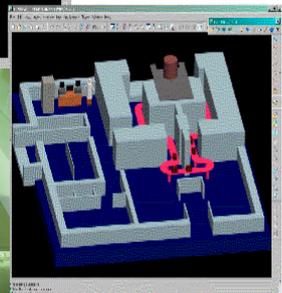
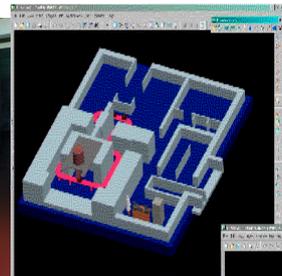
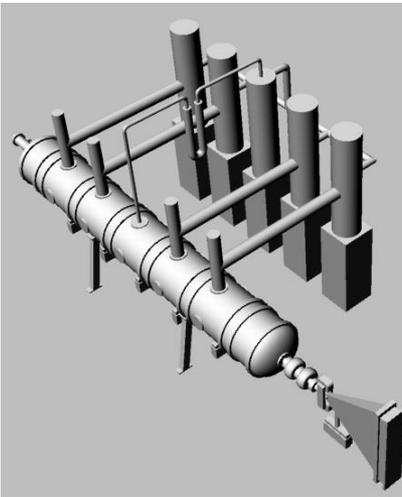


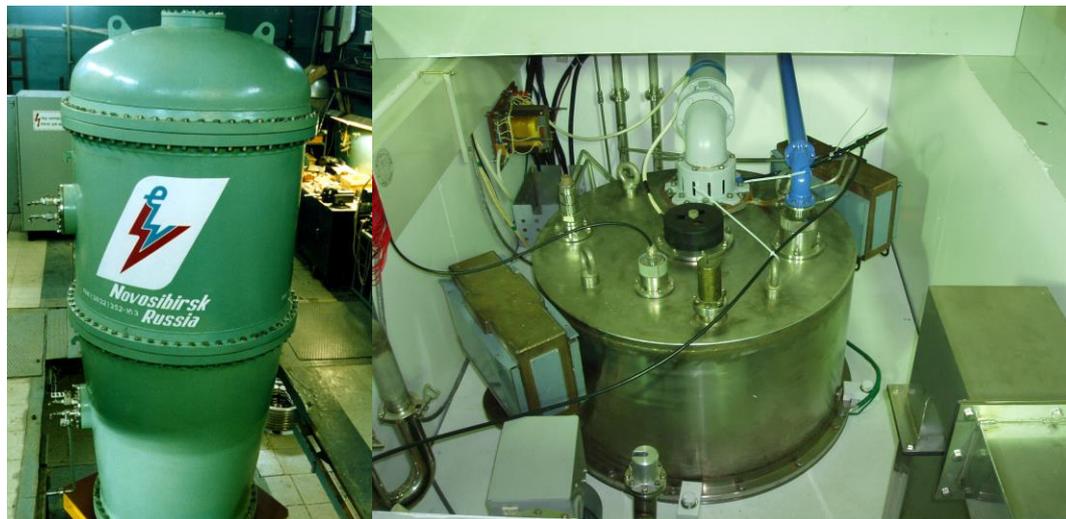
High-power industrial accelerator ILU-14 for E-beam and X-ray processing.

Aleksandr Bryazgin Budker INP, Novosibirsk, Russia



Industrial accelerators

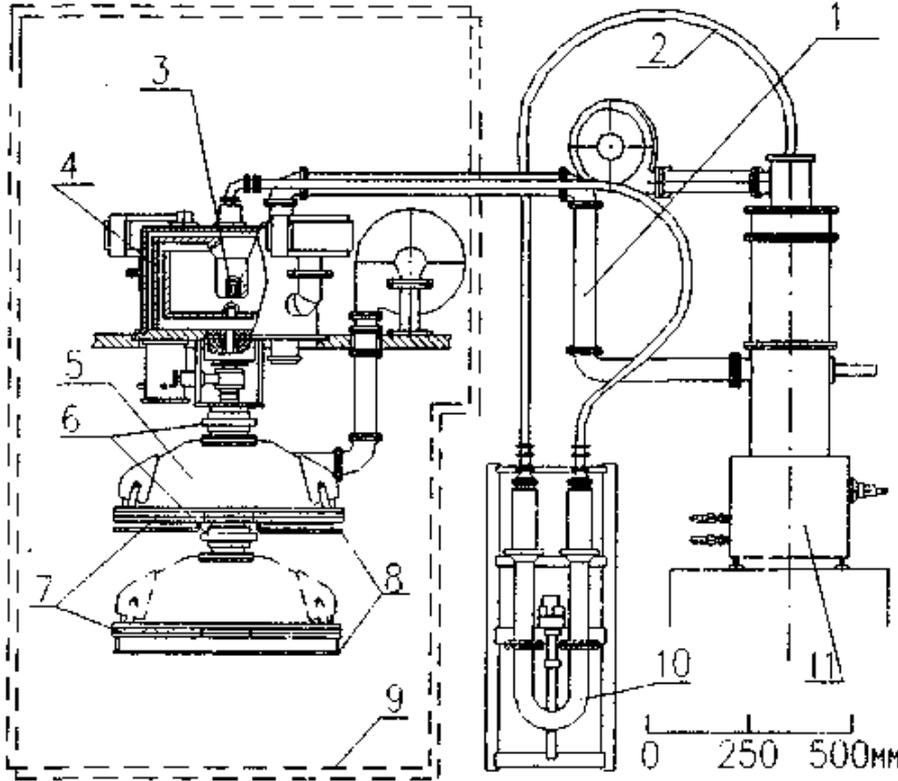
- The ILU electron accelerators are produced by Budker Institute of Nuclear Physics. They cover the energy range from 0.8 to 10 MeV, the beam power is up to 100 kW.
- ELV accelerators is DC accelerator with energy up to 2.5 MeV and power up to 400 kW.



ILU Accelerators

Parameters	ILU-6	ILU-8	ILU-10	ILU-14(12*)
Electron Energy	1.7-2.5 MeV	0.8-1 MeV	4-5 MeV	7.5 – 10 MeV 5-7.5 MeV*
Beam Power	20 kW	20 kW	50 kW	100 kW 60 kW*
Local Shield Weight		76 t		

ILU-8 in Local Shield

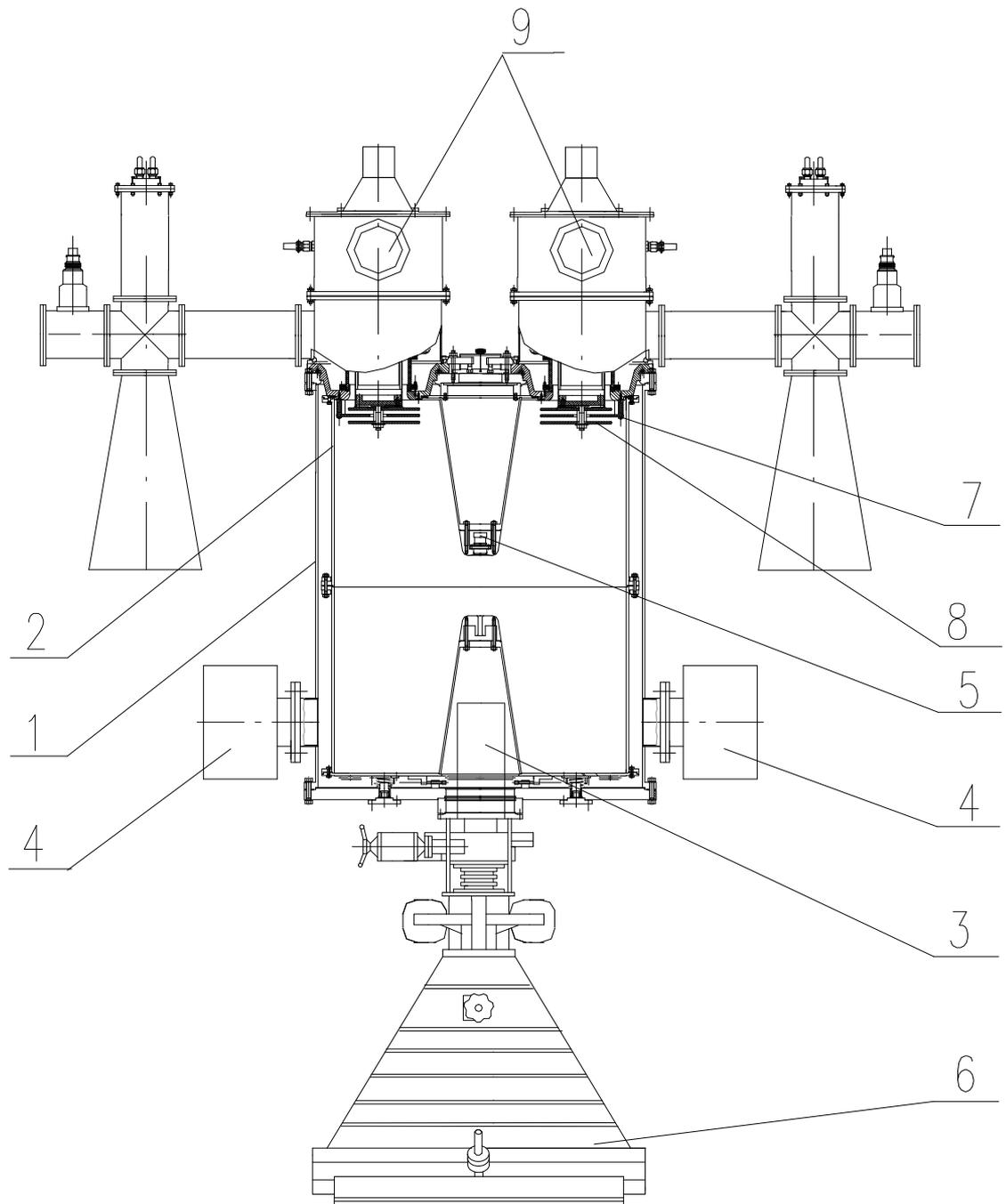


Main features of ILU
accelerators

- Compact
 - Self-excitation, No master generator
 - No insulation and gas systems
 - Pulse
 - RF triod GI-50
- Energy 0.8-1 MeV
 - Av. Current 0-20 mA
 - Pulse current 0-500 mA
 - Pulse duration 800 mks
 - Pulse repetition 1-50 Hz
 - RF frequency 175 MHz
 - Dim D800x800 mm

ILU-10

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



ILU-10 in Poland, RadPol SA, 2008

- Energy 5 MeV
- Beam power 50 kW
- Treatment of polymer pipes
- Treatment of cables
- Movable accelerator between two conveyors.

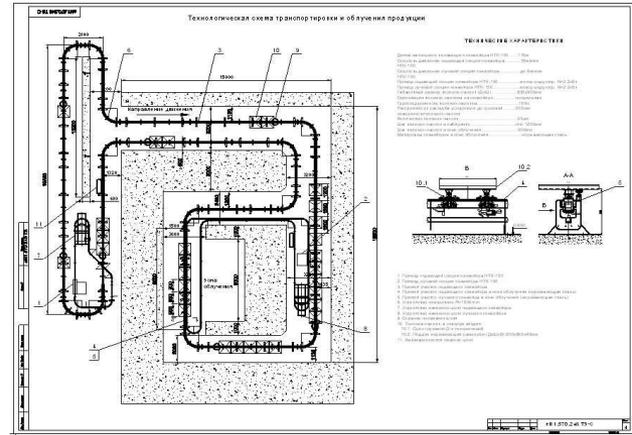


ILU-10 in Novosibirsk pharmaceutical plant 2013





Парк Ядерных Технологий



- Sterilization plant based on ILU-10 accelerator in Park of Nuclear Technology in Kazakhstan (2013)

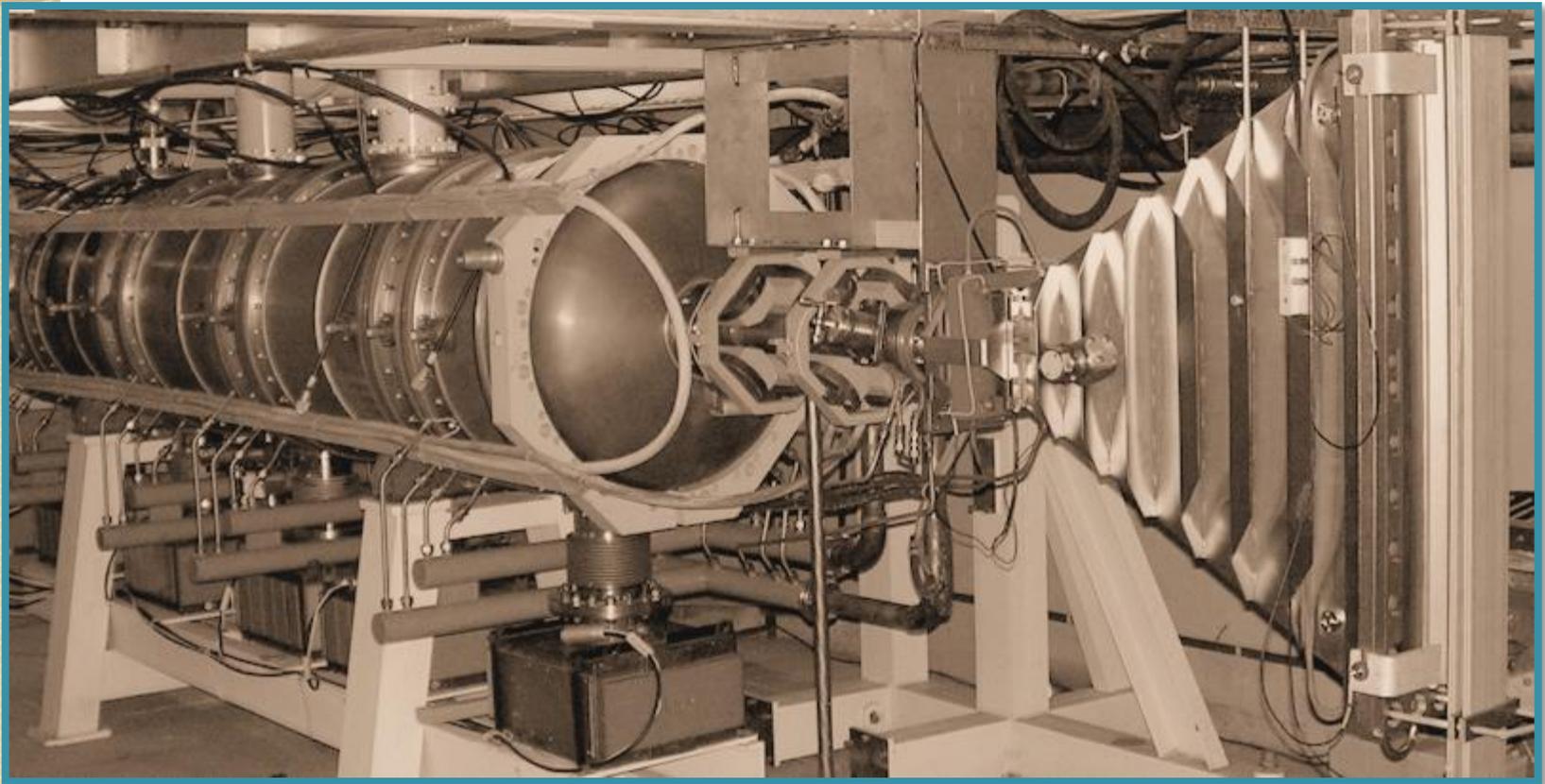
ILU-14

7,5-10 MeV, 100

kW

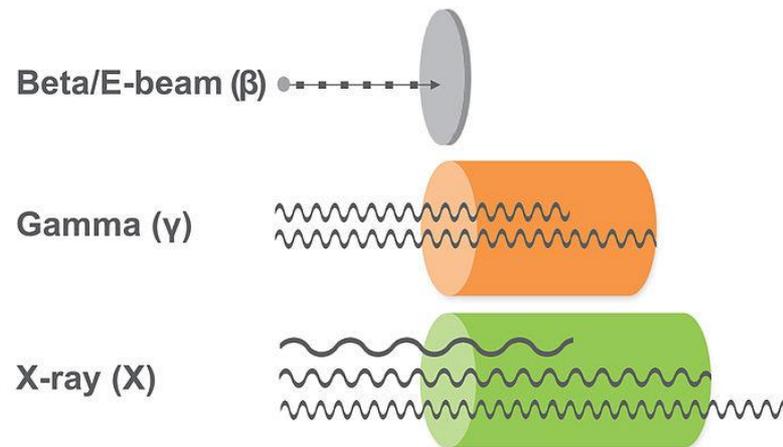
ILU-12

5-7,5 MeV, 60 kW

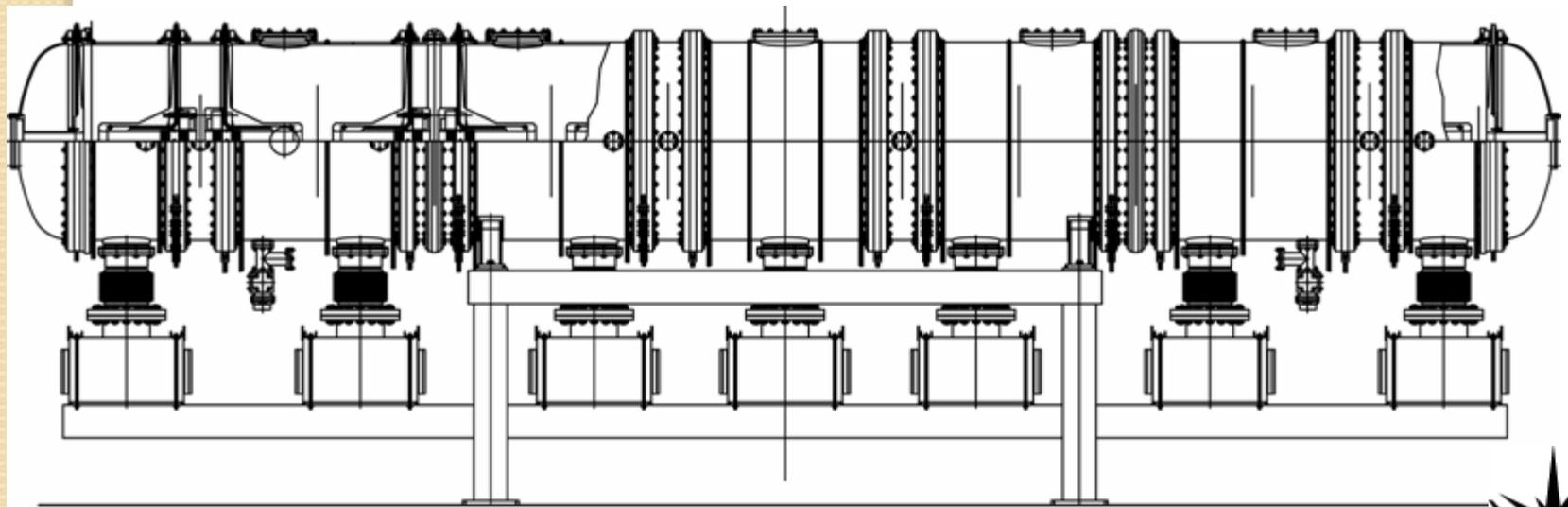
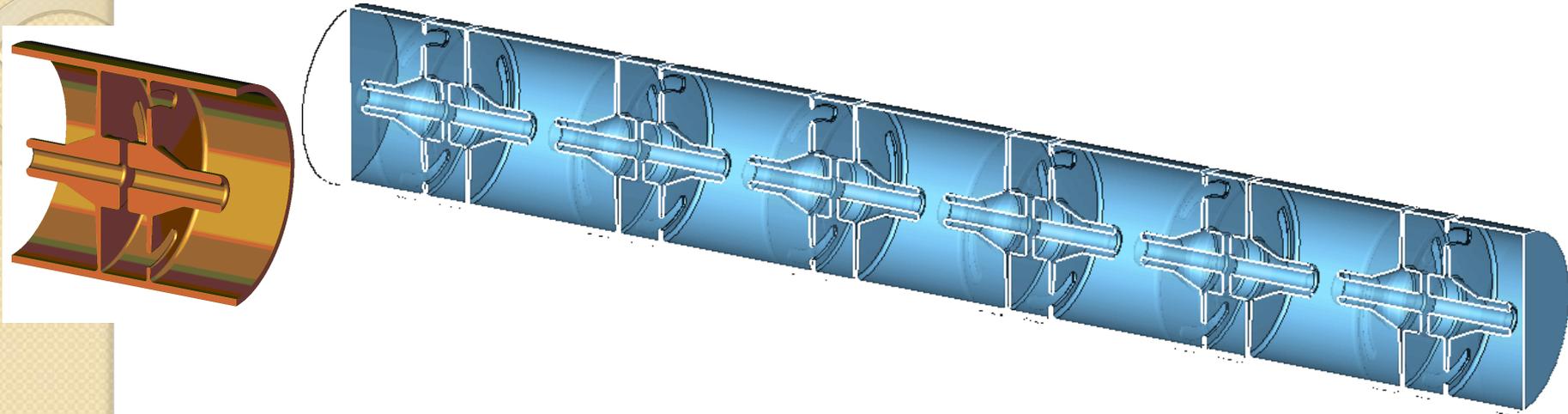


Accelerator for food irradiation.

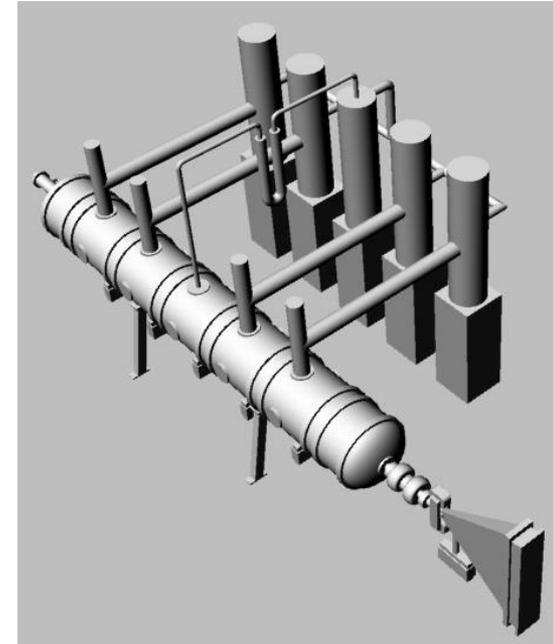
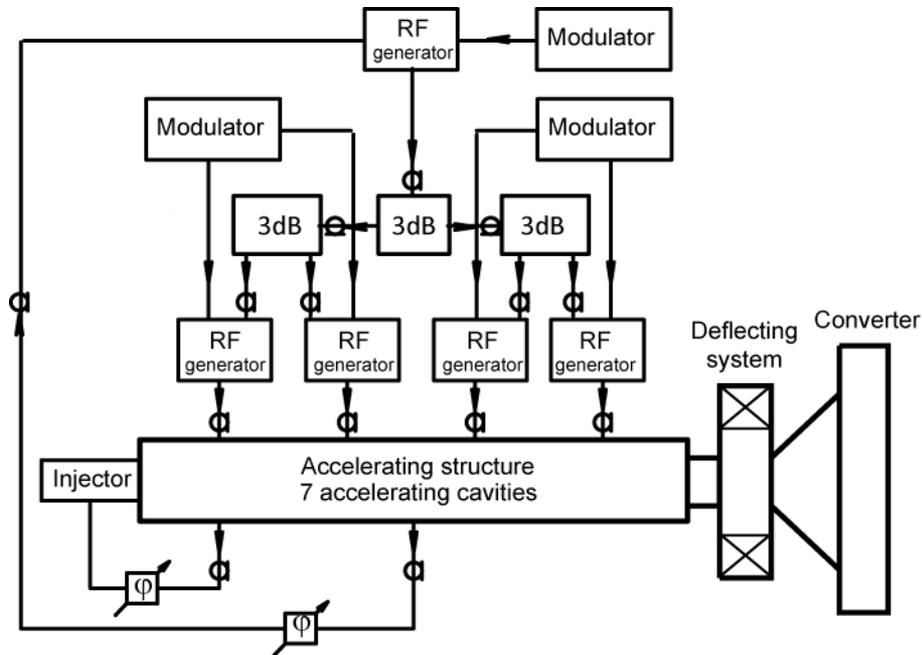
- Even 10 MeV E-beam not enough for penetration => X-ray
- X-ray conversion has no good efficiency => need more power, more energy (but not more 7.5 MeV for USA and 5 MeV for other countries).
- If thickness of product allows e-beam, we must use e-beam because efficiency => 2 fast switch mode: E-beam – up to 10 MeV, X-ray – 7.5 (5) MeV.



Accelerating structure



ILU-14 accelerator



<i>Operating frequency, MHz</i>	<i>176</i>	<i>Full efficiency, %</i>	<i>26</i>
<i>Electron energy, MeV</i>	<i>7,5-10</i>	<i>Modulator pulse duration, μs</i>	<i>500</i>
<i>Average beam power, kW</i>	<i>100</i>	<i>Repetition rate, Hz</i>	<i>Up to 50</i>



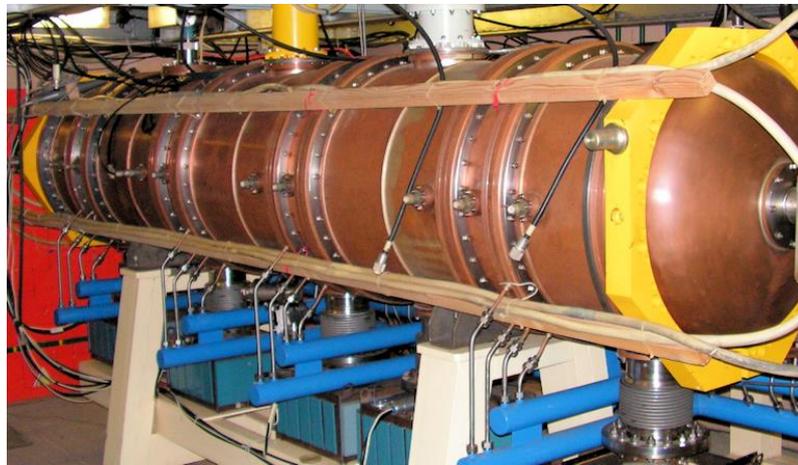
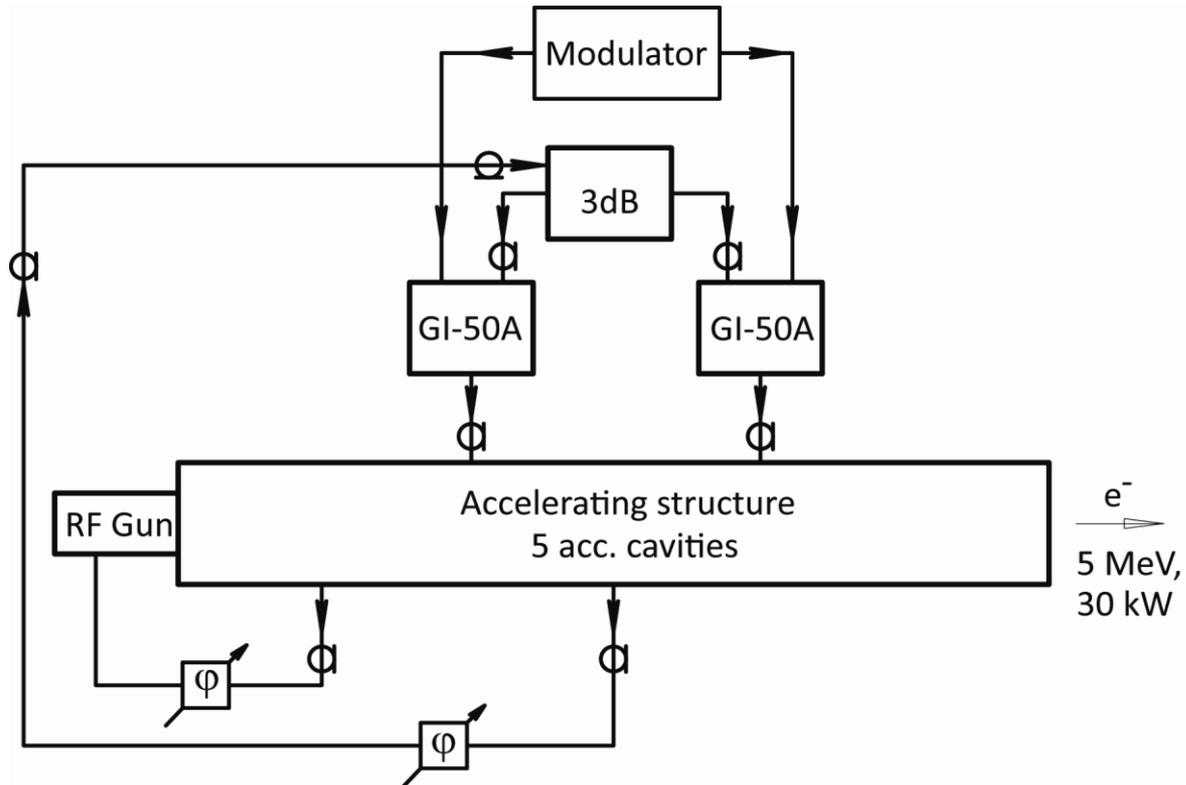
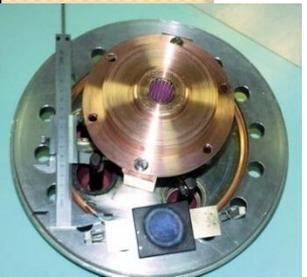
5 MeV accelerator prototype

- ILU 14 has specially designed modular structure of the RF system and accelerating structure that allowed us to carry out the tests of all the main accelerator units at 5 MeV accelerator prototype.

The prototype was manufactured at BINP workshop and tested in pulsed mode in 2008. The test results allowed us to prove and measure the following:

- a) accelerating structure electric strength by modeling the accelerating rate that corresponded to ILU-14 operation conditions (7.5 MeV and 10 MeV);
- b) accelerating structure cooling system efficiency;
- c) obtaining the required pulsed beam current from the RF gun;
- d) beam transmission coefficient and energy spectrum;
- e) serviceability of RF system elements (power inputs, feeders etc.).

5 MeV accelerator prototype



Accelerator prototype

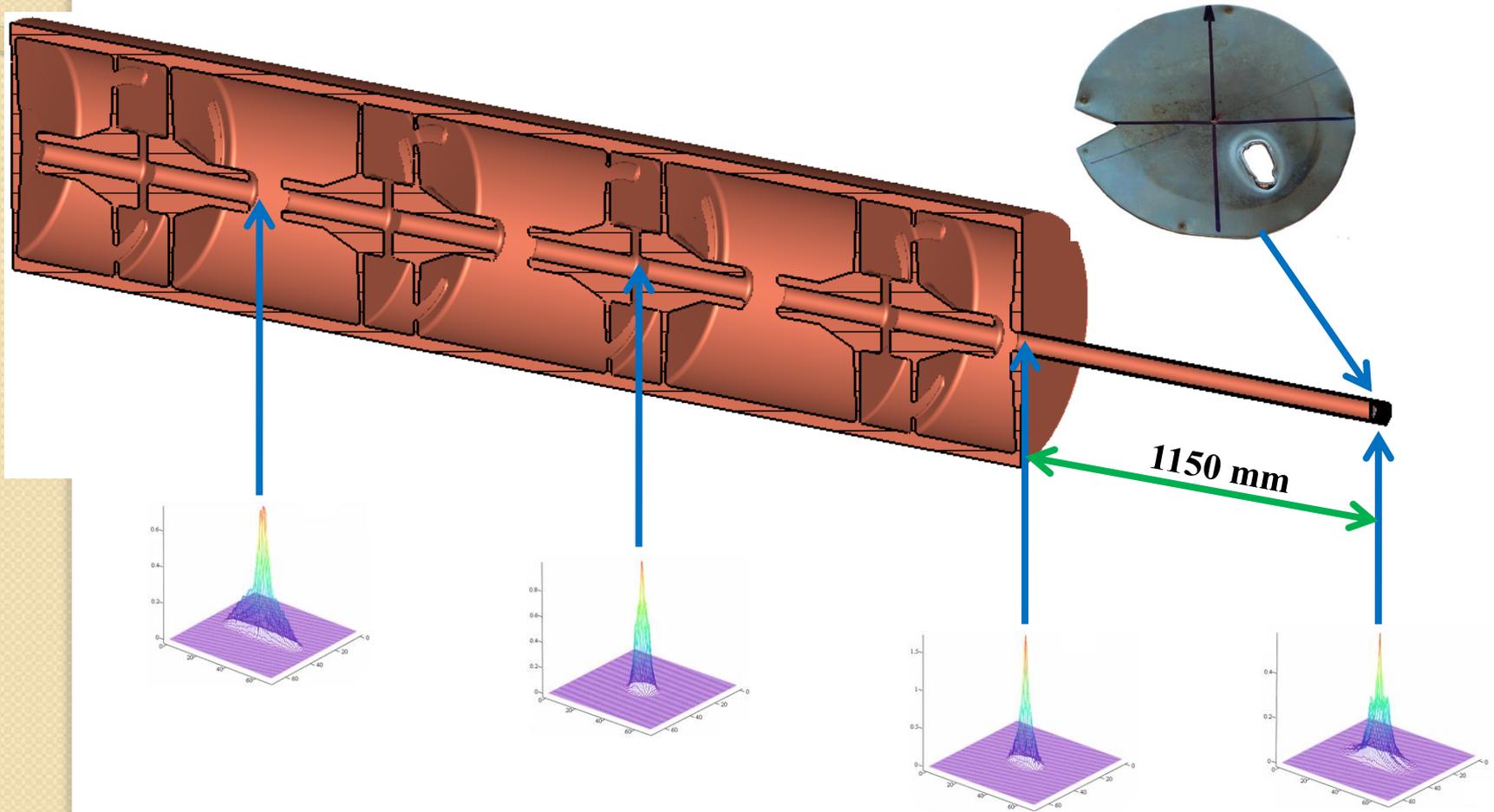


Two generators with feeders

Accelerating structure with beam scanning system

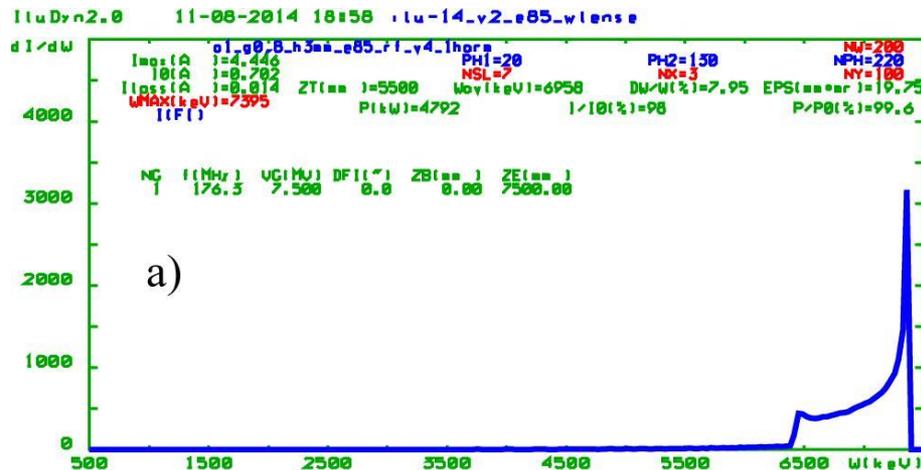


Beam cross-size calculation & measurements at accelerator prototype

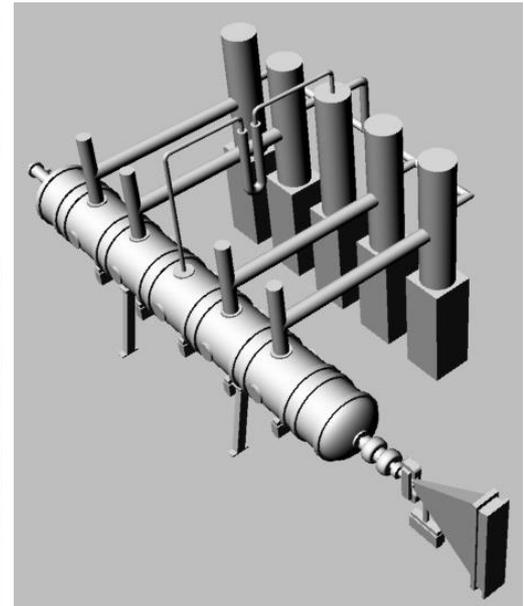


Parameters obtained at the accelerator prototype

- Maximal accelerating voltage **7.5 MV**
- Maximum beam pulsed current **600 mA** at electron energy of **5 MeV**
- **96%** beam passing through the structure
- Structure electron efficiency of **73%** at electron energy of **5 MeV**
- Beam average power **50 kW**.



ILU-14 tests



Tests ILU-14 in Novosibirsk

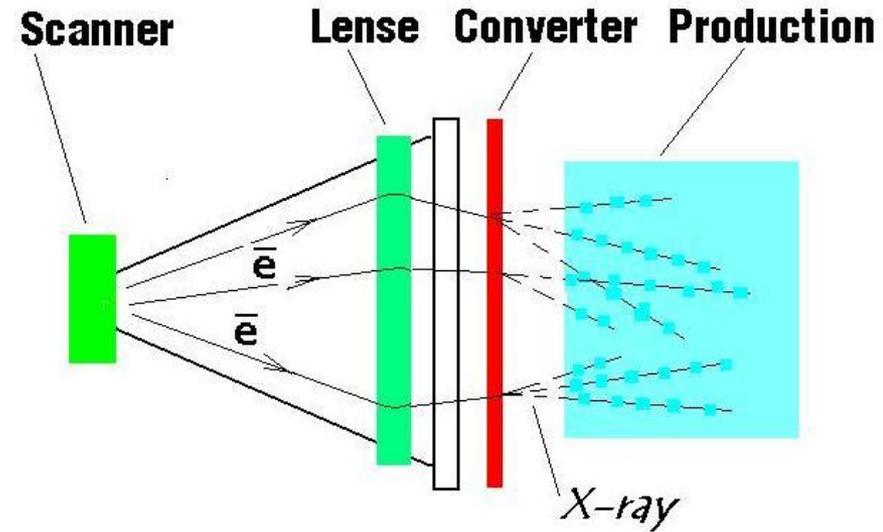
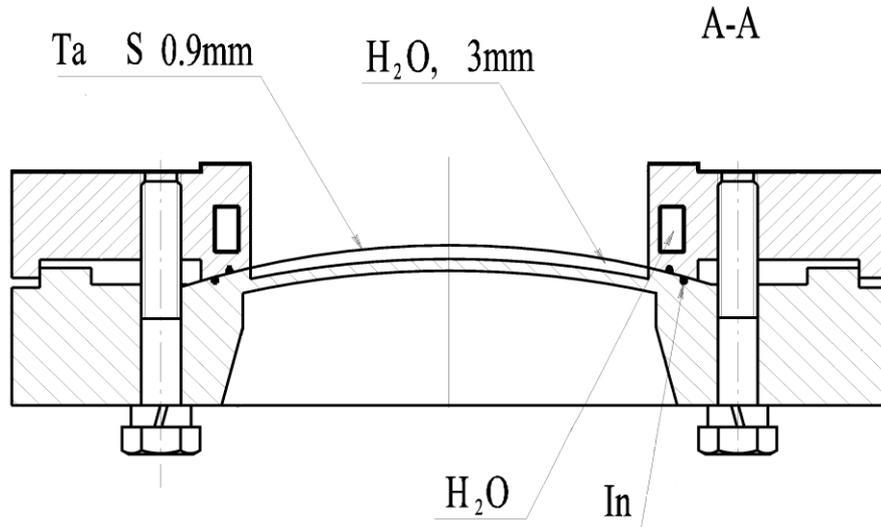
Variant	Output electron energy	Pulse repetition rate	Beam pulsed current	Beam average current	Power
1	9.2 MeV	35 Hz	420 mA	7 mA	64 kW
2	10 MeV	25 Hz	420 mA	5 mA	50 kW

ILU-14 on pilot plant for irradiation medical waste.

Moscow. Start of operation in 2014.



X-ray converter



Conversion rate X/ray/Ebeam power

E(MeV)	Ta thickness	60 deg	360 deg
7.5	0.9	13,2%	16,9 %
5	0,7	8,3%	12%

**Thank you for your
attention**