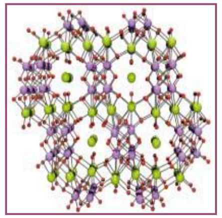
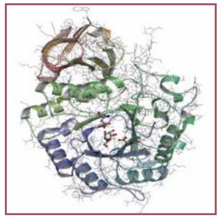
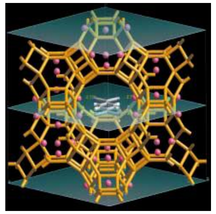
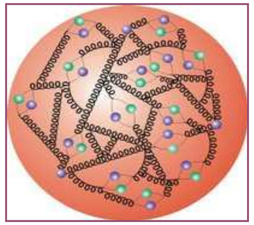
International center for neutron research based on the PIK reactor

Vladimir Voronin,

NRC "Kurchatov institute"-PNPI

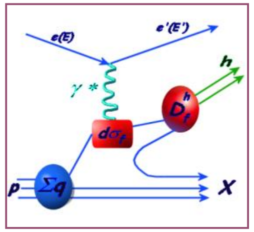
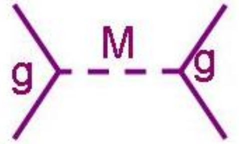
Why we need neutrons?

Types of neutron experiments

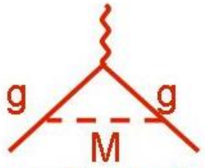





Experiments with neutron

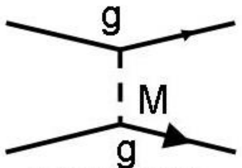
- Neutron as instrument
  - Structure and dynamics of matter
- Neutron as an object of research
  - Property of fundamental interactions

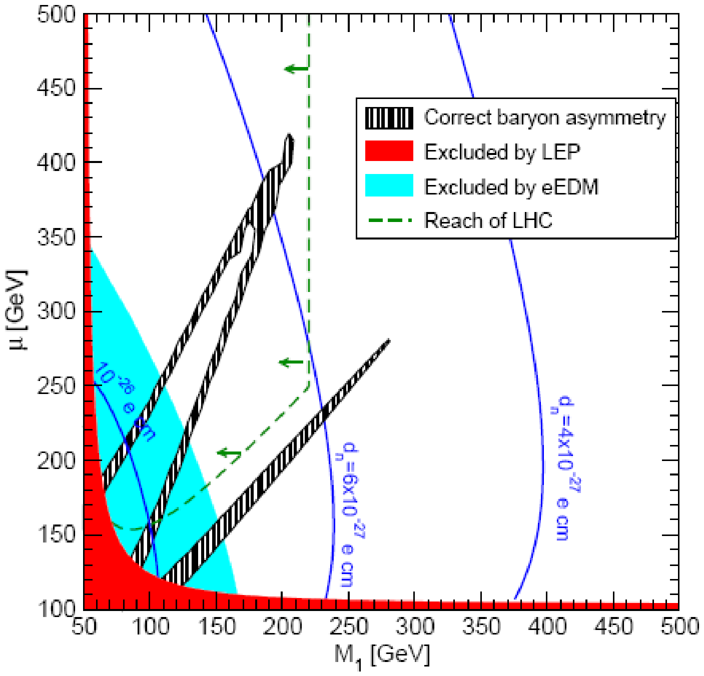
A new resonance



New virtual effects



A new force



New SM: Unique role for low energy studies in the LHC era (and beyond!)

Two frontiers in the search for new physics

Collider experiments (pp, e^+e^-, etc) at higher energies ($E >> M_Z$)

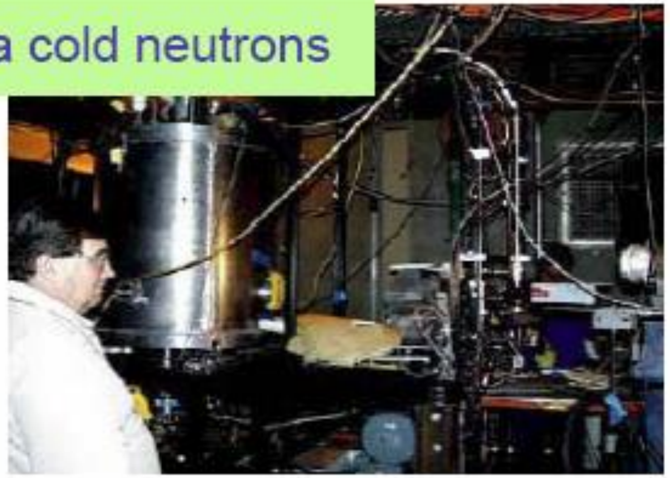
Large Hadron Collider

CERN

High energy physics

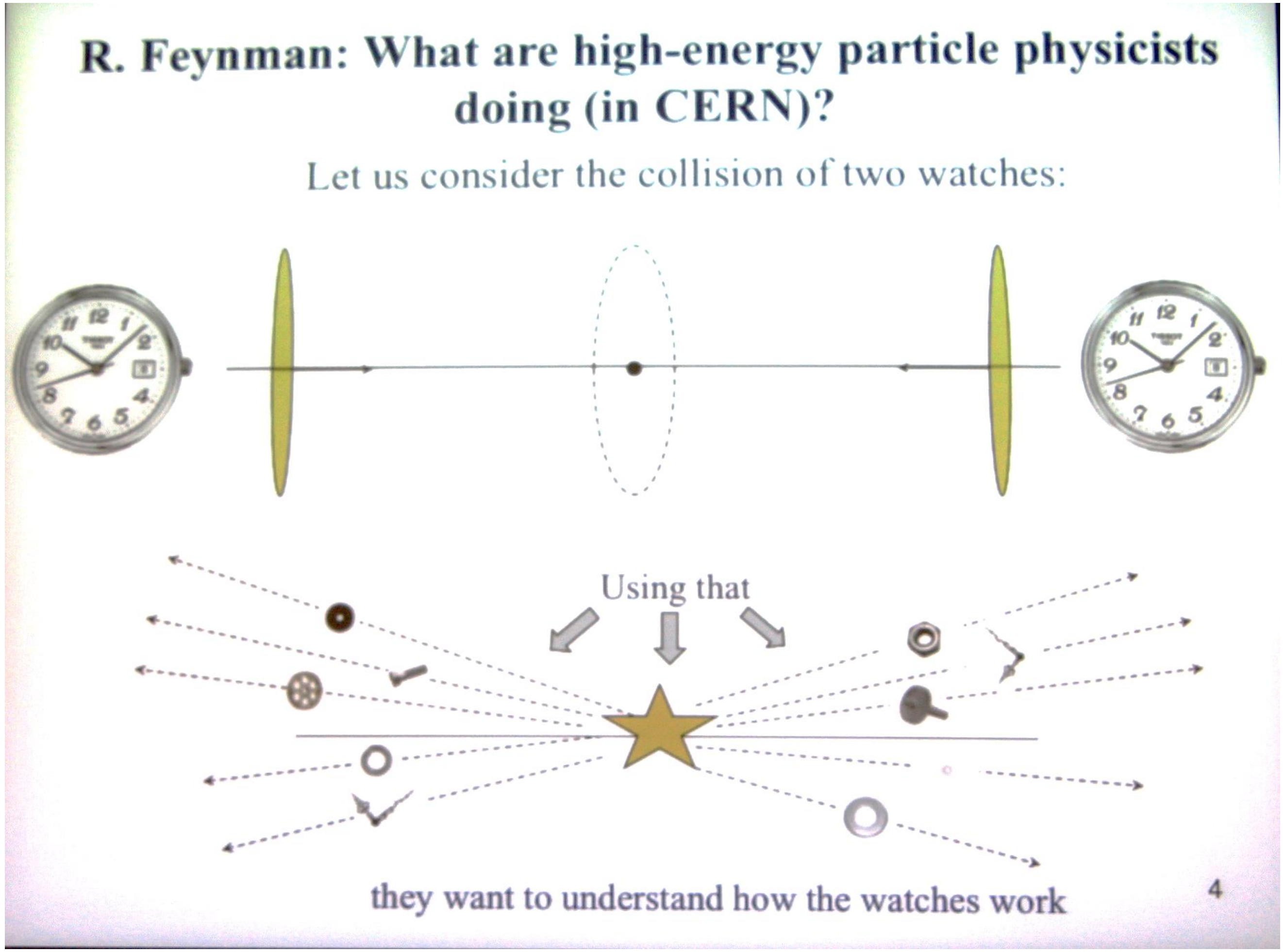
Indirect searches at lower energies ($E < M_Z$) but high precision

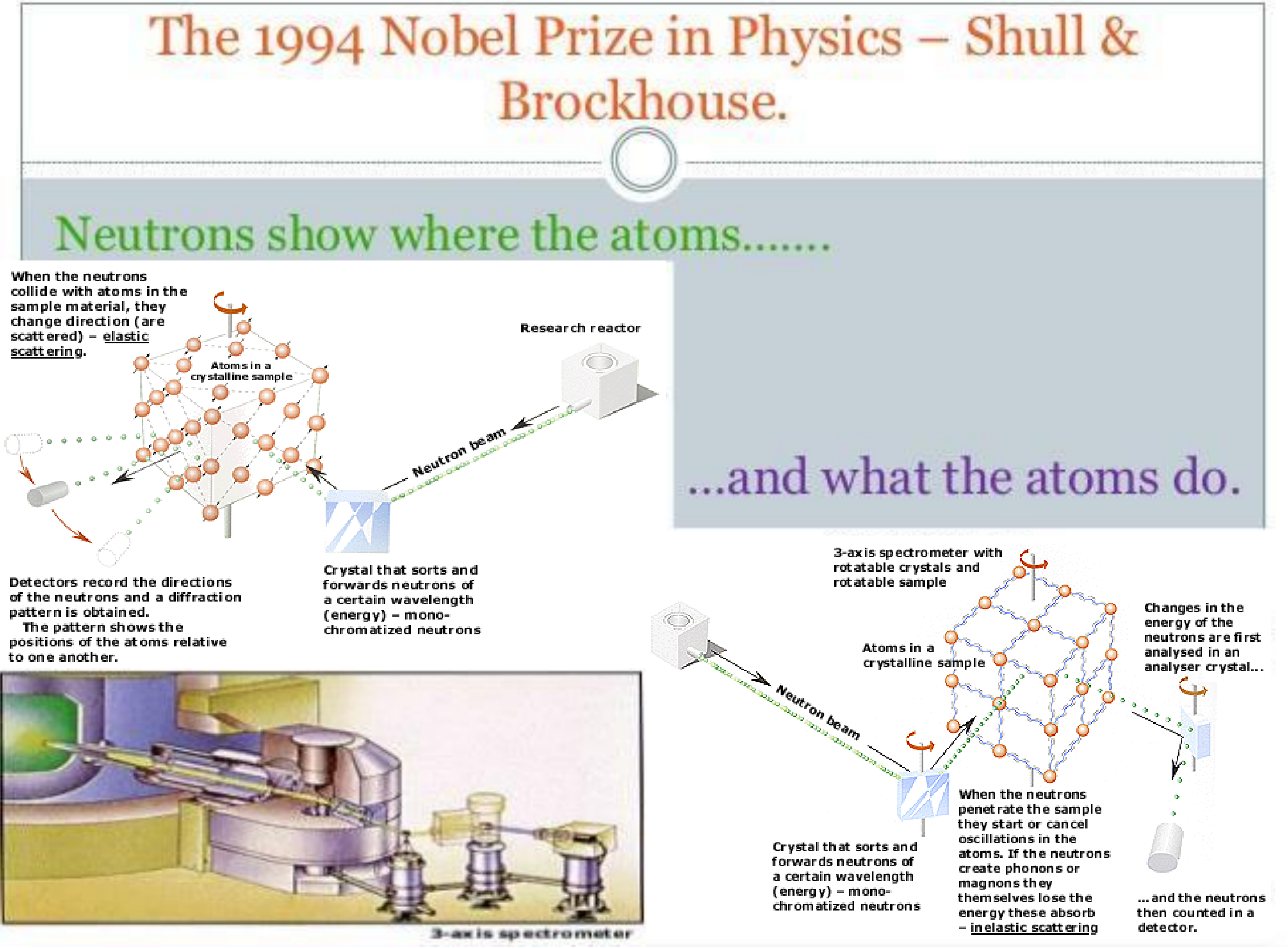
Ultra cold neutrons



Particle, nuclear & atomic physics

Collider (high energy) and neutron (low energy) experiment





Neutrons offer many advantages as a probe to study materials, matter:

(i) a wide range of length and timescales,

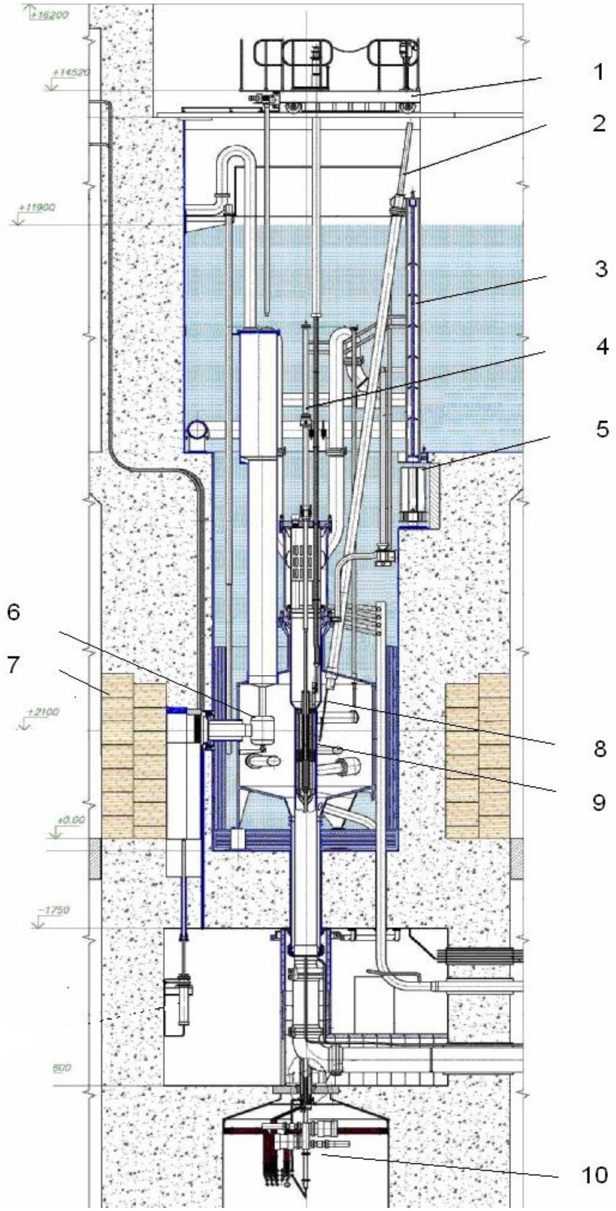
(ii) Cold and thermal neutron energy close to the excitation energy,

(iii) an ideal probe for magnetism,

(iv) high sensitivity and selectivity to the chemical elements and isotopes,

(v) deep penetration into materials

PIK reactor as neutron source

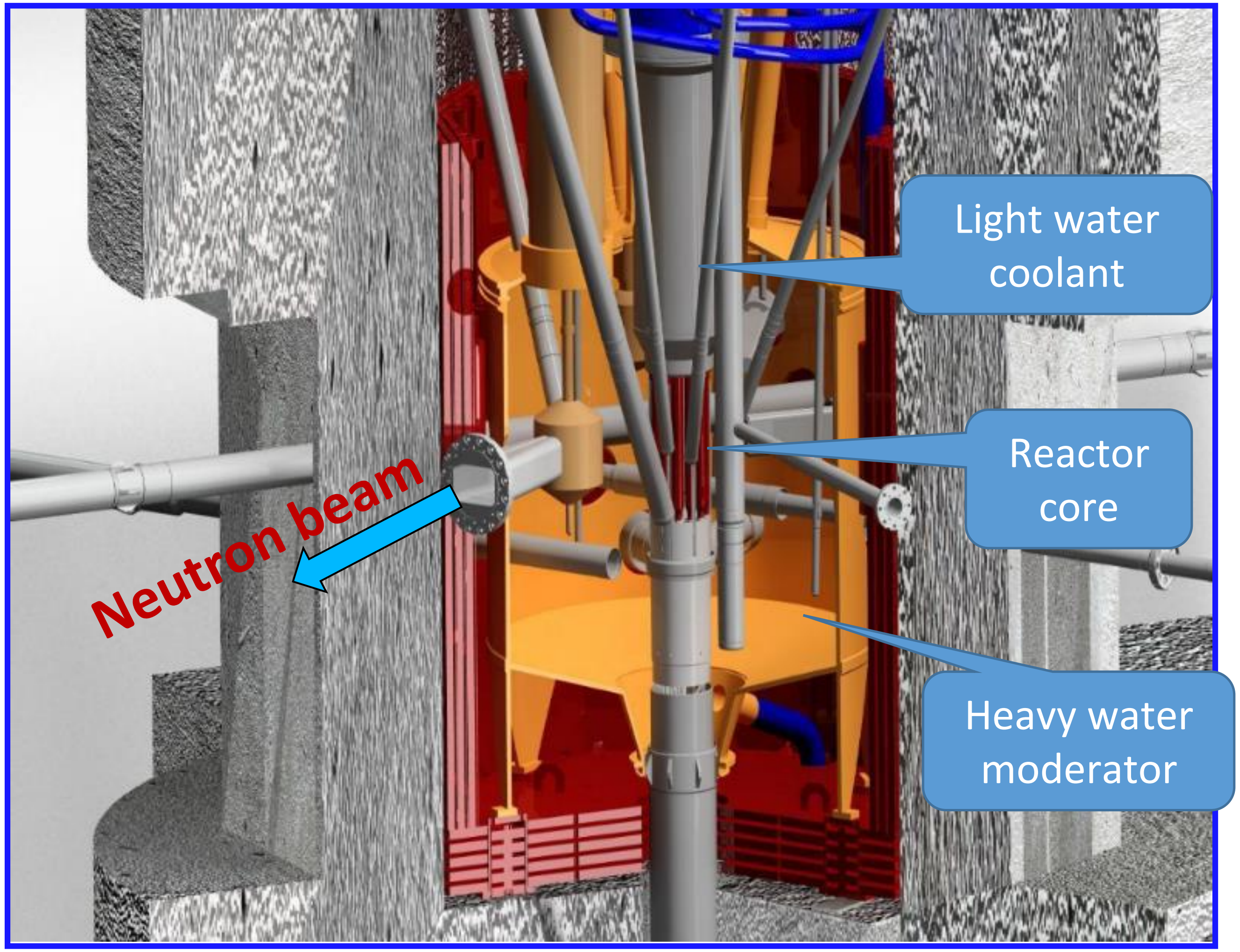


High flux research reactor PIK

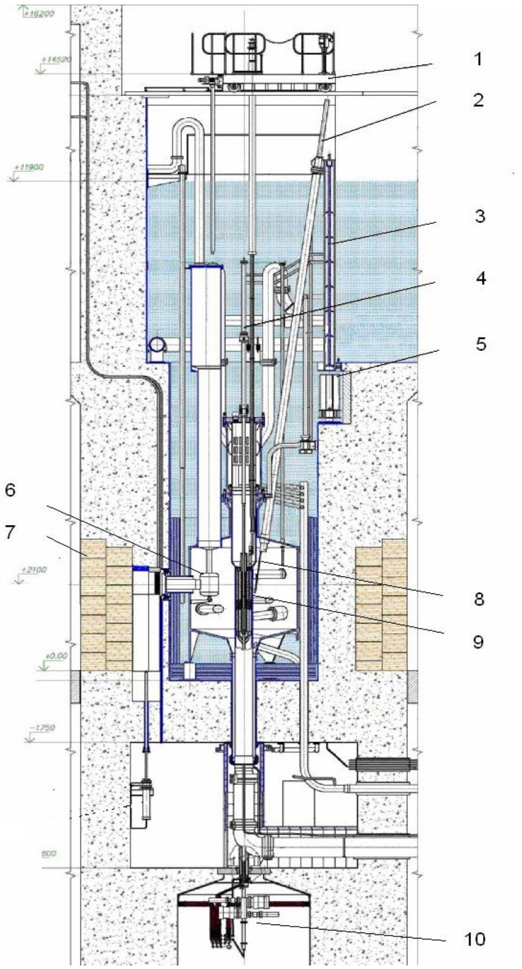
PIK is aimed for production of neutron beams with the maximal possible fluxes.

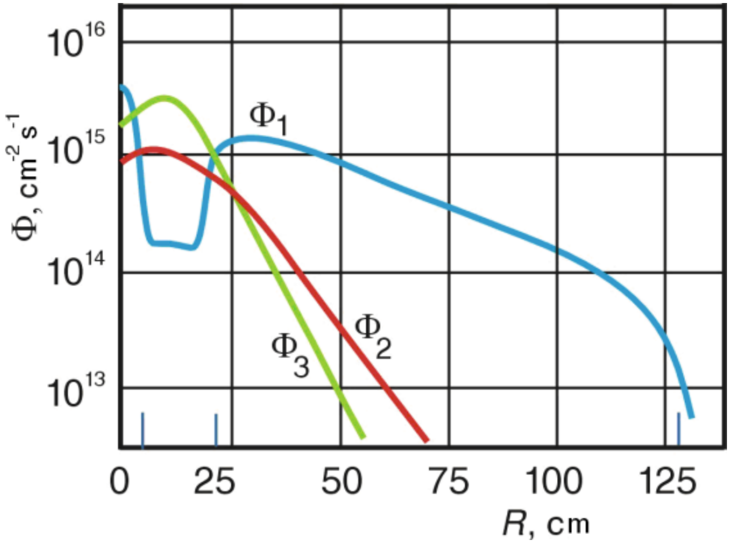
We need:

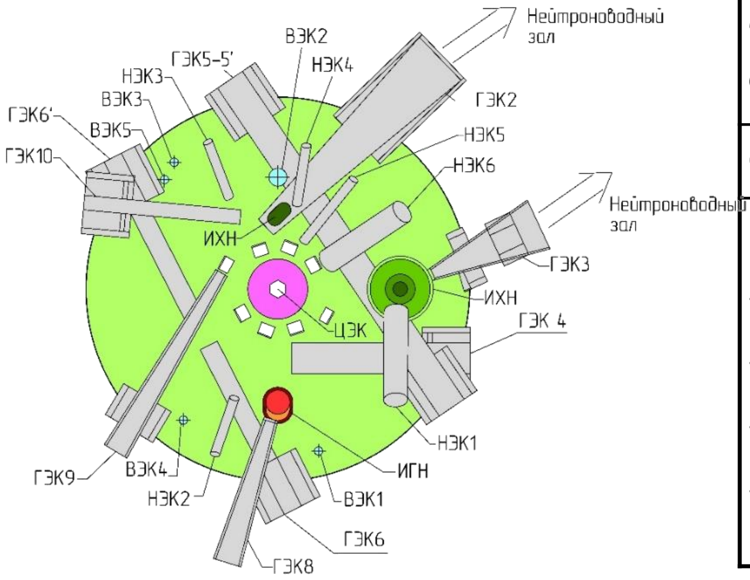
1. High neutron fluxes inside the reactor
2. Neutron thermalization system to provide required energy
3. Neutron transportation system
4. Neutron scattering station



Reactor PIK parameters



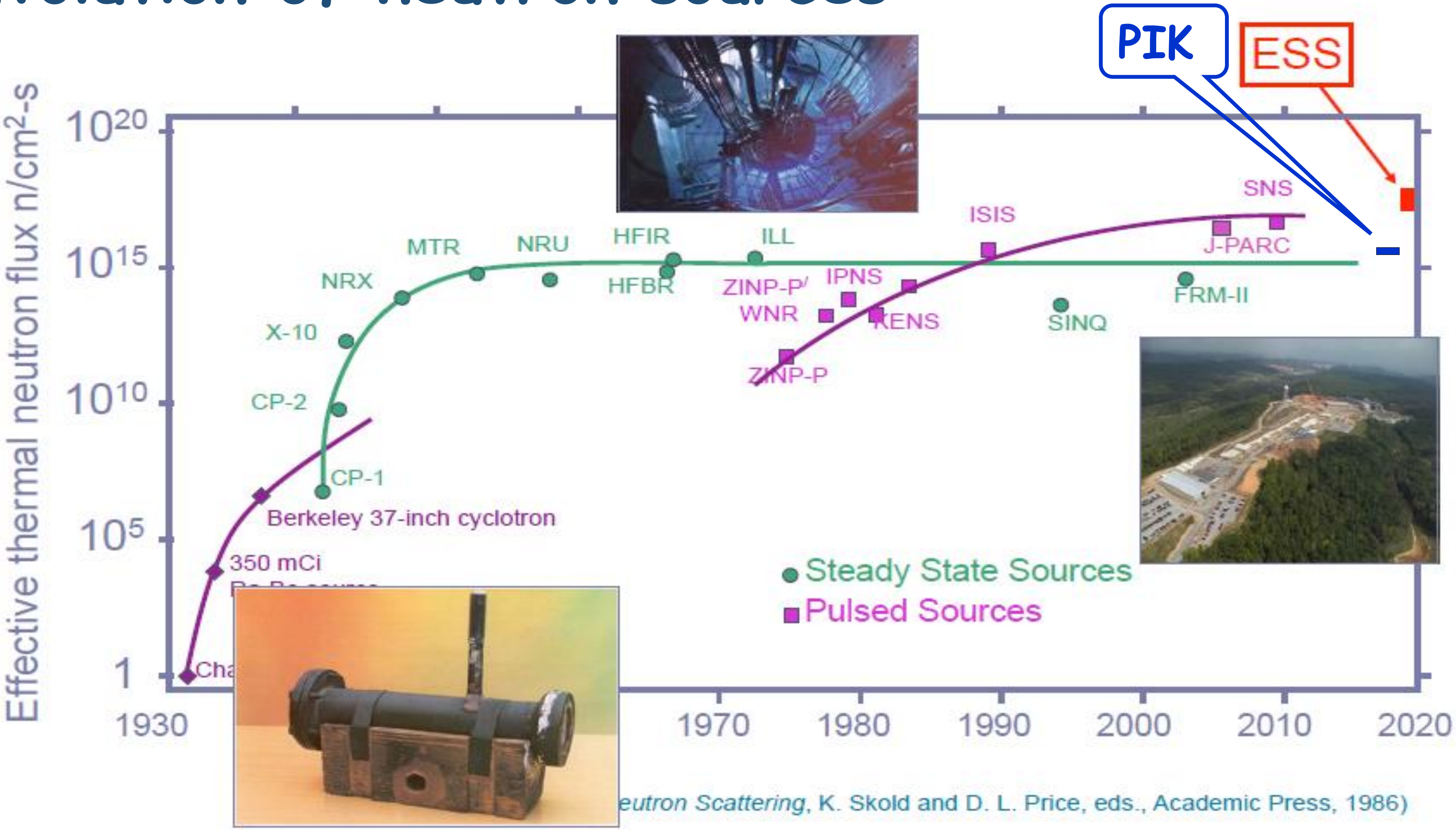




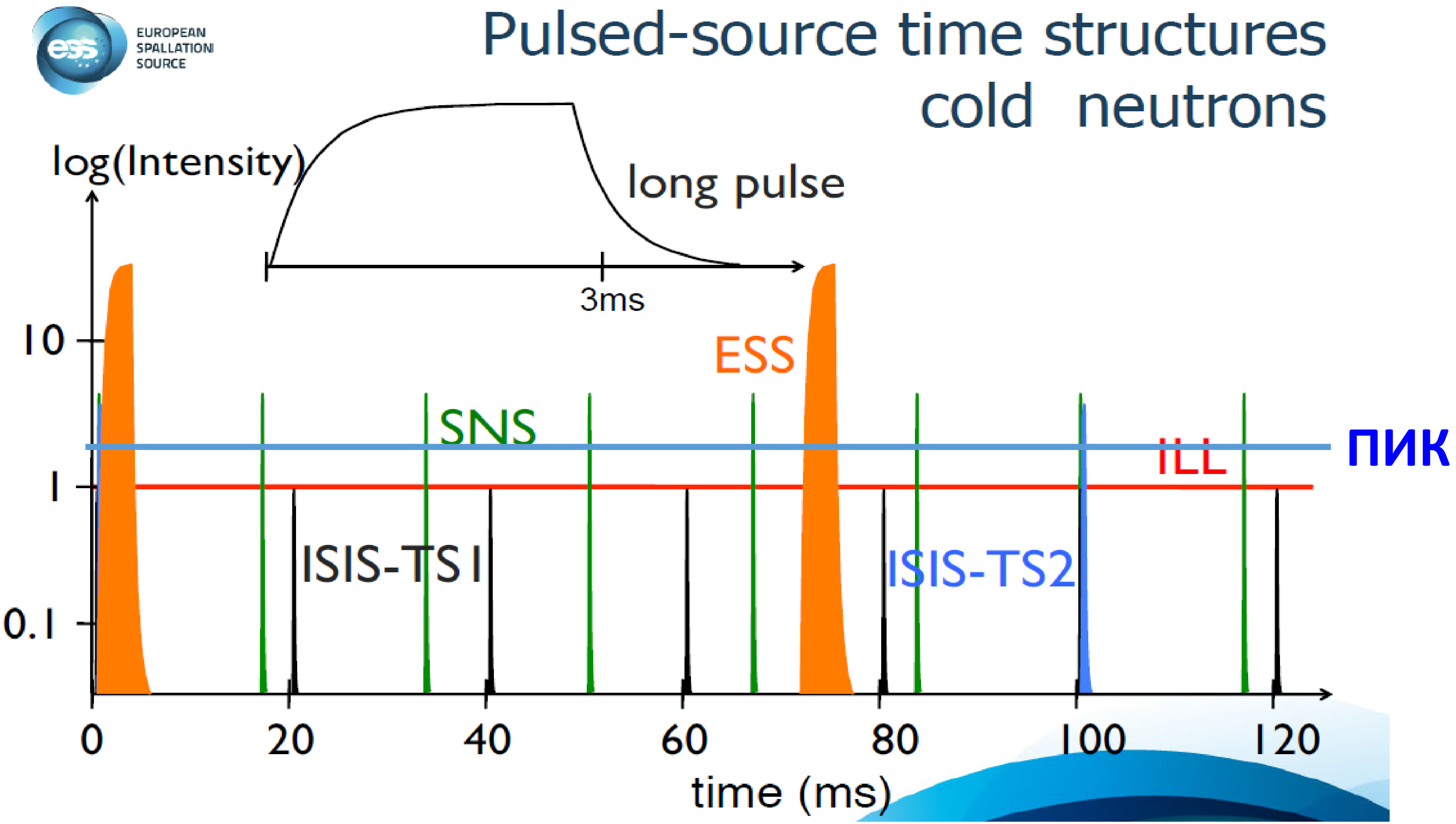
	Value
Power	100 MW
Reactor core volume	50 l
Core height	500 mm
Coolant	H_2O
Reflector	D_2O
Maximal neutron flux in moderator	1.3×10^{15} n/cm²c
Maximal neutron flux in central trap	5×10^{15} n/cm²c
Operation cycle	~30 day
Experimental channels - Horizontal (HEC) - Vertical (VEC) - Inclined (IEC) - Central (CEC)	 10 6 6 1

PIK and European neutron landscape

Evolution of neutron sources



Comparison of neutron sources

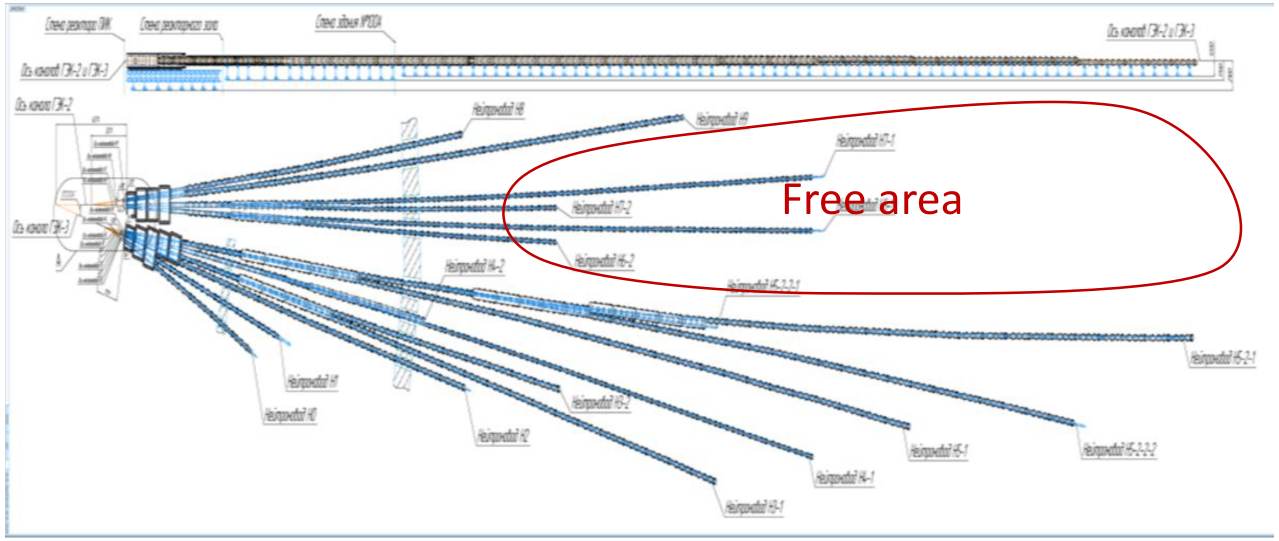


PIK is part of the Strategy on Germany Neutron Research: 2015-2045

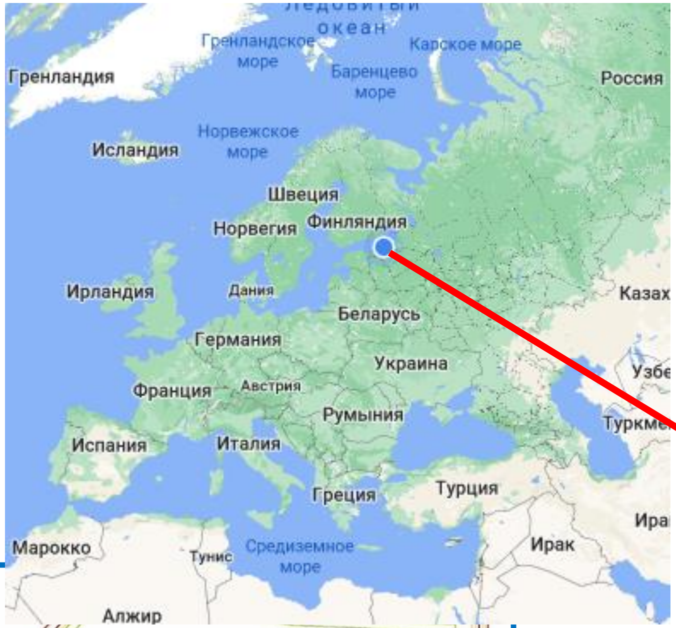
Update 2017 Sebastian M. Schmidt, Thomas Brückel, Stephan Förster and Martin Müller
Original version 2015 Sebastian M. Schmidt, Andreas Schreyer, Helmut Dosch

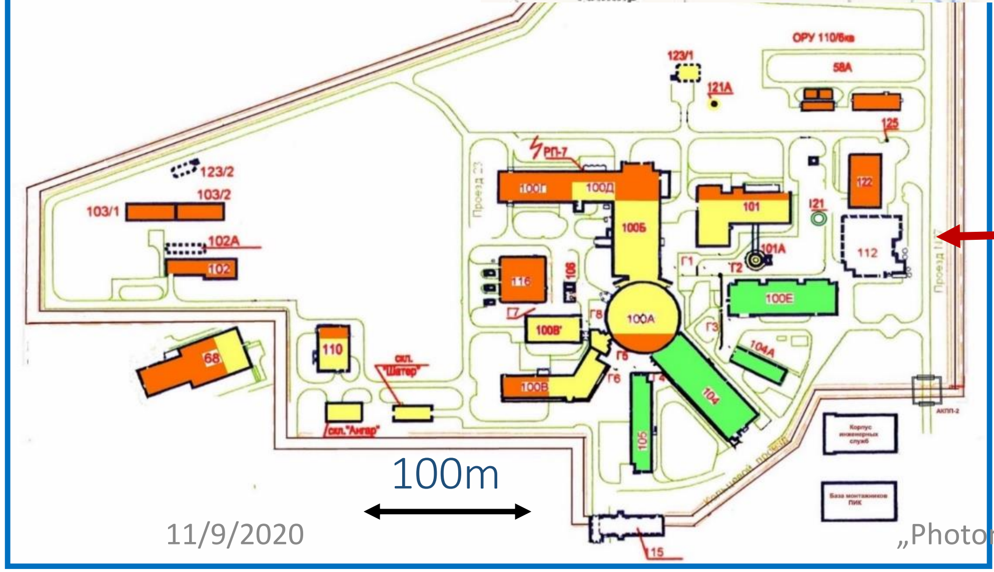
PIK could be the base of International center for neutron research

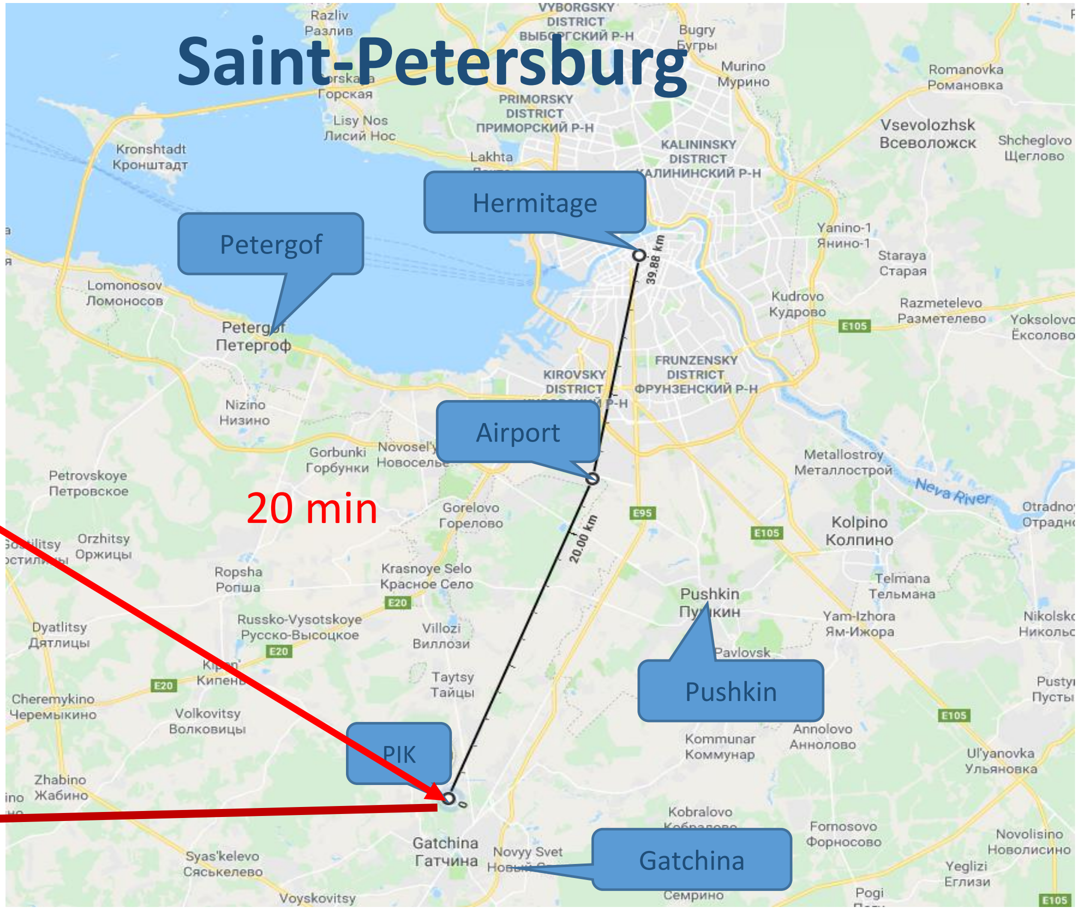
1. Two stations of Phase 1 with international contribution will be commissioned 2020.
2. CREMLIN+ (2020-2022) (Connecting Russian and European Measures for Large-scale research INfrastructures) (goal – To enhance science cooperation between the six Russian megascience facilities and the European RI counterparts) **Work Package 4 - Science Cooperation with the PIK research reactor in the field of neutron sources**
3. Free neutron beam positions for collaborates



Location of the reactor PIK complex (NRC "Kurchatov institute"-PNPI, Gatchina, Russia)



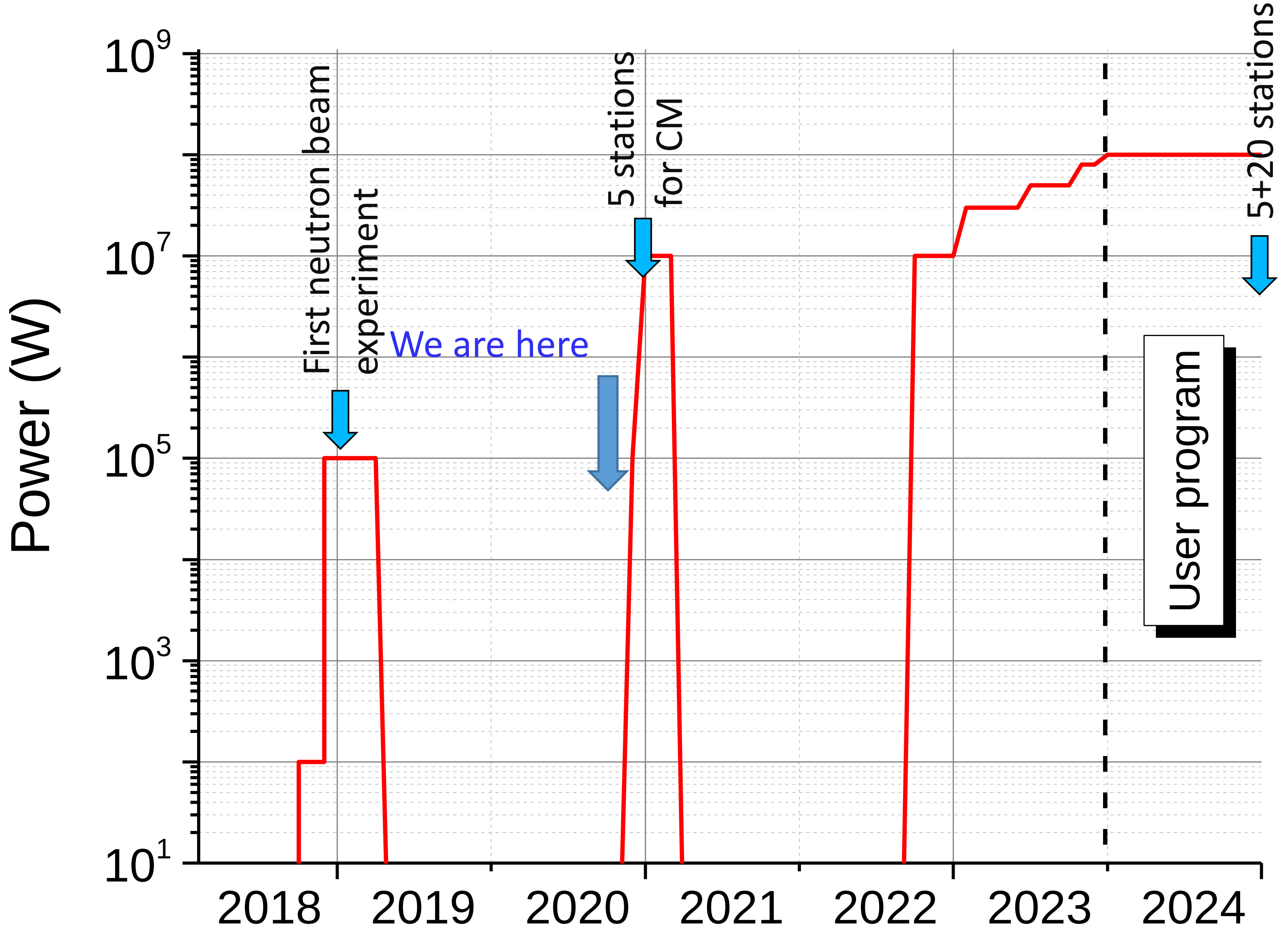




PIK commissioning and instrumentation program

PIK reactor (NRC “Kurchatov institute”-PNPI, Gatchina, Russia).

Reactor PIK commissioning: time schedule



Instrumentation Program

Phase 1 (2020) - 5 test stations of the first phase

Phase 2 (2024)

Neutron sources –

Two cold neutron source (HEC 2 and HEC 3)

Hot neutron source – HEC 8

Ultra cold neutron source – HEC 4

Instrumentation base (20 stations)

Experimental stations for condensed matter (13)

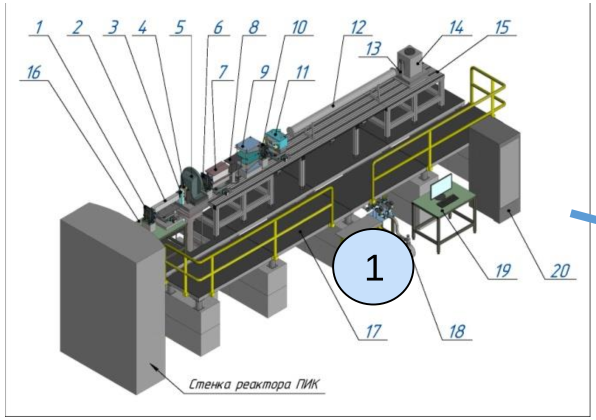
- Diffractometers (3)
- Spectrometers of inelastic scattering (5)
- SANS machines (3)
- Reflectometers (2)

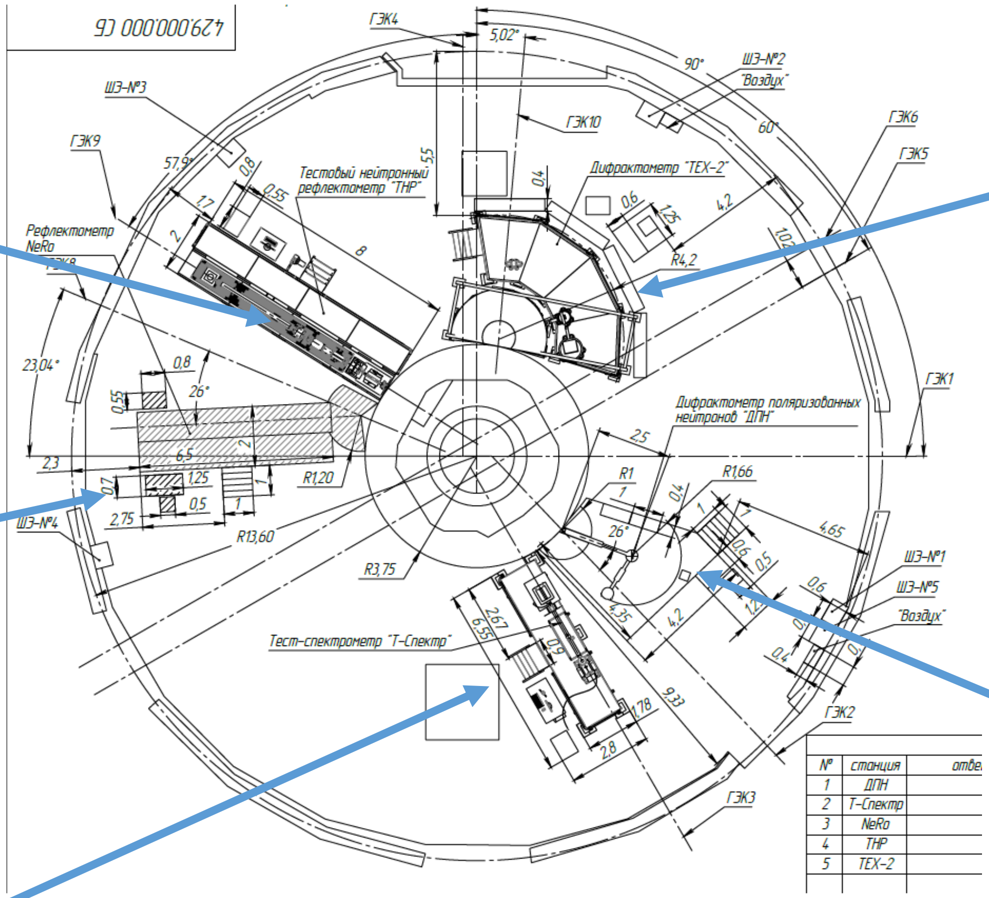
Experimental stations for fundamental physics (7)

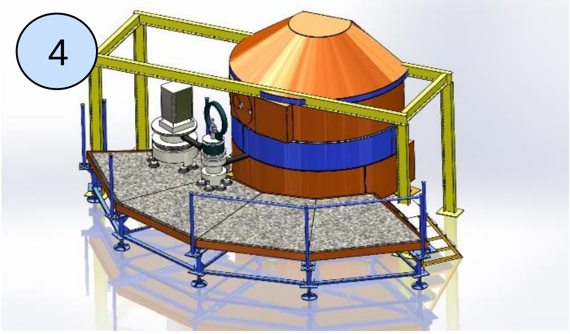
- Stations with CN (2)
- Neutrino physics facility (1)
- Stations for nuclear spectroscopy (3)
- Fission physics (1)

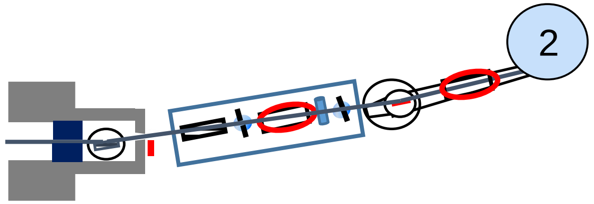
Phase 1

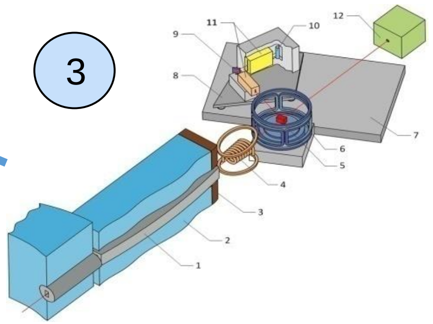
5 station for condense matter physics (commissioning 2020).

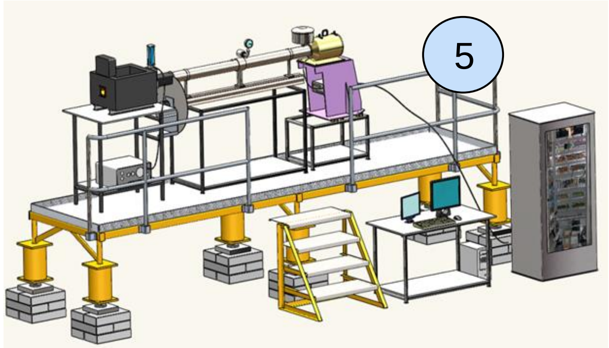








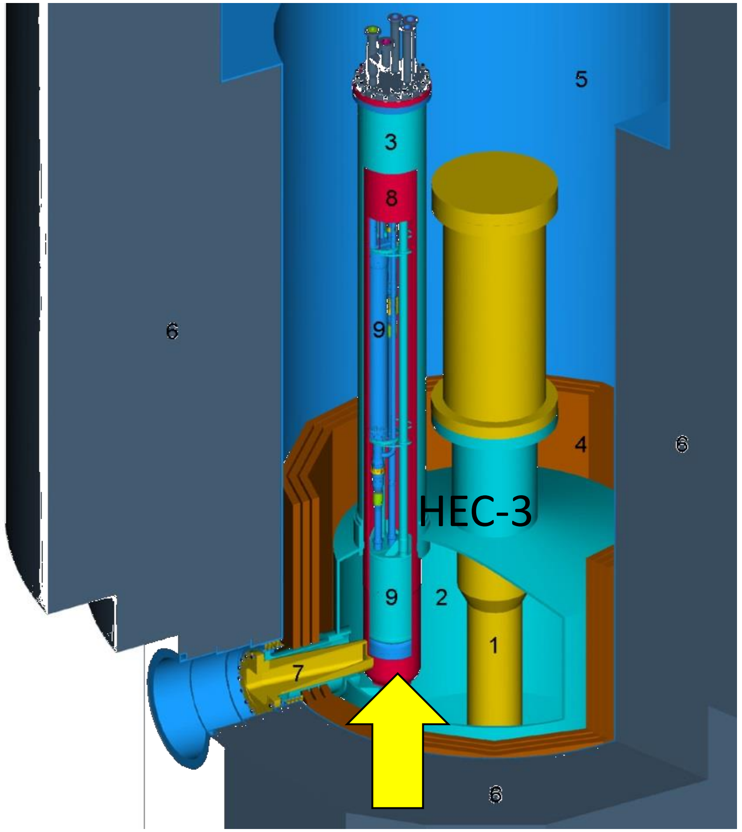


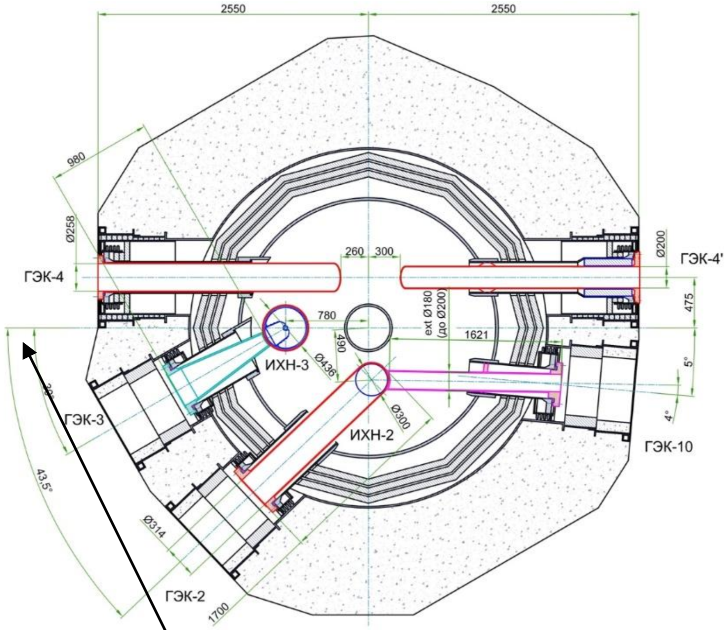


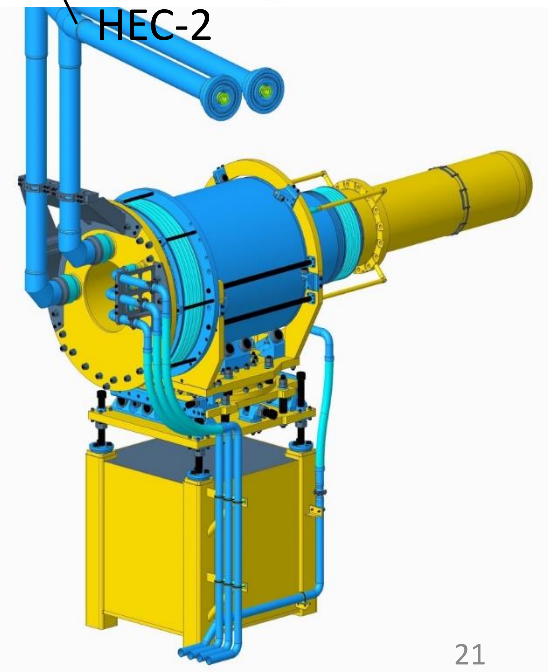
1. TNR test neutron reflectometer
2. NERO Polarized Neutron Reflectometer (GKSS)
3. DPN polarized neutron diffractometer
4. Textured Diffractometer TEX-2 (GKSS)
5. Test neutron spectrometer

Phase 2

Cold neutron sources (CNS)



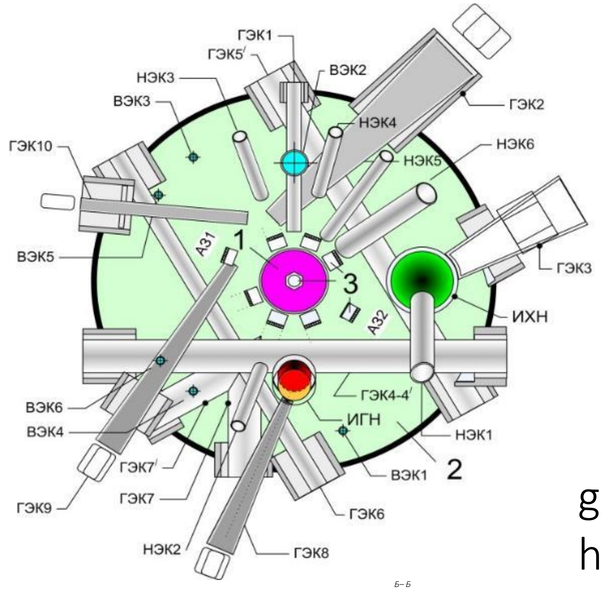


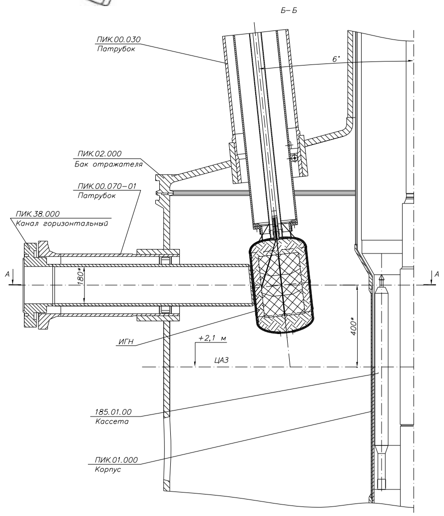


CN source - parameters
Liquid deuterium - 25 L, **T = 20 K**
The distance from the active zone of the reactor-60cm
Heat release – 5-6 kW.

UCN source - parameters
Liquid deuterium - 20 L,
T = 20 K
Heat release – 7 kW.

Hot neutron source

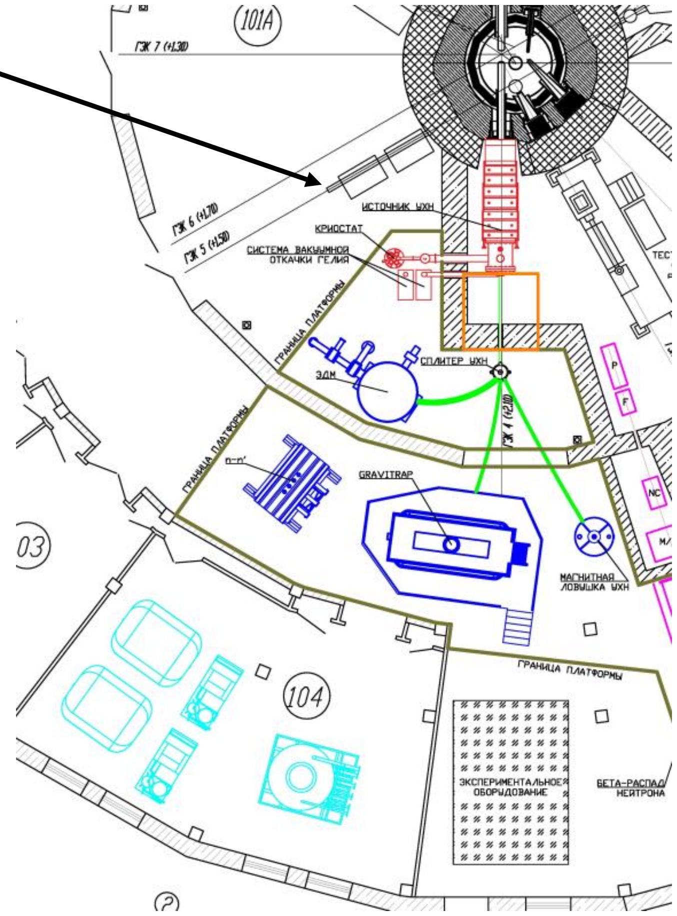




graphite radiation heating
T=1500-2000 K
V ~ 5 liter

Ultra cold neutron source

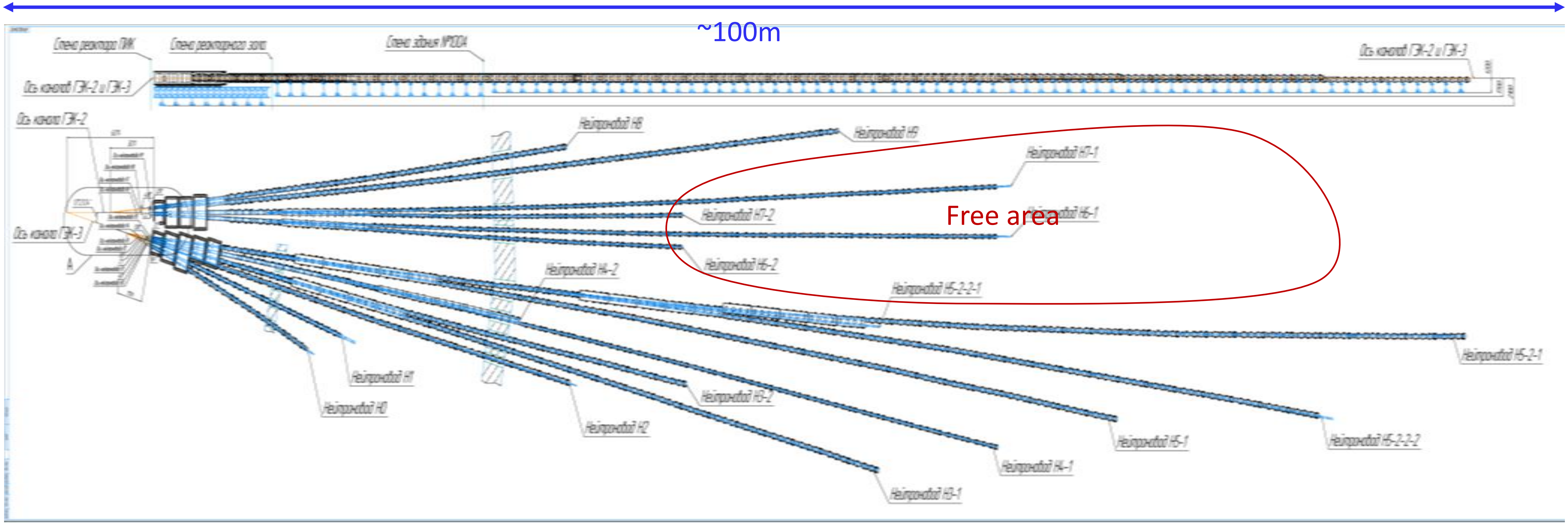
Superfluid He-4 converter on beam HEC-4
T-(0,7-0.9)K
V~35л



UCN density ~ $2 \cdot 10^3$n/cm^3
(100 times better wherever)

Phase 2

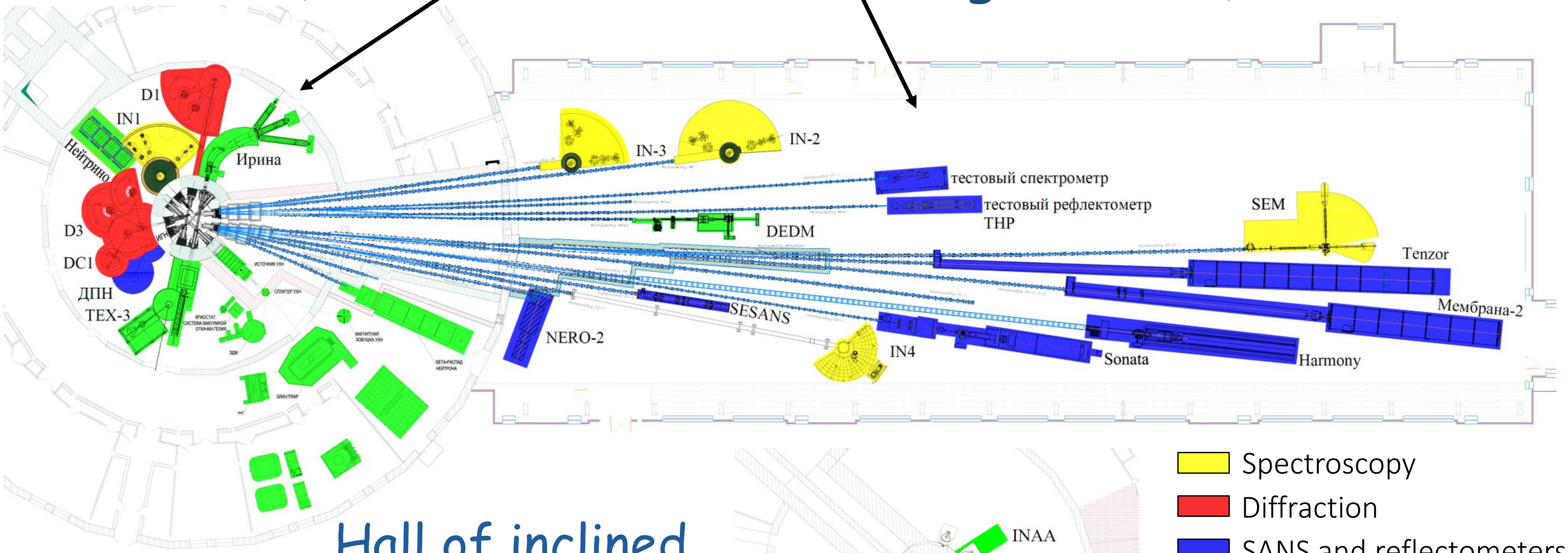
Neutron guide system



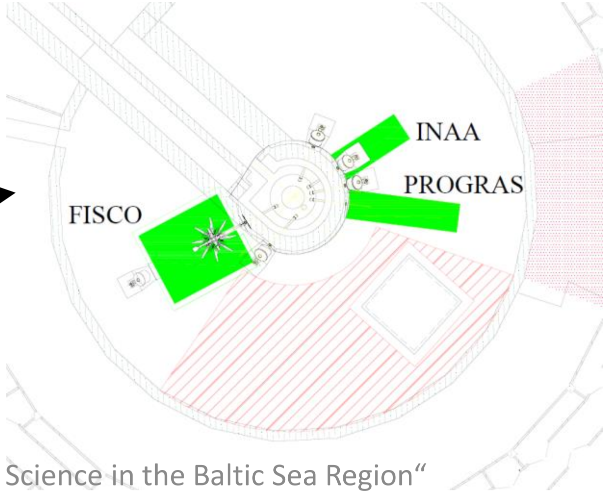
Length ~ 1 km.

Up to 40 experimental positions (neutron flux (3-12) 10^{10} n/cm^{2}s)

Layout of experimental PIK station (hall of HEC and neutron guide hall)



Hall of inclined channel



- Spectroscopy
- Diffraction
- SANS and reflectometers
- Fundamental physics

Road map of instrumentation program

#			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**								**10-100MW**				**~100MW**			
1		**Project**																						
2		**Experimental channel**																						
3		**HNC HEC-8**																						
4		**UCNS HEC-4**																						
5		**CNS HEC-2**																						
6		**CNS HEC-3**																						
7		**Neutronguide system**																						
										Neutron stations														
2		SESANS																						
4		INAA									**Phase 1**													
5		«Нейтрино» (Neutrino)																						
6		D1																						
7		Мембрана – 2 (Membrane – 2)																						
8		DC-1																						
3		SONATA																						
1		IN-1																						
9		IN-3												**Phase 2**										
10		ИРИНА (IRINA)																						
11		«Бета-распад нейтрона» (neutron beta decay)																						
12		Tenzor																						
13		IN-2																						
14		IN-4																						
15		D3																						
16		SEM																	**Phase 3**					
17		FISCO																						
18		Harmony																						
19		PROGRAS																						
20		DEDM																						

Welcome to Gatchina and NRC "Kurchatov Institute"- PNPI