Optical Design of the Energy Recovery Linac FEL at Peking University

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Outline

- Description of PKU-ERL-FEL
- Design consideration
- Results of the optical design
- Further work
I

Description of PKU-ERL-FEL
Aims:

provide IR-FEL for users,
study ERL technology

Components:
DC-SC injector
Rossendorf Type linac (TESLA 9-cell cavity)
Undulator with mirrors
Beam transmission system
ERL-FEL of Peking University (PKU-ERL-FEL)
# PKU-ERL-FEL parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inject Energy</td>
<td>5MeV</td>
</tr>
<tr>
<td>Maximum Energy</td>
<td>30MeV</td>
</tr>
<tr>
<td>Bunch Frequency</td>
<td>26MHz</td>
</tr>
<tr>
<td>Bunch Charge</td>
<td>~60pC</td>
</tr>
<tr>
<td>Bunch length at Entrance of Undulator</td>
<td>~1ps</td>
</tr>
<tr>
<td>Macro Pulse Length</td>
<td>2ms</td>
</tr>
<tr>
<td>Rep. Frequency of Macro Pulse</td>
<td>10Hz</td>
</tr>
<tr>
<td>Energy Spread (rms)</td>
<td>0.24%</td>
</tr>
<tr>
<td>Transverse Emittance (rms, n.)</td>
<td>~3 μm</td>
</tr>
<tr>
<td>Length of Undulator</td>
<td>1.5m</td>
</tr>
<tr>
<td>$\lambda_u$ of Undulator</td>
<td>3cm</td>
</tr>
<tr>
<td>K of Undulator</td>
<td>0.5-1.4</td>
</tr>
<tr>
<td>Optical Cavity Length</td>
<td>11.52m</td>
</tr>
<tr>
<td>Wavelength of FEL</td>
<td>4.7-8.3 μm</td>
</tr>
</tbody>
</table>
DC-SC Injector

Cavity design is completed

Cryostat is under design
The cryogenic system

Compressor (TCF20)

Pumping Sys.

SC Accelerator

Cold Box

4.2K

2000L Dewar

2K Sys.

DCSC Injector
Undulator

Undulator will be manufactured in China.
Design Consideration
- Achromatic \( (R_{16}=R_{26}=0) \)
- Isochronous \( (R_{56}=0) \)
- Small bending angle (15 degree)
- Energy spread acceptance of undulator
- Small beta function in undulator
- Large energy spread acceptance in the second arc (7% at full width from the experience of JAREI and Jlab)
Compensation of the second order matrix term
Trajectory length of the loop is variable
Space for installation of facilities
Space charge and CSR
III

Results of the optical design
Merger

- Achromatic
- Adequate $R_{56}$
- Reduce the influence of space charge
- Fit the need of linac
- Good transmission for the return beam
Transverse beta function and emittance

![Graph showing beta function and emittance in the context of FEL 2006, Z.C. Liu]
Longitudinal beta function and emittance

[Graphs showing longitudinal beta function and emittance with and without SC.]
Arc1

- TBA arc, turning 180 degree
- Isochronous
- Achromatic
- Compensation of $T_{166}$, $T_{266}$ and $T_{566}$
Beta function and dispersion
Bunch Compression

- Four dipole chicane
- $R_{56} = -0.2 \text{m}$
- Compress the bunch to 1 ps (FWHM)
- CSR takes a little influence
Undulator

$\beta_x = 0.4m$ in the undulator center
(without the effect of undulator field on the beam)
Arc2

- TBA arc, turning 180 degree
- $R_{56}$ is variable
- Achromatic
- Energy spread acceptance is 7% (full width)
- Lengthening the return bunch and making the whole loop isochronous

\[ R_{56,arc2} = -(R_{56,chicane} + R_{56,other}) \]

- Compensation of $T_{166}, T_{266}$ and $T_{566}$
Beta function and dispersion

![Graph showing Beta function and dispersion](image)
Further Work

- The parameters of the whole loop will be further optimized with other codes and compared with present results.
- Beam behavior in undulator will be simulated and the beta function within and after this part will be optimized.
Thanks !