Progress on CEPC High Efficiency Klystron Development

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Institute of High Energy Physics
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Oxford, UK
Outline

◆ Plan and goal
  • 650MHz/800kW meets CEPC project demands
  • 80% efficiency

◆ 1st prototype tube
  • Mechanical design and manufacture
  • Plant and infrastructure preparation

◆ High efficiency design
  • 2nd prototype optimization
  • Multi-beam klystron consideration
Strategy and plan (2016 to 2021)

3 or more klystron prototypes

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>Step2</td>
<td></td>
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<td></td>
<td>2nd</td>
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<td>Step3</td>
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<td>3rd</td>
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<td>4th</td>
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<td>more</td>
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</tbody>
</table>

Efficiency: 60% - - - - - → 70% - - - - - → 80%
**1st prototype tube**

Conventional method based on 2nd harmonic cavity in order to investigate the design and manufacture technologies for high power CW klystron.

### Design Parameters

<table>
<thead>
<tr>
<th>Main parameters</th>
<th>Goal</th>
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</thead>
<tbody>
<tr>
<td>Freq. (MHz)</td>
<td>650</td>
</tr>
<tr>
<td>Vk (kV)</td>
<td>-81.5</td>
</tr>
<tr>
<td>Ik (A)</td>
<td>15.1</td>
</tr>
<tr>
<td>Perveance (µP)</td>
<td>0.65</td>
</tr>
<tr>
<td>Efficiency (%)</td>
<td>&gt;60</td>
</tr>
<tr>
<td>Output power (kW)</td>
<td>800</td>
</tr>
<tr>
<td>1dB bandwidth (MHz)</td>
<td>±0.5</td>
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</table>
Components manufacture

Modulator anode
Input coupler
Cooling pipe
Gun welding edge
Cavity body
Cavity nose
Coil
Collector
Assembly unit

Focusing electrode and support assembly

Modulator anode assembly
Cavity brazing and cold test

Cold test for CAV2, 3&4 is finished and frequency value is within the design scope.
Cathode and output window

Cathode opening

Window water pressure test

Window vacuum leak detection
Window test stand preparation

- Vacuum evacuate port
- Support
- Ion pump
- W.G
- Window
- Vacuum W.G
Plant construction

Dimension of new building

Jan. 28, 2019
Mar. 3, 2019
Mar. 27, 2019
Apr. 12, 2019
Baking furnace preparation

Top view

Furnace cover and body

Vacuum system

Factory testing
**High efficiency design**

**Original plan**

- **Scheme 1**: Optimize cavity chain by using the same gun as 1\textsuperscript{st} tube
- **Scheme 2**: With high voltage gun (110 kV/9.1 A), low perveance
- **Scheme 3**: MBK, 54 kV/20A electron gun

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Scheme 1</th>
<th>Scheme 2</th>
<th>Scheme 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq. (MHz)</td>
<td>650</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>Voltage (kV)</td>
<td>81.5</td>
<td>110</td>
<td>54</td>
</tr>
<tr>
<td>Current (A)</td>
<td>15.1</td>
<td>9.1</td>
<td>20(2.5\times8)</td>
</tr>
<tr>
<td>Beam No.</td>
<td>1</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Perveance (µP)</td>
<td>0.65</td>
<td>0.25</td>
<td>1.6(0.2\times8)</td>
</tr>
<tr>
<td>Efficiency (%)</td>
<td>&gt;70</td>
<td>~80</td>
<td>&gt;80</td>
</tr>
<tr>
<td>Power (kW)</td>
<td>800</td>
<td>800</td>
<td>800(100\times8)</td>
</tr>
</tbody>
</table>
**Scheme 1**

- Gun, collector, focusing magnet and tube length are same with 1st prototype and optimization cavity chain with CSM method.

- CST(3D) EFF: 68.5%, ~3.5% higher than 1st prototype

Efficiency improvement is unacceptable, future work will be concentrated on Scheme 2 and 3.
**Scheme 2**

- **High efficiency design**

AJDISK(1D) EFF: 85.6%

KLYC(1D) EFF: 85.6%

EMSYS(2.5D) EFF: 81.4%

CST(3D) EFF (asymmetrical output): 78%

3D simulation on symmetrical output cavity is in progress.
Scheme 2

- **High efficiency design**

**Transfer curve**

**Gain curve**

**Bandwidth**
Scheme 2

**RF Cavity design**

The design of other cavities is also in progress.
Scheme 3

**Gun design**

- Gun potentials in CST
- Gun beam trajectories in CST
- Klystron beam trajectory in DGUN
Scheme 3

- Cavities design

Input cavity

Output cavity

Cavity chain optimization
Scheme 3

- High efficiency design

More than 80% efficiency in CST
Summary

• The components machining, brazing, welding and assembly are in progress in collaboration company.

• Pursuing 1st prototype processing and manufacturing and it will be completed at the end of June 2019.

• The high efficiency design is concentrated on high voltage klystron and multi-beam klystron.

• The design work of 1st high efficiency klystron will end in this June and then 2nd prototype (1st high efficiency klystron) will be processed and manufactured in June next year.

• The multi-beam klystron design are ongoing simultaneously.
Thanks for your attention!