MASER (Measuring Analyzing & Simulating Emissions in Radio frequencies)
— a toolbox for low frequency radio astronomy —

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A Toolbox for Data Providers
- Distribute data catalogues
- Distribute data for direct access
- Standard APIs

A Toolbox for Scientists
- Search for data of interest
- Visualize online data
- Use a library of tools and codes

An Open Toolbox
- Interoperable standards
- Virtual Observatory access
- Reuse of existing software

Interfaces
- Distribution of catalogues (events and products) : **VESPA**
- Online visualization: **Das2**+**Autoplot**

What Data?

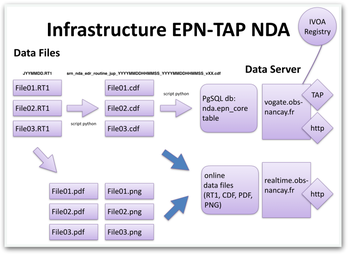
- Low Frequency radio data: up to ~100 MHz
- Mostly spectrograms (time-frequency)
- Ground observatories and Space platforms
- Catalogues of events
- Raw and derived data
- Standard formats (CDF) and metadata

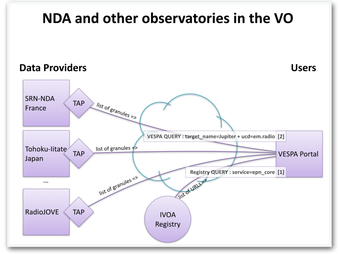
Main Tools and Software

- **ExPRES** (Exoplanetary & Planetary Radio Emissions Simulator) Simulation of CMI [maser cyclotron instability] emissions. Public query interface coming soon.
- **Maser4py**: Python (3.5+) software library https://github.com/maserlib/maser4py (open source)
- **ARTEMIS-P** (ray tracing code for planetary radio emissions) [available soon]
- **Das2** servers (currently under test): Meudon and Nançay. http://voparis-maser-das.obspm.fr/das2/server
- **Project interfaces**: Juno-Ground-Radio, RadioJOVE

- **Virtual Observatory** (Interoperable) interfaces using IVOA protocols, through VESPA (Virtual European Solar and Planetary Access
- Network of databases with same data discovery interface, that can be queried simultaneously.
- Databases from all fields in Solar System (Sun, Space Physics, Planetary…) are connected.

- Member of the **Helio-Python** working group
- Interoperability:
  - IHDEA: https://ihdea.net
  - IPDA: https://planetarydata.org
  - IVOA: http://www.ivoa.net
- Link with SPASE under study
  - Reorganization of Observatories and instruments
  - NumericalData and Display Data
- Distributing CDPP radio datasets through authenticated webservices



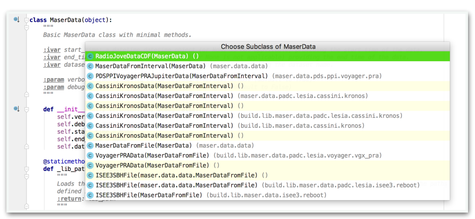


Open Source Library

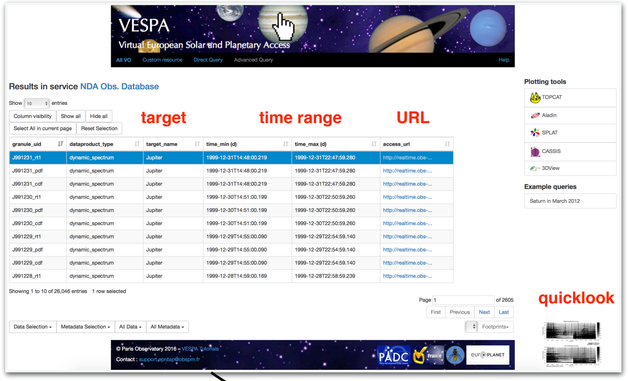
- **Maser4py** library:
  - Data reader classes for LF radio data collections, Unit tests built-in https://github.com/maserlib/maser4py/tree/develop
  - Generic tools and software for LF radio astronomy
  - Ground segment software for Solar-Orbiter/RPW, CDF file building helper tools
- **Maser4idl** library:
  - some software for STEREO and Wind, as well as HELIO. Cassini/RPWS/HFR to come soon
  - CDF building tools

Maser4py data classes

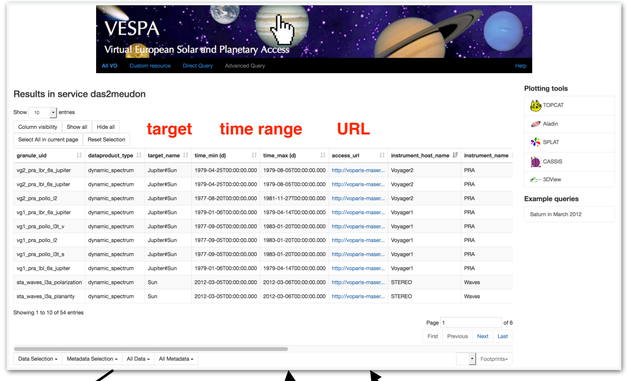
maser.data.cdpp	develop	tested
maser.data.cdpp.demeter.ice	develop	tested
maser.data.cdpp.interball.polrad	develop	tested
maser.data.cdpp.isee3.sbh	develop	tested
maser.data.cdpp.demeter.ice	develop	tested
maser.data.cdpp.ulysses.urap		coming soon
maser.data.cdpp.viking.v4n	develop	tested
maser.data.cdpp.wind.waves	develop	tested
maser.data.nancay	feature/data	
maser.data.nancay.nda	feature/data	
maser.data.nancay.nda.junon	feature/data	
maser.data.nancay.nda.newroutine	feature/data	
maser.data.nancay.nda.routine	feature/data	
maser.data.nancay.nenufar	feature/data	
maser.data.padc.lesia.cassini.kronos	develop	tested
maser.data.padc.lesia.cassini.rpws	develop	tested
maser.data.padc.lesia.voyager.vgx_pra	feature/data	
maser.data.padc.radiojove.radiojove_spx	feature/data	
maser.data.pds.ppi.pds	feature/data	
maser.data.pds.ppi.cassini.rpws	feature/data	
maser.data.pds.ppi.cassini.rpws.hfr	feature/data	
maser.data.pds.ppi.cassini.rpws.wbr	feature/data	
maser.data.pds.ppi.cassini.voyager.pra	feature/data	
maser.data.solo…	develop	on the move
maser.data.wind…	develop	on the move

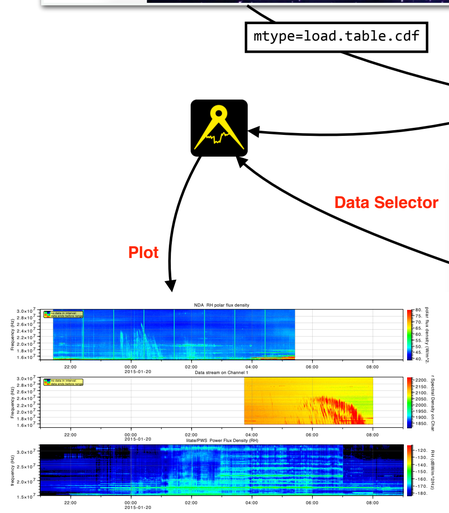


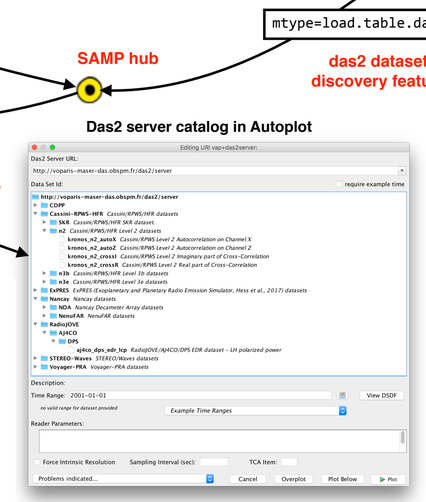
VESPA result page in Nançay/NDA EPN-TAP service

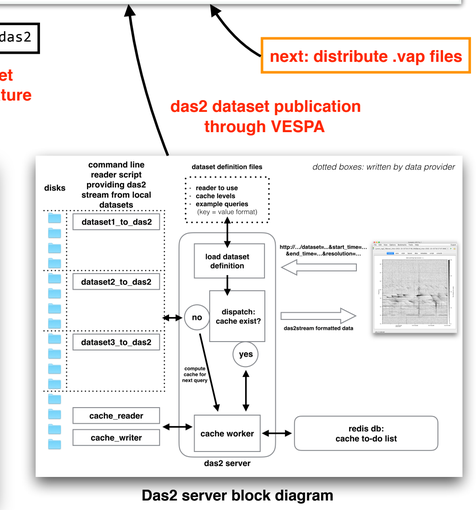


VESPA result page for all das2server dataset in Meudon



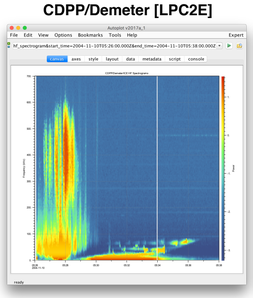




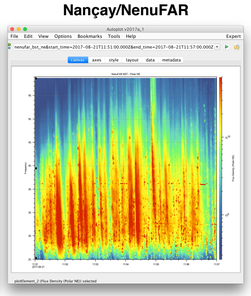


Das2 server block diagram

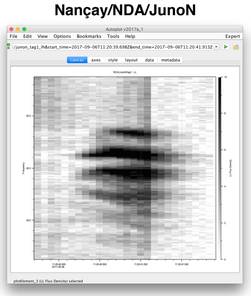
CDPP/Demeter [LPC2E]



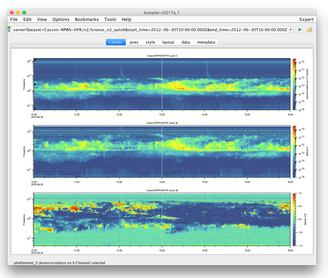
Nançay/NenuFAR



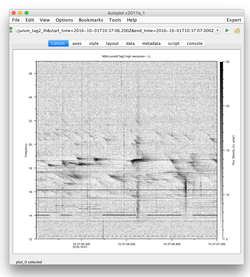
Nançay/NDA/JunoN



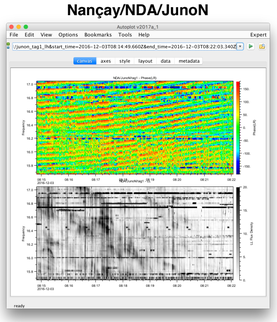
Cassini/RPWS/HFR



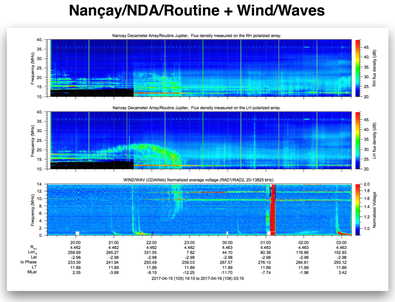
Nançay/NDA/JunoN



Nançay/NDA/JunoN



Nançay/NDA/Routine + Wind/Waves



2019 Deployment Plan

- **Datasets (das2 + VESPA)**
  - **CDPP**: Interball, Viking, Demeter, Wind, Ulysses, STEREO, Cassini, Cluster, ISEE3…
  - **LESIA**: Cassini, STEREO, Ulysses, Wind, ISEE3, Voyager, Radio-Exopla, RadioJOVE (amateurs)…
  - **Nançay**: NDA-Routine, NDA-NewRoutine, NDA-JunoN, NenuFAR…
- **Catalogs (VESPA)**
  - Historic: Voyager-Nançay (1977-1981) catalogs
  - Jovian radio emissions (Marques et al 2017)
  - Solar radio emissions (Reid et al 2016)
  - Heliophysics Feature Catalog (HELIO-HFC)
- **Space Missions support (das2 + VESPA)**
  - Solar Orbiter/Parker Solar Probe
  - Juno-Ground Radio
- **Codes**
  - ExPRES run-on-demand interface.
  - Implementation of Helio-Python guidelines

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