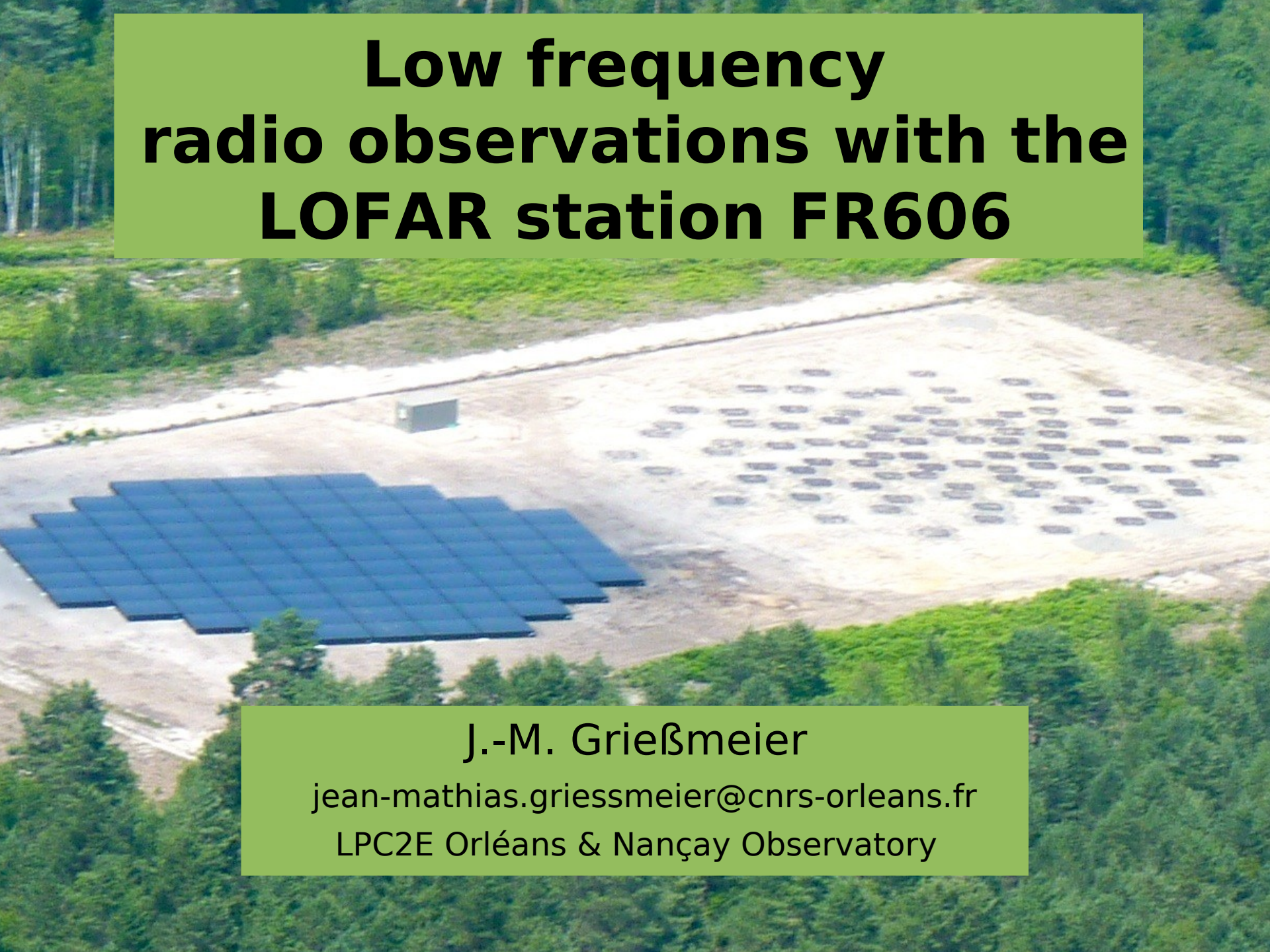
Low frequency radio observations with the LOFAR station FR606



J.-M. Grießmeier

jean-mathias.griessmeier@cnrs-orleans.fr

LPC2E Orléans & Nançay Observatory

LOFAR

38 stations in NL

12+1 internat. stations (x2)

---

51 stations

[96+48(*16)] ant./station

Σ 54048 antennae

frequency: 10/30-250 MHz

distances: 0-1000 km

angular resolution: 2-40’’

time resolution: >5.12μs

frequency resolution: kHz

sensitivity: < mJy

LOFAR FR606 at Nançay

- international mode: ~90% of observing time
- stand-alone mode: 10+% of the time
- 3-4% of total LOFAR collecting area
- low spatial resolution → wide beam
- good sensitivity
- observing time available
- ideal for high observing cadence (1/week)

→ particularly suited for pulsar studies

Outline

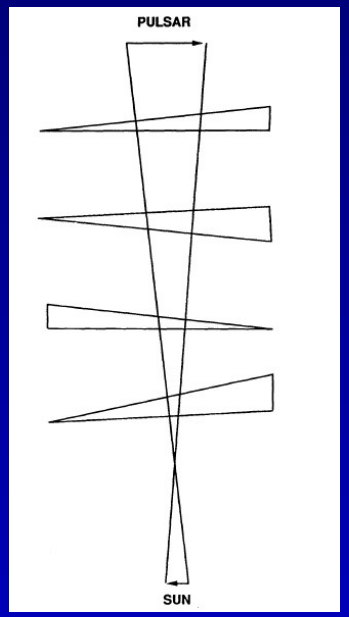
- introduction
- pulsar monitoring
- gamma-ray pulsars
- LBA catalogue

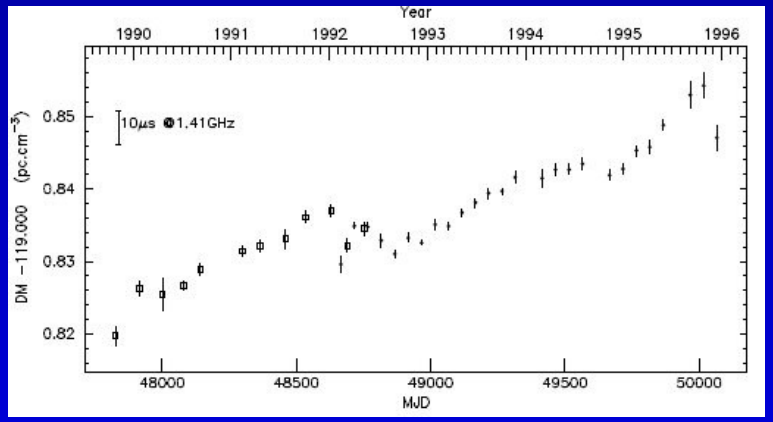
M. Serylak
J.-M. Griessmeier
L. Bondonneau

Pulsar monitoring

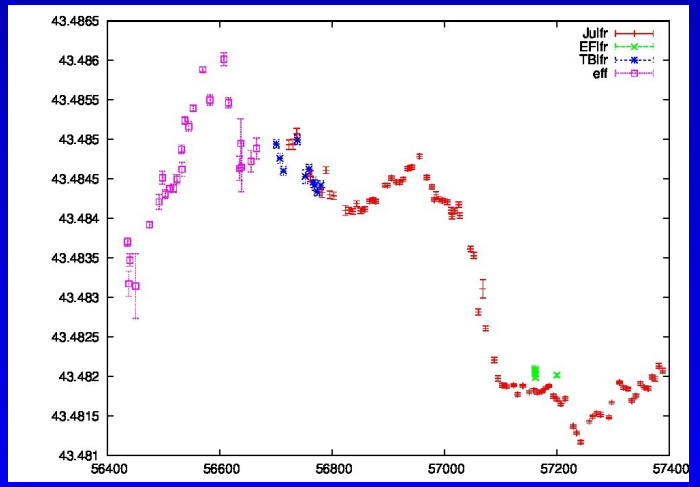
normally, pulsars are very stable, but occasionally, they do change!

- changes in pulse profile
- changes in rotation period
- changes in DM, RM, scattering, ...





[Cognard et al. 1997]

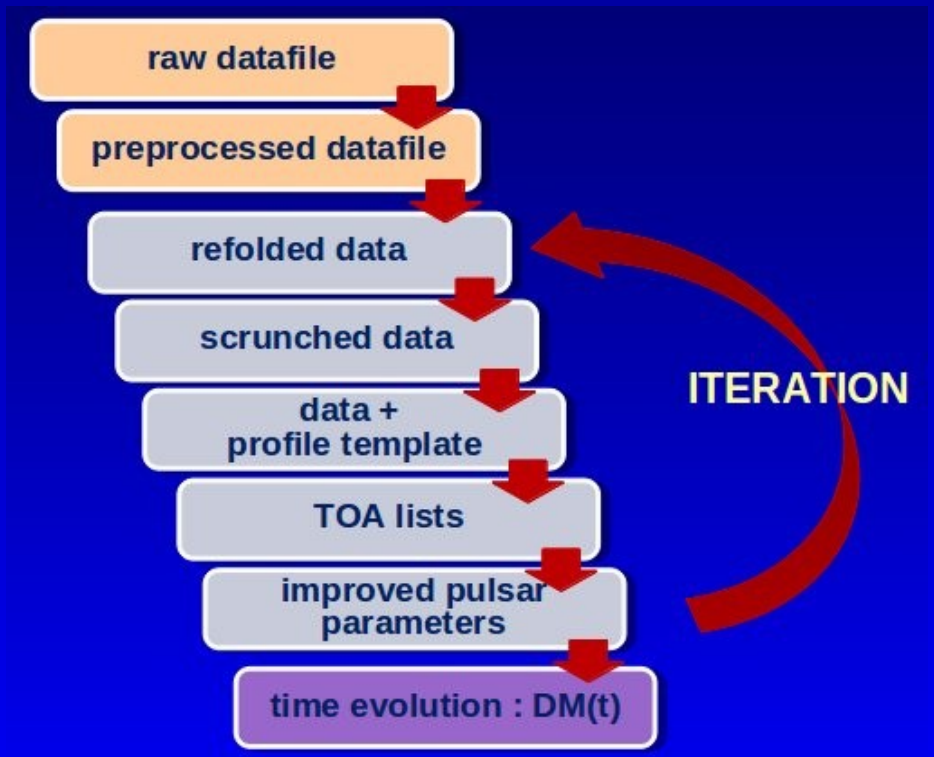


[J. Donner, in prep.]

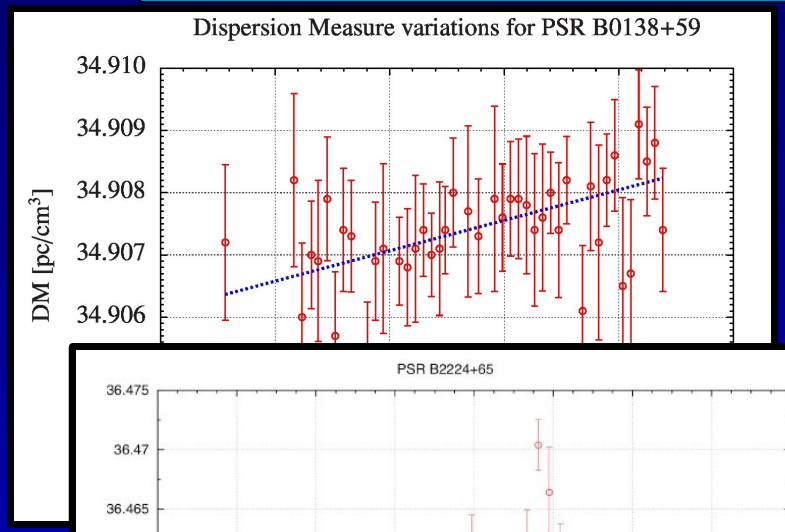
Pulsar monitoring

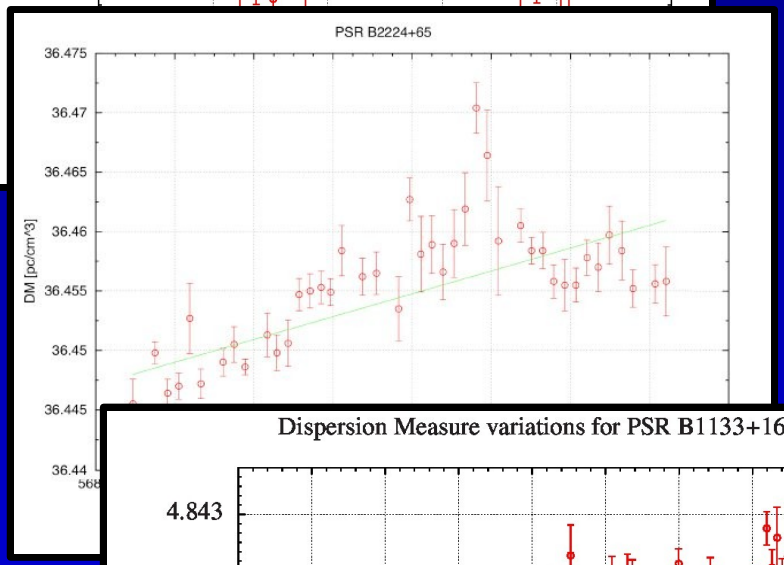
observations:

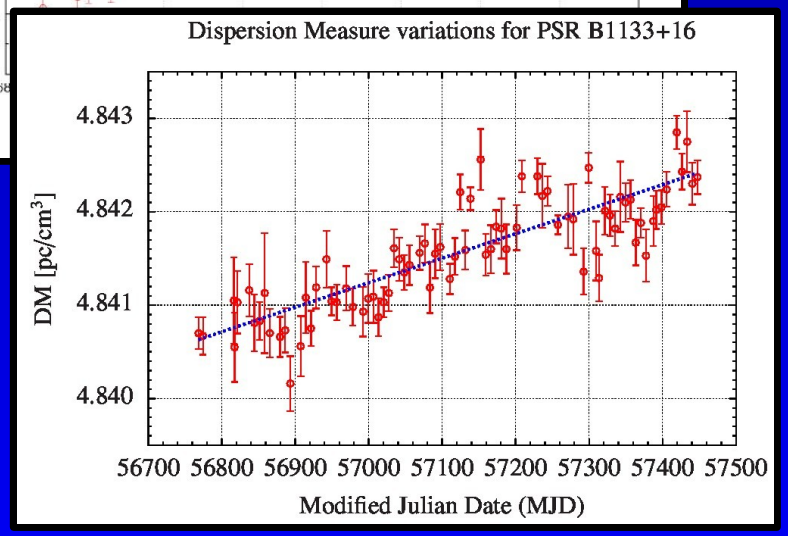
- international LOFAR stations in France, Germany, UK, Sweden
- data since early 2013 (cycle 0 - now)
- weekly monitoring of ~100 pulsars
- data processing e.g. at Nançay

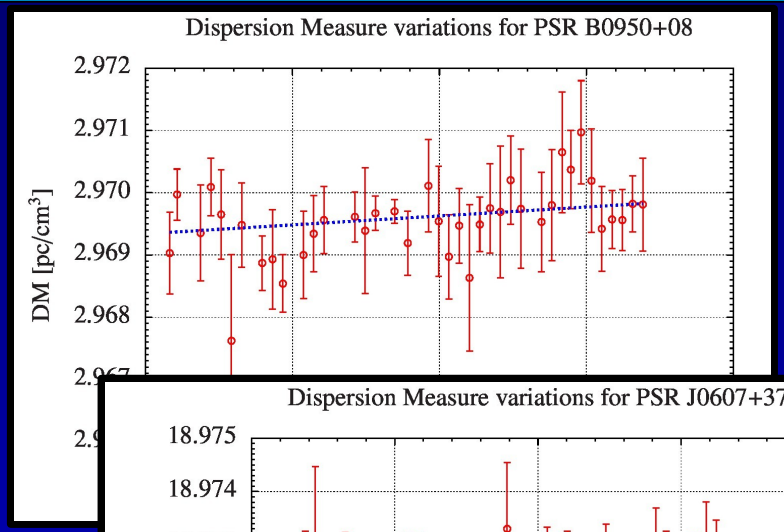


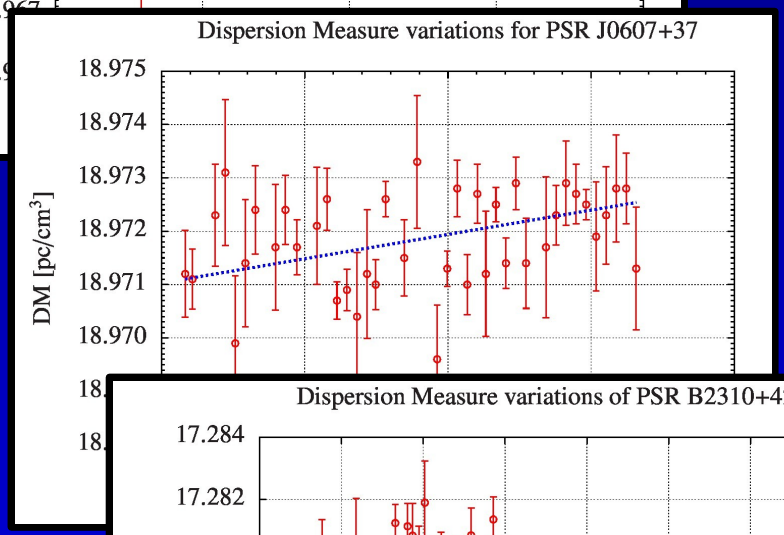
Dispersion measure variations

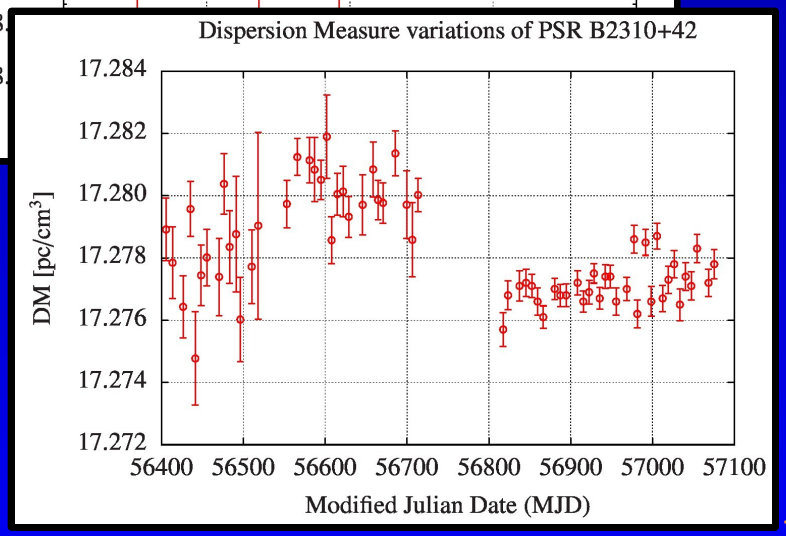




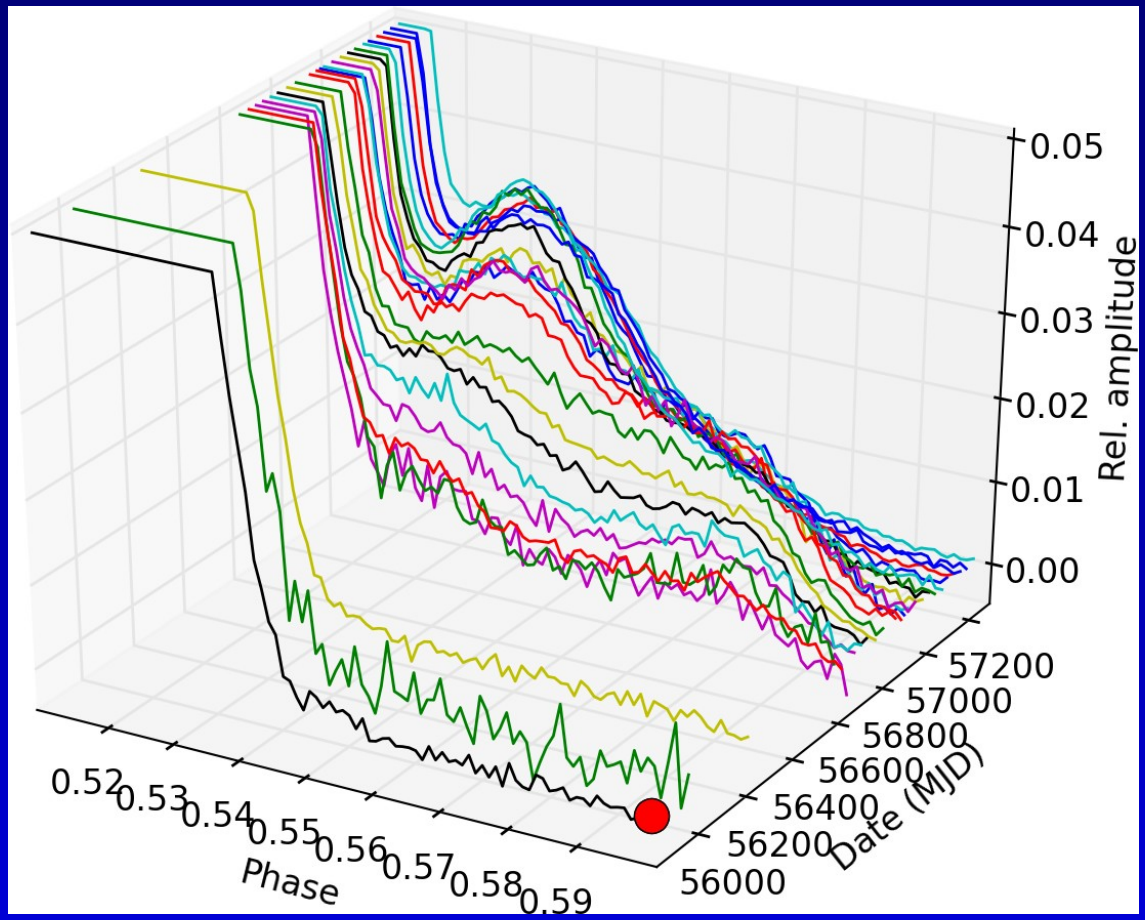








Pulsar monitoring: B2217+47



[Michilli et al., in prep]

Pulsar monitoring

project:

- international LOFAR stations in France, Germany, UK, Sweden
- data since early 2013 (cycle 0 - now)
- weekly monitoring of >100 pulsars
- data processing e.g. at Nançay

next steps:

- combine data before/after June 2014 (Artemis/LuMP)
- continue observations (increase timespan)
- follow-up data-analysis

goal:

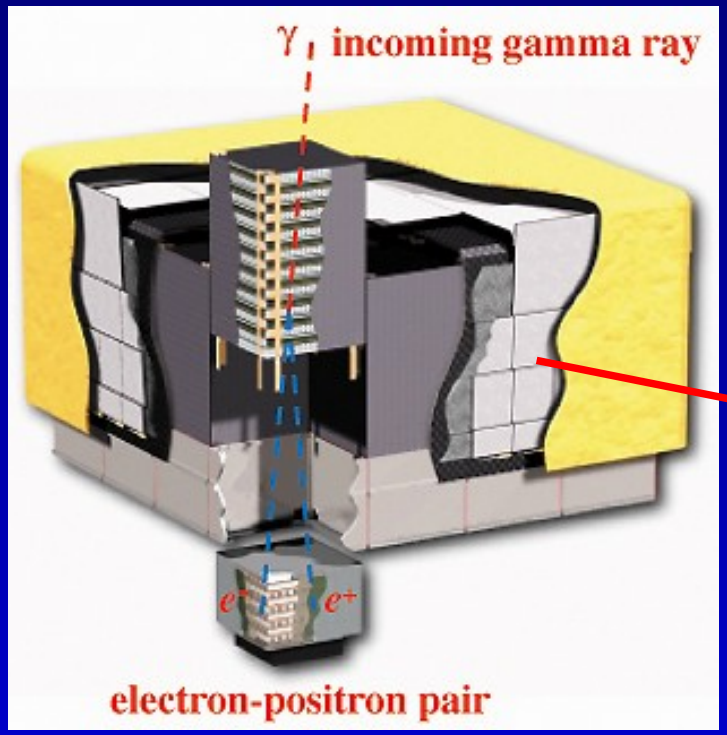
→ ISM studies (density, turbulence, ...)
→ monitor changes of the pulsar (e.g. profile, glitches, ...)
→ help improve high-precision pulsar timing at higher freq.

Outline

- introduction
- pulsar monitoring
- gamma-ray pulsars
- LBA catalogue

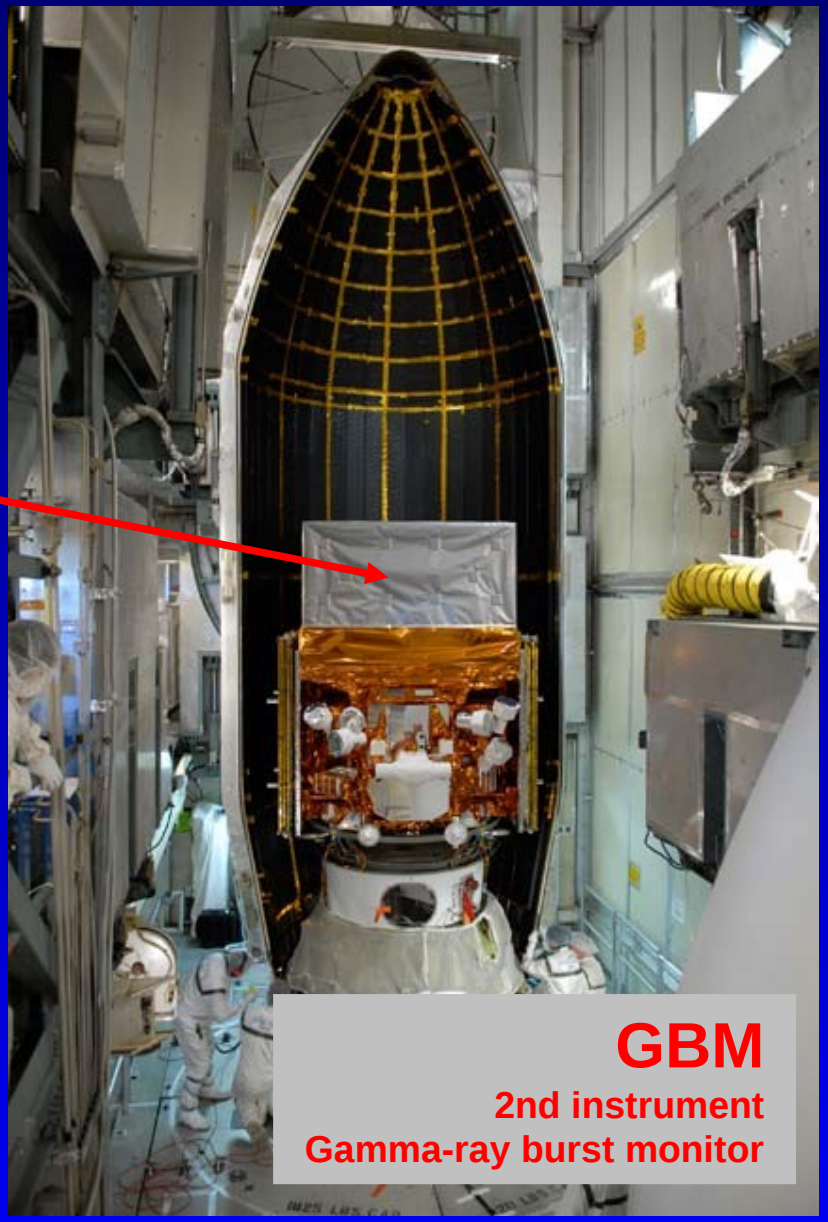
D. Smith
J.-M. Griessmeier
G. Theureau
I. Cognard

Fermi LAT

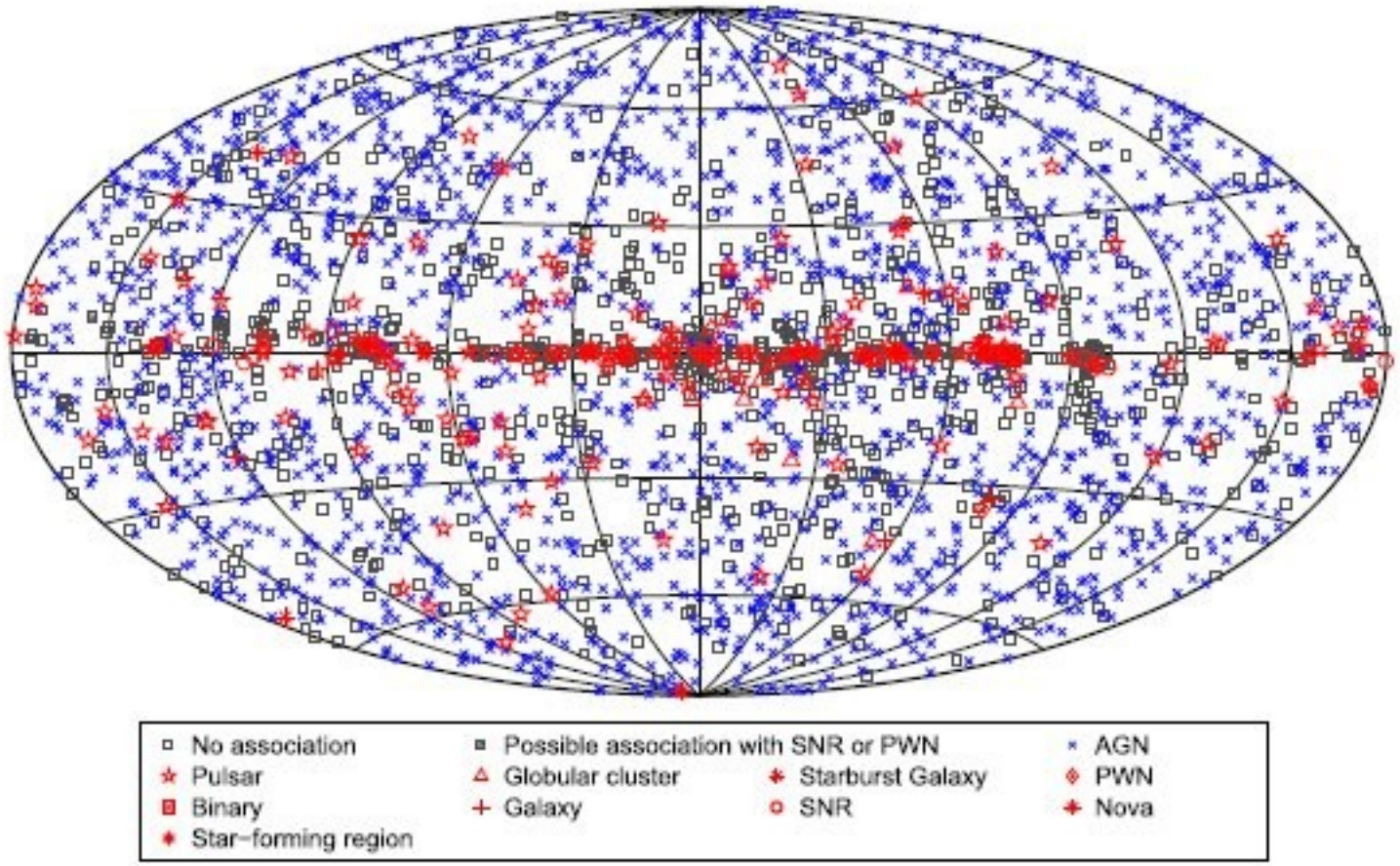


Large Area Telescope
30 MeV to 300 GeV

The whole sky, 3 times per day



The Fermi sky



3FGL source catalog

[Acero et al. 2015]

3033 total sources (>4σ)

Red: Firm I.D. (232, mostly pulsars)

Blue: 'Association' (> ⅓ of sources, mostly blazars)

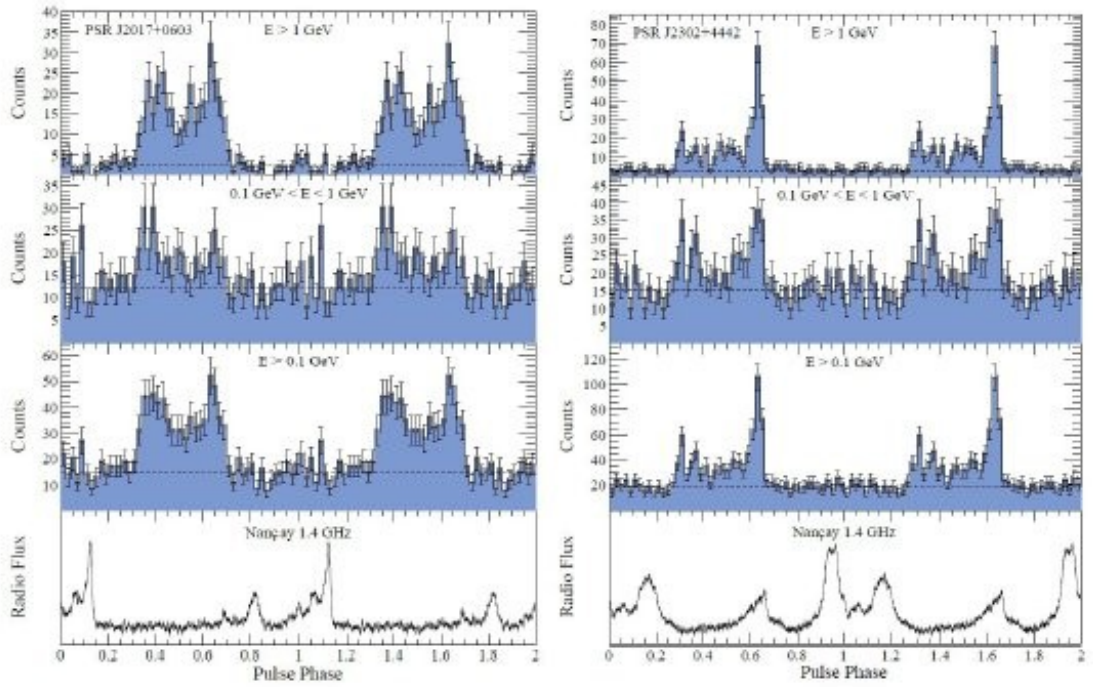
Black: No I.D. (< ~⅓ of sources). Treasure trove!

The Fermi pulsars

new radio MSPs:

- discovered with Fermi
- confirmed in radio (NRT)

  [e.g. Cognard et al. 2011; Guillemot et al. 2012]

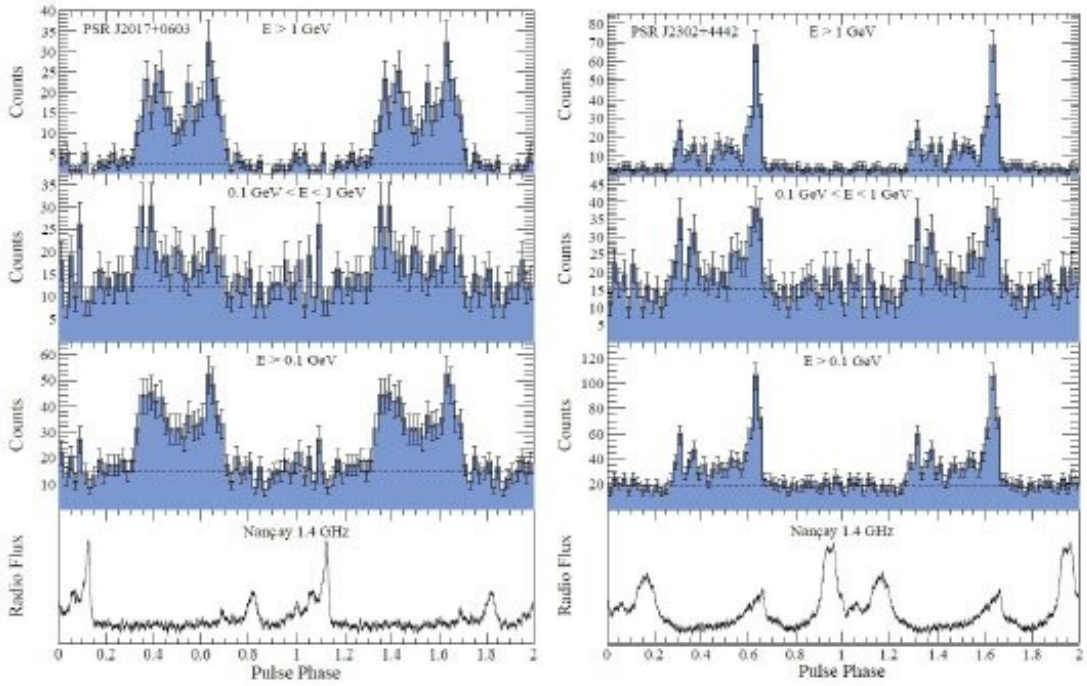


The first two MSPs J2017+0603 and J2302+4442 seen by FERMI (3 energy bands) and Nançay

The Fermi pulsars

new radio MSPs:
- discovered with Fermi
- confirmed in radio (NRT)
  [e.g. Cognard et al. 2011; Guillemot et al. 2012]

other Fermi pulsars were followed-up in radio, but remain “radio-quiet”



The first two MSPs J2017+0603 and J2302+4442 seen by FERMI (3 energy bands) and Nançay

Why radio-quiet?

a pulsar is radio-quiet because...

weak radio emission

low chance for FR606

Why radio-quiet?

a pulsar is radio-quiet because...

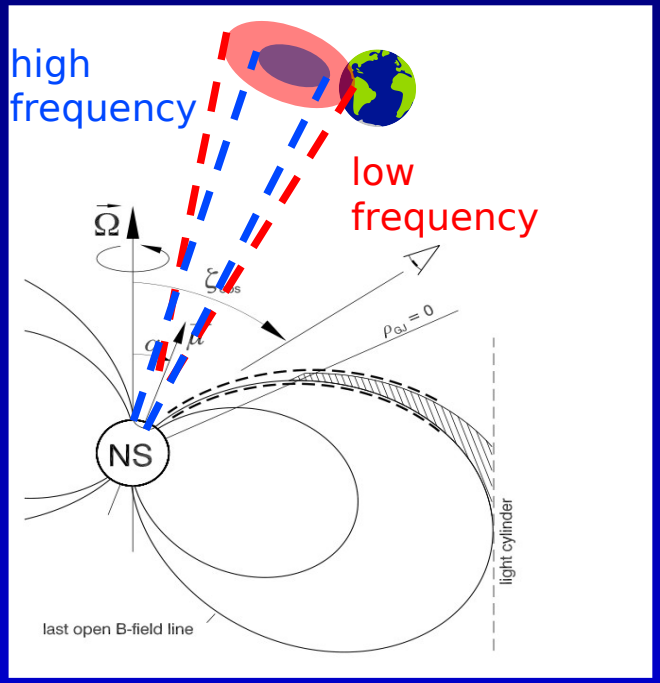
weak radio emission

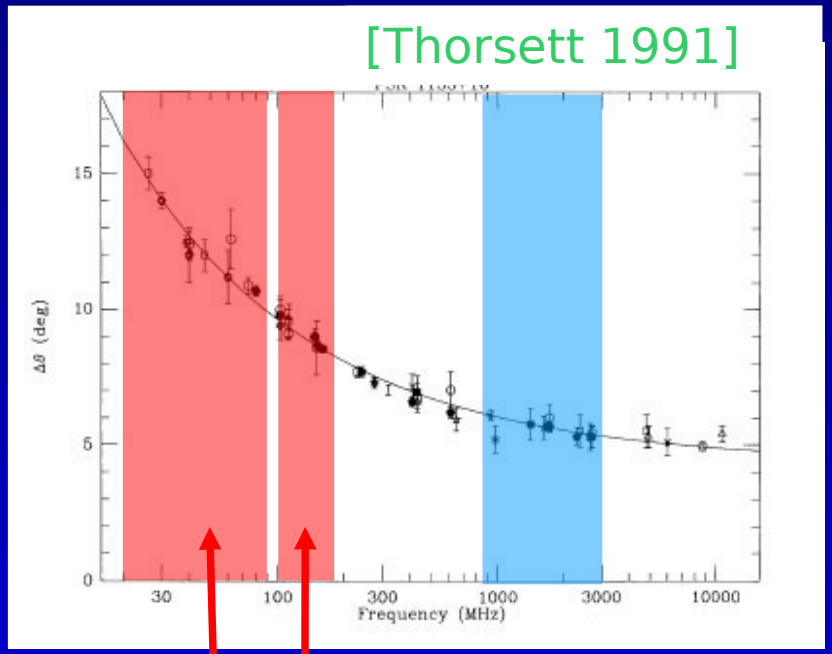
low chance for FR606

radio-beam misses Earth

beam might cross Earth at low frequency

Radio beaming





Frequently, the radio beam is wider at low frequency

LOFAR HBA

LOFAR LBA

FR606 nondetections

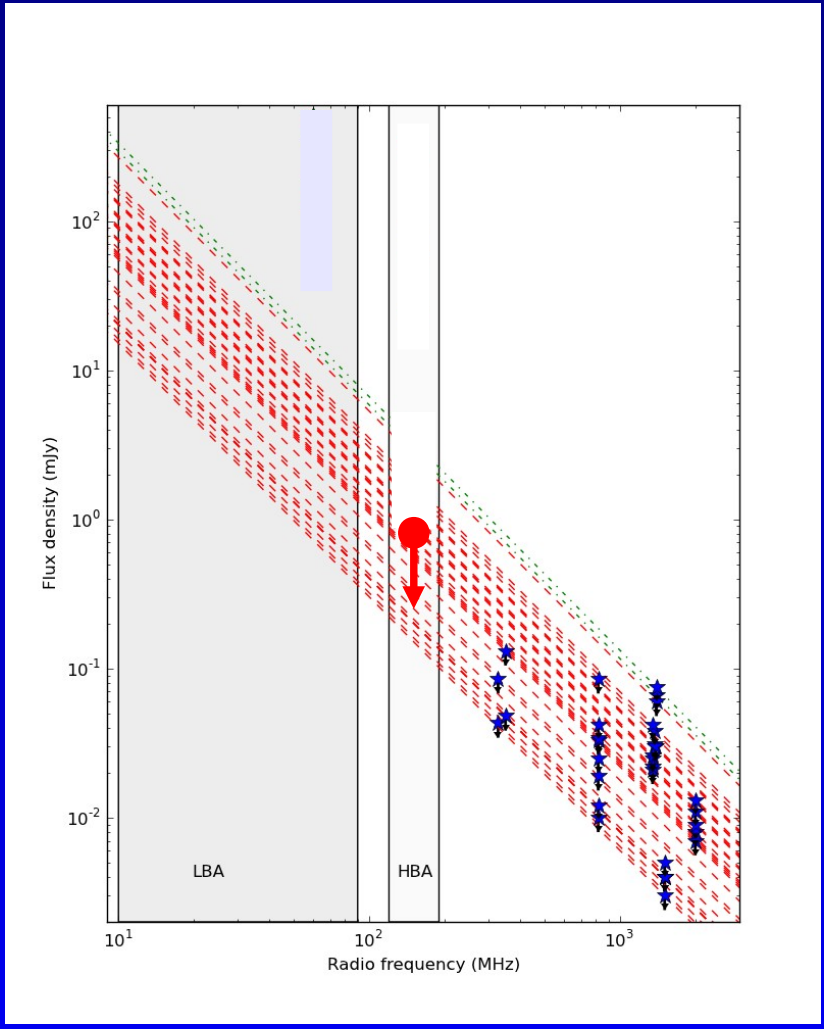
- international LOFAR station FR606
- data processing at Nançay
- 21 targets, ~10h/target
- so far: almost all targets observed (non-detections)

- what can we learn from non-detections?
  → upper limits on flux and spectral index!

Flux limit for nondetections

- so far: almost all targets observed (all non-detections)

→ upper flux limits



Fermi radio-quiet follow-up

project:

- international LOFAR station FR606, data processing at Nançay
- 21 targets, ~10h/target

status:

- so far: almost all targets observed once (non-detections)
- working on flux limit

next steps:

- re-observe (1 target/week)
- improved processing
- maybe try lower frequencies (LBA, 10-90 MHz)?

goal:

→ contribute to pulsar population studies

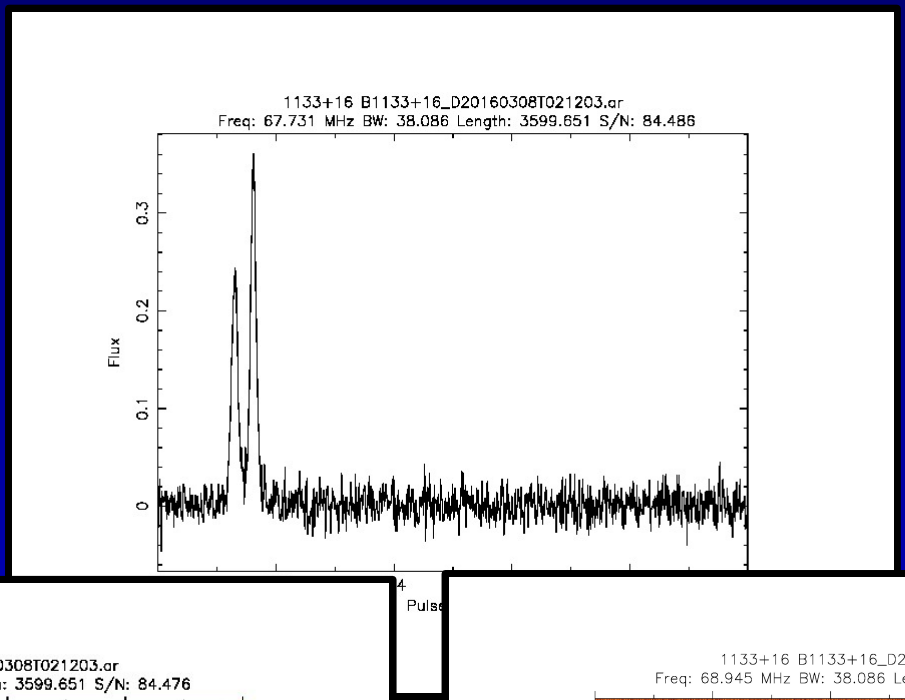
→ find an interesting MSP ?

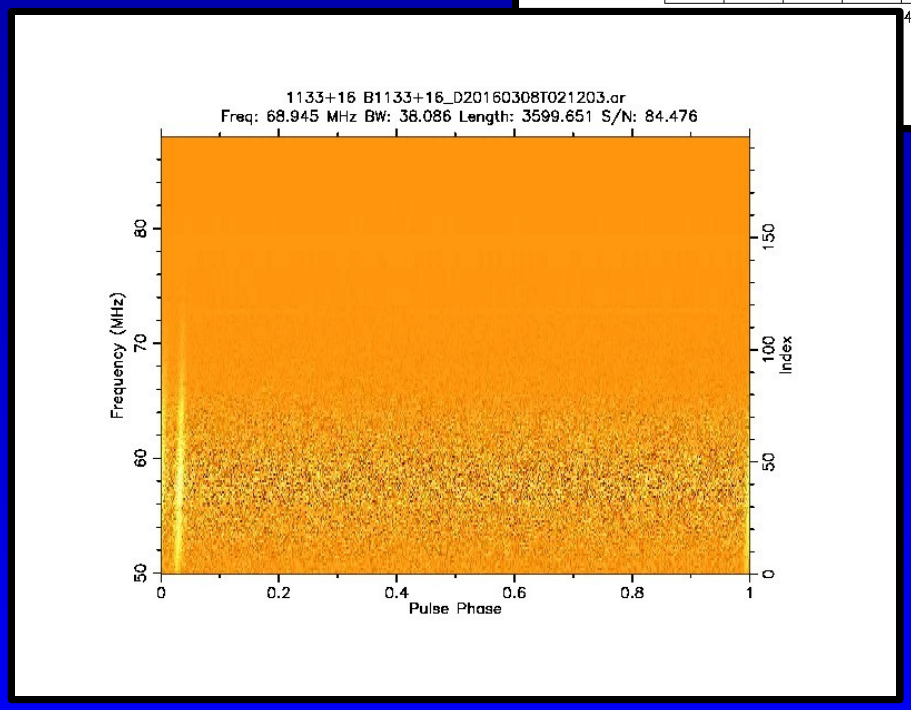
Outline

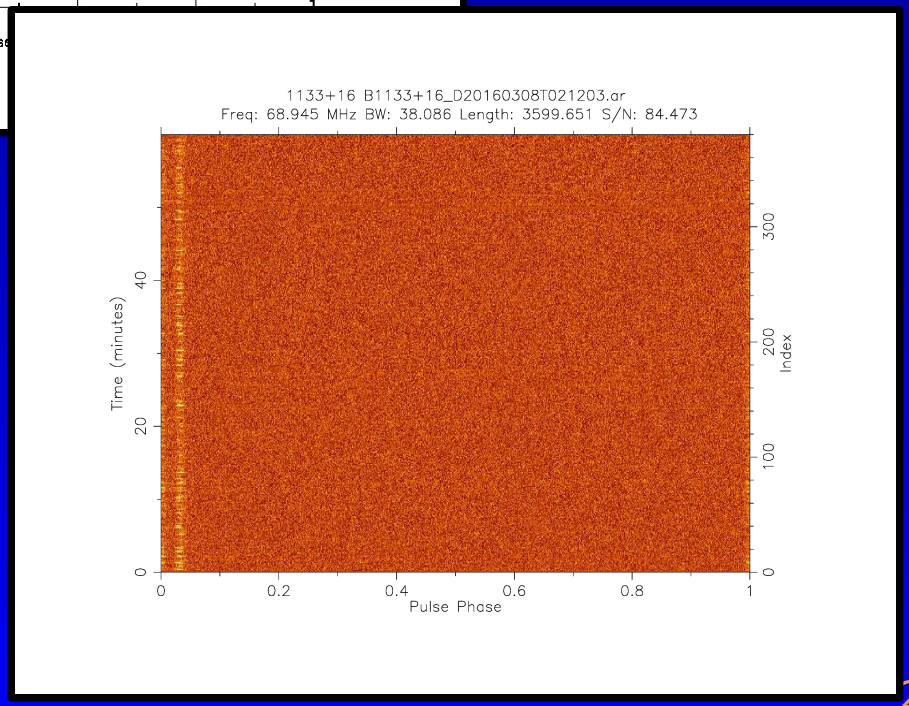
- introduction
- pulsar monitoring
- gamma-ray pulsars
- LBA catalogue

J.-M. Griessmeier
M. Serylak

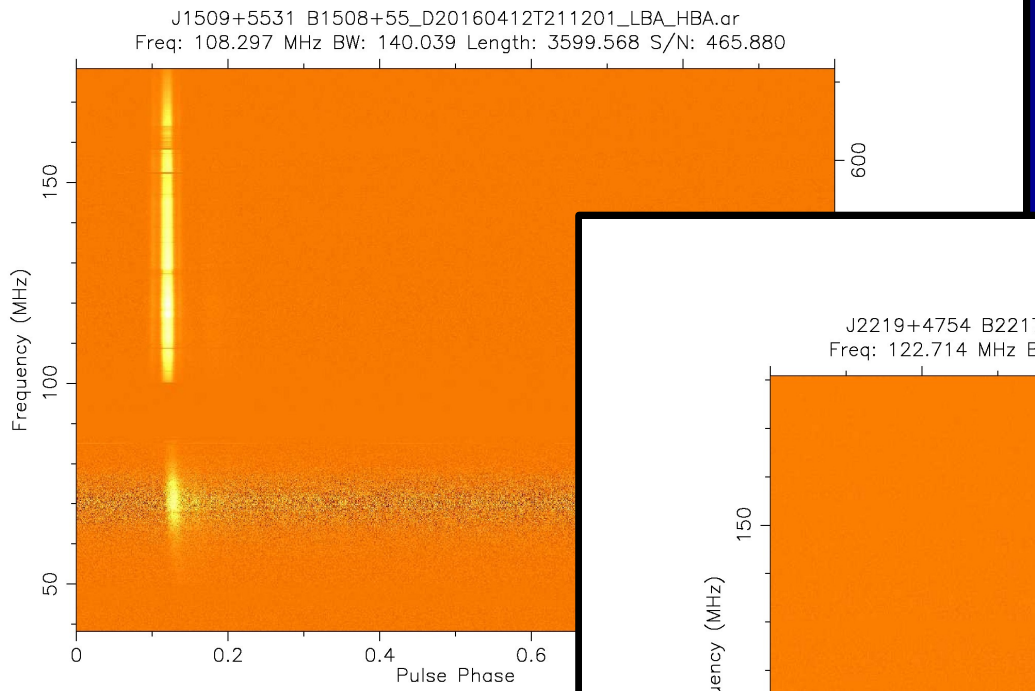
LBA observations

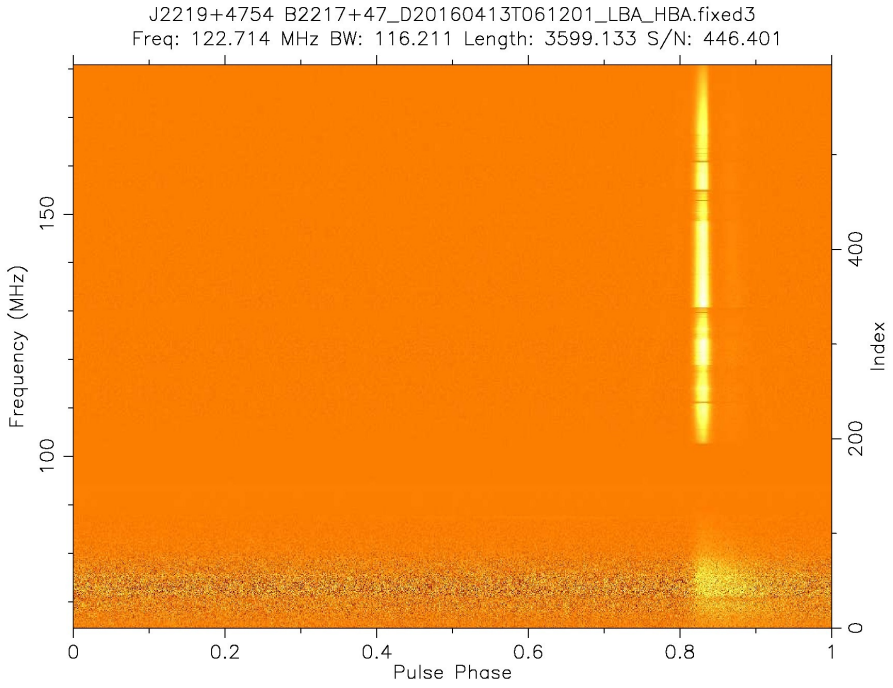




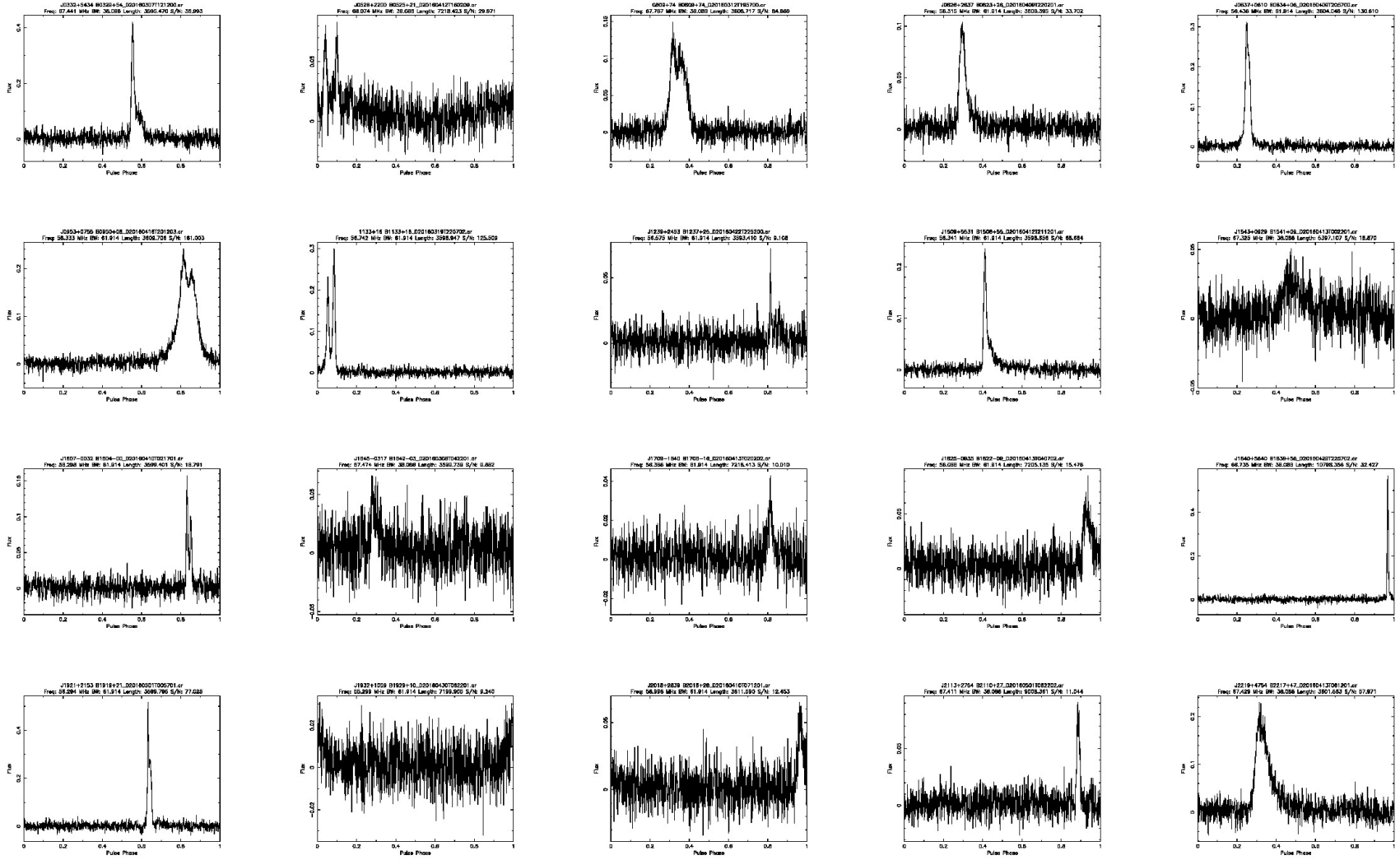


Joint LBA+HBA observations





LBA catalogue



LBA catalogue

project:

- international LOFAR station FR606, data processing at Nançay
- 8 h/week (observations since ~04/2016)

status:

- 20 detections

next steps:

- complete catalogue, compare to LOFAR observations
- improved processing
- maybe try lower frequencies (LBA, 10-90 MHz)?

goal:

→ contribution to pulsar population studies
→ study ISM at low frequencies
→ frequency-dependent DM?
→ (in a second step): pulsar monitoring
→ preparation for NenuFAR