An Idea on Upgrade of the FLASH Gun Section

1. Present setup
2. A proposal – 0.3 m upstream shift of the gun
3. Conclusion and Outlook

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Present setup

8 mm diameter collimator
1.27 m downstream of the cathode
The position limited by the cryo-module

Dark current + 1 nC beam
(45 MV/m, $I_{\text{main}} = 278$ A)

Dark current
(45 MV/m, $I_{\text{main}} = 278$ A)

Dark current
(45 MV/m, $I_{\text{main}} = 283$ A)

Dark current
(45 MV/m, $I_{\text{main}} = 290$ A)
Present Operating Condition

Original design of the FLASH injector (K. Flöttmann and Ph. Piot, EPAC 2002)

40 MV/m gun gradient $\rightarrow$ 44 MV/m

Measurement with 3.34 Pfwd $\rightarrow$ Simulation with 44 MV/m

$P_{\text{mean}} = 4.8910$
$P_{\text{rms}} = 0.04192$

20 ps long flat-top laser profile $\rightarrow$ 5 ps rms Gaussian
A proposal

0.3 m elongation between the gun and ACC1

Distance from the cathode
- to the laser mirror: 0.66 m $\rightarrow$ 0.96 m
- to the collimator: 1.27 m $\rightarrow$ 1.57 m
- to ACC1: 2.4 m $\rightarrow$ 2.7 m
## Beam Simulation

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Present setup</th>
<th>Proposed setup</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser, transverse (radial)</td>
<td>0.85 mm (rms)(^1)</td>
<td>0.73 mm (rms)(^2)</td>
</tr>
<tr>
<td>Laser, temporal (Gaussian)</td>
<td>5 ps</td>
<td>5 ps</td>
</tr>
<tr>
<td>Gun max RF field</td>
<td>44 MV/m</td>
<td>44 MV/m</td>
</tr>
<tr>
<td>Max solenoid field</td>
<td>0.174 T</td>
<td>0.173 T</td>
</tr>
<tr>
<td>ACC1 mas RF field</td>
<td>30 MV/m</td>
<td>30 MV/m</td>
</tr>
<tr>
<td><strong>Beam simulation result at 20 m (200 000 macro-particles)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projected transverse (\varepsilon)</td>
<td>2.0 mm mrad (no (\varepsilon_{\text{therm}}))</td>
<td>1.75 mm mrad (no (\varepsilon_{\text{therm}}))</td>
</tr>
<tr>
<td>Slice (\varepsilon)</td>
<td>0.8 mm mrad (no (\varepsilon_{\text{therm}}))</td>
<td>0.8 mm mrad (no (\varepsilon_{\text{therm}}))</td>
</tr>
<tr>
<td>Bunch length</td>
<td>1.67 mm (rms)</td>
<td>1.82 mm (rms)</td>
</tr>
<tr>
<td>Beam size at the mirror</td>
<td>2.64 mm (rms)</td>
<td>2.25 mm (rms)</td>
</tr>
<tr>
<td>Beam size at the collimator</td>
<td>1.47 mm (rms)(^3)</td>
<td>1.25 mm (rms)</td>
</tr>
</tbody>
</table>

\(^1\) with 3.0 mm laser iris; \(^2\) with 2.5 mm laser iris; \(^3\) 1.8 mm in measurement
Dark Current Simulation

Dark current simulation result at 6 m (20,000 macro-particles)
Dark current starts from the cathode area (2 mm rms)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Present setup</th>
<th>Proposed setup</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collimator position</td>
<td>1.27 m</td>
<td>1.57 m</td>
<td></td>
</tr>
<tr>
<td>Without collimator</td>
<td>3385</td>
<td>2604</td>
<td>20% ↓</td>
</tr>
<tr>
<td>With 8 mm φ collimator</td>
<td>1808</td>
<td>801</td>
<td>55% ↓</td>
</tr>
</tbody>
</table>
With 0.3 m longer distance between the gun and ACC1;

• The dark current, originated from the cathode area, will be reduced at ACC1.
• The gained space can be used for installing dark current kicker and more diagnostics.
• Transverse emittance is reduced.
• Beam size at the vacuum mirror and at the collimator will be smaller \(\rightarrow\) smaller wake effect.

Next steps;
• Find the actual operating parameter in more detail.
• Other operating conditions, e.g. gun gradient or laser temporal profile, will be considered.