

The Introduction to CSNS and Its Upgrade Project CSNS-II

Speaker: Prof Sheng Wang

Presented by: Ruirui Fan

Institute of High Energy Physics, CAS

ISINN-32 ， May. 25, 2026



In the late 1950s, Wang Ganchang was part of the research team in Dubna.



70th Anniversary of JINR

On May 14, 2026, the academic symposium "Chinese Scientists in Dubna" was held in Beijing.

Outline

I. A brief introduction to IHEP

II. The status of CSNS

III. The Upgrade project CSNS-II

IV. Tech. transferring and proton beam utilization

V. Summary

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The brief introduction of IHEP

IHEP
Staff: ~1600
Funding:~0.5B$

1950	1953	1958	1973
Institute of Modern Physics	Institute of Physics	Institute of Atomic Energy	Institute of High Energy Physics



IHEP' real start is from the construction of Beijing Electron Positron Collider (BEPC) in 1980's, and now is a large and comprehensive center for HEP and multidisciplinary research

Frontiers of Basic Science

Particle & Astro-particle Physics

- Accelerator-based HEP Experiments
- Particle Astrophysics & Neutrino Experiments
- Particle Detection and Electronics
- Particle Physics Theory

Strategic High-Tech

Accelerator Physics and Technologies

- High Luminosity Electron Accelerators
- High Intensity Proton Accelerators
- Applied Research and Technology Transfer

Multi-disciplinary research

Radiation Technologies and Applications

- Synchrotron Radiation & Applications
- Neutron Scattering & Applications
- Nuclear Analytical Techniques & Applications

Three Pillars: Basic science research, Technology R&D, Facility Construction and Management

The brief introduction of IHEP



The brief introduction of IHEP



IHEP Yuquan Campus, Beijing City



CSNS & SAPS Pre-Research, Dongguan Campus, Guangdong Province



Jinan Campus, Shandong Province



HEPS & PAPS, Huairou Campus, Beijng City

The brief introduction of IHEP



TIANFU Cosmic Ray Research Center, Chengdu, Sichuan



LHAASO measurement and control base in Sichuan



JUNO Experiment in Jiangmen



AliCPT-1 Experiment Campus

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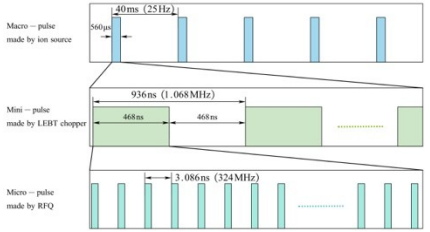
V. Summary

CSNS campus

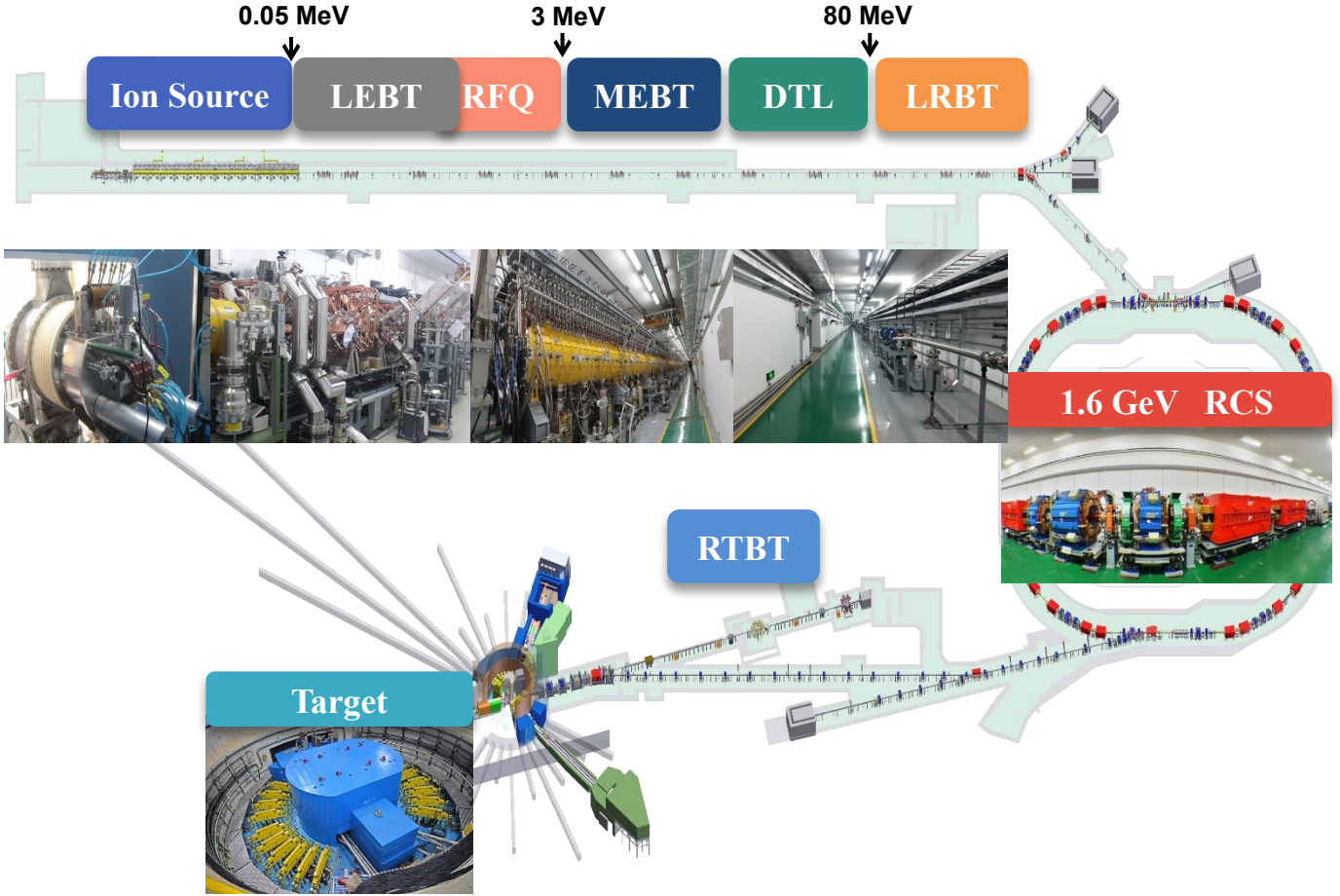


- Proposed at year of 2000
- Budget: about 2.2 B CNY
- Construction started at Sep. 2011, and finished at Mar. 2018
- User program started in Oct. 2018
- Beam power increased from 20kW to 185kW
- Operation with long user hours and high availability
- 11 neutron instruments and in user program

CSNS Facility

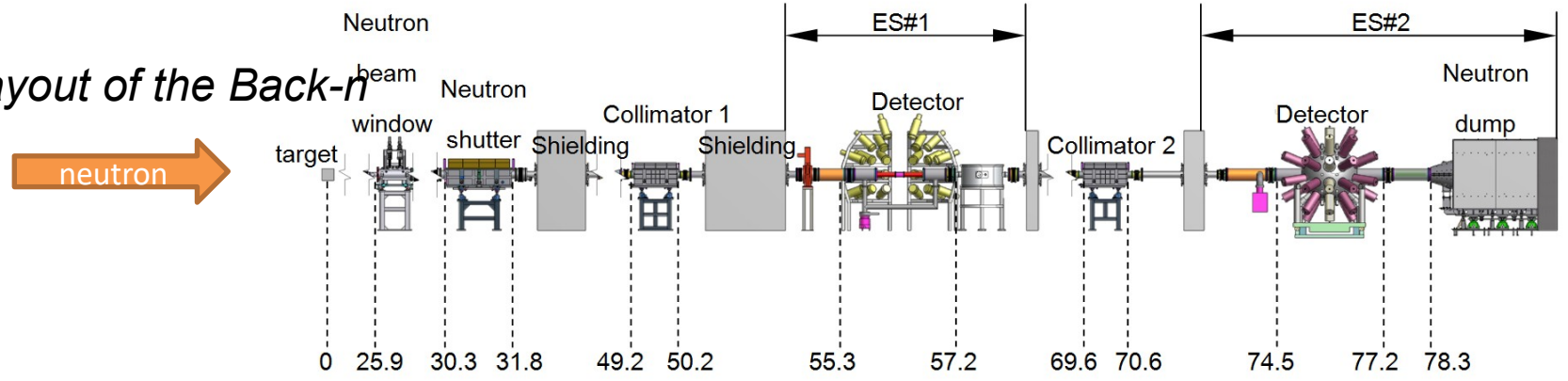


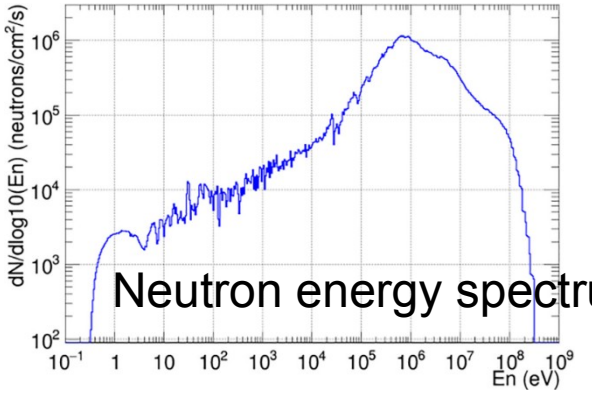
Beam Power on target [kW]	100
Proton energy [GeV]	1.6
Average beam current [uA]	62.5
Pulse repetition rate [Hz]	25
Linac energy [MeV]	80
Linac type	NC
Linac RF frequency [MHz]	324
Macropulse duty factor	1.05
RCS circumference [m]	228
RCS harmonic number	2



Back-n White neutron source

Layout of the Back-n



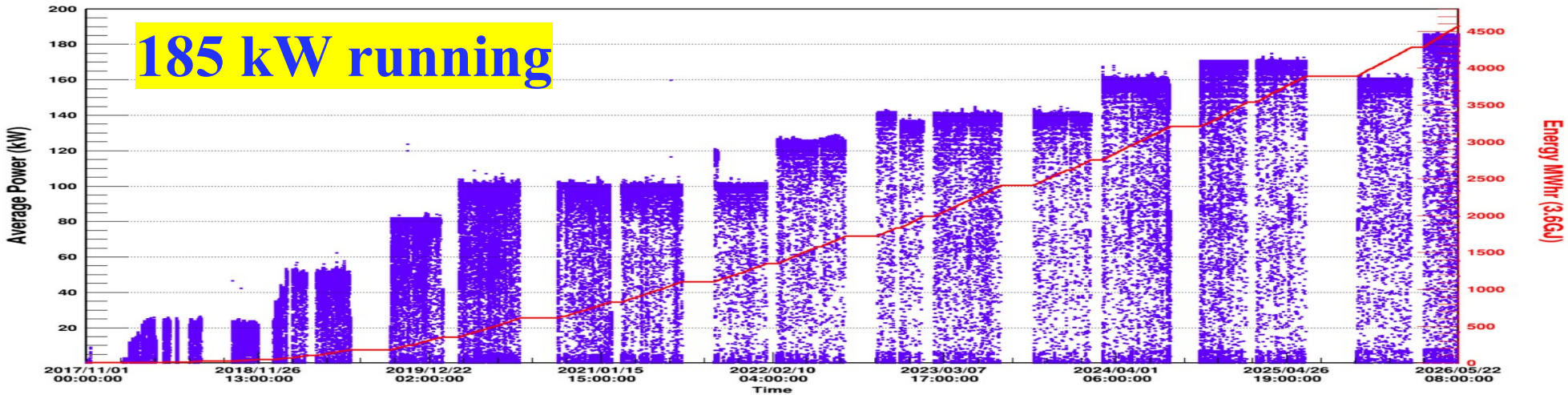


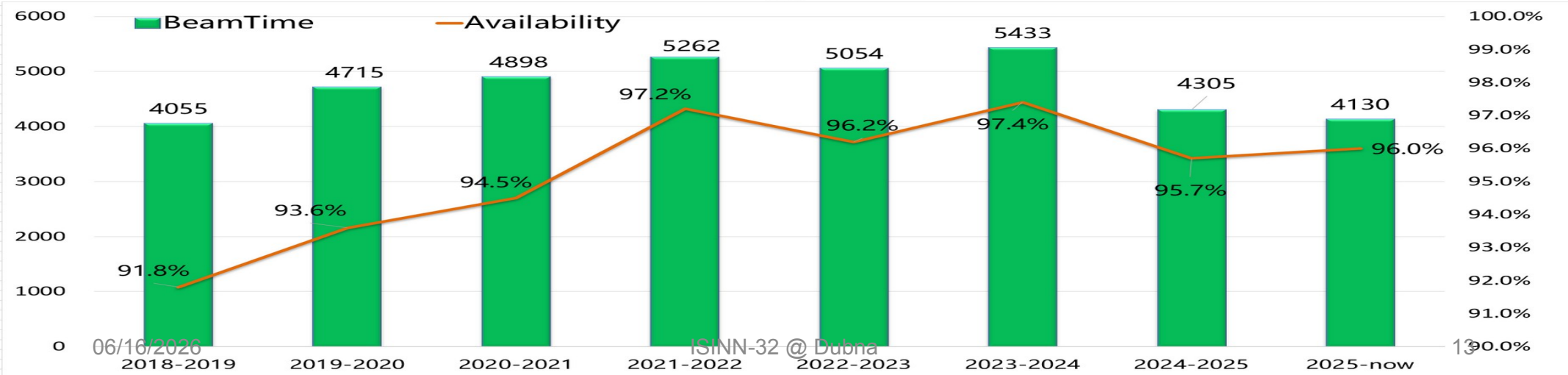
Energy range	flux (neutrons/cm²/s)
0.1-1 eV	4.08×10^{3}
1-10 eV	1.79×10^{4}
10-100 eV	3.01×10^{4}
0.1-1 keV	5.01×10^{4}
1-10 keV	1.23×10^{5}
10-100 keV	4.30×10^{5}
0.1-1 MeV	2.98×10^{6}
1-10 MeV	2.77×10^{6}
10-200 MeV	6.21×10^{5}
Total	7.03×10^{6}

- The back-streaming neutrons are leading to the Back-n tunnel
- The ES#1: 55m
- ES#2: 70m
- Thermal neutrons to 300 MeV.
- The highest neutron flux: 1E7 n/cm²/s.
- different neutron beam spots and fluxes can be obtained by using different collimator

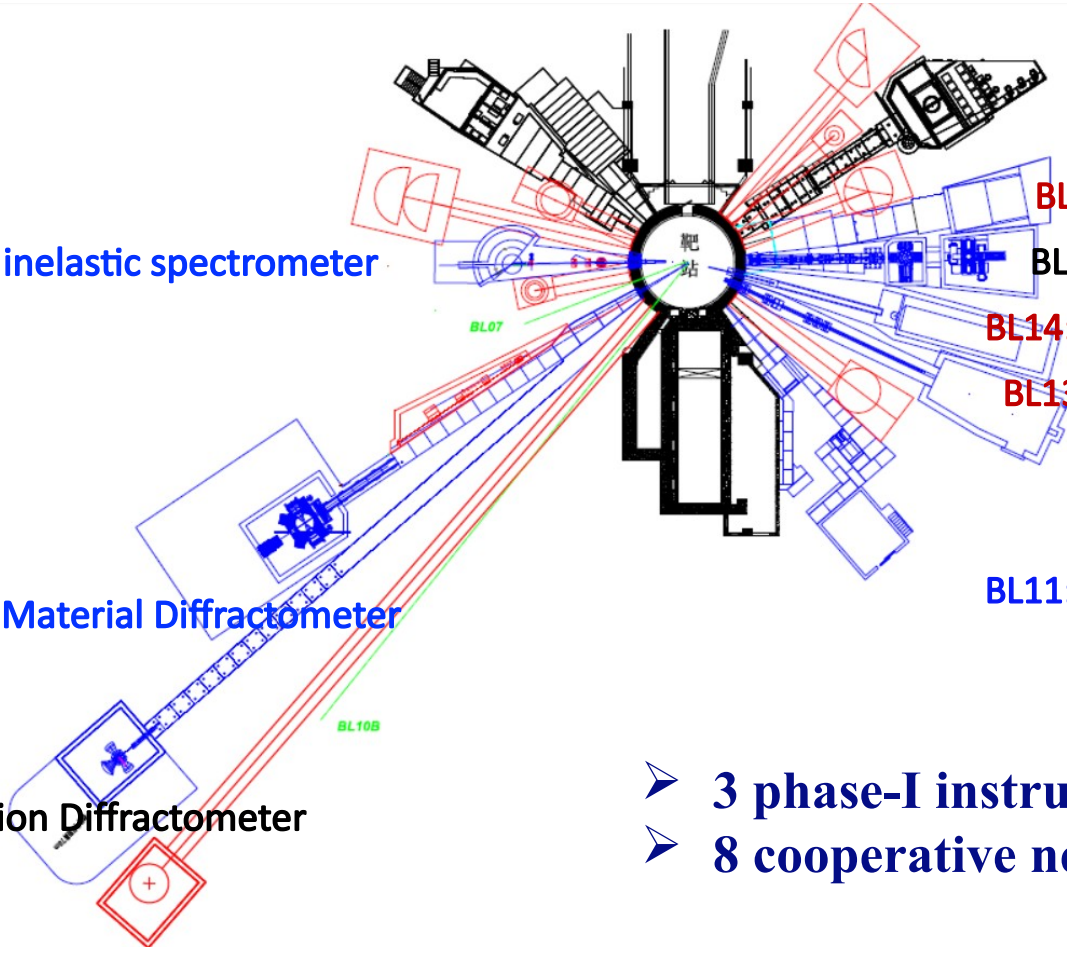
Detailed content is available in Ruirui Fan's talk

CSNS Beam Power History





Neutron Instruments



BL05: High energy inelastic spectrometer

BL16: Multiple Physics Instrument

BL15: High Pressure Diffractometer

BL14: Very small angle neutron scattering

BL13: Energy resolved neutron imaging

BL11: Atmosphere Neutron Irradiation

BL08: Engineering Material Diffractometer

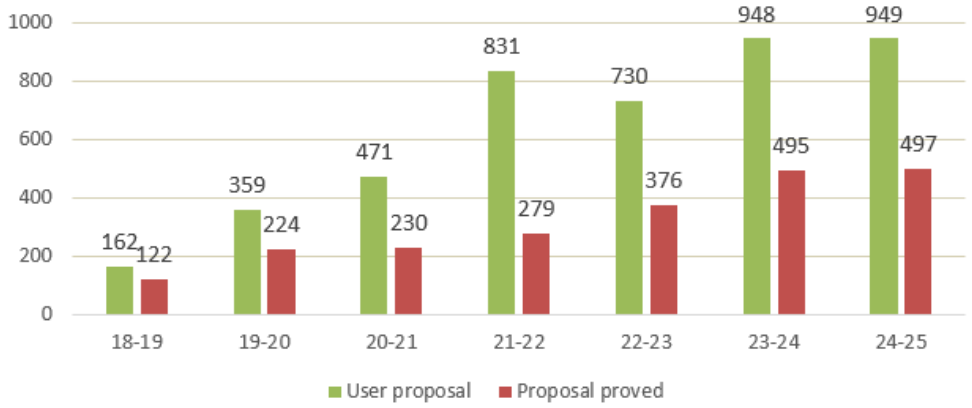
BL09: High resolution Diffractometer

- 3 phase-I instruments
- 8 cooperative neutron instruments

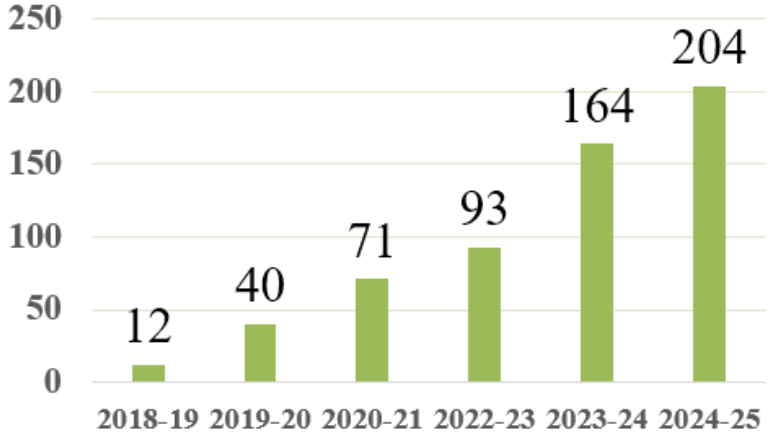
The User Program

https://user.csns.ihep.ac.cn (in both Chinese and English)

- Registration user: 10,000+
- A total of over 2,500 projects from 268 units were completed, with industry users comprising approximately 9.5% of the total.
- Two rounds of proposal calls each year.

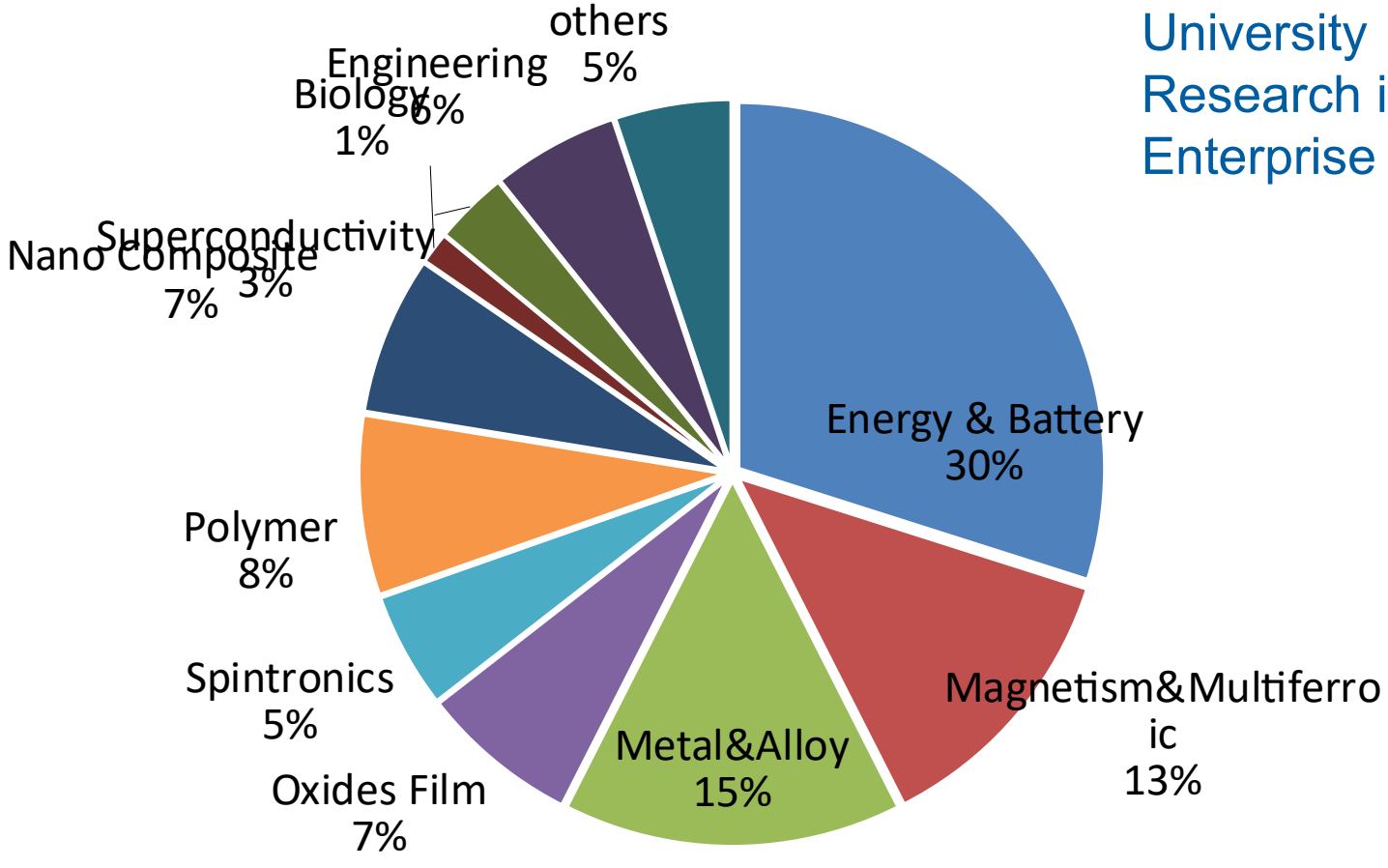


User proposal VS. Proposal proved



User publications

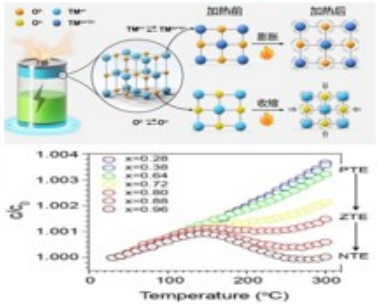
Research Areas



University： ～45%
Research institution： ～49%
Enterprise： ～6%

The frontiers of science and technology

Energy

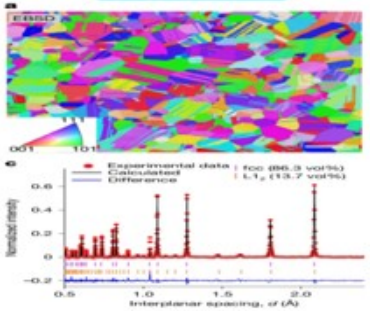


Negative thermal expansion and oxygen-redox electrochemistry

Diffraction: Structural disorder

Nature 640, 941–946 (2025)

Alloy

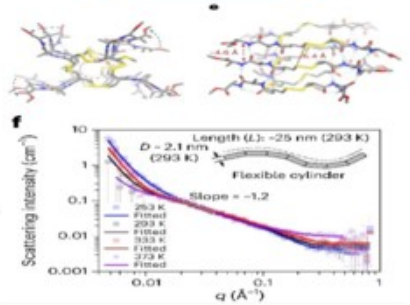


Dual-scale chemical ordering for cryogenic properties in CoNiV-based alloys

Diffraction: Dislocation

Nature 645, 385–391 (2025)

Life

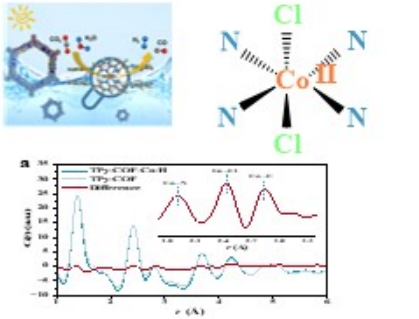


Dual dynamic helical poly with conformational adaptivity and configurational recyclability

SANS: Folding structure

Nature Chemistry 09, 30 (2025)

Catalyst



Covalent Organic Framework Stabilized Single CoN4Cl2 Site Boosts Photocatalytic CO2 Reduction into Tunable

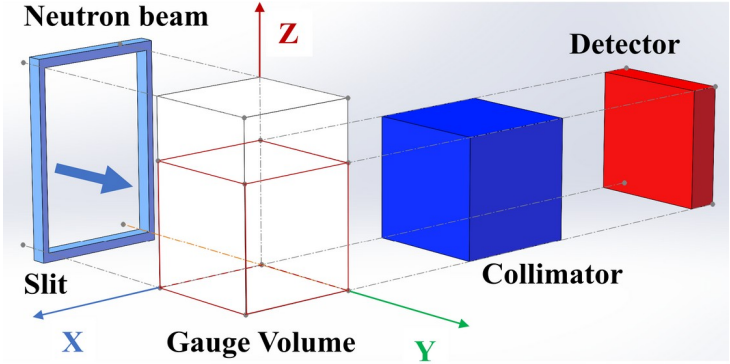
PDF: Local structure

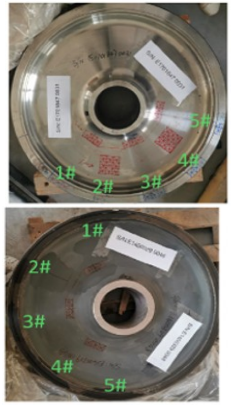
Angew. Chem. Int. Ed. 64, e202415202 (2025)

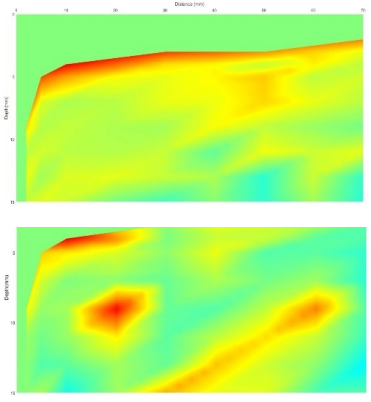
Supporting user results are published in Nature 、 Science, Nature Energy, Nature Sustainability, Nature Chemistry, JACS et al. 76.7% publications are located in CAS top 5% based on IF.

The examples in industry application

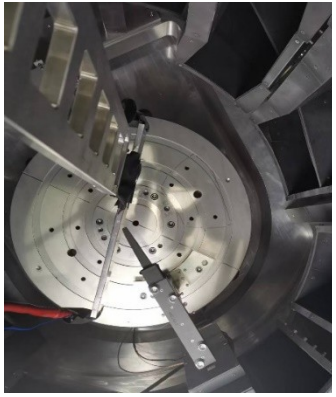


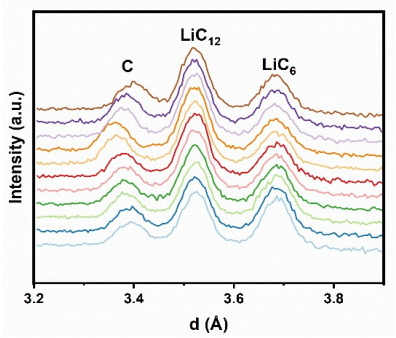


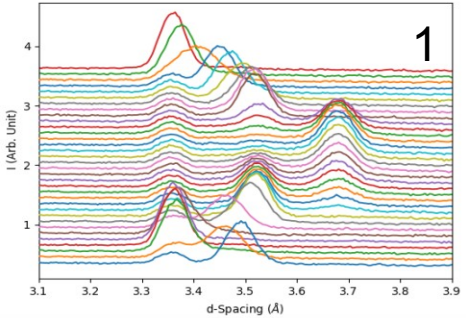


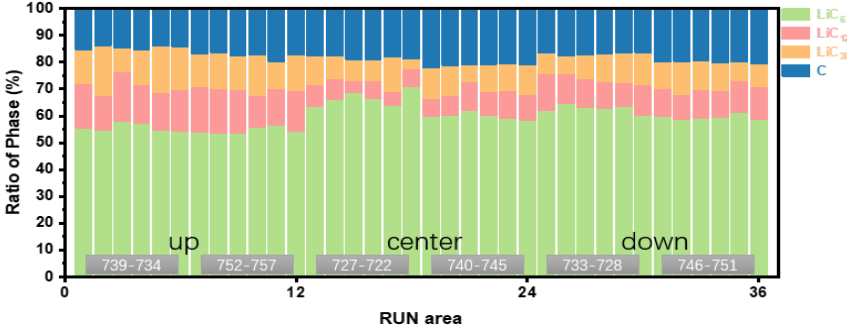


Residual stress of high-speed train wheels before and after service









Vehicle battery: inhomogeneity degree during charge and dis-charge

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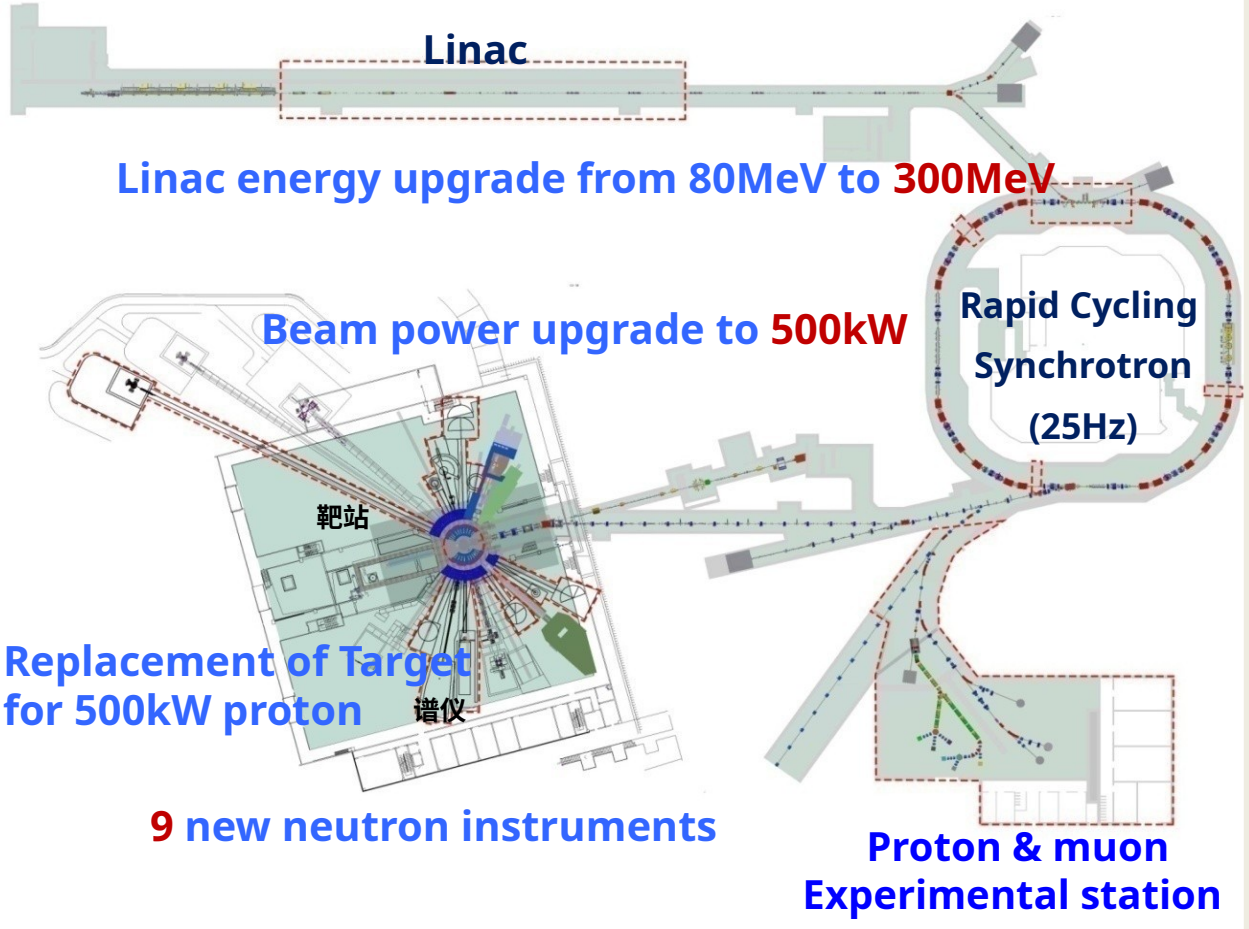
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China Spallation Neutron Source-II

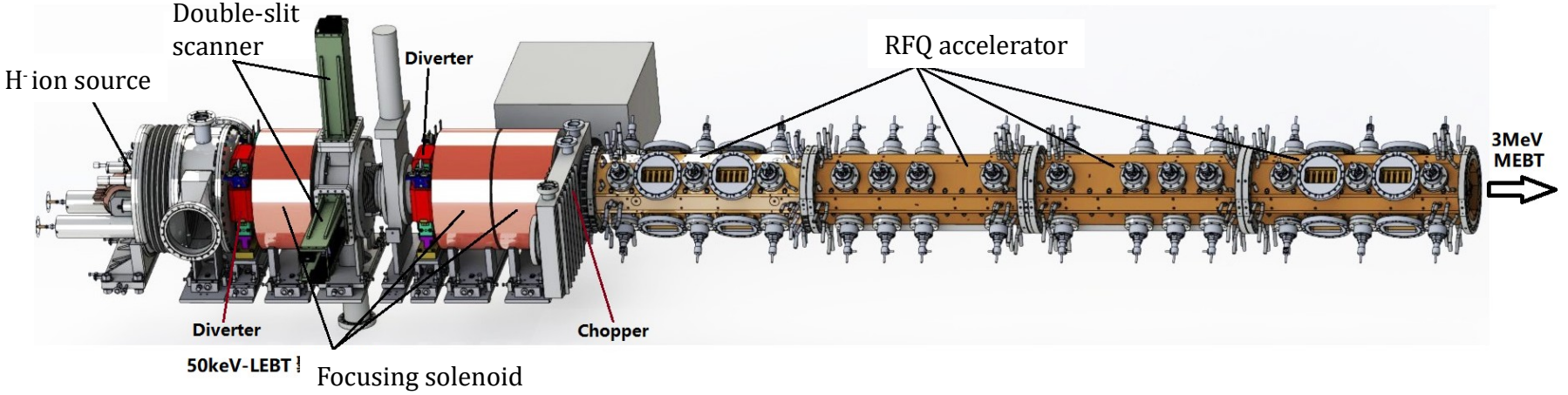


- Project Budget: 2.9 B CNY
- Funded by central and Guangdong local government
- Design and R&D completed
- Construction: 2024.1~2029.10
  （5 years and 9 months）

Beam Power Upgrade （two-step）

1. Linac （80MeV） + RCS upgrade 150~200kW （the first step）
   - ✓ New dual harmonic RF system
   - ✓ Adding AC trim quadrupoles, sextupoles and octupoles
   - ✓ New injection region
2. Linac （300MeV+） + upgraded RCS 500kW (the second step)
   - ✓ SC linac to 300MeV
   - ✓ Upgrade the power supplies for main magnets

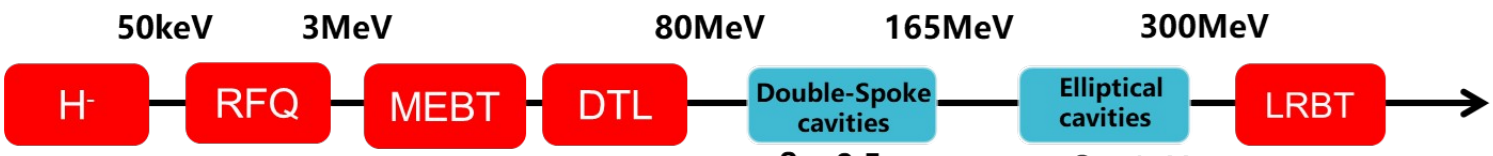
The Front End of CSNS Accelerator

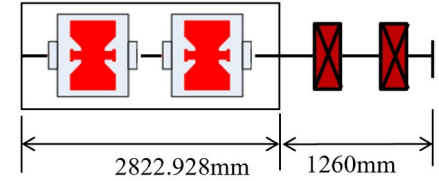


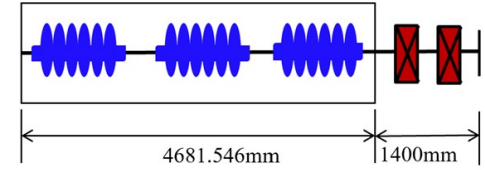
H- ion source, LEBT, chopper, RFQ

- The LEBT has 3 solenoids, initially designed for the former penning ion source.
- The penning source has been replaced by RF-driven H^- ion source in Sep. of 2021.
- The ion source current is up to 60 mA, and throttled to the required value.
- New LEBT and new RFQ for CSNS-II is under construction and test in the lab.

Linac Upgrade







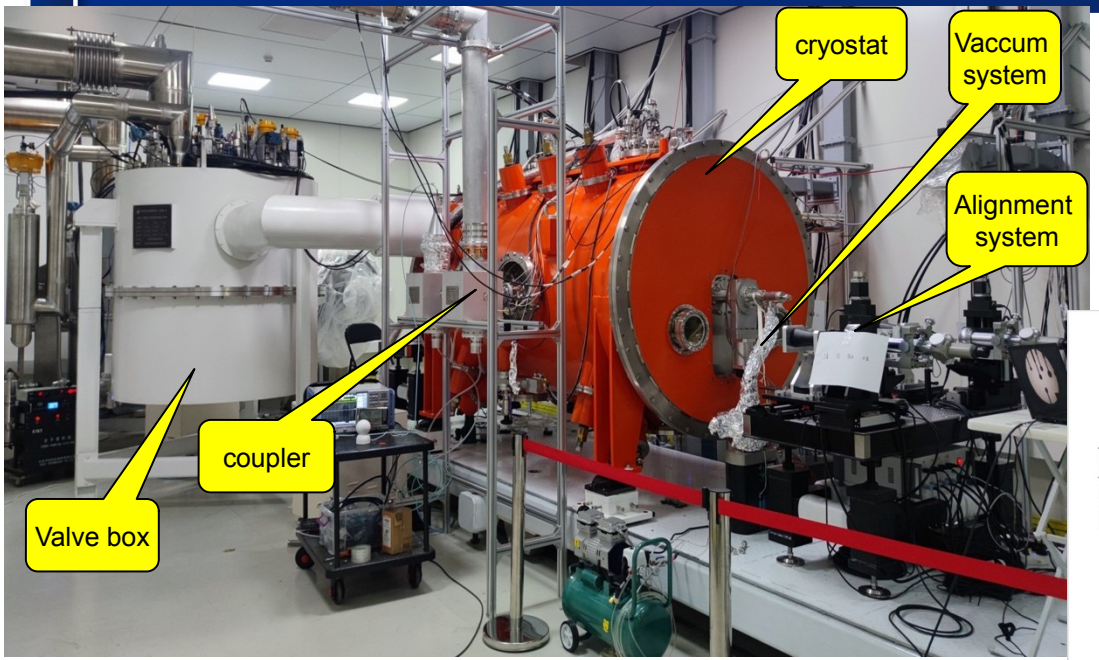
- The tunnel reserved is 92m.
- The energy gain >2.4MeV/m

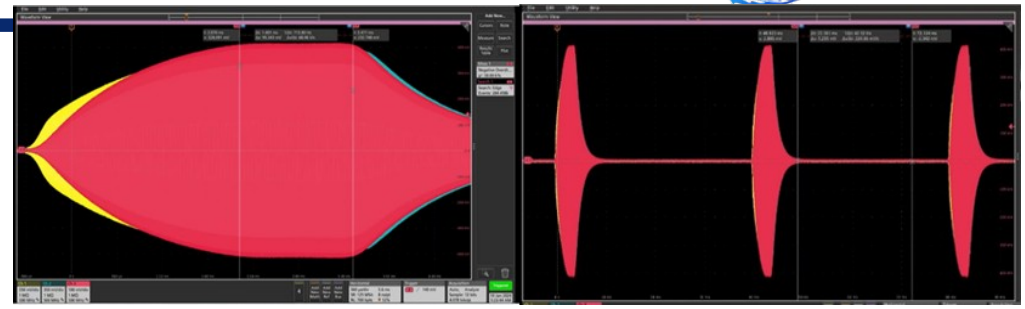
	CSNS	CSNS-Ⅱ
Particle species	H^-	H^-
Pulse repitition frequency(Hz)	25	25+25
Linac beam energy (MeV)	80	300
Average current(μA)	62.5	625
Peak current (mA)	15	50
Pulse width(μs)	500	500

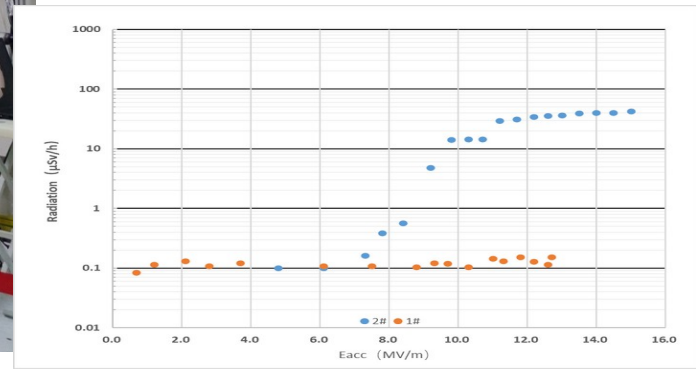
Special requirements;

- Energy jitter <0.04%
- Energy spread: <0.03%
- High availability (>97%)

Horizontal testing







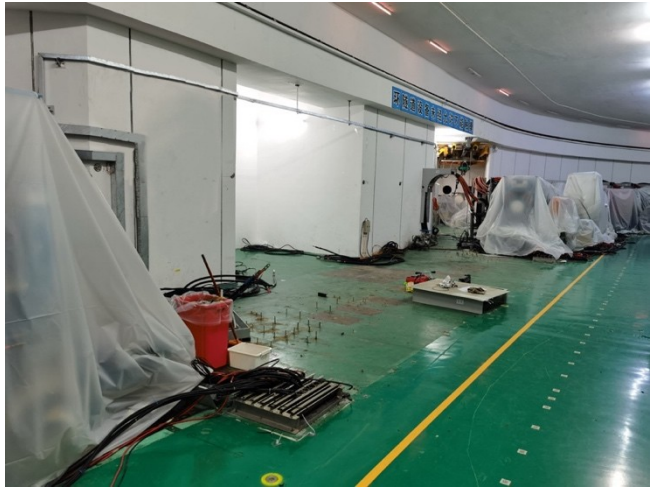
Eacc:
1#
12.8MV/m
2#
15.2MV/m

- ✓ **The successful integration of the cryostat and the completion of the high-power conditioning process for the couplers mark significant milestones.**
- ✓ Horizontal testing yielded promising results with a maximum gradient of 15.2 MV/m and a static heat load of 16.3 W.
- ✓ Further measurements are required to accurately determine the dynamic heat load.

Upgrade of RCS Injection System



CSNS Injection



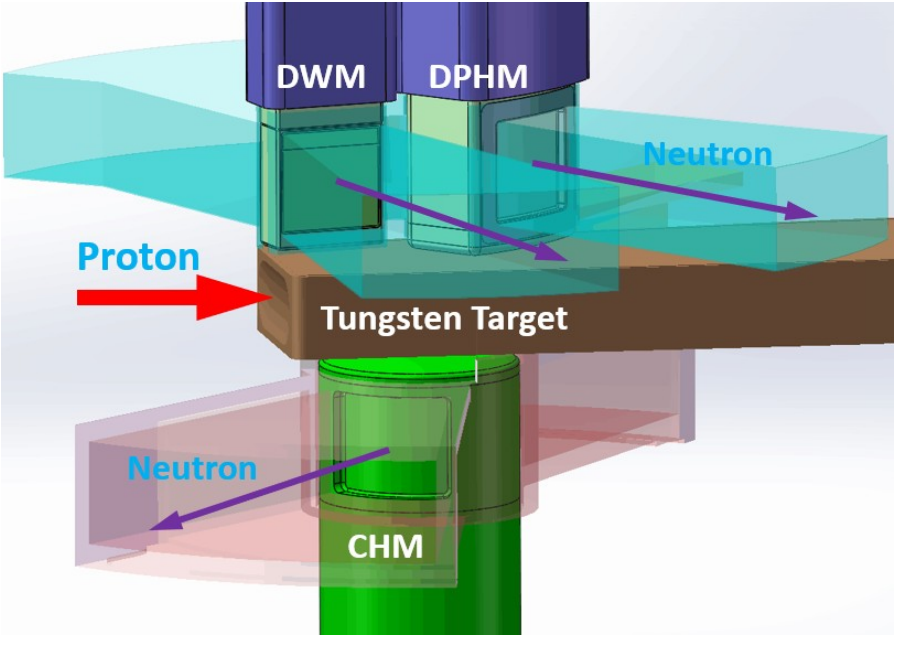
dismantling



CSNS-II Injection

Jun. 20- Aug.31

The brief introduction of CSNS Target Station

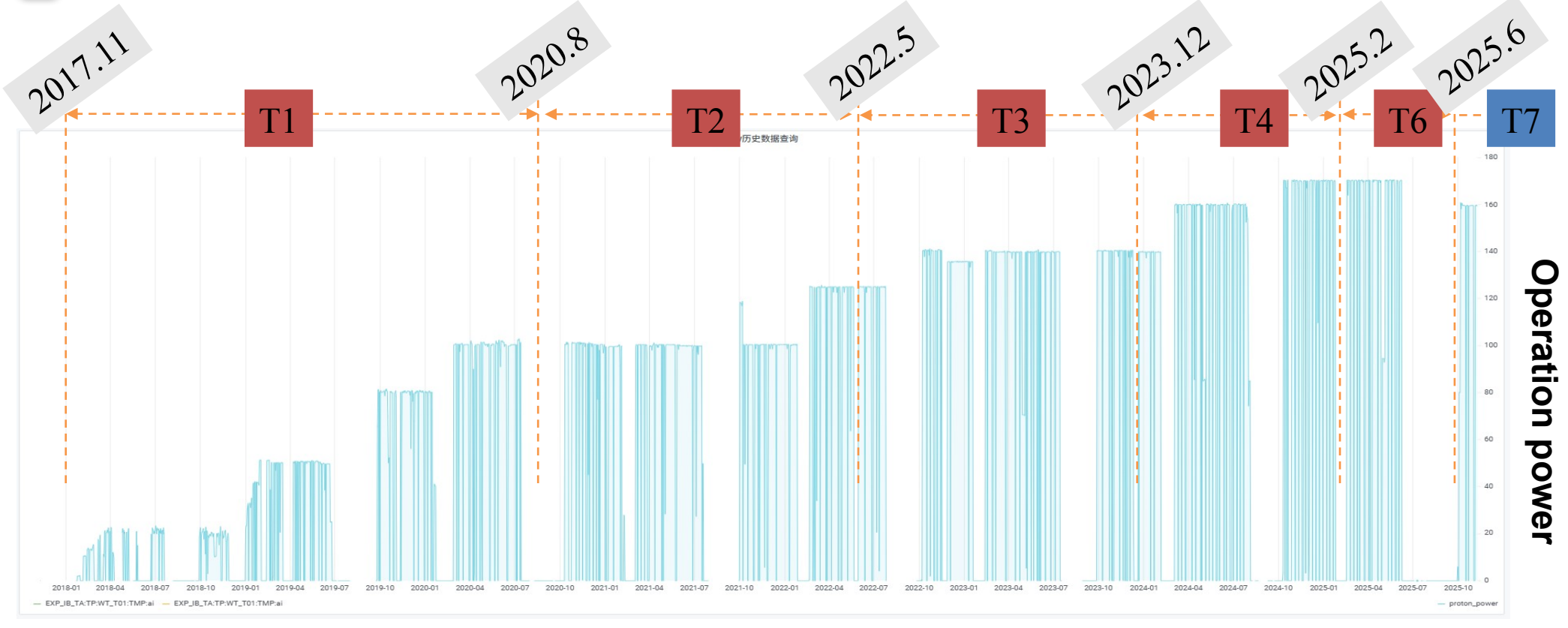


The target and moderators

The main parameters in CSNS TS

items	Parameters or index
Neutron Efficiency （n/p/sr)	0.1
Target	W plates， Ta Cladding
Moderators	Decoupled Water （300K）， Coupled parahydrogen （20K）， Decoupled
Reflector	Be/SS316
Cryogenic System	Provides para-hydrogen at 18~21K@15bar
Utility System	Light water cooling system
Remote handling system	Replace and storage the irradiated components

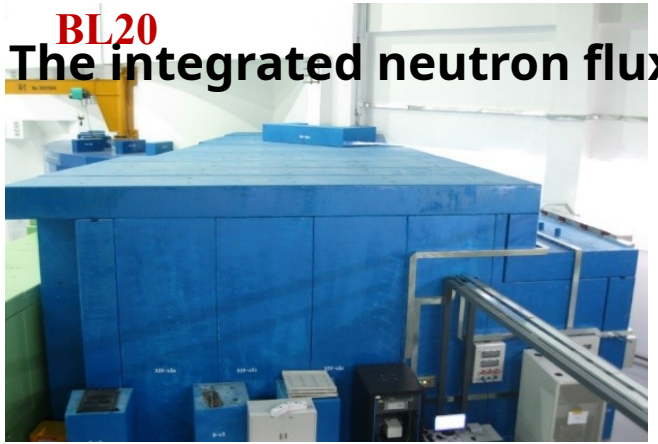
The operation status of the Target

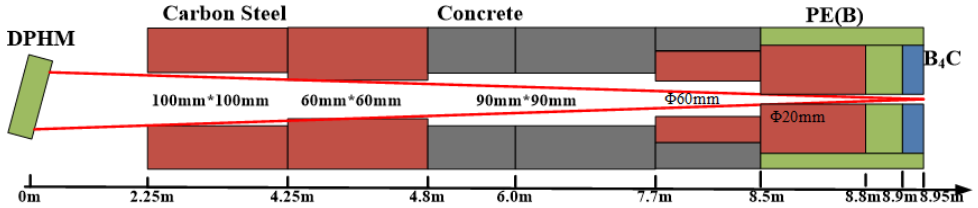


- ✓ **In the past 8 years of operation, 6 targets have been replaced.**
- ✓ **One was forced to be replaced due to a leak in water pipe of target trolley in 2025**

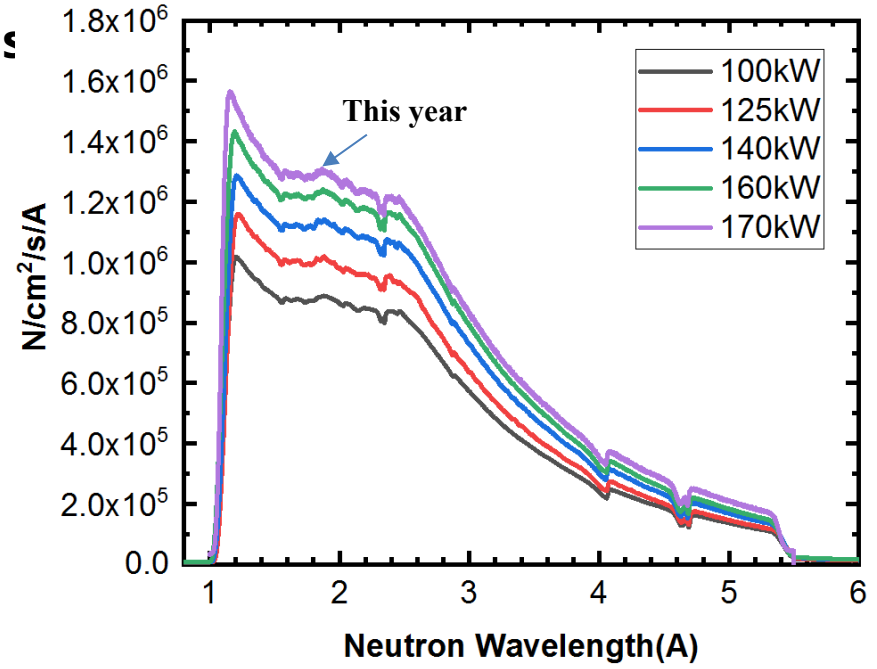
Neutron performance of CSNS TS

- **Neutron wavelength spectra basically unchanged under different power conditions.**
- **The integrated neutron flux increases [illegible]er.**



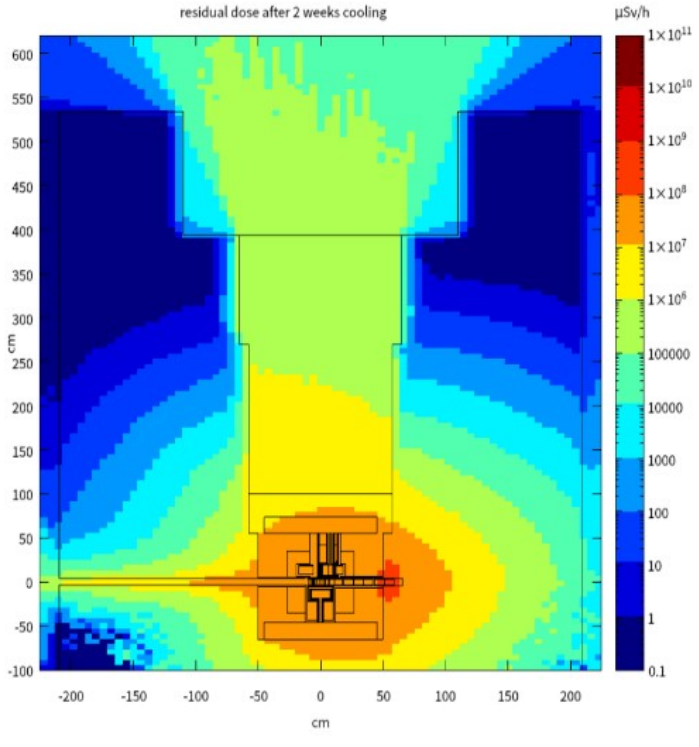


BL20 test beamline → Wide side of the DPHM



The neutron spectra at the BL20 sample position

How we upgrade the Target Station in Phase II?

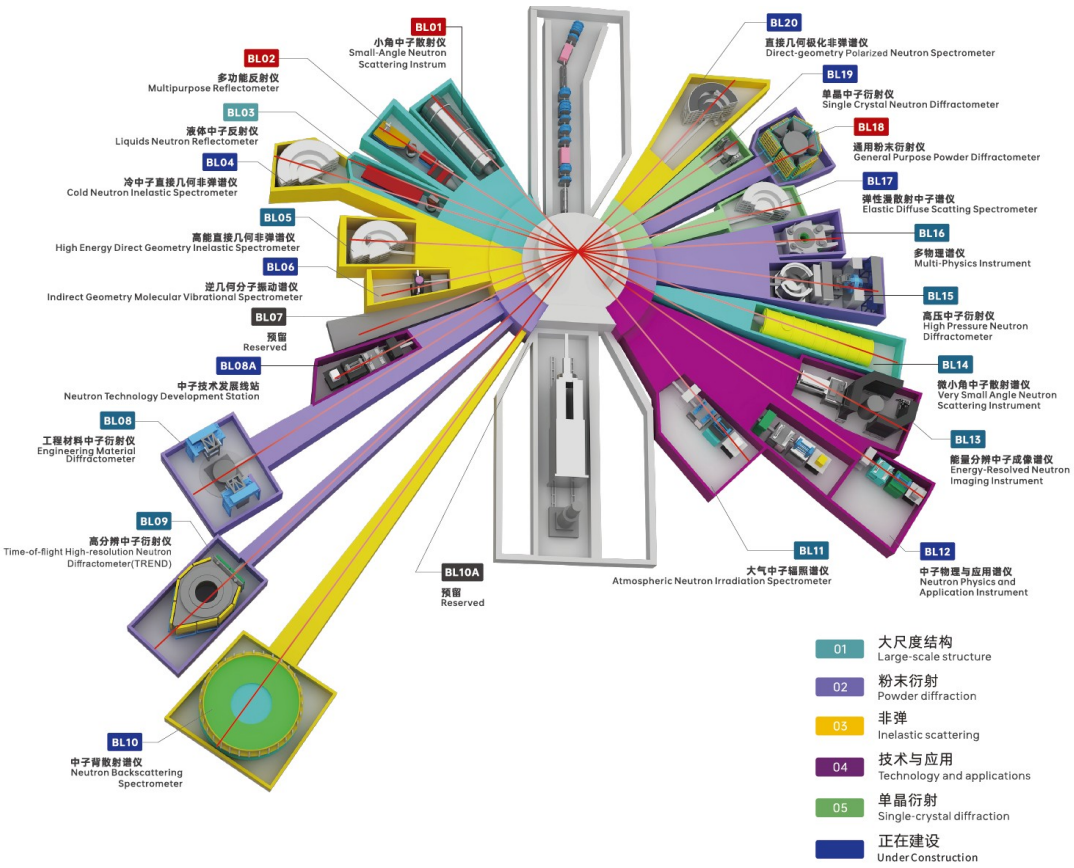


Target	Target material	Tungsten(19.2 g/cm3), Ta-cladded, Ta:0.5mm
	Target thickness	600 mm
	Tungsten cross section area	200 mm(H)×70 mm(V)
	Target & Reflector coolant	D_2O (>95%)
Moderator	CHM hydrogen	Ø150 mm×100 mm
	CHM pre-moderator	Light water(300K), 10 mm except 15 mm from target side
	CHM view area	100 mm(H) ×106 mm(V)
	Height of CHM center	-139 mm from target center
	CHM & DPHM hydrogen	20 K, 1.5 Mpa, >99% Para-hydrogen
	DPHM hydrogen size	110 mm(H)×110 mm(V) ×50 mm
	DPHM poison material	Gd, 0.5 mm, 5.0 mm offset from center
	DWM water size	Light water(300K), 115 mm(H)×110 mm(V) ×40 mm
	DWM & DPHM view area	100 mm(H) ×102 mm(V)
	Height of DWM & DPHM center	135 mm from target center
	decoupler and liner	Cd, 0.6 mm
Reflector	Be	Ø540 mm×700 mm
	Stainless Steel	Ø1000 mm×1000 mm

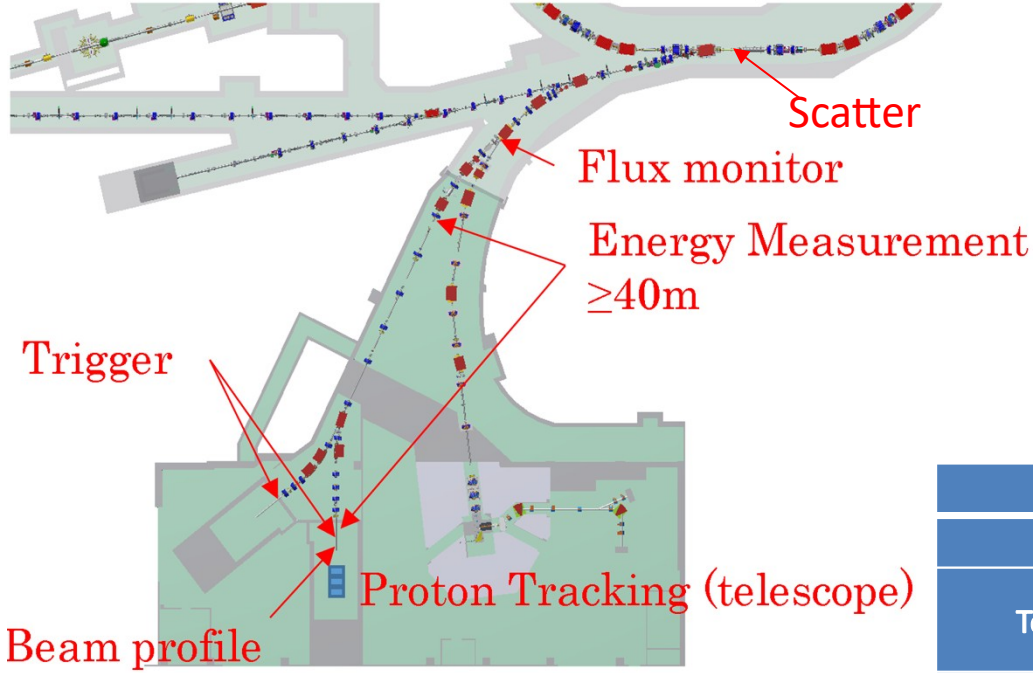
Replace the center components of TS to bear the 500kW proton beam power!

CSNS Instrument Suite

Powder Diffractometer	General Purpose Powder Diffractometer (GPPD)
	Multi Physics Instrument (MPI)
	High-resolution Powder Diffractometer (TREND)
	High pressure diffractometer (HP)
Large Scale	Small Angle Neutron Scattering instrument (SANS)
	Very Small Angle Neutron Scattering (VSANS)
	Multi-Purpose Reflectometer (MR)
	Liquid Neutron Reflectometer (LNR)
Industry Application	Engineering Material Diffractometer (EMD)
	Energy Resolved Neutron Imaging (ERNI)
	Atmosphere Neutron Irradiation (ANIS)
Direct Geometry Spectrometer	High energy inelastic spectrometer (HD)
	Cold Neutron Inelastic Spectrometer (CNIS)
	Polarized Chopper Spectrometer (PACS)
Indirect Geometry Spectrometer	Molecular Vibration Spectrometer (IMVS)
	Neutron Backscattering Spectrometer (NUBS)
Single Crystal	Elastic Diffuse Scattering Spectrometer (EDS)
	Single Crystal Neutron Diffractometer (SCND)
Nuclear physics & technique	Back-streaming white neutrons (Back-n)
	Neutron Technology Develop Station (NTDS)
	Neutron Physics & Application Instrument (NPAI)
	High-energy Proton Experimental Station （HPES）
	Muon station （MELODY）



Utilization of High Energy Proton beam



- A rotated scatter is used to extract the proton beam from RCS before main beam extraction. A energy degrader in beamline is used to adjust the proton energy in 0.8-1.6 GeV.
- Two test terminals, a control room and detector test area will be constructed in hall.
- Five advanced measurement devices for measurements of proton energy, position, T0 signal and beam-spot and flux monitor.

Detector	Parameter name	Value
T0 Trigger	Time resolution	≤1ns
Telescope device	Layer number	6
	Pos. resolution	≤ 10μm
Energy measurement	Det. size	2cm*2cm
	Energy range	0.8~1.6GeV
Beam spot measurement	Pos. resolution	150μm
Flux measurement	Det. size	≥10mm×10mm
	Range	1-10000

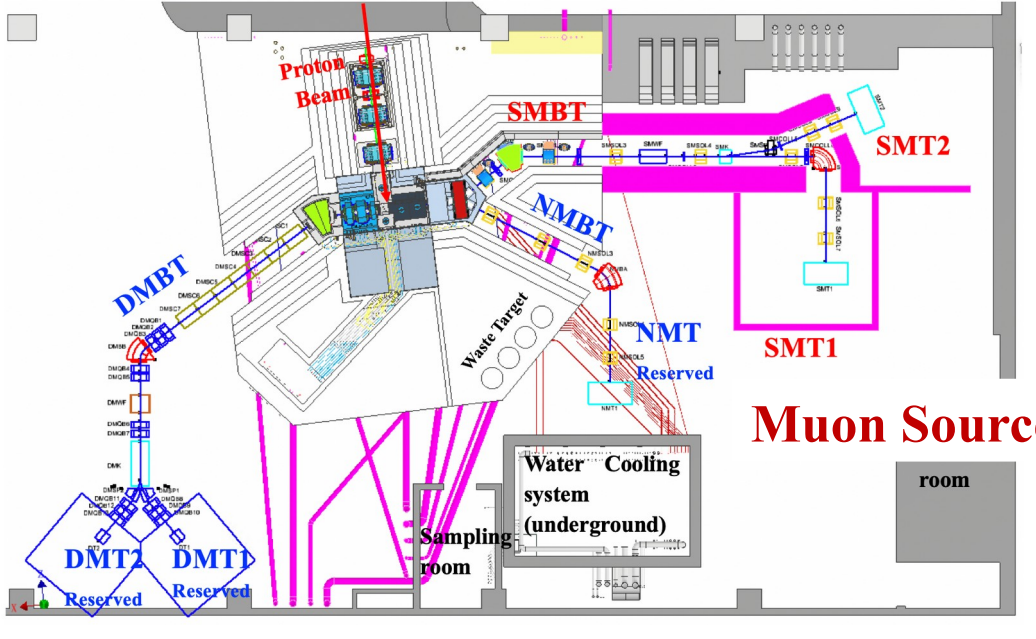
Provide a muon research platform for users

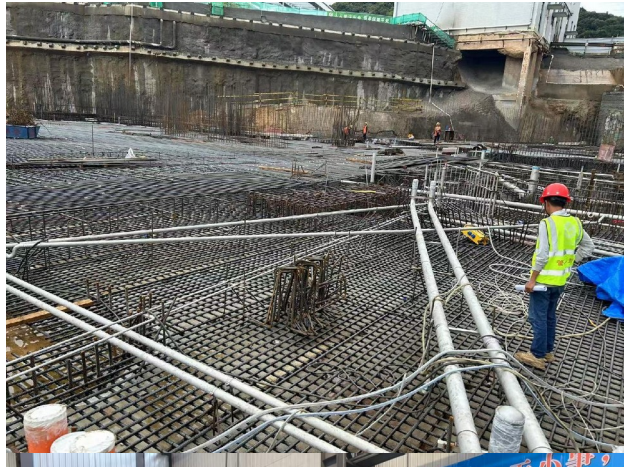
- **CSNS II will construct a muon source and the muon source project will extract 1 pulse from the 25Hz to hit a copper target.**

  Technique Design of the Target Station reviewed in 2025.7

  Technique Design of the Muon Beamline reviewed in 2025.8

  Technique Design of the Spectrometer reviewed in 2025.9







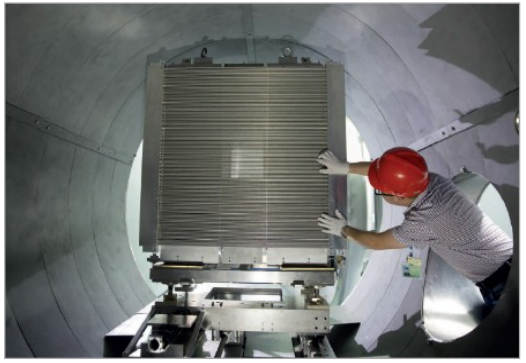
Neutron Technologies and Applications

		Material	Condensed Matter	Chemistry	Soft Matter	Life Science	Heritage	Geology	Industry	Nuclear Physics
Powder Diffraction	General Purpose Powder Diffractometer	√	√	√		√		√	√	
	Engineering Material Diffractometer	√	√				√	√	√	
	High Pressure Diffractometer	√	√	√				√	√	
	Multiple Physics Instrument	√	√	√	√	√	√	√	√	
	High Resolution Diffractometer	√	√	√		√	√	√	√	
Single Crystal Diffraction	Single crystal Diffractometer	√	√	√		√	√	√		
	Elastic Diffuse Scattering	√	√	√		√				
Large Scale	Small Angle Neutron Scattering	√	√	√	√	√	√	√	√	
	Very Small Angle Neutron Scattering	√	√	√	√	√	√	√	√	
	Multipurpose Reflectometer	√	√	√			√			
	Liquid neutron reflectometer	√	√	√	√	√	√			
Spectroscopy	High energy inelastic spectrometer	√	√	√		√				
	Cold Neutron Inelastic Spectrometer	√	√	√		√				
	Polarized Neutron Spectrometer	√	√	√		√				√
	Molecular Vibrational Spectrometer	√	√	√	√	√				
	Neutron Backscattering Spectrometer	√	√	√	√	√				
Imaging	Energy resolved neutron imaging	√	√	√			√	√	√	
Others	Atmosphere Neutron Irradiation	√							√	√
	Neutron Physics and Application	√	√	√					√	√
	Neutron Technology Development								√	√
	Muon Test Station	√	√	√		√	√			
	High Energy Proton Test Station						√		√	√

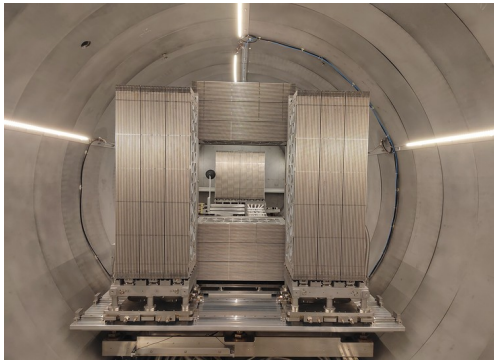
Detectors development

Various detectors have been developed for 11 instruments totally.

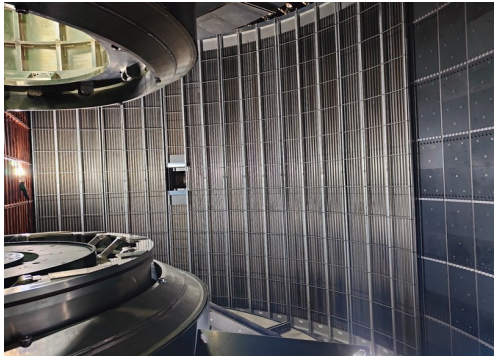
LPSD @ SANS (2018)



LPSD @ VSANS (2023)



LPSD @ HD (2023)



LPSD @ TRENRD (2024)



Scintillator @ EMD(2022)



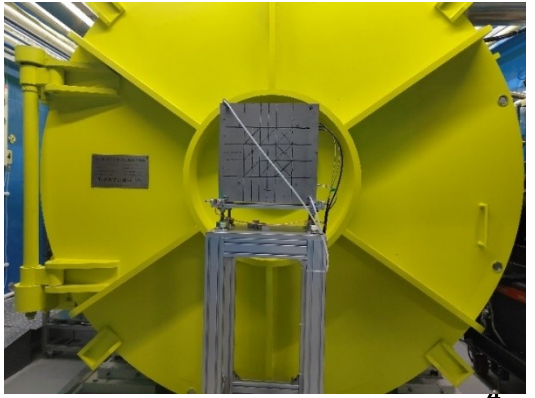
Scintillator @ ERNI(2023)



Imaging @ ERNI (2023)



GEM @ VSANS(2023)

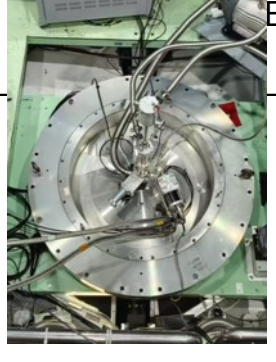


Sample Environment

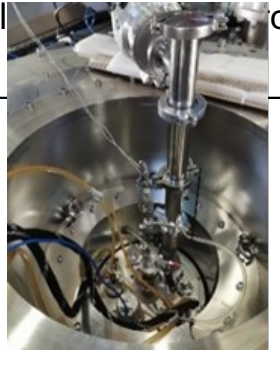
Type	Specific type	Current	Future
Low T.	CCRs, He-3 inserts , DR inserts , etc	0.3 ~ 800K	**0.04 ~ 800K**
High T.	Traditional furnace, Induction furnace, etc	1600℃	**≥ 2000℃**
High Pressure	GP, CPC, PE-cell, Gas adsorption analyzer, etc	10GPa	**10GPa@50K**
Magnet	Superconducting magnet, Pulsed magnet, etc	9T	**14T**
		50nNm ~	**+ 50kV/m,**



CCR-10



Helium-3 insert





Gas inserts



HOT05+HOT07



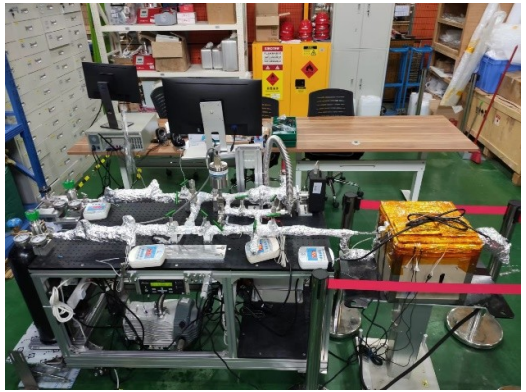
5T magnet at VSANS

Current polarized instrument capability

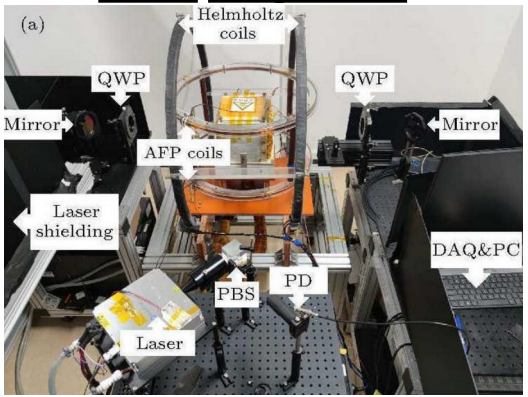
- CSNS established in-house development capability for SEOP ^{3}He system

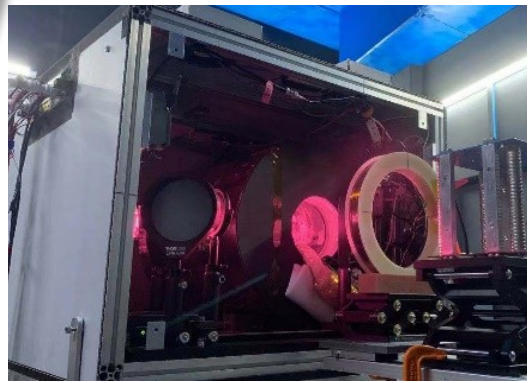
1. In-house ^{3}He cell fabrication and filling



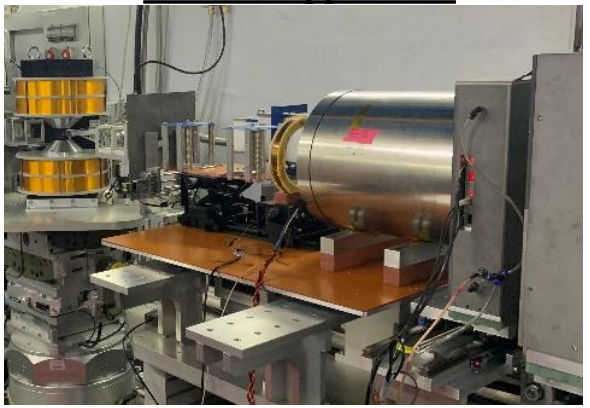


2. Off-situ and in-situ SEOP ^{3}He spin filter





3. Beamline commission and scientific application

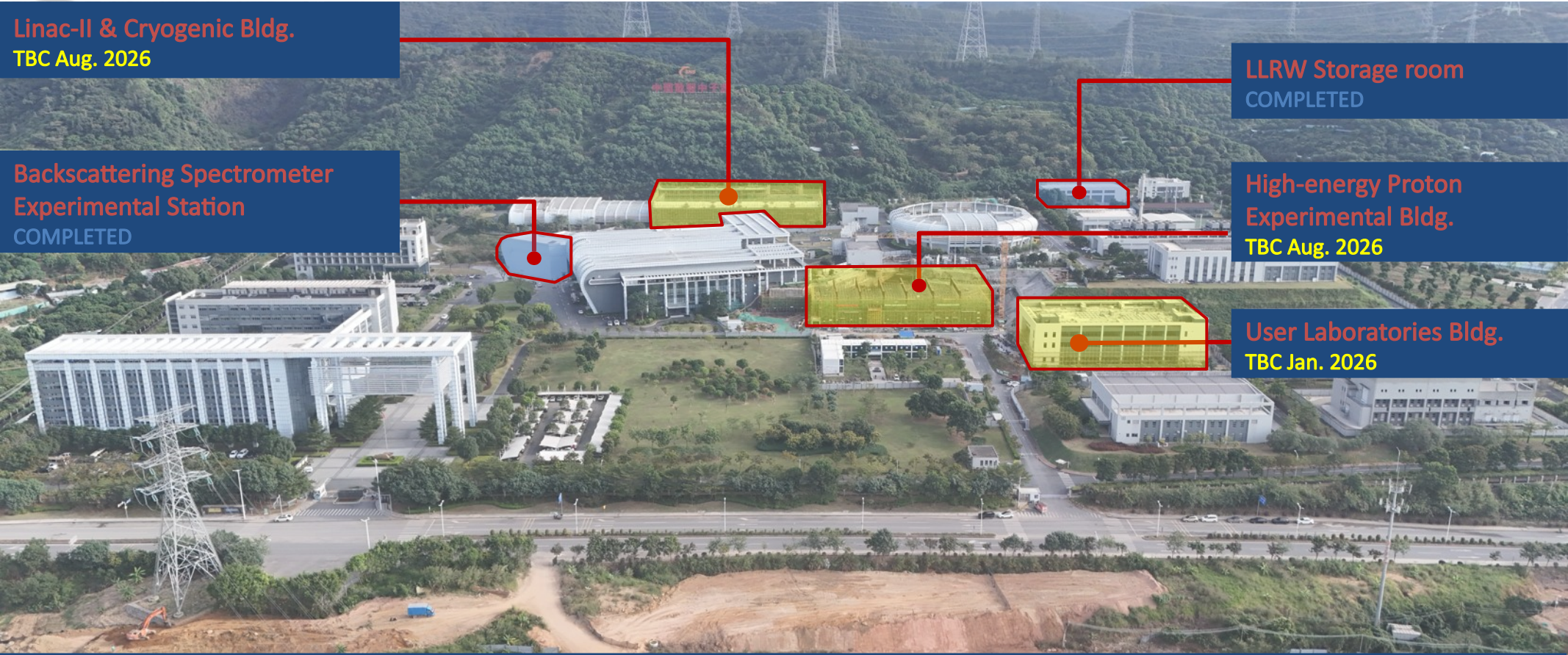




CSNS-II New Buildings



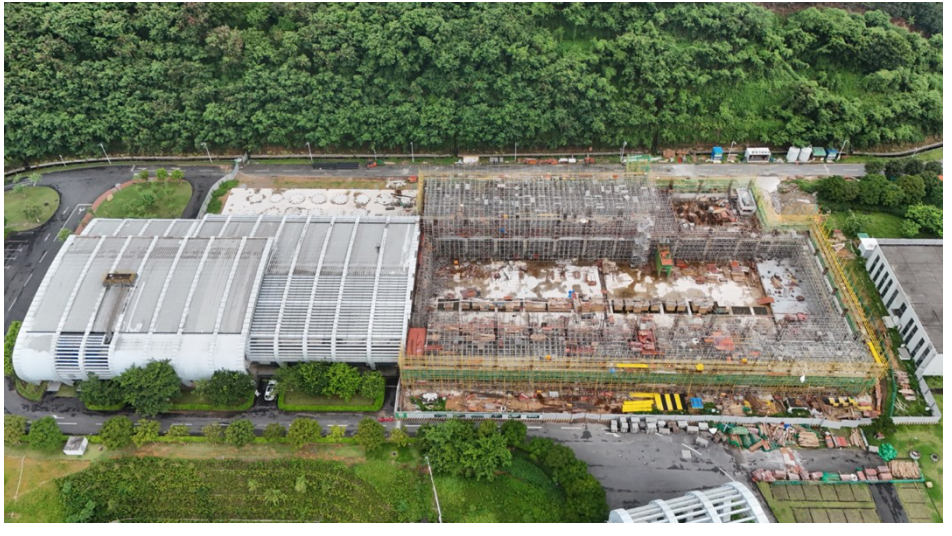
Civil Engineering – Current Status



Total Bldg. Footprint Area： 11530m²
Total Floor Area： 19397m²
Floor Area Ratio： 0.29

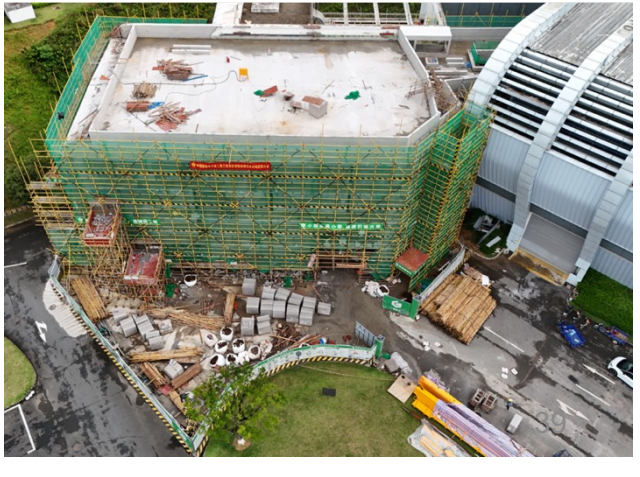
Progress of Civil Engineering





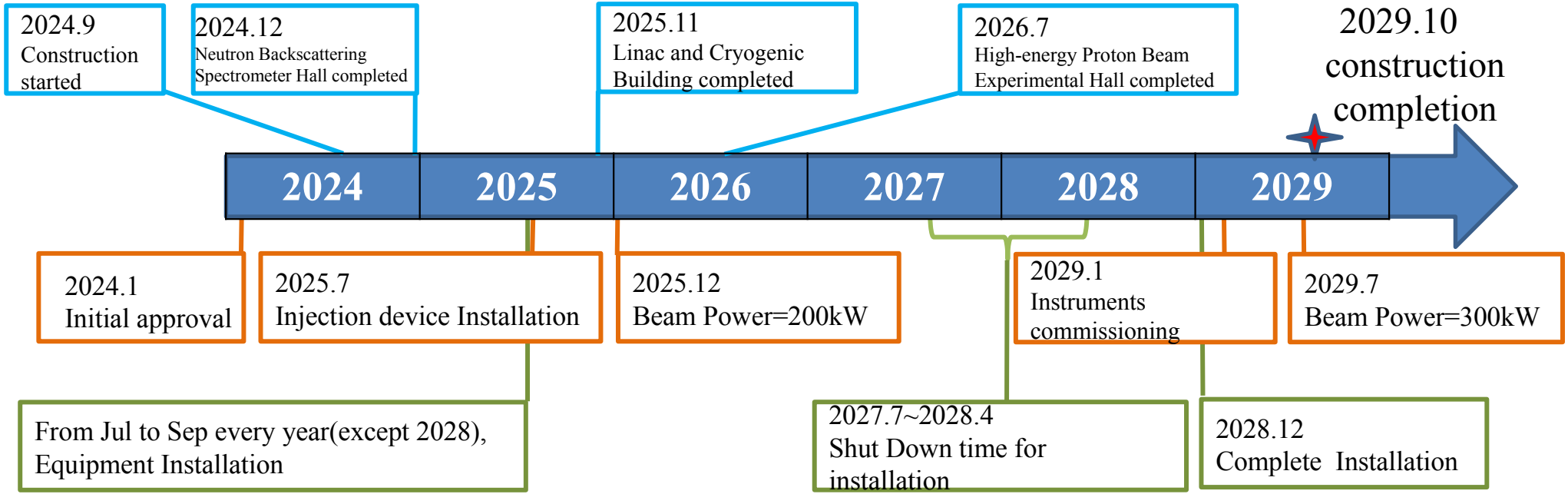






CSNS-II CPM

During the construction period, the open operation is minimally impacted due to the implementation of a well-planned installation and commissioning plan.



Plans to maintain user operation almost unaffected during CSNS II construction

Outline

I. A brief introduction to IHEP

II. The status of CSNS

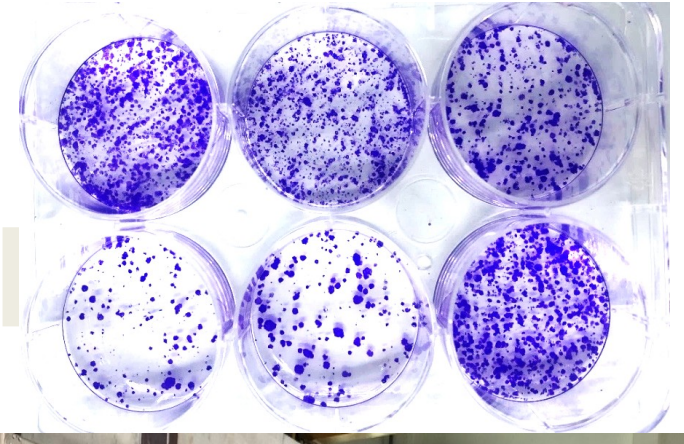
III. The Upgrade project CSNS-II

IV. Tech. transferring and proton beam utilization

V. Summary

Technology Transfer: development of BNCT

- Accelerator based neutron source + boron-based drugs
- Binary targeted and cell-level precision radiotherapy combined with drugs
- Test facility: RFQ+Lithium target， developed at the CSNS campus, used for cell and animal test





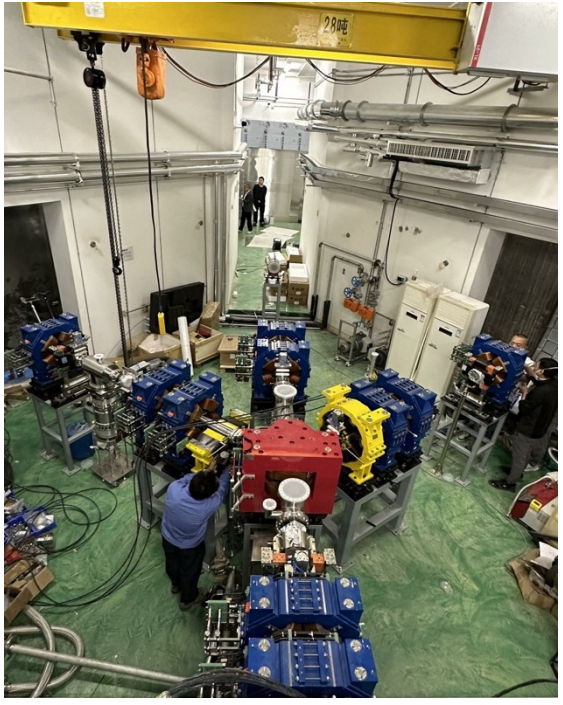


D-BNCT02 Clinical Facility

- Delivered to Dongguan People's Hospital
- Installation and accelerator commissioning completed
- Clinical treatment started in 2026

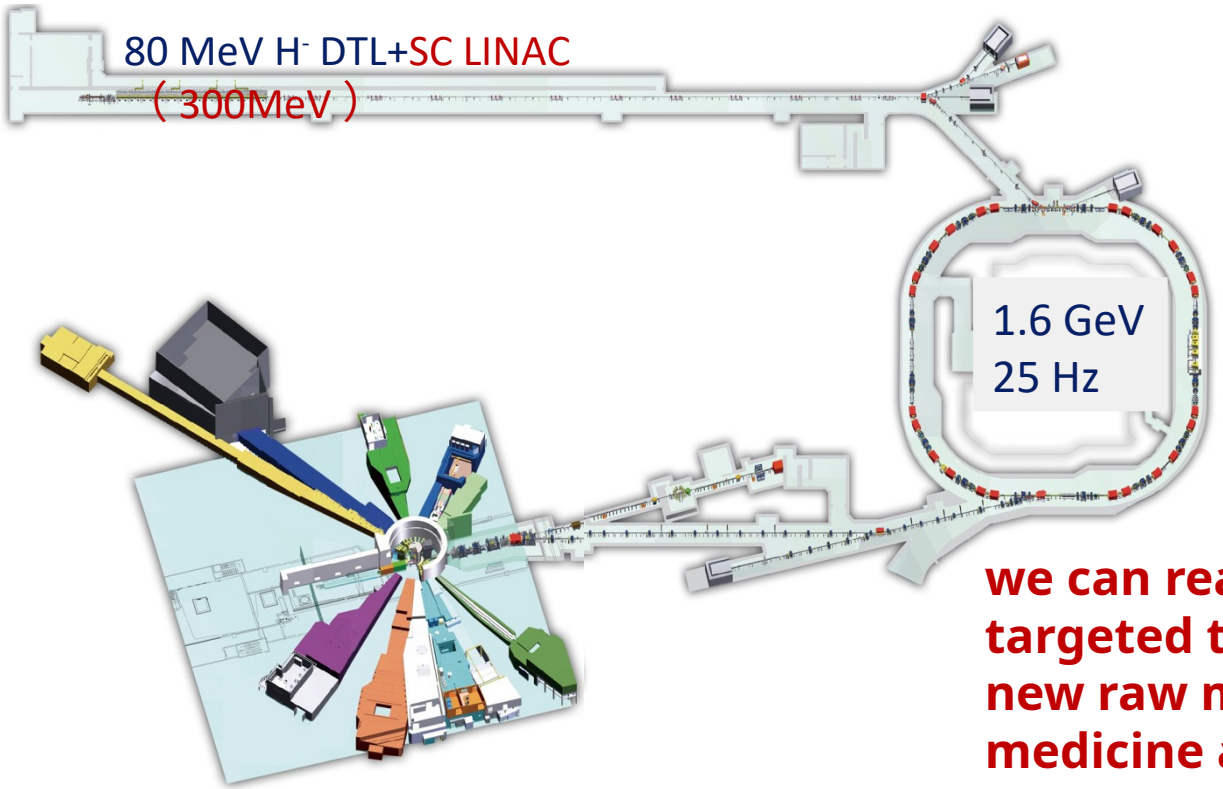






Production of α Isotopes using CSNS Linac

Ra-223、 Ac-225、 Pb-212， etc



- **Rep. rate:**

  25 —— 50Hz

- **Beam energy:**

  80 —— 300MeV

- **Beam power:**

- **5 —— 100kW@25Hz**

we can realize efficient production of targeted therapeutic isotopes, providing new raw material support for nuclear medicine and tumor targeted therapy.

Southern Advanced Photon Source

- The 4th generation medium-energy (3.5GeV) diffraction-limited storage ring
- Attosecond coherent pulses Embedded with SAPS
- SAPS will be located next to CSNS （Neutron technique + X-ray technique）
- SAPS research and test platform finished
- R&D on key techniques
- Plans to start construction during next 5 years



Tight collaboration between CSNS and FLNP since 2007

Academic Activities:

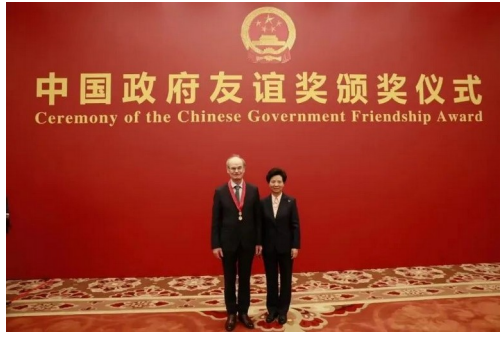
- ICANS -18 Meeting in 2007, ICANS-24, 2023 Dongguan
- CSNS Members visited FLNP and attended ISSNN meeting, 2016
- AONSA Meeting in 2023, Dongguan
- FLNP JINR – CSNS IHEP (China) Workshop on the neutron scattering technology and multi-disciplinary research, 2024, Dubna
- The first Sino-Russia Neutron Scattering meeting in 2024, Yekaterinburg
- CSNS and FLNP jointly held the International Seminar on Interaction of Neutrons with Nuclei(ISINN), 2025, Dongguan
- More than 30 Russian experiments were carried out in Back-n and Neutron scattering, CSNS, Dongguan



FLNP JINR-CSNS workshop, 2024



ISINN, 2025





Famous Physicist Gledenov conducted Back-n experiment, 2025

Academic Activities

- **On March 25, 2026, Prof. Hesheng Chen was granted the JINR honorary doctoral diploma in Dubna.**
- **CSNS and FLNP signed the MOU during the workshop in JINR, in May 2024**





Joint China-Russia Projects

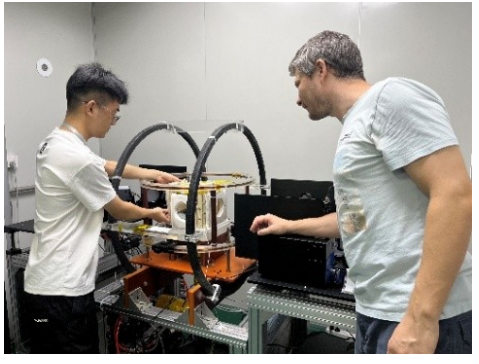
“Neutron scattering technology and multi-disciplinary research”- 1.85M$ (China)

Main tasks

1. Cold/ultra-cold neutron facility
2. Neutron guides
3. Detectors and electronics
4. Neutron polarization & Sample environment
5. Neutron scattering experiments

Based on the China Spallation Neutron Source and the IBR-2 Pulsed Reactor, we will promote comprehensive cooperation between the two facilities, jointly tackle the development of the first four key technologies listed above, collaboratively develop advanced neutron scattering methodologies and experimental techniques, conduct multidisciplinary research collaborations in neutron scattering, and expand the application of neutron scattering in multidisciplinary research.

Detailed content is available in Prof Tianjiao Liang’s talk



JINR research staff operating He3 pumping station at CSNS



Neutron scattering experiment in SANS

Summary

- ✓ CSNS (China Spallation Neutron Source) opened to users in 2018. Currently, CSNS operates at 185 kW with high availability, reliability.
- ✓ Some nuclear physics experiments were conducted utilizing Back-n.
- ✓ CSNS-II has already begun construction, aiming to increase the beam power to 500 kW. It will also involve the development of more neutron spectrometers, as well as muon and high-energy proton experimental stations.
- ✓ In addition to neutron scattering applications, other beam utilizations based on the CSNS accelerator are currently underway or planned for development.

Thank you !



Be curious and go deep into matter, like a neutron.

Be accelerated like a proton in a synchrotron.