



# Solar Radioastronomy and X-rays Observations: synergies between ground observatories and SO/PSP (+STEREO A & "WIND")

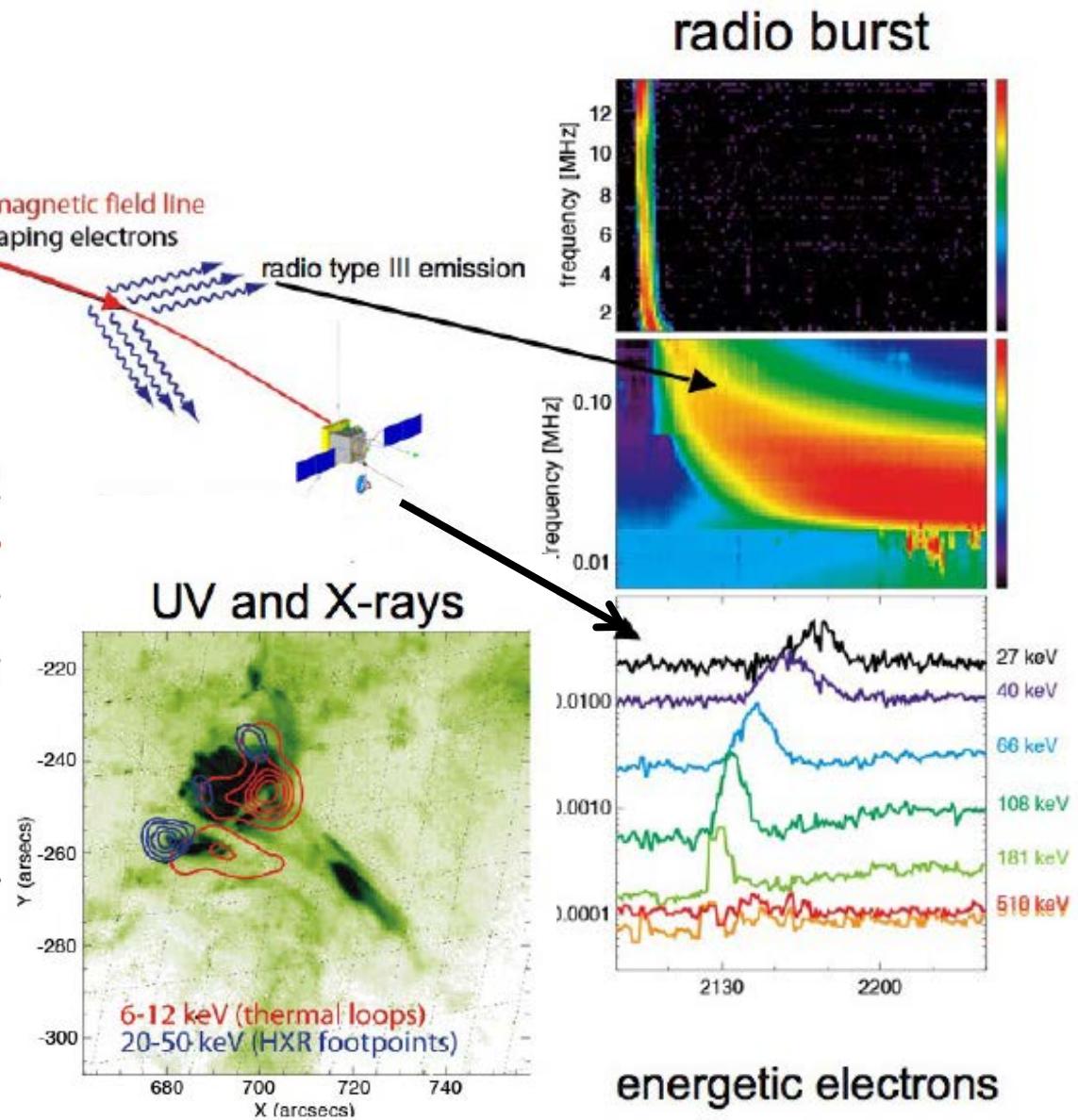
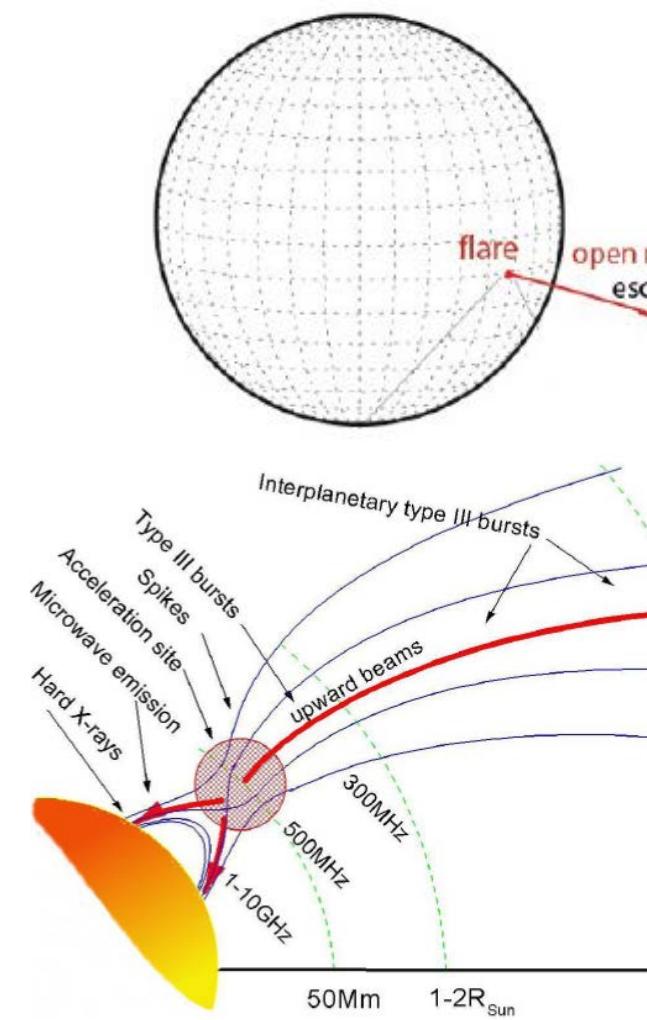
M.Maksimovic et al.

LESIA, Paris Observatory, Meudon  
*[milan.Maksimovic@obspm.fr](mailto:milan.Maksimovic@obspm.fr)*

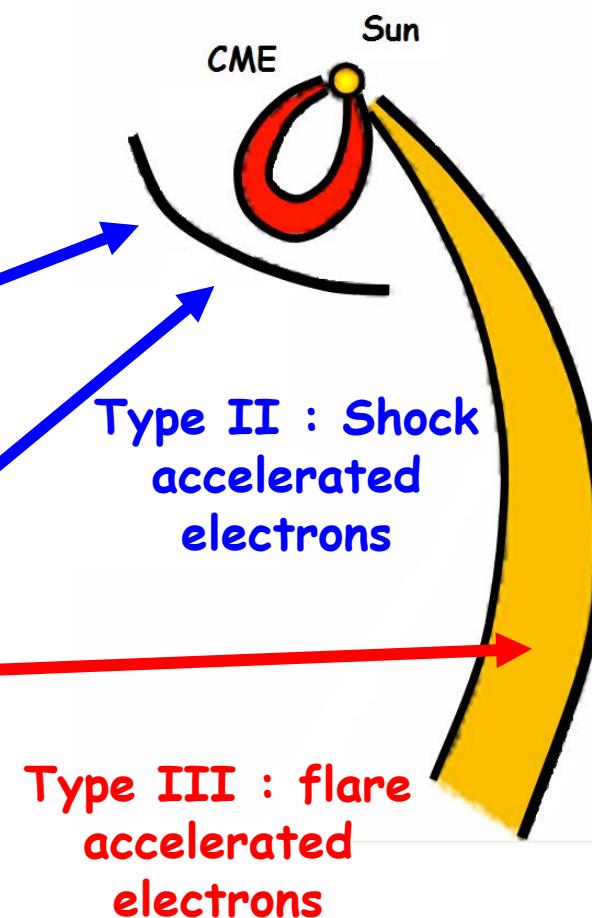
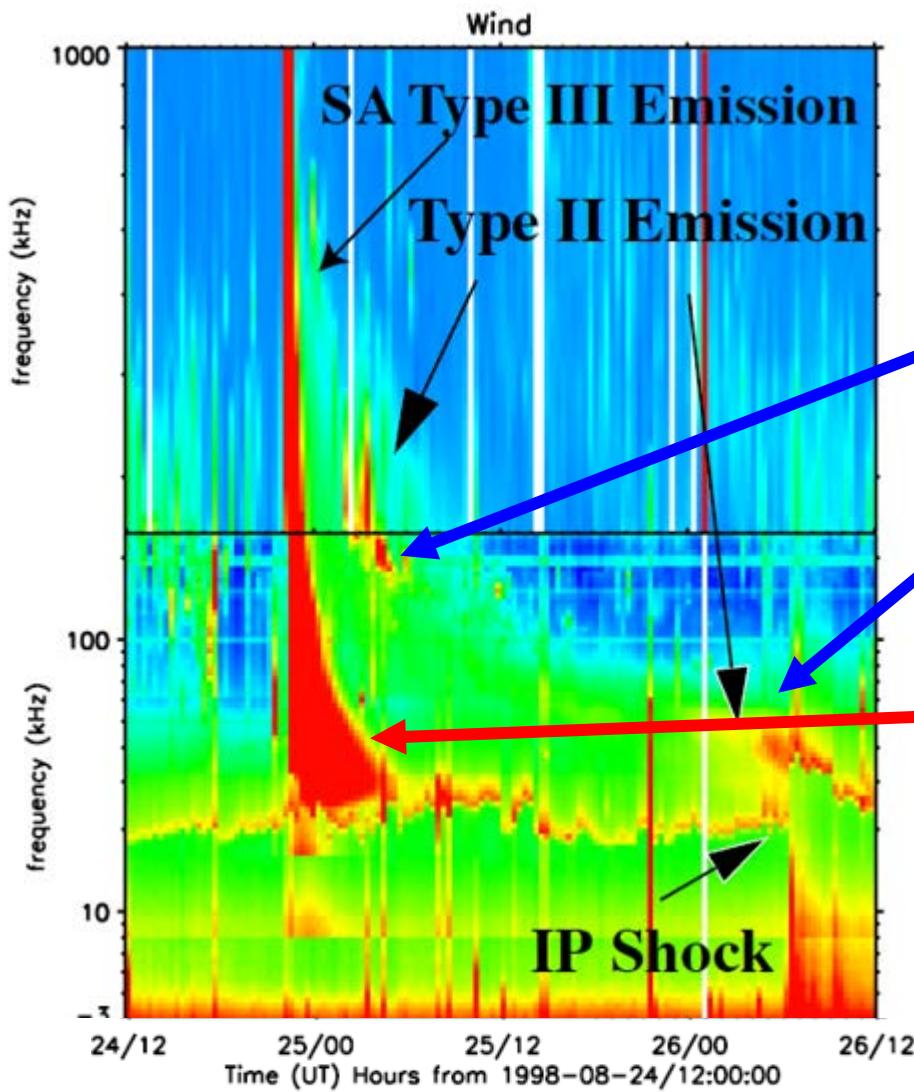
*Alliance meeting, 06 February 2018,  
Manchester, UK*



# Solar Radio Bursts

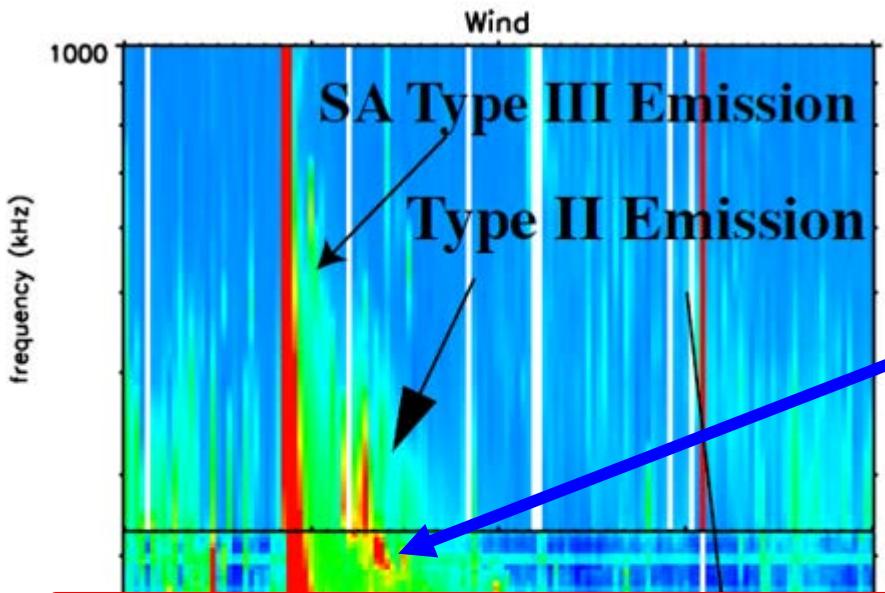


# Type III & Type II solar radio bursts

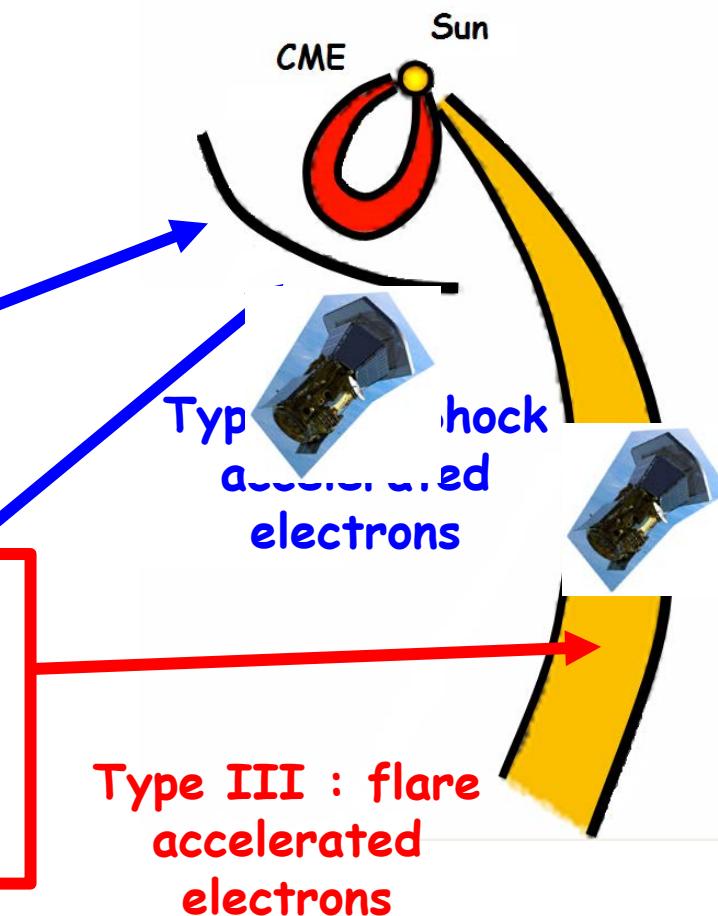
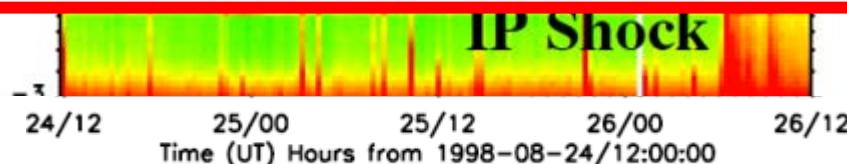


- Emission at  $F_p$  or the harmonic
- $F_p \propto \sqrt{N_e} \propto 1/R$

# Type III & Type II solar radio bursts

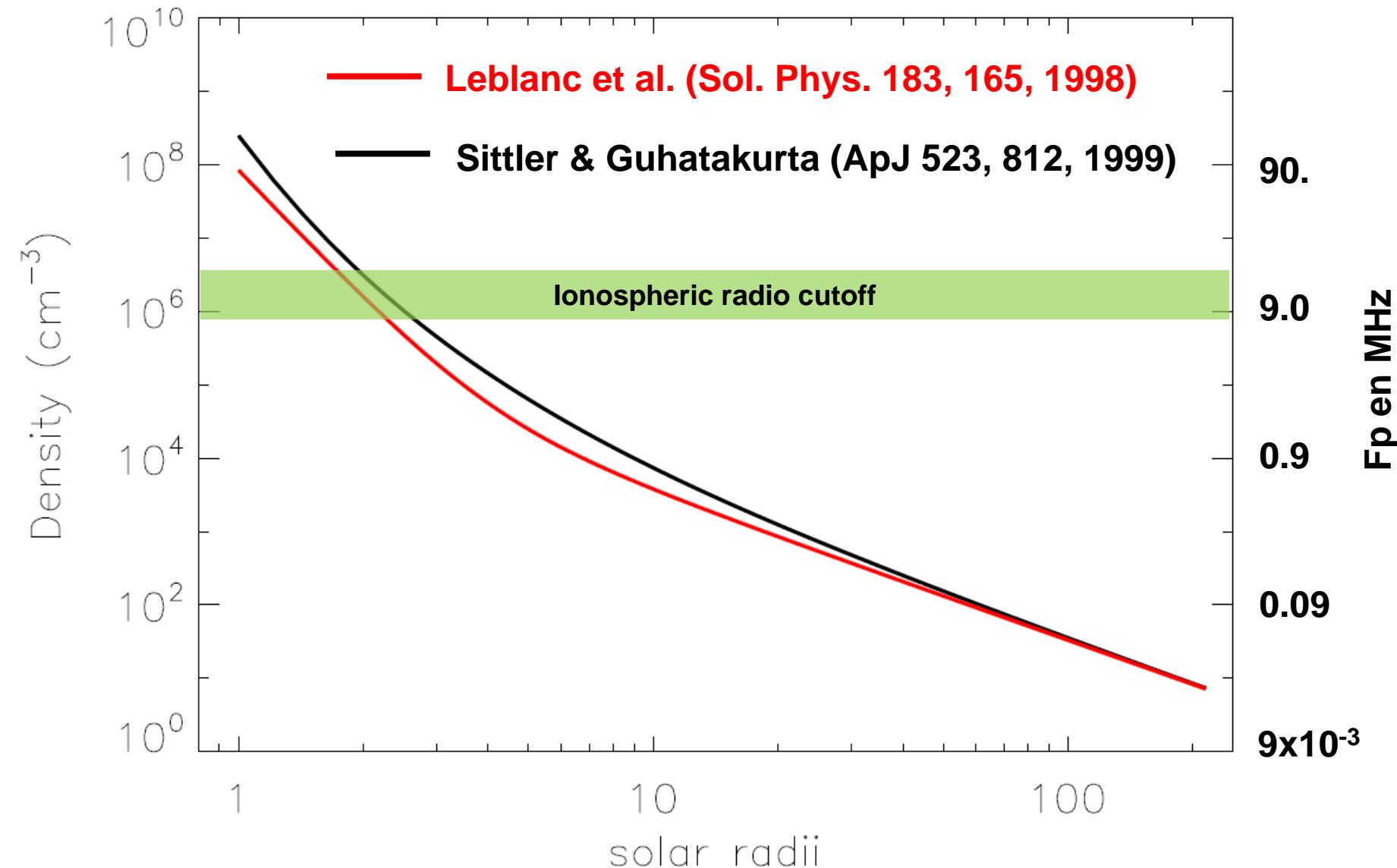


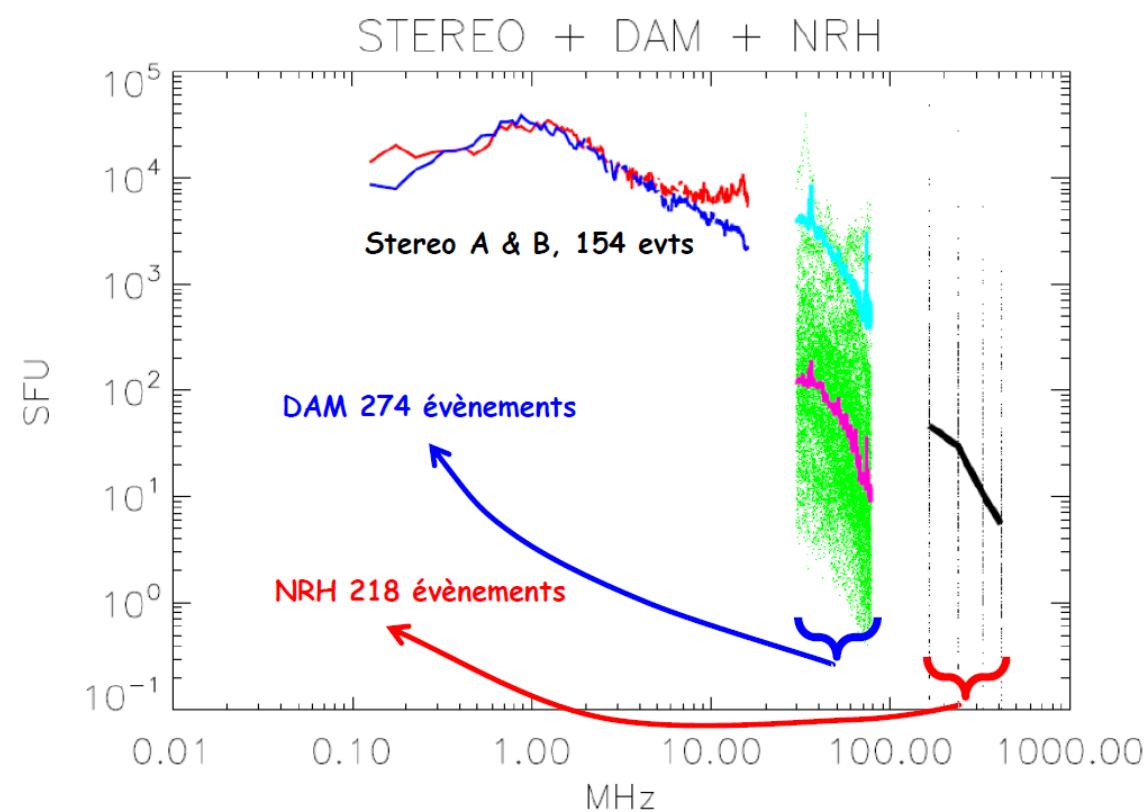
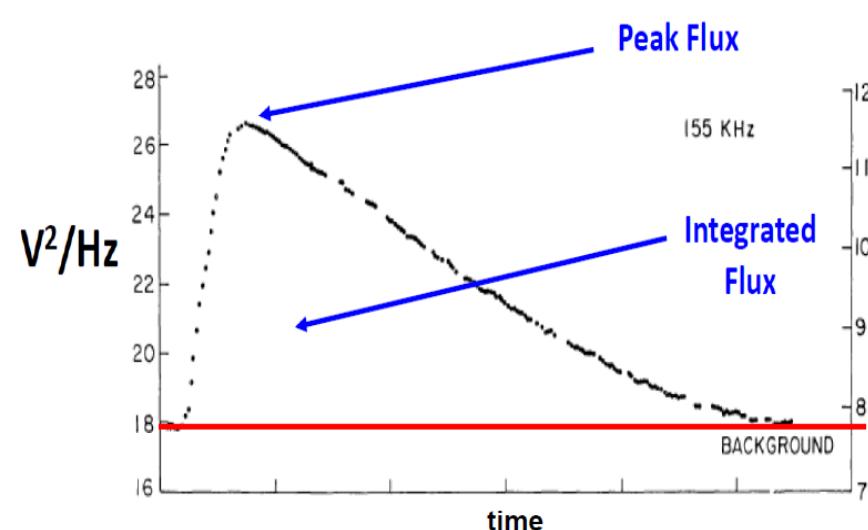
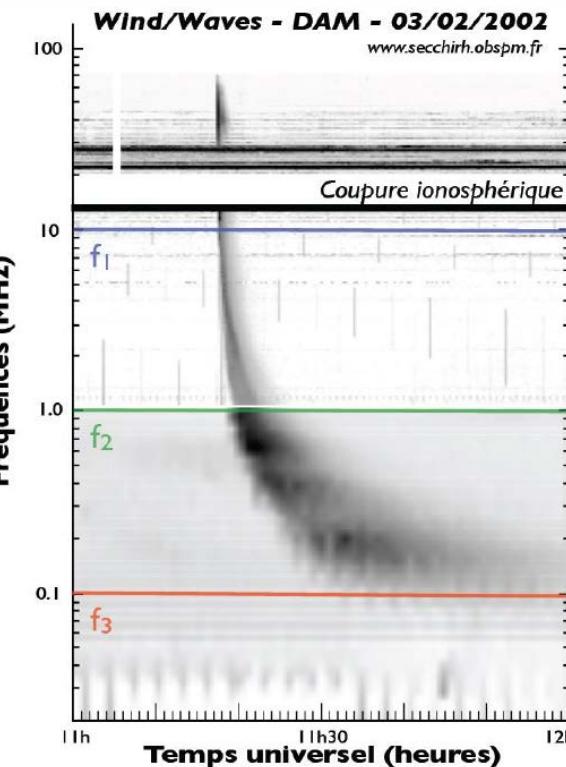
- FIELDS : up to 20 MHz
- RPW : up to 16 MHz
- Direction Finding capabilities on both

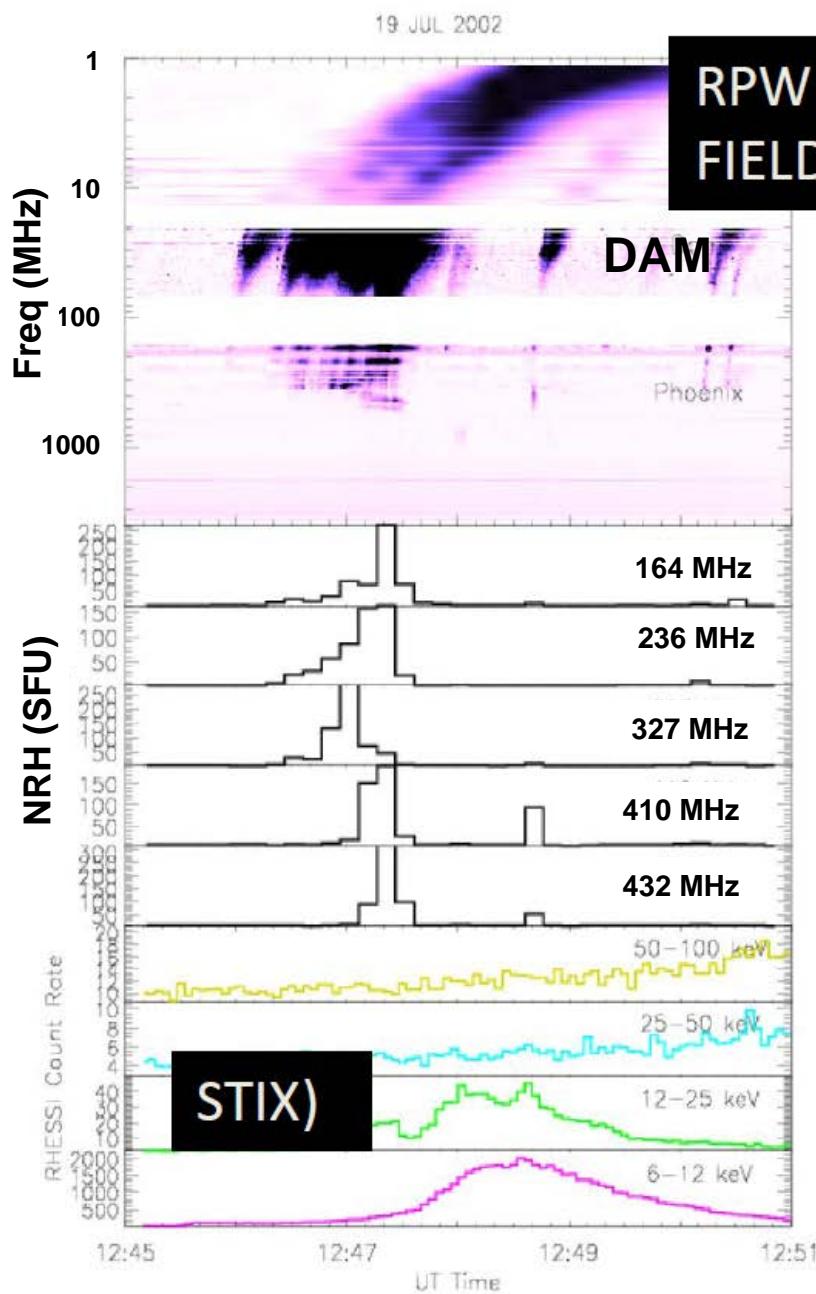


- Fp or the harmonic  $\propto 1/R$

# Radio frequency versus distance

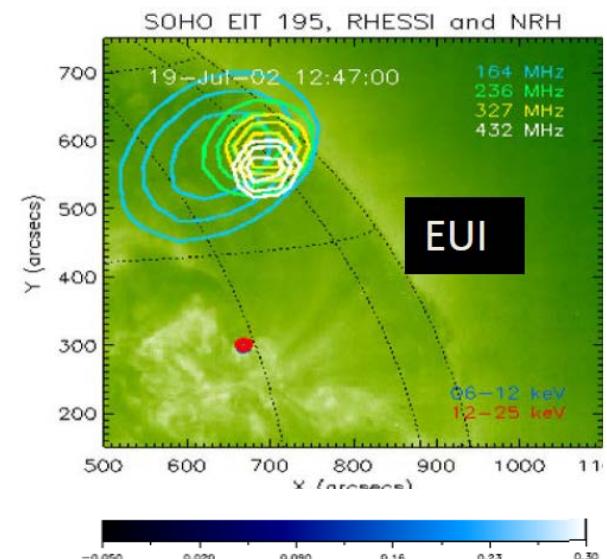




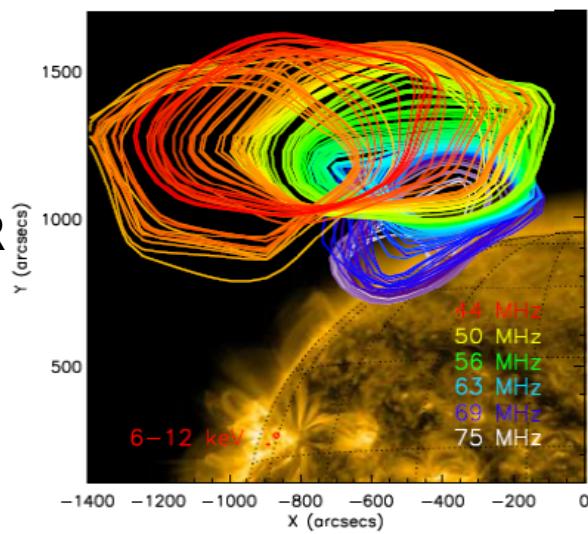


## NRH Nançay RadioHeliograph

**DAM:**  
Nançay  
Decametric Array



**LOFAR**



# Nançay RadioHeliograph

L.Klein, S.Masson, A.Hamini



- Frequency range:  
**150 - 450 MHZ**
- **47 antennae**
- **648 baselines from 50 to 3200 m**
- ! Soon: **1128 baselines**
- Spatial resolution:  
**4 to 0.3 arcmin**
- Time resolution:  
typically **125 ms**
- Duration of observation:  
**7 h/day**

+ORFEES SpectoHeliograph :**140 MHZ-1 GHZ**

# Radio Monitoring at <http://secchirh.obspm.fr/>

Radio Monitoring

17 May 2013  
8h Composite I  
(dm->km spectra) survey

Home	New Day
Prev Day	Next Day

NRH Movies

Hour selection

08h --> 16h

**08h --> 09h**

09h --> 10h

10h --> 11h

11h --> 12h

12h --> 13h

13h --> 14h

14h --> 15h

15h --> 16h

Survey selection

**Composite I**

Composite IIa

Composite IIb

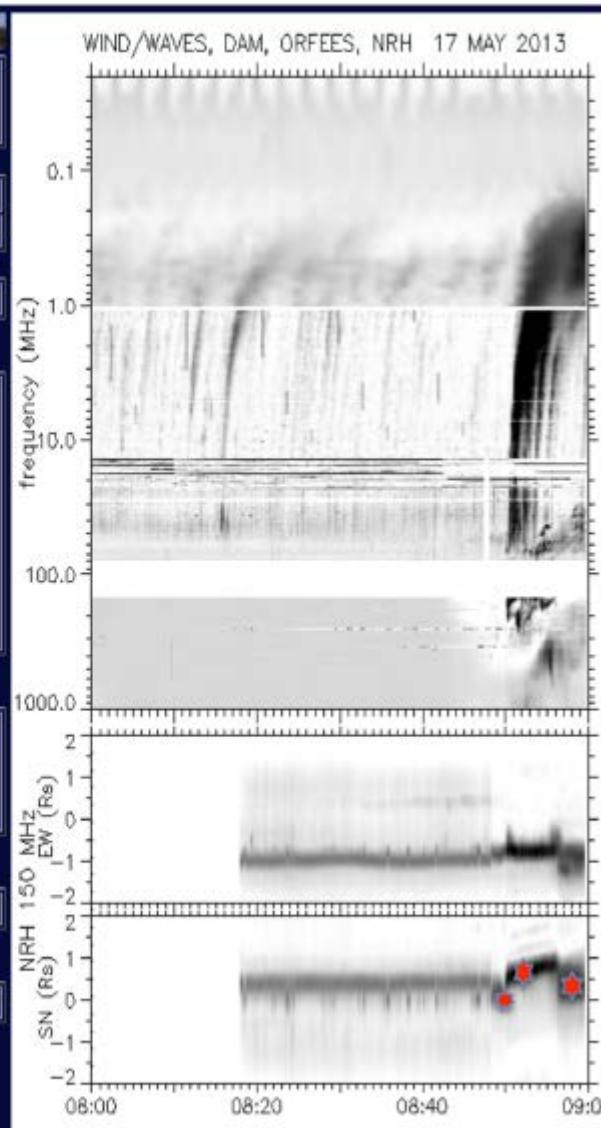
24h Waves/Waves

CMEs

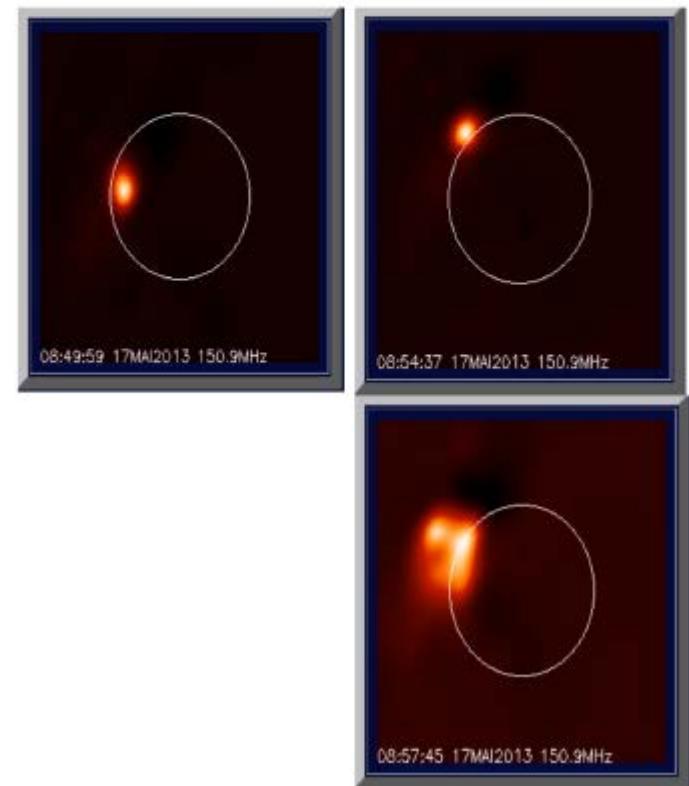
SOHO	STEREO
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Flares

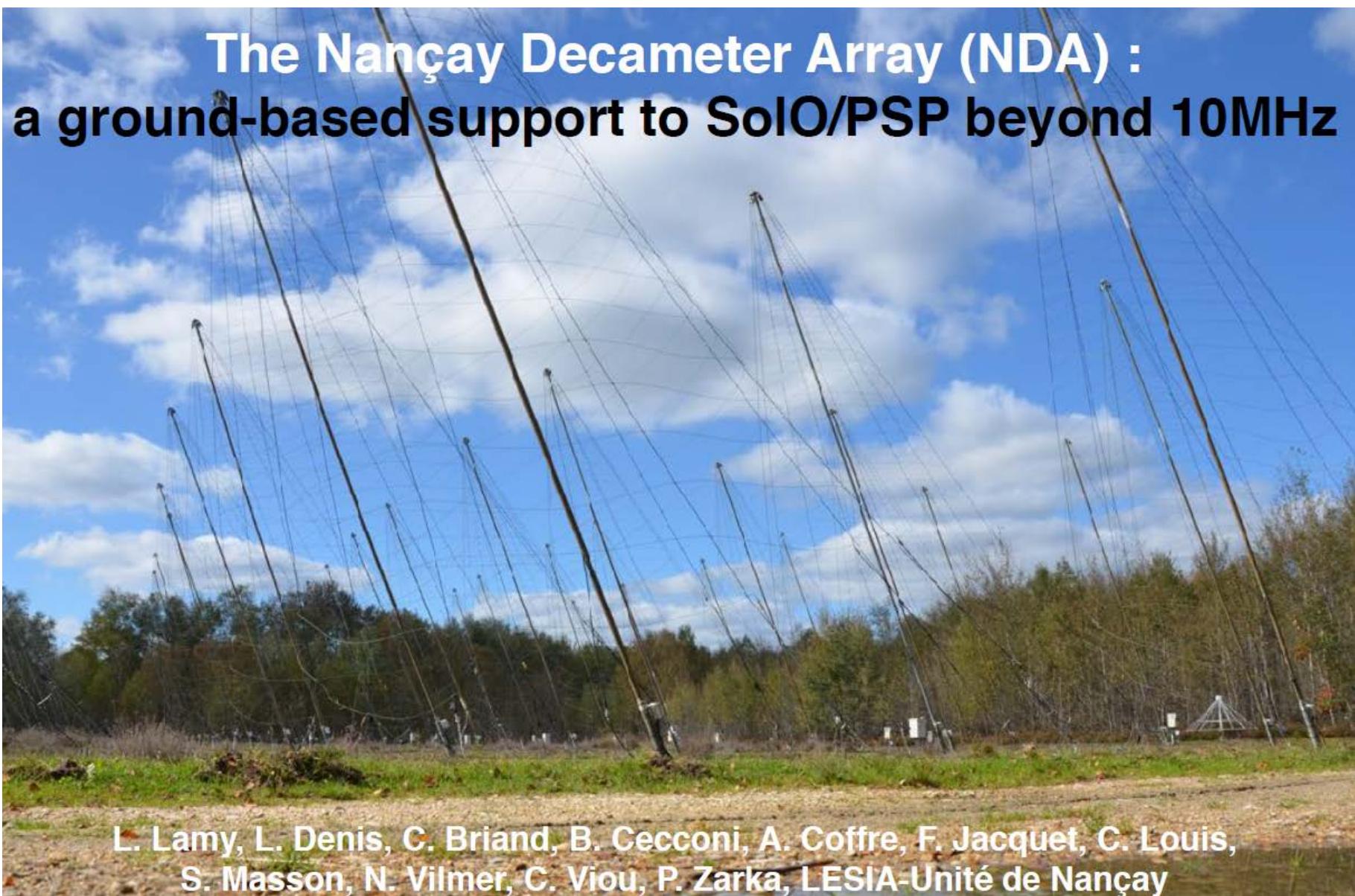
RHESSI



Eruption of May 17, 2013 Spectra (left)  
and images at 3 instants (red stars on  
the left)



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



L. Lamy, L. Denis, C. Briand, B. Cecconi, A. Coffre, F. Jacquet, C. Louis,  
S. Masson, N. Vilmer, C. Viou, P. Zarka, LESIA-Unité de Nançay

# 4 digital receivers operating simultaneously

Receiver	Measurements	Channels	Spectral range (MHz)	Resolution (ms × kHz)	Data volume (per 8 h)	Format
Routine (1990–...)	RR, LL <sup>1</sup>	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
		2	10–88 (Sun)		768 MB	FITS
Mefisto (2013–...)	RR, LL	2+2 <sup>2</sup>	10–35	100 × 50	180 MB	FITS
JunoN (2016–...)	RR, LL, LR + Waveform	4	6–56 (Jupiter)	2.6 × 3.05 <sup>3</sup>	2.9 TB	binary
				83.2 × 12.2 <sup>4</sup>	22.6 GB	

Sensitivity

20000 Jy

600 Jy

1500 Jy

Lamy et al., arxiv, in press

## Performances of the full array :

144 helical antenna (RH / LH polarizations)

High gain (25 dB) + large beam ( $7^\circ \times 12^\circ$ )

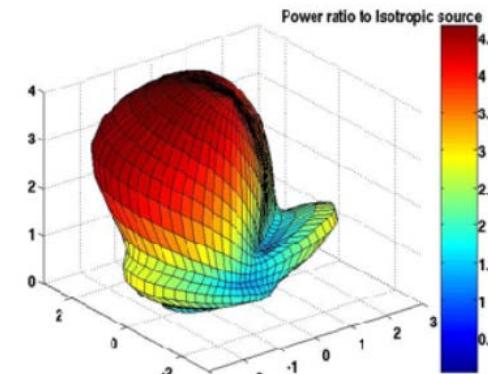
$A_{\text{eff}} 30\text{MHz} \sim 4000\text{m}^2 (\sim 10^3 \text{ Jy})$

f = 10-120MHz

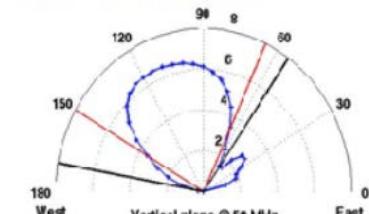
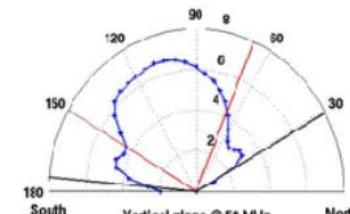
Phased array > Jupiter, Sun (8h / day)

Long-term + high res. t-f measurements

Noise diodes calibration (every 1h)



PhD A. Bellétoile



# 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 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

The screenshot shows the VESPA (Virtual European Solar and Planetary Access) web interface. At the top, there's a navigation bar with tabs for "All VO", "Custom resource", "Direct Query", and "Advanced Query". Below the navigation bar, the title "Virtual European Solar and Planetary Access" is displayed, along with a large image of the solar system and a hand cursor icon.

**EPN Resources**

A list of datasets is shown under the heading "EPN Resources":

- AMDA - Planetary and heliospheric plasma data at CDPP/AMDA (67722 results)
- CLIMSO - CLIMSO coronagraphs at pic du midi de Bigorre (169937 results)
- HFC1AR - Heliospheric Feature Catalog active regions (94697 results)
- HFC1T3 - Heliospheric Feature Catalog type 3 radio bursts (90345 results)
- IPRT - IPRT/AMATERAS data (1410 results)

**RadioJOVE**

A detailed view of a dataset from the RadioJOVE catalog is shown. The title "VESPA" and "Virtual European Solar and Planetary Access" is at the top, followed by a list of observations:

granne_id	EF	telescope_type	target_name	time_min (s)	time_max (s)	access_url
E_201110_14200000000000000000	image	sun	2017-10-01T14:27:08.399	2017-11-01T14:27:08.399	<a href="#">https://lumein.jaxa.jp</a>	
E_201110_14200000000000000000	image	sun	2017-10-01T14:27:03.000	2017-11-01T14:27:03.000	<a href="#">https://lumein.jaxa.jp</a>	
E_201110_14200000000000000000	image	sun	2017-10-01T14:26:08.399	2017-11-01T14:26:08.399	<a href="#">https://lumein.jaxa.jp</a>	
E_201110_14200000000000000000	image	sun	2017-10-01T14:06:03.000	2017-11-01T14:06:03.000	<a href="#">https://lumein.jaxa.jp</a>	
E_201110_14200000000000000000	image	sun	2017-10-01T14:06:03.000	2017-11-01T14:06:03.000	<a href="#">https://lumein.jaxa.jp</a>	
E_201110_14200000000000000000	image	sun	2017-10-01T14:06:03.000	2017-11-01T14:06:03.000	<a href="#">https://lumein.jaxa.jp</a>	
E_201110_14200000000000000000	image	sun	2017-10-01T14:06:03.000	2017-11-01T14:06:03.000	<a href="#">https://lumein.jaxa.jp</a>	
E_201110_14200000000000000000	image	sun	2017-10-01T14:06:03.000	2017-11-01T14:06:03.000	<a href="#">https://lumein.jaxa.jp</a>	
E_201110_14200000000000000000	image	sun	2017-10-01T14:06:03.000	2017-11-01T14:06:03.000	<a href="#">https://lumein.jaxa.jp</a>	
E_201110_14200000000000000000	image	sun	2017-10-01T14:06:03.000	2017-11-01T14:06:03.000	<a href="#">https://lumein.jaxa.jp</a>	

**Results in service: CLIMSO**

A table showing results for the CLIMSO service, with columns for "granne\_id", "EF", "telescope\_type", "target\_name", "time\_min (s)", "time\_max (s)", and "access\_url". The results are identical to the ones shown above for the RadioJOVE dataset.

**Plotting tools**

- TROPICAT
- Aladin
- SPLAT
- CASSIS
- 3DView

**Example queries**

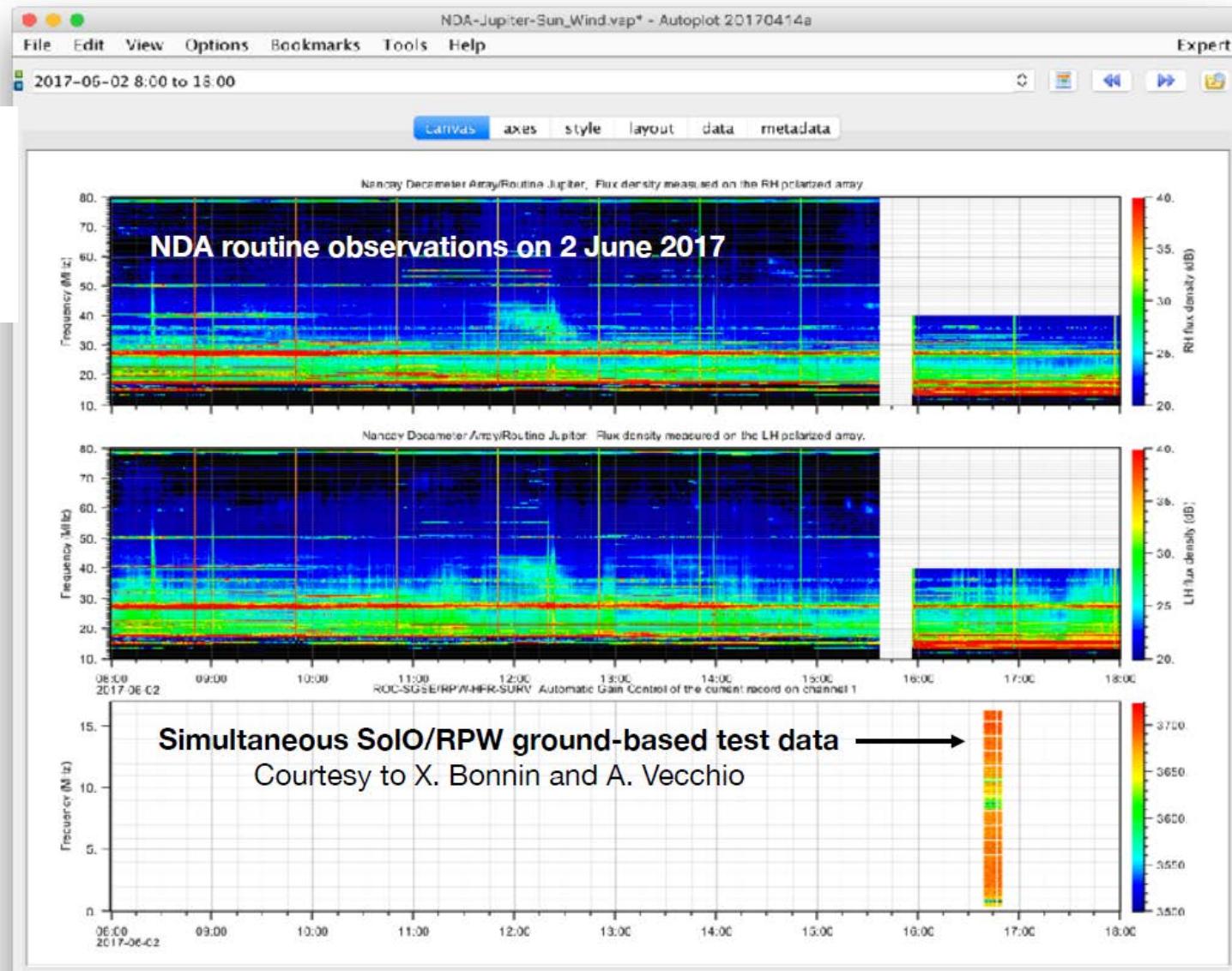
Saturn in March 2012

# Synergy between Nançay HF and spatial LF observations

Access  
through  
Autoplot

CDF

CDF



# What about other radio observatories ?

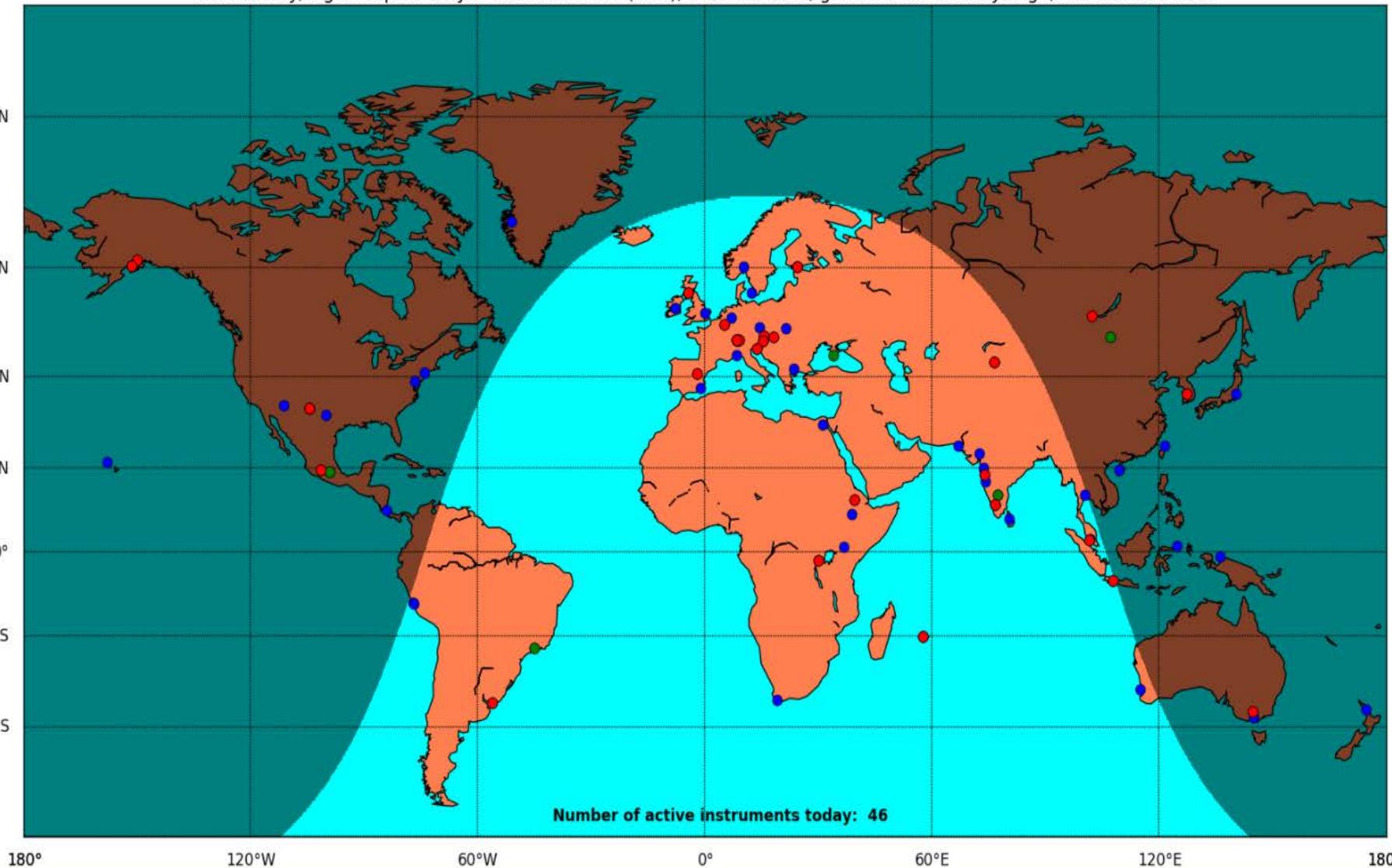
- The request for SO/PSP (RPW/FIELDS) would be to have at disposal a full 24h/7d coverage in the range ~10 MHz to ~1 GHz (or more) from ground
- Common data products (frequency range, time resolution ...)
- Calibrated radio fluxes (possibly polarization) in SFU
- The data possibly already exist (see e-Callisto network)
- **The need is to gather the data, process them (CDF formats) and put them at disposal on a common server with quicklook products etc ...**

# e-Callisto

## International Network of Solar Radio Spectrometers



Callisto Day/Night Map for 23 Jan 2018 11:07:45 (UTC), blue=no data, green=data two days ago, red=current data



# Conclusions

- The brainstorming is starting @ LESIA (meeting in March)
- The CESRA community should be involved !
- The Solar Orbiter MADAWG (Modelisation and data Analysis Working Group) should be involved
- Should try to be ready for PSP 1st Perihelion.  
Tricky.
- Announcement : possible CNES post-doc position in Meudon - deadline March 15