

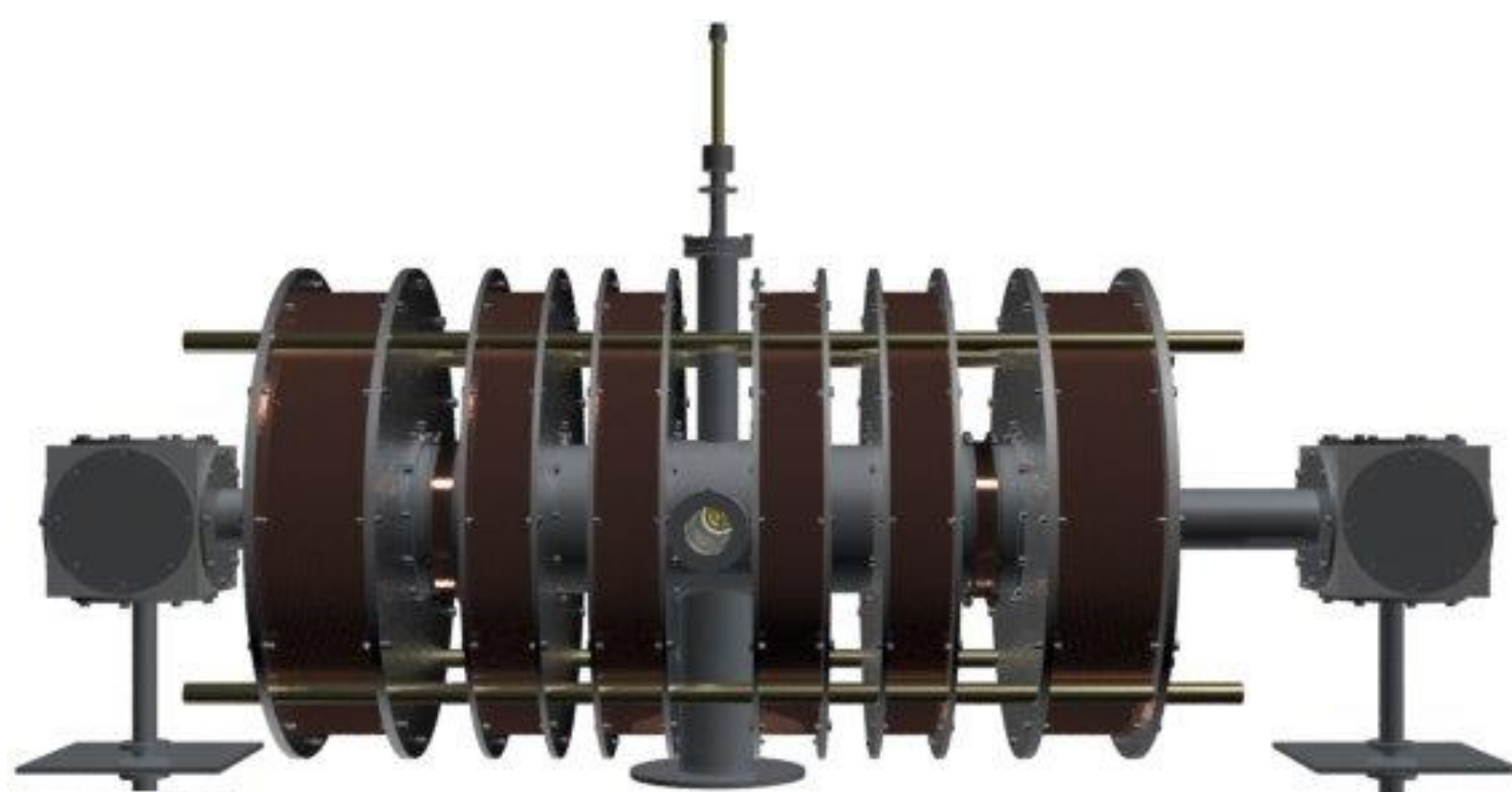
# AUTORESONANCE PULSE-PERIODIC PLASMA ACCELERATOR FOR RADIATION STERILIZATION OF SPECIALIZED FEEDS

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The aim of the biological experiment was to study the radiation effect of pulse-periodic X-ray radiation on granulated feed for laboratory mice and rats Altromin 1324 Forti (Germany) for the purpose of implementing the method of radiation sterilization.

The experimental setup is an axisymmetric system in which a cylindrical high-frequency resonator (TE<sub>118</sub> mode) is placed in a static magnetic field of a mirror configuration generated by three pairs of coils. Axisymmetric pulsed magnetic field coils are installed at the 2<sup>nd</sup> and 7<sup>th</sup> antinodes of the electric field of the standing wave. The direction of the current in the pulsed coils ensures the creation of a magnetic field opposite to the static one. The time variation of the pulsed magnetic field induction provides:

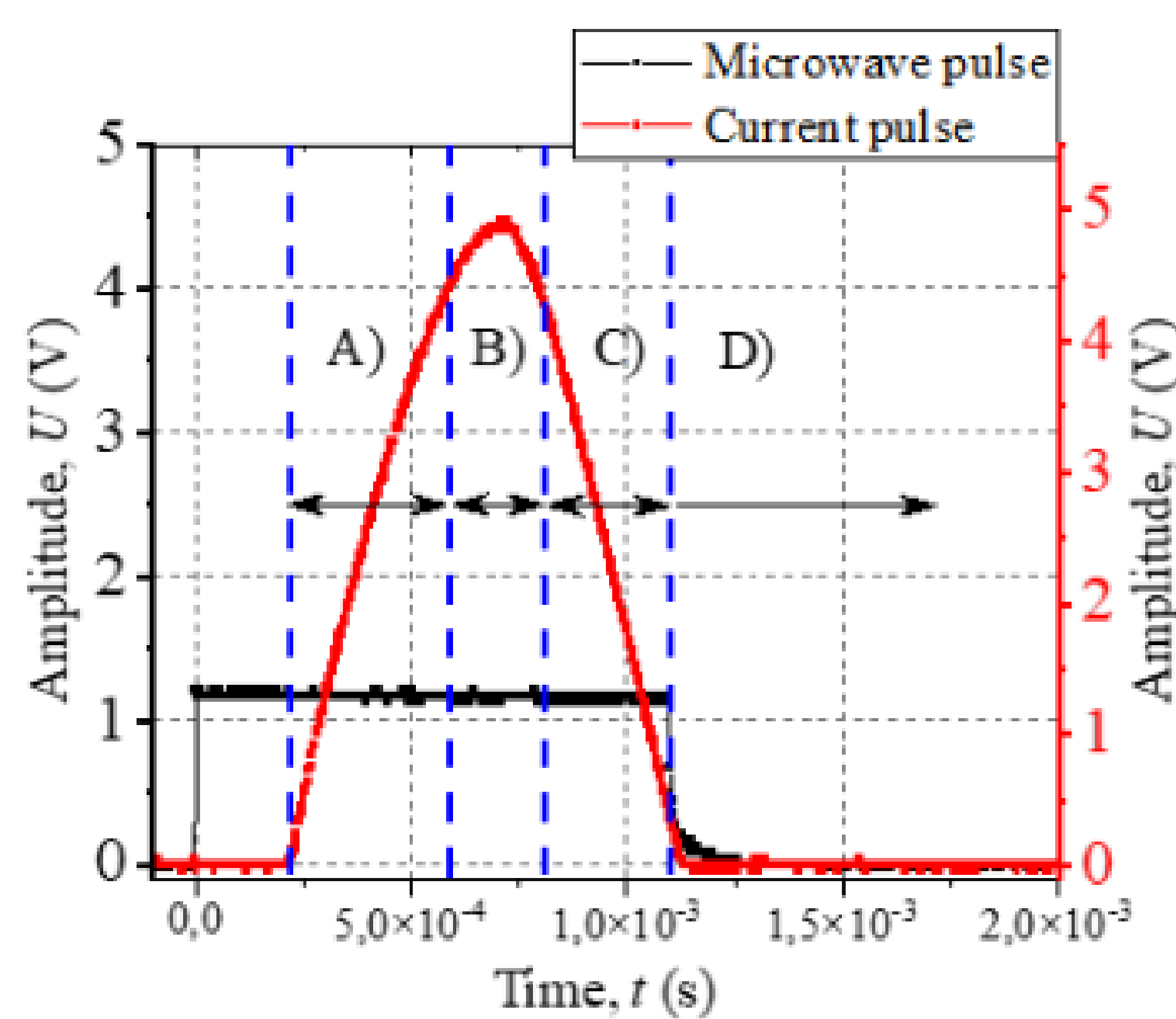
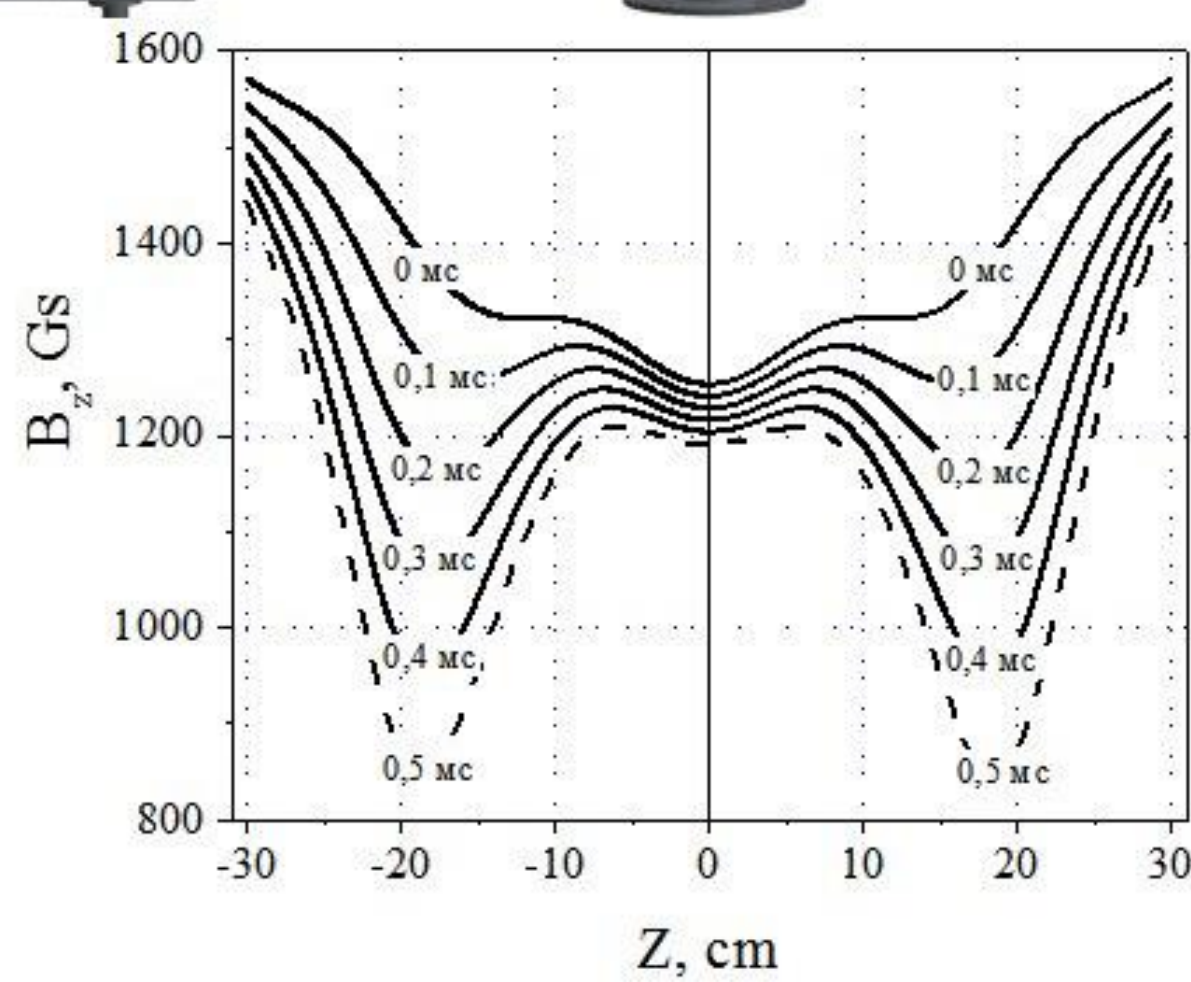
- a “dip” in the static magnetic field down to the level corresponding to the ECR value for the operating frequency of the resonator, leading to plasma formation;
- restoration of the initial profile of the static magnetic field, resulting in the capture and acceleration of electrons from the produced plasma in two symmetric zones of the setup;
- dumping of the generated plasma bunches into the central region of the trap.



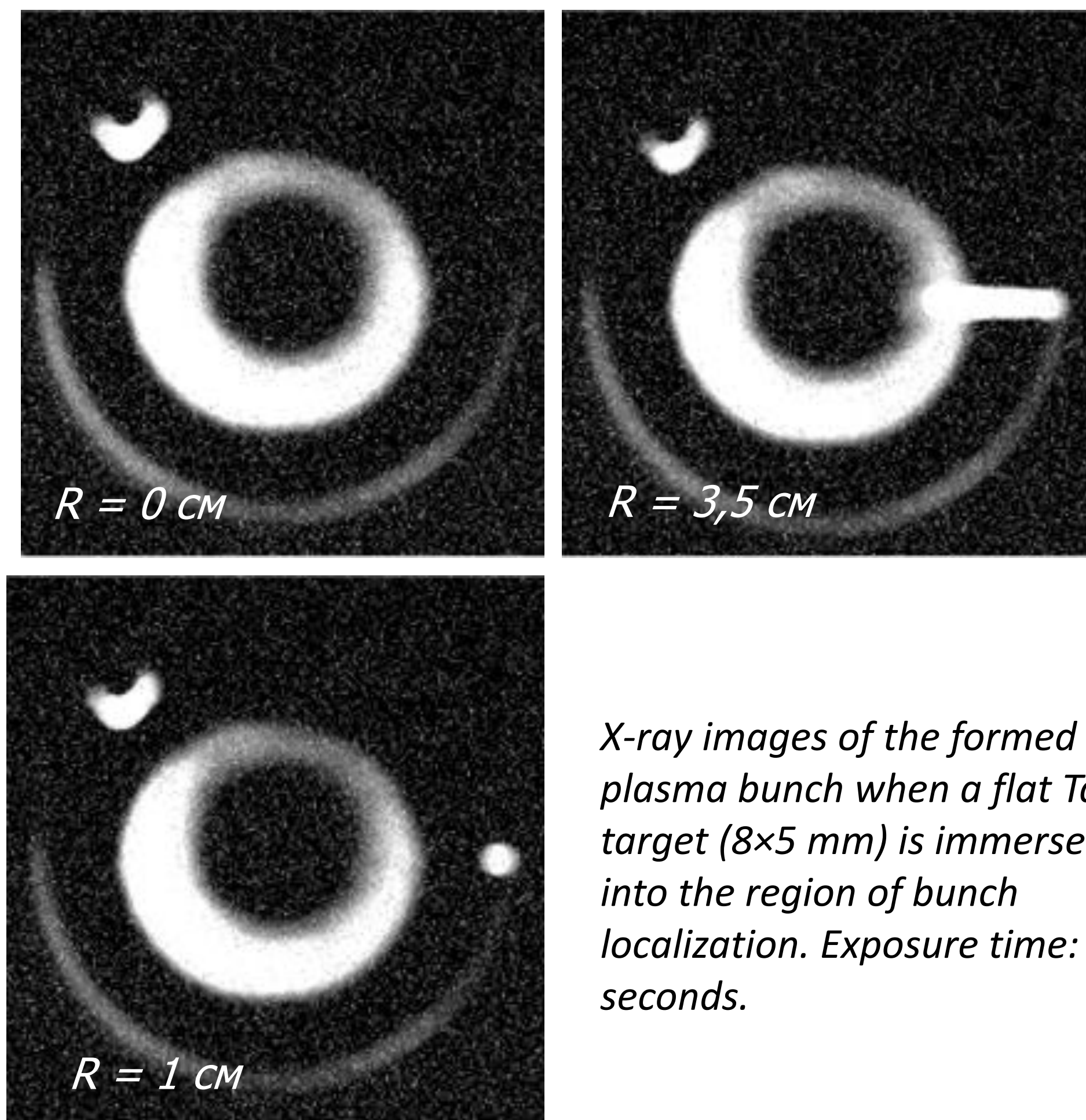
3D – View of the experimental setup

The magnetic field of the pulsed coils provides a local reduction of the static magnetic field induction to the ECR level for the operating frequency of the resonator.

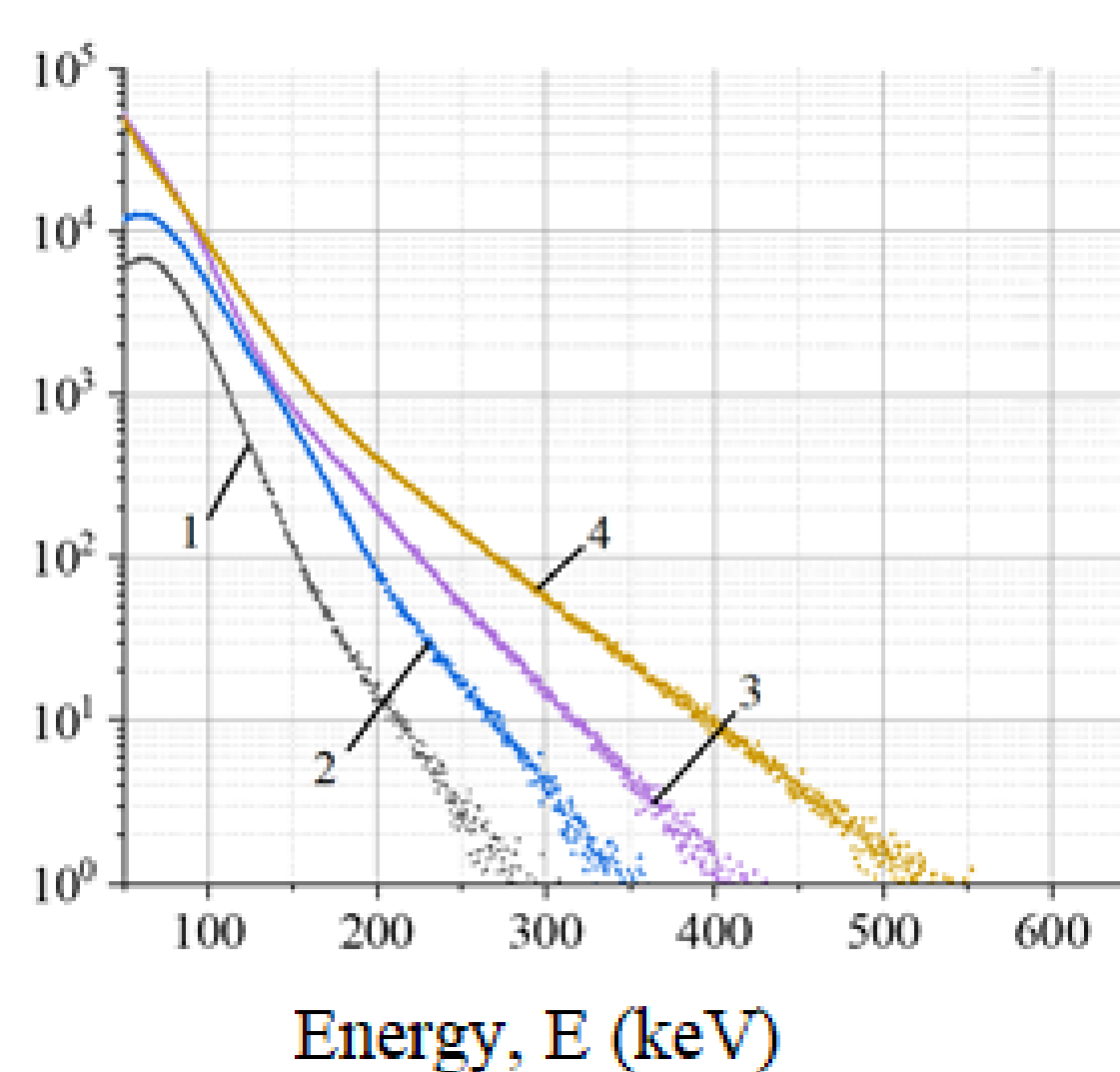
The resonator is powered by a magnetron generator with an output power in the range of 1.0–5 kW, operating in a periodic rectangular pulse mode with a pulse duration of 1 ms and a pulse repetition interval ranging from 1 ms to 1 second.



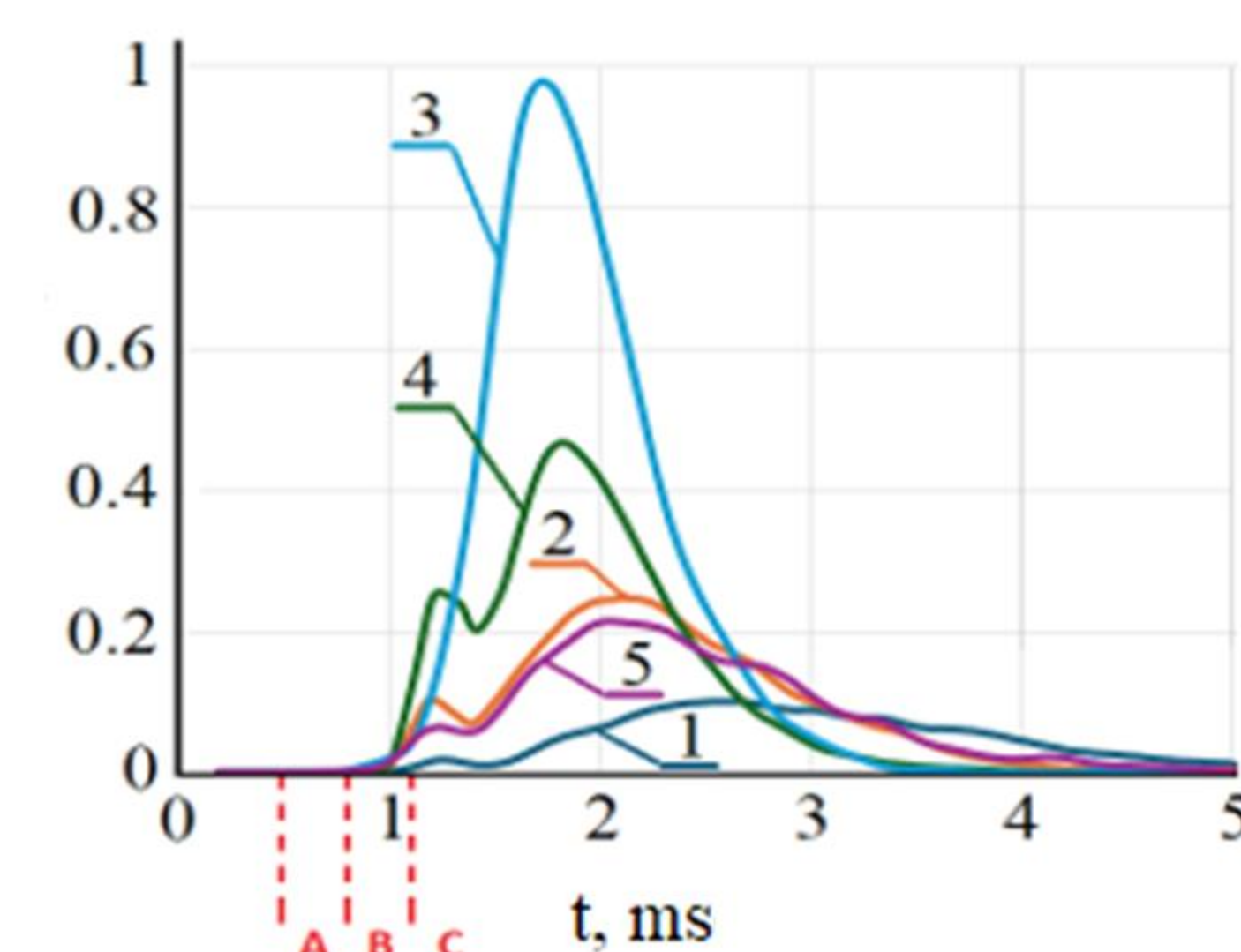
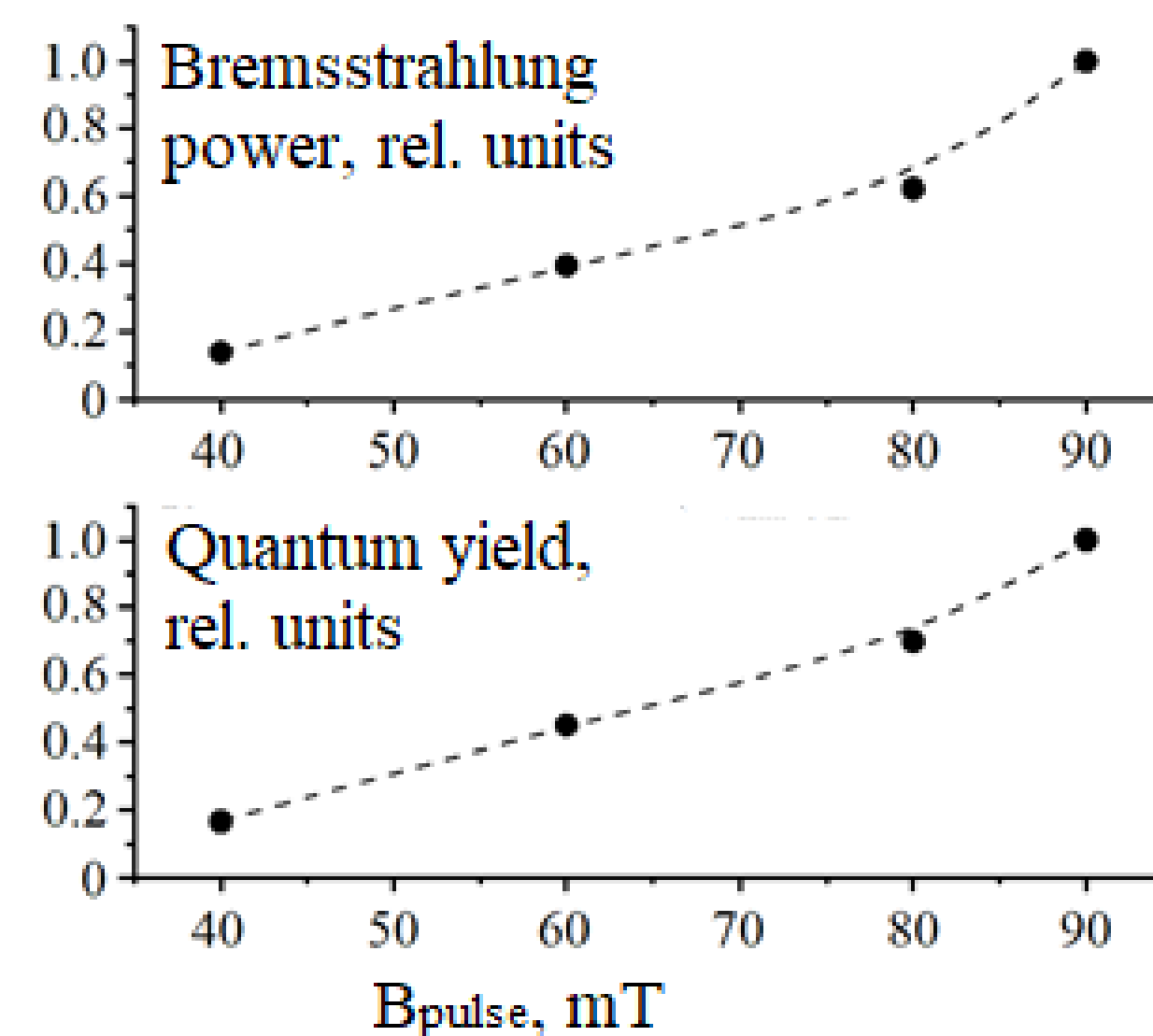
The mutual temporal arrangement of the pulsed processes in the GA mode, specifically the relative timing of the microwave pulses and the pulsed magnetic field, is shown in the figure. In the initial phase (A) the pulsed field rises; in phase (B) ECR plasma injection occurs; phase (C) represents the acceleration of trapped electrons in the GA mode; phase (D) is the confinement of the accelerated electrons in the magnetic field of the mirror configuration.



X-ray images of the formed plasma bunch when a flat Ta target (8x5 mm) is immersed into the region of bunch localization. Exposure time: 90 seconds.

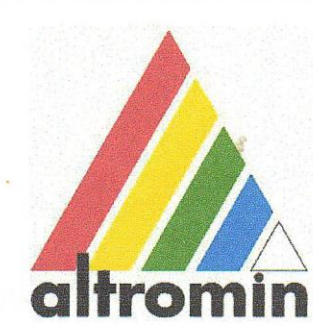


Hard bremsstrahlung spectra for variations of  $B_{pulsed}$ : 1 – 40; 2 – 60; 3 – 80; 4 – 90 mT; at operating parameters:  $p = 1.7$  MPa,  $P_{mw} = 2.5$  kW over an effective time  $t_{eff} = 68$  s. Quantum yield and average power of hard bremsstrahlung in relative units, obtained from processing the spectra.



Oscillograms of hard bremsstrahlung power at ( $W_{Le\ max} \sim 0.53$  MeV), obtained in the plasma bunch confinement region with a NaI(Tl) detector operating in current mode and processed using the moving average method, for different pressures in the working volume: 1 – 1.1 mPa; 2 – 1.3 mPa; 3 – 1.7 mPa; 4 – 2 mPa; 5 – 2.7 mPa.

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## Producer Certificate

Description: Maintenance diet for rats and mice  
 Type: 1324  
 10mm pellets, attached paper bags & 12.5 kg  
 Customer: Globe Medical LLC, Russia  
 Batch no. / Lot no.: 202308180906  
 Order no.: Altromin Delivery note, No. 55426  
 Production date: 18.08.2023  
 Expiry date: 18.05.2024

Guaranteed nutritional values  
 % in air-dry substance

Value*	Tolerance**
Crude protein	19,2 16,8 – 21,6
Crude fat	4,1 3,1 – 6,1
Crude fibre	6,1 4,4 – 7,8
Crude ash	6,9 4,9 – 7,9
Moisture	11,3 < 12,4
NiE - Nitrogen free extracts	52,4

\* The product complies with the specifications and quality requirements of Altromin and therefore has been approved for delivery.

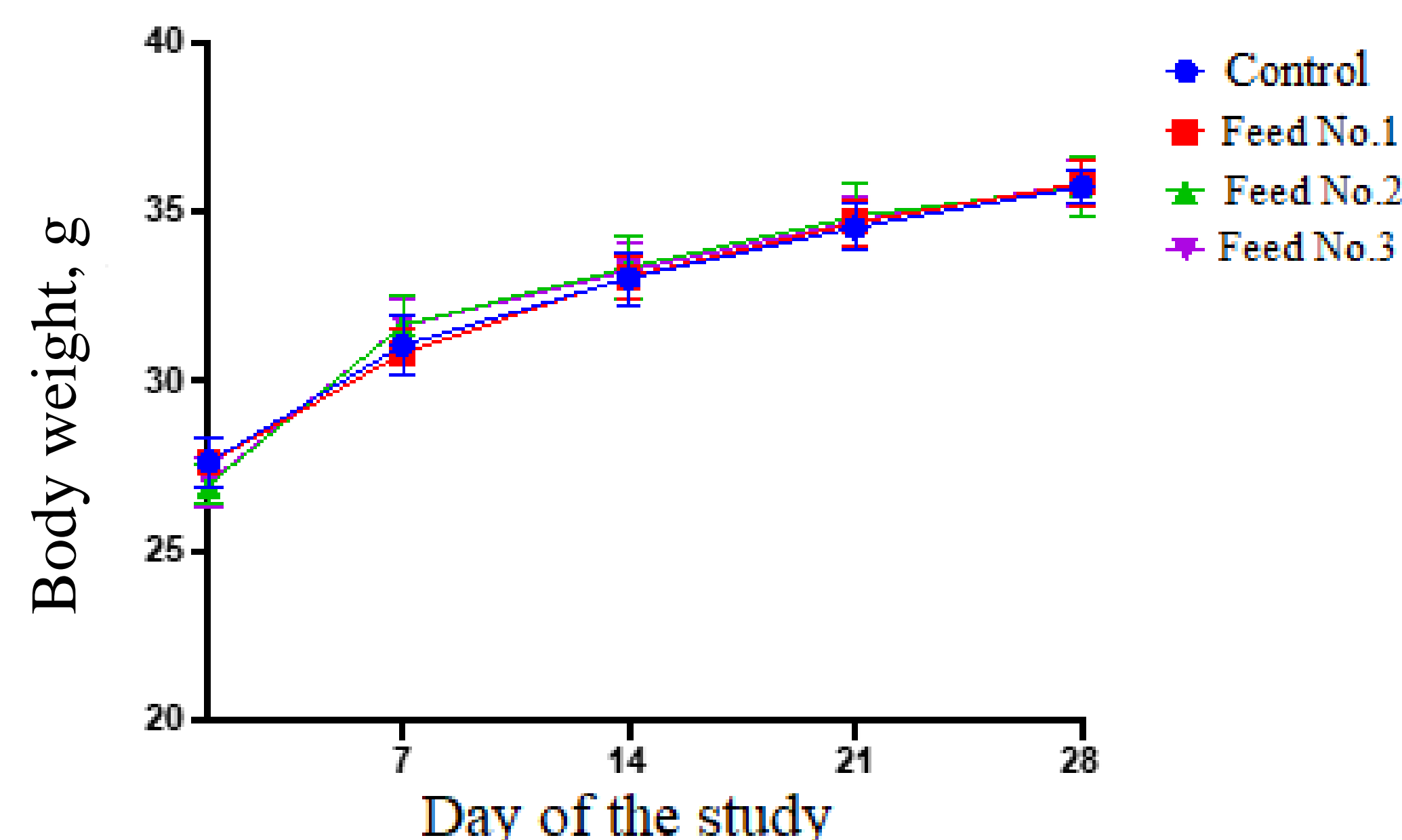
Physical analysis  
 Pellet hardness kg/cm<sup>2</sup> - Kahl: 22

Sensory evaluation  
 Olfactory: ok  
 Visual: ok

This product is compliant with the specifications and quality requirements of Altromin and therefore has been approved for delivery.

Date: August 28th 2023

Hans-Leopold Altromin  
 QA-Management



In the study, male outbred ICR mice with SPF status were used. The animals were fed for 28 days with granulated feed Altromin 1324 Maintenance Diet – Rats/Mice (Altromin Spezialfutter GmbH & Co KG, Germany) with different sterilization methods. During the in-life observation period, no clinical abnormalities were detected in the animals. Analysis of body weight dynamics and body weight gain shows that the radiation sterilization methods did not affect the growth and development of the animals; the body weight gain indicators remained within the control values.

	Control (standard feed)	Feed No. 1	Feed No. 2	Feed No. 3
Body weight (g)				
Before the experiment	27,6±2,1	27,6±2,1	27,3±1,3	27,2±1,7
28 days of feeding	35,7±1,4	35,8±1,8	36,1±2,1	35,8±1,9
Weight gain in 28 days (%)	29,9±6,5	30,5±9,9	32±4,7	31,9±4,3
Organ weight (g)				
Liver	2,00 ± 0,21	1,99 ± 0,11	2,02 ± 0,27	2,00 ± 0,19
Kidneys	0,456 ± 0,025	0,459 ± 0,035	0,468 ± 0,039	0,472 ± 0,050
Spleen	0,089 ± 0,016	0,091 ± 0,014	0,093 ± 0,015	0,096 ± 0,023
Heart	0,163 ± 0,014	0,166 ± 0,011	0,164 ± 0,013	0,165 ± 0,012
Brain	0,495 ± 0,022	0,501 ± 0,029	0,498 ± 0,014	0,494 ± 0,015

The studied feed sterilization methods preserve the main properties of the feed. It was also noted that radiation-sterilized feed is characterized by increased hardness compared to autoclaved feed, which may potentially be an advantage for natural wear of incisors in rodents. It should also be noted that the shelf life of feed sterilized by irradiation is significantly longer than that of autoclaved feed.