NSC KIPT Main Building

EB facilities at NSC KIPT

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About NSC KIPT NASU

Kharkov Institute of Physics and Technology (the KIPT, earlier referred to as Ukrainian Institute of Physics and Technology), being one of oldest and largest centers of physical science in Ukraine, was created in 1928 for the purpose of developing urgent lines of research (at that time - nuclear physics and solid-state physics).

The distinctive properties of the Institute were always the combination of the fundamental approach to solving the problems with a practical orientation of work and a wide range of the studies done.

On October 10, 1932, an outstanding result was received by A.K.Valter, K.D.Sinelnikov, A.I.Lejpunsky, G.D.Latyshev, namely, the nucleus of lithium atom was caused to undergo fission.

In post-war years the KIPT was one of the active participants working on the problem of use of atomic energy in the USSR. Systematic measurements of constants of neutron and other particle interactions with fissile and structural materials have been performed.

In 60-70th many unique experimental facilities: a number of electron and ion accelerators, including the largest USSR electron linear accelerator, a family of thermonuclear installations "Uragan", were constructed.

From 1972 still the end 1991 the Institute executed functions of a main organization in the USSR in the field of radiation materials science and radiation technologies.

The world-known are the schools of academicians L.D.Landau, K.D.Sinelnikov, A.K.Valter, I.M.Lifshits, V.E.Ivanov, B.G.Lazarev, A.I.Akhiezer, Ya.B.Fainberg, D.V.Volkov.

In 1993 the Institute was given the status of the first in Ukraine National Science Center (the NSC KIPT).

Nearly 300 Candidates and 80 Doctors of Sciences, 7 Members of National Academy of Sciences of Ukraine work here. More than fifty persons are the winners of State and Nominal Prizes. From 1981 more than 60 monographs have been written by the scientists of the NSC KIPT.

NSC KIPT structure	The basic lines of research work
Institute of Solid-State Physics, Materials Science and Technologies	*Solid-state Physics. Physics of radiation effects and radiation materials science. Materials Technologies*
Institute of High-Energy Physics and Nuclear Physics	*Nuclear physics, physics of electromagnetic interactions, physics and engineering of electron accelerators.*
Institute of Plasma Electronics and New Methods of Acceleration	*Plasma electronics and physics of high-current beams. Physics and engineering of heavy charged particle accelerators. New methods of acceleration.*
Institute of Plasma Physics	*Plasma Physics and controlled fusion*
Akhiezer Institute for Theoretical Physics	*Theoretical physics*

Detail information about NSC KIPT is presented on website https://www.kipt.kharkov.ua/en/

A.K. Valter
(1905-1965)
Academician of Academy of Science of USSR

He directed and took direct part in the construction of a number of accelerators, in particular:

-2.5 MeV Van de Graaff electrostatic horizontal type ion accelerator (1935-36),

- 1.8 GeV electron linear accelerator(1968).

He was a scientific superviser of all experiments in nuclear physics and physics of elementary particles. In 1946 he founded the Department of Experimental Nuclear Physics at the Kharkiv State University.

Developing of Electron Linear Accelerator in the KIPT

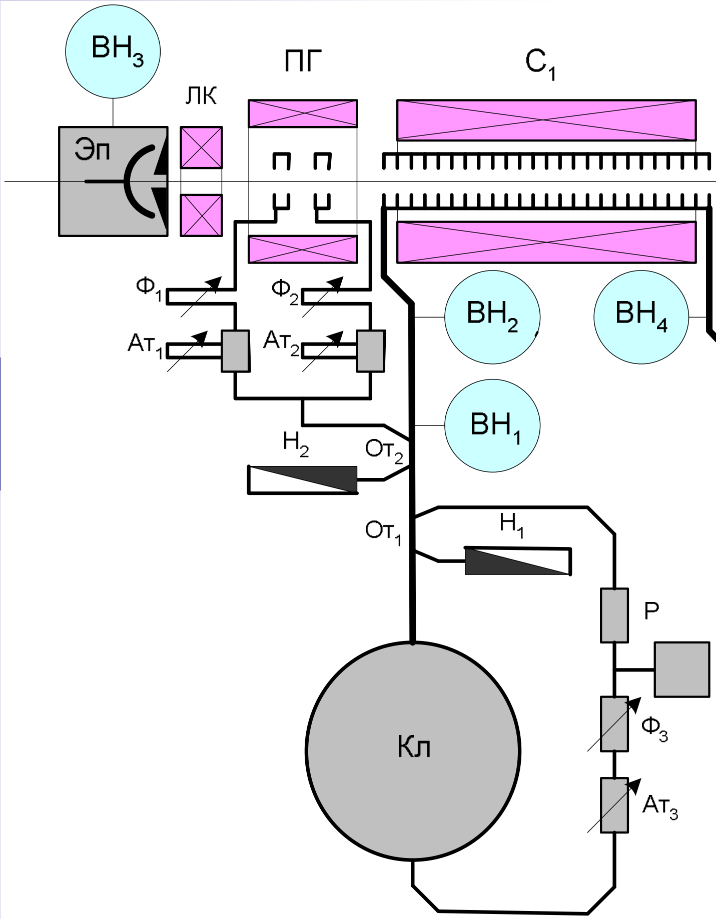
History

1953 LUE-0.7	
1954 LUE-3.5	
1956 LUE-30	
1958 LUE-90	
1963 LUE-300	1975-1987 UIC
1964 LUE-40	
1965 LUE-2000	1985
1987 LUE-10	

New history

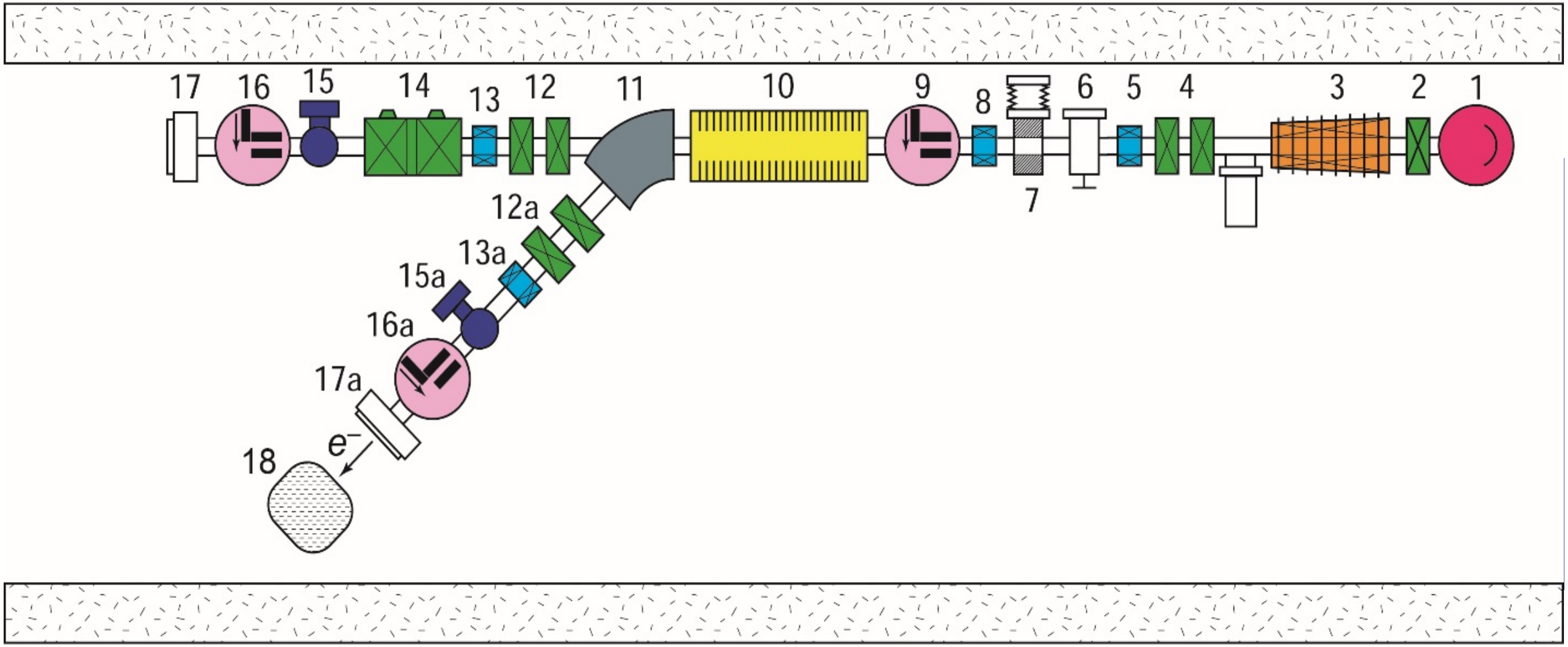
1991 LUE-60	For SSR-600
1992 LIC	Laser initiation
1993 KUT-1	For sterilization
1993 LUE-10	Modernization
1996 EPOC	
2002 KUT-20	For isotope production
2004 LUE-100	
2007 KUT-20 KUT-30	Modernization
2008 LUE-60M	NESTOR

UIC - 10 MeV Electron Linear Accelerator of IHEPNP



Energy, MeV	*10*
Current-pulse width, μs	*2*
Average current, μA	*200*
Energy spread, %	*5-10*
Max irradiation dose	*~2kGy/s*

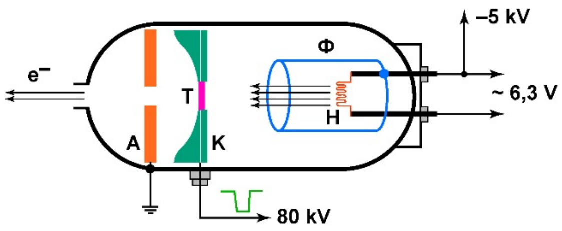
30 MeV Electron Linear Accelerators of IHEPNP



Schematic view of 30 MeV Electron linear Accelerator with output devises:

1 – Electron gun
2, 14 – Magnetic lenses
3, 10 – Acceleration sections
4, 12, 12a – Quadruple lenses
5,8, 13,13a – Correctors
5 – Automatic valve
6 – Collimator
9, 16, 16a - Faraday cups
11 – Magnetic energy analyzer
15, 15A - Beam current monitors
17, 17a – Electron beam output windows
18 – Target for irradiation

30 MeV Electron Linear Accelerators of IHEPNP



Electron gun schematic view

Main parameters	
Energy, MeV	*6 -30*
Current-pulse width, μs	*2*
Average current direct beam line, μA	*80*
Average current 60^0 beam line, μA	*55*
Energy spread, %	*1.5-5*
Max irradiation dose,	*~800Gy/s*

Detail information about LUE-30	
1. Main parameters	
Beam energy	6-30 MeV
Average beam current	2-80 μA
Repetition rates: Klystron modulator Electron gun modulator	 50, 100 Hz 3, 6, 12, 25, 50, 100 Hz
Current-pulse width	2 μs
Beam dimensions: Direct beamline 60^0 beamline	 3-10 mm 6-15 mm
2. Electron gun	
Acceleration voltage	5 kV
Electron beam current	0.1 μA
Anode voltage	80 kV
Cathode material	LaB_6
Cathode diameter	16 mm
3. Acceleration system	
Sections	2
Length of first section	445 mm
Length of second section	4.44 m
Electron group velocity	0.038
Electron energy after 1 section	5 MeV
RF power of Klystron generator	20 MWatt
Frequency	2797.2 MHz
Klystron type	KIU-12AM
Pressure in the vacuum system	$2 \cdot 10^{-6}$ mm Hg

Electron Linear Accelerators of “Accelerator” Science and Research Establishment

Accelerator KUT-1

Year	1993
Energy, MeV	9
Number of sections	1
Current-pulse width, μs	4
Repetition rate, pps	300
Average current, μA	800

Max irradiation dose, kGy/s	~8

Accelerator LUE-10

Year (update)	1993
Energy, MeV	9-12
Number of sections	1
Current-pulse width, μs	4
Repetition rate, pps	300
Average current, μA	1000

Max irradiation dose, kGy/s	~10

Impotence of Sewage Sludge Problem

[1]In Ukraine, during the cleaning of household and industrial sewage, a large amount of sediment is formed which is an environmentally hazardous waste because it contains heavy metals whose concentrations exceed the normative parameters of DSTU 7369: 2013 and is characterized by high bacterial and parasitic contamination.

An ecologically dangerous sewage sludge (SS) created at biological treatment plants is introduced for further dewatering and decontamination on mud grounds.

Today in Ukraine, about 1 billion tons of sediment have been accumulated on the sludge sites. More than 10 thousand hectares of land have been seized for their placement (more than 300 hectares in Kharkiv region). Most sediment are today overcrowded and are environmentally hazardous objects, as they pollute the atmosphere, soils, surface and groundwater.

Promising and environmentally safe is the utilization of SS by recycling them into organomineral mixtures, which can be used as fertilizers in agriculture. This applies to SS that do not contain excess heavy metals. However, such sediments are contaminated with pathogenic microflora and eggs of worms, and require preliminary disinfection.

Improvement of effective, ecological and affordable methods of intensifying the decontamination of sediments of biological treatment plants stored at sludge sites and developing technologies for their further utilization into an environmentally safe organomineral mixtures for fertilizers in agriculture is relevant.

Necessary to develop a new more effective technology for Sewage Sludge Treatment!
Determination of heavy elements[2] with high accuracy is needed!

1 -By Fomina I.G. - Increase of ecological safety by utilization of sediments of biological treatment facilities (on the example of the Kharkov area). –Manuscript. Dissertation for a Candidate Degree in Technical Sciences, Scientific Research Institute «Ukrainian Scientific Research Institute of Ecological problems» and V. N. Karazin Kharkiv National University. – Kharkiv, 2015.
2 - SEGEBADE, Chr; WEISE, Hans-Peter. **Comparison of sensitivity estimates for low energy photon and classical gamma-ray spectroscopy applied to photon activation analysis**. *Journal of Radioanalytical Chemistry*, 1978, 45.1: 209-220.

National Standard of Ukraine DSTU 7369:2013

Waste Water: Requirements for waste water and its sediments for irrigation and fertilization

This standard establishes the basic requirements for sewage and sediment used for irrigation and fertilization. It applies to waste water from cities (mixtures of household, industrial, atmospheric, and also near to them in the composition of industrial waste water) and sediments that are formed in the process of urban wastewater treatment, and products of their processing (fertilizers) on the basis of sediments.

Maximum permissible concentrations (MPC) of heavy metals and their background content (BC) in the main types of soils of forest-steppe and steppe zones (dry matter)

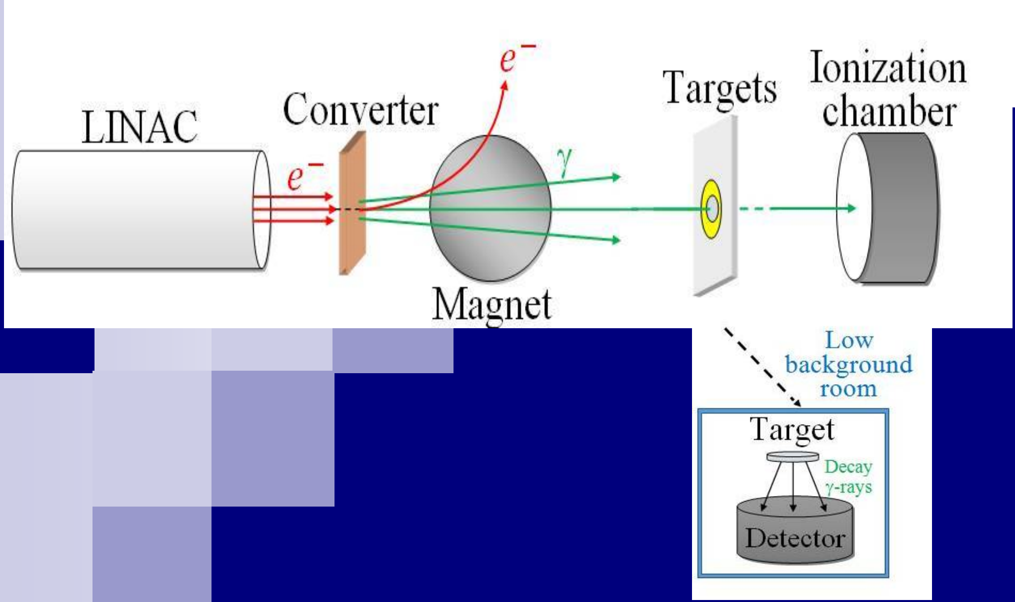
Element	Value MPC, μg/kg		Value of background content, μg/kg	
	forest-steppe zone (pH<7)	steppe zone (pH>7)	Average content	Regular content in soil
Sr	50-70			
Hg	2-5			
Cd	3	5	0.5	0.01-1
Pb	100	150	10	0.1-20
Cr	100	300	200	2-50
Zn	300	500	50	3-50
Cu	100	200	20	1-200
Mn	1500	3000	850	-
Ni	50	70	40	2-50
Co	30	50	8	1-10
Mo	4	5	3	0.2-5

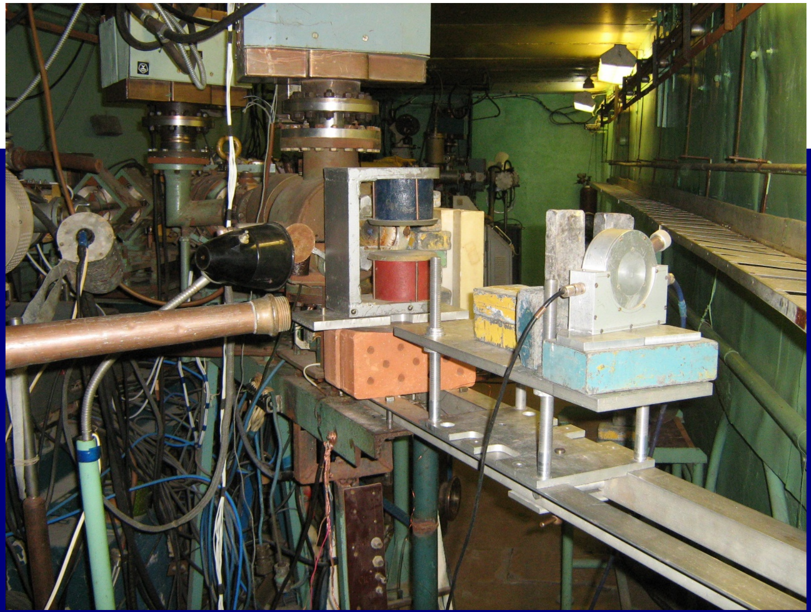
in dry sewage sludge →

P	0.7 mass%
N	1.5 mass%

Application of Photoactivation Analysis for Heavy and Light Elements Determination

General Scheme of experiment





View of 60^0 beamline

LINAC	Linear electron accelerator up to 30 MeV
Convertor	Tantalum 100 μm
Magnet	Beam Deflection magnet
Targets	Dry Sewage Sludge pressed into cup holder
Ionization chamber	Used as a monitor for registration bremsstrahlung flux behind targets
Detector	HP(Ge) detector Canberra

Opportunities of Photoactivation Analysis Application for Heavy and Light Elements Determination

Element	Abundance,%	Reaction	T1/2	Eγ, keV	Detection limit μg/g
Sr	^{88}Sr-82.58 ^{86}Sr-9.86 ^{84}Sr-0.56	$^{88}Sr(\gamma,n)^{87m}Sr$ $^{86}Sr(\gamma,n)^{85m}Sr$ $^{84}Sr(\gamma,n)^{883}Sr$	2.81h 67.7m 33h	388 232 381	0.02 0.3 30
Hg	^{198}Hg-9.97	$^{198}Hg(\gamma,n)^{197m}Hg$	23.8h	134	1
Cd	^{116}Cd-7.49	$^{116}Cd(\gamma,n)^{115}Cd$	53.5h	528	1
Pb	^{204}Pb-1.4	$^{204}Pb(\gamma,n)^{203}Pb$	52.1h	279	1
Cr	^{52}Cr-83.78	$^{52}Cr(\gamma,n)^{51}Cr$	27.8d	320	3
Zn	^{68}Zn-18.45	$^{68}Z(\gamma,p)^{67}Cu$	61.9h	185	1
Cu	^{65}Cu-30.85 ^{63}Cu-69.15	$^{65}Cu(\gamma,n)^{64}Cu$ $^{63}Cu(\gamma,2n)^{61}Cu$	12.8h 3.3h	1346 283	36 2
Mn	^{55}Mn-100	$^{55}Mn(n,\gamma)^{56}Mn$ $^{55}Mn(\gamma,n)^{54}Mn$	2.58h 312.5d	847 835	4 15
Ni	^{58}Ni-66.07	$^{58}Ni(\gamma,n)^{57}Ni$	36h	1378	0.5
Co	^{59}Co-100	$^{59}Co(\gamma,n)^{58}Co$	70.78d	811	2
Mo	^{100}Mo-9.82 ^{94}Mo-9.15	$^{100}Mo(\gamma,n)^{99}Mo$ $^{99}Mo \rightarrow ^{99}mTc$ $^{94}MO(\gamma,n)^{93m}Mo$	66.2h 6h 6.95h	140 263	0.2 0.8
N	^{14}N-99.63	$^{14}N(\gamma,n)^{13}N$	10 min	511	0.02
C	^{12}C-98.93	$^{12}C(\gamma,n)^{11}C$	20.3 min	511	0.1
P	^{31}P-100	$^{31}P(\gamma,n)^{30}P$	2.5m	511	40
O	^{16}O-99.75	$^{16}O(\gamma,n)^{15}O$	2m	511	0.05
F	^{19}F-100	$^{19}F(\gamma,n)^{18}F$	110 min	511	0.001

Propositions for Irradiation of Sewage Sludge

Small volume of SS in package (liquid, wet or dry)

Dimension Limits of packages:
Height < 20 cm
Length < 20 cm
Width < 5 cm
(10 MeV electron depth penetration is ~5cm)
Total max volume – 2000 cm^3(~2 kg)

Max Irradiation efficiency of 30 MeV Linac (60^{O} beamline 10 MeV, 55 μA) ~200 kg/hour with using the conveyor system to the dose 10kGy

Usefull for irradiation samples of sewage sludge for further laborary research

Large volume of liquid SS

Developing a new target device for the pumping of sewage sludge across the irradiation zone (for example, volume – 1000 cm^3, pumping speed – 1 liter/s)

Max Irradiation efficiency of KUT-1 or LUE-10 (10 MeV, 1mA)- ~3600 liters/hour to the dose 10kGy

Usefull for irradiation of large volume of sewage sludge for further research in field condition

Thank you for your attention!