Search of the flare stars radio emission in the frequency range of 16.5 – 33 MHz

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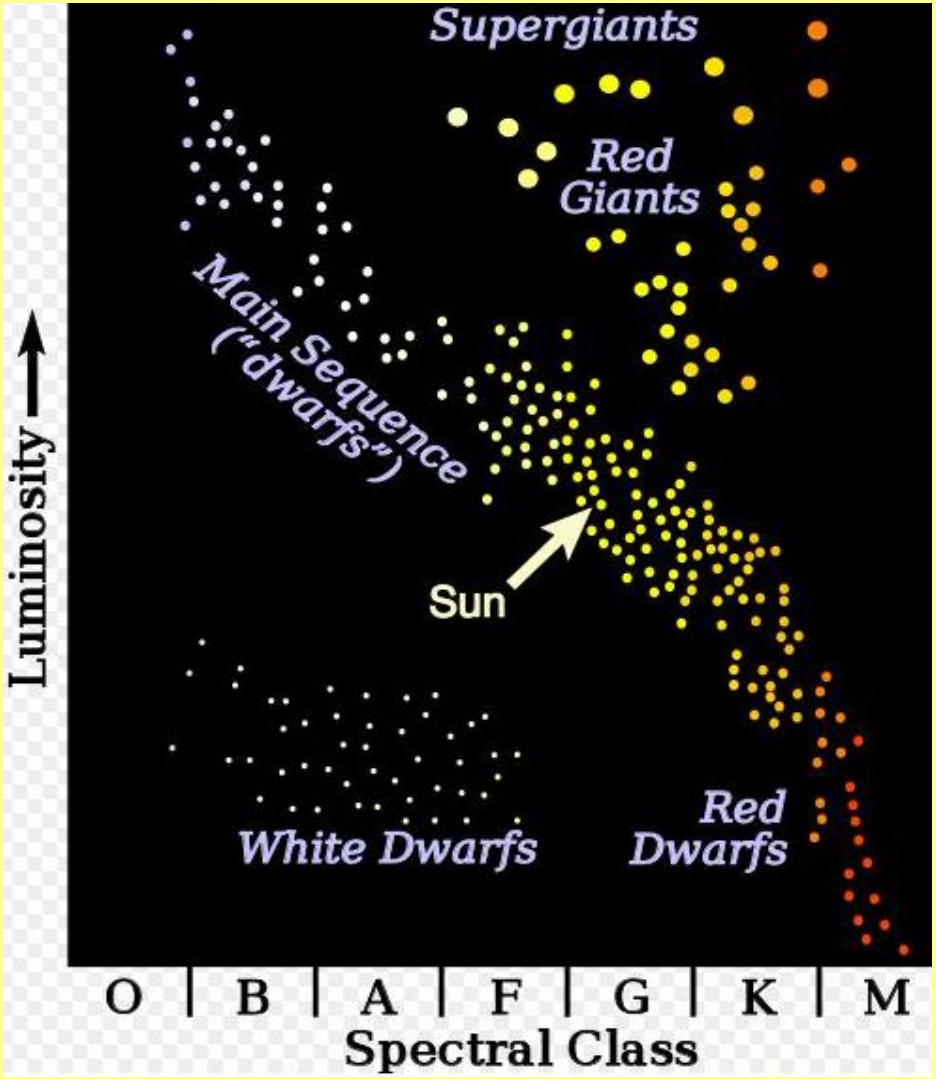
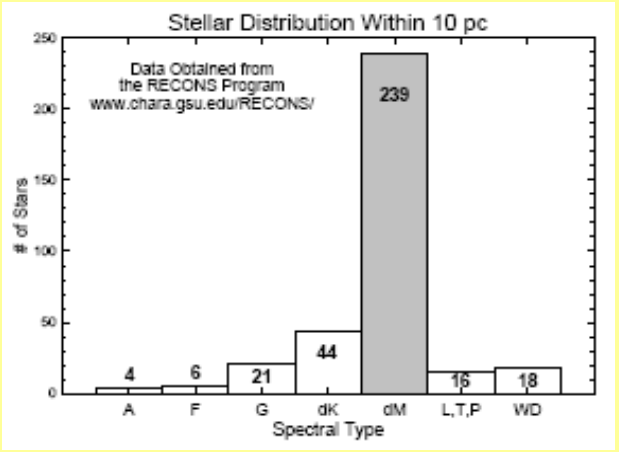
General information



Red dwarf flaring stars are objects of the lower part of Main Sequence of the Herzsprung-Russell diagram. The sporadic transient powerful flares are taking place on these stars.



More than 80 flare stars are known at the present time; more than half lie within 10 pc of the Sun.

The terms "flare star", "red dwarf" and "dMe star" are often used interchangebly.

General information

General properties of the star first of all are defined by its mass, radius and luminosity.

the red dwarfs

$R = 0.1 \div 0.8\ R_{Sun}$

$m = 0.06 \div 0.6\ M_{Sun}$

$t = 10^{5} \div 10^{10}$ years

$I = 0.01 \div 0.4\ I_{Sun}$

$T_{eff} \approx 3500K$

the Sun

$R_{Sun} = 7 \cdot 10^{10}$ sm

$M_{Sun} = 2 \cdot 10^{33}$ g

$t \approx 10^{7}$ years

$I_{Sun} = 3.9 \cdot 10^{33}$ erg/s

$T_{eff} \approx 5700K$

Historical overview

1924 – the phenomemon of stellar flares was discovered accidently by Hertzsprung.

1949 – Joy called attention to similar transient outbursts on UV Cet, YZ CMi, and WX UMa. UV Cet has since come as the prototype of flare stars.

Since end of 40th systematical researches of these stars were carried out.

September, 29, 1958 – first radio flare from UV Cet was registered by Lowell. 76-meter parabolic antenna was used.

By **1976** the number of flare stars were more than 70.

In the period of **1986 - 1995** Abranin and his group observed radio emission from stars AD Leo and EV Lac with the radio telescope UTR-2 at decameter wavelengths. They registered events, which were considered as bursts from flare stars, but they detected a small number of events and it was at 3 separated frequencies of the frequency range of 10 – 30 MHz.

Observations

Radio emission from flare stars in the range of 16.5 – 33 MHz was registered with the **radio telescope UTR-2 (Kharkiv, Ukraine)** during observational campaigns of 2009 – 2011

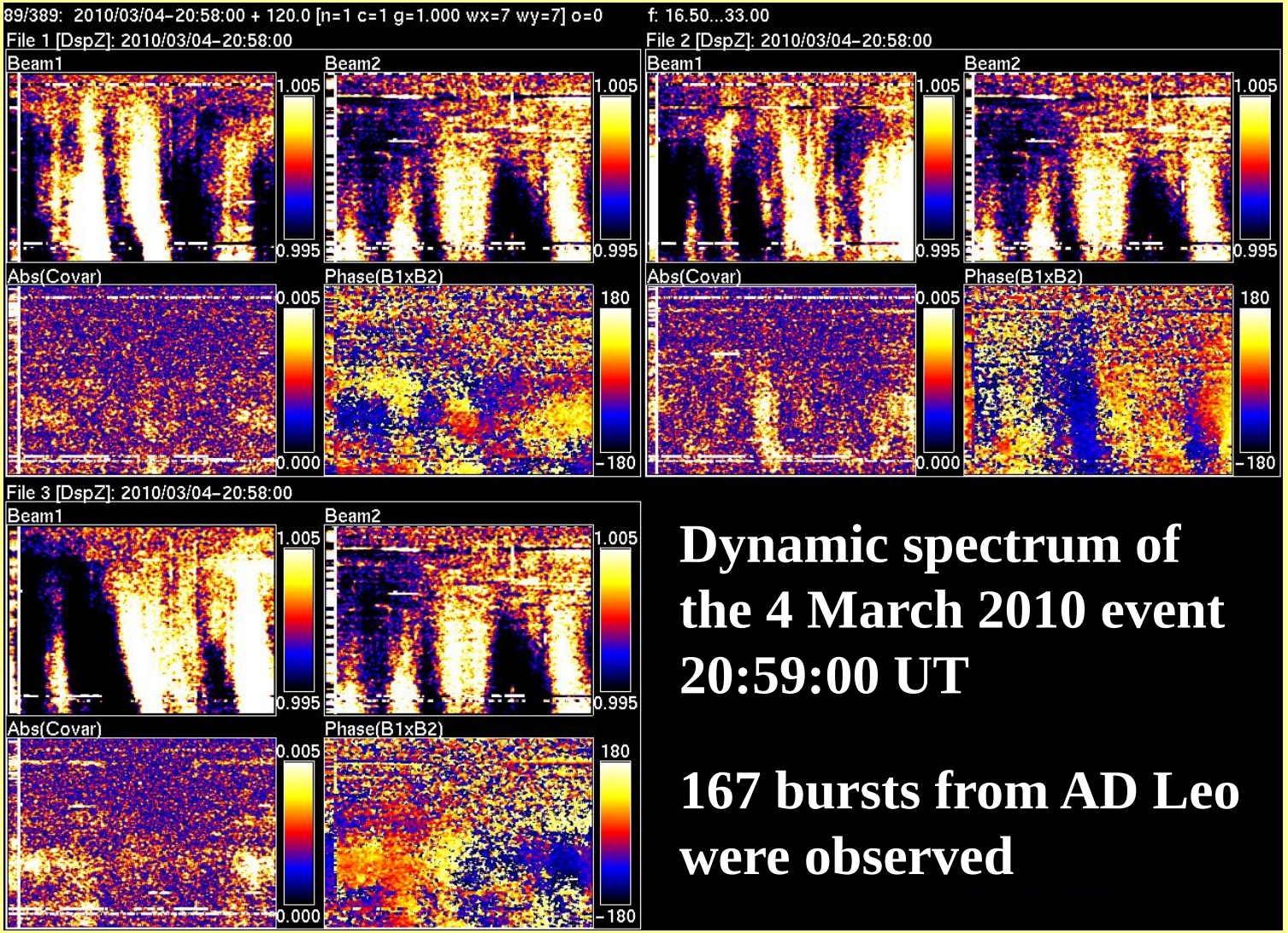
AD Leonis – 16-20 February 2009,
1-5 March 2010,
1-6 March 2011.

Time of observations 19.00 – 3.00 (local time=UT+3)

In UTR-2 observations three sections of the radio telescope with a total area of 30000 m^2 were used. It provides the beam of $1^o x 13^o$. Registrations were carried out with the DSP-Z (Digital Spectral Polarimeter) with high frequency (4 kHz) and time (100 ms) resolution.

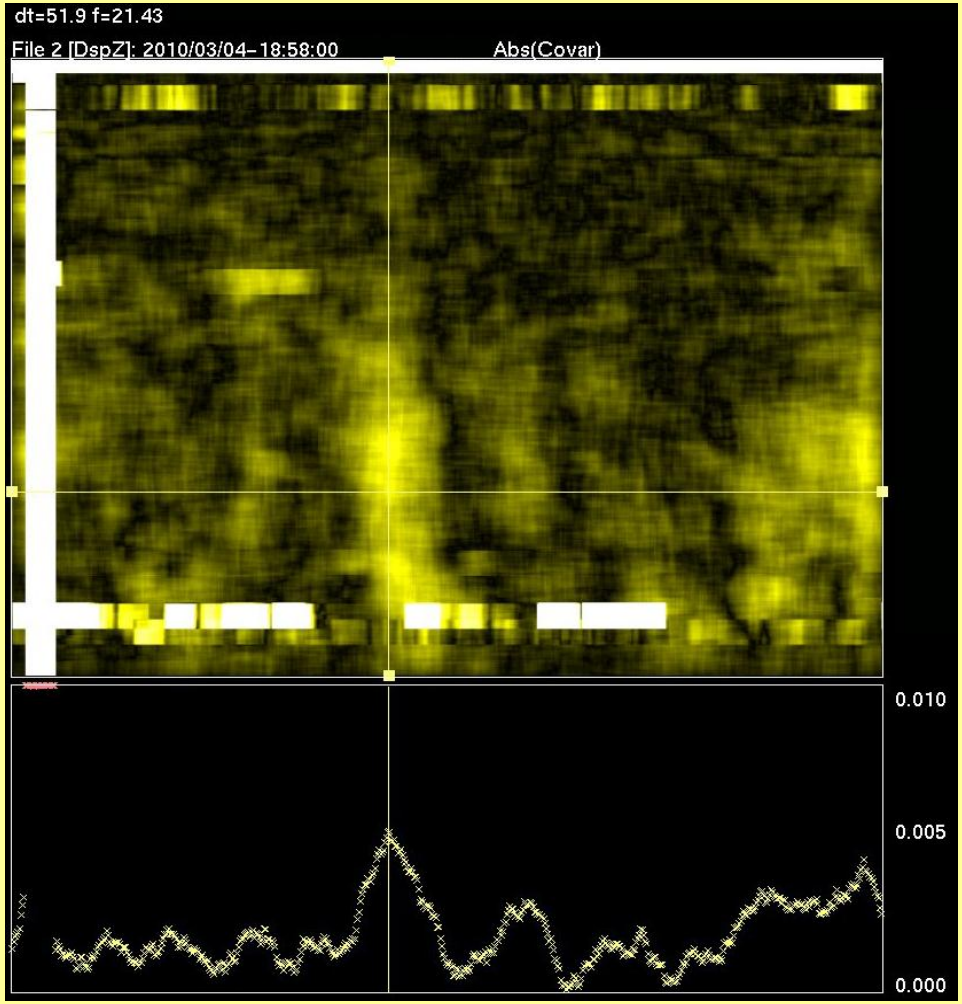
Pictures of the radio telescope UTR-2

ON – OFF method

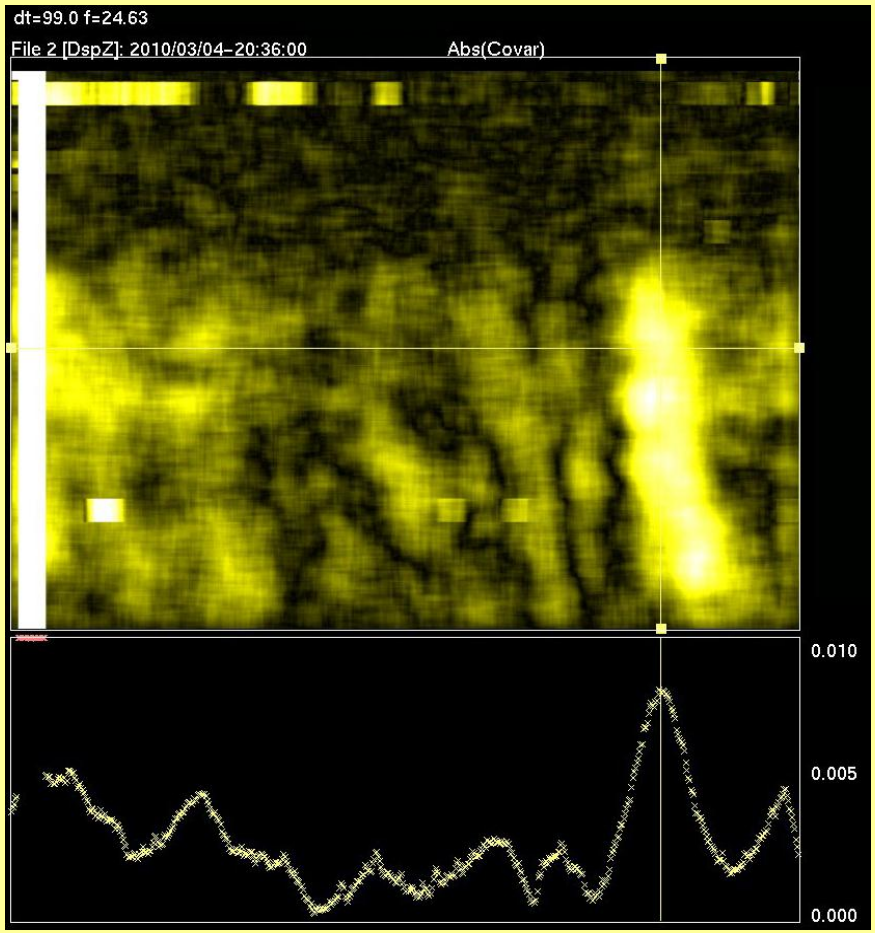


Three beams of the radio telescope were used (Beam 1, Beam 3 and Beam 5).
For each beam we have 4 images – radio emission, which were received with the North – South antenna, radio emission, which were received with the East – West antenna, cross-spectrum and phase spectrum of signal.

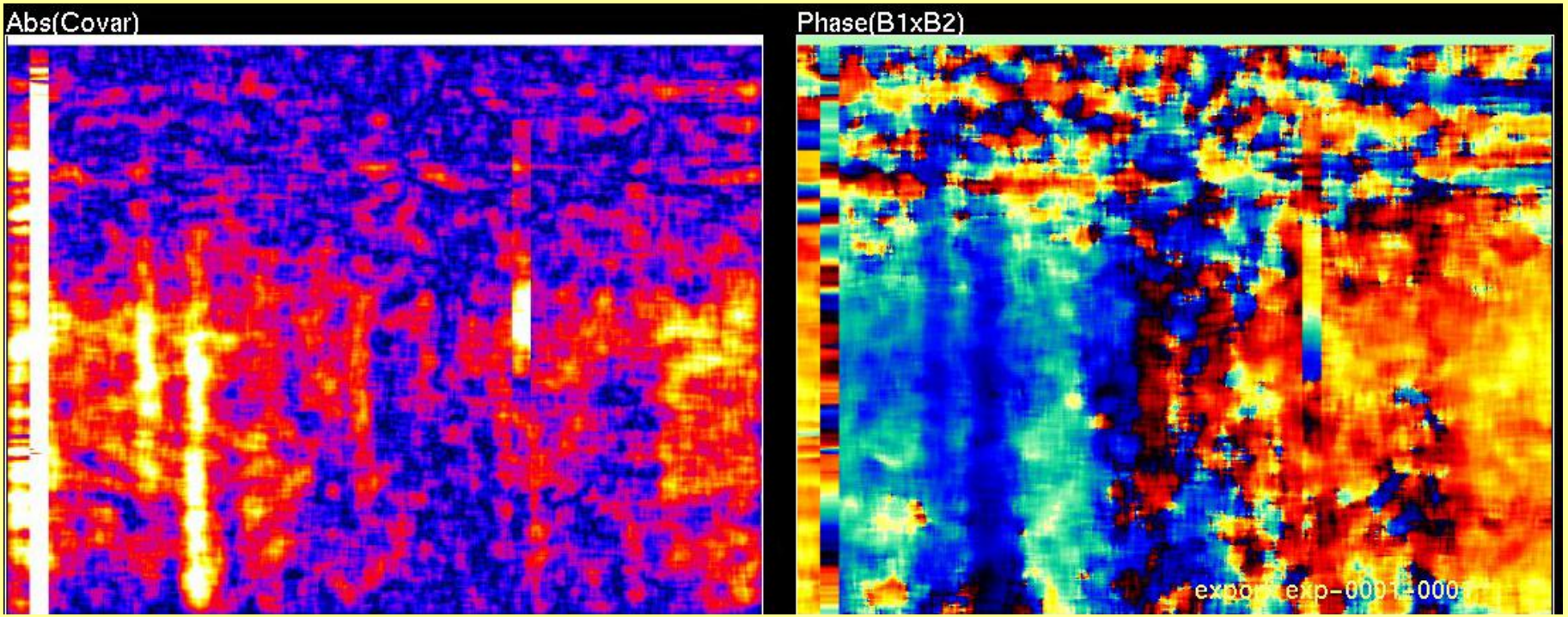
Results



Large number of the time profiles of observed bursts are either **not symmetrical wtih fast rise and slow decay** of the profile, or **symmetrical**

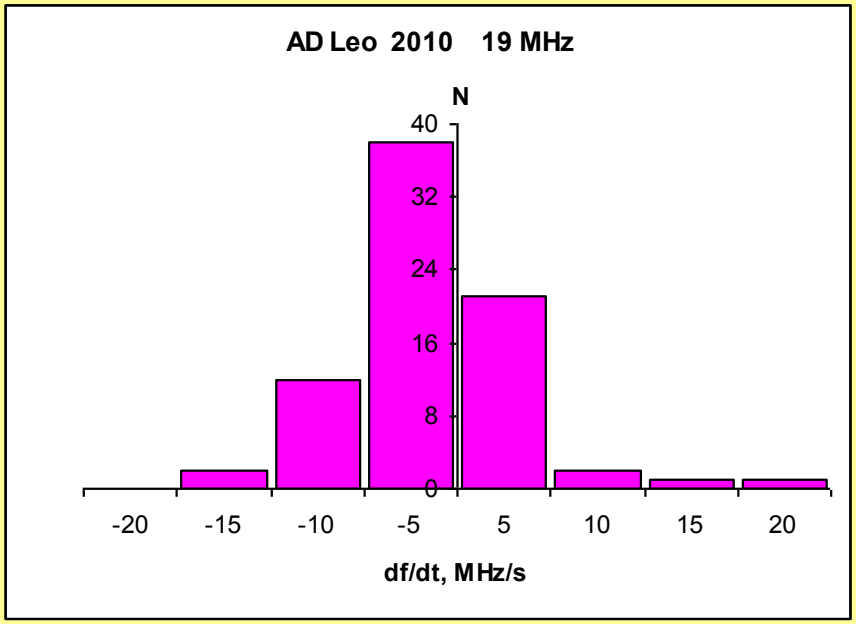


Results

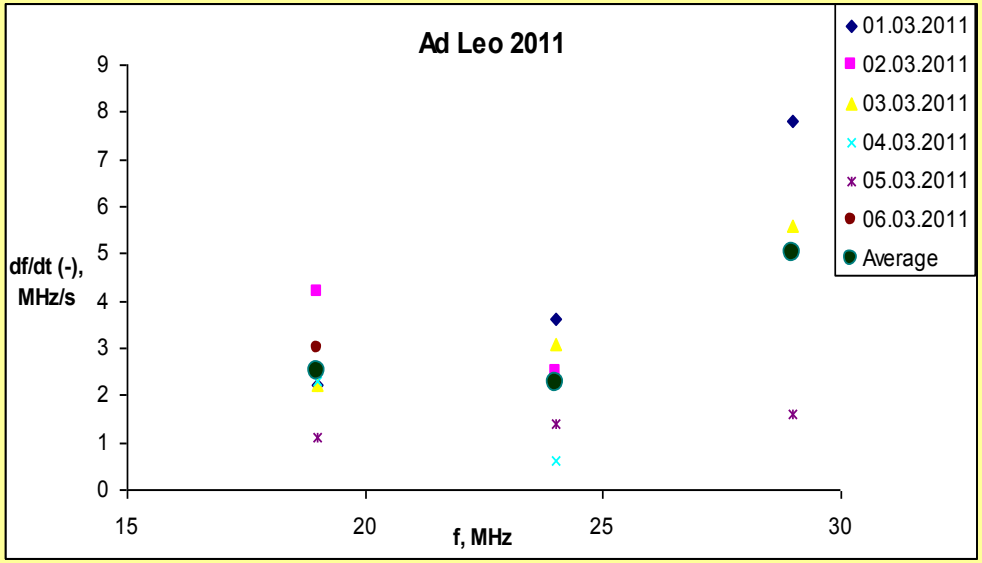


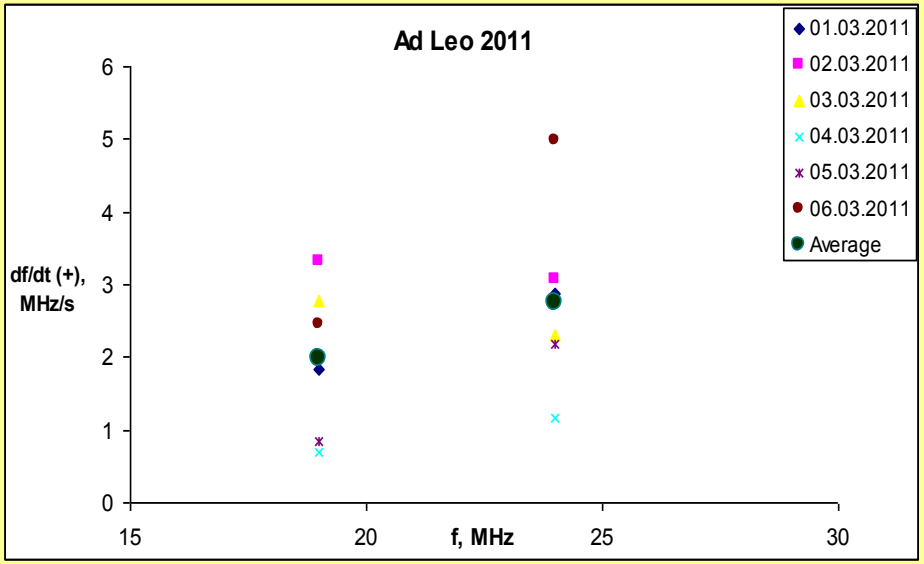
The highest number of the bursts were isolated,
but several events with burst pairs,
and even groups of bursts were observed.

Results. Frequency drift rate.



According to our observations flare star bursts have **both positive and negative frequency drifts**.
Negative frequency drift rates are in the range of **0.2 – 5 MHz/s**,
positive one ranged **from 0.2 to 4.2 MHz/s**.
There are several events with changing of drift rate sign.

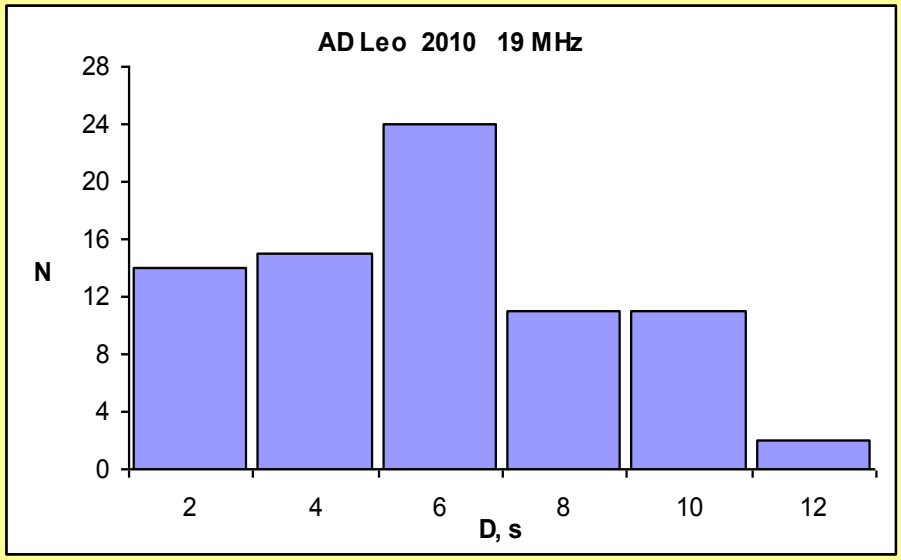




Negative Positive

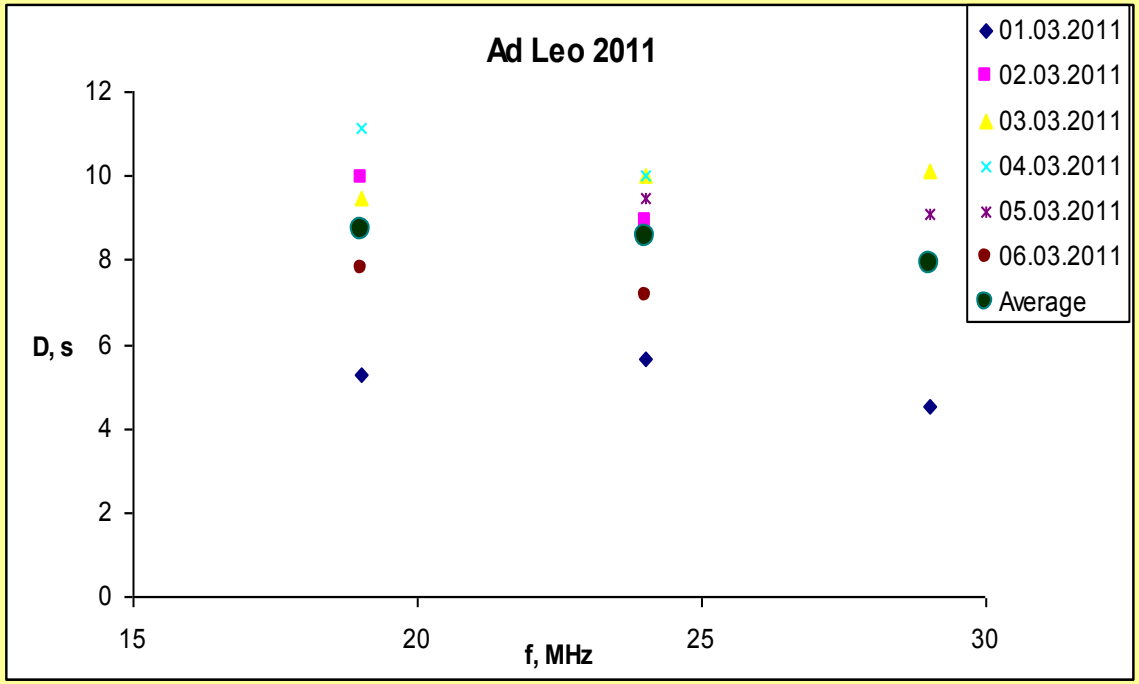
average drift rate dependence on frequency

Results. Duration.



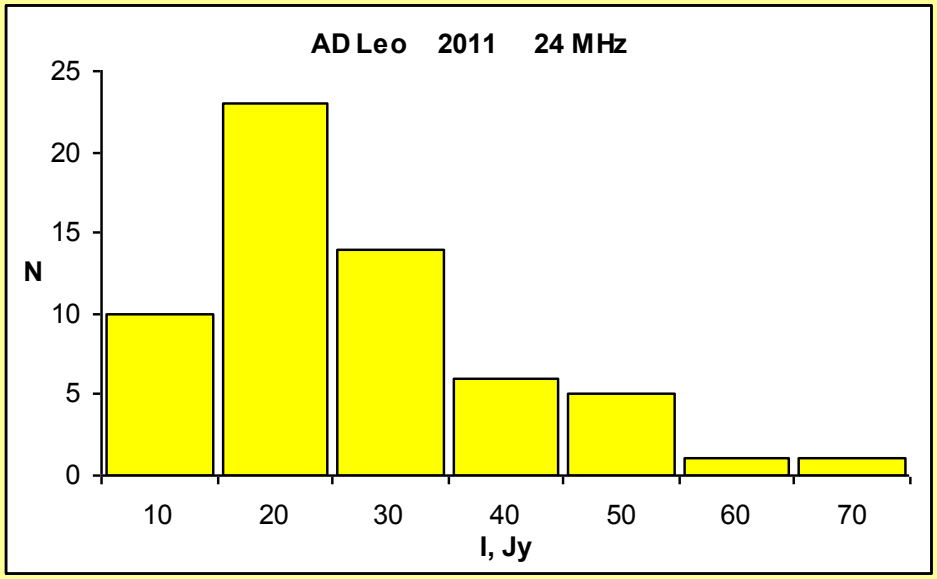
The duration of flare star bursts is in the range of **2 – 12 s**.

Duration has a **small decreasing with frequency**, and in some cases there are no duration changes with frequency.



Average duration dependence on frequency

Results. Flux.



One of the important charasteristics of flare stars radio emission is flux.

For AD Leo the lowest flux value was of 4 Jy, while the highest value of flux was of 307 Jy.

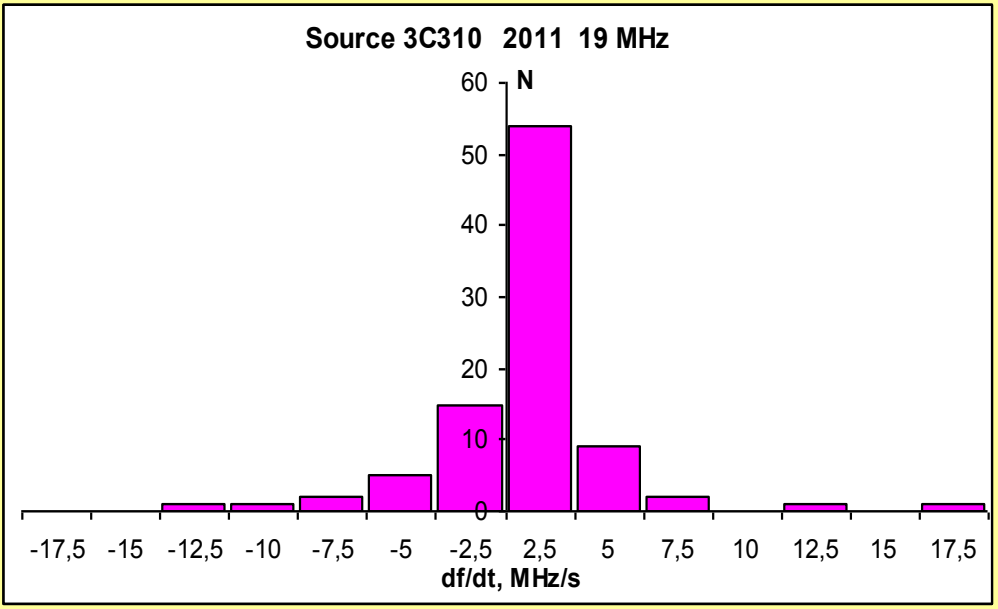
The average range of flux is of **10 – 50 Jy**.

Brightness temperatures of radio emission from AD Leo **are equal to** $(1.2 \div 5.8) \cdot 10^{16}$**K**.

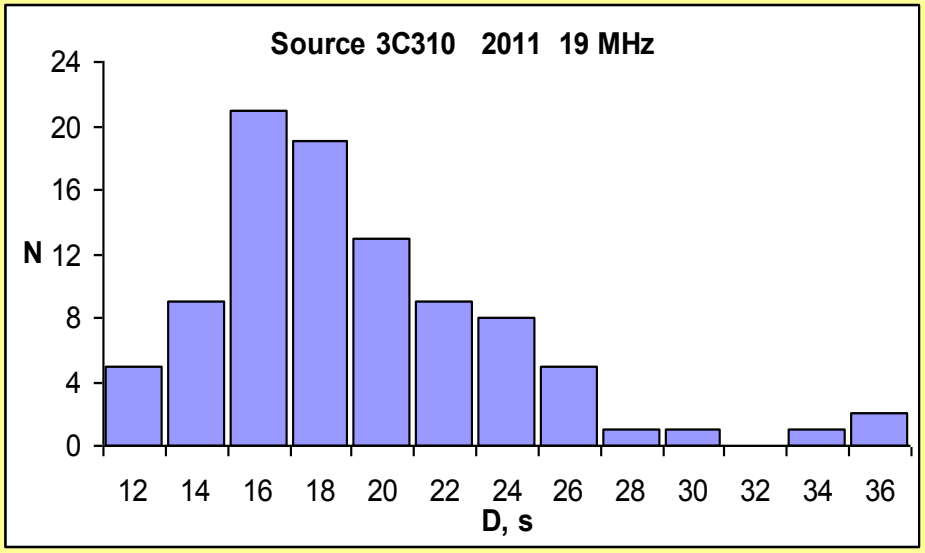
This fact is the evidence for **non-thermal generation mechanism of radiation** from flare stars .

Continuous source 3C310

Time of observations 3.00 – 7.00 (local time=UT+3) **148 events**



Events observed from **3C310** have both positive and negative frequency drift rates, but the largest number of **frequency drift rates are positive** and is of **0.1 – 2.5 MHz/s**.

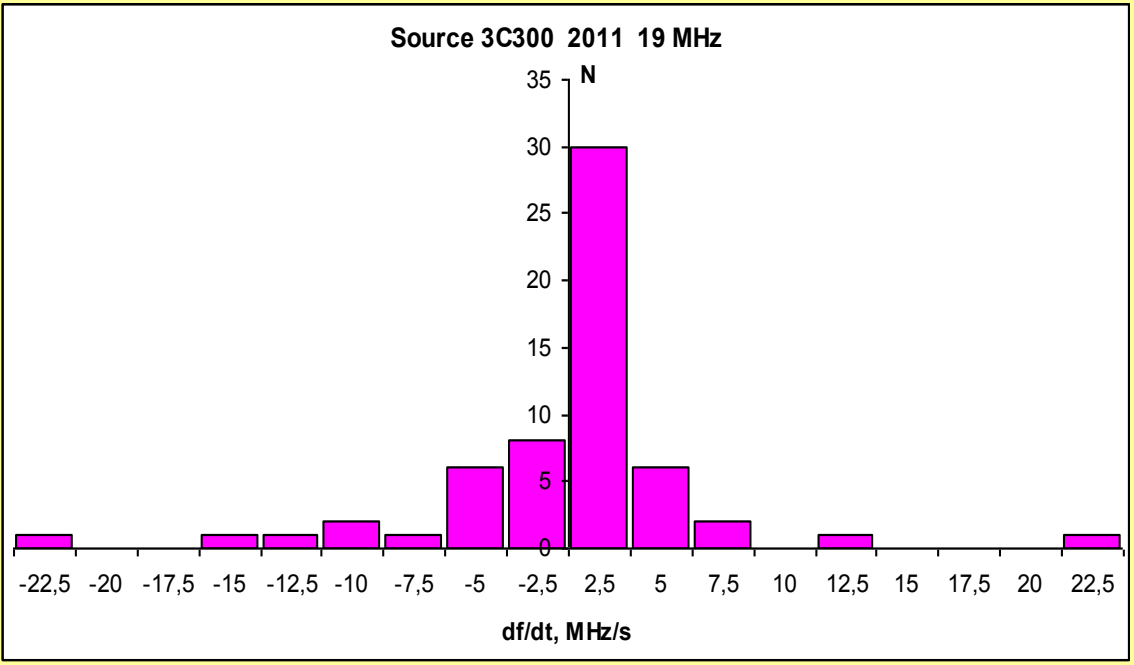


Events have fluxes of **50 – 350 Jy**. Some rare events have higher values of flux (even about 1300 Jy).

Durations of events from 3C310 are of **12 – 26 s**.

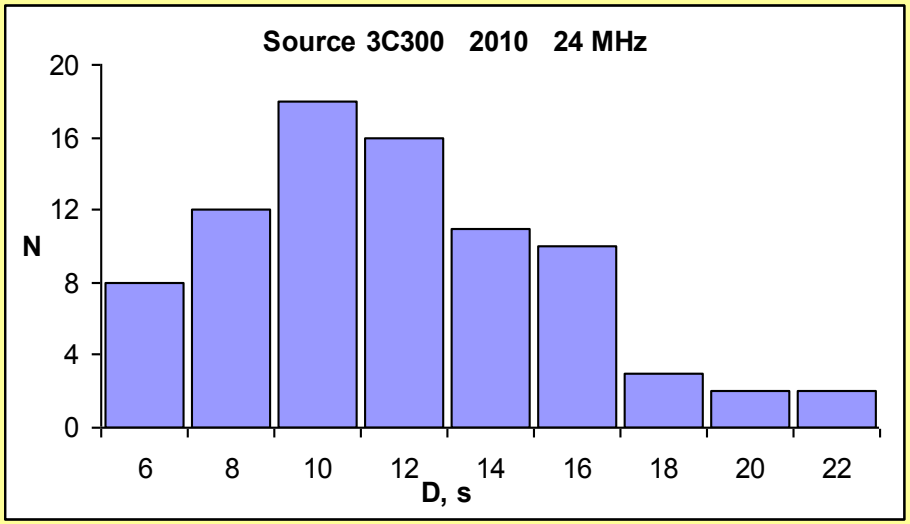
Continuous source 3C300

Time of observations 3.00 – 7.00 (local time=UT+3) **149 events**



Events of radio emission registered from **3C300** have also both positive and negative drift rates.

The distribution of events on frequency drift rates is very wide, but it has **well-defined maximum** for events with **positive drift rates of 0.3 – 5 MHz/s**.



Fluxes of events are of **20 – 500 Jy**, the most powerful event with flux of about 1700 Jy was registered at frequency 19 MHz.

Events durations are of **8 – 16 s**.

Conclusions

1. Observations with unique sensitivity, high time and frequency resolutions allowed to look for flare stars radio emission and its properties at lowest frequencies with ground-based radio telescope UTR-2.
2. The main properties (frequency drift rate, duration, flux) of the AD Leo bursts at decameter wavelengths (16.5 – 33 MHz) were analyzed.
3. Criteria to single out AD Leo events from events of ionospheric propagation were used:
   - ON-OFF method,
   - resemblanse (visual, characteristics) of events with solar type III bursts,
   - difference between parameters of events from AD Leo and continuous sources


Thank you for attention!