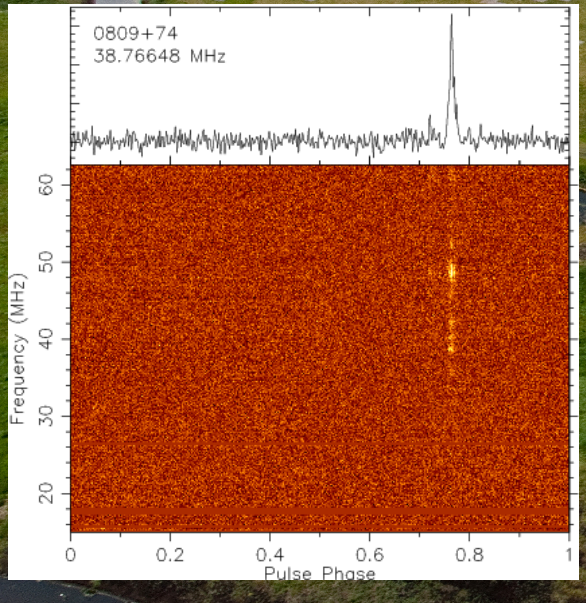
Pulsar Emission at the Bottom-End of the Electromagnetic Spectrum

Vlad Kondratiev (ASTRON)
on behalf of ***LOFAR Pulsar Working Group***

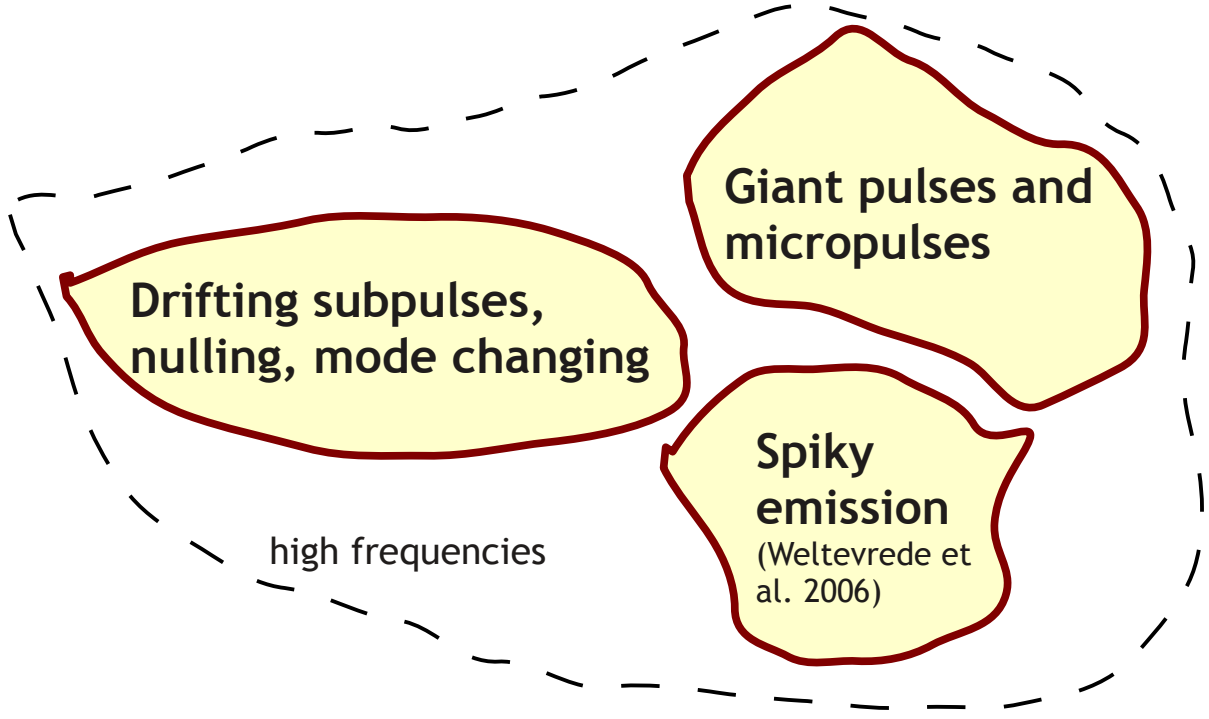


LOFAR Pulsar Working Group

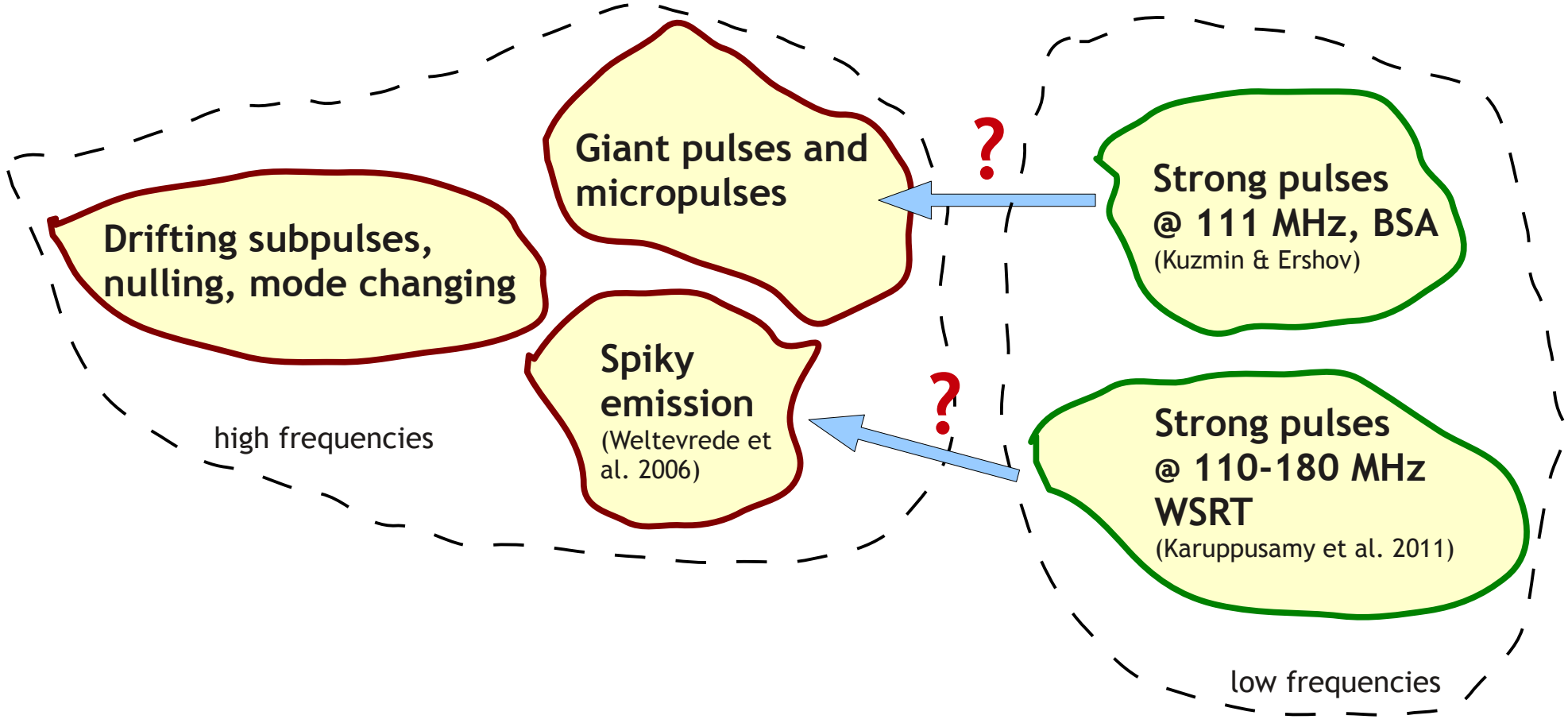
Anastasia Alexov	*UvA*
Thijs Coenen	*UvA*
Jean-Mathias Grießmeier	*CNRS/Université d'Orléans*
Tom Hassall	*University of Southampton*
Jason Hessels	*ASTRON/UvA*
Aris Karastergiou	*University of Oxford*
Evan Keane	*MPIfR*
Vlad Kondratiev	*ASTRON*
Michael Kramer	*MPIfR*
Masaya Kuniyoshi	*MPIfR*
Joeri van Leeuwen	*ASTRON/UvA*
Aris Noutsos	*MPIfR*
Maura Pilia	*ASTRON*
Maciej Serylak	*Nançay, CNRS/Université d'Orléans*
Charlotte Sobey	*MPIfR*
Ben Stappers	*University of Manchester*
Joris Verbiest	*MPIfR*
Patrick Weltevrede	*University of Manchester*
Kimon Zagkouris	*University of Oxford*

and Anya Bilous *(University of Virginia)*

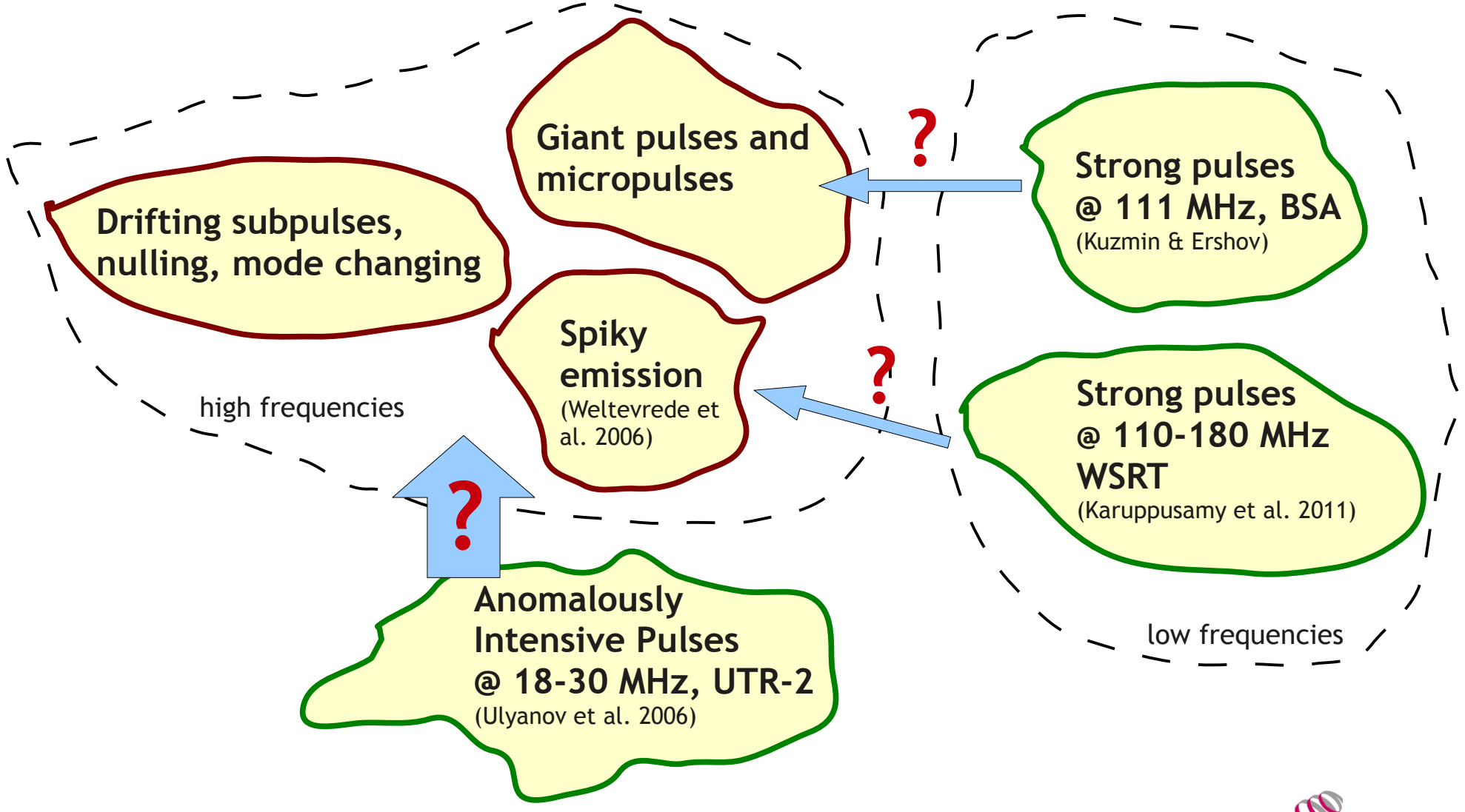
Variety of pulsar radio emission

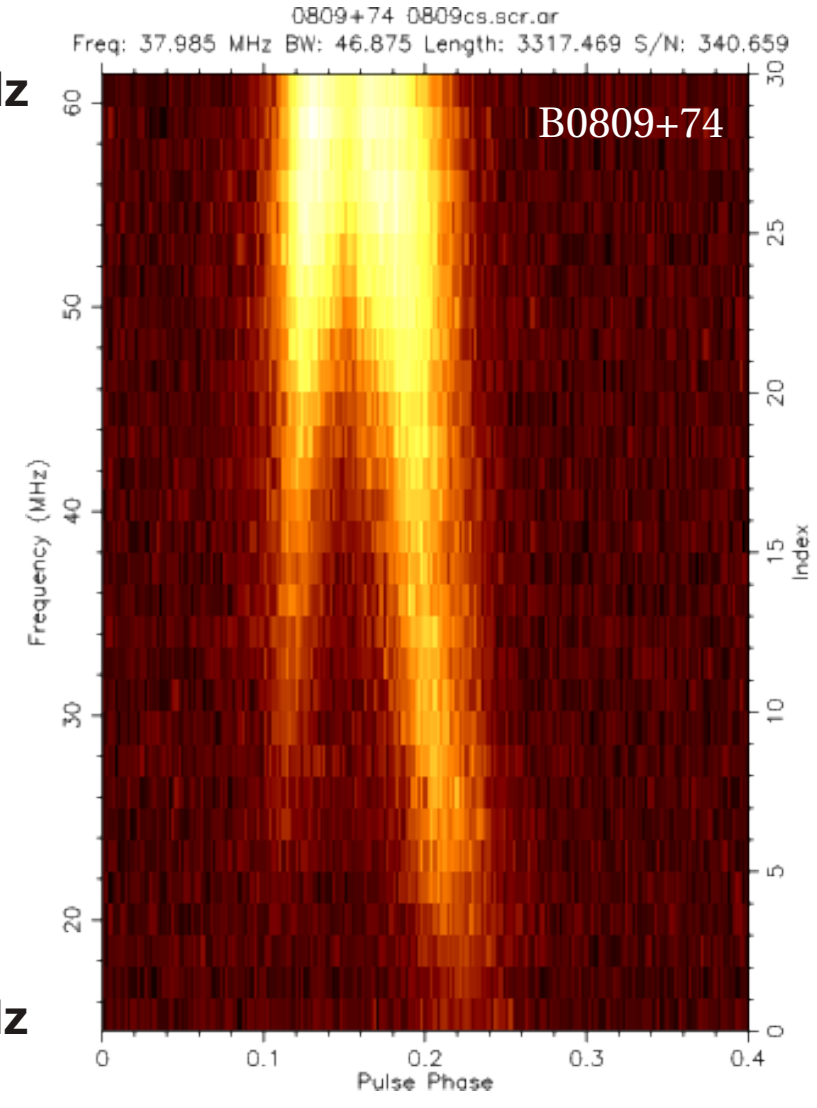


Variety of pulsar radio emission



Variety of pulsar radio emission





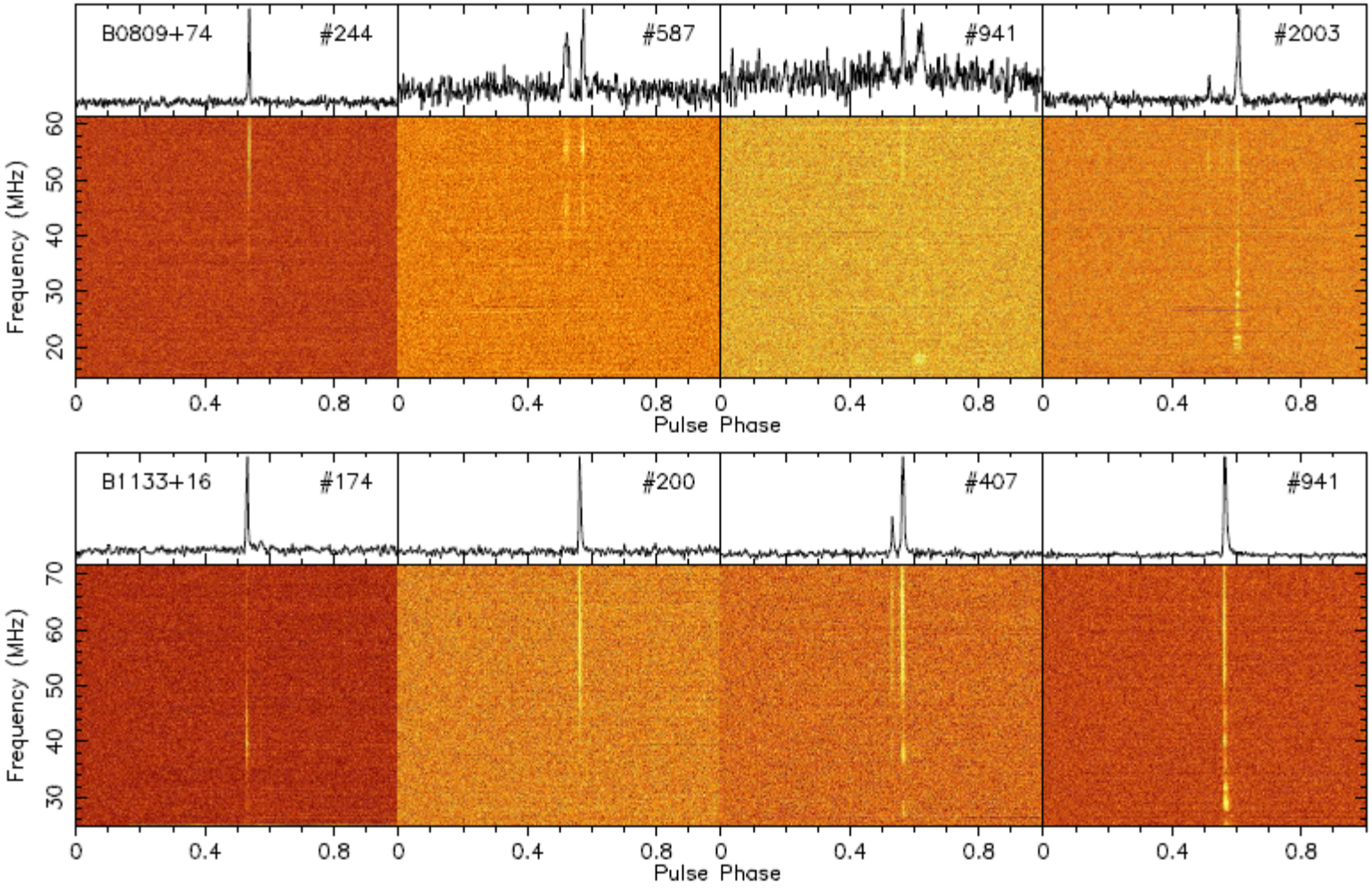
By studying pulsar emission at the lowest accessible frequencies, can we learn something new and fundamental?

LOFAR provides full coverage of the 10–90 MHz window.

Observations

- LBA Superterp
- 15–62 MHz
- 1 hour/obs
- $\Delta f \approx 6$ kHz
- $\Delta t = 491.52$ μs
- Stokes I

Bright narrow-band pulses

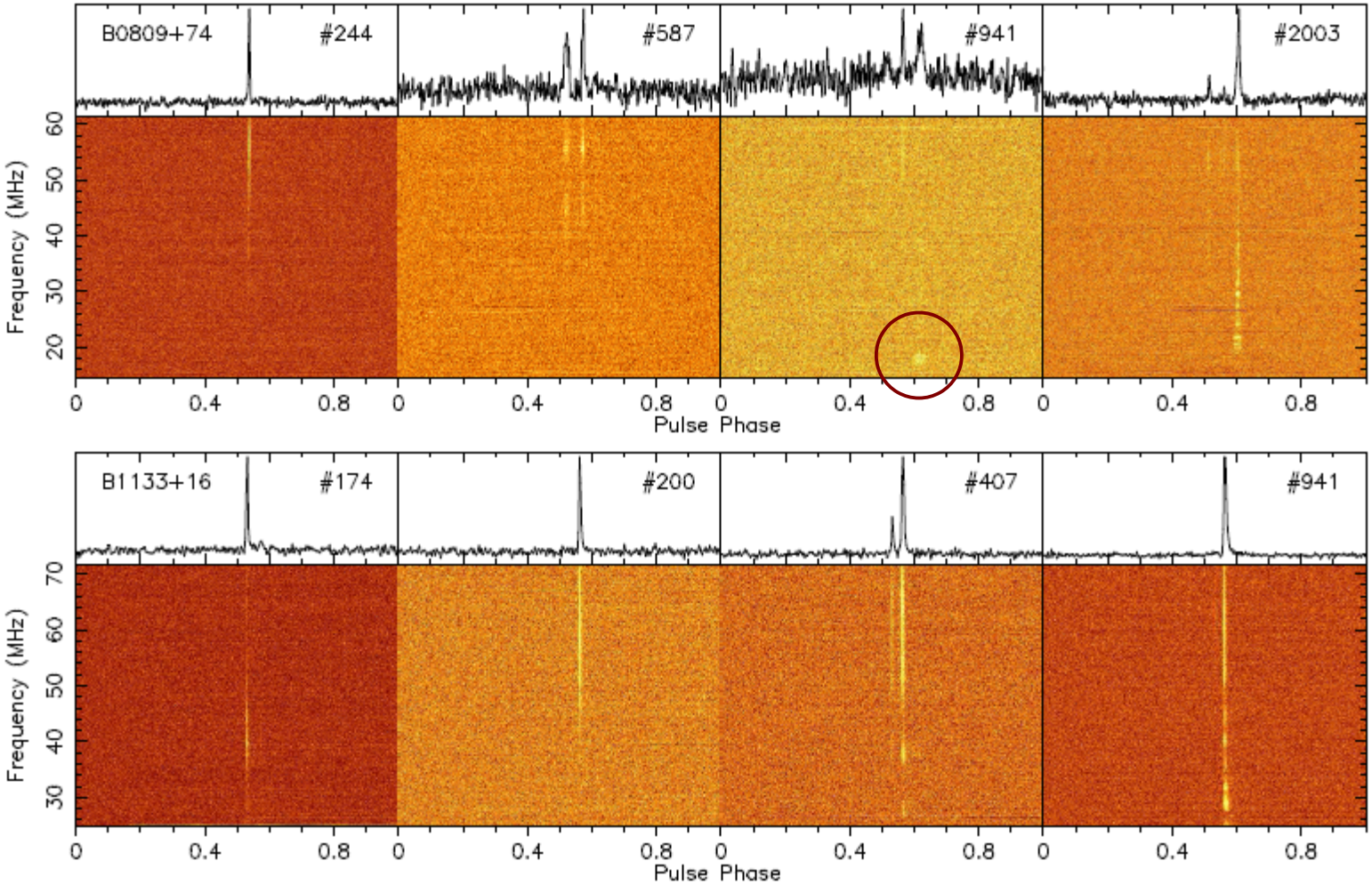


B0809+74

B1133+16

Kondratiev et al. (in prep)

Bright narrow-band pulses



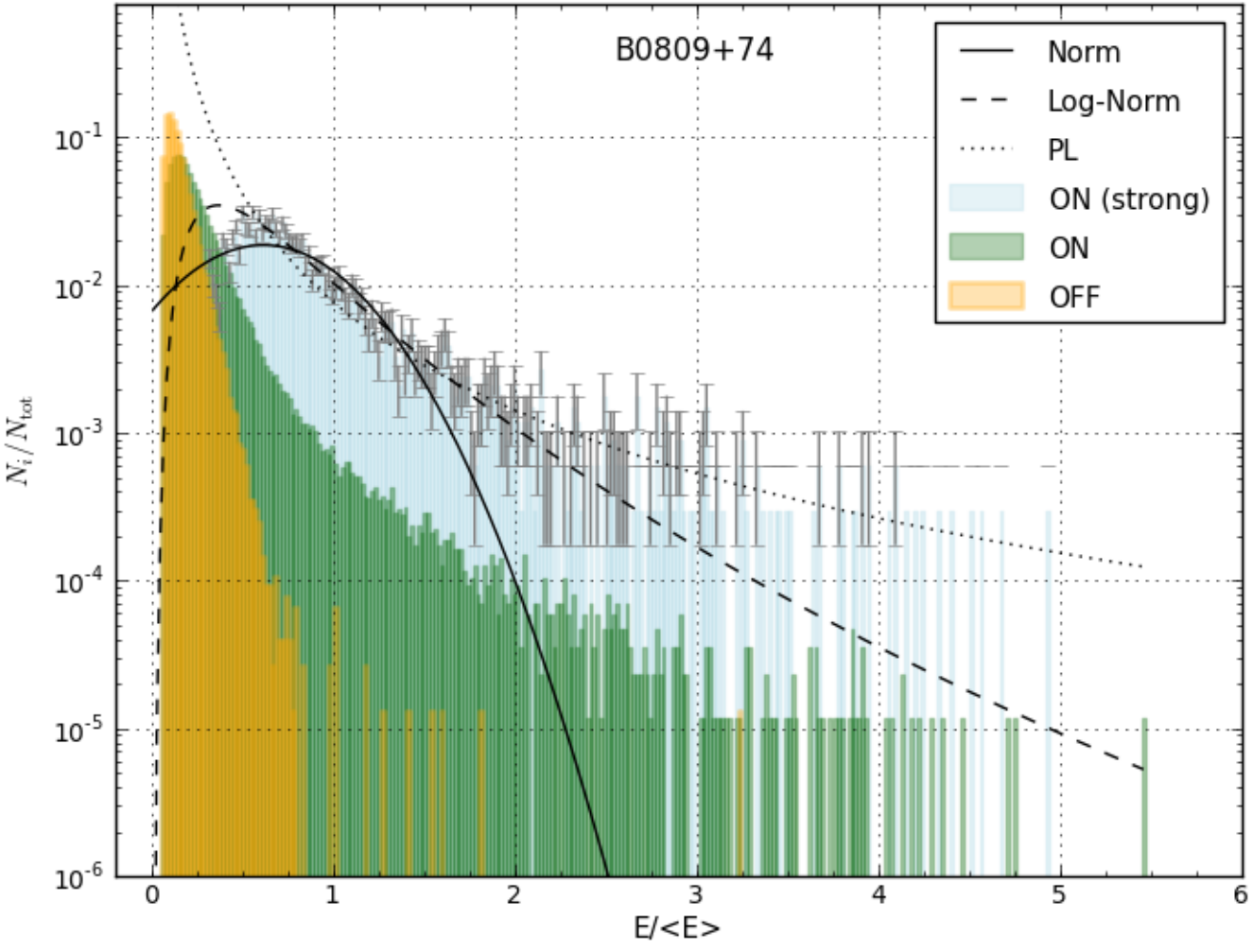
B0809+74

B1133+16

Kondratiev et al. (in prep)

LOFAR

Pulse energy distribution



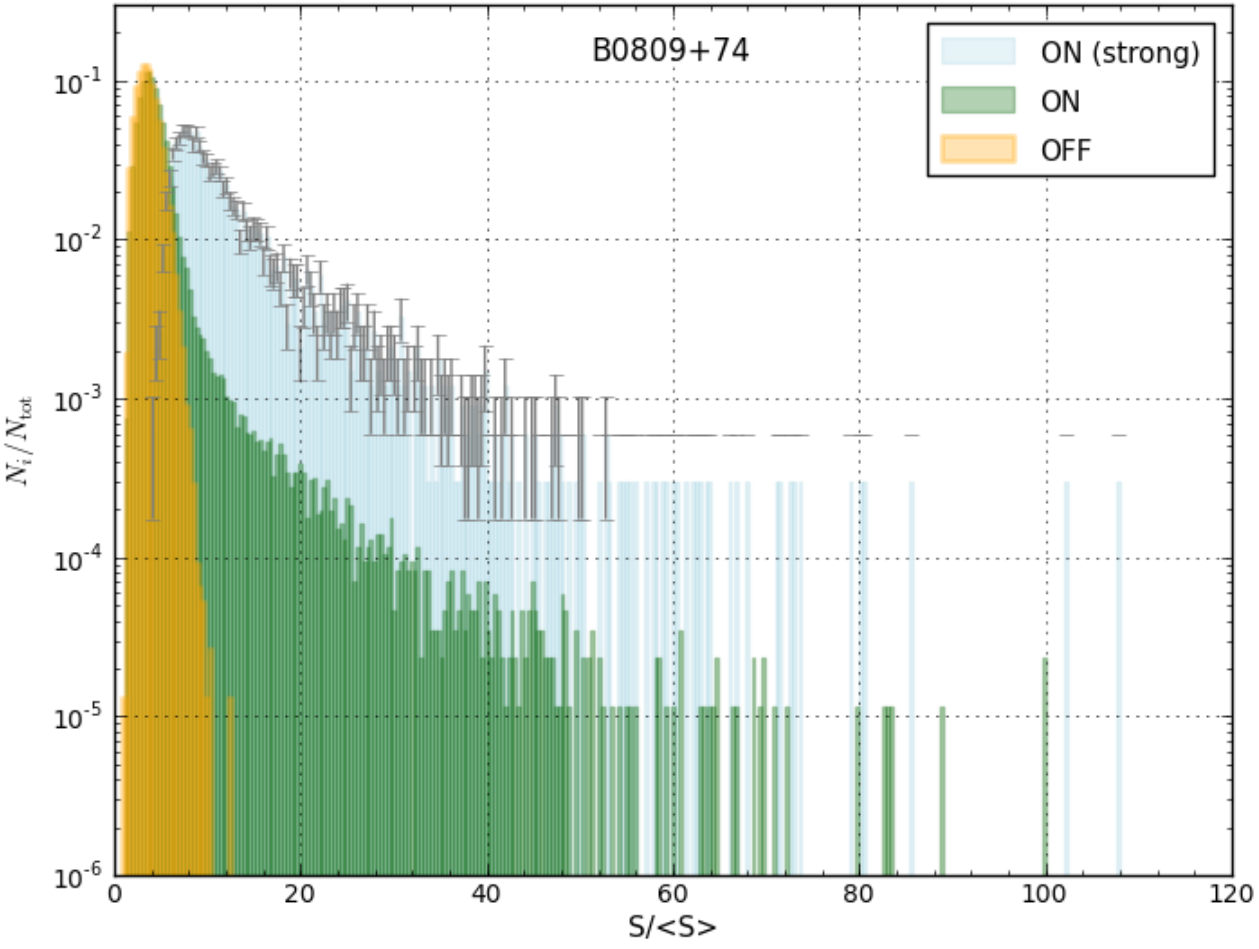
B0809+74

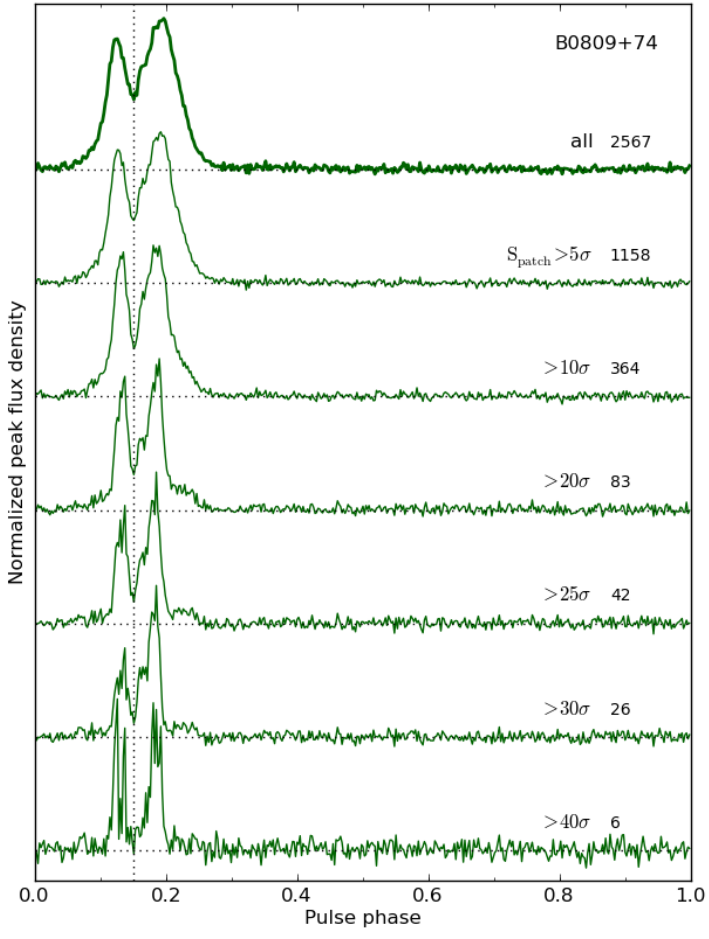
- Energies < 10 ‹E›
- Can't diffirentiate between Log-Norm and PL
- In general, Log-Norm fits better
- PL works better for high-energy tail

Kondratiev et al. (in prep)

Peak flux densities

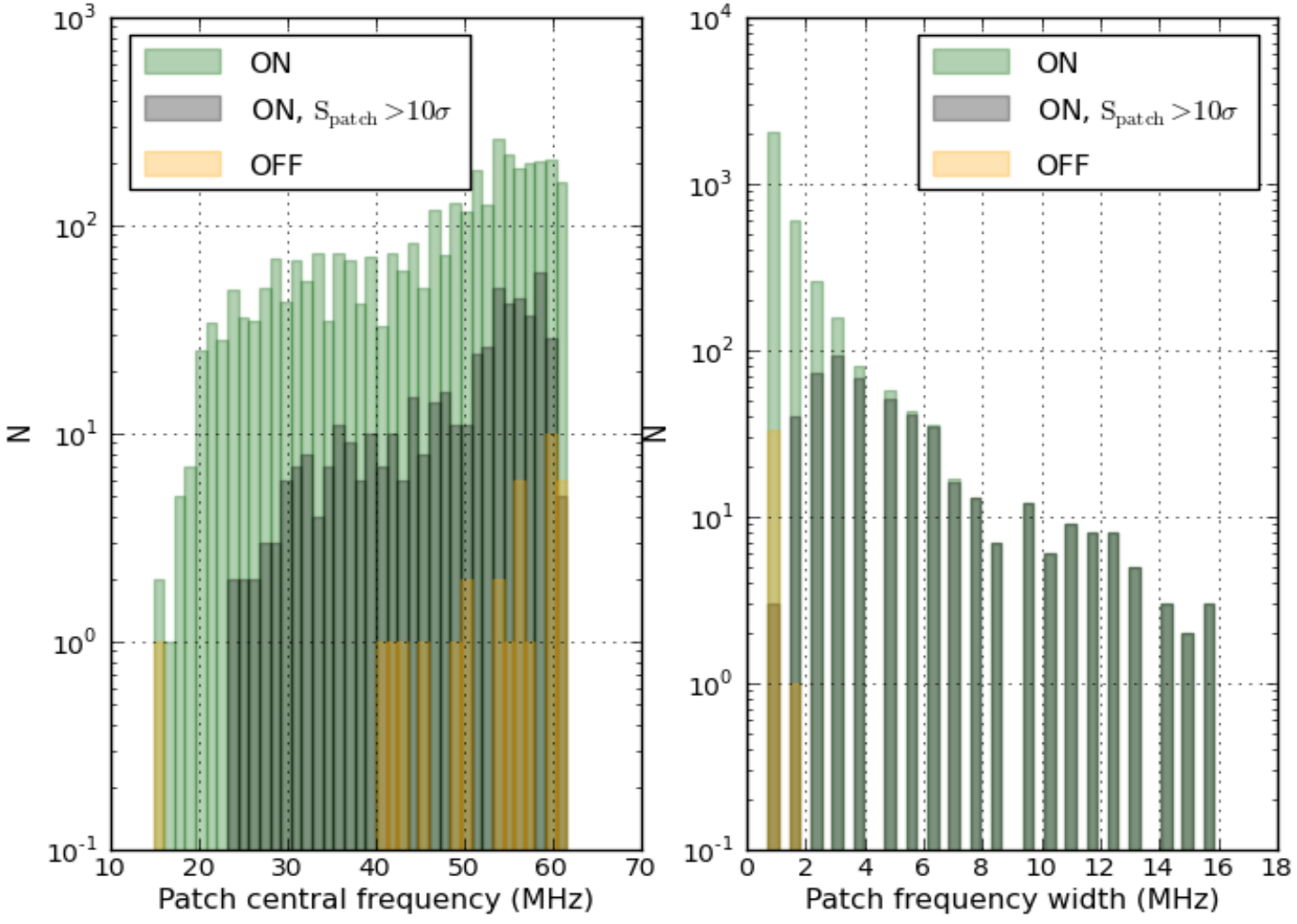
B0809+74





Kondratiev et al. (in prep)

Pulse spectra



B0809+74

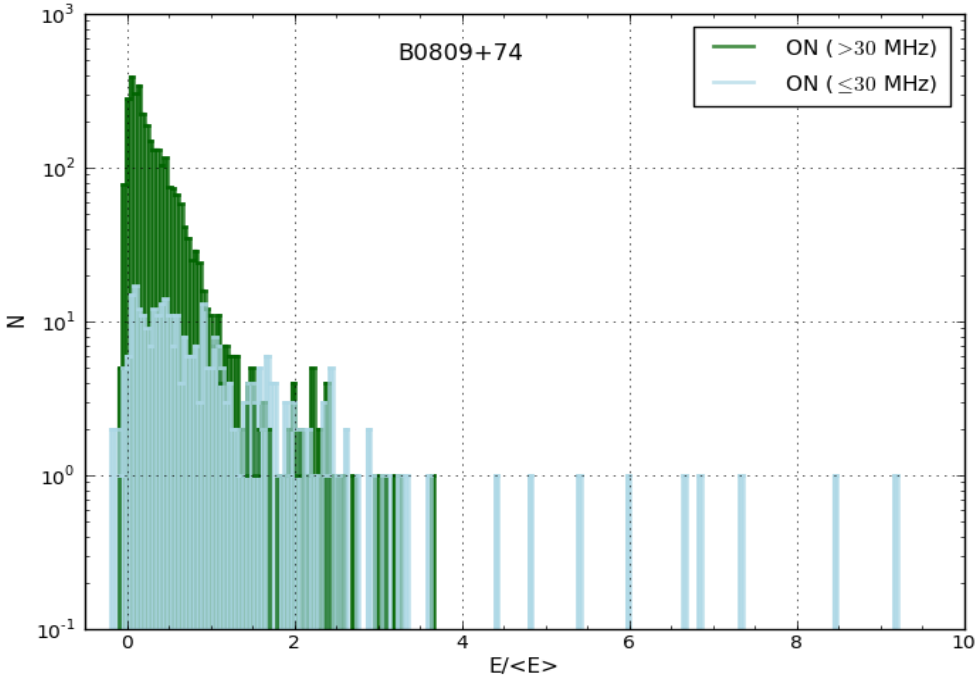
- Δf ~ 1 – 16 MHz peaking at 3 MHz
- For B1133+16 emission is much broader

Kondratiev et al. (in prep)

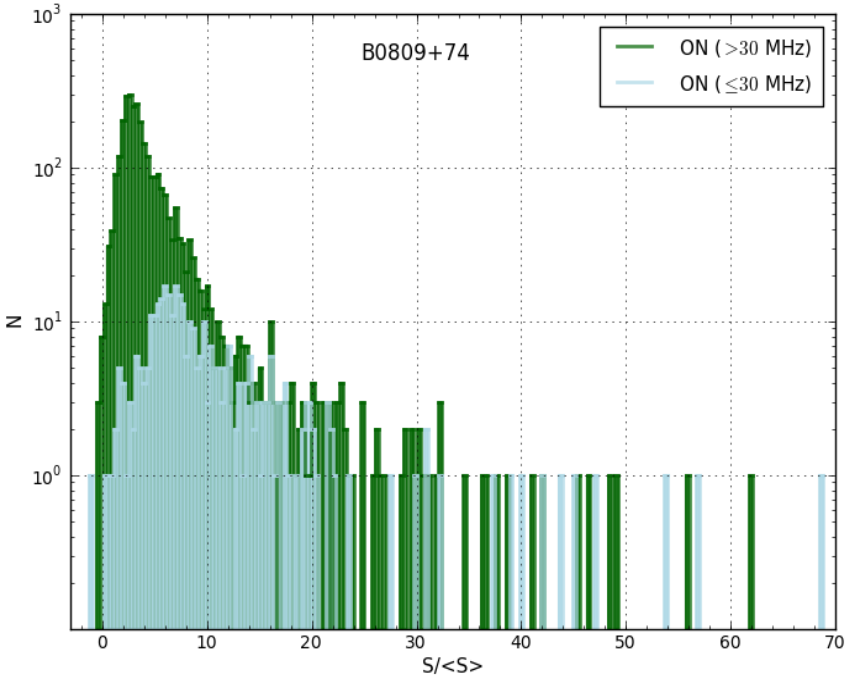
≤ 30 MHz vs. >30 MHz

B0809+74

Energies

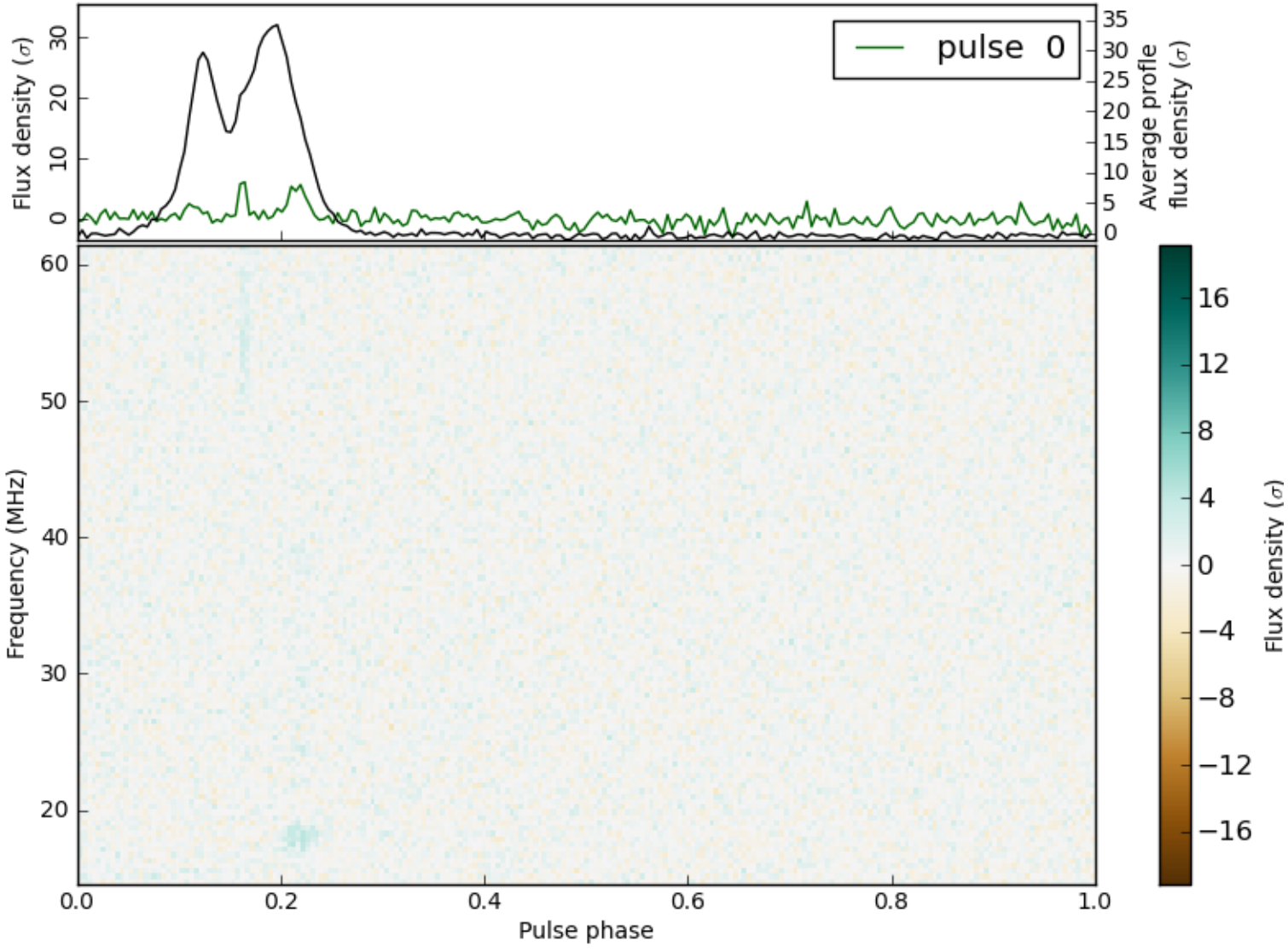


Peak flux densities



Kondratiev et al. (in prep)

Pulse ``super-sequence''

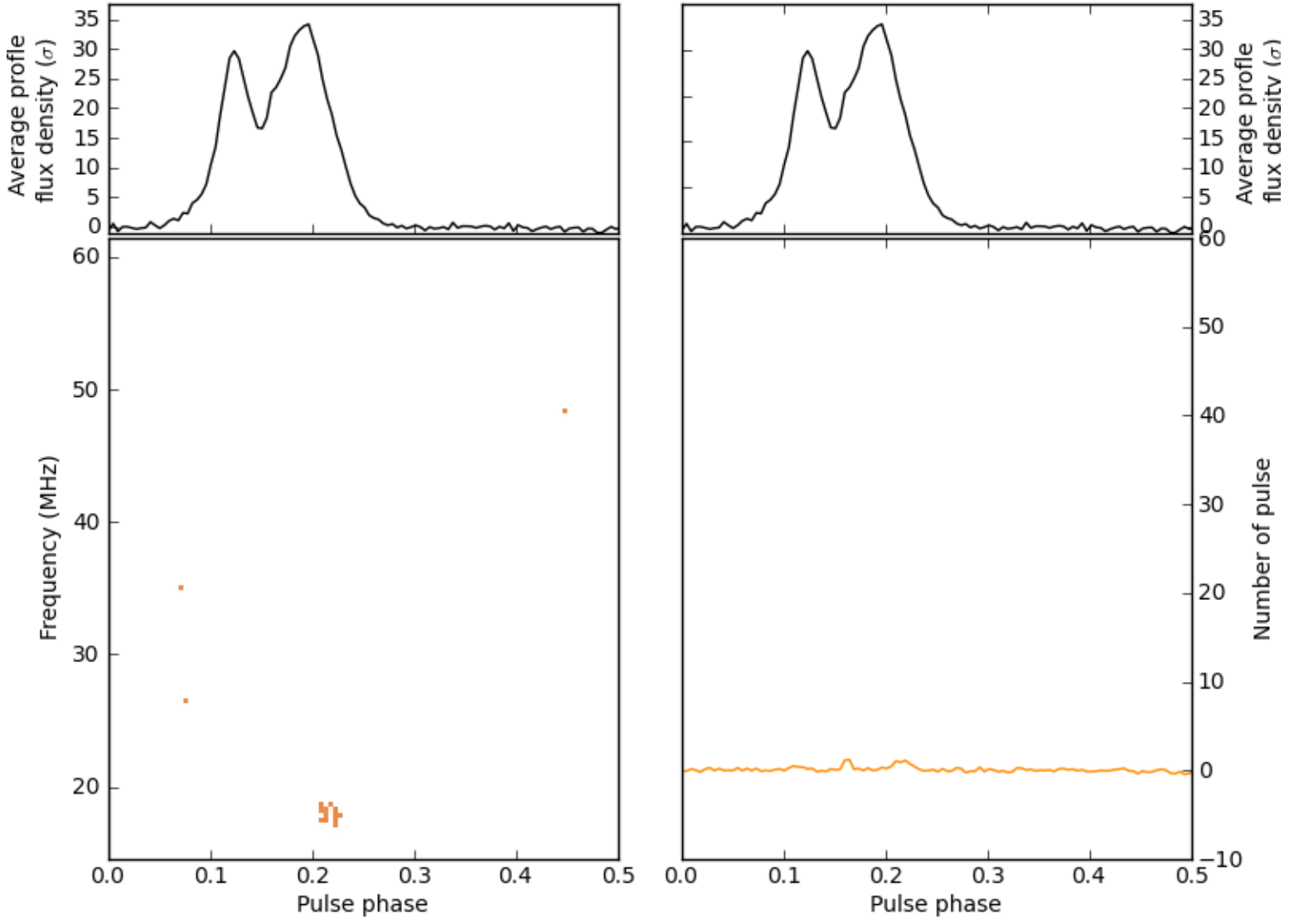


B0809+74

Kondratiev et al. (in prep)

LOFAR

Pulse ``super-sequence'' (afterglow)

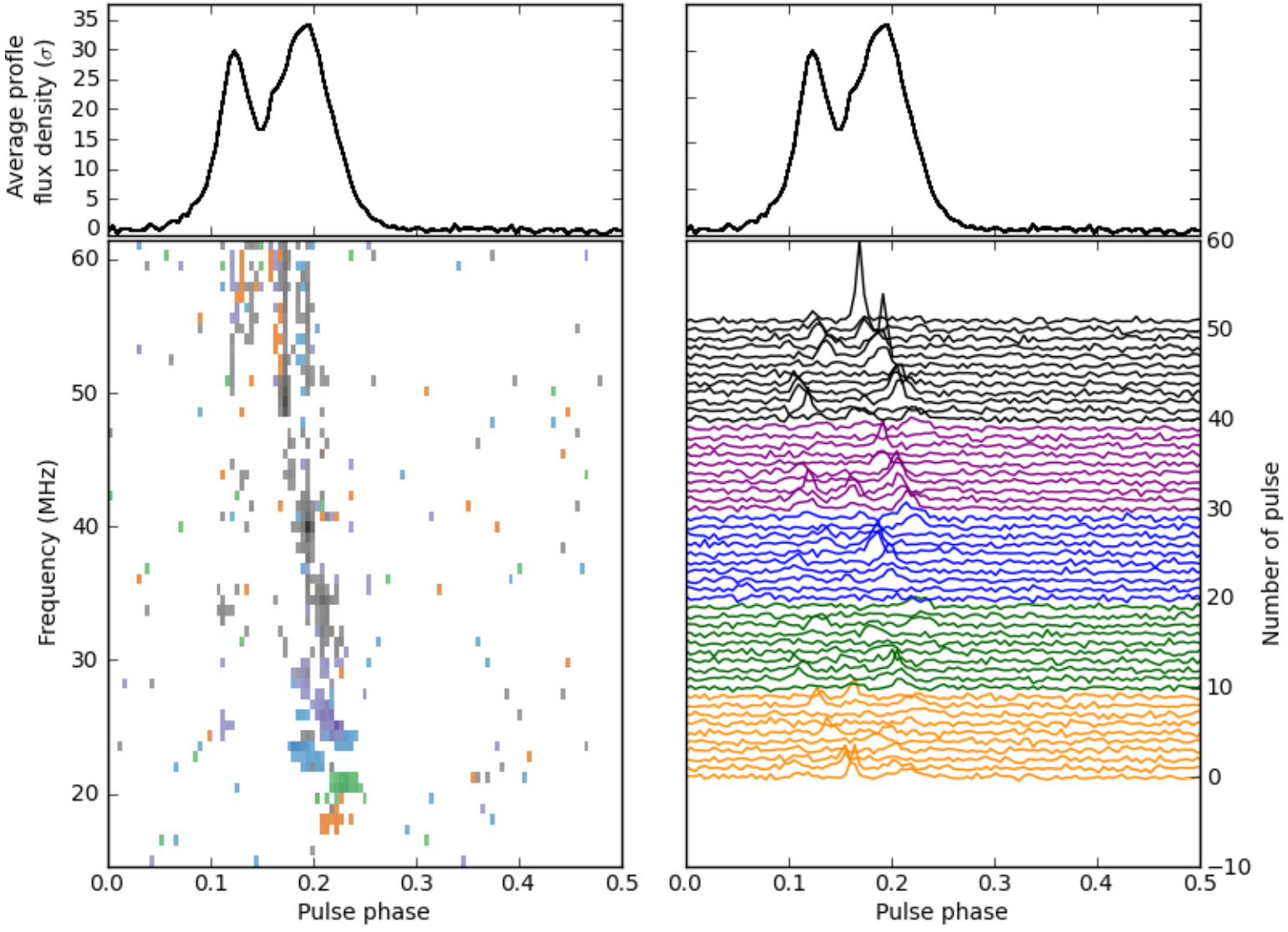


B0809+74

Kondratiev et al. (in prep)

LOFAR

Pulse ``super-sequence''

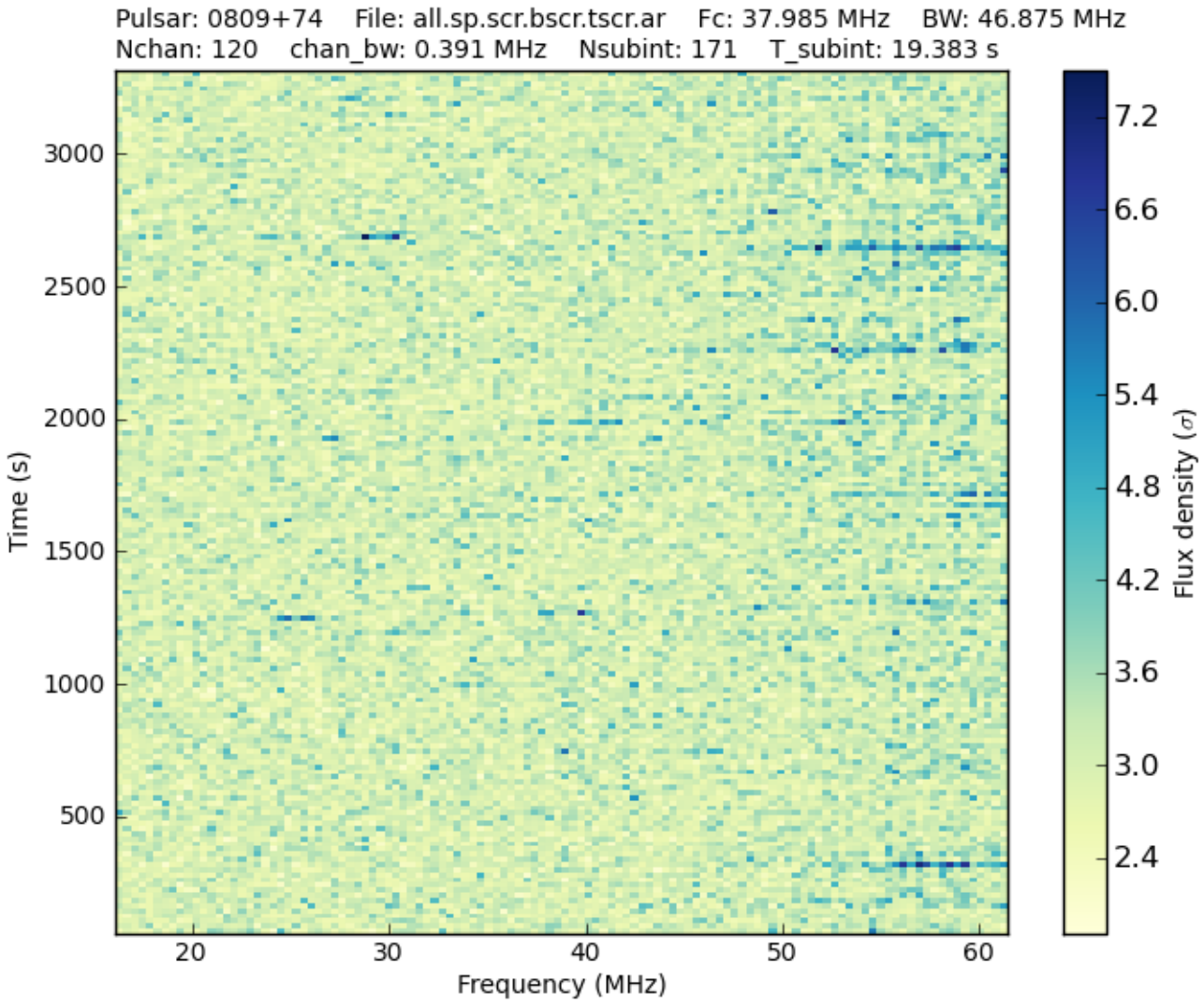


B0809+74

Kondratiev et al. (in prep)

LOFAR

Narrow-band origin? ISM?



B0809+74

ISM scintillations are averaged out (frequency resolution of 400 kHz)

$\Delta\nu_d$ ~ 7 kHz @60 MHz

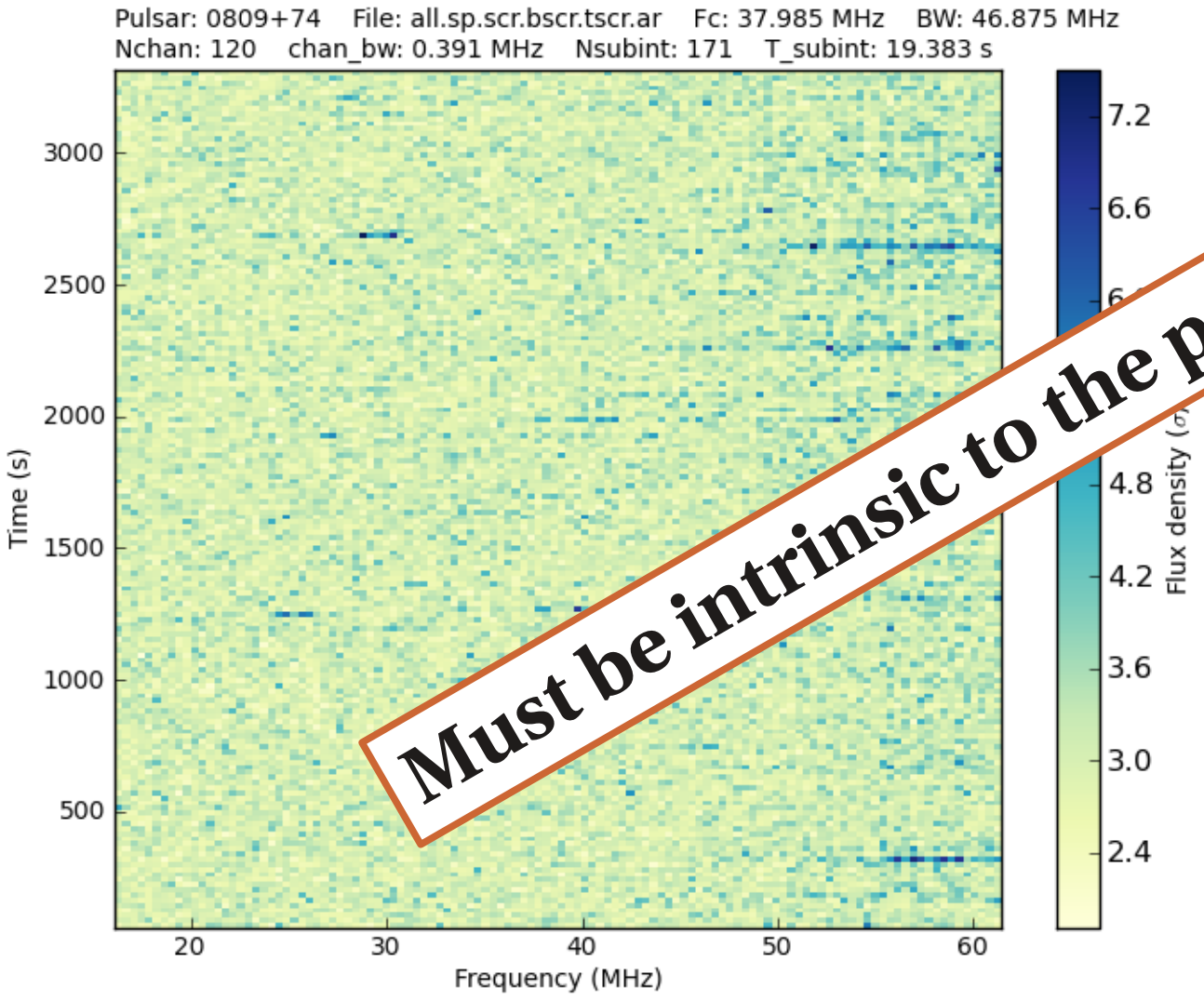
$\Delta\nu_d$ ~ 2 kHz @40 MHz

In agreement with BSA and DKR-1000 observations (Smirnova & Shishov 2008)

Kondratiev et al. (in prep)

Narrow-band origin? ISM?

B0809+74



Must be intrinsic to the pulsar ?..

ISM scintillations are averaged out (frequency resolution of 400 kHz)

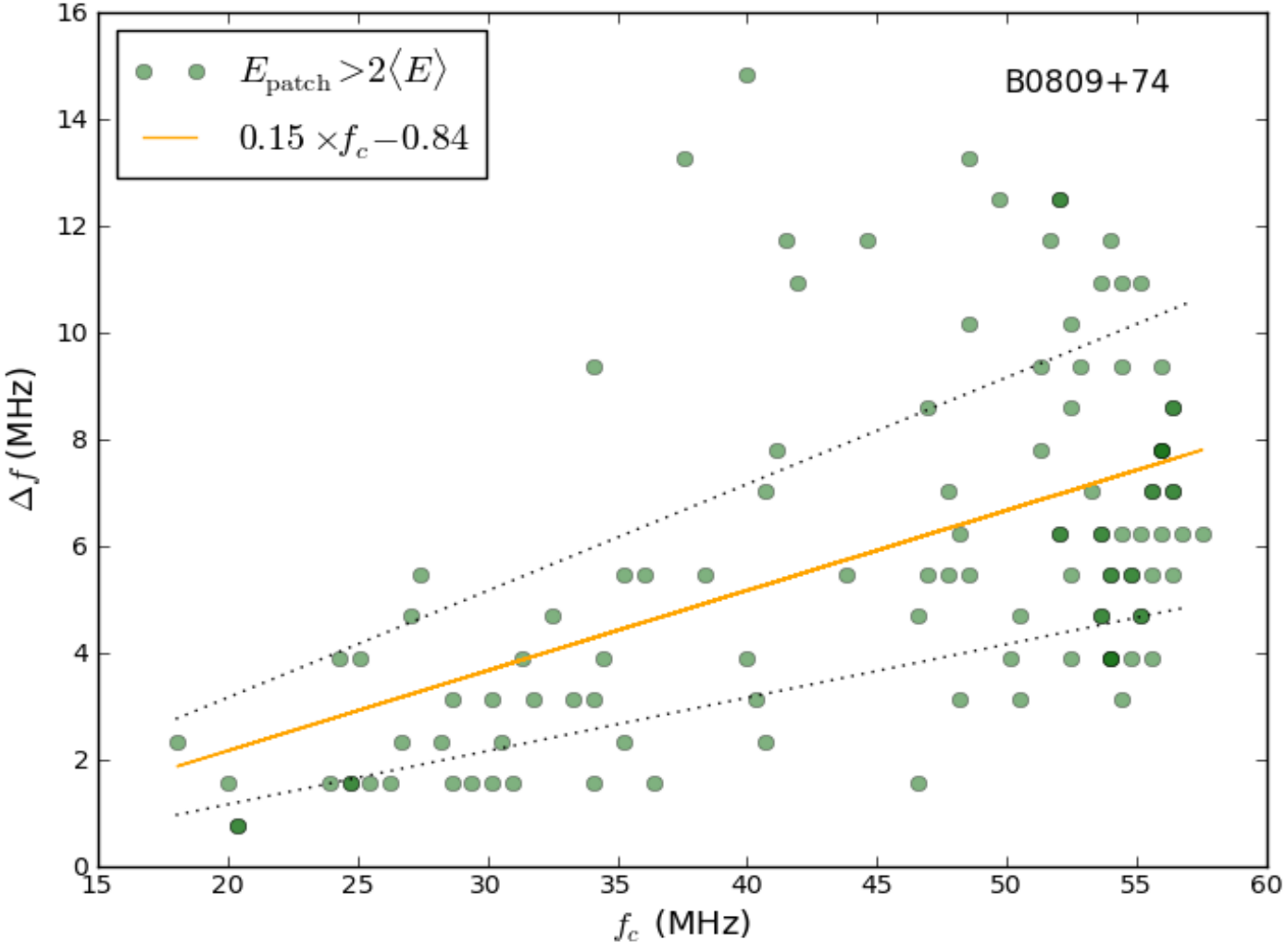
$\Delta\nu_d$ ~ 7 kHz @60 MHz

$\Delta\nu_d$ ~ 2 kHz @40 MHz

In agreement with BSA and DKR-1000 observations (Smirnova & Shishov 2008)

Kondratiev et al. (in prep)

Strong plasma turbulence?



B0809+74

- $\Delta f/f_c \sim 0.15$
- Strong plasma turbulence model (SPT, Weatherall 1998) predicts $\Delta f/f \sim 0.1$–0.2
- SPT → plasma flow in the radio emission region is likely to be unsteady

Kondratiev et al. (in prep)

Summary

- We observe occasional **bright narrow-band pulses** from the PSR B0809+74 at frequencies 15–62 MHz. Their spectra can be **as narrow as 1 MHz** and tend to have a width of 3 MHz. The emission from the PSR B1133+16 is much broader.

- We identified **pulse sequences** from the PSR B0809+74 where narrow patch of emission **is drifting up in frequency** from pulse to pulse. We see evidence for similar frequency drift for at least one other pulsar.

- The origin of these narrow-band pulses is likely to be **pulsar-intrinsic** rather than due to propagation effects in ISM or ionosphere.

- At the moment observed pulse properties of the PSR B0809+74 **do not allow us to relate** low-frequency bright narrow-band pulses to ``spiky emission'', or to giant pulses or regular emission.

- Spectral width of strong emission patches scales with increasing frequency as $\Delta f/f_c \sim 0.15$ for the PSR B0809+74 and **qualitatively agrees with** the prediction of **the SPT model**. This supports the relation between bright narrow-band pulses at low frequencies and giant pulses.

Thank you!