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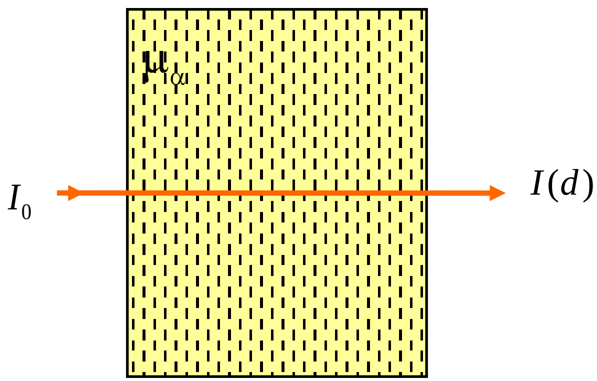
EXPERIMENTAL INVESTIGATION OF BIMODAL TEMPORAL DISTRIBUTIONS OF ULTRASHORT LASER PULSES AFTER PROPAGATION THROUGH THE HOMOGENEOUS LAYER OF HIGH SCATTERING BIOLOGICAL MEDIUM FOR THREE VALUES OF WAVELENGHT

Moskow, 2011

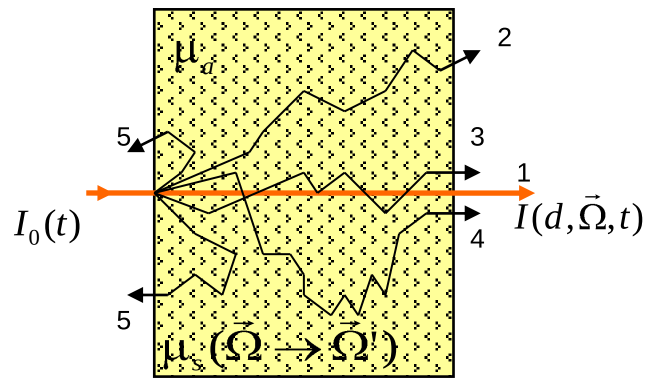
Light propagation through absorbing and scattering media

(a) Absorbing medium



Only ballistic photons

(b) Scattering medium

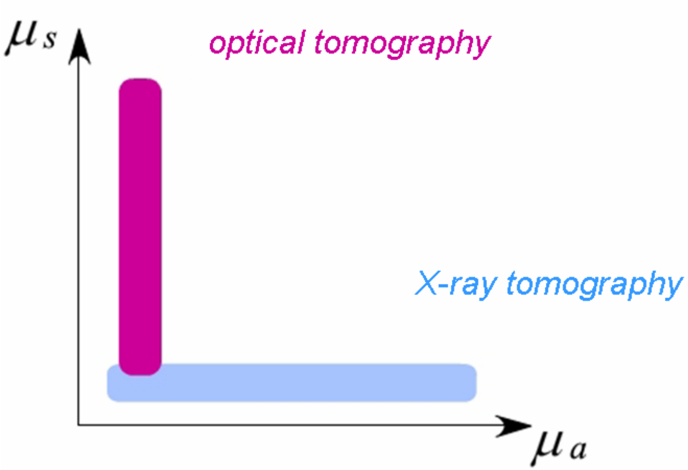


1 –ballistic photons;

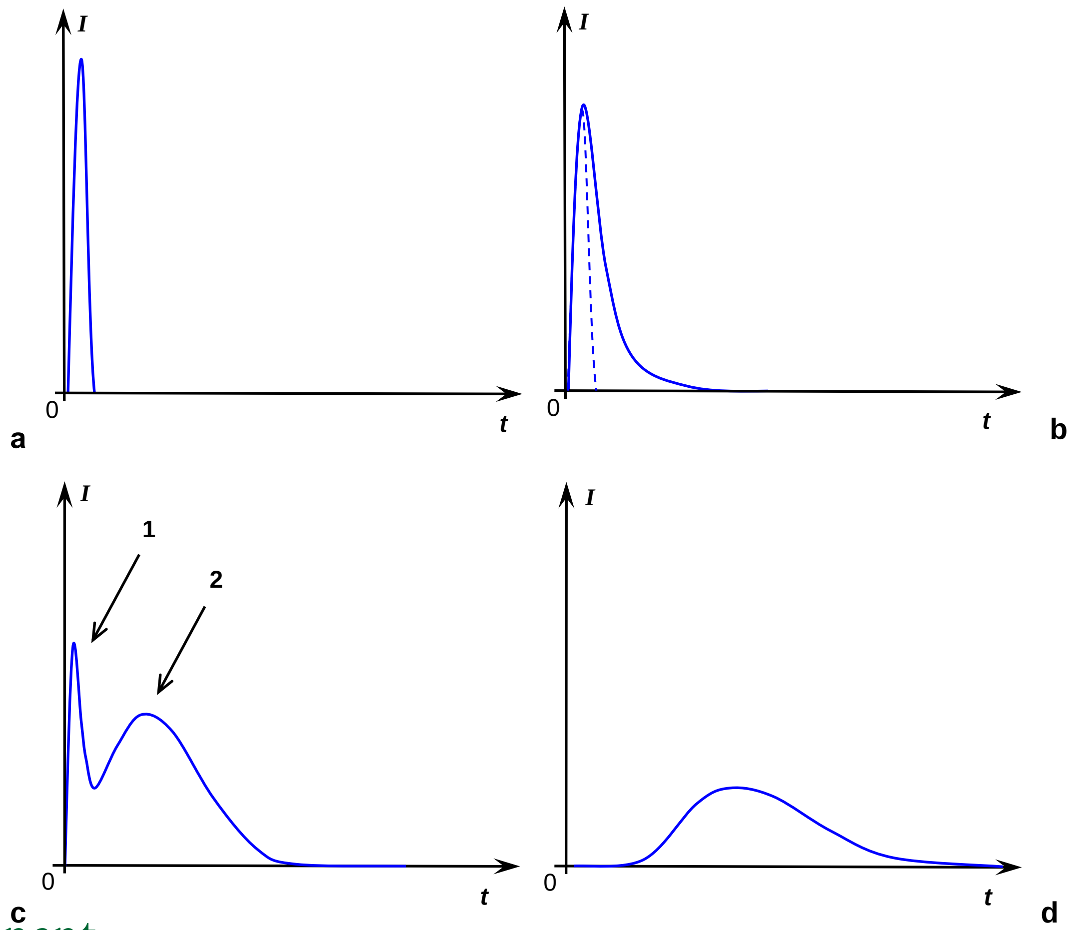
2 - off-axis photons;

3, 4 - near-axis photons which scattered to small (3) and large (4) angles;

5 - backpassed photons (5).



An evolution of the temporal distribution of an ultrashort laser pulse passed through a high-scattering medium



a – ballistic component

b – diffuse component for small concentrations of the scatterer

c – bimodal form which containing both ballistic (1) and scattered (2) photons, for intermediate concentrations of the scatterer

d – diffuse component for large concentrations of the scatterer

4 The mathematics of the nonstationary axial model of the light propagation through the high-scattering medium

The flux of photons:

$$F(t,x) = U_0\, m v \delta(mvt - mx) \exp(-mx) +$$
$$+ U_0\, \eta(mvt - mx) \frac{v m_s x}{\sqrt{(vt)^2 - x^2}} I_1\left(m_s \sqrt{(vt)^2 - x^2} \right) \exp(-mvt)$$

v – the speed of light in the medium

U_0 – the energy of the initial pulse

$I_1()$ – modified Bessel function of the 1-st kind of the 1-st order

$\delta()$ – Dirac delta-function

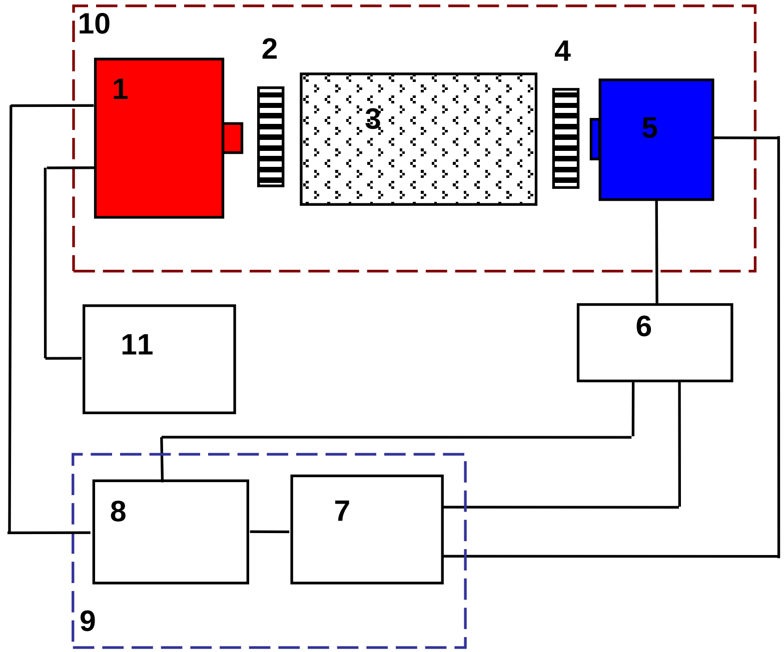
$\eta()$ – Heaviside function

$m = m_a + m_s$ – the radiation extinction coefficient

m_a – the radiation absorption coefficient

m_s – the radiation scattering coefficient

The experimental setup block-scheme



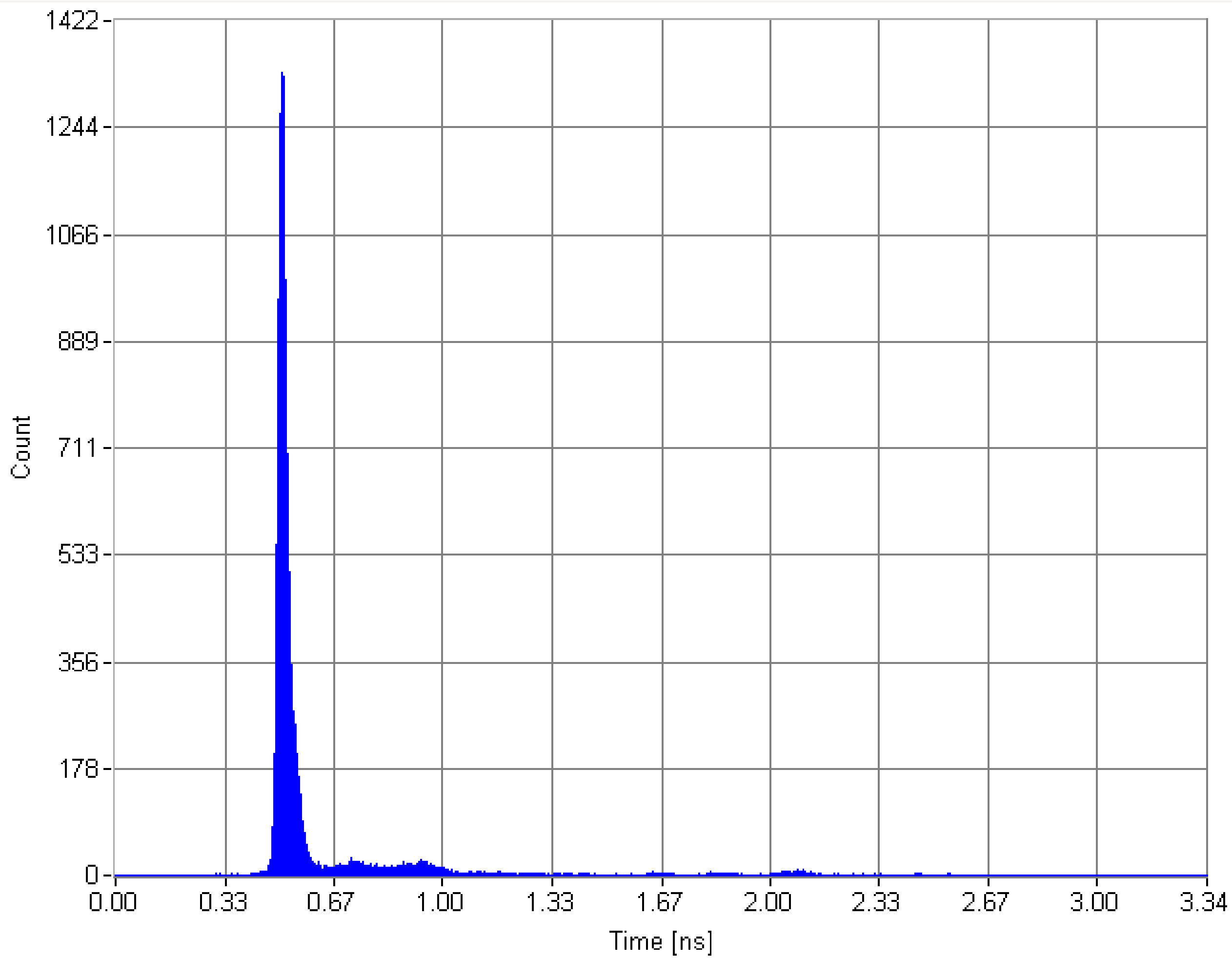
1 – the femtosecond pulse Ti:Sa laser; 2 – the variable attenuator; 3 – the rectangular cuvette with the model biological high-scattering media; 4 – the filter;

5 – the microchannel photomultiplier tube; 6 – the preamplifier; 7 – microchannel photomultiplier tube management; 8 – the registration board SPC-830;

9 – personal computer; 10 – light protection module; 11 – laser power supply

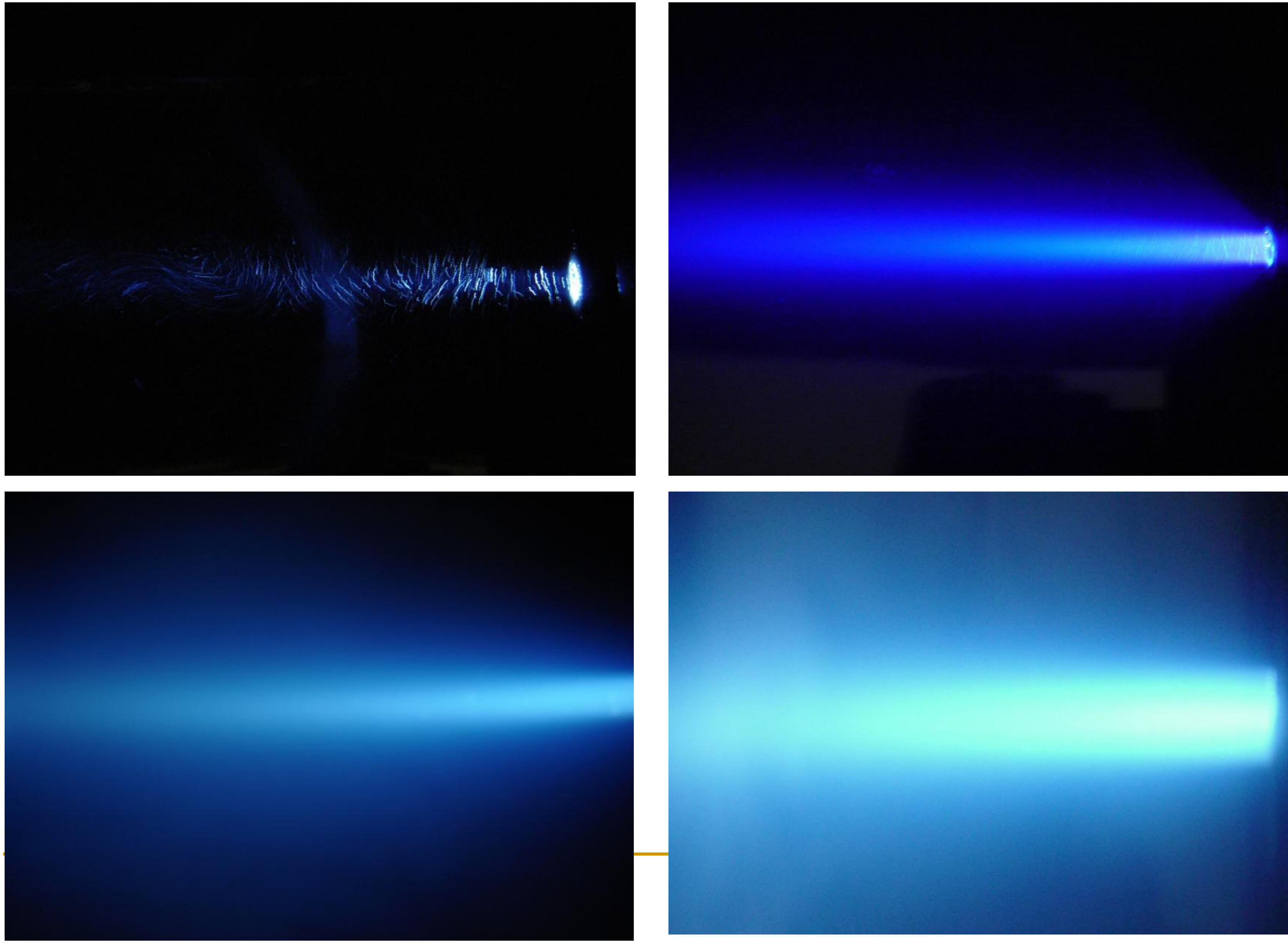
6 The experimental setup

7 The experimental temporal distribution of the initial laser pulse



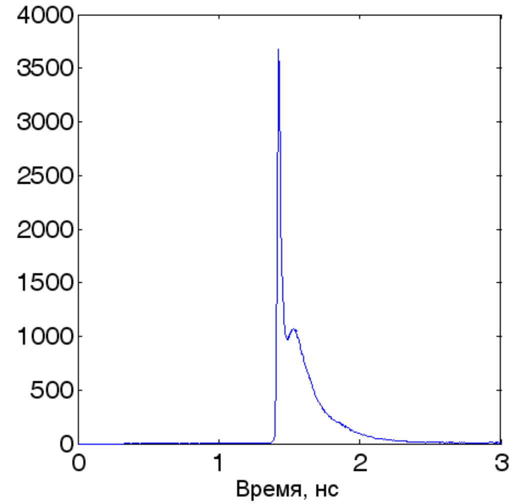
The model object of high-scattering medium (the milk solution in the water)

Light propagation through scattering media

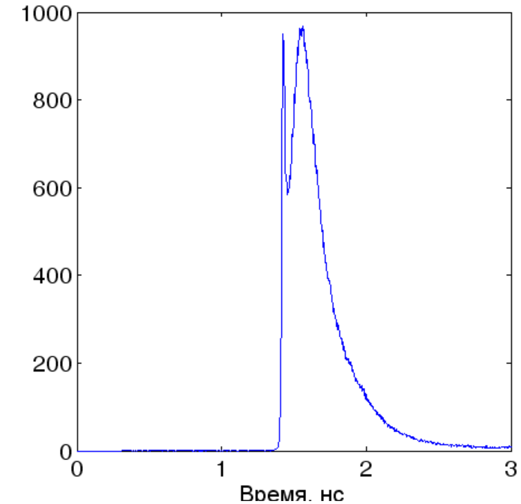


The bimodal temporal distribution of ultrashort laser pulses passed through HSM for different milk concentrations

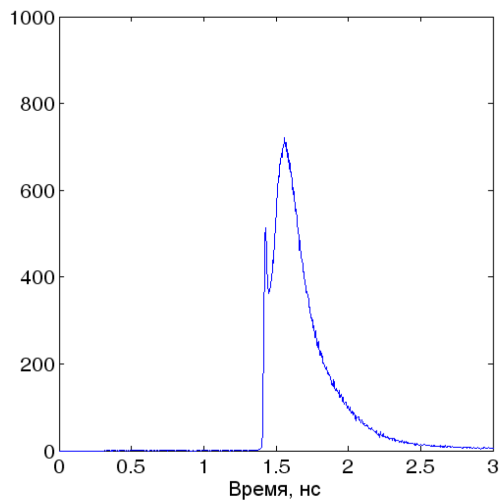
a $n = 0{,}24\%$



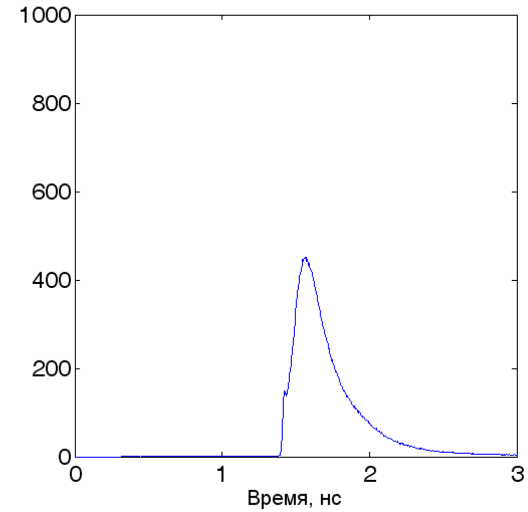
b $n = 0{,}26\%$



c $n = 0{,}27\%$



d $n = 0{,}29\%$

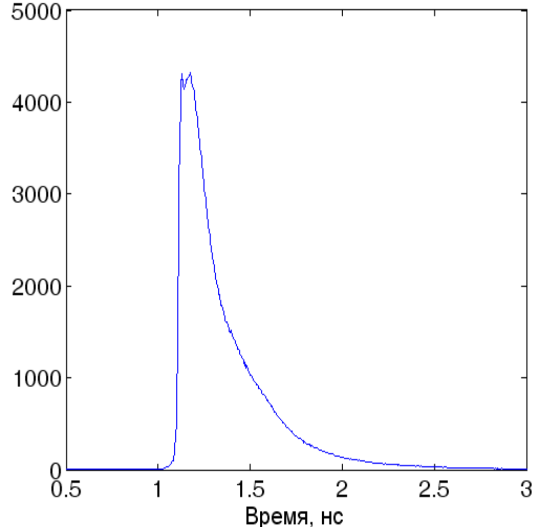


$n = 0{,}2 \div 0{,}33\%$

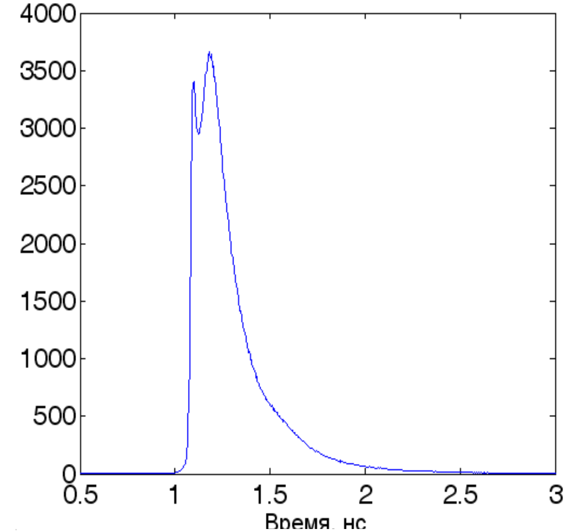
λ=750 nm

The bimodal temporal distribution of ultrashort laser pulses passed through HSM for different milk concentrations

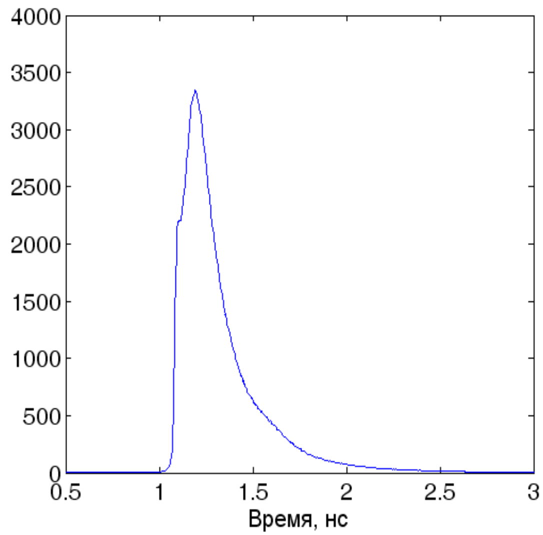
a $n = 0{,}20\%$



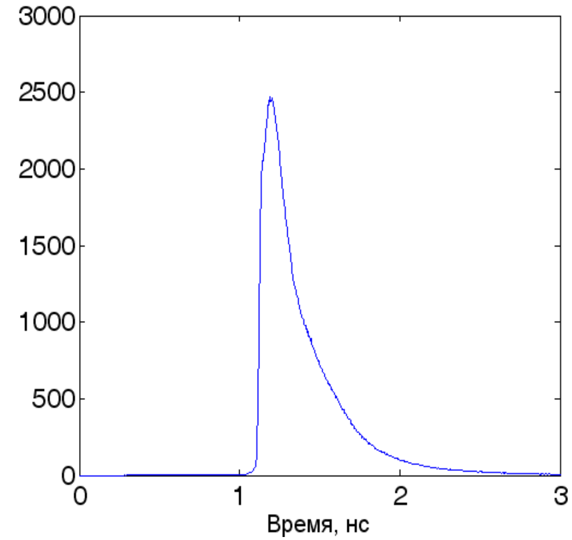
b $n = 0{,}21\%$



c $n = 0{,}215\%$



d $n = 0{,}22\%$

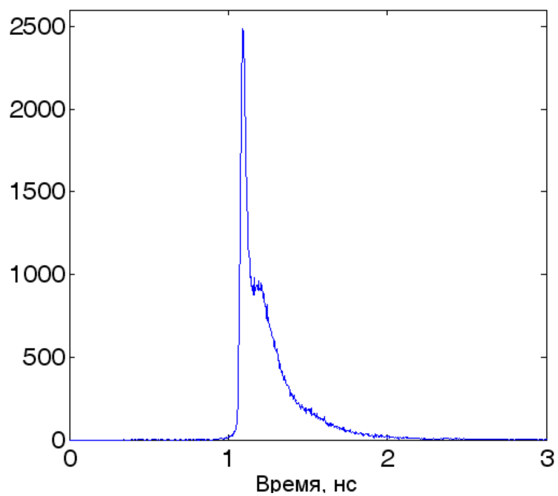


$n = 0{,}17 \div 0{,}27\%$

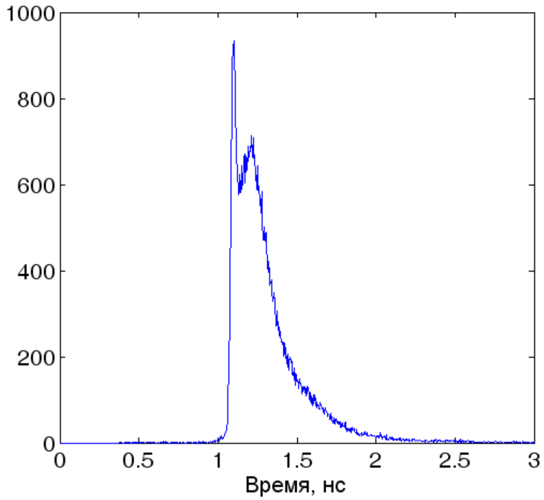
λ=825 nm

The bimodal temporal distribution of ultrashort laser pulses passed through HSM for different milk concentrations

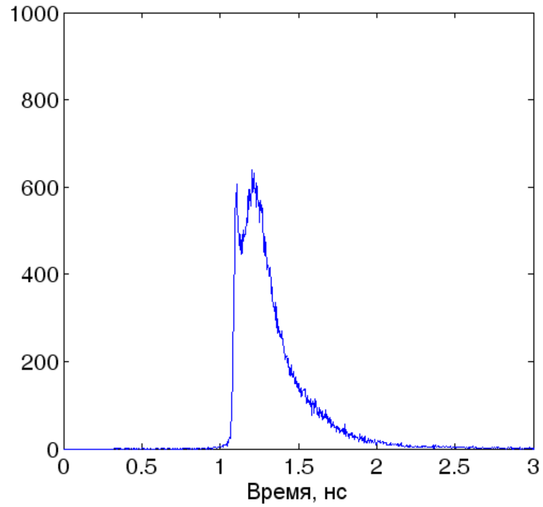
a $n = 0{,}28\%$



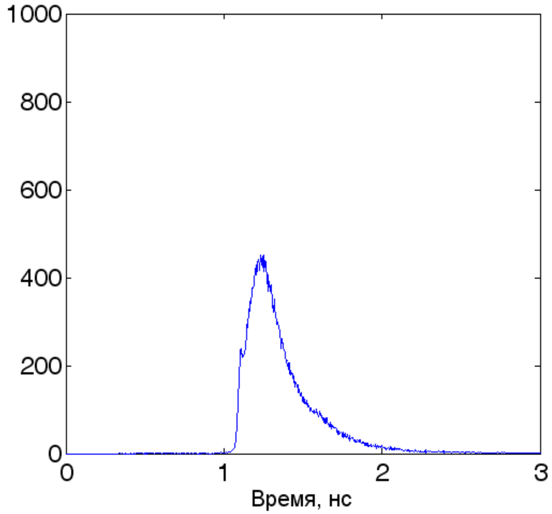
b $n = 0{,}30\%$



c $n = 0{,}31\%$



d $n = 0{,}33\%$



$n = 0{,}27 \div 0{,}39\%$

λ=900 nm

Conclusions

1. We have investigated the evolution of the temporal distribution at three values of wavelength.
2. A laser radiation passed through a high-scattering medium has a complicated temporal structure.
3. The presented experimental setup allows observing the bimodal temporal distribution in the narrow range of high-scattering medium characteristics.
4. As a result of our investigation we have found a narrow range of milk concentration, in which we can observe the bimodal temporal distribution.
5. We can determine the optical characteristics of high-scattering medium on the base of the obtained bimodal temporal distributions.

Thank you for your attention!