CEPC Key Technology R&D

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Fermi National Accelerator Laboratory
Outline

- Introduction of CEPC Accelerator
- CEPC Accelerator Key Technologies
- R&D Program and status
- Conclusions
CEPC-SppC Project

Circumference: 100 km
CEPC Beam Energy: 45.5 – 120 GeV
SPPC Beam Energy: 35 - 50 TeV
CEPC SR Power < 100 MW
CEPC Schedule (ideal)

CEPC Schedule (ideal)

- CEPC data-taking starts before the LHC program ends around 2035
- Earlier than the FCC-ee
- Possibly concurrent, but advantageous and complimentary to the ILC

1st Milestone: Pre-CDR (by the end of 2014) ; 2nd Milestone: R&D funding from MOST (in Mid 2016);
3rd Milestone: CEPC CDR Status Report (by the end of 2016); 4th Milestone: CEPC CDR Report (by the end of 2017);
5th Milestone: CEPC TDR Report and Proto (by the end of 2022); 6th Milestone: CEPC construction (by the end of 2030);
CEPC Site Exploration

1. QingHuangDao, Hebei (completed preCDR)
2. Huangling, Shaanxi (2017.1 signed contract to exp.)
3. ShenShan, Guangdong, (completed in August, 2016)
4. ...
Physics Goals of CEPC

Electron-positron collider (45.5, 80, 120 GeV)

– **Higgs Factory**
  • Precision study of Higgs ($m_H$, $J^{PC}$, couplings)
  • Looking for hints of new physics
  • Luminosity $>2.0 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$

– **Z & W factory**
  • Precision test of standard model
  • Rare decays
  • Luminosity $>1.0 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$

– **Flavor factory: b, c, t and QCD studies**
# Machine Parameters of CEPC Main Ring

<table>
<thead>
<tr>
<th></th>
<th>Higgs Wang Dou 20170607</th>
<th>W Wang Dou 20170306</th>
<th>Z Wang Dou 20170607</th>
<th>Z-high lumi Wang Dou 20170306</th>
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<tbody>
<tr>
<td>Number of IPs</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Energy (GeV)</td>
<td>120</td>
<td>80</td>
<td>45.5</td>
<td>45.5</td>
</tr>
<tr>
<td>SR loss/turn (GeV)</td>
<td>1.67</td>
<td>0.33</td>
<td>0.034</td>
<td>0.034</td>
</tr>
<tr>
<td>Half crossing angle (mrad)</td>
<td>16.5</td>
<td>16.5</td>
<td>16.5</td>
<td>16.5</td>
</tr>
<tr>
<td>Piwinski angle</td>
<td>3.19</td>
<td>5.69</td>
<td>11.8</td>
<td>4.29</td>
</tr>
<tr>
<td>N/bunch ($10^{11}$)</td>
<td>0.968</td>
<td>0.365</td>
<td>0.22</td>
<td>0.455</td>
</tr>
<tr>
<td>Bunch number</td>
<td>412</td>
<td>5534</td>
<td>5100</td>
<td>21300</td>
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<tr>
<td>Beam current (mA)</td>
<td>19.2</td>
<td>97.1</td>
<td>53.9</td>
<td>465.8</td>
</tr>
<tr>
<td>SR power /beam (MW)</td>
<td>32</td>
<td>32</td>
<td>1.9</td>
<td>16.1</td>
</tr>
<tr>
<td>Bending radius (km)</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Momentum compaction ($10^{-5}$)</td>
<td>1.14</td>
<td>1.14</td>
<td>1.14</td>
<td>4.49</td>
</tr>
<tr>
<td>$\beta_{ip} x/y$ (m)</td>
<td>0.171/0.002</td>
<td>0.171/0.002</td>
<td>0.171/0.002</td>
<td>0.16/0.002</td>
</tr>
<tr>
<td>Emittance $x/y$ (nm)</td>
<td>1.31/0.004</td>
<td>0.57/0.0017</td>
<td>0.18/0.0037</td>
<td>1.48/0.0078</td>
</tr>
<tr>
<td>Transverse $\sigma_{ip}$ (um)</td>
<td>15.0/0.089</td>
<td>9.9/0.059</td>
<td>5.6/0.086</td>
<td>15.4/0.125</td>
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<tr>
<td>$\xi_{IP}/\xi_{IP}$</td>
<td>0.013/0.083</td>
<td>0.0055/0.062</td>
<td>0.004/0.039</td>
<td>0.008/0.054</td>
</tr>
<tr>
<td>RF Phase (degree)</td>
<td>128</td>
<td>126.9</td>
<td>135</td>
<td>165.3</td>
</tr>
<tr>
<td>$V_{RF}$ (GV)</td>
<td>2.1</td>
<td>0.41</td>
<td>0.049</td>
<td>0.14</td>
</tr>
<tr>
<td>$f_{RF}$ (MHz) (harmonic)</td>
<td>650</td>
<td>650 (217800)</td>
<td>650</td>
<td>650 (217800)</td>
</tr>
<tr>
<td>Nature $\sigma$ (mm)</td>
<td>2.72</td>
<td>3.37</td>
<td>3.9</td>
<td>3.97</td>
</tr>
<tr>
<td>Total $\sigma$ (mm)</td>
<td>2.9</td>
<td>3.4</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>HOM power/cavity (kw)</td>
<td>0.41 (2cell)</td>
<td>0.36 (2cell)</td>
<td>0.11 (2cell)</td>
<td>1.99 (2cell)</td>
</tr>
<tr>
<td>Energy spread (%)</td>
<td>0.098</td>
<td>0.065</td>
<td>0.037</td>
<td>0.037</td>
</tr>
<tr>
<td>Energy acceptance (%)</td>
<td>1.5</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Energy acceptance by RF (%)</td>
<td>2.1</td>
<td>1.1</td>
<td>0.65</td>
<td>1.1</td>
</tr>
<tr>
<td>$n_{y}$</td>
<td>0.26</td>
<td>0.15</td>
<td>0.16</td>
<td>0.12</td>
</tr>
<tr>
<td>Life time due to beamstrahlung (min)</td>
<td>52</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>$F$ (hour glass)</td>
<td>0.96</td>
<td>0.98</td>
<td>0.99</td>
<td>0.96</td>
</tr>
<tr>
<td>$L_{max}/IP$ ($10^{34}$cm$^{-2}$s$^{-1}$)</td>
<td>2.0</td>
<td>5.15</td>
<td>1.03</td>
<td>11.9</td>
</tr>
</tbody>
</table>
CEPC Man Ring SRF Layout

- Double Ring
- Common cavities for Higgs
- Two RF sections in total
- Two RF stations per RF section
- 14 modules per RF station
- 28 modules per RF section
- 56 modules in total
- Six 2-cell cavities per module
- One klystron for two cavities
**Injector Linac (base line design)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
<th>Pre-CDR</th>
<th>CDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e^-/e^+$ beam energy</td>
<td>$E_{e^-}/E_{e^+}$</td>
<td>GeV</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Repetition rate</td>
<td>$f_{rep}$</td>
<td>Hz</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>$e^-/e^+$ bunch population @ 10 GeV</td>
<td>$N_{e^-}/N_{e^+}$</td>
<td>$2 \times 10^{10}$</td>
<td>$6.25 \times 10^9$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$N_{e^-}/N_{e^+}$</td>
<td>nC</td>
<td>3.2</td>
<td>1</td>
</tr>
<tr>
<td>Energy spread ($e^-/e^+$)</td>
<td>$\sigma_\varepsilon$</td>
<td>&lt;1×10&lt;sup&gt;-3&lt;/sup&gt;</td>
<td>&lt;2×10&lt;sup&gt;-3&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Emitance ($e^-/e^+$)</td>
<td></td>
<td>mm·mrad</td>
<td>&lt;0.3</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>$e^-$ beam energy on Target</td>
<td></td>
<td>GeV</td>
<td>4</td>
<td>4 (2)</td>
</tr>
<tr>
<td>$e^-$ bunch charge on Target</td>
<td></td>
<td>nC</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
CEPC Accelerator Key technologies

- Polarized electron gun
  - Super-lattice GaAs photocathode DC-Gun
- High current positron source
  - bunch charge of ~3nC,
  - 6Tesla Flux Concentrator peak magnetic field
- SRF (High Q SC Cavity and High power coupler)
  - Max operation Q0 = 2E10 @ 2 K
  - High power coupler: 300kW (Variable)
- High efficiency Klystron
  - ~80% goal for 650MHz klystron
- Large Scale Cryogenics
  - 12 kW @4.5K refrigerator, Oversized, Custom-made, Site integration
CEPC Accelerator Key technologies

- Low field dipole magnet (booster)
  - $L_{mag}=4m$, $B_{min}=31Gs$, Errors $<5E^{-4}$
- IR region QD0
  - Field gradient $200T/m$, magnetic length $1.46m$
  - Central field $13T$
- Electro-static separator for deflect the e+ and e- bunches
  - Maximum operating field strength: $20kV/cm$
  - Maximum deflection: $145 urad$
- Vacuum system
  - Dipole copper chamber
  - RF shielding bellows
  - NEG coating
- ...
CEPC SRF R&D Plan (2017-2022)

- Two small Test Cryomodules (650 MHz 2 x 2-cell, 1.3 GHz 2 x 9-cell)
- Two full scale Prototype Cryomodules (650 MHz 6 x 2-cell, 1.3 GHz 8 x 9-cell)

Schedule:
- 2017-2018 (key components, IHEP Campus)
  - high Q 650 MHz and 1.3 GHz cavities, N-doping + EP
  - 650 MHz variable couplers (300 kW), 1.3 GHz variable couplers (10 kW)
  - high power HOM coupler and damper, fast-cool-down and low magnetic module, reliable tuner
- 2019-2020 (test modules integration, Huairou PAPS)
  - Horizontal test 16 MV/m, $Q_0 > 2E10$
  - beam test 1~10 mA
- 2021-2022 (prototype modules assembly and test, Huairou PAPS)
# SRF Hardware Specification

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Qualification</th>
<th>Normal Operation</th>
<th>Max. Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>650 MHz 2-cell Cavity</td>
<td>VT 4E10 @ 22 MV/m</td>
<td>1E10 @ 16 MV/m (long term)</td>
<td>2E10 @ 20 MV/m</td>
</tr>
<tr>
<td></td>
<td>HT 2E10 @ 20 MV/m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3 GHz 9-cell Cavity</td>
<td>VT 3E10 @ 25 MV/m</td>
<td>2E10 @ 20 MV/m</td>
<td>2E10 @ 23 MV/m</td>
</tr>
<tr>
<td>650 MHz Input Coupler</td>
<td>HPT 400 kW sw</td>
<td>300 kW</td>
<td>400 kW</td>
</tr>
<tr>
<td>1.3 GHz Input Coupler</td>
<td>HPT 20 kW peak, 4 kW avr.</td>
<td>&lt; 15 kW peak</td>
<td>18 kW peak</td>
</tr>
<tr>
<td>650 MHz HOM Coupler</td>
<td>HPT 1 kW</td>
<td>&lt; 0.2 kW</td>
<td>1 kW</td>
</tr>
<tr>
<td>650 MHz HOM Absorber</td>
<td>HPT 5 kW</td>
<td>&lt; 2 kW</td>
<td>5 kW</td>
</tr>
<tr>
<td>650 MHz Cryomodule (six 2-cell cavities)</td>
<td>static loss 5 W @ 2 K</td>
<td>static loss 8 W @ 2 K</td>
<td>static loss 10 W @ 2 K</td>
</tr>
<tr>
<td>Tuner (MR &amp; Booster)</td>
<td>tuning range and resolution 400kHz/1Hz</td>
<td>200 kHz / 1 Hz</td>
<td>400 kHz / 1 Hz</td>
</tr>
<tr>
<td>LLRF (MR &amp; Booster)</td>
<td>amp &amp; phase stability 0.1%, 0.1 deg</td>
<td>amp &amp; phase stability 1%, 1 deg</td>
<td>amp &amp; phase stability 0.1%, 0.1 deg</td>
</tr>
</tbody>
</table>
**SRF Key Components**

- **650 MHz**
  - 2-cell cavity & tuner
  - 5-cell cavity
  - $Q > 2E10 \at 20 \text{ MV/m}$

- **HOM coupler**
  - 1 kW

- **HOM absorber**
  - 5 kW

- **1.3 GHz TESLA cavity** (high Q high gradient study)

- **650 MHz variable coupler**
  - 300 kW

- **650 MHz & 1.3 GHz cryomodule**
  - < 5 W @ 2K

- **1.3 GHz variable coupler**
  - 20 kW
RF design of 650MHz 2-cell cavity

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
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<tbody>
<tr>
<td>R/Q (Ω)</td>
<td>212.731</td>
</tr>
<tr>
<td>G</td>
<td>284.113</td>
</tr>
<tr>
<td>Ep/Eacc</td>
<td>2.38</td>
</tr>
<tr>
<td>Bp/Eacc [mT/(MV/m)]</td>
<td>4.17</td>
</tr>
</tbody>
</table>

Qe (all ports) : 2.65E+11. If Q0 = 4E10, then Q0 (measured) decrease to 3.48E10.
650MHz 2-cell Cavity Fabrication

- A prototype of 650 MHz 2-cell cavity has begun fabrication at IHEP factory.
CEPC MR 650 MHz Cryomodule design

- Operating at 2 Kelvin of superfluid helium.
- Six 2-cell 650 MHz superconducting cavities, six high power couplers, six mechanical tuner and two RT HOM absorbers, et al.
- Fast cool-down capability. Static heat load budget of whole cryomodule is 5 W at 2 K.
Layout of IHEP New SRF Facility

- Platform of Advanced Photon Source Technology R&D (PAPS), Huairou Science Park, Huairou, Beijing

High Energy Photon Source (HEPS) 2018 - 2024

PAPS 2017 - 2019

4500 m² SRF lab

SRF Lab
Beam Test
Magnet

Construction: 2017 - 2019
Ground Breaking: May 31, 2017
3 VT dewars
2 HT caves
500m² CR
FPC aging in CR ISO7
Optic inspection.
Pre-tuning
Furnace
Nb₃Sn oven
Nb-Cu sputtering
T-mapping
Second sound
……

New Cryogenic system:
- 2.5KW@4.5K and 300W@2K LHe system
- 210m³/h gas recycle and 100m³/h gas purify capability
15 ~ 30 MeV, CW 1 ~ 10 mA
Test 650MHz Cavity
Test 650MHz High efficiency klystron

**PAPS Beam Test System**

- DC photo cathode gun
- 1.3 GHz test module
- 650 MHz test module
High Efficiency Klystron R&D

- CEPC high efficiency klystron:
  - 650MHz/800kW
  - Efficiency > 80%

- Schedule:
  2016 – 2017  Design Classical klystron
  2017 – 2018  Fabrication Classical klystron and test
  2017 – 2018  Design High efficiency klystron
  2018 – 2019  Fabrication 1\textsuperscript{st} High efficiency klystron and test
  2019 – 2020  Fabrication 2\textsuperscript{nd} high efficiency klystron and test
  2020 – 2021  Fabrication 3\textsuperscript{rd} high efficiency klystron and test
High Efficiency Klystron R&D

- 9 cavities with BAC method, simulation result shows 85% efficiency.
Large scale Cryogenic system R&D

- 8 cryoplants: each cryoplant to provide cooling for one RF station;

- Booster ring: 8 stations, 32 cryomodules, 4 cryomodules/each station

- Collider ring: 8 stations, 80 cryomodules, 10 cryomodules/each station

The CEPC heat loads require whole plant capacity of 75.75KW @4.5K. Eight 12 kW @4.5K refrigerators will be employed. The total capacity can reach $96KW@4.5K$
Large scale helium refrigerator R&D

Technical Institute of Physics and Chemistry (IPC), CAS.

10-12kW Refrigerator flow chart

| 压缩机功耗（kW） |  |  |
|-----------------|------------------|
| C-100           | 2151.35          |
| C-200           | 1290.96          |
| C-300           | 0.00             |
| CC1             | 0.00             |
| CC2             | 0.00             |
| CC3             | 0.00             |
| **Total**       | **3442.31**      |

| 制冷量（kW）         |  |  |
|-------------------|------------------|
| 4.5K              | 12.676           |
| 2K                | 0.000            |
| **总换热量（kW）** | **2094.755**     |
| **总UA (kJ/K.s)** | **687.485**      |
| 液氮消耗 L/h       | 191              |
Large scale helium refrigerator R&D

- IPC 10kW@20K Refrigerator

- 2~4K Refrigerator R&D

<table>
<thead>
<tr>
<th>考核内容</th>
<th>项目指标</th>
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<th>2016</th>
<th>2017</th>
<th>2018</th>
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<tbody>
<tr>
<td>系统</td>
<td>制冷量</td>
<td><a href="mailto:2.5KW@4.5K">2.5KW@4.5K</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>超流氦系统</td>
<td>500W@2K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>液氦系统</td>
<td><a href="mailto:250W@4.5K">250W@4.5K</a></td>
<td></td>
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<tr>
<td>稳定运行考核时间</td>
<td>3天</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>关键技术</td>
<td>透平最高绝热效率</td>
<td>75%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>冷压缩机最高绝热效率</td>
<td>60%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 10kW@20K低温制冷设备现场测试结果 
10.8kW@19.7K，连续稳定运行3天，透平效率≥76%

- 制冷功率10.8kW

- 系统的流程方案
  - 论证及设计
  - 新流程方案关键技术设计
  - 核心技术实验和验证系统设计

- 关键子设备及核心实验台仿真、优化、控制策略研究

- 整套设备定型
  - 子设备设计、生产、监管、验收
  - 各子系统装配、调试，智能控制

- 工艺、检测、控制规范建立

- 验收子设备

- 2500W系统集成，达到指标
Booster Low field dipole magnet R&D

To verify the magnet design and field simulation, a 1m long prototype dipole magnet (booster) was developed and measured

- Supported by IHEP workshop

Specifications of the dipole magnets (from Pre-CDR)

- Quantity: 5120
- Magnetic length: 8m
- Gap height: 40mm
- Maximum field: 614Gs
- Injection field: 31Gs
- Repetitive frequency: 0.1Hz
- Good field region: 52mm
- Field uniformity: 5E-4 (0.015Gs@inj.)
- Field reproducibility: 1E-3 (0.03Gs@inj.)
- Linearity of excitation: 95%
Field measurement of the prototype magnet

- The field uniformity at low field both for pure steel core and St:Al=1:2 core becomes 10 time worse than that at high field.

- To meet the field uniformity of 5E-4, the minimum field of the magnet should be higher than 100Gs.

- The measured remnant field in the magnet gap is about 4-6Gs, which is 13%-20% of the low field of 30Gs. So the field performance of the magnet is seriously dependent on the magnetic properties and production quality of the steel laminations.
Booster Low field dipole magnet R&D

The ways to improve the field qualities of the magnet

- To increase the minimum field of the magnet from 30Gs to 100Gs. It needs to increase the injection energy of the booster and thus to increase the energy and cost of the Linac.

- To develop high quality silicon steel laminations with very low remnant field. If the remnant field of silicon steel laminations can be induced to 1Gs, the field performance of the magnet at low field can be improved 5 times. However, is it possible?

- To design the low field magnet without magnetic core. It can get out of the remnant field influence on the field quality of the magnet. However, without the magnetic core, the excitation efficiency of the magnet will be low, the mechanical precision of the coils has to be improved at least 50 times compare the magnet with magnetic core, and the cost of the magnets will increase dramatically.
**Design of Electrostatic Separator**

- In the CEPC, the e- and e+ beams in the storage ring need to be designed from single rings to double loops and from double rings to single rings in the process of accumulation and collision.
- Because e- and e+ are in the opposite direction of the electrostatic field, the process can be accomplished by an electrostatic separator.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separator length</td>
<td>4.5m</td>
</tr>
<tr>
<td>Inner diameter of separator tank</td>
<td>540mm</td>
</tr>
<tr>
<td>Electrode length</td>
<td>4.0m</td>
</tr>
<tr>
<td>Electrode width</td>
<td>260mm</td>
</tr>
<tr>
<td>Nominal gap</td>
<td>110mm</td>
</tr>
<tr>
<td>Maximum operating field strength</td>
<td>20MV/m</td>
</tr>
<tr>
<td>Maximum operating voltage</td>
<td>±110kV</td>
</tr>
<tr>
<td>Maximum conditioning voltage</td>
<td>±160kV</td>
</tr>
<tr>
<td>Maximum deflection</td>
<td>62.5urad</td>
</tr>
<tr>
<td>Horizontal good field region (1% limit)</td>
<td>±80mm</td>
</tr>
<tr>
<td>Nominal vacuum pressure</td>
<td>2.7e-8 Pa</td>
</tr>
</tbody>
</table>

- **Electrode**
  - Field homogeneity: 1% in 10 x 10 mm$^2$
    - Electrode shape

Field distribution

Field homogeneity
**Design of Electrostatic Separator**

- A separator unit including: a pair of electrodes, UHV tank, metal-ceramic supports, high voltage feedthrough, High voltage circuit, vacuum system.

- **Electrode** *(a pair of hollow metal flat plate)*
- Dimension: 4m long and 260mm wide
- Material: Titanium
- Separated direction: Horizontal
- Field strength: 2MV/m
Vacuum system R&D

The materials and shapes of the vacuum chambers are analyzed and compared, final choice will be done by R & D results of vacuum chambers prototypes.

- CEPC copper bending vacuum chamber design
  - Elliptical: 100mm×55mm,
  - Thickness: 6mm,
  - length: 8000mm

The copper chamber manufacturing procedure:
- Extrusion of the beam pipe and cooling channel,
- Machining of the components to be welded,
- Chemical cleaning,
- Electron-beam welding,
- Welding of the end flanges and water connections,
- Leak checks,
- NEG coating of the inside chamber.
Vacuum system R&D

- For CEPC, the fingers are designed to maintain a relatively high contact pressure of 150±10 g/finger, and the slit length between fingers is set to be 20mm.
- The RF-shield should absorb the maximum expansion of 10 mm and contraction of 20 mm, allowing for the offset of 2 mm.
- The step at the contact point is limited to less than 1mm.
- The cooling water channel is attached considering the reflecting power of the synchrotron radiation, Joule loss and HOM heat load on the inner surface, and the leaked HOM power inside the bellows.

A three-dimensional drawings of RF bellows are designed.
CEPC R&D Fund ( ~ 250 M CNY )

- IHEP fund:
  - Research of High Q cavity: 1.82 M CNY
  - 650MH/300kW klystron development: 3.71 M CNY
  - Digital BPM: 1 M CNY

- Most fund:
  - SRF Technology R&D: 7.35 M CNY
  - Injector key technology R&D: 4.25 M CNY

- PAPS fund:
  - SRF infrastructure construction: ~150 M CNY
  - Cavity: ~20 M CNY
  - High power test: ~40 M CNY

- Director Special fund:
  - 650MH/800kW/80% klystron development: 20M CNY

- Year 2018 Most Found application:
  - Low field Magnets: 3.5 M RMB
  - Electrostatic Separator: 3.5 M RMB
  - Vacuum system: 3 M RMB
Conclusion

- 100km CEPC accelerator baseline design progress well.
- Design and key technologies' R&D are progress well.
- About 250M CNY fund from MOST and IHEP for CEPC key technology R&D, hopeful more fund in 2018.
- CEPC CDR to be finished for accelerator at the end of 2017.
Thanks for your attention!