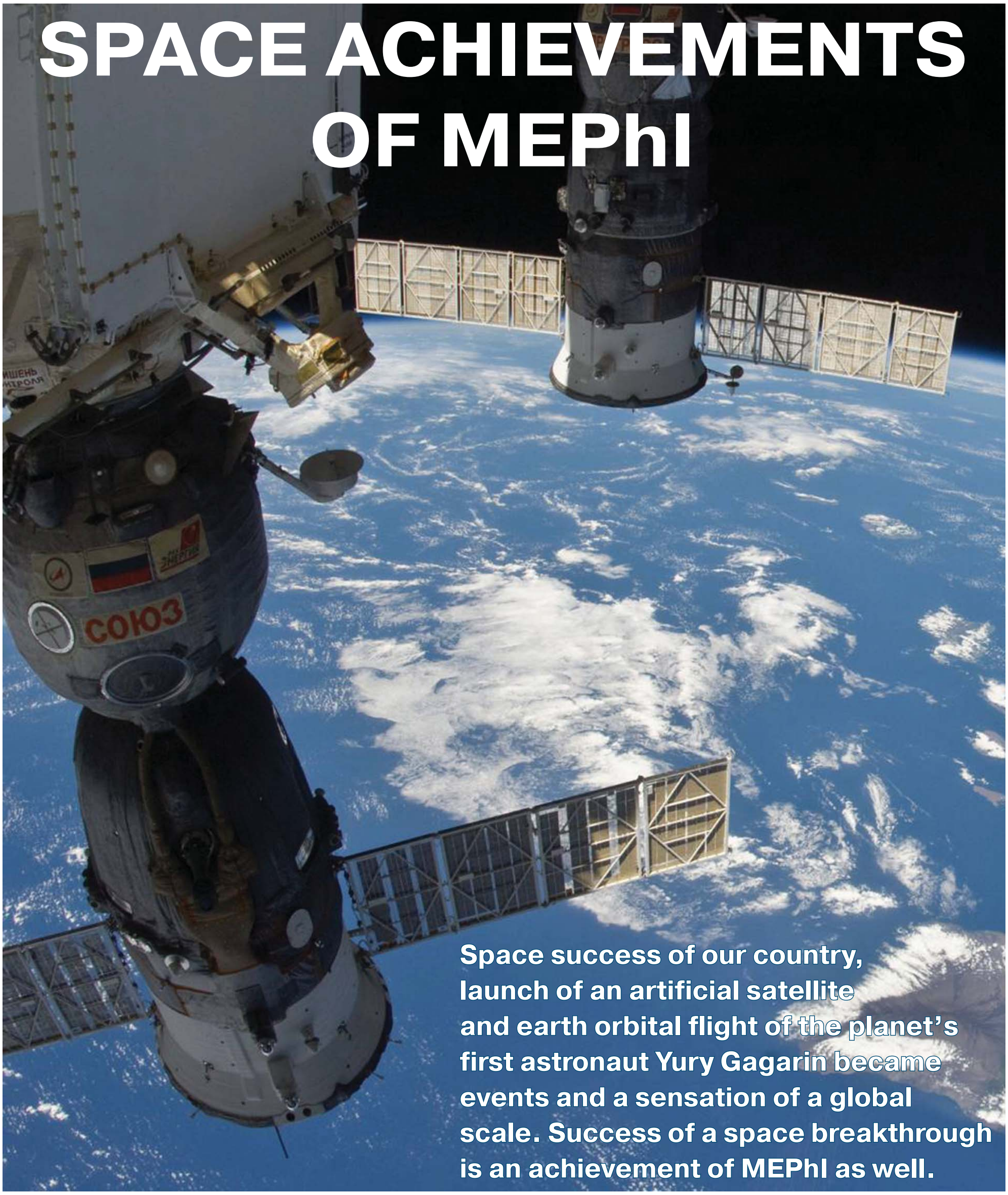
World of MEPhI

SPACE ACHIEVEMENTS OF MEPhI



Space success of our country, launch of an artificial satellite and earth orbital flight of the planet's first astronaut Yury Gagarin became events and a sensation of a global scale. Success of a space breakthrough is an achievement of MEPhI as well.

SPACE IS NOT ONLY MISSILE LAUNCHES

Space Physic Institute of MEPhI conducts research on space-related subjects with the use of nuclear-physical methods for about 40 years. Director of the Institute, honored scientist of the Russian Federation, full member of the Russian Academy of Cosmonautics named after K.E. Tsiolkovsky, Professor Arkady Moiseevich Galper.

Today there are several experimental facilities in space, developed with the participation of the MEPhI staff, including the famous international experiment PAMELA. One of the major cosmic mysteries is dark matter. The Director of the Space Physic Institute MEPhI Arkady Galper told about the race for it.

– Is MEPhI engaged only in applied research or is there a place for basic science?

– Of course, we have departments that create advanced developments under the auspices of the State Corporation "Rosatom". For example, a "nuclear truck" which is able to significantly reduce the time of flight, e.g. to Mars. However, there are groups in MEPhI, including my own, dealing with problems of general physics and cosmology that is basic research.

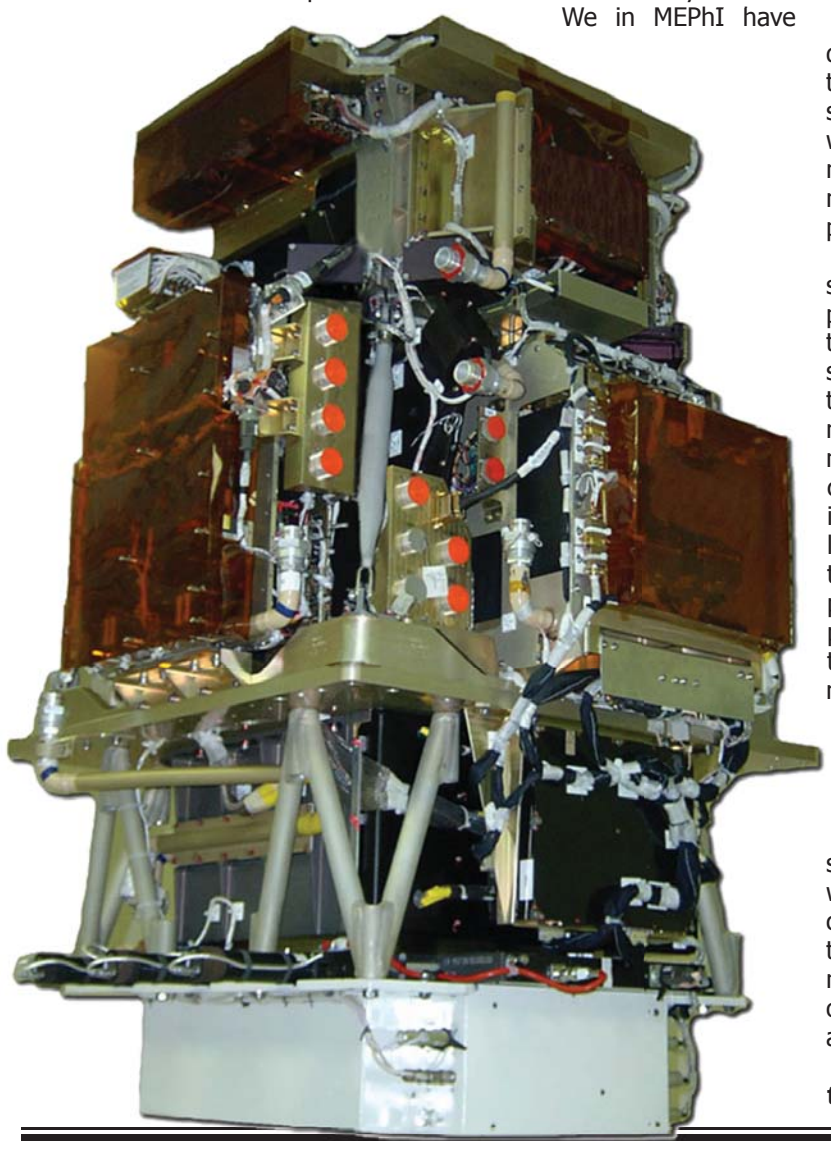
The Day of Astronautics is our holiday as well – many of nuclear scientists work on projects for the space industry and astrophysics. On the 4th of October 1957 our first satellite flew and started the era of direct research in space.

– And now?

– In March 2016 we ended work for the direct studies of cosmic radiation with the use of the device, called PAMELA. This is device with the magnetic field. Positive and negative particles are deflected in different directions, what allows to clearly see and study cosmic particles coming to us from the Galaxy from the nearest possible sources, to measure their charge, mass and energy. And, what is very important, to separate particles and antiparticles, for example, electrons and positrons, protons and antiprotons.

– What is that device?

– It has a great history! The fact is that in the early 1990-ies we were approached by the researchers from the Italian National Institute for Nuclear Physics. Together we decided to measure fluxes of cosmic rays.



We in MEPhI have been working in space for a long time – since 1960-ies. And we always cooperate with our foreign colleagues: together with the Italians we proposed a program of "ROME" – the Russian-Italian mission. It was new for the Institute. We started preparation for our great experiment with the development of scientific instrumentation and partial tests in space.

– Did you manage to open something new?

– We succeeded to conduct a very interesting study – examined the particles that fall into the eyes of the astronauts, and they see flashes. This is partly a biological problem. Some cosmic particles create in the eyes effects perceived by the person as light. The results of this work were published in the Nature journal.

– What happened next?

– Since the beginning of 2000-ies we had another great experiment. It is just about the PAMELA, which consists of several types of various detectors, which registered interesting for us particles.

We have set an important physical task. The fact is that at the beginning of last century there was such a notion as "dark matter". During the study of clusters of galaxies, we drew attention to the fact that they all revolve around a certain "centre". This rotation determines the gravitational force, and galaxies, thanks to its speed, can refrain from falling in the center. It was suggested that in the cluster's center there is a substance which have a gravitational mass and, accordingly, restrain these galaxies around during their rotation. No one knew what kind of matter is in the center. It is as if it doesn't exist! Or it is invisible. Moreover there are several times more dark matter in our Universe than normal baryon one!

– What does it consist of?

– At that time we thought that dark matter consists of dark particles, that is those that does not shine. The pursuit of dark matter was purely theoretical: scientists made assumptions about the mass and the properties of its particles.

These theoretical calculations showed that these hypothetical particles are very unusual. First, they are neutral, that is, does not shine like other particles during the excitation. Secondly, they are massive: the Standard model has no place for them. After the discovery of the Higgs boson nothing new were found. Quite a likely sequel could be the opening of the massive particles that comprise dark matter. Third, these particles have very small interaction cross section with ordinary matter. They freely pass through it, but they have gravitational interaction.

– Where did they come from?

– It is believed that in the early stages of the Universe when it was in a state of very high excitation energy and its temperature was enough for the birth of new particles, and these particles originated. As they poorly interact, they survived to our time.

– Is it possible to register these particles?

– It is a very interesting question. If dark matter exists, it means it exists in the world around us – in the Solar system. Its density is very small, and the probability that hypothetical particles will collide with each other is also low. However, their interaction leads to a very interesting result – appearance of the known particles like electron and positron. The mass of these particles during such interaction is transmitted to the energy of newly born. Although hypothetical particles seem to be stable, they can disintegrate. Most likely, in result there are fundamental particles, which are then transformed into elementary one, known to us.

Therefore, we need to look for traces of dark matter annihilation in space: among the stream of cosmic rays it's necessary to record, for example, positrons and antiprotons. That is a relatively rare particles, which can be found in cosmic radiation, but very irregularly.

– And you organized a search for them, aren't you?

– Yes, we decided to search for antiparticles. This experiment can be made in accelerators, speeding up particles to enormous energies. It is done, for example, at the Large Hadron Collider.

There is another way – to observe the direct interactions of heavy dark matter particles with nuclei, for example, by means of devices consisting of a large volume of liquid xenon or another noble gas. There a heavy particle collides with a nucleus, which this gas consists of, gives him some of the energy, and we calculate the mass of the particle, based on the deflection of the nucleus.

Similar experiments are conducted at huge facilities located mostly underground. They are called "direct experiments". We chose a different path, starting to search in the flux of cosmic rays of heterogeneity, for example, of antiprotons where, it would seem, they should not be. This method is called "indirect", because we seek not particles, but what is in the result...

– Was the PAMELA experiment conceived precisely for this?

– Of course. It was aimed to look for these traces in the streams of positrons, antiprotons and even anthelion, which could arise from the annihilation of dark matter particles.

– Did you manage to succeed?

– PAMELA spent for about ten years in space, and it helped us a lot. In particular, it was proved that the spectrum of positrons does not coincide with our theoretical idea about the number of these particles, even if we take into account all the known factors of particle production in the sources, passing through the Galaxy and getting to our Solar system. If we count it all, we will see that a flow is another – their number is even growing. And one of the first explanations of this effect, named "anomalous PAMELA effect", is based on the annihilation of dark matter particles for electron and positron. It can be seen on the electrons as well, but the problem is that there are so many of them so that it's much more difficult.

A similar situation is with antiprotons. And it is also one of the main results of the PAMELA experiment.

– And will it draw a line under the search for dark matter?

– No, there are already those who try to explain our results otherwise. And it is quite logical. However, the PAMELA results are very important, because it is one of the cases potentially pointing to dark matter.

Also I want to remind that the process of annihilation can produce electrons and positrons. But also there could be gamma-quanta! If there are two gamma-quanta, then the energy of each of them is almost equal to the mass of the dark matter particle. Entire research areas are developing around it. For example, the current Russian project Gamma-400. A new era of science will begin soon...

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BUT ALSO A BIG SCIENCE

The Institute of Astrophysics as a scientific unit of MEPhI was formed in 1997 to perform work under the federal space program. Since its foundation the Institute is headed by a member of several scientific councils of the Russian Academy of Sciences, Professor Yuri Dmitrievich Kotov.

During the existence of the Institute it has conducted numerous studies of cosmic gamma radiation, which allowed to clarify the mechanism of generation of astrophysical objects, including solar flares.

In the mid 1980-ies the Government of the USSR took a decision to implement a program of fundamental scientific research of the Sun using satellites. The project planned to run three orbiting solar observatories "CORONAS-I", "CORONAS-F" and "CORONAS-FOTON" consecutively. Each satellite had to be equipped with scientific instruments capable of recording solar data in a wide range of electromagnetic radiation from gamma and x-radiation to radiowaves.

MEPhI was among executors of this program in terms of creating scientific equipment for research of x-ray and gamma-ray radiation from solar flares for the first two satellites.

A number of specialists from scientific institutions of Russia, who created scientific instruments for the spacecraft "CORONAS-F", including scientific supervisor of the experiment Yury Kotov, was awarded the prize of the Government of the Russian Federation for the creation of a complex of scientific equipment with a new information channels to record corpuscular and electromagnetic radiation of the Sun, and also for priority results of observations of solar activity and its impact on the Earth.

The spacecraft "CORONAS-PHOTON" became the third in a series of satellites of the CORONAS programm. It has the following objectives: study of processes of energy accumulation and its transformation into energy of accelerated particles during solar flares, study of mechanisms of acceleration, dissemination and interaction of energetic particles in the solar atmosphere, study of correlation between the solar activity and physical-chemical processes in the upper atmosphere of the Earth.

The project was entrusted to the Institute of Astrophysics MEPhI. The University has become the lead organization for the creation of on-board scientific equipment "PHOTON", ground infrastructure to process the aggregate of scientific data from devices, as well as creation and functioning of the Centre of rapid processing, acquisition and storage of data received by telemetry from the satellite.

The spacecraft "CORONAS-PHOTON" was launched on the 30th of January 2009 into earth orbit with an altitude of about 550 km and an orbital inclination of 82.5 degrees. There was a large complex of scientific instruments on board – 14 devices, including 3 telescopes and 8 spectrometers. It included devices developed in MEPhI: "NATALIA-2M", BRM (Fast x-ray monitor), FOKA (multi-channel monitor of ultraviolet radiation) and "PENGUIN-M" developed jointly with colleagues from the Ioffe Institute.

Scientific information was received by the Research Center for Earth Operative Monitoring, transferred to the Institute of Astrophysics MEPhI via the Internet, where it was processed and laid on a special-purpose server of MEPhI within no more than 30 minutes after acceptance to provide it to participants of scientific experiments.

After express analysis of the telemetric data, all participants sent an electronic application to MEPhI to issue control commands of devices to generate and send it to the board of control files.

The work of MEPhI employees was highly appreciated by the leadership of the Russian Academy of Sciences. In particular, the President of the RAS Yuri Osipov noted in the congratulatory telegram that "launch of this orbital scientific observatory has started the implementation of an extensive research program in the field of fundamental space research. Creation of a unique complex of scientific equipment "CORONAS-PHOTON" is a vivid example of fruitful cooperation of scientists and specialists from the RAS institutes, higher educational institutions and scientific organizations. Particularly valuable is the direct participation of students and postgraduates of MEPhI at all stages of works on creation and ground processing of scientific instruments of the world level. It allowed the younger generation of Russian scientists to gain practical knowledge and valuable experience in working together with qualified specialists of rocket and space industry of our country during the creation and processing of scientific equipment".

Currently, the Institute of Astrophysics MEPhI is developing the equipment of new generation for the registration of soft, hard x-ray and gamma-radiation for interplanetary space mission "INTERHELIOZOND", meteorological geostationary satellites "ELECTRO-L" and for the experiment at the International space station.

We are sure that the majority of MEPhI staff and students know that there are cosmonauts among famous graduates: twice Hero of the Soviet Union Nikolay Rukavishnikov and Hero of the Russian Federation Sergey Avdeev.

In 1971 the MEPhI graduate Nikolay Rukavishnikov made a flight into space. In April 1971 he was awarded the title of Hero of the Soviet Union for the flight on the spacecraft "Soyuz-10" and for docking with the orbital station "Salute". His second flight on "Soyuz-16" took place in 1974, and the third – as a part of the international crew in 1979.

Sergei Avdeev flew three times in space. Each of the first two flights lasted a half of a year, the third time he worked at the station a year and two weeks. In sum, S.V. Avdeev worked in weightlessness 747 days 14 hours 16 minutes. This peculiar record for the longest human stay in space station is recorded in the Guinness Book of records.

Plesetsk cosmodrome
A spacecraft "CORONAS-PHOTON"
Launched on January 30, 2009

POSTGRADUATE STUDENT OF DEPARTMENT "LASER MICRO- AND NANOTECHNOLOGIES" SUCCESSFULLY DEFENDS THESIS IN FRENCH UNIVERSITY

A post-graduate student of MEPhI Department № 87 Maria Kholodtsova has successfully defended her PhD thesis in the University of Lorraine (Nancy, France) with the right of getting PhD in Physical and Mathematical Sciences in the Russian Federation.

The topic is "Spatio-temporal modeling of interaction between laser radiation and multilayer epithelium in vivo tissue in the presence of metal nanoparticles in multimodal spectroscopy".

DEPARTMENT №70 POST-GRADUATE CONDUCTS SERIES OF EXPERIMENTS IN INTERNATIONAL LABORATORY OF HIGH MAGNETIC FIELDS AND LOW TEMPERATURES IN POLAND

A post-graduate student Maxim Osipov from the MEPhI Department №70 "Physics of solid state and nanosystems" has conducted measuring in the International Laboratory of High Magnetic Fields and Low Temperatures in Wroclaw. This laboratory has welcomed specialists in the field of solid state physics for conducting measuring on its unique equipment since 1964.

During those two weeks in the Laboratory the young scientist conducted measuring of magnetic characteristics of high-temperature superconductors at a superconducting magnet OxfordInstruments with a magnetic field up to 15 Tesla.

The research has been conducted as a part of partnership with a Russian company producing superconducting tapes of the 2nd generation SuperOx, the test samples of which were the object of the research.

The trip turned out to be very fruitful; he measured magnetic characteristics of many unique superconducting samples. Moreover, it was very useful to communicate with professors and Laboratory research fellows as well as colleagues from Russian institutions. This time there was a chance to talk with colleagues from Kiev, Kharkov, and from the Moscow Institute of Crystallography, RAS.

FROM RUSSIAN THEORY TO WORLD PRACTICE

Evgeny Savin, a post-graduate student of the Department №14: "I have taken a six-month internship by the grant of the President of the Russian Federation in the laboratory RadiaBeam Technologies (Los Angeles, USA), where conducted a research of modern methods to accelerate charged particles, including compact metal-dielectric accelerating structure. The company is exploring new types of acceleration, power supplies, magnets, produce a wide range of instruments and equipment, including THz optics and sensors. I got into the environment where it is possible to observe the entire development process of the device, starting from an idea, calculations and ending with the device setting.

Now in the world accelerators are mostly made of metal. One of the projects I worked on is associated with the development of dielectric micro linear accelerator. It will be smaller, cheaper, easier to manufacture, and consume less energy. However, its cheapness ultimately should not affect the structure characteristics. I was directly responsible for optimization of the geometry of the accelerating section to obtain parameters that are required for effective operation of the facility, and also conducted measurement of test models and different dielectrics to define new vectors for the calculations. We used a sapphire as a dielectric. It pleased that today one of the cleanest sapphires are made in Russia.

In the course of work, I have learned new programs for calculation, methods of measurements and saw in practice things that I had studied in theory. Sometimes I had not enough knowledge to do the task, but the colleagues always succored, gave good advice, and as a result, all the work was done. Ultimately, we will create a prototype of the accelerator to be proposed for replacement of the radioactive source. One of the outcomes of my internship was publication of research results achieved in conjunction with a colleague from the American firm which were included in the number of scientific articles of the journal "Nuclear Instruments and Methods in Physics Research" by Elsevier.

It's worth to sent us to study in other countries. I received a lot of experience, became more fluent in English and met the leading scientists and engineers. Besides, I'll need new knowledge in order to advance science in Russia".

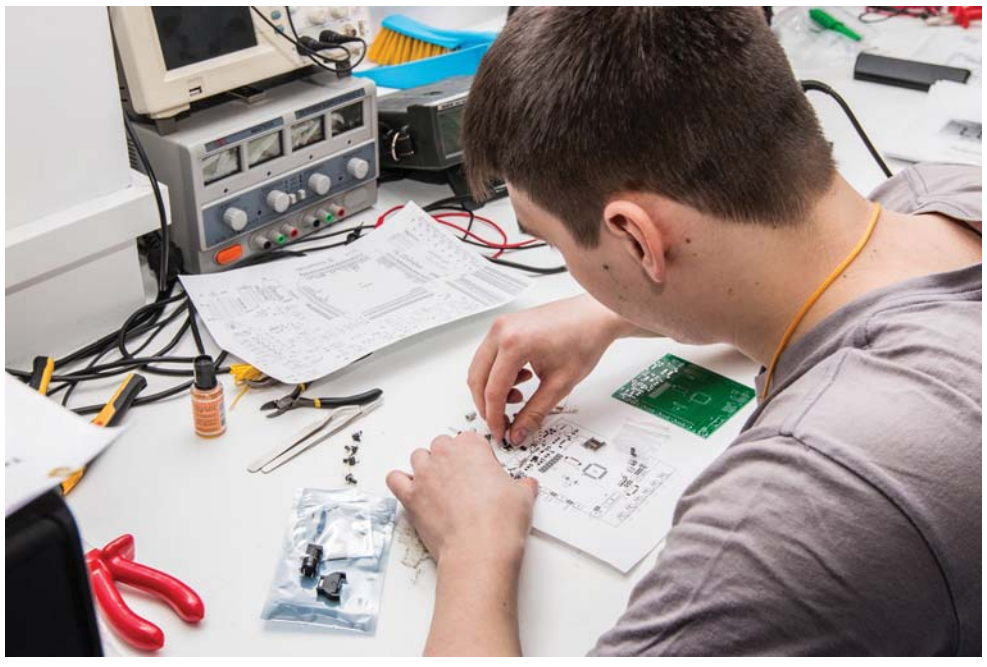
STUDENT OF MEPHI TO PROTECT HONOR OF RUSSIA IN WORLDSKILLS CHAMPIONSHIP

The first Intercollegiate championship "Young professionals" (WorldSkills Russia) in high-tech professions has ended. The event gathered students from several dozen technical universities of Russia at the University.

A Student of MEPhI Artem Sokolovsky is among the winners of the championship and has become a candidate for inclusion in the expanded Russian national team, which gives him the opportunity to defend the honor of Russia at the world championship WorldSkills, which will take place in 2017 in Abu Dhabi (United Arab Emirates).

– I really like the idea of the WorldSkills competition. It is a contest of all professions from a pastry chef to IT specialists – each profession is called a competence. The general concept of the contest is the following: contestants perform tasks in their profession, for example, tilers lay tile, bakers bake cakes etc. The contest lasts for 5 days; each day is a new task.

In my competence "electronics" I had to carry out four tasks. The first one was to get the electronic circuit into the operation conditions, given that we had only a draft of the initial scheme, and then to build the PCB for the invented circuit. The first part of the task I did OK with small mistakes, but there were difficulties with the PCB, because I had never done such a difficult thing before. Eventually I did practically everything. On the second day there was printed circuit board and we had to solder all the electronic components to it. I soldered almost everything, but, alas, did not have time to install a large display. So it was impossible to check the functionality of the circuit without it.



On the third day I had to find errors in connected circuit, found four errors out of five. One was very strange: a pin of the microcontroller was cut. And the second task was to program a robot. For that purpose I had the chassis, rangefinder and a servo drive. And I received maximum points for my robot. The program was that the robot was moving only in the direction where there was space, and if there was no place to go he had to stop.

A little personal information:

– Artem, where did you come from and why did you choose MEPhI?

– I arrived from Kostroma. Since the childhood I wanted to do physics, electronics, and choosing a University I was interested by MEPhI. So I've entered it.

– What is meant by winning the Championship?

– For me winning means a lot, I really wanted to prove to myself that I'm worth something in electronics, and that the time spent for favorite pastime did not go in vain.

– Is it your first victory or do you have more achievements?

– It is my first win during my study at the University, and at school there were winnings in contests and competitions both regional and Russian.

– What else are you fond of, any hobby?

– During first two years in MEPhI I was singing in a choir, but then our ways diverged because of the lack of time. I am a member of a University gymnastics team. In my spare time I conduct classes for children in electronics (programming), teach in the summer school on electronics "MYTH".

– What are your plans after graduation?

– There is no clear plan, I am thinking about postgraduate study, will continue to work, teach and learn myself.

– A few tips for those who have just joined the University this year.

– I would like to advise them to find the area and the activity that is most interesting to them, and to develop in this direction in spite of what others may think and say. And of course don't forget to study.