

# X-ray transmission tomography for detonation investigation

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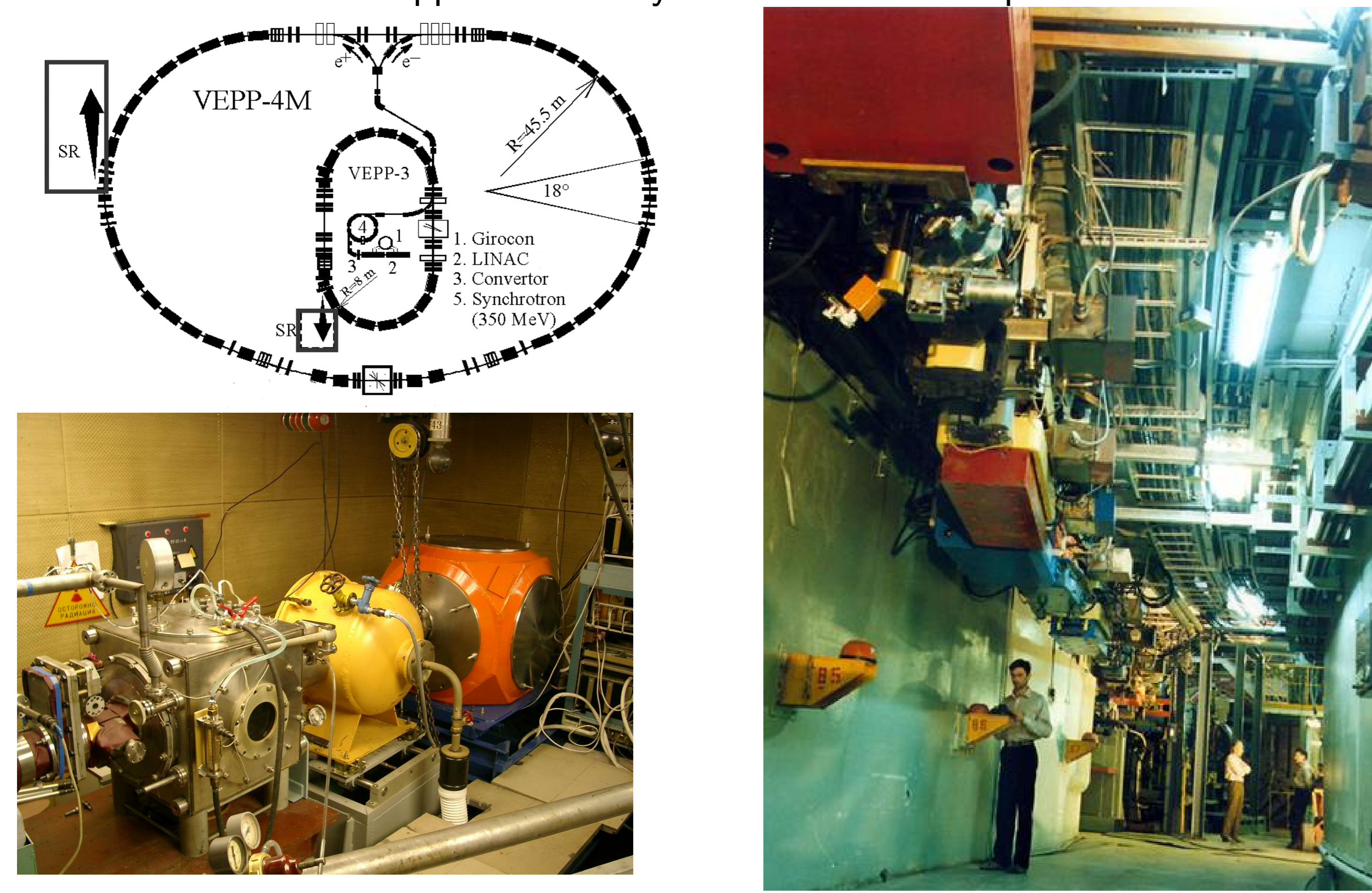
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## Abstract

This paper gives a description of a high-speed X-ray tomographic technique and the results of its application to finding the density distribution of detonation products of condensed explosives from measurements using synchrotron radiation. The data obtained for a cylindrical charges of pressed pure TNT and mixture of 50% TNT with 50% RDX. The features of the employed technique and the distribution obtained are analyzed. The technique as a whole and the results obtained can be used to test and refine the known equations of state for detonation products and to construct new ones.

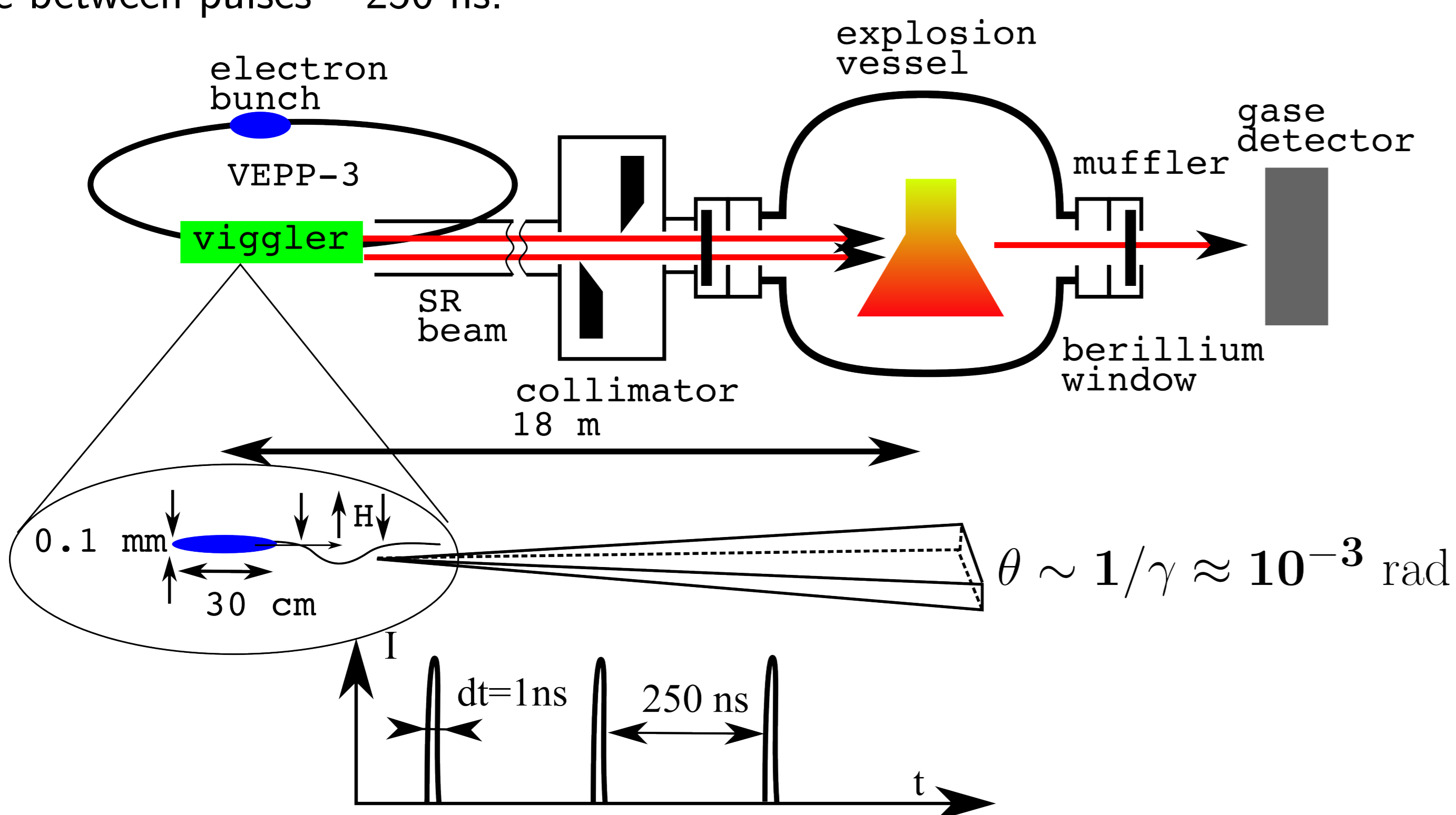
## Complex VEPP-3, VEPP-4. Novosibirsk

The VEPP-3 electron-positron storage ring, perimeter: 74.4 m, maximal energy: 2000 MeV. One of its applications – synchrotron radiation production for users.

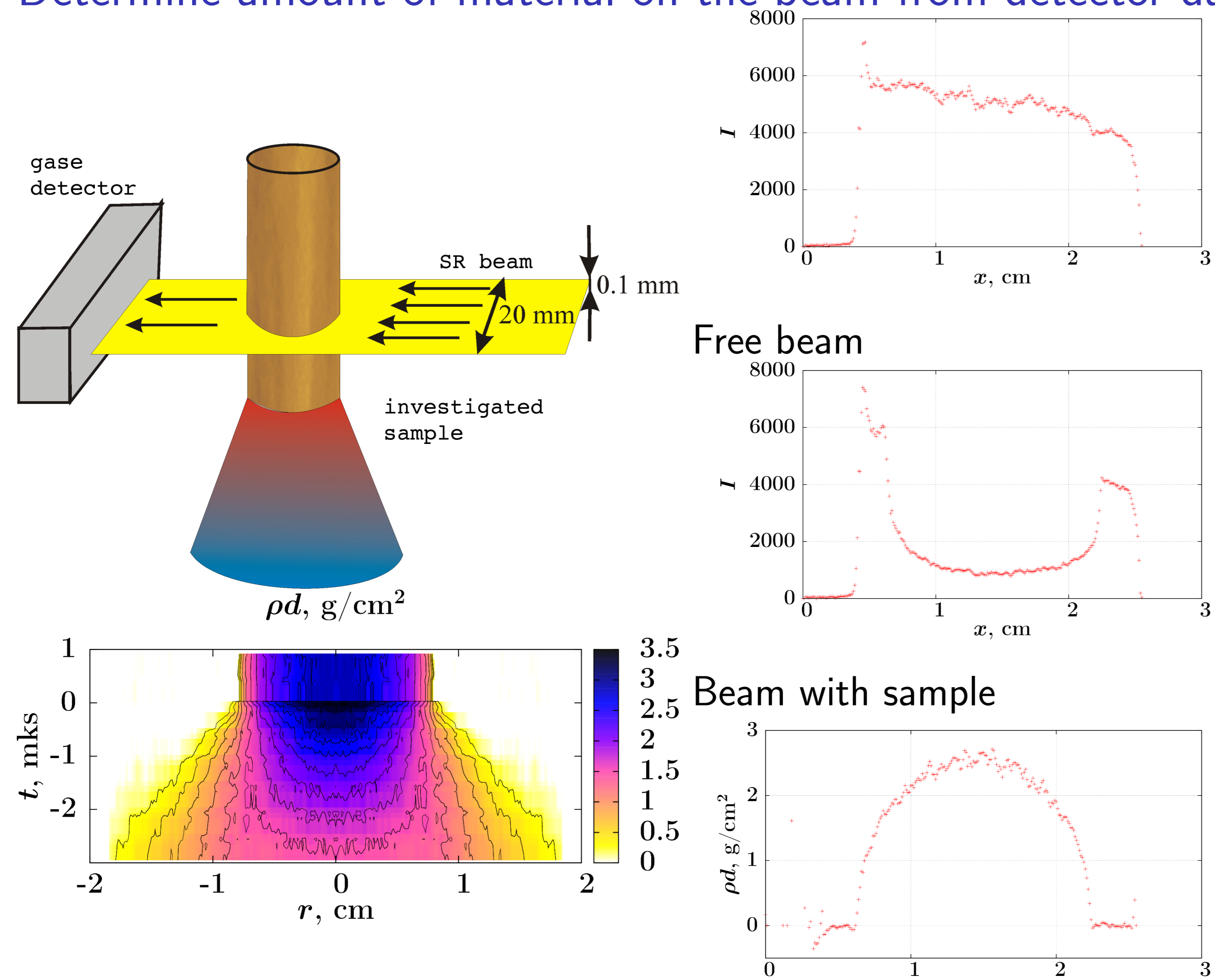


## Experimental setup for density dynamic investigation

**X-ray beam properties.** Photon energy – 20 – 30 kV, pulse duration – 1 ns, time between pulses – 250 ns.



## Determine amount of material on the beam from detector data



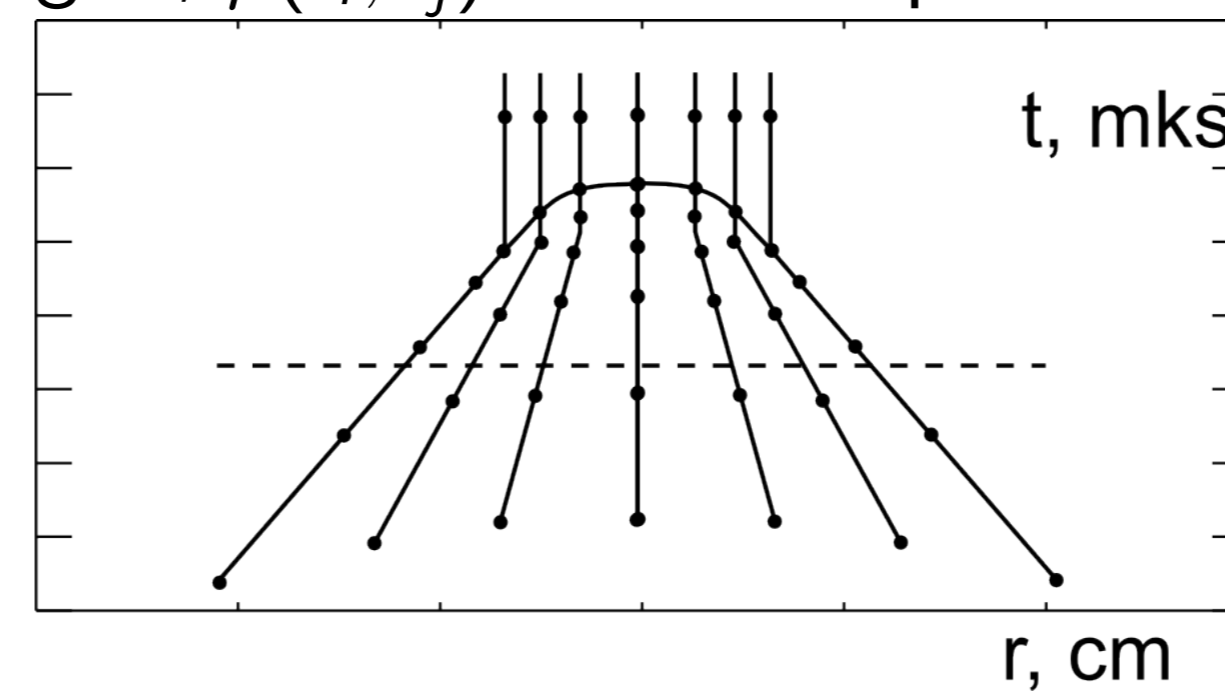
Shadow after calibration

## Reconstructing of the spatial density distribution from x-ray shadow Direct task.

$$F(x, t_i) = \int_{-\sqrt{R_0^2 - x^2}}^{+\sqrt{R_0^2 - x^2}} \rho(x^2 + y^2) dy$$

Reverse task.

1. Abel inversion  $\rho(r) = -\frac{1}{\pi} \int_r^{R_0} \frac{F'(x)}{\sqrt{x^2 - r^2}} dx$ . Simple method but huge mistake and noise in reconstructed density.
2. Nonlinear multidimensional minimization.  $\rho(r, t)$  – cubic splines on the presented grid,  $\rho(r_i, t_j)$  – varied parameters,  $F$  and  $F'$  – experimental and tested shadows.

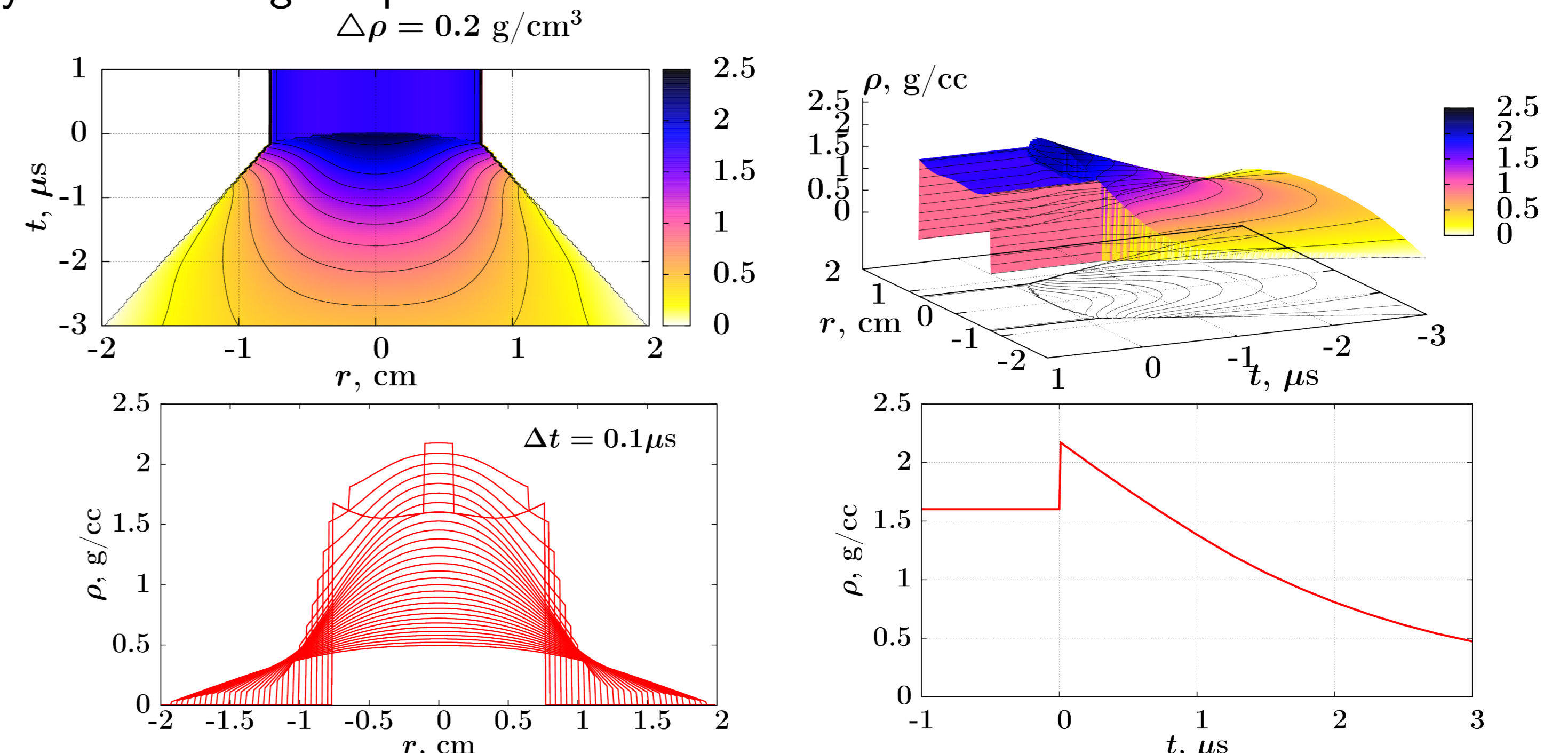


$$(\rho_1, \rho_2, \dots, \rho_n) \Rightarrow \rho'(r, z) \Rightarrow F'(r, t)$$

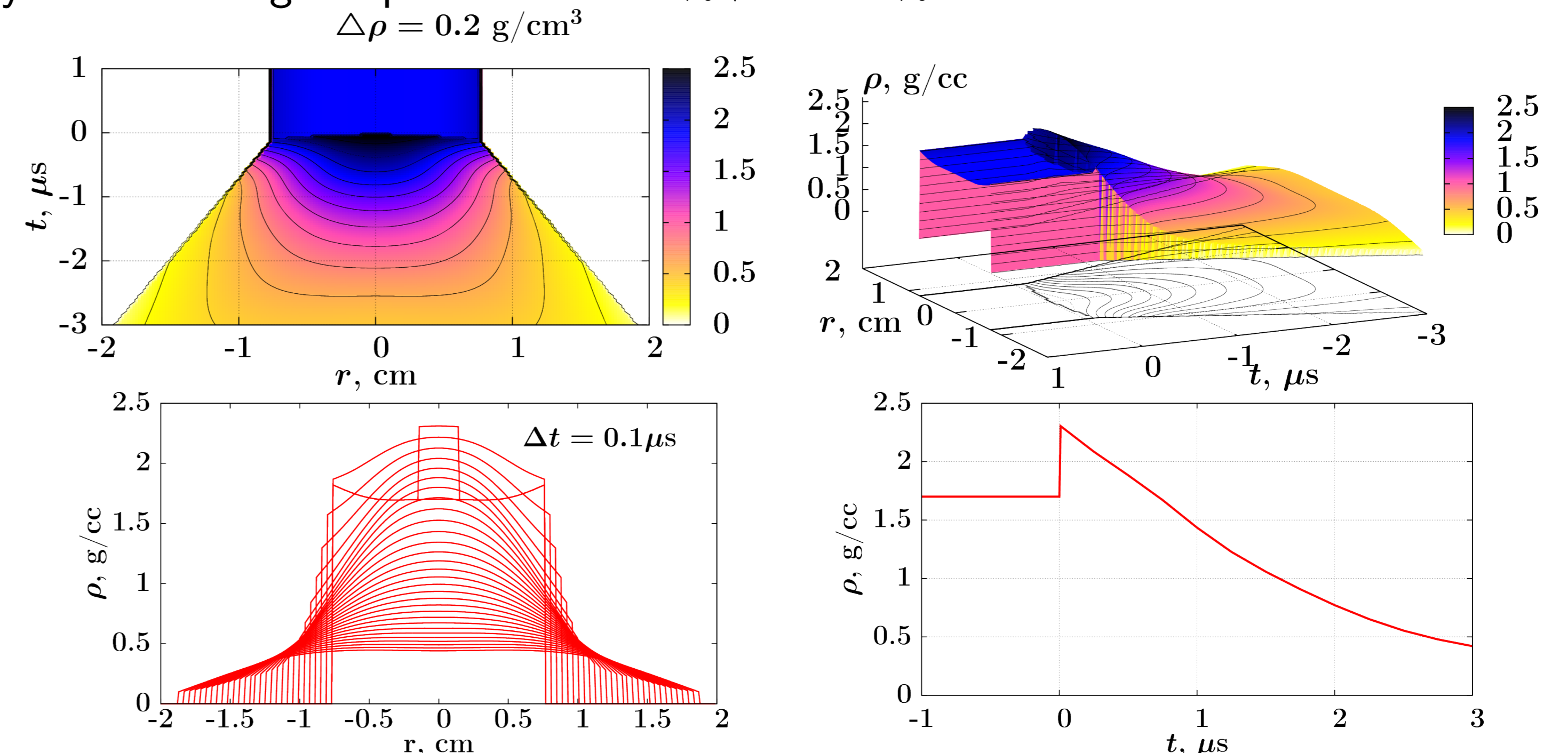
$$Rho(\rho_1, \rho_2, \dots, \rho_n) = \sum_i (F_i - F'_i)^2 \Rightarrow \rho(r, t)$$

## Spatial density distribution

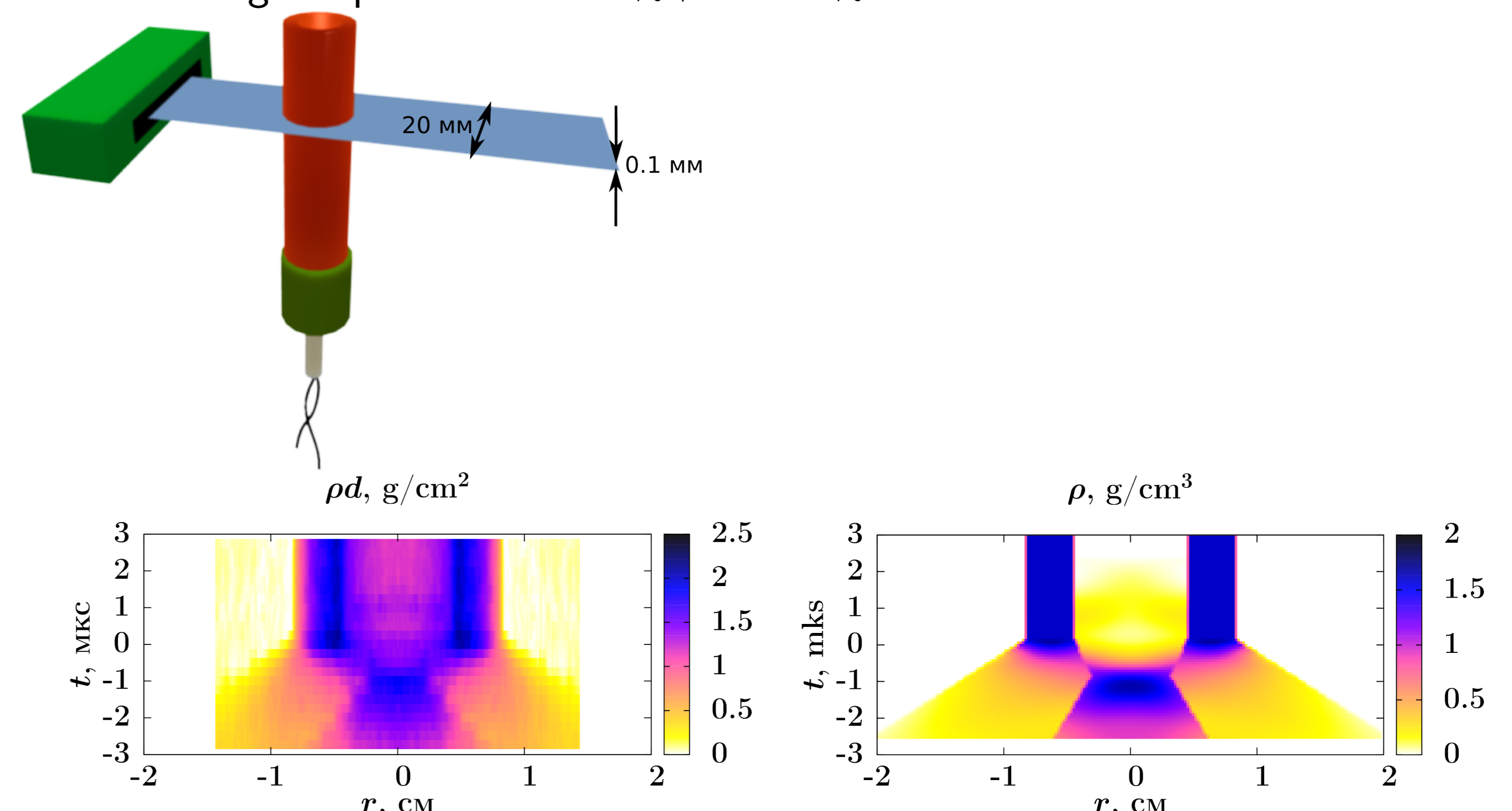
Cylindrical charge of pressed TNT detonation.



Cylindrical charge of pressed TNT50%+RDX50% detonation.



Tubular charge of pressed TNT50%+RDX50% detonation.



## Bibliography

- ▶ Application of synchrotron radiation to explosion investigation. Bibliography. <http://ancient.hydro.nsc.ru/srexpl>
- ▶ Siberian Synchrotron Radiation Centre <http://ssrc.inp.nsk.su>
- ▶ GSL - GNU Scientific Library. <http://www.gnu.org/software/gsl>