Present status of the Rossendorf Superconducting RF Photo injector development

Jochen Teichert

Forschungszentrum Rossendorf
Zentralabteilung Strahlungsquelle ELBE
PF 510119, 01314 Dresden
J.Teichert@fz-rossendorf.de

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The radiation source ELBE – 40 MeV, 1 mA, cw linac

- First beam in April 2001
- Nuclear physics experiments are running since January 2002
- Channeling radiation since September 2003
- FEL 1 since May 2004
- FEL 2, neutron & positron beamlines planned for 2006
Rossendorf SRF Photo Gun Parameters

Normal-conducting cathode inside SC cavity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavity</td>
<td>Niobium 3+½ cell (TESLA Geometry)</td>
</tr>
<tr>
<td></td>
<td>Choke filter</td>
</tr>
<tr>
<td>Operation</td>
<td>T = 1.8 K</td>
</tr>
<tr>
<td>HF frequency</td>
<td>1.3 GHz</td>
</tr>
<tr>
<td>HF power</td>
<td>10 kW</td>
</tr>
<tr>
<td>Electron energy</td>
<td>9.5 MeV</td>
</tr>
<tr>
<td>Average current</td>
<td>1 mA</td>
</tr>
<tr>
<td>Cathode</td>
<td>Cs₂Te</td>
</tr>
<tr>
<td></td>
<td>thermally insulated, LN₂ cooled</td>
</tr>
<tr>
<td>Laser</td>
<td>262 nm, 1W</td>
</tr>
</tbody>
</table>
# Rossendorf SRF Photo Gun Parameters

## Planned Operation Modes and Beam Parameters

<table>
<thead>
<tr>
<th></th>
<th>ELBE</th>
<th>High Charge</th>
<th>BESSY-FEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse Frequency</td>
<td>13 MHz</td>
<td>≤1 MHz</td>
<td>1 kHz</td>
</tr>
<tr>
<td>Bunch Charge</td>
<td>77 pC</td>
<td>1 nC</td>
<td>2.5 nC</td>
</tr>
<tr>
<td>Bunch Length (FWHM)</td>
<td>5 ps</td>
<td>20 ps</td>
<td>50 ps</td>
</tr>
<tr>
<td>Peak Current</td>
<td>15.4 A</td>
<td>50 A</td>
<td>125 A</td>
</tr>
<tr>
<td>Average Current</td>
<td>1.0 mA</td>
<td>≤1 mA</td>
<td>2.5 µA</td>
</tr>
<tr>
<td>Norm trans. Emittance&lt;sub&gt;n&lt;/sub&gt; (rms)</td>
<td>1.5 µm</td>
<td>2.5 µm</td>
<td>3 µm</td>
</tr>
</tbody>
</table>
Rossendorf SRF Photogun – 3½ Cell Cavity Design

1. 3 GHz, 10 kW
optimized half cell & 3 TESLA cells

$E_{z,\text{max}} = 50 \text{ MV/m (TESLA cells)}$

= 32 MV/m (1/2 cell)

TESLA 500 specification, i.e. $E_{\text{acc}} = 25 \text{ MV/m}$ and $Q_0 = 1 \times 10^{10}$
Rossendorf SRF Gun - 3½ Cell Niobium Cavity

Niobium RRR 300 (RRR 40)
total length:
cell diameter:
NbTi flanges
3 TESLA shape cells
cathode half-cell with 12 mm hole
beam tube:
flange for 10 kW power coupler
2 HOM couplers (TESLA type)
1 pick-up
cathode side:
choke filter with pick-up
two tuners:
  half-cell tuner
  TESLA cells tuner
Rossendorf SRF Gun – Cavity warm tuning

for “field flatness” tuning a bead-pull machine and a warm tuning apparatus was built.
Rossendorf SRF Gun – Cavity warm tuning
Rossendorf SRF Gun – Cavity warm tuning

![Graph showing cavity warm tuning](image-url)
Rossendorf 3½ Cell SRF Gun - Tuning System

<table>
<thead>
<tr>
<th></th>
<th>Half cell</th>
<th>TESLA cells</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>range</strong></td>
<td>±0.25mm</td>
<td>±0.3mm</td>
</tr>
<tr>
<td><strong>resolution</strong></td>
<td>2nm</td>
<td>2nm</td>
</tr>
<tr>
<td><strong>load</strong></td>
<td>±2250N</td>
<td>±2700N</td>
</tr>
<tr>
<td><strong>frequency</strong></td>
<td>±137kHz</td>
<td>±286kHz</td>
</tr>
</tbody>
</table>

- half-cell tuner
- TESLA-cells tuner
- choke-cell setting
Rossendorf $3\frac{1}{2}$ Cell SRF Gun - Tuning System

Tuner test bench
Operation at cryogenic temperature (liquid N$_2$)
Cavity is simulated by a spring
Rossendorf 3½ Cell SRF Gun – Cryomodule design

- He & N₂ ports
- vacuum vessel
- Beam line connection
- cavity
- liquid N shield
- cathode transfer
- cathode alignment
- RF coupler port
- He vessel
- cavity alignment
Main parts have been delivered:
- vacuum vessel
- magnetic shield
- liquid N$_2$ shield
the SRF gun cryostat will be connected to the ELBE He cryoplant (220 W @ 1.8 K)

The 13 m long transfer line (1.8 K He & gas return) and the distribution box are ordered, will be installed in Dec./Jan. shut-down.
Rossendorf 3½ Cell SRF Gun – Diagnostic Beamline

Current: Faraday cups & ICTs
Energy & energy spread: C bent magnet
Transverse emittance: slit mask
Bunch length: Cherenkov radiator + streak camera
electro-optical sampling