Detection of the Individual Pulses of the Pulsar B0809+74; B0834+06; B0943+10; B0950+08; B1133+16 at Decameter Wave Range

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Introduction

The main goal of this study is registration or estimation of the peak flux density of 11 pulsars (PSRs) which can be detected at the Decameter wave range by post detect technique. In the frame of this work we are carrying out observation company for investigation of these pulsars. We succeeded in recording of the strong single pulses for 5 PSRs with peak flux density about 100 Jy and more in the maximum. The flux density estimations for average profiles and single pulses were made also. The registration of anomalous intensity pulses (AIP) at Decameter wave range is the most interesting result of this work.

We will not use a common term "Giant Pulse" (GP) to characterize the irregular strong pulses because we understand that a number of their characteristic may later differ from the ones of GP. Until now the main research of Giant Pulses was carried out for the millisecond pulsars. Only last time the list of pulsars that have GPs was augmented by usual PSRs. The lowest frequency at which GP emission was recorded was 112 MHz. There is no information about GP in the Decameter wave band.

However, this information very important for theoretical investigations of pulsars, for defining of the peculiarities of process of GPs generation and mechanism of pulsar radio emission as a whole.

Observations

All observations of pulsars at Decameter range were carried out by using UTR-2 radio telescope. Each pulsar was observed using 60-channel receiver and/or wide band digital spectra polarimeter (DSP). The UTR-2 had the frequency band between 23.0-24.0~MHz when the 60 channel receiver was used or 18-30 MHz when DSP was used. Each receiver covered a channel-width of 4-12.3 kHz and was separated by up to 20 kHz from its nearest channel receiver (only if the 60 channel receiver was used). In each channel the signals were detected and were digitized using a 16-bit analog-to-digital converter with a time resolution from 2 up to 20ms. Rubidium standard oscillator was used at UTR-2 to generate local oscillator and sampling frequencies. The post detector Dispersion Measure removed technique was used.

Four sessions of observations were carried out. The best data sets for five PSRs are presented below.

Results

Radio emission of single pulses for five pulsars (B0809+74; B0834+06; B0943+10; B0950+08; B1133+16) was found at frequencies 18-30 MHz. The radio emission is caused by the strong

subpulses that have peak intensity of more than 20 times larger than peak intensity of average profiles. The intensity of single pulses has a strong variation in frequency and time. The probability of detection of the anomalous intense pulses does not exceed several percents at Decameter wave range. Usually such pulses are detected in short series (not more than 10 pulses). Typical band values of detection for the pulses with anomalous intensities lie in the range from 0.2 to 0.5 octaves.

The probability of registration of the individual pulses of all 11 pulsars with different sensitivity is present in the Table 1. The number “0” in this table is corresponding to zero probability of detection of single pulses for a pulsar at the frequency range 18-30 MHz. The number “1” in the Table 1 corresponds to the possibility of detection of one single pulse per 8.5 minutes observation at the frequency range 18-30 MHz. The number “2” corresponds to the possibility of detection of a short series (not more than 10 pulses) of single pulses per 8.5 minutes observation at the same frequency range. The number “3” is corresponding to possibility of detection of a long series (more than 10 pulses) or some short series of single pulses per 8.5 minutes observation at the same frequency range. The sensitivities of our observation for each pulsar are presented in the Table 2.

Table 1 The quality estimation of the probability of detection of single pulses at the frequency range 18-30 MHz

#	*PSRB*	Quality estimation (number from 0 up to 3)				Number of files in the data analyses	Total observation time, minutes	Average number
		0	1	2	3			
1	0809+74	12	33	84	11	140	1190	1.67
2	0823+26	20	-	-	-	20	170	0
3	0834+06	-	3	6	1	10	85	1.8
4	0917+63	16	-	-	-	16	136	0
5	0943+10	7	4	6	1	18	153	1.06
6	0950+08	3	5	2	-	10	85	0.9
7	1133+16	10	24	77	14	125	1062.5	1.76
8	1237+25	23	-	-	-	23	195.5	0
9	1322+83	7	-	-	-	7	59.5	0
10	1508+55	14	-	-	-	14	119	0
11	1530+27	22	-	-	-	22	187	0

Table 2 The sensitivity of UTR-2 at f_c = 22 MHz for different PSRs

#	*PSRB*	T_{SKY},°K	S, Jy (Δf=12.2 kHz, $\Delta\tau$=20 ms)	S, Jy (Δf=180 kHz, $\Delta\tau$=5 ms.)
1	0809+74	24000	66.9	23.9
2	0823+26	22000	60.4	21.6
3	0834+06	20000	69.1	24.7
4	0917+63	26000	67.7	24.2
5	0943+10	20000	65.0	23.2
6	0950+08	19000	63.6	22.7
7	1133+16	21000	63.2	22.6
8	1237+25	24000	66.3	23.7
9	1322+83	24000	73.1	26.1
10	1508+55	30000	76.2	27.2
11	1530+27	36000	98.1	35.0

The average profile and single pulses for the best data for different pulsars are presented below.

Conclusions

The radio emission in the single basis of five pulsars (B0809+74; B0834+06; B0943+10; B0950+08; B1133+16) were detected at Decameter range (from 18 up to 30 MHz) for the first time.

Peak flux densities in Anomalous intensities of pulses of five pulsars can be 20 – 50 times stronger than the intensity of corresponding average profiles.

Average and peak flux densities for eleven pulsars are estimated.

The contribution to average spectra of pulsars from strong single pulses is comparable with contribution of usual pulses at decameter range. Probably anomalous intensity pulses are connected with subpulse structure at Decameter range.

The scintillations on ionosphere inhomogeneous and interplanetary scintillations give some contribution into modulation of intensity of strong pulses in decameter wave range but can not explain all properties of AIPs. Probably pulsar plasma in magnetosphere gives main contribution to the amplification of AIPs.

Properties of GPs and AIPs are very similar but some differences of these properties are discovered.

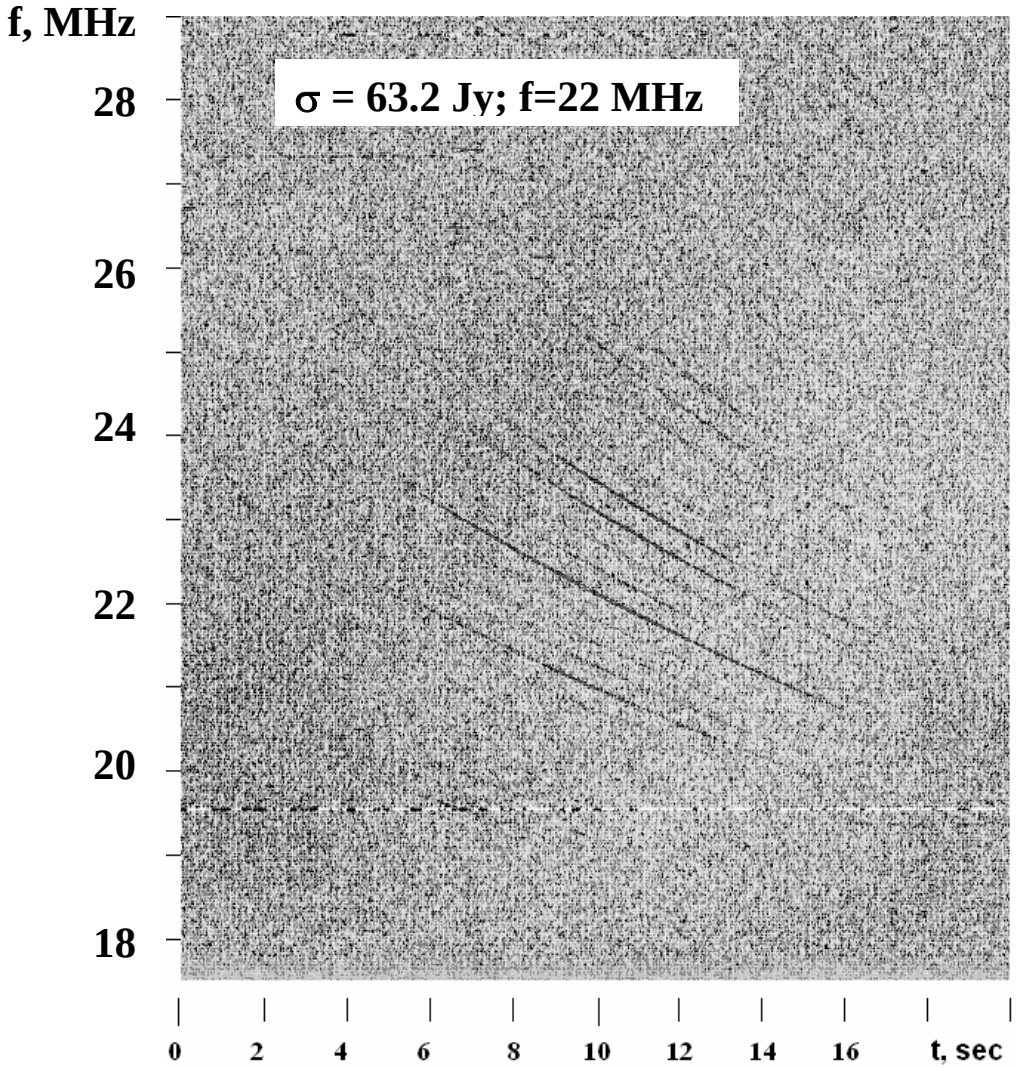

Fig. 1

Example of detection of anomalous intensity pulses for PSR B1133+16 without Dispersion Measure remove. Observation at 25 February 2000. Parameters of registration are following: number of channels N = 1024; bandwidth of one channel Δf = 12.2 kHz; time resolution $\Delta\tau$= 20 msec.

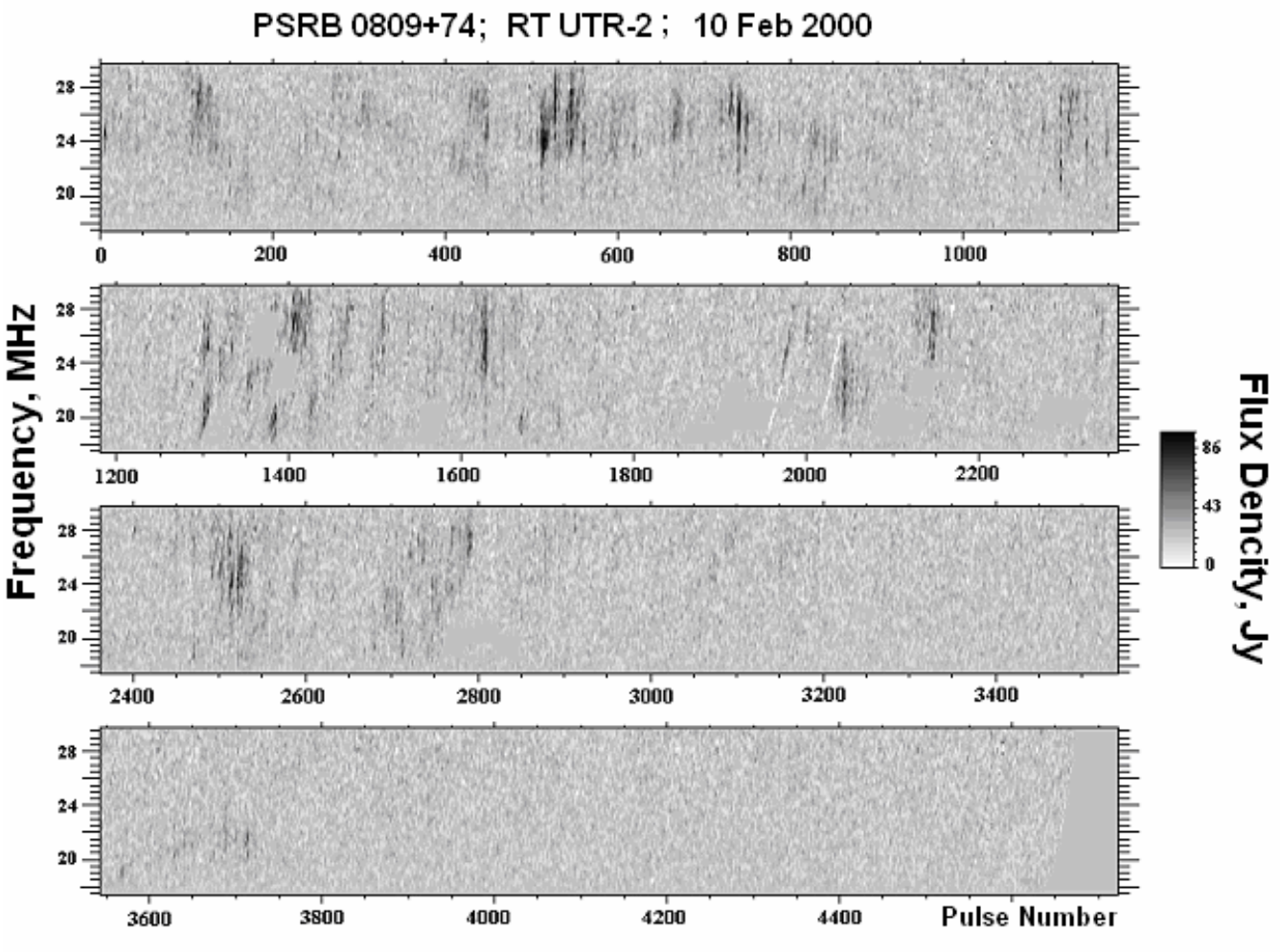

Fig. 2

The results of the wide band observation of single pulses of PSR B0809+74 are showed. The strong variations of intensities are found.

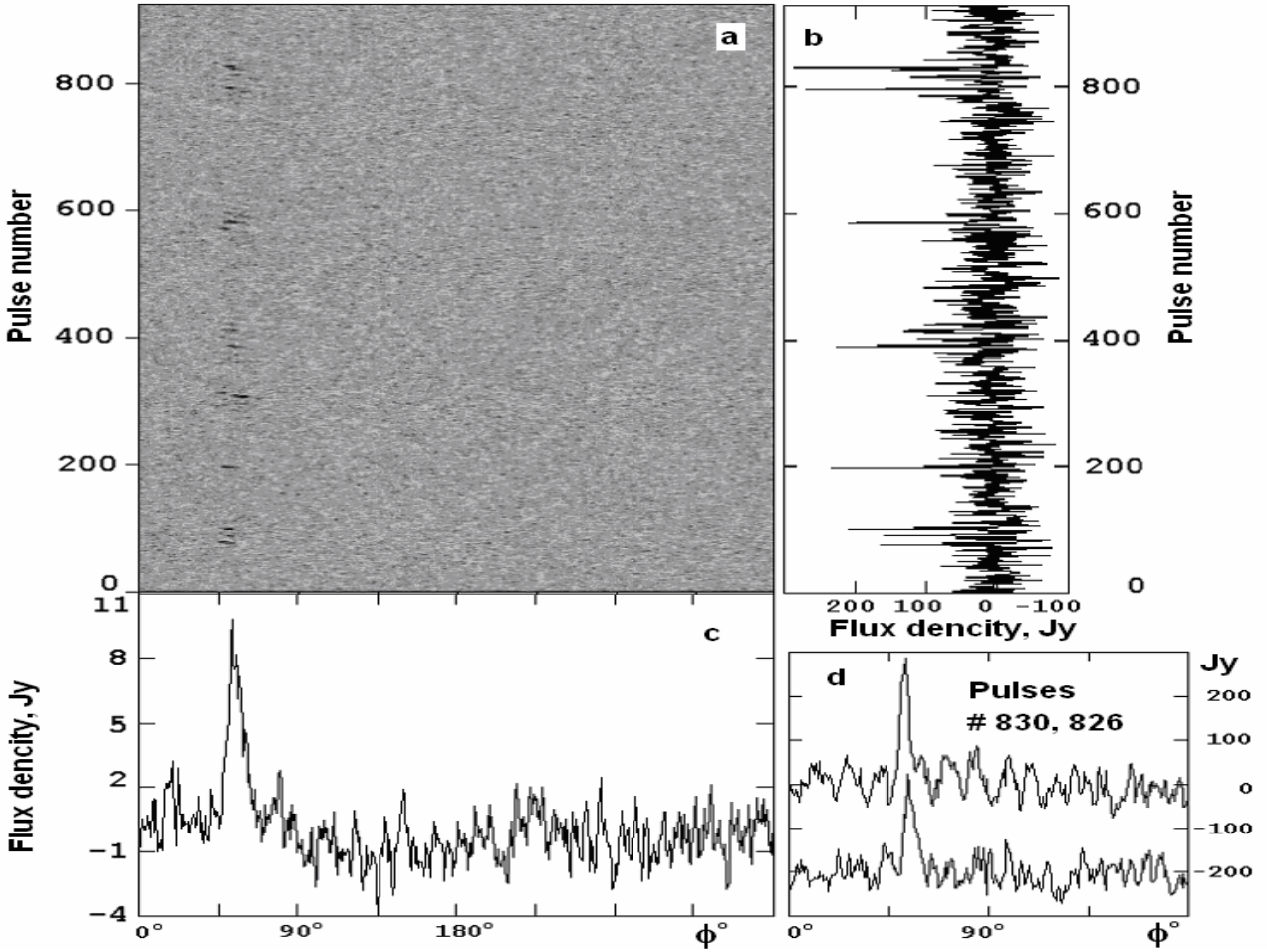

Fig. 3

The sequence of single pulses of PSR B0809+74 at 05 February 2003.

a – Subpulses stripes in the pulse train of PSR B0809+74 at 24 MHz;

b – Intensity variations of single pulses which were present near longitude of the maximum intensity of average profile;

c – Average profile of PSR B0809+74, which has been obtained from 927 single pulses (a). The width of the average profile at the 0.5 intensity level is 9.4°;

d – Two single pulse profiles with anomalous intensities (Top pulse # 830). Width of the pulse # 830 at the 0.5 intensity level is 3.4° and width of the pulse # 826 at the 0.5 intensity level is 6.8°.

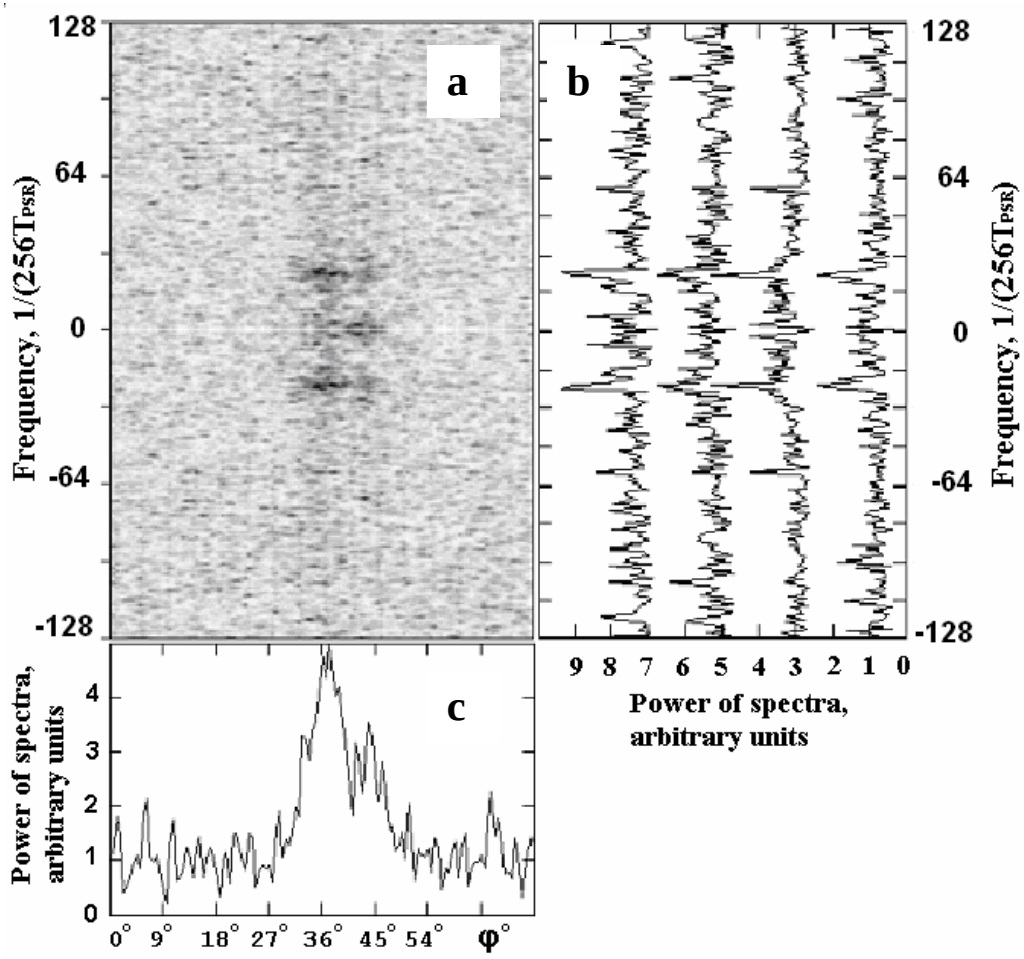

Fig. 4

The average spectra of intensities of individual pulses of PSR B0809+74. Observations at 05 February 2003. The parameters of data analyses are following: Δf = 180 kHz; fc = 24 MHz; $\Delta\tau$ = 5 msec.

a – Average spectra of intensities fluctuations of individual pulses of PSR B0809+74 in the window of main pulse. The frequency range near f(T_3) = ±23/(256*T_{PSR}) (where T_{PSR} is the pulse rotation period) corresponds to the secondary order period T_3, which is important characteristic of the subpulse structure in the pulse radio emission;

b – The average spectra of intensity fluctuations of individual pulses at different longitudes near the maximum of the average profile;

c – The average power of the fluctuation spectra at different longitudes.

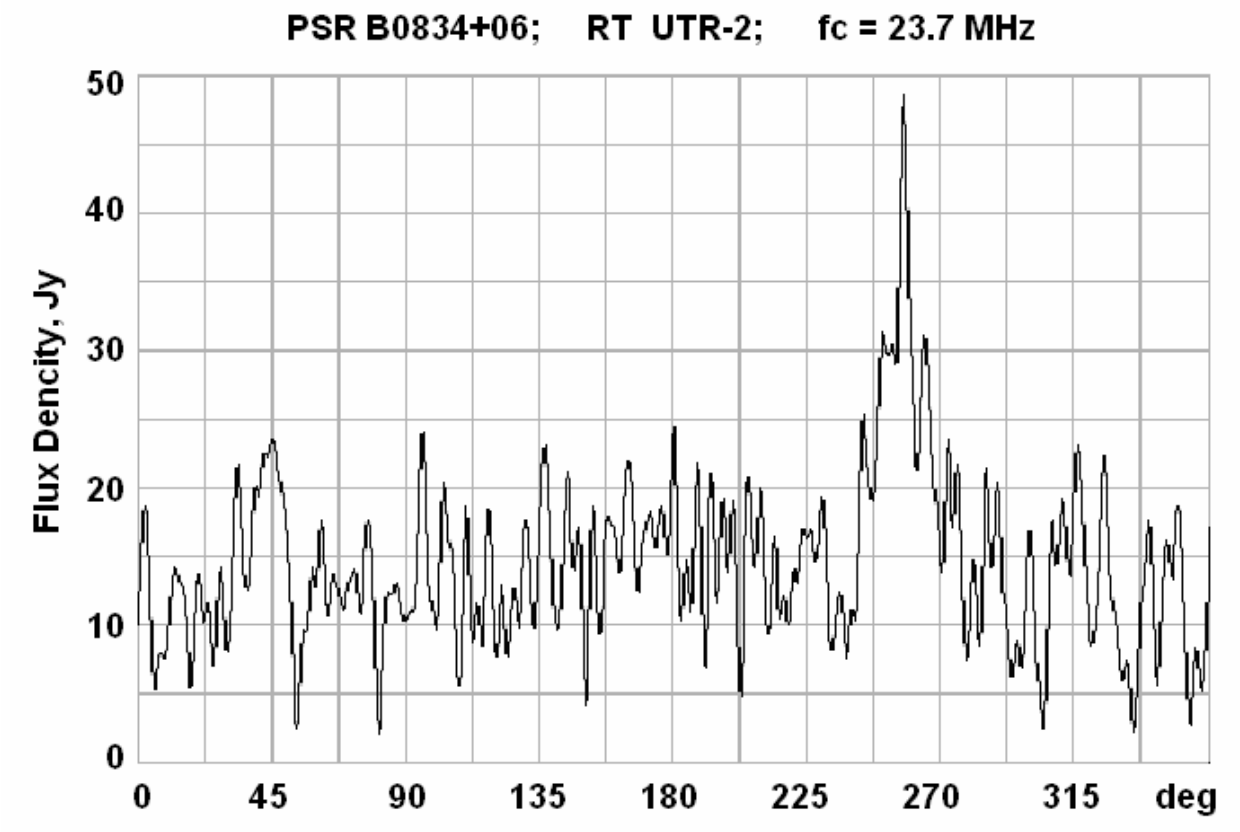

Fig. 5

Detection of anomalous intensity single pulse for PSR B0834+06. Observation at 24 November 2002. Parameters of registration are following: number of channels N = 60; bandwidth of one channel Δf = 4.0 kHz; time resolution $\Delta\tau$= 5 msec.