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INP AS RUz

CALCULATIONS OF EPITHERMAL NEUTRON ABSORBED DOSE IN THE PHANTOM OBJECT

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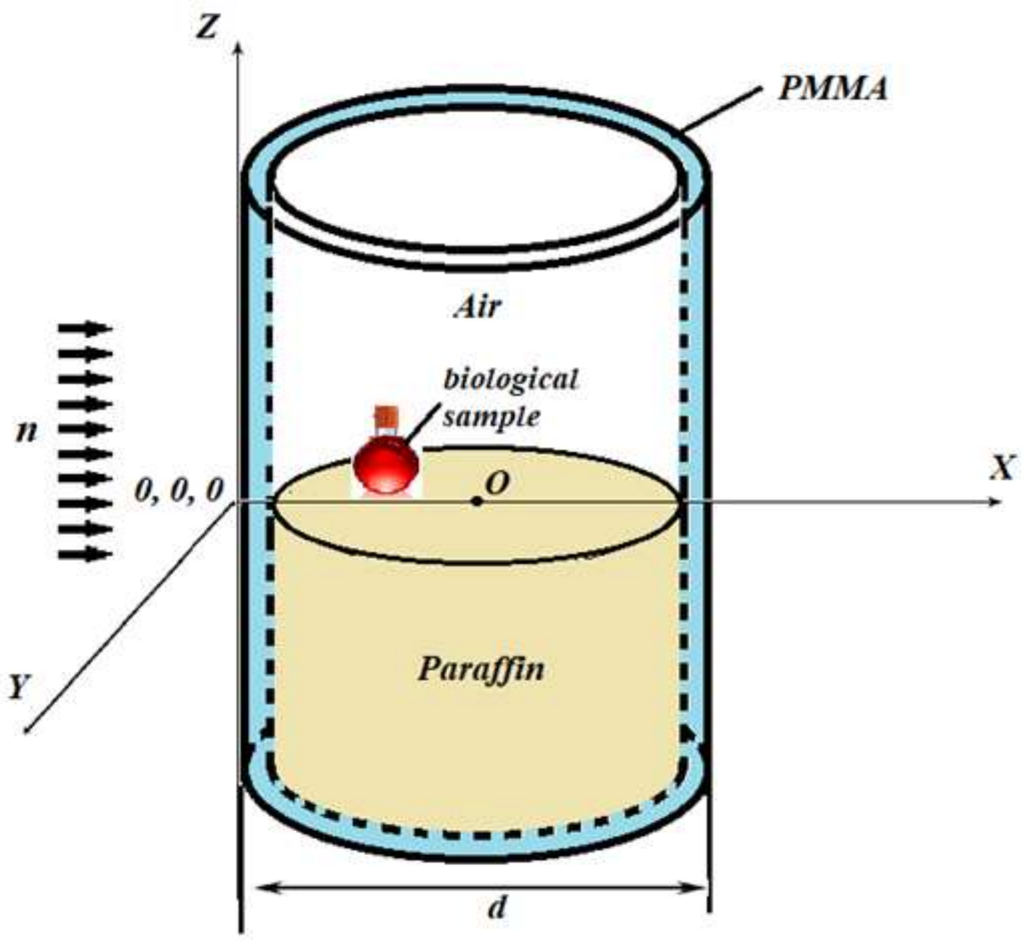
Motivation

At the planning radiation for treating patients with brain tumors, calculations of absorbed doses for a biological object are necessary. Such calculations are carried out by different methods, in particular using phantom objects. To determine the absorbed dose in biological samples when irradiated with an epithermal neutron beam of the VVR-SM reactor (INP AS RUz), calculations were made for a phantom object.



The phantom object was made of polymethylmethacrylate (PMMA) and contained a biological sample (tissue of human tumor). A phantom object in the form of a cylinder with a diameter of d = 20 cm, a wall thickness of 0.5 cm, is located directly behind the exit of the horizontal channel. The central axis of the channel and the geometric center of the cylinder (phantom) are in the same plane. The center of the coordinate system - the point r(0;0) is located in the front wall of the phantom at a distance of d/2 from its center. The biological sample (tumor), spherical shape with a diameter of 2 cm is inside the phantom object at various points.

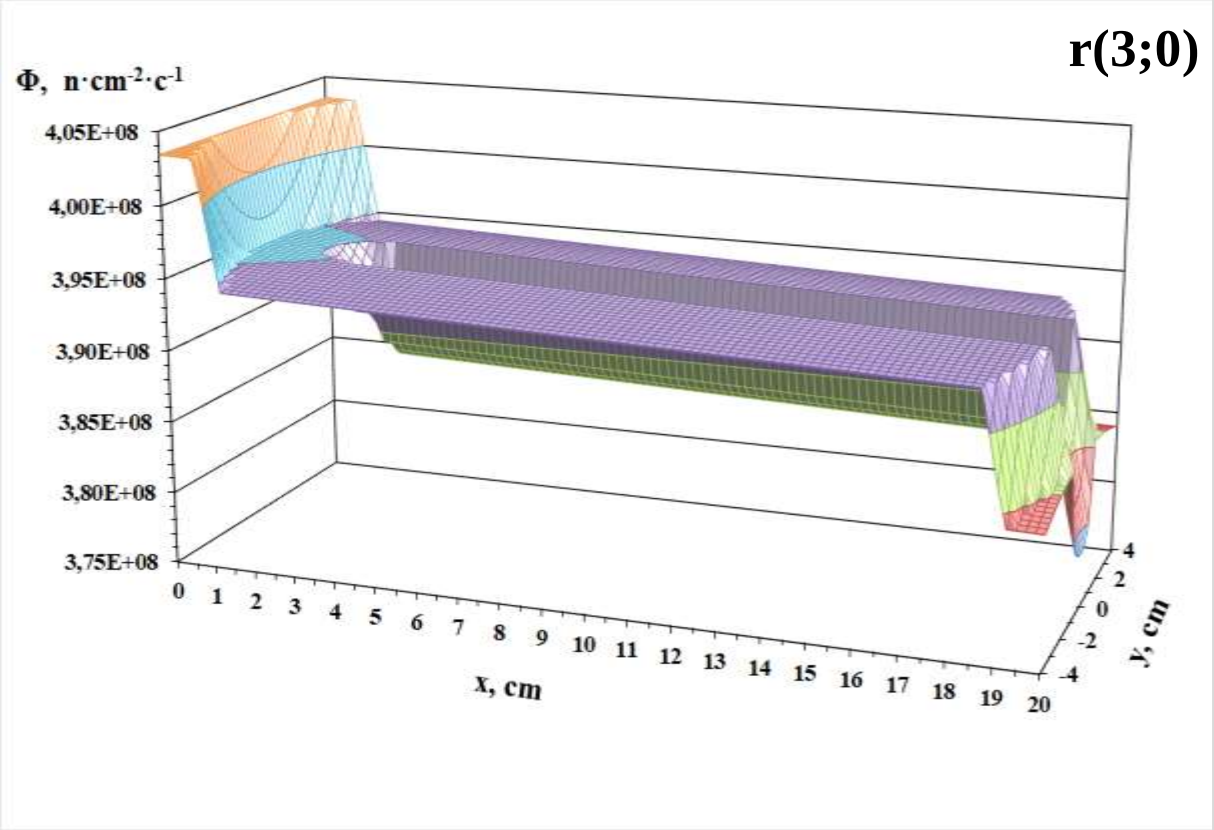
Calculation

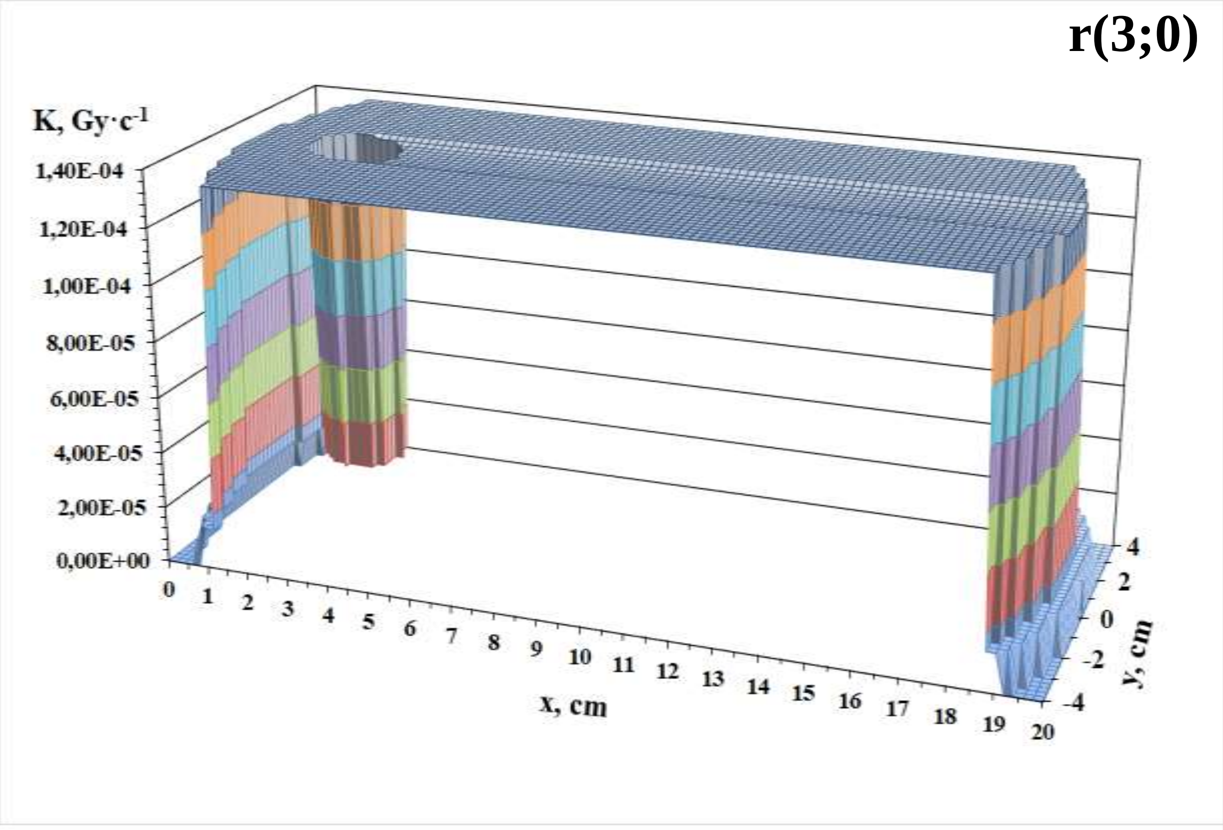
To estimate the absorbed doses, experimentally determined and calculated (MSNP code) values of epithermal neutron flux in the horizontal channel of the reactor were used [*Abdullaeva, G.A., Koblik, Yu.N.,Kulabdullaev, G.A., Kim, A.A., Djuraeva, G.T., Nebeshyi, A.F., Saitjanov, Sh.N., 2013. Determination of kerma in biological tissue with gadolinium when irradiated by epithermal neutron beam of the VVR-SM reactor. Atomic Energy. v.115, N3, 166-169*].

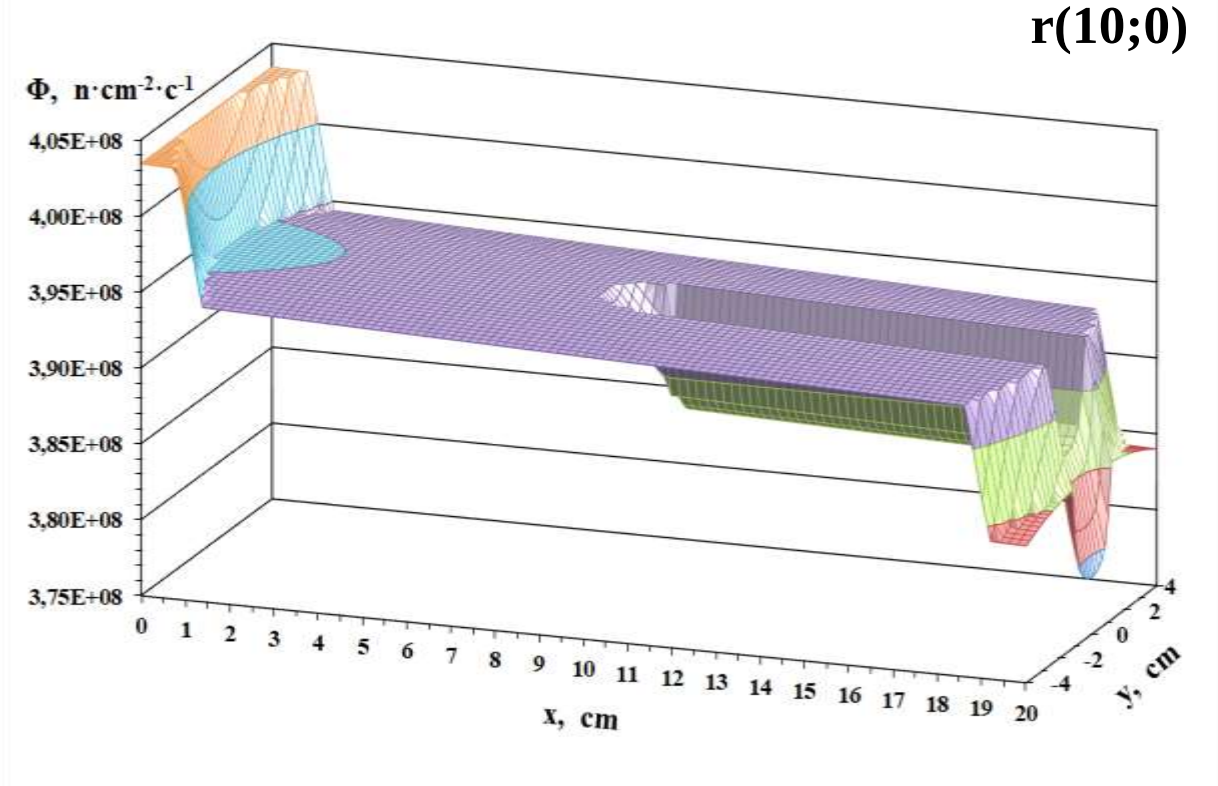
Calculations are performed for a horizontal section passing through the center of the phantom.

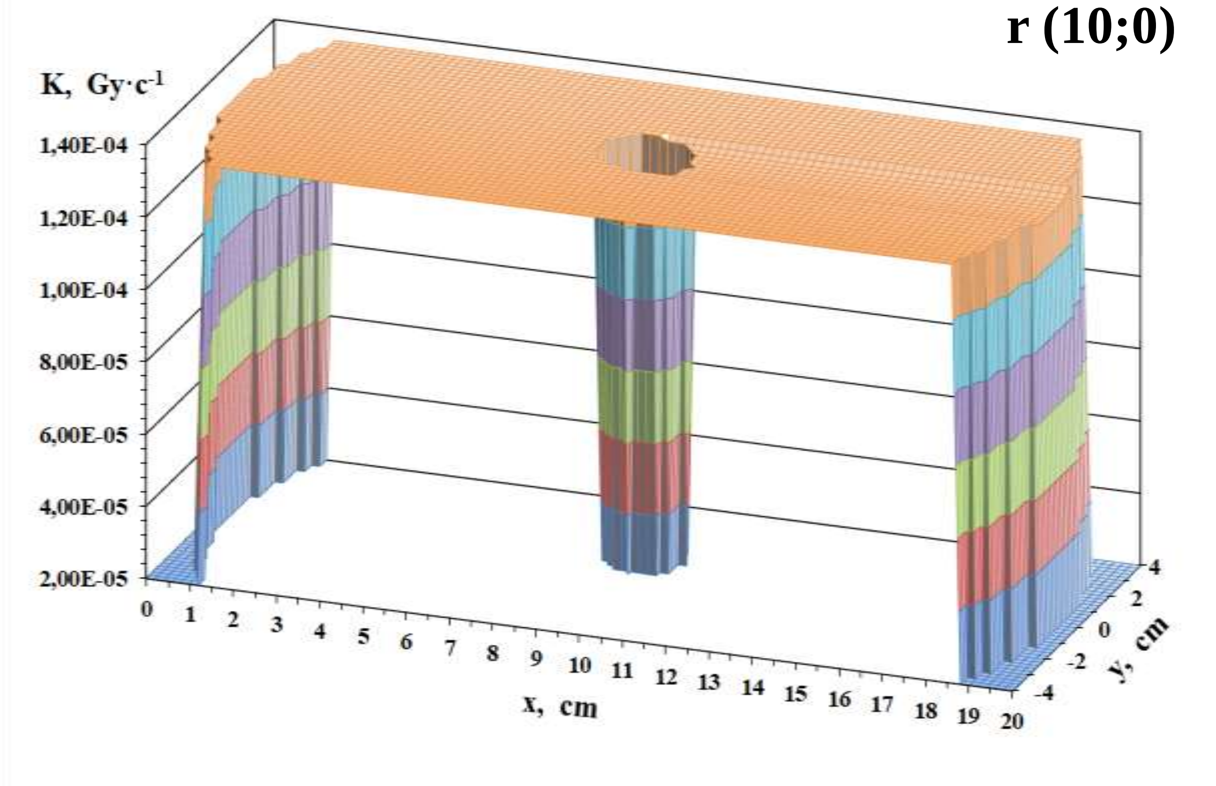
According to calculations, the epithelial neutron flux coming from the reactor horizontal channel to the phantom object was $\Phi_{air} = 4.034 \cdot 10^8$ $n \cdot cm^{-2} \cdot s^{-1}$. After the passage of the epithermal neutron flux through the phantom object, the flux decreases to $3.879 \cdot 10^8$ $n \cdot cm^{-2} \cdot s^{-1}$. The kerma of the epithermal neutron in the front plane of the phantom object was $K_{air} = 6.695\ 10^{-6}$ Gy/s, and the kerma after passing the phantom is $6.655 \cdot 10^{-6}$ Gy/s.

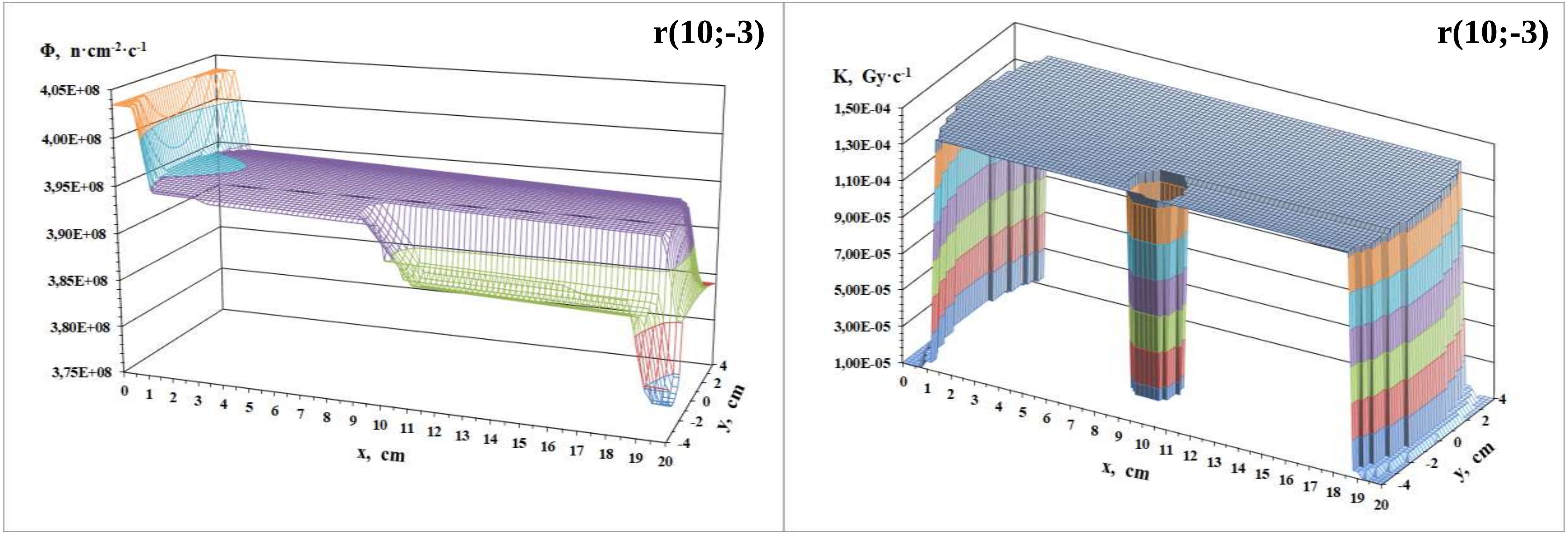
The epithelial neutron flux (Φ) and the epithermal neutron kerma (K) for different coordinates of the biological sample placement – r(x; y)



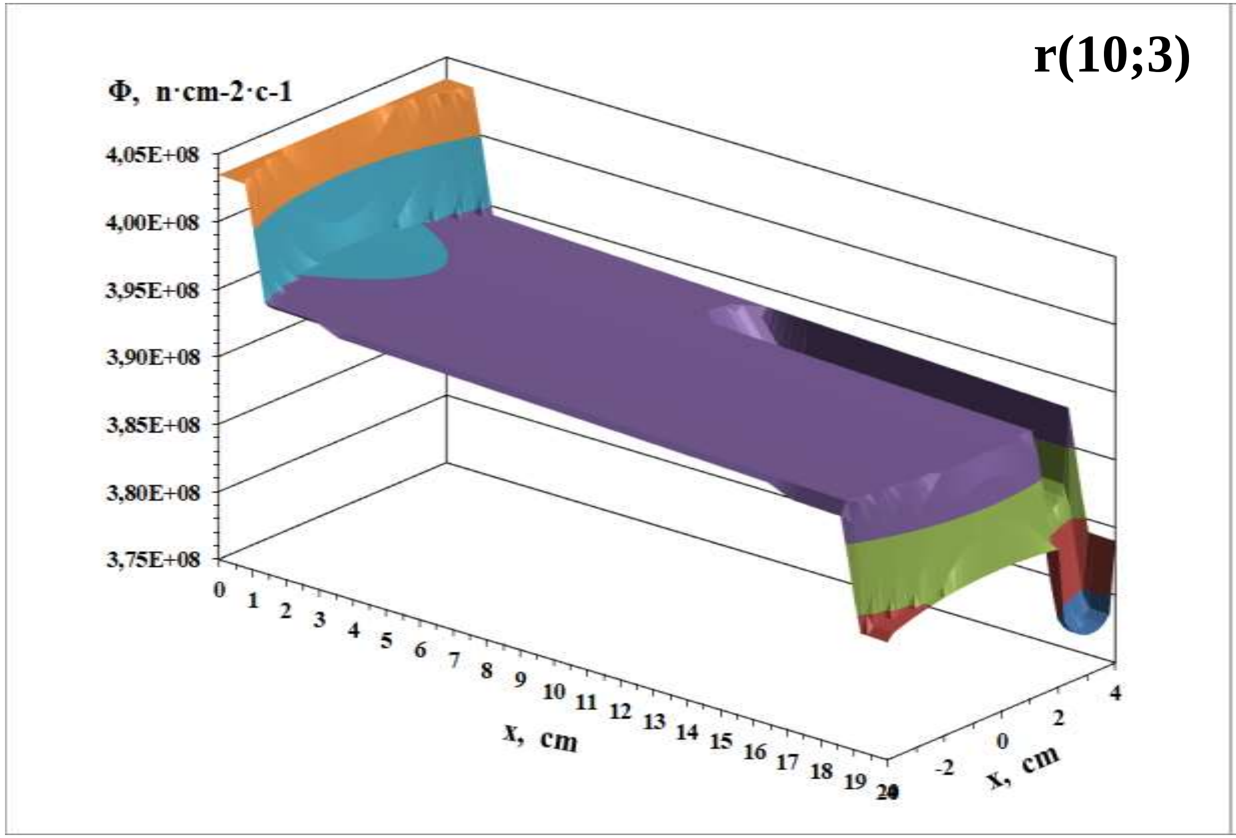


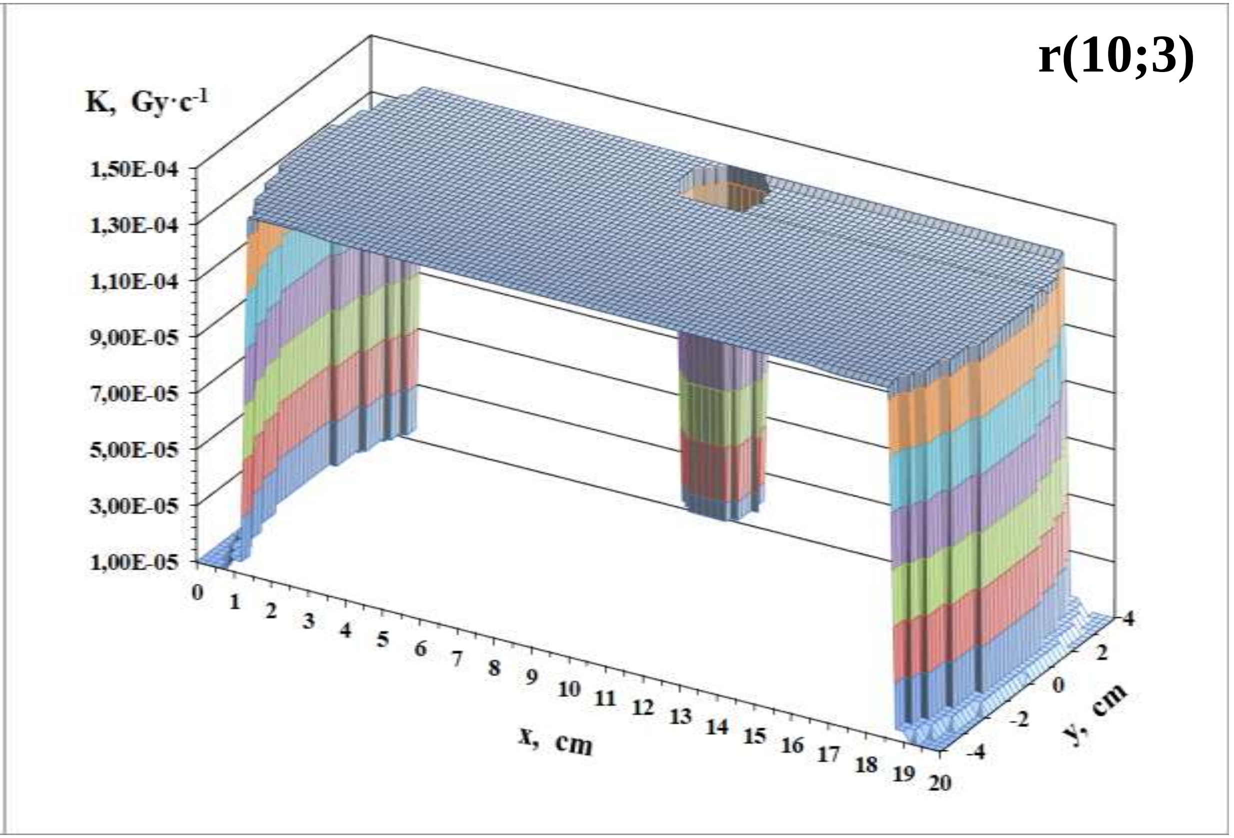

r(10;0)
Φ, n·cm-2·c-1
4,05E+08
4,00E+08
3,95E+08
3,90E+08
3,85E+08
3,80E+08
3,75E+08
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
x, cm
4 2 0 -2 -4
y, cm

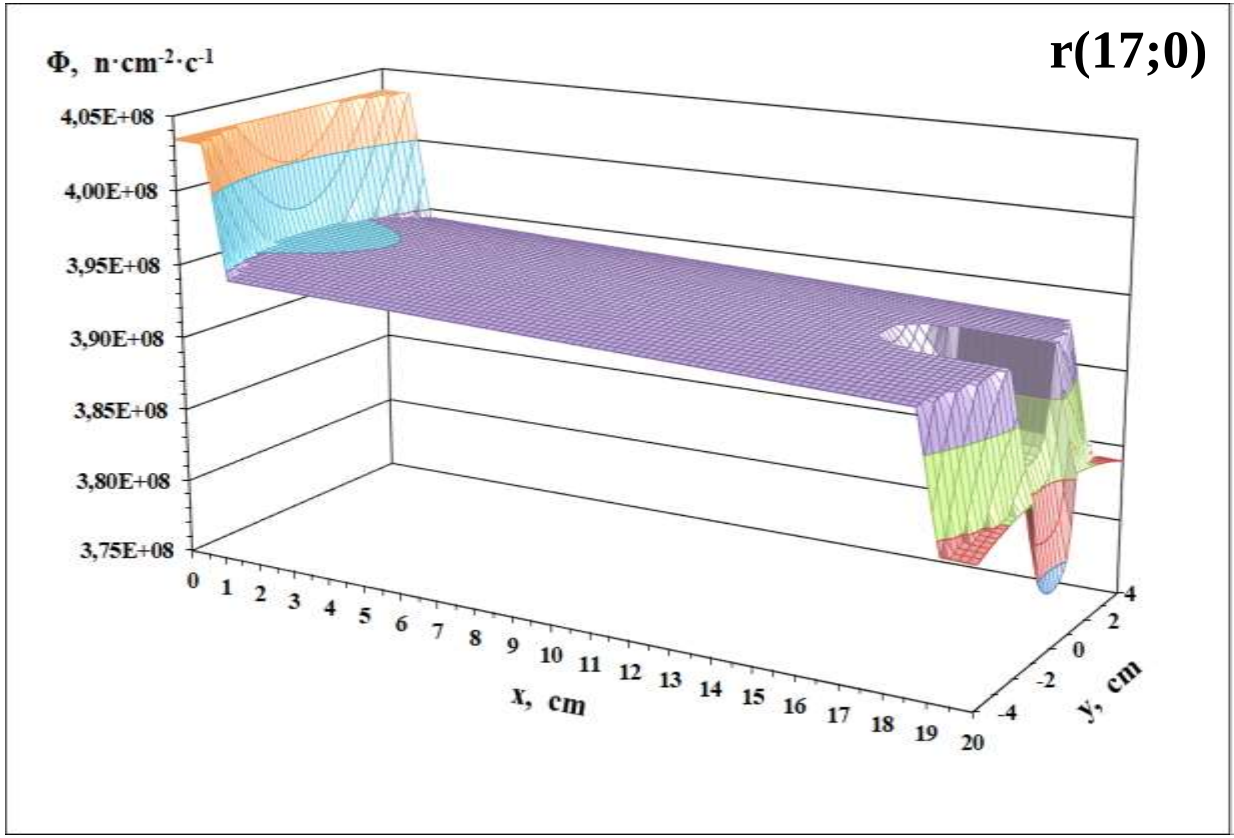

r (10;0)
K, Gy·c-1
1,40E-04
1,20E-04
1,00E-04
8,00E-05
6,00E-05
4,00E-05
2,00E-05
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
x, cm
4 2 0 -2 -4
y, cm

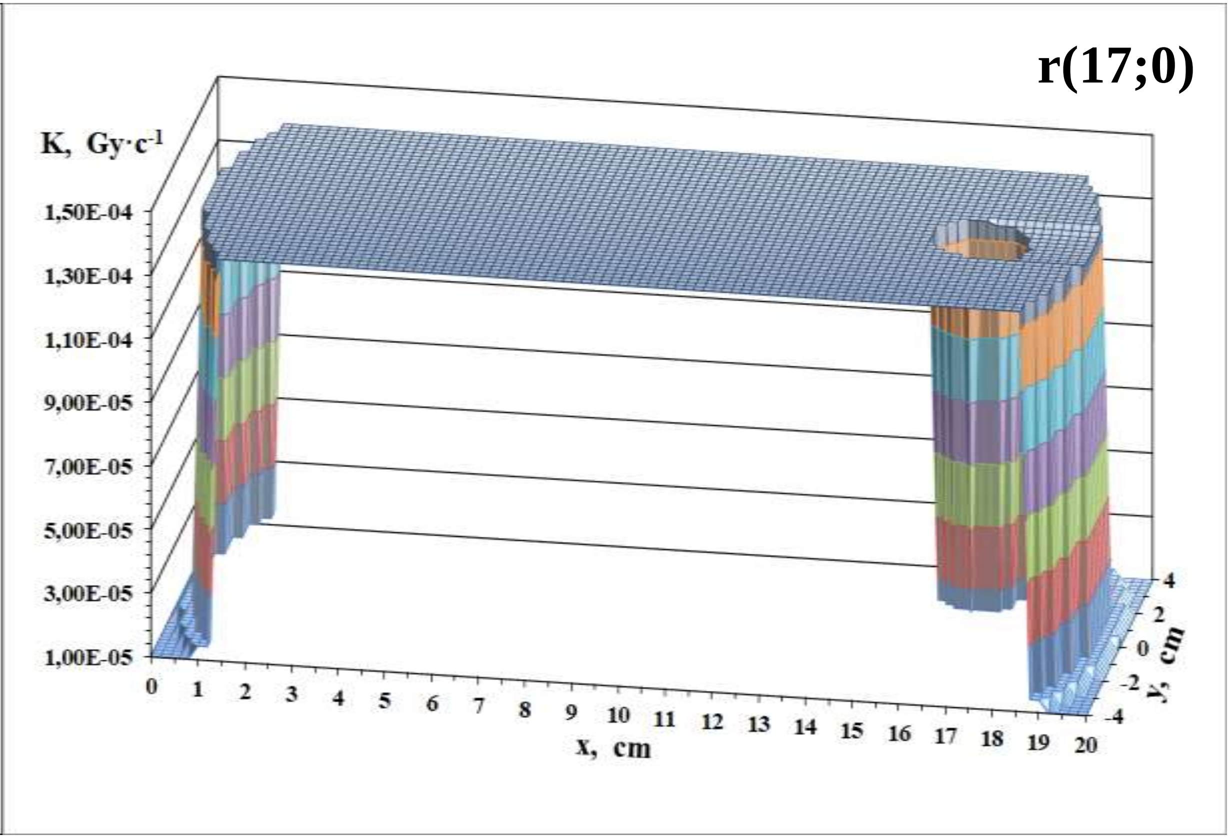


r(10;-3)
Φ, n·cm-2·c-1
4,05E+08
4,00E+08
3,95E+08
3,90E+08
3,85E+08
3,80E+08
3,75E+08
x, cm
y, cm
r(10;-3)
K, Gy·c-1
1,50E-04
1,30E-04
1,10E-04
9,00E-05
7,00E-05
5,00E-05
3,00E-05
1,00E-05
x, cm
y, cm


r(10;3)
Φ, n·cm-2·c-1
4,05E+08
4,00E+08
3,95E+08
3,90E+08
3,85E+08
3,80E+08
3,75E+08
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
x, cm
-2 0 2 4
x, cm


r(10;3)
K, Gy·c-1
1,50E-04
1,30E-04
1,10E-04
9,00E-05
7,00E-05
5,00E-05
3,00E-05
1,00E-05
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
x, cm
-4 -2 0 2 4
y, cm


r(17;0)
Φ, n·cm-2·c-1
4,05E+08
4,00E+08
3,95E+08
3,90E+08
3,85E+08
3,80E+08
3,75E+08
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
x, cm
-4 -2 0 2 4
y, cm


r(17;0)
K, Gy·c-1
1,50E-04
1,30E-04
1,10E-04
9,00E-05
7,00E-05
5,00E-05
3,00E-05
1,00E-05
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
x, cm
-4 -2 0 2 4
y, cm

The results of calculations of the neutron flux and neutron kerma in the phantom object

r(x;y), cm	(3;0)	(10;0)	(17;0)	(10;3)	(10;-3)
Φ_{air}, n cm^{-2} c^{-1}	3,95007E+08	3,94372E+08	3,93739E+08	3,93962E+08	3,93962E+08
$\Phi_{b.t.}$, n cm^{-2} c^{-1}	3,91610E+08	3,90980E+08	3,90352E+08	3,90573E+08	3,90573E+08
K_{air}, Gy/c	1,36561E-04	1,36315E-04	1,36070E-04	1,36164E-04	1,36164E-04
$K_{b.t.}$, Gy/c	2,35214E-05	2,34853E-05	2,34493E-05	2,34607E-05	2,34607E-05

* b.t. – biological tissue

The ratio of the neutron flux and neutron kerma in the phantom object with biological sample and without it for different placements

r(x;y), cm	(3;0)	(10;0)	(17;0)	(10;3)	(10;-3)
$\Phi_{b.t.}/\Phi_{air}$	9,91E-01	9,91E-01	9,91E-01	9,91E-01	9,91E-01
$K_{b.t.}/K_{air}$	1,72E-01	1,72E-01	1,72E-01	1,72E-01	1,72E-01

Conclusion

Thus, a scheme for absorbed dose calculating at irradiation with epithermal neutron beam the phantom object with biological samples inside has been created. Such a phantom object is destined for experimental studies on irradiation of biological samples (tumors) and allows accurate to obtain the absorbed dose values. With the help of the proposed phantom object, it is possible to estimate the irradiation effect of epithelial neutrons on tumor in vitro.

Thank you for attention!

Благодарю за внимание!