CASE STUDY 5:

FEL driven by Plasma Injector

A Group 9 Collaboration:
FEL driven by Plasma Injector

● Goal:

*Use the output from a plasma injector to drive an FEL in the UV range.*

● Background:

- Laser driven plasma generates a relativistic electron beam with small emittance
- Advantage: Injectors will be short
- Challenge: Deal with high energy spread
Initial Situation

- Given by case study:
  - Normalized emittance $\epsilon = 200$ nm
  - $E=300$ MeV; $\Delta E=1\%$
  - Wavelength $\lambda=50$ nm
- Estimated beam parameter:
  - $Q=40$ pC
  - $\beta=2m$

Courtesy of: R.W. Aßmann
Optimize the beam current to overcome the impact of energy spread of 1%.
Why 40 pC bunch charge?

- Maier et al. has shown: [2]

<table>
<thead>
<tr>
<th>E in nm</th>
<th>E in MeV</th>
<th>ΔE</th>
<th>I in kA</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>~300</td>
<td>&lt;1%</td>
<td>~2-10</td>
</tr>
</tbody>
</table>
Peak Current Optimization

- Based on Ming Xie model: [3]

Our choice of \(I_{\text{Peak}}\) is at 10 kA. This limits the length of the undulator to a buildable value.

Space Charge has to be considered at \(I>10\) kA.
Undulator Parameters

- Based on Ming Xie model [3]:
  - Wavelength fixed at ~50 nm
  - Saturation length at I=10kA L=5.3 m
  - Output Power P=6 GW
Dealing with 1% Energy Spread by Longitudinal Decompression
Longitudinal Decompression
Dealing with 1% Energy Spread by Transversal Decompression
Transversal Decompression

• Beam line:

Accelerator        Quadrupoles        Dipole        Quadrupoles        Undulator

• Undulator [1]:

„Transverse gradient undulator (TGA) by canting the magnetic poles. Each pole is canted by an angle with respect to the xz plane. The higher energy electrons are dispersed to the higher field region (positive x) to match the FEL resonant condition.“
Transversal Decompression
Bibliography


[4] BeamOptik Simulation: D. Simon, Johannes Gutenberg-University Mainz, Germany,

Further Information:


Thank you for your attention