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

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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

<table>
<thead>
<tr>
<th>Parameters</th>
<th>ILU-6</th>
<th>ILU-8</th>
<th>ILU-10</th>
<th>ILU-14(12*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron Energy</td>
<td>1.7-2.5 MeV</td>
<td>0.8-1 MeV</td>
<td>4-5 MeV</td>
<td>7.5 – 10 MeV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5-7.5 MeV*</td>
</tr>
<tr>
<td>Beam Power</td>
<td>20 kW</td>
<td>20 kW</td>
<td>50 kW</td>
<td>100 kW</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60 kW*</td>
</tr>
<tr>
<td>Local Shield Weight</td>
<td>76 t</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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
- Avg. 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
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

- Operating frequency, MHz: 176
- Full efficiency, %: 26
- Electron energy, MeV: 7.5-10
- Modulator pulse duration, μs: 500
- Average beam power, kW: 100
- Repetition rate, Hz: Up to 50
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

<table>
<thead>
<tr>
<th>Variant</th>
<th>Output electron energy</th>
<th>Pulse repetition rate</th>
<th>Beam pulsed current</th>
<th>Beam average current</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.2 MeV</td>
<td>35 Hz</td>
<td>420 mA</td>
<td>7 mA</td>
<td>64 kW</td>
</tr>
<tr>
<td>2</td>
<td>10 MeV</td>
<td>25 Hz</td>
<td>420 mA</td>
<td>5 mA</td>
<td>50 kW</td>
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</tbody>
</table>
X-ray converter

Conversion rate X-ray/E-beam power

<table>
<thead>
<tr>
<th>E(MeV)</th>
<th>Ta thickness</th>
<th>60 deg</th>
<th>360 deg</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5</td>
<td>0.9</td>
<td>13.2%</td>
<td>16.9%</td>
</tr>
<tr>
<td>5</td>
<td>0.7</td>
<td>8.3%</td>
<td>12%</td>
</tr>
</tbody>
</table>
Project of center radiation pasteurization of food based on ILU-14.
Thank you for your attention