

# BINP industrial e- accelerators and their application

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# BINP in general

- High energy physics and  $e^+e^-$  colliders
- Accelerator physics and technology
- Thermonuclear research
- Theoretical physics

## Basic research

- Synchrotron radiation and FEL
- Industrial accelerators
- Physics for medical application
- Accelerator mass spectrometer

## Applied research

Total staff of BINP is ~2700:

- Scientists ~ 500
- Engineers ~ 400
- Laboratory technicians ~ 400
- Workshop personnel ~ 1000
- Administration ~ 200
- Support personnel ~ 200

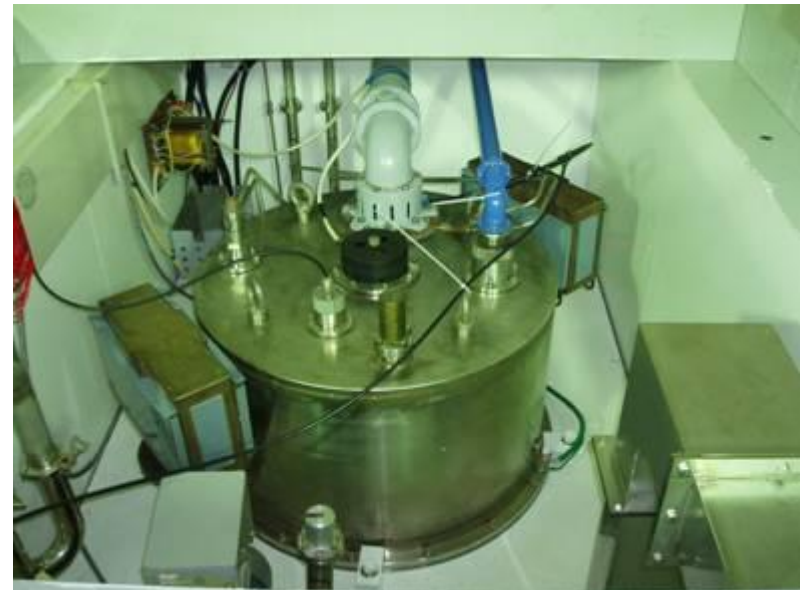
# Industrial accelerators

- RF-type ILU accelerators cover the energy range from 0.8 to 10 MeV with the beam power is up to 100 kW.
- DC-type ELV accelerators have the energy up to 2.5 MeV and power up to 500 kW.



ELV accelerator

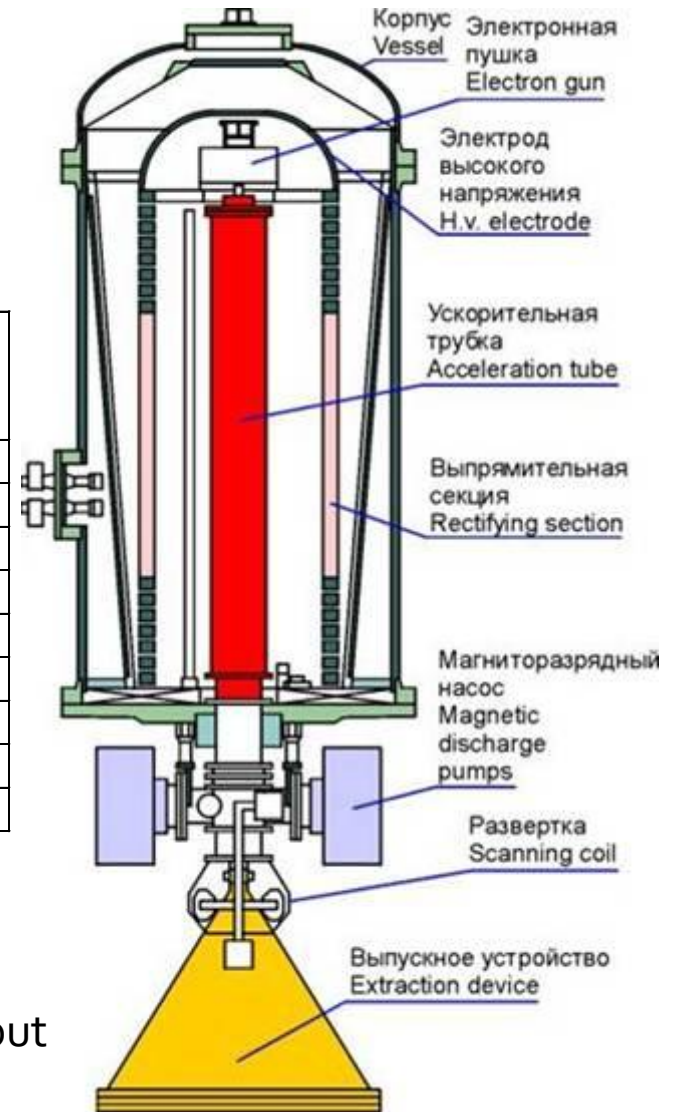
ILU accelerator



# ELV accelerator

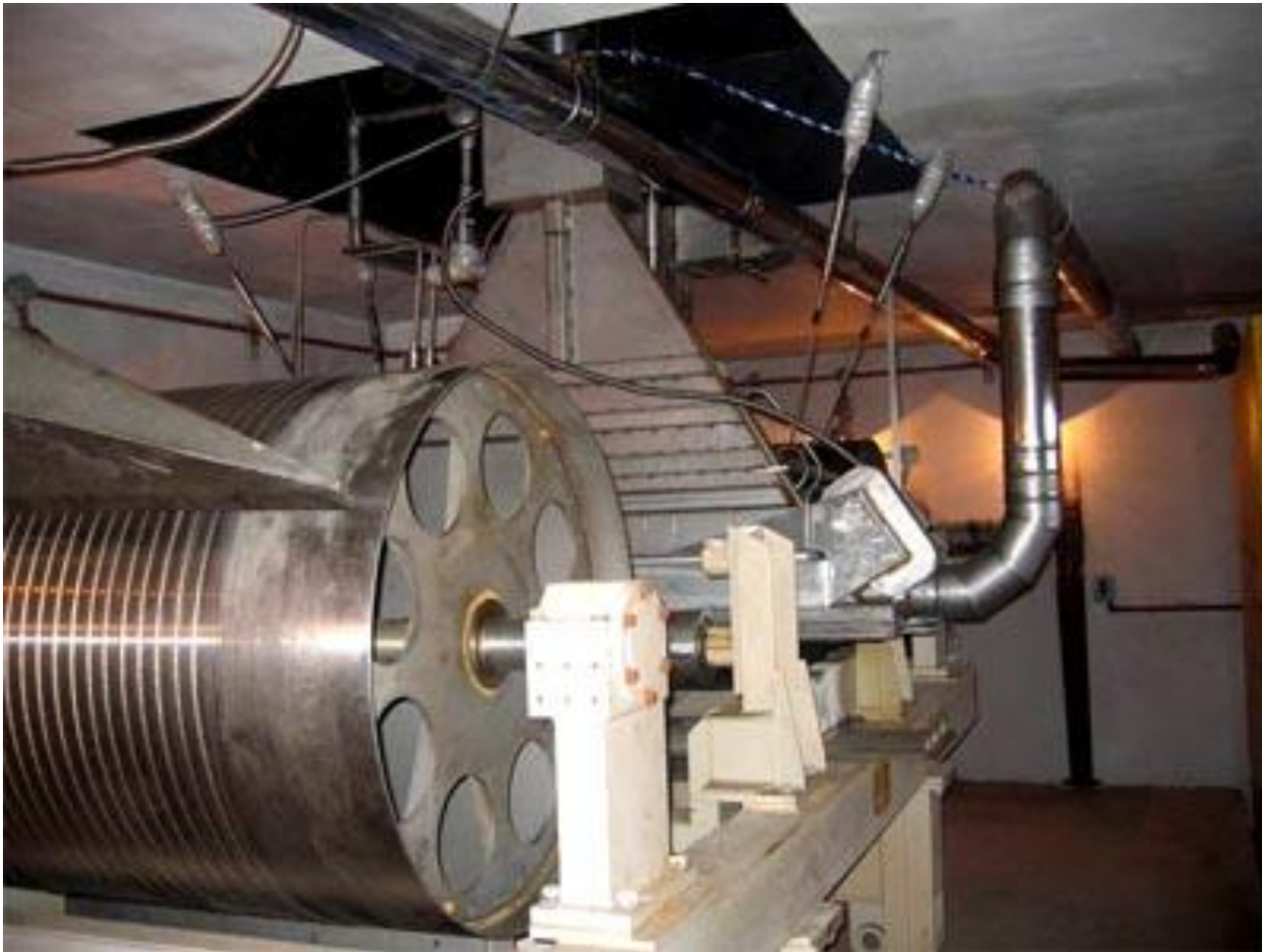
## Main parameters

	Energy range, MeV	Beam power, kW	Maximum beam current, mA
ELV-0.5	0.4-0.7	25	50
ELV-1	0.4-0.8	25	50
ELV-2	0.8-1.5	20	25
ELV-3	0.5-0.7	50	100
ELV-4	1.0-1.5	100	100
ELV-6	0.8-1.2	100	100
ELV-6M	0.75-0.95	160	200
ELV-8	1.0-2.5	100	50
ELV-12	0.6-1.0	400	500



Schematic layout

# Cable and wire treatment



ELV-8 beam extraction cone with the underbeam cable/wire transport system.  
Production capability is 300-500 m/min.

# Polluted water cleaning



ELV-12 three-head beam extraction system at dyeing factory in South Korea. The productivity of the system is 10,000 m<sup>3</sup>/hour

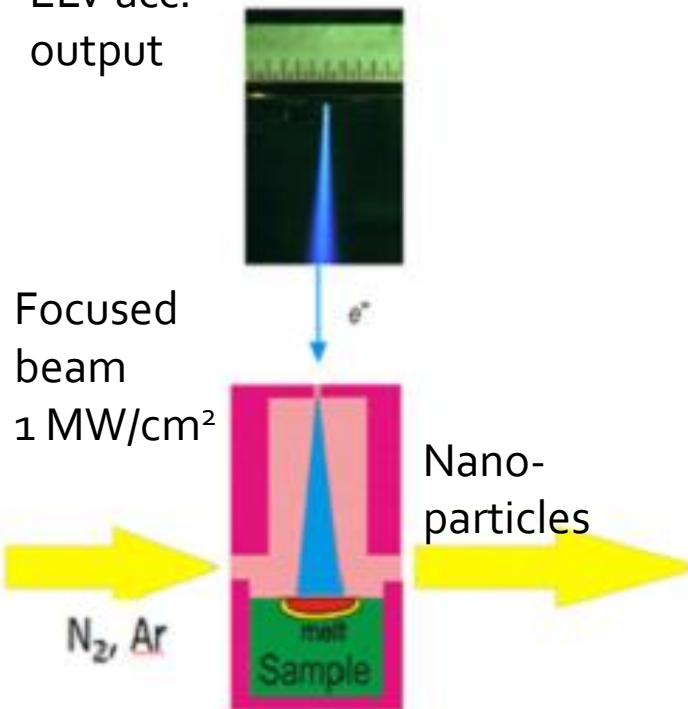
# Grain disinfestations



ELV-8 accelerator using for grain disinfestations with productivity of 1000 t/hour

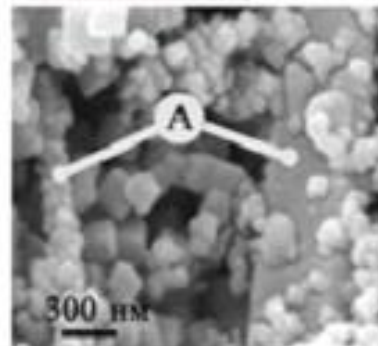
# Nano-size powder production

ELV acc.  
output

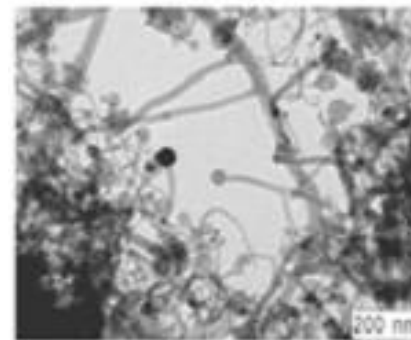


- Up to ~10 kG/h nanopowder with 70 kW ELV
- Oxides: TiO<sub>2</sub>, SiO<sub>2</sub>, MgO, Al<sub>2</sub>O<sub>3</sub>, Gd<sub>2</sub>O<sub>3</sub>, Y<sub>2</sub>O<sub>3</sub>, etc.
- Nitrides: AlN, TiN, etc.
- Pure metals: Ta, Mo, Al, Ni, Ag, Cu, etc.
- Semiconductors

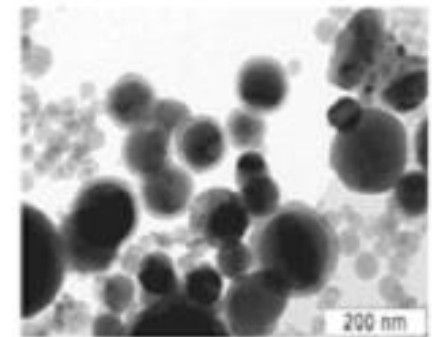
TiN powder



Si nanostructures



Cu nanocorpuscles





# ELV accelerators delivering

Former USSR: 50 machines

China: 60 machines

Korea: 15 machines

Japan: 3 machines

Poland: 2 machines

Germany, Czech Republic, India, Malaysia: 5 machines

# ILU accelerators parameters

Parameters	ILU-6	ILU-8	ILU-10	ILU-14
Electron energy (MeV)	1.7-2.5	0.8-1	4-5	7.5 – 10
Beam Power (kW)	20	20	50	100
Local Shield Weight (t)	-	76	-	-



ILU-8 in local shielding,  
Japan 2005



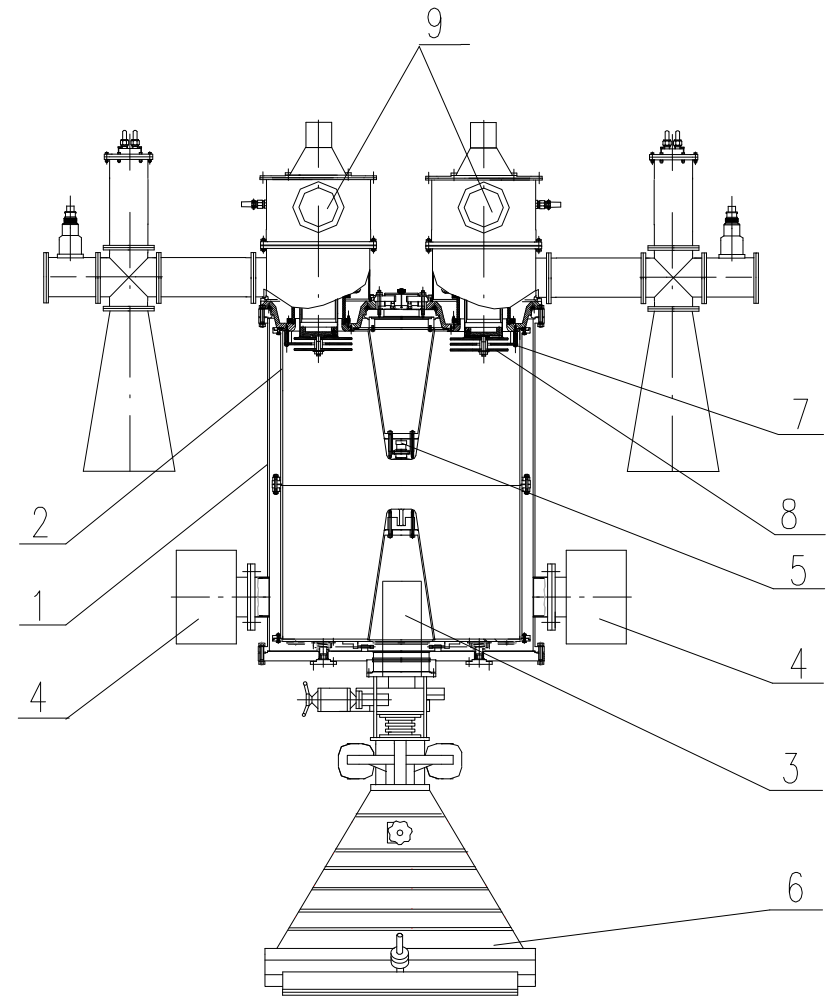
ILU-8 in local shielding,  
Korea 1997



ILU-10, Poland 2005

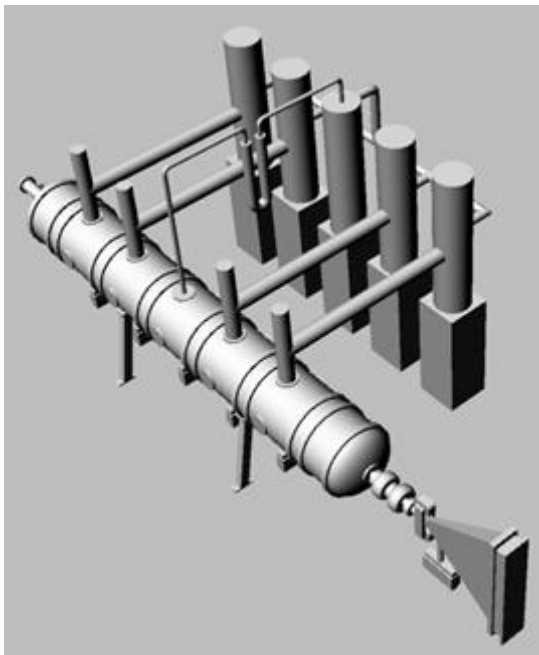
# ILU-10 detailed view and parameters

- Energy 4-5 MeV
- Av. Current 0-10 mA
- Pulse current 0-400 mA
- Pulse duration 500  $\mu$ s
- Pulse repetition 1-50 Hz
- RF frequency 115 MHz
- Dim. D1280x1480 mm

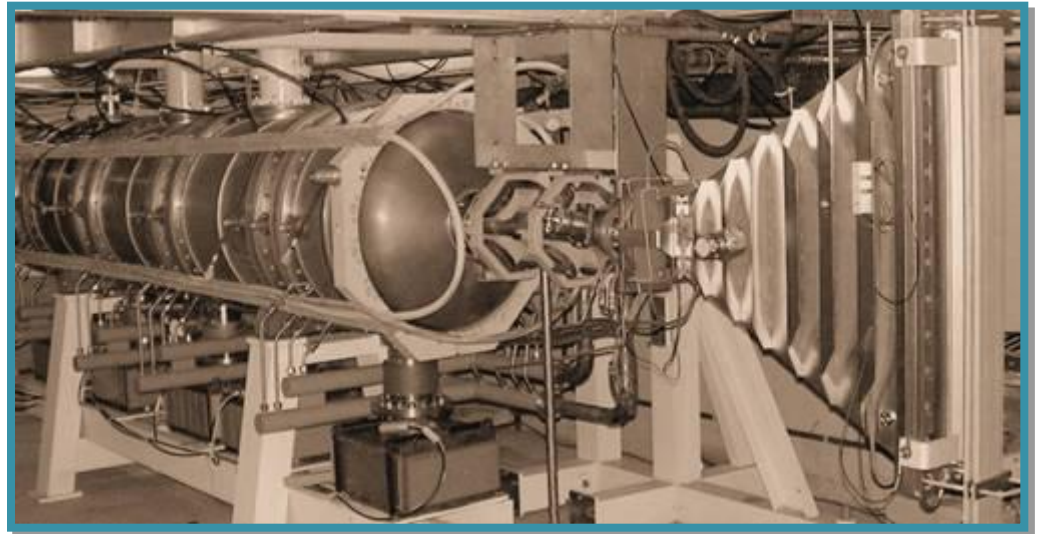


# High energy ILU-14 accelerator

Operating frequency, MHz	176	Full efficiency, %	26
Electron energy, MeV	7,5-10	Pulse duration, $\mu\text{s}$	500
Average beam power, kW	100	Repetition rate, Hz	Up to 50



General view with modulators



ILU-14 photo at BINP

# Typical areas of ILU application

- Plastic cross-linking
  - Irradiation of cables
  - Producing of thermo-shrinkable tubes.
  - Producing plastic pipes and fittings for hot water supply systems.
  - Producing of PE foam with close cells.
- **Sterilization of single use medical goods in packs.**
  - **Syringes, medical clothes, tools and etc.**
- **Production of pharmacological goods.**
- **Sterilization of pharmacological goods.**
- **Sterilization of food containers.**
- **Food pasteurization.**
- Improving of properties of semiconductors.
- Teflon degradation

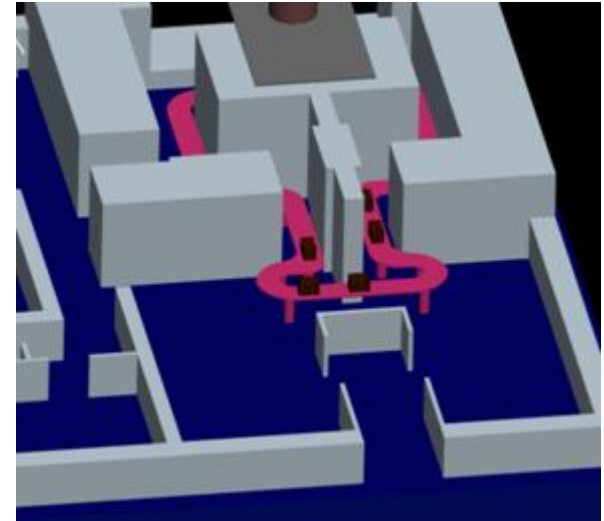
# Medical products sterilization



Conveyor under the ILU-10 extraction device in Izhevsk city. A facility capacity is up to 100,000 syringes/hour

# Pharmacy sterilization

Big company in Altai region producing pharmaceuticals from natural materials is equipped with ILU-10 accelerator



Plant schematically



Load area



Unload area

# ILU-14 at Federal Medbio Center in Moscow



High energy high capacity accelerator ILU-14 was recently installed in Moscow at the Federal Medico-biological Center (FMBC) to study technologies of radiative sterilization of various medical goods, products and equipment



# Radiative enzymes immobilization

Radiative immobilization of enzymes by electron beam allows developing of new highly effective remedies with new features (immozimaza, trombovasim, dienei, etc.)

A technology of immobilization was developed by Novosibirsk Institute of Cytology with BINP. Remedies are produced by a private company in Novosibirsk



Pack of trombovasim



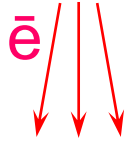
ILU assembling at the medical plant



Radiation technology medical plant

# ILU and decontamination

Electron beam



Cytology Institute and BINP are developing a technology of the livestock enterprises waste decontamination with the help of electron beam from ILU-14



Kudriashi livestock waste cleaning facility

# ILU accelerator delivering

Russia and USSR: 23 machines

Poland: 3 machines

Hungary: 1 machine

India: 1 machine

China: 6 machines

Czech Rep.: 1 machine

Romania: 1 machine

Italy: 1 machine

Korea: 1 machine

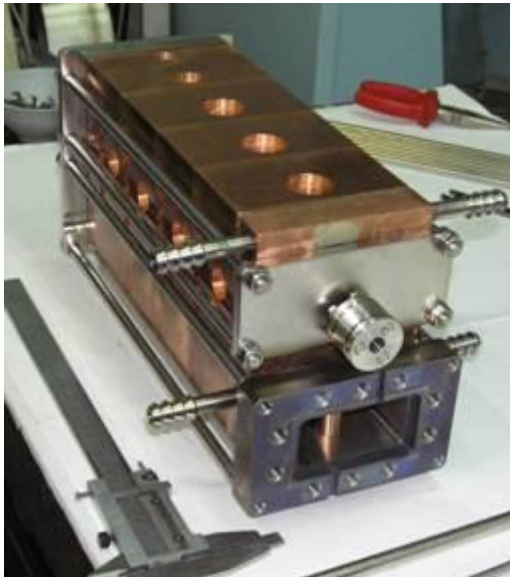
USA: 2 machines

Japan: 1 machine

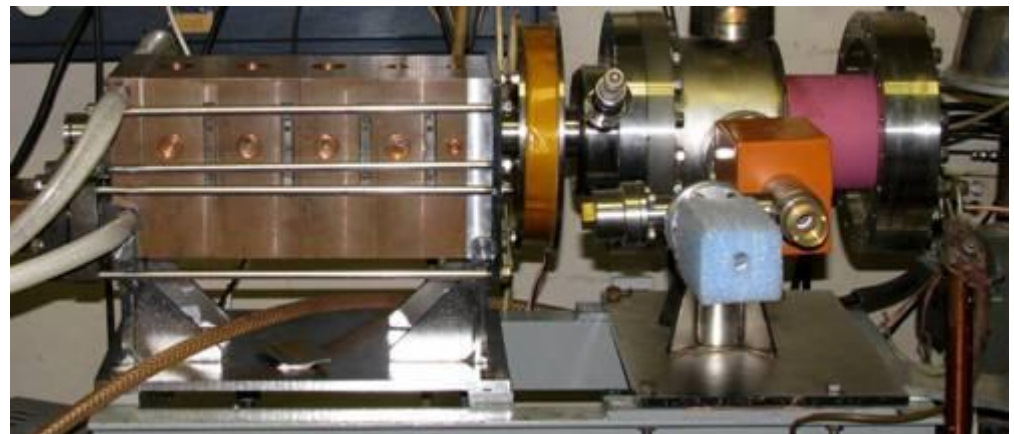
# Compact 3 GHz electron accelerator

Compact RF linear electron accelerator with parallel cavities feeding was developed recently at BINP. Advantages of new device are promising for such applications as IMRT cancer therapy, cargo inspection systems, radiative catalysis, etc.

Main parameters: RF frequency  $\sim 3$  GHz, energy up to 10-20 MeV, average power up to 5 kW and the current is up to 500 mA



Parallel feeding  
accelerator structure

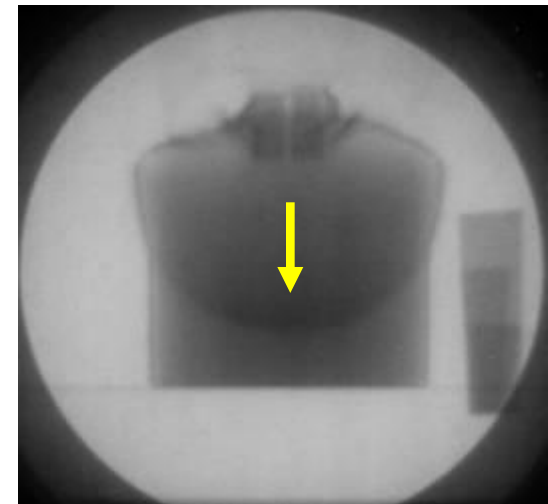


Radiative catalysis system based on the  
BINP compact linear accelerator

# High intensity induction electron accelerator

High intensity induction accelerator for X-ray radiography of extremely dense objects was developed at BINP.

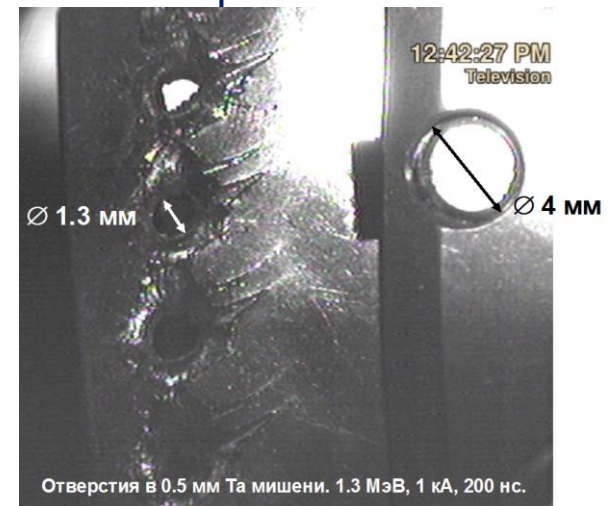
Main parameters: energy is 2 MeV, current is 2 kA, two 200 ns pulses with the gap in the range of 2.5 -10  $\mu$ s, beam size at the target is less than 2 mm.



X-ray pic of the detonation front in explosion



General view of induction accelerator with modulators



# Summary

- BINP is one of the world's leading scientific center for development of electron accelerators for basic science and industrial applications
- "Break through" directions in this field will concern (a) development of new accelerator equipment (compact, mobile, reliable accelerators with higher performance than today), (b) radiation technologies (new materials, medical and biology applications, etc.)
- A network of "radiation technology centers" equipped with several ion/electron accelerators covering wide spectrum of application areas is necessary (example: SR centers)