The Nançay Decameter Array (NDA) : a ground-based support to SolO/PSP beyond 10MHz

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SolO/PSP meeting, Meudon, 6 Nov. 2017

Decameter array built in 1975-1977

CESRA conference proceedings, 1975

PROJECT OF A LARGE COLLECTING ARRAY AT NANÇAY

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Since 1970 the « decametric » radio astronomy group studies solar and Jovian emissions in the range 80 to 20 MHz. The existing equipment has been described by Boischot (1974). It was primarily designed to obtain high frequency and time resolution spectra. The experience gained during a mission to Arecibo when the 1000ft dish was used with the Nançay spectrographs showed the great interest of increasing the sensitivity by using a large collecting area.

Hence, a project of a 144 antennas array (72 left-hand and 72 right-hand polarized antennas) has been studied, which will allow to observe a source several hours a day, will have an instantaneous bandwidth of at least one octave, and a large collecting area providing a gain of 24 db in both polarizations, i.e. about 25 times the gain of our present antennas. The primary antenna is the so-called « Tee-Pee » antenna designed by Erickson and Fisher (1974) for the Clark Lake Radio Observatory (California). It is made of eight coppered-steel helices wounded on a conical structure (Fig. 1) allowing to observe frequencies between 120 and 20 MHz with a nearly constant gain. According to the sense of winding of the antennas, left and right hand circular polarizations may be obtained.

This type of antenna can be easily phased by a simple rotation around the cone axis — in practice by a simple commutation of the wires connected to the antenna output —. But this kind of phasing is frequency dependent, and limits the instantaneous bandwidth of the array (3 MHz at C.L.R.O.).

To secure a large enough bandwidth both this phasing by rotation and the usual phasing by delay-lines, which is achromatic, must be used. The grouping of the antennas has been optimized with a computer, to give the largest bandwidth and the longest tracking possibility, with a nearly constant gain.

The phasing by rotation will be used inside groups of 2 *EW* × 4 *NS* antennas, and the array will have 6 *EW* × 3 *NS* such groups, the relative phase of which can be changed by variable delay lines.

Fig. 2 gives an example of gain computation. The main characteristics of the array are summarized in Table 1.

C. CHIUDERI, M. LANDINI, A. RIGHINI (editors), *First European Solar Meeting* (Florence, February 25-27, 1975) Osservazioni e Memorie Osservatorio di Arcetri (Firenze) n. 105.

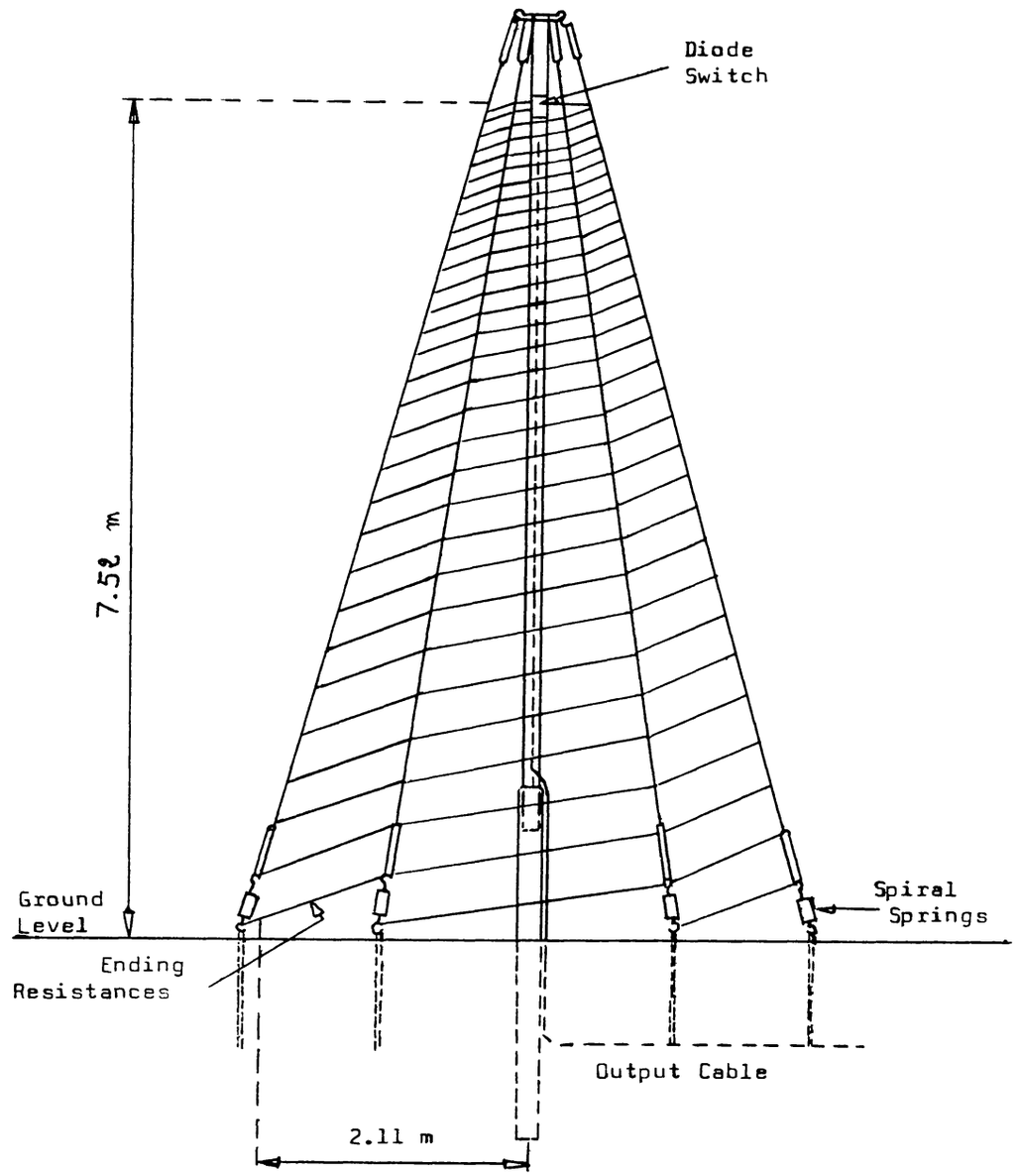
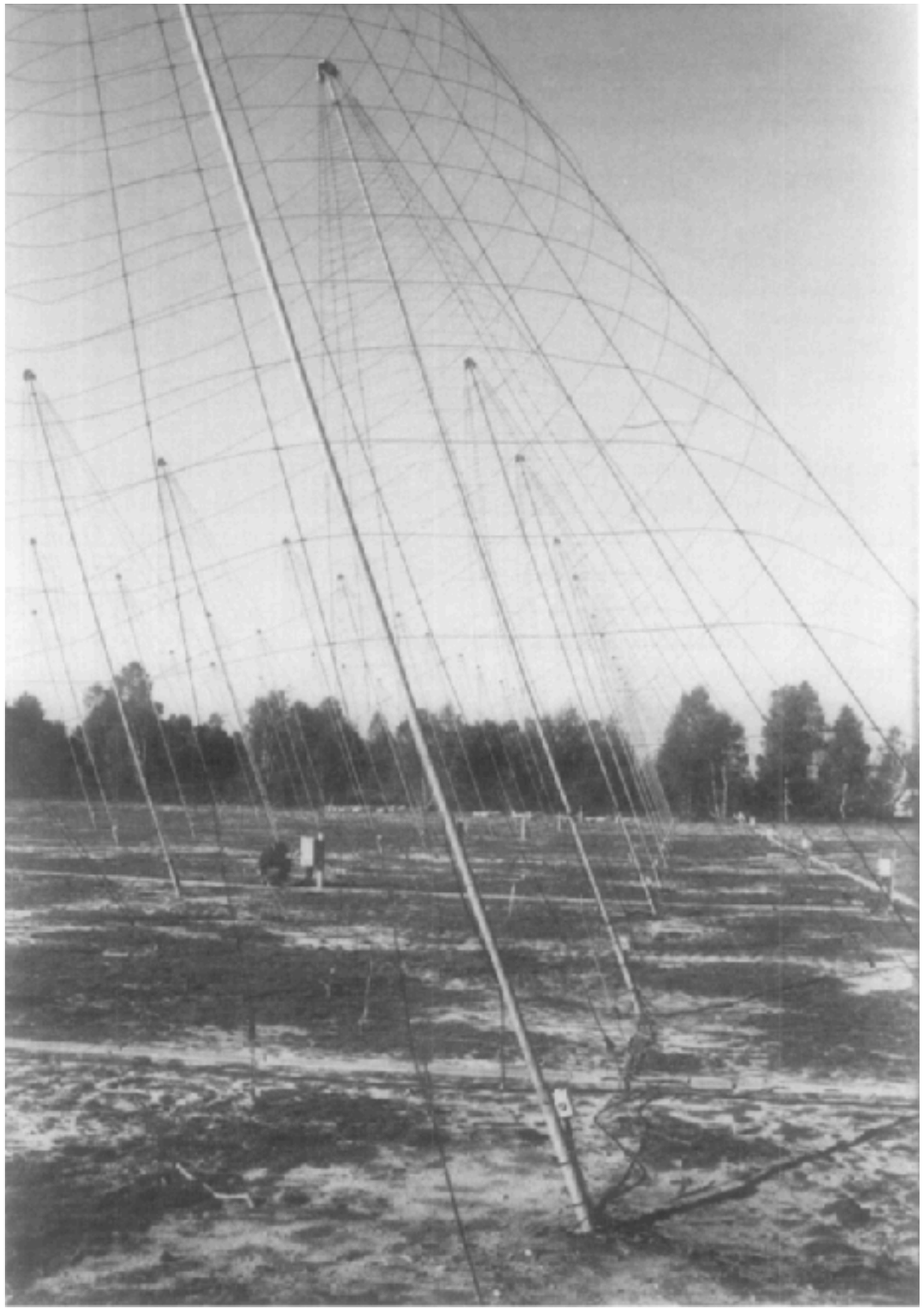


FIG. 1

Conical log spiral antenna (Tee-Pee). The central pipe and the wires going from top to bottom form the supporting structure on which eight electrical wires are wound. Actually this structure will be inclined at an angle of 20° southward.

Decameter array built in 1975-1977



Boischot et al., 1980, Lecacheux et al., 2000

<u>Performances of the full array :</u>

144 helical antenna (RH / LH polarizations)

High gain (25 dB) + large beam (7°x12°)

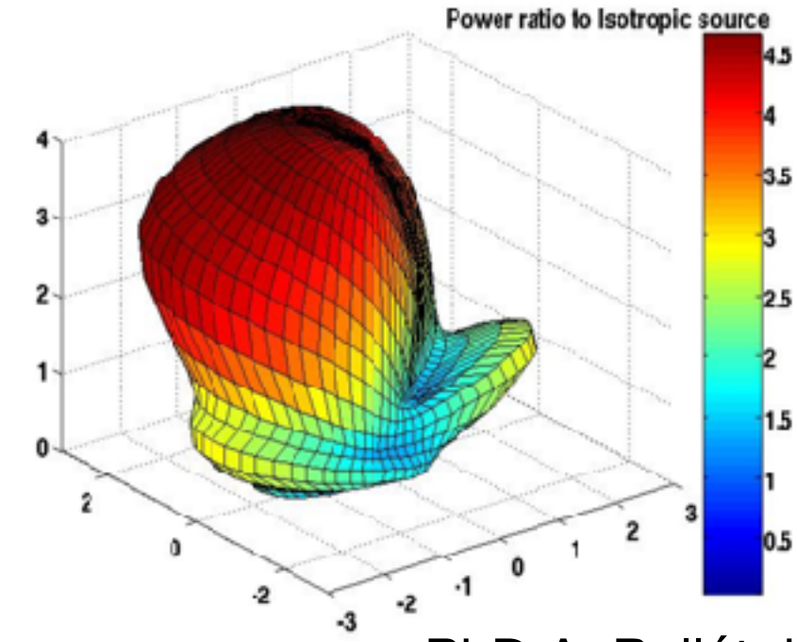
$A_{eff\ 30MHz} \sim 4000m^2$ ($\sim 10^3$ Jy)

f = 10-120MHz

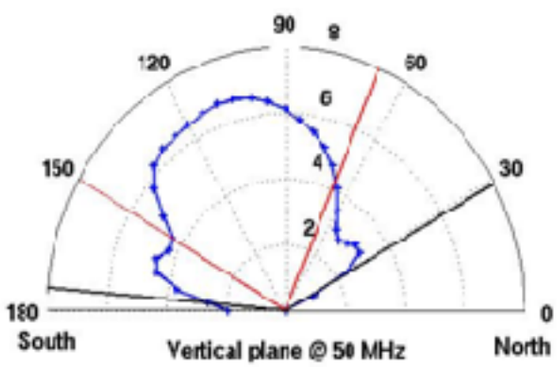
Phased array > Jupiter, Sun (8h / day)

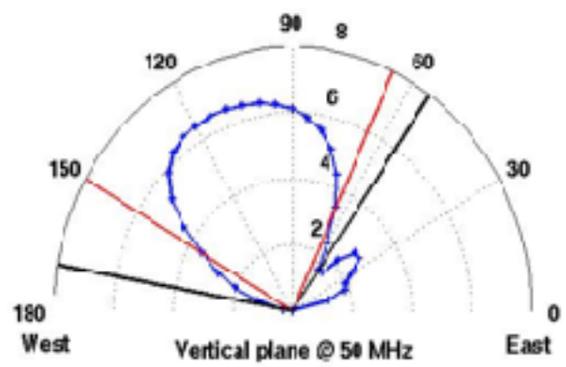
Long-term + high res. t-f measurements

Noise diodes calibration (every 1h)



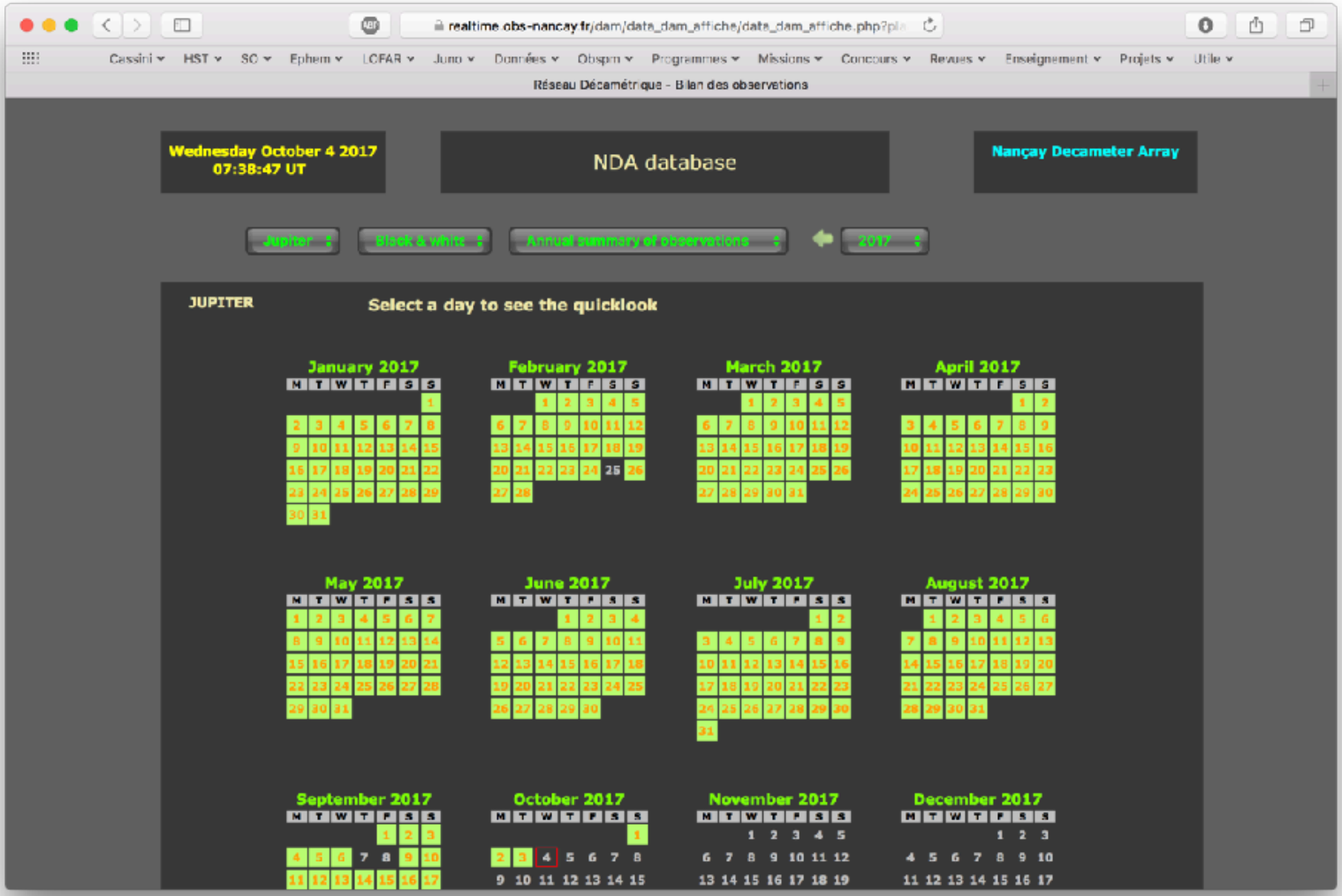
PhD A. Bellétoile



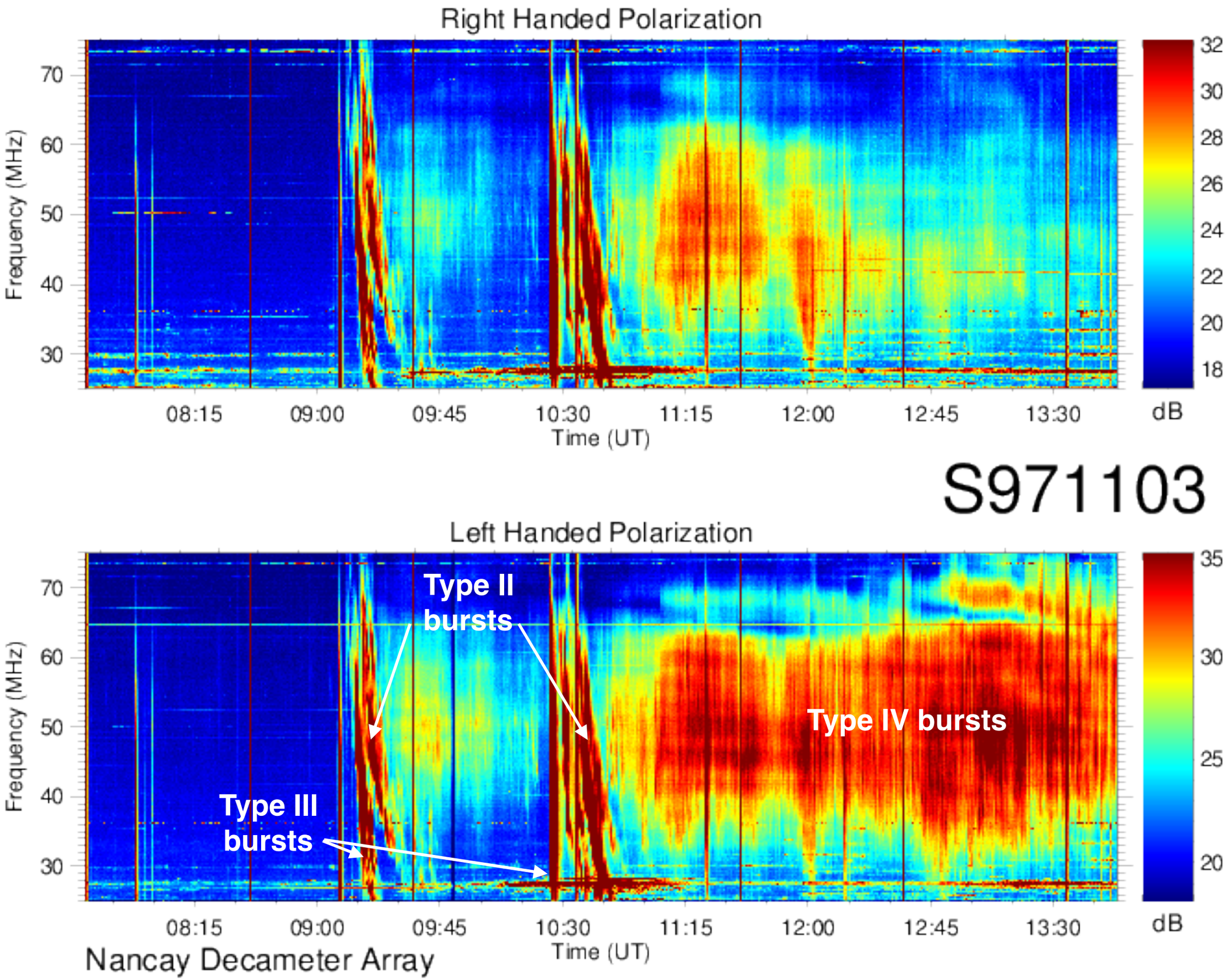


Digital observations since 1990

https://www.obs-nancay.fr/



Tracking of solar radio bursts



4 digital receivers operating simultaneously

Receiver	Measurements	Channels	Spectral range (MHz)	Resolution (ms × kHz)	Data volume (per 8 h)	Format
Routine (1990–...)	RR, LL[1]	2	10–40 (Jupiter)	500 × 75 kHz	22 MB / 8h	binary, CDF
			10–80 (Sun)	500 × 175		binary
New Routine (2012–...)	RR, LL, LR	4	10–40 (Jupiter)	500 × 49	567 MB	FITS
	RR, LL	2	10–88 (Sun)		768 MB	FITS
Mefisto (2013–...)	RR, LL	2+2[2]	10–35	100 × 50	180 MB	FITS
JunoN (2016–...)	RR, LL, LR + Waveform	4	6–56 (Jupiter)	2.6 × 3.05[3]	2.9 TB	binary
				83.2 × 12.2[4]	22.6 GB	

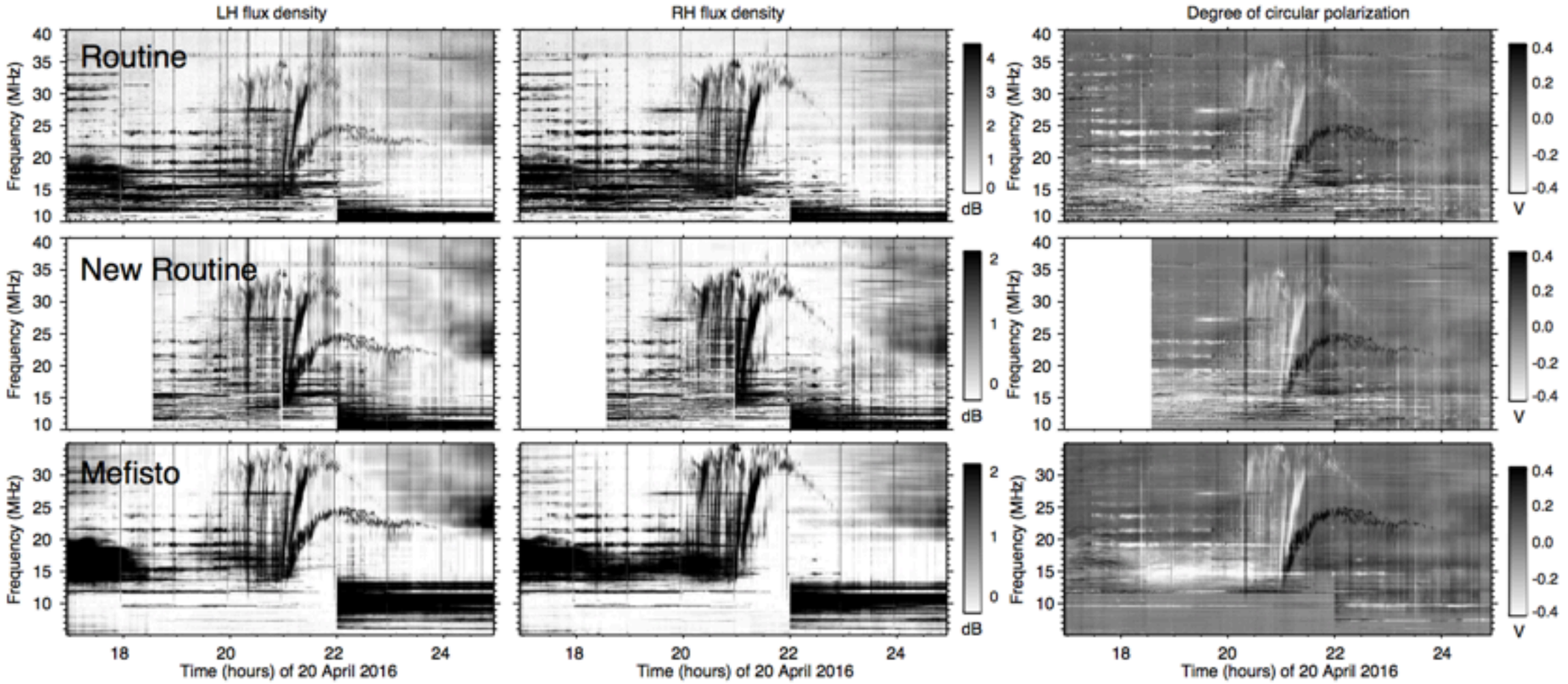
Sensitivity

20000 Jy

600 Jy

1500 Jy

Lamy et al., arxiv, in press



Lecacheux et al., 2000

Zarka et al., 2012

Lecacheux et al., 2013

Nançay/NDA data access

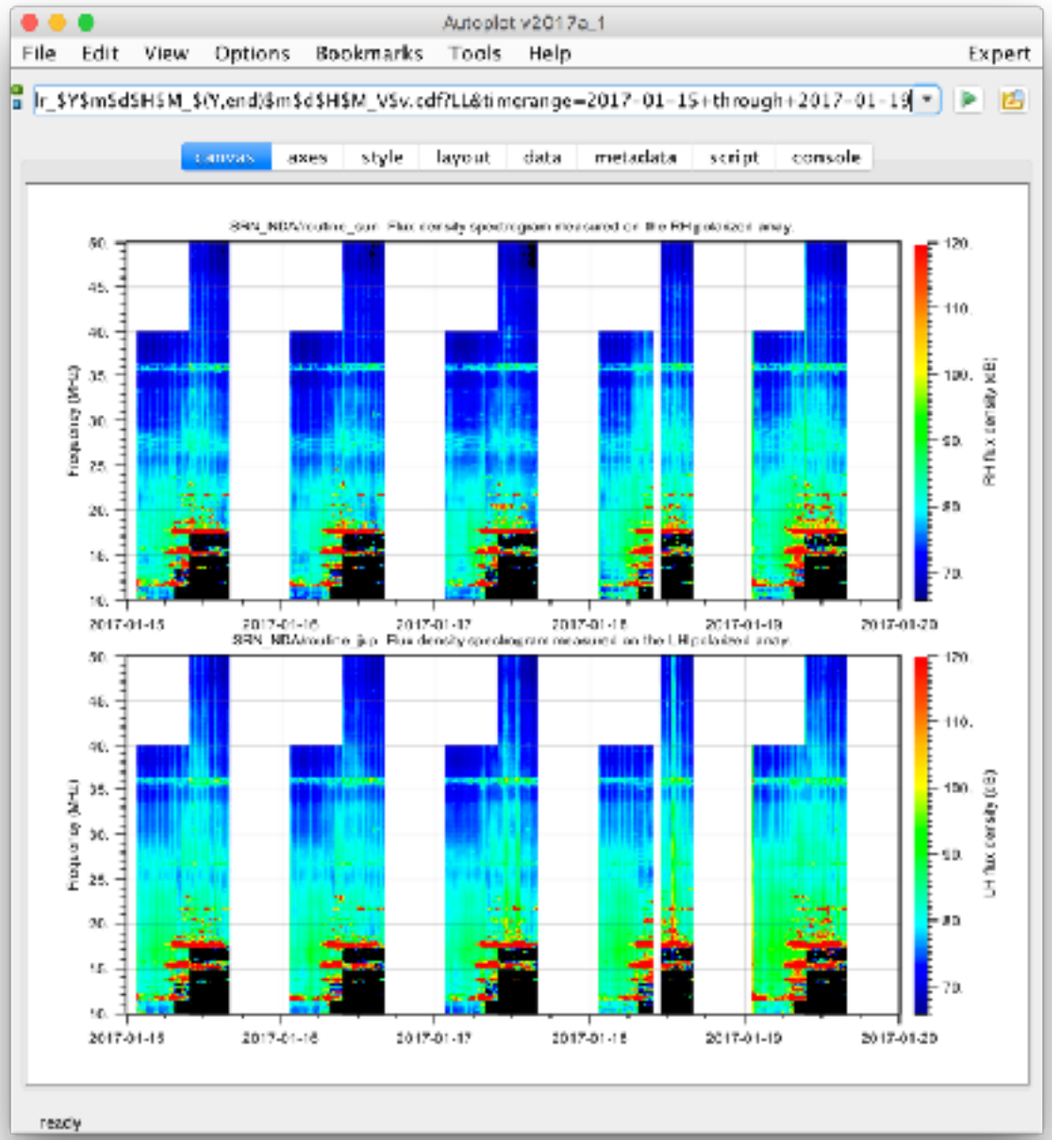
- Data formats:
  - raw binary files
  - CDF (Routine: done; NewRoutine: ongoing…)
    Same set of metadata (ISTP+VESPA) as Solar Orbiter RPW CDF
    See: SOL-SGS-TN-0009_MetadataStandard_2.0.pdf
  - FITS (never been validated, transition to CDF)

- Software:
  - Maser4py library “data” module include Nançay/NDA Python 3.x classes (also SolO/RPW)
  - IDL routines also available

- Remote access:
  - Autoplot + CDF files: .vap files available (example)
  - Autoplot + Das2server: direct access from autoplot

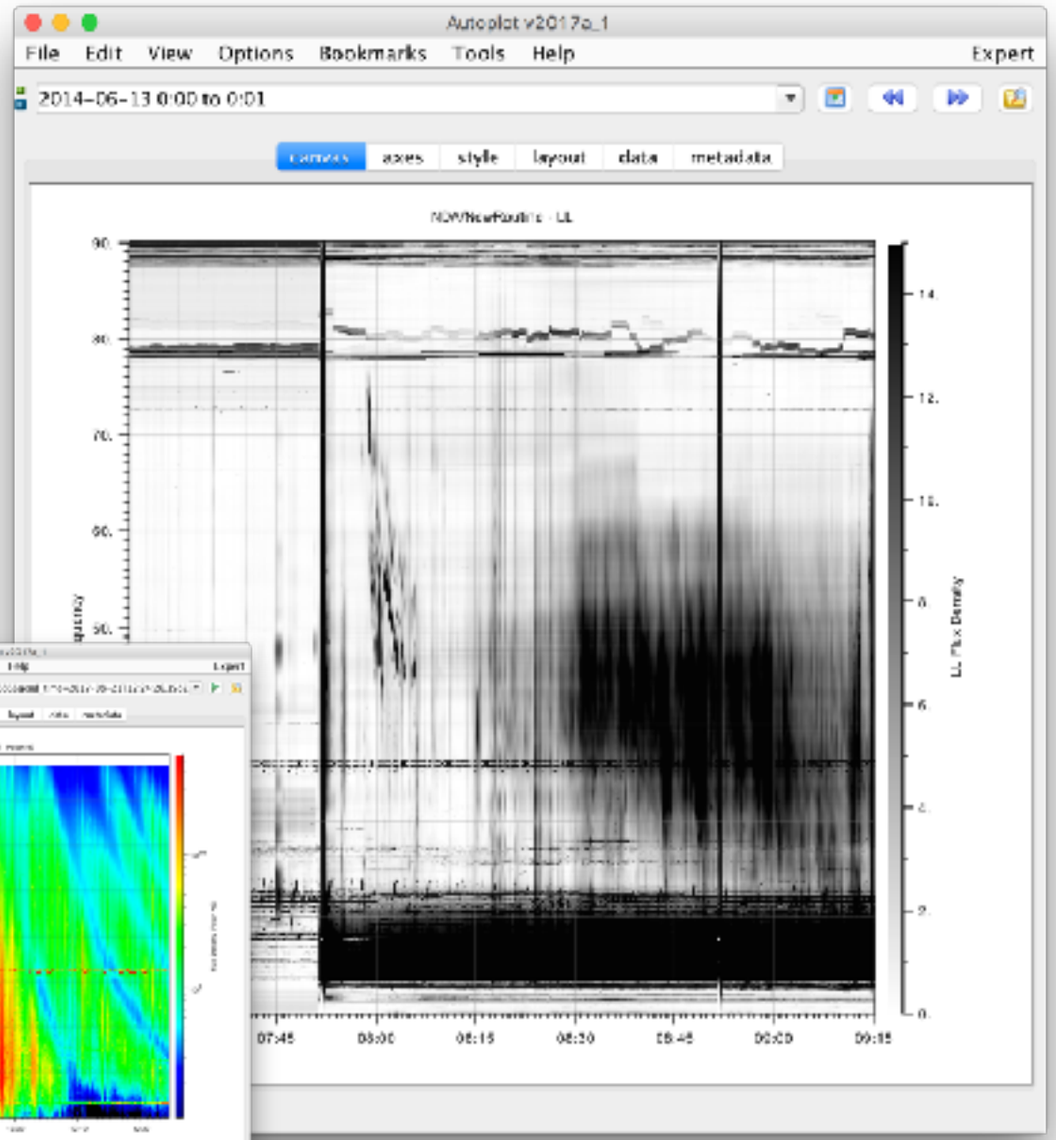
Access through Autoplot

- CDF files

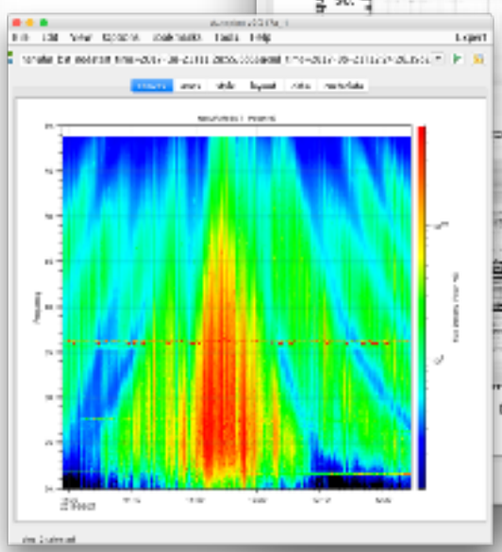


Routine

- Das2server interface



NewRoutine

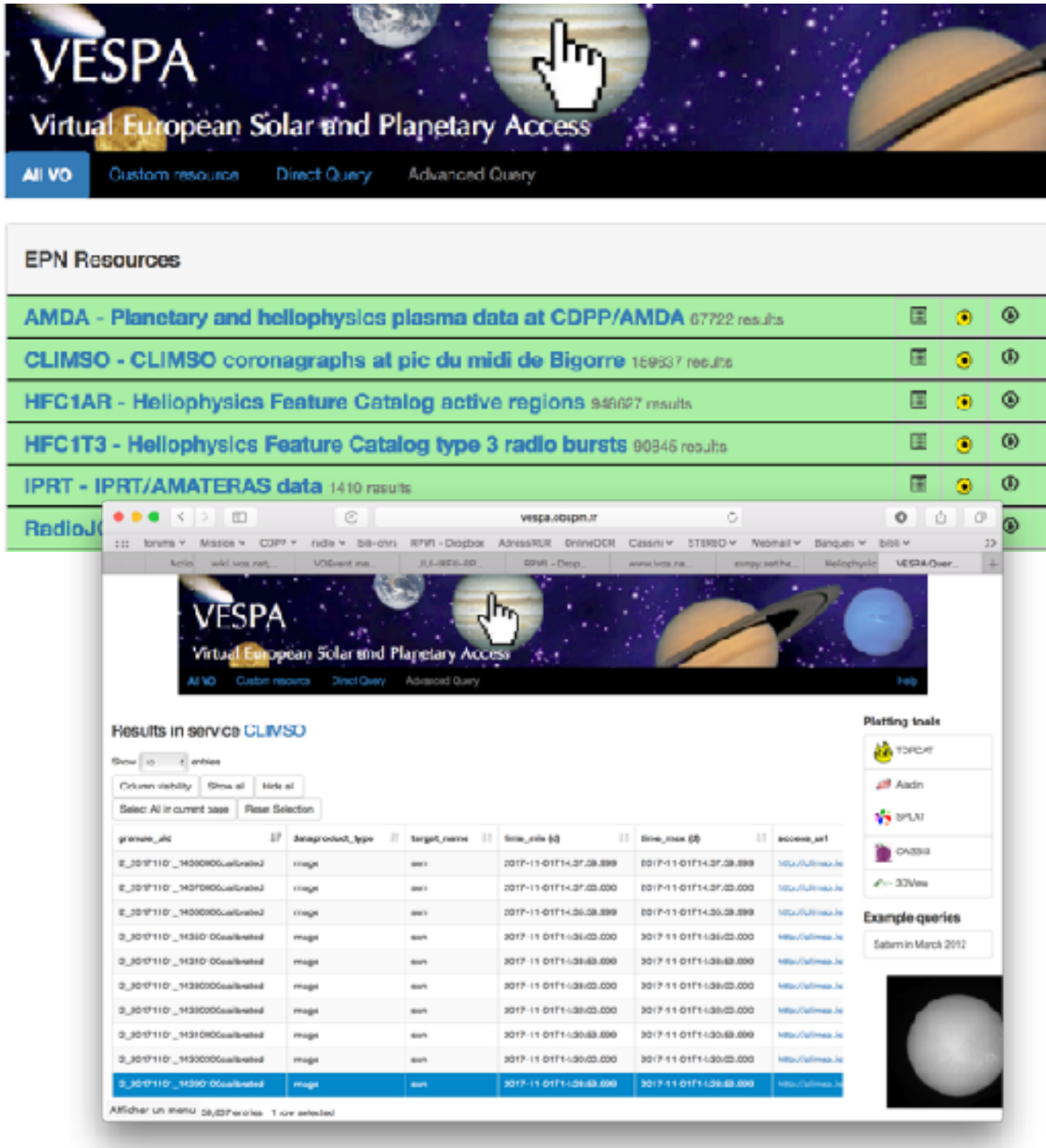


NenuFAR

Access through VESPA

- VESPA (Virtual European Solar and Planetary Access)
  metadata on data coverage (time, spectral, spatial), access, target…

- 35+ datasets currently available.
  Relevant to Solar Orbiter science:
  - **Images**: CLIMSO (solar coronograph @ Pic du Midi, France); BASS2000 and MEDOC to come soon.
  - **Radio**: Nançay/NDA, RadioJOVE; Iitate (Japan); discussion ongoing with e-Callisto network
  - **Catalogs**: HELIO/HFC; any other catalogs?
  Also planned: Solar Orbiter @ ESAC

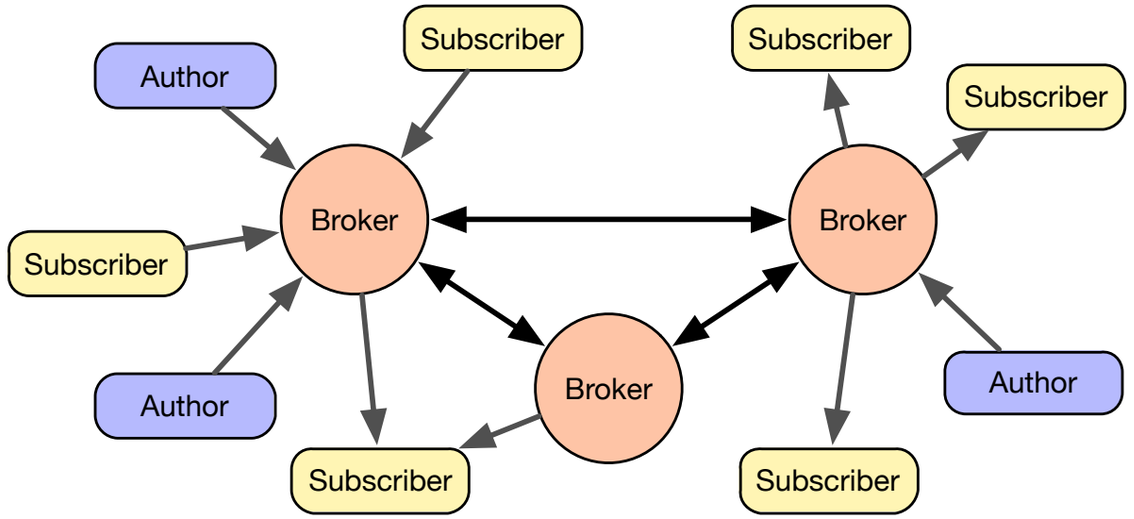


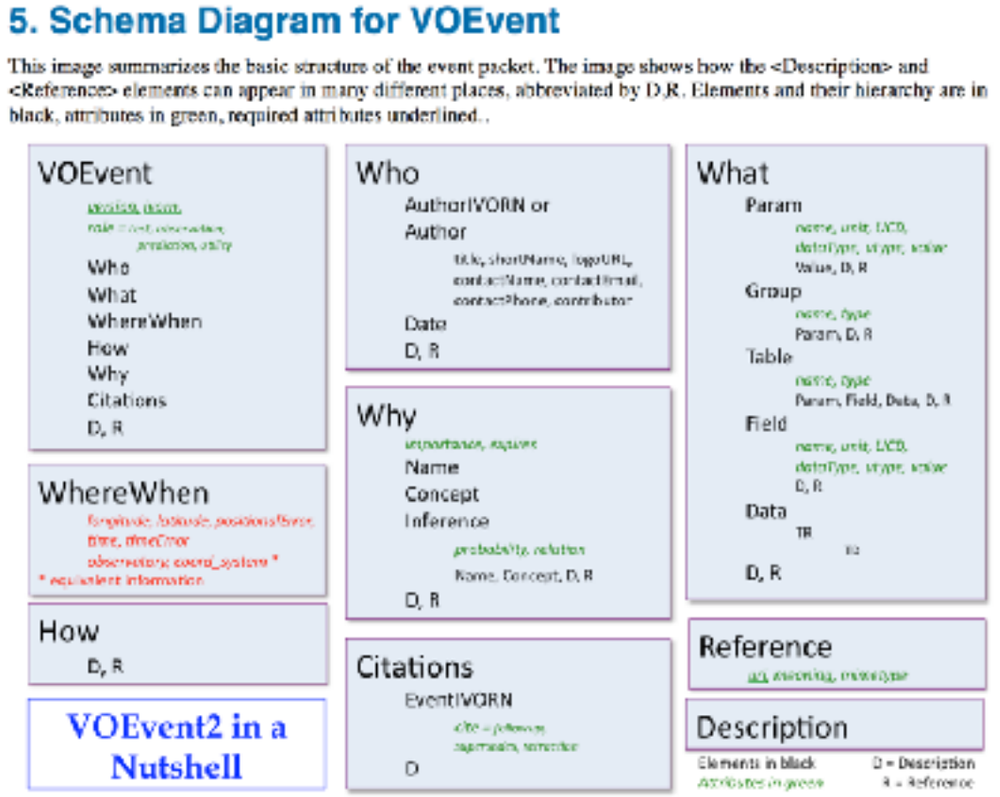
Solar event triggered observations

- Lot of projects are implementing VOEvent-based alert systems in all sky observation domains.

- Full VOEvent ecosystem includes the VOEvent message standard (how to build or parse messages) and the VOEvent Transport Protocol (how to distribute and fetch messages)

- SDO-HEK is using VOEvent v1.1 message syntax, but not the VOEvent transport protocol. Access through SolarSoft or SunPy (not really possible to be used as a trigger)





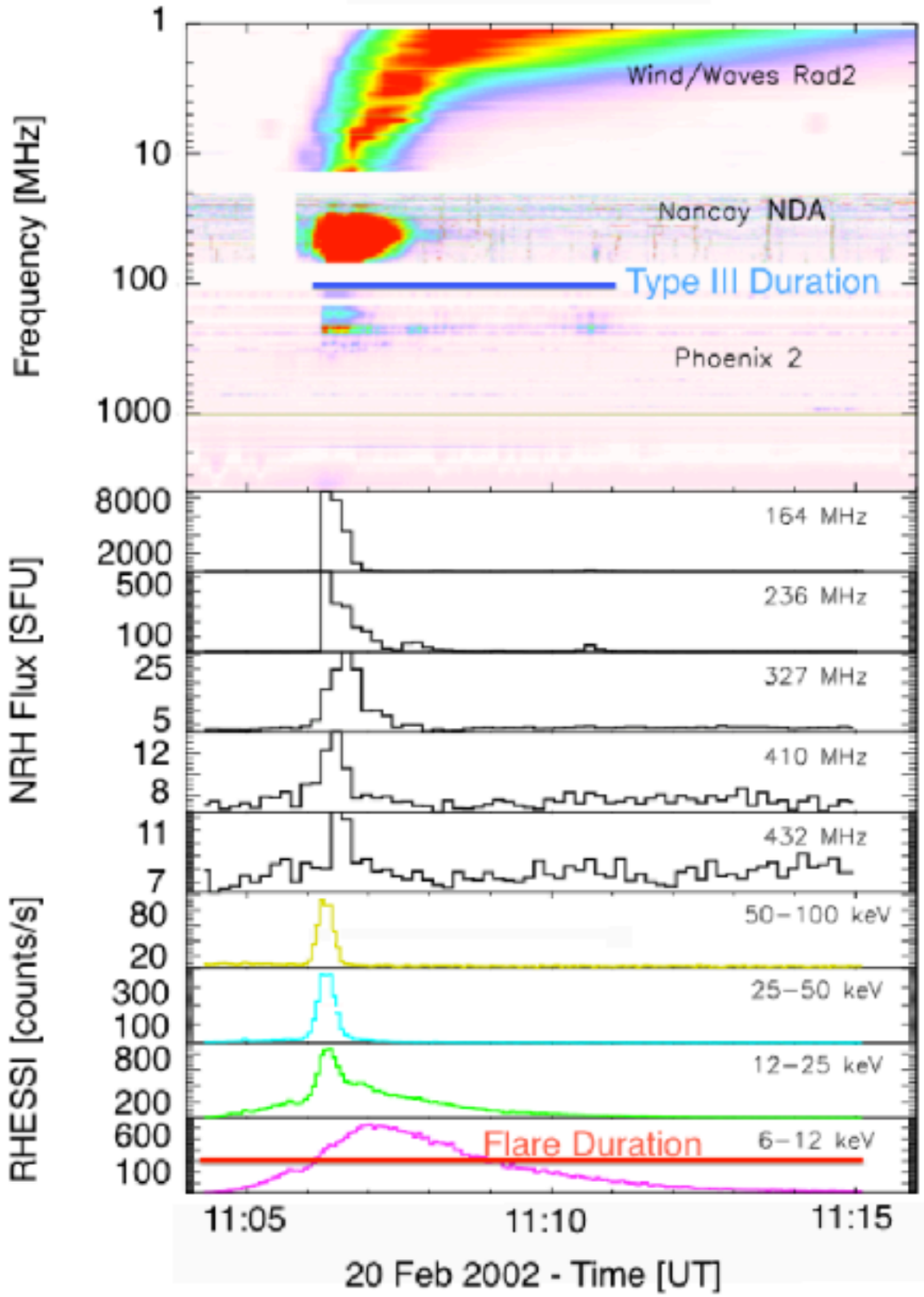
VOEvent at Nançay

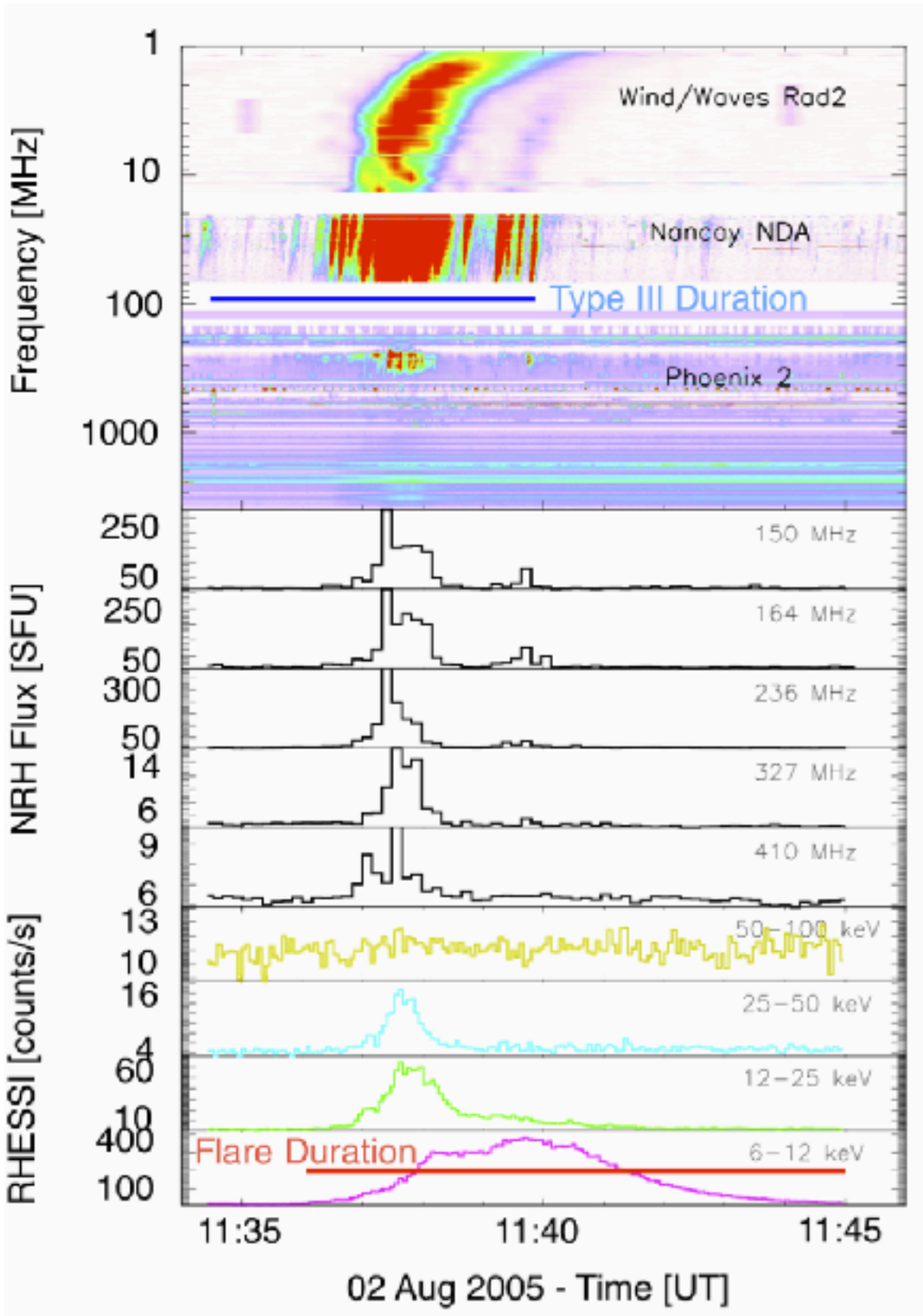
- **Triggered observations**
  upon receiving an event (e.g., Solar Flare):
  high resolution observation sequence with solar pointing could be triggered on NDA
  (or other instrument: LOFAR-FR606, NenuFAR…)

- Implementation ongoing on NenuFAR pipeline for astrophysical transients.
  Plan is to build on this experience.

- **Production of events ?**
  upon observing an event (e.g., a solar burst)
  Still to be evaluated.

Synergy between Nançay HF and spatial LF observations



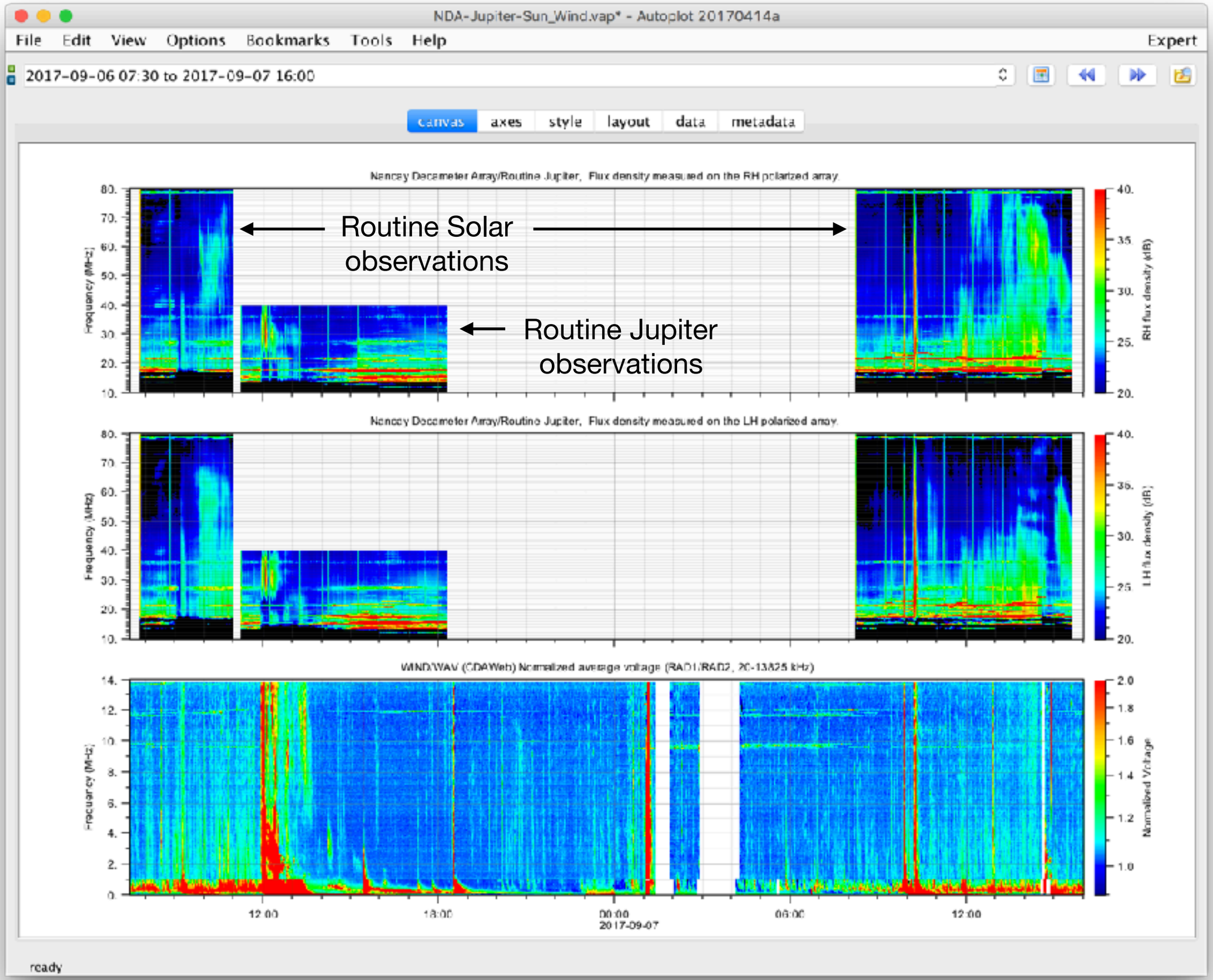


Reid & Vilmer, 2017

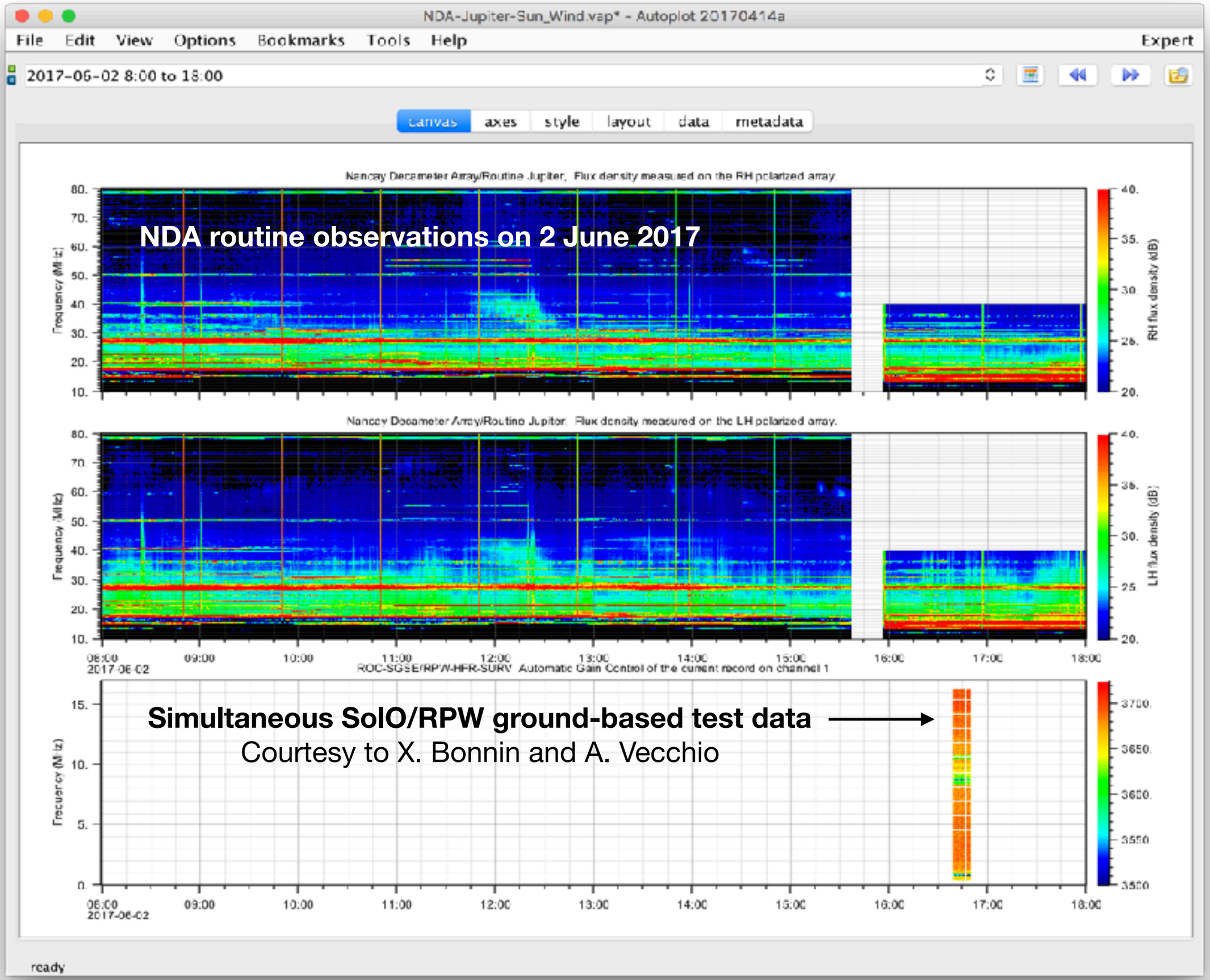
Synergy between Nançay HF and spatial LF observations

CDF

CDA web



Synergy between Nançay HF and spatial LF observations



CDF

CDF

Ground-based support to SolO/PSP

NDA inputs (open to discussion) :

- Temporal coverage : single facility in Europe able to provide daily 10-90MHz ground-based support

- Hourly absolute flux calibration sequences + Stokes parameters + Spectral overlap over 10-16MHz

- High resolution measurements can be coordinated with SolO/PSP : regular bursts mode, alerts ?

- Delivery of NDA routine data after the observation : useful to track radio activity in near real-time ?

- Synergy with other facilities in Nançay :
NRH (see next talk)
LOFAR, NenuFAR (high sensitivity, imaging, survey beam…)



