Compact ERL Linac

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Compact ERL is a test accelerator to demonstrate performance needed for future 5-GeV class ERL X-ray light sources.

- Energy 60 – 200 MV
- Current 100mA
- Emittance 0.1〜1mm mrad

Superconducting cavities are key components to realize successful ERL operation.
Injector

Required parameters for injector linac cavity

- Frequency 1.3 GHz
- $E_{acc} = 14.5$ MV/m
- High current CW operation, 100mA

Accelerate up to $5 \sim 10$ MeV with three 2-cell cavities.

Input coupler should handle total of 1MW.

- Double feed for each cavity
- Input power: 167 kW/coupler

Harmful HOMs are suppressed with 4 or 5 HOM couplers for each cavity.

See poster TUPO056 by K. Watanabe
2-cell injector cavity

- Same cell shape with STF-BL cavity and slightly enlarged beampipe
- Two input port for each cavity
- Two types, loop and antenna, of HOM couplers are applied
- 4 or 5 HOM couplers per one cavity

Basic cavity Parameters for Injector at KEK

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Frequency</td>
<td>1.3</td>
<td>GHz</td>
</tr>
<tr>
<td>Number of Cell</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>R/Q</td>
<td>205</td>
<td></td>
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<tr>
<td>Operating Gradient</td>
<td>14.5</td>
<td>MV/m</td>
</tr>
<tr>
<td>Number of Input coupler</td>
<td>2</td>
<td></td>
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<tr>
<td>Coupler power</td>
<td>167</td>
<td>kW</td>
</tr>
<tr>
<td>Coupler coupling</td>
<td>$3.3 \times 10^5$</td>
<td></td>
</tr>
<tr>
<td>Number of HOM coupler</td>
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<td></td>
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<tr>
<td>Operating Temperature</td>
<td>2</td>
<td>K</td>
</tr>
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Results of 1\textsuperscript{st} vertical test (2009.Apr)

- Eacc achieved to 30 MV/m.
- Heating of HOM probe at high Eacc

Could keep Eacc = 15 MV/m for 11 hours without HOM probe heating
Cryomodule (Input coupler, tuner)

- Design of cryomodule is almost completed.
- Input couplers will be tested this autumn with 300 kW klystron.
Main Linac

Required parameters for main linac cavity
- Frequency 1.3 GHz
- \( E_{\text{acc}} = 15 \sim 20 \) MV/m
- Energy recovery
- High current CW operation, >100mA

Due to CW high current operation, strong HOM damping is essential to avoid beam instabilities and large heat loads.

Total of eight 9-cell cavities are planned. To achieve 200MeV, 2-turn ERL is under discussion.
KEK-ERL model-2 Cavity

1) Cell shape is optimized to reduce HOM impedances
   - Iris diameter 80mm, elliptical shape at equator
   - Cell diameter 206.6mm
2) Eccentric-fluted beampipe
   - Suppress Quadrupole HOMs
3) Large beampipes mounted with RF absorber
   - Bempipe diameter 100mm and 120mm

Main parameters for the acceleration mode

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<tbody>
<tr>
<td>Frequency</td>
<td>1300 MHz</td>
<td>Coupling</td>
<td>3.8 %</td>
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<tr>
<td>Rsh/Q</td>
<td>897 Ω</td>
<td>Qo x Rs</td>
<td>289 Ω</td>
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<td>Ep/Eacc</td>
<td>3.0</td>
<td>Hp/Eacc</td>
<td>42.5 Oe/(MV/m)</td>
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</table>
Results of vertical tests

- Maximum Eacc = 15 ~ 17 MV/m
- Eacc was limited by field emission
- Large X-ray signals were observed

Rotating mapping system

Array of Si PIN diode

See poster TUPPO055 by K. Umemori
Cryomodule development

- HOM damper
  - HIP ferrite of new-type IB004
  - Comb-type RF bridge
  - Making proto-type
    (See poster THPPO050 by M. Sawamura)

- Input coupler
  - Cold and warm window
  - HA997 ceramic is used
  - High power tests are in progress
    (See poster THPPO047 by H. Sakai)
Input coupler

- Principle parameters
  - Input power: 20kW (Max. \( E_{acc} = 20 \text{MV/m} \))
  - \( QL : 5 \times 10^6 - 2 \times 10^7 \) (Variable coupling)
- HA997 ceramic is used
- Test stand was constructed
- High power tests are in progress for the components, such as ceramics and bellows.

Basic design of input coupler
HOM damper

Low temperature measurement of RF absorber’s characteristics

- RF absorber should work at 80K
- Temperature dependence was measured while cooling with refrigerator

Ferrite $\mu''$ at 80K

Temperature and frequency dependence of IB004 ferrite

- HIP ferrite of new-type IB004
- Comb-type RF bridge
- Making proto-type
Summary

Injector

- Two-cell injector cavity was fabricated.
- First vertical test was done and Eacc reached to 30 MV/m.
- While heating problem occurred at high Eacc, it was possible to keep 15 MV/m for 11 hours.
- Input couplers were fabricated and will be tested soon.
- Design of cryomodule is almost completed.

Main linac

- 9-cell Nb cavity was fabricated and vertical tests were performed. Cavity was suffered from field emission.
- X-ray mapping system works well and observed X-ray trace.
- Cryomodule design is under way.
- High power test stand was constructed. Component test is in progress for input coupler.
- Low temperature measurements were done for several RF absorbers. Making a prototype of HOM damper