The technique of investigation of space-time parameters of the master oscillator with fiber optical smoothing based on the slip photo recorder

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Abstract. The basic goal of this work is the development of investigation technique of space-time parameters of broadband oscillator of the powerful Luch Facility of the Russian Federal Nuclear Center designed to smooth radiation profile during passage of fiber optical line. The smoothing is achieved by means of modes mixing because of wave length dispersion in fiber optics, as a result the speckled radiation structure is removed. The optical scheme for recording radiation and the photochronograph with slot scan have been prepared to carry out measurements. The measurements of duration, impulse shape and space-time heterogeneity of laser radiation at output of formation system of reference radiation with fiber optical smoothing were carried out using that developed technique.

1. Scheme of diagnostics
The mentioned of broadband oscillator (B.O.) is designed to increase the radiation homogeneity of targets in the powerful laser Luch facility [1]. The width of radiation spectrum of B.O. is 2nm at energy of laser impulse to 50vJ at wave length \( \lambda =1054\, \text{nm} \).

Optical scheme of diagnostics (figure 1) presents reduced two-lens telescope (lenses L1 and L2) corresponding to output aperture of B.O. with the size of photo recorder cathode.

Output plane of fiber optical line of B.O. with scale of order 1:80 for recording of small scale space structure has been changed according to exit slop.

Short focal lens L2 together with L1 focus the radiation to the size comparable to photodiode receiver to record integrated after aperture of impulse shape of laser radiation.
Figure 1. Scheme of diagnostics. OF-optical fiber, PA–preamplifier, W–wedge, Qu–quantron, PC–Pockels cell, Gl–Glun prism, $\lambda/4$–quarter wave plate, PD–photodiode, P–polarizator, GT–Galileo’s telescope, Col–optical fiber collimator, Fl–filters, HSER-5–photochronograph, Osc–oscillograph

Collecting lens L4 with focal length 3sm was used to record interated shape of laser impulse by photochronograph that allowed fully to focus the whole spot of laser impulse into photochronograph slot.

Synchronization of photochronograph was performed by laser impulse reflected from polarizator surface which is included in two-pass preamplifier and later the radiation is reduced by set of filters.

The photochronograph of type HSER-5 [2] was used. The electronic optical converter of type SPO-23 was used as time analyzing cascade in the device.

This photochronograph has the following metrological characteristics:
- sweep time of recorded – 11ns on screen;
- space resolution – 10 pairs/mm at contrast 10%;
- time resolution of recording – 70ps at with of the installed enter slot 100mcm;
- dynamic range of recording-not less 200 after criterium of duration change 20% in the linear regime of recording.

Two types of photodetectors were used for integrated recording of impulse shape:
- Photodiode DET08CFC [3]-InGaAs with bandwidth 5GHz and working spectrum range from 800 to 1700nm;
• Photodiode APD2 [4]-avalanche photodiode based on Ge from upper boundary of frequency not less 1GHz and diameter of sensitivity area 0,2mm. Spectral current sensitivity A/W at wave length 0,632mcm corresponds to 0,15 and at wave length 1,06mcm corresponds to 0,5. Digitization of signals from diodes was performed by oscillograph Lecroy R610Zi [5] with bandwidth 1GHz.

2. Space-time recording
Special scan image of vertical laser radiation cross-section at output of optical fiber is shown on figure 3a. The spellings of upper, medium and low parts of laser impulse cross-section at output of optical fiber are demonstrated in figure 3b.

![Figure 3](image)

**Figure 3.** Recording of vertical radiation cross-section at output of optical fiber (a) and spellings of upper, medium and low parts of radiation cross-section at output of optical fiber (b).

After receiving the spellings one can judge about local duration of every zone of cross-section (2,1-2,65ns) and space-time heterogeneity of signal (50ps).

Taking into account the scale of optical scheme, space resolution in the plane of optical fiber was of order 1mcm. Heterogeneity with average size of order 5-7mcm with fluctuation intensity of order 7-10% from maximum was recorded in the space structure in the plane of optical fiber.

Recorded enveloping impulses have complex time structure with high-frequency modulation with period from 0,3 to 1ns. Duration of some impulses range from 0,2 to 0,5 ns/ such shape of laser impulse can be explained by stray modes in the initial resonator of B.O. which are not smoothed in fiber line.

The efficiency of obtained data by means of application in the photo recorder the CCD camera will allow to perform in future work setup of B.O. in the regime of real time. Thus, the efficiency of preparation and control of parameters before giving smoothed impulse in amplifying cascades of the Luch facility during powerful experiment can be provided.

3. Integrated time characteristics
We carried out the measurements of duration and impulse shape of integrated laser radiation using photochronograph of type HSER -5 and high speed photodiodes of type APD2 and DET08CFC.

The results of measurement demonstrate the advantage of photochronograph both at recording space and time characteristic of laser radiation impulse. In application of high speed slit photo recorder with big dynamic range, the better time resolution was achieved than in application of photodiode recording.

The normalized integrated values of laser radiation impulses recorded using photochronograph of type HSER -5 and photodiodes of type APD2 and DET08CFC are shown in the figure 4.
Figure 4. Integrated on the whole aperture time shapes of laser impulse, recorded by photo recorded and high speed photodiodes.

It should be noted that time values of laser impulse at half-height, which were recorded by different devices, are different.

Passport characteristics of response time of the used photodiodes are limited by passing band of the applied oscillograph in 1GHz and this must not lead to distortion of the recorded time parameters.

However, duration recorded by photodiodes of type APD2 was 5ns, DET08CFC was 5.7ns. In recording using photochronograph of type HSER-5 durations were 3.1ns and 2.9ns, respectively.

Most likely, prolongation of the recorded duration of laser impulse is connected with its complex structure. As it was reported in Chapter 2, in recording by photochronograph enveloping of output impulse of B.O. presents the train of subnanoseconds peaks moving with high frequency.

The result of recording with photodiodes can be superposition of response to single pulse train that leads to the widening of the recording enveloping by means of dragging of some impulses by semiconductive detectors.

Conclusion
The device was created for optimization of parameters of broadband oscillator in real time by means of control of space-time characteristics of laser radiation. The advantage of split photochronograph based on electronic optical converter compared to semiconductive detectors by means of high space and time resolution was demonstrated.

References
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