Project of an experiment to search for neutron-antineutron oscillations at reactor WWR-M

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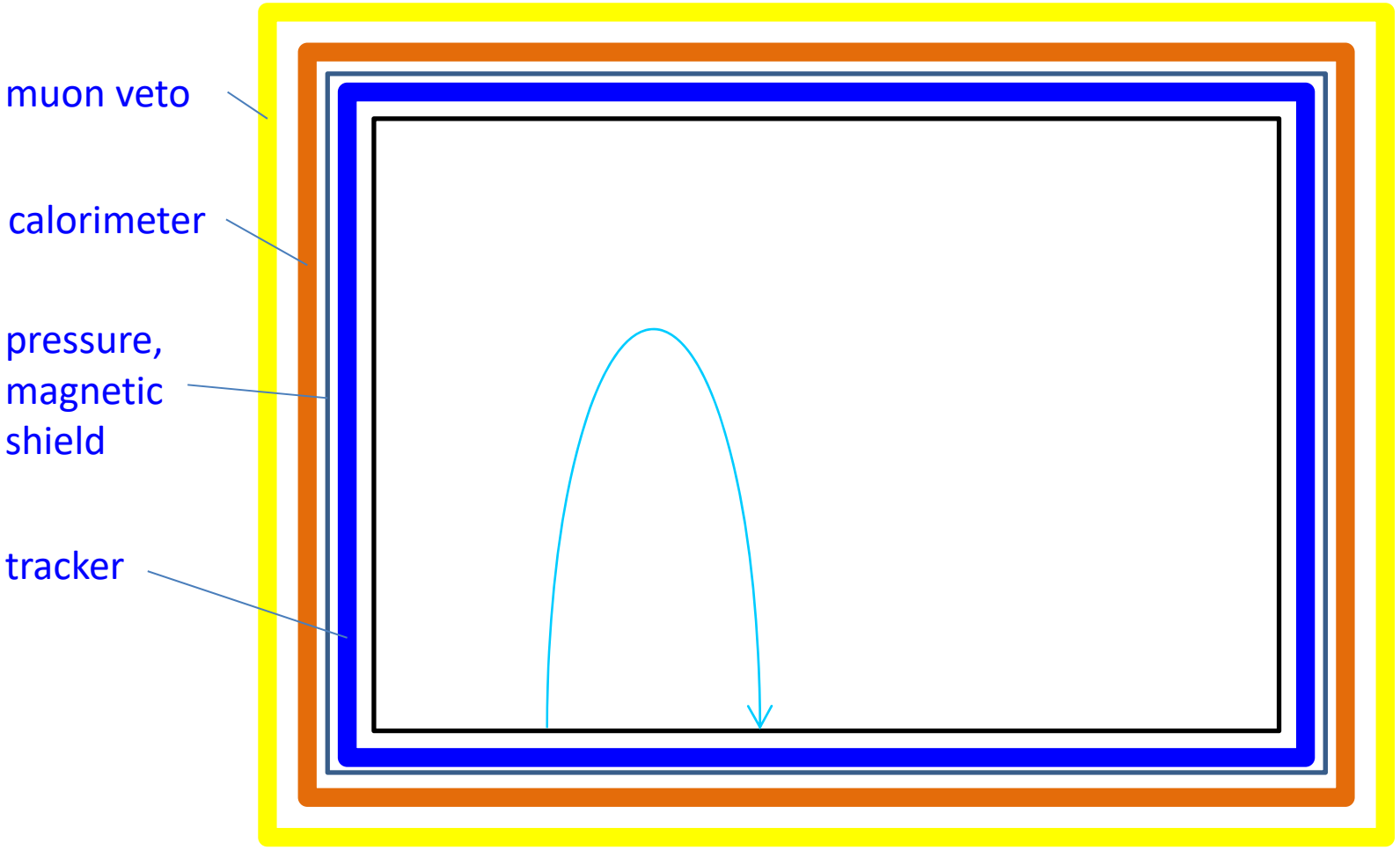
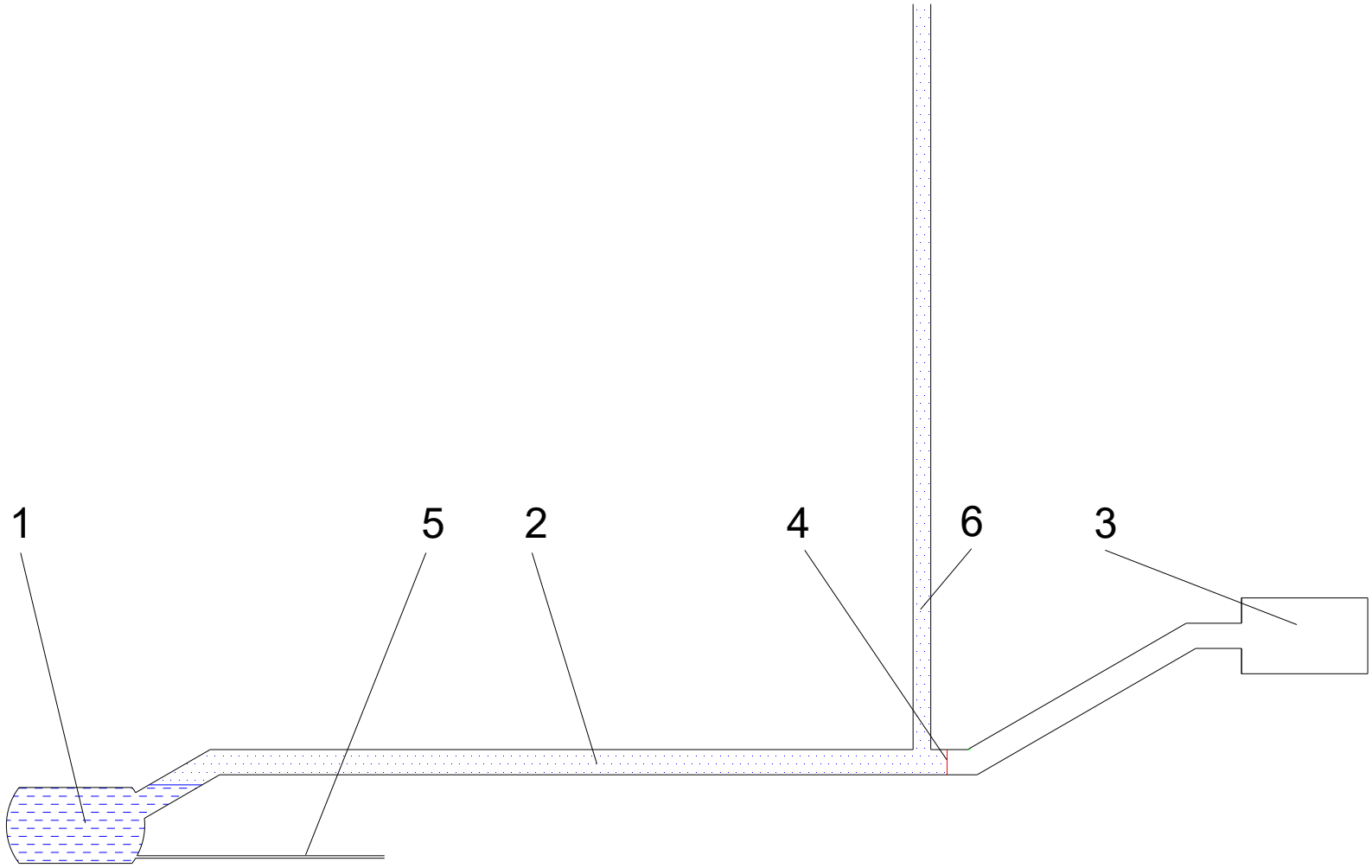
Particle Physics with Neutrons at the ESS
Stockholm, Sweden, 10-14 December 2018

NNbar via UCN



$N \cdot t^2$ – discovery potential

MC model of UCN source at reactor WWR-M



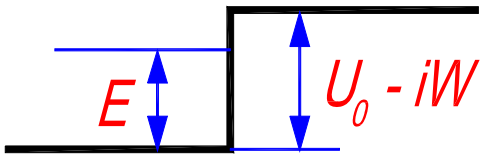
(*1*) source chamber; (*2*) neutron guide; (*3*) UCN trap; (*4*) membrane in front of the inlet to the UCN trap;(*5*) pipe for filling the chamber; (*6*) pipeline for evacuation of the chamber (UCN gravitational shutter)

What is the probability for UCÑ to be reflected?

$$\tilde{R} = \left| \frac{k_1 - k_2}{k_1 + k_2} \right|^2 \qquad k_1^2 = \frac{2m\tilde{E}_\perp}{\hbar^2} \qquad k_2^2 = \frac{2m}{\hbar^2}\left(\tilde{E}_\perp - \tilde{U}\right)$$

$$\tilde{U} = \tilde{U}_0 - i\tilde{W} \qquad \tilde{\eta} = \frac{\tilde{W}}{\tilde{U}_0}$$

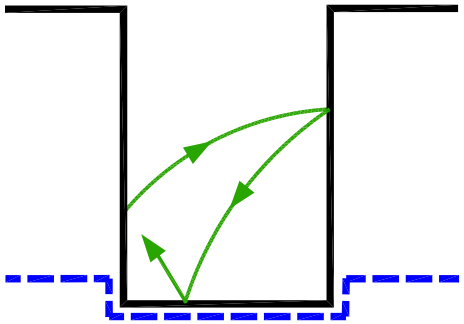
$$\tilde{R} = \left| \frac{1 - \sqrt{1 - \frac{\tilde{U}_0}{\tilde{E}_\perp}(1 - i\tilde{\eta})}}{1 + \sqrt{1 - \frac{\tilde{U}_0}{\tilde{E}_\perp}(1 - i\tilde{\eta})}} \right|^2$$



We can consider two cases:

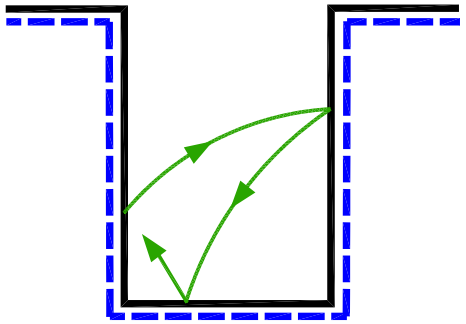
1. $\tilde{R} = 0$

(pessimistic case)



2. $\tilde{R} = \tilde{R}\,(\eta = 0.2) \approx 0.8$

(optimistic case)

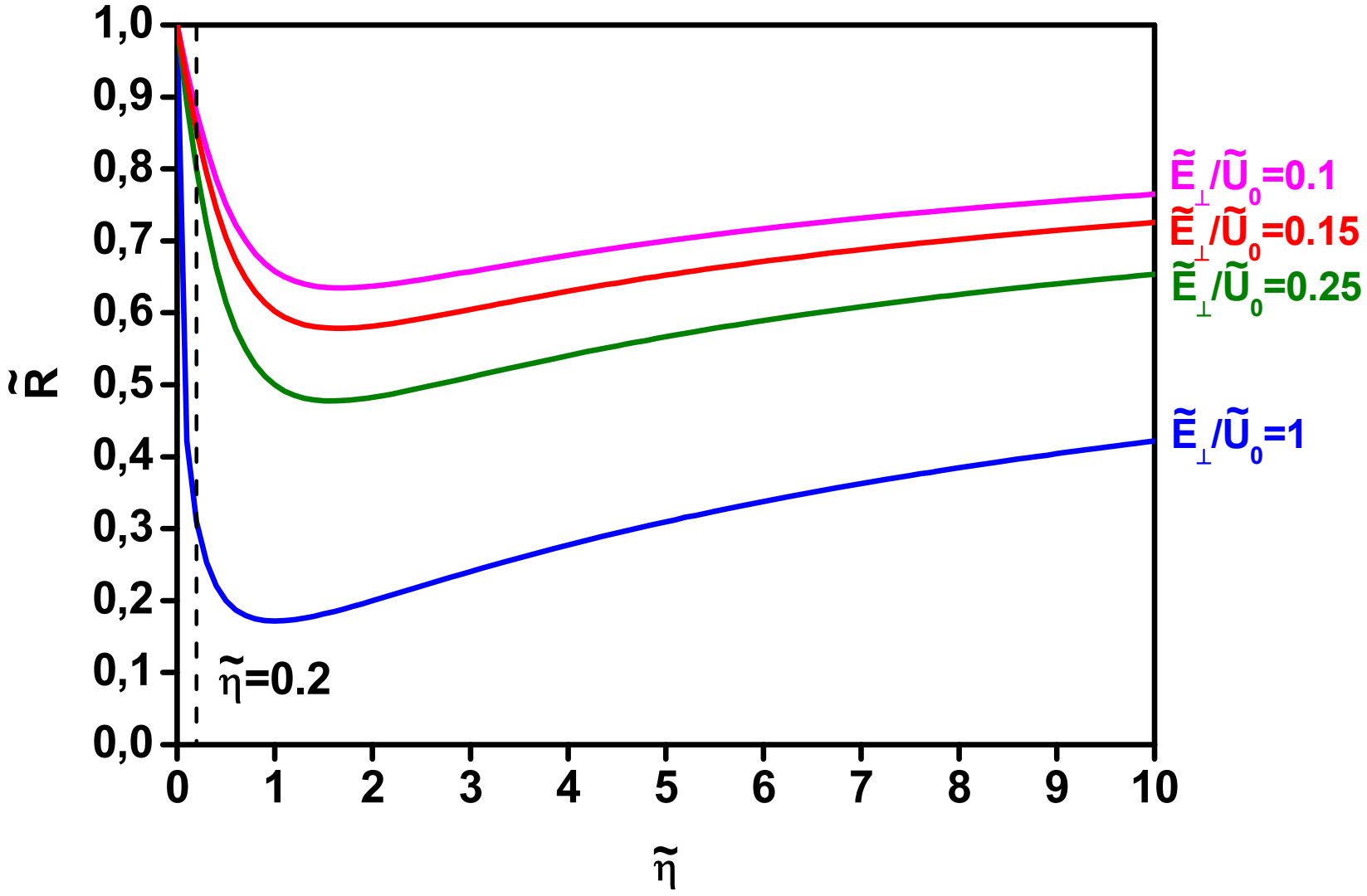


$U_0 - iW$ for n ——

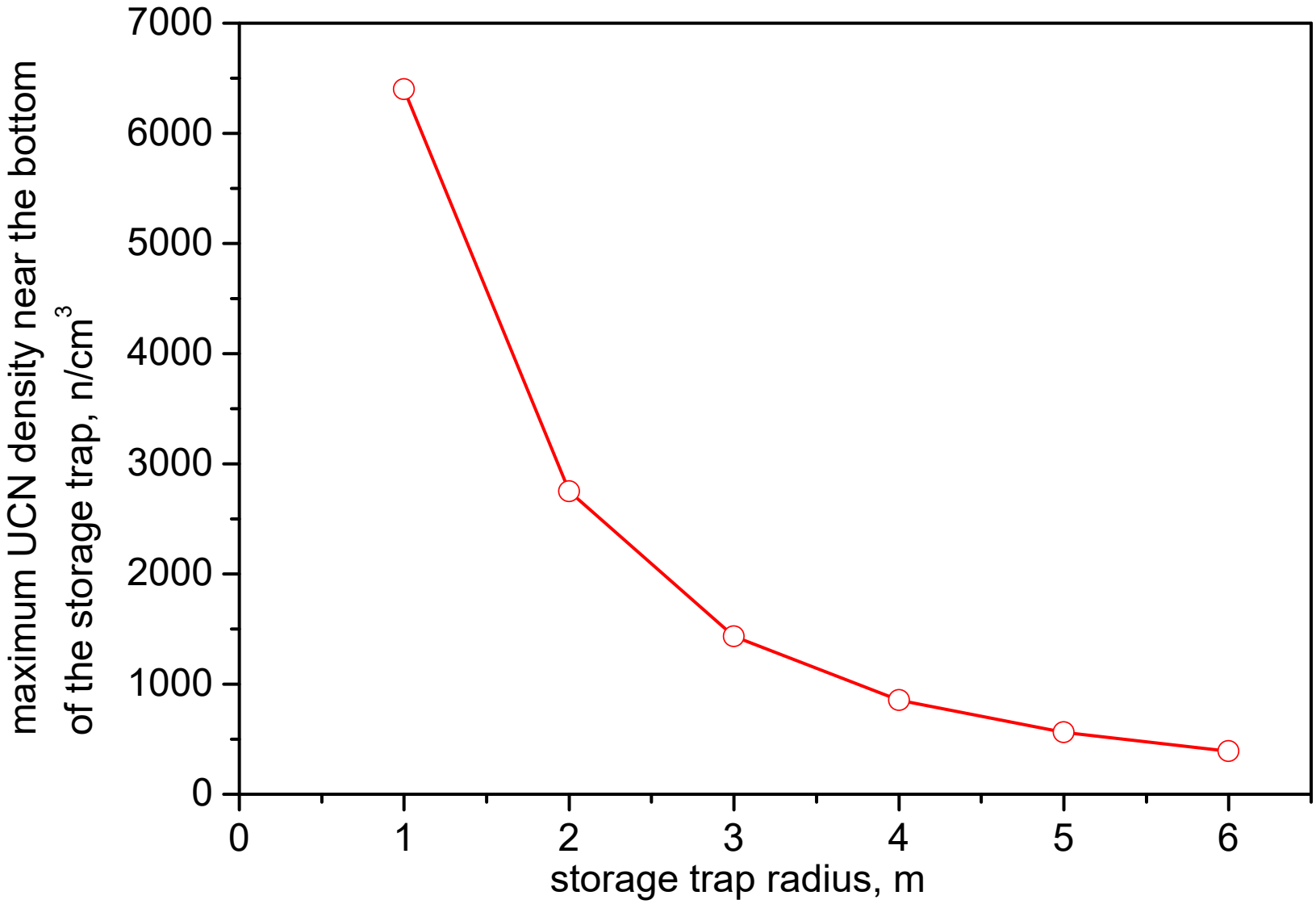
$\tilde{U}_0 - i\tilde{W}$ for ñ – – –

4th UCN Workshop, Russia 2003
http://nrd.pnpi.spb.ru/UCN_CNS/ucn/fomin.pdf

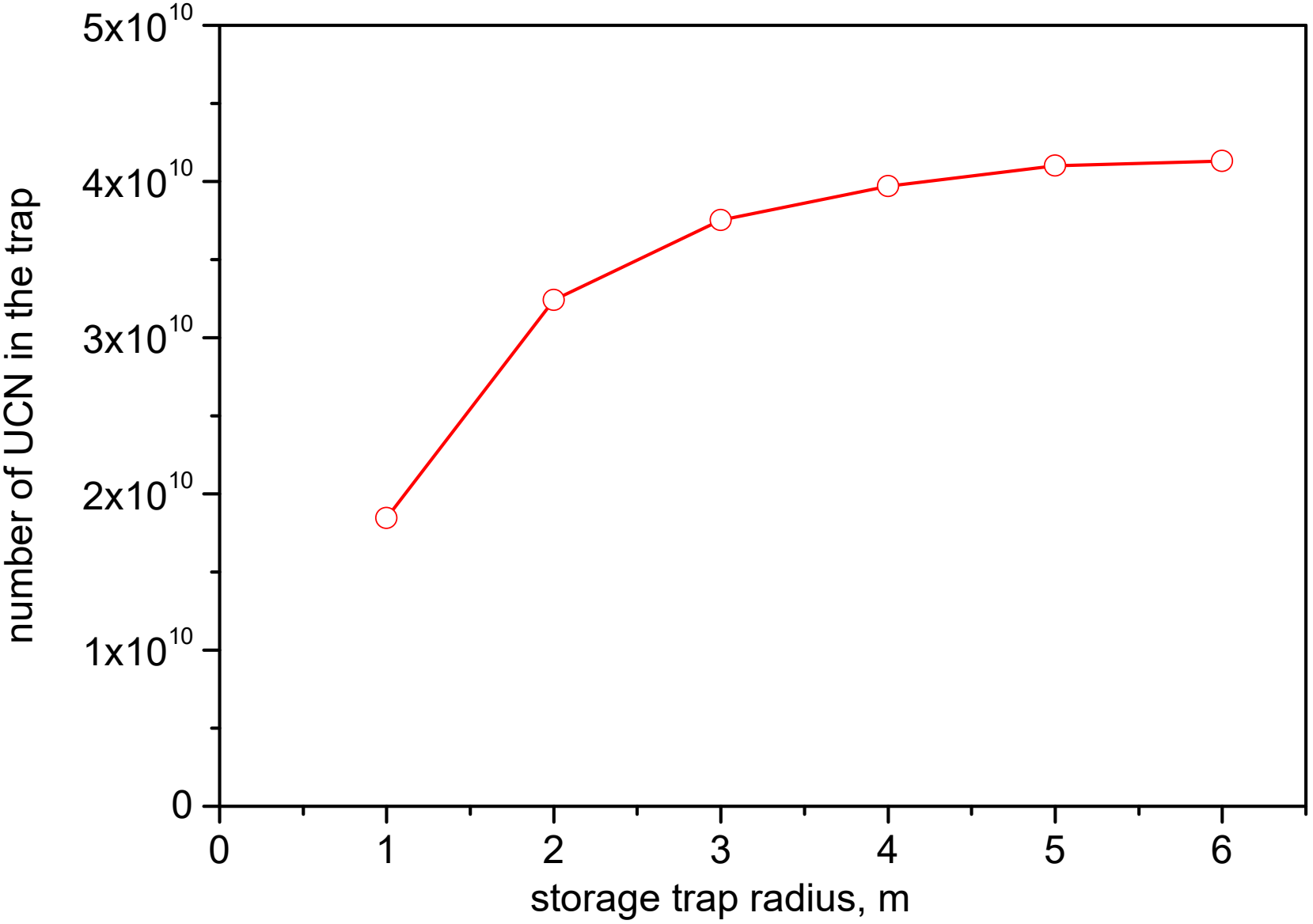
Reflection coefficient for UCÑ



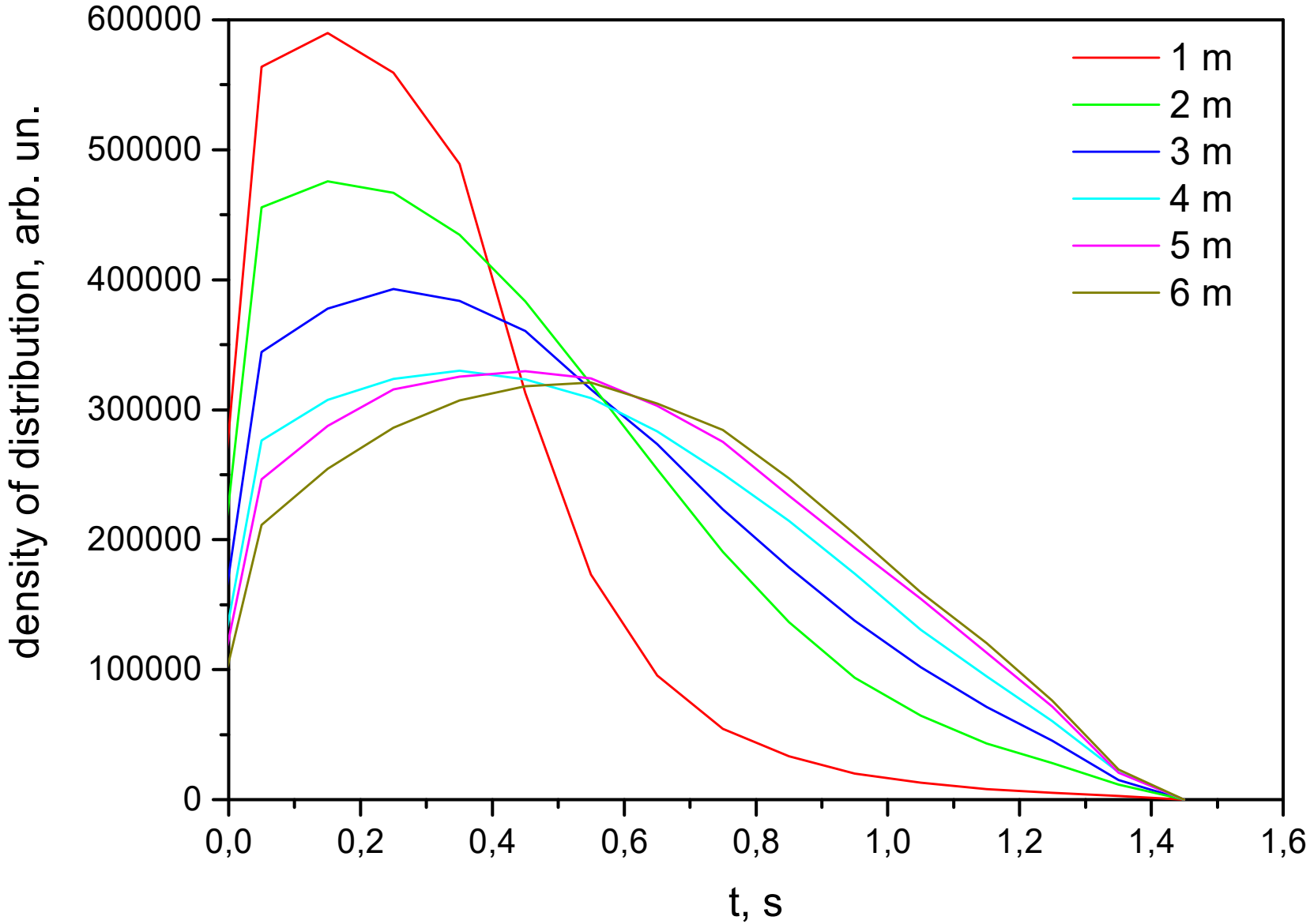
UCN density for different storage trap radius



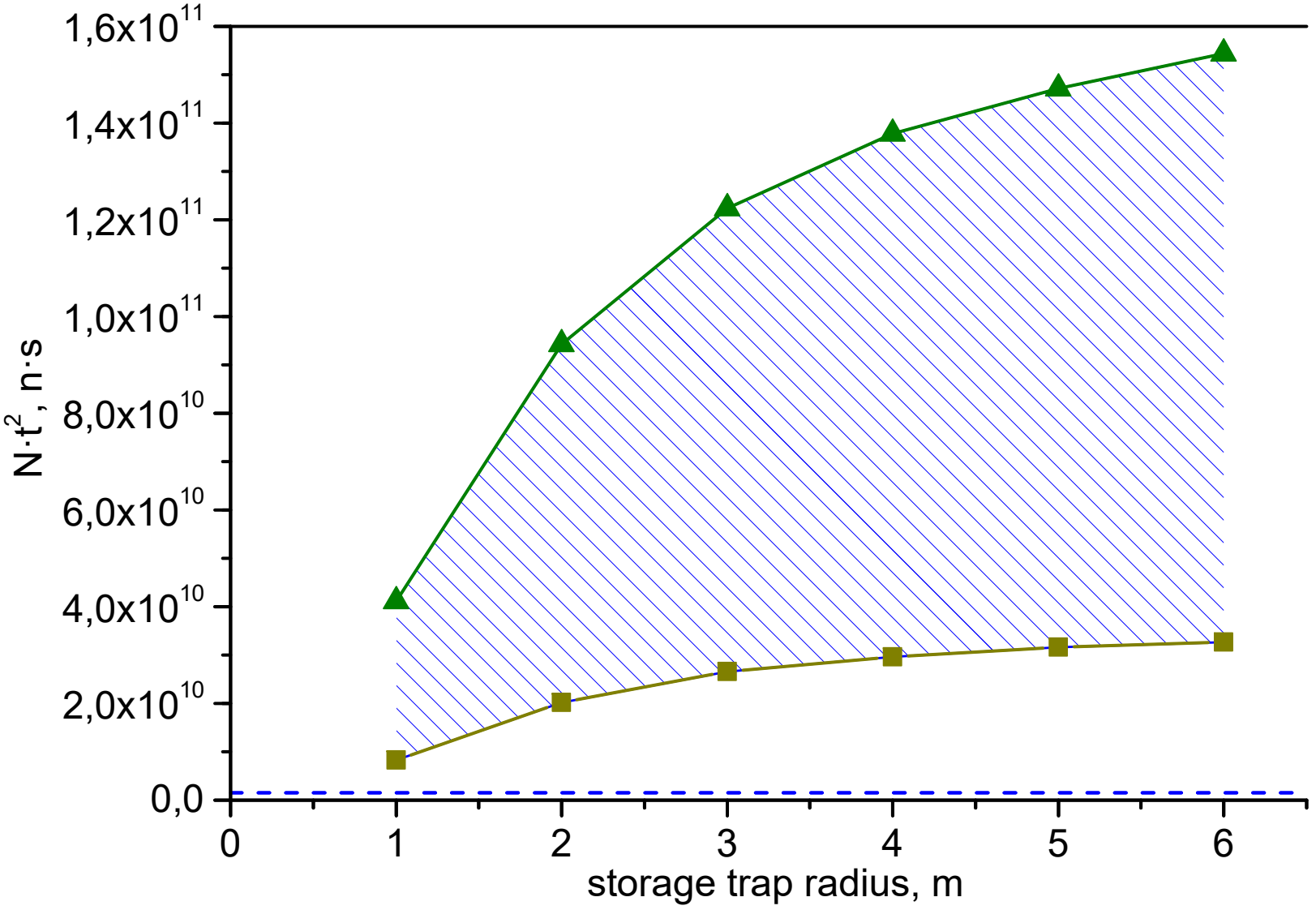
UCN number in the trap for different storage trap radius



UCN time of flight for different storage trap radius



$N \cdot t^2$ for different storage trap radius



Oscillation period

$$\tau_{n\tilde{n}} = \sqrt{\frac{(N \cdot t^2) \cdot T \cdot \varepsilon}{\tilde{N}}}$$

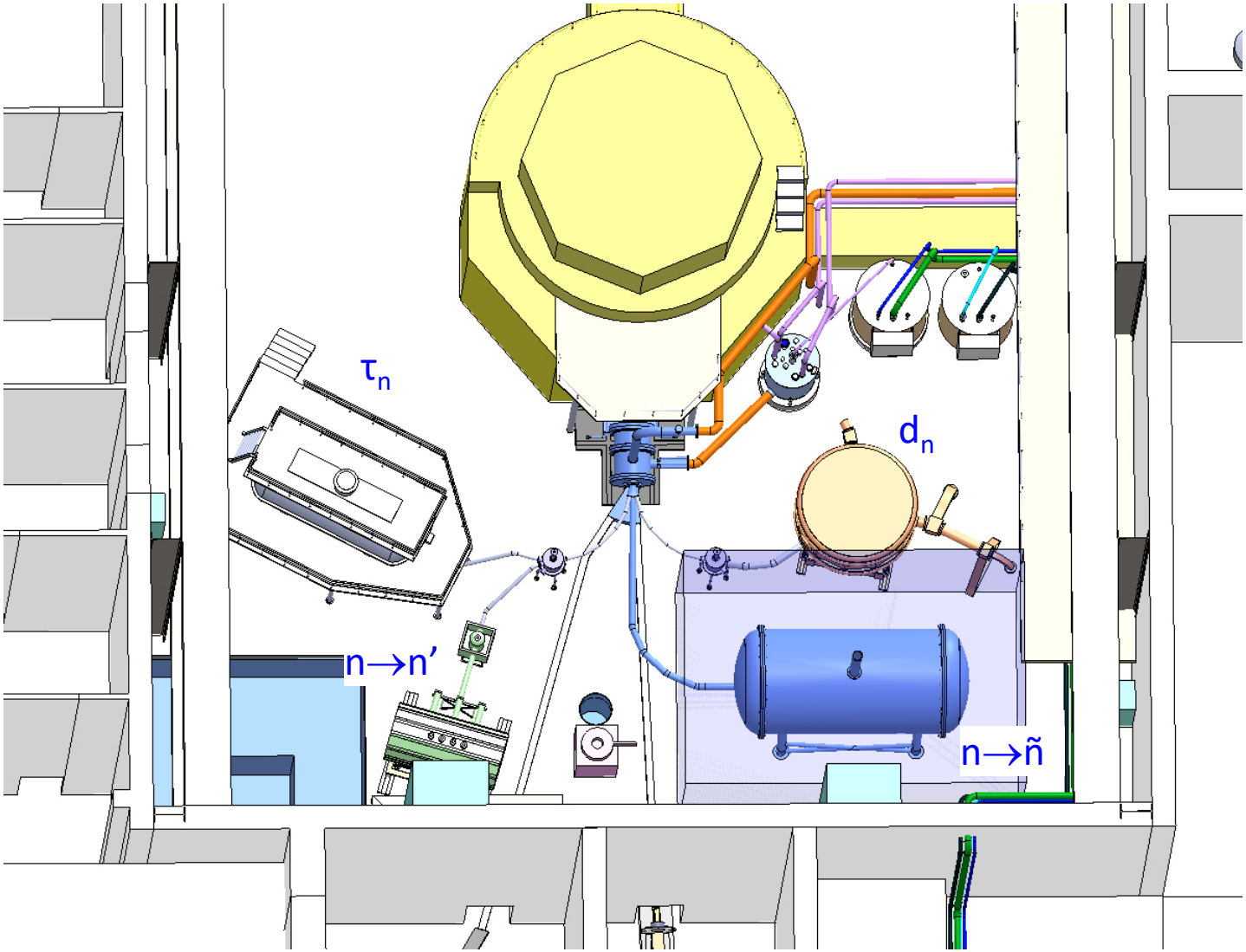
$$T \sim 3 \; years$$

$$\varepsilon = 0.9$$

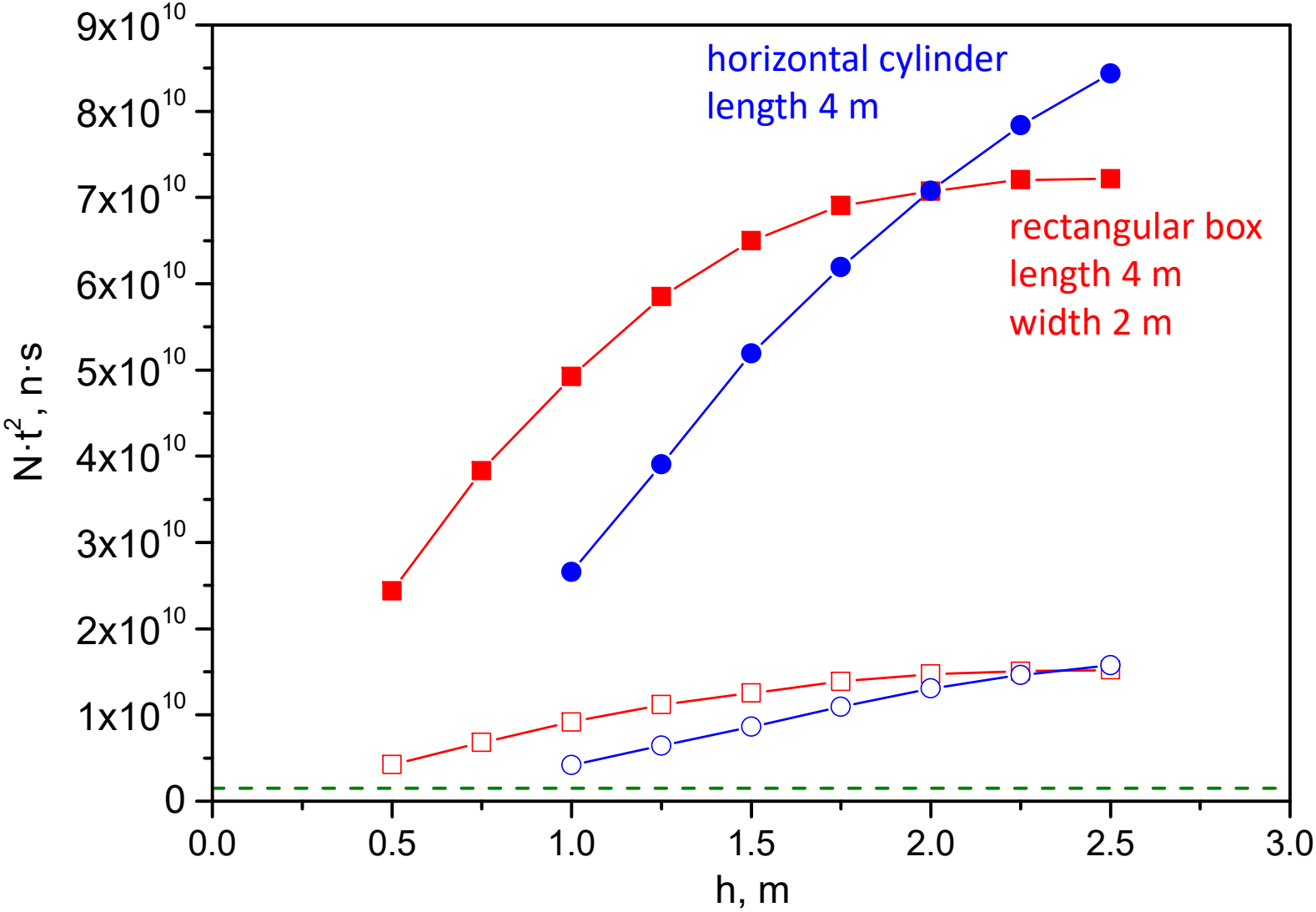
$$\tilde{N} = 0 \; (\leq 2.3 \; \textbf{at 90\% CL})$$

$$\tau_{n\tilde{n}} \geq (1 \div 2) \cdot 10^9 \; \textbf{s (90\% CL)}$$

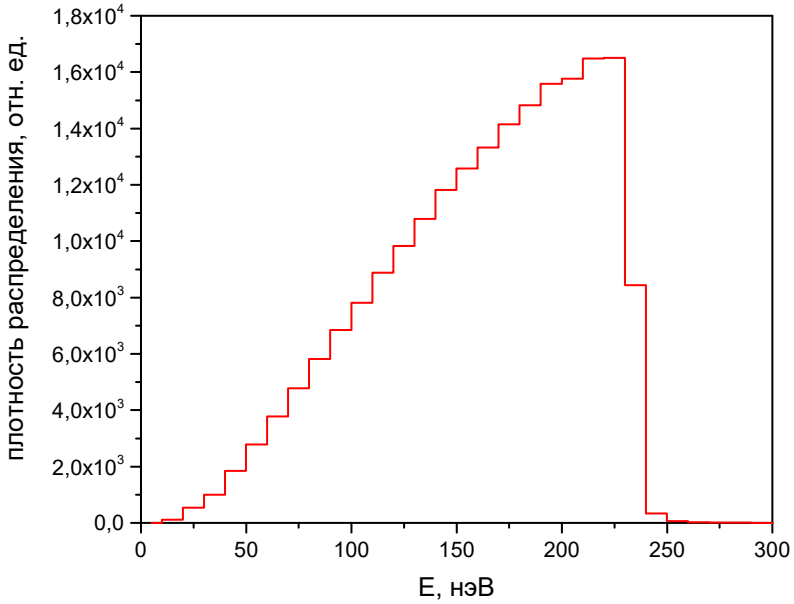
UCN facilities at reactor WWR-M

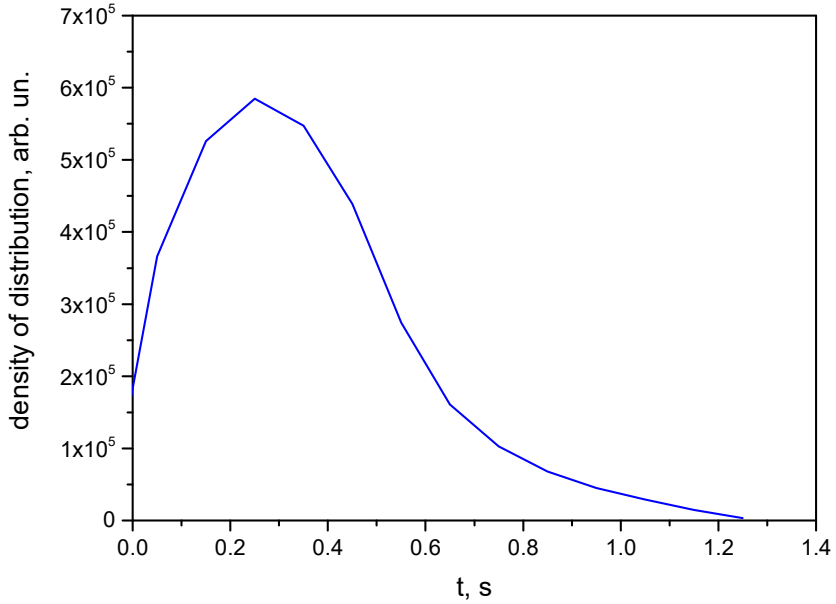


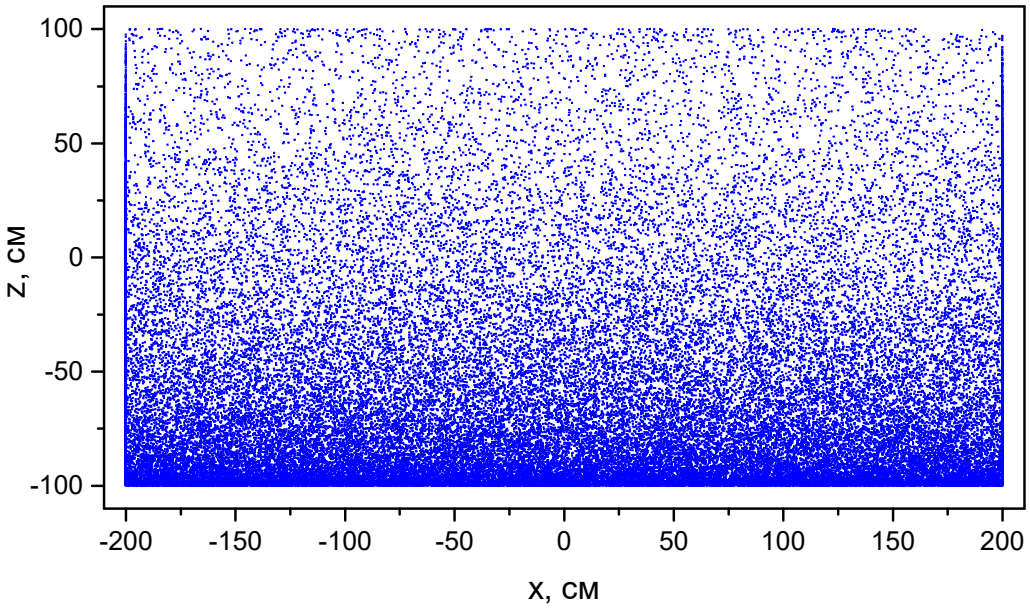
$N \cdot t^2$ for different storage trap height

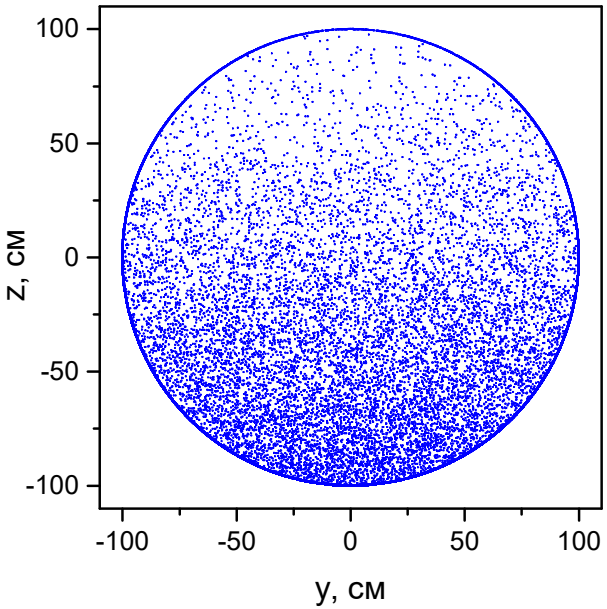


UCN storage simulation

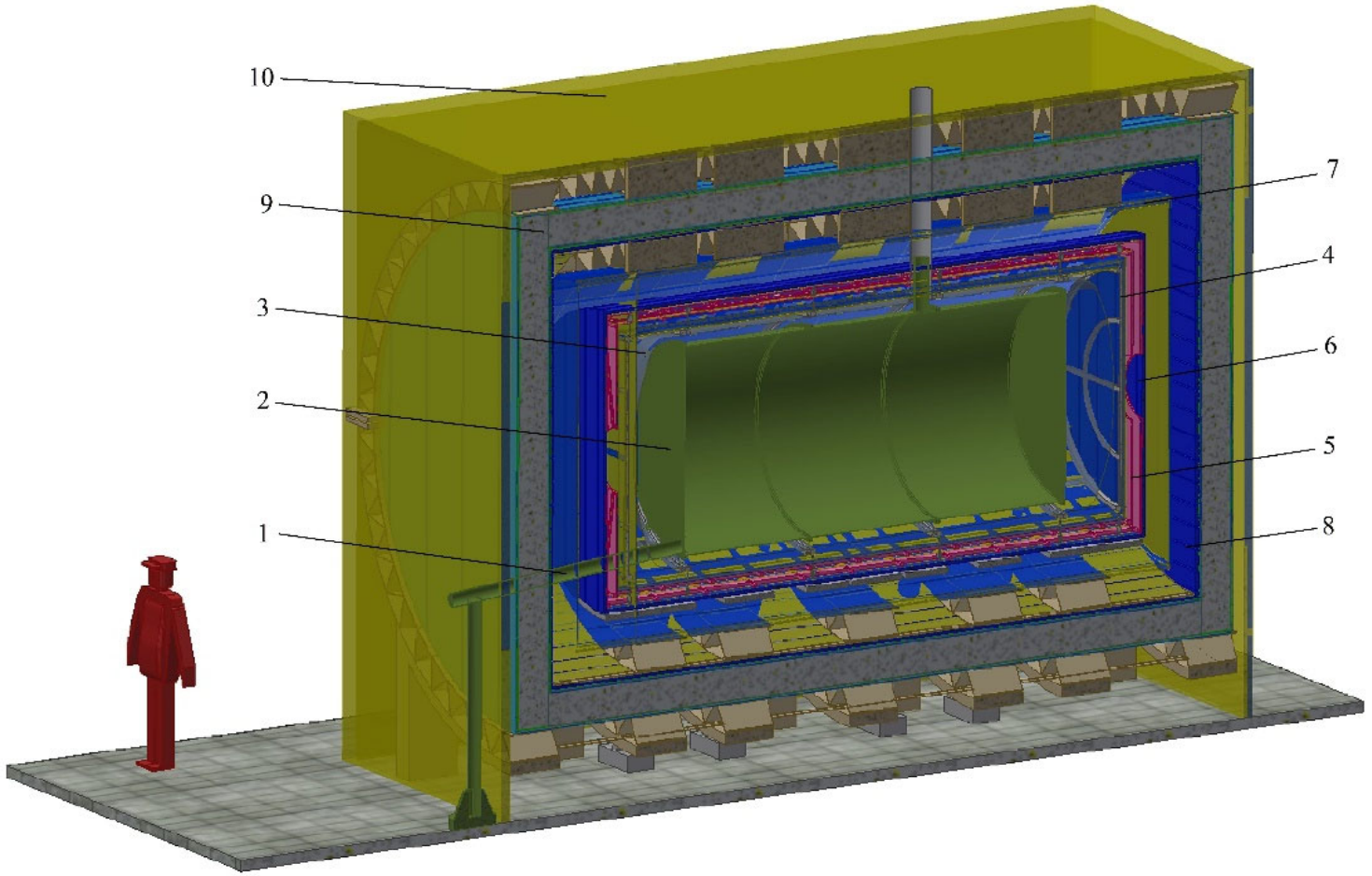






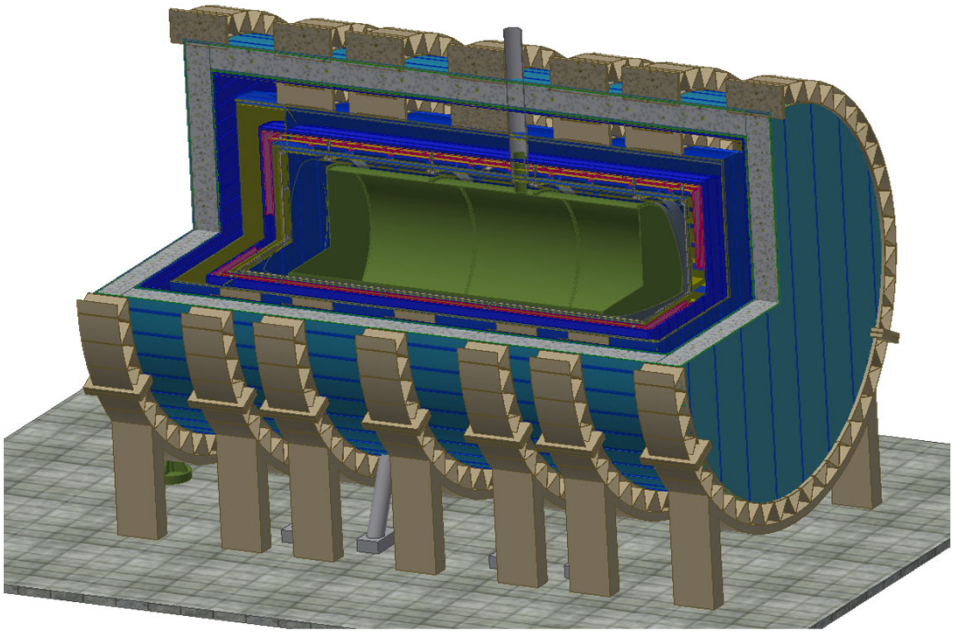


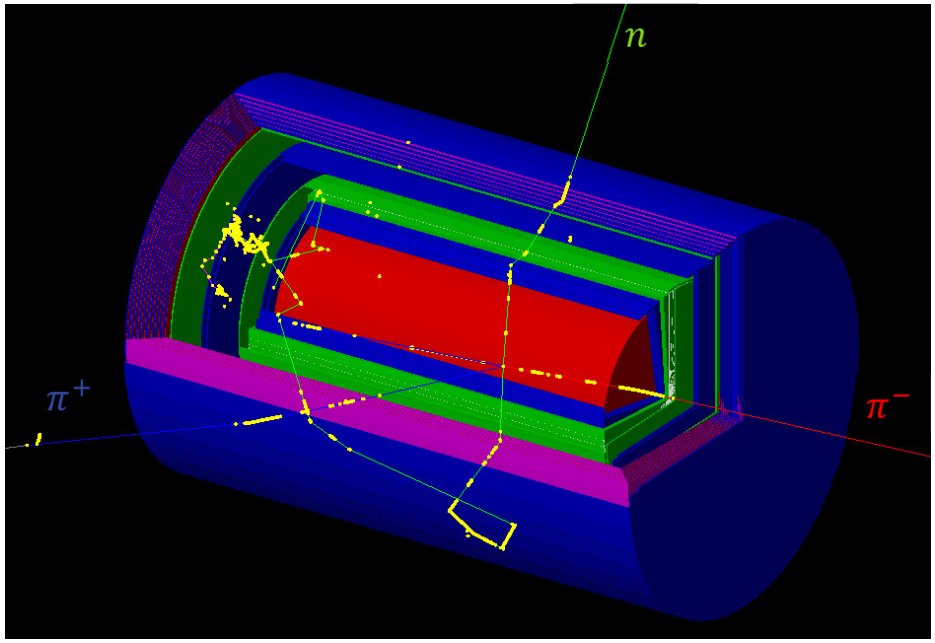
Design of the setup



1 – neutron guide, 2 - UCN trap, 3 - vacuum chamber, 4 – trek detector (inner part), 5 - magnetic shield, 6 - hodoscope (internal part), 7 - trek detector (middle part), 8 - hodoscope (external part), 9 - calorimeter, 10 – active shielding

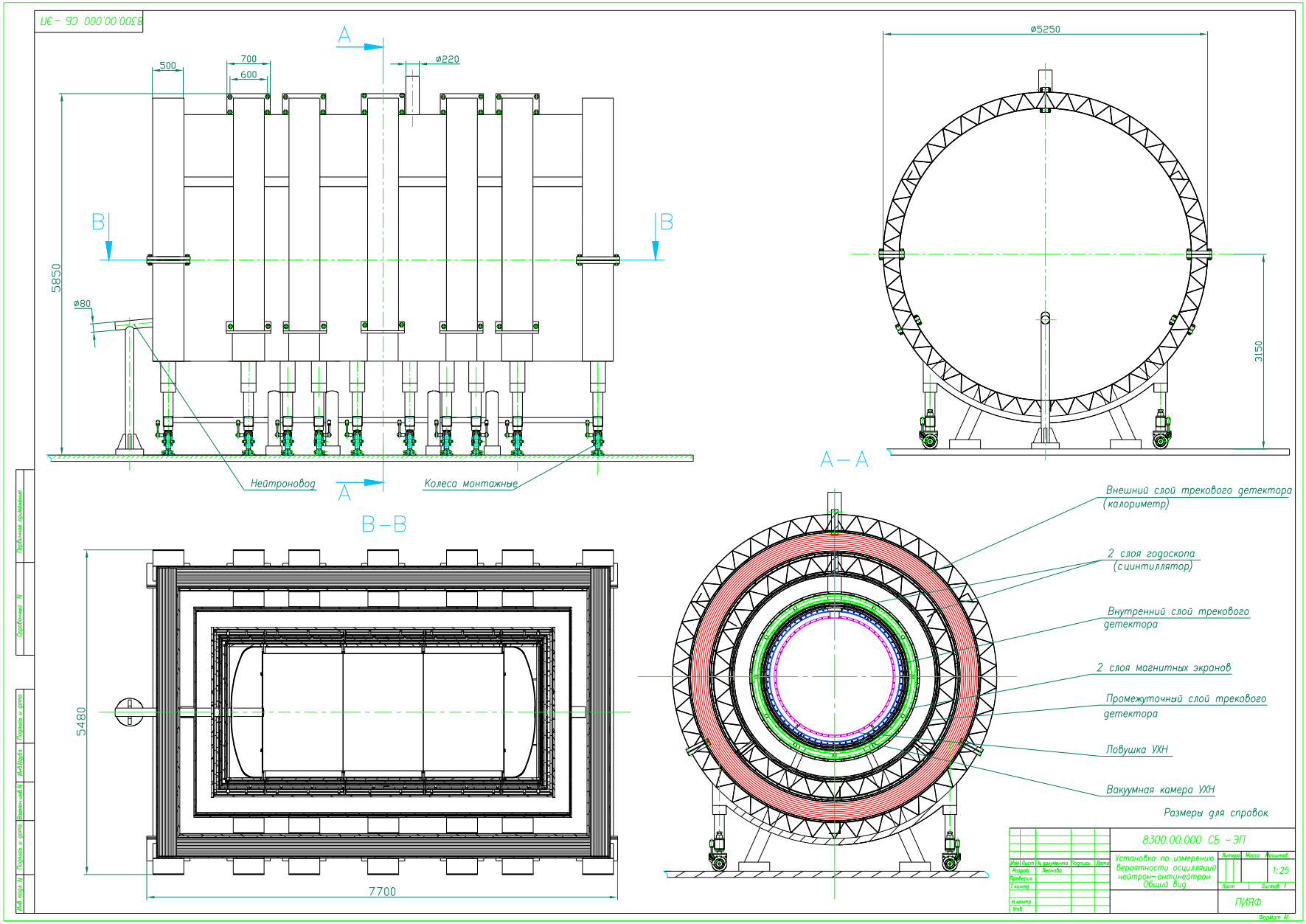
GEANT4 simulation



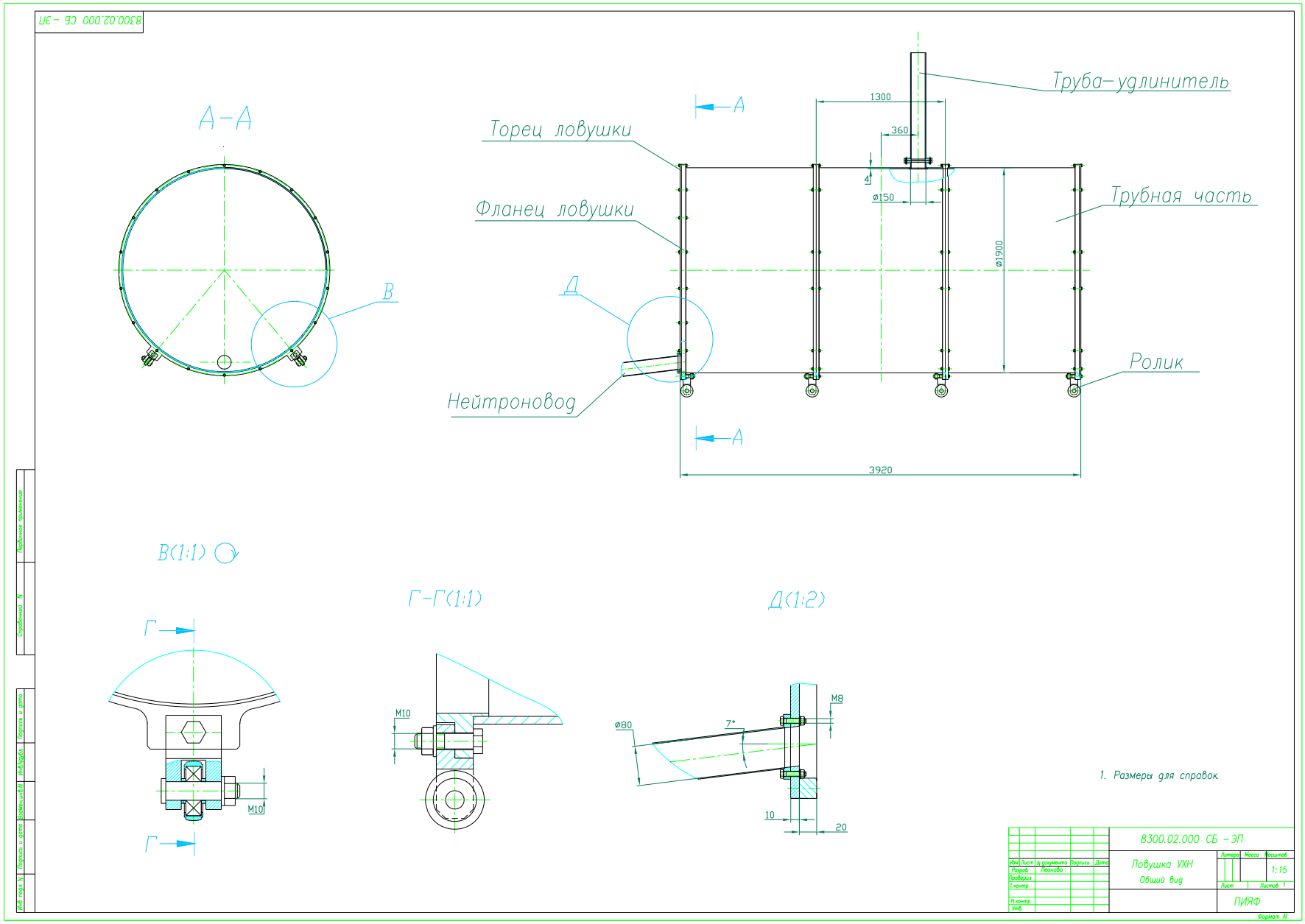


The detector efficiency is calculated to be (68±2)%

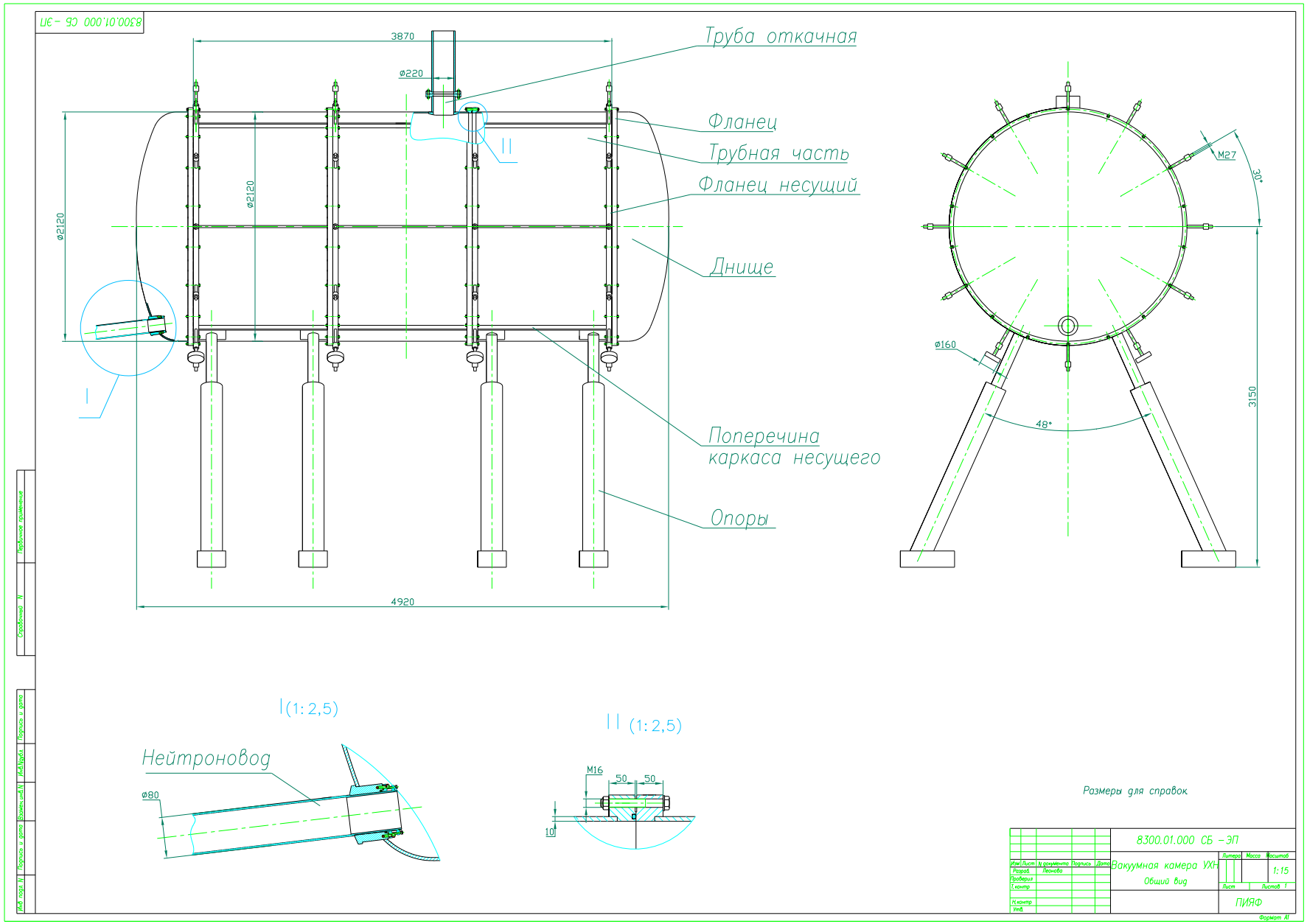
Design of the setup



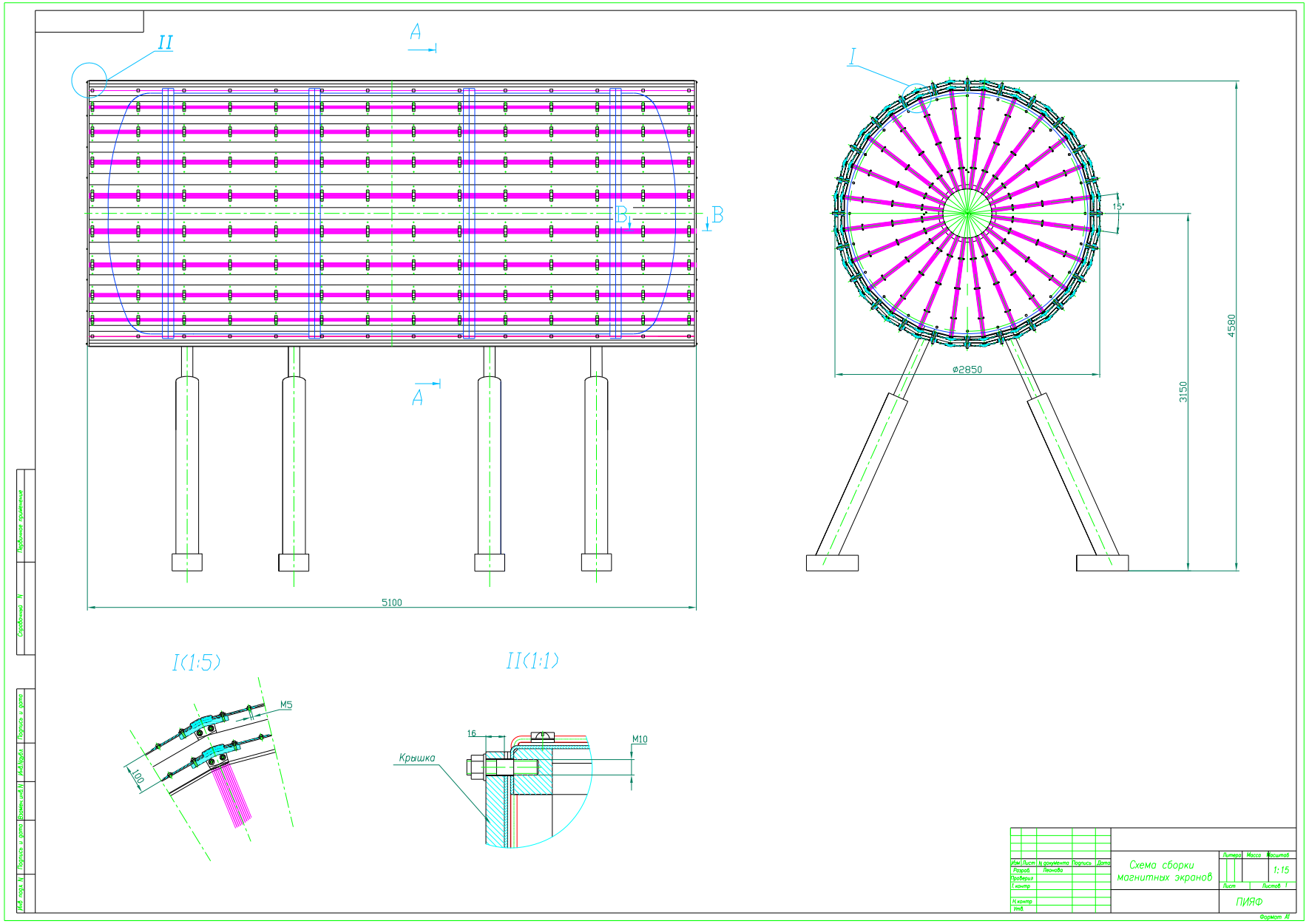
UCN trap


8300.02.000 СБ – ЭП
А–А
В
Труба–удлинитель
Торец ловушки
Фланец ловушки
Трубная часть
Ролик
Нейтроновод
Д
А
1300
360
4
ø150
ø1900
3920
В(1:1)
Г–Г(1:1)
Д(1:2)
Г
M10
M10
M8
ø80
7°
10
20
1. Размеры для справок.
8300.02.000 СБ – ЭП
Ловушка УХН
Общий вид
Литера
Масса
Масштаб
1:15
Лист
Листов 1
ПИЯФ
Формат А1

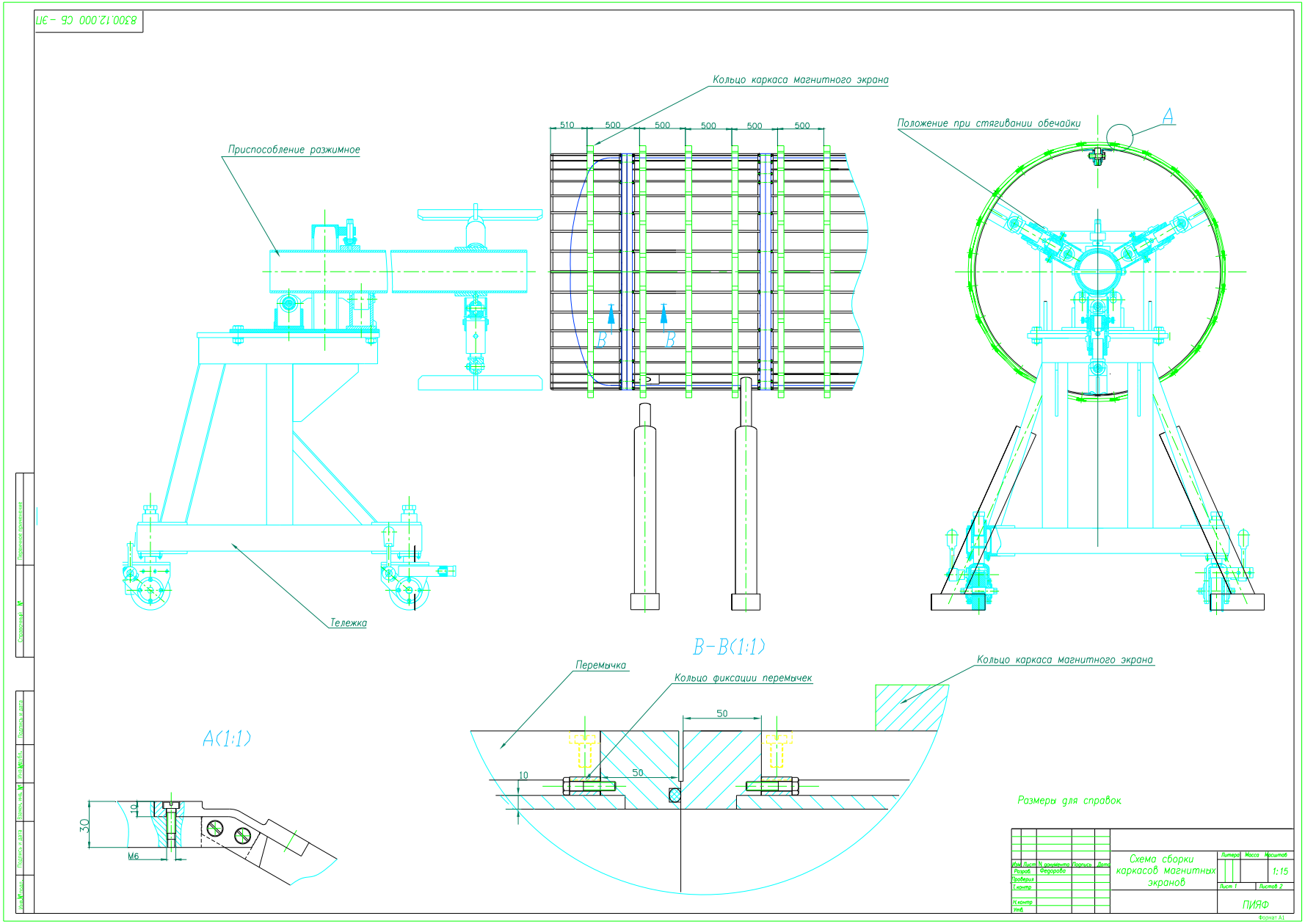
Vacuum chamber



Magnetic shielding

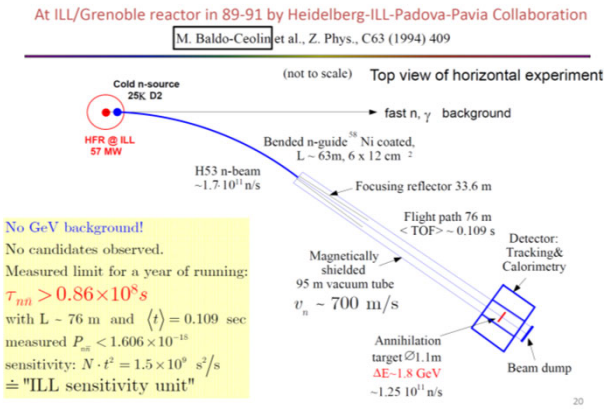


Magnetic shielding



Size matters

ILL



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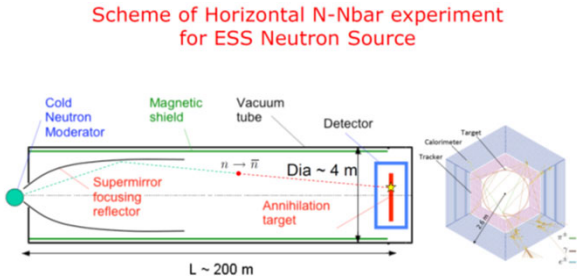
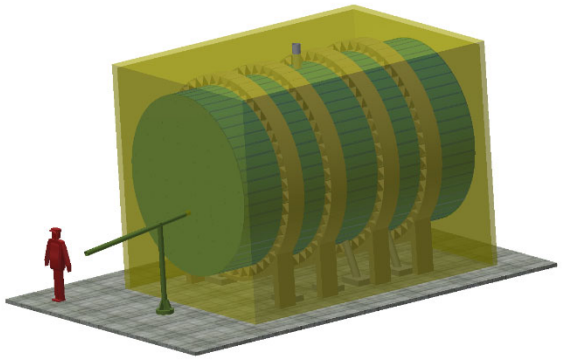


WWR-M



ESS

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WWR-M

Conclusion

1. Designed storage trap for NNbar oscillation experiment at reactor WWR-M: horizontal cylinder with diameter 2 m, length 4 m.

2. Increase of the experiment sensitivity is about $10 \div 40$ times to ILL level.

3. Oscillation period for 3 years:

$$\tau_{n\tilde{n}} \geq (0.6 \div 1.2) \cdot 10^9 \text{ s (90\% CL)}$$

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