



## PRESENT STATE AND DEVELOPMENT PROSPECTS OF ACCELERATOR TECHNOLOGY IN RESEARCH AND PRODUCTION ENTERPRISE "TORIY"



Since 1959

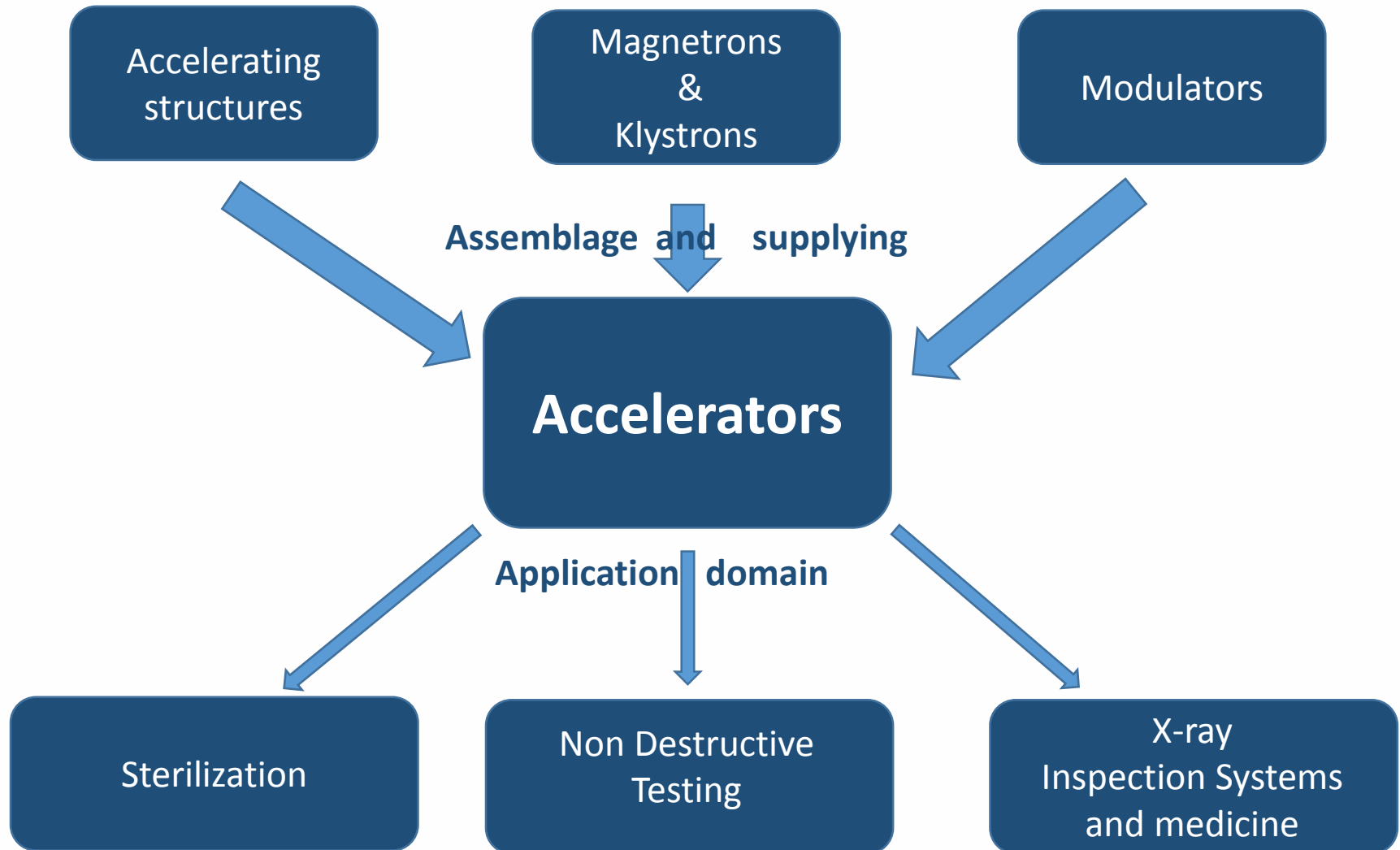


## ELECTRON ACCELERATORS DEVELOPED AND MANUFACTURED BY RPE "TORIY" AND BE IN SERVICE AS OF 2016 YEAR

	Electron accelerator model name	The operating organization	Country
1	Y-003	The Institute of Physical Chemistry and Electrochemistry RAS (IMPB RAS)	Russia
2	Y-003	Scientific-research Institute of technical physics and automation	Russia
3	Y-003	Institute of nondestructive testing	Russia
4	УЭЛБ-10-10	Moscow Engineering Physics Institute	Russia
5	УЭЛБ-10-10	ZAO «INTEKH»	Russia
6	Y-003	Open Joint-Stock Company ELECTROVIPRYAMITEL	Russia
7	Y-003	Research Institute of Scientific Instruments (RISI)	Russia
8	УЭЛБ-10-10	"Research and Production Enterprise "TORIY"	Russia
9	УЭЛБ-10-10	"Research and Production Enterprise "TORIY"	Russia
10	УЭЛП-8-2Д	JSC Machine-Building Plant ZiO-Podolsk	Russia
11	УЭЛП-6-2Д	AEM-technology Joint-Stock Company	Russia
12	ЭЛП-4	Institute of radiation problems	Azerbaijan
13	ЭЛП-4	Scientific and Practical Materials Research Center	Belarus
14	Y-003	Joint Institute of Solid State and Semiconductor	Belarus
15	УЭЛБ-10-10	State Scientific Institution "THE JOINT INSTITUTE FOR POWER AND NUCLEAR RESEARCH - SOSNY"	Belarus
16	Y-003	Joint Institute for Nuclear Research	Ukraine
17	Y-003	Institute of Nuclear Physics AS RUz	Uzbekistan
18	ЭЛП-6	Institute of Applied Radiation Chemistry	Poland
19	УЭЛБ-10-10	Institute of Nuclear Chemistry and Technology	Poland
20	УЭЛБ-10-10	Institute of Nuclear Chemistry and Technology	Poland
21	ЭЛП-6	The National Polytechnic School	Ecuador
22	Y-003B	The Leibniz Institute of Surface Modification	Germany
23	УЭЛБ-10-10	Institute of Nuclear Physics and Chemistry, China Academy of Engineering Physics	China



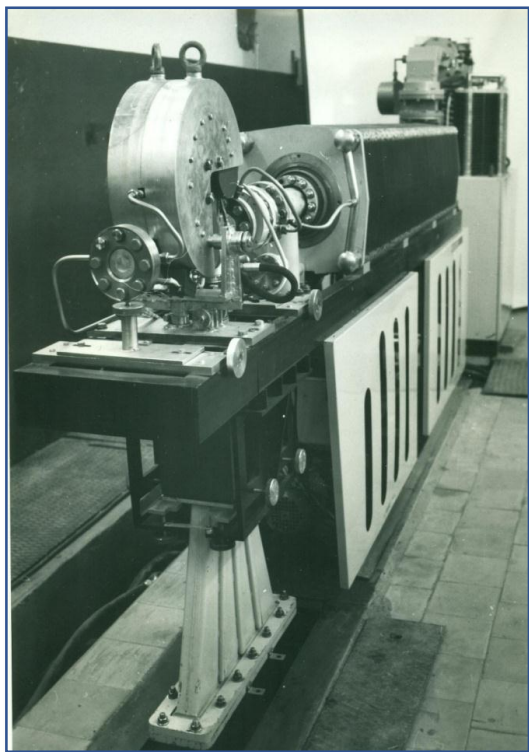
## Development and manufacturing





## LINEAR ACCELERATORS ELU-4, ELU-5-1-5, ELU-6, U-003, UELV-10-10

In 1966 “Toriy” which previously was called “Titan” successfully developed the USSR's first industrial electron accelerator ЭЛУ-4 (ELU-4) with the power of 5 kW and an energy of 5 MeV



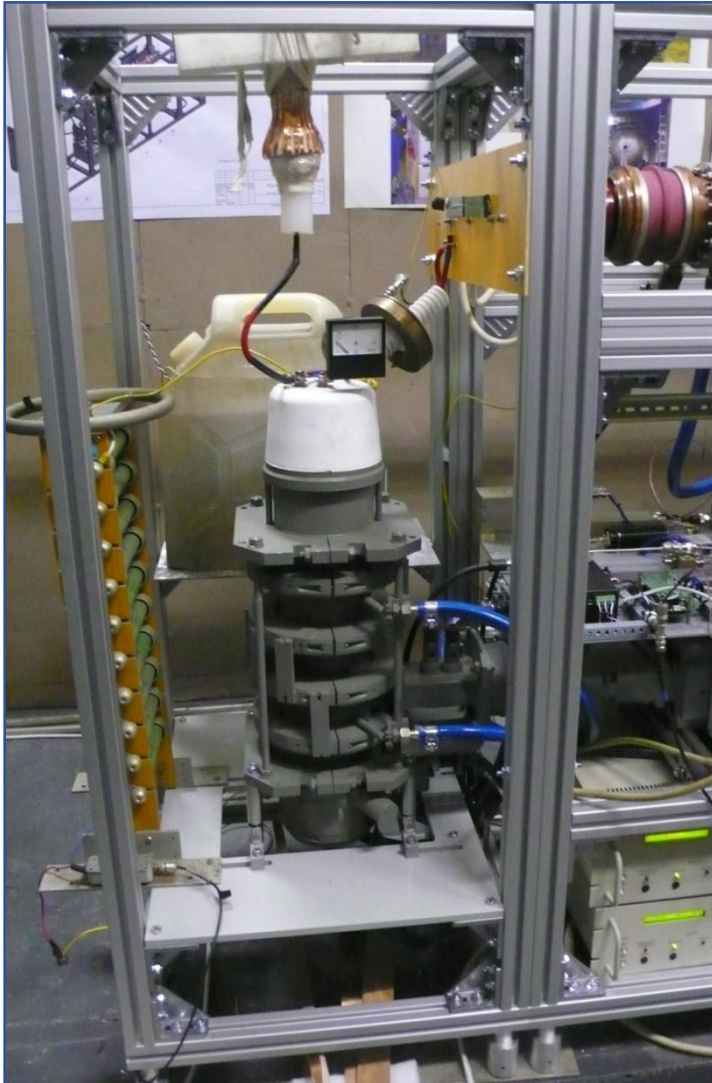
In the period from 1964 to the present time, “Toriy” produced about 100 samples of accelerators ELU-4, ELU-5-1-5, ELU-6, U-003, UELV-10-10 for radiation technologies and for sterilization research.

More than 300 samples of МИ-325 (MI-325), MI- 435 and MI-470 magnetrons.

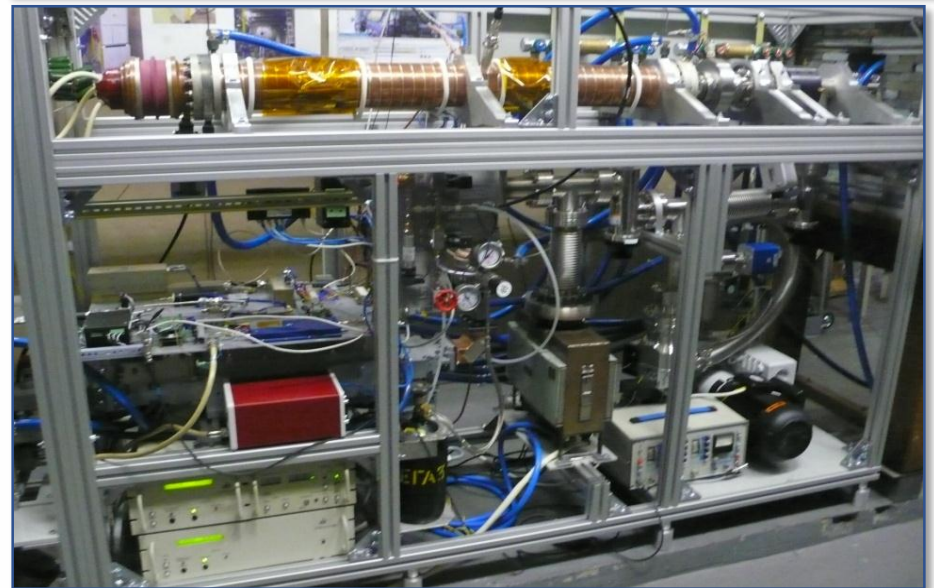




## LINEAR ACCELERATOR UELR-10-15 FOR STERILIZATION



Beam Energy, MeV	5 – 10
Electron Beam Average Power, kW	1 – 15
Pulse Repetition Rate, Hz	up to 400
Scan Length, mm	400 – 600
Scan Frequency, Hz	1 – 30
Microwave Tube	Klystron KIU-147A
Modulator	Solid State





## LINEAR ACCELERATORS FOR RADIOGRAPHY (NDT)

Parameters	UELР-6-2D	UELР-8-2D	UELР-10-2D
Electron Energy, MeV	3 – 6	3 – 8	5 - 10
Dose Rate, Gy/min	1 – 10	1 – 15	10 – 40
Bremsstrahlung Radiation Field Assymetry, %, not more	5	5	5
Focal Spot Size, mm, not more	1	1	1
Form and Dimension of Operating Field at Distance 2 m, m	circle, ø 0,5	circle, ø 0,5	circle, ø 0,5



Parameters	UELR-6-2D	UELR-8-2D	UELR-10-2D
Acceptable non-uniformity of Dose Rate within Operation Field, %	10	10	10
Maximum Permissible Duration of Single Exposition, min	not limitation	not limitation	not limitation
Minimal Interval between Exposures, min	1	1	1
Maximum Steel Thickness, mm	50 – 350	50 – 380	100 – 500



**X-RAY INSPECTION SYSTEM ST-6035 for vehicles and sea containers****The Russian Border check-point Pogranichny, Vladivostok region**

Electron Energy, MeV	6.0 / 3.5
Pulse Repetition Rate, Hz	2 × 200
Total Number of Detectors	2112
Scanning Height, m	up to 4.5
Penetration in Steel, mm	400
Wire Detection without Barrier, mm	Ø 0.8
Contrast Sensitivity, %	0.5





## X-RAY INSPECTION SYSTEM ST-2630T for inspection of cargo transported by railway

- High image quality
- Inspection at train speed up to 70 km/h
- Reliable material discrimination
- Subsystem of train cars optical scanning is included

Put into Operation - 2017

Electron Energy, MeV	6.0 / 3.5
Pulse Repetition Rate, Hz	50 to 2000
Pulse Repetition Rate with Material Discrimination,	2×50 to 2×1000
Total Number of Detectors	1440
Scanning Height, mm	8370
Penetration in Steel, not less, mm	350
Wire Detection without Barrier, mm	Ø 1.0
Contrast Sensitivity, not more, %	2.0



## MICROWAVE TUBES FOR LINEAR ACCELERATORS

	Magnetron	CW klystron	Pulsed klystrons				
	MI-470	KU-399	KIU-40	KIU-111	KIU-147	KIU-147A	KIU-168
Center frequency, MHz	1885	2450	991	2450	2450	2856	2856
Output pulse power, MW	10	-	4.7	5	5	6	6
Output average/CW power, kW	30	25	70	5	25	25	5
Cathode voltage, kV	50	10	65	50	50	52	52
Number of electron beams	1	18	6	40			
Focusing	solenoid	permanent magnets	solenoid	permanent magnets			



**MULTIBEAM KLYSTRONS**  
**KIU-111, KIU-147, KIU-147A, KIU-168, KIU-271**



**Klystron  
Electron  
Gun**



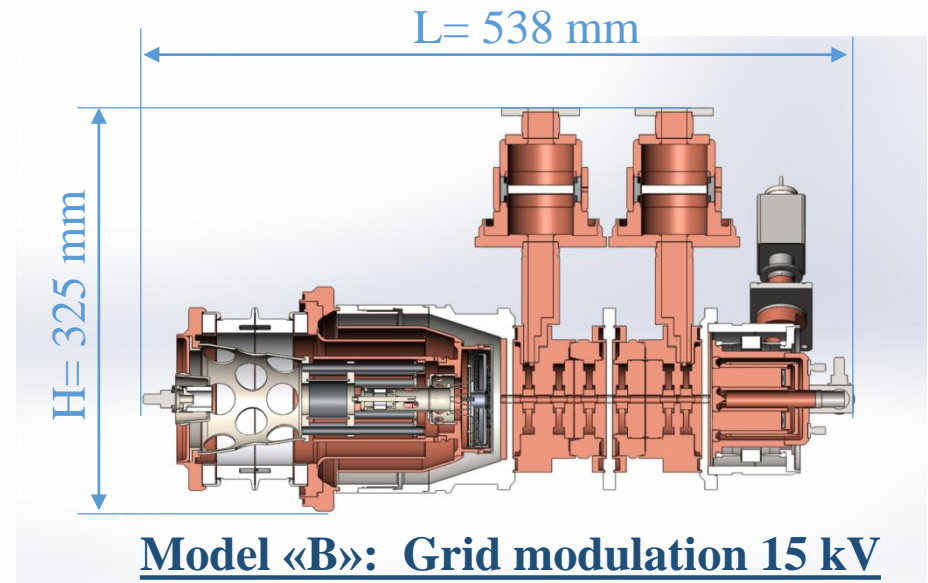
**Klystron  
Cavity  
Unit**



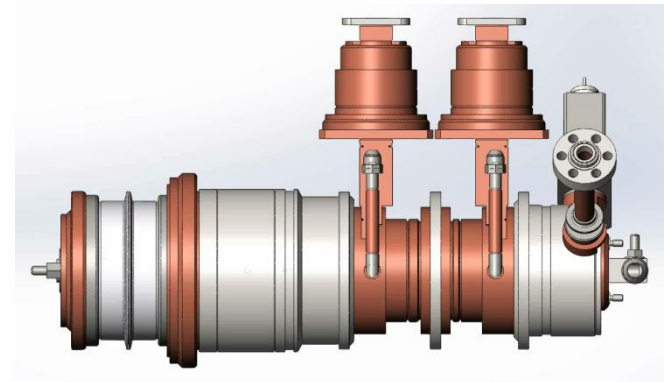
## MULTIBEAM KLYSTRON KIU-271 5712 MHz

Center frequency, MHz	5712
Output pulse power, MW	3
Output average power, kW	10
Cathode voltage, kV	45
Number of electron beams	30
Focusing	permanent magnets
Weight, kg	30
Overall dimension, cm	53,8 x 32,5

### Model «A»: Anode modulation 45 kV



Cathode Voltage 45 kV

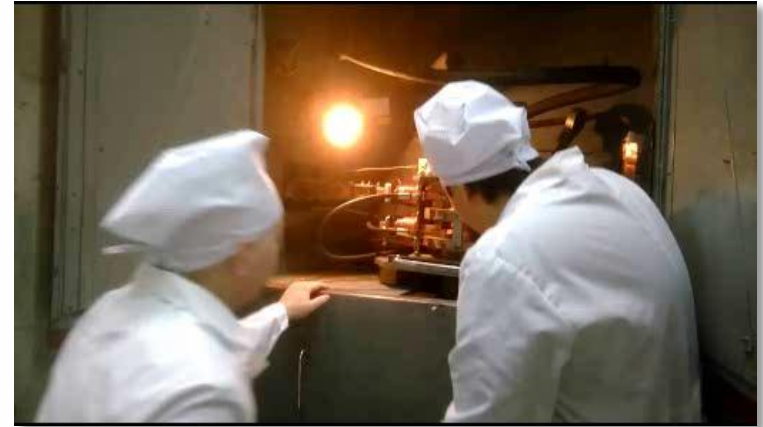






## MULTIBEAM KLYSTRON 5712 MHz

- Linear accelerators for nondestructive testing
- Linear accelerators for X-ray inspection systems
- Linear accelerators for industrial digital radiography Linear accelerators for industrial X-ray analysis
- Linear accelerators for environmental application
- Linear accelerators for sterilization



Klystron testings





## ACCELERATING SECTION 5712 MHz

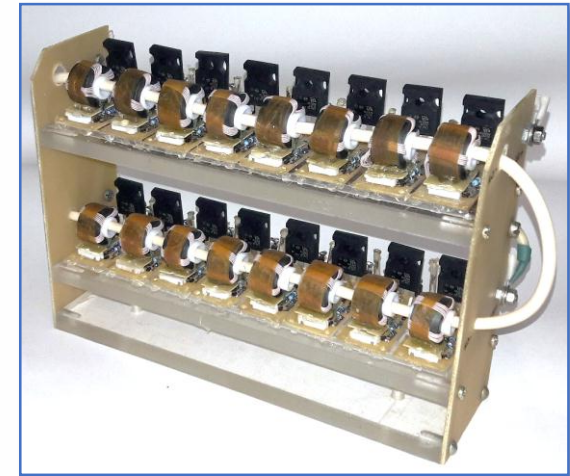




## SOLID STATE MODULATOR

Operating voltage, kV	15
Pulse ratio	[10 to 1000]
Pulse length, $\mu\text{s}$	[ 5– 1000]
Power, W	300

## SOLID-STATE SWITCHES ARRAY



## RACKMOUNT CHASSIS DESIGN

