

Relief & Waterfall

Abnormalities at first sight

Introduction

The ambulatory ECG examination (Holter examination) is characterized by a large amount of data that needs to be processed. The evaluation of such examination record is often time-consuming and requires extensive work for the physician. The software BTL CardioPoint-Holter significantly reduce the possibility of overlooking an important cardiac even. The software BTL CardioPoint-Holter utilizes its unique tools called Relief and Waterfall. These tools allow the physician to look at the signal from different perspectives and make his job much simpler and faster. Both tools provide an immediate visual analysis of the Holter record and reveal all irregularities in the signal, so that no cardiac event will be missed.

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1. RELIEF

The Relief tool can be used in two basic modes:

- AF:** The optimal method for tracking waveform changes (e.g. arrhythmia, or atrial fibrillation/flutter, SVET, P-Q, Q-T interval changes, size, shape and position of P and T waves, etc.)
- ST:** Used to detect absolute anomalies (ST depression/elevation, R and T wave alternations, etc.)

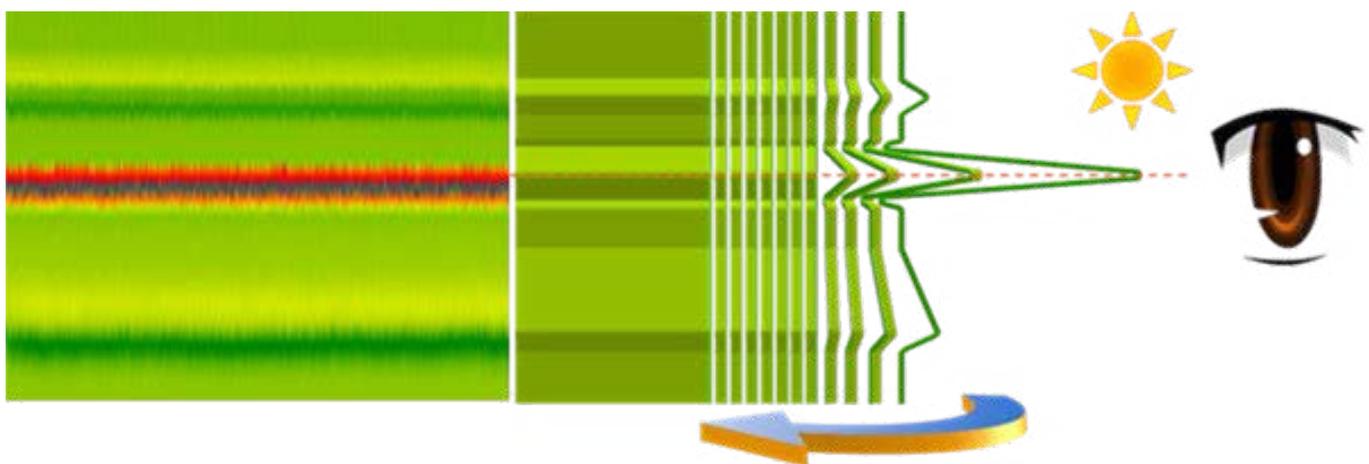
1.1 Mode AF

The Relief tool gives a completely different look at an ECG signal. Instead of the normal ECG waveform, it displays the data in wavy plane, which might not be understandable at first. From the data shown in this format, it is possible to read information that cannot be read from the classic ECG signal display as easily. The Relief tool displays the cardiac events in a different context and in a broader range than any other classic tool for ECG signal processing and representation.

DISPLAY PRINCIPAL

The image below shows the formation of the Relief tool image. It allows one to visualize all of the heartbeats in their time order, sorted one behind each other. Notice that all R peaks are aligned. Viewing this group of sorted beats from the top-down position, the yellow and red colours indicate a rise of the ECG curve. The redder the colour is, the steeper the rise (e.g., the beginning of the P wave, R peak

or T wave). The colour green indicates plane parts or ECG curve drop. Light green is displayed where there is no increase or no drop (i.e. isoline), while the darker shade of green represent drops of ECG curve (e.g., end of P wave, R peak or T wave). The Relief image is reminisce of a mountain range with the sun shinning on it, so that its peaks (P wave, R peak or T wave) cast a shadow over the valleys behind it.

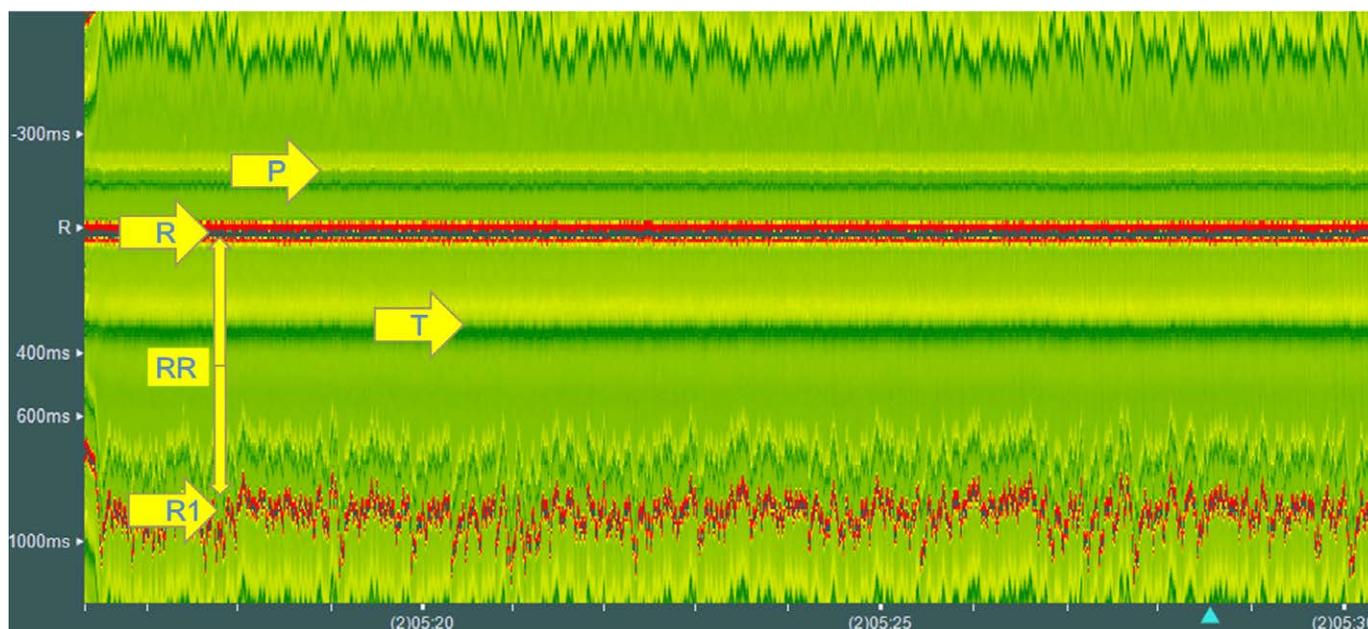
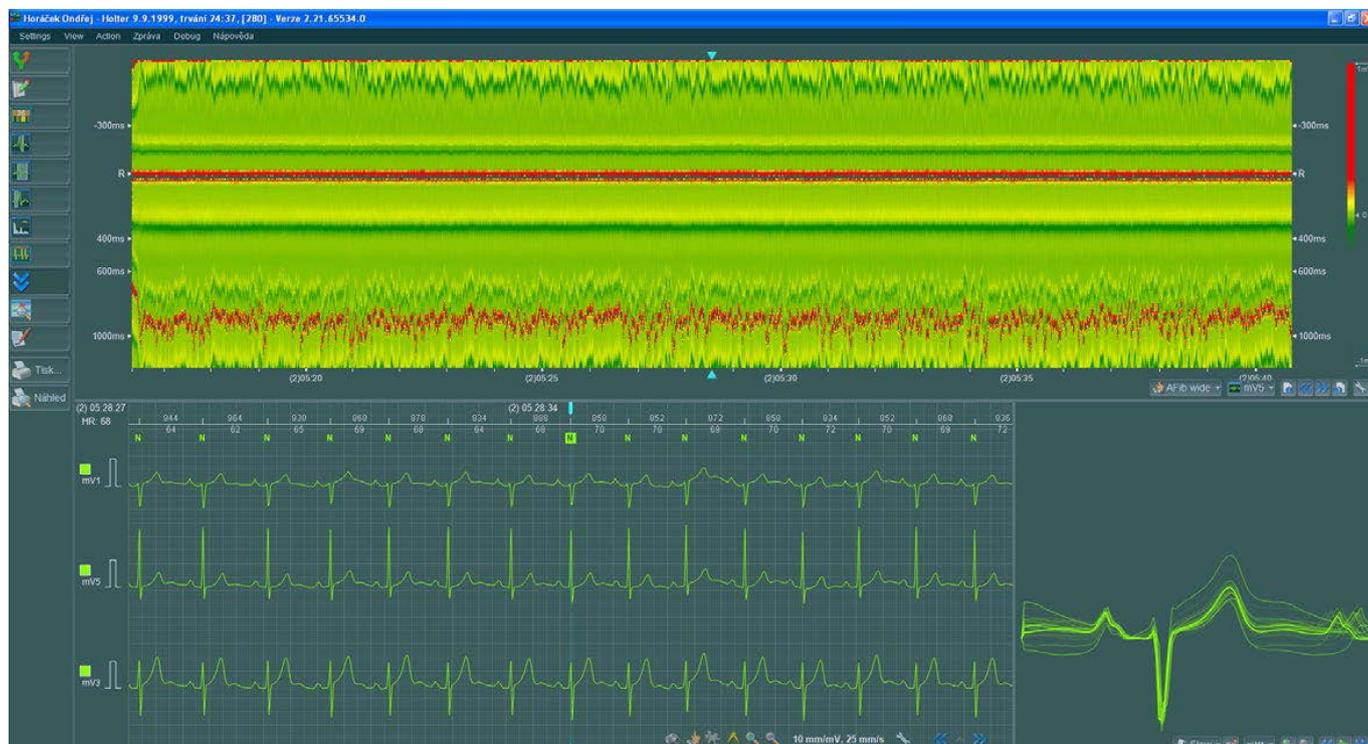


- Each QRS complex is displayed from a top-down view.
- QRS complexes from the one selected lead are lined up with each other to form the Relief image.
- If all the elements of the pQRS complex are homogenous, then the image is smooth and uniform. Any single irregularity in a natural pQRS complexes development immediately manifests itself as sudden ripple in the Relief image.

1.2 Illustrative examples

SINUS RHYTHM VERIFICATION:

Sinus rhythm with a normal PQ:

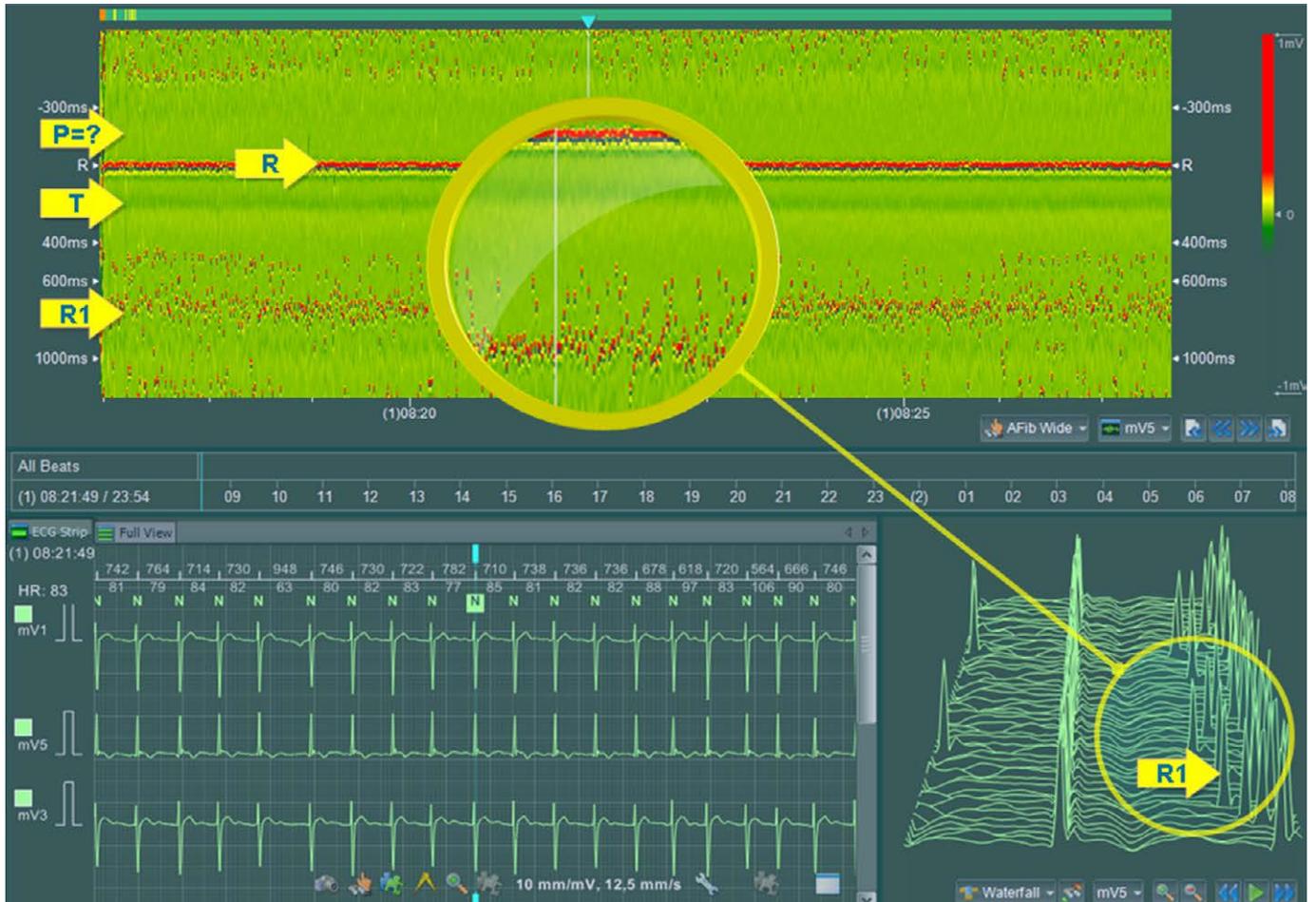


Normal record - the smooth surface indicates:

- E(P) Line: P wave (atrial depolarization)
- (R) Line: R peak (ventricular depolarization)
- (T) Line: T wave (ventricular repolarization)
- (R1) R peak of following complex (i.e. shows following RR interval)

SUPRAVENTRICULAR ARRHYTHMIA (ATRIAL FIBRILLATION / FLUTTER) VERIFICATION:

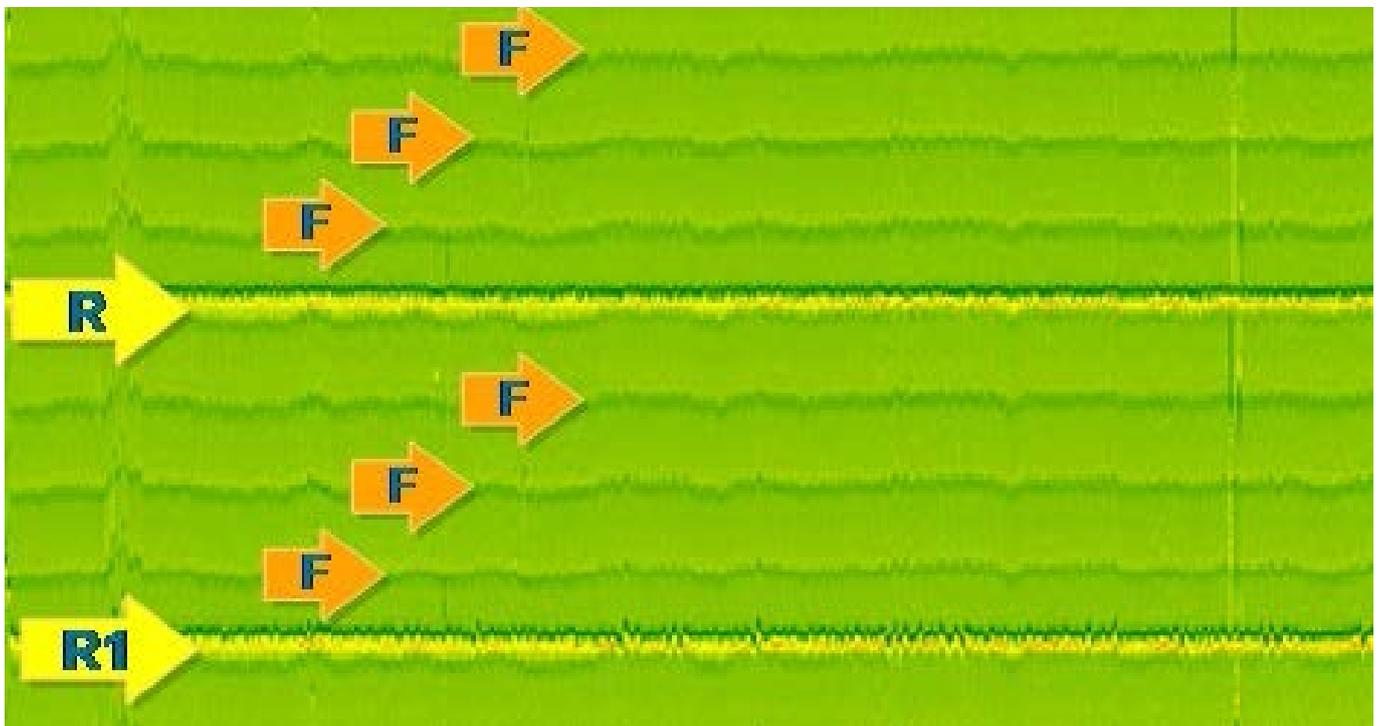
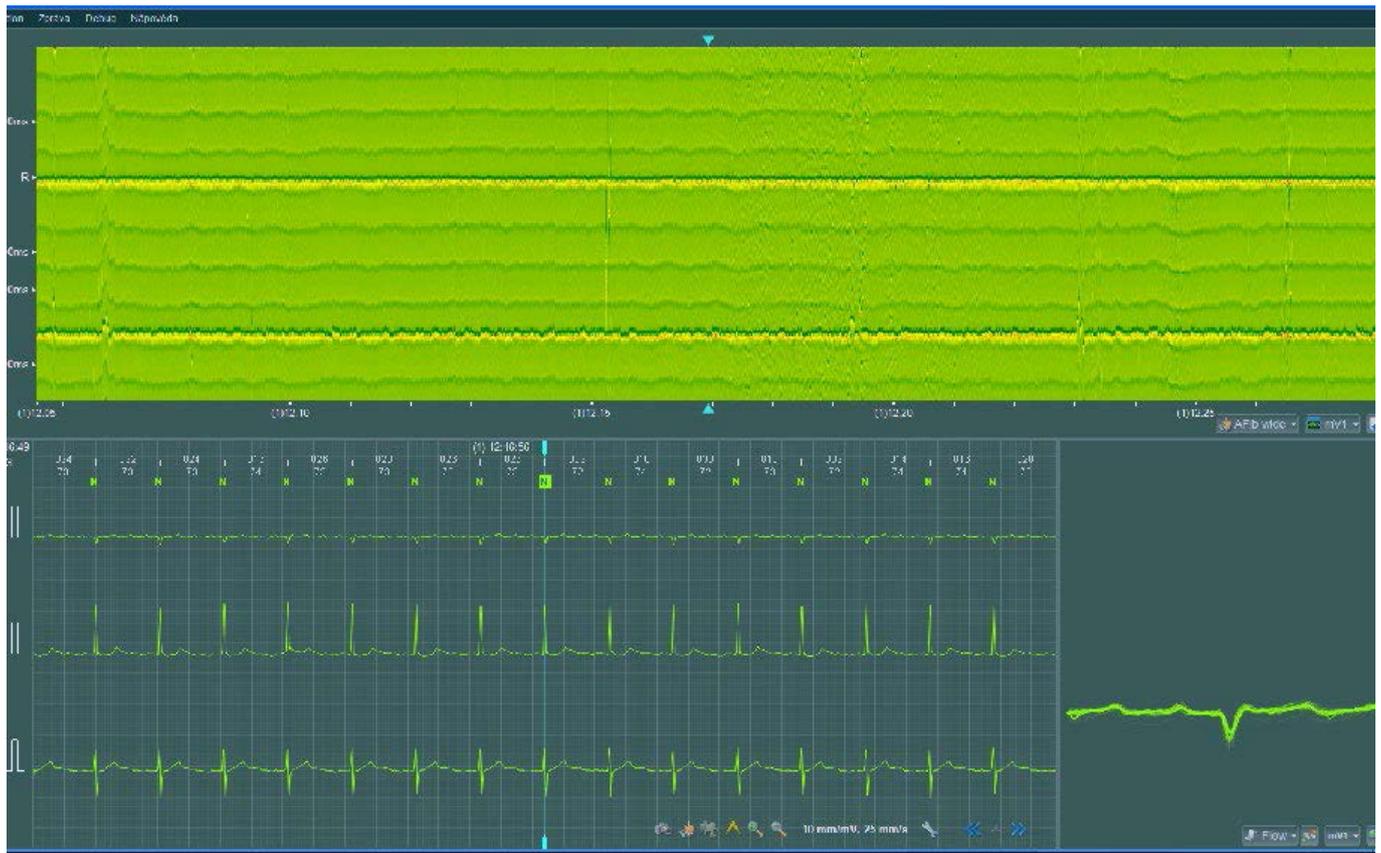
Atrial fibrillation:



Atrial fibrillation with all its characteristics:

- (P=?): P wave is missing.
- (R1): Irregular RR interval manifests itself with chaotic R peak distribution.

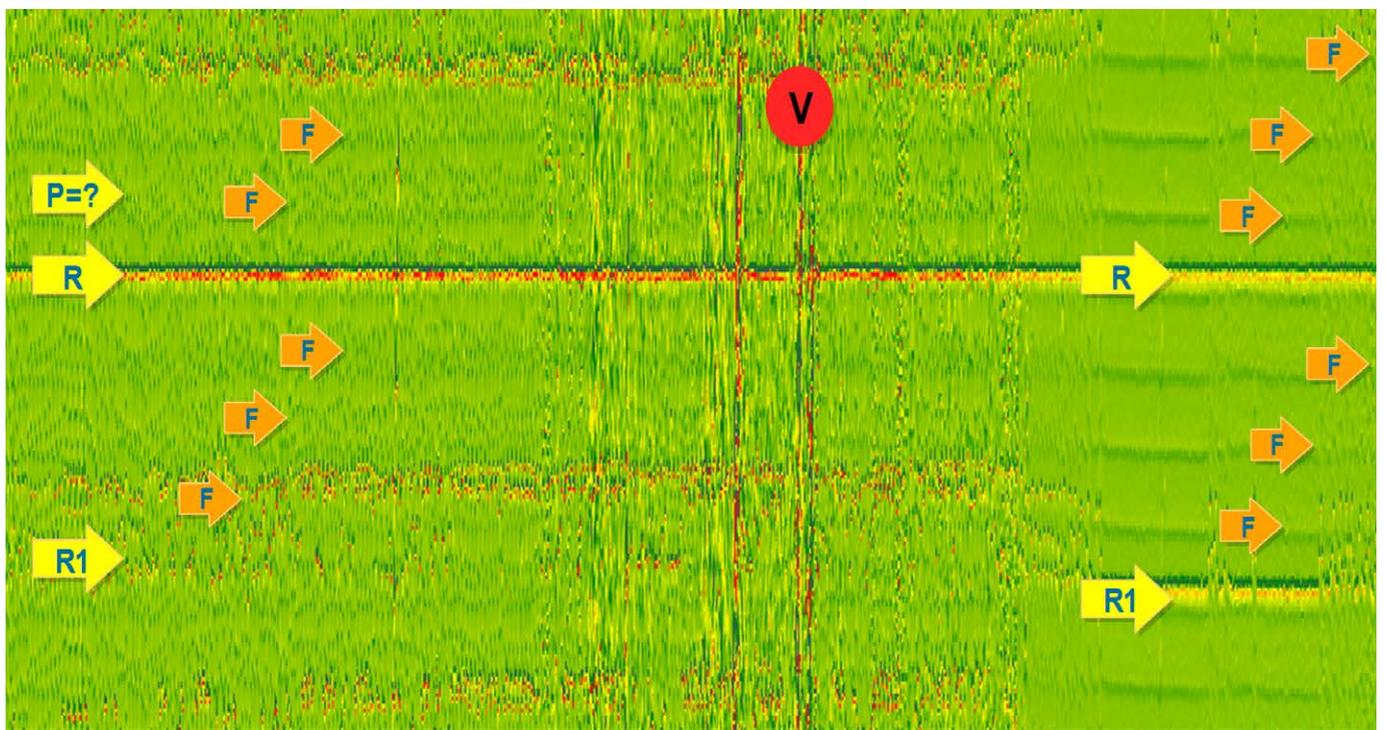
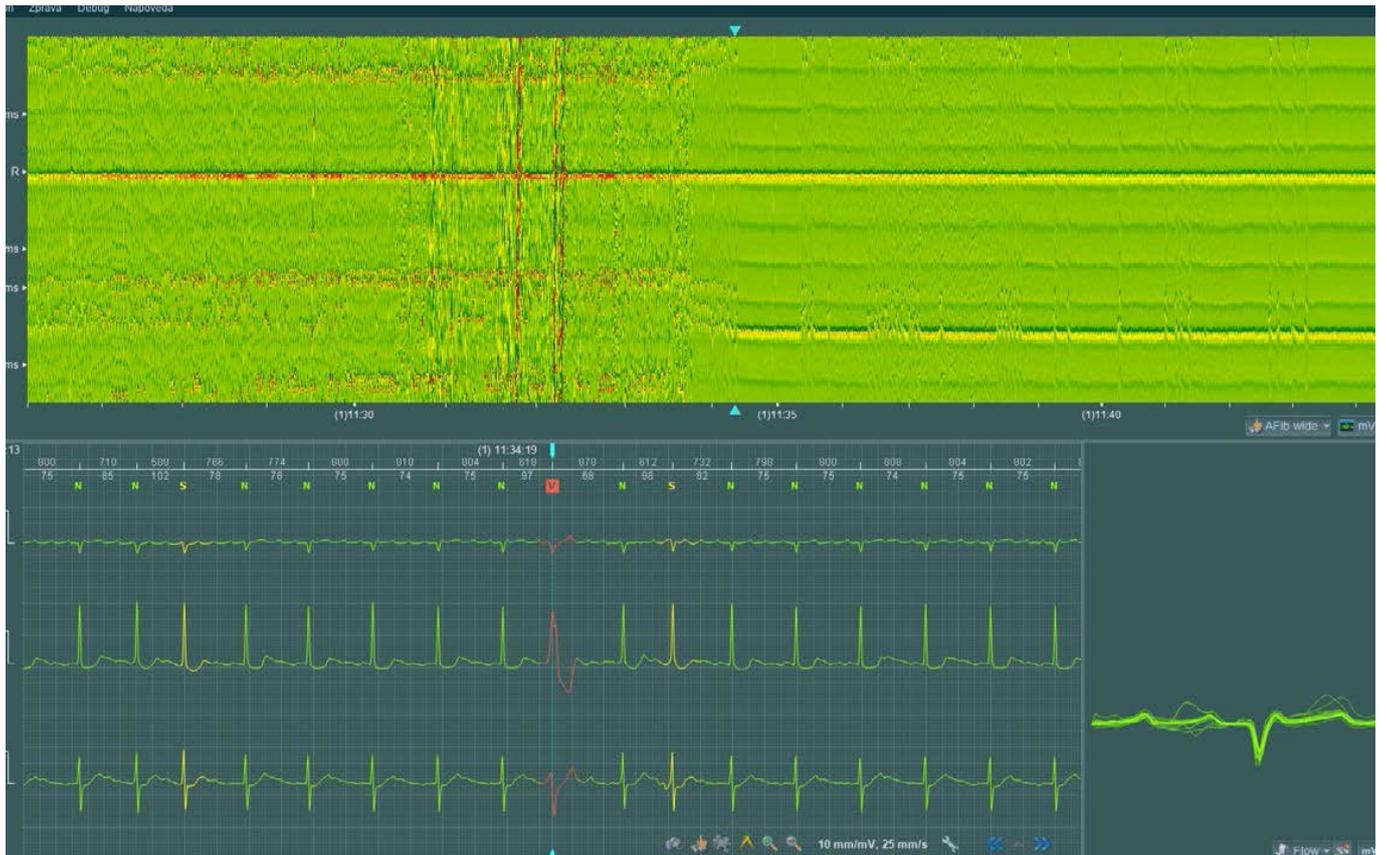
Atrial Flutter with regular AV conduction 4:1:



The image clearly shows regular atrial waves (F) with a period of around 200ms. Each fourth is continued with a ventricular response (R and R1); the ventricular rhythm is absolutely regular. R and R1 lines are parallel with each other.

- (F) Line: F waves (represents atrial activity)
- (R) Line: R peak (represents ventricular depolarization)
- (R1): Following R1 peaks are located in a row, the RR interval thus remains regular.

Atrial flutter with varying AV conduction (4:1, 3:1 and 2:1 AV block with superimposed Wenckebach phenomenon):



On the left:

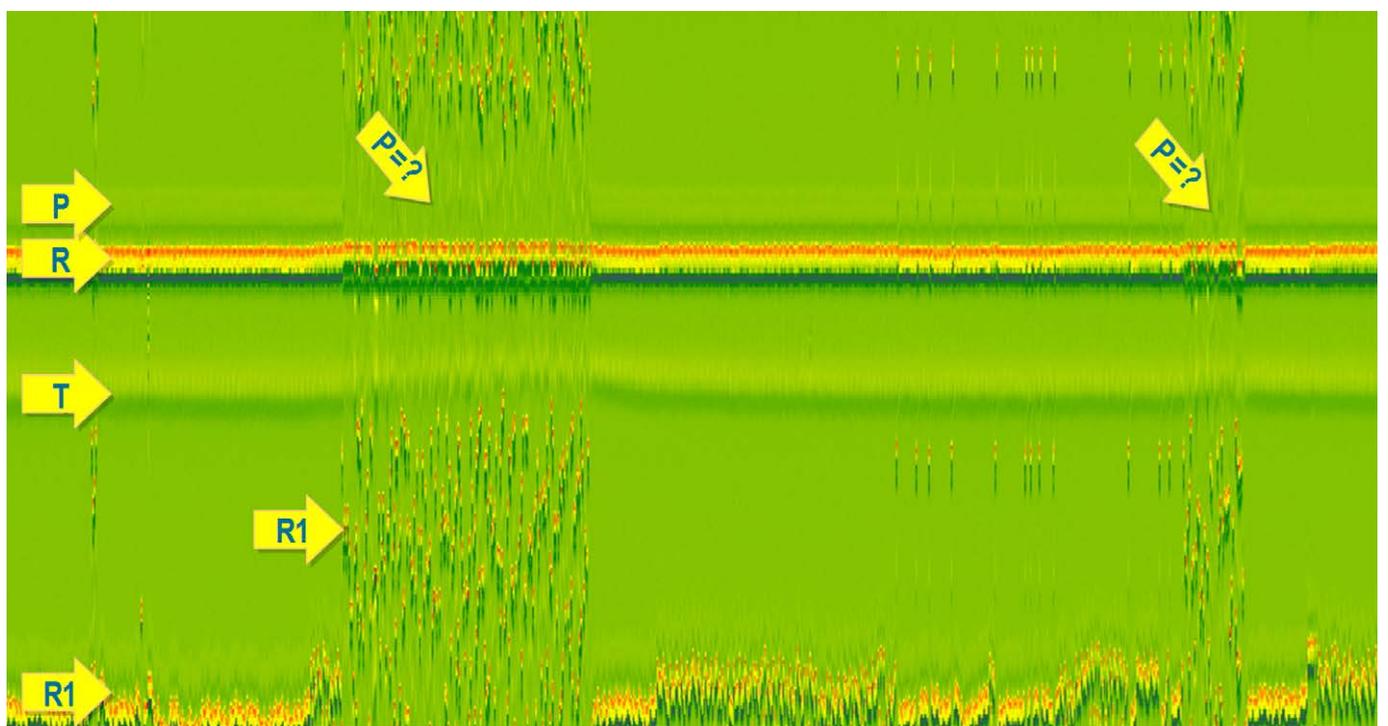
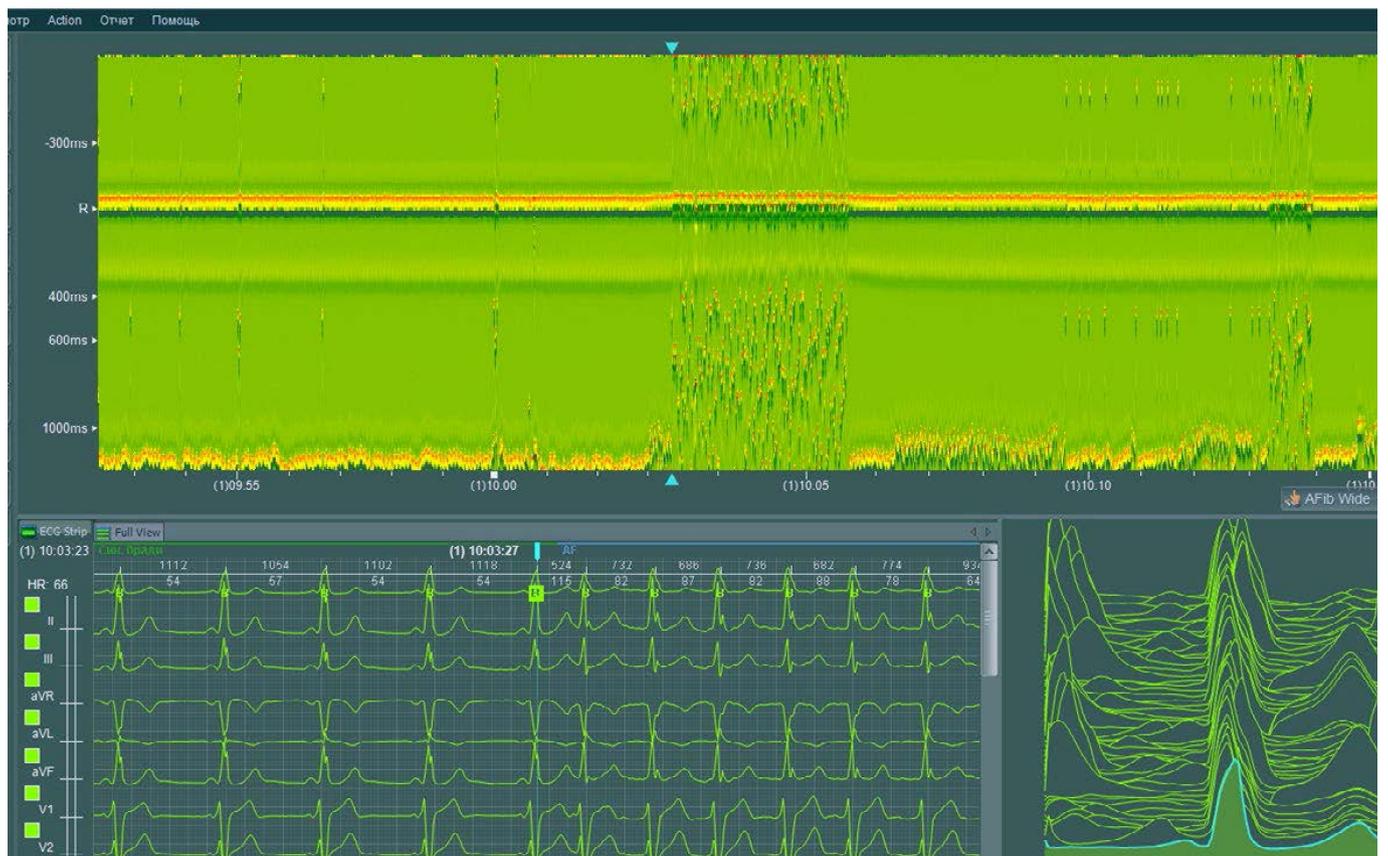
Atrial flutter with varying AV conduction (4:1, 3:1 and 2:1), irregular ventricular activity appears, RR interval is irregular.

- (F) Line: F waves (atrial activity) - parallel dark strips indicate that a regularity starts to appear.
- (R1): Irregular R

On the right:

Atrial flutter with varying AV conduction 4:1 with a regular atrial activity 250/min. Vertical lines on a signal surface (V) and presence of higher count of VES.

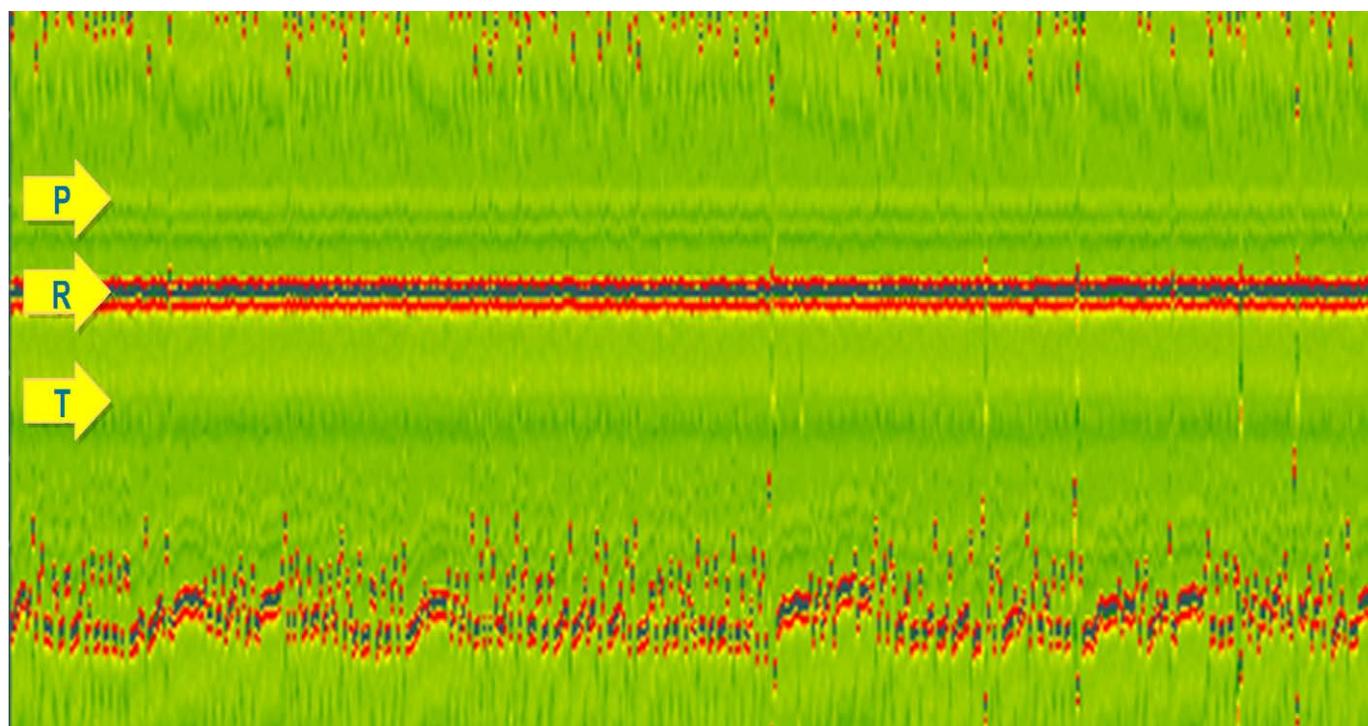
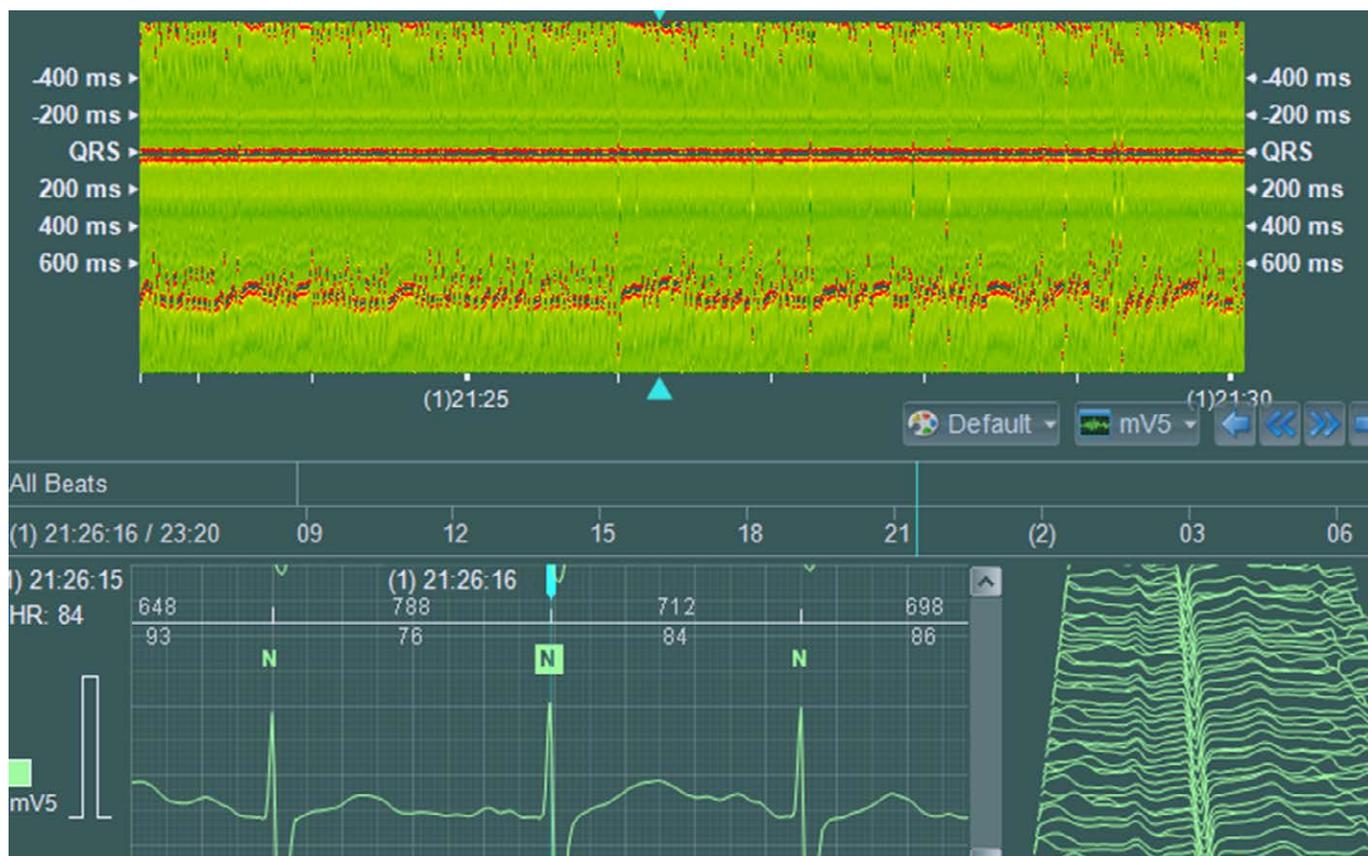
Paroxysms of Atrial fibrillation in Pre-excitation WPW Syndrome:



Clearly visible interruption of Sinus rhythm at two locations.
Premature beats presence at several locations.

- (P) Line: P wave (represents the atrial depolarization)
- (R) Line: R peak (represents ventricular depolarization)
- (T) Line: T wave (represents ventricular repolarization)
- (P=?): P wave is missing
- (R1): Following R peaks chaotically distributed, RR interval is shortened and irregular.

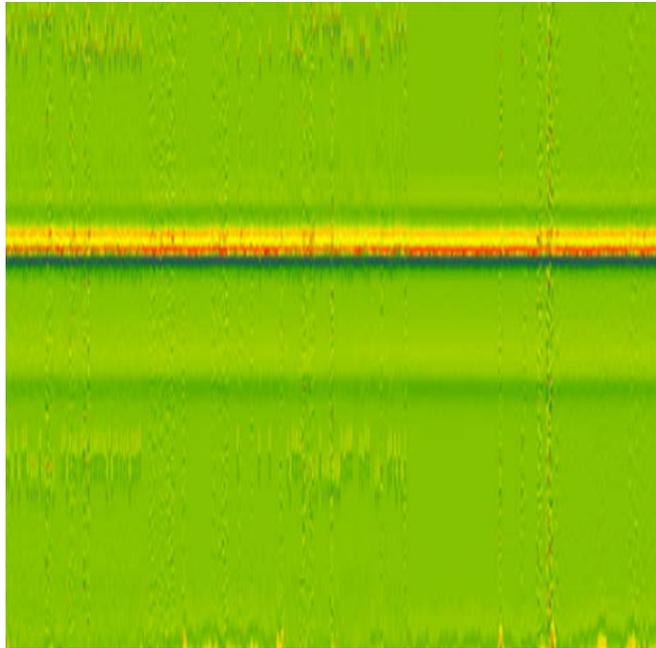
Verifying P wave presence and shape P “mitrale” / LA enlargement with bifidity of P wave:



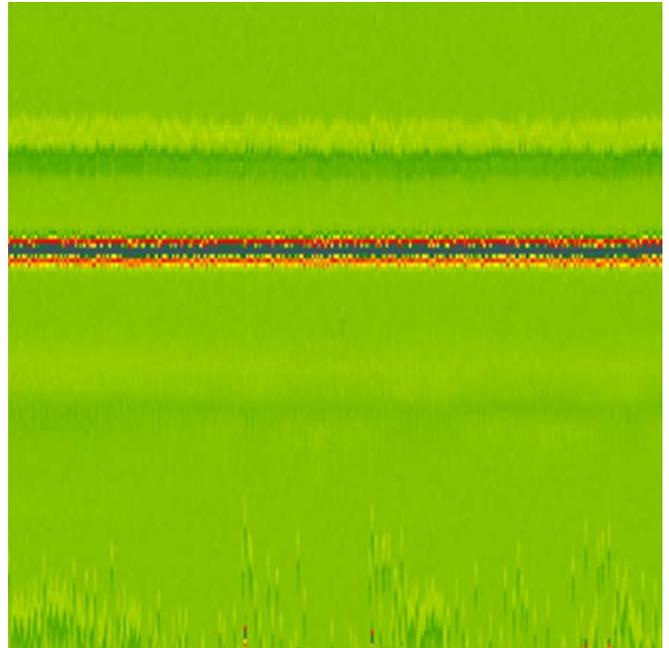
- (P) Line: Clearly visible broad wave with two peaks (difficult to see on ECG signal strip)
- (R) Line: R peak (represents ventricular depolarization)
- (R) Line: R peak (represents ventricular depolarization)
- (T) Line: T wave (represents ventricular repolarization)

IMMEDIATE ANALYSIS OF PQ INTERVAL DURATION:

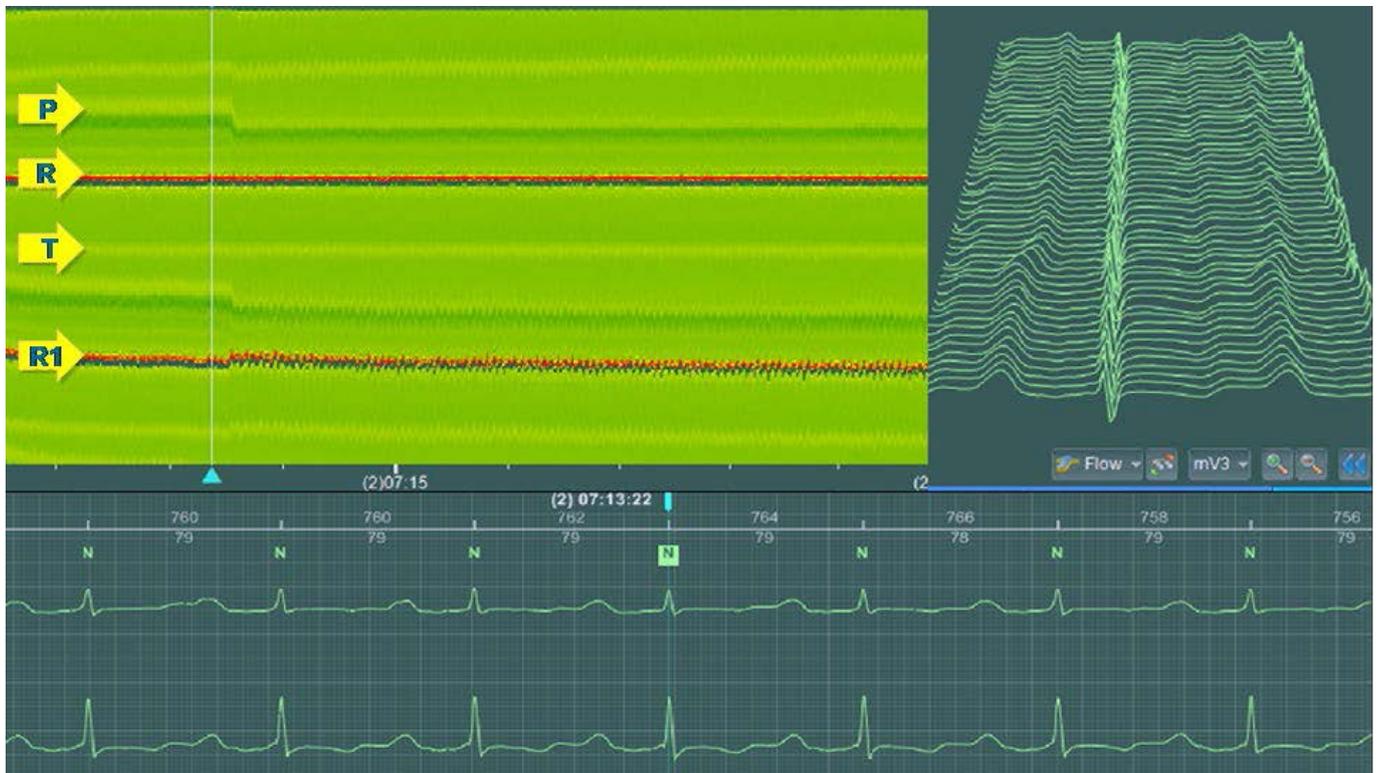
Sinus Rhythm: PQ interval 0.11sec. Typical pre-excitation: Sy WPW type B



Sinus Rhythm: PQ >0.20sec. AV block 1st degree

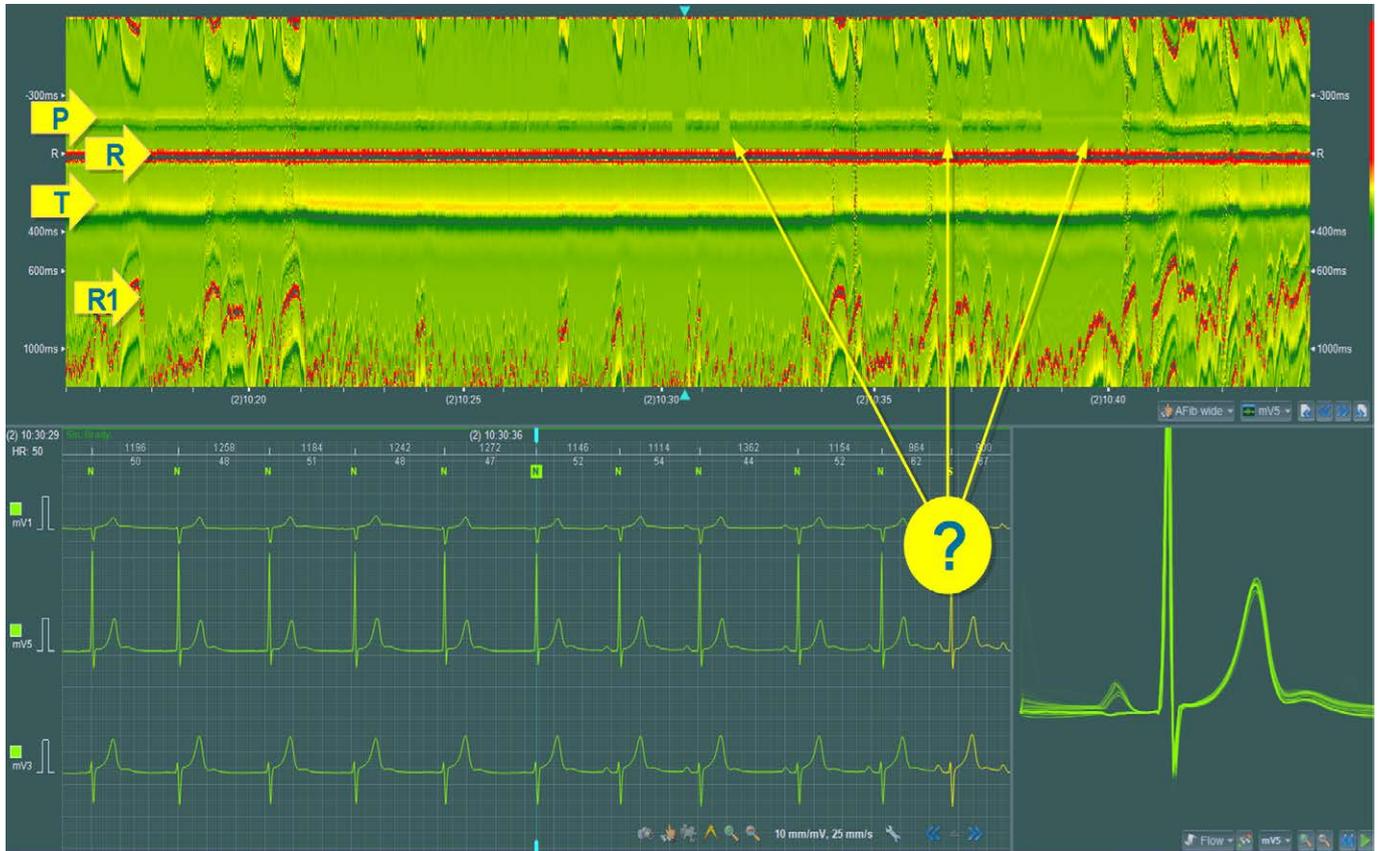


Irregular 1st Degree AV Block. Alternate of PQ interval:



- On the left: AV conduction disorder, intermittent AV block 1st degree and the AV conduction is slow (PQ >200ms)
- On the right: Normal AV conduction (PQ <200ms)

Sinus rhythm was interrupted with ectopic rhythm from the top of the right atrium:

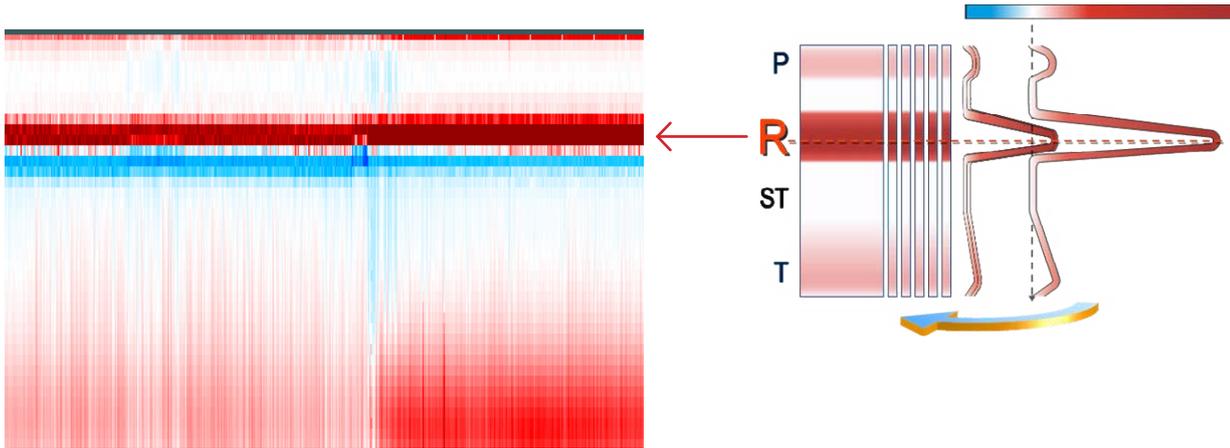


1.3 ST Mode

This mode provides a fast and simplified evaluation of ST segment changes that might not be so easily detected with the use of traditional methods for ECG signal processing. It also allows one to immediately evaluate the seriousness, duration and location of suspicious parts of the signal in the overall record.

DISPLAY PRINCIPAL

The principal of Relief image formation in the ST mode is nearly the same as in the AF mode. The difference lies only in used colour shades. In the ST mode each signal level (amplitude) has its own unique colour or colour shade regardless of whether the signal rises or drops.



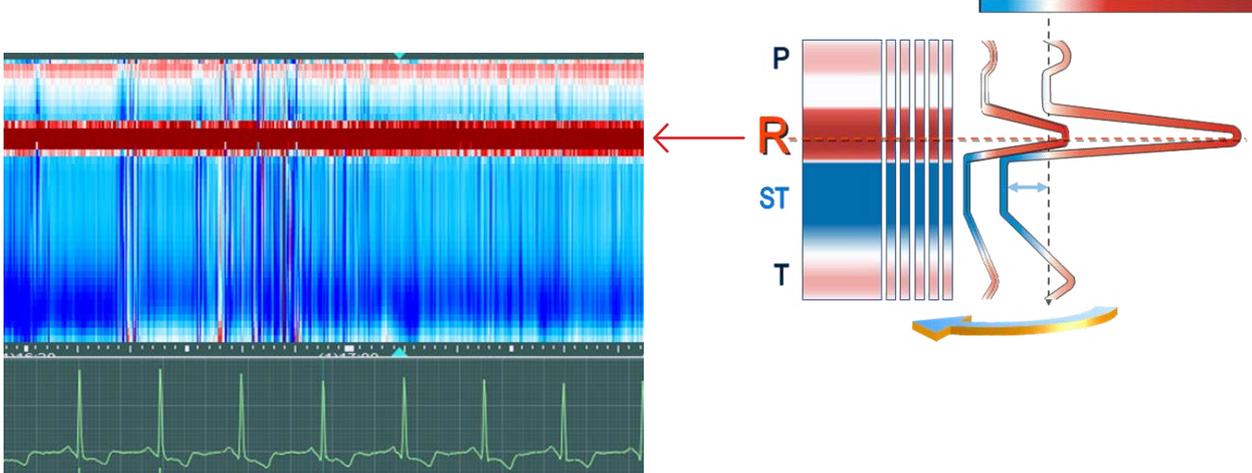
ST segment at normal level:

- The pQRS complex will be coloured based on the current signal level according to the picture above
White: Isoline
Red: Above the isoline - positive
Blue: Below the isoline - negative
- Coloured QRS complexes are displayed from a top-down view.
- pQRS sections are formed so that one complex follows the other. As a result, a coloured strip appears. The colour change indicates a level change.

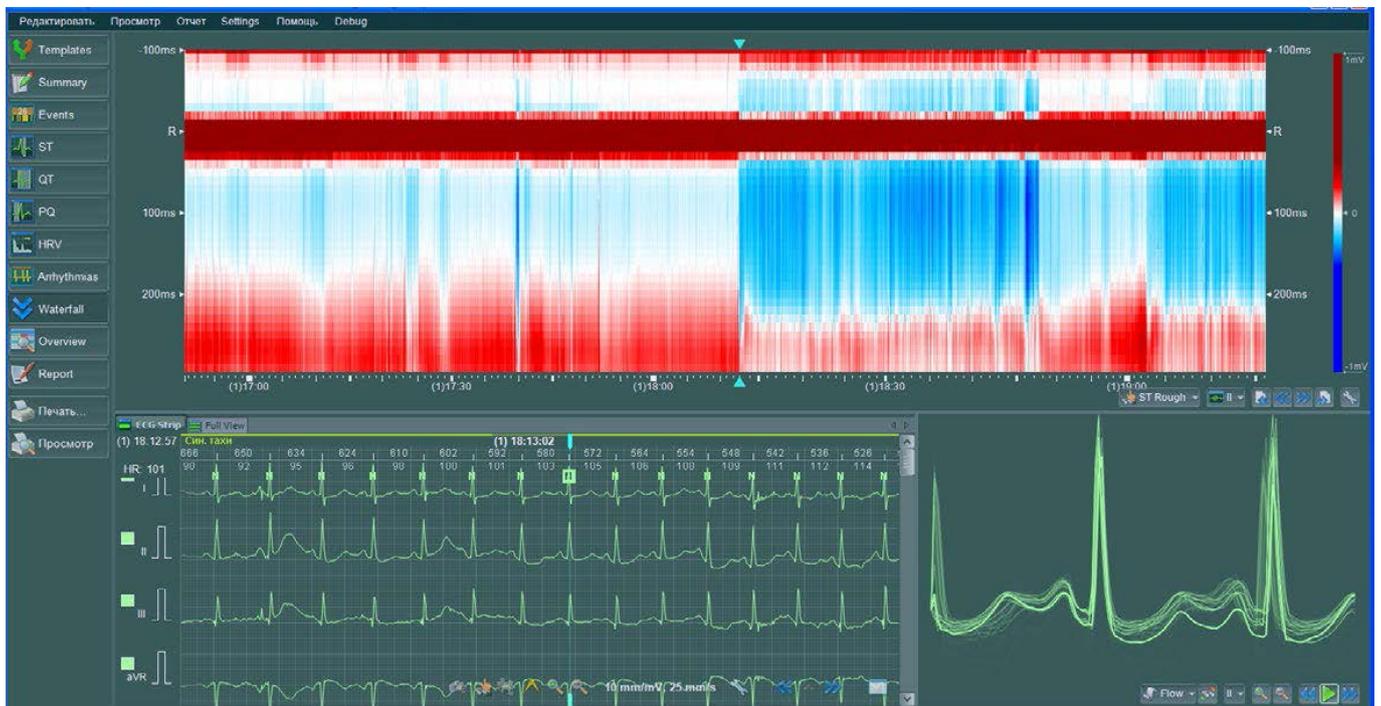
1.4 Illustrative examples

ST DEPRESSION:

ST depression: Characteristic for subendocardial ischemia



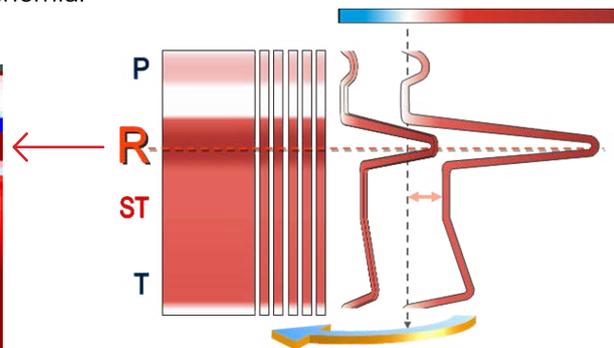
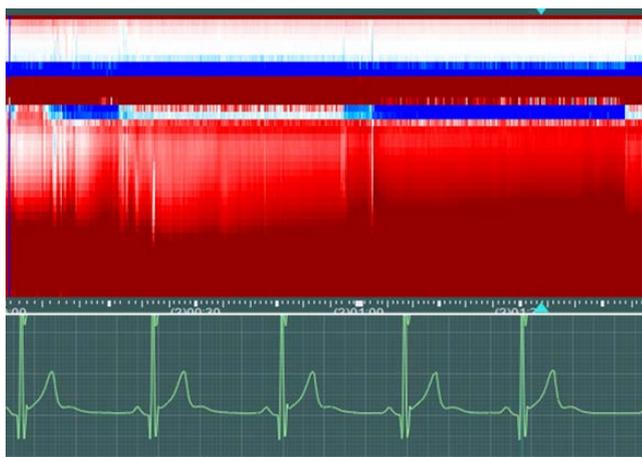
ST depression means that the ST segment is below the isoline.



Apparent transition from normal ST to ST depression.

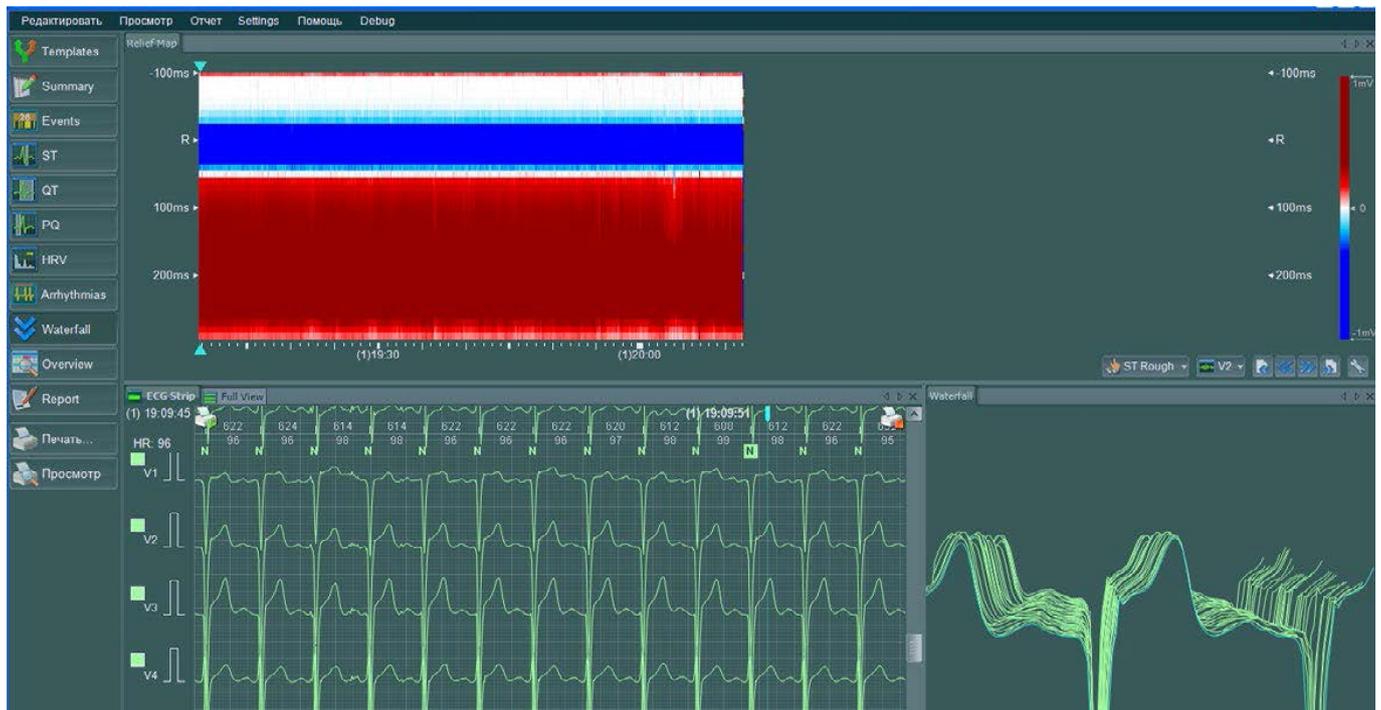
ST ELEVATION:

ST elevation: Characteristic for subendocardial ischemia.



ST elevation means the ST segment is above the isoline.

Pathological peaks QS and ST segment shift above the isoline (necrosis):



1.5 Conclusion

The Relief tool images provide a simplified, yet really complex, look at an ECG signal. This unique tool allows one to immediately visually analyse all the irregularities that are not typically visible when using traditional methods for ECG signal analysis.

2. WATERFALL

The **Waterfall** tool displays the heart-beats one behind each other in a cross-section view so that the result is reminiscent of a waterfall. In the background of normal QRS complexes, all the irregularities (deformation, redirecting, peak alternation, interval duration change, ectopia, premature beats) can be clearly observed. The **Waterfall** tool allows one to look at the signal from various angles. It is then possible to select the angle (view) that is the best to observe a particular pathology.

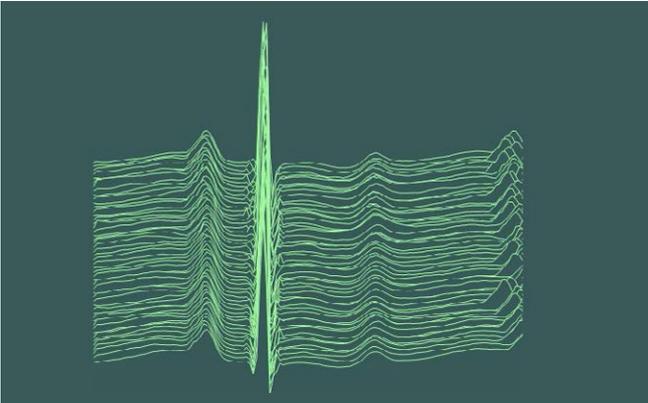
2.1 View modes

OVERLAY

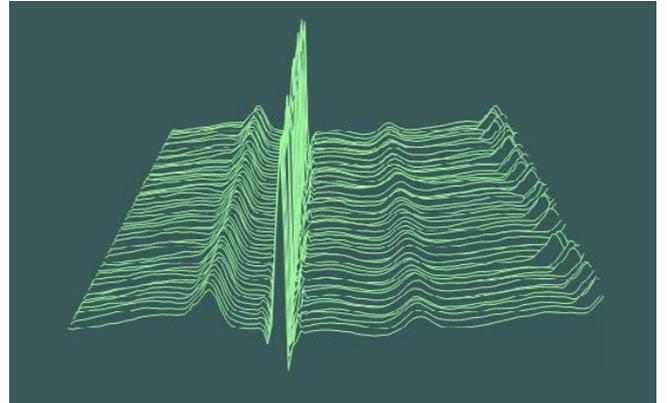
The current complex is superimposed in the front; the other complexes are displayed behind it.



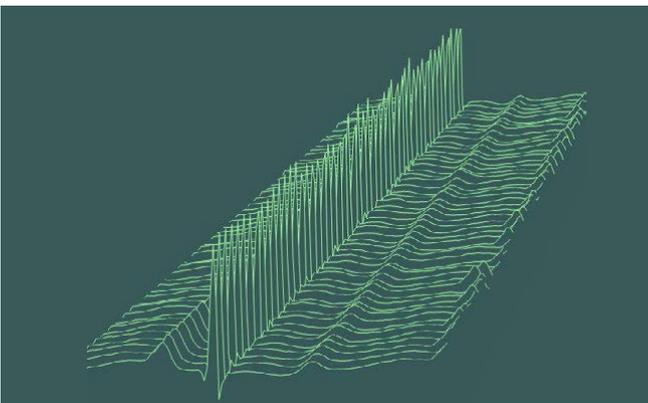
WATERFALL



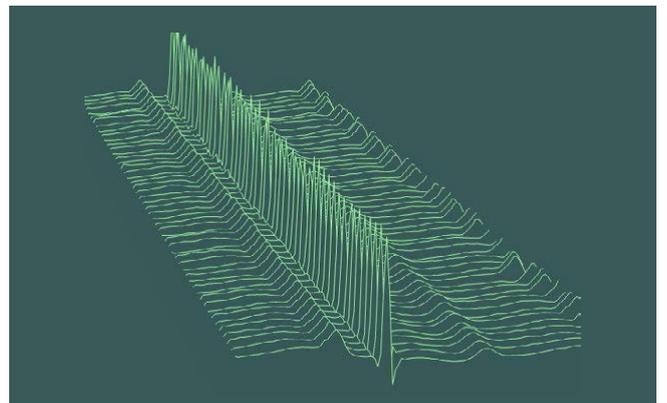
1. View without the perspective function



2. View with the perspective function turned on

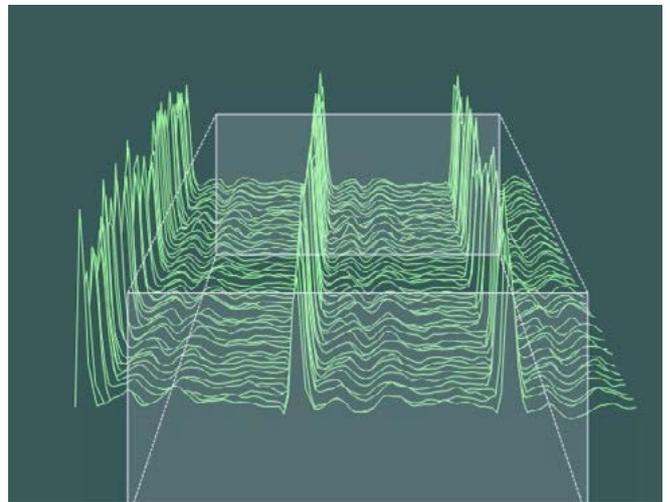
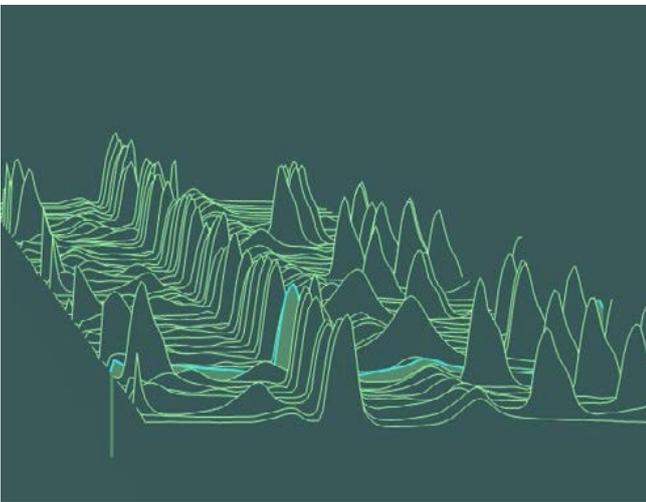
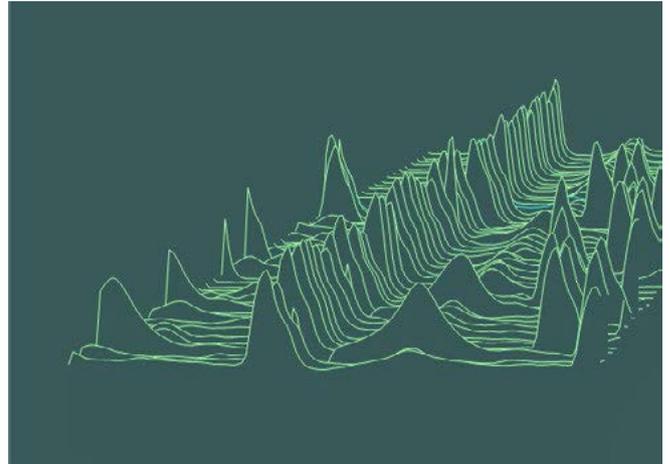
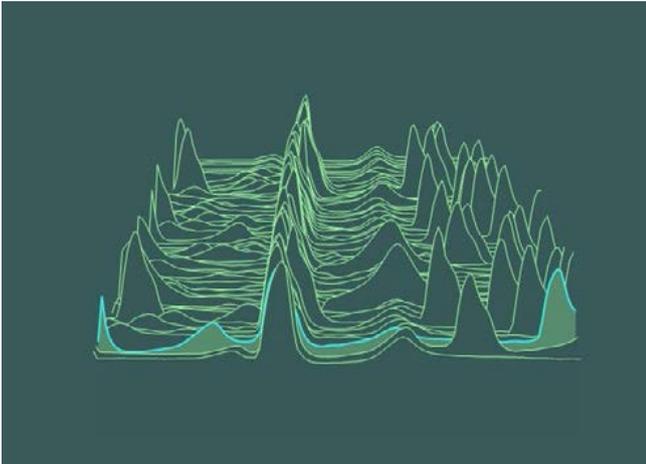


3. This angle is suitable to observe the ST segment and T wave development.



4. This angle is suitable to observe the P wave development.

2.2 Illustrative examples



2.3 Advantages of using the Relief and Waterfall tool together

The use of **Relief** and **Waterfall** tools are a practical choice to optimize the speed, accuracy, efficiency and diagnostics reliability in ECG signal processing. Each user will have a complex view of the signal in a broad time range. These tools simply and quickly reveal all the pathologies in the signal.



About BTL CardioPoint

The BTL CardioPoint is a versatile software solution integrating ECG, Stress test, Holter, ABPM and Spirometry into one unified platform with one patient database and the same logic of controls for each module. The software has a fully customizable interface, and its layout and work steps can be easily adapted. The operator is allowed to arbitrarily add or move tables, ECG strips and other windows. Fast and intuitive work is ensured by an ergonomically optimized user interface with shortened mouse tracks and hotkeys. Colour schemes are designed for both dark and light ambience. The BTL CardioPoint can be used as a stand-alone cardiology system, or it can be seamlessly integrated into an existing ambulatory or hospital system. The BTL CardioPoint is software that adapts to the user, instead of the user having to adapt to the software.

