NRH status and projects

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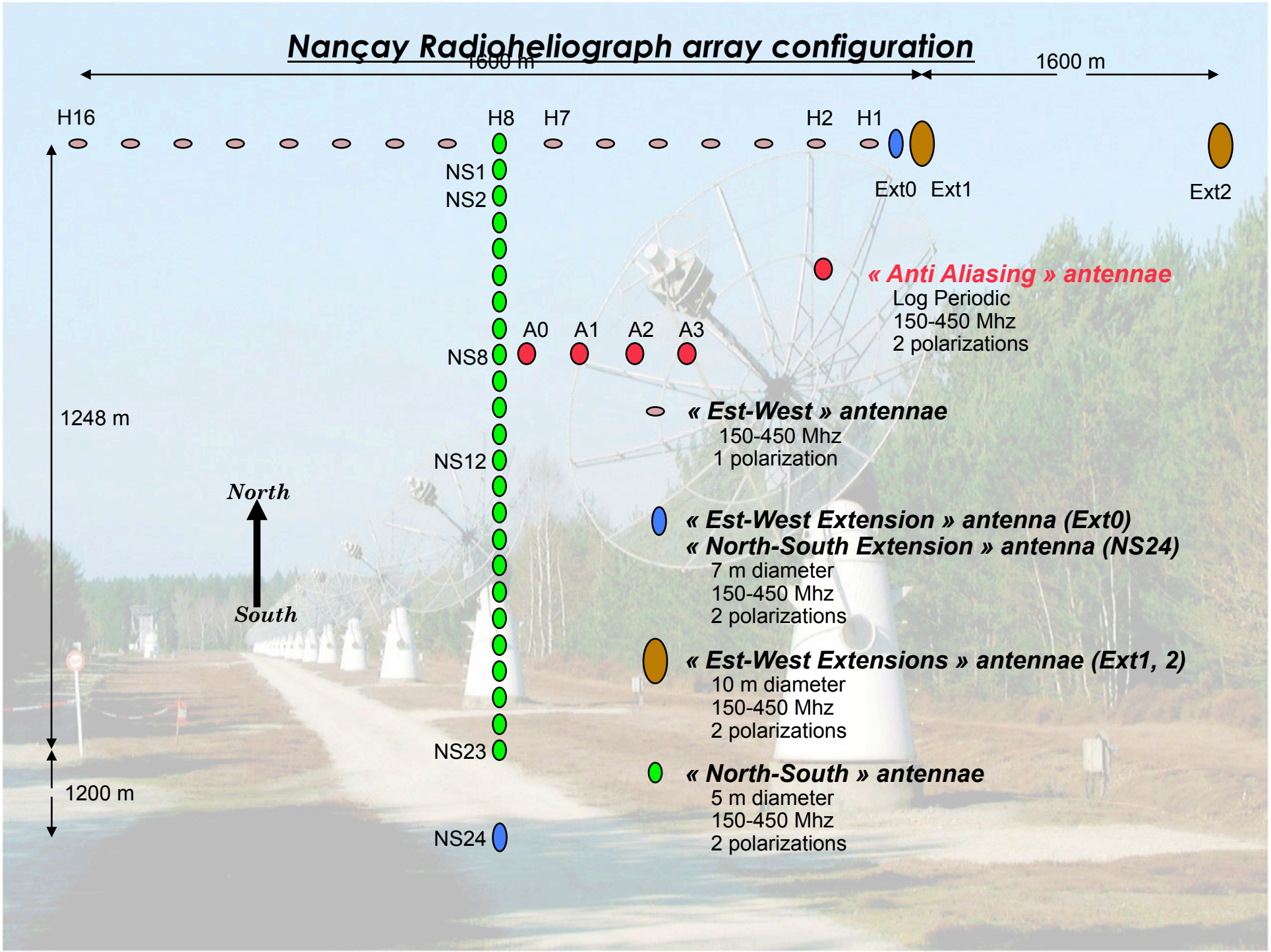
NRH Workshop Meudon 2009
June 29-30

NRH status and projects

- Outline
  - Brief description
    - Strengths and weaknesses
  - Improvements
    - Higher frequency (610 MHz) add
    - Correlator replacement

NRH status and projects


Nançay Radioheliograph array configuration
1600 m
1600 m
H16
H8
H7
H2
H1
NS1
NS2
NS8
NS12
NS23
NS24
A0
A1
A2
A3
Ext0
Ext1
Ext2
1248 m
1200 m
North
South
« Anti Aliasing » antennae
Log Periodic
150-450 Mhz
2 polarizations
« Est-West » antennae
150-450 Mhz
1 polarization
« Est-West Extension » antenna (Ext0)
« North-South Extension » antenna (NS24)
7 m diameter
150-450 Mhz
2 polarizations
« Est-West Extensions » antennae (Ext1, 2)
10 m diameter
150-450 Mhz
2 polarizations
« North-South » antennae
5 m diameter
150-450 Mhz
2 polarizations

NRH status and projects

- Frequency range: 150 – 450 MHz
  - 450 ~easily connected to Xray, EUV, optical observations
  - 150 ~easily connected to high corona and heliosphere
- Time resolution: 5 ms * number of frequencies
  - Daily observations 5 to 10 frequencies at 10/sec, I and V.
- Low instrumental polarization:
  - Can observe bursts with a few % circular polarization

NRH status and projects

- Arrays and antennas
  - 46 antennas: enough for detailed snapshots
  - Arrays design is not up to date:
    - Historical design (NRH was built on old adding interferometers)
    - The Nançay station is not so great (1200*1600m)
  - Antennas sizes and sensitivity
    - Sensitivity of most correlations is proportionnal to λ
      - Limitation on the high frequency side
    - Long baselines (mostly useful for rotationnal synthesis) are more sensitive (antennas with parabolic collectors).

NRH status and projects

- Spatial resolution etc.
  - Baselines used for snapshots are limited to 800m (EW) and 1200m (NS)
    - Resolution 1 to 3 arcmin. Is it sufficient ?
      - Very difficult to improve (we should buy a lot of ground)
      - 1D imaging has a 2 to 4 times better resolution, relevant for simple sources.
      - Rotationnal synthesis: 4 times better (EW), 2 times better (NS).
- Short baselines
  - Dense coverage of uv plan starting from minimum baselines ~50m.
    - Insufficient for quiet sun at 450 MHz, acceptable at F < 300 MHz
    - Convenient for bursts.
- Field of view:
  - small antennas means wide FOV. > 6° at 450 MHz (excellent)

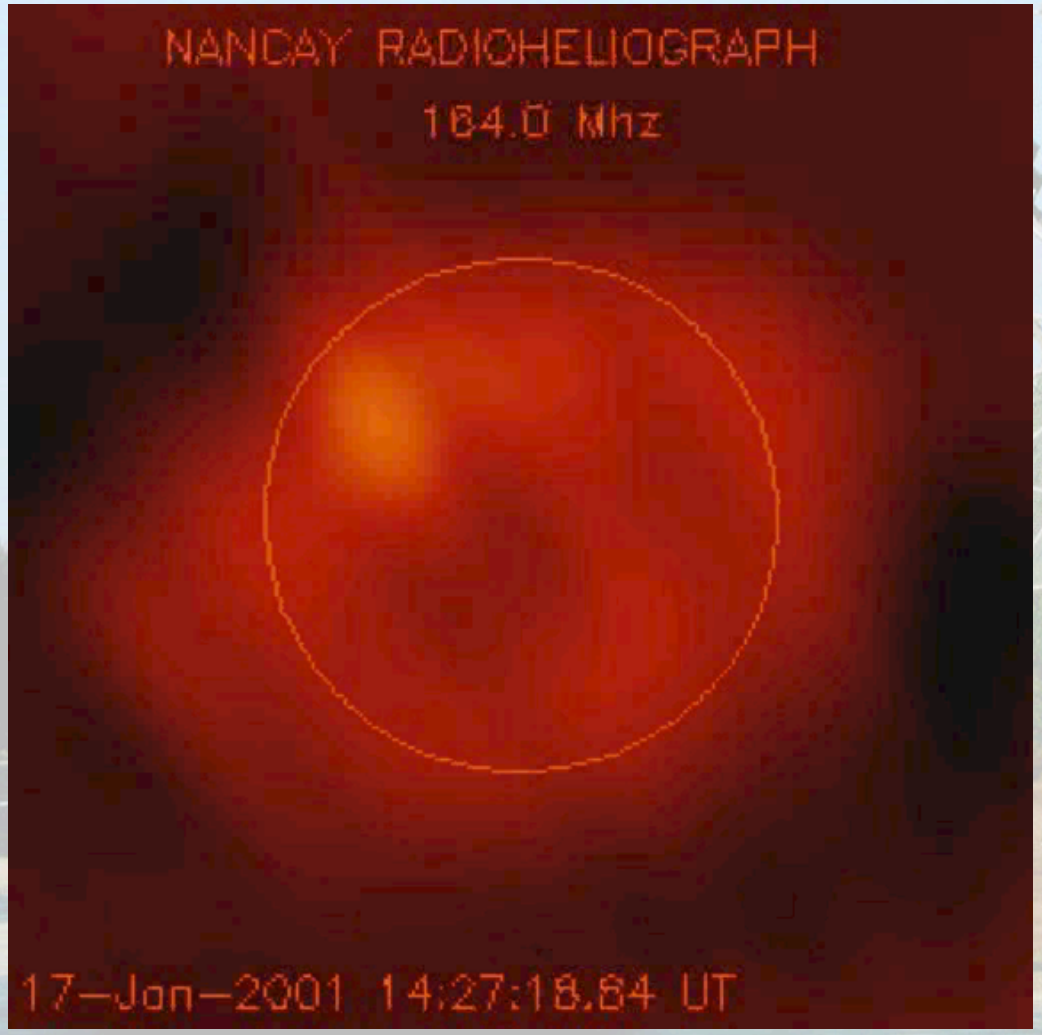
NRH status and projects

- Radio interferences
  - Far from towns: the noise of electronic gadgets is limited
  - Cannot avoid the general european background of TV, GSM, telecom…
    - Situation is getting worse, with digital broadcast (TV and audio), mobile internet.
  - French regulation (still) allows some protection.
  - Local RFI are a permanent problem (some buildings are quite close to the antennas)
    - Despite constant efforts, calibrations are disturbed by local emitters, mainly digital devices.

NRH status and projects

- NRH has no RFI mitigation capability
  - It is a low bandwidth instrument (700 kHz). That helps.
  - From a study for FASR (2 elements interferometer:
    - The classic system with banks of narrow filters can remove medium level low bandwidth telecom signals, with simple detection of low bandwidth signals.
    - It is more difficult for powerful interferences
    - That kind of RFI suppression doesnt apply to NRH, due to its internal elctronics.
- We try to have the best status in the (very few) bands ~allocated to radioastronomy:
  - 74, 151, 327, 408, 610 MHz.

NRH status and projects : Ionosphere



- Ionosphere at 164 MHz
- Very severe case (includes some distorsion)
- In most cases: smaller motion and no distorsion.
- Likely to occur at low site angle
- Angular effects proportionnal to λ^2

NRH status and projects : Ionosphere

- Possible corrections
  - For NRH: almost none
    - Try to follow a stable source on the sun, if any (noise storm).
    - It is difficult to measure motions on the quiet sun emission: the source contrast is too low.
  - Its a serious problem only at the lower frequency when the sun is low (winter)
  - Around LOFAR:
    - There will be an effort to produce models of ionosphere.
    - When ?: the constraints are very high.
      - We need a 3D model of ionosphere on the line of sight, including waves, with a <1mn time resolution…

NRH status and projects

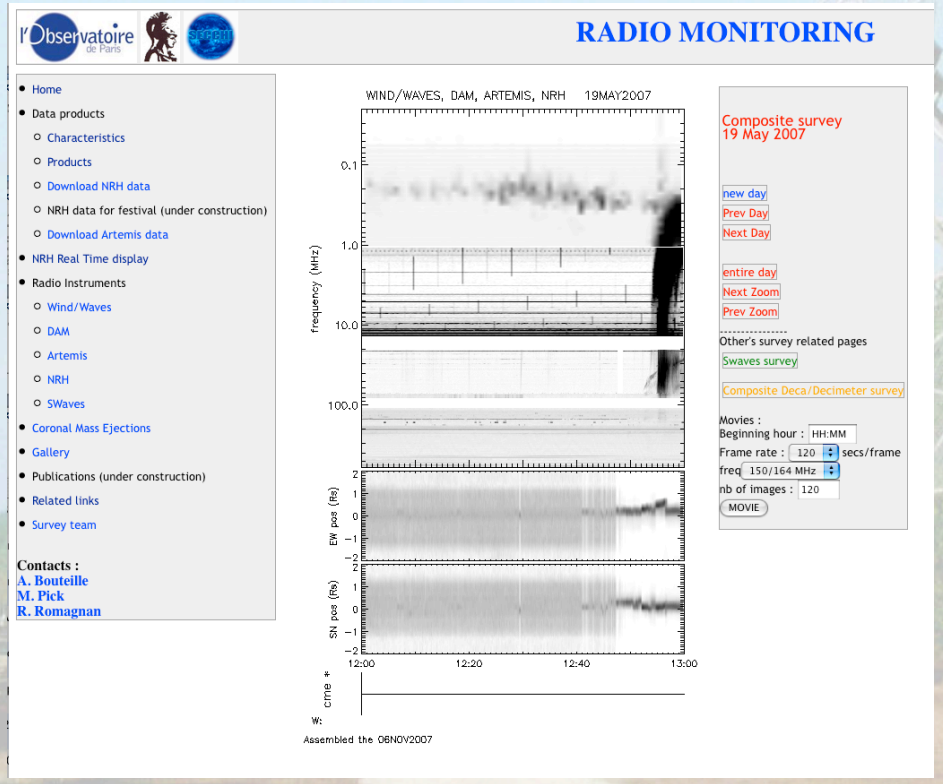
- Calibration
  - Assumes stability over days
  - Antennas complex gains are determined a few time per week by a strong radio source (3C405) observation
    - Sufficient for bursts snapshots
    - Insufficient for quiet sun rotational synthesis maps (have to do some kind of selfcal)
    - Could be improved by a new correlator
  - T_B ~10% accuracy
    - Remaining a possible small absolute position error

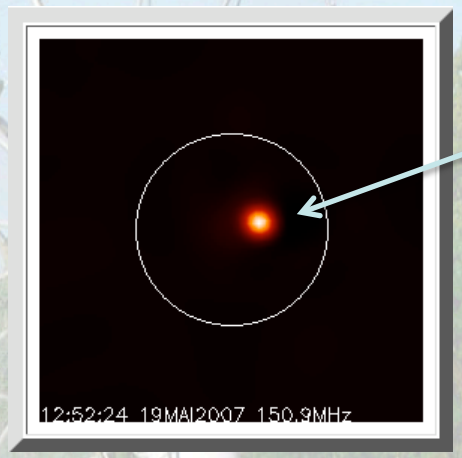
NRH status and projects

- Data / software
  - Experienced data distribution system (since 1996)
    - High time resolution data (5 GB/day) are still offline. Slow, time consuming access.
  - Solarsoft NRH package.
    - New functions to develop TBD
  - Database (http://bass2000.obspm.fr)
  - Radio monitoring site (http://secchirh.obspm.fr)
    - CMEs, radio positions and spectras)
  - Integration into the Solar Weather Browser (Brussels) and Festival (IAS Orsay)

Radio monitoring web site

- Merging radio spectras (600 MHz – 20 KHz), NRH images and CMEs

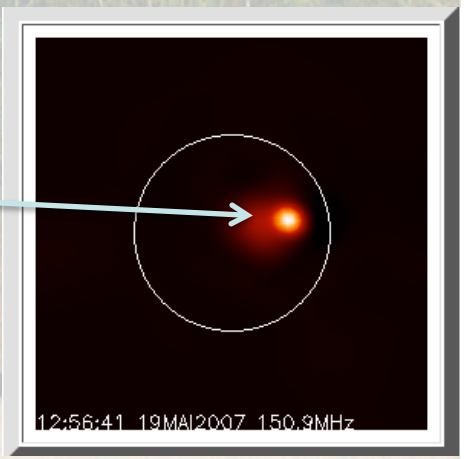




T2 burst

Movies

T3 burst

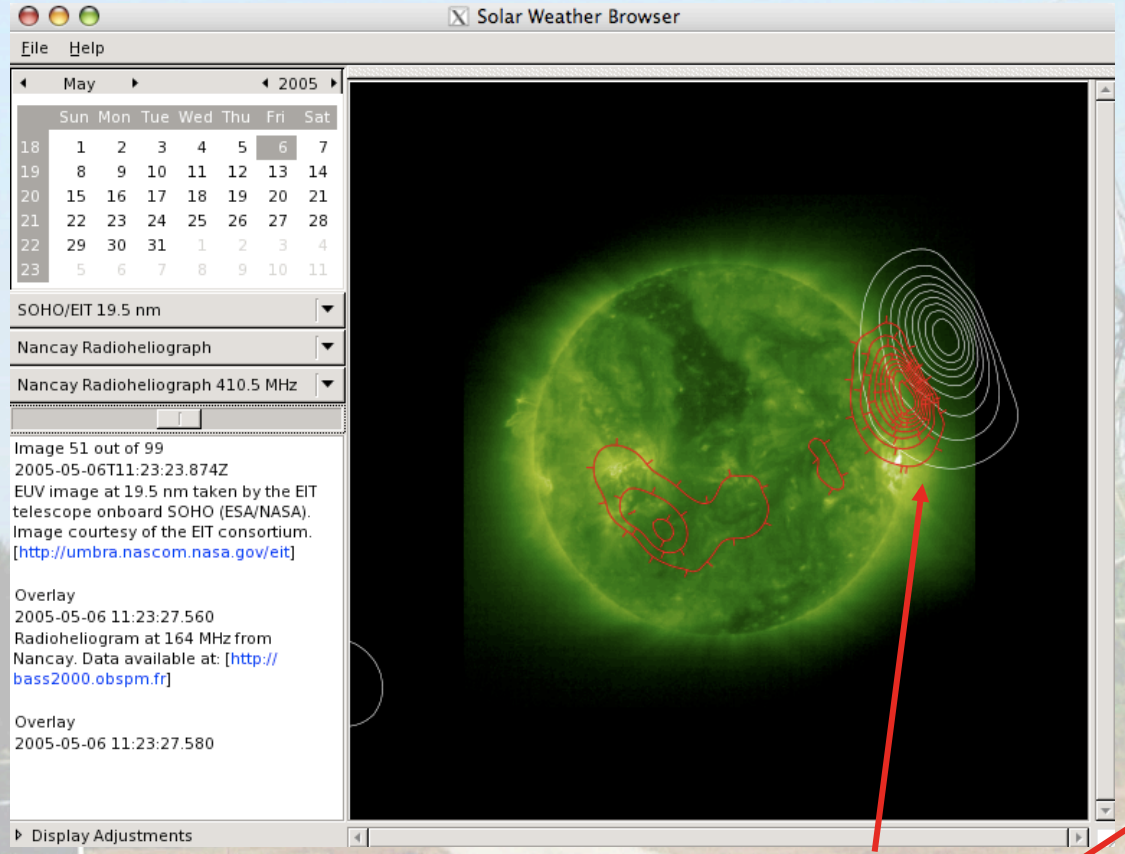


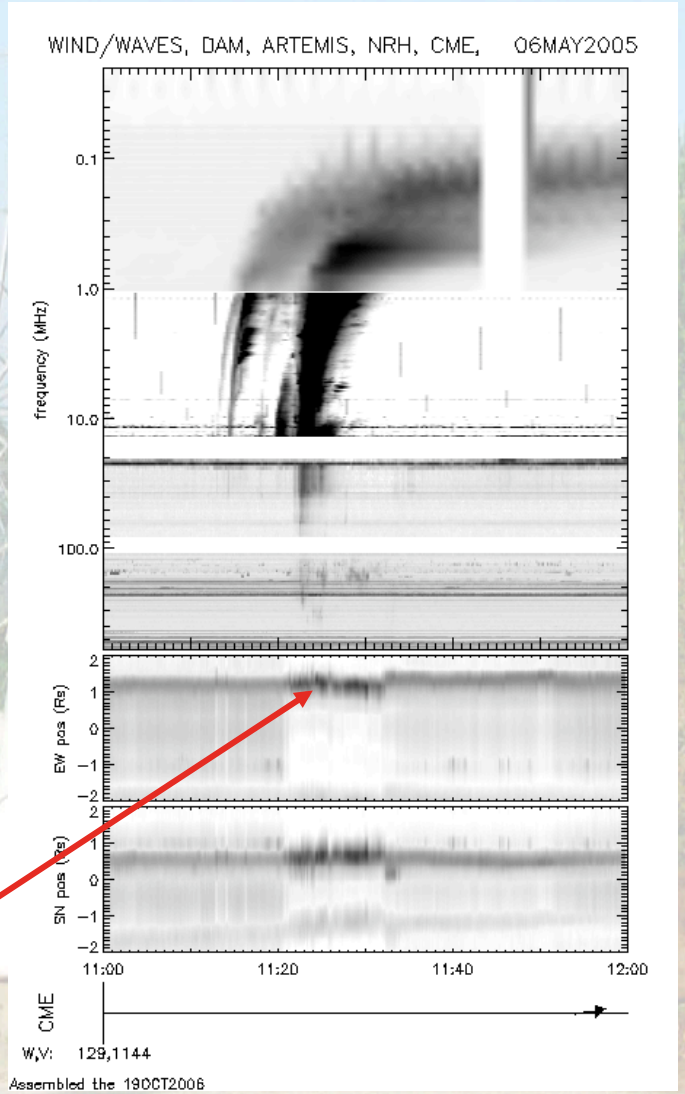
2007, May 19: Flare, Type 2, Type 3 radio bursts

http://secchirh.obspm.fr

Solar Web Browser

http://sidc.oma.be/SWB





May 6,2005

Type III burst

Soho, Stereo, NoRH, NRH…

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NRH status and projects

- Operating and maintenance cost (USN): rather inexpensive
  - 3 FTE (observations, electronic) + general support (1 FTE)
  - CNRS-PNST: 8-15 K€ /year
  - Paris Observatory: 12 K€ (+ energy, buildings, network)
- The technical team may run the instrument for > 10 years
- The realtime system will be changed in 2010 (2 FTE, ~10 k€)
  - Will decrease the operation cost by at least 8 k€)

NRH status and projects

- What upgrades ?
  - Replace everything (arrays, correlator), increase the bandwidth…: make a new, modern RH
    - Not realistic, considering the strength of Solar Physics in France, or of Solar radioastronomy in Europe (cost up to 10 M€)
  - Find limited upgrades with a good scientific or technical return.
    - Add a single higher frequency (610 MHz)
    - Replace the correlator by a more capable one.
    - An extension toward lower frequencies is not considered, because LOFAR should do the job (but, with what observing time?)

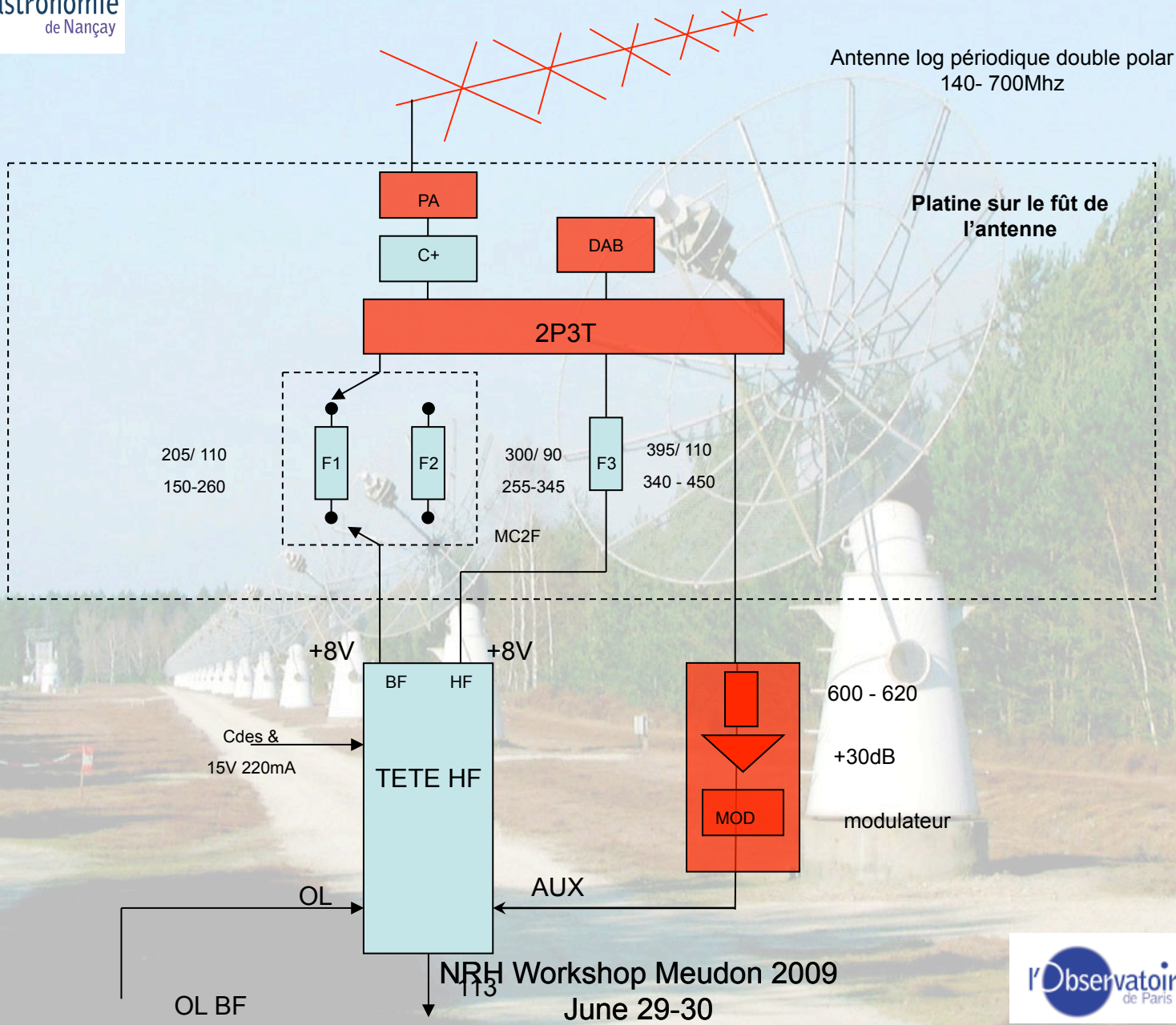
NRH status and projects

- Correlator upgrade
  - Reasons
    - Only 648 baselines (should be 1035)
      - Better calibration with all the redundancies
    - 1994 technology, unreliable control electronics
      - May lead to long duration failures.
  - Proposal
    - Replace the correlator and control cards by a much more compact FPGA system.
    - Cost (20-30 K€, 1-2 FTE). Estimation due for next september.
    - The proposal doesnt include RFI rejection: to difficult to do without major and expensive modifications.

NRH status and projects

- Adding one higher frequency
  - Reasons
    - High scientific return expected for flare studies
  - General scheme
    - Same antennas, at the same locations
    - No modification to the wide band 150-450 MHz system
    - Minimal modifications to controls and software
    - Piggyback 10 or 20 MHz frequency channel added on each antenna (wider channel may induce intermodulations)

MODIF ANTENNE EST OUEST



NRH status and projects

- 610 MHz add
  - Constraints
    - Synchronize with the shift from analog to digital TV (end of 2010?)
    - At least one year building and running prototypes on ~3 antennas (may perturb usual solar observations)
    - The main operation (modification of 46 antennas) may require a long stop of the NRH (6-12 months), ideally around 2011-2012. Alternatively, we may have a smoother process (modified antennas can be correlated with unmodified).
  - Cost
    - ~300 k€ (6-7k€ /antenna). That is not so small.
    - Manpower: not yet estimated (mechanics, analog).

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Thank you

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