DC-SRF photoinjector was upgraded for PKU-FEL. A 3.5-cell SC cavity is the key component of the DC-SRF photoinjector. Two 3.5-cell SRF cavities was fabricated with large grain and fine grain niobium (from Ningxia OTIC) at Peking University. Vertical test shows the Eacc reaches 23 MV/m with Q=1.2×10^{10} at highest gradient. The 3.5-cell LG Nb cavity was installed to the new DC-SRF photoinjector and will be tested with the cryomodule.
PKU—FEL

RF Power Source

Main ACC

Injector

2K CBX

Cryo Sys

VTS
The DC-SRF photoinjector consists of a DC Pierce gun with a 1.3 GHz 3.5-cell SC cavity.

- Compatibility of photocathode and SC cavity
- Compact structure
- CW mode
- Provide high average current (mA)
- High quality electron beams
DC-SRF Cryomodule
Key component: 3.5-cell SC Cavity
# Design Parameters

<table>
<thead>
<tr>
<th>Mode</th>
<th>TM010, π -mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>1300MHz</td>
</tr>
<tr>
<td>$Q_0$</td>
<td>$\geq 5 \times 10^9$</td>
</tr>
<tr>
<td>$E_{acc}$</td>
<td>15 MV/m</td>
</tr>
<tr>
<td>Effective acc length</td>
<td>0.417 m</td>
</tr>
<tr>
<td>$G$</td>
<td>242 $\Omega$</td>
</tr>
<tr>
<td>$r/Q$</td>
<td>417 $\Omega$</td>
</tr>
<tr>
<td>$E_{peak}/E_{acc}$</td>
<td>2.12</td>
</tr>
<tr>
<td>$B_{peak}/E_{acc}$</td>
<td>4.95 mT/(MV/m)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mid-cell</th>
<th>Left cup (1st cell)</th>
<th>Right cup (1st cell)</th>
<th>End-cup</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Requator$</td>
<td>103.3</td>
<td>105.3</td>
<td>105.3</td>
<td>103.3</td>
</tr>
<tr>
<td>$R_{iris}$</td>
<td>35</td>
<td>6</td>
<td>35</td>
<td>39</td>
</tr>
<tr>
<td>$R_c$</td>
<td>42.0</td>
<td>17.14</td>
<td>17.14</td>
<td>40.3</td>
</tr>
<tr>
<td>$a$</td>
<td>12</td>
<td>3</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>$b$</td>
<td>19</td>
<td>3</td>
<td>20</td>
<td>13.5</td>
</tr>
<tr>
<td>Length</td>
<td>57.7</td>
<td>35.19</td>
<td>37.72</td>
<td>56.0</td>
</tr>
</tbody>
</table>
No multipacting for good surface treatment

Simulation with MultiPac

Simulation with FishPact
Stiffen Ring Optimization

<table>
<thead>
<tr>
<th>Lorentz force factor</th>
<th>Tuning range</th>
<th>Δf/0.1mm</th>
<th>Force /0.1mm</th>
<th>Flatness change (±0.4mm deformation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 Hz/(MV/m)^2</td>
<td>±200 kHz</td>
<td>70 kHz</td>
<td>1000 N</td>
<td>&lt;3%</td>
</tr>
</tbody>
</table>

Tuner test with 1-cell cavity

No influence on DC structure within ±0.4 mm
Cross talk between Pickup and main coupler

\[ P_{tt} \approx P_{ct} \]

2-cell copper cavity meas.

\[ \frac{P_{tt}}{P_{ct}} = 10^6 \]

SC status

cross-talk can be neglected
LG 3.5-cell cavity
RF Measurement

Field Flatness Tuning

HOM
BCP & 1250°C purification in China
Vertical test at Jlab

Cavity actions since second test

1. Bead pull for field flatness
2. Ultrasonic cleaning
3. BCP etching (30 micron at equators and ~100 um near cathode hole)
4. HPR, 1 passes
5. First assembly
6. HPR, 4 passes
7. Final assembly
8. Pump down and leak check
9. Cool down
10. RF test at 2 Kelvin
11. warm up to room temperature and cool down again
12. re-test at 2 Kelvin

Cavity actions since third test

1. Ultrasonic cleaning
2. Vacuum furnace treatment 800C X 2hr
3. Ultrasonic cleaning
4. BCP etching (~25 micron at equators)
5. HPR, 3 passes (nozzle head w/ 45 degree jet)
6. First assembly (all parts except bottom flange)
7. HPR, 3 passes (nozzle head w/ 45 degree jet)
8. Final assembly
9. Pump down and leak check
10. Cool down
11. RF test at 2 Kelvin
12. More LHe transfer
13. re-test at 2 Kelvin
3rd RF Test

PKU 3-1/2 cell
Test1: +HPR at JLab
Test3: +BCP 30um + HPR at JLab
Test3+: +Warm-up to RT and cool down

![Graph showing Q0 vs. Eacc (MV/m) with data points for different tests.](image)
4th RF test

PKU 3-1/2 Cell Photo-Injector Cavity
June 11-12, 09

Multipacting barriers encountered during
1st power rise and processed through
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