

# LOFAR Dynamic Spectrum Data

J.-M. Griessmeier

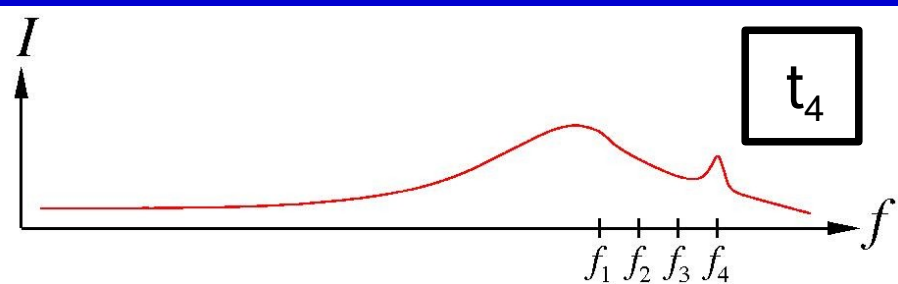
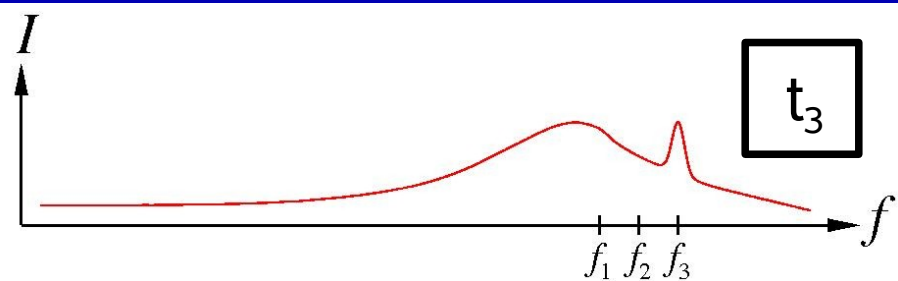
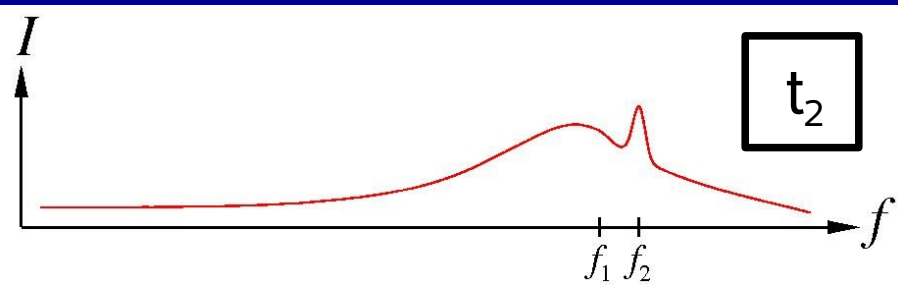
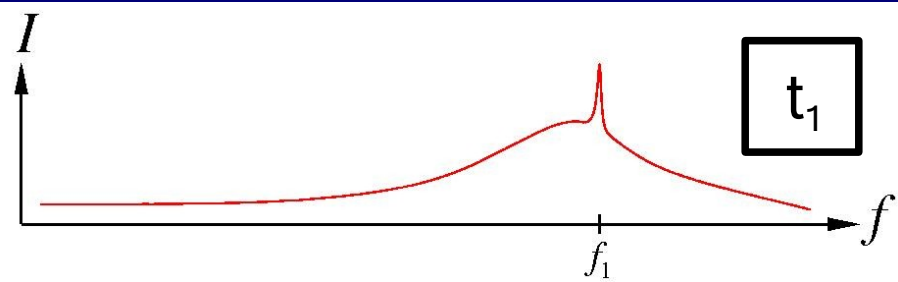


[jean-mathias.griessmeier@cnrs-orleans.fr](mailto:jean-mathias.griessmeier@cnrs-orleans.fr)

## Outline:

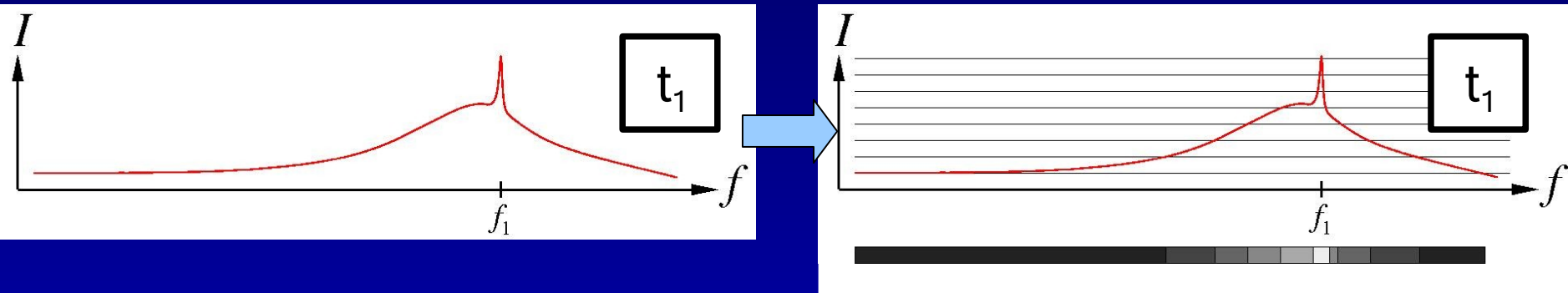
- dynamic spectra
- LOFAR dynamic spectrum pipeline
- dynamic spectra checklist
- first dynamic spectra with LOFAR

# Dynamic spectra



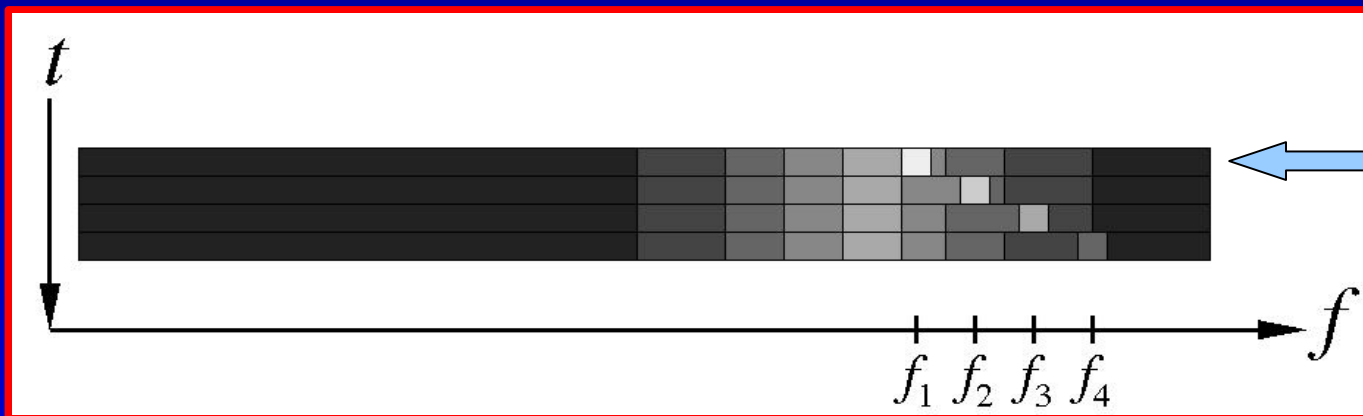
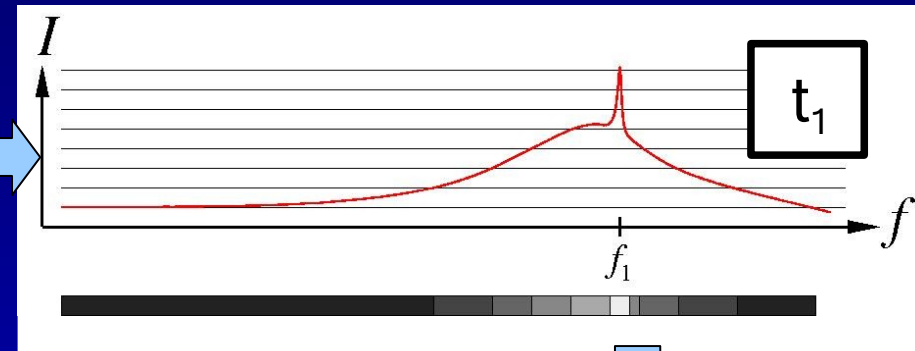
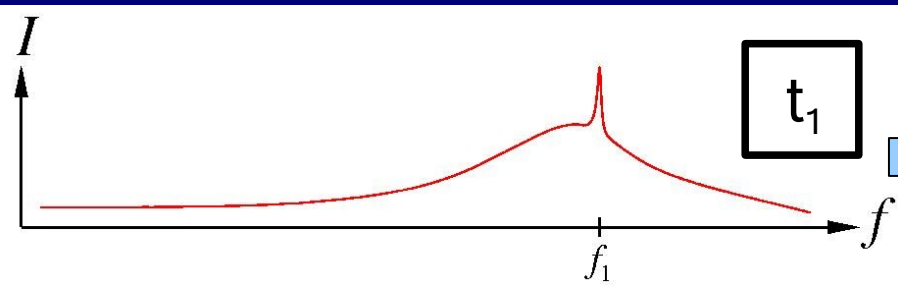
record spectra at different times

# Dynamic spectra



transform intensity to color scale

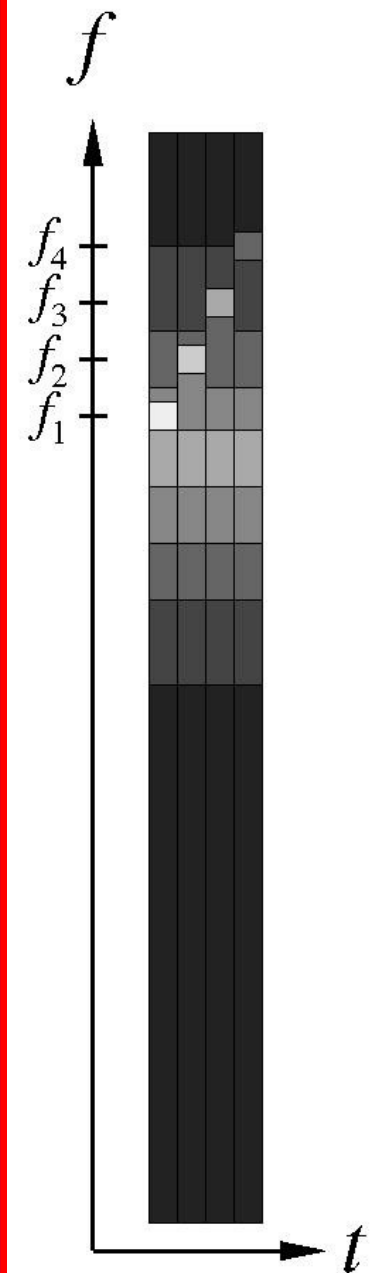
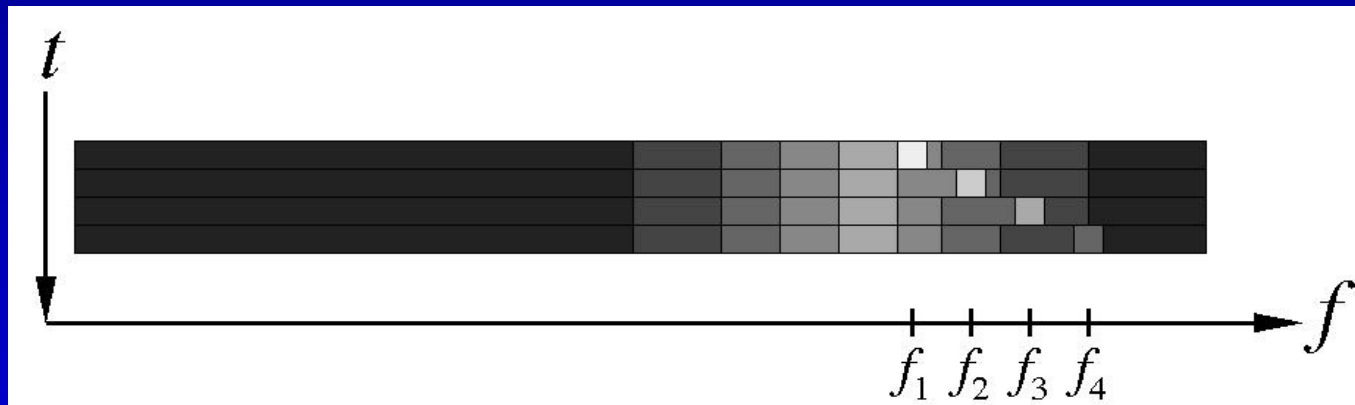
# Dynamic spectra



combine

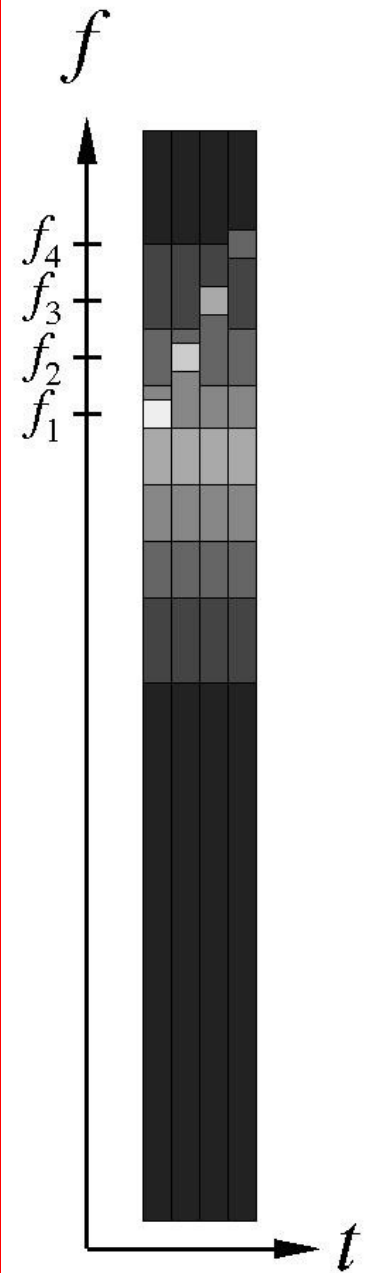
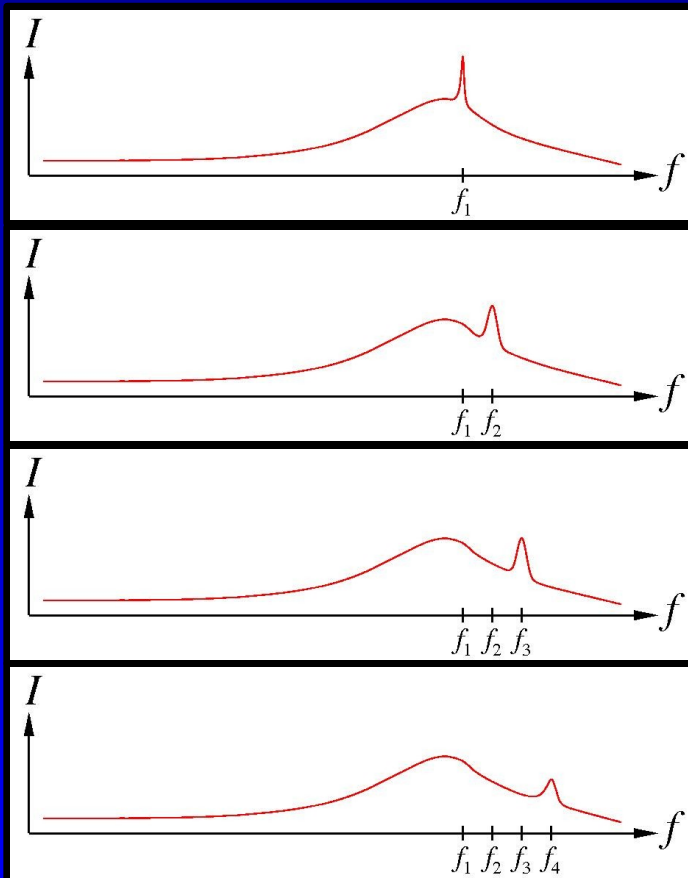
# Dynamic spectra

rotate to confuse users



# Dynamic spectra

- contain same information!
- $n$  spectra  $\Rightarrow$  1 dynamic spectrum
- $n > 10^4$  (or more!)
- quickly show transient features
- require a trained eye



# Conservation of information

Mode	$N_{\text{time}}$	$N_{\text{frequency}}$
raw voltages	$t_{\text{total}} \times f_{\text{sample}}$	1
subband data	$t_{\text{total}} \times f_{\text{sample}} / 1024$	$512 \times 2$
channel data	$t_{\text{total}} \times f_{\text{sample}} / 1024 / 256$	$512 \times 2 \times 256$

$$\Delta f \times \Delta t = 1 !$$



# Conservation of information

Mode	$N_{\text{time}}$	$N_{\text{frequency}}$	$\Delta t$	$\Delta f$
raw voltages	$t_{\text{total}} \times f_{\text{sample}}$	1	6.25/5 ns	160/200 MHz
subband data	$t_{\text{total}} \times f_{\text{sample}} / 1024$	$512 \times 2$	6.4/5.12 $\mu\text{s}$	$\sim 156.3/195.3$ kHz
channel data	$t_{\text{total}} \times f_{\text{sample}} / 1024 / 256$	$512 \times 2 \times 256$	$\sim 1.64/1.31$ ms	$\sim 0.61/0.76$ kHz

$$\Delta f \times \Delta t = 1 !$$

e.g.

- 195.3125 kHz = 5.12  $\mu\text{s}$
- 1 kHz = 1 ms
- 1 Hz = 1 s
- 1 mHz = 1 ks

- (dynamic) spectra cannot “create” information
- temporal resolution is traded for spectral resolution

# Time or frequency?



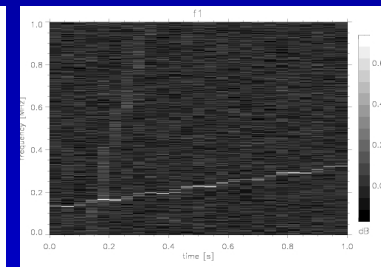
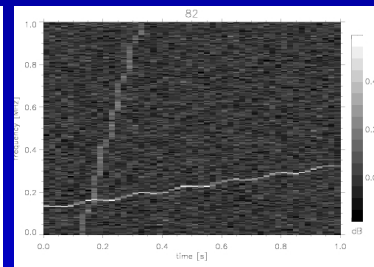
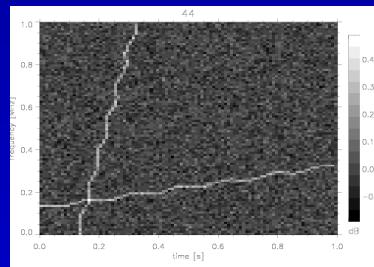
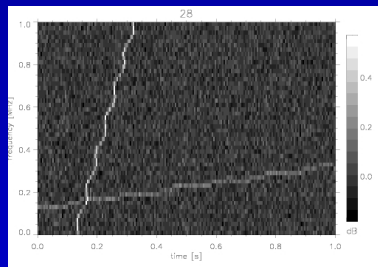
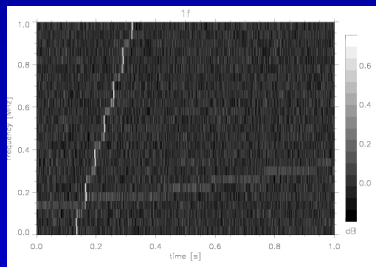
$\Delta f = 4$

$\Delta f = 2$

$\Delta f = 1$

$\Delta f = 0.5$

$\Delta f = 0.25$



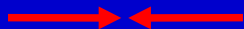
$\Delta t = 0.25$

$\Delta t = 0.5$

$\Delta t = 1$

$\Delta t = 2$

$\Delta t = 4$



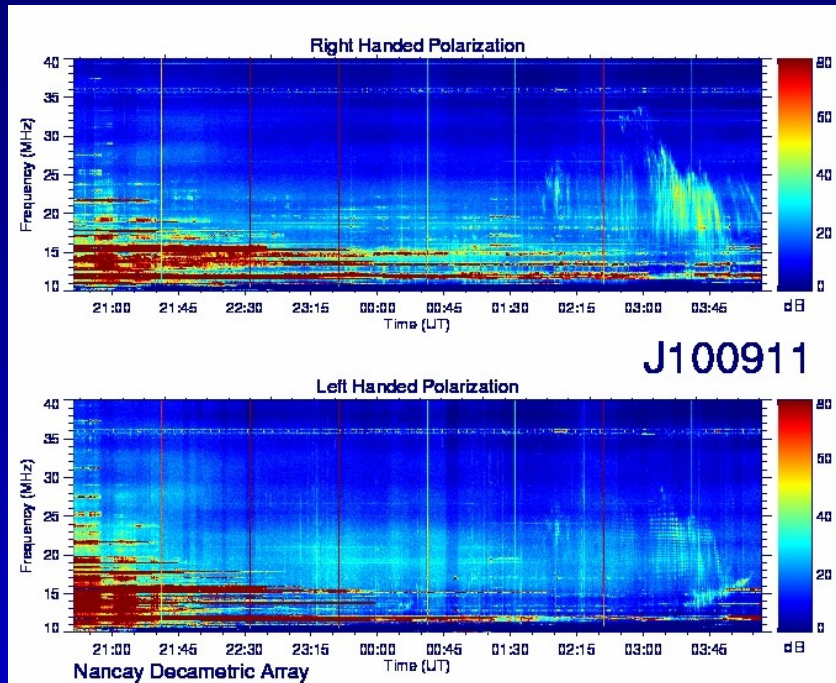
adapt time/frequency resolution to science case!

## Why use dynamic spectra?

- planets (TKP/PWG)
- sun (solar KSP)
- interplanetary scintillation
- flare stars (TKP)
- terrestrial lightning (CRKSP)
- strong pulsars (TKP/PWG)
- RFI monitoring

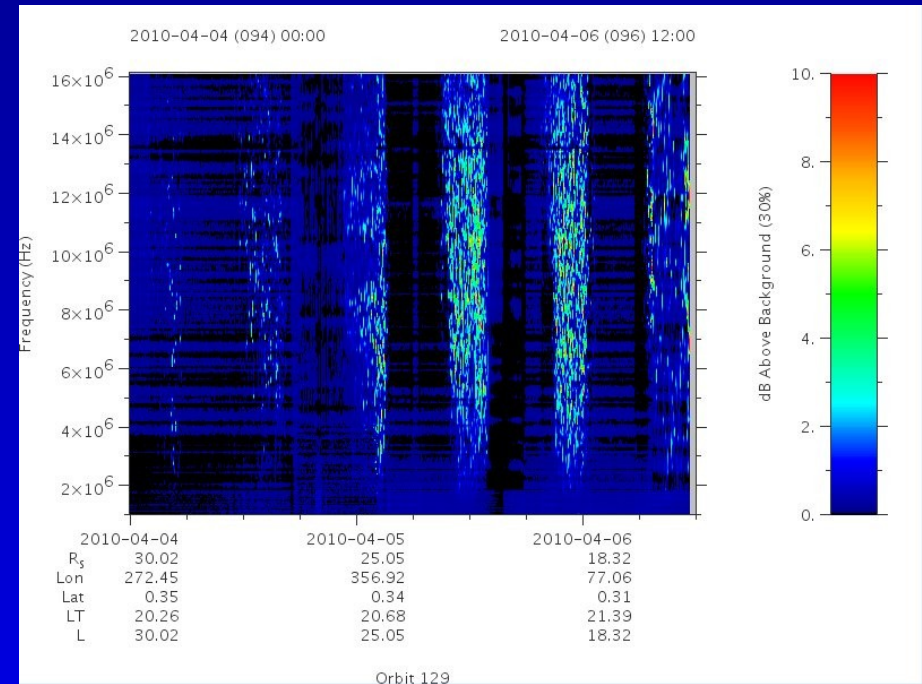
different time-scales and frequency-scales!

# Planets



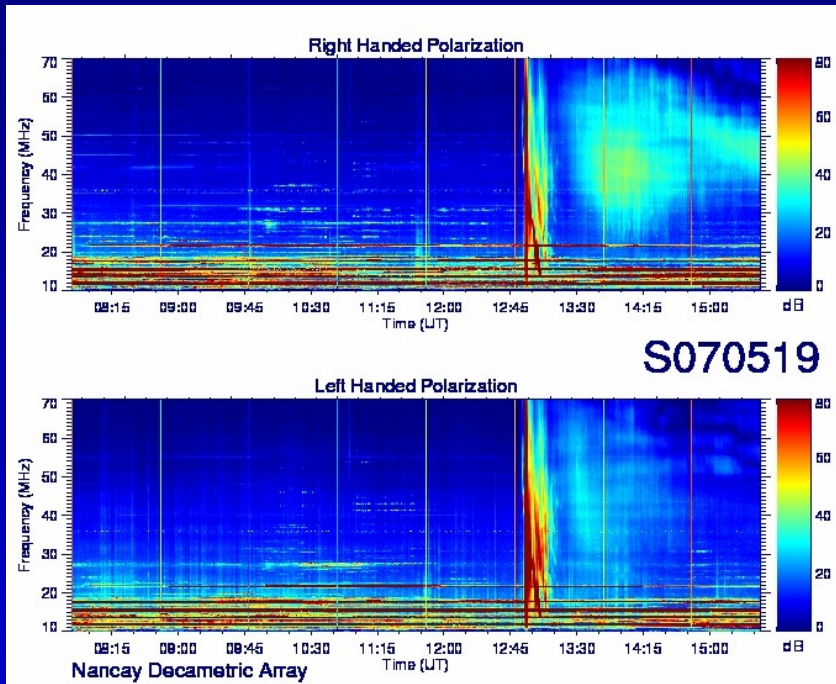
Jupiter decametric  
emission (Nancay/NDA)

⇒ today's colloquium!



Saturn lightning  
(Cassini)

# The Sun



Solar radio emission  
(Nancay/NDA)



# Flare stars

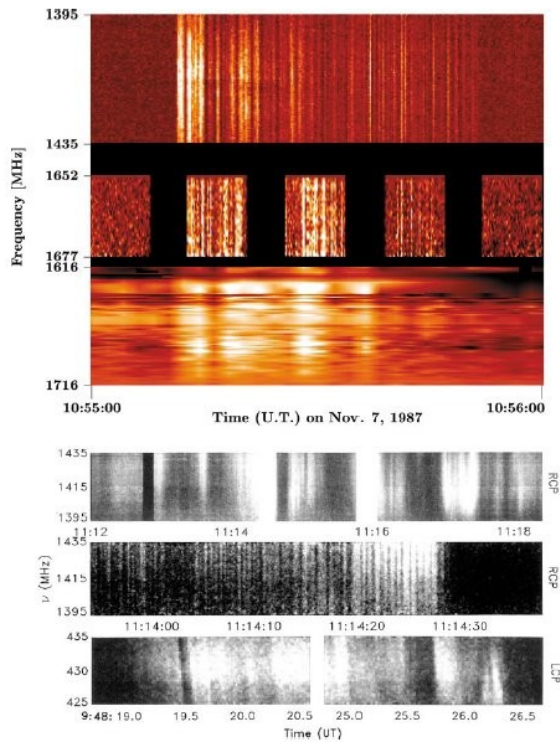
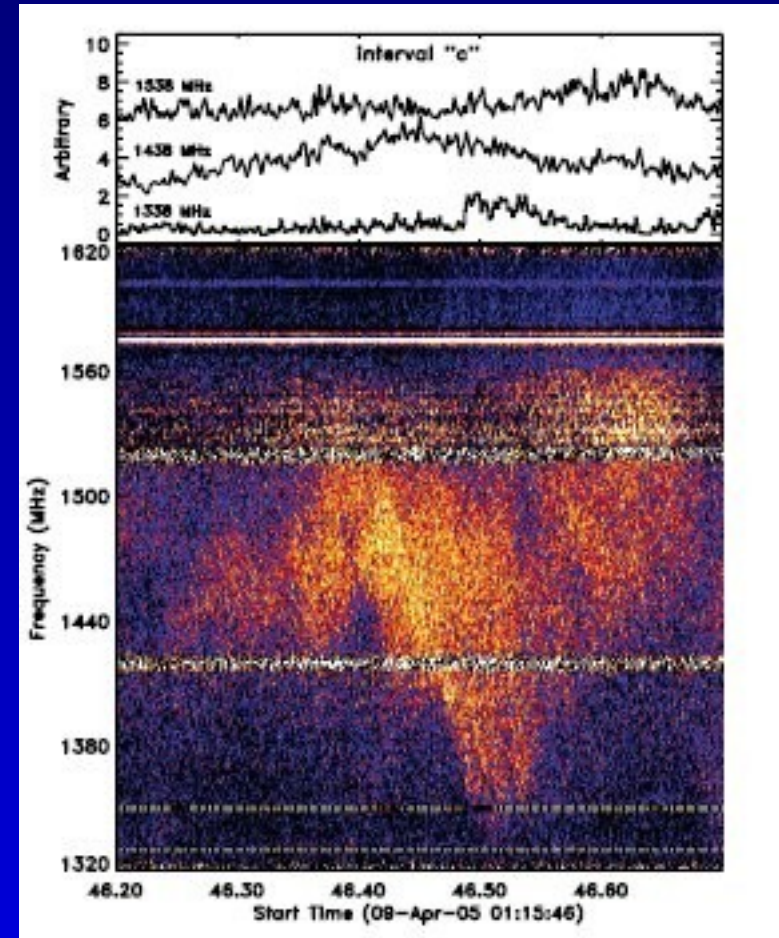


Figure 2 Gallery of radio dynamic spectra of M dwarf flares. Upper three panels show a flare on AD Leo, recorded with the Arecibo (*top*), Effelsberg (*middle*), and Jodrell Bank (*bottom*) telescopes in different wavelength ranges (see also Güdel et al. 1989a). Bottom three panels show flares on AD Leo (*top* and *middle*) and YZ CMi (*bottom*), observed at Arecibo (after Bastian et al. 1990). Reproduced with permission of the AAS.

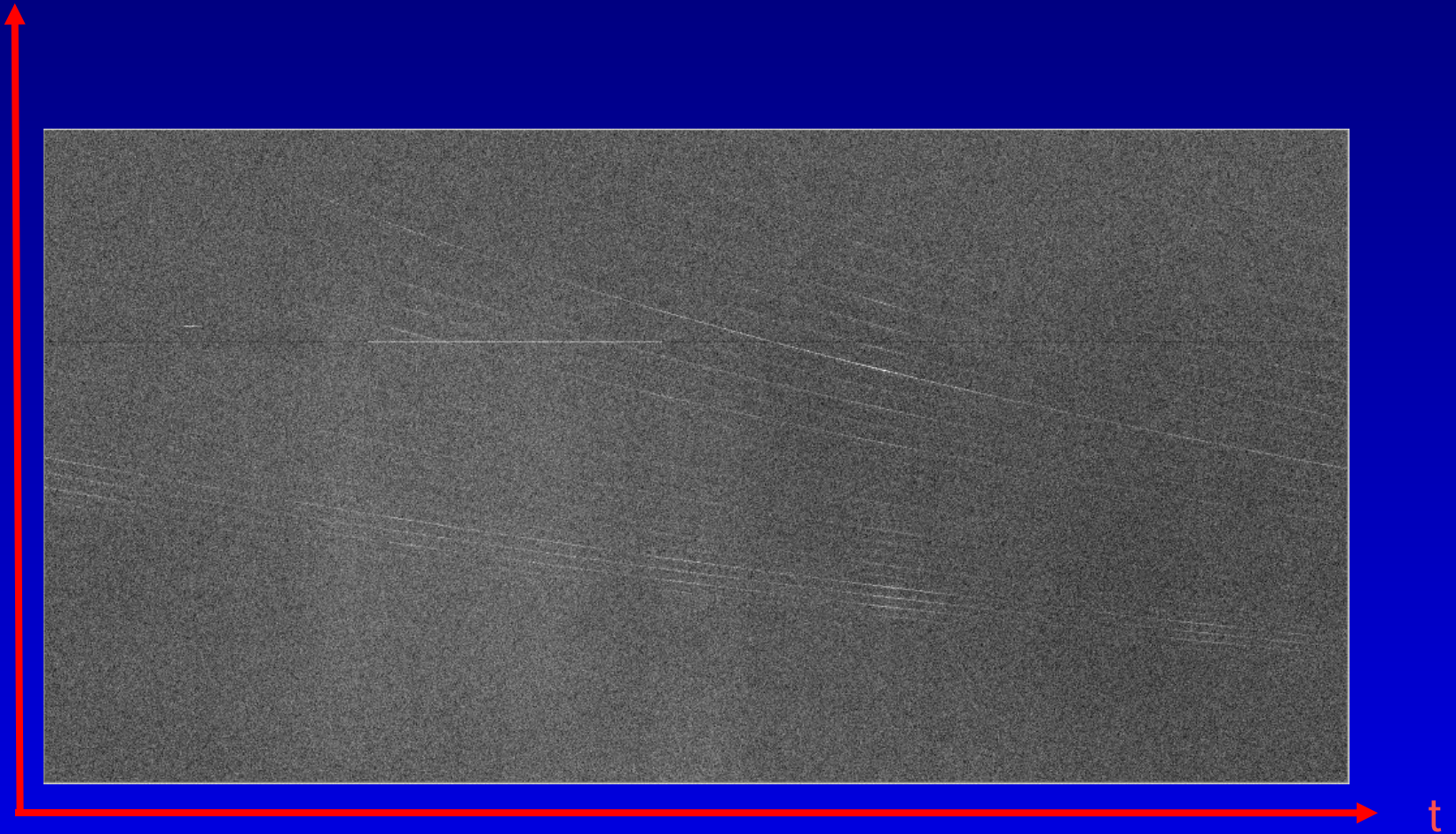
AD Leo, YZ CMi  
(Arecibo, Effelsberg,  
Jodrell Bank)  
[Güdel, ARA&A, 2002]



AD Leo (Arecibo)  
[Osten et al. ApJ, 2008]

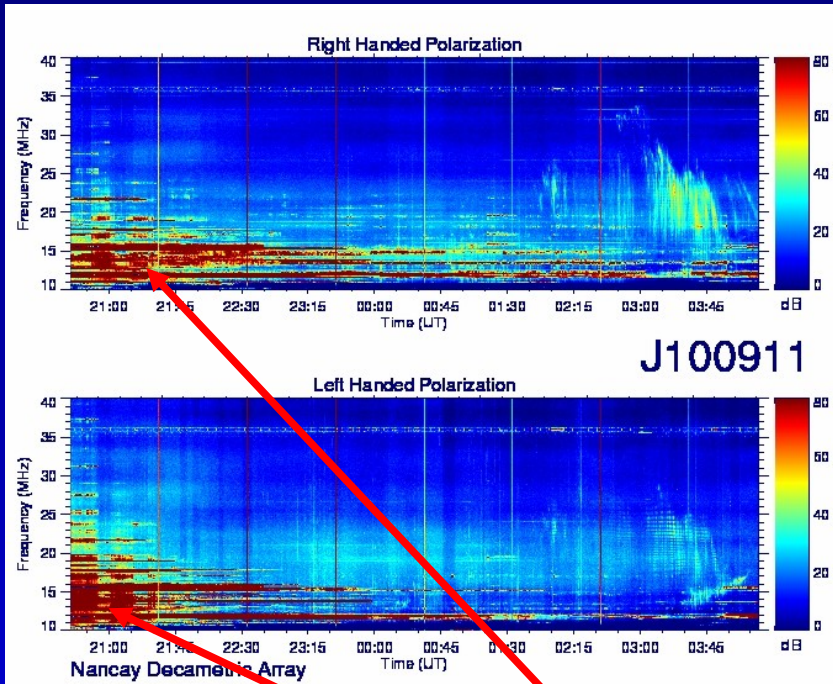
# Pulsars

freq.



PSR 0809  
(UTR-2)

# RFI monitoring



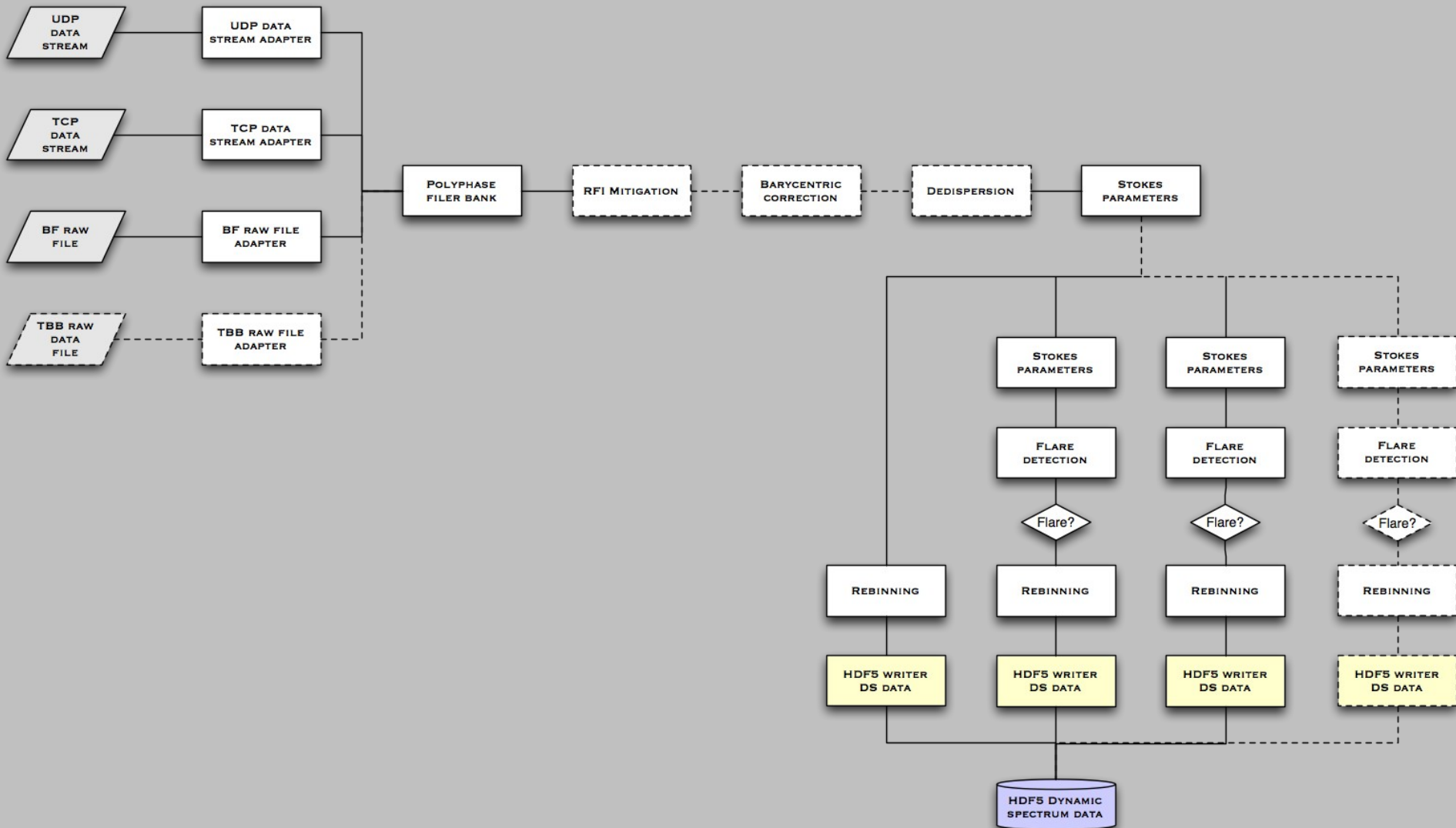
RFI  
(Nancay)



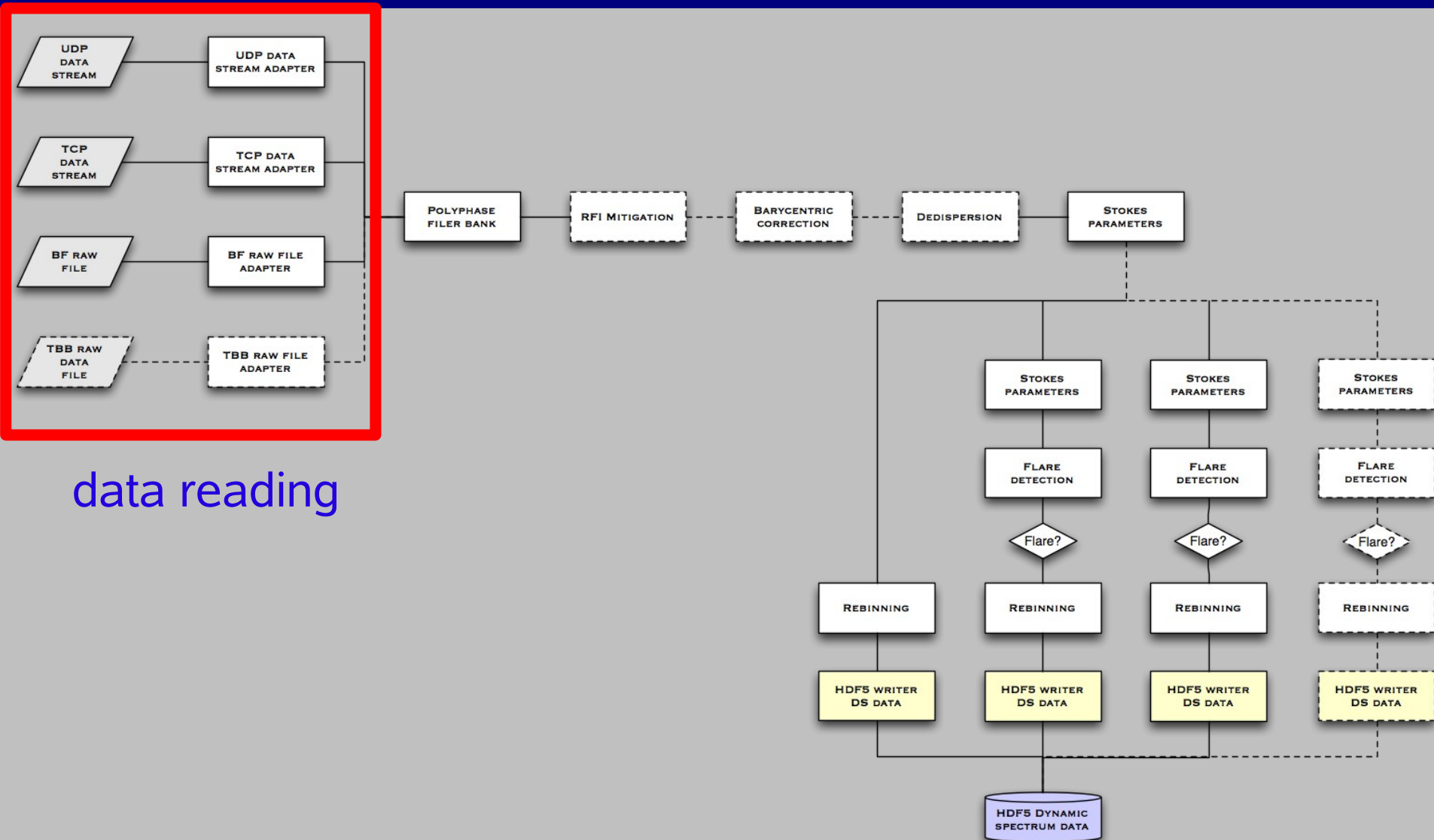
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- LOFAR dynamic spectrum pipeline
- dynamic spectra checklist
- first dynamic spectra with LOFAR

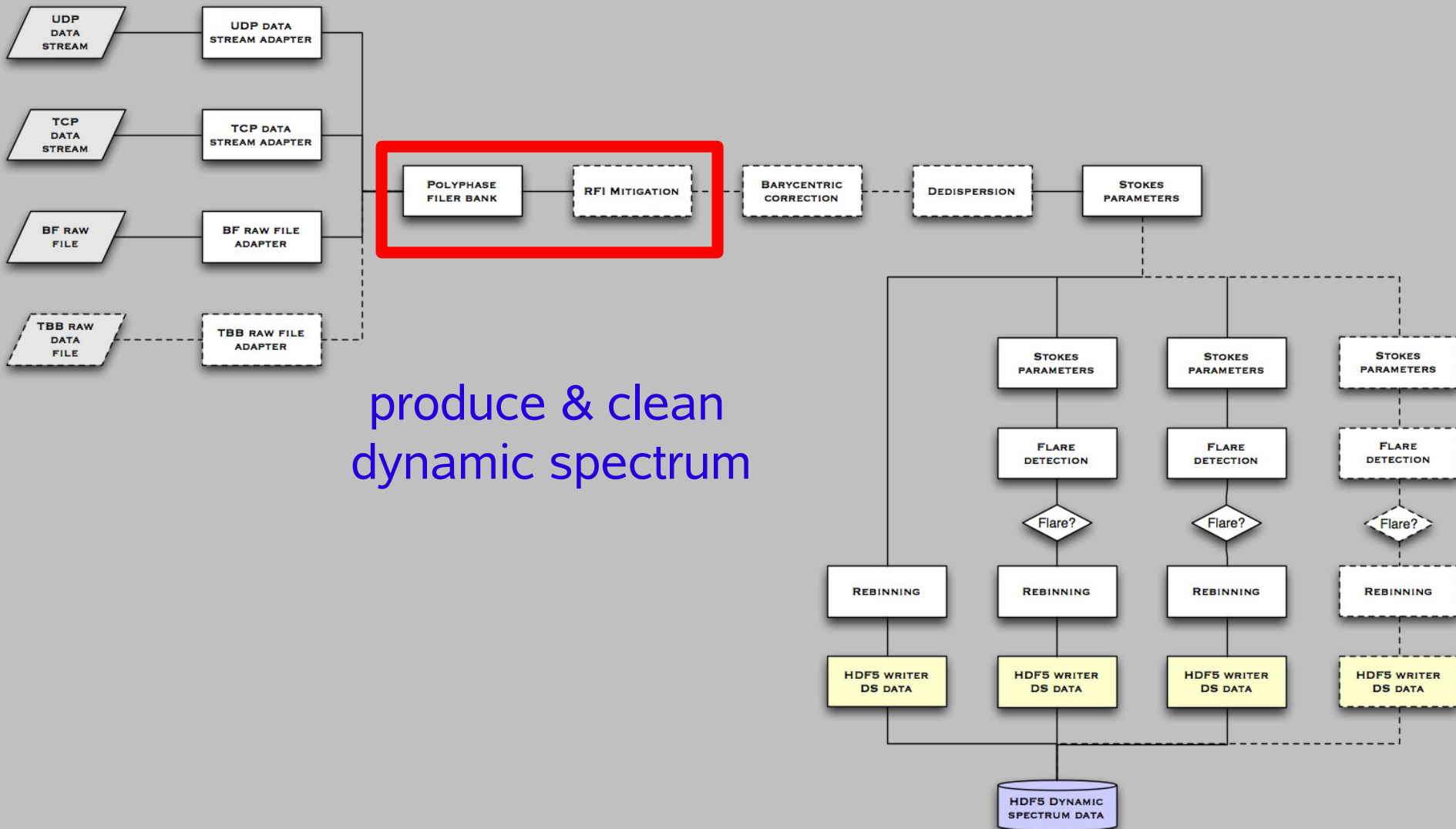
# LOFAR dynamic spectrum pipeline



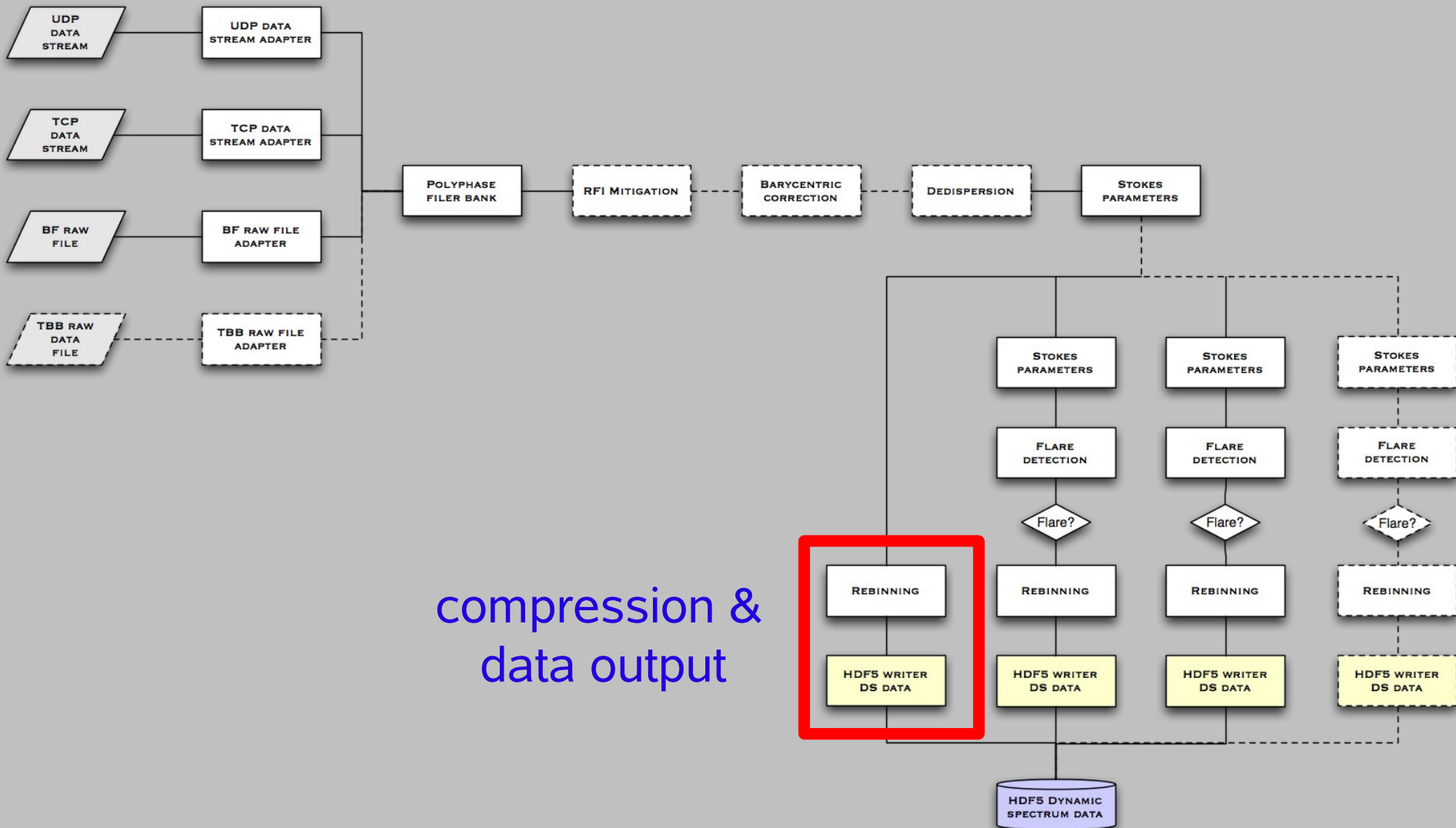
# LOFAR dynamic spectrum pipeline



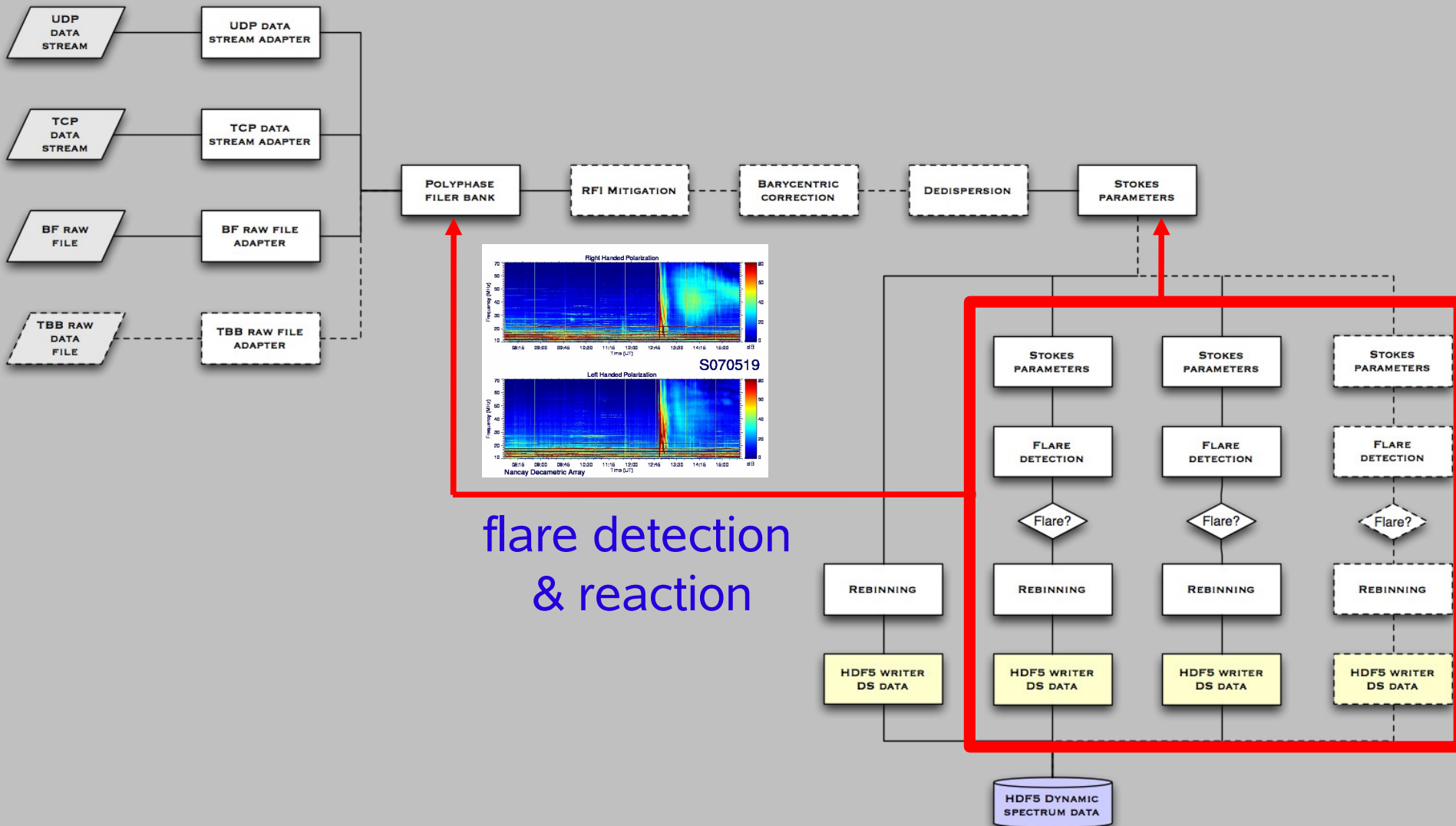
# LOFAR dynamic spectrum pipeline



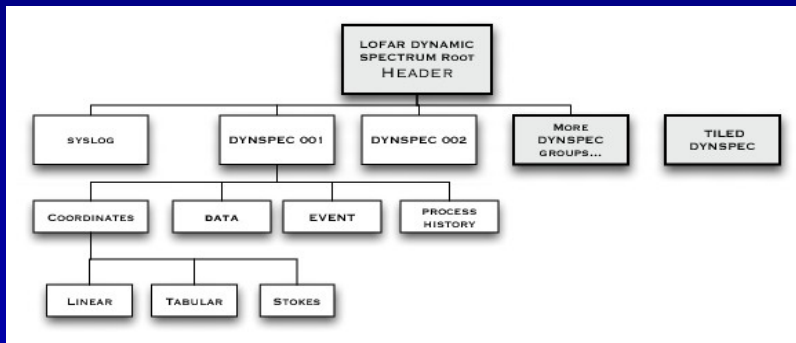
# LOFAR dynamic spectrum pipeline



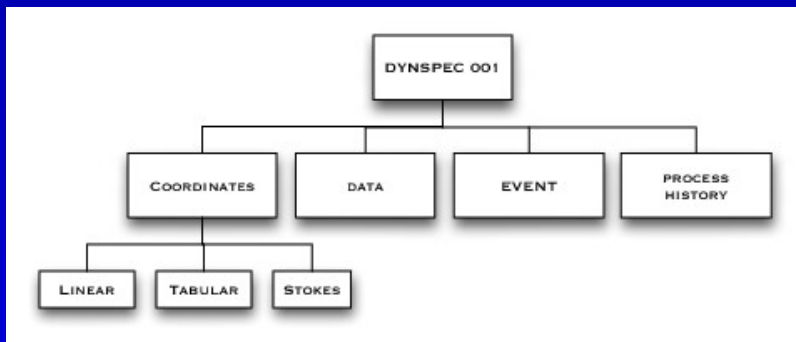
# LOFAR dynamic spectrum pipeline



# LOFAR dynamic spectrum data file



data format



LOFAR-USG-ICD-006

## LOFAR Data Format ICD Dynamic Spectrum Data

Document ID: LOFAR-USG-ICD-006

Version 2.00.01

SVN Repository Revision: 5308

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SVN Date: 2010-07-13

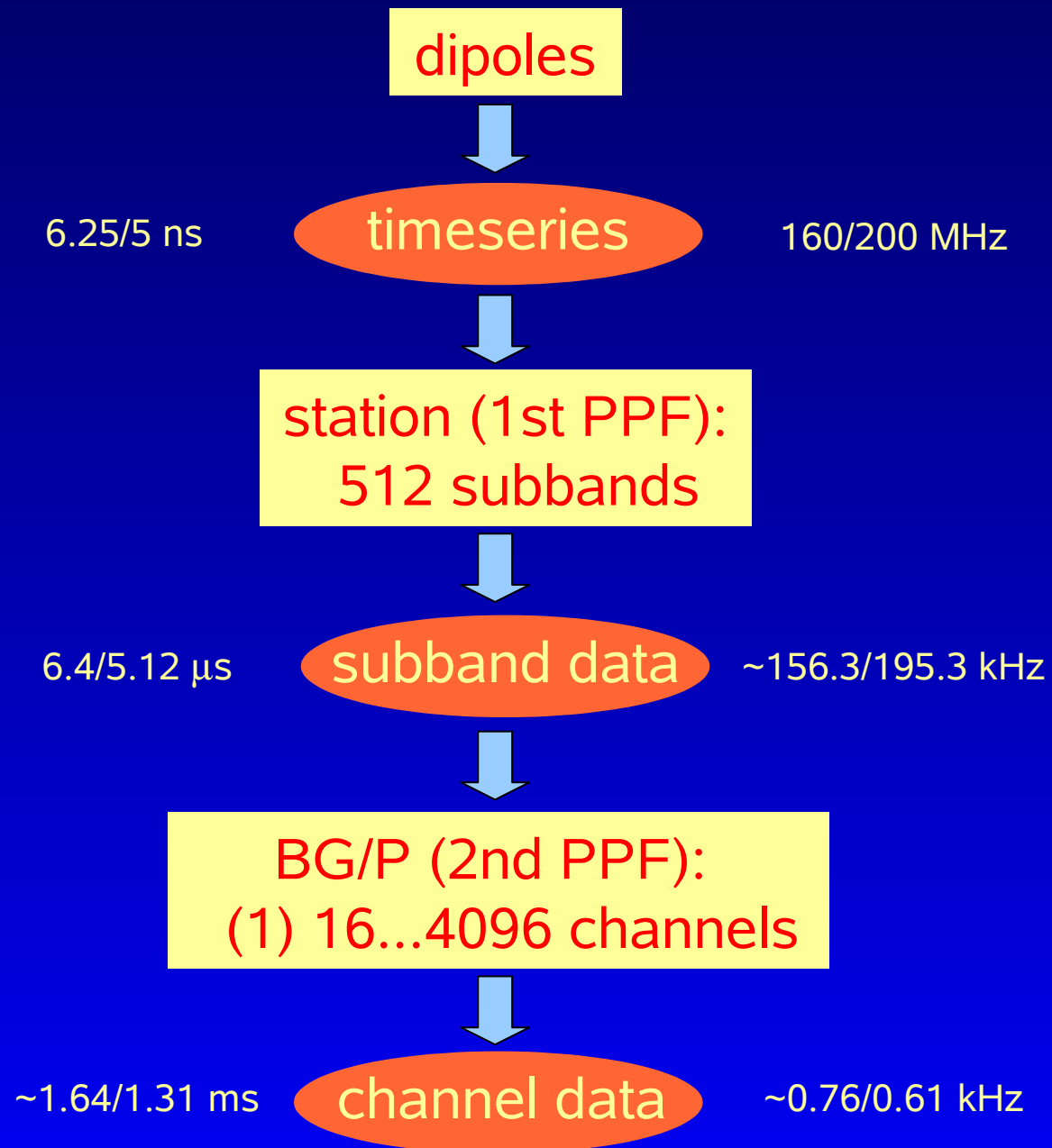
### Contents

Change record	3
1. Introduction	4
1.1. Purpose and Scope	4
1.2. Context and Motivation	4
2. Overview	4
3. Organization of the data	4
3.1. High level LOFAR Dynamic Spectrum Data file structure	4
3.2. Hierarchical Structure of the HDF5 file	5
3.3. Overview of Dynamic Spectrum Groups	5
3.4. Dynamic Spectrum Data flow	6
4. Detailed Data Specification	6
4.1. The Root (Primary) group	6
4.1.1. Common LOFAR Attributes	7
4.1.2. Additional Dynspec Root Attributes	10
4.2. Syslog Group	13
4.3. The DynSpec group	13
4.4. The Tiled DynSpec group	15
4.5. The Coordinates group	16
4.5.1. Linear coordinate	16
4.5.2. Tabular coordinate	17
4.5.3. Stokes coordinate	18
4.6. The Data group	18
4.7. The Event group	20
4.8. The Processing History group	20
5. Interfaces	21
5.1. Interface requirements	21
5.2. Relation to other workpackages	21

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# Dynamic spectrum checklist

- check datarate before observation (GB/s)
- full polarisation or Stokes I (data volume x 1/4)?
- use LBA\_INNER if international stations included
- use  $\geq 16$  channels
- discard channel 0
- check for dropped data blocks
- PPF filter introduce time delay (joint campaigns)

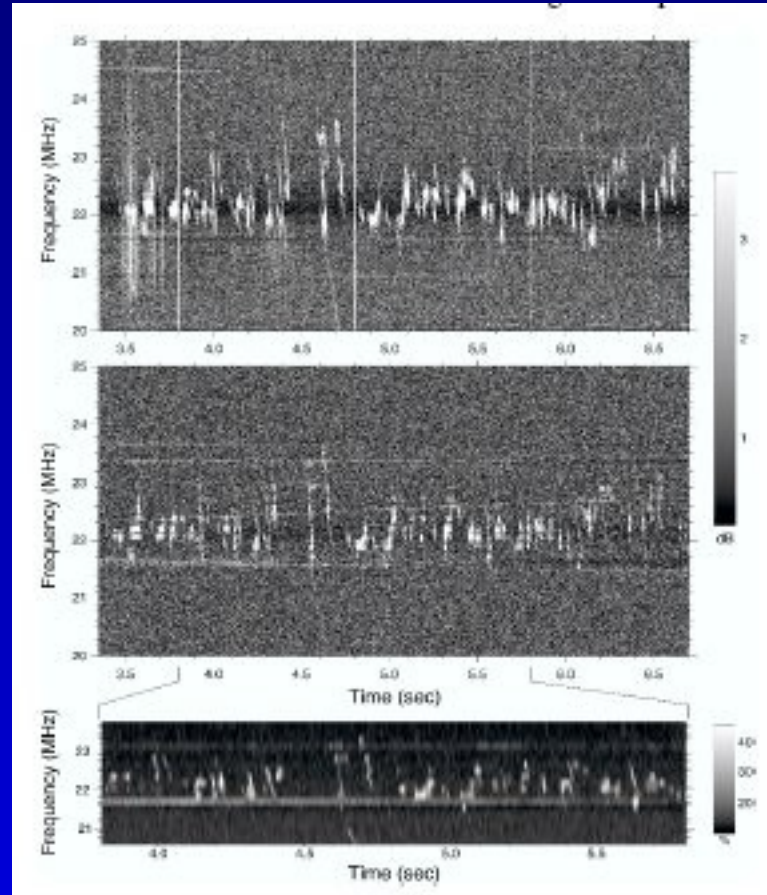
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# Simultaneous observation (2005/11/30)

Nancay (NDA)

LOFAR/ITS

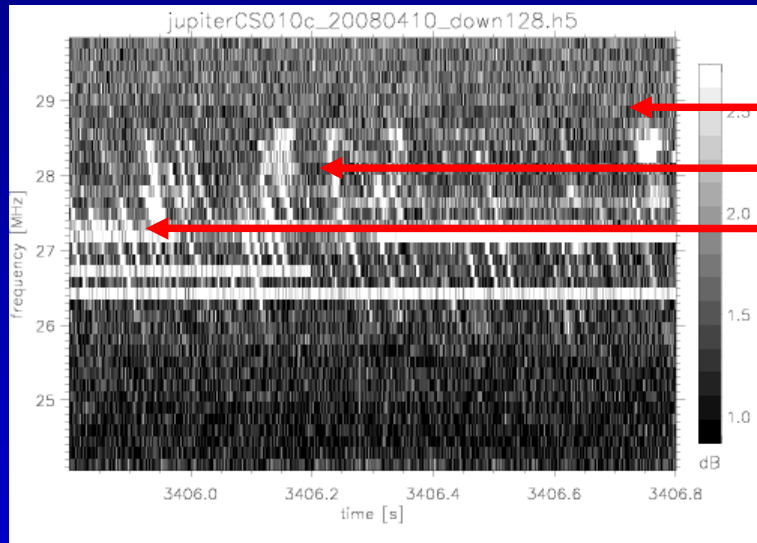


Jupiter decametric  
emission

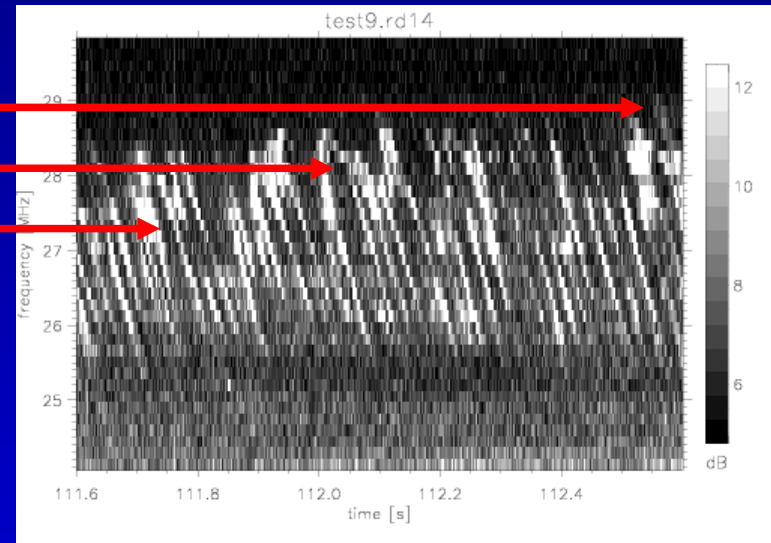
[Nigl et al. A&A, 2007]

# Simultaneous observation (2008/04/10)

## Jupiter decametric emission (Nancay/NDA)



LOFAR (CS10)

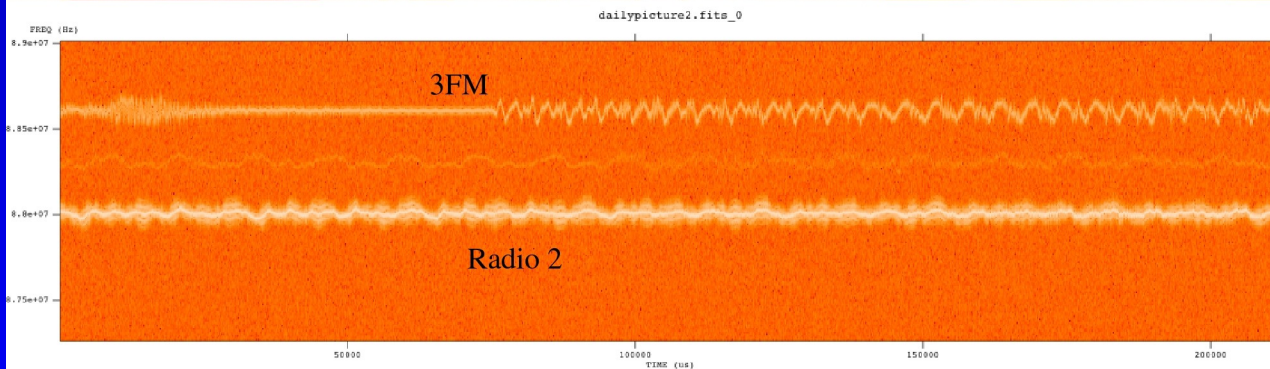
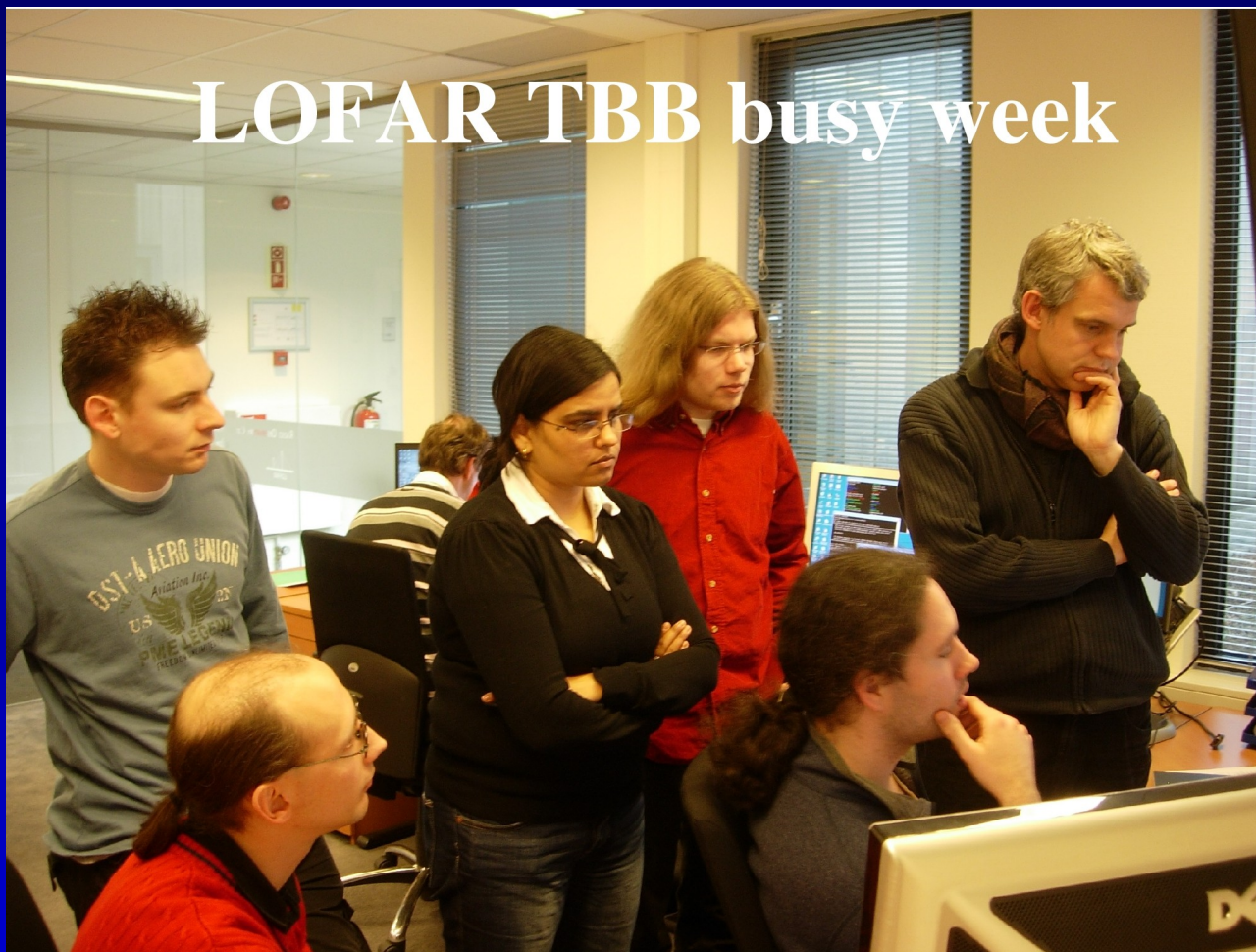


Nancay (NDA)

$\Delta t = 0.8$  msec  
(of  $6.4 \mu\text{sec}$ )

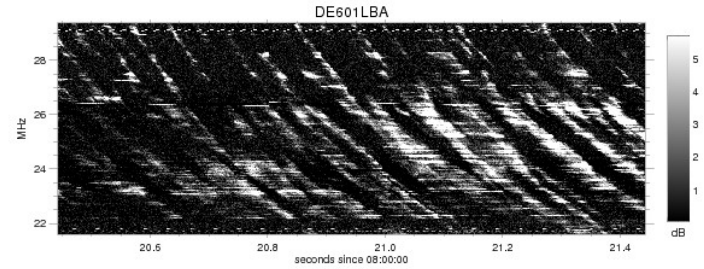
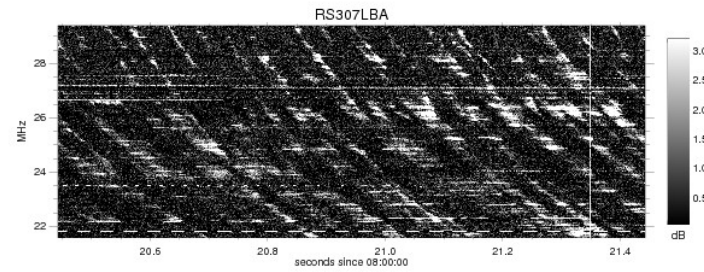
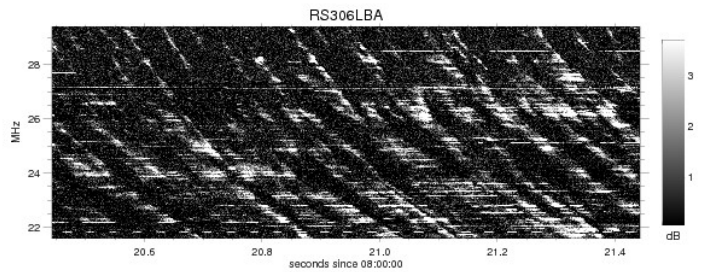
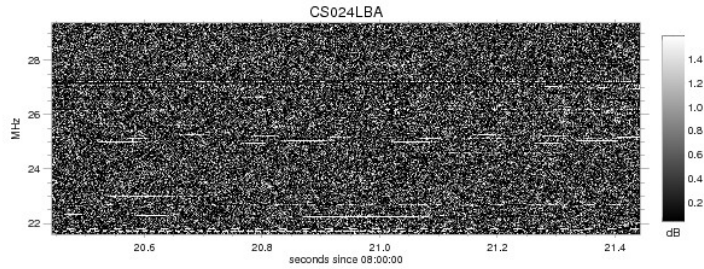
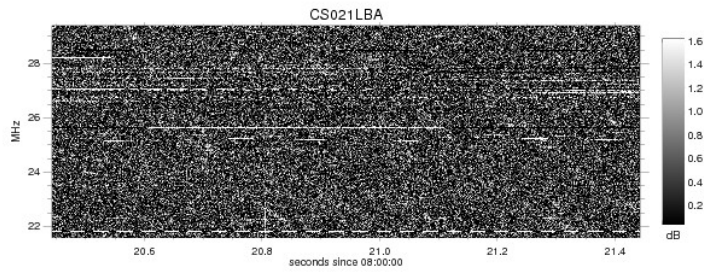
$\Delta f = 156$  kHz

# LOFAR TBB busy week



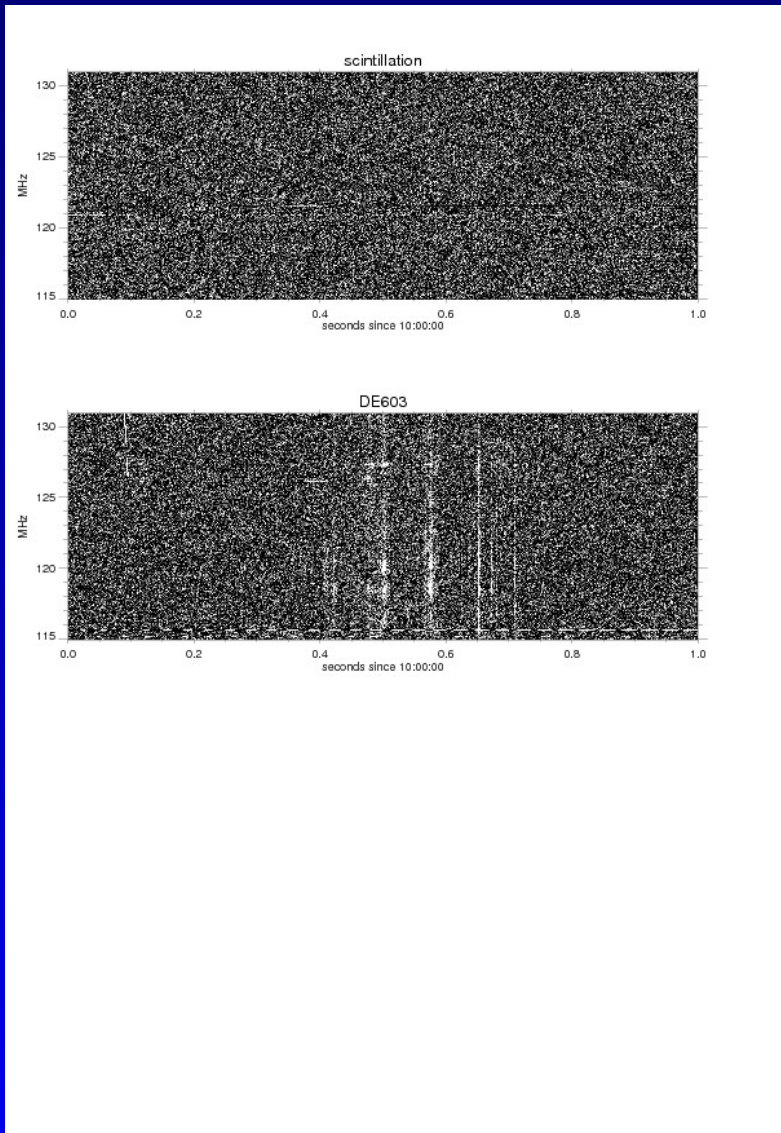


# Jupiter (2010/06/03)



Jupiter emission

# Scintillation (2010/06/25)



Scintillation?  
[courtesy  
R. Fallows]



