Status of CSNS Project

Shinian FU
for CSNS project

Institute of High Energy Physics, CAS
Outline

- Project Overview
- Civil Construction
- Accelerator Design and Construction
- Target & Instruments
- Summary
Project Overview
Facility Design

- The phase-I CSNS facility consists of an 80-MeV H⁻ linac, a 1.6-GeV RCS, beam transport lines, a target station, and 3 instruments.

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<tr>
<th>Project Phase</th>
<th>I</th>
<th>II</th>
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<tbody>
<tr>
<td>Beam Power on target [kW]</td>
<td>100</td>
<td>500</td>
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<tr>
<td>Proton energy [GeV]</td>
<td>1.6</td>
<td>1.6</td>
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<tr>
<td>Average beam current [μA]</td>
<td>62.5</td>
<td>312.5</td>
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<tr>
<td>Pulse repetition rate [Hz]</td>
<td>25</td>
<td>25</td>
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<tr>
<td>Linac energy [MeV]</td>
<td>80</td>
<td>250</td>
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<tr>
<td>Linac type</td>
<td>DTL</td>
<td>+Spoke</td>
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<tr>
<td>Linac RF frequency [MHz]</td>
<td>324</td>
<td>324</td>
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<tr>
<td>Macropulse ave current [mA]</td>
<td>15</td>
<td>40</td>
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<tr>
<td>Macropulse duty factor</td>
<td>1.0</td>
<td>1.7</td>
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<tr>
<td>RCS circumference [m]</td>
<td>228</td>
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<td>RCS harmonic number</td>
<td>2</td>
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<tr>
<td>RCS Acceptance [πmm-mrad]</td>
<td>540</td>
<td>540</td>
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<tr>
<td>Target Material</td>
<td>Tungsten</td>
<td>Tungsten</td>
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Linac

RCS

1.6 GeV, 62.5 μA, 25Hz

Target station

Neutron instruments

Ṗn= 100 kW

RTBT

LRBT

DTL

RFQ
Civil Design

- Total long-term construction site area is about 0.67km². 0.27km² has been occupied for phase-I construction. The remaining land is planned for future expansion for new project.
- Facility buildings, including Linac, RCS, transport line, target, have a total area of 30,431m². Auxiliary buildings, including administration office, test halls, occupy a total area of 36,258m².
Civil Design

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Baseline Budget and Support

- Approved budget
  - **1.67B CNY** from central government for project construction
  - **0.5B CNY** from Guangdong/Dongguan local government for additional support
  - **~0.5B CNY** from Dongguan local government for the site preparation and infrastructure
  - **30M CNY** from CAS for initial R&D
  - Personnel salary provided by CAS (now ≈300 staff, finally to 400)
0-order CPM
0-order CPM
0-order CPM

- 2012.03: Civil Construction start
- 2013.09: Frontend installation
- 2013.12: DTL installation
0-order CPM
0-order CPM
0-order CPM
Challenges

- **Primary challenges**
  - complete project scope at high quality with limited time and budget
  - preserve potential for future development (beam power upgrade & many other application requirements)
  - relatively small scale of R&D

- **Physics**
  - space charge & halo, ramping, fringe field, impedance & instabilities

- **Engineering**
  - rapid-cycling technology, high-yield target & moderator, …
  - first-time practice in China (low industrial base level)

- **Budget**
  - ~US$270M (accelerator, target, 3 instruments, buildings)
Civil Construction
Site Preparation

May 2009

August 2011
Residential Construction

- The Dongguan local government provided $33,453m^2$ land at Songshan Lake for apartment room construction.
- Construction of the first 10 buildings has been completed with 230 rooms, and additional 320 rooms will soon start construction.
Accelerator Design and Construction
**Linac Design**

**Input Energy (MeV)**
- Ion Source: 0.05
- RFQ: 3.0
- DTL: 80

**Output Energy (MeV)**
- Ion Source: 0.05
- RFQ: 3.0
- DTL: 80

**Pulse Current (mA)**
- Ion Source: 20/40
- RFQ: 20/40
- DTL: 15/30

**RF frequency (MHz)**
- Ion Source: 324
- RFQ: 324
- DTL: 324

**Chop rate (%)**
- Ion Source: 50
- RFQ: 50
- DTL: 50

**Duty factor (%)**
- Ion Source: 1.3
- RFQ: 1.05
- DTL: 1.05

**Repetition rate (Hz)**
- Ion Source: 25
- RFQ: 25
- DTL: 25

**EMQ option in FFDD lattice**

**Electrostatic chopper in LEBT**
Front-end

• **H- ion source**

  A Penning source has been set up. It is now under beam extraction test. The first extracted H- beam reached 20 mA this week.

• **LEBT with a chopper**

  Space charge neutralized LEBT with an electrostatic deflector as a chopper at the entrance of the RFQ. A prototype of the chopper reaches a fast rise time less than 17ns in a proton beam test.
Front-end

- **RFQ**

  A four-vane type RFQ at 324 MHz composed of two coupled resonators. Four modules have been brazed for assembly and field tuning.

- **RF Power**

  Two sets of Burle 4616 Tetrode feed 530 kW total RF power to the RFQ. In the power test, the source can reach 400 kW pulse power with pulse length of 700μs at 25 Hz, better than specification.
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DTL

- Tank and drift tube
  
  The DTL linac is composed of 4 tanks with a total length of 35 m. Each tank is about 9m long and assembled with 3 technical modules. EMQs in FFDD lattice provide focusing in equipartioning design.

- The first tank is under fabrication. Tank is made of a carbon steel tube with copper plated on the inner surface. A feature of the DTL is the use of OFC in all parts of DTs. SAKAE coil is adopted for the quadrupole.
• **RF Power**

RF power source for DTL is 324 MHz klystron from CPI, with maximum output power of 3 MW. Two sets of 400 Hz AC series resonance high voltage power supply is under manufacture.

• **LLRF**

A full digitalized LLRF system was tested with amplitude and phase variations in the cavity less than \( \pm 0.25\% \) and \( \pm 0.35^\circ \) with beam loading, much better than the requirements of \( \pm 1\% \) in amplitude and \( \pm 1^\circ \) in phase.
RCS Design

- Lattice of 4-fold symmetry, triplet.
- 227.92m circumference.
- Four long straight sections for injection, acceleration, collimation and extraction.
- 24 main dipoles with one power supply.
- 48 main quadrupoles with 5 power supplies.
- Ceramic vacuum chambers for the main magnets.
- 8 RF ferrite loaded cavities to provide 165 kV.
• **RCS Main Dipole**
  Two prototypes were fabricated to address the issue of laminate crack. Based the successful experience we started the mass production at IHEP workshop.

• **RCS Main Quadrupole**
  Overcome crack trouble of the coil epoxy resin. Contracted with IHEP workshop and the first one has been manufactured. 72 hours test run has been conducted without any crack.

Field measurement show a satisfactory results.
Power supply

White resonant circuit is chosen as the power supply to provide AC+DC current to the main magnets. Power source and choke are now under mass production. To compensate for the field deformation due to the magnet core nonlinearity, harmonic injection technology is successfully introduced into the power supplies in the test of the prototype.
Ring RF
Ferrite loaded cavity’s resonant frequency shifts from 1.02 MHz to 2.44 MHz in 20 ms by a bias current supply. Cavity design is improved, under mass production.

8 sets of 500 kW transmitter have been in mass production.
Mass production of the ceramic chambers for RCS main Q and D magnets has started.

A curved magnetron sputtering facility for TiN coating has been set up at IHEP and glow discharge has been got in the first test for the prototype dipole ceramic chamber.
• RCS Injection & Extraction

The stripping foil facility has been manufactured with 20 carbon foils on a rotating frame. One of the two injection pulsed bump power supplies of 9,000A made in R&D phase can be directly used.

• 8 kicker magnets have been put into mass production and the first one will be accepted in August. Their power supplies are now under fabrication and the first one is scheduled in Sept. 2013.
Target & Instruments
• **Target**

Target station design has been finalized. It is optimized for 100 kW operation in the first phase and reserved the feasibility to upgrade its capability to 500 kW. The target is maintained with a horizontal plug while the moderator and reflector are maintained with a vertical plug.

• **TMR Mock-up**

A mock-up of the **Target-Moderator-Reflector** remote-handling system has been set up to confirm the design and to demonstrate the maintenance scheme.
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• **Instruments**

3 instruments: General Purpose Powder Diffractometer, Reflectometer, SANS. High resolution slit has been made with a position resolution below 2 μm.

• **Detectors**

A $^3$He-MWPC with an active area: 200mm*200mm has been made and tested with neutron beam from CARR rector, with a position resolution below 2 mm.
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Summary

- CSNS is designed with the capability for upgrading from 100kW to 500kW beam power with repetition rate 25Hz.
- It is the first high power proton accelerator in China, facing many challenges.
- Project construction started in Sept. 2011, and will be completed in March 2018.
- Mass production of the accelerator components is going well, as planned.
- Before the end of 2013 the front-end of the accelerator will be installed in the linac tunnel.
- International collaboration has a great contribution.
Thanks for your attention!