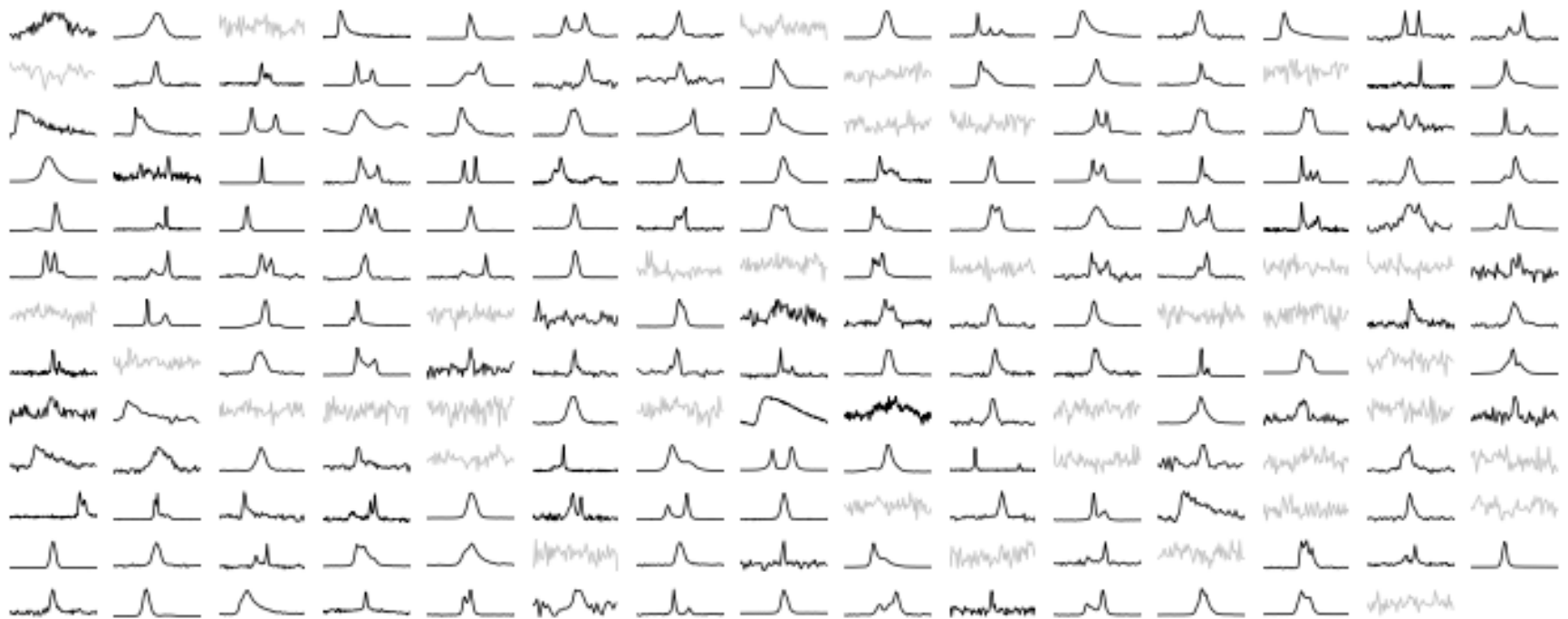
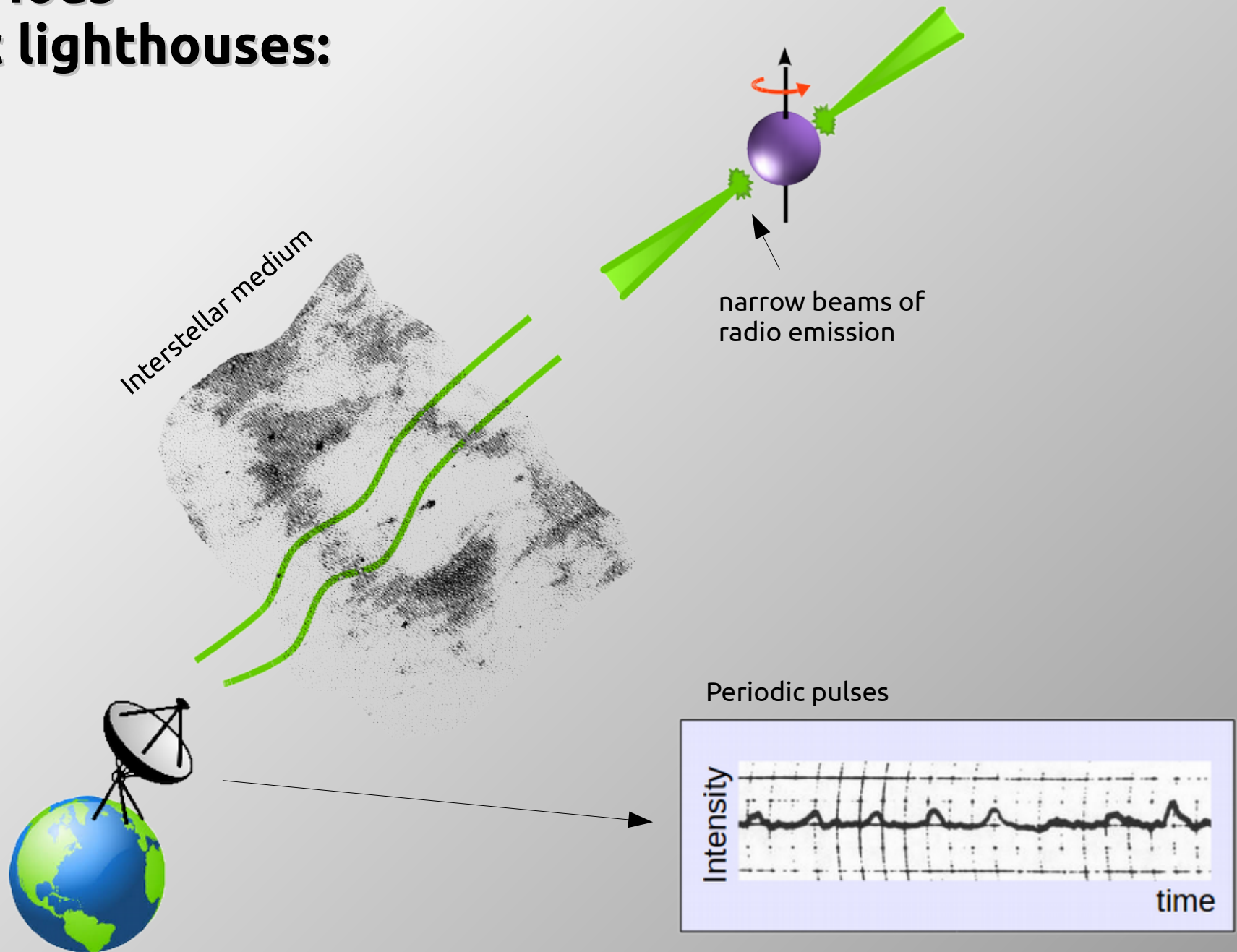


LOFAR census of non-millisecond pulsars

Anya Bilous, Radboud University Nijmegen
and LOFAR PWG



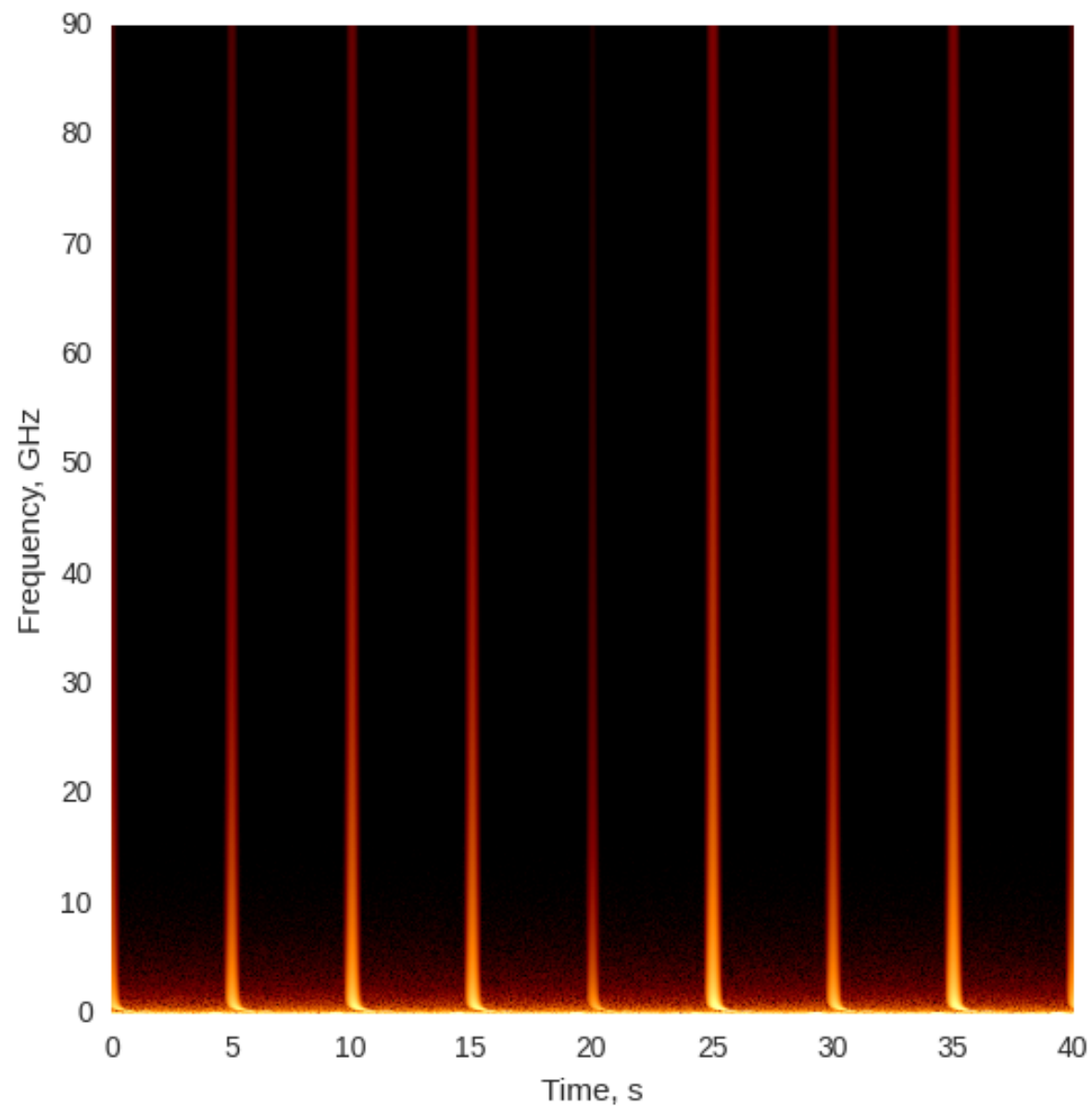
Pulsars, mysterious cosmic lighthouses:



Simulated ultra-broadband pulse recording

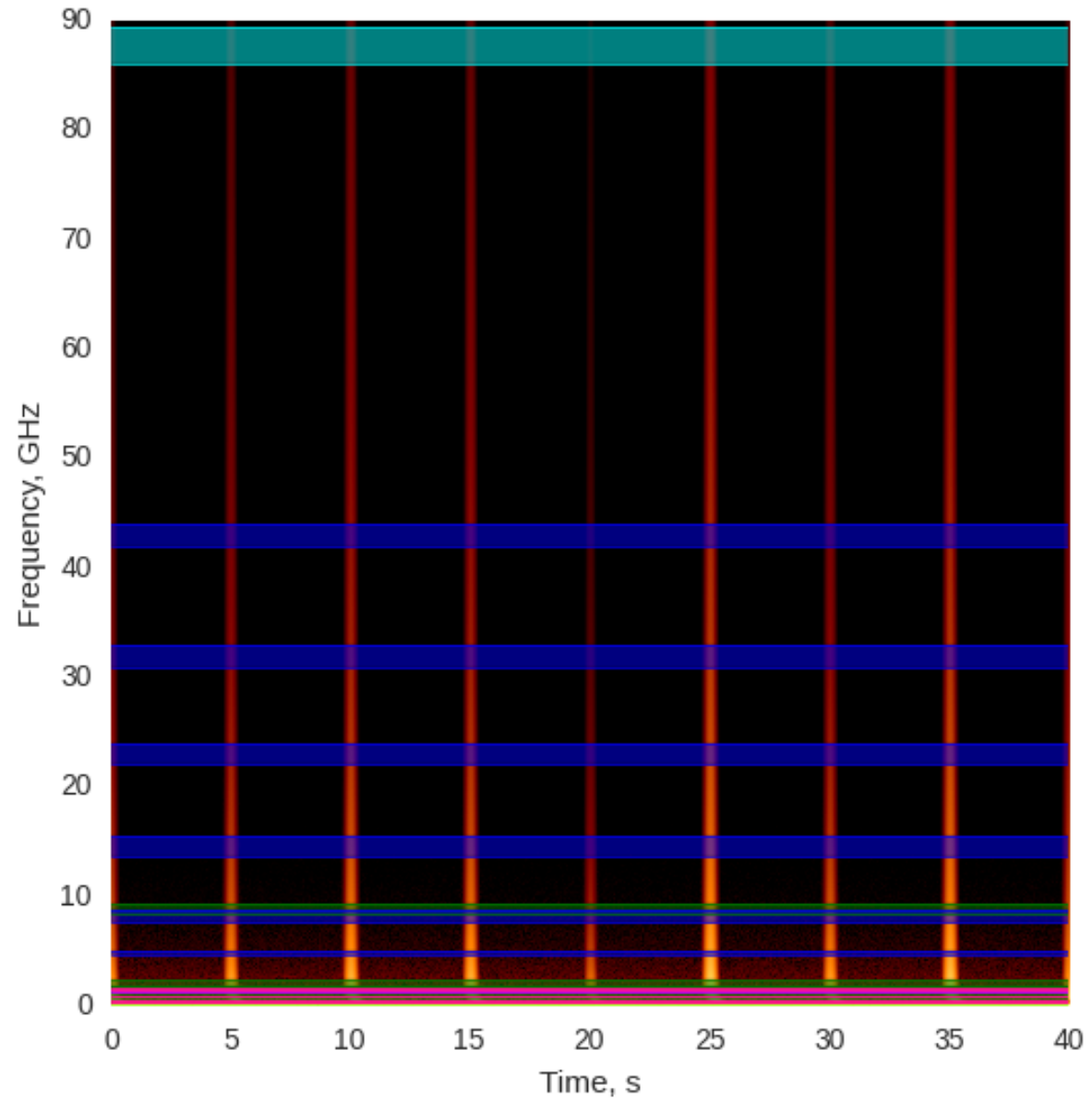
DM = 15 pc/cm³

P = 5 s



Simulated ultra-broadband pulse recording

DM = 15 pc/cm³
P = 5 s



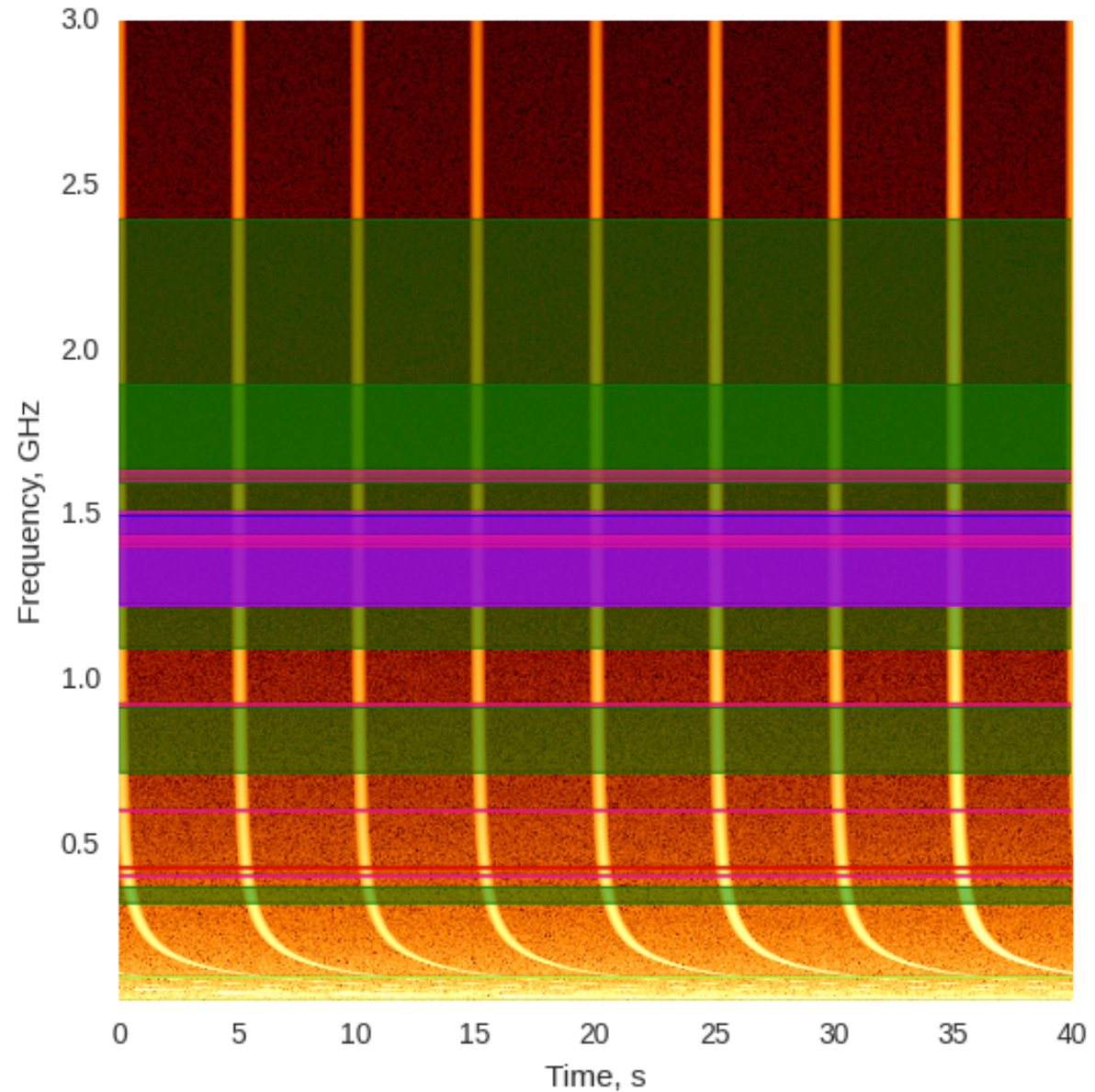
IRAM
Effelsberg
GBT

Parkes
Jodrell Bank
Pushchino

Arecibo

Simulated ultra-broadband pulse recording

DM = 15 pc/cm³
P = 5 s



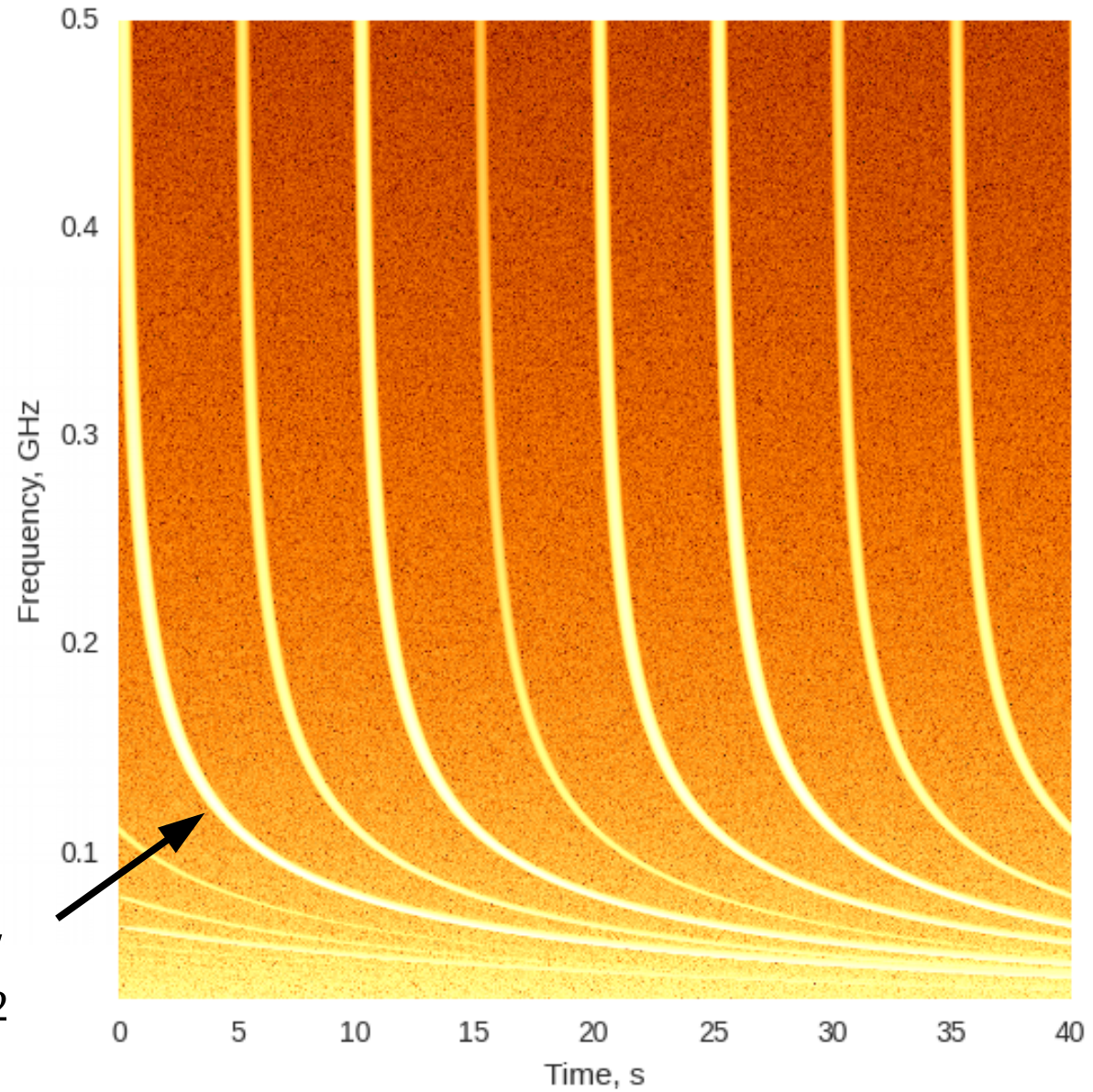
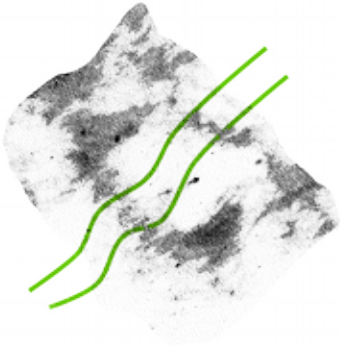
IRAM
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Dispersive delay

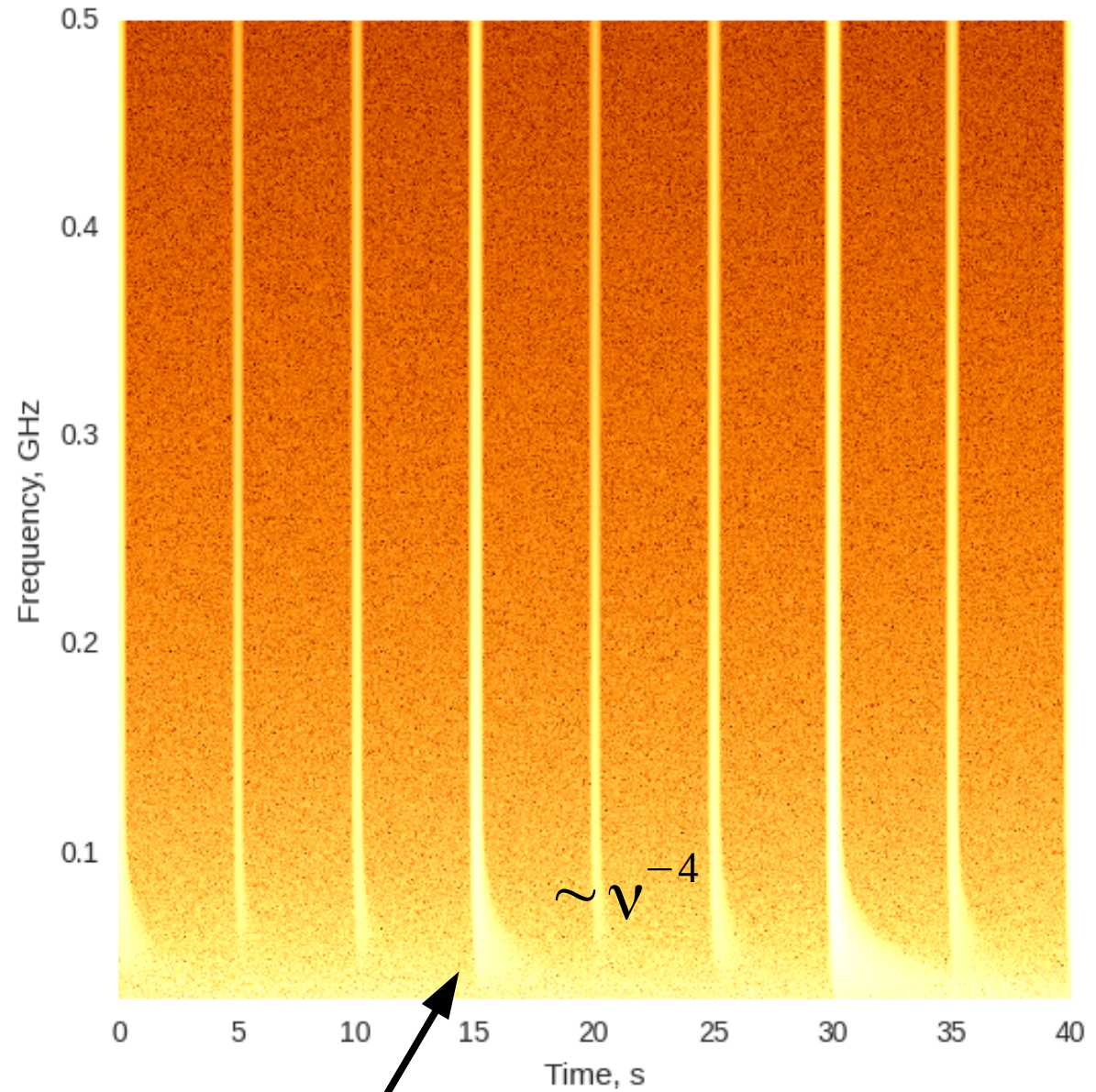
$$\delta t \sim DM / \nu^2$$



Simulated ultra-broadband pulse recording

DM = 15 pc/cm³
P = 5 s

Dispersive delay
removed



Scattering

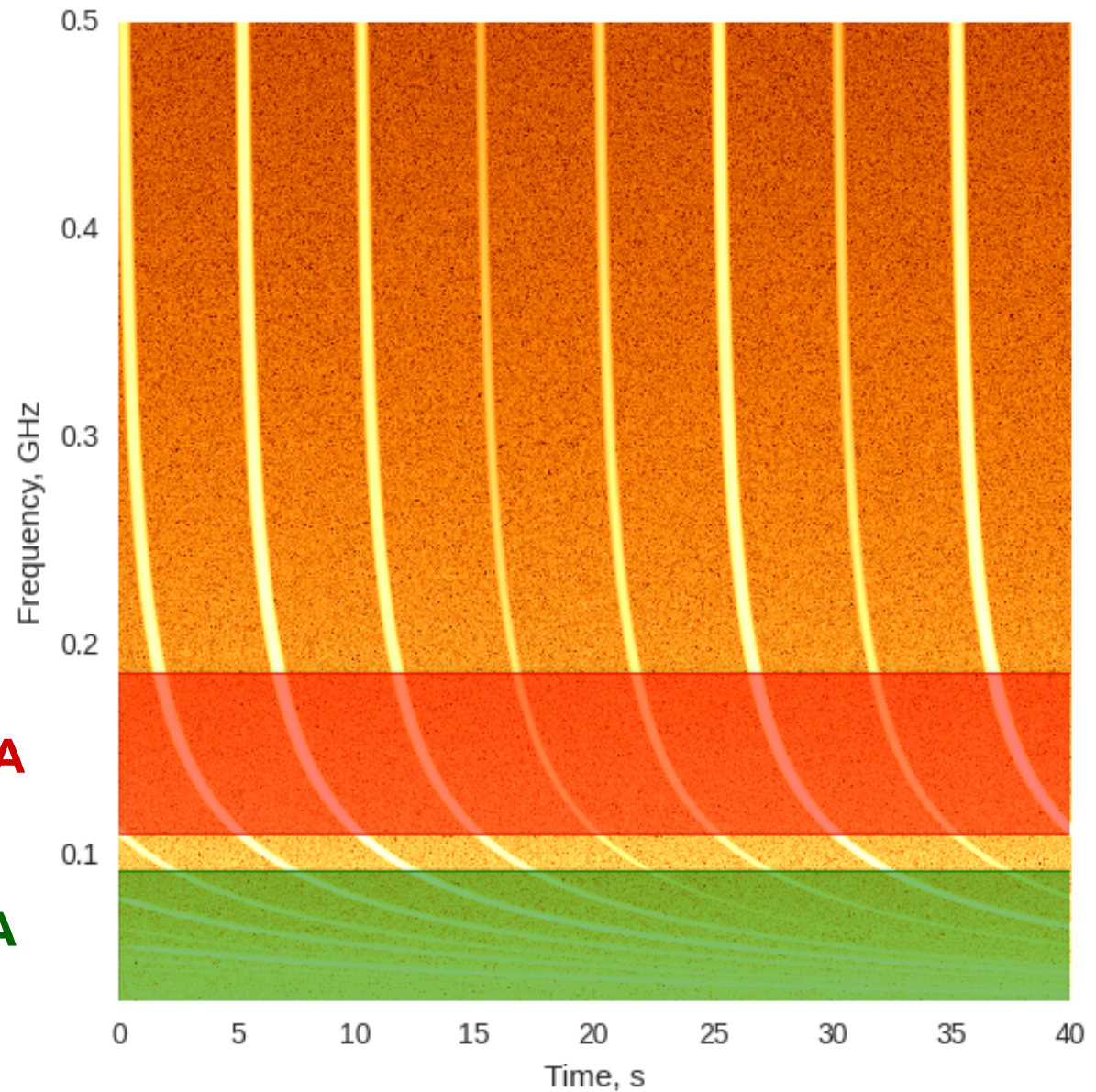


Simulated ultra-broadband pulse recording

DM = 15 pc/cm³
P = 5 s

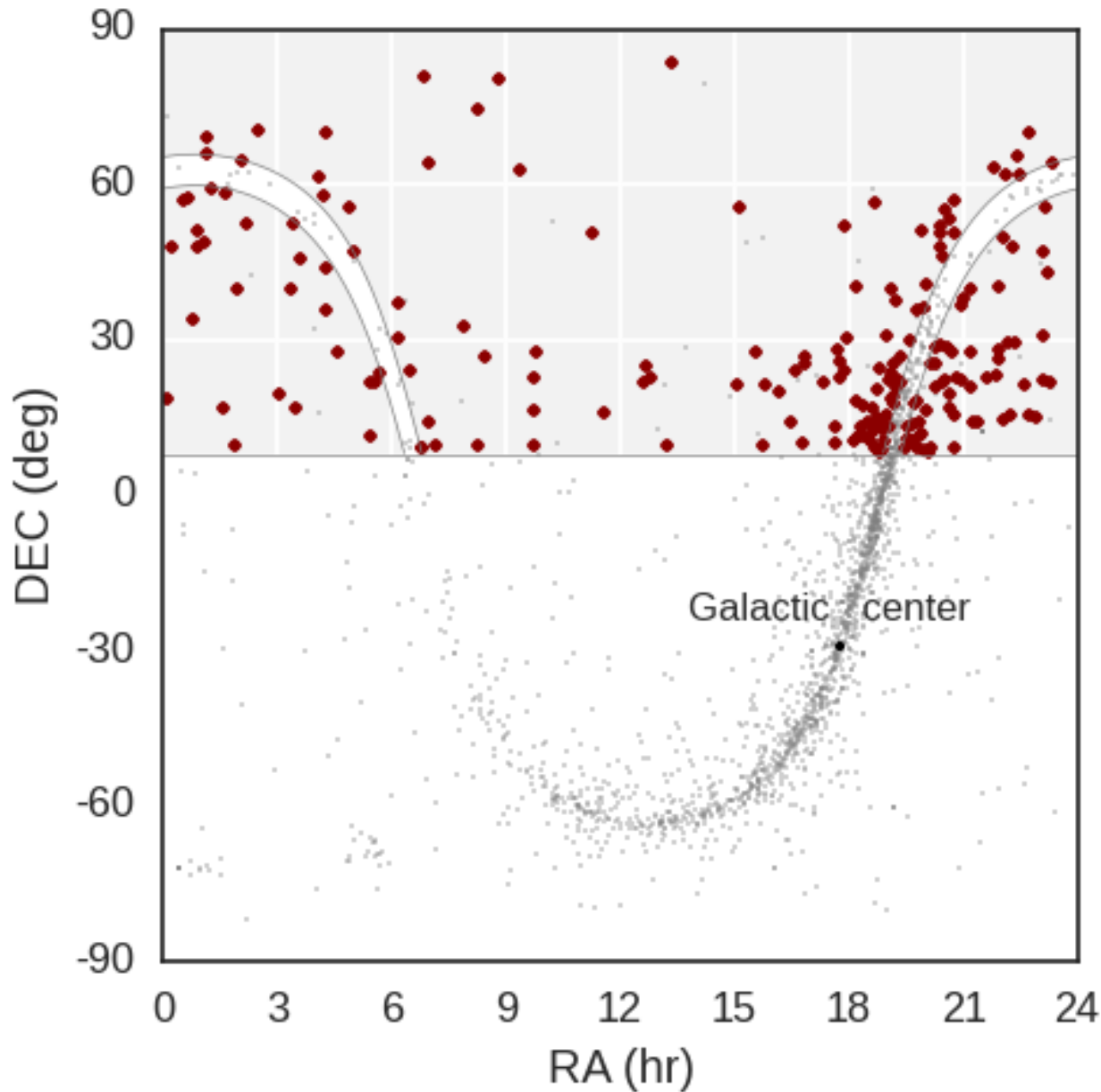
LOFAR HBA

LOFAR LBA



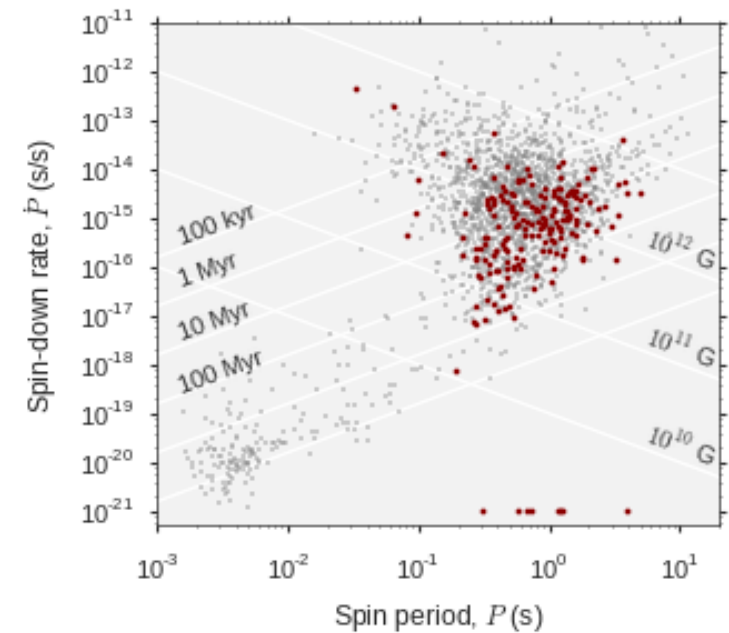
First LOFAR census of normal pulsars

- standard set of measurements
- large number of sources

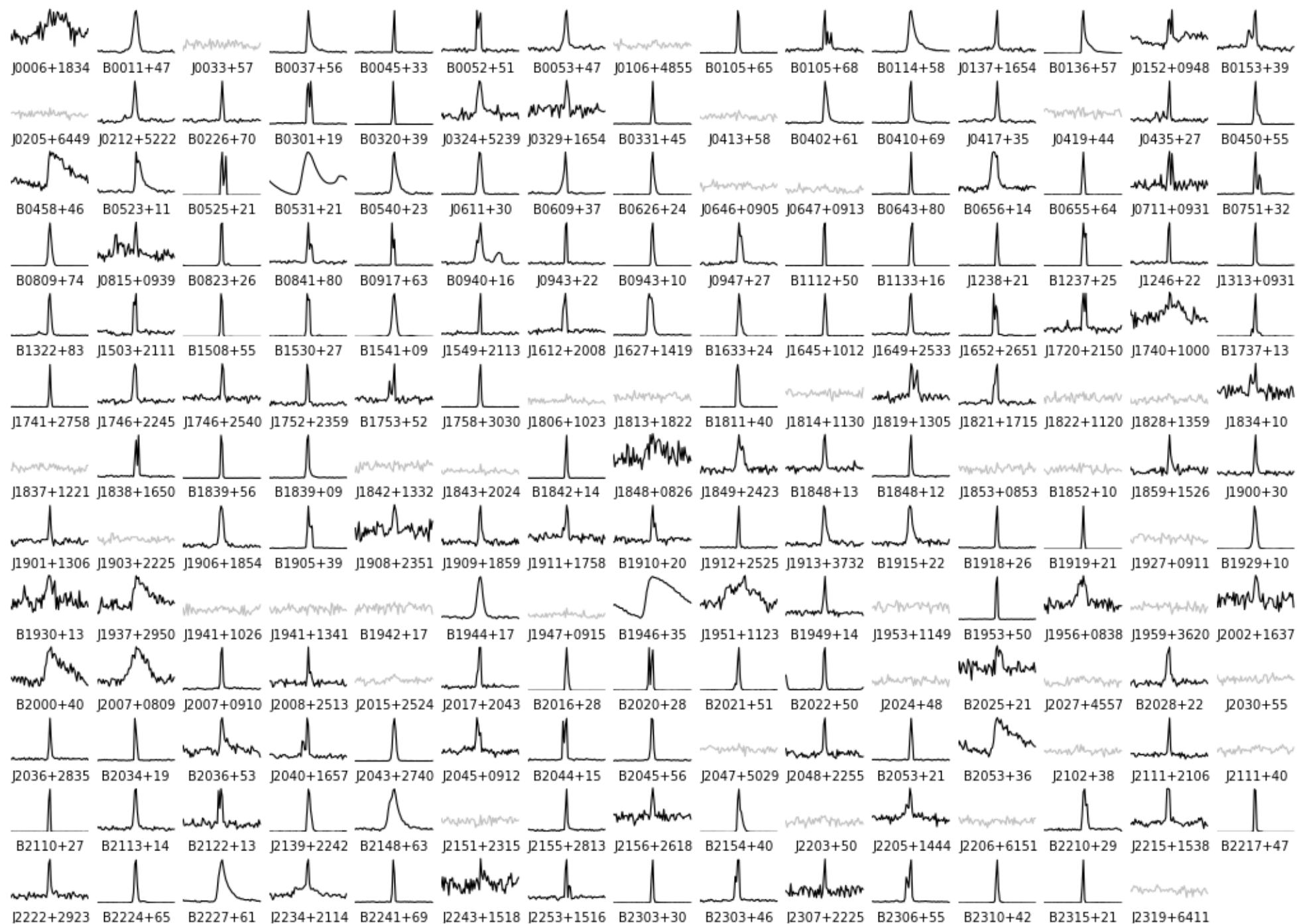


**194 Northern sources
outside Galactic plane**

**starting with HBA
following with LBA**



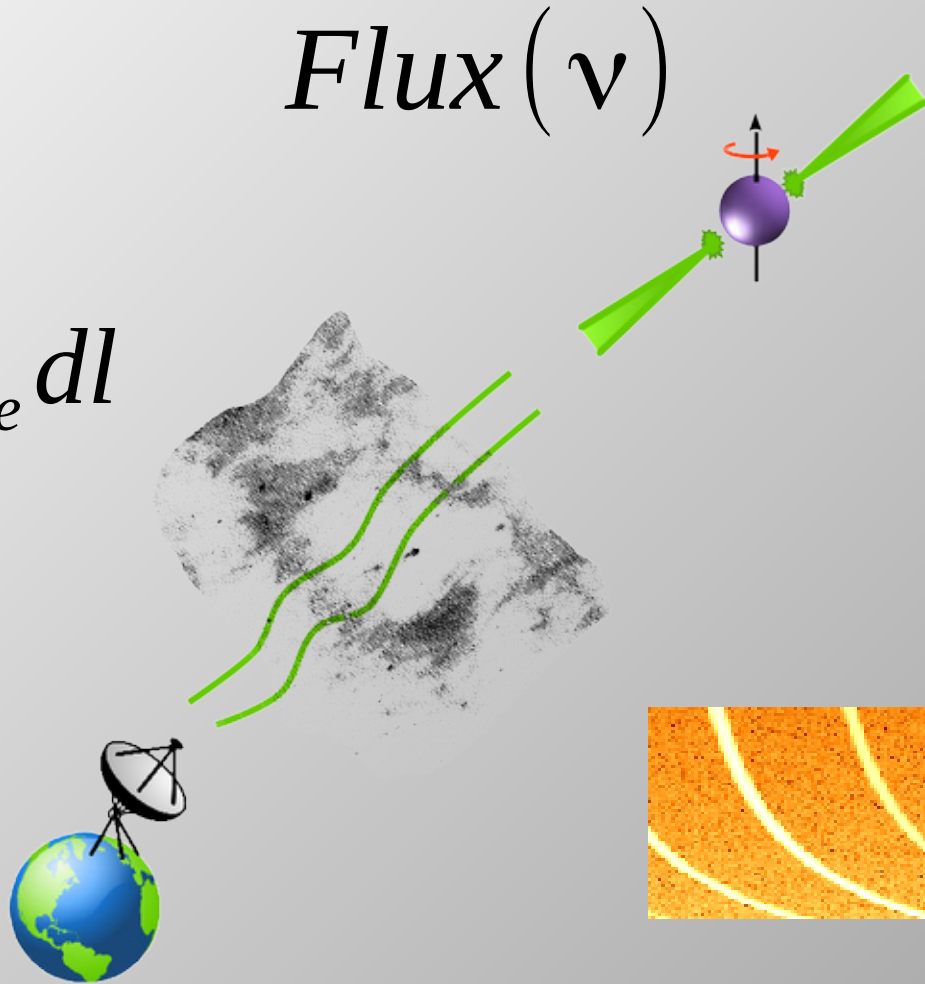
LOFAR HBA CENSUS
All normal PSRs with well-known coordinates above DEC=8 and |GB|=3 (v.3)



Two basic observables:

$$DM = \int n_e dl$$

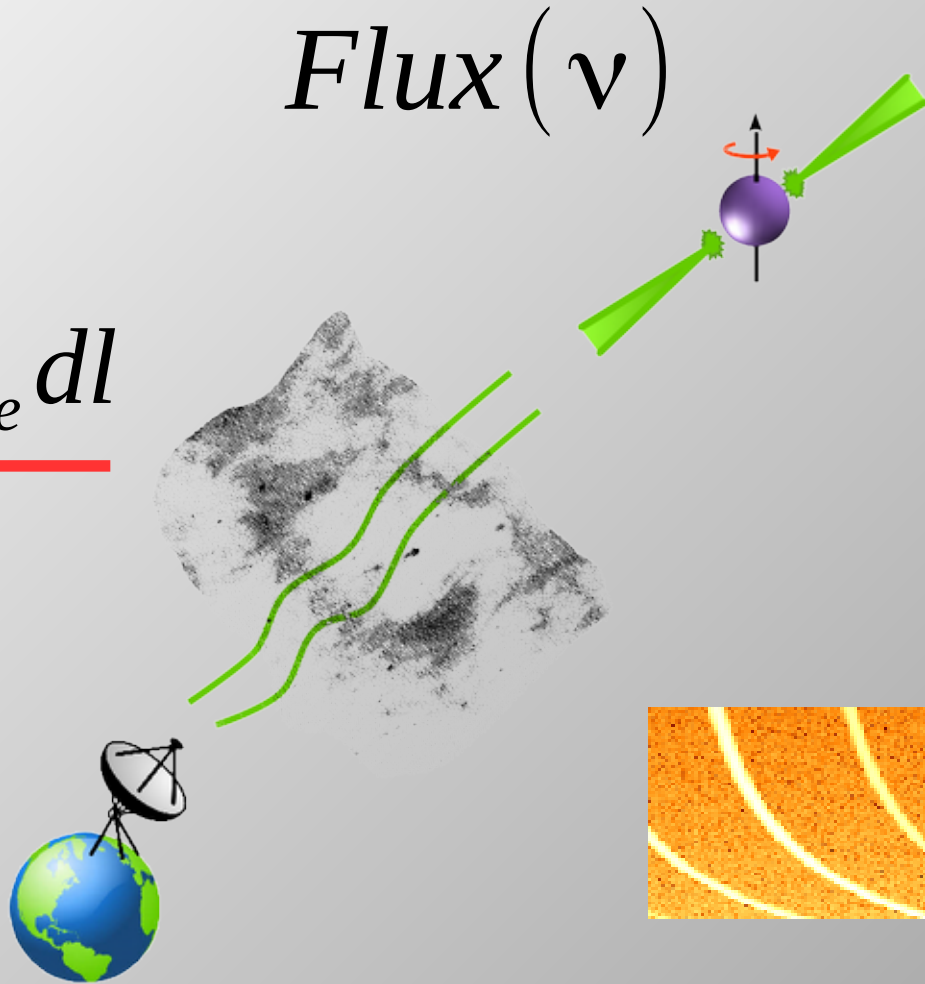
Flux(ν)



Two basic observables:

$$\underline{DM = \int n_e dl}$$

Flux(ν)



Dispersion measures:

- Census DMs are typically >10 times more precise than DMs in ATNF catalogue (0.0015 vs 0.025 pc/cm³)
- Median DM accuracy: 0.004% (1 additional electron per each 13 km of interstellar distance)
- For ~20 pulsars DM accuracy is sufficient to start detecting intrinsic DM variations with sessions ~3 months apart

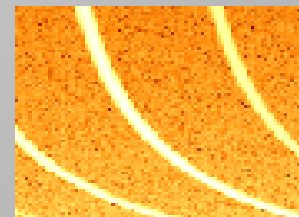
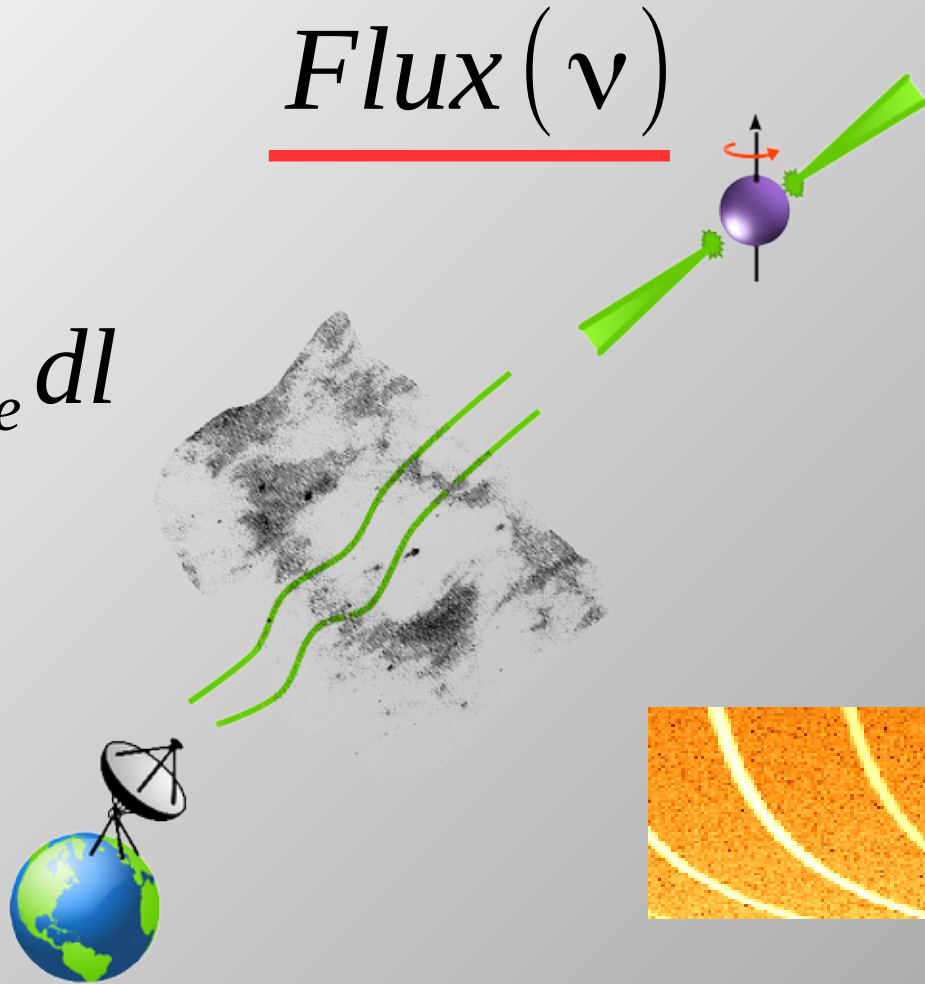
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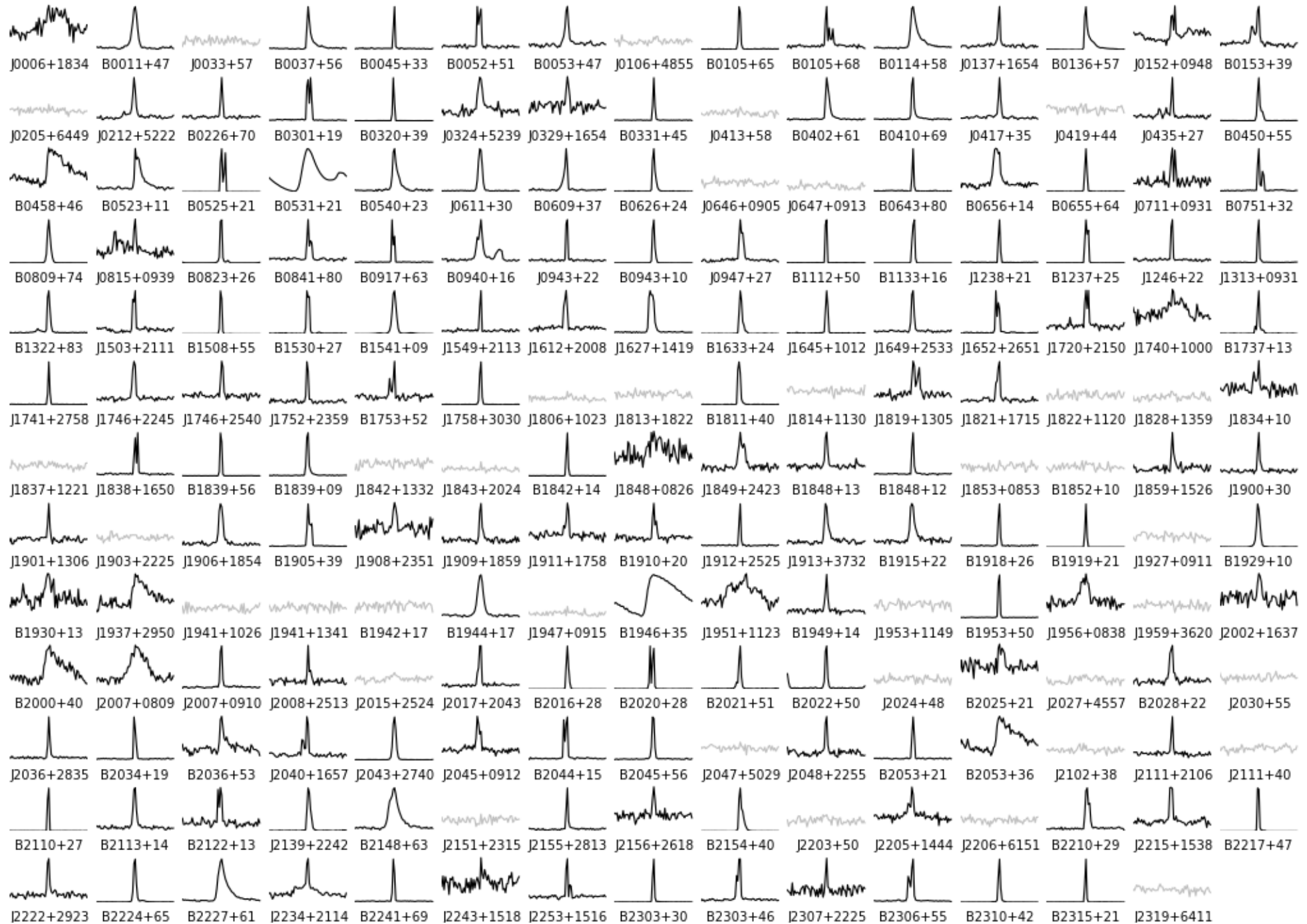


Flux calibration (timing campaign data)

- Flux calibration based on radiometer equation (Kondratiev et al., in prep)
- Three beam models (Arts 2011, Noutsos 2015, **Hamaker-Carozzi**), none is good (fluxes depend on elevation)
- Temporal variation much larger ($\sim 50\%$) than predicted by interstellar scintillation (but may be intrinsic to pulsars themselves)

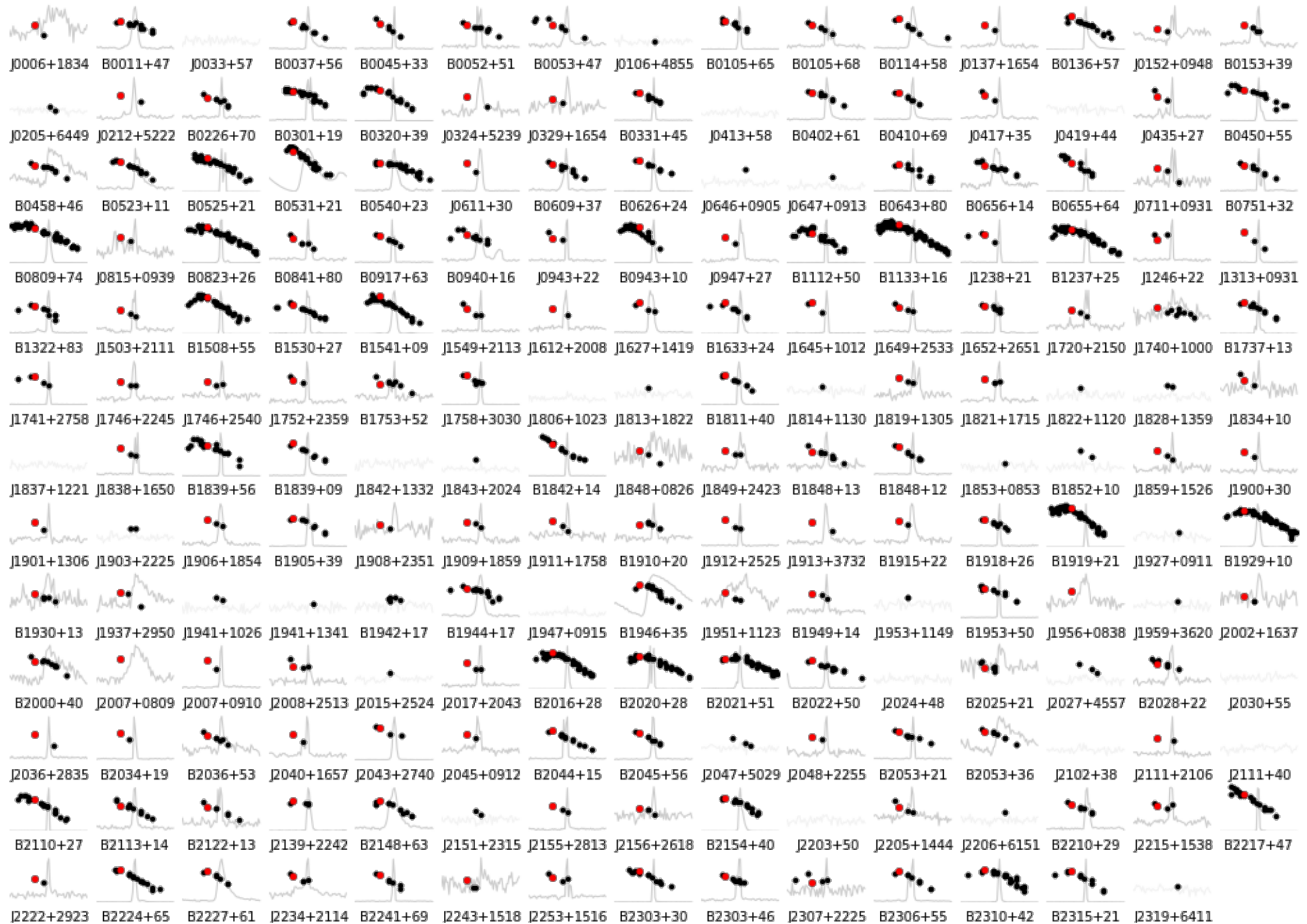
Single observation of high-S/N pulsar: **flux to within 50%.**

LOFAR HBA CENSUS
All normal PSRs with well-known coordinates above DEC=8 and |GB|=3 (v.3)

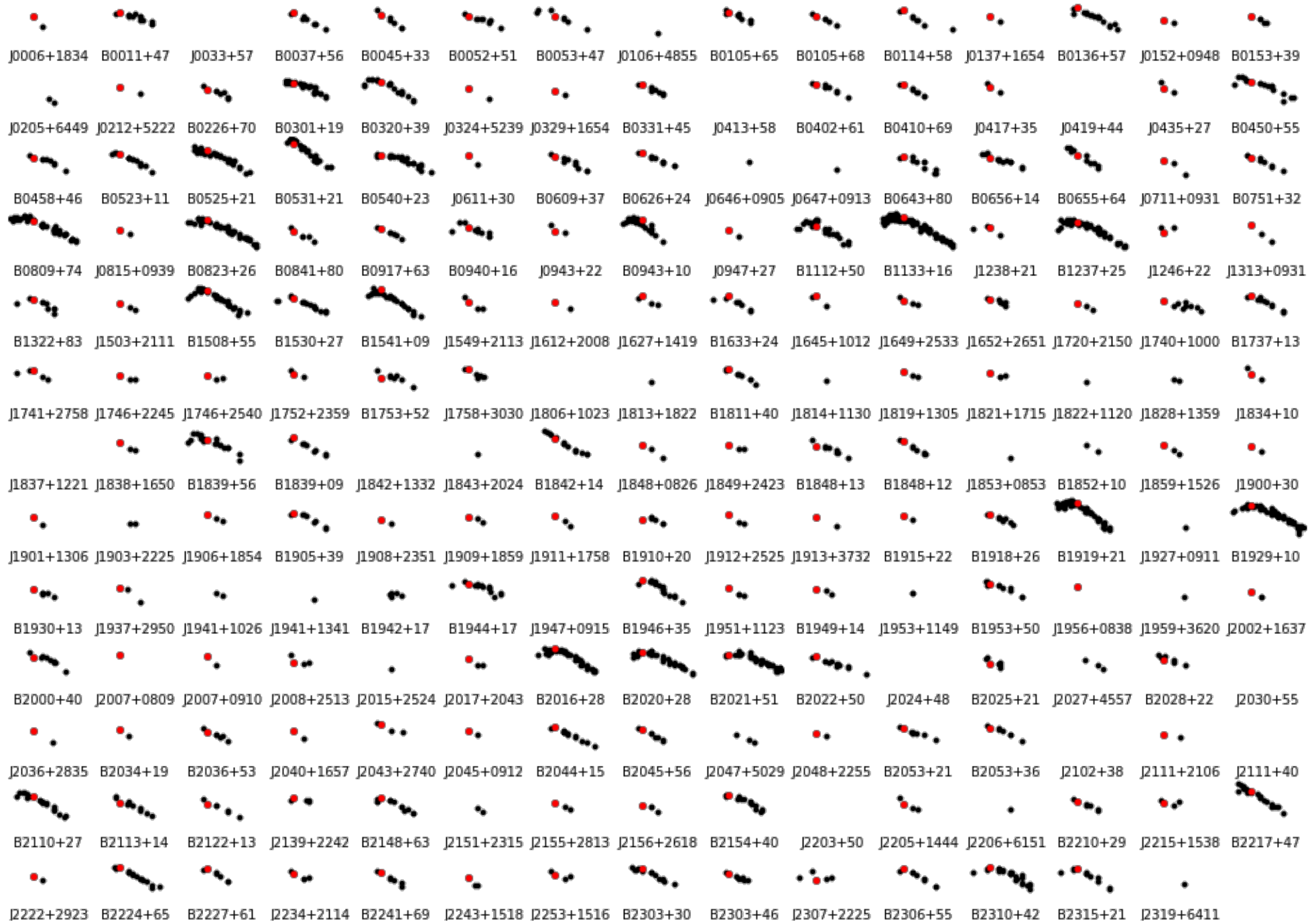


LOFAR HBA CENSUS

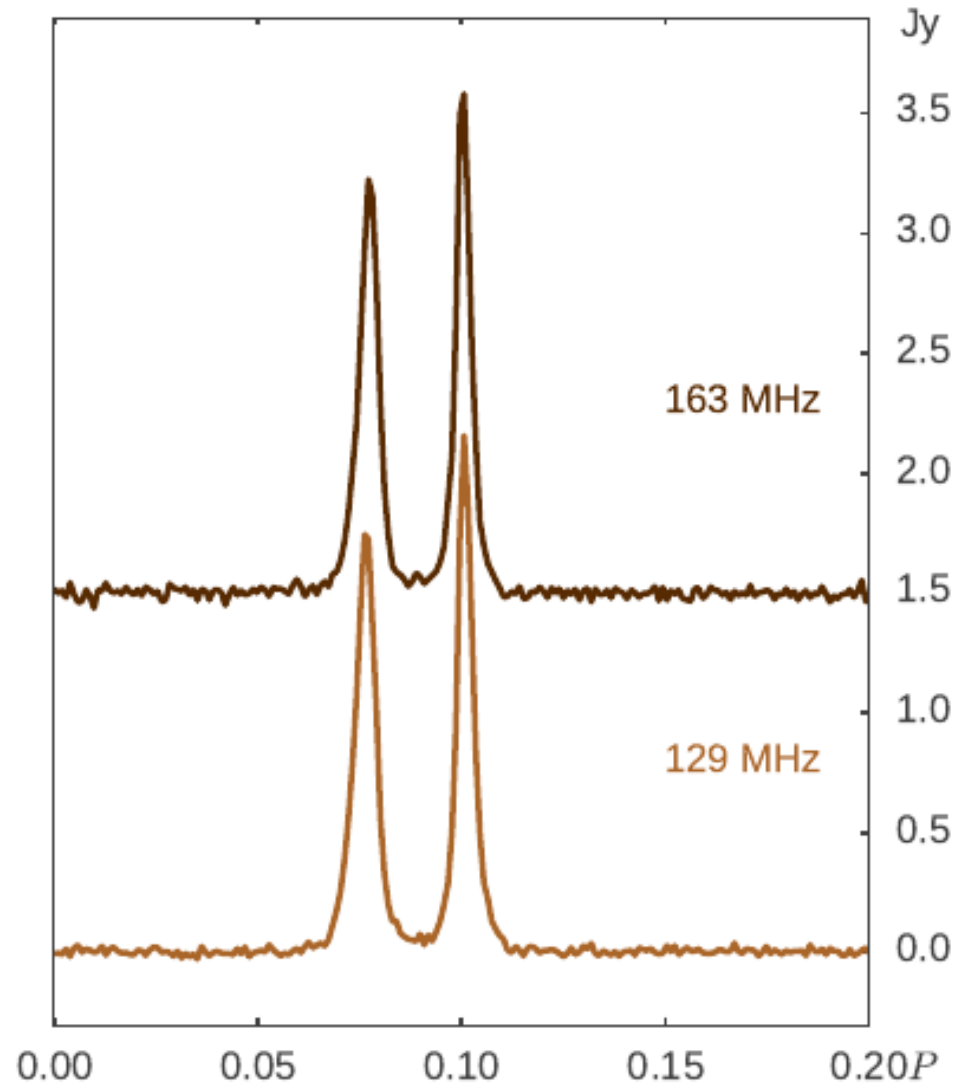
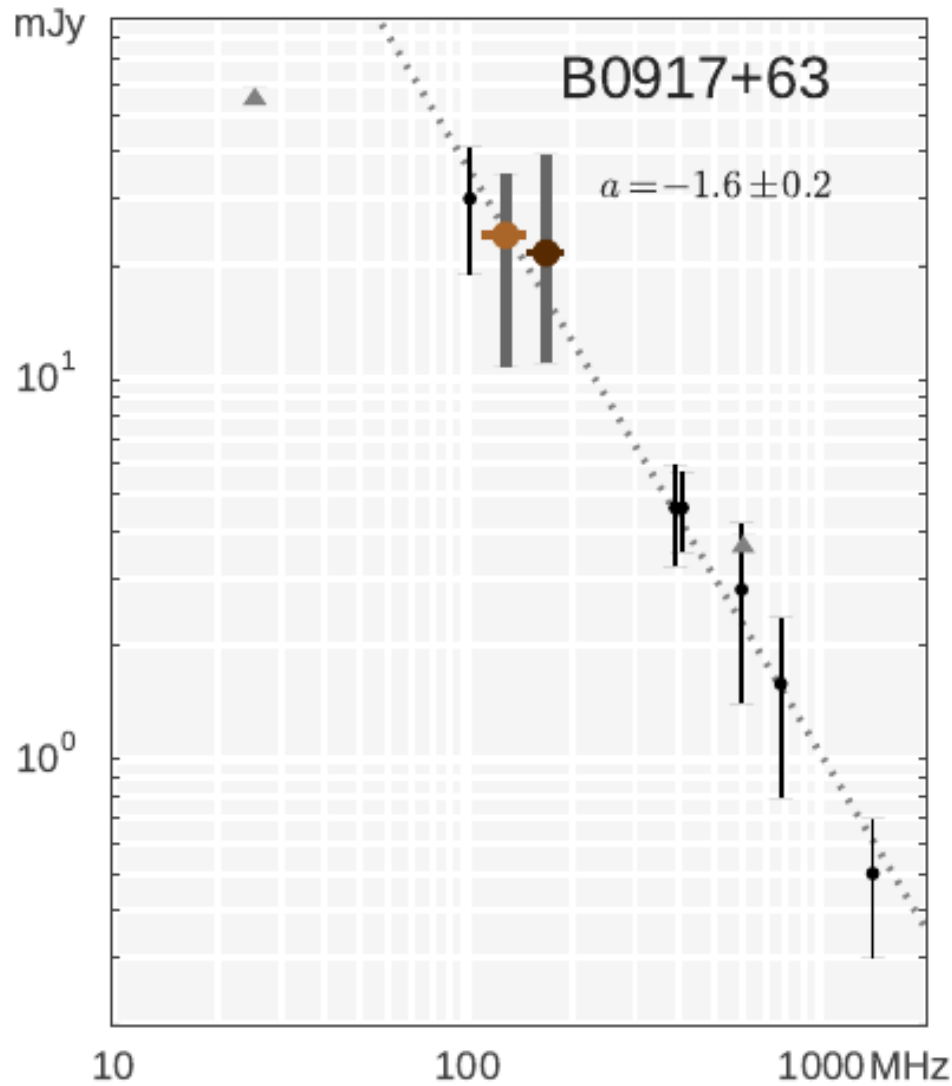
All normal PSRs with well-known coordinates above DEC=8 and |GB|=3 (v.3)



LOFAR HBA CENSUS
All normal PSRs with well-known coordinates above DEC=8 and |GB|=3 (v.3)



Coming LBA data: low-frequency turnover?



Summary:

- Great telescope operating in relatively unexplored and potentially interesting frequency range
- Large sample of normal pulsars with no bias towards “easier” ones
- The goal of creating a reference image of pulsar low-frequency emission (plus precise ISM measurements)

So far:

- Precise DM measurements for 158 pulsars.
- 150 MHz fluxes for 158 pulsars, spectral indices for 79 pulsars.