



# Реакторный комплекс ТИК. Текущий статус. (серия 7)

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*НИЦ «Курчатовский институт»-ПИЯФ*



# Краткое содержание предыдущих серий

1975 – Start construction

1986 – Completed at 80% but Chernobyl accident

1991 – Continuation of construction but revolution

1991-1999 – stagnation

1999 – Continuation of construction but volatile funding

2009 – “First day” complex for 100W

2010 – PNPI join to program NRC KI

2011 – Physical start (100W)

2013 – Complex for 100kW

## Commissioning

2018 – 100kW

2020 – license for 10MW

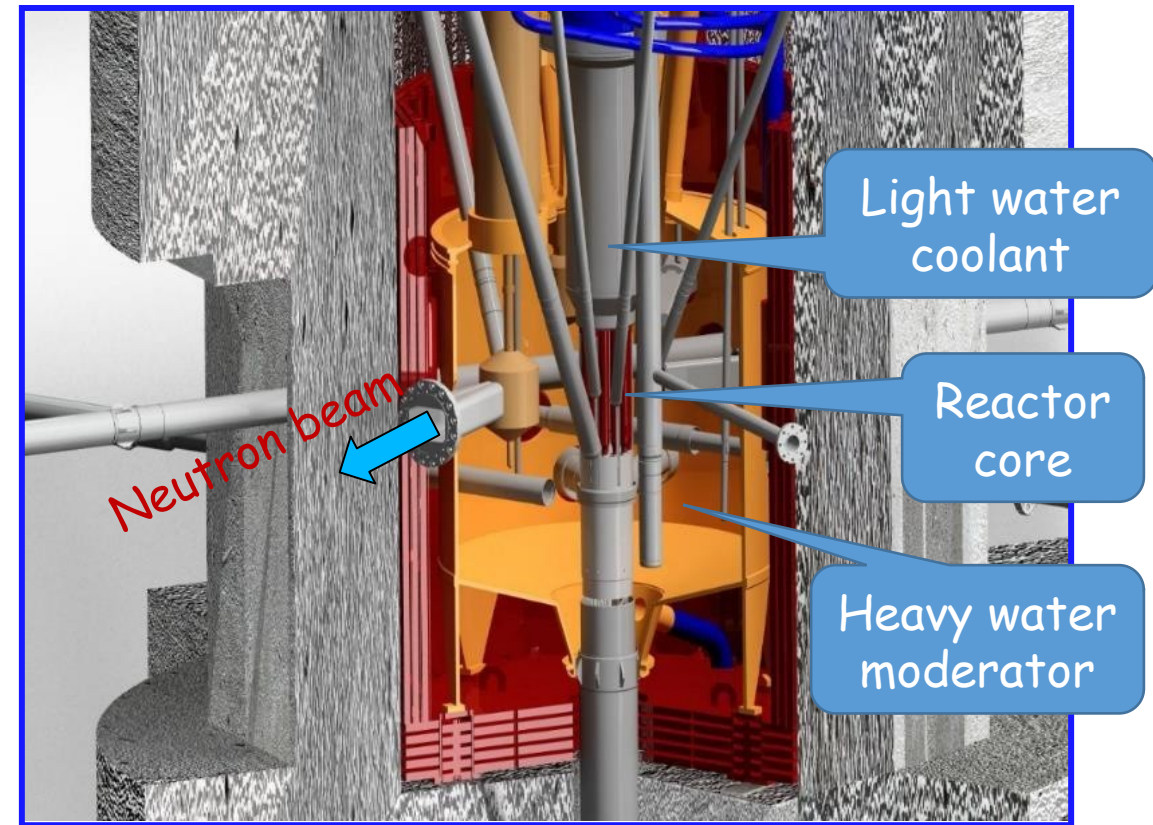
2020 – commissioning “First day” stations

8 February 2021. - The energetic regime exploitation

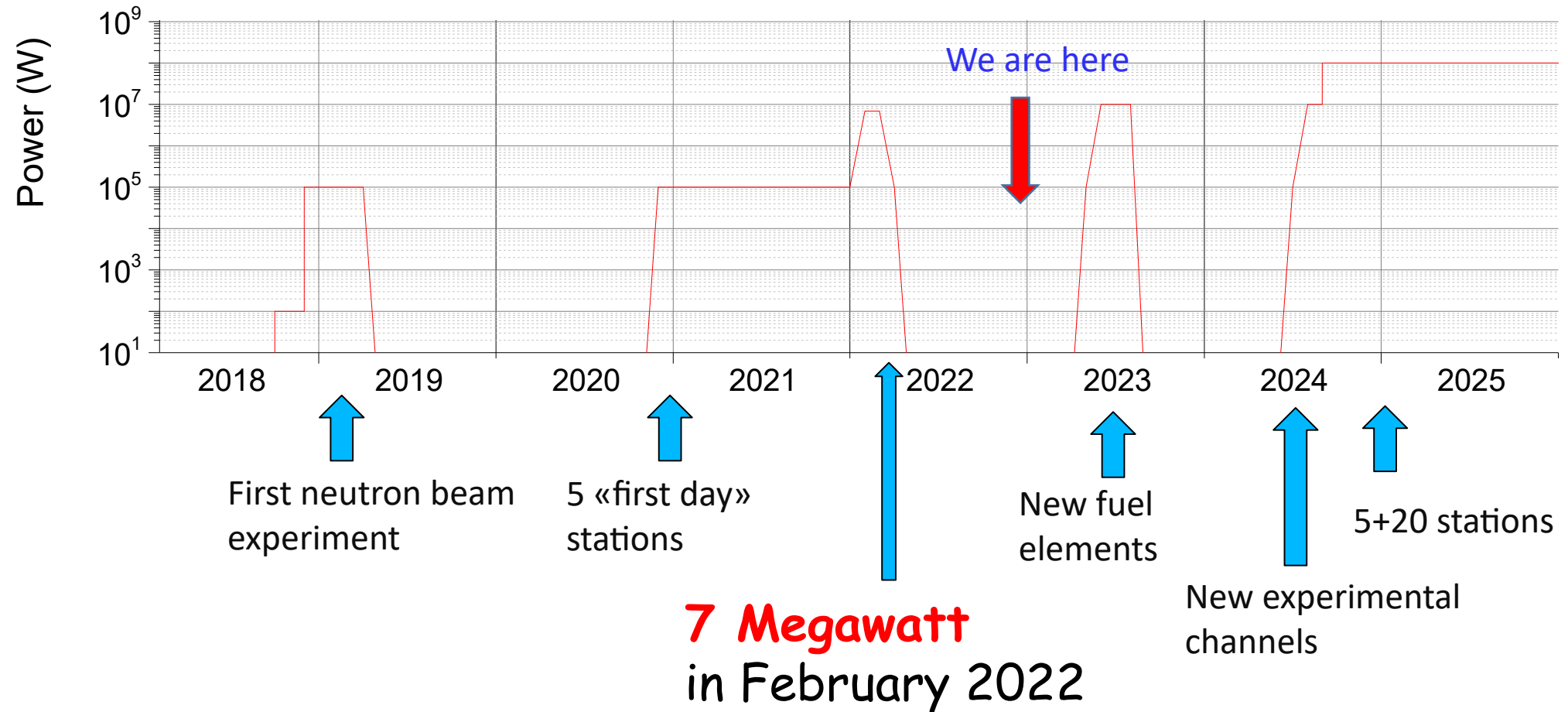
2022 – 7 MW power

2023- Project P2 commissioning

2033 - New fuel elements

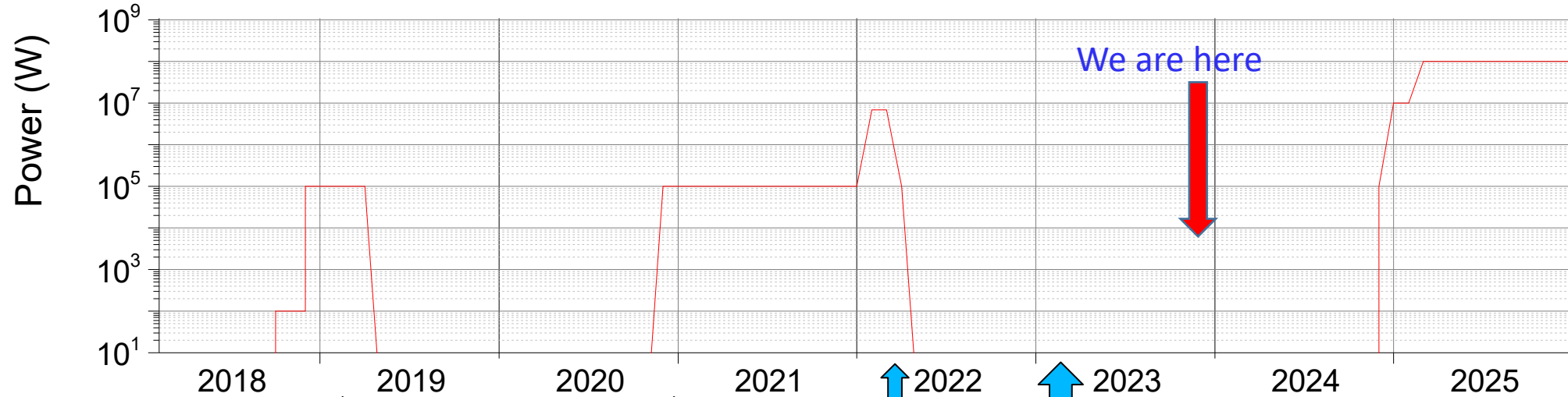


# Roadmap of PIK commissioning (2022)





# Roadmap of PIK commissioning (2023)



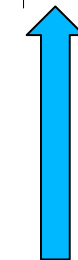
First neutron beam experiment



5 «first day» stations



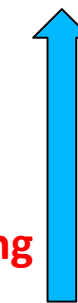
**7 Megawatt**  
in February 2022



**P2 commissioning**



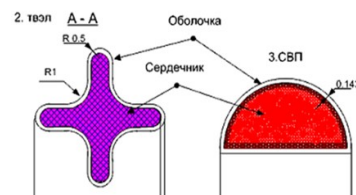
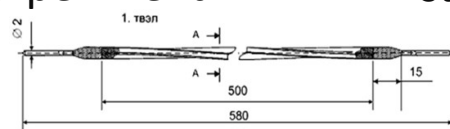
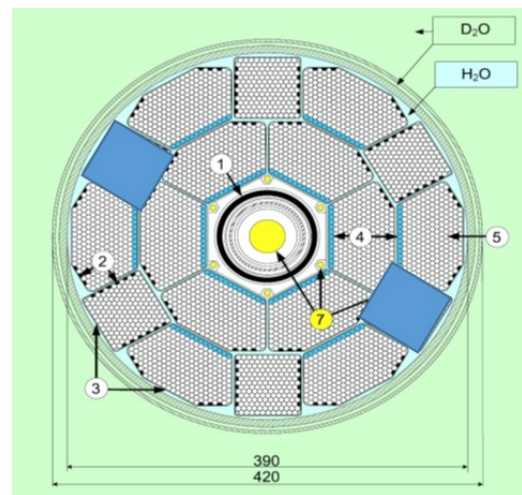
New fuel elements



New experimental channels



5+20 stations





# Reactor PIK instrumental program

1. Cold neutron source - HEC 3
2. Hot neutron source - HEC 8
3. Ultra cold neutron source - HEC 4
4. Instruments (20 stations)
  1. Experimental stations for condensed matter (13)
    - Diffractometers (3)
    - Spectrometers of inelastic scattering (5)
    - SANS machines (3)
    - Reflectometers (2)
  2. Experimental stations for nuclear and particle physics (7)

**Commissioning all instruments - 2024-2025**



# Roadmap of instruments commissioning

#		2019		2020				2021				2022				2023				2024					
		III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV		
0	Reactor PIK commissioning	100 kW				10MW				10MW				~100MW											
1	Project of instruments																								
2	Experimental channel																								
3	HNC HEC-8																								
4	UCNS HEC-4																								
5	CNS HEC-3																								
	CNS HEC-3 prototype																								
6	Neutronguide system																								
		Optical and vacuum elements fabrication																							
		Mounting																							
		Neutron stations																							
1	SESANS																								
2	INAA																								
3	«Нейтрино» (Neutrino)																								
4	D1																								
5	DC-1																								
6	D3																								
7	IN-1																								
8	IN-2																								
9	ИРИНА (IRINA)																								
10	DEDM																								
11	FISCO																								
12	Tenzor																								
13	Мембрана – 2 (Membrane – 2)																								
14	IN-3																								
15	IN-4																								
16	SONATA																								
17	SEM																								
18	Harmony																								
19	PROGRAS																								
20	«Бета-распад нейтрона» (neutron beta decay)																								

Commissioning

- Nuclear physics and particle physics
- Large scale
- Structure
- Spectroscopy





# Roadmap of instruments construction and commissioning

#		2019		2020				2021				2022				2023				2024					
		III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV		
0	Reactor PIK commissioning	100 kW				10MW								10MW				10MW							
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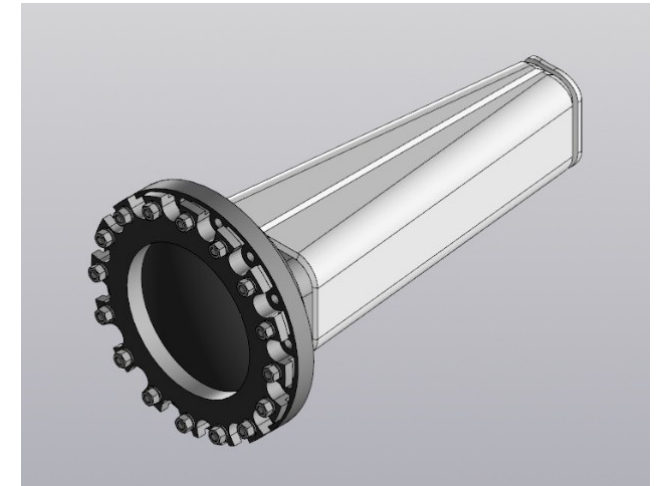
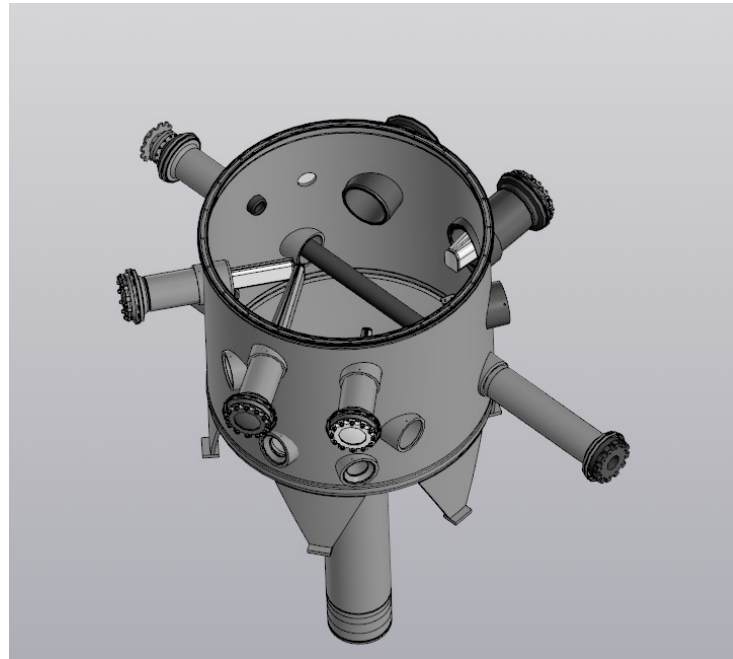
Commissioning

■ Nuclear physics and particle physics  
■ Large scale  
■ Structure  
■ Spectroscopy

# Модернизация экспериментальных каналов (2021-2023) COMMISSIONING - 2024

Оптимизация конструкции (мембрана) и использование гелия в качестве наполнителя позволяет увеличить поток нейтронов на выходе канала на 15-20%

№	Наименование канала
1	ГЭК 2
2	ГЭК 3
3	ГЭК 8
4	ГЭК 9
5	ГЭК 10
6	ГЭК 4
7	ГЭК 5-5' (ИРИНА)
8	ГЭК 6
9	ГЭК 6'
10	НЭК 1
11	НЭК 6



## Выполнение

- Разработка конструкторской документации АО «НИКИЭТ»



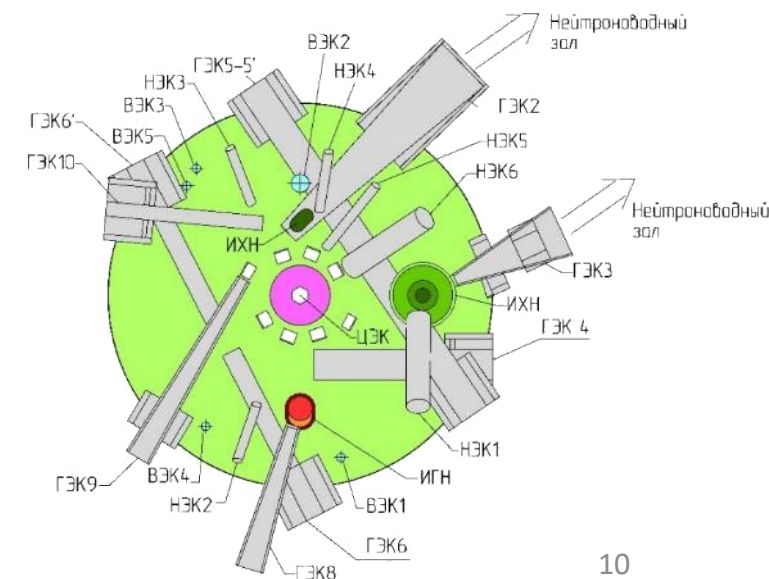
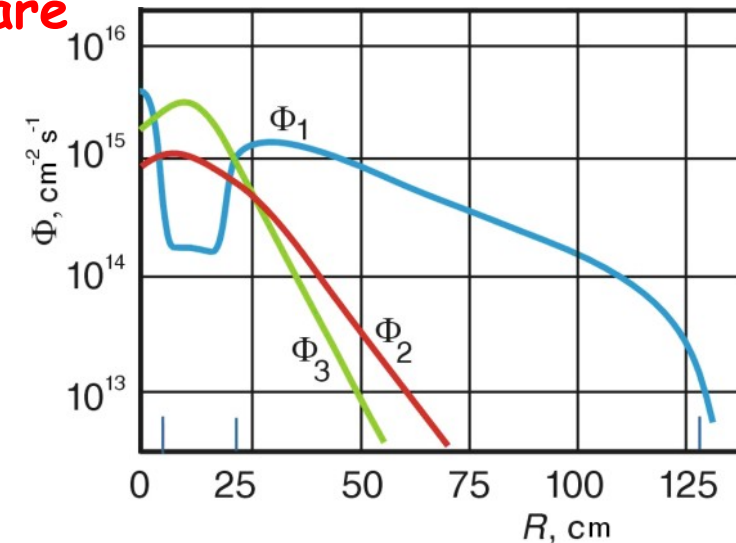
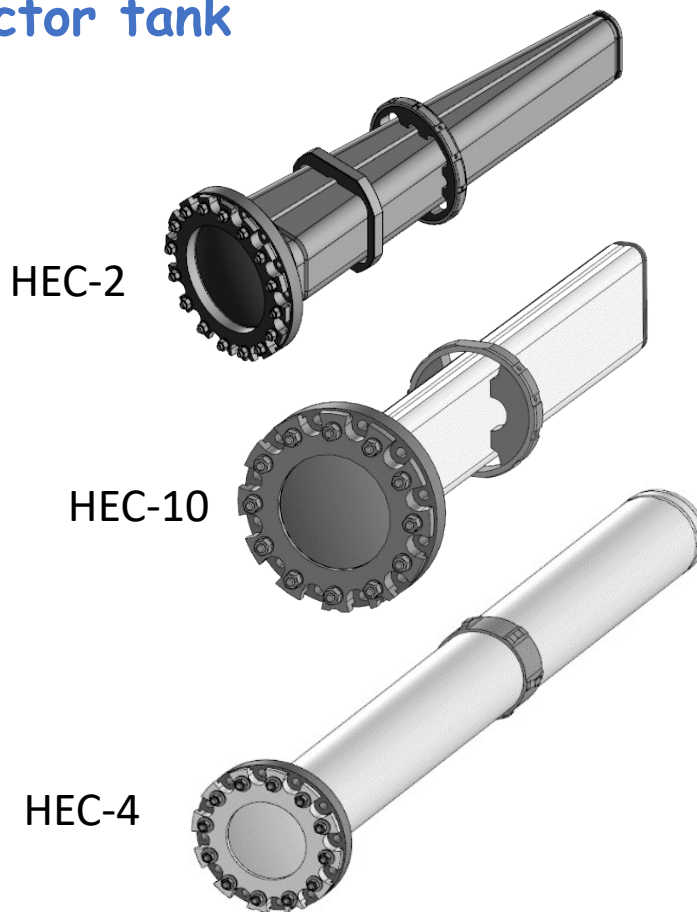
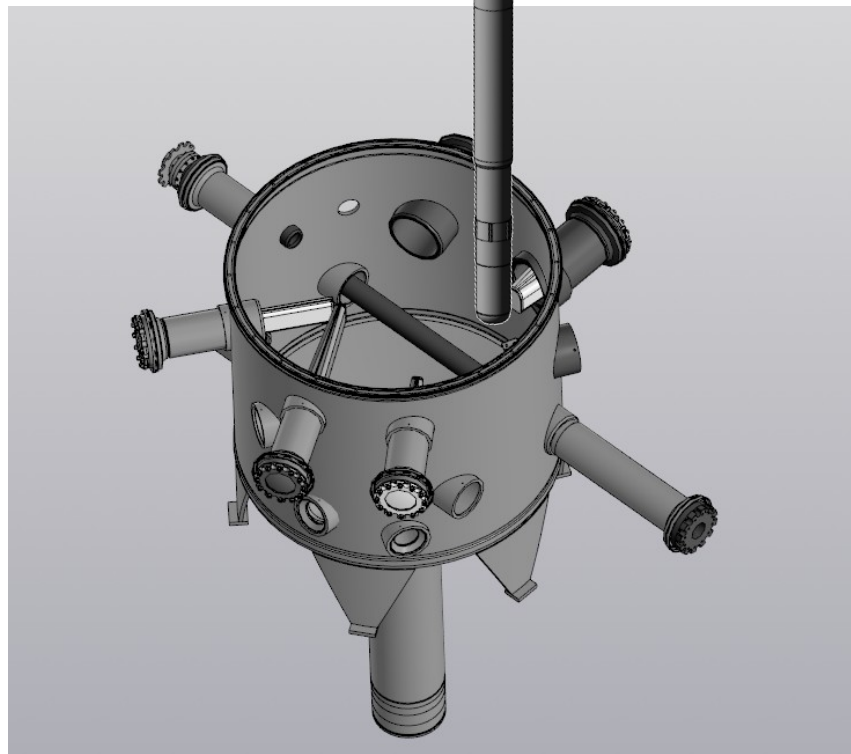


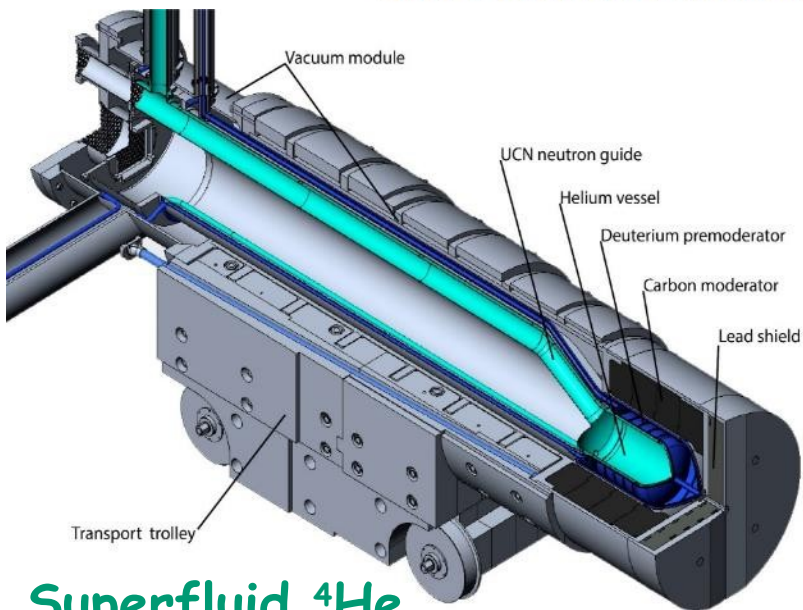
# Experimental channels (2023)

The new design of the channel and the use of helium as a filler makes it possible to **increase the neutron flux** at the channel output **by 15-20%**

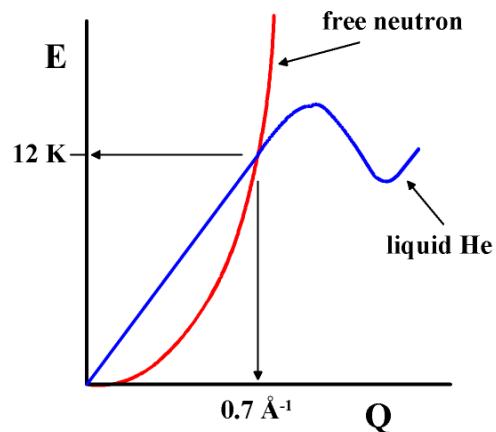
The project was approved by the state expertise. All channels are under manufacturing.

08.2024 — Installation in the reactor tank

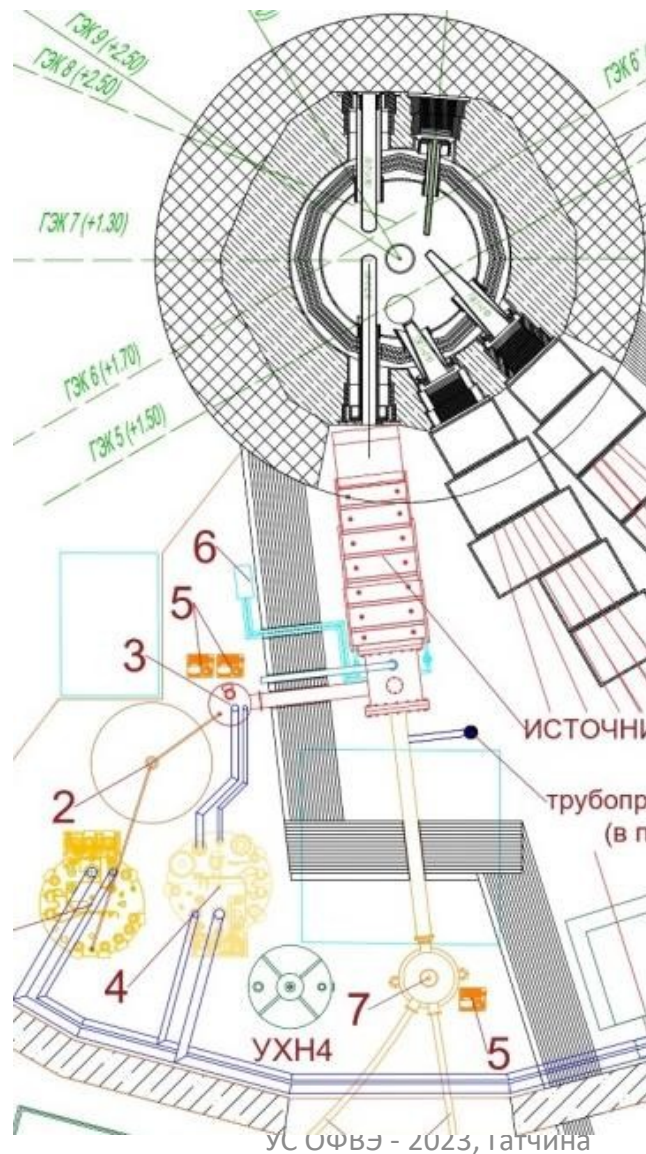




Superfluid  $^4\text{He}$   
converter at  
HEC-4  
 $T=1.15\text{K}$   
 $V\sim 35$  litre



$E < 10^{-7}$  eV



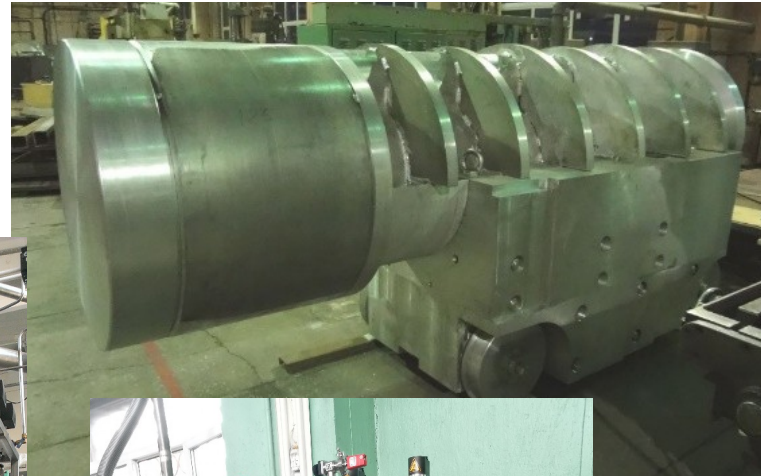
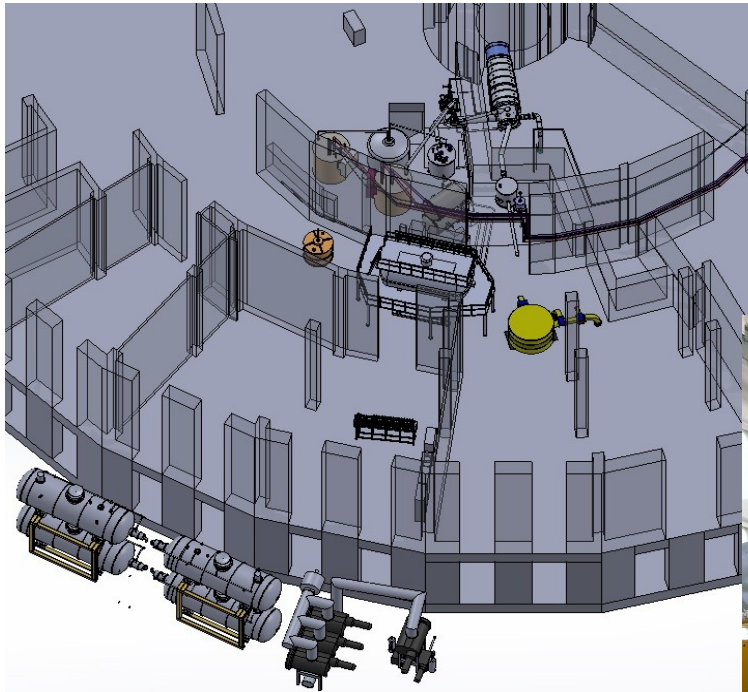
UCN source parameters:

Parameter	Value
UCN converter temperature, K	1.15
Thermal neutron flux, $\text{cm}^{-2}\text{s}^{-1}$	$2.8 \cdot 10^{10}$
$9\text{\AA}$ flux density, $\text{cm}^{-2}\text{s}^{-1}\text{\AA}^{-1}$	$5 \cdot 10^8$
UCN density in UCN source, $\text{cm}^{-3}$	$1,3 \cdot 10^3$
UCN density in the EDM trap, $\text{cm}^{-3}$	$3,5 \cdot 10^2$
Energy release in the helium chamber, W	3,85
Energy release in the pre-moderator chamber, W	10,7
Energy release in the lead shield, W	267

\* ЖЭТФ, 1946, 16, 391; J. Phys. USSR, 1945, 9, 461.



Степень готовности – 80% → 90%

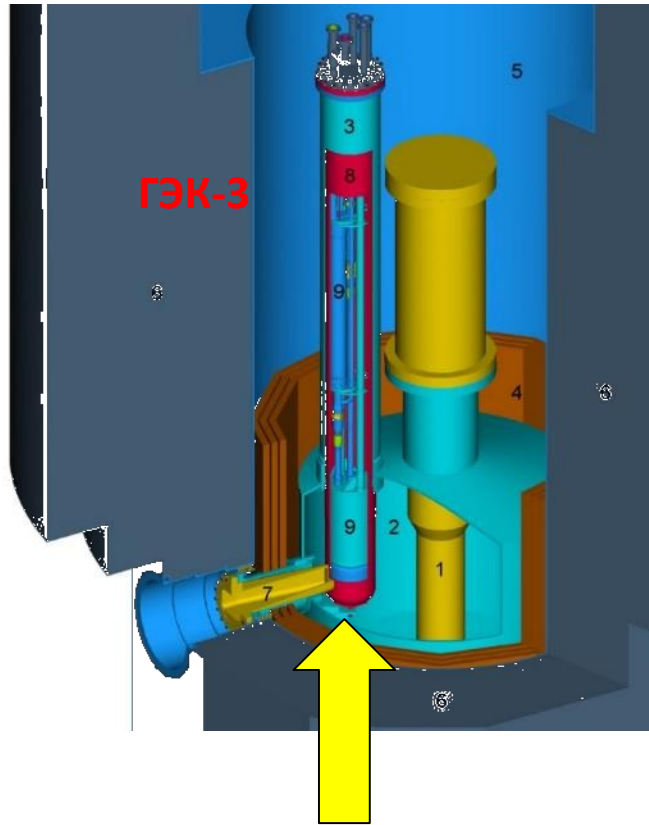


### Выполнение

- Строительные задания - 100%
- Конструкторская документация – 100%
- Закупка стандартных комплектующих – 100%
- Закупка нестандартных комплектующих - 80%
- Контрольная сборка - 70%



# Cold neutron source HEC-3 (2022-2024) Commissioning - 2024



Создан прототип, изготовлены и закуплены ключевые элементы – Термосифон, криогенное оборудование (Linde).

Степень готовности – 50%



Заклучен договор, разработана РКД на весь комплекс ИХН

Степень готовности – 60%



### CN source parameters

Liquid deuterium - 25 L,  $T = 20\text{ K}$

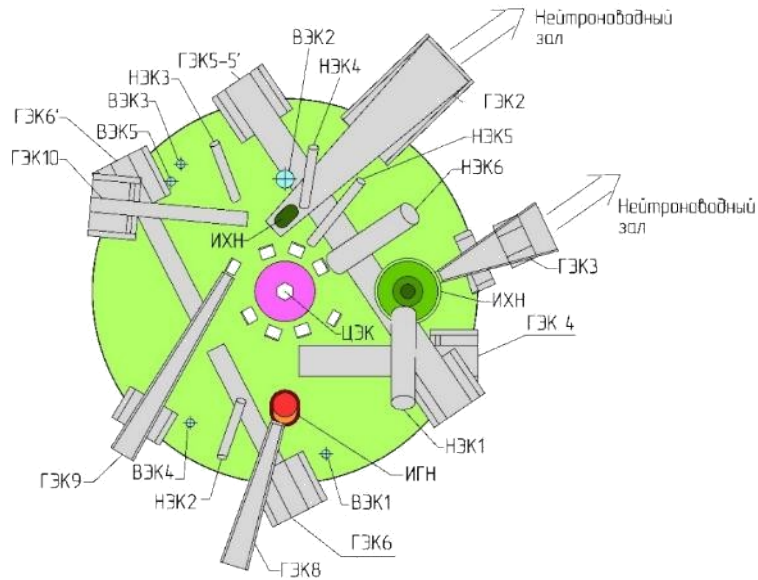
The distance from the active zone of the reactor-60cm

Heat release - 5-6 kW.

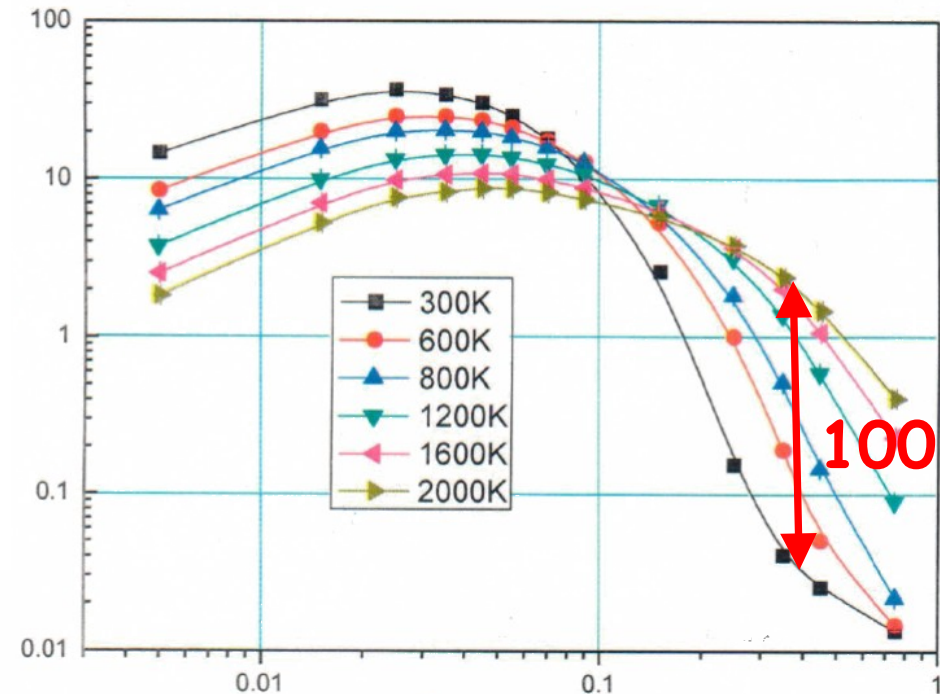
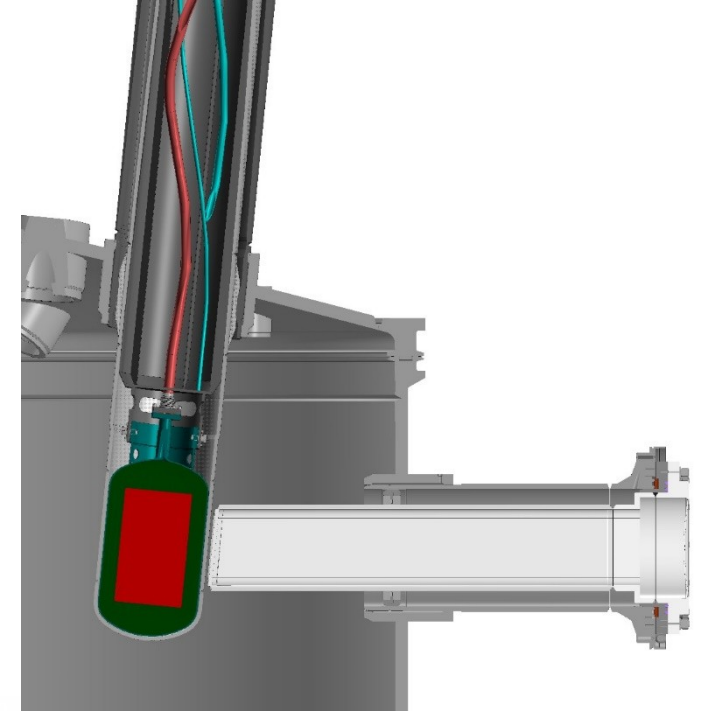
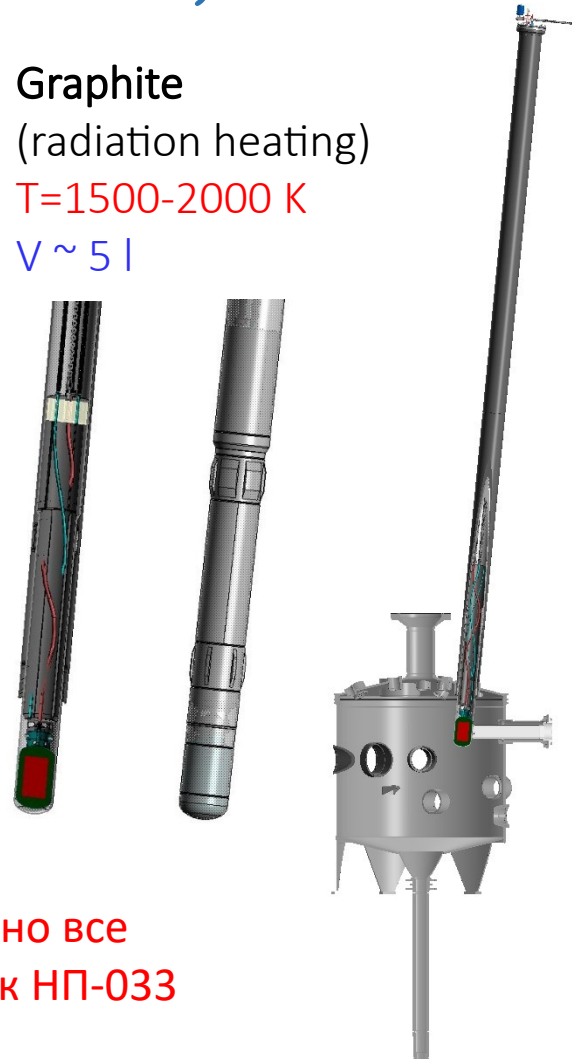




# Hot neutron source (HNS-8) (2021-2023) Commissioning - 2024



Graphite  
(radiation heating)  
 $T=1500-2000\text{ K}$   
 $V \sim 5\text{ l}$



## Выполнение

- Строительные задания - 90%
- Конструкторская документация – 10%

Разработана РКД на внешние системы, закуплено все внешнее оборудование, РКД на контейнер – 3к НП-033

Степень готовности – **30%**. Есть сложности с **внутриреакторной частью**

12/29/2023

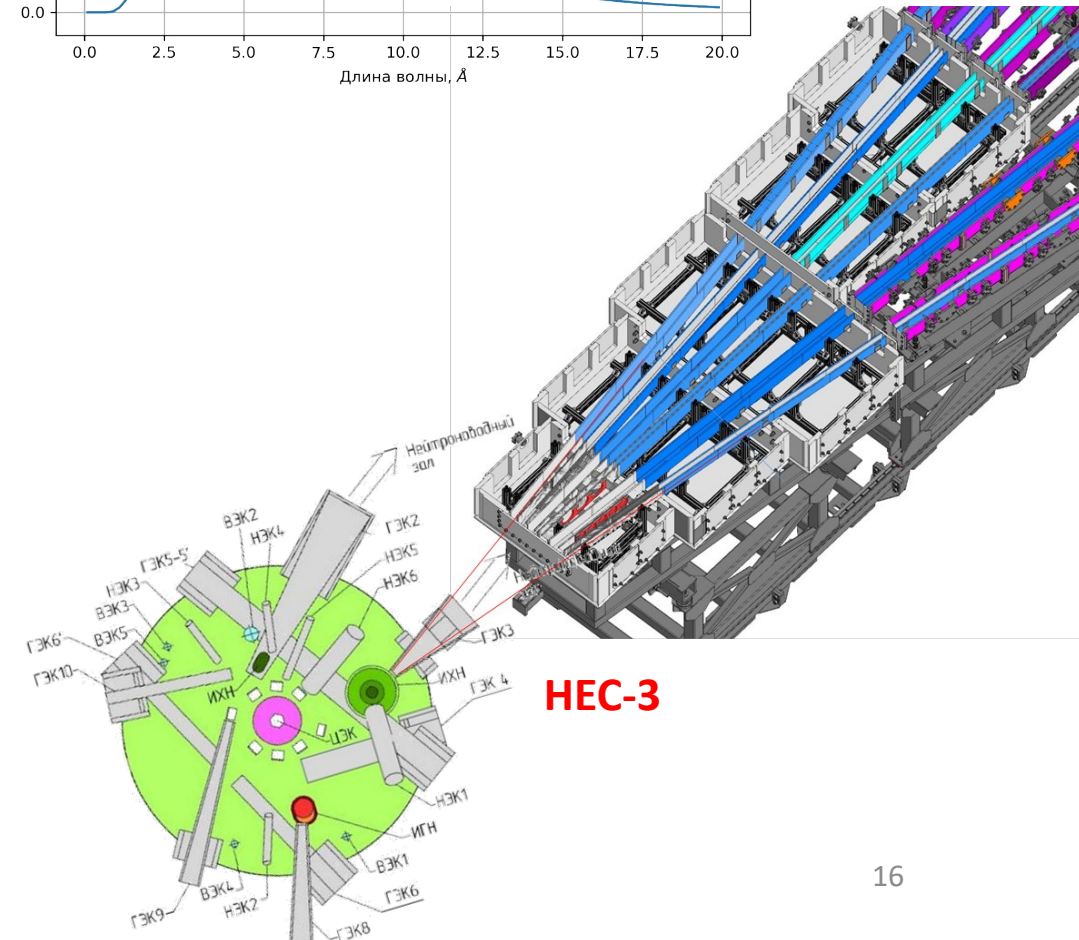
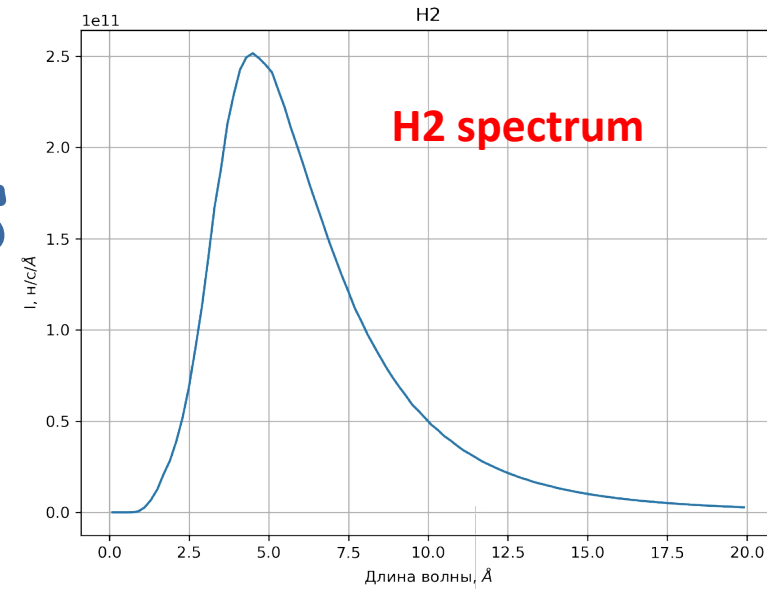
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# Neutronguide parameters

Channel	Width, mm	Height, mm	Flux, $10^9 \text{H/cm}^2/\text{c}$	$\lambda$ , Å
<b>ГЭК-3</b>				
H0	30	100	<b>7,8</b>	6,0
H2	60	200	<b>11</b>	4,5
H3-1	60	150	<b>7,3</b>	4,5
H3-2	60	30	<b>8,6</b>	4,5
H4-2	30	150	<b>4,6</b>	4,5
H5-1	50	40	<b>1,1</b>	5,0
H5-2-2-1	50	40	<b>3,4</b>	5,0
H5-2-2-2	50	40	<b>3,3</b>	5,0
H5-2-1	50	40	<b>3,2</b>	5,0
<b>ГЭК-2</b>				
H9	60	200	<b>3,2</b>	2,0
H6-1	30	200	<b>1,5</b>	2,0
H6-2	30	200	<b>1,3</b>	2,0
H7-1	30	200	<b>1,3</b>	2,0
H7-2	30	200	<b>1,4</b>	2,0





# Neutronguide hall (2022)



Vacuum tubes for neutronguides



Optical elements



Степень готовности элементов НС – 95%

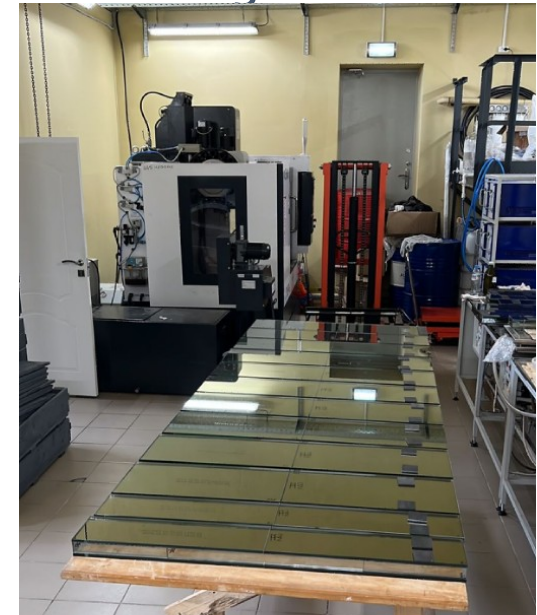
Оптических элементов – 90%





# Neutronguides (06.2023)

Neutronguide elements and optics completed by 100%.  
Ready for mounting in 2024





# Neutronguide hall. View on 09.2023



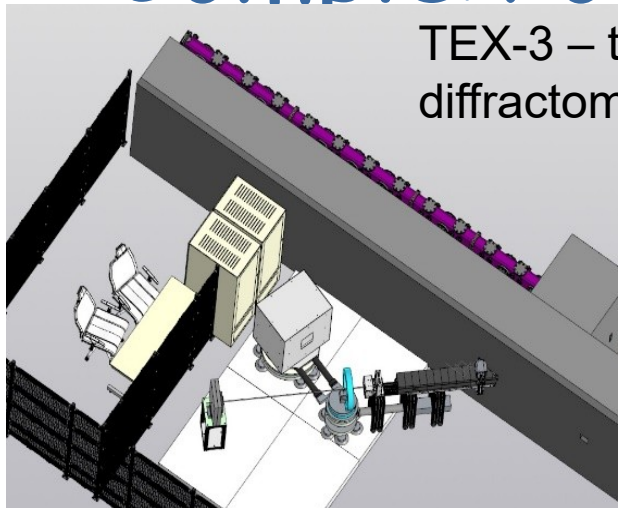
The hall is prepared for construction work on making holes for neutron guides.

**Start of reconstruction work 01.02.24**



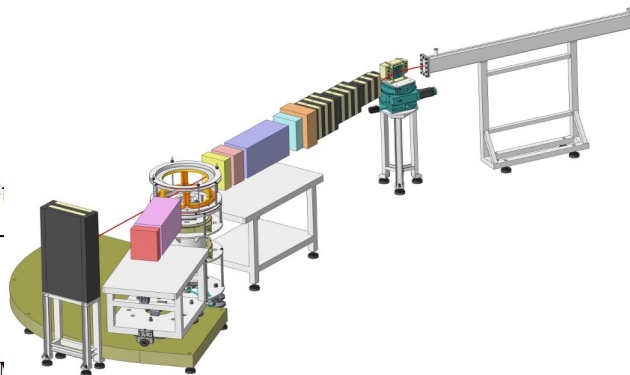


# Complex of diffractometers



TEX-3 – texture diffractometer

DPN – monocrystalline polarized diffractometer



Diffractome

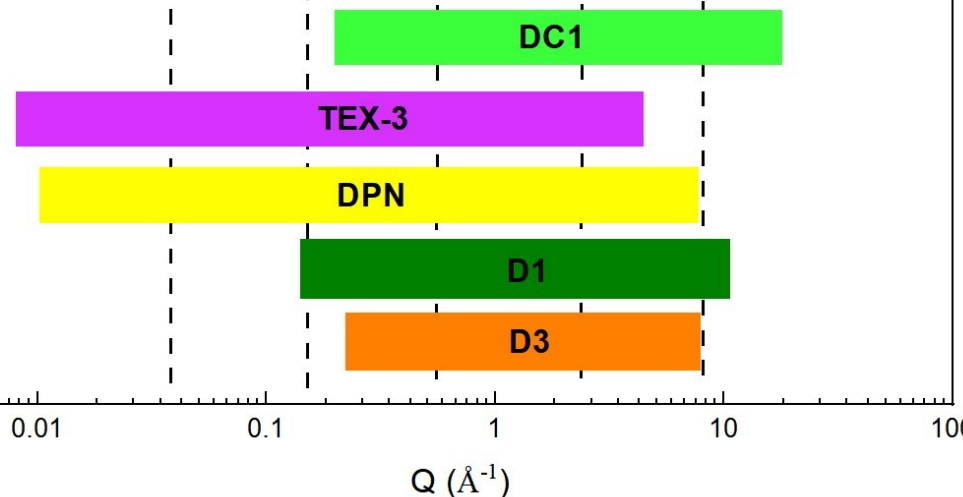
Metallurgical Systems

Micelles  
Polymers

Proteins

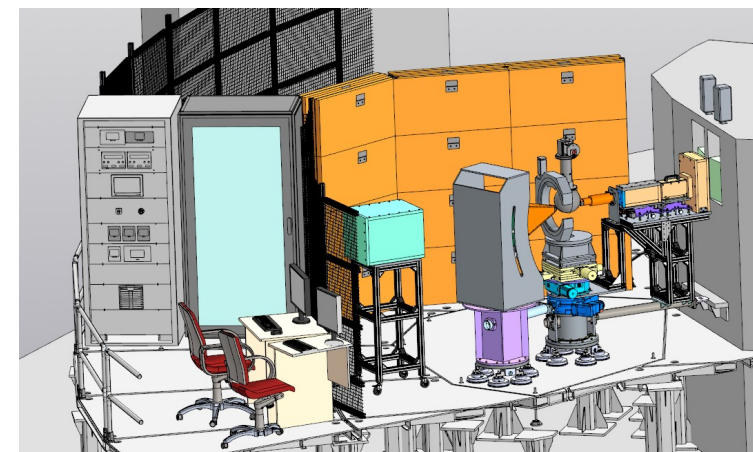
Systems

Anharmonicity

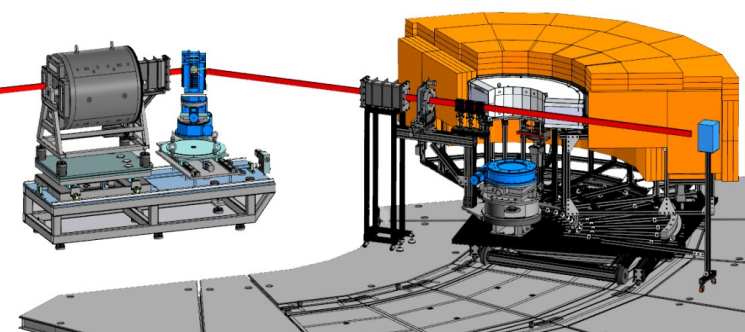


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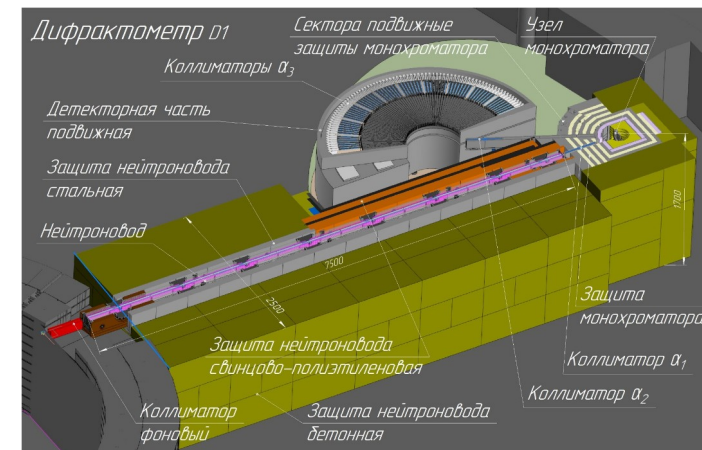
Four-circle diffractometer DC1



Powder multi-detector thermal neutron diffractometer D3



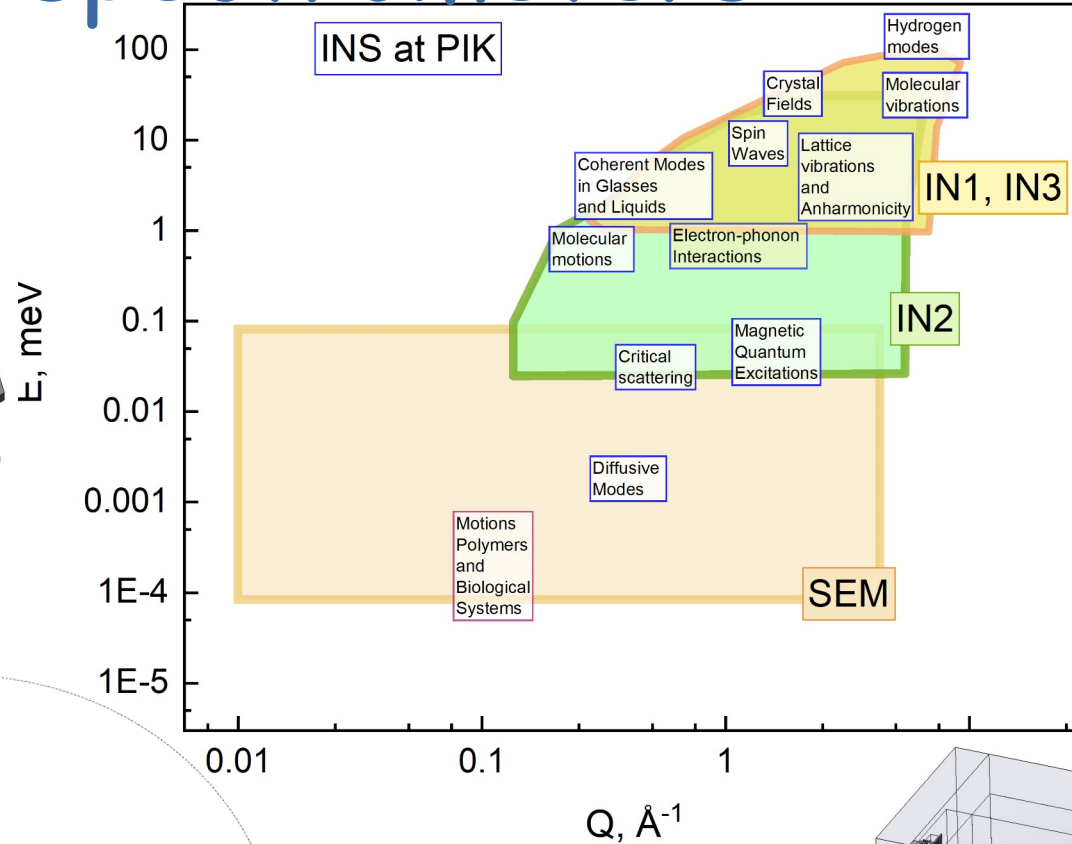
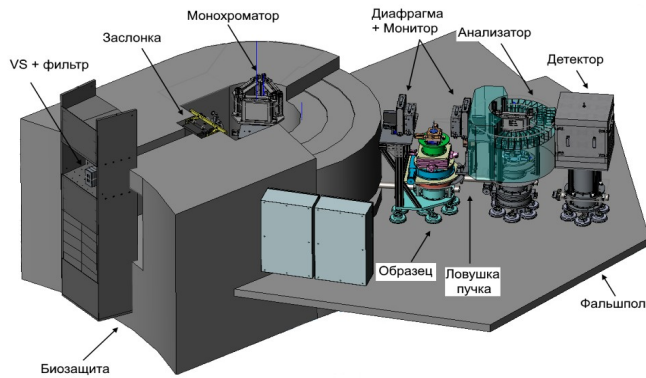
D1 – High-resolution powder diffractometer



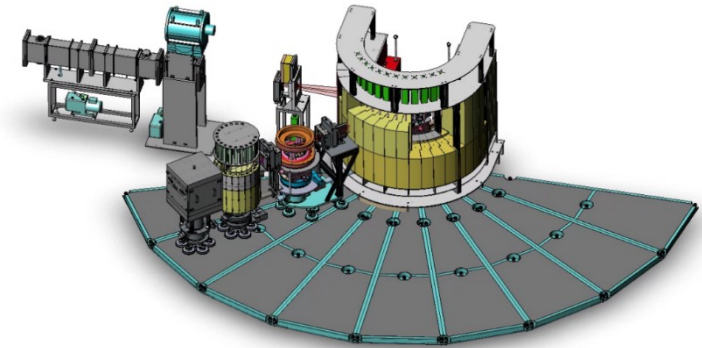


# Complex of spectrometers

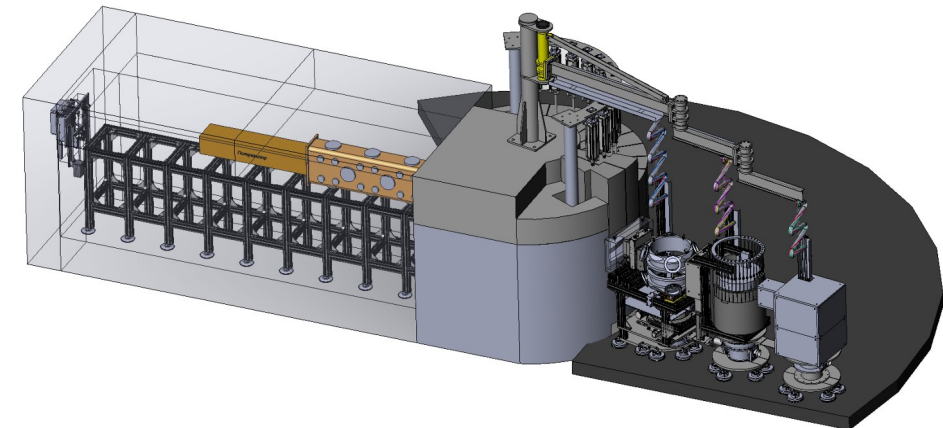
### Triple-axis thermal neutron spectrometer IN-1



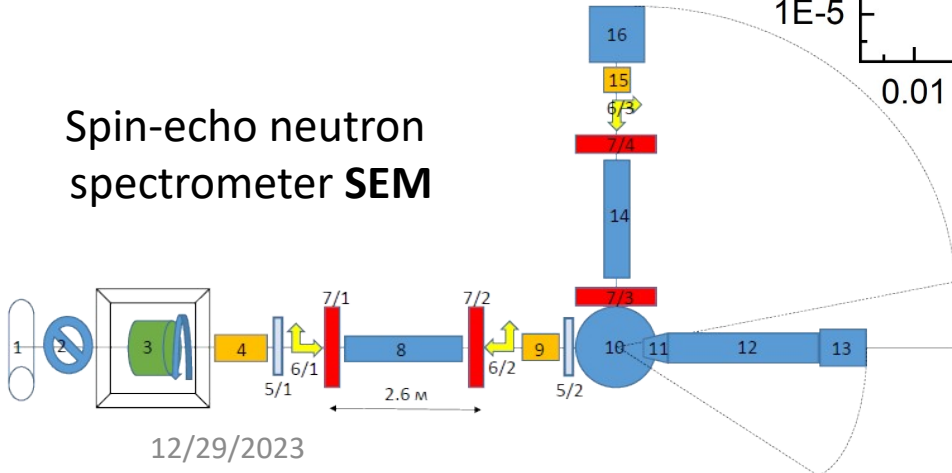
### Triple-axis cold neutron spectrometer IN-2



### Triple-axis polarized neutron spectrometer IN-3



### Spin-echo neutron spectrometer SEM



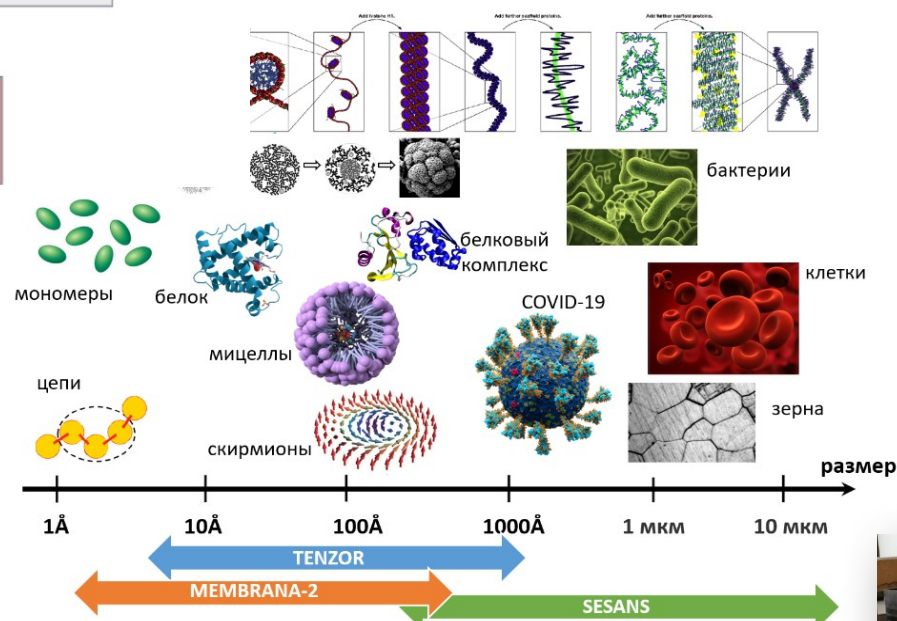
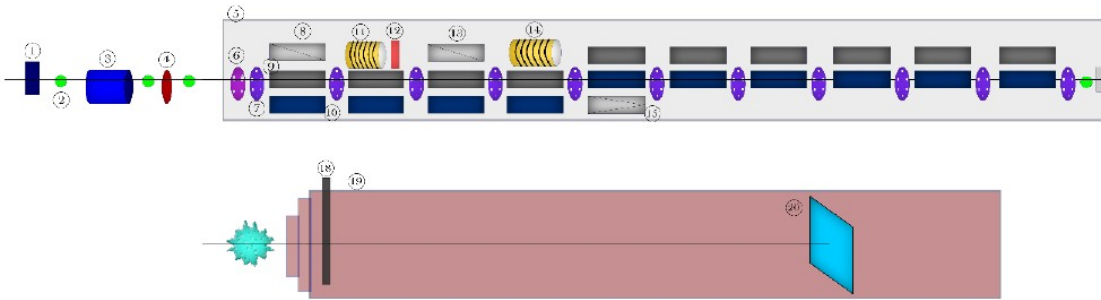
12/29/2023

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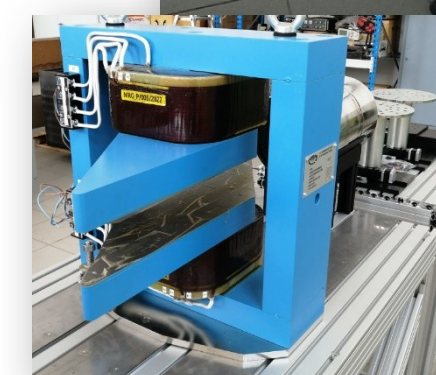
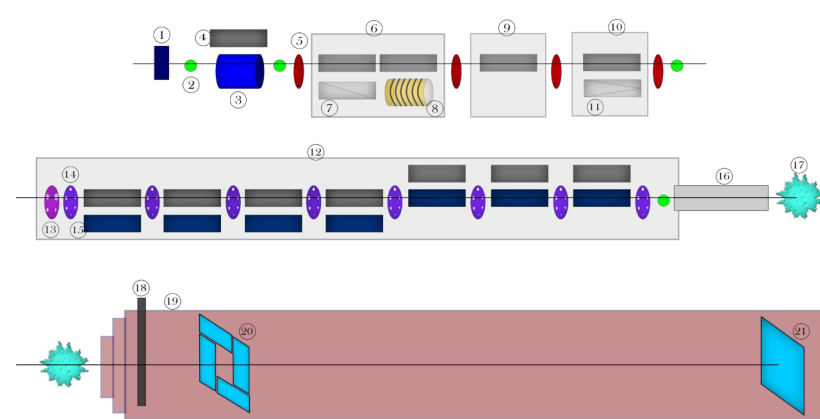
# Small angle scattering machines

**SESANS** –  
 Spin echo small-angle  
 diffractometer

**Tensor** – Small angle polarized diffractometer



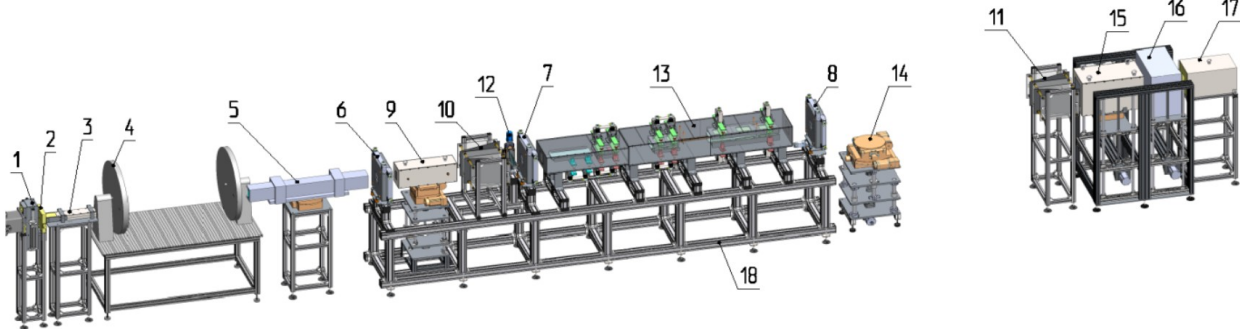
**Membrane** – Small angle diffractometer



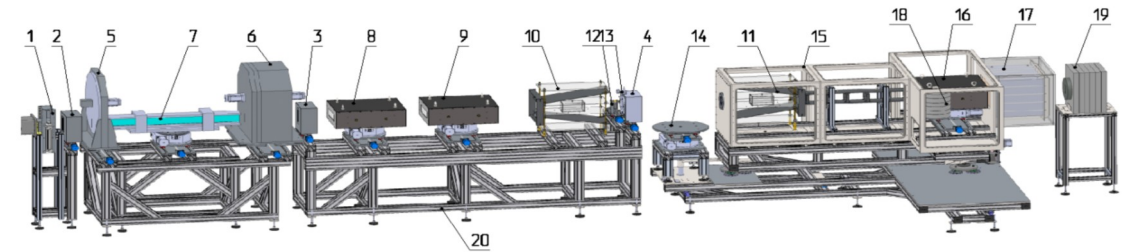
12/29/2023

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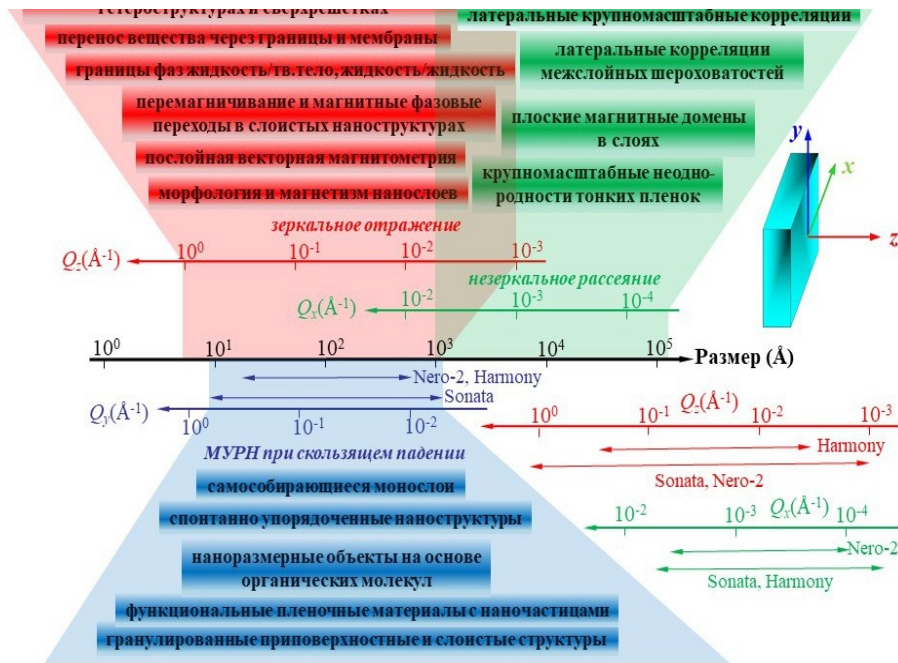
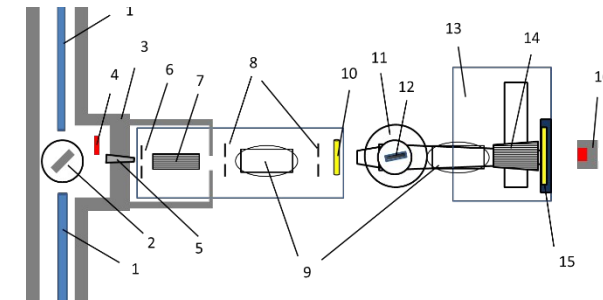
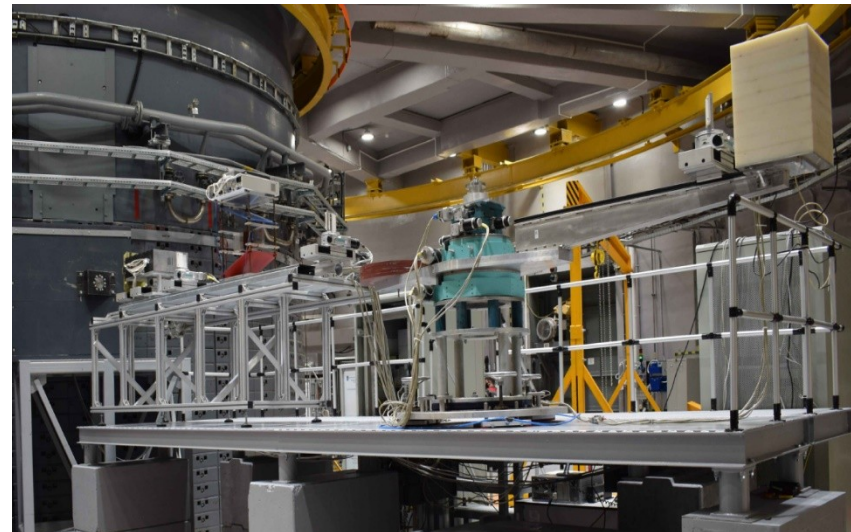
## HARMONY – Reflectometer with vertical scattering plane



## SONATA – High flux reflectometer



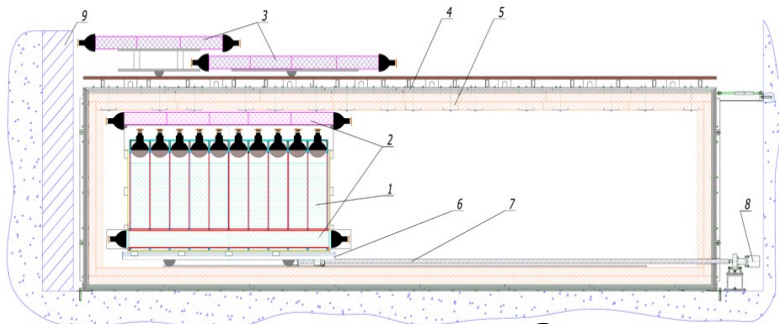
## NERO-2 – High resolution reflectometer



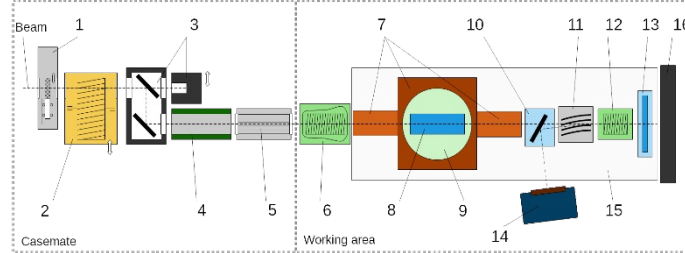


# Particle and nuclear physics

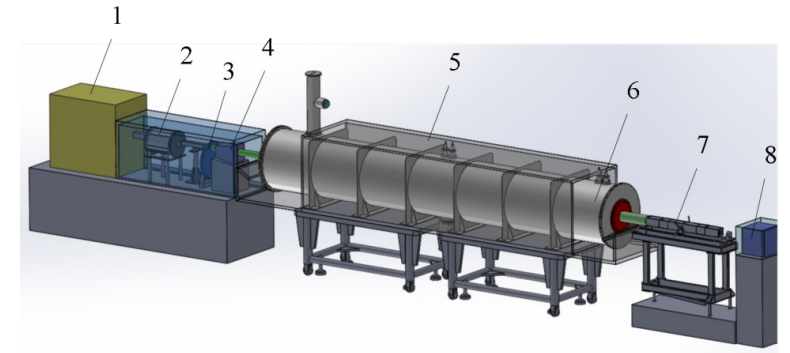
## NEUTRINO-4 - 90%



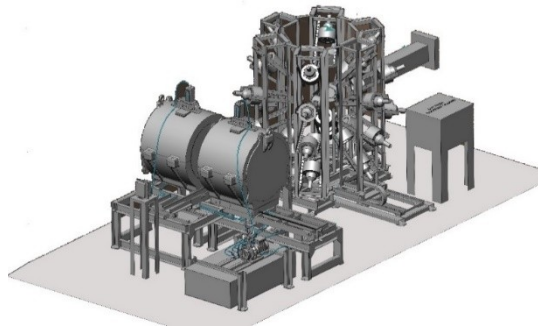
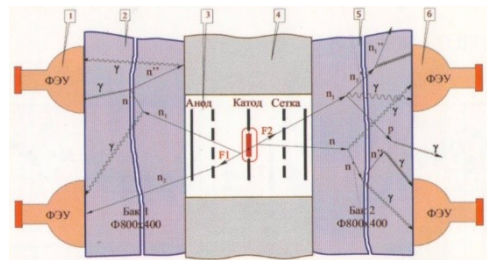
## DEDM Setup for Crystal 60% Diffraction Experiments



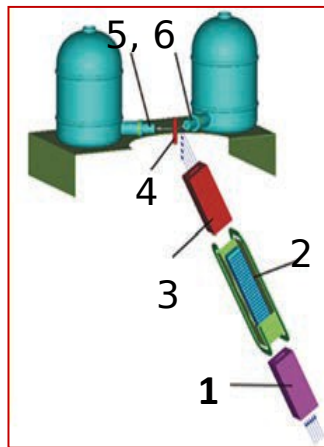
## Neutron beta-decay 30%



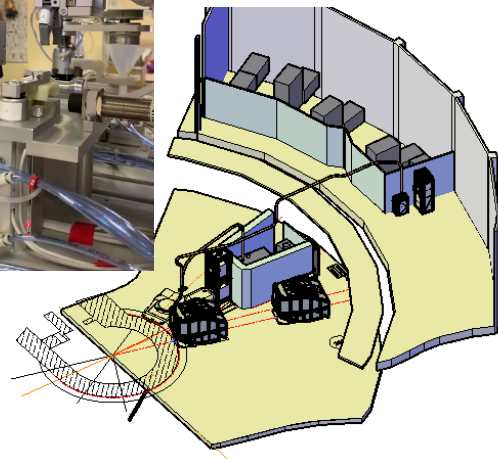
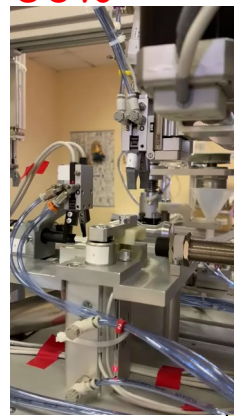
## FISsion COrrrelations 60%



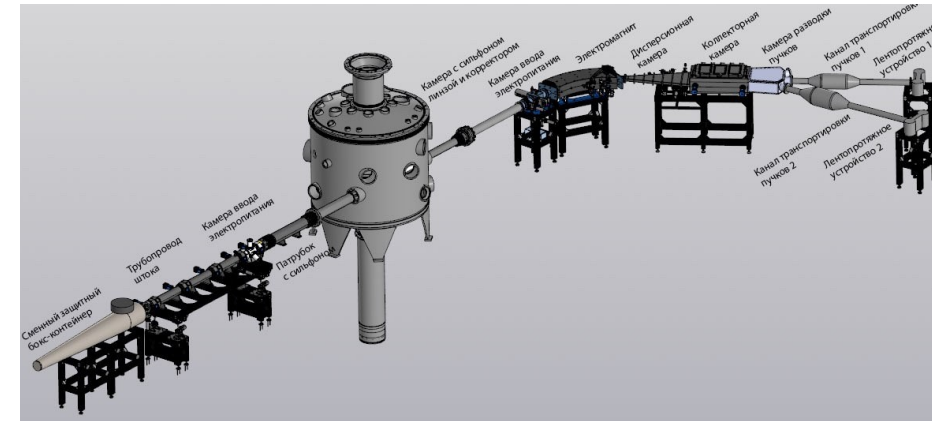
## Prospect - Study the (n,γ)-reaction by thermal neutron -50%



## INAA - Neutron activation analysis 90%



## Investigation Radioactive Isotopes with Neutron (IRINA) facility - 70%









# С НОВЫМ ГОДОМ!!!

