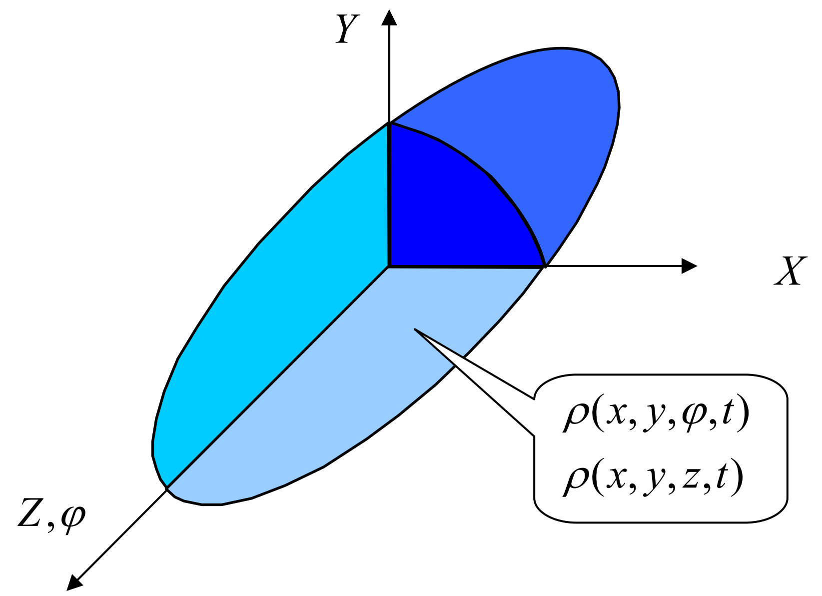
TECHNIQUE AND INSTRUMENTATION FOR BUNCH SHAPE MEASUREMENTS

A.Feschenko

Institute For Nuclear Research (INR), Moscow 117312, Russia



Bunch shape $\rho(x,y,\varphi,t)$

or $J(\varphi,t)=\int\rho(x,y,\varphi,t)dxdy$

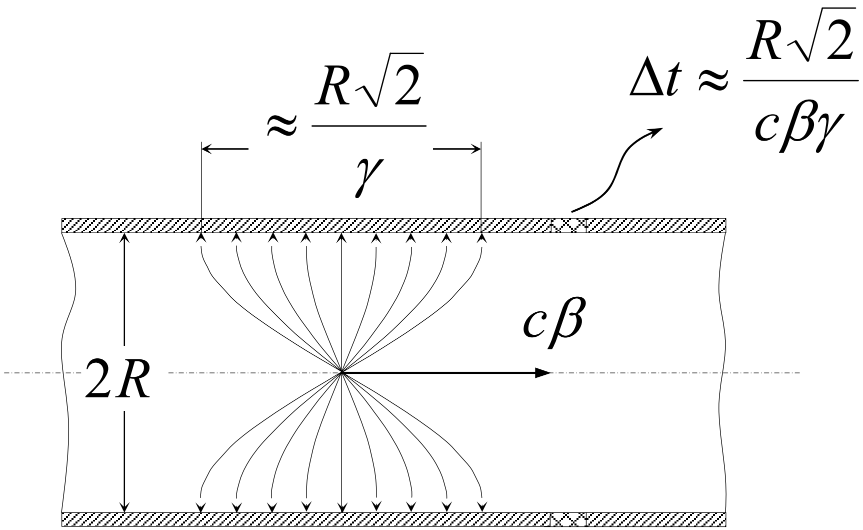
or $J(\varphi)=\int\rho(x,y,\varphi)dxdydt$

The main requirement for Bunch Shape Measurements is sufficient Phase Resolution

For typical Bunch Phase Durations ~10° phase resolution must be about 1°

For f=400 MHz phase resolution of 1° is equivalent to time resolution of 7 ps.

The equivalent bandwidth: ΔF =72 GHz.



Configuration of electric field of point charge moving in a metal pipe.

For W=100 MeV and *R*=2 cm

ΔF=2.5 GHz.

<u>The way out</u> is localization of space region where the information transfer occurs.

There are different possibilities to shrink the area of information transfer:

1. Cherenkov radiation;
2. Detached electrons in case of H- (including photo-detachment);
3. δ-electrons;
4. Transition radiation;
5. X-rays;
6. Electrons obtained due to residual gas ionization;
7. Low energy secondary electrons;
8. etc.

The main characteristics of Low Energy Secondary Electrons influencing BSM parameters

- Energy distribution
- Angular distribution
- Time dispersion (delay of emission)

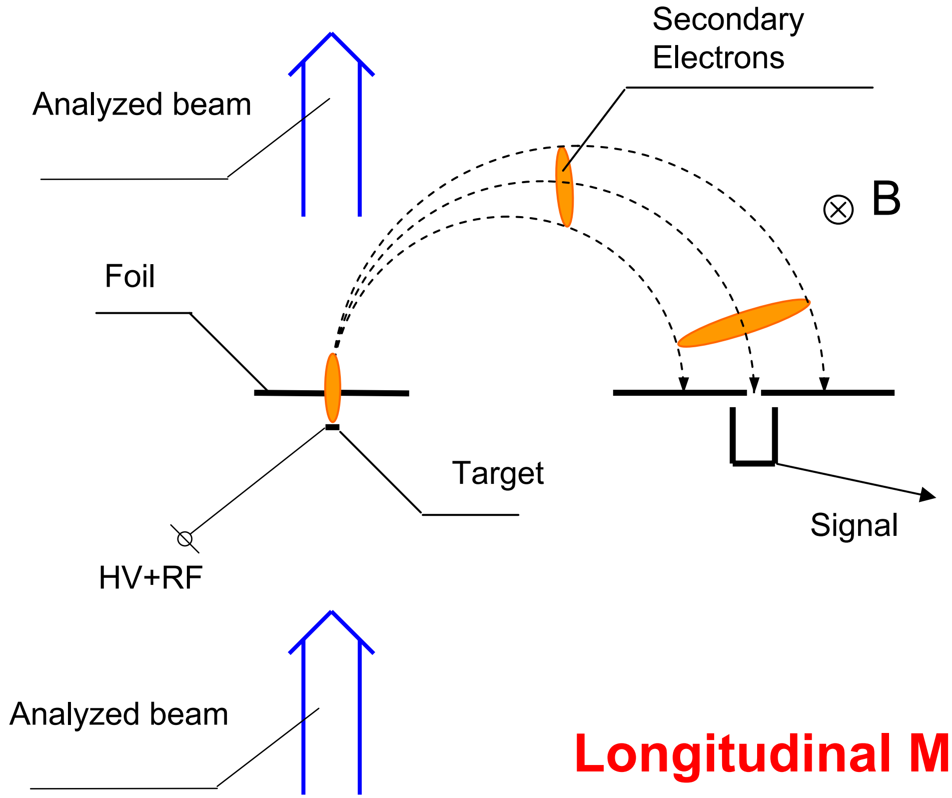
These characteristics almost do not depend on type or on energy of primary particles

Time dispersion is principal reason of limitation of BSM phase resolution.

Theoretical value of time dispersion for metals is 10^{-14}s ÷ 10^{-15}s.

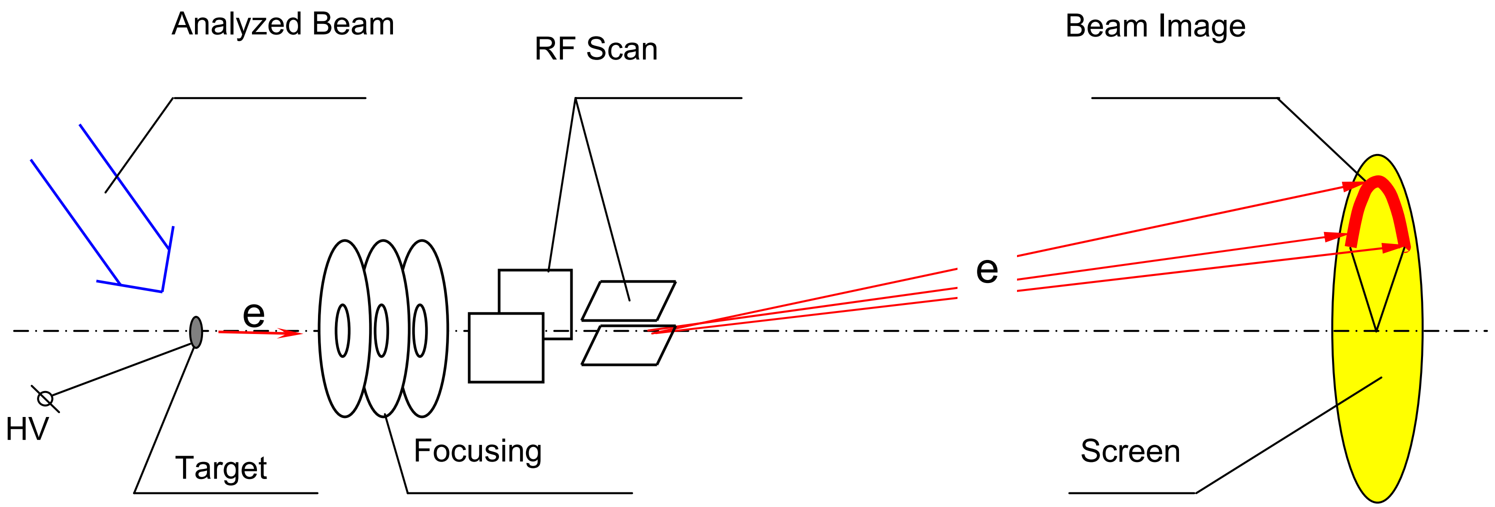
Experiment gives the upper limit of time dispersion. Depending on the accuracy the upper limit was found to be from (4±2) ps to several hundred ps.

(Witkover R.L. A Non-destructive Bunch Length Monitor For a Proton Linear Accelerator // Nucl. Instr. And Meth. – 1976, V. 137, No. 2, - pp. 203-211)



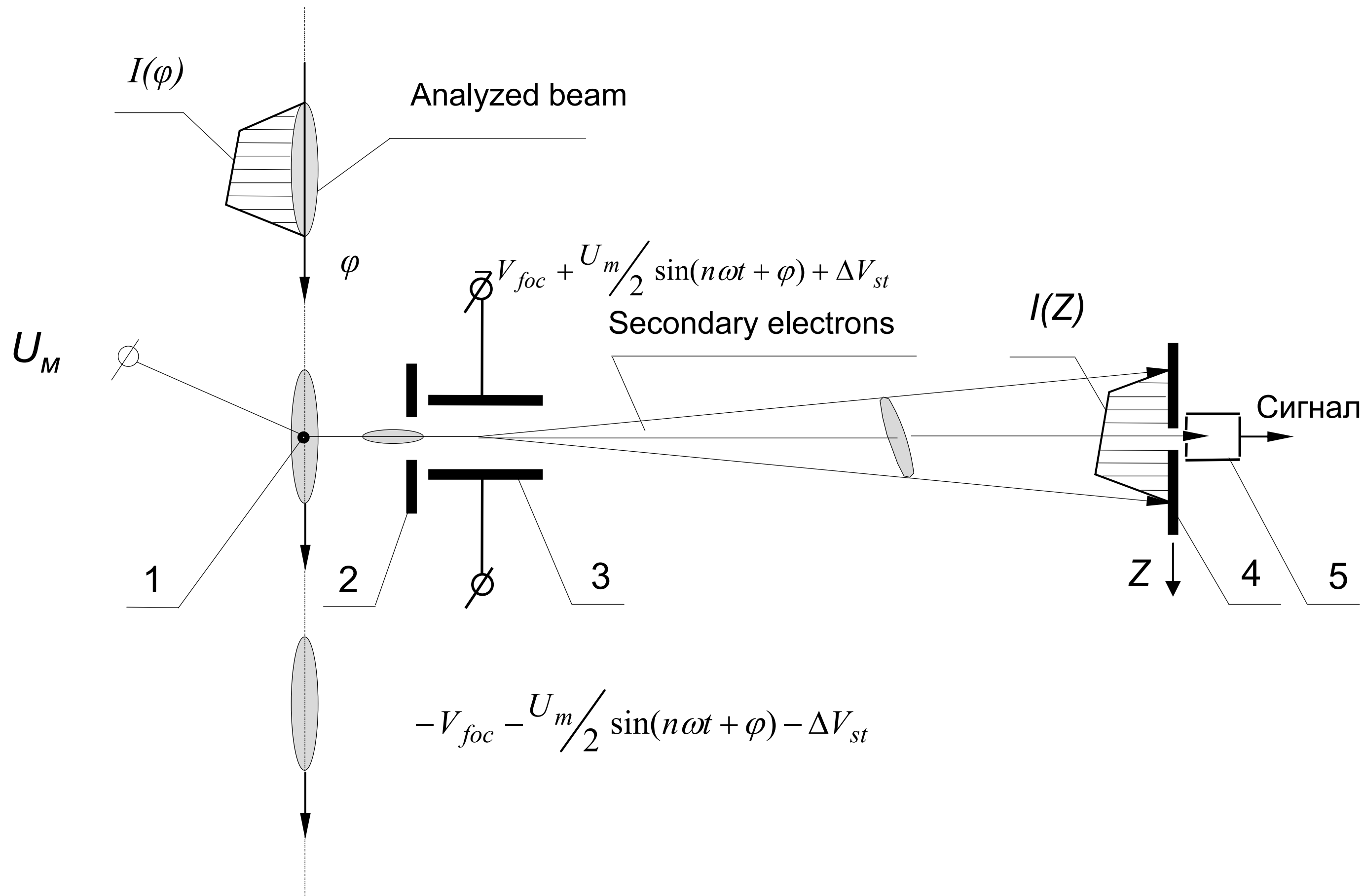
Longitudinal Modulation

I.A.Prudnikov et all. A Device to Measure Bunch Phase Length of an Accelerated Beam. USSR invention license. H05h7/00, No.174281, 1963 (in Russian).



Transverse Circular Modulation

Configuration of INR Bunch Shape Monitor



1 - target, 2 - input collimator, 3 - rf deflector combined with electrostatic lens, 4 - output collimator, 5 – collector of electrons

Evaluation of phase resolution

Displacement of electrons at output collimator

$$Z_L = Z_{\max} \sin \varphi$$

Phase resolution $$\Delta\varphi = \frac{\Delta Z_L}{Z_{\max}}$$

where ΔZ_L - full width at a half maximum of electron beam size for a δ-function bunch,

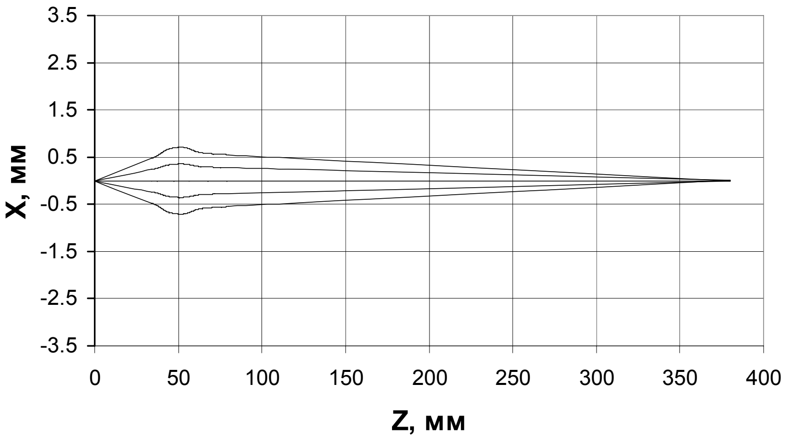
Z_{max} – amplitude of electron displacement at output collimator.

In practice we use: $$\Delta\varphi = \frac{\sqrt{(2\sigma)^2 + (\Delta Z_0)^2}}{Z_{\max}}$$

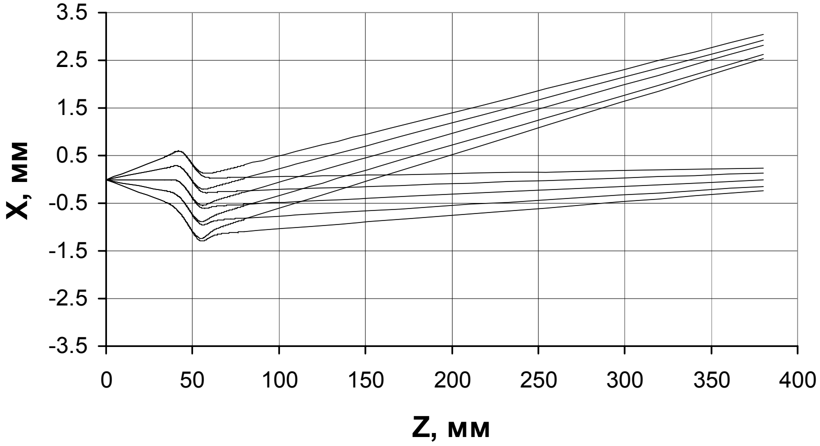
where ΔZ_0 – focused beam size observed experimentally for rf deflection off, σ – rms size of the focused electron beam for a δ-function bunch

Example of electron trajectories

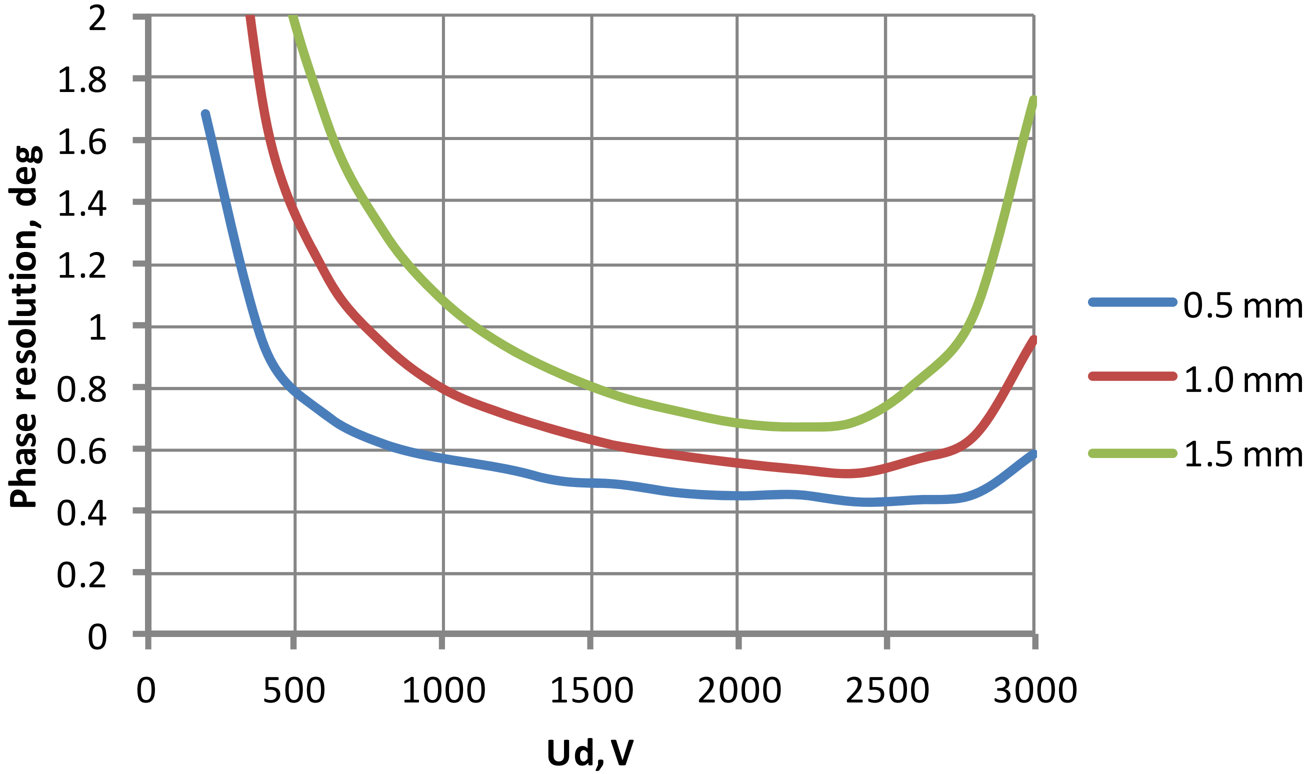
Trajectories for optimum focusing and rf deflection off



Trajectories electrons efor two groups of electrons entering rf deflector at different phases (phase difference equals 5° at f=1300 MHz)



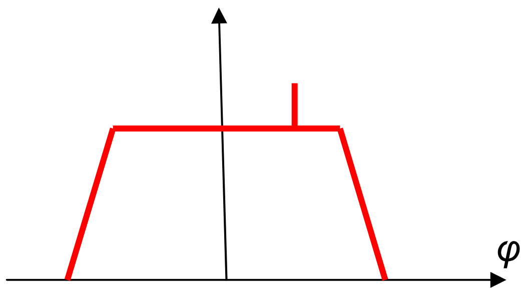
Dependence of Phase Resolution on Amplitude of Deflecting Voltage for different Input Collimators (f=352.2 MHz)

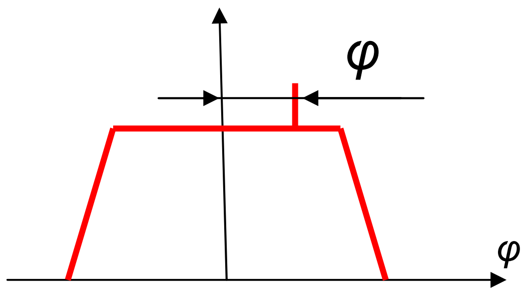


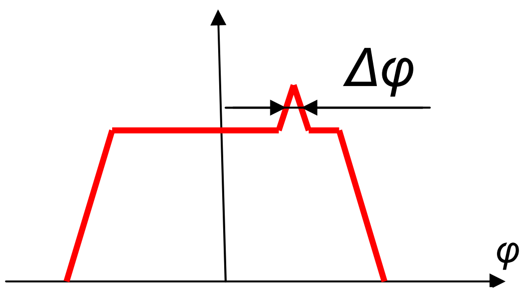
Influence of analyzed beam space charge

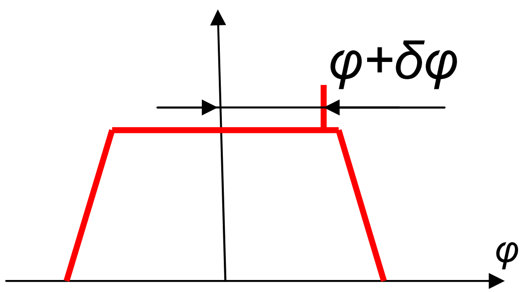
Increasing of the focused beam size

Changing of the average position of the focused electron beam at the output collimator





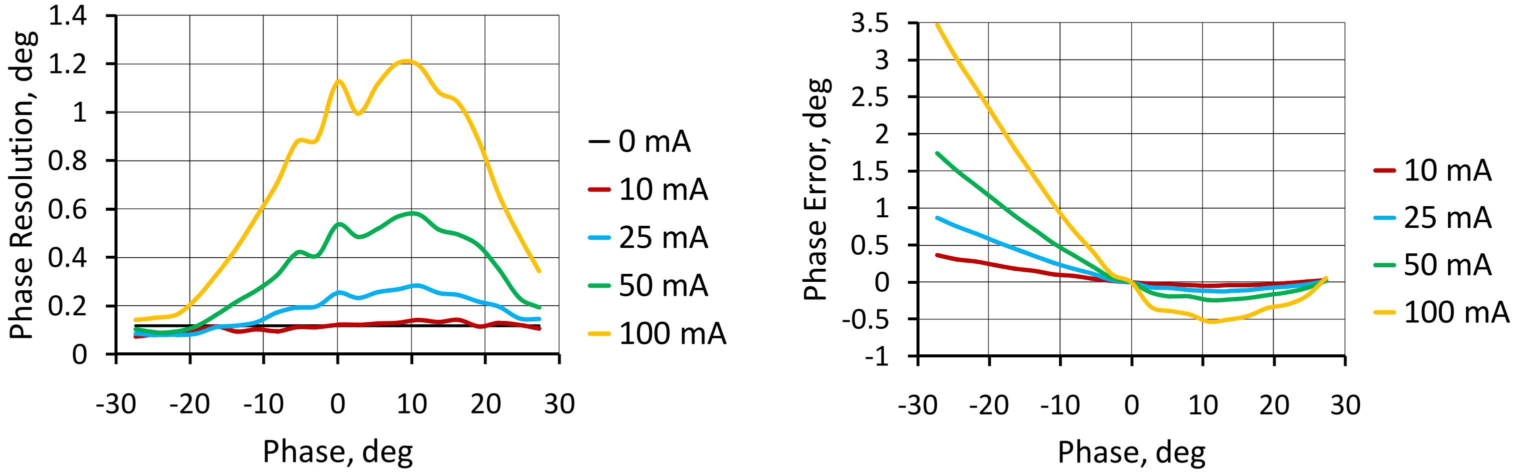




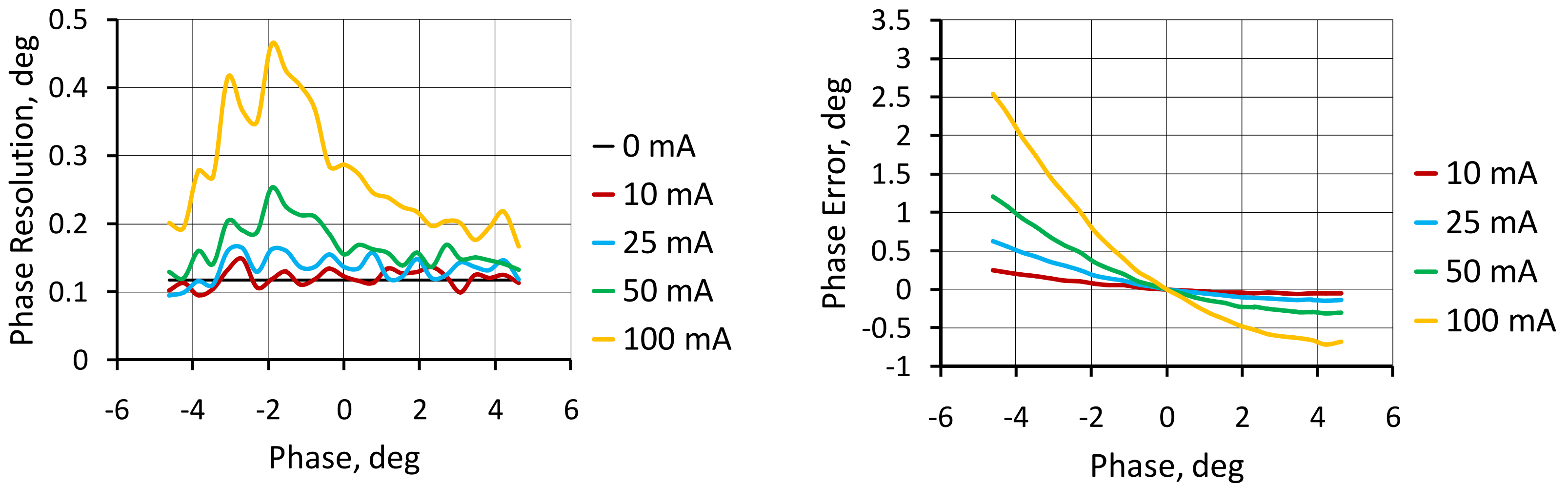
Aggravation of Phase Resolution

Arising of Phase Reading Error *δφ*

Influence of analyzed beam space charge

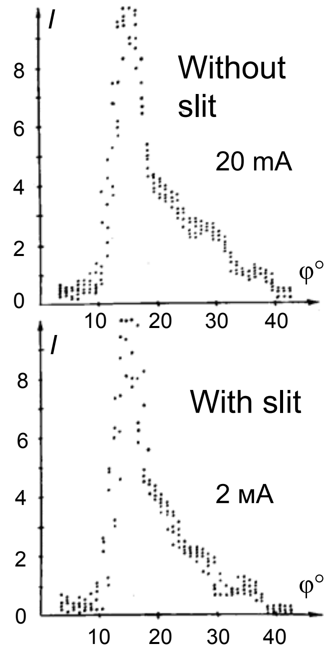


Resolution and phase reading error for W=3 MeV H-minus, σy=2.6 mm, σz=2.6 mm, σφ=13º, Zo=0 mm, f=366 MHz (Model #1)



Resolution and phase reading error for W=200 MeV, H-minus, σy=1.2 mm, σz=1.2 mm, σφ=2.1º, Zo=0 mm, f=366 MHz (Model #2)

Results of experimental test of space charge influence in INR linac at 20 MeV beam

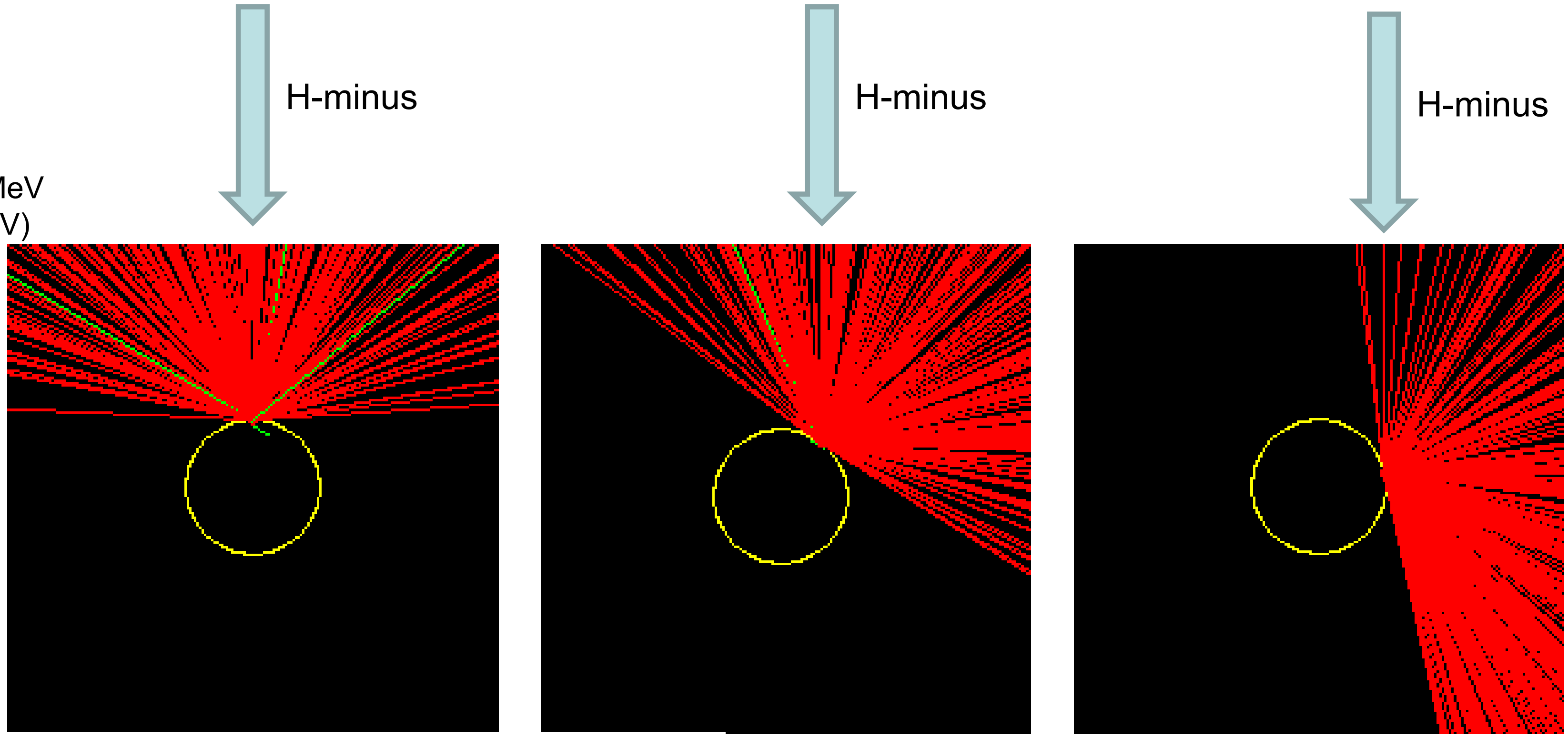


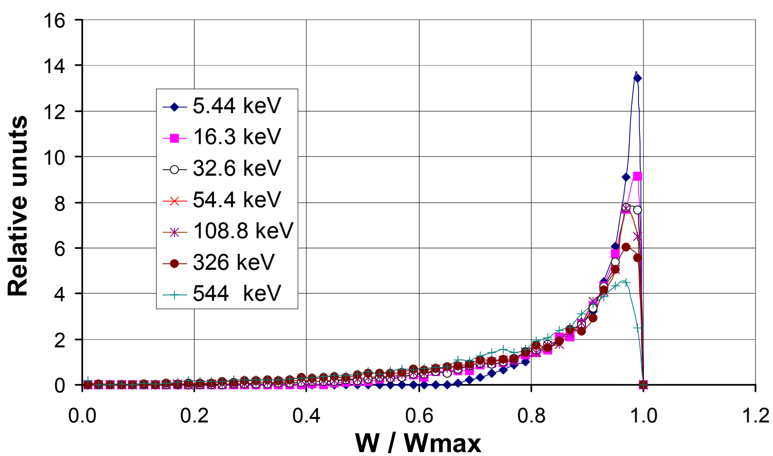
Detector Modifications

1. Bunch Shape Monitor (BSM) for H-minus
2. Bunch Length and Velocity Detector (BLVD)
3. Detector of Thee-Dimensional Distribution of Particles in Bunches (3D-BSM)

Bunch Shape Monitor (BSM) for H-minus

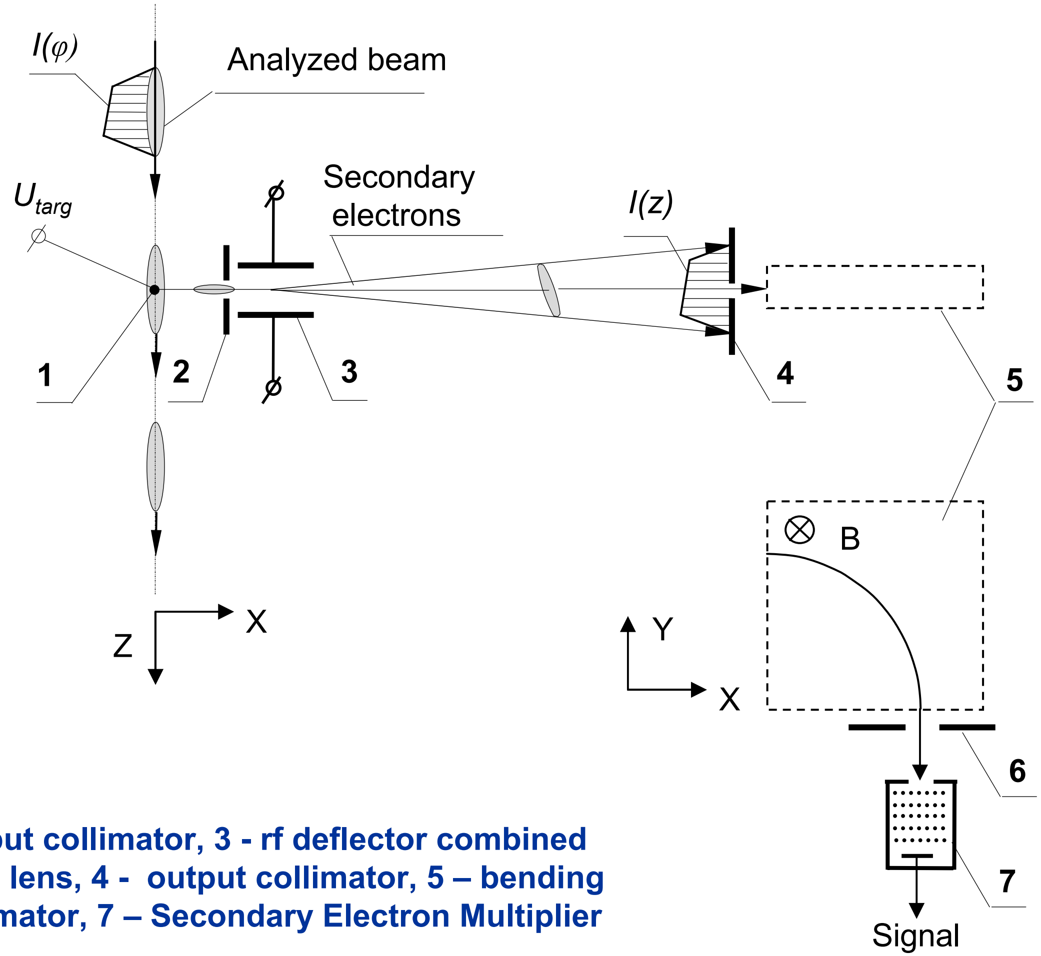
W=100 MeV
(54.4 keV)





Energy distribution of electrons passed through input BSM collimator

Bunch Shape Monitor (BSM) for H-minus



1 - target, 2 - input collimator, 3 - rf deflector combined with electrostatic lens, 4 - output collimator, 5 – bending magnet, 6 – collimator, 7 – Secondary Electron Multiplier

Bunch Length and Velocity Detector (BLVD)

BLVD is a BSM, which can be mechanically translated along the beam line.

A time of flight method of energy measurements is implemented.

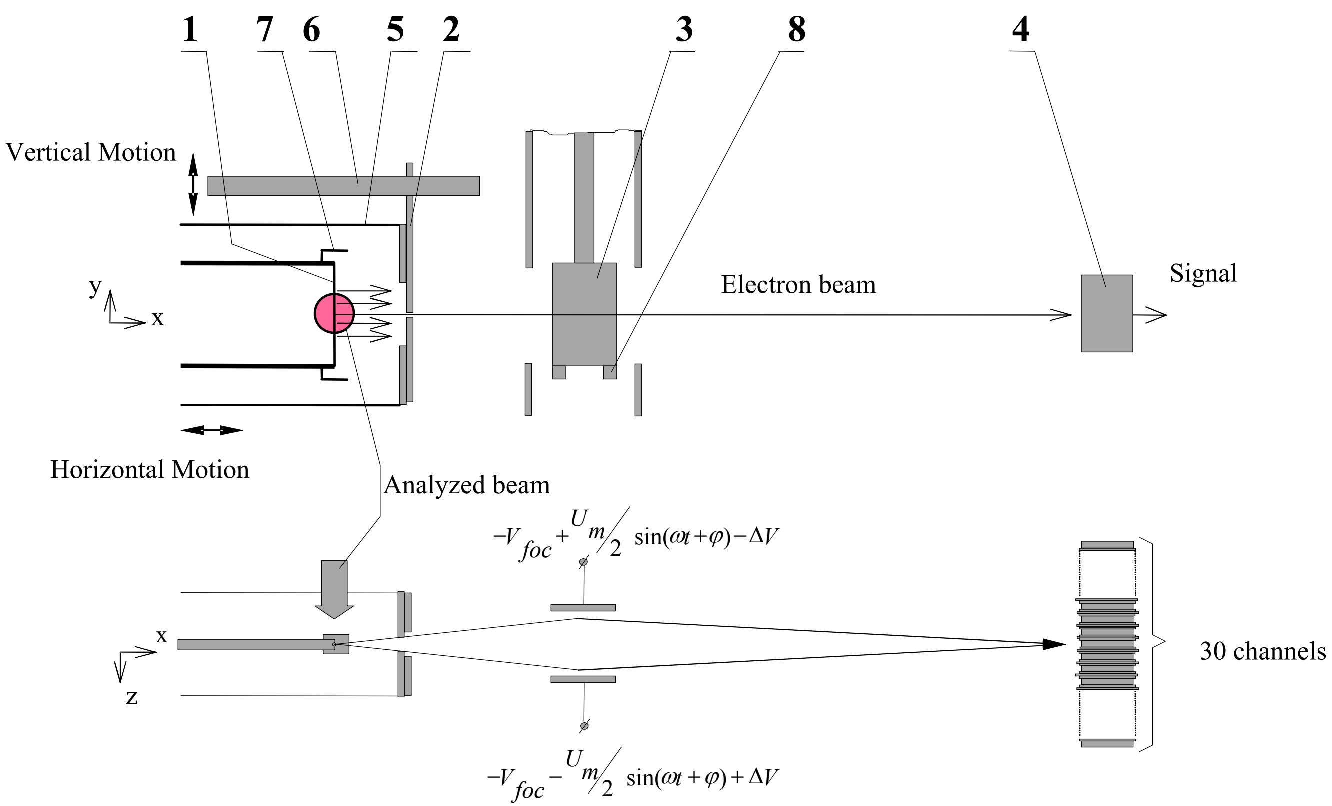
The translation results in a shift in phase of the observed distribution.

Measuring the value of the translation and the value of the shift one can find an average velocity of the beam.

The accuracy of velocity measurements:

- Systematic ±0.1%
- Total ±(0.3÷0.4)%.

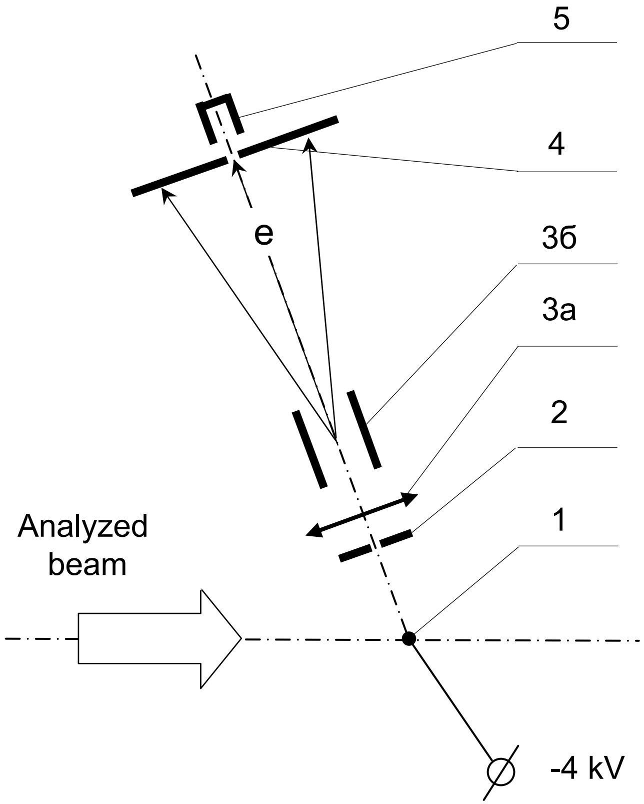
Three Dimensional Bunch Shape Monitor (3D-BSM)



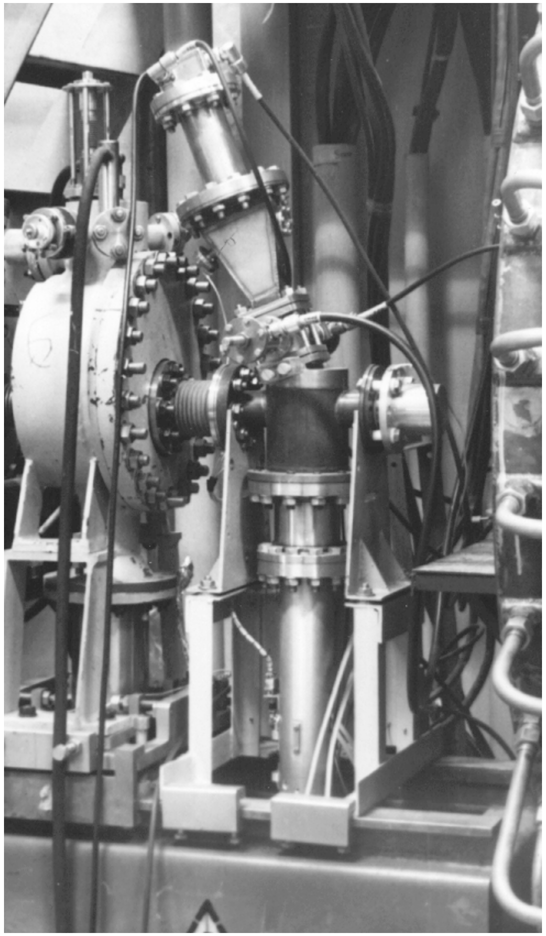
BSMs developed and built in INR

Тип детектора	Лаборатория	Анализируемый пучок	Год запуска	Кол. детекторов
BSM	ИЯИ РАН	H+ (20 МэВ, 100 МэВ)	1988	1
BSM	SSC	H- (2,5 МэВ)	1993	1
BLVD	CERN Linac-3	Pb 27+ (0,25МэВ/н, 4,2МэВ/н)	1994	1
BSM	SSC	H- (2,5 МэВ)		1
BSM	SSC	H- (70 МэВ)		1
BSM	SSC	H- (600 МэВ)		1
3D-BSM	CERN Linac-2	H+ (50МэВ)	1996	1
BLVD	KEK	H- (3 МэВ)	1996	1
BSM	DESY	H- (10 МэВ,30 МэВ)	1997	2
BLVD	DESY	H- (50МэВ)	1997	1
BLVD	ИЯИ РАН	H+ (160МэВ)	1997	1
BSM	CERN Linac-2	H+ (10 МэВ, 30 МэВ)	1999, 2000	2
BSM	SNS ORNL	H- (7,5 МэВ, ≈90 МэВ)	2003-2004	4
BSM	SNS ORNL	H- (≈180 МэВ)	2007	1
BSM	SNS ORNL	H- (≈1 ГэВ)	2008-2010	3
BSM	CERN Linac-4	H- (3÷160 МэВ)	2012 (2013)	1
BSM	J-PARC	H- (≈200 МэВ)	2012	3
BSM	LANSCE	H+,H- (0,75;100 МэВ)	2014	2

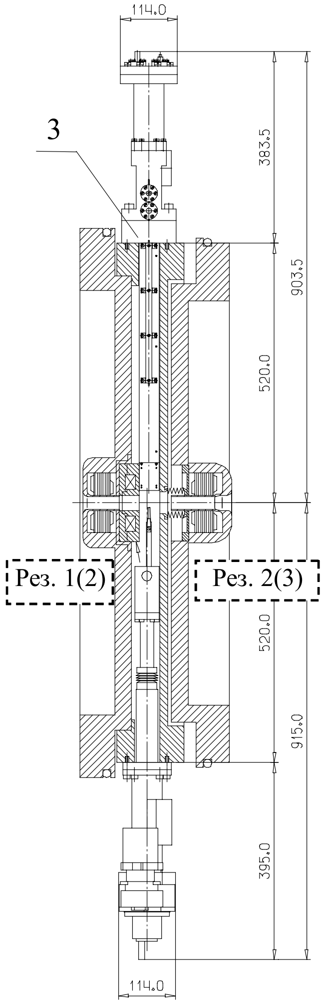
The first INR Bunch Shape Monitor

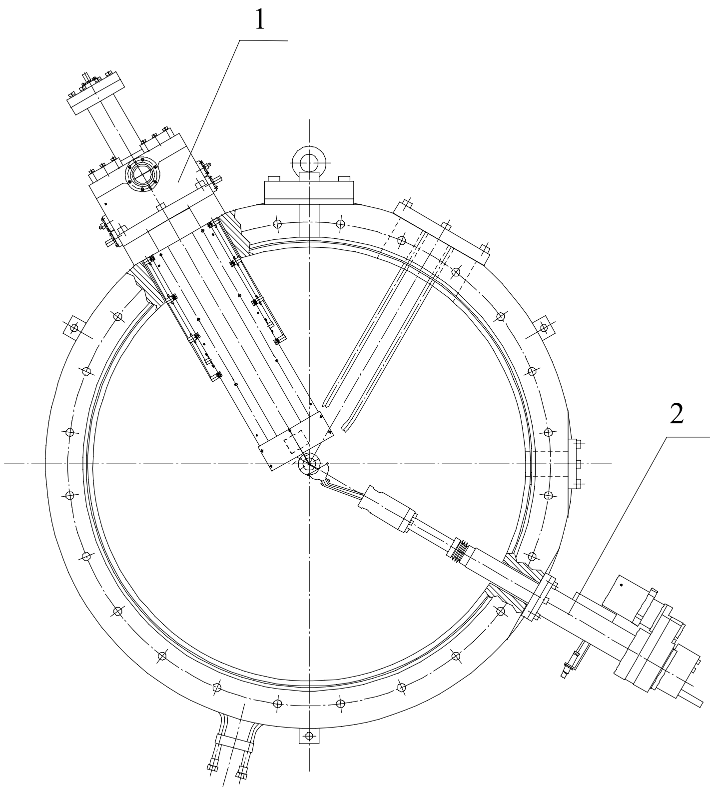


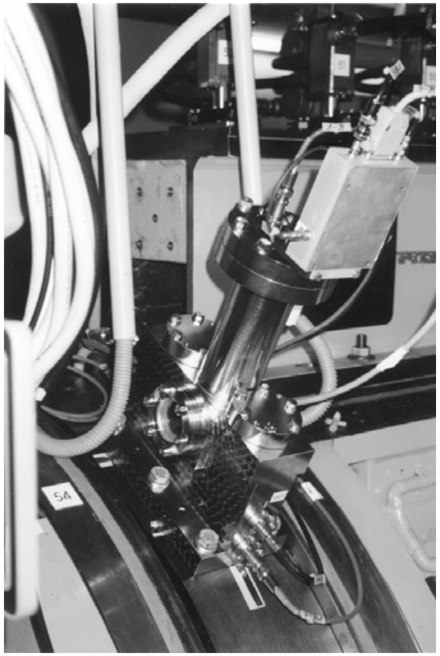
(1 – target, 2 – input collimator, 3a – electrostatic lens, 3б – rf deflector, 4 – output collimator, 5 – collector of electrons)

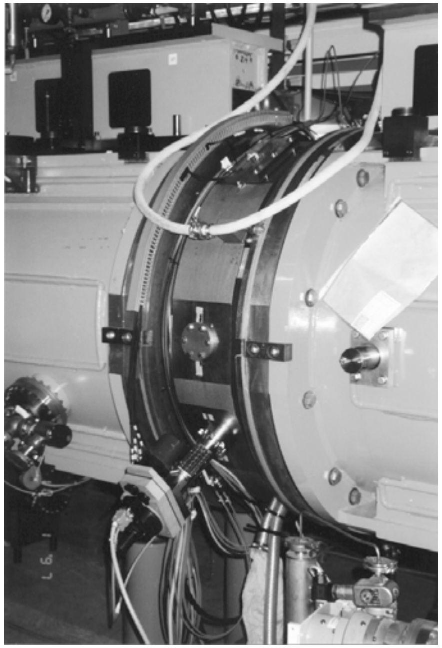


BSMs for DESY Linac-3 and CERN Linac-2

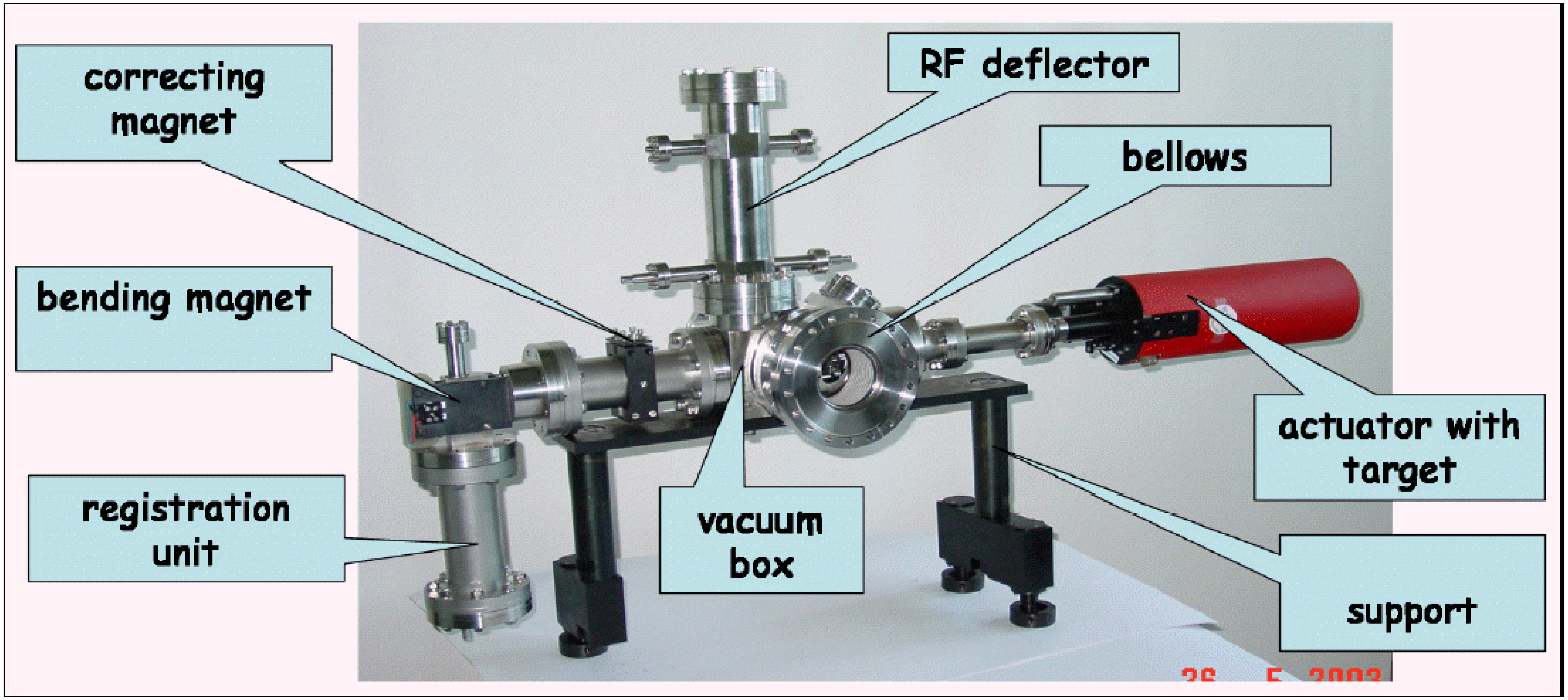


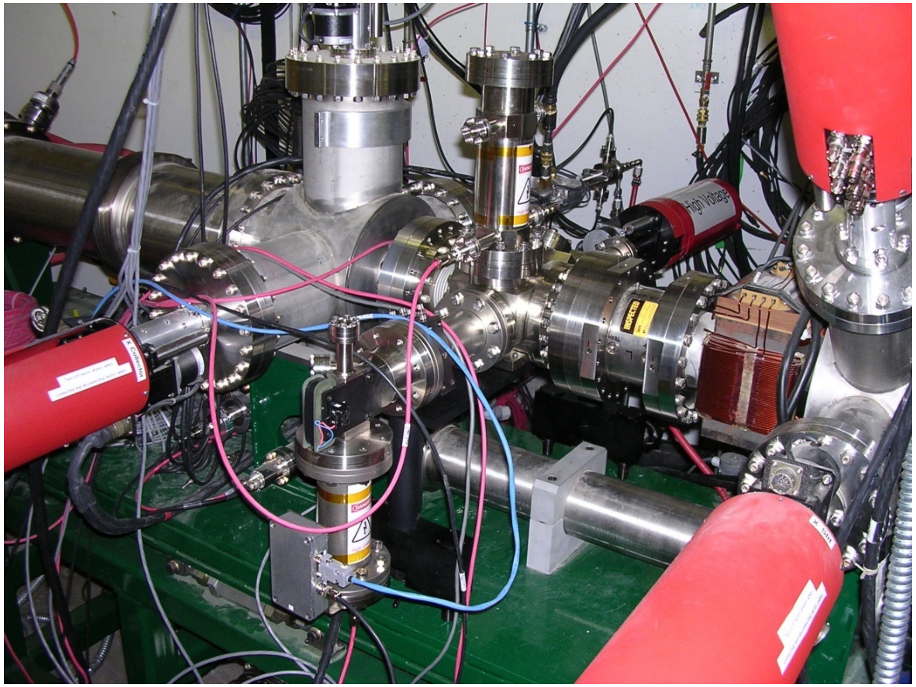




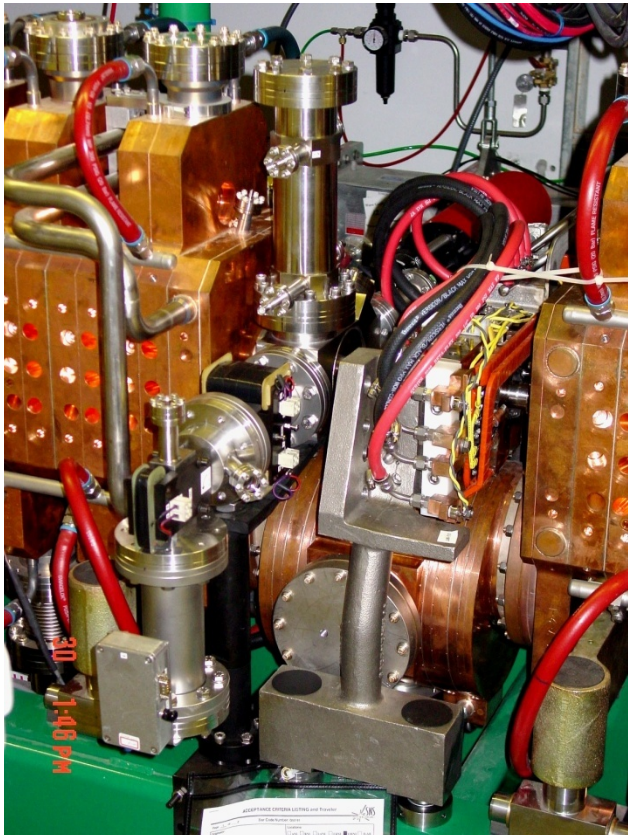


General View of SNS test BSM



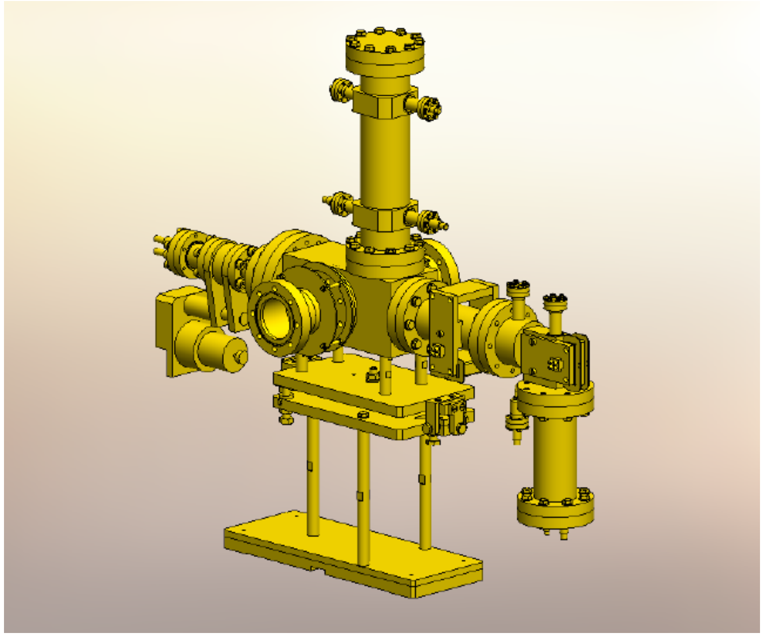


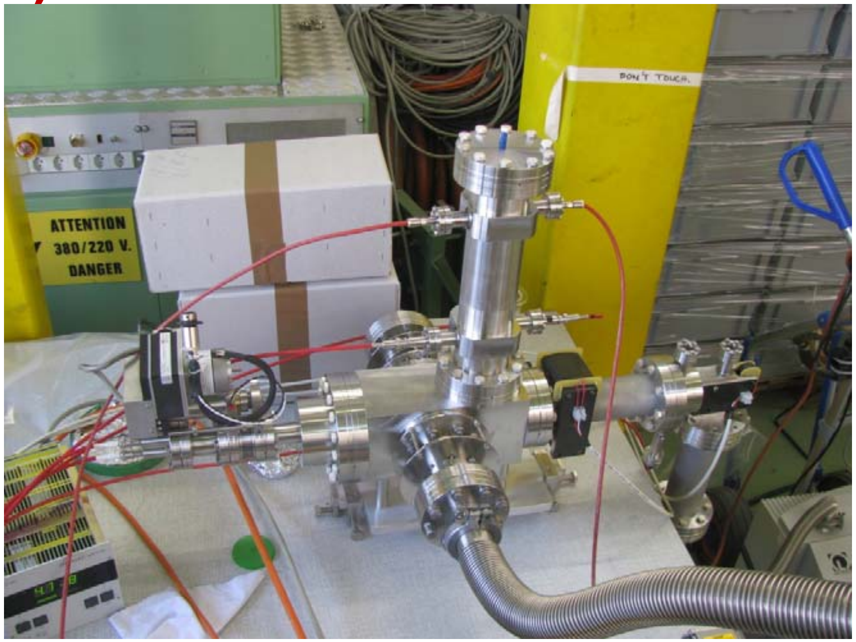
BSM installed in D-plate
(August 2003)

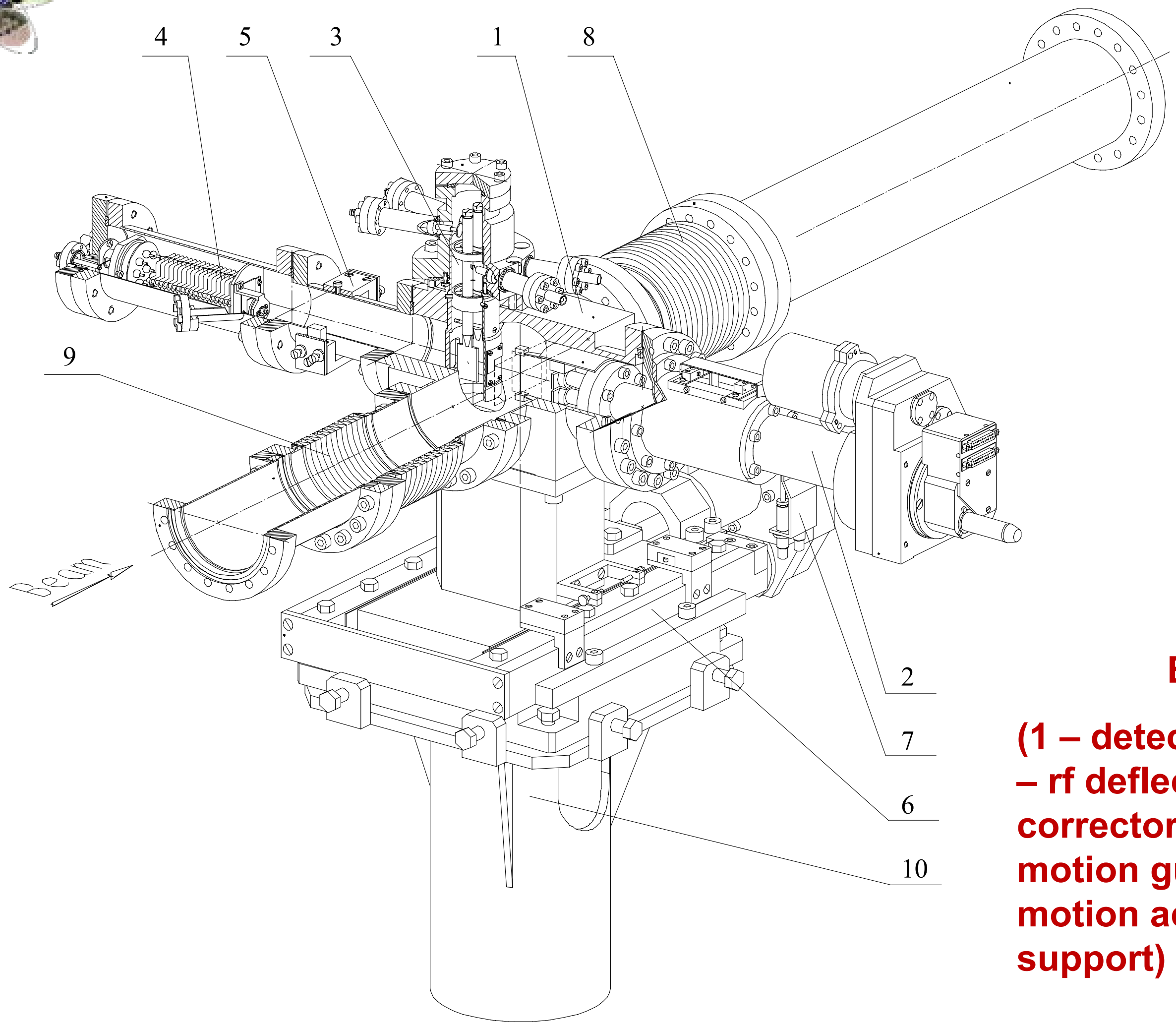


BSM installed in intersegments 7, 9 and 11 of CCL Module #1 (July 2004)

BSM for new CERN Linac-4 (November 2011)



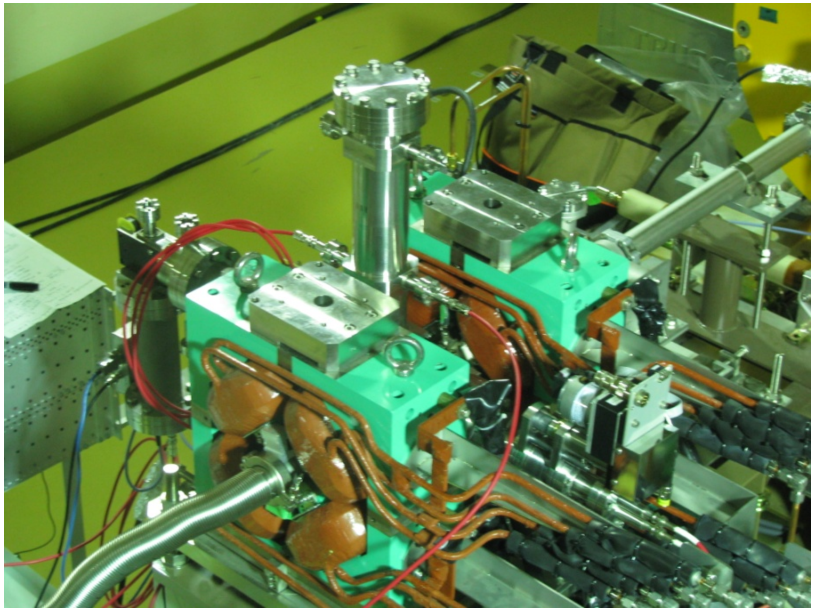


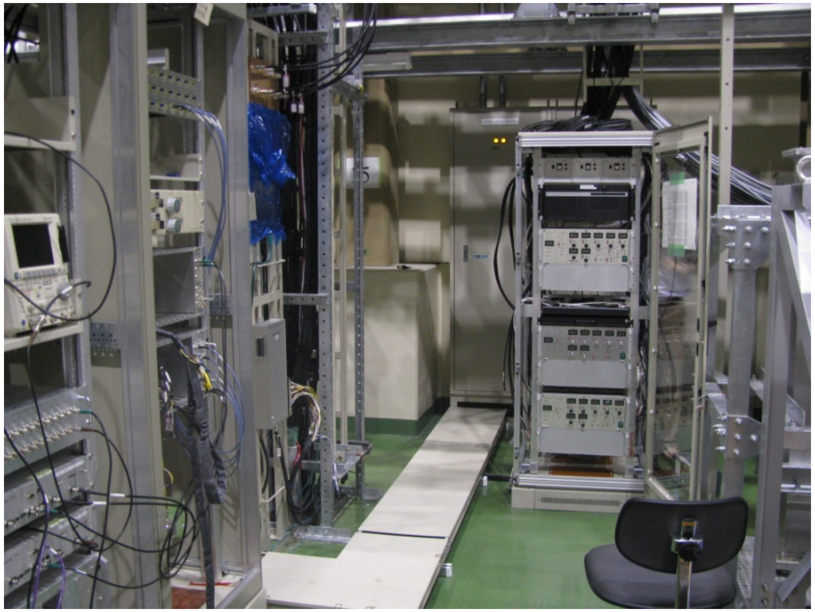


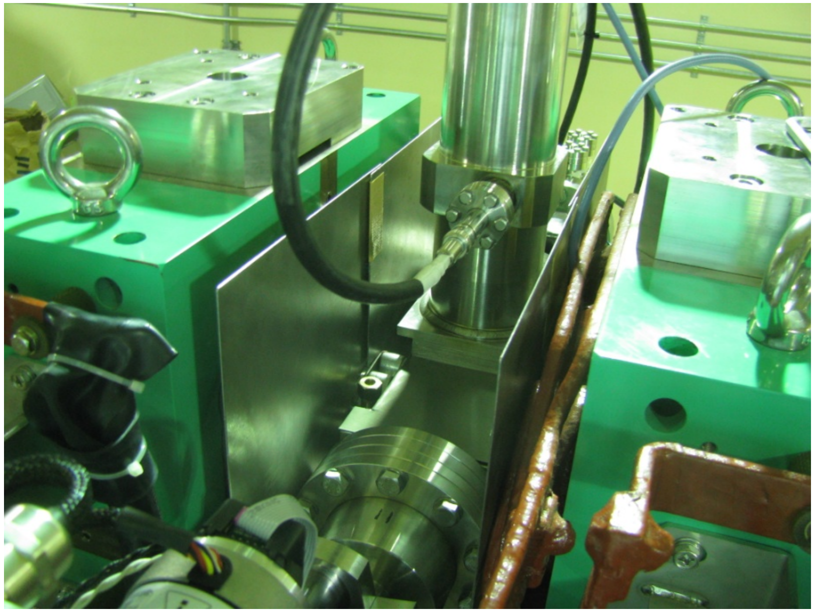
BLVD for DESY Linac-3

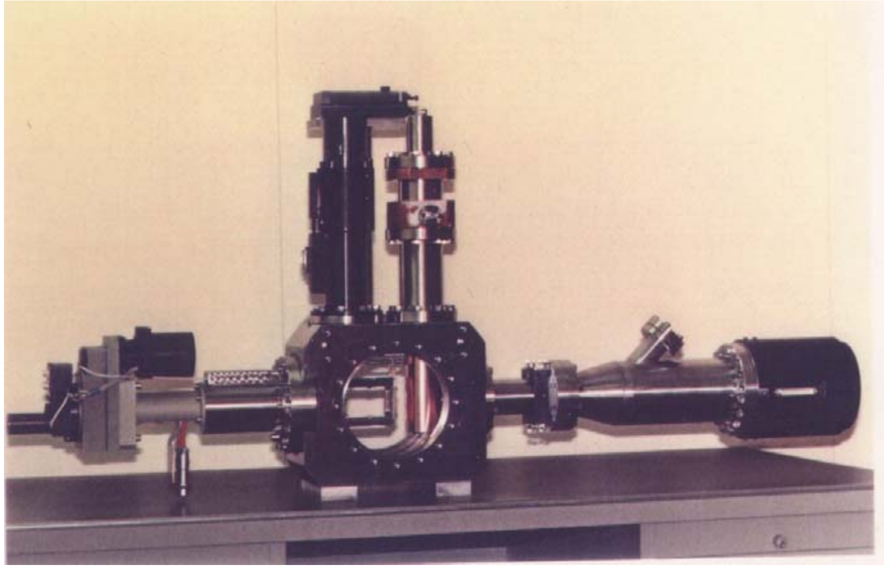
(1 – detector body, 2 – target actuator, 3 – rf deflector, 4 – registration unit, 5 – corrector magnet, 6 – longitudinal motion guide rail , 7 – longitudinal motion actuator, 8,9 – bellows, 10 – support)

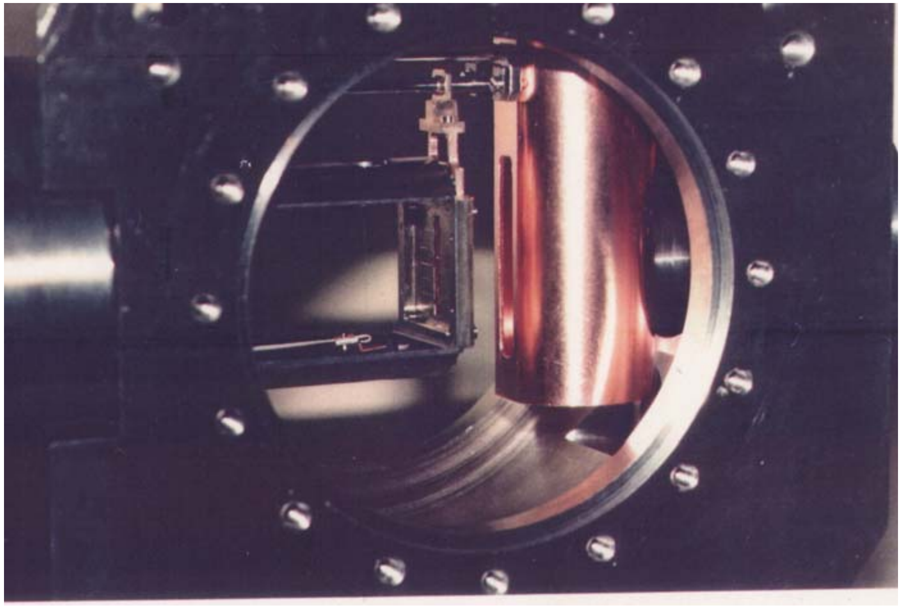
BSMs for J-PARC Linac (August-September 2012)





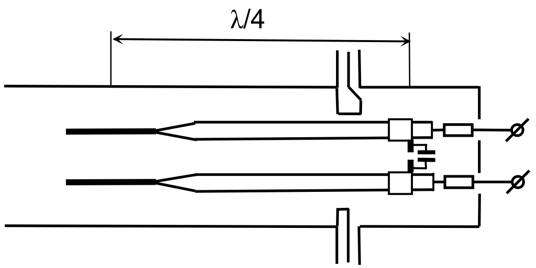


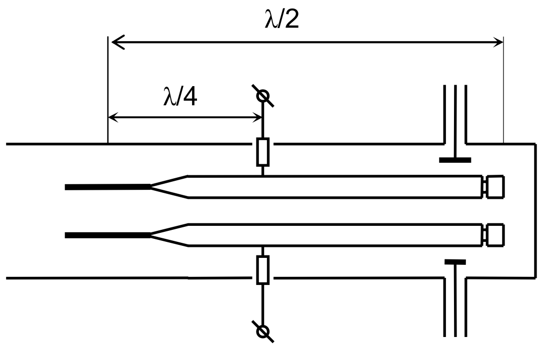


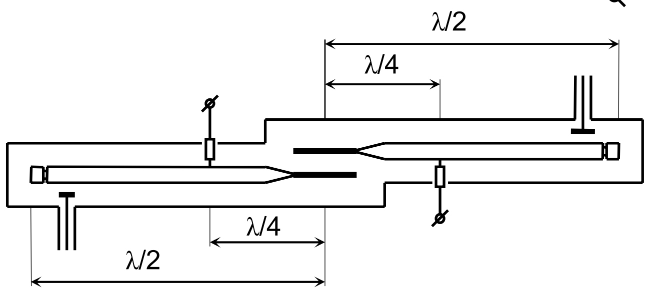


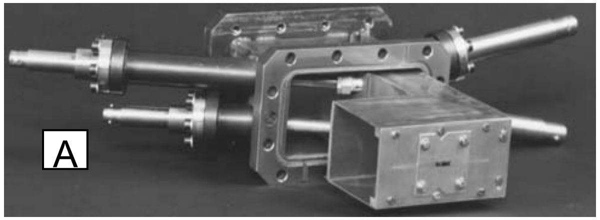
3D-BSM view

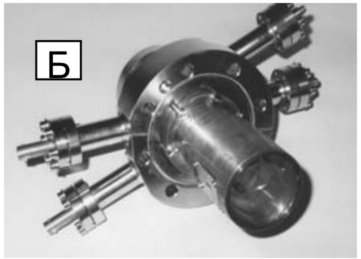
Examples of rf deflectors for BSMs.

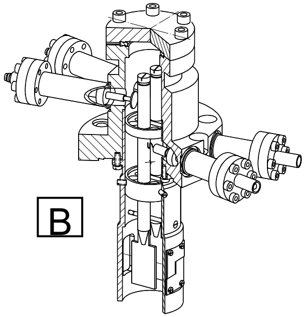




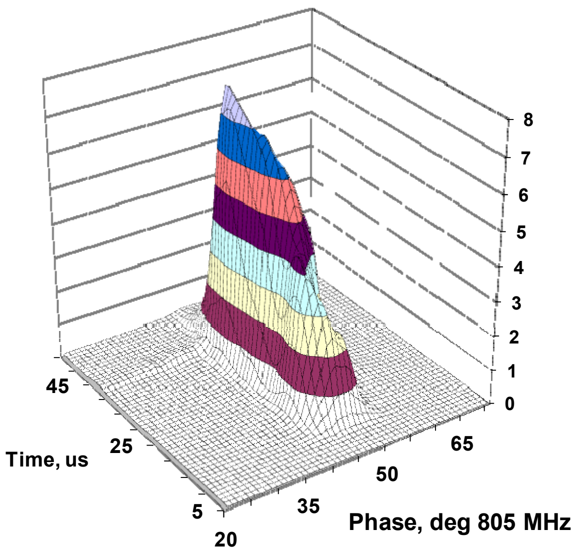


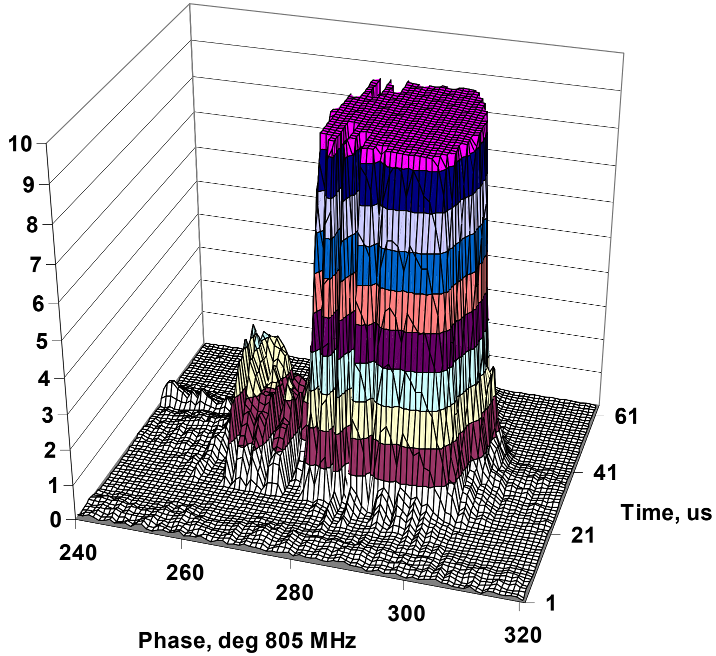


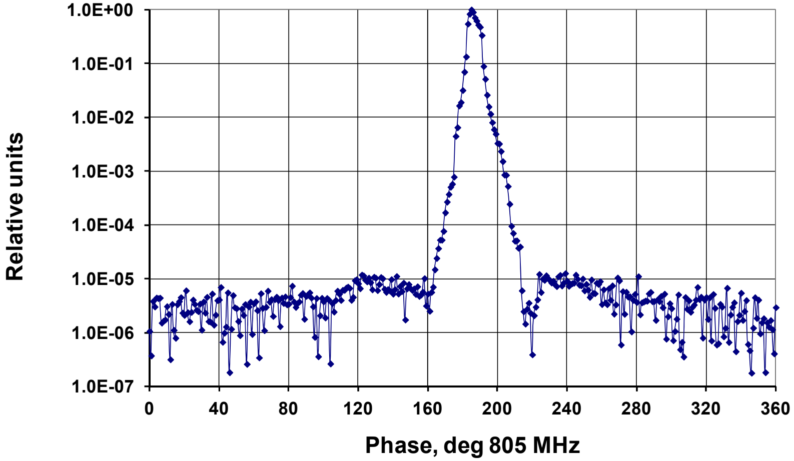




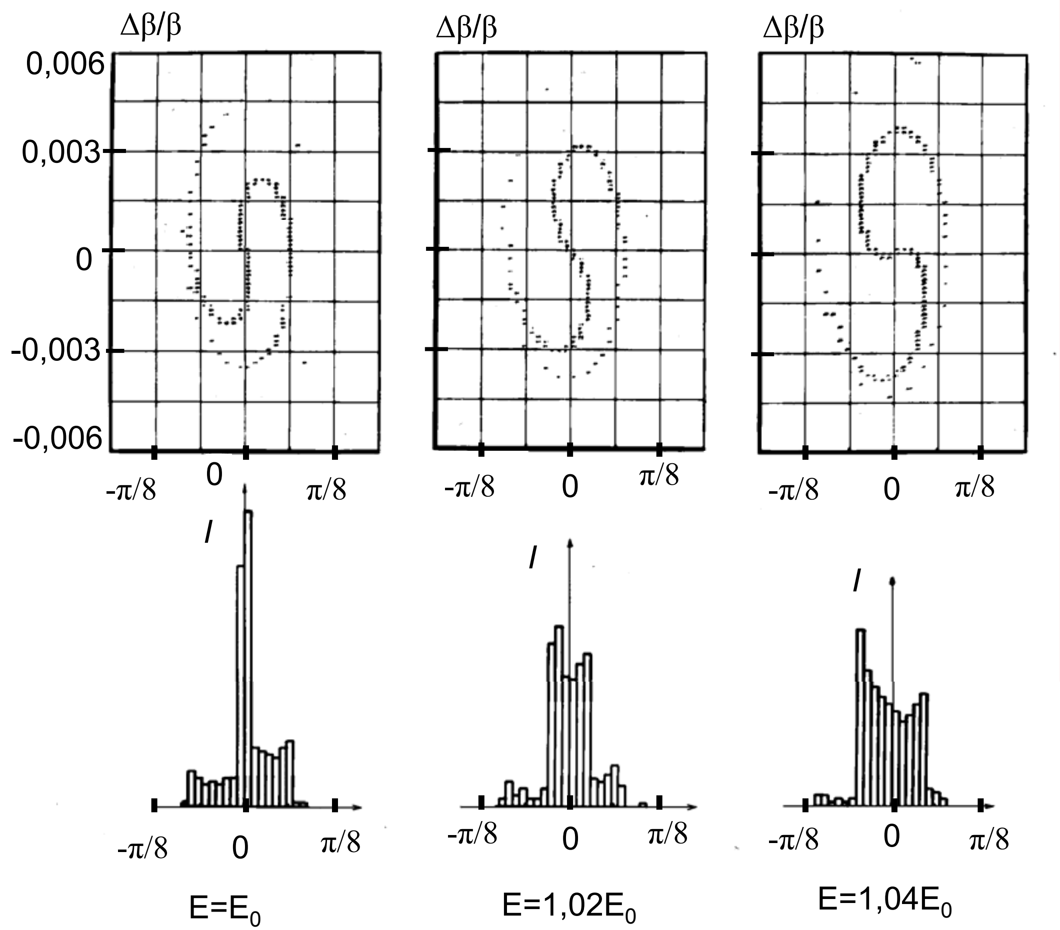
Some Measurement Results





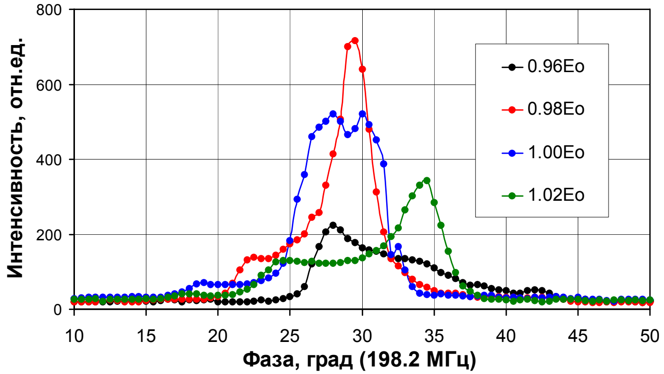


Setting of accelerating field amplitude in DTL Tank 1 of INR Linac (20 MeV). Simulations.

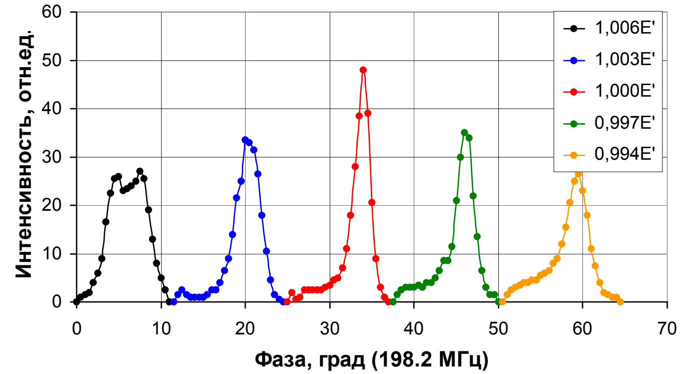


Beam portraits in longitudinal phase space at the exit of Tank 1 for different amplitudes

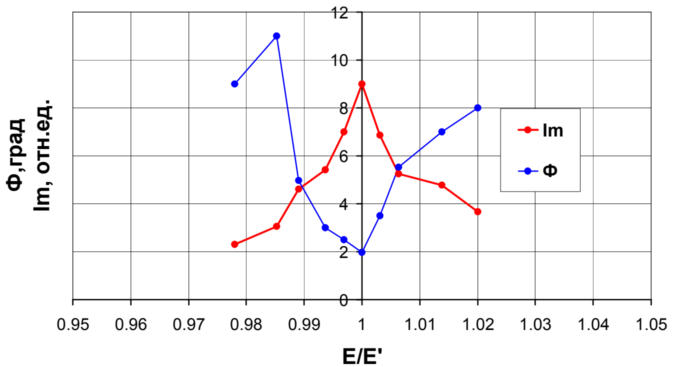
Setting of accelerating field amplitude in DTL Tank 1 of INR Linac (20 MeV). Experimental results.



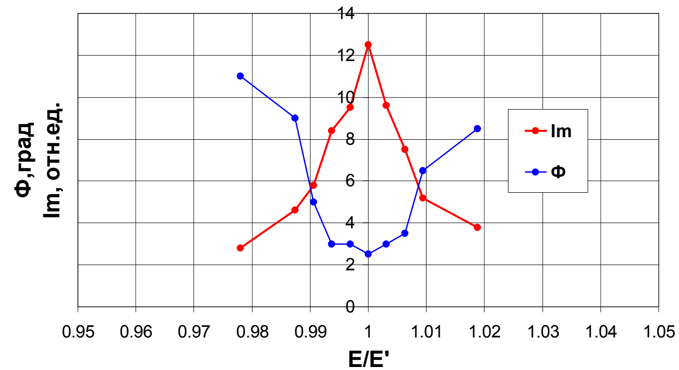
Bunch shapes for different amplitudes.



Bunch shapes in the vicinity of extremum of functions $I_m(E)$ и $\Phi(E)$.

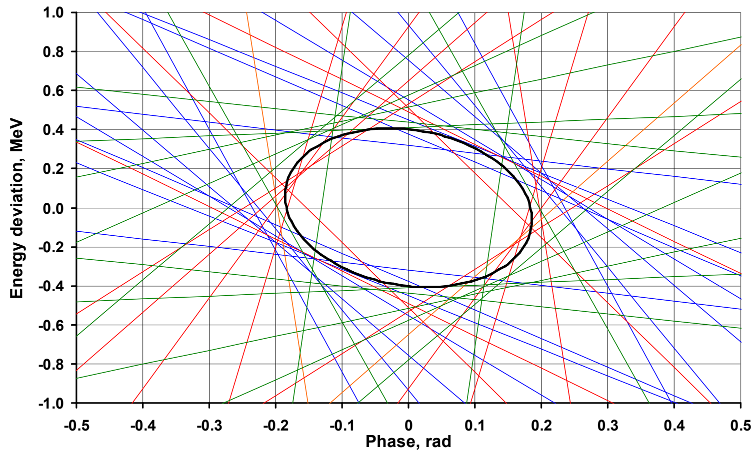


Functions $I_m(E)$ and $\Phi(E)$ in the vicinity of extremum for nominal injection energy

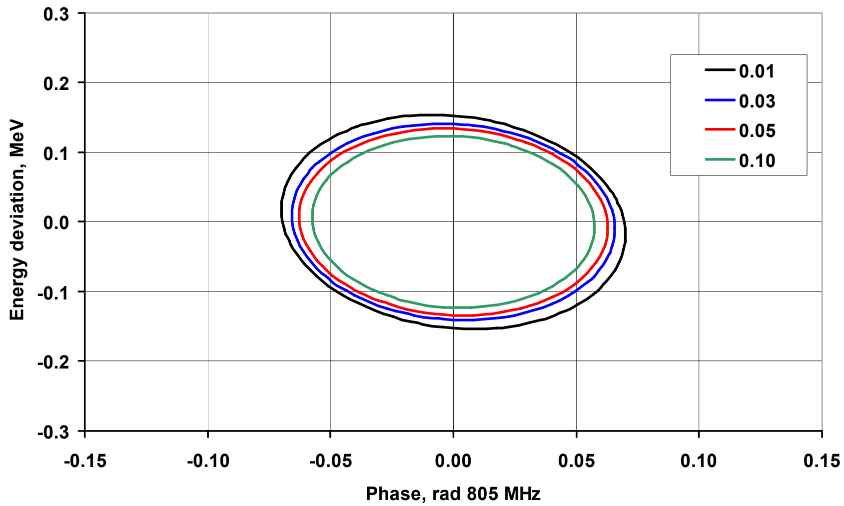


Functions $I_m(E)$ and $\Phi(E)$ in the vicinity of extremum for injection energy less than nominal value by 1%.

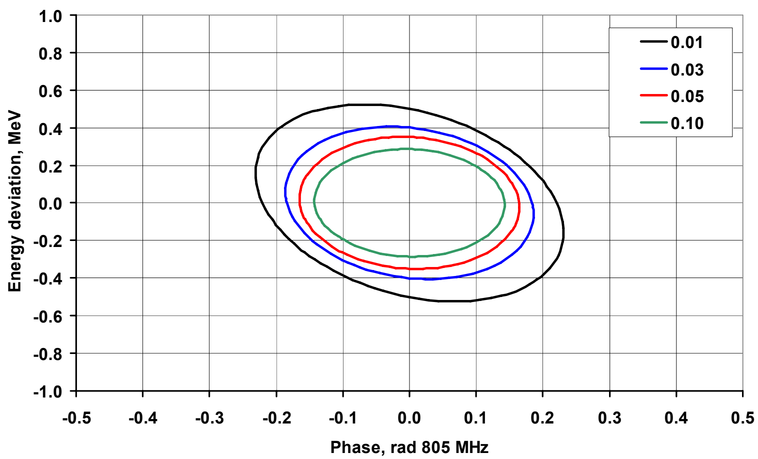
Longitudinal emittance in CCL1 of SNS Linac.



Bunch boundaries transformed to the entrance of CCL#1 and an equivalent phase ellipse

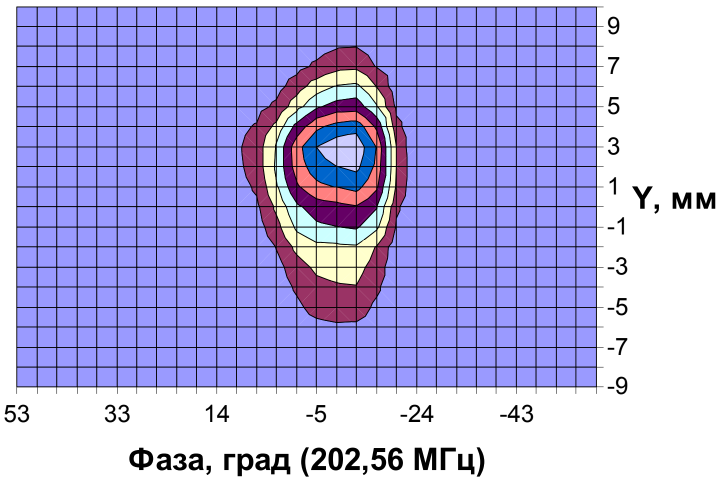


Equivalent phase space ellipses for different threshold levels. RMS bunch size definition is used

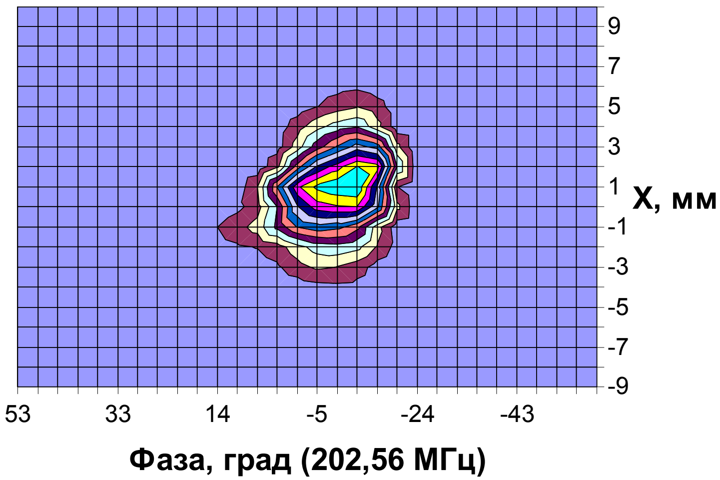


Equivalent phase space ellipses for different threshold levels. Full width at the base bunch size definition is used

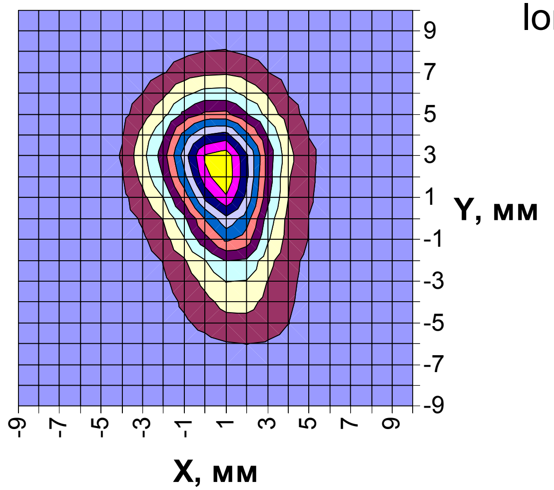
Some results of 3D-measurements at CERN Linac-2



Integral projection of bunch on longitudinal vertical plane (phase-Y).

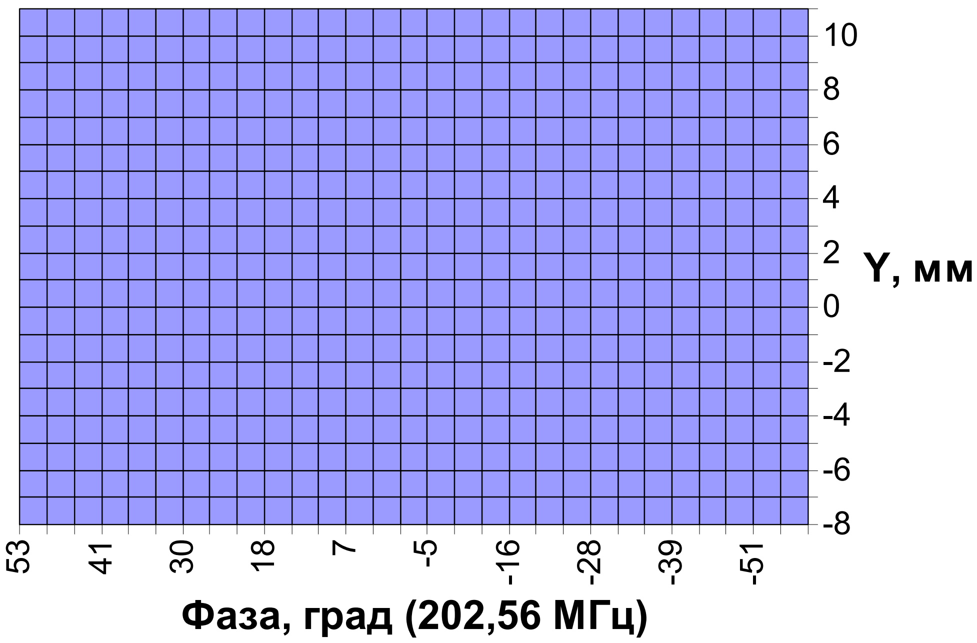


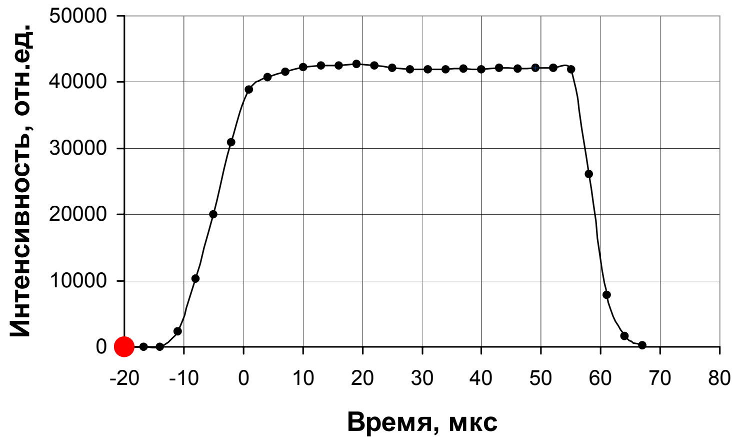
Integral projection of bunch on longitudinal horizontal plane (phase-X).

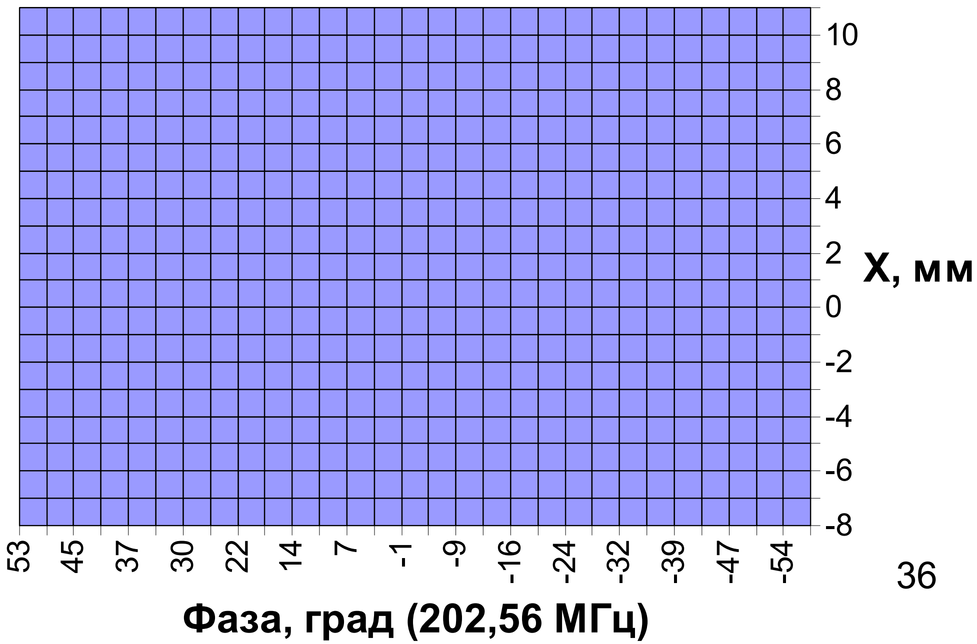


Integral beam cross section

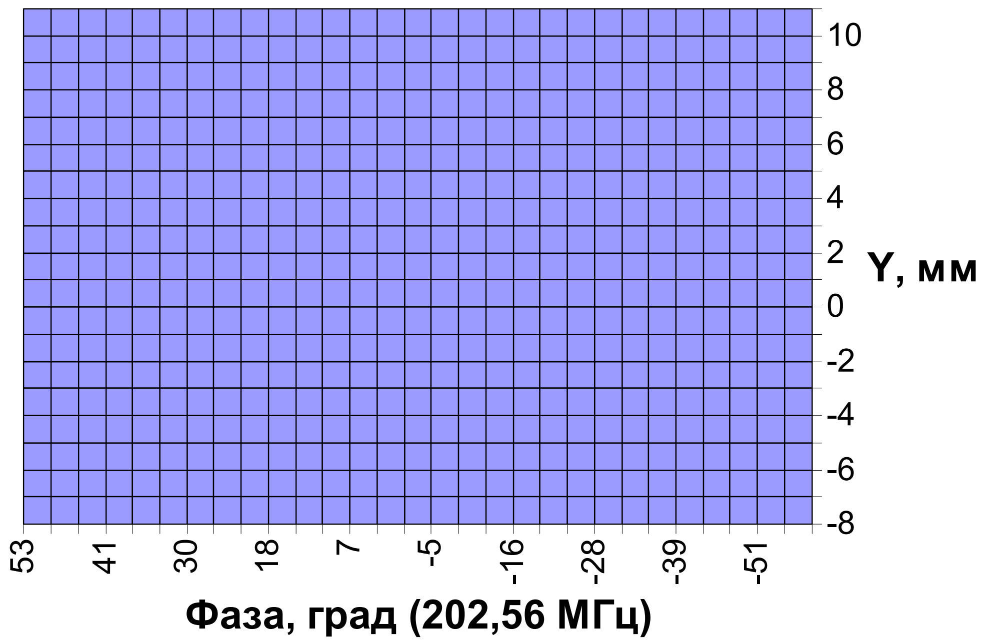
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

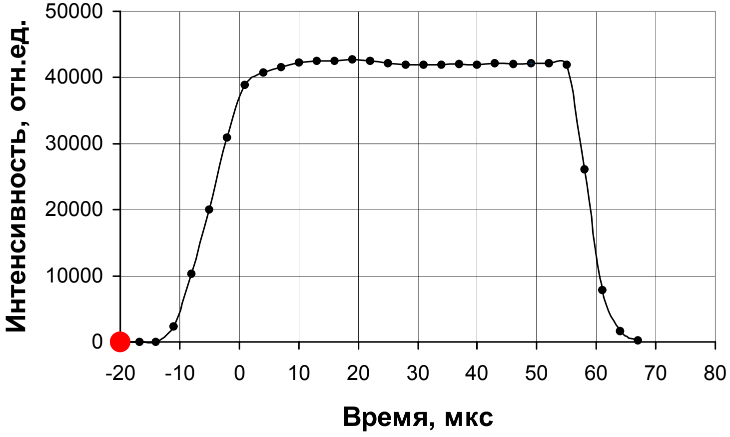


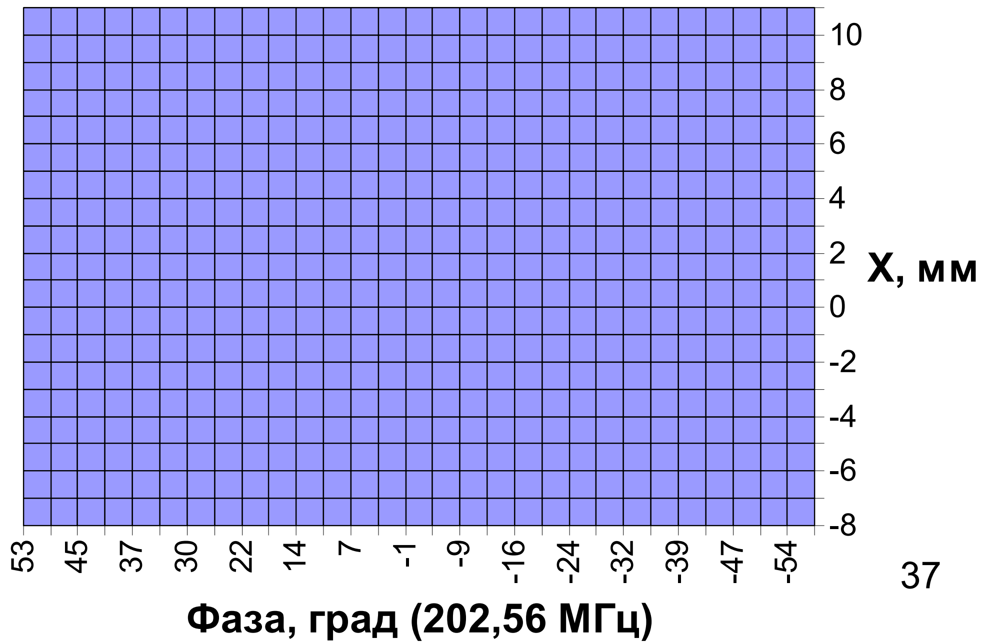




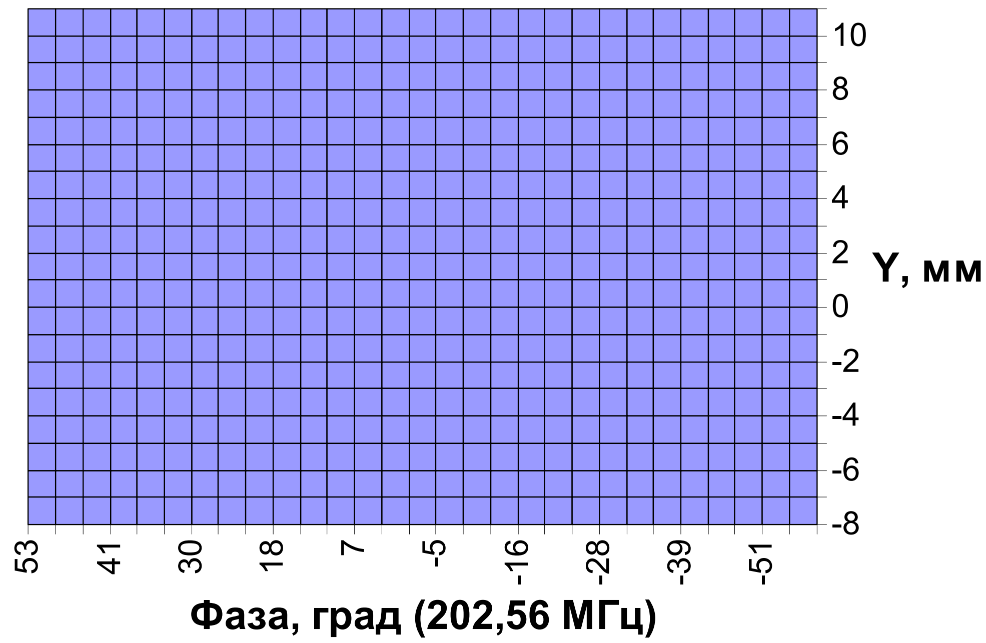
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

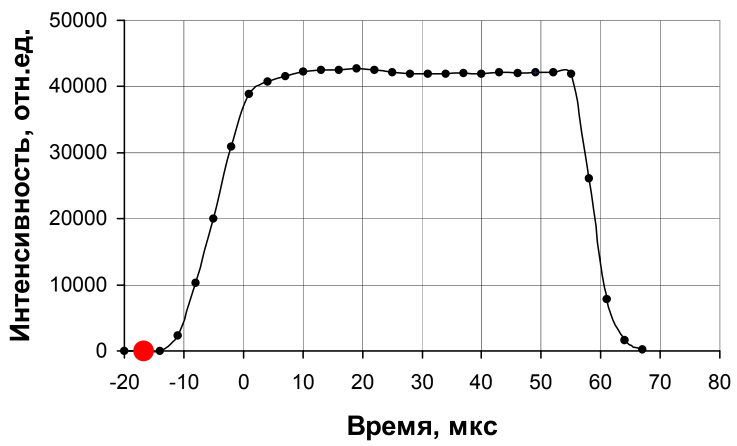


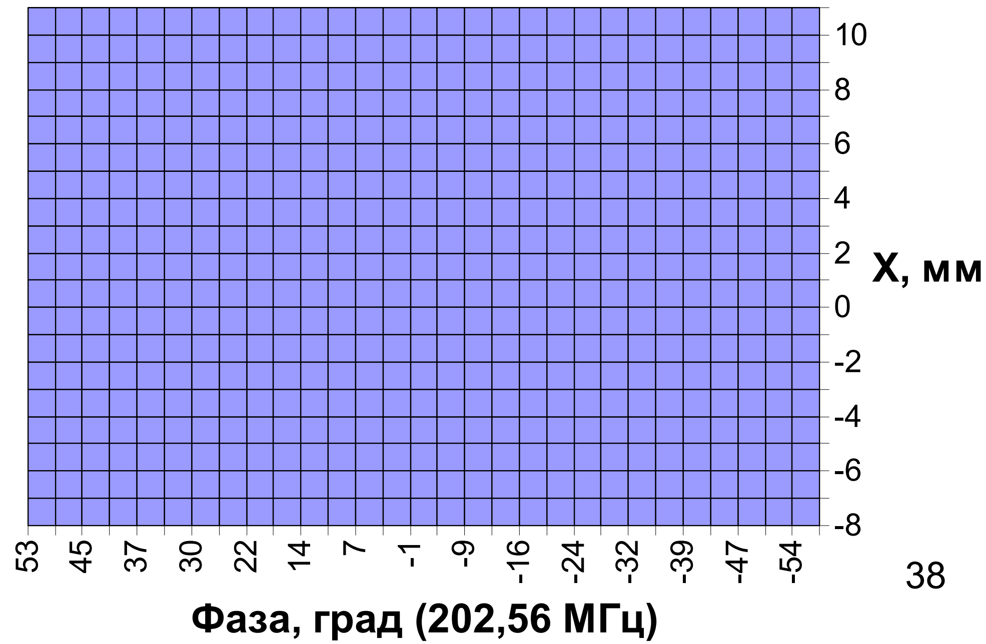




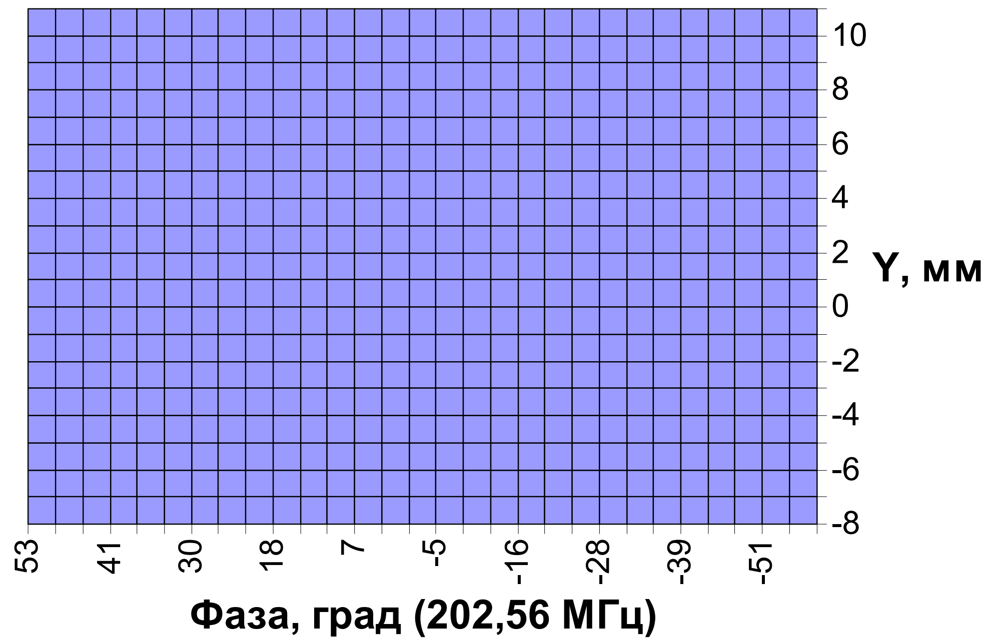
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

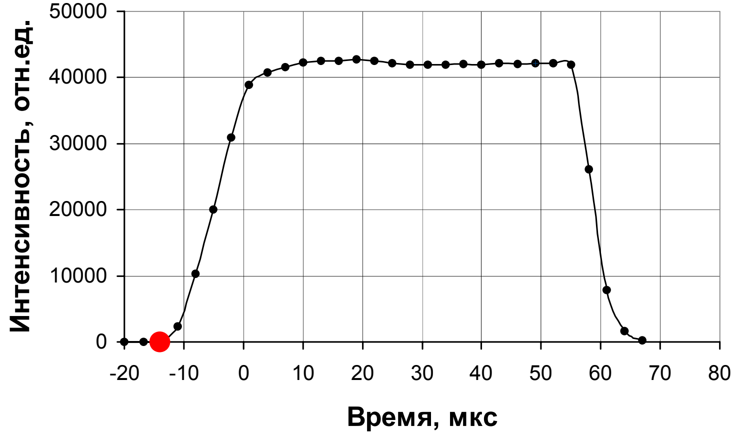


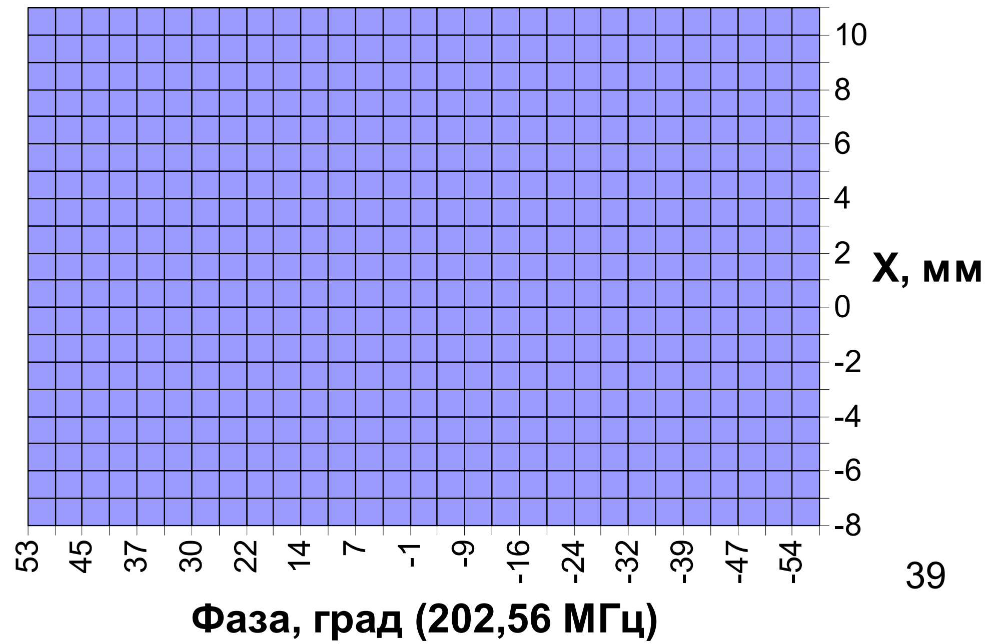




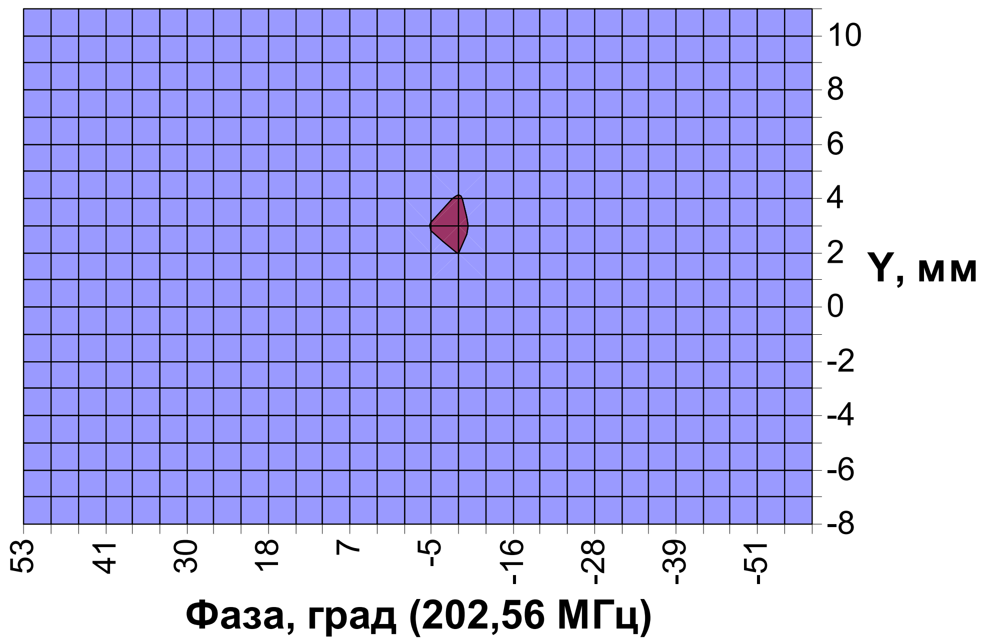
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

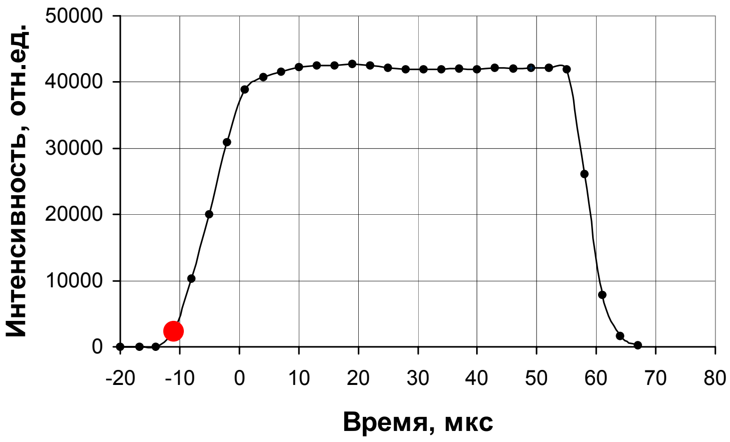


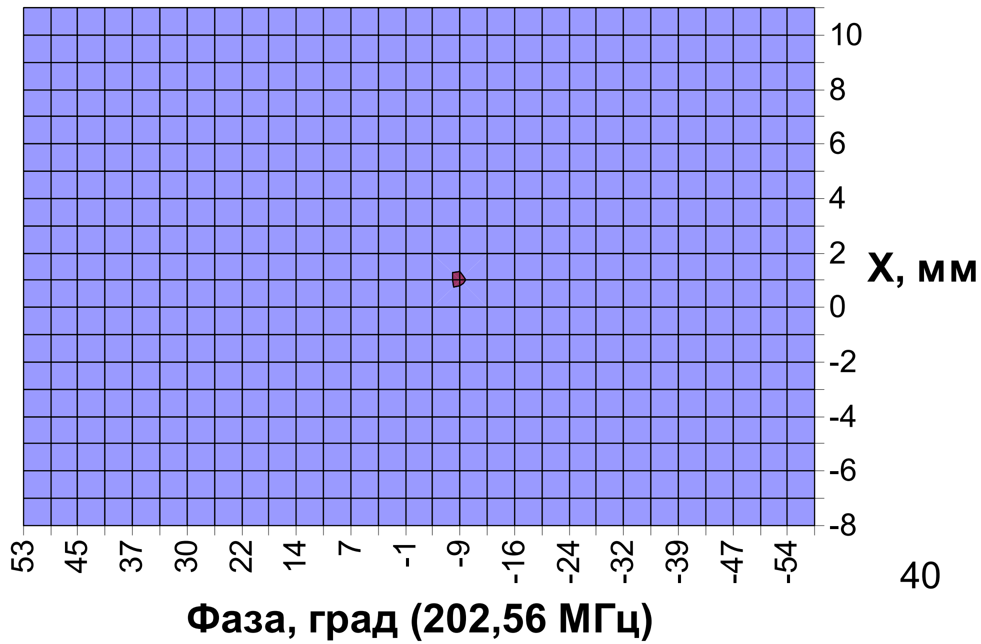




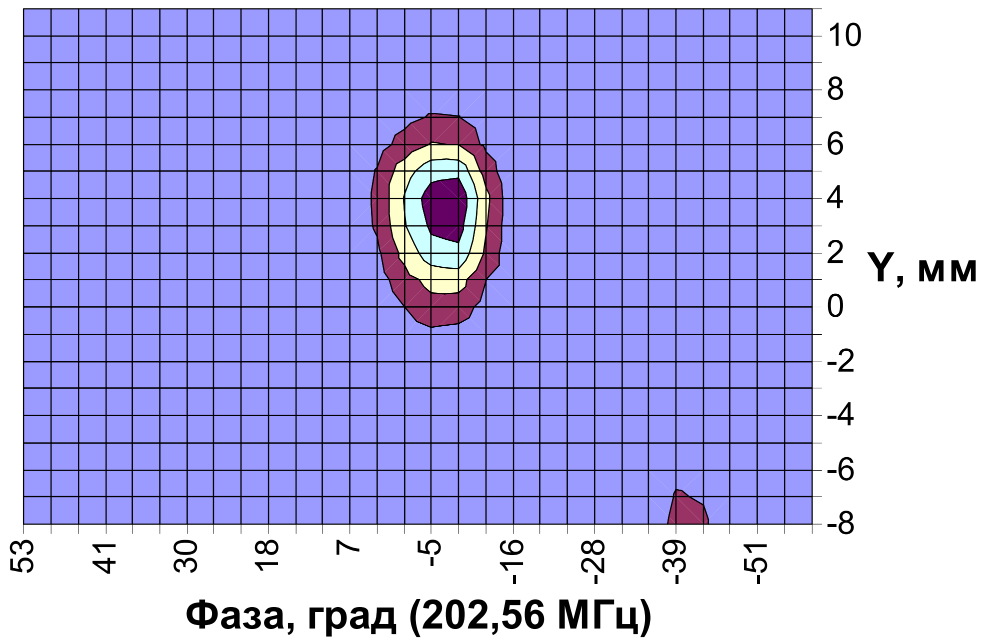
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

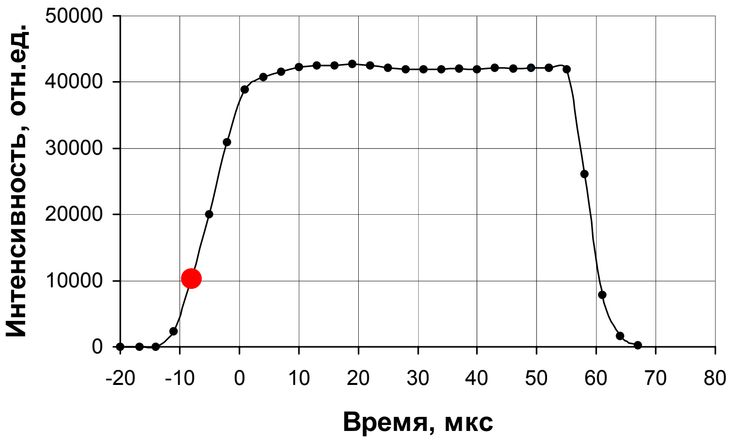


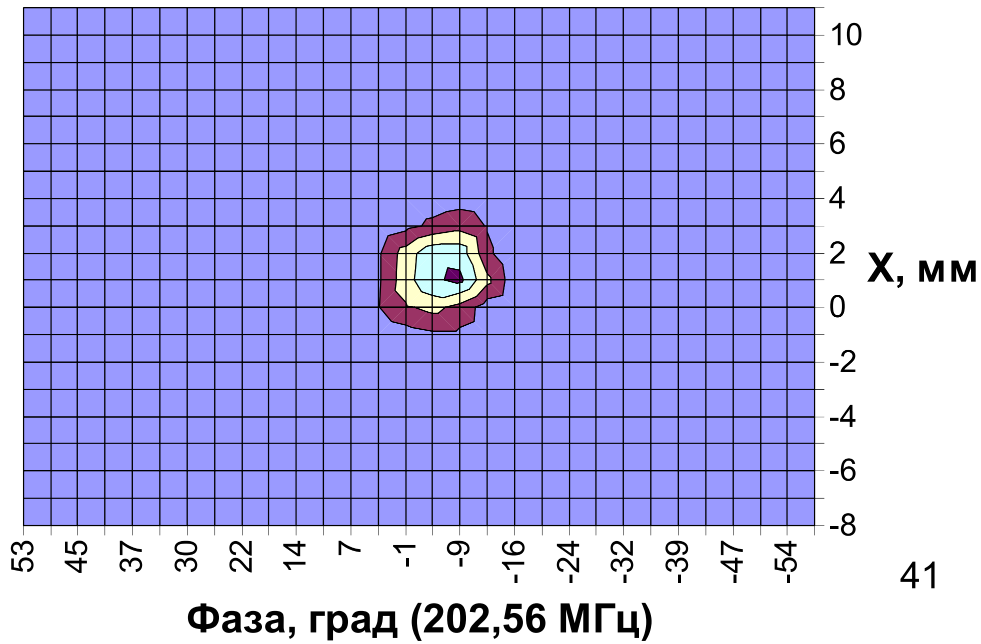




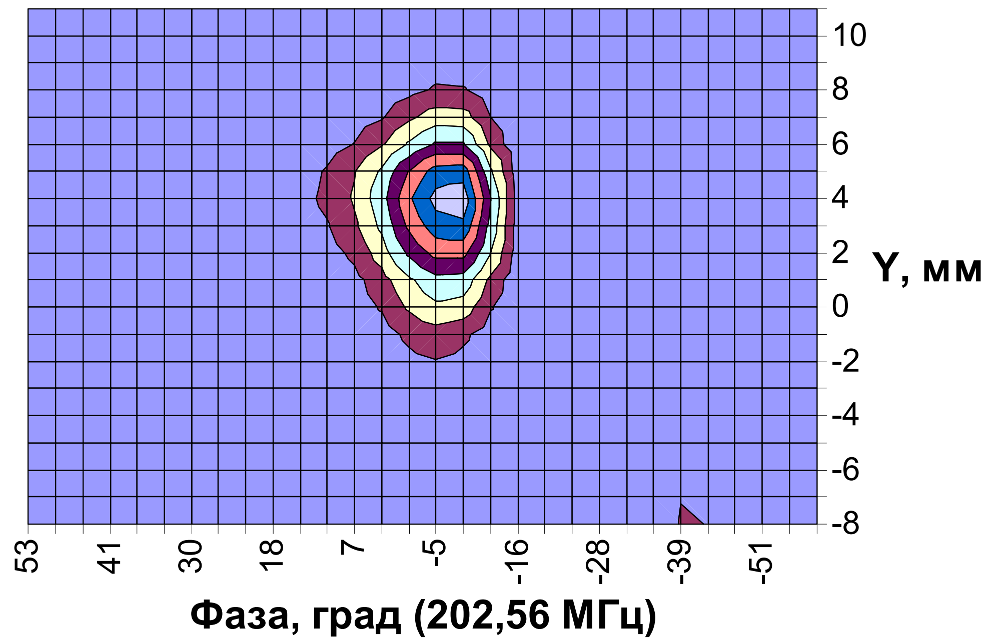
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

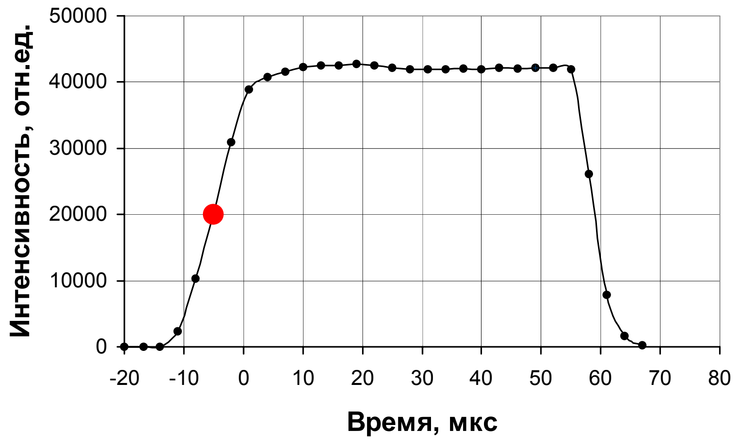


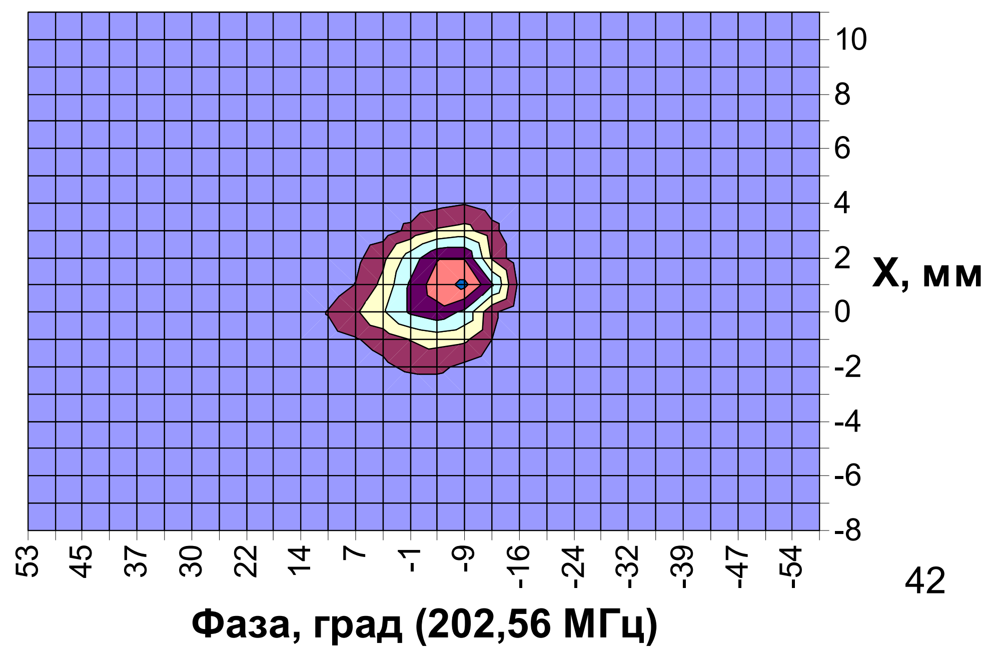




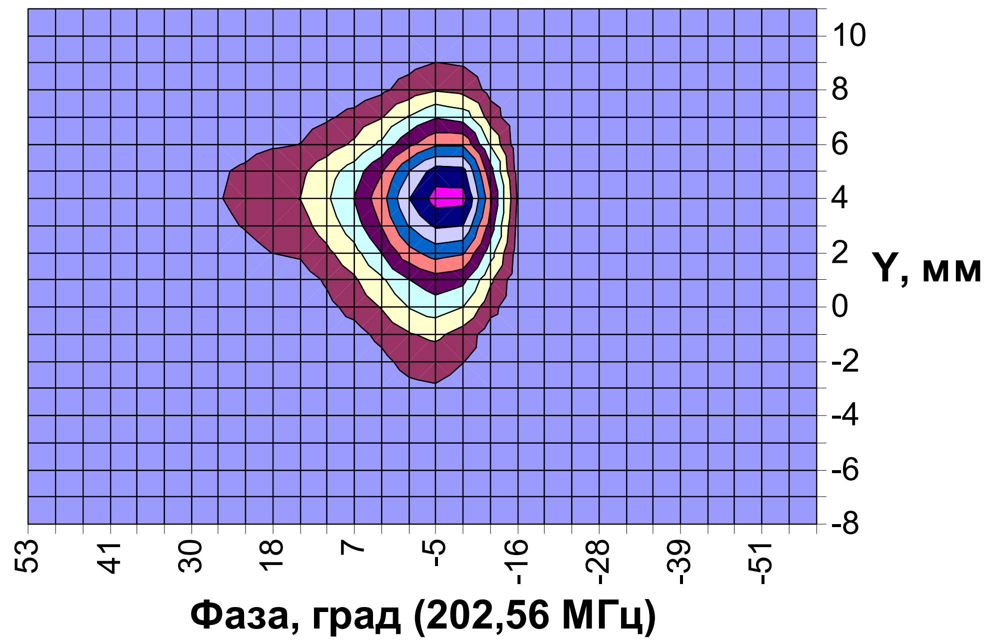
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

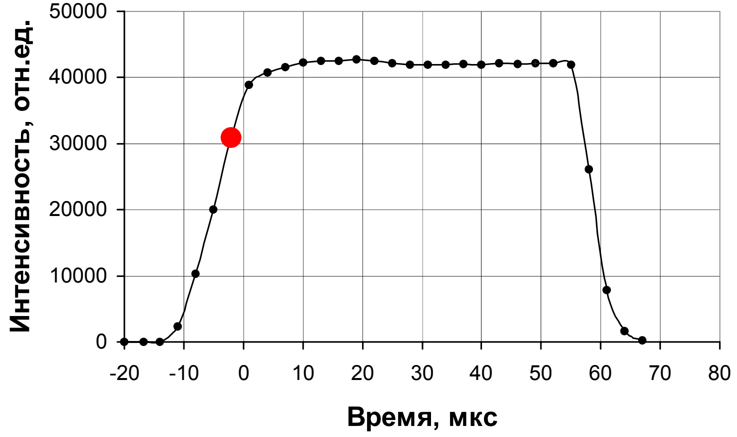


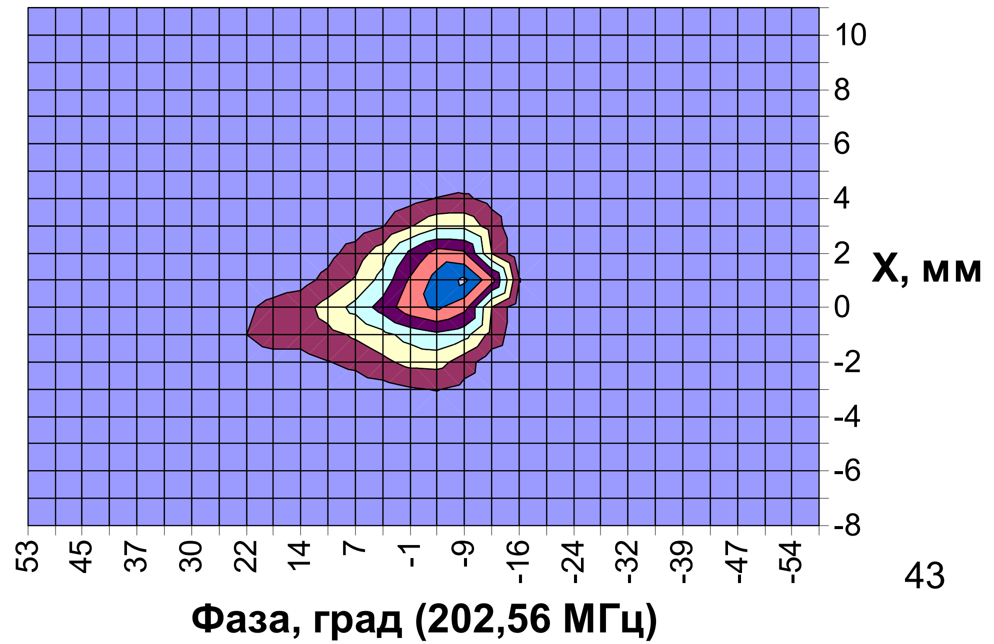




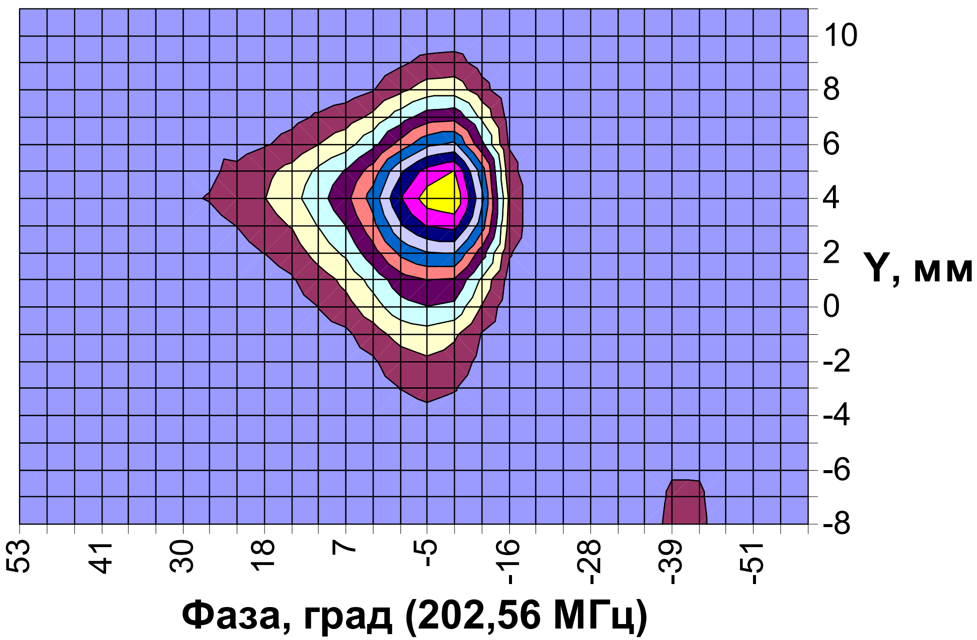
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

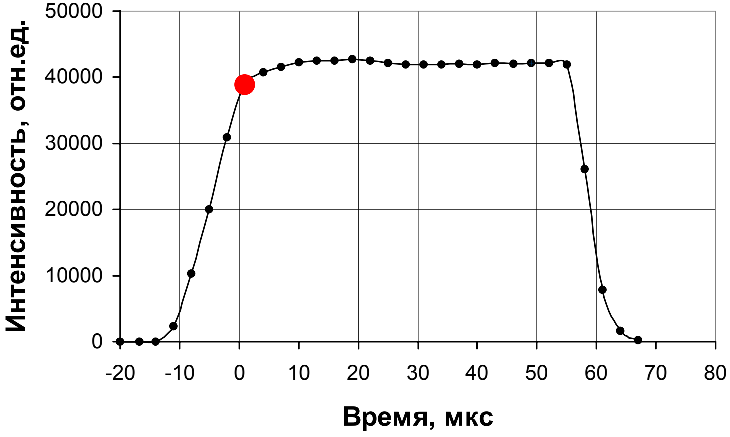


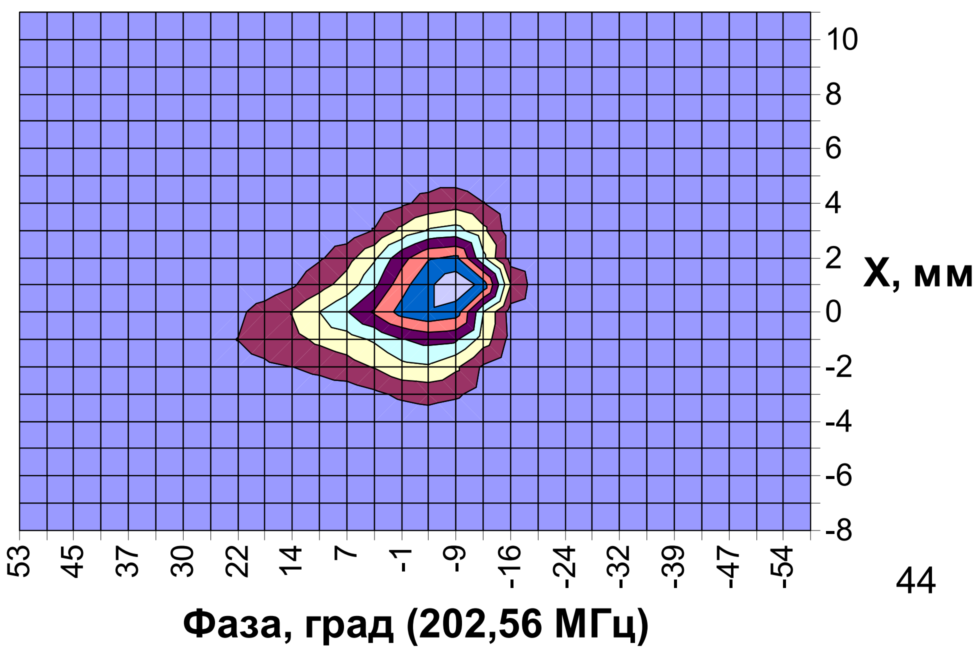




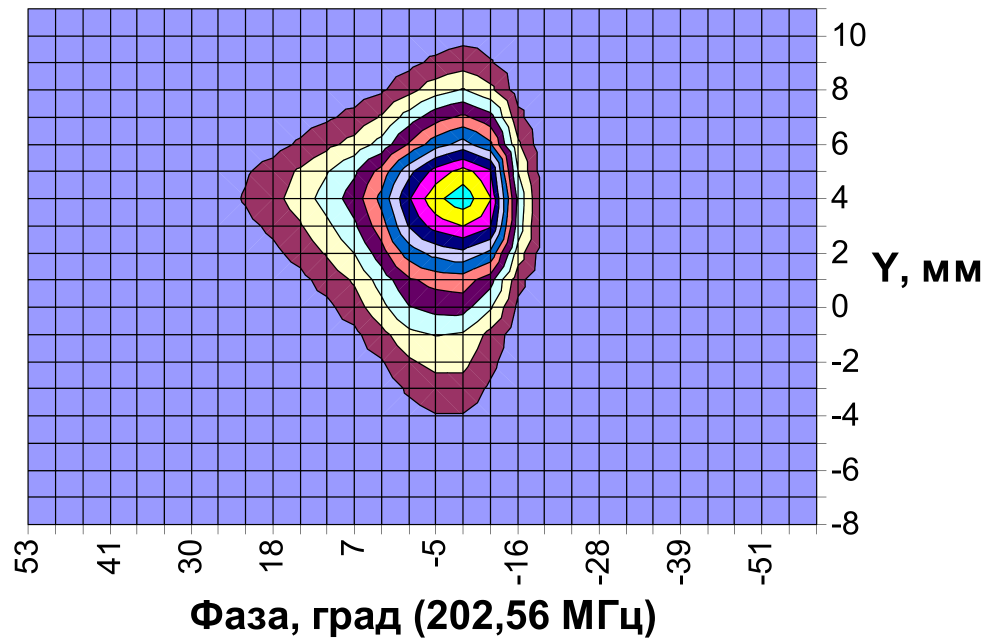
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

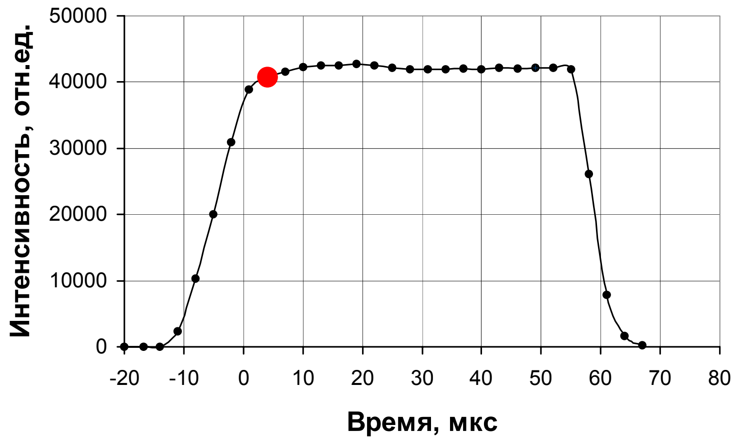


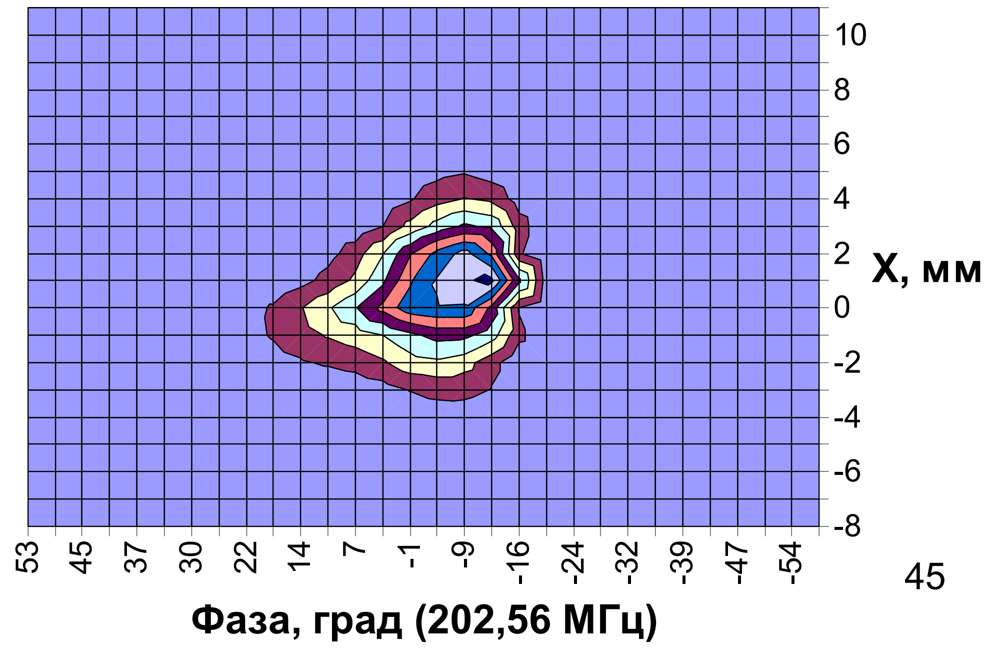




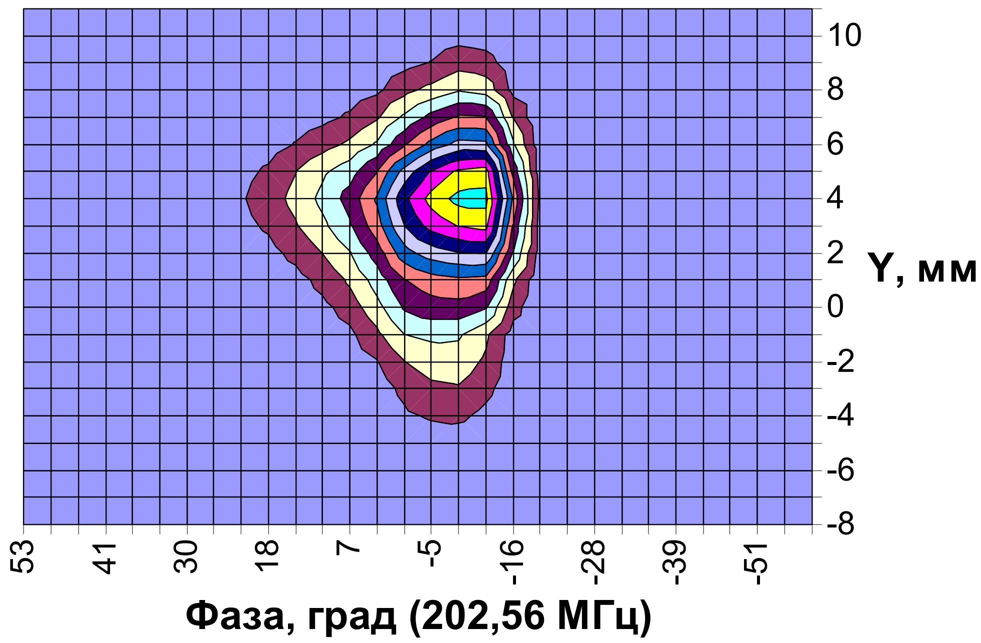
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

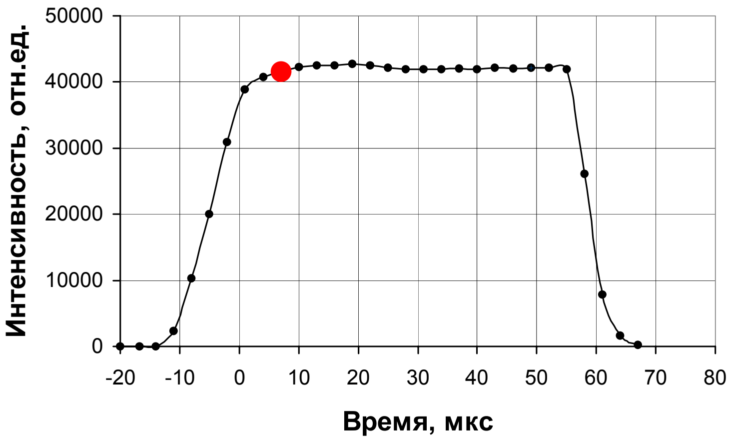


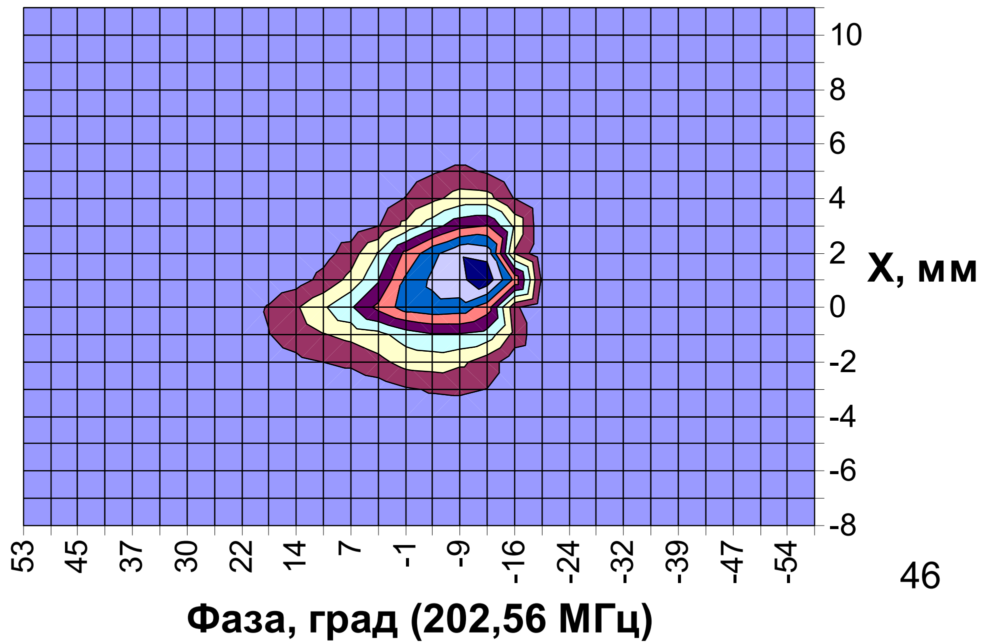




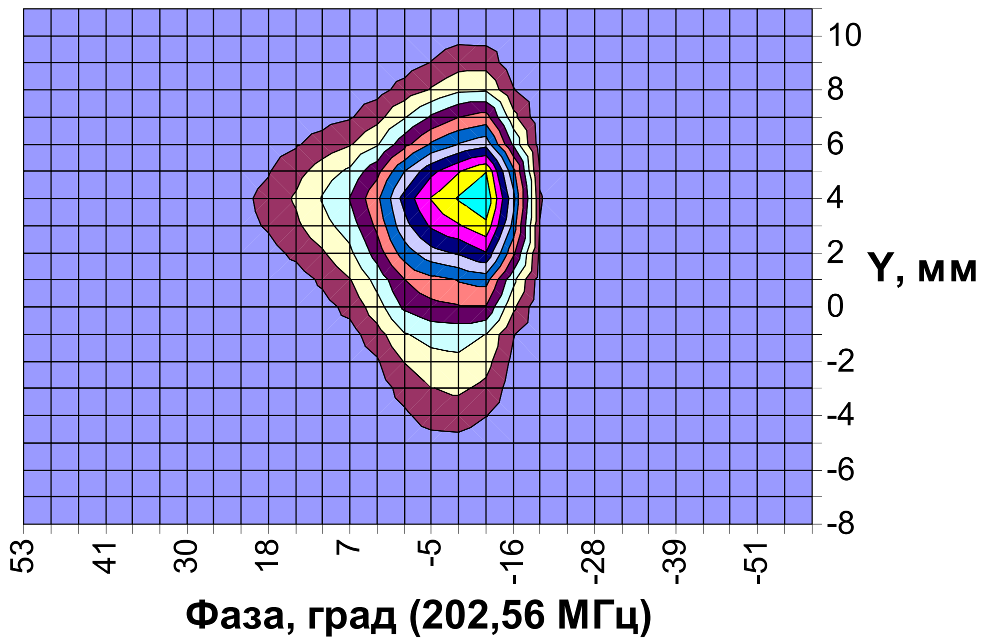
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

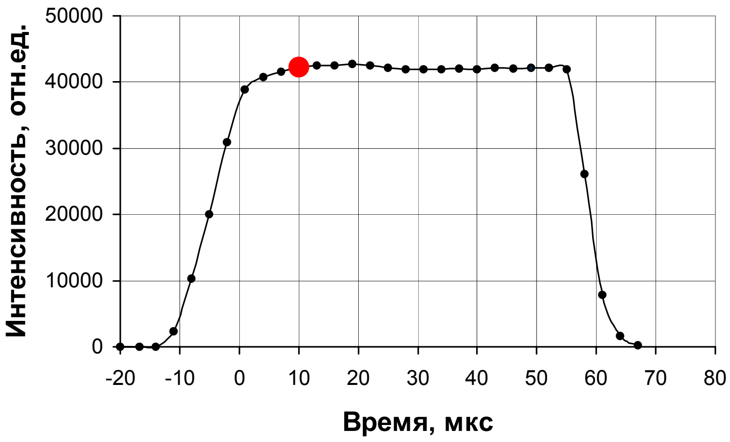


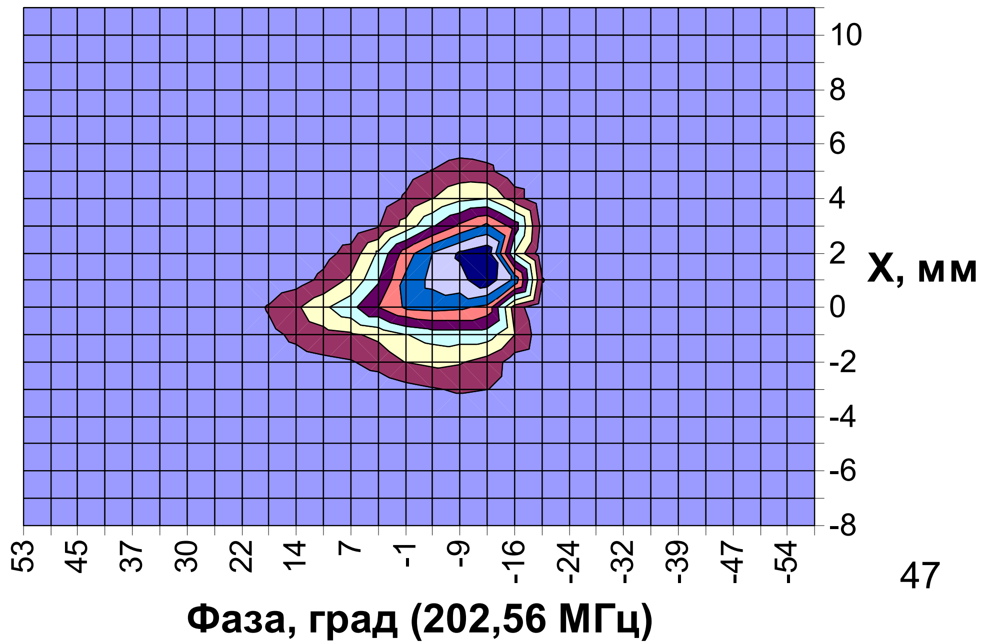




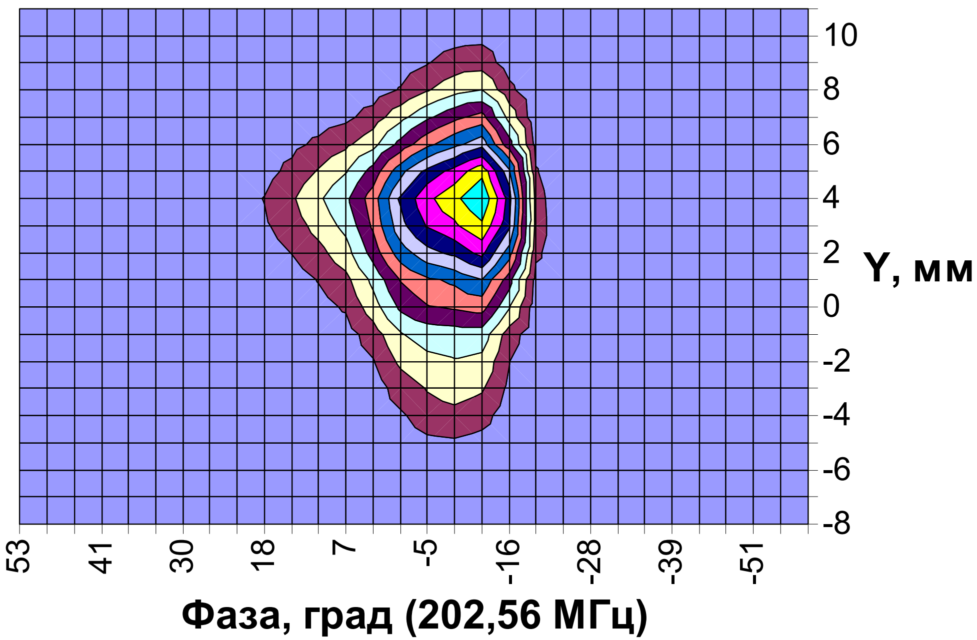
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

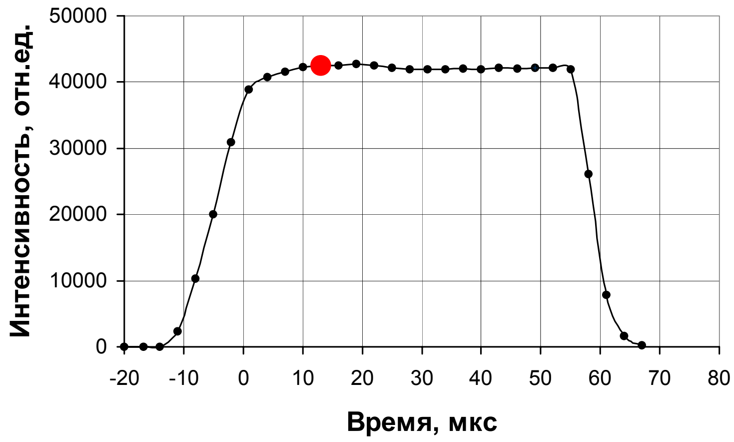


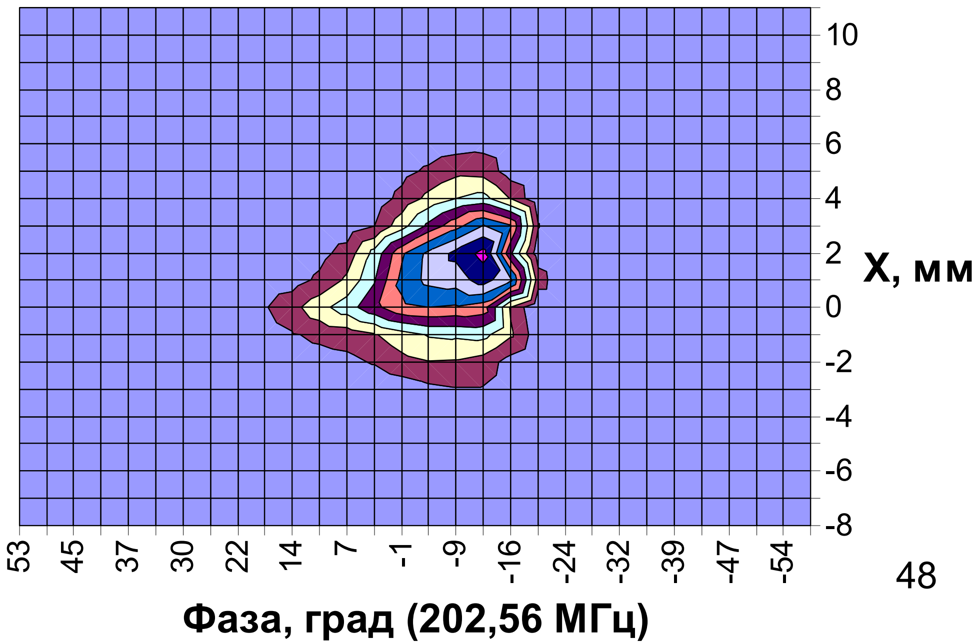




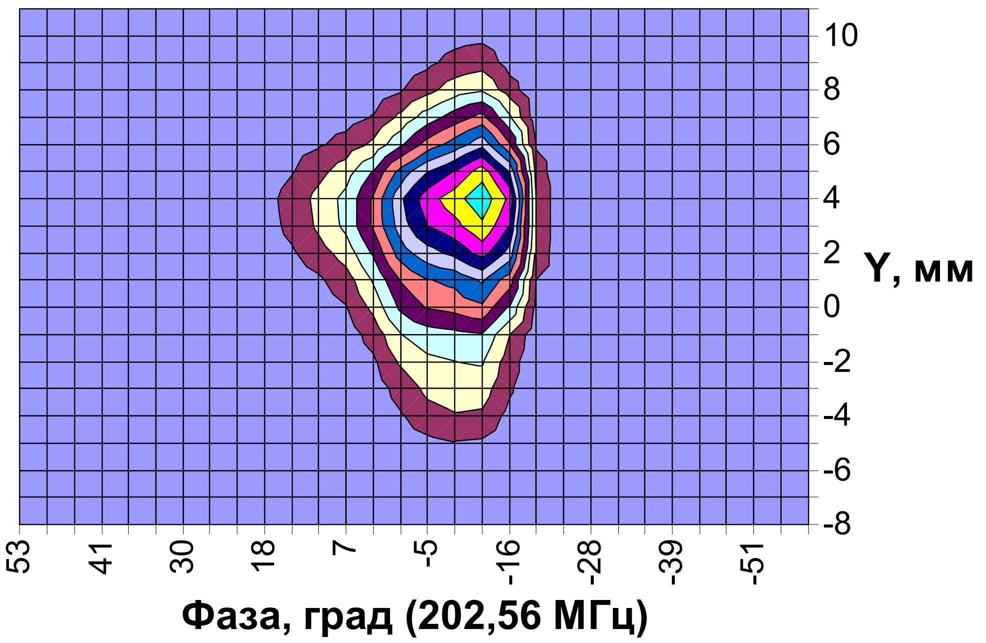
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

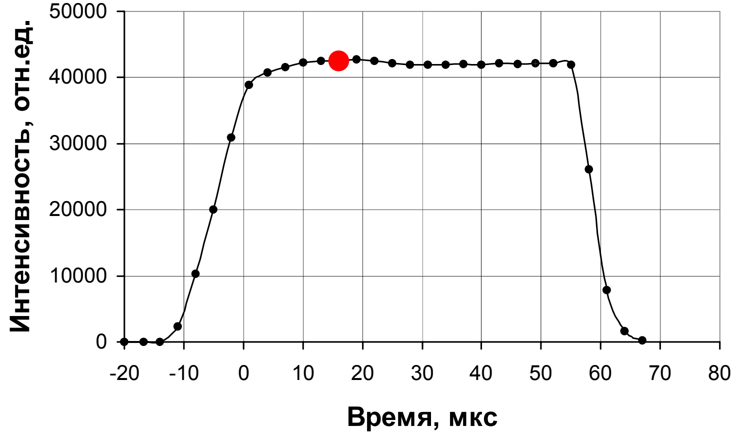


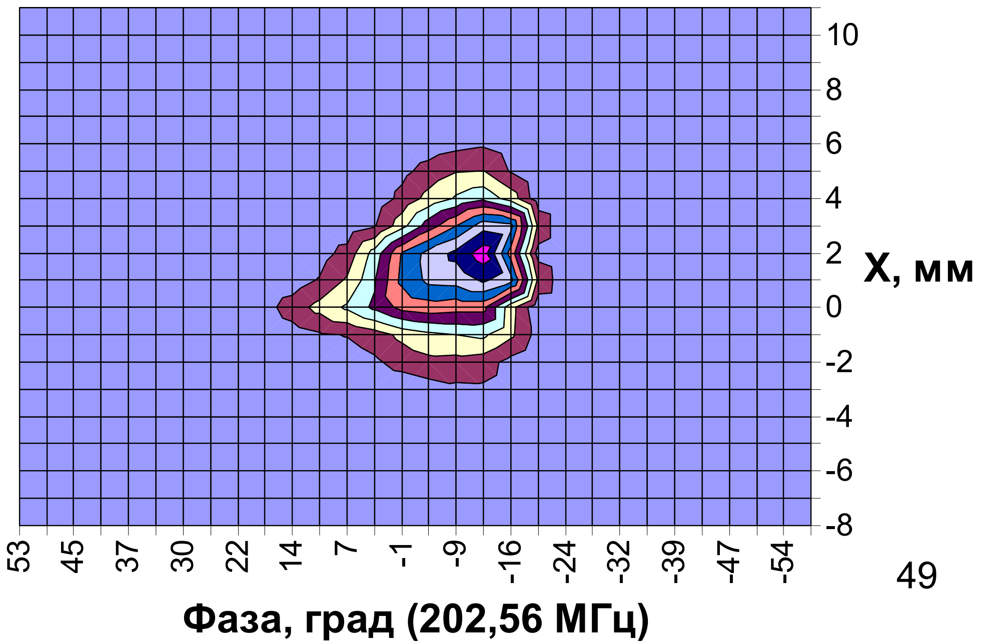




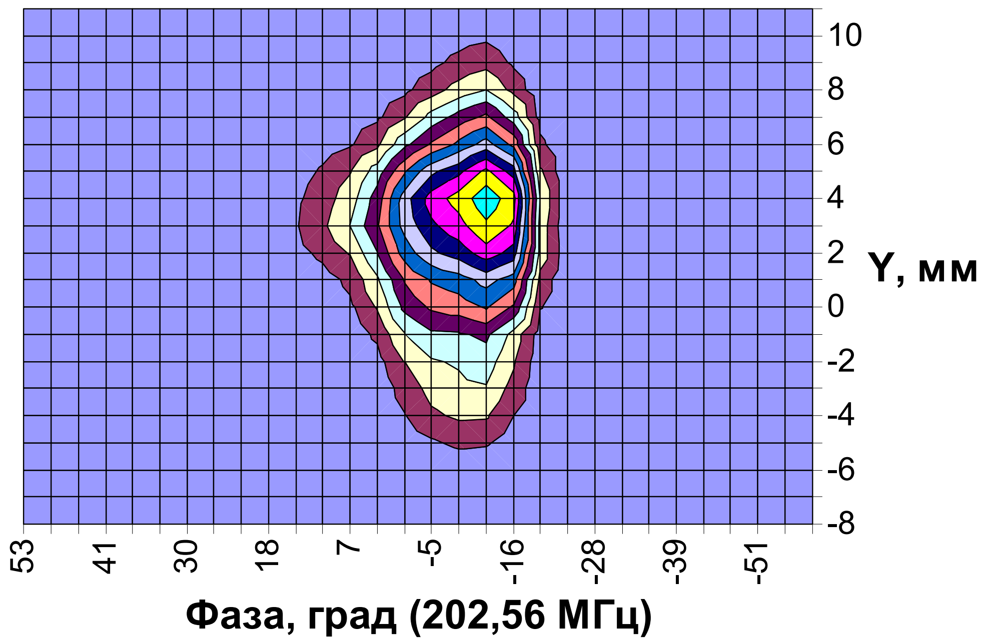
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

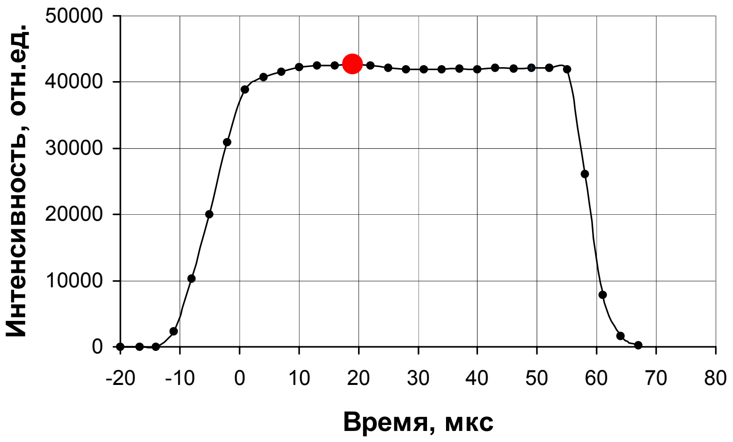


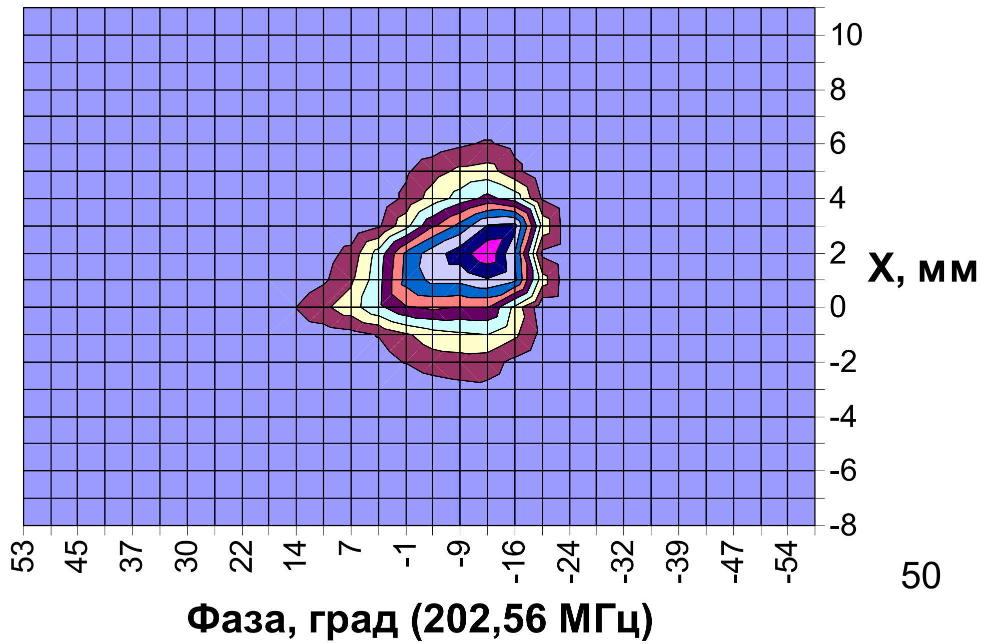




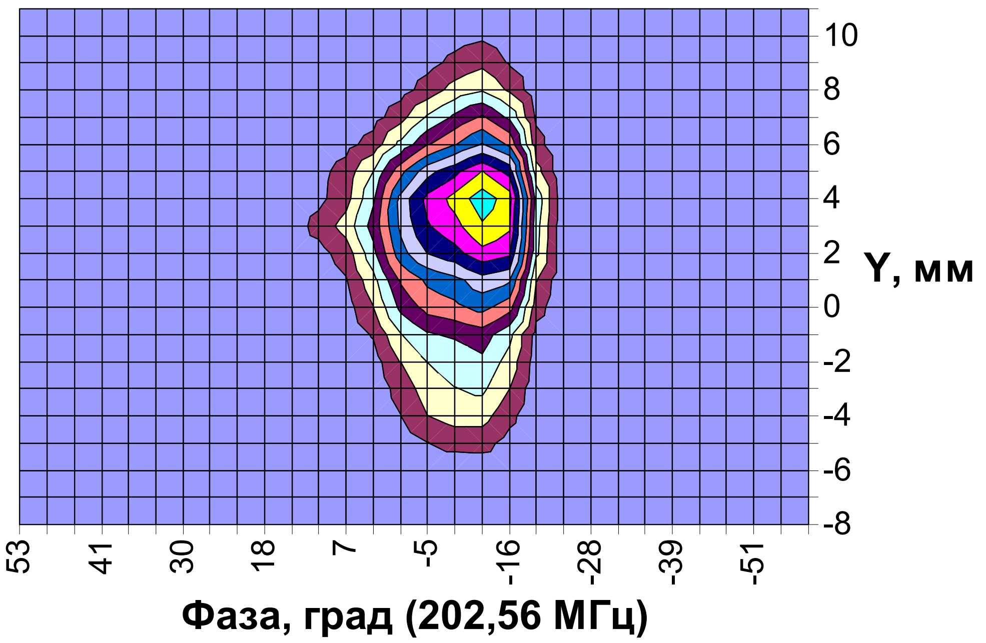
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

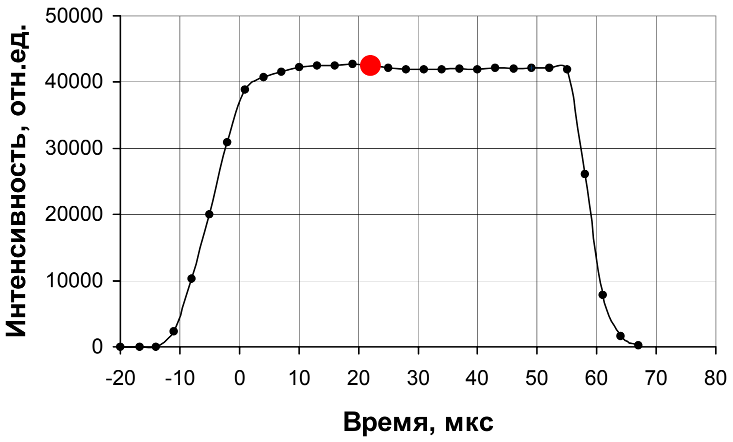


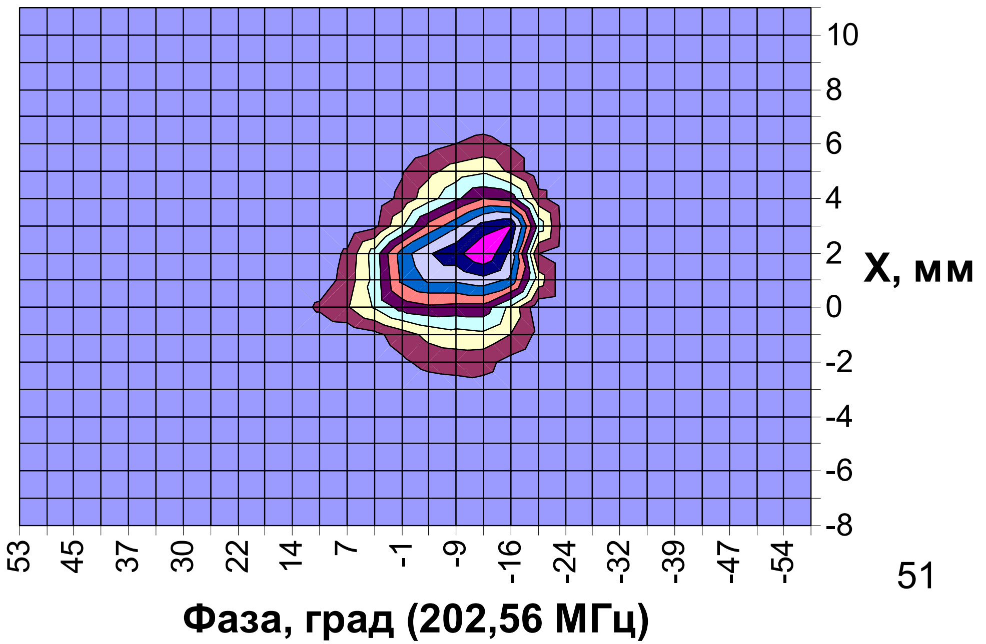




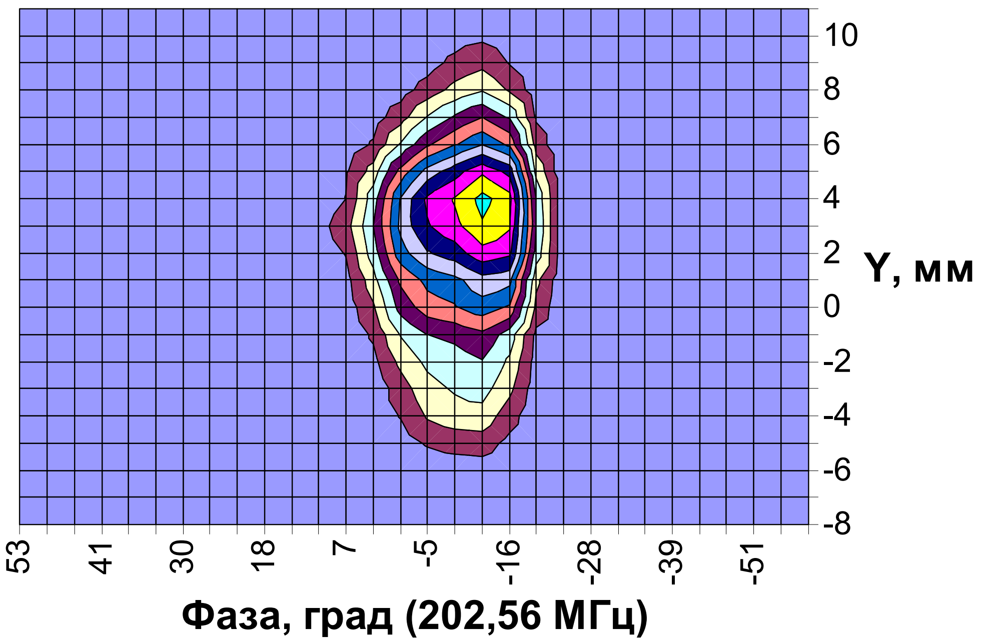
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

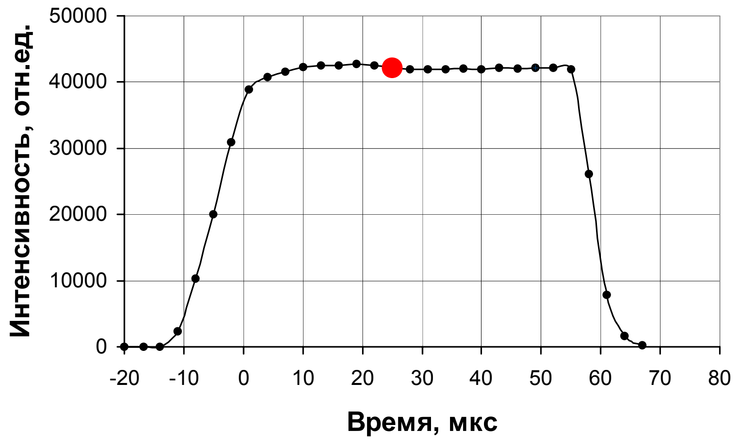


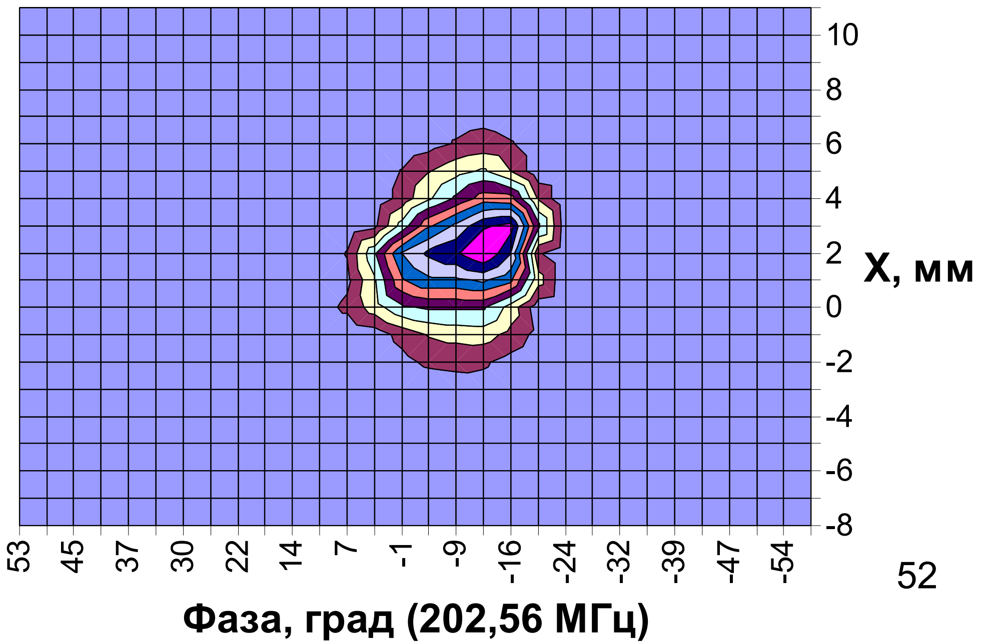




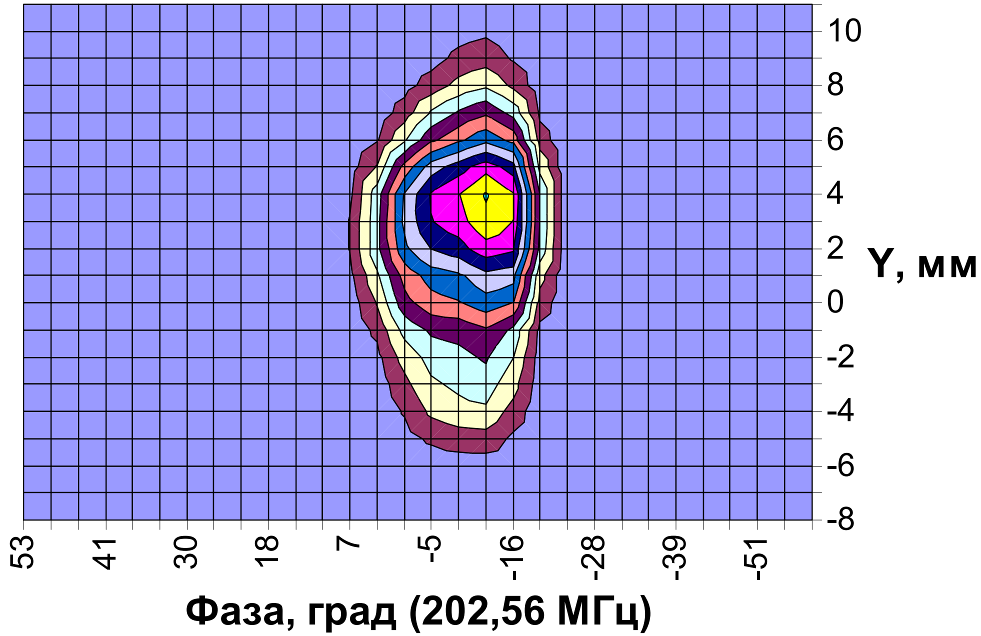
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

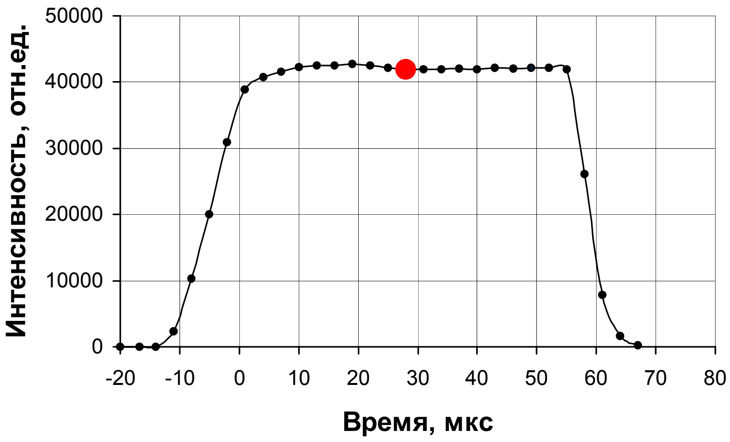


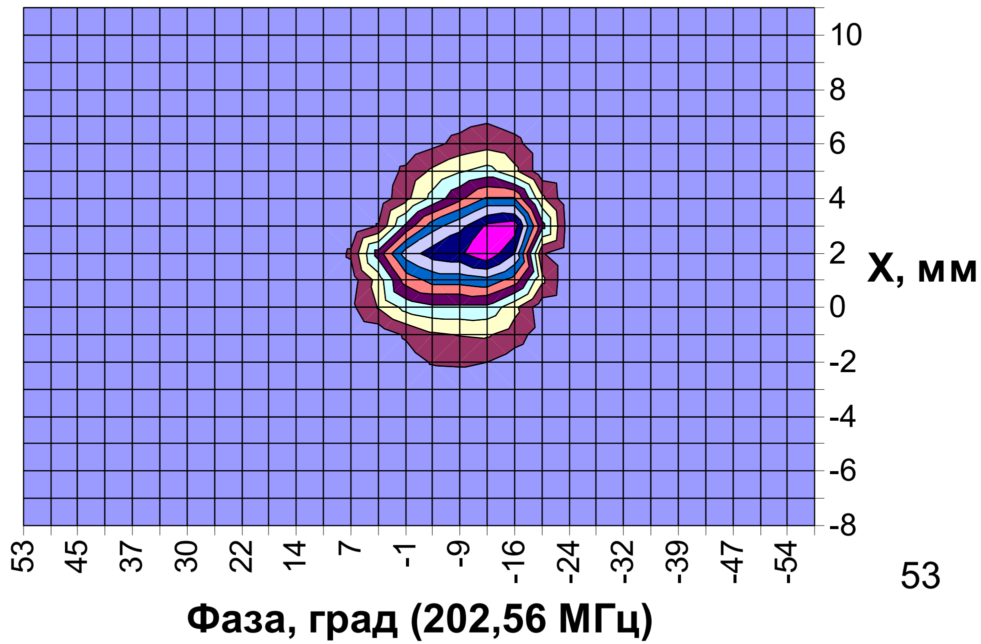




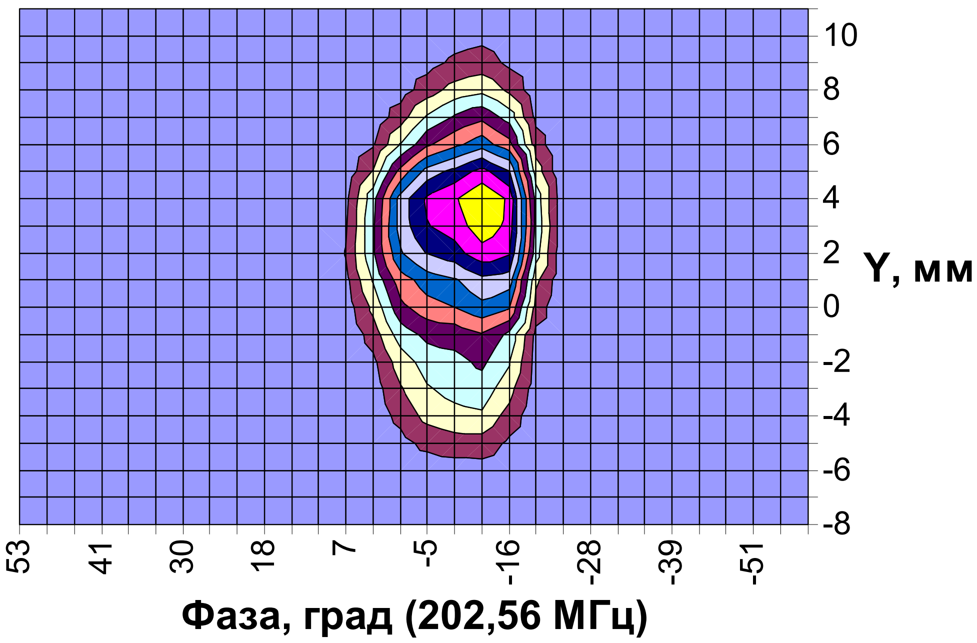
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

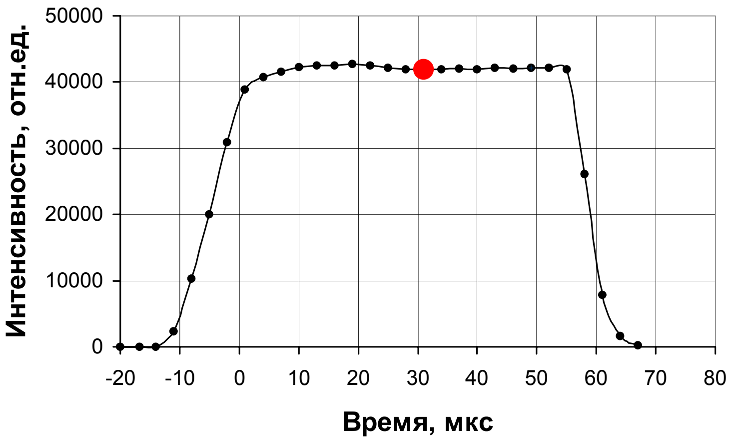


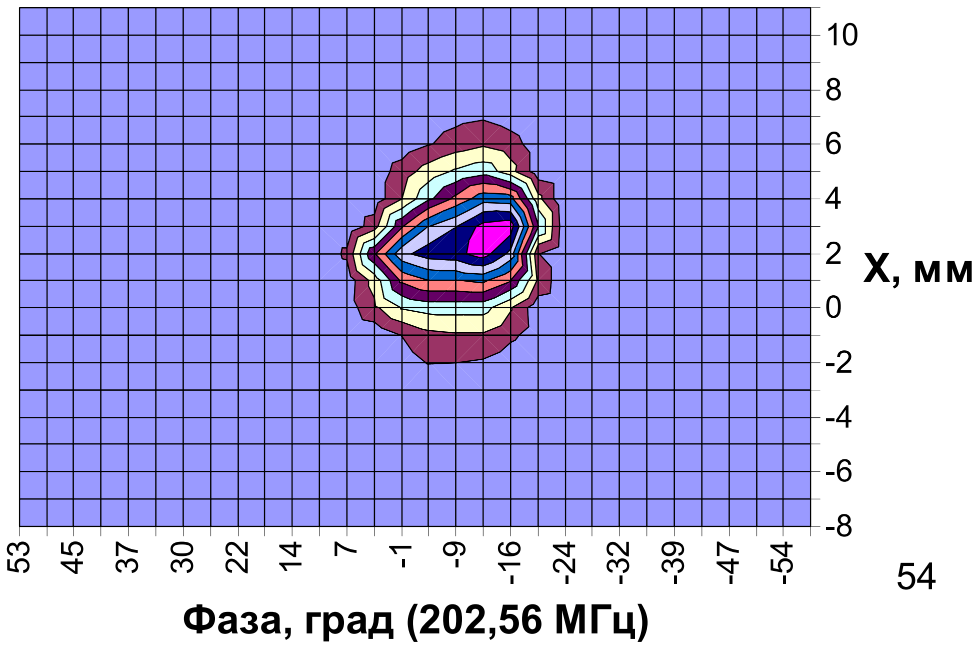




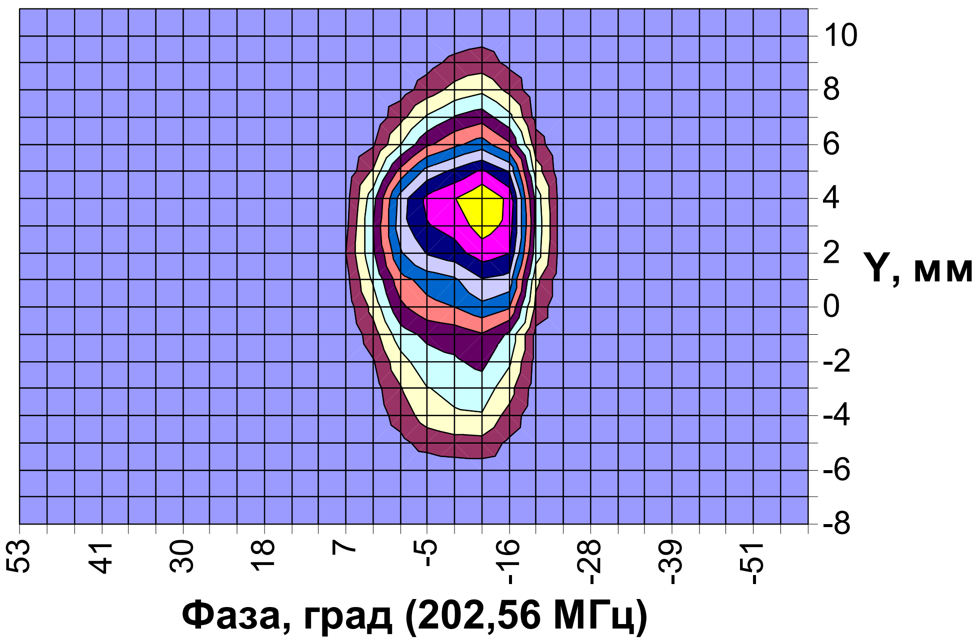
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

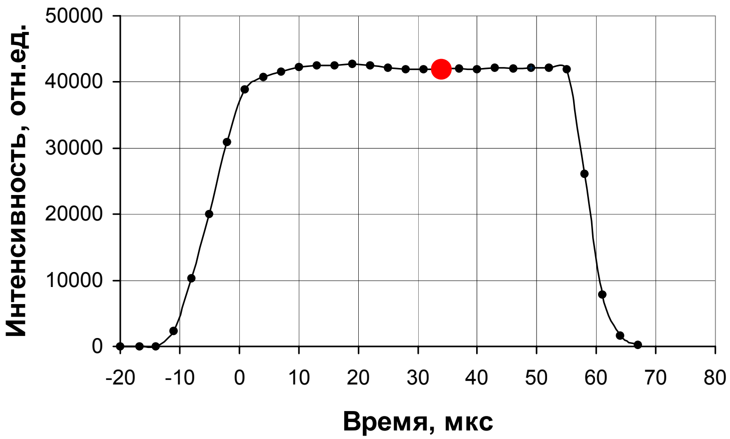


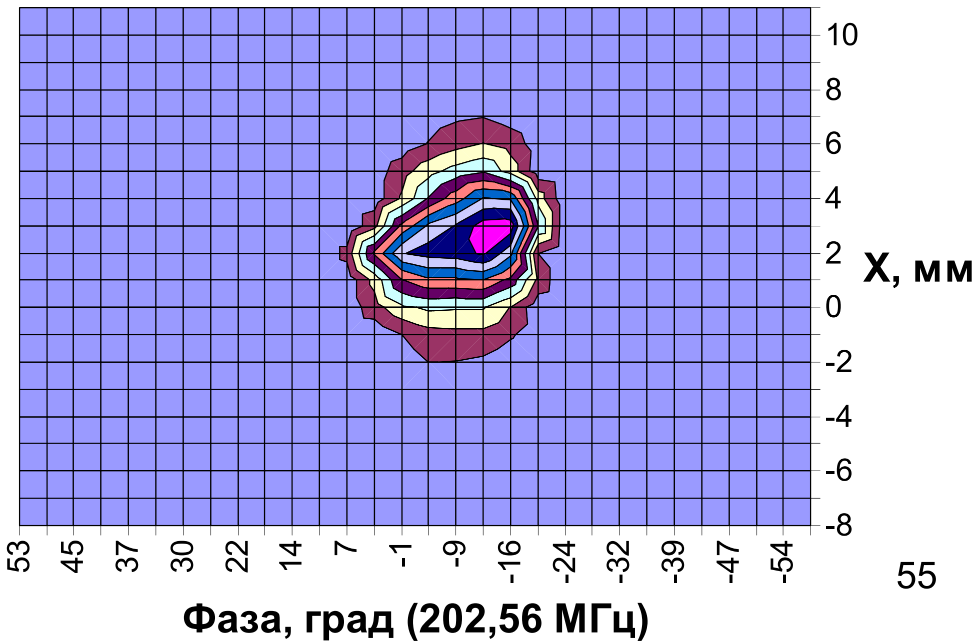




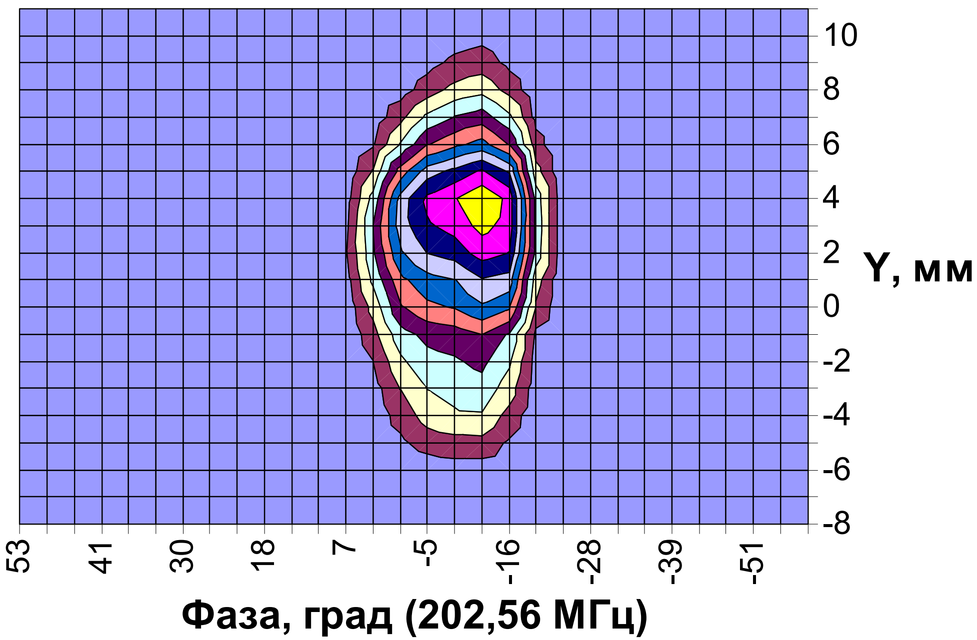
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

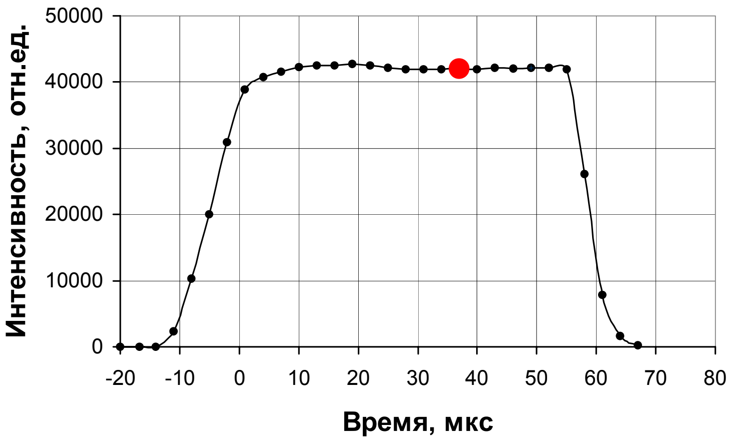


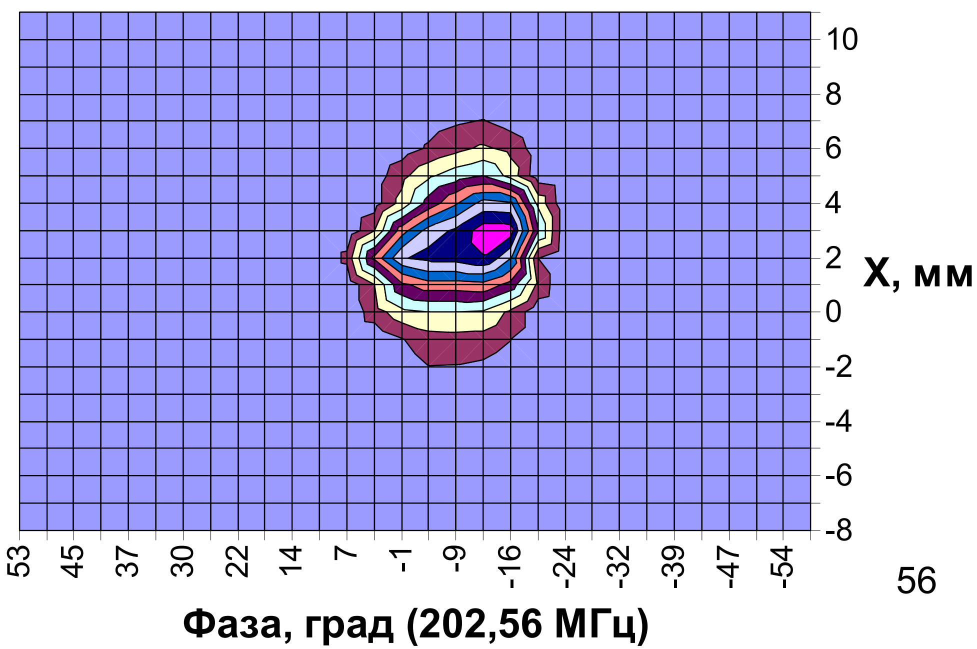




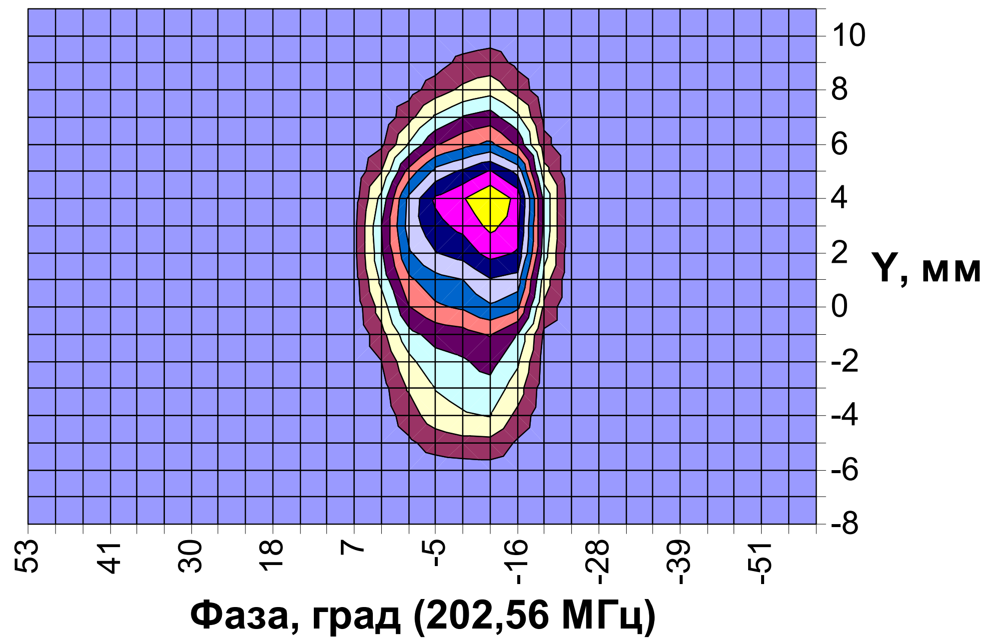
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

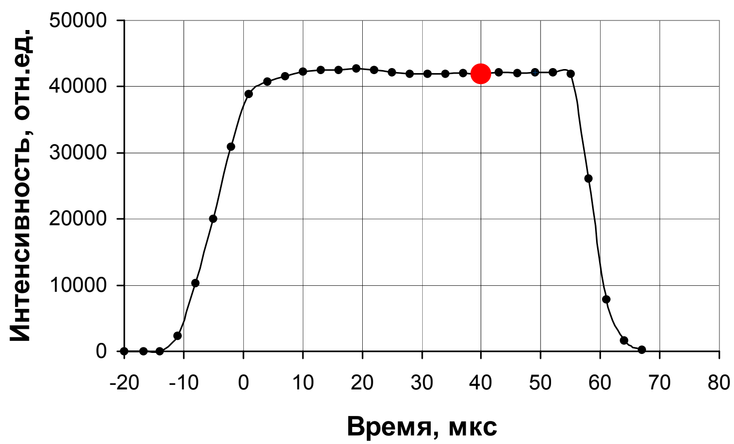


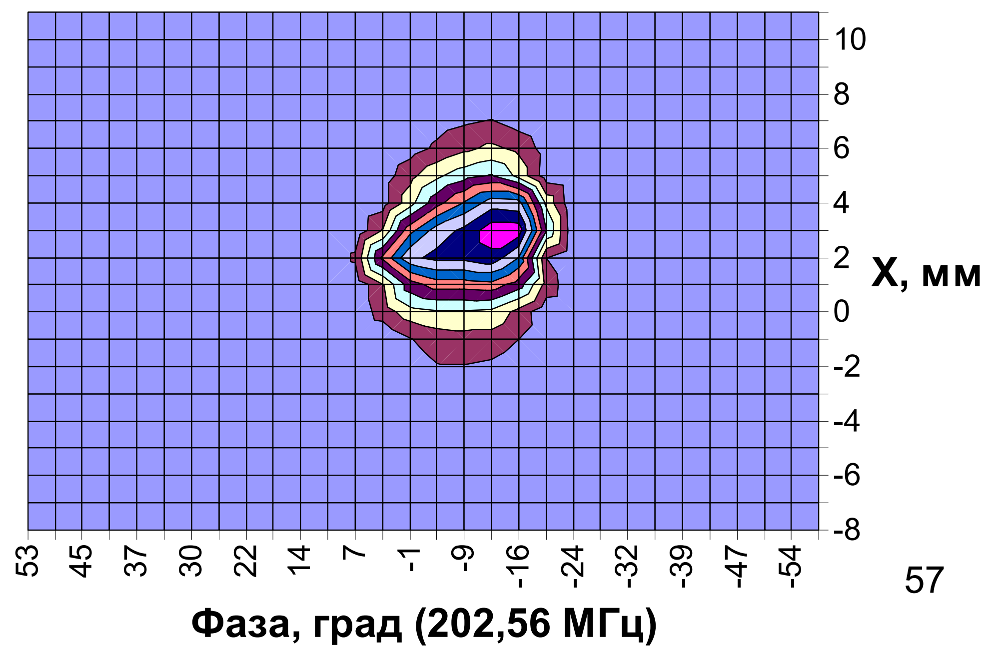




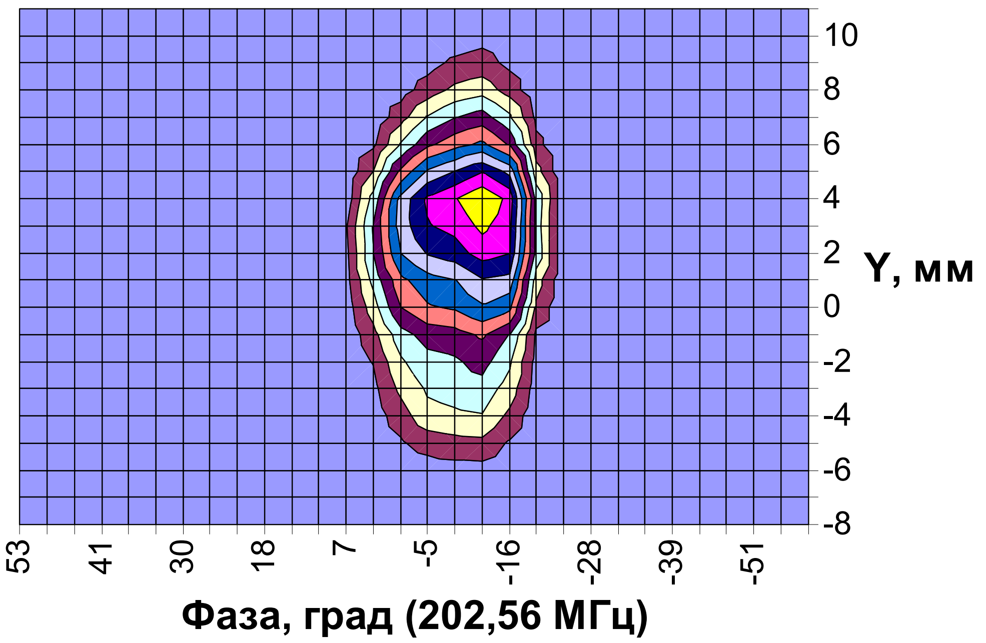
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

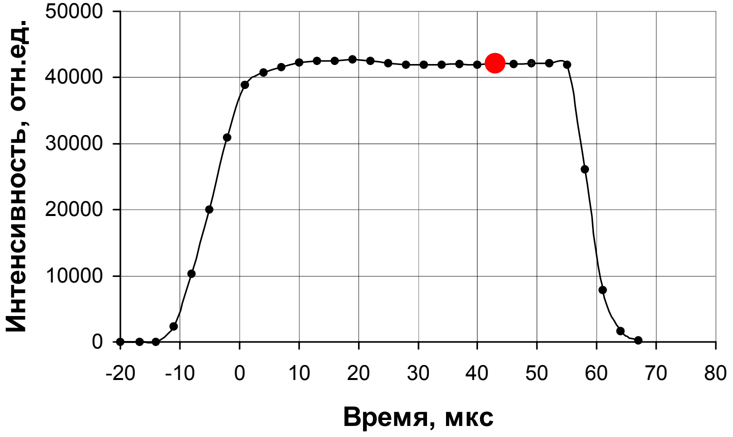


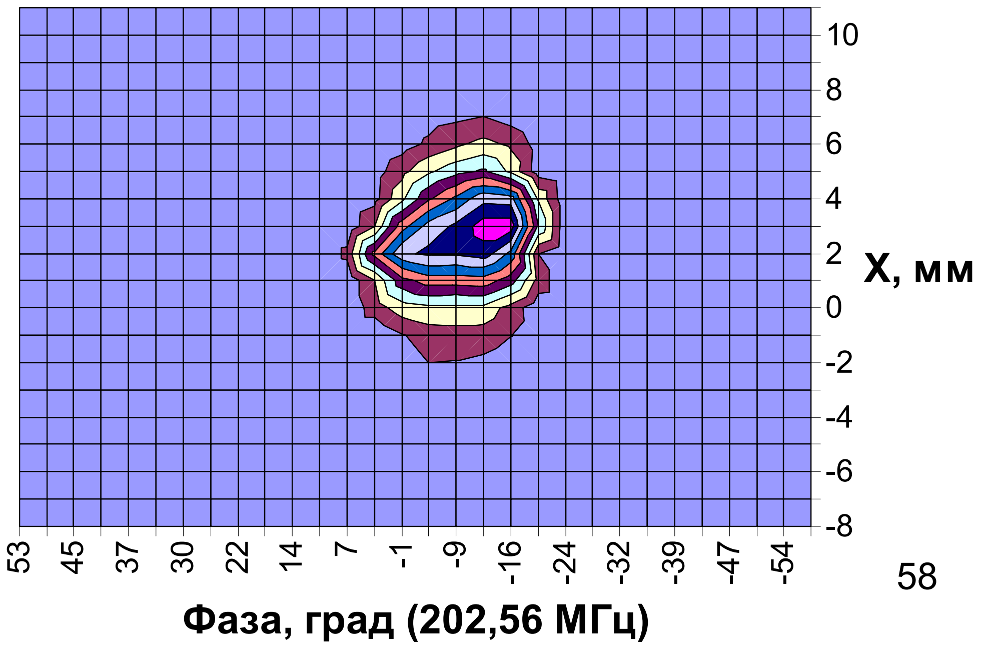




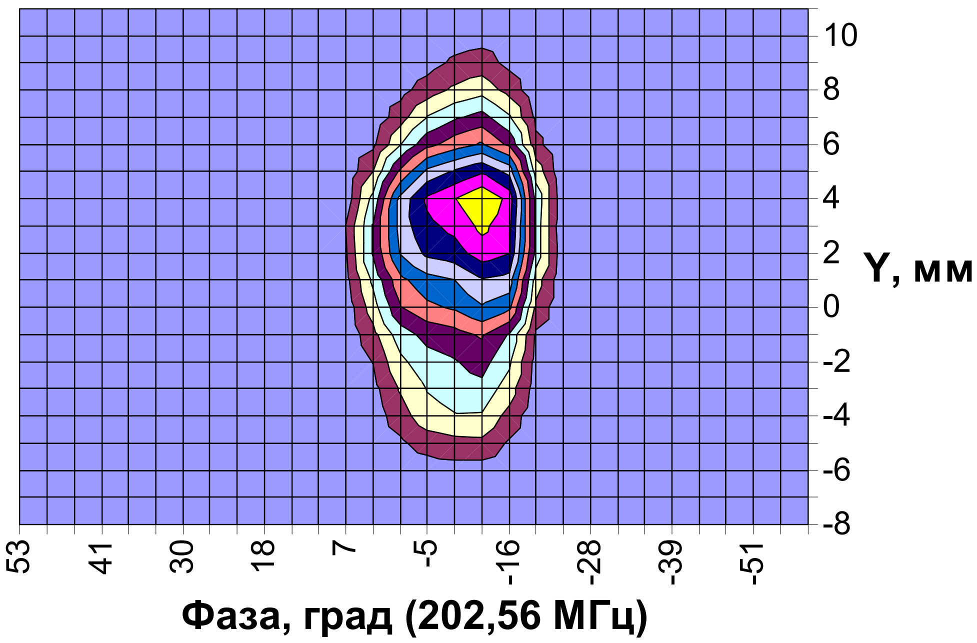
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

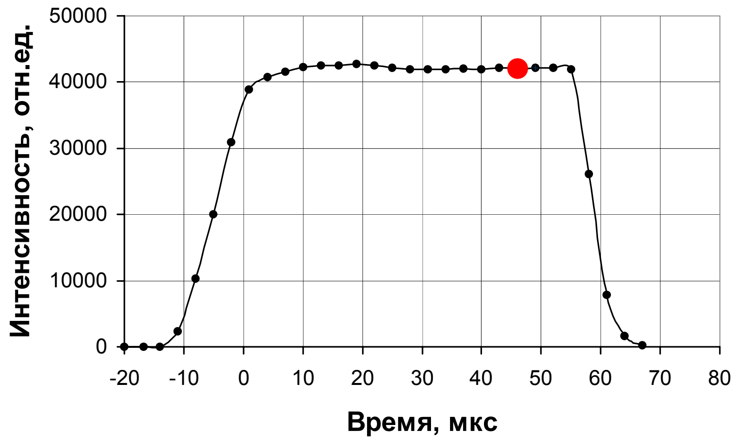


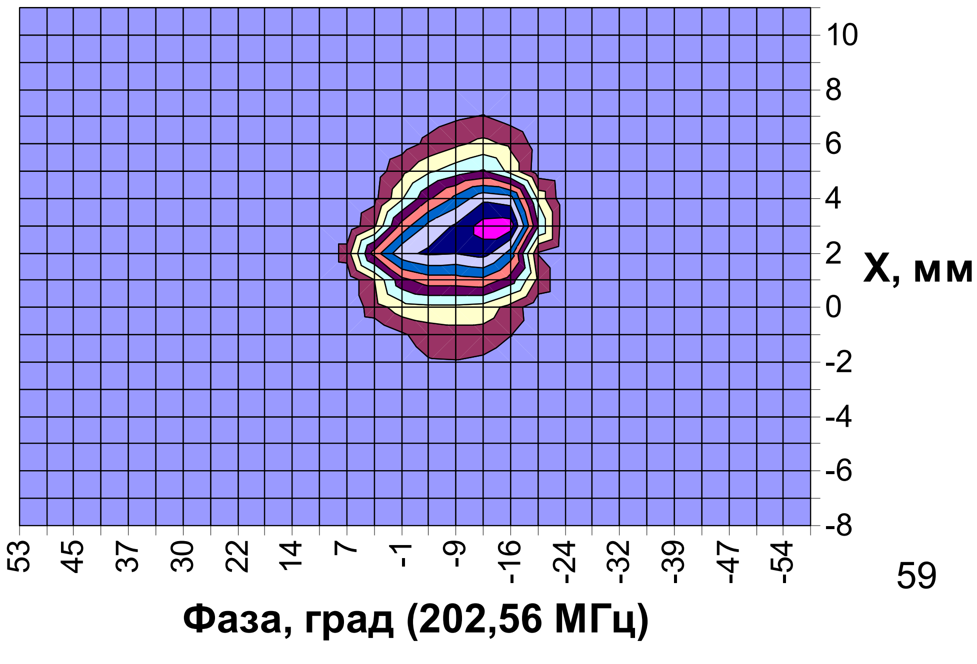




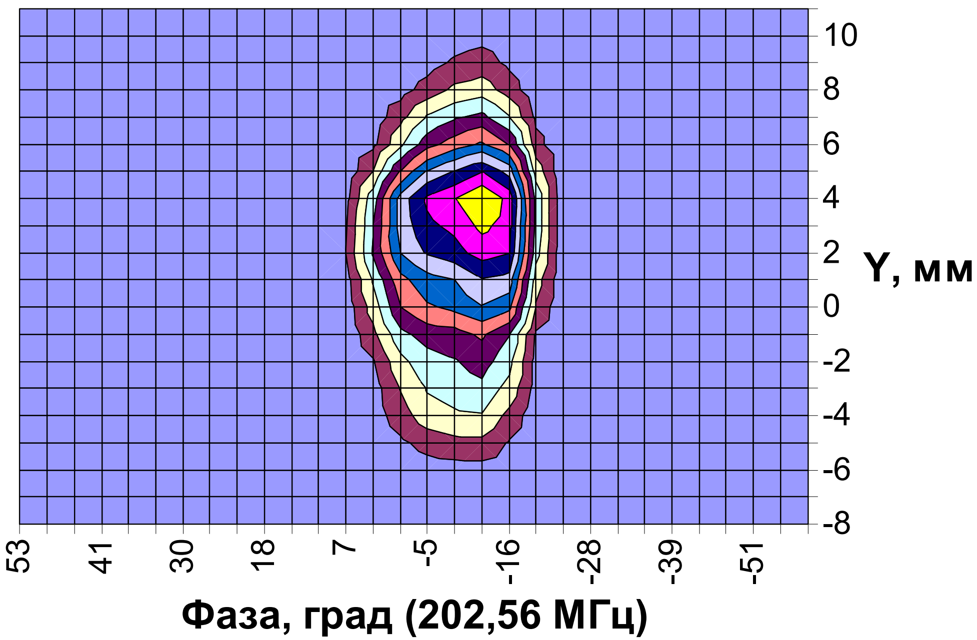
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

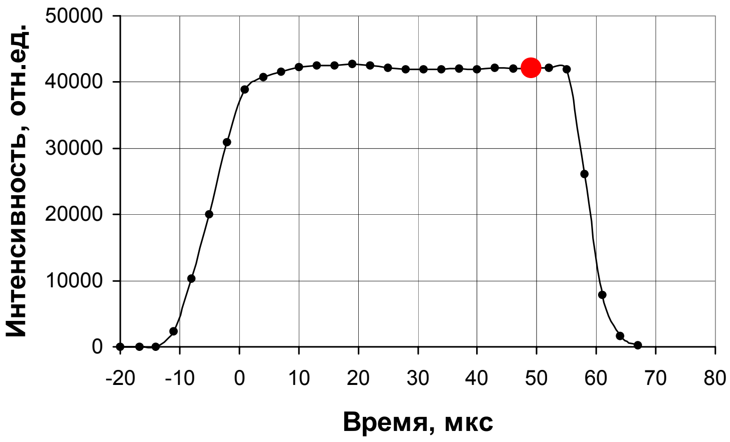


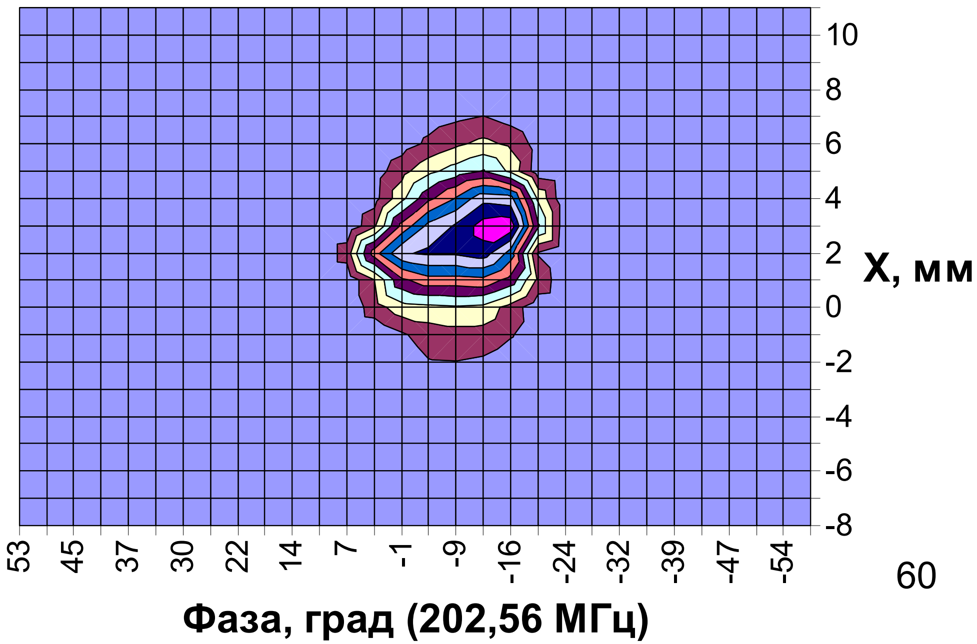




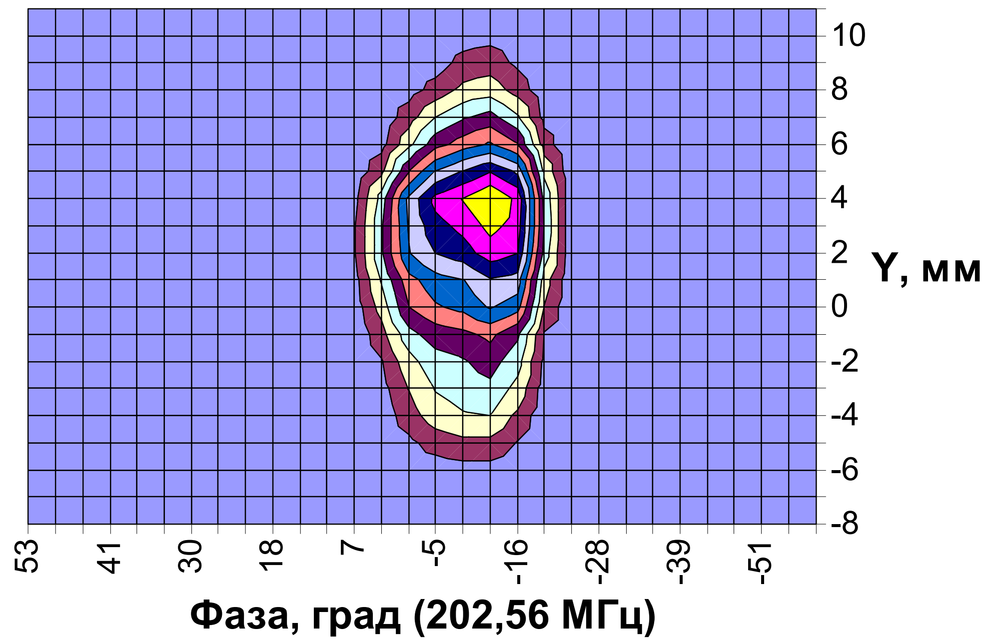
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

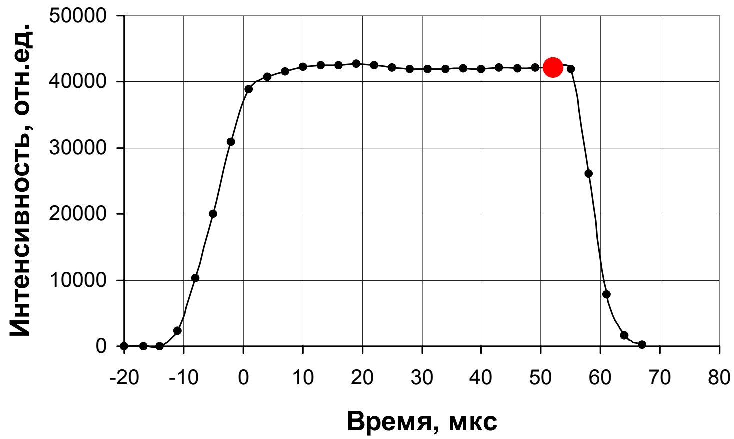


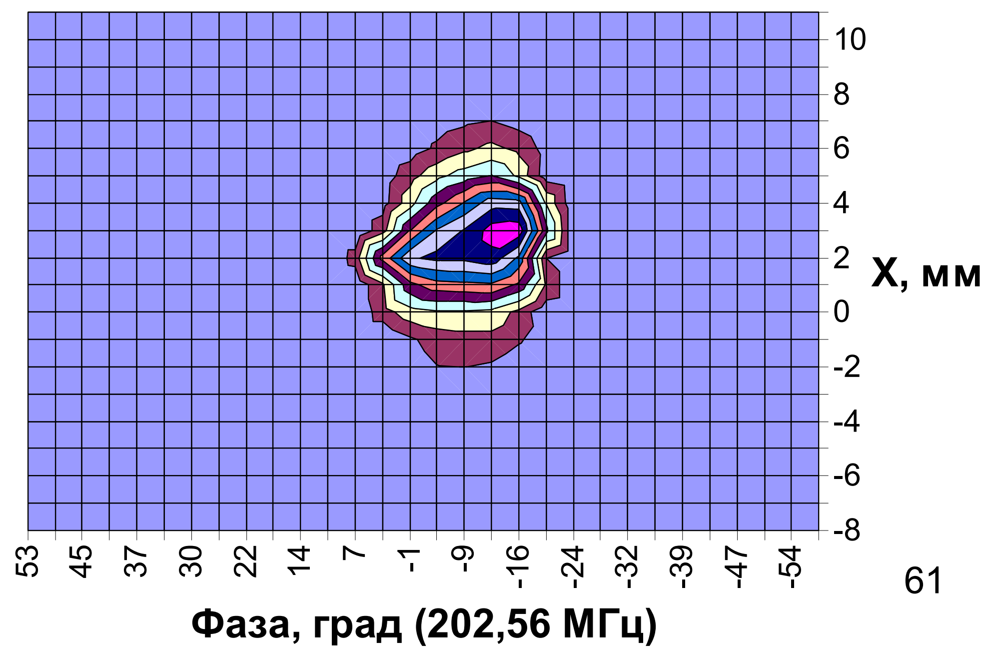




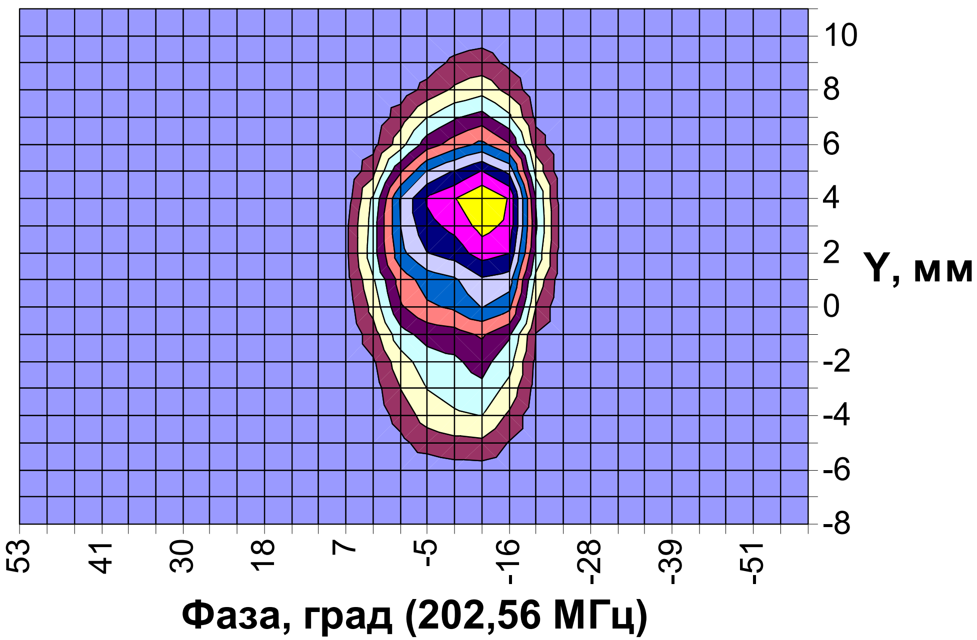
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

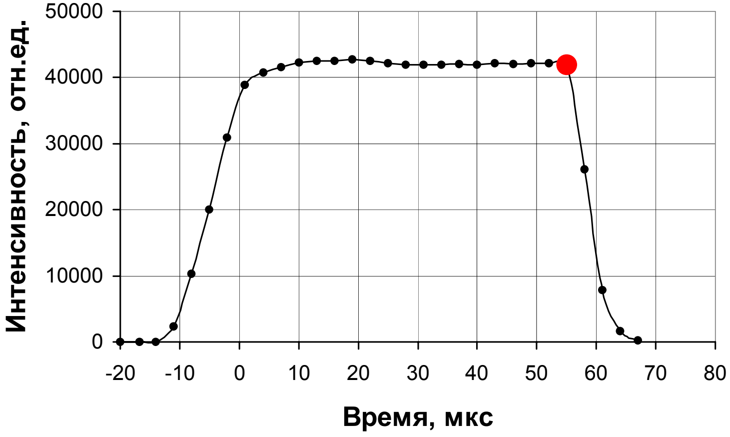


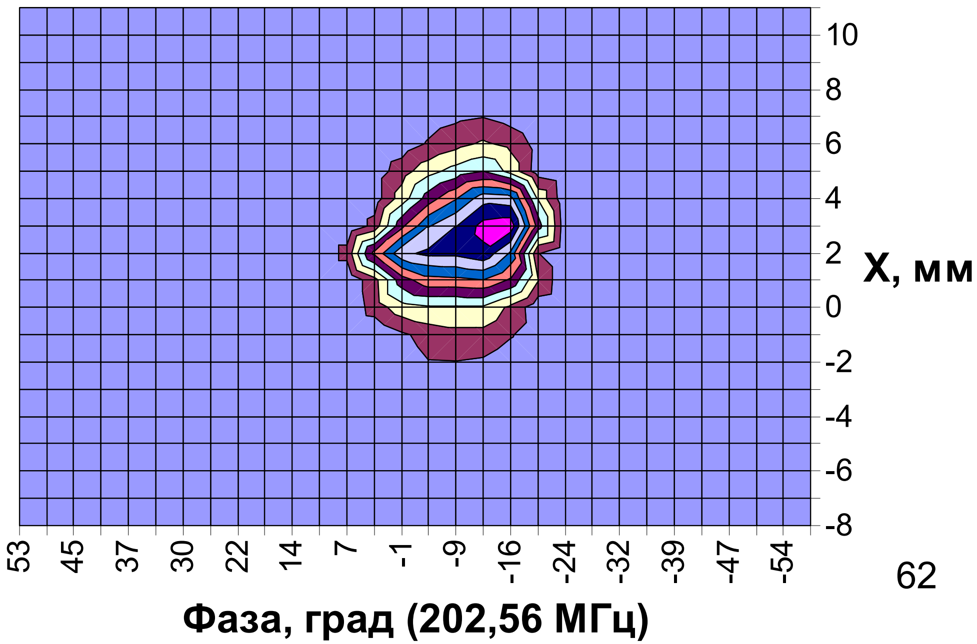




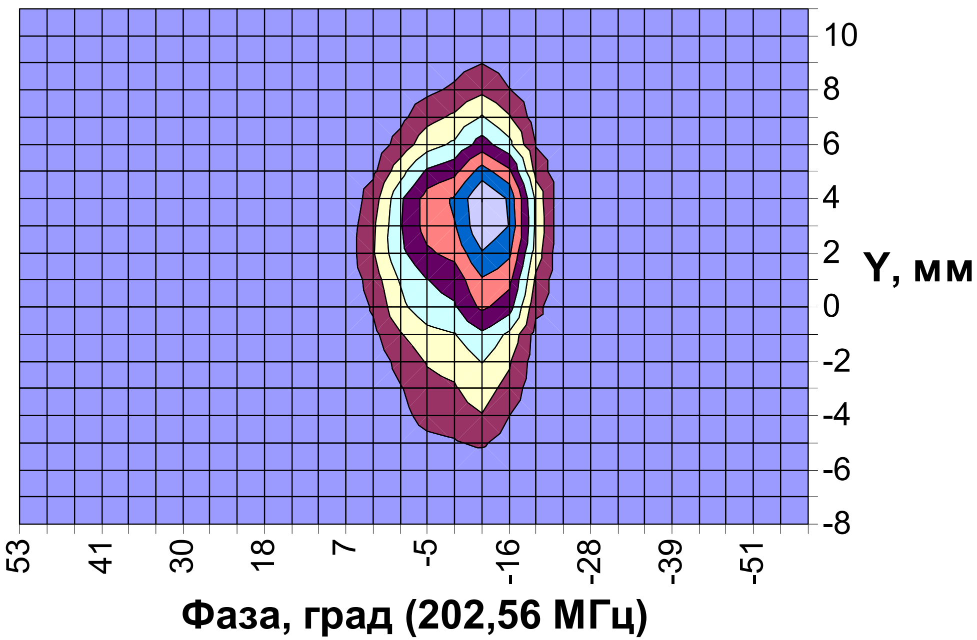
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

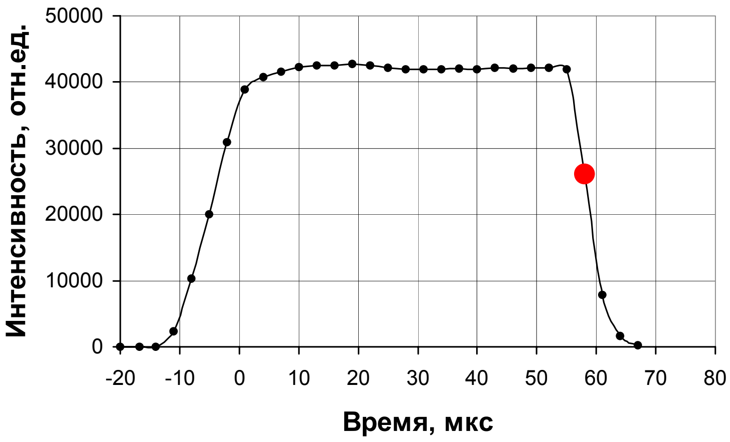


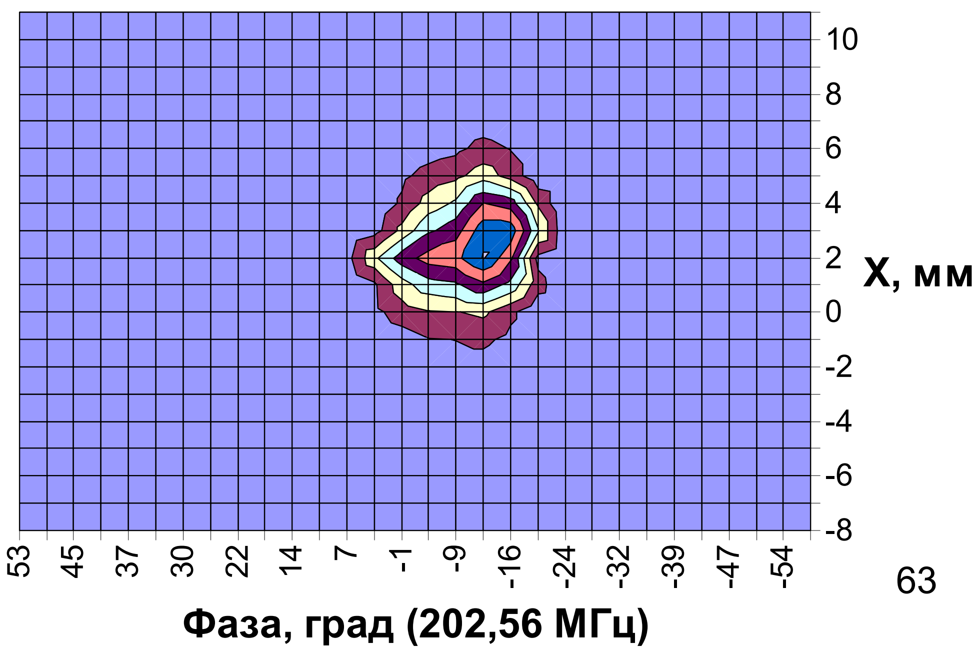




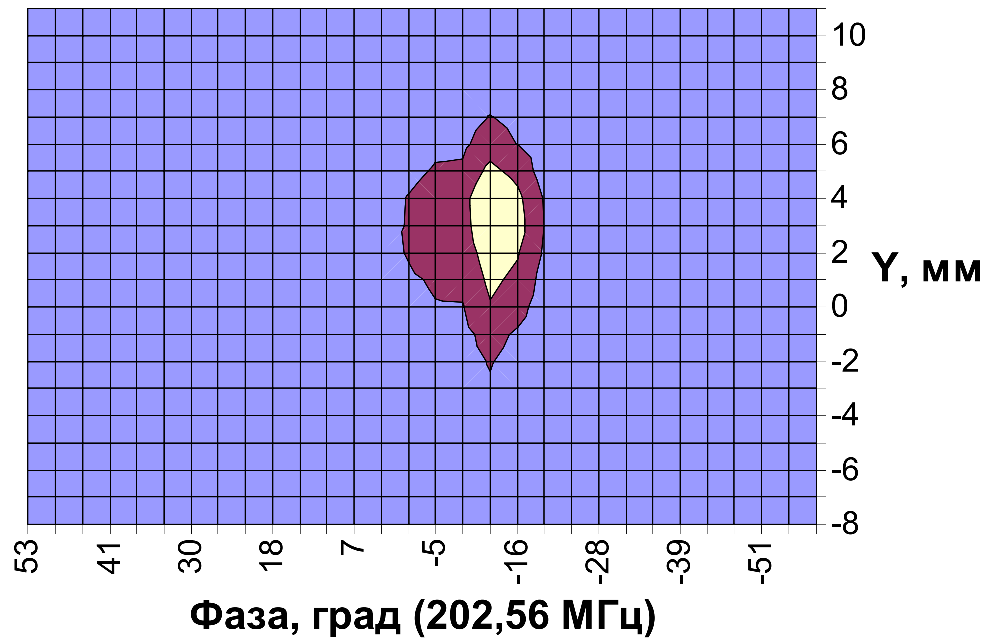
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

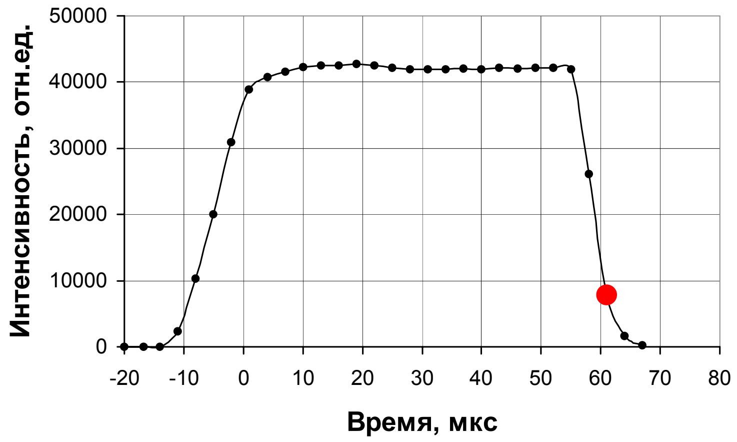


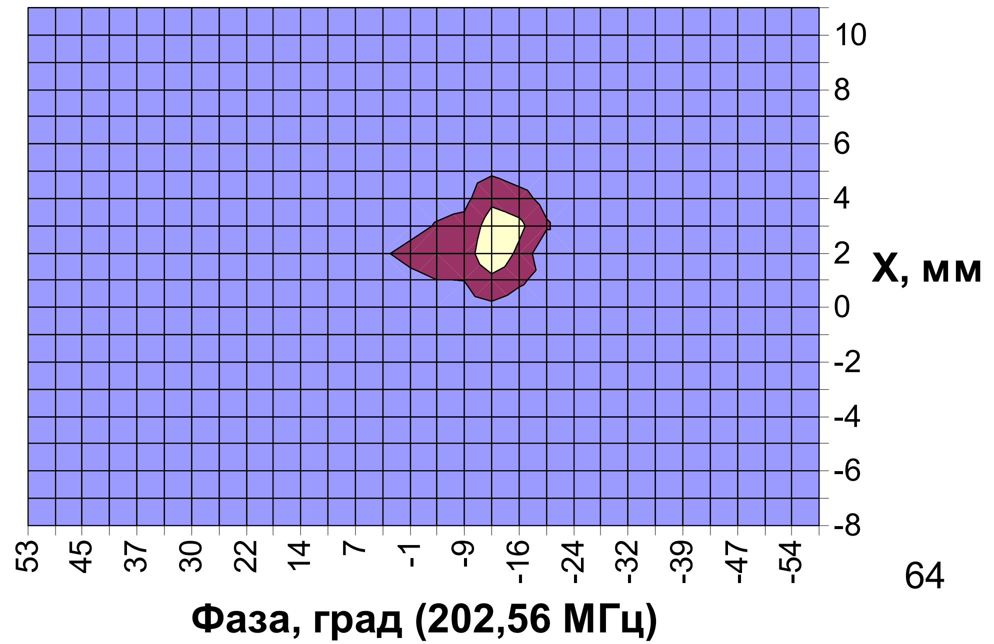




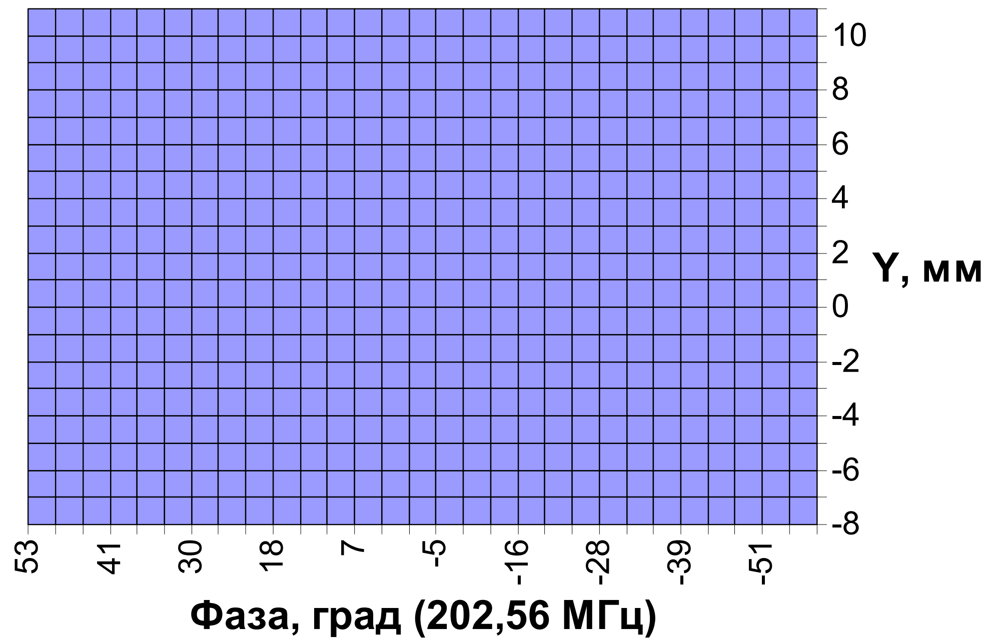
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

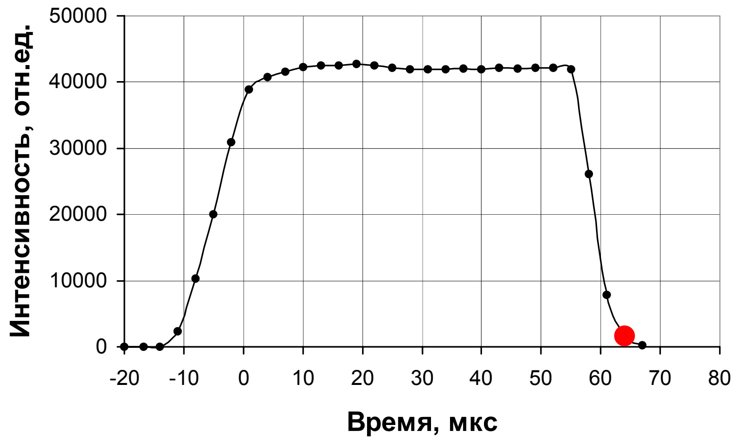


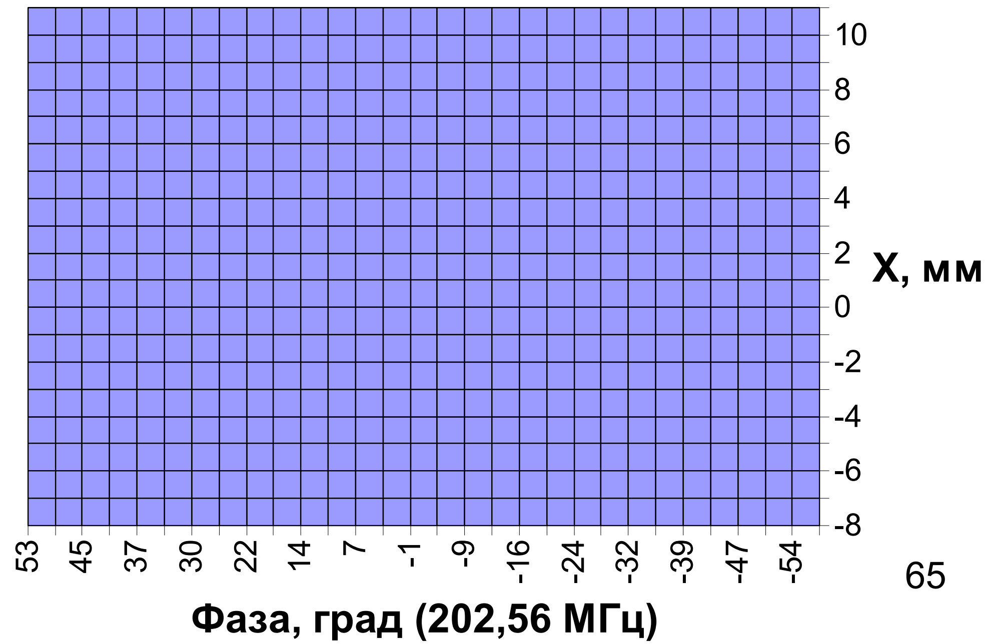




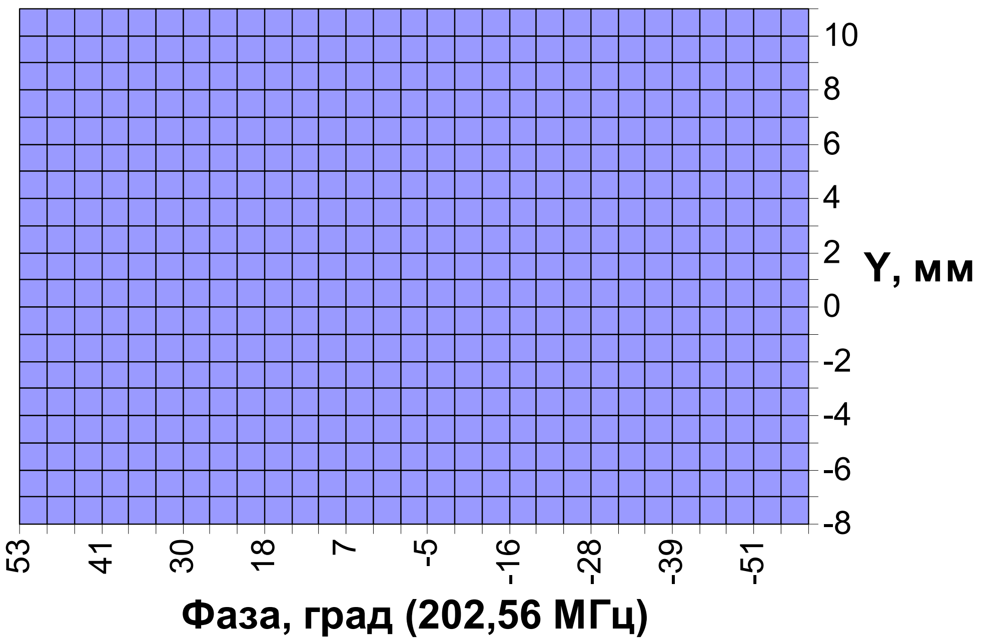
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse

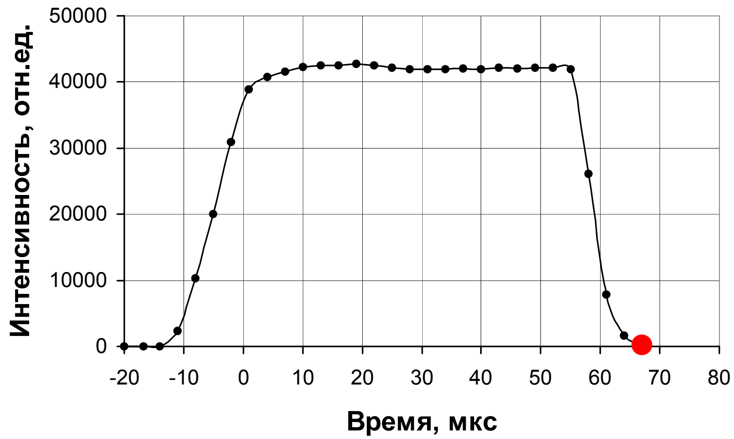


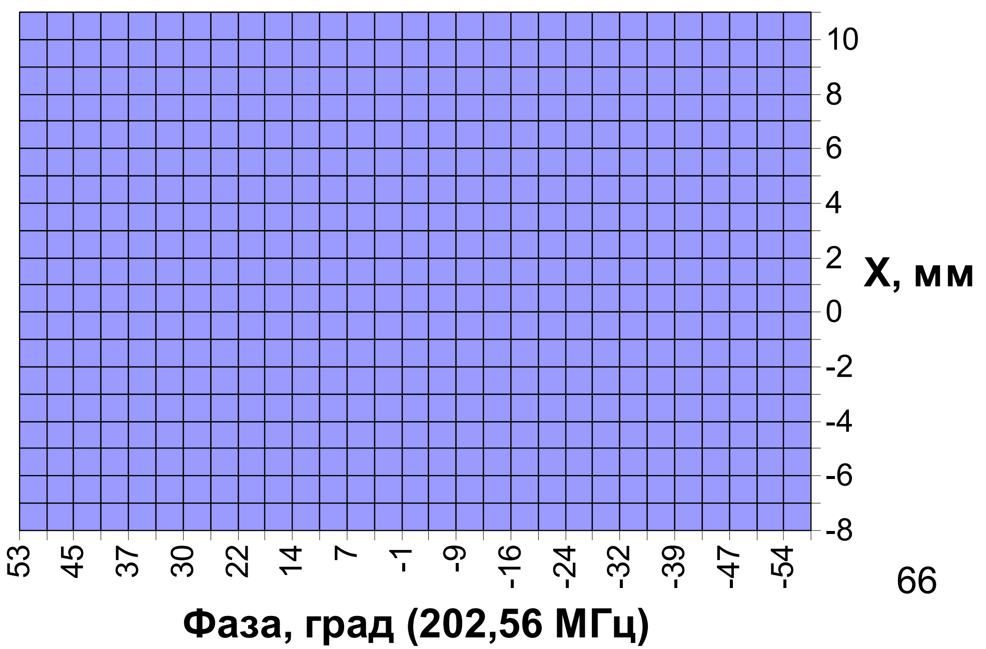


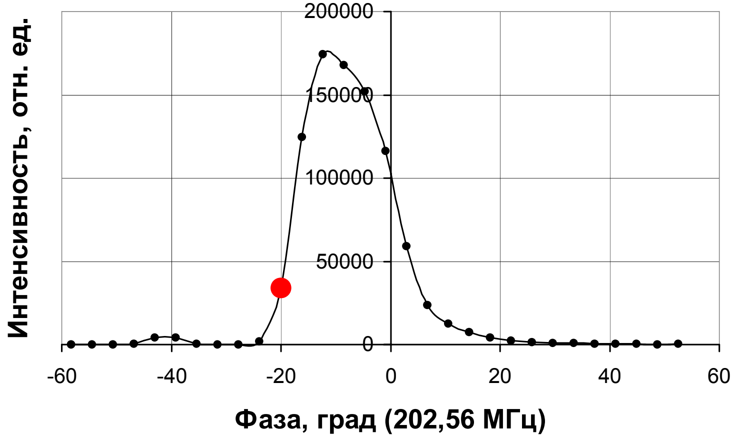


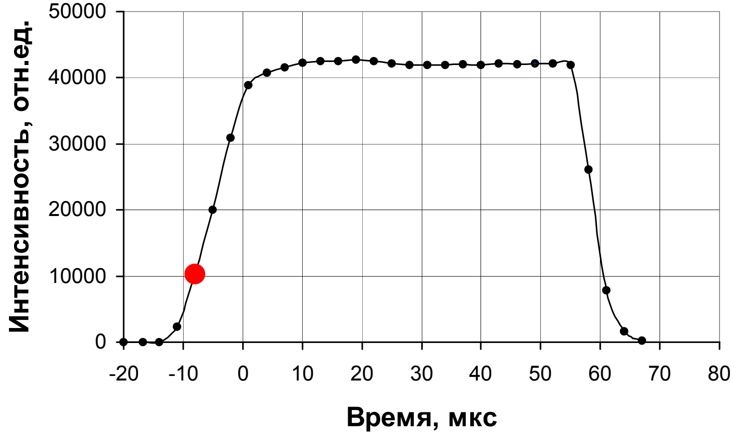
Behavior of 3-D distribution projection on longitudinal vertical and horizontal planes within the beam pulse





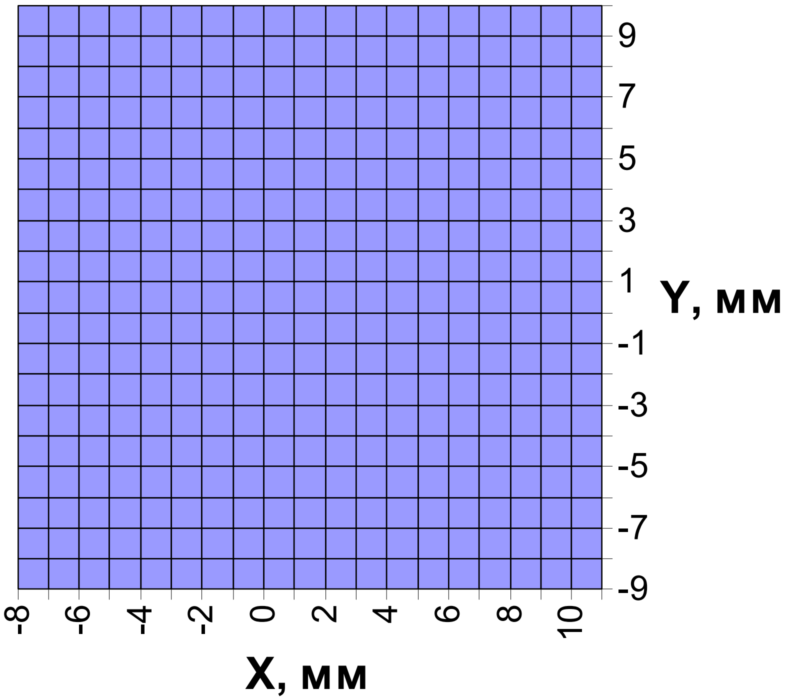


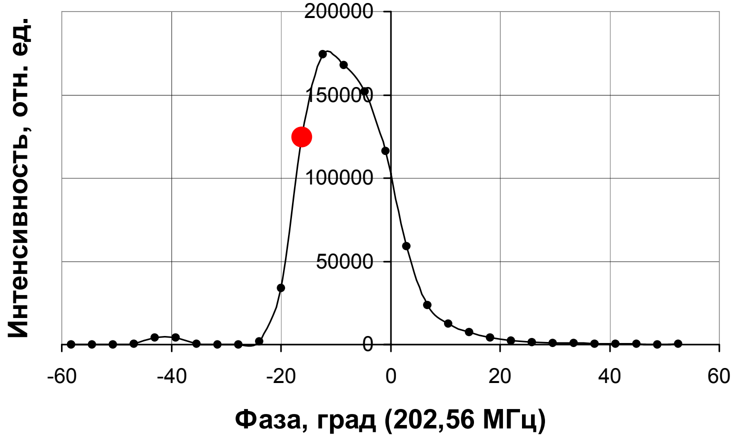


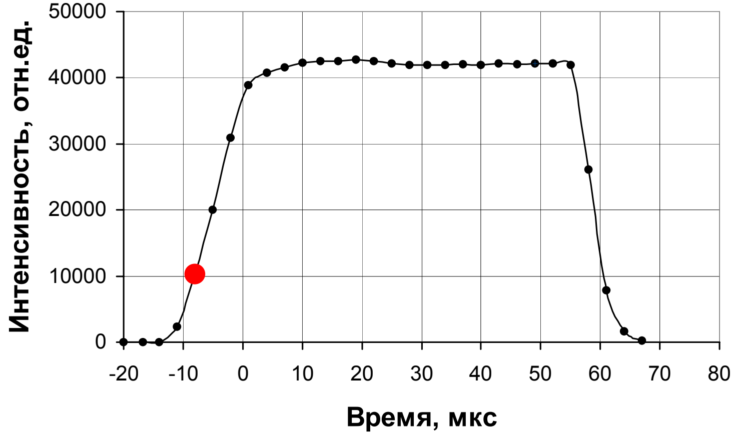


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

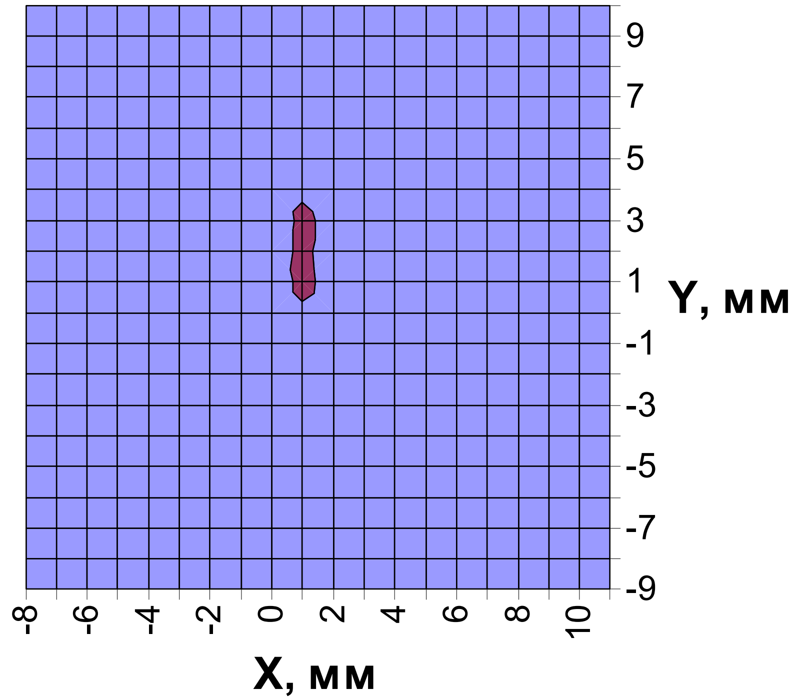
Bunch #1



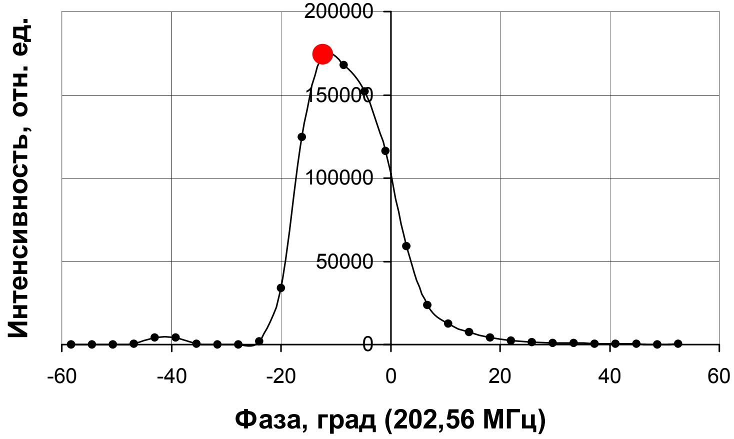


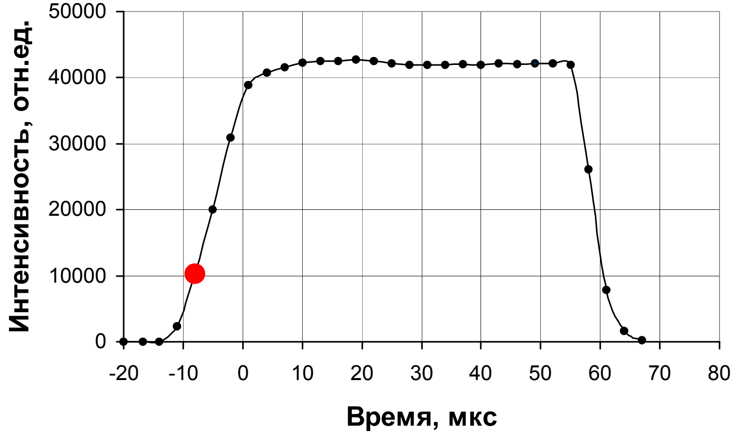


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

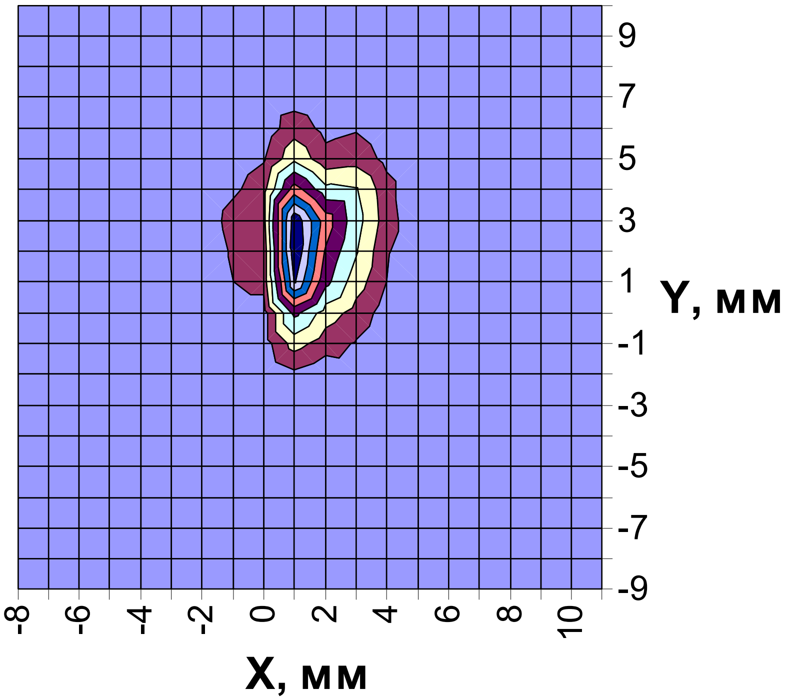


Bunch #1

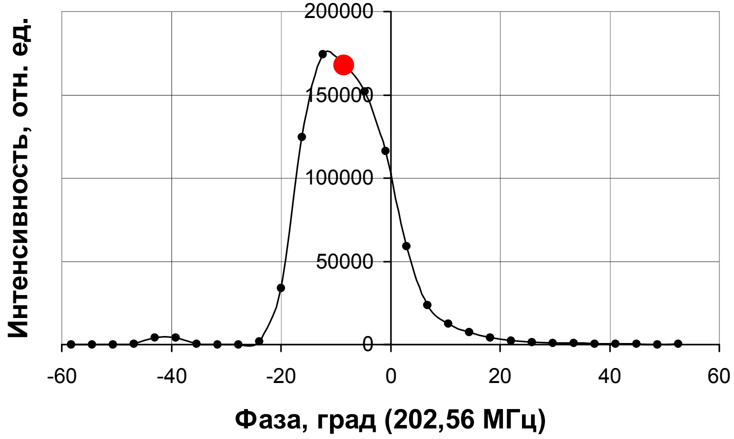


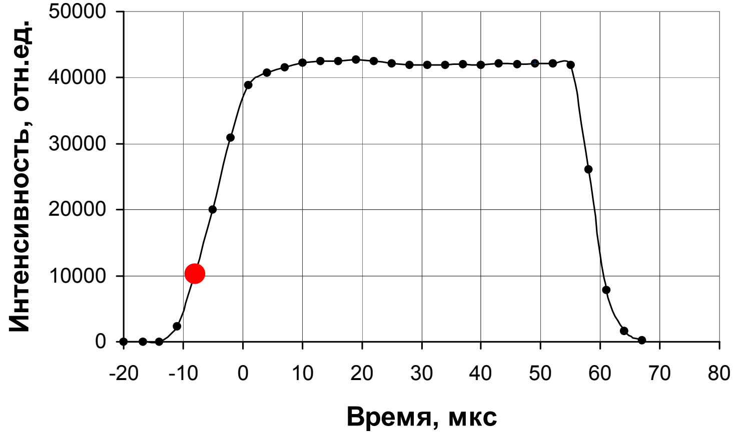


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse



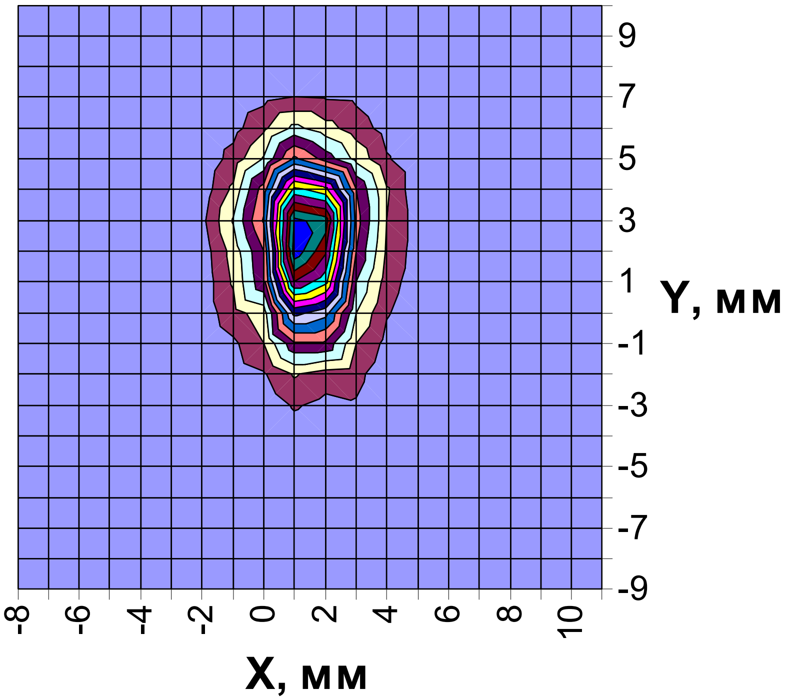
Bunch #1

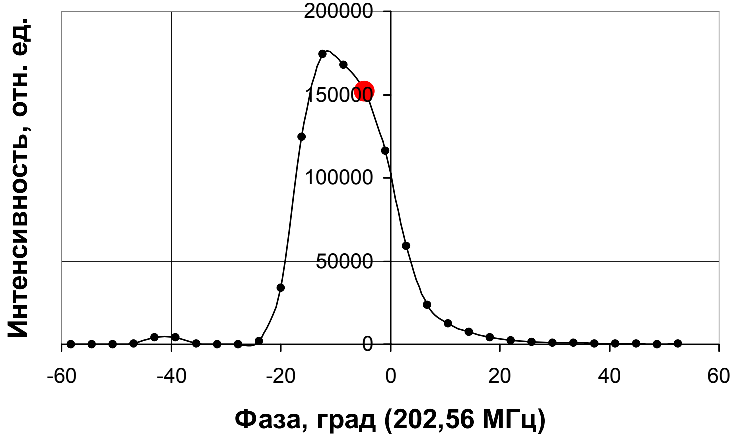


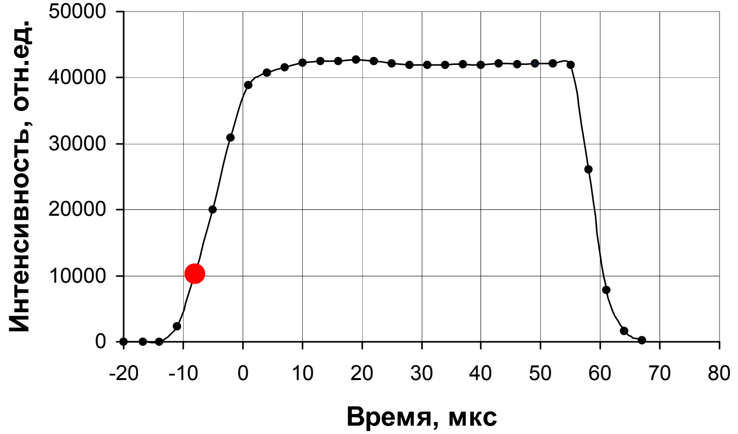


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #1

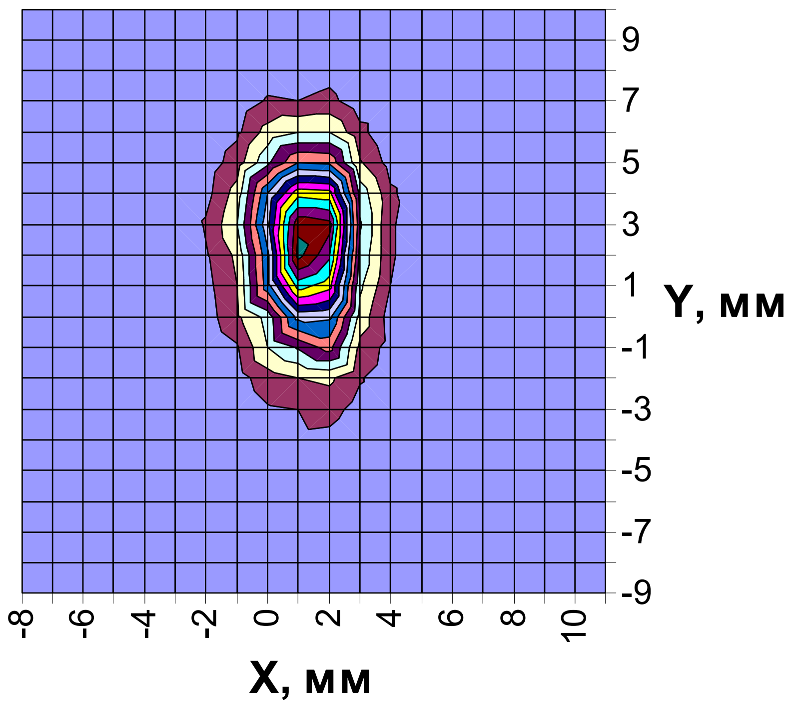


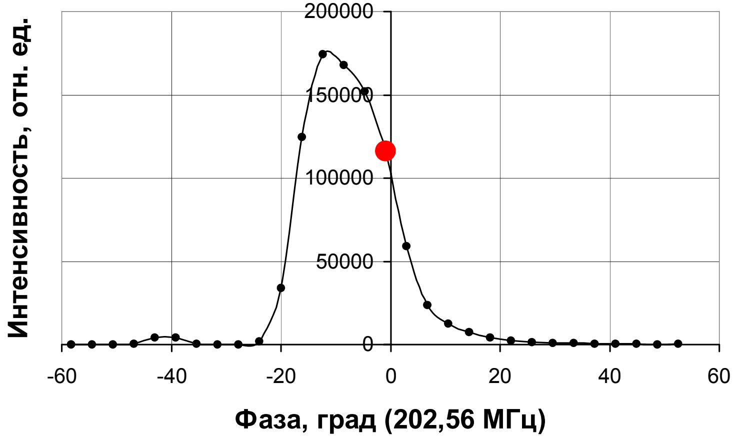


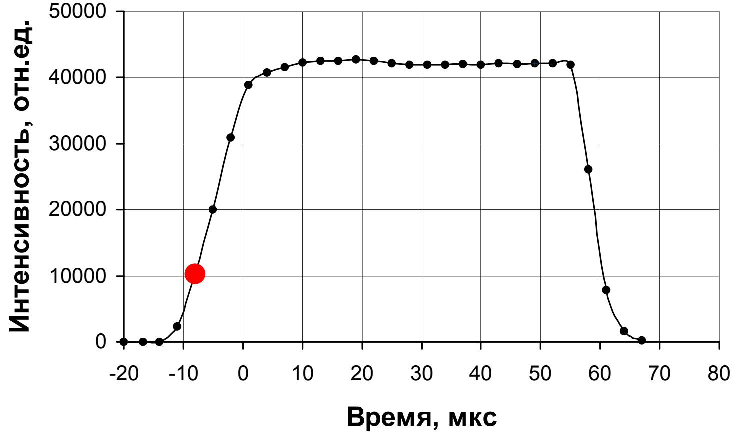


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #1

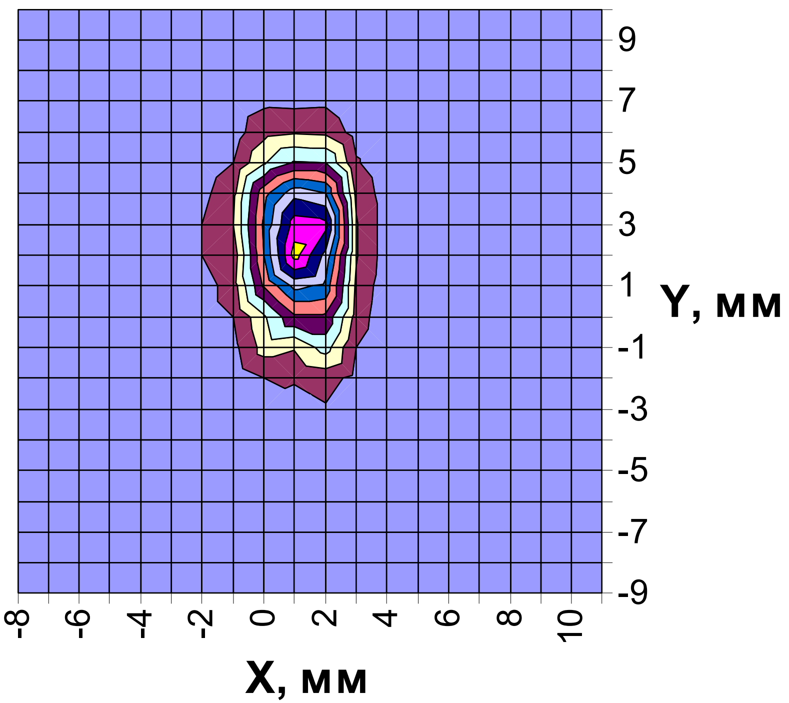


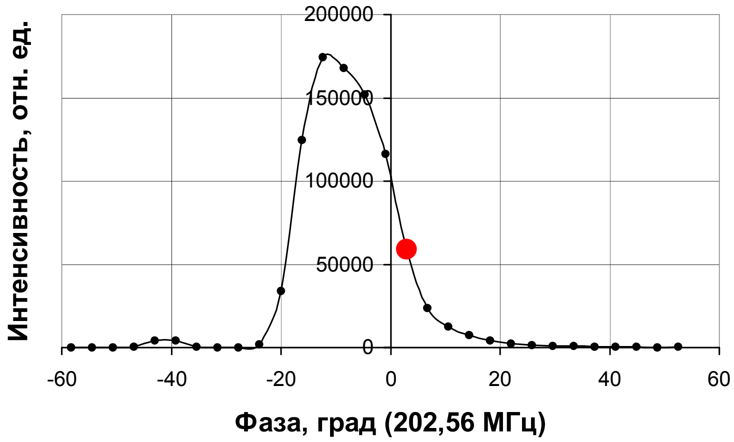


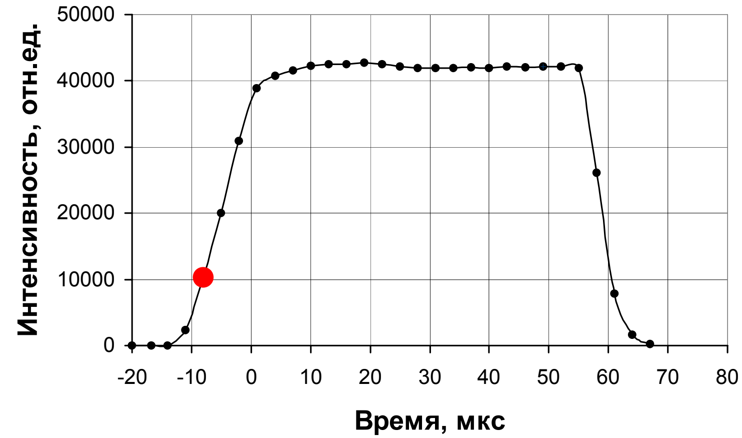


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #1

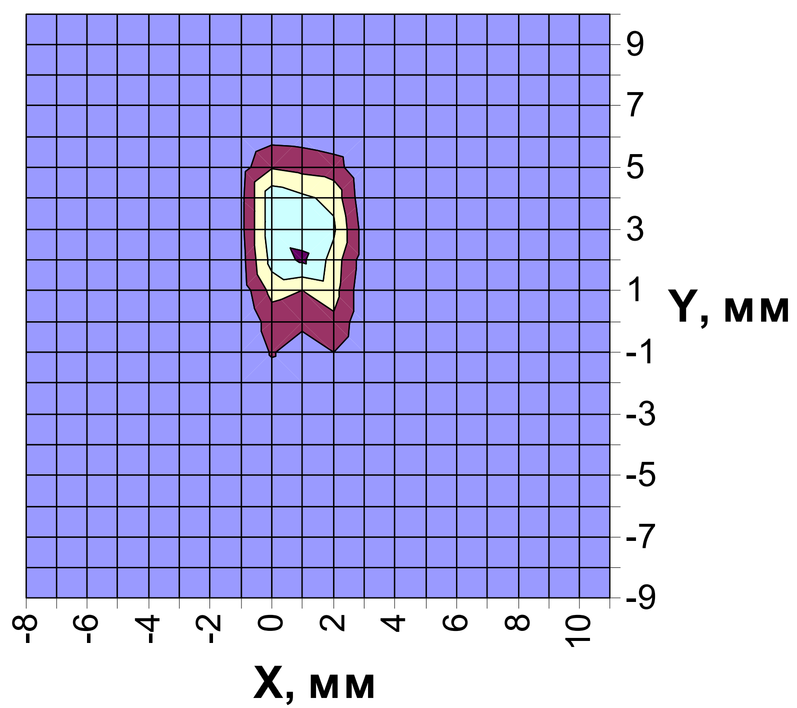


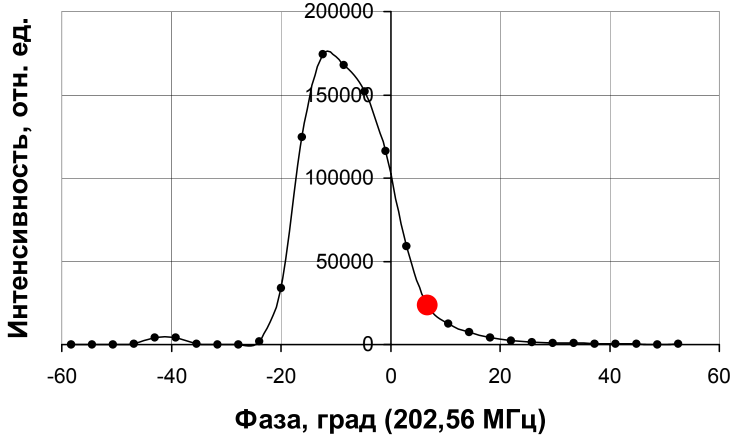


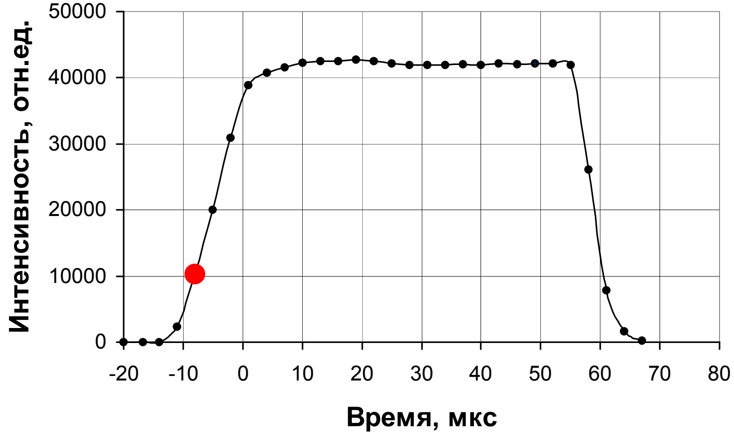


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #1

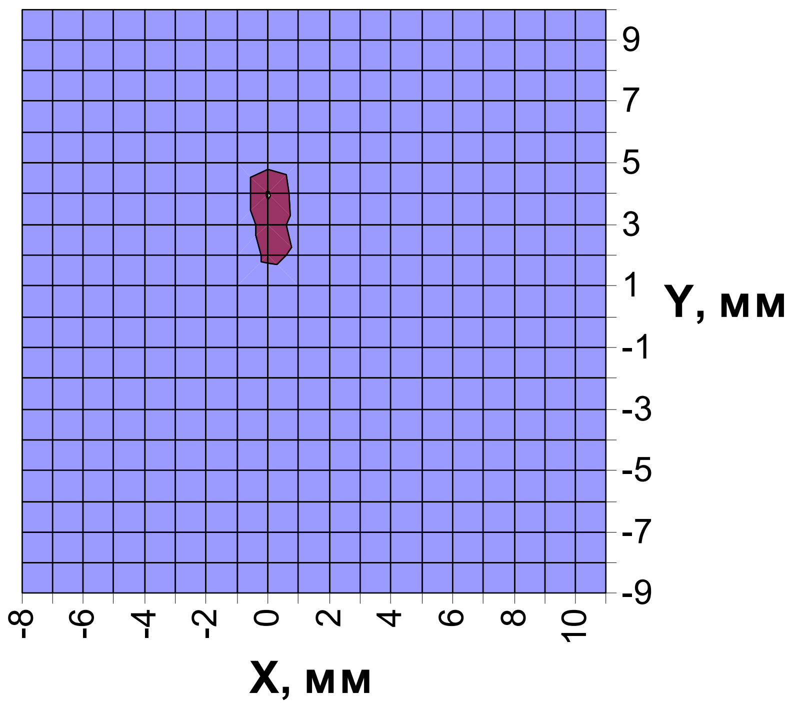


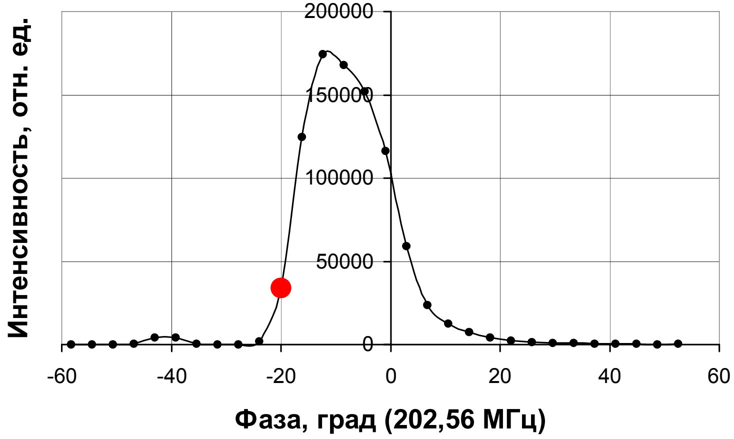


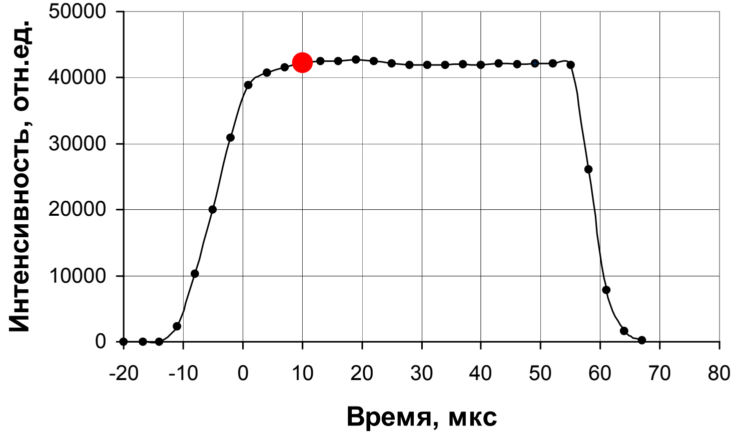


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #1

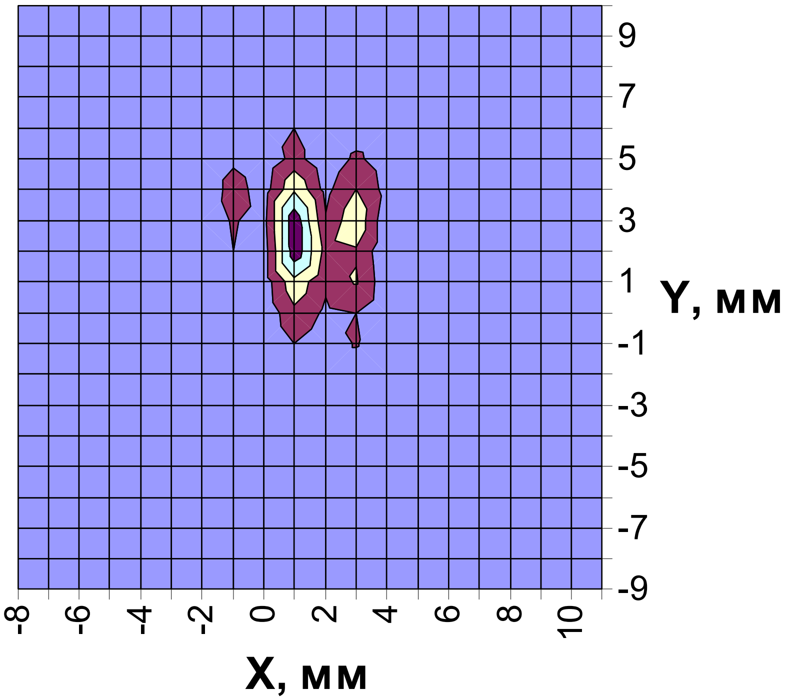


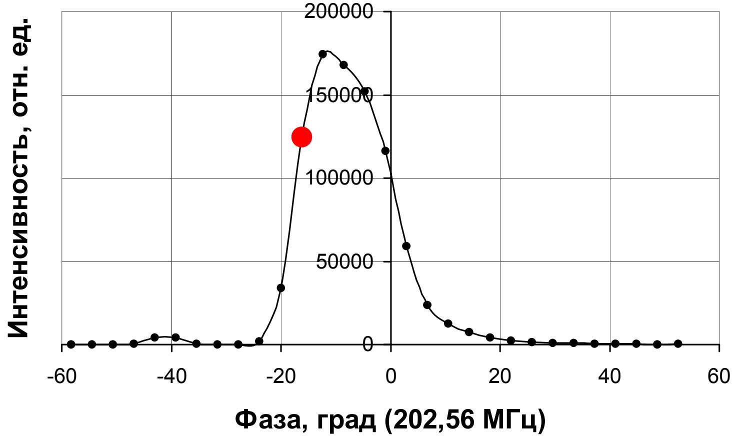


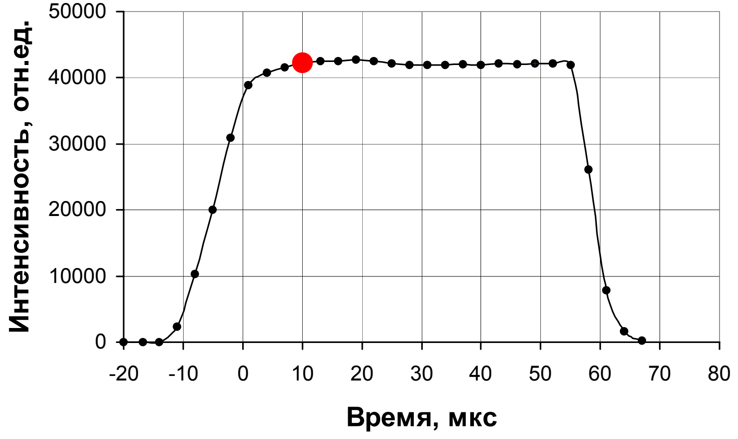


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #2

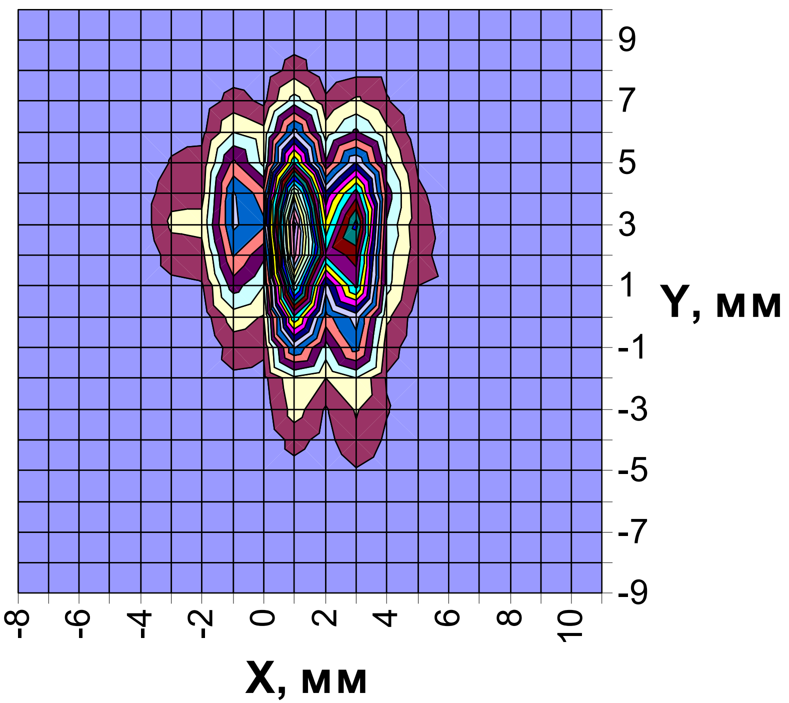


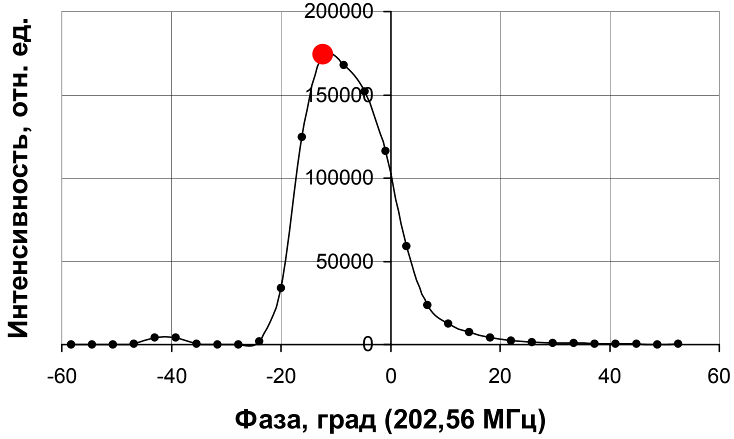


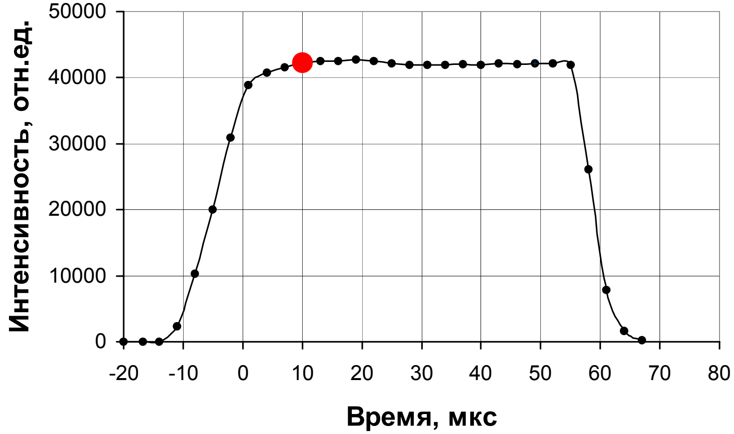


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #2

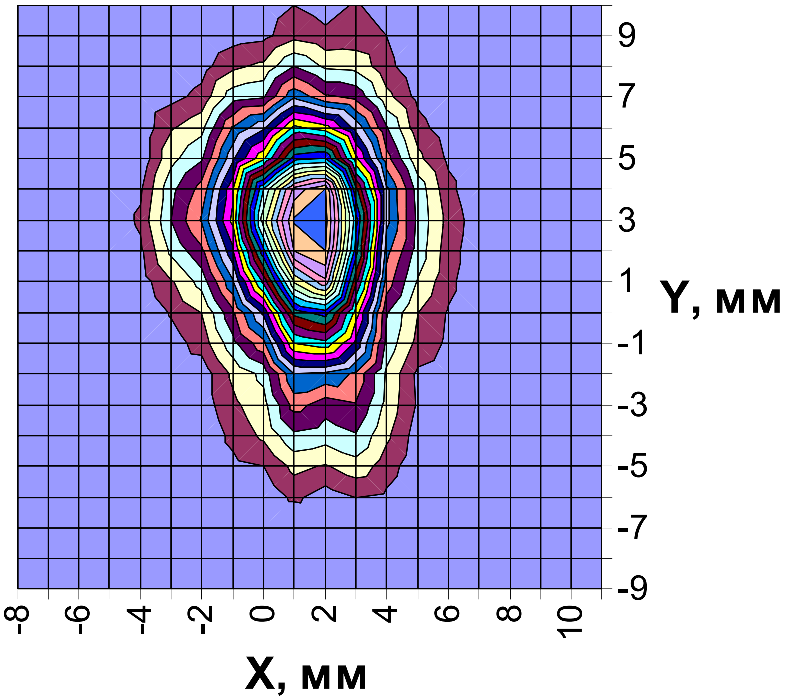


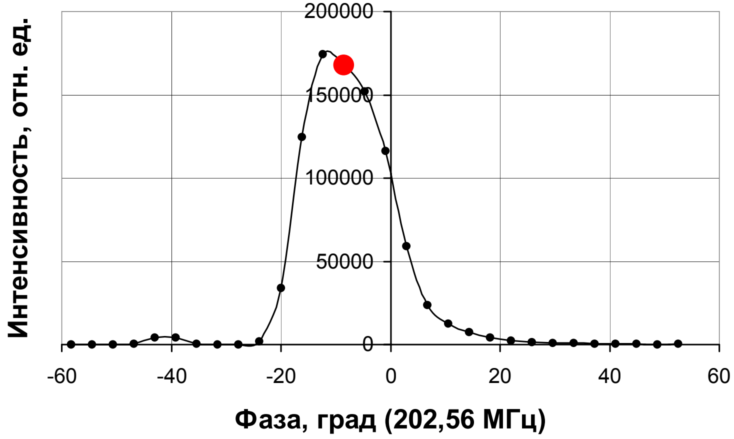


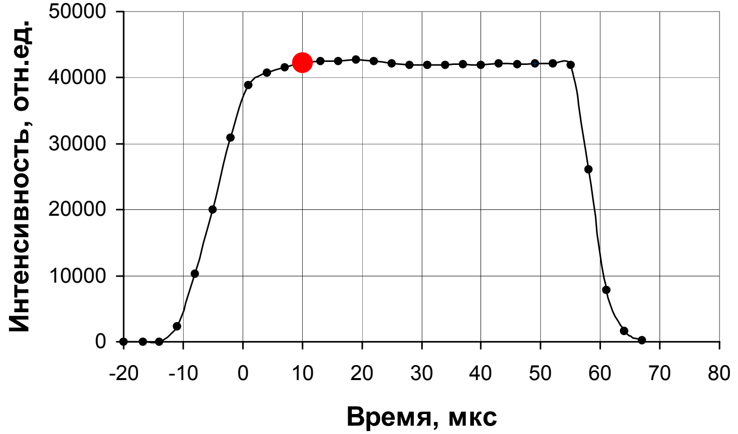


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #2

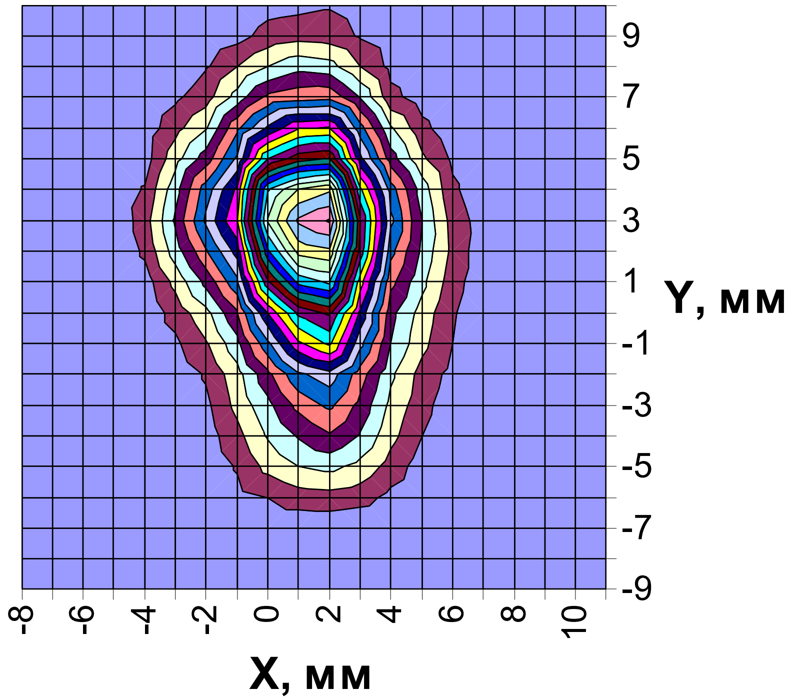


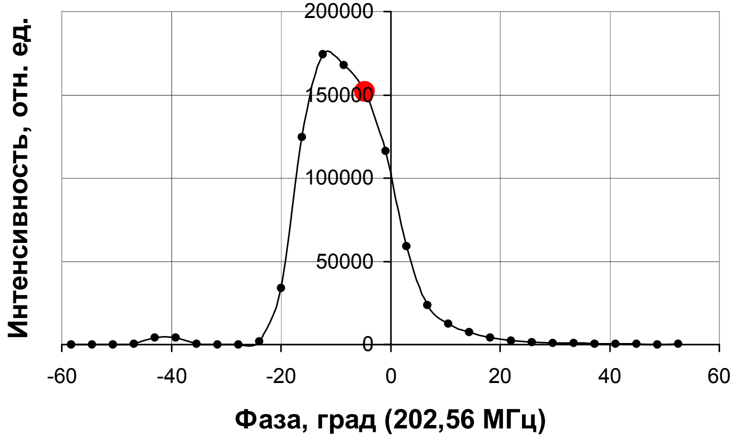


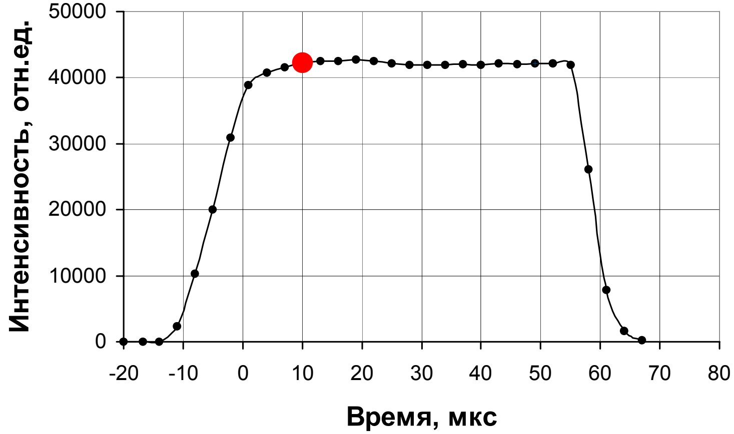


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #2

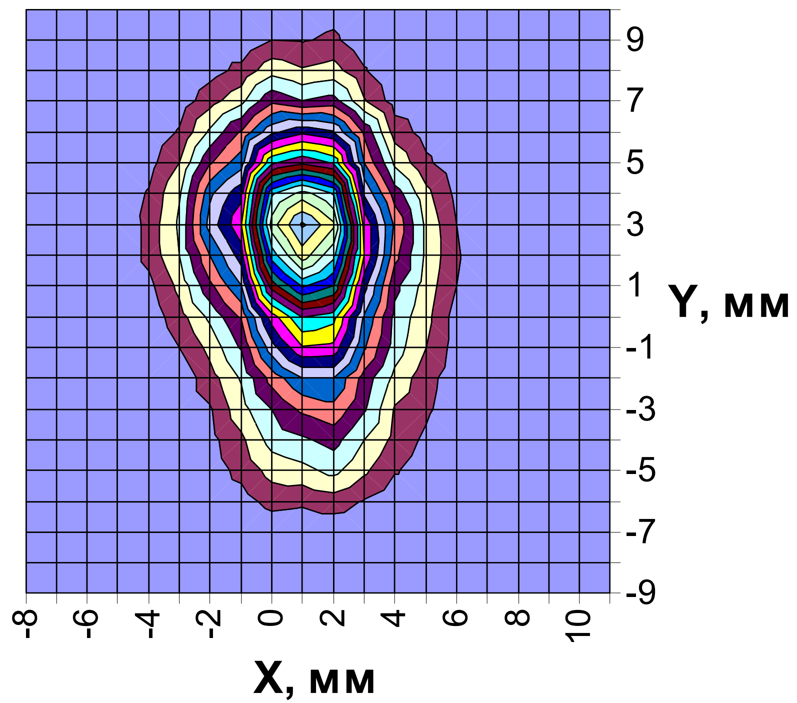


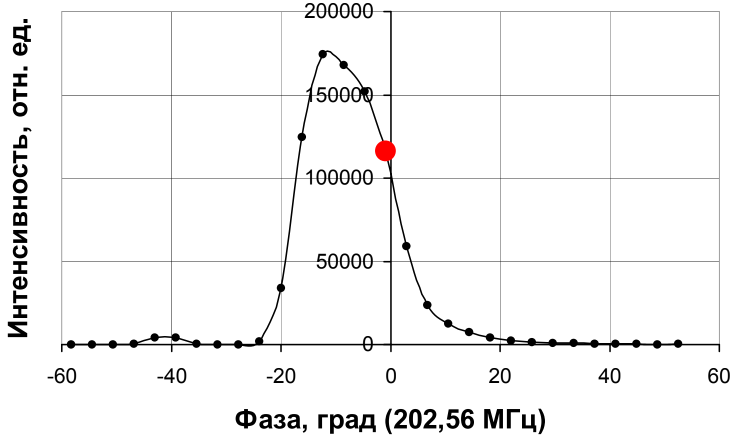


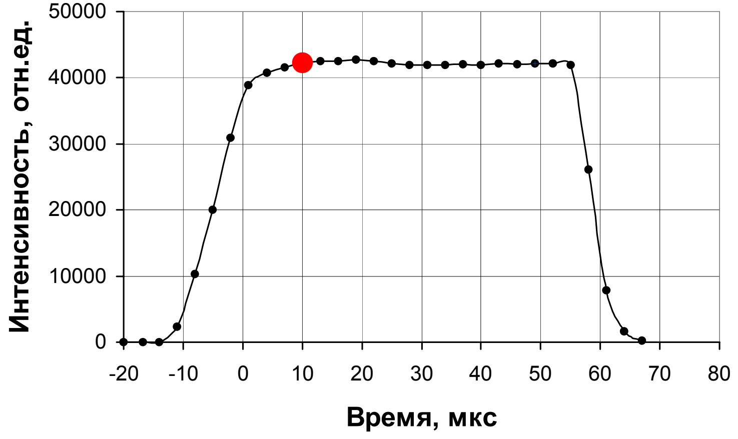


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #2

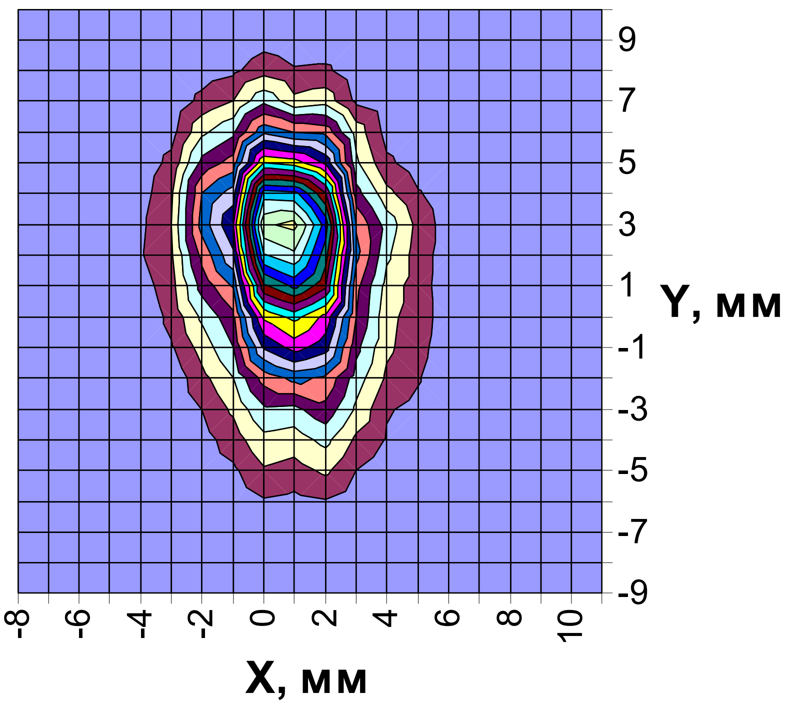


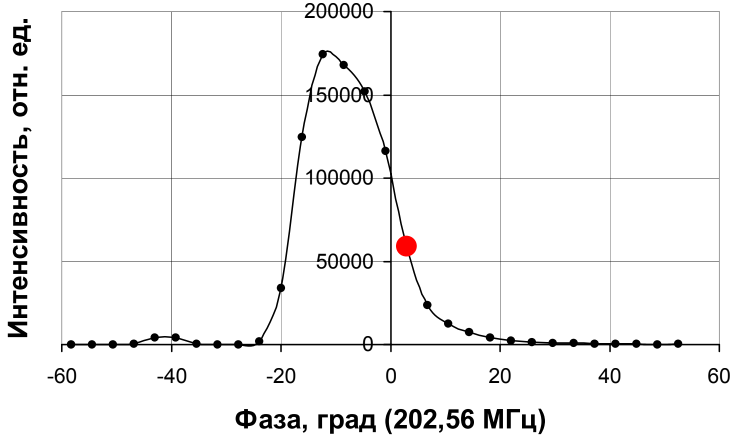


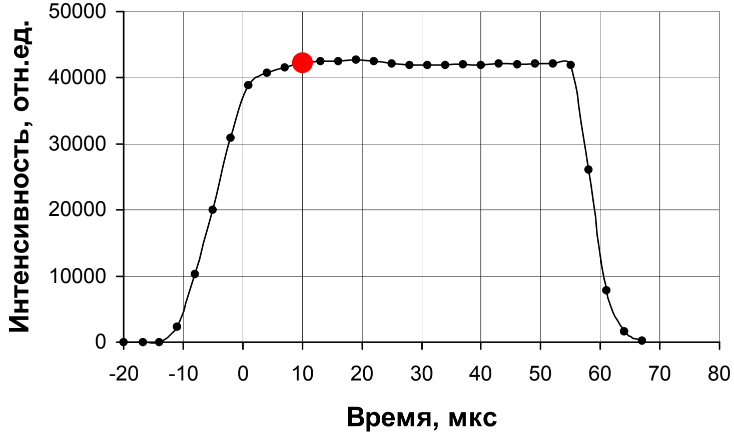


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #2

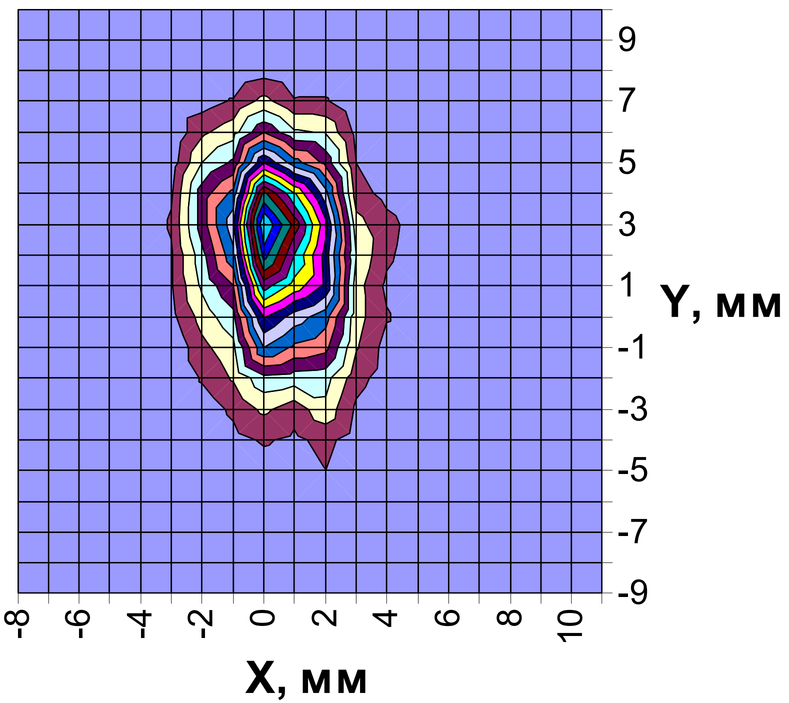


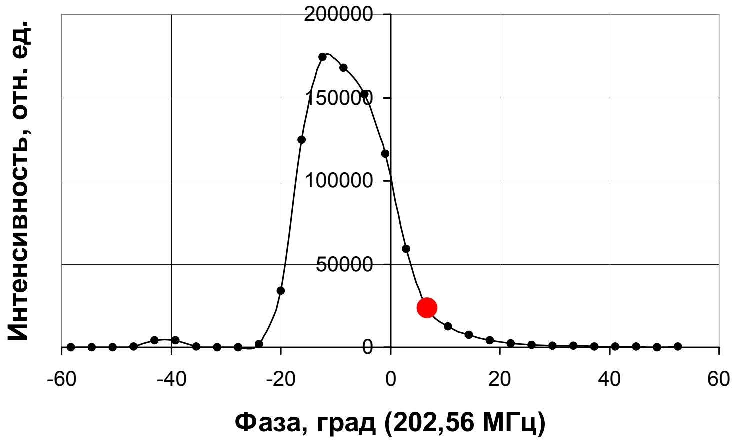


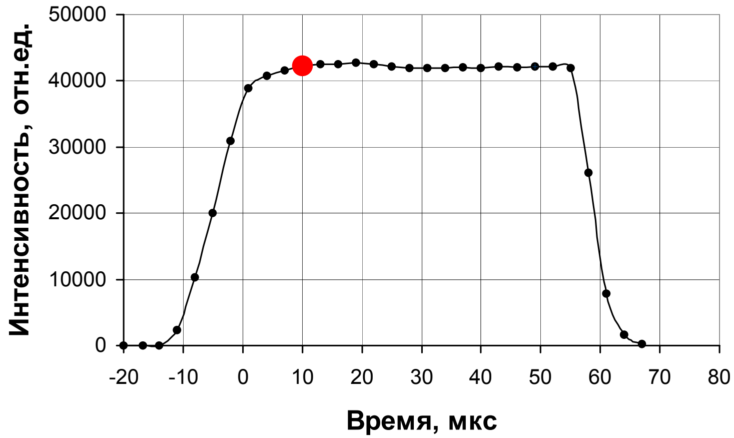


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

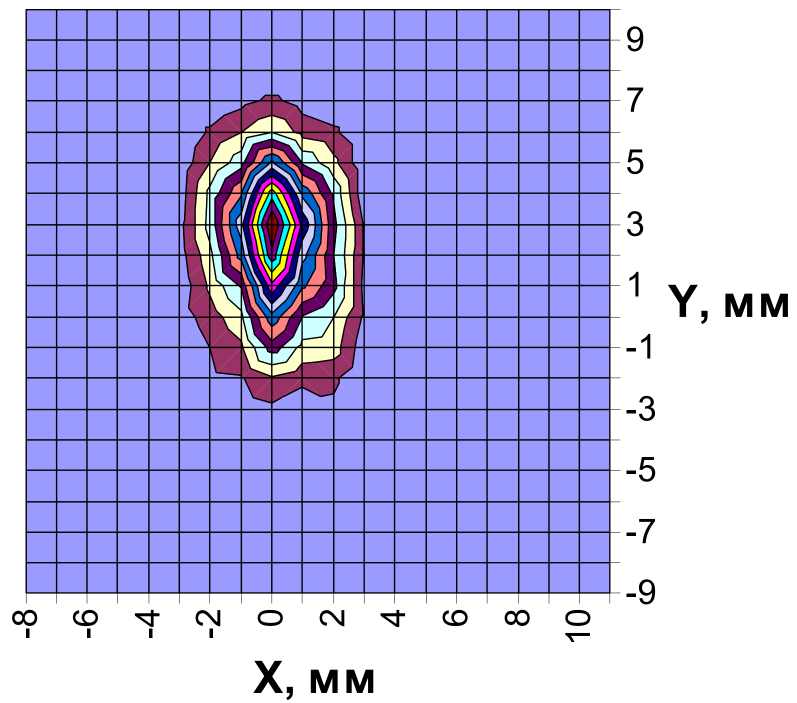
Bunch #2



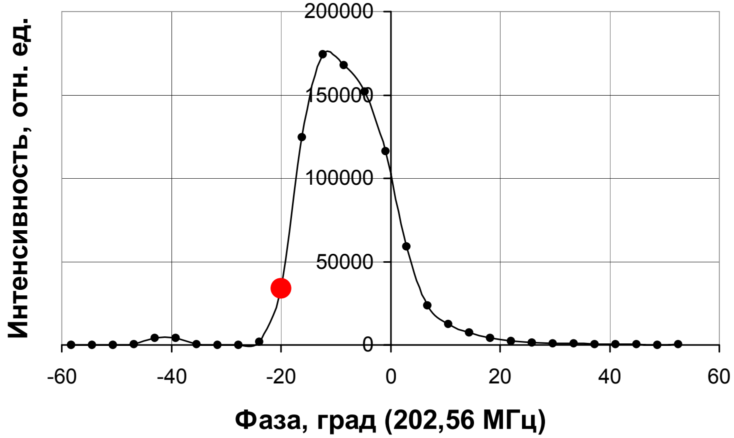


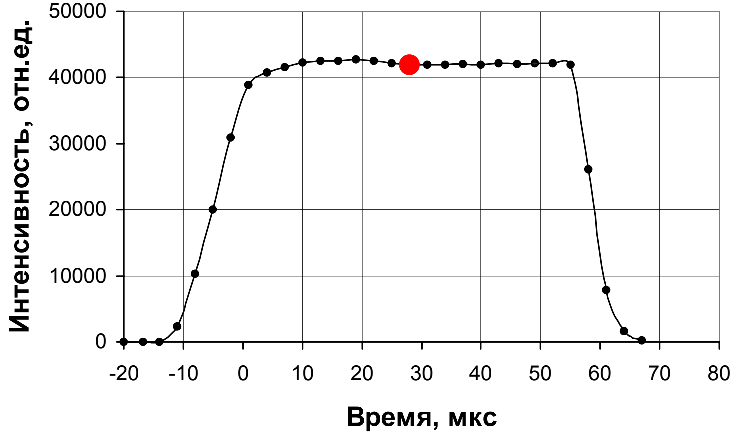


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse



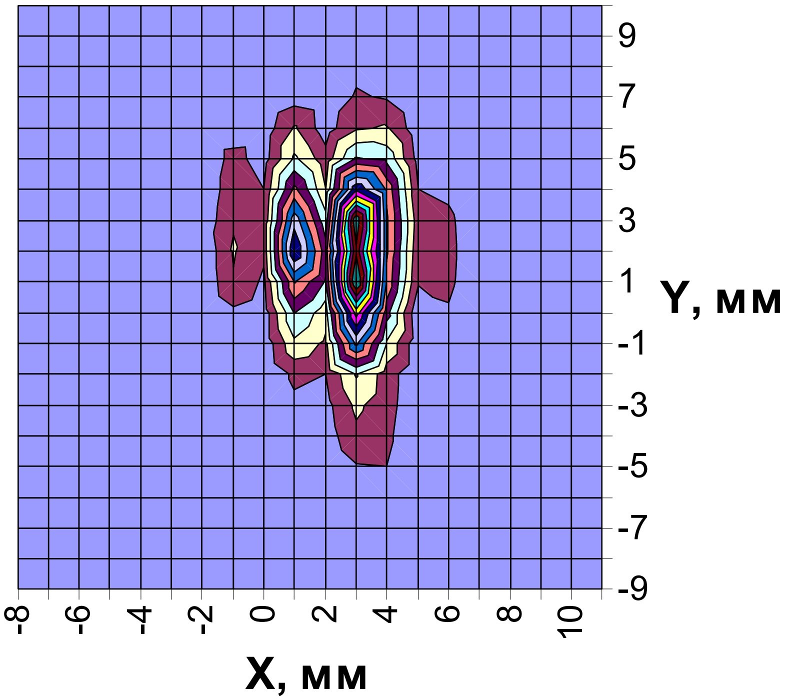
Bunch #2

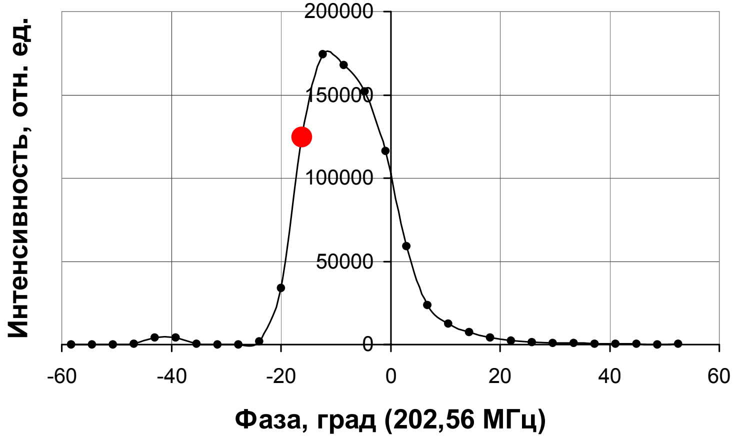


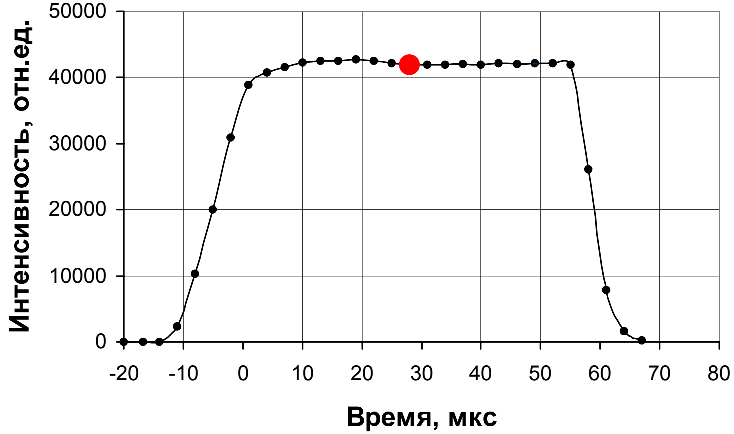


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

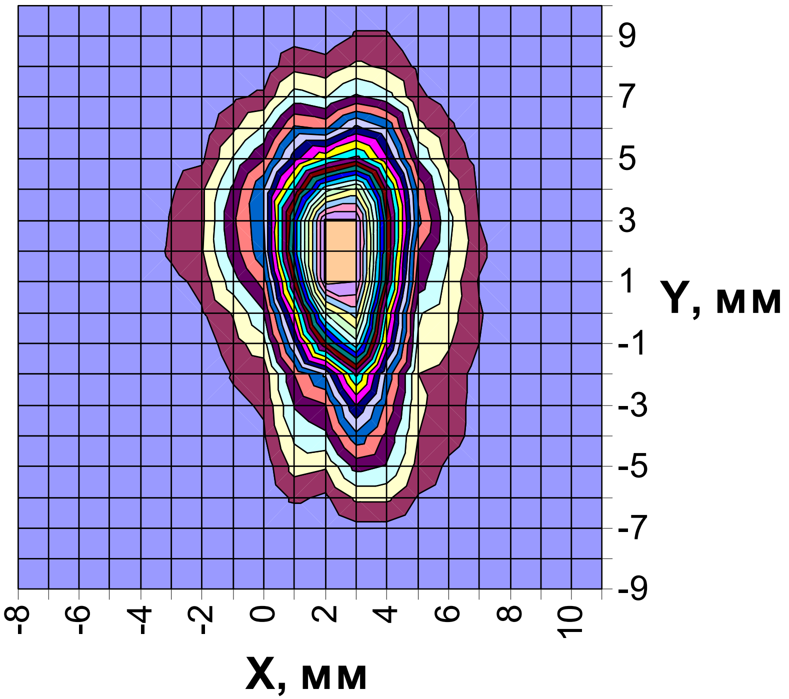
Bunch #3



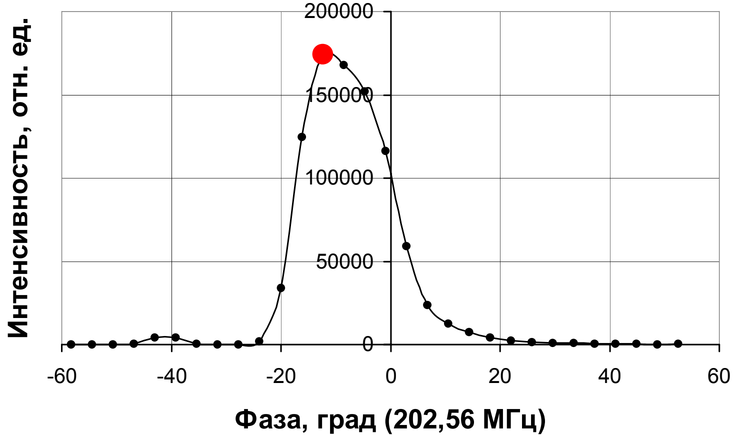


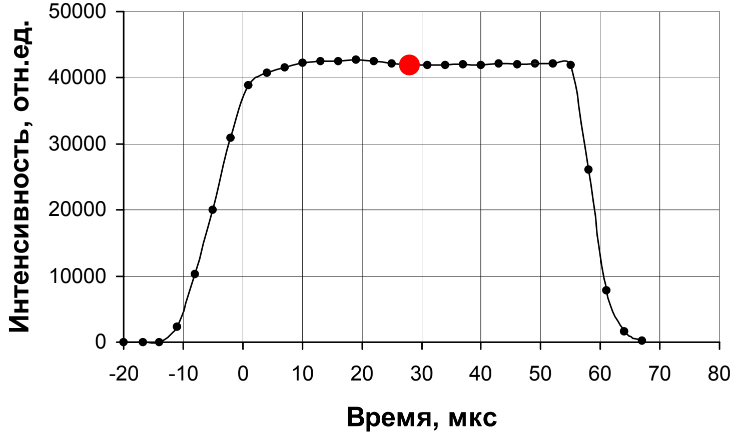


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse



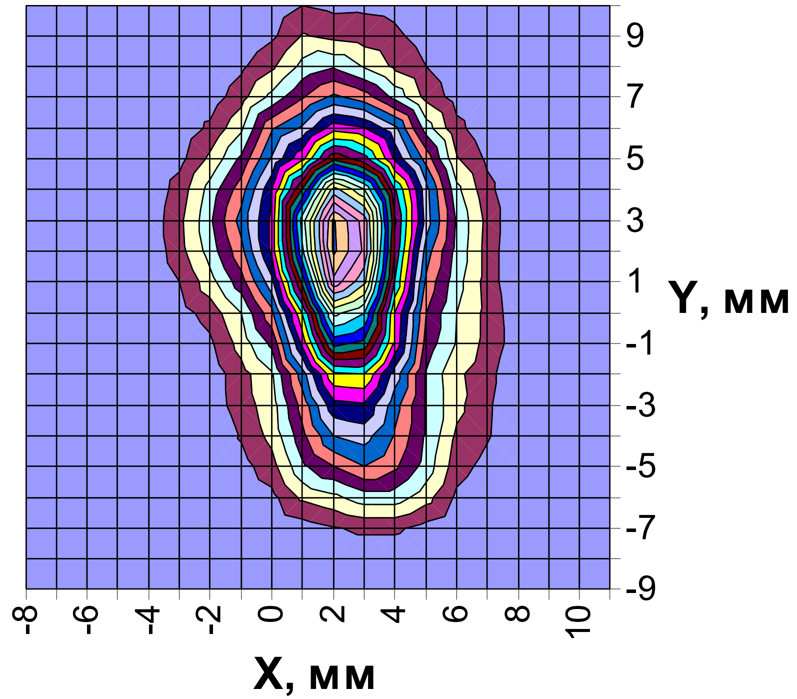
Bunch #3

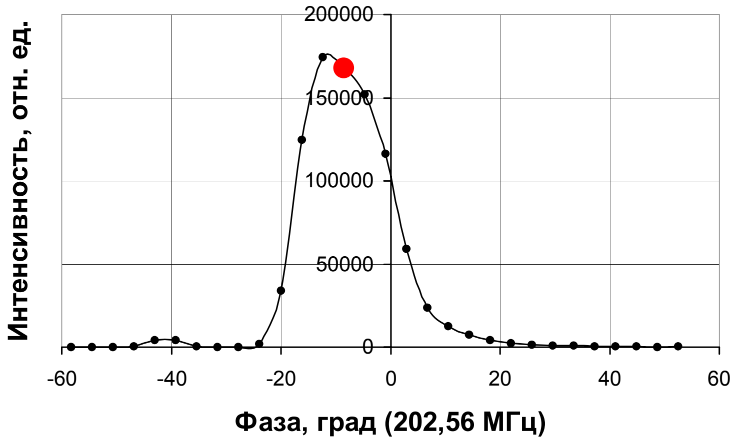


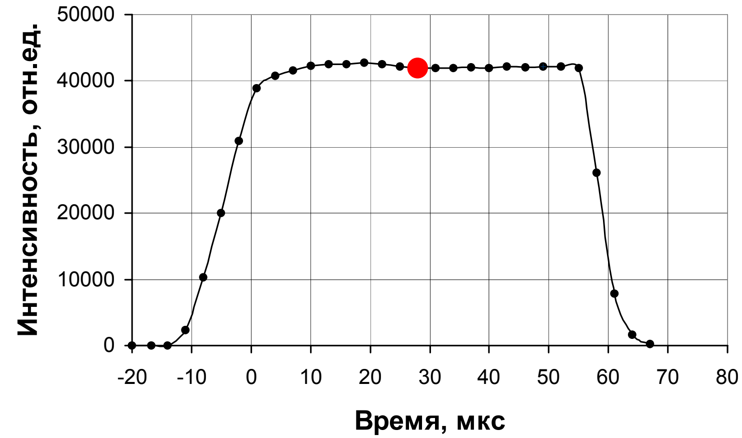


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #3

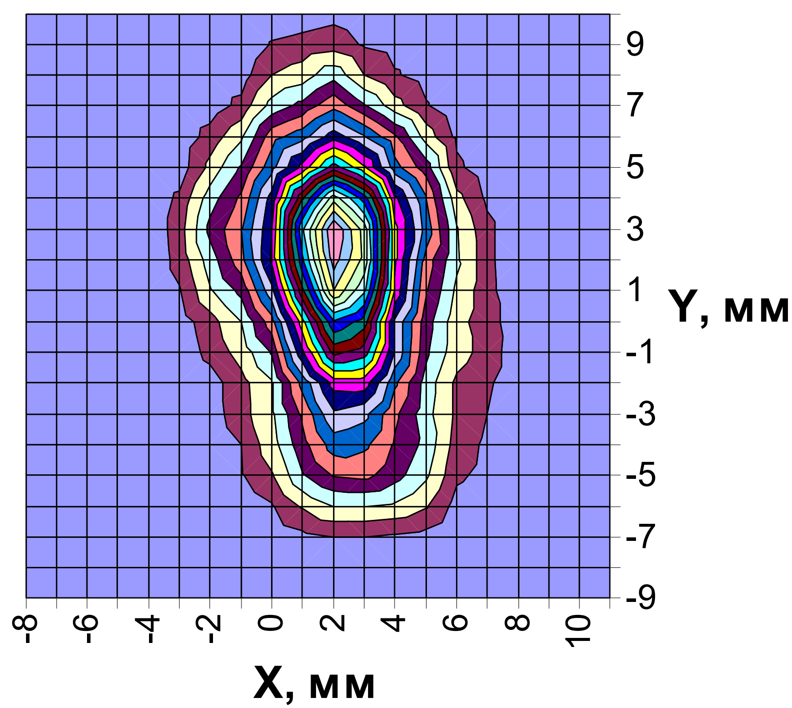


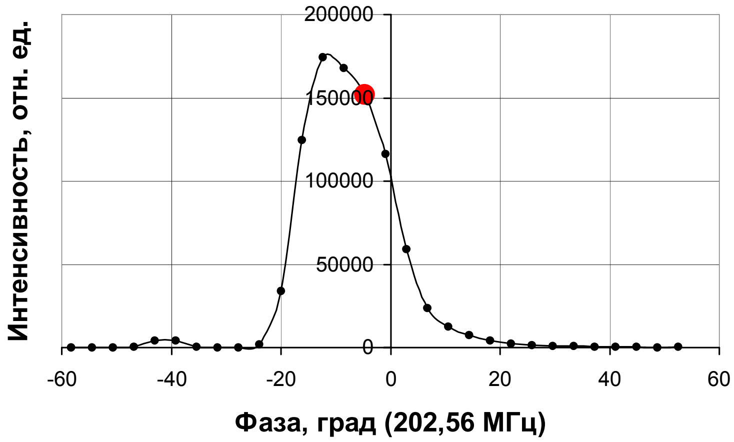


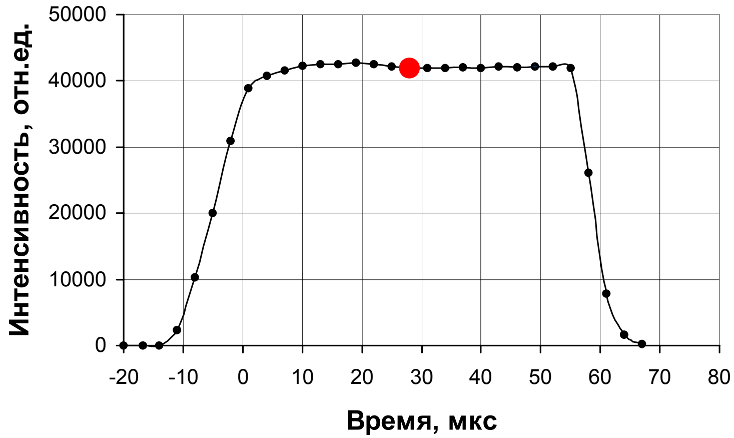


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #3

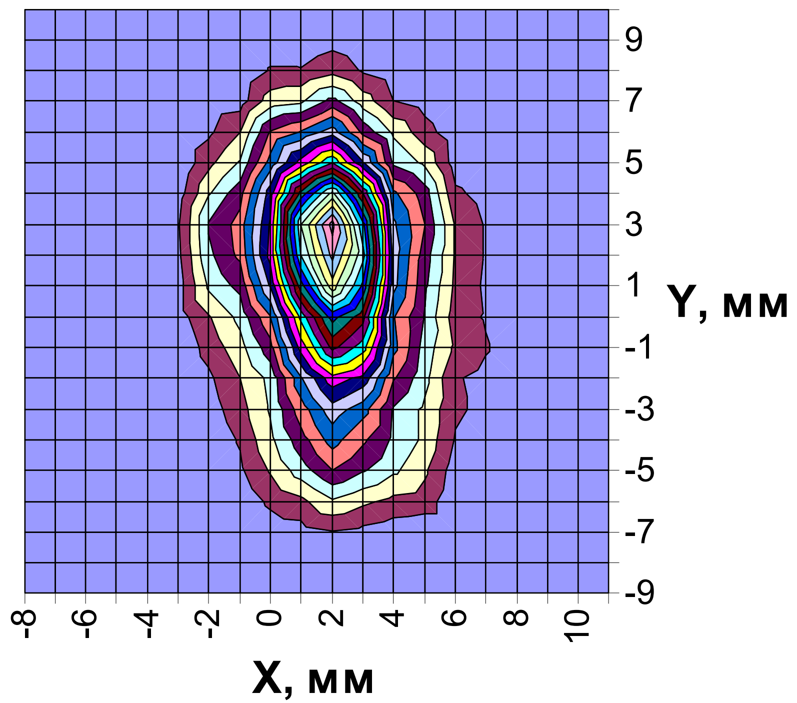


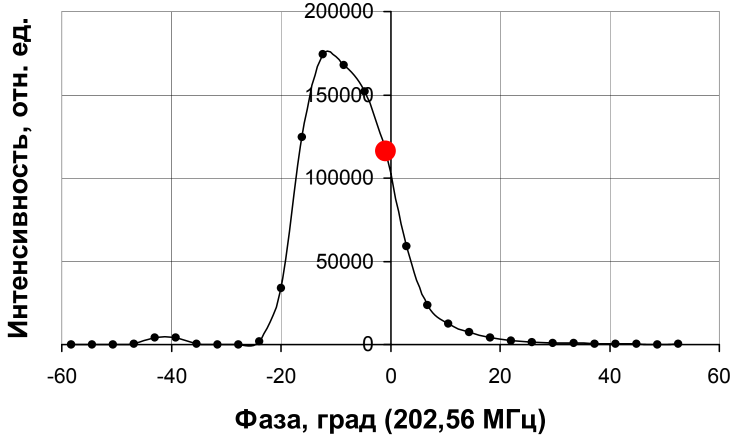


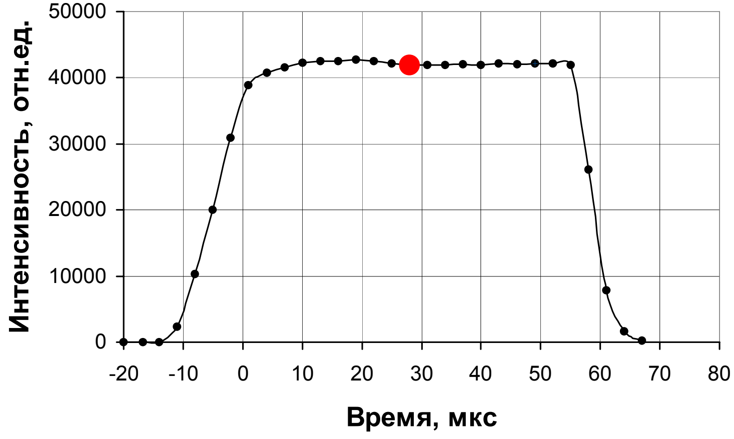


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #3

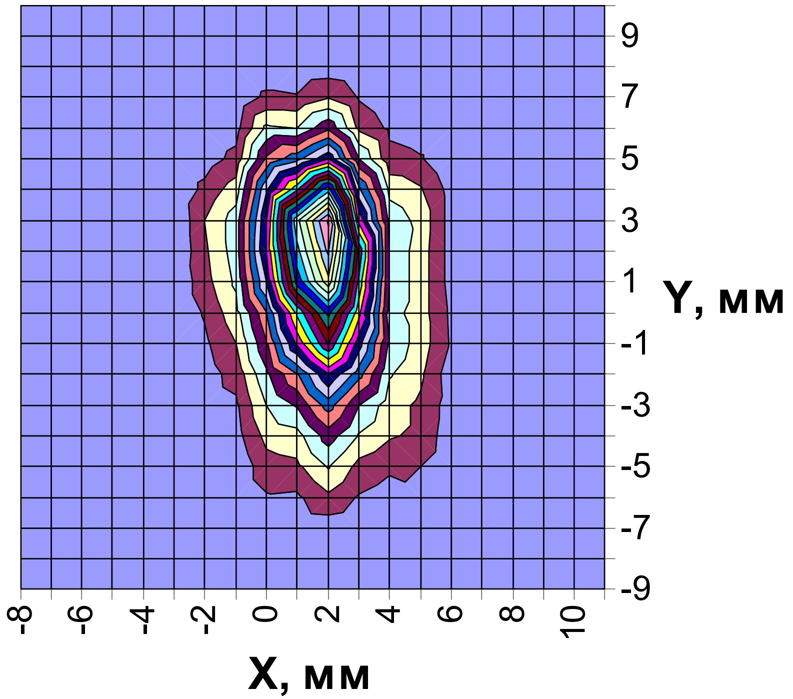


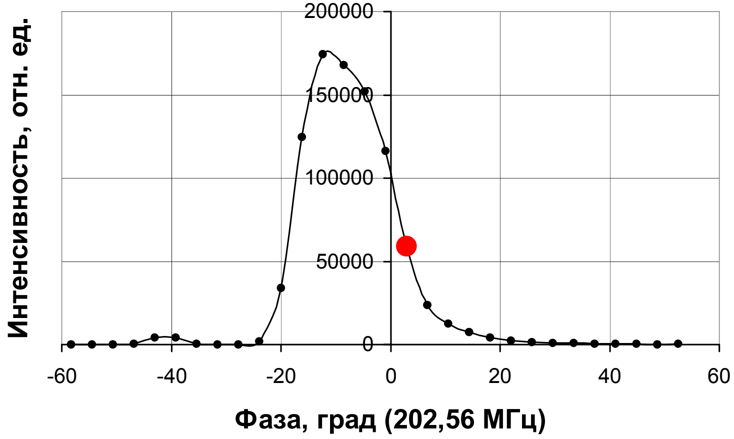


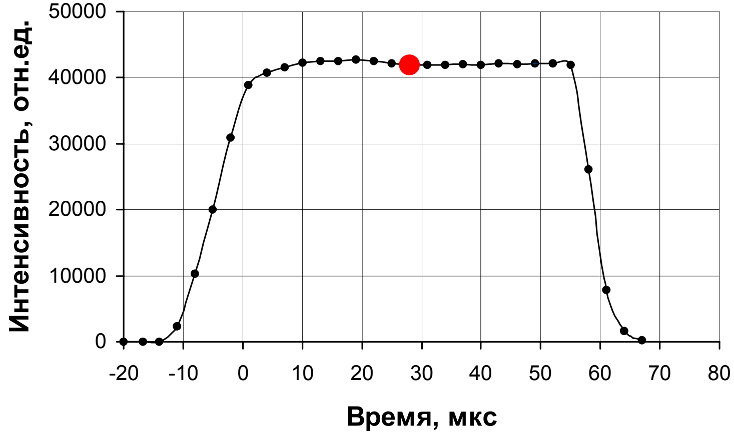


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

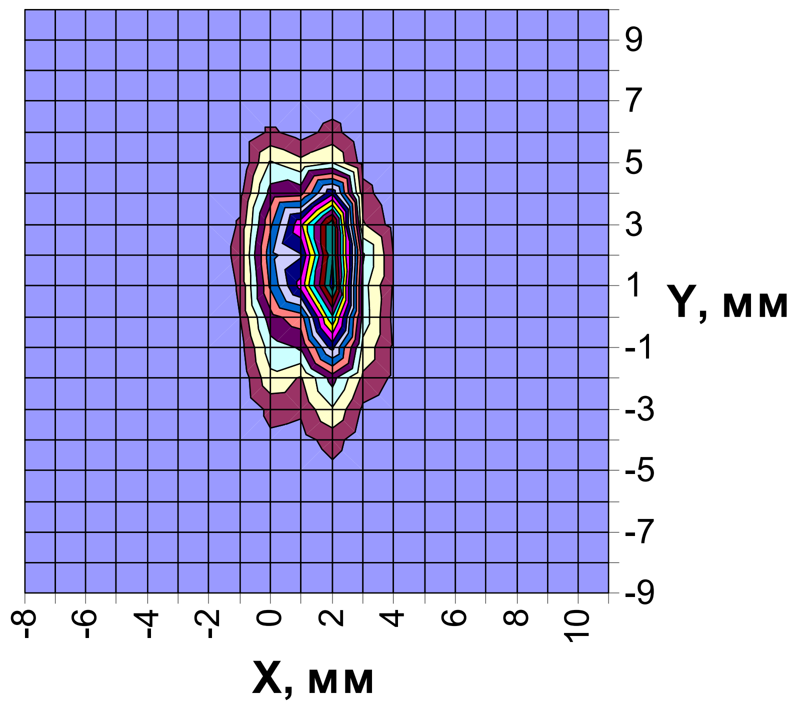
Bunch #3



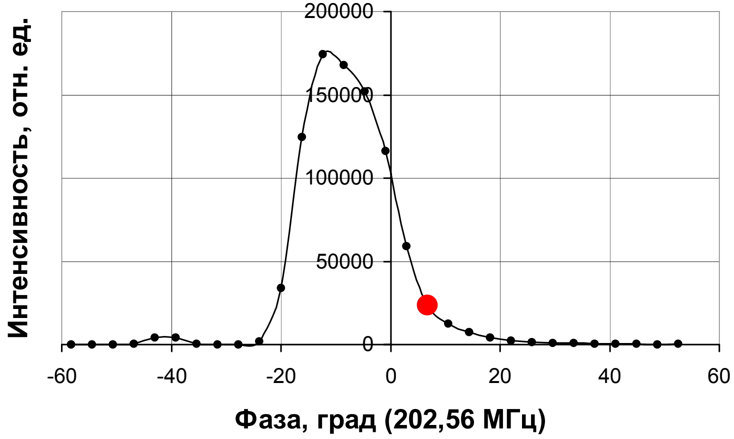


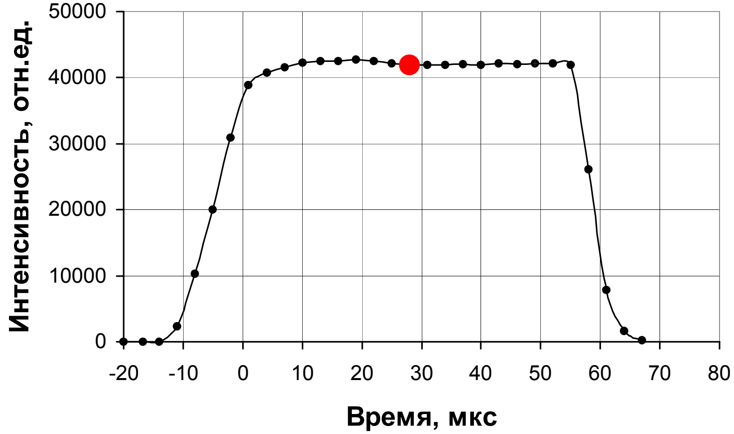


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse



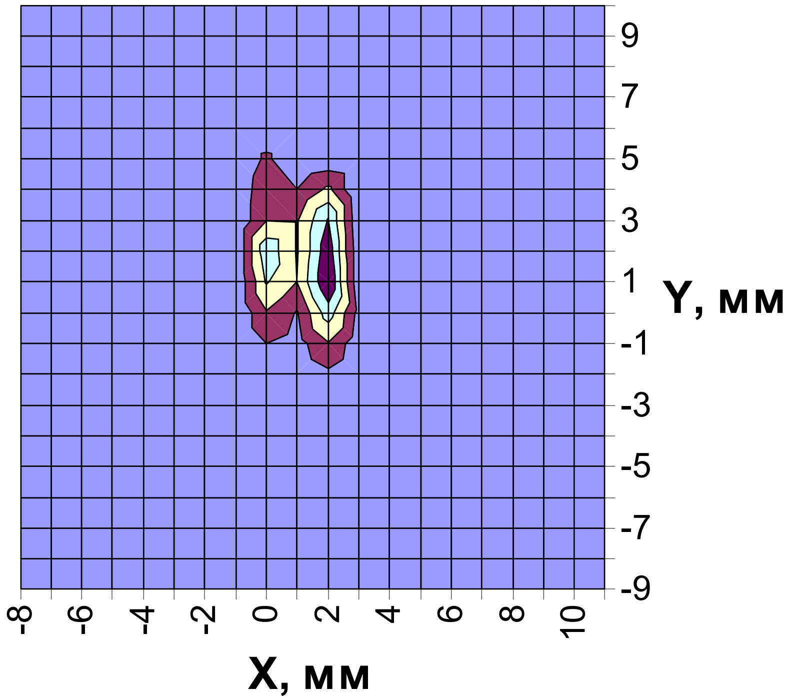
Bunch #3

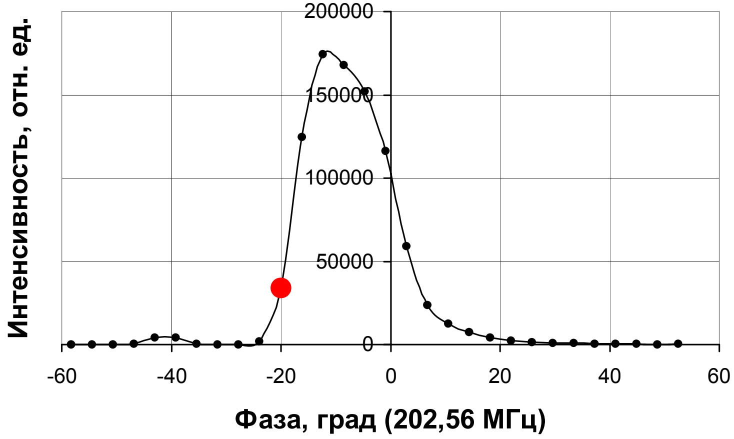


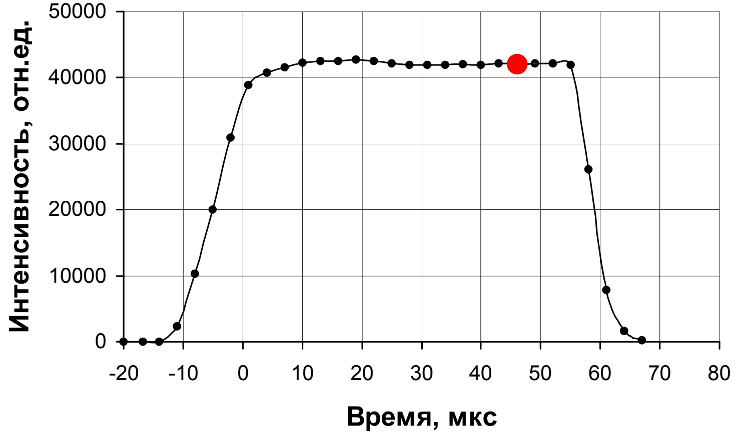


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #3

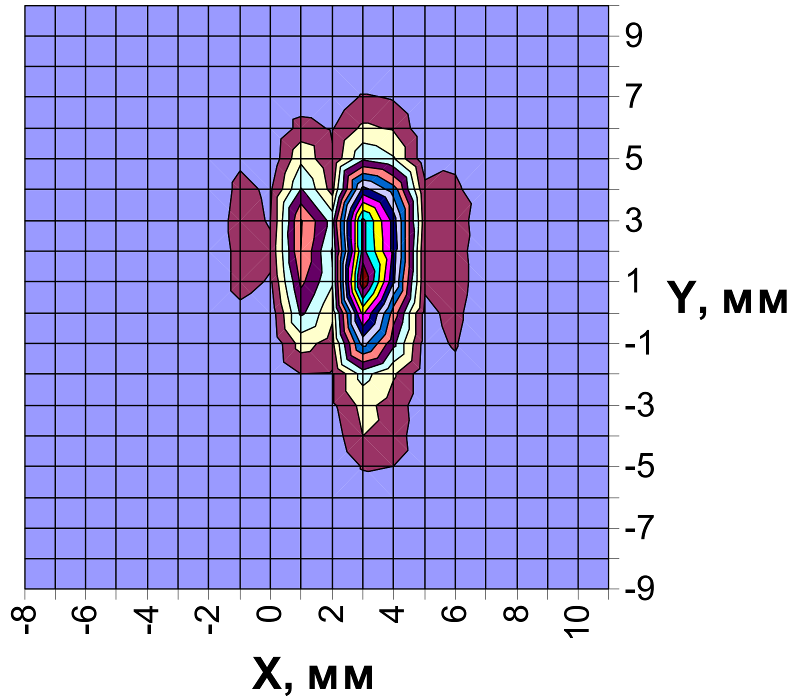


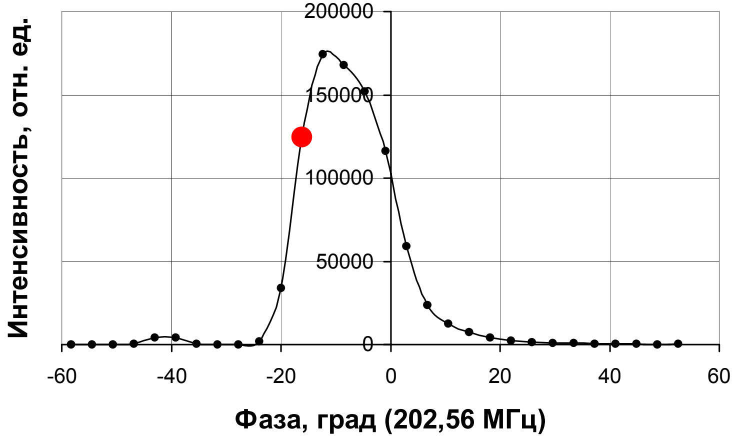


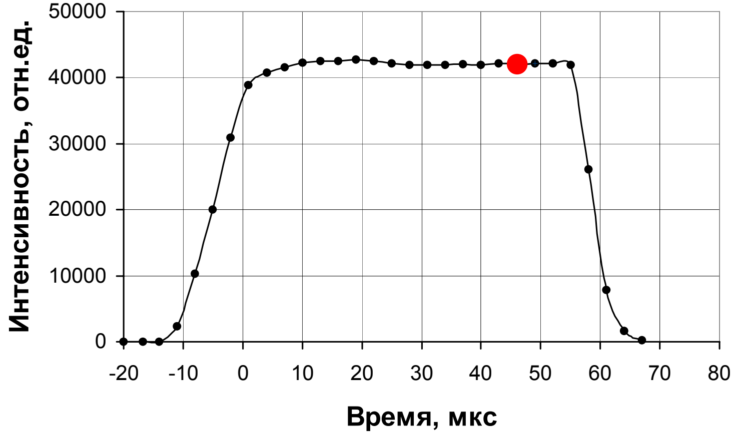


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #4

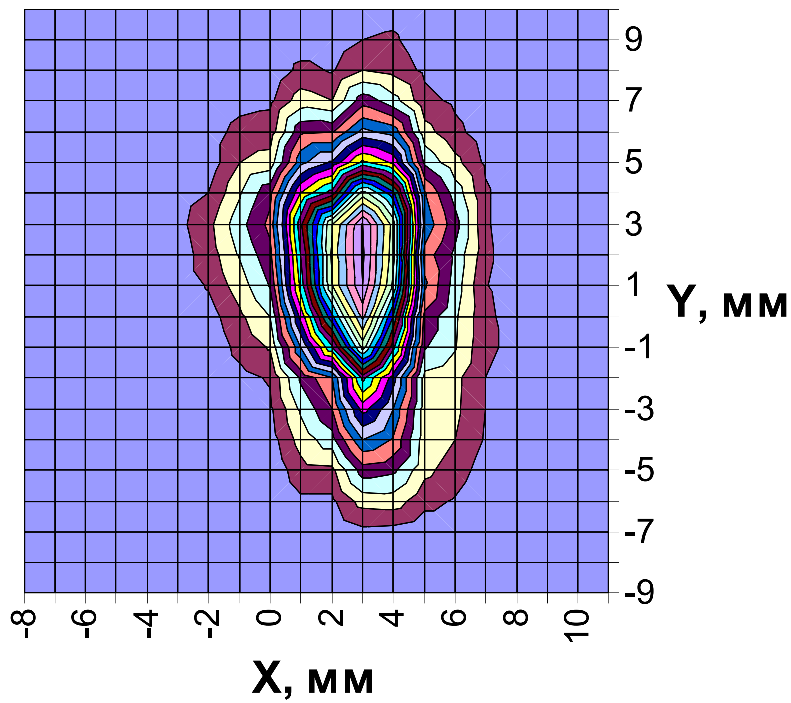


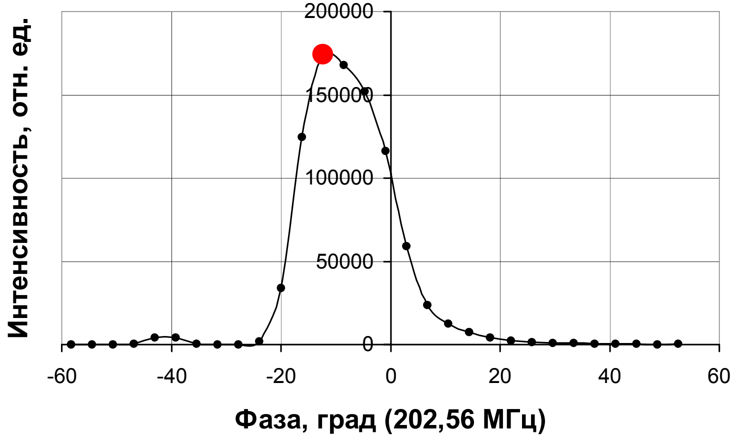


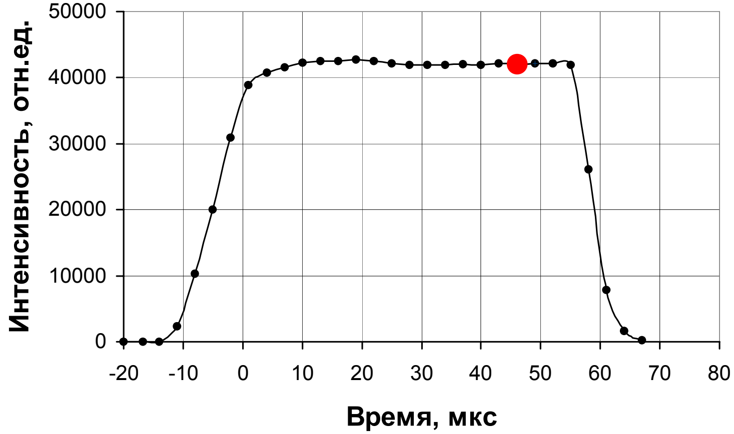


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #4

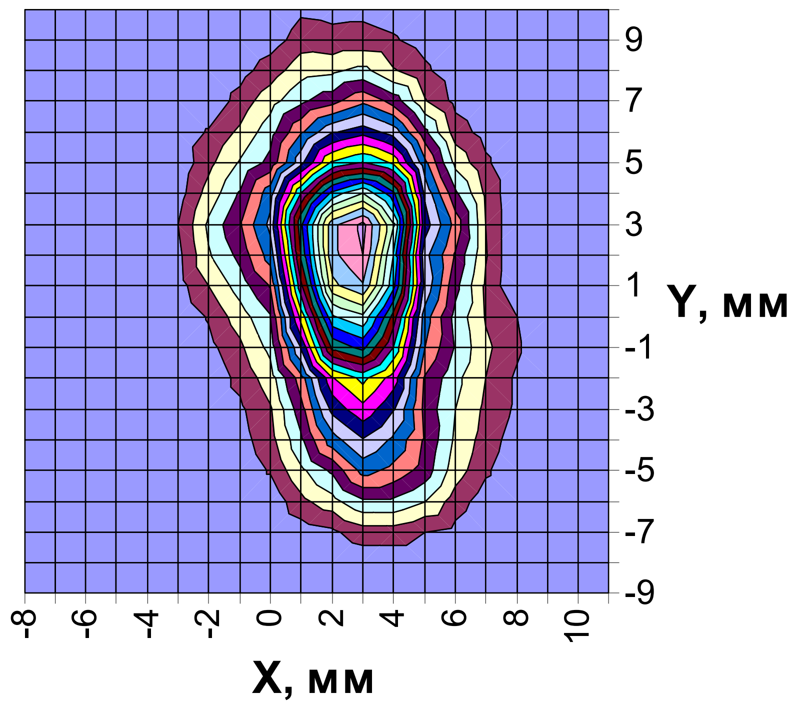


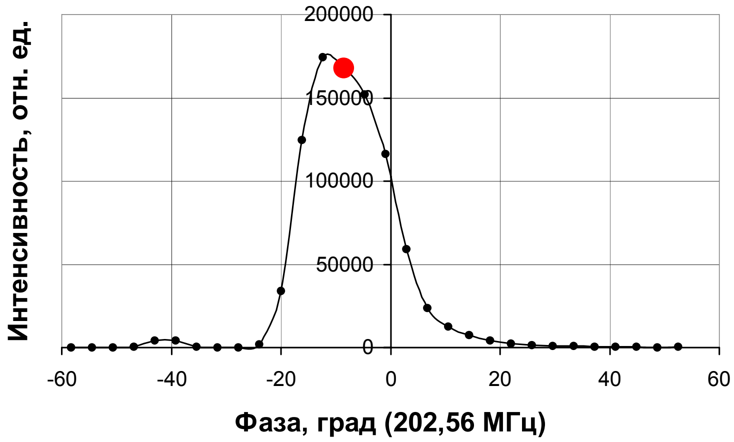


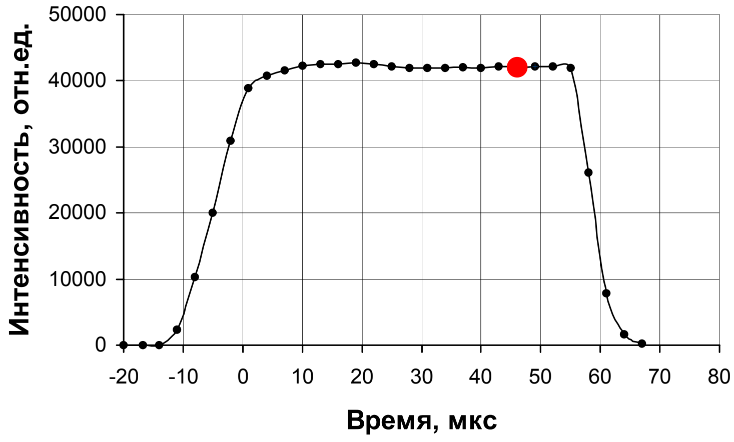


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #4

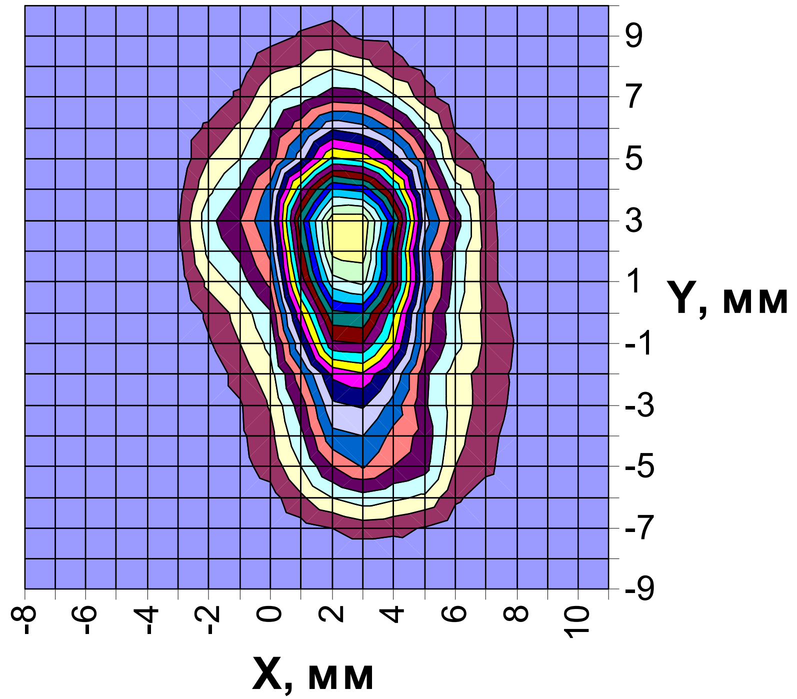


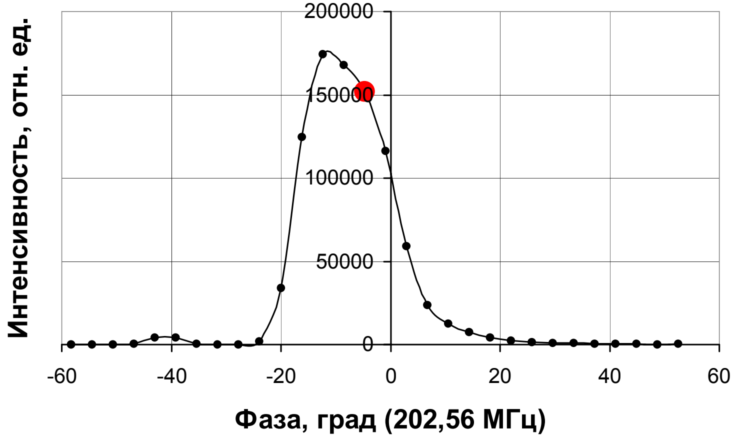


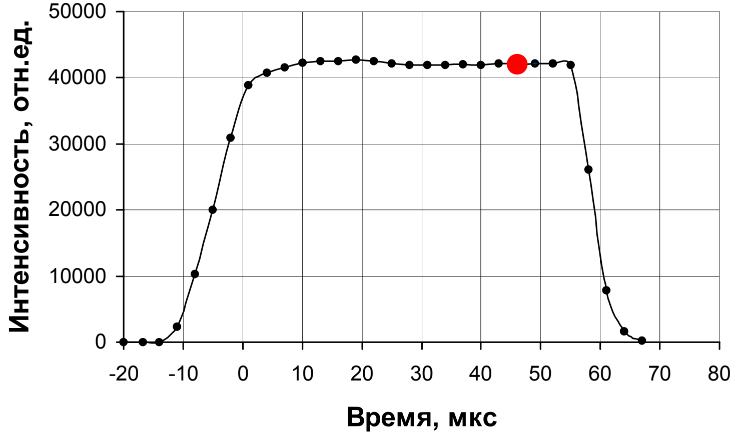


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #4

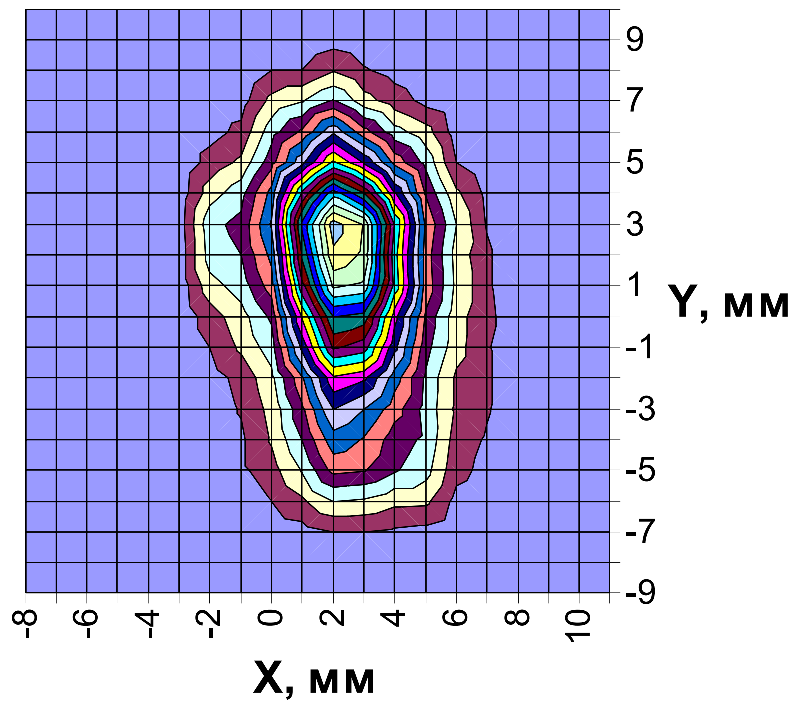


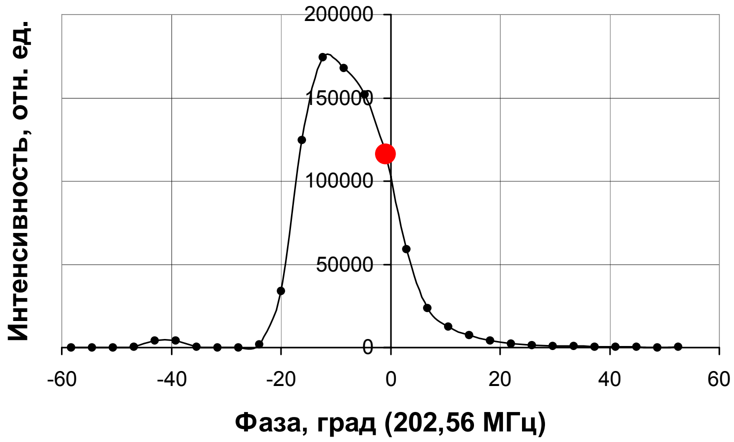


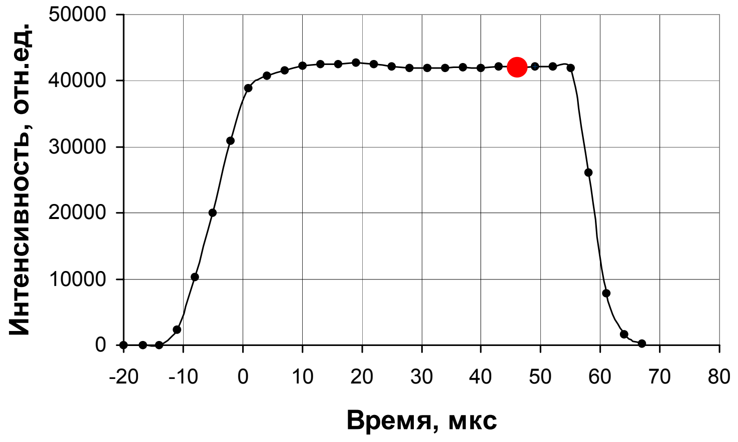


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #4

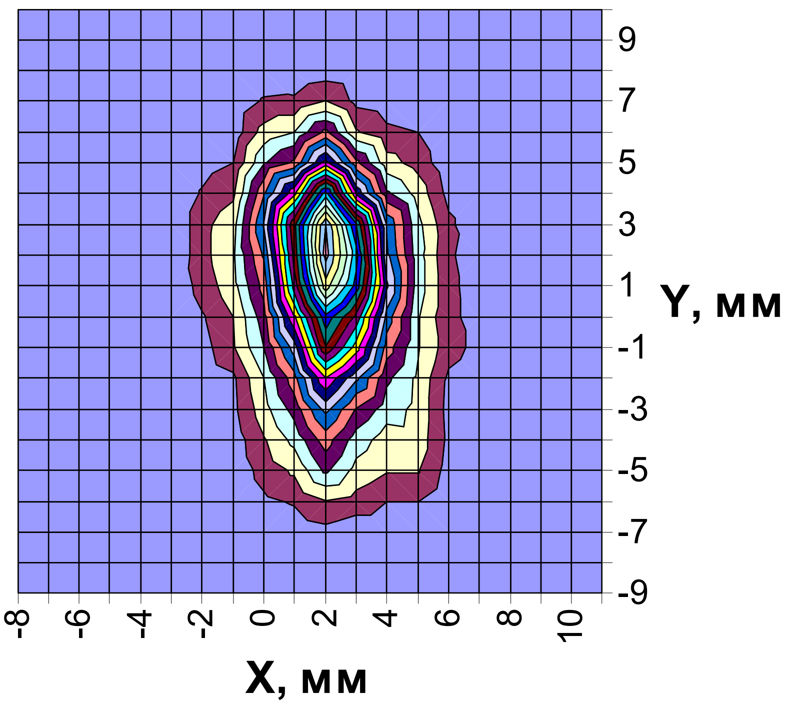


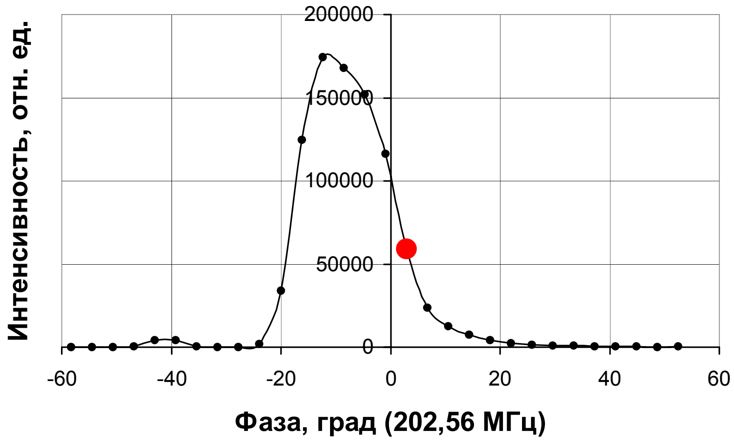


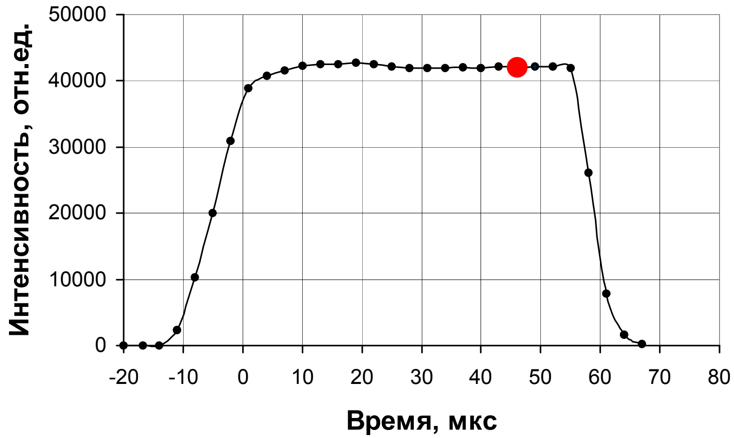


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #4

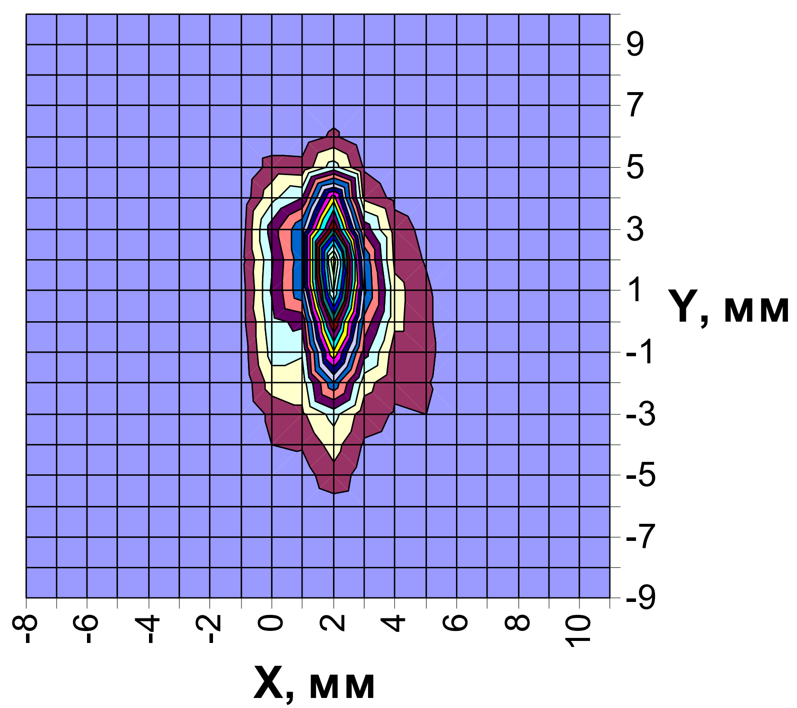


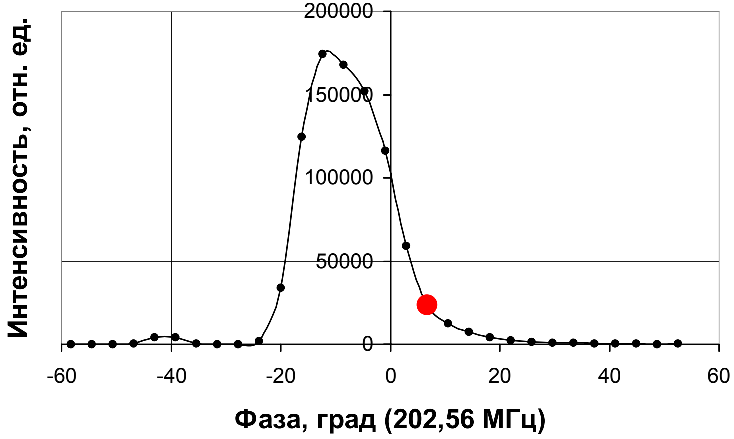


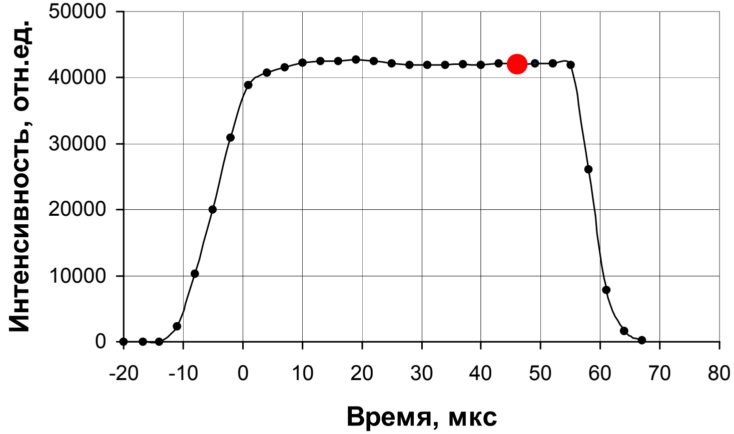


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

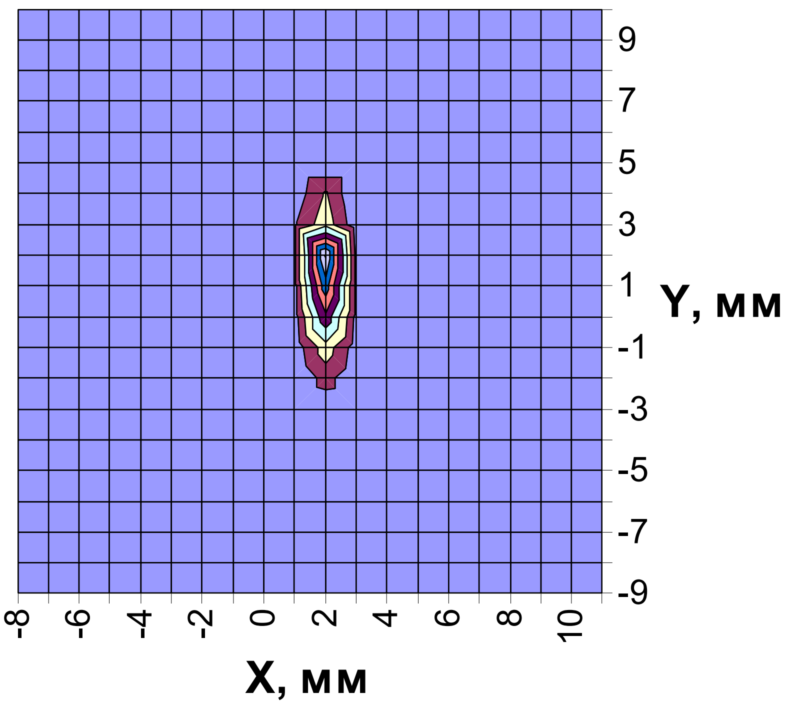
Bunch #4



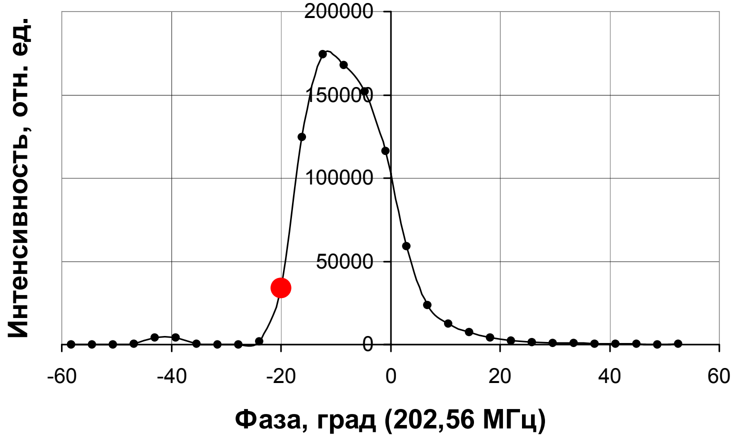


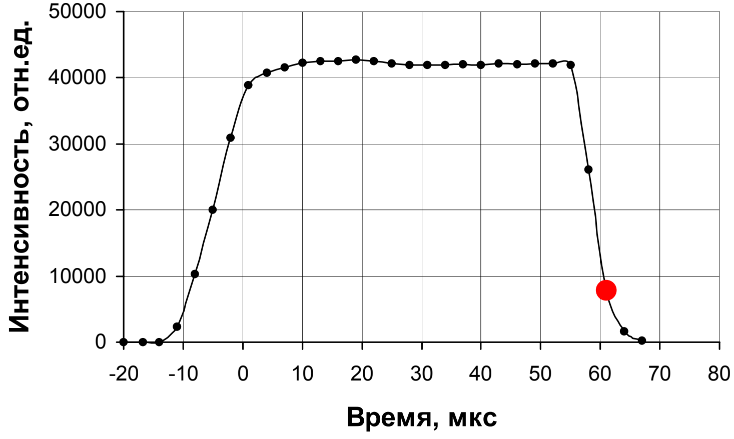


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse



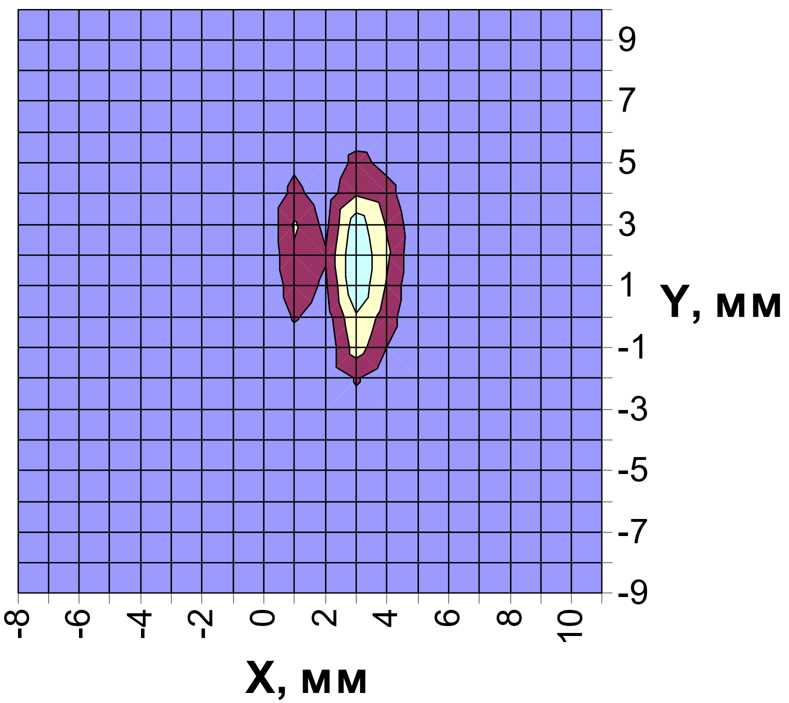
Bunch #4

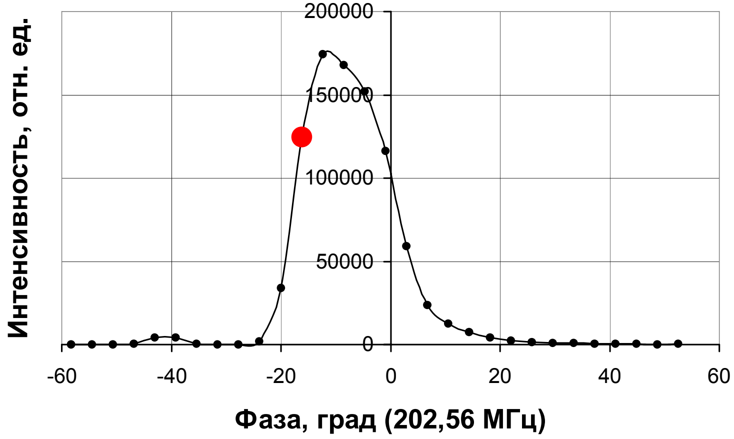


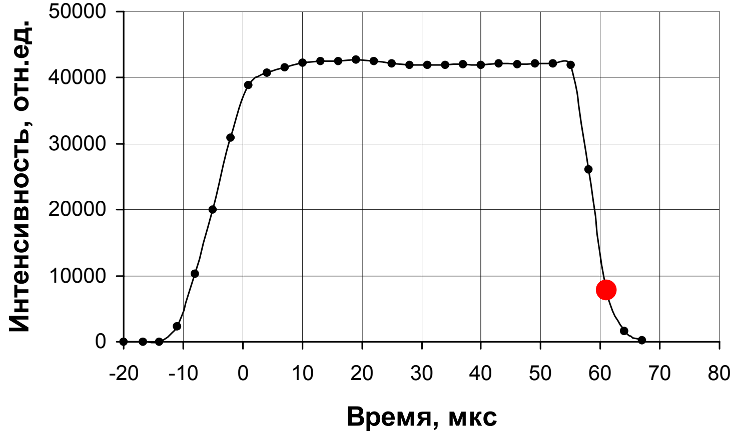


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #5

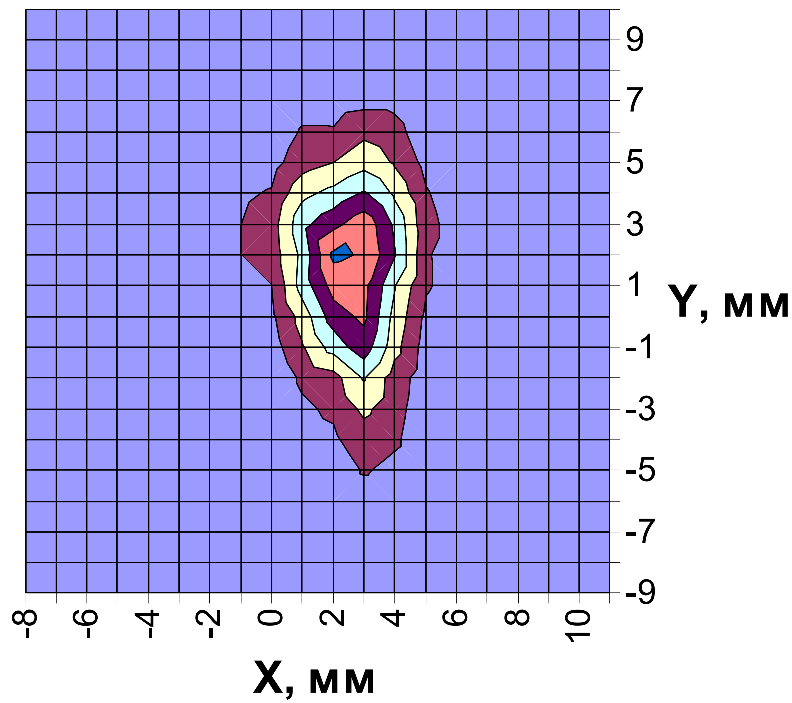


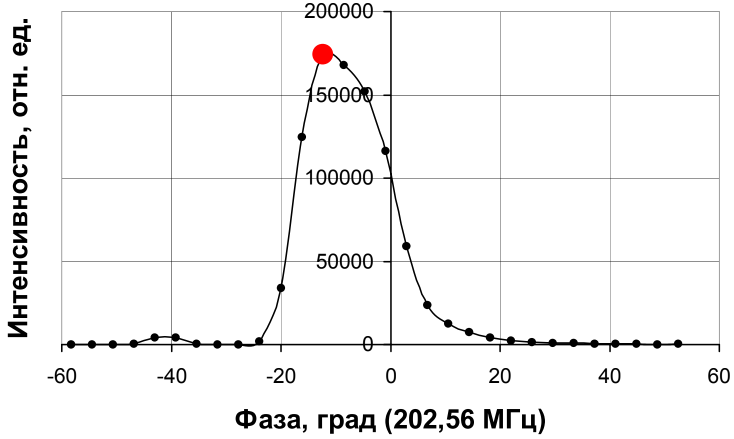


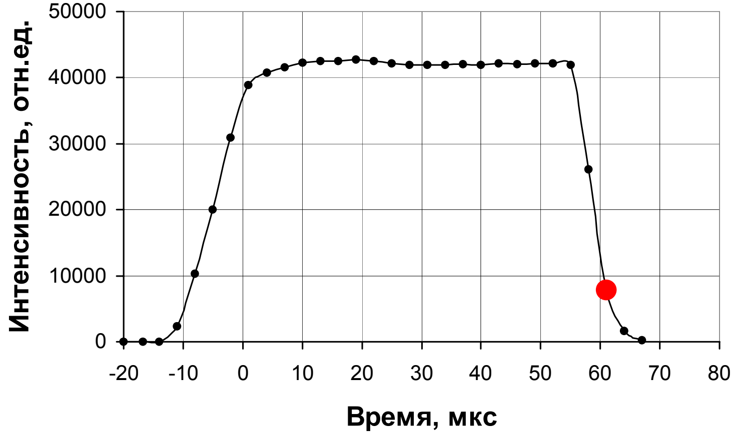


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

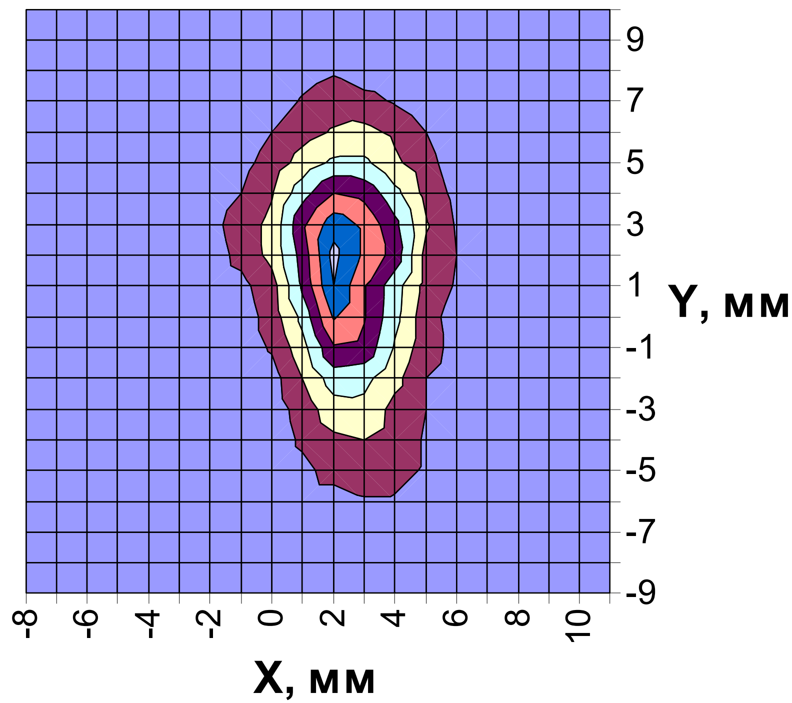
Bunch #5



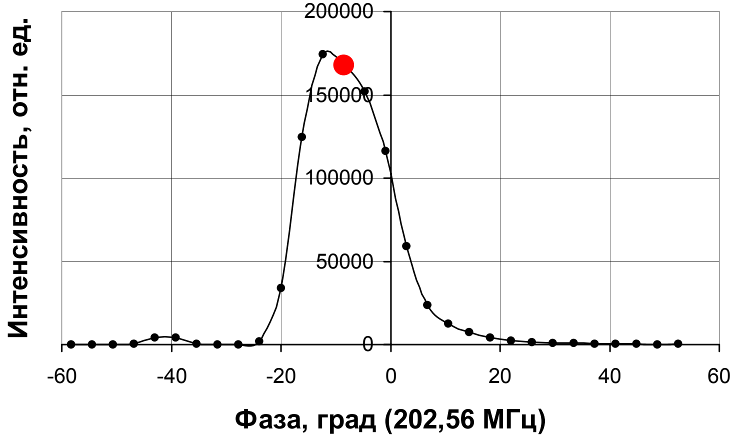


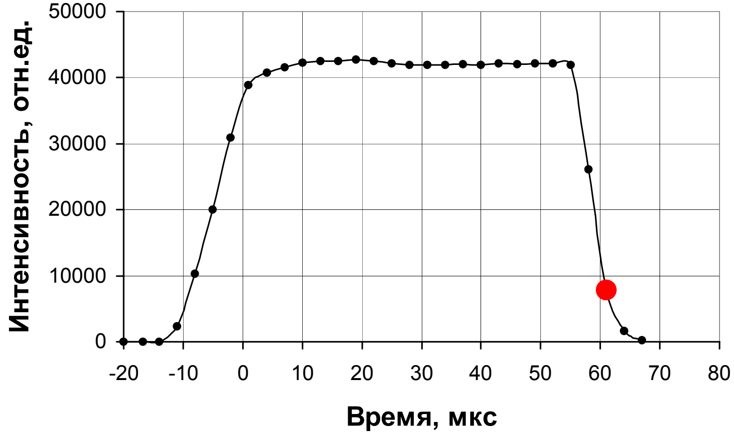


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse



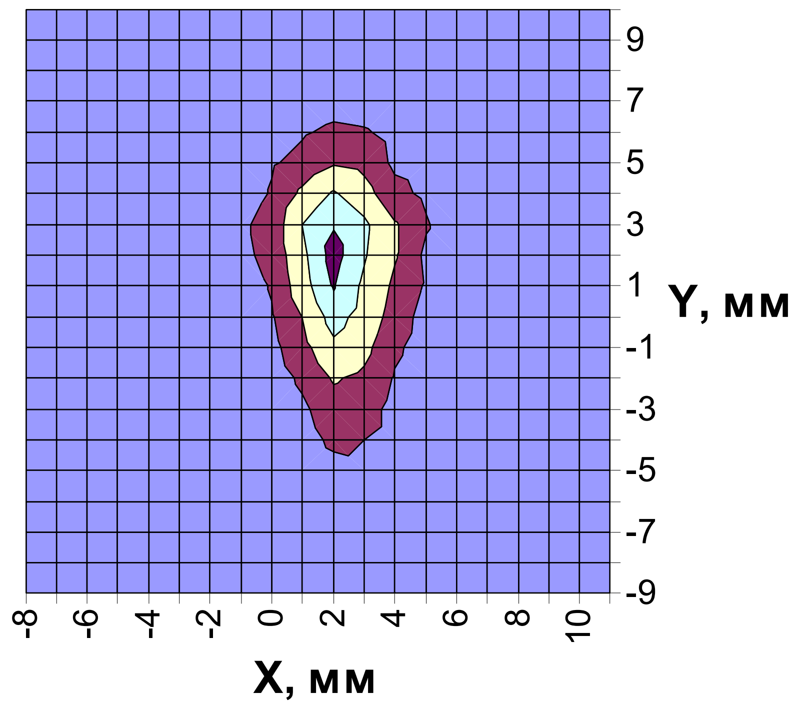
Bunch #5

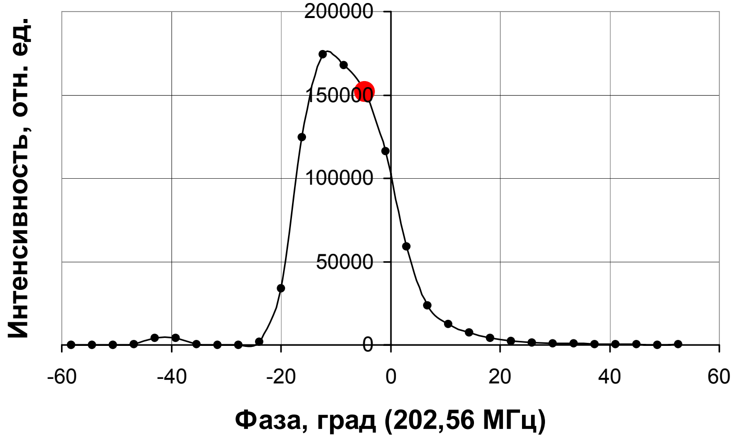


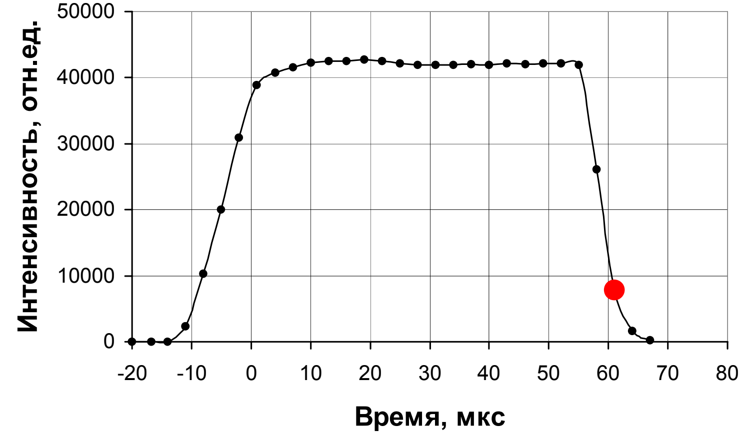


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #5

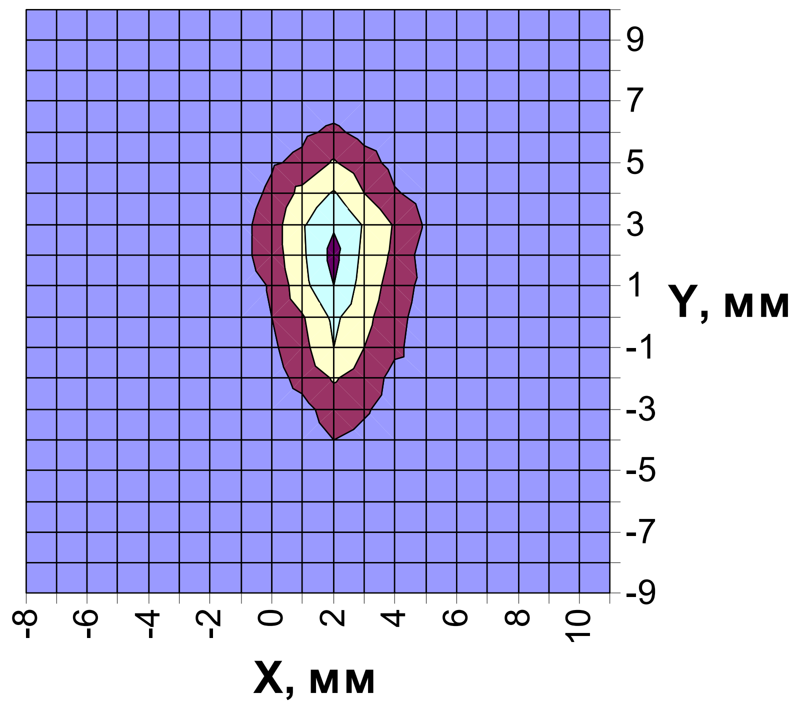


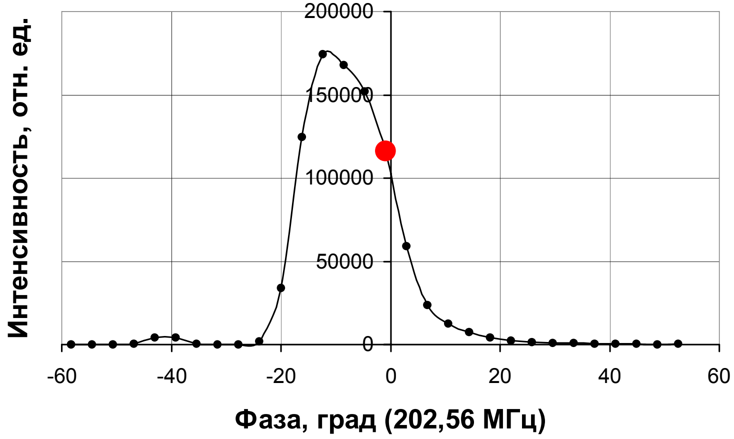


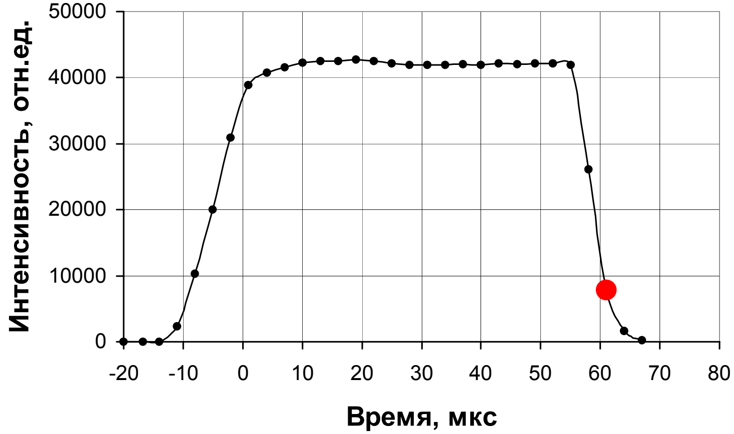


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #5

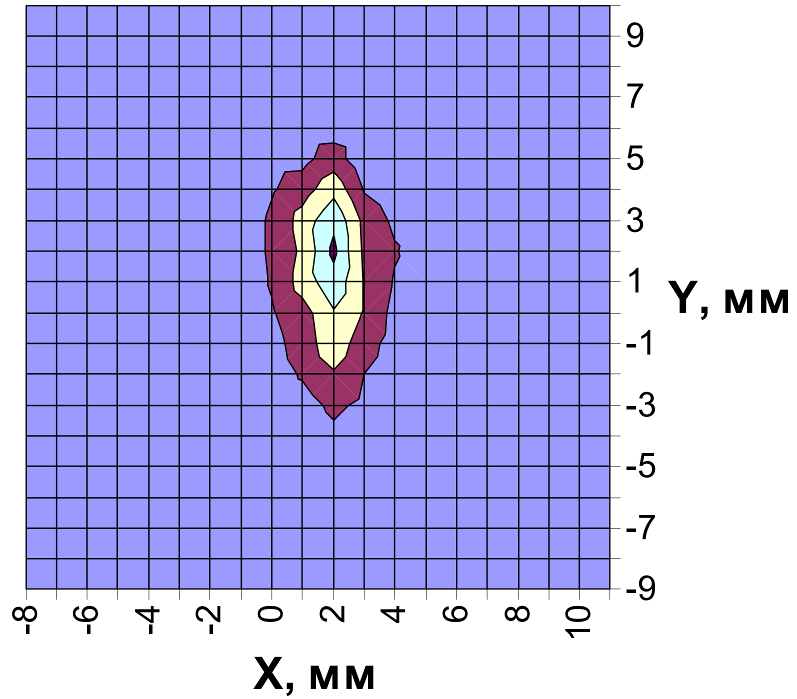


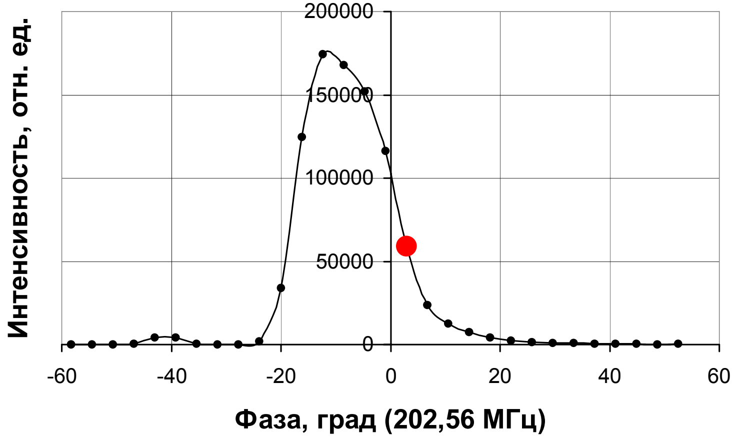


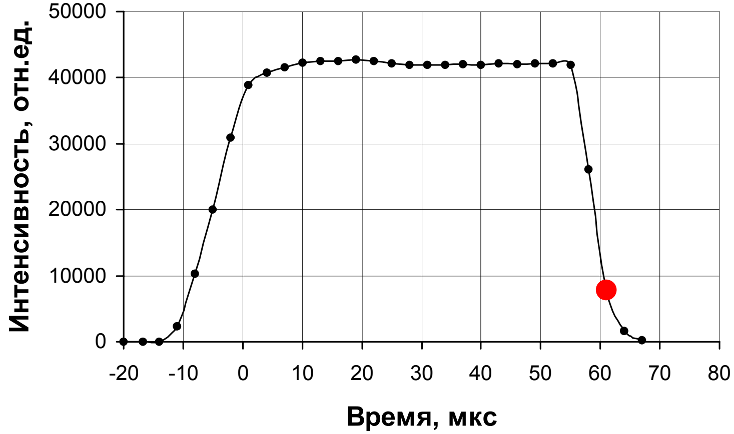


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #5

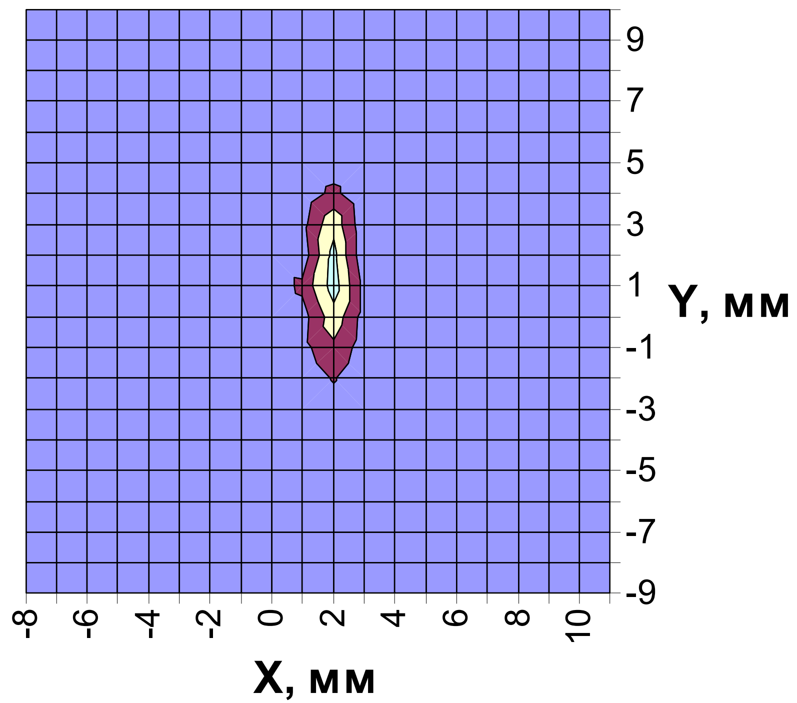


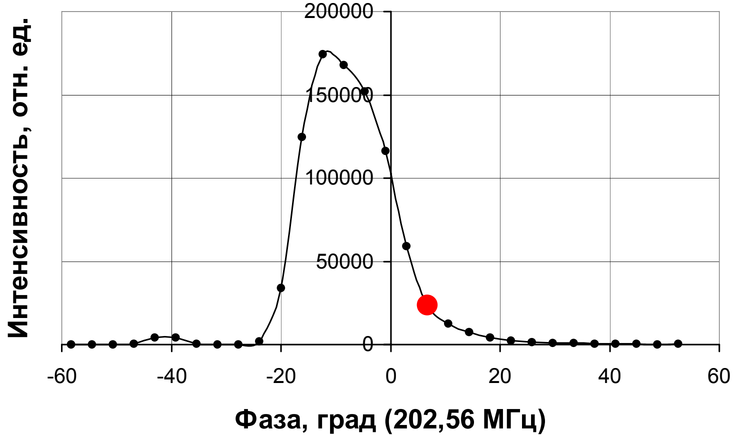


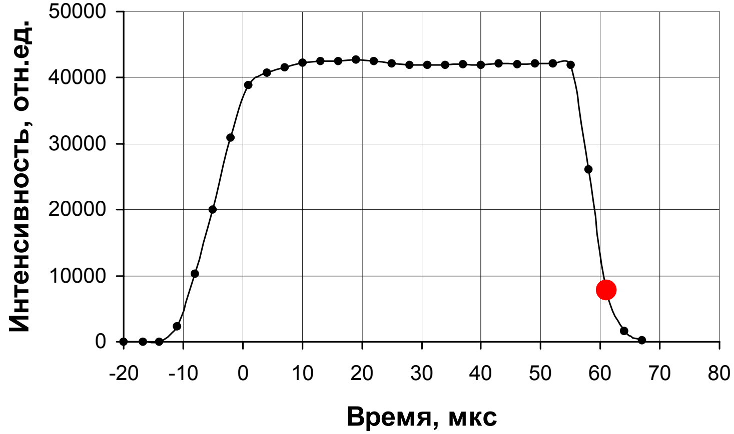


Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #5

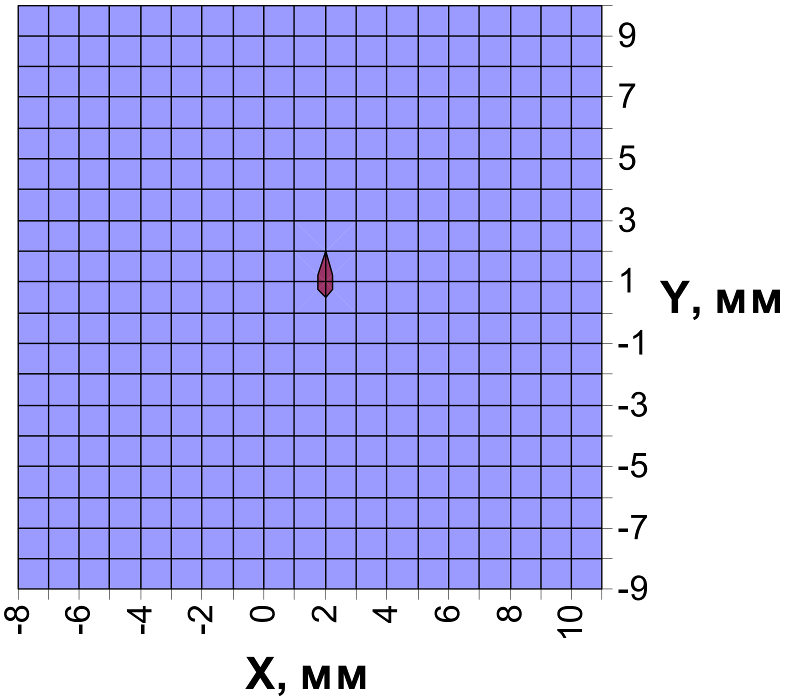






Transverse cross section of a bunch in different phases and at different moments of time within the beam pulse

Bunch #5



Summary

Bunch shape monitors with RF scanning of low energy secondary electrons developed and bult in INR are **used for longitudinal parameters measurements of beams of different particles (protons, H-minus ions, heavy ions) within the energy range from several MeV to 1 GeV in several accelerators. The accuracy of measurements is about 1° at several hundred MHz.**