The Construction Status of CSNS Linac

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Sep.2, 2014, Geneva
Outline

- The introduction to CSNS accelerators
- The commissioning of ion source
- The RF conditioning of RFQ
- Construction status of DTL
- Commissioning plan of DTL
- Summary
A Brief Review to CSNS

<table>
<thead>
<tr>
<th></th>
<th>CSNS</th>
<th>Upgrade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam power (kW)</td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>Rep. rate (Hz)</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Target number</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ave. current (µA)</td>
<td>62.5</td>
<td>312</td>
</tr>
<tr>
<td>Kinetic energy (GeV)</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Inj. Energy (MeV)</td>
<td>80</td>
<td>250</td>
</tr>
</tbody>
</table>
China Spallation Neutron Source (CSNS)
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Ion Source Commissioning

**Output energy**  50 keV  
**Temperature of Cs oven**  150~170 °C

**Repetition rate**  25 Hz  
**Temperature of Cs transport line**  ~300 °C

**Pulse H⁻ beam width**  500 µs  
**Extraction voltage**  17 kV  
**Pulse H⁻ beam current**  50 mA  
**Current of Analyzing magnet**

**Flux of H₂**  10~12 SCCM  
**Pulse arc current**

**Pulse arc width**  600 µs  
**Chamber vacuum**  2~3×10⁻³ Pa

①: hydrogen feeding, ②: discharge current: 50A, ③: extraction voltage: 17kV, ④: extraction current: 300mA (electrons and H⁻)

H⁻ beam at ACCT: 55mA, 500 ms and 25 Hz
Emittance vs. beam current. Left: X plane. Right: Y plane. At 0.2 mmmrad, current of X plane and Y plane is 15mA and 25mA, respectively.
# RFQ Tuning

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output energy</td>
<td>3.0 MeV</td>
</tr>
<tr>
<td>Repetition rate</td>
<td>25 Hz</td>
</tr>
<tr>
<td>Pulse H(^{-}) beam width</td>
<td>500 µs</td>
</tr>
<tr>
<td>Pulse H(^{-}) beam current</td>
<td>40 mA</td>
</tr>
<tr>
<td>RF Freq.</td>
<td>324 MHz</td>
</tr>
<tr>
<td>Length</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Field tuning (before)

Field tuning (after)
437 kW @700 μs/25 pps.
Input RF frequency is near 324.16 MHz,
Two power couplers’ VSWR are 2.09 and 2.03,
**DTL Layout**

![DTL Layout Diagram]

<table>
<thead>
<tr>
<th>DTL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>35.44 m</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>324 MHz</td>
</tr>
<tr>
<td><strong>Beam energy</strong></td>
<td>3-80.1 MeV</td>
</tr>
<tr>
<td><strong>Number of Tanks</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>Copper RF power</strong></td>
<td>5.3 MW</td>
</tr>
<tr>
<td><strong>Peak current</strong></td>
<td>15 mA</td>
</tr>
<tr>
<td><strong>Aperture radius</strong></td>
<td>8-12 mm</td>
</tr>
<tr>
<td><strong>Number of Cells</strong></td>
<td>161</td>
</tr>
</tbody>
</table>
DTL Layout

China Spallation Neutron Source

50keV
Ip=20/40mA

H⁻
LEBT
RFQ
MEBT
DTL

3MeV
324MHz
β = 0.01

80 MeV
324MHz
β = 0.39

Number of Cells 161

Number of Tanks 4

Copper RF power 5.3 MW

Beam energy 3-80.1 MeV

Peak current 15 mA

Aperture radius 8-12 mm

Length 35.44 m

Frequency 324 MHz

β = 0.08
DTL Layout

China Spallation Neutron Source

Parameters

- DTL1
- DTL2
- DTL3
- DTL4
- DTL1-1
- DTL1-2
- DTL1-3

DTL Layout

- Length: 35.44 m
- Frequency: 324 MHz
- Beam energy: 3-80.1 MeV
- Number of Tanks: 4
- Copper RF power: 5.3 MW
- Peak current: 15 mA
- Aperture radius: 8-12 mm
- Number of Cells: 161

Diagram shows the layout with
- Water cooling channel
- Movable tuner
- Ridged waveguide
- Post coupler
- Stems
- Slug tuner
- Support stand
- Turbo pump station
- Ion pump station
DTL: Features

- Electroplating Tank
- Compact Electro-Quadrupole Magnets:
  - Advanced fabrication technology
  - OFC (Oxygen Free copper)DT
- Q-Magnet measurement
- High accuracy alignment

Q-magnet hollow coil
Tank Status

• Each physical tank consists of 3 mechanical segments.
• 6 segments have been completed, and the other 6 will be completed at the end of 2014.
• The DT installation of the first tank will begin at the beginning of September.
Quadrupole field measurement

The magnetic field of the Q-magnet was measured several times by a rotating coil during the fabrication process.

- The first measurement is done just after the construction of the magnet.
- The next two measurements are done before and after EBW of DT.
- Final step for fine polishing is an Iteration process.
Drift Tube Status

- 63 drift tubes for DTL1 have been completed.

- For the other 3 tanks, half of totally 126 DTs have been completed, and the rest will be completed at the end of Feb. 2015
Quadrupole field measurement

- The higher order multipole components less than 0.3%
- The deviation less than ±30µm

Rotating coil measurement

Deviations between the mechanical center and the magnetic center
Rotating angle

- Quadrupole rotation $\alpha<\pm3\text{mrad}$
# RF properties

<table>
<thead>
<tr>
<th>Tank No.</th>
<th>meas.(calc.)</th>
<th>m/c(%)</th>
<th>freq.(MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTL1-1</td>
<td>70099(78023)</td>
<td>90</td>
<td>405.03</td>
</tr>
</tbody>
</table>

![Network analyzer](image1.png)

![Pick-ups](image2.png)
Bead-pull Measurement System

- Network Analyzer
- Bead-Pull Support
- Bead-Pull motor control
- NA Control and Data acquisition program

Diagram of Bead-Pull support structure
RF windows

The CSNS DTL requires four RF windows at 324MHz. Each window will transmit up to 80 kW of average power and 2 MW peak power at 25 Hz with 620 microsecond pulses. The RF windows designed and manufactured by Thales, will test at the full average power for 24 hours to ensure no problems with such a power level.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>324MHz</td>
</tr>
<tr>
<td>Peak power</td>
<td>2MW</td>
</tr>
<tr>
<td>VSWR(:1)</td>
<td>&lt;1.05</td>
</tr>
<tr>
<td>Max.Average power</td>
<td>~100kW</td>
</tr>
<tr>
<td>Repetition rate</td>
<td>25Hz</td>
</tr>
<tr>
<td>RF on Pulse length</td>
<td>620μs</td>
</tr>
</tbody>
</table>
Ridged Waveguide

1. Cold model
2. FORGED OFC BLOCK
3. Annealing
4. ROUGH MACHINING
5. NATURAL AGING
6. FINISH MACHINING
7. BRAZING
8. RF TESTING
9. OFC BLOCK
10. FLANGE
Temporal Beam Diagnostic system:
1 BPM, 1 CT, 2 FCT, 1 QEM, 1 x-y steering magnet, 1 EM, 1 WS
1 Energy degrader/Faraday cup, 1 Beam dump (0.163 kW)
DTL Commissioning Plan

Temporal Beam Diagnostic system:
- 1 BPM, 1 CT, 2 FCT, 1 QEM, 1 x-y steering magnet, 1 EM, 1 WS
- 1 Energy degrader/Faraday cup, 1 Beam dump (0.163 kW)
## Planned commissioning Schedule

<table>
<thead>
<tr>
<th>Project</th>
<th>Start Date</th>
<th>End Date</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS+LEBT</td>
<td>Nov. 15, 2014</td>
<td>Dec. 31, 2015</td>
<td>1.5 months</td>
</tr>
<tr>
<td>RFQ+MEBT</td>
<td>Feb. 15, 2015</td>
<td>Mar. 31, 2015</td>
<td>1.5 month</td>
</tr>
<tr>
<td>DTL1</td>
<td>Aug. 1, 2015</td>
<td>Sep. 30, 2015</td>
<td>2 months</td>
</tr>
<tr>
<td>DTL2-4+LRBT</td>
<td>July. 1, 2016</td>
<td>Sep. 30, 2015</td>
<td>3 months</td>
</tr>
<tr>
<td>RCS</td>
<td>Oct. 1, 2016</td>
<td>Jul. 31, 2017</td>
<td>10 months</td>
</tr>
<tr>
<td>RTBT</td>
<td>Aug. 1, 2017</td>
<td>Aug. 31, 2017</td>
<td>1 month</td>
</tr>
<tr>
<td>First beam on target</td>
<td>Aug. 1, 2017</td>
<td>Aug. 31, 2017</td>
<td></td>
</tr>
<tr>
<td>Beam power to 10kW</td>
<td>Aug. 1, 2017</td>
<td>Sep 30, 2017</td>
<td></td>
</tr>
<tr>
<td>CSNS to acceptance goal</td>
<td>Dec. 31, 2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Official acceptance</td>
<td>Mar. 2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beam power to 100kW</td>
<td>Mar.1,2018</td>
<td>Mar.1,2021</td>
<td>3 years</td>
</tr>
</tbody>
</table>
Summary

• The commissioning of ion source has been successfully performed.

• The RF conditioning for RFQ has been successfully done.

• There is delay on the DTL construction, but still on the schedule for official acceptance.

• The beam commission for DTL tank-1 will start on the May, 2015, and the beam commissioning for whole DTL will be completed on the Sep., 2016.
Thanks for your attention!