Budker Institute of Nuclear Physics, Novosibirsk, Russia

ACCELERATORS OF ELV SERIES: CURRENT STATUS AND FURTHER DEVELOPMENT.

D.S. Vorobev, E.V. Domarov, M.G. Golkovskii, Y.I. Golubenko, A.I. Korchagin, D.A. Kogut. N.K. Kuksanov, A.V. Lavrukhin, R.A. Salimov, A.V. Semenov, S.N. Fadeev. P.I. Nemytov

The Budker Institute of Nuclear Physics of Russian Academy of Science are developing and manufacturing of electron accelerators of the ELV-type for their use in the industrial and research radiation-technological installations beginning 1970. The ELV-type accelerators were designed with use of the unified systems and units enabling thus to adapt them to the specific requirements of the customer by the main parameters such as the energy range, beam power, length of extraction window, etc.

Due to high power of electron beam in wide energy range, high efficiency of conversation of electricity power to electron beam power and simple procedure of accelerator control by operator ELV accelerators are the most popular Russian accelerator. They are well known in the world, especially in China and South Korea. By now, more than 200 accelerators have been delivered both within Russia and abroad. .

ACCELERATORS
ELV

Placements of ELV Accelerators

- 50 accelerators were delivered inside of former USSR
- more then100 accelerators were delivered in China
- 19 accelerators were delivered in South Korea
- 2 accelerators were delivered in Japan
- 2 accelerators were delivered in Poland
- 7 Accelerators were delivered in Germany, Chech Republic, Malaysia, Phillipines, Turkey
- 4 Accelerators were delivered to India.

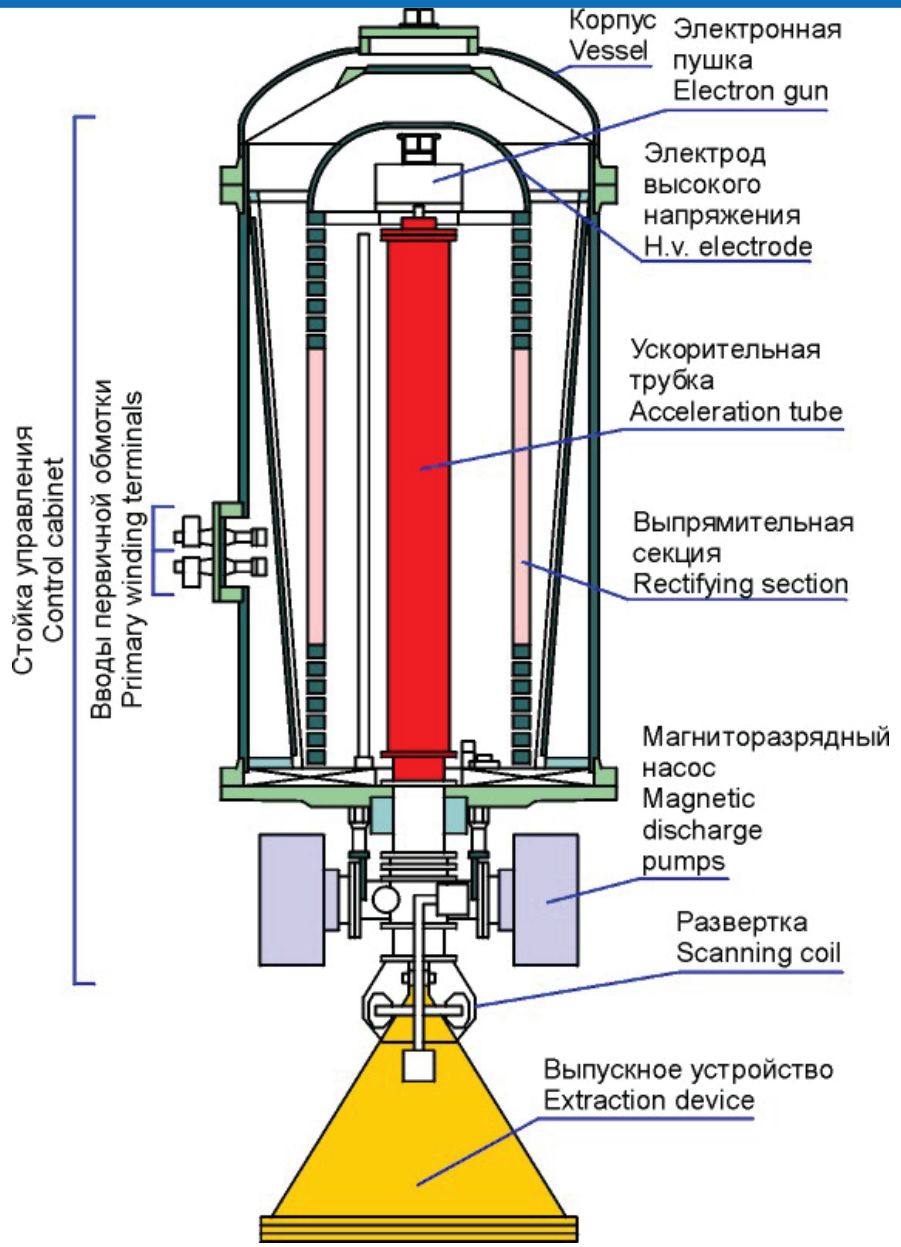
Cable handling system for ELV accelerator in China

ELV accelerators are operating at LG cable Korea

Cable irradiation factory (Kolchugino, Russia)

2 In & 2 Out wires treatment by one ELV accelerator in JSC "Electrocable Works, Kolchugino" Speed of each line – 400 m/min

Accelerator design



The composition includes: Automated control system, Power supply, Gas system, Water cooling system

Parameters of the ELV Accelerators

- BINP proposes a number of electron accelerators of the ELV-type covering the energy range from 0.4 to 3 MeV with a beam of accelerated electrons of up to 130 mA and maximum power of up to 100 kW. Special case is 1 MeV 400 kW beam power electron accelerator ELV 12. High energy efficiency of accelerator is 60- 80%. All models have similar concept but differ in overall dimensions, length of accelerator tube, and the number of high-voltage rectifying sections. This makes it easy to adapt accelerators to the requirements of technology. Accelerators are continuously modified while saving the modification. So the power of the ELV-4, ELV-6, ELV-8 accelerators was increased to 100 kV. The system of automated control of accelerators and communication with technological lines is constantly developing.

	Energy range, MeV	Beam power, kW	Maximum beam current, mA
ELV-0.5	0.4-0.7	25-65	50-130
ELV-1	0.4-0.8	25	50
ELV-3	0.5-0.7	50	100
ELV-4-1,5	1.0-1.5	100	67
ELV-4-1	0,8-1	100	100
ELV-6	0.8-1.2	100	100
ELV-6M	0.75-0.95	160	200
ELV-8	0,8-2.5	100	50
ELV-12	0.6-1.0	400	500
ELV-15	1,5-3,0	100	50

ELV-15 Accelerator

ELV-8 has an energy range from 0.8 MeV to 2.5 MeV, a beam current of 50 mA, and a power of 100 kW.

ELV-15 has an energy range from 1,5 MeV to 3 MeV, a beam current of 50 mA, and a power of 100 kW.

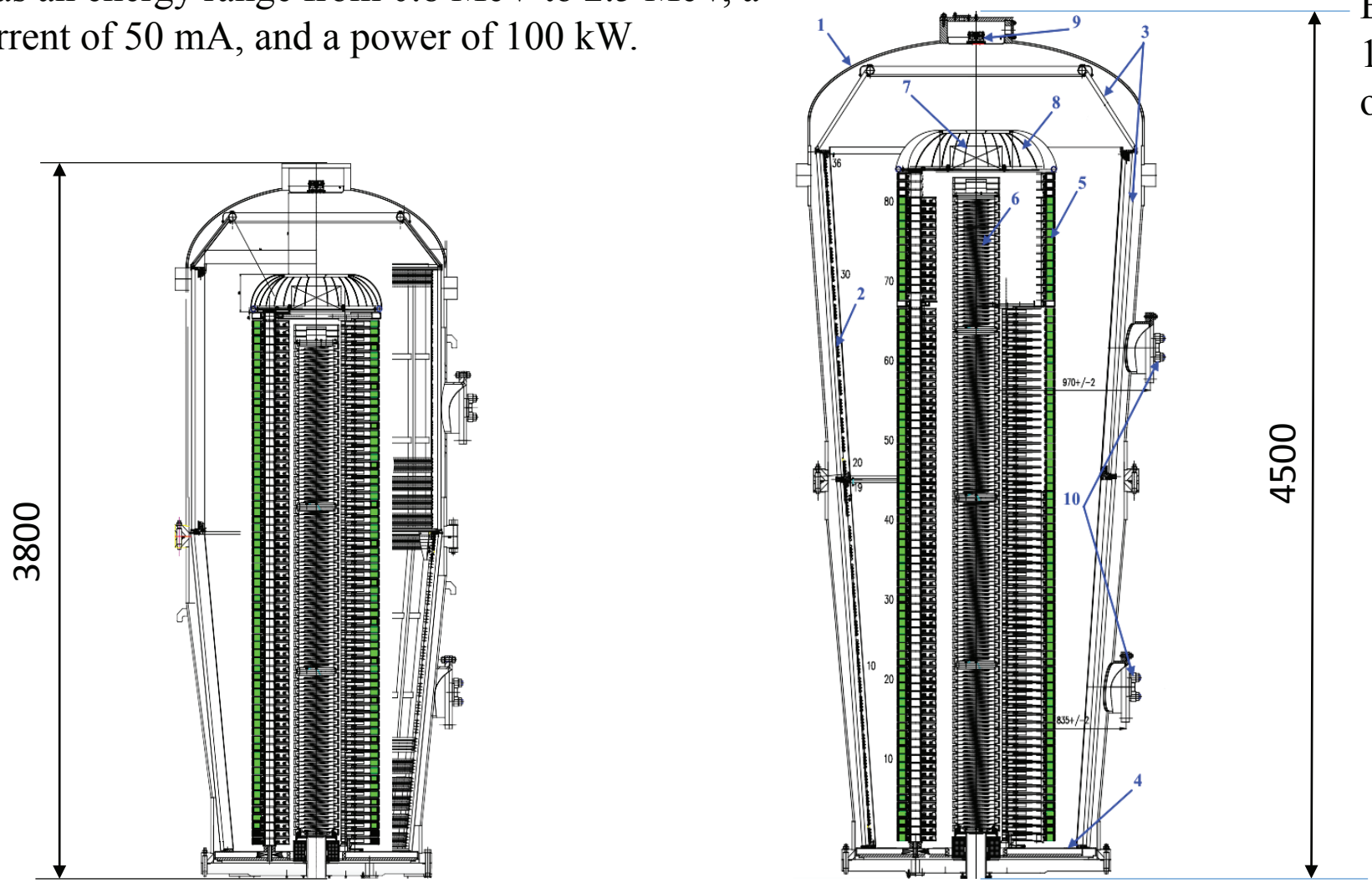


Figure 1 - Rectifiers ELV-8 (left) and ELV-15 (right)

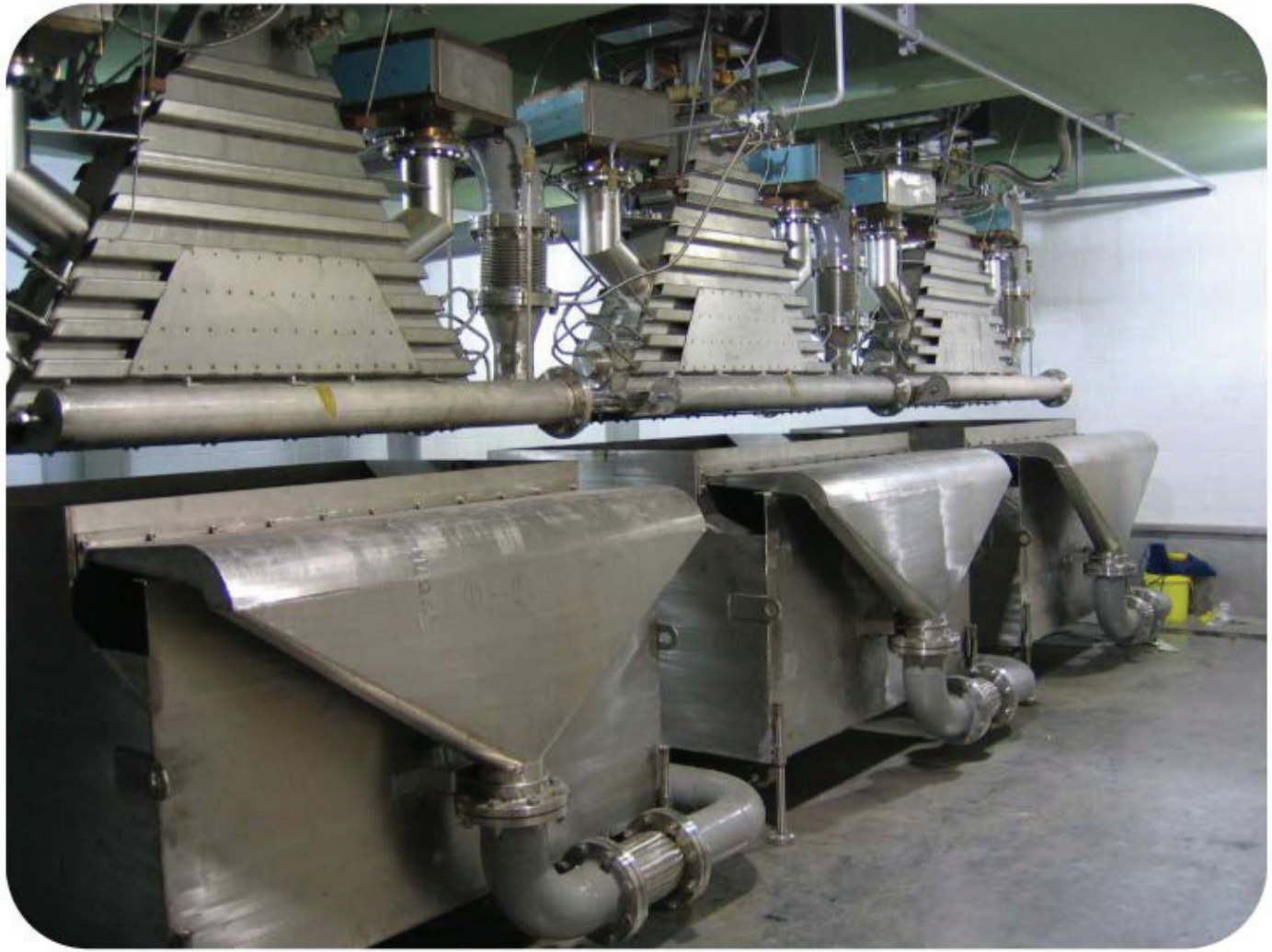
1 - vessel; 2 - primary winding; 3.4 - magnetic circuits; 5 - rectifier sections; 6 - accelerating tube; 7 - injector control unit; 8 - high voltage electrode; 9 - optical channels for injector control; 10 - primary winding terminals.

ELV-12 Accelerator

The energy range from 0.6 to 1 MeV. Beam current 500 mA. Beam power 400 kW.

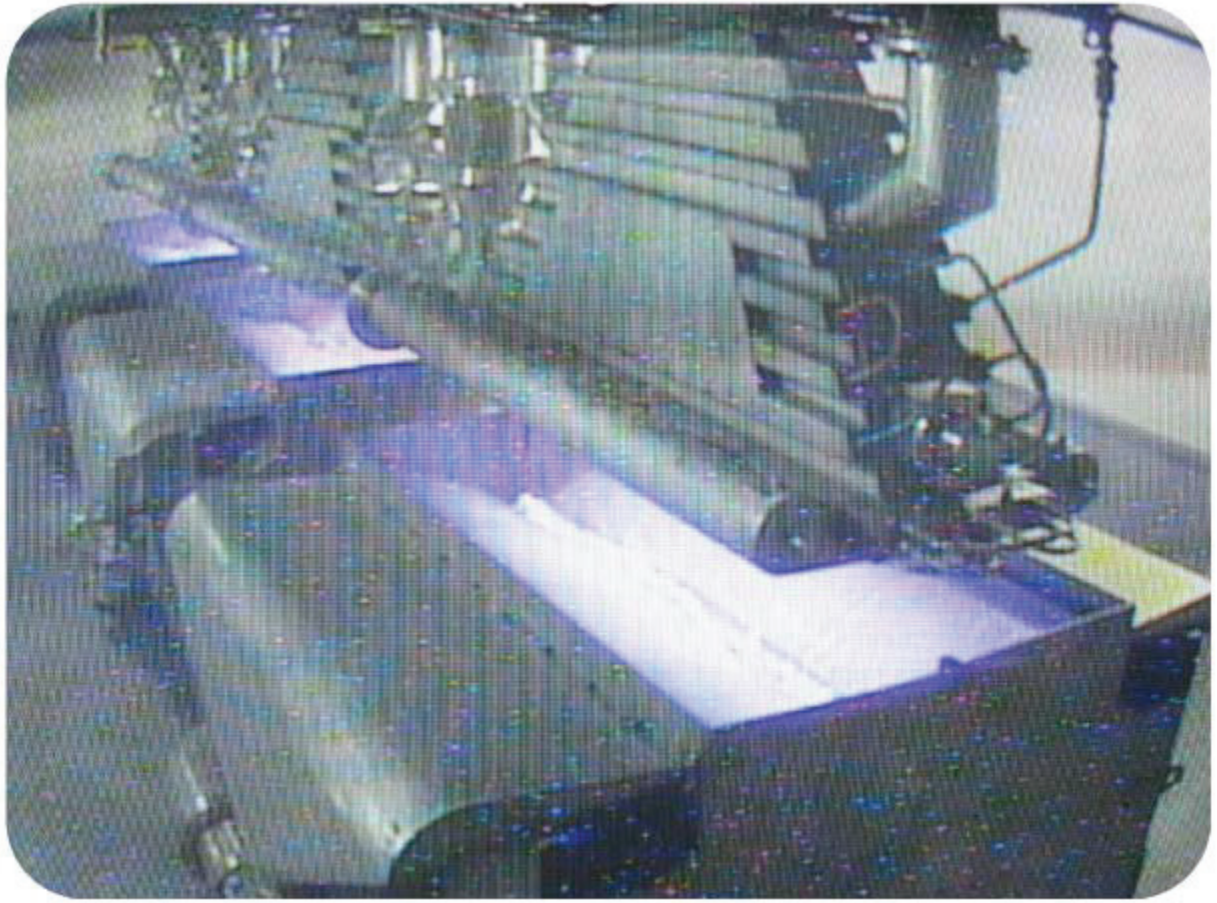
http://www.inp.nsk.su/sites/promusk/eng

Reaction hall ELV-12 accelerator in Dyetec (Taegy)



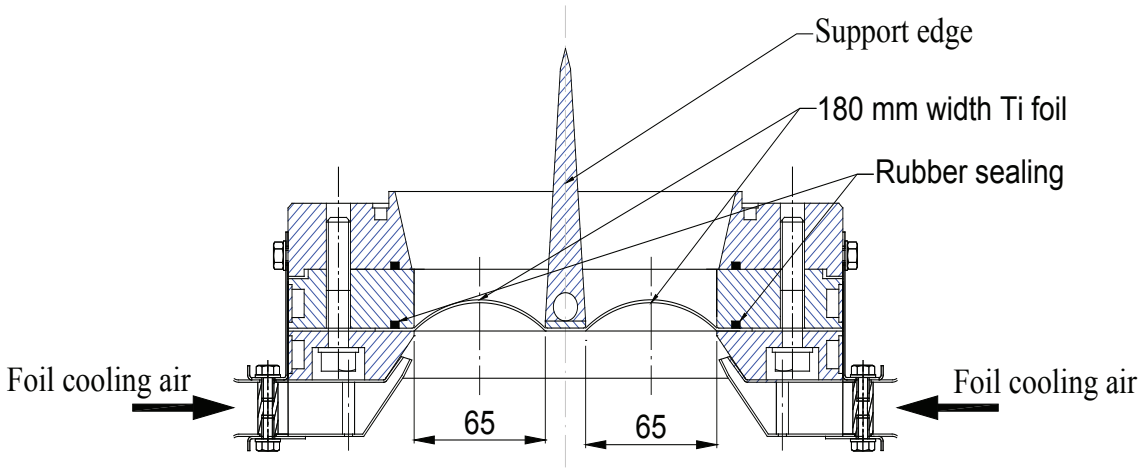
http://www.inp.nsk.su/sites/promusk/eng

ELV-12 Accelerator



Irradiation treatment process. luminescence of water during irradiation.

Local shield accelerator ELV-0.5



ELV-0.5 Accelerator, 0.5 MeV x 130 mA, Taiyuan, China. The radiation shield is open and the extraction device is visible.

The window extraction device for ELV-0,5.

The accelerator in local radiation protection is also a new direction. They are especially attractive for the irradiation of films and tape materials, including industrial rubber goods.

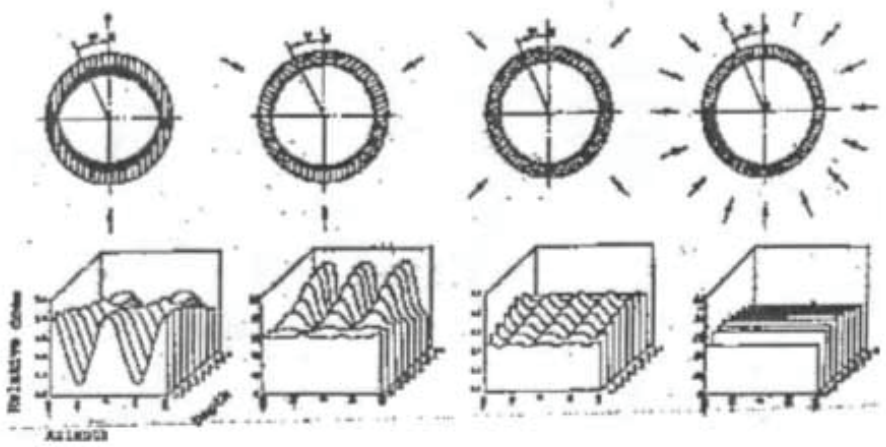
Mobile Accelerator (EB-Tech, South Korea)

- 20 kW mobile accelerator
- 30 mA beam current
- 0.7 MeV Energy
- All equipment in two trailers
- Waste water and gas treatment

http://www.inp.nsk.su/sites/promusk/eng

ADDITIONAL POSSIBILITIES

Usually, double-side irradiation of wires and cables is used. However, big size cables required high-energy accelerators. To reduce electron energy and improve the absorbed dose azimuthal inhomogeneity, four-side and ring irradiation systems were developed in BINP.



The calculated distribution of the absorbed dose of the cable in azimuth and depth at 2-sided, 3-sided, 4-sided and circular irradiation.

For four-sided irradiation with a given insulation thickness (depending on the outer diameter of the wire, and especially for wires of large cross section), the required electron penetration depth is 2-4 times less than for bilateral irradiation, which leads to a decrease in the required electron energy by 1.5-2.5 times . This greatly simplifies and reduces the cost of the accelerator used.

4-side irradiation system

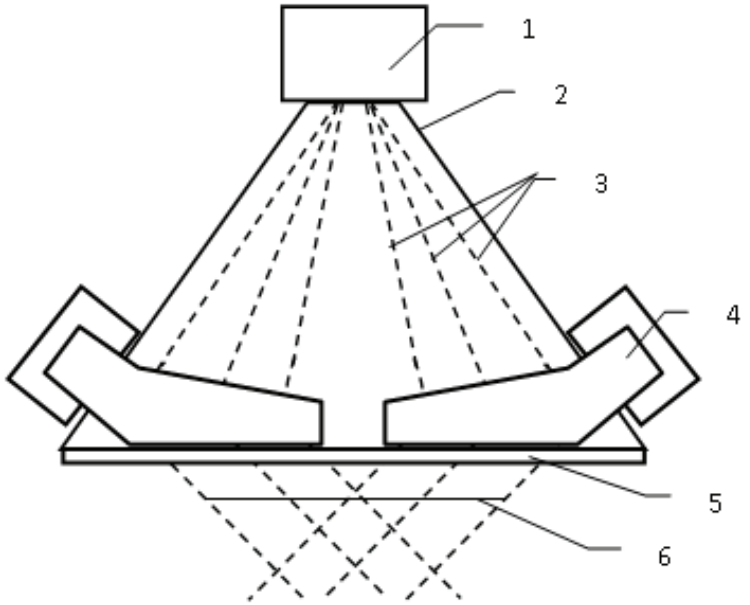


Fig.1. Schematic diagram of the four-sided irradiation system: 1 - scanner system together with shift magnet; 2 - extraction chamber; 3 - electron trajectories; 4 - turned magnet; 5 - extraction window; 6 - irradiation area.

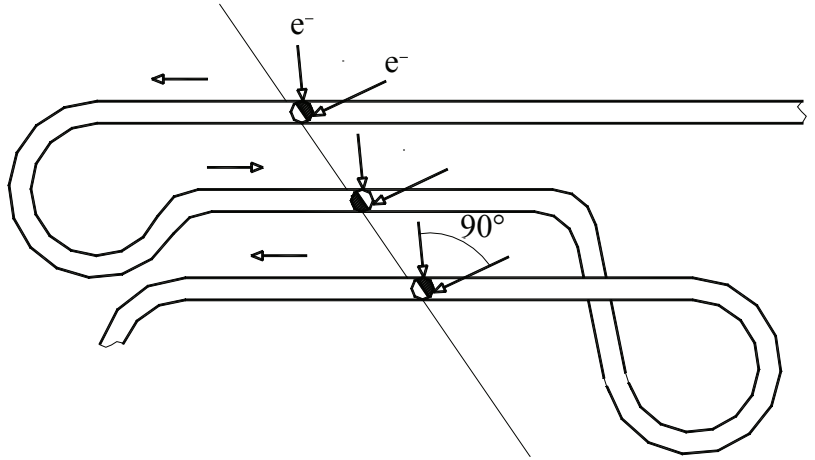
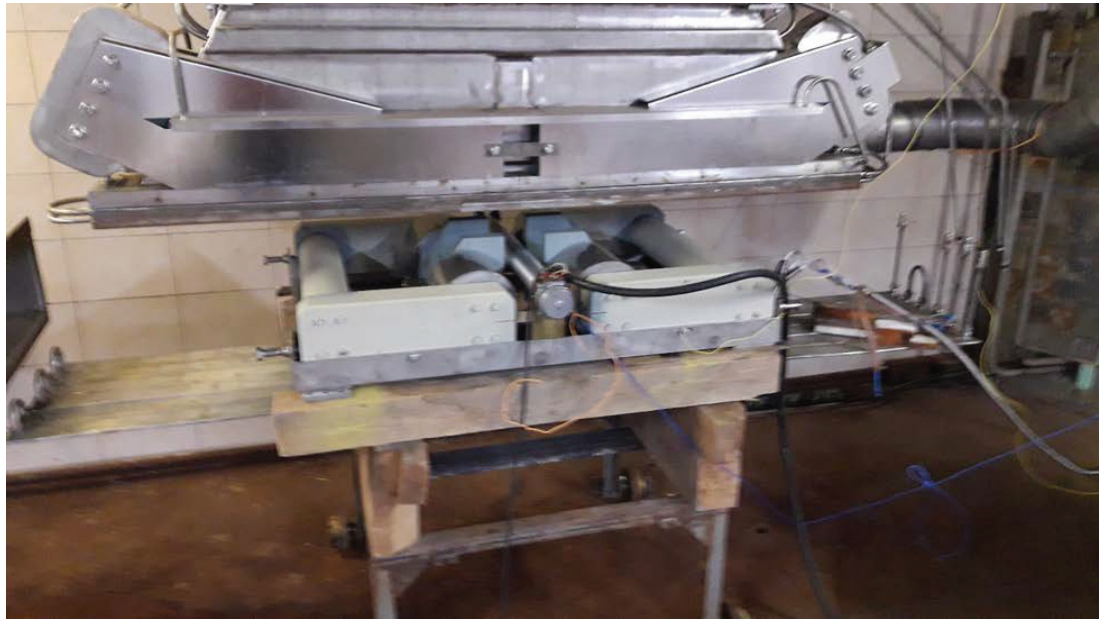
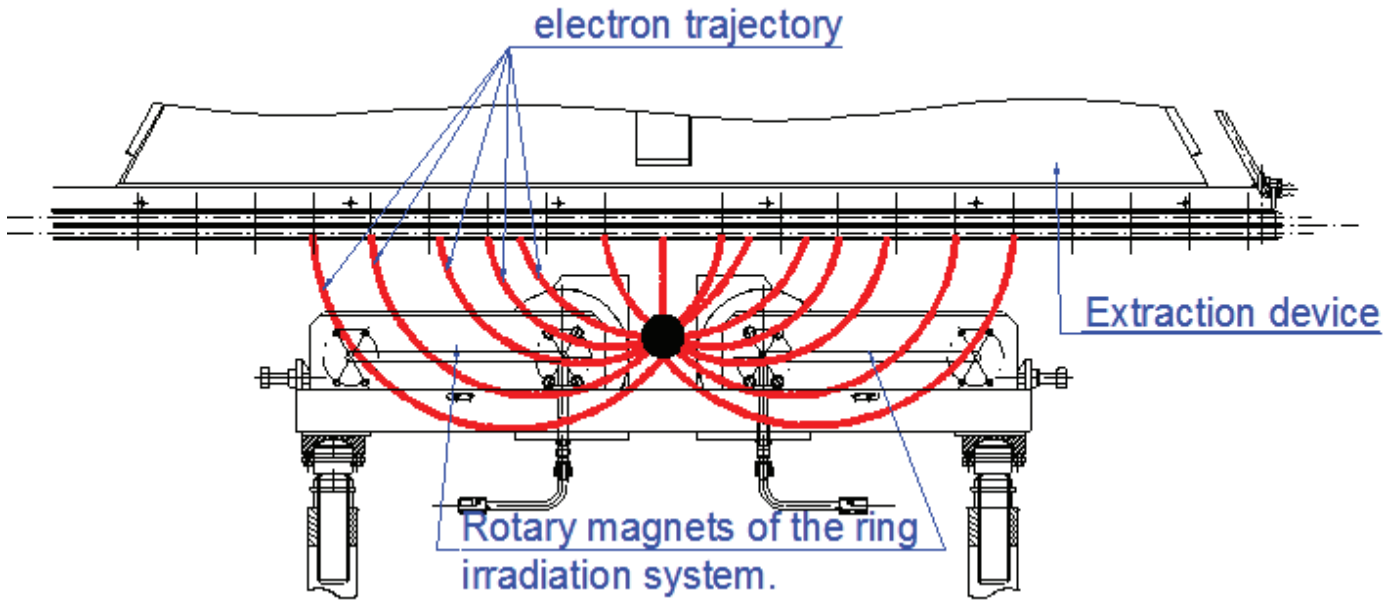


Fig.2. Principle of fore sides irradiation

The operation principle relies upon deviation of an electron beam by a magnetic field. The electron beam being accelerated pass thru scanning system results to forming rectangular raster. Further being effected by constant transversal field of turn magnets electron beam deviated on some angle (see Fig. 1). Shape of magnet's poles and a magnetic field force are selected so that the electrons deviated on an angle of 45° symmetrically of the extraction device axis, with irrespective of a place of an entrance. Being transported through an irradiation zone a cable orientation is changed for 180° on each pass, thus four-sided irradiation is occur (see Fig.2).

Ring irradiation system





Treatment of large cables (up to 60 mm in diameter) can be done by using the ring irradiation system. Cable is passing only 1 time through irradiation area

Main application of ELV Accelerators

- Modification of polymer products
- Modification of the polyethylene insulation for the production of thermoresistant wires and cables 0.5-120 mm^2 with the capacity of up to 200 m/min
- The production of heat shrinkable pipes, films and bands with the capacity of up to 1000 kg/h
- The production of prepregand gel
- The production of artificial leather and rubber-technical products with the capacity of up to 1000 m/h
- Curing lacquer-paint coatings on different bases for the building industry of up to 500 m2/h

Concentrated beam extraction to atmosphere

Accelerator parameters: Energy 1.4 MeV, Beam current 50 mA, Beam power 70 kW. The beam diameter at the exit from the extraction device is 2,5 mm.

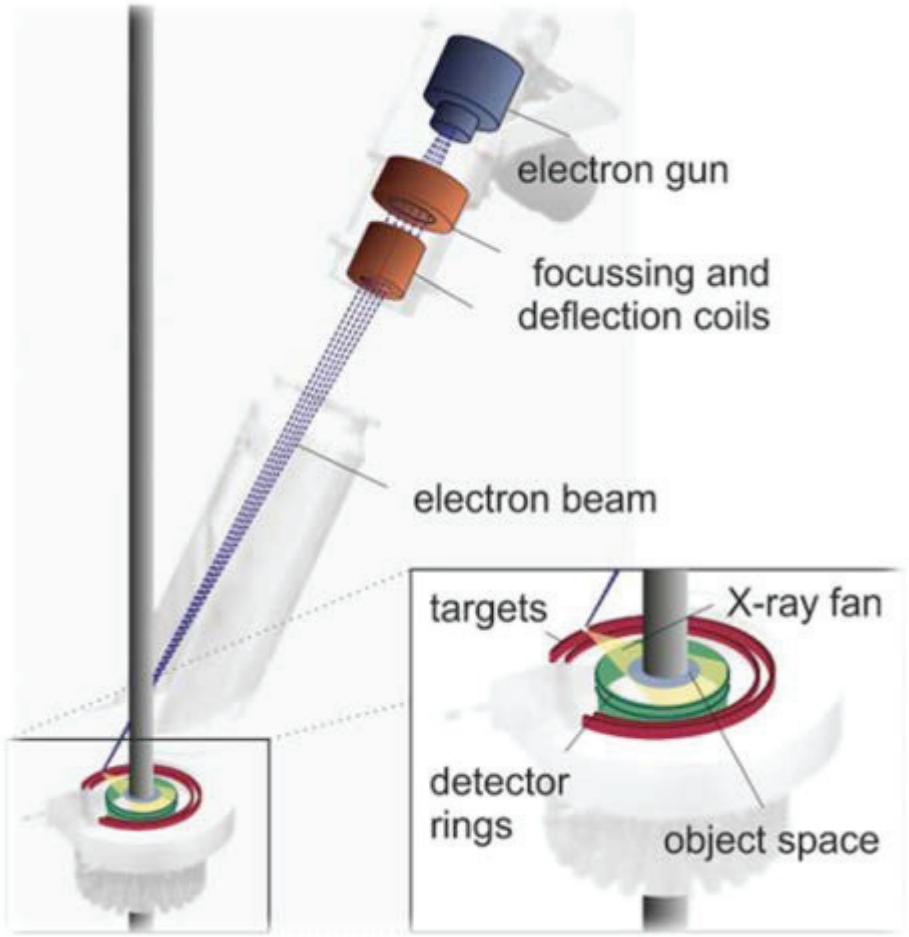
Producing of SiO2 nano-powder

Evaporation of quartz sand

Productivity – tens killograms per hour

HECToR (Helmholtz-Zentrum Dresden, Germany)

ELV accelerators are widely used for scientific purposes. For example High Energy Computed Tomography Scanner In Helmholtz-Zentrum Dresden-Rossendorf (Germany, Dresden)



http://www.inp.nsk.su/sites/promusk/eng

Collaboration with Shanxi Yitaike Electrical Equipment

CELV 壹泰科 壹泰科电工设备

Taiyuan, China

- 27 accelerators are installed in China
- Full set (Shield design, Accelerator, Technology line)

http://www.inp.nsk.su/sites/promusk/eng

Collaboration with EB-Tech

eb TECH
이비테크(주)

Daejeon, South Korea

- 20 accelerators are delivered to customers in South Korea, China, Turkey, Malaysia

We are ready for collaboration.
Thank you for attention!