16 december 2021
lpI, Moscow, Russia

The I nternational School for Youth
“Innovative nuclear-physical methods of high-tech medicine”
December, 16-17, 2021, Moscow, Russia

About the project «Development of new technologies for the diagnosis and radiotherapy of socially significant diseases by proton and ion beams using binary nuclear-physics methods»

Irina Zavestovskaya

LPI of RAS, Department of Nuclear Physics and Astrophysics,
Laboratory of Radiation Biophysics and Biomedical Technologies
MEPhI, Institute of Engineering Physics for Biomedicine, Moscow, Russia

Russian Federal Scientific and Technical Program for the Development of Synchrotron and Neutron Research and Research Infrastructure for 2019-2027

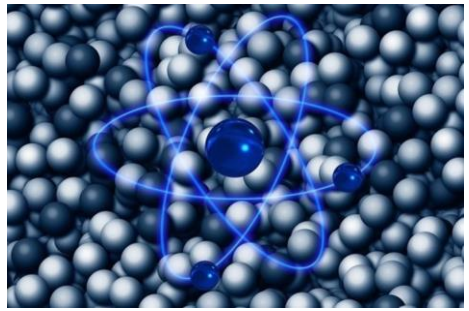
/Decree of the RF President No. 356 of July 25 , 2019/

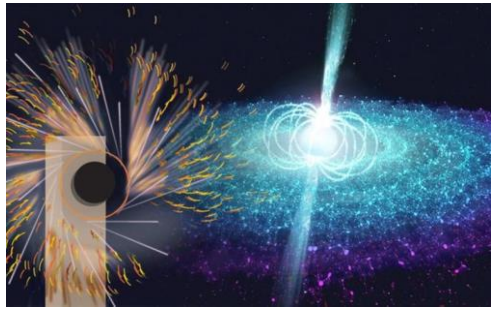
МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ

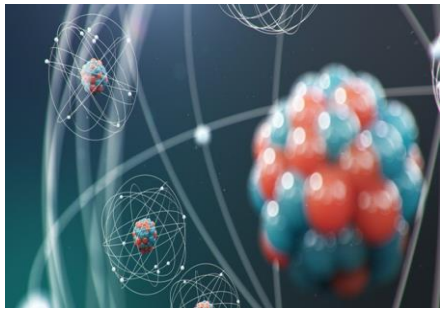
The program was developed in order to comprehensively solve the problems of accelerated development of synchrotron and neutron research, necessary for the creation of breakthrough technologies, as well as to ensure the creation and development of research infrastructure in the Russian Federation.

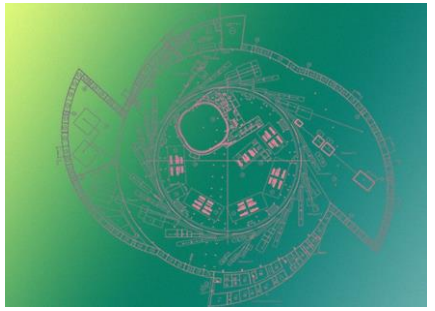
4 scientific directions:

- Synchrotron and neutron research in the field of materials science for the development of high-tech production technologies
- Synchrotron and neutron research in the field of living systems, organic and hybrid materials
- Synchrotron and neutron research in the field of socio-humanitarian sciences
- **Development of accelerator, reactor and nuclear technologies, including in the field of nuclear medicine**









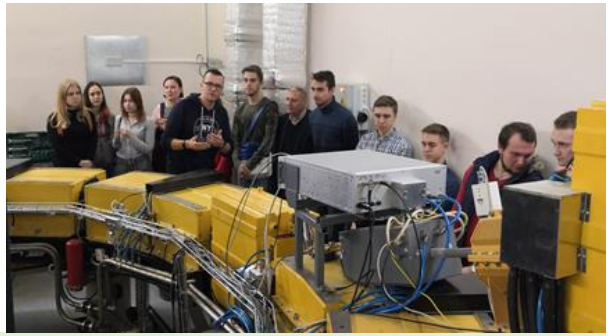
Development of new technologies for diagnostics and radiation therapy of socially significant diseases with proton and ion beams using binary nuclear physics methods

Goal: Reducing mortality from cancer

Proton and ion therapy

- Efficiency → New nuclear physics methods
- Availability → Compact proton synchrotrons

Agenda: *Physical and biomedical foundations of new technologies of proton and ion therapy and their implementation*



Identical domestic proton synchrotrons - research and medical, carbon beam of the U-70 (KI), neutron generator (Obninsk)

Installation of a proton synchrotron at the LPI at the Moscow site and a medical proton complex at the N.I. Botkin clinics in

Training world-class specialists
Young internships
specialists in world centers

An effective network for advanced research and training of world-class specialists in the field of nuclear medicine, radiation diagnostics and therapy.

Partners

Russian

ИФВЭ НИЦ КИ

ИБХ

НИИЯФ МГУ

Foreign

University at Buffalo

MAYO CLINIC Cancer Center

Delhi University (India)

GSI Helmholtzzentrum für Schwerionenforschung

Business

PROTOM

АМПЛИТУДА

Зеленоградский нанотехнологический центр

Organizations that have confirmed their interest in new technologies:

РОСАТОМ

НМИЦ НЕЙРОХИРУРГИИ имени академика Н.Н. БУРДЕНКО

НМИЦ ОНКОЛОГИИ им. Н. Н. Блохина

ОИЯИ

ФМБА России
ФНКЦРиО
ФЕДЕРАЛЬНЫЙ НАУЧНО-КЛИНИЧЕСКИЙ ЦЕНТР МЕДИЦИНСКОЙ РАДИОЛОГИИ И ОНКОЛОГИИ

Государственный научный центр Федеральный медицинский биофизический центр имени А.И. Бурназяна ФМБА России

НАЦИОНАЛЬНЫЙ МЕДИЦИНСКИЙ ИССЛЕДОВАТЕЛЬСКИЙ ЦЕНТР Гематологии

The main Institutes

ФИАН

МИФИ

ФГБУ "НМИЦ радиологии" Минздрава России

The main breakthrough result: Advanced development of radiological methods and their implementation on compact domestic medical proton synchrotrons

Expected result

By 2024, it is planned to create a large international team that performs advanced research and trains world-class specialists with new educational programs and advanced training programs for researchers, engineers and medics, in the field of radiation diagnostics and therapy, nuclear medicine, including nuclear nanomedicine on the base of the LPI and the co-executors of the project – MRRC and MEPhI, as well as their Russian and foreign partners.

Technologies of proton radiography (imaging) using the maximum proton energy,

Technologies of combined action of various hadron beams (protons-neutrons, protons-ions, multi-ion therapy),

Binary nuclear-physical technologies aiming at the development of targeted proton therapy technologies using promising nanoparticles and their-based systems as sensitizers of therapy and active agents for diagnostics.

The latter area involves a significant development of the field of modern nuclear medicine through integration with nanomedicine, which uses unique properties of nanoparticles for cancer diagnosis and therapy.

International team


A.V. Kabashin


Paras Prasad


S.M. Deyev


A.D. Kaprin


M. Durante


A.L. Popov


A.A. Popov


V.E. Balakin


V.A. Ryabov


A. Kolobov


I. Zavestovskaya

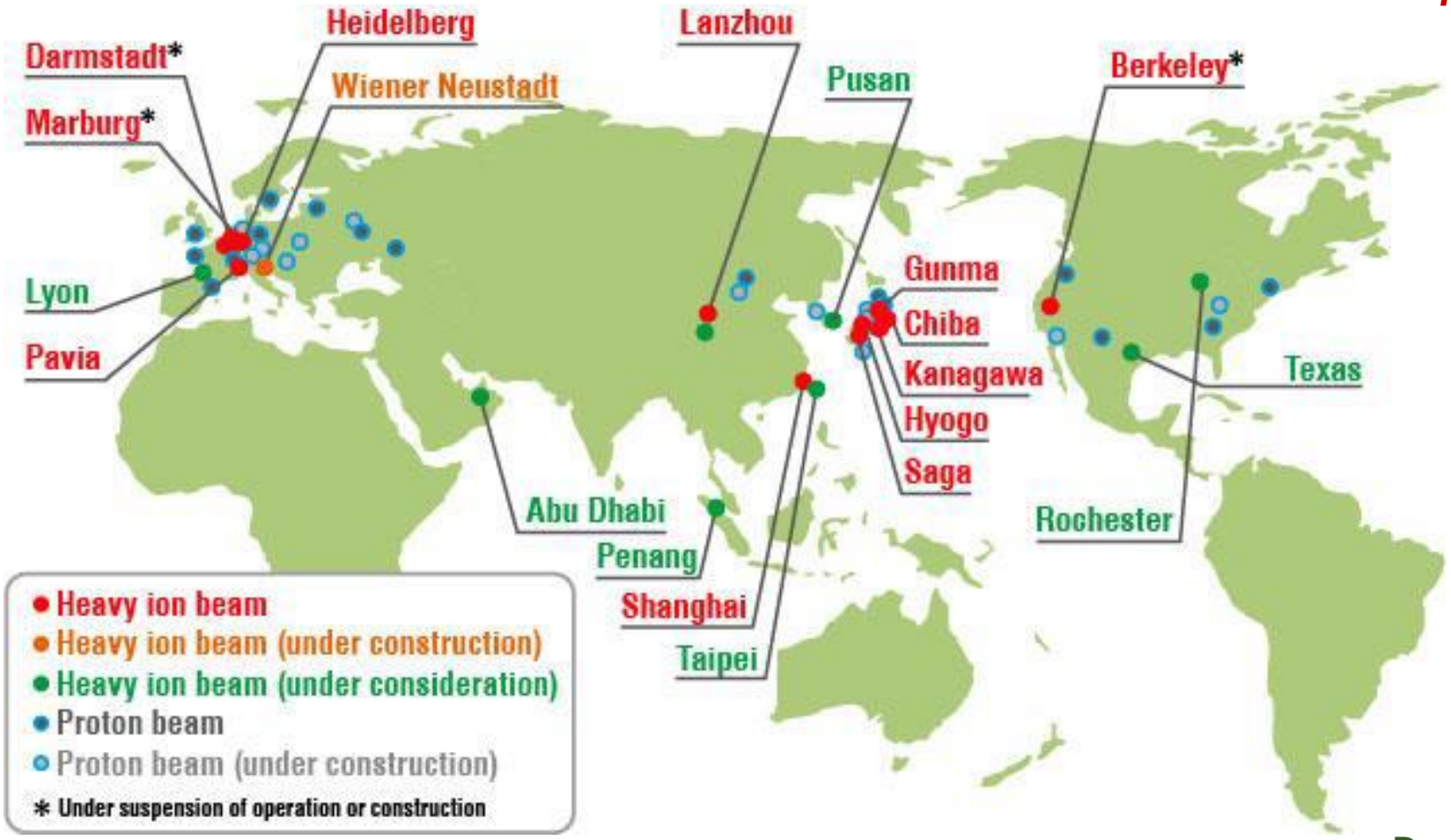
16 Dec. 15.00 – 15.40

Prof. Marco Durante

GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany

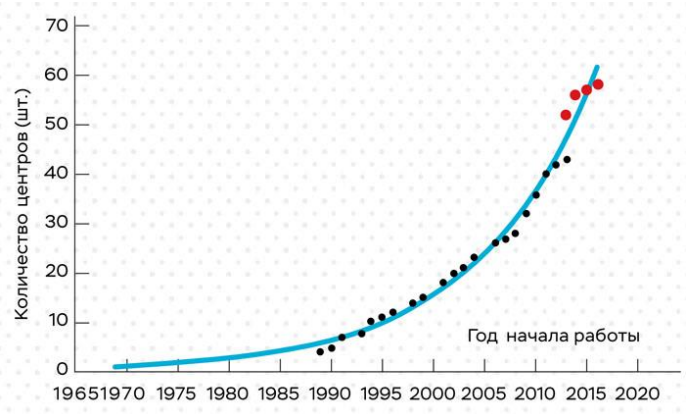
The future of heavy ion therapy

Hadron therapy Centers



Proton therapy centers 86

Heavy ion beam centers 12



Dynamics of growth of Hadron therapy centers

Proton therapy centers in the Russian Federation

- Medical synchrotron developed by Academician V.E. Balakin

  CPT "Prometheus" - PhTC, LPI, Protvino
- **Center for proton therapy at the MRRC (Obninsk) from 2016**
- **Center for Proton Therapy of the Berezin Medical Institute** from 2019

  - high cost (Varian Systems equipment)

  - little experience of the staff
- **FMBA Center (Dimitrovgrad) C235 cyclotron from IBA with the involvement of JINR**
- **technologies from 2019**
- **ITC JINR (Dubna) Phasotron of the Laboratory of Nuclear Problems**
- **Synchrotron ITEP KI (Moscow)**

16 Dec. 14.20 – 15.00

Prof. Yurii D. Udalov

Federal Scientific and Clinical Center for Medical Radiology and Oncology of the FMBA of Russia,

The first results of proton therapy treatment of cancer patients in the FMBA of Russia

15-40- 16-20

Prof. Inna V. Droshneva

P. Hertsen Moscow Oncology Research Institute, Moscow

Radiotherapy in the treatment of malignant tumors

PTC Prometheus

- **The implemented technique of irradiation with a narrow pencil beam and the system of choice of irradiation provide inaccessible to competitors.**
- **The beam size in the orthogonal plane is no more than 3 mm for 150 MeV.**
- **The maximum achievable energy at the domestic synchrotron of 330 MeV will make it possible to use it for proton tomography (the latest experimental development that can make proton therapy even more accurate) of the entire human body.**

Synchrotron Main Parameters

Range of accelerated proton energies, MeV	30 - 330
Range of energies for treatment, MeV	70 - 250
Acceleration time for 250 MeV, sec	0.9
Intensity of extracted beam, protons per cycle	up to 4×10^9
Outer diameter of the ring, m	5
Accelerator weight, tons	15
Average energy consumption during treatment, kW	30

- **Proton therapy complex “Prometheus” is focused on the integration to the already existing medical centers and hospitals.**
- **The small dimensions of the accelerator itself, the outer diameter is 5 meters, and the weight of the entire installation, not exceeding 15 tons, makes it possible to place the complex in relatively small rooms in existing medical centers.**
- **Focus on the use of modern automated and robotic means of immobilization and positioning through the use of positioning means to abandon bulky magnetic gantry-type proton beam positioning systems.**

New fundamental tasks of the project

- **Radiation therapy technologies based on the combined action of proton and neutron/carbon ions radiation, allowing to create a high dose gradient between tumor and normal tissues, and at the same time, to increase the damaging effect.**

17 Dec. 14-20. Sergey N. Koryakin

A.F. Tsyb Medical Radiological Research Center, Obninsk

New technologies of hadron therapy based on the combined action of rare and dense ionizing radiation


U-70 synchrotron, IHEP, Protvino

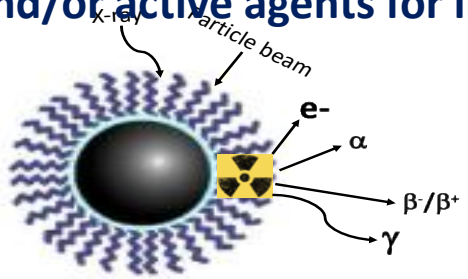

Prometeus proton accelerator, Obninsk

- **Binary technologies for proton therapy based on usage promising nanoparticles, nanocomposites and multifunctional systems as radiosensitizers for proton therapy and/or active agents for imaging. Radiopharmaceutical Medicines *in situ*.**

16 Dec. 16-40 Sergey Yu. Taskaev

Budker Institute of Nuclear Physics of Siberian Branch RAS, Novosibirsk

Boron neutron capture therapy of malignant tumors



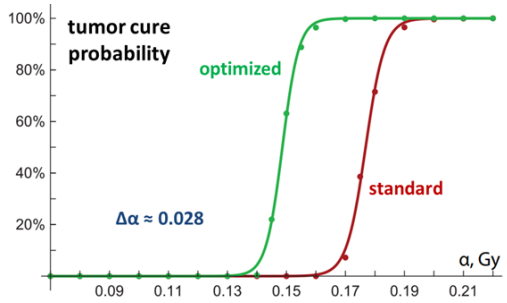
16 Dec. 17-20 Alexander E. Shemykov, LPI

Radiobiological research on the proton therapy complex "Prometheus"

- **Modeling of the processes that determine the effectiveness of radiation therapy: dynamics of changes in the size and possible movement of a tumor during irradiation, irradiation modes (fractionation, intensity modulation, sensitization with nanoparticles, etc.) and changes in the radiosensitivity of tumor cells.**

16 Dec. 18-00 . Maxim B.Kuznetsov, LPI

Optimization of fractionated radiotherapy via mathematical modeling



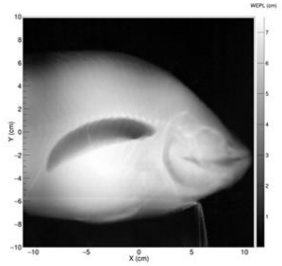
Mathematical modeling shows that the use of optimized schemes leads to notable expansion in the curative range of the values of tumor radiosensitivity parameter.

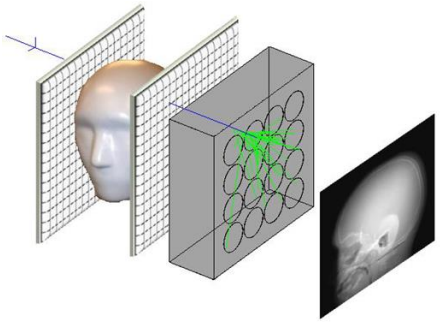
Large applied tasks of the project

- **Development of the method of proton radiography and tomography, which makes it possible to determine the path length of protons inside the patient's body with millimeter and submillimeter accuracy and significantly increase the image contrast and thereby significantly increase the efficiency of using proton therapy.**

17 Dec. 15-00. Alexander A. Pryanichnikov, LPI

Development of low intensity beam irradiation modes for proton imaging

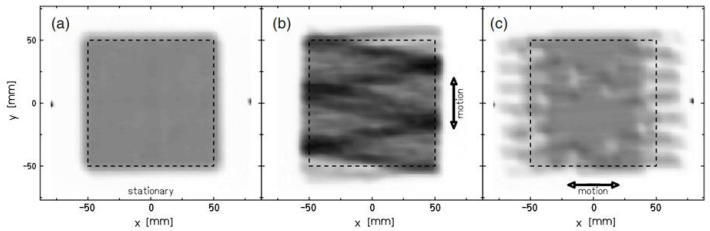


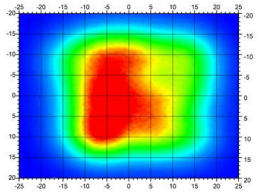


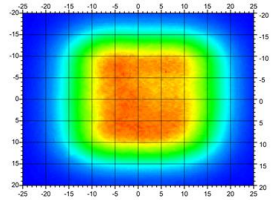
- **Proton and ion therapy technologies that take into account the movement and displacement of the tumor and internal organs during a proton therapy session, arising from the heartbeat and breathing or involuntary movements of the patient.**

17 Dec. 15-40. Mikhail A. Belikhin, LPI

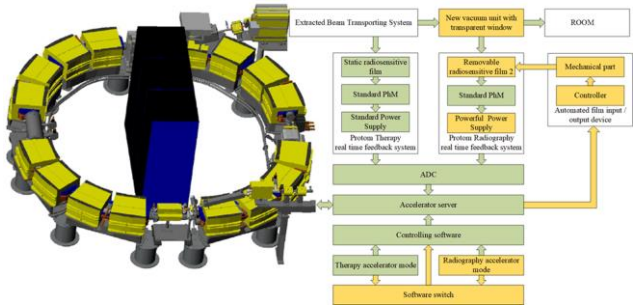
Proton therapy of intrafractional moving tumors.

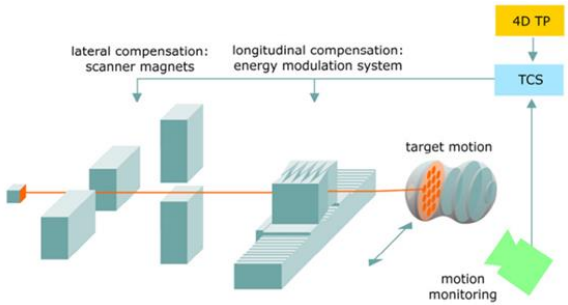


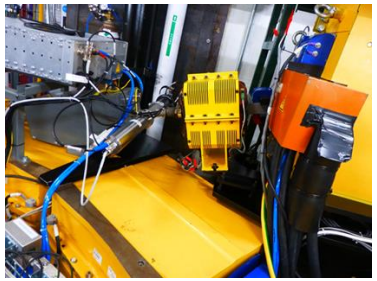


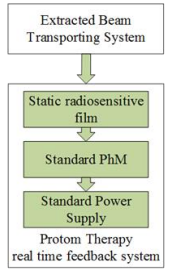


- **Improvement and modernization of the proton synchrotron based on the solution of the large applied problems set in the project and the technologies developed in the project. Development of two detectors - alpha particles and single-proton events.**









Technical runs

- 2003 – The 1st Protom Synchrotron
- 2010 – Protvino City Hospital, Protvino, Russia
- 2010 - Central Military Hospital, Ruzhomberok, Slovakia
- 2011 – McLaren Hospital, Flint, MI, USA
- 2015 - MRRC, Obninsk, Russia
- 2016 – MGH, Boston, MA, USA
- 2019 – P-Cure, Shilat, Israel
- 2021 – MIT Bates, USA (for Australian Bragg Center for PT)

Start of treatment

- 2015 – Protvino City Hospital, Protvino, Russia
- 2016 – MRRC, Obninsk, Russia
- 2018 – McLaren Hospital, Flint, MI, USA.
- 2020 – MGH, Boston, MA, USA

Patients irradiated worldwide

- 2020 – 500th patient
- 2021 – 1000th patient

Protom Synchrotron Geography

Protom Production Line

The production of upgraded PTC Prometheus and compact ion accelerators based on the nuclear physics technologies developed in the project by Protom Company and SC Rosatom and placement in RF nuclear medicine centers opens the way for solving the problem of availability of effective proton and ion diagnostics and therapy.

Joint section for students and schoolchildren, 17 Dec.

16.40 – 17.20

Anton Fojtik
Czech Technical University in Prague
MEPhI, Russia
Rendezvous of nanotechnology with radiotherapy and radiobiology

17.20 – 18.00

Vladimir A. Klimanov
Burnasyan Federal Medical Biophysical Center
Innovative technologies of remote radiotherapy

18.00 – 18.40

Andrey A. Postnov
N. N. Burdenko National Medical Research Center of Neurosurgery
MEPhI, Russia
Oxygen isotope-15 in the history of medicine

Scientific and educational activities within the framework of the project

2021

- I International Youth School "Innovative nuclear-physical methods of high-tech medicine", December 16-17, LP

2022

- II International Youth School "Innovative nuclear-physical methods of high-tech medicine", 26-29 May, Obninsk
- I International Scientific Conference "Innovative Technologies of Nuclear Medicine and Radiation Diagnostics and Therapy", October 24-26, LPI
- III International Youth School "Innovative nuclear-physical methods of high-tech medicine", October 22-23 Oct., LPI/MEPhI

2023 год

- IV International Youth School "Innovative nuclear-physical methods of high-tech medicine", 6-9 July, Dimitrovgrad
- II International Scientific Conference "Innovative Technologies of Nuclear Medicine and Radiation Diagnostics and Therapy", October 23-25, LPI
- III International Youth School "Innovative nuclear-physical methods of high-tech medicine", October 21-22 Oct., LPI/MEPhI

Контакты

https://protonschool.lebedev.ru/

- e-mail: protonschool@lebedev.ru

Scientific and educational activities within the framework of the project

International Scientific Seminar "Radiation Biophysics and Biomedical technologies"
Head I.N. Zavestovskaya
Weekly on Thursdays (Wednesdays) at 16.00. LPI with the possibility of remote connection.

Education programs

2022 год

- Перспективные технологии ядерной медицины для внедрения в практику высокотехнологичных центров РФ
- Комплексные технологии при проведении протонной и ионной терапии в онкологии: отечественный опыт и перспективы

2023 год

- Перспективные технологии ядерной медицины для внедрения в практику высокотехнологичных центров РФ
- Перспективные технологии лучевой диагностики и терапии на основе отечественного парка ускорительной техники

Thank you for your attention

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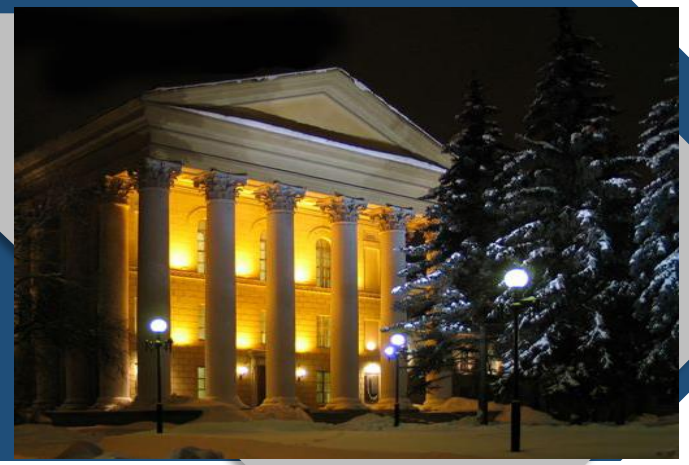

Aknowledgements

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