

# SOLAR RADIO OBSERVATIONS in France (Nançay)

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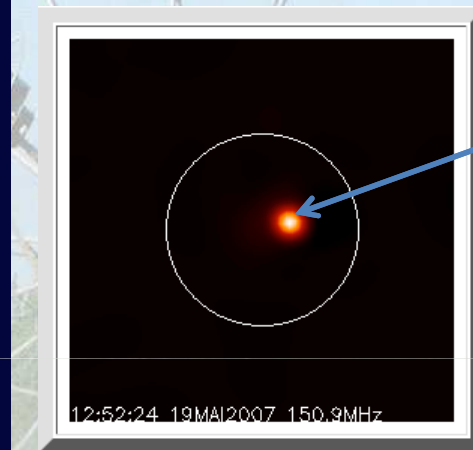
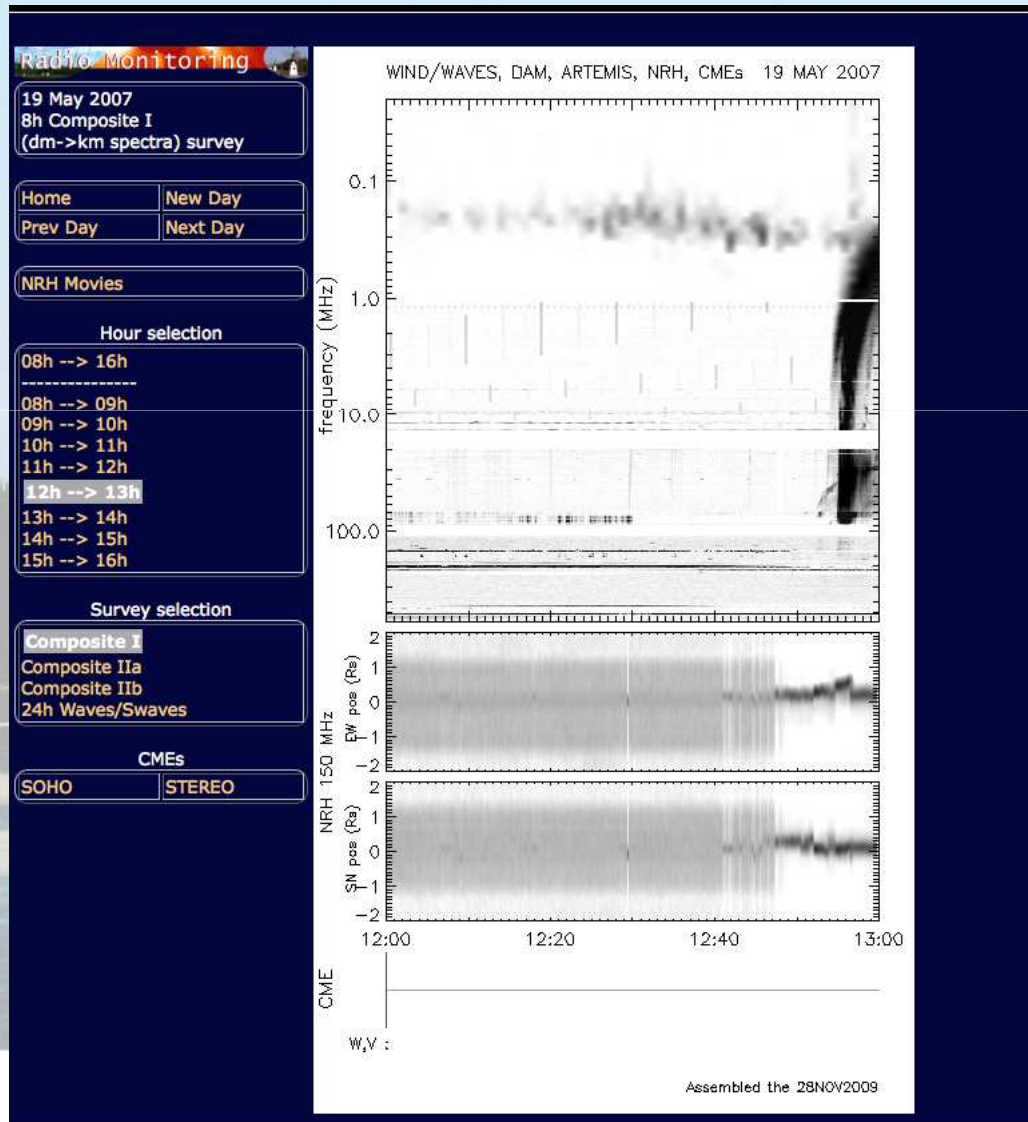
**Space Weather Working Team Plenary**  
**Brussels 28 June 2011**

# Solar Radio Monitoring and Radio Observations in Nançay (Paris Observatory)

- **Unique set of instruments and tools to detect and analyse solar activity at radio wavelengths and distribute observations:**
  - **Nançay Radioheliograph (NRH)**, solar-dedicated radioheliograph operating between 150-450 MHz (emissions originating from 0.1 to 0.5 solar radii).  
(data available through BASS2000 or through the radio monitoring site)
  - **DAM** spectrograph operating from 10 to 80 MHz
  - A tool at LESIA in Meudon (Web site » **Radio monitoring** ») which combines radio images and spectra from both ground-based and space-based instruments together with providing characteristics of CMEs. I
  - **A new spectrograph 130 - 1000 MHz (Orfeus)** (under construction) linked to the FEDOME project of Space Weather with the French army
- **LOFAR** will allow to complement this set of observations with images at lower frequencies than Nançay (e.g. the DAM frequencies) (the core in the Netherlands is at the same longitude than Nançay)

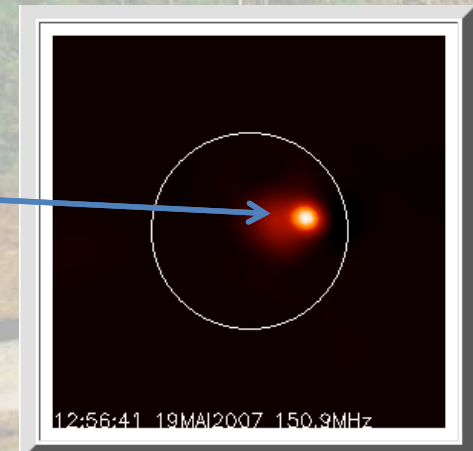
# « Radio monitoring » web site <http://secchirh.obspm.fr>

- Radio spectra (600 MHz – 20 KHz), NRH images and CME information

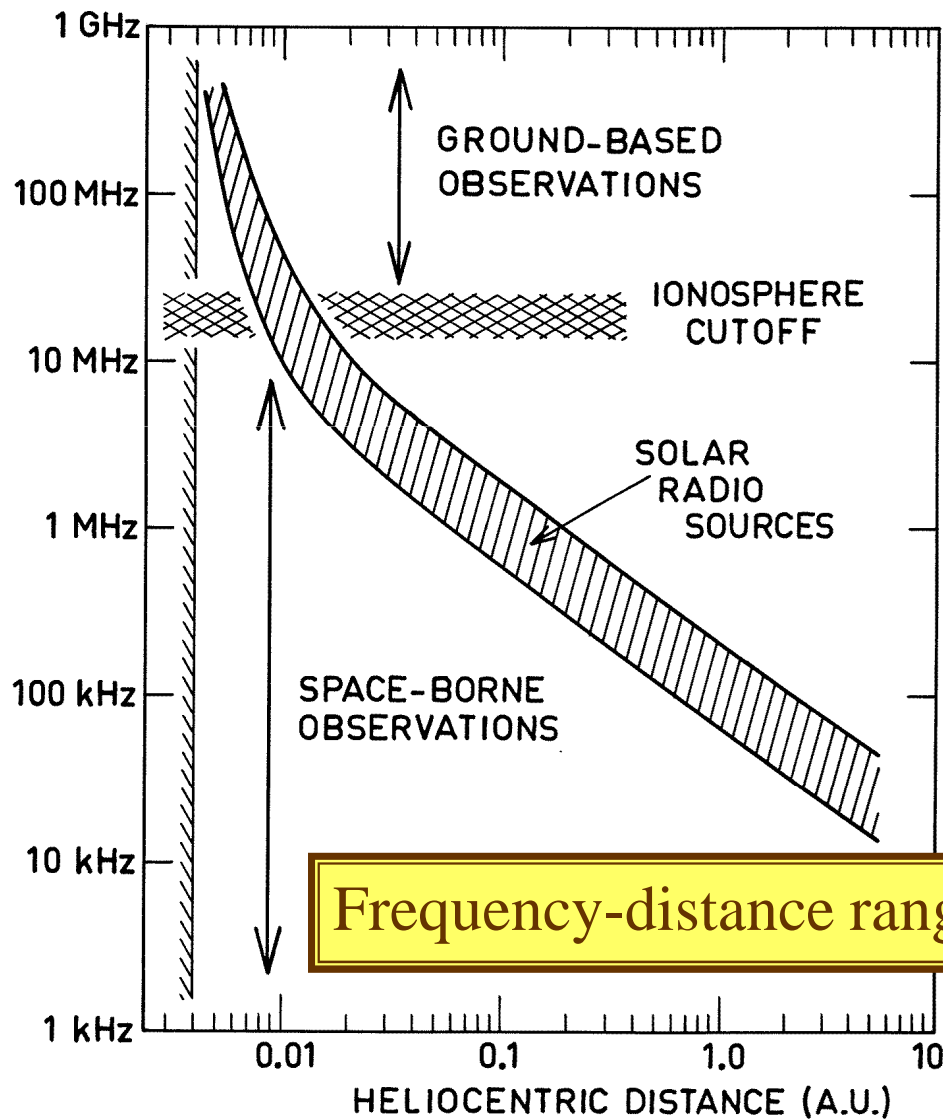


Sursaut T2

Sursaut T3



# Radio emissions in the corona and the interplanetary medium



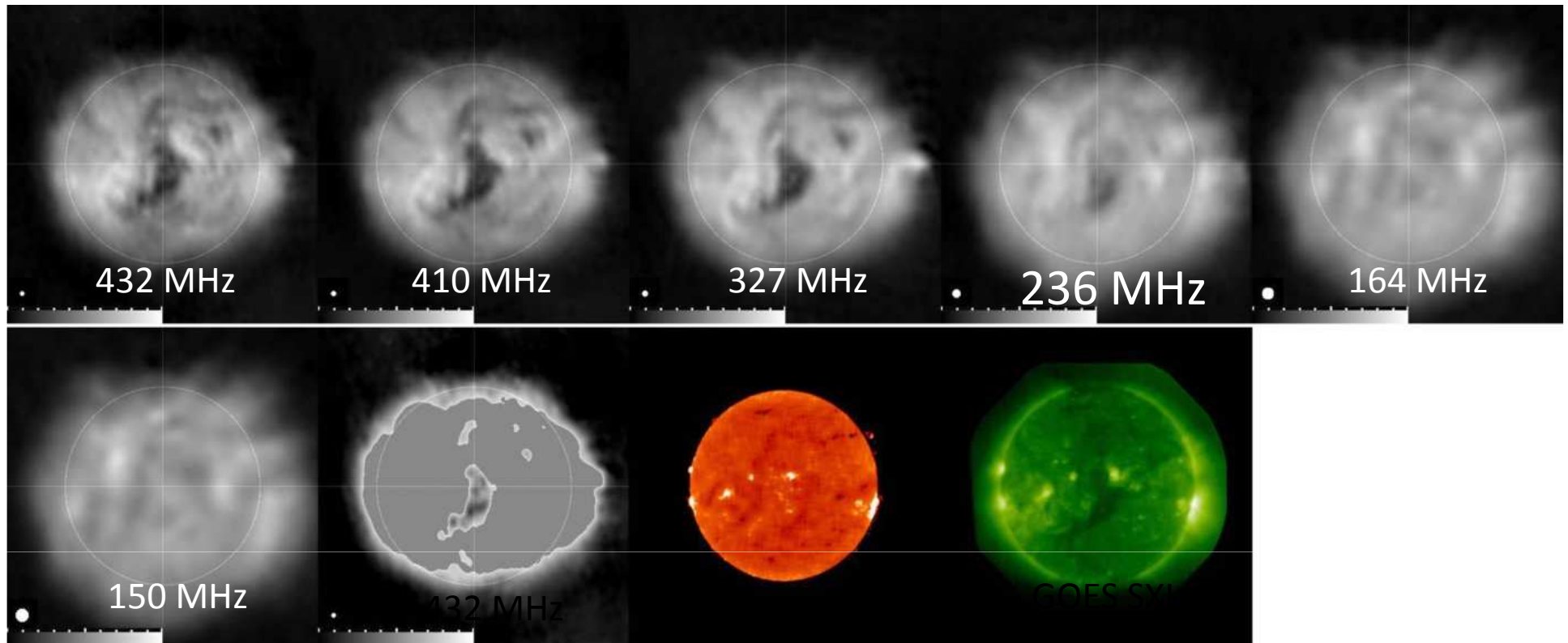
$$f_p = 9 \sqrt{N_e}$$

kHz      cm<sup>-3</sup>

in IP space

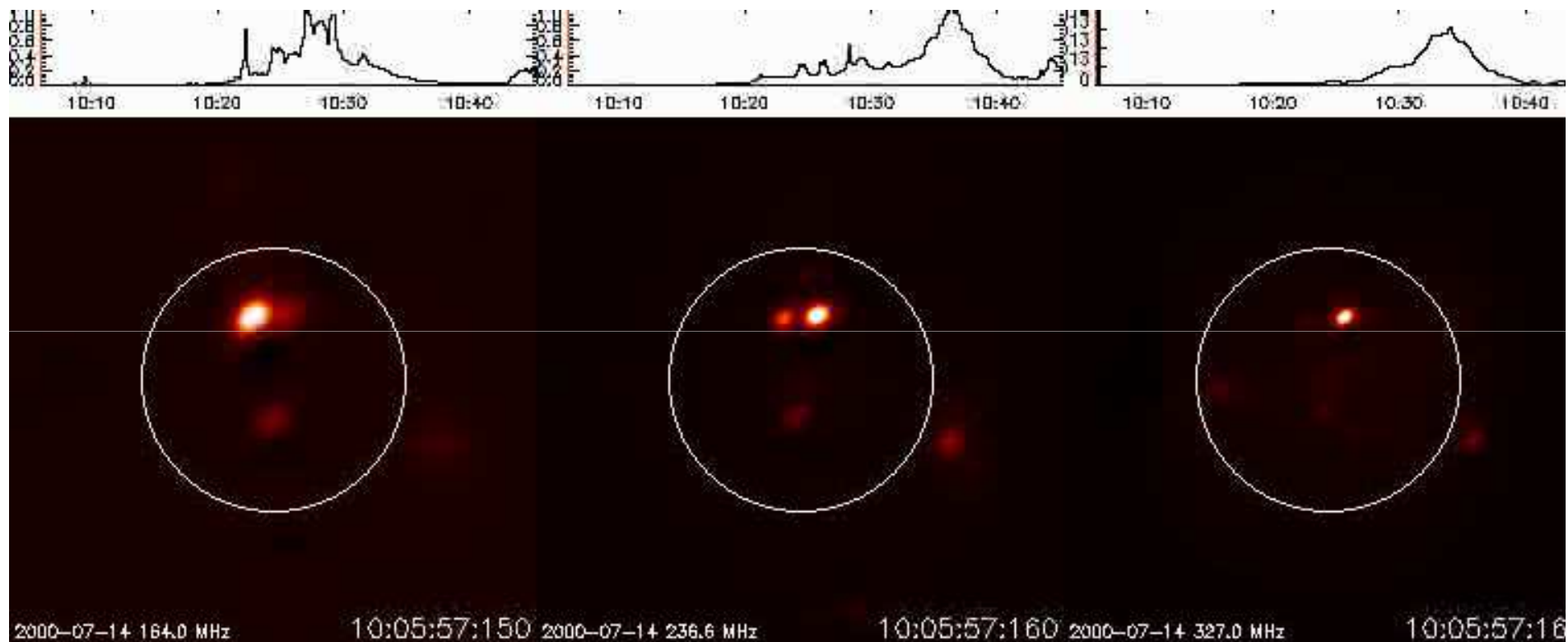
$$f \approx R^{-1}$$

Frequency-distance ranging



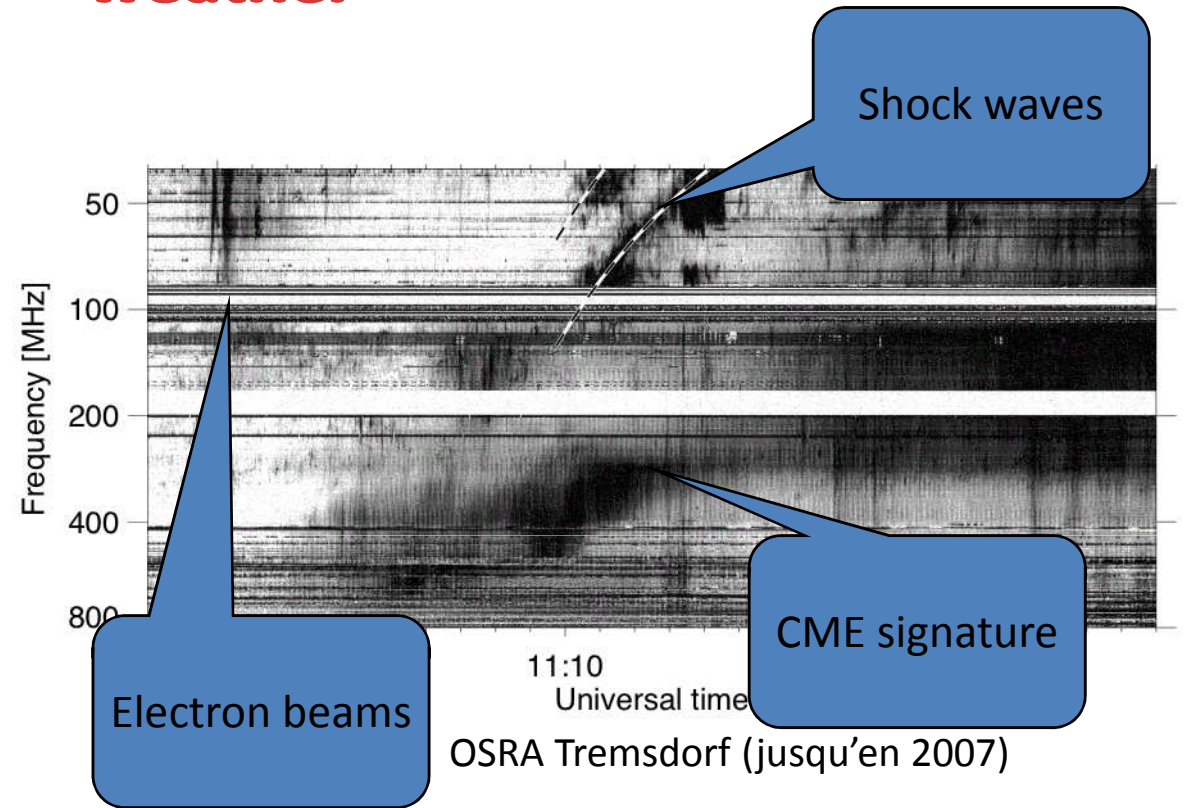
Observations of coronal structures with rotational synthesis images with the Nançay Radioheliograph (NRH)

From Mercier and Chambe 2009  
160 days from 2004 to 2011

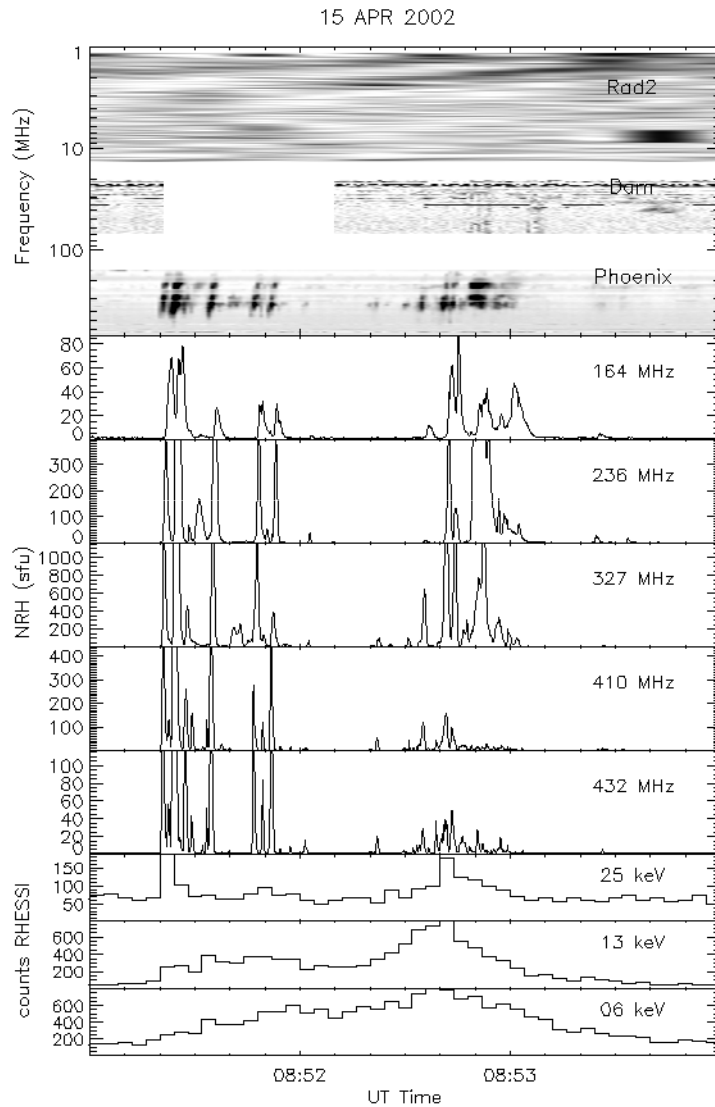


The Bastille Day Flare observed with the Nançay Radioheliograph (courtesy K.L. Klein)

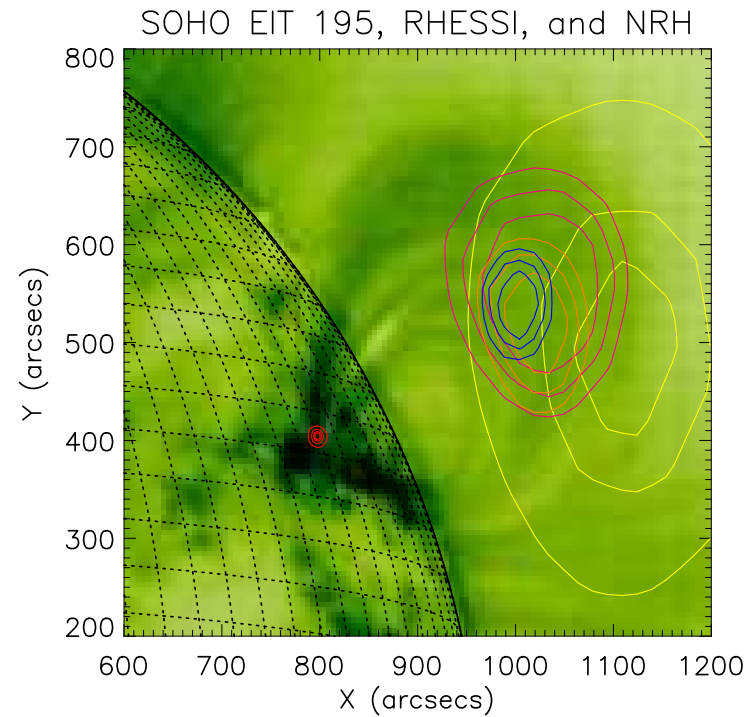
# Radio images and spectra for solar physics and space weather



Reid, Vilmer, Kontar, 2011



Solar flares and electron acceleration  
And propagation in the corona towards  
IP space:  
Combining radio (NRH, PHOENIX/Zürich)  
and X-ray observations (RHESSI)

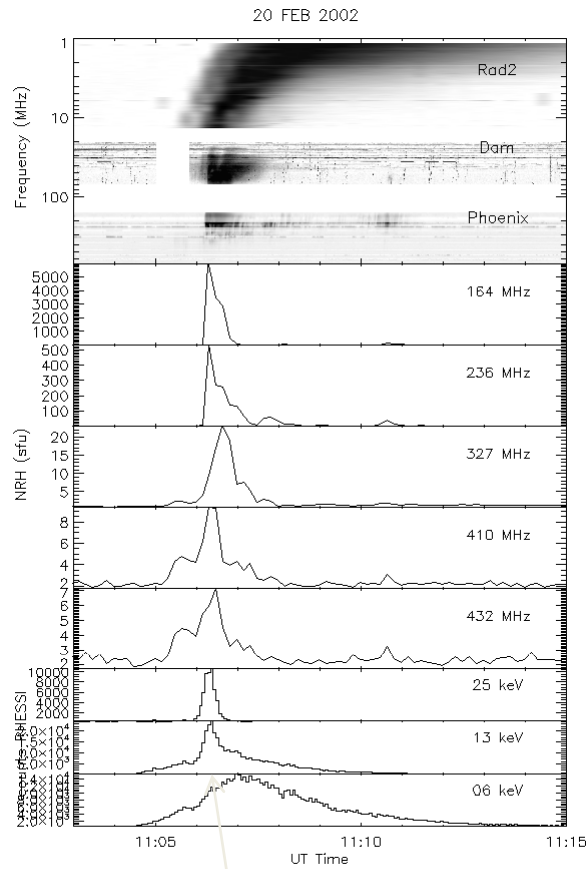


FP7 Space HESPE

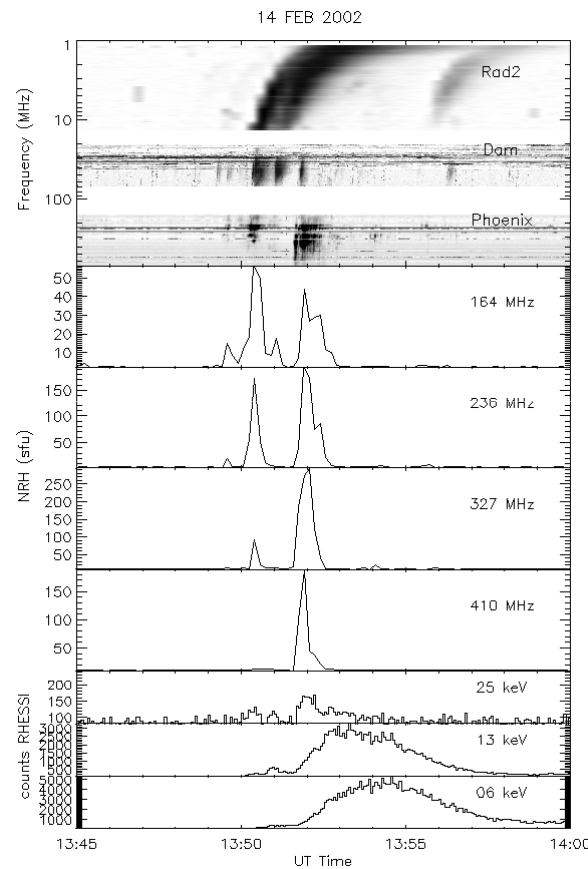




# A few more examples

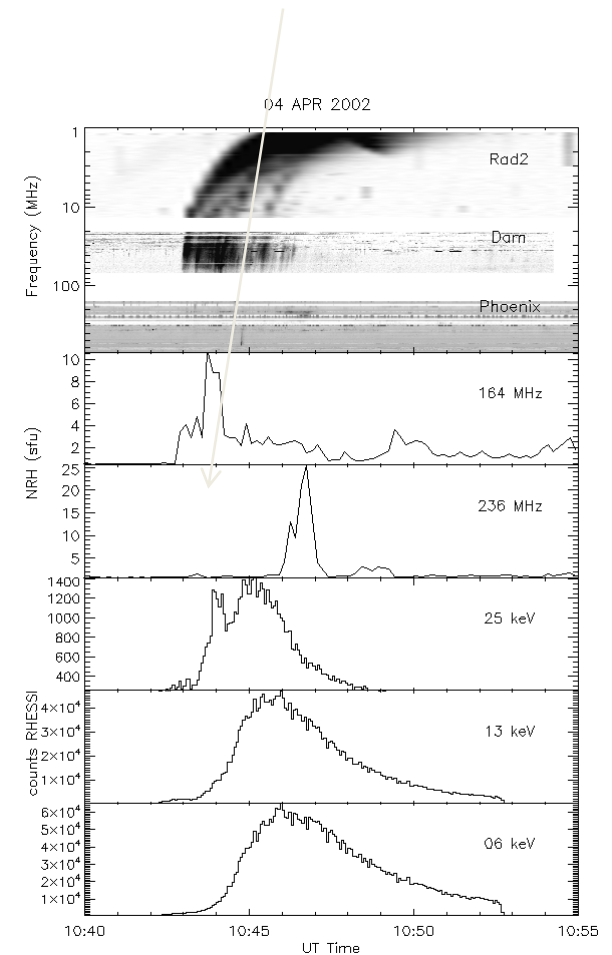


Simultaneous radio and X-rays



Radio emission before, during and after the HXR burst

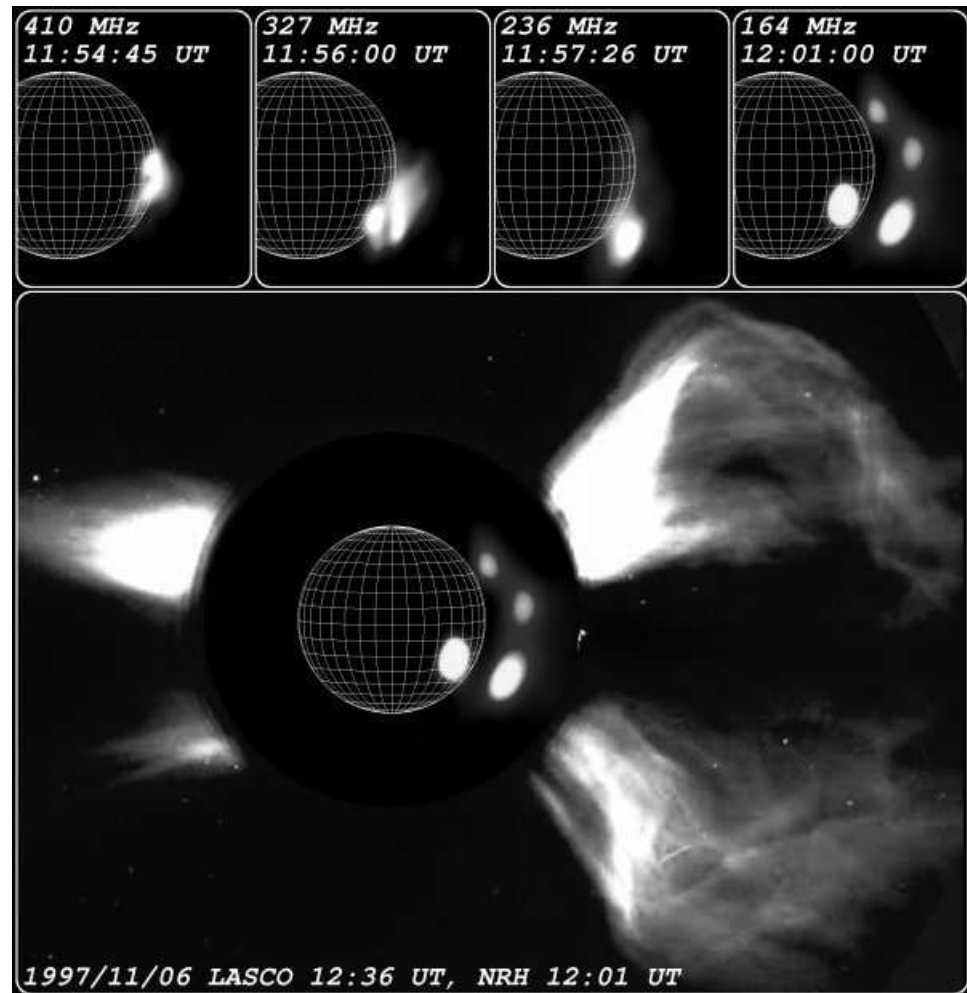
## Faint metric/decimetric emissions



# Electron acceleration and radio emissions related to CME lift-off

Radio observations of the CME development from the flare site

Electron acceleration in successive magnetic interactions at larger distances from the flare  
Note the comparable extent of the radio source and of the CME.

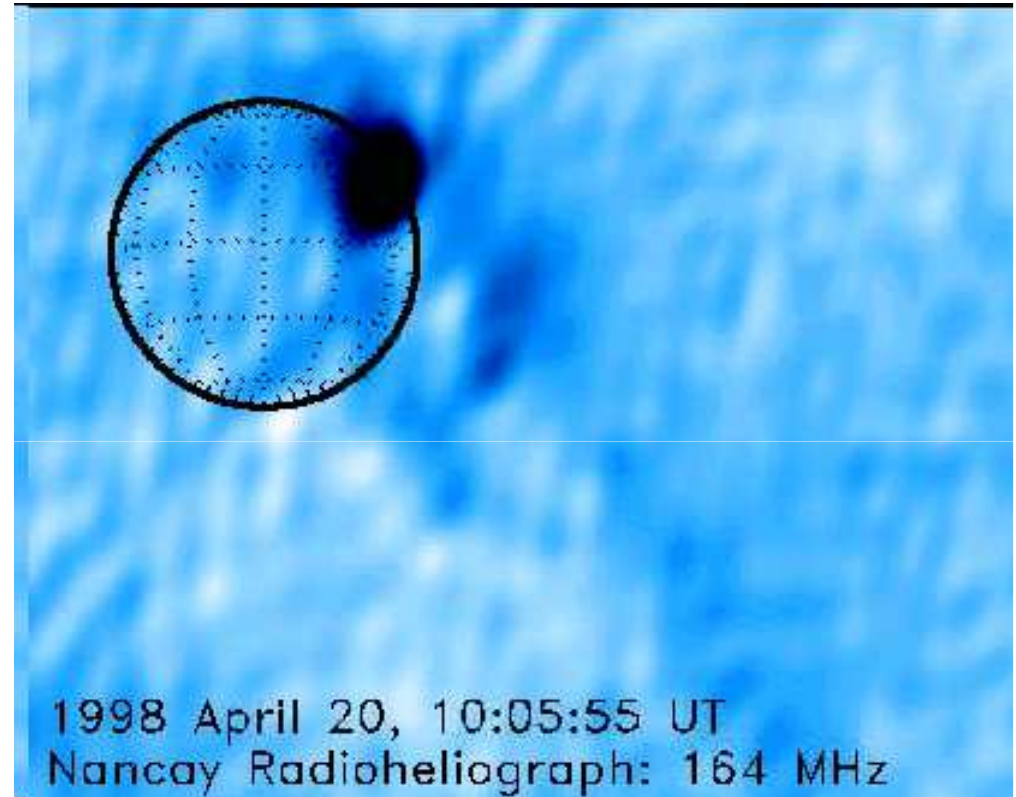


Maia et al., 1999

# Mapping *CME* loops with relativistic electrons

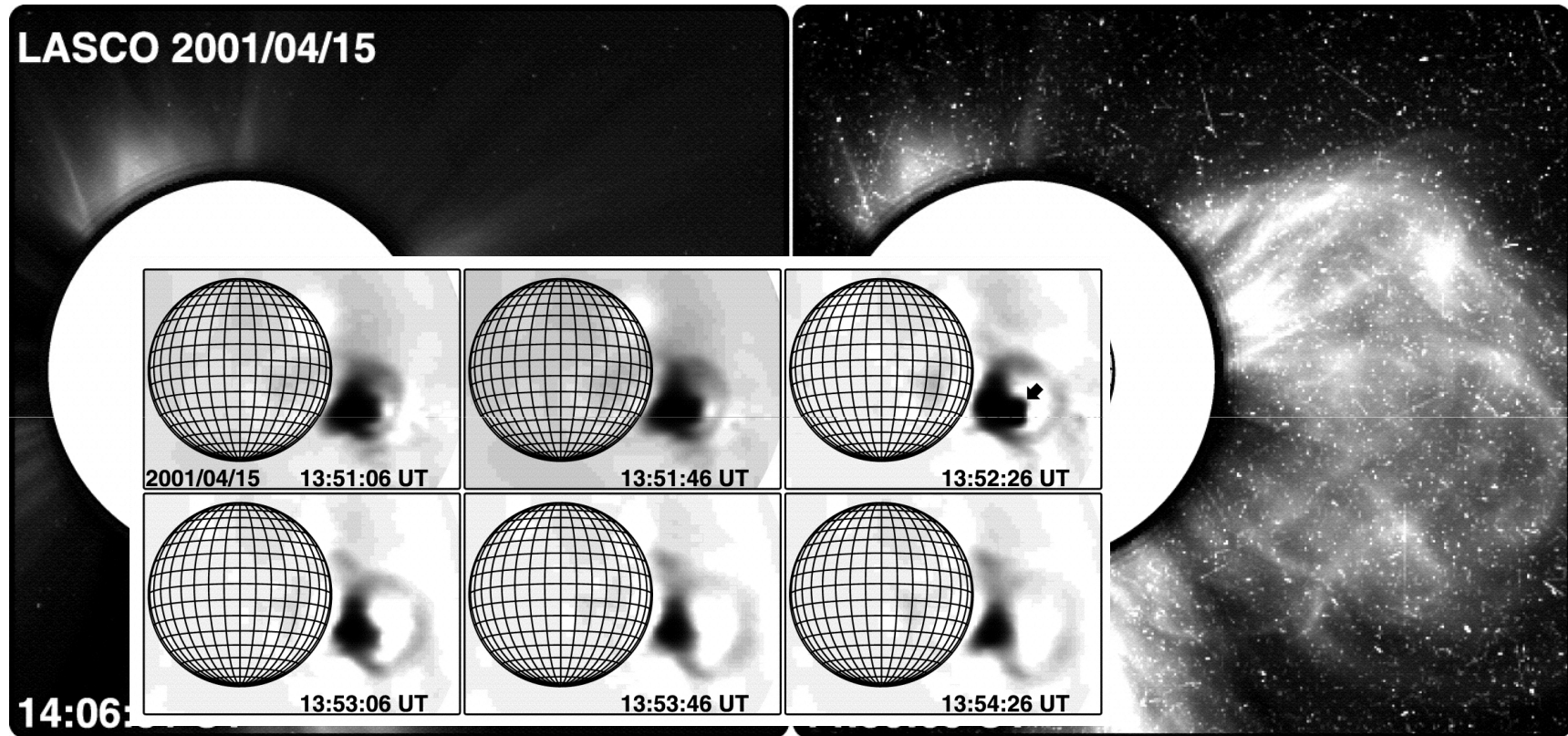
- Synchrotron radiation from relativistic  $e^-$   
The first radio CME

QuickTime™ et un décompresseur MPEG-4 vidéo sont requis pour visionner cette image.



Bastian, Pick,  
Kerdran, Maia,  
Vourlidas, 2001,  
ApJ 558, L65

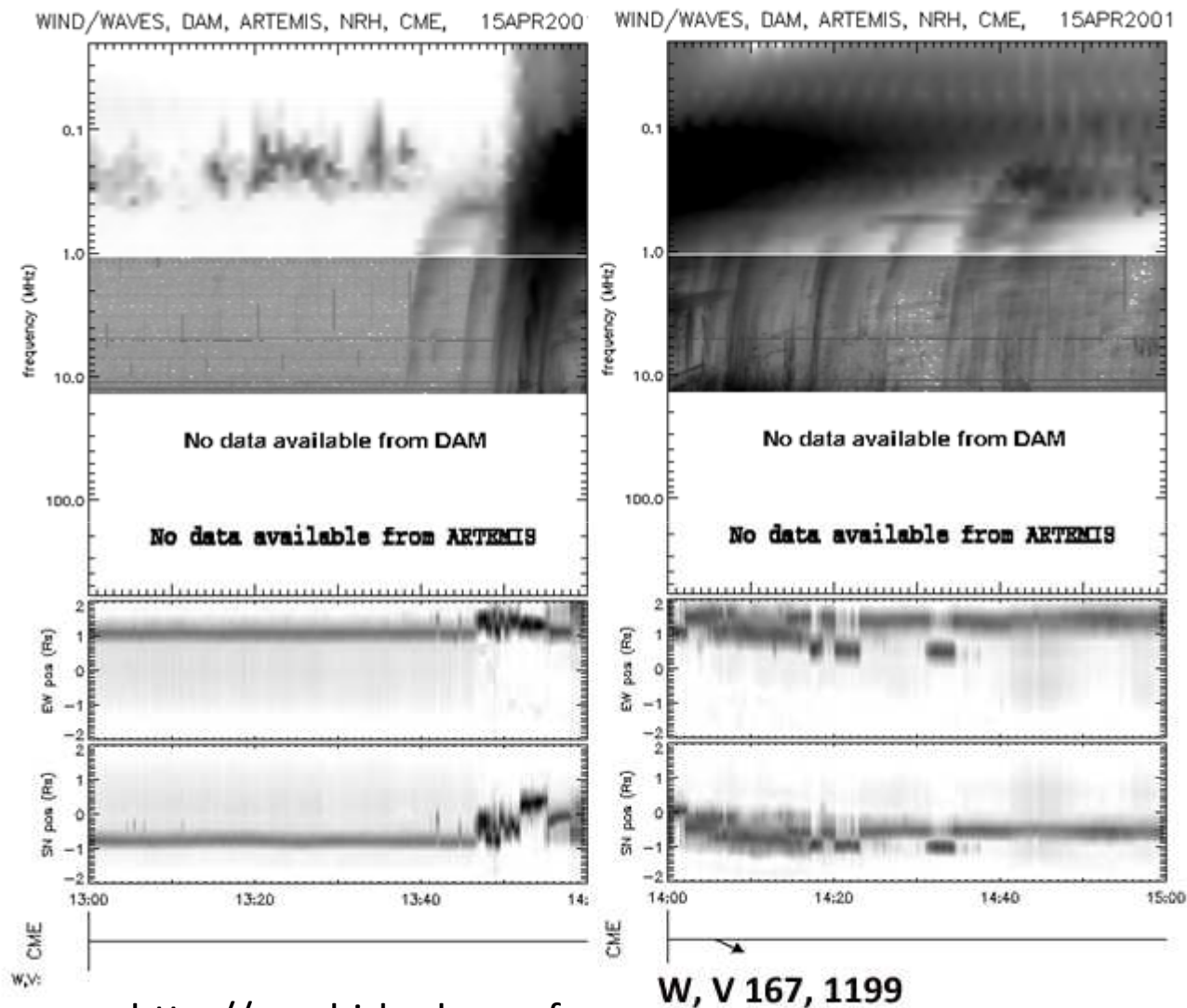
# Energetic electrons in the corona and injection in the IP space during a large SEP event



Maia et al 2007 ApJ 660, 874 : large SEP event of 2001 April 15

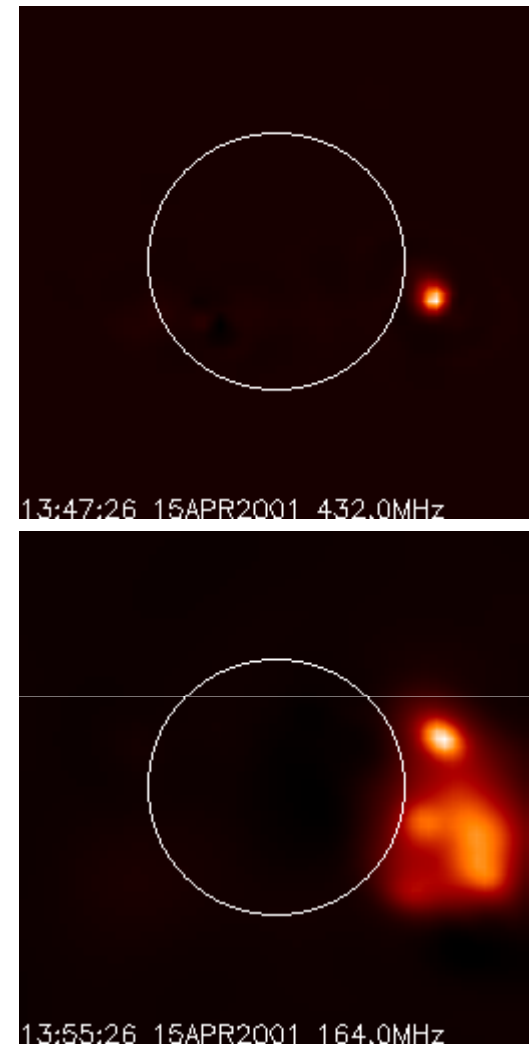
- Nançay RH : synchrotron radiation of relativistic electrons ( $\geq 1$  MeV) in CME-related loops, while CME still occulted
- Energetic electrons accelerated in the aftermath of CME (post-CME current sheets?)

# 15 Avril 2001 Monitoring radio



<http://secchirh.obspm.fr>

Contacts: A. Bouteille, M. Pick, R. Romagnan



# Space Weather FEDOME Project



G. Auxépales, Nançay



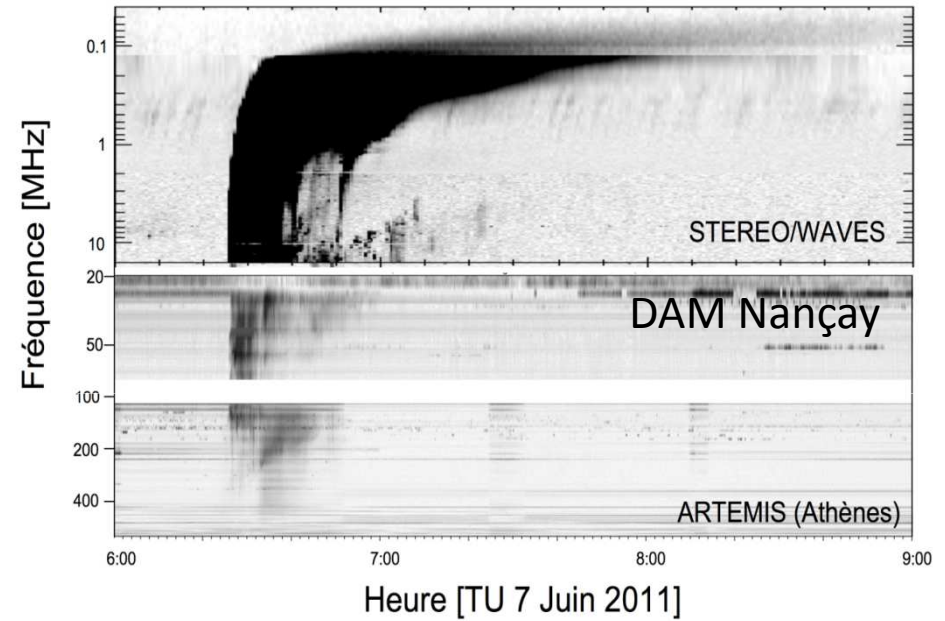
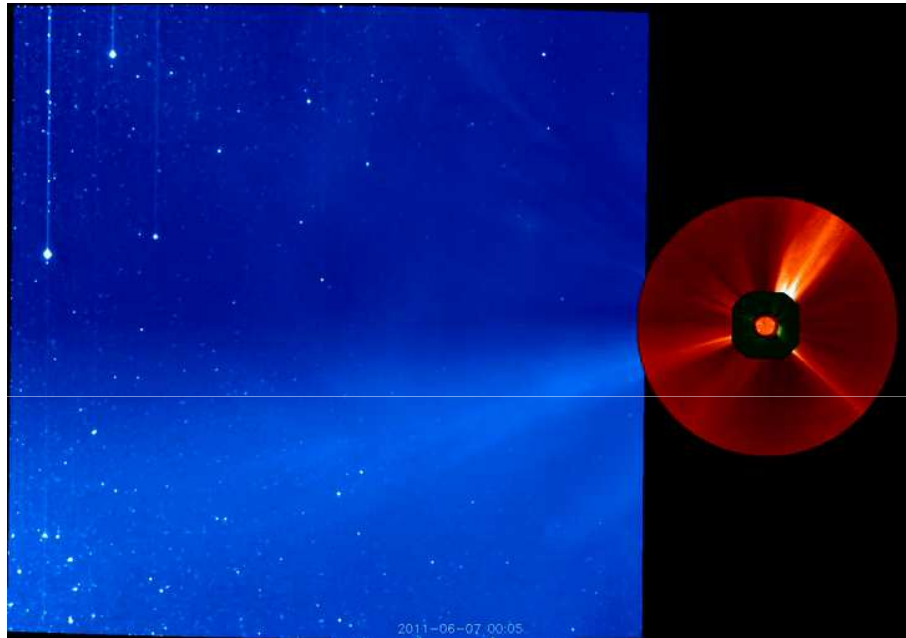
Spectro numérique ROACH  
14 bits, 2\*500 Msamples/s

- FEDOME (Fédération de données pour la météorologie de l'espace) : « demonstrator » for a space weather service for French Air Force
- ORFEES: a radiospectrograph 130-1000 MHz in Nançay (in construction; first observations 9/2011 – solar radio survey )

- To produce regular radio observations: NRH, DAM, ORFEES
- To produce data and tools in real time for FEDOME (data and tools publicly available)
- To provide expertise (space weather lectures at LESIA)

A. Kerdraon, K.-L. Klein, S. Pau, A. Bouteille, M. Rabouam (Lesia), G. Auxépales, G. Kenfak, P. Lespagnol (USN))

# The 7 June 2011 flare and CME



- CME (STEREO/COR & HI)
- Radio bursts: dm type III & m type IV (STEREO/WAVES & Artemis)
  - Radio-monitoring: <http://secchirh.obspm.fr>