Present Status of CSNS

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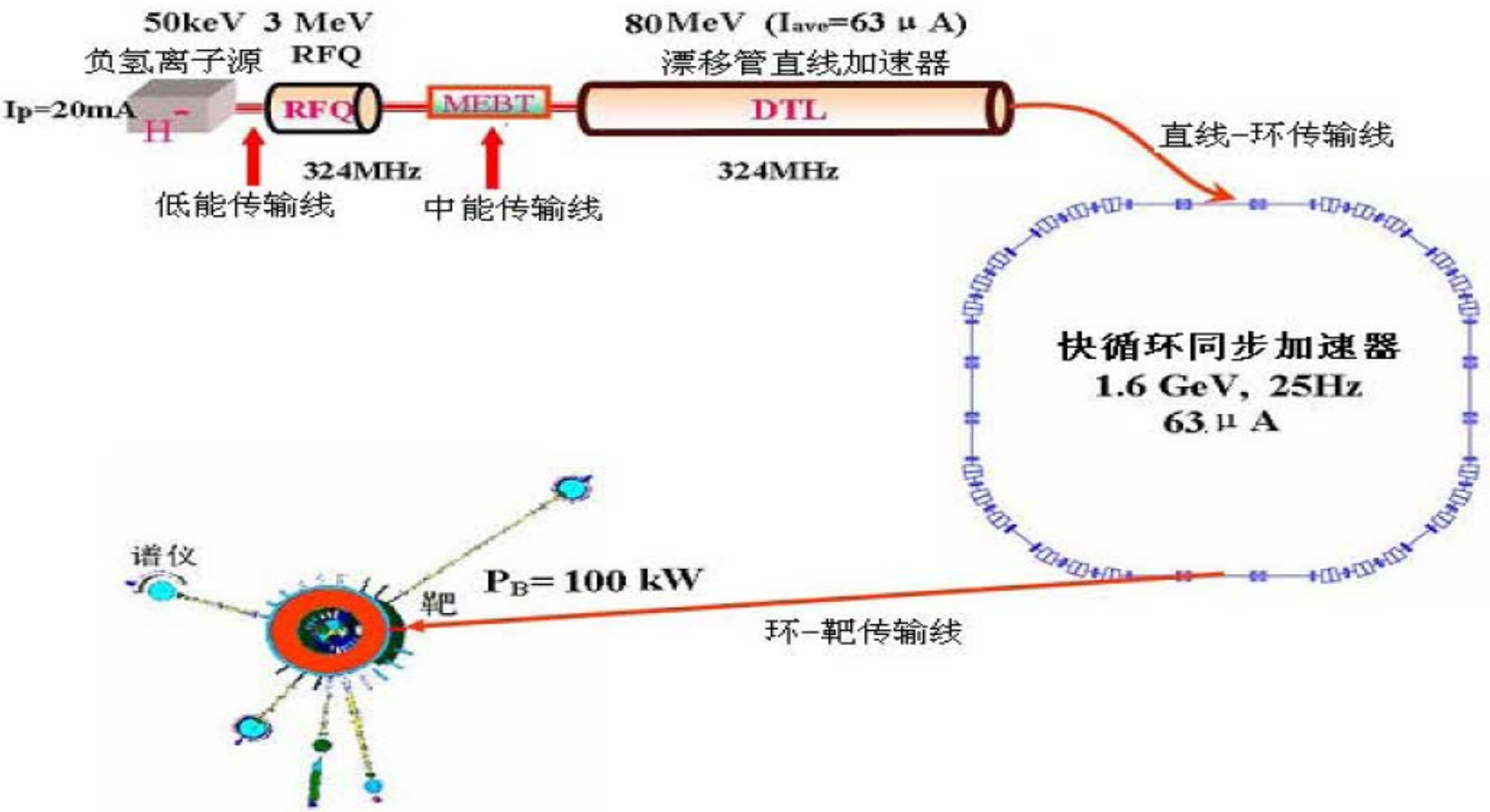
CSNS
CHINESE ACADEMY OF SCIENCES

Project Overview

CSNS overview



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

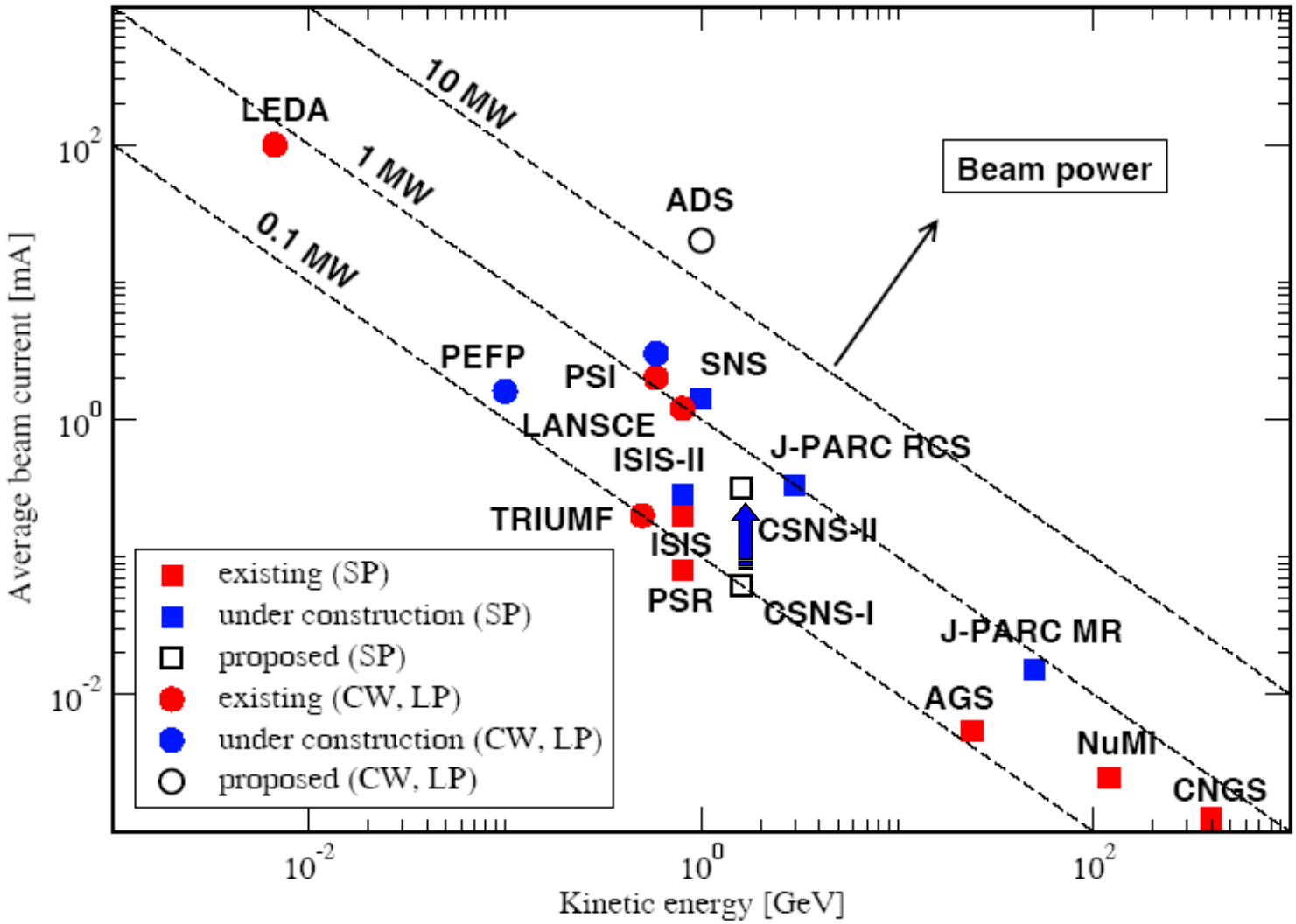
Beam power (kW)	Repetition rate (Hz)	Beam current (μA)	Energy (GeV)	Max neutron flux* ($n/cm^2/s$)
10	25	6.3	1.6	10^5

* Measured at 14m from moderator

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**

Power Map of Proton Accelerators



Key Milestones

February 2001	Idea of CSNS discussed
June 2005	Proposal approved in principle by central government (CD-0)
January 2006	CAS funded 30M CNY for R&D 1
July 2007	Guangdong funded 40M CNY for R&D 2
December 2007	Proposal reviewed
September 2008	Proposal approved
October 2009	Feasibility study reviewed
April 2010	Site preparation start
February 2011	Feasibility study approved (CD-1)
May 2011	Preliminary design approved (CD-2)
September 2011	**construction start (CD-3)**

Baseline Schedule

prototyping R&D	Jan. 2006 –
detail design	Jan. 2011 – Dec. 2011
construction start	Sept. 2011
civil construction	May 2012 – August 2015
component fabrication	Sept. 2011 – July 2015
installation & tests	November 2013 – Sept. 2017
RCS commissioning start	July 2016
first beam on target	Sept. 2017
project complete/operation start	March 2018 (6.5 years from start)

Human Resources

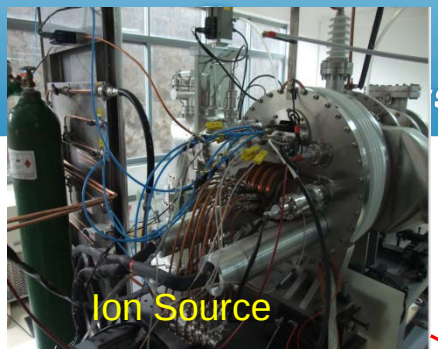
A new branch of IHEP has be setup in Dongguan, with 400 new positions. 223 new staff have been hired by the new branch.

Prof. Yuanbo Chen is in charge of the branch. The administration of the branch is established.

Personnel current status

No.	Division	Present (FTE)
1	Accelerator	170
2	Experiment	117
3	Conventional Facility	21
Total		308

Progress of Accelerator


Ion Source

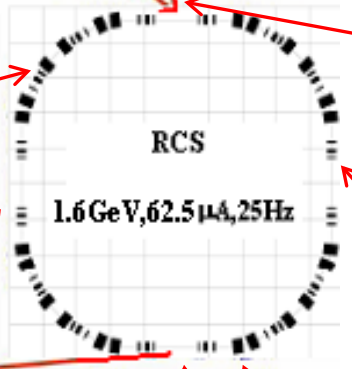

RFQ

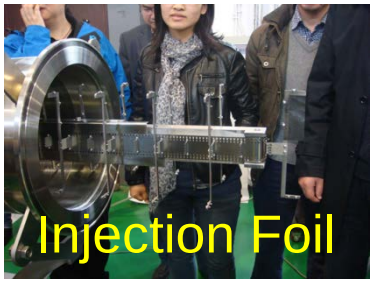

DTL

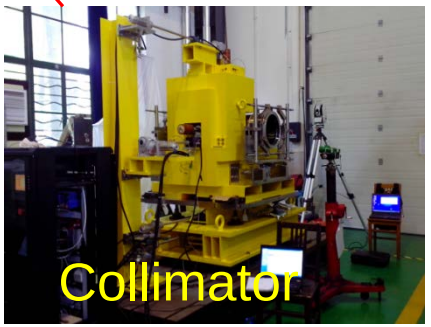

LRBT Q


50keV
H- IS
3 MeV
RFQ
80MeV
Ip=20mA
H-
RFQ
MEBT
DTL
LRBT
324MHz
324MHz
LEBT


Main Quadrupole

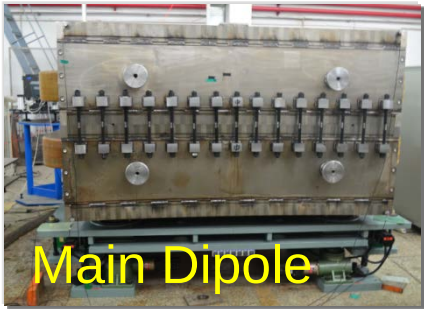

RCS
1.6GeV,62.5μA,25Hz
RTBT


Injection Foil

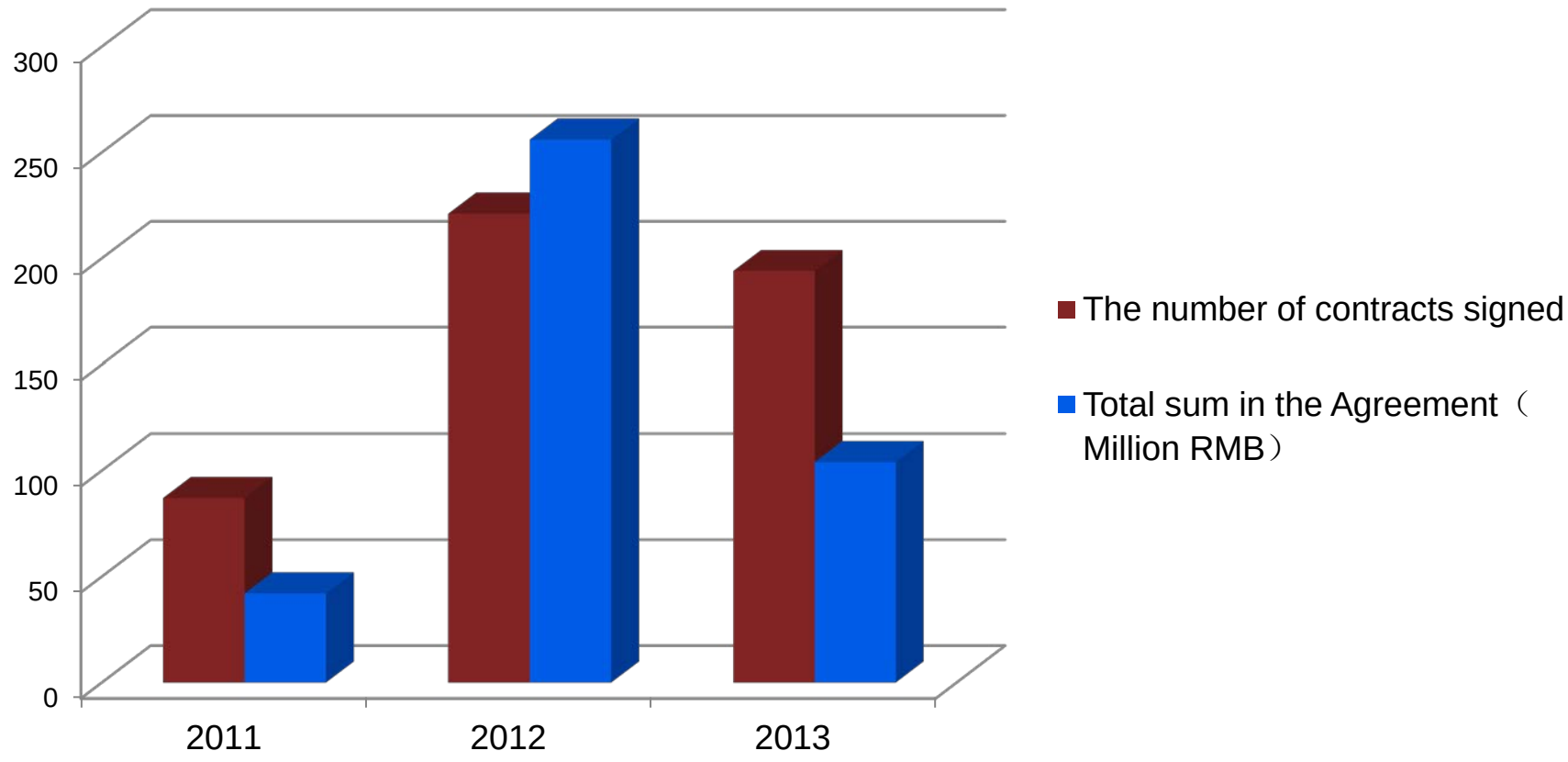

Collimator


Ring Cavity

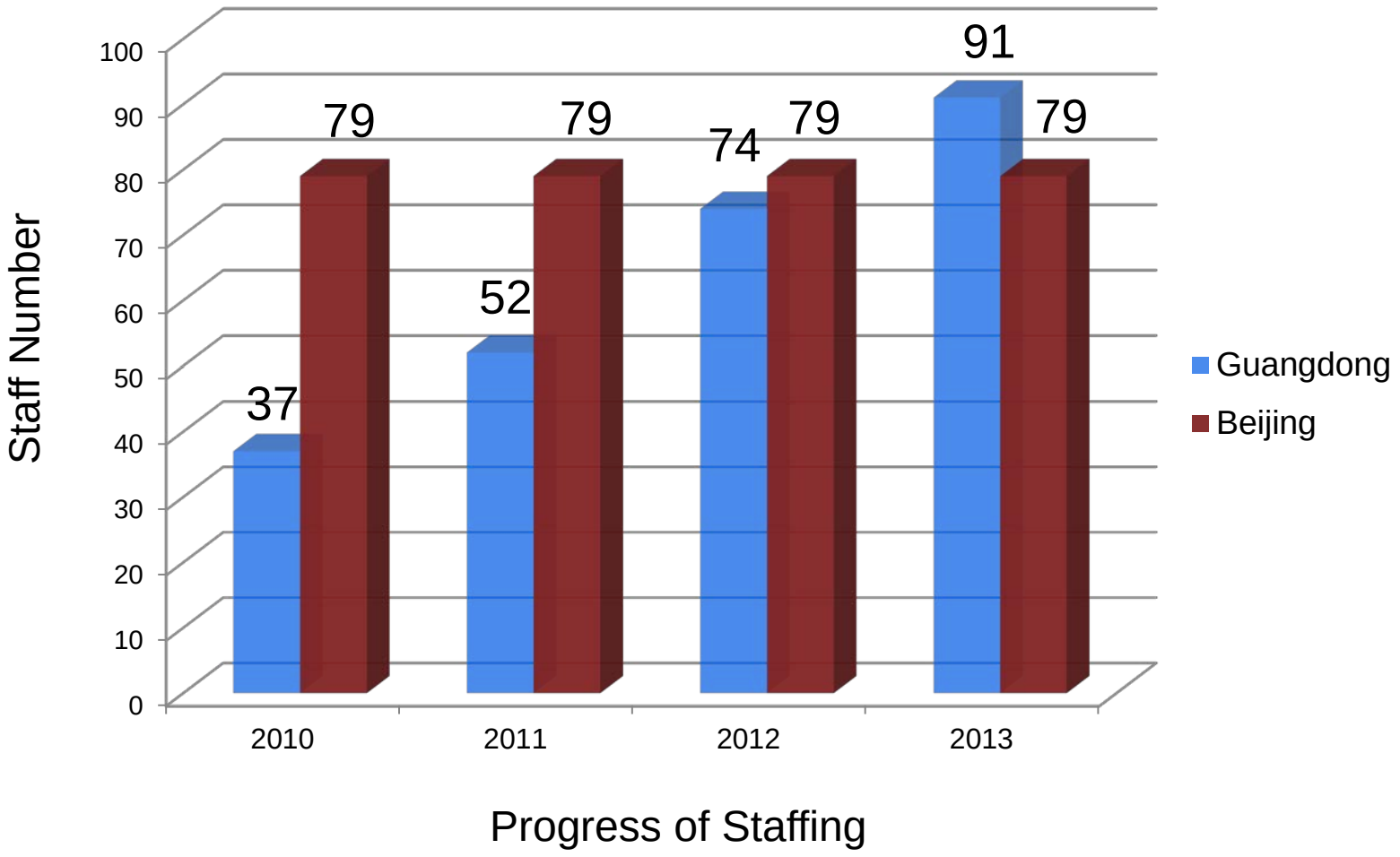

Kicker


Main Dipole

Budget management



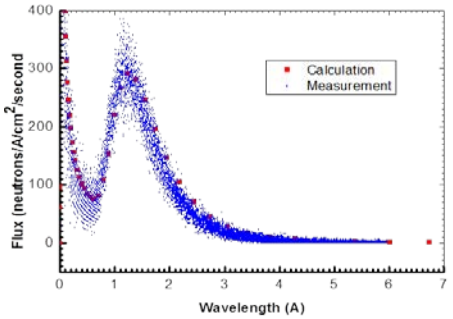
Manpower management

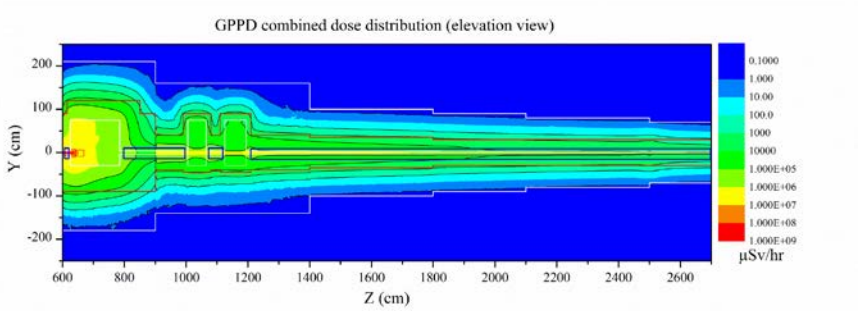


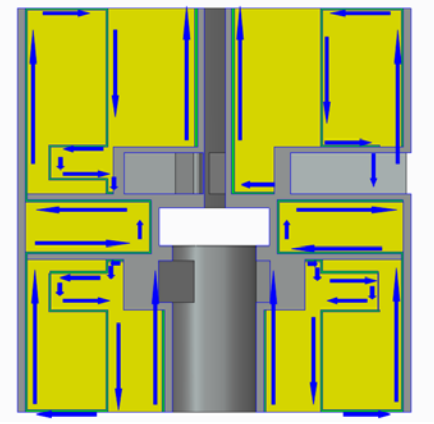
Progress of Experimental System

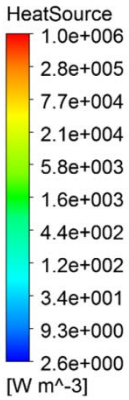
Neutronics system

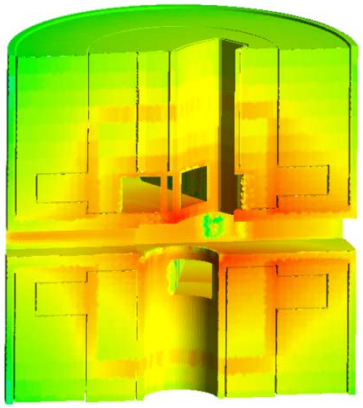
- Neutronics experimental study and development of instrumentation are carrying on.
- Preliminary shielding design of three day-one instruments finished.
- Thermal analysis support the engineering design of key components.
- MC INC code development started.

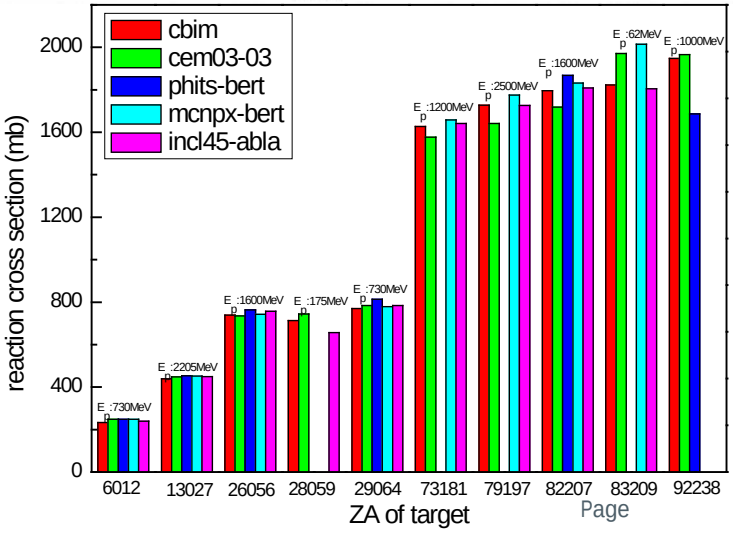




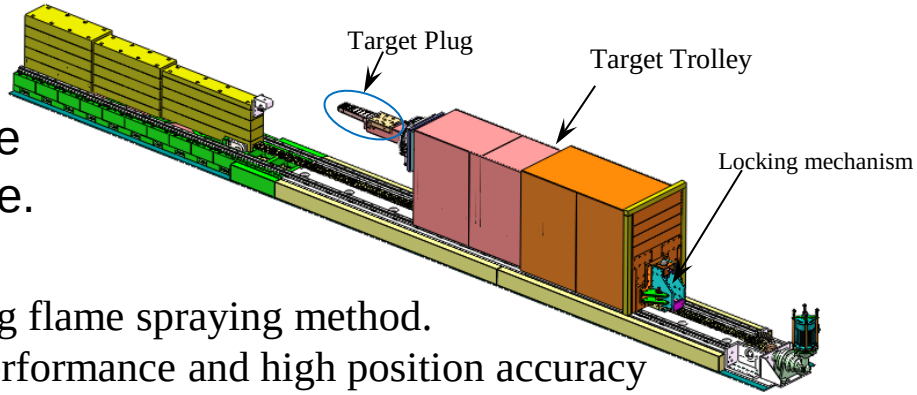






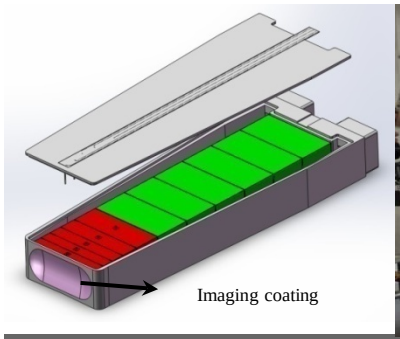


Target system



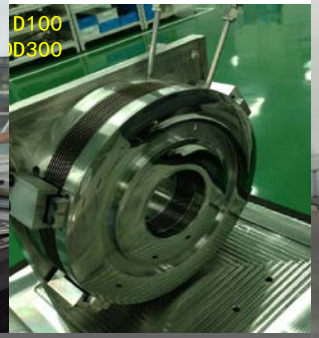
- **overall design** finished, and passed the review organized by CSNS project office.
- **Prototypes to test key technology:**

(1) **Imaging coating**: Prepared imaging coating using flame spraying method.
(2) **Seal performance for Target Plug**: good seal performance and high position accuracy
(3) **Pillow Seal prototype**: Thickness of diaphragm is 0.3mm. Leak rate of 10^{-7}Pa.m^3/s has been achieved .
(4) **Target Trolley prototype**: high position accuracy (0～0.18mm) and reliable locking



(1) Target plug


(2) Seal performance tests

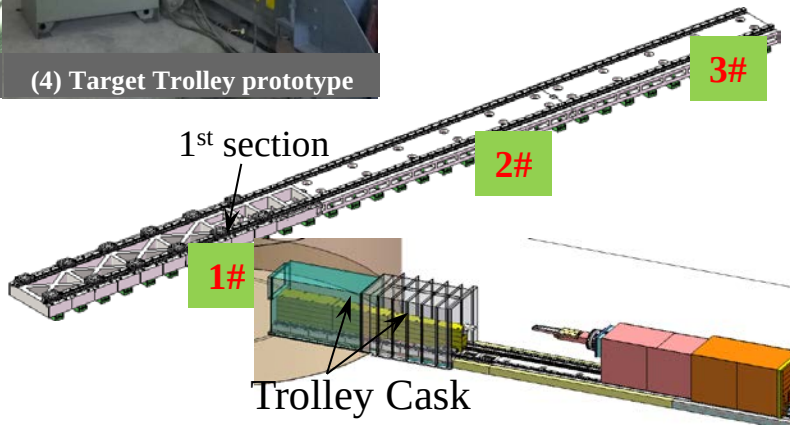


(3) Pillow Seal prototype


(4) Target Trolley prototype

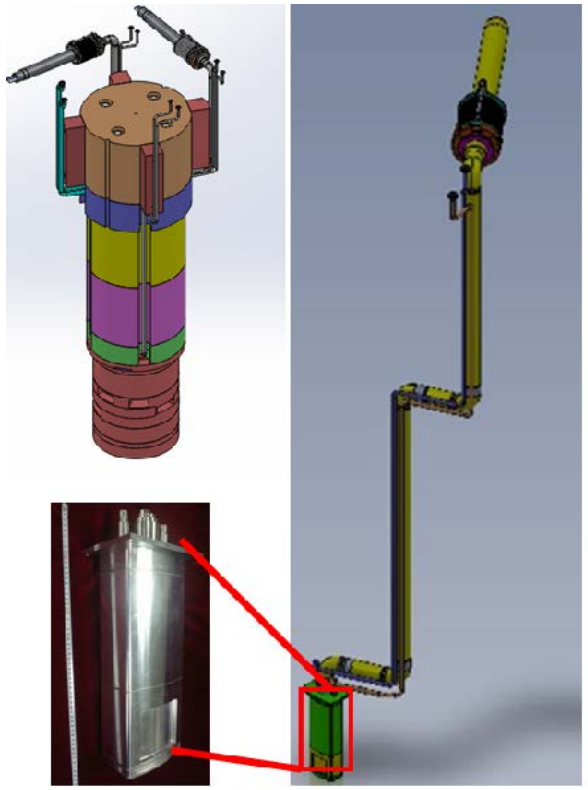
➢Preparation for the installation in 2014:

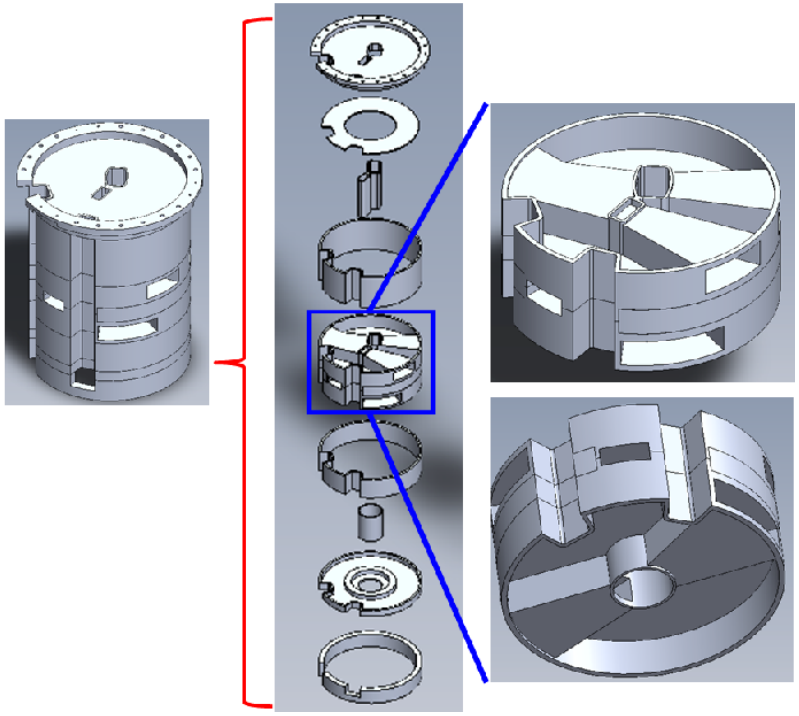
(1) **Rail Assembly**: The first section is being manufactured in Shanghai.
(2) **Trolley Cask**: Detailed designed is finished and will be installed by CNI23 Construction company.



Moderator and Reflector System

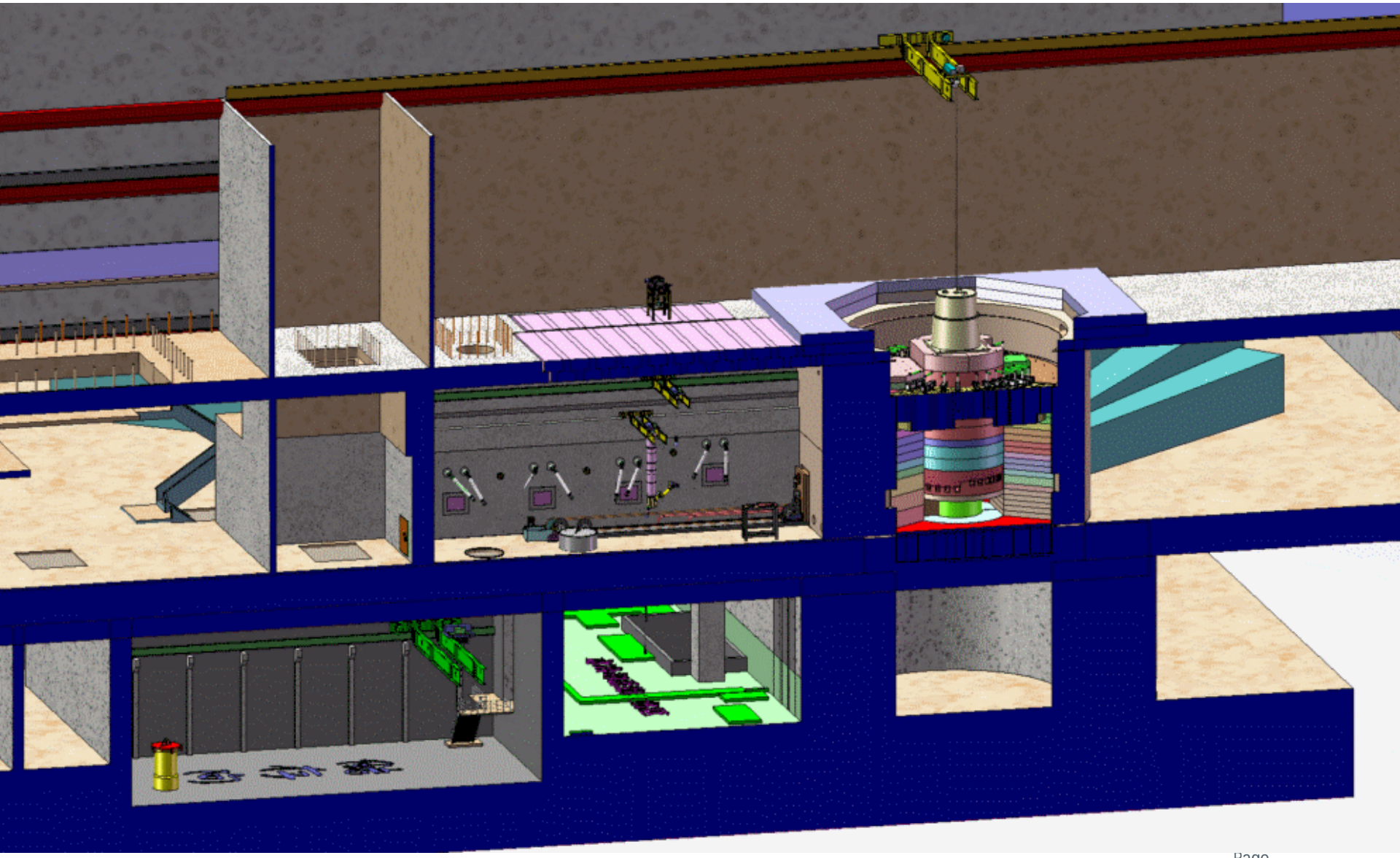
- **Single vertical MR plug**, similar to SNS/JPARCMR, was adopted.
- **Detailed engineering design** finished, and manufacture will start soon.
- **Prototype of DPHM** will be completed at the end of this year. Its main body finished about 3 weeks ago.





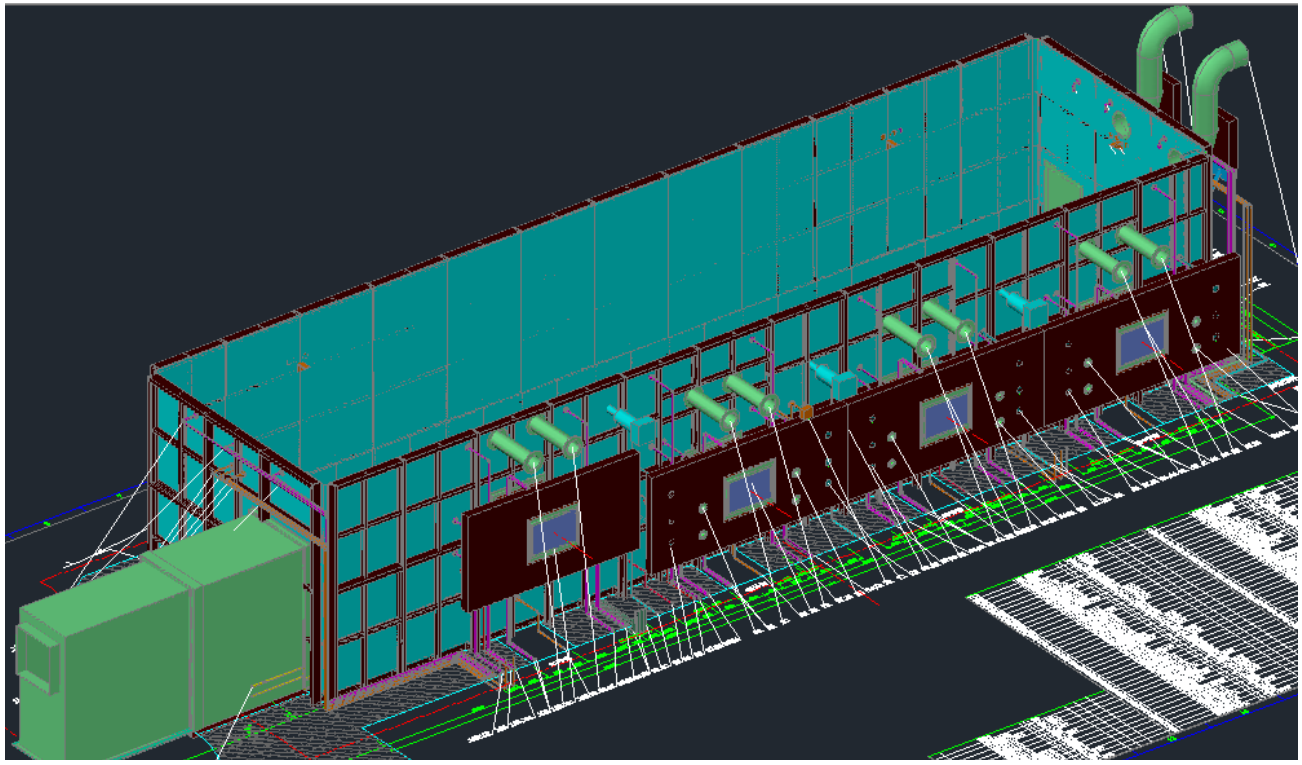
- The installation at site of whole MR will be finished in April 2016, according to CPM of CSNS.

Remote Handling



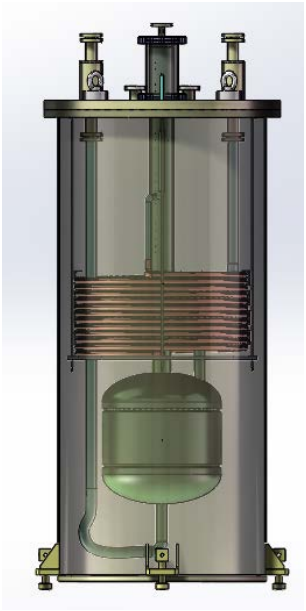
Remote Handling System

- **Interface of the hot cell** defined
- **Hot cell steel liner** designed
- **Maintenance mockup** for MR plug at high bay and for target trolley in hot cell set up to optimize TMR detailed design
- **Equipment selection** for the hot cell finished

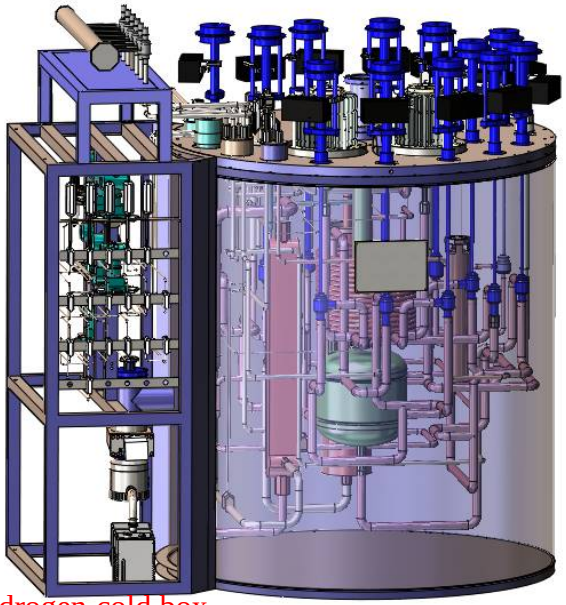


Cryogenic system

- **Helium refrigerator:** contracted with Linde, and will arrive in Aug. 2014.
- **Hydrogen cold box**: engineering design finished, and will complete manufacturing by the end of 2014.
- **Accumulator**: engineering design finished on the commissioning experience of the prototype, and will complete manufacturing in the early of 2014.
- **cryogenic control**: logical design finished, and will complete programming by the end of 2014.



Schematic of the accumulator



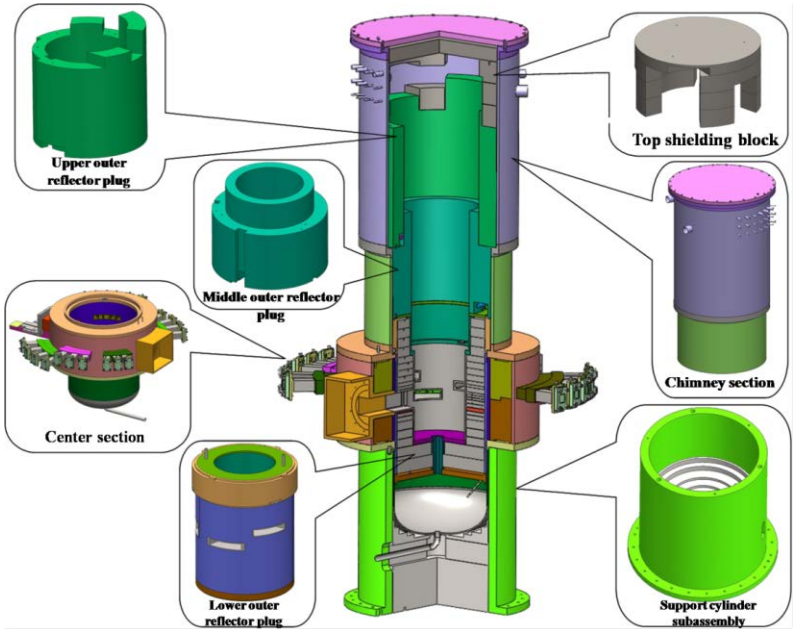
Schematic of hydrogen cold box

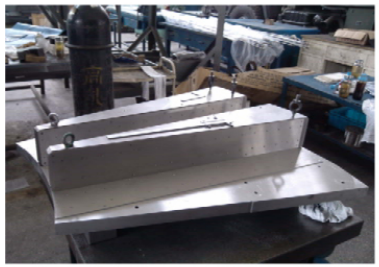
Major Schedule：

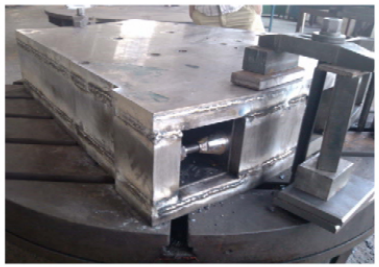
- **Early of 2016:** acceptance test for helium refrigerator.
- **Middle of 2016**: commissioning for cryogenic system.
- **September 2016**: joint commissioning with moderator.

Helium Vessel: manufacture

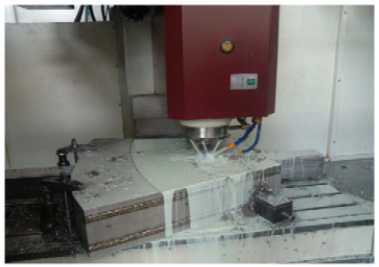
- **Contract**: Signed with Nanjing Chenguang Group in October 2012
- **Formal machining**: started in January 2013
  - skirt and 5-6-7 neutron beam-port block finished
  - water jacket and lower cylinder assembled and welded
  - cylinders for chimney section rolled and welded.
  - inner vessel shielding, outer reflector plug casted




Tube block lined with Cd


Tube block assembling


Insert the mandrel to correct


Intermediate machining


Skirt


Cylinders for chimney section


Lower assembly water jacket


Inner vessel shielding rough casting

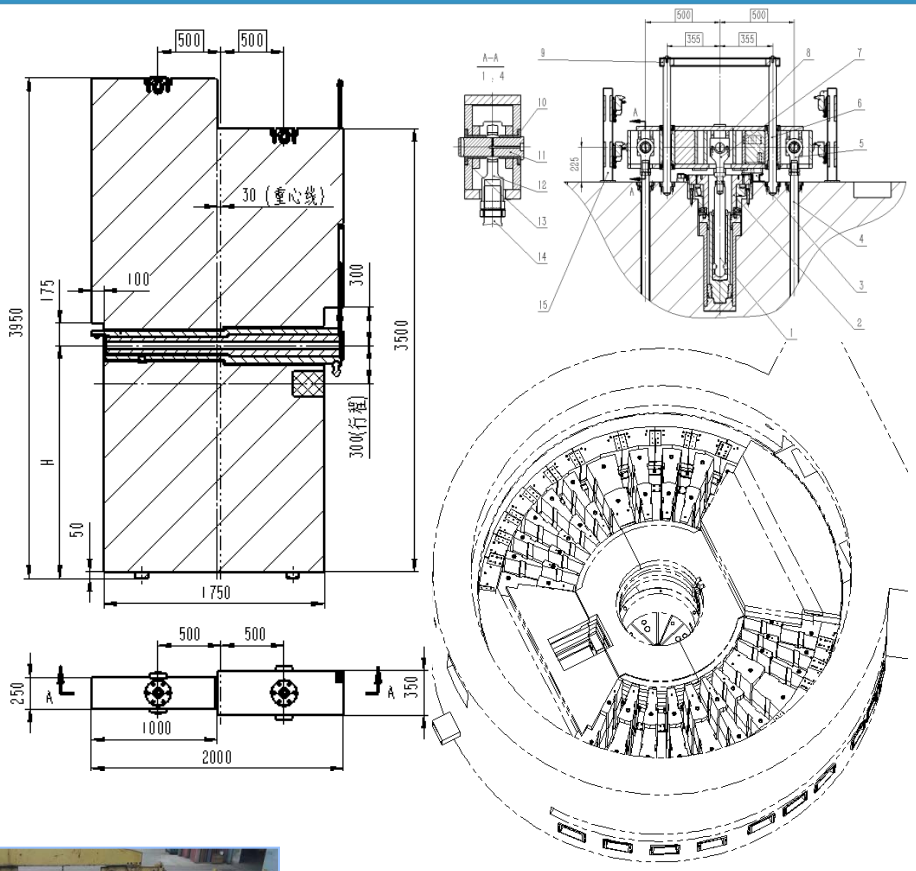
Target Shielding system

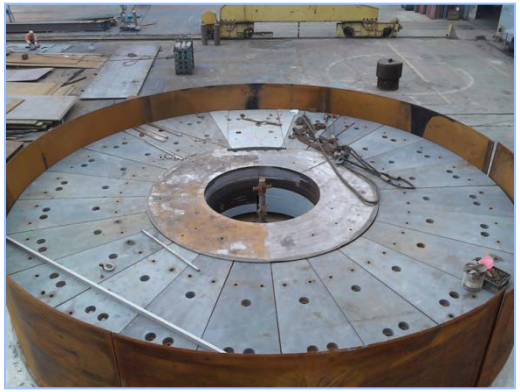
➢MC Simulation:

- 1.2-meter-thick barytes concrete out of 4.8-meter-radius steel can satisfy the radiation need.
- 2.5-meter-thick concrete outside TS can shield the un-instrumented beam hole.

➢Steel shield bidden

- base plate, outliner, bottom steel shielding, bulk shielding, neutron shutters and their hydraulic drivers.



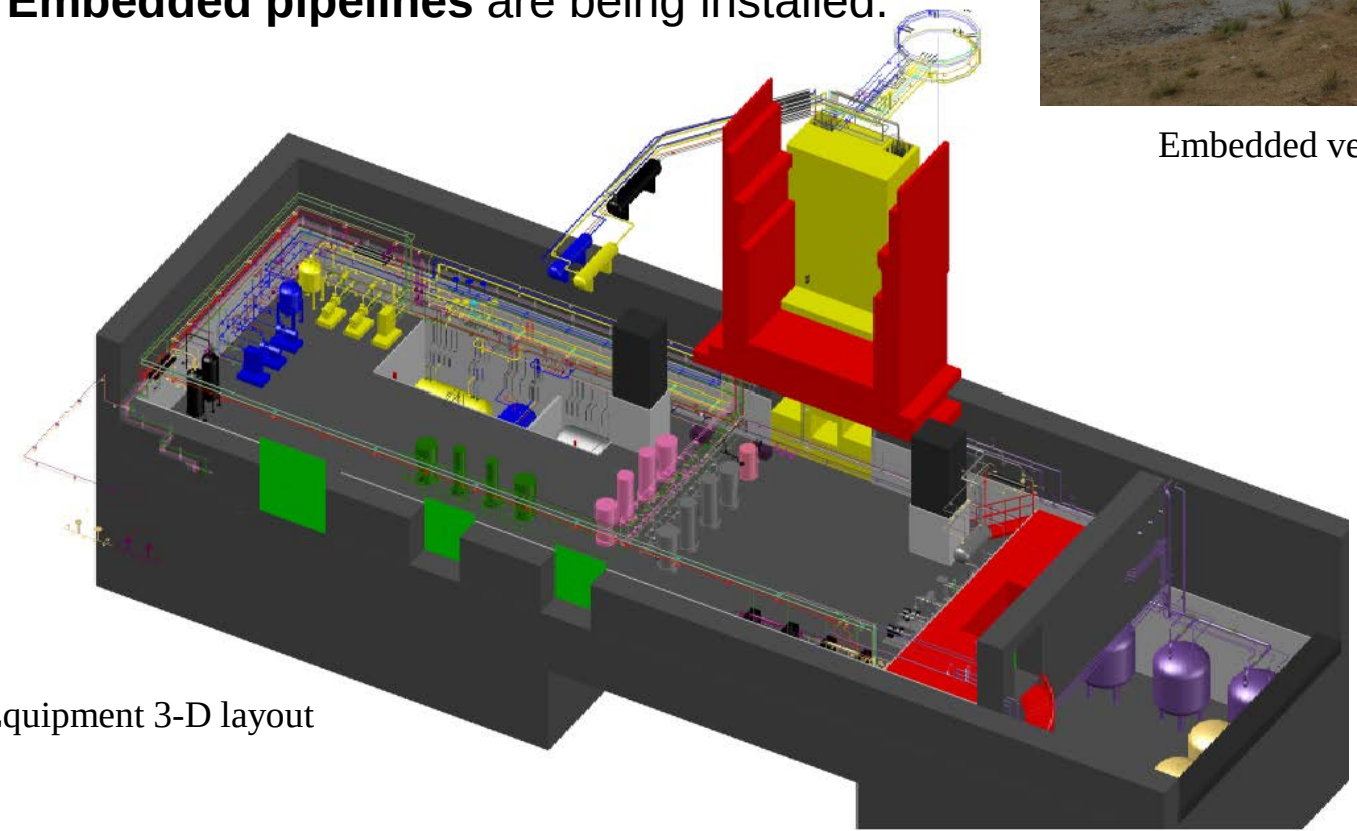


The manufacture and pre-assembly of the base plate, outliner and bottom steel shielding have been completed , and the installation will start in May 2014.

Utility system: cooling water

- **Design** finished in October 2013.
- **Domestic expert review** will be held by the end of this year.
- **9 embedded water tanks** have been delivered to the CSNS site.
- **Embedded pipelines** are being installed.

Embedded vessel at construction site



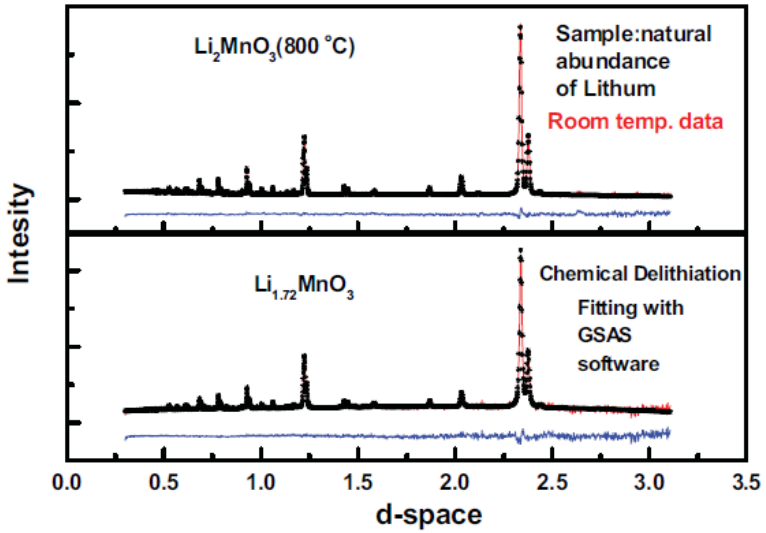
Equipment 3-D layout

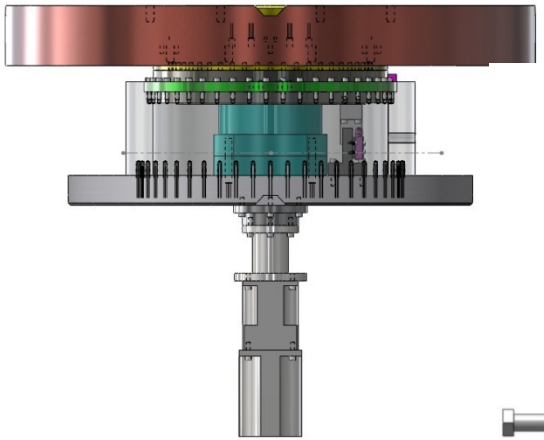
Progress in neutron instruments and users

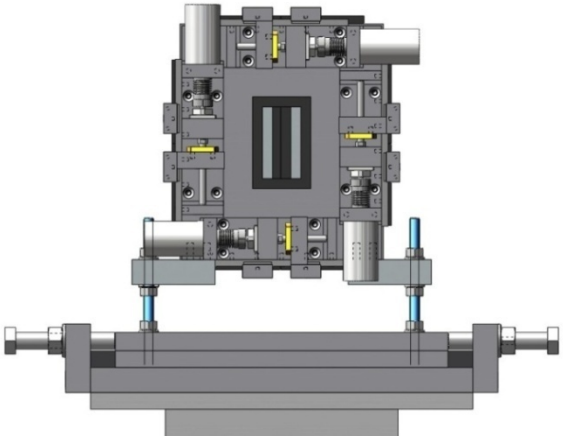
- General design of three day-one instruments is completed in 2013.
- Other possibilities are seeking for supporting new state-of-the-art instruments: national materials R&D project , local government, power users of superconductor community……
- Next national user meeting will be held at Dongguan next month.

Neutron Instrument：GPPD

- **General design :** finished
- **Key components:** mechanical design of rotation table and 4-blade slit reviewed for consequent fabrication
- **Users:** a work group established
- **Experiment:** Collaborated with key users, data of a Li-battery material collected on Powgen3@SNS

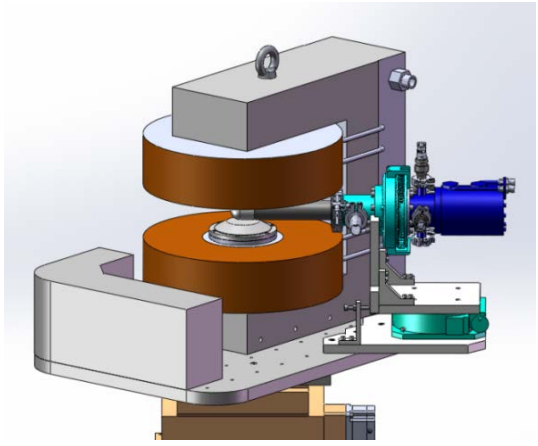




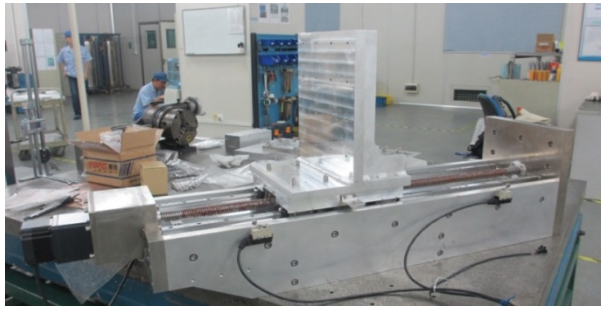


Neutron instruments: Reflectometer

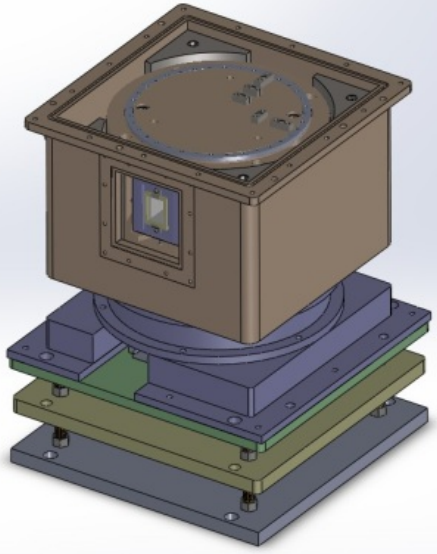
- **General design:** review passed.
- **Mockup:** the 2nd shutter, linear shift, and air pads for reflection arm fabricated

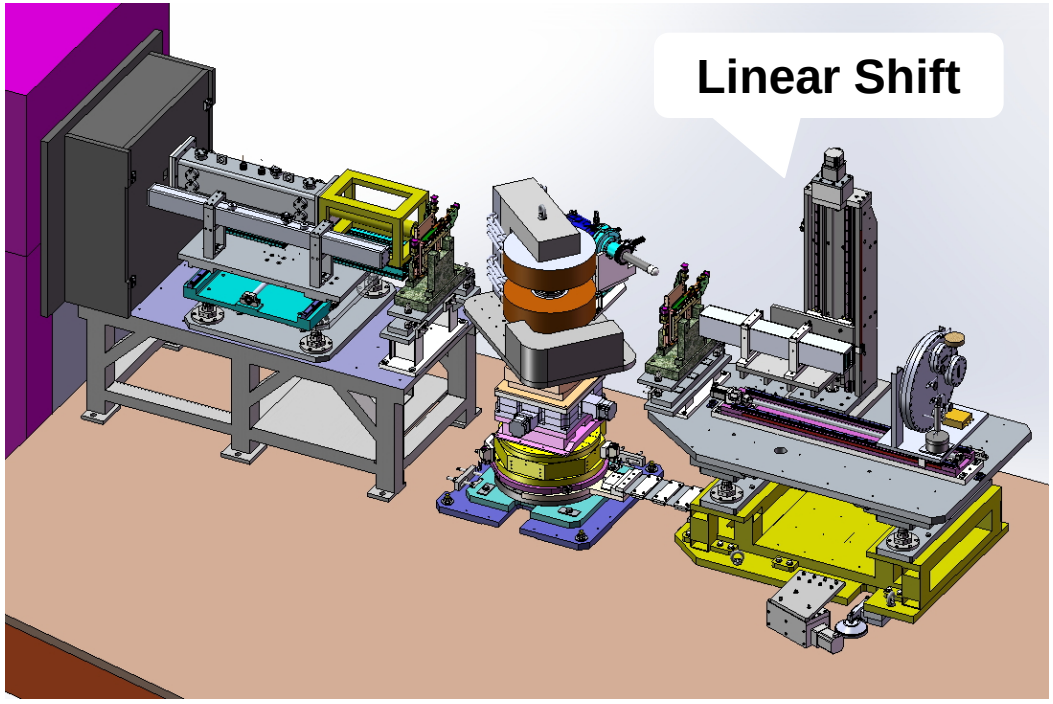


Sample environments



2nd Shutter

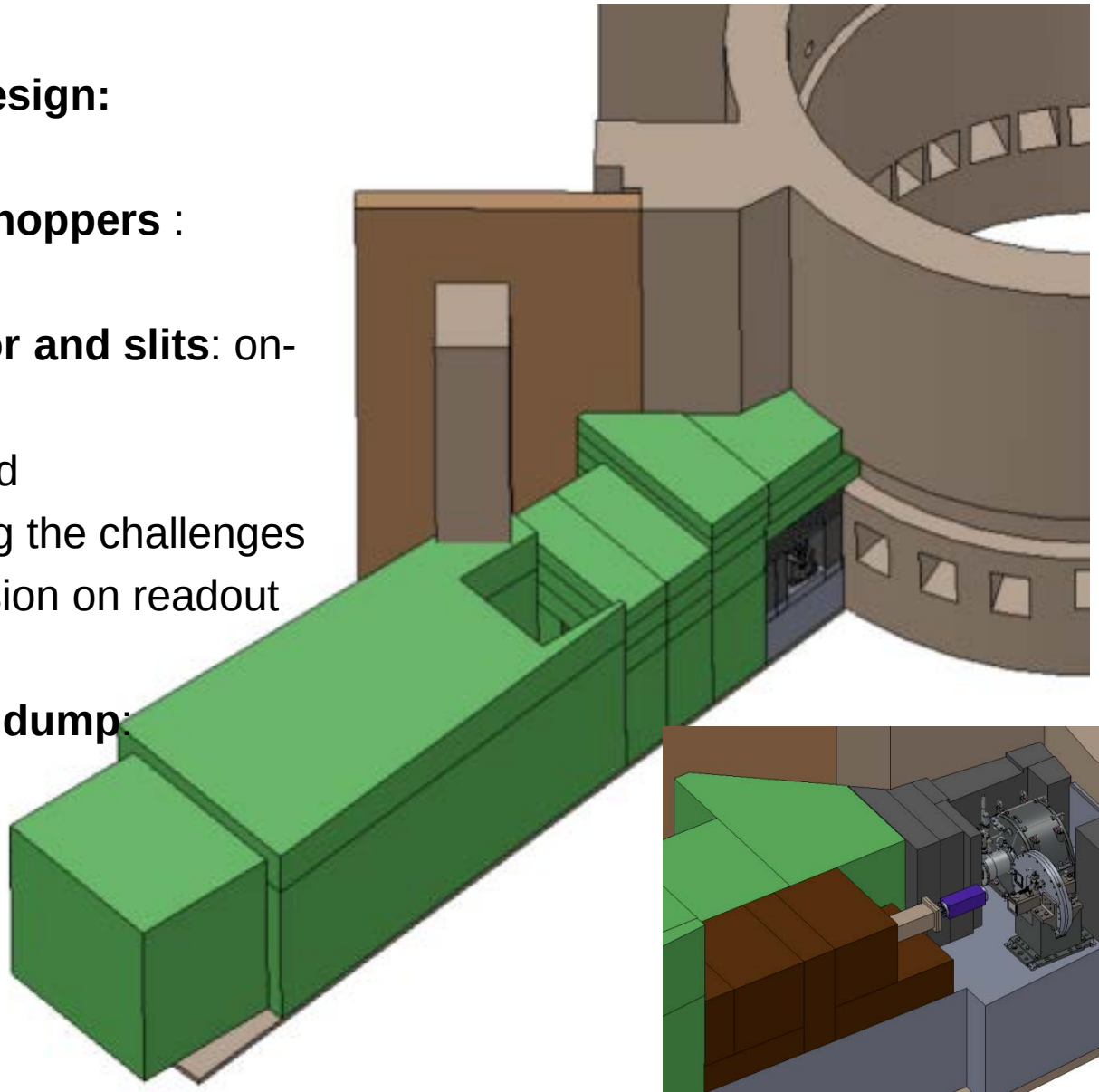




SANS

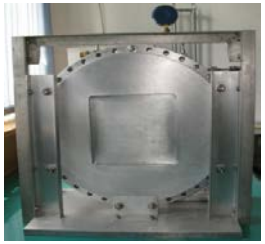
Current Engineering Design:

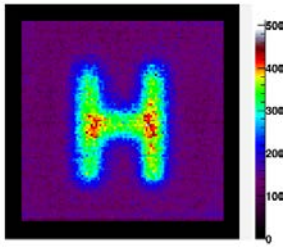
- **Target inserts and choppers** : completed
- **Frame-overlap-mirror and slits**: on-going
- **Collimator**: completed
- **Sample area**: meeting the challenges
- **Detector**: major decision on readout electronics
- **Shielding and beam dump**: new issues

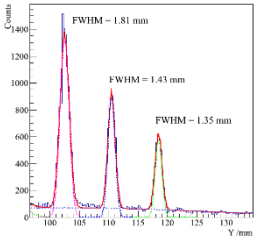


^{3}He-MWPC- 200mm*200mm

- Active area: 200mm*200mm
- Detection efficiency: ~50%@ 2Å
- Pixel size: 2mm*2mm
- Max Counting rates: 10^5 n/s



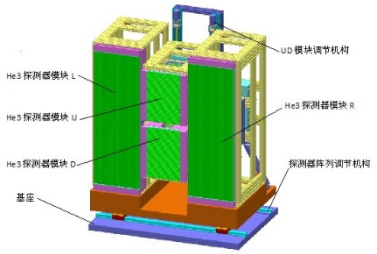


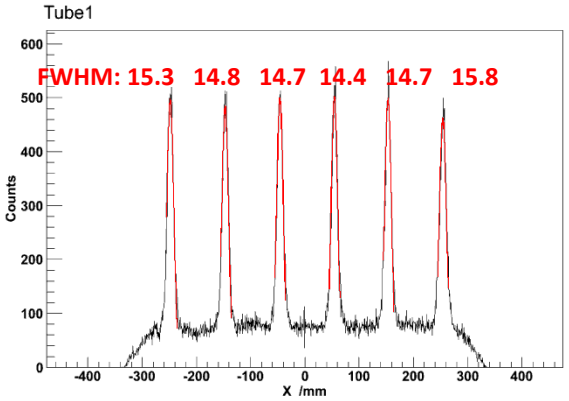


- **Neutron beam test @ CARR**
  - **Position resolution(FWHM)**
    X : 1.23mm, Y: 2mm

^{3}He tube-LPSD for SANS

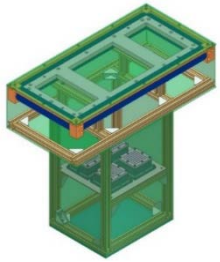
Effective area	1m×1m
Diameter	8mm
Effective length	1000mm，200mm
Detection efficiency	>50%@1.8Å
Maximum counting rate @ single tube	10 kHz
Pixel size	<1cm×1cm
Time resolution	2μs





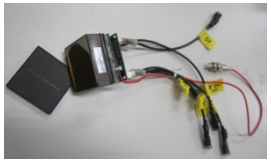
Position resolution

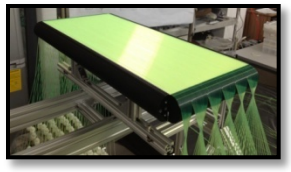
Shifting Scintillator Neutron Detector (SSND)



- Module size 500mm × 250mm
- Pixel size is 5mm × 50mm
- Detection efficiency: over 50%@ 2Å

Samples	AST-26139	BC704#	EJ426
Mass ratio of ^{6}LiF vs ZnS(Ag)	1:2	1:2	1:3
Neutron counter rate (n/s*cm^2)	1.33±0.02	0.69±0.03	0.77±0.03
Neutron detection efficiency (%)	60.5±1.0	30.1±1.1	32.4±1.1
Neutron detection efficiency in manual (%)	**None**	None	36.0



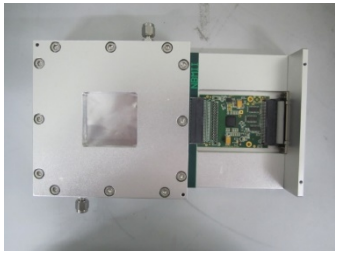


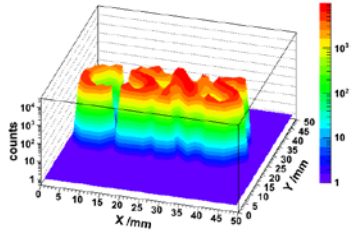
tested by ^{252}Cf:

Number of photoelectrons ~100 – 200

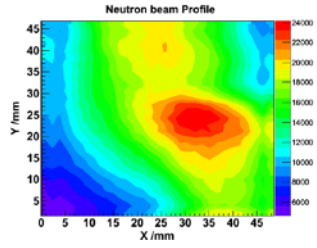
Neutron beam monitor Based on GEM detector

Parameter	Specification
Active Area	50mm*50mm
Neutron Flux	<10^8n/cm^2.s
Spatial Resolution	<3mm
Timing Resolution	<1μs
Efficiency@1.8Å	~4%
Max Counting Rate	>1MHz
Working mode	Real-time



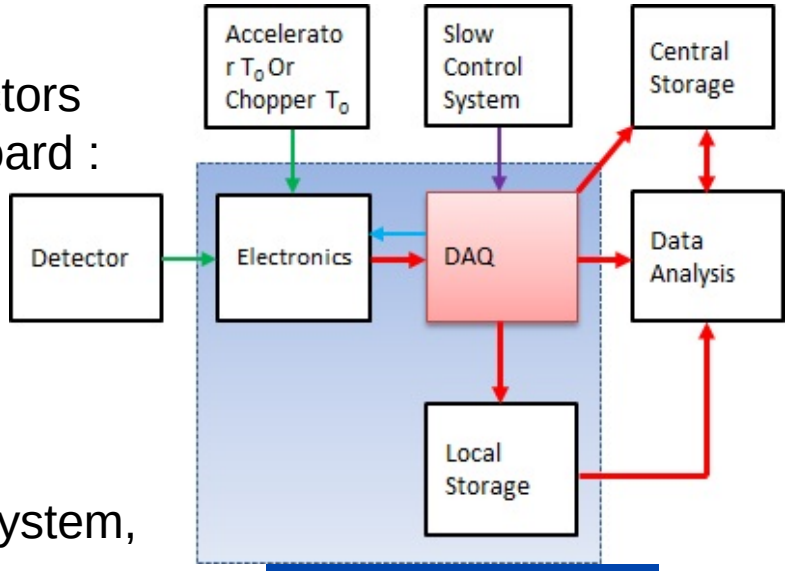


Tested neutron beam：
position resolution of 3mm;
good 2D imaging capability

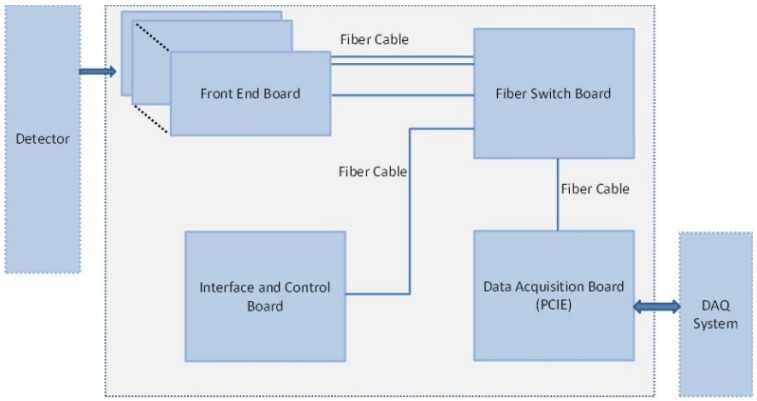


Data Acquisition System

- **Electronics**
  - same structure for 3 types of neutron detectors
  - Fiber Switch Board and Data Acquisition Board : completed
  - ASIC for Front End Board: design on-going
- **DAQ**
  - data format confirmed
  - software framework distributed
  - interface with front-end electronics, offline system, and control system tested
  - programming experiment information

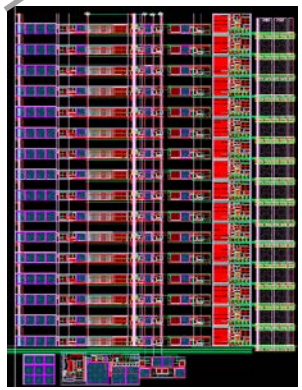


Block diagram



Electronics system

Layout of ASIC

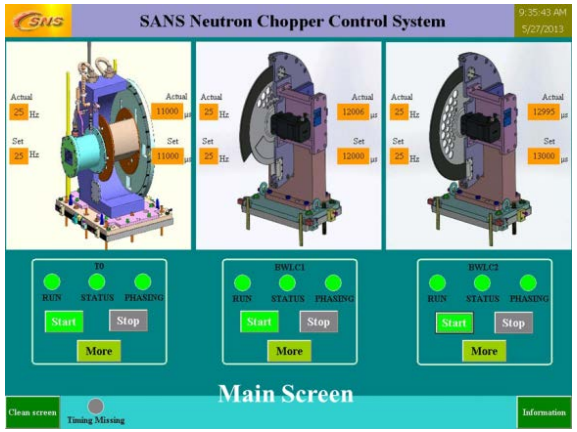


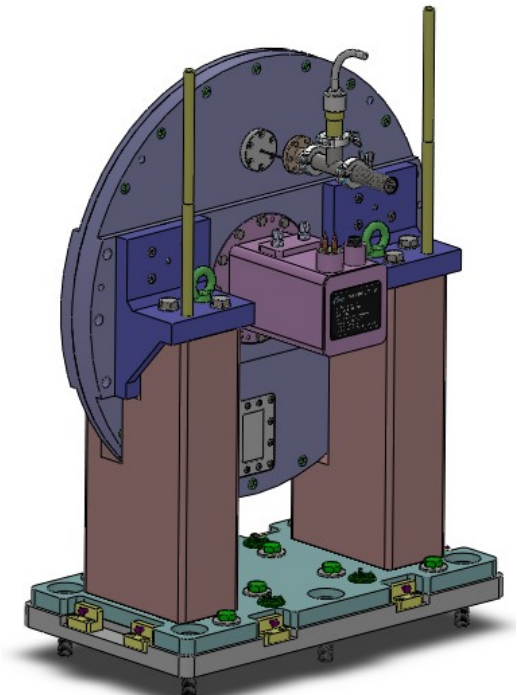
DAB

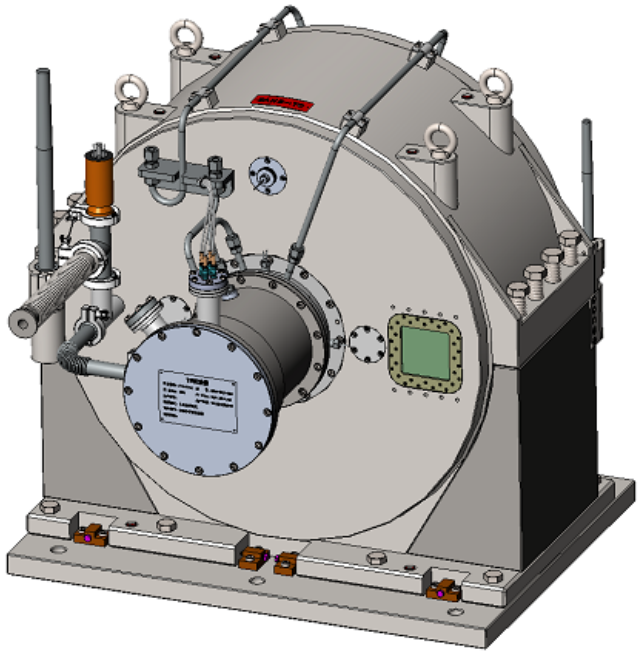
FSB

Neutron Choppers

- **Disk chopper**: mechanical design completed. The batch production will start in June, 2014.
- **T0 chopper**: the first one for SANS, mechanical design completed, and the fabrication started.
- I**ntegrated control**: tested. Real time phase data will be sent to DAQ.

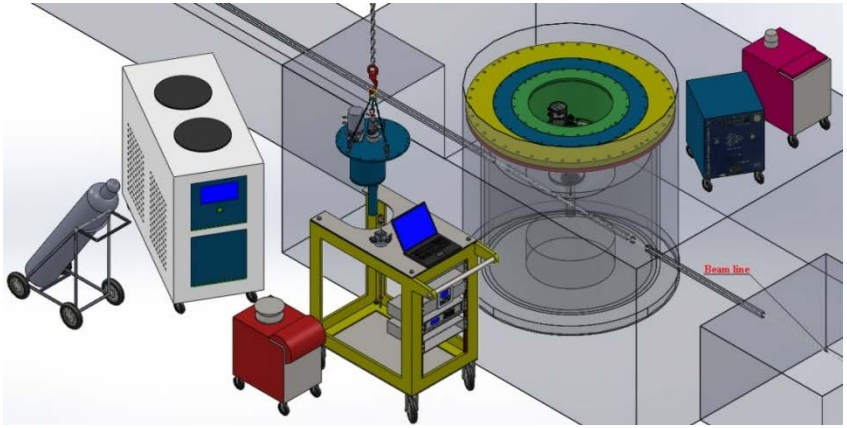




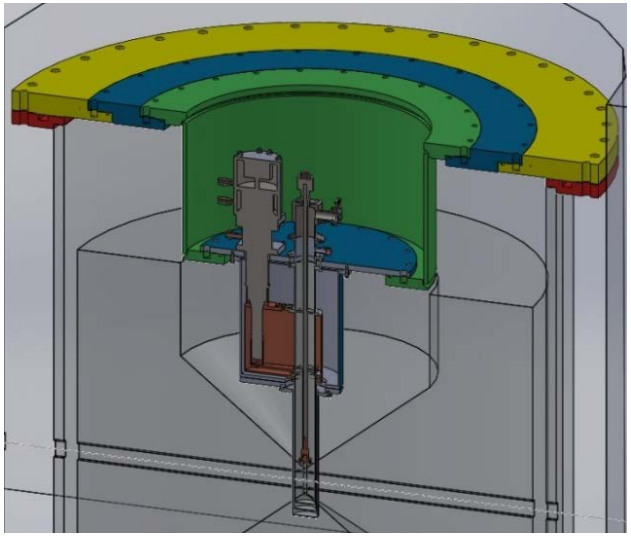


Sample Environment

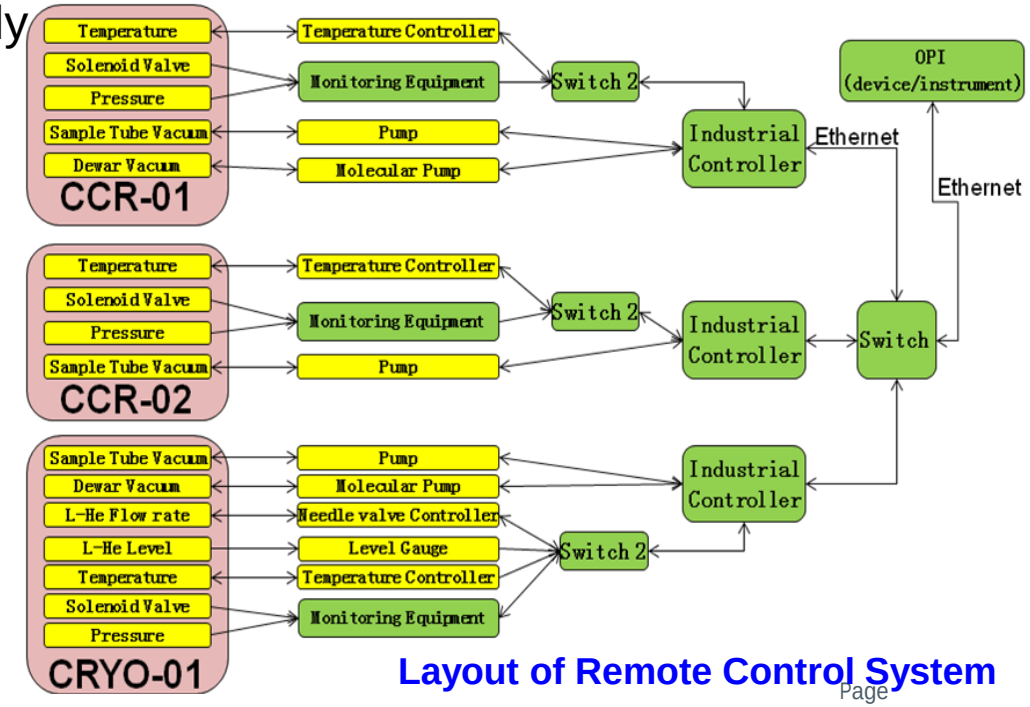
- **Detailed design** of cryostats (CCR-01, CRYO-01) and cryofurnace (CCR-02): completed (including of mechanics, control and interface with the utility system)
- **Remote control** of temperature and molecular pump: successfully tested.



Devices Layout of CCR-01 System



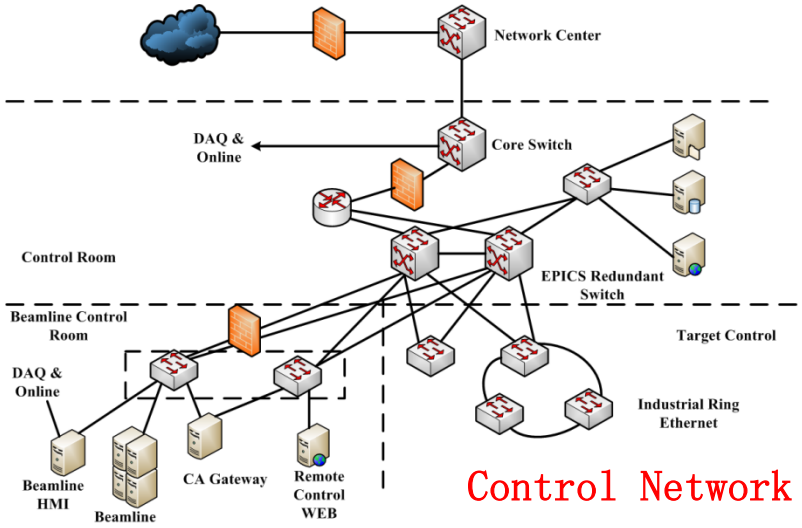
Mechanical system of CCR-01

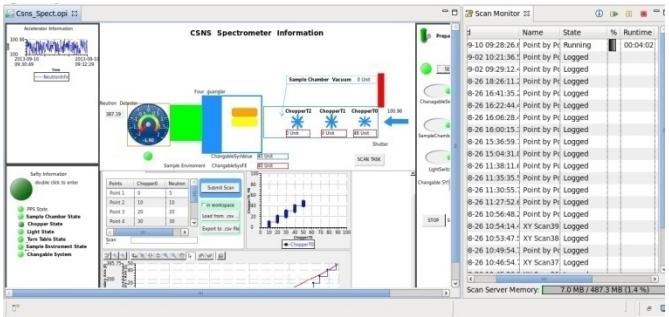


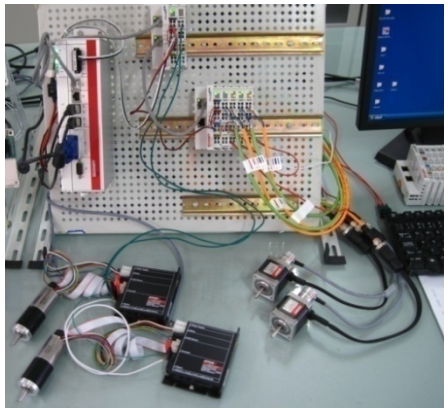
Layout of Remote Control System

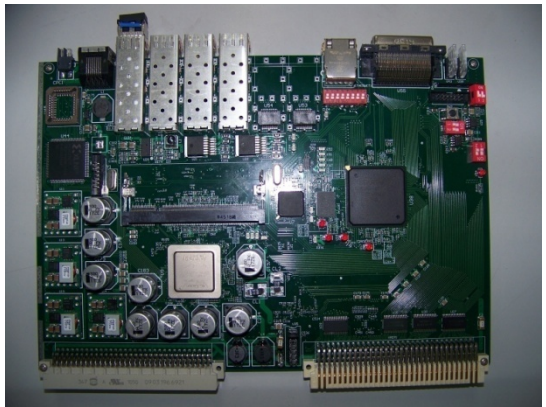
Experimental Control System

- **Control Framework:** established, including of target control, instrument control and control network
- **Control software framework:** first version released
- **Front control:** some successfully tested, such as CCR, proton beam imaging, motion control……
- **T0 fan-out:** board made, No errors in 27 hours



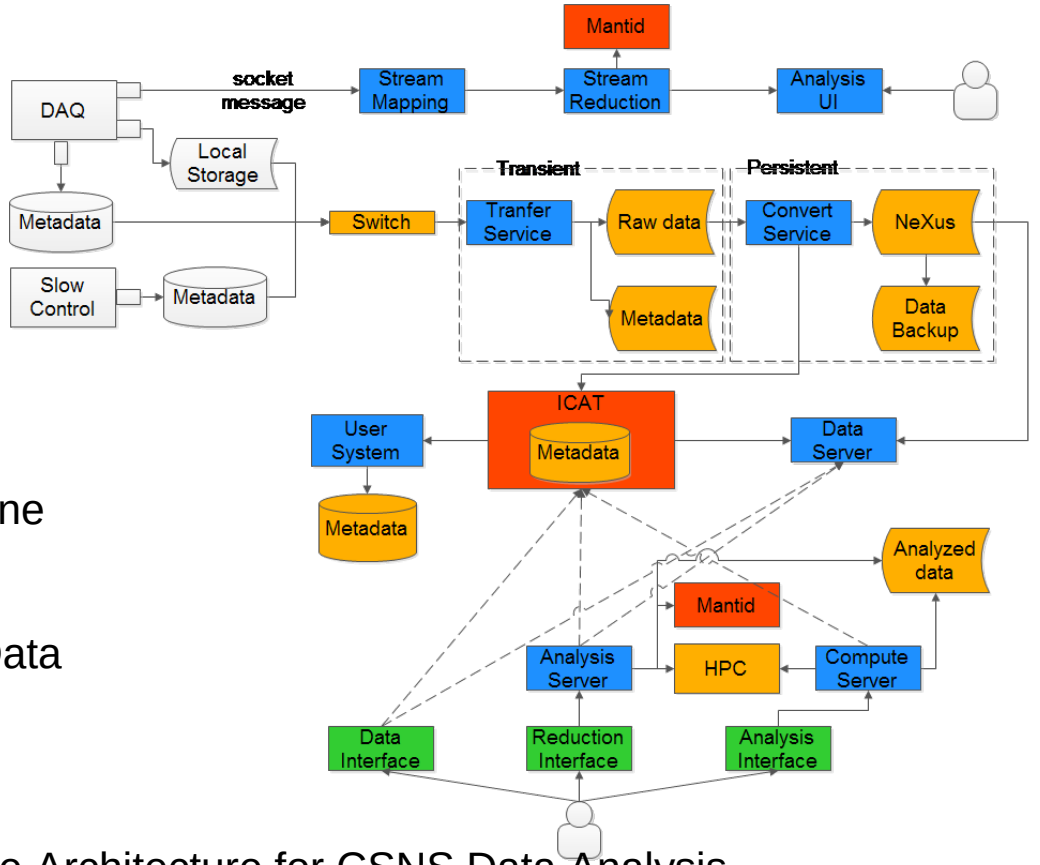






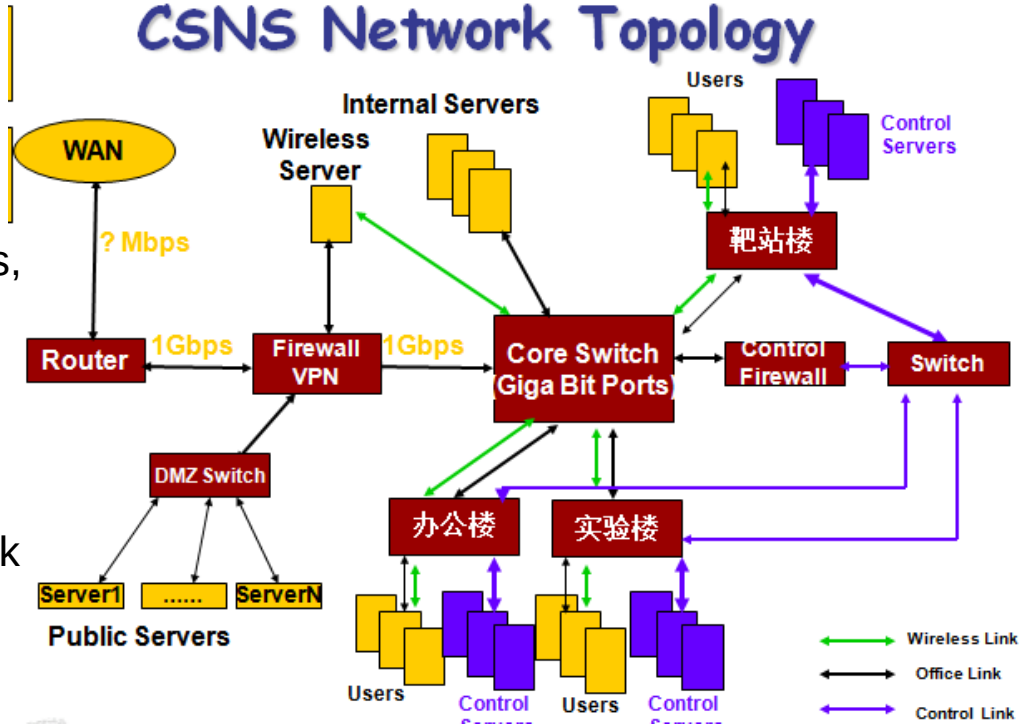
Data analysis and software

- **Kick-Off in March 2013**
- **3 Fulltime Staffs (present)**
  - Background of Material Science
  - Software Engineers Required
- **Task**
  - Data Reduction & Analysis, On-line Analysis Software
  - Data Management, Web-based Data Portal
- **Progress**
  - Implementation of Design Software Architecture for CSNS Data Analysis
  - Determination of Format for Event Data and Meta Data
  - Builds of CSNS Analysis Framework and Data Portal
  - Setup of Developing Environment and Prototype of Data Portal



Network and Computing system

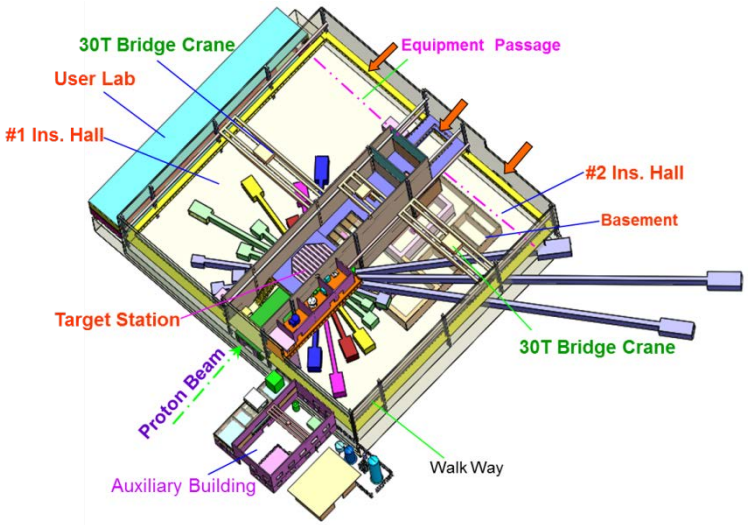
- **Founded in Sep. 2013**
- **Task**
  - CSNS IT Infrastructure, IT Services, Computing/storage Services Provision and Operation
- **Progress**
  - The design and plan for the network and computing environment is completed.
  - Machine room is under construction and will be ready in Nov. 2013.
  - The network services will be ready in Dec. 2013.
  - The Public IT services and support system will be ready in Feb. 2014.



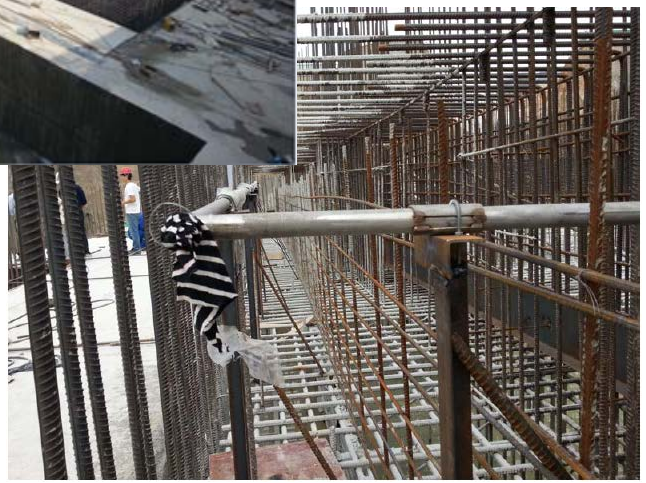
- **staffs（now)**
  - 10 people(2 full time,8 part time) from IHEP Computing Center
  - Network: 7 System: 3
  - Another full-time 8 staffs will be there in the future

Construction of target station building

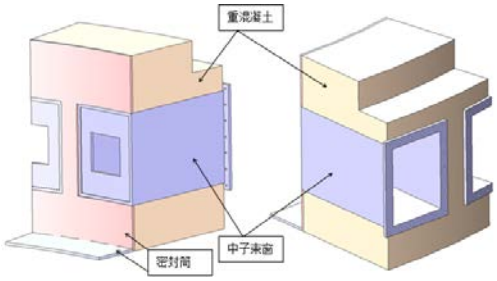
- **Whole construction process**: documented.



- **Base of the whole building**: being constructed; the embedded parts being mounted.



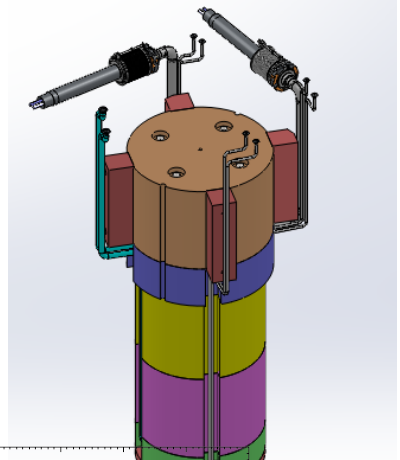
- **Moulding technics of barytes heavy concrete**: laboratorial mix concentration decided, slump and setting time of pre-cast samples being tested

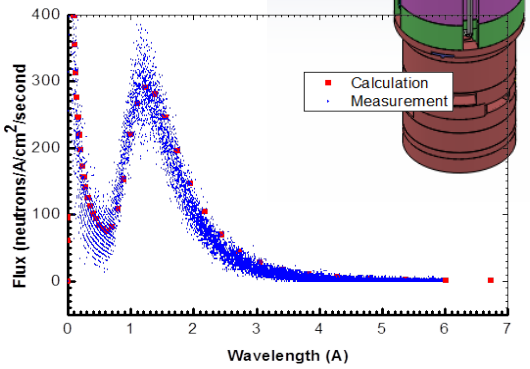


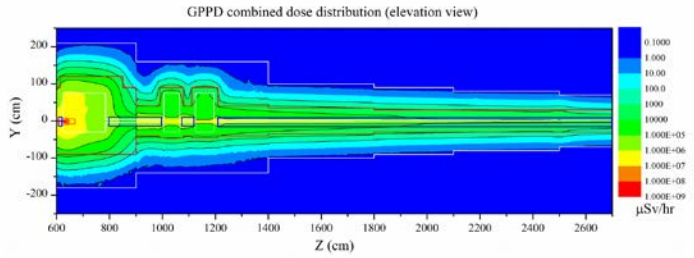
- **Regular works**: construction drawings verification, drawing understanding support for builder, spot surveillance

Highlights of the design

- Horizontal target trolley + single vertical MR plug (SNS/JPARC-type) has been selected as the CSNS TMR configuration.
- Neutronics modeling verified by the measurement of neutron energy spectrum of CPHS (Compact Proton Hardon Source) at Tsinghua university.
- Preliminary shielding design of three day-one instruments finished.

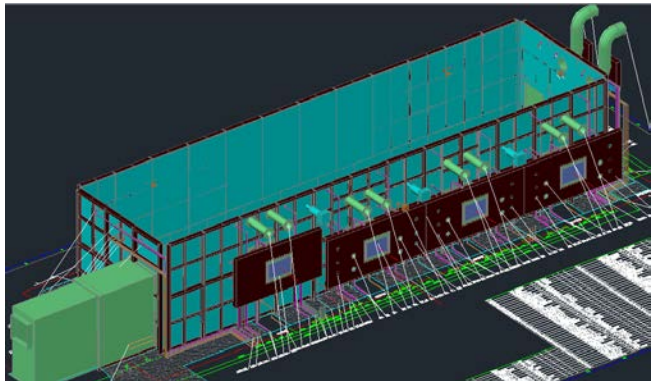


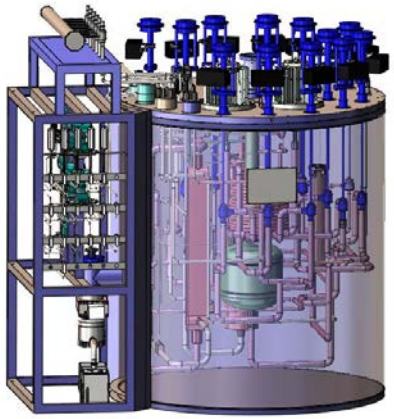


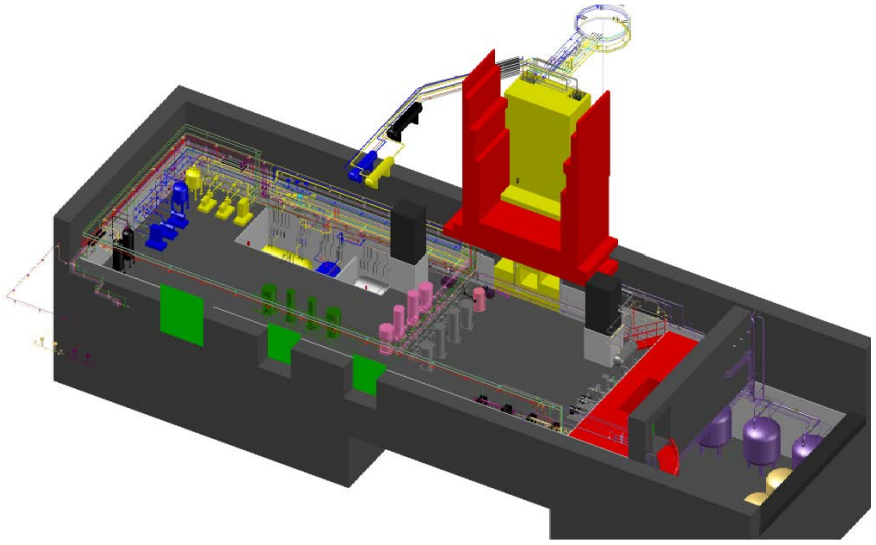


Highlights of design (continued)

- Engineering design of hot cell and equipment selection finished, and operational mockup has been set up to test the maintenance of TMR.
- Engineering design of water cooling system, hydrogen cold box and accumulator finished.

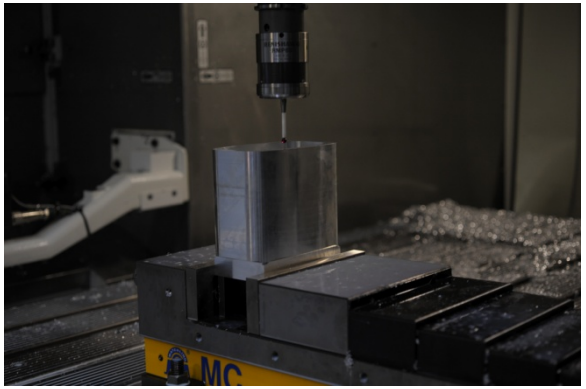


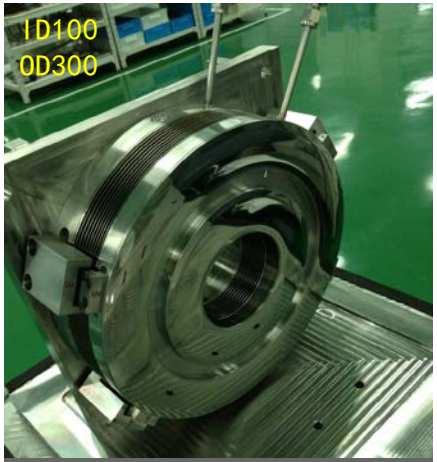




Highlights of prototypes

- Prototype of decoupled and poisoned hydrogen moderator will complete by the end of this year.
- Prototypes of pillow seal and trolley for target plug was accepted.



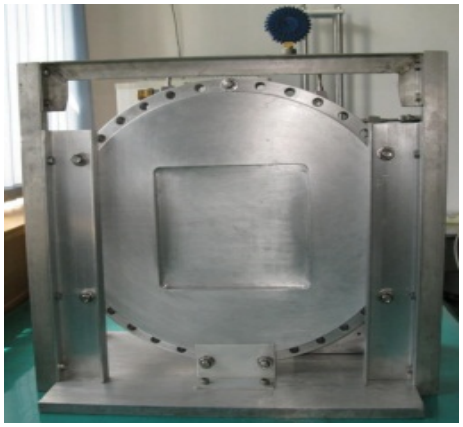


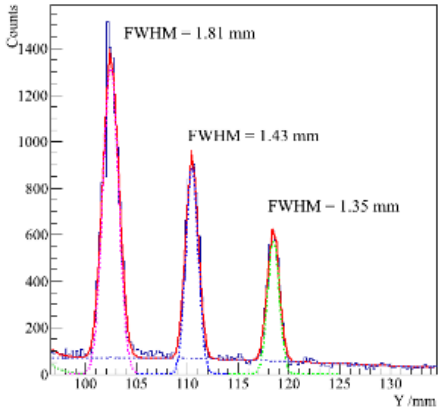
Pillow Seal prototype

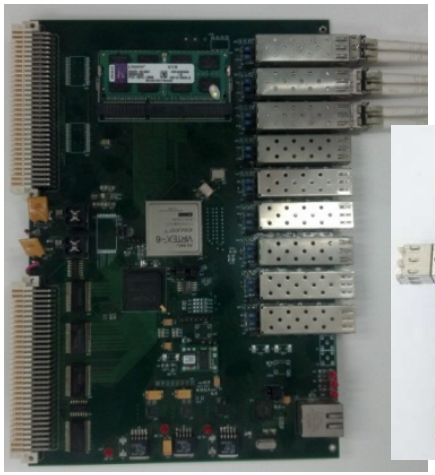
Target Trolley prototype

Highlights of prototypes (continued)

- **Position resolution of 1.23x2 mm for MWPD results from test with neutron beam @CARR.**
- **Fiber Switch Board and Data Acquisition Board have been tested. Jiont test with detectors will be done in next year.**

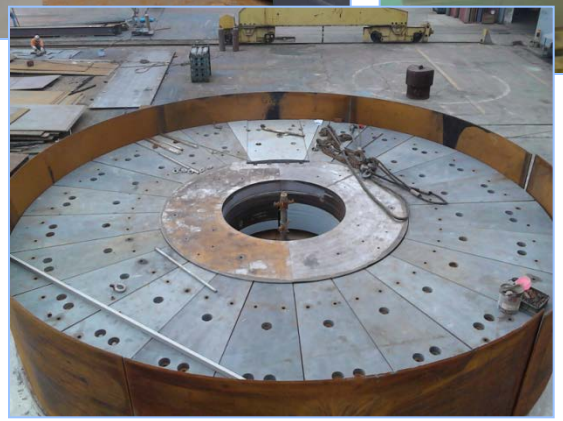






Highlights of bidding & manufacture

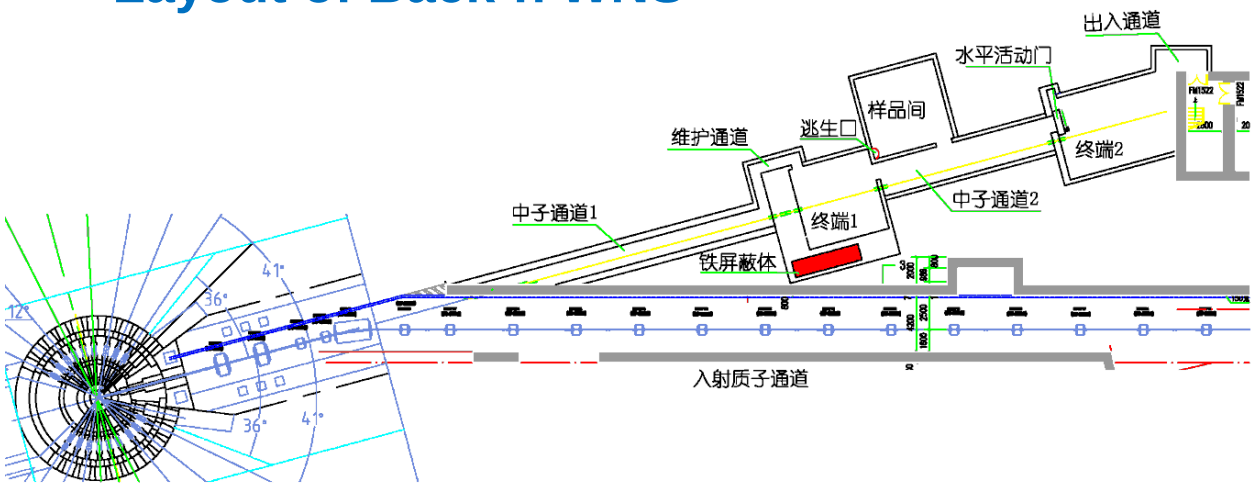
- Formal machining of helium vessel started in January 2013.
- Fabrication of steel blocks for bulk shielding , including of base plate, outliner and bulk shielding, started in October, 2012.
- Neutron shutters have been bidden in October, 2013.



CSNS White Neutron Source and Applications

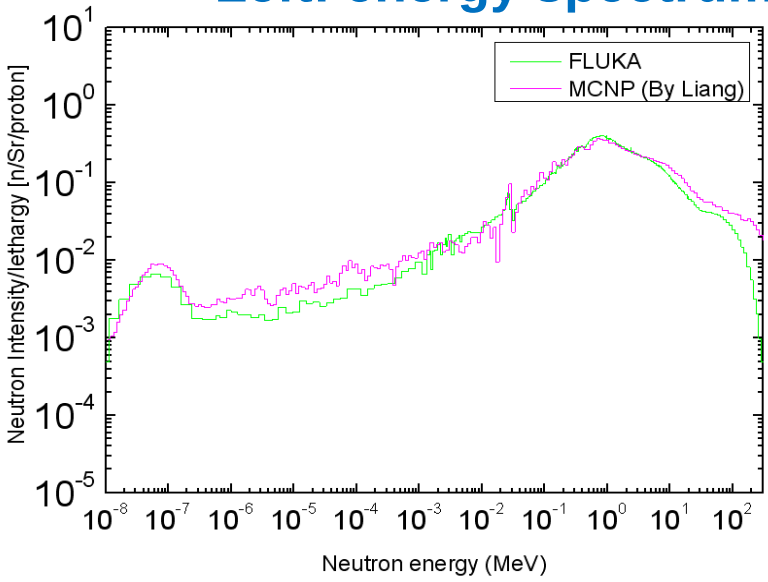
- High-performance WNSs have very important applications in nuclear data measurements which are imminently required in many research fields： nuclear physics, nuclear astrophysics…
- CSNS Back-streaming white neutron source (Back-n WNS): the back-streaming neutrons along the proton path have typical characteristics of a WNS, being comparable to the world-best WNSs.
- WNS: will be constructed in the cooperation with users

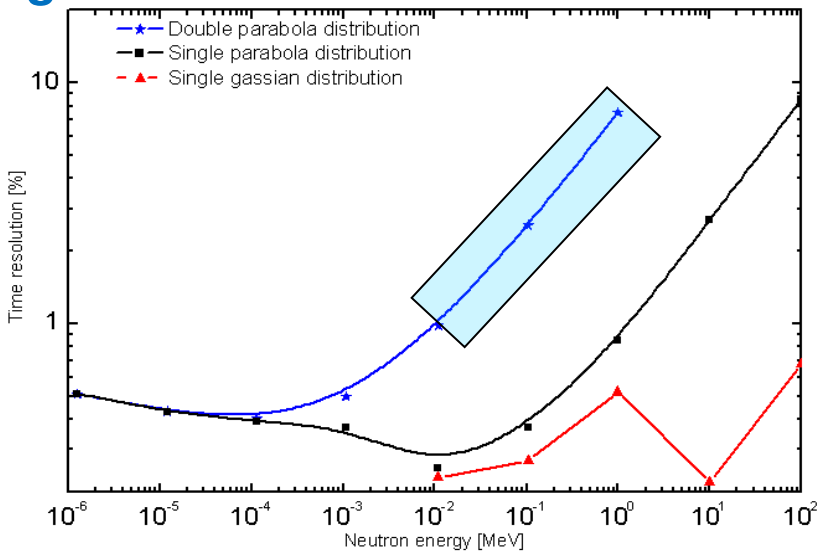
Layout of Back-n WNS



Back-n WNS has very intense flux, very good energy spectrum and good time resolution. In most cases, it satisfies the experimental requirements in parasitic mode. For those requiring very high time resolution, one can use dedicated modes.

Left: energy spectrum; Right: time resolution





China Neutron Scattering Society

- **China Neutron Scattering Society was established March 2013, as a branch of China Physical Society:**
  - Inst. of Physics, CAS;
  - Chinese Inst. of Atomic Energy;
  - IHEP, CAS;
  - > 20 Universities…..
- **The mission of China Neutron Scattering Society:**
  - Promote neutron scattering sciences and application, as well as the neutron instrumentation R&D
  - Training users and students
  - Road map of neutron scattering sciences and facilities in China
  - International cooperation and exchanges
  - ……

Site Preparation

09/05/2009

Groundbreaking Ceremony 20 Oct. 2011

Site leveling complete

Foundation excavation, pit support and retaining, piling

Tunnels construction


中国散裂中子源工程进展照片（2013.11）

The construction site now


中广东建工

Civil Construction

散裂中子源
China Spallation Neutron Source

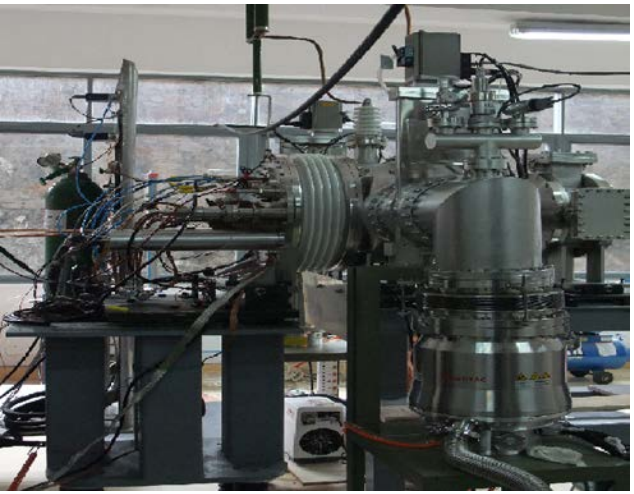
Linac Tunnel

Linac Service Building

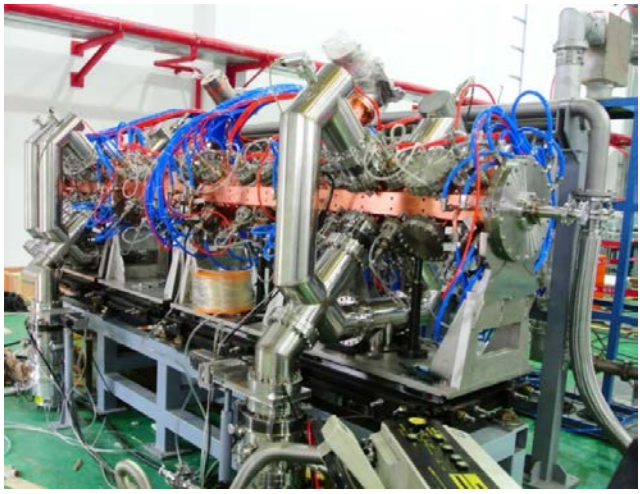
RCS Building

Target station

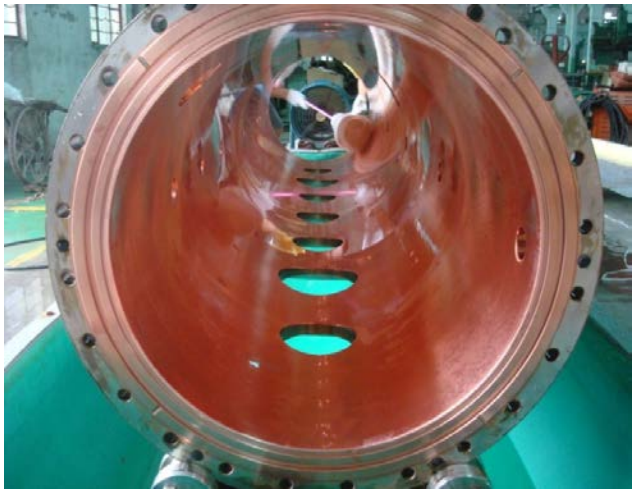
Accelerator



H^- ion source has been setup with a stable H^- beam current of 50mA at 700us, 25Hz.



RFQ (324MHz) has been fabricated. It has passed high power conditioning in the test.



More than half of the DTL drift tubes with EM quadrupole have been manufactured.

Mass production of ring magnet is in good progress. 14 dipoles and 13 quadrupoles for the RCS ring have been completed。

Mass production of ring power supply started after the prototype passed acceptance test.

The first ferrite-loaded cavity of ring RF has been successfully manufactured and high-power tested.


中国散裂中子源加速器首台设备投入安装

Target Station

Hot-cell shell has been positioned at the target station

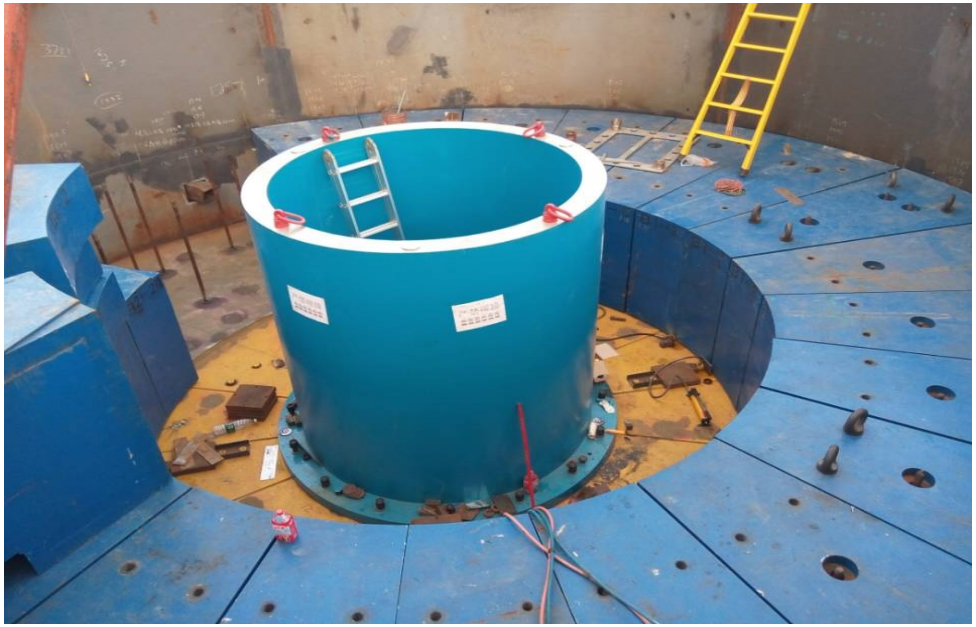
Target Station

Outer liner has been in position

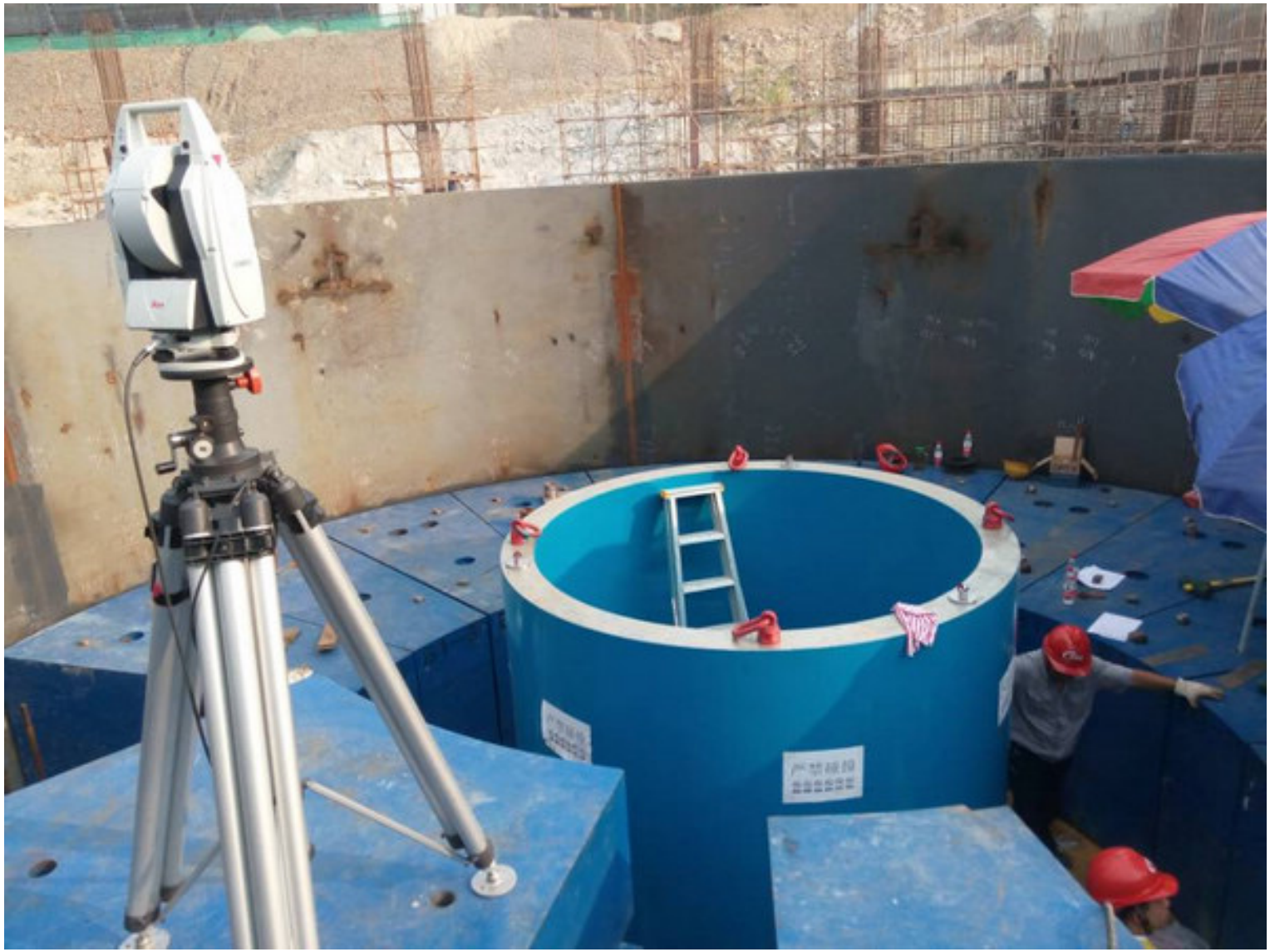
Target Station

Base plate has been installd

Target Station



Helium vessel support skirt has been installed



Access road

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中国科学院
高能物理研究所
东莞分部

Residence place for Staff and guest

Thank you very much for supports to CSNS !