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

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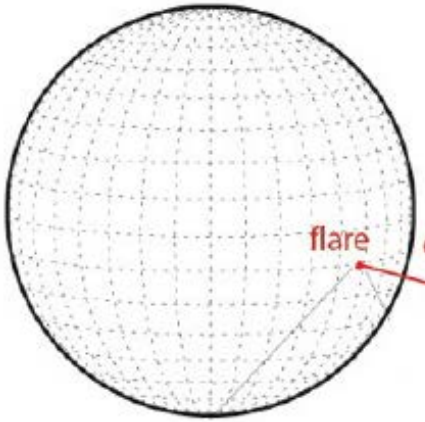
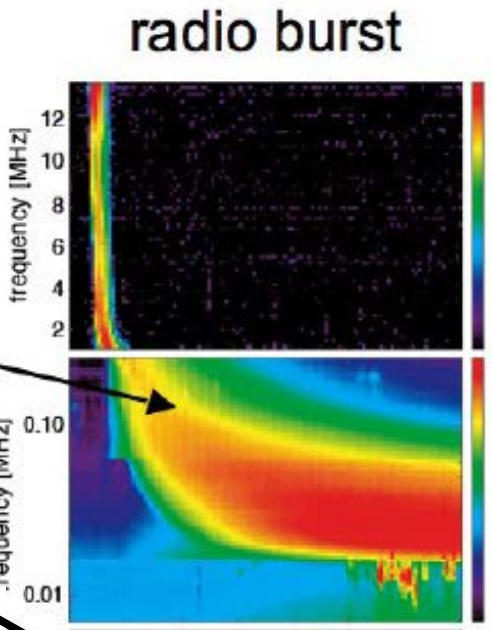
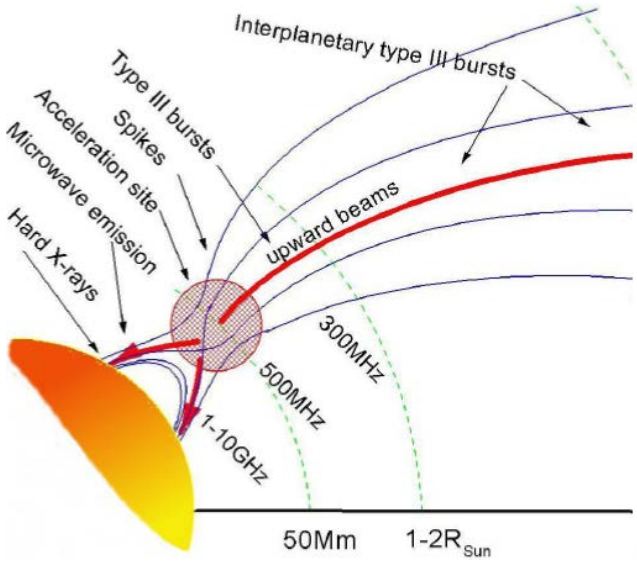
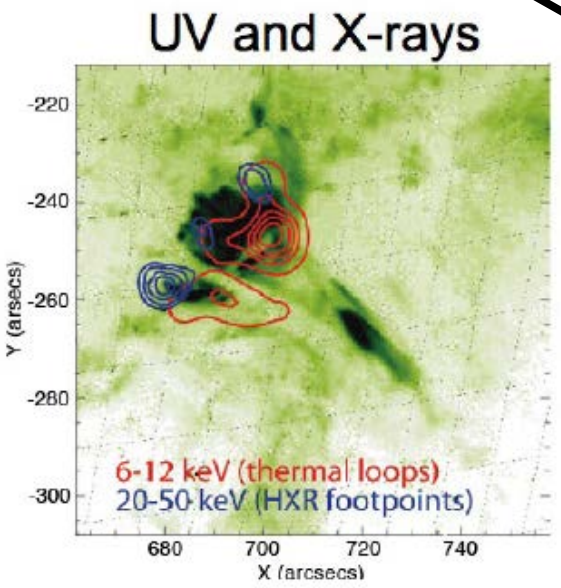
Alliance meeting, 06 February 2018, Manchester, UK

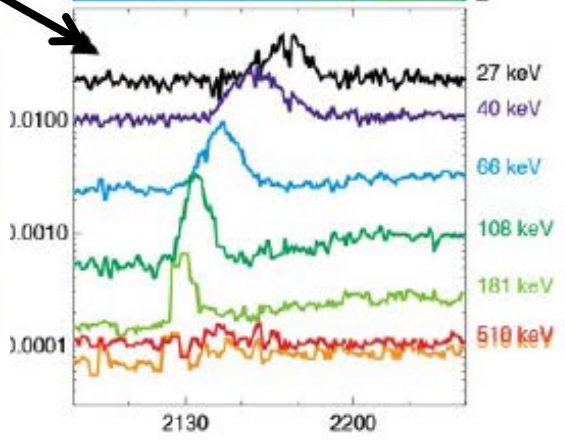
Solar Radio Bursts





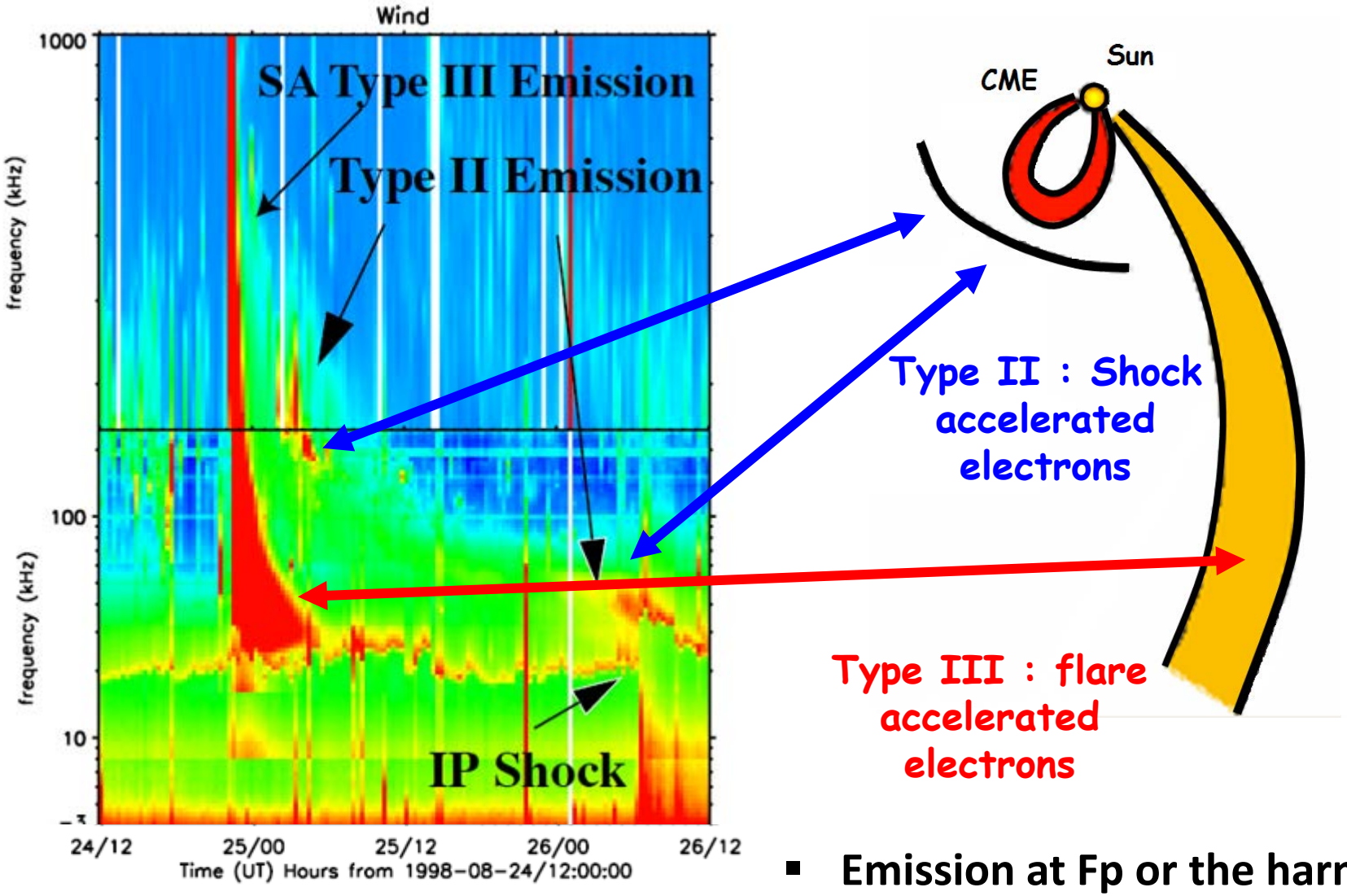






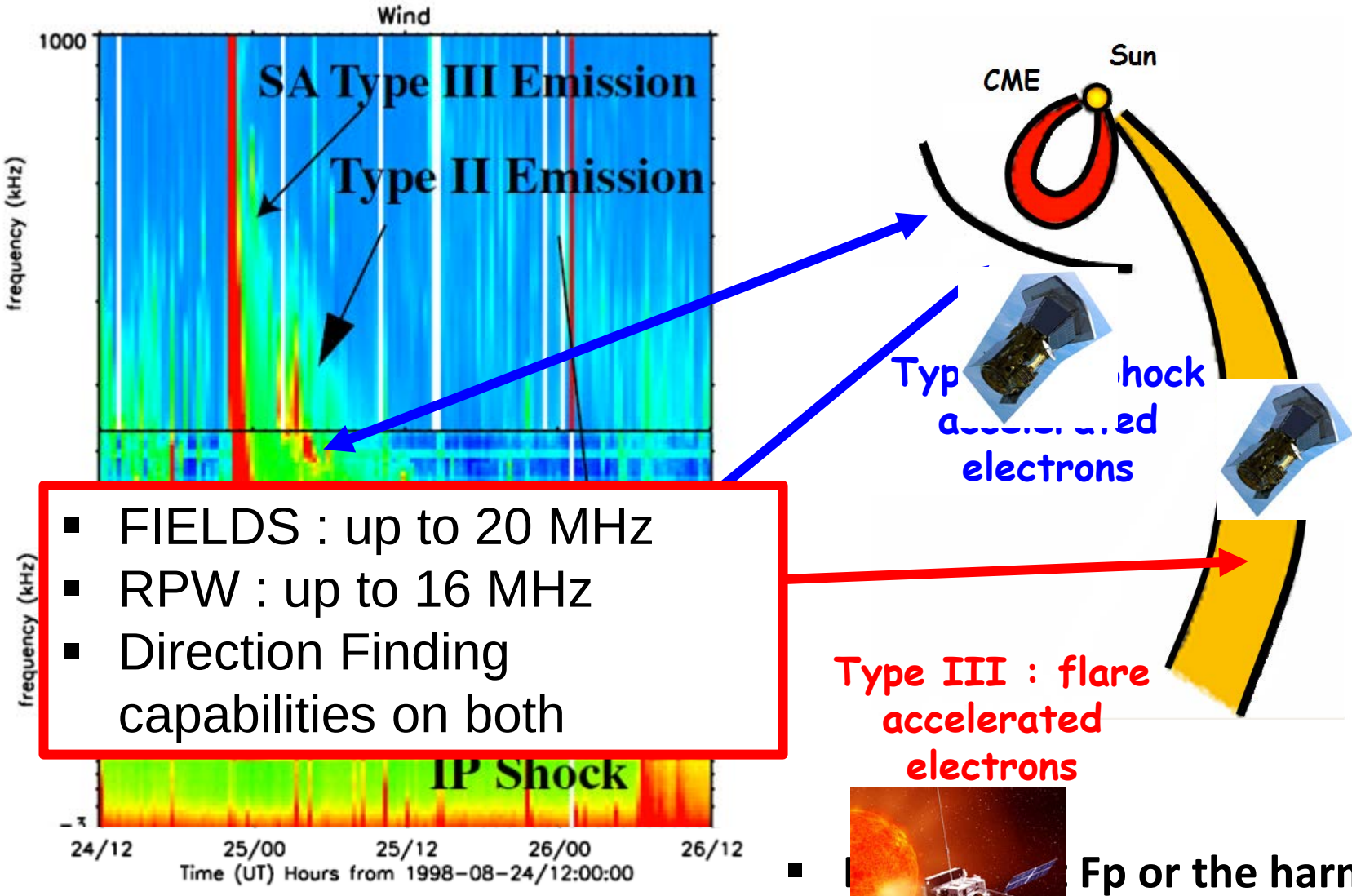
energetic electrons

Type III & Type II solar radio bursts



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

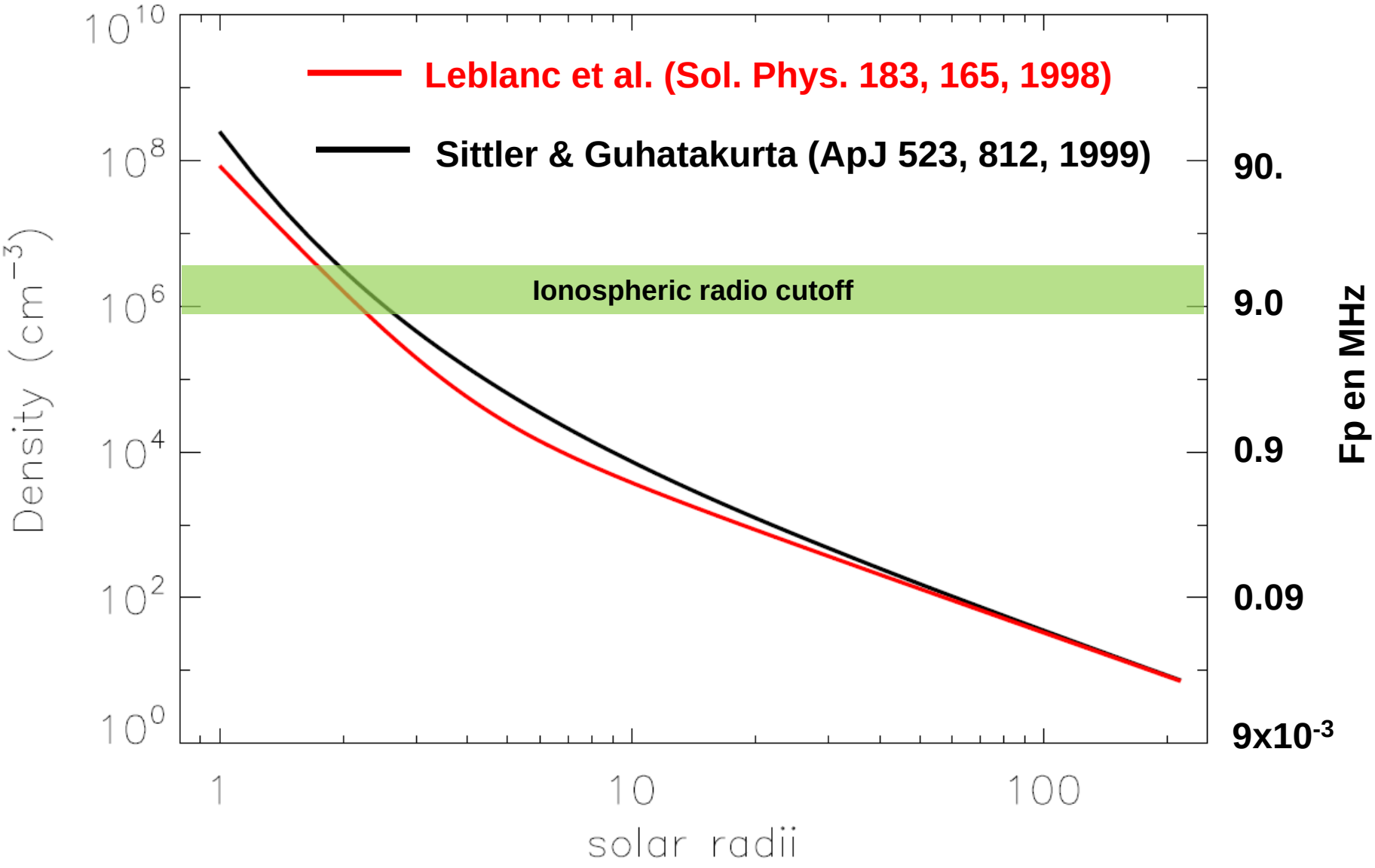
Type III & Type II solar radio bursts

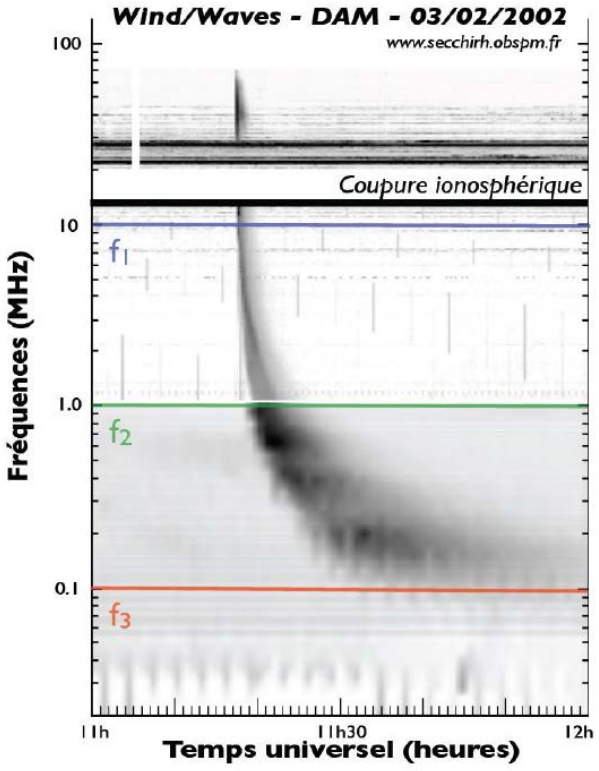


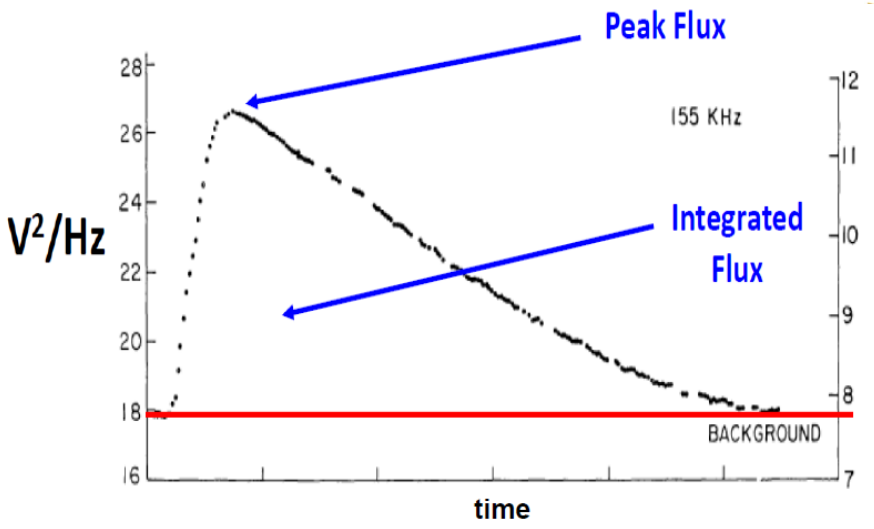
- FIELDS : up to 20 MHz
- RPW : up to 16 MHz
- Direction Finding capabilities on both

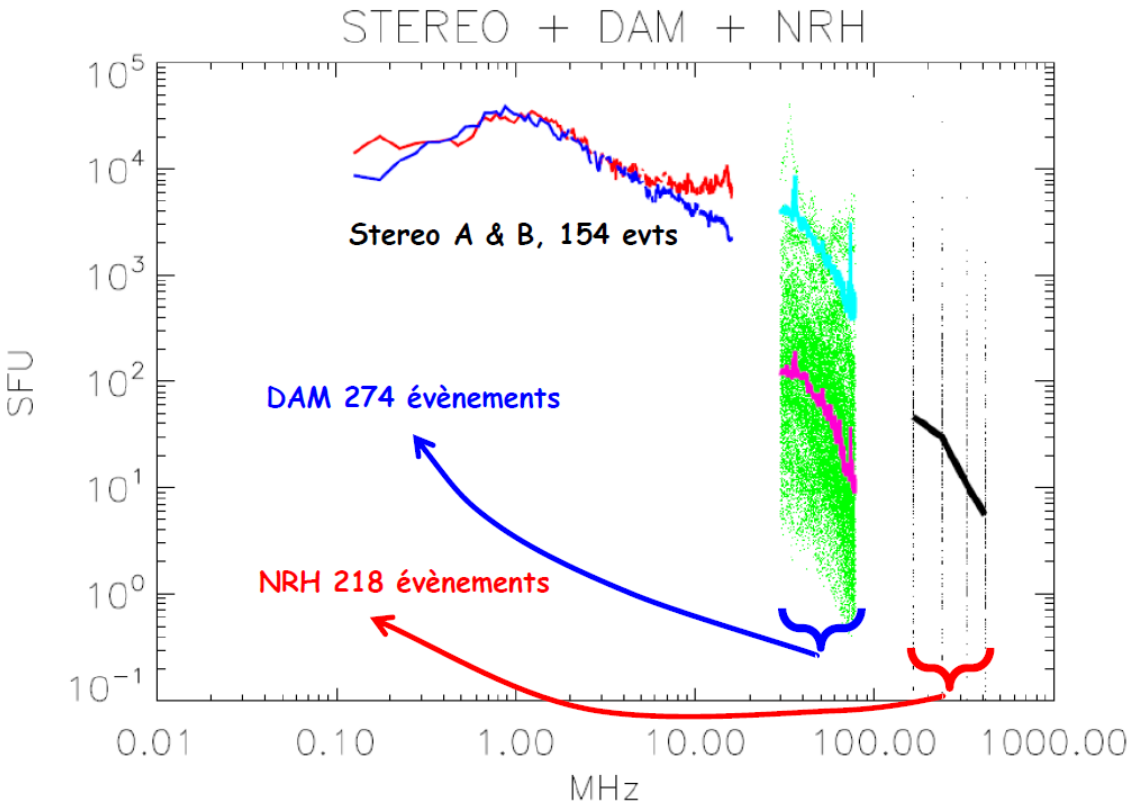
- Fp or the harmonic
- $\propto 1/R$

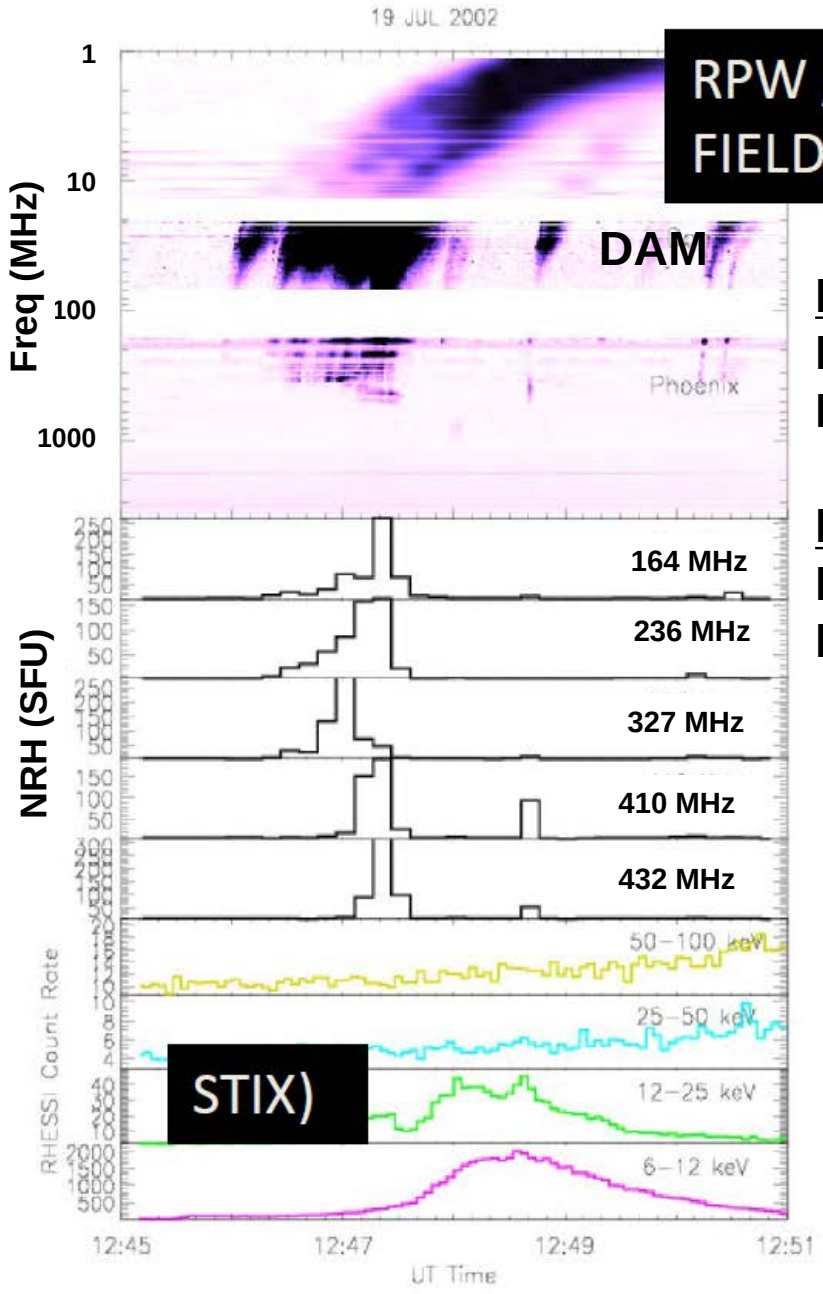
Radio frequency versus distance




Wind/Waves - DAM - 03/02/2002
www.secchirh.obspm.fr
Coupure ionosphérique
100
10
1.0
0.1
f1
f2
f3
Fréquences (MHz)
11h
11h30
12h
Temps universel (heures)

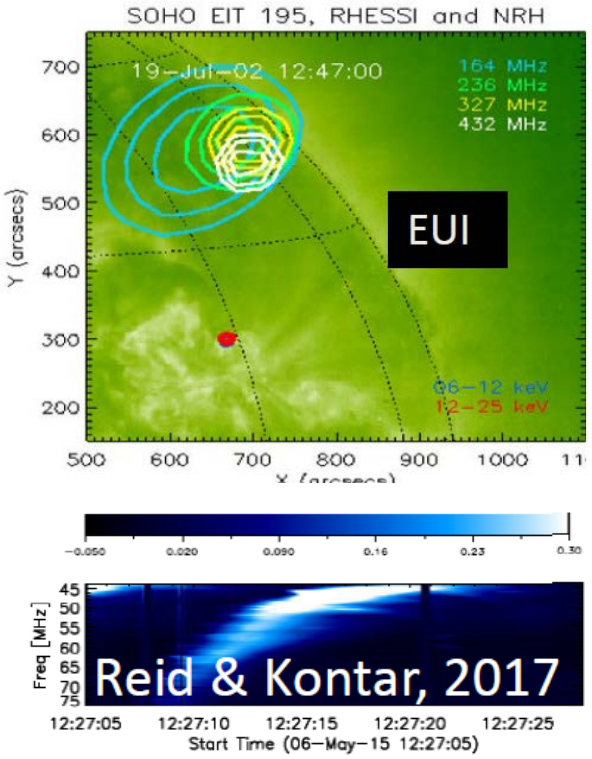

Peak Flux
Integrated Flux
155 KHz
BACKGROUND
V²/Hz
time


STEREO + DAM + NRH
Stereo A & B, 154 evts
DAM 274 évènements
NRH 218 évènements
SFU
MHz

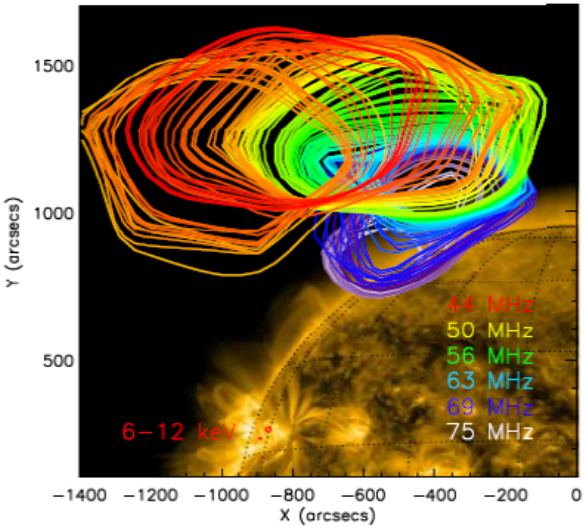


NRH
Nançay
RadioHeliograph

DAM:
Nançay
Decametric Array



LOFAR



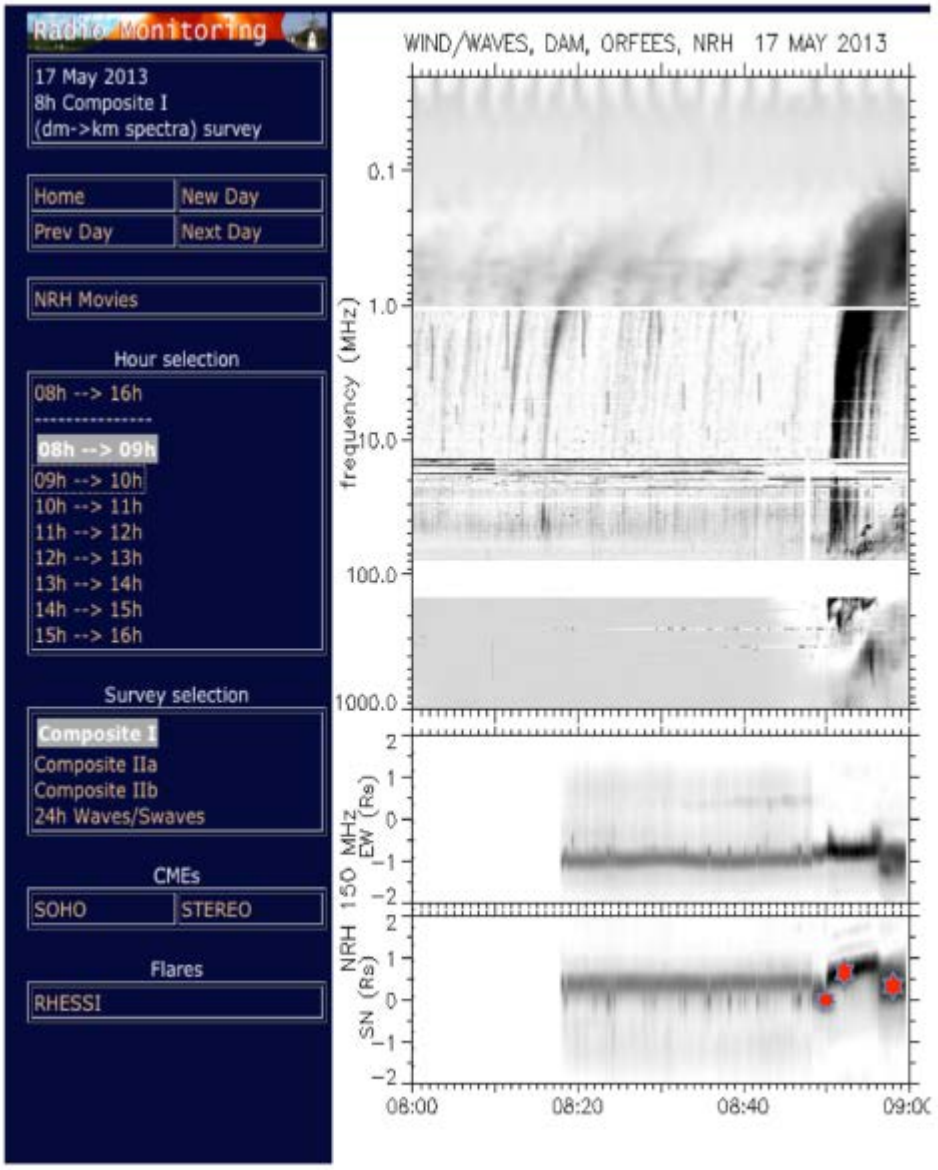
Nançay RadioHeliograph

L.Klein, S.Masson, A.Hamini

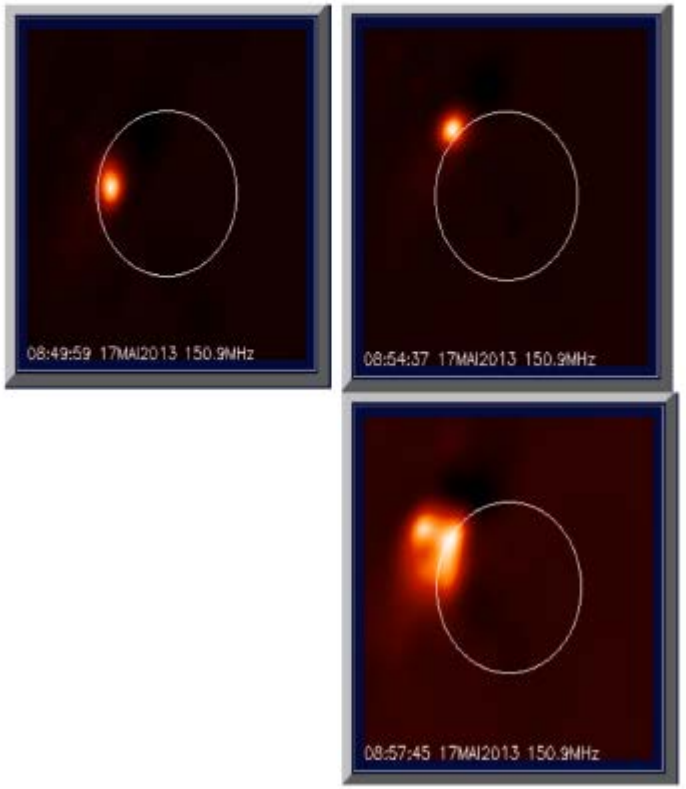
- **Frequency range: 150 - 450 MHZ**
- **47 antennae**
- **648 baselines from 50 to 3200 m**
- **! Soon: 1128 baselines**
- **Spatial resolution: 4 to 0.3 arcmin**
- **Time resolution: typically 125 ms**
- **Duration of observation: 7 h/day**

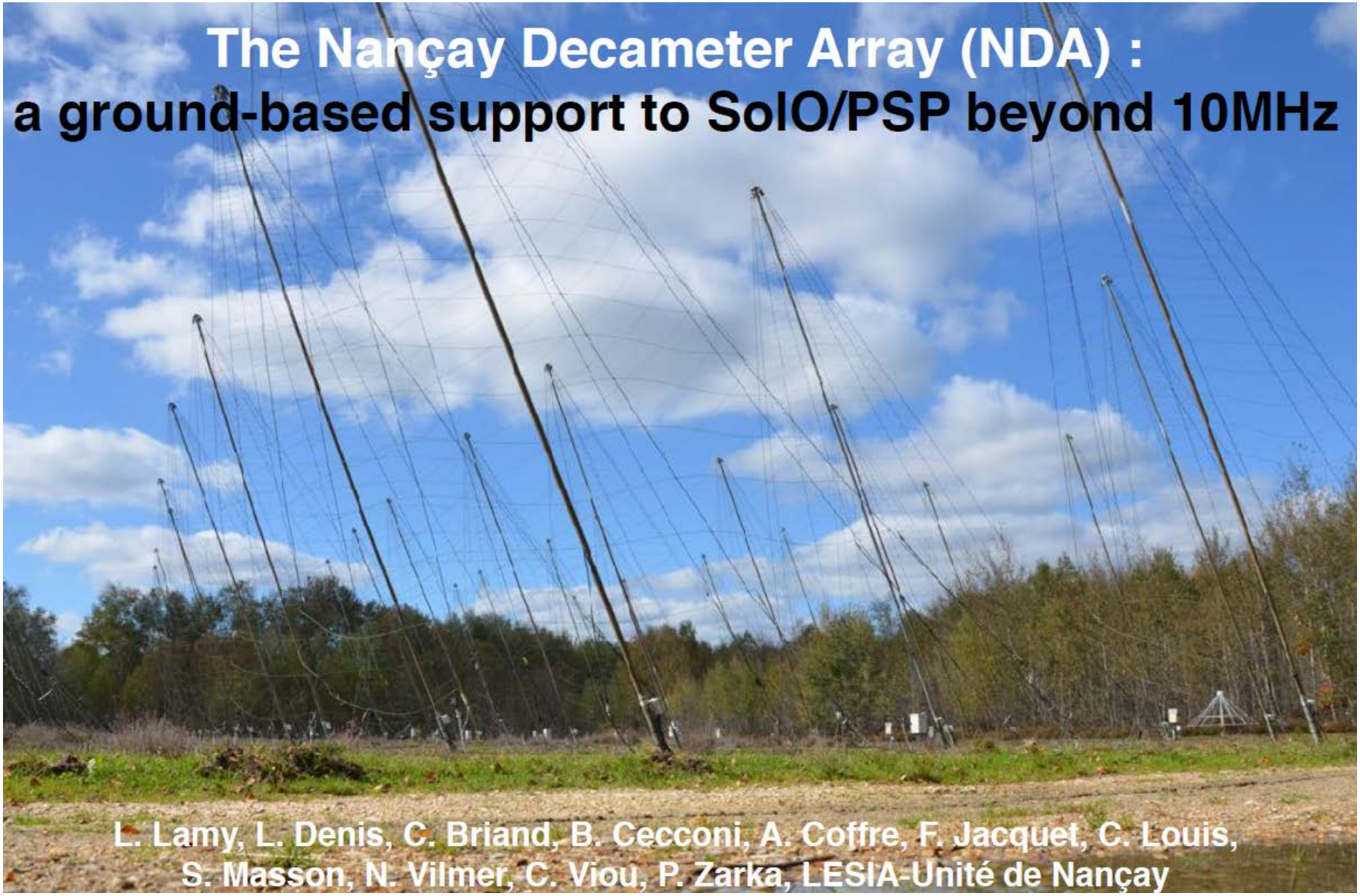
+ORFEES SpectoHeliograph :140 MHZ-1 GHZ

Radio Monitoring at http://secchirh.obspm.fr/



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[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

Performances of the full array :

144 helical antenna (RH / LH polarizations)

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

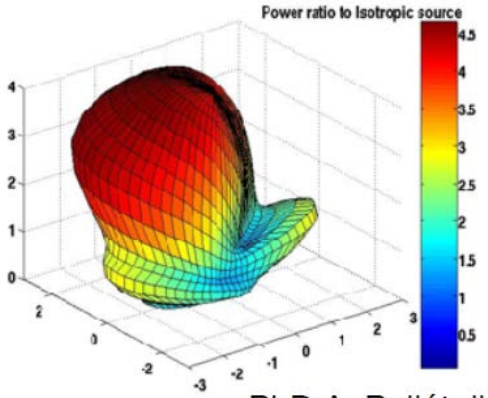
$A_{eff\ 30MHz} \sim 4000m^2$ ($\sim 10^3$ Jy)

f = 10-120MHz

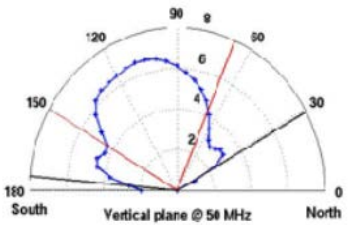
Phased array > Jupiter, Sun (8h / day)

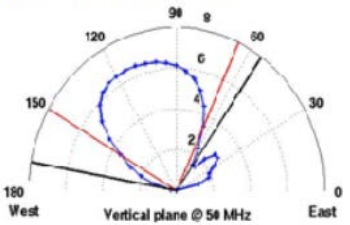
Long-term + high res. t-f measurements

Noise diodes calibration (every 1h)



PhD A. Bellétoile





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)

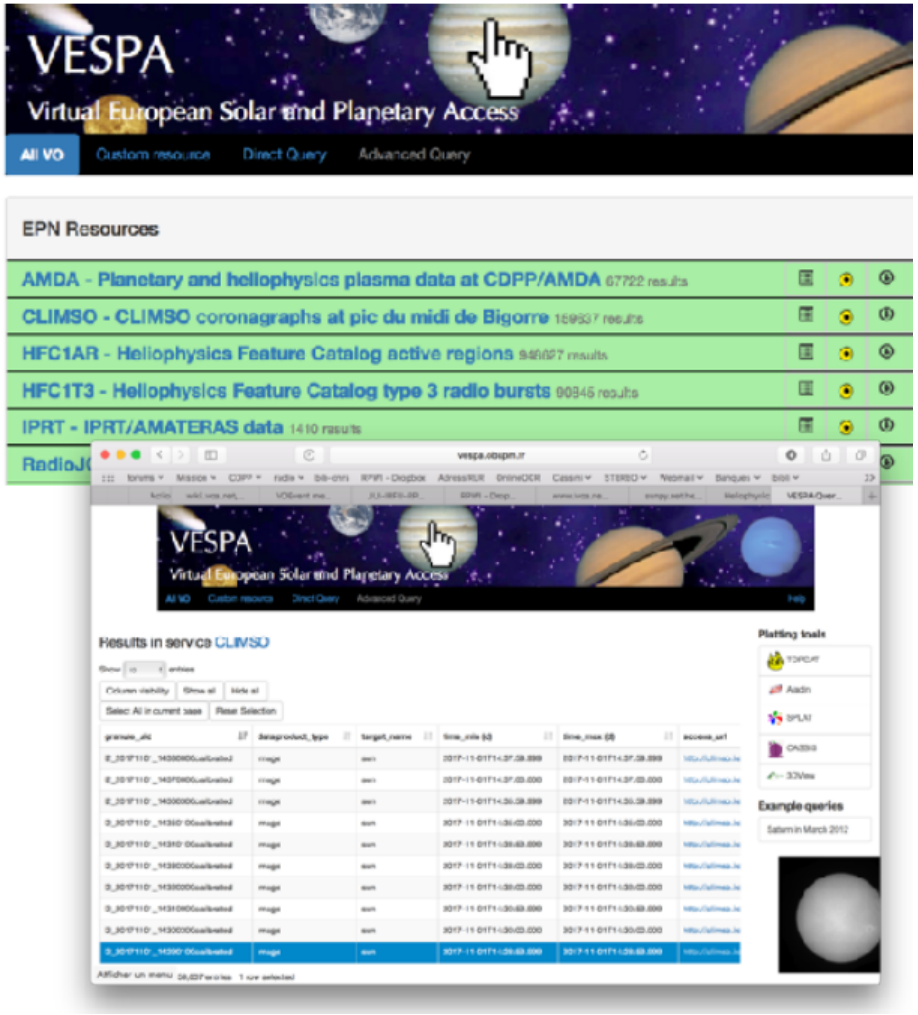
- Software:
  - Maser4py library "data" module include Nançay/NDA Python 3.x classes (also SolO/RPW)
  - IDL routines also available

- 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

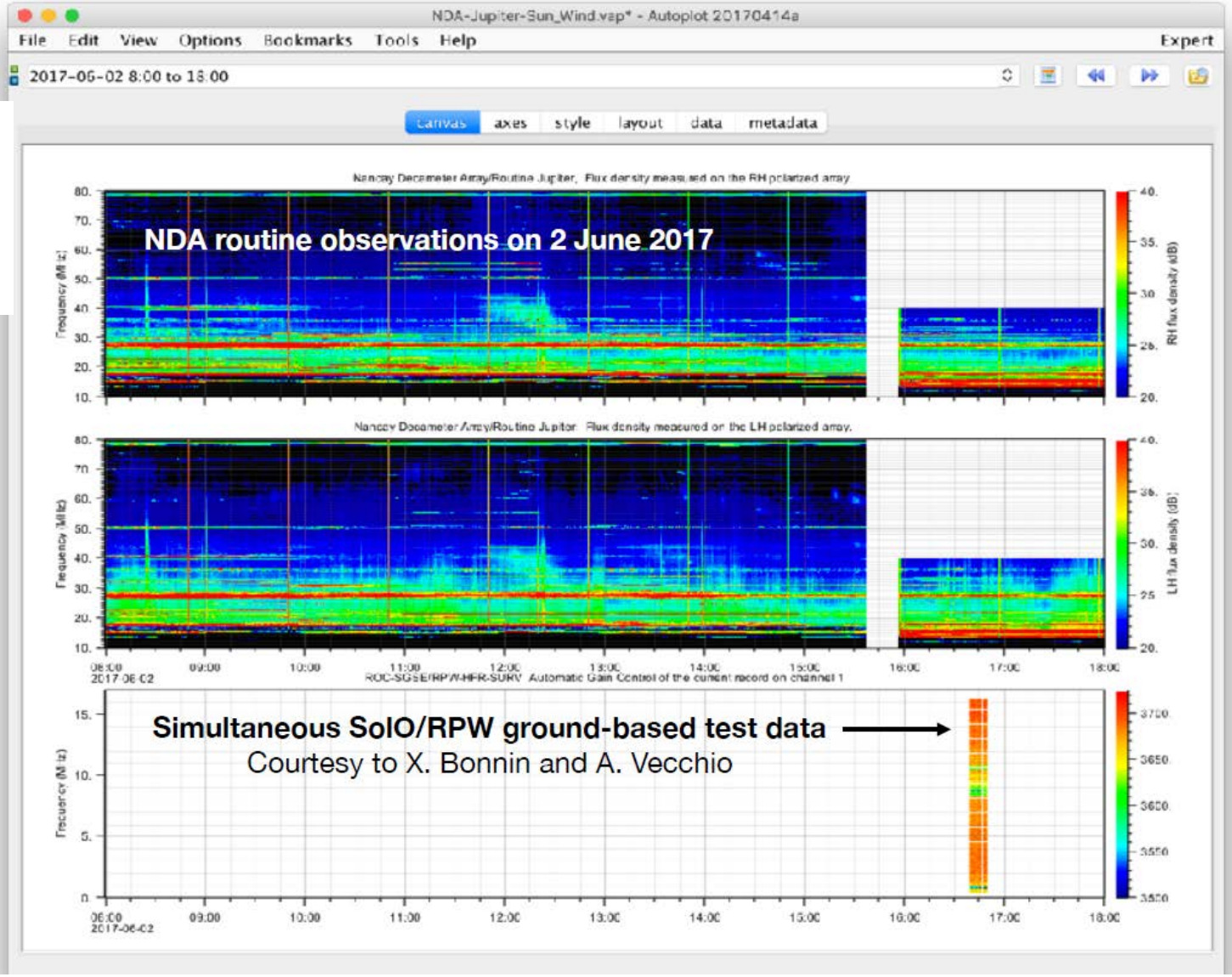


Synergy between Nançay HF and spatial LF observations

Access through Autoplot

CDF

CDF

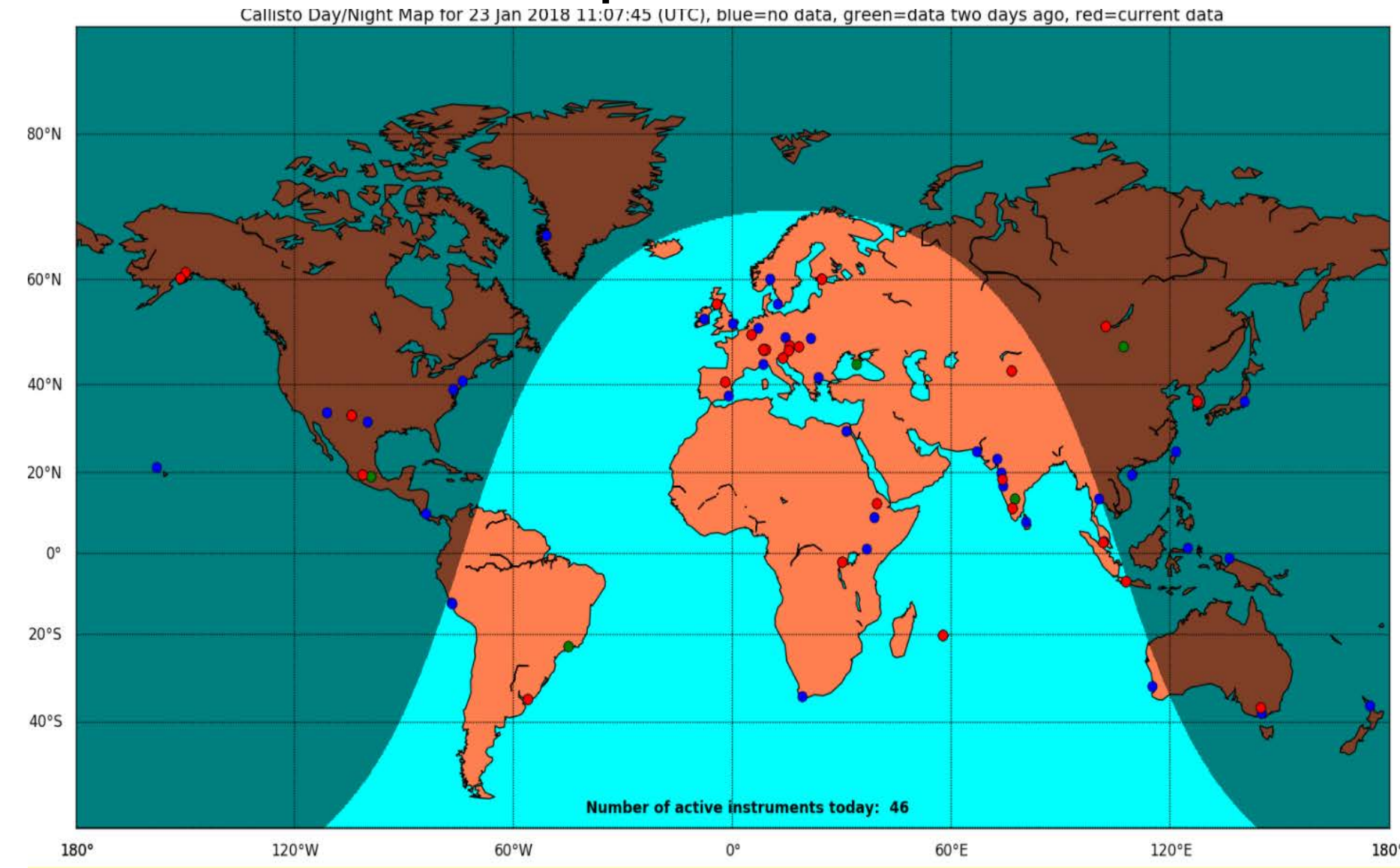


What about other radio observatories ?

- 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



Conclusions

- The brainstorming is starting @ LESIA (meeting in March)
- The CESRA community should be involved !
- The Solar Orbiter MADAWG (Modelisaton 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