JUNO-Ground-Radio Observation Support

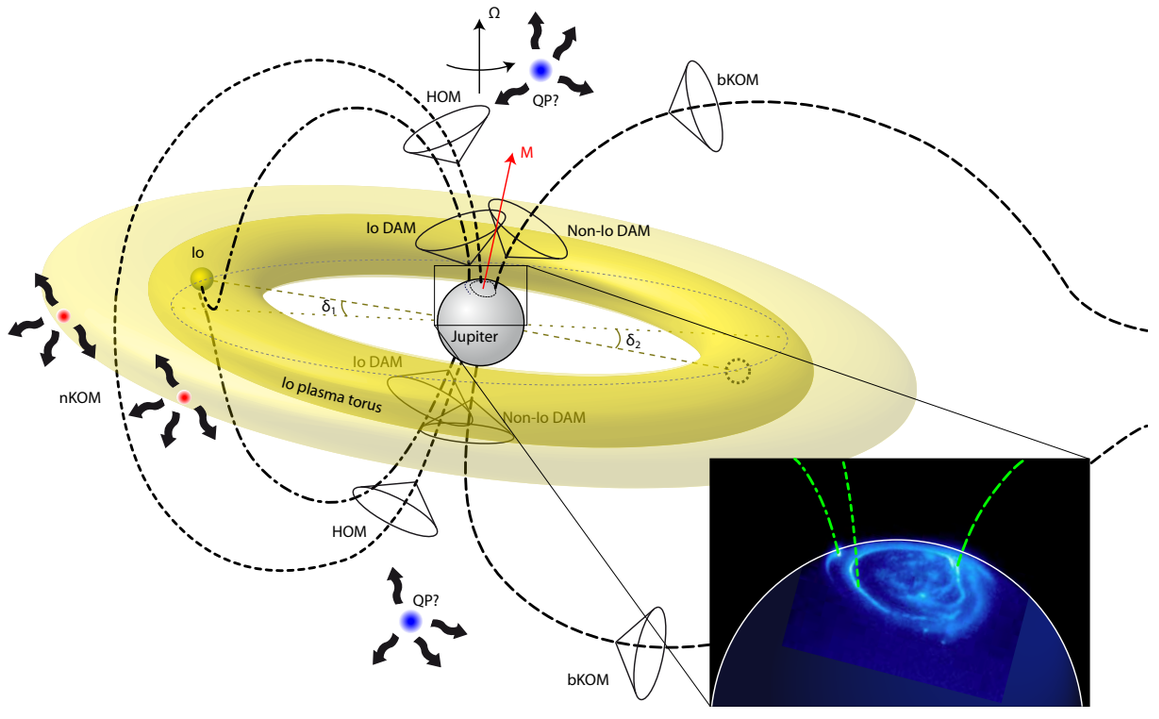
Baptiste Cecconi, Renaud Savalle
& the JUNO-Ground-Radio team

Outline

- JUNO mission & radio ground support
- Observation Planning
- Data Distribution and Tools
- Status and Future Work

JUNO Mission

- NASA lead space mission to Jupiter arriving July 2016, dedicated to origins and interior of Jupiter (hence its magnetic field)



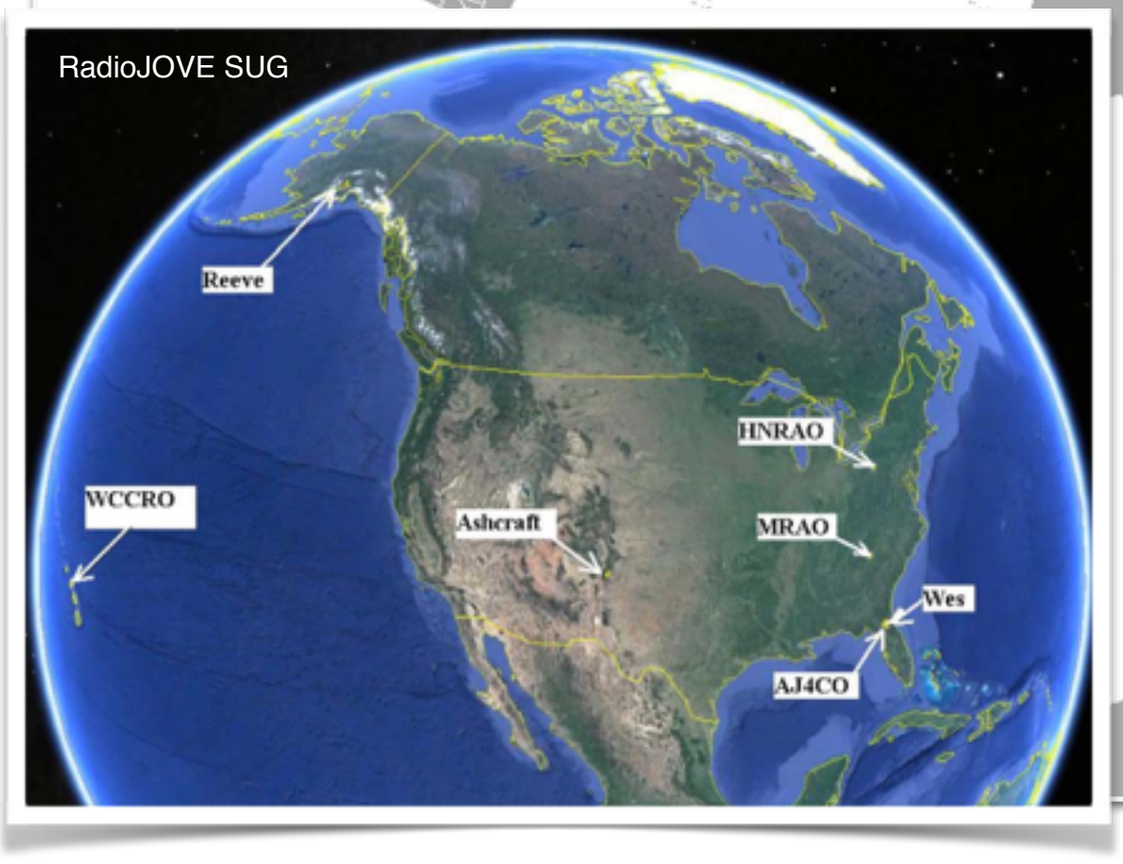
JUNO Ground Radio Observation Support

- **Professional low frequency telescopes (10-40 MHz)**:
  - Nançay (France): Decameter Array, LOFAR station
  - Europe: LOFAR (PL, SE, FR)
  - Kharkov (Ukraine): UTR-2
  - Japan: Iitate and Fukui observatories
  - New Mexico (USA): LWA1

- **Radio Emission modeling/prediction tools**
  - ExPRES tool: http://maser.obspm.fr/serpe, by Obs Paris team (France)
  - JRM (Jovian Radio Map) iPhone App, by Kochi College team (Japan)

- **Amateur community: RadioJOVE**
  - 2000 RadioJOVE kits out there (single frequency at ~20 MHz)
  - about 10 “RadioJOVE-SUG” (Spectrograph User Group): USA

JUNO Ground Radio Observation Support



professional

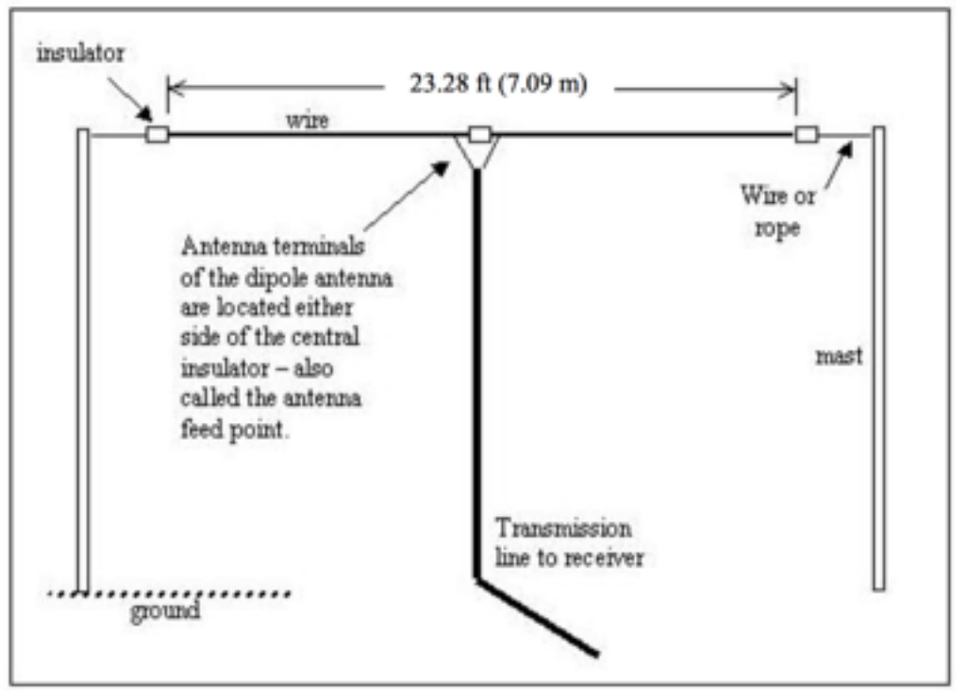
amateurs

RadioJOVE

- **RadioJOVE** is an EPO project developed in the USA: http://radiojove.org
  - **Goal**: introducing low frequency radioastronomy concepts to students, teachers, amateur radio community and the general public.
  - **The participants are building their own radio telescope**, using a kit sold by the Radio JOVE team. This instrument can observe the sky at frequencies around **20 - 30 MHz**.
  - The users can share their observations on an archive web site, and on a mailing list.
  - About 2000 kits have been shipped to date, all over the world.

- Radio-JOVE web site: http://radiojove.gsfc.nasa.gov

- Radio-JOVE data Archive : http://radiojove.org/cgi-bin/calendar/calendar.cgi



Planning Tool

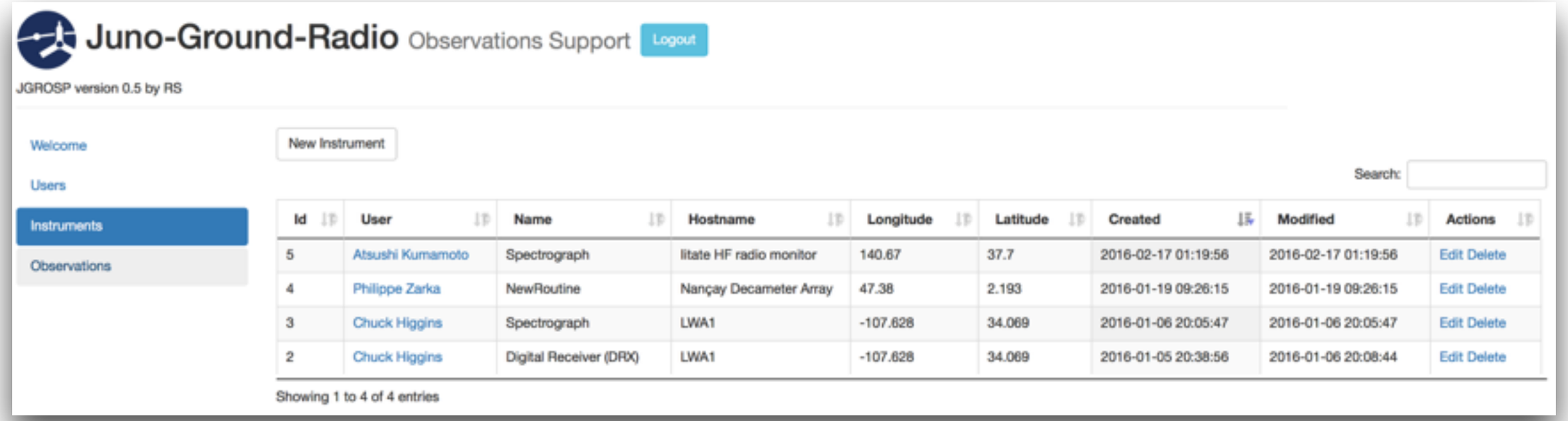
- https://voparis-juno.obspm.fr (registration required)

- Observation teams submit their observations plans
  - Observatory Name
  - Instrument Name
  - Start and Stop times
  - Spectral and temporal resolutions

- Planning freely available on
  http://maser.lesia.obspm.fr
  (or any where else if needed, please contact us if you want to connect to the planning database for any purpose).

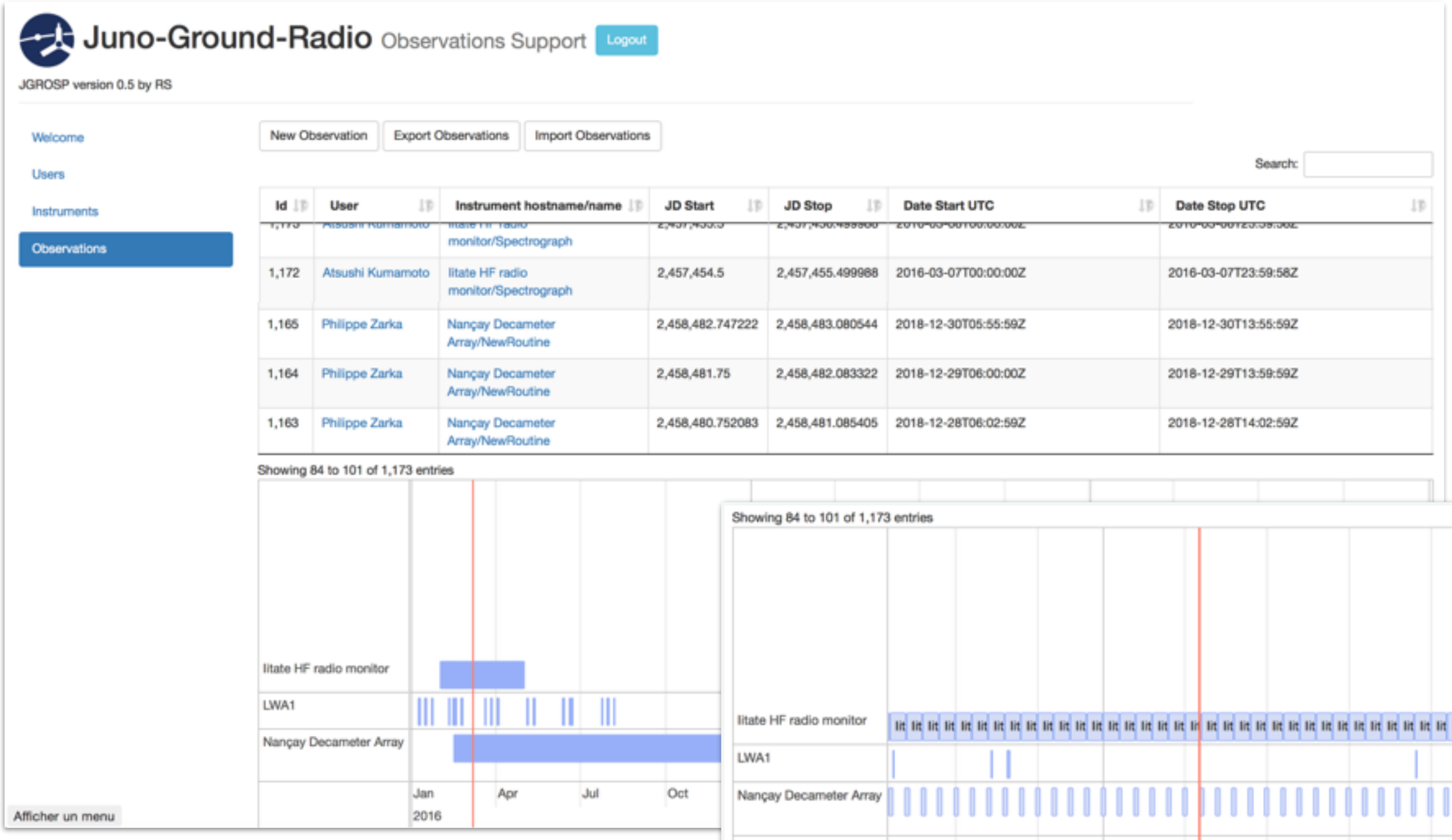
Planning Tool

Instruments



Planning Tool

Observations



Using: http://visjs.org/timeline_examples.html

Overview of Europlanet/VESPA

- VESPA* is a “virtual research infrastructure”. It provides tools to share, access and work with data using standard protocols.

- VESPA is using existing standards developed by the astronomy community (IVOA). Hence the infrastructure is not maintained by VESPA.

- VESPA data services are hosted by science teams, and must registered with the IVOA registry to be accessible from VO tools.

The Europlanet H2020 Research Infrastructure project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

**VESPA: Virtual European Solar and Planetary Access. http://www.europlanet-vespa.eu/*

Data Distribution Server

- Each team distributes their own data, using GAVO/DaCHS, with support from VESPA.

- They install a server following VESPA tutorials. This includes:
  - a TAP service: for automated remote access and search;
  - Apache web server: for sharing data files if needed;
  - AWStats access statistic tool: for monitoring purposes.

- This server can easily be used to share other datasets once installed.

- The VESPA team is providing online support for setting up services: http://discussions.europlanet-vespa.eu

Data Distribution Format

- Each team distributes their data using standard format. We recommend CDF. Scripting from any documented format to CDF is easy (especially with PyCDF Python library).

- CDF Metadata are compliant with ISTP (Space Physics), PDS4 (Planetary Sciences). CDF files can then be archived at NASA/PDS next to the JUNO archive.

- Raw or original format (such as FITS, HDF5 or native format) can also be distributed, so that usual user can still use their own software.

CDF Header ISTP Section

```
"Project"              1:    CDF_CHAR     { "ObsNancay>Observatory of Nancay" }
                       2:    CDF_CHAR     { "VOPDC>VO Paris Data Center" } .
"Discipline"           1:    CDF_CHAR     { "Planetary Physics>Waves" } .
"Data_type"            1:    CDF_CHAR     { "EDR>Experiment Data Record" } .
"Descriptor"           1:    CDF_CHAR     { "routine_jup" } .
"Data_version"         1:    CDF_CHAR     { "01" } .
"Instrument_type"      1:    CDF_CHAR     { "Radio Telescope" }
"Logical_file_id"      1:    CDF_CHAR     { “nda_routine_jup_edr_000000000000_000000000000_V05.cdf" } .
"Logical_source"       1:    CDF_CHAR     { "nda" } .
"Logical_source_description"
                       1:    CDF_CHAR     { "Jupiter Routine Observations from the Nancay Decameter Array" } .
"File_naming_convention"
                       1:    CDF_CHAR     { "source_descriptor_yyyymmddhhmm_yyyymmddhhmm_ver" } .
"Mission_group"        1:    CDF_CHAR     { "Nancay Decametric Array" } .
"PI_name"              1:    CDF_CHAR     { "A. Lecacheux" } .
"PI_affiliation"       1:    CDF_CHAR     { "Observatoire de Paris" } .
"Source_name"          1:    CDF_CHAR     { "NDA>Nancay Decametric Array" } .
"TEXT"                 1:    CDF_CHAR     { " " } .
"Generated_by"         1:    CDF_CHAR     { "LESIA" }
                       2:    CDF_CHAR     { "ObsNancay" } .
"Generation_date" .
"LINK_TEXT"            1:    CDF_CHAR     { "Nancay DAM webpage" } .
"LINK_TITLE"           1:    CDF_CHAR     { "Nancay DAM archive" } .
"HTTP_LINK"            1:    CDF_CHAR     { "http://www.obs-nancay.fr/" } .
"MODS" .
"Parents" .
"Rules_of_use" .
"Skeleton_version"     1:    CDF_CHAR     { "0.5" } .
"Software_version"     1:    CDF_CHAR     { "0.5" } .
"Time_resolution" .
"Acknowledgement" .
```

CDF Header PDS4 Section

```
“PDS_Observation_start_time"        1:    CDF_CHAR     { "0000-01-01T00:00:00.000Z" } .
“PDS_Observation_stop_time"         1:    CDF_CHAR     { "0000-01-01T00:00:00.000Z" } .
“PDS_Observation_target"            1:    CDF_CHAR     { "Jupiter" } .
“PDS_Observation_type"              1:    CDF_CHAR     { "Radio" } .
```

CDF Header VESPA Section

```
“VESPA_dataproduct_type"            1:    CDF_CHAR     { "DS>Dynamic Spectra" } .
“VESPA_target_class"                1:    CDF_CHAR     { "planet" } .
“VESPA_target_region"               1:    CDF_CHAR     { "aurora" }
                                    2:    CDF_CHAR     { "magnetosphere" } .
“VESPA_target_element"              1:    CDF_CHAR     { "DAM radio emissions" } .

“VESPA_time_min"                    1:    CDF_REAL8    { 0.0 } .
“VESPA_time_max"                    1:    CDF_REAL8    { 0.0 } .
“VESPA_time_sampling_step_min"      1:    CDF_REAL4    { 0.0 } .
“VESPA_time_sampling_step_max"      1:    CDF_REAL4    { 0.0 } .

“VESPA_spectral_range_min"          1:    CDF_REAL8    { 0.0 } .
“VESPA_spectral_range_max"          1:    CDF_REAL8    { 0.0 } .
“VESPA_spectral_sampling_step_min"  1:    CDF_REAL4    { 0.0 } .
“VESPA_spectral_sampling_step_max"  1:    CDF_REAL4    { 0.0 } .

“VESPA_instrument_host_name"        1:    CDF_CHAR     { "NDA>Nancay Decameter Array" } .
“VESPA_instrument_name"             1:    CDF_CHAR     { "Routine" } .
“VESPA_measurement_type”            1:    CDF_CHAR     { "phys.flux.density;em.radio" } .
“VESPA_access_format"               1:    CDF_CHAR     { "cdf" } .
```

CDF Variables

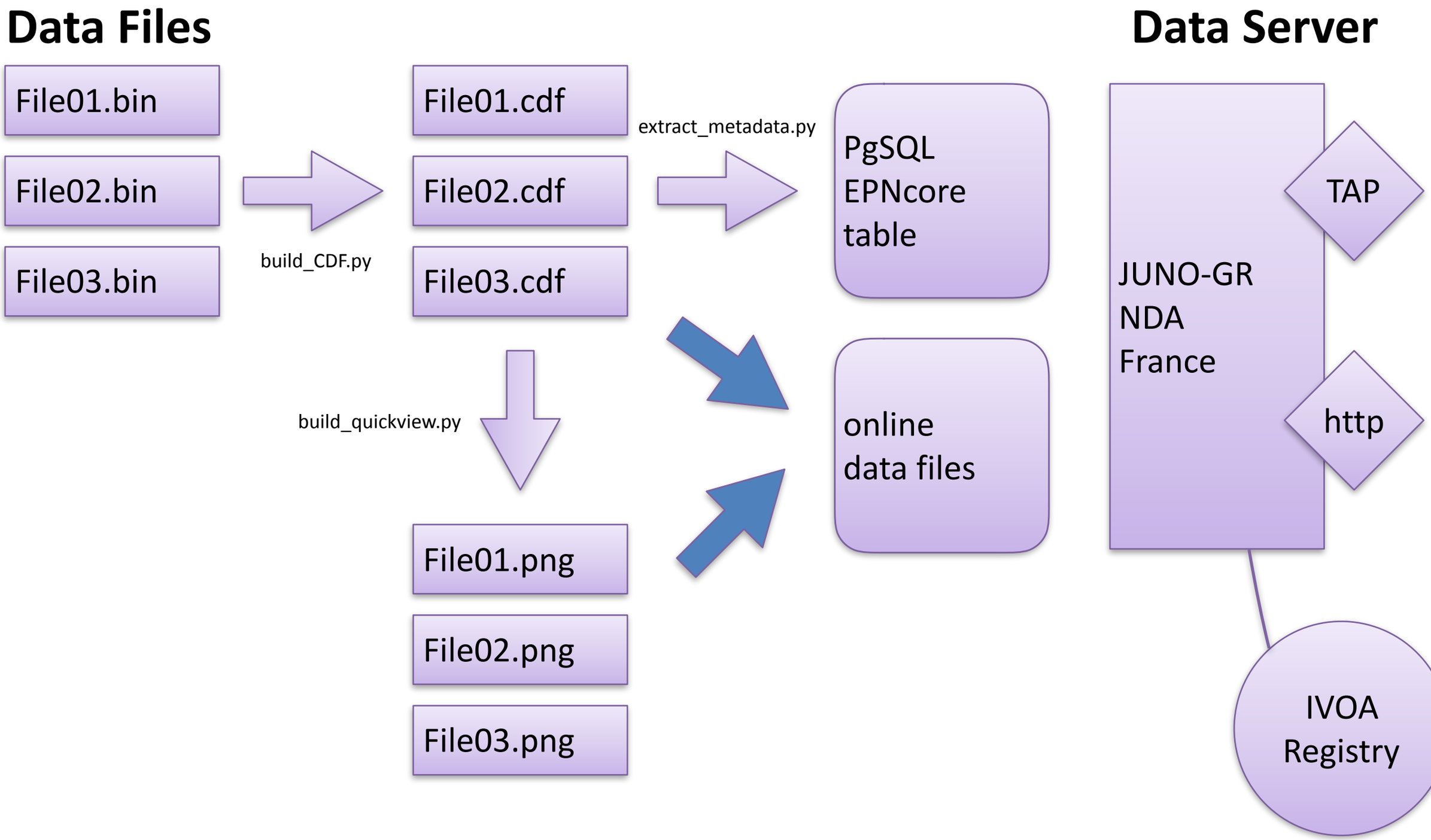
Variable Name	Data Type	Number Elements	Dims	Sizes	Record Variance	Dimension Variances
"Epoch"	CDF_EPOCH	1	0		T	
"ISO_DATE"	CDF_CHAR	24	0		T	
"JD_TIME"	CDF_REAL8	1	0		T	
"FLUX_RR"	CDF_REAL4	1	1	400	T	T
"FLUX_LL"	CDF_REAL4	1	1	400	T	T
"FLUX_RL"	CDF_REAL4	1	1	400	T	T
"FLUX_LR"	CDF_REAL4	1	1	400	T	T
"FLUX_XX"	CDF_REAL4	1	1	400	T	T
"FLUX_YY"	CDF_REAL4	1	1	400	T	T
"FLUX_XY"	CDF_REAL4	1	1	400	T	T
"FLUX_YX"	CDF_REAL4	1	1	400	T	T
"FLUX_S"	CDF_REAL4	1	1	400	T	T
"FLUX_Q"	CDF_REAL4	1	1	400	T	T
"FLUX_U"	CDF_REAL4	1	1	400	T	T
"FLUX_V"	CDF_REAL4	1	1	400	T	T
"Frequency"	CDF_REAL4	1	1	400	F	T

CDF Variables Attributes

```
"CATDESC"     CDF_CHAR     { "LH polar flux density" }
"DEPEND_0"    CDF_CHAR     { "Epoch" }
"DEPEND_1"    CDF_CHAR     { "Frequency" }
"LABL_PTR_1"  CDF_CHAR     { "Frequency" }
"DICT_KEY"    CDF_CHAR     { "electric_field>power" }
"DISPLAY_TYPE"
              CDF_CHAR     { "time_series" }
"FIELDNAM"    CDF_CHAR     { "LH_FLUX" }
"FILLVAL"     CDF_REAL4    { -1.0e+31 }
"FORMAT"      CDF_CHAR     { "E12.2" }
"LABLAXIS"    CDF_CHAR     { "LH polar flux density" }
"UNITS"       CDF_CHAR     { "W/m^2/Hz" }
"VALIDMIN"    CDF_REAL4    { 0.0 }
"VALIDMAX"    CDF_REAL4    { 1.0e+06 }
"VAR_TYPE"    CDF_CHAR     { "data" }
"SCALETYP"    CDF_CHAR     { "log" }
"SCALEMIN"    CDF_REAL4    { 0.0 }
"SCALEMAX"    CDF_REAL4    { 20.0 }
"UCD"         CDF_CHAR     { "phys.flux.density;em.radio" } .
```

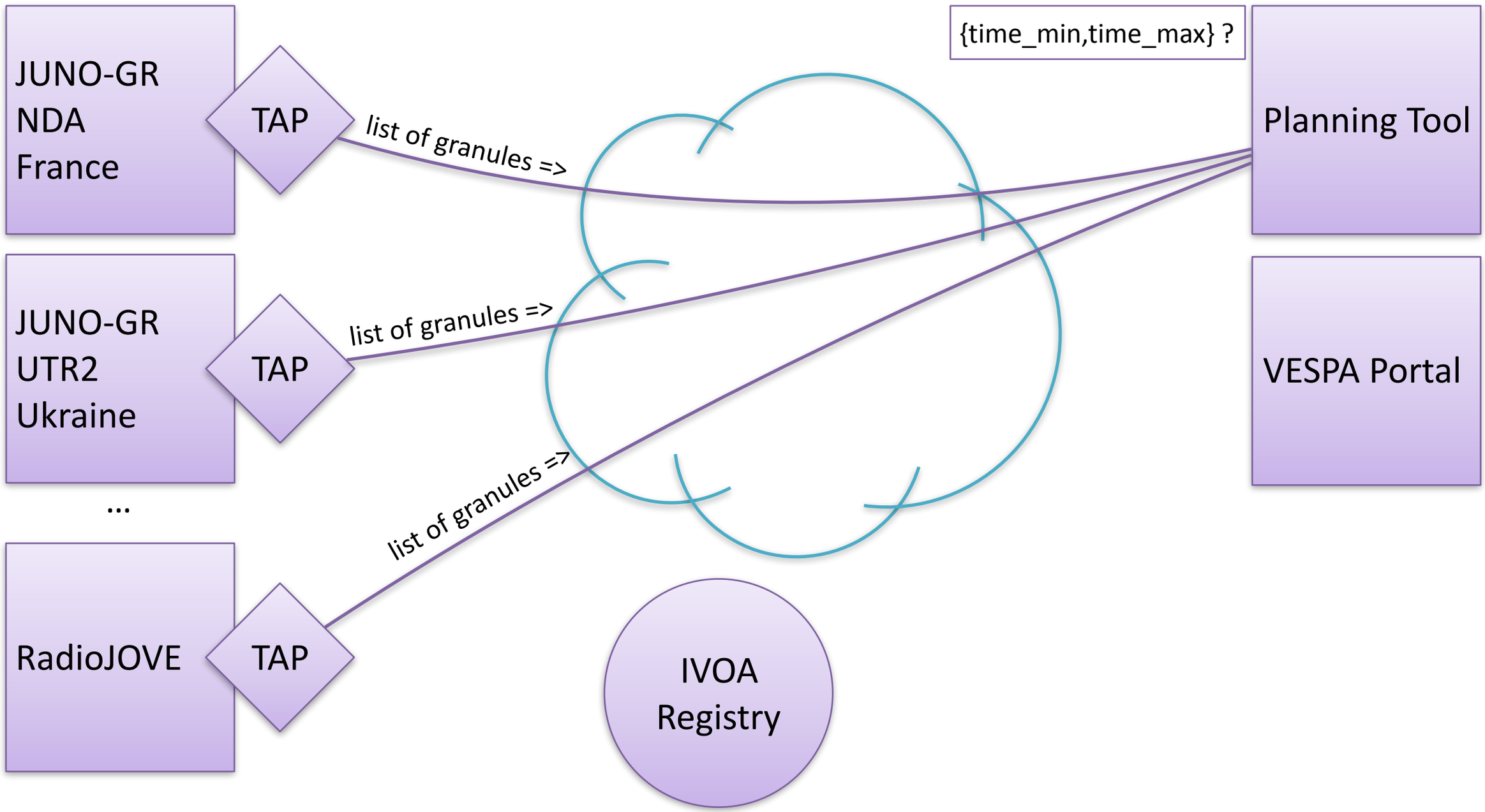
JUNO-Ground-Radio

using VESPA infrastructure: on data provider side



JUNO-Ground-Radio

using VESPA infrastructure: getting real observations times



JUNO-Ground-Radio

using VESPA infrastructure: getting real observations times

Data Providers

Users

JUNO-GR
ND
Fra

{time_min,time_max} ?

Tool

JU
UT
Uk

rtal

Rad

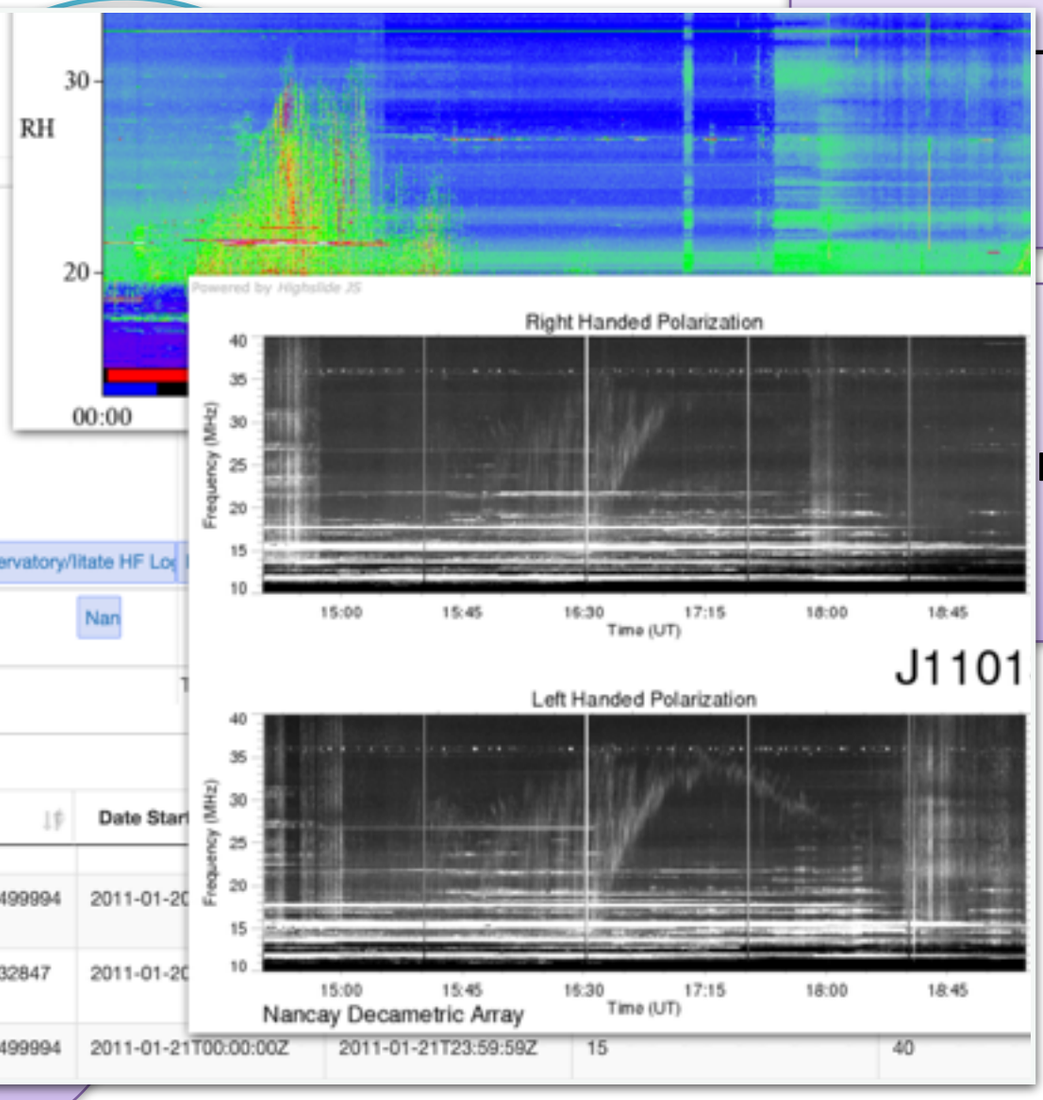
Juno-Ground-Radio Observations Support Logout

JGROSP version 0.7 by RS

- Welcome
- Users
- Instruments
- Observation Planning
- Available Observations

Iitate Observatory	Iitate Obse	Iitate Observatory/Iitate HF Lo	Iitate Observatory/Iitate HF Lo
Nancay Decameter Array	Nan	Nan	Nan
		Tue 1 February 2011	Wed 2

Id	Instrument hostname/name	JD Start	JD Stop	Date Start			
	Receiver						
762	Iitate Observatory/Iitate HF Log Periodic Antenna	2,455,581.5	2,455,582.499994	2011-01-20			
2,698	Nancay Decameter Array/Routine Receiver	2,455,582.132708	2,455,582.32847	2011-01-20			
763	Iitate Observatory/Iitate HF Log Periodic Antenna	2,455,582.5	2,455,583.499994	2011-01-21T00:00:00Z	2011-01-21T23:59:59Z	15	40



All VO | Custom resource | Direct Query | Help

Query form: All VO

Target name: Jupiter

Resource type: granule

Dataset ID:

Time selection: Data range is included in

Time min:

Dataproduct type: image, spectrum, dynamic_spectrum, spectral_cube

Target class: asteroid, comet, dwarf_planet, exoplanet, interplanetary_medium, planet

the range between

Time max:

Measurement type: em.radio

Location +
Spectral +
Time +
Photometry +
Instrument +
Optional +

Plotting tools

- TOPCAT
- Aladin
- VOSpec
- SPLAT

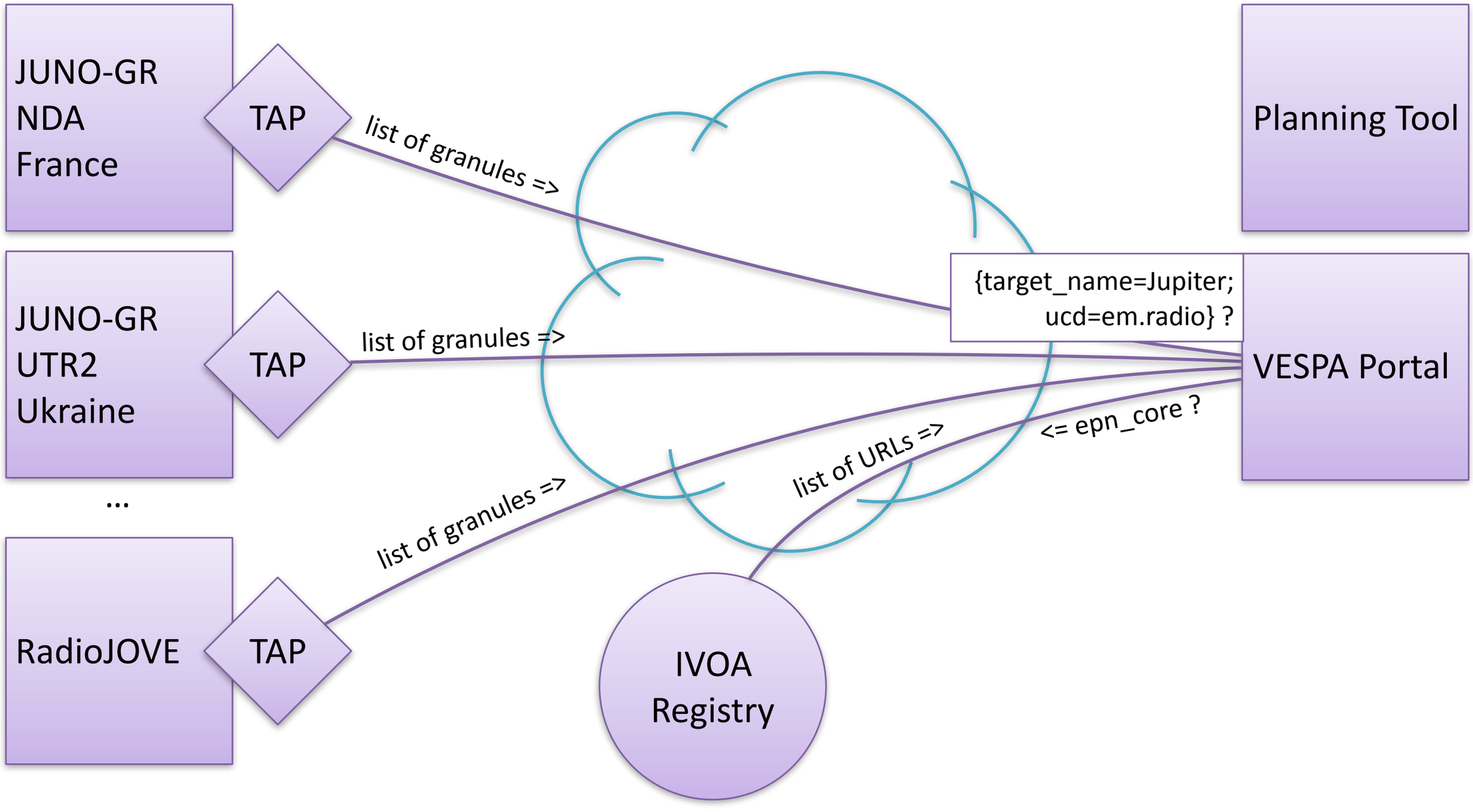
Example queries

- Saturn in March 2012

JUNO-Ground-Radio
using VESPA infrastructure

Data Providers

Users



VESPA

Virtual European Solar and Planetary Access

All VO | Custom resource | Direct Query | Help

Results in service dam

Show 20 entries | Search: | Show / hide columns | Select all | Deselect all | Full Text

dataproduct_type	target_name	time_min (d)	time_max (d)	access_url
dynamic_spectrum	jupiter	2012-07-07T06:00:00	2012-07-07T06:00:00	J120707.xml
dynamic_spectrum	jupiter	2012-03-31T18:00:00	2012-03-31T18:00:00	J120331.xml
dynamic_spectrum	jupiter	2013-02-03T18:00:00	2013-02-04T00:00:00	J130203.xml
dynamic_spectrum	jupiter	2012-08-22T00:00:00	2012-08-22T06:00:00	J120822.xml
dynamic_spectrum	jupiter	2011-09-27T00:00:00	2011-09-27T06:00:00	J110927.xml
dynamic_spectrum	jupiter	2013-02-15T18:00:00	2013-02-16T00:00:00	J130215.xml
dynamic_spectrum	jupiter	2012-08-30T00:00:00	2012-08-30T06:00:00	J120830.xml
dynamic_spectrum	jupiter	2011-02-11T18:00:00	2011-02-11T18:00:00	J110211.xml
dynamic_spectrum	jupiter	2011-05-11T06:00:00	2011-05-11T06:00:00	J110511.xml
dynamic_spectrum	jupiter	2012-12-10T18:00:00	2012-12-11T06:00:00	J121210.xml
dynamic_spectrum	jupiter	2012-12-16T18:00:00	2012-12-17T00:00:00	J121216.xml
dynamic_spectrum	jupiter	2012-12-24T18:00:00	2012-12-25T00:00:00	J121224.xml
dynamic_spectrum	jupiter	2012-07-05T06:00:00	2012-07-05T06:00:00	J120705.xml
dynamic_spectrum	jupiter	2011-01-14T18:00:00	2011-01-14T18:00:00	J110114.xml

Plotting tools

- TOPCAT
- Aladin
- VOSpec
- SPLAT

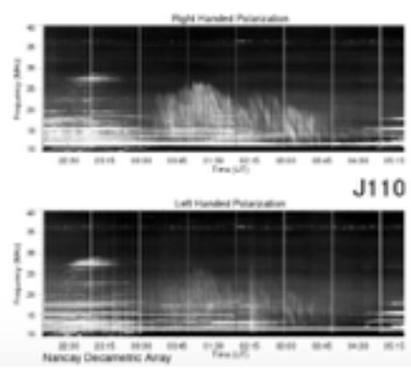
Example queries

- Saturn in March 2012

SELECTED DATA

No data selected

PREVIEW



VESPA

Virtual European Solar and Planetary Access

All VO | Custom resource | Direct Query | Help

Results in service iitate

Warning : Only first 1000 results are displayed

Full Text

Show 20 entries | Search: | Show / hide columns | Select all | Deselect all

dataproduct_type	target_name	time_min (d)	time_max (d)	access_url
dynamic_spectrum	Jupiter	2011-10-27T00:00:00	2011-10-27T23:59:59.500	it_h1_hf_20111027_v01.cdf
dynamic_spectrum	Jupiter	2011-10-28T00:00:00	2011-10-28T23:59:59.500	it_h1_hf_20111028_v01.cdf
dynamic_spectrum	Jupiter	2011-10-29T00:00:00	2011-10-29T23:59:59.500	it_h1_hf_20111029_v01.cdf
dynamic_spectrum	Jupiter	2011-10-30T00:00:00	2011-10-30T23:59:59.500	it_h1_hf_20111030_v01.cdf
dynamic_spectrum	Jupiter	2011-10-31T00:00:00	2011-10-31T23:59:59.500	it_h1_hf_20111031_v01.cdf
dynamic_spectrum	Jupiter	2011-11-01T00:00:00	2011-11-01T23:59:59.500	it_h1_hf_20111101_v01.cdf
dynamic_spectrum	Jupiter	2011-11-02T00:00:00	2011-11-02T23:59:59.500	it_h1_hf_20111102_v01.cdf
dynamic_spectrum	Jupiter	2011-11-03T00:00:00	2011-11-03T23:59:59.500	it_h1_hf_20111103_v01.cdf
dynamic_spectrum	Jupiter	2011-11-04T00:00:00	2011-11-04T23:59:59.500	it_h1_hf_20111104_v01.cdf
dynamic_spectrum	Jupiter	2011-11-05T00:00:00	2011-11-05T23:59:59.500	it_h1_hf_20111105_v01.cdf
dynamic_spectrum	Jupiter	2011-11-06T00:00:00	2011-11-06T23:59:59.500	it_h1_hf_20111106_v01.cdf
dynamic_spectrum	Jupiter	2011-11-07T00:00:00	2011-11-07T23:59:59.500	it_h1_hf_20111107_v01.cdf
dynamic_spectrum	Jupiter	2011-11-08T00:00:00	2011-11-08T23:59:59.500	it_h1_hf_20111108_v01.cdf
dynamic_spectrum	Jupiter	2011-11-09T00:00:00	2011-11-09T23:59:59.500	it_h1_hf_20111109_v01.cdf
dynamic_spectrum	Jupiter	2011-11-10T00:00:00	2011-11-10T23:59:59.500	it_h1_hf_20111110_v01.cdf

Plotting tools

- TOPCAT
- Aladin
- VOSpec
- SPLAT

Example queries

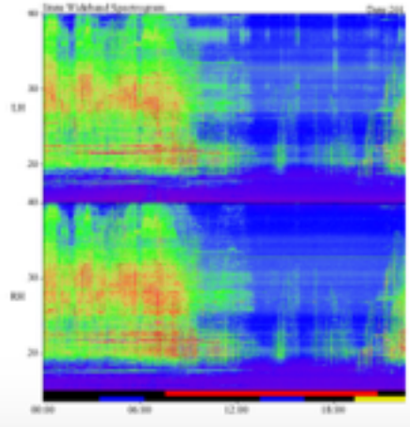
- Saturn in March 2012

SELECTED DATA

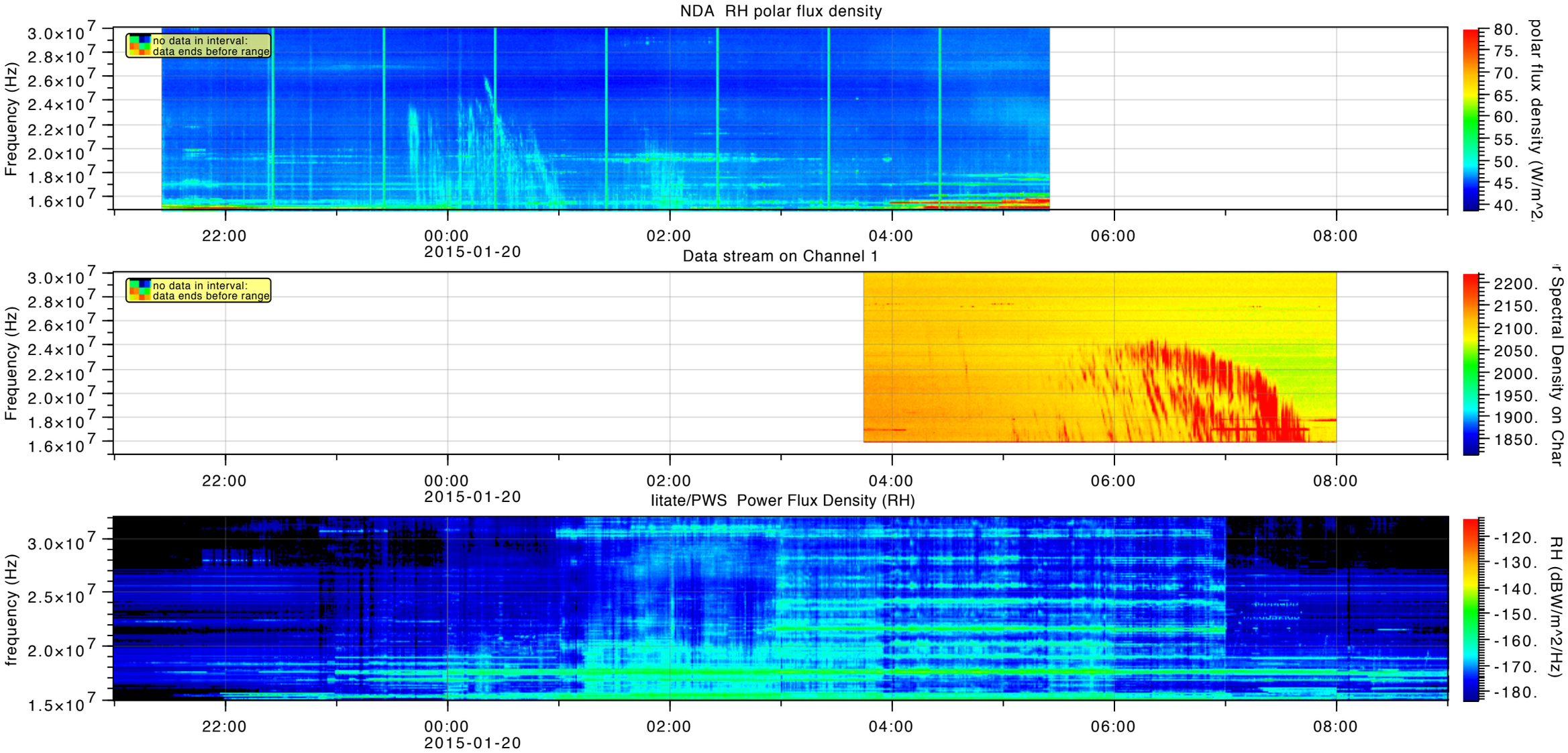
2 selected data

- 2 : dynamic_spectrum

PREVIEW



Data in Autoplot
sent from VESPA portal, using SAMP



JUNO-Ground-Radio
Observation Support team

- All data providers use the same infrastructure:
  - VESPA server + CDF files with same metadata
- Metadata compliant with:
  - **International Solar Terrestrial Program** guidelines:
    ok with NASA/SPDF or CNES/CDPP
  - **NASA Planetary Data System – Planetary Plasma Interaction** node recommendation
  - **EPNcore**: automated distribution in VESPA
- Usage of CDF:
  - Data can be plotted in various tools (such as **autoplot** or **TOPCAT**, both include SAMP).
- Usage of VESPA:
  - Unified access.
  - Used for scheduling (time_min/max)

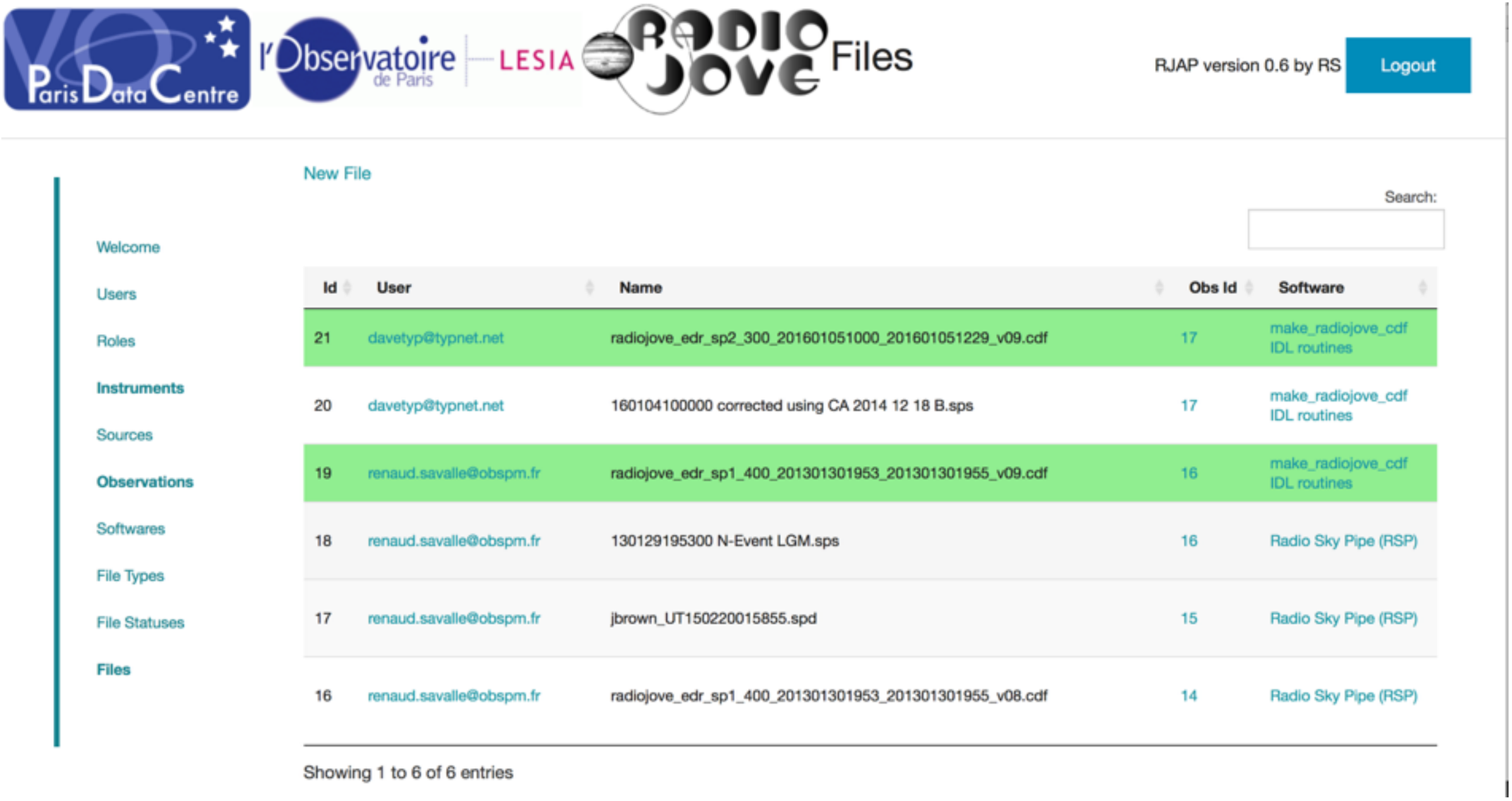
RadioJOVE archive+distribution

- Ongoing project with RadioJOVE team to prepare archive of their data in NASA/PDS/PPI.

- Data submission website:
  https://voparis-radiojove.obspm.fr
  registration required, data validation by science team. Once validated, data is converted into CDF, preview file is computed and data is put online in VESPA infrastructure.

- Data collection is being assessed with NASA/PDS/PPI for archive (started April 2016).

RadioJOVE submission interface



Once validated, data product is automatically online in VESPA
A tweet is sent with the generated quicklook, to thank the amateur provider.

Tools Summary

- Web site: http://maser.lesia.obspm.fr
  MASER: Measurement Analysis and Simulation of Emissions in Radio *(sounds better in French…)*
- Planning Tool: https://voparis-juno.obspm.fr
  (Twitter support planned for new submissions)
- Data distribution support: http://discussions.europlanet-vespa.eu
- RadioJOVE archive: https://voparis-radiojove.obspm.fr
  (Twitter just added for new submissions: @radiojove_arch)
- Online support and discussion:
  https://maser.slack.com (#juno-ground-support)
- Accessing data: http://vespa.obspm.fr

Status

- ♺ JUNO-Ground-Radio section of MASER Web site
- ♺ Data distribution servers:
  - [FR] Nançay Decameter Array: registered but must be updated;
  - [JP] Iitate Observatory: ready but not registered; CDF ready.
  - [USA] LWA1: under construction (C. Higgins in charge)
  - [UKR] UTR-2: planned for June.
  - [EU] LOFAR: status unknown
  - [USA] RadioJOVE: ready (data coming).
- ✓ Online tutorials, support and discussion tools
- ✓ Accessing data (VESPA)
- ✓ Planning (inputs from each participant to be completed)
- ♺ ExPRES: new public access release planned for 2017.