Low-Frequency Studies of Pulsars

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and
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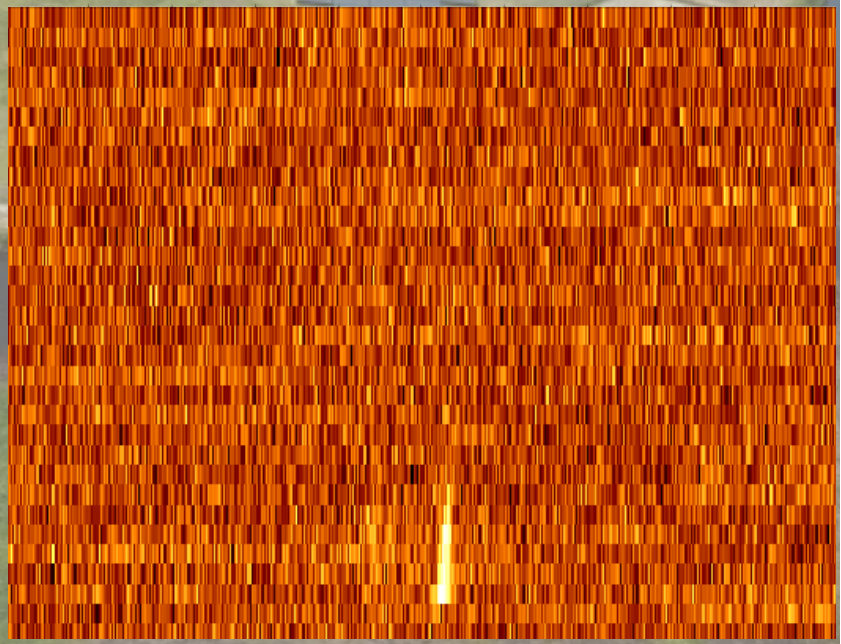
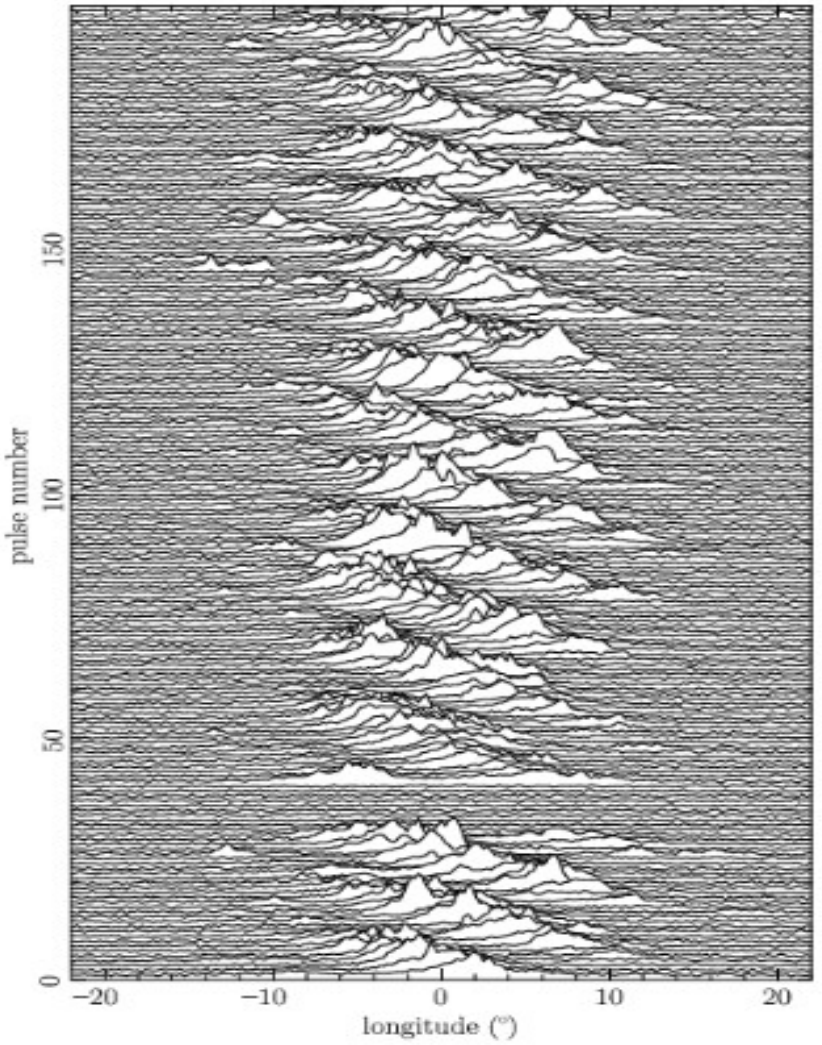


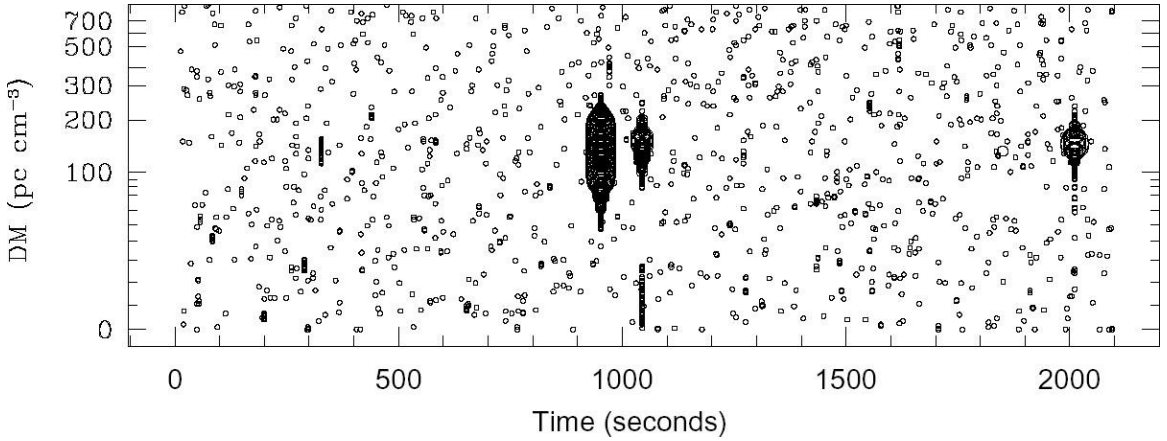
Single-pulse phenomena

Drifting subpulses, nulling



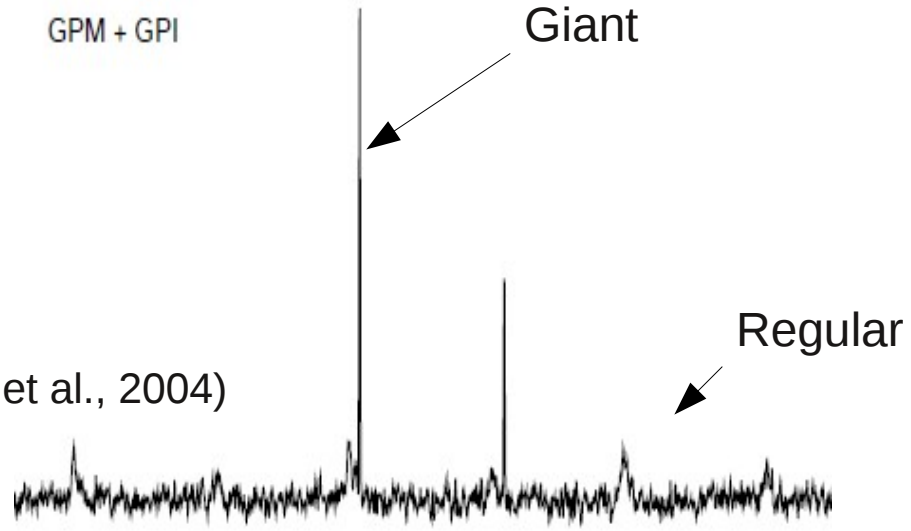
(van Leeuwen et al., 2002)

RRATs



(McLaughlin et al., 2006)

Giant pulses / micropulses

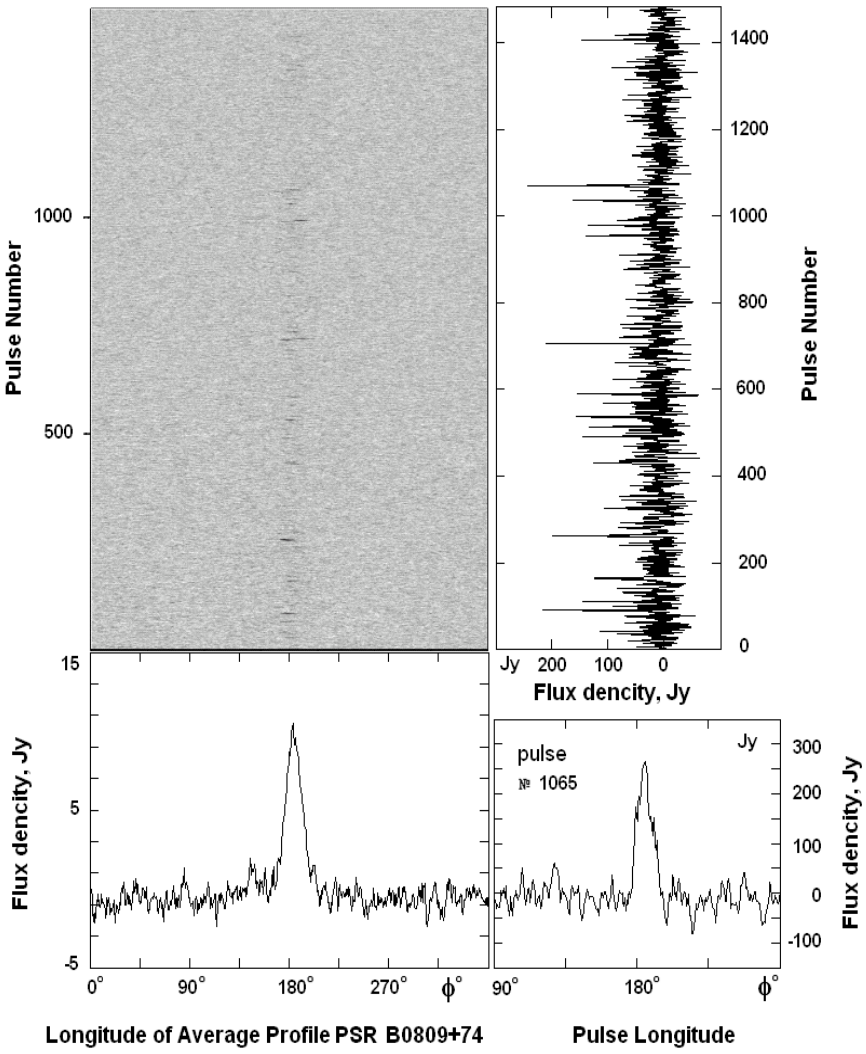


(Soglasnov et al., 2004)

@ low freqs < 30 MHz

- Termed «AIPs» by Ul'yanov et al.
- B0809+74, B0950+08, B1133+16, B0823+26, B0834+06, B0943+10
- $S_{peak} > 20\ S_{peak}$ of average profile
- Occur in groups
- Very rare, only 5-10% of observing time
- Very narrow spectra, 1.5-5 MHz wide; sometimes in 2-3 emission bands

PSR B0809+74



Ul'yanov et al. (2006)
UTR-2 @ 18-30 MHz

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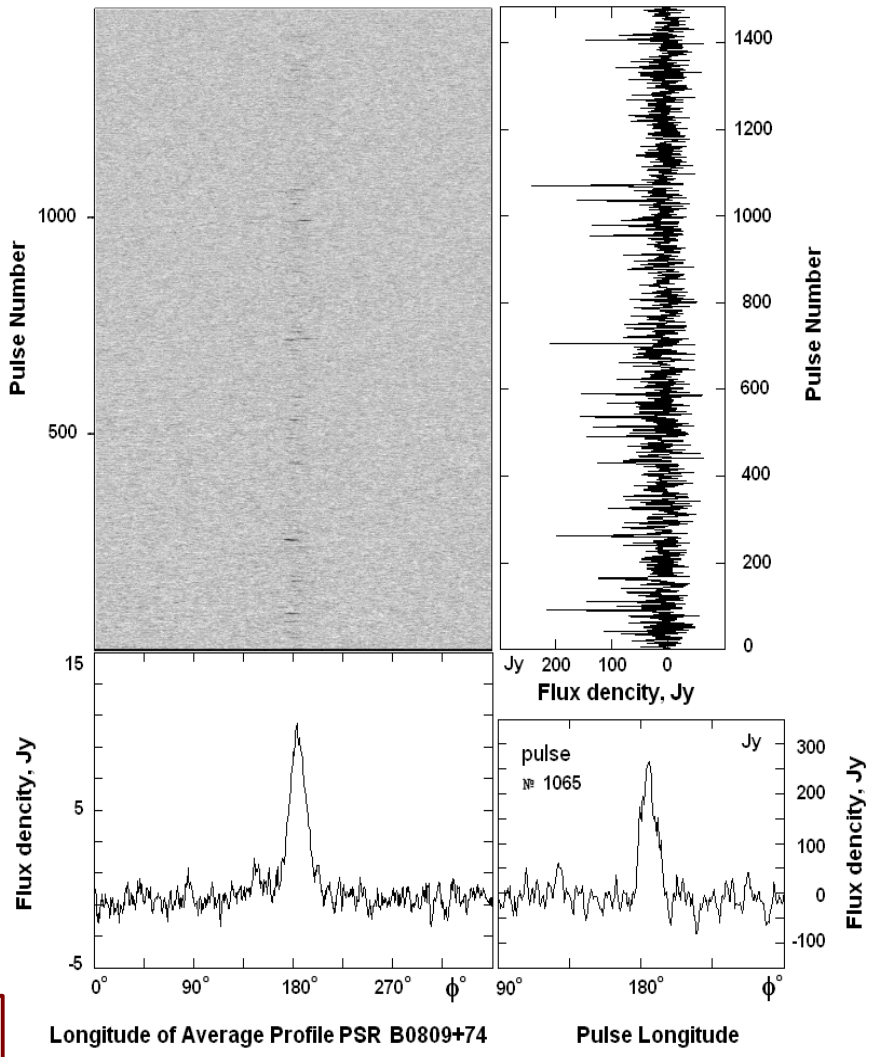
• link to other single-pulse phenomena (giant pulses, micropulses, spiky emission) ?
• Insight into pulsar emission mechanism

PSR B0809+74



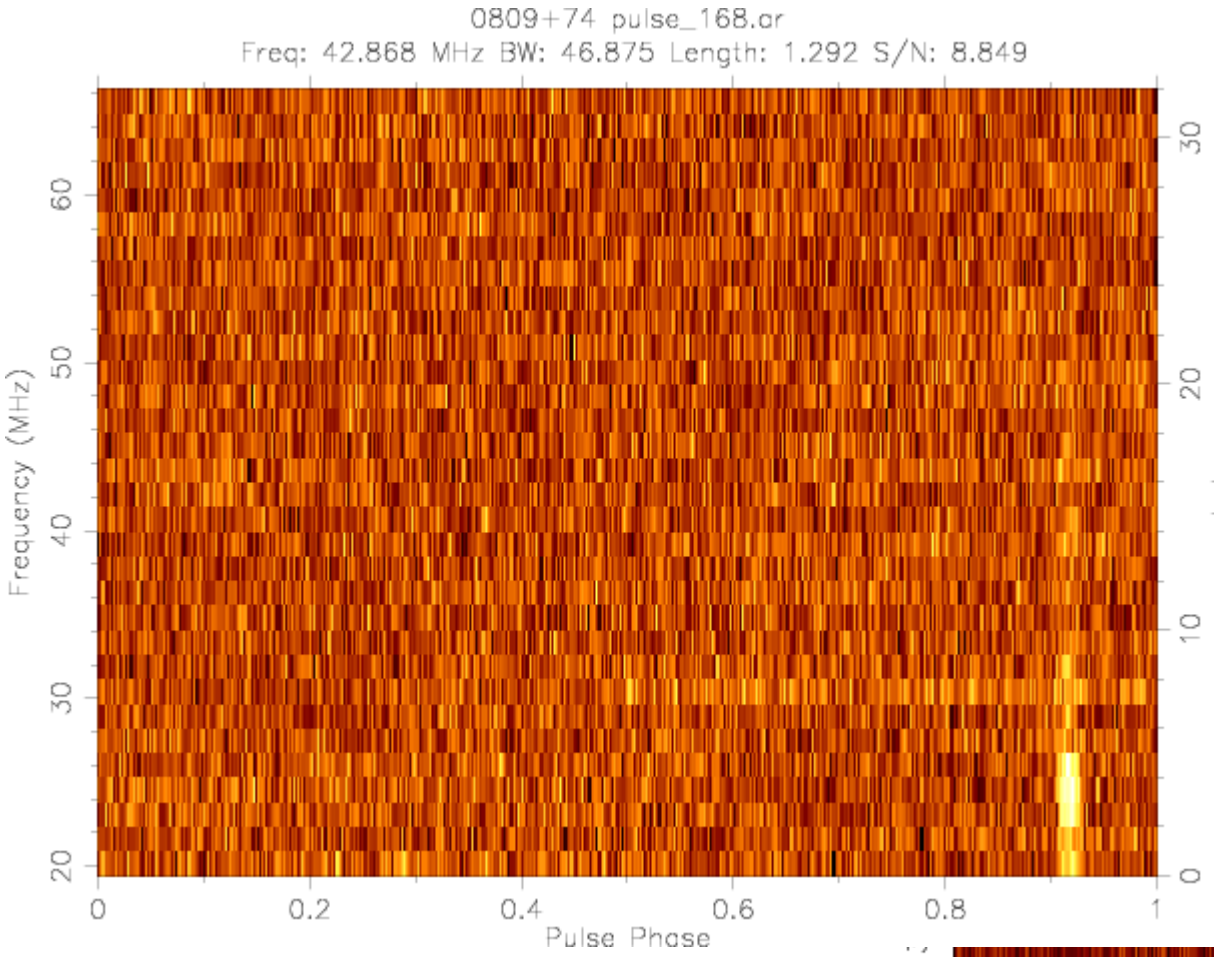
Ul'yanov et al. (2006)
UTR-2 @ 18-30 MHz

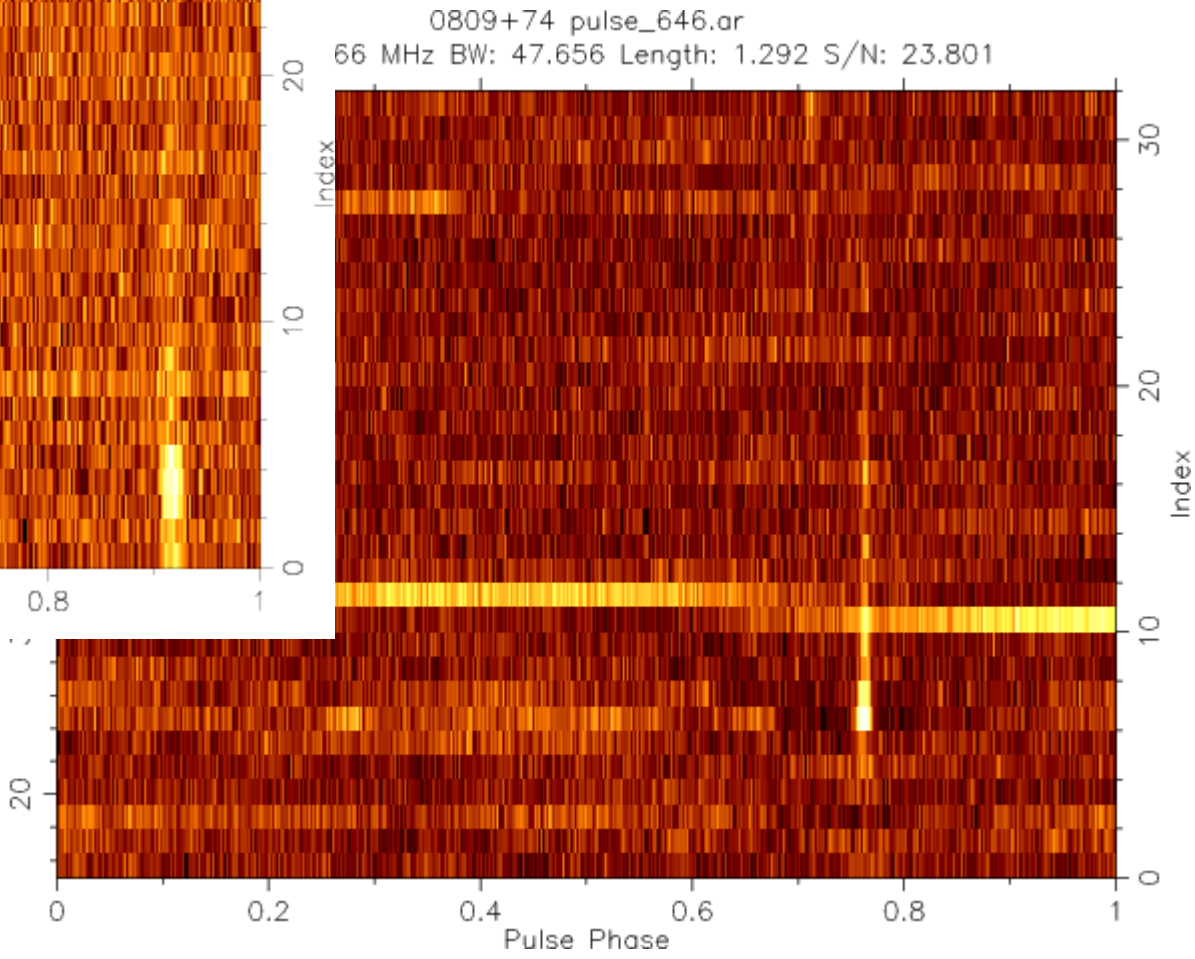
LBA observations

- LBA Superterp
- 6 / 5 stations
- 20-70 / 15-65 MHz
- 1-2 hour/obs
- 7-8 obs/pulsar
- 240 / 244 subbands
- 32 chan/subband
- IS+CS
- Δt = 1.3 / 2.6 ms

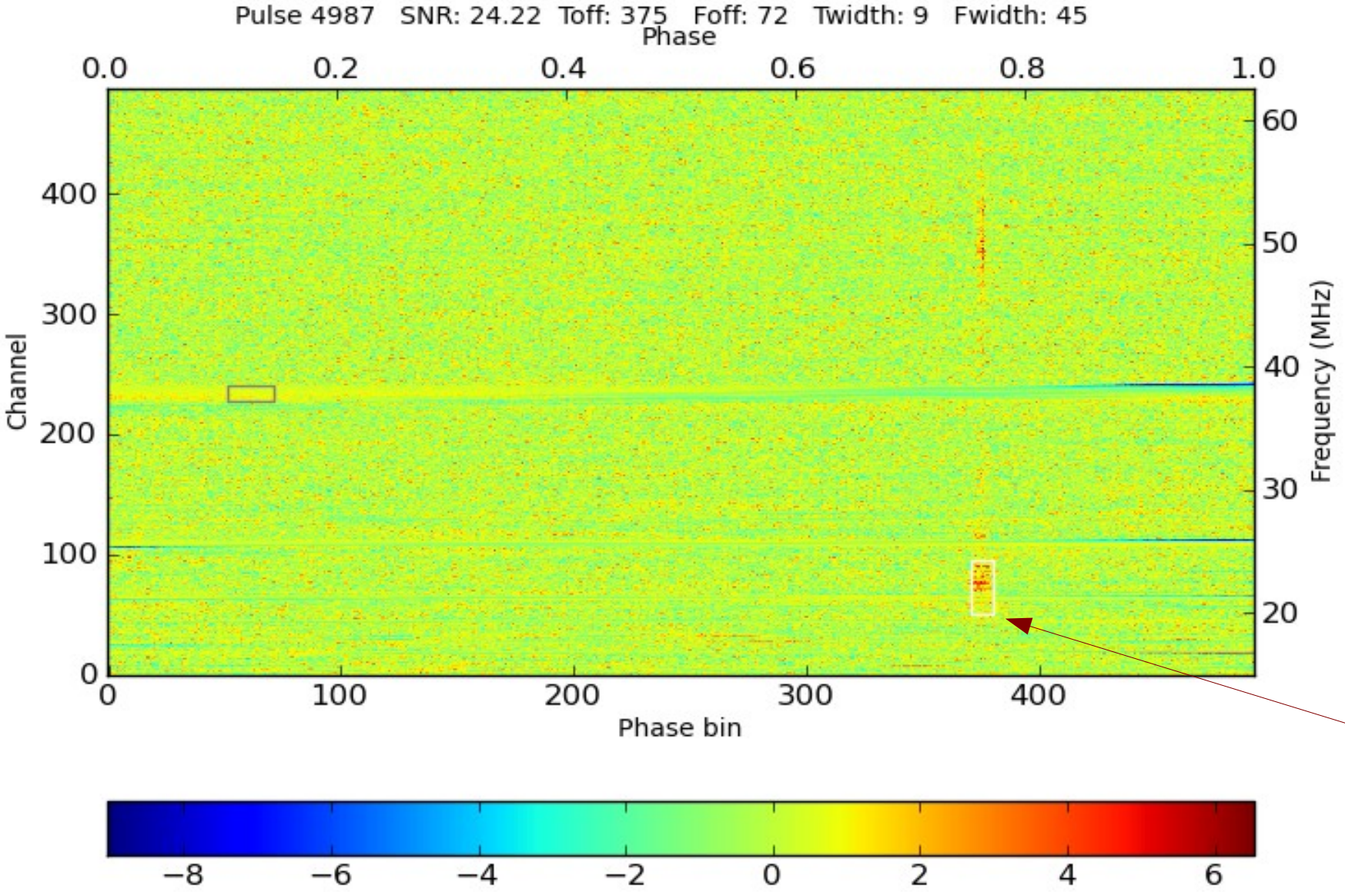
AIPs examples

B0809+74



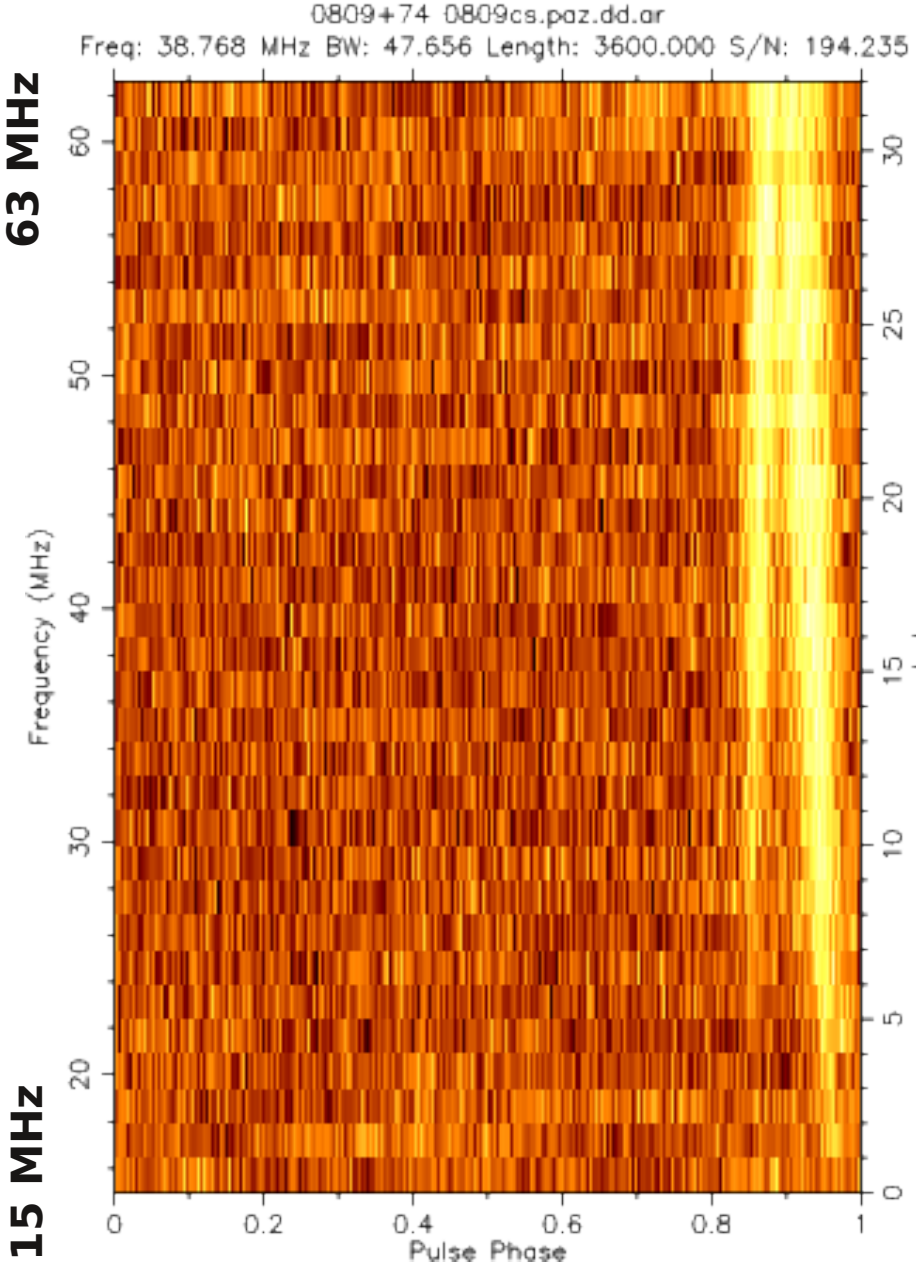


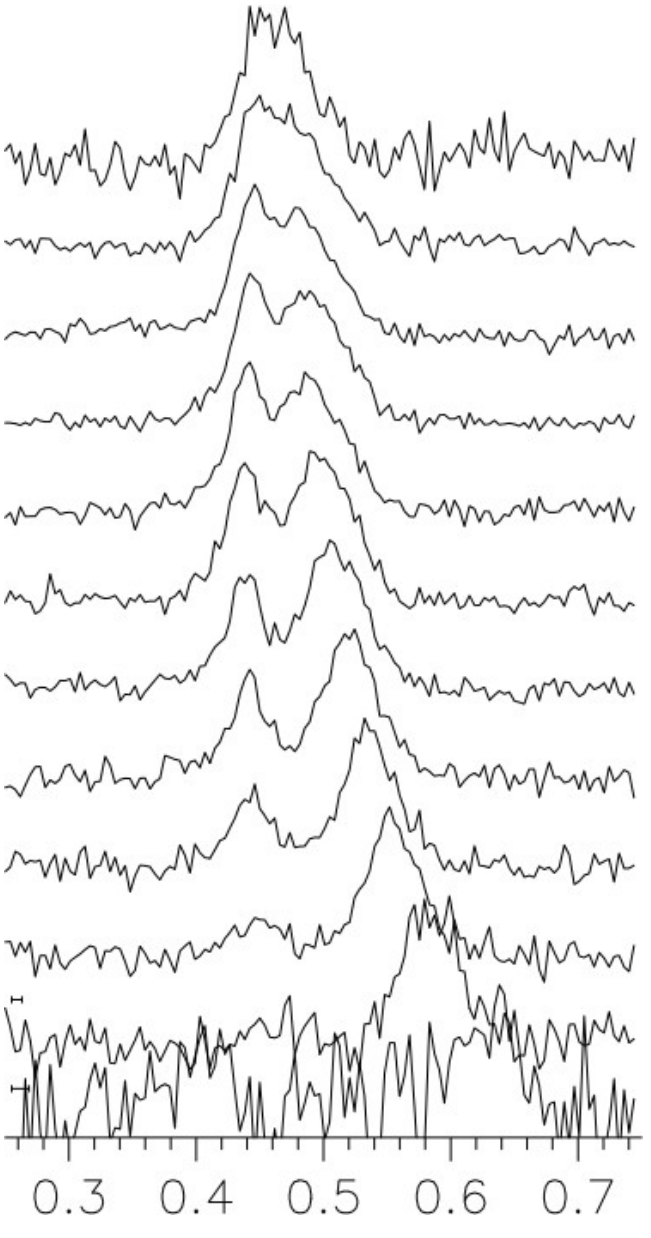
2-D search for AIPs



Average Profile

B0809+74





72-78 MHz
66-72 MHz
60-66 MHz
54-60 MHz
48-54 MHz
42-48 MHz
36-42 MHz
30-36 MHz
28-34 MHz
22-28 MHz
16-22 MHz
10-16 MHz

Profiles

B0809+74

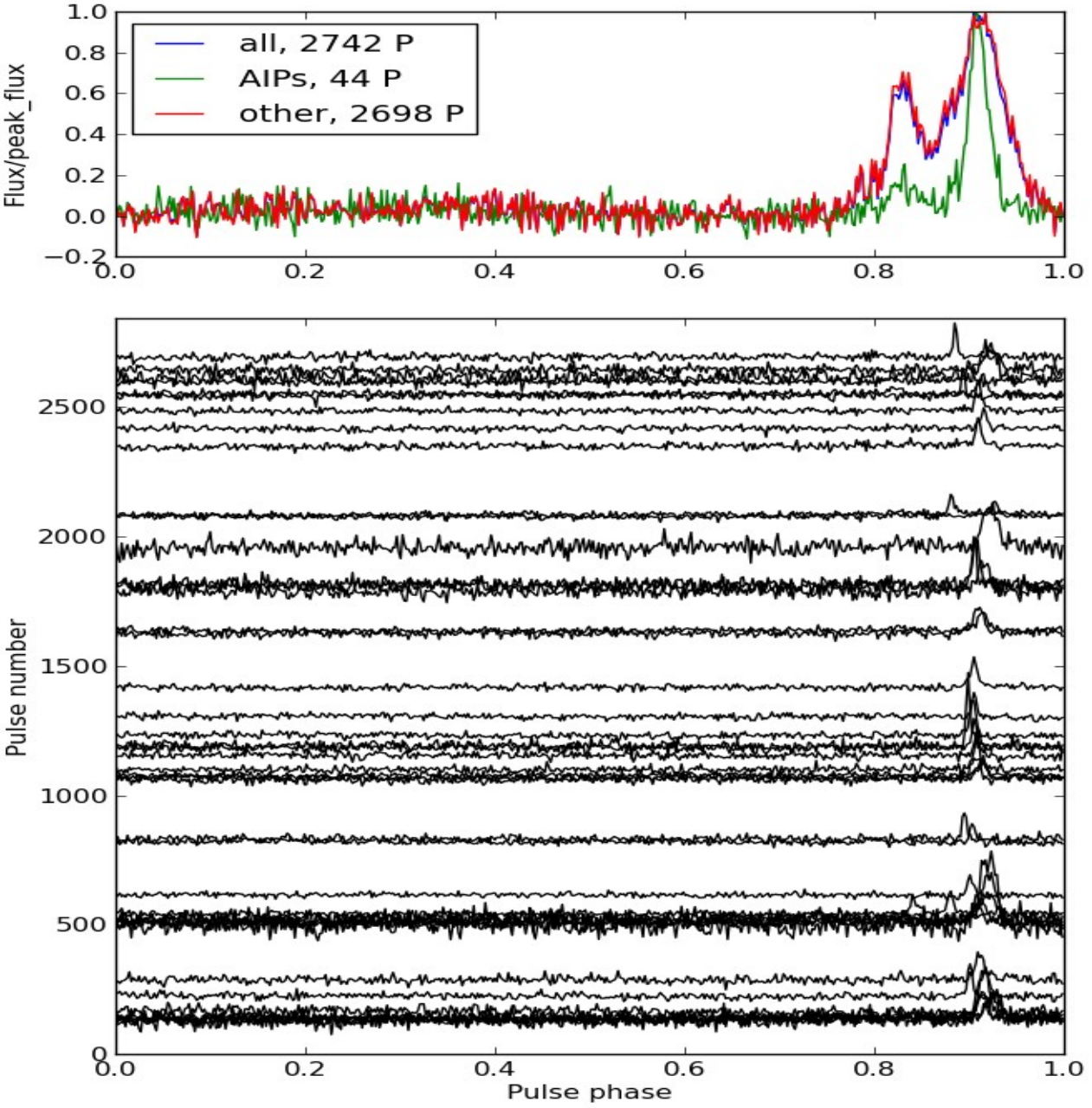
AIPs: 4-6% of P

$S_{peak} / \langle S_{peak} \rangle \sim 35$

max $S_{peak} = 112$

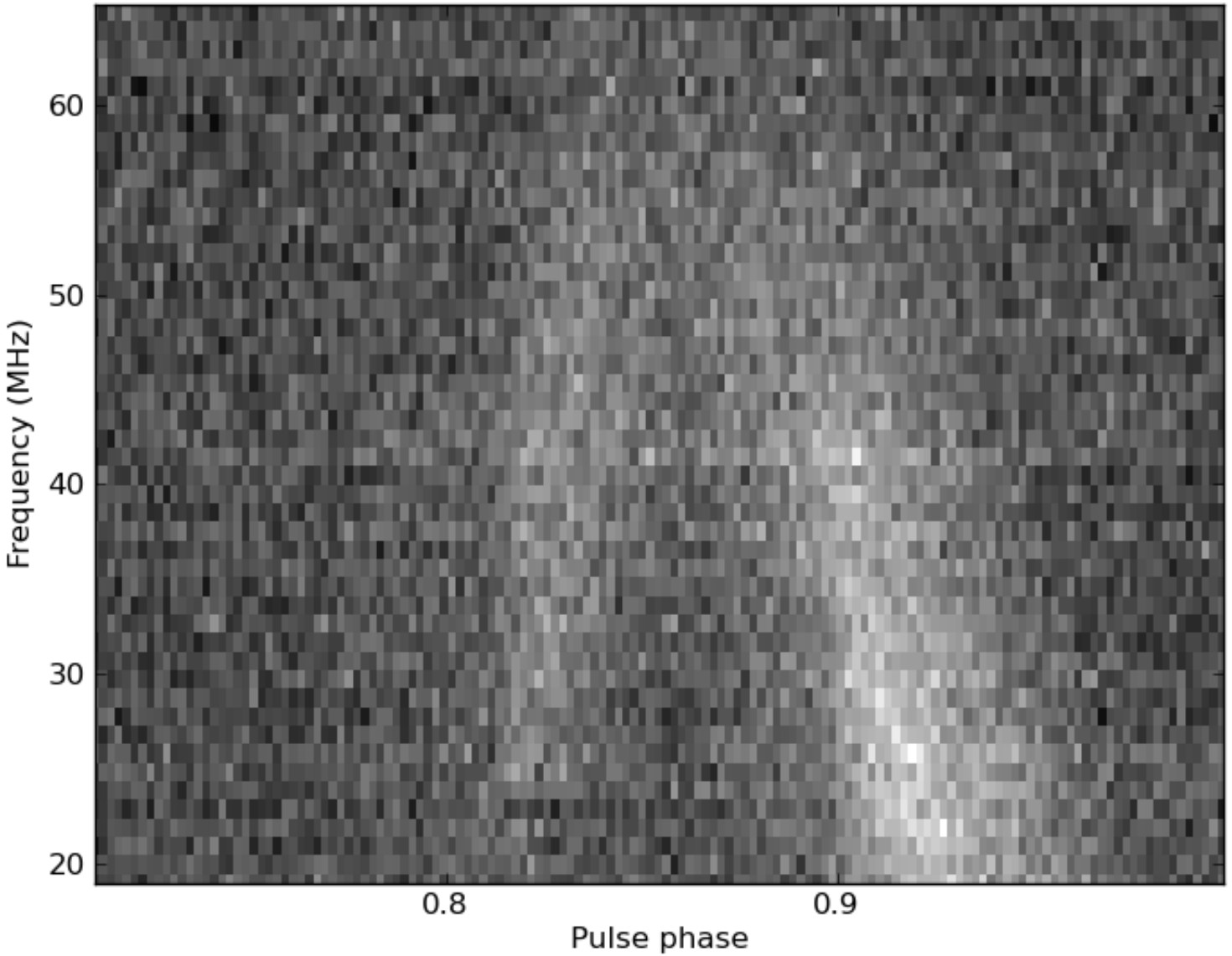
$E/\langle E \rangle \sim 26$

max E = 103



Spectra

B0809+74



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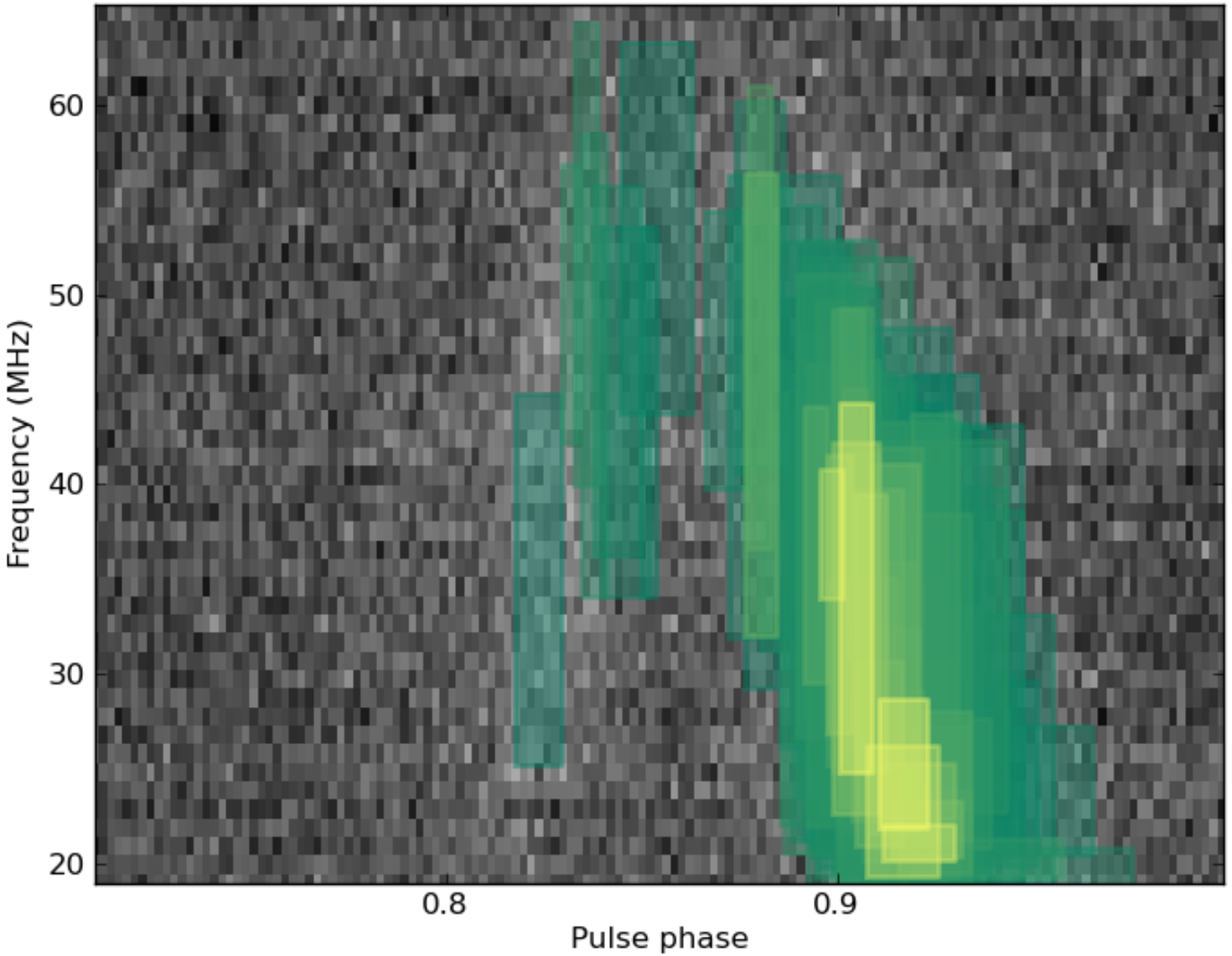
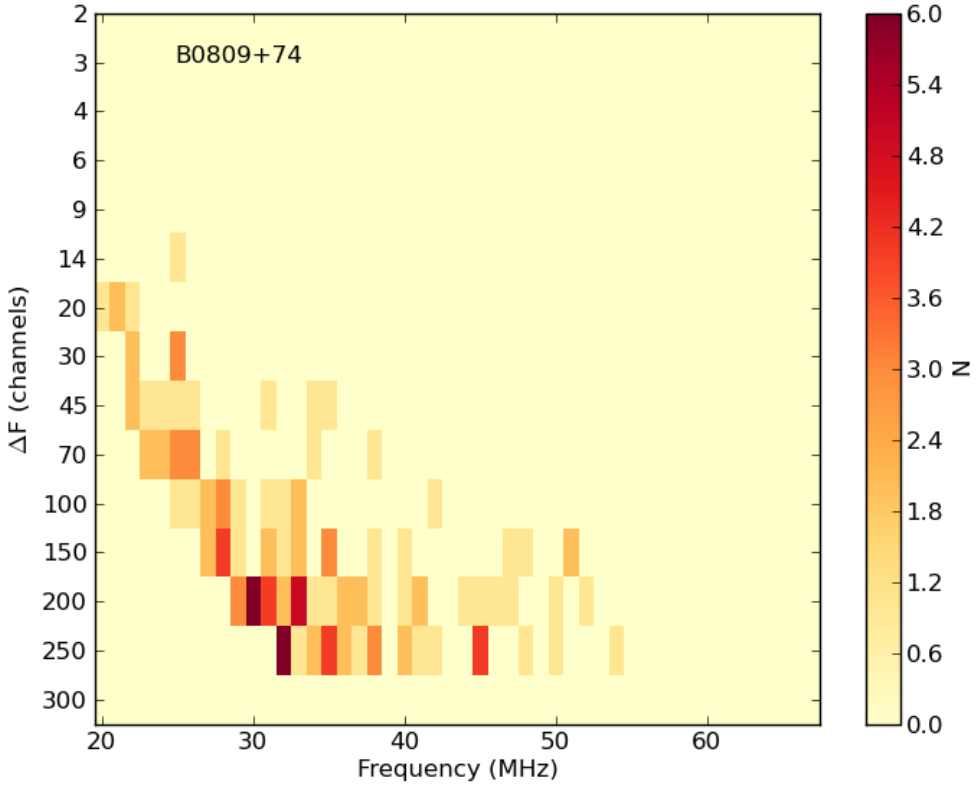
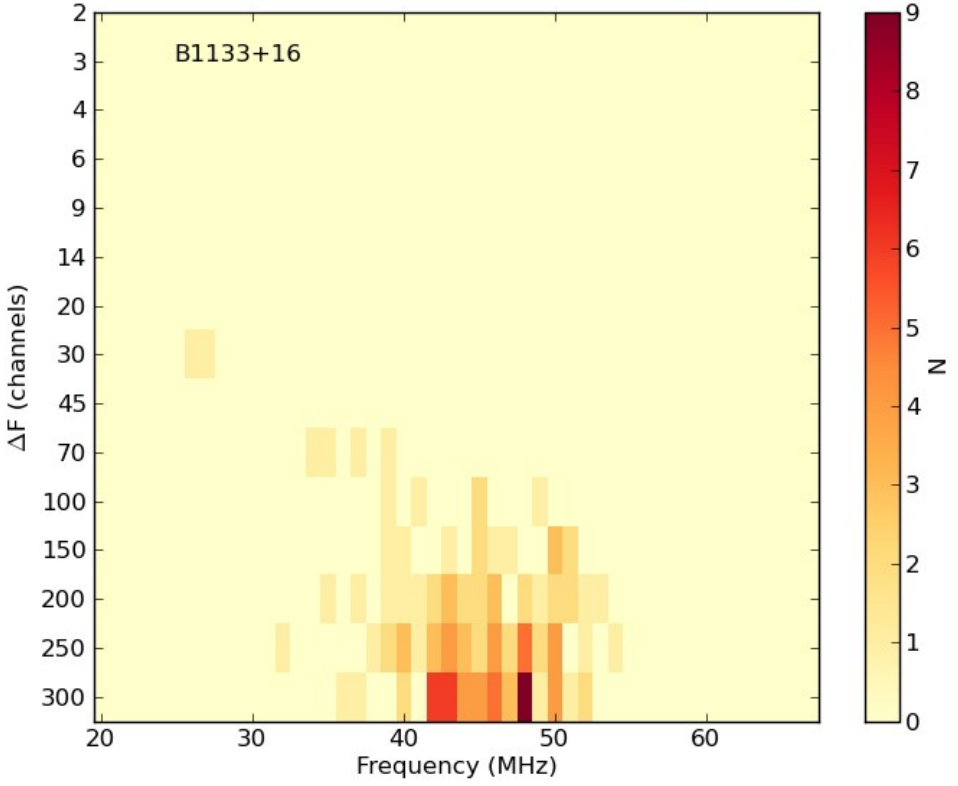


2-D histograms of Δf vs. f



B0809+74



B1133+16

Origin of AIPs

- Propagation?

  → ISM scintillations?

  $\Delta\nu < 100$ Hz @20 MHz

  Channel width is 6 kHz, but we decimated in f by 16

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  Pulses are seen consistently in observations
  Profile morphology of AIPs is different

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- Intrinsic to the pulsar. Emission mechanism?

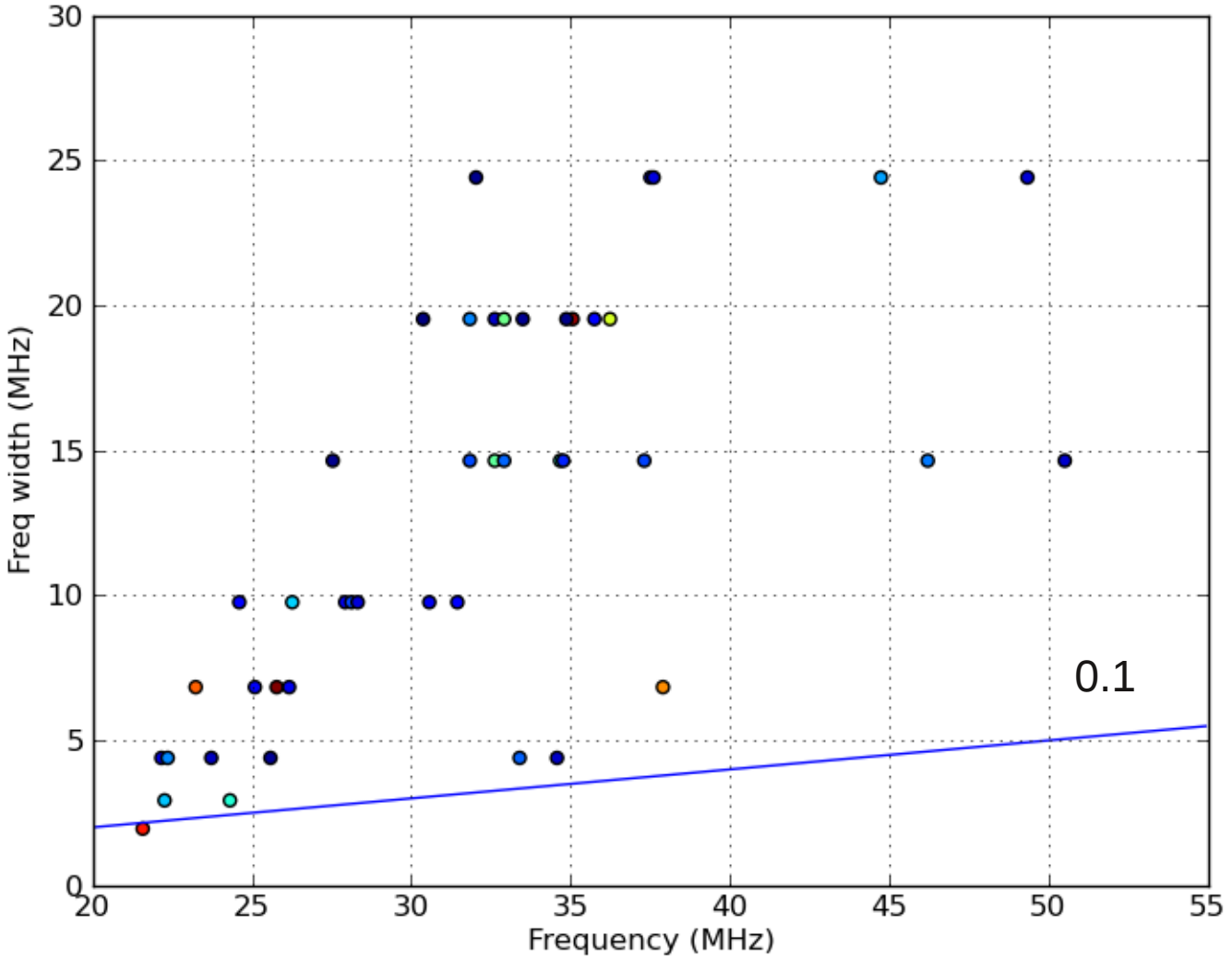
  → Related to subpulse component (Ul'yanov et al. 2006)?
  → Link to GPs, microGPs, spiky emission?
  → Strong plasma waves?

Spectrum width vs. frequency

B0809+74

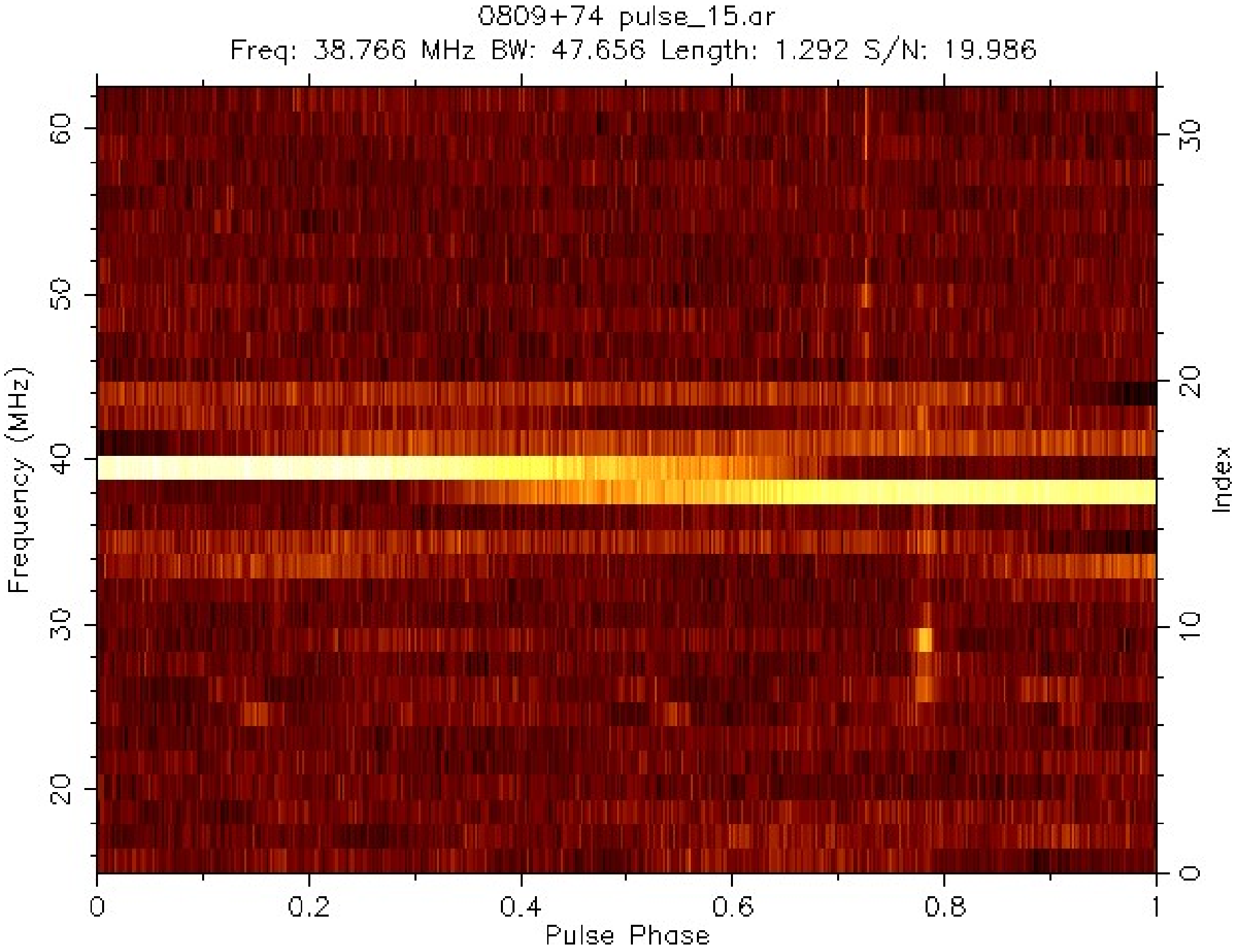
Spectrum width increases with increasing frequency

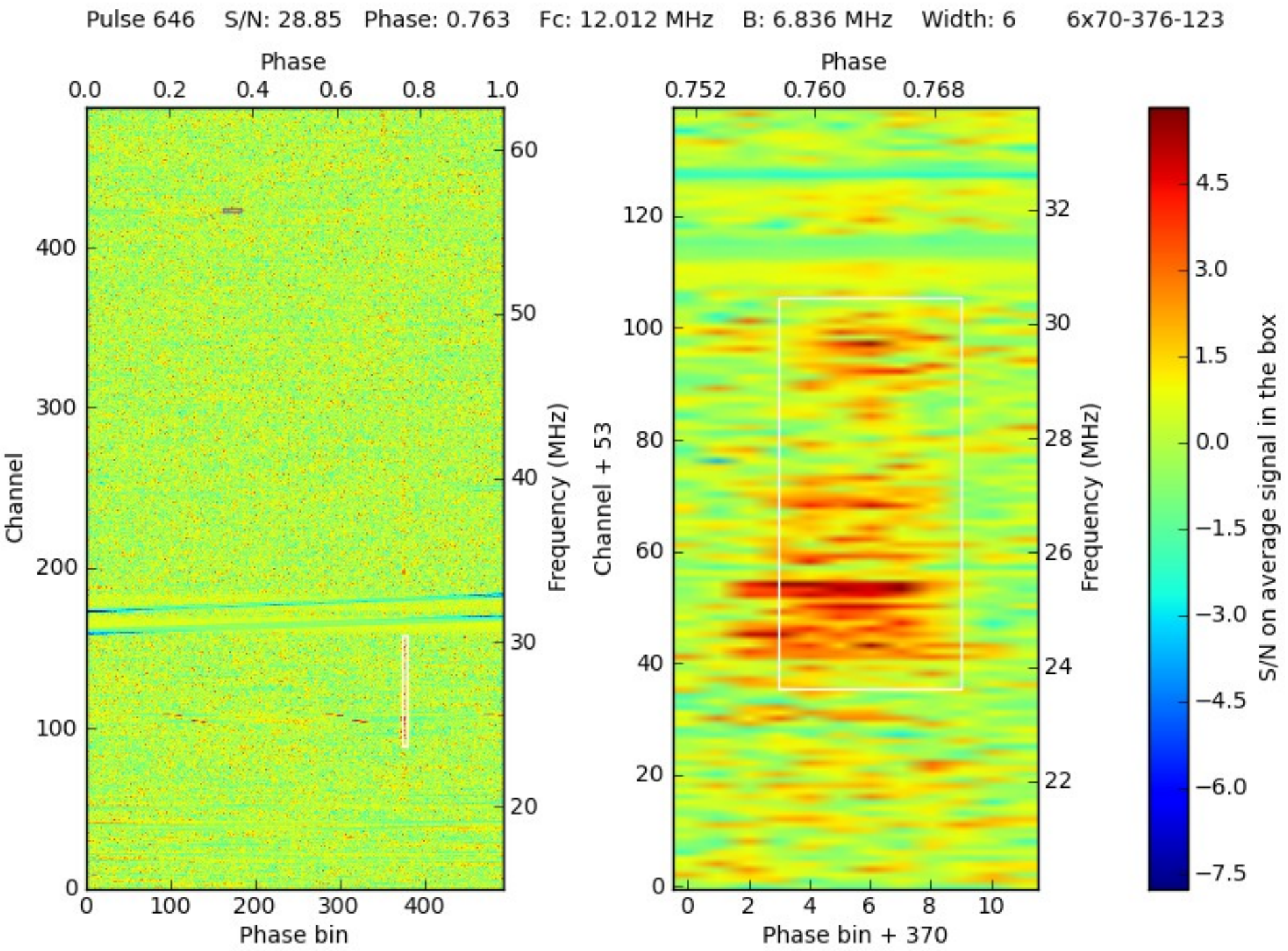
SPT (strong plasma turbulence) models predict $\Delta f/f \sim 0.1\text{-}0.2$

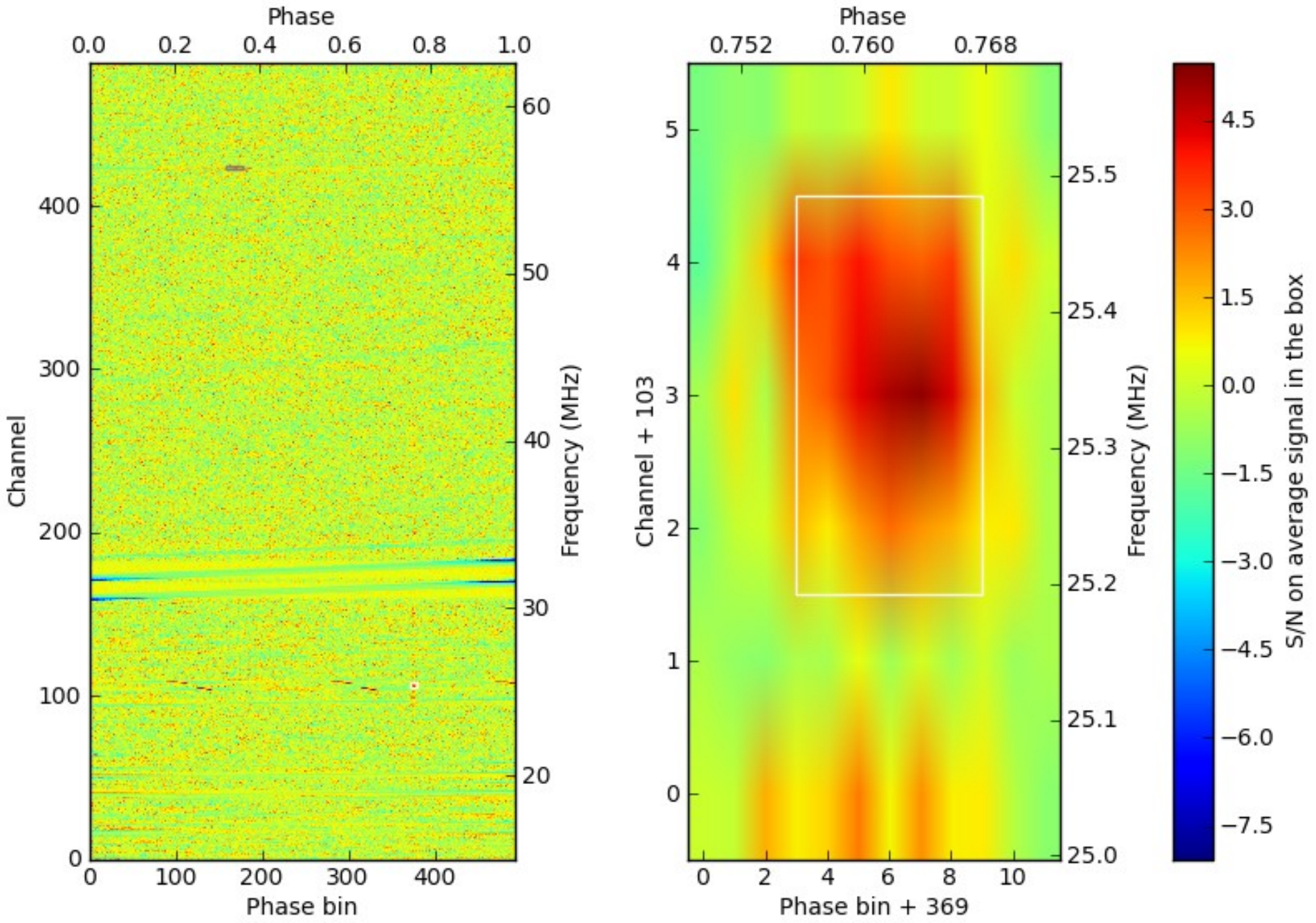


Summary

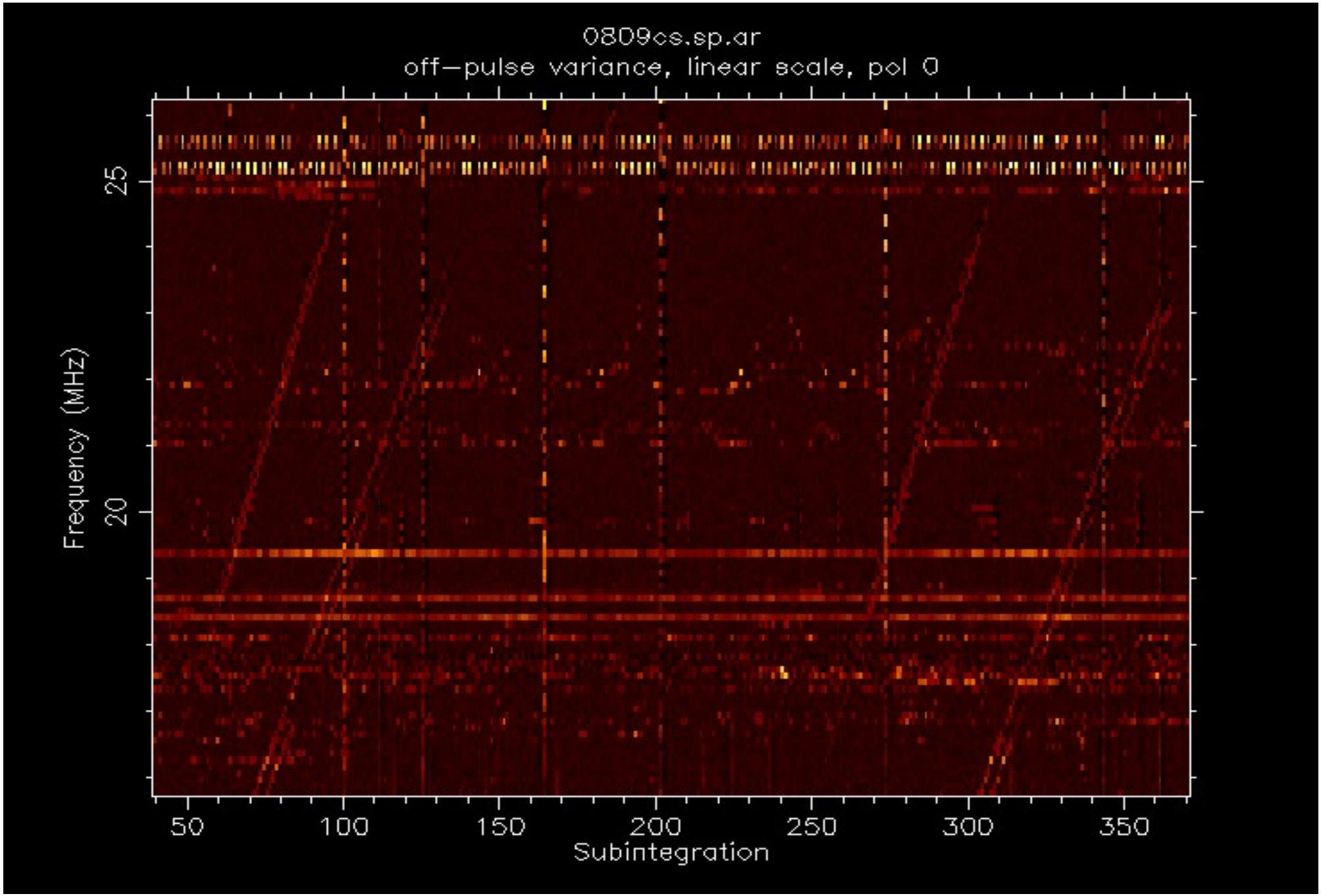
- Bright, low-frequency, narrow-band pulses from pulsars B0809+74 and B1133+16 are consistently observed with LBAs.
- The origin of these pulses is pulsar-intrinsic rather than due to propagation effects in ISM and/or ionosphere.
- These pulses resemble somewhat giant pulses by their energy and duration, however further study is necessary, in particular instantaneous 10-240 MHz observations. At least for the case of B0809+74, pulse frequency width scales with the increasing frequency.
- Observations and data processing of other pulsars with potentially the same phenomenon has begun.
- Presence of such bright individual pulses at these low frequencies argues in favour of LBA 20-30 MHz survey (LoMASS).


0809+74 pulse_15.ar
Freq: 38.766 MHz BW: 47.656 Length: 1.292 S/N: 19.986
Frequency (MHz)
60
50
40
30
20
0
0.2
0.4
0.6
0.8
1
Pulse Phase
30
20
10
0
Index


Pulse 646 S/N: 28.85 Phase: 0.763 Fc: 12.012 MHz B: 6.836 MHz Width: 6 6x70-376-123
Phase
0.0 0.2 0.4 0.6 0.8 1.0
Channel
Frequency (MHz)
Phase bin
Phase
0.752 0.760 0.768
Channel + 53
Frequency (MHz)
Phase bin + 370
S/N on average signal in the box


Pulse 646 S/N: 13.04 Phase: 0.761 Fc: 10.352 MHz B: 0.293 MHz Width: 6 6x3-375-106
Phase
0.0 0.2 0.4 0.6 0.8 1.0
Channel
0 100 200 300 400
Frequency (MHz)
20 30 40 50 60
Phase bin
Phase
0.752 0.760 0.768
Channel + 103
0 1 2 3 4 5
Frequency (MHz)
25.0 25.1 25.2 25.3 25.4 25.5
Phase bin + 369
0 2 4 6 8 10
S/N on average signal in the box
4.5 3.0 1.5 0.0 −1.5 −3.0 −4.5 −6.0 −7.5

RFI environment



Profiles

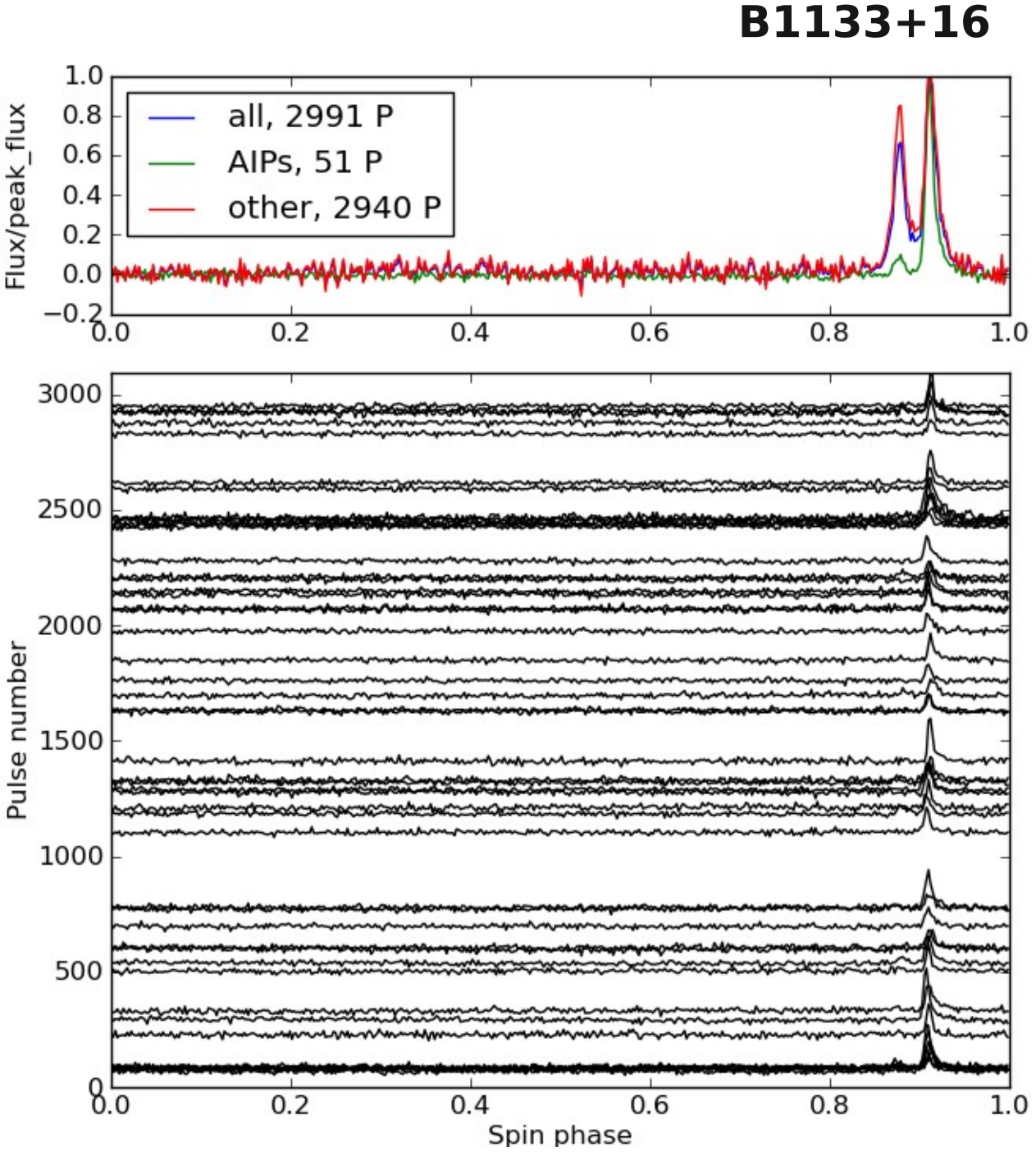
AIPs: ~3% of P

$S_{peak} / \langle S_{peak} \rangle \sim 41$

max $S_{peak} = 198$

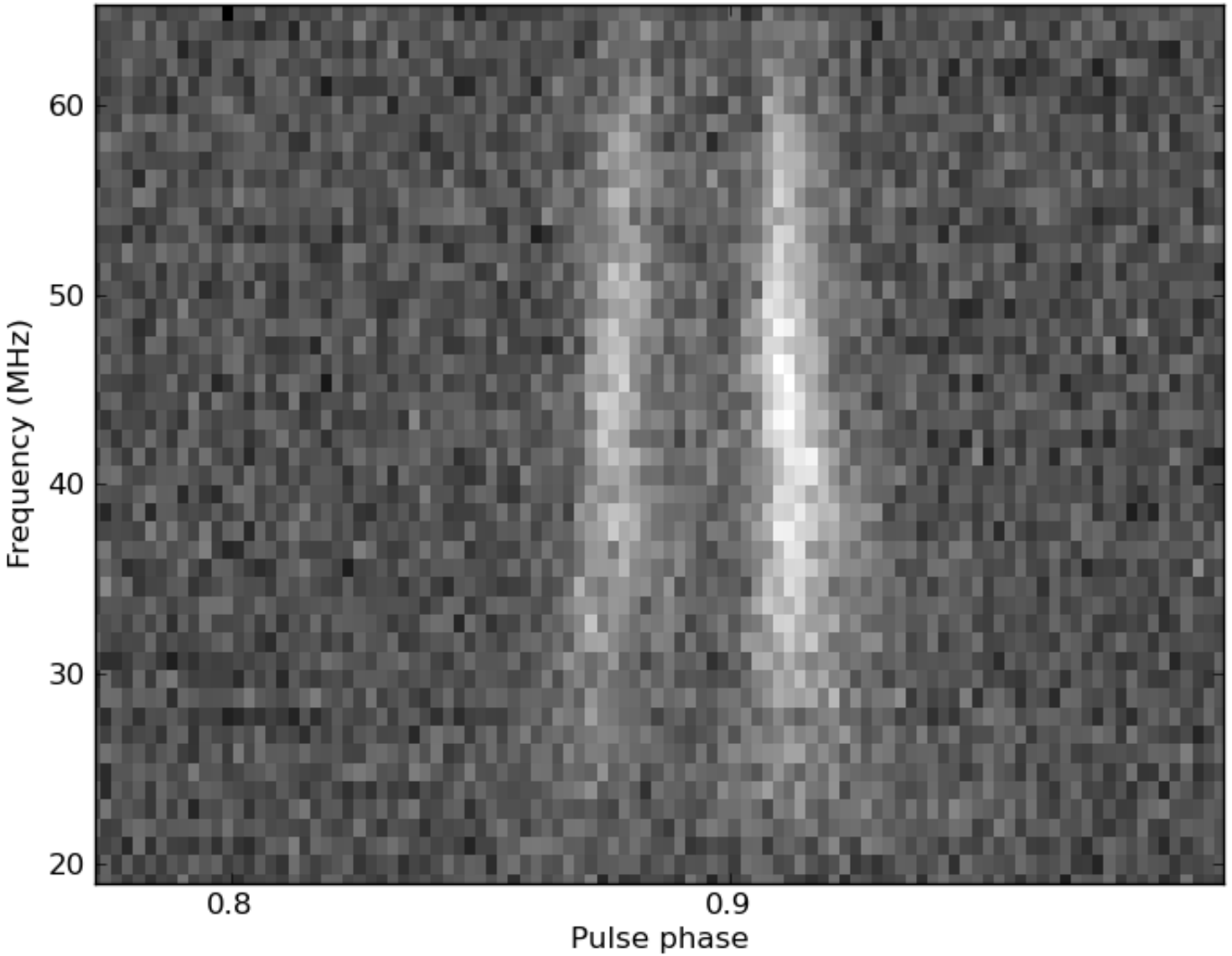
$E/\langle E \rangle \sim 37$

max E = 180



Spectra

B1133+16



Spectra

B1133+16