The Design and Construction Status of Injection and Extraction system for CSNS/RCS

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Outline

• The introduction to CSNS accelerators
• The design of CSNS/RCS
• The design of injection and extraction system for RCS
• Construction status of injection system
• Construction status of extraction system
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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China Spallation Neutron Source (CSNS)
# Planned commissioning Schedule

<table>
<thead>
<tr>
<th>Component</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-Mar.1,2021</td>
<td></td>
<td>3 years</td>
</tr>
</tbody>
</table>
Lattice consists of 16 triplet cells, with a gap in the middle of arc, and with long free space in dispersion free straight section.
Lattice consists of 16 triplet cells, with a gap in the middle of arc, and with long free space in dispersion free straight section.

- Four-fold symmetry - Separated functions
- Triplet structure - Small magnet aperture
- Dispersion-free long uninterrupted straight - For collimation & injection/extraction
- Straight at arc with large dispersion - high efficiency mom. collimation
- The all-triplet structure is not good for chromaticity correction and dynamic aperture
Beam injection

- H- stripping and painting method are used to match the small emittance beam from linac to large emittance beam in RCS.
- The injection is performed in a 11 m long straight section,
- Four horizontal painting magnets (BH), four vertical painting magnets (BV), and four shift orbit bump magnets (BC).
- Shift bump magnets works in DC mode.
Beam injection

- H- stripping and painting method are used to match the small emittance beam from linac to large emittance beam in RCS.

- Shift bump magnets works in DC mode.
The collection of dump beams

- Depending on the thickness of stripping foil, a little part of H- can not converted, and bulk of them are H0, a small fraction of them are H-. To control these particles, the second stripping foil is adopted.
- The bulk of H0 are converted into proton and sent to injection dump through BC4 and a septum to dump.
- The small part of H- escape from main foil stripping, will mostly stripped by the second foil and absorbed by a local absorber (benefits from very small beam power).
- The stripped electrons will be moved by the field of shift bump magnet, and collected by a collector.
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Injection painting Scheme

Both correlated painting and anti-correlated scheme are available
The Extraction Scheme of RCS

- Two 1.6GeV proton bunches are extracted by one-turn extraction from RCS in each RCS cycle.
- The beam is vertically kicked by a series of kicker to a horizontal bending Lambertson type septum.
The bunch length is about 60~80ns, and the space between two bunch is about 330~350ns. The rise time of kicker is required to be less than 265ns and flat top field need to be kept more than 550ns.
Effects of flat top field error malfunction of kickers

The statistics of 20 groups of random errors
Effects of flat top field error malfunction of kickers

3 \sigma = 2\%  

The statistics of 20 groups of random errors
The Construction Status

- The prototype painting PS are used for Horizontal painting magnet, and the vertical painting PS will be soon completed;

- The totally 8 painting magnets has been delivered to CSNS site, and now the field measurement has been making;

- The first kicker magnet, as prototype, has been tested, and the other kicker magnet are now under installation in the CSNS site;

- The PS for the first kicker has been tuned and tested, and the other 7 PS are now under mass production
Painting Pulse Power Supply
Painting Pulse Power Supply

China Spallation Neutron Source
The Setting and output waveform for painting PS
The Painting Magnet and Field measurement
The Painting Magnet and Field measurement

±1.07%

Good field region: 72mm–62mm

y = 0

X (mm)
The Kicker and Power Supply
The Waveform of Kicker PS

Rise time: 264ns
The flat top: 600ns
The flatness: ±0.98%
Lambertson: under fabrication

Leakage stray field: 0.47‰, 0.7mrad impact to circulating beam.
Thanks for your attention!