NUCLEAR RESEARCH AT INP-ALMATY:

Science, Technology, Safety, Security, Cooperation

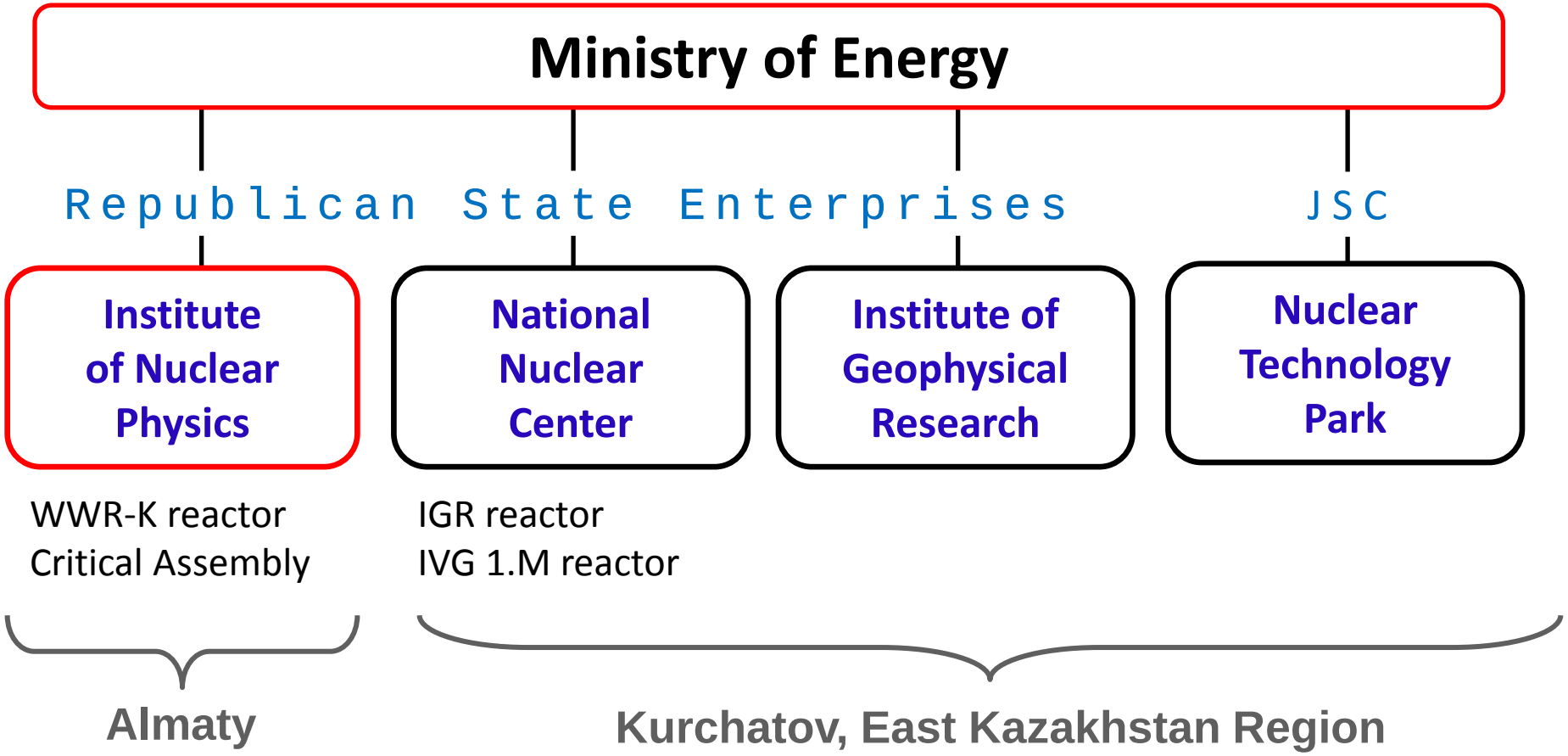
9th APCTP-BLTP JINR
Joint Workshop
at Kazakhstan
Almaty, June 27 – July 4, 2015

Petr Chakrov
Institute of Nuclear Physics
Almaty, Kazakhstan

INSTITUTE OF NUCLEAR PHYSICS

in nuclear research infrastructure of Kazakhstan

2015



INSTITUTE OF NUCLEAR PHYSICS (INP)

Established in 1957

Staff: 650, including
70+ doctors and candidates of science

MAIN SITE:

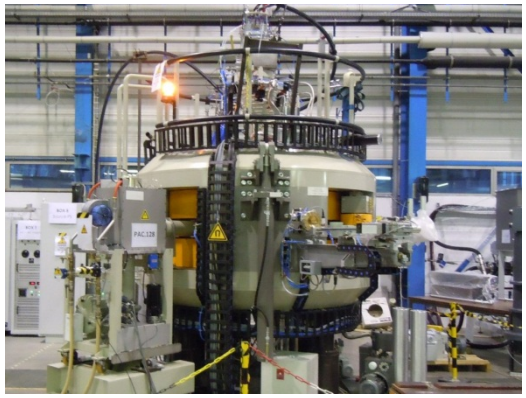
- **Alatau, 20 km far from Almaty**

BRANCHES:

- **Astana**
- **Aksay**
- **Azgir**

INP BASIC FACILITIES

- **Research Reactor WWR-K**
- **Critical Assembly**
- **Cyclotron U-150M**
- **Linear Tandem Accelerator UKP-2-1**
- **Heavy Ion Cyclotron DC-60**
- **Electron Accelerator ELV-4**
- **Under construction: cyclotron Cyclone-30**



ОРИОН РЕГИСТРАР, Инк., АҚШ
Тіркеу Куәлігі

Қазақстан Республикасы, Алматы қ.,
Ибрагимов 1 көшесінде орналасқан

Қазақстан Республикасының Индустрия және
жаңа технологиялар министрлігінің Атом энергиясы комитетінің
«Ядролық физика институты» шаруашылық жүргізу құқығындағы
республикалық мемлекеттік кәсіпорнының

САПА МЕНЕДЖМЕНТІ ЖҮЙЕСІ

ИСО 9001:2008

*сапа стандарты бойынша ОРИОН РЕГИСТРАР бағалауынан өтіп,
оның талаптарына сәйкес екендігін осы куәлікпен растайды.*

Бұл САПА МЕНЕДЖМЕНТІ ЖҮЙЕСІ келесі жұмыстарға қолданылады:

Ядролық зерттеулер.
Ядролық технологияларды әзірлеу және қолдану.

Тіркеу мерзімі: 27.07.2011 – 26.07.2014
Тіркеу шарты бойынша бұл мекеме өз жүйесін стандарт талаптарына сай және жасалынған өзгертулерге байланысты қамтамасыз етуі тиіс, ал ОРИОН оған тиісті бақылауды жүзеге асырады.
Куәлігінің № 00007-00001. Куәлігі № F0000008-4.
ЕАС кодтары: 35

ANAB ACCREDITED — IAF MEMBER OF MULTILATERAL RECOGNITION ARRANGEMENT

President — 15/08/2013 Date

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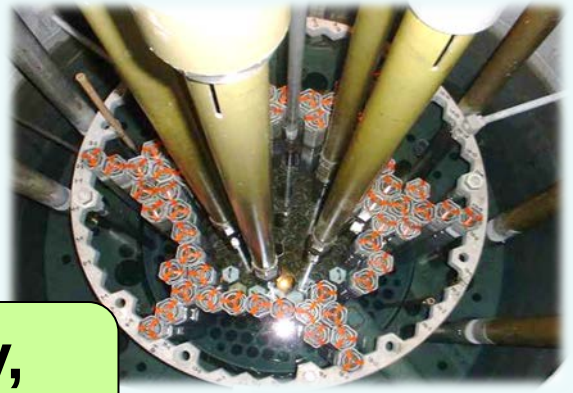
INP ACTIVITIES

- Basic research
- Applied research
- Technology development
- Designing
- Production and Services

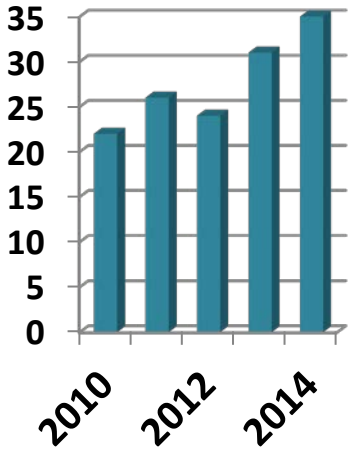
PRIMARY R&D AREAS:

Nuclear Physics

Radiation Physics of Solids



Radioecology, Analytical Techniques

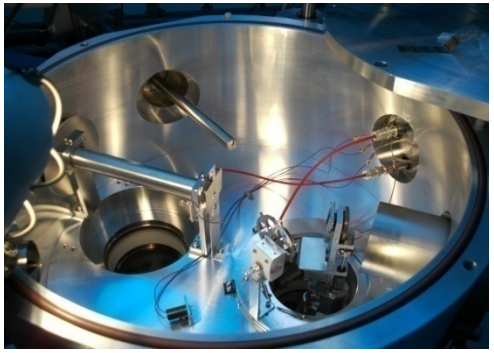


Radiochemistry, Radiopharmaceutics

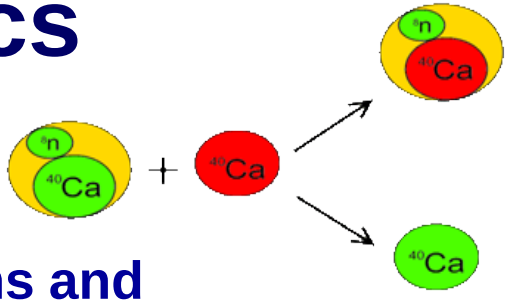
Accelerator Technologies

Reactor Investigations

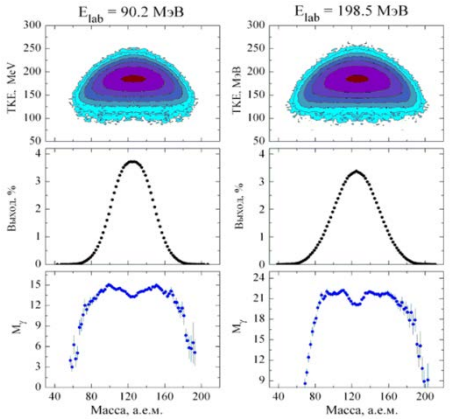
In Kazakhstan,
INP stably keeps high rank
in scientific publications
(the only research institute in top-5)



Nuclear Physics

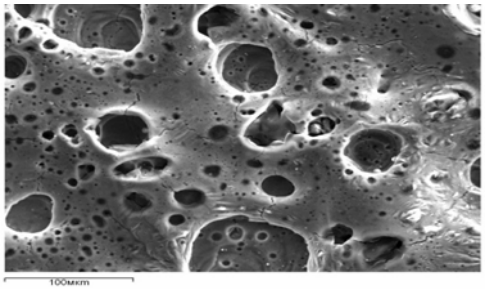


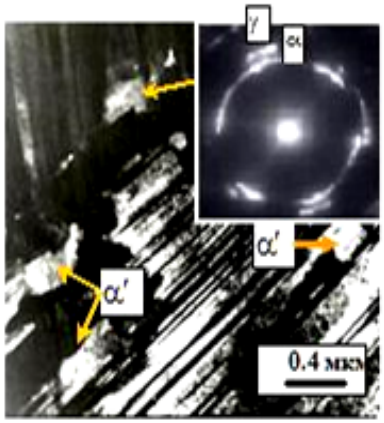
- **Investigations of nuclear reactions mechanisms and structure of light and mean nuclei in range of low and mean energies**
- **Investigations of exchange reactions and radiative capture for astrophysical applications and thermonuclear fusion**
- **Investigations of inclusive cross-sections of nuclear reactions, related to development of accelerator-driven nuclear systems (ADS)**
- **Investigation of trans-uranium elements fission**



Solid state physics

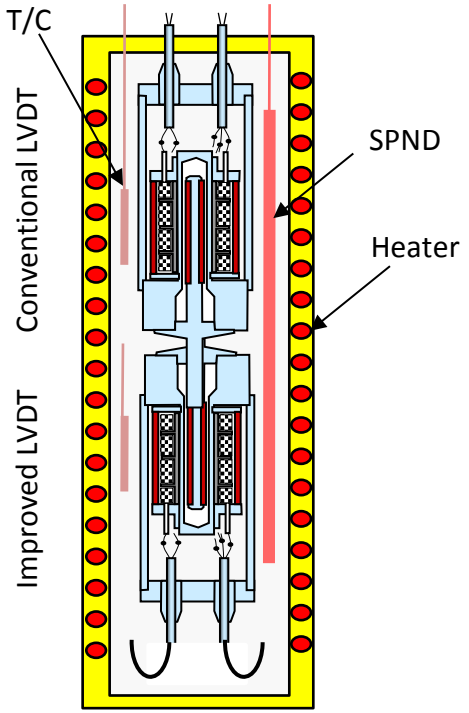
- Radiation physics of solids, computer simulation of radiation effects
- Radiation material science
- Ion beam modification of materials
- Ion-plasma synthesis of exotic alloys, superconductors, semiconductors
- Proton-conducting oxides
- Hyperfine interactions in investigations of surface layers

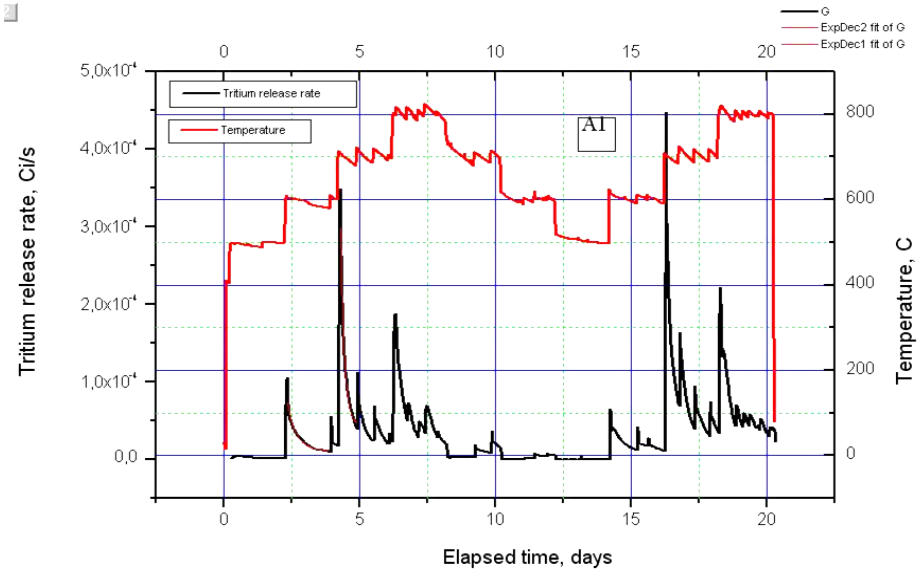




Reactor investigations

- Physics of nuclear reactors
- Nuclear safety
- Irradiation testing of nuclear materials and components
- Reactor technology for medicine and industry





International research projects at WWR-K reactor

- **High-birnup irradiation test of lithium ceramics for fusion reactor blanket**
- **Irradiation tests of differential transformers for fission products pressure gages**
- **Comparative irradiation tests of various grades beryllium**
- **High-burnup tests of HTGR fuel**
- **Irradiation tests of oxidation-resistant graphite**
- **Comparative study of radiation resistance of US and Russian stainless steels**
- **Comparative testing of technologies for medical radioisotopes production developed in Kazakhstan and Japan**
- **Development of technology for neutron transmutation doping of silicon**

Radioecology

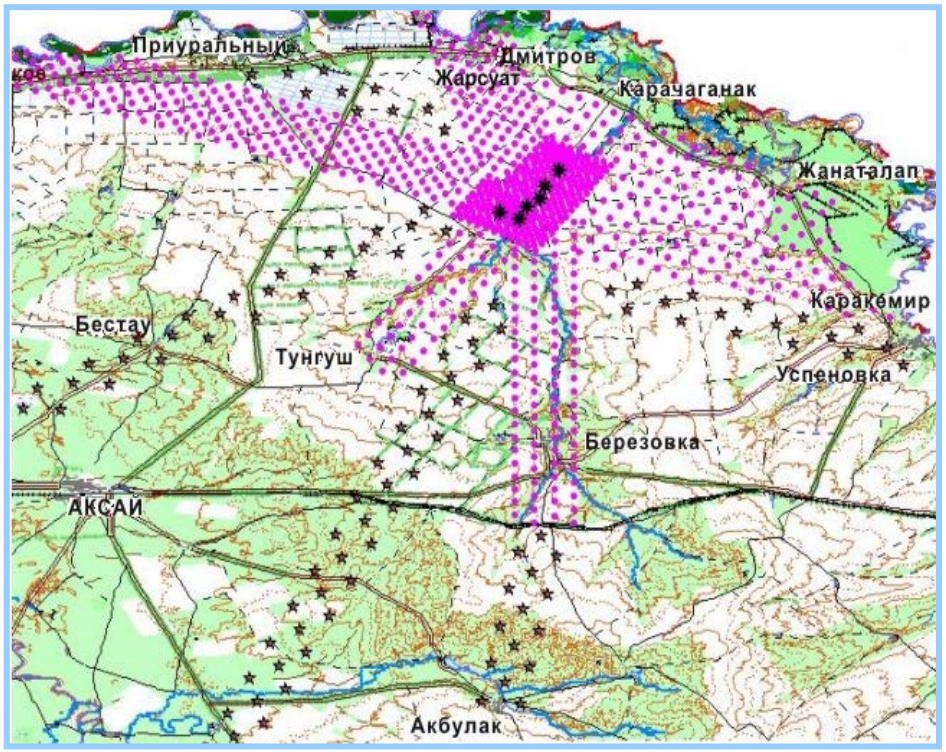
- **Complex radiological investigation of contaminated territories, establishment of radiological monitoring systems**
  - 456 nuclear explosions at Semipalatinsk testing site
  - 32 nuclear explosions at other sites (including 23 at sites currently controlled by INP)
  - BN-350 fast breeder reactor (under decommissioning)
  - 5 research reactors and critical assemblies, 4 operating, 2 in INP
  - Uranium mining and processing
  - Natural radionuclides from extraction of petroleum
- **Radiation and hydrochemical monitoring of the transbondary rivers**
- **INP operates the largest and most capable radionuclide analysis laboratory in the region**
- **Development and application of technologies for cleanup of contaminated territories and equipment**

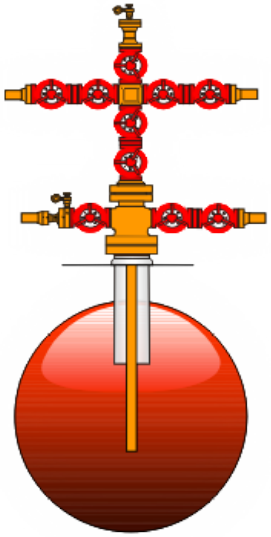
Ensuring of radiation safety of “Lira” facilities at Karachaganak oil-gas-condensate field in West Kazakhstan

*** 6 large cavities created in 1980s by nuclear explosions at a depth of ~1000 m**

*** under INP supervision since 1998 (Aksay branch)**

- investigations and permanent monitoring
- radiation safety control
- equipment maintenance
- decommissioning planning





TECHNOLOGIES FOR INDUSTRY AND MEDICINE

Radioisotopes production and application

Radiation processing and radiation sterilization

Nuclear-physical methods of analysis

RADIOISOTOPE PRODUCTS FOR INDUSTRY

SEALED GAMMA-SOURCES ^{192}Ir, ^{124}Sb, ^{60}Co, ^{204}Tl, ^{109}Cd

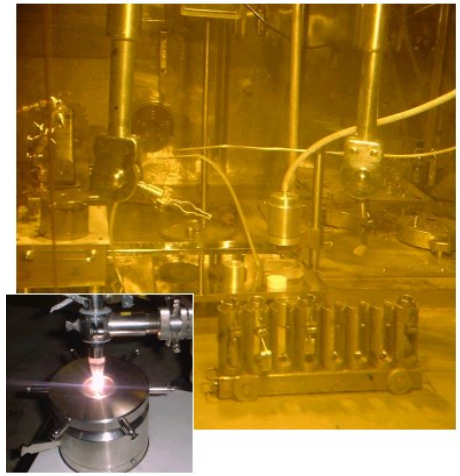
- industrial radiography (NDT)
- control of technological processes (nuclear gages)
- instruments calibration

ISOTOPE MARKERS ^{60}Co

- depth marking during wells logging

BULK-SOLUTIONS ^{57}Co, ^{109}Cd

- export



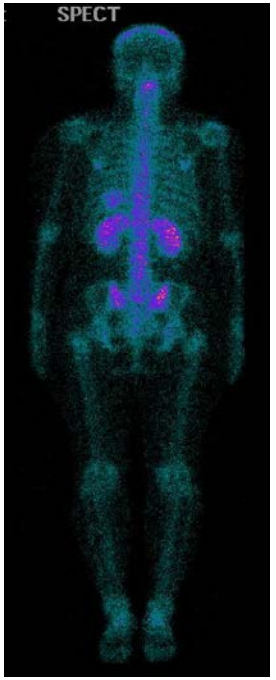
RADIOISOTOPE PRODUCTS FOR MEDICINE

FOR DIAGNOSTICS

- Radiopharmaceuticals with ^{201}Tl, ^{99m}Tc, ^{131}I, ^{67}Ga
- Portable ^{99m}Tc generator
- Diagnostic kits (under trials)
- ^{68}Ge (under development)

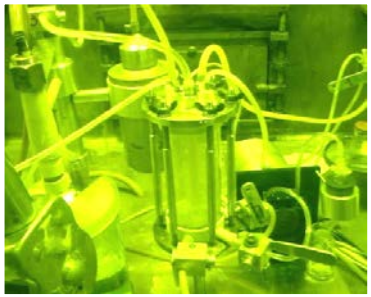
FOR THERAPY

– Radiopharmaceuticals with ^{131}I, ^{153}Sm, ^{177}Lu (pre-clinical and clinical trials)



RADIOISOTOPE TRACERS

– Solutions ^{85}Sr, ^{134}Cs, ^{60}Co, ^{131}I
for ecological and biomedical investigations



SUPPORT OF NUCLEAR MEDICINE DEVELOPMENT IN KAZAKHSTAN

- Supply of radiopharmaceuticals
- Engineering support for establishment of nuclear medicine centers
  - Designing
  - Equipment installation
  - Commissioning
- Maintenance of cyclotrons and radiochemical equipment
- Import, transportation and storage of radioactive sources
- Disposal of radioactive waste
- Staff training and certification in radiation safety

ESTABLISHMENT OF NUCLEAR MEDICINE AND BIOPHYSICS CENTER in the Institute of Nuclear Physics

- New radiopharmaceutical production facility (cyclotron, clean rooms, hot cells)
- Radiation sterilization facility
  → **INP, to be completed in 2015**
- Clinical complex
  → **Ministry of Health**

- **Production of radioisotope products for medicine**
- **Development and testing of new radiopharmaceuticals**
- **Radionuclide diagnostics**
- **Radionuclide therapy**
- **Staff training**

RADIATION TECHNOLOGIES

- **Radiation sterilization**
  - **syringes, bandages, cotton wool, disposable clothing, tissue, catheters, gloves, vials…**
- **Polymerization, radiation cross-linking**
  - **hydrogel dressings for medicine**
- **Ion- track membranes**

ION-TRACK MEMBRANES

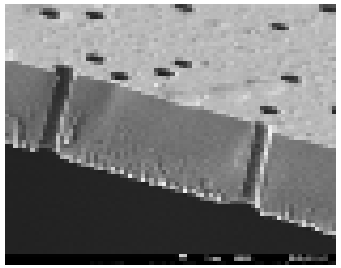
Astana branch of INP

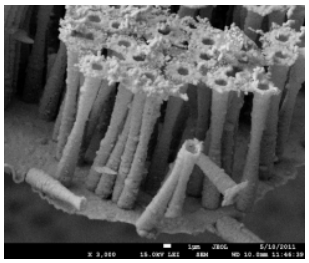
DC-60 HEAVY ION CYCLOTRON, designed and manufactured in JINR, installed in 2006

Irradiation of polymer film by accelerated heavy ions with specified parameters, export sales

Development of purpose-designed membrane filters (water cleanup, medicine, microbiology)

Production of nano-sized metal structures using the track membranes





Growing market
Innovative products
New wide area for R&D

Minimization of highly enriched uranium at INP' WWR-K reactor

- **Repatriation of spent HEU reactor fuel to Russian Federation**
- **Down blending of fresh HEU materials to LEU**
- **Conversion of the research reactor and critical assembly from HEU to LEU fuel**
- **Development of non-HEU radioisotope production**

Repatriation of spent HEU reactor fuel

Phase 1: 2008 – 2009

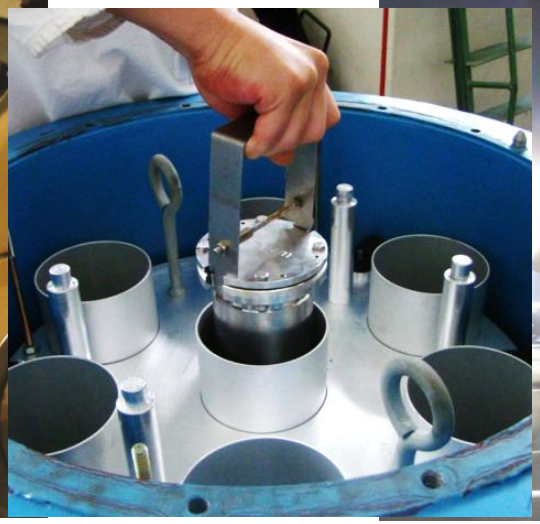
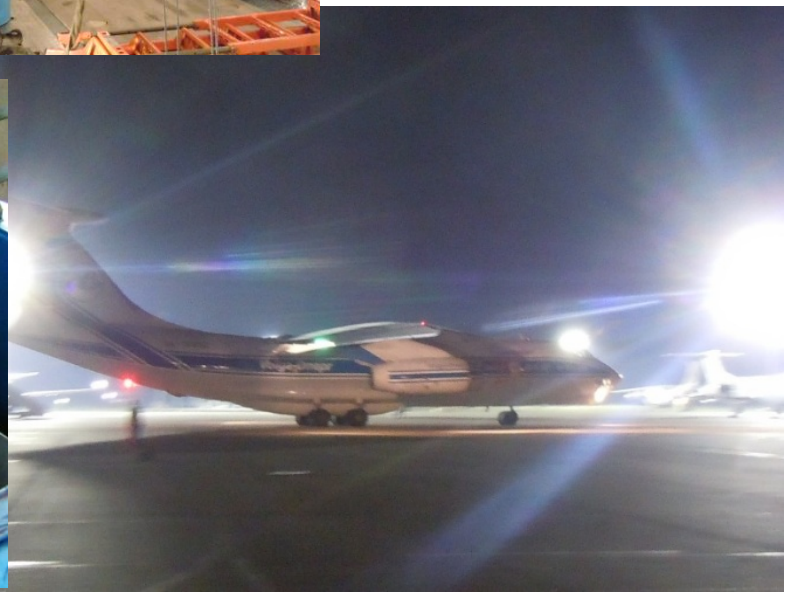
Phase 2: 2014

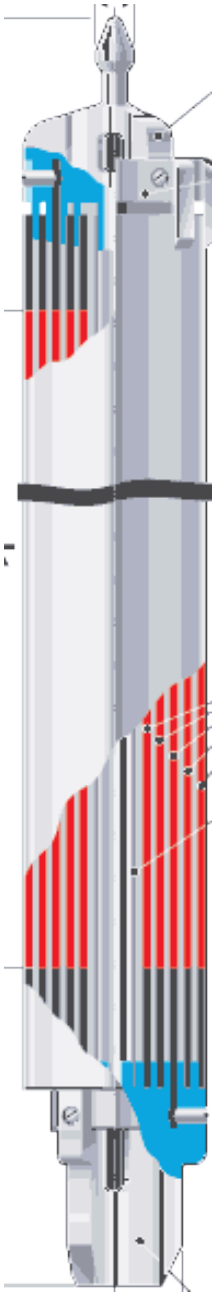
Phase 3: 2017

Down blending of bulk HEU to LEU

- Shipment of HEU material from INP to Ulba plant (East Kazakhstan)
- Down blending at Ulba plant, LEU return to INP

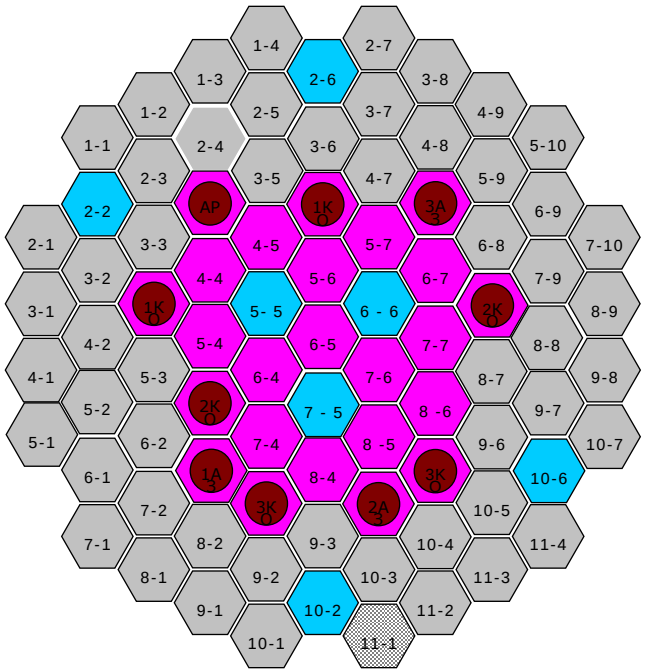




WWR-K reactor conversion to LEU fuel

U-235
36%



U-235
19.7%

5-tube fuel assemblies

UAl_4–Al

Water reflector

$1 \cdot 10^{14}$ n/(cm^{2}s)

8-tube fuel assemblies

UO_2–Al

Beryllium reflector

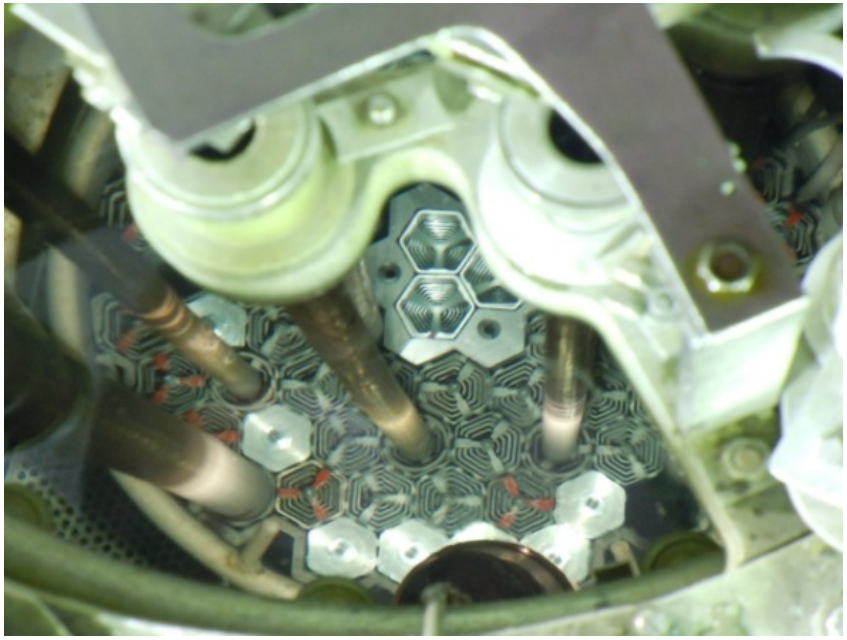
$2 \cdot 10^{14}$ n/(cm^{2}s)

WWR-K reactor conversion to LEU fuel

Irradiation trial of 3 LEU lead test assemblies in WWR-K reactor was performed in 2011-2013, post-irradiation examinations in 2014

Modification of reactor systems will start in August, 2015

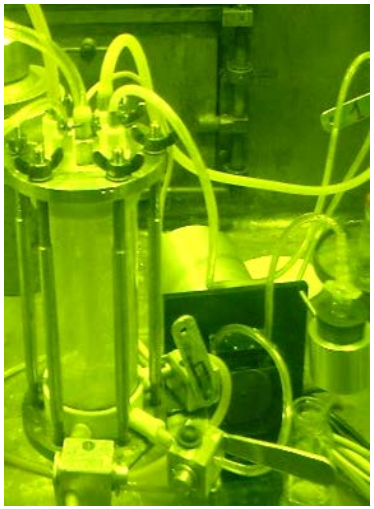
Conversion is to be completed early in 2016



The same LEU fuel is used for conversion of the Critical Assembly at INP

Development of non-HEU $^{99}Mo/^{99m}Tc$ production

- Natural Mo (n,γ) ^{99}Mo 1,1 Ci/g
- No processing of irradiated Uranium
- Central “Gel”-generator since 2001
- Portable “Gel”-generator since 2011
  (1 Ci/generator at the end of production)
- Proven pharmaceutical quality
- New generator production GMP facility to be completed in 2015



2001 2011 2015

Establishment of Nuclear Security Training Center at INP

to train personnel of nuclear organizations and state authorities in

- **Physical protection of nuclear facilities and nuclear materials**
- **Control and accounting of nuclear materials**
- **Counter nuclear smuggling**

2015 status:

- **Detailed architectural/engineering design is under state review**
- **Development of training curriculum**
- **Pilot courses already started**

INP international collaboration

- **R&D:**
  - **Basic nuclear physics**
  - **Material science**
  - **Radioecology**
  - **Radioisotopes**
  - **Ion-track membranes**
- **HEU minimization, conversion to LEU**
- **Nuclear Security**
- **Education and Training**

- **Research institutions in CIS, Europe and Japan**
- **US national laboratories and universities**
- **International Atomic Energy Agency**
- **Joint Institute of Nuclear Research (Dubna)**
- **International Science and Technology Center**
- **Forum for Nuclear Cooperation in Asia**
- **APCTP !**

Thanks for your attention

and have a great week in Almaty!