



**ROSATOM**

STATE ATOMIC ENERGY CORPORATION

## **Solutions and capabilities of State Corporation «Rosatom» for construction of centers of irradiation for processing industrial and agricultural products. Prospects of technologies development**

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# Radiation processing in the world

## Europe:

~ 40 centers of irradiation

Austria, Belgium, Bulgaria, Croatia, Germany, Greece, Hungary, Ireland, Italy, Portugal, Romania, Serbia, Montenegro, Sweden, Switzerland, Netherlands, United Kingdom

## Russian Federation and CIS countries:

8 centers of irradiation

## North America:

~ 50 centers of irradiation  
USA, Canada

## South America

~ 15 centers of irradiation  
Argentina, Brazil, Chile, Mexico, Peru, Colombia, Venezuela, Cuba, Colombia

## East, South and Southeast Asia, Oceania:

~ 60 centers of irradiation  
China, Vietnam, Thailand, India, Bangladesh, Pakistan, Indonesia, Japan, Korea, Taiwan

## Africa and Middle East:

~ 11 centers of irradiation

Egypt, Ghana, South Africa, Iran, Israel, Jordan, Saudi Arabia, Syria, Turkey

**There are more than 108 centers of irradiation in 47 countries irradiating food products**

60 countries allow consumption of irradiated products

# Main applications of radiation technologies in a production sector

## Multipurpose centers of irradiation



### Sterilization and decontamination of:

- medical goods
- implants and transplants
- blood and its components

### Decontamination of:

- food products
- canned products
- agricultural products
- pet food

### Sterilization and decontamination of:

- pharmaceutical products and components
- hygiene products and perfumery
- biologically active supplements

## Chemistry and Biotechnology



### Applications in chemical industry:

- cracking of oil
- production of biofuel
- production of composite materials
- modification of polymers and polymeric products

### Biotechnologies – applications in agriculture:

- speeding up the slowly ongoing processes in the food industry
- increasing the yield and speeding up the planting

## Ecology and other applications



- water treatment, waste water purification of plants and factories
- gas purification and smoke extraction
- disinfection of medical waste
- non-destructive testing – Industrial radiography

### Disinfestation:

- crops
- processing of books

**Stable market growth of products where the radiation technologies** can be applied (microbiological requirements grow accordingly)

**The widespread use** of radiation technologies in the EU

# Technical solutions for the application of radiation processing

## Linear accelerator

A linear accelerator that generates a beam of electrons with scanners placed in a protective unit

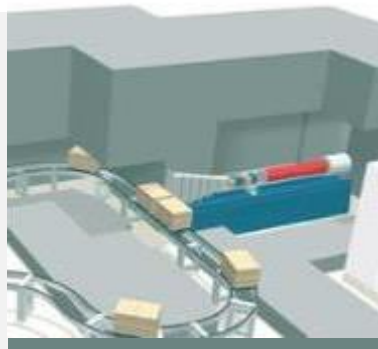
**Advantages:** high performance, ease of process control and safety of use, no need for recycling and recharging the sources of ionizing radiation (Co-60), low capital and operating costs

To ensure the high penetrating power of radiation it is possible to use a converter to convert the electron beam to bremsstrahlung (with energies up to 5 MeV)

**Specialization:** Sterilization of medical goods and pharmaceuticals, modification of polymers, processing of spices and grain

### The main parameters used in linear accelerators:

- energy of electrons from 5 up to 10 MeV
- Electron beam power 10–20 kW



## Gamma facility

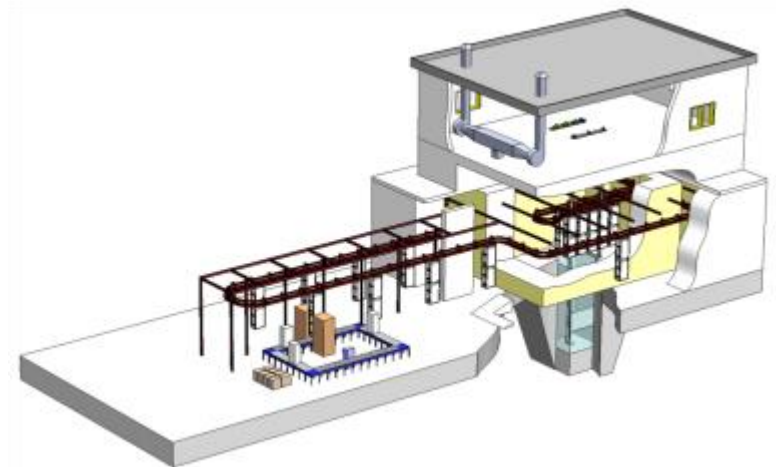
Radiation facility using the radionuclide sources of ionizing radiation (Co-60)

### The main parameters:

- Minimum and maximum capacity of the radiator— 500 kCi - 3000 kCi

**Advantages:** high penetration of  $\gamma$ -irradiation, a wide range of irradiation doses, multifunctionality

**Specialization:** decontamination of food products; disinfestation of grain, sterilization of medical goods and pharmaceuticals



# Radiation sterilization of medical goods

**The market share of the sterilization market in the world is 50-60%**

At that, both technologies are used: gamma ionizing radiation and linear accelerators with applicable radiation doses 15-25 kGy.

**Radiation sterilization** is carried out under the ionizing radiation effect. A complete biological inactivation of the bacteria contained in the product comes under the ionizing radiation effect, with no residual radioactivity

- Almost all disposable medical goods are exposed to sterilization — more than 250 types
- Sterilization ensures destruction of vegetative and spore forms of pathogenic and non-pathogenic microorganisms within the material making it clinically safe
- Non-sterile medical products could lead to infection and death of the patient. All medical products that come into contact with damaged human tissues should be exposed to sterilization

## **The advantages of radiation sterilization over other methods:**

- High degree of microbial inactivation
- High performance and speed of processing
- Safety of the radiation process
- Product safety (no risk of hazardous substances in products)
- Possibility of use of the products immediately after irradiation
- Sterilization of products in transport packing



# Radiation processing of food products

Preservation of products is the most important task of the food industry. World statistics shows that each year between 20% and 45% of the collected food raw materials is lost

## Purpose of processing:

- Reducing the risk of intestinal diseases and infectious diseases transmitted through food
- Reducing the risk of toxicities in the food products by stop using preservatives
- Increasing the shelf life of food products

Food irradiation is permitted in more than 40 countries, including the US and EU countries. The largest volumes of irradiated food in the EU are in the Netherlands, Belgium and France.

## Dispelling the myth about the danger of radiation:

### Radiation:

- does not make the product radioactive
- does not reduce their nutritional value
- does not change their organoleptic qualities and products appearance

**To date, international researches** have not established any visible changes of food after irradiation with the doses permitted by the IAEA, FAO and WHO



**RADURA** – sign for marking the products being irradiated

# Radiation processing of agricultural products

## Problem

### Storage pests in warehouses and silos:

- reduce seed germination
- contaminate grain and grain products
- reduce their weight
- worsen the quality of food

### Losses of grain products, cereals and flour because of storage pests are:

- at least 10-15% in the first months of storage
- up to 40% in the following months

## Current non-radiation techniques: for disinfestation of agricultural products

- mechanical: cooling, heat treatment
- chemical: fumigation, spray, wet, wet and gas pest control

### Disadvantages:

- lack of efficiency
- high probability of a need to reprocess, which increases the processing costs
- risk of exposure of chemicals on humans



## Radiation processing

- causes immediate sexual sterilization of insects and significantly reduces their life expectancy
- slows down the development of the secondary population due to the presence of sterile individuals
- allows to reduce the contamination of products in 5 times
- allows to reduce losses by 3-5% per year (based on the assumption that the annual grain losses during storage are 10-15%)
- provides rapid and uniform processing of large batches
- is an environmentally friendly technology



*electron beam in  
the irradiation  
chamber for grain  
processing*

**The efficiency and safety of irradiation process is confirmed by many years of experience (1980-2007).**

As the example - the practical use of technology on the silos at the Odessa seaport

# Radiation modification of polymers



**Radiation cross-linking of polymers** is a binding of macromolecules into the three-dimensional network by cross-linking under the influence of ionizing radiation

## **Main application:**

- vulcanization of natural and synthetic rubber (tire industry)
- cross-linking of thermoplastics



**Radiation modification of tires and its components**

## **Processing components:**

- innerliner
- rubberized cord
- cover rubber

## **Effect:**

- improvement of tires performance - increases the strength of the rubber, decreases the thickness of the rubber components
- reducing the rejected products

**Cross-linking of thermoplastics**

## **Main application:**

- cable insulation
- heat-shrinkable products: films, tapes, tubes, etc.

**The advantages of radiation crosslinking of thermoplastics over alternative technologies:**

- crosslinking comes in the finished shaped object
- does not require the use of chemical additives, irradiation process therefore is ecologically safe
- It enables to retreat the cross-linked polymers



# Other applications of radiation technologies

## Radiation processing of cosmetic products



- It is used for processing of finished products and raw materials for the production of cosmetics
- It saves the marketable condition of products (consistency, color, smell)
- It minimizes the use of harmful preservatives

## Radiation processing of herbs



- It allows (due to low temperature and speed of the irradiation process) to preserve the quality of herbs
- It allows to process the product without exposing it to elevated temperatures, water or solvents
- It reduces the risk of intestinal diseases and infectious diseases, (infectious agents may be present on medicinal herbs)

## Radiation processing of products to be put on a long-term storage



- Strategic reserves (leather, textiles, food)
- Archival documents, museum exhibits
- The method provides a long-term preservation of the products, hence it can effectively fight against insects and mold

## Radiation of pet food



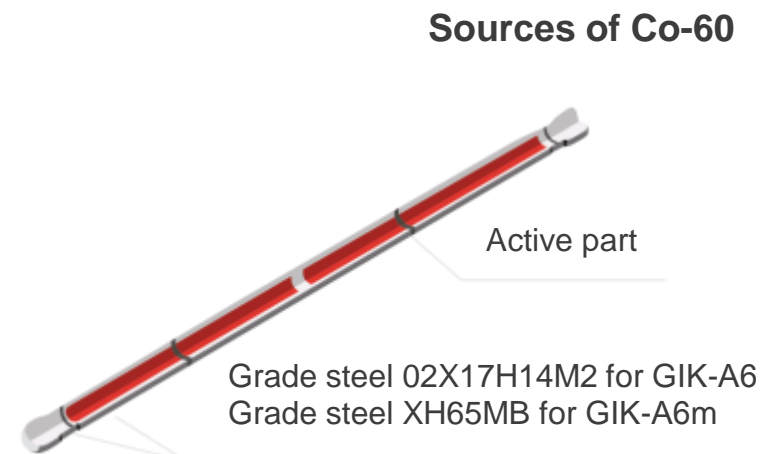
- It reduces the microbiological bacteria content and disinfestation
- It helps reduce the risk of infectious animal diseases
- It provides an increase in the shelf life of the finished product

# Competences of State Corporation «Rosatom»



**Enterprises of State Corporation «Rosatom» have all the necessary competencies to provide with a turnkey solutions in accordance with international quality standards and can provide:**

- Production and supply of radiation equipment, designing and engineering, construction, commissioning and maintenance of centers of irradiation based on both technologies: gamma ionizing radiation (Co-60) and linear accelerators
- Stable and safe delivery of ionizing radiation sources (Co-60), produced by one of the leading producers of radioactive isotopes in the world - Federal State Unitary Enterprise «MAYAK»
- Education and training of the center of irradiation personnel



# The implemented project «Center of irradiation «Sterion» in Russia



## Example of the irradiation process of medical products at the center of irradiation «Sterion» in Russia

### Delivery of products

- Delivery of products to the storage warehouse
- Input control of products in accordance with the requirements of the irradiation process

### Processing of goods in the center of irradiation

- The automated process of loading the products onto a conveyor
- Transporting products to the radiation processing area
- Automated unloading of products

### Storage and handling of products

- Transporting the products to the short- and long-term storage warehouses
- Dispatching the products from the storage warehouses

# Cooperation with «United Corporation for Innovations»

## «Rosatom»

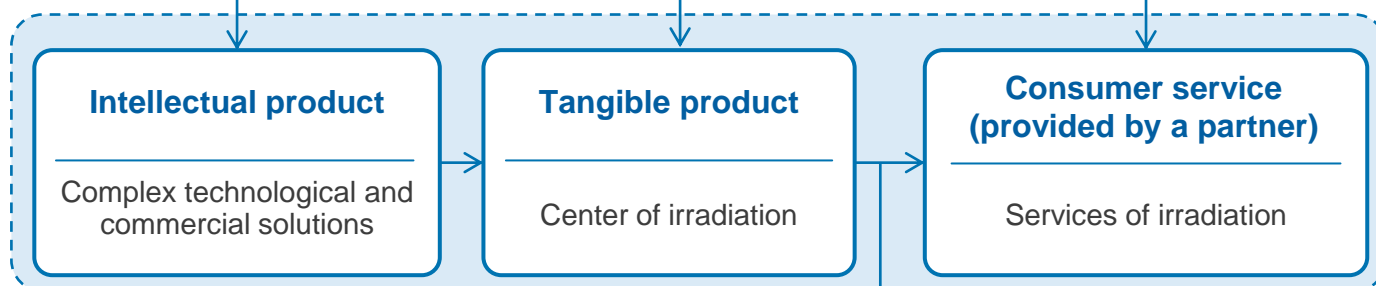
- Equipment by JSC «NII-EFA» and JSC «NIITFA»
- Co-60 by FSUE «MAYAK»
- Project engineering
- Construction
- ...
- Other products and services

## Key roles of «United Corporation for Innovations»

- System integrator of State Corporation «Rosatom» products
- Project management company
- Business developer

## Key functions of «United Corporation for Innovations»

- An analysis of existing demand and future needs on the market
- Development of competitive technological solutions on the basis of existing and developing products and technologies in the State Corporation «Rosatom»
- Developing a business model project
- Attracting project financing
- Engineering
- Development and implementation of the project for construction of Center of irradiation



- Standard project of center of irradiation
- Tried and true technologies for processing various products
- Tried and true business processes at center of irradiation

- Management of the center of irradiation project: engineering, supply of equipment, installation, commissioning, guarantee maintenance, supply of expendable materials

- Providing the services to end customers in different market segments

**Sale of a turnkey project to a company**

## Customers

- Producers of medical products
- Medical providers
- Producers of agricultural products
- Producers of food products

cash flow

# Competences of «Scientific Research Institute of Technical Physics and Automation» and «D.V.Efremov Institute of Electrophysical Apparatus»

## The main technological enterprises of State Corporation «Rosatom» in the field of radiation technologies application



### Joint Stock Company «D.V.Efremov Institute of Electrophysical Apparatus»

Production of E-beam accelerators:

- UELV-3-3 (USA, 2006)
- UELR-3-1 (Russia, 2007)
- LUER-5-1 (Slovakia, 2007)
- LUER-10-10 (South Korea, 2008; China, 2010)
- LUER-8-6 (Uzbekistan, 2010)
- UELR-10-10 (Vietnam, 2010)
- UELR-10-10 (Russia, 2008, 2012 and 2013)
- LUE-10-10 (Russia, 2015)



### Joint Stock Company «Scientific Research Institute of Technical Physics and Automation»

Production of radiation technological equipment, including:

- Transport system - suspended pusher conveyor with retractable devices (suspensions)
- A two-level automatic control system comprising of:
  - cabinet unit of power automation (lower level)
  - cabinet unit if programmable logic controllers (lower level)
  - workstation (upper level)
- Security and video control systems
- Supervising installation, adjustments, dosimeter test, commissioning

Supplied to: Vietnam; Cuba; Syria; Portugal; Bangladesh, Peru,