Status of CSNS Project

Shinian FU
for CSNS project

Institute of High Energy Physics, CAS

CSNS
CHINESE ACADEMY OF SCIENCES

IPAC2013, Shanghai, China , May 13-17,2013

Outline

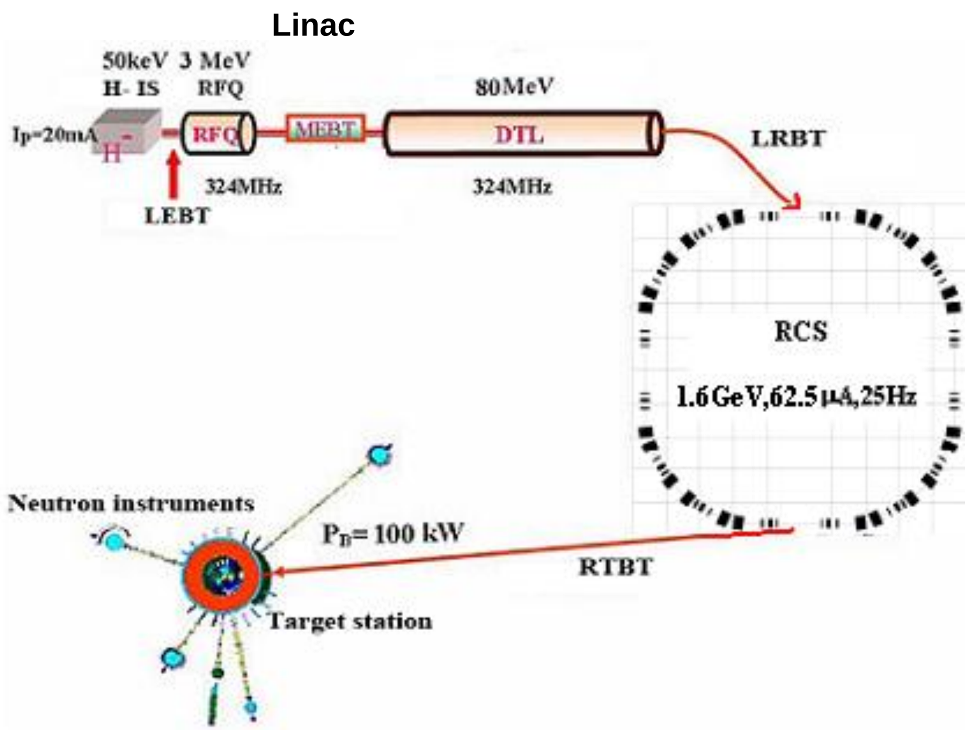
- Project Overview
- Civil Construction
- Accelerator Design and Construction
- Target & Instruments
- Summary

Project Overview

Facility Design

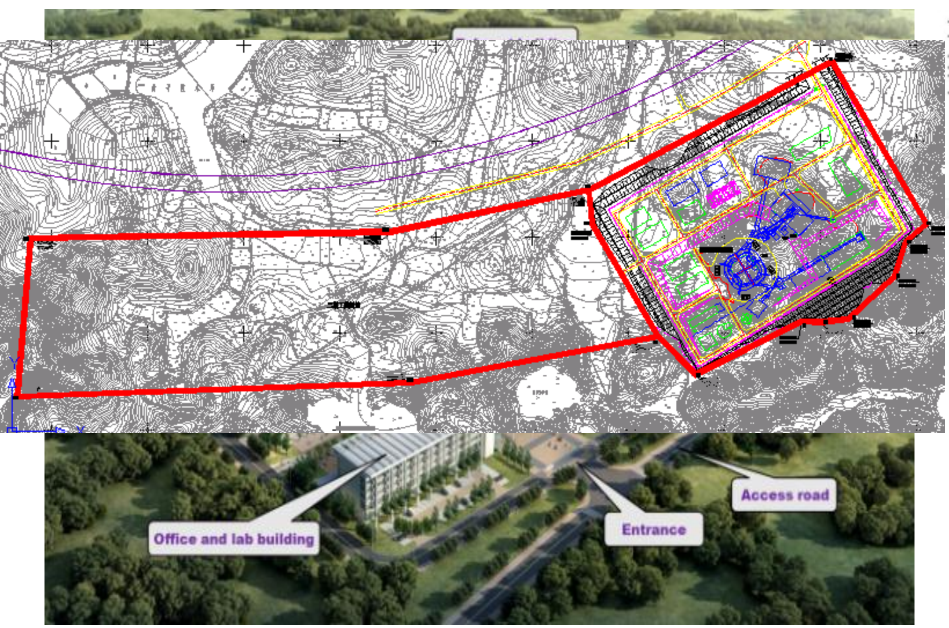
- **The phase-I CSNS facility consists of an 80-MeV H^- linac, a 1.6-GeV RCS, beam transport lines, a target station, and 3 instruments.**

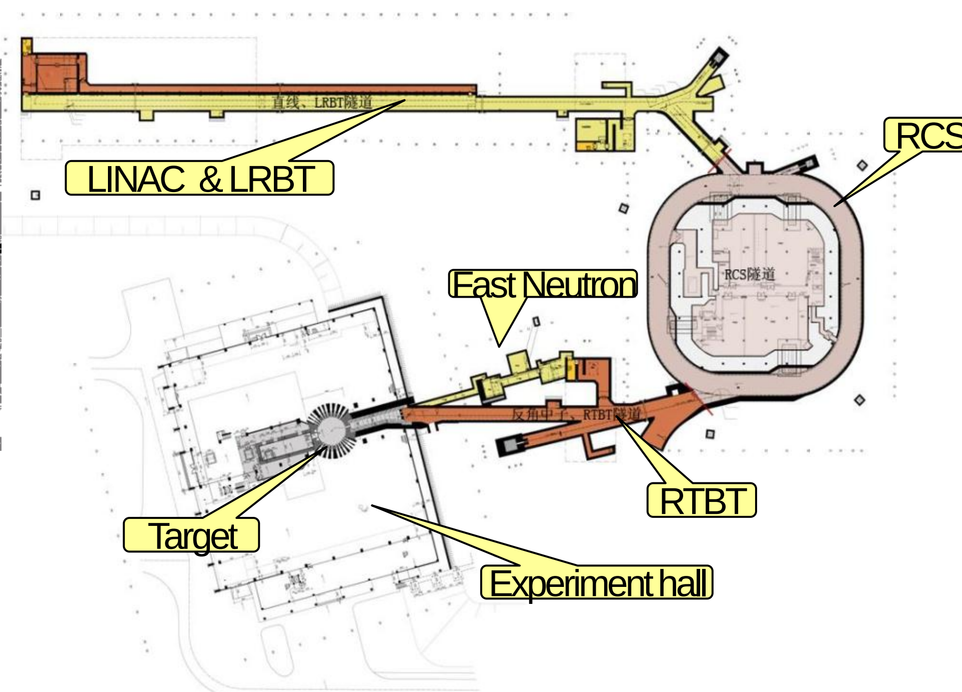
Project Phase	I	II
Beam Power on target [kW]	100	500
Proton energy [GeV]	1.6	1.6
Average beam current [μ A]	62.5	312.5
Pulse repetition rate [Hz]	25	25
Linac energy [MeV]	80	250
Linac type	DTL	+Spoke
Linac RF frequency [MHz]	324	324
Macropulse. ave current [mA]	15	40
Macropulse duty factor	1.0	1.7
RCS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



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.





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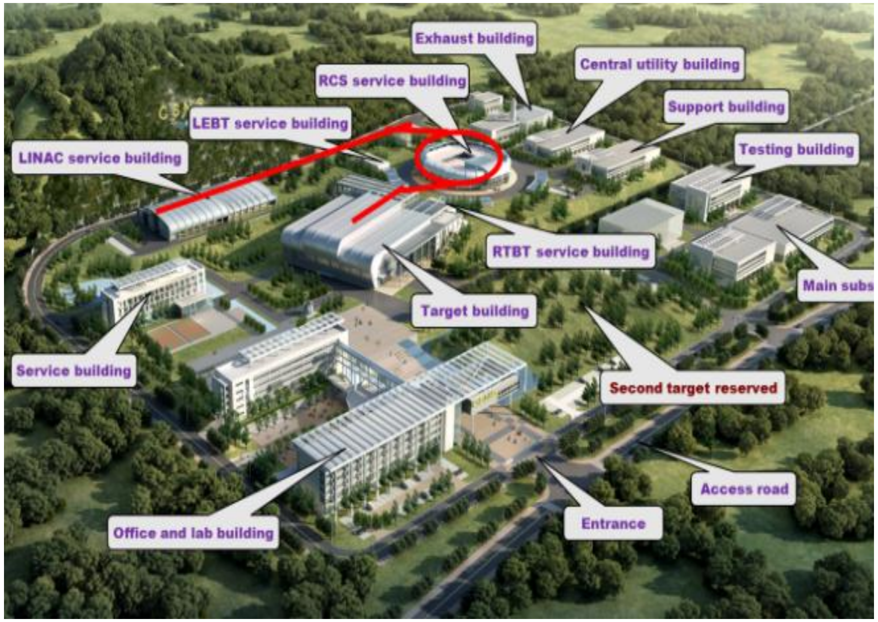

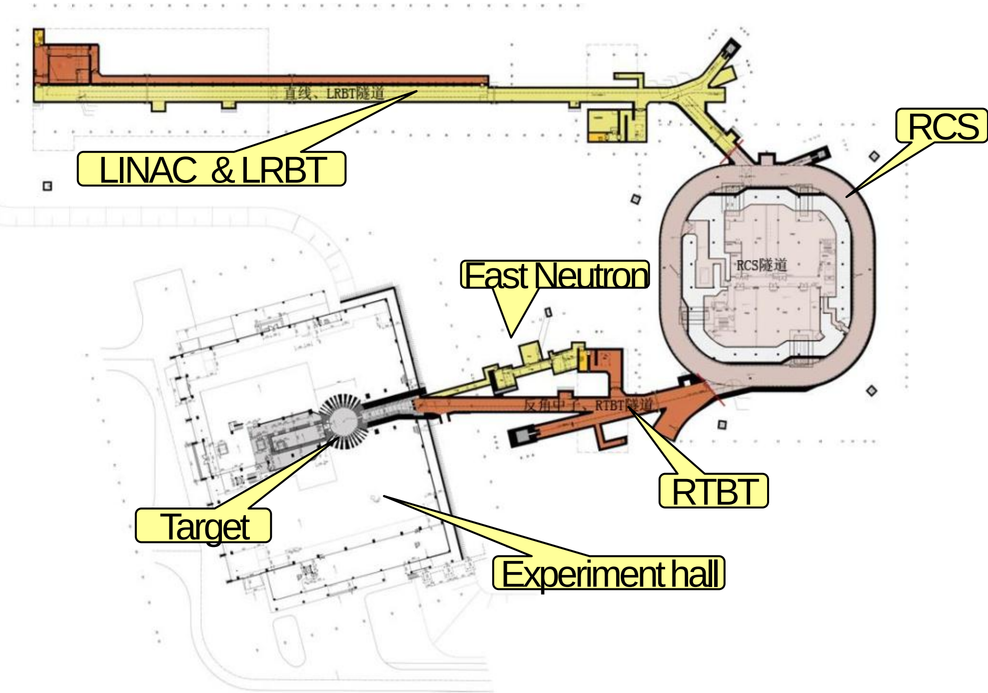

Baseline Budget and Support

- 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)

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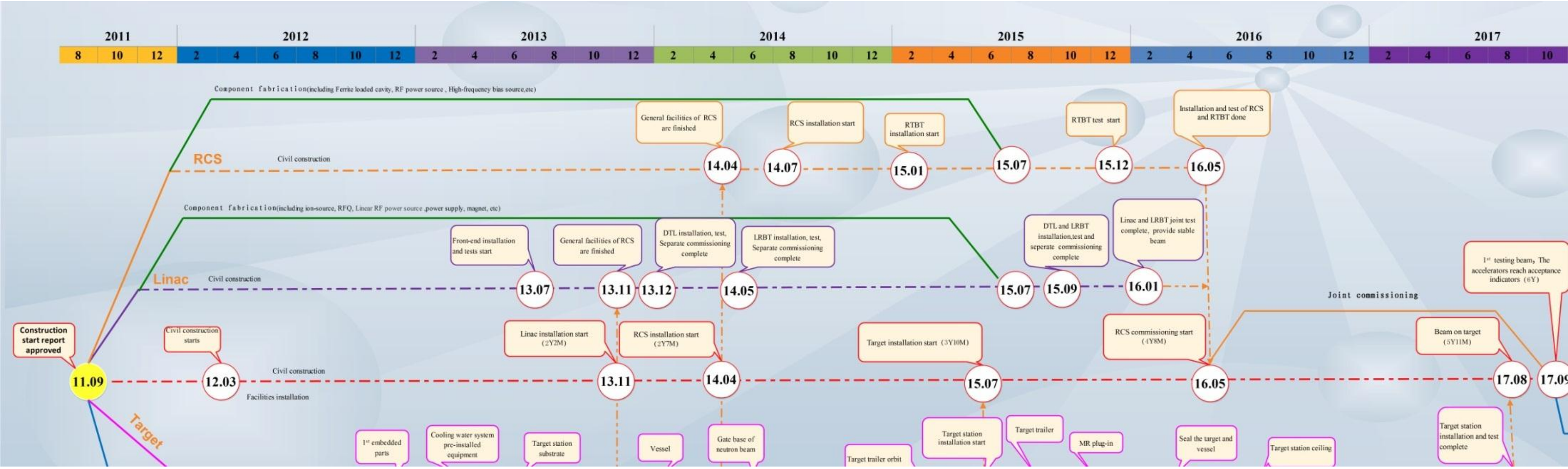
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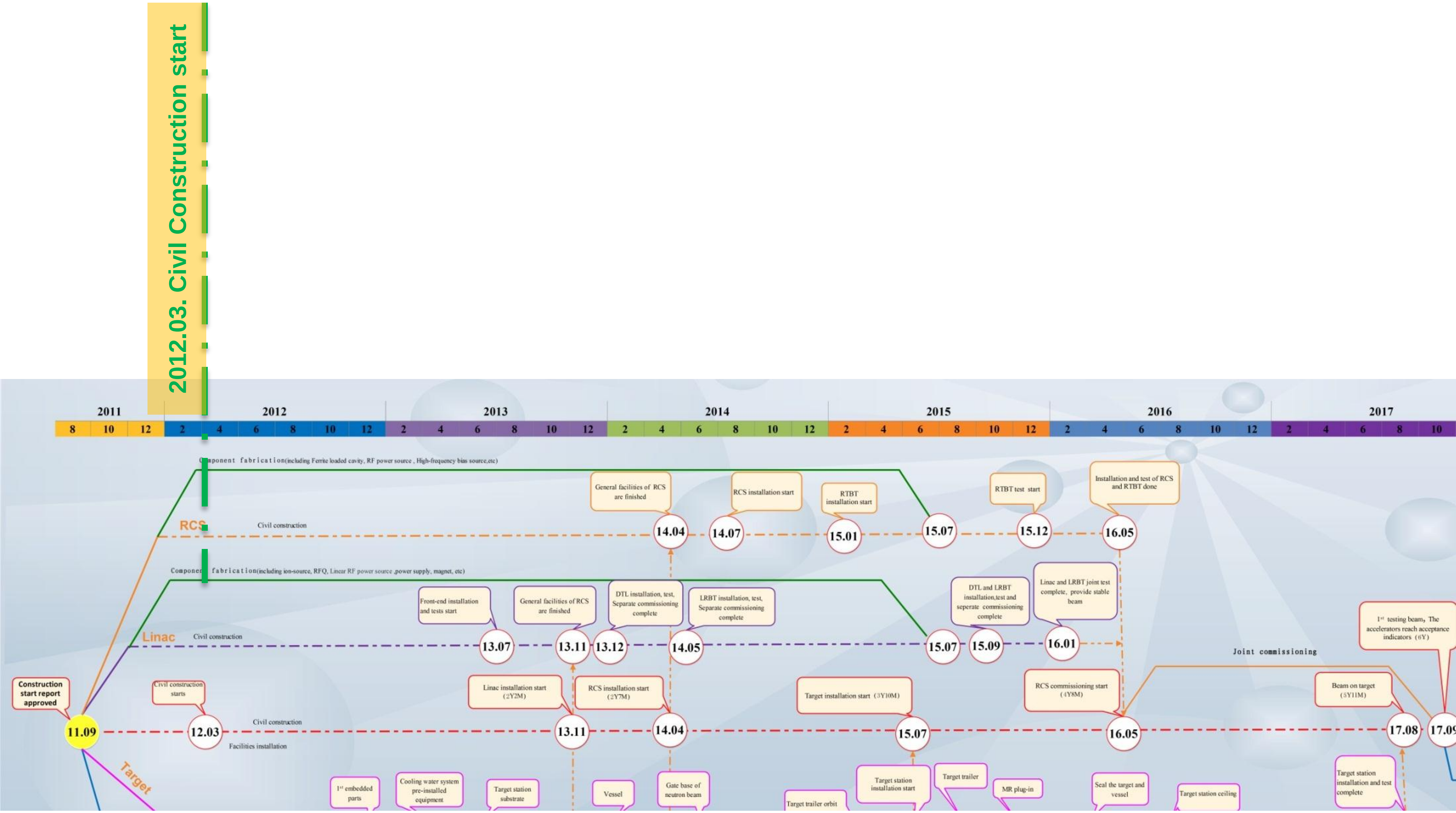
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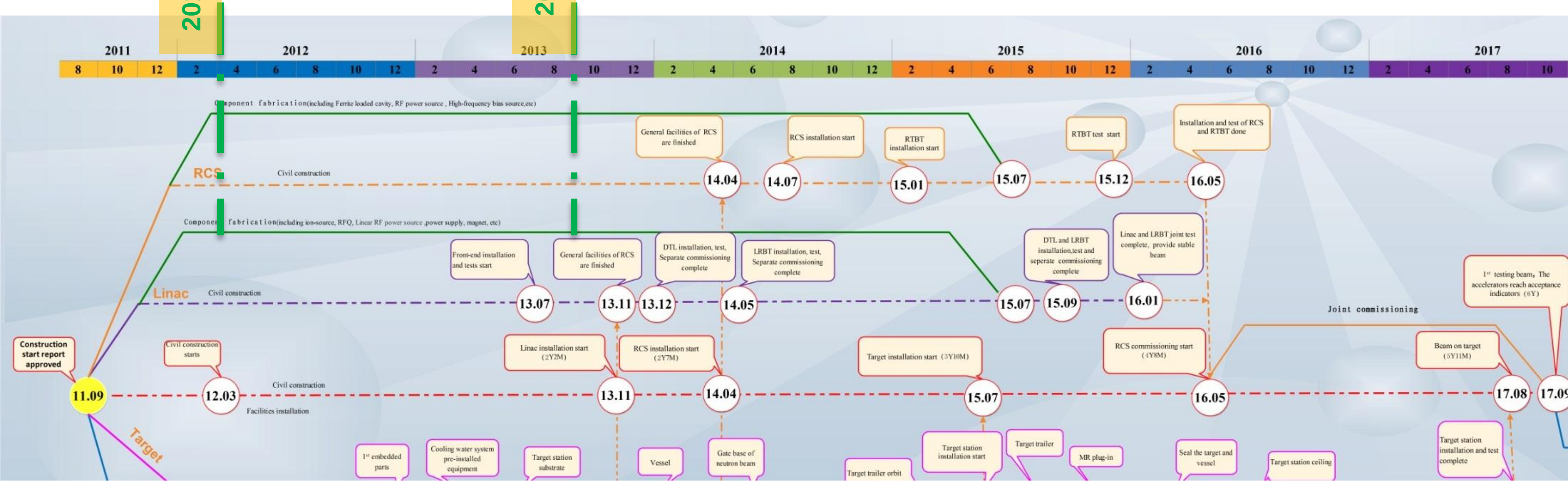

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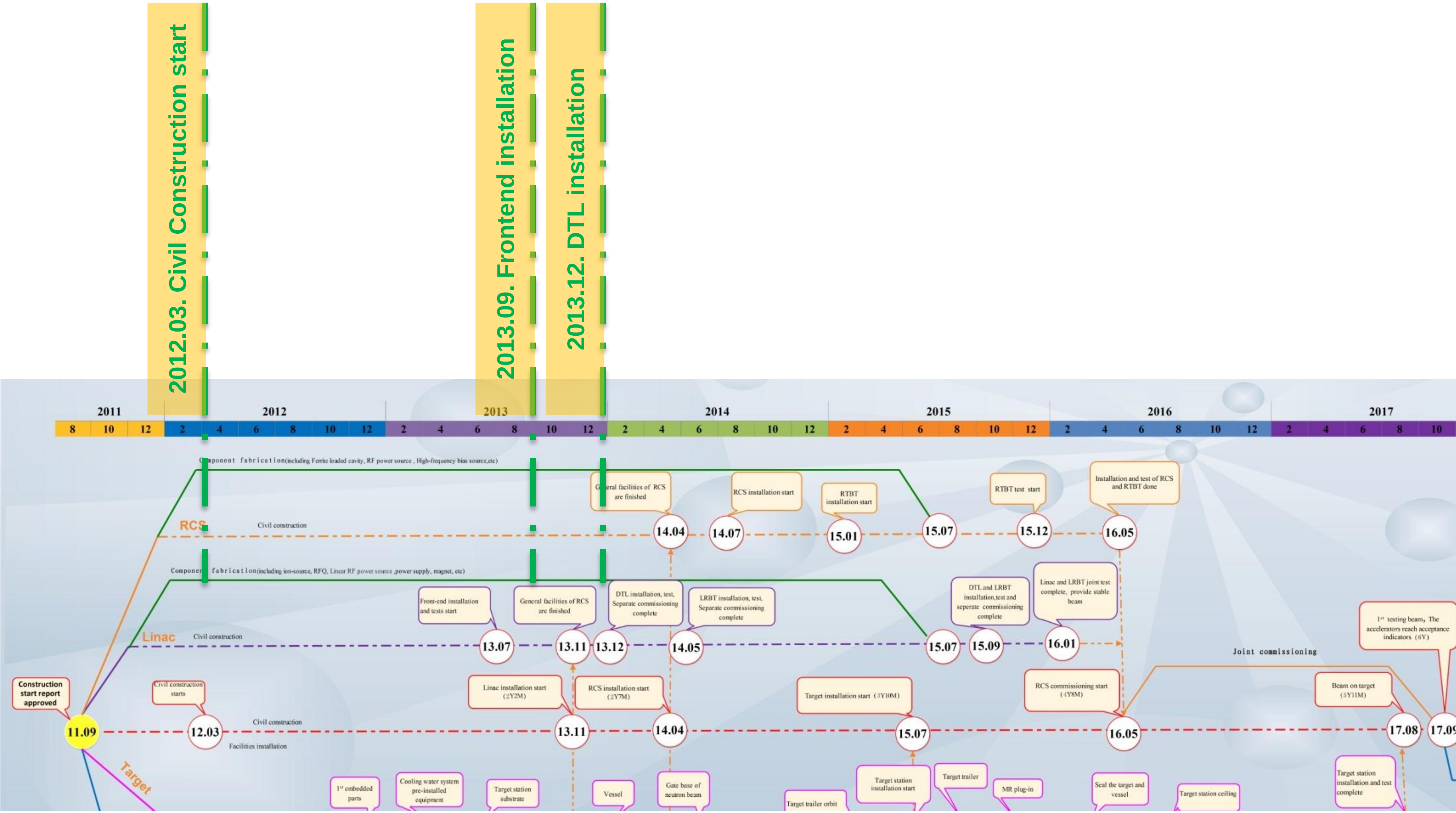
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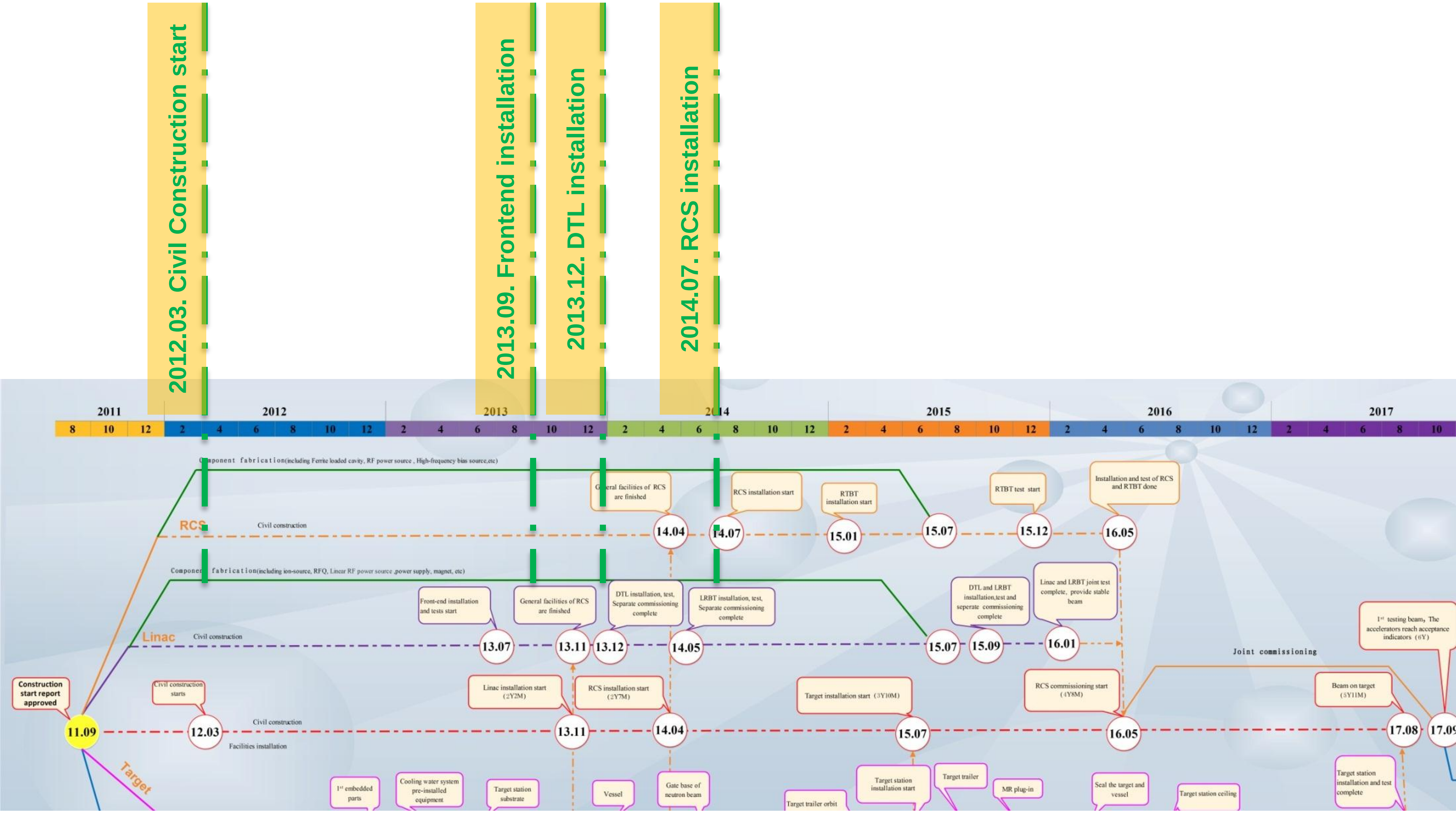
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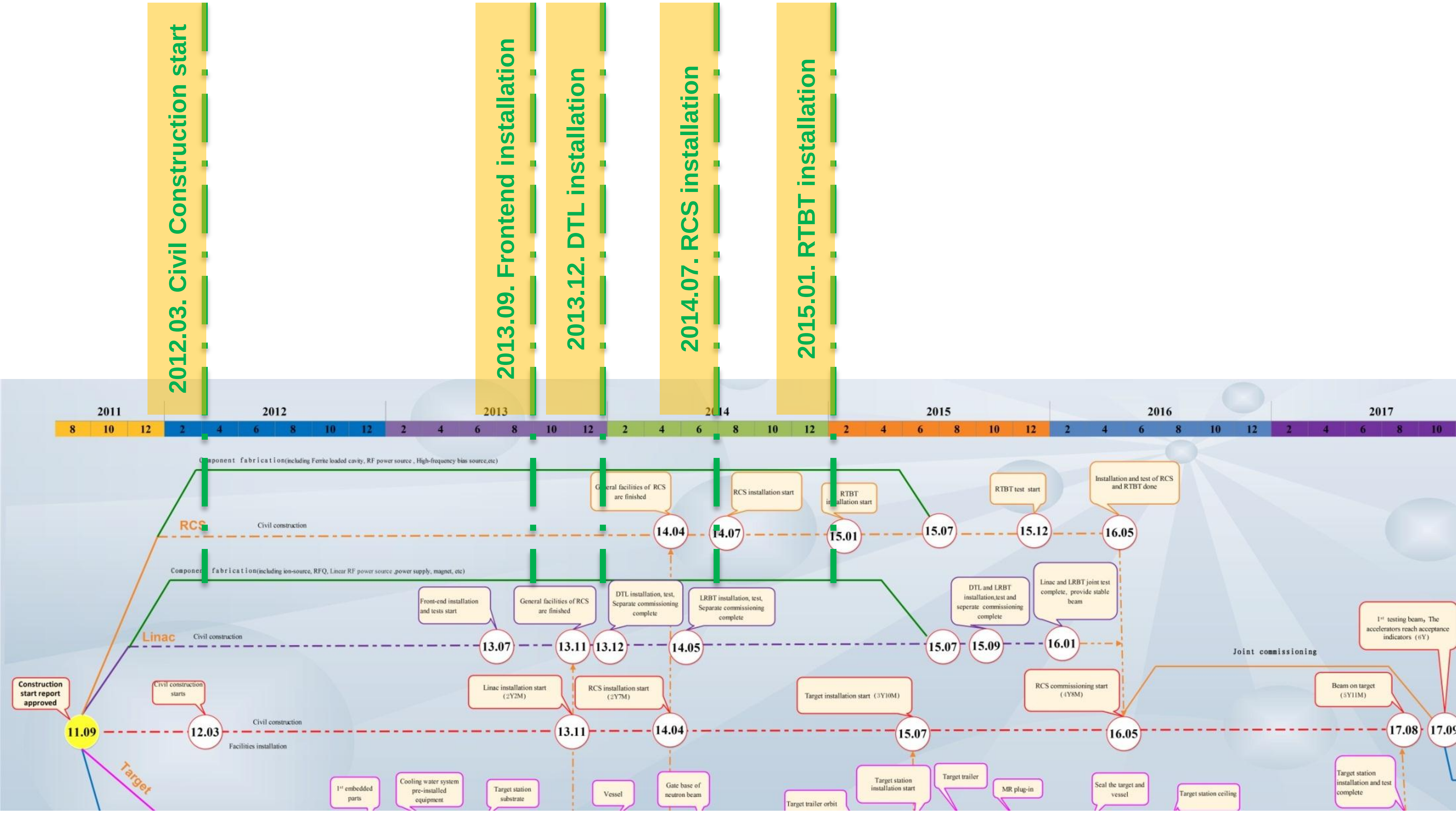
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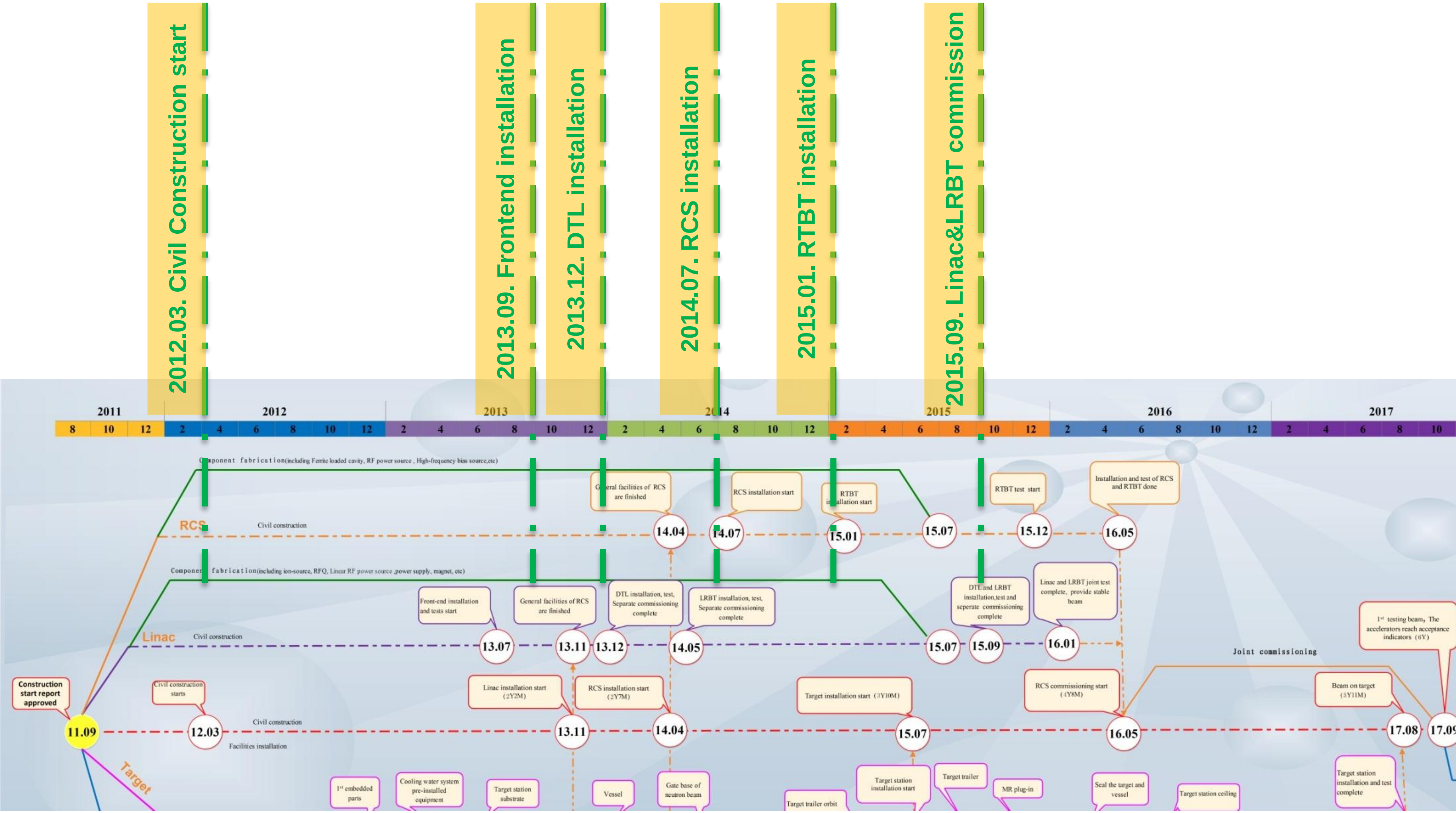
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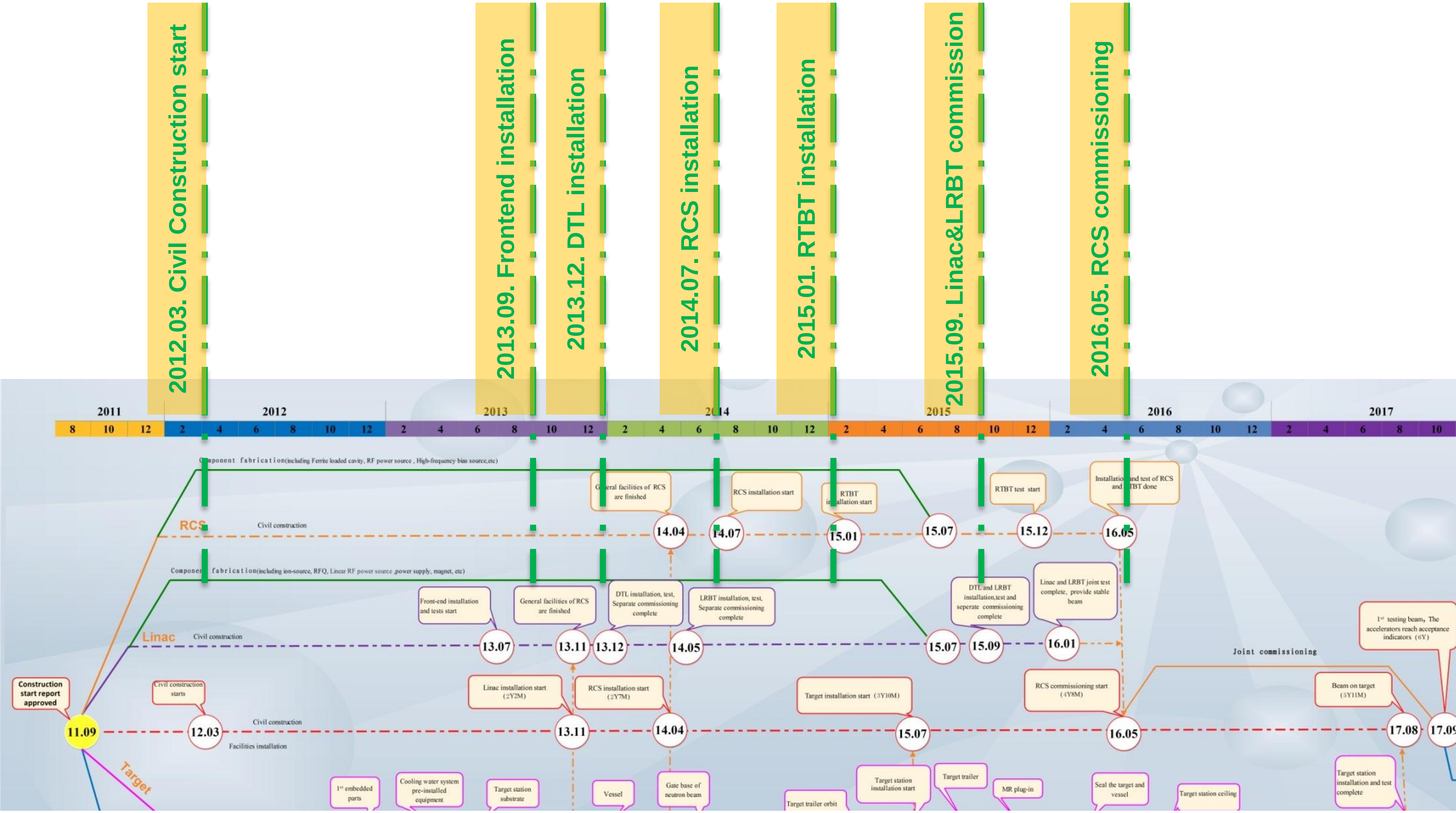
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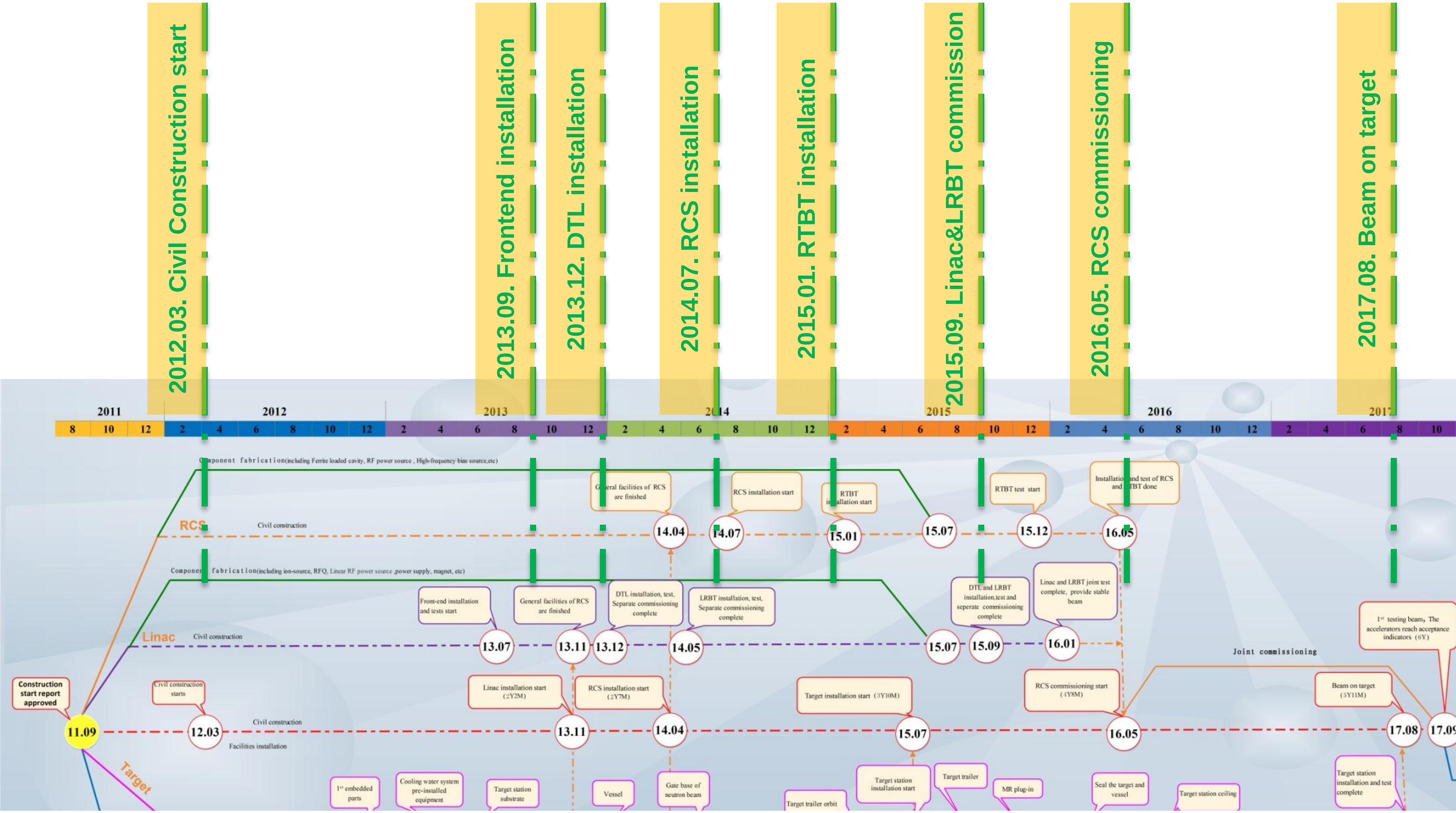
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Challenges

- 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

Sept. 2012

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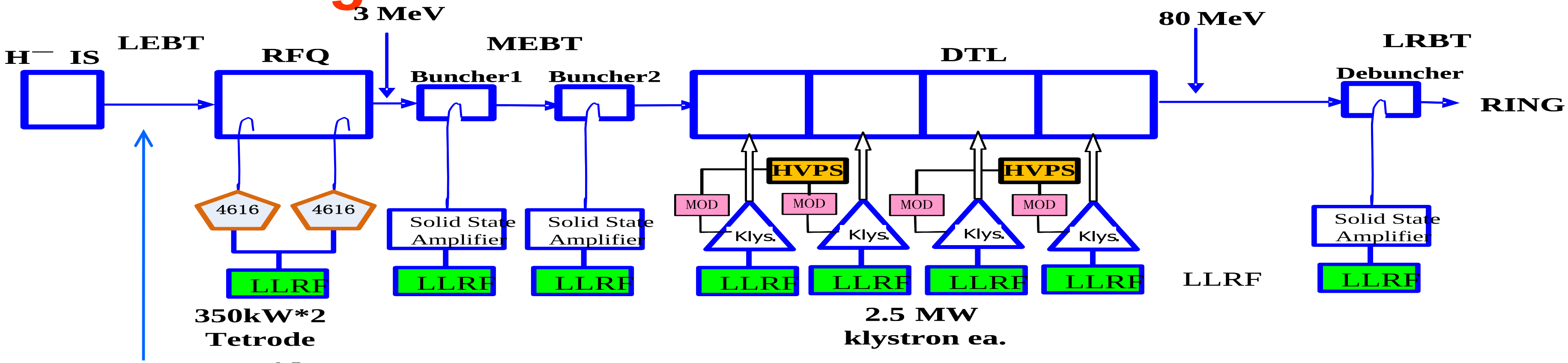
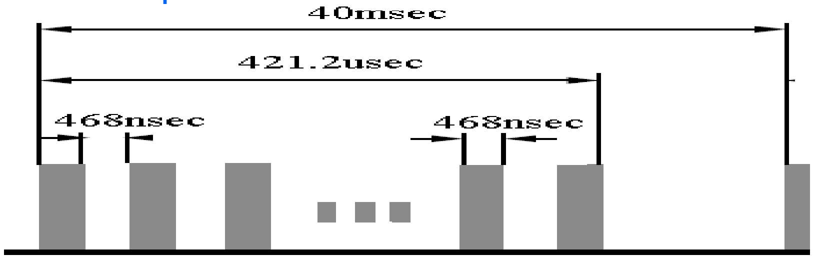
Residential Construction

- **The Dongguan local government provided 33,453m² 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





EMQ option in FFDD lattice

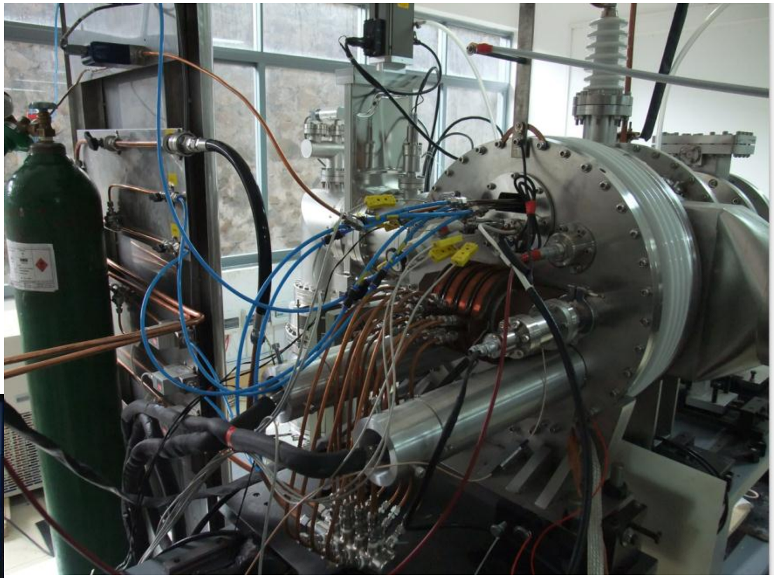
Electrostatic chopper in LEBT

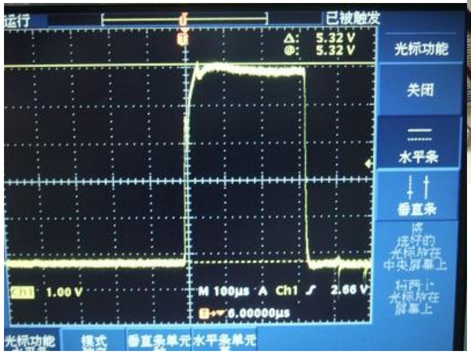
	Ion Source	RFQ	DTL
Input Energy（MeV)		0.05	3.0
Output Energy(MeV)	0.05	3.0	80
Pulse Current (mA)	20/40	20/40	15/30
RF frequency (MHz)		324	324
Chop rate (%)		50	50
Duty factor (%)	1.3	1.05	1.05
Repetition rate (Hz)	25	25	25

Front-end

- **H- ion source**

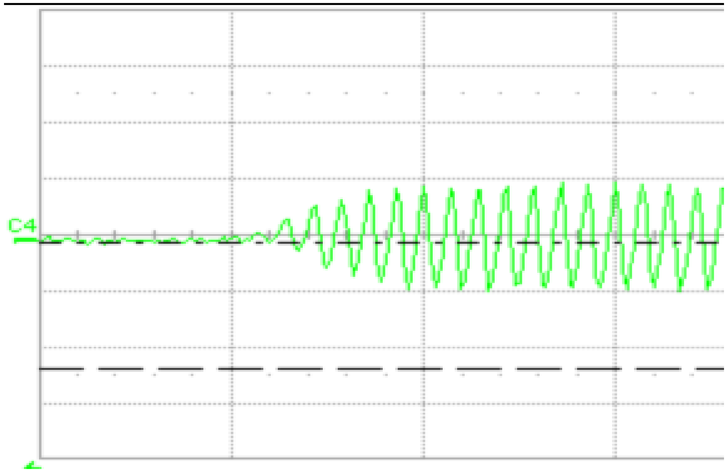
  A Penning source has been set up. It is now under beam extraction test. The first extracted H- beam reached 20 mA this week.





- **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.



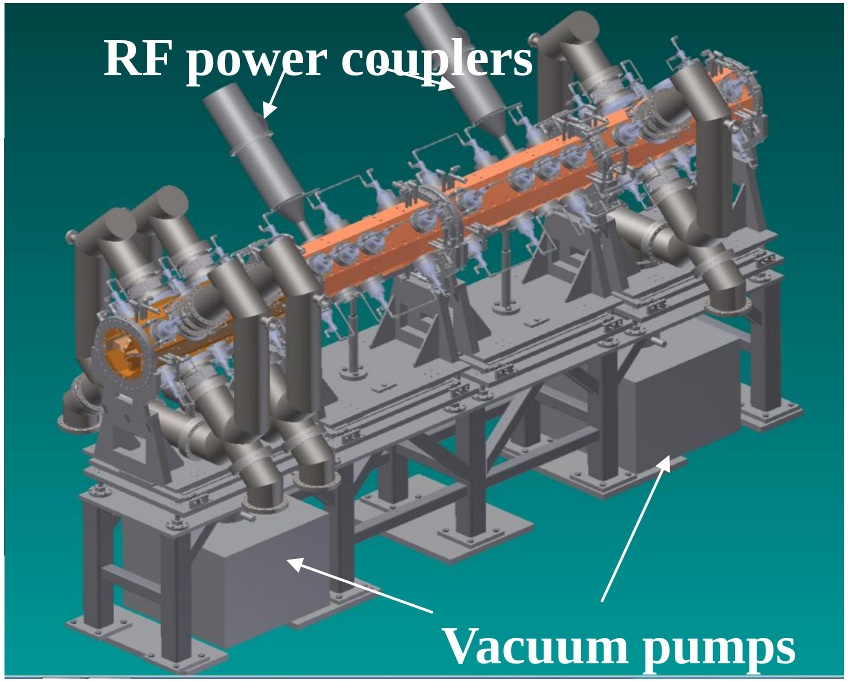
Front-end

- **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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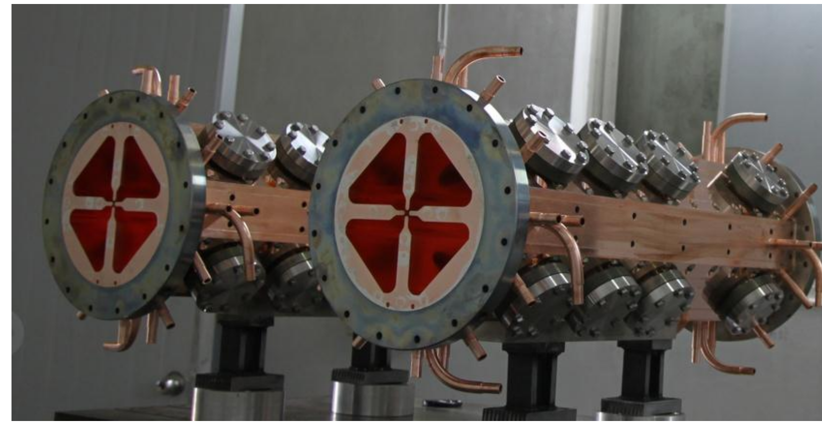

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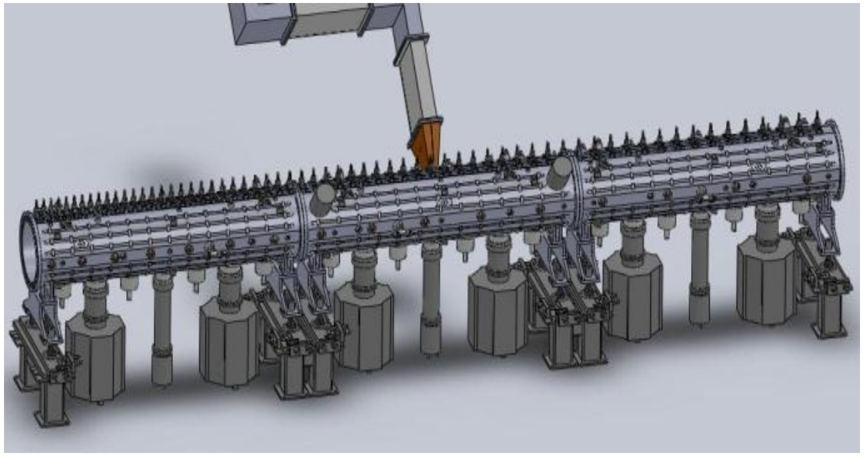
DTL

- **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.**

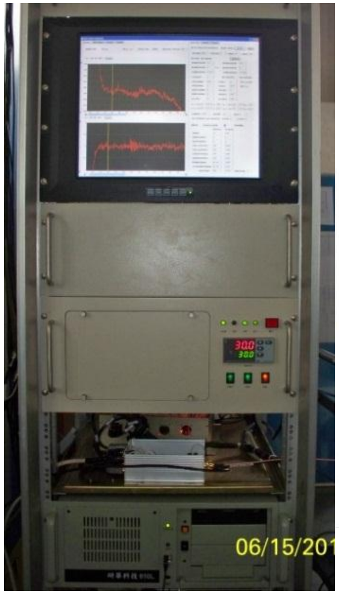


- **RF Power**

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.

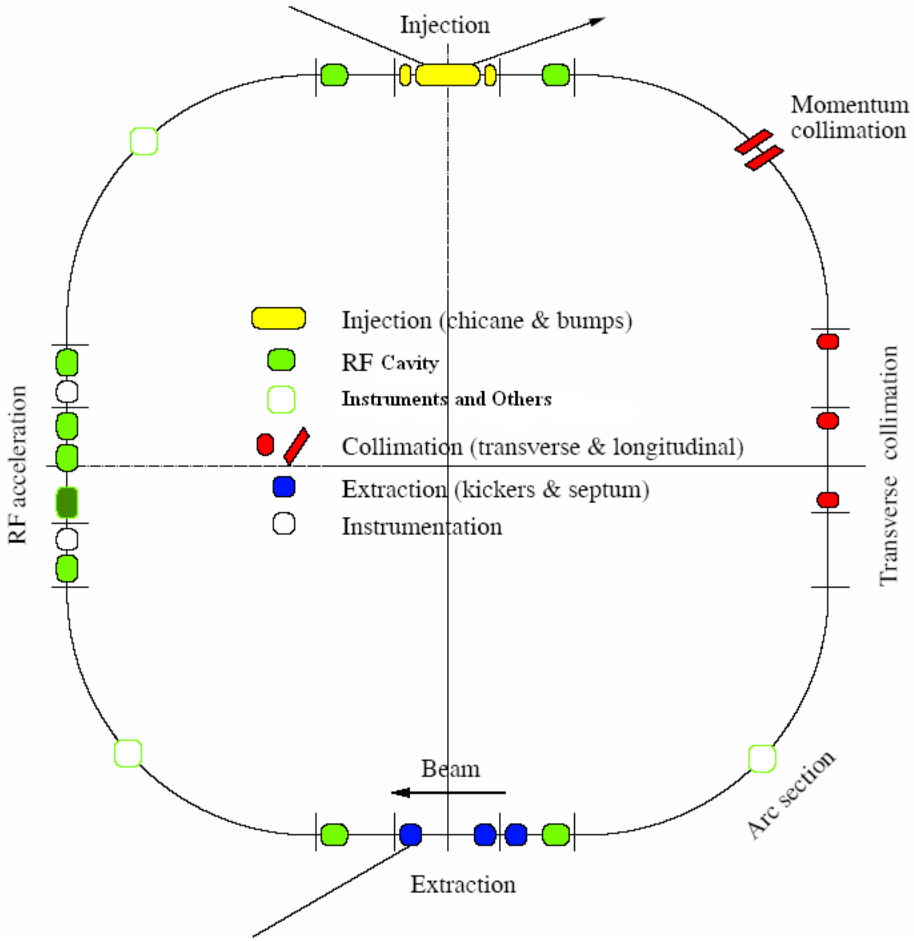
- **LLRF**

A full digitalized LLRF system was tested with amplitude and phase variations in the cavity less than ±0.25% and ±0.35° with beam loading, much better than the requirements of ±1% in amplitude and ±1° 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.

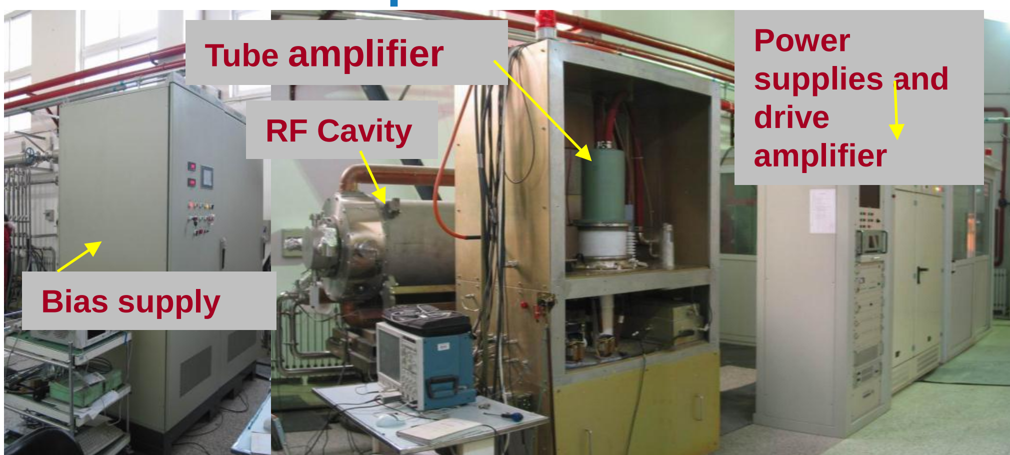
  Field measurement show a satisfactory results.

Power supply

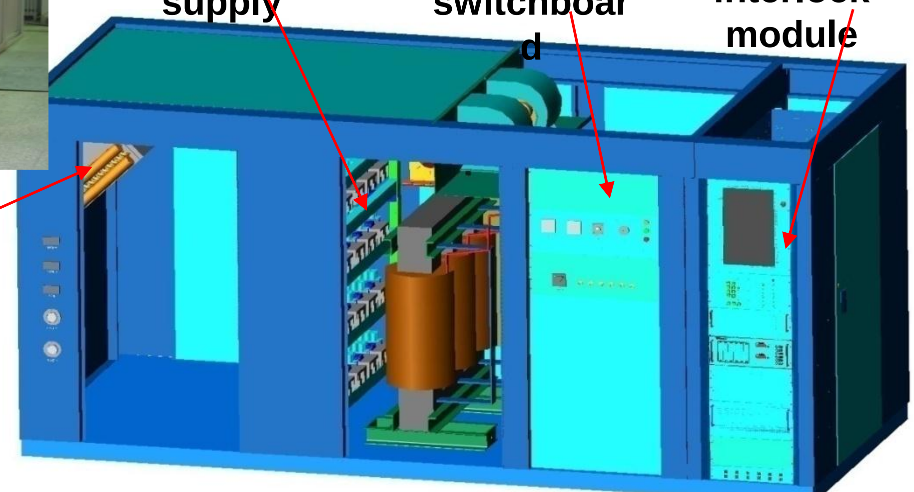
White resonant circuit is chosen as the power supply to provide AC+DC current to the main magnets. Power source and choke are now under mass production. To compensate for the field deformation due to the magnet core nonlinearity, harmonic injection technology is successfully introduced into the power 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.



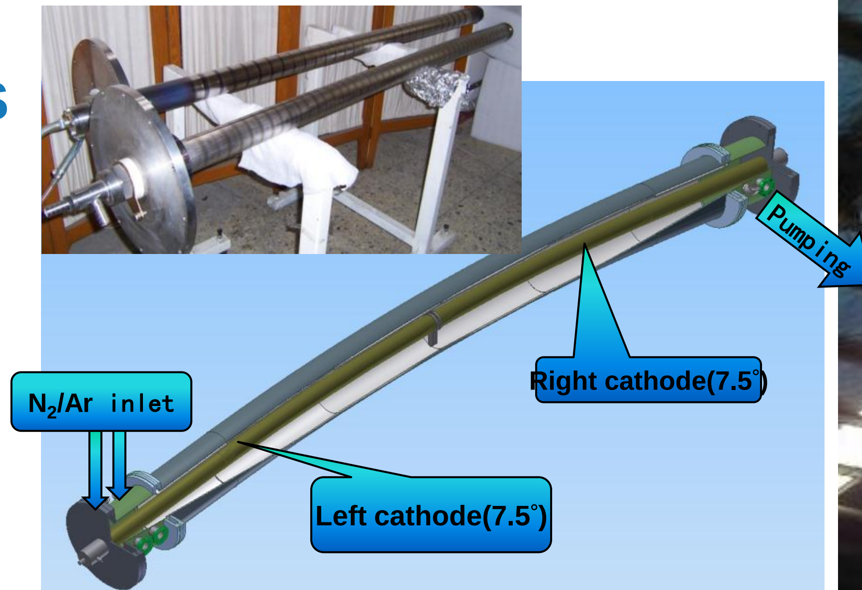
8 sets of 500 kW transmitter have been in mass production.



Ceramic Chamber

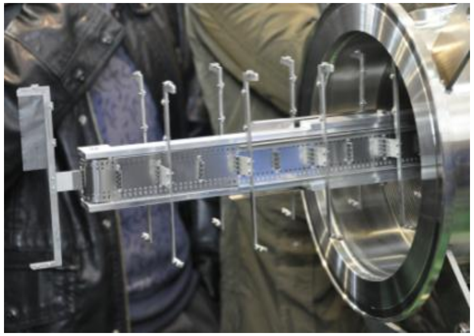
Mass production of the ceramic chambers for RCS main Q and D magnets has started.

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

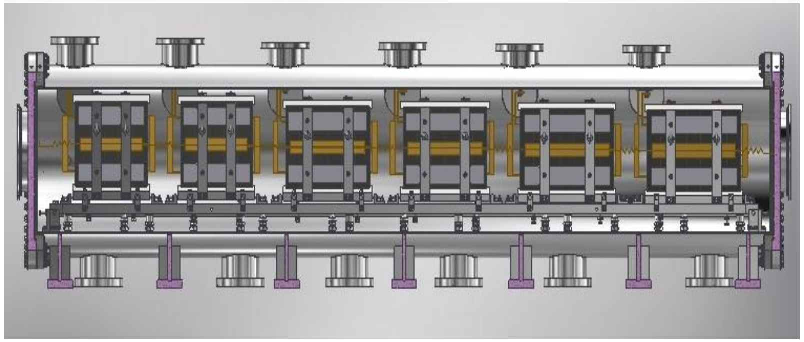


- **RCS Injection & Extraction**

  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.



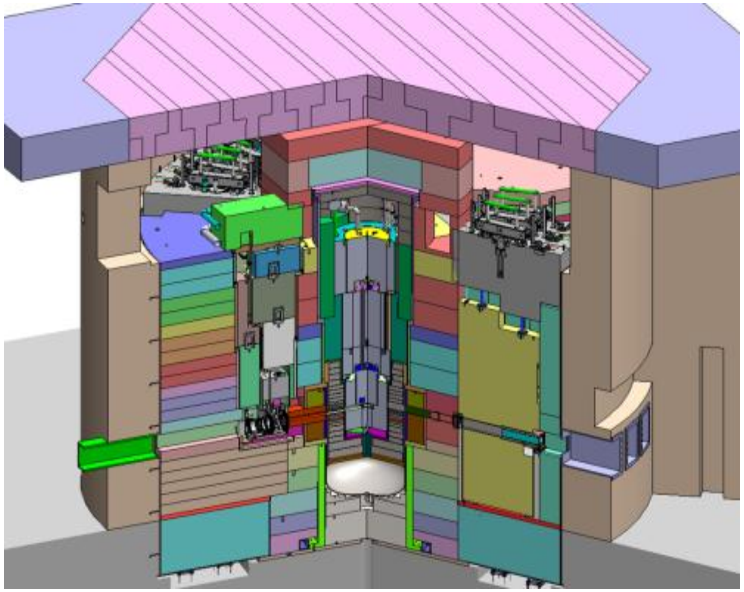
- **8 kicker magnets have been put into mass production and the first one will be accepted in August. Their power supplies are now under fabrication and the first one is scheduled in Sept. 2013.**



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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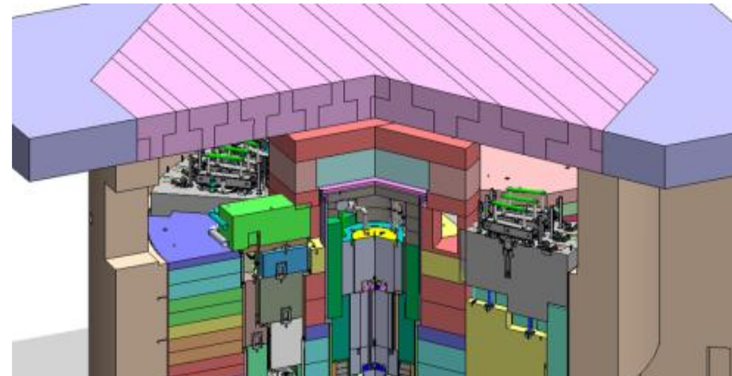

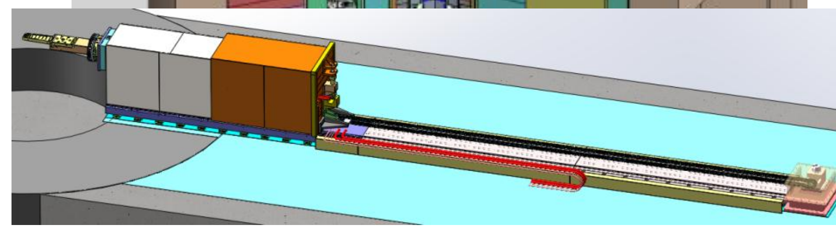

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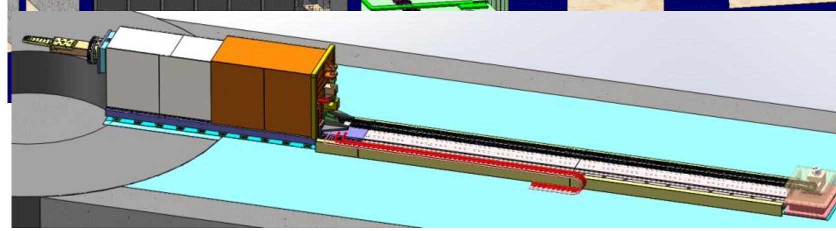
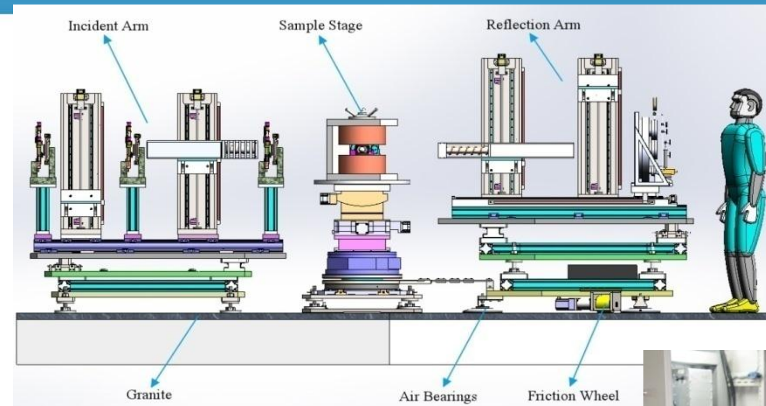


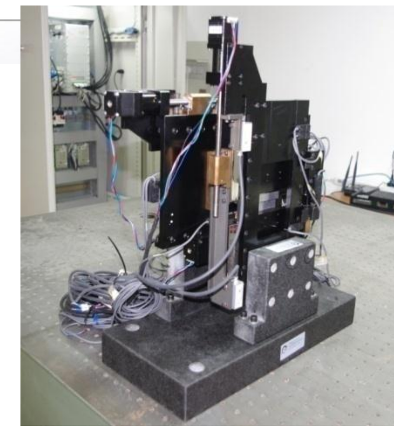
• TMR Mock-up

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.

- **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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1	Yong Li	MOPEA036 Transport Line Orbit Correction for CSNS/RTBT
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3	Yuwen An	MOPFI030 An Introduction of the Design of the Injection System and the Extraction System of the Proton Irradiation Accelerator
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15	Shou Yan Xu	WEPEA023 Space-charge Effects and Resonance for Different CSNS/RCS Working Points
16	Shou Yan Xu	WEPEA024 Combine Effects of Space Charge and Chromaticity Sextupoles at CSNS/RCS
17	Hua Shi	WEPFI027 Simulation of Ferrite-loaded Coaxial Cavity of CSNS RCS
18	Hong Sun	WEPFI028 RF System of the CSNS Synchrotron
19	Xiao Li	WEPME022 Overview of the CSNS/RCS LLRF Control System

Cont.

20	Renhong Liu	WEPME023 Study of the Vibration of the AC Dipole and Magnetic Measurement Girder for CSNS/RCS
21	Xuan Wu	THPEA010 Design and Implementation of the Remote Control System of the Digital Magnet Power Supply of China Spallation Neutron Source
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24	Huachang Liu,	THPFI025 Design and Experimental Results of an Electro-static Pre-chopper for CSNS LEBT
25	Lei Liu	THPFI026 Design for CSNS Beam Dump Window
26	Lei Liu	THPFI027 Study on Structure and Thermal Analysis of CSNS Beam Dumps
27	Xiaojun Nie	THPFI028 Anti-earthquake Structural Design on CSNS Beam Dump
28	Haijing Wang	THPFI029 The Structure Design and Analysis of Proton Beam Window for CSNS
29	Jianli Wang	THPFI030 The Design of Remote Maintaining System In RTBT Line and Target Interface
30	Jiebing Yu	THPFI031 Development of Beam Collimators for the 1.6 GeV Rapid Cycling Synchrotron of CSNS
31	Haijing Wang	THPFI032 The Analysis of Proton Beam Window for CSNSIII
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33	Siming Guo	THPWA015 Simulation of a High Sensitivity Neutron Detector
34	Hongping Jiang	THPWO042 Macroparticle Simulation Studies of a Beam-core Matching Experiment
35	Jun Peng	THPWO045 Commissioning Plans for the CSNS Linac
36	Sheng Wang	THPWO046 The Preparation for the Commissioning of CSNS Accelerators

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!