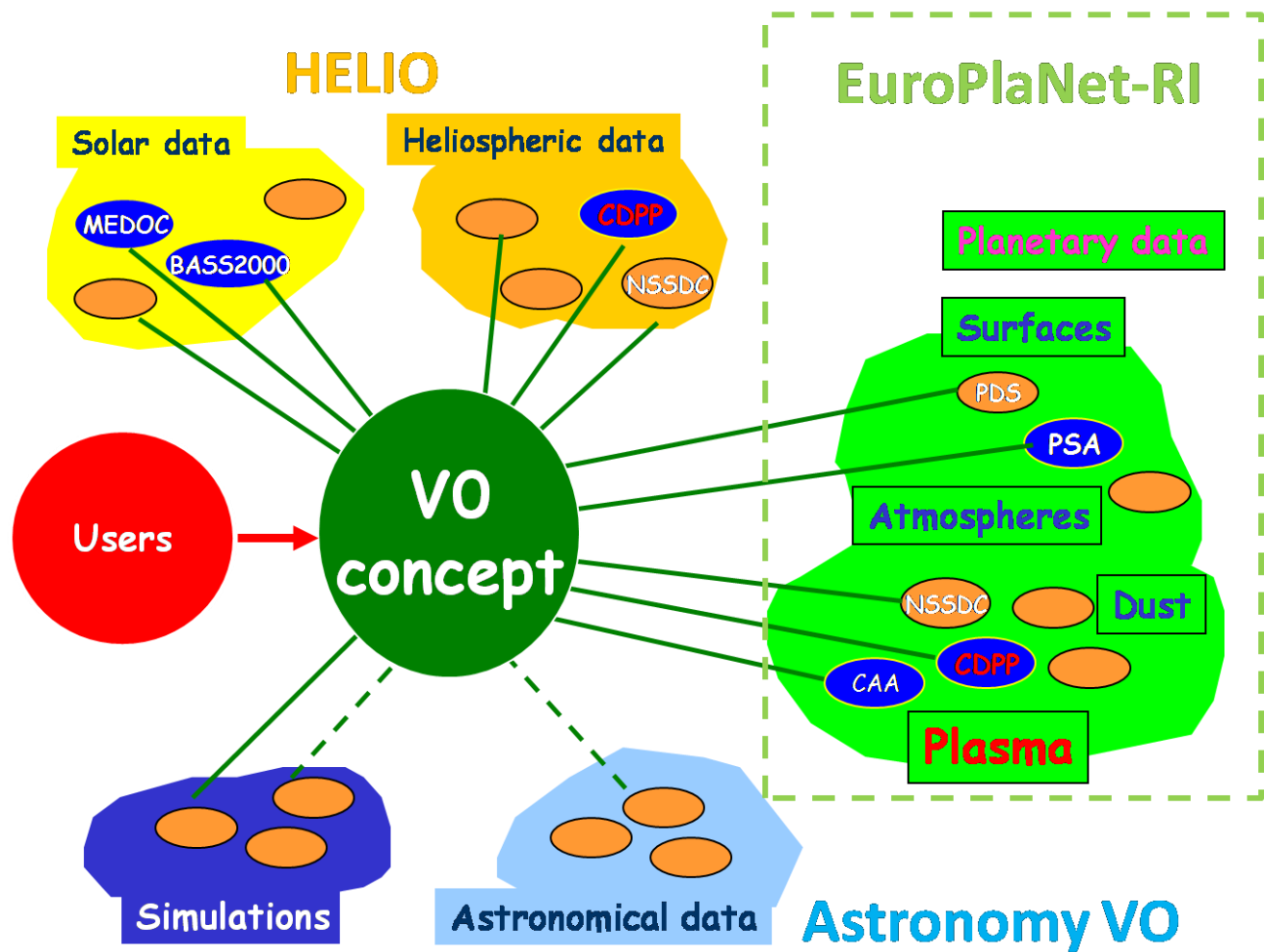
⁴Co-Libri, Cremefer 11290 Montréal, France

⁴Space Research Institute, Austrian Academy of Sciences, OAW, Graz, Austria

⁶CNES, Centre spatial de Toulouse, 18 avenue Edouard Belin, 31401 Toulouse, France



Towards a prototype of Virtual Observatory in Planetology?





Europlanet-RI IDIS (Integrated & Distributed Information System)

5 **thematic nodes** and 1 technical node

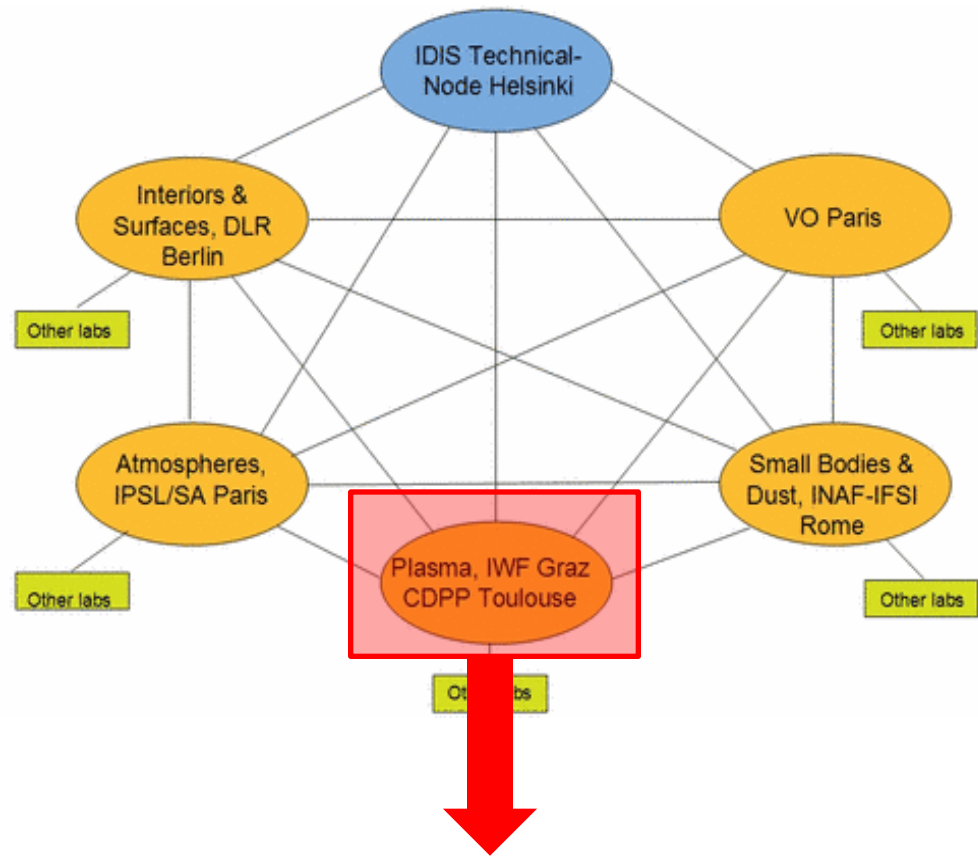
Its objective:

Develop Virtual Observatory tools

In order to access data from

- laboratory measurements
- ground+space-based observations**
- modeling results

allowing comparative and pluri-disciplinary studies of planetary objects and environments



Plasma Node

<http://europlanet-plasmanode.oeaw.ac.at/>



Science Case 3.1

Solar wind interaction with Jupiter and Saturn aurorae

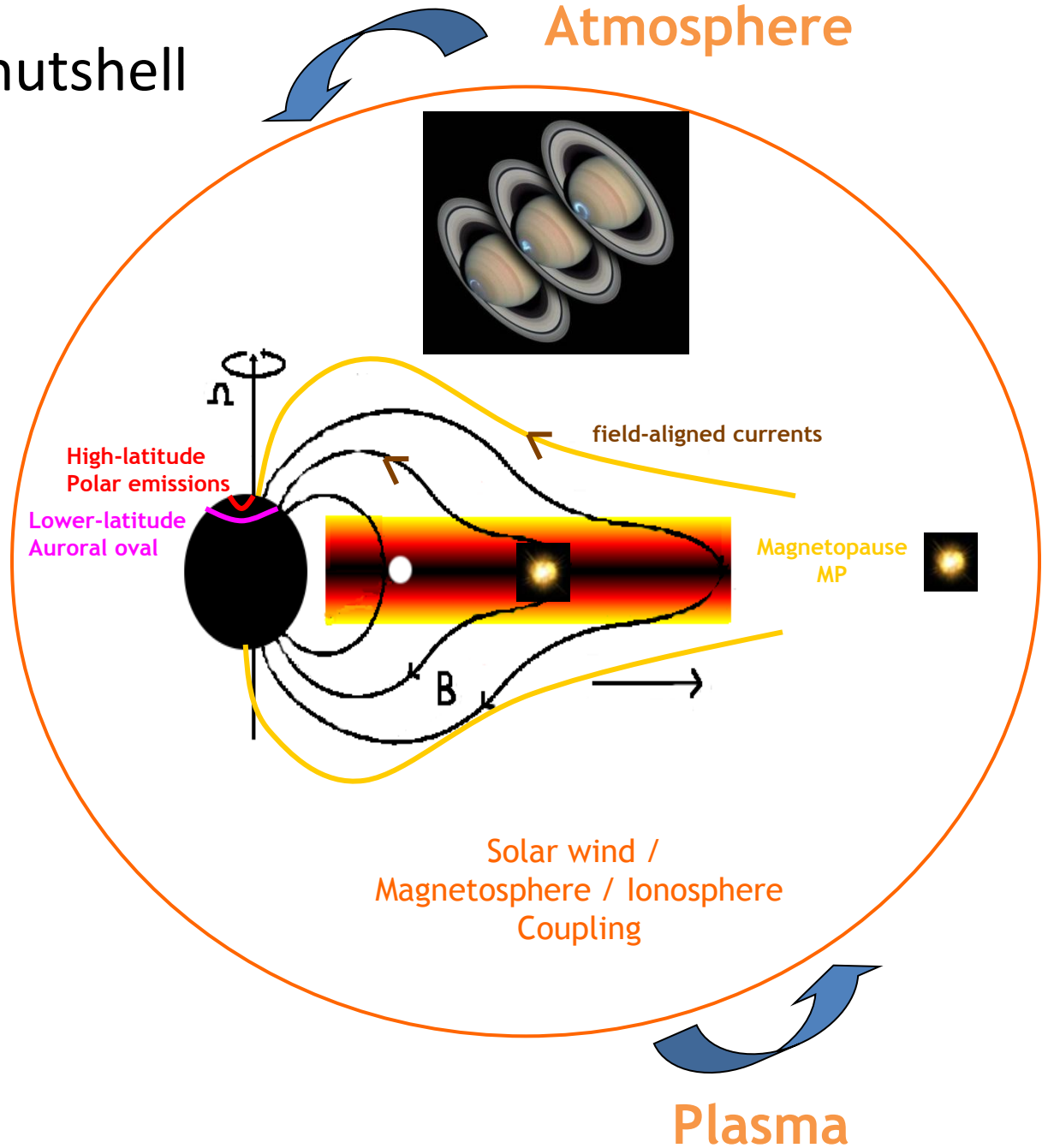
The Physical Problem in a nutshell

Auroral emissions (**observed remotely**) occur in the atmospheres of giant planets

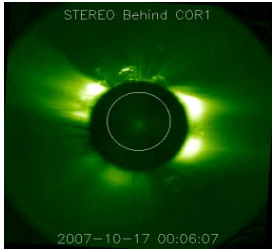
Their origin is the precipitation of electrons or ions (**observed in-situ**) along planetary magnetic field lines

Therefore, energetic processes observed in-situ in the ionized space environment of giant planets will have atmospheric counterparts owing to this coupling

Auroral emissions will diagnose the dynamics of their magnetosphere

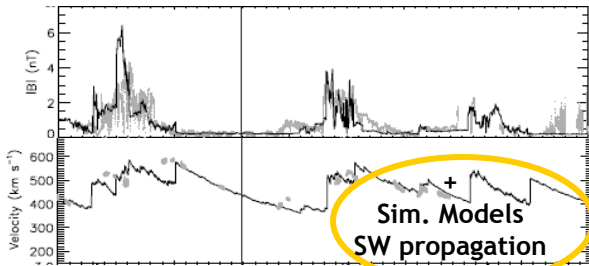


Plasma (multi-points)



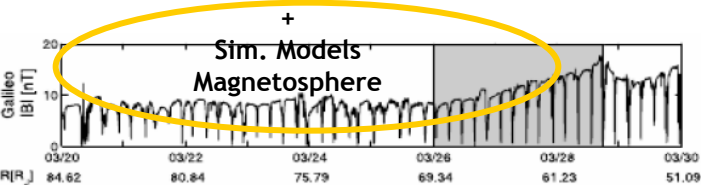
Solar data
SOHO LASCO
movies

Heliospheric data



ULYSSES MAG/SWOOPS
Ascii, cdf, binary files ...

Cassini MAG/CAPS/MIMI, Galileo MAG/PLS/EPD

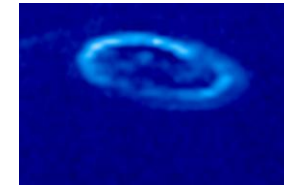


Planetoplasma data

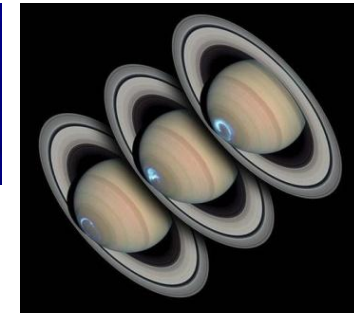
The overall analysis
requires:

Access to heterogeneous data
(format, origin, databases)

Use of specialized tools
developed by
different communities

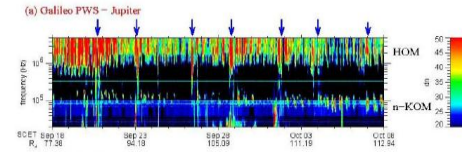


Cassini UVIS
Galileo UVS
Binary

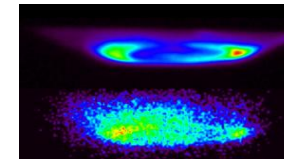


HST (STIS), IUE
Fits, ..

Atmosphere (multi-λ)



IRTF



Cassini RPWS
Galileo PWS

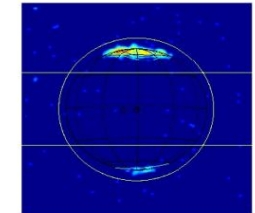
XMM EPIC
Chandra ACIS

XMM-Newton
0.2 – 2.0 keV

+
Ref. Models
Spectroscopy



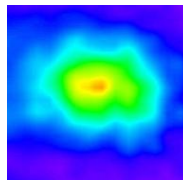
Chandra Jupiter X-Rays - 2007-Feb-24 21:23:16
t_{exp} = 16.66ks



Brightness
(B)

CML ~ 60° - 290°

Cassini INCA





In-situ Plasma Data The CDPP/AMDA Service



AMDA (Automated Multi-Dataset Analysis) Functionalities

Web-based facility for online analysis of space physics data

<http://cdpp-amda.cesr.fr>

Evolving in the VO paradigm

Automated access to data

⇒ the user plays with **parameters**, not with data files

Produces and exploits **time-tables**

Its **7 functionalities** allow to use and couple these two objects

1. Visualization editor

2. Download data

3. Parameter editor

4. External data

5. Visual search

6. Conditional search

7. Time-Table manager



Illustration :

Substorm activity at Saturn

Solar wind data observed at Earth and propagated at Saturn

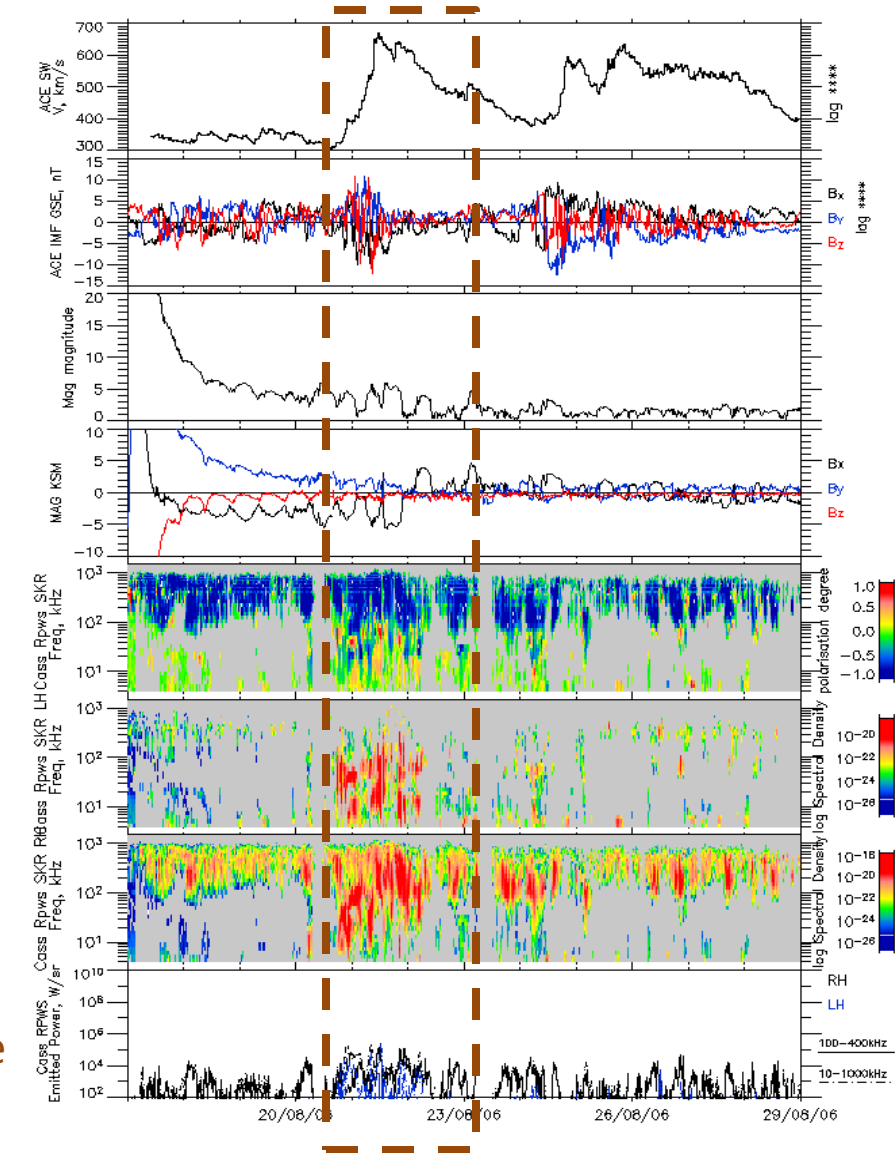
Cassini Magnetometer data

MAPSKP data in AMDA (remote access to CESR)

Cassini SKR radio data in AMDA (remote access to LESIA)

Cassini radio emissions

In-situ observations show the arrival at Saturn of a solar wind disturbance (top) that triggers a magnetic reconfiguration (middle) of the magnetosphere and drives more intense radio auroral emissions (bottom)

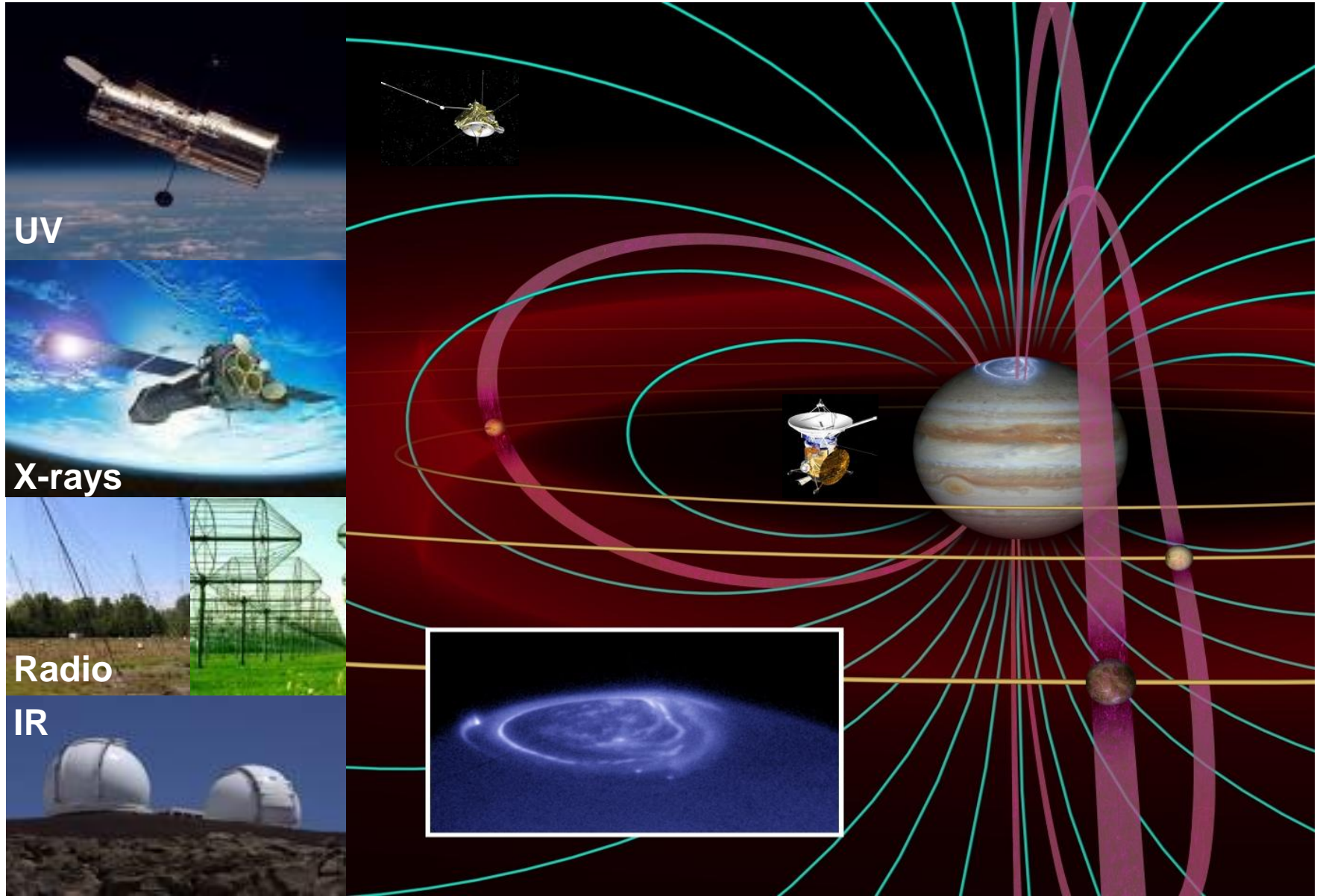


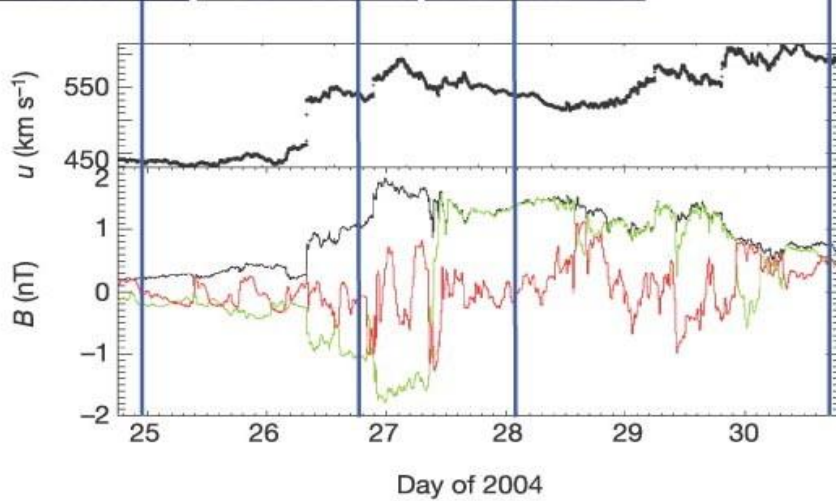
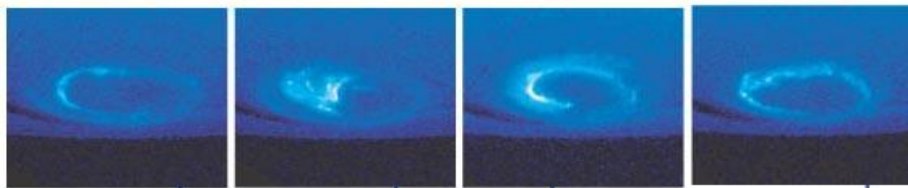


Multi-wavelength observations of giant planet auroral emissions

IVOA Tools

Access to spatial, temporal, and multi-spectral information





Temporal
(Aladin?)

- Data visualization
- Time series

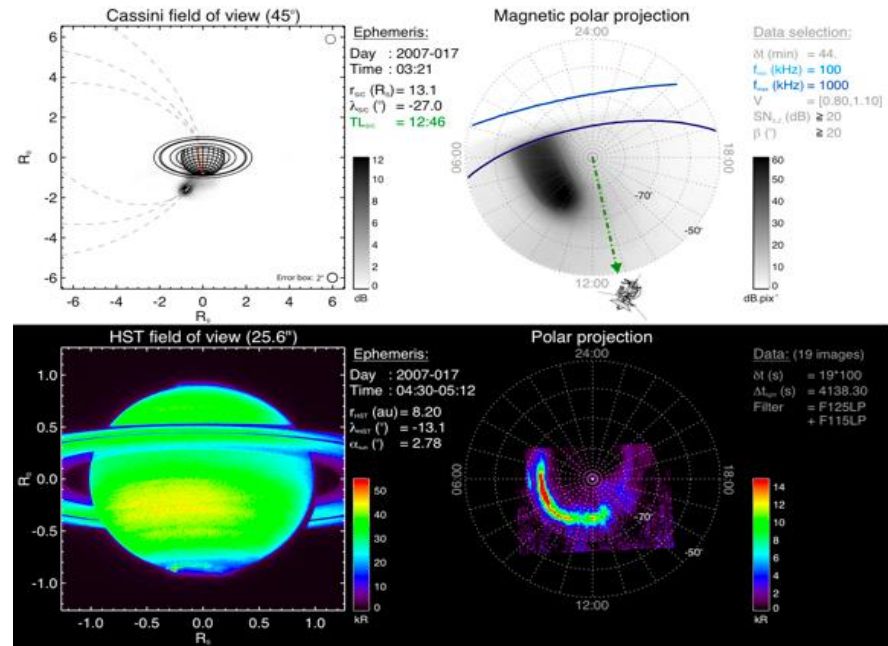
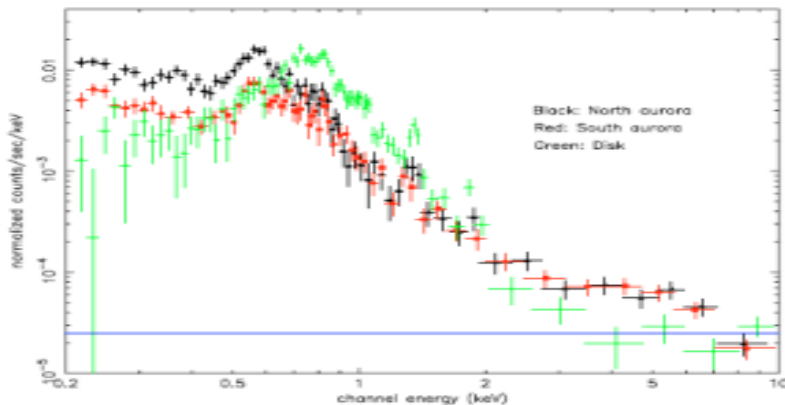
Targeted VO tools

- Data projection
- Spatial localization

Spatial
(Topcat ?
Aladin?)

Multi-spectral
(VOSPec?
SpecView?)

- Data superposition
- Spectral analysis





Case Study: Aladin

Illustration: Accessing the relevant HST observations (<1000)

HST Archive in Baltimore, search by keywords in abstract database

The screenshot shows a Mozilla browser window titled "MAST HST Abstract Search - Mozilla" with the address bar containing "http://archive.stsci.edu/hst/abstract.html". The page features a navigation menu with items like "MAST", "STScI", "Tools", "Mission_Search", "Tutorial", and "Site Search". Below the menu, there are links for "HST Home", "About HST", "Getting Started", "Registration", "Archive Status", "HST Search", "HSTonline Search", and "Suggestions".

The main content area is titled "HST ABSTRACT SEARCH" and contains the following text:

Search the HST proposal abstracts and/or proposal titles for specific strings of interest. You may also search the HST abstracts database for a specific Guest Investigator (either in combination with a string search of the abstracts or alone). You may enter lists of expressions separated by commas. See the [help](#) for more details.

The search form includes the following fields and options:

- "String to be searched for within the abstract:" with the input "aurora,+saturn" (circled in red).
- A checked checkbox for "Display Abstract?".
- "String to be searched for within the title:" with an empty input field.
- "Investigator first name:" and "and/or last name:" with empty input fields.
- "Proposal id or a list of ids separated by commas:" with an empty input field.
- "Cycle or a list of cycles separated by commas:" with an empty input field.
- "submit" and "Reset" buttons.

At the bottom of the page, there is a "Help" link. The Windows taskbar at the bottom shows the Start button, several open applications (including Microsoft Office and Mozilla), and the system clock displaying "15:13".

Illustration: Accessing HST observations (abstract search)

HST Archive in Baltimore, search by keywords in abstract database

The screenshot shows a Mozilla browser window titled "MAST HST Abstract Search - Mozilla". The address bar displays the URL "http://archive.stsci.edu/hst/abstract.html". The page content includes a search result for "HST Cycle 12 proposal [10083](#): HST UV Images of Saturn's Aurora Coordinated with Cassini Solar Wind Measurements" by John T. Clarke - Boston University. The abstract text describes a proposal for simultaneous solar wind and auroral imaging measurements during the Cassini mission in early 2004. The number "10083" in the title is circled in red. The browser's taskbar at the bottom shows the Start button, several open applications, and the system clock at 15:17.

MAST HST Abstract Search - Mozilla

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop http://archive.stsci.edu/hst/abstract.html Search Print

nightside **aurora** with Cassini UVIS. Both the distributions of the **auroral** emissions and the energy of the precipitating particles can be measured simultaneously at conjugate points north and south. This proposal is to conduct one such simultaneous observation, which will demonstrate the potential for future cycles. We request 5 HST orbits to observe a large fraction of one complete **Saturn** rotation at the same time as Cassini UVIS. The rotational coverage has been shown to be of central importance in recent STIS images of **Saturn's auroral** activity, which is concentrated in an "active sector" connected with the strongest SKR radio emissions.

HST Cycle 12 proposal [10083](#): HST UV Images of Saturn's Aurora Coordinated with Cassini Solar Wind Measurements
John T. Clarke - Boston University

A key measurement goal of the Cassini mission to **Saturn** is to obtain simultaneous solar wind and **auroral** imaging measurements in a campaign scheduled for Jan. 2004. Cassini will measure the solar wind approaching **Saturn** continuously from 9 Jan. - 6 Feb., but not closer to **Saturn** due to competing spacecraft orientation constraints. The only system capable of imaging **Saturn's aurora** in early 2004 will be HST. In this community DD proposal we request the minimum HST time needed to support the Cassini mission during the solar wind campaign with UV images of **Saturn's aurora**. **Saturn's** magnetosphere is intermediate between the "closed" Jovian case with large internal sources of plasma and the Earth's magnetosphere which is open to solar wind interactions. **Saturn's aurora** has been shown to exhibit large temporal variations in brightness and morphology from Voyager and HST observations. Changes of **auroral** emitted power exceeding one order of magnitude, dawn brightenings, and latitudinal motions of the main oval have all been observed. Lacking knowledge of solar wind conditions near **Saturn**, it has not been possible to determine its role in **Saturn's auroral** processes, nor the mechanisms controlling the **auroral** precipitation. During Cassini's upcoming approach to **Saturn** there will be a unique opportunity to answer these questions. We propose to image one complete rotation of **Saturn** to determine the corotational and longitudinal dependences of the **auroral** activity. We will then image the active sector of **Saturn** once every two days for a total coverage of 26 days during the Cassini campaign to measure the upstream solar wind parameters. This is the minimum coverage needed to ensure observations of the **aurora** under solar wind pressure variations of more than a factor of two, based on the solar wind pressure variations measured by Voyager 2 near **Saturn** on the declining phase of solar activity. The team of proposers has carried out a similar coordinated observing campaign of Jupiter during the Cassini flyby, resulting in a set of papers and HST images on the cover of Nature on 28 February 2002.

Start Nicolas Andre ... 2 Microsoft Of... Inbox for ndr... Europlanet Microsoft Power... 3 Mozilla 15:17

Illustration: Accessing the relevant HST observations (datasets)

HST Archive in Baltimore, search by keywords in abstract database

Data for proposal 10083 as of Tue Sep 11 13:17:59 GMT 2007

51 records (0 proprietary) returned.

Submit marked data for retrieval from STDADS

Mark all Unmark all Mark public Unmark public Mark proprietary Unmark proprietary

Row	Mark	Targname	RA	Dec	Instrument	Operating Mode	Cent Wave (Å)	Exp Time	Start Time	Dataset Name	Release Date	Ro
1	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 38 43.79	+22 29 07.83	STIS	ACCUM	1368.68	540.00	2004-01-10 04:41:15	O8WI01010	2004-01-10 09:02:22	1
2	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 38 44.03	+22 29 07.53	STIS	TIME-TAG	1453.25	640.20	2004-01-10 04:24:35	O8WI01S1Q	2004-01-10 08:59:51	2
3	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 38 43.59	+22 29 08.09	STIS	TIME-TAG	1453.25	640.20	2004-01-10 04:55:32	O8WI01S7Q	2004-01-10 09:10:25	3
4	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 25.64	+22 28 14.32	STIS	ACCUM	1368.68	540.00	2004-01-08 04:42:39	O8WI02010	2004-01-08 06:44:53	4
5	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 24.27	+22 28 16.08	STIS	ACCUM	1368.68	540.00	2004-01-08 06:16:45	O8WI02020	2004-01-08 10:47:48	5
6	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 22.87	+22 28 17.88	STIS	ACCUM	1368.68	540.00	2004-01-08 07:52:44	O8WI02030	2004-01-08 12:38:43	6
7	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 21.47	+22 28 19.67	STIS	ACCUM	1368.68	540.00	2004-01-08 09:28:43	O8WI02040	2004-01-08 21:28:42	7
8	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 20.07	+22 28 21.47	STIS	ACCUM	1368.68	540.00	2004-01-08 11:04:42	O8WI02050	2004-01-08 21:50:21	8
9	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 25.88	+22 28 14.02	STIS	TIME-TAG	1453.26	640.20	2004-01-08 04:25:59	O8WI02C6Q	2004-01-08 06:41:51	9
10	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 25.43	+22 28 14.59	STIS	TIME-TAG	1453.26	640.20	2004-01-08 04:56:56	O8WI02CCQ	2004-01-08 10:35:43	10
11	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 24.50	+22 28 15.79	STIS	TIME-TAG	1453.26	740.20	2004-01-08 05:58:25	O8WI02CHQ	2004-01-08 10:45:17	11
12	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 24.06	+22 28 16.35	STIS	TIME-TAG	1453.25	740.20	2004-01-08 06:31:02	O8WI02CNQ	2004-01-08 11:35:59	12
13	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 23.10	+22 28 17.58	STIS	TIME-TAG	1453.25	740.20	2004-01-08 07:34:24	O8WI02CSQ	2004-01-08 12:36:12	13
14	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 22.66	+22 28 18.15	STIS	TIME-TAG	1453.25	740.20	2004-01-08 08:07:01	O8WI02CYQ	2004-01-08 21:17:38	14
15	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 21.70	+22 28 19.38	STIS	TIME-TAG	1453.26	740.20	2004-01-08 09:10:23	O8WI02D3Q	2004-01-08 21:26:11	15
16	<input type="checkbox"/>	SATURN-AURORA-SOUTH	06 39 21.26	+22 28 19.94	STIS	TIME-TAG	1453.25	740.20	2004-01-08 09:43:00	O8WI02D9Q	2004-01-08 21:37:15	16

Illustration: Accessing the relevant HST observations (preview)


Preview of data possible but quality is not good enough ...

MAST: HST Preview - Mozilla

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop <http://archive.stsci.edu/cgi-bin/mastpreview?mission=hst&dataid=08w102040> Search Print

Home Bookmarks



Preview calibrations are uncertain so preview data should be used for diagnostic/quick-look purposes only.

[FITS format](#) [More preview format options](#)

Target Name: SATURN-AURORA-SOUTH	Observation Date: Jan 8 2004 9:28AM	Instrument: STIS
RA: 06 39 21.47	Exp Time: 540	Filter/Grating: MIRCUV
Dec: +22 28 19.67	Release Date: Jan 8 2004 9:28PM	Aperture: 25MAMA
Data Quality:	Mode: ACCUM	Config: STIS/FUV-MAMA
Quality Comment:		

Original observing program:
[10083 - Clarke, John T. - Boston University](#)
HST UV Images of Saturn's Aurora Coordinated with Cassini Solar Wind Measurements
SOLAR SYSTEM - Cycle 12 - Status: completed

Retrieve Data

- [Information](#) on HST previews.
- Display FITS image using [Aladin](#).

Done

Start Nicolas Andre - ... 2 Microsoft Of... Inbox for ndr... Europlanet Microsoft Power... 3 Mozilla 16:27

Illustration: Visualizing HST observations with Aladin

Visualization of data with Aladin offered and of good quality !

The screenshot shows a Mozilla browser window titled "Aladin sky atlas - Mozilla". The address bar contains the URL: `http://archive.stsci.edu/cgi-bin/nph-aladin.pl?frame=launching&script=get+Local%28http%3A%2F%2Farchive.st...`. The page header features the logos for the Observatoire de Strasbourg (OS) and the Aladin project. The main interface includes a menu bar with "Load...", "Save...", "Tools...", "Print...", "Help...", and "Detach". Below the menu, there are controls for "Position" (set to "J2000") and "&from=STScI", and a "Pixel" resolution dropdown set to "8 bits". The central area displays a grayscale astronomical image of a celestial object, with a yellow square cursor and a pink crosshair. To the right of the image is a vertical toolbar with icons for "select", "dist", "draw", "tag", "text", "filter", "rgb", "assoc", "tsamp", "cont", "zoom", "mgiss", and "pixel". Further right is a panel with an eye icon and a list of data sources: "USNOB1", "NED", "Simbad", and "O8W02040". The bottom status bar shows "Applet cds.aladin.Aladin started". The Windows taskbar at the bottom includes the Start button, several open applications (Nicolas Andre..., 2 Microsoft Of..., Inbox for handr..., Europlanet, Microsoft Power...), and the Mozilla browser icon, with the system clock showing 16:27.



Beyond Aladin ?

Extending Aladin functionalities
to satisfy our user requirements

Correcting HST observations

- Automated pre-treatment from HST pipeline:

(correction of dark background noise, flat field, geometrical distortion, absolute and wavelength photometric calibration, etc ...)

- **Additional corrections required :**

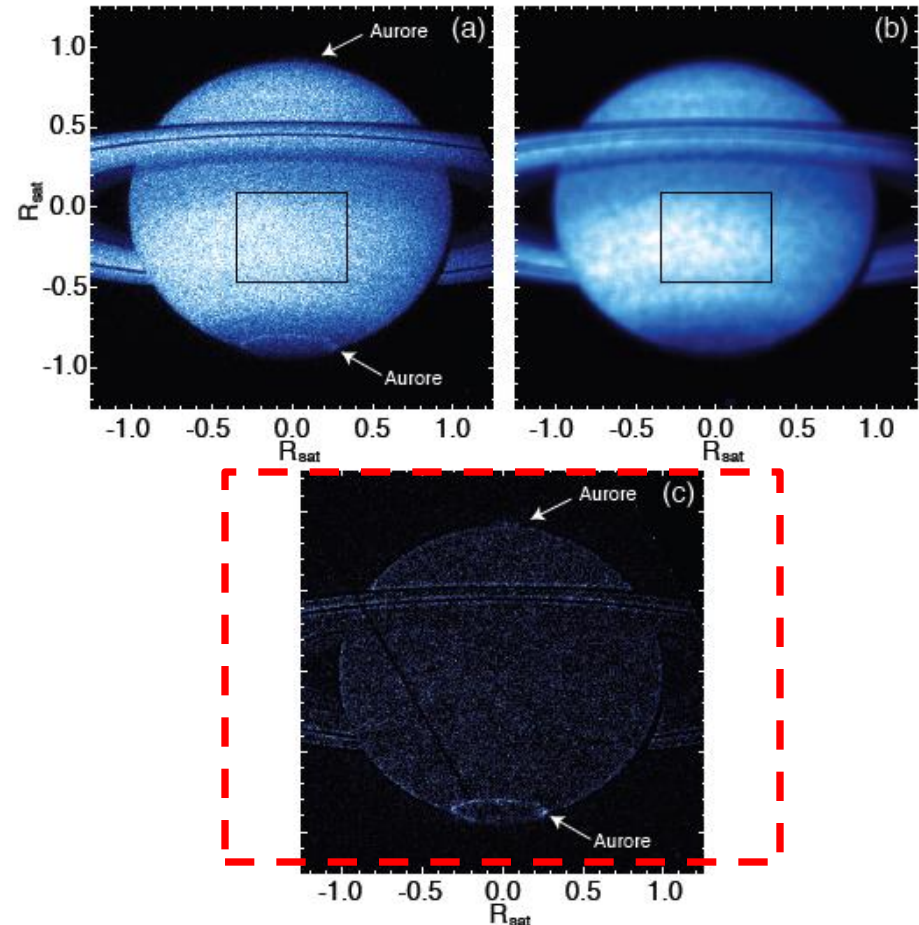
‘parasite’ emissions

- Reflected flux by the planet
- diffused emissions (terrestrial geocorona)

IDL routines to be plugged in Aladin?

Our expert:

Laurent Lamy (LESIA, Imperial College)



Need for projecting / localizing HST observations

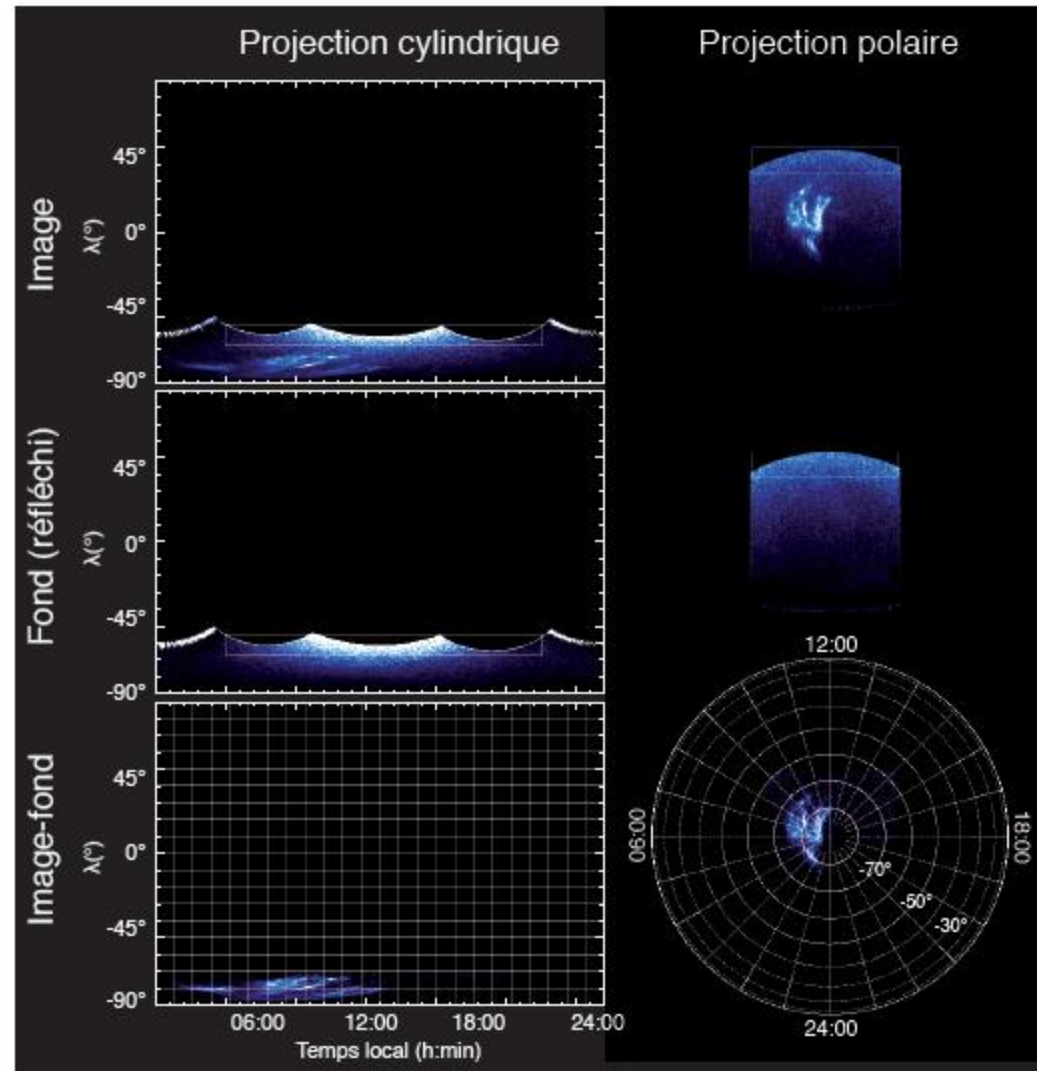
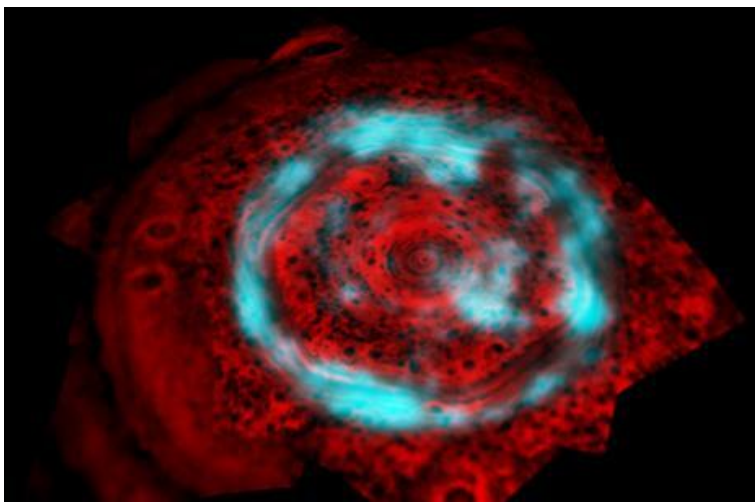


FIG. C.3: Projections cylindrique et polaire de l'image HST-STIS-SRF2 prise le 26 janvier 2004 à 19h16 (idem figure C.2e) ainsi que du réfléchi solaire déterminé pour le filtre SRF2 et la campagne 2004. Le fond soustrait sur les images finales a été lissé sur 20 pixels puis normalisé sur l'image à l'aide du rapport des intensités correspondant aux rectangles blancs.

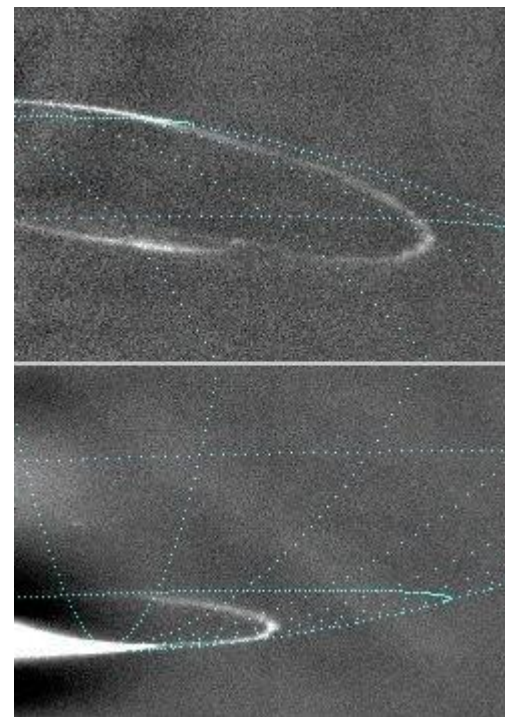
Correlating HST observations with X-ray, IR and VIS observations

Aladin could be used too

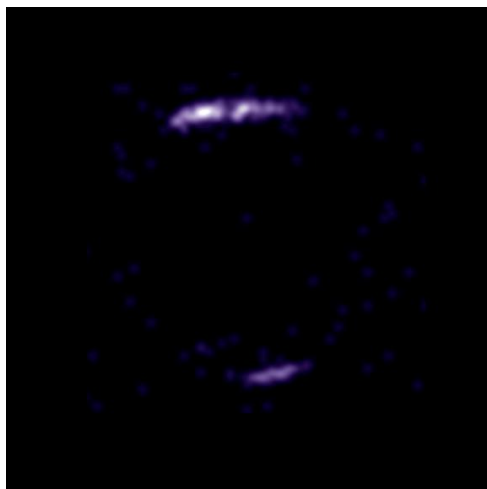
Stallard et al., Nature, 2009



Cassini/ISS Image at Jupiter



Chandra Image
Jupiter



In addition: HST database recently connected to Specview

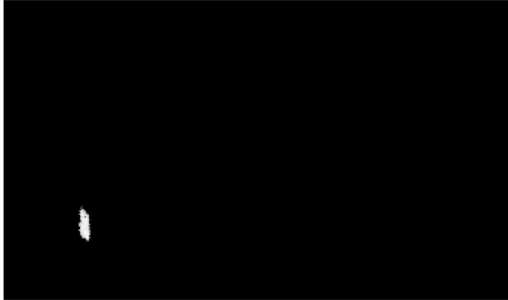
MAST: HST Preview - Mozilla Firefox

Fichier Édition Affichage Historique Marque-pages Outils ?

http://archive.stsci.edu/cgi-bin/mastpreview?mission=hst&dataid=O6BAA65SQ

Les plus visités Débuter avec Firefox À la une

Courrier :: Boîte de réception Europe1 : Radio d'Actualité et News Pol... HSTONLINE Search MAST: HST Preview



Preview calibrations are uncertain so preview data should be used for diagnostic/quick-look purposes only.

[Preview in FITS format](#) [More preview format options](#)

Exposure Information

Target Name: JUP-SOUTH2	Observation Date: Jan 13 2001 8:16PM	Instrument: STIS
RA: 03 57 46.90	Exp Time: 260.018	Filter/Grating: G140L
Dec: +19 41 47.71	Release Date: Jan 13 2002 8:20PM	Aperture: 52X0.5
Data Quality: OK	Mode: TIME-TAG	Config: STIS/FUV-MAMA

Quality Comment: NO APPARENT PROBLEMS

Original observing program:
8657 - Clarke, John T. - Boston University
Jovian Auroral Variability Due to the Solar Wind/Magnetosphere Interaction
SOLAR SYSTEM - Cycle 9 - Status: completed

Recently available

[Retrieve Data](#)

Information on HST previews.
View/Customize [plot of preview data](#)
Display / Customize [plot of VO FITS file using Specview](#). **w
Paper(s) referencing "8657":

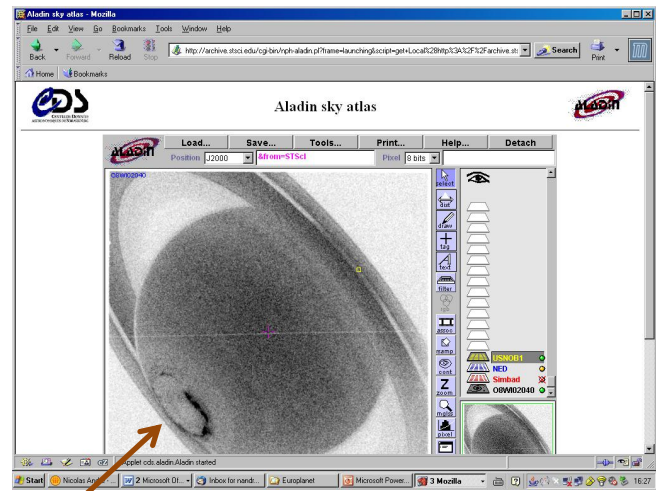
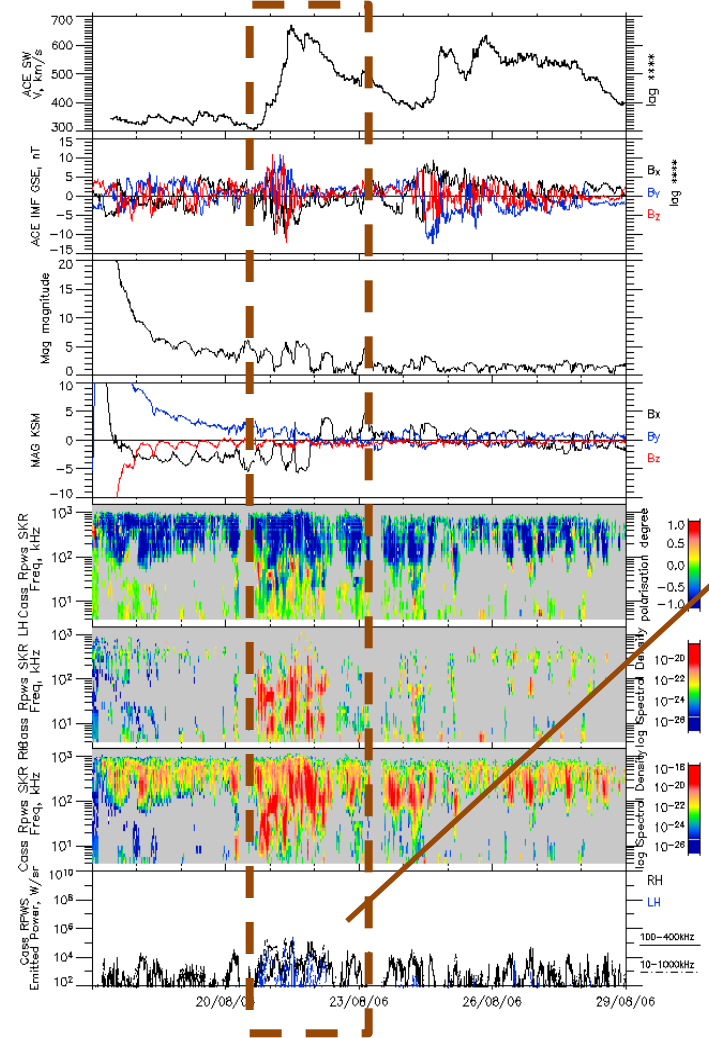
1. **Jupiter's main auroral oval observed with HST STIS** -- Grodent, D., Clarke, J.T., Kim, J., Waite, J.H., Cowley, S.W.H. - [2003JGRA.108k.SMP2G](#)
2. **Jupiter's main auroral oval observed with HST STIS** -- Grodent, D., Clarke, J.T., Kim, J., Waite, J.H., Cowley, S.W.H. - [2003JGRA.108.1389G](#)
3. **Simultaneous Chandra X ray, Hubble Space Telescope ultraviolet, and Ulysses radio observations of Jupiter's aurora** -- Elsner, R. F., Lugaz, N., Waite, J.H., Cravens, T.E., Gladstone, G.R., Ford, P., Grodent, D., Bhardwaj, A., MacDowall, R.J., Desch, M.D., Majeed, T. - [2005JGRA.11001207E](#)
4. **Jupiter's polar auroral emissions** -- Grodent, D., Clarke, J.T., Waite, J.H., Cowley, S.W.H., Gerard, J.-C., Kim, J. - [2003JGRA.108i.SMP6G](#)

Terminé

démarrer MAST: HST Preview - ... Bibliography Oral_Andre_FMI09 [... Oral_Andre_ASOV09 ... Ecoutez Europe1 en ... 21:46

A possible service

1. Visualization editor
2. Download data
3. Parameter editor
4. External data
5. Visual search
6. Conditional search
7. Time-Table manager
8. Astronomical data



Do they exist HST observations for the identified time period?

If yes, visualize them (with Aladin) and download them if requested by the user

Our proposed approach

Data Finder:

learn how to find all existing astronomical giant planet auroral observations (-> Time-Table, catalogue)

- 1) in UV (e.g., from the HST Science Data Archive),
- 2) in X-ray (e.g., from the XMM-Newton Science Archive)
- 3) in IR and 4) in Radio, using available astronomical catalogues, VO and associated search engines

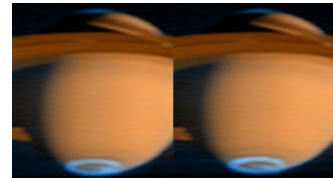
Data Access:

learn how to understand and read the corresponding data and metadata, together with their calibration files (standard(s), protocol(s), ...)

Use of Existing Tools:

learn how to use the VO tools mentioned previously with the corresponding astronomical data

- 1) as they stand,
- 2) also with existing planetary data on giant planet auroral emissions obtained from planetary spacecraft (e.g., from the Cassini UVIS, Cassini VIMS, Galileo UVS instruments at PDS),
- 3) identify the technical and scientific limitations (if any) of these VO tools in order to satisfy our requirements



Adaptation of Existing Tools to our Needs:

learn how to extend the existing tools and develop relevant and associated Added Value Services in order to fully satisfy our requirements

Connection between AMDA and VO tools:

learn how to connect our AMDA service with corresponding data and tools in an interoperable or integrated way

AMDA



AMDA+

