International center for neutron research based on the PIK reactor

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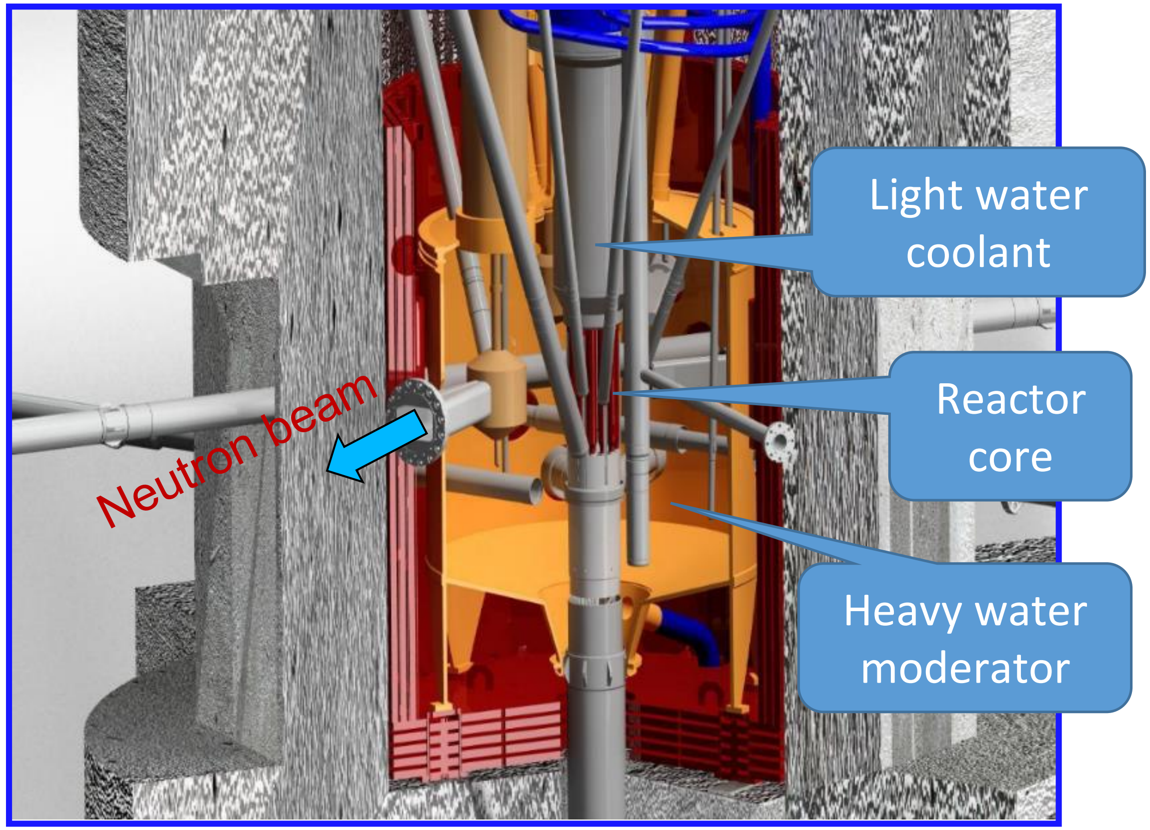
NRC "Kurchatov institute"-PNPI

High flux research reactor PIK

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

We need:

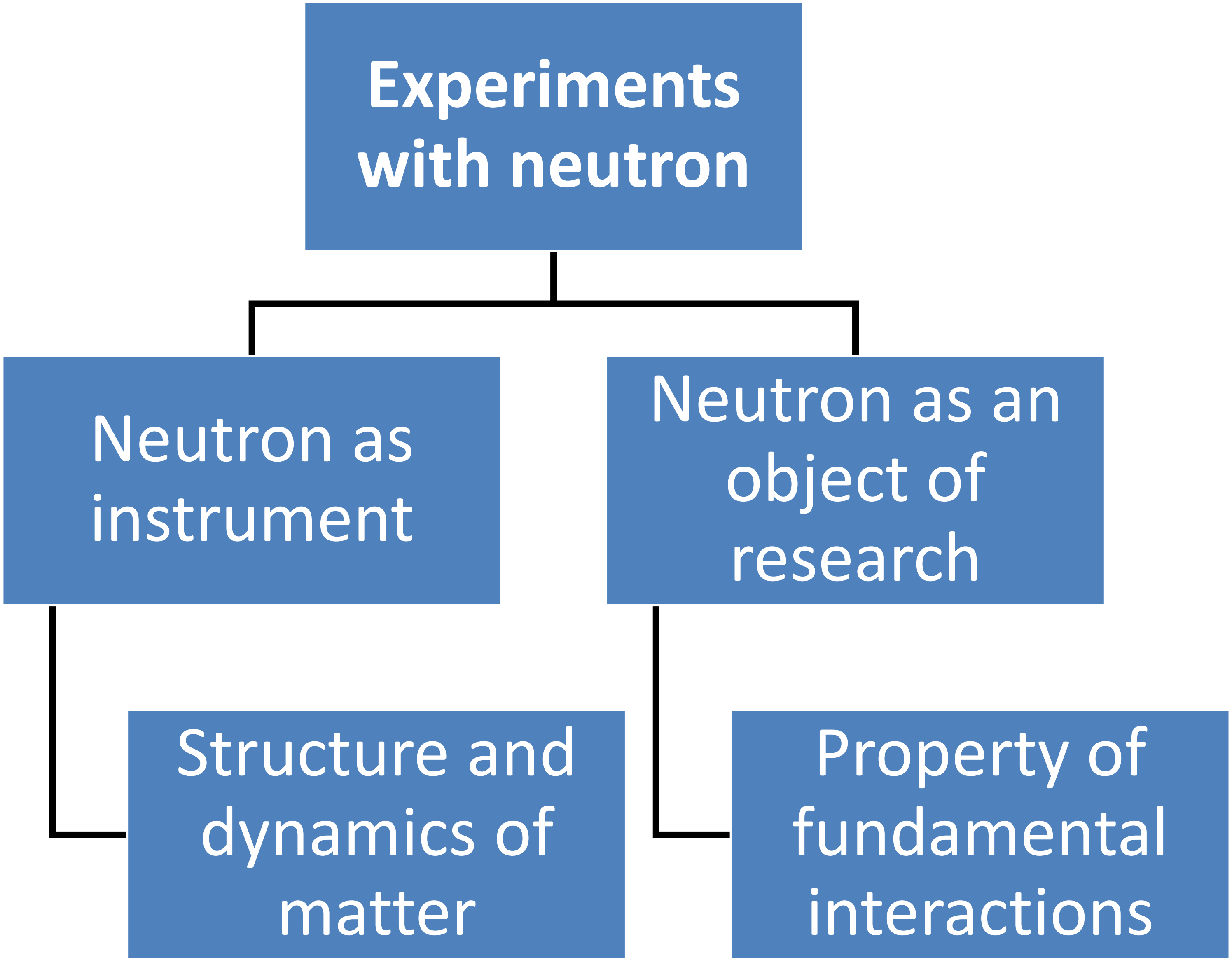
1. High neutron fluxes inside the reactor
2. Neutron termalization system to provide required energy
3. Neutron transportation system
4. Neutron scattering station



NATIONAL RESEARCH CENTRE
«KURCHATOV INSTITUTE»

PETERSBURG NUCLEAR PHYSICS INSTITUTE
Russia, 188300, Leningrad District , Gatchina, Orlova Roscha

Why we need neutrons?



Neutron as an object of research

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 ($E >> M_Z$)

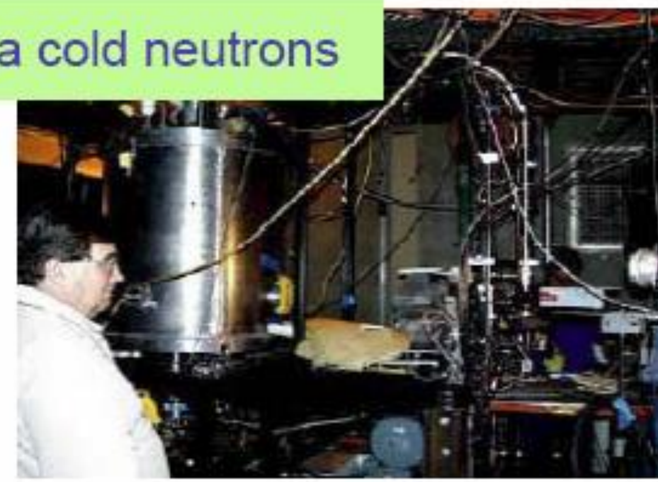
Indirect searches at lower energies ($E < M_Z$) but high precision

Large Hadron Collider

CERN

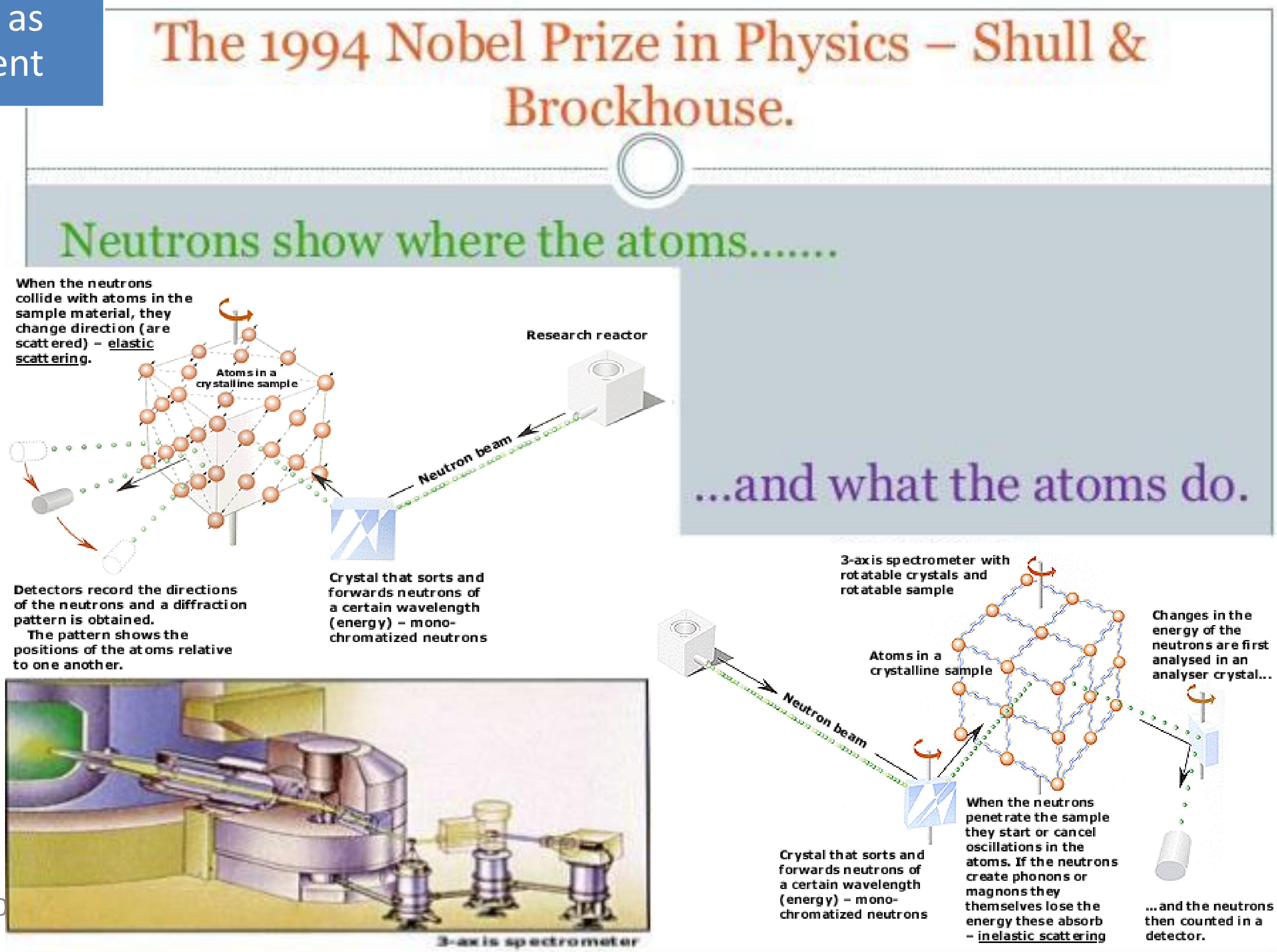
High energy physics

Ultra cold neutrons



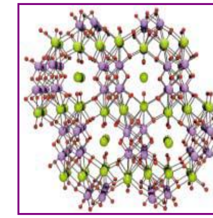
Particle, nuclear & atomic physics

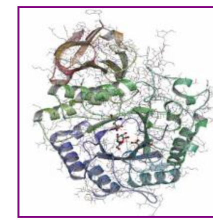
Neutron as instrument

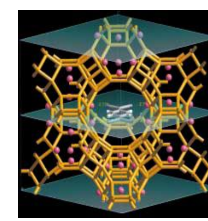


Neutron as instrument

SCIENCE WITH NEUTRONS







Neutrons offer many advantages as a probe

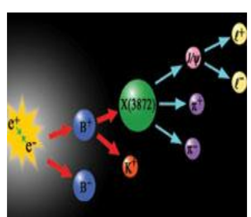
to study materials, matter:

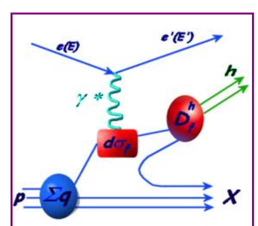
(i) a wide range of length and timescales,

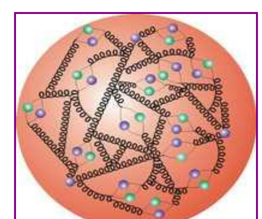
(ii) an ideal probe for magnetism,

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

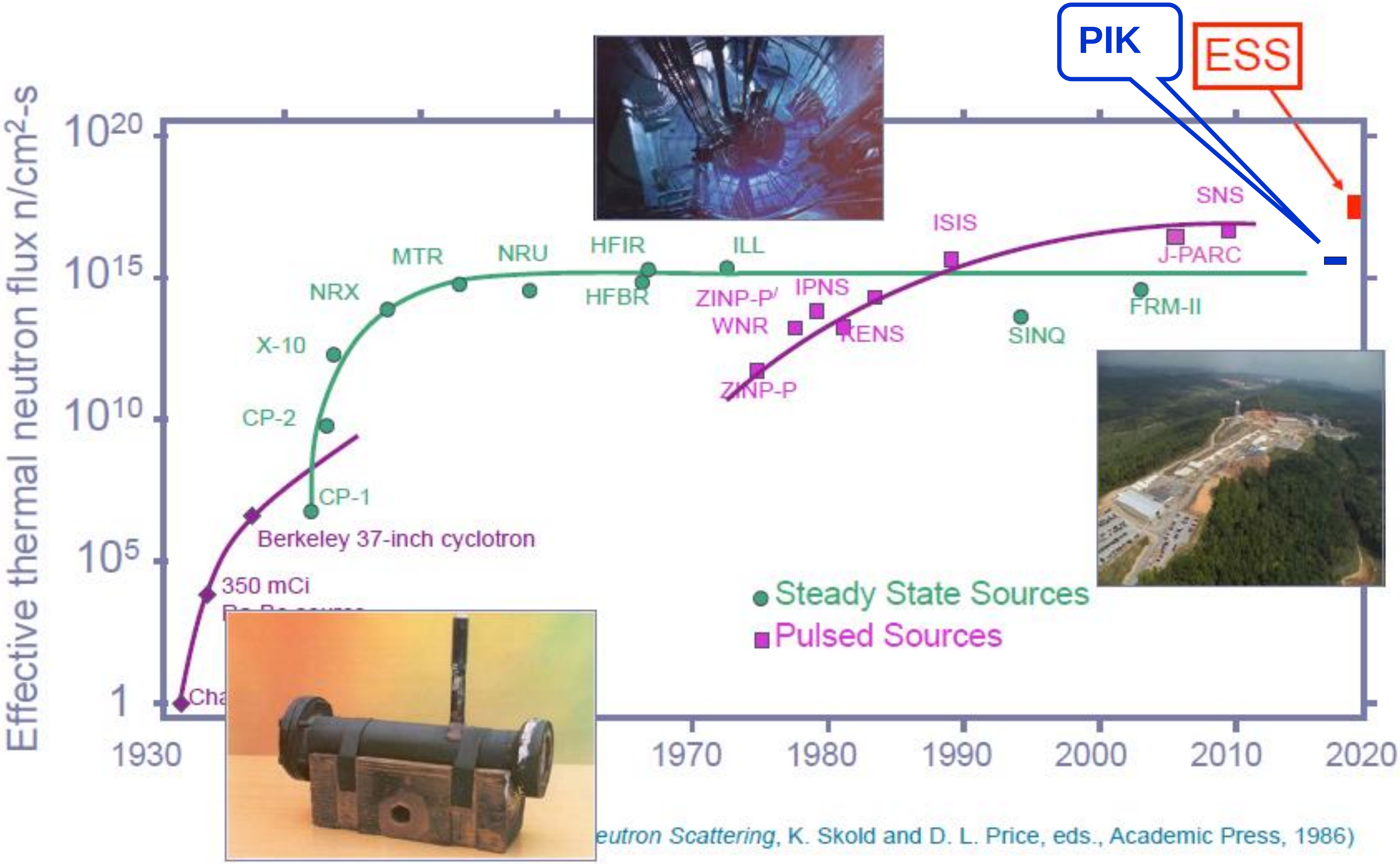
(iv) deep penetration into materials





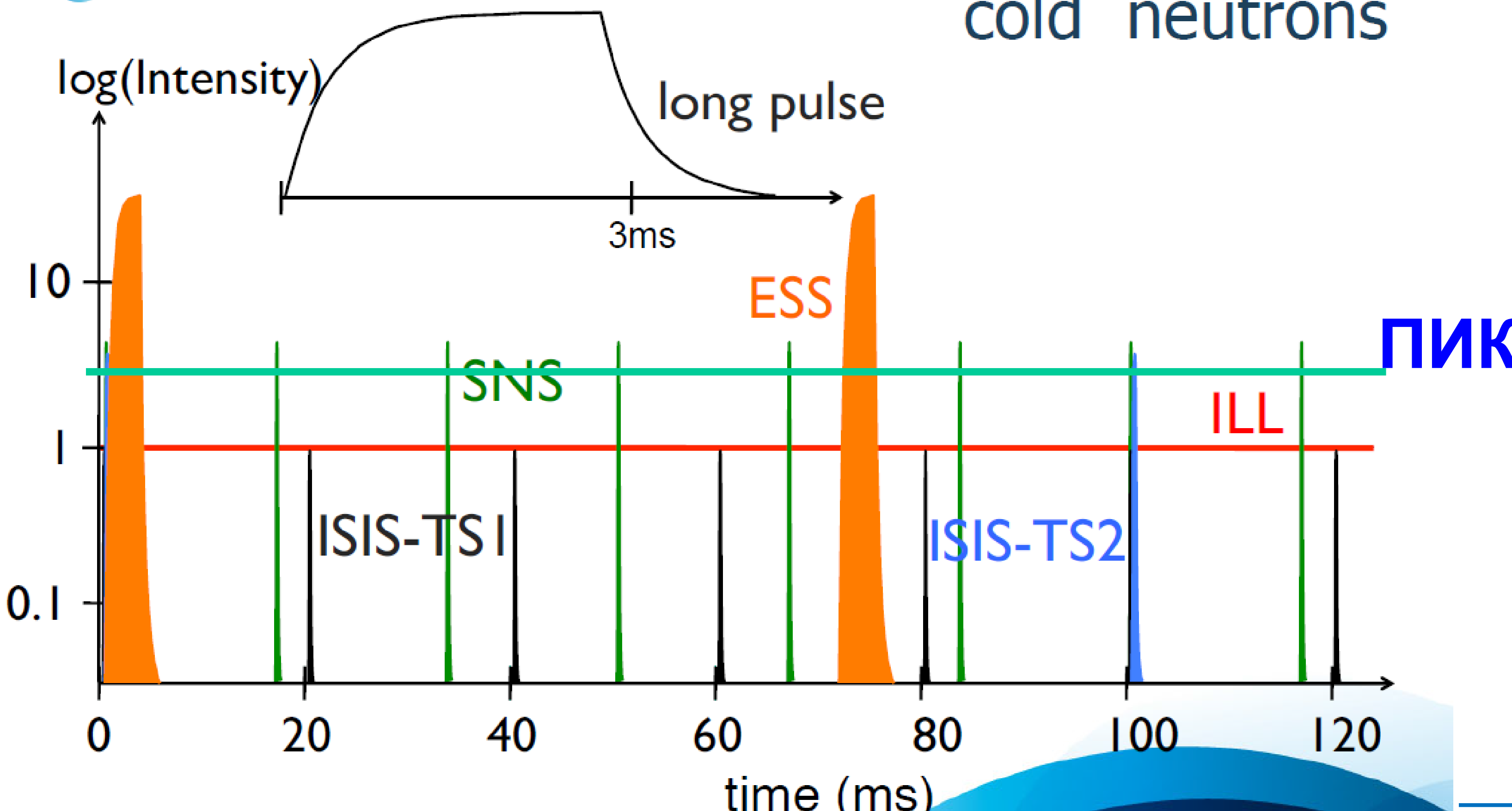


Evolution of neutron sources

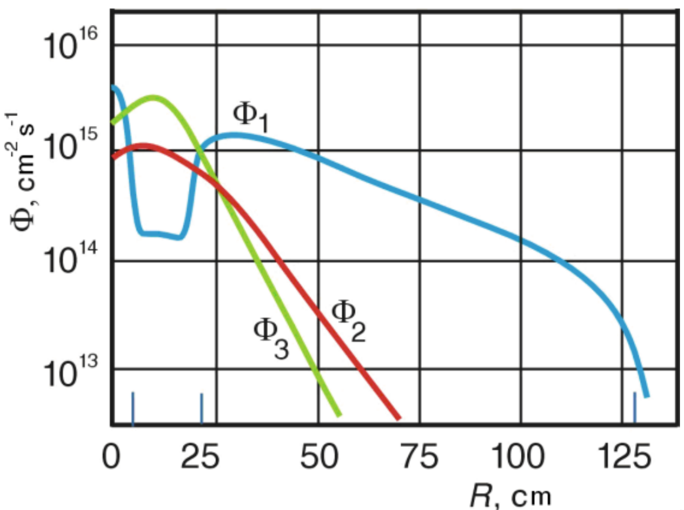


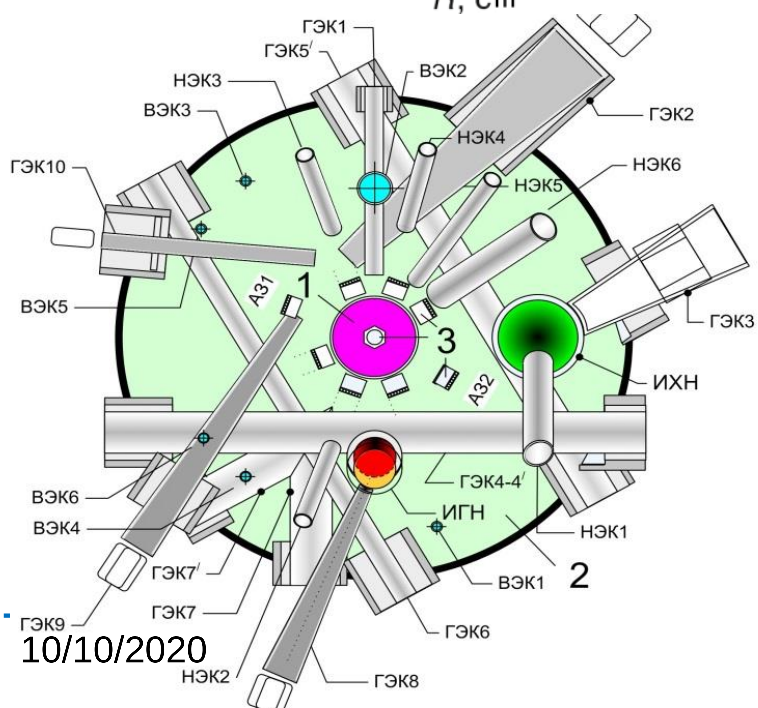
Comparison of neutron sources

Pulsed-source time structures
cold neutrons



Reactor PIK parameters



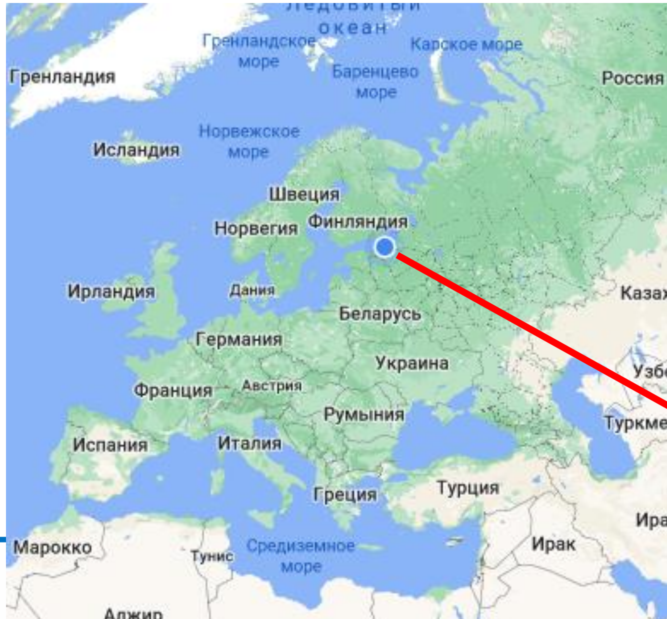


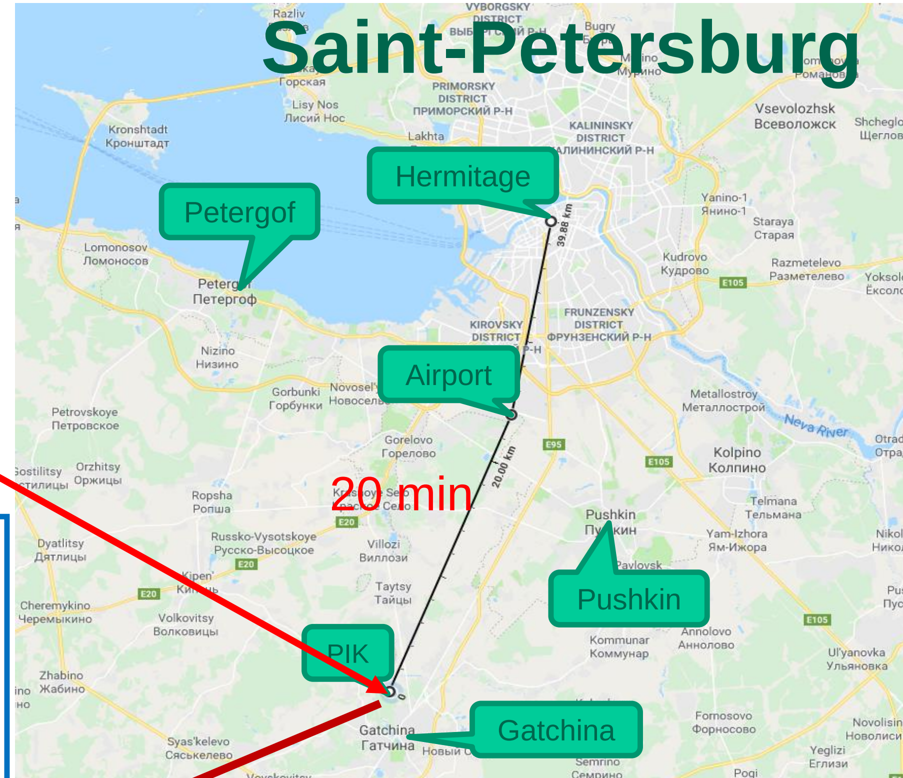
	Value
Power	100 MW
Reactor core volume	50 l
Core height	500 mm
Coolant	H_2O
Reflector	D_2O
Maximal neutron flux in moderator	$1.3x10^{15}$ n/cm²c
Maximal neutron flux in central trap	$5x10^{15}$ n/cm²c
Operation cycle	~30 day
Experimental channels	
- Horizontal (HEC)	10
- Vertical (VEC)	6
- Inclined (IEC)	6
- Central (CEC)	1

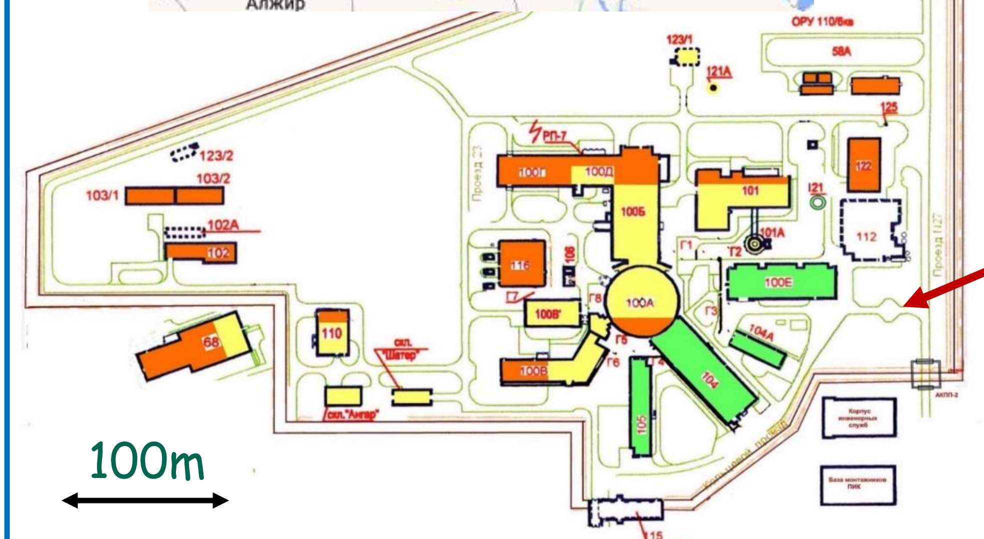
Comparison of High-Flux Neutron Research Reactors

Facility/ Location	Commissioning Date	Power	Maximum Flux Density	Number of Instruments on Beams
PIK Gatchina, Russia	2020 (under commissioning)	100 MW	**5×10^15** n/cm²s	50
HFR Grenoble, France	1971	58 MW	**1.5×10^15** n/cm²s	40
HFIR Oak Ridge, USA	1965 (updated 2007)	85 MW	**2.5×10^15** n/cm²s	12
FRM2 Munich, Germany	2005	20 MW	**0.8×10^15** n/cm²s	27
BER2 Berlin, Germany	1973	10 MW	**0.086×10^15** n/cm²s	25
OPAL Sydney, Australia	2006	20 MW	**0.4×10^15** n/cm²s	7
CARR Beijing, China	2010	60 MW	**0.8×10^15** n/cm²s	6
WWR-M Gatchina. Russia	1959	18 MW	**0.45×10^15** n/cm²s	14

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







Some history. First PIK mention

РЕАКТОР ДЛЯ ФИЗИЧЕСКИХ ИССЛЕДОВАНИЙ – ПИК

А.Н.Ерыкалов, Д.М.Каминкер, К.А.Коноплев,
Ю.В.Петров, В.М.Соколов.

КРАТКАЯ СВОДКА ПАРАМЕТРОВ РЕАКТОРА ПИК

Назначение	– Научно-исследовательски
Мощность средняя	– 10 Мвт
Мощность максимальная	– 100 Мвт
Объём активной зоны	– 50 ÷ 60 л
Среднее удельное энерговыделение	– 2 ÷ 1,6 Мвт/л.
Замедлитель и теплоноситель	– H_2O
Тип ТВЭ	– СМ-2
Загрузка U 235	– 20 – 24 кг
Обогащение	– 90%
Доля металла в активной зоне	– 30 ÷ 40%
Число ловушек	– I
Заполнитель ловушки	– H_2O
Максимальный невозмущенный поток в ловушке	– $(4÷5)10^{15}$ н/см^{2}сек.
Отражатель	– D_2O
Число горизонтальных каналов	– 12 ÷ 15
Максимальный поток тепловых нейтронов в каналах при 100 Мвт	– ~ 10^{15} н/см^{2}сек.
Давление в первом контуре	– 50 бар
Глубина выгорания горючего	– ~ 30%
Кампания	– ~ 5 . 10^3 Мвт.суток.

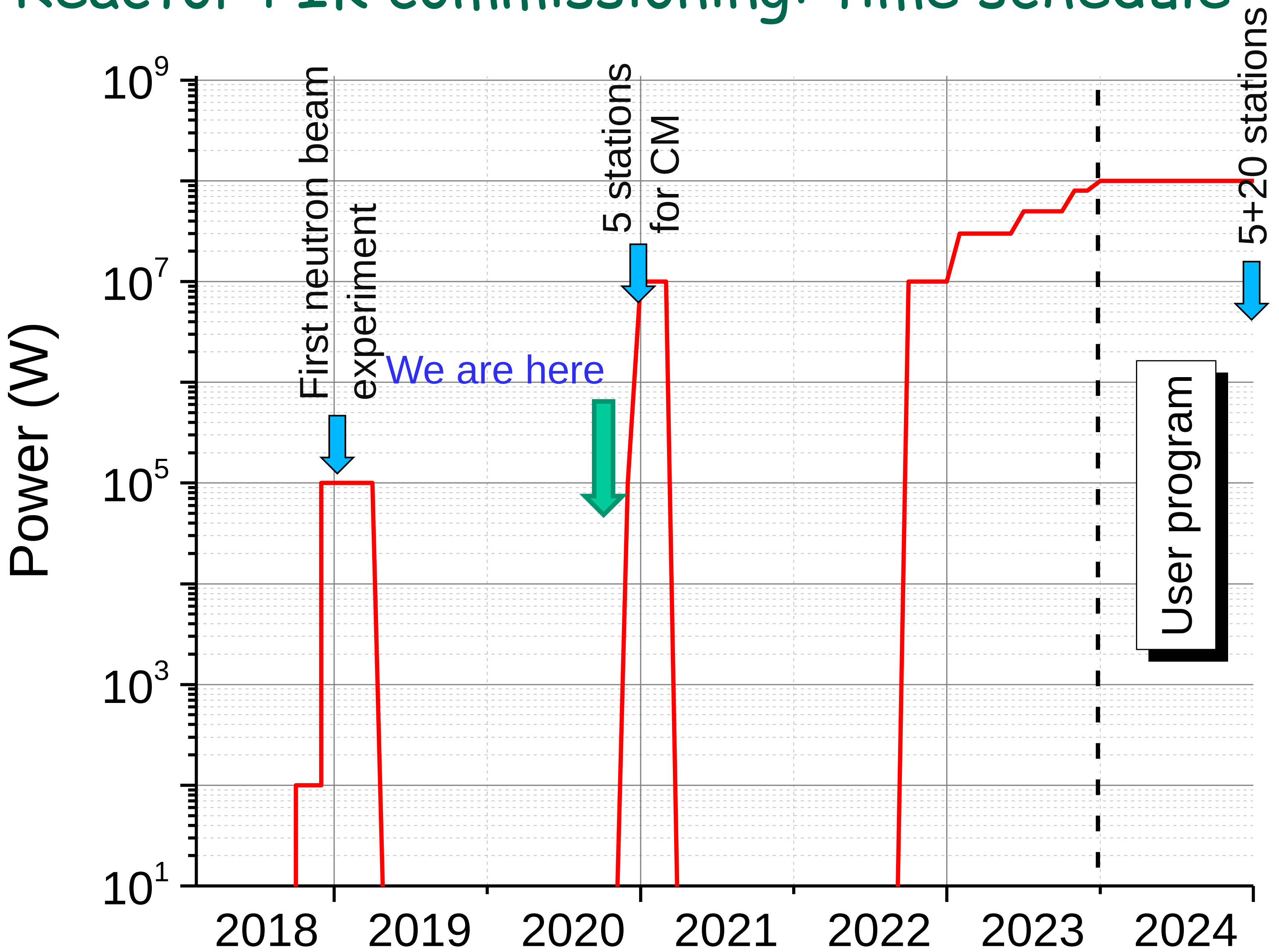
PIK reactor (NRC "Kurchatov institute"-PNPI, Gatchina, Russia).

2019 – 100kW first step of commissioning

2020 – 10MW next step of PIK commissioning

2022-2023 – 100 MW

Reactor PIK commissioning: time schedule



Instrumentation Program

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

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)

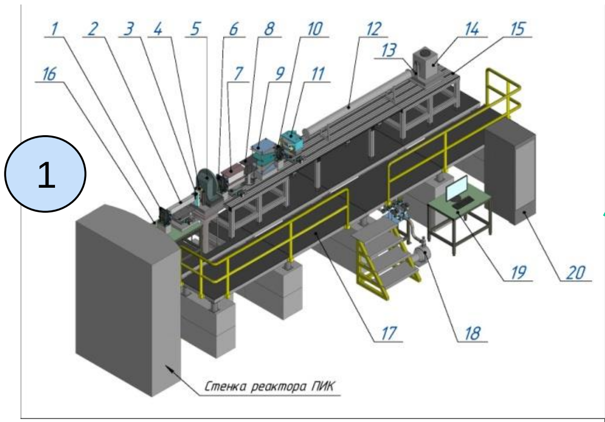
Experimental stations for condensed matter (13)

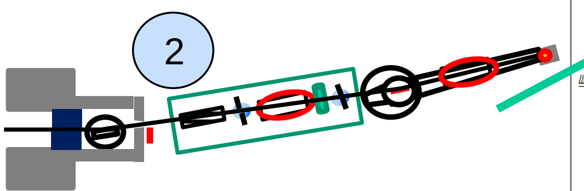
- Diffractometers (3)
- Spectrometers of inelastic scattering (5)
- SANS machines (3)
- Reflectometers (2)

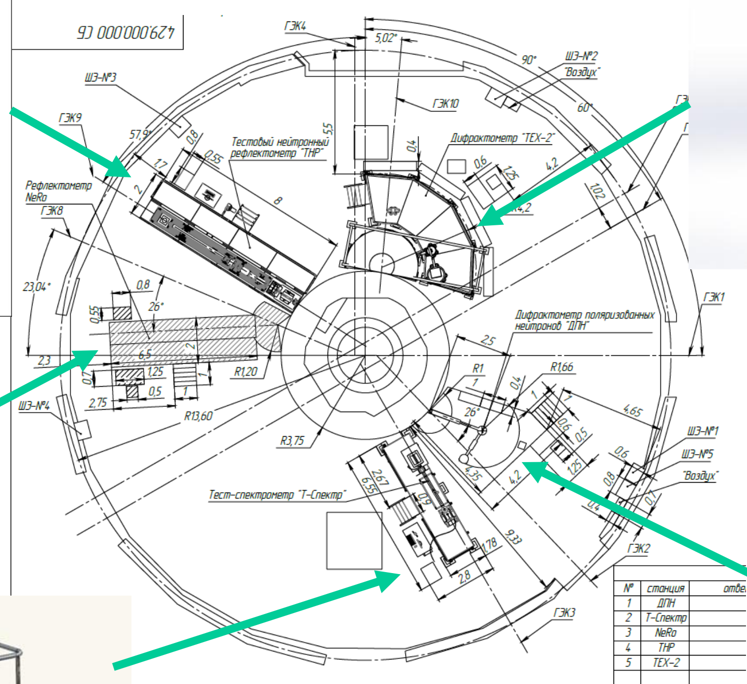
Experimental stations for fundamental physics (7)

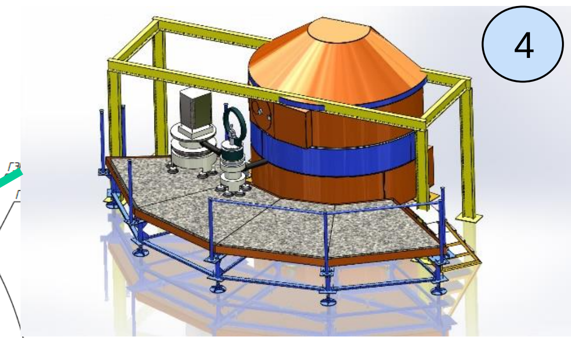
- Stations with CN (2)
- Neutrino physics facility (1)
- Stations for nuclear spectroscopy (3)
- Fission physics (1)

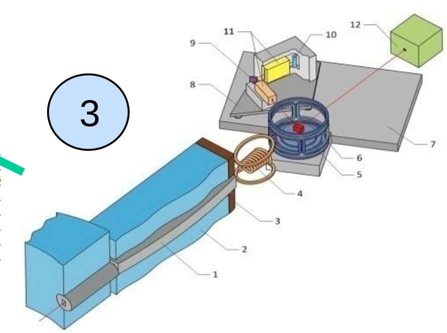
5 station for condense matter physics (commissioning 2020).

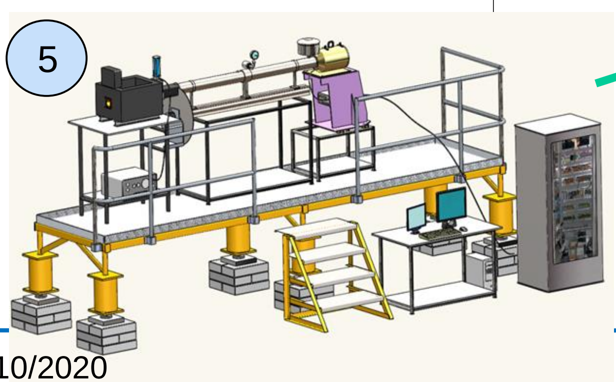






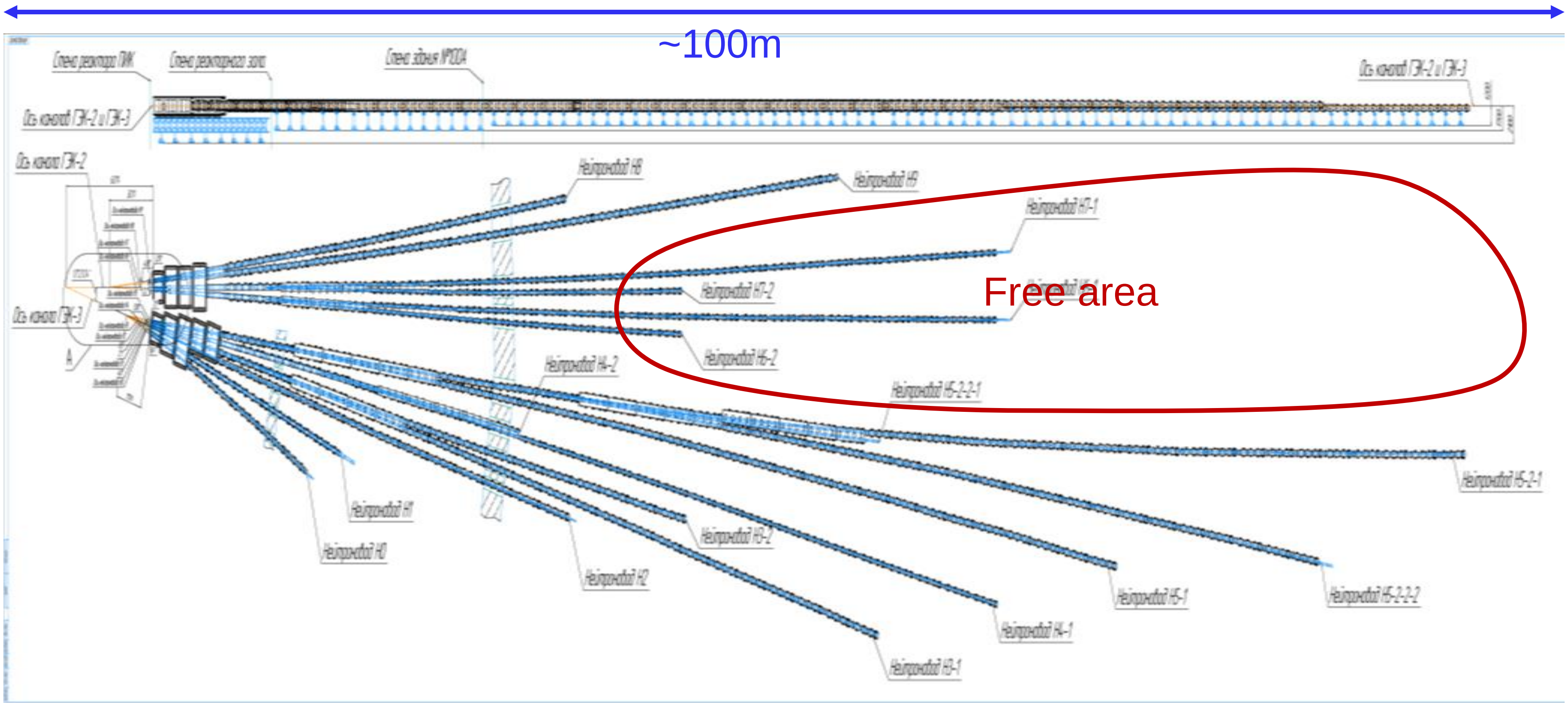






1. TNR test neutron reflectometer
2. NERO Polarized Neutron Reflectometer (GKSS)
3. DPN polarized neutron diffractometer
4. Textured Diffractometer TEX-2 (GKSS)
5. Test neutron spectrometer

Neutron guide system

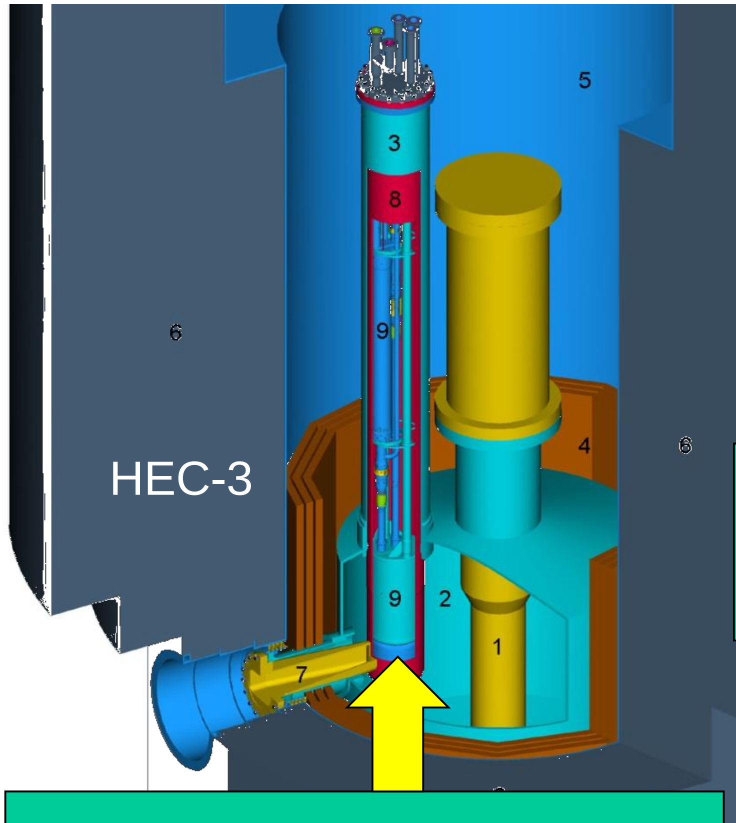


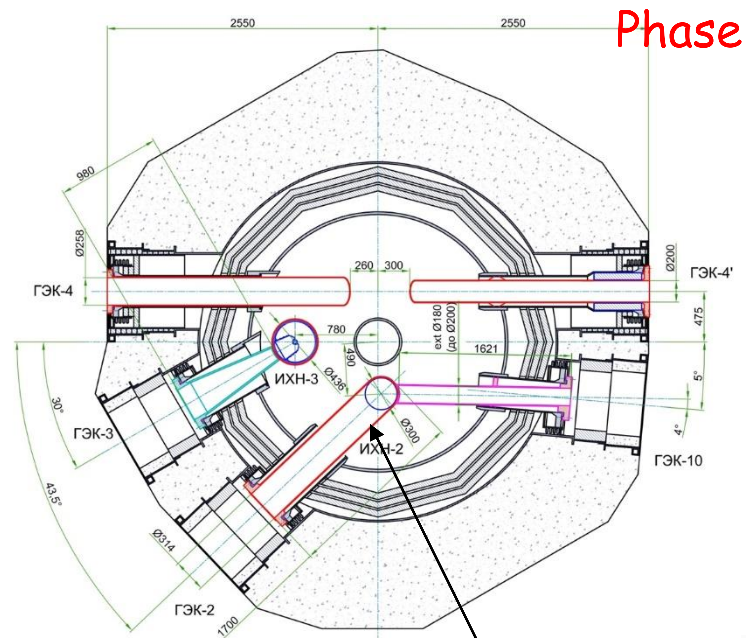
Length ~ 1 km.

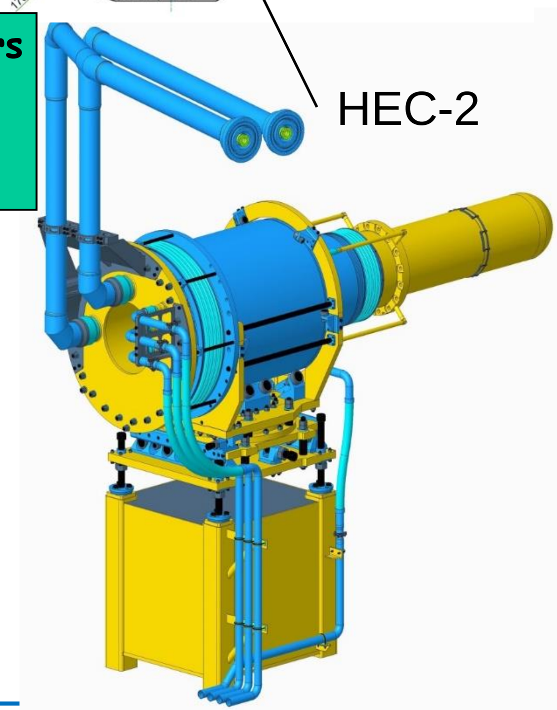
Up to 40 experimental positions (neutron flux (3-12) 10^{10} n/cm^{2}s)

Phase 2

Cold neutron sources (CNS)





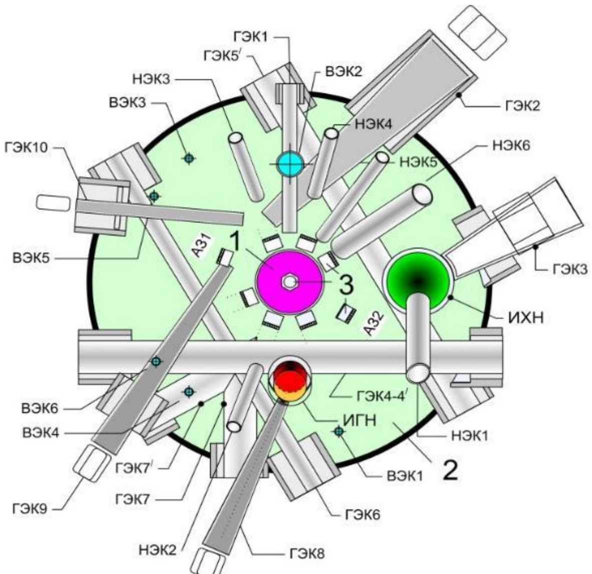


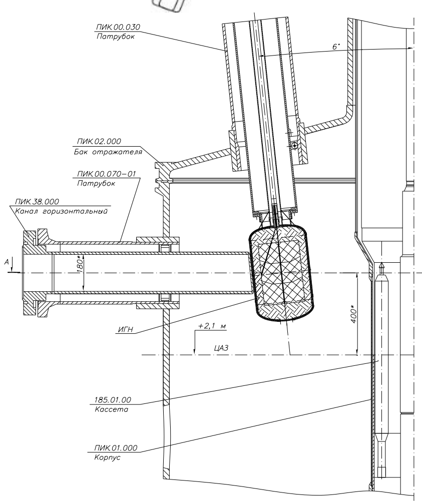
UCN source - parameters
Liquid deuterium - 20 L,
T = 20 K
Heat release – 7 kW.

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.

Hot neutron source

Ultra cold neutron source





graphite radiation heating

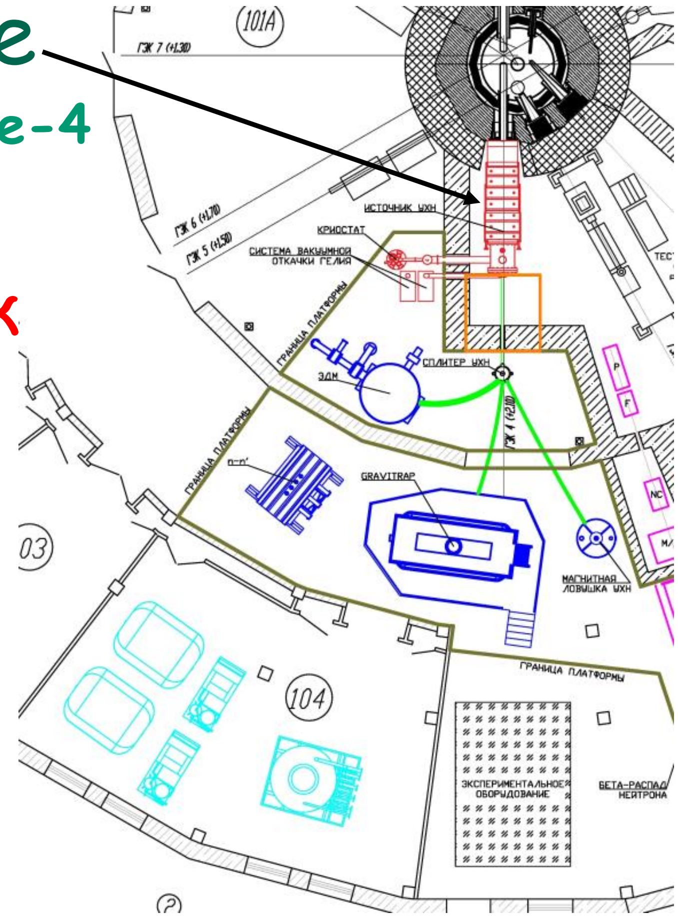
T=1500-2000 K

V ~ 5 liter

Superfluid He-4 converter on beam HEC-4

T-(0,7-0.9)K

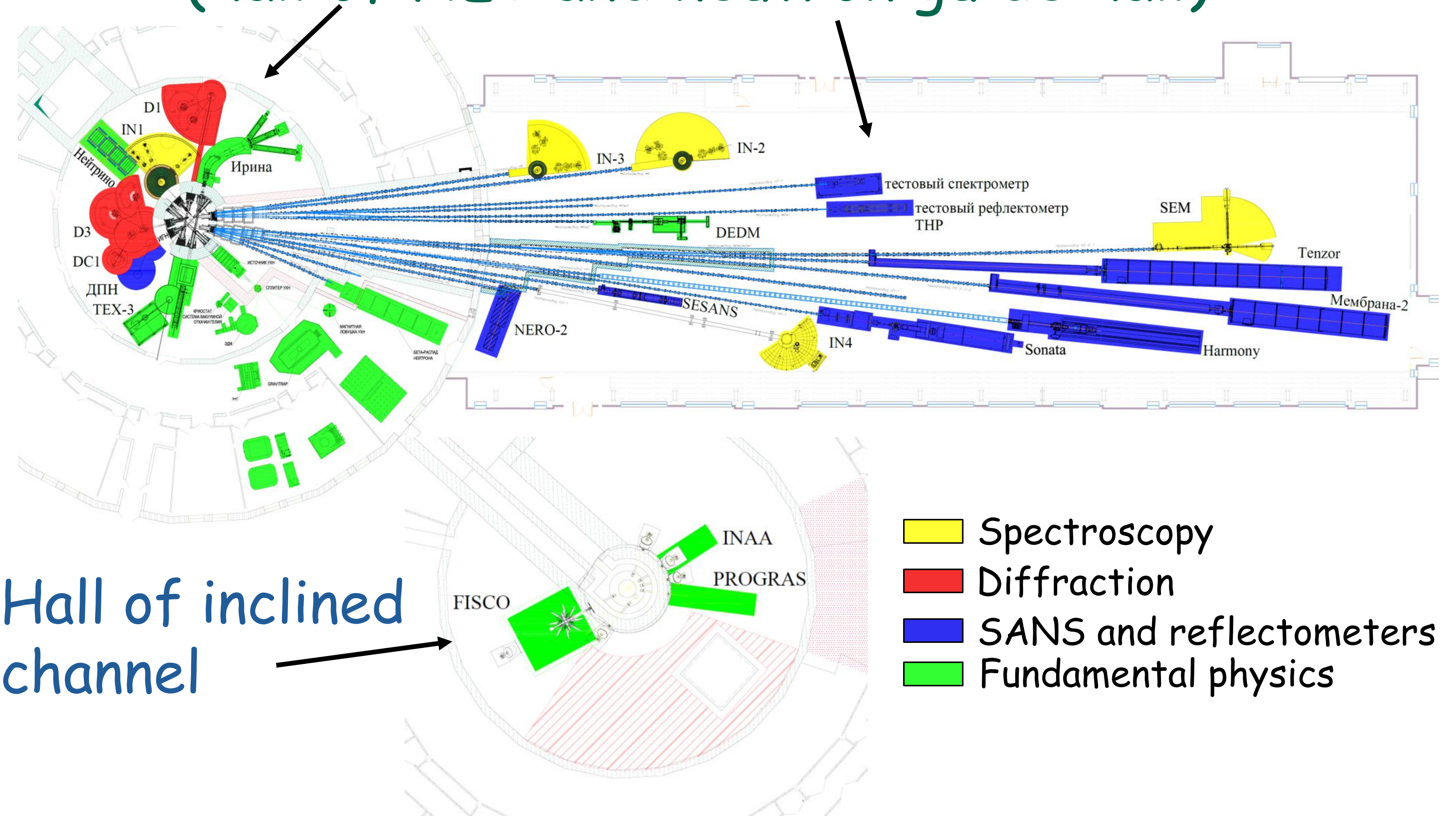
V~35л



UCN density ~ $2 \cdot 10^3 n/cm^3$

(100 times better wherever)

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



Hall of inclined channel

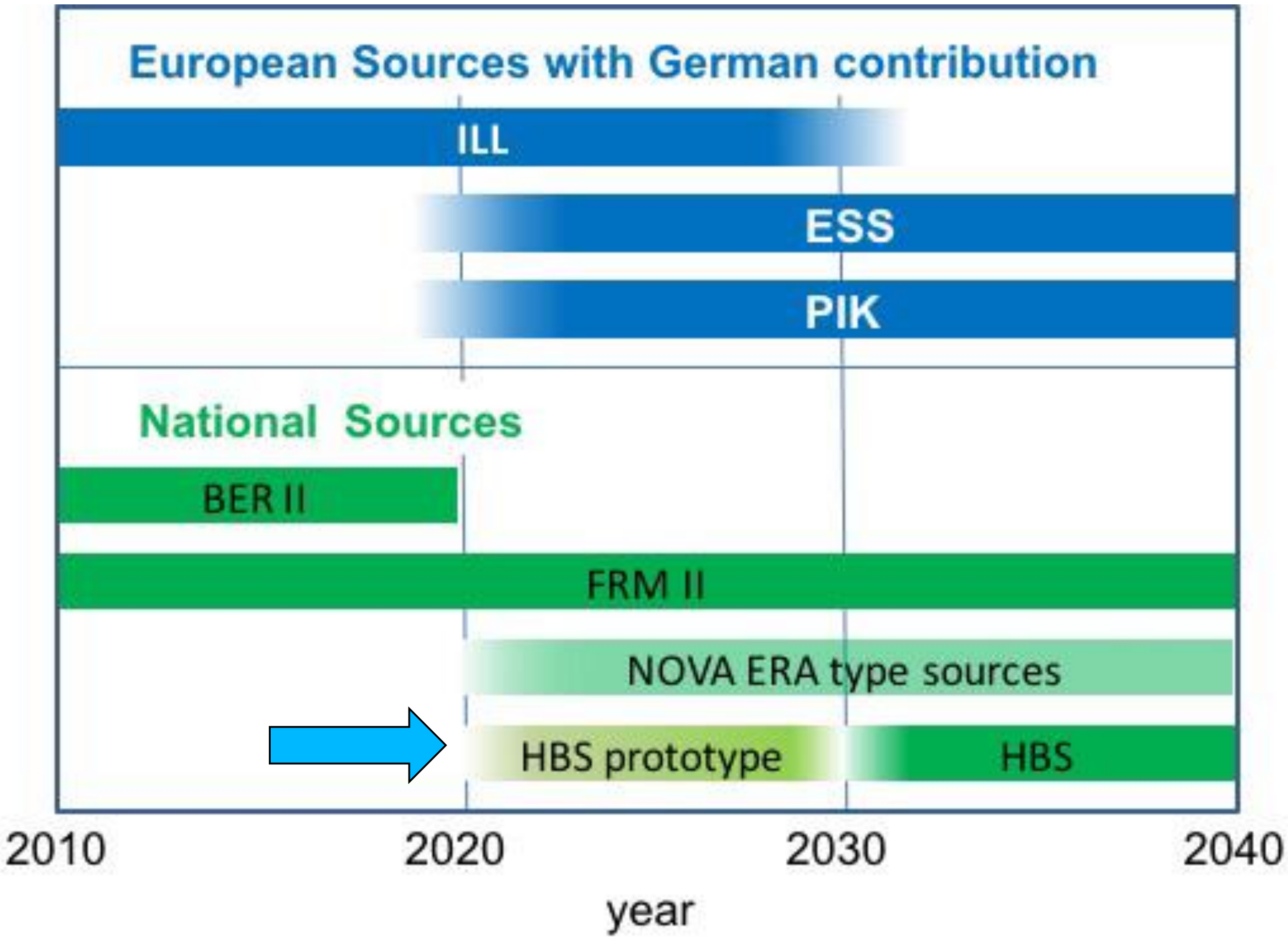
Road map of instrumentation program

#			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																						

PIK is the basis of ICNR

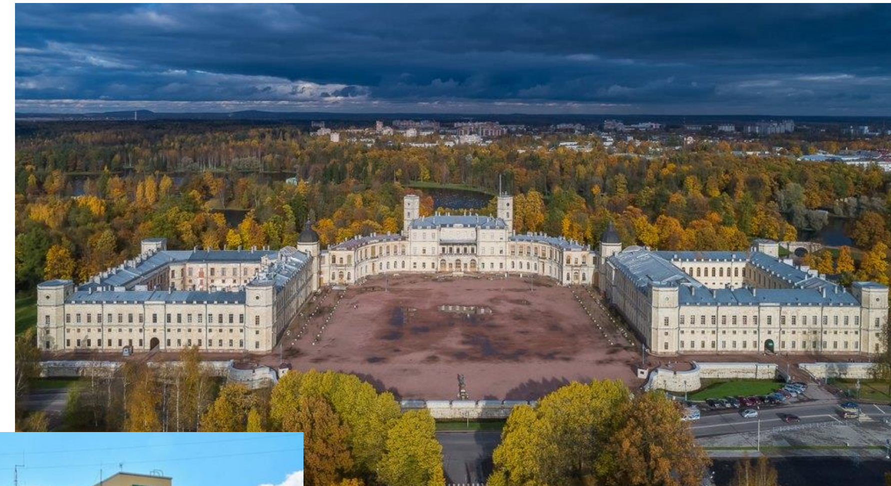
1. Two stations of **Phase 1** with international contribution will be commissioned 2020.
2. CREMLIN+ (2020-2022) (Connecting Russian and European Measures for Large-scale research INfrastructures) (goal – To enhance science cooperation between the six Russian megascience facilities and the European 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

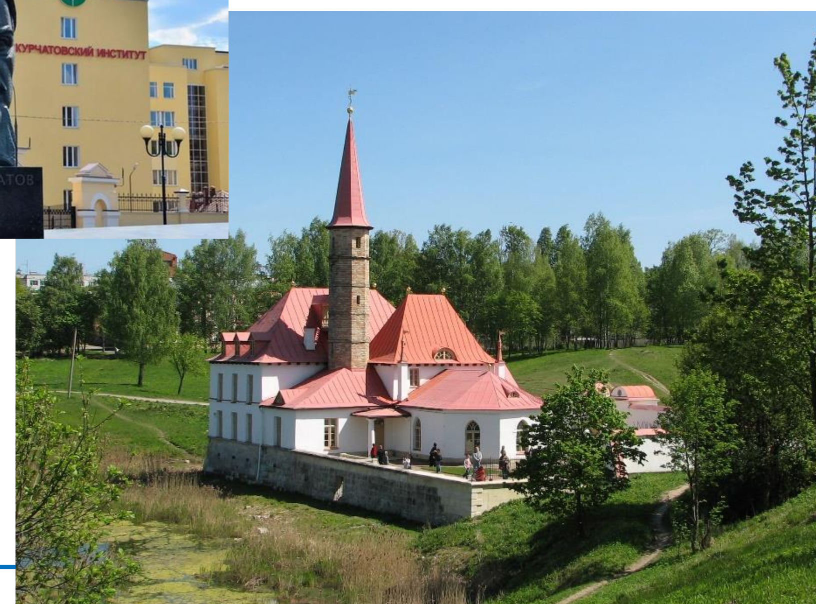
PIK is part of the Strategy on Germany Neutron Research: 2015-2045



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

Welcome to Gatchina and ICNR





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