Solar Radio Data "Orfees and Radioheliograph"

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Solar Radio Observations at Nançay

- Continuous monitoring, 8:30-15:30 UT, 1 GHZ-10 MHZ (ionosphere permitting)
- A unique combination of complementary instruments
  - Imaging: Nançay Radioheliograph (NRH)
    - 10 frequencies between 150 and 450 MHZ
  - Solar flux spectra
    - NDA: 10 to 80 MHZ
    - Orfees: 140 to 1000 MHZ

Orfees Description

General characteristics

- Frequency: 140 MHZ-1 GHZ
- Time resolution: 0.1 sec
- Frequency resolution: 0.1 to 1.6 MHZ
- Duration of observation: 7 h/day
- Available since October 03, 2012
- Data:
  - Science: fits files, website "radio-monitoring"
    → Stokes I and V (V not correctly calibrated at present)
  - FEDOME: data available in real time, real-time page at Nançay website

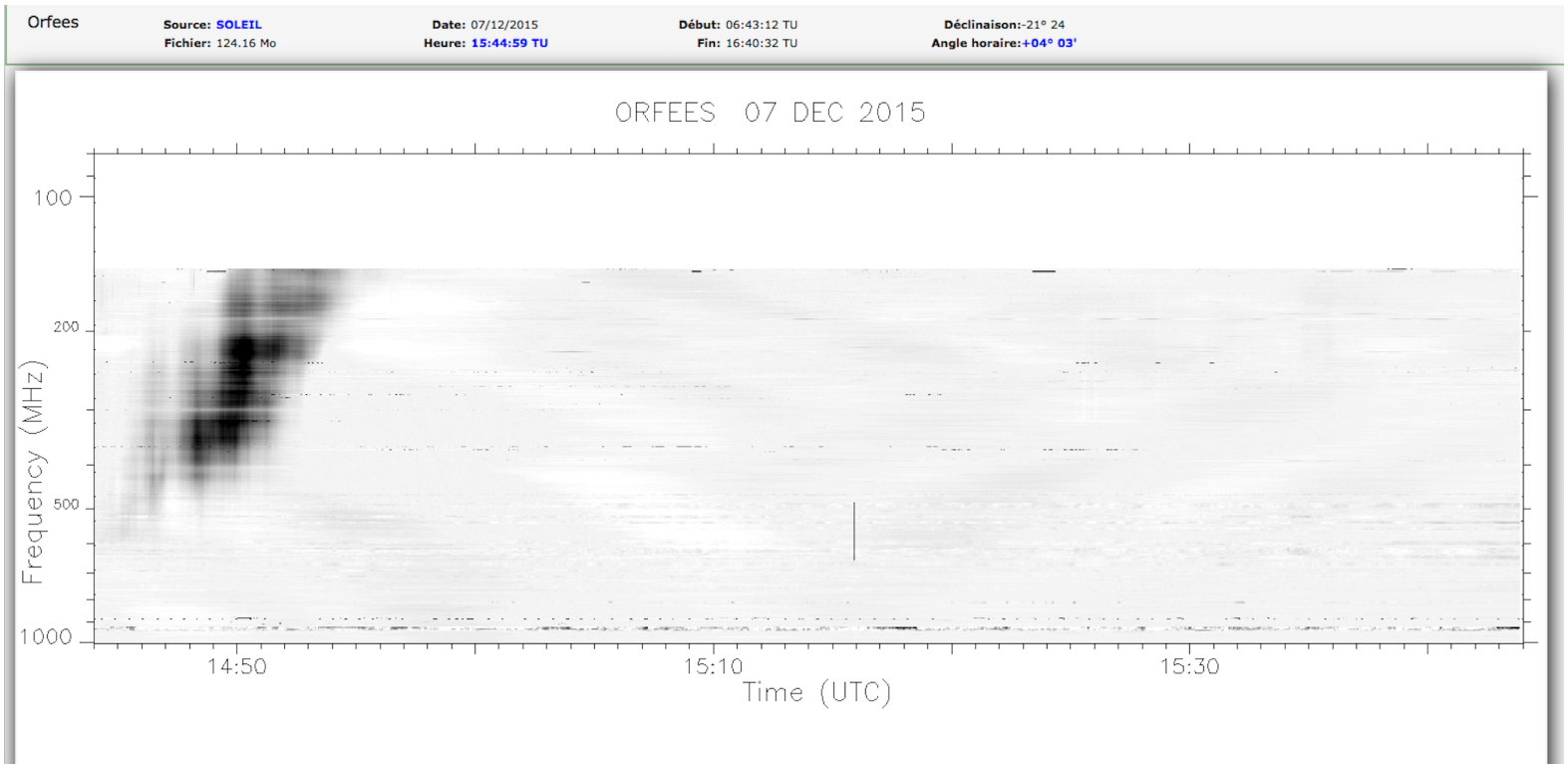
Orfees Antenna

- Diameter: 5 meter
- Type: log periodic antenna (specially made to cover the band 140 MHZ-1GHZ).



Orfees Spectrum

- Nançay real time website.
- Radio-monitoring website.

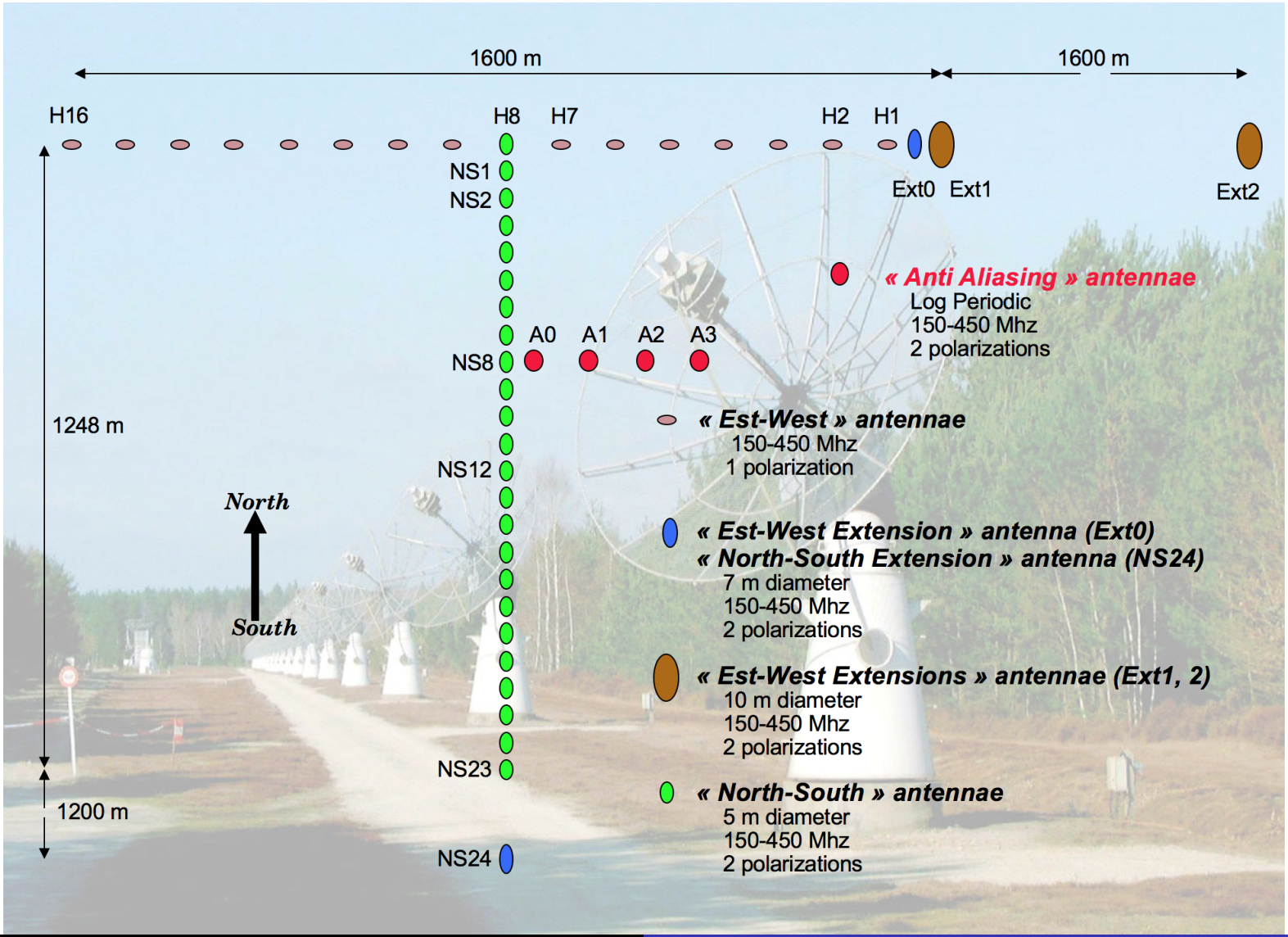


Nançay Radioheliograph

General characteristics

- Frequency range: 150 - 450 MHZ
- 47 antennae
- 648 baselines from 50 to 3200 m
  - → No observations since January 2015, major upgrade (data acquisition, correlator,...)
  - → Soon: 1128 baselines
- Spatial resolution: 4 to 0.3 arcmin (according to frequency, snapshot or synthesis, sun position)
- Data: Stokes I and V
- Time resolution: typically 125 ms
- Duration of observation: 7 h/day

Nançay Radioheliograph Configuration

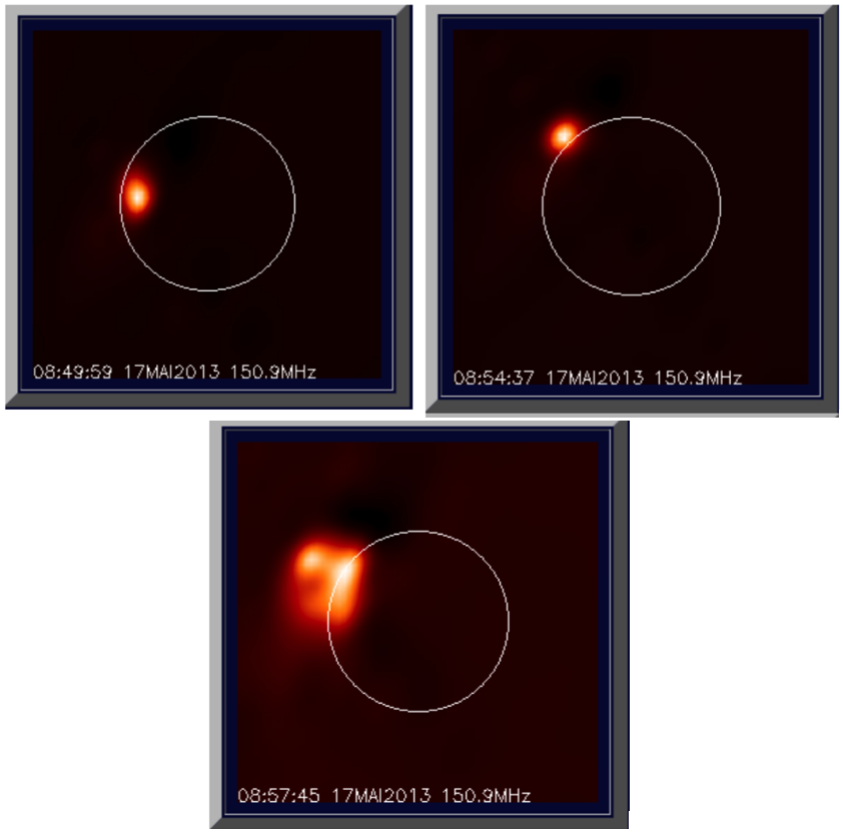


Nançay Radioheliograph: sky view



Nançay Radioheliograph Movies

Eruption of May 17, 2013



Radio-monitoring Website

- Data exploitation of various solar radio instruments
- Daily generation overview plot and movies
- Quicklook plots and NRH movies easily used by the radio community

Radio-monitoring Website

European instruments

- Synthetic spectrum: 0.05 -1500 MHZ (Nançay, Humain (Bruseel), Artemis (Thermopyles))
- CME positions
- Time 1D location maps of NRH at 2 frequencies

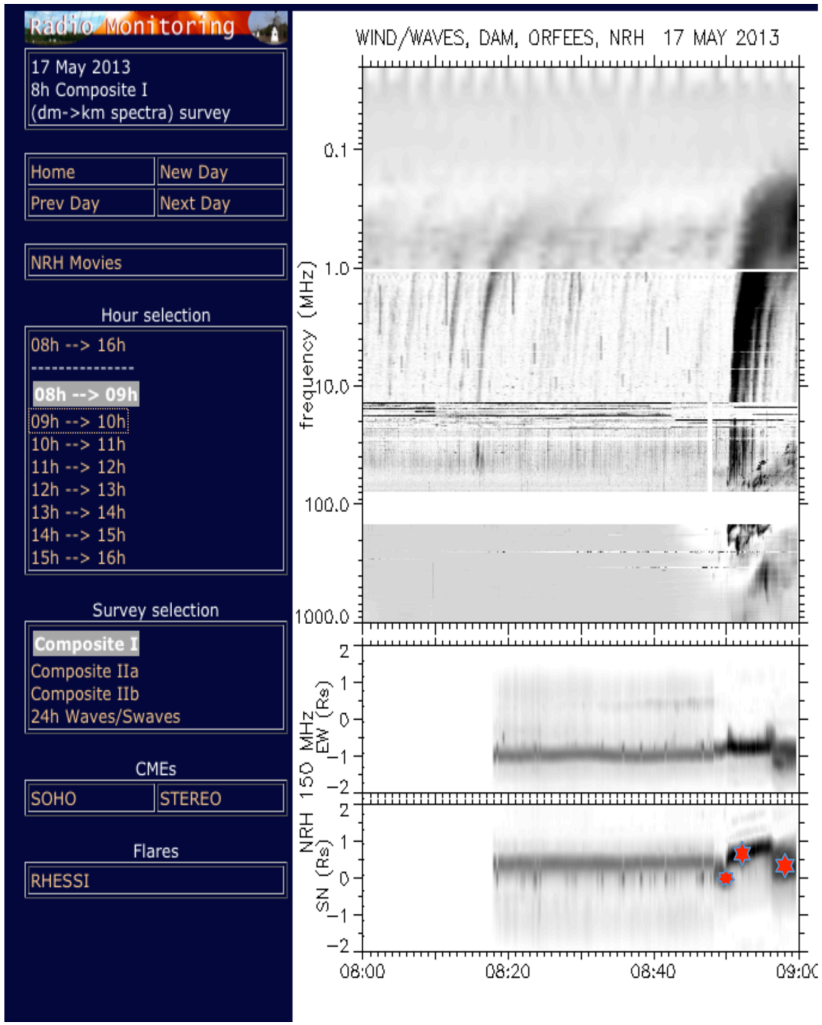
Spectra 24H

- Waves, Swaves
- Pacific zone (0-8h UT): Culgoora (Australia) and Yunnan (China)

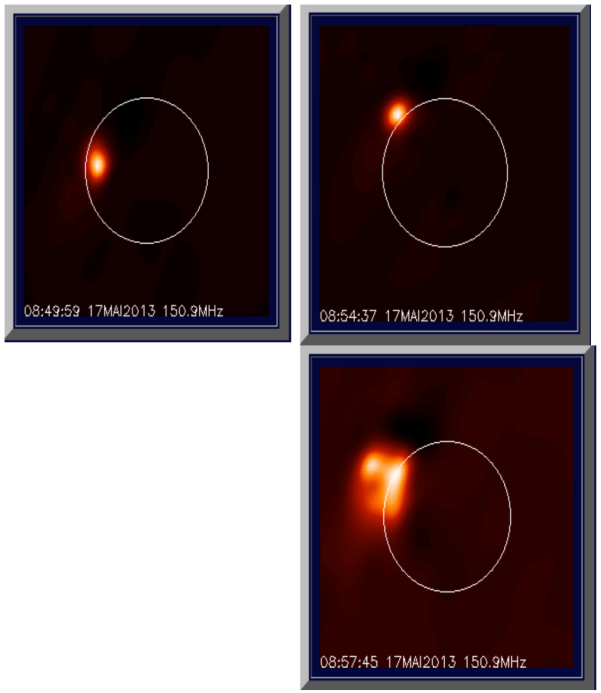
Data download

- Distribution of NRH and Orfees data

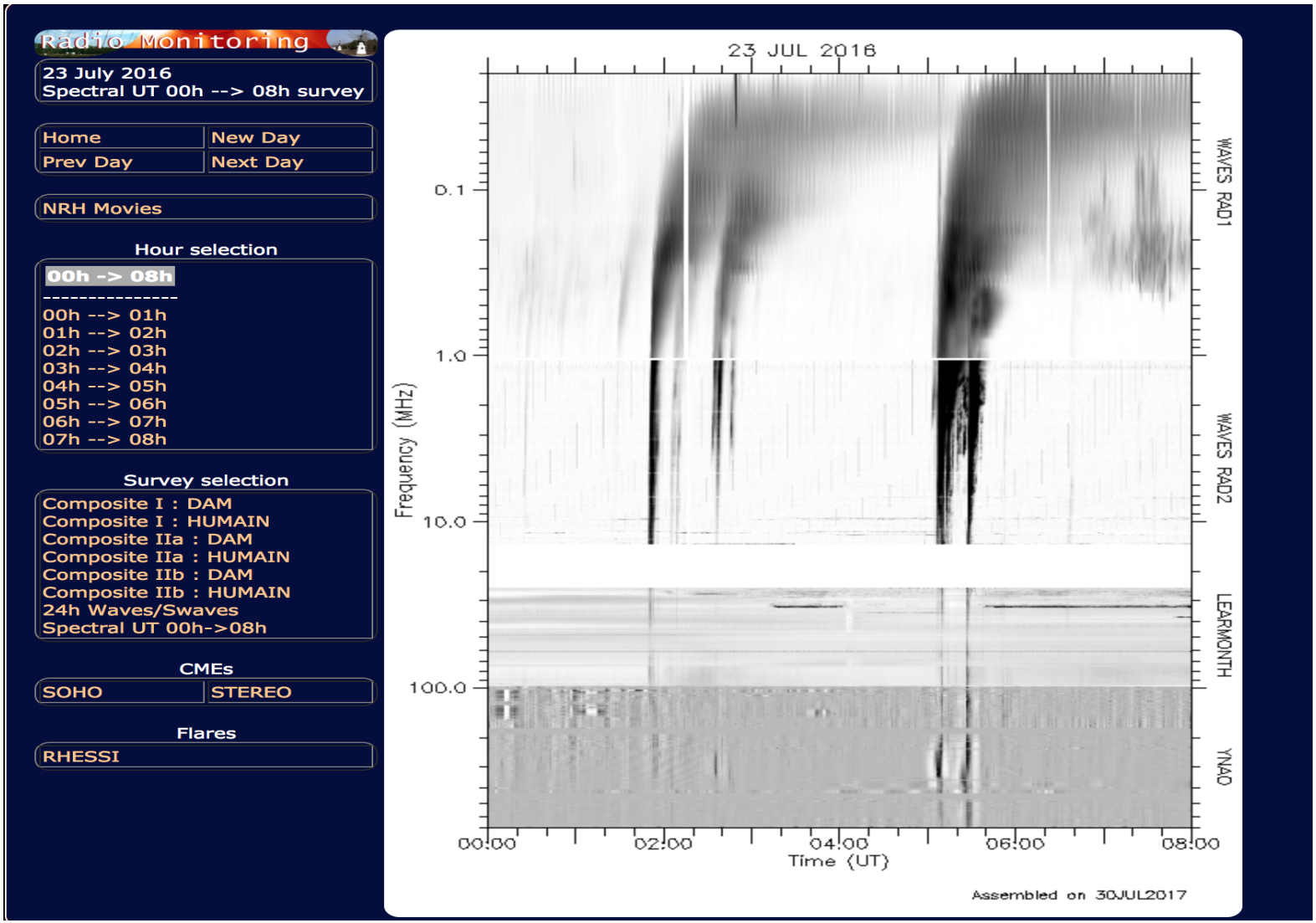
Radio-monitoring Website (European Instruments)



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



Radio-monitoring Website (Pacific Zone)



New Solar Radio Database

- Conception and realization of database for radio-solar observations at Nançay
- International solar and heliospheric community, as well as virtual observatory tools
- Distribution of NRH, NDA and Orfees data

Interface of Solar Radio Database



Orfees Data

- Format FITS
  - High resolution (time resolution = 0.1 sec., number of frequencies =998, file size=2.7 Gb/day)
  - Low resolution (time resolution = 1 sec., number of frequencies =998, file size= 200 Mb/day)

- Distribution via radio-monitoring website

Orfees Data

Primary

```
SIMPLE  =                    T
BITPIX  =                  -32
NAXIS   =                   +0
DATE-CRE= '2013-05-22'
DATE-OBS= '2013-05-22'
TIME-OBS= '07:57:58.000'
DATE-END= '2013-05-22'
TIME-END= '15:38:38.000'
PHYSPARA= 'I+V     '
OBJECT  = 'SOLEIL  '
OBS-TYPE= 'RADIO   '
ORIGIN  = 'OBSERVATOIRE DE
 NANCAY FRANCE'
CONTACT = 'ALAIN KERDRAON'
TELESCOP= 'RADIO SPECTROMETER
INSTRUME= 'ORFEES  '
EXTEND  =                    T
```

No data in primary extend

HEADER
DATA

TTYPE : name of the data
TFORM : format of the data
TUNIT : units of the data

Format of the data :
XxxY where
Xxx : number of elements
(if xxx = 1 then data is scalar
Array otherwise)
Y : type of the data :
L : bool, X/B : bit, I,J,K : int
E : float

Extend 1 (frequencies arrays)

```
XTENSION= 'BINTABLE'
 BITPIX  =                  +8 /
NAXIS   =                  +2 /
EXTNAME = 'FREQUENCIES'
NAXIS1  =                +4080
NAXIS2  =                   +1
PCOUNT  =                   +0
GCOUNT  =                   +1
FREQUNIT=                   +6
TFIELDS =                  +11
```

```
TFORM10 = '1J      '
 TTYPE10 = 'NP_B5   '
TFORM11 = '102E    '
TTYPE11 = 'FREQ_B5 '
TUNIT11 = 'MHZ     '
```

```
TFORM8  = '1J      '
TTYPE8  = 'NP_B4   '
 TFORM9  = '91E     '
TTYPE9  = 'FREQ_B4
 TUNIT9  = 'MHZ
```

```
TFORM6  = '1J      '
TTYPE6  = 'NP_B3   '
TFORM7  = '175E    '
TTYPE7  = 'FREQ_B3 '
TUNIT7  = 'MHZ     '
```

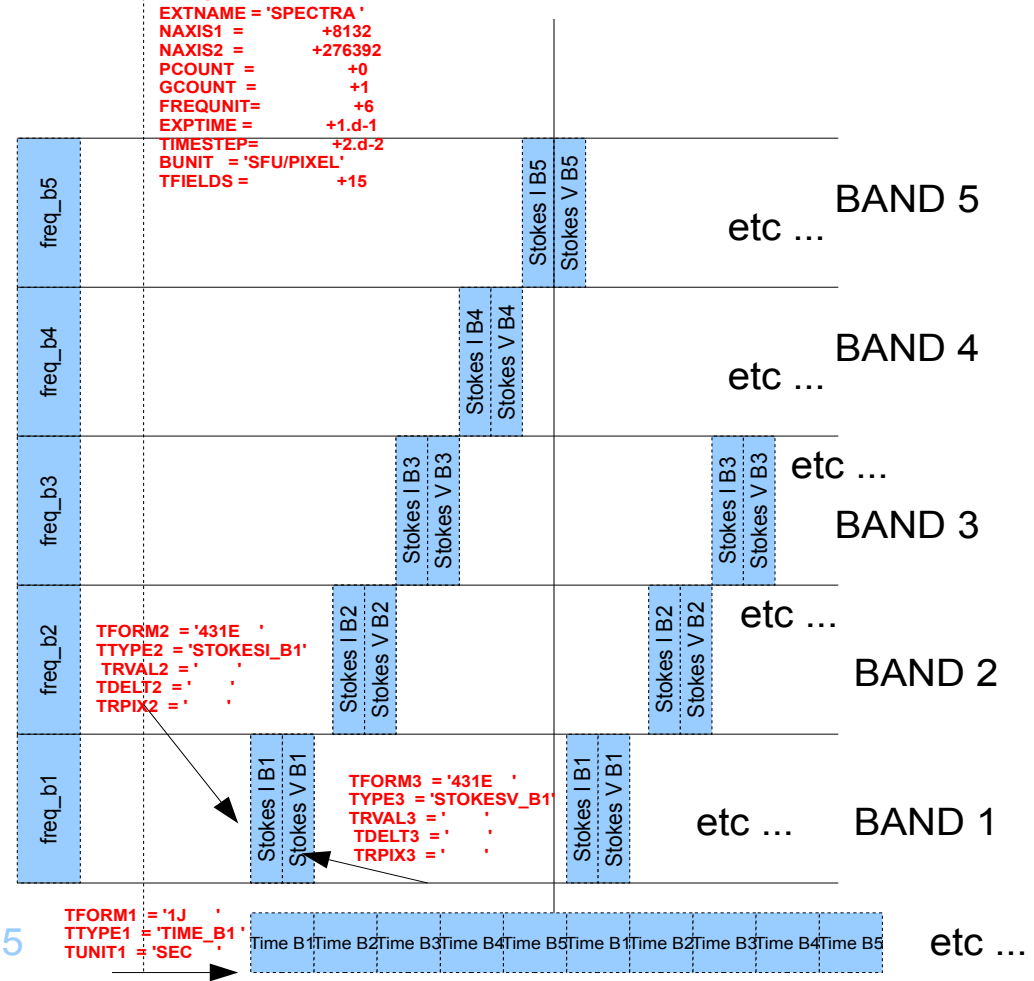
```
TFORM4  = '1J      '
TTYPE4  = 'NP_B2   '
TFORM5  = '215E    '
TTYPE5  = 'FREQ_B2 '
TUNIT5  = 'MHZ     '
```

```
TFORM2  = '1J      '
TTYPE2  = 'NP_B1   '
TFORM3  = '431E    '
TTYPE3  = 'FREQ_B1 '
TUNIT3  = 'MHZ     '
```

```
TFORM1  = '1J      '
TTYPE1  = 'N_BANDS '
```

Extend 2 (data)

```
XTENSION= 'BINTABLE'
BITPIX  =                  +8
NAXIS   =                   +2
EXTNAME = 'SPECTRA '
NAXIS1  =                +8132
NAXIS2  =              +276392
PCOUNT  =                   +0
GCOUNT  =                   +1
FREQUNIT=                   +6
EXPTIME =                +1.d-1
TIMESTEP=                +2.d-2
BUNIT   = 'SFU/PIXEL'
TFIELDS =                  +15
```



NRH Data

Formats

- Visibility
- Image Files (FITS)

Software

- Used independently and with GUI (IDL)
- Available on solar soft

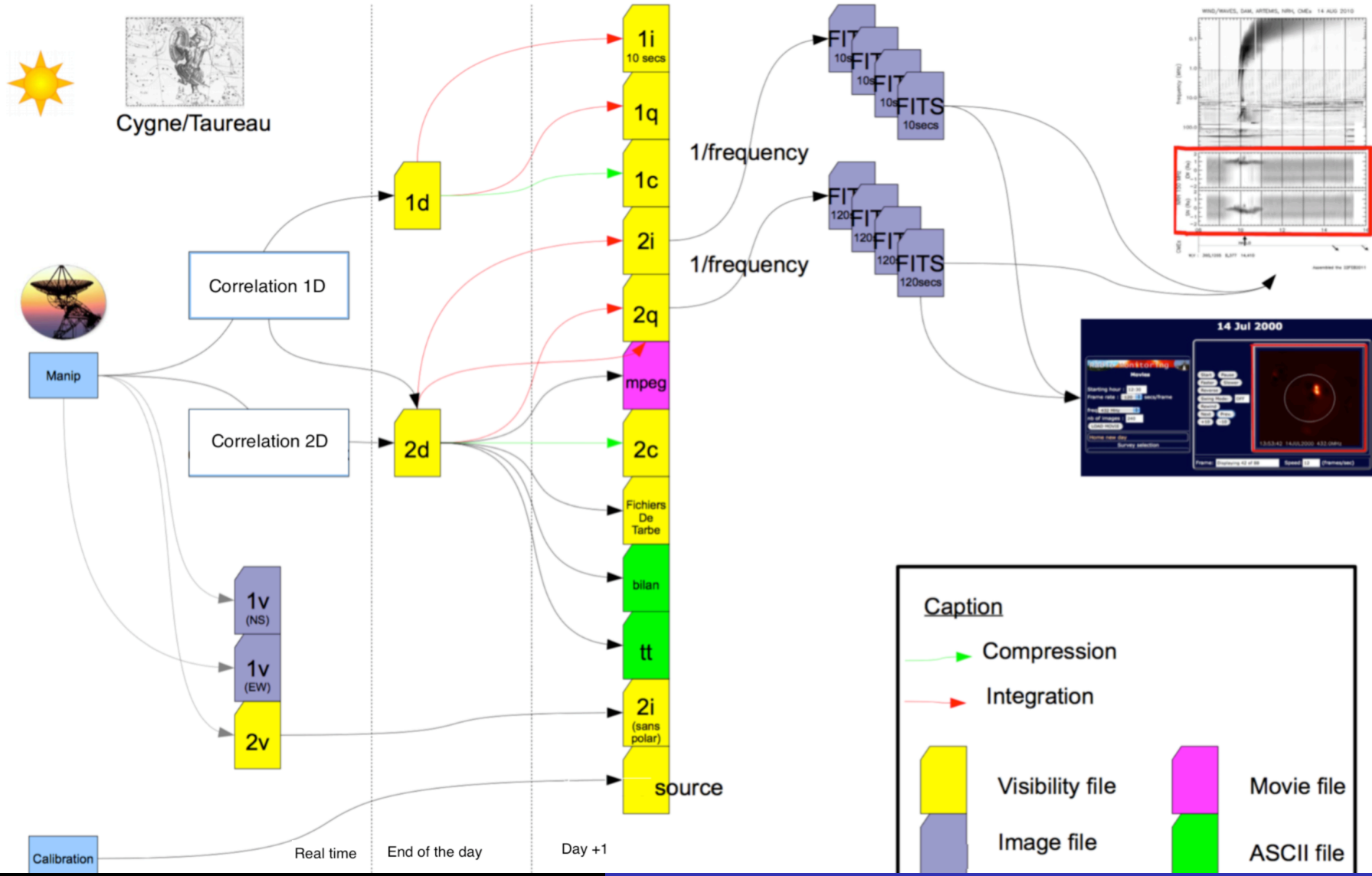
Archiving

- Data available since 1996

Distribution of visibility files

- High resolution data: on demand via the website

NRH Data


Cygne/Taureau
Manip
Correlation 1D
Correlation 2D
1d
2d
1v (NS)
1v (EW)
2v
Calibration
1i 10 secs
1q
1c
2i
2q
mpeg
2c
Fichiers De Tarbe
bilan
tt
2i (sans polar)
source
1/frequency
1/frequency
FITS 10secs
FITS 120secs
14 Jul 2000
Caption
Compression
Integration
Visibility file
Image file
Movie file
ASCII file
Real time
End of the day
Day +1

NRH Data (old file)

File contains: header and data

Header of acquisition (10 integers)

- Compressed acquisition number: 0 to 255.
- Number of Frequencies: 0 to 9
- Hour: TU or TS
- Minute: TU or TS
- Second: TU or TS
- Hundredth: TU or TS
- Gain 2D
- Gain 1d EW
- Gain 1d NS
- Free (1 integer)

Data: 648 Harmonics (648 x 4 = 2592 integers)

- cos non polar
- sin non polar
- cos polar
- sin polar

Free unit: 6 integers

NRH Data (new file)

Header of acquisition(10 integers)

- Compressed acquisition number: 0 to 255.
- Number of Frequencies: 0 to 9
- Hour: TU or TS
- Minute: TU or TS
- Second: TU or TS
- Hundredth: TU or TS
- Gain 2D
- Gain 1d EW
- Gain 1d NS
- Free (1 integer)

Data: 1128 Harmonics (1128 x 4 = 4512 integers)

- cos non polar
- sin non polar
- cos polar
- sin polar

Free unit: 2 integers

NRH Data (Header)

Header of file

- Head length: 32bit
- File size: 32bit
- Acquisition length: 16bit
- Type of file acquisitions: 16bit
- Coding of acquisitions: 16bit
- Acquisition representation: 16bit
- Number of acquisitions head: 16bit
- Number of acquisitions: 16bit
- Number of 2D values: 16bit
- Number of 1D EW values: 16bit
- Number of 1D NS values: 16bit
- Description: 48bit
- Integration time, in milliseconds: 32bit
- Date: 48bit
- Source reference: 48bit
- Meridian time: 64bit
- Declination: 64bit
- Clock: 16bit
- Start time: 64bit
- End time: 64bit
- Number of frequencies: 16bit

NRH Data (Header)

- Frequencies table: 160bit
- Correction of trajectory: 16bit
- Compression: 16bit
- Receiver cycle: 16bit
- Description: 624bit
- EW Network depointing: 16bit
- NS Network depointing: 16bit
- Dipoles rotation, antennae 2, 4 EW: 16bit
- Dipoles rotation, antenna 0 NS: 16bit
- Position of the antennae according to the EW axis: 1536bit
- Antenna position according to the NS axis
- Correlation table (antenna ref, antenna): $2x$ nbcorel $x8$ bits
- 10 Correlation table: $10x$ $(8 + 4x\text{nbant})$ $x16$ bits
  - Frequency (KHZ)
  - Date (Day, month, year)
  - Reference (2 characters)
  - Clock (Hour, minute)
  - Gains coefficient
    - Gain non polar
    - Gain polar
    - Phase non polar
    - Phase polar

NRH Data (Header)

- Description: $2x80x8$ bits
- Activity: $1x80x8$ bits
- Failures: $3x80x8$ bits
- Events not compressed: $15x80x8$ bits
- Swap endian: $1x32$ bits
- Number of the last record(klumax): $1x32$ bits
- Correction dtu: $1x32$ bits

- Number of Antenna (nbant): $1x32$ bits
- Number of Correlation(nbcorel): $1x32$bits
- Receiver gain: nbant $x16$ bits
- Gains per antenna: nbant $x16x16$ bits

Thank you for your attention