FLNP JINR – CSNS IHEP (China)
Workshop on the neutron scattering technology and multi-disciplinary research

Development of cold neutron moderators at FLNP

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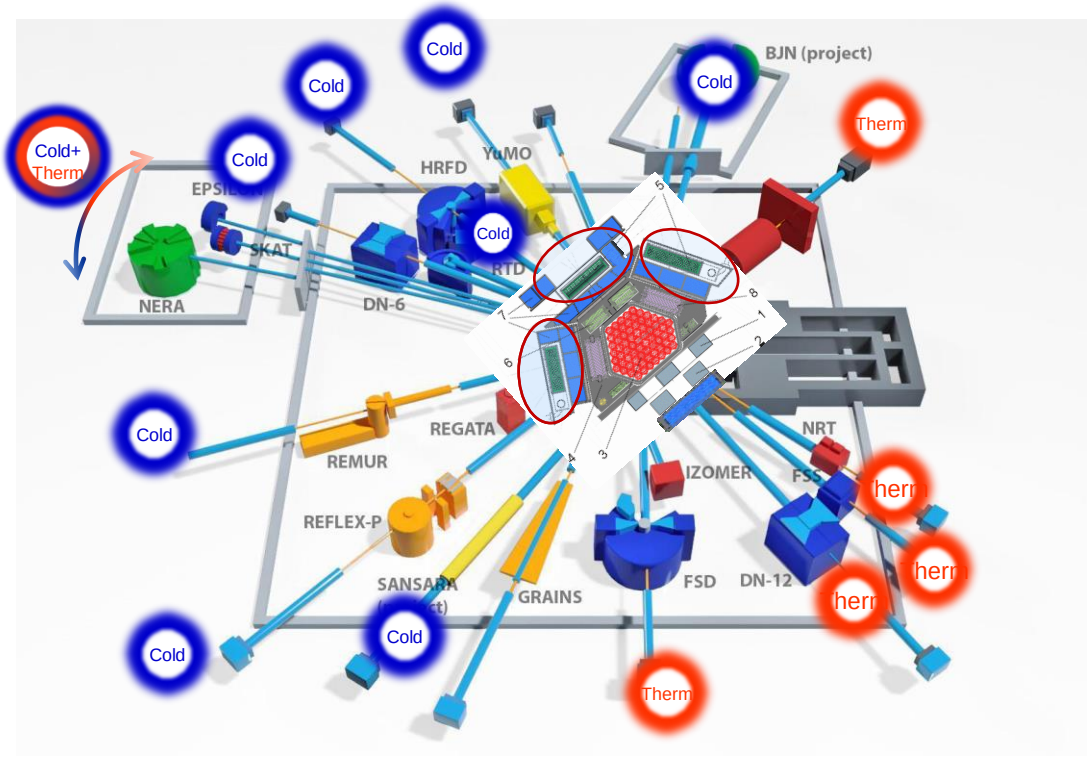
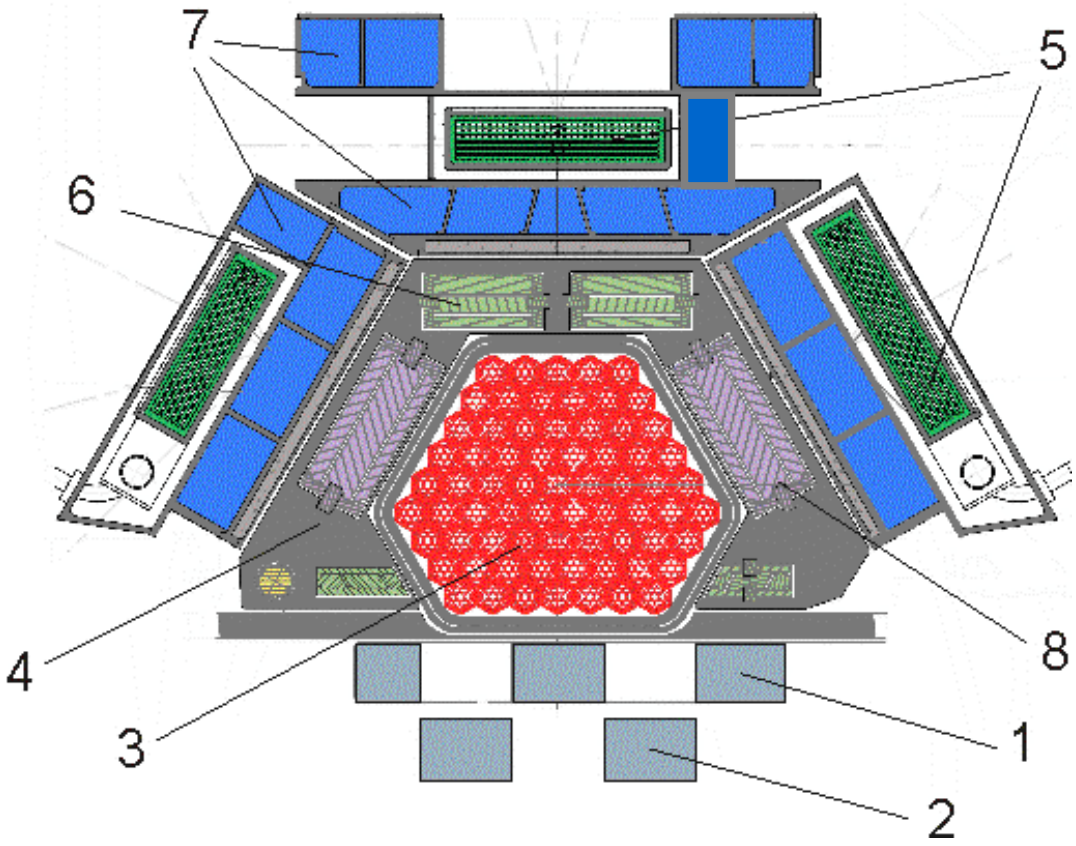
Frank Laboratory of Neutron Physics

Dubna, 2024

Complex of moderators of the IBR-2 reactor (cold moderators and ambient temperature water moderators)

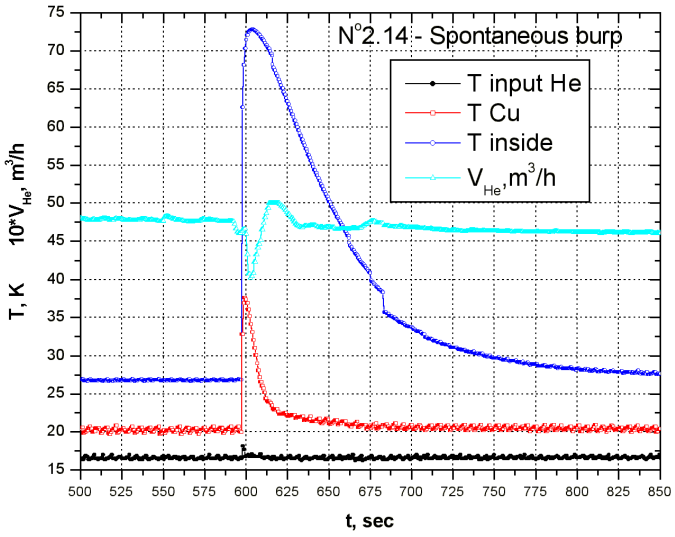


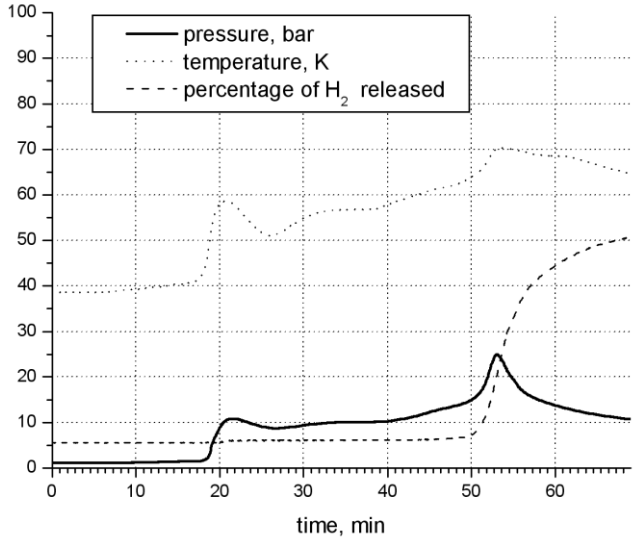
Complex of moderators of the IBR-2 pulsed reactor



1. Main moveable reflector,
2. Auxillary moveable reflector,
3. Fuel assembly,
4. Stationary reflector,
5. Cold moderators,
6. Emergency system,
7. Water moderators,
8. Control rods

Methane as a cold moderator material





Layer, 5 mm, T irrad.= 20-21K,

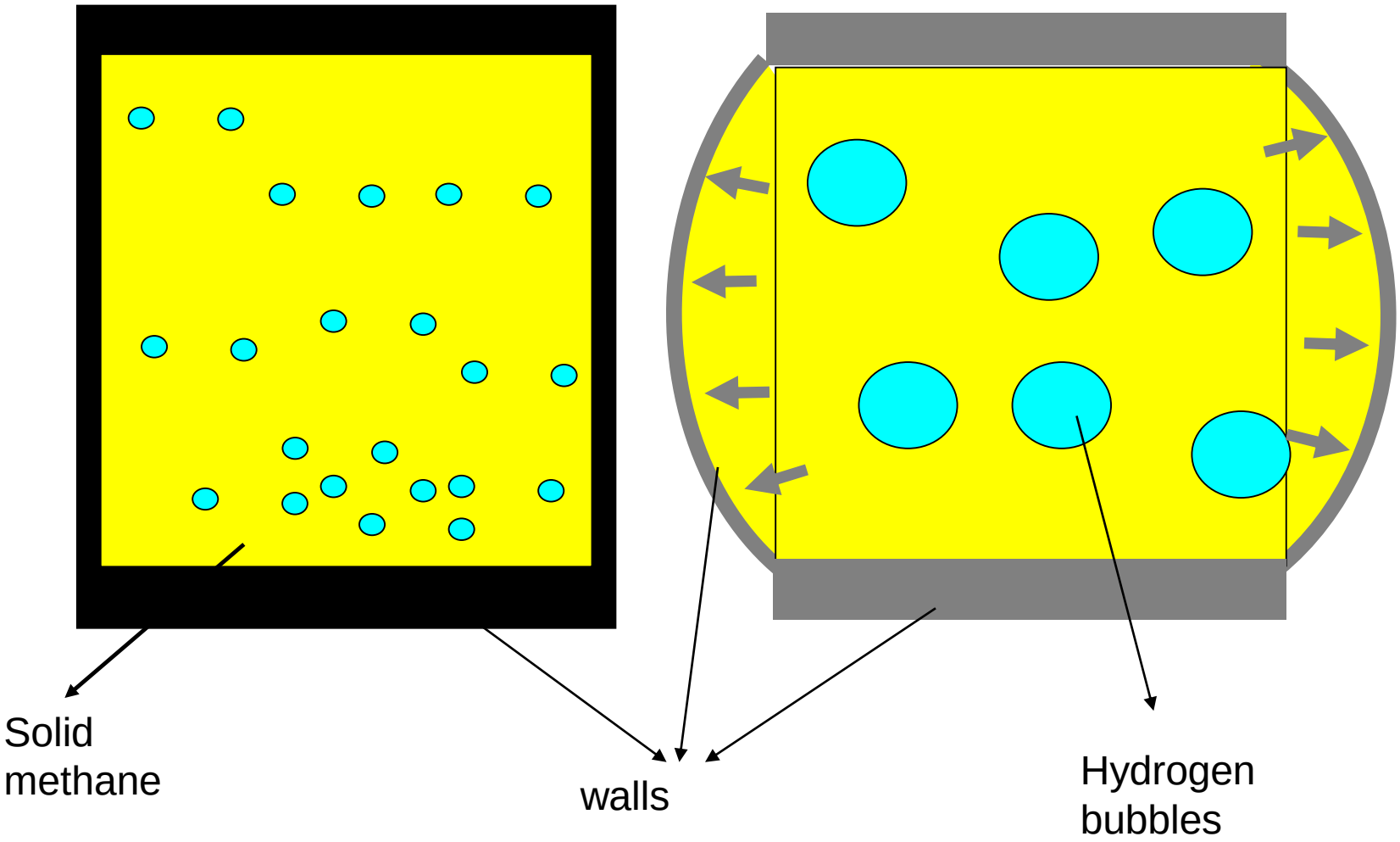
Irradiation time 30 h

*) 1 hour of irradiation ≡ 0.81 MGy

Experimental study of swelling of irradiated solid methane during annealing

Before annealing

At annealing



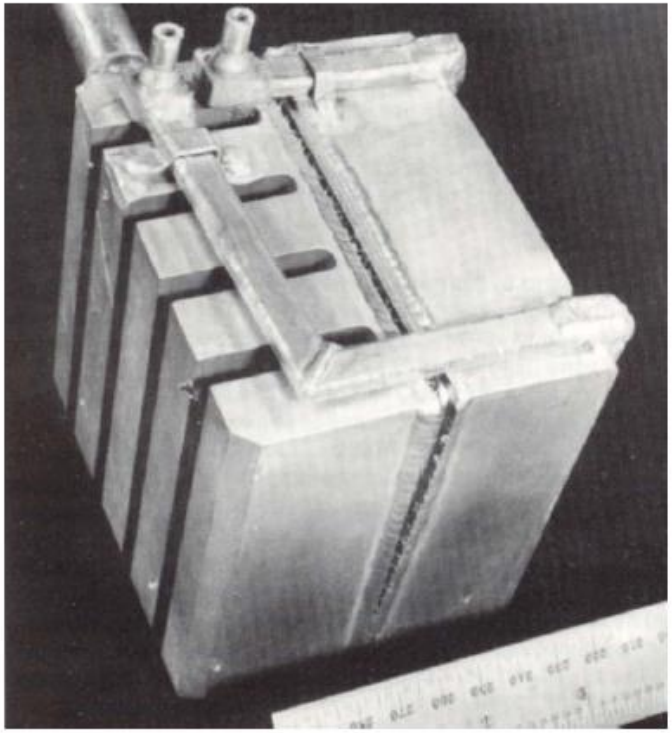


Figure 1

Ruptured solid methane moderator container

(IPNS Progress Report 1985 – 1986)

Radiolytic hydrogen production:

in solid methane:

- 3 10^{-7} mol/J for absorbed dose >> 10 kJ/g.

in mesithylene:

- 3.9 10^{-8} mol/J = 11.7 % of solid methane;

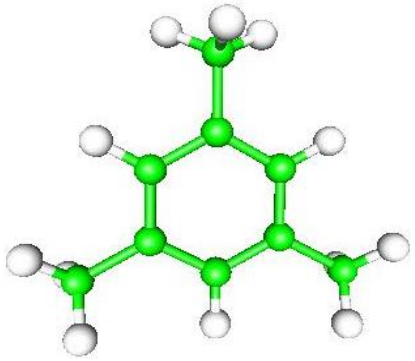
in mesithylene + toluene, 50 by 50 % :

- 1.8 10^{-8} mol/J = 5.5 % of methane.

Experimental results obtained at the URAM-2 facility (FLNP,JINR, Dubna)

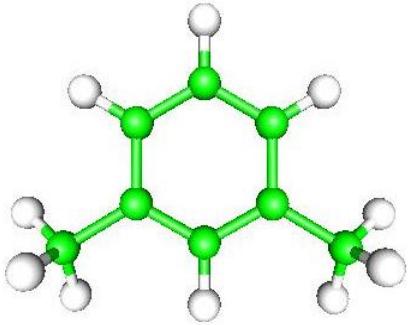
Solid mesitylene as a material for cold moderators

mesitylene



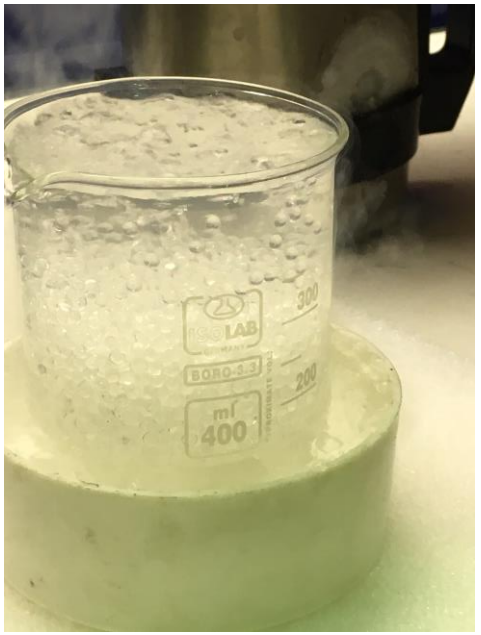
T_m = 227 K

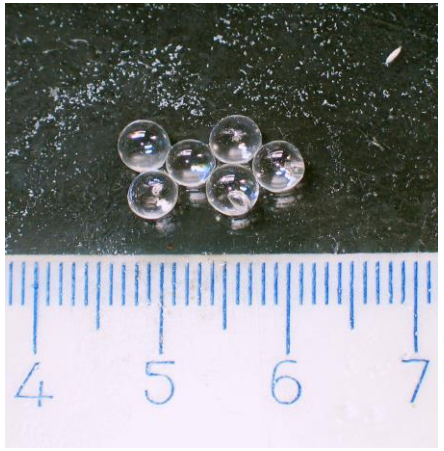
m-xylene



T_m = 225 K

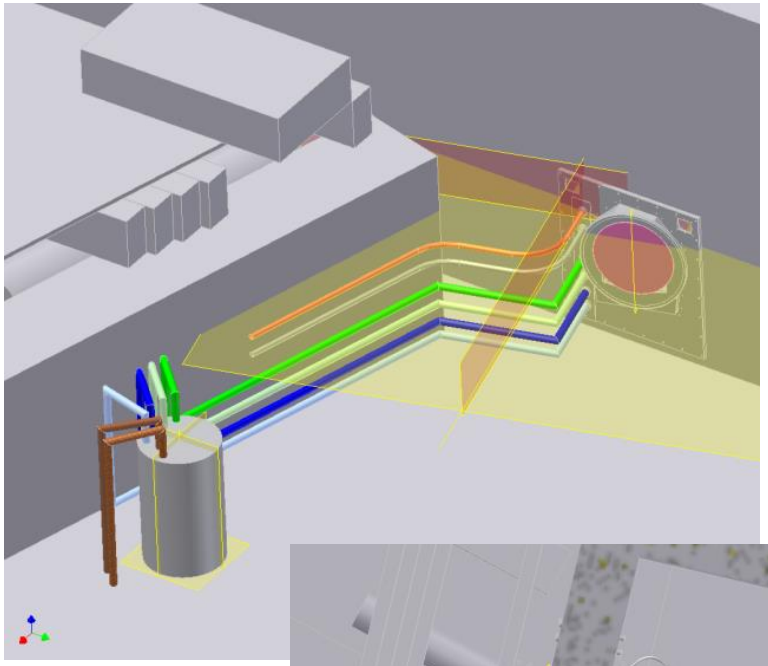
Solid beads of the frozen mixture of mesitylene and m-xylene

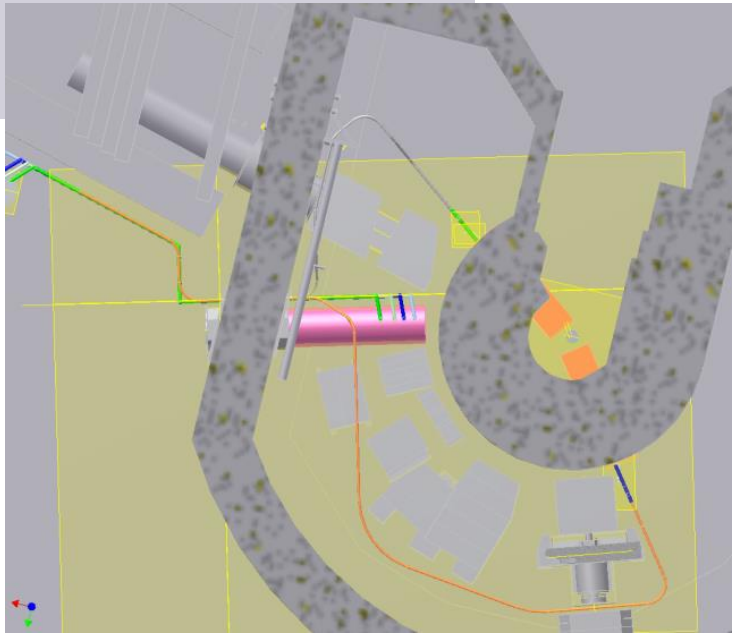




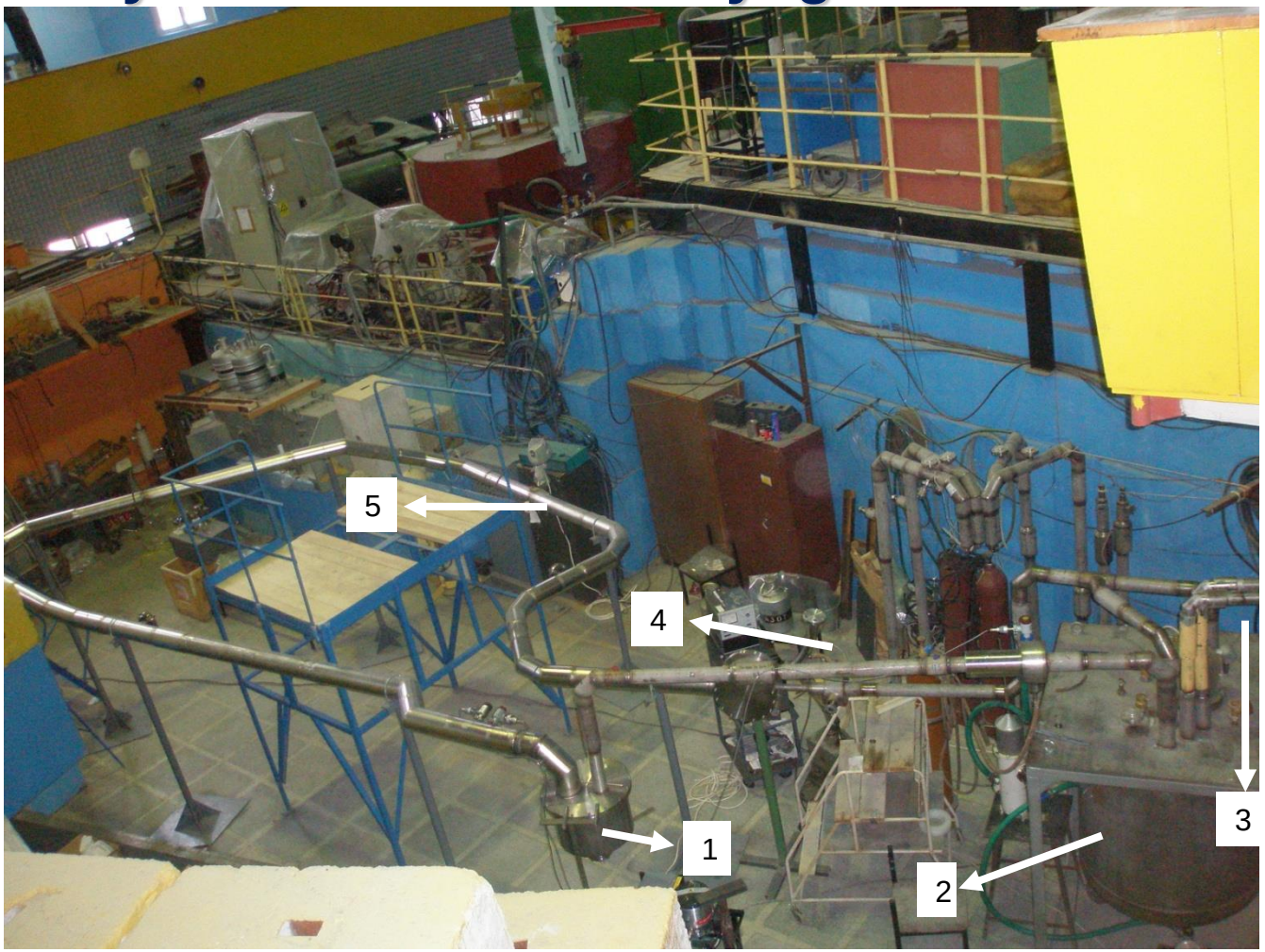
- **Mixture of mesitylene with m-xylene or pseudocumene is of glassy structure and has good neutron thermalization property and radiation resistance (no reaction of recombination of radicals).**
- **Not explosive material.**
- **Wide range of working temperatures of cold moderator: 20 - 150 K.**

Cryogenic transport pipeline for moderators of 2-3 and 7-10 beams of the IBR-2 reactor



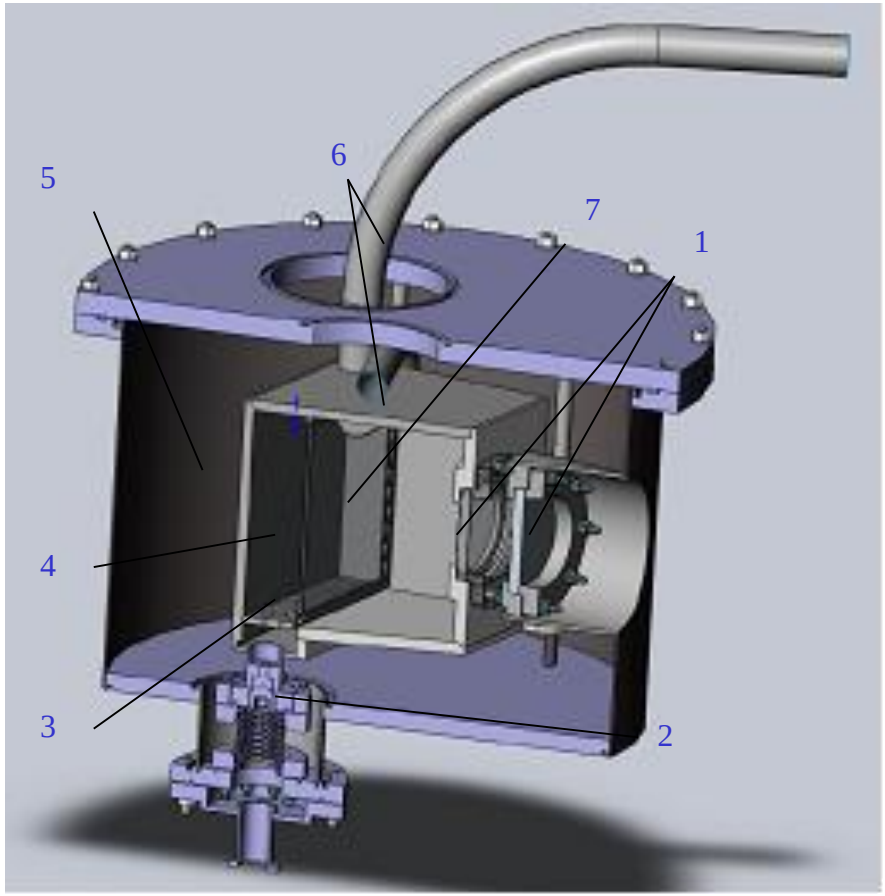


The mock up of the conveying path and technological system of the IBR-2 cryogenic moderator

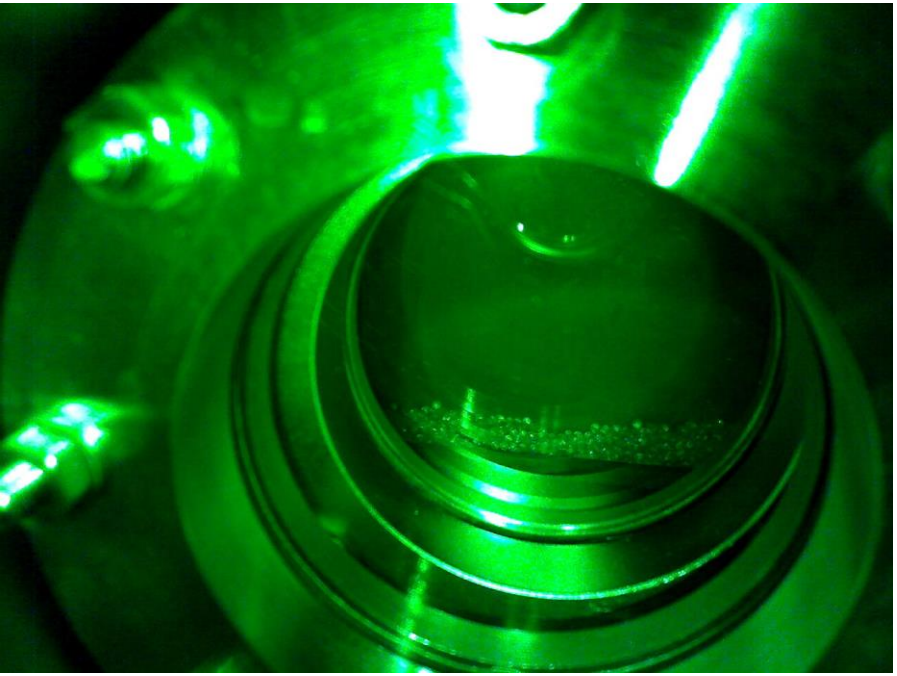


1 – chamber-imitator of cryogenic moderator, 2 – thermal exchanger with helium blower, 3 - cryogenic pipelines from\to refrigerator, 4 – loading machine, 5 – transport cryogenic pipeline

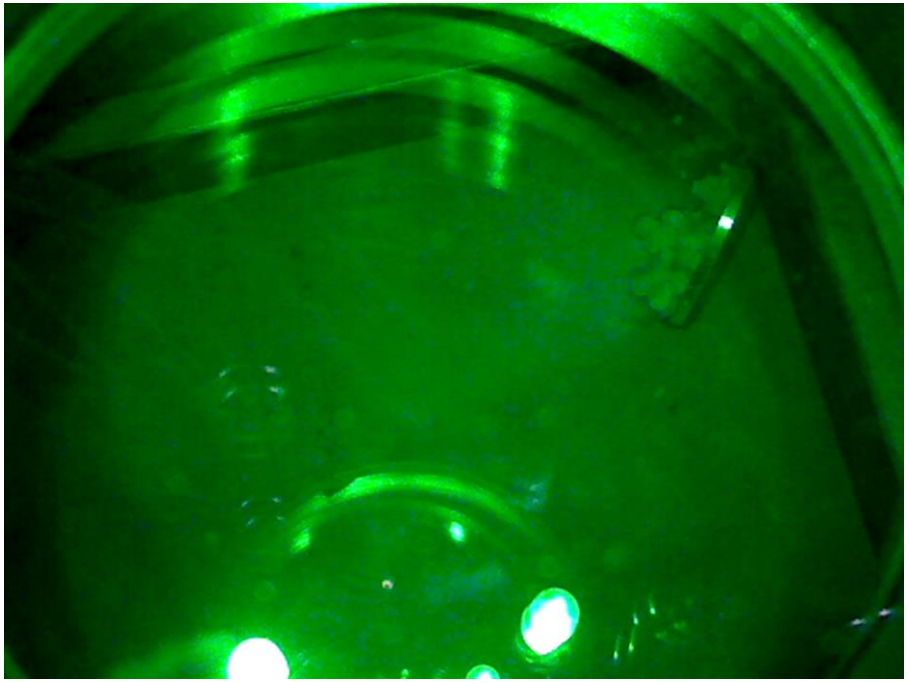
Cut-off of three dimensional model of the chamber-imitator



1 - Thick glass windows,
2 - Drainage system,
3 - Grating,
4- Volume for beads,
5 - Vacuum jacket,
6 - Pipes of incoming helium with beads and out coming helium,
7 - glass wall

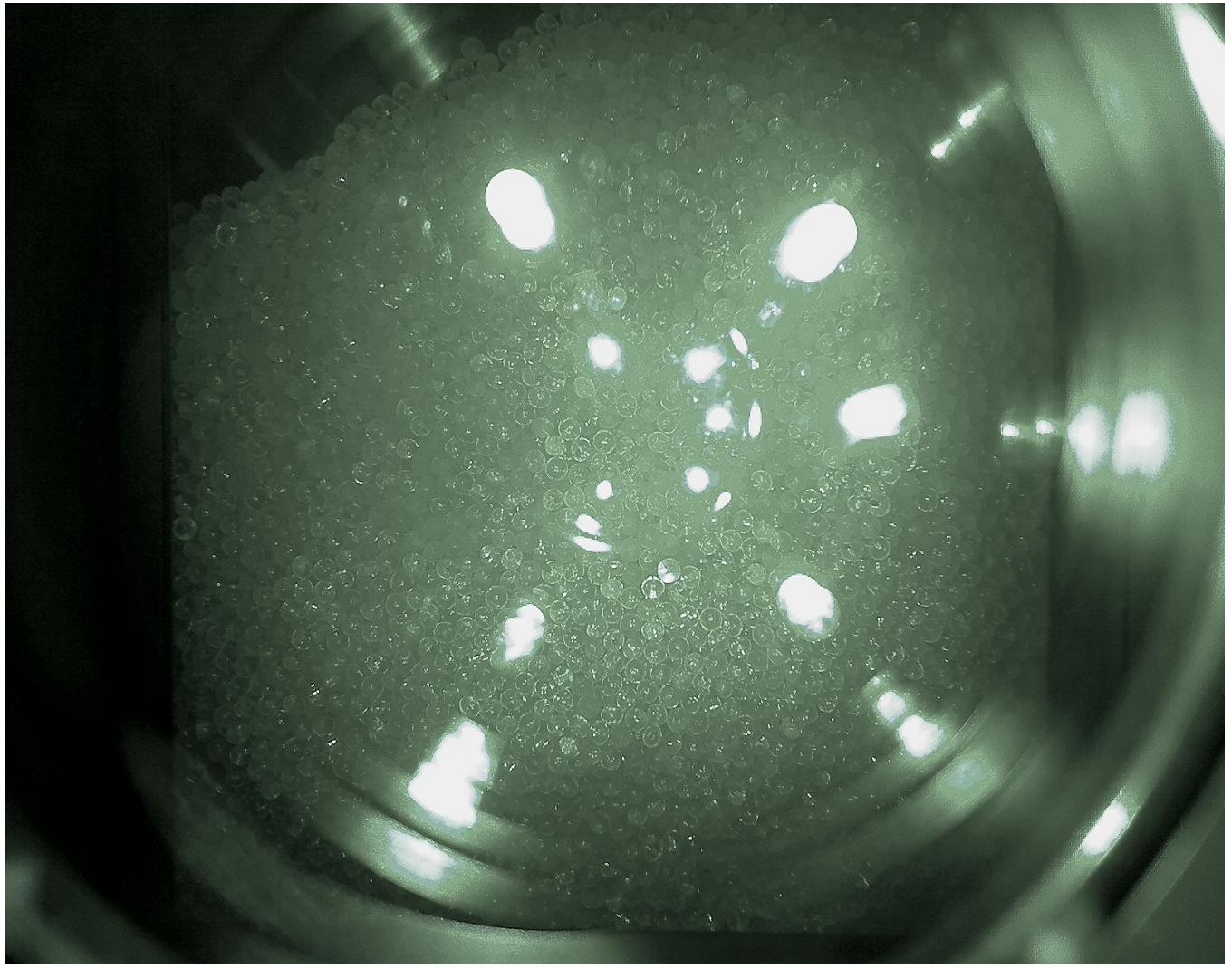


Temperature inside the chamber is 40 K



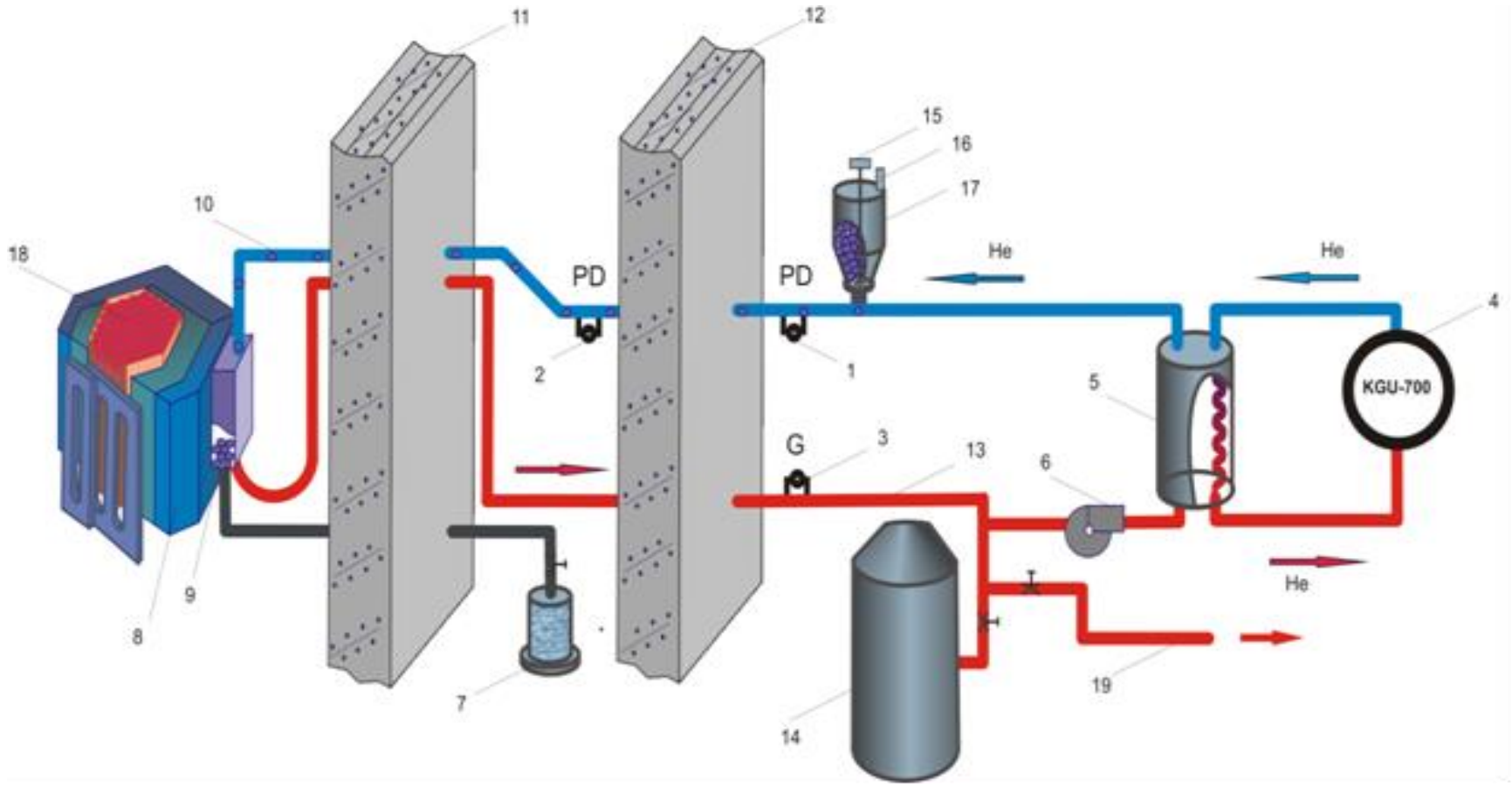
Temperature inside the chamber is 160 K

View through windows into the chamber

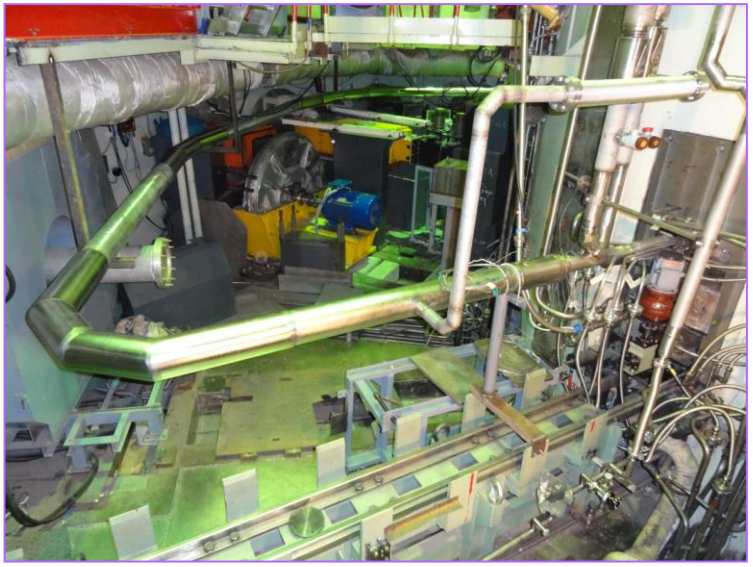


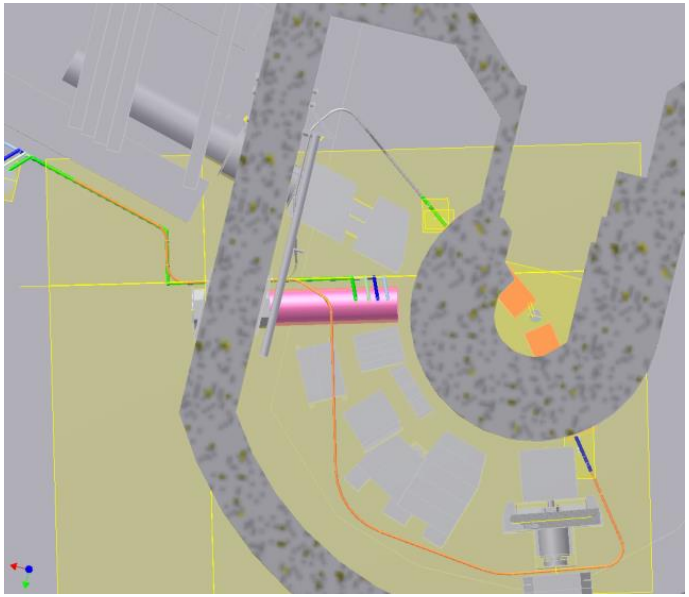
Completely loaded chamber (18 cm x 18 cm x 4 cm) by beads.
Temperature inside is ~50K
(1 l of volume of cryogenic moderator is ~ 24 000 of beads, d=3.8 mm)

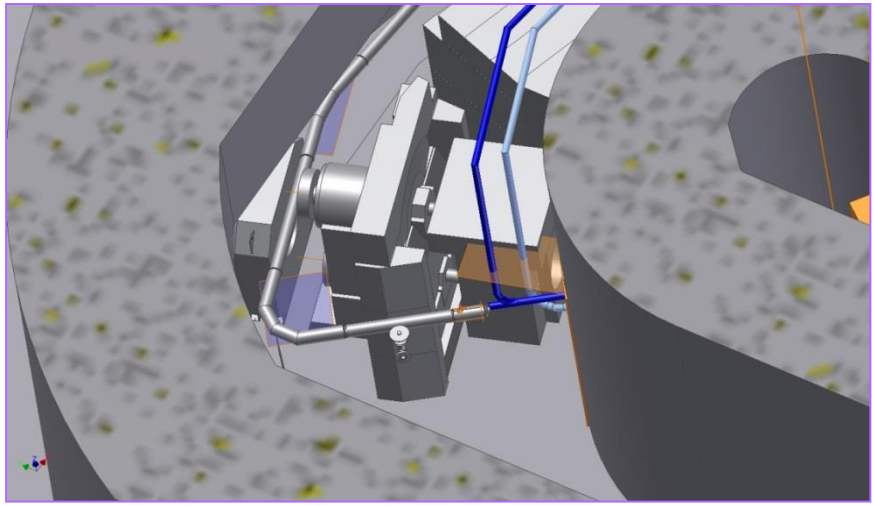
Principal scheme of the IBR-2 moderator system



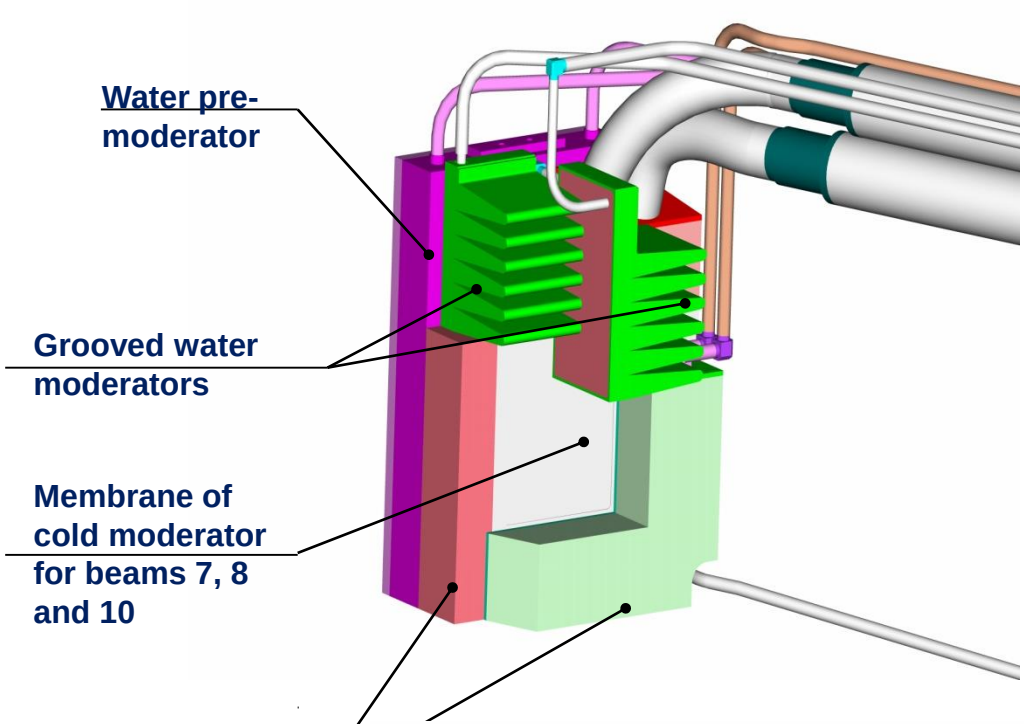
Cold moderator with connected pipelines installed at the working place

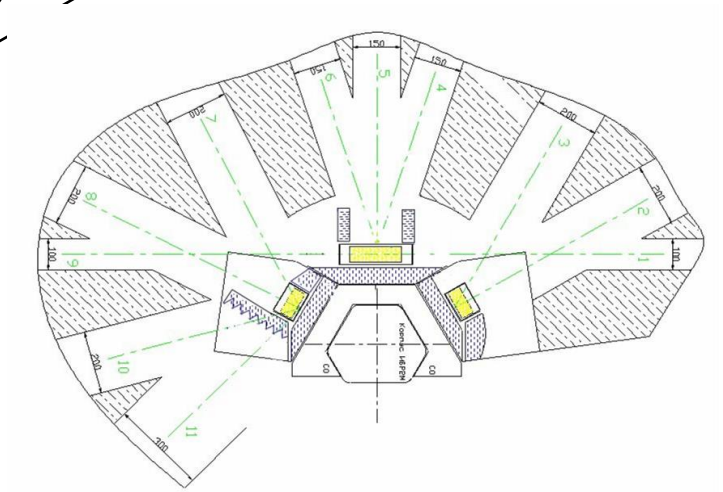






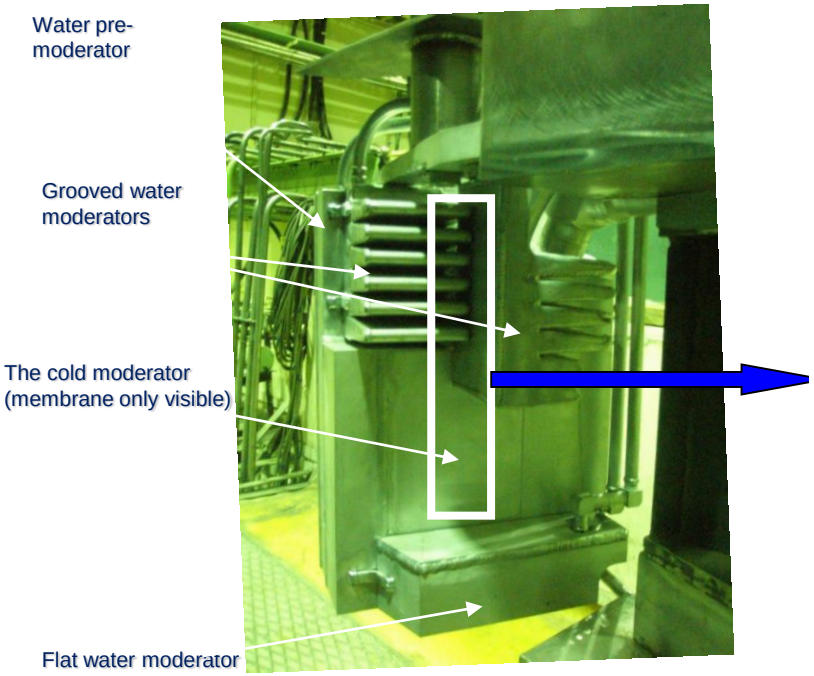
Bi-spectral moderator for beams 7,8,10,11 (7 instruments)

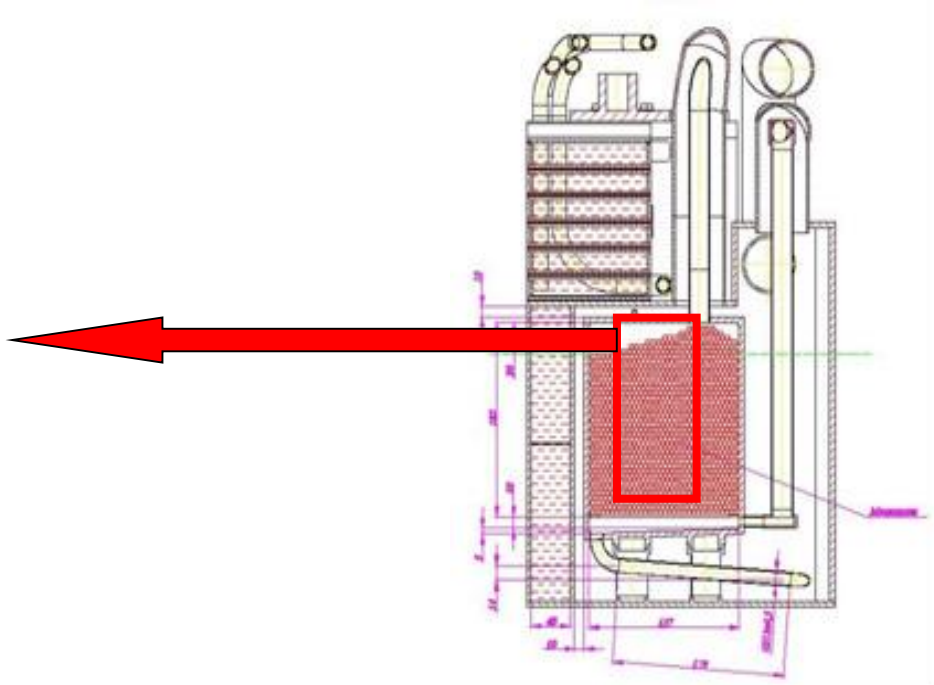




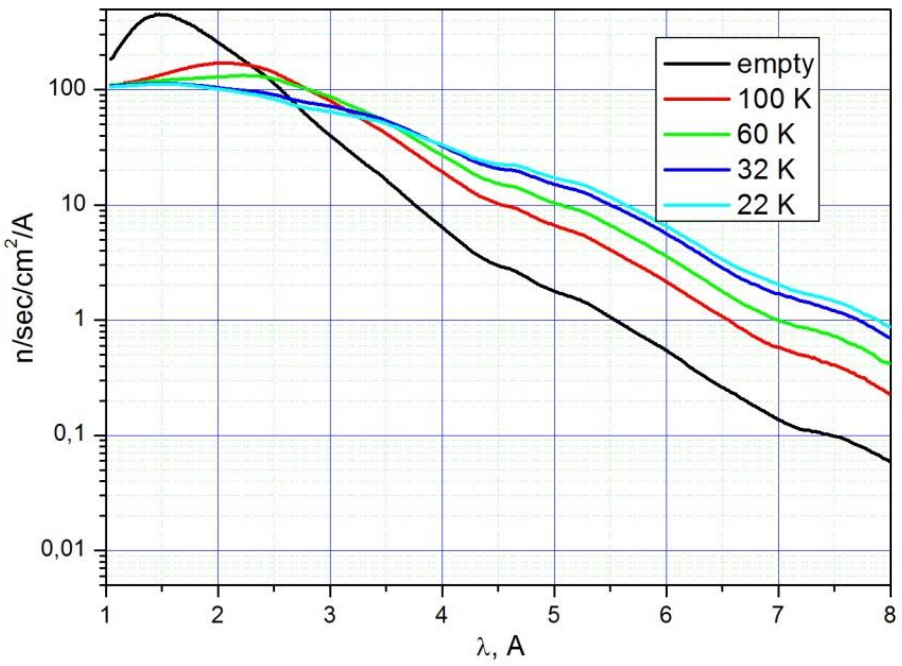
Height: 44 cm
Cold moderator: 18 x 15 x 4 cm^3

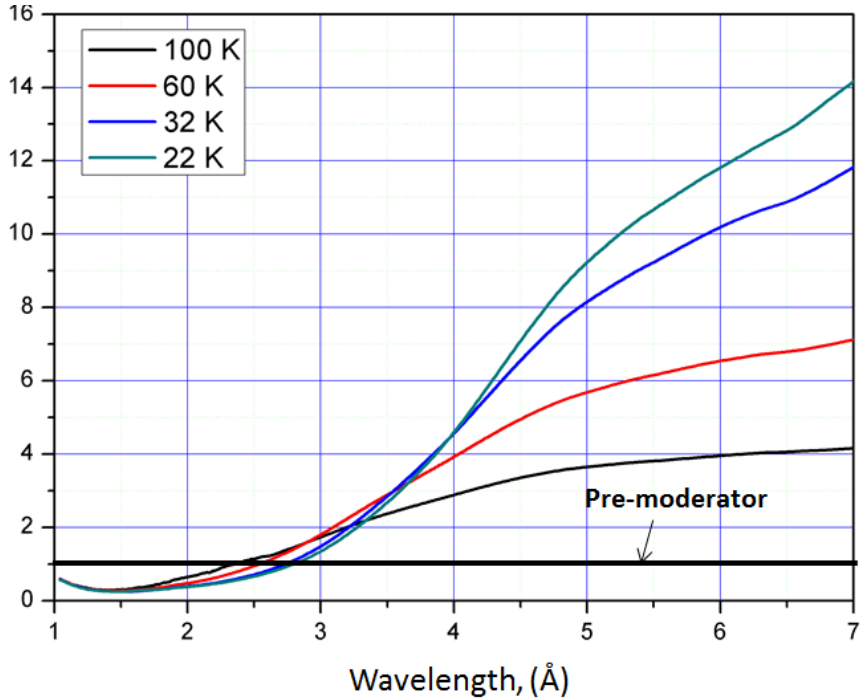
2D images of cold moderator chamber at different level of filling. Images contain neutrons λ = 0,7Å.



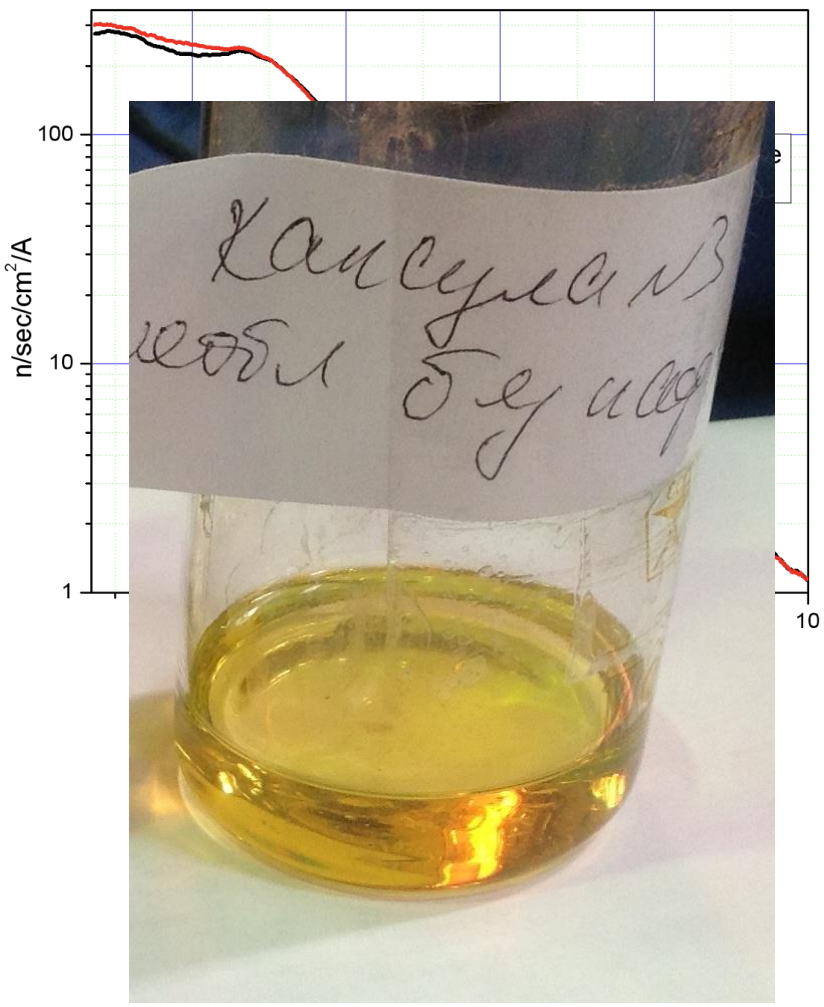


Neutron spectra and gain factor in cold neutron region

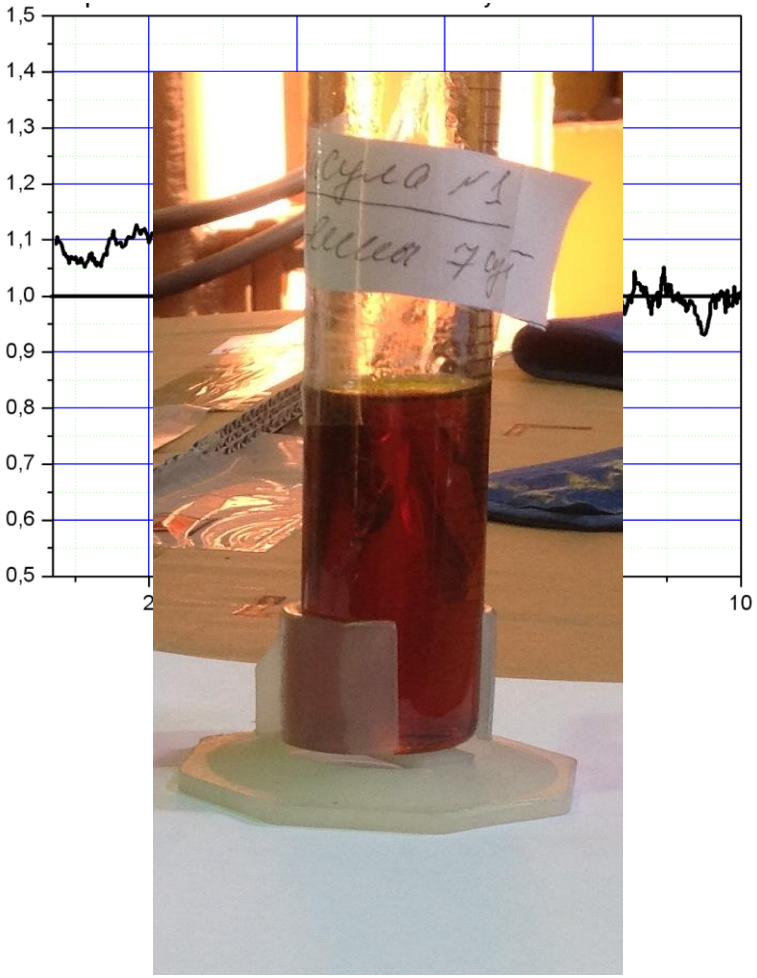




Measurements of spectra change after 7 days of irradiation

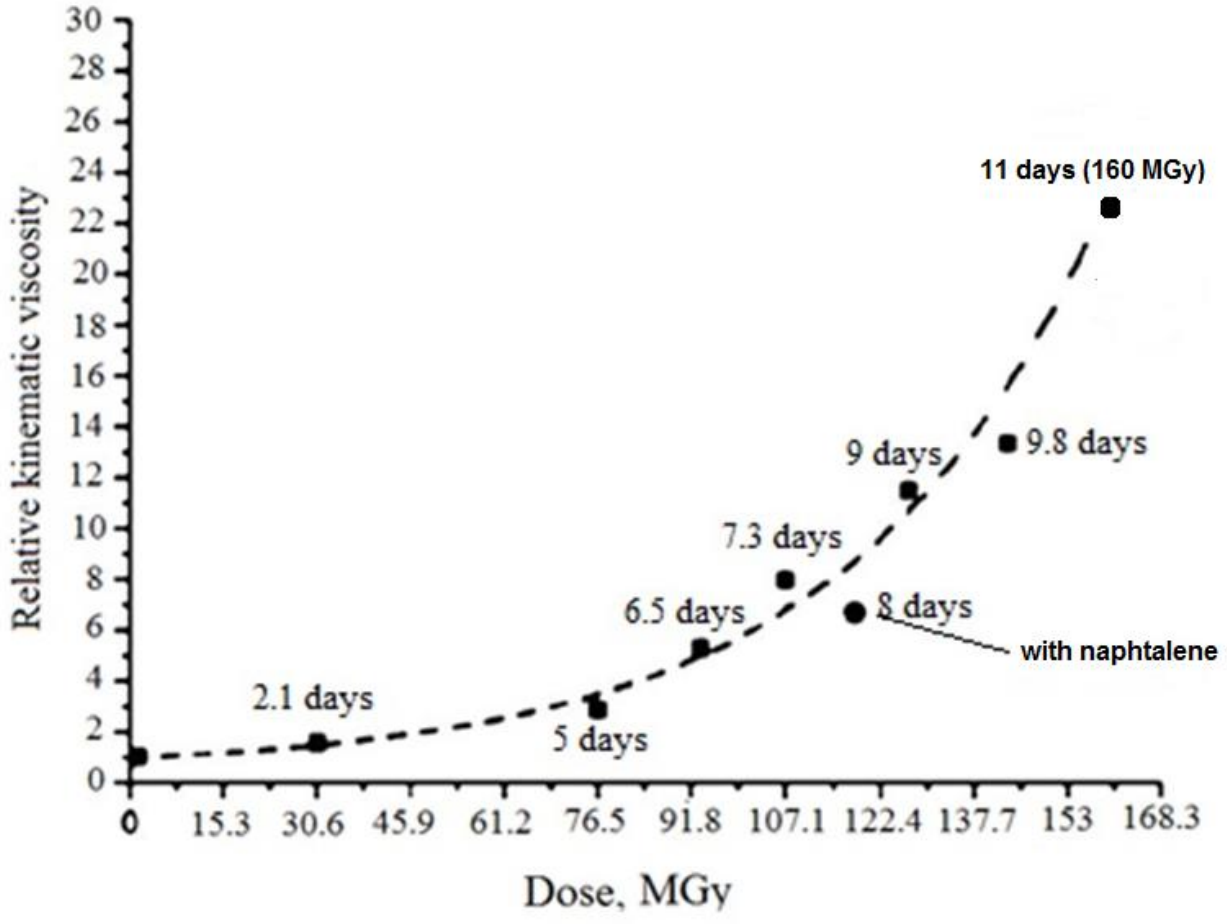


3 days of irradiation



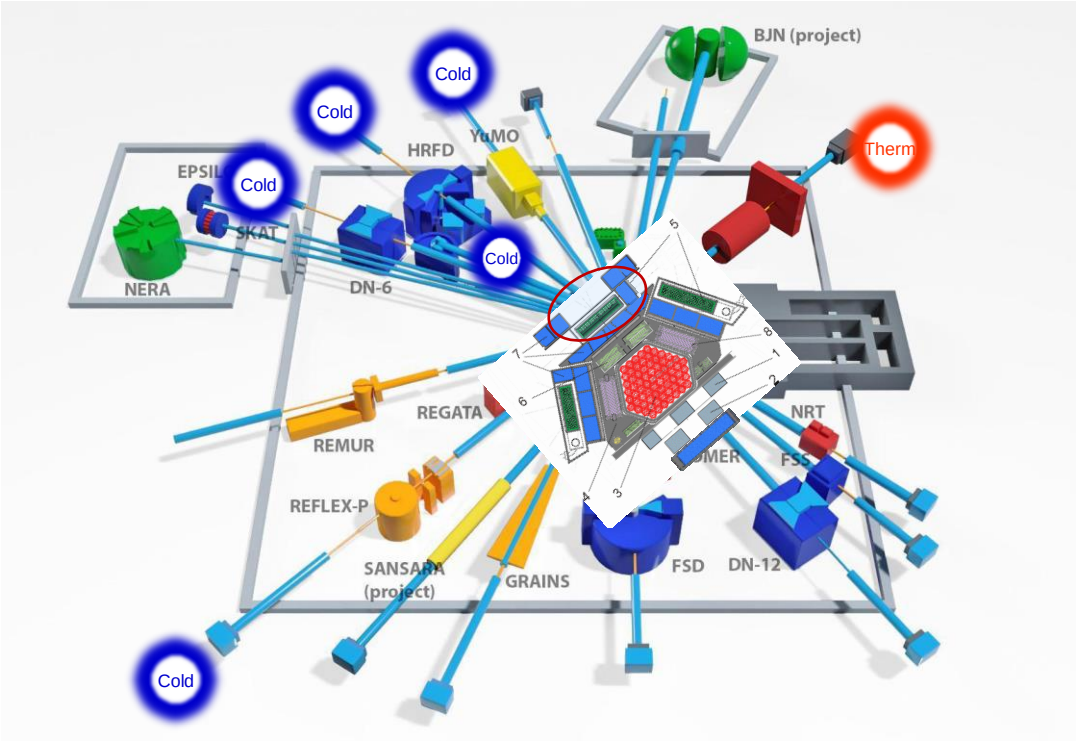
7 days of irradiation

Viscosity research

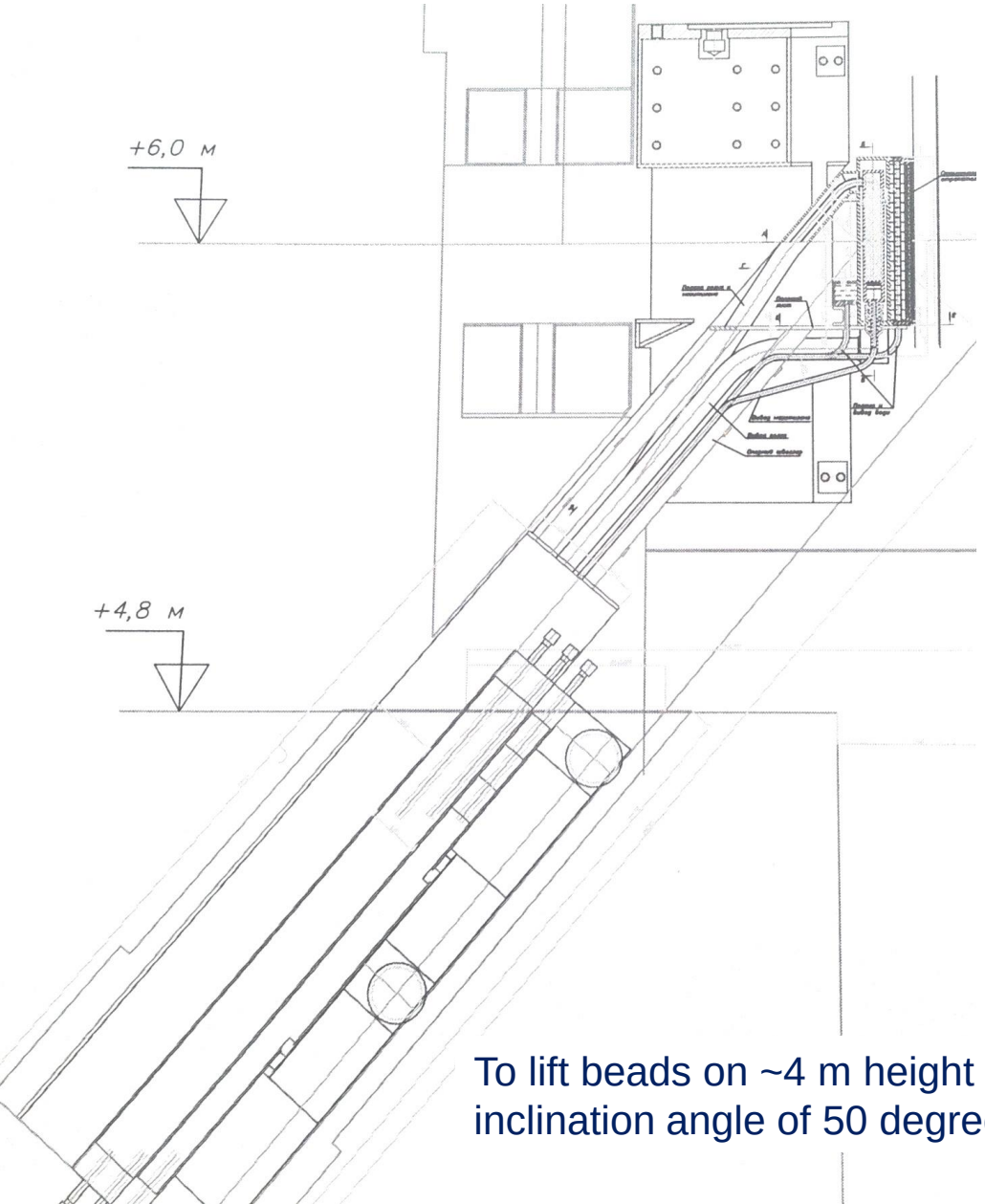


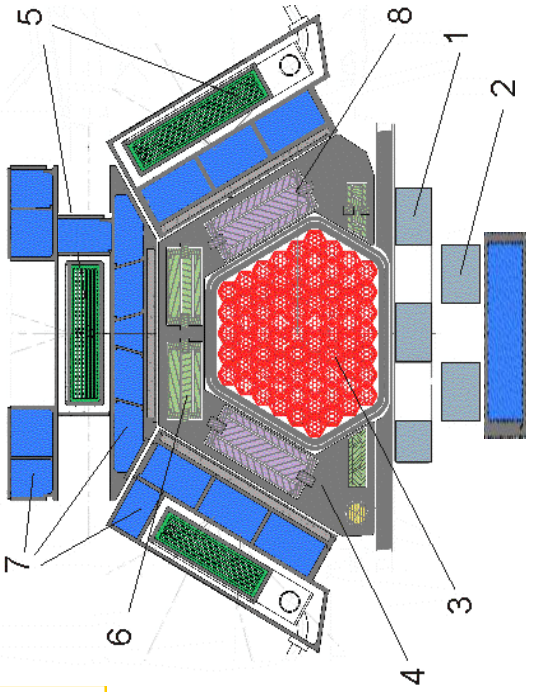
Life time of the moderator's material in cold mode is corresponds to the reactor run

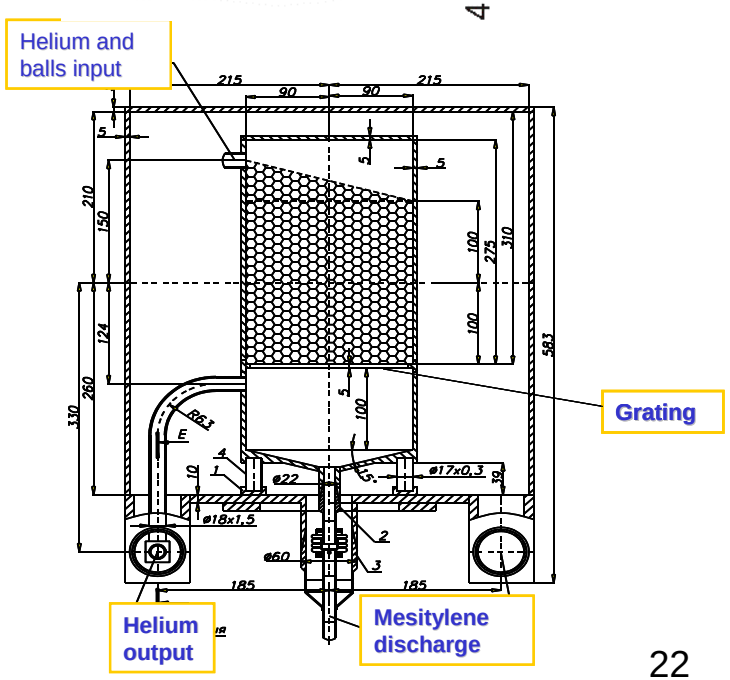
Complex of moderators of the IBR-2 reactor. Central direction. Cold moderator for beams 1, 4, 5, 6, 9 (6 instruments)



Cold moderator for beams 1, 4, 5, 6, 9 (6 instruments)

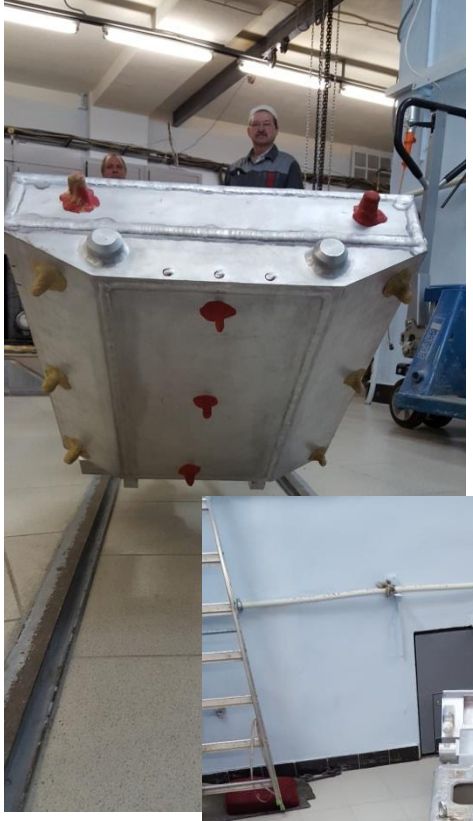


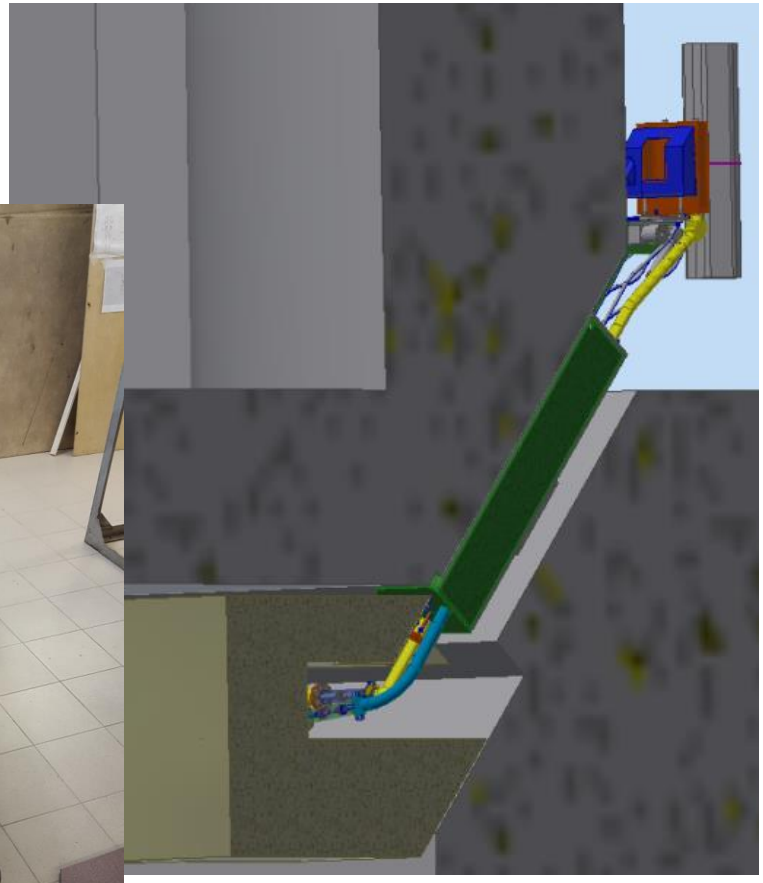


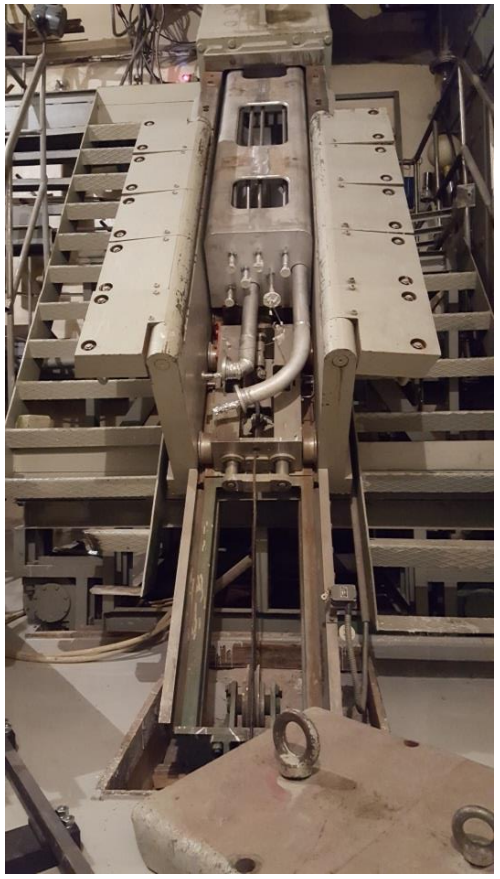


To lift beads on ~4 m height with inclination angle of 50 degrees

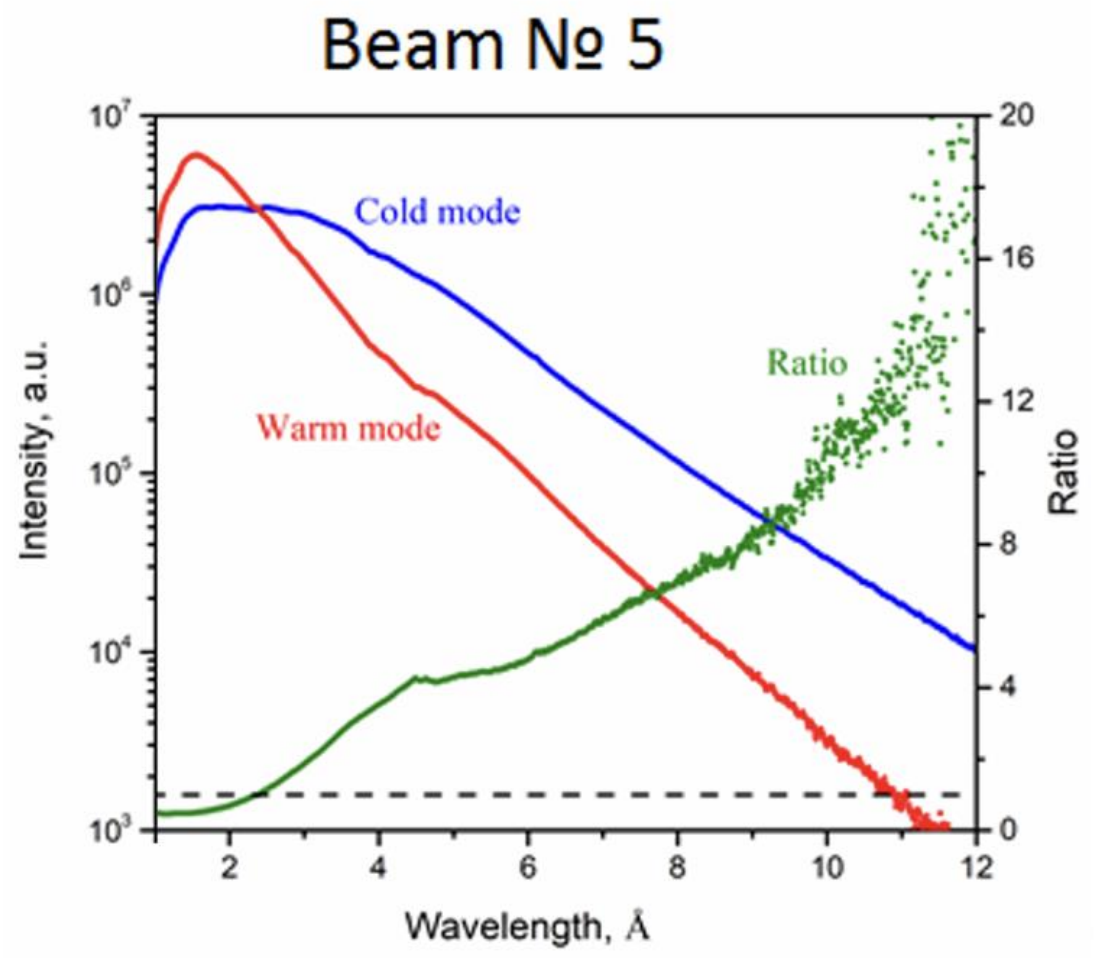
Moderator for the central direction



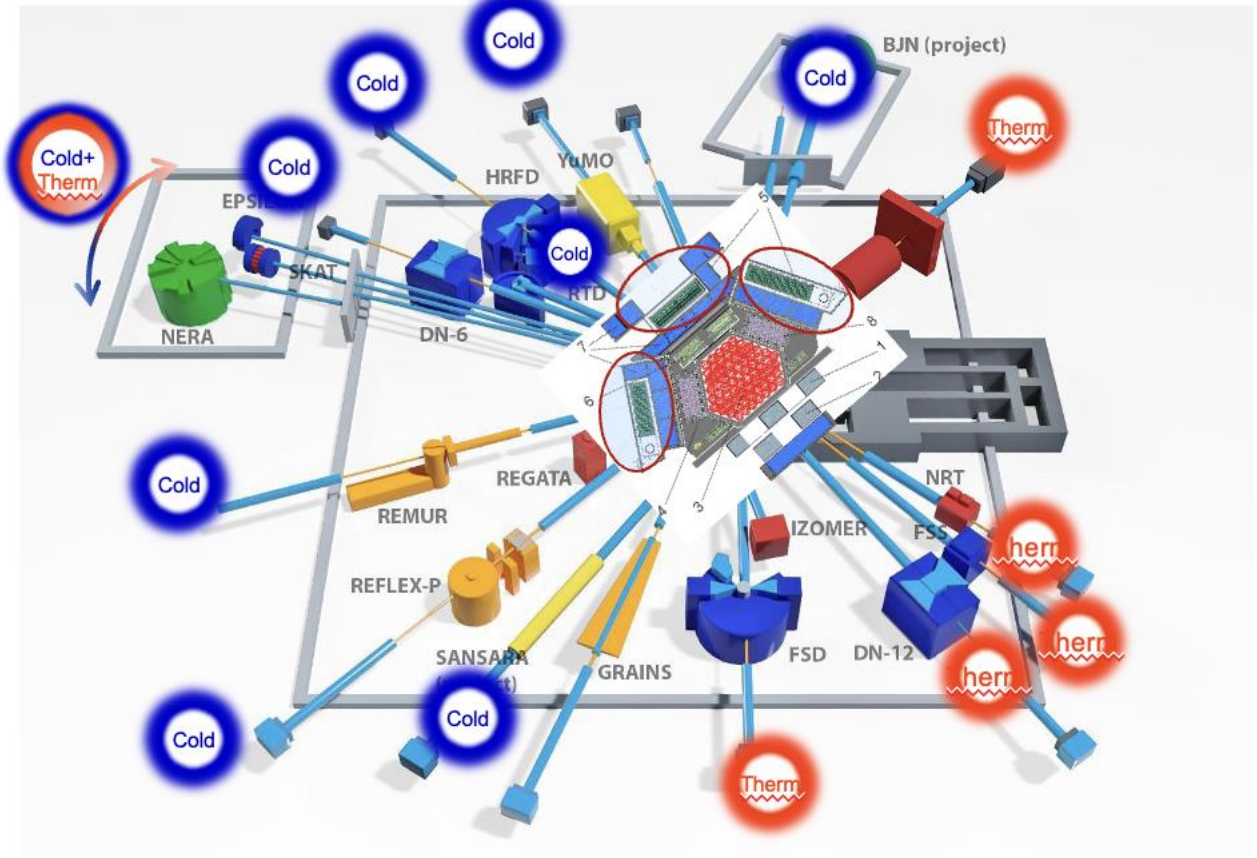




Neutron spectra and gain factor in cold neutron region of CM 201



Complex of moderators of the IBR-2 reactor



Thank you for your attention!