High-temperature superconducting undulators for compact free electron lasers

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About the project

• 3 prototype coils are planned:
  • Horizontal racetrack (HR),
  • Vertical racetrack (VR),
  • Helical design around the beam pipe (hel.).

• 2 of each kind to be built + 1 short model.
HR Coil  
coil body + support

helical Coil  
3D printed coil body

VR Coil  
coil body + support
# Points to be addressed

<table>
<thead>
<tr>
<th></th>
<th>Horizontal racetrack</th>
<th>Vertical racetrack</th>
<th>Helical design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undulator period $\lambda_u$</td>
<td>15 mm / 13 mm</td>
<td>13 mm</td>
<td>13 mm</td>
</tr>
<tr>
<td>Gap between magnetic poles $g$</td>
<td>6 mm</td>
<td>6 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>Magnetic flux density $B$ (amplitude) on axis for full model</td>
<td>$3.1 , \text{T} / 2.4 , \text{T}$</td>
<td>$2.2 , \text{T}$</td>
<td>$2.8 , \text{T}$</td>
</tr>
<tr>
<td>Conductor cross-section</td>
<td>$4 \times 5 , \text{mm}^2$</td>
<td>$4 \times 5 , \text{mm}^2$</td>
<td>$4 \times 6 , \text{mm}^2$</td>
</tr>
<tr>
<td>Geometry</td>
<td>mirror models or single coils</td>
<td>5 periods short model</td>
<td></td>
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<tr>
<td></td>
<td>anticryostat should be feasible</td>
<td>4 mm diameter pipe</td>
<td></td>
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<tr>
<td>Temperatures</td>
<td>4.2, 10, 20, 77 K; Quench/transition should be possible</td>
<td></td>
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</tbody>
</table>

**may freeze in humid environment (→ N2 ?)**
Required measurements

- Single racetrack coils HR & VR:
  - one physical point

- Helical and mirror models:
  - For 5 periods every half period
  - and over time
  - Every 2 mm one point
  - and over time
Required measurements

- Addition for the helical undulator:
  - Measurement of cylindrical surface for $B_{x,y,z}$ within beam pipe
Simulations of superconducting undulators

REBCO (h) $B_y(80\%)$

- Beam axis
- vacuum
- 5 mm
- 3.5 T
- 1.5 kA/mm$^2$, $B_{\text{conductor}}$
- iron
- tape

$\lambda_u$ (mm)

$B_y(80\%)$ (T)

$g$ (mm)

3 4 5 6 7 8 9 10 11 12

0.0 0.4 0.8 1.2 1.6 2.0 2.4 2.8 3.2 3.4