Introduction to China Spallation Neutron Source

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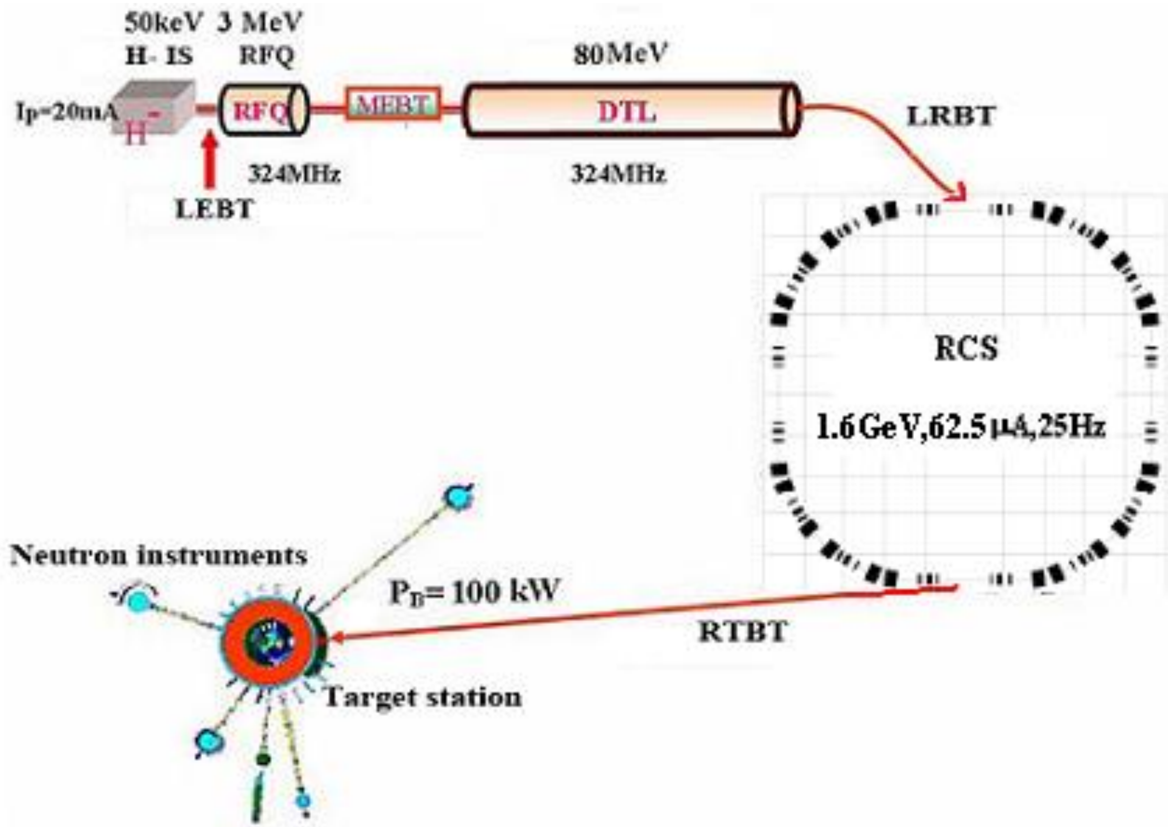
CSNS
CHINESE ACADEMY OF SCIENCES

Project Overview

Chinese Spallation Neutron Source (CSNS)



	CSNS-I	CSNS-II
Beam power (kW)	100	500
Repetition rate (Hz)	25	25
# of Target	1	1
current (μA)	62.5	312
beam energy (GeV)	1.6	1.6
Linac energy (MeV)	80	250

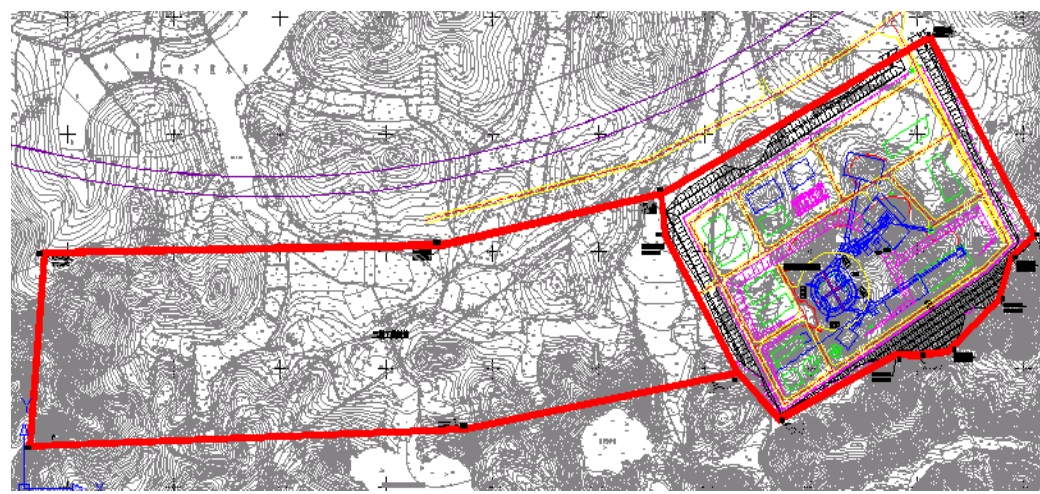
Site: Dongguan, Guangdong

Design Philosophy

- Build facility within the approved budget and time schedule
  - phase-I budget 1.67B CNY (~US$250M)+marching fund
  - 6.5 year construction duration
- Build advanced facility with upgrade potential: 100kW beam power at phase I (with minimum initial cost, lower energy linac + high energy RCS), expandable to 500kW at Phase II (Using SC cavities to increasing energy of Linac to 250MeV, R&D is finished)
- Adopt proven technology to reduce risk
  - first high-power proton beam facility in China
  - high operational reliability for user facility
- Develop domestic technology to control cost
  - keep final fabrication in China as much as possible
  - closely collaborate with world leaders

Strong supports from the local governments

- 500M RMB match fund
- Land of 0.67km^2：0.27-km^2 land for phase-I. slope protection
- 3.6-km dedicated road to the site was finished.
- 110kV/10kV transform station: ready
- in charge of the management of civil engineering and will take care the deficit of the budget of the civil engineering if any.

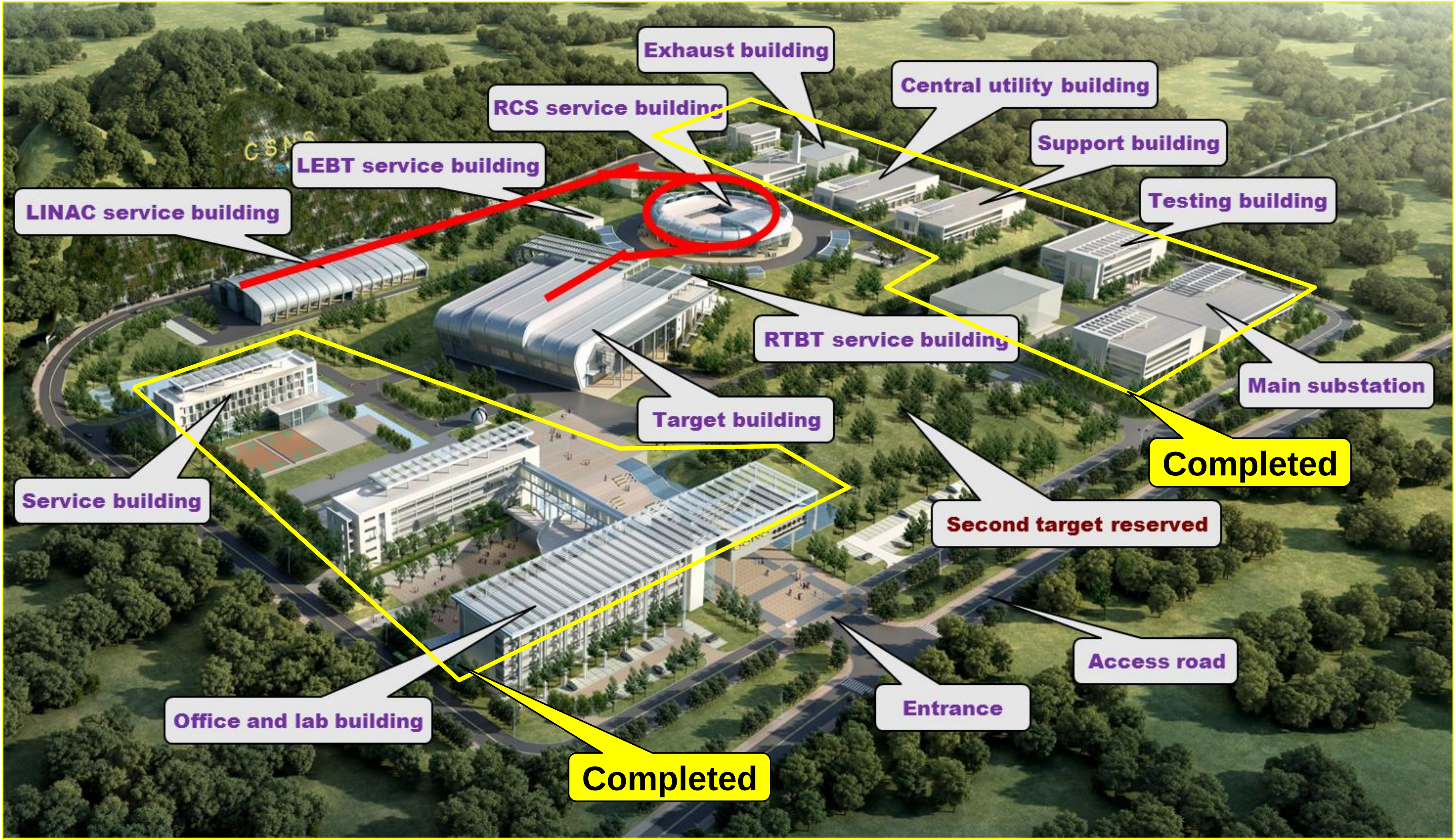


Key Milestones

Feb. 2001	Idea of CSNS discussed
June 2005	proposal approved in principle (CD-0)
Jan. 2006-Dec. 2013	Prototyping R&D
Dec. 2007	proposal reviewed
Sept. 2008	proposal approved
October 2009	feasibility study reviewed
February 2011	feasibility study approved (CD-1)
May 2011	preliminary design approved (CD-2)
Sept. 2011	construction start (CD-3)
Sept. 2011–Sept. 2015	component fabrication
May 2012 – July 2015	civil construction
May 2014- Sept. 2017	installation & tests
May 2016	RCS commissioning start
Sept. 2017	First beam on target
March 2018	project complete/operation start (6.5 years)

Status of Civil Construction

Layout of CSNS



Key requirements

- Area size of construction site 0.267 (0.667) km^2
- Floor area of buildings and structures 69729.89 m^2
  - Facility buildings：35700.87 m^2
  - Office and aux. buildings：34029.02 m^2
- Electrical power (operational demand) 34.3 MW
- Cooling Tower water flow rate（at peak operation）5500 t/hr, its cooling capacity is about 32 MW.
- Quantity of excavation 293312（m^3）
- Concrete 10 km^3
- Steel 14 kt


中国散裂中子源装置地A点拍摄（09.5.9）


中国散裂中子源工程进展照片（2015.1）
2015年1月22日

Progress of Civil Construction

- Civil construction budget is approximately 80% finished.
- Building for Office & lab, test & assembling, utility are completed.
- Linac Tunnel: water seepage found Spring 2013, solved with XYPEX + Retaining walls. Delayed 10 month.
- Interior for Linac tunnel and service building is completed. Utility equipment installation started.
- RCS tunnel interior has finished.
- Target building has finished structure level construction.

LINAC tunnel, installation started

LINAC service building

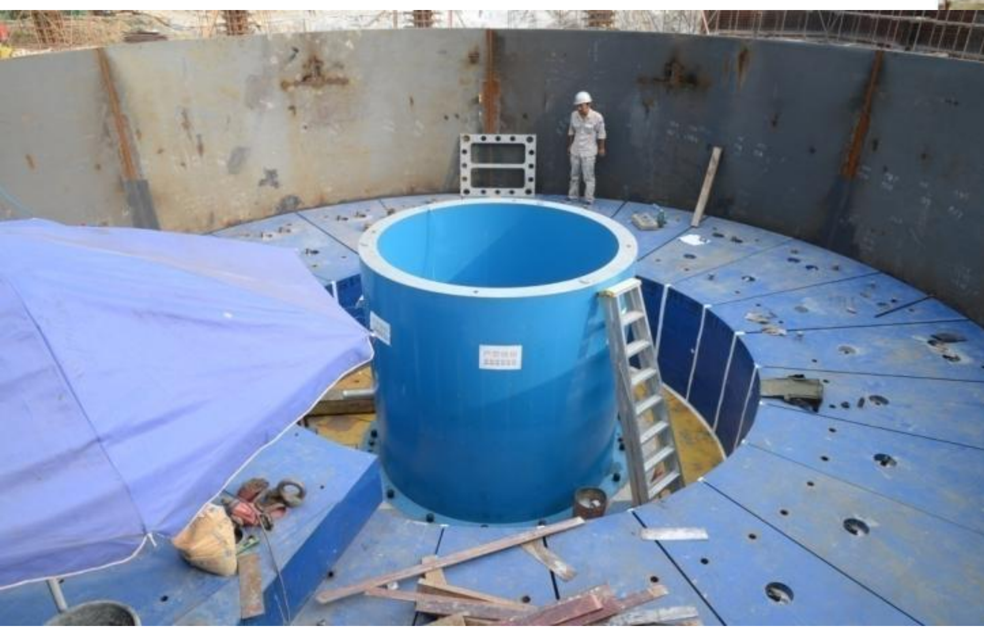
RCS tunnel

RCS tunnel and service building


中国散裂中子源装置地（2014. 11. 19. 拍摄）

Target installation

Hot cell 18m×4.65m×4m



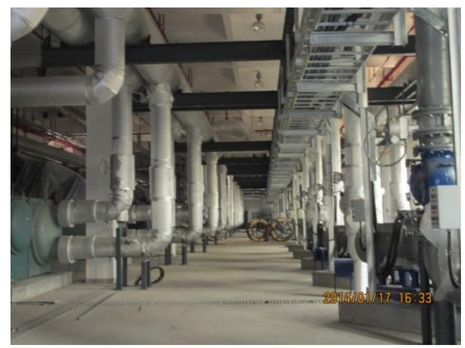
Foundation of Helium Vessal

Target Toundation and Cylinder

Equipment installation in utilities buildings

- Water cooling system available.
- Pure water station: water quality coincident with requirement.
- Compressed air station: all installation completed.
- Power supply: Five step-down electric distribution substations have passed the acceptance and start power transmission.
- Test buildings: satisfied for the test experiments .






Progress of Accelerator System

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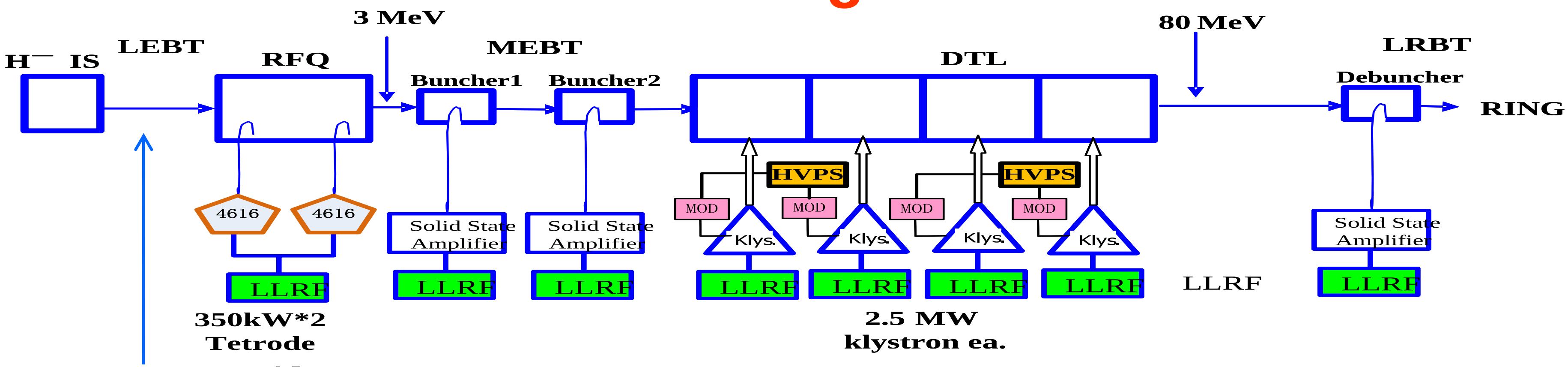
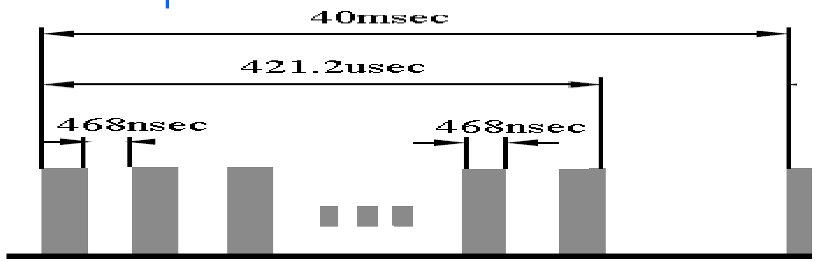
Linac Design





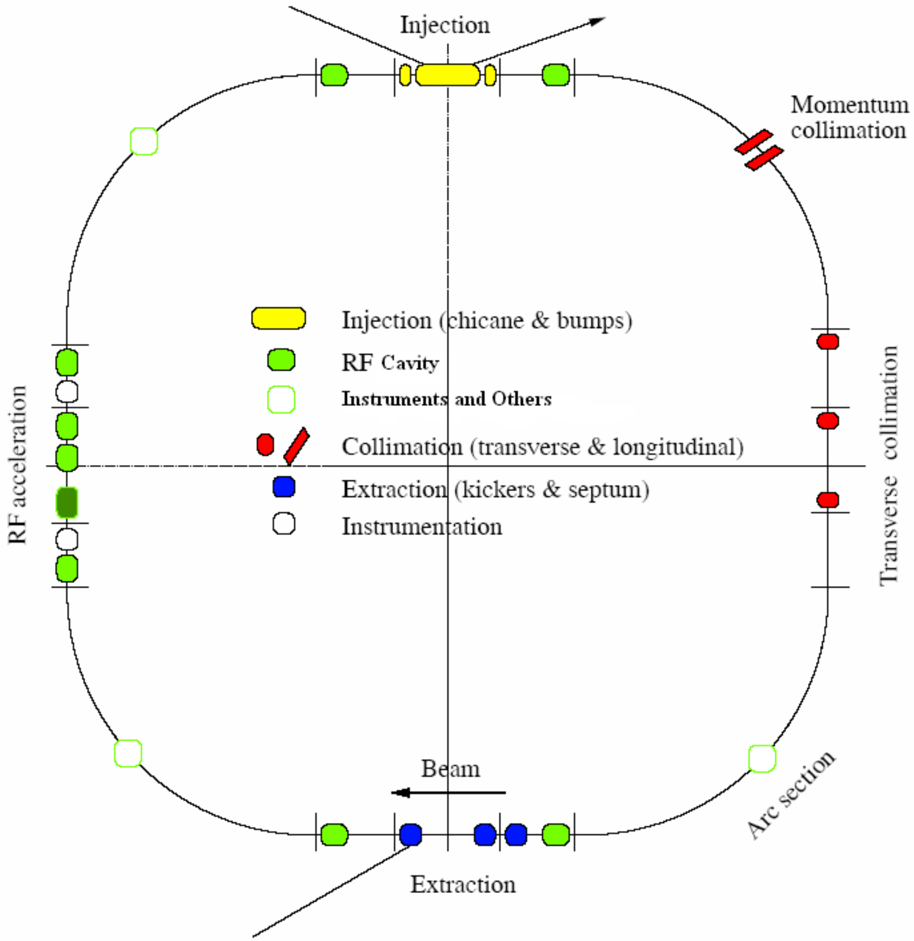
EMQ option in FFDD lattice for DTL

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

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 quadruples with 5 power supplies.
- Ceramic vacuum chambers for the AC&pulsed magnets.
- 8 RF ferrite loaded cavities to provide 165 kV.



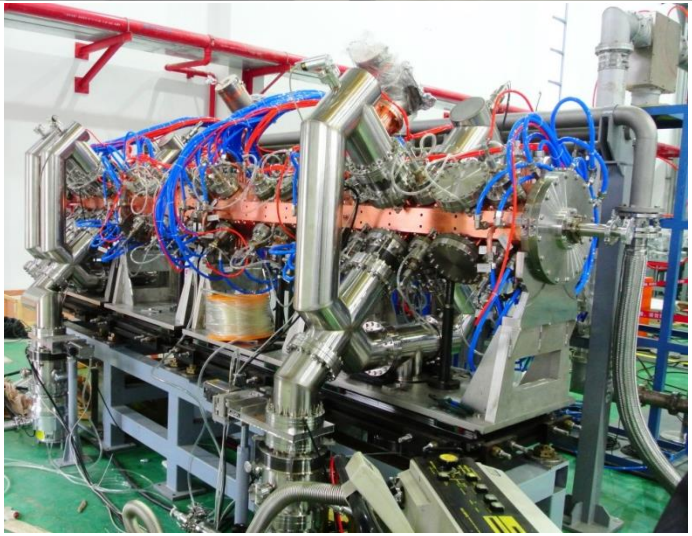
Front-end

- **H- ion source**

A penning H-ion source installed in the Linac tunnel. Nov. 15

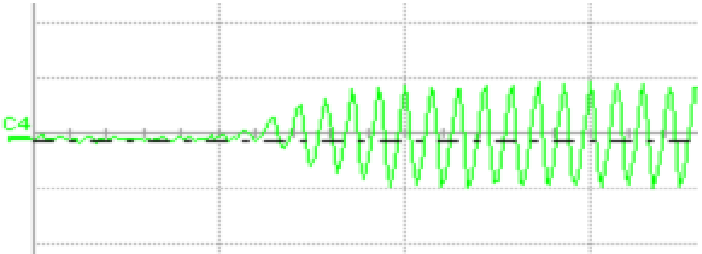
- **RFQ**

A 324MHz RFQ has been fabricated. It is installed in test hall for high power conditioning before move into the tunnel.



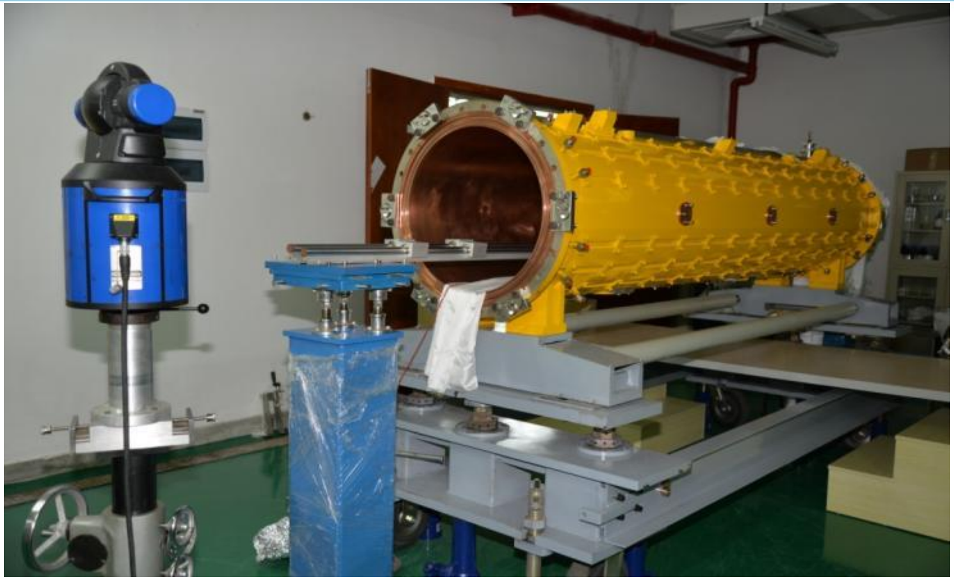
- **LEBT chopper**

A prototype of the electrostatic chopper reaches a fast rise time less than 17ns in a proton beam test of a space charge neutralized LEBT.



DTL

About half of the drift tubes with EM quadruple have been manufactured. Four unit tanks have been electroplated.

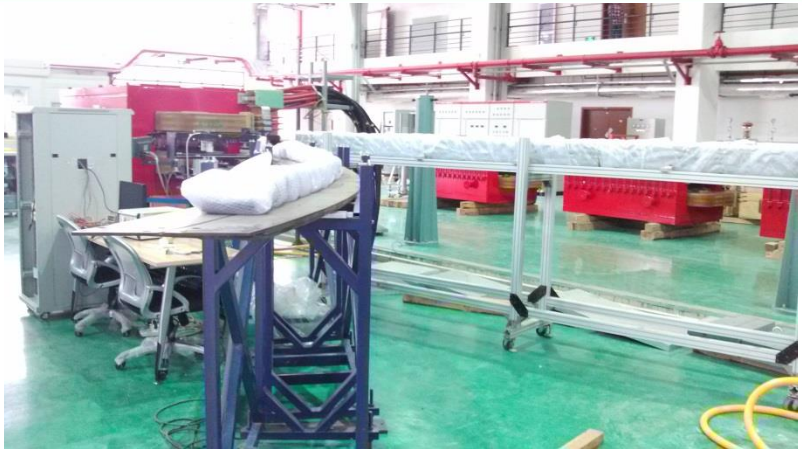


Linac RF

Two tetrode RF power sources for the RFQ have also been installed in the test hall at CSNS site for high power conditioning of the RFQ； Two sets of the 400Hz resonance high-voltage pulsed power supply for klystron have been completed. The first klystron is read for installation, and the rest will be OK in the end of this year.

Magnets

Mass production is near finished. Hall measurement system, quadruple measurement system and curved dipole measurement system have been set up in the test hall at CSNS site. Field mappings are under way .



Power supply

Mass production started after the first one had passed the acceptance test.

The chook and capacitance of White resonance circuit have been installed at the test hall together with AC and DC power supplies for magnet measurement.

Other DC power supplies are also ready for magnet measurement at the test hall.

Ring RF

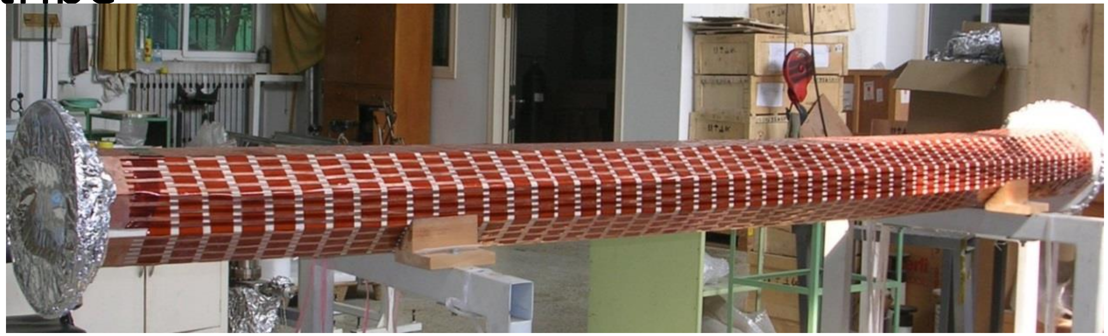
The first ferrite-loaded cavity and its bias power supply, high power RF source have been successfully manufactured and high-power tested. Now they are installed in the test hall for long-term high power test for demonstration of their stability.

The remaining 7 sets of ring RF system are under mass production.

Vacuum Pipes

The first 3m long curved ceramic chamber for dipole magnet and the first ceramic chamber for quadruple magnet have been successfully developed, the rest are under mass production.

A new formation method for RF-cage of the ceramic chamber was invented at CSNS. We braid copper stripe together with Kapton stripe to form the cage.

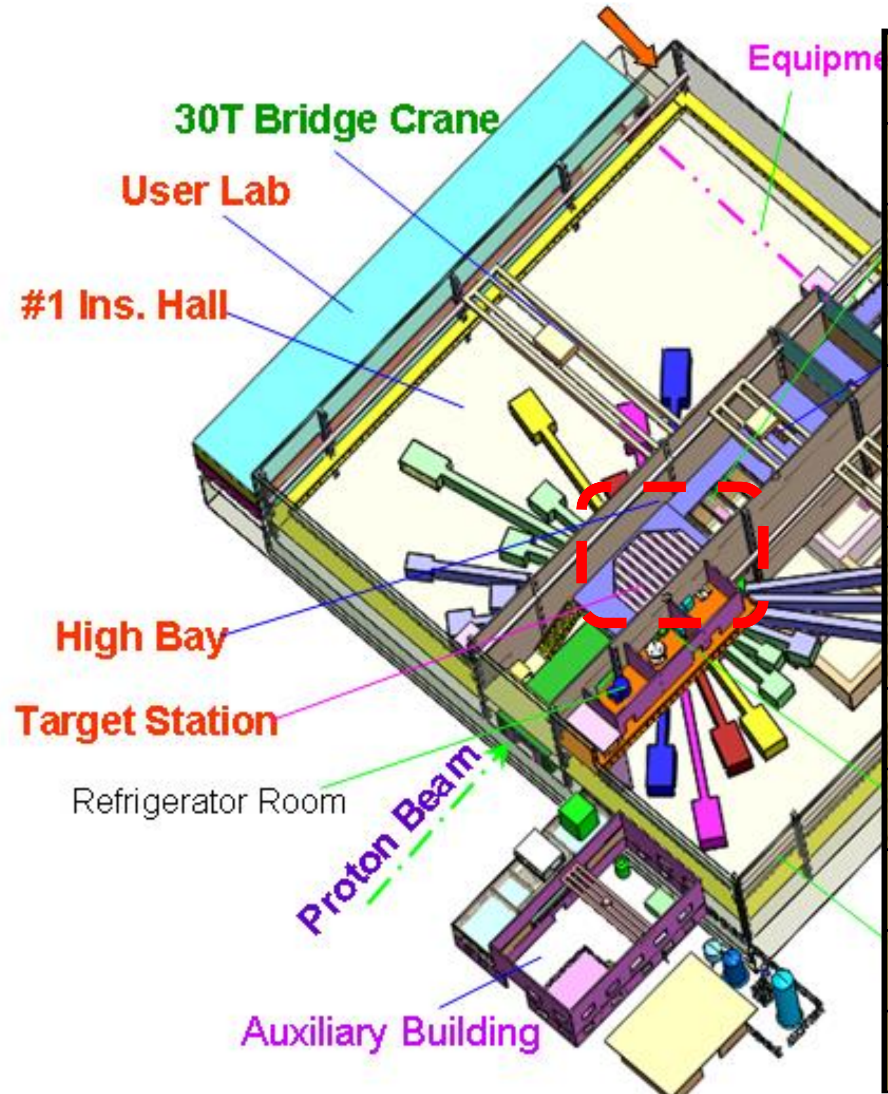


CSNS target station and instruments

Major design consideration

- **High neutron production**
  - 1.6GeV proton beam; cladding W target; Be reflector; heavy water cooling (light water at beginning due to budget limit)
- **Diverse neutron performance**
  - 3 wings moderators: H_2O (300K, decoupled), H_2 (20K, decoupled+poisoned), H_2 (20K, coupled)
- **High neutron utilization**
  - compact configuration between TMR and bulk shielding; moderation by para-hydrogen; supermirror neutron guide; efficient position sensitive neutron detector with large coverage
- **Optimization for 100 kW, but keeping the upgrade capacity to 500 kW**
  - Optimize the TMR for the beam power of 100 kW
  - Design shields with dose control < 2.5 μSv/h up to 500 kW
  - Embedded coolant pipes and tanks meet to requirement of 500 kW

Main design parameters

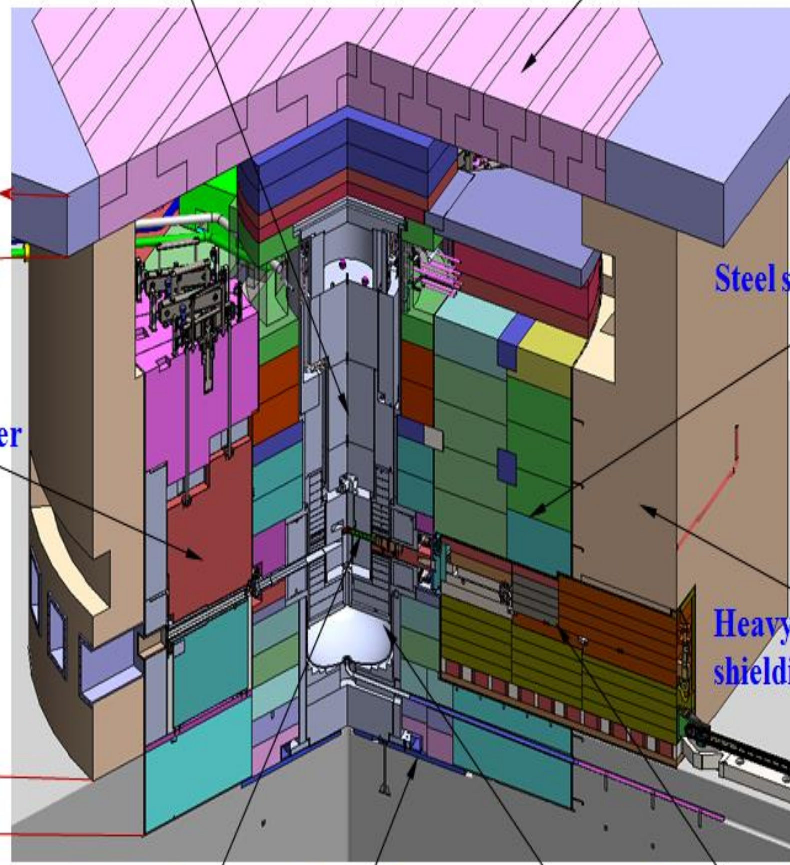


Parameters	Phase I	Phase II
Beam power on target (kW)	100	500
Proton energy on target (GeV)	1.6	
Average beam current (μA)	62.5	312.5
Pulse repetition rate (Hz)	25	
Target	1; Tungsten	
Moderators	3; LH2(C), LH2(DP), H2O(D)	
Reflector	Be/Fe	
Beam ports	20	
Neutron instruments	3	20
Dose control in hall (μSv/h)	2.5	
Operation （hrs/yr)	5000	

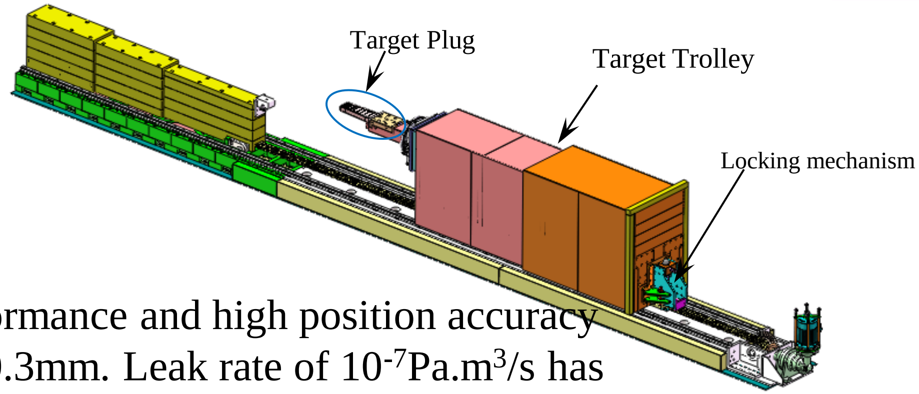
Target station

TMR maintenance: the horizontal target plug plus vertical MR plug, similar to the SNS/JPARC type.

- Feasible for 500 kW upgrade
- More compacted configuration between TMR and shielding
- Small seal between trolley and helium vessel
- Separated room for liquid hydrogen system at the building roof
- High-bay to define a radiation control area for target station out from scattering hall



Target system



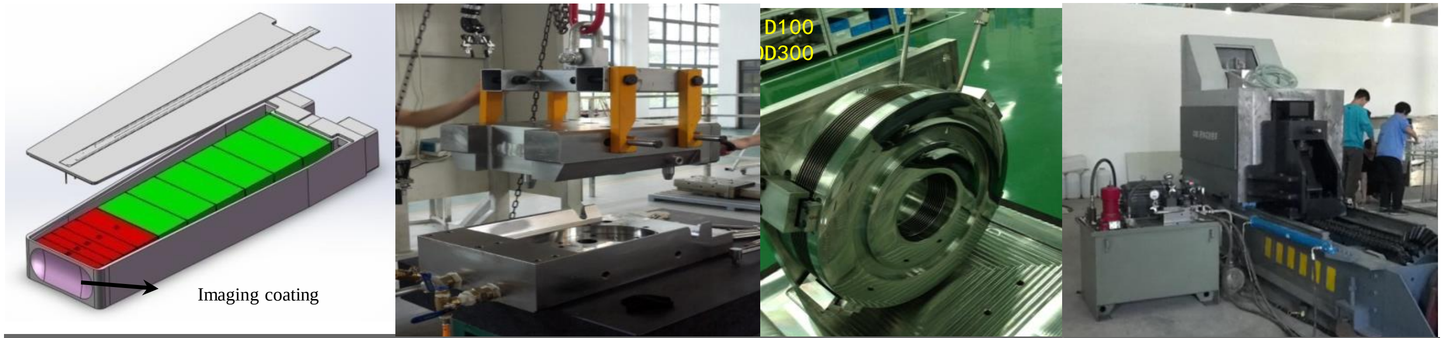
- **overall design:** optimized for 100 kW

- **Prototypes to test key technology:**

Seal performance for Target Plug: good seal performance and high position accuracy

Pillow Seal prototype: Thickness of diaphragm is 0.3mm. Leak rate of 10^{-7} Pa.m^3/s has been achieved .

Target Trolley prototype: high position accuracy (0～0.18mm) and reliable locking

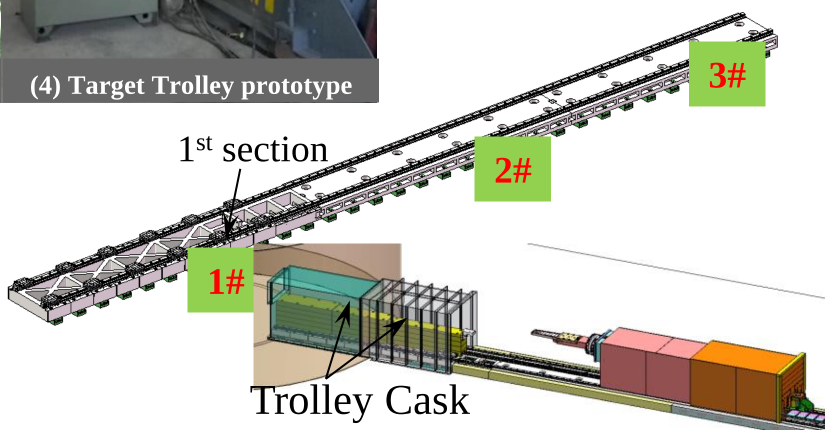


(1) Target plug (2) Seal performance tests (3) Pillow Seal prototype (4) Target Trolley prototype

Preparation for the installation:

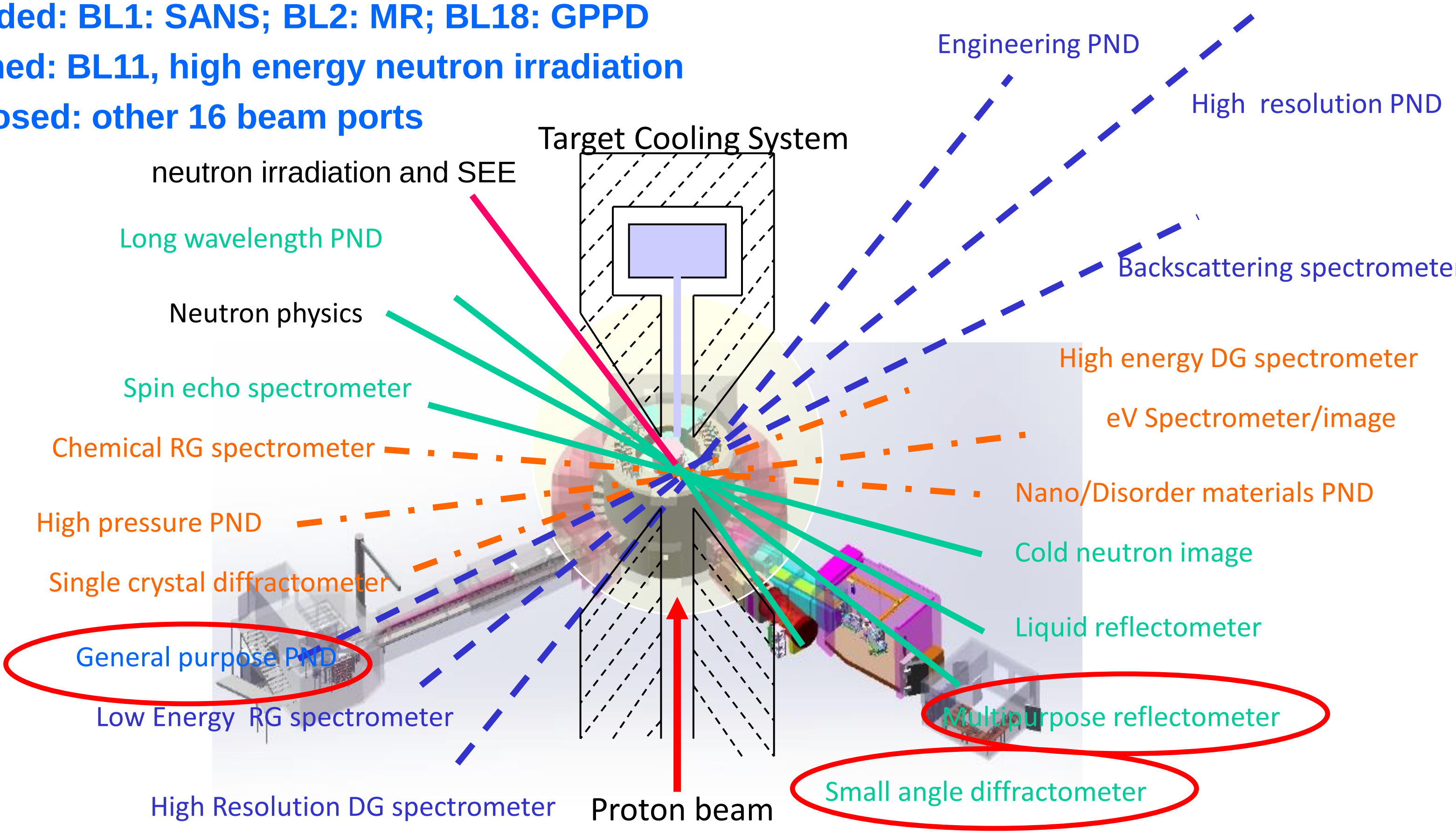
(1) **Rail Assembly**: The first section is being manufactured in Shanghai.

(2) **Trolley Cask**: Detailed designed is finished and will be installed by CNI23 Construction company.



Neutron instruments

- **20 beam lines**
- **Founded: BL1: SANS; BL2: MR; BL18: GPPD**
- **Planned: BL11, high energy neutron irradiation**
- **Proposed: other 16 beam ports**



(PND: Powder Neutron Diffractometer; RG/DG: Reversal/Direct Geometry)

Moderator：

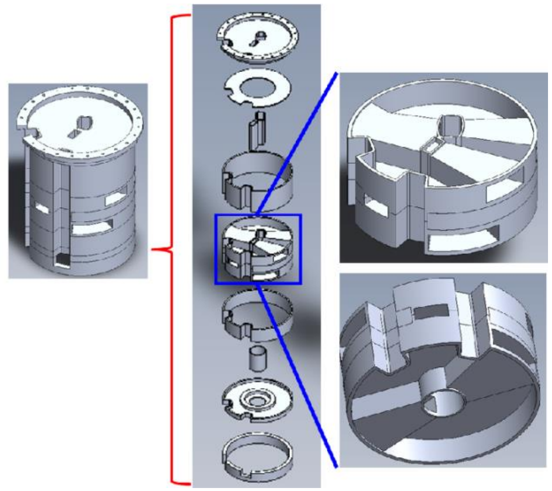
D+P, LH2 (20K）

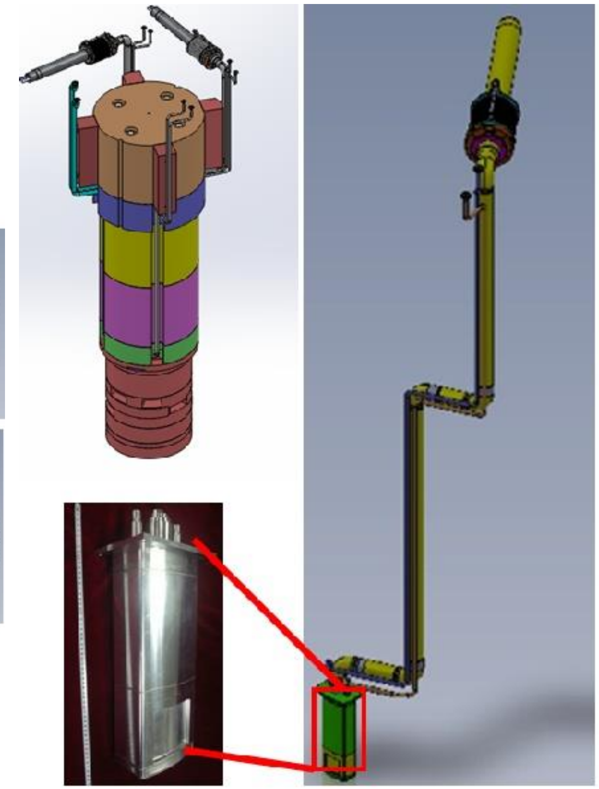
C,LH2 (20K)

D, Water (300K)

Moderator and Reflector System

- **vertical MR plug**, similar to SNS/Jparc MR



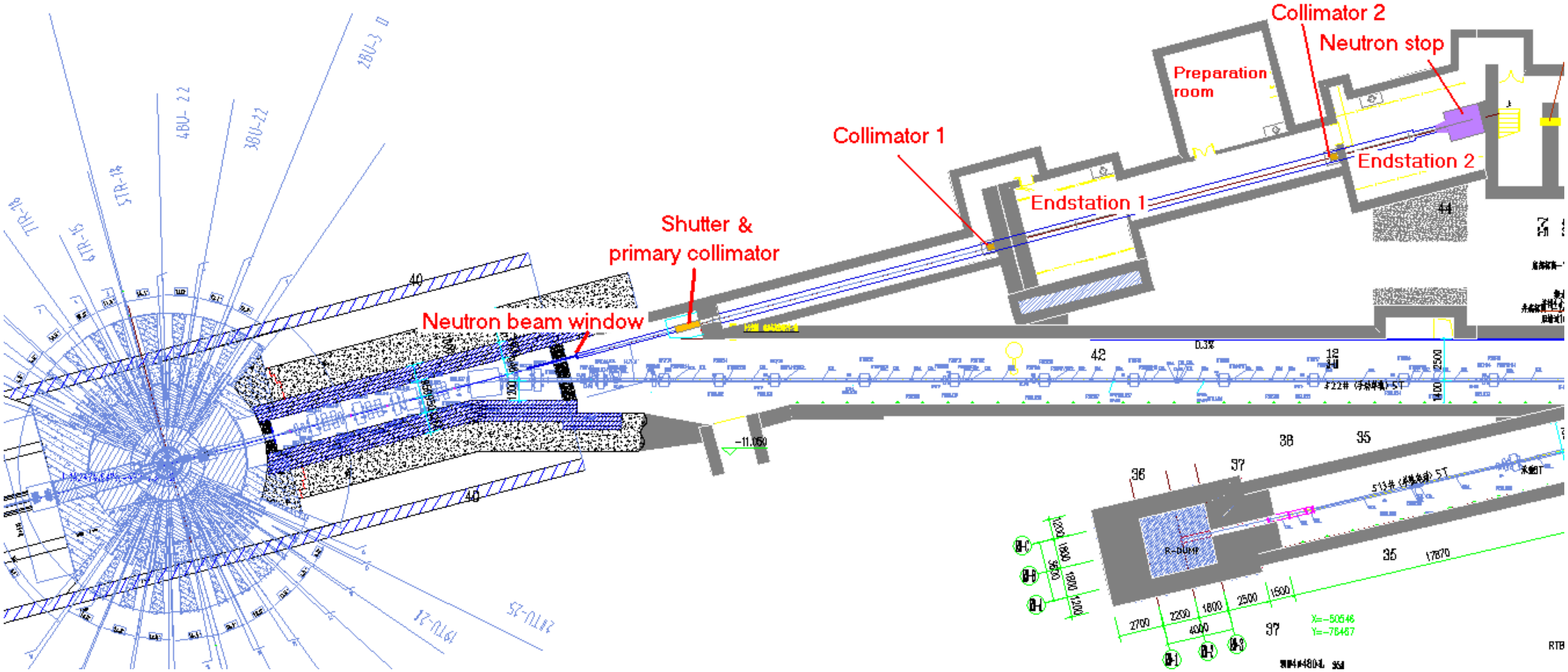


- **Detailed engineering design** finished.
- **Prototype of DPHM** accepted in March, 2014.

- **Two contracts to manufacture three moderators and reflector plug , have been bided.**

White Neutron Source

Take the advantages of the back stream neutrons from the target as a white neutron source for nuclear data measurement.



6th International Advisory Committee of CSNS

(Dongguan, Dec. 14-16 2014)

16 members from SNS,J-Parc,KEK,ISIS,PSI,CERN,BNL…

Closing Remark

- The civil construction finished about 85%. Buildings for office & lab, test & assembling, utility began to use.
- Linac Tunnel: water seepage found Spring 2013, and solved with XYPEX + retaining walls. 10 month delayed.
- Utility installation goes well, many systems are available.
- The manufacture of the accelerator and experimental systems are going smoothly. The installation started.
- We optimize the accelerator installation procedure to keep the date of the first neutron beam (Sept. 2017).
- Great efforts to promote the user community and to prepare the day-one experiments.
- More spectrometers are under discussion.
- Look forward for more international cooperation in the commissioning, spectrometers and user applications.