Status of the CSNS Project

2010.10.18
Yuanbo Chen
CSNS Project Management

CSNS
CHINESE ACADEMY OF SCIENCES

Outline

- **Project Overview**
  - milestones, site, budget, schedule, personnel, organization
- **Design Introduction**
  - design philosophy, specification & acceptance, accelerator, target, instruments
- **A&D Activities**
- **Summary**

Project Overview

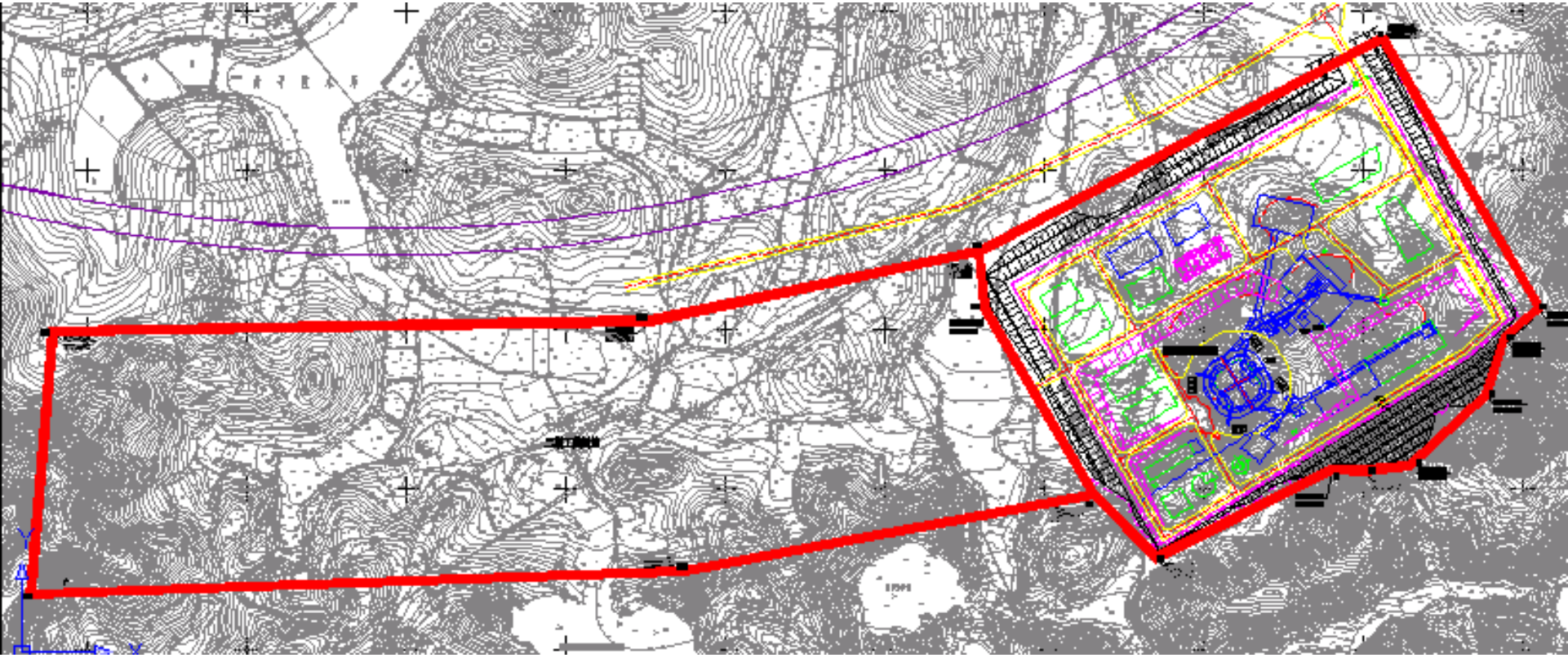
Key Milestones

February 2001	idea of CSNS discussed
June 2005	proposal approved in principle by central govern
January 2006	CAS funded 30M CNY for R&D 1
July 2007	Guangdong funded 40M CNY for R&D 2
December 2007	review of the proposal
September 2008	proposal approved by central government (CD-1)
October 2009	review of the feasibility study
April 2010	ground leveling start
December 2010	ground breaking expected to start construction

Site Selection

- **The site of CSNS has been selected at Dongguan, Guangdong Province.**
- **CSNS is the first large scientific facility in southeastern part of China. It can balance the present uneven distribution of the facilities, and promote advanced researches in the economic developed zone of Guangdong-Hongkong.**

Site Area



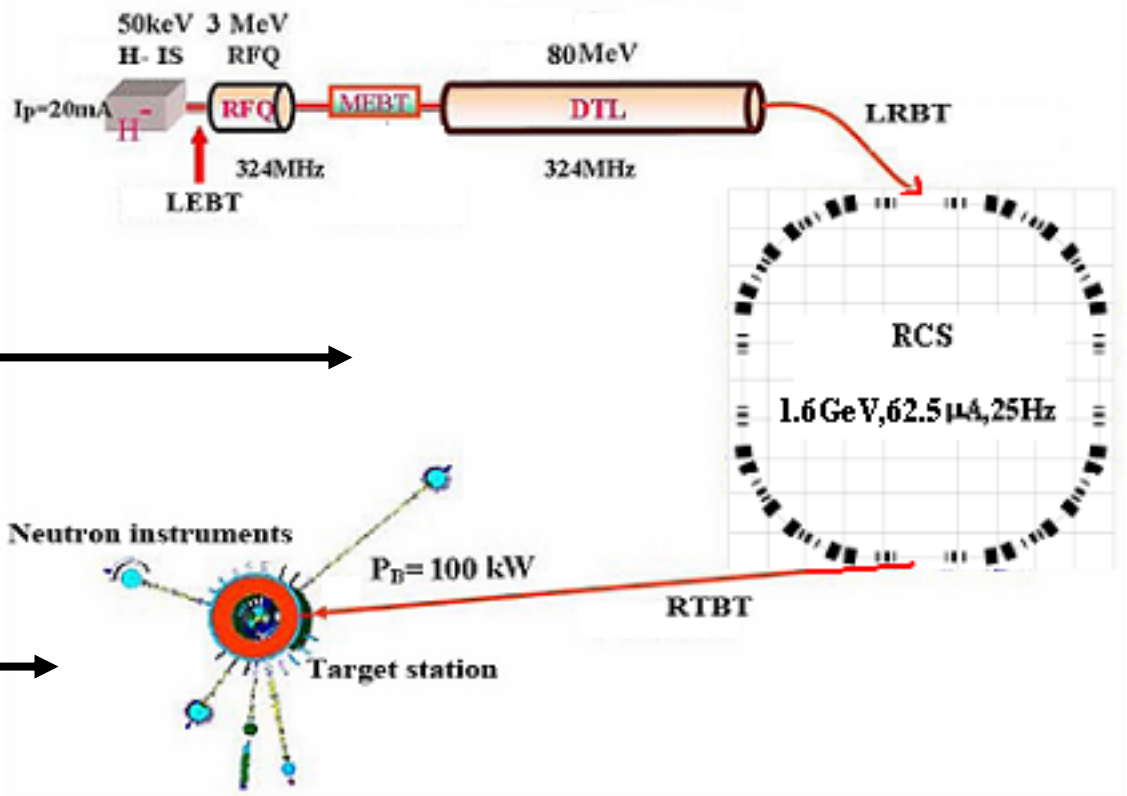
The Dongguan local government provided a land of about 0.67km^2 for CSNS facility. 0.27-km^2 is planned for the phase-I construction.

CSNS Project

Linac

Rapid Cycling Synchrotron

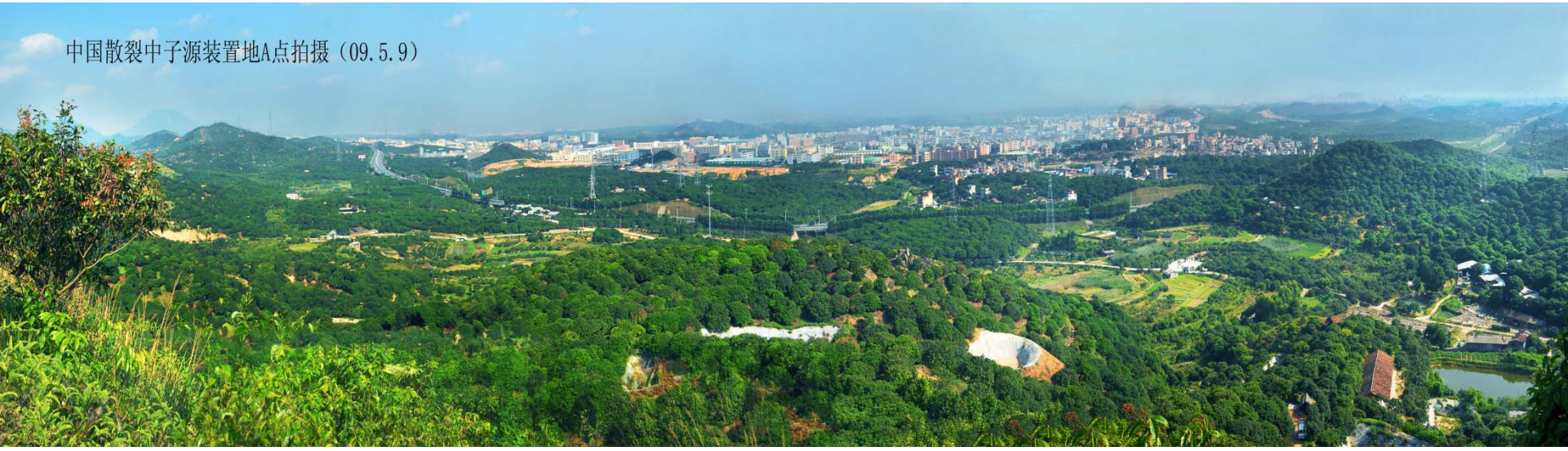
Target and Instruments



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.

CSNS Facility Layout (Phase-I)

Site Preparation



Site Preparation

RCS location

Target station location

Budget

- Baseline
  - 1.4B CNY (agreed) from central government for project construction
  - 0.5B CNY and land (committed) from Guangdong/Dongguan local government for additional supports
- R&D
  - 30M CNY (received) from CAS for R&D 1
  - 40M CNY (received) from Dongguan government for R&D 2 (included in 0.5B CNY from Guangdong/Dongguan)
- Operation
  - 0.14B CNY per year from central government

Schedule

Prototyping R&D: January 2006 – December 2010 (5 years)

Construction start: December 2010

Civil construction: December 2010 – December 2013 (3 years)

Component fabrication: December 2010 – December 2014 (4 years)

Installation & tests: August 2013 – August 2015 (2 years)

Integrated system commissioning: Dec. 2014 – June 2016 (1.5 years)

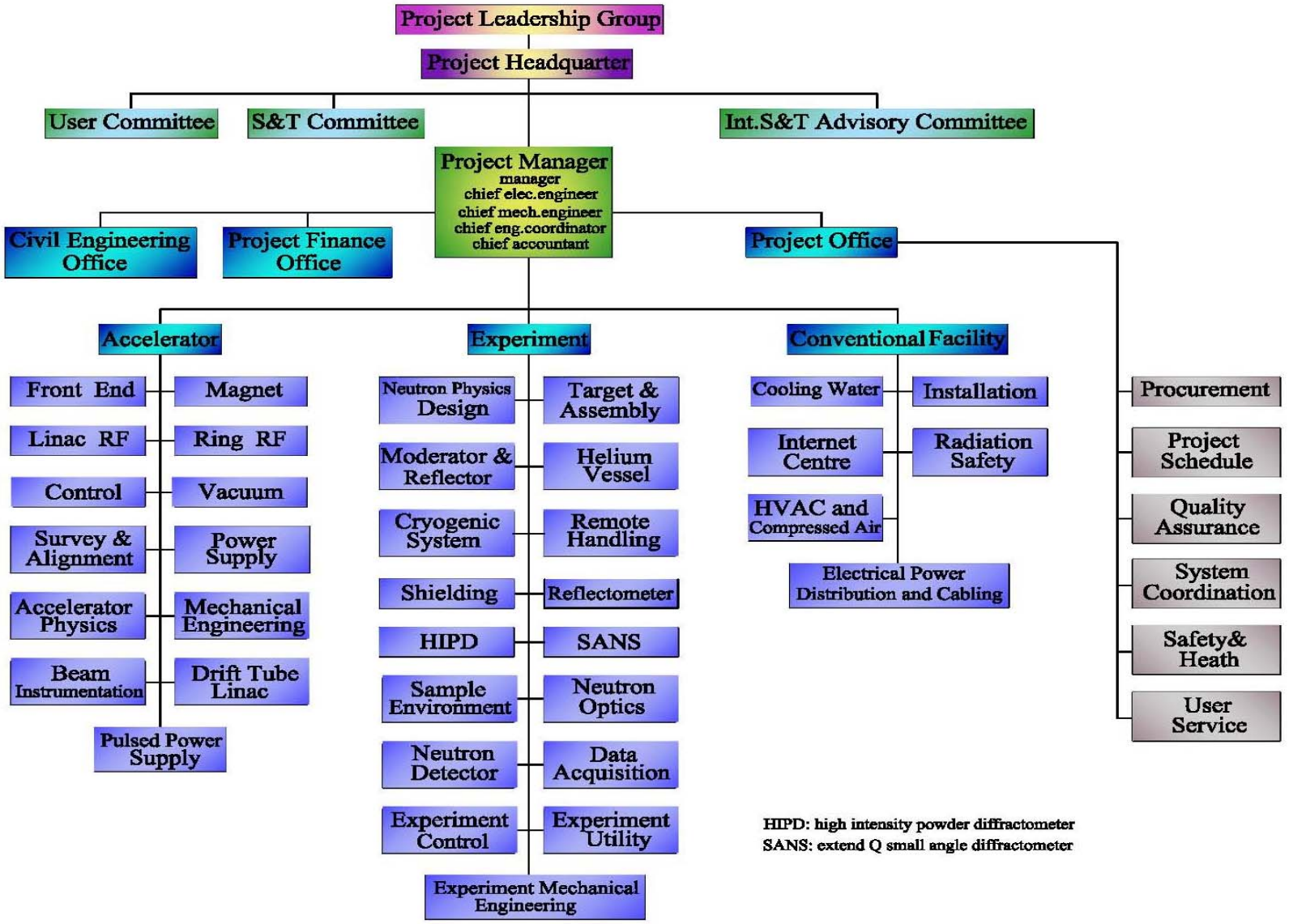
1st beam on target/operation start: June 2016

Project complete: June 2017 (6.5 years from construction start)

Personnel Needs

No.	Division	Peak (FTE)	Present (FTE)
1	Accelerator	160	104
2	Experiment	136	70
3	Conventional Facility	95	21
Total		391	195

Organization Chart



Design Introduction

Design Philosophy

- **Build facility within approved budget and time schedule**
  - **total phase-I cost ~1.4B CNY (~US$207M)**
  - **6.5 year construction duration**
- **Build an advanced facility with upgrade potential**
  - **beam power of 100kW for Phase I and 500kW for phase II**
  - **expandable to higher power (with minimum initial cost)**
- **Adopt proven and reliable solutions as much as possible**
  - **first high-intensity proton machine in China**
  - **high operational reliability for an accelerator-based user facility**
- **Develop domestic technology to control cost**
  - **Keep final fabrication in China as much as possible**

Design Goal

Beam power (kW)	Repetition rate (Hz)	Beam current (μA)	Energy (GeV)	Max neutron flux* ($n/cm^2/s$)
100	25	63	1.6	10^6

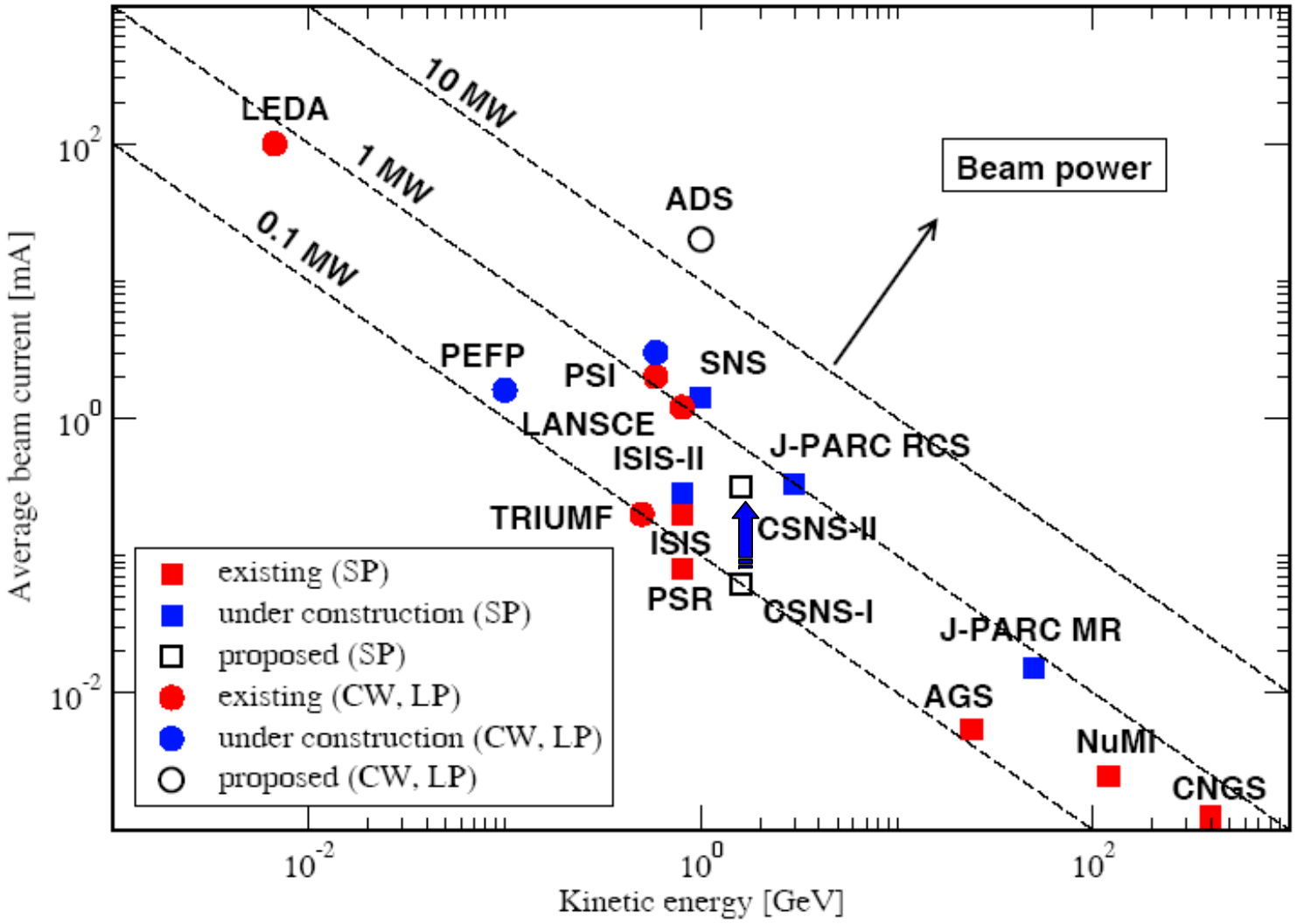
- Acceptance goal (1/10 beam power) is proposed.
- Design goal will be met three years after acceptance.

Acceptance Goal

Beam power (kW)	Repetition rate (Hz)	Beam current (μA)	Energy (GeV)	Max neutron flux* ($n/cm^2/s$)
10	25	6.3	1.6	10^5

* Measured at 14m from modulator

Power Map of Proton Accelerators

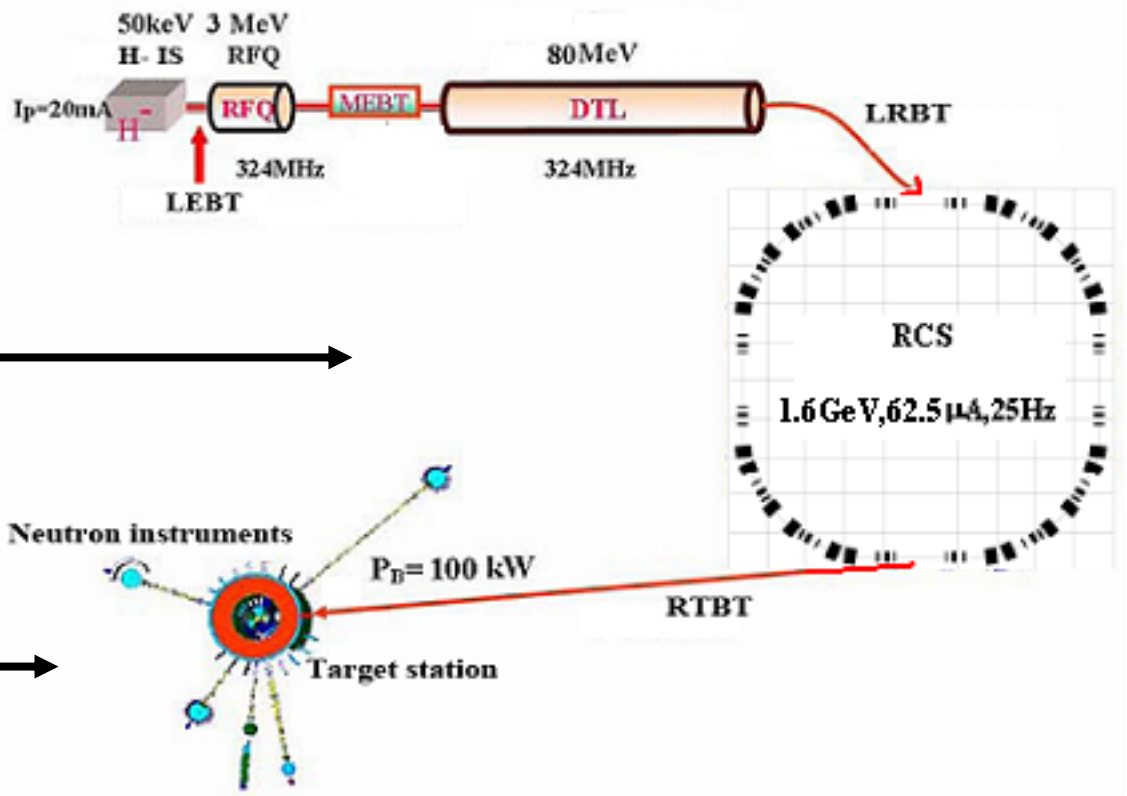


CSNS Facility Layout

Linac

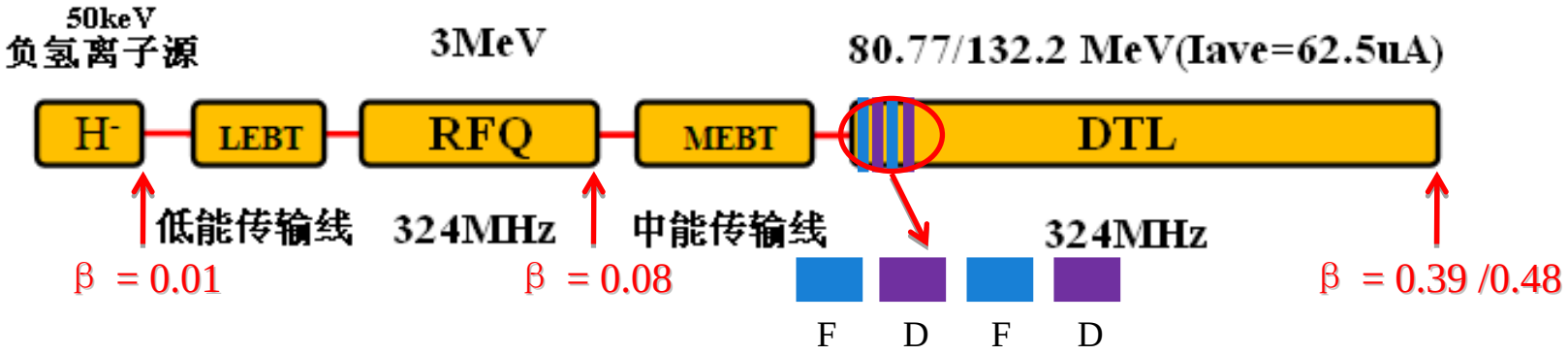
Rapid Cycling Synchrotron

Target and Instruments



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.

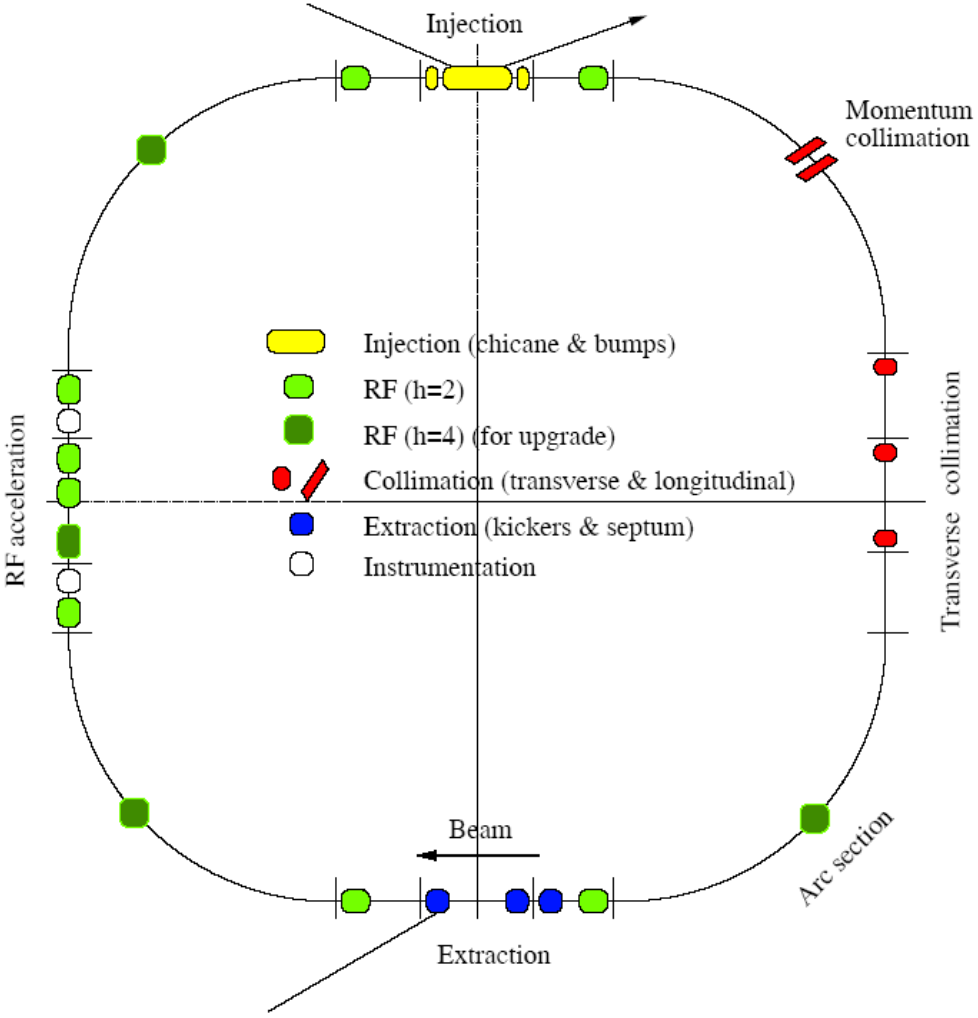
Linac



- **H^- ion source: ISIS type, 50keV, 20mA pulsed current**
- **LEBT: 1.68m**
- **RFQ linac: four-vane type, 3MeV, 20mA pulsed current, 324MHz**
- **MEBT: 3.03m**
- **DTL: four tanks, 80MeV, 15mA pulsed current, 324MHz, 34.5m**
- **Space beyond the end of the linac is to be left to allow upgrades: further three drift tube tanks to increase the linac energy to 132MeV and deliver 200kW of beam power. A superconducting linac to increase the energy to 250MeV and deliver ~500kW of beam power.**

Rapid Cycling Synchrotron (RCS)

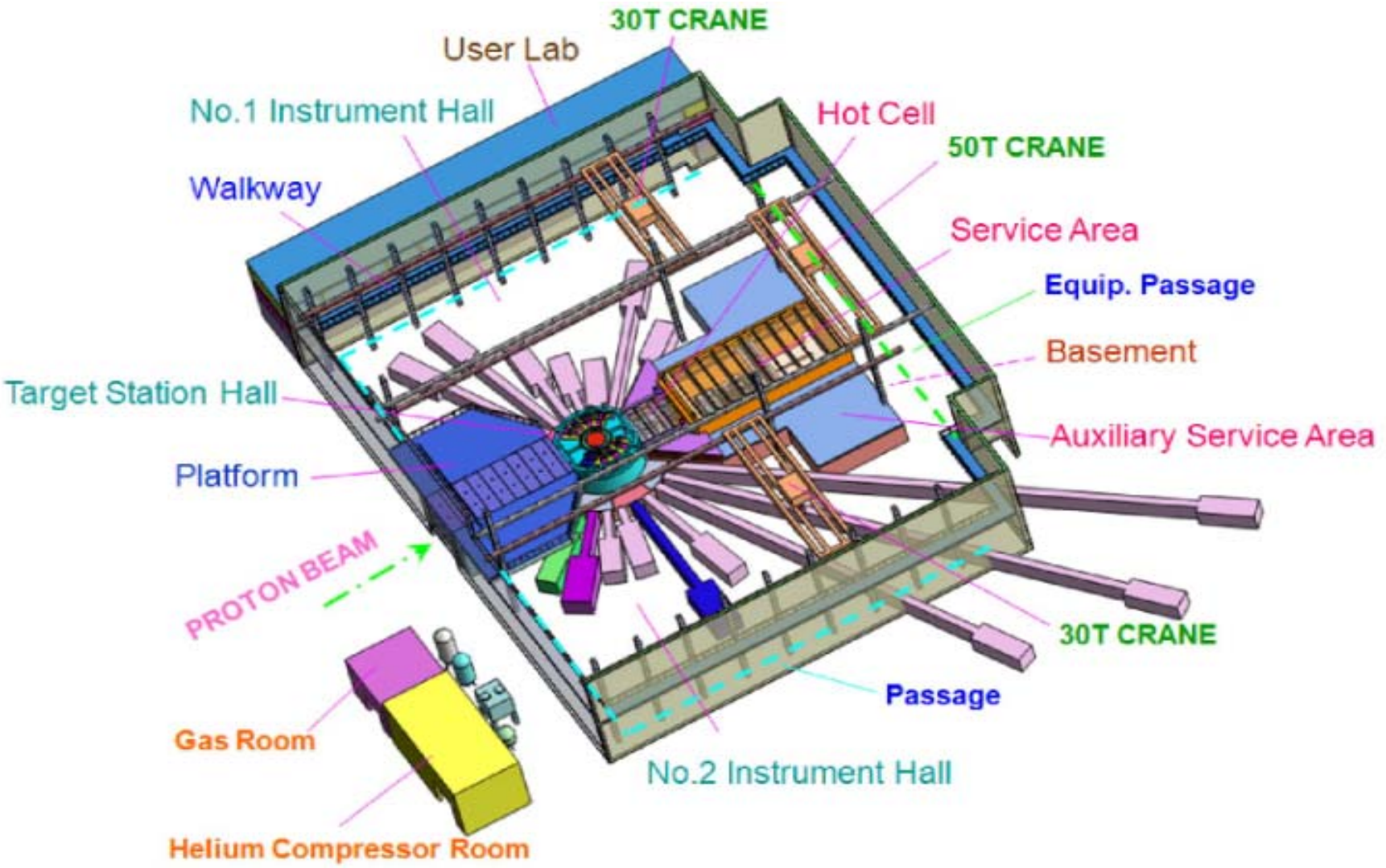
- Lattice of 4-fold symmetry, triplet configuration
- 1.6GeV at 25Hz
- 227.92m circumference
- 540π mm·mrad acceptance
- 80-MeV injection energy for phase I
- four long straight sections for injection, acceleration, collimation and extraction
- Upgradeable with increased injection energy (beam current)



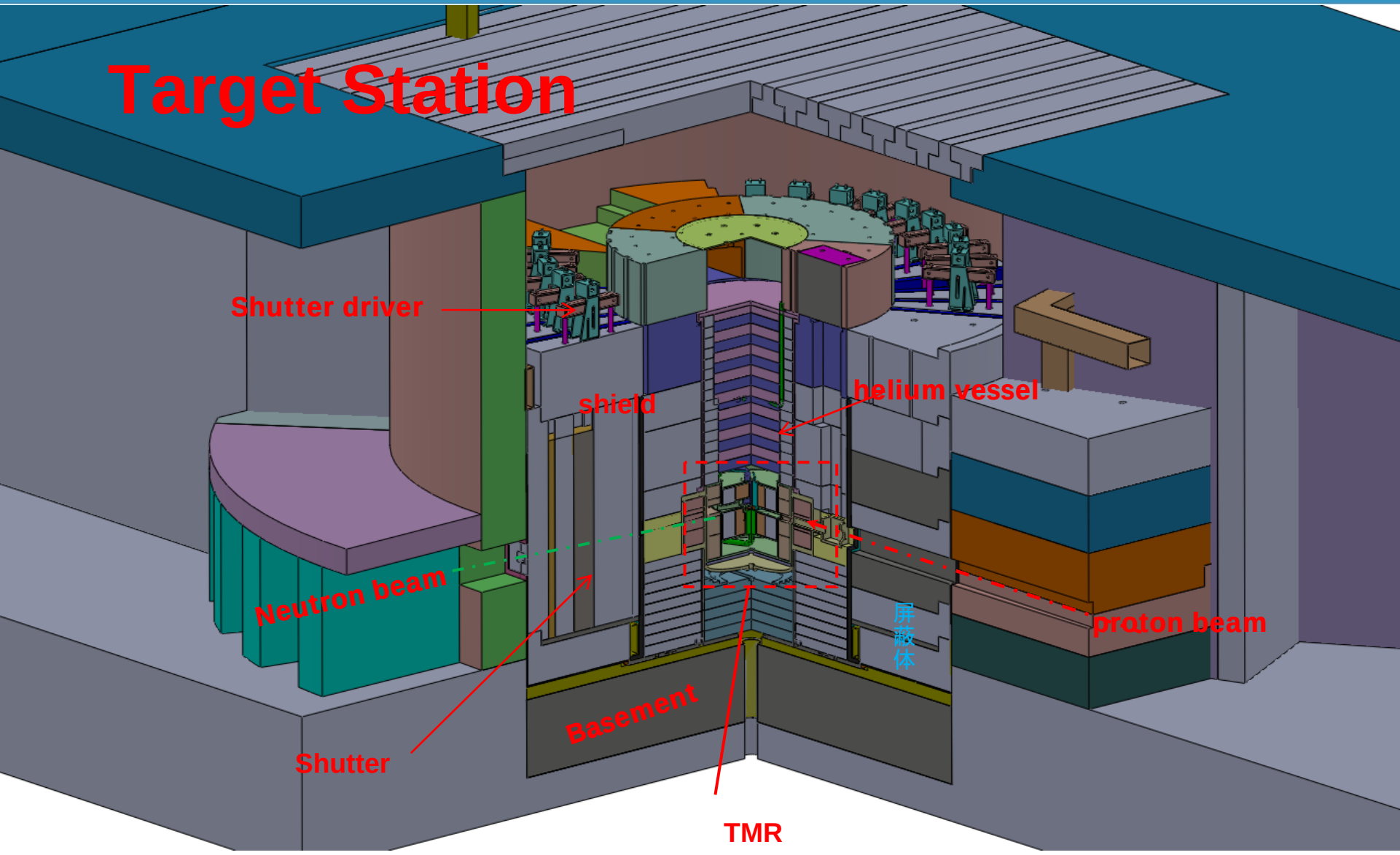
Target and Instrument Design Highlight

- The target station is to be built with a 500kW capability.
- **Target:** Tungsten clad by Tantalum and cooled by D_2O
- **Moderator:** 3 types of H_2O (300K), decoupled H_2(20K), coupled H_2(20K)
- **Reflector:** Beryllium (D_2O cooled)/Iron (Ø700/1000×1000mm) + Cd liner
- **TMR maintenance:** horizontal handling + vertical M-R plug
- **Shielding:** consisting 5m iron + 1m heavy concrete for 500kW power
- **20 Neutron beam ports:** vertical shutter system, neutron guide inserts
- **3 Instruments:** high-flux powder diffractometer, small-angle diffractometer, and multipurpose reflectometer
- **Super-mirror guide:** transport thermal neutrons efficiently
- **Neutron detector:** ^{3}He LPSD and 2D PSD

Instrument Hall



Target Station



TMR geometry model

Decoupled & Poisoned Hydrogen Moderator (DPHM)

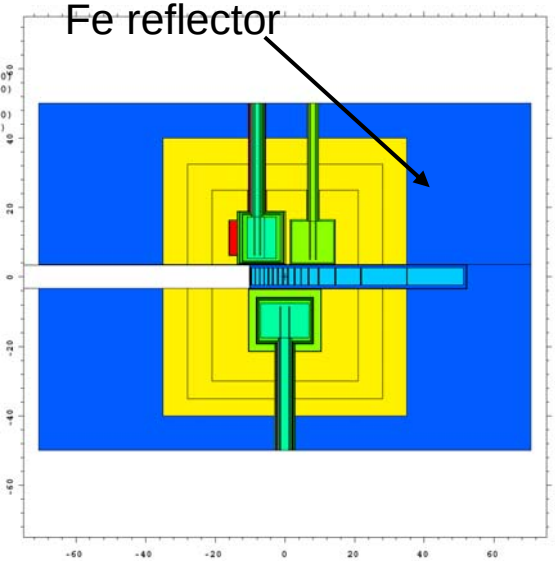
Decoupled Water Moderator (DWM)

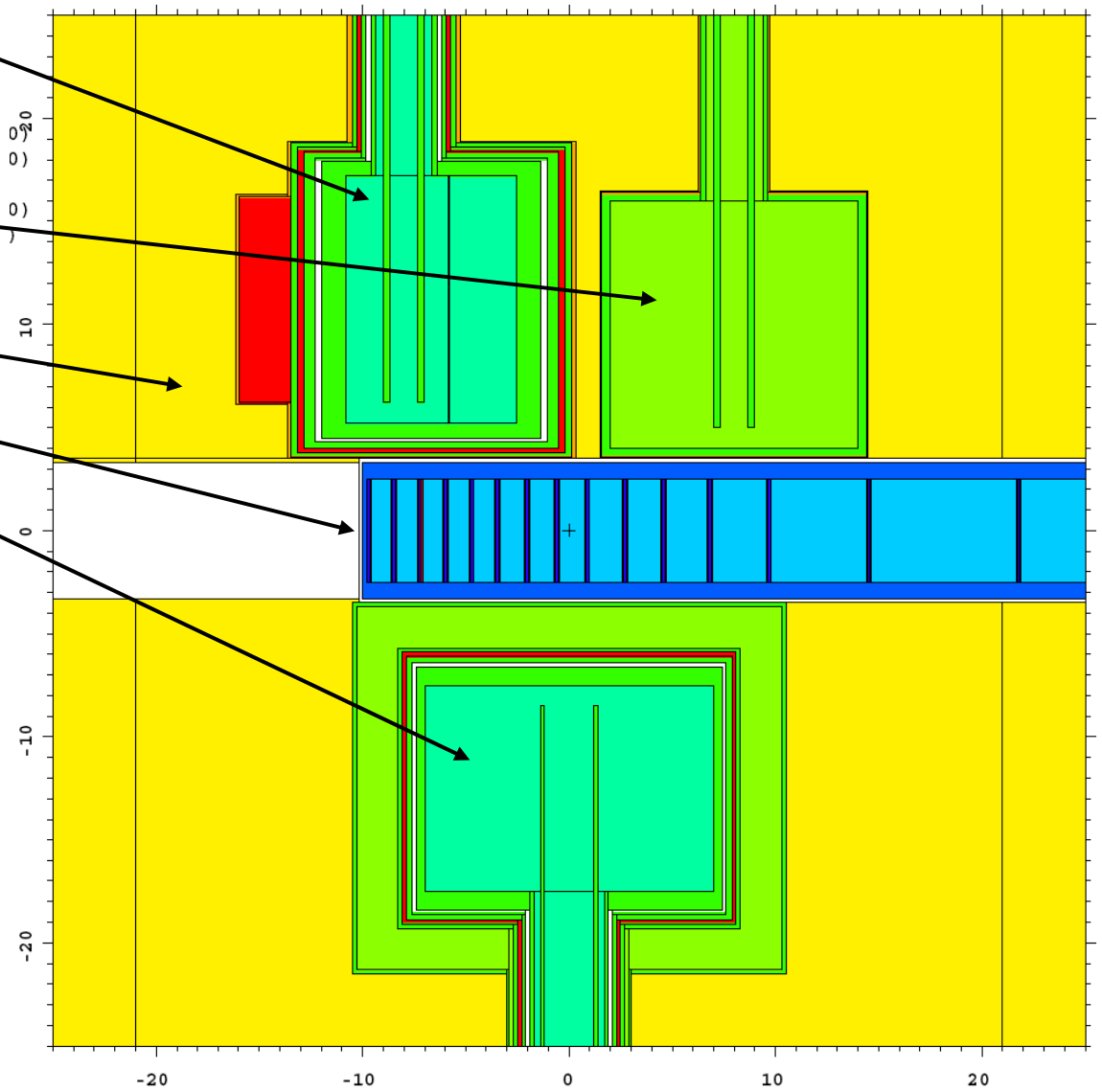
Be reflector

Target

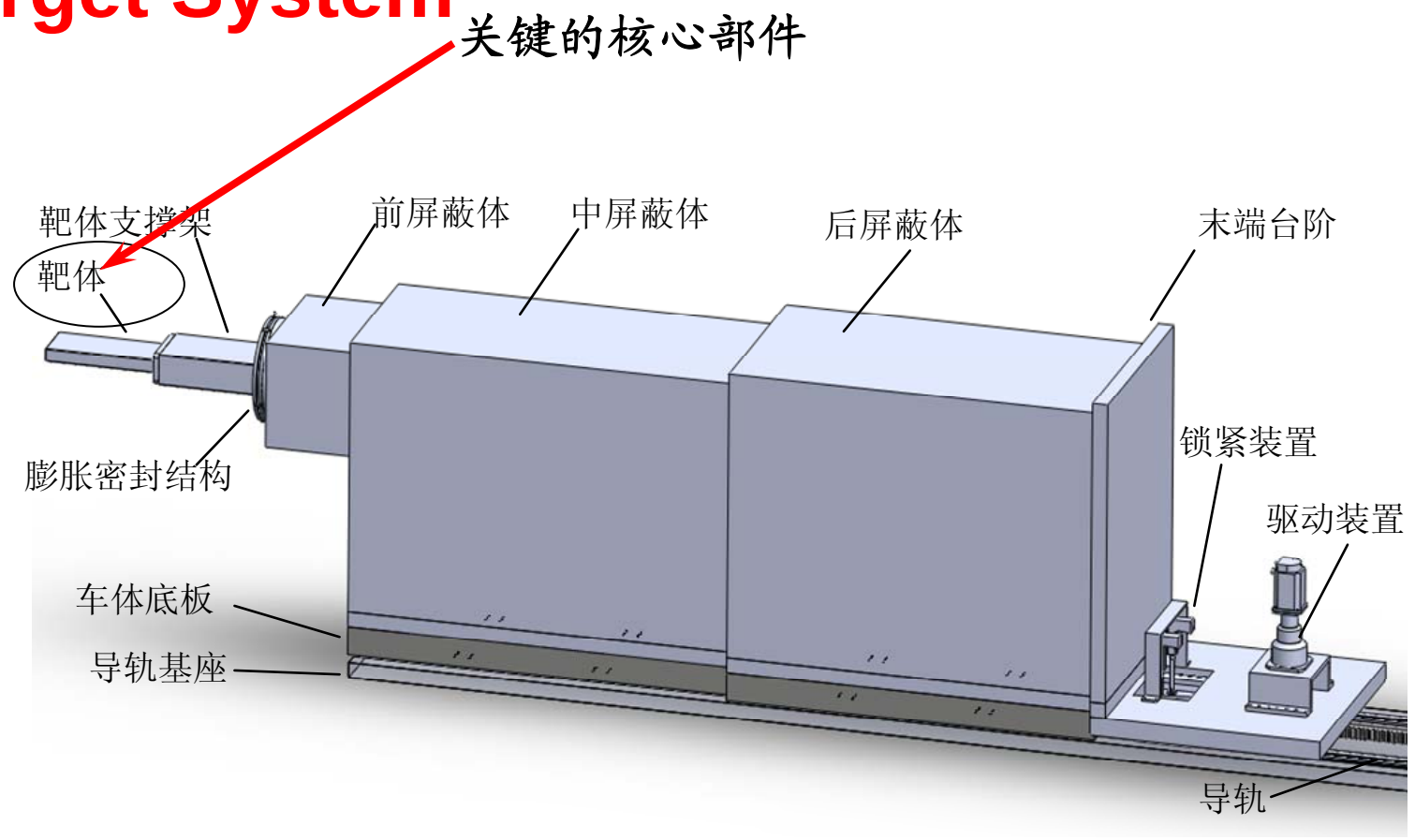
Coupled Hydrogen Moderator (CHM)

Fe reflector



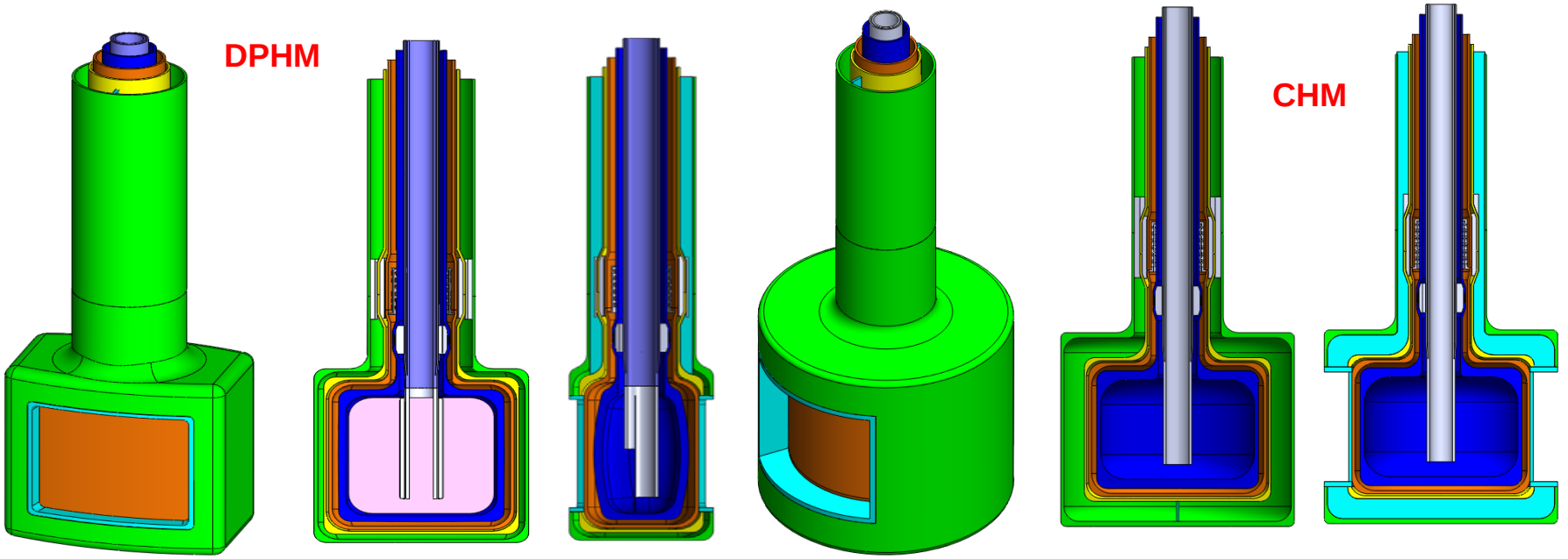


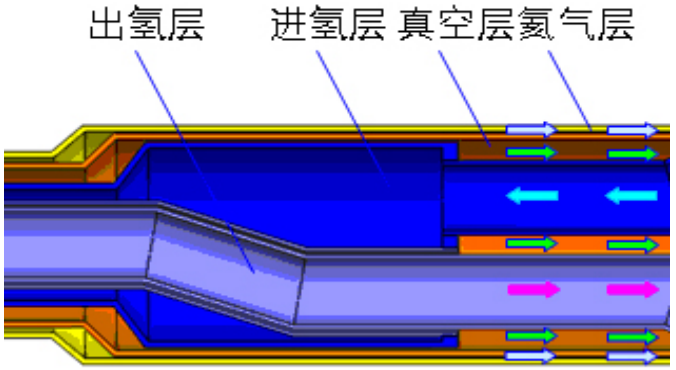
Target System



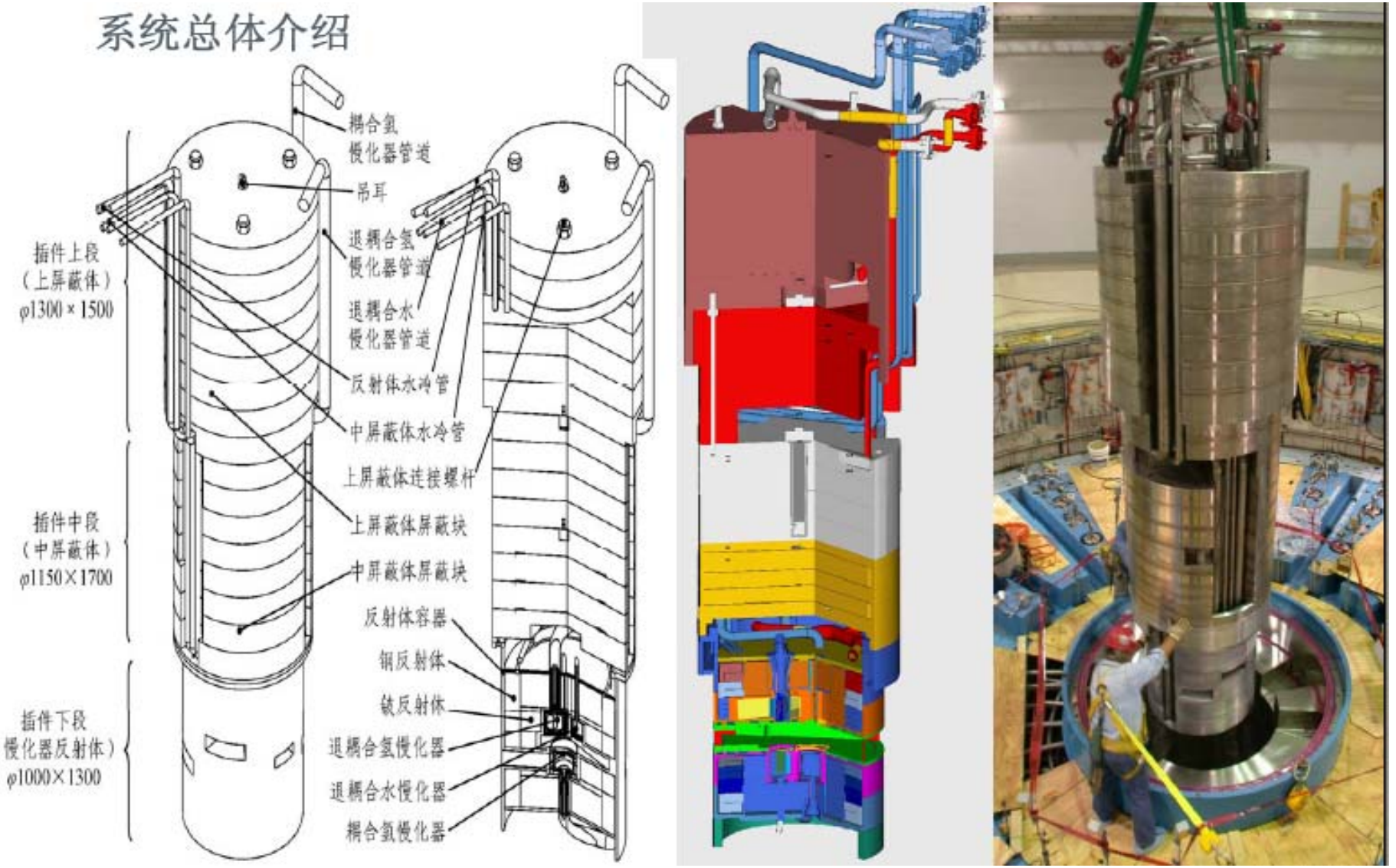
靶体系统构成示意图

Moderators and transfer line

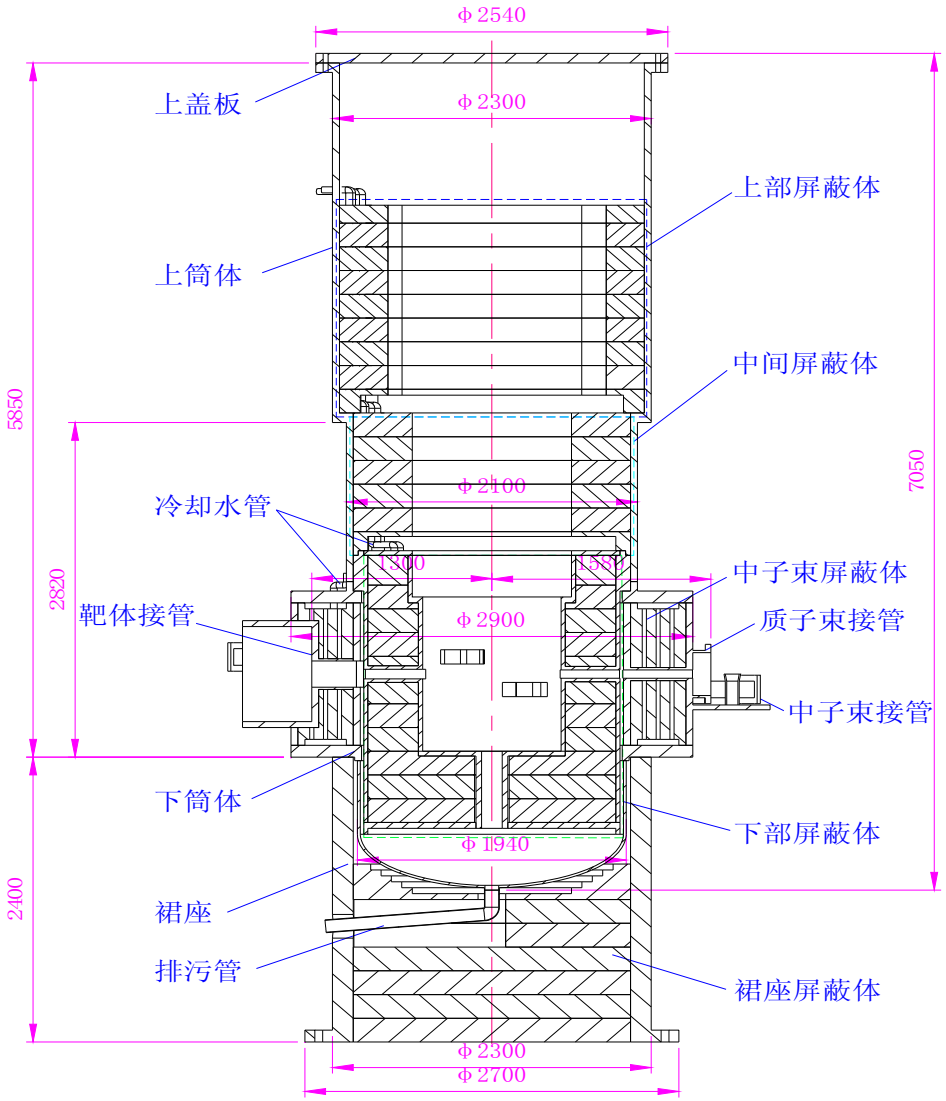


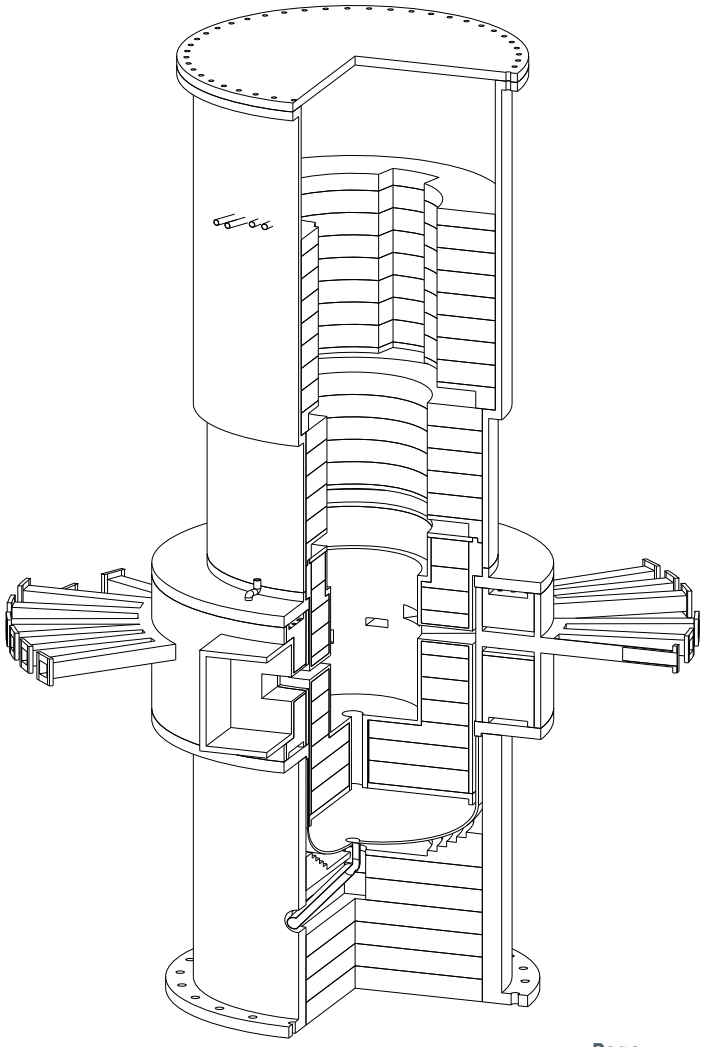


Plug of Moderator and reflector

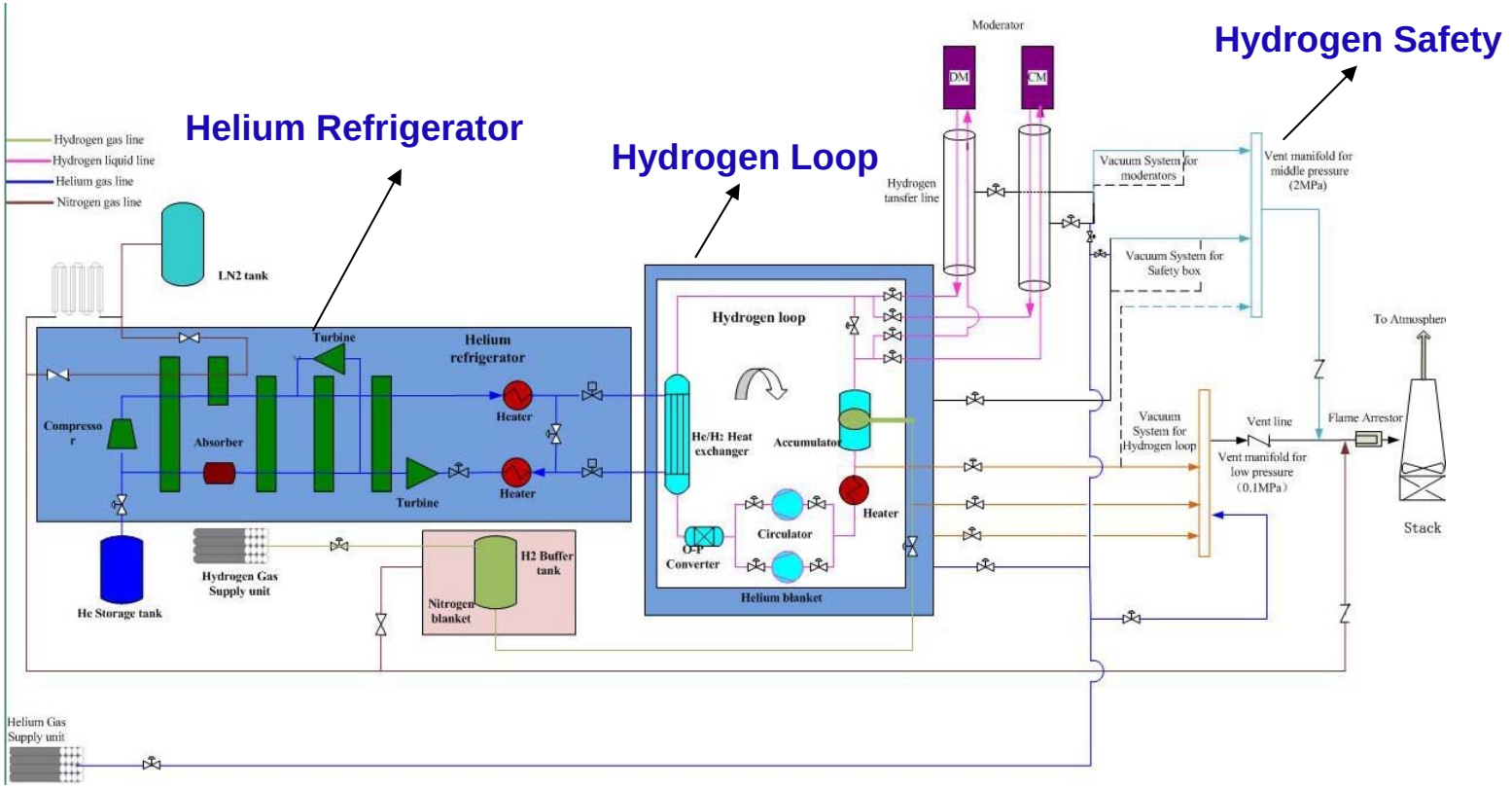


Helium vessel





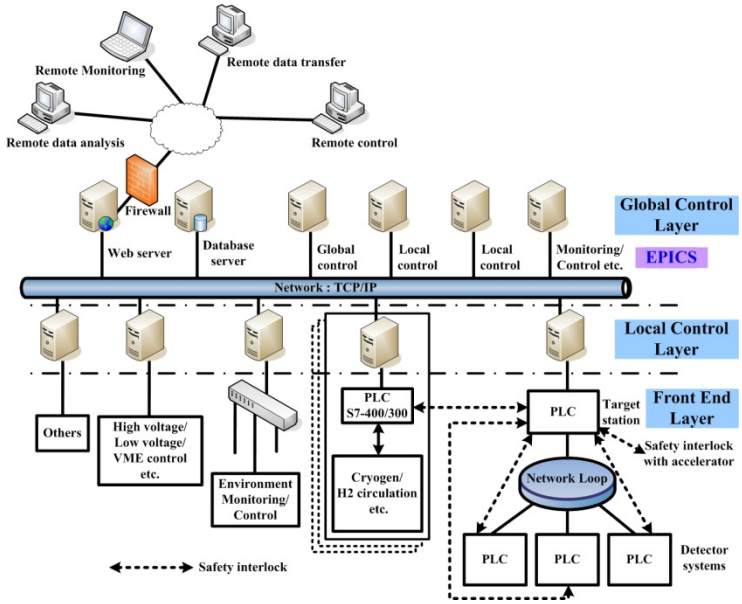
Cryogenic System

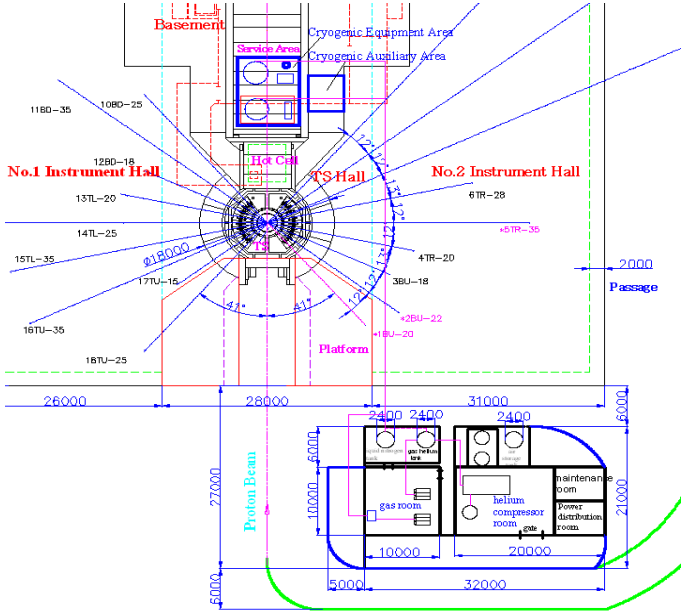


Helium Refrigerator	**HX Flow rate**	**110g/s**	**Hydrogen Loop**	**Flow rate**	**87.1g/s**
	HX Temperature	**14.9-20.9K**		**Temperature**	**18.5-21.7K**
	Operation pressure	**1.15/7.5bar**		**Max. operational pressure**	**1.5MPa**
	Design pressure	**2.5MPa**		**Design pressure**	**2.5MPa**
	Refrigeration capacity	**2500W/21K**		**Heat Removal**	**2400W**

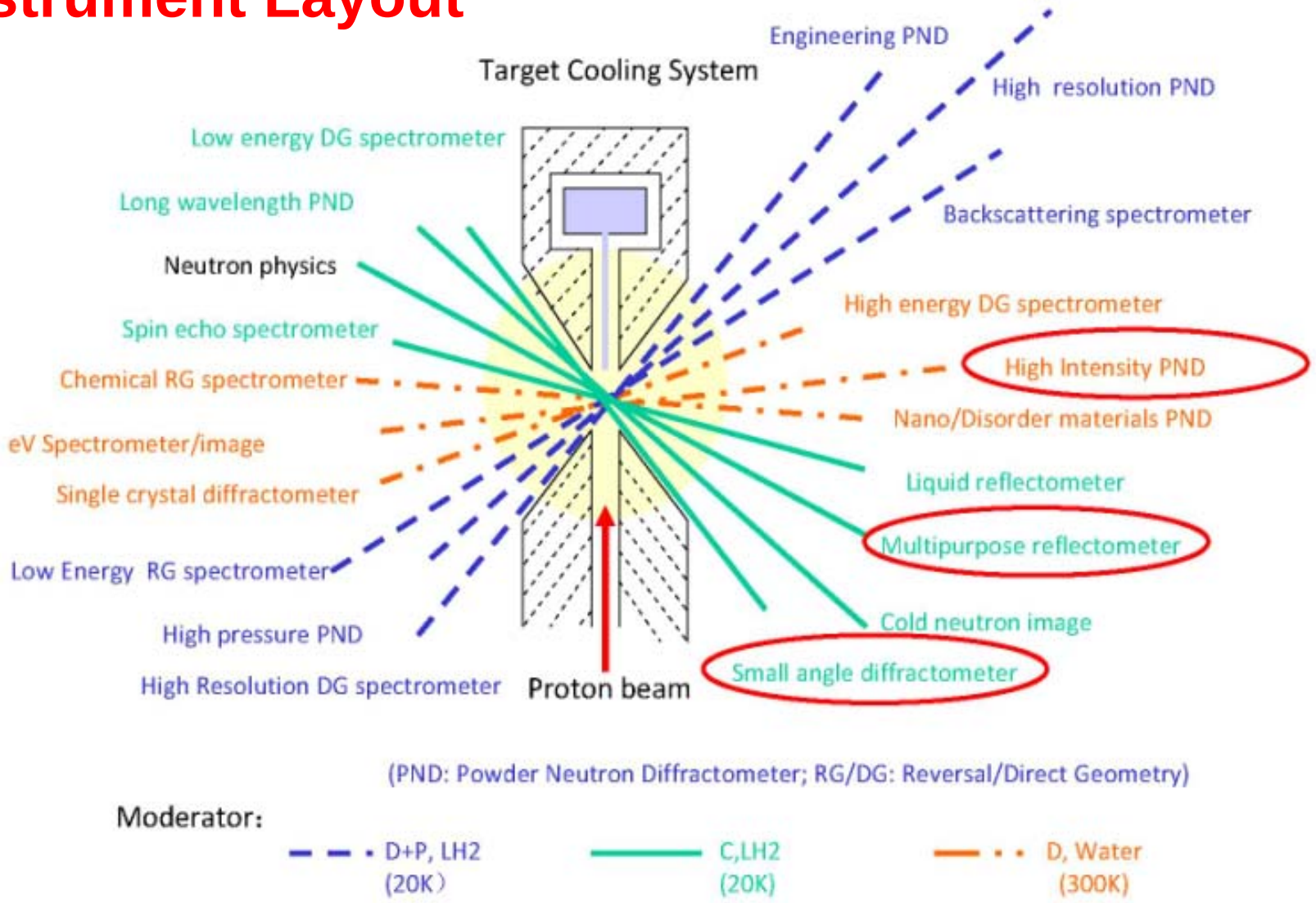
Control and Utility

- **Experimental control**
  - To control the behaviors and monitor the status of the devices of the target station and instruments
  - 3 layers: Global Control, Local Control, Front End
  - EPICS: software frame
  - PLC (Yokogawa): frontend unit
- **Experimental utility**
  - water supply & drainage system
  - ventilation & compressed air system
  - power distribution system



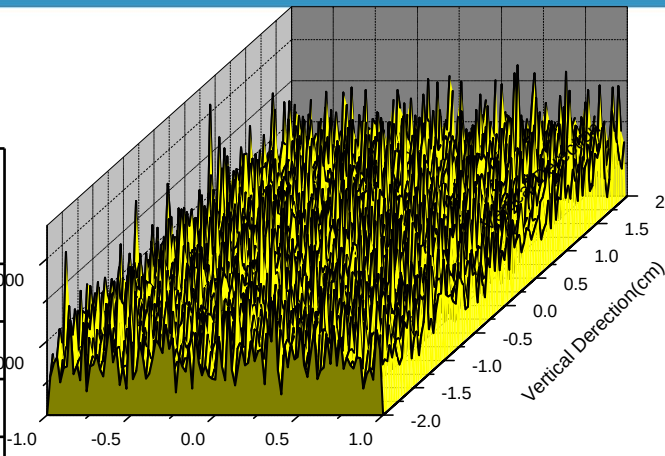


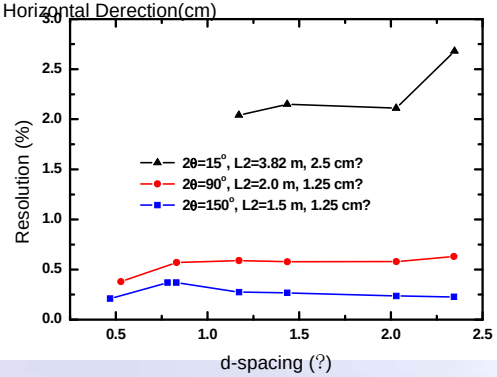
Instrument Layout

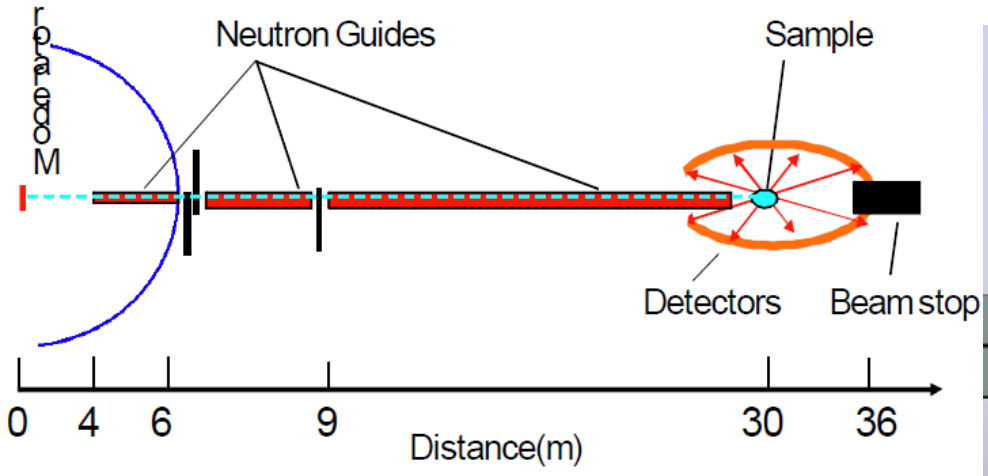


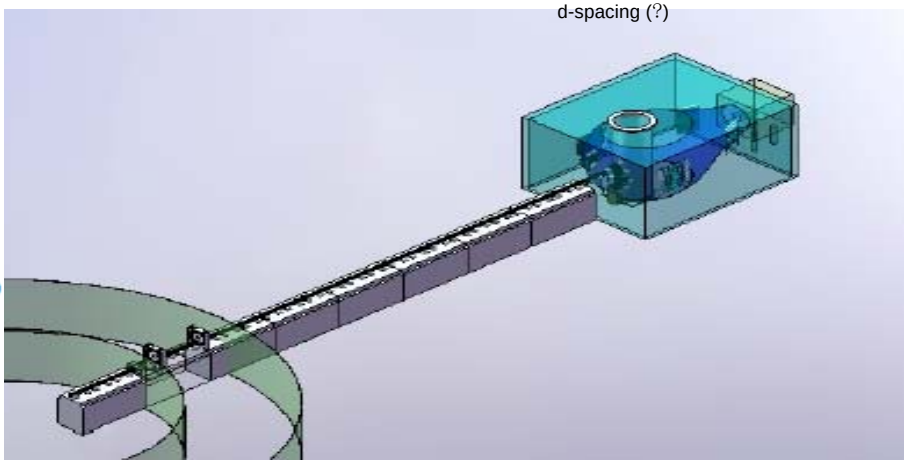
Neutron instrument: HIPD design

Moderator		decoupled water moderator（300 K）
Bandwidth(Δ λ)		4.5 Å
Max. Beam Size		40(h)×20(w) mm
Flux at sample position		~10^7 n/cm^2/s
Best Resolution(Δd/d)		0.2 % at 2θ=150°
Guide		Taper focus, m=3
Source to sample distance L1		30 m
Sample-detector distance L_2	2θ=150°	1.5 m
	2θ=90°	2.0 m
	2θ=15°	3.8 m



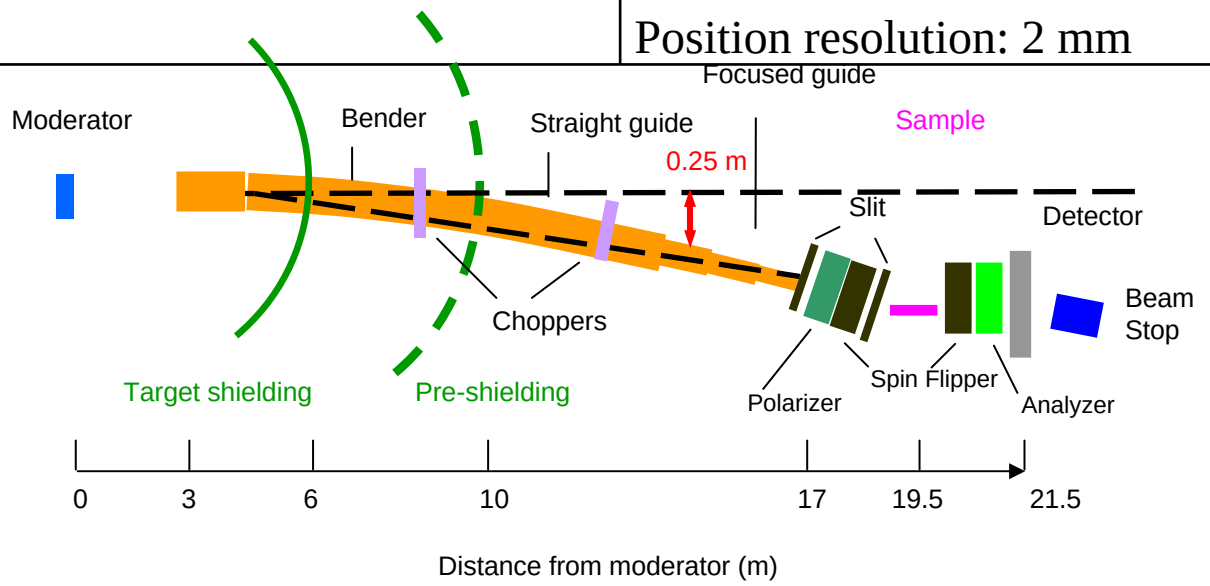






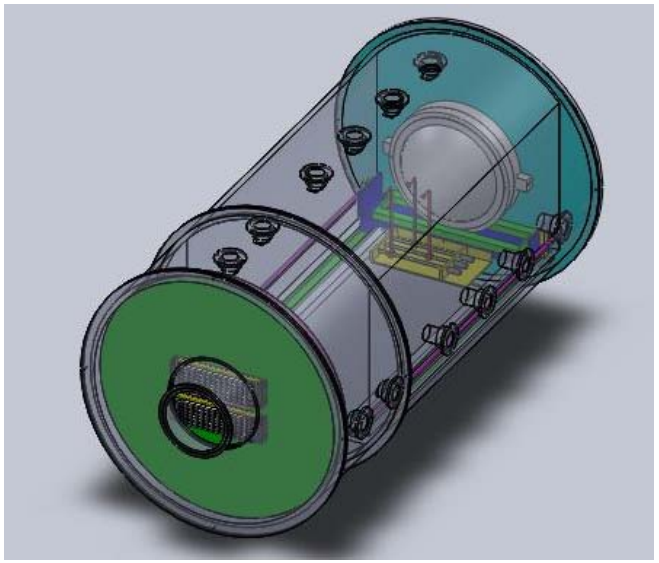
Neutorn instruments: REFL design

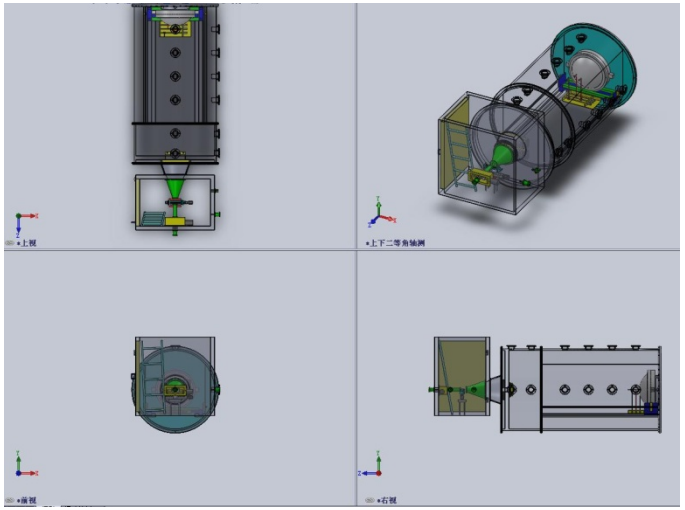
Moderator	Coupled liquid H2 (20 K)
Bandwidth（Δ λ）	6 Å
Guide	Bender+Sraight+Taper 40 × 60 → 20 × 30 mm²
Source to sample distance L1	19.5 m
Sample to detector distance L2	2 m
Sample table	6-axis movements
Polarizer/analyzer	Supermirror type
Detector	2D position-sensitive detector Position resolution: 2 mm

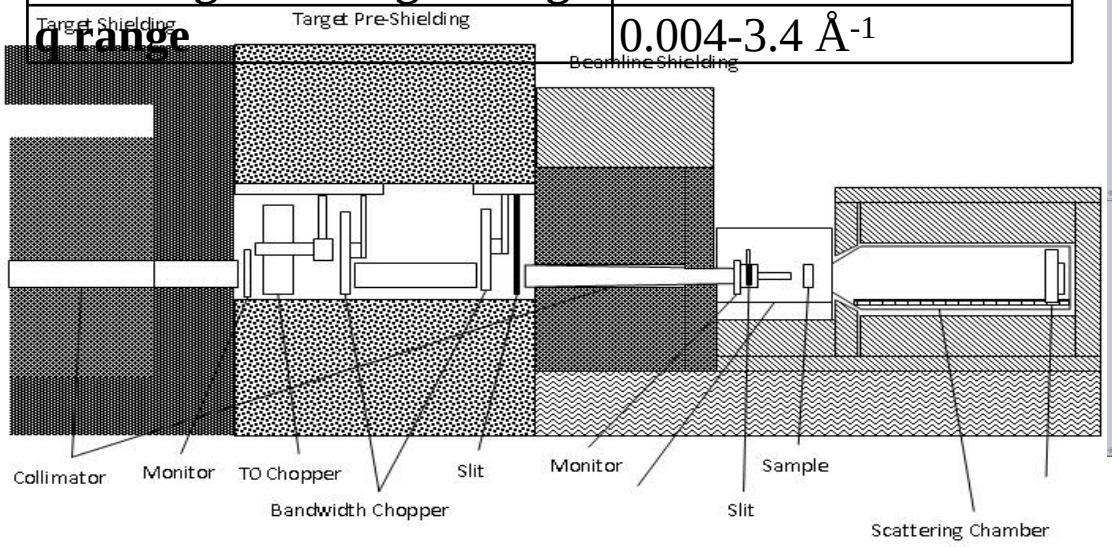


Neutron instruments: SANS

Moderator	Coupled hydrogen （20K）
Moderator to sample distance	14 m
Sample to detector distance	5 m
Detector	
Effective area	50×50 cm^2
Resolution	1 cm (FWHM)
Distance to sample	1~5 m
Working wavelength range	0.4-8 Å
q range	0.004-3.4 $Å^{-1}$







R&D Activities

R&D Activities

- R&D and prototyping work has been carried out since 2006.
  - R&D 1: 30M CNY funded by CAS (from January 2006)
  - R&D 2: 40M CNY funded by Guangdong (from June 2007)
- Over 30 prototyping items (covering most key technologies) have been selected.
- Fabrications of most prototypes have been completed and tests are underway.

R&D Activities

- **Accelerator**

  DTL (1/3 tank)

  RCS dipole and quadrupole magnets and field measurement system

  RCS magnet PS

  RCS ferrite loaded RF cavity

  RCS ceramic vacuum chamber

  H^- ion source test stand

  LEBT chopper

  linac RF pulsed PS

  linac Modulator and crowbar

  RCS RF PS

  RCS injection bump magnet and pulsed PS

  RCS extraction kicker magnet and pulsed PS

  key components of beam instrumentation (BPM, BLM, ….)

  key components of control system (PS control, timing, ….)

R&D Activities

- **Target station**

  target material tests

  moderator and cooling system

  decoupled & poisoned, reflector material and engineering

  shutter

  helium vessel seal & control

  H_2O moderator

- **Instruments**

  neutron super-mirror guide

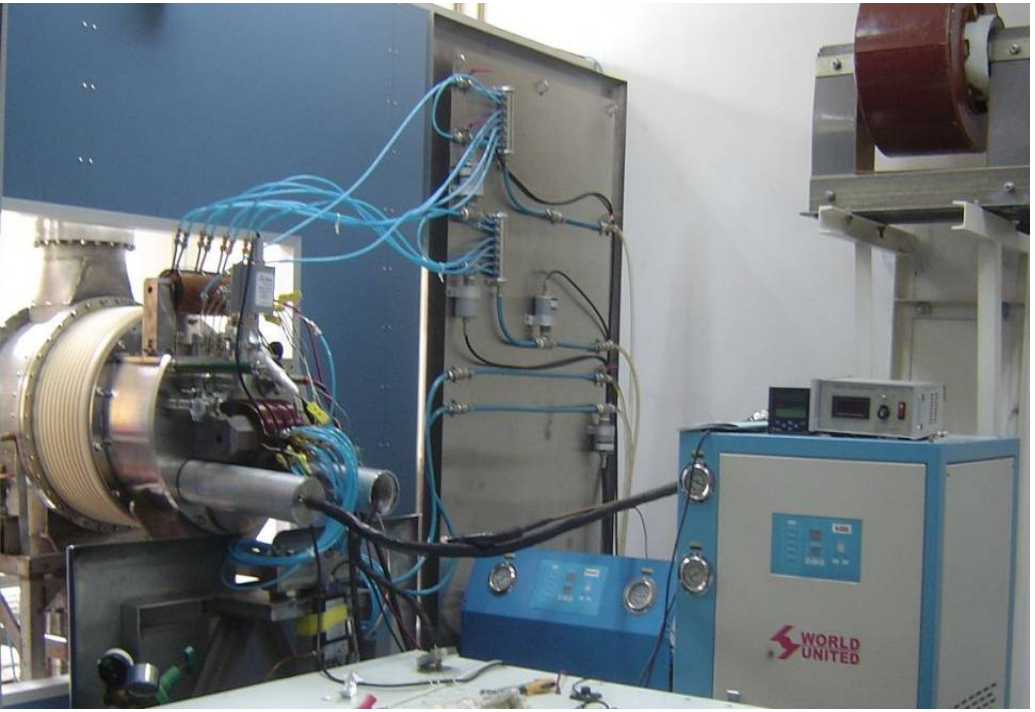
  bandwidth limited chopper

  neutron detector

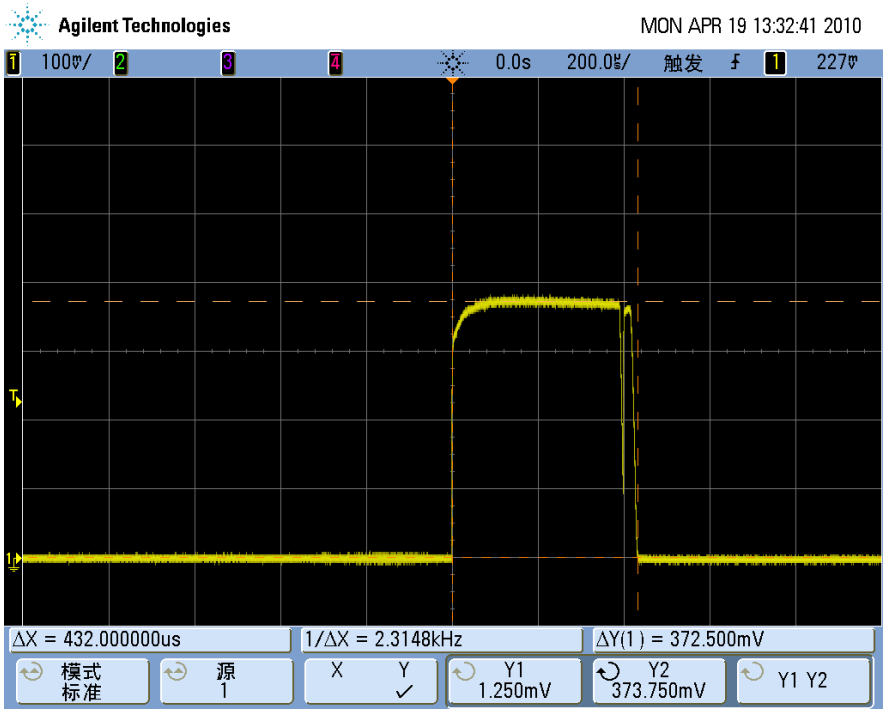
  position sensitive detector

  detector electronics

H^- Ion Source Test Stand



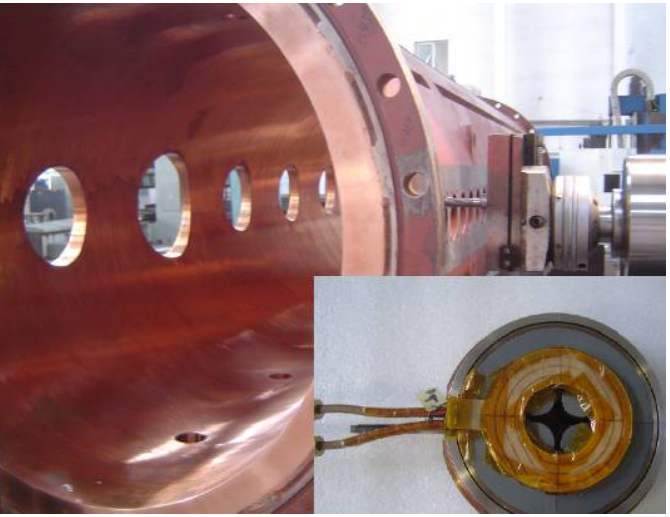
test stand at IHEP



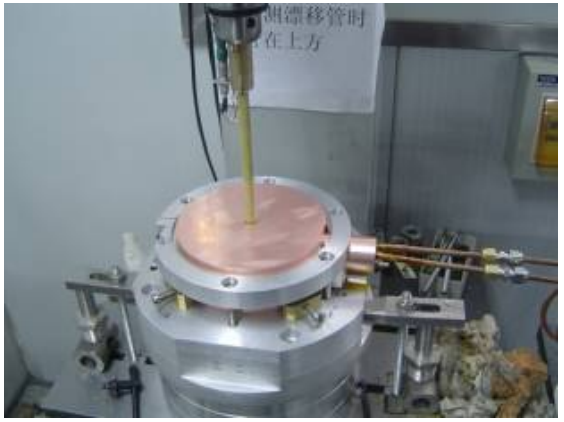
30-mA output H^- beam observed on April 19, 2010

DTL

- **Key technologies have been developed.**



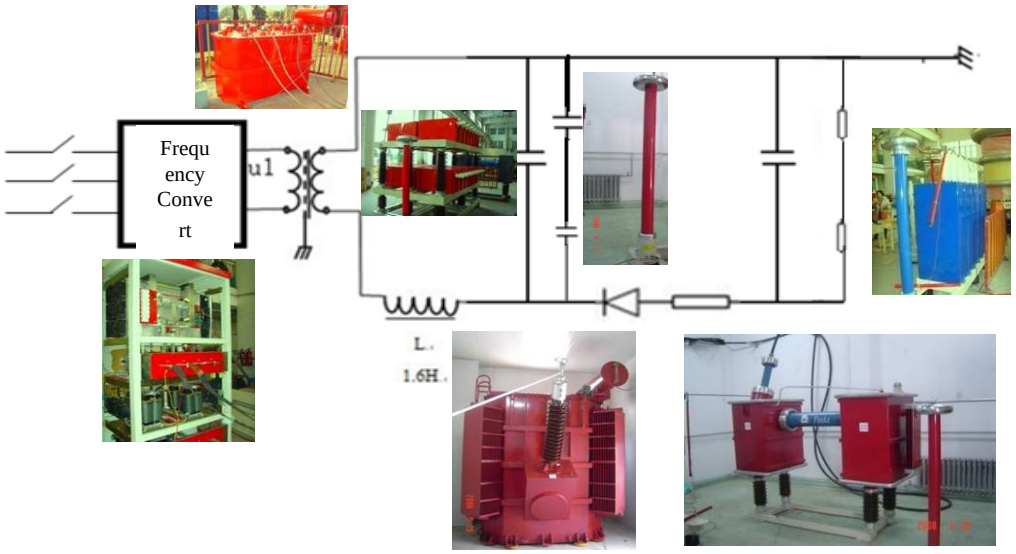
Prototype of first tank



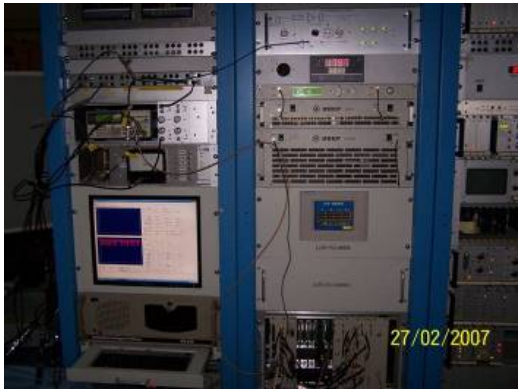
Drift tube by electron welding

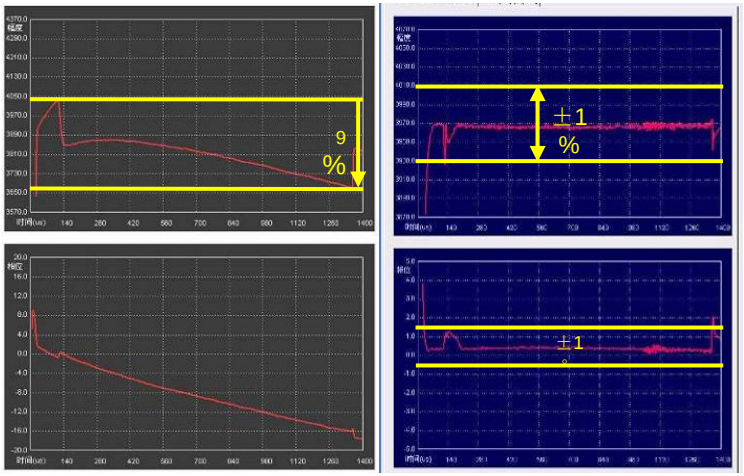
Sakae coil and quadrupole at rotating coil measurement

Linac RF Power Source



AC resonant HV pulsed power supply for klystron bas been developed.

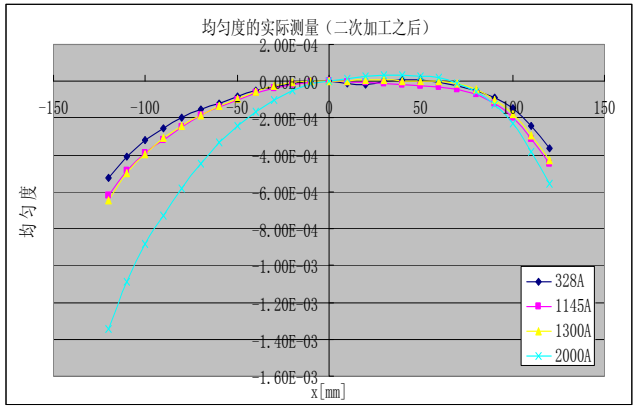


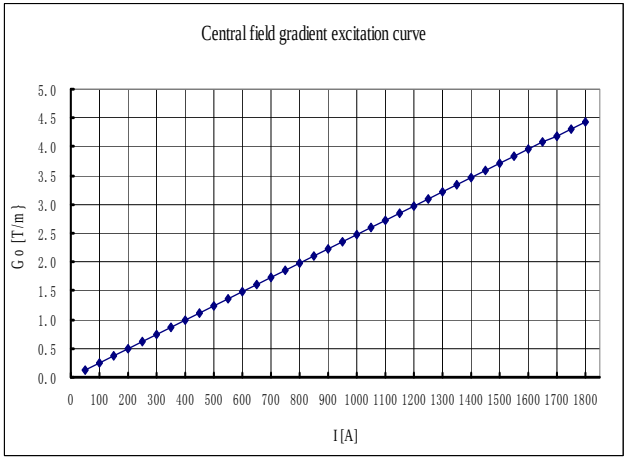


FPGA based digital LLRF control system

RCS Magnets

- **Dipole and quadrupole prototypes are fabricated. Measurement system developed, with a preliminary results.**





RCS Magnet Power Supply

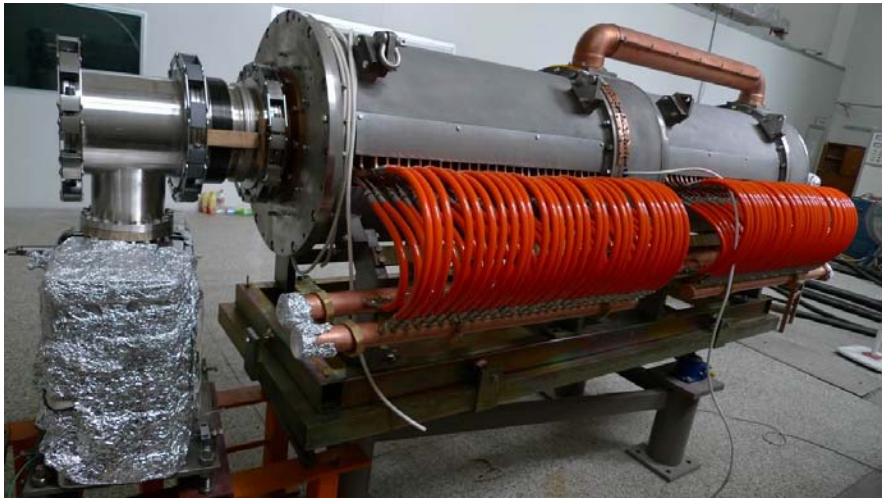
- A prototype power supply for the RCS dipole magnet is fabricated. It composed of DC (1260A) + AC(900A) sources, choke, and capacitor bank.

power supply

choke

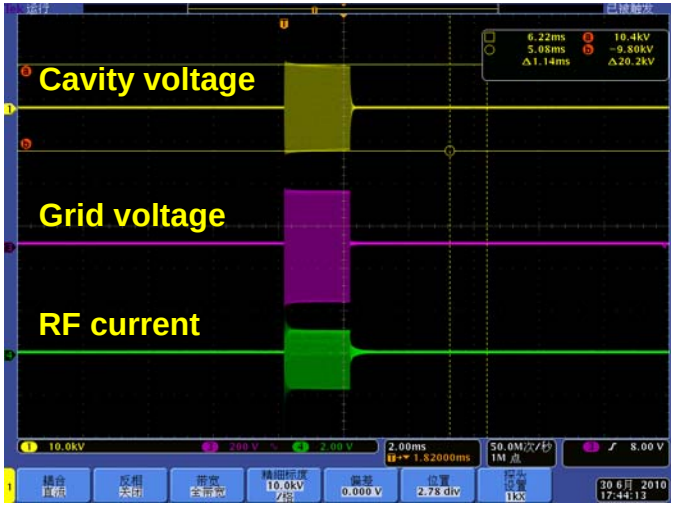
capacitor bank

RCS RF System



Prototype ferrite loaded cavity

Frequency Characteristics test of cavity



High power tests of power source with cavity are underway.

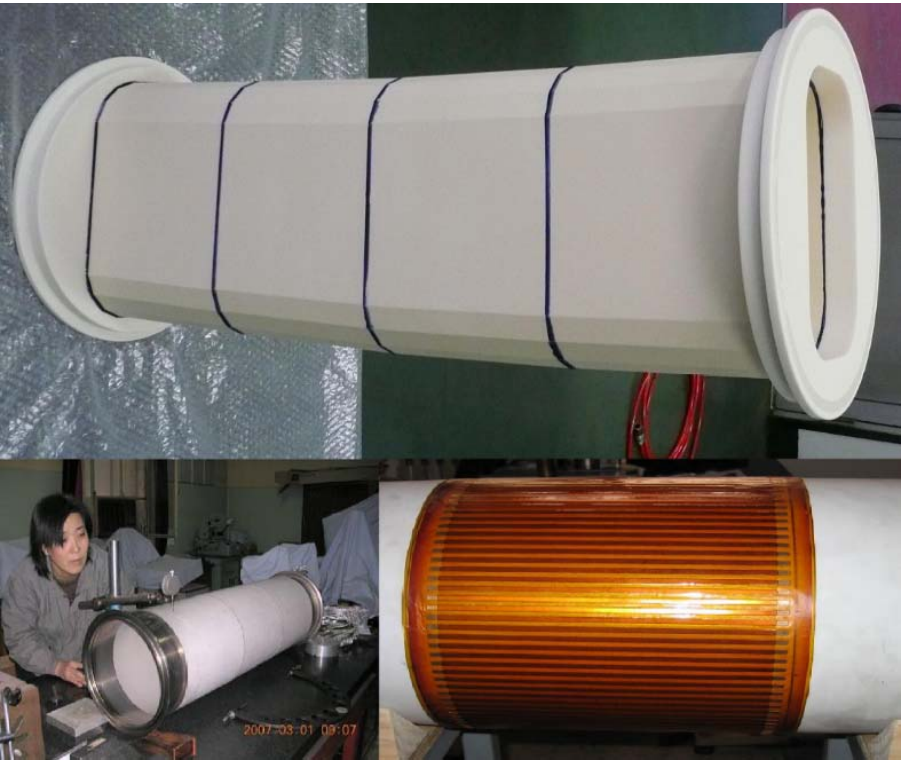
Injection and Extraction Magnet and PS

Injection bumper

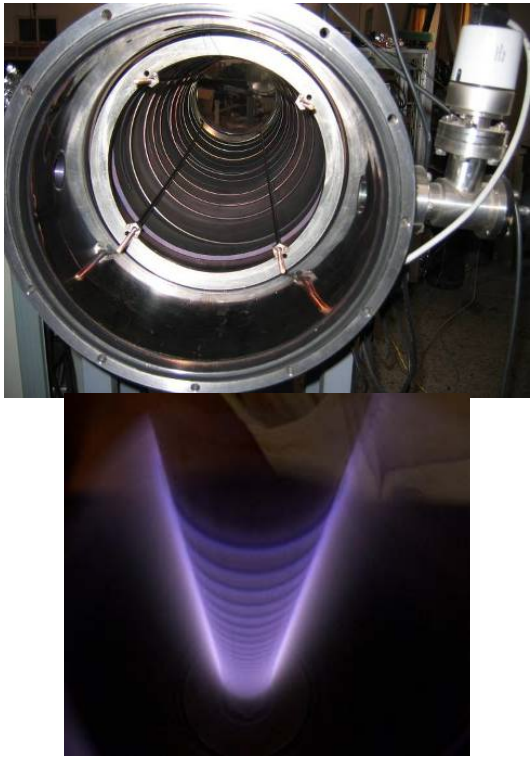
Extraction kicker

RCS Vacuum Chambers

- Ceramic vacuum chambers for magnets are made.

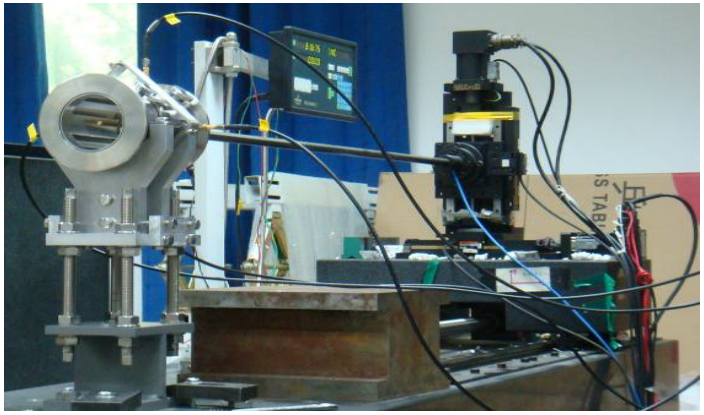


Metallic brazing (J-PARC) and glass joint (ISIS)

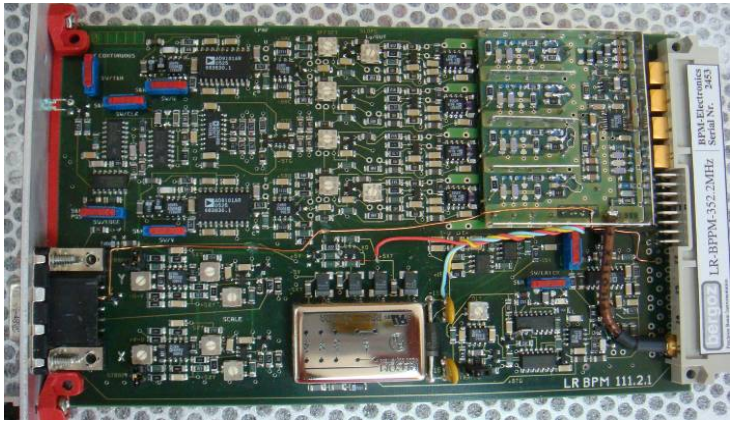


NiT coating

Control and Instrumentation



BPM mapping



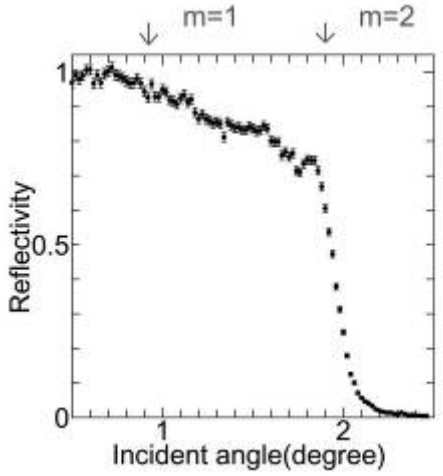
BPM electronics

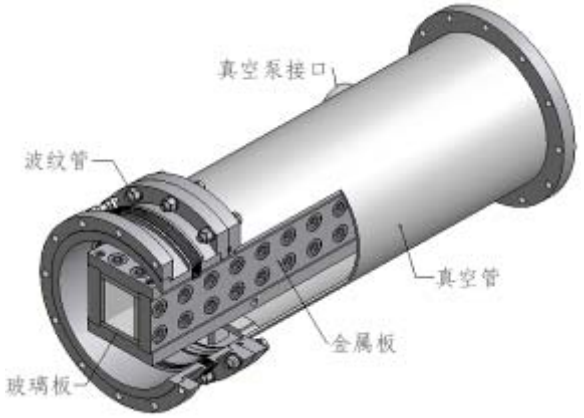
Ion source control

Timing system EVG and EVR

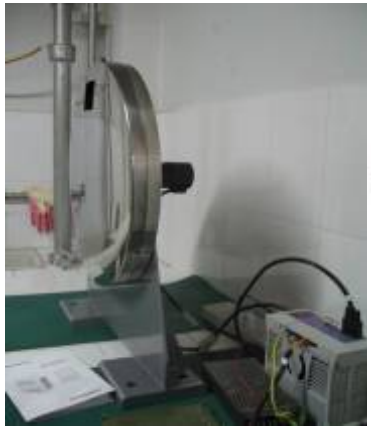
Neutron Guide and Chopper

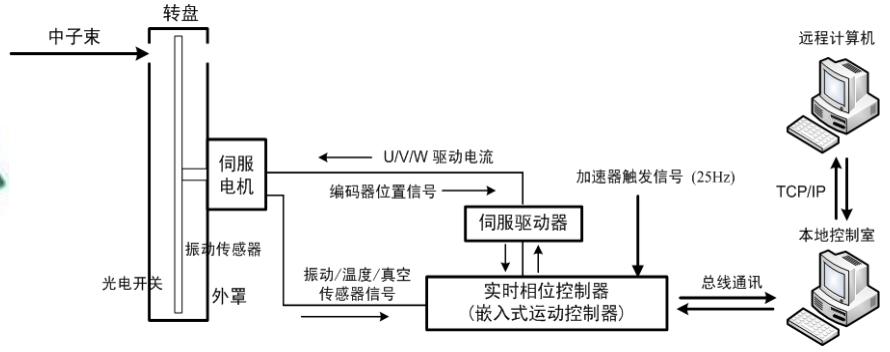
Neutron Guide: **Super mirror films were made by magnetic controlled sputtering at IOP. Assembly to form a guide is underway.**





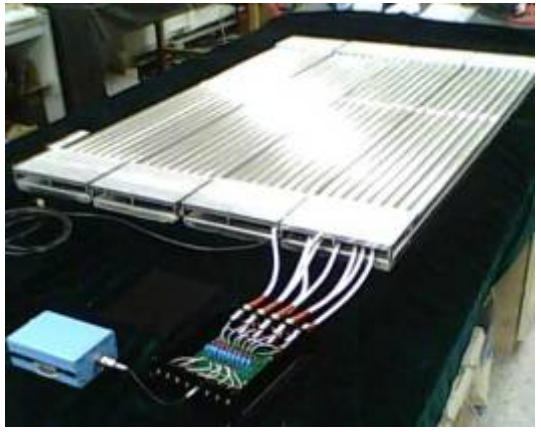
Chopper: **A mockup and its control system were made.**



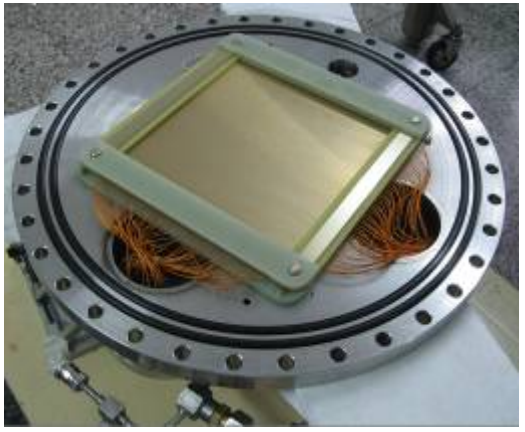


Neutron Detectors

^{3}He Neutron Detector: An array was assembled with 40 tubes and a small neutron source was set up for test.



2D Neutron Detector: A prototype was made and under test.



Summary

- CSNS site was decided at Dongguan, Guangdong province.
- CSNS is designed with the capability for upgrading from 100kW to 500kW.
- Most of the key components are under prototyping.
- Review of feasibility study was performed in October 2009.
- Construction of the project is planed to start in this year, and complete in 2017.
- We are facing many challenges to achieve the specific goals. The collaborations (international and domestic) will be important to the success of the project.

Thank you for attentions!