

# **Heart Rate Variability Saga**

**N.I.Yabluchansky**

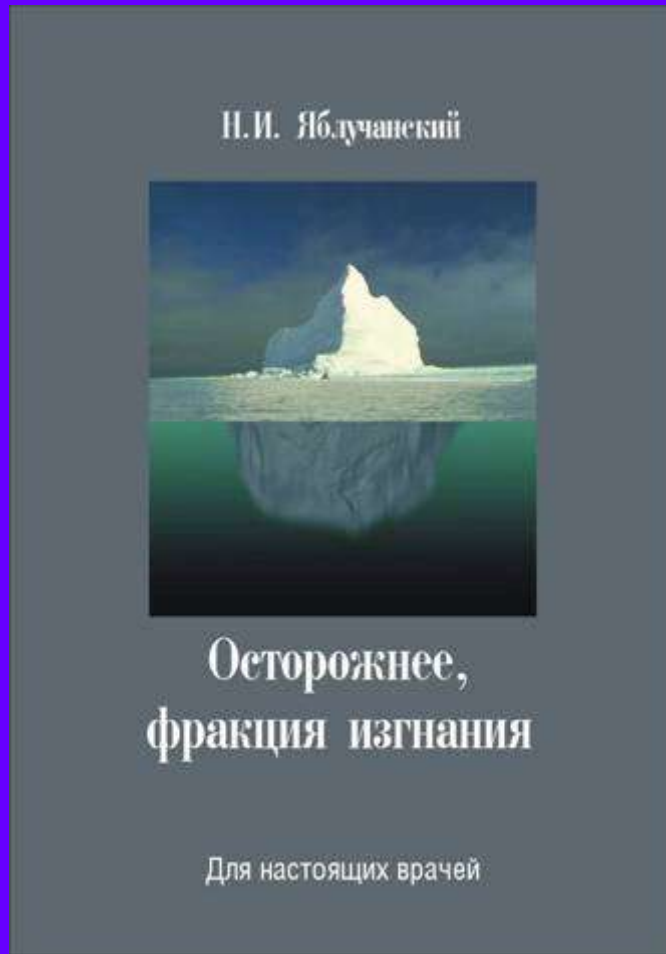
# History tribute

- HRV is a well - known phenomenon and the up-to-date technology.
- Prognostic value since the Meyer's waves discovery.
- Physiological mechanisms - R.M. Bayevskiy.
- Intensification of applications since 70th after the introduction of personal computers.
- 1981- the power spectral analysis methods application, the establishment of prognostic value in AMI.
- The recent elaborations – the methods of the mathematical theory of chaos, mathematical modelling, independent components, other

# About the Supporters, Opponents and Golden Mean

- Supporters - fetishization.
- Opponents - negation.
- Golden mean - the common sense

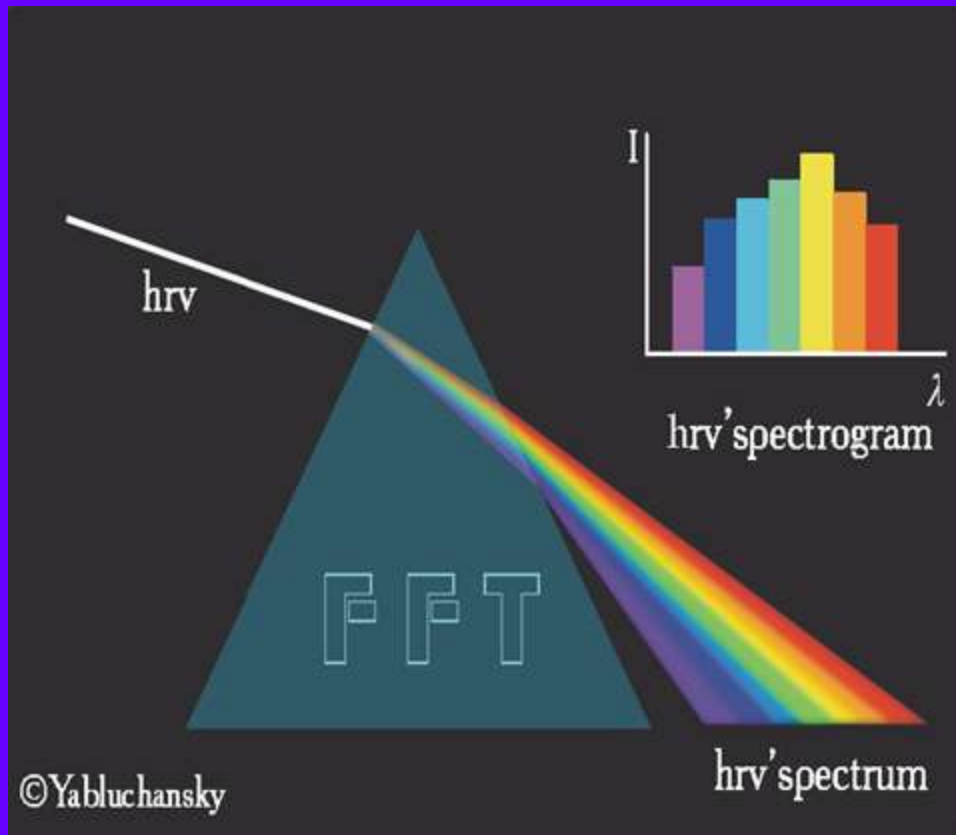
# SAGA – a song about the golden mean.



- HRV - the iceberg.
- The iceberg has two parts.
- For the supporters - above-water.
- For the opponents - underwater.
- “The golden mean” - iceberg as the phenomenon

## What is HRV?

(physical sense under the microscope of power spectral analysis).



- Superposition of elementary functions.
- Elementary functions are connected with the regulation systems (and not only with the sinus rhythm).
- Higher frequencies are more typical] for the parasympathetic link, average frequencies – for sympathetic link, and low frequencies - to humoral link of NHR

# What is HRV?

(clinical sense).

- HRV is totality of all its properties, from the changeability of the momentary period of the heart contractions to its reasons, caused and determined by the nonlinearity of sympathetic, parasympathetic and humoral regulation by their ramified connections between each other, with the subcortical and cortical formations, and also reactions to the mental, physical and other forms of stress

# we believe

- ● HRV – is a “mirror” of the regulatory systems (in the influence on the heart).
- ● HRV – is a “mirror” of all the regulation links.
- ● High-frequency spectra - gravity to the parasympathetic regulation.
- ● Average (low-) frequency spectra - gravity to the sympathetic regulation.
- ● Ultra-low frequency spectra - the long-term gravitating to the humoral regulation.
- ● HRV - the measure of the common level of health.
- ● HRV - the genetically determined individuality [individual peculiarity] of NHR.
- ● HRV - the predictor of cataclysms.
- ● HRV - the effective tool of the control of medical interferences.
- ● HRV - the remarkable technology !

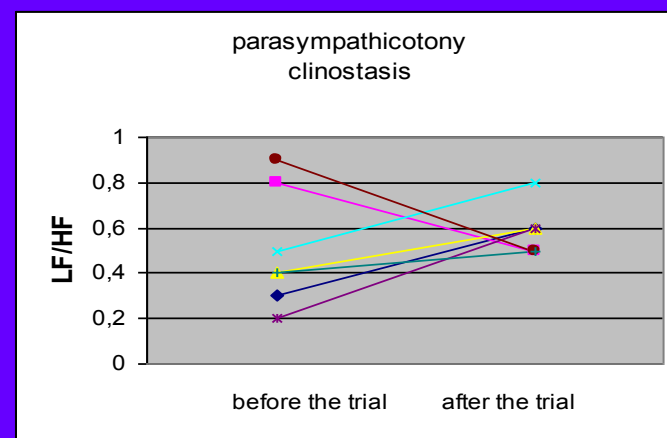
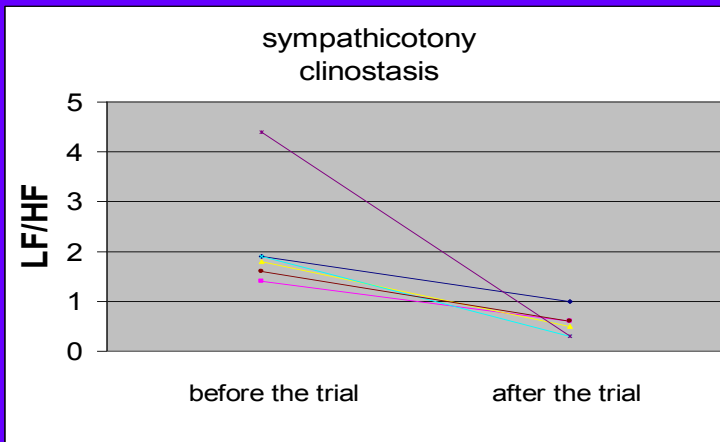
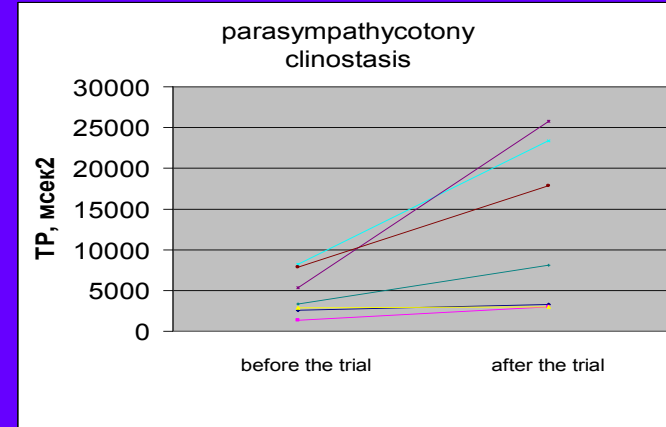
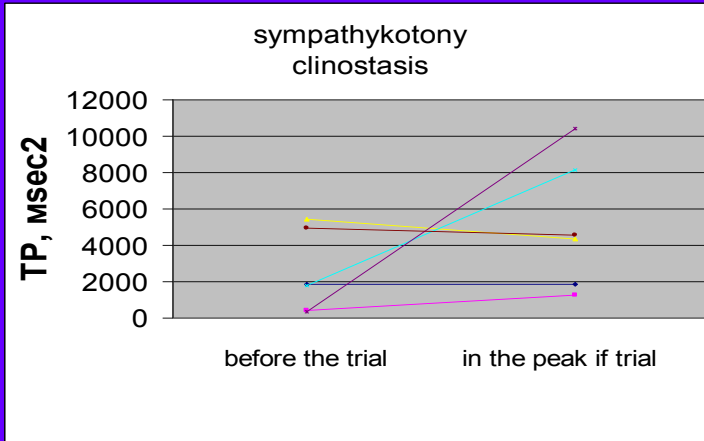






# HRV and genetic determination of the regulation

## HRV reactions are exclusively individual

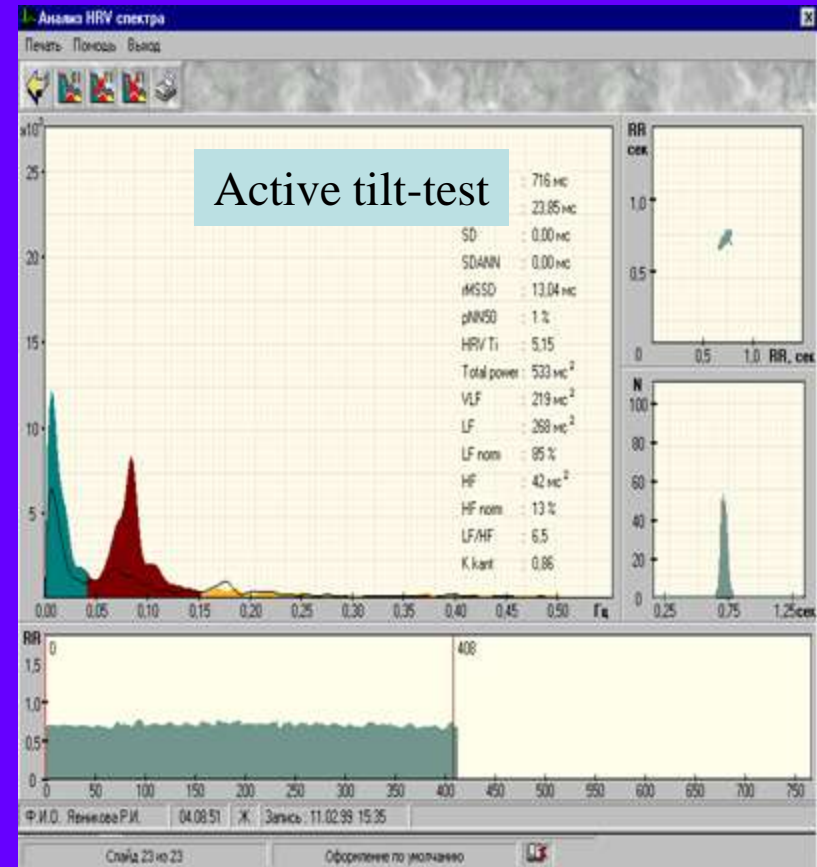
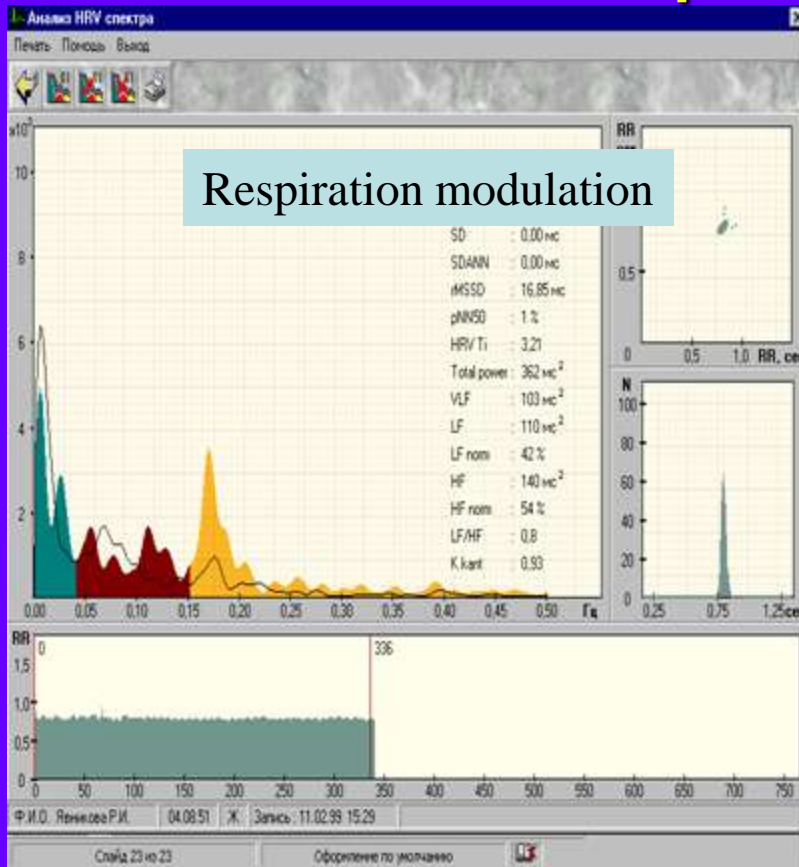


# we do not believe.

- High-frequency spectra - parasympathetic regulation in the pure form.
- Low-frequency spectra - sympathetic and/or sympatho-parasympathetic regulation in the pure form.
- Extremely low-frequency spectra - the long-term gravitating to the humoral regulation in the pure form.
- HRV - the independent predictor of cataclysms.
- HRV - limitation by sinus rhythm

# HRV - the echo of regulatory processes

## The simplest standard tests



The respiration modulation increases the high-frequency power; and active tilt-test –low-frequency domain

*Please, pay your attention: both trials have an influence on structure and power of all spectral components!*

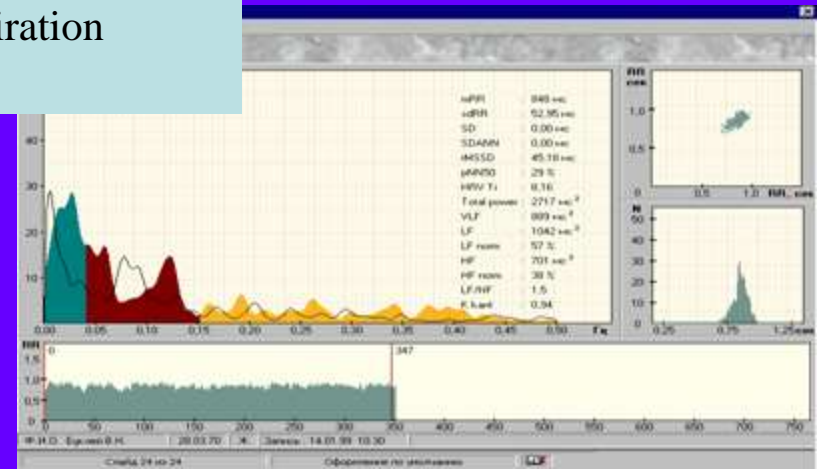
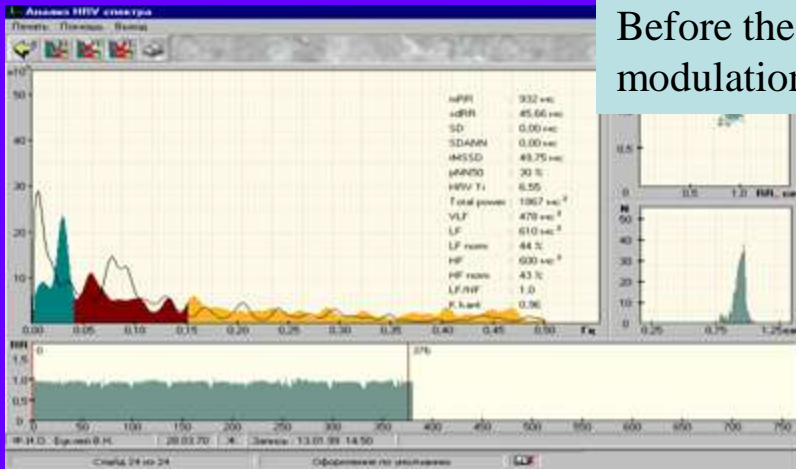
# HRV - the echo of regulatory processes

## The “deformation” of the results of the simplest standard tests with medicines

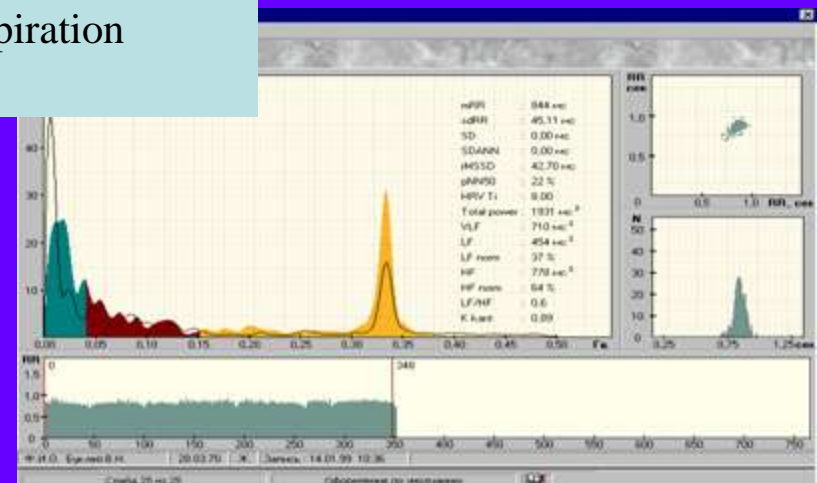
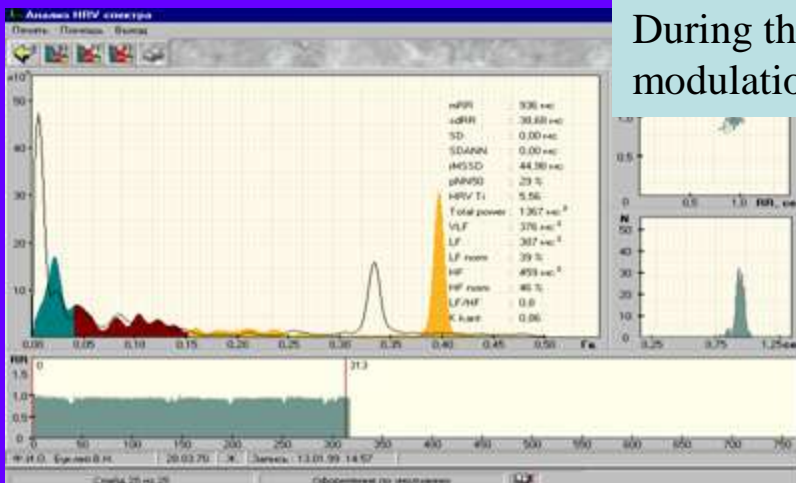
theophedrin

propranolol

Before the respiration modulation

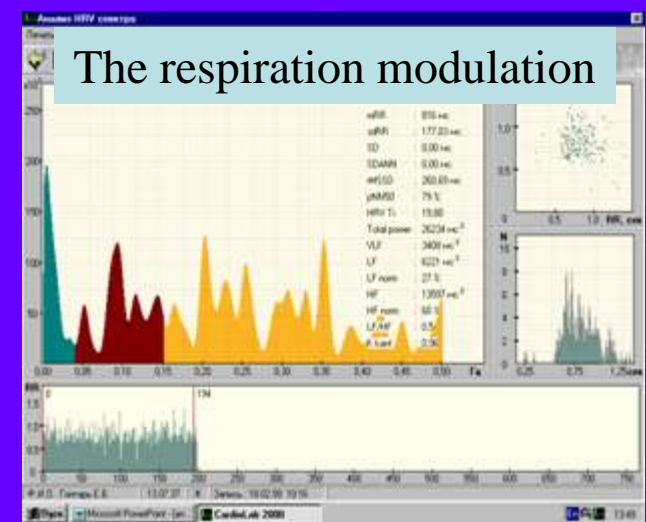
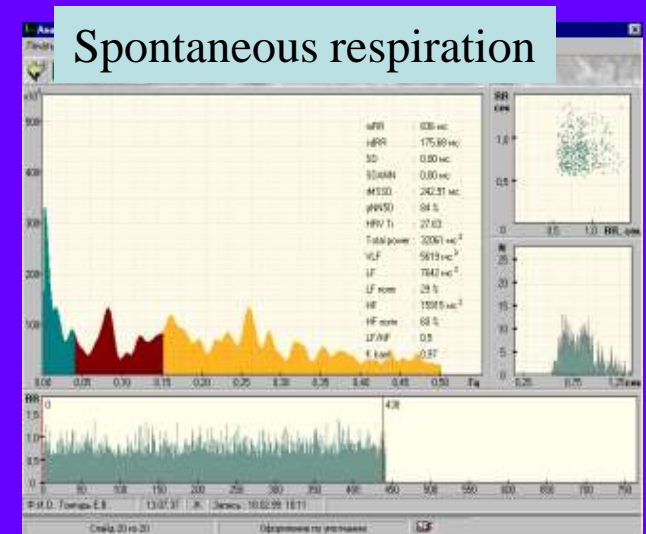
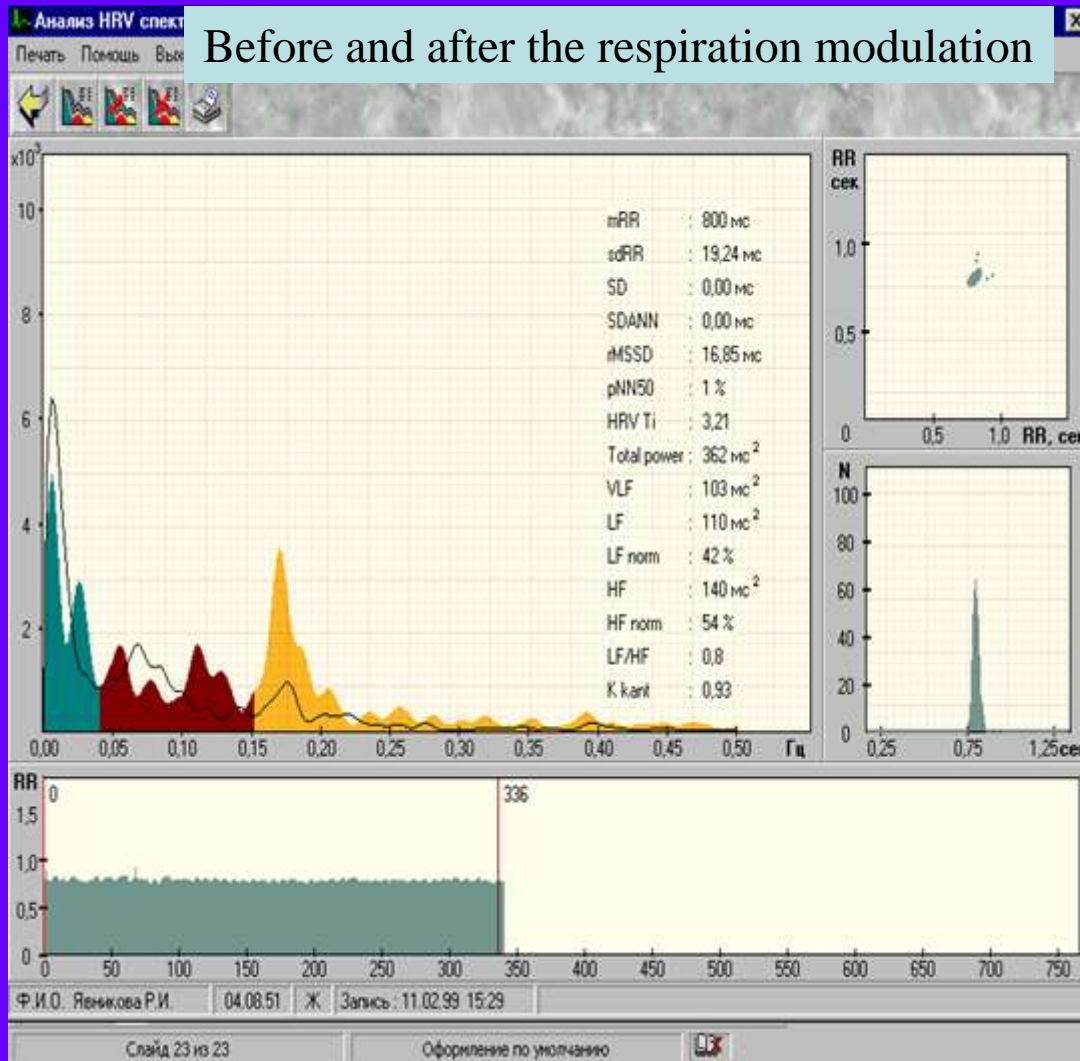


During the respiration modulation



# HRV - the echo of regulatory processes

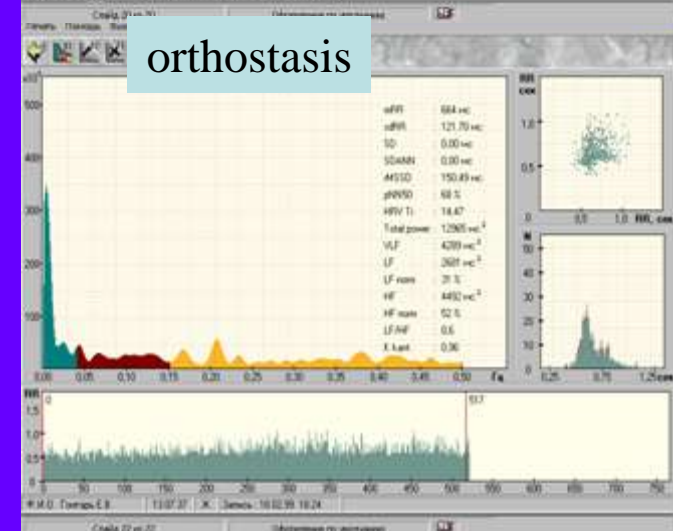
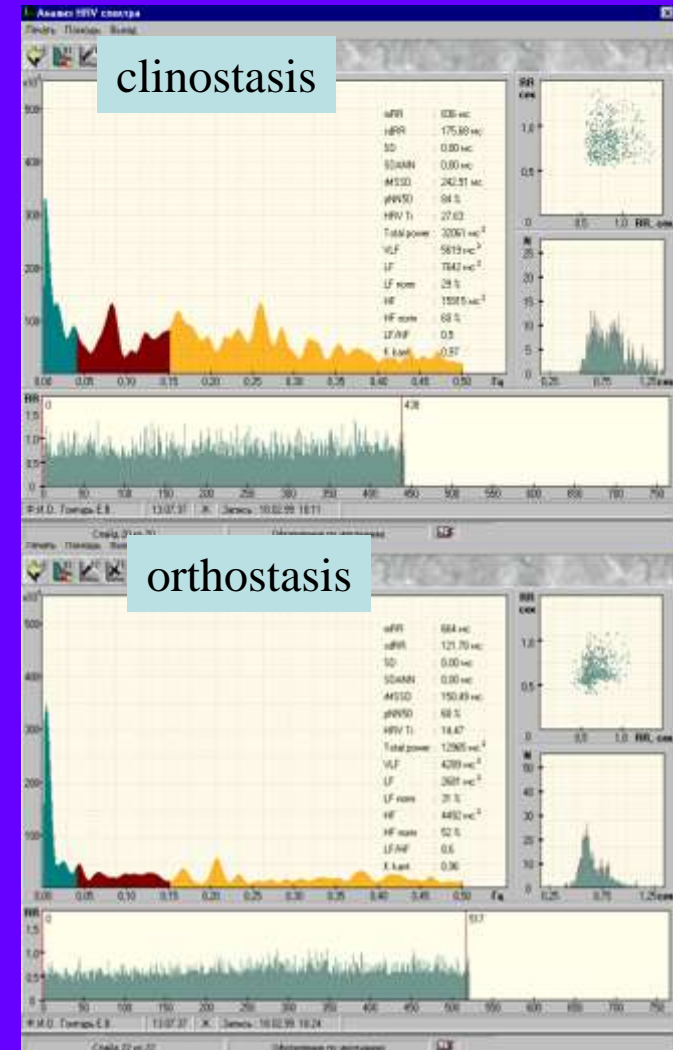
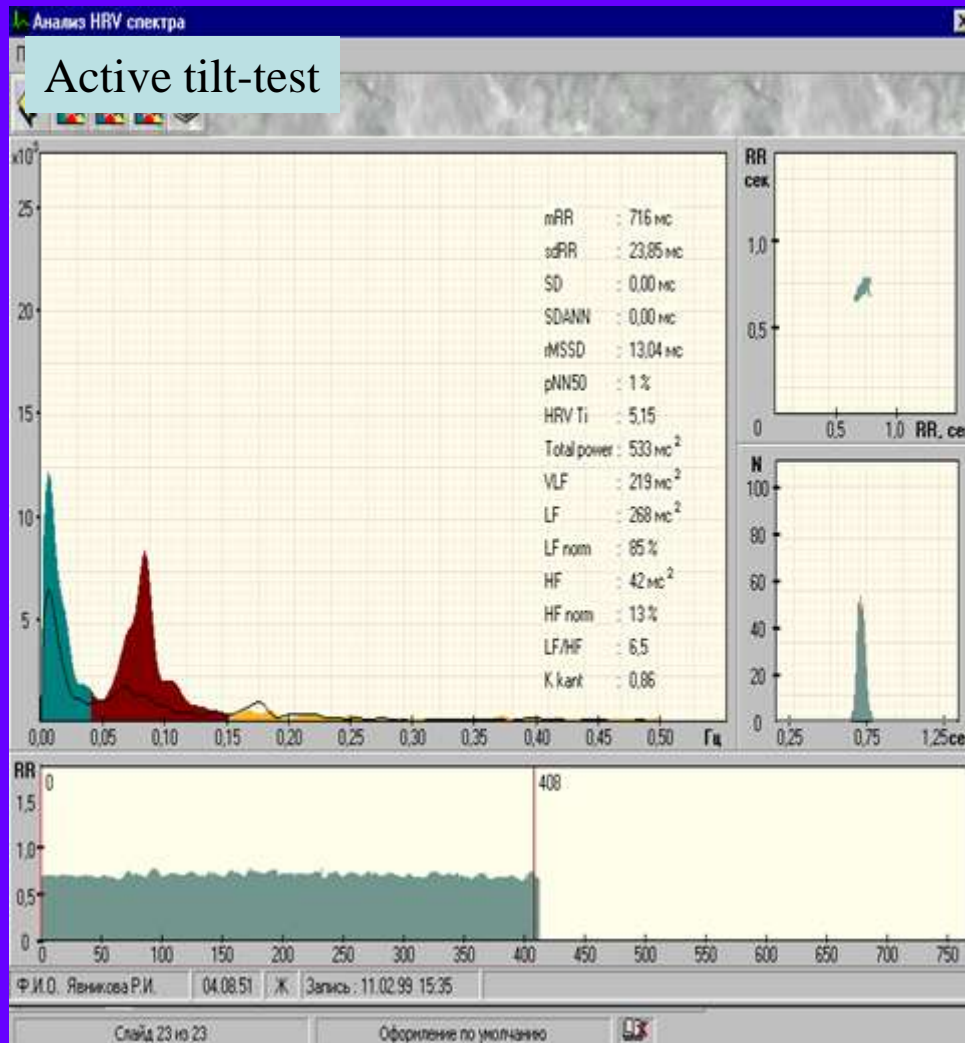
## Atrial fibrillation (to the right) in the respiration modulation test is not worse than the sinus rhythm





# HRV - the echo of regulatory processes

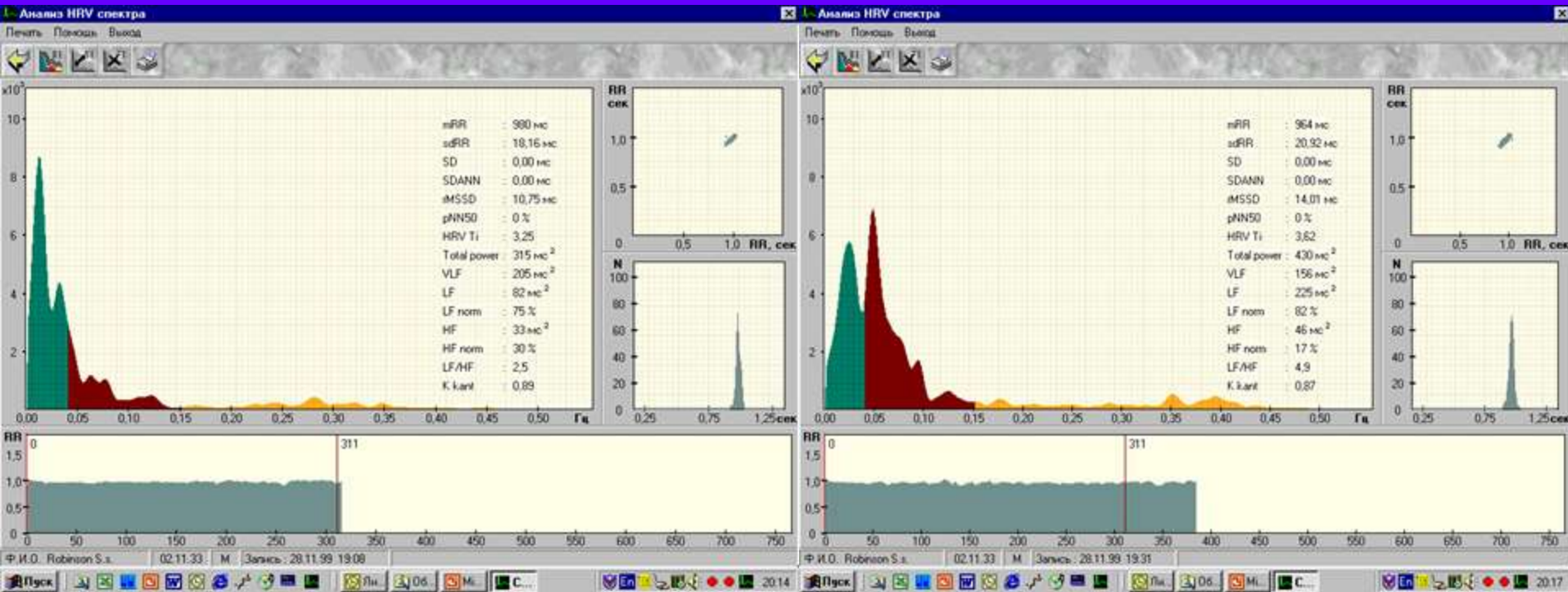
## Atrial fibrillation (to the right) in active tilt-test is not worse than the sinus rhythm





# HRV - the echo of regulatory processes

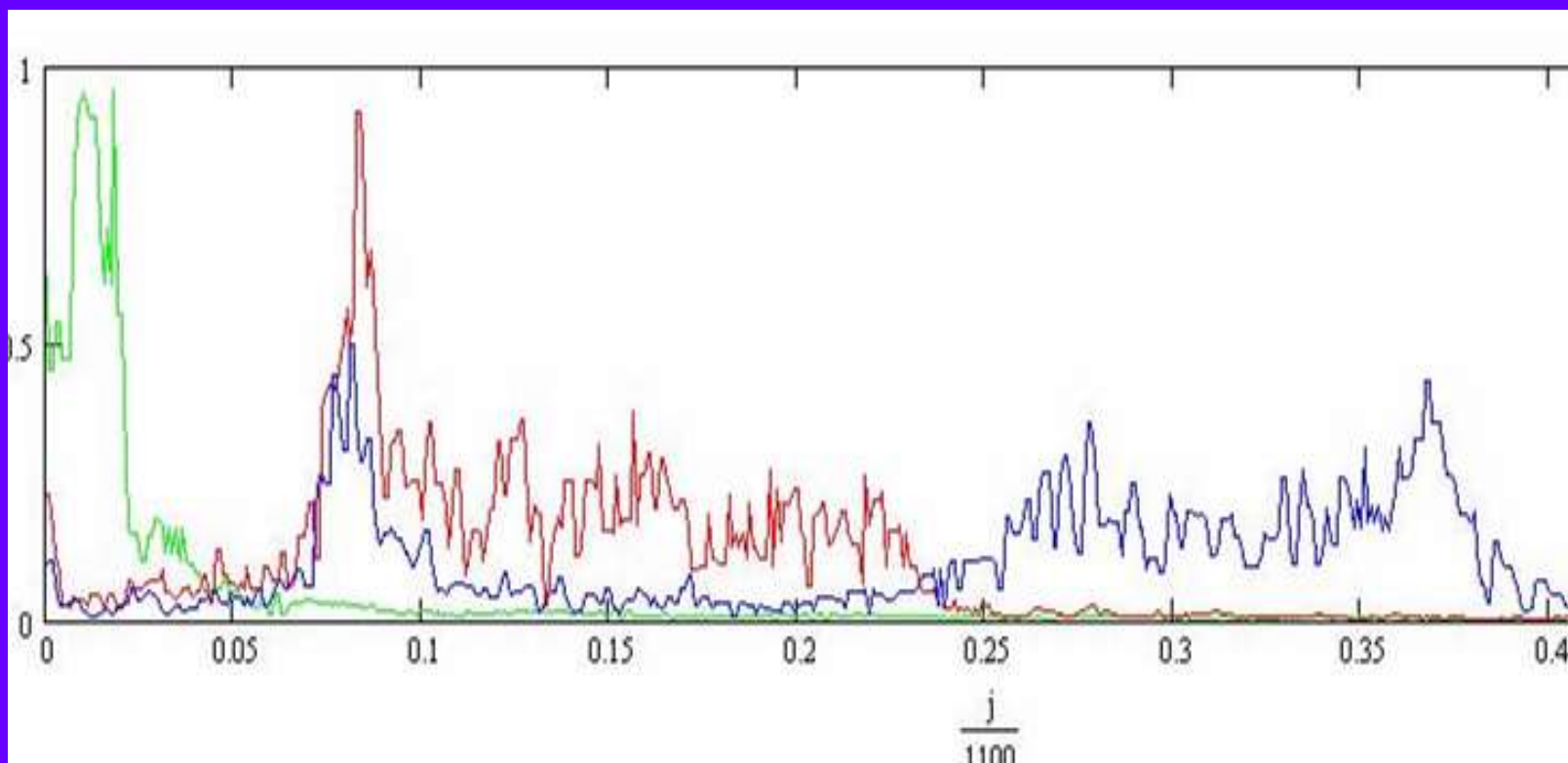
## The enalapril influence



One hour later after 2,5 mg enalapril maleat in-take: Spectral total power is increasing due to the low-frequency components

## HRV - the echo of regulatory processes

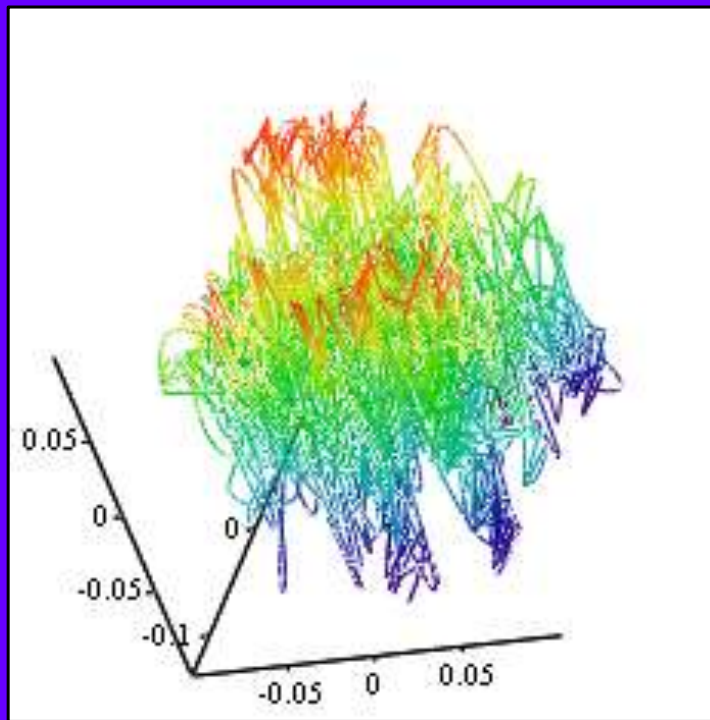
### The representation of NHR regulatory branches in the HRV spectral domains



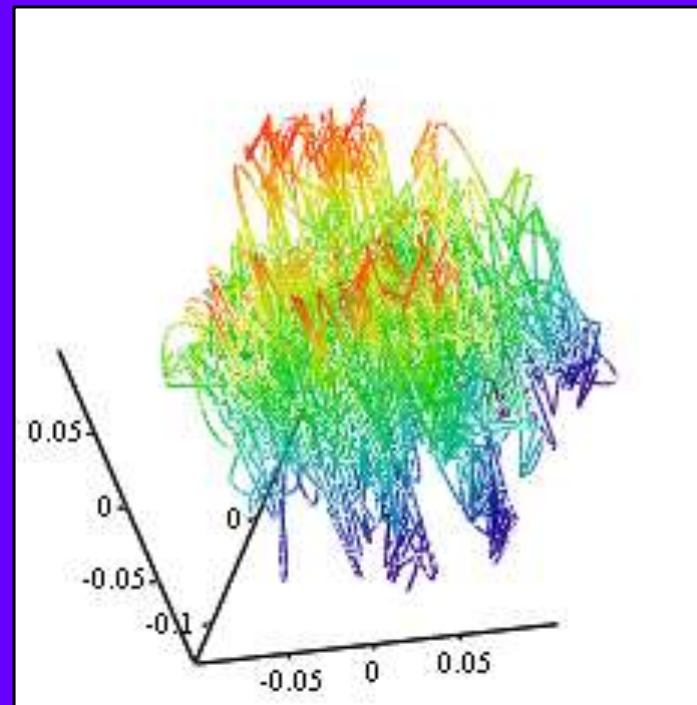
G (green), S (red), P (blue) - humoral, sympathetic and parasympathetic branches of NHR in the frequency ranges of HRV, according to the data of mathematical modelling

# HRV - the echo of regulatory processes

## The representation of NHR regulatory branches in the HRV spectral domains



(x,y,z)

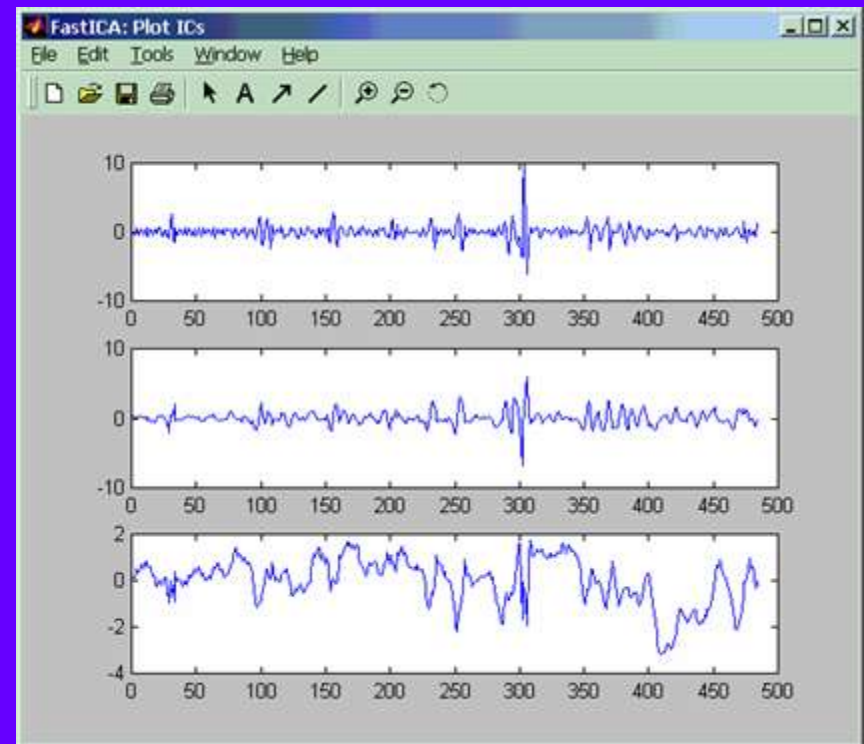
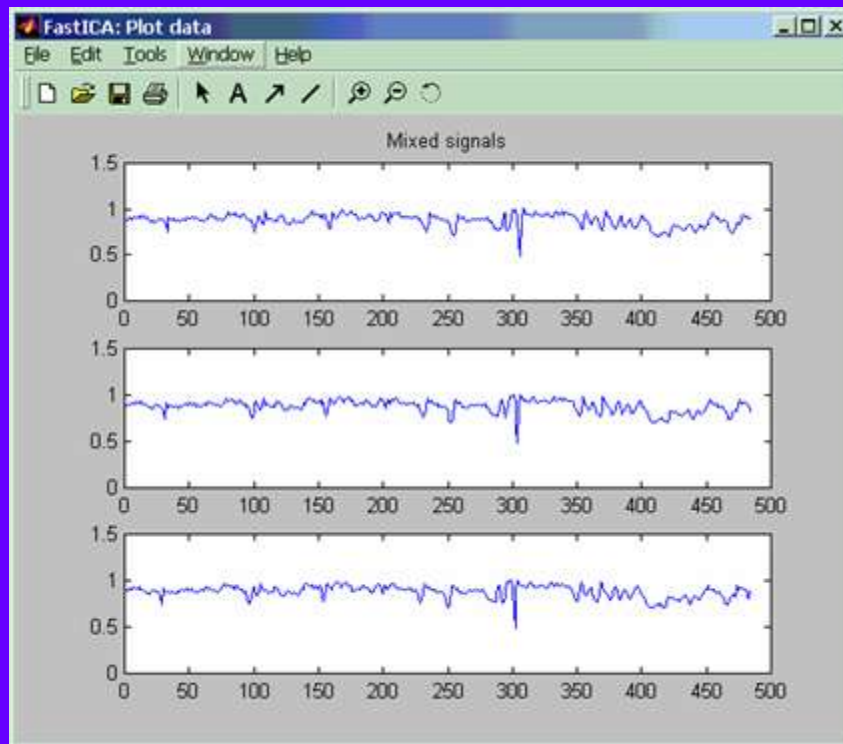


(x,y,z)

G (green), S (red), P (blue) - humoral, sympathetic and parasympathetic branches of NHR in the frequency ranges of HRV, mathematical theory of chaos

# HRV - the echo of regulatory processes

## The representation of NHR regulatory branches in the HRV spectral domains



The method of the independent components, the extraction independent signals, which correspond to different regulation links from rhythmograms



# We understand.

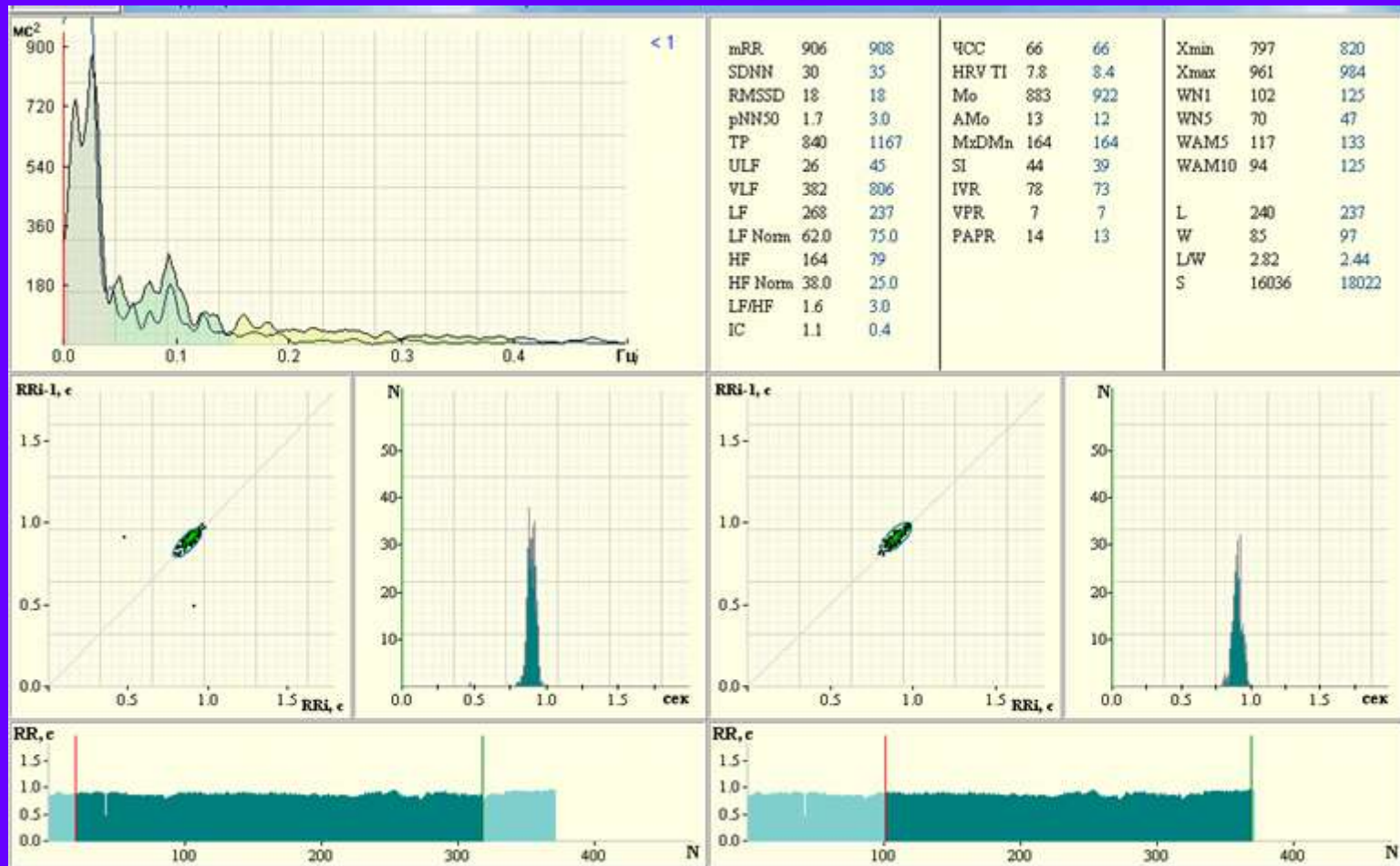
- Hard protocol.
  - o Preresearch stabilization of state.
  - o Quasi-stationary conditions for a research.
- Its own interval for each of the spectral components.
  - o Short interval for high-frequency.
  - o Intermediate - for middle frequency.
  - o Long-term – for low frequency.
- Qualitative evaluation of quantitative indices.
  - o Orientation by an order of values.
- Accurate use of the statistics.
  - o Priority of nonparametric statistics.
  - o Evidence-based application of parametric statistics.
- Only certified devices

# We do not understand.

- Weakening limitations to the protocol.
  - Application to the transient processes.
- One interval to all spectral components.
  - Short records.
  - Intermediate records.
  - Prolonged records.
- Quantitative estimation of quantitative indices.
  - Orientation to values themselves.
- Degradation of interpretation.
  - Direct understanding of regulator impressiveness of domains.
- Direct transfer of the protocol of short records to the Holter records.
  - Mixing of quasi-stationary and transient processes.
  - Use of terminology of short records in Holter records.
- Limitations by sinus rhythm.
- Careless application of the statistics.
  - Parametric statistics out of the substantiation.
- Uncertified devices

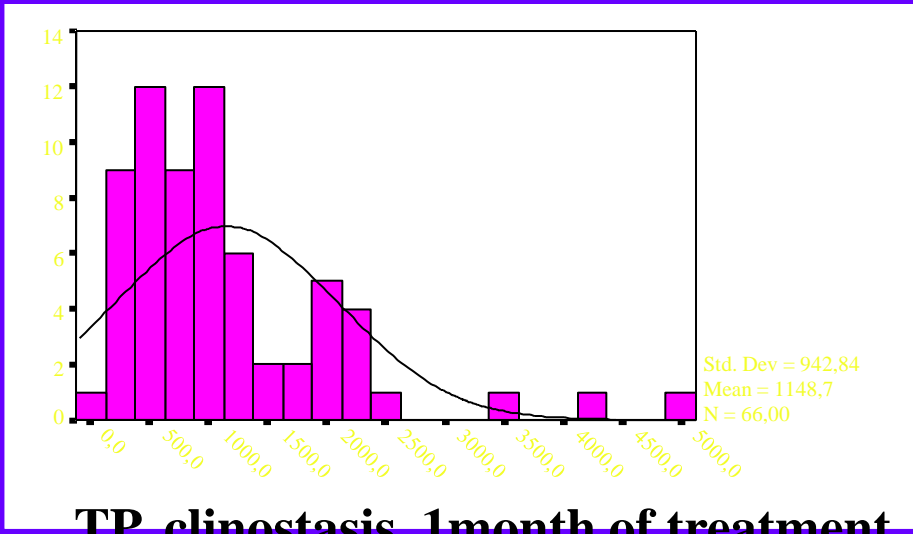


# HRV - Qualitative estimation for quantitative indices.

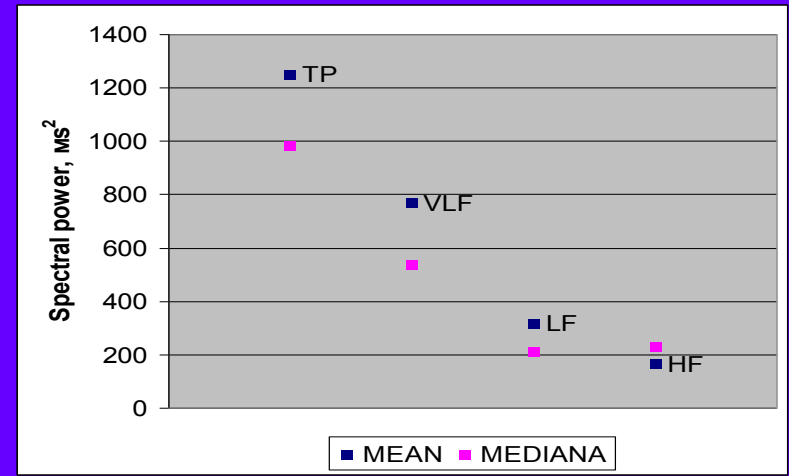
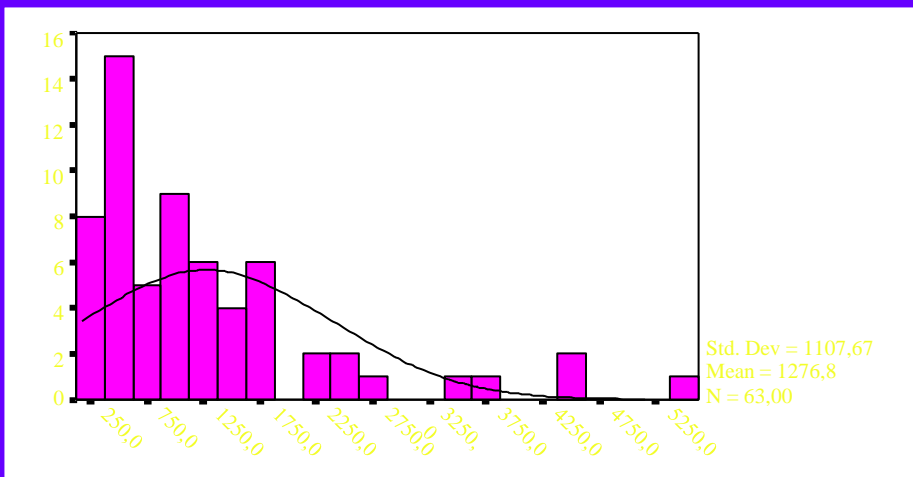


The small shift on rhythmogram and sensitive change in the HRV indices with the preserved qualitative picture

# HRV- indices in the parametric and nonparametric statistics



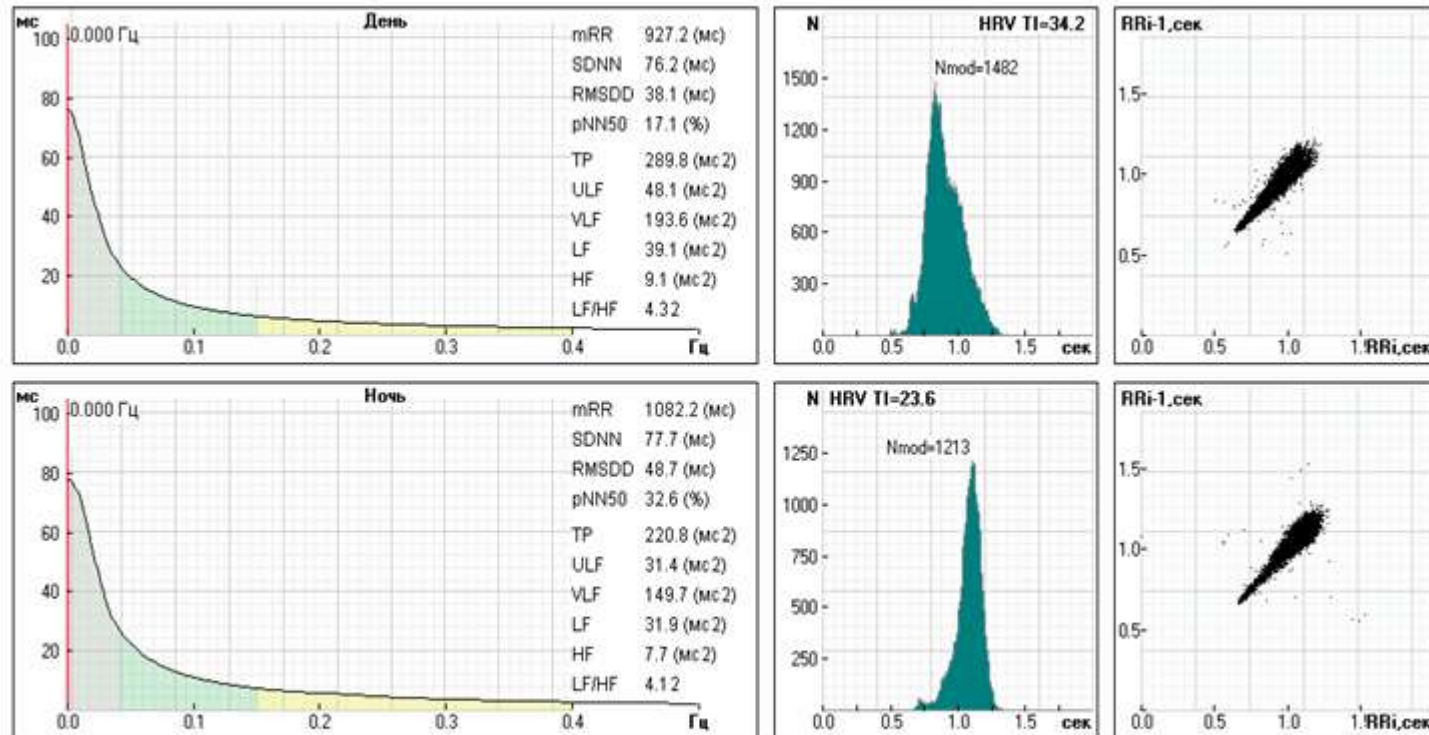
TP	N	M	SD	Min	Max	25%	50%	75%
before	6 6	1051	970	11	4997	357	805	1335
after	6 6	1250	1060	17	5425	622	980	165



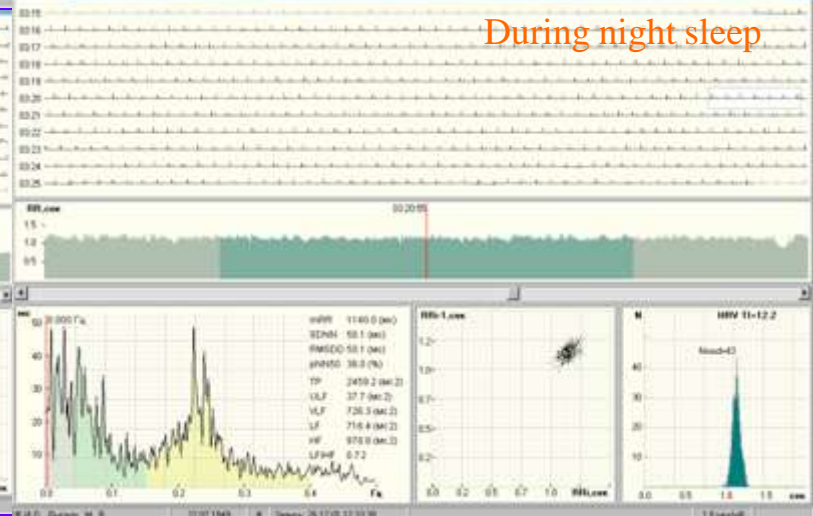
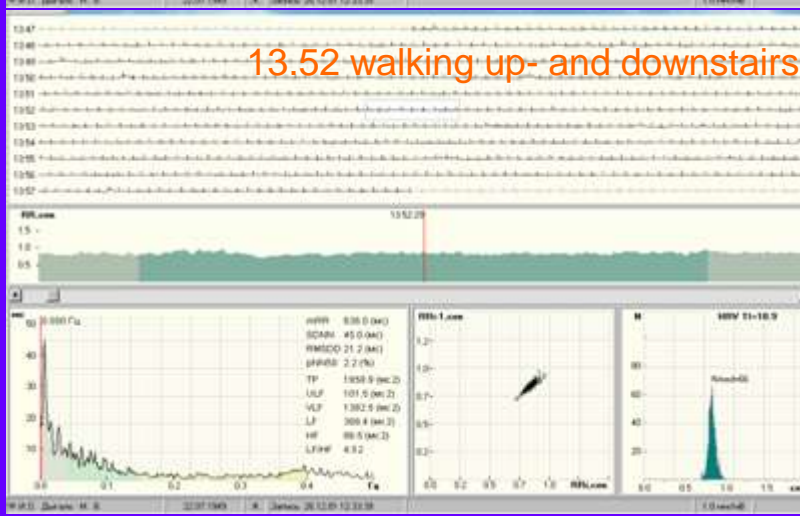
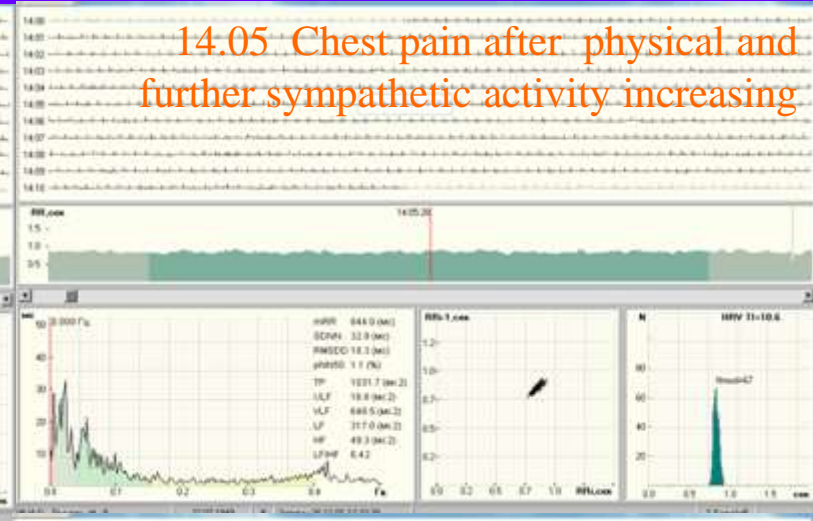
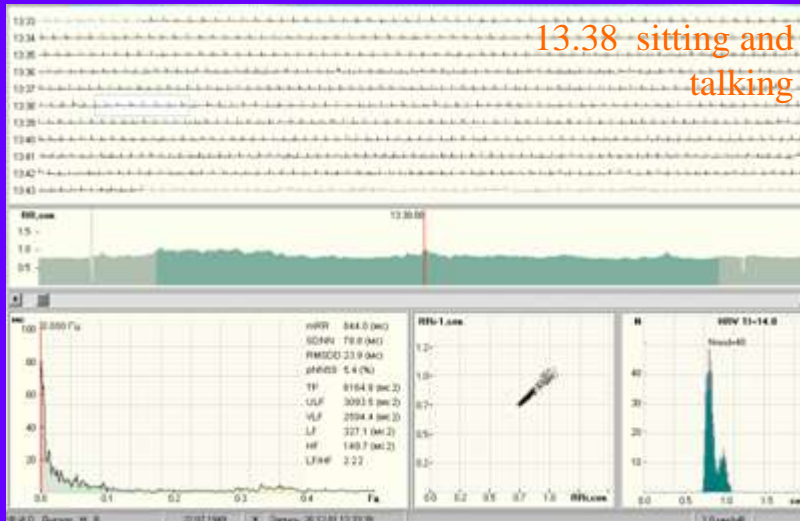
*non-normal distribution, preference nonparametric statistics*

# “Dull” average daily and average nightly Holter HRV

Спектральные характеристики variability сердечного ритма

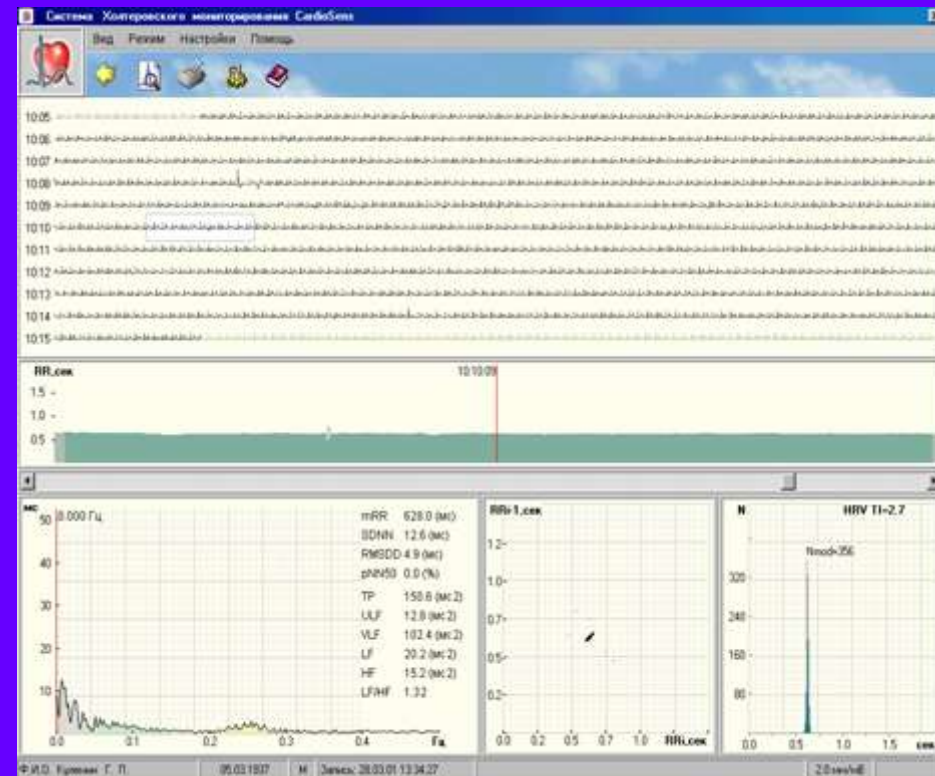
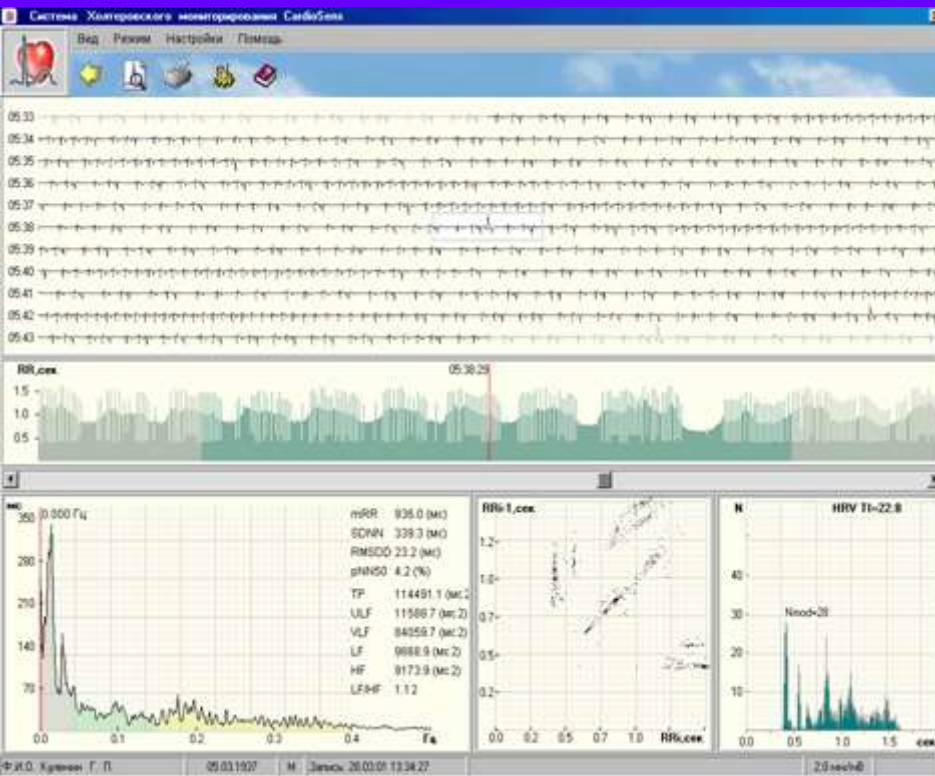


# “Shining” in the short time intervals Holter HRV





# Holter HRV, is it a subject to averaging?



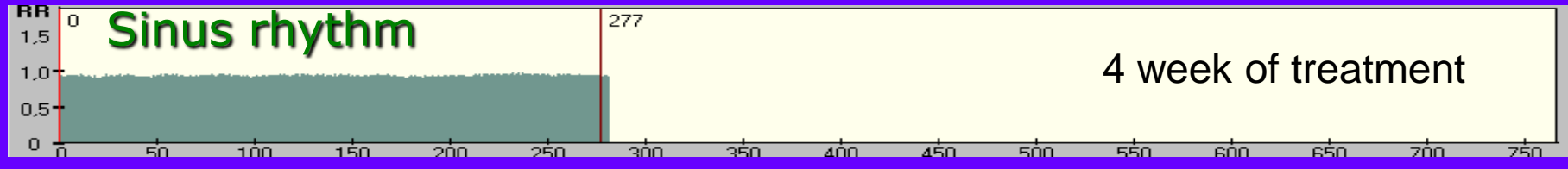
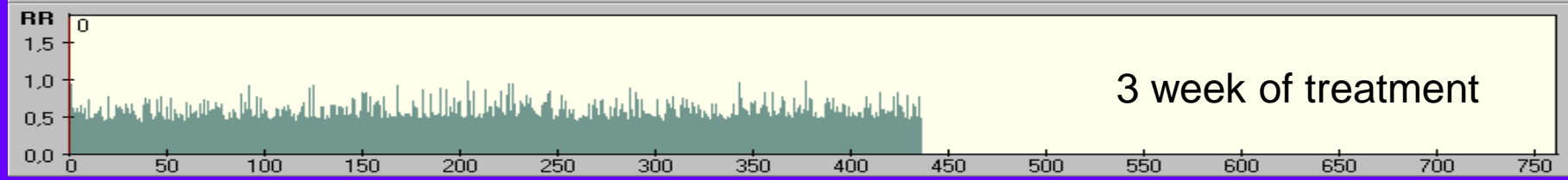
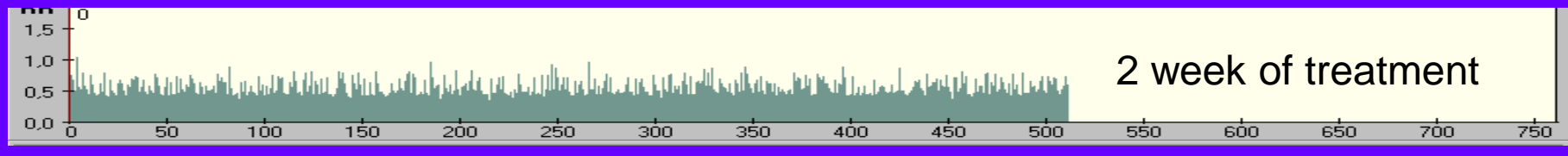
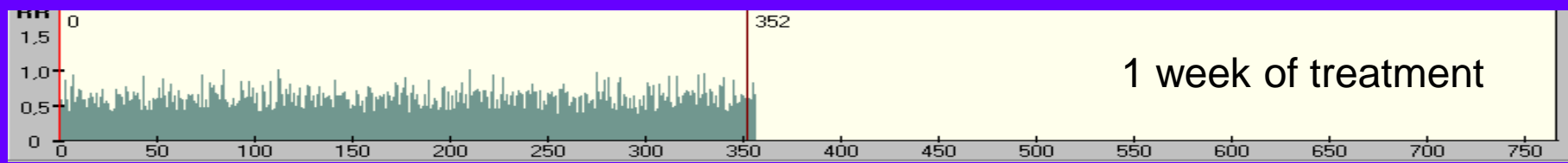
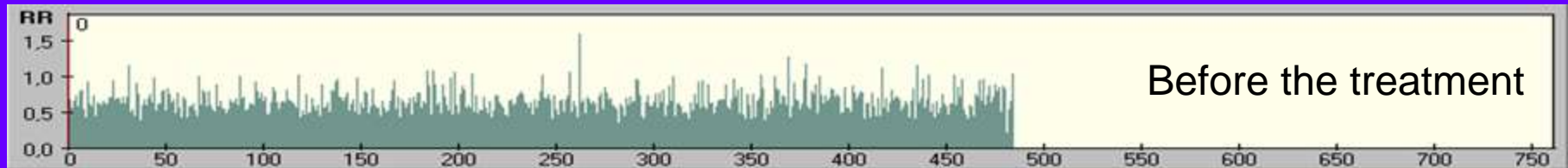
Different periods in one Holter record in one patient, please, focus your attention on spectra - low-frequency power is greater to the left! Please, pay your attention on the RR-distributions - to the right mono -, to the left - polymodal !

# We assume

- HRV with non-sinus rhythm with the limitations of unappliance of standards ECA and AOEFS; a special case – atrial flutter.
- New technologies, connected with the mathematical theory of chaos.
- New technologies, connected with the method of the independent components.
- Mathematical modelling



# Changes In RR-intervalogram : AF therapy with amiodaron

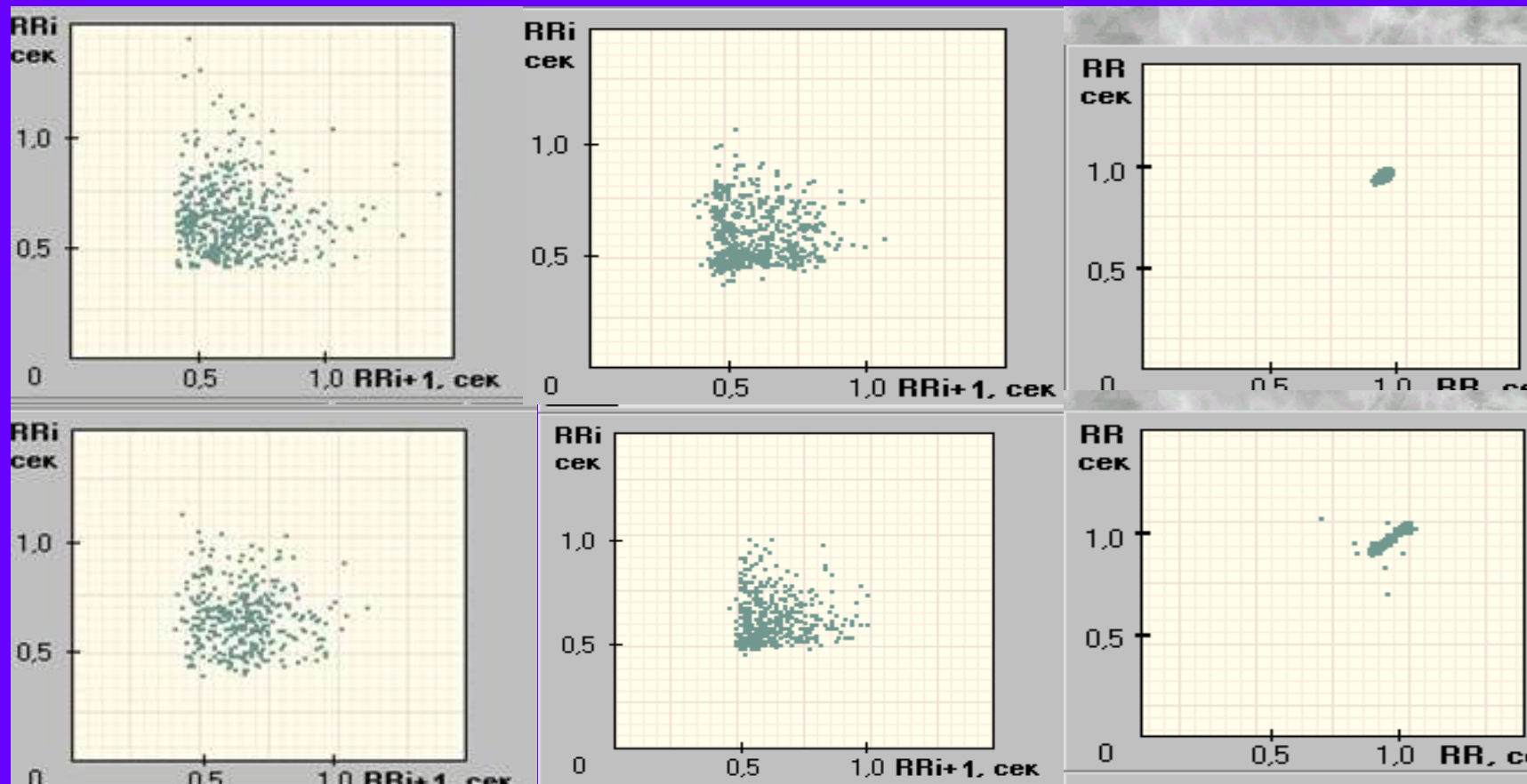


# Changes in skaterogram with the AF therapy with amiodaron

Before the treatment

2 week of treatment

4 week of treatment



1 week of treatment

3 weeks of treatment

6 weeks of treatment

# Changes in the HRV spectrum with the AF therapy with amiodaron

Before the treatment

2 weeks of treatment

4week of treatment



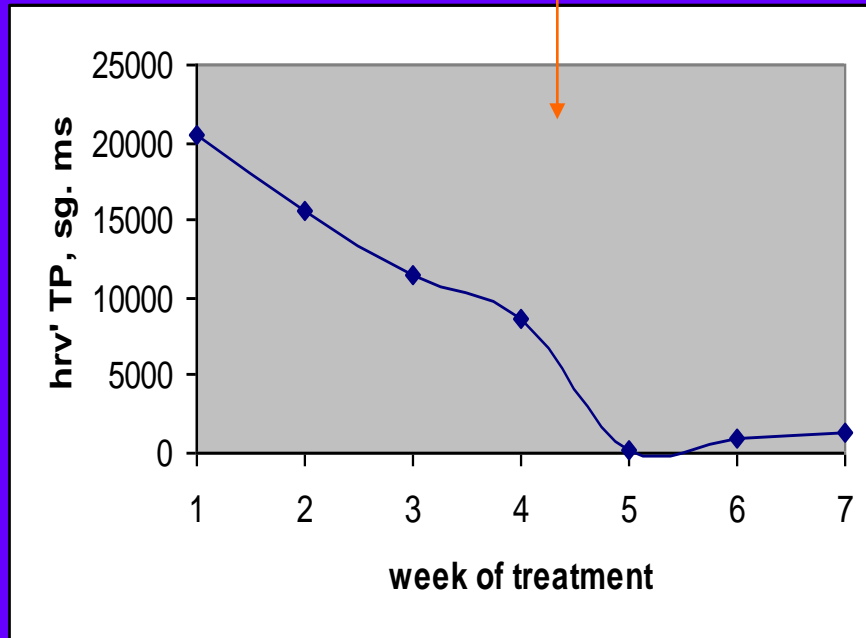
1 week

4 weeks

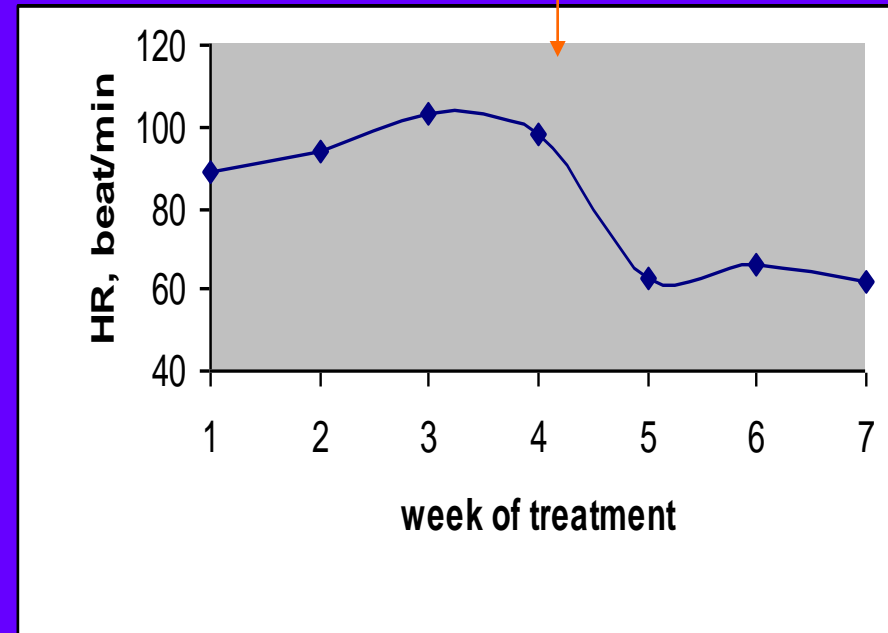
6 weeks

# Changes TP HRV and HR with the AF therapy with amiodaron

cardioversion



cardioversion



# We remember .

- o HRV.
  - o Multilevel regulation.
  - o Under the mental sight.
  - o Interface of heart and regulation.
  - o Quality of interface.
  - o Sinus (?), atrioventricular (?,!) level of interface

# Sinus node and AV- connection.

- o Central place of sinus node and AV- connection in the relations between ANS and biomechanics of heart is the base of judgments about ANS by HRV.
- o The proper interface in the system "ANS - heart" is carried out, however, only in the absence of the pathology of sinus node and AV- connection.
- o The syndrome of the weakness of sinus node, Atrial Flatter and other phenomena influences on the system "ANS - heart" interface.
- o Simplest method of solution of task - addition the electrophysiological studies of heart to the HRV technology in the necessary cases
- o "Two" sinus node and one NHR
- o Fraktalisation of sinus node, HRV spectra in fractals are similar



# “Two” sinus nodes and one NHR

## Fractalization of sinus node, HRV spectra in fractals are similar



One regulation is in both fractals, the “degeneration” of the vegetative link

# Future.

- ○ Remarkable technology.
- ○ In the system of other technologies.
- ○ Asymptotic output to “the golden mean”.
- ○ Tool of scientific studies.
- ○ Tool of routine clinical practice

# Appeal to the navigators.

- o Care of technology.
- o Development of technology.
- o Popularization of technology.
- o Support of the practical introduction of technology.
- o Instruction in the philosophy technology of high-quality clinical method.
- o Propagation of technology experience to a study of other periodic phenomena