500kV Gun development at KEK

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Outline

- Introduction
- Gun development
  - Gun
  - Cathode preparation system
- Laser development
- Summary
Compact ERL (test facility)

Principal parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Beam energy</td>
<td>35-125 MeV</td>
</tr>
<tr>
<td>Beam current</td>
<td>10-100 mA</td>
</tr>
<tr>
<td>Normalized emittance ( \varepsilon_n = \varepsilon/(\gamma\beta) )</td>
<td>1 mm·mrad (77 pC/bunch)</td>
</tr>
<tr>
<td></td>
<td>0.1 mm·mrad (7.7 pC/bunch)</td>
</tr>
<tr>
<td>Energy spread (rms)</td>
<td>(&lt; 3 \times 10^{-4})</td>
</tr>
<tr>
<td>Bunch length (rms)</td>
<td>1 – 3 ps (non compress.)</td>
</tr>
<tr>
<td></td>
<td>100 fs (bunch compression)</td>
</tr>
</tbody>
</table>

* With some emittance growth due to CSR

Conceptual design report:
KEK Report 2007-7/
JAEA-Research 2008-032

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Reason why two 500kV DC guns develop

- There are a lot of development elements of the 500kV DC gun.
  - Insulator breaking (punch-through problem)
  - Extreme high vacuum (<1E-10Pa)
  - Dark current from electrodes
    (<10nA@E~10MV/m)

  The gun system for R&D machine is indispensable to establish a technology of high beam current operation of ~100mA.

- For a backup when a serious damage is occurred in installed gun system while operation.
2\textsuperscript{nd} 500kV gun system concept

- Using \textit{titanium} for the chamber and flanges to decrease outgassing rate.

- Design that enables \textit{easy maintenance}, considers \textit{extendibility} and \textit{compatibility} with the 1\textsuperscript{st} 500kV gun.
  - Two ceramic tube structure, large maintenance port, compatible flange structure are employed.
  - A more large-scale ceramic tube can be connected by a part of remodeling.

- Using a specialized pumping system for extreme high vacuum.
  - Combination of NEG pumps and a \textit{bakeable cryopump}.

- Decreases cathode preparation duty.
  - Using a \textit{multiple cathode preparation} system.
Multiple activated photocathode preservations

Long-term gun operation is guaranteed by multiple puck system.

Loading Chamber
Multiple cathode cleaning by atomic hydrogen

Activation Chamber
Multiple NEA-surfaces are formed simultaneously.

Gun chamber
< 10^{-10} Pa

Installation of Puck
Quick exchanges of Puck

Valve
Transfer line
Puck revolver

2^{nd} 500kV gun system

Multiple cathode cleaning by atomic hydrogen

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Design of the 2nd 500kV Gun

- Ceramic insulators
- Stock chamber (Titanium)
- Loading chamber (SUS)
- Bakeable cryopump connection
- Activation chamber (SUS)
- Gun Chamber (Titanium)
- NEG pump connection
- e-beam
Vacuum system

**Stock Chamber (Ti+CP)**
- NEG pump: 1.6 m$^3$/s
- Ion pump: 0.1 m$^3$/s

**Gun chamber (Ti+CP)**
- NEG pump: ~10 m$^3$/s (max. ~25 m$^3$/s)
- Bakeable cryopump:
  - 3 m$^3$/s for H$_2$ @1E-7 Pa
  - (TMP: ~1 m$^3$/s for baking)

**Activation Chamber (SUS+CP)**
- NEG pump: 0.8 m$^3$/s
- Ion pump: 0.2 m$^3$/s

**Loading Chamber (SUS+CP)**
- Ion pump: 0.1 m$^3$/s
- (TMP: 0.3 m$^3$/s for baking, cleaning process)

**Vacuum gauges for XHV**
- AT gauge
- Bent Belt Beam (3B) Gauge

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Design and fabrication

Titanium chamber (12.Feb)
Photocathode DC Gun Test Facility at KEK

Evaluation of cathode, beam control and monitor system by 200kV gun system.
Laser system for injector commissioning at KEK

- Drive laser for AR-south injector commissioning test area (started since 2009)
- Requirement for 10mA operation of cERL: 1.3GHz (repetition), 530nm (wavelength), 20ps (pulse duration), 1.5W (power)
- System has been built based on commercial units (1.3GHz oscillator, fiber amplifier, SHG, etc.)
- 100mW (2ω) output has been achieved. Enough for first commissioning of the injector up to 1mA. Development of higher power amplifier is on going.
Pulse train shaping (pulse train of 1000 bunches) has been introduced for burst operational mode. This is for commissioning phase of ERL operation.

In order to test high bunch charge beam, lower rep.rate higher intensity Ti:sapphire laser system will be used.

Laser transport line and input chamber are made.
Summary

2\textsuperscript{nd} 500kV gun development

- Design of the gun chamber, the insulators, and the preparation chambers were finished.
- Bakeable cryopump is employed for the gun.
- Vacuum test will be started at April 2010.
- Design of the multiple cathode preparation system is progressed.

Laser system

- Development of 1.3GHz fiber laser system for 1mA beam commissioning is almost reach the target.
- Development of higher power amplifier is on going.