



High Power Electron Accelerators for Industrial and Environmental Application

BINP, Novosibirsk, Russia

2010



- B INP develops and manufactures ELV accelerators since 1970.
- These accelerators initially were developed for application in industries



By now over 120 ELV accelerators had been delivered inside Russia and abroad. They are well known in the world. ELV accelerators are the most popular accelerators not only in former USSR but in China and Korea also.

- Total operation time of these accelerators is over 800 accelerator-years



INP proposes a series of electron accelerators of the ELV-type covering:

- the energy range 0.4 - 2.5 MeV with a maximum beam current up to 100 mA and maximum beam power 100 kW
- the energy range 0.6 - 1.0 MeV with a maximum beam current up to 0.5 A and maximum beam power 400 kW

Parameters of the ELV accelerators

	Energy range, MeV	Beam power, kW	Maximum beam current, mA
ELV-mini	0.2-0.4	20	50
ELV-0.5	0.4-0.7	25	40
ELV-1	0.4-0.8	25	40
ELV-2	0.8-1.5	20	25
ELV-3	0.5-0.7	50	100
ELV-4	1.0-1.5	50	100
ELV-6	0.8-1.2	100	100
ELV-6M	0.75-0.95	160	200
ELV-8	1.0-2.5	90	50
ELV-12	0.6-1.0	400	400
Torch	0.5-0.8	500	800



Parameters of typical delivered accelerator

Last 30 signed contracts required:

28 accelerator with power 100 kW

2 accelerator with power 50 kW.

0 accelerators with power < 50 kW

9 accelerators with max. energy 2.5 MeV

8 accelerators with max. energy 1.5 MeV

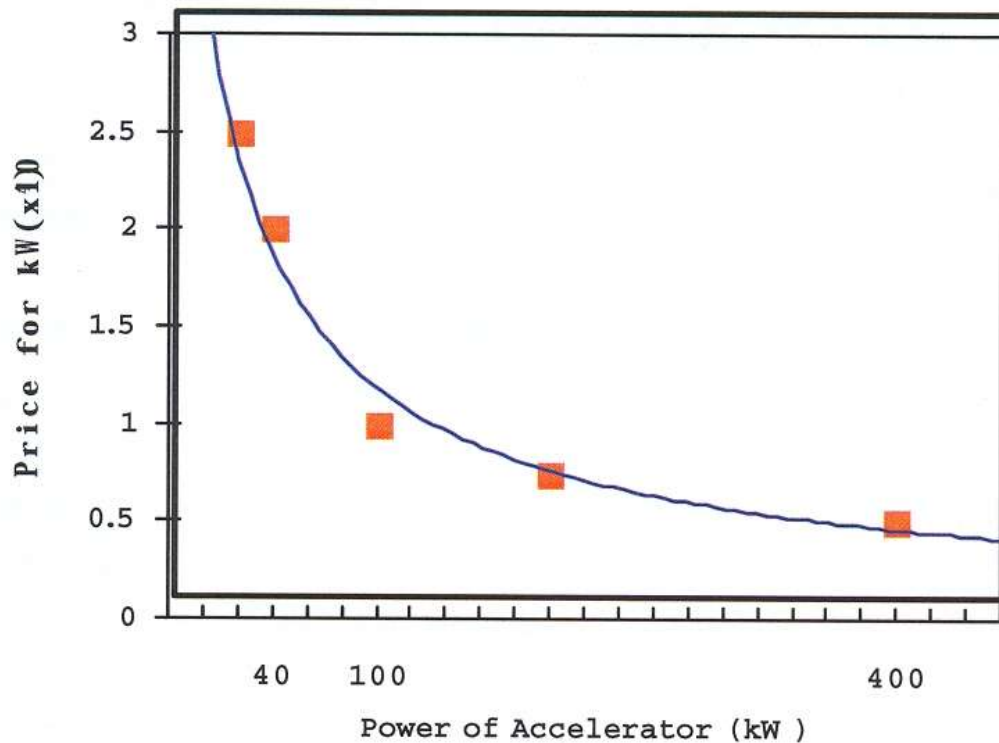
8 accelerators with max. energy 1.0 MeV

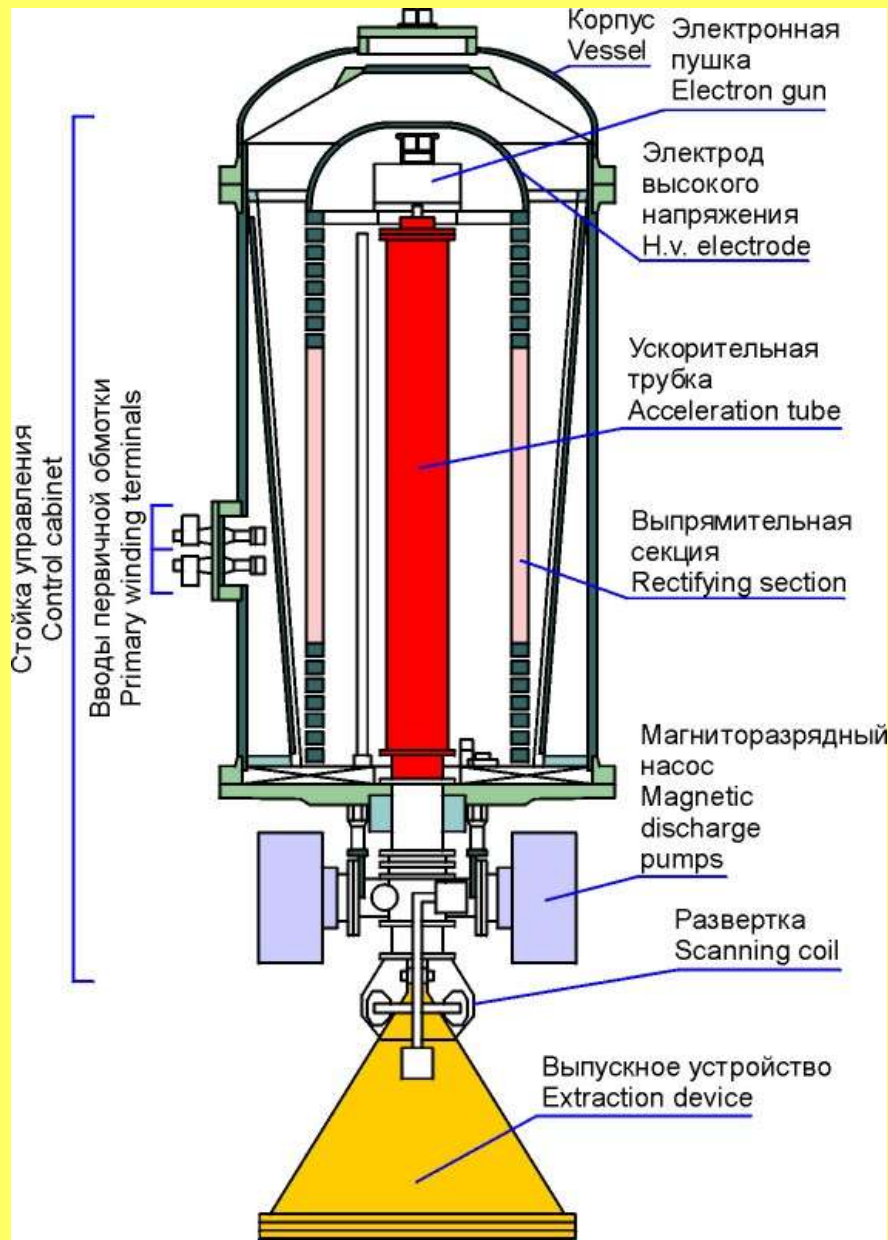


Delivery place of last 30 accelerators:

- 1 accelerator - India
- 1 accelerator - Kazackstan
- 2 accelerators - Russia
- 3 accelerators - Korea
- 23 accelerators - China

Power (kW)	Price (M\$)	Cost for 1 kw (10^4 \$)
20	0.5	2.5
40	0.8	2
100	1.0	1.5
200	1.5	0.75
400	2	0.5





The ELV accelerators are designed with use of the unified systems and units enabling thus to adapt them to the any specific requirements of the customer by the main parameters such as the energy range, beam power, length of extraction window, etc.



H/V Generator: Rectifying Sections Column



Accelerating tube and Primary winding





ELV-8 accelerator after assembling of H/V rectifier





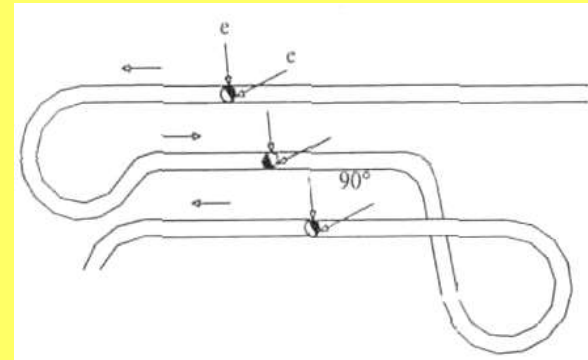
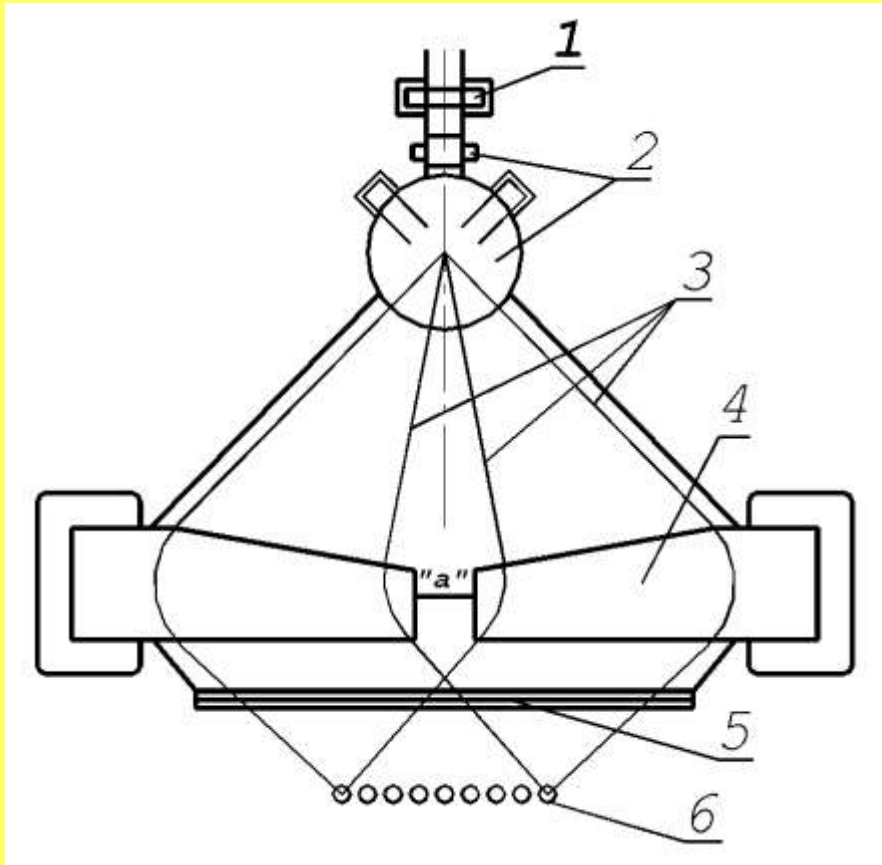
ELV- 8
accelerator



Operator controls accelerator through PC



4-side irradiation system



Extraction device equipped with 4-side irradiation system



Synchronization of accelerator and technological equipment

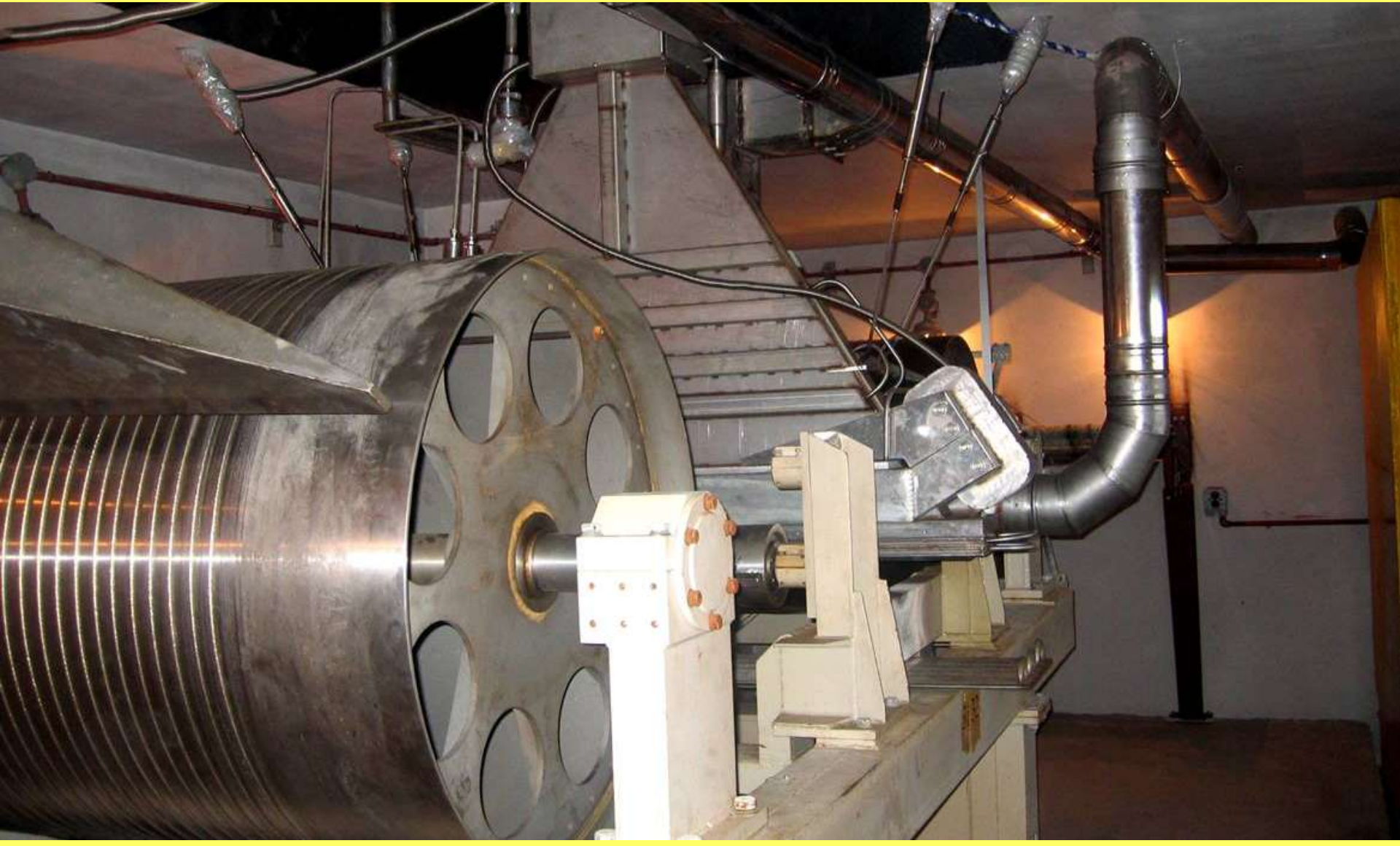
- Accelerator is used only together with technology equipment. Control systems of accelerator and technologies are combined.
- As accelerator control code are master code, in spite of technology control code can be more complicate.
- Parameters of processing are controlled from accelerator control console.
- Usually one accelerator is used for some pay off and take up devices simultaneously.

Monitor for technology hall

Ускоритель ЭЛВ-4
Комплекс П6

Энергия электронов, МэВ	1.15
Ток пучка, мА	30
Скорость, м/мин	225
Остаток з/г кабеля на П6, м(мин)	-3423(-15)

Underbeam transportation system



Pay off and take up devices



Irradiation chamber for film treatment



Irradiation chamber for film treatment



Building for accelerator (Russia)



Building for accelerator (South Korea)



Building for accelerator (Turkey)



China: construction of building and accelerator assembling simultaneously





Finally: everything is O.K.





99% of EB processing require the beam power less than 100 kW and only 1% need the beam power up to some Megawatts. And this 1% is very important due to environment protection.

To compete with other processes in economic evaluation, the electron beam system should consider following points:

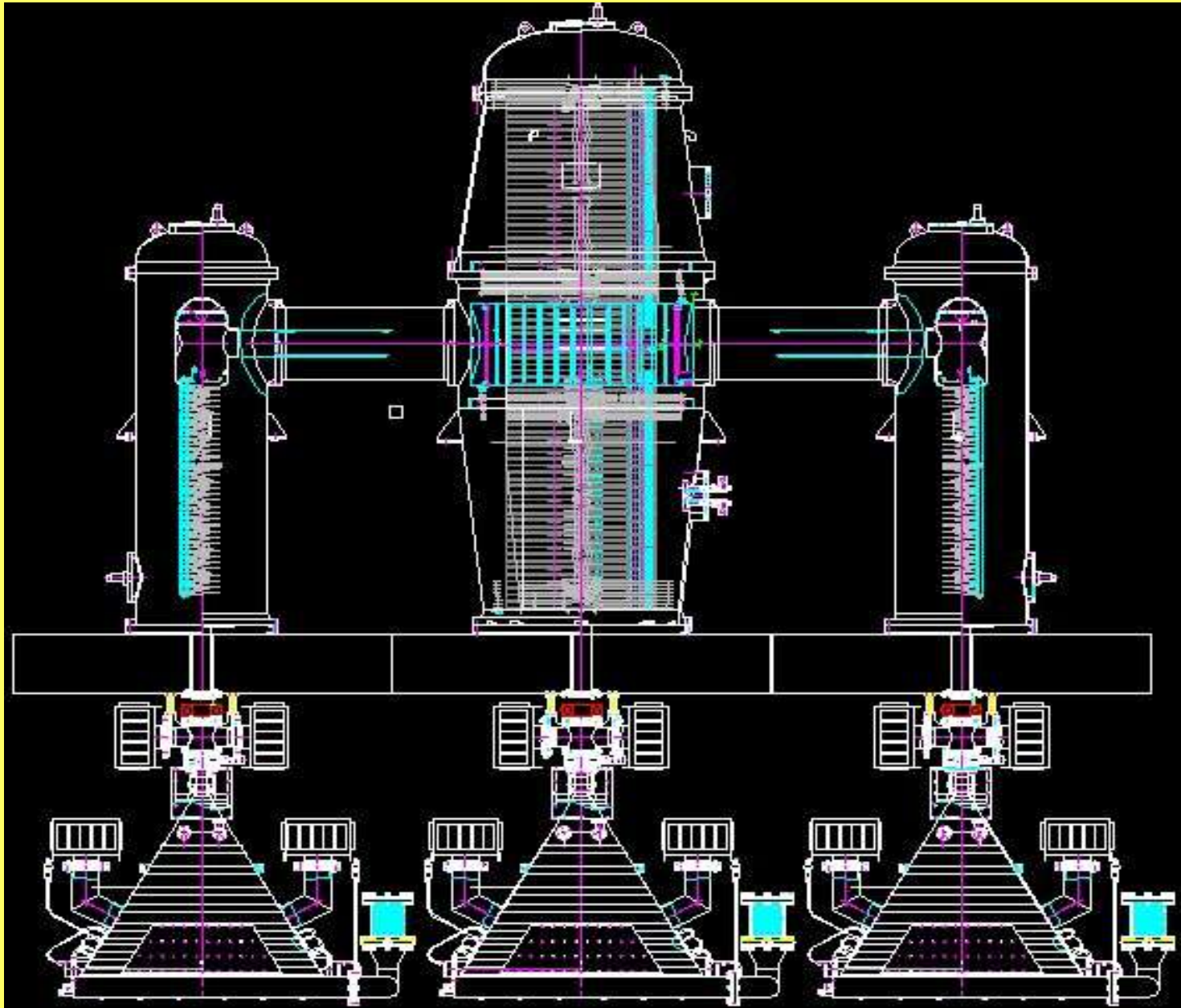
- Reduce the required doses
- Improve efficiencies
- Reduce the cost for Electron Beam facilities



Requirements to accelerators for environmental application

- Energy range 0.6 - 1.0 MeV (flue gas)
- Energy range 1.0 - 2.0 MeV (waste water)
- Power of electron beam up to some MW
- It should consist of some hundred kW units
- Efficiency – 85 – 95%
- Continuously operation
- Computer control system
- High reliability in operation

ELV-12 accelerator (1.0 MeV*400 kW)



Accelerator ELV-12 co-manufactured with EB-Tech



Budker INP

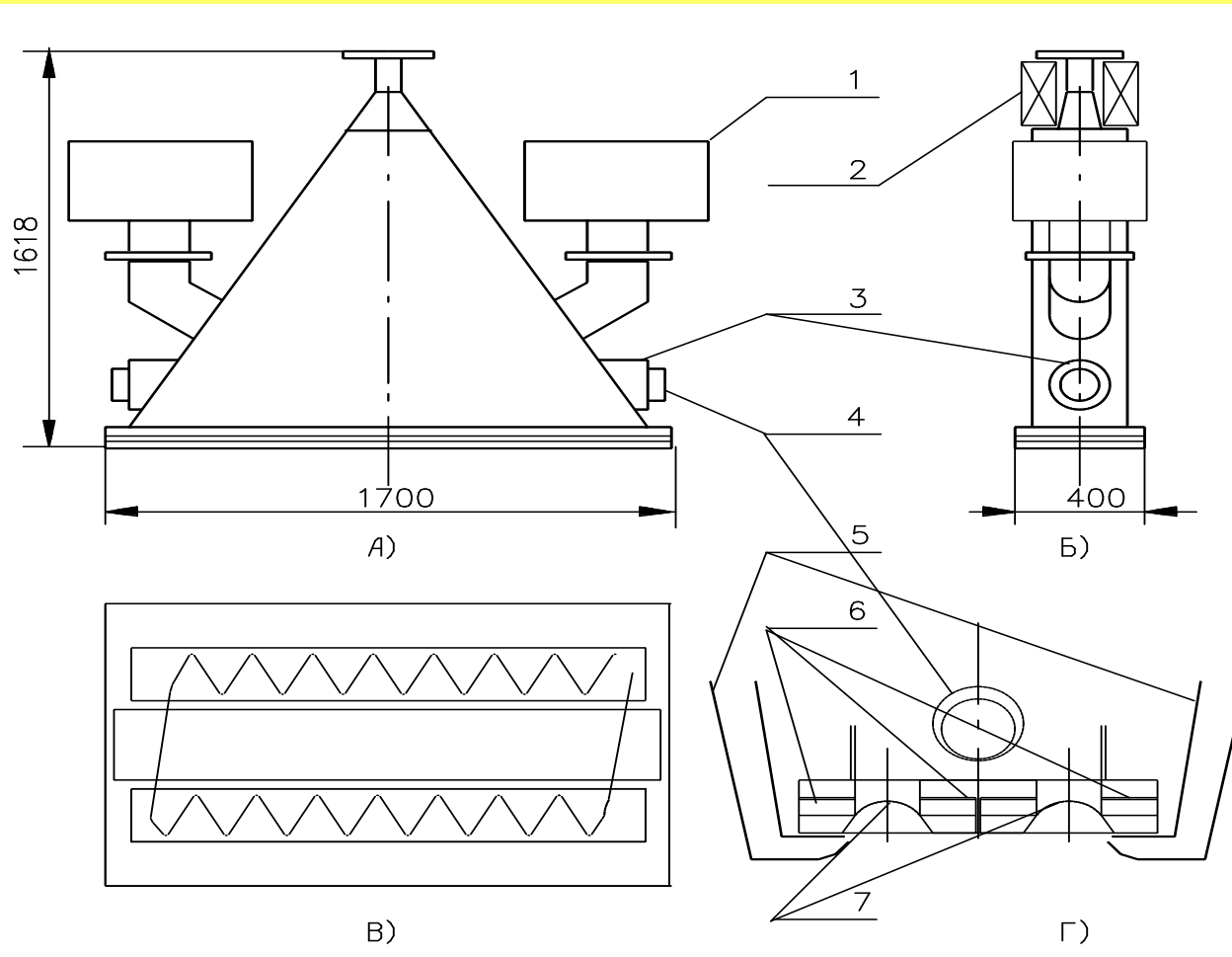


Two-window extraction device



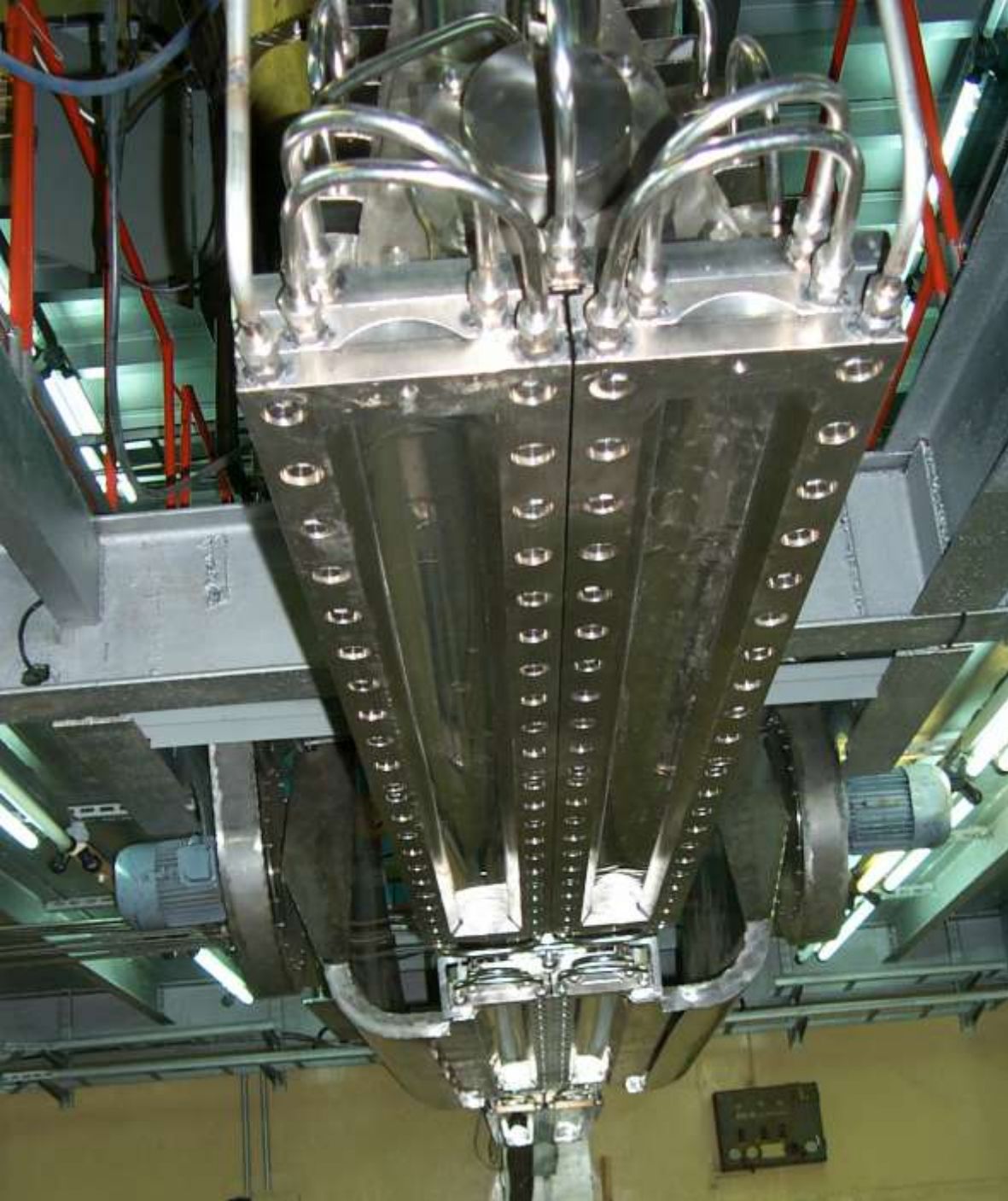
Budker INP

1—ion pumps, 2—
coils and cores of
the beam scanning
system,
3—protection
cylinder flange, 4—
protection cylinder,
5- foil blow air jet
cooling,
6- frame for
fixation of foil, 7 -
extraction foils





Budker INP



Two-window extraction device



12/1/2001



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Control system of installation for the treatment of dying waste water





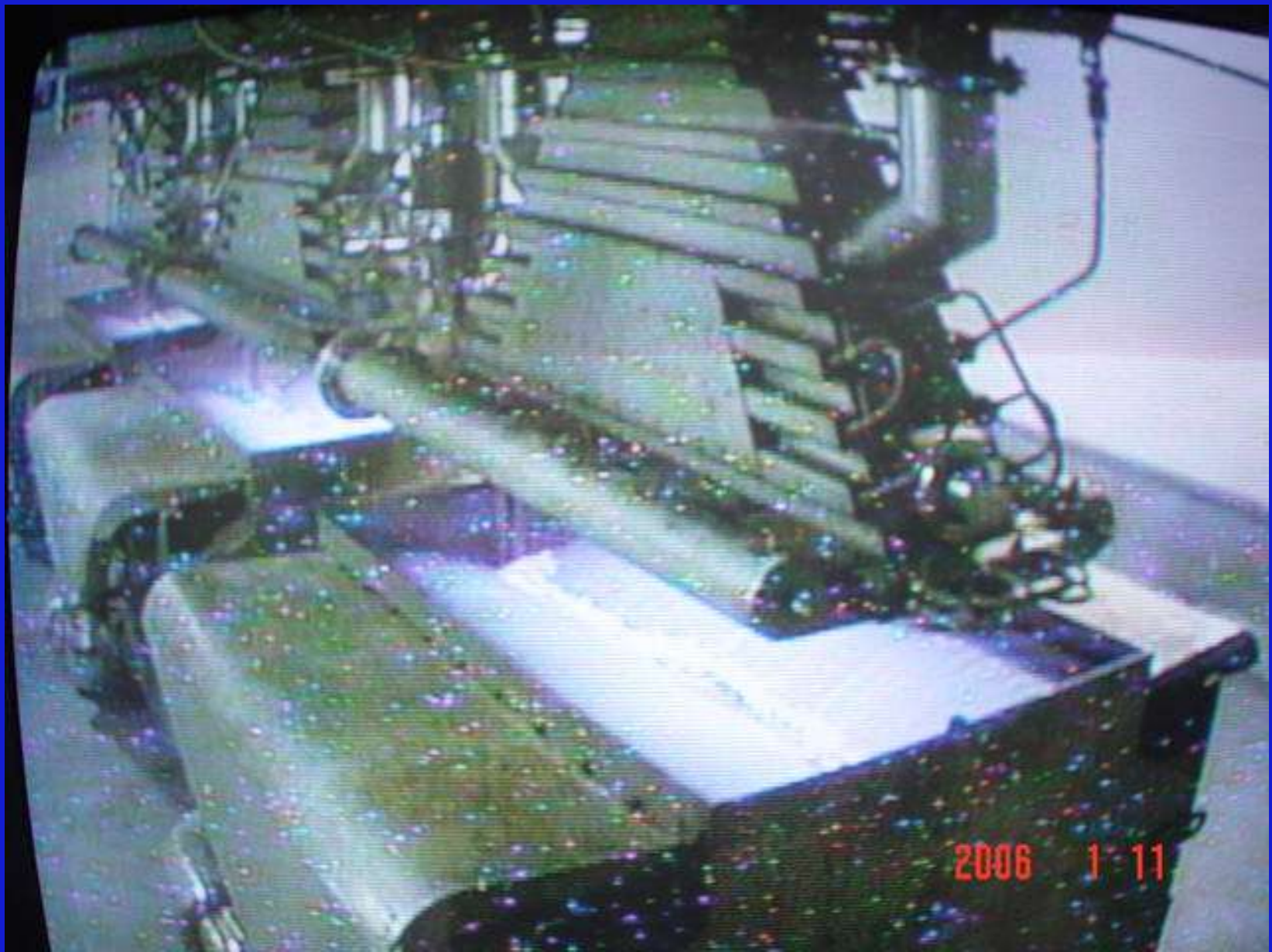
Control system
of accelerator
allows
continuously
monitoring of
the beam
position in
output window

Reaction hall of accelerator





Luminescence of water by EB

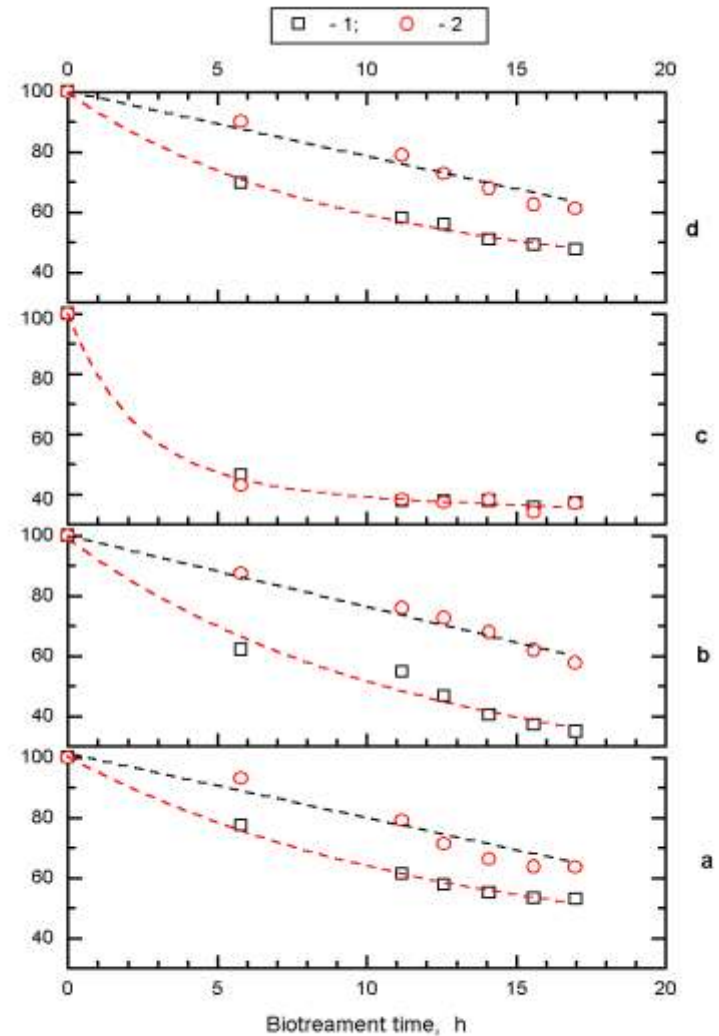


Effect of irradiation and biological treatment on wastewater parameters:

a-TOC; b-COD_{Cr}; c-COD_{Mn}; d-BOD.

1- after EB treatment

2- without EB treatment



**Location of
Pilot Plant**



Industrial plant

**Wastewater Treatment Facility in
Daegu Dyeing Industrial Complex**



Building for Accelerator ELV-4 in Dyetec (Taegy)

Building for Accelerator ELV-12 in Dyetec (Taegy)



Removal efficiency of electron beam treatment with ELV-12 accelerator

PARAMETERS	PH	BOD	COD(Mn)	COLOR
INFLUENT	12	2 000	900	1000
EFFLUENT	7	40	70	200

Productivity: 10 000 M³/day

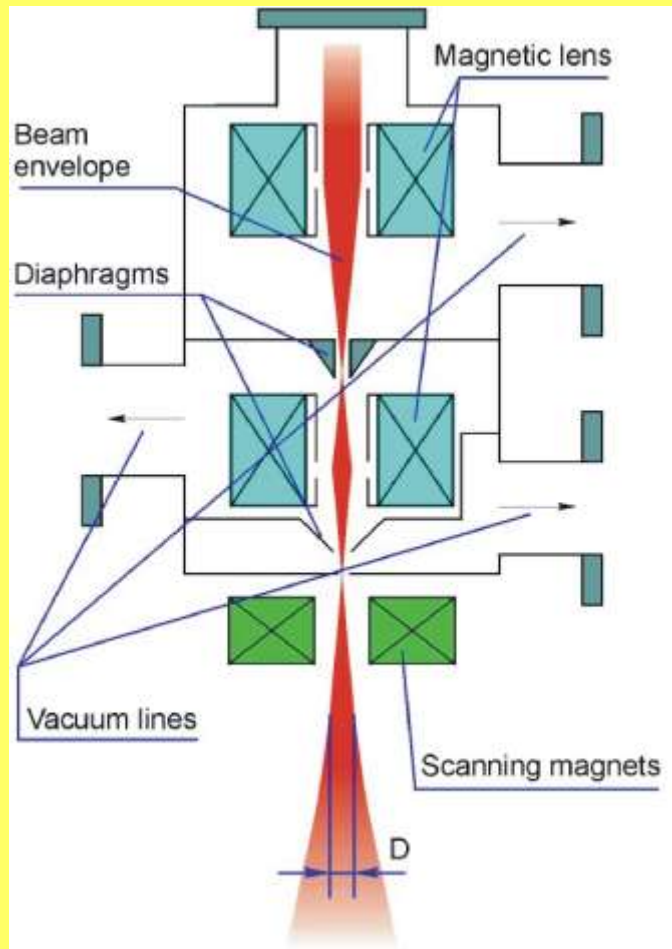
Additional activity 2009-2010

- Producing of nanopowders and nanotubes by focused electron beam
- Movable electron accelerator

Device for extraction of focused electronbeam into atmosphere



B u d k e r I N P

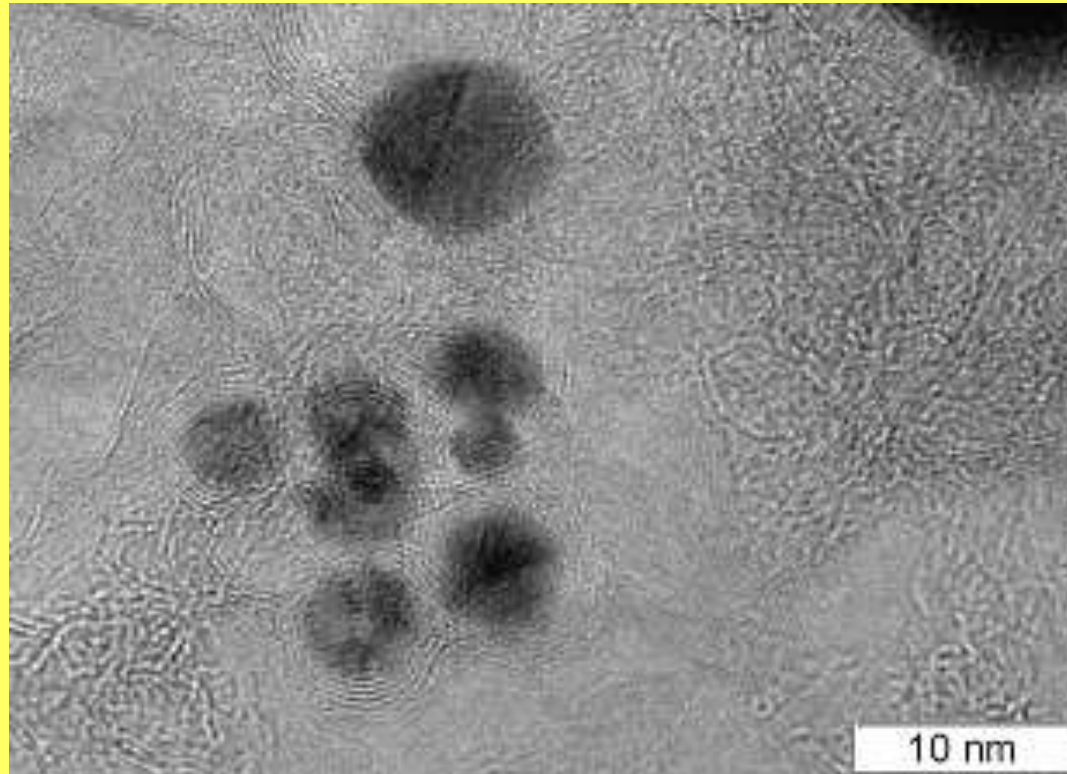


Producing of nanopowders

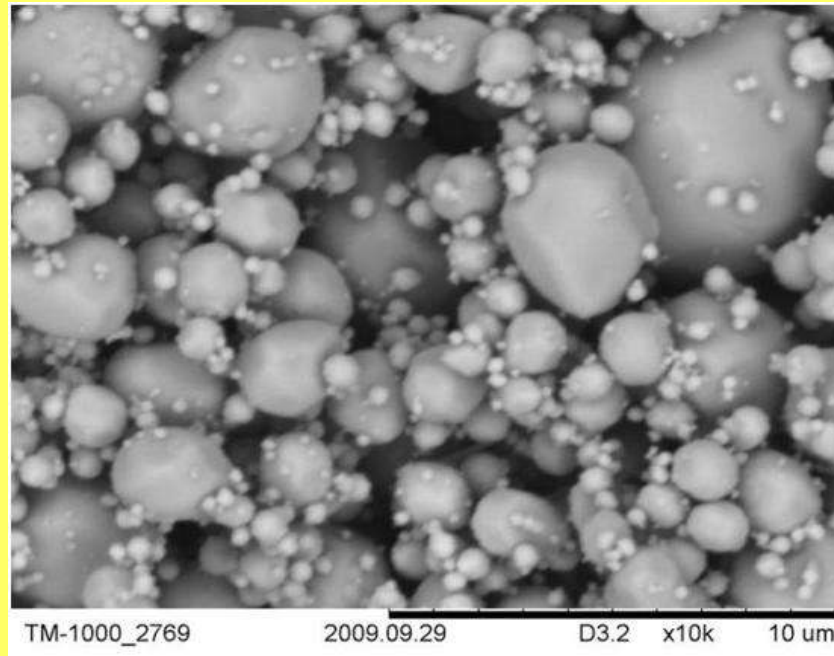
There was many experiments with different institutions. The new nanopowders were obtained:

WC, W, W₂O₅, Y₂O₅, Bi, Bi₂O₃,

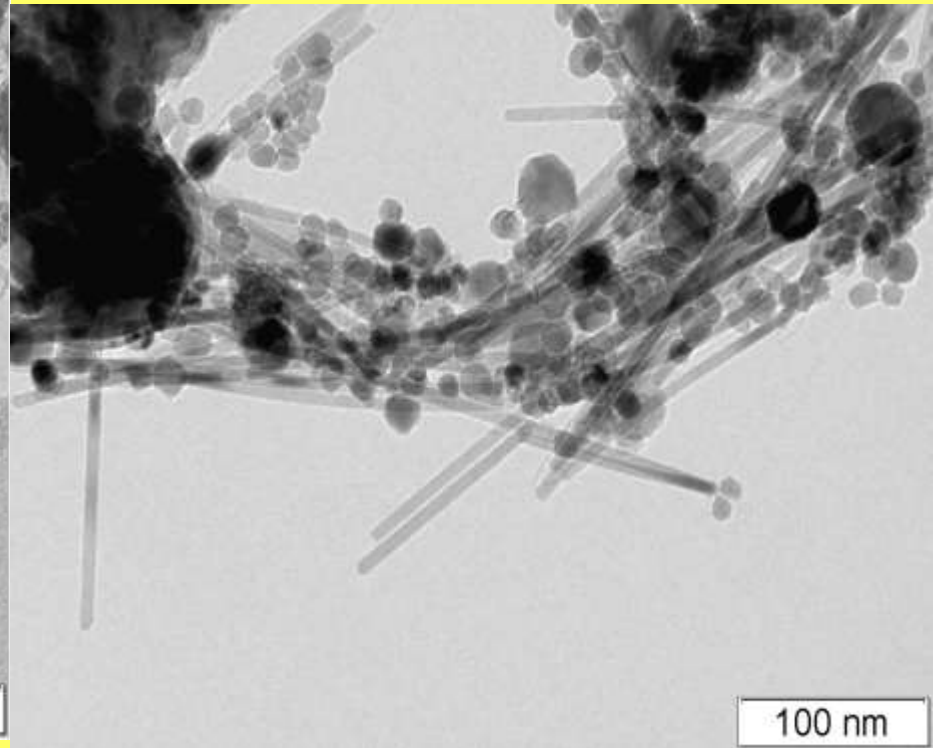
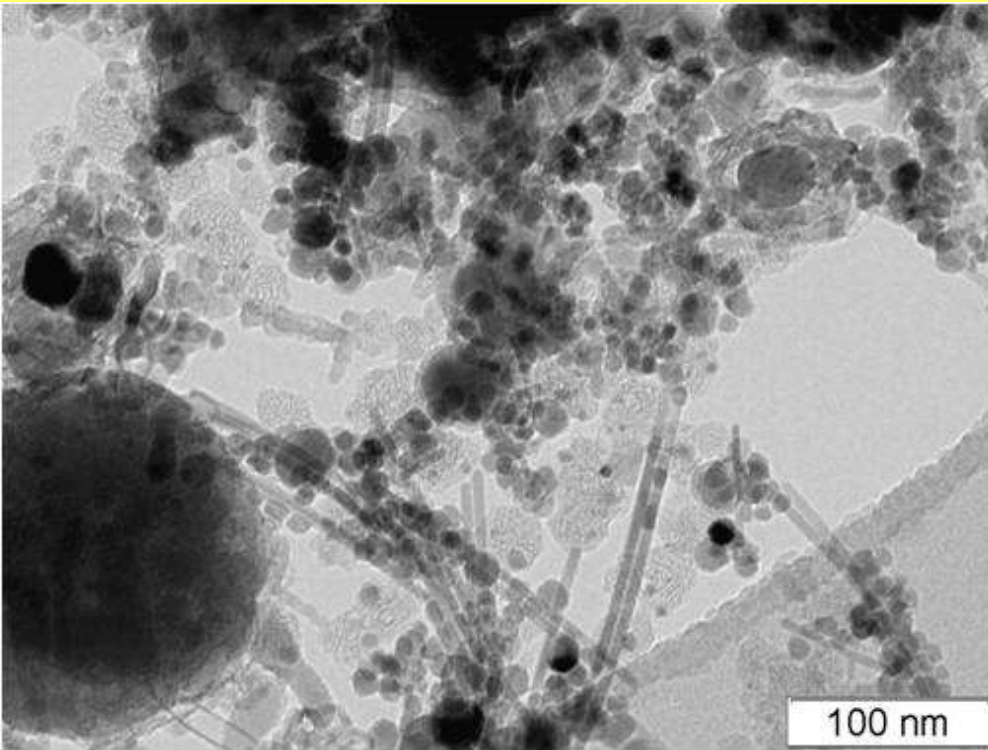
Nanoparticles of W, TEM picture



Bi nanopowder



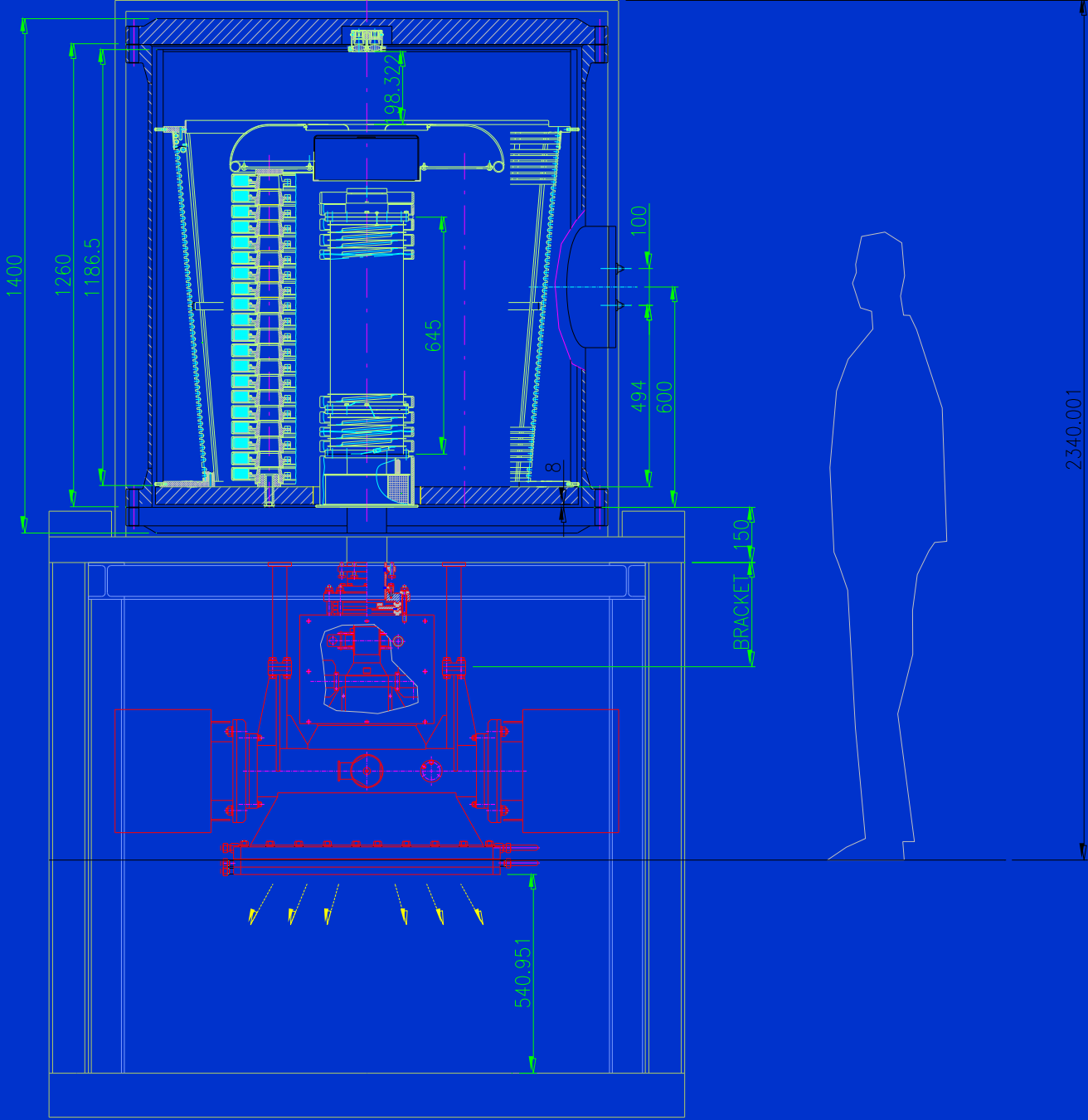
TEM picture of nanotubes.



Movable accelerator was developed by BINP together with firm EB-TECH from South Korea.
Accelerator before transportation



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Accelerator parameters:
Max. energy - 0.65 MeV
Max. Current – 35 mA
Purpose of accelerator:
Electron beam treatment
of waste water



Irradiation chamber is open

Not so convenient for adjustment



Accelerator passed 140 km during
4 hours. After transportation it was put in
operation after 15 min



Conclusion

- ELV accelerators according to the set of parameters and possibilities for users are one of the best in the world for today.
- We are open for collaboration. From consulting to delivery. You are welcome

Thank You
for attention