

Sporadic Radio Emission of the Sun at Frequencies 10-30 MHz

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This work is carried out within the frame of INTAS projects 97-1964, 03-5727

The UTR-2 (Kharkov, Ukraine) is the world-largest decameter radio telescope

sensitivity	5 Jy
effective area about	150000 m ²
operation frequency	10-30 MHz
beam at 25 MHz	30'



LOFAR workshop, April 23-27, 2007



LOFAR workshop, April 23-27, 2007



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Digital Spectral Polarimeter

instant operational bandwidth	12 MHz
central frequency from	6 to 64 MHz
time resolution selectable	up to 2 ms
frequency resolution fixed	12 kHz
dynamic range	72 dB



60-channel spectrometer

time resolution selectable	up to 10 ms
frequency resolution fixed	300 kHz
dynamic range	40 dB

The phenomena observed in decameter range:

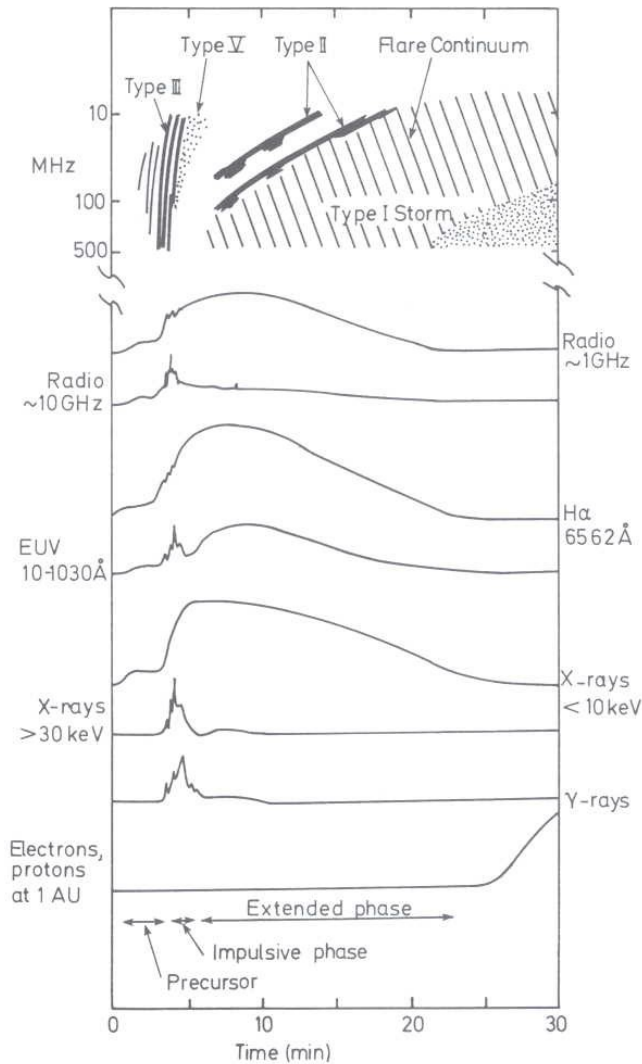
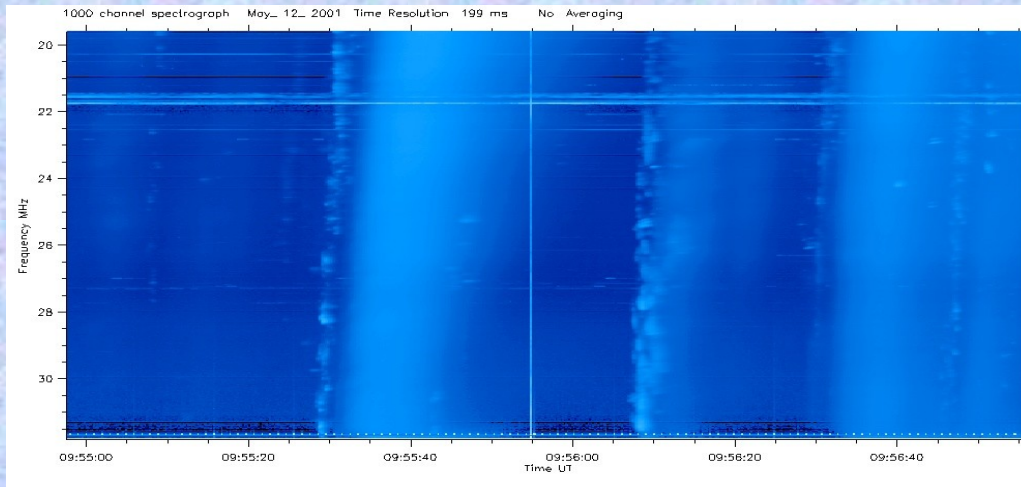


Fig. 4.1 - A schematic representation of the different phases of a typical solar flare as observed in electromagnetic and particle radiation. (Adapted from Kane 1974.)

- Type III bursts (single, storms of Type III bursts, groups of Type III bursts, U- and J- bursts, Type III burst with fine structure)
- Type IIIb bursts (single, IIIb-III pairs)
- Type II bursts (standard, Type II burst with herring-bone structure)
- drifting pairs (single, storms of DPs, DPs on Type III bursts)
- s-bursts
- decameter spikes
- absorption burst
- nonquiet "quiet" Sun

Type III bursts

Typical Type IIIb-III pairs

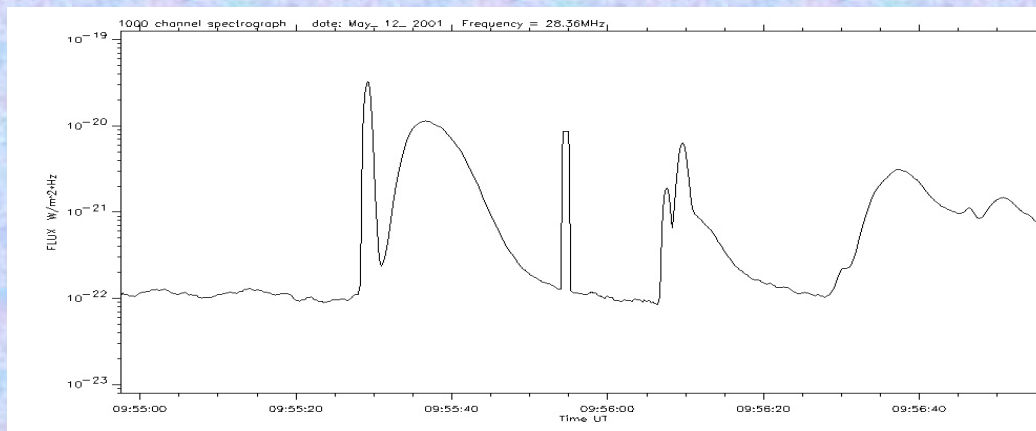


Parameters of Type III bursts

burst drift rate 3 MHz/s
duration 9 s
flux density 100 s.f.u.

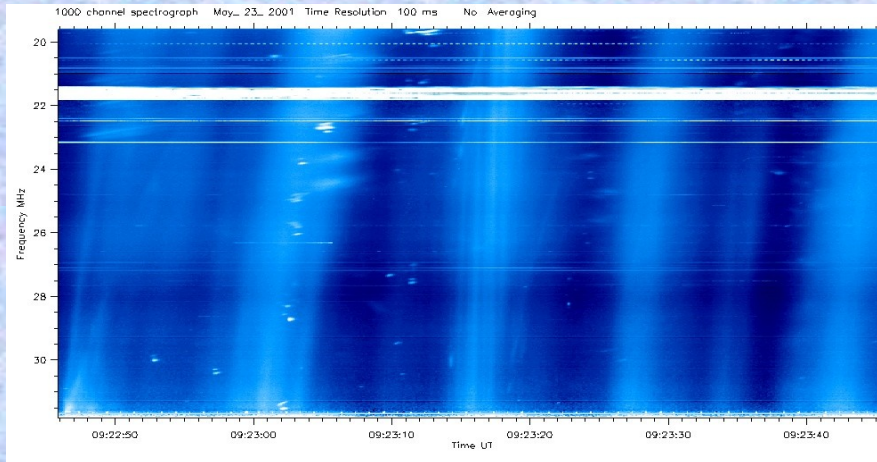
Parameters of Type IIIb bursts

burst drift rate 4 MHz/s
duration 3 s
flux density 300 s.f.u.

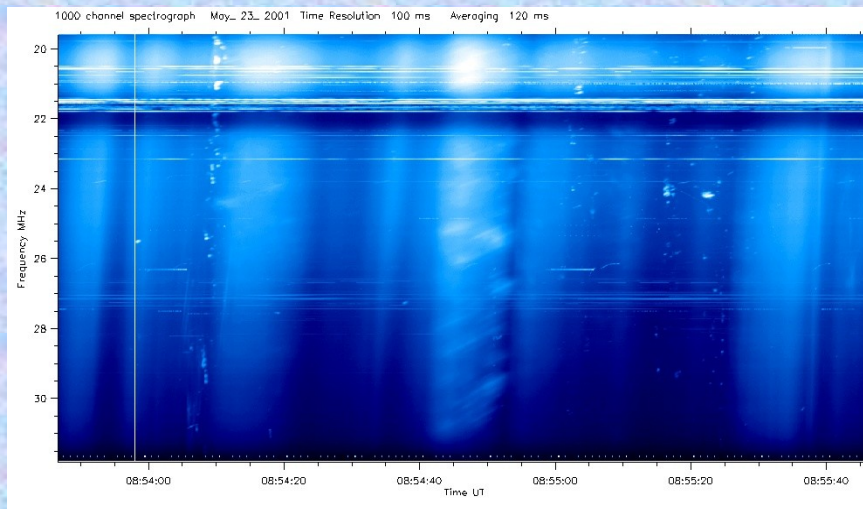


Type III bursts with fine structure

There are time-structured Type III bursts with sub-bursts having either *higher* or *lower drift rates* with respect to that of the envelope

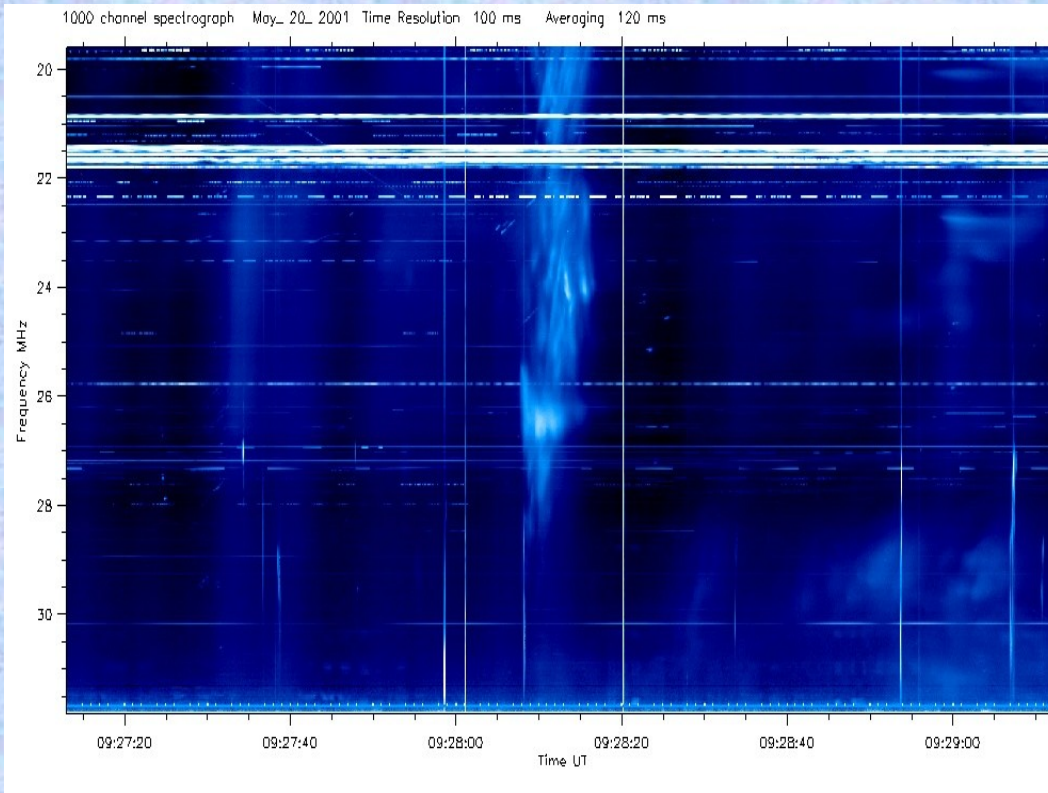


envelope drift rate	3 ÷ 4 MHz/s
envelope duration	4 ÷ 5 s
flux	up to $1 \cdot 10^{-20}$ W/m ² · Hz
sub-bursts drift rate	> 10 MHz/s
sub-bursts duration	1 s



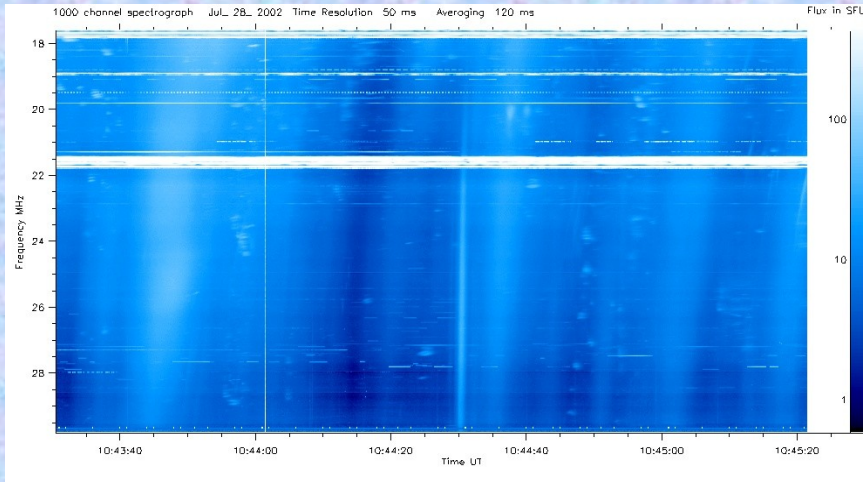
envelope drift rate	3 ÷ 4 MHz/s
envelope duration	7 ÷ 8 s
flux	up to $1 \cdot 10^{-19}$ W/m ² · Hz
sub-bursts drift rate	0.1 MHz/s
sub-bursts duration	1 s

The Type III burst has appearance of a spindle with sub-bursts having both negative and positive drift rates

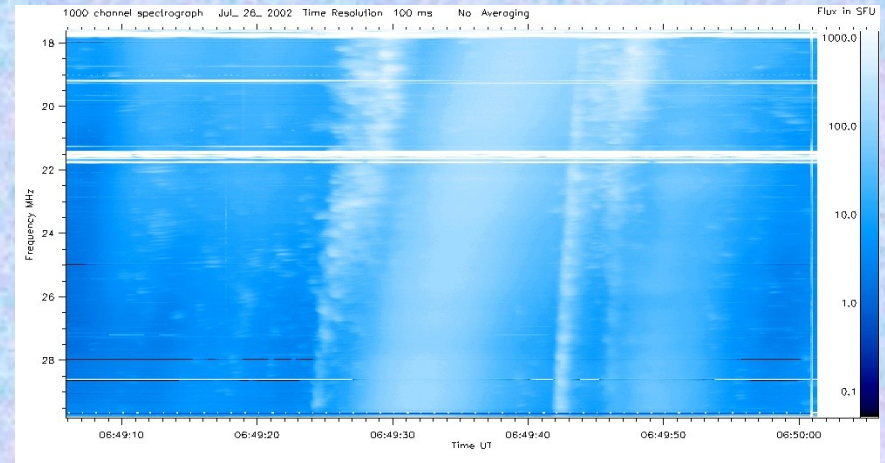
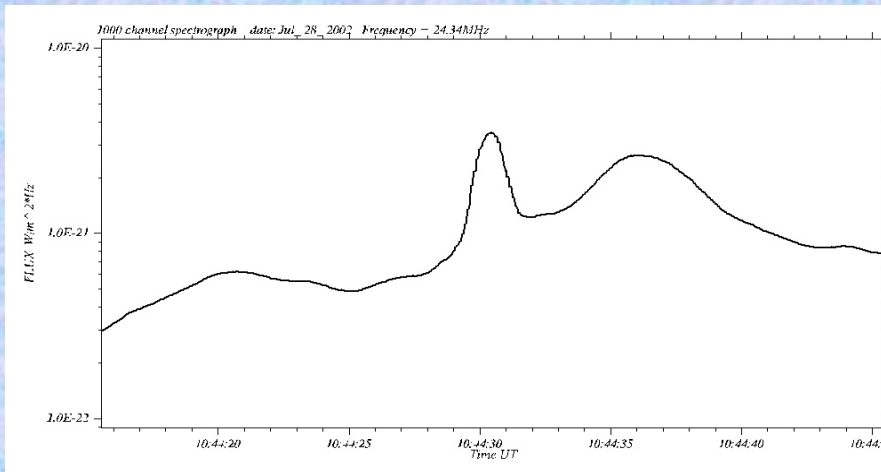


envelope drift rate $3 \div 4 \text{ MHz/s}$
envelope duration $5 \div 8 \text{ s}$
flux up to $1 \cdot 10^{-20} \text{ W/m}^2 \cdot \text{Hz}$
sub-bursts drift rates
 $-0.7 \text{ MHz/s} < df/dt < 0.9 \text{ MHz/s}$
sub-bursts duration $\sim 1 \text{ s}$

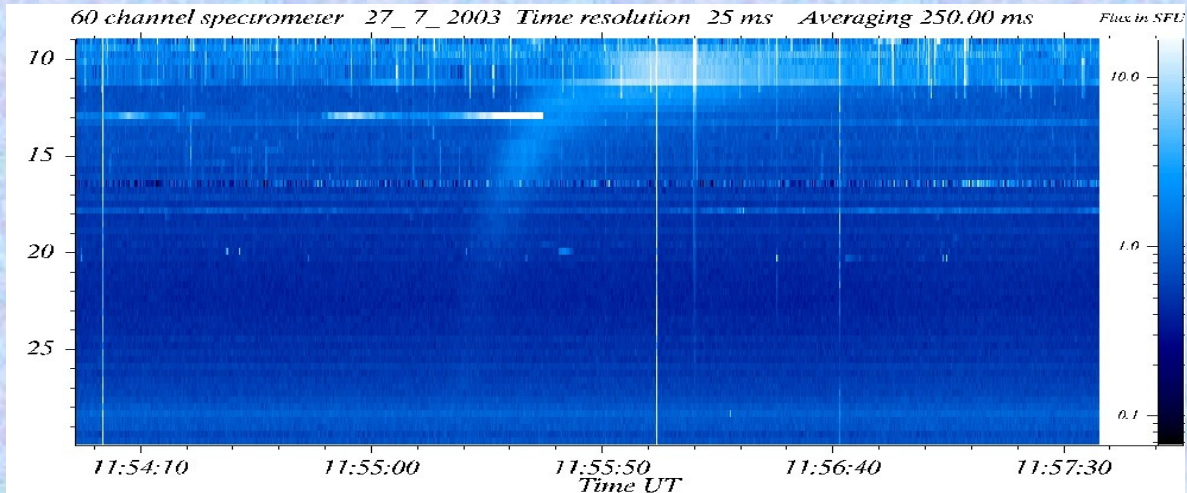
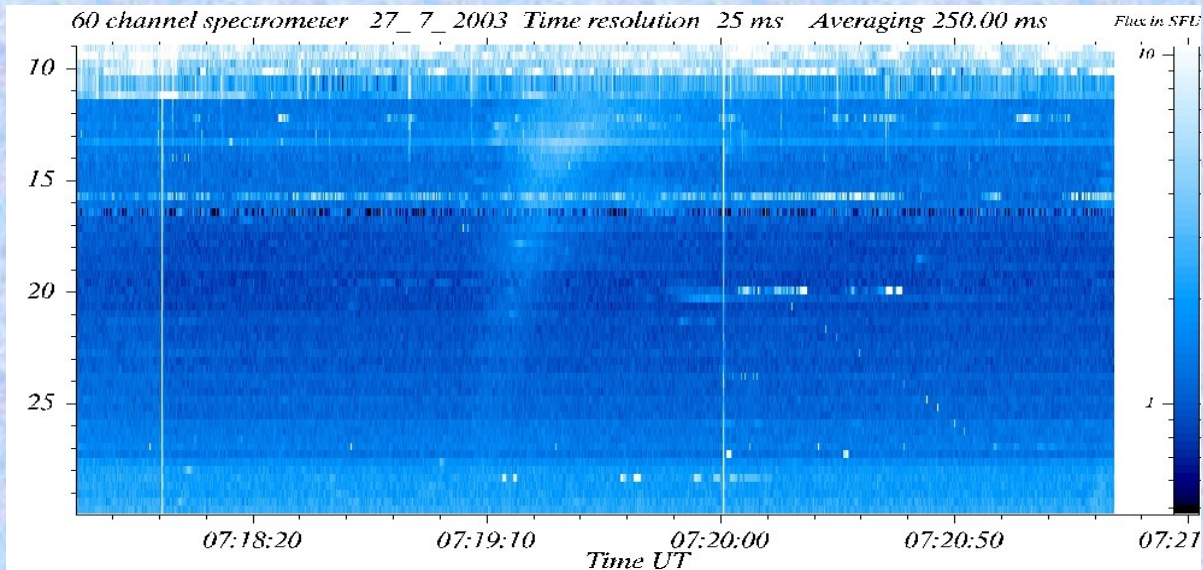
Type III-like bursts



duration 1–2 s
drift rates from 5 to 40 MHz/s
fluxes 10–1000 s.f.u.

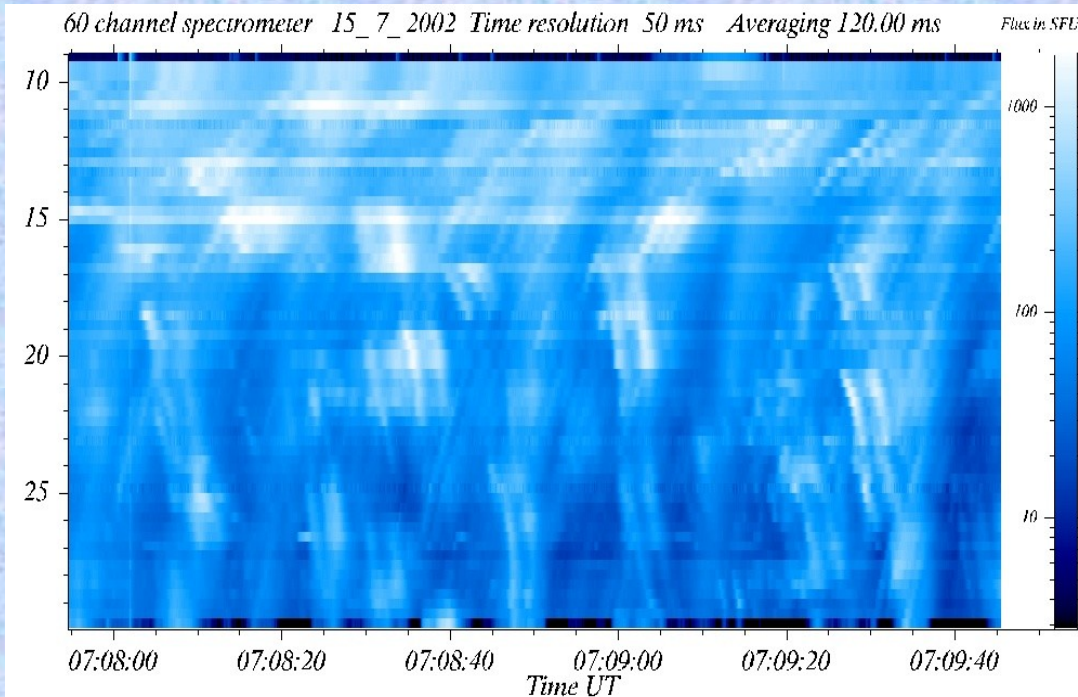


U- and J- bursts



Drift pairs bursts

storm of drift pair bursts



drift pairs with **positive**
and **negative** drift rates
frequency drift rate 1-2MHz/s
life-time of element 1-1.5s
time delay between
elements 1- 2s
frequency band of DP
2.5-4 MHz

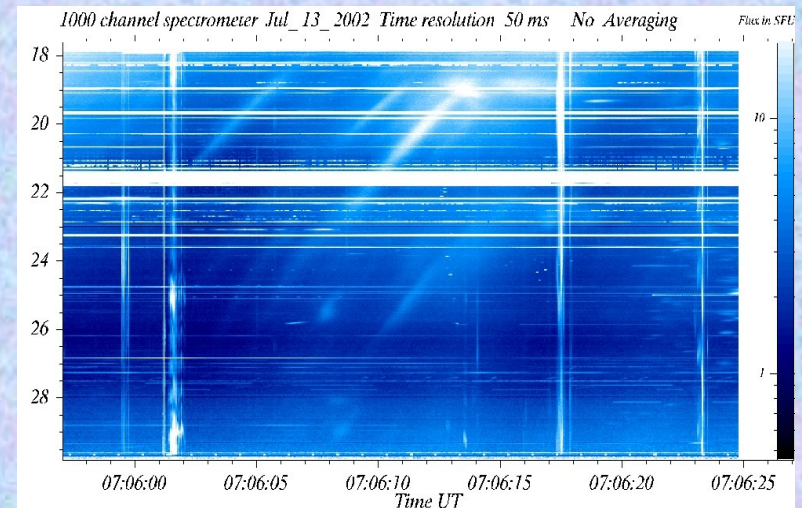
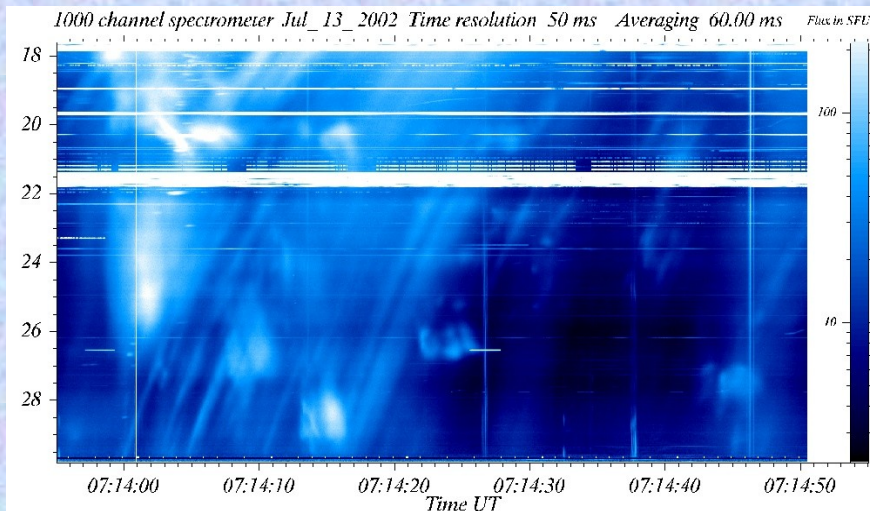
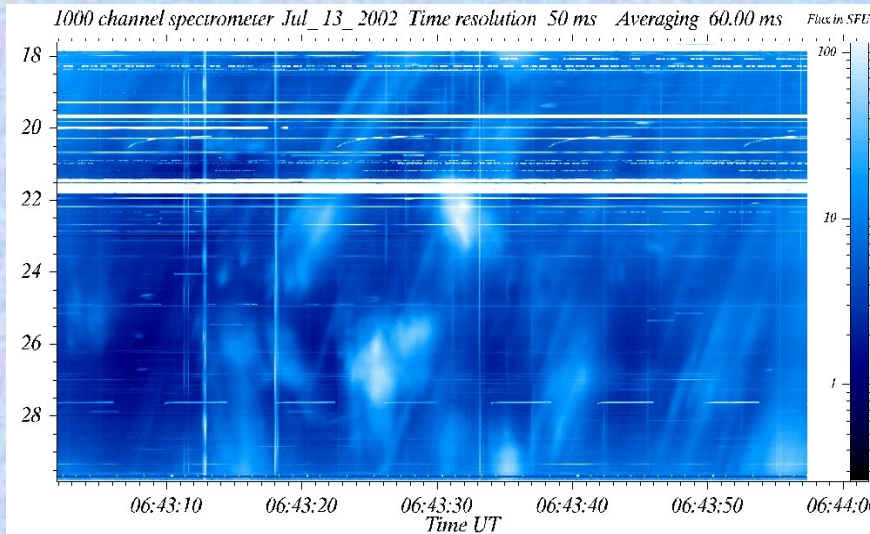
S-bursts

only burst with **negative** drift rates
lack of the second element

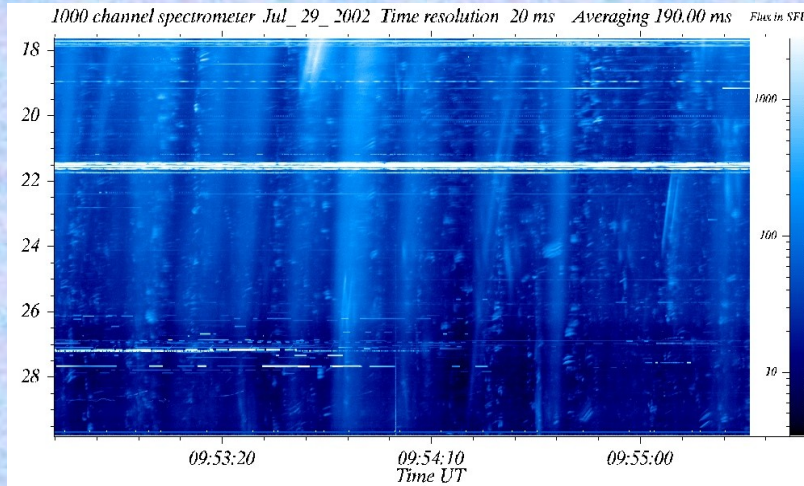
s-burst drift rates $|df/dt| = 0.5 \div 1 \text{ MHz}$

s-burst durations $\Delta t \leq 0.5 \text{ s}$

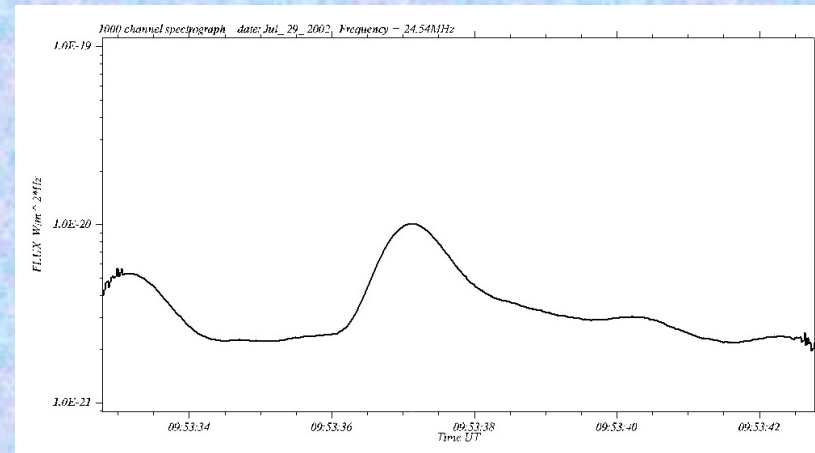
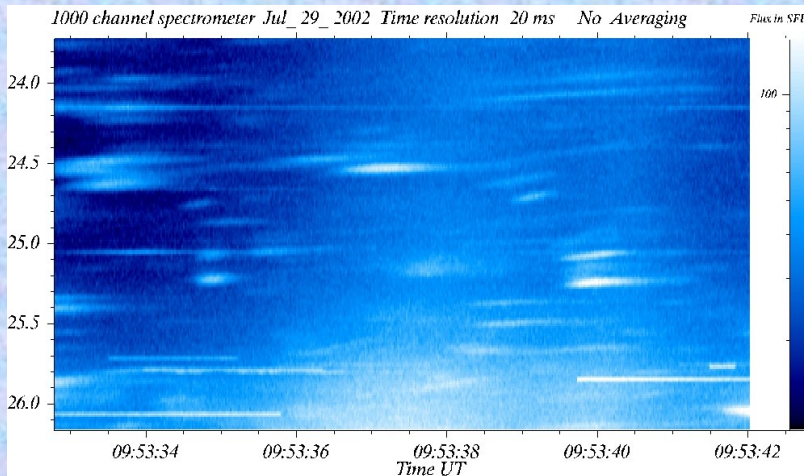
frequency band up to 10 MHz



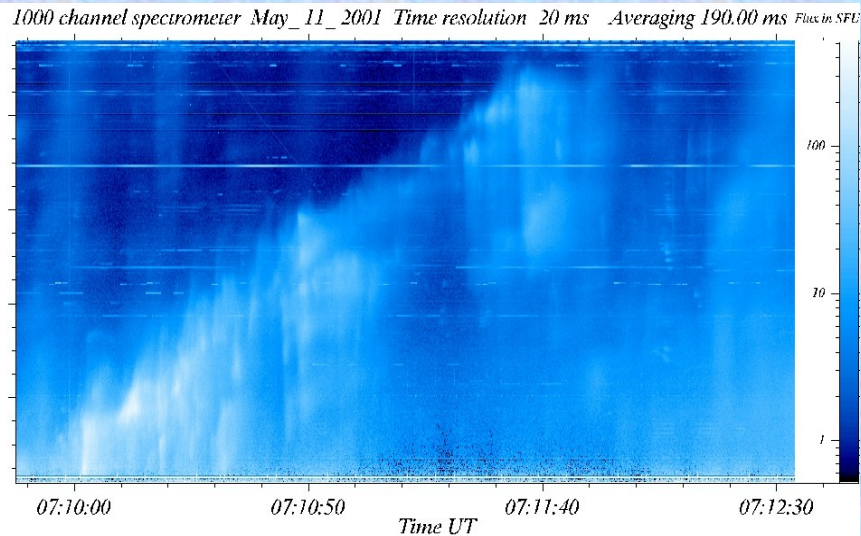
Decameter spikes



duration 1-1.2s
frequency band 70kHz
fluxes 1-1000 s.f.u.



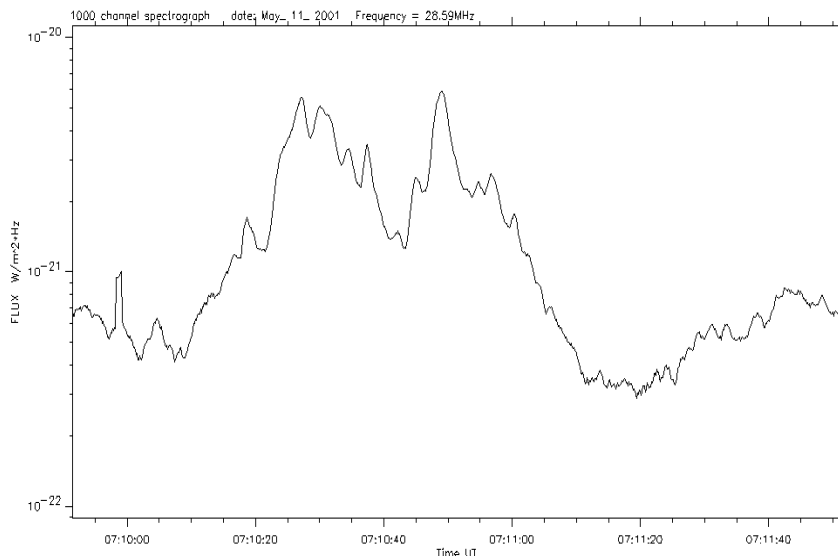
Type II bursts



Type II burst consists of lanes and has a fine structure in the form of sub-bursts

Type II drift rate $df / dt = -0.07 \text{ MHz} / \text{s}$

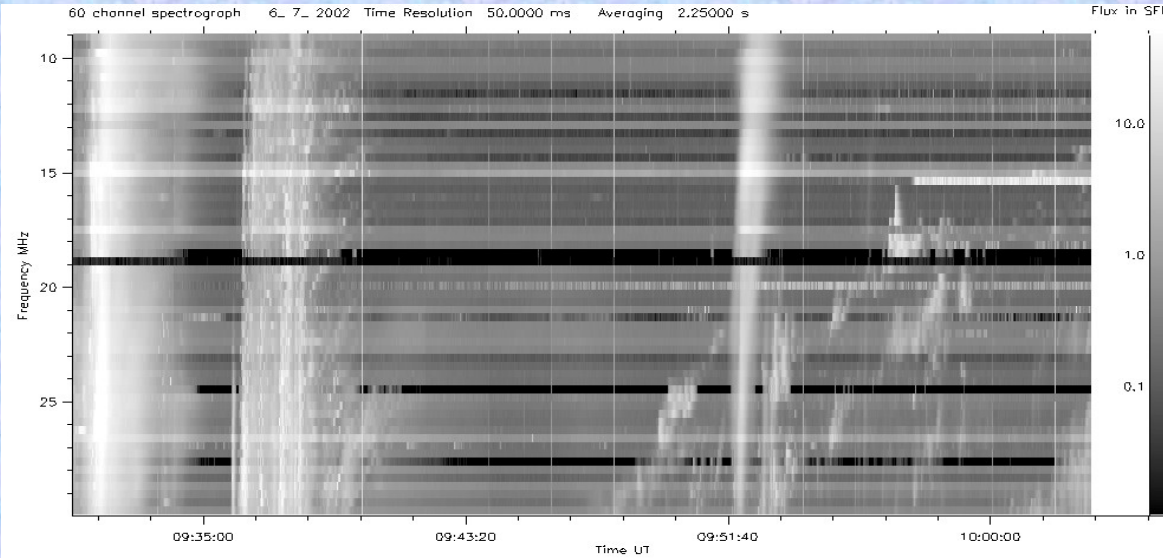
flux $S = 1 \div 5 \cdot 10^{-22} \text{ W} / \text{m}^2 \text{ Hz}$



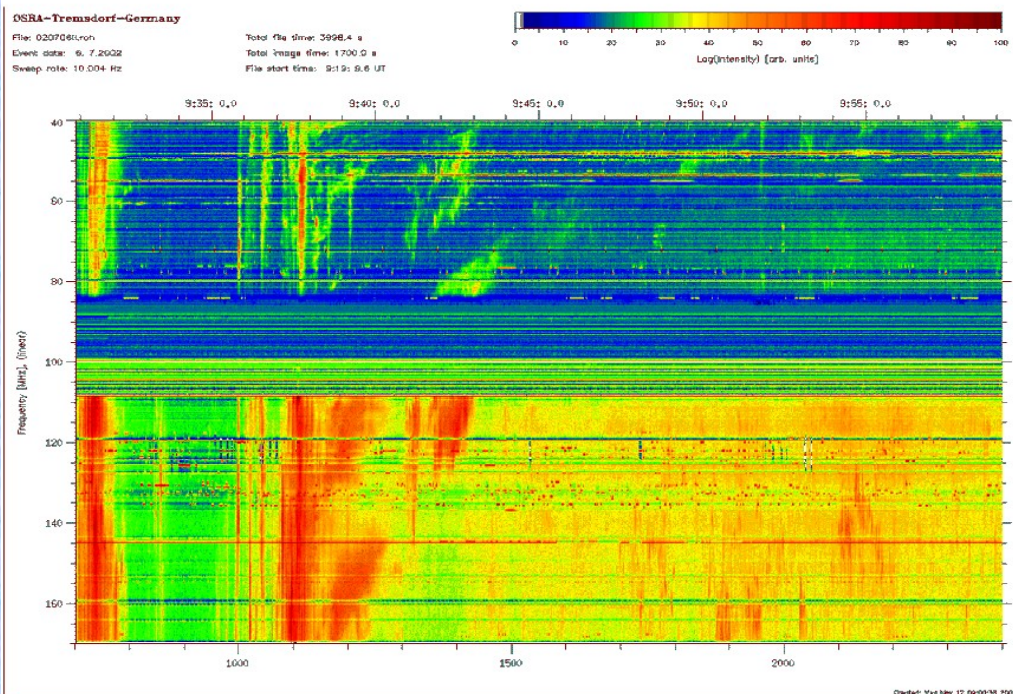
sub-bursts have **positive** and **negative** frequency drifts

$$|df / dt| = 1 \div 3 \text{ MHz} / \text{s}$$

sub-burst duration $\approx 1 \text{ s}$



Cloudy structure of Type II burst with fast drifting sub-bursts



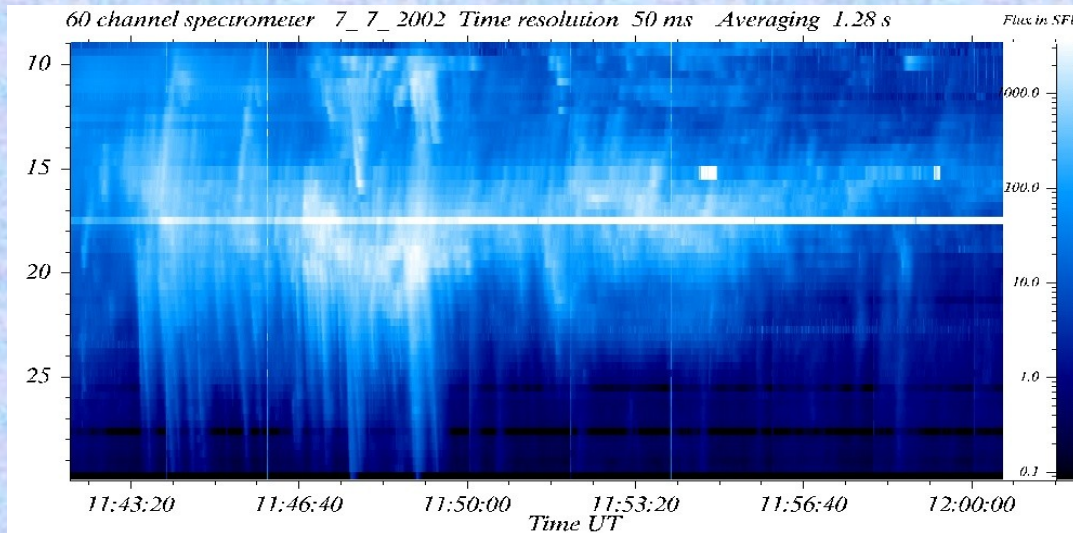
Type II drift rate

$$df / dt = -0.03 \text{ MHz} / \text{s}$$

flux

$$S = 10^{-19} \text{ W} / \text{m}^2 \text{ s}$$

Type II burst with herringbone structure



waving backbone
average drift rate

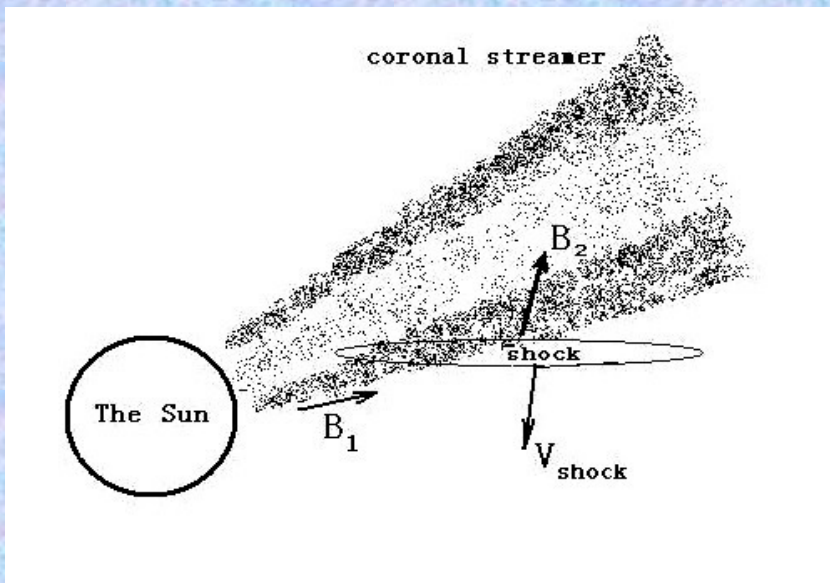
$$df/dt \approx 0$$

sub-burst durations

$$\Delta t = 3 \div 6 s$$

sub-burst drift rates

$$|df/dt| = 0.5 \div 1.5 \text{ MHz/s}$$

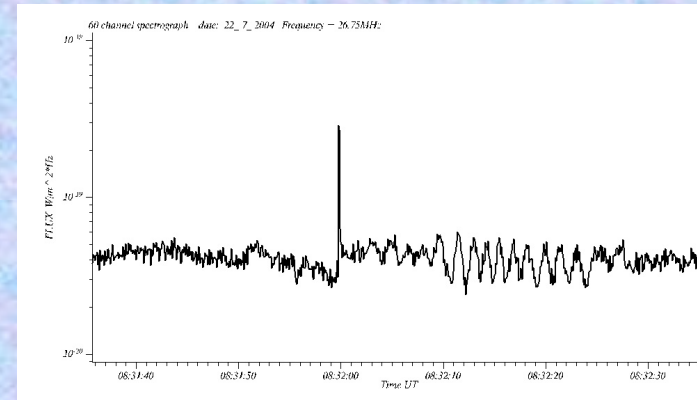
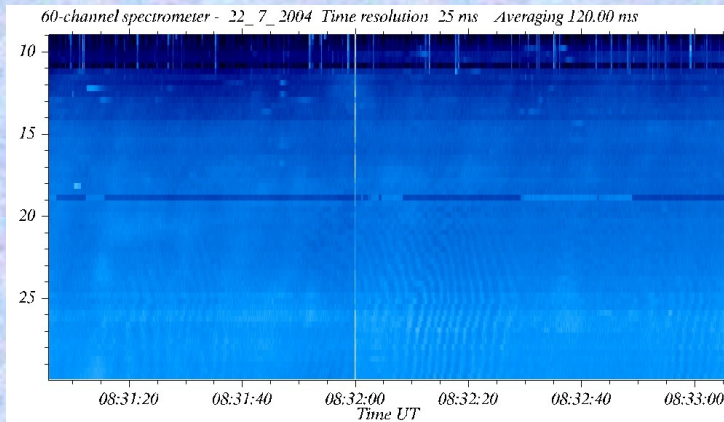
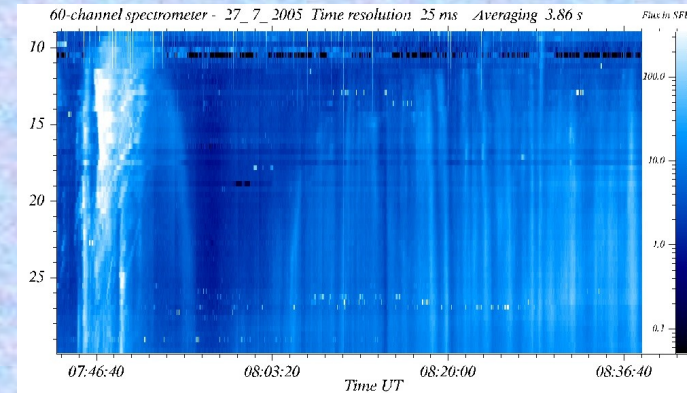
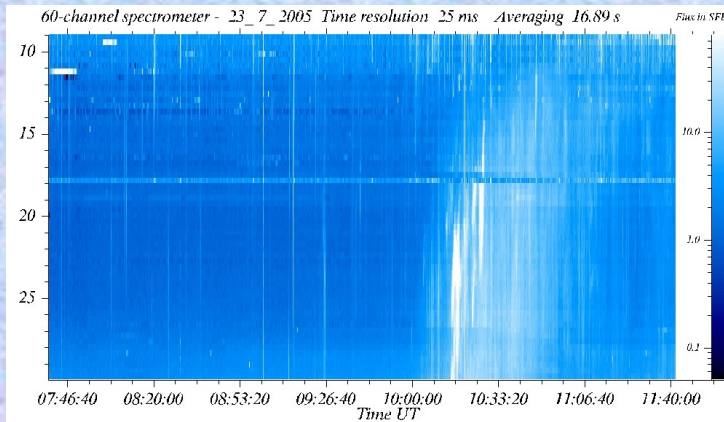


Coronal structure parameters
found from decameter radio
data

transversal sizes
of coronal structures $\approx 0.1 \cdot R_S$

density jump $\Delta n \approx 6 \cdot 10^5 \text{ cm}^{-3}$

Type IV bursts



duration >2 hours
drift rates 10kHz/s
fluxes 10-100 s.f.u.

Fine structure in the form of
- fiber bursts in emission and absorption
- zebra patterns

Conclusions

Observations at UTR-2 radio telescope with new back-end facilities allowed to observe **for the first time** :

- decameter Type II bursts at frequencies 10-30MHz
- fine structure of Type II bursts
- waving backbone of Type II bursts
- fine structure of Type III bursts
- Type III-like bursts
- decameter U- and J- bursts
- decameter Type IV bursts (fiber bursts, zebra-pattern, bursts in absorption)
- decameter s-bursts
- spikes
- difference of drift pairs with positive and negative rates and fine structure of drift pairs