New observations of three AXPs at low radio frequencies

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Anomalous pulsars

- ✓ Geminga
- ✓ **Anomalous X-ray pulsars (AXPs)**
- ✓ Soft gamma-ray repeaters(SGRs)
- ✓ X-ray dim isolated neutron stars (XDINSs)
- ✓ Compact X-ray objects in remnant of supernova (CCO)
- ✓ Transient pulsars (RRATS + switch off)…

№	Source	*P*, *c*	*P*'	lg L_x (erg/s)	lg $\dot{E}$ (erg/s)
			AXP		
1	1E1048.1-5937	6.45	12.2×10^{-11}	34.30	33.51
2	**1E2259+586**	**6.98**	$\mathbf{7.3 \times 10^{-13}}$	**34.90**	**31.93**
3	**4U0142+61**	**8.69**	$\mathbf{3 \times 10^{-12}}$	**34.90**	**32.26**
4	RXSJ 170849-4009	11.00	3×10^{-11}	35.95	32.95
5	1E1841-045	11.77	4.7×10^{-11}	35.48	33.06
6	AXJ 1845.0-0258	6.97		34.70	
7	**XTEJ 1810-197**	**5.54**	$\mathbf{1 \times 10^{-11}}$	**~36**	**33.6**
8	CXOU J 0110043.1-721134	8.0			
9	**1E 1547.0-5408**	**2.07**	$\mathbf{2.3 \times 10^{-11}}$	**33.4**	**35.00**
10	**PSR J 1622-4950**	**4.33**	$\mathbf{1.7 \times 10^{-11}}$		**33.93**
			SGR		
1	SGR0526-66	8.1	8.3×10^{-13}	36 – 37	
2	SGR1806-20	7.48	1.1×10^{-10}	35.30	33.79
3	**SGR1900+14**	**5.16**	$\mathbf{1.23 \times 10^{-10}}$	**34.48**	**34.50**
4	SGR1627-41	6.4?		~35	
5	SGR1801-23				
			XDINS		
1	J 1856.5-3754 (RX 1856)	7.055			
2	J 0720.4-3125 (RX 0720)	8.39		31.48	
3	**1RXSJ 130848.6+212708**	**10.31**	$\mathbf{(0.7 - 2.0) \times 10^{-11}}$	**32.61**	**33.30 – 33.76**
4	J 1605.3+3249 (RBS 1556)	6.88			
5	J 0806.4-4123 (RX 0806)	11.37			
6	J 0420-5022 (RX 0420)	3.45			
7	**1 RXS J 214303.7+065419**	**9.44**		**(28 – 31)**	**(31.0)**

Observations

- **LPA:** 111.5 ± 1.5 MHz,

  3.3 / cos δ, A ≈20 000 m

- **Cross Type Radio Telescope**: 87 MHz, 62 MHz, 42 MHz

  15 / cos δ, A ≈5 – 8 ×10 m

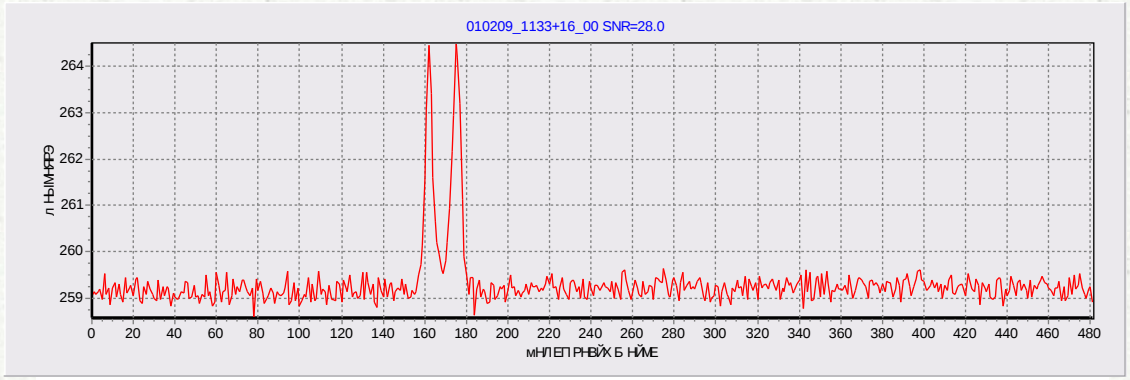
- **Receivers**: 64 ×20 kHz, Δt = 25.6 ms, 51.1 ms, 61.9 ms
- **Digital receiver:** 512 ×5 kHz, Δt ≥0.2 ms

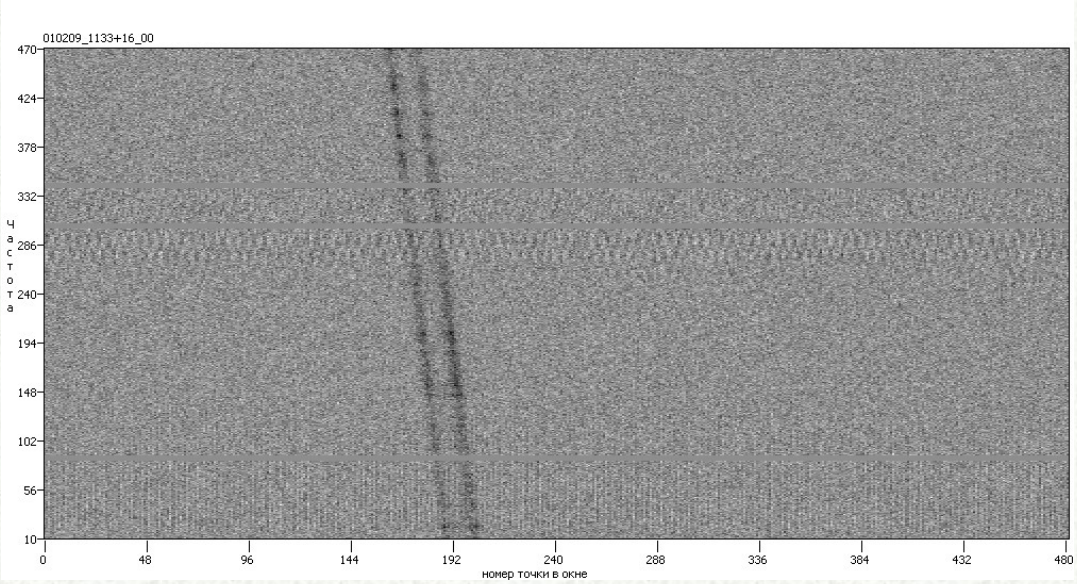
1E 2259+586, 4U 0142+61

Recording of 53 and 46 periods or 26 and 23 double periods at 111 MHz

XTE J1810-197 – 109 periods at 62 MHz

J1133+16





S = 1000 mJy

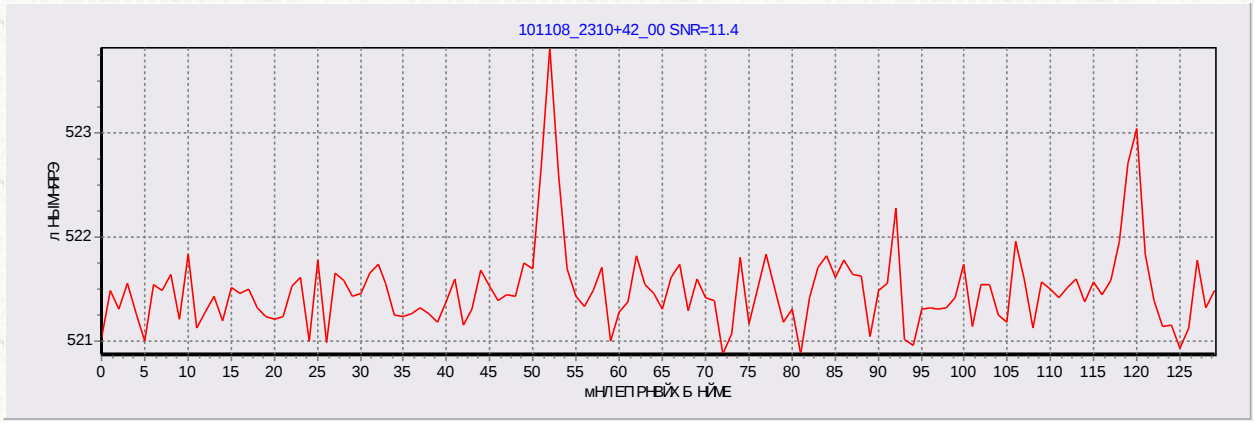
P = 1,1 s

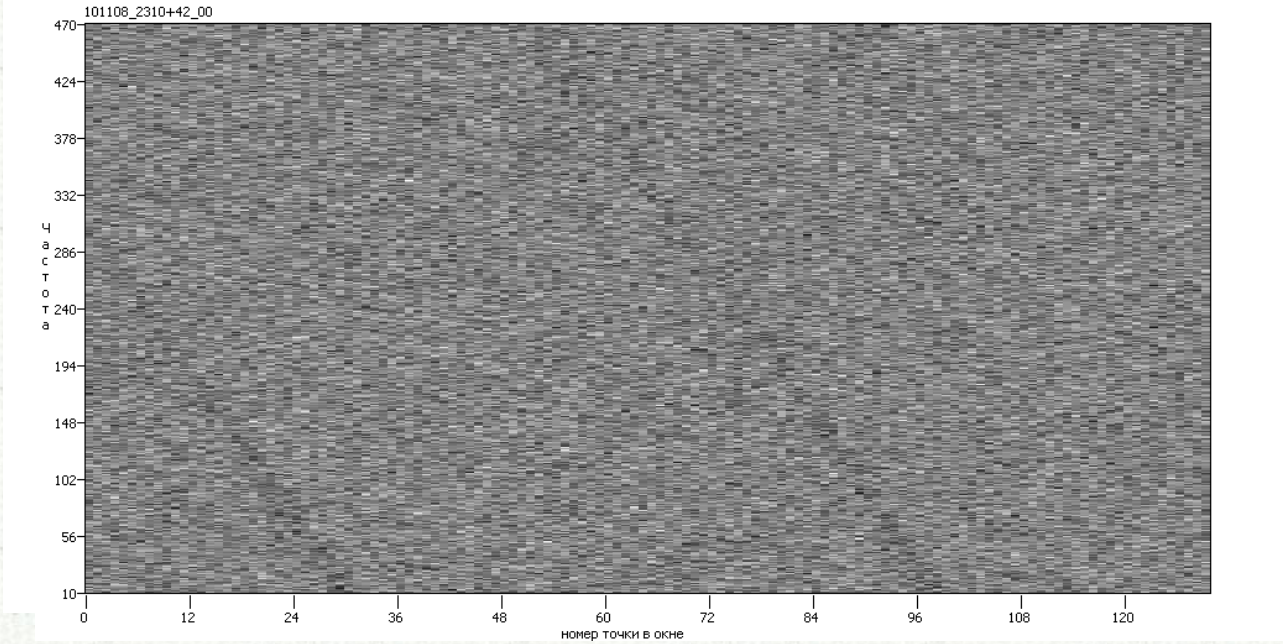
DM = 4,8

Δt = 2,56 ms

482 periods

J2310+42





S = 110 mJy

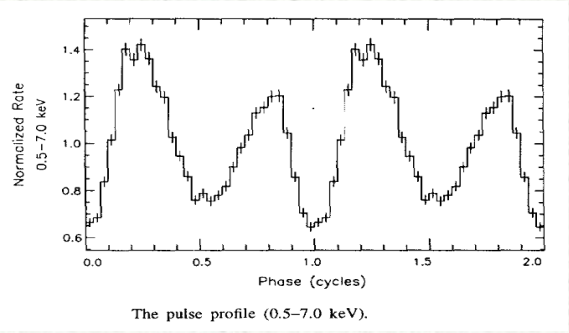
P = 0,35 s

DM = 17,3

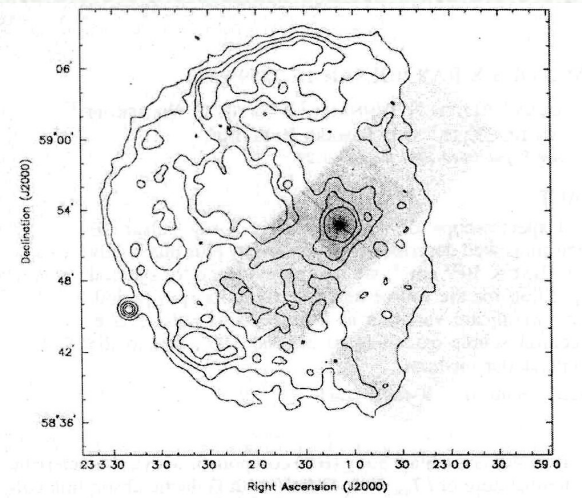
Δt = 5,12 ms

375 groups

1E2259+586



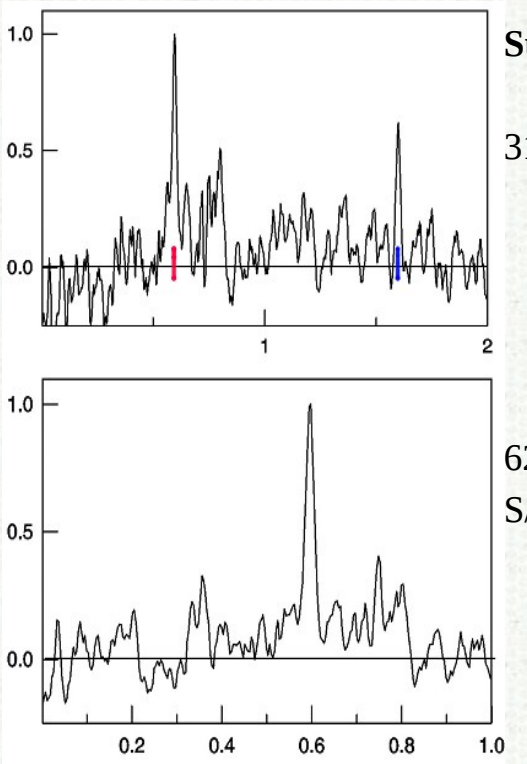
The pulse profile (0.5–7.0 keV).



Chandra ACIS 0.5–7.0 keV image processed as described in § 2.3. The bright line that passes through the source is the ACIS transfer (or trailed) image (Weisskopf et al. 2000). The false gray scale represents the number of counts detected. The *ROSAT* image (Rho & Petre 1997) is superposed for comparison and to give a better view of the SNR.

Patel et al. 2001

111.23 MHz



Sum of 12 days

312 periods

624 periods

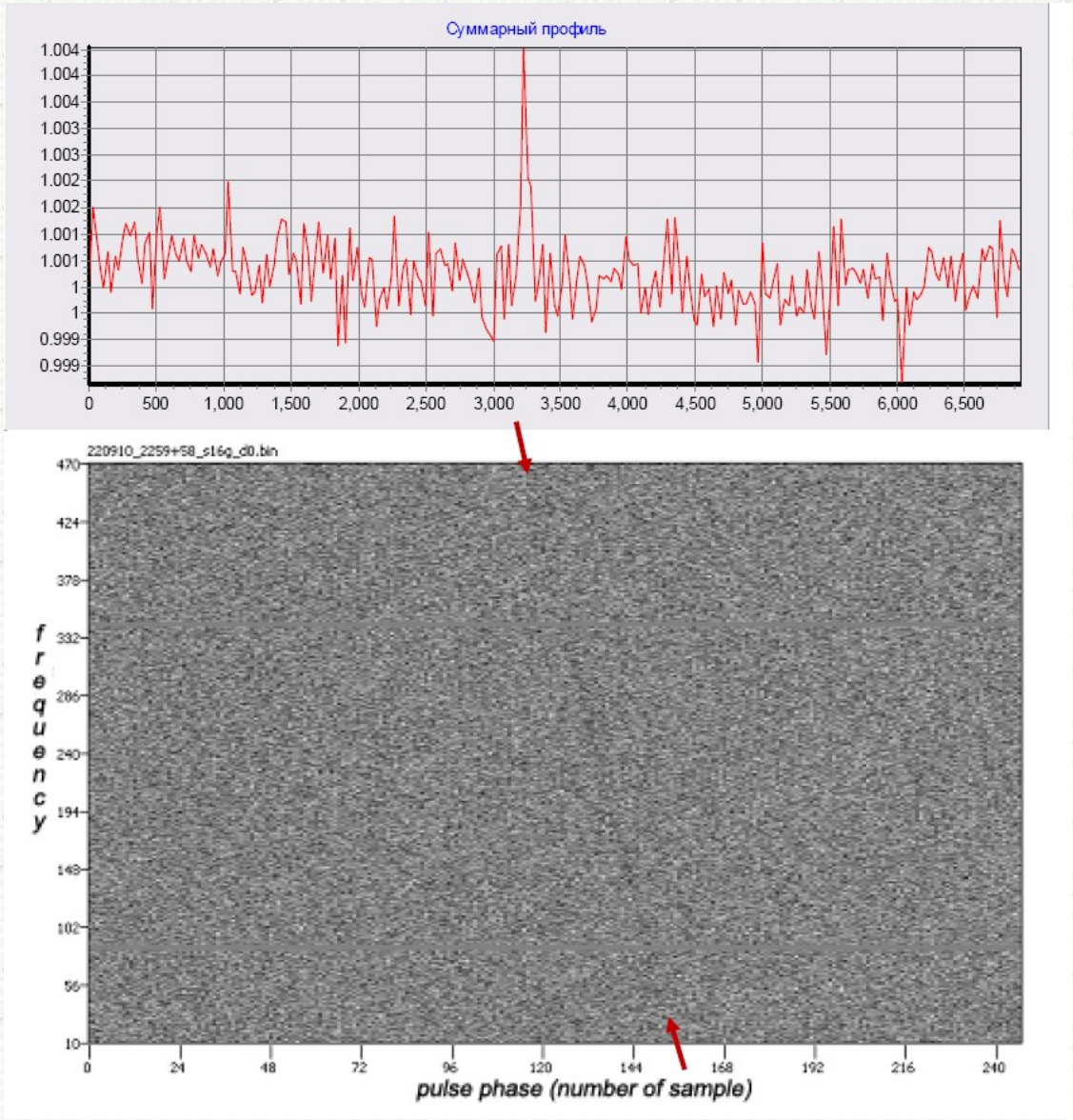
S/n = 10

Pulse profile obtained when the observing window equals twice the apparent period (p = 6.978 s). The summing of 12 days have been made with the superposition of visible pulses at the phase ~ 0.58 (red arrow). Second pulse shows up at the phase 1.58 (blue arrow). The mean profile for one period obtained by the folding of data (lower).

Malofeev et al 2001, 2004, 2005

1E2259+586

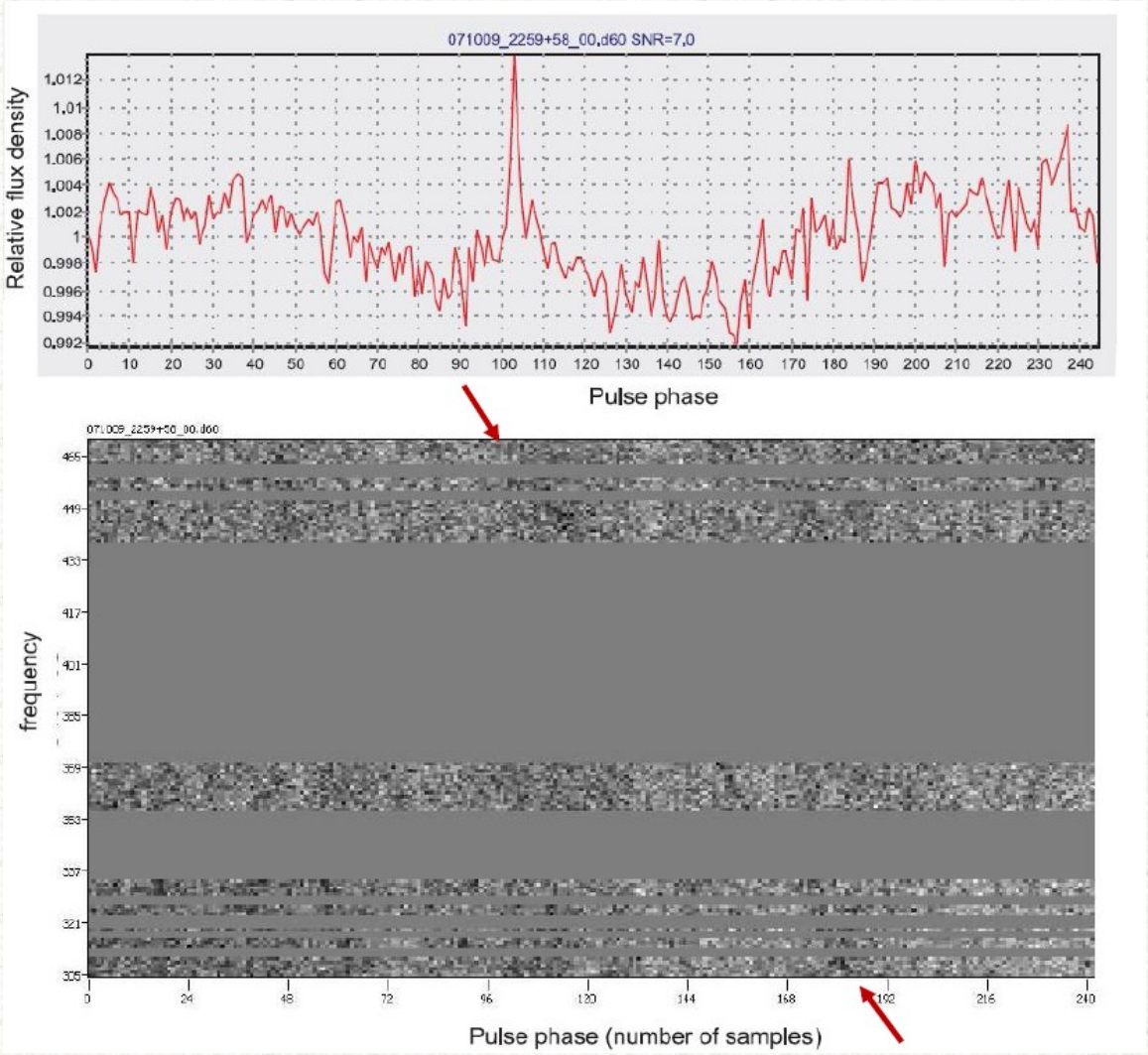
111.23 MHz



The observation at new digital receiver. The upper panel shows the dedispersed sum of 72 periods *(sum of 4 observation sessions 16,20,21,22 sept 2010).* The bottom panel shows the dispersion slope in frequency and time.

1E2259+586

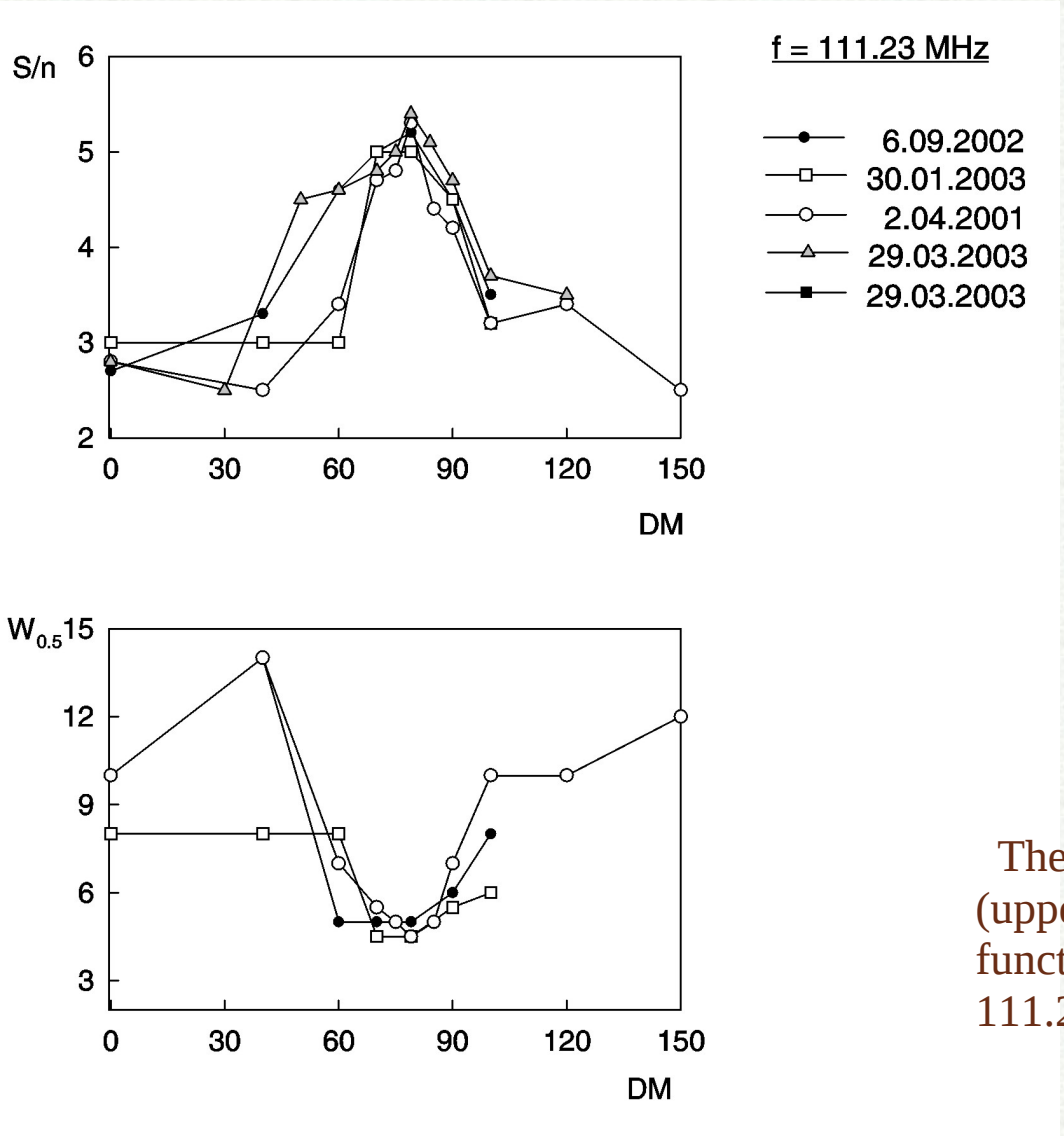
62 MHz



The observation at new digital receiver. The upper panel shows the dedispersed sum of 38 periods. The bottom panel shows the dispersion slope in frequency and time.

1E2259+586

111.23 MHz

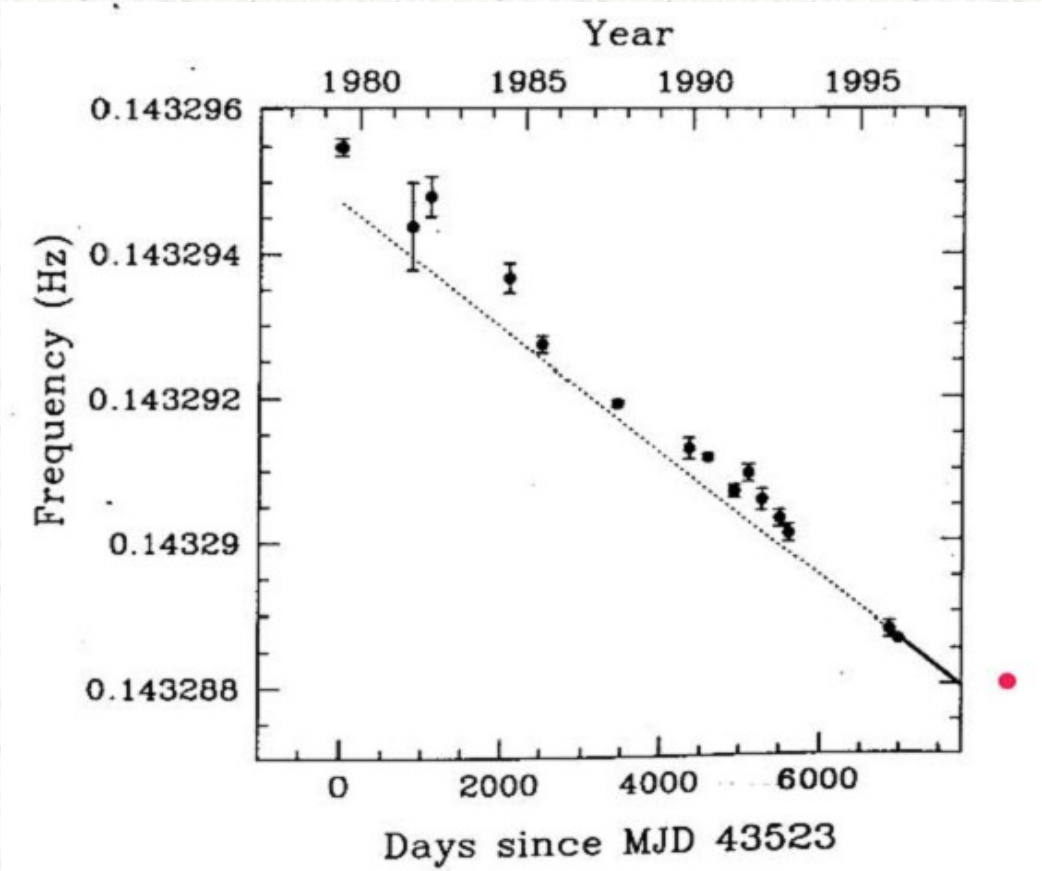


DM ~ 79 cm pc

D ~ 3.6 kpc

The search signal – to – noise ratio (upper) and pulse width (lower) as a function of dispersion measure at 111.23 MHz

1E2259+586



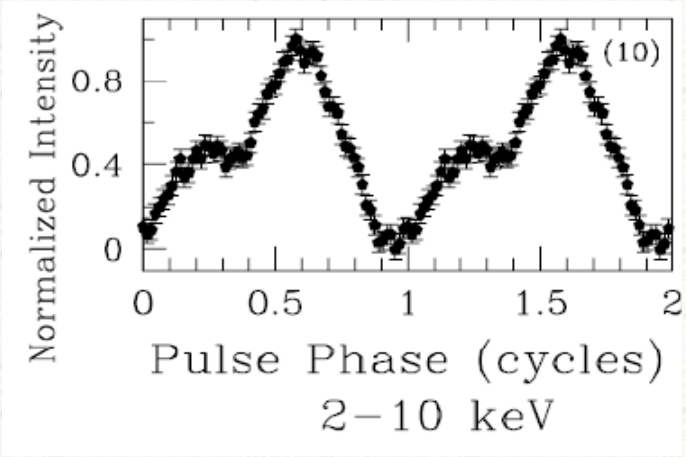
-Previously observed spin frequencies for 1E 2259+586 (see Baykal & Swank 1996, and references therein)

Pulse frequency history

Kaspi et al. 1999

4U 0142+61

Average pulse profile (2 – 10 keV)

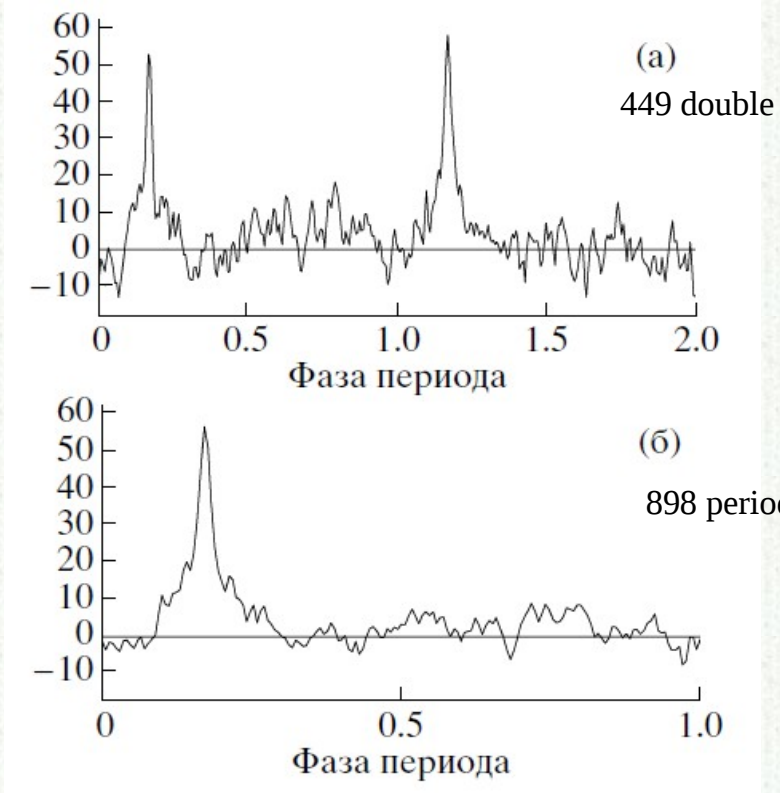


(Dib et al., 2006)

An optical counterpart *(R = 24.98)*
F. Hulleman et al., Nature 408, 689, 2000.

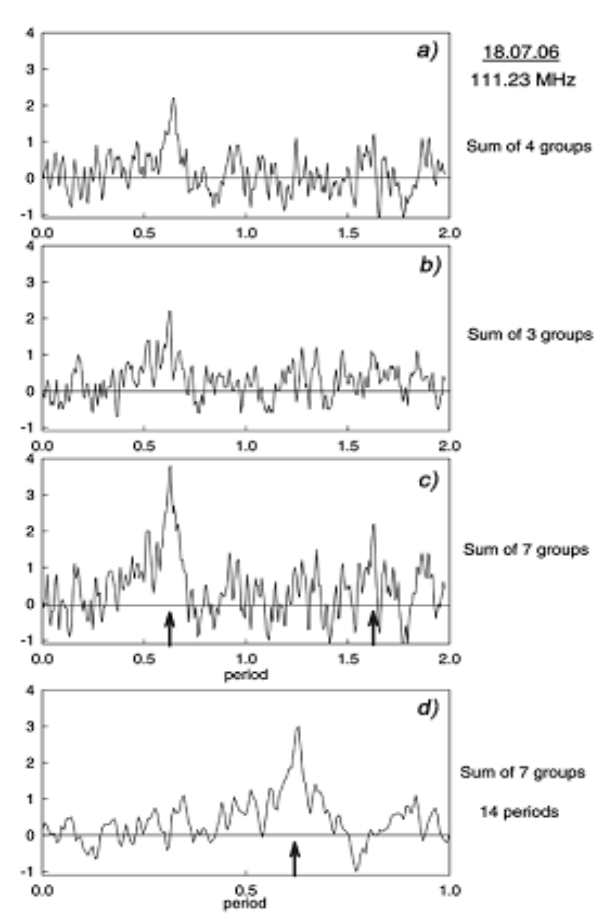
Optical pulsations (27%)
B.Kern, C.Martin, Nature 417, 527, 2002.

111.23 MHz



The integrated profiles have been obtained by summing 24 observation sessions.

Malofeev et al., 2010

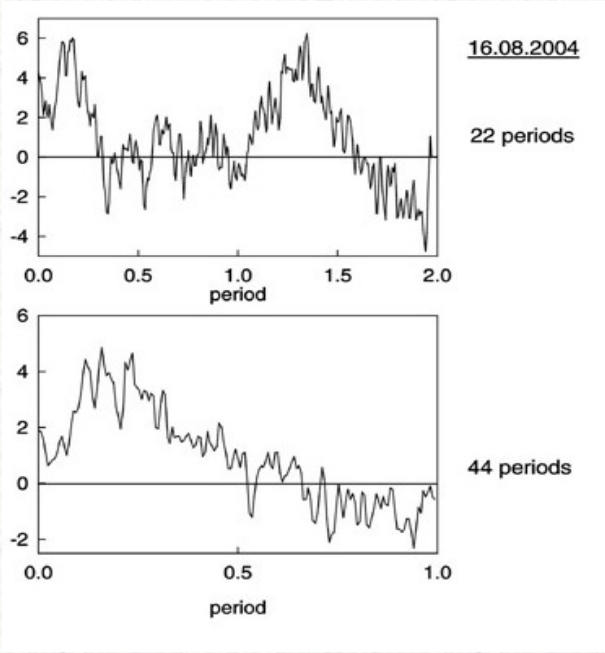


Examples of integrated profiles (relative units) obtained by summing (a) three and (b) four other groups of double rotational periods of the pulsar. (c) Sum of these groups, i.e., the sum of seven double rotational periods. (d) Convolution with one period, i.e., the sum of 14 pulses.

Malofeev et al., 2010

4U 0142+61

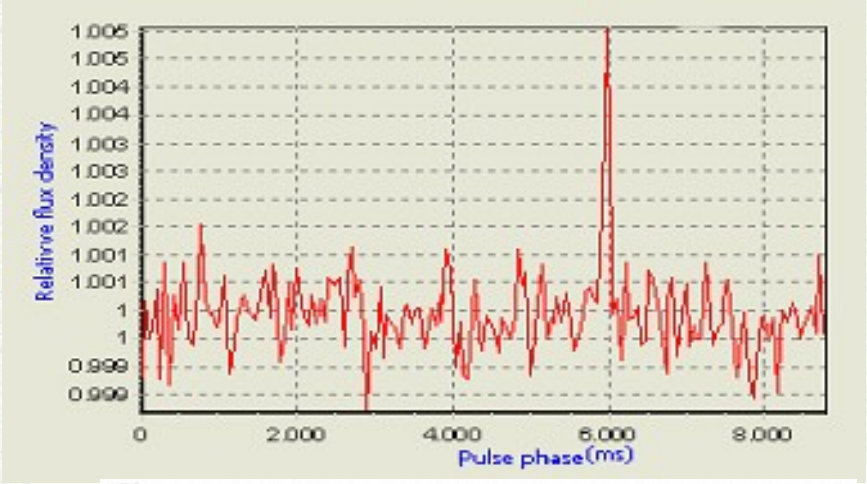
111.23 MHz

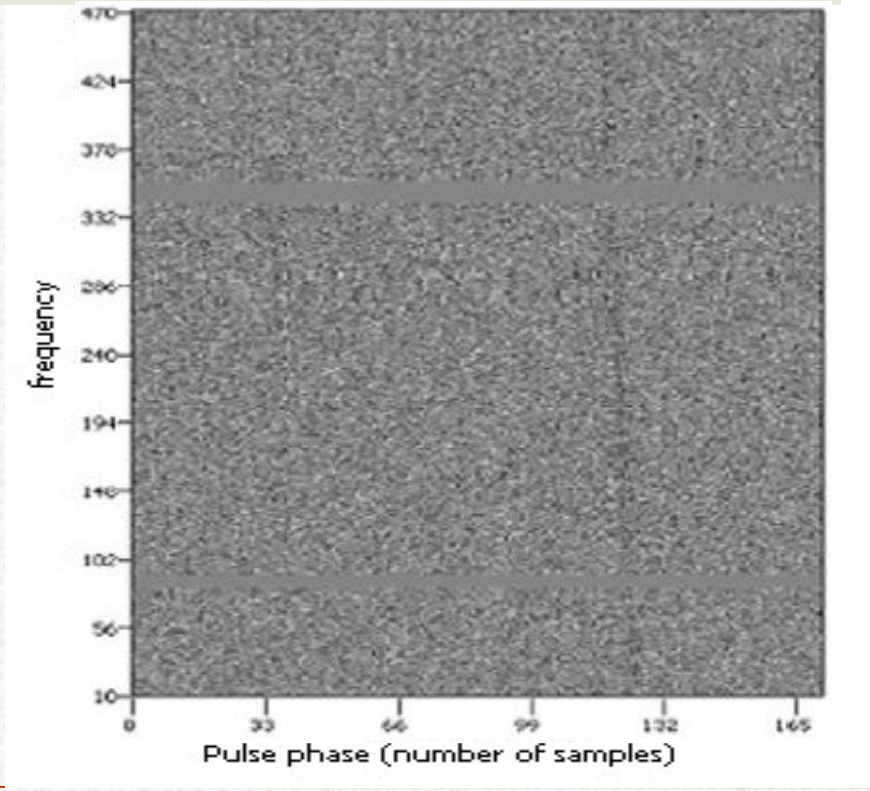


An example of wide pulse

4U 0142+61

111.23 MHz

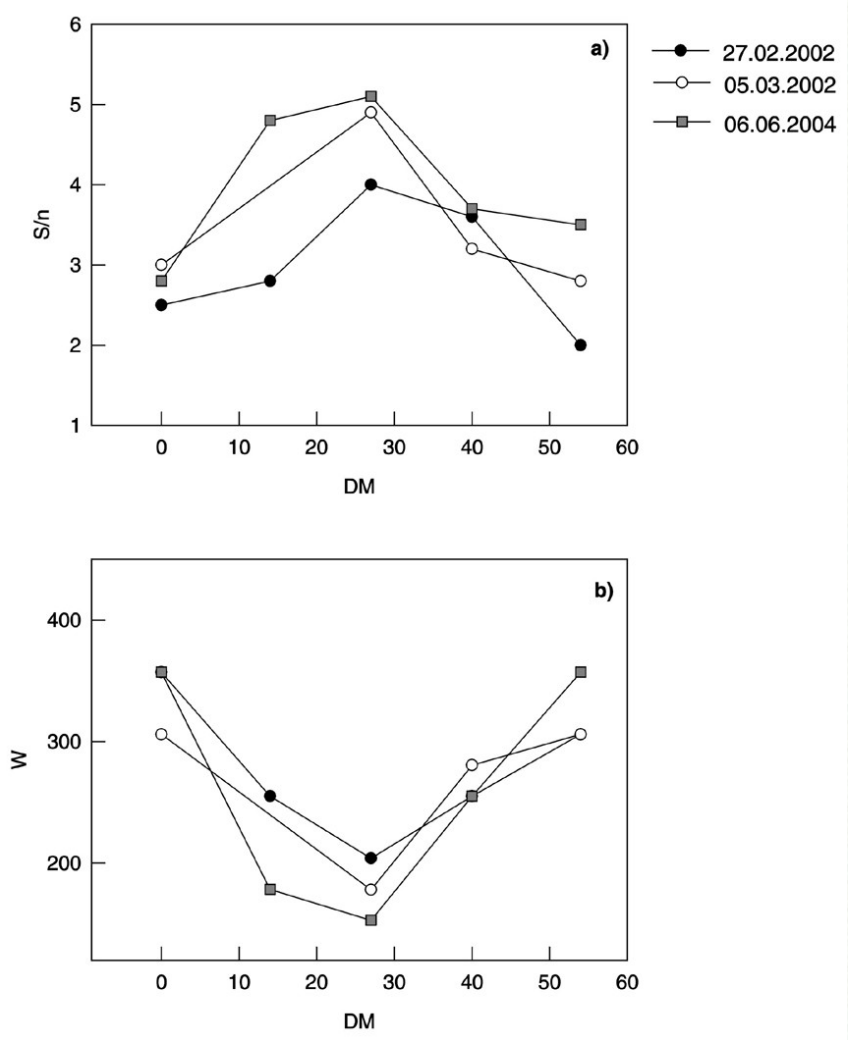




The observation at new digital receiver. The upper panel shows the dedispersed sum of 37 periods. The bottom panel shows the dispersion slope in frequency and time.

4U 0142+61

111.23 MHz

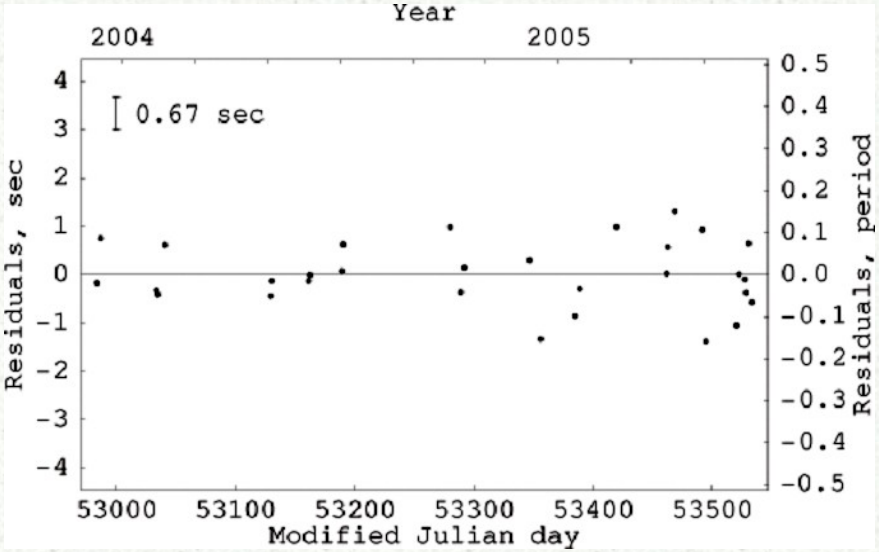


DM ~ 27 cm pc

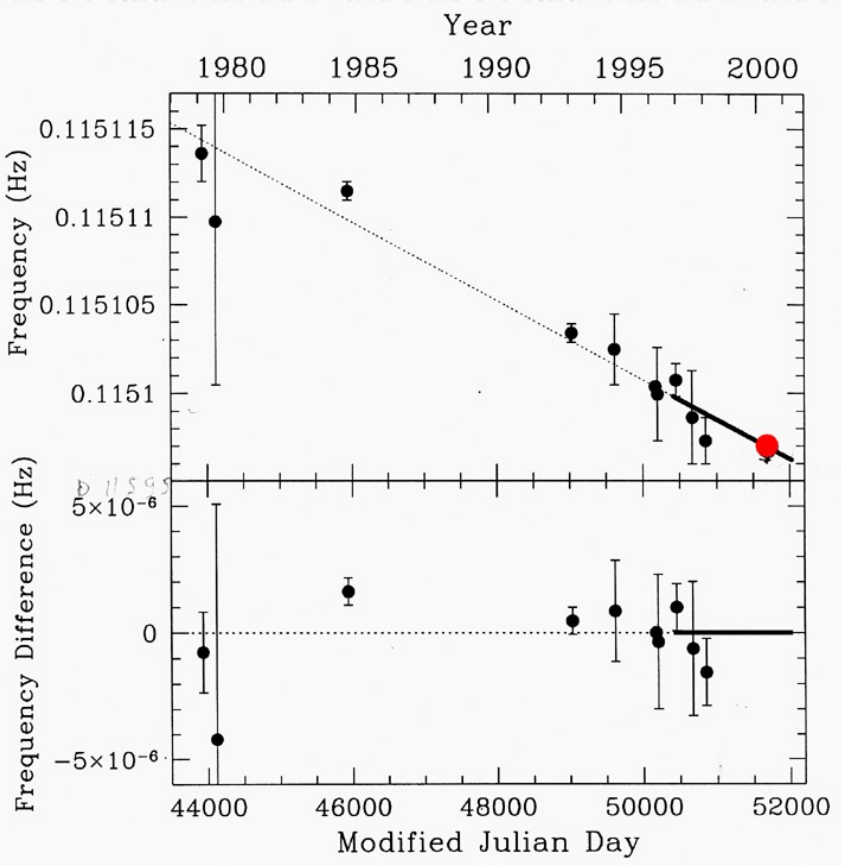
D ~ 1.4 kpc

The search signal – to – noise ratio (upper) and pulse width (lower) as a function of dispersion measure at 111.23 MHz

4U 0142+61



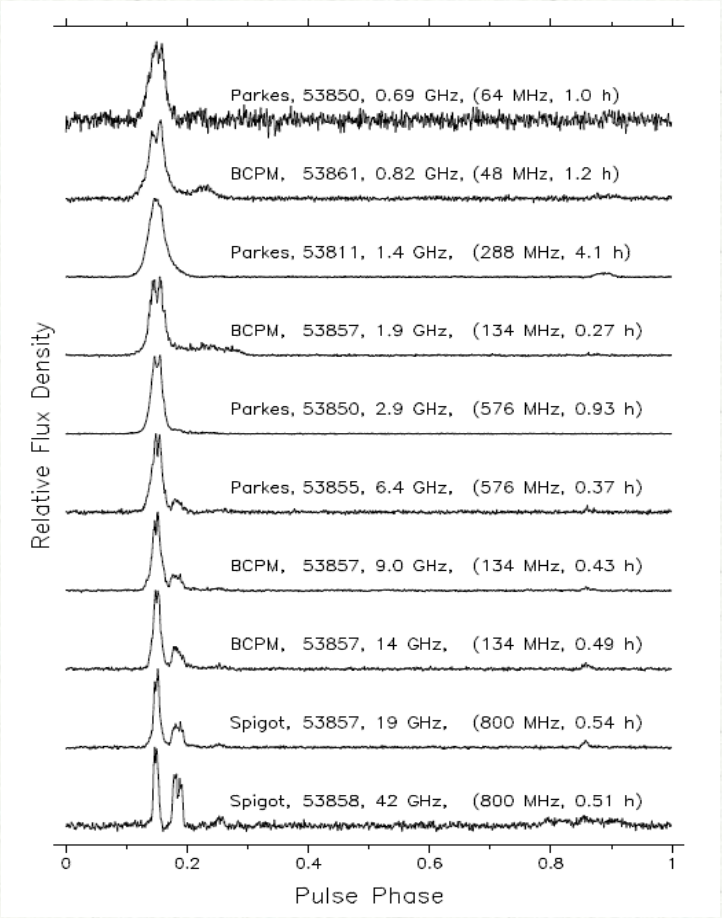
Arrival time residuals for 4U 0142+61

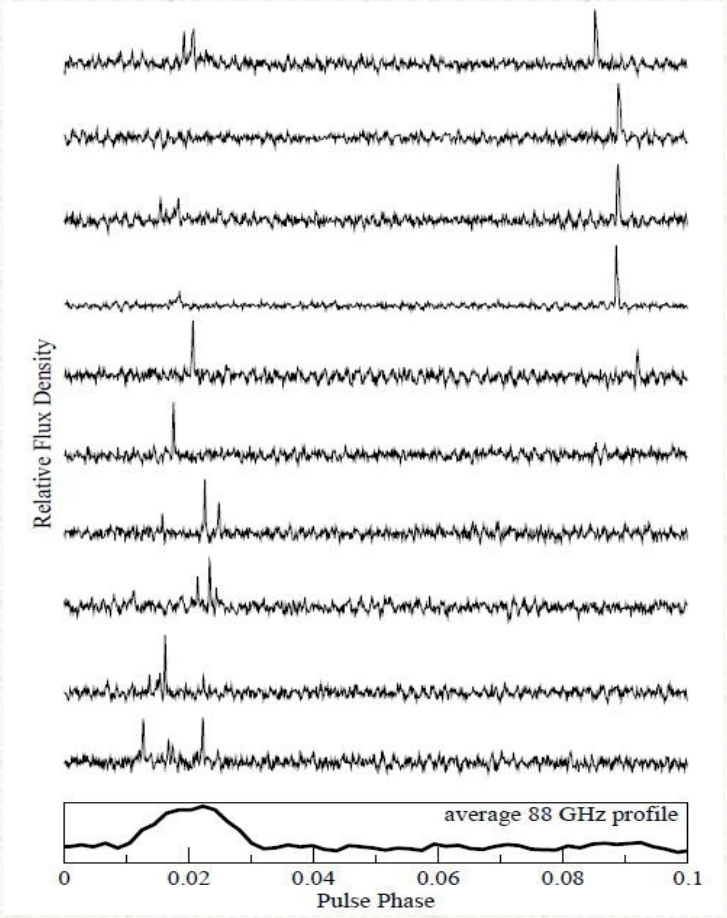


Pulse frequency history for 4U 0142+61

Kaspi et al. 2002

XTE J1810-197



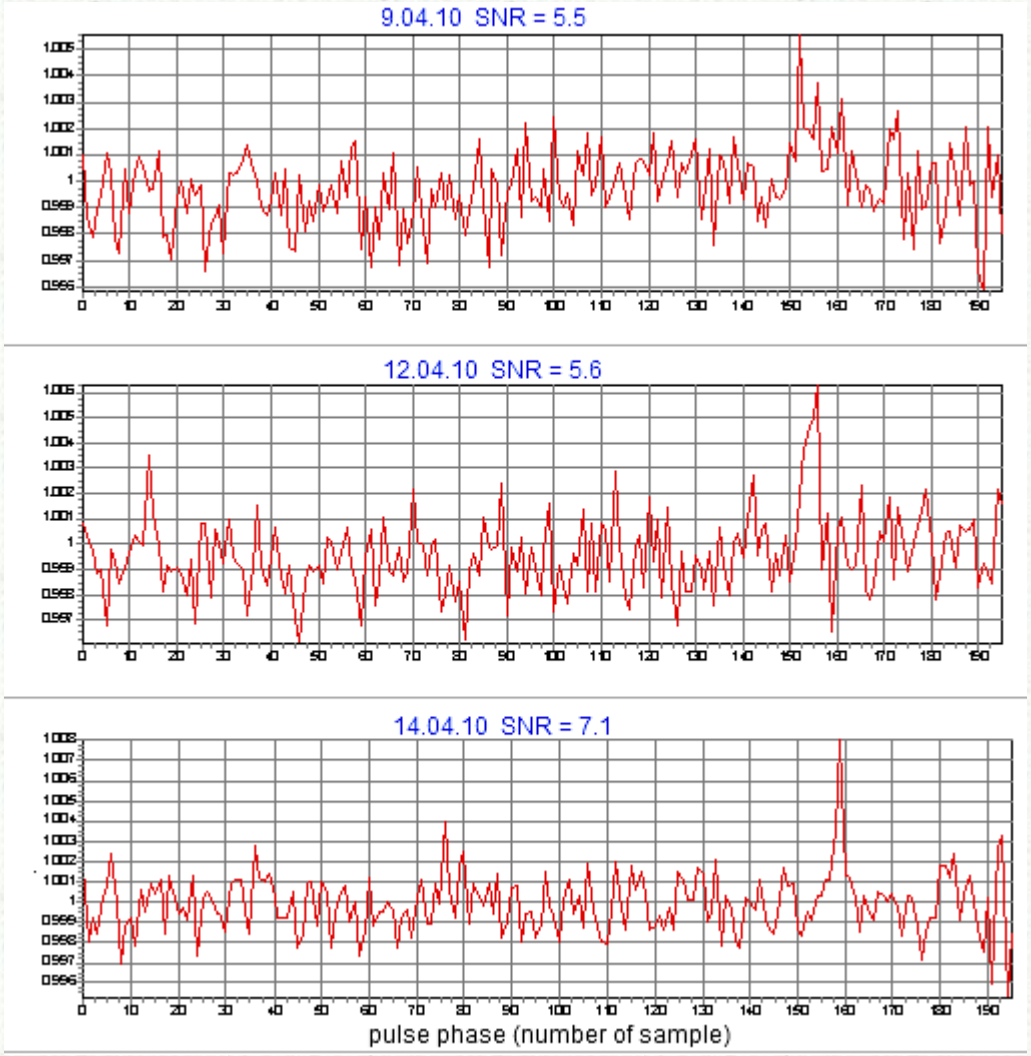


Profiles of 10 individual pulses and an

Camilo et al., 2007

XTE J1810-197

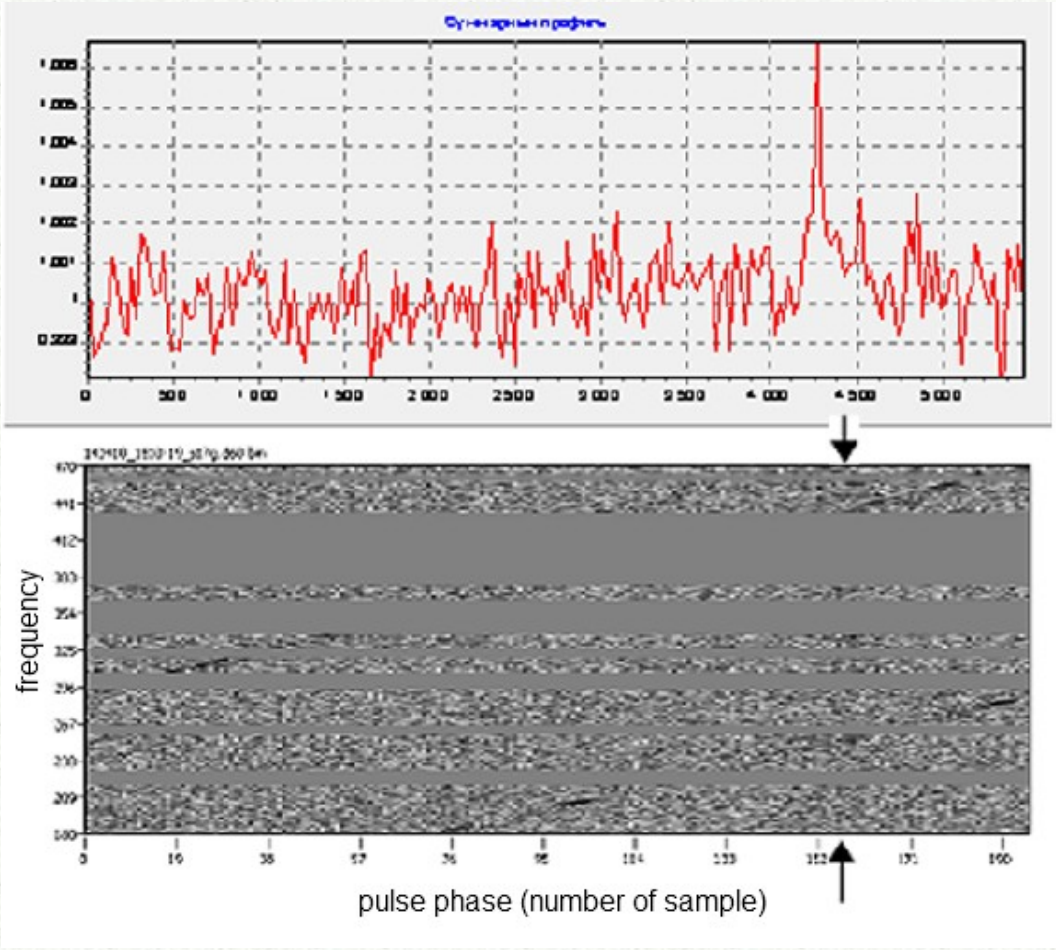
62 MHz



The examples of pulse profiles

XTE J1810-197

62 MHz



<S> = 160 mJy

The observation at new digital receiver. The upper panel shows the dedispersed sum of 51 periods. The bottom panel shows the dispersion slope in frequency and time with the compensation for DM.

Parameters of AXPs at 111 MHz

	1E 2259+586 *(Fahlman, Gregory 1981)*	**4U 0142+61**
MJD Range	51 244 - 52 749 *Gavriil and Kaspi, 2002* (50 356 - 52 016)	53100 - 54150 *Gavriil and Kaspi, 2002* (50411 - 52028)
N TOA	89 (67)	17 (34)
p (s)	6.97894846 (6) (6.978948446 (4))	8.68832935(6) (8.688329121(8))
p' (10^{-13} s/s)	4.87(2) (4.8430 (8))	18.713(4) (19.612(2))
Epoch MJD	51995.5827 (51995.5827)	51704 (51704)
DM ($cm^{-3}pc$)	79 (4)	27(4)
D (kpc)	3.6 (3.5 - 4.5)	1.4 (1 – 5)
S (mJy)	35 б =25	30 б =20
L (erg/s)	$3 \cdot 10^{28}$ (α =2.5) α>2 (S_{600}<2.3 mJy, Lorimer et al.1998)	$1.5 \cdot 10^{27}$ (α =2.5)
$W_{1/2}$ (ms)	120 (20) ~1.7% ~27%	230(20) ~2.6% ~34%
B (G)	$1.2 \cdot 10^{14}$	$2.6 \cdot 10^{14}$
T (year)	$2.2 \cdot 10^{5}$	$0.74 \cdot 10^{5}$

Conclusions

- ✓ We have detected weak pulsed radio emission from three AXPs 1E 2259+586, 4U 0142+61 and XTE J1810-197 at low frequencies.
- ✓ The main difference between the radio from the X-ray pulsed emission is that the radio integrated profiles are much narrower.
- ✓ We have obtained independent estimates of the distances to pulsars by determination of the dispersion measure, which are within the intervals of distances determined using other methods.
- ✓ The presence of radio emission from 4 AXPs: 1E 2259+586, 4U 0142+61, XTE J1810-197, 1E 1547.0-5408 *(Malofeev et al. 2001, 2009; Camilo et al. 2006, 2007)*, recent detection of a radio-loud magnetar J1622-4950 *(Levin et al. 2010)* and weak SGR J1900+14 *(Shitov et al. 2000)*, together with the detection of the long-period radio pulsar J1847-0130 *(McLaughlin et al. 2003)*, similar to those of AXPs and SGRs, suggests the need to re-examine radio emission mechanisms in the magnetar model, or to consider other AXP and SGR models that do not involve super strong magnetic fields.