# Program of scientific and applied experiments on the ISS Russian Segment

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Russian Federal Space Agency (Roscosmos)

UN/Malaysia Expert Meeting on Human Space Technology
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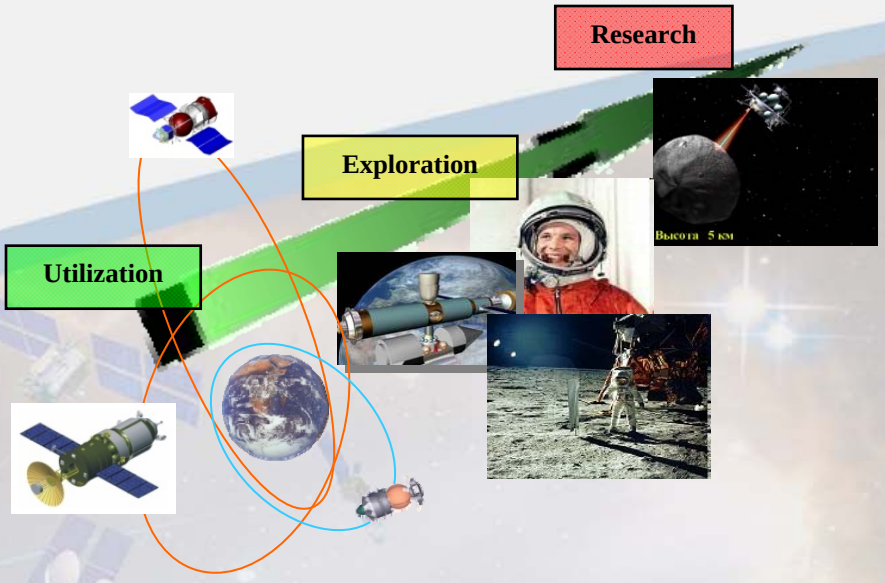
# ISS as a unique test-bed for scientific ideas and advanced technologies.




More than 20 years of PERMANENT human residence in space

ISS is a important stage of human space exploration

## Goals and objectives:

- Experience of human continuous life and work in space in the multinational community.

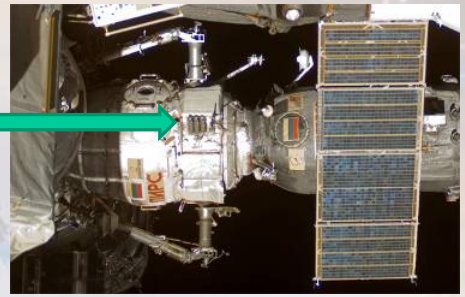
- Testing living organisms and materials under space conditions for future production of unique samples with unattainable for ground manufacturing properties.

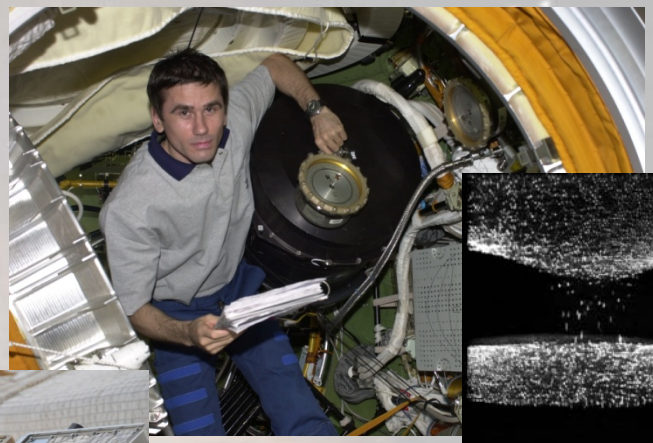
- Research in various areas of science and engineering sensitive to the microgravity, space vacuum and radiation and other conditions in ISS orbit.

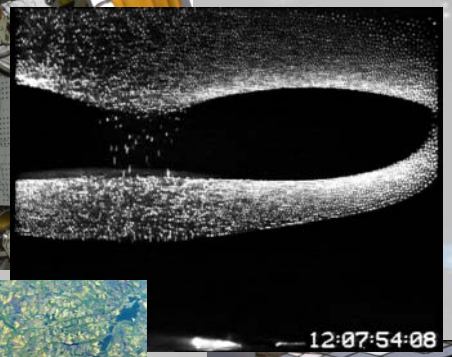
- Development of technologies for future exploration projects, repair work and

# Areas of the research results implementation

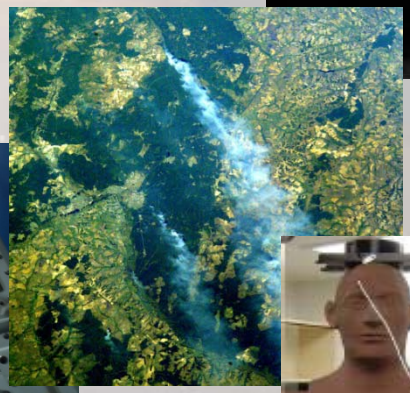
## Fundamental sciences

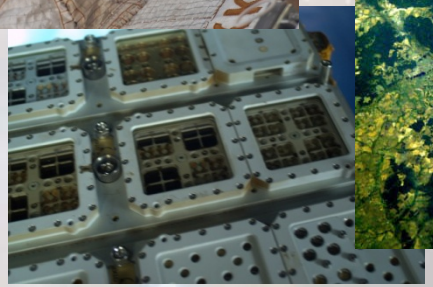







## Applied sciences





## Future exploration technologies

# Peculiarities of R&D on the ISS RS

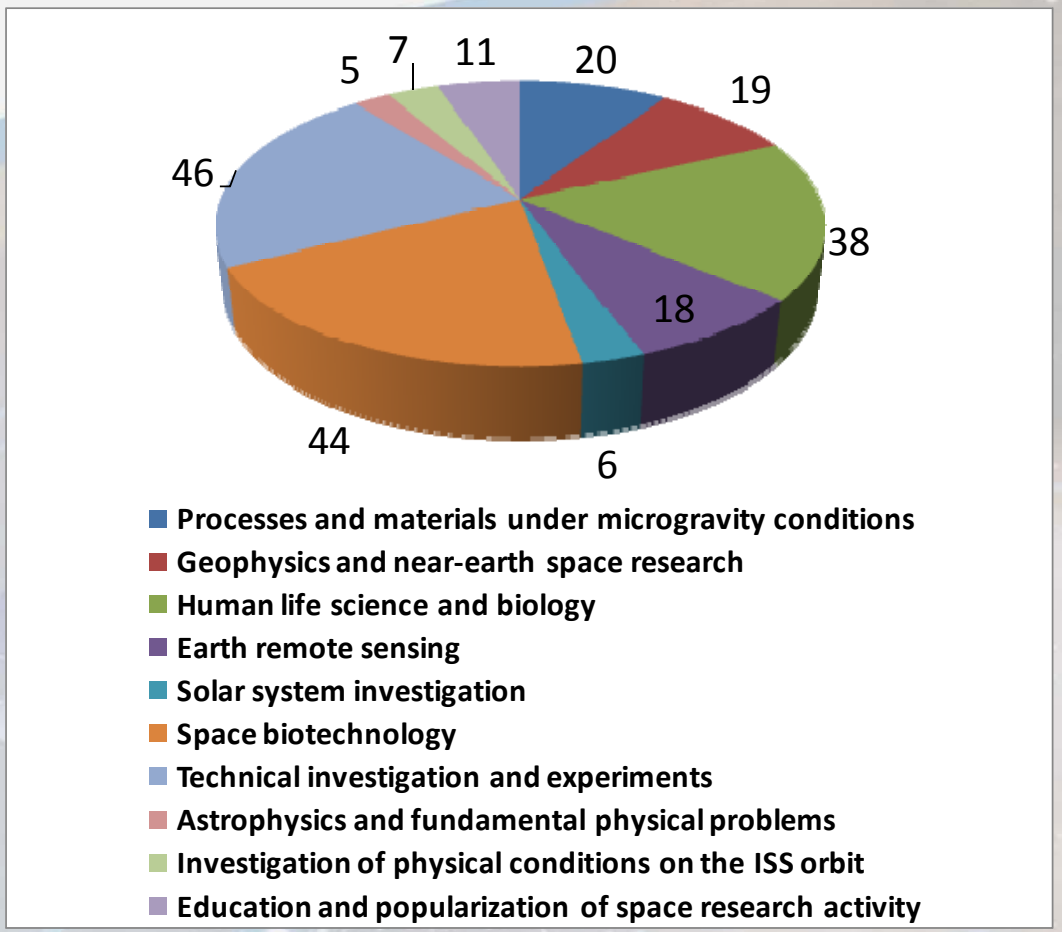
## Advantages of research on ISS

- Orbital altitude of ISS allows effective observations along the **whole electromagnetic bandwidth**.
- It also corresponds the **maximum level of ionosphere ionization** allowing the effective ionosphere plasma research, including active experiments.
- ISS meets Earth remote sensing requirements **for scanning overview experiments**, however, the orbit inclination prevents monitoring of the significant part of the Russia territory.
- The large complex spatial structure of the ISS allows **simultaneous measurements in the spaced locations**,. On the other hand a significant part of the celestial sphere is unavailable for observations.
- ISS has long operation period (20+ years), which is **suitable for long-term tasks** like monitoring of "space weather“ or exposing of different samples. On the other hand, the long-term monitoring of specific objects needs for the independent system of stabilization.
- Utilization of ISS infrastructure for **small satellites launch** and for **automatic spacecrafts maintaining** at the periodical docking.
- The crew presence allows a **gradual upgrade of experimental base, repair works** and replacement of equipment or components, **assembling of large structures** part-by-part.
- The study of **peculiarity of people life and work** in space remains a major task of scientific program

## Disadvantages of research on ISS

- **Harsh conditions for thermal stabilization** for high-precision optical systems due to frequent sunrises and sunsets.
- ISS is subject to a **wide range of vibrations**. This imposes constraints on the precision of astronomical experiments and makes impossible to reach microgravity level below $10^{-5}$g for gravitation sensitive experiments.
- The **ISS own atmosphere** may hinder some experiments that require ultra-high vacuum.
- Due to ISS radiation and a lot of electric equipment we have not very low level of **electromagnetic interference**.

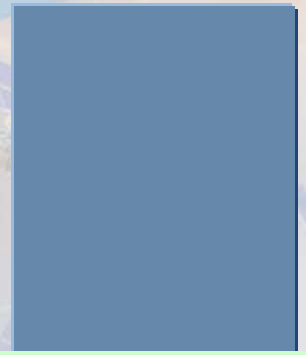
# Russian long term research program



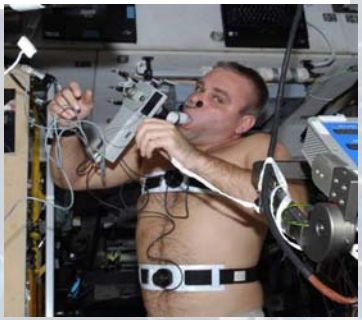

- 214 space experiments in the Russian long term research program
- 105 of them were conducted by 2011.
- About 130 unites of scientific equipment of about ton total mass are housed on the ISS RS.
- Hundreds of scientists are involved in the scientific program from more than 40 organizations.
- Much more room will be available in the next few years for additional experiments

# Biomedicine

- Health care in the long flights on the ISS, experiments for future flights to the other planets.
- Study of mechanisms of biological adaptation to space flight conditions (weightlessness, radiation, artificial habitat).



**Weightlessness countermeasures**



**M.Suraev conducts Dykhanie experiment**

**Pilot-M: Study of psychophysiological state of cosmonaut-operator**

**Matroshka: study of radiation environment with different phantoms in- and outside ISS**

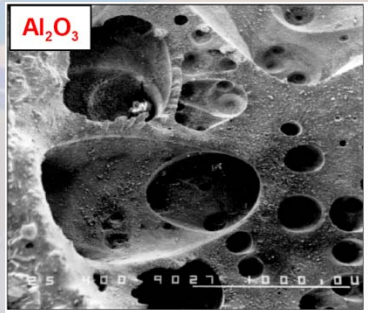

**Plant biology**

**Biorisk: Study of microbiological risks. Some bacterial and fungi strains can survive for 2 years in open space.**

- Some results of these medical research are also applicable in clinical practice on Earth.
- The future missions to the Moon and Mars will be much more difficult and fully autonomous which requires even increasing safety and efficiency of medical care.

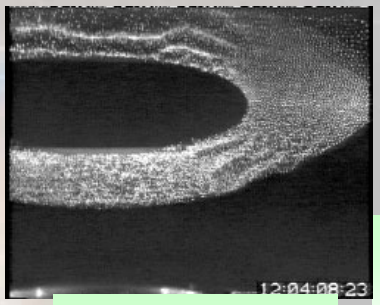
# Microgravity

- Crystal growth, new materials and structures, physics of burning and synthesis, liquids, phase transitions, low temperatures under microgravity conditions.

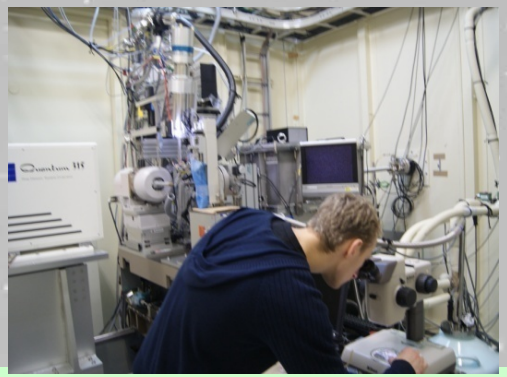




**SHS: Self propagating High-temperature Synthesis of different high-melting inorganic materials. Results can be used for repair works in space and building on other planets**



**Nonlinear waves in plasma crystal**



**Crystallizator: High quality protein crystals growth. Russian scientists fulfill X-ray analysis at the Japanese synchrotron Radiation Facility.**

**Multizone furnace MEP-01**

For next decade:

- High quality crystals growth semiconductors, metals and dielectrics by different methods with multizone furnace.
- Fluid and transport physics, low temperatures.
- **Ekran-M** experiment: Synthesis of semiconductor multilayer heterostructures in space vacuum ($p<10^{-12}$ mm Hg) by Molecular Beam Epitaxy technology behind the molecular shield could improve nano-electronics, in particular raising the efficiency of solar cells as much as 60%.

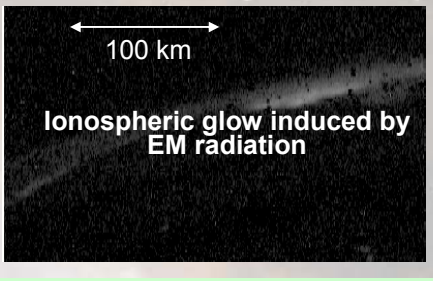
**Ekran-M**

# Geophysics

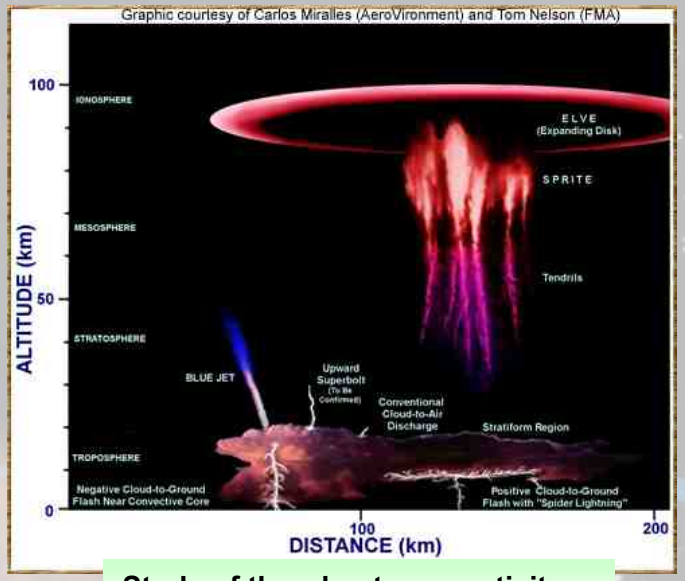
- Study of geophysical processes from outer space, including the processes in the upper atmosphere and near-Earth space environment

**Vsplesk facility preparation (Inc.#17)**

**Experiment Vsplesk: development of earthquake forecasting methods with the precursor-bursts of high-energy charged particles in the near-Earth space**



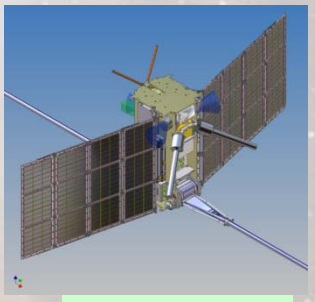

**Experiment Relaxation: Study of atmospheric optical phenomena on the orbital altitudes**



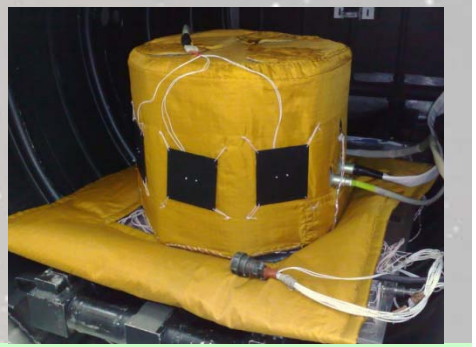

**Study of thunderstorms activity**

For next decade:

- physics of atmosphere and ionosphere
- plasma physics and space weather effects
- study of disaster (earthquakes, climate change etc.) forecasting methods and precursors



**Microsputnik Chibis**



**Outer detectors of Photon-Gamma apparatus in the thermo vacuum test chamber**

# Earth remote sensing

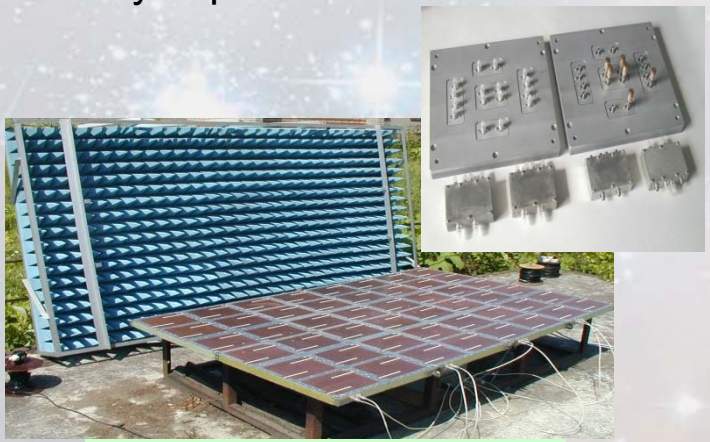
- New methods and tools for the Earth observation and ecological monitoring from space.

➢ Monitoring of ocean bioproductivity for research and fishing needs.

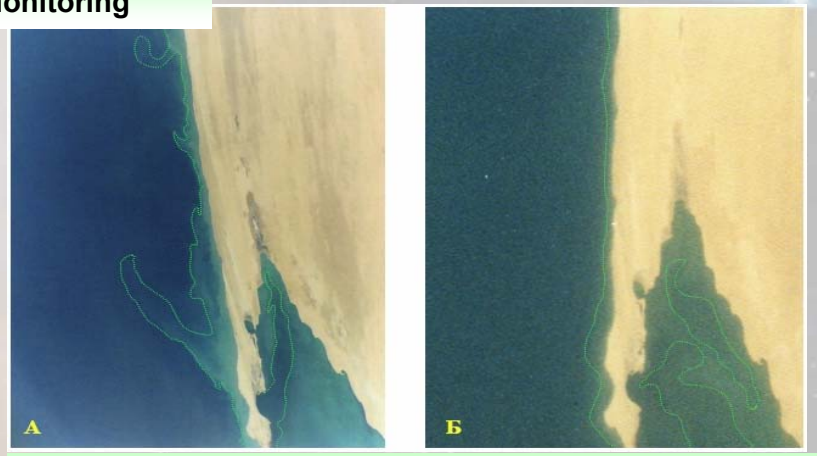

Glacier monitoring

For next decade:

- ➢ Optical study of the atmosphere – ground and ocean system.
- ➢ Radiometry experiments



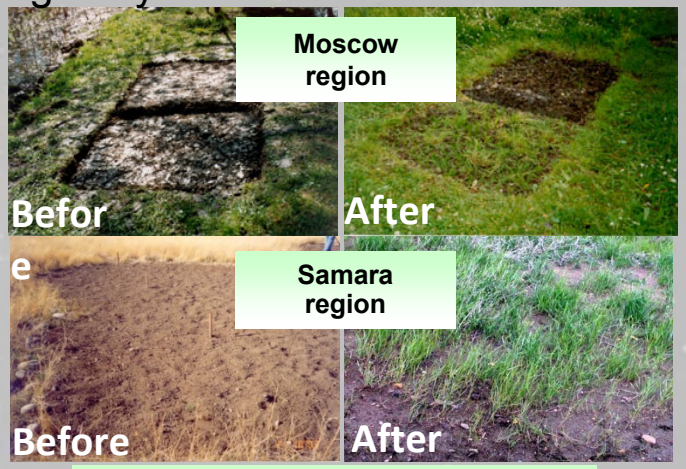
8 – channel microwave radiometer
*(λ = 21 cm)*




**Geographical location and shape of high-productive water area of Canary upwelling in intensification 06.01.2008 г.(А) and relaxation 12.06.2005 г.(Б) periods.**

# Biotechnology

- Study of the biological and biotechnological processes in space, development of basic technologies for manufacturing of bio-products under microgravity conditions.




Recultivation of oil polluted parcels of land (2007 – 2008)

- Search for AIDS, Hepatitis-B vaccine, anticancer drugs
- Diagnostic systems and immunomodulators
- Fungi strains: remedies and stimulators of plant growth
- The effective bacterial forms for oil biodegradation

For next decade:

- Study of influence of space conditions on the cultivated strains, cells and intercellular environment.
- Development of bioreactors, biospecific sorbents, methods and tools for bioproduct detection and other equipment for various strain cultivation and bioproducing.
- And much more investigation for next generation medicine (vaccines, drugs and strains).

Glove box use in Aseptic experiment

Hybridizator Recomb-K

Thermostat-container "AQUA-01"

# Space techniques and technologies

- The development of space technique, technologies, energy systems and their application to the research on ISS RS and for further space exploration.
- Study of physical conditions in the ISS orbit and its impact on the safety of the crew, space equipment and materials.

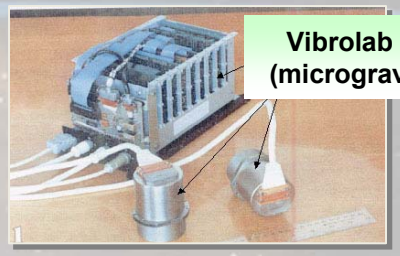
Leaks finding with special pointer

Corrosion of aluminum alloy under combined action of ultrasound and water condensate (x 200)

Veterok devises on board of ISS RS (air parameters control)

For next decade:

- Increase the efficiency and safety of space exploration, ISS resource prolongation. New methods and technologies to find leaks, disruptions, corrosion points, protection against radiation and other negative factors of space.
- Development of new technologies for preservation of Earth's ecosystem, by removing from the surface those power-consuming and waste-producing industries, in particular energy generation industry, for instance:
  - **Znamya-3** experiment - test in flight a new concept and design with 2 reflectors rotating in opposite directions and verify major characteristics.
  - **Znamya-SB** experiment - centrifugal film structure as solar energy concentrator or solar battery for energy transformation and transmission to the Earth.
- Automation and robotization of the space activity.



Vibrolab apparatus (microgravity control)

Znamya experiment

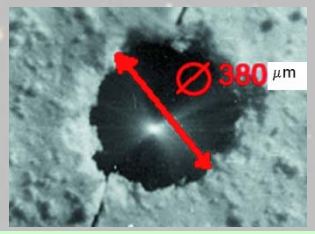
# Solar system and astrophysics investigations

- Sun, planets and small bodies of the Solar system.
- Study of the interplanetary matter on board the ISS by contact methods (mass spectrometric, physical and chemical methods of analysis of near-Earth space dust).
- The structure of the Universe and processes outside the Solar system and associated fundamental physical problems.

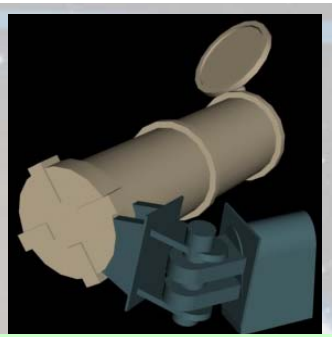
- **Platan** experiment: Study of iron group nuclei in galactic cosmic rays and ions in solar cosmic rays. Detection of micro-particles around the ISS.

- **BTN-neutron** experiment: Studying of charged and neutral particles during Solar Particle Events; detecting of Gamma Ray Bursts "simultaneously" with HEND/Mars Odyssey for interplanetary triangulation;

**PLATAN (PLAstic Track ANalyzer) – multilayer lavsan based detector**



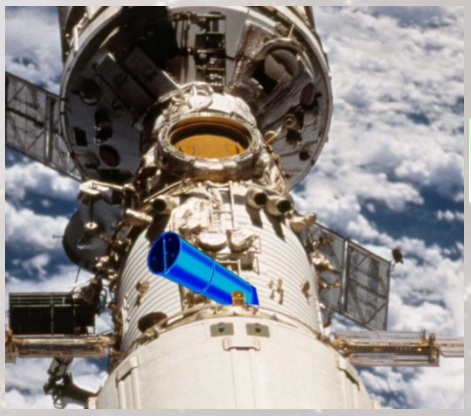

**Hole caused by a debris particle**
**The number of such particles appears to be 2 times more than predicted**



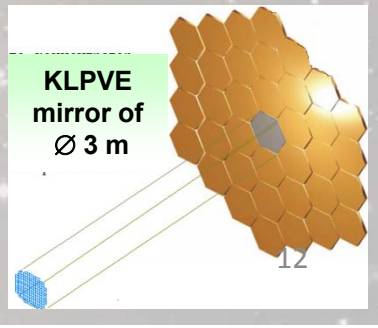
**Telescope of ∅ 600 mm for Planet monitoring**

For next decade:

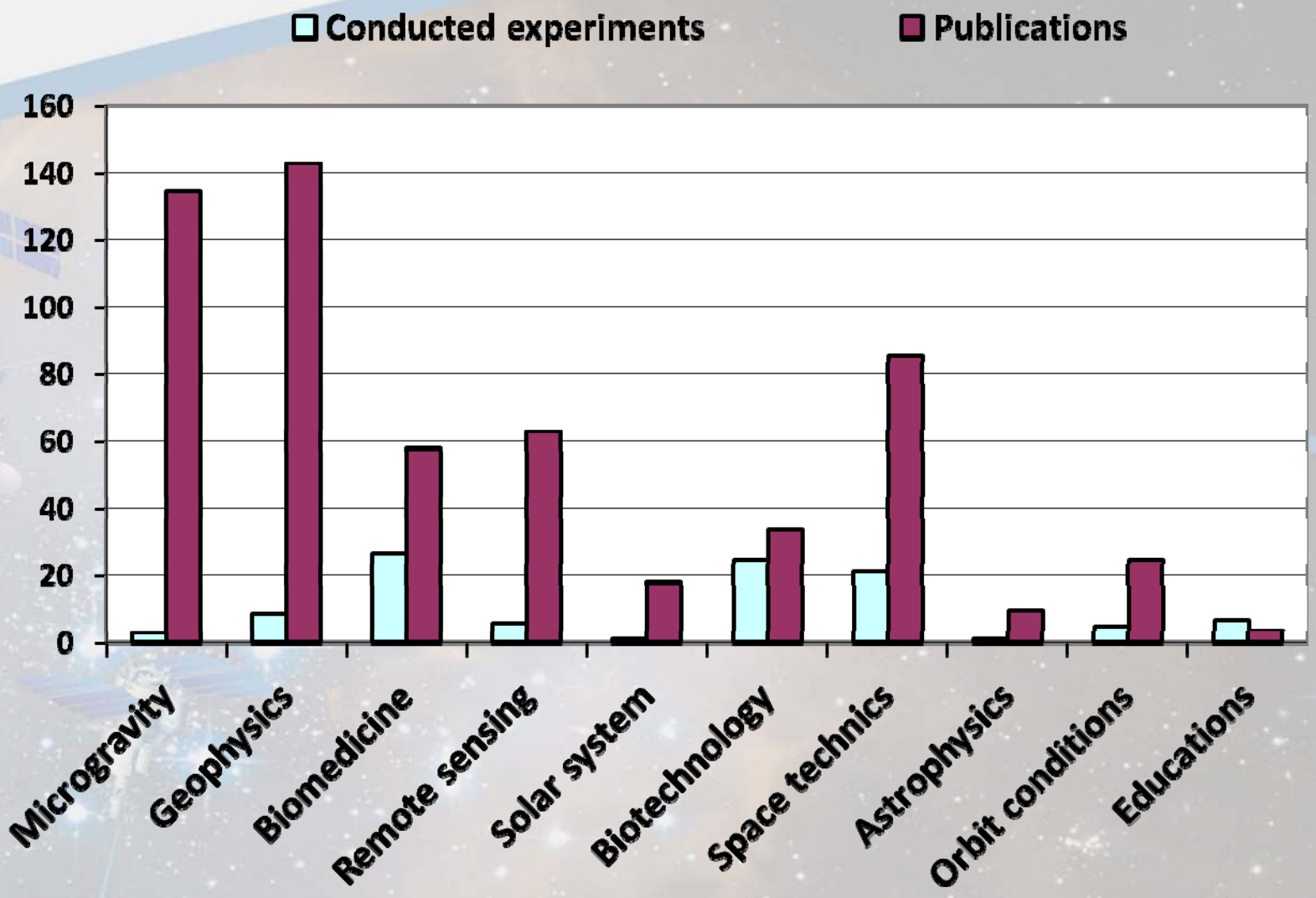
- Solar system investigations:
  - **Planet monitoring** (study of planet's surface, atmosphere, clouds; exoplanets, debris and asteroids)
  - **Dust and microparticle detector.**
- Astrophysical experiments:
  - **KLPVE** – study of ultra high energy particles >$10^{19}$eV
  - **MVN** – all the sky monitoring in X-rays
  - **Lira-B** – high precision photometrical and coordinate measurements



**Future location of Lira-B telescope**



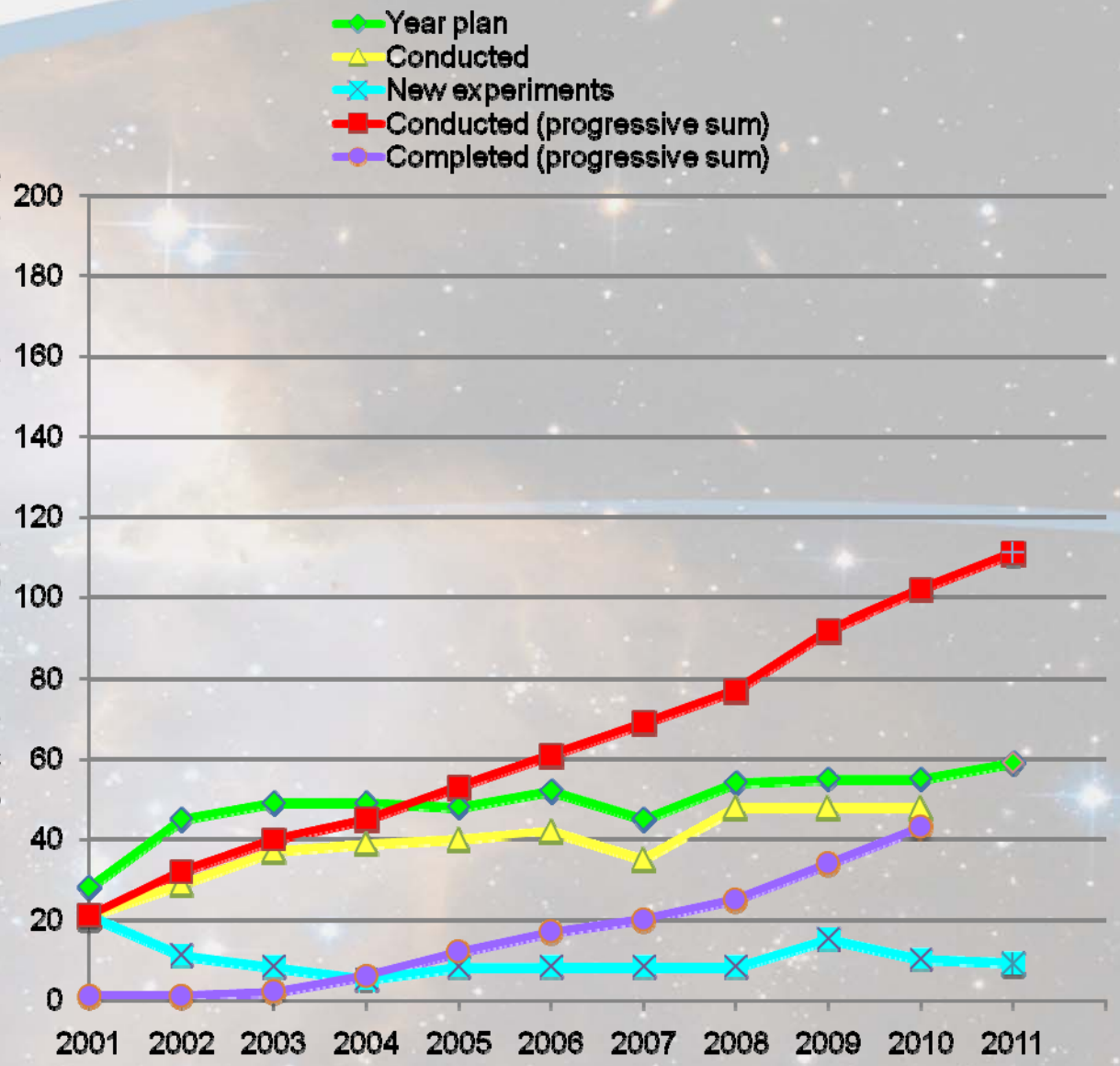
# Experiments and publications




**Results were presented in more than 600 scientific articles and reports.**
**They are stored also in the Roscosmos data bank and are available for further use.**

# The number of experiments, planned and implemented

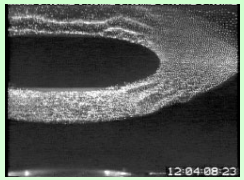
- 105 Russian space experiments were conducted by 2011;
- 43 space experiments are completed (>6,000 scientific sessions).
- 62 experiments are carrying out, 109 experiments are preparing;
- Forecast: by 2015 the number of scientific experiments will grow up to 200.



# International cooperation

## ESA

***Upon the Frame Agreement signed***
***Joint Experimental Program is enforced***



***In the* first line**

***Plasma crystal***
***Matroshka***
***Immuno***
***Relaxatsiya (ATV-reentry)***
***Dal'nost' (GTS-2 )***

**In the second line**

***Bars (Lipidis)***
***Display (Pasta)***
***VIPIL***
***Peritektika (Parsec)***
***DSMIX***
***VILMA***
***… about 10 experiments***

**Dozens of experiments in future**

## JAXA

**Russian *Crystallizer* experimental program has been joined with *PCG* experiments on Japan Protein Crystallization Research Facility**

**Scientific protocols of *Aquarium-AQH* and *Matroshka-P* experiments have been signed.**

**Investigation of Medaka fish in *Aquarium-AQH***

***Matroshka-P - Padles***

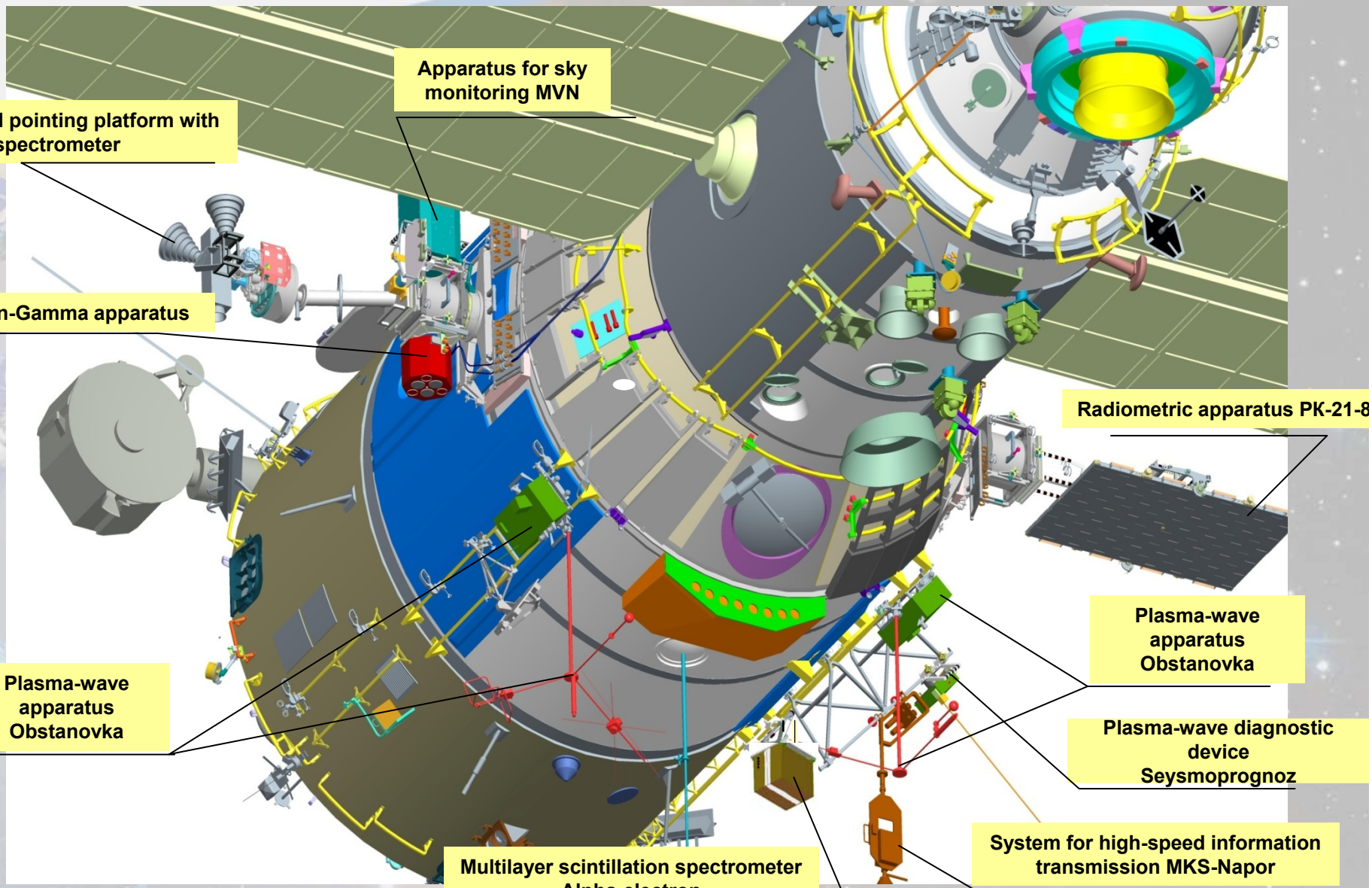
## NSAU

The Program of Scientific & Applied Experiments has been updated in framework agreement between Roscosmos and National Space Agency of Ukraine.

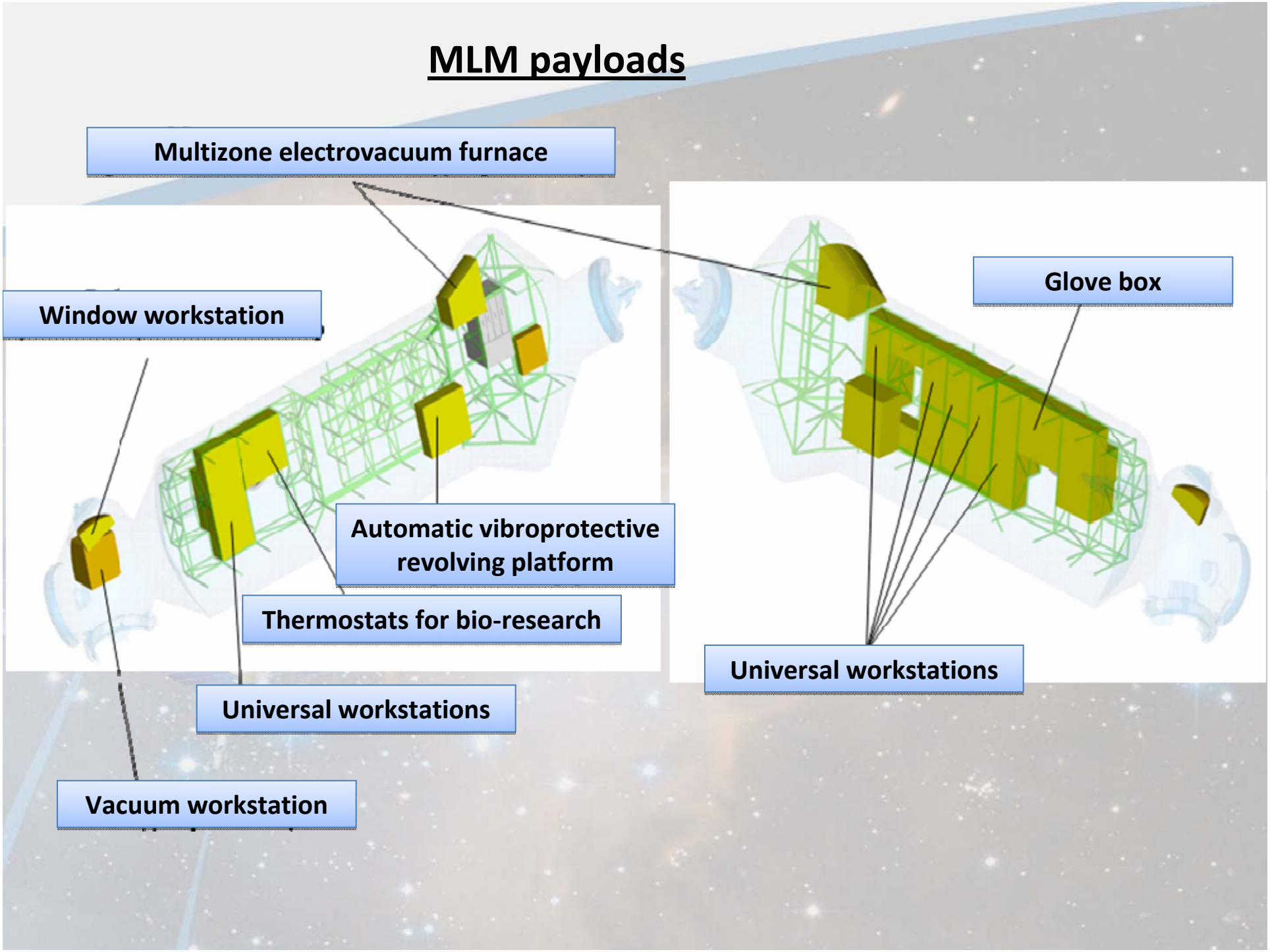
## NASA

Suggestions on possible areas of future scientific collaboration with NASA have been elaborated

# Service module development

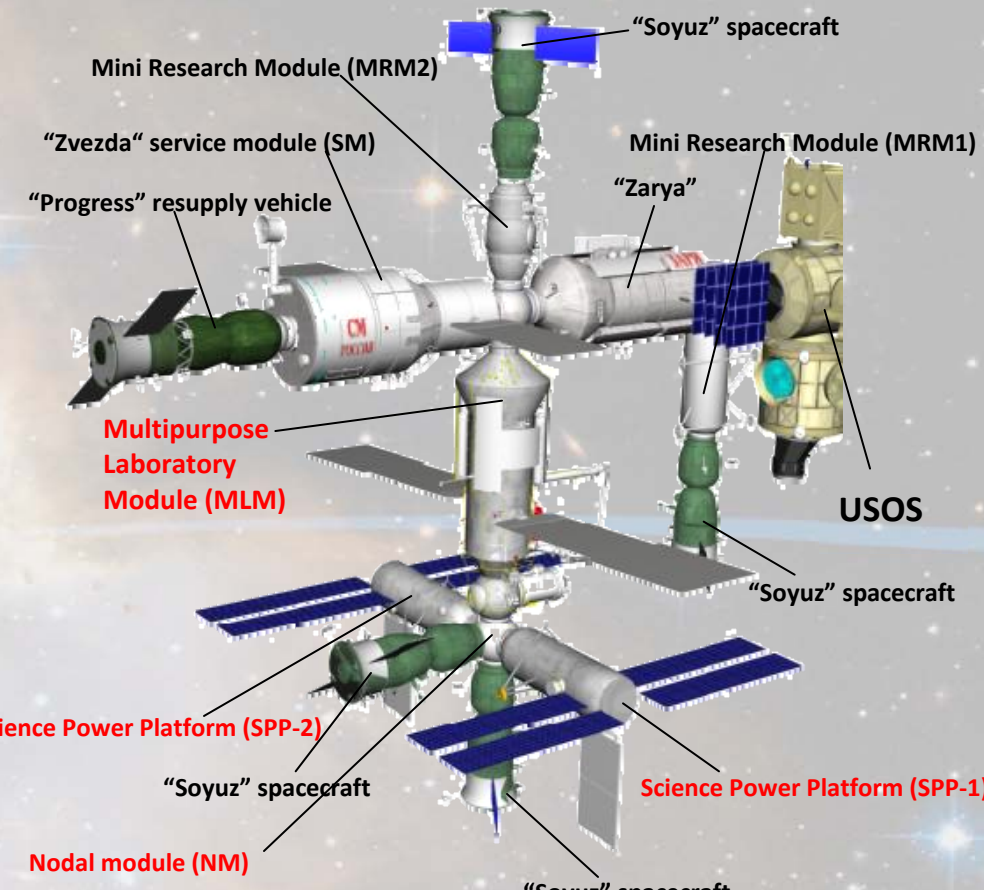


# MLM payloads

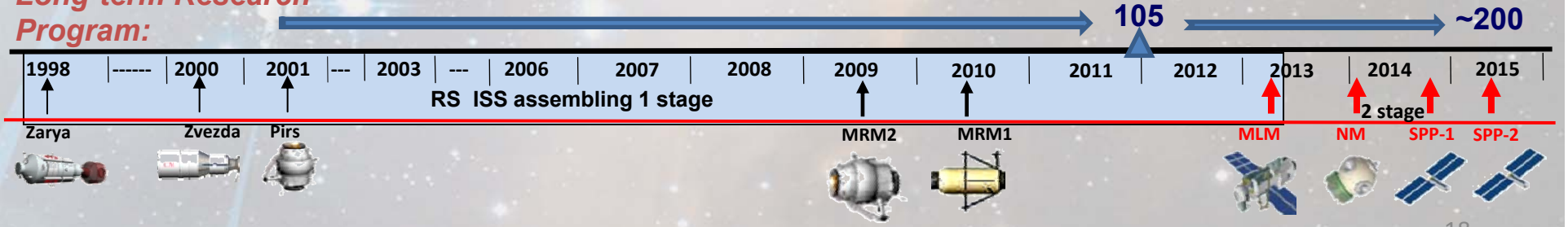


# Future research capabilities of ISS RS

- **MLM will support approximately 40% of the total amount of experiment planned for the ISS RS**
- **Two scientific and power supply modules of about 15 kW each by 2015. This provides fully independent power supply of RS ISS**
- **Data relay system based on «Luch» satellites (up to 300 Mbps).**
- **Starting from 2016 Russia plans also to use for experiments automatic spacecraft "OKA-T" maintained at the periodical docking with ISS.**
- **In total, the plans call for 8 modules of the ISS RS by 2015, with total power capability of 30 kW and about 40 cubic meters of the pressurized volume for scientific payloads.**




***Long-term Research Program:***

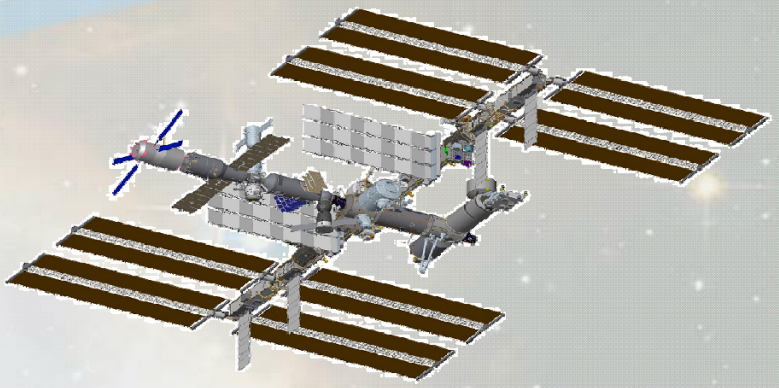


## Main lines of development of ISS RS in next decade:

1. Completion of ISS RS development – increasing of payload facilities in ISS RS (new modules and scientific equipment).
2. ISS RS utilization for:
   - Basic research (biology, astrophysics, geophysics, fluid physics and materials in microgravity, etc.);
   - Development of new technologies for space production of ultrapure substances, bioproducts and medicine onboard the ISS RS;
   - Development of methods and tools for disease prevention, diagnostics and medical treatment;
   - Development of facilities for future manned orbital and interplanetary missions (life support systems improvement, large-size structures assembling, inflatable and solidified structures, satellites maintaining etc.);
   - Developments of methods and facilities for study of natural recourses and Earth remote sensing for different customers.
3. Development of new logistic facilities including manned spacecraft of new generation taking into account future interplanetary missions and space exploration.
4. Unique ISS experience is the basis for further international cooperation in space research and exploration. Roscosmos suggests to develop the joint programs of such investigations.

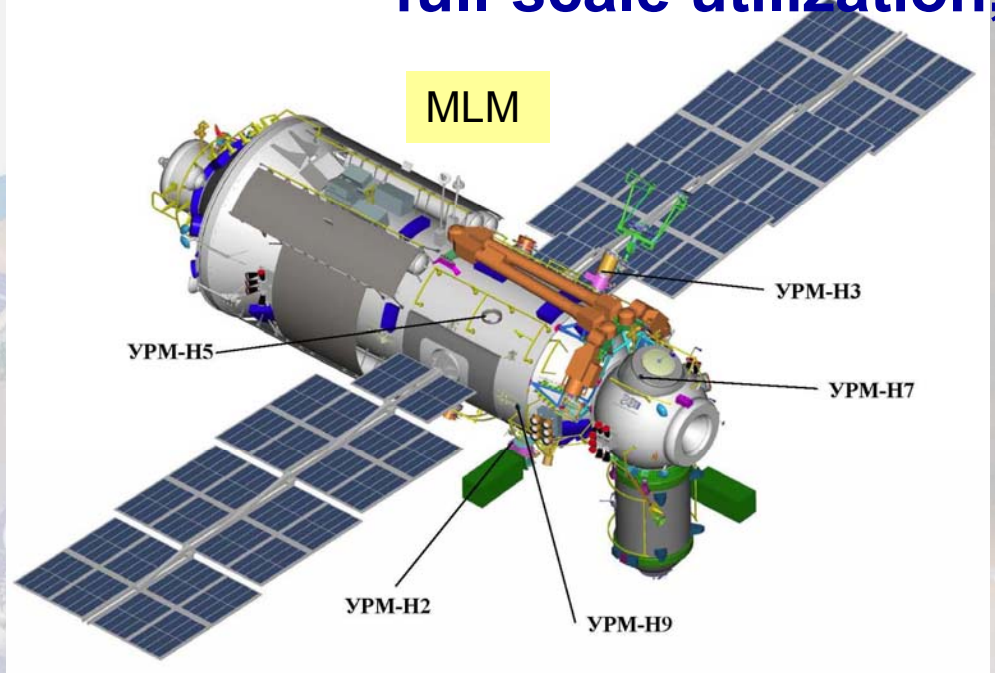
# Conclusions

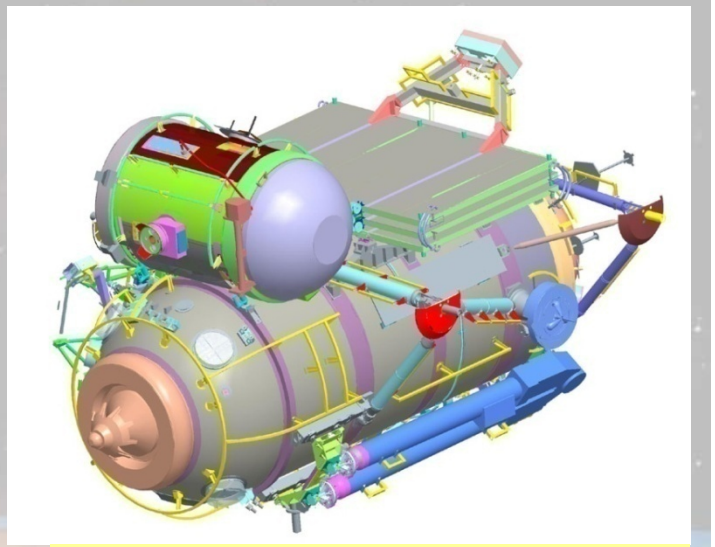
- International space station as a unique space laboratory for basic and applied researches has become a symbol of intellectual potential of humanity.
- Fully utilizing of the ISS upon the assembling completion will give us many new exciting results.
- We have already promising outcomes from the ISS utilization now and we'll see many benefits in future both for Earth needs and further space exploration (Lunar and Martian programs).
- It is necessary to facilitate for the researchers the access onboard the ISS to conduct the dedicated experiments in this unique space laboratory.
- There are promising opportunities on the basis of mutual interests for cooperation of scientists over the world to improve the efficiency of research programs and use of the ISS resources. Some joint experiments are already conducted, the others are preparing to run.



# Thank you for attention!

# Completion of the ISS development – beginning of full-scale utilization, 2011-2014



Mini Research Module (MRM1)

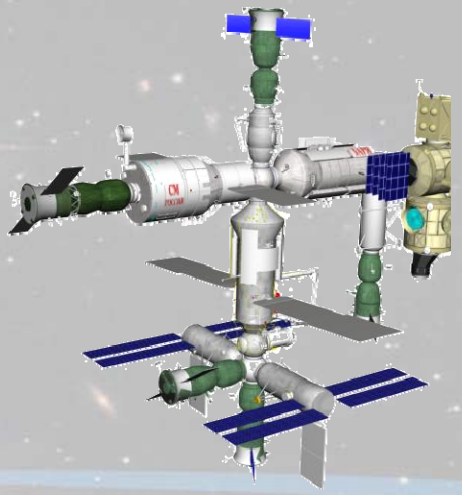
- Universal workstations inside (16) and outside (13) will be mounted (see some of them in the figure above)
- payload pressurized volume about 8 $м^3$, power capability of 2,5 kW (enabling of experiments with electric furnaces)
- ERA arm and automated airlock
- New universal facilities and tools (multizone furnace, spectrophotometer, vibroprotecting and pointing platforms, glove box, thermostats etc.)

Mini Research Module (MRM2)

# Completion of the ISS development – beginning of full-scale utilization

***Russian segment***

***2010 год*** ***2015 год***



**Российские космические эксперименты ведутся в рамках «Долгосрочной программы научно-прикладных исследований и экспериментов на РС МКС»**

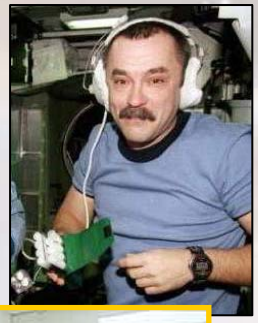
Управление Программой

**Координационный научно-технический совет**

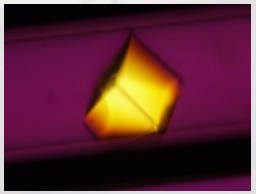
**(КНТС Роскосмоса)** – орган, работающий на основе **тесного сотрудничества Роскосмоса и Российской академии наук.**

# Российские космические эксперименты

## Прикладные научные исследования



Высотная гроза в УФ диапазоне

Кристалл белка

- Медицина («Сонокард», «Дыхание», «Пневмокард» и др.)
- Биотехнология («Астровакцина», «Женьшень-2», «Биоэмульсия» и др.)
- Наблюдение за земной поверхностью, атмосферой и океаном («Русалка», «Сейнер», «Релаксация», «Молния-Гамма»)

# Российские космические эксперименты

## Эксперименты в обеспечение будущего освоения человеком Солнечной системы



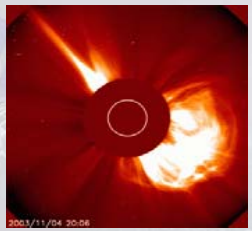


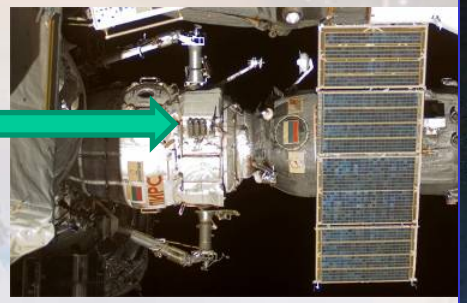


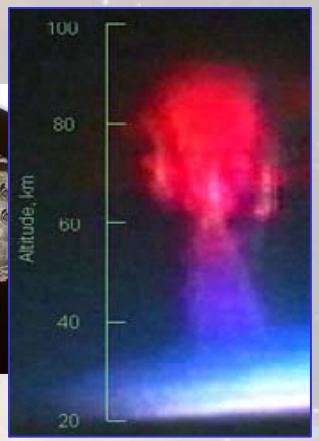
- Человек в космосе («Пилот», «Типология», «БИМС» и др.)
- Радиационная обстановка («Брадоз», «Матрёшка-Р»)
- Жизнеобеспечение («Бар», «Ветерок»)
- Технологии («СВС», «Контур»)
- Образовательные («МАИ-75», «РадиоСкаф», «Тень-Маяк»)

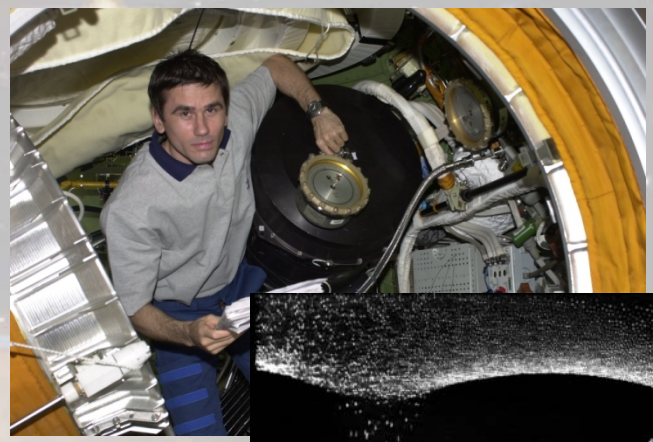
# Areas of the research results implementation

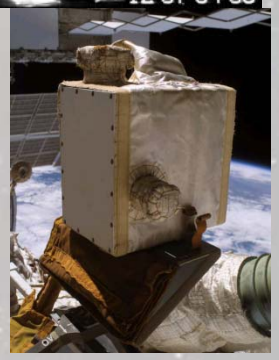
## Фундаментальные научные исследования







- Физика гравитационно-чувствительных явлений («Плазменный кристалл», «Изгиб», «Кулоновский кристалл»)
- Экзобиология («Биориск-МСН»)
- Космические лучи («Платан»,«БТН-Нейтрон»)
- Солнечно-земные связи и геофизика («Всплеск», «Импульс»)