The photoelectron gun designed to be rotationally symmetric but the observed beam has azimuthal asymmetry:

Transverse distribution

X trace space

Y trace space

Emittance vs. laser XY rms

Emittance vs. I_{main}

Bunch charge vs. laser energy

Also there was found that the simulated optimum machine parameters do not coincide with experimental data:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. accelerating gradient at the cathode, MV/m</td>
<td>60</td>
</tr>
<tr>
<td>Frequency, MHz</td>
<td>1300</td>
</tr>
<tr>
<td>Unloaded quality factor</td>
<td>~20000</td>
</tr>
<tr>
<td>Beam momentum after gun, MeV/c</td>
<td>7</td>
</tr>
<tr>
<td>RF peak power, MW</td>
<td>6.5</td>
</tr>
<tr>
<td>RF pulse duration, µs</td>
<td>≤650</td>
</tr>
<tr>
<td>Repetition rate, Hz</td>
<td>10</td>
</tr>
</tbody>
</table>

Possible origins of e-beam asymmetry

- Vacuum mirror (checked: not a reason)
- One side RF feed
- Solenoid imperfections

Check by simulations

Particle tracking simulations:

There is an RF field asymmetry and it has an influence on the beam

Optimum: I_{main} → Max B
**Gun quadrupoles**

**Experiment with two main solenoid polarities**
(Larmor angle experiment)

- Beam at the screen for **normal** polarity of the main solenoid
- Beam at the screen for **opposite** polarity of the main solenoid

The most probable place of the beam asymmetry origin

- $\alpha$ – beam Larmor angle without beam distortion
- $\beta$ – Larmor angle of the distorted beam

**Beam shape simulations by a rotational quadrupole**

1. The kick optics can be modeled as a **rotated quadrupole**
2. A rotated quadrupole near the coupler is effective at compensating for the kick, cancelling both the coupler emittance and the astigmatic focusing.

- $I_{\text{main}} = -361 \text{A}$
- $I_{\text{main}} = +361 \text{A}$

**Experiments with the gun quads**

- **Sol.pol.** = Positive
- **Sol.pol.** = Negative

**Parameters of the 2nd quad design:**
- Combination of a normal and a skew quads:
  - Gun.Q1 is the normal quad
  - Gun.Q2 is the skew quad
- Aluminum frame
- 0.56 mm copper cable
- 140 windings per coil
- 2 thermal switchers (80 degC max)
- Non-magnetic screws
- Fixed by radiation-hard cable tie
- $Q_{\text{grad}} = 0.0117 \text{ T/m} @ 1\text{A}$

**Emittance measurements with Gun Quads:**
- Gun Q1 = -0.6A
- Gun.Q2 = -0.5A

"rounder" and smaller emittance!